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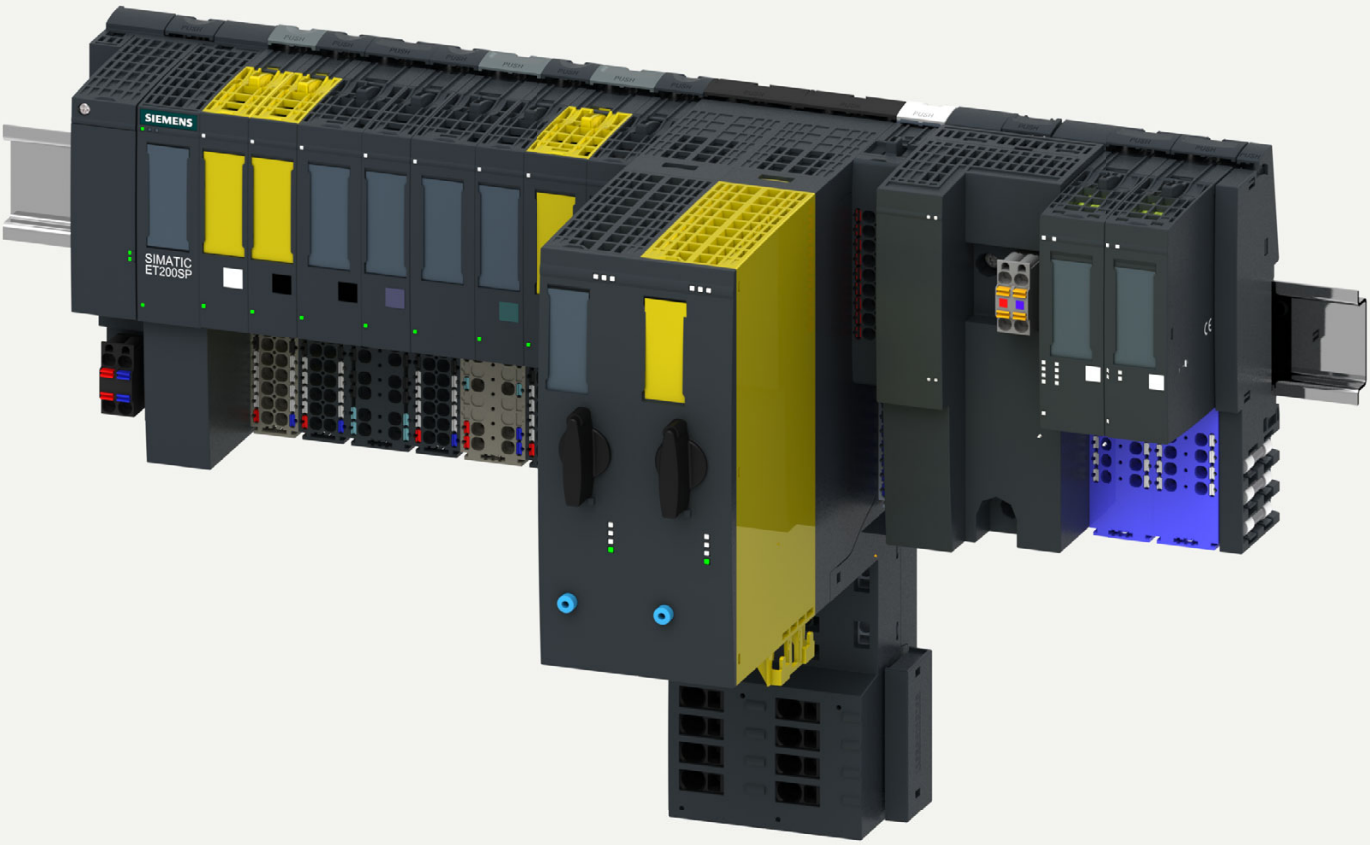

Edition 03/2026

This document contains a compilation of all manuals for the ET 200SP system family. Use the bookmarks on the edge of the screen to navigate.

Manual Collection

SIMATIC

ET 200SP

ET 200SP Distributed I/O System

support.industry.siemens.com

SIEMENS
SIMATIC

Distributed I/O system ET 200SP

Compact Operating Instructions
Original instructions

1 Notes on Safety and Product Conformity

Function

SIMATIC products control, regulate and monitor applications in automation systems, for example in the field of industrial automation technology and process engineering.

EU and UK Declaration of Conformity

- You can find the EU Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14031/cert?ct=444&ci=526).
- You can find the UK Declaration of Conformity here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14031/cert?ct=444&ci=5596).
- You can find the EU Declaration of Conformity for SIPLUS and SIPLUS RAIL here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/18161/cert?ct=444&ci=526).
- You can find the UK Declaration of Conformity for SIPLUS and SIPLUS RAIL here on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/18161/cert?ct=444&ci=5596).

Firmware

You will find the latest firmware versions (for devices that support a firmware update) on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109804718).

Documentation

The complete documentation consists of product information, the system manual, equipment and function manuals. You can find these in the Manual Collection (https://support.industry.siemens.com/cs/ww/en/view/84133942) on the Internet.

Retention of the documentation

Retain this documentation for later use.

1. Download the documentation after receiving your product and before initial installation/commissioning.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above.
2. Also retain this version of the documentation.

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Intended use

SIMATIC products are intended for use in industry. If you plan to use the product in a different environment, check the conditions required for such use.

The product may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety information. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products.

WARNING

Intended use

SIMATIC products are intended for automation of machine plants, process control and process engineering. Refer to the associated documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942) to learn about the intended area of application of the respective product (e.g. ambient conditions, possible use in safety-critical systems).

If third-party products and components are used, these have to be recommended or approved by Siemens.

Proper transport, proper storage, setup, assembly/disassembly, installation, commissioning, operation, maintenance and decommissioning are required to ensure that the product and its accessories operate safely and without any problems.

Non-observance may result in death or serious physical injury.

Read the notes in the corresponding documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942)**.**

Observe the ambient conditions for intended operation as described in the "Technical specifications" section of the associated documentation.

WARNING

Connection of the power supply

The power supply may only be connected by qualified and authorized personnel. In particular, observe the information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942) and on the nameplate of the device.

NOTE

The power supply must be connected by the operator/user in accordance with the national regulations regarding installation.

WARNING

Danger from voltage/current!

Only perform assembly and disassembly work when the device is de-energized.

Only install products with IP20 degree of protection according to IEC 60529 in enclosures, cabinets, or electrical equipment rooms suitable for the end use that meet at least this degree of protection.

WARNING

Electric shock due to externally supplied plant units

Even if the main supply to the plant is disconnected, externally supplied plant units can continue to carry voltage. An electric shock on contact with live parts can lead to death or serious injury.

Therefore, ensure that the plant is completely disconnected from the power supply before starting work. This means that all externally supplied plant units must also be disconnected from the power supply.

WARNING

Electric shock due to permissible electric potential difference

Due to the permissible electric potential difference, a dangerous voltage may be present at the inputs of modules. An electric shock on contact with live parts can lead to death or serious injury.

Therefore, ensure that the plant is completely disconnected from the power supply before starting work. This means that all externally supplied plant units must also be disconnected from the power supply.

WARNING

Safety functional extra low voltage

The product must be operated with safety functional extra low voltage (SELV, PELV). You can find more information on safety functional extra low voltage in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942) of the fail-safe I/O and in the data sheets of the power supplies to be used.

Use a power supply unit with output voltage that does not exceed 36 V DC even in the event of a fault.

Observe the maximum permissible switching conditions specified in the equipment manual for F-RQ modules.

Follow the notes and warnings in the respective equipment manual.

CAUTION

BusAdapters for fiber-optic cables contain a laser system and are classified as a "CLASS 1 LASER PRODUCT" in accordance with IEC 60825-1.

Can cause personal injury.

Avoid eye contact with the laser beam. Do not open the housing. Read the information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942).

WARNING

Personal injury due to uncontrolled movement

When using Motion Control, uncontrolled movements can occur which result in personal injury of unknown extent.

Follow the safety instructions described in the Motion Control function manuals (https://support.industry.siemens.com/cs/ww/en/view/84133942).

Electromagnetic Compatibility

The product is intended for operation in the Industrial EMC environment class.

Ensure that your automation system is installed in compliance with EMC requirements, as described in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942) for the product.

NOTICE

Interference emission / Interference immunity

Operation of the product can cause radio interference in residential areas.

If higher EMI is expected at the place of use than is intended for the industrial area according to EN61000-6-2, additional measures are required (e.g. ESD, overvoltage protection).

ATEX-/UKEX device intended for use in hazardous area

If the product is intended for use in a potentially explosive atmosphere (gas/air or gas/dust mixture), observe the special information in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942). The intended use (e.g. ATEX zone, degree of protection, temperature class) is indicated on the product (in the declaration of conformity and usually also on the nameplate).

NOTE

As a rule, country-specific requirements for the operator also apply when a product is used in a potentially explosive atmosphere (e.g. Directive 1999/92/EC for the EU).

Safety in potentially hazardous atmospheres

SIMATIC systems are suitable for use in zones with occasional presence of hazardous gas atmospheres (equipment group II, Cat. 3, gases, vapors, mists). You can find information, restrictions and special conditions in the respective system manuals.

To avoid damage, determine a suitable installation location and select suitable products. It is mandatory to define the following points before planning your automation system:

- Hazardous plant areas
- Potentially existing atmosphere
- Relevant requirements for the products

⚠ WARNING

Explosion hazard

If work in areas with potentially hazardous atmospheres is not carried out correctly, an explosion may occur. Explosions can lead to serious personal injury or damage to the plant.

Only suitably qualified specialists are allowed to plan and perform activities in areas with potentially hazardous atmospheres. In hazardous areas, always de-energize the SIMATIC system before starting activities.

Cleaning

If you need to clean the product, use dry ESD cleaning cloths (observing the protective measures for ESD).

Requirement: All supply voltages present on the device are switched off. Observe the five safety rules for working in and on electrical installations.

Maintenance and repair

The product is maintenance-free. Repairs to the product may only be carried out by the manufacturer.

Recycling and disposal

For environmentally sustainable recycling and disposal of your electronic waste, contact a company certified for the disposal of electronic waste. Dispose of the product in accordance with the applicable regulations in your country.

Accessories

You can find information on the approved accessories in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942).

Functional safety

⚠ WARNING

Danger to humans and the environment

To avoid danger to people and the environment, under no circumstances may you bypass safety functions or take measures that amount to or result in bypassing safety functions. The manufacturer is not liable for the consequences of such manipulation or for damages resulting from the failure to heed this warning.

Perform a safety inspection for safety-related functions throughout the entire system, including all safety-related components.

For fail-safe I/O, observe the notes and warnings in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942) especially for:

- Connecting/wiring
- Parameter assignment
- Status, fault displays and alarms
- Maintenance (recurring tests, software/firmware updates)
- Checking for proper function
- Technical specifications

You can find use cases for achieving the required safety class (SIL) in the documentation (https://support.industry.siemens.com/cs/ww/en/view/84133942).

⚠ WARNING

Check the firmware version for fail-safe approval

When using a new firmware version, check whether it is approved for the respective device.

The attachments of the certificate (https://support.automation.siemens.com/WW/view/en/49368678/134200) for SIMATIC Safety specify the firmware version that is approved.

Ensure that fail-safe capability is enabled for F-CPUs.

The PROFIsafe address must be set or assigned for fail-safe I/O.

Perform function tests for safety functions according to your automation task. They may only be used in production when the correct operation of the safety-related functions is ensured.

⚠ WARNING

Unexpected malfunctions of machines caused by radio devices/cell phones

Malfunctions are possible when radio devices or cell phones are used in the direct proximity of F-I/O. This can result in death, serious injury or property damage.

If you scan the 2D matrix code/ID Link or use the "SIEMENS Industry Support App" with a powered-on F-I/O, then deactivate all radio connections of the radio device/cell phone beforehand. Alternatively, power off the F-I/O before scanning.

Power off radio devices in the immediate proximity of the F-I/O.

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

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For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).

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We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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SIEMENS

SIMATIC

ET 200SP
Distributed I/O system

System Manual

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Introduction

1

Purpose of the documentation

This documentation provides important information on configuring, installing, wiring and commissioning the ET 200SP distributed I/O system.

Basic knowledge required

A basic knowledge of automation technology is required to understand the documentation.

Validity of the documentation

This documentation applies to the distributed I/O system, ET 200SP.

Definition

In this document, " motor starter" always refers to all variants of the ET 200SP motor starters.

Conventions

Please pay particular attention to notes highlighted as follows:

NOTE

Notes contain important information on the product, handling the product or on part of the documentation to which you should pay particular attention.

ID link for the digital nameplate

The ID Link is a globally unique identifier according to IEC 61406, which you will find in the future as a QR code on your product.

The figure shows an example of an ID link for the digital input module DI 8x24 VDC HF.

You can recognize the ID link by the frame with a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product.

Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner or reader app. Call the ID link.

In the digital nameplate, you will find product data, manuals, declarations of conformity, certificates and other helpful information about your product.

Standards

You can find a dated reference to the respective standards or the EC Declaration of Conformity on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14031/cert?ct=439&ci=526)

Special information

WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Proper use of hardware products

This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens.

Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults.

EU note: Start-up/commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed fulfills the regulations/specifications of Directive 2006/42/EC.

NOTE

Important note for maintaining operational safety of your plant

Plants with safety-related features are subject to special operational safety requirements on the part of the operator. Even suppliers are required to observe special measures during product monitoring. For this reason, we inform you in the form of personal notifications about product developments and features that are (or could be) relevant to operation of systems from a safety perspective.

By subscribing to the appropriate notifications, you will ensure that you are always up-to-date and able to make changes to your system, when necessary.

Log onto Industry Online Support. Go to the following links and, on the side, right click on "email on update":

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/ww/en/ps/13751)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/ww/en/ps/13828)
- SIMATIC WinAC RTX (F) (https://support.industry.siemens.com/cs/ww/en/ps/13915)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/ww/en/ps/13683)
- Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/14667)

NOTE

When using F-CPUs in safety mode and fail-safe modules, observe the description of the SIMATIC Industrial Software SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/de/view/54110126/en) fail-safe system.

1.1 Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.
- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (https://support.industry.siemens.com).

1.2 Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

1.3 ET 200SP Documentation Guide

1.3.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet. (https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.3.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.3.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.3.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety information 2

2.1 Warnings in this document

You can find explanations of the warnings used in this document in the "Legal information" section.

2.2 Safety-related symbols

2.2.1 Devices without explosion protection

The following table contains an explanation of the symbols located in your SIMATIC device, its packaging or the accompanying documentation.

Symbol	Meaning
	General warning sign **Caution/Notice** You must read the product documentation. The product documentation contains information about the potential risks and enable you to recognize risks and implement countermeasures.
	Read the information provided by the product documentation. ISO 7010 M002
	Ensure the device is only installed by electrically skilled person. IEC 60417 No. 6182
CABLE SPEC.	Note that connected mains lines must be designed according to the expected minimum and maximum ambient temperature.
EMC	Note that the device must be constructed and connected in accordance with EMC regulations.
230V MODULES	Note that a 230 V device can be exposed to electrical voltages which can be dangerous. ANSI Z535.2

Symbol	Meaning
24V MODULES	Note that a device of Protection Class III may only be supplied with a protective low voltage according to the standard SELV/PELV. IEC 60417-1-5180 "Class III equipment"
INDOOR USE ONLY INDUSTRIAL USE ONLY	Be aware that the device is only approved for the industrial field and only for indoor use.
	Note that an enclosure is required for installing the device. Enclosures are considered: • Standing control cabinet • Serial control cabinet • Terminal boxes • Wall enclosure

2.2.2 Devices with explosion protection

The following table contains an explanation of the symbols located in your SIMATIC device, its packaging or the accompanying documentation.

Symbol	Meaning
ONLY EX MODULES	The assigned safety symbols apply to devices **with Ex approval**. You must read the product documentation. The product documentation contains information about the potential risks and enable you to recognize risks and implement countermeasures.
	Read the information provided by the product documentation. ISO 7010 M002
	Ensure the device is only installed by electrically skilled person. IEC 60417 No. 6182
F<2N DISPLAY F<4N HOUSING	Observe the mechanical rating of the device.
CABLE SPEC.	Note that connected mains lines must be designed according to the expected minimum and maximum ambient temperature.
EMC	Note that the device must be constructed and connected in accordance with EMC regulations.
U = 0V	When the device is under voltage, note that it may not be installed or removed, or plugged or pulled.

Symbol	Meaning
230V MODULES	Note that a 230 V device can be exposed to electrical voltages which can be dangerous. ANSI Z535.2
24V MODULES	Note that a device of Protection Class III may only be supplied with a protective low voltage according to the standard SELV/PELV. IEC 60417-1-5180 "Class III equipment"
INDOOR USE ONLY INDUSTRIAL USE ONLY	Be aware that the device is only approved for the industrial field and only for indoor use.
ZONE 2 INSIDE CABINET IP54	For Zone 2 potentially explosive atmospheres, be aware that the device may only be used when it is installed in an enclosure with a degree of protection ≥ IP54.
ZONE 22 INSIDE CABINET IP6x	For Zone 22 potentially explosive atmospheres, be aware that the device may only be used when it is installed in an enclosure with a degree of protection ≥ IP6x.

2.3 Intended use

The system is used to control machines and plants.

Intended use also includes observance of this documentation, in particular the safety instructions and conditions of use. See Technical specifications (Page 356) section.

2.4 Changes to the device and spare parts

Modifications to the device can impair the safety and function of the device:

- Do not make any changes or modifications to the device.
- Do not remove or tape over safety instructions on the device.
- Do not tape over, cover or obstruct ventilation slots.
- Only use original spare parts and accessories.

2.5 Target group and personnel qualifications

All persons working with this device require the following knowledge:

- Contents of this document as well as contents of the enclosed documents
- Handling the device (after instruction)
- Relevant standards and regulations
- Accident prevention regulations

The following activities are reserved for specially qualified personnel:

Working on electrical parts

Work on electrical parts may only be performed by the following persons:

- Qualified electricians
- Persons trained in electrical engineering under the direction and supervision of qualified personnel

Commissioning and configuration

Commissioning and configuration requires general knowledge in the field of automation technology.

2.6 Personal protective equipment

The personal protective equipment depends on the activity and is determined by the operator.

To avoid material damage during packing, unpacking and installation activities we recommend:

- ESD wrist strap
- ESD shoes

2.7 Safe working

2.7.1 Working on electrical parts

- Only work on electrical parts if you are a qualified specialist (see section Target group and personnel qualifications (Page 23)).
- Always observe the country-specific safety rules.
- Notify all those who will be affected by the procedure.
- Follow the 5 safety rules according to DIN EN 50110-1 (VDE 0105-1):

1. Disconnect
2. Secure to prevent reconnection
3. Verify safe isolation from the supply (all poles)
4. Ground and short-circuit
5. Erect barriers around or cover adjacent live parts

The 5 safety rules must be applied in the above order prior to starting work on an electrical system. After completing the work, proceed in the reverse order.

It is assumed that every electrician is familiar with the 5 rules.

2.8 Residual risks

Despite all the technical and procedural risk reductions that have been carried out, not all dangers can be avoided.

The following sections describe these residual risks and measures to avoid them.

2.8.1 Live parts

Electrocution on contact with live parts leads to life-threatening injuries (death).

Operation

- Do not open the device.
- Never use damaged devices.
- Pull the plug and not the cable.

Installation and connection

- Only work on electrical parts if you are a qualified specialist (see section Target group and personnel qualifications (Page 23)).
- Adhere to the protective measures for safe working on electrical parts (see section Working on electrical parts (Page 24)).
- Fuse the connection cables according to the current-carrying capacity of the cable used, taking into account the applicable standards.
- Install the device in a control cabinet. The enclosures, cabinets or electrical equipment rooms must guarantee protection against electric shock and spread of fire.
- Ground the device in compliance with the applicable regulations.
- For the 24 V DC supply (SELV/PELV), only use power supply units that provide safe electrical extra-low voltage in accordance with IEC 61131-2 or IEC 61010-2-201.

Maintenance

- Only work on electrical parts if you are a qualified specialist (see section Target group and personnel qualifications (Page 23)).
- Adhere to the protective measures for safe working on electrical parts (see section Working on electrical parts (Page 24)).

2.8.2 External power supply to modules

Even if the main supply to the plant is disconnected, externally supplied modules can continue to carry voltage. An electric shock on contact with live parts can lead to death or serious injury.

For special SIMATICmodules, e.g. relay modules, you can connect or switch voltages larger than 24 V DC, e.g. 230 V AC. In some applications, these modules are supplied with voltages from outside the system (external power supply). In the event of an external power supply, a dangerous voltage may still be present on these modules even if the system is disconnected.

Maintenance

Ensure the following points before starting work:

- The plant is completely disconnected from the power supply.
- All externally supplied plant units are disconnected from the power supply

2.8.3 Voltage dangerous to touch due to permissible electric potential difference

Due to the permissible electric potential difference, a dangerous voltage may be present at the inputs of modules. An electric shock on contact with live parts can lead to death or serious injury.

Special SIMATIC modules, such as analog input modules, have isolated channels. In this case, there is no connection between the potential of the sensor and the potential of the module. If a dangerous voltage within the permissible electric potential difference occurs at the sensor, this voltage may also be present at the measurement channel of the module.

You can find the permissible electric potential differences in the technical specifications section of the modules' Equipment Manuals.

Maintenance

Ensure the following points before starting work:

- The plant is completely disconnected from the power supply.
- All externally supplied plant units are disconnected from the power supply

2.8.4 Conductive pollution

Electrocution during transmission of electrical energy via conductive contamination to the body leads to life-threatening injuries (death).

- Install the device in a control cabinet.
- Keep the control cabinet free of conductive contamination.

2.8.5 Overheating

Smoke development and fire due to overheating of the device and cables lead to burns and life-threatening injuries (death).

To avoid overheating:

- Ensure the correct installation position.
- Ensure sufficient air supply (e.g. do not tape over or cover ventilation slots, maintain mounting clearances).
- Only use undamaged cables.

Installation and connection

- Follow the instructions for the mounting position.
- Adhere to the specified ventilation clearances.
- Fuse the connecting cables according to the cable cross-section.

Maintenance

- Check plug-in connections and cables regularly for damage.

2.8.6 Uncontrolled movements

Uncontrolled movements of driven machine or system parts during commissioning, operation, maintenance and repair.

- Follow the safety instructions described in the function manuals.

2.8.7 Unsafe operating states

Unsafe operating states may result in personal injury of unknown extent.
The following factors can be triggers:

- Manipulation of the software, e.g. viruses, trojans or worms

Manipulation of the software, e.g. viruses, trojans or worms

- Adhere to the protective measures against tampering with the software (see section Industrial cybersecurity (Page 33)).
- Perform available updates in a timely manner.
- Protect files stored on removable media from malware with appropriate protective measures, e.g. virus scanner.
- Set up access protection for the CPU.

2.9 Behavior in case of emergency

- Force EMERGENCY OFF

When the safe operating state has been restored:

- Unlock the EMERGENCY OFF mechanism.
- The person responsible for the system ensures that the system starts up in a controlled and defined manner.

2.10 Material damage

2.10.1 Transport and storage

- Only pack, store, transport and ship electronic components, modules or devices in the original product packaging or in other suitable materials, e.g. conductive foam rubber or aluminum foil.
- Observe the limits during transport and storage. See Technical specifications (Page 356) section.

2.10.2 Installation and connection

- We recommend touching components, modules and devices only if they are grounded by one of the following measures:
  - With an ESD wrist strap.
  - With ESD shoes or ESD grounding strips in ESD areas with conductive flooring.
- Place electronic components, modules and devices only on conductive surfaces (e.g. tables with ESD coating, conducting ESD plastic foam, ESD packing bags, ESD transport containers).
- Ensure that there is sufficient overvoltage protection.

Do not install/remove the following elements when the power is on

- Read the section Removing and inserting I/O modules/motor starters (hot swapping) (Page 324).
- Observe the special conditions for hazardous areas in the section Marks and approvals (Page 357).

New properties/functions

3

What's new in Edition 11/2025 of the ET 200SP System Manual compared with Edition 06/2025

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Backup and restore configuration of the ET 200SP CPU by a central user	As of FW version V4.1 of a ET 200SP CPU, a central user can also back up and restore the configuration. Read about the rules you need to follow when backing up and restoring.	Section Backing up and restoring the CPU configuration (Page 307)
	Integrated security		
	Temporary account lockout for local user accounts	Starting from STEP 7 V21, you can set up a temporary account lockout for local user accounts for ET 200SP CPUs with FW version V4.1 or higher. The temporary account lockout provides protection against brute force attacks.	Section Temporary account lockout in case of brute force attacks (Page 239)
	SIMATIC S7 data	This appendix in the ET 200SP System Manual provides you with an overview of the data that the ET 200SP distributed I/O system generates and makes available to you.	Appendix SIMATIC ET 200SP data (Page 402)
	Communication of the CPU		
	New function for OPC UA	Enables cross-vendor communication.	Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) Function Manual
	Activating IP forwarding through a data record transfer	For ET 200SP CPUs as of FW version V4.1, you can also activate/deactivate the "IP forwarding" function for local interfaces of the CPU via data record transfer.	

What's new in Edition 06/2025 of the ET 200SP System Manual compared with Edition 11/2024

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Information on the data integrity and the signed firmware update of I/O modules	Data integration and signed firmware updates offer protection against manipulation of the system and increase the system security.	Section Secure operation of I/O modules (Page 66)
	BaseCarrier	New, wire-free assembly technology offers a customer-specific PCB for reduced mounting times and avoiding faulty wiring. Use of "BaseCarriers" instead of conventional "BaseUnits".	Section Installing and uninstalling BaseCarrier (Page 135)

What's new in Edition 11/2024 of the ET 200SP System Manual compared with Edition 11/2023

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Retentive memory area for syslog messages	ET 200SP CPUs FW version V4.0 or higher store syslog messages retentively. This means that events that require a restart of the CPU also remain in the syslog storage.	Section Industrial cybersecurity (Page 33)
	Central user management	System-wide, central management of users and user groups outside TIA Portal via UMC server. User management for comprehensive automation solutions with multiple projects, users, and user groups. Users and user groups can work in all projects in which they are activated and for which they have been assigned the appropriate rights. During operation, users can be added to a group, removed from a group, or their passwords can be changed. All without the CPU configuration having to be changed or loaded.	Section Central user management (Page 242)
	SIMATIC Controller Profiling	Using the new instruction "Profiling", you can start or stop the profiling of an ET 200 CPU with firmware version V4.0 or higher. When starting the profiling, specify the configuration with which the profiling data is to be recorded.	STEP 7 online help

What's new in Edition 11/2023 of the ET 200SP System Manual compared with Edition 11/2022

What's new?		What are the customer benefits?	Where can I find the information?
New contents	General safety information	The section contains a compilation of general safety information for the ET 200SP distributed I/O system.	Section General safety information
	Section "Industrial cybersecurity"	Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyberattacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities. The section contains the following information: • Basic information on the subject of industrial cybersecurity • Measures to protect individual components and the entire system against manipulation and unwanted access.	Section Industrial cybersecurity (Page 33)

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Syslog messages	As of TIA Portal version V19 and FW version V3.1, you can forward the syslog messages of an ET 200SP CPU to a syslog server.	Section Industrial cybersecurity (Page 33)
	Local user management	As of TIA Portal version V19 and FW version V3.1, ET 200SP CPUs have improved management of users, roles and CPU function rights (User Management & Access Control, UMAC). As of the above-mentioned version, you manage all project users along with their rights (e.g. access rights) for all CPUs in the project. You do this in the editor for users and roles in the TIA Portal.	Section Local user management (Page 229)
	SIMATIC Controller Profiling	With SIMATIC Controller Profiling you can analyze and evaluate the runtime behavior of your user program on an ET 200 CPU as of FW Version V3.1. All the relevant information can be displayed graphically and evaluated in a web browser.	Application example SIMATIC Controller Profiling (https://support.industry.siemens.com/cs/us/en/view/109750245)

What's new in Edition 11/2022 of the ET 200SP System Manual compared with Edition 04/2022?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Support of PROFINET system redundancy R1	The redundant ET 200SP R1 system ensures high availability through redundant PROFINET connections. In contrast to S2 devices, R1 devices are equipped with two interface modules. If one interface module fails, the R1 device can still be reached by the H-CPUs via the second interface module. Thus, R1 devices have a higher availability than S2 devices.	Starting with section System overview (Page 69)
	BaseUnit BU type M0		Starting with section System overview (Page 69)
	IM 155-6 PN R1 interface module		Starting with section System overview (Page 69)

What's new in Edition 04/2022 of the ET 200SP System Manual compared with Edition 05/2021?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	New shield terminal for connecting cable shields	The new stacked shield terminal provides extended space for clamping thanks to two clamping positions. In addition, a supporting element absorbs torsional and bending forces.	Section Connecting cable shields for I/O modules (Page 172)

What's new in Edition 05/2021 of the ET 200SP System Manual compared with Edition 09/2019?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Modules for hazardous area	The Ex BaseUnits and Ex I/O modules enable the connection of intrinsically safe devices from the hazardous area Zone 0 and Zone 1.	System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/de/view/109795533-/en) Starting from section System overview (Page 69)

What's new in Edition 09/2019 of the ET 200SP System Manual compared with Edition 02/2018?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	BaseUnits BU30-MS7, BU30-MS8, BU30-MS9 and BU30-MS10 for fail-safe motor starters	A simple, wire-saving group shutdown for fail-safe motor starters. In contrast to the earlier solution (BU30-MS5 and BU30-MS6), the fail-safe signal only has to be wired to the first motor starter. The fail-safe signal is internally routed via the BaseUnits.	Section Selecting a motor starter with suitable BaseUnit (Page 94) Section Forming potential groups (Page 102) Section Wiring BaseUnits for motor starters (Page 174)

Industrial cybersecurity 4

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyberattacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

In the first part of this section you will find basic information on the subject of industrial cybersecurity. Subsequent sections describe recommended measures for protecting the entire system and individual components from manipulation and unwanted access.

NOTE

Security-relevant changes to software or devices are documented in the section New properties/functions (Page 29).

4.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

4.2 Security update notification

Observe the special information on maintaining the operational security of your plant in the section Introduction (Page 11).

Set up notification of security updates

To receive notifications about security updates, proceed as follows:

1. Register on mySiePortal (https://sieportal.siemens.com/en-ww/home).
2. Enter the keyword "Security" in the search engine.
3. Choose the "Search in Knowledge base" option.
4. Enter the name or article number of the product in the product search.
5. Select the "Other types" option from the filter menu for "Type," and then choose "Download" and "Product note".
6. For the document you want to be informed about, select "Add to my favorites" using the 3 dots on the right.

   For example, if you would like to be informed about all firmware versions of the CPUs, select the entry "Firmware update S7-1500 CPUs incl. displays and ET 200 CPUs (ET 200SP, ET 200pro)".
7. In the following dialog, enter the name, select the storage location and the "Notify me" option for the favorite. Then click on the "+ Add to my favorites" button.

Result: You will be notified by email each time the document is changed.

Under "mySiePortal" > "Lists & notifications" > "My notifications", you can display your notifications and delete them if necessary.

4.3 Basic information on industrial cybersecurity

4.3.1 Definition of industrial cybersecurity

Industrial cybersecurity is generally understood to mean all measures to protect against the following threats:

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability (e.g. due to the destruction of data or denial of service (DoS))

4.3.2 Objectives of industrial cybersecurity

The objectives of industrial cybersecurity are:

- Ensuring trouble-free operation of industrial plants and production processes
- Prevention of risks to people and production from cybersecurity attacks
- Protection of industrial plants against espionage and manipulation
- Protection of industrial automation systems and components against unauthorized access and data loss

- Provision of a practical and cost-effective concept for securing existing plants and devices without their own security functions
- Use of existing, open, and proven industrial cybersecurity standards
- Compliance with legal requirements

An optimized and adapted security concept applies to automation and drive technology. The security measures must not impede or endanger production.

4.4 Integrated security concept and security strategies

4.4.1 Comprehensive security concept "Defense in Depth"

With Defense in Depth, Siemens provides a multi-layer security concept that offers industrial plants comprehensive and far-reaching protection in accordance with the recommendations of the IEC 62443 international standard.

Productivity and know-how are protected on 3 levels:

Plant security

Plant security uses various methods to secure the physical access of people to critical components. This starts with classic building access and extends to securing sensitive areas using access control (for example, code card, iris scan, fingerprint or access code).

Network security

Automation networks must be protected against unauthorized access. This is achieved through security measures on the product, but also those in the product-related environment.

System integrity

Targeted measures must be taken to protect existing know-how or prevent unauthorized access to automation processes.
The measures protect against unauthorized configuration changes and identify attempts at manipulation.

You can find more information on the topics of Defense in Depth, plant security, network security, and system integrity on the SIEMENS Industrial cybersecurity (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html) Web page.

You can also visit the download center (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security/downloads.html) to obtain more information on the topic of industrial cybersecurity. The "Operational Guidelines", for example, provide recommendations on basic security measures for secure machine and plant operation in an industrial environment.

4.4.2 Security management

The ISO 27001 and IEC 62443 standards call for a comprehensive approach in information technology (IT) and operational technology (OT) to protect against cyber attacks.

Responsibility for cybersecurity and IT security

Every operator of machinery and equipment is responsible for:

- Establishment of cybersecurity and IT security as an important criterion in the procurement and selection of machines and software applications.
- Use of suitable measures to protect production resources, data, and communication from manipulation and theft
- Provision of all necessary resources and training to employees to fully support these goals

For this purpose, suitable measures must be selected after a risk assessment and a cost-benefit analysis in order to protect material and intellectual property and prevent damage from occurring. These measures should be integrated into corporate processes and procedures, evaluated regularly, and firmly anchored in the corporate culture. In addition to protecting intellectual property, the protection of personal data must be ensured at all organizational units and levels.

Siemens will provide you with information and support. Subscribe to the Security feeds (https://www.siemens.com/cert) for information on vulnerabilities. Register on mySiePortal (https://sieportal.siemens.com/en-ww/home) and create filters to be notified when important information is published. The procedure is described in the section Notification of security updates (Page 34). Consider using Siemens Cybersecurity Services.

Responsibility in the digital supply chain

Cybersecurity should play a critical role in the evaluation and procurement process. The entire life cycle of a product should be considered to ensure protection against current and future risks. These include, for example, security updates throughout the product life cycle, including guidelines for secure disposal of the product.

Siemens plans and announces the provision of security updates, as well as total discontinuation of products, as part of product support.

Employee awareness

Regular training in cybersecurity and continuous testing of training success are essential so that cybersecurity measures are internalized in processes and work instructions. This involves general training in the use of software and IT hardware for company communication and as work tools, e.g.:

- secure handling of USB devices
- encrypted communication
- use of VPN
- rules for passwords and use of access
- setting up two-factor authentication
- educating employees about the dangers posed by malware, phishing, social engineering, etc.

Furthermore, if applicable, production equipment and software training should always include the topic of cybersecurity.

Maintaining the security concept through updates

Keeping software up-to-date is essential, for example, to benefit from the following measures:

- Implementation of new security strategies, protocols and techniques
- Closing of security vulnerabilities
- Elimination of security vulnerabilities

To this end, it is necessary to keep a constant eye on the further development of protective measures and, if necessary, the expansion of requirements.

Recommendations:

- Set up notifications for (security) updates
- Subscribe to information on vulnerabilities
- Monitor and implement the further development of the technology, especially in the area of cybersecurity

Always keep technology and knowledge up to date.

Consideration of the risks posed by cyber attacks in the Threat and Risk Assessment (TRA)

Make an inventory of all software, hardware, and infrastructure devices, in order to identify risks to the location or organization. Incident response procedures must be incorporated into all IT and manufacturing processes. The choice of risk mitigation measures should be based on a cost-benefit analysis and classification of risks. This is followed by the introduction of cybersecurity rules and procedures and the training of personnel.

Living the concept

Technical solutions alone are not sufficient to effectively counter threats.

Cybersecurity must be part of the corporate culture and process landscape and must be internalized and lived by all employees.

Continuously monitoring the security situation

You have the following options to monitor the cybersecurity situation continuously:

- Setting anomaly references and creating allow and deny lists based on normal network communication and production machine behavior. The SINEC software family offers you reliable security tools (https://www.siemens.com/global/en/products/automation/industrial-communication/sinec-network-software/cybersecurity.html) to detect potential vulnerabilities in OT networks, quickly initiate suitable measures and effectively resolve security vulnerabilities.
- Establishment of an intrusion detection system (IDS) that generates alarms when unusual behavior occurs in the network
- Introduction of a Security Information and Event Management (SIEM) system to collect, analyze, and evaluate events in real time to enable early countermeasures
- Measures regarding network security: e.g. network segmentation, firewalls, VPN, DMZ (demilitarized zones)

4.5 Operational application environment and security assumptions

4.5.1 Intended use

SIMATIC products are intended for use in industry. If you plan to use the product in a different environment, check the conditions required for such use.

The product may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety information. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products.

Operational reliability and intended use

Observe the "Special information" section in Introduction (Page 11).

Area of application

Observe the "Area of application" section in System overview (Page 69).

4.5.2 Requirements for the operational application environment and security assumptions

Siemens recommends the following security measures:

- Threat and Risk Assessments (as part of security management)
- Network security concepts
  - Network segmentation
  - Asset and network management
  - Network protection
  - Remote access
- Access control concepts (utilizing access control systems)
  - Physical protection
  - Physical enterprise security
  - Physical product security

Threat and Risk Assessment

Vulnerabilities and risks are identified, and countermeasures are proposed to ensure the security of the system, networks, and data.

Network security concepts

You can find information on network security in the white paper "Industrial Network Security Architecture", available from the Download Center (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security/downloads.html) on the Industrial Cybersecurity (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html) website.

Access control concepts

Physical protection

In addition to closing off and/or monitoring entire production facilities, it may be necessary to physically secure cabinets or even individual components such as circuit breakers.

Physical enterprise security

You can ensure physical corporate security by the following measures, among others:

- Closed off and monitored company premises
- Access control, locks/card readers, and/or security personnel
- Accompaniment of non-employees by company personnel
- Employees are trained on and embrace security processes within the company

Physical production security

You can ensure physical production security by the following measures, among others:

- Separate access control for critical areas, such as production areas.
- Installation of critical components in lockable cabinets/control rooms with monitoring and alarm capabilities. The cabinets/control rooms must be secured with a cylinder lock. Do not use simple locks, such as universal, triangular/square, or double-bit locks.
- Radio field planning to limit WLAN coverage areas, preventing them from extending beyond defined zones (e.g. factory floor).
- Guidelines that prohibit the use of external, insecure data storage media (such as USB flash drives) and IT devices (such as laptops) on systems.

4.6 Security properties of the devices

The security properties of the individual devices are listed in the Equipment Manuals.

4.7 Secure operation of the system

4.7.1 Introduction to secure operation of the system

This section describes measures recommended by Siemens to protect your system from manipulation and unauthorized access.

4.7.2 Hardening measures

System hardening, also referred to simply as hardening, is the secure configuration of products or systems. The aim is to close vulnerabilities and take various measures to reduce the attack surfaces for cyberattacks.

Measures for system hardening include, for example:

- Secure configuration in which only software components and services actually needed for operation are installed or activated.
- Access control in which restrictive user and rights management system is implemented.

4.7.3 Secure configuration

Secure configuration involves control over all software components, along with their interfaces, ports, and services.

Activated services and ports pose a risk, for example of unauthorized access to the network and to programs.

To minimize the risk, activate solely the required services at all the automation components. Take into account all activated services (especially web servers, FTP, remote maintenance etc.) in the security concept. Consider the default states of ports and services in your security concept.

You can find an overview of all ports and services used in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

4.7.4 Access control

In addition to physical protection, also establish logical safeguards to control access to your system:

- Use a restrictive user and rights management system, e.g. for accessing the CPUs and TIA Portal
- Observe the information regarding password management in the section Protection (Page 226) and in the STEP 7 online help (TIA Portal).

4.7.5 Handling of sensitive data

Data protection information

Siemens Aktiengesellschaft observes the applicable data protection laws, including the General Data Protection Regulation (GDPR), in particular the rules of data minimization and data-protection-friendly default settings (privacy by design, privacy by default).

This means for the products in this system:

Products with user management save user names and passwords to manage access rights. User names are also saved in logging alarms. These logging alarms are provided with a time stamp and stored in the internal cache of the CPU. They can be forwarded to a central syslog server.
You can find more information in the section Syslog messages (Page 56).

In addition, the products do not store any personal data.

If you establish a reference to an identifiable person by linking these data with other data (for example shift schedules), or if you store personal data on the same medium (for example a hard disk), you must yourself ensure that the data protection regulations are observed.

Information on the secure removal of data from the CPU, interface module, and SIMATIC Memory Card is provided in the section Secure decommissioning (Page 43).

Storage of security-related data

When storing your security-relevant data on your PC, independently ensure secure data storage.

Observe also the section Data worth protecting (Page 53).

4.7.6 Regular firmware updates

NOTE

Outdated firmware versions might not be monitored for security vulnerabilities.

- Always keep your plant/products up to date to benefit from bug fixes and to minimize potential risks.
- Use email notifications to be automatically informed about firmware updates.

For more information, refer to:

- The section Firmware update (Page 332)
- The section Notification of security updates (Page 34)

4.7.7 Notifications about security vulnerabilities (Siemens Security Advisories)

A vulnerability is a security vulnerability in information security. A vulnerability can pose a threat as it provides intruders with the opportunity to access system resources and manipulate or steal data. Many vulnerabilities allow availability to be impaired.

Siemens ProductCERT

If Siemens identifies or fixes security gaps (Security Vulnerabilities) in the products, this will be published in the Security Advisories.

You can find the documents for SIMATIC on the following Siemens AG Web page: Siemens ProductCERT and Siemens CERT (https://new.siemens.com/global/en/products/services/cert.html?s=SIMATIC#SecurityPublications)

"SIMATIC" is the default in the "Search Security Advisories" search field. You can also enter other product names or other terms in the search field and search for them.

On this page, you will also find all necessary information on handling vulnerabilities:

- Contact persons for matters related to vulnerabilities
- Options for automated notifications regarding vulnerabilities
- Notifications are also possible in CSAF format
- Option to subscribe to RSS feeds and newsletters
- List of all current vulnerabilities and detailed information such as:
  - Description
  - Score according to Common Vulnerability Scoring System (CVSS)
  - Measures
  - Availability
  - Etc.

Set up Security feeds (https://www.siemens.com/cert) to receive notifications about security-related topics.

If you suspect or have discovered a vulnerability in a Siemens product, please inform us immediately. To do this, press the "Contact" button on the CERT Services page (https://www.siemens.com/cert) and follow the instructions.

4.7.8 Data backup

Secure your configuration and parameter settings so that you can quickly restore this data if needed.

4.7.9 Security checks

Security checks for data, files and archives serve to protect data integrity at the storage location and during file transfer from manipulation and transmission errors. This is often achieved using digital checksums that are provided alongside the data. Tools (such as SHA-256 or SHA-512) for calculating and verifying these checksums are provided in many systems and named according to their respective calculation methods.

File Integrity Guidelines describe the prescribed procedure for integrity checks.

Integrity protection is a protection function for engineering data and firmware files.

Communication integrity means protecting communication against unauthorized manipulations to ensure high system availability. A central element in this regard is, for example, the use of digital checksums when accessing controllers. (Source: Industrial Cybersecurity website (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html))

4.7.10 Secure decommissioning

4.7.10.1 Introduction

In the following section, you will find information on how to properly decommission individual components of your automation system. Decommissioning is necessary when the component has reached the end of its service life.

Decommissioning includes environmentally sound disposal and secure removal of all digital data of electronic components with storage medium.

4.7.10.2 Securely removing data

Before disposing of components of your automation system, you should securely delete all data from the storage media of these components. How to securely delete data from the devices so that it cannot be recovered is described below.

NOTICE
Data misuse resulting from non-secure deletion of data Incomplete or non-secure deletion of data from data memories can result in data misuse by third parties. For this reason, ensure secure deletion of data from all storage media used before disposing of the product.

Secure erasure of data from the CPU and SIMATIC Memory Card

To delete all data from the data memories of the CPU, reset the CPU to factory settings. The function deletes all information that was saved internally on the module.

For secure deletion of the data, follow these steps in the order given:

1. Format the SIMATIC Memory Card.

   The formatting deletes all contents from the SIMATIC Memory Card.

   Formatting with STEP 7:

   – Establish an online connection.
   – Open the online and diagnostics view of the CPU (either from the project context or via "Accessible devices").
   – In the dialog window, select "Functions > Format memory card" and then click the "Format" button.

2. Reset the CPU to factory settings.

   We recommend resetting the CPU in STEP 7. When you reset a CPU to factory settings, select the options shown in the figure before the reset.

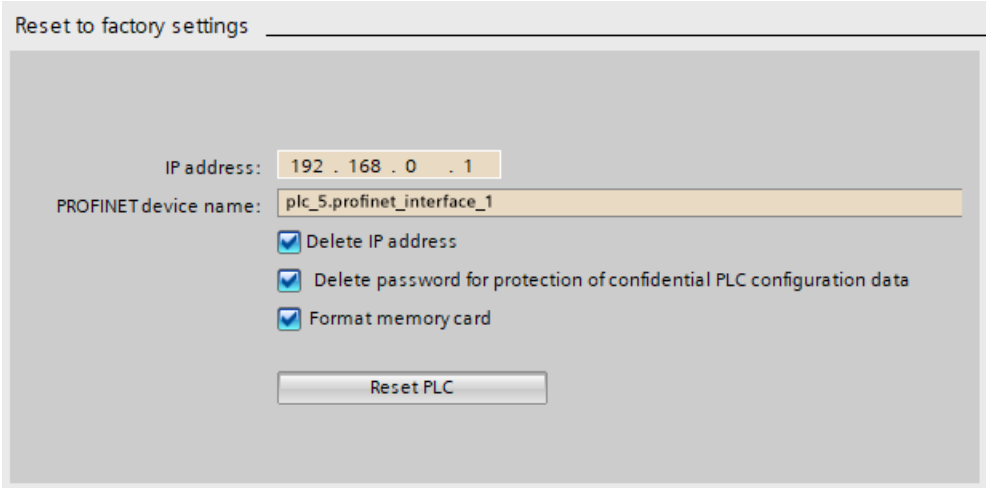

Figure 1-1 Resetting the CPU to factory settings

NOTE

If you reset the CPU using STEP 7 and you have selected the "Format memory card" option, you can skip step 1 of the described sequence of steps.

Result: All data that was still contained in the data memories of the modules and the SIMATIC Memory Card has been deleted. You can now dispose of the components.

For more information on resetting the CPU to factory settings, refer to the section Resetting the CPU to factory settings (Page 339).

NOTE

If you no longer plan to use the SIMATIC Memory Card after formatting it, destroy it before disposing of it.

A secure destruction method is to shred the card to such a degree that it cannot be reconstructed. For this, you can also use a waste disposal service that specializes in data storage medium destruction.

Secure erasure of data from the interface module

With the following tools, you can securely erase the data from the interface module:

- STEP 7 < V19
- SIMATIC Automation Tool
- MultiFieldbus Configuration Tool (MFCT)
- PRONETA

Follow these steps in the order given:

1. Establish an online connection.
2. Open the Online and Diagnostics view of the IM (either from the project context or via "Accessible devices").
3. In the dialog box "Functions > Reset to factory settings", select the option "Delete I&M data" and then the "Reset" button.

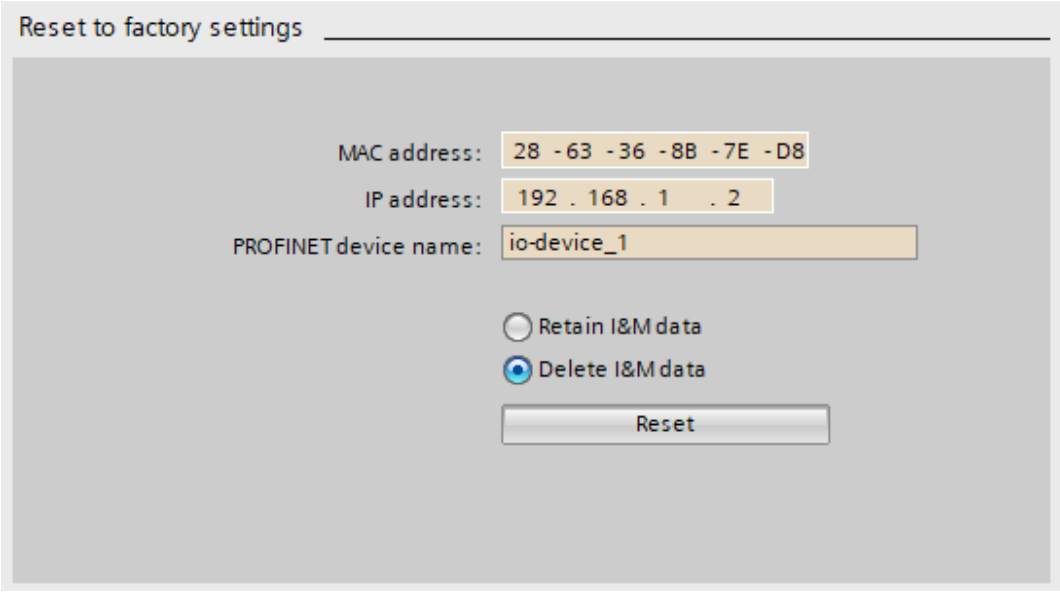

Figure 1-2 Resetting an interface module to factory settings

Result: All the data that was still in the data memories of the interface module was deleted. You can now dispose of the components.

For more information on resetting the interface module to factory settings, refer to the section Resetting an interface module to factory settings (Page 342).

NOTE

STEP 7 ≥ V19

Only the communication parameters will be securely deleted for "Reset to factory settings" with the "Delete I&M data" option enabled when you use STEP 7 ≥ V19.

Deleted communication parameters:

- IP address
- Device name
- PROFINET configuration data

If you want to securely remove all data, use one of the tools listed above for this purpose.

4.7.10.3 Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal service and dispose of the equipment according to the applicable regulations in your country.

NOTE

Recycler Guides

Disassembly of electronic devices may only be carried out by specialists trained in the recycling of electronic products.

The Siemens Recycler Guides provide step-by-step disassembly instructions and material composition information of the products. This information helps recyclers direct specific materials to specialized recyclers and thus maximize the recovery of resources.

You can find the Recycler Guides in the SiePortal (https://sieportal.siemens.com/en-ww/home) in the "Support" area by using the search term "Recycler Guide".

4.8 Secure operation of the engineering software

For more information on secure operation of the engineering software, refer to the TIA Portal online help.

4.9 Secure operation of CPUs

4.9.1 Introduction to secure operation of CPUs

This section describes measures recommended by Siemens to protect your device from manipulation and unauthorized access.

4.9.2 Secure configuration

Information about ports, services and default states can be found in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925) and the Equipment Manual.

4.9.3 User management and access control

4.9.3.1 Administration of user accounts

Creating and managing user accounts with appropriate usage rights is an important measure, as every active user represents a potential security risk.

Take the following security measures:

- Train your personnel in understanding their rights and password assignment
- Regularly check the user accounts

You can find information on creating and managing user accounts in the Protection (Page 226) section under "User management" and in the online help for STEP 7 (TIA Portal).

4.9.3.2 Assigning secure passwords

Using non-secure passwords can easily lead to data misuse. Non-secure passwords can be easily guessed or decrypted.

- Therefore, always change the default passwords during commissioning and use different passwords for different users, functions and devices.
- When changing passwords, do not use passwords (or parts of passwords) that have been used in the past.
- Also, change passwords for functions you don't personally use to prevent misuse of such unused functions.

- Always keep your passwords confidential and ensure that only authorized individuals have access to the respective passwords.
- Exceed the required minimum password length and use a combination of lowercase letters, uppercase letters, numbers and special characters.

The STEP 7 online help (TIA Portal) provides information on creating secure passwords.

Overview of all components and functions with password protection

Components and functions with password protection	Comment
SIMATIC S7 app	See the SIMATIC S7 app (https://new.siemens.com/global/en/produkte/software/mobile-apps/simatic2go.html)
Syslog (with certificate protection)	See section Syslog messages (Page 56)
CPU	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section Secure Communication
OPC UA	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section OPC UA Communication
SNMP Community-String (similar to a password)	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section SNMP
Secure communication (with certificate protection)	See the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section Secure Communication
Web server	See the Web Server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193560)

4.9.3.3 Password management

- You can find comprehensive recommendations for assigning secure passwords in the Industrial Security Configuration Manual (https://support.industry.siemens.com/cs/us/en/view/108862708).
- Set guidelines for assigning passwords and intervals for password changes.
- Settings for checking password policies when passwords are assigned or changed can be configured in the TIA Portal. You can find more information in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
- Changing and resetting the password for protection of confidential configuration data

  You can find information on the following topics in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925):

  – Description on how to change the password
  – Description on how to delete or reset the password
  – Description on how to assign the password via a SIMATIC Memory Card.

- For user management and access control, use the local/central user management.
- Using a password provider: A password provider can be set up in STEP 7, see the section Know-how protection (Page 255).
- In addition, you can use commercially available password management programs.

Setting password protection without engineering system

You can change your password for a user account in the user management via the web server of the CPU:

- API method Api.ChangePassword: Changing a password in runtime

You can find more information about the available methods of the web server's Web API in the Web server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193560).

4.9.3.4 Setting protection levels

For detailed information about setting up protection levels for the CPU and assigning user authorizations, refer to the Configuring access protection for the CPU (Page 251) section and the STEP 7 online help (TIA Portal).

4.9.3.5 Certificate management

You can use TIA Portal to create, assign, and manage certificates for the following functions of the ET 200SP CPUs:

- Secure Open User Communication
- OPC UA communication
- Secure PG/HMI communication
- Web server

You can find all the relevant information about "Certificate management" in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

4.9.4 Protection functions

Integrated protection functions of the CPU protect against unauthorized access.

You can find an overview of the protection functions supported by your CPU in the respective Equipment Manual.

A description of the protection functions and their activation can be found in the section Protection (Page 226).

4.9.5 Signed firmware update for CPUs

Signed firmware update

A signed firmware update ensures the authenticity and integrity of the firmware loaded onto a device.

It protects you against installing malicious firmware in case:

- Firmware was modified
- Firmware was downloaded from an incorrect internet source

Principle of the signed firmware updates for CPUs

Firmware updates for CPUs contain a digital signature.

The digitally signed firmware update files are available for download on the Siemens Support website (https://support.industry.siemens.com/cs/de/en/view/109478459).

The CPU verifies the authenticity and integrity of the firmware update file before installation using the digital signature with standardized asymmetric cryptography methods. As a result, the CPU can detect a manipulated or corrupted firmware update file and reject it.

Note that the CPU performs the verification only after the complete firmware download has taken place.

The procedure for carrying out firmware updates for CPUs is described in the section Firmware update (Page 332).

Diagnostics alarms and remedy

The success/failure of the signed firmware update is reported:

- In the diagnostic buffer of the CPU
- On the display of the CPU if the CPU has a display
- In the Syslog storage of the CPU

In case of firmware update rejection, proceed as follows:

1. Check whether the firmware update file used by you originates from a secure source and was downloaded unchanged. As a check, calculate the hash value of the downloaded firmware update file and compare it with the value specified on the download page.
2. Download the firmware again from the Siemens Support Web page.
3. Repeat the firmware update.

You can find information on the procedure for calculating and comparing hash values on the Internet (https://support.industry.siemens.com/cs/de/de/view/109483101/en).

4.9.6 Secure Boot for CPUs

Secure Boot

Secure Boot verifies, before the boot process, whether firmware has been falsified, for example through manipulation or accidental falsification.
Secure Boot ensures the authenticity and integrity of the firmware executed by the device.

Principle of "Secure Boot" for CPUs

CPUs starting from article number 6ES751x-xxx03-0AB0 verify the authenticity and integrity of the firmware to be executed using "Secure Boot" before their startup.

The verification is carried out using standardized asymmetric cryptography methods.

In addition to the signed firmware update for CPUs (Page 51), Secure Boot prevents a manipulation of the firmware by a physical intervention into the CPU.

Secure Boot is integrated in the CPU and cannot be deactivated for security reasons.

4.9.7 Web server

The CPUs have an integrated Web server.

It comes with built-in security features:

- Activation for specific interfaces
- Access via the secure transmission protocol "HTTPS" using the CA-signed or self-signed Web server certificate
- Authentication via local or central user management
- Changing the password of local users during runtime using Web-API

The functions are described in detail in the Web server (https://support.industry.siemens.com/cs/ww/en/view/59193560) Function Manual.

4.9.8 Secure Communication/OPC UA

Additional protection is provided by the protection functions of the secure communication and OPC UA protocols.

Information about the protocols Secure Communication and OPC UA can be found in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

4.9.9 Sensitive data

Security-relevant and sensitive data can be protected through appropriate measures such as passwords and protection functions.
For certain data, protection is already essential and implemented within the system (e.g. certificate management in the TIA Portal).

Sensitive data	Comment	Where can I find more information?
Confidential configuration data (private keys, passwords/access data)	Protection by using a strong password	Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section Protection of confidential configuration data
User management data	-	STEP 7 online help
Configuration of CPUs and interface modules	Protection through PROFINET Security Class 1	PROFINET with STEP 7 Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856)
Blocks (data blocks, logic blocks)	Know-how protection, copy protection, write protection	Section Protection (Page 226)
Data deemed sensitive by the operator	Backups, other configuration data, analysis data	Section Backing up and restoring the CPU configuration (Page 307)

4.9.10 Backups and data backups

Regular backups or data backups after successful installation should be part of a successful security concept. Whether for restoring a project if required, if the changes made do not yield the desired results, or for saving an installation in an emergency.

Backing up a STEP 7 project:

- Project backup via the SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300)
- Project backup via TIA Portal, see FAQ What options are there in STEP 7 (TIA Portal) for backing up projects and what is the significance of the backup files of the projects? (https://support.industry.siemens.com/cs/en/de/view/92561565)

You can find more information in the section Backing up and restoring the CPU configuration (Page 307).

4.9.11 Additional measures for network security

To secure a CPU via further measures, the following options are available:

- Deployment of CP 1543SP-1 with security functions

  The use of an Ethernet CP provides you with additional access protection through a firewall and possibilities to establish secure VPN connections. See also operating instructions SIMATIC NET: S7-1500 - Industrial Ethernet CP 1543-1 (https://support.industry.siemens.com/cs/us/en/view/67700710) and S7-1500 - Industrial Ethernet SIMATIC CP 1545-1 (https://support.industry.siemens.com/cs/us/en/view/109771664).

The following measures additionally increase the protection against unauthorized access to functions and data of the CPU from external sources and via the network: You can find information on these topics in the section Further measures for protecting the CPU in Overview of the protective functions of the CPU (Page 226).

- You can find information on network security and network components for protection from unauthorized access in the PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856), section Network security.

4.9.12 Remote access to CPU

4.9.12.1 Using a Web server

When using Web servers, traditional firewalls are no longer sufficient to protect modern networks.

You can find information on potential risks when using web servers in the Web Server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193560).

4.9.12.2 Remote access via Internet

Communication via SINEMA Remote Connect (SINEMA RC)

The "SINEMA Remote Connect" (SINEMA RC) application is available for remote maintenance purposes. SINEMA RC uses OpenVPN to encrypt the data. The center of communication is the SINEMA RC server, which is used for communication between the devices and manages the configuration of the communication system.

You can use the CP 1543-1 communication processor for remote maintenance via SINEMA RC.

More information on communication via SINEMA RC can be found in the Operating instructions S7-1500 - Industrial Ethernet SIMATIC CP 1543-1 (https://support.industry.siemens.com/cs/de/de/view/109986722/en) and on the Internet.

4.9.12.3 Remote access via TIA Portal

Communication via TIA Portal Cloud Connector

The TIA Portal Cloud Connector enables you to access the local PG/PC interface and the SIMATIC hardware connected to it from a TIA Portal Engineering in a cloud environment.

Use the "TIA Portal Cloud Connector" via a VPN solution (for example, SINEMA RC).

More information on communication via TIA Portal Cloud Connector in the STEP 7 (TIA Portal) online help. You can find details on working with the TIA Portal Cloud Connector in this application example (https://support.industry.siemens.com/cs/de/de/view/109747305/en).

4.9.13 Recording Security events

Syslog storage

Syslog stands for "System Logging Protocol," a standard for transmitting log messages triggered by security events. Predefined events in a network device are collected as security events in the device (syslog client) and stored as syslog messages in the local cache.

A syslog server collects and categorizes syslog messages, which can then be analyzed and filtered and displayed in various ways. Additionally, notifications for critical events can be configured.

The following security events, for example, are collected in the CPU diagnostic buffer:

- Going online with the correct or incorrect password
- Manipulated communication data detected
- Manipulated data detected on memory card
- Manipulated firmware update file detected
- Changed protection level (access protection) downloaded to the CPU
- Password legitimization restricted or enabled (via an instruction or, if applicable, the CPU display)
- Online access denied due to the possible number of simultaneous access attempts being exceeded
- Timeout when an existing online connection is inactive
- Logging on to the Web server with the correct or incorrect password
- Creating a backup of the CPU
- Restoring the CPU configuration (Restore)

The above-listed security events are also stored as syslog messages in the local cache of a CPU as of firmware version V3.1. You can find an overview of all syslog messages in the following Entry (https://support.industry.siemens.com/cs/ww/en/view/109823696).
The content of a syslog message is based on IEC 62443-3-3.

You can find more information in the section Syslog messages (Page 56).

Connection to a SIEM system

A SIEM system (Security Information and Event Management) analyzes security events in real time and can be installed, for example, on the syslog server.

4.9.14 Syslog messages

Using syslog messages

International standards and national regulations for the IT security of automation components require, for example, the ability to log safety-related events.
Syslog (System Logging) is an IETF standard protocol (RFC 5424) for the transfer of recorded events and meets this requirement. A CPU records the following events, for example:

- Security events
- Firmware updates
- Changes to the user program
- Changes to the configuration
- Changes to the operating state

The collecting of security-relevant events cannot be deactivated. Each CPU as of FW version V3.1 saves syslog messages in a local cache. By querying this cache, you can view the syslog messages and identify potential security risks.

For CPUs as of FW version V4.0, the local cache is located in the retentive memory area. As a result, syslog messages are retained after a POWER OFF/POWER ON transition or when the CPU is switched off. As a result, events that require one or more CPU restarts are also retained in syslog storage, such as restoring the CPU configuration.

The cache of a CPU is organized as a ring buffer. If the storage limit of the cache is reached and additional security events occur, the oldest messages in the cache are overwritten.

You have the option of transferring the security events collected by the CPU to a syslog server in the network.

NOTE

Deleting the retentive syslog storage

If you want to expand or store a CPU as of FW version V4.0, the syslog messages are retained in the syslog storage of the CPU. To prevent unwanted transmission of saved syslog messages, return the CPU to factory settings (reset to factory settings) before removing or storing.

After a successful reset, the syslog storage only contains one boot up entry, which provides information about the reset to factory settings.

Forwarding to a syslog server

From STEP 7 V19 and a CPU as of FW version V3.1, it is possible to transfer syslog messages to a server, e.g. SINEC INS. The syslog messages are transferred to the syslog server via the syslog protocol. The syslog server saves all syslog messages from its connected devices. Messages of system and network events are stored centrally in a storage location in the syslog server. At the syslog server interface, you can view the collected syslog messages and thereby determine the source of potential security risks or problems.

If you want CPUs to transfer their syslog messages to a syslog server, configure either a TLS or UDP connection. Syslog messages are sent to the syslog server via port 514 (UDP) or port 6514 (TLS over TCP) by default.

Use solely a TLS connection in productive operation. TLS ensures that all syslog messages from the CPU are securely transferred to the syslog server.

You can also use a UDP connection for commissioning and testing scenarios. A UDP connection is not secured. A UDP connection does not even guarantee transferring of all syslog messages to the configured syslog server.

Processing in a Security Information and Event Management system (SIEM system)

In order to be able to accept and process the incoming syslog messages, a SIEM system must "understand" the syslog protocol according to RFC 5424.

The SIEM system breaks down the incoming syslog messages into individual elements. These elements are assigned to their own event within the SIEM system. Within this event, it is analyzed whether there are connections between the individual syslog messages. In this way, the SIEM system detects possible attack vectors and, if necessary, informs the user, e.g. in the event of multiple attacks at several points in the system.

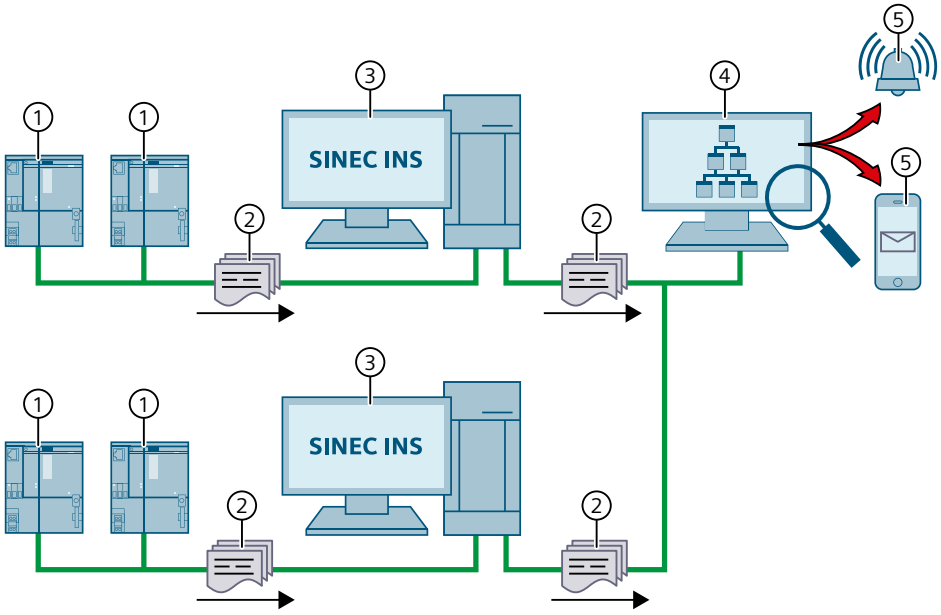

① CPUs
② Syslog messages
③ Syslog server, e.g. SINEC INS
④ SIEM system
⑤ Notify user

Figure 1-3 Forwarding and processing of syslog messages

More information

More information on network management with SINEC INS is available in the "SIMATIC NET: Network management SINEC INS V1.0 SP2" (https://support.industry.siemens.com/cs/us/en/view/109781023) manual.

You can find information on the structure of syslog messages in the Structure of the Syslog messages (Page 61) section.

4.9.14.1 Transfer the syslog messages to a syslog server

A CPU can send syslog messages to a syslog server via a TLS or UDP connection.

Recommendation: Use solely a TLS connection for the productive operation. You can also use a UDP connection for commissioning or testing scenarios.

Transmitting syslog messages via a TLS connection

A TLS connection ensures that all syslog messages from a CPU are securely transmitted to the syslog server. If the TLS connection is interrupted, the syslog messages are cached in the CPU cache. The CPU only sends the cached syslog messages when the TLS connection to the syslog server is established again.

Each syslog message is transferred to a syslog server only once. If you address another syslog server in the settings for the syslog server, syslog messages that have already been transferred are not transferred to a newly configured syslog server.

Since the cache of a CPU is organized as a ring buffer, the oldest messages are overwritten as soon as the memory limit is reached and further security events occur. Overwriting syslog messages that have not yet been transferred to a syslog server is reported as a security event (overflow event) in syslog storage. If syslog messages are overwritten over a long period of time, the overflow event is repeated regularly. As soon as the first message is sent back to the syslog server, another security event is generated. This security event confirms that syslog messages are being transferred back to the syslog server.

Message in the diagnostic buffer of the CPU

If a syslog server is configured in the CPU properties, the CPU records overwriting of non-transmitted syslog messages in the diagnostic buffer also.

As soon as a non-transmitted syslog message is overwritten, the CPU reports maintenance demanded as an incoming event in the diagnostic buffer. In addition, the MAINT LED of the CPU also signals incoming maintenance demanded.

As soon as the syslog messages are sent back to the syslog server, the CPU reports maintenance demanded as outgoing event in the diagnostic buffer. If the CPU does not report any further maintenance demanded, the MAINT LED also turns off again.

Information on the status and error display of the CPU can be found in the respective device manuals.

Requirements

If you want to transfer the syslog messages of a CPU to a syslog server, the following requirements must be met:

- STEP 7 as of version V19
- CPU as of FW version V3.1
- A project has been created in STEP 7
- The device or network view of STEP 7 is open

Procedure

To configure the CPU to transfer syslog messages to a syslog server, following these steps:

1. Select the required CPU in the device or network view of STEP 7.
2. In the Inspector window, navigate to "Properties > Protection & Security > Syslog > Syslog server".
3. In the "Connection to syslog server" area, select the "Enable transfer of syslog messages to a syslog server" option. The selection options below become editable.
4. Select one of the following options from the "Transport protocol" drop-down list:
   - "Transport Layer Security (TLS) - server and client authentication": Encrypted data transfer, syslog server and client (CPU) must authenticate themselves.
   - "Transport Layer Security (TLS) - only server authentication": Encrypted data transfer, only the syslog server needs to authenticate itself.
   - "UDP": Unencrypted data transfer, syslog server and client (CPU) do not need to authenticate themselves.

   In the next sections you can read how to select the certificates for authentication (logon) depending on the settings specified.
5. In the "Addresses of the syslog servers" column, enter a valid server address.
6. In the "Port" column, enter a valid port number.
   By default, STEP 7 uses the following port numbers:
   - Standard TCP port for TLS: 6514
   - Standard UDP port: 514

Result: You have configured the transfer of syslog messages to a syslog server.

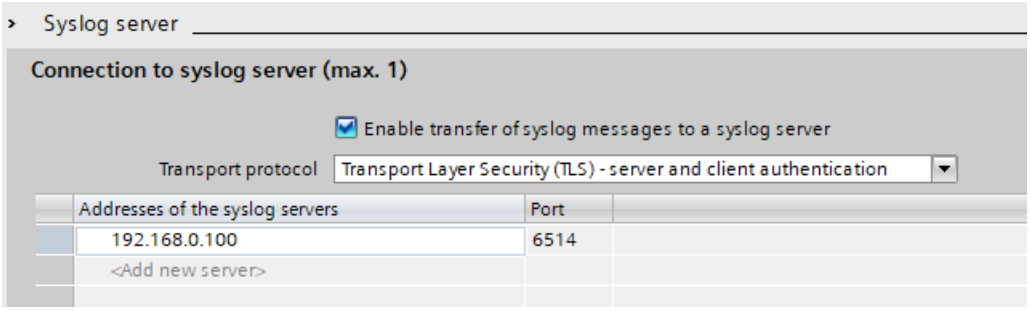

Figure 1-4 Transfer of syslog messages to a syslog server configured

Selecting the client certificate

STEP 7 provides the required client certificate for a CPU for the TLS transport protocol. If the certificate is managed within the CPU, you can either choose an existing certificate or create a new certificate. To do so, follow these steps:

1. Select the required CPU in the device or network view of STEP 7.
2. In the Inspector window, navigate to "Properties > Protection & Security > Syslog > Certificates for Syslog".
3. Select the appropriate certificate in the "Client certificate" field.

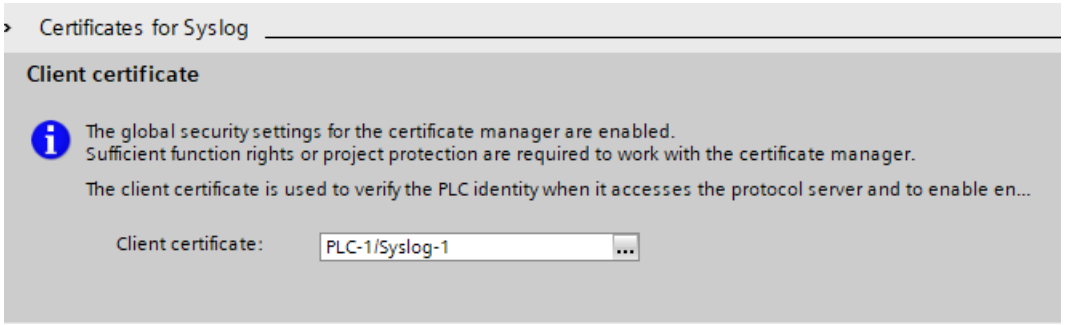

Selecting the server authentication

After selecting the TLS transport protocol, the configured syslog server must authenticate itself. This ensures that the CPU only connects to a trusted server. If you want to waive server authentication, activate the automatic acceptance of server certificates during runtime. To configure these settings, follow these steps:

1. Select the required CPU in the device or network view of STEP 7.
2. In the Inspector window, navigate to "Properties > Protection & Security > Syslog > Certificates for Syslog".
3. In the "Trusted servers" area, specify whether the connected syslog server is to be authenticated. In this case, it is necessary to complete the following information:
   - Add trusted server: Add a valid server certificate in the "Common name of subject" column.
   - Automatically accept certificates during runtime: Activate the "Automatically accept server certificates during runtime" option. Editing in the table is then not possible.

NOTE

No authentication with automatically accepted server certificates

If you enable the "Automatically accept server certificates during runtime" option, a server does not need to authenticate itself. This means that the CPU can also connect to unknown servers that could represent a security risk.

Only select this option during commissioning or in a protected environment.

4.9.14.2 Structure of the Syslog messages

A CPU collects syslog messages in a local cache. These syslog messages are structured according to the syslog protocol (RFC 5424) and consist of the following elements:

- HEADER
- STRUCTURED-DATA
- MSG (Message)

The following sections describe the structure and parameters of the individual elements.

Structure of the HEADER element

The header contains all the data required for further processing of the syslog message. A space separates the individual parts of the header (exception: No space between PRI and VERSION). A CPU transmits the following header in syslog messages, for example:

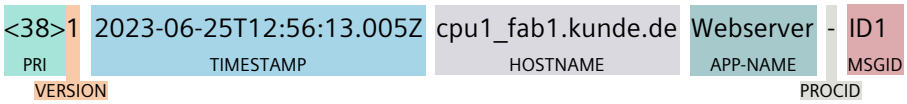

Figure 1-5 Example: HEADER of the syslog message of a CPU

The following table describes the parameters in the prescribed order.

Parameter	Description
PRI	PRI encodes the priority of the syslog message, divided into Severity (severity of the message) and Facility (origin of the message). The PRI value is formed as follows: • PRI = Facility x 8 + Severity Possible values: • Severity – 0 = Emergency: system is unusable – 1 = Alert: action must be taken immediately – 2 = Critical: critical conditions – 3 = Error: error conditions – 4 = Warning: warning conditions – 5 = Notice: normal but significant condition – 6 = Informational: informational messages – 7 = Debug: debug-level messages • Facility – 1 = User-level messages – 2 = Mail system – 3 = System daemons – 4 = Security/authorization messages – 5 = Messages generated internally by syslog – 6 = Line printer subsystem – 7 = Network news subsystem – 8 = UUCP subsystem – 9 = Clock daemon – 10 = Security/authorization messages – 11 = FTP daemon – 12 = NTP subsystem – 13 = Log audit – 14 = Log alert

Parameter	Description
	A CPU does not use all of the listed severity/facility values.
VERSION	Version number of the syslog specification.
TIMESTAMP	The device sends the time stamp in the format "2023-06-25T12:56:13.005Z" as UTC time without time zone and correction for daylight-saving/standard time.
HOSTNAME	Contains the name or the IP address (PROFINET interface X1) of the device or system from which the syslog message has been sent. IPv4 address according to RFC1035: Bytes in decimal representation: XXX.XXX.XXX.XXX IPv6 address according to RFC4291 Section 2.2 "-" is output if information is missing.
APP-NAME	Contains the component (device part or application) from which the message has been generated. "-" is output if information is missing.
PROCID	The process ID serves to clearly identify the individual processes, for example during analysis and troubleshooting. "-" is output if information is missing.
MSGID	ID to identify the message. "-" is output if information is missing.

Structure of the STRUCTURED-DATA element

STRUCTURED-DATA provides information in an interpretable and decomposable data format. The following applications are possible, for example:

- More information about the syslog message
- Application specific information

STRUCTURED-DATA can contain one or more elements (SD-ELEMENT). Each SD element must be enclosed in square brackets. If STRUCTURED-DATA consists of multiple SD elements, the individual SD elements are separated by a space.

Each SD-ELEMENT consists of its name (SD-ID) and one or more name-value pairs (SD-PARAM). Each name-value pair consists of a parameter name (PARAM-NAME) and the associated value (PARAM-VALUE). A space separates the individual components (SD-ID and SD-PARAM) within an SD element.

A CPU transmits the following SD ELEMENT in a syslog message, for example:

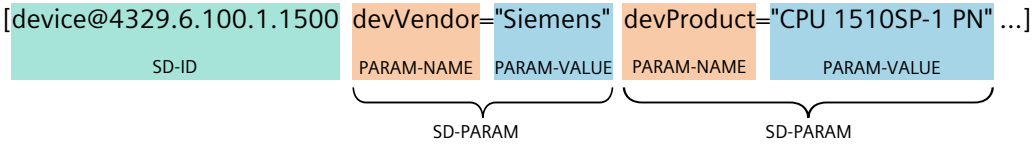

Figure 1-6 Example: SD ELEMENT of the syslog message of a CPU

Structure of the MSG element

In the MSG (MESSAGE) element, a CPU transmits the simplified name of the event in English. The following table shows what the content of a message of the MESSAGE element can look like.

MESSAGE	Description
SE_LOCAL_SUCCESSFUL_LOGON	The local logon has been successful (e.g. on the operator display of the CPU).

More information

You can read more information about the structure and transmission of syslog messages in the following RFCs (Request for Comments):

- The syslog protocol (RFC 5424) (https://tools.ietf.org/html/rfc5424)
- Transferring syslog messages via Transport Layer Security (RFC 5425) (https://tools.ietf.org/html/rfc5425)
- Transferring syslog messages via UDP (RFC 5426) (https://tools.ietf.org/html/rfc5426)

4.10 Secure operation of interface modules

Device-specific security information and instructions for interface modules can be found in the respective Equipment Manual.

4.10.1 Data integrity for interface modules

Data integrity refers to the completeness and correctness (integrity) of data, which is an essential prerequisite for the proper functioning of systems.

Measures for data privacy, data consistency, and data security ensure that data used within devices cannot be damaged, altered (manipulated), or deleted during processing or transmission, and at the very least, any changes to the data are detected.

Data integrity for interface modules

To detect intentional or accidental changes to data within an interface module and its associated modules, the possibility of dynamic integrity checking is introduced for PROFINET interface modules.

The ability to detect integrity breaches enhances the resilience of the distributed I/O system.

Data integrity within a distributed I/O system is entirely covered within the interface module and does not pertain to other components of the automation system.

Principle

The interface module calculates checksums based on its used data and the supplied data from the associated modules, such as parameter settings, IP address, device name, MAC address and I&M data. The interface module stores the checksums in the I&M4 data area.

A CRC (Cyclic Redundancy Check) is always the same for a specific, unchanged memory content. When the memory content changes, the interface module (IM) calculates a different checksum for this content by reading and comparing the I&M4 data. By comparing with the initial CRC, you can determine whether the data in the memory has been modified or not:

- CRC stayed the same: No change in the data within this memory area of the interface module IM
- CRC changed: The data within this memory area of the IM was modified

Only you, as the user, know whether changes to the data of an interface module were intentional or not. If changes were not intentional, you can detect that the data of the interface module has been compromised through changed CRCs and respond accordingly.

I&M data

PROFINET devices provide Identification and Maintenance data (I&M data), which is a set of predefined data structures containing the internal module status. With this data, a module can be identified, its serial number can be determined, etc.

The CRC checksums are mapped in the maintenance data **I&M4** of the interface module.

NOTE

Requirements for calculating the CRCs

The CRCs via the memory contents of the interface module are calculated only when you request to read the I&M4 data.

The CRCs cover not only the interface module itself but can also take into consideration combined checksums from associated modules (refer to the section on the structure of the data record for I&M data). Process data is not included in the calculation of CRCs.

Example:

- You put your distributed I/O system into operation and read the CRC CHK_OVERALL with the value "0x55AAA678" ("16#55AAA678") from the interface module via the I&M4 data.
- As long as no changes have been made to the data of the interface module or the associated modules, each subsequent read will give the value "0x55AAA678" or "16#55AAA678".
- Once you read a different CRC CHK_OVERALL, for example, "0xCC9876FF", you will realize that there must have been changes to the data of the interface module or the associated modules.

The quality of the statement regarding the data integrity of the distributed I/O system improves with each module associated with the interface module that supports I&M4 data. Refer to the Equipment Manual of the respective module to find out if and from which firmware version the module supports I&M4 data.

The structure of the I&M data 0 to 4 is described in the section Record structure for I&M data (Page 318).

Spare parts scenario

The spare parts scenario is ensured. This means that you can replace interface modules with the same article number. For the "new" interface module, the static data such as the serial number and MAC addresses will change. Note that this is why the replacement will be reflected in the changed identification data CHK_STATIC_LOCAL and consequently also in CHK_OVERALL.

More information on the spare parts scenario and compatibility can be found in the Equipment Manual of the interface module.

4.10.2 Signed firmware update for interface modules

Signed firmware update

A signed firmware update ensures the authenticity and integrity of the firmware loaded onto a device.

It protects you against installing malicious firmware in case:

- Firmware was modified
- Firmware was downloaded from an incorrect internet source

Information on whether your interface module supports signed firmware updates is available in the Technical specifications section of the corresponding Equipment Manual.

Principle of signed firmware updates for interface modules

Firmware updates of interface modules may include a digital signature. The digitally signed firmware update files are available for download on the Siemens Support website.

The interface module verifies the authenticity and integrity of the firmware update file before installation using the digital signature with standardized asymmetric cryptography methods. As a result, the interface module can detect a manipulated or corrupted firmware update file and reject it.

Note that the interface module performs the verification only after the complete firmware download has taken place.

Subsequently, a notification is sent to the firmware update tool regarding the success or failure of the signature verification.

You still have all the options for firmware updates, as described in the Firmware update (Page 332) section, when performing signed firmware updates for interface modules. If the firmware update was not successful, the module will continue to run with the previous firmware.

Diagnostics alarms and remedy

When performing a firmware update for an interface module with an established connection between the IM and CPU, there are the following options for notifications in the CPU's diagnostic buffer:

- Successful integrity check of the firmware for the interface module
- Rejection of non-secure firmware for the interface module

You can find more information in the channel diagnostics table in the equipment manual of the interface module.

In case of firmware update rejection, proceed as follows:

1. Check whether the firmware update file used by you originates from a secure source and was downloaded unchanged. As a check, calculate the hash value of the downloaded firmware update file and compare it with the value specified on the download page.
2. Download the firmware again from the Siemens Support Web page.
3. Repeat the firmware update.

You can find information on the procedure for calculating and comparing hash values on the Internet (https://support.industry.siemens.com/cs/de/de/view/109483101/en).

4.11 Secure operation of I/O modules

Device-specific security information and instructions for I/O modules can be found in the respective Equipment Manual.

4.11.1 Data integrity for I/O modules

Data integrity for I/O modules

In order to detect intentional or accidental changes to the data of an interface module and the assigned modules, the dynamic integrity check for I/O modules is introduced. Information on whether your I/O module supports the data integrity check is available in the Technical specifications section of the corresponding Equipment Manual.

Principle

The interface module calculates checksums based on its used data and the supplied data from the associated modules, such as serial numbers, parameter settings, calibration data and I&M data of I/O modules. The interface module stores the checksums in the I&M4 data area.

You can find more information on the principle of data integrity and I&M4 data in the section Data integrity for interface modules (Page 63).

Spare parts scenario

The spare parts scenario is still ensured. This means that you can replace I/O modules with the same article number. For the "new" I/O module, the static data such as the serial number will change. Note that the replacement is therefore reflected in the following modified I&M4 data of the interface module:

- CHK_STATIC_SUBS
- CHK_OVERALL_SUBS
- CHK_OVERALL

You can find the structure of I&M data in the section Record structure for I&M data (Page 318).

4.11.2 Signed firmware update for I/O modules

Signed firmware update

A signed firmware update ensures the authenticity and integrity of the firmware loaded onto a device.

It protects you against installing malicious firmware in case:

- Firmware was modified
- Firmware was downloaded from an incorrect Internet source

Signed firmware update for I/O modules

Firmware updates for I/O modules can contain a digital signature. Information on whether your I/O module supports signed firmware updates is available in the Technical specifications section of the corresponding Equipment Manual.

The digitally signed firmware update files are available for download on the Siemens Support Web page.

Principle, diagnostics alarms, and remedies

The principle and diagnostics of the signed firmware update are the same for interface modules and I/O modules. The information in the section Signed firmware update for interface modules (Page 65) applies.

See also

Firmware update (Page 332)

4.12 Secure operation of the power supply modules

Device-specific security information and instructions for the power supply modules can be found in the respective Equipment Manual.

System overview

5

5.1 What is the SIMATIC ET 200SP distributed I/O system?

SIMATIC ET 200SP

SIMATIC ET 200SP is a scalable and highly flexible distributed I/O system for connecting process signals to a higher-level controller via a fieldbus.

Customer benefits of the system

Compact design

- Small size and high variability through scalability
- Maximum level of clarity through innovative labeling system in minimum space
- System-integrated load current supply

Easy to use

- Compact modules, fixed wiring with single-cable and multi-cable connection
- Less time due to connection technology Connection system with push-in terminals
- Adaptation of the configuration for future expansions through integrated configuration control

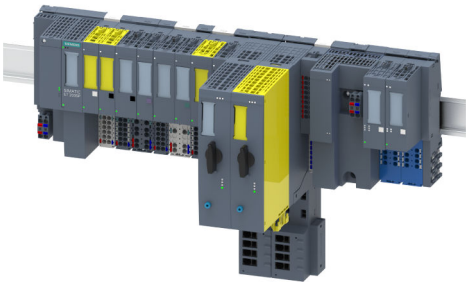

Safety Integrated

- Easy integration of fail-safe CPUs and modules
- All F-parameters set in software

Communication standards

- PROFINET IO
- PROFIBUS DP
- EtherNet/IP
- Modbus TCP
- ET-Connection
- AS-Interface
- IO-Link
- Point-to-point (RS232, RS485)
- DALI
- DMX
- CAN/CANopen

High performance

- Isochronous PROFINET IO with the PROFIsafe and PROFIenergy profiles

Energy efficiency

- PROFIenergy as integrated function

CPU

- PROFINET interface
- IO controller
- I-device
- Optional CM DP module for connection to PROFIBUS DP
- available as PC-based system, combines CPU, HMI and Windows/Linux Application on a single device

Modules for hazardous area

- Modules for the connection of devices in hazardous areas of Zone 0 and Zone 1.

Motion integrated

- All CPUs offer integrated Motion Control functions. For extended motion control function the Technology CPUs are available.

Motor starter

- Easy integration of motor starters with overload and short-circuit protection
- Compact design with a maximum connectable motor output of up to 5.5 kW

Powerful technology

- Modules for Counting, Positioning, Weighing and Measuring functions of electrical parameters

Figure 1-7 SIMATIC ET 200SP distributed I/O system - Customer benefits

Area of application

Thanks to its multifunctionality, the SIMATIC ET 200SP distributed I/O system is suitable for a wide range of applications. Its scalable design allows you to tailor your configuration to local requirements. Various CPUs/interface modules are available for connection to PROFINET IO, PROFIBUS DP, EtherNet/IP or Modbus TCP.

SIMATIC ET 200SP with CPU allows intelligent pre-processing to relieve the higher-level controller. The CPU can also be used as standalone device.

By using fail-safe CPUs, you can implement applications for safety engineering. Configuration and programming of your safety program takes place the same way as for standard CPUs.

An extensive range of I/O modules extends the area of application of the ET 200SP system.

SIMATIC ET 200SP is designed with degree of protection IP20 and is intended for installation in a control cabinet.

With use of an ET 200SP R1, you increase the availability of the system through redundant interface modules.

Configuration

The SIMATIC ET 200SP distributed I/O system is installed on a mounting rail. It consists of:

- CPU/interface module
- Up to 64 I/O modules, which can be plugged into BaseUnits in any combination
- Up to 31 motor starters
- A server module that completes the configuration of the ET 200SP.

Configuration example

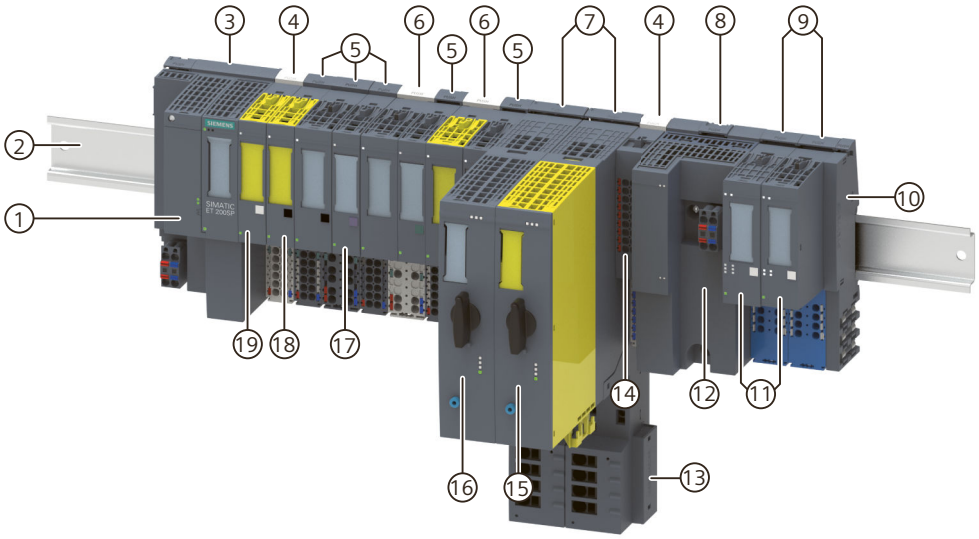

① BusAdapter
② Mounting rail
③ CPU/interface module
④ Light-colored BaseUnit BU..D with infeed of supply voltage
⑤ Dark-colored BaseUnits BU..B for conducting the potential group further
⑥ Light-colored BaseUnit BU..D with infeed of supply voltage
⑦ BaseUnit for motor starters
⑧ Ex BaseUnit for Ex power module
⑨ Ex BaseUnit for Ex I/O module
⑩ Server module (included in the scope of supply of the CPU/interface module)
⑪ Ex I/O module
⑫ Ex power module
⑬ Infeed bus cover
⑭ Potential distribution module
⑮ ET 200SP fail-safe motor starter
⑯ ET 200SP motor starter
⑰ I/O module
⑱ Fail-safe output module
⑲ Fail-safe input module

Figure 1-8 Example configuration ET 200SP

5.2 What are fail-safe automation systems and fail-safe modules?

Fail-safe automation systems

Fail-safe automation systems (F-systems) are used in systems with higher safety requirements. F-systems control processes and ensure that they are in a safe state immediately after shutdown. In other words, F-systems control processes in which an immediate shutdown does not endanger persons or the environment.

Safety Integrated

Safety Integrated is the integrated safety concept for automation and drive technology from Siemens.

Proven technologies and systems from automation technology are used for safety systems. Safety Integrated includes the complete safety sequence, ranging from sensor, actuator and fail-safe modules right through to the controller, including safety-related communication via standard fieldbuses. Drives and controllers handle safety tasks in addition to their actual functions.

Fail-safe modules

The key difference between fail-safe modules (F-modules) and standard modules is that they have an internal two-channel design. This means the two integrated processors monitor each other, automatically test the input and output circuits, and switch the fail-safe module to a safe state in the event of a fault.

The F-CPU communicates with a fail-safe module via the safety-related PROFIsafe bus profile.

Fail-safe motor starters

Fail-safe motor starters enable safety-related tripping of motor loads. Fail-safe motor starters are not PROFIsafe nodes. Motor starters operate together with the fail-safe modules of the ET 200SP system.

Area of application of ET 200SP with fail-safe I/O modules

By using the ET 200SP distributed I/O system with fail-safe I/O modules, you are replacing conventional safety engineering configurations. This includes the replacement of switching devices for emergency STOP, protective door monitors, two-hand operation, etc.

5.3 How are SIMATIC Safety F-systems structured with ET 200SP?

SIMATIC Safety F-system with ET 200SP

The figure below shows an example of a configuration for a SIMATIC Safety F-system with ET 200SP distributed I/O system and PROFINET IO. You can configure the PROFINET IO lines with copper cable, fiber-optic cable or WLAN.

Fail-safe I/O modules and non-fail-safe I/O modules can be combined in an ET 200SP configuration.

The fail-safe IO controller (F-CPU) exchanges safety-related and non-safety-related data with fail-safe and non-fail-safe ET 200SP modules.

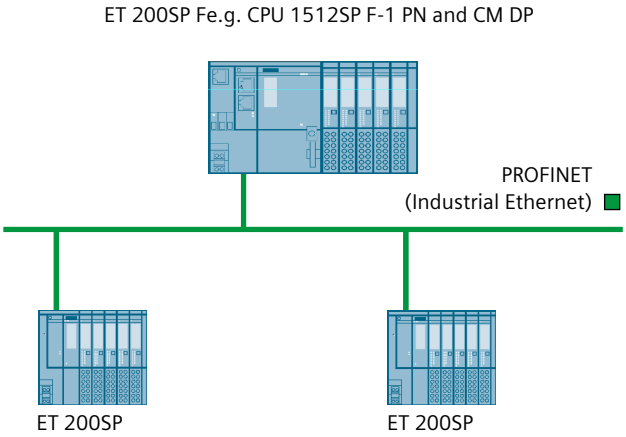

Figure 1-9 Fail-safe SIMATIC Safety automation system (sample configuration)

Fail-safe ET 200SP I/O modules

The following fail-safe I/O modules are available for the ET 200SP distributed I/O system:

- Fail-safe power modules are used to supply the potential group load voltage and for the safety-related tripping of the load voltage for non-fail-safe output modules.
- Fail-safe digital input modules detect the signal states of safety-related sensors and send the relevant safety frames to the F-CPU.
- Fail-safe digital output modules are suitable for safety-related shutdown procedures with short circuit and cross-circuit protection up to the actuator.

ET 200SP fail-safe motor starters

Fail-safe motor starters are suitable for safety-related tripping of motor loads.

Example of a configuration with fail-safe I/O modules

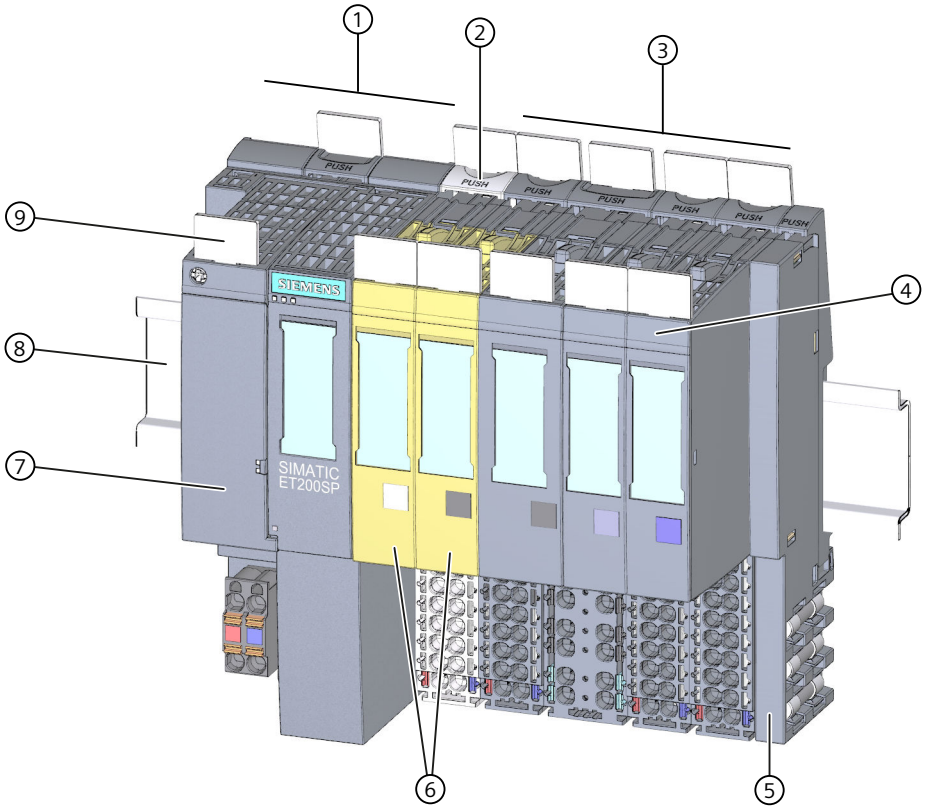

① Interface module
② Light-colored BaseUnit BU..D with infeed of supply voltage
③ Dark-colored BaseUnits BU..B for conducting the potential group further
④ I/O module
⑤ Server module (ships with the interface module)
⑥ Fail-safe I/O modules
⑦ BusAdapter
⑧ Mounting rail
⑨ Reference identification label

Figure 1-10 Example of a configuration of the ET 200SP with fail-safe I/O modules

Hardware and software requirements

Fail-safe modules ET 200SP are supported by IM155-6PN ST interface modules as of firmware V1.1.1, IM155-6PN HF as of firmware V2.0, IM155-6PN HS as of firmware V4.0 and IM155-6DP HF as of firmware V1.0.

You require the STEP 7 Safety Advanced option package, V12 or higher including HSP 54, for configuration and programming of the ET 200SP fail-safe modules with the SIMATIC Safety fail-safe system.

You require the F-Configuration Pack V5.5 SP10 or later for configuring and programming the ET 200SP failsafe modules with the Distributed Safety failsafe system.

You require the F-Configuration Pack V5.5 SP12 or later for configuring and programming the ET 200SP failsafe modules with the F/FH Systems failsafe system.

ET 200SP fail-safe motor starters are supported by interface modules IM155-6PN BA, firmware V3.2 or higher, IM155-6PN ST, firmware V3.1 or higher, IM155-6PN HF, firmware V3.1 or higher and IM155-6DP HF firmware V3.0 or higher.

You require SIMATIC Step 7 V14 or higher for configuration and programming of ET 200SP fail-safe motor starters. The F-Configuration Pack is not needed for configuration and programming of the ET 200SP fail-safe motor starter.

NOTE

Configuration of ET 200SP motor starters, SIMATIC Step 7 V13 or higher, is possible with a GSD file (GSDML).

Use in safety mode only

Safety mode is the F-I/O operating mode that allows safety-related communication using safety frames.

Safety mode of motor starters is characterized by the fail-safe digital input (F-DI) and availability of the 24 V power supply.

You can only use the ET 200SP fail-safe I/O modules in safety mode. They cannot be used in non-fail-safe mode.

Achievable safety classes

The fail-safe modules are equipped with integrated safety functions for safety mode.

You can achieve the safety classes of the table below:

- With the appropriate parameter assignment of the safety functions in STEP 7
- With a specific combination of fail-safe and non-fail-safe I/O modules
- With a special arrangement and wiring of the sensors and actuators

Table 1-1 Safety classes that can be achieved with ET 200SP in safety mode

Safety class in safety mode		
According to IEC 61508	**According to ISO 13849-1**	
SIL2	Category 3	(PL) Performance Level d
SIL3	Category 3	(PL) Performance Level e
SIL3	Category 4	(PL) Performance Level e

More information

You will find the use cases and wiring for the relevant safety class in the manuals of the fail-safe I/Os and the fail-safe motor starters.

5.4 Components

Overview of ET 200SP modules and accessories

NOTE

A complete overview of the ET 200SP modules and accessories is available in the Product information on documentation of the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/de/de/view/73021864/en).

Basic components of the ET 200SP distributed I/O system

Table 1-2 Basic components of the ET 200SP

Basic component	Function	Figure
Mounting rail in accordance with EN 60715	The mounting rail is the rack of the ET 200SP distributed I/O system. You install the ET 200SP system on the mounting rail. The mounting rail is 35 mm high.	
SIMATIC system rail	The system rail is the mounting rack of the ET 200SP R1 distributed I/O system. The ET 200SP R1 system must be installed on the system rail. You can also mount all other interface modules on the system rail to improve the stability of the system.	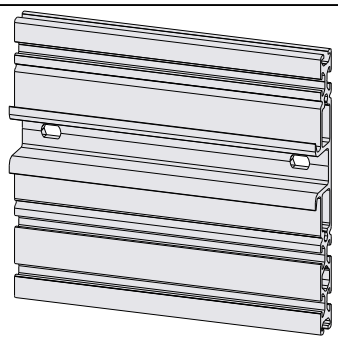
CPU/Fail-safe CPU	The (F) CPU: • Runs the user program. The F-CPU also runs the safety program. • Can be used as an IO controller or I-Device on PROFINET IO or as a standalone CPU • Links the ET 200SP to the IO devices or the IO controller • Exchanges data with the I/O modules via the backplane bus. Additional CPU functions: • Communication via PROFIBUS DP (the CPU can be used as a DP master or DP slave in combination with the CM DP communication module) • Integrated Web server • Integrated technology • Integrated trace functionality • Integrated system diagnostics • Integrated safety • Safety mode (when using fail-safe CPUs)	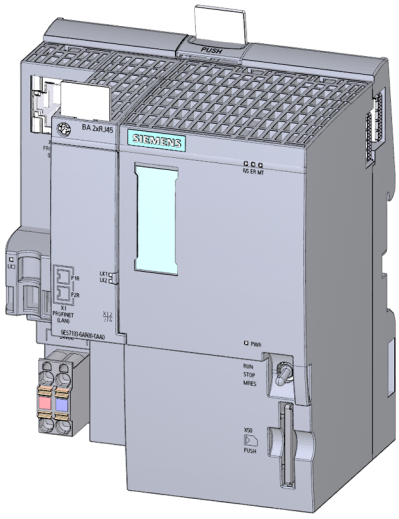

Basic component	Function	Figure
Communication module CM DP	The communication module CM DP • Connects the CPU with PROFIBUS DP • The bus connection is an RS485 interface.	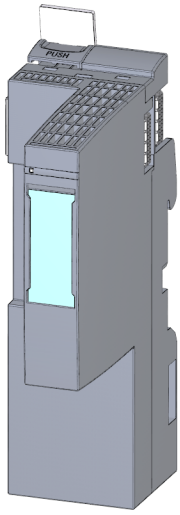
Interface module for PROFINET IO	The interface module: • Can be used as IO device on PROFINET IO • Links the ET 200SP with the IO controller • Exchanges data with the I/O modules via the backplane bus.	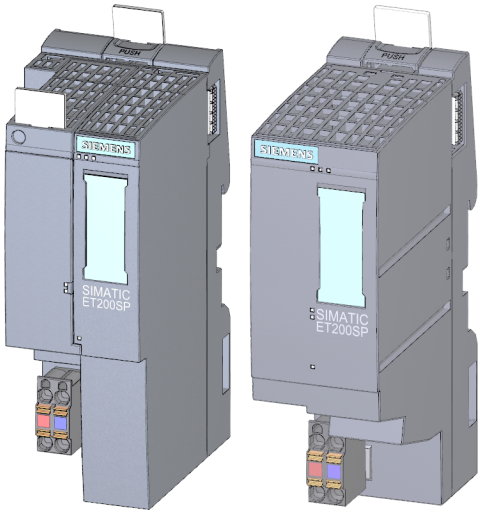
Interface module for MultiFieldbus	The interface module: • Use as IO device on PROFINET IO • Links the ET 200SP with the IO controller • Links the ET 200SP via EtherNet/IP • Links the ET 200SP via Modbus TCP • Exchanges data with the I/O modules via the backplane bus You can find more information about MultiFieldbus in the MultiFieldbus Function Manual (https://support.industry.siemens.com/cs/ww/en/view/109773209) and in the Interface Module IM 155-6 MF HF Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/109773210).	
Interface module for PROFIBUS DP	The interface module: • Can be used as DP slave on PROFIBUS DP • Links the ET 200SP with the DP master • Exchanges data with the I/O modules via the backplane bus.	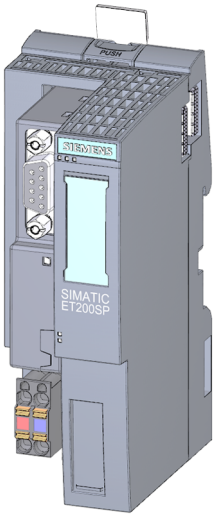

Basic component	Function	Figure
Interface modules and BaseUnit BU type M0 for redundant connection	The ET 200SP R1 system: • Use as redundant IO device on PROFINET IO • Connects the ET 200SP to the IO controller • Exchanges data with the I/O modules via the backplane bus.	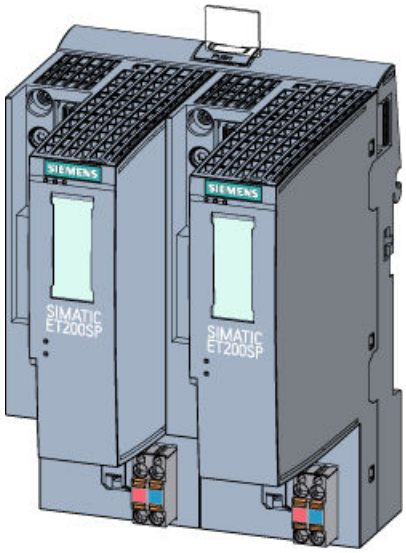

Basic component	Function	Figure
BusAdapter	The BusAdapters allow free selection of the connection technology for PROFINET IO. The following versions are available for PROFINET CPU/interface modules: • For standard RJ45 connector (BA 2×RJ45) ① • For direct connection of the bus cable (BA 2×FC) ② • For standard M12 connector (D-coded) with screw-type terminal or plug-in push-pull version (BA 2xM12) ③ • For POF/PCF fiber-optic cable (BA 2xSCRJ) ④ • As media converter for POF/PCF fiber-optic cable ⇔ standard RJ45 plug (BA SCRJ/RJ45) ⑤ • As media converter for POF/PCF fiber-optic cable ⇔ direct connection of the bus cable (BA SCRJ/FC) ⑥ • For glass fiber-optic cable (BA 2xLC) ⑦ • As media converter for glass fiber-optic cable ⇔ standard RJ45 plug (BA LC/RJ45) ⑧ • As media converter for glass fiber-optic cable ⇔ direct connection of the bus cable (BA LC/FC) ⑨ • For single-mode fiber-optic cable with maximum length of 20 km (BA 2xLC-LD, long distance) ⑩ • As media converter for glass fiber-optic cable with an LC plug connector ⇔ standard RJ45 connector (BA LC-LD/RJ45) ⑪ • As media converter for glass fiber-optic cable with an LC plug connector ⇔ standard M12 plug or M12 push-pull connector (BA LC-LD/M12) ⑫	① ② ③ 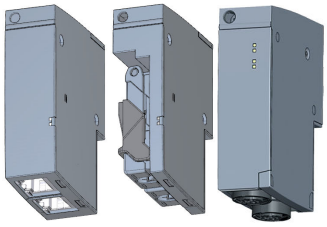 ④ ⑤ ⑥ 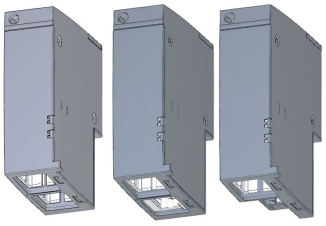 ⑦ ⑧ ⑨ 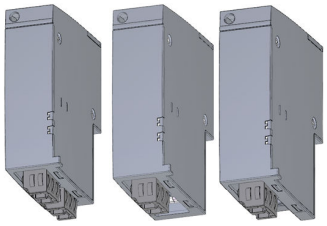 ⑩ ⑪ ⑫ 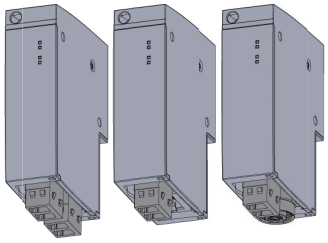
	For mixed ET 200SP/ET 200AL configuration, you require the BusAdapter BA-Send 1xFC ① (plugged into the BaseUnit BU-Send). Connect the bus cable for ET-Connection to the BusAdapter BA-Send 1xFC.	① 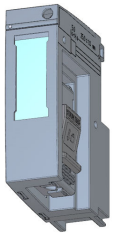

Basic component	Function	Figure
BaseUnit	The BaseUnits provide the electrical and mechanical connection of the ET 200SP modules. Place the I/O modules or the motor starter onto the BaseUnits. Respectively suitable BaseUnits are available for the different requirements. You can find additional information in section Selecting the BaseUnit for I/O modules (Page 92).	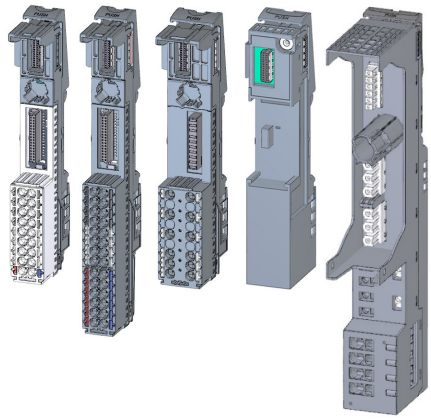
Ex BaseUnit	You need the following BaseUnits for an Ex module group: • Ex BaseUnit for Ex power module • Ex BaseUnit for Ex I/O module	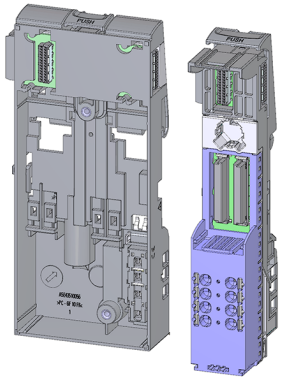
BaseUnit ET 200SP R1	Connects the IM 155-6 PN R1 redundant interface modules to the backplane bus. It enables data exchange with the I/O modules. Note: Interface modules cannot be plugged in if the associated supply voltage connector is plugged in. Only use BusAdapters of the same type.	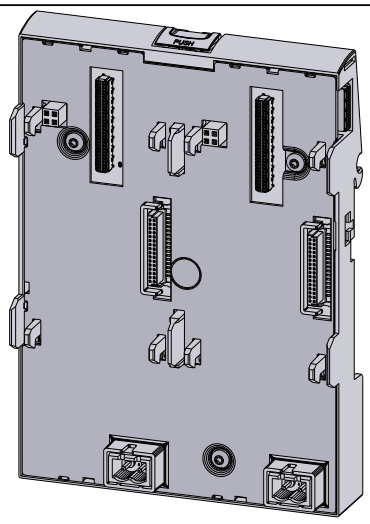

Basic component	Function	Figure
PotDis-BaseUnit potential distribution module	You use the potential distribution module to distribute a variety of potentials (P1, P2). This allows you to implement a multi-cable connection without external terminals with 16-channel digital modules. The assembly has two parts: • If you need additional potential terminals, plug a PotDis-TerminalBlock in the PotDis-BaseUnit. • Alternatively, plug a BU cover (15 mm) on the PotDis-BaseUnit. With potential distribution modules, you may only connect to the PotDis-TB versions BR-W and n.c.-G potential, which exceed the voltage level of SELV/PELV. Other SELV/PELV potential groups should be separated with light-colored PotDis BUs. Suitable PotDis-BaseUnits are available in each case for the different requirements. You can find additional information in section Selecting a PotDis-BaseUnit (Page 98).	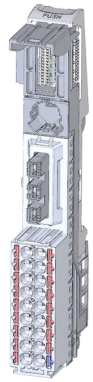
PotDis-TerminalBlock	If you need additional potential terminals for a PotDis-BaseUnit, plug a PotDis-TerminalBlock in the PotDis-BaseUnit. Voltages greater than SELV/PELV are only permitted for the PO PotDis-TBs BR (bridged) and NC (not connected). The same applies to PE. Voltages at the terminals of the PotDis modules connected to the P1/P2 rails must not be greater than SELV/PELV. Suitable PotDis-TerminalBlocks are available in each case for the different requirements. You can find additional information in section Selecting a PotDis-TerminalBlock (Page 99).	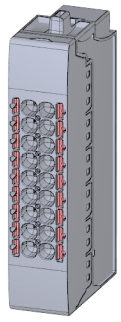
Fail-safe power module	The fail-safe power module allows the safety-related shutdown of digital output modules / fail-safe digital output modules.	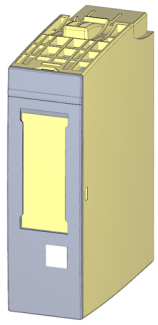

Basic component	Function	Figure
Ex power module	The Ex power module supplies the downstream Ex I/O modules via the power bus on the Ex BaseUnit of the Ex power module. An Ex BaseUnit is required for installing the Ex power module.	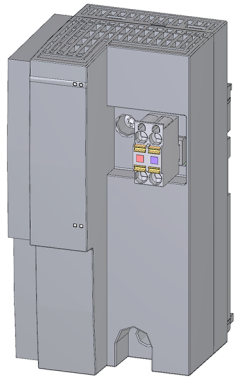
I/O module / Fail-safe I/O module / Ex I/O module	The I/O module determines the function at the terminals. The controller detects the current process state via the connected sensors and actuators, and triggers the corresponding reactions. I/O modules are divided into the following module types: • Digital input (DI, F-DI, Ex-DI) • Digital output (DQ, F-DQ PM, F-DQ PP, F-RQ, Ex-DQ) • Analog input (AI, F-AI, Ex-AI) • Analog output (AQ, Ex-AQ) • Technology module (TM, F-TM-C) • Communication module (CM) • Power module (F-PM-E)	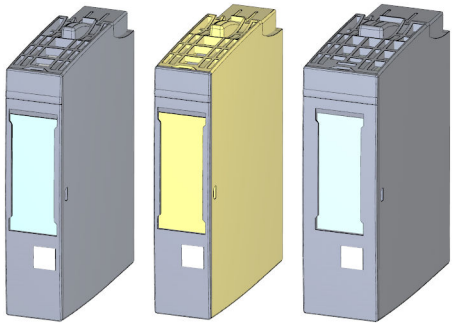
Motor starter/fail-safe motor starter	The motor starter is a switching and protection device for 1-phase and 3-phase loads. The motor starter is available as a direct-on-line and reversing starter.	

Basic component	Function	Figure
Vale terminal AirLINE SP type 8647 (Bürkert GmbH & Co. KG) [1] [2]	Basic component: Valve terminal AirLINE SP type 8647 (Bürkert). For more information on the AirLINE SP, type 8647 (e.g. data sheet and operating instructions), please contact Bürkert (https://www.burkert.co.uk/en/type/8647) directly. Function: Valve terminals are common in industrial automation and are used as pilot valves for controlling pneumatic actuators, for example in areas of the food, pharmaceutical and water treatment industries. The ET 200SP in combination with the AirLINE SP, type 8647 from Bürkert provides a universal interface between process and plant control that enables the flexible, modular configuration of pilot valves and I/O modules. The valve terminal can also be fitted to the base of the control cabinet with the help of the AirLINE Quick Adapter. This further reduces the space required in the control cabinet and considerably simplifies installation of the pneumatic system. [1] [2]	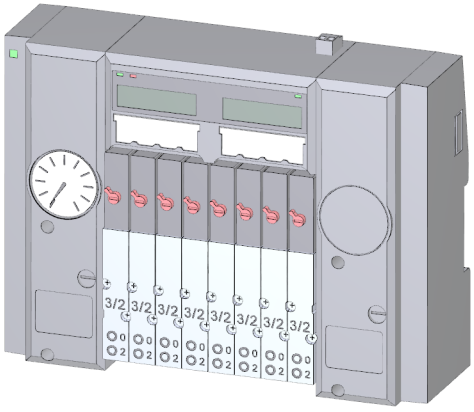
BU cover	Insert the BU cover on the BaseUnits: • Whose slots are not equipped with I/O modules/ motor starters//PotDis-TerminalBlocks • Whose slots have been reserved for future expansion (as empty slots). You can keep a reference identification label for the planned I/O module inside the BU cover. There are three versions: • For BaseUnits with a width of 15 mm ① • For BaseUnits/Ex BaseUnits with a width of 20 mm ② • For BaseUnits of motor starters with a width of 30 mm ③	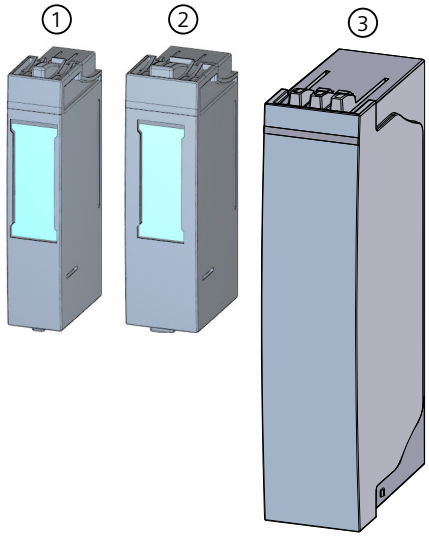
Server module	The server module completes the configuration of the ET 200SP. The server module includes holders for 3 spare fuses (5 × 20 mm). The server module ships with the CPU/interface module and is available as spare part.	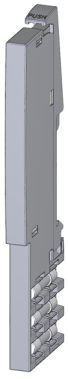

Basic component	Function	Figure
Coding element	The coding element codes the I/O module with the BaseUnit. There are two versions: • Mechanical coding element ①: Ensures the coding • Electronic coding element ②: This version also has an electronic, rewritable memory for module-specific configuration data (such as the F-destination address for fail-safe modules, parameter data for the IO link master).	① ② 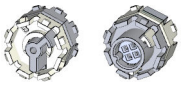

1) Note: The description contains non-binding information on supplementary products that are manufactured and marketed not by Siemens but by third-parties outside the Siemens group ("third-party firms"). These third parties organize the manufacture, sale and delivery of their products independently Their terms and conditions of business and delivery apply in this case.
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Accessories of the ET 200SP distributed I/O system

Table 1-3 Accessories of the ET 200SP

Accessories	Function	Figure
24 V DC connector	Application of the 24 V DC supply to the connector, and connection, e.g. to the CPU/interface module/Ex power module. The 24 V DC connector is available as a spare part.	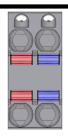
Shield connection	The shield connection allows the low-impedance contacting of cable shields with minimum installation times.	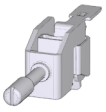
Labeling strips	Attach the labeling strips to the modules for system-specific labeling of the ET 200SP distributed I/O system. The labeling strips can be printed. The labeling strips can be ordered as accessories (Page 382) on a roll for thermal transfer printers or as DIN A4 format sheets for laser printers.	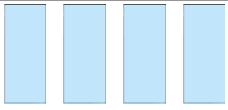

Accessories	Function	Figure
Reference identification labels	The labels enable the reference identification labeling of the ET 200SP components. The labels can be ordered on a mat for thermal transfer and inkjet printers as accessories (Page 382).	
Color identification labels	The color identification labels are module-specific and can be ordered for the process terminals, AUX terminals and additional terminals as accessories (Page 382).	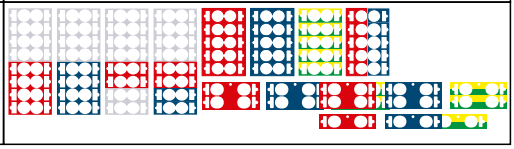

Accessories of the SIMATIC ET 200SP motor starters

Table 1-4 SIMATIC ET 200SP motor starter accessories

Accessories	Function	Figure
3DI/LC module	The optional 3DI/LC module has three digital inputs and one LC input. For reasons of operational safety, input LC is permanently set to manual local mode. By parameterizing the inputs DI1 - DI3 with motor CLOCKWISE or motor COUNTER-CLOCKWISE, you can control the motor in manual local mode. The functions of the 3DI/LC module are not relevant to functional safety. Detailed information on the functions when using a 3DI/LC module can be found in the Manual (https://support.industry.siemens.com/cs/ww/en/view/109479973).	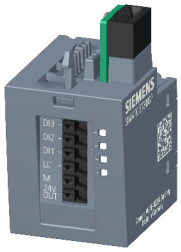
Mechanical bracket for BaseUnit	Use the mechanical bracket for additional fixing of the motor starter. You can use the mechanical bracket on 7.5 mm and 15 mm mounting rails.	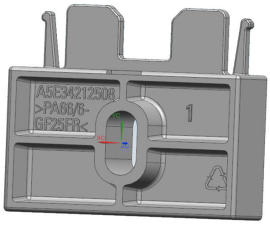
Infeed bus cover	For finger-safe termination of the infeed bus, use the cover.	

Accessories	Function	Figure
Fan	You can use the motor starter at higher ambient temperatures if a fan is installed.	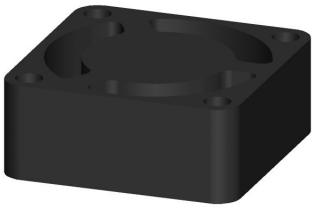

Application planning

6

Overview

The BaseUnits (BU) are classified according to different types. Every BaseUnit type is distinguished by characteristics that match certain I/O modules and motor starters (see the following table and graphics).

You recognize the BU type for an I/O module by the last two digits of an I/O module's article number.

The BU type onto which you can plug the respective I/O module is printed on the I/O modules. You can therefore read which BU type you need straight from the I/O module (see Factory labels (Page 192) (page 122)).
Example: On the output module DQ 16x24VDC/0.5A ST with article number 6ES7132-6BH01-0B**A0** the information "BU: A0" is printed. This means you can plug this I/O module into a BaseUnit of BU type "A0", which means any BaseUnit whose article number ends in "A0". I/O modules that are suitable for two BU types are labeled accordingly, for example "BU: A0, A1".

NOTE

You will find a complete module overview of the ET 200SP distributed I/O system and an overview of possibilities of combining BaseUnits and I/O modules /motor starters in the Product information for documentation of the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/de/de/view/73021864/en).

NOTE

Use of Ex modules

If you are using Ex I/O modules for the connection of intrinsically safe devices from Zone 0 or Zone 1 in the ET 200SP configuration, observe the information for plant planning in the System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/de/view/109795533/en).

Table 1-5 Selecting a suitable BaseUnit for interface modules

Select BaseUnit	Interface module (example)	Examples of suitable interface modules for BU types	
		Interface module (example)	BaseUnit
BU type **M0**	Interface module • 6ES7...**M0** • 24 V DC • 100 mm wide	IM 155-6 PN R1 (6ES7155-6AU00-0H**M0**)	BU (6ES7193-6BR00-0H**M0**)

Table 1-6 Selecting a suitable BaseUnit for I/O modules

Select BaseUnit	I/O module (example)	Examples of suitable I/O modules for BU types	
		I/O module (example)	BaseUnit
BU type **A0** See Digital, fail-safe, communication, technology or analog modules without temperature measurement (Page 92)	Digital, fail-safe, technology or communication module • 6ES7...**A0** • 24 V DC • 15 mm wide	DI 16×24VDC ST (6ES7131-6BH00-0B**A0**)	BU15-P16+A0+2D (6ES7193-6BP00-0D**A0**)
BU type **A1** See Analog modules with temperature measurement (Page 93)	Analog module **with** temperature measurement* • 6ES7...**A1** • 24 V DC • 15 mm wide	AI 4×RTD/TC 2-/3-/4-wire HF (6ES7134-6JD00-0C**A1**)	BU15-P16+A0+2D/T (6ES7193-6BP00-0D**A1**)
	Analog module **without** temperature measurement** • 6ES7...**A1** • 24 V DC • 15 mm wide	AI 4xU/I 2-wire ST (6ES7134-6HD00-0B**A1**)	
BU type **B0** (BU..B, dark-colored BaseUnit)	Digital output module with relay • 6ES7...**B0** • Up to 230 V AC • 20 mm wide	RQ 4×120VDC-230VAC/5A NO ST (6ES7132-6HD00-0B**B0**)	BU20-P12+A4+0B (6ES7193-6BP20-0B**B0**)
BU type **B1** (BU..B, dark-colored BaseUnit)	Digital modules • 6ES7...**B1** • Up to 230 V AC • 20 mm wide	DI 4×120..230VAC ST (6ES7131-6FD00-0B**B1**)	BU20-P12+A0+4B (6ES7193-6BP20-0B**B1**)
BU type **C0** (BU..D, light-colored BaseUnit)	Fail-safe power module • 6ES7...**C0** • 24 V DC • 20 mm wide CM AS-i Master ST/F-CM AS-i Safety ST • 6ES7...**C1** • Up to 30 V DC • 20 mm wide	CM AS-i Master ST (3RK7137-6SA00-0B**C1**)	BU20-P6+A2+4D (6ES7193-6BP20-0D**C0**)

* For compensation of the reference junction temperature for thermocouples. BU type A1 is required if you measure the reference junction temperature with an internal temperature sensor or if you need the additional 2×5 terminals.
If you use the internal reference junction temperature with BU type A1, ensure an even temperature distribution at the terminals. The specified accuracy of the utilized analog module is then adhered to. If necessary, you can increase the accuracy via user calibration.

** Analog modules **with and without** temperature measurement can also be plugged into BU type A0.

Select BaseUnit	I/O module (example)	Examples of suitable I/O modules for BU types	
		I/O module (example)	BaseUnit
BU type **C1** (BU..B, dark-colored BaseUnit)	F-CM AS-i Safety ST • 6ES7...**C1** • Up to 30 V DC • 20 mm wide	F-CM AS-i Safety ST (3RK7136-6SC00-0B**C1**)	BU20-P6+A2+4B (6ES7193-6BP20-0B**C1**)
BU type **D0**	AI Energy Meter • 6ES7...**D0** • Up to 400 V AC/ 480 V AC • 20 mm wide	AI Energy Meter 480VAC ST (6ES7134-6PA20-0B**D0**)	BU20-P12+A0+0B (6ES7193-6BP00-0B**D0**)
BU type **F0**	F-RQ 1×24VDC/24..23-0VAC/5A • 6ES7...**F0** • Up to 230 V AC • 20 mm wide	F-RQ 1×24VDC/24..230VA-C/5A (6ES7136-6RA00-0B**F0**)	BU20-P8+A4+0B (6ES7193-6BP20-0B**F0**)
BU type **U0**	DQ 4×24...230VAC/2A HF • 6ES7...**U0** • Up to 400 V AC/480 V AC • 20 mm wide	DQ 4×24...230VAC/2A HF (6ES7132-6FD00-0C**U0**)	BU20-P16+A0+2D (6ES7193-6BP00-0B**U0**)

* For compensation of the reference junction temperature for thermocouples. BU type A1 is required if you measure the reference junction temperature with an internal temperature sensor or if you need the additional 2×5 terminals.
If you use the internal reference junction temperature with BU type A1, ensure an even temperature distribution at the terminals. The specified accuracy of the utilized analog module is then adhered to. If necessary, you can increase the accuracy via user calibration.

** Analog modules **with and without** temperature measurement can also be plugged into BU type A0.

Table 1-7 BaseUnit for motor starters

		Selecting the BaseUnit									
		BU-30--MS1	**BU-30--MS2**	**BU-30--MS3**	**BU-30--MS4**	**BU-30--MS5**	**BU-30--MS6**	**BU-30--MS7**	**BU-30--MS8**	**BU-30--MS9**	**BU-30--MS10**
24 V infeed		**x**		**x**							
500 V infeed		**x**	**x**			**x**		**x**	**x**		
F-DI terminals (no routing of the F-DI signal possible)						**x**	**x**				
F-DI infeed								**x**			**x**
F-DI routing									**x**	**x**	
Motor starters											
DS 0.1 - 0.4 A HF	3RK1308-0A-A00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 0.3 - 1A HF	3RK1308-0A-B00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*

* The F-DI terminals or F-DI infeed/routing have no function with this combination.

DS 0.9 - 3A HF	3RK1308-0A-C00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 2.8 - 9A HF	3RK1308-0A-D00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 4.0 - 12A HF	3RK1308-0AE-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 0.1 - 0.4 A HF	3RK1308-0B-A00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 0.3 - 1A HF	3RK1308-0BB-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 0.9 - 3A HF	3RK1308-0BC-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 2.8 - 9A HF	3RK1308-0B-D00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 4.0 - 12A HF	3RK1308-0BE-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
F-DS 0.1 - 0-.4 A HF	3RK1308-0C-A00-0CP0	x	x	x	x	x	x	x	x	x	x
F-DS 0.3 - 1A HF	3RK1308-0CB-00-0CP0	x	x	x	x	x	x	x	x	x	x
F-DS 0.9 - 3A HF	3RK1308-0C-C00-0CP0	x	x	x	x	x	x	x	x	x	x
F-DS 2.8 - 9A HF	3RK1308-0C-D00-0CP0	x	x	x	x	x	x	x	x	x	x
F-DS 4.0 - 12A HF	3RK1308-0CE-00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 0.1 - 0.4 A HF	3RK1308-0D-A00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 0.3 - 1A HF	3RK1308-0D-B00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 0.9 - 3A HF	3RK1308-0D-C00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 2.8 - 9A HF	3RK1308-0D-D00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 4.0 - 12A HF	3RK1308-0D-E00-0CP0	x	x	x	x	x	x	x	x	x	x

* The F-DI terminals or F-DI infeed/routing have no function with this combination.

Additional information

Additional information on the functional assignment of the terminals and on the associated BaseUnits can be found in one of the following manuals:

- Manual for the relevant I/O module (https://support.industry.siemens.com/cs/ww/en/ps/14039/man)
- Manual BaseUnits (https://support.industry.siemens.com/cs/ww/de/view/59753521/en)
- Motor starter (https://support.industry.siemens.com/cs/ww/en/view/109479973) manual

6.1 Selecting the BaseUnit for I/O modules

6.1.1 Digital, fail-safe, communication, technology or analog modules without temperature measurement

Selection of a suitable BaseUnit

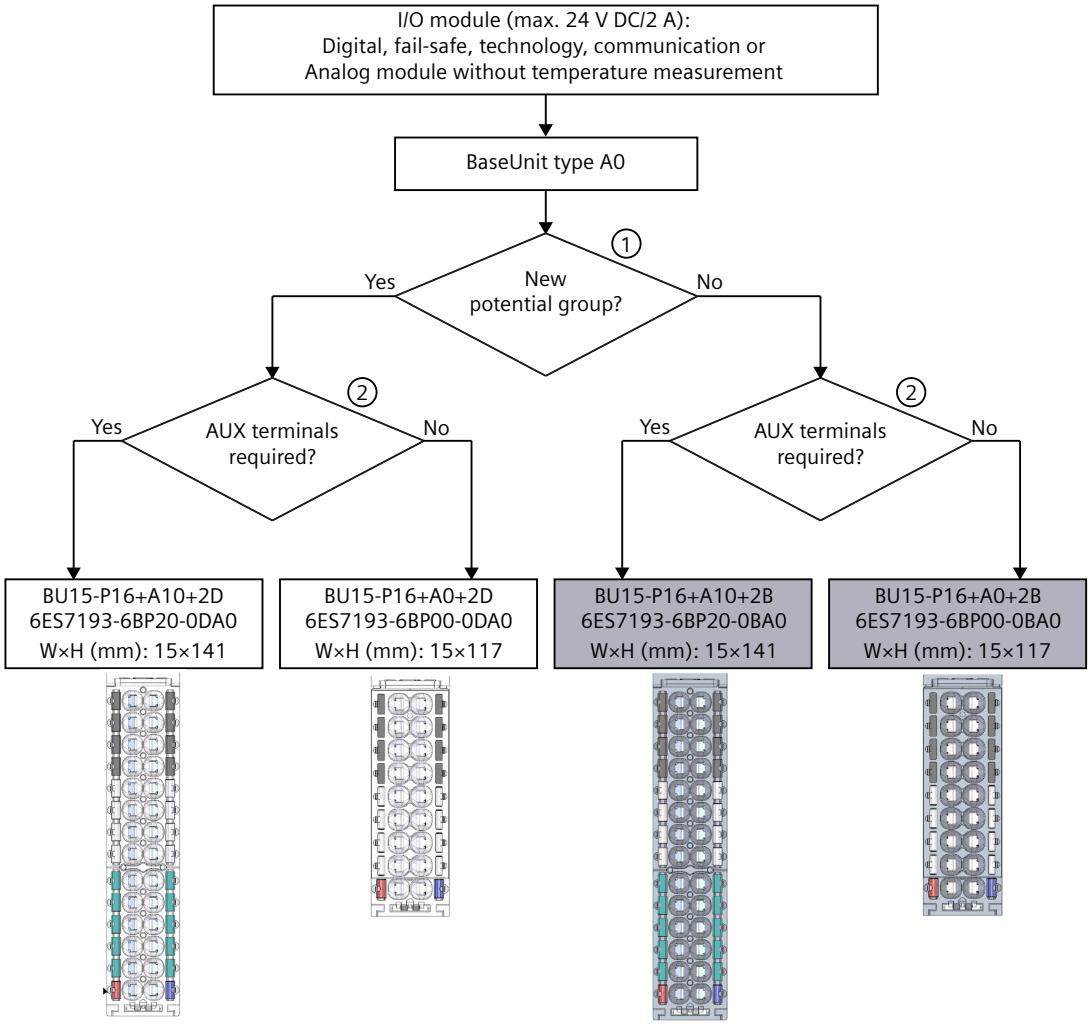

① Light-colored BaseUnit: Configuration of a new potential group, electrical isolation from adjacent module on the left. The first BaseUnit of the ET 200SP is usually a light-colored BaseUnit for the incoming supply voltage L+. A potential group opened with a light-colored BU type U0 must not contain any dark-colored BaseUnit of BU type A0 or A1.
Exception: If you insert an AC I/O module as the first I/O module, an AI Energy Meter 400VAC or an AI Energy Meter 480VAC, the first BaseUnit in the ET 200SP configuration can be a dark-colored BaseUnit. The requirement is that you use a CPU or IM 155-6 (as of V3.0).
Dark-colored BaseUnit: Conduction of the internal power and AUX buses from the adjacent module on the left.

② AUX terminal: 10 internally bridged terminals for individual use up to 24 V DC/10 A or as protective conductors.
Example: Multiple cable connection for DI 8×24VDC ST

Figure 1-11 Digital, fail-safe, communication, technology or analog modules without temperature measurement

6.1.2 Analog modules with temperature measurement

Selection of a suitable BaseUnit

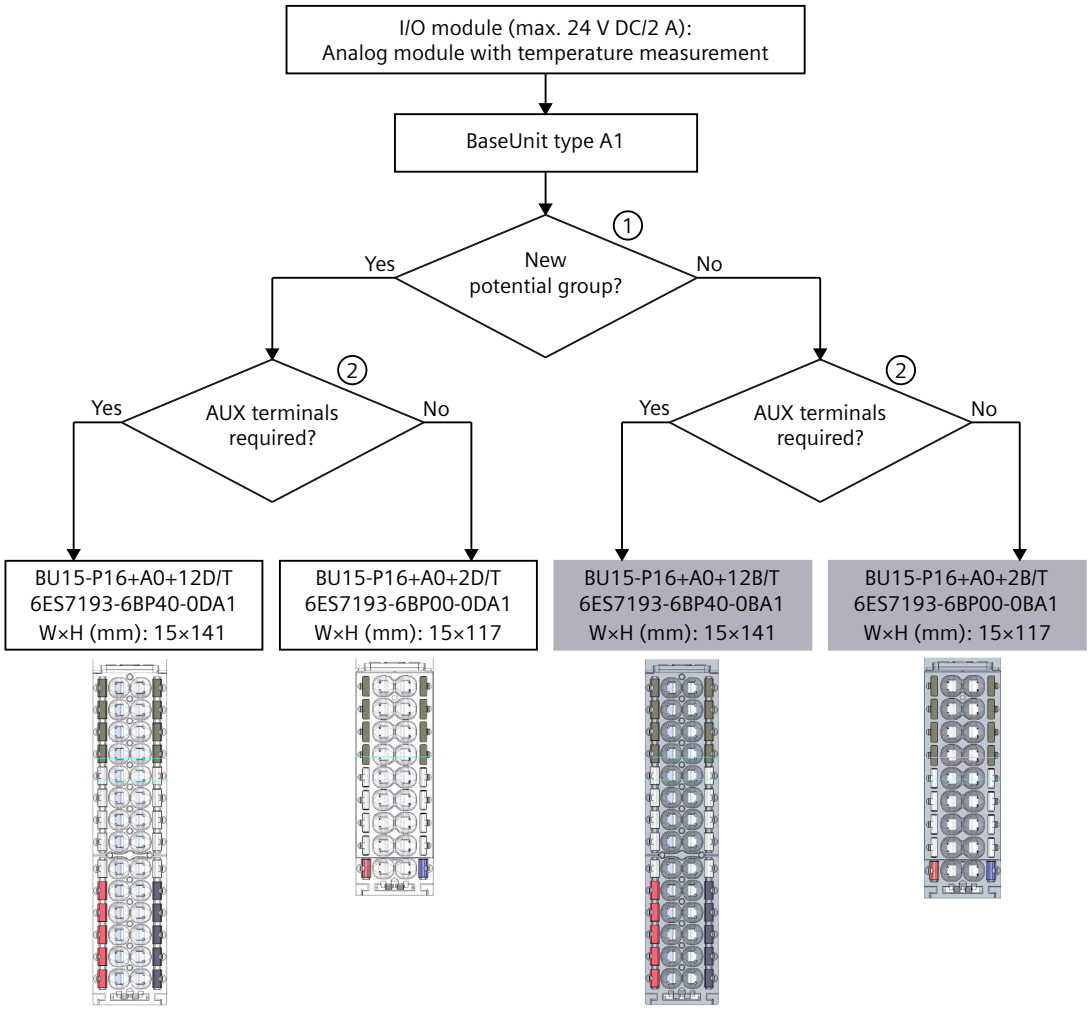

① Light-colored BaseUnit: Configuration of a new potential group, electrical isolation from adjacent module on the left. The first BaseUnit of the ET 200SP is usually a light-colored BaseUnit for incoming supply voltage L+.
Dark BaseUnit: Continuation of the internal power and AUX buses from the adjacent module on the left.

② Additional terminals: 2×5 internally bridged terminals for individual use up to 24 V DC/2 A
Example: Sensor supply for AI 4×U/I 2-wire ST

Figure 1-12 Analog modules with temperature measurement

6.2 Selecting a motor starter with suitable BaseUnit

6.2.1 Selecting a BaseUnit for motor starters

The motor starter BaseUnits "BU30-MS1", "BU30-MS2", "BU30-MS3" and "BU30-MS4" are compatible with all non-fail-safe motor starters. The motor starter BaseUnits "BU30-MS1", "BU30-MS2", "BU30-MS3", "BU30-MS4", "BU30-MS5", "BU30-MS6", "BU30-MS7", "BU30-MS8", "BU30-MS9" and "BU30-MS10" are compatible with all fail-safe motor starters. You will find an overview of available BaseUnits for motor starters here (Page 88). With the different BaseUnits, you can form different potential groups for the 24 V DC electronics supply (L+/M) and for the AC infeed.

Voltage range

The voltage range of the AC infeed is between 48 V AC and 500 V AC.

Selection criteria for the BaseUnit

The figure below shows the criteria you use to select the appropriate BaseUnit:

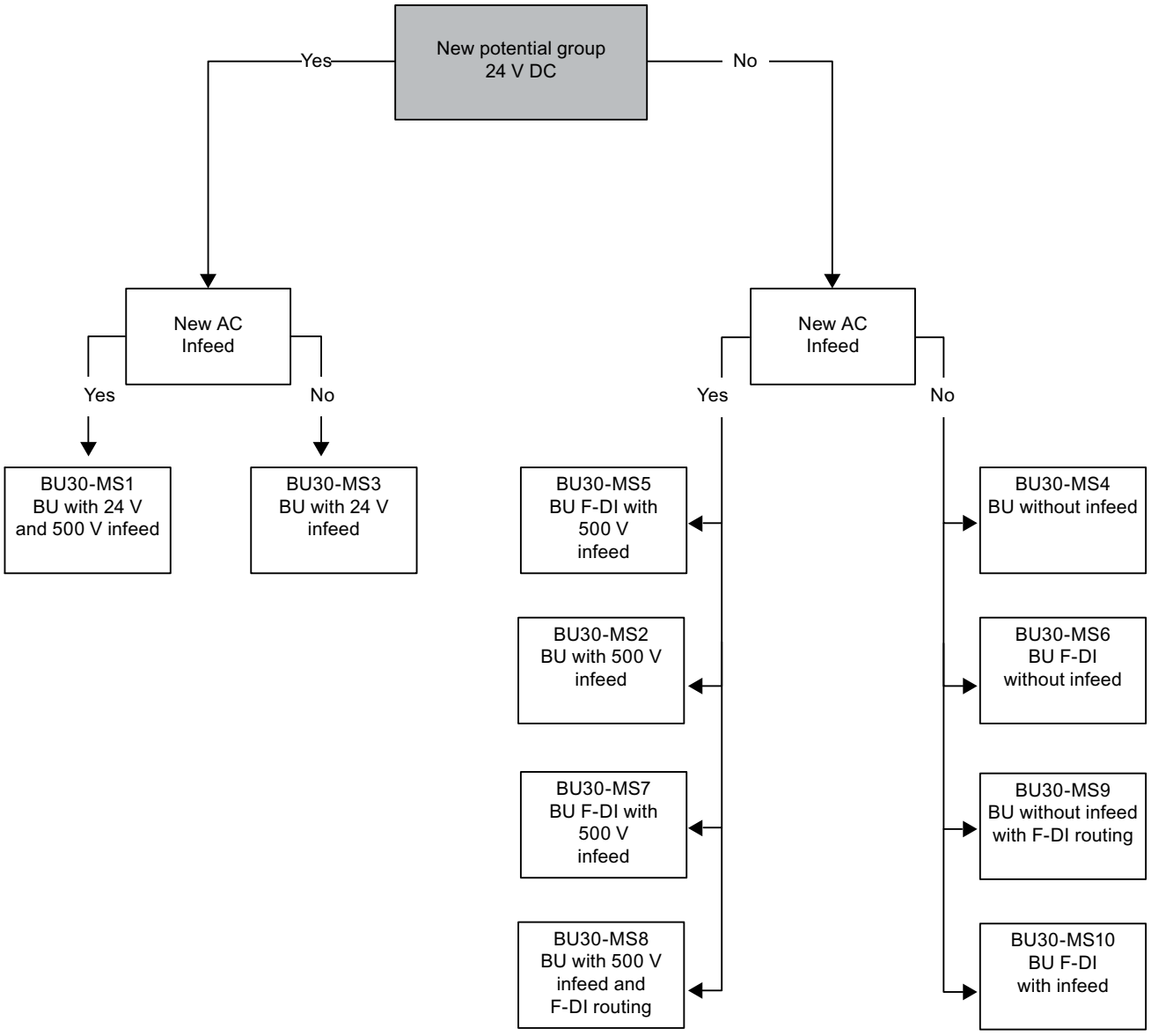

Form separate potential groups on the infeed bus for single-phase (L, N, PE) and three-phase (L1, L2, L3, PE) operation.

6.2.2 Selecting the motor starter

You select the suitable motor starter using the load type according to the following scheme:

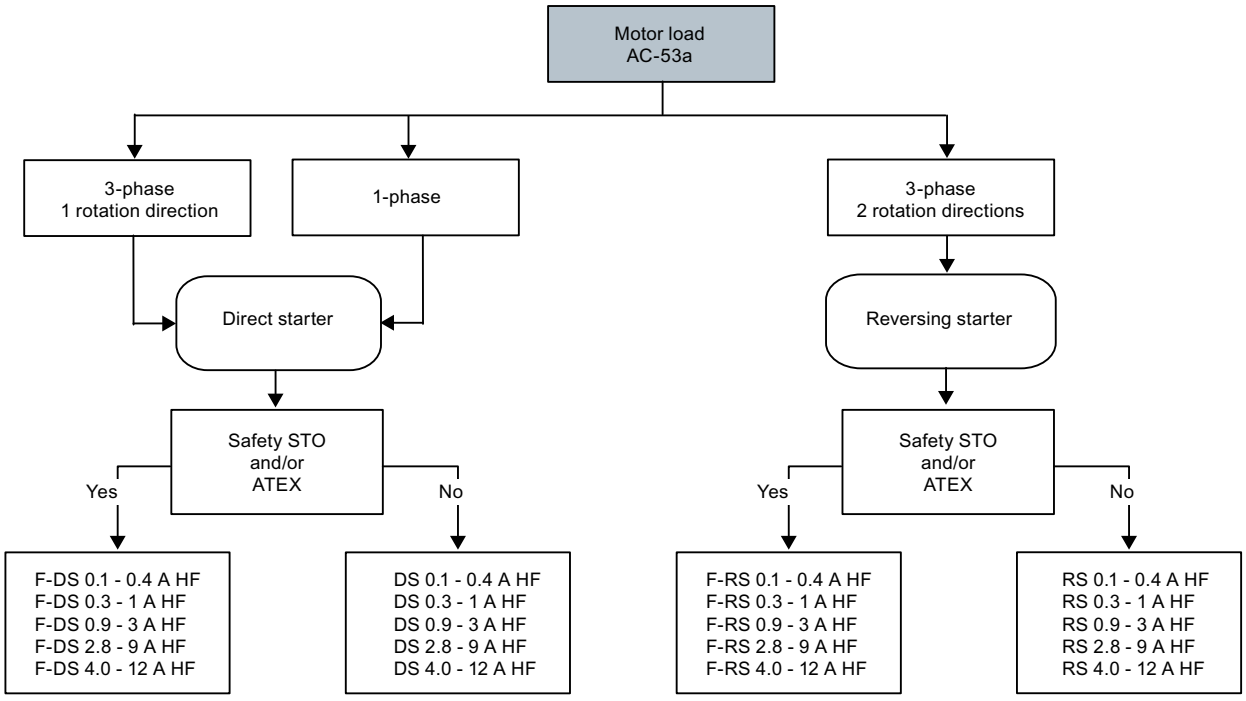

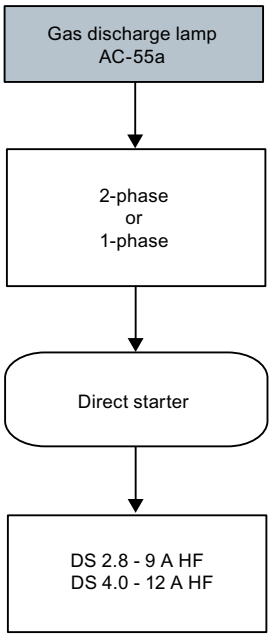

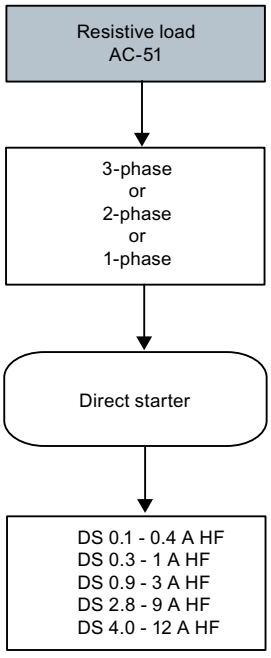

6.2.3 Selecting accessories for motor starters

Observe the installation conditions of the station with ET 200SP motor starters. The figure below shows the criteria the station must meet:

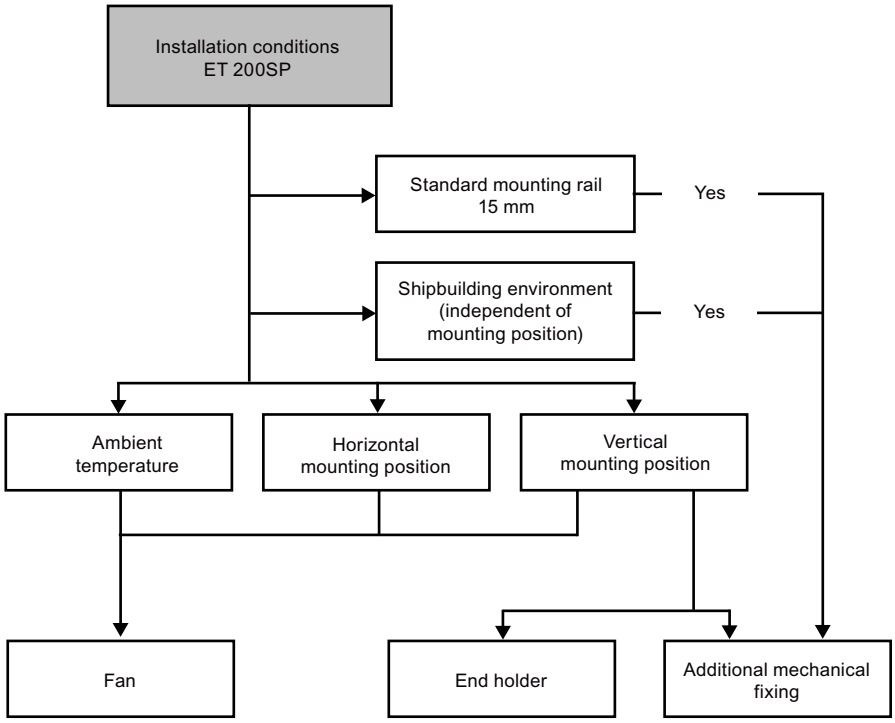

6.3 Selecting potential distributor modules

6.3.1 Selecting a PotDis-BaseUnit

Selection of a suitable PotDis-BaseUnit potential distributor module

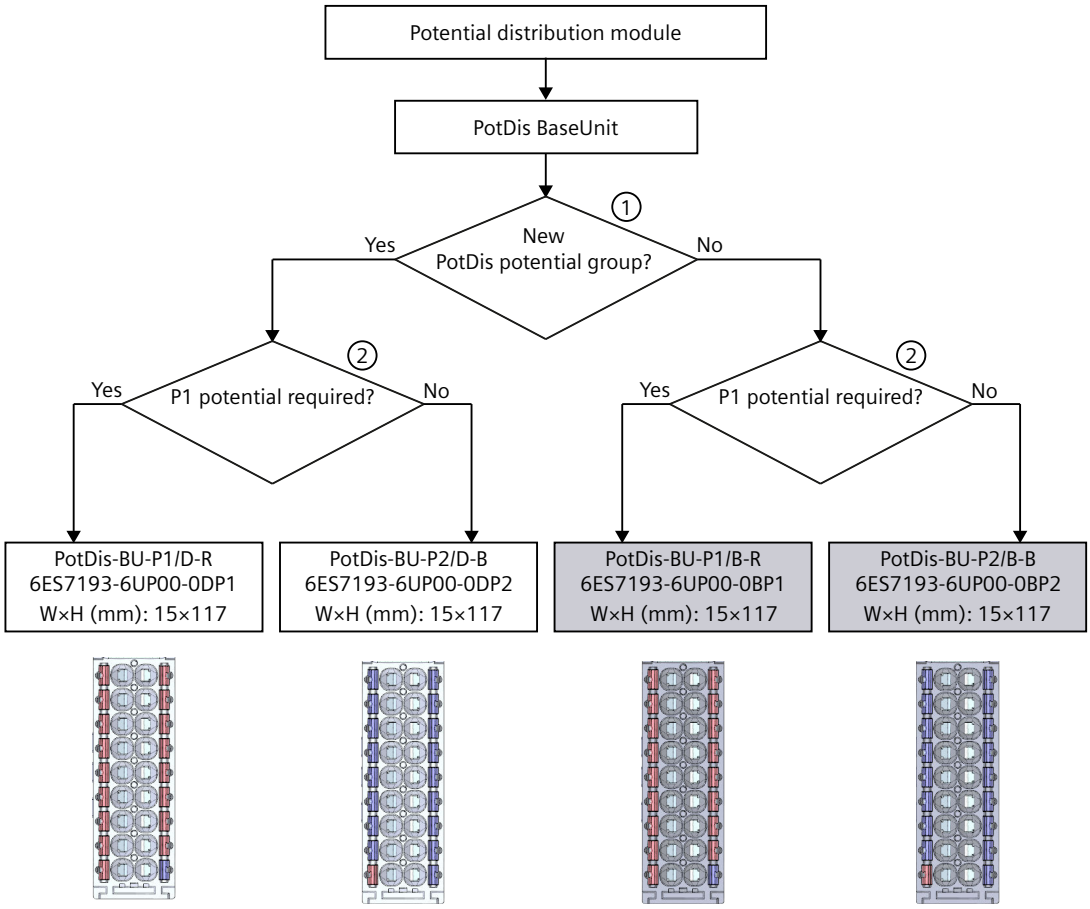

① Light-colored PotDis-BaseUnit: Configuration of a new potential group, electrical isolation from adjacent module on the left. The first BaseUnit of the ET 200SP is usually a light-colored BaseUnit for the incoming supply voltage.

② P1 terminal: 16 internally bridged terminals for individual use up to 48 V DC/10 A
Example: Multiple cable connection for DI 16×24VDC ST

Figure 1-13 PotDis-BaseUnits

Please note:

- The potential groups opened with a light-colored PotDis-BU must not contain any I/O modules. You can integrate any dark-colored PotDis-BUs into I/O module potential groups provided they are based on an SELV/PELV supply.
- If you do not need the additional terminals of the PotDis-TB in a potential distributor module, replace the PotDis-TB with a BU cover. You may only connect one potential group within a combination of PotDis-BU and PotDis-TB.

- Only SELV/PELV potentials are permitted on PotDis-BUs. Separate different SELV/PELV potential groups using light-colored PotDis-BUs.
- With potential distributor modules, you may only connect to the PotDis-TB versions BR-W and n.c.-G potential, which exceed the voltage level of SELV/PELV.
- PotDis terminals are not directly configurable as PotDis via GSD/GSDML. When configuring with GSD, always use an dummy module; with GSDML, integrate a free space.

Additional information

Additional information on the potential distributor modules (PotDis-BaseUnits and PotDis-TerminalBlocks) is available in the BaseUnits (https://support.industry.siemens.com/cs/ww/de/view/59753521/en) manual.

6.3.2 Selecting a PotDis-TerminalBlock

Selection of a suitable PotDis-TerminalBlock

With a PotDis-TerminalBlock you are expanding a PotDis-BaseUnit potential distributor module by an additional 18 potential terminals.

You can freely combine PotDis-TerminalBlocks and PotDis-BaseUnits.

The following PotDis-TerminalBlocks are available:

Table 1-8 Selection of TerminalBlock PotDis-TB

PotDis-TerminalBlocks		
TerminalBlock	**Explanation**	**Application**
PotDis-TB-P1-R	Terminal block with 18 terminals with red spring releases with connection to the supply voltage P1 of the PotDis-BaseUnit with SELV/PELV.	Provision of 18 x P1 potential, e.g. for P1 sensor supply with 3-wire connection for 16-channel digital input modules
PotDis-TB-P2-B	Terminal block with 18 terminals with blue spring releases with connection to ground (P2) of the PotDis-BaseUnit	Provision of 18 x P2 potential, e.g. for ground of the sensor supply with 2-wire connection for 16-channel digital output modules
PotDis-TB-n.c.-G	Terminal block with 18 terminals with gray spring releases without connection to each other or to a voltage bus of the PotDis-BaseUnit	Provision of 18 x n.c. (not connected), for reserving ("parking") unused signals/lines, e.g. for antivalent sensors in the same potential group
PotDis-TB-BR-W	Terminal block with 18 terminals connected to each other with white spring releases without connection to a voltage bus of the PotDis-BaseUnit	Provision of 17 terminals with shared potential (the 18th terminal is used for infeed) for supply of external consumers

Additional information

Additional information on the potential distributor modules (PotDis-BaseUnits and PotDis-TerminalBlocks) is available in the BaseUnits (https://support.industry.siemens.com/cs/ww/de/view/59753521/en) manual.

6.4 Hardware configuration

Maximum mechanical configuration

As soon as **one** of the following rules applies, the maximum configuration of the ET 200SP has been reached:

Table 1-9 Maximum mechanical configuration

Properties	Rule
Number of modules	Maximum of 12/30/32/64 I/O modules (depending on the CPU used/the interface module used; see CPU (https://support.automation.siemens.com/WW/view/en/90466439/133300) and interface module (https://support.automation.siemens.com/WW/view/en/55683316/133300) manuals)
	For every 6 F-modules F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0), the maximum configuration is reduced by 1 module.
Number of motor starters	Maximum of 31 motor starters
Backplane bus length of the ET 200SP	maximum 1 m mounting width (without CPU/interface module, including server module)

Electrical maximum configuration for I/O modules

The number of operable I/O modules of a potential group is limited by the following factors:

- Power consumption of the I/O modules
- Power consumption of the components supplied via these I/O modules

The maximum current carrying capacity of the terminals on the BaseUnit L+/M amounts to 10 A. "Current carrying capacity" refers to the current load via the power bus and the infeed bus of the ET 200SP station. Consider the current carrying capacity when using a motor starter.

Maximum electrical configuration for motor starter power bus (24 V DC)

To determine the current requirement of an individual motor starter via the power bus, take account of the following parameters:

- Current consumption via DC infeed in the ON state
- Current consumption via DC infeed when switching on (40 ms peak load)
- Increased power consumption through fan operation
- Current requirement via encoder supply of the connected DI module

The maximum current carrying capacity of the 24 V potential group is 7 A across the entire permissible temperature range.

Maximum electrical configuration for motor starter infeed bus (500 V AC)

To determine the current requirement of an individual motor starter via the infeed bus, proceed as follows:

Calculate the current requirement via the main current paths of the individual motor starter. In doing so, take into account the parameter I_e (set rated operational current of the motor starter). The permissible overload characteristics of the motor feeder for motors are determined with the thermal motor model. You calculate the current value ($I_{infeed\ bus}$) for the infeed bus of the ET 200SP system according to the following formula:

$I_{infeed\ bus} = \sum_n (I_e * 1.125)$
n = number of motor starters of a potential group on the infeed bus

Refer to the Manual (https://support.industry.siemens.com/cs/ww/en/view/109479973) for details of how to assign the basic rated operational current I_e parameter.

The following values apply for the potential group of the AC infeed:

- The maximum current carrying capacity is 32 A at an ambient temperature of up to 50 °C.
- The maximum current carrying capacity is 27 A at an ambient temperature of up to 60 °C.
- The maximum current carrying capacity for applications according to UL requirements is 24 A at an ambient temperature of up to 60 °C.

Address space

The address space depends on the CPU/interface module (see CPU (https://support.automation.siemens.com/WW/view/en/90466439/133300) Manual) and the interface module used (see Interface module (https://support.automation.siemens.com/WW/view/en/55683316/133300) Manual):

- For PROFINET IO: Dependent on the IO controller/IO device used
- For PROFIBUS DP: Dependent on the DP master used

6.5 Forming potential groups

6.5.1 Basics

Introduction

Potential groups for the ET 200SP distributed I/O system are formed by systematically arranging the BaseUnits.

Requirements

For formation of potential groups, the ET 200SP distinguishes between the following BaseUnits:

- BaseUnits BU...D (recognizable by the light-colored terminal box and the light-colored mounting rail release button):
  - Opening of a new potential group (power busbar and AUX bus are interrupted to the left)
  - Feeding in the supply voltages (DC or AC) up to an infeed current of 10 A, depending on the BaseUnit used.
- BaseUnits BU...B (recognizable by the dark-colored terminal box and the dark-colored mounting rail release button):
  - Conduction of the potential group (power busbar and AUX bus continued)
  - Tapping the supply voltages (DC or AC) for external components or looping through with a maximum total current of 10 A, depending on the BaseUnit used.
- BaseUnits BU30-MSx (BaseUnit for the motor starter only)

  Depending on the version, the BaseUnits in the "BU30-MSx" model series possess the following properties:
  - Opening a new potential group or continuing an existing one
  - Feeding in the supply voltage L+ up to an infeed current of 7 A DC
  - Opening a new load group or continuing an existing one by means of 500 V AC infeed bus
  - Feeding in the line voltage up to an infeed current of 32 A AC
  - Feeding in and routing the F-DI signal

NOTE

The BaseUnits BU...B of type B1 and D0 loop through the voltage buses P1/P2 and the AUX bus. The buses are not tapped by the module.

Placement and grouping of I/O modules

Each BaseUnit BU...D that you install in the ET 200SP configuration opens a new potential group and supplies all subsequent I/O modules (on BaseUnits BU...B) with the necessary supply voltage. The first 24 V DC I/O module to the right of the CPU/interface module must be installed on a light-colored BaseUnit BU...D. Exception: If you insert an AC I/O module or an AI Energy Meter as the first I/O module, the first BaseUnit in the ET 200SP configuration can be a dark-colored BaseUnit. The requirement is that you use a CPU or IM 155-6 (as of V3.0).

If you want to place another BaseUnit BU...B after a BaseUnit BU...D, disconnect the power busbar and AUX bus and open a new potential group at the same time. This allows individual grouping of the supply voltages.

NOTE

All BaseUnits placed in a load group have to match the infeed potential of the corresponding light-colored BaseUnit.

Do not connect any BaseUnit of the "BU...B" type on the right of the BaseUnit of a motor starter (BU30-MSxx).

Placing and connecting potential distribution modules

Potential distribution modules provide potential distributors integrated into the system that you can use to configure a rapid, space-saving customized replacement for standard potential distribution systems.

You can place potential distribution modules at any location within the ET 200SP distributed I/O system. To do so, you must observe the same design rules as for placing and connecting I/O modules. Potential distribution modules are only suitable for SELV/PELV.

A potential distribution module consists of a potential distributor BaseUnit (PotDis-BU) and (if necessary) a potential distributor terminal block (PotDis-TB) plugged onto it. If you do not need the additional terminals of the PotDis-TB, install a BU cover (15 mm) on the PotDis-BaseUnit.

You must not place a BaseUnit for I/O modules in a PotDis potential group formed with a light-colored PotDis-BaseUnit.

NOTE

Identical voltages with potential distribution modules

You can only connect identical (supplied) SELV/PELV voltages to the terminals of a potential distribution module or PotDis potential group. Example: You only connect 24 V DC.

Placement and grouping of I/O modules and motor starters

For the potential group (L+/M), the following slot rules apply within the motor starter modules and other I/O modules of the ET 200SP:

- An unassembled BaseUnit (BaseUnit with BU cover) must be inserted between the CPU, an interface module or an I/O module and the motor starter. This is not necessary between the motor starters.
- The empty slot can take on the potential (24 V DC) of the potential group on the left of it (L+, M), i.e. I/O modules and motor starters can be operated in the same potential group.
- If you would like to insert an I/O module on the right of a motor starter, then use only one BaseUnit of the BU...D Typ A0 type (light terminal box).
- The BaseUnits BU30-MS2, BU30-MS4, BU30-MS5, BU30-MS6, BU30-MS7, BU30-MS8, BU30-MS9 and BU30-MS10 can continue the potential group of other BaseUnit types. However, note the following exceptions:
  - Only a BaseUnit of type BU30-MS1 or BU30-MS3 may follow an AS-i module (AS-i potential group).
  - Only BaseUnits with fail-safe motor starters can be connected together in the same potential group of an F-PM-E.

WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Hazardous electrical voltage can cause electric shock, burns and property damage.

Disconnect your system and devices from the power supply before starting any assembly tasks.

AUX bus (AUX(iliary) bus)

BaseUnits with additional AUX terminals (e.g. BU15-P16+**A10**+2D) enable the additional connection of a potential (up to the maximum supply voltage of the module), which is applied via the AUX bus.

In the case of light-colored BaseUnits, the AUX bus is interrupted to the left. In the case of BaseUnits BU30-MS1 to BU30-MS7 and BU30-MS10 , the AUX bus is interrupted to the left. The AUX bus of BU30-MS8 and BU30-MS9 is used for F-DI routing.

The AUX bus can be used individually:

- As a PE bar, in which case you may plug a maximum of 8 BaseUnits in the corresponding potential group
- For additionally required voltage

NOTICE
AUX bus as PE bar If you use an AUX bus as a protective conductor bar, attach the yellow-green color identification labels to the AUX terminals, and establish a functional connection to the central protective conductor connection. If you stop using the AUX bus as a protective conductor bar, make sure you remove the yellow-green color identification labels and remove the connection to the central protective conductor connection again. If you use the AUX bus as a protective conductor bar, the corresponding protective conductor tests must be conducted by the installer of the system before commissioning. In addition, both ends of the ET 200SP system assembly must be mechanically fixed to the mounting rail in this case (e.g using 8WA1010-1PH01 ground terminals); this connection can only be detached by using a tool.

The AUX bus is designed as follows:

- Maximum current carrying capacity (at 60 °C ambient air temperature): 10 A
- Permissible voltage: Depending on the BaseUnit type (see BaseUnit manual (https://support.automation.siemens.com/WW/view/en/59753521))

NOTE

The AUX potential must always be identical to the potential group of the supply voltage if it is not being used as PE.

Self-assembling voltage buses

You must feed in the supply voltage L+ via the BaseUnit BU...D, BU30-MS1 or BU30-MS3 .

Each BaseUnit BU...B allows access to the supply voltage L+ via terminals (red/blue). The motor starter BaseUnits "BU30-MS1", "BU30-MS2", "BU30-MS3", "BU30-MS4", "BU30-MS5", "BU30-MS6", "BU30-MS7", "BU30-MS8", "BU30-MS9" and "BU30-MS10" do not have this access.

Operating principle

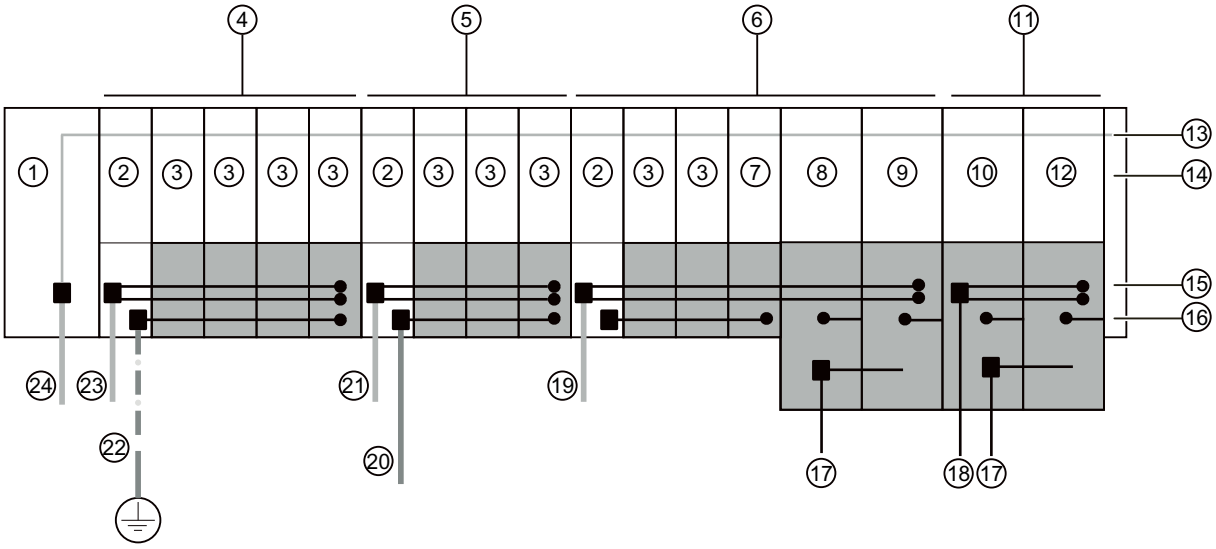

1	CPU/interface module	14	Server module
2	BaseUnit BU...D	15	Self-assembling voltage buses P1/P2
3	BaseUnit BU...B	16	AUX bus
4	Potential group 1	17	Infeed bus 500 V AC (L1, L2(N), L3, PE)
5	Potential group 2	18	Supply voltage L+
6	Potential group 3	19	Supply voltage L+ (3)
7	BaseUnit BU...B with dummy module	20	Additionally required voltage
8	BaseUnit BU30-MS2	21	Supply voltage L+ (2)
9	BaseUnit BU30-MS4	22	Protective conductor (green/yellow)
10	BaseUnit BU30-MS1	23	Supply voltage L+ (1)
11	Potential group 4	24	Supply voltage 1L+
12	BaseUnit BU30-MS4		
13	Backplane bus		

Figure 1-14 Placing the BaseUnits

Connecting different potentials to the power or AUX bus

NOTE

If you apply different potentials to the power busbar or AUX bus within an ET 200SP station, you need to separate the potential groups with a BaseUnit BU...D.

6.5.2 Forming potential groups with BaseUnit type B1

Introduction

The AC I/O modules of the ET 200SP are required to connect sensors/actuators with alternating voltage 24 to 230 V AC.

Requirements

BaseUnits BU20-P12+A0+4B (BU type B1) and

- DI 4x120..230VAC ST digital input module
- DQ 4x24..230VAC/2A ST digital output module

Operating principle

Connect the required module-dependent alternating voltage for the AC I/O modules directly to the BaseUnits BU20-P12+A0+4B (terminals 1L, 2L/1N, 2N). Insert the AC I/O modules on the BaseUnits.

NOTE

Placing the BaseUnits for AC I/O modules

If you insert an AC I/O module as the first I/O module, then a BaseUnit BU20-P12+A0+4B can also be the first BaseUnit to the right of the CPU/interface module in the ET 200SP configuration.

The requirement is that you use a CPU as of V3.0 or IM 155-6 (as of V3.0).

- The BaseUnits BU20-P12+A0+4B do not monitor the connected alternating voltage. Please note the information on limiting the overvoltage and power rating in the AC I/O module manuals.
- Pay attention to the type of the BaseUnits during configuration.

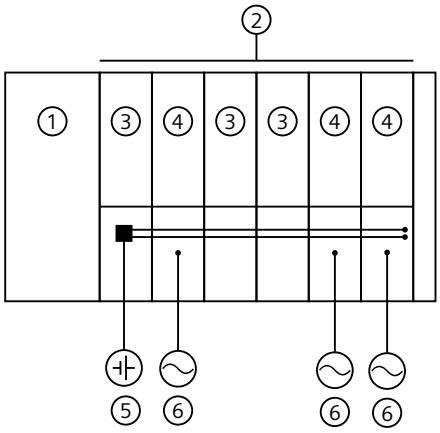

① CPU/interface module
② 24 V DC potential group
③ BaseUnits with DC I/O modules
④ BaseUnits BU 20-P12+A0+4B with AC I/O modules
⑤ Direct voltage
⑥ Alternating voltage

Figure 1-15 Placing the BaseUnits for the AC I/O modules

6.5.3 Forming potential groups with fail-safe modules

Introduction

ET 200SP distributed I/O systems can be configured using fail-safe and non-fail-safe modules. This chapter provides an example of a mixed configuration comprising fail-safe and non-fail-safe modules.

Example of an ET 200SP configuration with fail-safe and non-fail-safe modules

In principle, it is not necessary to operate fail-safe and non-fail-safe modules in separate potential groups. You can divide the modules into fail-safe and non-fail-safe potential groups and install them.

The figure below shows an example of a configuration with fail-safe and non-fail-safe modules within a single ET 200SP distributed I/O system.

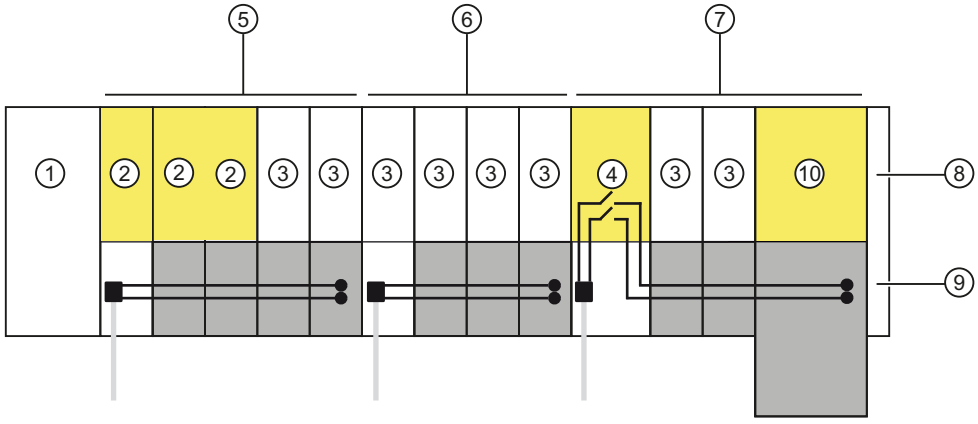

① IM 155-6 PN HF interface module

② F-module

③ Non-fail-safe module

④ Power module F-PM-E 24VDC/8A PPM ST

⑤ Mixed fail-safe and non-fail-safe potential group with BaseUnits BU15..D and BU15..B. You achieve SIL3/Cat. 4/PLe for the fail-safe modules. No safety category can be achieved with the non-fail-safe motor starter.

⑥ Non-fail-safe potential group with BaseUnits BU15..D and BU15..B

⑦ Fail-safe potential group with BaseUnits BU20..D, BU15..B and BU30-MSx. Up to SIL2/Cat. 3/PLd is possible if you disconnect the self-assembling voltage bus and thus the non-failsafe modules.

⑧ Server module

⑨ Self-assembling voltage buses P1/P2

⑩ Fail-safe motor starter F-DS HF

Figure 1-16 ET 200SP - example of a configuration with fail-safe modules

6.5.4 Forming potential groups with Ex modules

Ex module group

When you form an Ex module group with Ex BaseUnits and Ex power module/Ex I/O modules, observe the information in the System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/de/view/109795533/en).

NOTE

Thermal decoupling required

For thermal decoupling of ET 200SP modules and Ex module groups, you must install the following in front of the first Ex power module:

- An empty slot with BU cover
  or
- Recommendation: Potential distributor (PotDis-TerminalBlock PotDis-TB-P1-R on a PotDis-BaseUnit PotDis-BU-P2/B-B). This allows for a distribution of the supply voltage for the downstream Ex power modules.

6.5.5 Forming potential groups with motor starters

Overview of the functions of the BaseUnits

	24 V infeed	24 V continuation from left module	24 V transmission	500 V infeed	500 V continuation from left module	500 V transmission	F-DI infeed	F-DI continuation from left module	F-DI routing
3RK1908-0AP00-0AP0	✓	--	✓	✓	--	✓	--	--	--
3RK1908-0AP00-0CP0	--	✓	✓	✓	--	✓	--	--	--
3RK1908-0AP00-0BP0	✓	--	✓	--	✓	✓	--	--	--
3RK1908-0AP00-0DP0	--	✓	✓	--	✓	✓	--	--	--
3RK1908-0AP00-0EP0	--	✓	✓	✓	--	✓	✓	--	--
3RK1908-0AP00-0FP0	--	✓	✓	--	✓	✓	✓	--	--
3RK1908-0AP00-0GP0	--	✓	✓	✓	--	✓	✓	--	✓
3RK1908-0AP00-0HP0	--	✓	✓	✓	--	✓	--	✓	✓
3RK1908-0AP00-0JP0	--	✓	✓	--	✓	✓	--	✓	✓
3RK1908-0AP00-0KP0	--	✓	✓	--	✓	✓	✓	--	✓

✓ Function available

-- Function not available

Properties of the 500 V AC infeed bus

The infeed bus has the following properties:

- The infeed bus is assembled by lining up the motor starter BaseUnits "BU30-MSx".
- The infeed bus distributes the energy to the SIMATIC ET 200SP motor starter within one load group.
- You can open load groups by plugging in a 500 V infeed BaseUnit (BU30-MS1, BU30-MS2, BU30-MS5, BU30-MS7 or BU30-MS8). With BaseUnits BU30-MS3, BU30-MS4, BU30-MS6, BU30-MS9 or BU30-MS10, you can continue the infeed bus from the left BaseUnit.
- Via the infeed bus, you have the option of supplying three-phase load groups via L1, L2 and L3 or with single-phase load groups via L and N.
- The permissible voltage range is between 48 and 500 V AC.
- The maximum current carrying capacity is up 32 A (3-phase) at 50 °C and 500 V. Pay attention to the derating values depending on the configuration.

Properties of the self-assembling voltage bus (L+)

Self-assembling voltage buses have the following properties:

- Maximum current: 7 A
- Rated voltage: 24 V

Pay attention to the derating values depending on the configuration.

The AUX1 bus is not supported in the BaseUnits of the SIMATIC ET 200SP motor starters. The AUX1 bus is used in ET 200SP motor starters for routing the F-DI signal in BU30-MS7 to BU30-MS10.

⚠ WARNING

Electric shock when operating the infeed bus without touch protection cover

There is a risk of electric shock when touching the infeed bus if you have not fitted a touch protection cover on the infeed bus on the right.

Always fit a touch protection cover on the infeed bus on the right (article number: 3RK1908-1DA00-2BP0).

⚠ WARNING

Electric shock when operating a BaseUnit without an inserted motor starter

If you fit a BaseUnit for motor starters without cover (e.g. option handling), there is a risk of an electric shock when touching the BaseUnit.

Always fit a cover on the BaseUnit (article number: 3RK1908-1CA00-0BP0).

Requirements

Use the following devices to form potential groups with motor starters:

- BaseUnits BU30-MSx
- 3RK1308-0xx00-0CP0 motor starters

Operating principle

Connect the supply voltage L+ via the BaseUnit BU30-MS1 and BU30-MS3 to the terminals 24 V DC and M.

You can operate the motor starter on a single-phase (L1, N, PE) or a three-phase (L1, L2, L3, PE) AC voltage system. You connect the required AC voltage directly to the BaseUnits BU30-MSx (terminals L1, L2(N), L3, PE). You plug the motor starter onto the BaseUnits.

NOTE

The motor starters' AC power supply is not connected to the AC power supply for the AC I/O modules (see Chapter "Forming potential groups with BaseUnit type B1 (Page 107)").

6.6 Configuration examples for potential groups

6.6.1 Configuration examples with BaseUnits

Table 1-10 Configuration examples with BaseUnits

BaseUnits	Configuration
BU15-P16+A0+-2D BU15-P16+A0+-2B	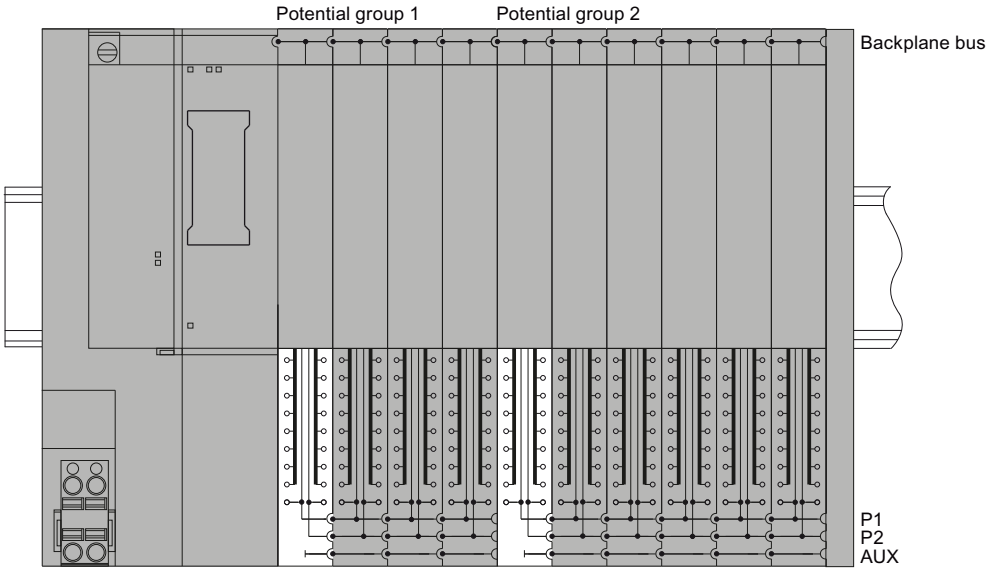

BaseUnits	Configuration
BU15-P16+A0+-2D BU15-P16+A0+-2B BU20-P12+A0+-0B	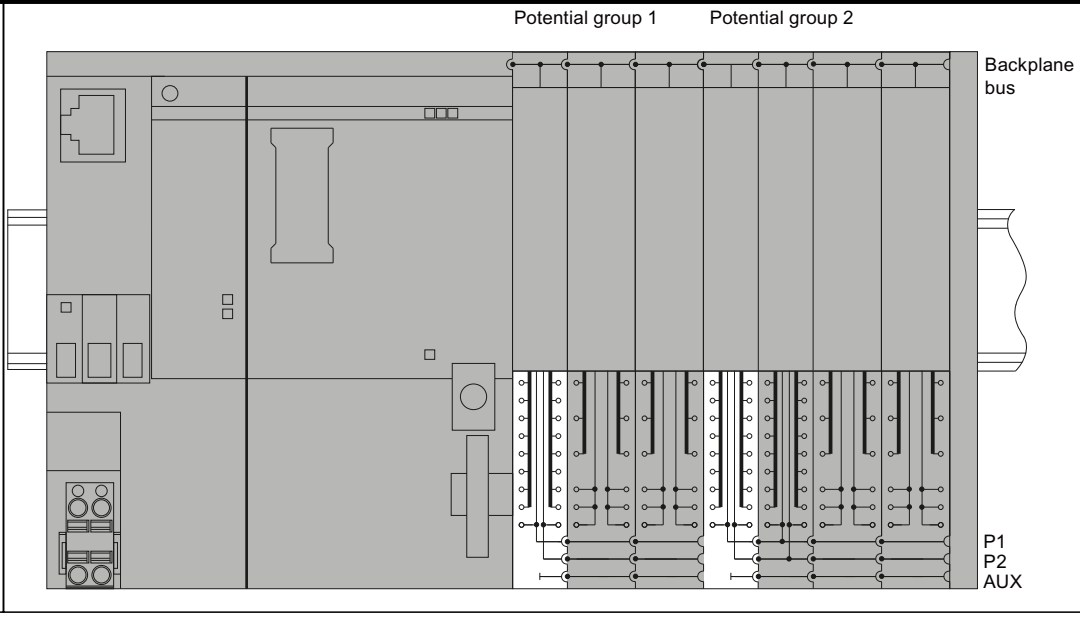

BaseUnits	Configuration
BU15-P16+A10-+2D BU15-P16+A10-+2B	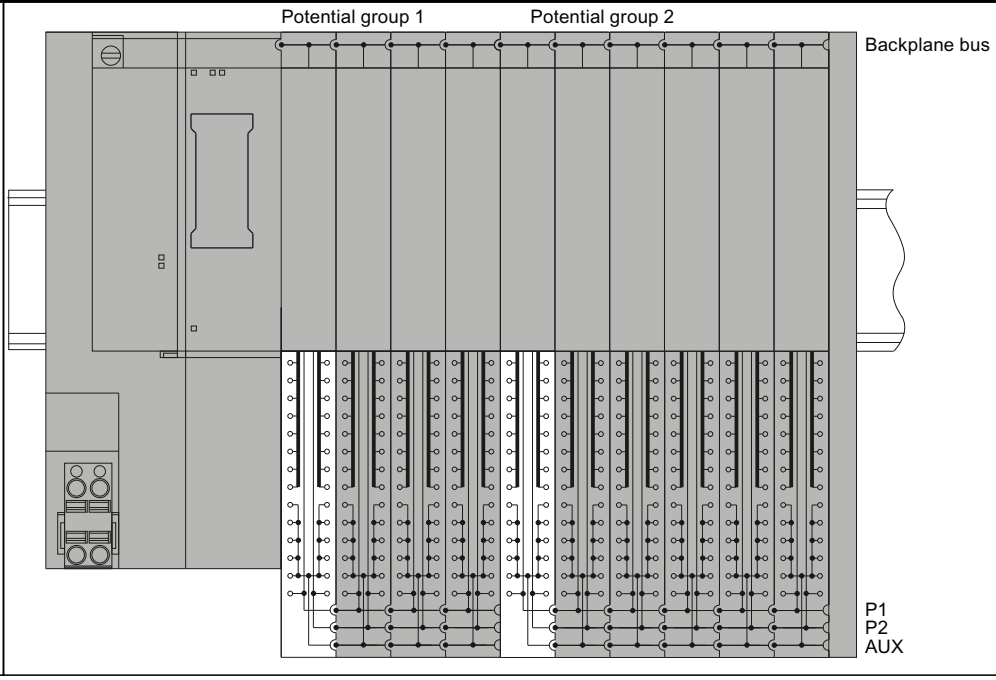

6.6.2 Configuration examples with potential distributor modules

3-wire connection

The potential distributor modules allow for a space-saving design. For a 3-wire connection, you can, for example, replace two digital input modules with 8 channels on a 141 mm long BaseUnit with a digital input module with 16 channels and a potential distributor module, each of which is only 117 mm long.

NOTE

You must not place a BaseUnit for I/O modules in a PotDis potential group formed with a light-colored PotDis-BaseUnit.

The figure below shows a configuration example with a DI 16×24VDC ST digital input module on a BU15-P16+A0+2B BaseUnit and a PotDis-TerminalBlock PotDis-TB-P1-R on a PotDis-BaseUnit PotDis-BU-P2/B-B.

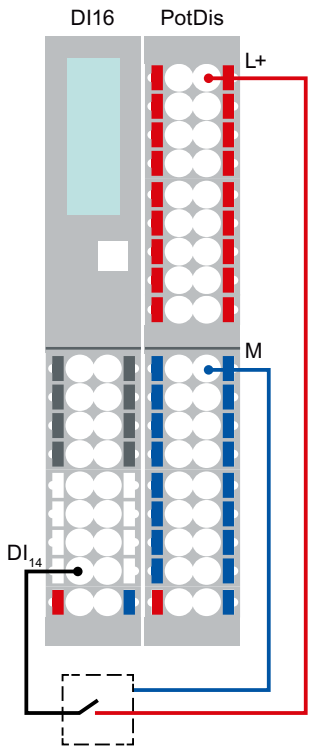

Figure 1-17 **Example: 3-wire connection**

Supply of external components

Another application of the potential distributor modules is the supply of potentials for external components. Potential distributor modules enable simple, compact, integrated and clear design.

Observe the current carrying capacity of each terminal: max. 10 A.

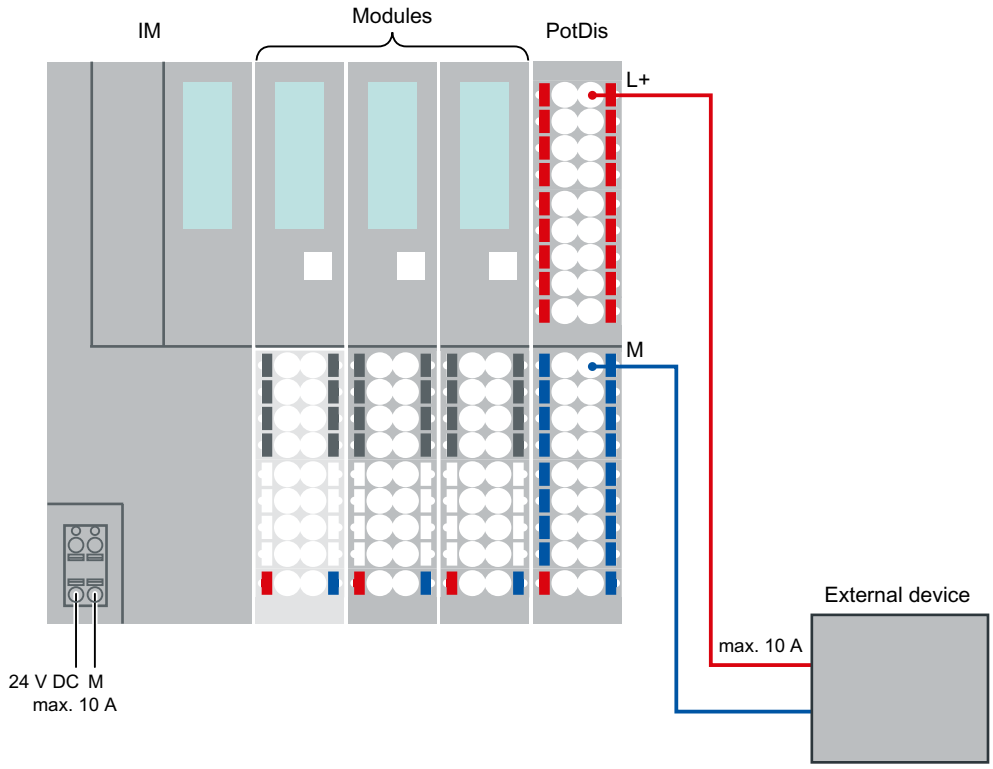

Figure 1-18 **Example: Supply of external components**

6.7 System redundancy R1

6.7.1 General notes on operating an ET 200SP R1 system

6.7.1.1 Example configuration of a system with ET 200SP R1

You need at least the following components for configuration of an ET 200SP R1 station:

- SIMATIC system rail (1 unit)
- BaseUnit BU type M0 (1 unit)
- Interface module IM 155-6 PN R1 (2 units)
- SIMATIC BusAdapter (2 units, e.g. BA 2×M12)
- BaseUnits and electronic modules (see section Configuration examples for potential groups (Page 112))
- Server module (1 unit)

- To operate a station with R1 system redundancy, you also need a set of R1-compatible S7-1500 CPUs (e.g. CPU 1517H-3 PN or CPU 1518HF-4 PN, 2 units).

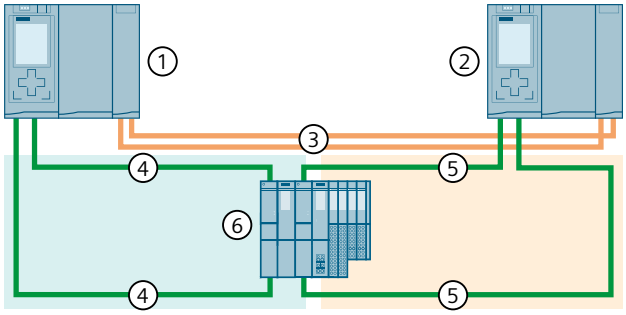

① CPU 1
② CPU 2
③ Two fiber-optic cables (redundancy connections)
④ PROFINET cable (PROFINET ring 1)
⑤ PROFINET cable (PROFINET ring 2)
⑥ ET 200SP I/O device (with system redundancy R1)

Figure 1-19 Configuration of S7-1500H with R1 devices in the PROFINET ring

You can find additional configuration examples in the SIMATIC S7-1500 S7-1500R/H Redundant System (https://support.industry.siemens.com/cs/ww/de/view/109754833) System Manual.

6.7.1.2 Commissioning an R1 station

After you configure an ET 200SP R1 station, you perform a commissioning maintenance cycle before the deployment in productive operation. This ensures that both redundant interface modules have been correctly contacted and can operate the electronic modules. The following is checked at the same time:

- Test for hardware integrity. Especially for hardware units that are not used while the device is passive and has no access to the SP bus. To ensure that the hardware is fully intact, perform at least a temporary takeover of the SP bus.
- After the maintenance cycle, the redundancy group must return to its pre-maintenance state.

To perform a commissioning maintenance cycle, proceed as follows:

The initial state is: The S7-1500H redundant system is in the RUN-Redundant system state. The ACT LED of one of the two interface modules (IM 1: regardless whether slot 0 or slot 1) is continuously lit.

1. Test step: Disconnect the interface module with the continuously lit ACT LED (IM 1) from the operating voltage by removing the connector from the 24 V connection. The station must assume the following state:
   - The LEDs of interface module 1 all go out.
   - The ACT LED of interface module 2 starts to flash.
   - In the CPU user program, an OB 70 (loss of redundancy) is reported on the station.
   - In the CPU user program, no OB 86 (station failure) is reported on the station.

2. Test step: Check the inputs and outputs via interface module 2. Use the engineering or configuration tool (e.g. user program or tag table).
3. Test step: Restore the operating voltage of interface module 1. The station must assume the following state after restart of interface module 1:
   - The ACT LED of interface module 2 lights up continuously.
   - In the CPU user program, an OB 70 (redundancy return) is reported.
   - The S7-1500H redundant system is again in the RUN-Redundant system state.
4. Test step: Disconnect the interface module with the permanently lit LED ACT (IM 2) from the operating voltage by pulling the plug out of the 24 V connection. The station must assume the following state:
   - The LEDs of interface module 2 all go out.
   - The ACT LED of the interface module 1 starts to flash.
   - In the CPU user program, an OB 70 (loss of redundancy) is reported on the station.
   - In the CPU user program, no OB 86 (station failure) is reported on the station.
5. Test step: Check the inputs and outputs via interface module 1. Use the engineering or configuration tool (e.g. user program or tag table).
6. Test step: Restore the operating voltage of interface module 2. The station must assume the following state after restart from interface module 2:
   - The ACT of interface module 1 is lit continuously.
   - In the CPU user program, an OB 70 (redundancy return) is reported.
   - The S7-1500H redundant system is again in the RUN-Redundant system state.
   - The system is again in the same state as before test step 1. The commissioning maintenance cycle has been successfully completed.

6.7.1.3 Increased availability

Compared to other ET 200SP interface modules, the system availability has been increased through use of PROFINET R1 redundancy. Even if one interface module fails, the function of the station is maintained.

The module automatically restarts to quickly return to the redundant state if one of the two redundant interface modules of a station fails (e.g. due to a critical error). This eliminates repair time.

Critical failures are stored in the device for later evaluation. You make this information available to Customer Support by reading the service data. You can find information on reading out the service data in the Interface Module IM 155-6 PN R1 Equipment Manual.

6.7.2 Improving the switchover time of the ET 200SP R1 system

Definition

The switchover time of the ET 200SP R1 station is the time that elapses after failure of the primary connection until the back-up IM has established the primary connection and takes control of the process. The response time is extended once during a redundancy switchover.

Composition of the cycle time and response time

You can find information and notes on the configuration of the CPU, the general composition of the cycle time and response time and how you can improve these times in the Cycle and Response Times (https://support.industry.siemens.com/cs/ww/en/view/59193558) Function Manual.

Improving the switchover time through configuration of the ET 200SP R1 station

To improve response times for an R1 system, we recommend that you follow the instructions below when configuring the ET 200SP R1 station:

- The shorter the PROFINET update time of an IO device, the shorter the response time of the R1 system tends to be.
- The fewer the number of I/O modules plugged into an R1 station, the shorter the response time of the R1 system tends to be.
- The smaller the input and output data range of the I/O modules, the shorter the response time of the R1 system tends to be.
- Certain module types increase the switchover time. Therefore, configure the stations in such a way that these module types are configured in a separate ET 200SP R1 station. This ensures that the switchover time of the ET 200SP R1 station that does not contain these module types is shorter.

  The following table provides you an overview of the modules that belong to these module types.

Name	MLFB
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter 480VAC/CT HF for 1 A or 5 A current transformer, with network analysis functions	6ES7134-6PA00-0CU0 (no longer available)
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter CT ST, for 1 A or 5 A current transformer	6ES7134-6PA01-0BU0
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter CT HF, for 1 A or 5 A current transformer, with network analysis functions	6ES7134-6PA01-0CU0
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter 480V AC ST	6ES7134-6PA20-0BD0
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter 480V AC/RC HF for Rogowski coils, current/voltage transformer 333 mV, with network analysis functions	6ES7134-6PA20-0CU0 (no longer available)

Name	MLFB
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter RC HF, for Rogowski coils or current/voltage transformer 333 mV, with network analysis functions	6ES7134-6PA21-0CU0
SIMATIC ET 200SP, Analog Input Module, AI Energy Meter RC ST, for Rogowski coils or current/voltage transformer 333 mV	6ES7134-6PA21-0BU0
SIMATIC ET 200SP, CM 4xIO-Link ST Communication module IO-Link Master V1.1	6ES7137-6BD00-0BA0
Technology Module SITRANS FST070 Ultrasonic Flow Transmitter	7ME3448-6AA00-0BB1
Technology Module SITRANS FCT070 Coriolis Flow Transmitter	7ME4138-6AA00-0BB1

NOTE

You can find additional information on switchover times from SIEMENS Customer Support.

Installation 7

7.1 Basics

Introduction

All modules of the ET 200SP distributed I/O system are open equipment. This means you may only install the ET 200SP distributed I/O system in housings, cabinets or electrical operating rooms and in a dry indoor environment (degree of protection IP20). The housings, cabinets and electrical operating rooms must guarantee protection against electric shock and spread of fire. The requirements regarding mechanical strength must also be met. The housings, cabinets, and electrical operating rooms must not be accessible without a key or tool. Personnel with access must have been trained or authorized.

Installation location

Install the ET 200SP distributed I/O system in a suitable enclosure/control cabinet with sufficient mechanical strength and fire protection. Take into account the environmental conditions for operating the devices.

Mounting position

You can mount the ET 200SP distributed I/O system in any position. The preferred mounting position is horizontal mounting on a vertical wall.

The ambient temperature may be restricted in certain installation positions. You will find more information in section Mechanical and climatic environmental conditions (Page 372).

Pay attention to chapter "Installation conditions for motor starters (Page 124)" when using motor starters.

Mounting rail

Install the ET 200SP distributed I/O system on a mounting rail in accordance with ISO 60715 (35 × 7.5 mm or 35 × 15 mm) or on a SIMATIC system rail.

The ET 200SP R1 system must be mounted on the SIMATIC system rail only.

You need to ground the mounting rail separately in the control cabinet. Exception: If you install the rail on grounded, zinc-plated mounting plates, there is no need to ground the rail separately.

NOTE

If the ET 200SP distributed I/O system is exposed to vibration and shock loads, both ends of the ET 200SP system assembly must be mechanically fixed to the mounting rail (e.g using 8WA1010-1PH01 ground terminals). This measure prevents the ET 200SP distributed I/O system from shifting to the side.

NOTE

If the ET 200SP, distributed IO system is exposed to increased vibrations and shock, fasten the mounting rail to the mounting surface at intervals of approx. 200 mm.

For increased vibration and shock loads, you can mount the ET 200SP system on the SIMATIC system rail.

The following are suitable surfaces for the mounting rails:

- Steel strip in accordance with Appendix A of EN 60715 or
- Tinned steel strip. We recommend these in conjunction with the mounting rails in the section Accessories/spare parts (Page 382).

NOTE

If you use mounting rails from other manufacturers, make sure that they have the required properties for your ambient climatic conditions.

Minimum clearances

The figure below shows the minimum clearances you must observe when installing or dismantling the ET 200SP distributed I/O system.

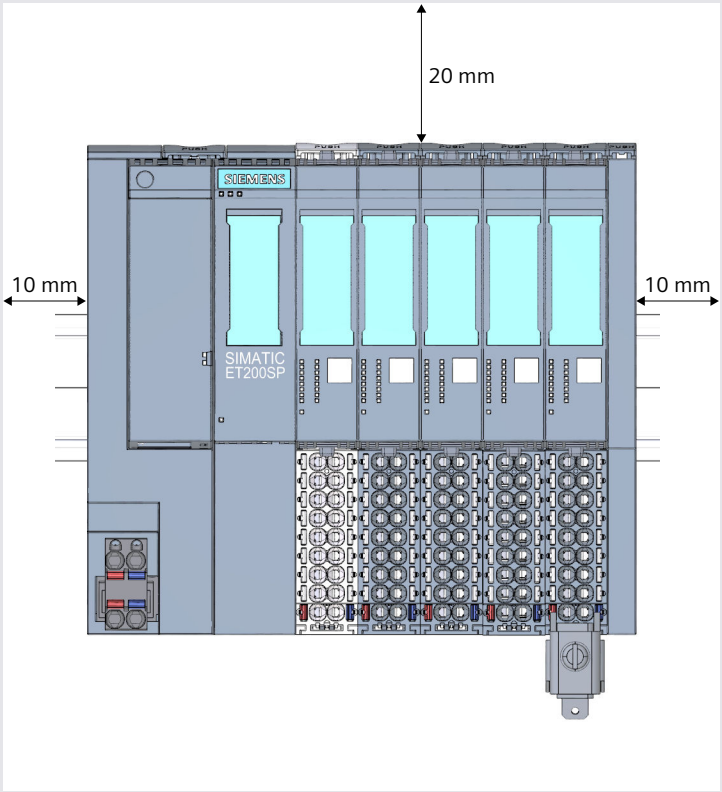

Figure 1-20 Minimum clearances

NOTE

Ex module group

When you are using an Ex module group in your configuration, you must observe other minimum clearances.

Additional information on minimum clearances and installing/removing Ex modules is available in the System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/de/view/109795533/en).

General rules for installation

⚠ WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Hazardous electrical voltage can cause electric shock, burns and property damage.

Disconnect your system and devices from the power supply before starting any assembly tasks.

Observe the following rules:

- Installation starts on the left-hand side with the CPU/interface module.
- A light-colored BaseUnit BU..D0, BU30-MS1 or BU30-MS3 with infeed of supply voltage L+ follows the CPU/interface module or is placed at the start of each potential group.
  If you use a CPU or IM 155-6 (V3.0 or higher), the first BaseUnit in the installation of the ET 200SP may also be a dark-colored BaseUnit of type B1 or D0.
- This is followed by BaseUnits BU..B, BU30-MS2 or BU30-MS4 (with a dark-colored terminal box).
- The matching I/O modules / motor starters can be plugged onto the BaseUnits. You will find matching combinations of BaseUnits and I/O modules / motor starters in Application planning (Page 88).
- The server module completes the configuration of the ET 200SP distributed I/O system.

NOTE

Mount the ET 200SP distributed I/O system only with disconnected supply voltage.

⚠ WARNING

Protection from conductive contamination

Taking into account the environmental conditions, the devices must be protected from conductive contamination.
This can be achieved, for example, by installing the devices in a control cabinet with the appropriate degree of protection.

Mounting rules for reducing the thermal load

The following rules reduce the thermal load of the ET 200SP distributed I/O system in the control cabinet:

- Separate 2 modules with high power dissipation with a module of low power dissipation or by an empty space.
- Mix modules with higher power dissipation and modules with less power dissipation. For example, modules with 16 outputs have a higher power dissipation than modules with 8 outputs.
- You should give preference to the horizontal mounting position.

- For vertical mounting position, plug modules with high power dissipation at the top, the interface module/CPU at the bottom.
- Mount an ET 200SP station with modules with high power dissipation in the lower area of the control cabinet.
- For a multi-tier configuration, plug modules with high power dissipation on the sides so that the waste heat can rise to the top unhindered.
- Avoid air movements at the terminals when using TC measurement with internal compensation.

7.2 Installation conditions for motor starters

Observe the following installation conditions when using an ET 200SP motor starter:

- Mounting position

  You can fit the motor starter vertically or horizontally. The mounting position refers to the alignment of the mounting rail The maximum permissible ambient temperature range depends on the mounting position:

  – Up to 60° C: Horizontal mounting position
  – Up to 50° C: Vertical installation position

  You also need to consider the current carrying capacity of the ET 200SP components.

  In the case of a vertical mounting position, use end retainers "8WA1808" at both ends of the ET 200SP station:

- Mounting rail

  Use one of the following mounting rails:

  – 35x15 mm DIN rail in accordance with DIN EN 60715
  – 35x7.5 mm DIN rail in accordance with DIN EN 60715
  – SIMATIC S7 mounting rail

- Current carrying capacity of the ET 200SP station
  Current carrying capacity refers to the current load via the power bus and the infeed bus of the ET 200SP station.

Depending on the ambient conditions and mounting position, you have to take account of the fan unit or additional mechanical fixings.

Mechanical brackets

Use the mechanical brackets in the following situations:

- When using a 15 mm mounting rail with a single motor starter installation, i.e. no motor starter mounted directly next to it in the system
- With a vertical mounting position
- For applications according to shipbuilding standards in all mounting positions with 7.5 mm and 15 mm mounting rails

Designing interference-free motor starters

For interference-free operation of the ET 200SP station in accordance with standard IEC 60947-4-2, use a dummy module before the first motor starter. No dummy module is required to the right of the motor starter.

Note the following mounting rules:

Use the following dummy module on the standard mounting rail between the previous module and the SIMATIC ET 200SP motor starter:

BU cover 15 mm: 6ES7133-6CV15-1AM0 with BaseUnit 6ES7193-6BP00-0BA0

For operation of the ET 200SP station with an unused BaseUnit, a cover must be provided for the open BaseUnit plug contacts (power connector, power bus connector, and backplane bus connector).

The cover protects the plug contacts against dirt. The BU cover can be ordered as an accessory.

Mount the dummy module

The figure below provides a schematic representation of how to implement measures for improving interference immunity.

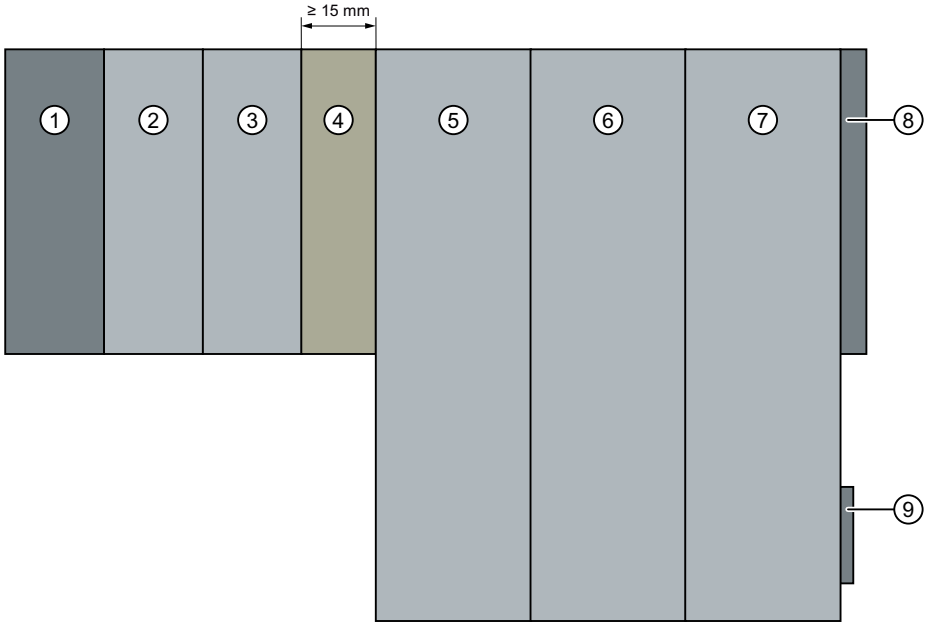

①	Interface module	⑥	Motor starter
②	Digital input module	⑦	Motor starter
③	Digital output module	⑧	Server module
④	Dummy module	⑨	Infeed bus cover
⑤	Motor starter		

NOTICE
Ensure interference immunity You must not plug any other module into the BaseUnit of the dummy module, otherwise interference immunity is no longer ensured.

7.3 Mounting the CPU/interface module

Introduction

The CPU/the interface module connects the ET 200SP distributed I/O system to the fieldbus and exchanges the data between the higher-level control system and the I/O modules / motor starters.

Requirement

The mounting rail is fitted.

Required tools

3 to 3.5 mm screwdriver (only for mounting and removing the BusAdapter)

Mounting the CPU/interface module

Watch the video sequence (https://support.automation.siemens.com/WW/view/en/95886218)

To install a CPU/interface module, follow these steps:

1. Install the CPU/interface module on the mounting rail.
2. Swivel the CPU/interface module towards the back until you hear the mounting rail release button click into place.

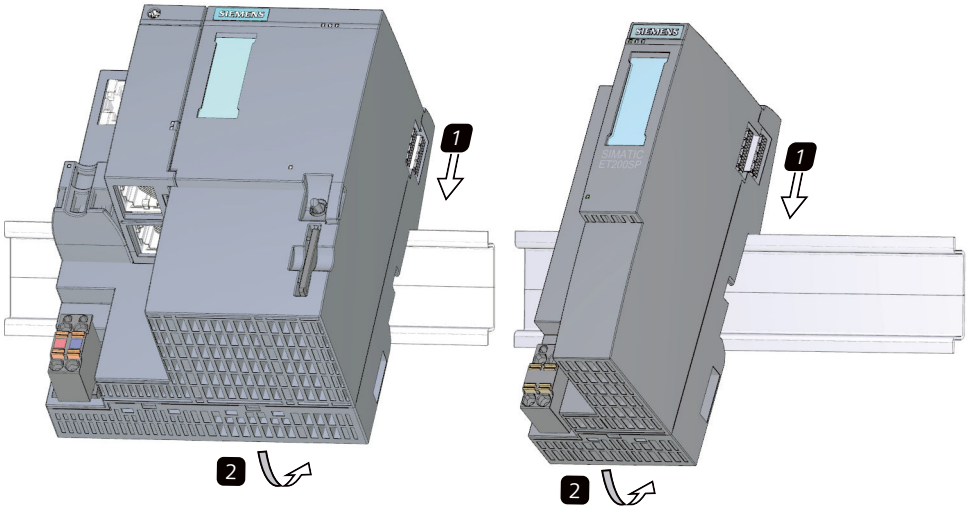

Figure 1-21 Mounting the CPU/interface module

Dismantling the CPU/interface module

The CPU/interface module is wired and BaseUnits are located to its right.

To remove the CPU/interface module, follow these steps:

1. Switch off the supply voltage for the CPU/interface module. Remove the 24 V DC connector from the CPU/interface module.
2. Confirm the mounting rail release on the first BaseUnit. At the same time, shift the CPU/interface module parallel to the left until it detaches from the rest of the module group.

   Note: The mounting rail release button is located above the CPU/interface module or BaseUnit.
3. While pressing the mounting rail release button on the CPU/interface module, swivel the CPU/interface module off of the mounting rail.

NOTE

It is not necessary to remove the BusAdapter from the CPU/interface module.

7.4 Installing ET 200SP R1

Introduction

The ET 200SP R1 system connects the ET 200SP distributed I/O system to the fieldbus and exchanges the data between the higher-level controller and the I/O modules / motor starters.

Requirement

The SIMATIC system rail is installed.

Tools required

3 to 3.5 mm screwdriver (only for mounting and removing the BusAdapter)

Mounting the ET 200SP R1 system

To mount the ET 200SP R1 system, proceed as follows:

1. Hang the BaseUnit BU type M0 onto the SIMATIC system rail.
2. Swivel the BaseUnit BU type M0 backwards until the system rail release audibly engages.
3. Plug the IM 155-6 PN R1 interface modules onto the BaseUnit BU type M0 until the lock audibly engages.
4. Plug the 24 V DC connectors into both interface modules.
5. Connect a BusAdapter to each interface module. Screw the BusAdapter to the interface module.

Removing the ET 200SP R1 system

To remove the ET 200SP R1 system, proceed as follows:

1. Switch off the supply voltage for the ET 200SP R1 system. Unplug the 24 V DC connectors from both interface modules.
2. Press the interface module release on the BaseUnit BU type M0. Detach the interface modules from the BaseUnit BU type M0.

3. Press the system rail release on the BaseUnit. Move the BaseUnit BU type M0 parallel to the left until it detaches from the rest of the module group.

   Note: The system rail release is located above the BaseUnit BU type M0.

4. With the system rail release pressed on the BaseUnit, swivel the BaseUnit BU type M0 off of the system rail.

NOTE

It is not necessary to remove the BusAdapter from the IM 155-6 PN R1 interface modules.

7.5 Installing the CM DP communication module

Introduction

You need the CM DP communication module to use the CPU with a DP master or DP slave.

Requirements

- The mounting rail is fitted.
- The CPU is installed.

Installing CM DP

To install the CM DP communication module, follow these steps:

1. Install the CM DP to the right of the CPU.
2. Swivel the CM DP towards the back until you hear the mounting rail release button click into place.

3. Slide the CM DP to the left until you hear it click into the CPU.

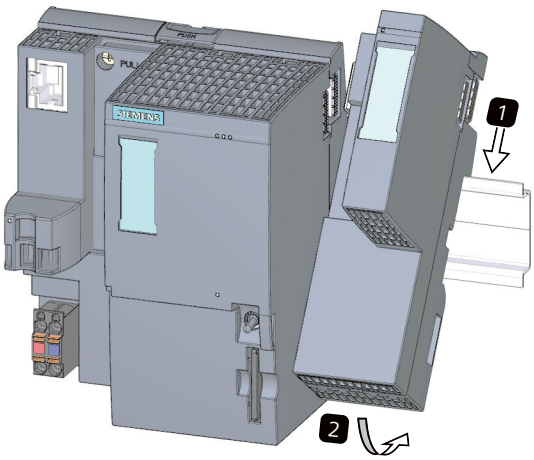

Figure 1-22 Installing CM DP

Removing a CM DP

The CPU and the CM DP are wired and BaseUnits are located to its right.

To remove the CM DP communication module, follow these steps:

1. Switch off the supply voltage on the CPU.
2. Press the mounting rail release button on the first BaseUnit and, at the same time, move the CPU and the CM DP parallel to the left until they detach from the rest of the module group (clearance about 16 mm).
3. Press the mounting rail release button on the CM DP and move it to the right until it detaches from the CPU (clearance about 8 mm).
4. While pressing the mounting rail release button on the CM DP, swivel the CM DP off of the mounting rail.

NOTE

It is not necessary to remove the bus connector from the CM DP unless you have to replace the CM DP.

7.6 Mounting BaseUnits for I/O modules

Introduction

The BaseUnits are used for electromechanical connection between the individual ET 200SP components. They also provide terminals for connecting external sensors, actuators and other devices.

Requirements

The mounting rail is fitted.

Required tools

3 to 3.5 mm screwdriver (only for dismantling the terminal box and the encoding element)

Installing a BaseUnit

Watch "Install configuration" video sequence (https://support.automation.siemens.com/WW/view/en/95886218)

To install a BaseUnit, follow these steps:

1. Hook the BaseUnit onto the mounting rail.
2. Swivel the BaseUnit backwards until you hear it click into place on the mounting rail.
3. Slide the BaseUnit parallel to the left until you hear it latch onto the preceding CPU/interface module or BaseUnit.

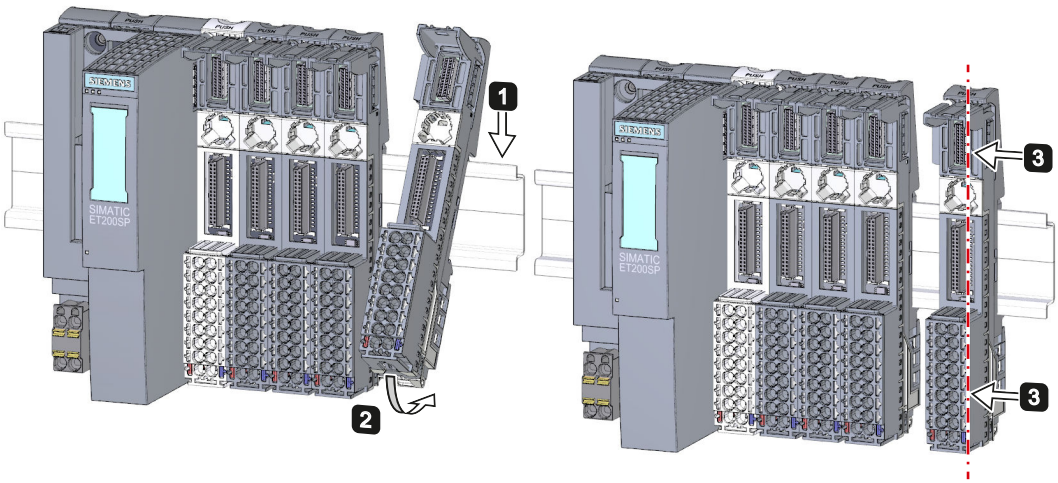

Figure 1-23 Installing a BaseUnit

Removing a BaseUnit

WARNING

Hazardous Voltage

Hazardous electrical voltage can cause electric shock, burns and property damage.

Disconnect your system and devices from the power supply before starting any assembly tasks.

To remove a BaseUnit, follow these steps:

The BaseUnit is wired and there are other BaseUnits to its right and left.

To remove a specific BaseUnit, move the adjacent modules. As soon as you have created a clearance of about 8 mm from the adjacent BaseUnits, you can remove the BaseUnit.

NOTE

You can replace the terminal box without removing the BaseUnit. Refer to section Replacing the terminal box on the BaseUnit (Page 330).

To remove a BaseUnit, follow these steps:

1. Switch off all supply voltages on the ET 200SP distributed I/O system.
2. Loosen the wiring on the BaseUnit (with a 3 to 3.5 mm screwdriver).
3. **Removing (from the right):**

   Press the mounting rail release on the relevant BaseUnit. Move the BaseUnit parallel to the right and swivel the BaseUnit off of the mounting rail while pressing the mounting rail release.

   Removing (from the left):

   Press the mounting rail release on the relevant BaseUnit and the BaseUnit located to its right. Move the BaseUnit parallel to the left and swivel the BaseUnit off of the mounting rail while pressing the mounting rail release.

   Note: The mounting rail release is located above the BaseUnit

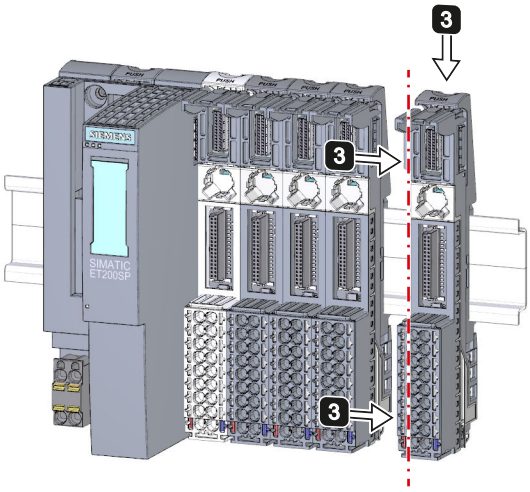

Figure 1-24 Removing the BaseUnit (removing from the right)

7.7 Mounting and dismantling BaseUnits for motor starters

Requirements

- The mounting rail is fitted.
- When using a 15 mm mounting rail, you must install the additional mechanical mounting (3RK1908-1EA00-1BP0).

NOTE

Mechanical bracket for BaseUnit

You will find out how to mount the mechanical bracket for the BaseUnit in chapter "Mounting the mechanical bracket for the BaseUnit (Page 149)".

CAUTION

Protection against electrostatic charge

When handling and installing the SIMATIC ET 200SP motor starter, ensure protection against electrostatic charging of the components. Changes to the system configuration and wiring are only permissible after disconnection from the power supply.

Mounting a BaseUnit

Proceed as follows to mount a BaseUnit for motor starters:

1. Hook the BaseUnit into the DIN rail from above.
2. Swing the BaseUnit to the rear until the BaseUnit audibly engages.

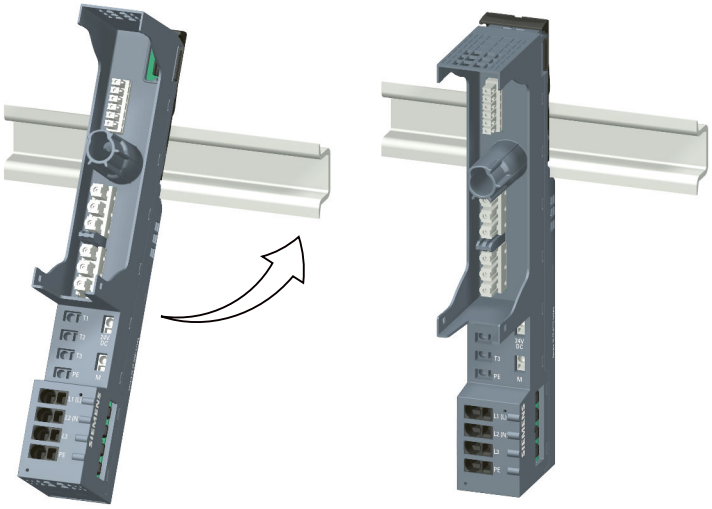

3. Slide the individual BaseUnits to the left to the previous BaseUnit until they audibly engage.

   Assemble the BaseUnits only on the DIN rail.

NOTE

The BaseUnits for motor starters can be plugged together with the BaseUnits for I/O modules.

Disassembling the BaseUnit

⚠ WARNING

Hazardous Voltage

Hazardous electrical voltage can cause electric shock, burns and property damage.

Disconnect your system and devices from the power supply before starting any assembly tasks.

To disassemble the BaseUnit, proceed as follows:

1. Disconnect the main power supply and the control current supply of the SIMATIC ET 200SP motor starter.
2. Actuate the DIN rail release on the BaseUnit of the motor starter.
3. Move the BaseUnit to the left. As soon as there is a clearance of approximately 8 mm to the neighboring BaseUnits, you can disassemble the BaseUnit of the motor starter.

4. Swing the BaseUnit away from the DIN rail while pressing the DIN rail release.

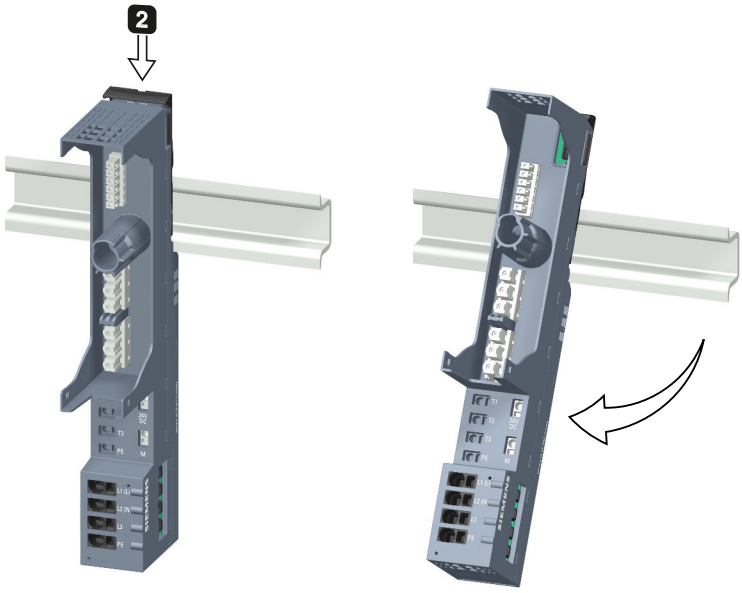

7.8 Installing and uninstalling BaseCarrier

7.8.1 Installing BaseCarrier

Requirements

- The printed circuit board with all the holes and connectors required is available to you. You can find more information in PCB Design Guide (http://support.automation.siemens.com/WW/view/en/109988377)

  Please note the following guidelines for obtaining possible approvals:

  – ATEX/IECEX/UKEX:

    For use of the BaseCarrier system in Zone 2, the customized printed circuit board must meet the applicable requirements according to the current version of EN IEC 60079-0, EN 60079-7, IEC 60079-0 and IEC 60079-7.

  – FM:

    In order to use the customized printed circuit board with the BaseCarrier as an FM Approved device, the printed circuit board must be FM Approved with the Base Carrier.

  – UL:

    The customized PCB must be UL rated according to ZPMV2 min 130°C, V-0.

- The bus housing with the bus PCB of the BaseCarrier is in position B.

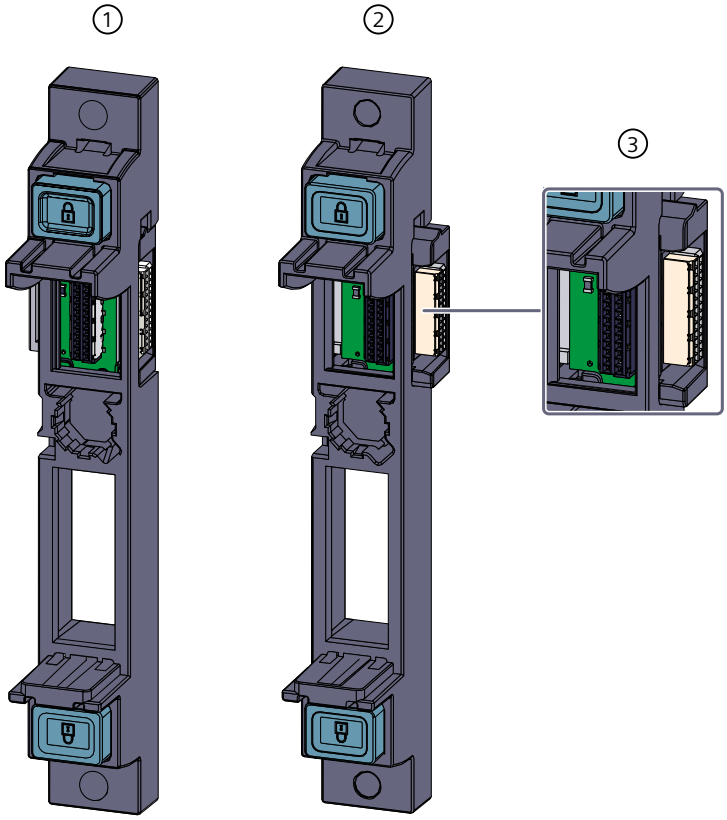

① Bus PCB in position A
② Bus PCB in position B
③ Detail of the bus circuit board

Figure 1-25 Positions of the bus PCB

Installing system with BaseCarrier

To install the BaseCarrier, follow these steps:

1. Screw the DIN rail to the printed circuit board. To do this, use the supplied hexagon socket-head screw adapters with a width A/F of 2.5 mm.

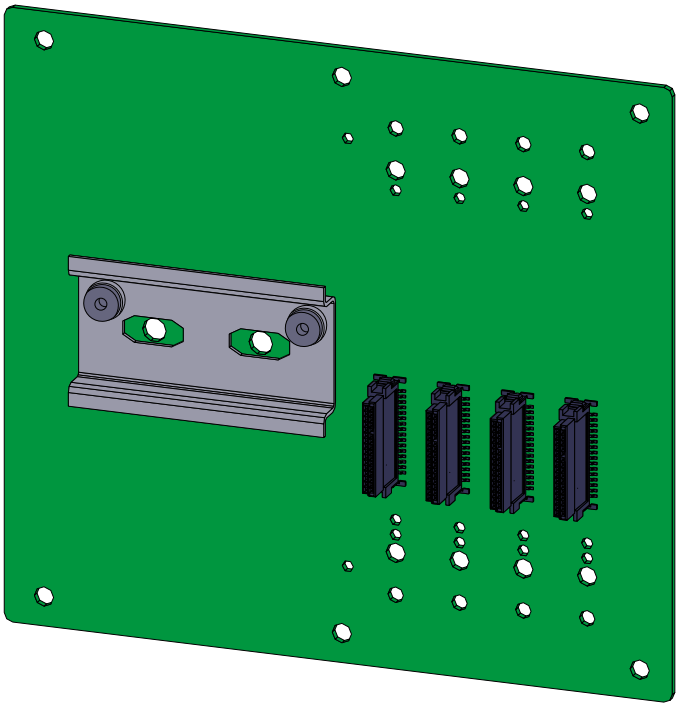

Figure 1-26 Mounted DIN rail on the printed circuit board.

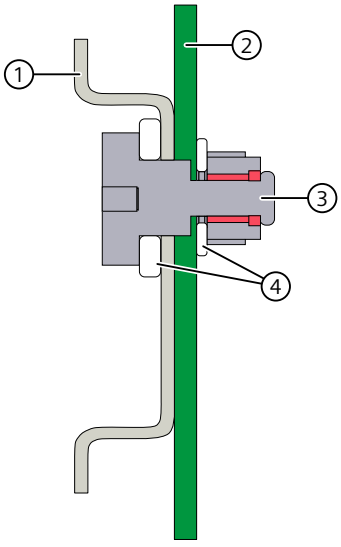

① DIN rail
② Printed circuit board
③ Screw adapter
④ Washer (not included in the scope of delivery)

Figure 1-27 Example of a mounted DIN rail on a thin printed circuit board with washes

2. Insert the I/O adapter in the first BaseCarrier.

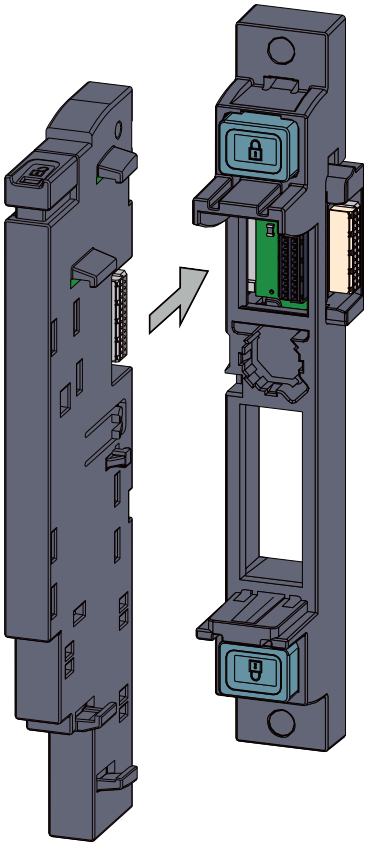

Figure 1-28 Inserting I/O adapter in the BaseCarrier

3. Position the first BaseCarrier using the centering pins and press the “Push-Lock” elements down. Ensure that both elements engage audibly.

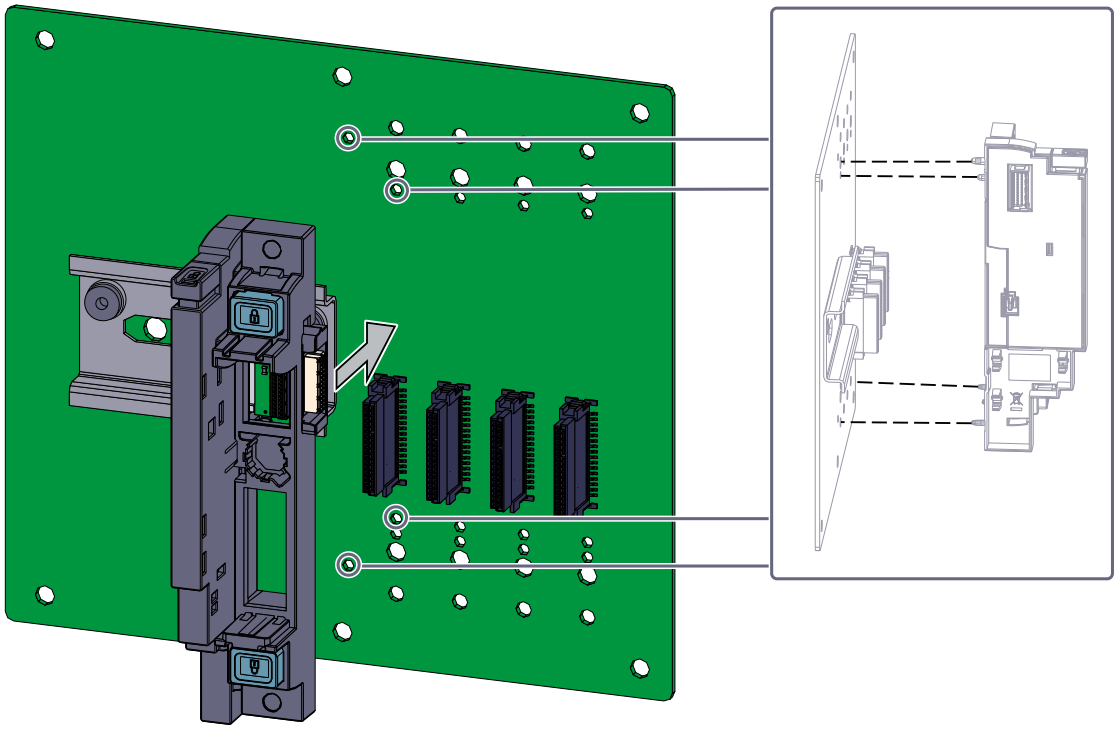

Figure 1-29 Holes on the printed circuit board

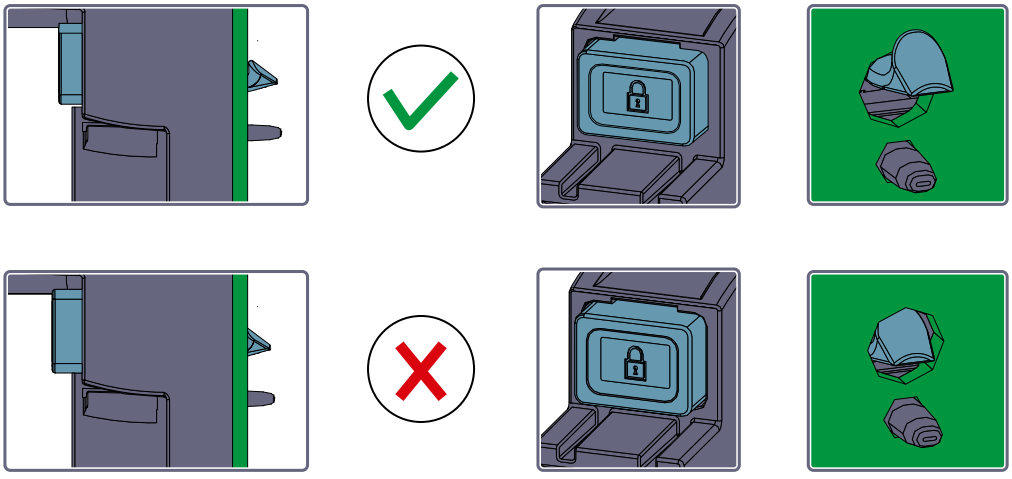

Figure 1-30 Visual control of the hooks

4. Connect the SP bus by sliding the bus housing with the bus PCB to the left in position A.

5. Insert the other BaseCarriers on the printed circuit board.

   Complete the setup with a BaseCarrier for the server module.

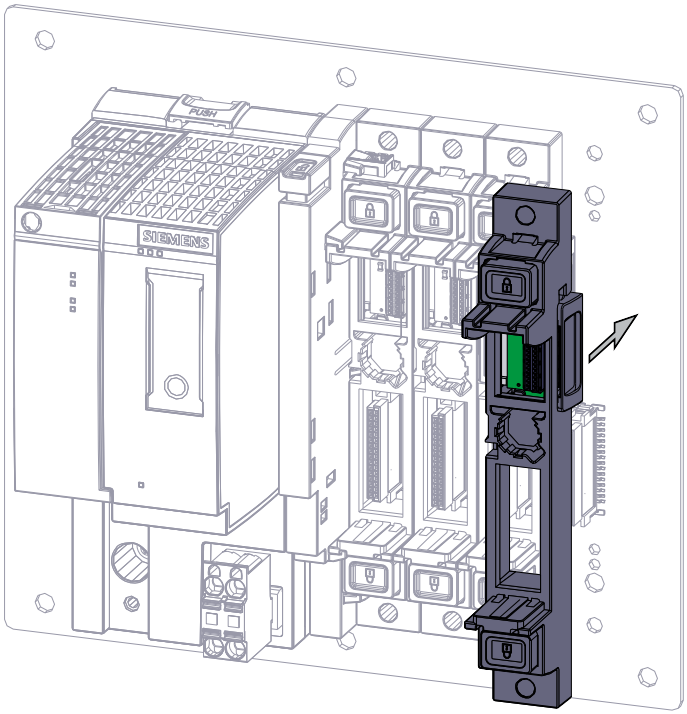

Figure 1-31 Mounting the last BaseCarrier

NOTE

Different position of the centering pins and corresponding holes

To ensure that you insert the right BaseCarrier type in the correct position, the centering pins and the corresponding holes on the printed circuit board for the BaseCarrier types are encoded differently.

6. To install the interface module, hang the interface module into the DIN rail ① and swing the interface module backwards ② until the DIN rail lock clicks into place. Slide the interface module to the right until it clicks into place on the I/O adapter ③.

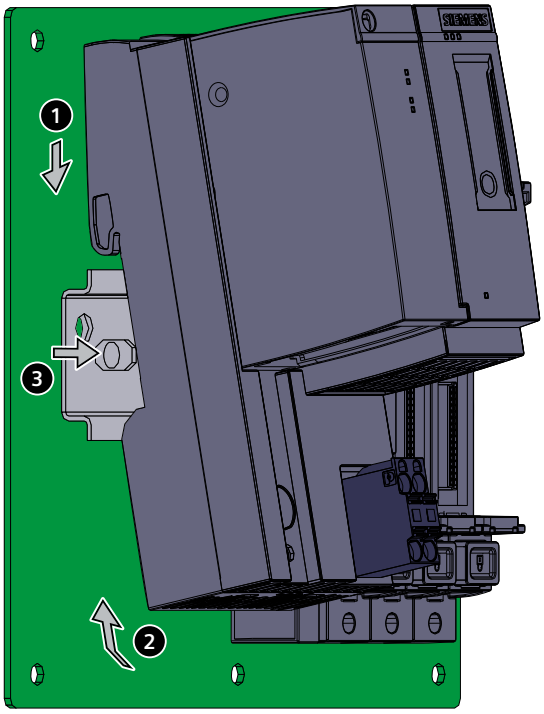

Figure 1-32 Installing the interface module

7. Place the end clamp on the DIN rail in front of the interface module and fix the end clamp by tightening the screw.

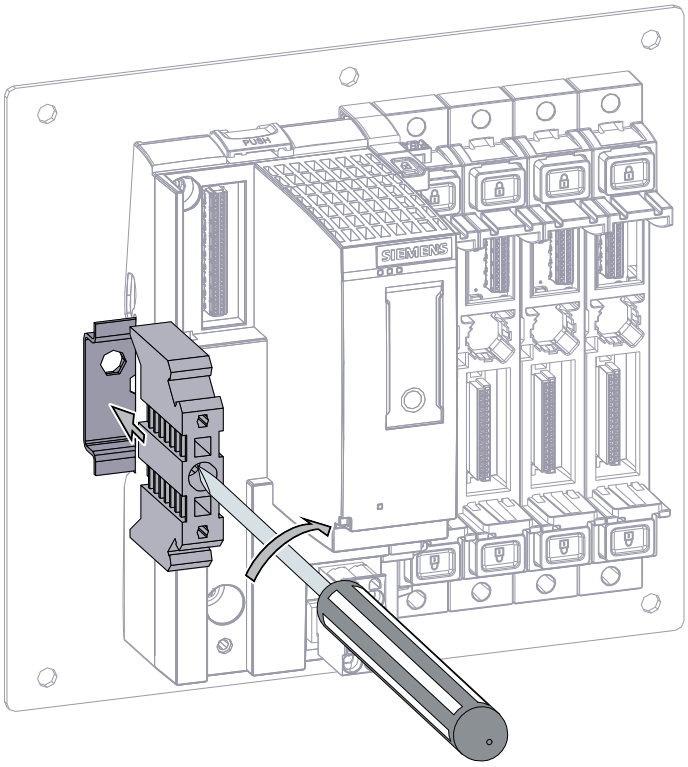

Figure 1-33 Attaching the end clamp

8. Insert the ET 200SP I/O modules and the server module into the BaseCarrier.

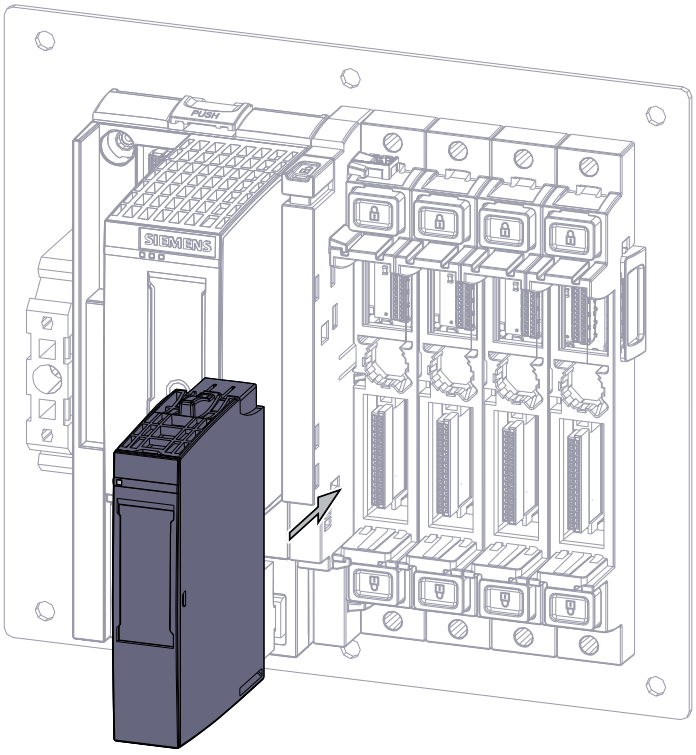

Figure 1-34 Setting up I/O modules

9. Put the SIMATIC bus adapter onto the interface module.

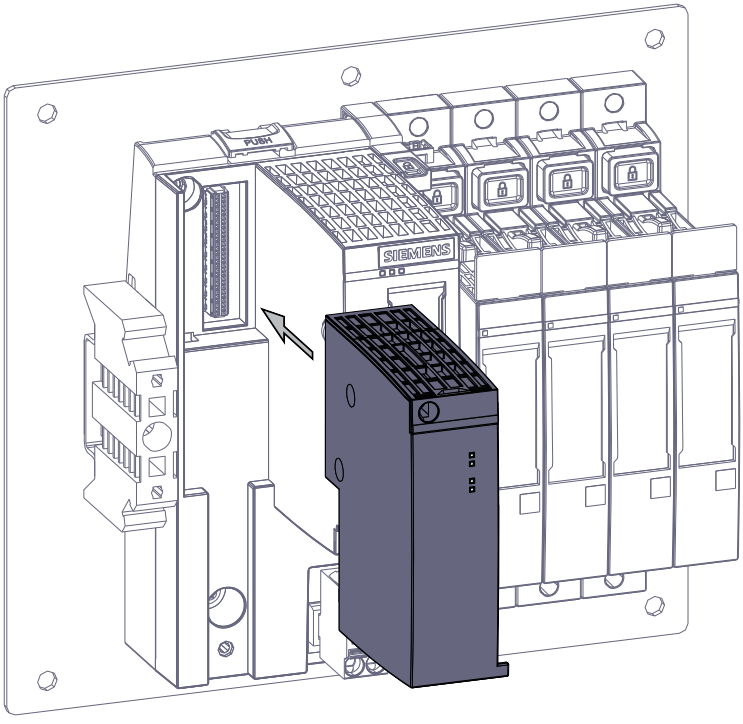

Figure 1-35 Inserting SIMATIC bus adapter to the interface module

7.8.2 Dismantling BaseCarrier

Dismantling ET 200SP system

To dismantle the system, proceed as follows:

1. Remove the BusAdapter and the I/O modules.
2. Loosen the screw of the end clamp and remove the end clamp.
3. To decouple the interface module from the I/O adapter, press the "Push lock" element on the I/O adapter and slide the interface module to the left.

Dismantling BaseCarrier

To dismantle the BaseCarrier, proceed as follows from right to left:

1. To detach the SP bus, slide the bus housing to the right in position B.

   Use a slotted screw as in the following image.

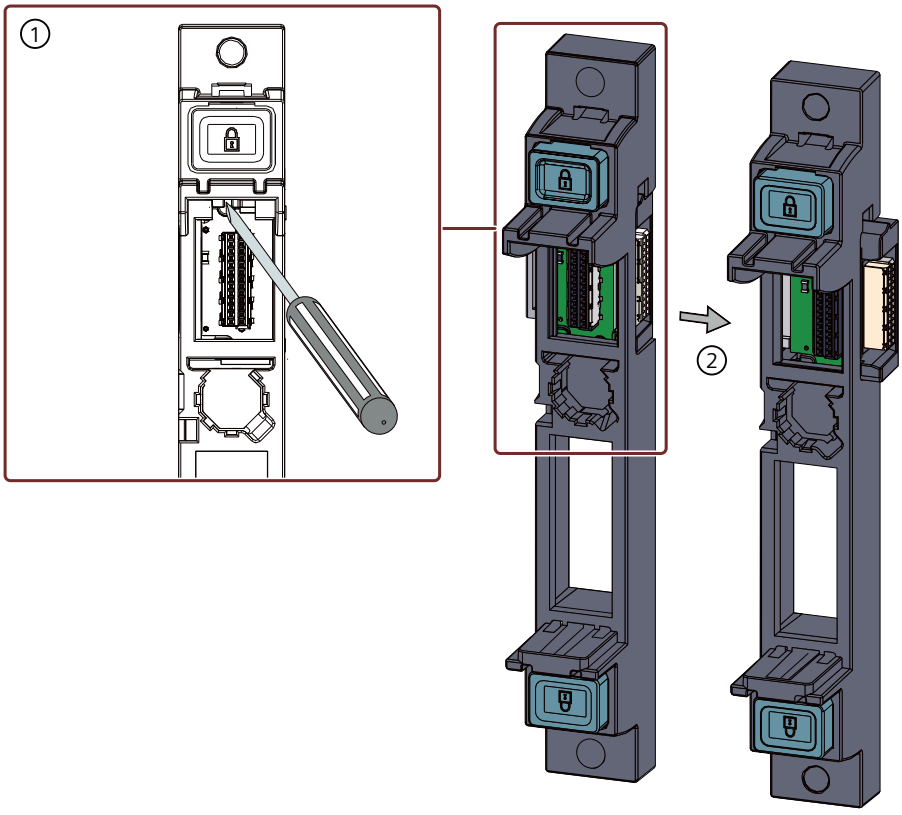

① Detailed view bus housing with attachment point for the screwdriver

② Bus housing from position A to position B

Figure 1-36 Detaching the bus PCB

2. To detach the BaseCarrier from the printed circuit board, press the slotted screw into the recesses on the "Push lock" elements.

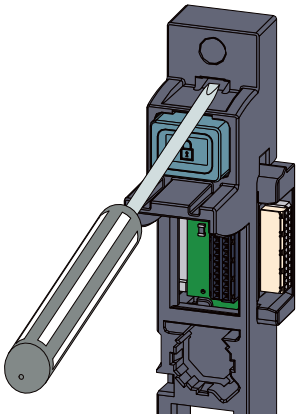

Figure 1-37 Detaching the BaseCarrier from the printed circuit board

The hooks come loose and you can pull the BaseCarrier off the printed circuit board.

3. To detach the I/O adapter from the BaseCarrier, press the slotted screw into the recesses on the I/O adapter ① and pull the I/O adapter from the BaseCarrier. Ensure that the bus housing is in position B.

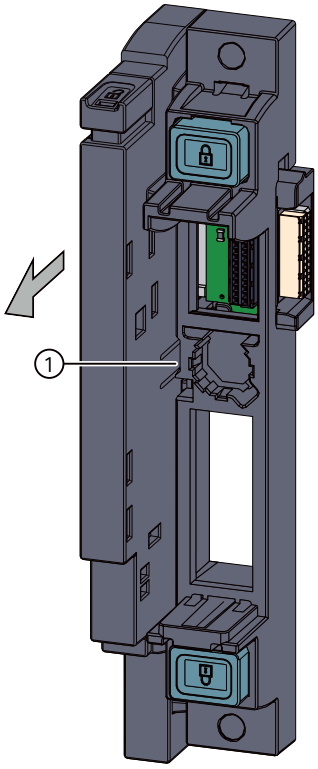

Figure 1-38 Detaching the I/O adapter from the BaseCarrier

7.9 Installing potential distributor modules

Introduction

You use the potential distributor module to distribute a variety of potentials (P1, P2).

Requirements

The mounting rail is installed.

Installing and uninstalling PotDis-BaseUnit

You install/uninstall PotDis-BaseUnits as you would the BaseUnits for I/O modules. You can find additional information in section Mounting BaseUnits for I/O modules (Page 130).

Installing and uninstalling PotDis-TerminalBlock

Installing

Plug the PotDis-TerminalBlock in die PotDis-BaseUnit. Proceed exactly as described in Section Inserting I/O modules / motor starters and BU covers (Page 184).

Uninstalling

To remove a PotDis-TerminalBlock, follow these steps:

1. Switch off all supply voltages on the ET 200SP distributed I/O system.
2. Simultaneously press the top and bottom release buttons of the PotDis-TerminalBlock.
3. Remove the PotDis-TerminalBlock from the front of the PotDis-BaseUnit.

7.10 Installing the server module

Introduction

The server module on the far right of the assembly/line completes the ET 200SP distributed I/O system.

Requirement

The last BaseUnit is mounted.

Installing the server module

Watch "Install configuration" video sequence
(https://support.automation.siemens.com/WW/view/en/95886218)

Proceed as follows to install a server module:

1. Hook the server module onto the mounting rail to the right of the last BaseUnit.
2. Swivel the server module backwards on the mounting rail.
3. Move the server module parallel to the left until you hear it latch onto the last BaseUnit that precedes it.

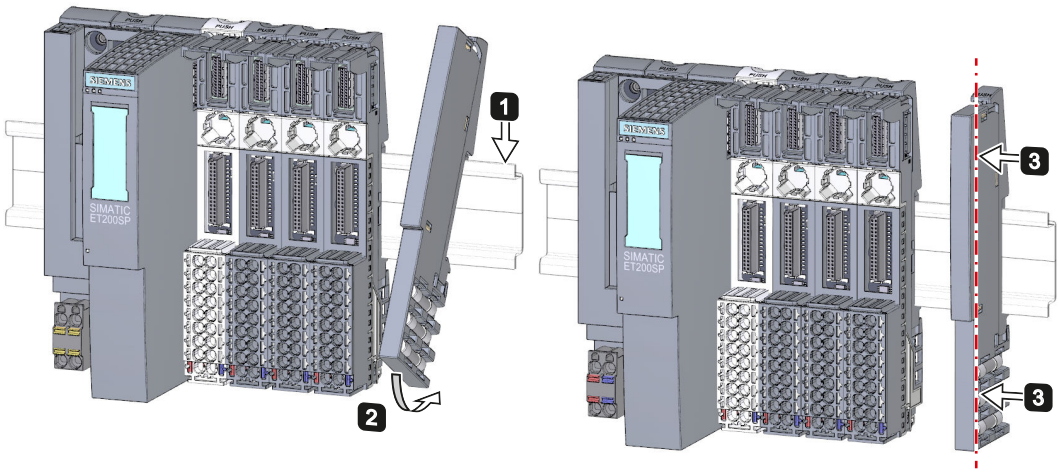

Figure 1-39 Installing the server module

Removing the server module

Proceed as follows to remove a server module:

1. Press the mounting rail release button on the server module.
2. Move the server module parallel to the right.
3. While pressing the mounting rail release button, swivel the server module off the mounting rail.

7.11 Mounting further accessories for motor starters

7.11.1 Mounting the cover for the 500 V AC infeed bus

Introduction

The 500 V infeed bus connects all SIMATIC ET 200SP motor starters. For finger-safe termination of the infeed bus, you must use the cover.

DANGER

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Hazardous electrical voltage causes electric shock, burns and property damage.

Disconnect your system and devices from the power supply before starting any assembly tasks.

DANGER

Infeed bus - electric shock

You must provide the infeed bus with a touch protection cover on the right (Article No.: 3RK1308-1DA00-2BP0).

Failure to do so will result in the danger of electric shock.

WARNING

Personal injury may occur

On the last plugged-in BaseUnit of a motor starter, place a cover on the opening of the contacts of the infeed bus.

Procedure

Proceed as follows to mount the infeed bus cover on a SIMATIC ET 200SP motor starter:

1. Press the cover onto the opening of the BaseUnit on the right until it audibly engages.

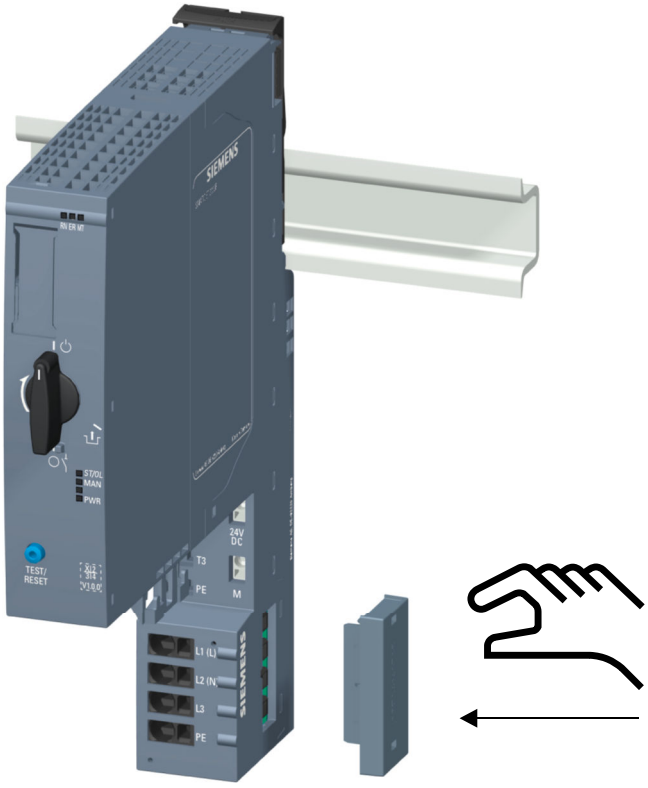

The cover can be removed again using 2 fingers and without tools.

7.11.2 Mounting the mechanical bracket for the BaseUnit

Introduction

To achieve higher stability, you can use a mechanical bracket on 7.5 mm and 15 mm mounting rails.

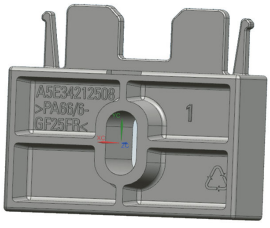

You must use the mechanical bracket in the following situations:

- When using a 15 mm mounting rail
- With a vertical mounting position
- For applications according to shipbuilding standards in all mounting positions with 7.5 mm and 15 mm mounting rails

You can find further information on the mechanical bracket in chapter "Installation conditions for motor starters (Page 124)".

Procedure

To mount the mechanical bracket, proceed as follows:

1. Insert the mechanical bracket into the opening at the bottom of the BaseUnit.

   You use the same mechanical bracket for both mounting rails, rotated through 180° respectively.

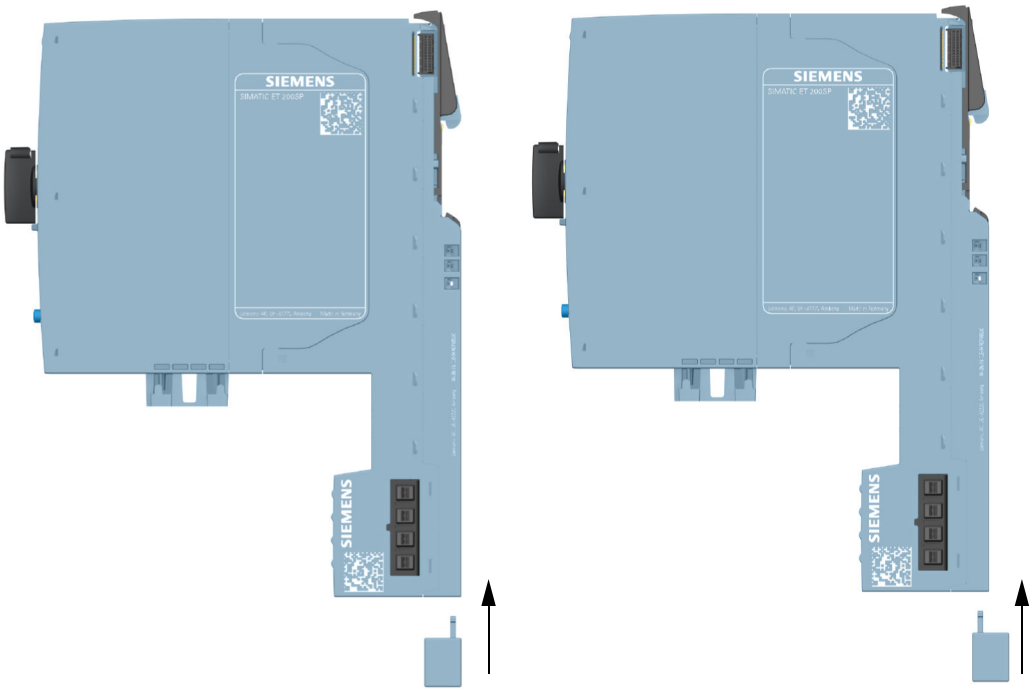

2. Hook the BaseUnit into the mounting rail.
3. Insert the mechanical bracket into the BaseUnit.
4. Screw the mechanical bracket securely onto the mounting panel. Use an M4 screw and a suitable washer.

The figures below show the mechanical bracket after installation on a 7.5 mm or 15 mm mounting rail.

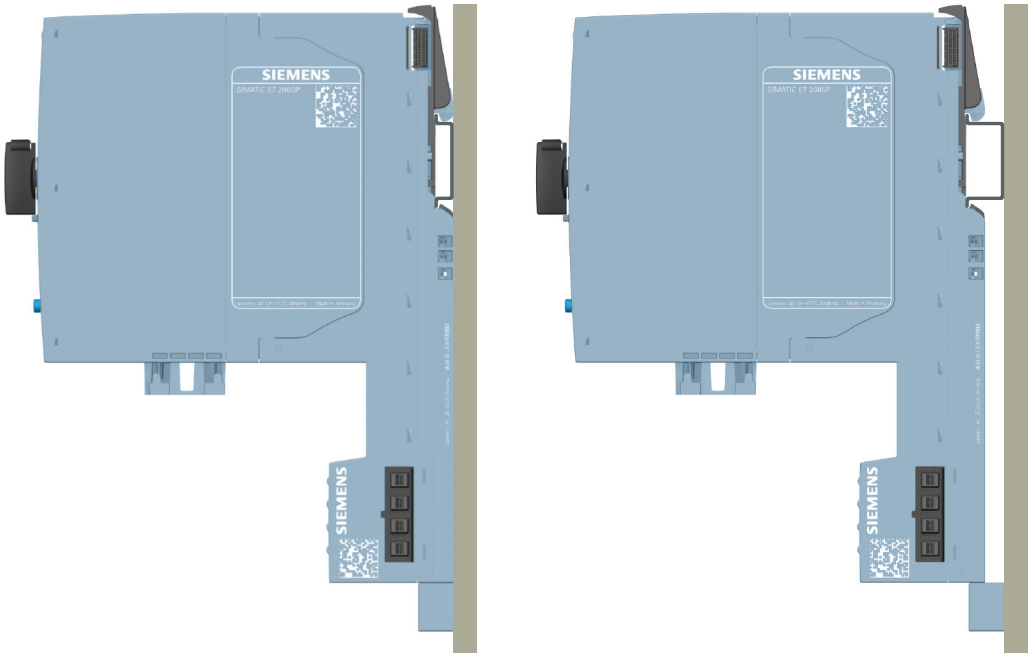

7.11.3 Mounting the BU cover

Introduction

BU covers are plugged onto BaseUnits whose slots have been reserved for future expansion (as empty slots). The BU covers for motor starters serve as touch protection covers for unoccupied slots.

⚠ DANGER

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Hazardous electrical voltage causes electric shock, burns and property damage.

Disconnect your system and devices from the power supply before starting any assembly tasks.

⚠ DANGER

BaseUnit without motor starter - electric shock

If you install a BaseUnit without motor starter in the ET 200SP system (e.g. options handling), you must provide the BaseUnit with a BU cover (Article No: 3RK1908-1CA00-0BP0).

Failure to do so will result in the danger of electric shock.

Procedure

To mount the BU cover onto a SIMATIC ET 200SP motor starter, insert the BU cover in the BaseUnit in parallel until both interlocks audibly engage.

Wiring 8

8.1 Rules and regulations for operation

Introduction

When installing the ET 200SP distributed I/O system as part of a plant or system, special rules and regulations need to be adhered to depending on the area of application.

This section provides an overview of the most important rules that must be observed for the integration of the ET 200SP distributed I/O system in a plant or system.

Specific application

Adhere to the safety and accident prevention regulations applying to specific applications, for example machine protection guidelines.

EMERGENCY STOP devices

EMERGENCY STOP devices in accordance with IEC 60204 (corresponds to DIN VDE 0113) must remain effective in all operating modes of the plant or system.

External fuses/switches

Install the external fuses/switches in the proximity of the ET 200SP distributed I/O system.

Excluding hazardous plant states

Hazardous operating states must not occur when

- the plant restarts after a voltage dip or power failure.
- Bus communication is reestablished following a fault.

If necessary, EMERGENCY STOP must be forced!

An uncontrolled or undefined startup must not occur after the EMERGENCY STOP is unlocked.

Line voltage

Below, everything you need to consider in terms of line voltage is described (refer to section Insulation, protection class, degree of protection and rated voltage (Page 376)):

- For fixed plants or systems without an all-pole mains disconnection switch, a mains disconnection device (all-pole) must be available in the building installation.
- For load power supplies, the configured rated voltage range must correspond to the local line voltage.
- For all power circuits of the ET 200SP distributed I/O system, the fluctuation/deviation of the line voltage from the rated value must be within the permitted tolerance.

24 V DC supply

Below you will find a description of what you need to pay attention to with 24 V DC supply:

- In the event of danger through overload, you must provide lightning protection measures:
  - For external lightning protection
  - For internal lightning protection: Only if greater values (phase - ground) or (phase - phase) are required for the power surge than those specified in the section Electromagnetic compatibility (Page 376).
- For 24 V DC supply: Ensure protection by electrical separation and separate cable routing or increased insulation of circuits with dangerous potentials from extra low voltage (SELV/PELV) in accordance with IEC 61131-2 / IEC 61010-2-201.

Requirements for power supplies in the event of voltage interruption

NOTE

To ensure adherence to IEC 61131-2, only use power packs/power supply units (e.g. 230/400 V AC → 24 V DC) with a mains buffering time of at least 10 ms. Observe the relevant requirements in your application (e.g. product standard for "burners" 30 ms according to EN 298 or 20 ms according to NAMUR recommendation NE 21) with respect to possible voltage interruptions. The latest up-to-date information on PS components is available on the Internet (https://mall.industry.siemens.com).

Of course, these requirements also apply to power packs/power supply units not constructed using ET 200SP or S7-1500/S7-300-/S7-400 design.

Protection against outside electrical influences

Below is a description of what you must pay attention to in terms of protection against electrical impacts and/or faults:

- Make sure that the system for discharging electromagnetic interference is connected to a functional earth or to protective conductor with a sufficient cross-section for all plants with an ET 200SP distributed I/O system.
- For supply, signal and bus lines, you must ensure that the laying of the lines and the installation is correct.
- For signal and bus lines, you must ensure that a wire/cable break or a cross-circuit does not lead to undefined states of the plant or system.

Reference

You can find more information in the Designing interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566) function manual.

8.2 Additional rules and regulations for the operation of the ET 200SP with fail-safe modules

8.2.1 Safety extra-low voltage (SELV, PELV) for failsafe modules and failsafe motor starters

WARNING

The failsafe modules must be operated with safety extra-low voltage (SELV, PELV).

You can find more information on safety extra-low voltage (SELV, PELV) in the data sheets of the applicable power supplies, for example.

The fail-safe modules operate with the 24 V DC rated voltage. The tolerance range is 19.2 V DC to 28.8 V DC.

The fail-safe motor starters operate with the 24 V DC rated voltage. The tolerance range is 20.4 V DC to 28.8 V DC.

Within the overvoltage range from 32 V DC to 36 V DC, the F-modules react in a fail-safe manner and the inputs and outputs are passivated. For overvoltages greater than 36 V DC, the F-modules are permanently de-energized.

Use a power supply unit that does not exceed U_m = 36 V DC even in the event of a fault. For more on this, refer to the information in the data sheet on overvoltage protection in the case of an internal error. Or implement appropriate measures to limit the voltage, e.g. use of an overvoltage protector.

All system components that can supply electrical energy in any form whatsoever must fulfill this condition.

Each additional circuit (24 V DC) used in the system must have a safety extra-low voltage (SELV, PELV). Refer to the relevant data sheets or contact the manufacturer.

Sensors and actuators with an external power supply can also be connected to F-modules. Make sure that power is supplied to these components from safety extra-low voltage (SELV, PELV) as well. The process signal of a 24 V DC digital module may not exceed a fault voltage U_m in the event of a fault.

WARNING

Even when a fault occurs, the permissible potential difference between the supply of the interface module (bus voltage) and the load voltage must not be exceeded.

An external direct electrical connection is one way to meet this requirement. This also prevents potential differences from causing voltage additions at the individual voltage sources, which would cause the fault voltage U_m to be exceeded.

8.2.2 Requirements for sensors and actuators for fail-safe modules and fail-safe motor starters

General requirements for sensors and actuators

Note the following important warning regarding safety-related use of sensors and actuators:

WARNING

Note that instrumentation with sensors and actuators bears a considerable **safety responsibility**. Also bear in mind that sensors and actuators generally do not have proof-test intervals of 20 years as defined in IEC 61508:2010 without considerable loss of safety.

The probability of hazardous faults and the rate of hazardous faults of safety functions must comply with an SIL-defined high limit. A listing of values achieved by F-modules in the technical specifications of the F-modules is available under "Fail-safe performance characteristics".

To achieve the required safety class, suitably qualified sensors and actuators are necessary.

Additional sensor requirements

General rule: To achieve SIL3/Cat. 3/PLe, it is sufficient that a sensor has a single-channel connection. However, to achieve SIL3/Cat. 3/PLe with a single-channel connected sensor, the sensor itself must be SIL3/Cat. 3/PLe-capable. Otherwise, this safety level can only be achieved through two-channel connection of sensors.

To achieve SIL3/Cat. 4/PLe, sensors must be connected by two channels.

WARNING

In the case of fail-safe input modules, the value "0" is output to the F-CPU after detection of faults. You therefore need to make sure that the sensors are implemented in such a way as to ensure the reliable reaction of the safety program when the sensor is in the "0" state.

Example: In its safety program, an EMERGENCY-STOP sensor must achieve the shutdown of the relevant actuator when it is in the "0" state (EMERGENCY-STOP button pressed).

Additional requirements for sensors for fail-safe motor starters

Only single-channel sensors that fulfill the required safety category themselves may be connected to the fail-safe motor starter's F-DI. Fail-safe laying must be observed in accordance with the required safety category.

WARNING

Safety-related shutdown using the F-DI

Depending on the I/O used, the shutdown takes place via one or two output channels (terminals):

- PM-switching: The shutdown takes place via two output channels.
- PP-switching: The shutdown takes place via one output channel.

Shutdown via only one output channel (PP-switching) achieves SIL 3 according to ISO 62061 and PLe/Cat.4 according to EN ISO 13849-1, if it is ensured that the cabling is installed in a cross-circuit-proof/P-short-circuit-proof manner.

Duration requirements for sensor signals

WARNING

Observe the following requirements for sensor signals:

- To ensure the correct detection of the sensor signals via fail-safe modules with inputs, you need to make sure that the sensor signals are output for a minimum duration.
- For pulses to be detected with certainty, the time between two signal changes (pulse duration) must be greater than the PROFIsafe monitoring time.

Reliable detection by F-modules with inputs

The minimum duration of sensor signals for F-modules with inputs depends on the configured input delay, the parameters of the short circuit test of the sensor supplies, and the configured discrepancy behavior for 1oo2 evaluation. The signal must be greater than the maximum response time of the configured application. Information on calculating the maximum response time can be found in the section "Response times" of the relevant F-module.

The maximum permitted switching frequency of the sensor signals results from the minimum duration.

Additional requirements for actuators

The fail-safe output modules test the outputs at regular intervals. The F-module briefly switches off the activated outputs and, if necessary, switches on the deactivated outputs. You can assign the maximum duration of the test pulses (dark and light period) with parameters.

Fast reacting actuators may briefly drop out or be activated during the test. If your process does not tolerate this, set the pulse duration of the light or dark test correspondingly or use actuators that have sufficient lag.

WARNING

If the actuators switch voltages greater than 24 V DC (e.g. 230 V AC), the outputs of a fail-safe output module and the parts carrying a higher voltage must be electrically isolated (in accordance with IEC 60664-1).

This is generally the case for relays and contactors. Particular attention must be paid to this with semiconductor switching devices.

Technical specifications of sensors and actuators

Refer to the manuals of the fail-safe modules for technical specifications to assist you in selecting sensors and actuators.

8.2.3 Crosstalk of digital input/output signals

When fail-safe digital output and input signals are in a single cable, F-DQ modules and F-PM-E modules may experience readback errors.

Cause: capacitive crosstalk

During the bit pattern test of the outputs or the sensor supply of the inputs, the steep switching edge of the output drivers caused by the coupling capacitance of the line may result in crosstalk to other non-activated output or input channels. This may then lead to a response of the readback circuit in these channels. A cross circuit/short-circuit is detected, which leads to safety-related tripping.

Remedy:

- Separate cables for F-DI modules, F-DQ modules, and F-PM-E modules or non-fail-safe DQ modules
- Separate cables for F-DQ channel and F-DI channels for the F-PM-E module
- Coupling relay or diodes in the outputs
- Disable the sensor supply test if safety class requirements allow it.

Cause: magnetic crosstalk

Note that an inductive load connected to the F-DQ channels can induce coupling of a strong magnetic field.

Remedy:

- Separate the inductive loads spatially or shield against the magnetic field.
- Configure the readback time to 50 ms or higher.

8.3 Additional rules and regulations for operation of an Ex module group

Ex module group

You can find the rules and regulations for operation of an Ex module group in the System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/de/view/109795533/en)

8.4 Additional rules and instructions for operation with motor starters

8.4.1 Protection against short circuit

The motor starter complies with type of coordination 1. Secure the feeder cable for the infeed bus according to current, country-specific rules for conductor protection.

WARNING

Hazardous Voltage at the Motor
Can Cause Death, Serious Injury, or Property Damage.

Following a short-circuit, the SIMATIC ET 200SP motor starter is defective. Replace the motor starter following a short-circuit.

8.5 Operating the ET 200SP on grounded incoming supply

Introduction

Below you will find information on the overall configuration of an ET 200SP distributed I/O system on a grounded incoming supply (e.g. TN-S network). The specific subjects discussed are:

- Disconnecting devices and short-circuit and overload protection according to IEC 60364 (corresponds to DIN VDE 0100) and IEC 60204 (corresponds to DIN VDE 0113)
- Load power supplies and load circuits.

Grounded incoming supply

In the case of grounded incoming supplies (TN-S system) the neutral conductor (N) and the protective conductor (PE) are each grounded. Both conductors form a part of the overvoltage concept. When a plant is in operation, the current flows across the neutral conductor. When a fault occurs, for example, a single ground fault between a live conductor and ground, the current flows through the protective conductor.

Safe electrical separation (SELV in accordance with IEC 61131-2 or IEC 61010-2-201)

Load power supplies/power supply modules with 24 V DC output voltage require safe electrical separation and voltage limiting (extra low voltage). Load power supplies/power supply modules with 24 V DC output voltage are not connected to the protective conductor. According to IEC 61131-2 and IEC 61010-2-201, this protection is referred to as SELV (Safety Extra Low Voltage).

The wiring of SELV circuits must be safely separated from the wiring of other circuits that are not SELV, or the insulation of all conductors must be dimensioned for the higher voltage.

Grounded extra-low voltage (PELV in accordance with IEC 61131-2 or IEC 61010-2-201)

Load power supplies/power supply modules with grounded 24 V DC output voltage require safe connection to the protective conductor and voltage limiting (extra low voltage).

According to IEC 61131-2 and IEC 61010-2-201, this protection is referred to as PELV (Protective Extra Low Voltage).

The wiring of PELV circuits must be safely separated from the wiring of other circuits that are not PELV, or the insulation of all conductors must be dimensioned for the higher voltage.

Configuration of ET 200SP with ungrounded reference potential

To conduct interference currents, the reference potential of the CPU/interface module and the BaseUnits BU15...D is connected internally via an RC combination (IM/CPU: R = 10 MΩ / C = 100 nF, BU15...D: R = 10 MΩ / C = 4 nF) with the mounting rail (functional grounding).

- This configuration conducts high-frequency interference currents and prevents static charges.
- It is always possible to configure an ungrounded setup of the ET 200SP distributed I/O system as the ET 200SP distributed I/O system has no fixed ground connection. The power pack/power supply module for 24 V DC must also be ungrounded and electrically isolated.

If you want to configure the ET 200SP distributed I/O system with grounded reference potential, connect the 1M connection of the CPU/interface module electrically with the protective conductor.

Short-circuit / overload protection

Various measures as protection against short-circuits and overloads are required for setting up a full installation. The type of components and the binding protective measures depend on which IEC (DIN VDE) regulation applies to your system configuration. The table refers to the figure below and compares the IEC (DIN VDE) regulations.

Table 1-11 Components and protective measures

	Refer to figure	IEC 60364 (DIN VDE 0100)	IEC 60204 (DIN VDE 0113)
Disconnecting device for controller, sensors, and actuators	①	Main switch	Disconnector
Short-circuit / overload protection: In groups for sensors and actuators	② ③	Single-pole protection of circuits	With grounded secondary circuit: **single-pole** protection otherwise: **all-pole** protection
Load current supply for AC load circuits with more than five items of electromagnetic equipment	②	Galvanic isolation by transformer **recommended**	Galvanic isolation by transformer **recommended**

Cable temperature measurement threshold

NOTE

Cable temperature measurement threshold

When choosing a cable, remember that the cable temperature in operation can be up to 30 °C higher than the ambient temperature of the ET200SP system (example: at an ambient temperature of 60 °C, a connection conductor must be dimensioned for a temperature range of at least 90 °C).

You should specify other connection types and material requirements based on the electrical characteristics of the circuits you use and the installation environment.

ET 200SP in the overall configuration

The figure below shows the overall configuration of the ET 200SP distributed I/O system (load current supply and grounding concept) with supply from a TN-S network.

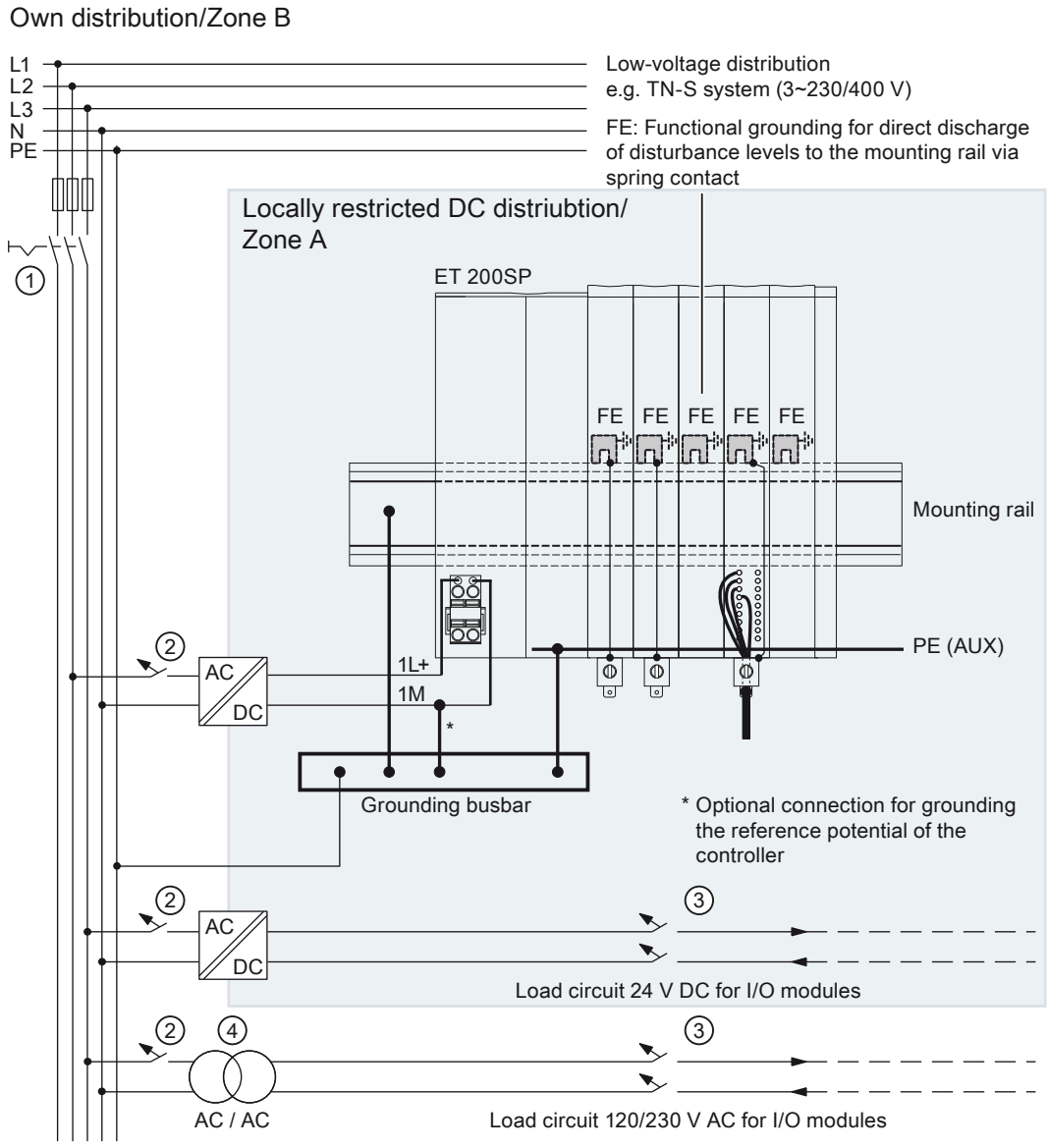

① Main switch

② Short-circuit / overload protection

③ Load current supply

④ Optional for galvanic isolation

Figure 1-40 ET 200SP in the total configuration

NOTE

In general, you need to connect the DC I/O modules of the ET 200SP distributed I/O system to your own distribution (or batteries) via an upstream, local power supply unit.
If you connect the DC I/O modules directly to your own distribution, you need to provide additional protective measures against overvoltages.

8.6 Electrical configuration of the ET 200SP

Electrical isolation

Electrical relationships

With the ET 200SP distributed I/O system, there is electrical isolation between:

- The load circuits/process and all other circuit components of the ET 200SP distributed I/O system.
- The communication interfaces of the CPU (PROFINET) or of the interface module (PROFINET/PROFIBUS) and all other circuit components.

The figures below show the electrical relationships of the ET 200SP distributed I/O system with the CPU and the interface module. Only the most important components are represented in the figures.

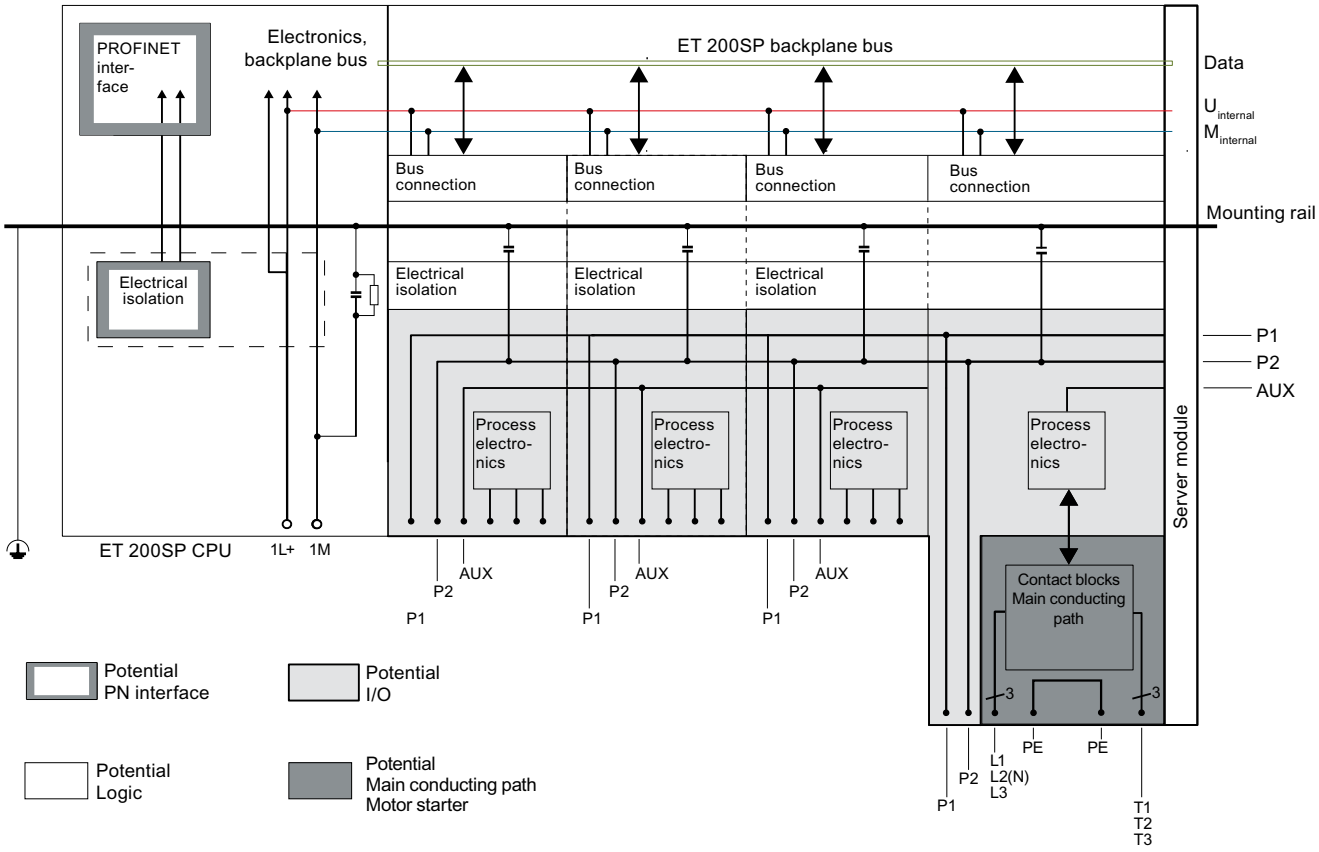

Figure 1-41 Electrical relationships for ET 200SP with CPU

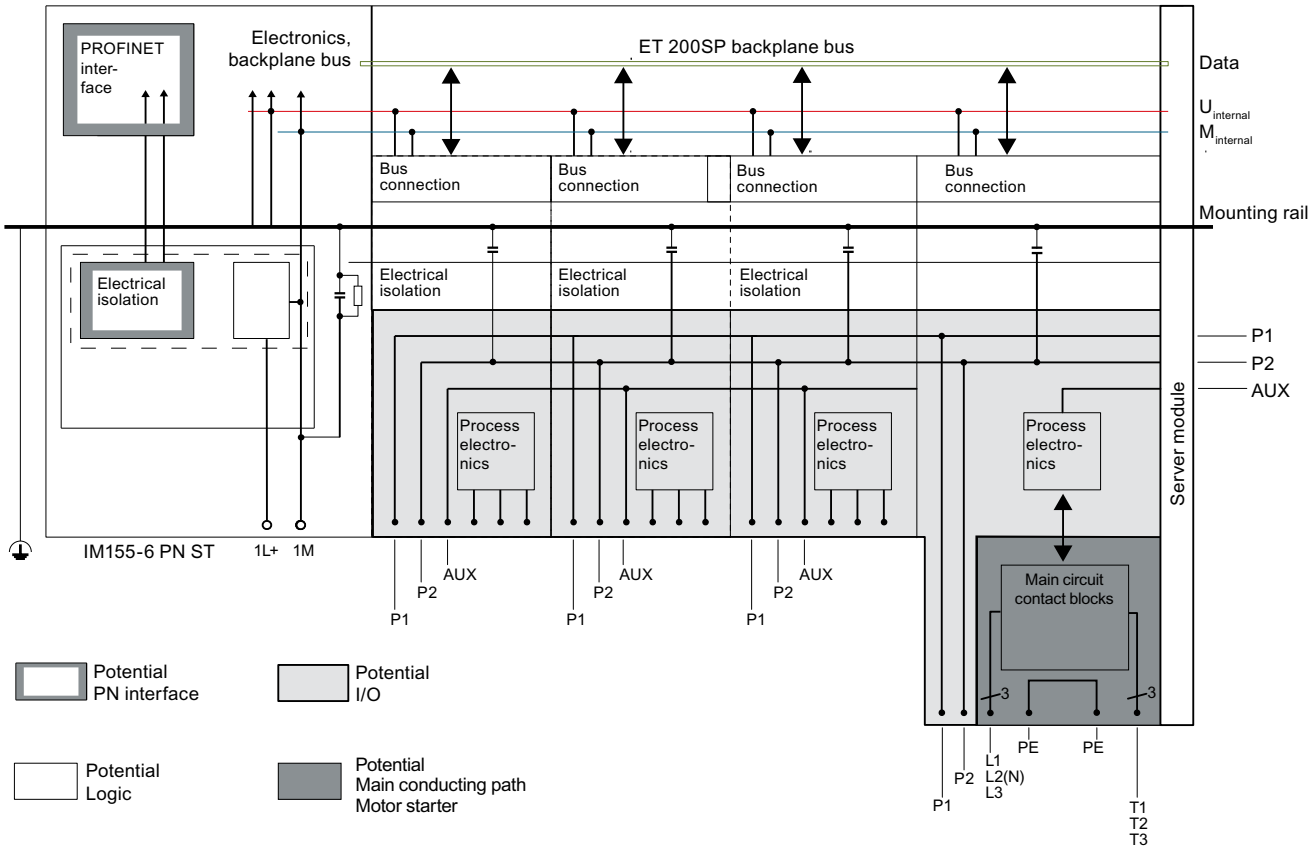

Figure 1-42 Electrical relationships for ET 200SP with interface module (using IM 155-6 PN ST as an example)

8.7 Wiring rules

Introduction

Use suitable cables to connect the ET 200SP distributed I/O system. Also select the cable insulation corresponding to the applied voltage. The tables below set out the wiring rules for CPU/interface module, BaseUnits and motor starter.

⚠ CAUTION

Use copper cables on connectors with terminal connections

Use solely copper cables (Cu) for all signal and supply lines that are connected to the device via terminals, e.g. 24 V DC power supply cable to the 24 V DC power supply connections.

Wiring rules for the CPU/interface module and BaseUnits for I/O modules

Wiring rules for ...		CPU/interface module (supply voltage)	BaseUnits (push-in terminal)
Permitted cable cross-sections of solid cables (Cu)		0.2 to 2.5 mm^2	
		AWG*: 24 to 13	
Connectable cable cross-sections for flexible cables (Cu)	Without wire end ferrule	0.2 to 2.5 mm^2	
		AWG*: 24 to 13	AWG*: 24 to 14
	With end sleeve (with plastic sleeve)***	0.25 to 1.5 mm^2**	0.14 to 1.5 mm^2
		AWG*: 24 to 16	AWG*: 26 to 16
	With TWIN end sleeve***	0.5 to 1 mm^2	0.5 to 0.75 mm^2 (see below)
		AWG*: 20 to 17	AWG*: 20 to 18
Stripping length of the cables		8 to 10 mm	
Wire-end ferrules in accordance with DIN 46228 with plastic sleeve***		8 and 10 mm long	
TWIN end sleeves		12 mm long	

* AWG: American Wire Gauge

** Wire end ferrules without plastic sleeve: 0.25 to 2.5 mm^2/AWG: 24 to 13

*** See note on wire-end ferrules

Note the following for BaseUnits with function version < FS10:

NOTE

Wire-end ferrules

Optimum results with respect to a high-quality and permanent electrical connection with maximum conductor pull forces at the same time can be achieved by using crimping dies, preferably with smooth surfaces, which are provided, for example, with rectangular and trapezoidal crimp cross-sections.

Crimping dies with a pronounced wave profile are unsuitable.

TWIN end sleeves for the cables of the I/O modules' push-in terminals

Due to the space required by TWIN end sleeves with 0.75 mm² cross-section, you must ensure a correct angle for the cable arrangement when crimping the TWIN end sleeve so that the cables are optimally arranged.

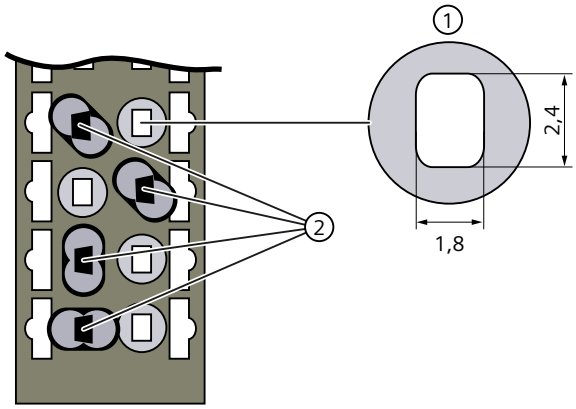

① Cross-section of the terminal compartment

② Crimping TWIN end sleeves at the correct angle

Figure 1-43 TWIN end sleeves

Wiring rules for motor starters

Wiring rules for ...		L1(L), L2(N), L3, PE	T1, T2, T3, PE, 24 V DC, F-DI, M	DI1 ... DI3, LC, M, 24 V OUT
Permitted cable cross-sections of solid cables (Cu)		1 to 6 mm²	0.5 to 2.5 mm²	0.2 to 1.5 mm²
		AWG: 18 to 10	AWG: 20 to 12	AWG: 24 to 16
Connectable cable cross-sections for flexible cables (Cu)	Without wire end ferrule	1 to 6 mm²	0.5 to 2.5 mm²	0.2 to 1.5 mm²
		AWG: 18 to 10	AWG: 20 to 12	AWG: 24 to 16
	With end sleeve	1 to 6 mm²	0.5 to 2.5 mm²	0.25 to 1.5 mm²
		AWG: 18 to 10	AWG: 20 to 12	AWG: 24 to 16
	With end sleeve (with plastic sleeve)	1 to 4 mm²	0.5 to 1.5 mm²	0.25 to 0.75 mm²
		AWG: 18 to 11	AWG: 20 to 16	AWG: 24 to 18
Stripping length of the cables		15 mm	10 mm	8 mm
End sleeves according to DIN 46228 with plastic sleeve		15 mm long	10 mm long	8 mm long

Safety standards for fail-safe motor starters

Fail-safe motor starters fulfill the following standards under certain conditions:

- PLe/Cat.4 according to EN ISO 13849-1
- Safety Integrity Level SIL 3 according to IEC 62061

To fulfill both standards, lay cross-circuit proof and P-cross-circuit proof control cables from the safe output of a sensor or F-DQ to the safe input of the motor starter, e.g. as a separately sheathed cable or in a separate cable duct.

Line protection

The line protection of the SIMATIC ET 200SP motor starter is provided for the motor outgoing feeder cable when the following condition is met:

The cross-section of the motor outgoing feeder cable must be dimensioned for the load ratios of the motor and for the cable-laying method.

Comply with national regulations. The user is responsible for the correct selection and dimensioning of the motor connection cable to DIN VDE 0100 and DIN VDE 0298-4 and/or UL 508.

The conductor protection for the incoming feeders must be ensured by the owner of the installation depending on the cross-section.

Cable temperature measurement threshold

NOTE

Cable temperature measurement threshold

When choosing a cable, remember that the cable temperature in operation can be up to 30 °C higher than the ambient temperature of the ET200SP system (example: At an ambient temperature of 60 °C, a connection conductor must be dimensioned for a temperature range of at least 90 °C).

You should specify other connection types and material requirements based on the electrical characteristics of the circuits you use and the installation environment.

8.8 Wiring BaseUnits for I/O modules

Introduction

The BaseUnits connect the ET 200SP distributed I/O system to the process. The following versions of the BaseUnits can be used:

- BaseUnits (with light-colored terminal box) for opening a potential group: BU..D
- BaseUnits (with dark-colored terminal box) for extending the potential group: BU..B
- BaseUnits with additional AUX terminals or additional terminals: BU..+10..

- BaseUnits with integrated thermal resistor for compensation of the reference junction temperature when connecting thermocouples: BU..T
- PotDis-BaseUnits (with light-colored terminal box) for opening a PotDis potential group: PotDis-BU..D
- PotDis-BaseUnits (with dark-colored terminal box) for extending the potential group: PotDis-BU..B

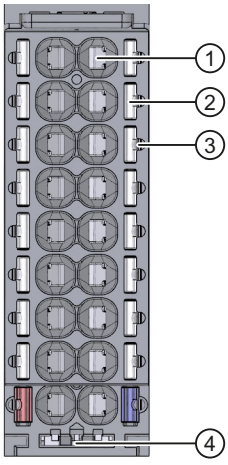

① Push-in terminal

② Spring release

③ Measuring probe (suitable probes: 1 mm diameter, length ≥ 10 mm while observing the permitted voltage category)

④ Holder for shield connection

Figure 1-44 View of the BaseUnit

NOTE

The pin assignment of the BaseUnit depends on the connected I/O module. Information on the BaseUnits and I/O modules can be found in the associated manuals.

Replacement of the terminal box on the BaseUnit is described in the section Replacing the terminal box on the BaseUnit (Page 330).

NOTE

Special terminal designations in the wiring and block diagrams of the I/O modules/BaseUnits

– **RES**: Reserve, these terminals must remain unconnected so that they can be used for future expansions

– **n.c.**: Not connected, these terminals have no function. However, they can be connected to potentials specifically defined for a module, for example, for the laying unused wires.

Requirements

- The supply voltages are turned off.
- Follow the wiring rules.
- Color identification labels (Page 195) (optional) have been applied.

Required tools

3 to 3.5 mm screwdriver

Tool-free connection of cables: single-wire without wire end ferrule, multi-wire (stranded) with wire end ferrule or ultrasonically sealed

Watch the video sequence (https://support.automation.siemens.com/WW/view/en/95886218)

To connect a wire without tools, follow these steps:

1. Strip 8 to 10 mm of the wires.
2. Only in the case of stranded conductors (except for 2.5 mm^2 cross-section):
   Seal or crimp the wire with wire end ferrules.
3. Insert the wire into the push-in terminal as far as it will go.

Connection of cables: multi-wire (stranded), without wire end ferrule, unprocessed

To connect a wire without a wire end ferrule, follow these steps:

1. Strip 8 to 10 mm of the wires.
2. Push with the screwdriver into the spring release.
3. Insert the wire into the push-in terminal as far as it will go.
4. Pull the screwdriver out of the spring release.

Removing wires

Using the screwdriver, press the spring release of the terminal as far as it will go and pull out the wire.

NOTE

When you press the spring release, you should not pull on the wire/cable at the same time. This prevents you from damaging the terminal.

8.9 Connecting cable shields for I/O modules

Introduction

- You need the shield connector to contact cable shields (e.g. for analog modules). The shield connector conducts interference currents on cable shields to ground via the mounting rail. It is not necessary to contact the shield at where the cable enters the cabinet.
- Fasten the shield connector to the BaseUnit.
- The shield connection consists of a shield support, a shield terminal and a supporting element.
- The shield connector is automatically connected to the functional ground (FG) of the mounting rail after installation.

Requirements

- BaseUnit must be one of the following types:
  - A0, A1
  - B0
  - C0, C1
  - F0
  - U0
- The shield terminal is suitable for cables with max. ∅ 7 mm each.

Required tools

- Stripping tool
- Slotted screwdriver with a 3.5 mm blade or Torx T10

Procedure

Watch the "Wiring BaseUnits" video sequence (https://support.automation.siemens.com/WW/view/en/95886218)

To connect the cable shield, follow these steps:

1. If required, connect the supply voltage L+ and ground to the BaseUnit.
2. Push the supporting element with the shield support into the guideway till the supporting element clicks into place.

   If you use a 7.5 mm mounting rail, you must first shorten the supporting element. To do so, unscrew the spacer of the support element.
3. Remove the cable insulation material around the shield terminal.

   Connect the cable to the BaseUnit and place the cable in the shield contact.

4. Insert the shield terminal into the corresponding clamping position of the shield support.
   - Clamping space height 1: 1.9 mm to 15.5 mm
   - Clamping space height 2: 10.9 mm to 23.5 mm
5. Tighten the shield terminal with approximately 0.5 Nm.

   When doing this, ensure that the terminal is completely in contact with the exposed protective braided shield.

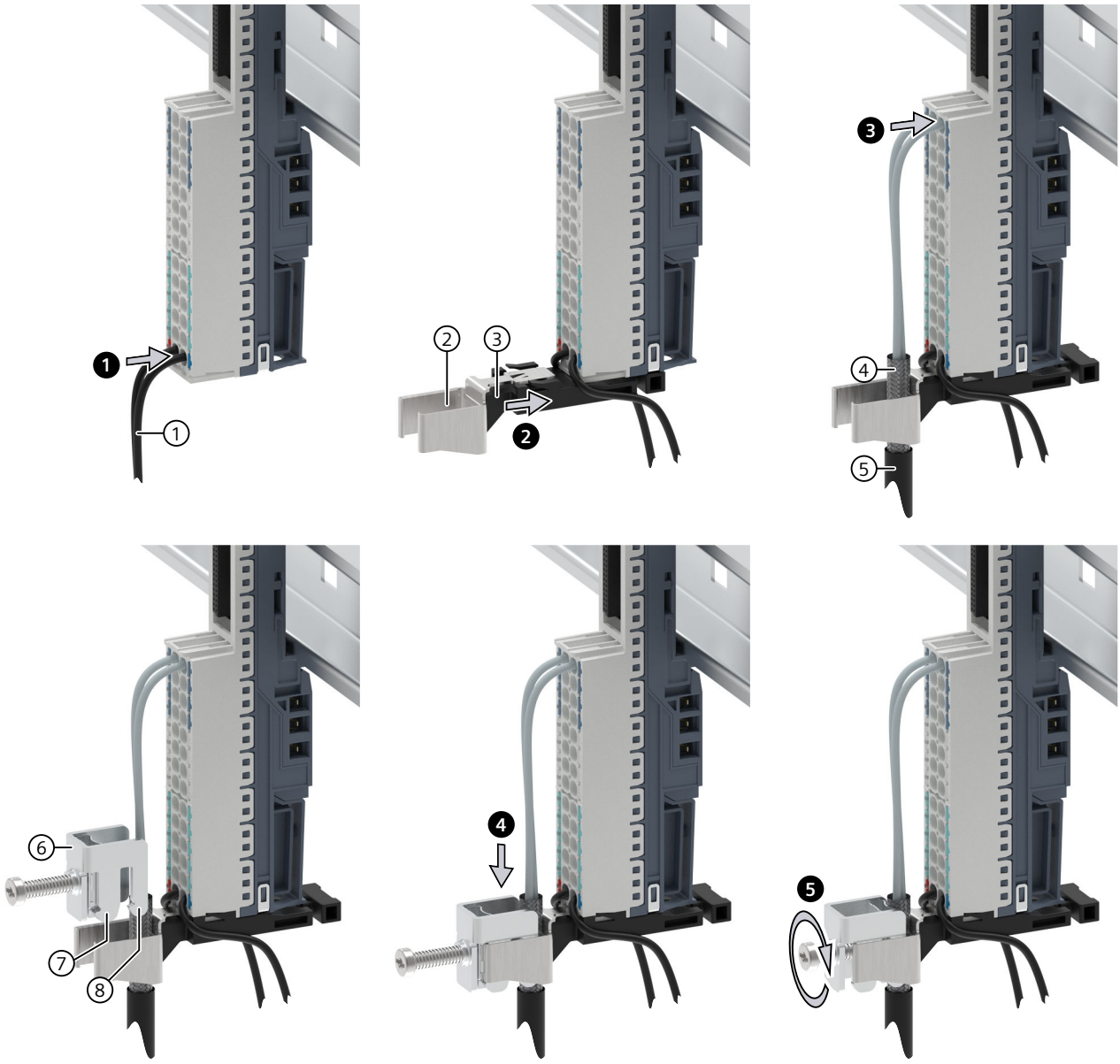

①	Supply voltage L+, M	⑤	Cable to the encoder
②	Shield support	⑥	Shield terminal
③	Supporting element	⑦	Suspension for clamping position 1
④	Insulation material removed (approx. 20 mm)	⑧	Suspension for clamping position 2

Figure 1-45 Mounting the shield contact

NOTE
Shield terminal does not have a null terminal.
Fix the shield terminal only when there is at least one inserted cable.

8.10 Wiring BaseUnits for motor starters

Introduction

The following versions of BaseUnits can be used:

- BU30-MS1 (with 24 V DC and 500 V AC infeed)
- BU30-MS2 (with 500 V AC infeed)
- BU30-MS3 (with 24 V DC infeed)
- BU30-MS4 (without infeed)
- BU30-MS5 (with 500 V AC infeed and single F-DI)
- BU30-MS6 (without infeed and with single F-DI)
- BU30-MS7 (with F-DI and 500 V AC infeed)
- BU30-MS8 (with 500 V AC infeed and F-DI routing)
- BU30-MS9 (with F-DI routing)
- BU30-MS10 (with F-DI infeed)

The following figure shows an example of a BaseUnit BU30-MS1 (with the maximum number of terminals):

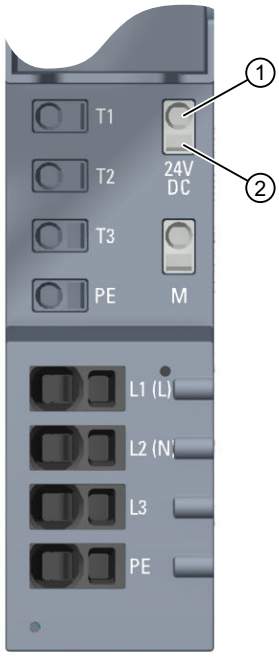

① Push-in terminal

② Spring release

Figure 1-46 Terminals on a BaseUnit BU30-MS1

The following figure shows an example of a BaseUnit BU30-MS5 (with the maximum number of terminals):

① Push-in terminal

② Spring release

Figure 1-47 Terminals on a BaseUnit BU30-MS5

DANGER

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Hazardous electrical voltage can cause electric shock, burns and property damage.

Turn off and lock out all power supplying this device before working on this device.

For wiring finely-stranded or stranded conductors without end sleeves on push-in connections, a screwdriver is required.

Requirements

- The supply voltages are switched off
- Observe the wiring rules

NOTICE

Interconnection of the F-DI input of BaseUnits BU-30-MS5, BU-30-MS6, BU-30-MS7 and BU-30-MS10 with surge filters

If your system requires overvoltage protection, you must interconnect the F-DI input of the BaseUnits BU-30-MS5, BU-30-MS6, BU-30-MS7 and BU-30-MS10 with surge filters.

Please see "Electromagnetic Compatibility" in the technical specifications.

Required tools

Use the screwdriver "SZF 1-0.6x3.5" (for finely-stranded cables only).

Connecting conductors: Solid without end sleeve, stranded (stranded wire) with end sleeve

To connect a cable, proceed as follows:

1. Insulate the cables in accordance with the table in chapter "Electromagnetic compatibility of fail-safe modules (Page 369)".
2. Only in the case of stranded conductors:

   Crimp the cable with end sleeves.
3. Insert the cable into the push-in terminal as far as it will go.
4. Pull on the cable to ensure it is tight.

Connecting conductors: multi-wire (stranded), without end sleeve, unfinished

To connect a cable, proceed as follows:

1. Insulate the cables in accordance with the table in chapter "Wiring rules (Page 166)".
2. Press the screwdriver into the spring release.
3. Insert the conductor into the push-in terminal until it engages.
4. Pull the screwdriver out of the spring release.
5. Check whether or not the conductor is firmly connected by pulling on the cable.

Video sequence

At the following Internet link, you can see a video about connecting conductors: Wire BaseUnits (http://support.automation.siemens.com/WW/view/en/95886218)

Releasing conductors

To release a conductor, proceed as follows:

1. Press the screwdriver into the spring release of the terminal until it engages.
2. Pull the conductor out.

NOTE

When pressing the spring release, you must not pull on the wire/cable at the same time. In this way, you avoid damaging the terminal.

8.11 Connecting the 3DI/LC module for the motor starter

You will find further information on the 3DI/LC module in the ET 200SP motor starter (https://support.industry.siemens.com/cs/ww/en/view/109479973) manual.

Procedure

The figure below shows the connections of the 3DI/LC module.

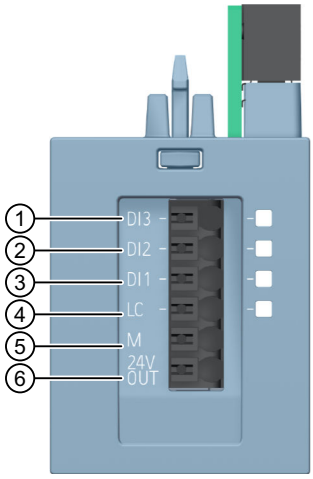

① Digital input 3
② Digital input 2
③ Digital input 1
④ Local control (manual local)
⑤ Ground
⑥ 24 V DC/ 100 mA output

NOTE

The digital inputs (1 to 4) are not isolated. The reference potential is M (5). Control the digital inputs only via a unit supplied from the 24 V DC output (6).

Connect only cables of a width not exceeding 30 m to the 3DI/LC module.

The supply (5 and 6) is protected against short-circuits.

Terminal sketch of the 3DI/LC module

The following diagram shows a terminal sketch of the 3DI/LC module:

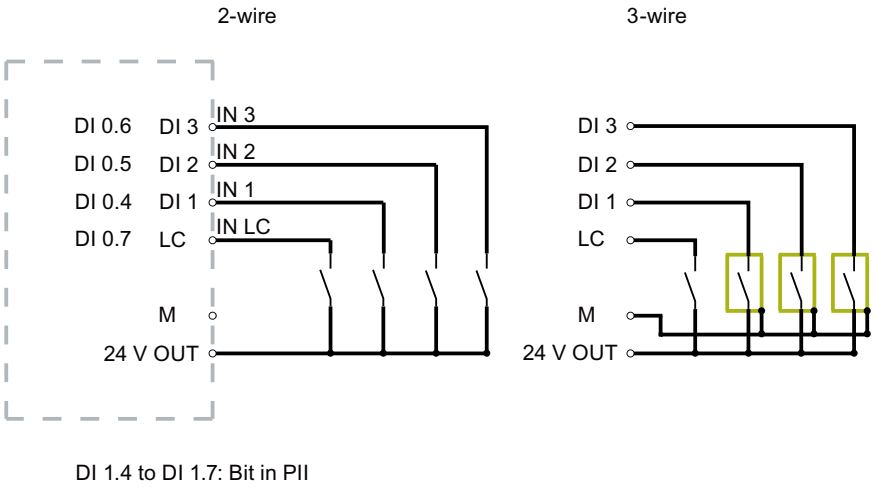

Figure 1-48 Connection example of inputs

8.12 Connecting the supply voltage to the CPU/interface module

Introduction

The supply voltage of the CPU/interface module is supplied by means of a 4-pin connector plug located on the front of the CPU/interface module.

Power supply unit

Only use power supply units of type SELV/PELV with safe electrically isolated functional extra low voltage (≤ 28.8 V DC).

Connection for supply voltage (X80)

The connections of the 4-pole connector have the following meaning:

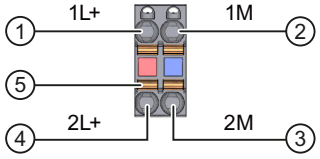

① +24 V DC of the supply voltage (current limited to 10 A)

② Ground of the supply voltage (current limited to 10 A)

③ Ground of the supply voltage for loop-through

④ +24 V DC of the supply voltage for loop-through

⑤ Spring opener (one spring opener per terminal)

1L+ and 2L+ and 1M and 2M are internally jumpered

Figure 1-49 Supply voltage connection

A strain relief is not present. The cable connector offers you the option of looping the supply voltage uninterrupted, even when it is unplugged.

For the maximum wire cross-sections, observe the information in the tables of the wiring rules (Page 166).

Requirements

- Only wire up the connector plug when the supply voltage is turned off.
- Follow the wiring rules (Page 166).

Required tools

3 to 3.5 mm screwdriver

Tool-free connection of cables: single-wire without end sleeve, multi-wire (stranded) with end sleeve or ultrasonically sealed

Watch video sequence: "Connect BusAdapter to the interface module" (https://support.automation.siemens.com/WW/view/en/95886218)

To connect a wire without tools, follow these steps:

1. Strip 8 to 10 mm of the wires.
2. Only in the case of stranded conductors:

   Seal or crimp the wire with end sleeves.
3. Insert the cable into the push-in terminal as far as it will go.
4. Push the wired connector plug into the plug socket of the interface module.

Connection of cables: multi-wire (stranded), without end sleeve, unfinished

To connect a wire without an end sleeve, follow these steps:

1. Strip 8 to 10 mm of the wires.
2. Using a screwdriver, press the spring release and insert the wire into the push-in terminal as far as it will go.
3. Pull the screwdriver out of the spring release.
4. Push the wired connector plug into the socket in the interface module.

Removing a wire

Using the screwdriver, press the spring release as far as it will go and pull out the wire.

8.13 Connecting interfaces for communication

Connect the communication interfaces of the ET 200SP distributed I/O system using the standardized connector or directly. If you want to prepare communication cables yourself, the interface assignment is specified in the manuals of the corresponding modules. Observe the mounting instructions for the connectors.

Detailed information on the available BusAdapters and the procedure for connecting PROFINET IO to the CPU/interface module is available in the BusAdapter (https://support.industry.siemens.com/cs/ww/en/view/109751716) manual.

8.13.1 Connecting PROFINET IO (RJ45 port) to the CPU

Introduction

You use the RJ45 bus connector to connect PROFINET IO (RJ45 port) directly to the CPU.

Required accessories

- Cable ties with standard width of 2.5 mm or 3.6 mm for strain relief
- Please observe the specifications in the PROFINET Installation Guide (https://www.profibus.com).

Mounting the bus connector

Mount the PROFINET connector in accordance with the instructions in the PROFINET Installation Guide (https://www.profibus.com).

Procedure

Insert the RJ45 bus connector into the PROFINET port (RJ45 port) on the CPU.

NOTE

Cable support and strain relief

If you are using a FastConnect RJ45 bus connector with 90° cable outlet (6GK1901-1BB20-2AA0), we recommend you provide strain relief for the PROFINET connecting cable. For this you need a cable tie with a standard width of 2.5 mm or 3.6 mm.

Use it to fasten the PROFINET connecting cable directly after it exits the bus connector to the provided cable support on the CPU (on the front directly below the PROFINET interface X1P3).

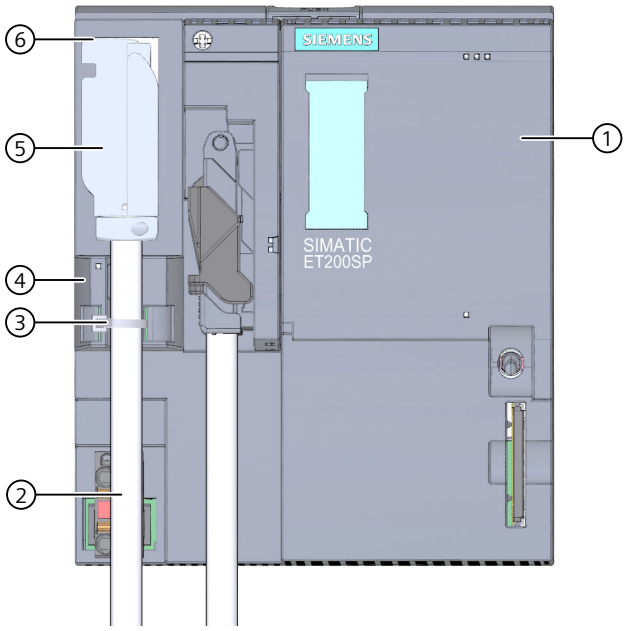

① CPU
② PROFINET connecting cable
③ Strain relief (cable tie)
④ Cable support
⑤ FastConnect RJ45 bus connector with 90° cable outlet
⑥ PROFINET connector (RJ45 port)

Figure 1-50 Connecting PROFINET IO (RJ45 port) to the CPU

8.13.2 Connecting the PROFIBUS DP interface to the interface module/communications module CM DP

Introduction

Using the bus connector (RS485), connect the PROFIBUS DP to the interface module/communications module CM DP.

Required tools

3 to 3.5 mm screwdriver

Procedure

To connect the PROFIBUS DP interface to the interface module / DP communication module CM DP, follow these steps:

1. Connect the PROFIBUS cable to the bus connector.
2. Plug the bus connector into the PROFIBUS DP connector.

3. Securely tighten the fixing screws of the bus connector (0.3 Nm).

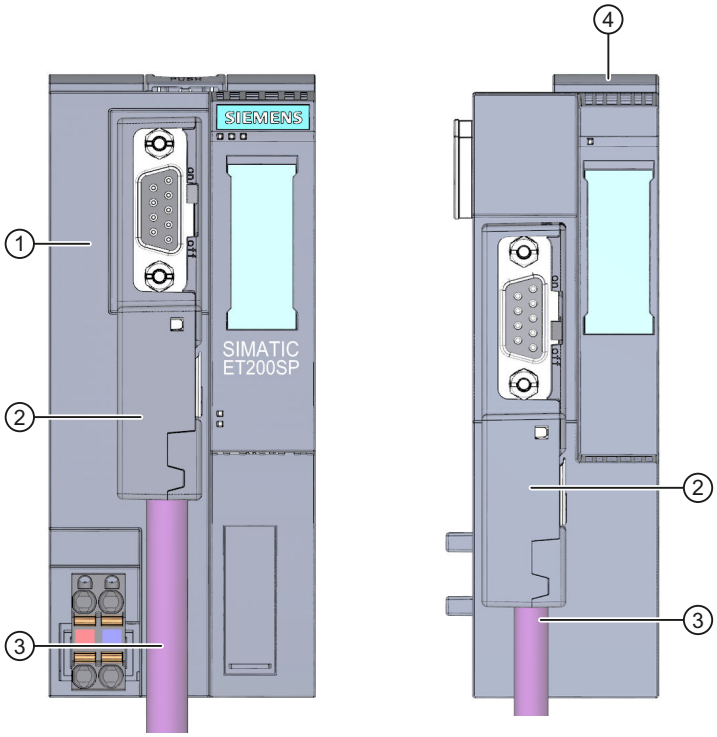

① Interface module
② PROFIBUS FastConnect bus connector
③ PROFIBUS connecting cable
④ Communications module CM DP

Figure 1-51 Connect PROFIBUS DP to the interface module/communications module CM DP

Reference

You can find additional information on the PROFIBUS FastConnect bus connector in the corresponding product information on the Internet (https://support.industry.siemens.com/cs/ww/de/view/109793857/en).

8.14 Inserting I/O modules / motor starters and BU covers

Introduction

- You insert the I/O modules on the BaseUnits. The I/O modules are self-coding and type-coded.
- You insert the PotDis-TerminalBlocks on the PotDis-BaseUnits.
- You insert the BU covers on BaseUnits whose slots are not equipped with I/O modules/PotDis-TerminalBlocks.

- You insert the BU covers on BaseUnits whose slots have been reserved for future expansion (as empty slots).
- The BU covers for motor starters serve as touch protection covers for unoccupied slots.

  The BU covers have a holder for the reference identification label on the inside. For future expansion of the ET 200SP, remove the reference identification label from the holder and insert it into the final I/O module.
  It is not possible to attach a reference identification label to the BU cover itself.

  There are three versions:

  – BU cover with a width of 15 mm
  – BU cover with a width of 20 mm
  – BU cover with a width of 30 mm (for motor starters)

Requirement

Refer to chapter "Application planning (Page 88)".

Plugging in I/O modules and BU covers

Watch video sequence: "Insert I/O modules"
(https://support.automation.siemens.com/WW/view/en/95886218)

Insert the I/O module or BU cover parallel into the BaseUnit until you hear both latches click into place.

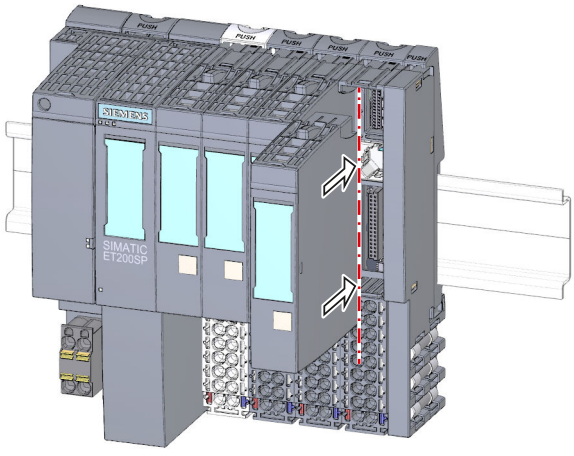

Figure 1-52 Plugging in I/O modules or BU covers (using an I/O module as example)

8.15 Mounting/disassembly of motor starters

8.15.1 Mounting the fan

Procedure

Proceed as follows to mount a fan on a SIMATIC ET 200SP motor starter:

1. Slide the fan onto the motor starter until you can hear the fan engage.

   Observe the blowing direction of the fan when mounting. The air stream must be directed to the inside of the motor starter. The correct blowing direction is indicated by arrows on the bottom of the fan.

2. Insert the connection plug into the opening above the fan.

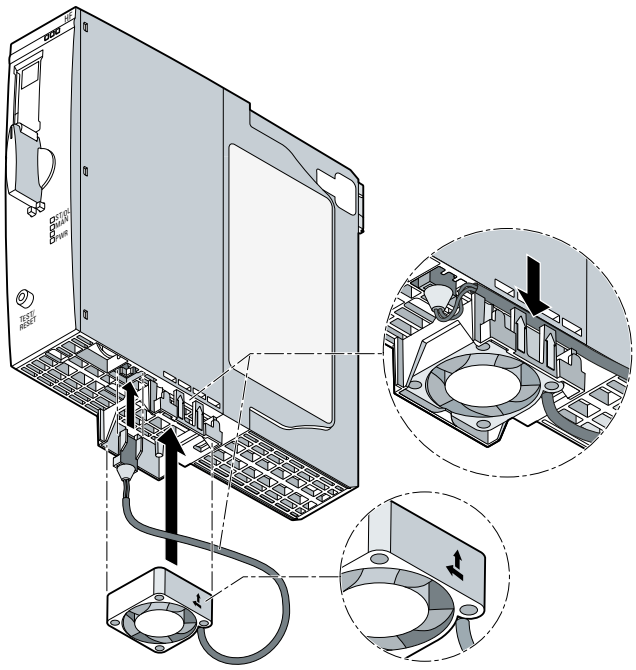

3. Secure the fan cable to the fixing eyes on the right-hand side of the fan cover.

NOTE

Specified ambient temperatures are not reached if the fan is incorrectly installed

If you do not observe the blowing direction of the fan when mounting, the specified ambient temperatures will not be reached. The device shuts down prematurely due to excessively high temperature.

8.15.2 Mounting/disassembly of motor starters

Procedure

CAUTION

Protection against electrostatic charge

When handling and installing the SIMATIC ET 200SP motor starter, ensure protection against electrostatic charging of the components. Changes to the system configuration and wiring are only permissible after disconnection from the power supply.

To assemble a SIMATIC ET 200SP motor starter, proceed as follows:

- Position the mechanical interlock of the SIMATIC ET 200SP motor starter in the assembly/disassembly position ②
- Place the SIMATIC ET 200SP motor starter onto the BaseUnit.
- Turn the mechanical interlock clockwise to the parking position ③
- Turn the mechanical interlock counterclockwise to the operating position (= end position) ①

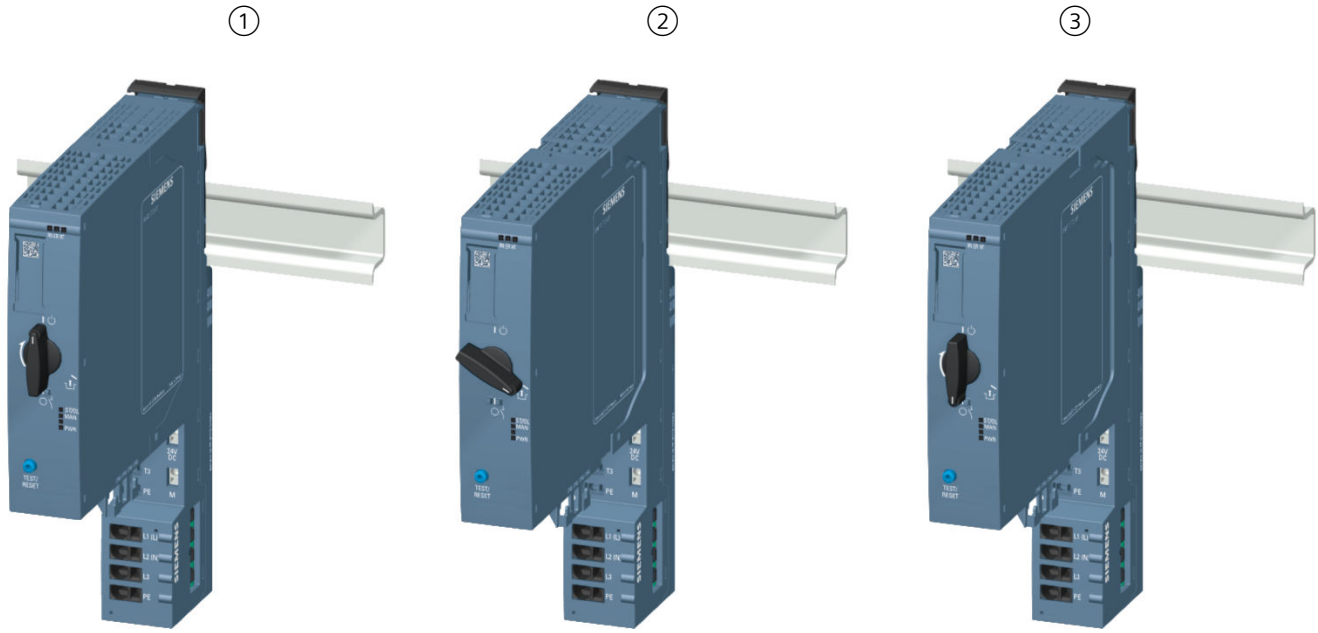

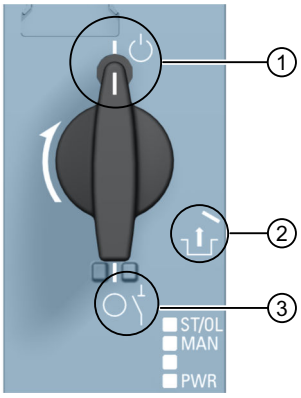

① Operating position/READY
The motor starter is firmly locked in the BaseUnit, and all electrical contacts are connected.

② Assembly/disassembly position
All electrical contacts are open, and you can use the SIMATIC ET 200SP motor starter in the BaseUnit, or you can remove it from the BaseUnit.

③ Parking position/OFF
In this position, you cannot remove the SIMATIC ET 200SP motor starter from the BaseUnit, but all electrical contacts are open. In addition, you can open the locking lever on the mechanical rotary interlock in this position, and fix the position with a padlock (shackle diameter 3 mm). This ensures the isolating function in accordance with IEC 60947-1.
In the parking position, the motor starter counts as a disconnected element for the head module. During operation, the parking position is therefore a hot swapping state. See also Removing and inserting I/O modules/motor starters (hot swapping) (Page 324)

NOTE

Parking position/OFF

This position is only permissible for maintenance purposes and not for continuous operation. In this position, dust protection and mechanical durability are not ensured.

If you do not use the motor starter for an extended period, remove it and attach the BU cover (3RK1908-1CA00-0BP0).

Mount the touch protection cover for the infeed bus on the last BaseUnit.

NOTE

Touch protection cover for the infeed bus

You will find out how to mount the touch protection cover of the infeed bus on a SIMATIC ET 200SP motor starter in chapter "Mounting the cover for the 500 V AC infeed bus (Page 148)".

To connect the assembly, mount the server module after the last BaseUnit.

NOTE

Server module

You can find out how to assemble/disassemble the server module in chapter "Installing the server module (Page 146)".

NOTE

Removing the motor starter

You will find out how to remove the motor starter in chapter "Replacing a motor starter (Page 330)".

8.15.3 3DI/LC module

Introduction

The optional 3DI/LC module with three inputs and one further LC input can be connected to the motor starter. The status of the inputs of the 3DI/LC module can be seen via the process image input (PII) of the motor starter.

NOTE

The 3DI/LC module can be used for the motor starter and the fail-safe motor starter.

The input actions can be parameterized. For reasons of operational safety, the LC input is permanently set to manual local mode. For example, by parameterizing the inputs DI1 - DI3 with motor CLOCKWISE or motor COUNTER-CLOCKWISE, you can control the motor in manual local mode.

The figure below shows the 3DI/LC module.

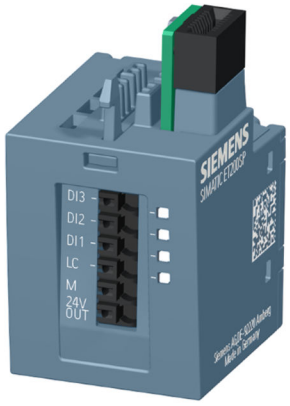

Assembly

⚠ WARNING

Risk of injury from automatic restart

When you mount the the 3DI/LC module, the motor starter can switch on autonomously if an ON command (DI1 to DI3) is active. This can result in property damage or serious injury caused by connected devices that are automatically started up.

Revoke the ON commands at DI1 to DI3 before mounting the 3DI/LC module.

Proceed as follows to mount a 3DI/LC module onto a motor starter:

1. Wire the 3DI/LC module according to the connection diagram.

   NOTE

   Connecting the 3DI/LC module

   You will find out how to connect the 3DI/LC module in chapter "Connecting the 3DI/LC module for the motor starter (Page 178)".

2. Slide the 3DI/LC module into the motor starter until the 3DI/LC module engages.

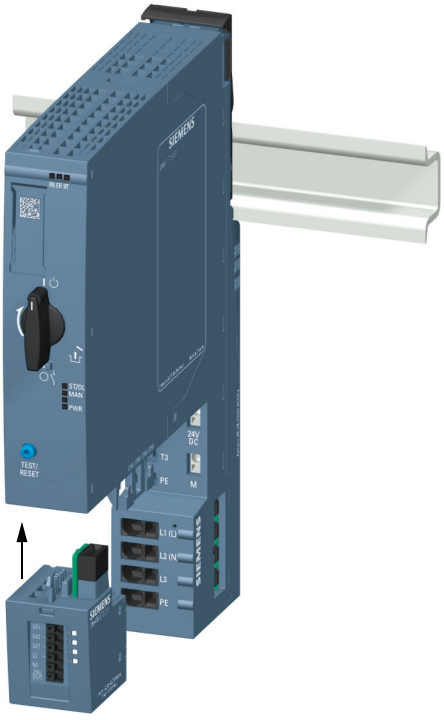

The figure below shows a motor starter with a mounted 3DI/LC module.

Disassembly

Proceed as follows to remove a 3DI/LC module from a motor starter:

1. Push the release lever on the rear of the 3DI/LC module.

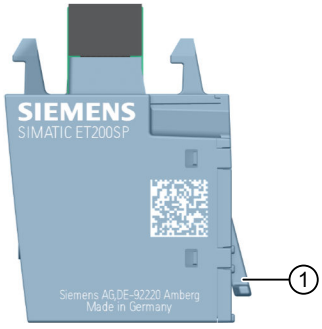

① Release lever

2. Remove the 3DI/LC module from the motor starter while pressing the release lever.

8.16 Labeling ET 200SP

8.16.1 Factory markings

Introduction

For better orientation, the ET 200SP is equipped with various markings ex factory, which help in the configuration and connection of the modules.

Factory markings

- Module labeling
- Color coding of module type
  - Digital input modules: white
  - Digital output modules: black
  - Analog input modules: light blue
  - Analog output modules: dark blue
  - Technology module: turquoise
  - Communication module: light gray
  - Special module: mint green
- Module information
  - Functional version of the module, e.g. "X/2/3/4" (= functional version 1)
  - Functional status in plain text
  - Firmware version of the module at delivery, e.g. "V1.0.0"
  - Information on the ID link
  - Color code for usable color identification label, e.g. "CC0"
  - Usable BaseUnit type, e.g. "BU: A0"
- Color coding of the potential group
  - Opening the potential group: Light-colored terminal box and light-colored mounting rail release button
  - Further conduction of the potential group: Dark-colored terminal box and dark-colored mounting rail release button
- Color coding of the spring releases
  - Process terminals: gray, white
  - AUX terminals: turquoise
  - Additional terminals: red, blue

– Terminals for self-assembling voltage buses P1, P2: red, blue

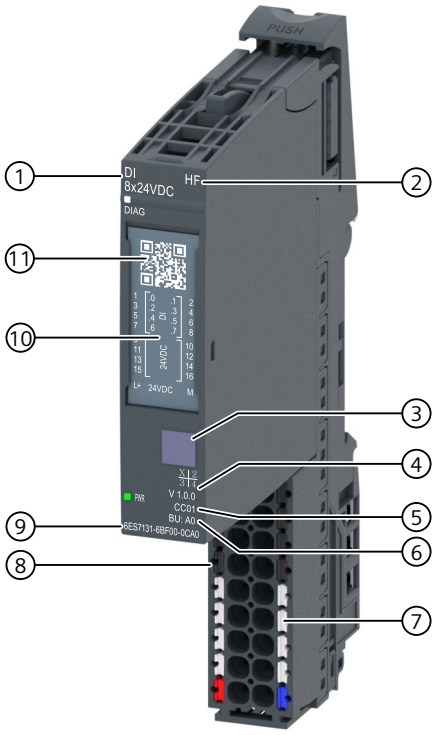

① Module type and name
② Function class
③ Color coding of module type
④ Function and firmware version
⑤ Color code for selection of the color coding labels
⑥ BU type
⑦ Color coding of the spring releases (by group)
⑧ Color coding of the potential group
⑨ Article number
⑩ Wiring diagram
⑪ 2D matrix code/ID link

Figure 1-53 Factory markings

8.16.2 Optional markings

Introduction

In addition to the factory markings, there are also other options for labeling and/or marking terminals, BaseUnits and I/O modules for the ET 200SP distributed I/O system.

Optional markings

Color identification labels

The color identification labels are module-specific labels for color coding the potentials of the I/O modules. A color code (e.g. 01) is printed on each color identification label and I/O module. The color code allows you to read which color identification label is required for the terminals of the associated BaseUnit directly from the I/O module.

The following versions of color coded labels are available:

- Module-specific color combinations for the process terminals (see the device manuals I/O modules (https://support.automation.siemens.com/WW/view/en/55679691/133300)). The different colors have the following meaning: Gray = input or output signal, red = potential +, blue = ground.
- For the AUX terminals in the colors yellow-green, blue or red
- For the add-on terminals in the colors blue-red
- For the potential distributor modules (see manual BaseUnits (https://support.automation.siemens.com/WW/view/en/59753521)):
  - For PotDis-BaseUnit PotDis-BU-P1/x-R: red
    For PotDis-BaseUnit PotDis-BU-P2/x-B: blue
  - For PotDis-TB-P1-R: red or gray
    For PotDis-TB-P2-B: blue or gray
    For PotDis-TB-BR-W: depending on application, yellow/green, blue, red or gray
    For PotDis-TB-n.c.-G: gray

Reference identification labels

The reference identification labels (in accordance with EN 81346) can be inserted onto each CPU/interface module, BusAdapter, BaseUnit, I/O module and PotDis-TerminalBlock. This makes it possible to create a fixed assignment between the reference identification label of the BaseUnit and the I/O module/PotDis-TerminalBlock.

With the standard plotter setting, the reference identification label is suitable for automatic labeling with E-CAD systems.

Labeling strips

The labeling strips can be inserted in the CPU/interface module, I/O module and BU cover and allow identification of the ET 200SP distributed I/O system. The labeling strips can be ordered on a roll for thermal transfer printers or as DIN A4 format sheets for laser printers.

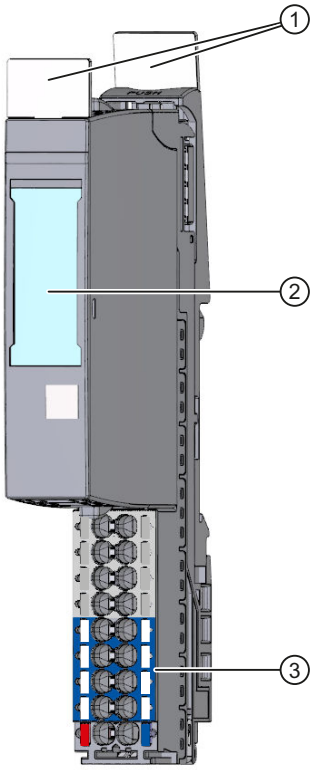

① Reference identification labels
② Labeling strips
③ Color identification labels

Figure 1-54 Optional markings

8.16.3 Applying color identification labels

Requirements

The BaseUnits must not be wired when you apply the color identification labels.

Required tools

3 mm screwdriver (only for removing the color identification labels)

Applying color identification labels

Press the color-coded labels into the terminal box of the BaseUnit.

NOTE

To remove the color-coded labels, you must first disconnect the wiring on the BaseUnit and then carefully lever the color-coded labels out of the holder using a screwdriver.

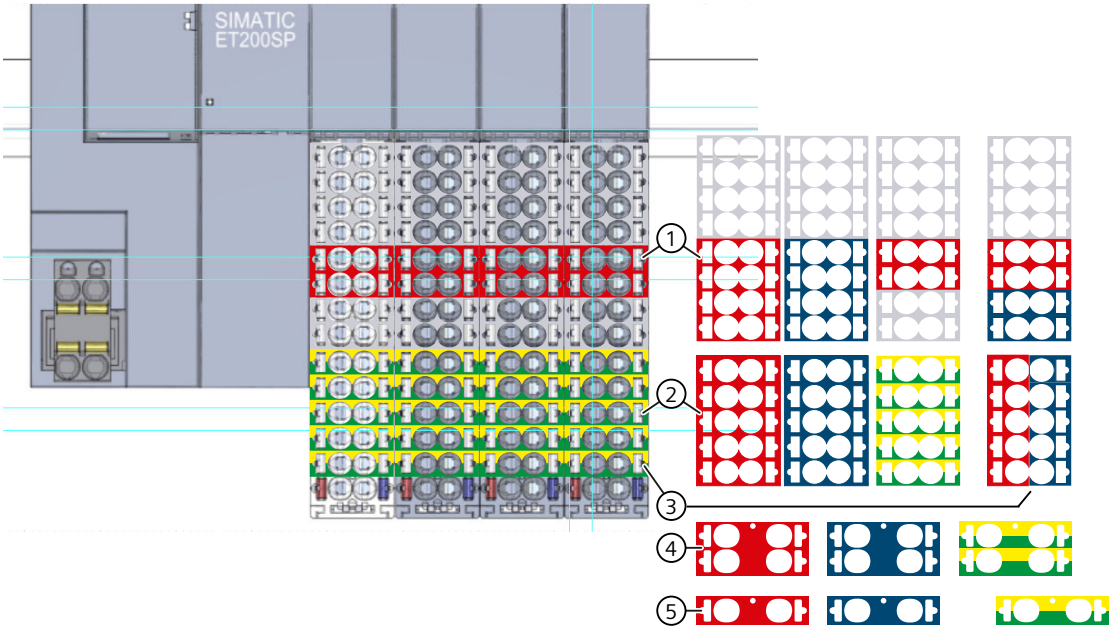

① Module-specific color identification labels (15 mm) for the process terminals. You can find additional information in the I/O Module (https://support.automation.siemens.com/WW/view/en/55679691/133300) manual.

② Color identification labels (15 mm) for the 10 AUX terminals

③ Color identification label (15 mm) for the 10 add-on terminals

④ Color identification labels (20 mm) for the 4 AUX terminals

⑤ Color identification labels (20 mm) for the 2 AUX terminals

Figure 1-55 Applying color identification labels (example)

NOTICE
AUX bus as PE bar If you use an AUX bus as a protective conductor (PE), attach the yellow-green color identification labels to the AUX terminals. If you stop using the AUX terminals as a protective conductor bar, remove the yellow-green color identification labels and make sure that the system is still protected.

NOTICE
Supply of incorrect potential possible Check that the color-coded labels/wiring is correct before commissioning the plant.

8.16.4 Applying labeling strips

Procedure

Watch video sequence: "Labeling"
(https://support.automation.siemens.com/WW/view/en/95886218)

Proceed as follows to install a labeling strip:

1. Label the strips.
2. Insert the labeling strip into the interface module or I/O module.

8.16.5 Applying reference identification labels

Procedure

Watch video sequence: "Labeling"
(https://support.automation.siemens.com/WW/view/en/95886218)

Proceed as follows to install a reference identification label:

1. Break off the reference identification labels from the sheet.
2. Insert the reference identification labels into the opening on the CPU/interface module, BusAdapter, BaseUnit, I/O module and PotDis-TerminalBlock. The insertion opening is located on top of the BaseUnit or the I/O module/PotDis-TerminalBlock.

NOTE
Reference identification label
The printable side of the reference identification label must be facing forward.

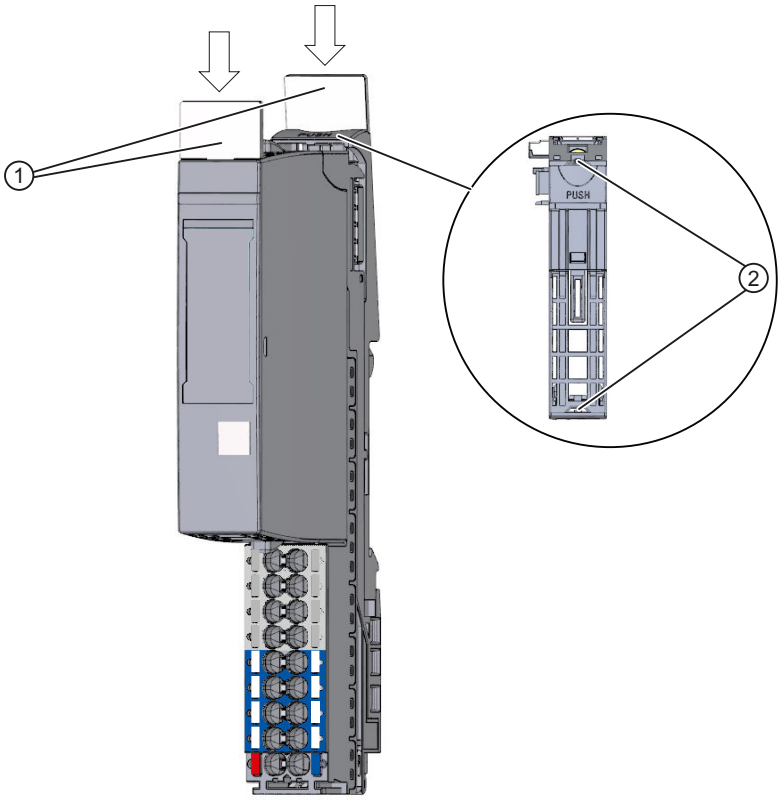

① Reference identification labels

② Opening for label

Figure 1-56 Applying reference identification labels

Configuring 9

9.1 Configuring ET 200SP

Introduction

The ET 200SP distributed I/O system is configured and assigned parameters with STEP 7 (CPU/interface module, I/O modules, motor starter and server module) or using configuration software of a third-party manufacturer (interface module, I/O modules, motor starter and server module).

"**Configuring**" is understood to mean the arranging, setup and networking of devices and modules within the device view or network view. STEP 7 graphically represents modules and racks. Just like "real" module racks, the device view allows the insertion of a defined number of modules.

When the modules are inserted, STEP 7 automatically assigns the addresses and a unique hardware identifier (HW identifier). You can change the addresses later. The hardware identifiers cannot be changed.

When the automation system is started, the CPU/interface module compares the configured planned configuration with the system's actual configuration. You can make parameter settings to control the response of the CPU/interface module to errors in the hardware configuration.

"**Parameterizing**" the components used signifies setting their properties. During parameter assignment, the hardware parameters are set and the settings for data exchange are made:

- Properties of the modules to which parameters can be assigned
- Settings for data exchange between components

STEP 7 compiles the hardware configuration (result of "configuring" and "assigning parameters") and downloads it to the CPU/interface module. The CPU/interface module then connects to the configured components and transfers their configuration and parameters. Modules can be replaced very easily because STEP 7 transfers the configuration and parameters when a new module is inserted.

Requirements for configuration of the CPU

Table 1-12 Requirement for installing the CPU

Configuration software	Requirements	Installation information
CPU 151xSP-1 PN: STEP 7 (TIA Portal) as of V13 Update 3	• PROFINET IO • PROFIBUS DP (optional): With the communication module CM DP	STEP 7 online help
CPU 151xSP F-1 PN: STEP 7 (TIA Portal) as of V13 SP1		
CPU 151xSP-1PN (as of FW version V1.8), CPU 151xSP F-1 PN (as of FW version V1.8): STEP 7 (TIA Portal) as of V13 SP1 Update 4		

Configuring a motor starter

You configure SIMATIC ET 200SP motor starters in exactly the same way as the I/O modules of the ET 200SP distributed I/O system. The GSD files can be used with STEP 7 V5.5 SP4 and higher, and TIA Portal V13 SP1 and higher.

Configuring ET 200SP

See the STEP 7 online help or the documentation of the configuration software manufacturer.

NOTE

For I/O modules that are installed on a BaseUnit BU..D (light-colored BaseUnit), you always have to set the parameter "Potential group" to "Enable new potential group". If you do not set this parameter correctly, the CPU/interface module goes to STOP and generates a parameter error.

NOTE

For PROFIBUS with configuration via GSD file

In the configuration software, you must set for the BU covers whether these are on a light-colored or dark-colored BaseUnit.

Configuring F-modules with a GSD file

If you want to configure F-modules with a GSD file, you need S7-FCT in order to calculate the F_iPar_CRC and assign the PROFIsafe addresses. Additional information can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109763833).

You can find S7-FCT on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

See also

GSD file (https://support.industry.siemens.com/cs/ww/en/view/57138621)

9.2 Configuring the CPU

9.2.1 Reading out the configuration

Introduction

When a connection to a CPU present in the configuration exists, you use the "Hardware detection" function to read out the configuration of this CPU, including centrally configured modules, and apply it to your project. You do not need to manually configure the CPU and the centrally present modules, as the physical configuration is read out automatically.

If you have already configured a CPU and the centrally present modules and you want to load the current configuration and parameters in a new project, it is advisable to use the "Upload device as new station" function. For additional information about this function, refer to section Backing up and restoring the CPU configuration (Page 307).

Procedure for reading out an existing configuration

1. Create a new project and configure an "Unspecified CPU".

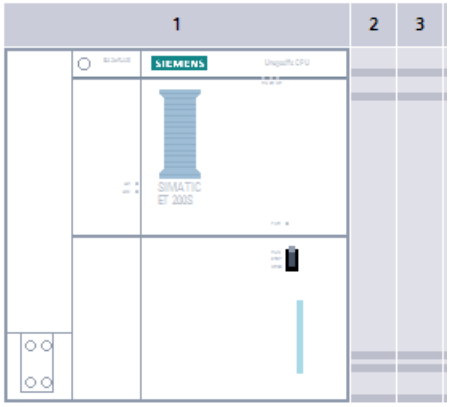

Figure 1-57 Unspecified CPU in the device view

2. In the device view (or in the network view), select the "Hardware detection" command in the "Online" menu.

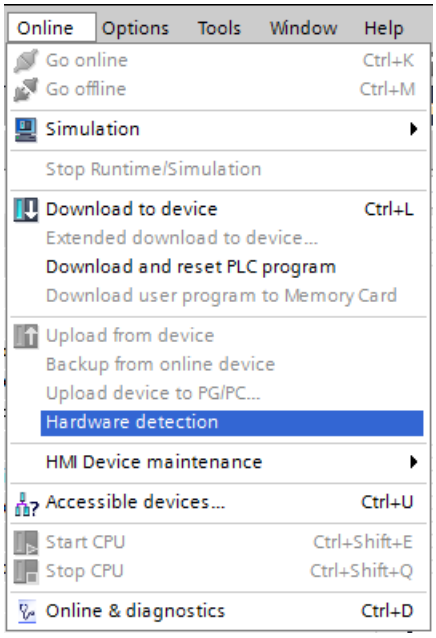

Figure 1-58 Hardware detection in the Online menu

You can also double-click the CPU and click "Detect" in the message.

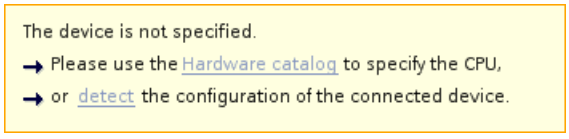

Figure 1-59 Hardware detection message in the device view

3. In the "Hardware detection for PLC_x" dialog box, click "Refresh". Then, select the CPU and the PG/PC interface and click "Detect".
STEP 7 downloads the hardware configuration including the modules from the CPU to your project.

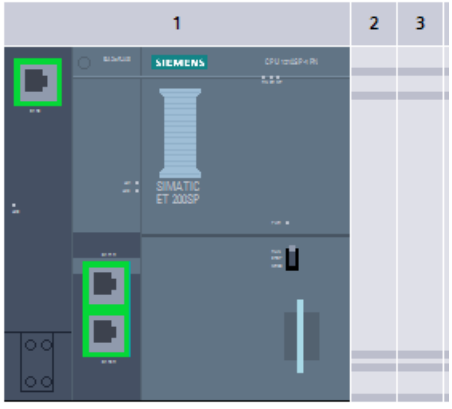

Figure 1-60 Result of the hardware detection in the device view

STEP 7 assigns a valid default parameter assignment for all modules. You can change the parameter assignment subsequently.

NOTE

If you want to go online after the hardware detection, you have to first download the detected configuration to the CPU; otherwise, an error may occur due to inconsistent configurations.

Properties of central modules

The properties of the CPUs have special significance for system behavior. You can set the following for a CPU using STEP 7:

- Startup behavior
- Parameter assignment of the interface(s), for example, IP address, subnet mask
- Web server, e.g. activation, user administration, and languages
- OPC UA server
- Global Security Certificate Manager
- Cycle times, e.g. maximum cycle time
- System and clock memory
- Protection level for access protection with assigned password parameter
- Time and day settings (daylight saving/standard)

The properties that can be set and the corresponding value ranges are specified by STEP 7. Fields that cannot be edited are grayed out.

Reference

Information about the individual settings can be found in the online help and in the manuals of the relevant CPUs.

9.2.2 Addressing

Introduction

In order to address the automation components or I/O modules, they have to have unique addresses. The following section explains the various address areas.

I/O address

I/O addresses (input/output addresses) are required in the user program to read inputs and set outputs.

STEP 7 automatically assigns input and output addresses when you connect the modules. Each module uses a continuous area in the input and/or output addresses corresponding to its volume of input and output data.

Module	Rack	Slot	I address	Q addr...	Type	Order no.	Firmware
PLC_1	0	1			CPU 1510SP-1 PN	6ES7 510-1DJ00-0AB0	V1.6
PROFINET-Schnittstelle_1	0	1 X1			PROFINET interface		
Port_1	0	1 X1 P1			Port		
Port_2	0	1 X1 P2			Port		
Port_3	0	1 X1 P3			Port		
	0	1 X2					
DI 4x120..230VAC ST_1	0	2	0		DI 4x120..230VAC ST	6ES7 131-6FD00-0BB1	V1.0
DQ 8x24VDC/0.5A ST_1	0	3		0	DQ 8x24VDC/0.5A ST	6ES7 132-6BF00-0BA0	V1.1
AI 8xRTD/TC 2-wire HF_1	0	4	1...16		AI 8xRTD/TC 2-wire ...	6ES7 134-6JF00-0CA1	V2.0
AQ 2xU/I HF_1	0	5		1...4	AQ 2xU/I HF	6ES7 135-6HB00-0CA1	V1.0

Figure 1-61 Example with input / output addresses from STEP 7

STEP 7 assigns the address areas of the modules by default to the process image partition 0 ("Automatic updating"). This process image partition is updated in the main cycle of the CPU.

Device address (e.g. Ethernet address)

Device addresses are addresses of programmable modules with interfaces to a subnet (e.g., IP address or PROFIBUS address). They are required to address the various devices on a subnet, for example, to download a user program.

Hardware identifier

STEP 7 automatically assigns a hardware identifier to identify and address modules and submodules. You use the hardware identifier in the case of diagnostic messages or operations, for example, to identify a defective module or the module addressed.

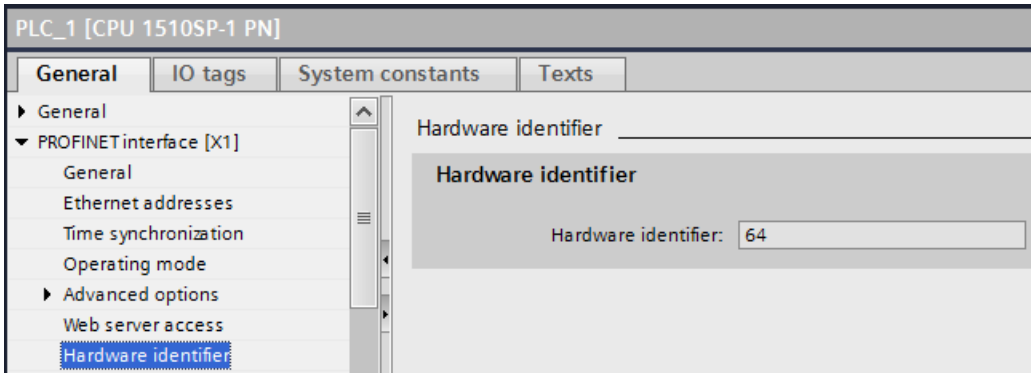

Figure 1-62 Example of a hardware identifier from STEP 7

In the "System constants" tab, you will find all hardware identifiers and their symbolic names (of the hardware identifier) for the selected module.

You can also find the hardware identifiers and names for all modules of a device in the default tag table of the "System constants" tab.

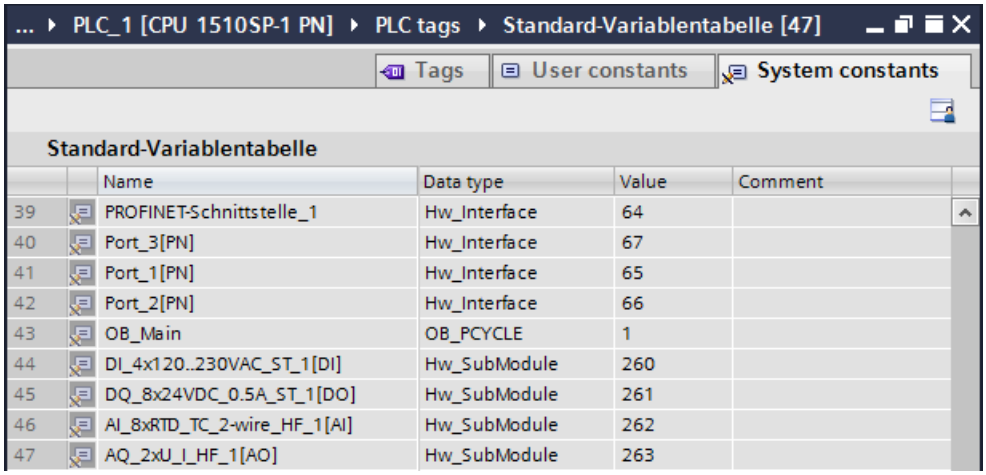

	Name	Data type	Value	Comment
39	PROFINET-Schnittstelle_1	Hw_Interface	64	
40	Port_3[PN]	Hw_Interface	67	
41	Port_1[PN]	Hw_Interface	65	
42	Port_2[PN]	Hw_Interface	66	
43	OB_Main	OB_PCYCLE	1	
44	DI_4x120..230VAC_ST_1[DI]	Hw_SubModule	260	
45	DQ_8x24VDC_0.5A_ST_1[DO]	Hw_SubModule	261	
46	AI_8xRTD_TC_2-wire_HF_1[AI]	Hw_SubModule	262	
47	AQ_2xU_I_HF_1[AO]	Hw_SubModule	263	

Figure 1-63 Example of an excerpt from a default tag table in STEP 7

9.2.3 Process images and process image partitions

9.2.3.1 Process image - overview

Process image of the inputs and outputs

The process image input and output is an image of the signal states. The CPU transfers the values from the input and output modules to the process image input and output. At the start of the cyclic program, the CPU transfers the process image output as a signal state to the output modules. Afterwards the CPU transfers the signal states of the input modules to the process image input.

Advantages of the process image

The process image accesses a consistent image of the process signals during cyclic program execution. If a signal state at an input module changes during program processing, the signal state is retained in the process image. The CPU does not update the process image until the next cycle.

You can only assign the addresses of a module to a single process image partition.

32 process image partitions

By means of process image partitions, the CPU synchronizes the updated inputs/outputs of particular modules with defined user program sections.

The overall process image is subdivided into up to 32 process image partitions (PIP).

The CPU updates PIP 0 in each program cycle (automatic update) and assigns it to OB 1.

You can assign the process image partitions PIP 1 to PIP 31 to the other OBs during configuration of the input/output modules in STEP 7.

After the OB has been started, the CPU updates the assigned process image partition for inputs and reads in the process signals. At the end of the OB the CPU writes the outputs of the assigned process image partition directly to the peripheral outputs without having to wait for the completion of the cyclic program processing.

9.2.3.2 Automatically updating process image partitions

You can assign one process image partition to each organization block. In this case, the user program automatically updates the process image partition. The exceptions are PIP 0 and isochronous OBs.

Updating the process image partition

The process image partition is divided into two parts:

- Process image partition of the inputs (PIPI)
- Process image partition of the outputs (PIPQ)

The CPU always updates/reads the process image partition of the inputs (PIPI) before processing of the associated OB. The CPU outputs the process image of the outputs (PIPQ) at the end of the OB.

The figure below illustrates the updating of the process image partitions.

PIPIx read in	Processing of the program in the called OB	PIPQx output

Figure 1-64 Updating process image partitions

9.2.3.3 Update process image partitions in the user program

Requirements

Alternatively, you can also use the following instructions for the process image update:

- "UPDAT_PI" instruction
- "UPDAT_PO" instruction

You will find the instructions in STEP 7 in the "Instructions" task card under "Extended instructions". The instructions can be called from any point in the program.

Requirements for updating process image partitions with the "UPDAT_PI" and "UPDAT_PO" instructions:

- The process image partitions must not be assigned to any OB. This means the process image partitions are not automatically updated.

NOTE

Update of PPI 0

PIP 0 (automatic update) cannot be updated with the "UPDAT_PI" and "UPDAT_PO" instructions.

UPDAT_PI: updates the process image partition of the inputs

With this instruction you read the signal states from the input modules into the process image partition of the inputs (PIPI).

UPDAT_PO: updates the process image partition of the outputs

With this instruction you transfer the process image partition of the outputs to the output modules.

Synchronous cycle interrupt OB

In the synchronous cycle interrupt OBs, you use the "SYNC_PI" and "SYNC_PO" operations to update the process image partitions of the operations. For additional information on the synchronous cycle interrupt OBs, refer to the STEP 7 Online Help.

Direct I/O access to the inputs and outputs of the module

As an alternative to access via the process image, you can directly access the I/O (write and read access) if this is necessary for program-related reasons. Direct (write) access to I/O also writes to the process image. This prevents a subsequent output of the process image from again overwriting the value written by direct access.

Reference

Additional information on process image partitions is available in the function manual, Cycle and response times (https://support.automation.siemens.com/WW/view/en/59193558).

9.3 Configuring the interface module

Configuring

Read the STEP 7 online help and/or the documentation of the configuration software manufacturer when configuring the interface module.

The F-destination address is saved permanently on the coding element of the ET 200SP fail-safe modules. Fail-safe motor starters do not need an F-destination address or a coding element.

NOTE

The supply voltage L+ must be applied to the F-module when the F-destination address is assigned.

NOTE

Note the following in conjunction with configuration control:

Before you can use configuration control together with F-modules, you must assign the F-destination address to the F-modules at the designated slots. For this, each F-module must be inserted in the slot configured for it. The actual configuration can then differ from the specified configuration.

For additional information on assigning the F-destination address, refer to the SIMATIC Safety - Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126) Programming and Operating Manual and to the online help for the *S7 Configuration Pack*.

9.4 Module-to-Module Communication (MtM)

Introduction

Module-to-Module Communication (MtM) offers the following advantages:

- Improved performance during transmission of data by bypassing the IO controller.
- Deterministic cycle times
- Cost-effective, high-performance solutions for applications where the performance of a specific technology module is not required.

Module-to-Module Communication (MtM)

Module-to-Module Communication (MtM) enables direct exchange of data between specific IO modules within a station via the interface module. This enables you to move small and/or time-critical tasks to the IO module. You achieve better performance while reducing the load on the CPU.

With Module-to-Module Communication (MtM), the interface module copies the input data of an IO module directly to a different IO module via the ET 200SP backplane bus. The IO module (data sink) carries out application-specific processing of the data.

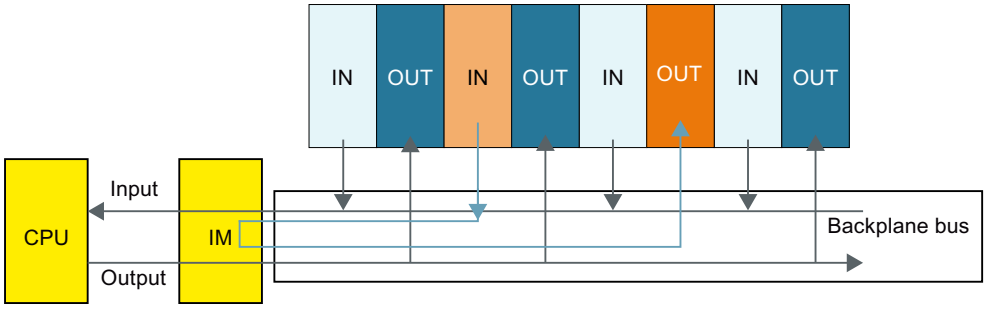

You configure the data source and data sink for Module-to-Module Communication (MtM) in the hardware configuration of the respective output module. Programming of the user program is **not** required in the variant for Module-to-Module Communication (MtM).

NOTE

The preparation of the input data in the output module (mapping) and the output of the data to the outputs are application- and technology-specific.
Example: The DQ 4x24VDC/2A HS digital output module supports

- the application cam control with Module-to-Module Communication (MtM) under the designation DQ 4x24VDC/2A HS **MCC MtM**

Additional information can be found in the manuals of the corresponding IO modules. An overview of which I/O modules support module-to-module communication (MtM) can be found in the ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/73021864)Product Information. Information on which interface module supports module-to-module communication (MtM) can be found in the Equipment Manuals of the interface modules.

See also

FAQ "How do you parameterize module-to-module communication?" (https://support.industry.siemens.com/cs/ww/en/view/109767618)

9.5 Value status

Introduction

Value status (QI, quality information) refers to status information of I/O channels that is made available to the user program via the process image input (PII). However, since the value status is partly derived from the diagnostics, there may be a time delay between the occurrence of the error and the message depending on the diagnostics.

Each bit of the value status is assigned to a channel and provides information about the validity of the process value of the respective channel (1 = no errors on the channel of the I/O module, 0 = value is bad).

The assignment of the value status bytes in the process image input depends on the module used. Detailed information can be found in the manual for the relevant I/O module.

Summary: Possible cause for value status = 0:

- A channel has an error (overflow/underflow, wire break, short-circuit, etc.)
- The supply voltage L+ is missing at the terminals or is not sufficient
- A channel has been deactivated
- PROFIenergy pause is activated

  If you set the "Continue working" mode, the value status remains = 1.
- Outputs are inactive (value status = 0: Module not plugged in. Value status is generated via interface module in distributed mode)

If, for example, there is a wire break at an input but the wire break diagnostics is disabled, the value status of the channel is set to "0" but no diagnostics is triggered. Diagnostics is only also triggered if the wire break diagnostics is enabled.

With module-by-module channel diagnostics of the I/O modules, these also map the value status module-by-module. The channels are mapped here module-by-module to value status = 0 or value status = 1.

Which interface modules support the value status?

The following interface modules support the value status:

- IM 155-6 PN ST
- IM 155-6 PN HS
- IM 155-6 PN/2 HF
- IM 155-6 PN/3 HF
- IM 155-6 PN R1
- IM 155-6 MF HF
- IM 155-6 DP HF

Which I/O modules support the value status?

The I/O modules of the function classes Standard, High Feature and High Speed support the value status.

Activating value status

Table 1-13 Value status depending on the respective configuration variant

	STEP 7 TIA (integrated I/O module; PROFINET and PROFIBUS)	**STEP 7 HSP (PROFINET and PROFIBUS)**	**GSD PROFINET (can be integrated in STEP 7 TIA and STEP 7)**	**GSD PROFIBUS (can be integrated in STEP 7 TIA and STEP 7)**
Select the I/O module from the hardware catalog and activate the value status	There is only **one** entry in the hardware catalog for each I/O module. In the configuration dialog, you can set whether the I/O module is to be operated with or without value status.		There are **multiple** entries in the hardware catalog for each I/O module. On selection in the hardware catalog, it must be determined whether the I/O module is to be operated with or without value status. The value status can be recognized by the suffix "QI".	
Input substitute value behavior	The "Input values with module failure" parameter (input substitute value behavior) is available for CPUs 1500 from FW version V2.0. If the I/O module is configured with value status, the parameter is fixed at "Input value 0". Input substitute value behavior can only be configured if no value status has been configured.	The "Input values with module failure" parameter is not available.	The "Input values with module failure" parameter (input substitute value behavior) is available for CPUs 1500 from FW version V2.0. The same restrictions apply as for I/O modules integrated in STEP 7 TIA. Due to the limited capabilities of the GSD, however, these are not locked in the GSD interface.	The "Input values with module failure" parameter is not available.

Special features for modules with MSI/MSO

The meaning of the value status of the basic submodule is described above. The value status of the MSI/MSO submodules are copies of the base submodule. The value status of the MSI/MSO submodules remains set to "0" as long as the base submodule has not been configured.

9.6 Substitute value behavior

The substitute value behavior in the ET 200SP distributed I/O system is executed by the IO controller for each IO module.

The respective output behaves according to its configured substitute value behavior:

- Current-free/voltage-free
- Output substitute value
- Keep last value

The substitute value behavior is triggered in the following cases:

- STOP controller
- Controller failure (connection interrupted)
- Deactivating the IO device
- Station stop, for example, due to:
  - Missing server module
  - At least one I/O module is installed on an incorrect BaseUnit
  - With the ET 200SP R1, the pulling of the server module during ongoing operation does not lead to a station stop

The "current-free/voltage-free" behavior takes effect in the following cases:

- IO module firmware update
- Reset to factory settings
- With enabled configuration control without presence of a valid control data record (DS196)
- Incorrectly configured module
- Module with incorrect parameter assignment

NOTE

Reducing a configuration

If you reduce the configuration of the ET 200SP distributed I/O system and download the configuration to the CPU, the modules which are no longer configured but still present retain their original substitute value behavior. This applies until the supply voltage is switched off at the interface module.

Basics of program execution 10

10.1 Events and OBs

Start events

The table below gives an overview of the possible event sources for start events and their OBs.

Table 1-14 Start events

Types of event sources	Possible priorities (default priority)	Possible OB numbers	Default system response [1]	Number of OBs
Starting [2]	1	100, ≥ 123	Ignore	0 to 100
Cyclic program [2]	1	1, ≥ 123	Ignore	0 to 100
Time-of-day interrupt [2]	2 to 24 (2)	10 to 17, ≥ 123	Not applicable	0 to 20
Time-delay interrupt [2]	2 to 24 (3)	20 to 23, ≥ 123	Not applicable	0 to 20
Cyclic interrupt [2]	2 to 24 (8 to 17, frequency dependent)	30 to 38, ≥ 123	Not applicable	0 to 20
Hardware interrupt [2]	2 to 26 (18)	40 to 47, ≥ 123	Ignore	0 to 50
Status interrupt	2 to 24 (4)	55	Ignore	0 or 1
Update interrupt	2 to 24 (4)	56	Ignore	0 or 1
Manufacturer-specific or profile-specific interrupt	2 to 24 (4)	57	Ignore	0 or 1
Synchronous cycle interrupt	16 to 26 (21)	61 to 64, ≥ 123	Ignore	0 to 2
Time error [3]	22	80	Ignore	0 or 1
Cycle monitoring time exceeded once			STOP	
Diagnostics interrupt	2 to 26 (5)	82	Ignore	0 or 1
Pull/plug interrupt for modules	2 to 26 (6)	83	Ignore	0 or 1
Rack error	2 to 26 (6)	86	Ignore	0 or 1
MC-servo [4]	17 to 26 (25)	91	Not applicable	0 or 1
MC-PreServo [4]	17 to 26 (25)	67	Not applicable	0 or 1
MC-PostServo [4]	17 to 26 (25)	95	Not applicable	0 or 1

1) If you have not configured the OB.

2) In the case of these event sources, besides the permanently assigned OB numbers (see column: Possible OB numbers) in STEP 7 you can assign OB numbers from the range ≥ 123.

3) If the maximum cycle time has been exceeded twice within one cycle, the CPU always assumes the STOP state, regardless of whether you have configured OB 80.

4) You will find more information on these event sources and the starting behavior in the S7-1500 Motion Control function manual.

Types of event sources	Possible priorities (default priority)	Possible OB numbers	Default system response [1]	Number of OBs
MC-Interpolator [4]	16 to 26 (24)	92	Not applicable	0 or 1
Programming error (only for global error handling)	2 to 26 (7)	121	STOP	0 or 1
I/O access error (only for global error handling)	2 to 26 (7)	122	Ignore	0 or 1

1) If you have not configured the OB.

2) In the case of these event sources, besides the permanently assigned OB numbers (see column: Possible OB numbers) in STEP 7 you can assign OB numbers from the range ≥ 123.

3) If the maximum cycle time has been exceeded twice within one cycle, the CPU always assumes the STOP state, regardless of whether you have configured OB 80.

4) You will find more information on these event sources and the starting behavior in the S7-1500 Motion Control function manual.

Response to triggers

The occurrence of a start event results in the following reaction:

- If the event comes from an event source to which you have assigned an OB, this event triggers the execution of the assigned OB. The event enters the queue according to its priority.
- If the event comes from an event source to which you have not assigned an OB, the CPU executes the default system reaction.

NOTE

Some event sources, such as startup, pull/plug, exist even if you do not configure them.

Assignment between event source and OBs

The type of OB determines where you make the assignment between OB and event source:

- With hardware interrupts and isochronous mode interrupts, the assignment is made during the configuration of the hardware or when the OB is created.
- In the case of the MC-Servo, MC-PreServo, MC-PostServo and MC-Interpolator, STEP 7 automatically assigns the OBs 91/92 as soon as you add a technology object.
- For all other types of OB, the assignment is made when the OB is created, where applicable after you have configured the event source.

For hardware interrupts, you can change an assignment which has already been made during runtime with the instructions ATTACH and DETACH. In this case, only the actually effective assignment changes, and not the configured assignment. The configured assignment takes effect after loading, and at startup.

The CPU ignores hardware interrupts to which you did not assign an OB in your configuration or which occur after the DETACH instruction. The CPU does not check whether an OB is assigned to this event when an event arrives, but only prior to the actual processing of the hardware interrupt.

OB priority and runtime behavior

If you have assigned an OB to the event, the OB has the priority of the event. The CPU supports the priority classes 1 (lowest priority) to 26 (highest priority). The following items are essential to the processing of an event:

- Calling and processing of the assigned OB
- The update of the process image partition of the assigned OB

The user program processes the OBs exclusively on a priority basis. This means the program processes the OB with the highest priority first when multiple OB requests occur at the same time. If an event occurs that has a higher priority than the currently active OB, this OB is interrupted. The user program processes events of the same priority in order of occurrence.

NOTE

Communication

Communication (e.g. test functions with the PG) always works permanently with the priority 15. So as not to unnecessarily prolong program runtime in the case of time-critical applications, these OBs should not be interrupted by communication. Assign a priority >15 for these OBs.

Programming guideline and programming style guide

The programming guideline gives you many recommendations and tips for optimal programming of the S7-1500 automation system.

The programming guidelines described in the programming style guide help you to create a uniform program code. You can better maintain and reuse the uniform program code. This allows you to detect or avoid errors early on, for example, through compilers.

You can find the programming guideline and programming style guide on the Internet (https://support.industry.siemens.com/cs/us/en/view/81318674).

Reference

You can find more information on organization blocks in the STEP 7 online help.

10.2 Asynchronous instructions

Introduction

In program processing, a differentiation is made between synchronous and asynchronous instructions.

The "synchronous" and "asynchronous" properties relate to the temporal relationship between the call and execution of the instruction.

The following applies to synchronous instructions: When the call of a synchronous instruction is ended, the execution is also ended.

This is different in the case of asynchronous instructions: When the call of an asynchronous instruction is ended, the execution of the asynchronous instruction is not necessarily ended yet. This means the execution of an asynchronous instruction can extend over multiple calls. The CPU processes asynchronous instructions in parallel with the cyclic user program. Asynchronous instructions generate jobs in the CPU for their processing.

Asynchronous instructions are usually instructions for transferring data (data records for modules, communication data, diagnostics data).

Difference between synchronous/asynchronous instructions

The figure below shows the difference between processing an asynchronous instruction and processing a synchronous instruction. In this figure the asynchronous instruction is called five times before the execution is completed, for example, a data record is completely transferred.

With a synchronous instruction, the instruction is fully executed in each call.

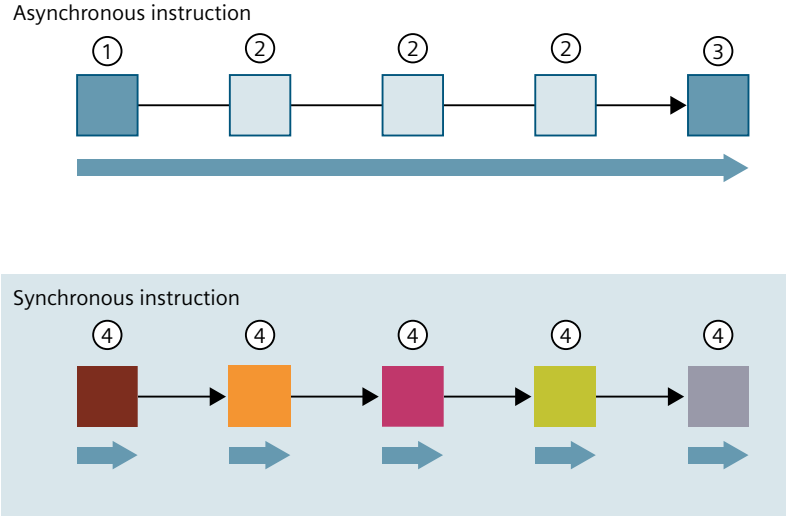

① First call of the asynchronous instruction, start of processing

② Intermediate call of asynchronous instruction, continuation of processing

③ Last call of the asynchronous instruction, termination of processing

④ The synchronous instruction is completely processed at each call

➡ Duration of the complete processing

Figure 1-65 Difference between synchronous and asynchronous instructions

Parallel processing of asynchronous instruction jobs

A CPU can process several asynchronous instruction jobs in parallel. The CPU processes the jobs in parallel under the following conditions:

- Several asynchronous instruction jobs are called at the same time.
- The maximum number of concurrently running jobs for the instruction is not exceeded.

The figure below shows the parallel processing of two jobs of the instruction WRREC. The two instructions are processed in parallel for a specific period here.

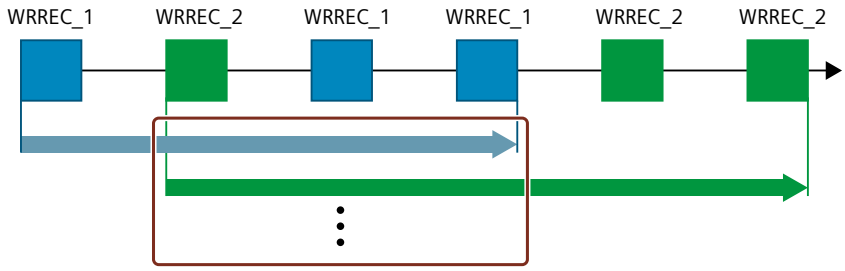

Figure 1-66 Parallel processing of the asynchronous instruction WRREC

NOTE

Dependencies between asynchronous instructions

The call sequence in the user program may differ from the processing sequence of the asynchronous instructions. This can lead to problems with dependencies between asynchronous instructions.

Solution: To ensure correct timing of processing, use the status outputs of the asynchronous instructions in a sequencer. If an asynchronous instruction is finished and this is acknowledged via the parameter DONE, then only the next asynchronous instruction should start.

Example: For the RecipeImport and RecipeExport recipe functions, you need a CSV file for the recipe data. If you use the same CSV file for import and export, then the two asynchronous statements are dependent on each other. Link the status of the DONE parameter of the RecipeImport instruction in a sequencer to the next step where the RecipeExport is executed. The link thus ensures correct processing.

Assignment of call to job of the instruction

To execute an instruction over multiple calls, the CPU must be able to uniquely assign a subsequent call to a running job of the instruction.

To assign a call to a job, the CPU uses one of the following two mechanisms, depending on the type of the instruction:

- Via the instance data block of the instruction (in the case of the "SFB" type)
- The input parameters of the instruction identifying the job. These input parameters must match in each call during processing of the asynchronous instruction.
  Example: A "Create_DB" instruction job is identified by the input parameters LOW_LIMIT, UP_LIMIT, COUNT, ATTRIB and SRCBLK.

  The following table shows which instruction you can identify with which input parameters.

Instruction	Job is identified by
DPSYC_FR	LADDR, GROUP, MODE
D_ACT_DP	LADDR
DPNRM_DG	LADDR

Instruction	Job is identified by
WR_DPARM	LADDR, RECNUM
WR_REC	LADDR, RECNUM
RD_REC	LADDR, RECNUM
CREATE_DB	LOW_LIMIT, UP_LIMIT, COUNT, ATTRIB, SRCBLK
READ_DBL	SRCBLK, DSTBLK
WRIT_DBL	SRCBLK, DSTBLK
RD_DPARA	LADDR, RECNUM
DP_TOPOL	DP_ID

Status of an asynchronous instruction

An asynchronous instruction shows its status via the block parameters STATUS/RET_VAL and BUSY. Many asynchronous instructions also use the block parameters DONE and ERROR.

The figure below shows the two asynchronous instructions WRREC and CREATE_DB.

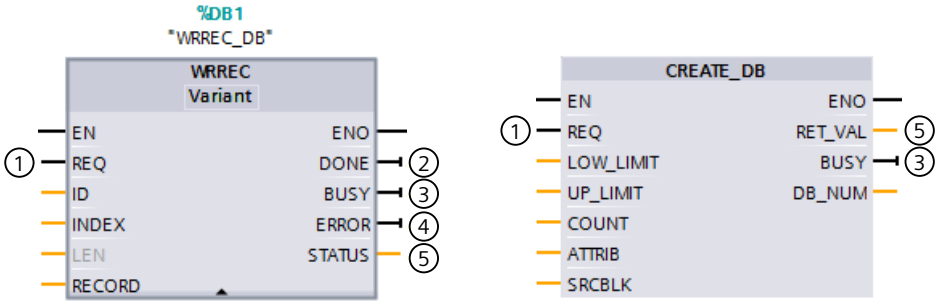

① The input parameter REQ starts the job to execute the asynchronous instruction.

② The output parameter DONE indicates that the job was completed without error.

③ The output parameter BUSY indicates whether the job is currently being processed. When BUSY =1, a resource is assigned for the asynchronous instruction. If BUSY = 0, then the resource is free.

④ The output parameter ERROR indicates that an error has occurred.

⑤ The output parameter STATUS/RET_VAL provides information on the status of the job execution. The output parameter STATUS/RET_VAL receives the error information after the occurrence of an error.

Figure 1-67 Block parameters of asynchronous instructions using the instructions WRREC and CREATE_DB as examples.

Summary

The table below provides you with an overview of the relationships described above. It shows in particular the possible values of the output parameters if processing is not completed after a call.

NOTE

Following every call, you must evaluate the relevant output parameters in your program.

Relationship between REQ, STATUS/RET_VAL, BUSY and DONE during a "running" job.

Seq. no. of the call	Type of call	REQ	STATUS/RET_VAL	BUSY	DONE	ERROR
1	First call	1	W#16#7001	1	0	0
			Error code (for example, W#16#80C3 for lack of resources)	0	0	1
2 to (n - 1)	Intermediate call	Not relev-ant	W#16#7002	1	0	0
n	Last call	Not relev-ant	W#16#0000, if no errors have occurred.	0	1	0
			Error code, if errors have occurred	0	0	1

Consumption of resources

Asynchronous instructions occupy resources in the CPU while they are being processed. The resources are limited depending on the type of CPU and instruction; the CPU can only process a maximum number of asynchronous instruction jobs simultaneously. The resources are available again after a job has been successfully completed or processed with an error.

Example: For the RDREC instruction, a 1512SP-1 PN CPU can process up to 20 jobs in parallel.

If the maximum number of concurrent jobs for an instruction is exceeded, the following occurs:

- The instruction returns error code 80C3 (lack of resources) in the block parameter STATUS.
- The CPU does not execute the job until a resource becomes free again.

NOTE

Lower-level asynchronous instructions

Several asynchronous instructions use one or more lower-level asynchronous instructions for their processing. This dependence is shown in the tables below.

Please note that, if there are several lower-level instructions, typically only one lower-level instruction is occupied at one time.

Extended instructions: maximum number of concurrently running jobs

Table 1-15 Maximum number of concurrently running jobs for asynchronous extended instructions and lower-level instructions used

Extended instructions	CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN	CPU 1512SP-1 PN CPU 1512SP F-1 PN
Distributed I/O		
RDREC	20	
RD_REC	10	
WRREC	20	
WR_REC	10	
D_ACT_DP	8	
ReconfigIOSystem	uses RDREC, WRREC, D_ACT_DP,	
DPSYC_FR	2	
DPNRM_DG	8	
DP_TOPOL	1	
ASI_CTRL	uses RDREC, WRREC	
PROFIenergy		
PE_START_END	uses RDREC, WRREC	
PE_CMD	uses RDREC, WRREC	
PE_DS3_Write_ET200S	uses RDREC, WRREC	
PE_WOL	uses RDREC, WRREC, TUSEND, TURCV, TCON, TDISCON	
Module parameter assignment		
RD_DPAR	10	
RD_DPARA	10	
RD_DPARM	10	
WR_DPARM	10	
Diagnostics		
Get_IM_Data	10	
GetStationInfo	10	
Recipes and data logging		
RecipeExport	10	
RecipeImport	10	
DataLogCreate	10	
DataLogOpen	10	
DataLogWrite	10	
DataLogClear	10	
DataLogClose	10	
DataLogDelete	10	

Extended instructions	CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN	CPU 1512SP-1 PN CPU 1512SP F-1 PN
DataLogNewFile	10	
Data block functions		
CREATE_DB	10	
READ_DBL	10	
WRIT_DBL	10	
DELETE_DB	10	
File handling		
FileReadC	10	
FileWriteC	10	
Reference information		
ResolveSymbols	10	
GetSymbolForReference	10	

Basic instructions: maximum number of concurrently running jobs

Table 1-16 Lower-level instructions used for asynchronous basic instructions

Basic instructions	CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN	CPU 1512SP-1 PN CPU 1512SP F-1 PN
Array DB		
ReadFromArrayDBL	uses READ_DBL (see Extended instructions)	
WriteToArrayDBL	uses READ_DBL, WRIT_DBL (see Extended instructions)	

Communication: maximum number of concurrently running jobs

Table 1-17 Maximum number of concurrently running jobs for asynchronous instructions and lower-level instructions used for Open User Communication

Open User Communication	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**	**CPU 1512SP-1 PN CPU 1512SP F-1 PN**
TSEND TUSEND	64	88
TRCV TURCV	64	88
TCON	64	88
TDISCON	64	88
T_RESET	64	88
T_DIAG	64	88
T_CONFIG	1	
TSEND_C	uses TSEND, TUSEND, TRCV, TCON, TDISCON	
TRCV_C	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON	
TMAIL_C	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON	

Table 1-18 Lower-level instructions used for asynchronous instructions for MODBUS TCP

MODBUS TCP	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**	**CPU 1512SP-1 PN CPU 1512SP F-1 PN**
MB_CLIENT	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON	
MB_SERVER	uses TSEND, TUSEND, TRCV, TURCV, TCON, TDISCON	

Table 1-19 Maximum number of concurrently running jobs for asynchronous instructions for S7 communication. The S7 communication instructions use a common pool of resources.

S7 communication	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**	**CPU 1512SP-1 PN CPU 1512SP F-1 PN**
PUT GET USEND URCV BSEND BRCV	192	264

Table 1-20 Lower-level instructions used for asynchronous instructions for communications processors

Communications processors	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**	**CPU 1512SP-1 PN CPU 1512SP F-1 PN**
PtP communication		
Port_Config	uses RDDEC, WRREC	
Send_Config	uses RDDEC, WRREC	
Receive_Config	uses RDDEC, WRREC	
Send_P2P	uses RDDEC, WRREC	
Receive_P2P	uses RDDEC, WRREC	
Receive_Reset	uses RDDEC, WRREC	
Signal_Get	uses RDDEC, WRREC	
Signal_Set	uses RDDEC, WRREC	
Get_Features	uses RDDEC, WRREC	
Set_Features	uses RDDEC, WRREC	
USS communication		
USS_Port_Scan	uses RDDEC, WRREC	
USS_Port_Scan_31	uses RDDEC, WRREC	
MODBUS (RTU)		
Modbus_Comm_Load	uses RDDEC, WRREC	
Modbus_Master	uses RDDEC, WRREC	
Modbus_Slave	uses RDDEC, WRREC	
ET 200S serial interface		
S_USSI	uses CREATE_DB	
SIMATIC NET		
FTP_CMD	uses TSEND, TRCV, TCON, TDISCON	

Table 1-21 Maximum number of concurrently running jobs for asynchronous instructions for OPC UA

OPC_UA	**CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN**	**CPU 1512SP-1 PN CPU 1512SP F-1 PN**
OPC_UA_Connect	10	
OPC_UA_Disconnect	10	
OPC_UA_NamespaceGetIndexList	10	
OPC_UA_NodeGetHandleList	10	
OPC_UA_NodeReleaseHandleList	10	
OPC_UA_TranslatePathList	10	

OPC_UA	CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN	CPU 1512SP-1 PN CPU 1512SP F-1 PN
OPC_UA_ReadList	10	
OPC_UA_WriteList	10	
OPC_UA_MethodGetHandleL-ist	10	
OPC_UA_MethodRelease-HandleList	10	
OPC_UA_MethodCall	10	
OPC_UA_ServerMethodPre	10	
OPC_UA_ServerMethodPost	10	
OPC_UA_ConnectionGetStatus	10	

Technology: maximum number of concurrently running jobs

Table 1-22 Maximum number of concurrently running jobs for asynchronous instructions for technology. The instructions for technology use a common pool of resources.

Technology	CPU 1510SP-1 PN CPU 1510SP F-1 PN CPU 1512SP-1 PN CPU 1512SP F-1 PN CPU 1514SP-2 PN CPU 1514SP F-2 PN CPU 1514SP T-2 PN CPU 1514SP TF-2 PN
Motion Control	
MC_Power MC_Reset MC_Home MC_Halt MC_MoveAbsolute MC_MoveRelative MC_MoveVelocity MC_MoveJog MC_MoveSuperimposed MC_Stop MC_WriteParameter MC_SetAxisSTW MC_MeasuringInput MC_MeasuringInputCyclic MC_AbortMeasuringInput MC_OutputCam MC_CamTrack MC_GearIn MC_TorqueLimiting MC_TorqueAdditive MC_TorqueRange	300

More information

You can find additional information on block parameter assignment in the STEP 7 online help.

Protection 11

11.1 Overview of the protection functions

Advantages and customer benefits of protection functions

The protection functions listed protect your investments from unauthorized access and manipulation, helping to secure plant availability.

Protection functions

To set up secure networks, the SIMATIC S7-1500 automation system offers an integrated security concept:

Table 1-23 Overview of protection functions

Protection function	Description
Integrity protection	The CPUs come with an integrity protection function as standard. This helps detect any manipulations: • In the engineering data on the SIMATIC Memory Card; see also information on the integrity protection of the SIMATIC Memory Card as of CPU FW version V3.1 in the next section • At the engineering data during data transfer between TIA Portal and CPU • At the engineering data during data transfer between HMI system and CPU • At the encrypted firmware
Protection of confidential configuration data	Protection of confidential CPU configuration data
Central user administration (as of firmware version 4.0)	Connection of a central server (UMC server) that is responsible for the administration and authentication of users. The central user management (User Management Component) allows the management of user groups and users independent of TIA Portal for comprehensive automation solutions.
Local user management (as of FW version V3.1)	Improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC). You can used the local user management in the editor to manage all project users along with their rights (e.g. access rights) for project users and roles in the TIA Portal.
Access protection (up to FW version V3.0)	Protection against unauthorized configuration changes using authorization levels
Know-how protection	Protection against unauthorized access and modifications to algorithms with password protection
Copy protection	Protection against duplication of programs by linking individual blocks to the serial number of the original memory card on the SIMATIC Memory Card
Protection by locking the CPU/interface module	Protection against unauthorized access by locking the front cover with a seal or a lock

You can find more information about security mechanisms of the SIMATIC automation systems in the Security with SIMATIC S7 controllers (https://support.industry.siemens.com/cs/ww/en/view/77431846) document and in the Com-

munication (https://support.industry.siemens.com/cs/us/en/view/59192925) Function Manual.

Integrity protection of the SIMATIC Memory Card, as of CPU FW version V3.1 or higher

With CPUs as of FW version V3.1, the integrity protection of the SIMATIC Memory Card depends on the password for protecting confidential configuration data that you assigned during the configuration of the CPU. This results in the following changes when using SIMATIC Memory Cards:

- To transfer a CPU to a card reader/USB memory device via drag and drop:
  For CPUs as of FW version V3.1, you need to enter the password of the CPU you want to use with the SIMATIC Memory Card. If you enter an incorrect password, the CPU will not start up after power on and will report the contents of the SIMATIC Memory Card as faulty.
- To insert a CPU from a card reader/USB memory device:
  In order to be able to verify the integrity of the included configuration in STEP 7, you must enter the password of the CPU from which the project was loaded. In this case, STEP 7 checks the data on the SIMATIC Memory Card and reports potential damage.
  Entering the password is optional. If you do not want to use the integrity check, you do not need to enter the password (restore project).

For CPUs with FW version V4.1 or higher, you can select whether you also want to protect the entire configuration of the CPU in addition to protecting the configuration data. The data is stored encrypted in the SIMATIC.S7S folder on the SIMATIC Memory Card and can only be decrypted with the password for protection of confidential configuration data.
If you revoke or add the setting for protection of all data, the contents of the SIMATIC.S7S folder on the SIMATIC Memory Card will be deleted at the next download to the CPU. Other files, such as recipes or backup files on the SIMATIC Memory Card, are not deleted. After the deletion, the CPU performs a restart.

You can find information on the folder structure on the SIMATIC Memory Card in the Structure and Use of the CPU Memory
(https://support.industry.siemens.com/cs/ww/en/view/59193101) Function Manual.

Secure communication

There is an increasing need to transfer data to external computers in encrypted form via Intranet or public networks.

SIMATIC S7-1500 CPUs and ET 200 CPUs with firmware version 2.0 and higher support the Internet PKI (RFC 5280) with STEP 7 as of V14. This makes the configuration and the operation of Secure Communication possible, for example:

- Hypertext Transfer Protocol Secure (HTTPS)
- Secure Open User Communication
- Secure Communication with OPC UA

A public key infrastructure (PKI) can issue, distribute and check digital certificates. For S7-1500 CPUs, you create certificates for various applications in the CPU properties in STEP 7, for example: TLS certificates for Secure Open User Communication, web server certificates, OPC UA certificates.

With STEP 7 and WinCC as of version V17, SIMATIC S7-1500 CPUs and ET 200 CPUs as of firmware version 2.9 support innovated and standardized secure PG/PC and HMI communication – referred to as Secure PG/HMI communication for short.

Further measures for protecting the CPU

The following measures additionally increase the protection against unauthorized access to functions and data of the ET 200SP CPU from external sources and via the network:

- Deactivation of the Web server
- Deactivation of the OPC UA server (you can find additional information on the security mechanisms for OPC UA server in the Communication (https://support.industry.siemens.com/cs/us/en/view/59192925) Function Manual)
- Deactivation of the time synchronization via an NTP Server
- Deactivation of the PUT/GET communication
- Deactivation of SNMP

When you use the Web server, protect your S7-1500 automation system against unauthorized access:

- By setting password-protected access rights for specific users in the user administration.
- By using the pre-set option "Permit access only via HTTPS".
  The option allows access to the web server only with the secure hypertext transmission protocol HTTPS.

When you use the OPC UA server, protect your S7-1500 automation system against unauthorized access:

- By not setting up OPC UA server access for the "Anonymous" user.
- By disabling the "Automatically accept client certificates during runtime" option.

Security functions in communications processors

Communications processors support security functions, such as access protection using a firewall, protection against data manipulation using VPN, FTPS, HTTPS, SNMPv3, and secure NTP.

More information

You can find more information on the protection functions described in the STEP 7 online help.

Siemens products and solutions are only one element of a comprehensive industrial security concept. Observe the additional information on Industrial Security (http://www.siemens.com/industrialsecurity).

11.2 Protection of confidential configuration data

As of STEP 7 V17, you have the option of assigning a password for protecting confidential configuration data of the respective CPU. This refers to data such as private keys that are required for the proper functioning of certificate-based protocols.

You can find detailed information on protecting confidential configuration data in the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) function manual.

NOTE

Replacement part scenario

Replacing the CPU in a replacement part scenario has an impact on the password for protection of confidential configuration data. When you replace the CPU, observe the rules for the replacement part scenario in the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) function manual.

11.3 Local user management

11.3.1 Useful information on local user management and access control

As of TIA Portal version V19 and CPU firmware version V3.1, ET 200SP CPUs have an improved way to manage users, roles and CPU function rights (User Management & Access Control, UMAC).

For HMI devices, authentication is not possible via either local or central users (TIA Portal V19/V20).

Starting from the above-named versions, you manage all project users along with their rights (e.g. access rights) for CPUs in the project in the editor for users and roles of the project in TIA Portal:

- To manage users along with their rights, for example, to control access rights, navigate to the "Security Settings > Users and roles" area in the project tree.

TIA Portal saves the assignment of the function rights of a CPU to user-defined roles and the assignment of these roles to users for each CPU. There are no system-defined roles with predefined function rights for CPUs.

The user management becomes effective in the respective CPUs after the configuration is loaded. Each CPU then "knows" who may access which service and execute specific functions.

This new approach is also referred to hereinafter as "local user management and access control".

NOTE

Support of central users and groups for CPU function rights

UMC (User Management Component) can also be used to manage users centrally in TIA Portal. With this component, you manage central users and groups on connected UMC servers, e.g. by connecting an MS Active Directory. The authentication is then implemented using UMC. The central user management for CPU-specific function rights via UMC is currently supported as of TIA Portal V20 and CPU FW version V4.0 (see Useful information on central user management and access control (Page 242)).

User management as a component of your security strategy

Carefully designed user management increases the security of your automation solution - but only if you ensure the confidentiality of the user-relevant information.

In addition, the rules for industrial cybersecurity must be observed, for example the security concept "Defense in Depth", in particular the remarks on plant security and hardening measures.

Detailed information is available in the section Industrial cybersecurity (Page 33).

Users, roles and function rights

Users and roles were also managed in the predecessor versions of TIA Portal under "Security settings > Users and roles". In addition to the existing user management options, e.g. for HMI devices, you can also manage all CPU function rights in this editor starting from TIA Portal Version V19.

The CPU function rights are effective in runtime, which is why you will find these rights on the "Runtime rights" tab in the editor for users and roles. For each CPU in the project, there is a section with all CPU function rights to choose from - separated according to CPU services such as PG/HMI communication (engineering access, access levels), web server and OPC UA.

Besides the user management for projects, additional user management possibilities were available for the web server and OPC UA server in the CPU properties (static user management for CPUs up to FW version V3.0):

- Users for the OPC UA server (authentication)
- Users for the web server (authentication and access control)

These additional user management possibilities have been integrated in the local user management in the project tree as of TIA Portal V19 and CPU FW version V3.1.

Introduction to local user management and access control

For CPUs up to firmware version V3.0, users were managed under the respective CPU properties for the individual services "Web server", "OPC UA", etc. Web server users were managed in the "Web server" area, OPC UA users in the "OPC UA" area.

To restrict access by the PG/HMI to the CPU using access levels, you assigned passwords for the respective levels. With this approach, for example, HMI accesses could be permitted without restriction, but write accesses could be made dependent on the knowledge of a password. You assigned the passwords for the different access levels in the "Protection & Security" area of the CPU properties. As a result, the access protection always applied to groups having the corresponding passwords and not to individual users.

With the introduction of local user management and access control in TIA Portal version V19, you use the "Security settings > Users and roles" area in the project tree in TIA Portal to manage all users, together with their roles and function rights, of a CPU. This same holds for the access protection for engineering/HMI accesses, which as of TIA Portal version V19 no longer relies on access levels with password protection by default but instead on the user management.

You can find more information on the new access protection here (Page 236).

As already introduced, e.g. for engineering rights, you use role assignments for combining individual function rights. In a further step, you assign the roles to individual users. The "Assigned rights" tab lists all function rights that were assigned to a user via roles and that the user can exercise for the corresponding CPU.

The following figure shows an example of the available and activated function rights of a CPU. At least one user must have full access to the CPU. Otherwise, the configuration cannot be compiled. A role with full access to the CPU must be created for this.

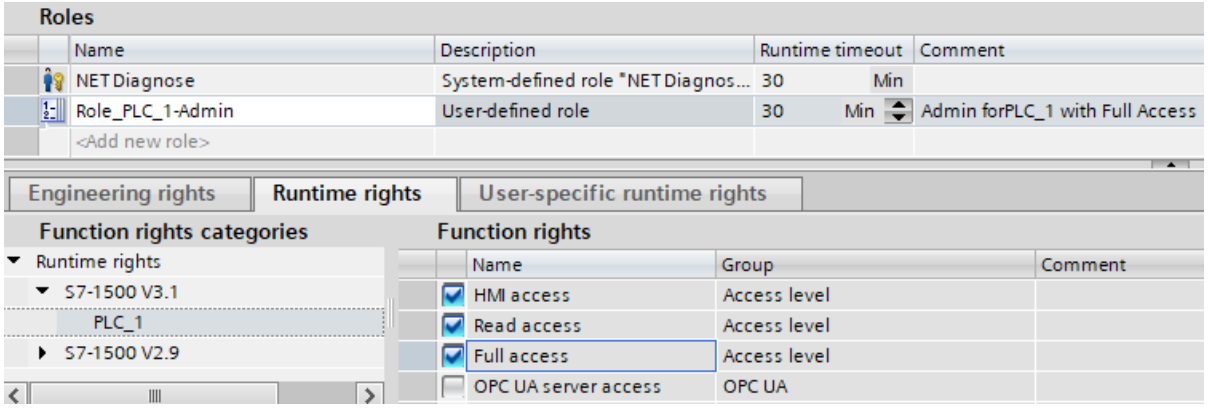

Figure 1-68 Assigning function rights of a CPU to a role

The following figure shows the assignment of the role with full access to a user ("Admin").

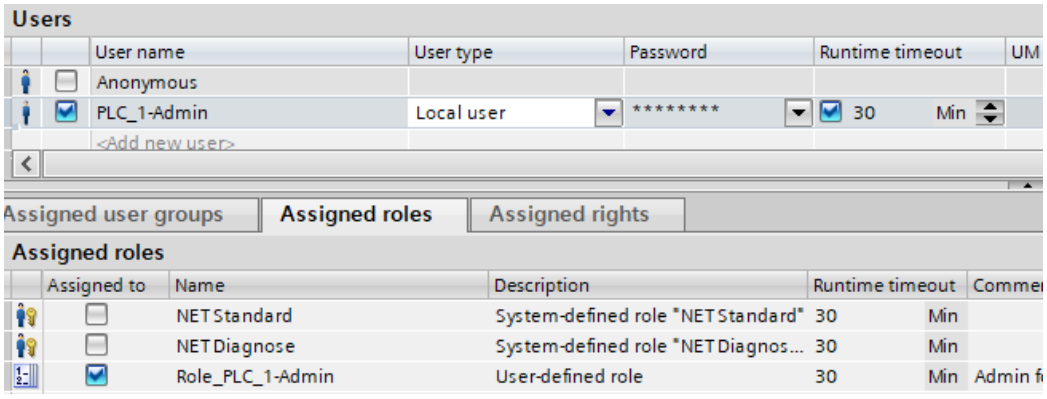

Figure 1-69 Assigning a role to a user

Requirement

CPU parameter assignment: To make use of users, roles and function rights for a CPU, the "Enable access control" option must be selected in the "Protection & Security > Access control" area.

In the "Configuration of user management" area, the "Local user management" option is preset, whereby the users are loaded to the CPU.

If you select the option "Central user management", you have to add additional parameters such as the UMC server address and server ID (see Useful information on central user management and access control (Page 242)).

No project protection is required for the user management.

Default characteristics

The "Enable access control" option is selected by default for the access control. Users can be configured with their assigned passwords and their roles and function rights.

Loading to device

If you want to download changes to the user configuration in RUN mode, the hardware configuration in the CPU and in the STEP 7 project must be unchanged. Otherwise, a transition to STOP is required to download the user configuration together with the changed hardware configuration.

Save your STEP 7 project and then configure only the desired changes in the user configuration. Load your project into the CPU.

Changes to the access rights for the "Anonymous" user can only be loaded in STOP mode.

A fail-safe ET 200SP CPU may only load a user to whom the runtime right "Full access including fail-safe" is assigned. Otherwise, STEP 7 displays an error message when loading the configuration.

Explanations of the options for the user management download (Load preview):

- If you select the option "Keep online user management data", the local user management is not downloaded to the CPU.
- If you select the option "Download all user management data (reset to project)", all passwords changed online via WebAPI are deleted. After the download, the configured local user data is valid.
- If you select the option "Update user management data, but keep online passwords" and have not changed existing user names, the passwords changed online via WebAPI are retained. Only changes to function rights and/or roles take effect. Newly configured users are downloaded with their settings and deleted users are no longer available after the download to the CPU.
  If you have changed a user name in the project and assigned a password to this user in the project, this setting takes effect after the download. The previously valid user name with the password changed online is deleted during the download.

Runtime timeout

You can set a runtime timeout for both the role and the user in "Security settings > Users and roles".

For an ET 200SP CPU, these settings are taken into account by the various services as follows:

- By means of the Web API you can, for example, create a web page or application that takes the settings for the runtime timeout into account. Standard web pages do not take the settings for the runtime timeout into account and use the default value.
- The other services (PG/HMI communication and OPC UA server) do not use the runtime timeout; the logged-in user is not logged out after the set time.

11.3.2 Advantages of local user management and access control

The advantages of the new local user management for CPUs and the changes associated with it are described in the following.

Quick activation/deactivation of local user management

The options for user management can be found in the "Protection & Security > Access control" area:

- Access control disabled: Every user has full access to all functions with the exception of the GDS Push function for the online transfer of certificates.

  ⚠ WARNING

  Disabled access control carries the risk of unauthorized access and thus the risk of personal injury and property damage.

  Only use this setting in a protected environment, such as during commissioning.

- Access control enabled: The configured users with their assigned roles and associated function rights become effective after the configuration is loaded.

Access protection for PG/HMI accesses, now with user authentication

While it was possible to assign passwords for access levels for CPUs with firmware versions <V3.1, you can configure users with corresponding function rights for the current CPUs. This means that PG/HMI accesses can be authenticated in the same way as OPC UA and web server accesses.

Everything in one place

Irrespective of the service for which you configure users, roles and rights for a CPU: you manage the data at the same place.

All users, no matter if you're managing their engineering rights for the project or their local runtime rights for individual CPUs in the project, can be found in the editor for users and roles in the project tree.

Powerful password functions

- Support for compliance with complexity rules for password creation:
  Already at the password creation stage, you can have the TIA Portal check for compliance with complexity rules, such as rules on password length, uppercase/lowercase letters (project tree, "Security settings > Settings" area).
  The complexity rules are also saved in the CPU when the user management is loaded. When the password is changed online, the CPU identifies and applies these rules. This prevents a user from overriding the complexity rules set by the configuration engineer and assigning an insecure password.
- The period of validity of passwords can be set:
  To ensure that a user does not have access to the CPU with a compromised password for an unlimited time, you can assign a period of validity. The time remaining until the validity expires is then displayed on login so that each user can change his password in time.

Loading the user management during operation

As of firmware version V3.1, certain security-relevant configuration data can be loaded in both STOP and RUN system state. This means that loading the hardware configuration does not necessarily lead to a CPU STOP.

You can load the following changes in both STOP and RUN system state (Download to device > Hardware configuration):

- Local user management extended/changed
- TIA Portal-configured certificates modified
- Syslog configuration changed

If you made additional changes to the hardware configuration (for example, modules added, parameters changed, etc.), then the CPU automatically requests the STOP state before loading the configuration.

Therefore, when loading just one user with modified roles/function rights to the CPU, for example, this process does not require the CPU to be in STOP state.

The load preview dialog contains a security area where you can define how the CPU is to handle user data changed since the last load operation (not when loading for the first time). This allows changes to user data (e.g. password changes during runtime) to be retained.

Loading the device as a new station - with user data

If you load a previously configured CPU into a new project, for example, because you do not have the original project, the user data is also loaded into the project and is available for further editing of the CPU settings.

Changing passwords during operation

You can use the web server API to write an application that any user can use to change his password at runtime, provided that the original password was entered correctly and the new password complies with the configured password policy.

Requirement: You have enabled access control for the CPU.

A use can change his own password at any time, even if the password has expired. If the password has expired, the user must change his password. Login is not possible with an expired password.

API methods used:

- Api.ChangePassword
- Api.GetPasswordPolicy

You can find more information about the API methods in the Web server Function Manual (https://support.industry.siemens.com/cs/us/en/view/59193560).

NOTE

Passwords changed at runtime take precedence over loaded passwords

If you changed your password during operation and subsequently load your project, the password assigned during runtime takes precedence over the password set in the project (default setting).

If you want to overwrite the passwords changed during runtime by loading the project, you must select the option "Load all user management data (reset to project data)". In this case, **all** passwords changed during runtime will be lost.

11.3.3 From access level to user function rights

The implementation of access protection for CPUs with the new local user management is described in the following.

Access levels as function rights

While access could only be controlled using passwords for ET 200SP CPUs up to FW version V3.0, you create corresponding users and roles with the necessary function rights for access control for CPUs as of FW version V3.1. The assignment between access level and the associated function right results from the already known access levels:

- Users who are to have full access must have a role with the function right "Full access".

  A CPU configuration can only be compiled and loaded if at least one user has the function right "Full access" or "Full access incl. fail-safe".
- Users who are to have read access must have a role with the function right "Read access".
- Users who are to have HMI access must have a role with the function right "HMI access".

If a user has none of these function rights, that user also has no access to the CPU.

The hierarchical organization of the access levels also remains the same for the corresponding function rights:

- A user with full access also has the function rights "Read access" and "HMI access".
- A user with read access also has the function right "HMI access".

NOTE

Compatibility of the "ENDIS_PW" instruction

The "ENDIS_PW" instruction can be used only to disable or enable passwords for protection levels. The "ENDIS_PW" instruction has no effect on assigned rights for users or roles.

Continued use of access levels

Even though the new local user management replaces the familiar access protection using corresponding function rights of individual users, the option exists to continue using this familiar access protection. This is required, for example, for HMI devices that only support access levels and are unable to make use of the new user management.

If you need configuration of an access level, for example, to grant access to an HMI device without user and password assignment, select the "Use legacy access control via access levels" option in the CPU properties.

NOTE

Users for OPC UA and web server

Independent of the access protection, you always have to configure the users for the web server and OPC UA server in the project tree ("Security settings > Users and roles" area).

Restrictions on continued use of the access levels

When using the "Legacy access control" option, you cannot select the access level directly in the table for setting the access levels. This selection can only be made for the new local user management in one way: using the access protection function rights of the "Anonymous" user.

The system creates the local "Anonymous" user in a project by default. With the help of this user, you define the behavior of the CPUs in the project for anyone who logs in without a user name and password. For security reasons, the anonymous user is deactivated and must be activated before use.

A link in the area where you set the access levels takes you to the editor for the required settings for the "Anonymous" user.

Examples:

- If the "Anonymous" user is deactivated or if the "Anonymous" user is activated and no function rights have been assigned to that user, then nobody can log in without a user name and password (corresponds to the access level "No access (complete protection")).
- If the "Anonymous" user is activated and the "Full access" function right for a CPU is assigned to that user via a corresponding role, the result of this setting is "No protection". You achieve the same effect with regard to access protection by setting "No access protection" in the "Protection & Security" area of the CPU properties.

Procedure

To activate the "Legacy access control" and set the required access level, follow these steps:

1. In the CPU properties, go to "Protection & Security > Access control".
2. Select the option "Enable access control" and, in addition, select the "Use legacy access control via access levels" check box.

   The access level selection cannot be used in this setting. You set the access level using the "Anonymous" user of the CPU.

   The "Anonymous" user is deactivated by default. This means that the resulting access level for users without a password is "No access (complete protection)" (default setting).
3. Go to "Security Settings > Users and roles" in the project tree.
4. Activate the "Anonymous" user, if you want to set a different access level than "No access (complete protection)". You can assign a role with function rights that grants access to the CPU without password input only to the activated "Anonymous" user.
5. You cannot assign function rights for a CPU directly to a user. You must first create a role: Therefore switch to the "Roles" tab and add a new role. Assign a meaningful name, e.g. "PLC1-Read-Access-Role". If you assign this role to a user, this user is to have read access to PLC1 during operation.
6. Assign the required function right for accessing the CPU named "PLC1" – in this case "Read access" – to the role "PLC1-Read-Access-Role".
7. Switch to the "Users" tab and assign the "PLC1-Read-Access-Role" role to the activated "Anonymous" user.

   Result: The "Anonymous" user has read access for PLC1. This means that the access level tables of the CPU "PLC1" in the project are preset to "Read access" (cannot be changed) and users who are not logged in only have read access.

For full access, or full access including fail-safe, you must configure a password for the full access in the table for the access protection. Anyone performing an action at runtime requiring full access to the CPU, e.g. a project is to be loaded to the CPU, must legitimize themselves for this action with this password.

Tip

To make the user rights transparent, use meaningful names for the respective roles. You create users and roles for the entire project; you must select the function rights of a role individually for each CPU in the project. A descriptive name allows you to recognize immediately the CPUs for which read access is granted and the CPUs for which no access is granted (complete protection).

11.3.4 Information regarding compatibility

In the following sections, you will find information on the behavior of the CPUs with local user administration when, for example, modules are exchanged in STEP 7 and on further use of projects and programs without local user administration.

Replacement part scenario

If you replace a CPU with firmware version <V3.1 with a CPU with firmware version V3.1 or higher, the program stored on the memory card runs the same as on the original CPU. The behavior with regard to the configured access levels and the users for the OPC UA server and web server corresponds to the behavior of the predecessor CPU.

In this case, the "Change password function" via the web server API is not accepted by the CPU because the CPU has been configured for firmware version < V3.1 and has no local user management.

Exchanging the CPU (upgrade)

If you exchange a CPU (FW <V3.1) in the TIA Portal for a current CPU (FW V3.1 or higher), the configured user data is affected as follows:

- The user data of the OPC UA server and web server is transferred to the "Users and roles" editor in the project tree.

NOTICE
Passwords are lost when the CPU is exchanged Make sure that the passwords are available before exchanging the CPU. They must be entered again in the "Users and roles" editor. Otherwise, you have to assign new passwords and inform the users.

- A corresponding role is created for each web server user in the "Users and roles" editor; the name of the role contains the CPU name, the string "Web" and the already configured web server user name. In this way, you can easily restore the original rights for each CPU by assigning these roles in the "Users and roles" editor.

- The "OPC UA server access" role is created for each OPC UA server user.
- OPC UA guest access and the web server user "Everybody" are migrated to the "Anonymous" user.
- Each OPC UA user and each web server user is listed in the "User" column in the "Users and roles" editor. If there is a web server user and a OPC UA user with the same name, only one user is created.
- For a protected project, you can select which action the CPU performs:
  - Migrate users (requirement: you are logged in as a user with the right to manage users and roles and the right to edit the project/configuration)
  - Remove users
  - Cancel
- The "Legacy access control via access levels" option is set for access protection.

Exchanging the CPU (downgrade)

If you exchange a CPU (FW V3.1 or higher) in the TIA Portal for a predecessor CPU (< FW V3.1), the configured user data is affected as follows:

- The local user management is no longer available.
- Users with function rights for the web server are not transferred.
- Users of the OPC UA server remain with their user rights in the "Users and roles" editor. No users are moved to the "OPC UA" area of the CPU parameters.
- It is no longer possible for users to change passwords during runtime (via web server API).

11.4 Temporary account lock in case of brute force attacks

Useful information about brute force attacks

In a brute force attack, combinations of credentials (for example, user name and password) are systematically tried out with the aim of gaining access to a user account. Trying all options requires a lot of computing effort and time until a correct combination of user name and password is found.

Brute force attacks are particularly effective with weak or simple passwords.

Protecting a CPU from brute force attacks

As of STEP 7 V19, you can define password policies in the project tree under "Security settings" and thus ensure that strong passwords are assigned.

As of STEP 7 V21, there is the additional option of setting up a temporary account lock for CPUs as of FW version V4.1. You can only configure the temporary account lock for local user accounts. For central user accounts, protection against brute force attacks is configured directly on the UMC server.

You specify a maximum number of failed login attempts per time unit (monitoring time). If the specified number of failed login attempts is reached within the monitoring time, the

period of the account lock (lockout duration) begins. During this time period, every login attempt is unsuccessful, regardless of whether the login data is correct or incorrect.

The indicator for hits ("correct password") is masked. The attacker does not receive any feedback about the temporary lock.

Configuring the locking of the local user account in STEP 7

To configure the locking of the local user account, follow these steps:

1. Place the required ET 200SP CPU from the hardware catalog in the network view.
2. Select the ET 200SP CPU in the network view of STEP 7.
3. In the Inspector window, navigate to "Properties > General > Protection & Security > Lockout of user account at runtime".
4. Select the "Lockout of the user account after failed login attempts" check box.

   The fields below become editable.
5. Edit the other fields according to the following options:
   - Max. failed login attempts:

     Define the number of failed login attempts that will be accepted by the ET 200SP CPU for a user account. If this number is reached within the monitoring time, the affected user account will be locked.

     Default: 5 failed login attempts
   - Monitoring time:

     Determine the time period between failed login attempts for a user account. The time period starts again after each failed login. If a valid login attempt is made within the time period, the time is reset.

     Default: 2 minutes
   - Lockout duration:

     Determine the time period for which the user account should be locked. The time period starts when the set number of failed login attempts for a user account is reached within the monitoring time. The ET 200SP CPU refuses all login attempts during the lockout duration. If an unsuccessful login attempt is made during the lockout duration, the set lockout duration starts again.

     Default: 2 minutes

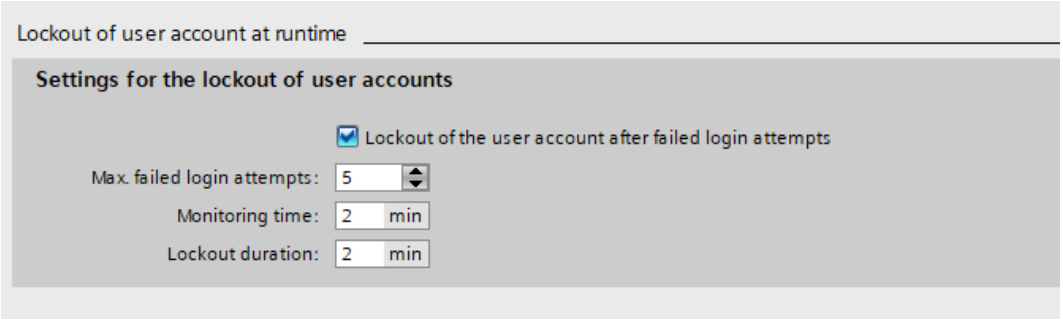

Figure 1-70 Configure the locking of the user account during runtime

6. Download the configuration to the ET 200SP CPU.

Result: You have configured the settings for lockout of user accounts and downloaded them to the ET 200SP CPU.

The following figure shows an example of the procedure for locking a user account. A maximum number of 4 incorrect login attempts was set here.

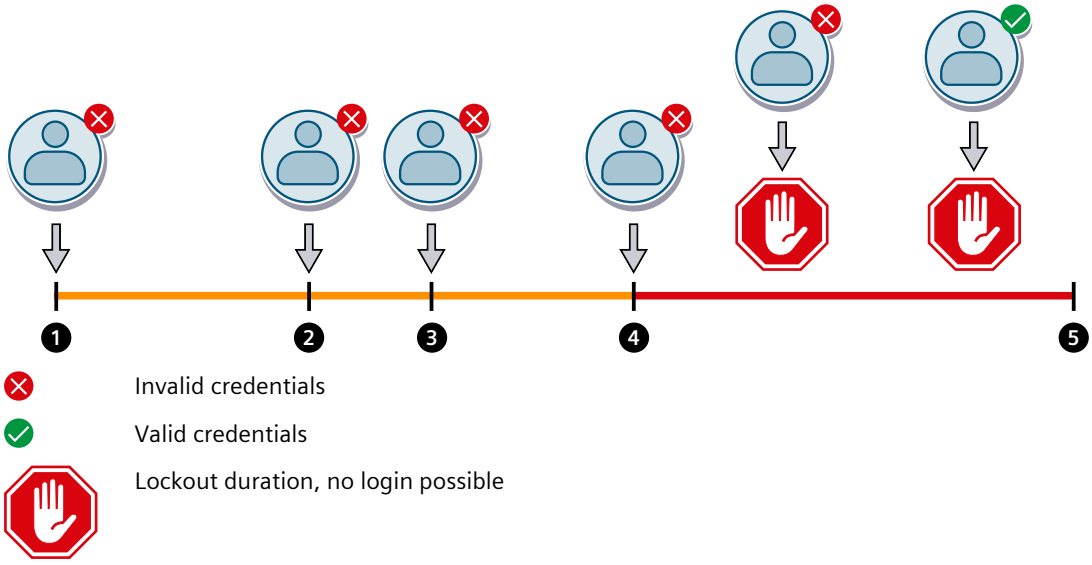

Figure 1-71 Sequence in the event of failed login attempts on an ET 200SP CPU

1. Failed login attempt no. 1:

   The set monitoring time starts. The counter for the number of failed login attempts is set to 1.

2. Failed login attempt no. 2 within the monitoring time:

   The set monitoring time starts again. The counter for the number of failed login attempts is incremented by 1.

3. Failed login attempt no. 3 within the monitoring time:

   The set monitoring time starts again. The counter for the number of failed login attempts is incremented by 1.

4. Failed login attempt no. 4 within the monitoring time:

   The set number of failed login attempts within the monitoring time has been reached. The set lockout duration starts.

   As long as the lockout duration is running, the CPU responds to each login as if it were an incorrect login attempt (no login possible). A login attempt with incorrect credentials during the lockout duration leads to a restart of the lockout duration.

5. After lockout duration elapses:

   Login attempts are again accepted by the CPU. The counter for the number of failed login attempts is reset to 0.

Influence of events on the temporary account lock

The following states and events belong to the temporary account lock:

- Incorrect login attempt detected
- Ongoing monitoring time
- Current lockout duration

The following events reset all states of the temporary account lock for all local users:

- Transition from POWER-ON to POWER-OFF
- Download to CPU

Password changes by local users during operation via the Web API have **no** effect on the temporary account lockout.

11.5 Central user management

11.5.1 Useful information on central user management and access control

As of TIA Portal version V20 and CPU firmware version V4.0, ET 200SP CPUs have the possibility to leave the authentication of users to a central UMC server.

As of the versions specified above, you manage users centrally and combine multiple users with the same roles/function rights into one group.

The central authentication service is performed in this case by the UMC (User Management Component).

You set up linking between user/group and assigned roles and function rights in the editor "Users and roles" in TIA Portal - as with the local user management.

For HMI devices, the authentication is not possible via either local or central users (TIA Portal V19/V20).

User management as a component of your security strategy

Carefully designed user management increases the security of your automation solution - but only if you ensure the confidentiality of the user-relevant information.

In addition, the rules for industrial cybersecurity must be observed, for example the security concept "Defense in Depth", in particular the remarks on plant security and hardening measures.

Detailed information is available in the section Industrial cybersecurity (Page 33).

Advantages of central user management

Central user management allows management of users and user groups independently of TIA Portal. This enables the user management to be scaled from a few users and CPUs in a single project (local user management) up to extensive automation solutions with multiple projects, users and user groups (central user management) – without increased workload.

If you use the central user management (UMC), you can, for example, configure user groups on the UMC server set up for this purpose. The users of a group then have the same roles and function rights on the CPU.

During operation, users can be added to or removed from a group or passwords can be changed on the UMC server. The CPU configurations do not need to be changed and reloaded.

WARNING

Decoupling the user management from the CPU involves risks

When central user management is used, the CPU or TIA Project has no way of checking the central user administration. UMC administrators must carefully check the effect of their changes with regard to modified roles and function rights.

Changes to central users at the time of the change do not affect the existing connection to the CPU at this time. These include, for example, the following changes:

- Delete a user on the UMC Server
- Users are moved to other groups on the UMC server and thus get other roles and rights.

The changed user configuration will only take effect when you log in again.

Requirements

The configuration in the editor for users and roles (TIA Portal) provides you with a wide scope of usage scenarios in connection with UMC:

- Programming device with TIA Portal is connected to a UMC domain. In this case, the users and groups can be synchronized in the editor for users and roles.
- Programming device with TIA Portal is not connected to a UMC domain but the names of the user groups/central users used in operation are known and can be added without contact to the UMC server.

  The names of the user groups/central users can also be entered without connection to the UMC domain and synchronized with the UMC domain later.

  The synchronization is not necessary for authentication of CPU users via a UMC server. The group names or user names only have to match to make use of the authentication service.

A CPU which needs to authenticate the querying users (e.g. via web, PG/HMI communication or OPC UA) for diverse online functions requires the following information for access to the authentication service:

- The UMC server address

  Example: https://central.umc.testnet:443/ra

  (443 = port for https, ra = remote authentication)
- A server ID (fingerprint of the server certificate).

  You can determine the fingerprint of a certificate through Windows (open the certificate, "Details" tab, "Fingerprint" field).

As an alternative to the server ID, you can configure a list of CA certificates. These certificates are used by the CPU to verify the certificate returned by the UMC server when a connection is established. In order for the verification to be successful, the entire certificate chain down to the root certificate must have been loaded. The verification does not work for end-entity certificates or for intermediate certificates without a certificate chain to the root certificate.

Further requirements for operation (Runtime):

- User groups and users have been set up on the UMC server.
- A connection can be established between the CPU and UMC server via the configured UMC server address.
- CPU time is current. As with local user management, central users are informed about the remaining validity of their password. CPU and UMC server must have the same date and time settings.

NOTE

No logon possible if the UMC server is not available or the CPU time is reset

- If you use only UMC users and UMC user groups to access the CPU during operation and the UMC server becomes unreachable, e.g. due to connection abort, then no one can log on anymore.
  - To enable access to the CPU in this case, configure at least one local user with the required roles/function rights.
- If you use UMC user groups or UMC users to access the CPU during operation, the CPU time must be up-to-ate.

  If the CPU time has been reset, e.g. by restoring the factory settings, and no NTP time synchronization has been configured, it is also not possible to log on via the central user management. Authentication of the UMC server using certificates requires an up-to-date CPU time.
  - To enable access to the CPU in this case, configure at least one local user with the required roles/functional rights to set the time (e.g. from the "Web server - Maintenance" group).
  - Alternatively, you can synchronize the CPU time using NTP servers (for information on configuration, see section Time synchronization (Page 312)).

Basic procedure for using the User Management Component (UMC)

The following basic steps are required to use the User Management Component (UMC):

1. Installation of UMC on one or more computers in the system.
2. Assigning a corresponding UMC version as a UMC ring server or UMC server. This creates a UMC system consisting of one or multiple UMC computers.
3. Creating users and user groups in UMC. These can exist only in UMC or can be imported from a Microsoft Active Directory.
4. Connection of the UMC agent that is installed on the computer with the TIA Portal installation. The connection can be established with the TIA Administrator or with the Windows command line.
5. Usage of UMC users and UMC user groups, for example, in the context of the TIA Portal project creation.
6. Authentication of UMC users after logging on via UMC.

NOTE

Enabled "Anonymous" user is always loaded

An enabled "Anonymous" user with its configured roles/function rights is loaded even if you only enabled the central user management. Local user management does not have to be additionally enabled for the "Anonymous" user to take effect.

Additional information on the UMC server

More information on setting up (installing, configuring) a UMC server as well as creating central users and groups can be found here (https://support.industry.siemens.com/cs/us/en/view/109780337).

11.5.2 Configuring central user management in the editor for users and roles

The procedure for the configuration of the central user management in the TIA Portal version V20 with an ET 200SP CPU is described below (firmware version as of V4.0).

We distinguish between the following use cases:

- The project is configured in the environment that has access to the UMC server.
- The project is created in an environment that has no access to the UMC server.

  This is, for example, the case for a machine that is configured independently of the later place of installation and environment. The parameters for the user management must still be modified at the installation location.

Requirements - TIA Portal has access to the UMC server

- TIA Portal, editor for users and roles: The needed roles have been configured and the required function rights for these roles have been assigned.
- There is an online connection to the UMC server.

Procedure - Creating a new user group

To create a new user group, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Select the "User groups" tab.
3. Click the "Add new UMC user group" button.

4. Log on to the UMC server as the admin user.
5. In the dialog for selecting the user groups, select the user groups to be imported into the editor.
6. Assign the desired roles to the groups.

Procedure - Creating a new central user

To create a new central user, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Select the "User" tab.
3. Click "Add user".

4. Log on to the UMC server as the admin user.
5. In the dialog for selecting the central users, select the users to be imported into the editor.
6. Assign the desired roles to the users.

Requirements - TIA Portal has no access to the UMC server

- TIA Portal, editor for users and roles: The needed roles have been configured and the required function rights for these roles have been assigned.
- There is no online connection to the UMC server at the time in which user management is configured.

NOTE

Case sensitivity of user name

Although the UMC server does not differentiate between upper and lower case of the user name/group name when logging on, deviations in case prevent the user from logging on for users/groups who are configured offline or unsynchronized in the TIA Portal.

Recommendation:

- Before login, synchronize users and user groups in the TIA Portal and download this configuration to the CPU. In this case, the case of the user name is not relevant during logon.
- If possible, import users/groups as described above.

Procedure - Creating a new user group

To create a new user group, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Select the "User groups" tab.
3. Click in the <Add new user group> field in the "Name" column.

   The TIA Portal enters a default name.
4. Modify the default name - this name will be used in the target environment of UMC.

   The name can also be modified in the target environment during commissioning.

Result: The groups are set up but not synchronized, i.e. no UM domain ID is assigned.

When a connection to the UMC server exists in the target environment, the following process takes place when a central user logs on:

- The CPU forwards the authentication request to the UMC server.
- After a successful check, the UMC server returns a list of groups to which the logged-on user belongs.
- The CPU determines the assigned roles and function rights for the user based on the group names.

Procedure - Creating a new central user

To create a new central user, follow these steps:

1. Open the editor for users and roles (project tree: Security settings > Users and roles).
2. Click in the <Add new user> field in the "User name" column.

   The user type "Local user" is preset.
3. Modify the default user name - this name will be used in the target environment of UMC.
4. In the column "User type" change the entry to "Central user".

Result: The central user has been set up but not yet synchronized, meaning that no UM domain ID is assigned.

In the target environment with a connection to a UMC server, you can still adjust the provisional group and central user names using the TIA Portal.

Changing the user type - Effects

- When you change the user type (central user > local user), the data for the connection to the UMC server is lost (UM domains ID).
- When the user type is changed from local user to a central user, the configured password and the comment are lost.

11.5.3 Configuring central user management for an ET 200SP CPU

The procedure for configuration of the ET 200SP CPU is described below (firmware version as of V4.0).

Procedure - CPU configuration for central user management

To configure the central user management for an ET 200SP CPU, follow these steps:

1. Place the CPU and navigate to the area "Protection & Security > Access control".
2. Ensure that access control has been enabled (access control via protection levels may be enabled or disabled).
3. Select the option "Use central user management (users taken from UMC server)".

   In addition, the local user management can also be activated in order to still be able to access the CPU if the connection to the UMC server fails, for example.
4. Add the specifications to the UMC server address and server ID for authentication of the UMC server.

   As an alternative to the server ID, you can also add the CA certificate or intermediate certificate for authentication. The CPU must have the entire certificate chain for verification of the server certificate including root certificate.

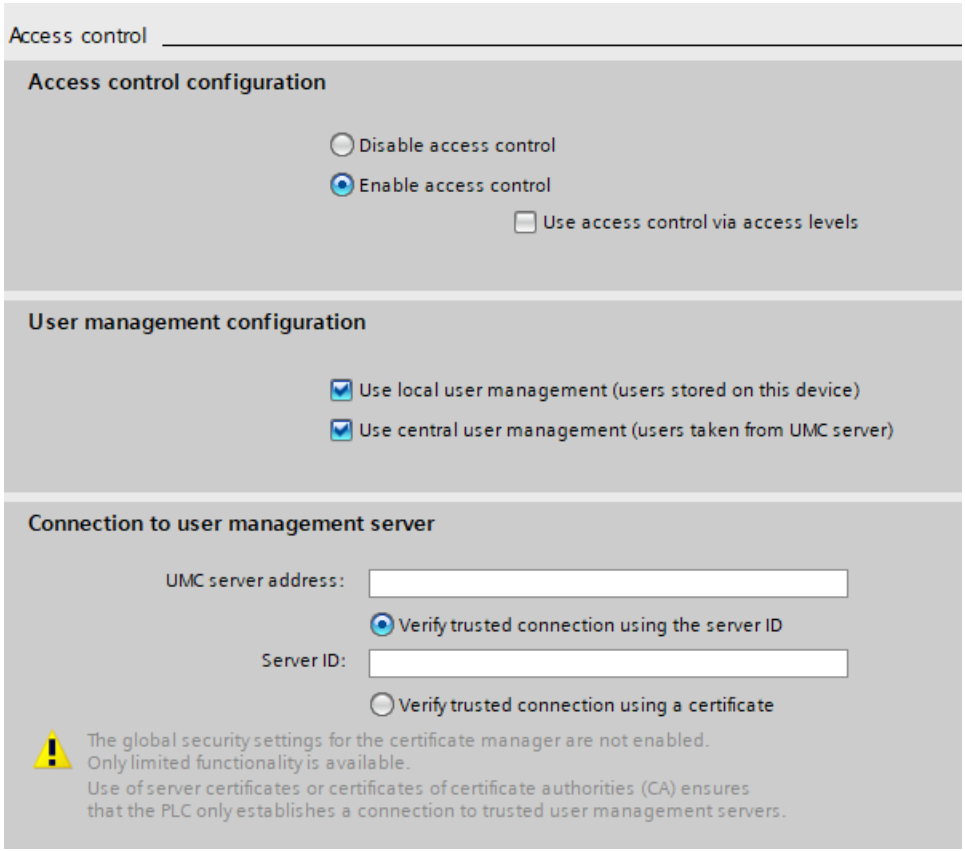

Changing the connection data for the UMC server

A user with a role that grants full access to the CPU can download modified connection data (UMC server address and server ID) in both STOP and RUN modes of the CPU.

11.5.4 Logon of central users

The processes for the logon of central users are described below from the perspective of different applications.

Requirements

- A UMC server is connected to the CPU (firmware version V4.0 or higher) and is accessible.
- The required central users and groups have been set up for the UMC server.
- The CPUs are configured accordingly for the central user management (roles and function rights) and the configuration is loaded.

Logging onto a protected CPU

If you access a CPU online and the operation requires function rights from users, a dialog appears, as with the local user management, which queries the user type. As of TIA Portal version V20, you can log on as central user.

Causes of a failed logon of a central user

Besides known causes, such as a wrong user name (not configured) or wrong password, the logon may, for example, fail due to network problems (UMC server not reachable) or an oversized response frame.

Tip

To handle such cases, set up a local user who can read the diagnostic buffer in the event of a failed logon and determine the exact cause.

In the diagnostic buffer, the causes are represented by an error code that you can interpret using the following table.

Each entry in the diagnostic buffer also leads to a corresponding syslog message so that connected evaluation systems can record the processes.

Table 1-24 Error codes for failed login

Error code	Meaning
#8000 0001	Missing configuration. The UMC server endpoint is not specified.
#8000 1000	Unspecified UMC system error.
#8000 1001	No DNS address configured.
#8000 1002	The DNS server is not reachable, e.g. because it was shut down as the remote port cannot be reached due to firewall settings.

Error code	Meaning
#8000 1003	During data exchange with the UMC server: The interface is currently receiving new parameters.
#8000 1004	The UMC server cannot be reached. The UMC server does not respond to the ARP telegram or there are problems with the TCP handshake to establish a connection.
#8000 1005	The IP address of the UMC server cannot be reached due to missing routing information.
#8000 1006	The UMC server refuses to establish the connection. Connection was closed unexpectedly.
#8000 2xxx	Internal, unrecoverable TLS error.
#8000 3001	Validation of the UMC server certificate failed. Possible causes: Verification against the chain of trust not possible. Certificate not valid or expired. Verification of Identity failed (subject alternative name, FQDN, IPv4 check). Server ID verification failed (fingerprint).
#8000 4001	UMC server does not respond (timeout).
#8000 4002	HTTP response telegram too long (system limit exceeded).
#8000 4003	Invalid HTTP response.
#8000 5xxx	Encoded HTTP status code of the HTTP request. Example of an encoding of Status Code 500 (#1F4) = Internal Server Error: Coding: #8000 5000 + #1F4 (=500) = #8000 51F4
#8000 6001	Syntax error in JSON response telegram from UMC server.
#8000 6002	JSON response telegram from the UMC server too long (system limit exceeded).
#8000 6003	Unexpected JSON format. The message has a valid JSON format, but it is not a valid UMC authentication response from the UMC server.
#8000 7xxx	Login failed (unknown error).

Logging on as an OPC UA client or as a web client

The user name and password are transferred via the UserNameIdentityToken during logon of an OPC UA client to the OPC UA server of the ET 200SP CPU.

The user name and password are also queried for web clients if you want to use the full functionality of the web server of the ET 200SP CPU. See also the Web server function manual, section "Authentication". The following process applies to OPC UA clients and web clients:

- For central users, the CPU forwards the authentication query to the UMC server.
- If the authentication is successful, the UMC server returns the assigned groups to which the user belongs.
- The CPU generates the corresponding session context and grants the authorizations (function rights from the determined roles).
- The client can then execute the access in the context of the session in accordance with the granted function rights.

How does the CPU (OPC UA server or the website of the web server) recognize whether the user is a local or a central user?

You have the freedom to configure a user both as a local user and as a central user. This results in an ambiguity about which service is responsible for the authentication and which user ultimately gains access. Since access permission for the user depends solely on the password in this case, you should use strong passwords, e.g. created by a password generator.

The following rules apply to ensure unambiguousness for the responsible authentication service (local or central user management):

- For logon of a local user, add the prefix "L:" (uppercase or lowercase) in front of the user name.
  Example: L:username

  If you do not use a prefix for the user names, central user management is automatically responsible (when central and local user management are used at the same time). If you use only one type of user management, access is unambiguous even without a prefix.
- A user name must not begin with the string "L:" (uppercase or lowercase).

11.6 Configuring access protection for the CPU

Introduction

The following section describes how to use the individual access levels of the CPUs. The description applies to ET 200SP CPUs up to firmware version V3.0. In later firmware versions, you use the local user management (Page 229) in the "Users and roles" editor in the project tree. The access levels are represented there by function rights of the same name, which you assign to individual users via roles.

The CPU offers four access levels to limit access to specific functions.

By setting up the access levels and the passwords for a CPU, you limit the functions and memory areas that are accessible without entering a password. You specify the individual

access levels as well as the entry of their associated passwords in the object properties of the CPU.

Rules for passwords

Ensure that passwords are sufficiently secure. Passwords must not follow a machine-recognizable pattern. Follow the rules below:

- Assign a password that is at least 8 characters long.
- Use different cases and characters: uppercase/lowercase, numbers and special characters.

Access levels of the CPU

Table 1-25 Access levels and access restrictions

Access levels	Access restrictions
Full access (no protection)	Any user can read and change the hardware configuration and the blocks.
Read access	With this access level, read-only access to the hardware configuration and the blocks is possible without entering a password, which means you can download the hardware configuration and blocks to the programming device. In addition, HMI access and access to diagnostics data is possible. Without entering the password, you cannot load any blocks or hardware configuration into the CPU. Additionally, the following are **not** possible without the password: • Writing test functions • Firmware update (online)
HMI access	With this access level only HMI access and access to diagnostics data are possible without entering the password. Without entering the password, you can neither load blocks nor the hardware configuration into the CPU, nor load blocks and hardware configuration from the CPU into the programming device. Additionally, the following are **not** possible without the password: • Writing test functions • Changing the mode (RUN/STOP) • Firmware update (online) • Display of the online/offline comparison status
No access (complete protection)	When the CPU has complete protection, no read or write access to the hardware configuration and the blocks is possible (without access authorization in the form of a password). HMI access is also not possible. The server function for PUT/GET communication is disabled in this access level (cannot be changed). Authentication with the password will again provide you full access to the CPU.

An enumeration of which functions are available in the different protection levels is available in the "Setting options for the protection" entry in the STEP 7 online help.

Properties of the access levels

Each access level allows unrestricted access to certain functions without entering a password, for example, identification using the "Accessible devices" function.

The default setting of the CPUs is "No access (complete protection)". In the default access level, the user is not allowed to read or modify the hardware configuration or the blocks. To obtain access to the CPUs, assign parameters alternatively in the properties of the CPU:

- A password for the protection level "No access (complete protection)"
- Another protection level, e.g. "Full access (no protection)".

Communication between the CPUs (via the communication functions in the blocks) is not restricted by the access level of the CPU, unless PUT/GET communication is deactivated in the "No access" (complete protection) access level.

Entry of the right password allows access to all the functions that are allowed in the corresponding level.

NOTE

Configuring an access level does not replace know-how protection

Configuring access levels offers a high degree of protection against unauthorized changes to the CPU by restricting the rights to download the hardware and software configuration to the CPU. However, blocks on the SIMATIC memory card are not write- or read-protected. Use know-how protection to protect the code of blocks on the SIMATIC memory card.

Behavior of functions with different access levels

The STEP 7 online help includes a table which lists the online functions that are available in the different access levels.

Selecting the access levels

To configure the access levels of a CPU, follow these steps:

1. Open the properties of the CPU in the Inspector window.
2. Open the "Protection" entry in the area navigation.

   A table with the possible access levels is available in the Inspector window.

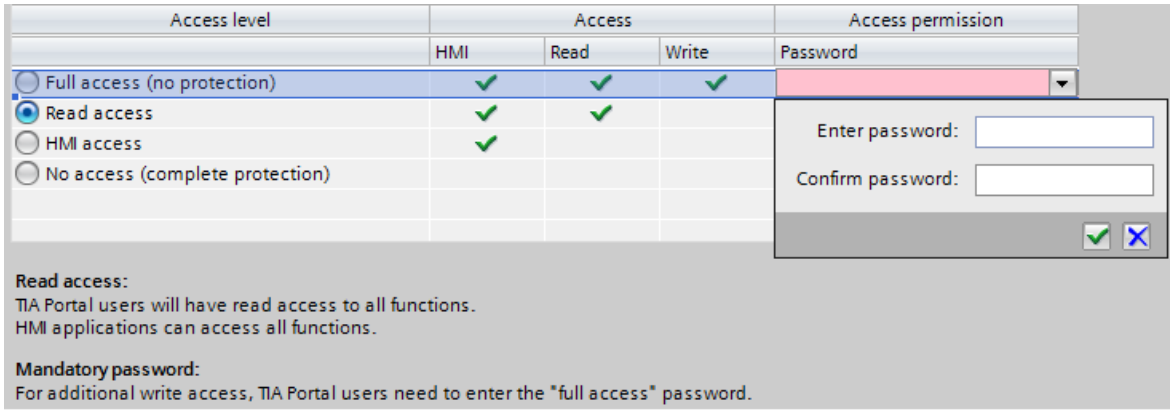

Figure 1-72 Possible access levels

3. Activate the desired protection level in the first column of the table. The green check marks in the columns to the right of the access level show you which operations are still available without entering the password. In the example (see above), read access and HMI access are still possible without a password.
4. In the "Enter password" column, specify a password for the access level "Full access" in the first row. In the "Confirm password" column, enter the selected password again to guard against incorrect entries.
5. Assign additional passwords as required for other access levels.
6. Download the hardware configuration for the access level to take effect.

The CPU logs the following actions with an entry in the diagnostic buffer:

- Input of the correct or incorrect password, as the case may be
- Changes in the configuration of access levels

Behavior of a password-protected CPU during operation

The CPU protection takes effect after you have downloaded the settings to the CPU.

Before an online function is executed, the CPU checks the necessary permission and, if necessary, prompts the user to enter a password. You can only execute password-protected functions from one programming device/PC at any time. Another programming device/PC cannot log on.

Access authorization to the protected data is in effect for the duration of the online connection or until you rescind the access authorization manually with "Online > Delete access rights".

Access levels for F-CPUs

For the fail-safe CPUs, there is an additional access level in addition to the four described access levels. For additional information on this access level, refer to the description of the fail-safe system SIMATIC Safety Programming and Operating Manual SIMATIC Safety - Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126).

11.7 Using the user program to set additional access protection

Access protection via user program

You can also restrict access to a password-protected CPU in STEP 7 via the ENDIS_PW operation. You can find a description of this block in the online help under the keyword "ENDIS_PW: Limit and enable password legitimation".

11.8 Know-how protection

Application

You can use know-how protection to protect one or more OB, FB or FC blocks as well as global data blocks in your program from unauthorized access. Enter a password to restrict access to a block. The password offers high-level protection against unauthorized reading or manipulation of the block.

Password provider

As an alternative to manual entry of password, you can connect a password provider to STEP 7. When using a password provider, you select a password from a list of available passwords. When a protected block is opened, STEP 7 connects to the password provider and retrieves the corresponding password.

To connect a password provider you have to install and activate it. A settings file in which you define the use of a password provider is also required.

A password provider offers the following advantages:

- The password provider defines and manages the passwords. When know-how protected blocks are opened, you work with symbolic names for passwords. A password is marked, for example, with the symbolic name "Machine_1" n the password provider. The actual password behind "Machine1" remains hidden from you.
  A password provider therefore offers you optimum block protection as the users do not know the password themselves.
- STEP 7 automatically opens know-how protected blocks without the direct entry of a password. This saves you time.

You will find more information on connecting a password provider in the STEP 7 online help.

Readable data

If a block is know-how protected, only the following data is readable without the correct password:

- Block title, comments and block properties
- Block parameters (INPUT, OUTPUT, IN, OUT, RETURN)
- Call structure of the program
- Global tags without information on the point of use

Further actions

Further actions that can be carried out with a know-how protected block:

- Copying and deleting
- Calling in a program
- Online/offline comparison
- Load

Global data blocks and array data blocks

You protect global data blocks (global DBs) from unauthorized access with know-how protection. If you do not have the valid password, you can read the global data block but not change it.

Know-how protection is not available for array data blocks (array DBs).

Setting up block know-how protection

To set up block know-how protection, follow these steps:

1. Open the properties of the block in question.
2. Select the "Protection" option under "General".

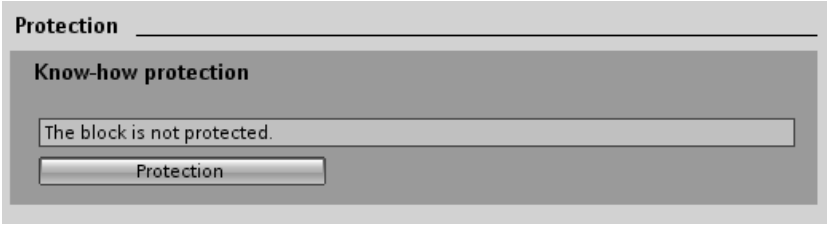

Figure 1-73 Setting up block know-how protection (1)

3. Click the "Protection" button to display the "Know-how protection" dialog.

Figure 1-74 Setting up block know-how protection (2)

4. Click the "Define" button to open the "Define Password" dialog.

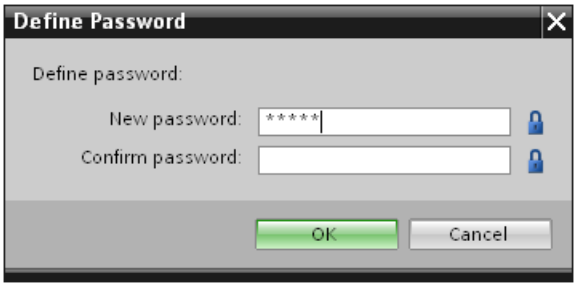

Figure 1-75 Setting up block know-how protection (3)

5. Enter the new password in the "New password" box. Enter the same password in the "Confirm password" box.
6. Click "OK" to confirm your entry.
7. Close the "Know-how protection" dialog by clicking "OK".

Result: The selected blocks are now know-how protected. Know-how protected blocks are marked with a lock in the project tree. The password entered applies to all blocks selected.

NOTE

Password provider

Alternatively, you can set up know-how protection for blocks with a password provider.

Opening know-how protected blocks

To open a know-how protected block, follow these steps:

1. Double-click the block to open the "Access protection" dialog.
2. Enter the password for the know-how protected block.
3. Click "OK" to confirm your entry.

Result: The know-how-protected block is open.

Once you have opened the block, you can edit the program code and the block interface of the block for as long as the block or STEP 7 is open. You must enter the password again the next time you open the block. If you close the "Access protection" dialog with "Cancel", you will be able to open the block but you cannot display the block code or edit the block.

If you copy the block or add it to a library, for example, this does not cancel the know-how protection of the block. The copies will also be know-how-protected.

Removing block know-how protection

To remove block know-how protection, follow these steps:

1. Select the block from which you want to remove know-how protection. The protected block must not be open in the program editor.
2. In the "Edit" menu, select the "Know-how protection" command to open the "Know-how protection" dialog.
3. Clear the "Hide code (Know-how protection)" check box.

Figure 1-76 Removing block know-how protection (1)

4. Enter the password.

Figure 1-77 Removing block know-how protection (2)

5. Click "OK" to confirm your entry.

Result: Know-how protection is removed from the selected block.

See also

Copy protection (Page 259)

11.9 Copy protection

Application

The copy protection allows you to protect your program against unauthorized duplication. With copy protection you associate the blocks with a specific SIMATIC memory card or CPU. Through the linking of the serial number of a SIMATIC memory card or of a CPU the use of this program or of this block is only possible in conjunction with a specific SIMATIC memory card or CPU.

Copy and know-how protection

Recommendation: to prevent unauthorized reset of copy protection, additionally apply know-how protection to a copy-protected block. To do this, first set up copy protection and then apply know-how protection for the block. You can find further information on setting up know-how protection in section Know-how protection (Page 255)

Setting up copy protection

To set up copy protection, follow these steps:

1. Open the properties of the block in question.
2. Select the "Protection" option under "General".

Figure 1-78 Setting up copy protection (1)

3. In the "Copy protection" area, select either the "Bind to serial number of the CPU" entry or the "Bind to serial number of the memory card" entry from the drop-down list.

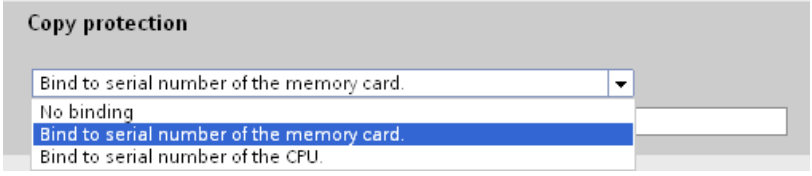

Figure 1-79 Setting up copy protection (2)

4. Activate the option "Serial number is inserted when downloading to a device or a memory card" if the serial number is to be inserted automatically during the uploading process (dynamic binding). Assign a password using the "Define password" button to link the use of a block additionally to the input of a password.
   Activate the option "Enter serial number" if you want to manually bind the serial number of the CPU or the SIMATIC memory card to a block (static binding).

5. You can now set up the know-how protection for the block in the "Know-how protection" area.

NOTE

If you download a copy-protected block to a device that does not match the specified serial number, the entire download operation will be rejected. This means that blocks without copy protection will also not be downloaded.

Removing copy protection

To remove copy protection, follow these steps:

1. Remove any existing know-how protection.
2. Open the properties of the block in question.
3. Select the "Protection" option under "General".
4. In the "Copy protection" area, select the "No binding" entry from the drop-down list.

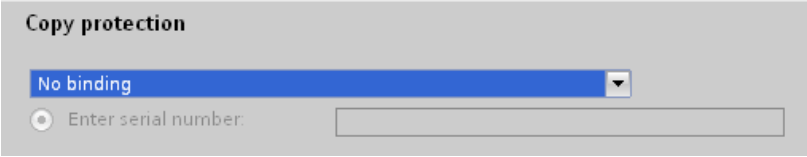

Figure 1-80 Removing copy protection

Configuration control (option handling) 12

Introduction

Configuration control (option handling) is used to operate various standard machine configuration levels in one project without changing the configuration or the user program.

Operating principle of configuration control

You can use configuration control to operate different standard machine configurations with a single configuration of the ET 200SP distributed I/O system.

- A station master is configured in a project (maximum configuration). The station master comprises all modules needed for all possible plant parts of a modular standard machine.
- The project's user program provides for several station options for various standard machine configuration levels as well as selection of a station option. A station option uses, for example, only some of the configured modules of the station master and these modules are inserted in the slots in a different order.
- The standard machine manufacturer selects a station option for a configuration of the standard machine. To do this, the project need not be modified, and it is not necessary to load a modified configuration.

You use a control data record you have programmed to notify the CPU/interface module as to which modules are missing or located on different slots in a station option as compared to the station master. The configuration control does not have an impact on the parameter assignment of the modules.

Configuration control allows you to flexibly vary the centralized/distributed configuration. This is only possible if the station option can be derived from the station master.

The following figure shows three configurations of a standard machine with the corresponding station options of the ET 200SP distributed I/O system.

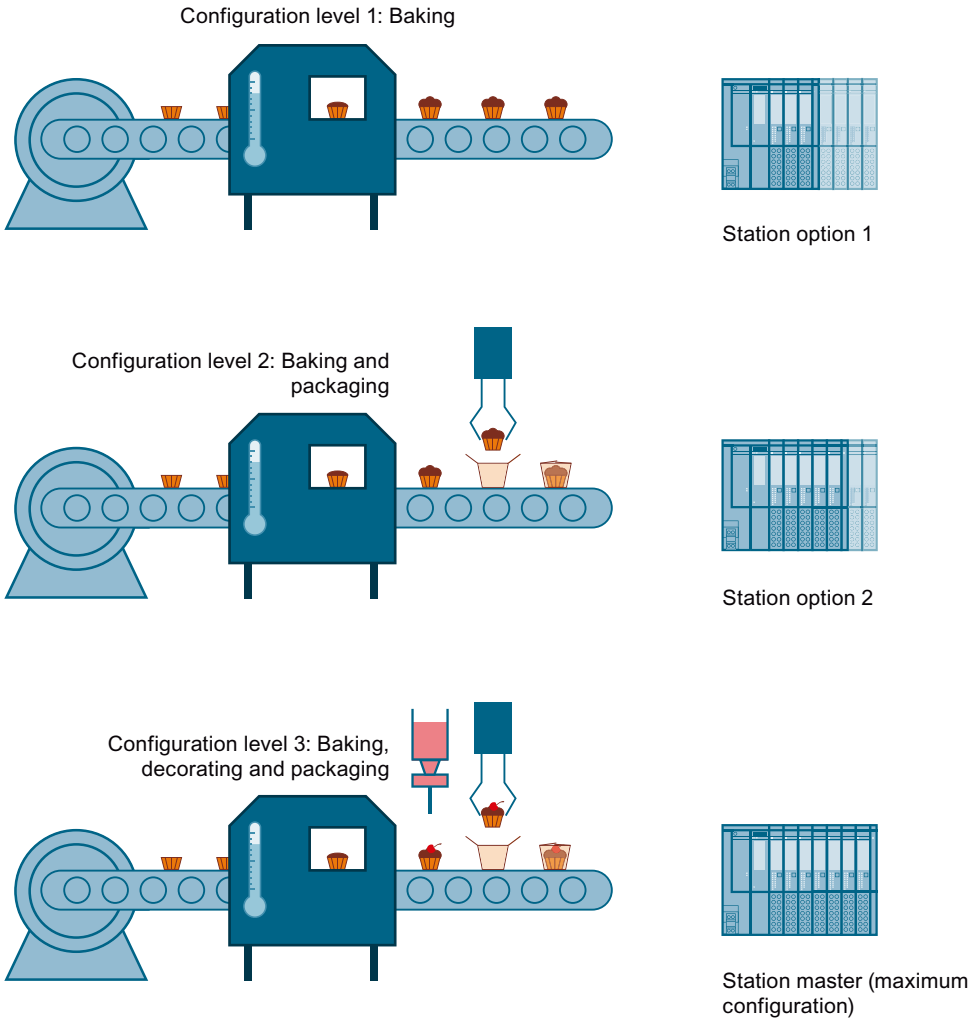

Figure 1-81 Various configuration levels of a standard machine with the corresponding station options of the ET 200SP distributed I/O system.

Advantages

- Simple project management and commissioning by using a single STEP 7 project for all station options.
- Simple handling for maintenance, versioning and upgrade:
- Hardware savings: Only those I/O modules are installed that are required for the machine's current station option.
- Savings potential in the creation, commissioning and the documentation for standard machines.
- Simple station expansion by using pre-wired empty slots. To expand, you simply exchange the BU cover for the new model. You can find further information on this in section Examples of configuration control (Page 280).

Procedure

To set up the configuration control, follow these steps:

Step	Procedure	See...
1	Enable configuration control in STEP 7	Section Configuring (Page 263)
2	Create control data record	Section Creating the control data record (Page 265)
3	Transfer control data record	Section Transferring the control data record in the startup program of the CPU (Page 276)

Library for configuration control

A library for configuration control is available on the Internet for download (https://support.industry.siemens.com/cs/#document/29430270?lc=en-WW). The library contains data types with the structure of the control data records for the ET 200SP distributed I/O system. You can implement your flexible automation solution inexpensively with the help of these data types.

NOTE

Configuration control in the case of motor starters

"Manual local" mode is possible in the case of motor starters when configuration control is active. The motor starter works with the last valid parameters. Do not change the parameterization while "manual local" mode is active.

12.1 Configuring

Requirements

Configuration control is supported by the ET 200SP distributed I/O system with both an ET 200SP CPU and with interface modules via PROFINET IO and PROFIBUS DP.

Centrally for ET 200SP CPU:

- STEP 7 Professional V13 Update 3 or higher
- CPU
  - CPU 1510SP-1 PN
  - CPU 1512SP-1 PN
  - CPU 1514SP-2 PN
  - CPU 1515SP PC2
- Firmware version V1.6 or higher

- All modules of the CPU must be able to start up even with different configurations.
  - The startup parameter "Comparison preset to actual configuration" of the CPU is set to "Startup CPU even if mismatch" (default setting) and the module parameter "Comparison preset to actual module" of the module is set to "From CPU" (default setting).
    or
  - The module parameter "Comparison preset to actual module" for the module is set to "Startup CPU even if mismatch".

Distributed via PROFINET IO:

- Engineering Tool (e.g. STEP 7)
- IM 155-6 PN BA/ST/HF/HS, IM 155-6 MF HF
- You have assigned the interface module to an IO controller.

Distributed via PROFIBUS DP:

- Engineering Tool (e.g. STEP 7)
- IM 155-6 DP HF
- You have assigned the interface module to a DP master.
- The startup parameter is set to "Operate if preset configuration does not match actual configuration"

Modules with submodules distributed across different ARs/fieldbuses may not be a part of the AR for the active configuration control.

Required steps

Enable the "Allow to reconfigure the device via the user program" parameter when configuring the CPU/interface module in STEP 7 (TIA Portal).

- The "Allow to reconfigure the device via the user program" parameter is located in the "Configuration control" area for an ET 200SP CPU.
- The "Allow to reconfigure the device via the user program" parameter is located in the "Module parameter" area under "General" for an IM 155-6 PN or IM 155-6 MF HF interface module.

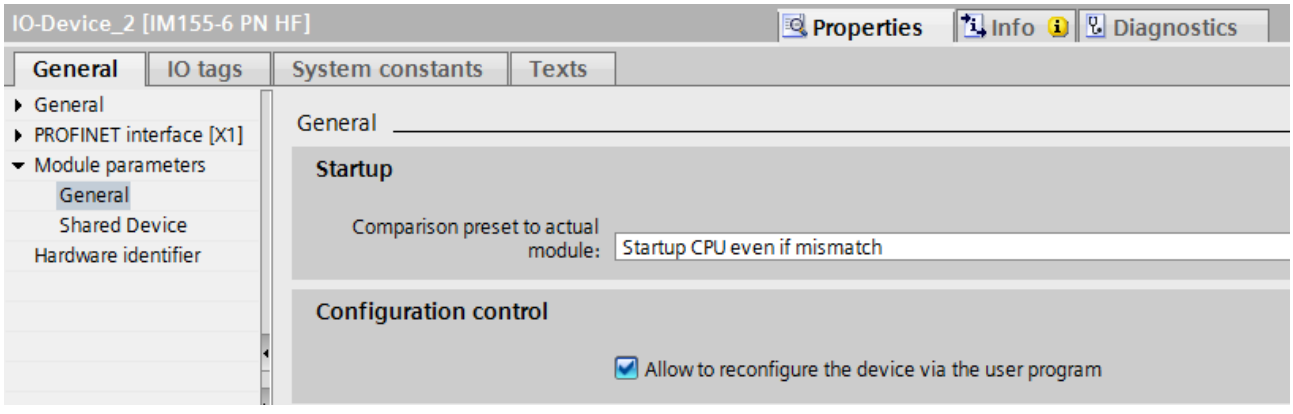

Figure 1-82 Enabling configuration control using an IM 155-6 PN HF as an example

12.2 Creating the control data record

12.2.1 Introduction

Required steps

To create a control data record for the configuration control, follow these steps:

1. Create a PLC data type that contains the structure of the control data record.
   The following figure shows a PLC data type "CTR_REC", which contains the structure of the control data record for an ET 200SP interface module.

CTR_REC

	Name	Data type	Default value	A...	V...	S...	Comment
1	Block_Lenght	USInt	134	☑	☑	☐	4 + (2 x number of Slots)
2	Block_ID	USInt	196	☑	☑	☐	
3	Version	USInt	2	☑	☑	☐	ET 200SP
4	Subversion	USInt	0	☑	☑	☐	
5	Slot 1	USInt	1	☑	☑	☐	assigned "real" slot
6	Add 1	USInt	0	☑	☑	☐	additional function
7	Slot 2	USInt	2	☑	☑	☐	assigned "real" slot
8	Add 2	USInt	0	☑	☑	☐	additional function
9	Slot 3	USInt	3	☑	☑	☐	assigned "real" slot
10	Add 3	USInt	0	☑	☑	☐	additional function
11	Slot 4	USInt	4	☑	☑	☐	assigned "real" slot
12	Add 4	USInt	0	☑	☑	☐	additional function
		USInt	5	☑	☑	☐	

Figure 1-83 Creating control data record 196 using an IM 155-6 PN HF as an example

2. Create a global data block.
3. In the data block, create an array that is based on the created PLC data type.

4. In the control data records, enter the slot assignments in the "Start value" column.

   The figure below shows the global data block "ConfDB". The data block "ConfDB" contains an array [0..5] of the PLC_DataType "CTR_REC".

ConfDB

	Name	Data type	Start value	R..	A...	V...	S..	Comment
1	Static							
2	Option	Int	0	☑	☑	☑	☐	Selection of record
3	ConfigControl	Array[0..5] of "CTR_REC"		☐	☑	☑		
4	ConfigControl[0]	"CTR_REC"			☑	☑		
5	ConfigControl[1]	"CTR_REC"			☑	☑		
6	Block_Length	USInt	0		☑	☑		4 + (2 x number of slots)
7	Block_ID	USInt	196		☑	☑		
8	Version	USInt	2		☑	☑		ET 200SP
9	Subversion	USInt	0		☑	☑		
10	Slot 1	USInt	1		☑	☑		assigned "real" slot
11	Add 1	USInt	0		☑	☑		additional function
12	Slot 2	USInt	2		☑	☑		assigned "real" slot
13	Add 2	USInt	0		☑	☑		additional function
14	Slot 3	USInt	3		☑	☑		assigned "real" slot
15	Add 3	USInt	0		☑	☑		additional function
16	Slot 4	USInt	4		☑	☑		assigned "real" slot
17	Add 4	USInt	0		☑	☑		additional function

Figure 1-84 Data block for configuration control

Rules

Observe the following rules:

- Slot entries in the control data record outside the station master are ignored by the CPU/interface module.
- The control data record must contain the entries up to the last slot of the station option.
- Multiple configured slots may not be assigned to the same actual slot. In other words, each station option slot may be present only once in the control data record.

Using communication modules

When configuration control (option handling) is used, you may insert the following communication modules:

- CM DP
- CP 1542SP-1
- CP 1543SP-1
- CP 1542SP-1 IRC
- BusAdapter BA-Send 1xFC

For the communication modules listed above, special slot rules apply for use with the ET 200SP CPUs:

If you insert the communication modules as mentioned above (e.g. CM DP) in the central configuration, then these modules cannot be influenced by the configuration control. You must therefore leave these modules in the slots preassigned in the station master and enter the slot numbers from the station master in the control data record ("Station option slot = Station master slot").

In a station option, all slots up to the module furthest from the CPU (see list above) must be present in the control data record.

The CM AS-i Master and F-CM AS-i Safety communication modules can be used for configuration control without the above-mentioned restrictions relating to slot numbers.

12.2.2 Control data record for an ET 200SP CPU

Slot assignment

The following table shows the possible slots for the various modules for an ET 200SP CPU:

Table 1-26 Slot assignment

Modules	Possible slots	Comment
CPU	1	Slot 1 is always the CPU
Station extension BA-Send	2	In a mixed configuration with ET 200AL modules, BA-Send is always on slot 2.
I/O modules	2 - 65	Downstream of CPU
Server module	2 - 66	The server module completes the configuration of the ET 200SP station after the CPU/the last I/O module.
ET 200AL I/O modules	67 - 82	For mixed configuration with ET 200AL modules

Control data record

For the configuration control of an ET 200SP CPU, you define a control data record 196 V2.0, which includes a slot assignment. The maximum slot of the configuration corresponds to the slot of the server module or last slot of an ET 200AL I/O module (in a mixed ET 200SP/ET 200AL configuration).

The table below shows the structure of a control data record with explanations of the individual elements.

Table 1-27 Configuration control: Structure of control data record 196

Byte	Element	Code	Explanation
0	Block length	4 + (maximum slot × 2)	Header
1	Block ID	196	
2	Version	2	
3	Version	0	
4	Slot 1 of the station master	Slot assignment 1 in the station option	**Control element** Contains the information on which module is inserted in which slot.

Byte	Element	Code	Explanation
		(always 1, because the CPU is always in slot 1)	The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module exists as empty slot (with BU cover), enter the slot number of the module + 128. (Example: module as empty slot on slot 3: Enter 131 in the control element) • If the module does not exist in the station option, enter 0. **Additional function** Contains information on whether a new potential group will be opened in the station option - by replacing a dark-colored BaseUnit with a light-colored BaseUnit. • If you replace a dark-colored BaseUnit with a light-colored BaseUnit, enter 1 as additional function. • If you accept the BaseUnit from the station master, enter 0 as additional function.
5	Additional function for slot 1		
6	Slot 2 of the station master	Slot assignment in the station option	
7	Additional function for slot 2		
8	Slot 3 of the station master	Slot assignment in the station option	
9	Additional function for slot 3		
:	:	:	
4 + ((server module slot - 1) × 2)	Server module slot	Server module slot assignment in the station option*	
4 + ((server module slot - 1) × 2) + 1	Additional function for server module slot		
:	:	:	:
136	First slot of ET 200AL (slot 67)	Slot assignment in the station option	**Control element ET 200AL** Contains information on which ET 200AL module is inserted in which slot. The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module does not exist in the station option, enter 0.
137	Reserved		
:	:	:	
166	Last slot of ET 200AL (slot 82)	Slot assignment in the station option	
167	Reserved		

* The server module must be present in the station option and must not be marked as empty slot (BU cover).

12.2.3 Control data record for an interface module

Slot assignment

The following table shows the possible slots for the various modules for an ET 200SP interface module:

Table 1-28 Slot assignment

Modules	Possible slots		Comment
Interface module	0		The interface module (slot 0) is not an element of the configuration control, but instead controls this.
Station extension BA-Send	1		For mixed configuration with ET 200AL modules, BA-Send is always on slot 1.
ET 200SP I/O module	1 - 12	for IM 155-6 PN BA	Downstream from the interface module
	1 - 30	for IM 155-6 PN HS	
	1 - 32	for IM 155-6 PN ST, IM 155-6 DP HF	
	1 - 64	for IM 155-6 PN HF, IM 155-6 PN/3 HF, IM 155-6 MF HF	
Server module	1 - 13	for IM 155-6 PN BA	The server module completes the configuration of the ET 200SP station after the last I/O module.
	1 - 31	for IM 155-6 PN HS	
	1 - 33	for IM 155-6 PN ST, IM 155-6 DP HF, IM 155-6 MF HF	
	1 - 65	for IM 155-6 PN HF, IM 155-6 PN/3 HF	
ET 200AL I/O module	34 - 49	for IM 155-6 DP HF	For mixed configuration with ET 200AL modules
	66 - 81	for IM 155-6 PN ST, IM 155-6 PN HF, IM 155-6 PN/3 HF, IM 155-6 MF HF	

Simplified control data record (V1)

For the configuration control of interface modules of the ET 200SP distributed I/O system, you define a control data record 196 V1.0, which includes a slot assignment. The maximum slot of the configuration corresponds to the slot of the server module or ET 200AL I/O module (in a mixed ET 200SP / ET 200AL configuration).

The table below shows the structure of a control data record with explanations of the individual elements.

Table 1-29 Structure of the simplified control data record V1.0

Byte	Element	Code	Explanation
0	Block length	4 + maximum slot	Header
1	Block ID	196	
2	Version	1	
3	Version	0	
4	Slot 1 of the station master	Slot assignment in the station option	**Control element ET 200SP** Contains the information on which ET 200SP module is inserted in which slot. The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module exists as empty slot (with BU cover), enter the slot number of the module + 128. (Example: module as empty slot on slot 3: Enter 131 in the control element) • If the module does not exist in the station option, enter 0.
5	Slot 2 of the station master	Slot assignment in the station option	
:	:	:	
4 + (slot server module - 1)	Server module slot	Server module slot assignment in the station option*	
:	:	:	:
4 + (first slot ET 200AL - 1)	First slot ET 200AL	Slot assignment in the station option	**Control element ET 200AL** Contains information on which ET 200AL module is inserted in which slot. The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module does not exist in the station option, enter 0.
:	:	:	
4 + (last slot ET 200AL - 1)	Last slot ET 200AL	Slot assignment in the station option	

* The server module must be present in the station option and must not be marked as empty slot (BU cover).

Control data record (V2)

If you change the potential groups in the station option compared to the station master, define a control data record 196 V2.0 for the ET 200SP interface module which contains a slot assignment. The maximum slot of the configuration corresponds to the slot of the server module or ET 200AL I/O module (in a mixed ET 200SP / ET 200AL configuration).

The table below shows the structure of a control data record with explanations of the individual elements.

Table 1-30 Structure of control data record 196 V2.0

Byte	Element	Code	Explanation
0	Block length	4 + (maximum slot x 2)	Header
1	Block ID	196	
2	Version	2	
3	Version	0	
4	Slot 1 of the station master	Slot assignment in the station option	**Control element ET 200SP** Contains the information on which ET 200SP module is inserted in which slot. The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module exists as empty slot (with BU cover), enter the slot number of the module + 128. (Example: module as empty slot on slot 3: Enter 131 in the control element) • If the module does not exist in the station option, enter 0. **Additional function** Contains information on whether a new potential group will be opened in the station option - by replacing a dark-colored BaseUnit with a light-colored BaseUnit. • If you replace a dark-colored BaseUnit with a light-colored BaseUnit, enter 1 as additional function. • If you accept the BaseUnit from the station master, enter 0 as additional function.
5	Additional function for slot 1		
6	Slot 2 of the station master	Slot assignment in the station option	
7	Additional function for slot 2		
8	Slot 3 of the station master	Slot assignment in the station option	
9	Additional function for slot 3		
:	:	:	
4 + ((server module slot - 1) × 2)	Server module slot	Server module slot assignment in the station option*	
4 + ((server module slot - 1) × 2) + 1	Additional function for server module slot		
:	:	:	:

* The server module must be present in the station option and must not be marked as empty slot (BU cover).

Byte	Element	Code	Explanation
4 + ((first slot ET 200AL - 1) x 2)	First slot ET 200AL	Slot assignment in the station option	**Control element ET 200AL** Contains information on which ET 200AL module is inserted in which slot. The value that you need to enter in the corresponding byte depends on the following rule: • If the module exists in the station option, enter the slot number of the module. • If the module does not exist in the station option, enter 0.
4 + ((first slot ET 200AL - 1) x 2) + 1	Reserved		
:	:	:	
4 + ((last slot ET 200AL - 1) x 2)	Last slot ET 200AL	Slot assignment in the station option	
4 + ((last slot ET 200AL - 1) x 2) + 1	Reserved		

* The server module must be present in the station option and must not be marked as empty slot (BU cover).

NOTE

If a BU cover or no I/O module is plugged on a light-colored BaseUnit, you should enter 1 in the additional function for the slot.

The function "Group diagnostics: Missing supply voltage L+" requires proper assignment of the slots to a shared supply voltage L+ (potential group). All light-colored BaseUnits must be known to the interface module. By entering 1 in the additional function, you make a light-colored BaseUnit known to the interface module, even if an I/O module is not inserted.

Combination of configuration control and shared device (for PROFINET)

The configuration control function in a shared device is therefore only for the I/O modules of the IO controller to which the interface module has subscribed. I/O modules that are assigned to no controller or a different controller behave like a station without activated configuration control.

You cannot make any change to the slot assignment for modules that are assigned to another IO controller or are not assigned to an IO controller (shared device on module level). The CPU assumes a one-to-one assignment for the modules.

If additional IO controllers subscribe to a module intended for configuration control (shared device on submodule level), only one-to-one assignment is permitted for this module. It is not possible to deselect such a module using the control data record (code 0 for this slot in the control data record). This means the combination of "Configuration control" and "Shared device on submodule level" is only possible to a limited extent.

Please note that all modules affected by the configuration control including all assigned submodules are reset when you change the module assignment. Submodules that are assigned to a second IO controller are affected as well.

Combination of configuration control and virtual IO modules

A combination of configuration control and virtual IO modules (interface-local coupling of IO data) is possible. However, you can only create the control data record for configuration control up to the last real slot. The virtual IO modules cannot be contained in the control data record. Virtual IO modules have a fixed slot/subslot that cannot be mapped and also cannot be contained in the remap record. If the control data record contains the virtual IO modules, the control data record becomes too long and the error code $80B1_H$ is returned. See section Feedback data record for interface modules (Page 273).

12.2.4 Feedback data record for interface modules

Operating principle

The feedback data record informs you about the accuracy of the module assignment and gives you the option of detecting assignment errors in the control data record. The feedback data record is mapped via a separate data record 197 V2.0. The feedback data record exists only with configured configuration control.

Slot assignment

The feedback data record refers to the configured station configuration and always includes the maximum configuration limits. The maximum configuration limits comprise 13/49/81 slots depending on the interface module in use. Partial reading of the feedback data record is possible.

The following table shows the slot assignment of the modules:

Table 1-31 Slot assignment

Modules	Possible slots		Comment
Station extension BA-Send	1		For mixed configuration with ET 200AL modules, BA-Send is always on slot 1.
ET 200SP I/O module	1 - 12	for IM 155-6 PN BA	Downstream from the interface module
	1 - 30	for IM 155-6 PN HS	
	1 - 32	for IM 155-6 PN ST, IM 155-6 DP HF	
	1 - 64	for IM 155-6 PN HF, IM 155-6 PN/3 HF, IM 155-6 MF HF	
Server module	1 - 13	for IM 155-6 PN BA	The server module completes the configuration of the ET 200SP station after the last I/O module.
	1 - 31	for IM 155-6 PN HS	
	1 - 33	for IM 155-6 PN ST, IM 155-6 DP HF	

Modules	Possible slots		Comment
Server module	1 - 65	for IM 155-6 PN HF, IM 155-6 PN/3 HF, IM 155-6 MF HF	The server module completes the configuration of the ET 200SP station after the last I/O module.
ET 200AL I/O module	34 - 49	for IM 155-6 DP HF	For mixed configuration with ET 200AL modules
	66 - 81	for IM 155-6 PN ST, IM 155-6 PN HF, IM 155-6 PN/3 HF, IM 155-6 MF HF	

Feedback data record

Table 1-32 Feedback data record

Byte	Element	Code	Explanation
0	Block length	4 + (number of slots x 2)	Header
1	Block ID	197	
2	Version	2	
3		0	
4	Slot 1 status	0/1	Status = 1: • Module from station master is inserted in the station option • Slot is marked as not available in the control data record Status = 0: • Module pulled • Incorrect module is inserted in the station option*
5	Reserved	0	
6	Slot 2 status	0/1	
7	Reserved	0	
:	:	:	
4 + ((max. slot - 1) × 2)	Max. slot status	0/1	
4 + ((max. slot - 1) × 2) + 1	Reserved	0	

* Not possible if the slot is marked as not available.

NOTE

The data in the feedback data record is always mapped for all modules. In a shared device configuration, it is therefore irrelevant which IO controller the respective modules are assigned to.

As long as no control data record has been sent, a one-to-one module assignment is assumed for the compilation of data record 197 (station master → station option).

Error messages

In case of error, the RDREC instruction returns the following error messages via the STATUS block parameter while reading the feedback data record:

Table 1-33 Error messages

Error code	Meaning
$80B1_H$	Invalid length; the length information in data record 197 is not correct.
$80B5_H$	Configuration control not configured
$80B8_H$	Parameter error The following events cause a parameter error: • Incorrect block ID in the header (not equal to 197) • Invalid version identifier in the header • A reserved bit has been set • The same slot in the station option has been assigned to more than one slot in the station master

12.2.5 Data records and functions

Supported data records and functions

The table below shows a comparison of the supported data records and functions depending on the CPU/interface module used.

	CPU...		Interface module (IM...)					
Supported data records and functions	**151xSP-1 (F) PN 1514SP-2 (F) PN**	**1515SP PC2**	**155-6 PN HS**	**155-6 PN HF 155-6 MF HF**	**155-6 PN/2 HF 155-6 PN/3 HF**	**155-6 PN ST**	**155-6 PN BA**	**155-6 DP HF**
Control data record (V2)	✓	✓	✓	✓	✓	✓	✓	✓
Simplified control data record (V1)	--	--	✓	✓	✓	✓	✓	--
Read back control data record*	✓	✓	✓	✓	✓	✓	✓	✓
Read feedback data record	--	--	✓	✓	✓	✓	✓	✓

* You can read back the control data record with the RDREC instruction.

12.3 Transferring control data record in the startup program of the CPU

Required steps

Transfer the created control data record 196 to the CPU/the interface module using the instruction WRREC (Write data record) instruction.

Parameters of the instruction WRREC

Below, you will find explanations of individual parameters of the WRREC instruction which you must supply with specific values in the configuration control context. You can find additional information on the WRREC instruction in the STEP 7 online help.

ID	Hardware identifier • Use the HW identifier of the CPU for the configuration control for centrally arranged modules. If you have selected the CPU in the network view or device view, the HW identifier is available in the **System constants** tab of the Inspector window. Use the value of the system constant "Local~Configuration". • Use the HW identifier of the interface module for the configuration control for distributed I/O. If you have selected the interface module in the network view or device view, the HW identifier is available in the **System constants** tab of the Inspector window. Use the value of the system constant "<Name_of_the_interface_module>~Head".
INDEX	Data record number: 196 (decimal)
RECORD	Control data record to be transferred. See the section Creating the control data record (Page 265) for the structure of the control data record.

Error messages

In case of error, the instruction WRREC returns the following error messages via the STATUS block parameter:

Table 1-34 Error messages

Error code	Meaning
$80B1_H$	Invalid length; the length information in data record 196 is not correct.
$80B5_H$	Configuration control parameters not assigned.
$80E2_H$	Data record was transferred in the wrong OB context. The data record must be transferred in the startup program.

Error code	Meaning
$80B8_H$	Parameter error A parameter error is caused by: • Incorrect block ID in the header (not equal to 196) • Invalid version identifier in the header • A reserved bit was set • A station master slot was assigned an invalid slot in the station option • Multiple slots in the station master are assigned to the same slot in the station option • For shared device on submodule level: Violation of defined restrictions

Selection of the station option in the user program

In order for the CPU to know which station option you want to operate, you must set up a possibility to select between the various control data records in the user program. You can implement the selection, for example, via an Int tag which references an array element.

Note that the tag used to select the control data record must be stored in the retentive memory area. If the tag is not retentive it will be initialized during the startup of the CPU and thus be unavailable for selection of the station option.

Special aspects relating to the transfer of the control data record to the CPU

- If you have enabled configuration control, the CPU is not ready for operation without a control data record. The CPU returns from startup to STOP if a valid control data record is not transferred in the startup OB. The central I/O is not initialized in this case. The cause for the STOP mode is entered in the diagnostics buffer.

  NOTE

  If an incorrect control data record is transferred to the CPU in the startup OB, the startup of the CPU may be prevented.

  In this case, perform a reset to factory settings of the CPU and then transfer a correct control data record.

- The CPU processes the WRREC instruction for transfer of the control data record asynchronously. For this reason, you must call WRREC in the startup OB repeatedly in a loop until the output parameters "BUSY" or "DONE" indicate that the data record has been transferred.
  - Tip: To program the loop, use the SCL programming language with the REPEAT ... UNTIL instruction.

```
REPEAT
 "WRREC_DB"(REQ := "start_config_control",
            ID := "Local~Configuration",
            INDEX := 196,
            LEN := "conf_LEN",
```

```
            DONE => "conf_DONE",
            BUSY => "conf_BUSY",
            RECORD := "ConfDB".ConfigControl["ConfDB".Option],
//Selection of control data record
            ERROR => "conf_ERROR",
            STATUS => "conf_STATUS");
UNTIL NOT "conf_BUSY"
END_REPEAT;
```

– In the graphical programming languages, you implement the loop using instructions for program control.

  Example in FBD: Use the LABEL (jump label) and JMP (jump at RLO=1) instructions to program a loop.

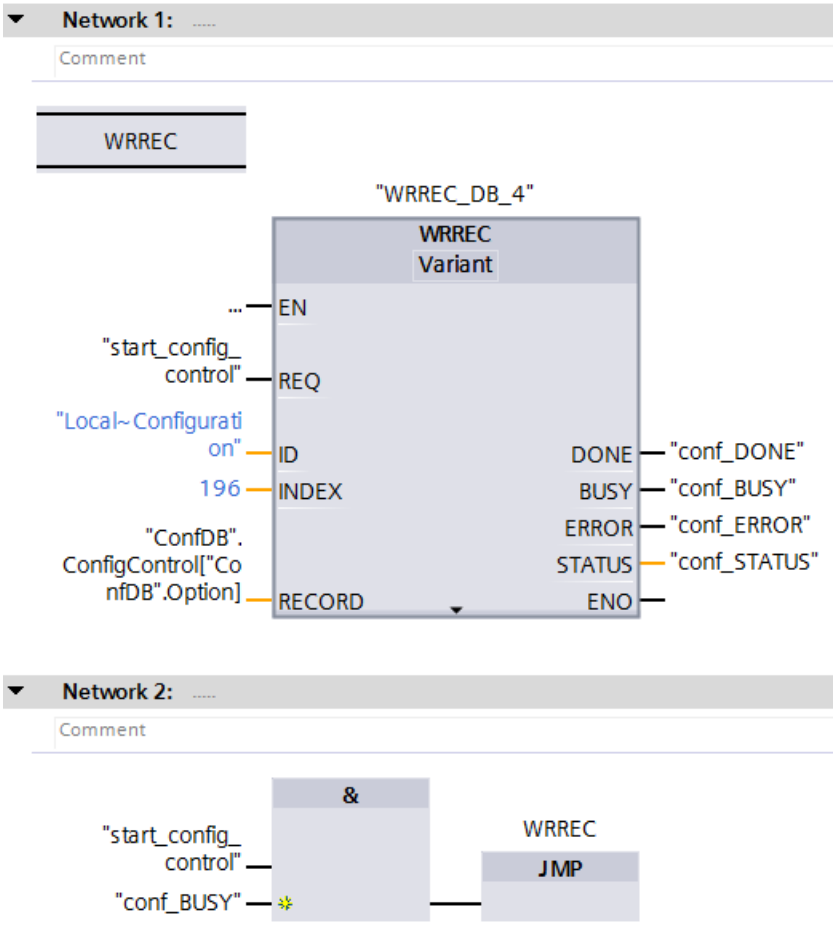

Figure 1-85 WRREC

- The control data record is stored retentively in the CPU. Note:
  - The retentivity of the control data record is independent of the retentivity settings in the STEP 7 memory area. This means that the memory area in which the control data record is configured does not have to be configured as retentive for this purpose.
  - If you write a control data record with modified configuration, the original data record 196 is deleted and the new data record 196 is saved retentively. The CPU will then restart with the modified configuration.
  - The control data record is saved retentively in the CPU, which means that it is not necessary to write the control data record 196 again at a restart if the configuration is unchanged. We recommend that a memory reset of the CPU be performed prior to commissioning to delete any control data record that may be present.

Special aspects relating to the transfer of the control data record to the interface module

- If you have enabled configuration control, the ET 200SP station is not ready for operation without a control data record. As long as no valid control data record has been transferred, the I/O modules are considered as failed by the CPU and exhibit substitute value behavior. The interface module continues to exchange data.
- The control data record is stored retentively in the interface module. Note:
  - If there have been no changes to the configuration, you do not need to rewrite the control data record 196 during restart.
  - If you write a control data record with modified configuration to the interface module, it will result in a station failure in the distributed I/O system. The original data record 196 is deleted and the new data record 196 is saved retentively. The station will then restart with the modified configuration.

12.4 Behavior during operation

Effect of discrepancy between station master and station option

For the online display and for the display in the diagnostics buffer (module OK or module faulty), the station master is always used and not the differing station option.

Example: A module supplies diagnostic information. This module is configured in slot 4 in the station master, but is inserted in slot 3 in the station option (missing module; see example in the next section). The online view (station master) shows a faulty module in slot 4. In the real configuration, the module in slot 3 indicates an error via an LED display.

Response when modules are missing

If modules are entered as not present in the control data record, the automation system behaves as follows:

- Modules designated as not present in the control data record do not supply diagnostics and their status is always OK. The value status is OK.
- Direct write access to the outputs that are not present or write access to the process image of the outputs that are not present: Remains without effect; no access error is signaled.
- Direct read access to the inputs that are not present or read access to the process image of the inputs that are not present: Value "0" is supplied; no access error is signaled.
- Write data record to module that is not present: Remains without effect; no error is signaled.
- Read data record from module that is not present: An error is signaled because a valid data record cannot be returned.

Inserting modules on empty slots

If you replace a BU cover placed on an empty slot with an I/O module when configuration control is enabled, the ET 200SP distributed I/O system behaves as follows:

- Interface module: When the BU cover is removed, a removal interrupt is signaled. When the I/O module is inserted, an insertion alarm (wrong module) is signaled.
- CPU: A removal/insertion interrupt is not signaled when the BU cover is removed or when the I/O module is inserted.

12.5 Examples of configuration control

A station master consisting of an interface module, three I/O modules and the server module is configured in STEP 7 in the following section.

Four station options are derived from the station master with the configuration control:

- Station option 1 with module that is not present
- Station option 2 with modified order of modules
- Station option 3 with empty slot
- Station option 4: Opening a new potential group

Station option 1 with module that is not present

The module that is located in slot 3 in the station master is not present in the station option 1. Slot 3 must be designated in the control data record accordingly with 0 (= not present). The server module is located in slot 3 in the station option.

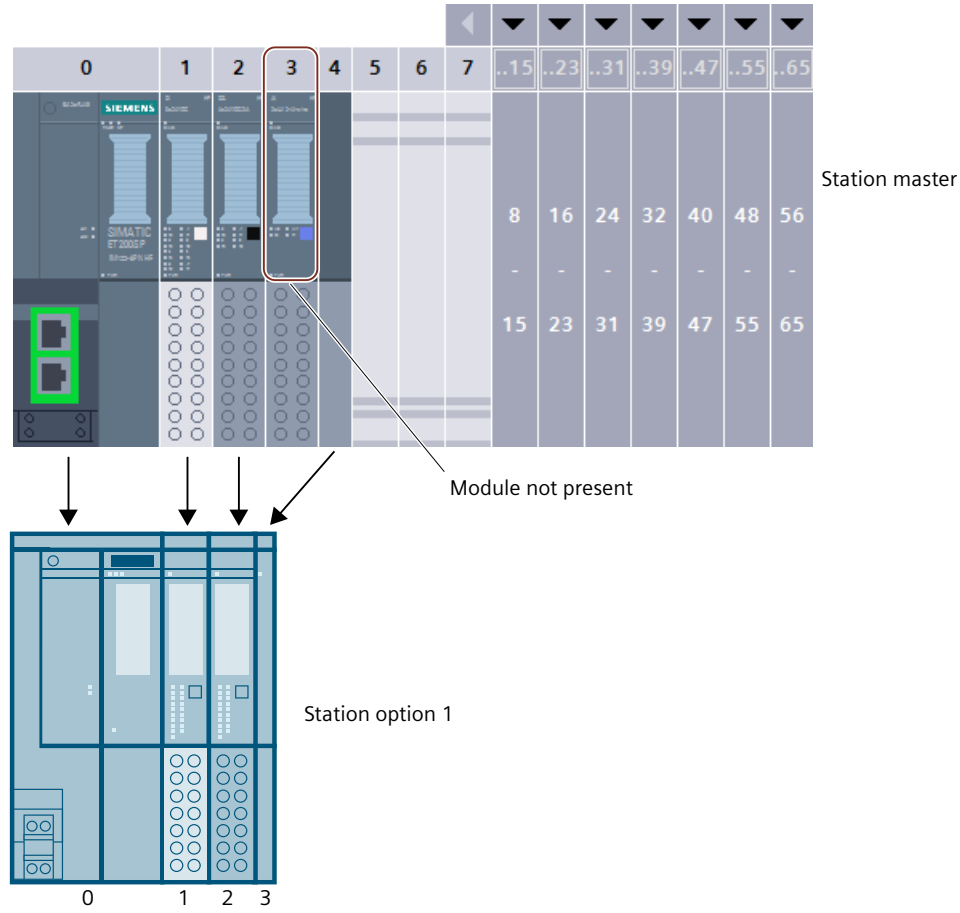

5			ConfigControl[1]	"CTR_REC"					
6			Block_Lenght	USInt	134				4 + (2 x number of slots)
7			Block_ID	USInt	196				
8			Version	USInt	2				ET 200SP
9			Subversion	USInt	0				
10			Slot 1	USInt	1				assigned "real" slot
11			Add 1	USInt	0				additional function
12			Slot 2	USInt	2				assigned "real" slot
13			Add 2	USInt	0				additional function
14			Slot 3	USInt	0				assigned "real" slot
15			Add 3	USInt	0				additional function
16			Slot 4	USInt	3				assigned "real" slot
			Add 4	USInt	0				additional function

Figure 1-86 Example: Hardware configuration of station option 1 with the associated control data record in STEP 7

Station option 2 with modified order of modules

The order of the modules at slots 2 and 3 is interchanged.

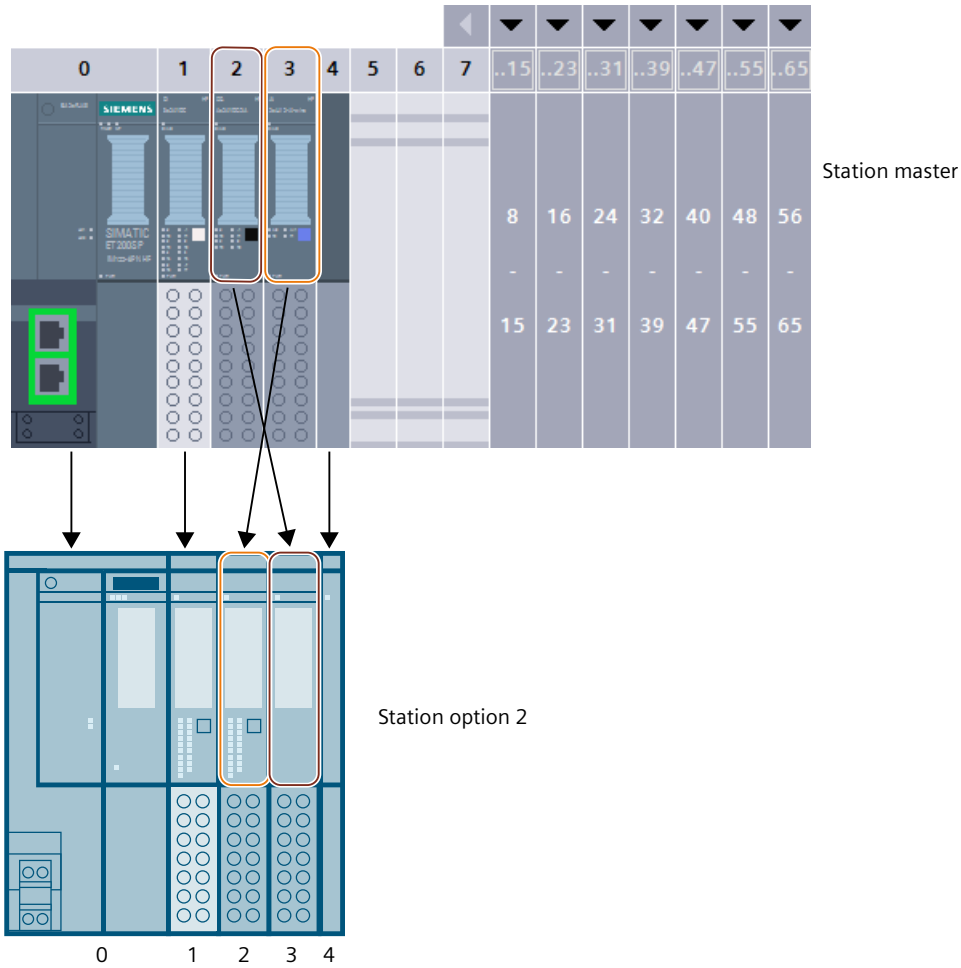

6			ConfigControl[2]	"CTR_REC"					
7			Block_Lenght	USInt	134				4 + (2 x number of slots)
8			Block_ID	USInt	196				
9			Version	USInt	2				ET 200SP
10			Subversion	USInt	0				
11			Slot 1	USInt	1				assigned "real" slot
12			Add 1	USInt	0				additional function
13			Slot 2	USInt	3				assigned "real" slot
14			Add 2	USInt	0				additional function
15			Slot 3	USInt	2				assigned "real" slot
16			Add 3	USInt	0				additional function
17			Slot 4	USInt	4				assigned "real" slot
				USInt	0				

Figure 1-87 Example: Hardware configuration of station option 2 with the associated control data record in STEP 7

Station option 3 with empty slot

The module that is located in slot 3 in the station master occupies an empty slot with BU cover in the station option. Enter the value 130 in slot 3 in the control data record.

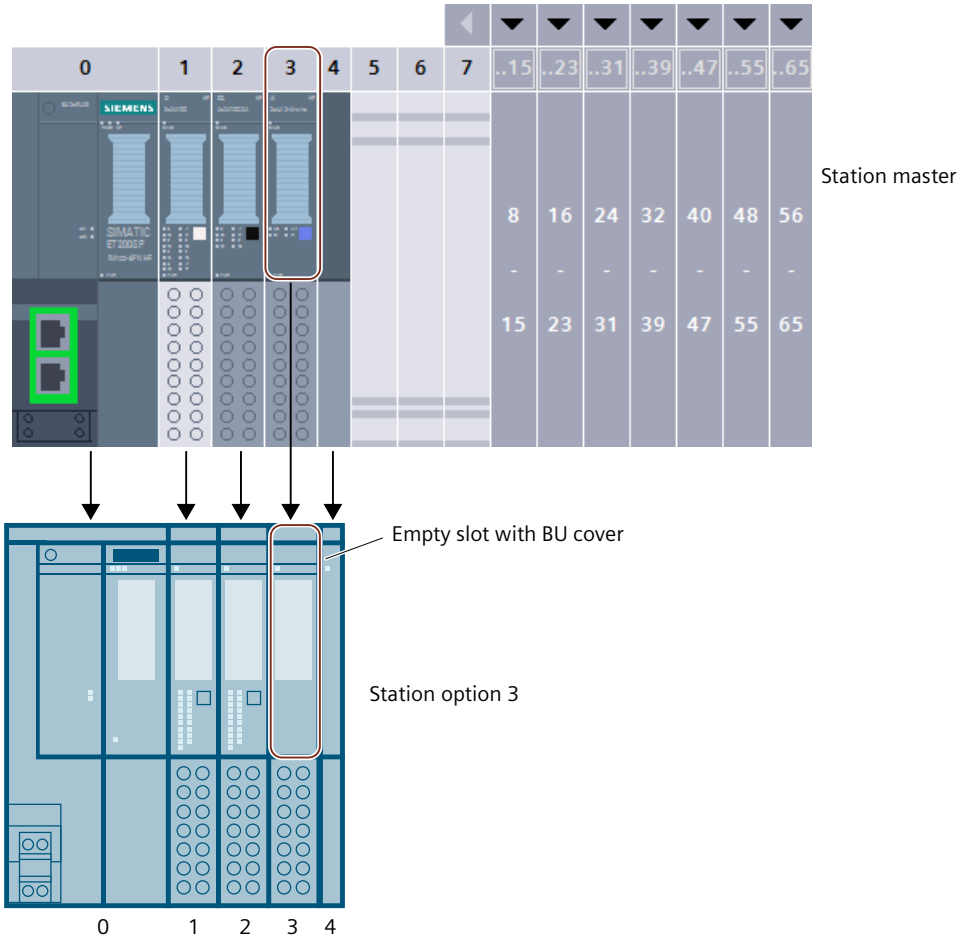

7			ConfigControl[3]	"CTR_REC"						
8			Block_Lenght	USInt	134					4 + (2 x number of slots)
9			Block_ID	USInt	196					
10			Version	USInt	2					ET 200SP
11			Subversion	USInt	0					
12			Slot 1	USInt	1					assigned "real" slot
13			Add 1	USInt	0					additional function
14			Slot 2	USInt	2					assigned "real" slot
15			Add 2	USInt	0					additional function
16			Slot 3	USInt	131					assigned "real" slot
17			Add 3	USInt	0					additional function
			Slot 4	USInt	4					assigned "real" slot

Figure 1-88 Example: Hardware configuration of station option 3 with the associated control data record in STEP 7

Station option 4: Opening a new potential group

A new potential group is opened at slot 3 of station option 4. In contrast to the station master, a dark-colored BaseUnit has been replaced by a light-colored BaseUnit. Enter the value 1 as additional function.

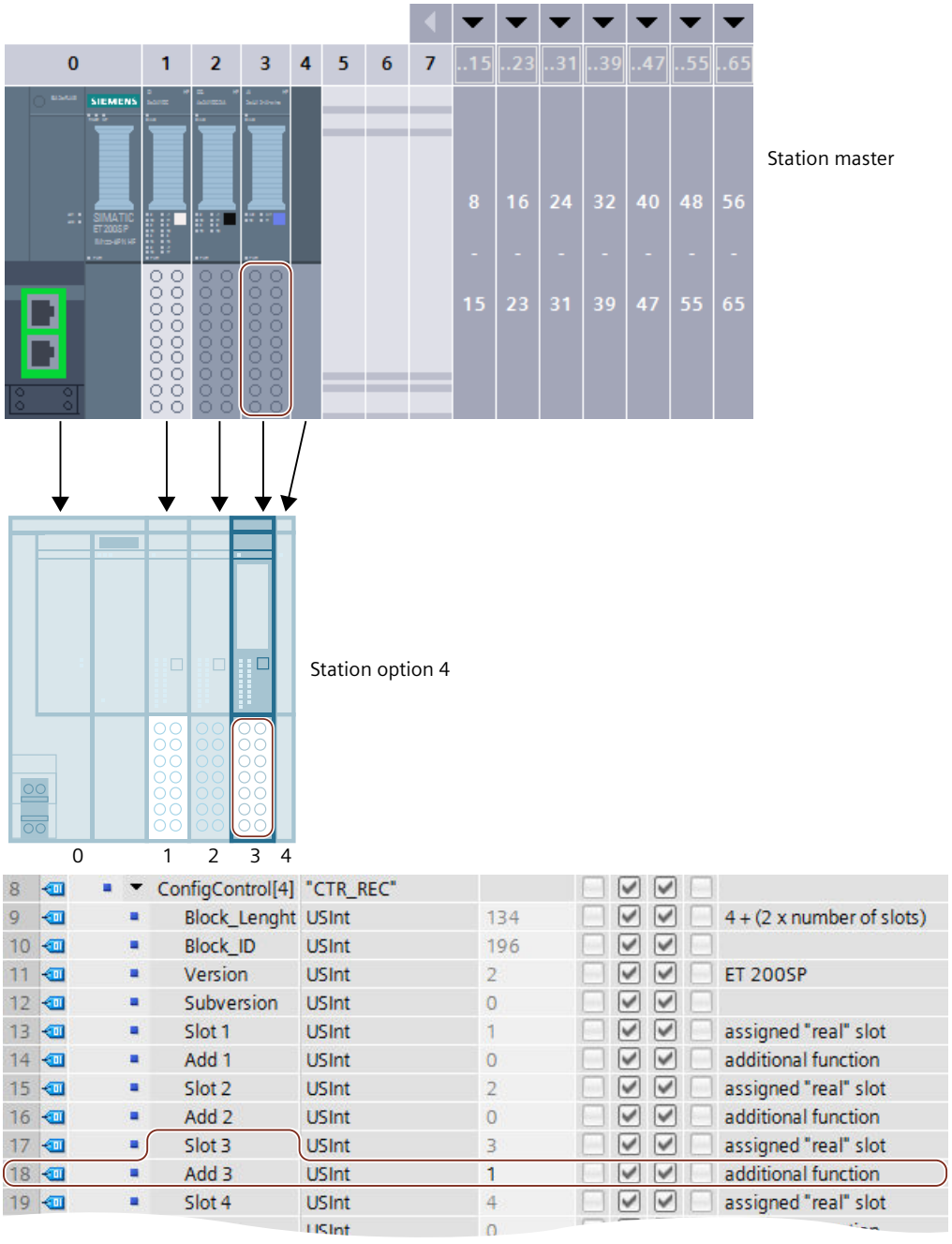

Figure 1-89 Example: Hardware configuration of station option 4 with the associated control data record in STEP 7

Commissioning 13

13.1 Overview

Introduction

This section includes information on the following topics:

- Commissioning the ET 200SP distributed I/O system on the PROFINET IO
- Commissioning the ET 200SP distributed I/O system on the PROFIBUS DP
- Startup of the ET 200SP distributed I/O system with empty slots
- Removing/inserting the SIMATIC memory card
- Operating modes of the CPU
- CPU memory reset
- Reassigning parameters during operation
- Identification and maintenance data

Commissioning requirements

NOTE

Performing tests

You must ensure the safety of your plant. You therefore need to run a complete functional test and make the necessary safety checks before the final commissioning of a plant.

Also allow for any possible foreseeable errors in the tests. This avoids endangering persons or equipment during operation.

NOTE

Check coding element in the I/O module

Make sure that the coding element is present in the I/O module before you plug in the I/O module for the first time. This reduces the risk of plugging the wrong type of module onto a wired BaseUnit when replacing a module.

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the system network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.automation.siemens.com/WW/view/en/67460624).

MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for bulk firmware update of ET 200 devices with MultiFieldbus-support and reading of service data for many other Siemens devices.

You can find MFCT on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109773881).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of the TIA Portal.

General function overview:

- Network browsing and creation of a table showing the accessible devices in the network.
- Flashing of device LEDs or HMI display to locate a device
- Loading addresses (IP, subnet, gateway) into a device
- Loading the PROFINET name (station name) into a device name
- Placing a CPU in RUN or STOP mode
- Setting the time in a CPU to the current time of your programming device/PC
- Downloading a new program to a CPU or an HMI device
- Downloading from CPU, downloading to CPU or deleting recipe data from a CPU
- Downloading from CPU or deleting data log data from a CPU
- Backup/restore of data from/to a backup file for CPUs and HMI devices
- Downloading service data from a CPU
- Reading the diagnostics buffer of a CPU
- General reset of a CPU's memory
- Resetting devices to factory settings
- Downloading a firmware update to a device

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/de/view/98161300).

13.2 Commissioning the ET 200SP for PROFINET IO

Requirements

- The CPU/interface module is in the "Factory settings" status or has been reset to factory settings (see section Interface module (https://support.automation.siemens.com/WW/view/en/55683316/133300)).
- For CPU: The SIMATIC memory card is as delivered or has been formatted.

13.2.1 ET 200SP CPU as an IO controller

Configuration example

To use the ET 200SP distributed I/O system as an IO controller, you require the CPU 151xSP-1 PN.

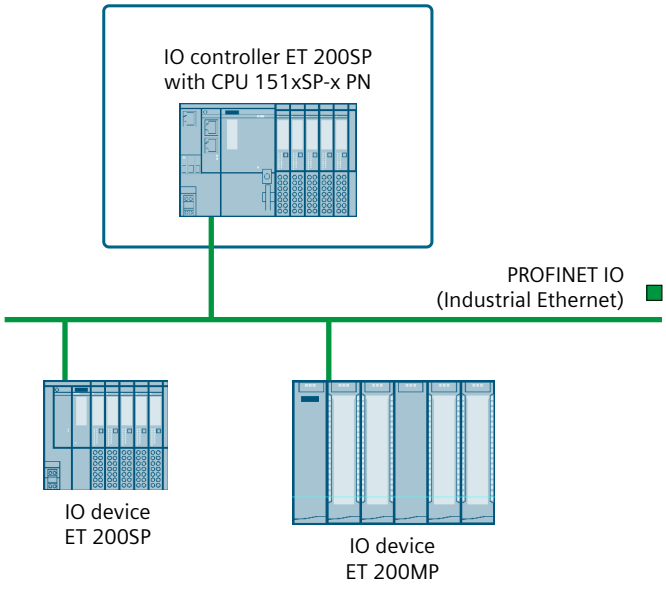

Figure 1-90 ET 200SP CPU as an IO controller

Commissioning procedure

To commission the ET 200SP distributed I/O system CPU as an IO controller for PROFINET IO, we recommend the following procedure:

Table 1-35 Procedure for commissioning the ET 200SP CPU as an IO controller for PROFINET IO

Step	Procedure	See ...
1	Installing ET 200SP	Section Installation (Page 120)
2	Connecting ET 200SP • Supply voltages • PROFINET IO • Sensors and actuators	Section Wiring (Page 153)
3	Inserting a SIMATIC memory card in the IO controller	Section Removing/inserting a SIMATIC memory card on the CPU (Page 296)
4	Configuring the IO controller[1]	Section Configuring (Page 199)
5	Checking the protective measures	-
6	Switching on supply voltages for the IO controller	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
7	Switching on supply voltages for IO devices	Documentation of the IO device
8	Downloading the configuration to the IO controller	STEP 7 online help
9	Switching IO controller to RUN mode	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
10	Checking LEDs	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
11	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. See section Test and service functions (Page 348)

[1] The IO devices are configured with the IO controller.

13.2.2 ET 200SP CPU as an I-device

Configuration example

You need the CPU 151xSP-1 PN to use the ET 200SP distributed I/O system as an I-device.

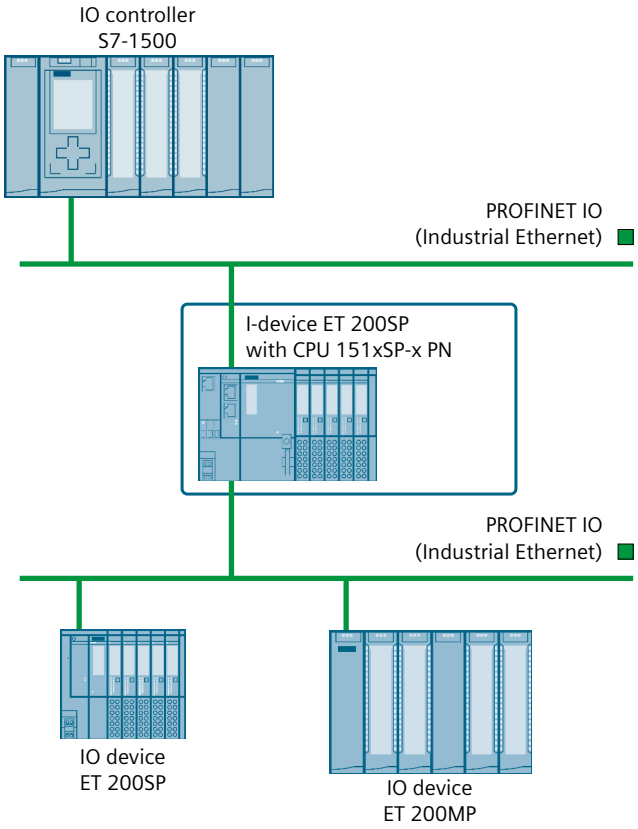

Figure 1-91 ET 200SP CPU as an I-device

Commissioning procedure

For commissioning of the ET 200SP distributed I/O system as an I-device on the PROFINET IO, we recommend the following procedure:

Table 1-36 Procedure for commissioning the ET 200SP as an I-device on the PROFINET IO

Step	Procedure	See ...
1	Installing ET 200SP	Section Installation (Page 120)
2	Connecting ET 200SP • Supply voltages • PROFINET IO • Sensors and actuators	Section Wiring (Page 153)
3	Inserting a SIMATIC memory card in the I-device	Section Removing/inserting a SIMATIC memory card on the CPU (Page 296)
4	Configuring the I-device	Section Configuring (Page 199)

Step	Procedure	See ...
5	Checking the protective measures	-
6	Switching on supply voltages for the IO controller	Documentation of the IO controller
7	Switching on supply voltages for I-device and IO devices	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual and documentation of the IO devices
8	Download configuration to the I-device	STEP 7 online help
9	Switching IO controller and I-device to RUN mode	Documentation of the IO controller and CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
10	Checking LEDs	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
11	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. See section Test and service functions (Page 348)

13.2.3 ET 200SP as an IO device

Configuration example

To use the ET 200SP distributed I/O system as an IO device, you need the IM 155-6 PNxx interface module.

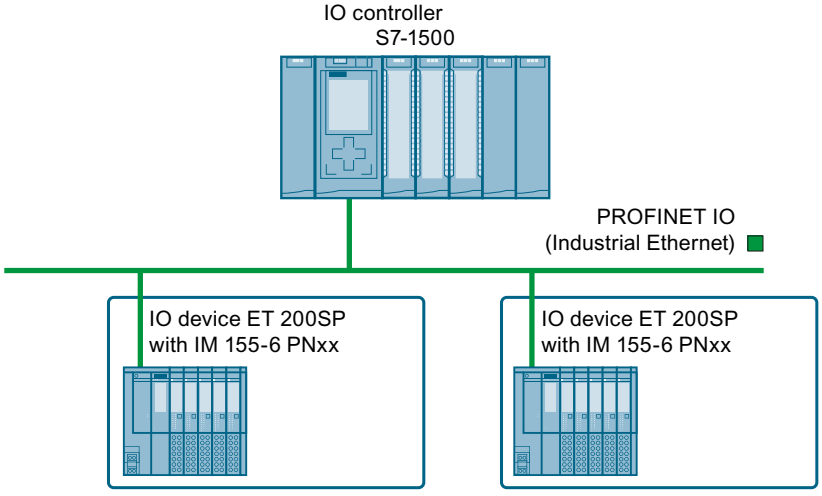

Figure 1-92 ET 200SP as an IO device

You can find information on further configuration variants of the ET 200SP distributed I/O system in redundancy mode in section "Configuration variants" of the Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833) System Manual.

Commissioning procedure

For commissioning of the ET 200SP distributed I/O system as an IO device on the PROFINET IO, we recommend the following procedure:

Table 1-37 Procedure for commissioning the ET 200SP as an IO device for PROFINET IO

Step	Procedure	See ...
1	Installing ET 200SP	Section Installation (Page 120)
2	Connecting ET 200SP • Supply voltages • PROFINET IO • Sensors and actuators	Section Wiring (Page 153)
4	Configuring IO controller	Documentation of the IO controller
5	Checking the protective measures	-
6	Switching on supply voltages for the IO controller	Documentation of the IO controller
7	Switching on supply voltages for IO devices	Interface module (https://support.automation.siemens.com/WW/view/en/55683316/133300) Manual
8	Downloading the configuration to the IO controller	STEP 7 online help
9	Switching IO controller to RUN mode	Documentation of the IO controller
10	Checking LEDs	Interface module (https://support.automation.siemens.com/WW/view/en/55683316/133300) Manual
11	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. Refer to section Test and service functions (Page 348)

13.3 Commissioning the ET 200SP on PROFIBUS DP

Requirements

- The CPU/interface module is in the "Factory settings" status or has been reset to factory settings (see section Interface module (https://support.automation.siemens.com/WW/view/en/55683316/133300)).
- For CPU: The SIMATIC memory card is as delivered or has been formatted.

13.3.1 ET 200SP as a DP master

Configuration example

To use the ET 200SP distributed I/O system as a DP master, you need the CPU 151xSP-1 PN and the CM DP communication module.

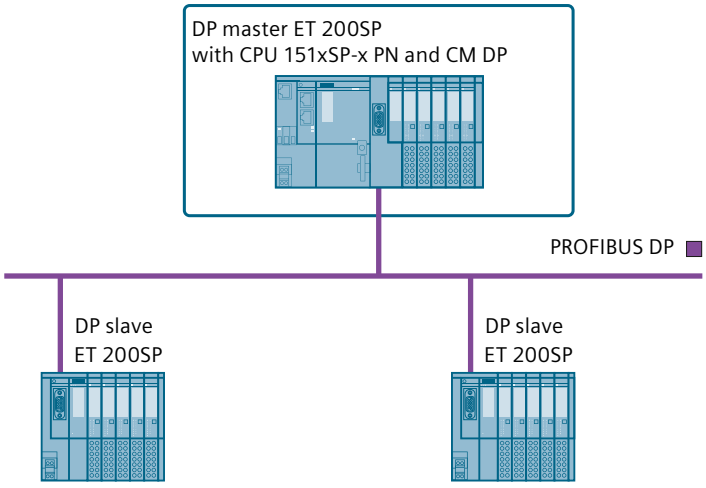

Figure 1-93 ET 200SP as a DP master

Commissioning procedure

To commission the ET 200SP distributed I/O system as a DP master on PROFIBUS DP, we recommend the following procedure:

Table 1-38 Procedure for commissioning the ET 200SP as a DP master on the PROFIBUS DP

Step	Procedure	See ...
1	Installing ET 200SP (with CPU and CM DP)	Section Installation (Page 120)
2	Connecting ET 200SP • Supply voltages • PROFIBUS DP • Sensors and actuators	Section Wiring (Page 153)
3	Inserting a SIMATIC memory card in the DP master (CPU)	Section Removing/inserting a SIMATIC memory card on the CPU (Page 296)
4	Configuring DP master (including PROFIBUS address)	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) and CM DP manual
5	Switching on supply voltages for DP master	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
6	Switching on supply voltages for DP slaves	Documentation of the DP slave

Step	Procedure	See ...
7	Download configuration to the DP master	STEP 7 online help
8	Switching DP master to RUN	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
9	Checking LEDs	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
10	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. See section Test and service functions (Page 348)

13.3.2 ET 200SP as I-slave

Configuration example

To use the ET 200SP distributed I/O system as I-slave, you need the CPU 151xSP-1 PN and the CM DP communication module.

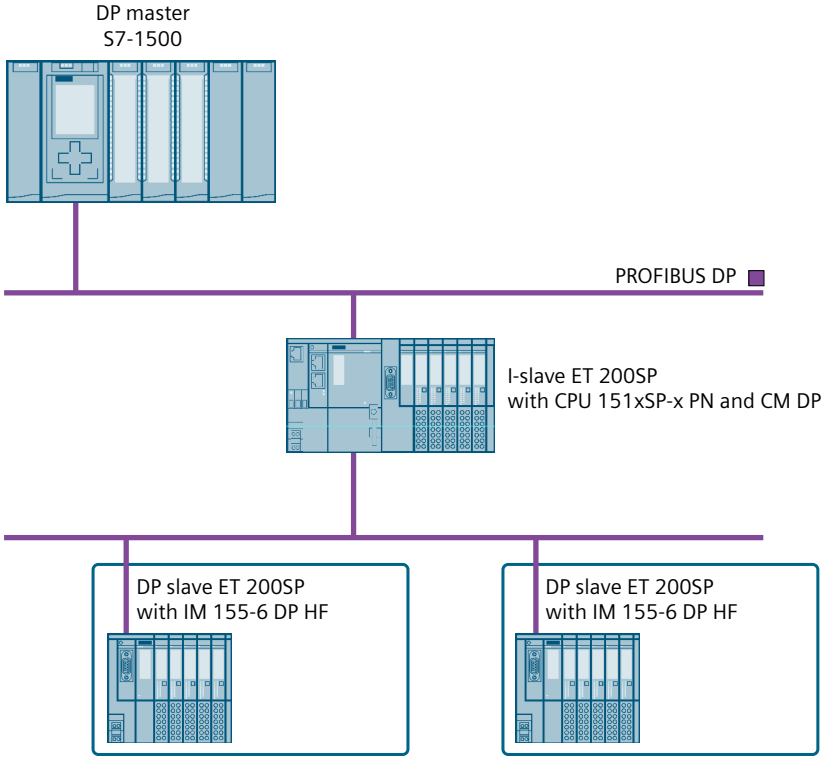

Figure 1-94 ET 200SP as I-slave

Commissioning procedure

For commissioning of the ET 200SP distributed I/O system as an I-slave on the PROFIBUS DP, we recommend the following procedure:

Table 1-39 Procedure for commissioning the ET 200SP as an I-slave for PROFIBUS DP

Step	Procedure	See ...
1	Installing ET 200SP (with CPU and CM DP)	Section Installation (Page 120)
2	Connecting ET 200SP • Supply voltages • PROFIBUS DP • Sensors and actuators	Section Wiring (Page 153)
3	Configuring DP master (including PROFIBUS address)	Documentation of the DP master
4	Inserting a SIMATIC memory card in the I-slave (CPU)	Section Removing/inserting a SIMATIC memory card on the CPU (Page 296)
5	Configuring I-slave (including PROFIBUS address)	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) and CM DP manual
6	Switching on supply voltages for DP master	Documentation of the DP master
7	Switching on supply voltages for I-slaves	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
8	Loading configuration in the DP master and I-slaves	STEP 7 online help
9	Switching DP master and I-slaves to RUN	Documentation of the DP master and CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
10	Checking LEDs	CPU 15xxSP-1 PN (https://support.automation.siemens.com/WW/view/en/90466439/133300) manual
11	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. See the Test functions and fault resolution (https://support.automation.siemens.com/WW/view/en/90466439/133300) section

13.3.3 ET 200SP as a DP slave

Configuration example

To use the ET 200SP distributed I/O system as a DP slave, you need the IM 155-6 DP HF.

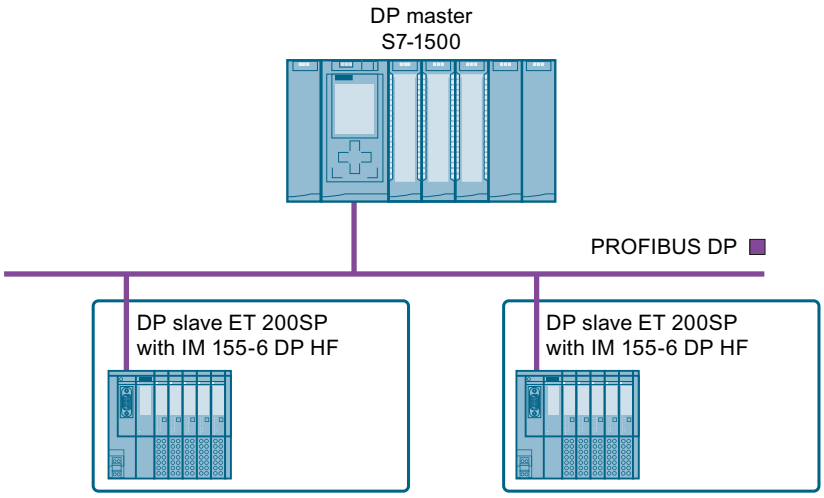

Figure 1-95 ET 200SP as a DP slave

Commissioning procedure

To commission the ET 200SP distributed I/O system as a DP slave on PROFIBUS DP, we recommend the following procedure:

Table 1-40 Procedure for commissioning the ET 200SP as a DP master for PROFIBUS DP

Step	Procedure	See ...
1	Installing ET 200SP (with IM 155-6 DP HF)	Section Installation (Page 120)
2	Setting the PROFIBUS address on the interface module	Section Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300)
3	Connecting ET 200SP • Supply voltages • PROFIBUS DP • Sensors and actuators	Section Wiring (Page 153)
4	Configuring DP master (including PROFIBUS address)	Documentation of the DP master
5	Switching on supply voltages for DP master	Documentation of the DP master
6	Switching on supply voltages for DP slaves	Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300) Manual
7	Download configuration to the DP master	STEP 7 online help

Step	Procedure	See ...
8	Switching DP master to RUN	Documentation of the DP master
9	Checking LEDs	Interface module (http://support.automation.siemens.com/WW/view/en/55683316/133300) Manual
10	Testing inputs and outputs	The following functions are helpful: Monitoring and modifying tags, testing with program status, forcing, controlling the outputs. Refer to section Test and service functions (Page 348)

13.4 Startup of the ET 200SP with empty slots

Procedure

You can configure the ET 200SP distributed I/O system with any number of empty slots.

To build the ET 200SP distributed I/O system with any number of empty slots, follow these steps:

1. Cover all empty slots with BU covers.
2. Finish the configuration with a server module.

Special consideration: A "Module missing in slot x" diagnostic message is generated by the CPU/interface module for empty slots in which I/O modules are configured.

13.5 Removing/inserting a SIMATIC memory card on the CPU

Requirement

The CPU only supports pre-formatted SIMATIC memory cards. If necessary, delete all previously stored data before using the SIMATIC memory card. You can find more information on deleting the content of the SIMATIC memory card in the function manual Structure and use of the CPU memory.

In order to work with the SIMATIC memory card, first ensure that the SIMATIC memory card is not write-protected. If it is, move the slider out of the lock position.

Inserting the SIMATIC memory card

To insert a SIMATIC memory card, follow these steps:

1. Ensure that the CPU is either switched off or in STOP mode.
2. Insert the SIMATIC memory card, as depicted on the CPU, into the slot for the SIMATIC memory card.

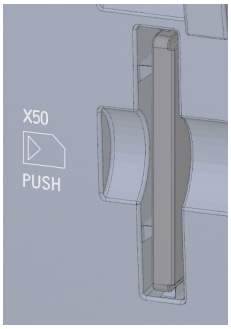

Figure 1-96 Slot for the SIMATIC memory card

3. Insert the SIMATIC memory card with light pressure into the CPU, until the SIMATIC memory card latches.

Removal of the SIMATIC memory card

To remove a SIMATIC memory card, follow these steps:

1. Switch the CPU to STOP mode.
2. Press the SIMATIC memory card into the CPU with light pressure. After audible unlatching of the SIMATIC memory card, remove it.

Only remove the SIMATIC memory card in POWER OFF or STOP mode of the CPU. Ensure that no writing functions (online functions with the programming device, e.g. loading/deleting a block, test functions) are active in STOP mode or were active before POWER OFF.

Reactions after removing/inserting the SIMATIC memory card

Inserting and removing the SIMATIC memory card in STOP, STARTUP or RUN mode triggers a re-evaluation of the SIMATIC memory card. The CPU hereby compares the content of the configuration on the SIMATIC memory card with the backed-up retentive data. If the backed-up retentive data matches the data of the configuration on the SIMATIC memory card, the retentive data is retained. If the data differs, the CPU automatically performs a memory reset (which means the retentive data is deleted) and then goes to STOP.

The CPU evaluates the SIMATIC memory card, and this is indicated by the RUN/STOP LED flashing.

Reference

You can find more information on the SIMATIC memory card in the function manual Structure and use of the CPU memory (https://support.industry.siemens.com/cs/ww/en/view/59193101).

13.6 Operating modes of the CPU

Introduction

Operating modes describe the status of the CPU. The following operating modes are possible using the mode selector:

- STARTUP
- RUN
- STOP

In these operating modes, the CPU can communicate, for example, via the PROFINET interface.

The status LEDs on the front of the CPU indicate the current operating mode.

13.6.1 STARTUP mode

Behavior

Before the CPU starts to execute the cyclic user program, a startup program is executed.

By suitably programming startup OBs, you can specify initialization tags for your cyclic program in the startup program. You have the option of programming no, one or several startup OBs.

Special features during startup

Note the following points regarding STARTUP mode:

- The CPU resets the process image input.
- All outputs are disabled or respond as configured for the given module: They provide a substitute value as set in the parameters or retain the last value output and bring the controlled process to a safe operational status.
- Before processing the start-up routine, the CPU transfers the I/O inputs to the process image input.

- After processing the start-up routine, the CPU releases the peripheral outputs.

  NOTE

  To read the current state of inputs during STARTUP, you can access inputs via the process image or via direct I/O access.
  To initialize outputs during STARTUP, you can write values via the process image or via direct I/O access. The values are output to the outputs during the transition to RUN mode.

- The CPU always starts up in warm restart mode.
  - The non-retentive bit memory, timers and counters are initialized.
  - The non-retentive tags in data blocks are initialized.
- During startup, cycle-time monitoring is not yet running
- The CPU processes the startup OBs in the order of the startup OB numbers. The CPU processes all programmed startup OBs regardless of the selected startup mode. (Figure "Setting the startup behavior").
- If a corresponding event occurs, the CPU can start the following OBs during startup:
  - OB 82: Diagnostics interrupt
  - OB 83: Pull/plug interrupt for modules
  - OB 86: Rack error
  - OB 121: Programming error (only for global error handling)
  - OB 122: I/O access error (only for global error handling)

    You can find a description of how to use global and local error handling in the STEP 7 online help.

  The CPU does not start all the other OBs until the transition to RUN mode.

Response when expected and actual configurations do not match

The configuration downloaded to the CPU represents the expected configuration. The actual configuration is the actual configuration of the ET 200SP distributed I/O system. If the expected configuration and actual configuration do not match, the setting of the "Comparison preset to actual configuration" parameter determines the behavior of the CPU. You can find additional information on hardware compatibility in the section Operating mode transitions (Page 302).

Cancellation of startup

If errors occur during startup, the CPU cancels startup and returns to STOP mode.

The CPU does not perform the startup or interrupts the startup under the following conditions:

- You have not inserted a SIMATIC memory card or have inserted an invalid one.
- You have not downloaded a hardware configuration to the CPU.

Configuring the startup behavior

You configure the behavior of the CPU in the Startup group in the CPU properties.

Setting the startup behavior

To set the startup behavior, follow these steps:

1. Select the CPU in the device view of the STEP 7 hardware network editor.
2. In the properties under "General" select the "Startup" area.

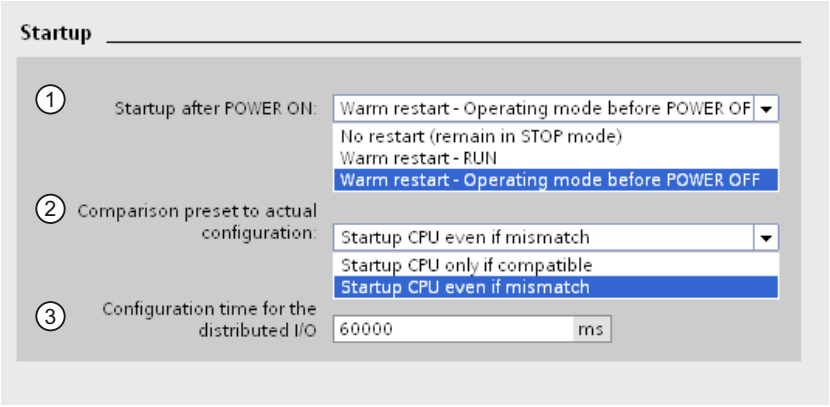

Figure 1-97 Setting the startup behavior

① Sets the startup type after POWER ON

② Defines the startup behavior when a module in a slot does not correspond to the configured module. You can set this parameter centrally, on the CPU or for each module. When you change the setting for a module, the setting made centrally for this module no longer applies.

- Startup CPU only if compatible: In this setting a module on a configured slot has to be compatible with the configured module. Compatible means that the module matches in terms of the number of inputs and outputs and with respect to its electrical and functional properties.
- Startup CPU even if mismatch: With this setting the CPU starts up regardless of the type of module plugged in.

③ Specifies a maximum period (default: 60000 ms) in which the I/O must be ready for operation. The CPU changes to RUN.

If the central and distributed I/O is not ready for operation within the configuration time, the startup characteristics of the CPU depends on the setting of the "Comparison preset to actual configuration" parameter.

Example for the "Comparison preset to actual configuration" parameter

"Startup CPU only if compatible":

The DI 16x24VDC ST input module with 16 digital inputs is a compatible replacement for a DI 8x24VDC ST input module with 8 digital inputs. The pin assignment and all electrical and functional properties are identical.

"Startup CPU even if mismatch":

Instead of a configured digital input module, you insert an analog output module or no module is present in this slot and thus in all subsequent slots. Although the configured inputs cannot be accessed, the CPU starts up.

Note that the user program cannot function correctly in this case and take the appropriate measures.

13.6.2 STOP mode

Behavior

The CPU does not execute the user program in STOP mode.

All outputs are disabled or react according to the parameter settings for the particular I/O module: They provide a substitute value as set in the parameters or retain the last value output keeping the controlled process in a safe operating status.

In STOP mode, the motor starter responds according to how it was parameterized for the CPU STOP state. The CPU STOP state can be circumvented with the manual local control (Local Control) function. If the CPU is switched off, a motor can be switched on in the motor starter's commissioning mode.

You will find additional information in the Motor starter (https://support.industry.siemens.com/cs/ww/en/view/109479973) manual.

13.6.3 RUN mode

Behavior

In "RUN" mode the cyclic, time-driven, and interrupt-driven program is executed. Addresses that are in the "Automatic Update" process image are automatically updated in each program cycle. See also the section Process images and process image partitions (Page 206).

Execution of the user program

Once the CPU has read the inputs, the cyclic program is executed from the first instruction to the last instruction.

If you have configured a minimum cycle time, the CPU will not end the cycle until this minimum cycle time is finished even if the user program is completed sooner.

A cycle monitoring time is set to ensure that the cyclic program is completed within a specified time. You can change the cycle monitoring time to suit your requirements. If the cyclic program has not finished running within this time, the system responds with a time error.

Further events such as hardware interrupts and diagnostics interrupts can interrupt the cyclic program flow and prolong the cycle time.

Reference

Further information about cycle and response times is available in the Function Manual Cycle and response times (https://support.automation.siemens.com/WW/view/en/59193558).

13.6.4 Operating mode transitions

Operating modes and operating mode transitions

The following figure shows the operating modes and the operating mode transitions:

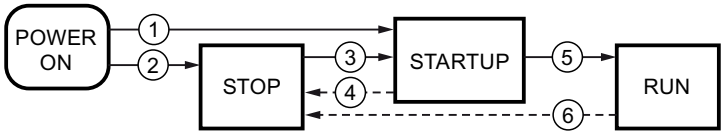

Figure 1-98 Operating modes and operating mode transitions

The table below shows the effects of the operating mode transitions:

Table 1-41 Operating mode transitions

No.	Operating mode transitions		Effects
1	POWER ON → STARTUP	After switching on, the CPU switches to "STARTUP" mode if: • The hardware configuration and program blocks are consistent. • The preceding "POWER OFF" was triggered by an interruption in the power supply. • Startup type "Warm restart - RUN" is set. Or • Startup type "Warm restart - mode before POWER OFF" is set and the CPU was in RUN mode before POWER OFF.	The CPU clears the non-retentive memory, and resets the content of non-retentive DBs to the start values of the load memory. Retentive memory and retentive DB contents are retained. The 500 newest entries in the diagnostics buffer are retained.
2	POWER ON → STOP	After switching on, the CPU goes to "STOP" mode if: • The hardware configuration and program blocks are inconsistent. Or • The "No restart" startup type is set. Or • Startup type "Warm restart - mode before POWER OFF" is set and the CPU was in STOP mode before POWER OFF.	The CPU clears the non-retentive memory, and resets the content of non-retentive DBs to the start values of the load memory. Retentive memory and retentive DB contents are retained. The 500 newest entries in the diagnostics buffer are retained.
3	STOP → STARTUP	The CPU switches to "STARTUP" mode if: • The hardware configuration and program blocks are consistent. • You set the CPU to "RUN" mode via the programming device and the mode switch in is RUN position. Or • You set the mode switch from STOP to RUN.	The CPU clears the non-retentive memory, and resets the content of non-retentive DBs to the start values of the load memory. Retentive memory and retentive DB contents are retained. The 500 newest entries in the diagnostics buffer are retained.

No.	Operating mode transitions		Effects
④	STARTUP → STOP	In the following cases, the CPU goes from "STARTUP" to "STOP" mode when: • The CPU detects an error during startup. • You set the CPU to "STOP" via the programming device or mode switch. • The CPU executes a STOP command in the Startup OB.	These operating mode transitions have no effect on data.
⑤	STARTUP → RUN	In the following cases, the CPU goes from "STARTUP" to "RUN" mode when: • The CPU has initialized the PLC tags. • The CPU has executed the startup blocks successfully.	
⑥	RUN → STOP	In the following cases, the CPU goes from "RUN" back to "STOP" mode when: • The CPU detects an error which prevents further work. • The CPU executes a STOP command in the user program. • You set the CPU to "STOP" via the programming device or mode switch.	

13.7 CPU memory reset

Basics of a memory reset

The CPU must be in STOP mode for a memory reset.

A memory reset returns the CPU to its "initial state".

Memory reset means:

- An existing online connection between your programming device/PC and the CPU is terminated.
- The content of the work memory and the retentive and non-retentive data (applies only to manual memory reset by the user) are deleted.
- The diagnostics buffer, time of day, IP address and the device name are retained.
- Subsequently the CPU is initialized with the loaded project data (hardware configuration, code and data blocks, force jobs). The CPU copies this data from the load memory to the work memory.

  Result:

  – If you set an IP address in the hardware configuration ("Set IP address in the project" option) and a SIMATIC memory card with the project is in the CPU, this IP address is valid after the memory reset.
  – Data blocks no longer have current values but rather their configured start values.
  – Force jobs remain active.

Detecting a CPU memory reset

The RUN/STOP LED flashes yellow at 2 Hz. After completion, the CPU switches to STOP. The RUN/STOP LED is on (constant yellow light).

Result after memory reset

The following table provides an overview of the contents of the memory objects after memory reset.

Table 1-42 Memory objects after memory reset

Memory object	Content
Actual values of the data blocks, instance data blocks	Initialized
Bit memory, timers and counters	Initialized
Retentive tags from technology objects (for example, adjustment values of absolute encoders)*	Retained
Diagnostics buffer entries	Retained
IP address	Retained
Device name	Retained
Counter readings of the runtime meters	Retained
Time of day	Retained

* The retentive tags from technology objects are retained but the content of certain tags is re-initialized in some cases.

NOTE

Password for protection of confidential configuration data

The password for protection of confidential configuration data is retained after a memory reset of the CPU. The password is only deleted when the "Delete password for protection of confidential PLC configuration data" option is set.

You can find additional information on the password for protection of confidential configuration data in the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) function manual.

13.7.1 Automatic memory reset

Possible causes of automatic memory reset

The CPU executes an automatic memory reset if an error occurs that prevents normal further processing.

Causes of such errors are:

- User program is too large, and cannot be completely loaded into work memory.
- The project data on the SIMATIC memory card is corrupt, for example, because a file was deleted.
- If you remove or insert the SIMATIC memory card and the backed-up retentive data differs in structure from that of the configuration on the SIMATIC memory card.

13.7.2 Manual memory reset

Reason for a manual memory reset

CPU memory reset is required to reset the CPU to its "original state".

CPU memory reset

Two options are available for performing a CPU memory reset:

- Using the mode selector
- Using STEP 7

Procedure using the mode selector

NOTE

Memory reset ↔ Reset to factory settings

The procedure described below also corresponds to the procedure for resetting to factory settings:

- Selector operation with inserted SIMATIC memory card: CPU executes a memory reset
- Selector operation without inserted SIMATIC memory card: CPU executes reset to factory settings

To reset the CPU memory using the mode selector, proceed as follows:

1. Set the mode selector to the STOP position.

   Result: The RUN/STOP LED lights up yellow.
2. Set the mode selector to the MRES position. Hold the selector in this position until the RUN/STOP LED lights up for the 2nd time and remains continuously lit (this takes three seconds). After this, release the switch.
3. Within the next three seconds, switch the mode selector back to the MRES position, and then back to STOP again.

Result: The CPU executes memory reset.

For information on resetting the CPU to factory settings, refer to the section Resetting the CPU to factory settings (Page 339).

Procedure using STEP 7

For a memory reset of the CPU using STEP 7 proceed as follows:

1. Open the "Online Tools" task card of the CPU.
2. Click the "MRES" button in the "CPU control panel" pane.
3. Click "OK" in response to the confirmation prompt.

Result: The CPU switches to STOP mode and performs a memory reset.

13.8 Reassigning parameters during operation

Introduction

You have the option of reassigning the parameters for the ET 200SP I/O modules during operation.

Changing parameters during operation

You make the parameter settings of the I/O modules using data records. Each I/O module has a separate data record. The instruction "WRREC" applies the changed parameters to the I/O module. The parameters that you have set with STEP 7 are not changed. After a POWER OFF/POWER ON of the ET 200SP, the parameters set with STEP 7 are valid again.

If you are using the CPU as an I-device, you reassign the parameters of the I/O modules via the I-device.

NOTE

If you write data records from the user program to the modules of the distributed I/O, make sure that these modules actually exist and are available. You can evaluate OB83 for this purpose. After inserting a module, the CPU does not call OB83 until the module has started up and its parameters are assigned. This ensures the execution of the data record operations without errors.

NOTE

You need to transfer the new parameters with the "WRREC" instruction after a POWER OFF/POWER ON of the ET 200SP.

Instruction for parameter assignment

The following instruction is provided for assigning parameters to the I/O module in the user program:

Instruction	Application
"WRREC"	Transfer the modifiable parameters to the addressed ET 200SP module.

Error message

In the event of an error, the following return values are reported:

Table 1-43 Error message

Error code	Meaning
$80E0_H$	Error in header information
$80E1_H$	Parameter error

Reference

You can find the structure of the parameter data record and the module-specific error codes in the manuals of the I/O modules (https://support.automation.siemens.com/WW/view/es/55679691/133300).

13.9 Backing up and restoring the CPU configuration

13.9.1 Overview

Backup from online device

You make changes where necessary in the system operation. You add new devices, replace existing devices or adapt the user program. If these changes result in undesirable behavior, you can restore the plant to an earlier state. Before you load a changed configuration to the CPU, first use the option "Backup from online device" to create a complete backup of the current device status. If you have assigned a password to protect confidential PLC configuration data, then this password is not secured.

When a backup is restored that has a password set for protection of confidential configuration data, the following applies:
The password in the CPU must match the password in the backup.
Transfer the password to the CPU before restoring the backup. You transfer the password

either using a SIMATIC Memory Card or online in STEP 7 via "Online & Diagnostics". If the password in the CPU does not match the password entered in STEP 7, the SIMATIC Memory Card will be rejected when restoring the backup. The CPU generates an entry in the diagnostic buffer.

You can find more information in section Protection of confidential configuration data (Page 229) and in the Communication (https://support.industry.siemens.com/cs/ww/de/view/59192925/en) Function Manual.

Upload from device (software)

With the option "Upload from device (software)", you load the software project data from the CPU to an existing CPU in the project.

Upload device as new station

If you are operating a new PG/PC on a system, the STEP 7 project that was used to create the system configuration might not be available. In this case, you upload the data to a project in your PG/PC with the "Upload device as new station" option.

Snapshot of the monitor values

To allow you to restore the actual values after changes, back up the actual values of the data blocks with the "Snapshot of the monitor values" option.

Overview of backup types

The table below shows the backup of CPU data depending on the selected type of backup and its specific characteristics:

	Backup from online device	Upload from device (software)	Upload device as new station	Snapshot of the monitor values
Current values of all DBs (global and instance data blocks) [1]	✓	✓	✓	✓
Blocks of the type OB, FC, FB and DB	✓	✓	✓	--
PLC tags (tag names and constant names)	✓	✓	✓	--
Technology objects	✓	✓	✓	✓ [3]
Hardware configuration	✓	--	✓	--
Actual values (bit memories, timers, counters)*	✓	--	--	--
Contents of the SIMATIC memory card	✓	--	--	--
Archives, recipes	✓	--	--	--
Entries in the diagnostics buffer	--	--	--	--
Current time	--	--	--	--

1) Only the values of the tags that are set as retentive are saved.

2) Only possible in the STOP operating state and for individual fail-safe blocks.

3) Nur die High_Speed_Counter and SSI_Absolute_Encoder modules

	Backup from online device	Upload from device (software)	Upload device as new station	Snapshot of the monitor values
Properties of the type of backup				
Backup possible for fail-safe CPUs	✓	✓ [2]	--	✓
Backup can be edited	--	✓	✓	✓
Backup possible in operating mode	STOP	RUN, STOP	RUN, STOP	RUN, STOP

[1] Only the values of the tags that are set as retentive are saved.

[2] Only possible in the STOP operating state and for individual fail-safe blocks.

[3] Nur die High_Speed_Counter and SSI_Absolute_Encoder modules

Example: Backup from online device

The following example shows the procedure for a complete backup of the current device state of the CPU in STEP 7. The S7-1500 automation system is in RUN mode. Before the backup, the CPU goes into STOP mode.

To start the backup, proceed as follows:

1. Right-click on the CPU in the project tree.
2. Select the "Backup from online device" command from the context menu.
   The "Upload preview" dialog window summarizes key information about the upcoming backup. You must switch the CPU to STOP mode to perform a backup.
3. In the "Action" column, select the "Stop module" command from the drop-down menu.
4. Click "Upload from device". The CPU switches to STOP mode. The backup of the CPU data starts. The backup is saved in the folder of the CPU under "Online backups" in the project tree.

Example: Restoring backup from online device

If you have backed up the CPU data earlier, you can transfer the backup back to the device. The saved backup is then restored on the CPU.

The automation system is in RUN mode. Before the restore operation, the CPU goes into STOP mode.

To start restoring the backup, proceed as follows:

1. Expand the folder of the CPU in the project tree. The lower-level objects are displayed.
2. Open the "Online backups" folder.
3. Select the backup you want to restore.
4. In the "Online" menu, select the "Download to device" command.
5. The "Load preview" dialog window summarizes key information about the upcoming restore operation. You must switch the CPU to STOP mode to restore a backup.
6. In the "Action" column, select the "Overwrite" command from the drop-down menu.

7. Click "Load". The CPU switches to STOP mode. The backup is transferred to the CPU and restored. The "Load results" dialog then opens. In this dialog, you can check whether the download was successful and select any other actions (no action, start modules).
8. Click the "Finish" button.

Rules for backup and restore

Observe the following rules when backing up/restoring:

- Complete the process quickly and without interruptions.
- The CPU and the programming device must be in a protected network.
- Decide in advance whether you want to back up/restore the data of a CPU in STEP 7 or via the web server of the CPU.
  If you start the operation in STEP 7, you must also finish it in STEP 7. The same applies if you use the web server.
  - To perform the operation in STEP 7, the user requires either the "PLC administrator" role or a role with the "Full access" function right.
  - To perform the operation via the web server of the CPU, the user requires a role with the "Create a backup of the CPU" or "Restore the CPU using a backup file" function right.
- The user who starts the operation must also complete the operation.
- If a user cancels the operation or the CPU cancels the operation due to an error, only the user who canceled the operation can resume it. To do so, the following intermediate steps are required:
  - Reset to factory settings
  - Download from STEP 7
  - Start a new backup/restore

Reference

You can find more information on the different backup types in the STEP 7 online help.

Emergency address (emergency IP)

The emergency address (emergency IP address) of a CPU was conceived for diagnostic and downloading functions, e.g. if the CPU can no longer be reached via the IP protocol due to loading of an incorrect project. You can find information on the emergency address in the Communication (https://support.industry.siemens.com/cs/ww/de/view/59192925/en) function manual.

Archiving multilingual project texts

When you configure a CPU, different categories of texts come into being, e.g.

- Object names (names of blocks, modules, tags, etc.)
- Comments (for blocks, networks, watch tables, etc.)
- Messages and diagnostic texts

Texts are provided by the system (e.g. diagnostic buffer texts) or are created during configuration (e.g. messages).

In a project, texts exist in one single language or in several languages after a translation process. You can maintain project texts in all languages, which are at your disposal in the project navigator (Languages & Resources > Project Texts). The texts arising during configuration can be loaded into the CPU.

The following texts containing the project data are loaded into the CPU in the chosen languages and are also used by the Web server:

- Diagnostic buffer texts (not editable)
- Module status texts (not editable)
- Message texts with associated text lists
- Tag comments and step comments for S7 GRAPH and PLC Code Viewer
- Comments in watch tables

The following texts containing the project languages are also loaded into the CPU in the chosen languages, but are not used by the Web server:

- Comments in tag tables (for tags and constants)
- Comments in global data blocks
- Comments of elements in block interfaces of FBs, FCs, DBs and UDTs
- Network titles in data blocks that are written in ladder logic (LAD), function block diagram (FBD) or statement list (STL)
- Block comments
- Network comments
- Comments of LAD and FBD elements

The CPUs support archiving of multilingual project texts in up to three different project languages. If the project texts for a particular project language nevertheless exceed the memory space reserved for them, the project cannot be downloaded to the CPU. The download is aborted with a notice that not enough memory space is available. In such a case, take measures to reduce the required storage space, for example by shortening comments.

NOTE

Size of the SIMATIC memory card

If, when loading projects, the required memory space is more extensive/larger than the memory space on the

SIMATIC memory card used, the download to the CPU is canceled. You receive an error message.

Therefore, make sure that there is enough available storage space on your SIMATIC memory card for loading projects.

You will find information on reading out the storage space capacity utilization of the CPU and the SIMATIC memory card in the Structure and use of the CPU memory (https://support.industry.siemens.com/cs/de/de/view/59193101/en) function manual.

You will find information on parameterization of multilingual project texts in STEP 7 in the STEP 7 online help.

13.10 Time synchronization

Introduction

All CPUs are equipped with an internal clock. The clock shows:

- The time of day with a resolution of 1 millisecond
- The date and the day of the week

The CPU takes into account the time change caused by daylight saving time.

You can synchronize the time of the CPUs with an NTP server in NTP mode (NTP: Network Time Protocol).

Operating principle

In NTP mode, the device sends time queries at regular intervals (in client mode) to the NTP server in the subnet (LAN). Based on the replies of the servers, the most reliable and most accurate time is calculated and the time of day of the CPU is synchronized. The advantage of this mode is that it allows the time to be synchronized across subnets. You can synchronize the time of day of up to a maximum of four NTP servers. You address a communications processor or an HMI device, for example, as sources for time synchronization via the IP addresses.

The update interval defines the interval between the time queries (in seconds). The value range of the interval is between 10 seconds and one day. In NTP mode, it is generally UTC (Universal Time Coordinated) that is transferred. UTC corresponds to GMT (Greenwich Mean Time).

NTP server for the ET 200SP CPU

You can assign an ET 200SP CPU to up to 4 NTP servers.

You have the following options to reset the IP addresses of the NTP servers:

- Configure IP addresses of the NTP servers in STEP 7.
- Set IP addresses of the NTP servers with the "T_CONFIG" instruction.
- Obtain IP addresses of the NTP servers via DHCP.
  As of firmware version V2.9, the CPU can also obtain the NTP servers via DHCP. You can find more information on the procedure and the DHCP communication protocol in the Communication (https://support.industry.siemens.com/cs/ww/de/view/59192925/en) function manual.

Configuring IP addresses of the NTP servers in STEP 7

To configure the IP addresses of the NTP servers in STEP 7, follow these steps:

1. Select the ET 200SP CPU in STEP 7.
2. In the properties of the CPU, navigate to "Time of day" > "Time synchronization"> "NTP mode".
3. For "Time synchronization:", select "Set NTP server in the project" from the drop-down list.
4. Enter the IP addresses of up to four NTP servers for "Server 1" to "Server 4".
5. Set the time interval of time queries for "Update interval". Set the update interval to between 10 s and 86400 s.

Setting the IP addresses of the NTP servers with the "T_CONFIG" instruction

Requirements:

- You selected the option "Set NTP server directly on the device (e.g. PLC program, display)" in the "Time synchronization" drop-down list in STEP 7.

Proceed as follows to set the IP addresses of the NTP servers with the T_CONFIG instruction:

1. Enter the IP addresses of up to four NTP servers in a tag of the data type IF_CONF_NTP.
2. Interconnect the tag of data type IF_CONF_NTP at the block parameter CONF_DATA of the T_CONFIG instruction.
3. Call the T_CONFIG instruction in the user program.

Result: The addresses of the NTP servers from the T_CONFIG instruction are transferred to the CPU.

If necessary, you can change the addresses of the NTP servers several times with T_CONFIG.

Reference

For additional information on time synchronization in the automation environment, refer to the following FAQ on the Internet (https://support.industry.siemens.com/cs/de/en/view/86535497).

13.10.1 Example: Configuring and changing NTP server

Automation task

You are using your own NTP server in your network with the IP address 192.168.1.15. Your own server provides you with the following advantages:

- Protection against unauthorized accesses from outside
- Every device that you synchronize with your own NTP server uses the same time.

You want to synchronize the ET 200SP CPU with this NTP server.

The following sections describe how to configure the IP address of the NTP server in STEP 7 or set it in the user program.

Configuring the IP address of the NTP server in STEP 7

Procedure

1. Select the ET 200SP CPU in STEP 7.
2. In the properties of the CPU, navigate to "Time of day" > "Time synchronization"> "NTP mode".
3. For "Time synchronization:", select "Set NTP server in the project" from the drop-down list.
4. For "Server 1:", enter the IP address of the NTP server: 192.168.1.15.
5. Download the hardware configuration to the CPU.

Result

The CPU synchronizes the time with the NTP server 192.168.1.15.

Set IP addresses of the NTP server with the "T_CONFIG" instruction

Requirements:

- You selected the option "Set NTP server directly on the device (e.g. PLC program, display)" in the "Time synchronization" drop-down list in STEP 7.

To set the IP address for the NTP server, use the following block parameters of the "T_CONFIG" instruction:

- Req: A positive edge at the block parameter "Req" starts a job of the "T_CONFIG" instruction.
- Interface: Enter the HW ID of the PROFINET interface 1 of the CPU at the block parameter "Interface". In this example, the HW ID is "64".
- Conf_Data: Area in which you save the IP addresses of the NTP server. Use the data type "IF_CONF_NTP" for this purpose.

Procedure

Proceed as follows to set the IP address of the NTP server in the user program to "192.168.1.15":

1. Create a global data block in the project tree under "Program blocks > Add new block". Name the global data block "NTP".
2. Create a tag of the data type "IF_CONF_NTP" in the global data block "NTP".

NTP

	Name	Data type	Start value	Comment
1	Static			
2	NTP_Server	IF_CONF_NTP		
3	Id	UInt	17	
4	Length	UInt	22	
5	Mode	UInt	0	
6	NTP_IP	Array[1..4] of IP_V4		
7	NTP_IP[1]	IP_V4		
8	ADDR	Array[1..4] of Byte		IPv4 address
9	ADDR[1]	Byte	192	IPv4 address
10	ADDR[2]	Byte	168	IPv4 address
11	ADDR[3]	Byte	1	IPv4 address
12	ADDR[4]	Byte	10	IPv4 address
13	NTP_IP[2]	IP_V4		
14	NTP_IP[3]	IP_V4		
15	NTP_IP[4]	IP_V4		
16	change_NTP-Server	Bool	false	
17	done	Bool	false	
18	busy	Bool	false	
19	error	Bool	false	
20	status	DWord	16#0	
21	err_loc	DWord	16#0	

Figure 1-99 Example: Data block with IF_CONF_NTP

3. Create a "T_CONFIG" instruction in the user program.
4. Connect the "T_CONFIG" instruction as follows.

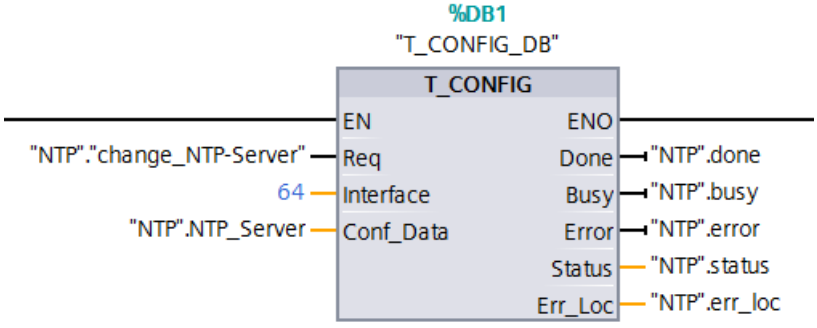

Figure 1-100 Example T_CONFIG: Changing the NTP server

5. In the user program, assign the IP address 192.168.1.15 to the data type "IF_CONF_NTP":
```
"NTP".NTP_Server.NTP_IP[1].ADDR[1] := 192;
"NTP".NTP_Server.NTP_IP[1].ADDR[2] := 168;
"NTP".NTP_Server.NTP_IP[1].ADDR[3] := 1;
"NTP".NTP_Server.NTP_IP[1].ADDR[4] := 15;
```
6. Generate a positive edge for the tag "change_NTP-Server" in the user program:
```
"NTP"."change_NTP-Server" := true;
```

Result

The CPU synchronizes the time with the NTP server 192.168.1.15.

13.11 Identification and maintenance data

13.11.1 Reading out and entering I&M data

I&M data

Identification and maintenance data (I&M data) is information saved on the module. The data is:

- Read-only (I-data) or
- Readable/writable (M-data)

Identification data (I&M0): Manufacturer information about the module that can only be read. Some identification data is also printed on the housing of the module, for example article number and serial number.
Maintenance data (I&M1, 2, 3): Plant-dependent information, e.g. installation location. Maintenance data is created during configuration and downloaded to the module.
All modules of the ET 200SP distributed I/O system support identification data (I&M0 to I&M3).

The I&M identification data supports you in the following activities:

- Checking the plant configuration
- Locating hardware changes in a plant
- Correcting errors in a plant

Modules can be clearly identified online using the I&M identification data.

Maintenance data (I&M4): Storage of a CRC checksum for interface modules IM 155-6 PN ST for ensuring data integrity of data used by the interface module.

NOTE

The BusAdapter and the interface module IM 155-6 PN HF support the identification data I&M0 to I&M4 (signature).

Options for reading out I&M data

- Via the user program
- Via STEP 7 or HMI devices
- Via the CPU web server

Reading I&M data via the user program

You have the following options to read the modules' I&M data in the user program:

- Using the RDREC instruction

  The record structure for distributed modules that are accessible via PROFINET IO/PROFIBUS DP, is described in the chapter Record structure for I&M data (Page 318).
- Using the Get_IM_Data instruction

Reference

The description of the instructions can be found in the STEP 7 online help.

Reading I&M data via STEP 7

Requirements: There must be an online connection to the CPU/interface module.

To read I&M data using STEP 7, follow these steps:

1. In the project tree, under "Distributed I/O" select the IO device IM 155-6 PN ST (for example)
2. Select **> IO device > Online & diagnostics > Identification & Maintenance**.

Entering maintenance data via STEP 7

STEP 7 assigns a default module name. You can enter the following information:

- Plant designation (I&M1)
- Location identifier (I&M1)
- Installation date (I&M2)
- Additional information (I&M3)

To enter maintenance data via STEP 7, follow these steps:

1. In the device view of the STEP 7 hardware network editor, select the interface module, for example.
2. In the properties under "General", select the "Identification & Maintenance" area and enter the data.

During the loading of the hardware configuration, the I&M data is also loaded.

Procedure for reading I&M data via the Web server

The procedure is described in detail in the Web server (https://support.automation.siemens.com/WW/view/en/59193560) Function Manual.

13.11.2 Data record structure for I&M data

Reading I&M records via the user program (distributed via PROFINET IO)

You directly access specific identification data using **Read data record** ("RDREC" instruction). You obtain the corresponding part of the identification data under the relevant data record index.

The data records are structured as follows:

Table 1-44 Basic structure of data records with I&M identification data

Content	Length (bytes)	Coding (hex)
Header information		
BlockType	2	I&M0: 0020_H I&M1: 0021_H I&M2: 0022_H I&M3: 0023_H I&M4: 0024_H
BlockLength	2	I&M0: 0038_H I&M1: 0038_H I&M2: 0012_H I&M3: 0038_H I&M4: 0038_H
BlockVersionHigh	1	01
BlockVersionLow	1	00
Identification data		
Identification data (see table below)	I&M0/index $AFF0_H$: 54 I&M1/index $AFF1_H$: 54 I&M2/index $AFF2_H$: 16 I&M3/index $AFF3_H$: 54 I&M4/Index $AFF4_H$: 54	

Table 1-45 Data record structure for I&M identification data

Identification data	Access	Default	Explanation
Identification data 0: (data record index AFF0 hex)			
VendorIDHigh	Read (1 byte)	00_H	This is where the name of the manufacturer is stored (42_D = SIEMENS AG).
VendorIDLow	Read (1 byte)	2 A_H	
Order_ID	Read (20 bytes)	6ES7155-6AU02-0BN0	Article number of the module (e.g. of the IM 155-6 PN ST interface module)

* A value of 0 indicates that the IM firmware does not yet support the CRC calculation of the assigned modules.
If the value is ≠ 0, the IM supports this function, regardless of whether the assigned modules support I&M4 data.

Identification data	Access	Default	Explanation
IM_SERIAL_NUMBER	Read (16 bytes)	-	Serial number (device-specific)
IM_HARDWARE_REVISION	Read (2 bytes)	1	Corresponding HW version
IM_SOFTWARE_REVISION	Read	Firmware version	Provides information about the firmware version of the module
• SWRevisionPrefix	(1 byte)	V	
• IM_SWRevision_Functional_Enhancement	(1 byte)	00 - FF_H	
• IM_SWRevision_Bug_Fix	(1 byte)	00 - FF_H	
• IM_SWRevision_Internal_Change	(1 byte)	00 - FF_H	
IM_REVISION_COUNTER	Read (2 bytes)	0000_H	Provides information about parameter changes on the module (not used)
IM_PROFILE_ID	Read (2 bytes)	0000_H	Generic Device
IM_PROFILE_SPECIFIC_TYPE	Read (2 bytes)	0005_H	Interface modules/BusAdapters
		0003_H	I/O modules and motor starters
		0001_H	CPU
IM_VERSION	Read	0101_H	Provides information on the version of the identification data (0101_H = Version 1.1)
• IM_Version_Major	(1 byte)		
• IM_Version_Minor	(1 byte)		
IM_SUPPORTED	Read (2 bytes)	$000E_H$	Provides information about the available identification data (I&M1 to I&M3)
Maintenance data 1: (data record index AFF1 hex)			
IM_TAG_FUNCTION	Read/write (32 bytes)	-	Enter a module identifier here that is unique plant-wide.
IM_TAG_LOCATION	Read/write (22 bytes)	-	Enter the installation location of the module here.
Maintenance data 2: (data record index AFF2 hex)			
IM_DATE	Read/write (16 bytes)	YYYY-MM-DD HH:MM	Enter the installation date of the module here.
Maintenance data 3: (data record index AFF3 hex)			
IM_DESCRIPTOR	Read/write (54 bytes)	-	Enter a comment describing the module.
Maintenance data 4: (data record index AFF4 hex)			
USI	Read (4 bytes)	0x63726331	UserstructureIdentifier: Internal, fixed value
CHK_OVERALL	Read (4 bytes)	-	Overall CRC of all individual CRCs
CHK_OVERALL_SUBS	Read (4 bytes)	0 or value*	Overall CRC of all assigned modules of the IM
CHK_STATIC_LOCAL	Read (4 bytes)	-	CRC of static data of the IM
CHK_STATIC_SUBS	Read (4 bytes)	0 or value*	CRC of all static data of the modules of the IM

* A value of 0 indicates that the IM firmware does not yet support the CRC calculation of the assigned modules.
If the value is ≠ 0, the IM supports this function, regardless of whether the assigned modules support I&M4 data.

Identification data	Access	Default	Explanation
CHK_OVERALL_SETUP	Read (4 bytes)	-	Overall CRC of all setup data of the IM and modules of the IM
CHK_REMANENT_LOCAL	Read (4 bytes)	-	CRC of retentive data of the IM
CHK_REMANENT_SUBS	Read (4 bytes)	0 or value*	CRC of all retentive data of the modules of the IM
CHK_WORKING_LOCAL	Read (4 bytes)	-	CRC of the parameters in STEP 7 for the IM
CHK_WORKING_SUBS	Read (4 bytes)	0 or value*	CRC of all parameters in STEP 7 for the modules of the IM
NOT USED	Read (14 bytes)	0	14 reserved bytes

* A value of 0 indicates that the IM firmware does not yet support the CRC calculation of the assigned modules.
If the value is ≠ 0, the IM supports this function, regardless of whether the assigned modules support I&M4 data.

Reading I&M data records with data record 255 (distributed via PROFIBUS DP)

The modules support standardized access to identification data via DS 255 (index 65000 to 65003). For more information on the DS 255 data structure, refer to the specifications of the Profile Guidelines Part 1: Identification & Maintenance Functions, Order No.: 3.502, Version 2.1, May 2016

13.11.3 Example: Read out firmware version of the CPU with Get_IM_Data

Automation task

You want to check whether the modules in your automation system have the current firmware. You can find the firmware version of the modules in the I&M0 data. The I&M0 data is the basic information for a device. The I&M0 data contains information such as:

- Manufacturer ID
- Order number, serial number
- Hardware and firmware version

To read out the I&M0 data, use the "Get_IM_Data" instruction. You read the I&M0 data of all the modules in the user program of the CPU using "Get_IM_Data" instructions and store it in a data block.

Conditions and parameters

To read out the I&M data of the CPU, use the following block parameters of the "Get_IM_Data" instruction:

- LADDR: Enter the HW ID of the module at the block parameter "LADDR".
- IM_TYPE: Enter the I&M data number (e.g. "0" for I&M0 data) at the "IM_TYPE" block parameter.
- DATA: Area for storing the read I&M data (e.g. in a global data block). Store I&M0 data in an area of data type "IM0_Data".

This example shows you how to read out the I&M0 data of an ET 200SP CPU. To read out the I&M0 data of a different module, simply use the HW ID of the module at the LADDR parameter.

Solution

Proceed as follows to read out the I&M0 data of the CPU:

1. Create a global data block to store the I&M0 data.
2. Create a structure of the data type "IM0_Data" in the global data block. You can assign any name to the structure ("imData") in this case.

SLI_gDB_Get_IM_Data

	Name	Data type	Start value
1	Static		
2	imData	IM0_Data	
3	done	Bool	false
4	busy	Bool	false
5	error	Bool	false
6	status	Word	16#0

Figure 1-101 Example: Data block for I&M data

3. Create the "Get_IM_Data" instruction in the user program, e.g. in OB 1.
4. Connect the "Get_IM_Data" instruction as follows:

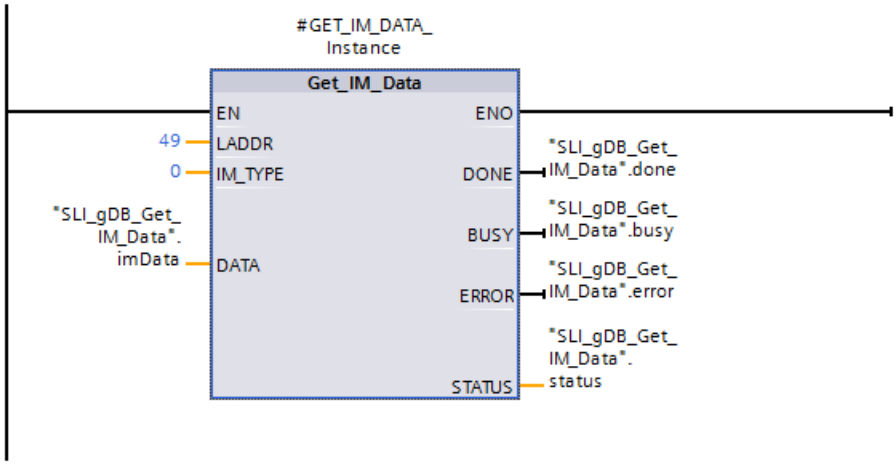

Figure 1-102 Example: Calling the "Get_IM_Data" instruction

5. Call the "Get_IM_Data" instruction in the user program.

Result

The "Get_IM_Data" instruction has stored the I&M0 data in the data block.

You can view the I&M0 data online in STEP 7, for example, in the data block with the "Monitor all" button. The CPU in the example is a 1512SP-1 PN (6ES7512-1DK01-0AK0) with the firmware version V2.5.

SLI_gDB_Get_IM_Data

	Name	Data type	Start value	Monitor value
1	Static			
2	imData	IM0_Data		
3	Manufacturer_ID	UInt	0	42
4	Order_ID	String[20]	''	'6ES7 512-1DK01-0...
5	Serial_Number	String[16]	''	'S C-DOS710132013'
6	Hardware_Revision	UInt	0	3
7	Software_Revision	IM0_Version		
8	Type	Char	' '	'V'
9	Functional	USInt	0	2
10	Bugfix	USInt	0	5
11	Internal	USInt	0	0
12	Revision_Counter	UInt	0	0
13	Profile_ID	UInt	0	0
14	Profile_Specific_Ty...	UInt	0	0
15	IM_Version	Word	16#0	16#0101
16	IM_Supported	Word	16#0	16#001E
17	done	Bool	false	TRUE
18	busy	Bool	false	FALSE
19	error	Bool	false	FALSE
20	status	Word	16#0	16#0000

Figure 1-103 Example: I&M0 data of an ET 200SP CPU

13.12 Shared commissioning of projects

Team Engineering

In Team Engineering several users from various engineering systems work on a project at the same time and access one ET 200SP CPU.

The users can edit separate parts of a master project independently of one another at the same time. The changes of the other editors are displayed in a synchronization dialog during the loading of the configuration in the CPU and synchronized automatically, if possible.

Certain online functions can also be executed at the same time from several engineering systems on a shared CPU, such as:

- Monitoring blocks on the CPU
- Modifying blocks on the CPU
- Trace functions

You can find detailed information on the topic of Team Engineering in the STEP 7 online help.

Maintenance 14

Maintenance of Ex modules

When you use an Ex module group, observe the information in the System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/de/view/109795533/en).

14.1 Removing and inserting I/O modules/motor starters (hot swapping)

Introduction

The ET 200SP distributed I/O system supports removal and insertion of I/O modules and motor starters (hot swapping) during operation (RUN mode):

- CPU/interface module HF, HS, R1: You can remove and insert any number of I/O modules/motor starters.
- ST, BA interface module: You can only remove and insert one I/O module/motor starter.

This section provides more information on removing and inserting I/O modules/motor starters.

I/O modules/motor starters must not be removed or inserted during operation (RUN operating state) in hazardous areas.

Requirements

The following table describes which modules you may insert and remove under which conditions:

Table 1-46 Removal and insertion of modules

Modules	Removal and insertion	Conditions
CPU	No	---
BusAdapter	No	---
CM DP module	No	---
Interface module	No	---
Interface module R1	Yes	The second interface module must be operational.
I/O modules	Yes	• Digital output modules: Only when load is switched off • Digital modules: For load voltage above the safe extra-low voltage: Only with switched off load voltage supply • Technology modules: Only with switched off supply voltage L+

Modules	Removal and insertion	Conditions
		• AI Energy Meter: – Only when measuring voltage on primary side is switched off, or – Without the special current transformer terminal, measuring voltage and load current must be through the converters, which means the machine or the load must be switched off in the process. With the special terminal, the process can continue because the current transformer is isolated safely. However, the measuring voltage on the module, at connections UL1-UL3, still needs to be isolated.
PotDis-TerminalBlock	Yes	Only in de-energized state.
Motor starter	Yes [1)]	Only when the load is disconnected; when switched on, the motor starter switches off automatically when the rotary interlock is operated.
Server module	No	---

1) The motor starter also counts as removed in the parking position

NOTICE

Risk of hazardous system states

If you remove and insert digital output modules with the load switched on or technology modules with the supply voltage switched on, this can result in hazardous system states.

The ET 200SP distributed I/O system or the connected sensors may be damaged as a result.

Therefore, a digital output module may only be inserted and removed when the load is switched off and a technology module may only be inserted and removed when the supply voltage is switched off.

NOTICE

Risk of hazardous system states

If you remove and insert the AI Energy Meter ST with the primary-side voltage switched on at the current transformer, this can result in hazardous system states.

The ET 200SP distributed I/O system may be damaged as a result.

For this reason, remove and insert the AI Energy Meter ST only in the following cases:

- When measuring voltage is switched off on the primary side, or
- When a special current transformer terminal is used that short-circuits the secondary side of the transformer when the module is removed

Do not remove or insert the AI Energy Meter ST until you have removed this current transformer terminal. With the special terminal, the process can continue because the current transformer is isolated safely. However, the measuring voltage on the module at the connections UL1-UL3 still needs to be isolated.

WARNING

Risk of injury from automatic restart

Inserting a motor starter can result in dangerous system states. The motor starter can restart again autonomously if an ON command is active.

This can result in serious injury caused by connected devices that are automatically started up.

Withdraw and insert a motor starter only after disconnecting the load.

Removing and inserting an I/O module or a motor starter in case of CPU/interface module HF, HS, R1

You can remove and insert any number of I/O modules/motor starters during operation. The CPU/interface module and the inserted I/O modules/motor starters remain in operation.

NOTICE

Reaction of the CPU to removal and insertion of the ET 200SP server module

Please note that the backplane bus is deactivated when you remove the server module, regardless of the CPU operating state. Also note that the outputs do not adopt their configured substitute value behavior when you remove the server module.

This means you should not remove the server module when the CPU is in STARTUP, RUN and STOP modes. If you have nevertheless removed the server module, perform a POWER OFF/POWER ON after you have inserted the server module again.

Removing and inserting BusAdapter or CM DP module

Do not remove or insert the BusAdapter or CM DP module when the supply voltage is switched on. If you remove the BusAdapter or CM DP module after CPU startup, the supply voltage of the BusAdapter or CM DP module is switched off automatically. To switch on the supply voltage again, you need to perform a POWER OFF/POWER ON after inserting the BusAdapter/CM DP module.

Removing and inserting I/O module or motor starter with interface module ST, BA

1. You can remove **one** I/O module/**one** motor starter during operation. If you remove another I/O module/motor starter, this results in a station stop of the ET 200SP distributed I/O system:
   - All I/O modules/motor starters of the ET 200SP distributed I/O system fail → Substitute value behavior.
   - The interface module continues to exchange data with the IO controller and report diagnostics.

   NOTE

   If you want to replace several I/O modules/motor starters during operation, you must replace them one after the other.

2. If you insert all but one of the I/O modules/motor starters withdrawn during operation, all I/O modules will start up again.

   NOTE

   I/O modules/motor starters inserted in empty slots and then removed are also regarded as withdrawn during operation.

3. After a POWER OFF/POWER ON of the supply voltage 1L+ of the interface module, all available I/O modules/motor starters start up again in line with the configuration. Evaluation of the I/O modules/motor starters removed during operation starts again (see 1).

Removing I/O modules

To remove an I/O module, follow these steps:

1. Simultaneously press the top and bottom release buttons of the I/O module.
2. Pull the I/O module out of the BaseUnit, parallel in a forward direction.

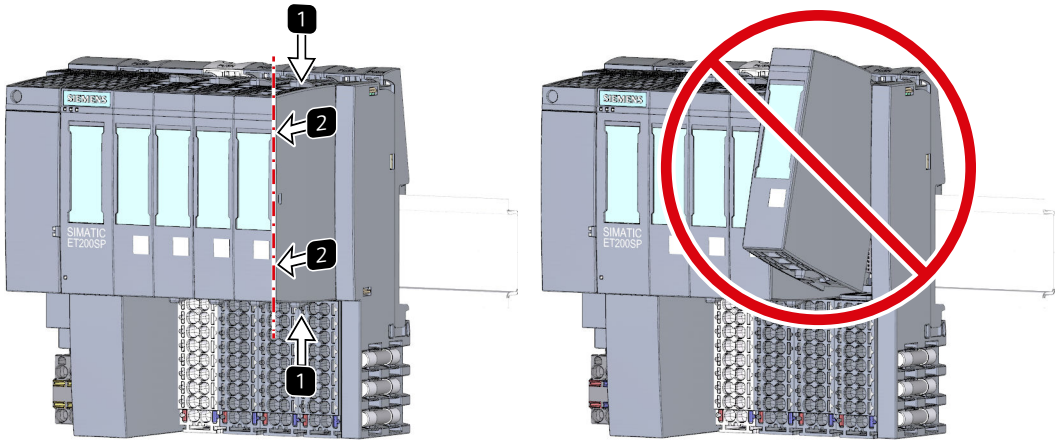

Figure 1-104 Removing I/O modules

14.2 Changing the type of an I/O module

Introduction

The coding element is a two-part element. When shipped from the factory, both parts are in the I/O module. When an I/O module is installed for the first time, a part of the coding element clicks into the BaseUnit. This mechanically prevents the insertion of a different module type.

There are two versions of the ET 200SP distributed I/O system:

- Mechanical coding element: Ensures the mechanical coding described above.
- Electronic coding element: In addition to the above-mentioned mechanical coding, this version also has an electronic, rewritable memory for module-specific configuration data (such as the F-destination address for fail-safe modules, parameter data for IO link master).

Requirement

Refer to section Application planning (Page 88).

NOTICE
Do not manipulate the coding element Making changes to the coding element may cause dangerous conditions in your plant and/or result in damage to the outputs of the ET 200SP distributed I/O system. To avoid physical damage, do not manipulate the coding.

Changing the type of an I/O module

You have already removed the I/O module.

To make a type change for an I/O module, follow these steps:

1. Push the coding element out of the BaseUnit using a screwdriver.
2. Put the coding element back onto the removed I/O module.
3. Insert the new I/O module (other module type) into the BaseUnit until you hear it click into place.

4. Label the new I/O module.

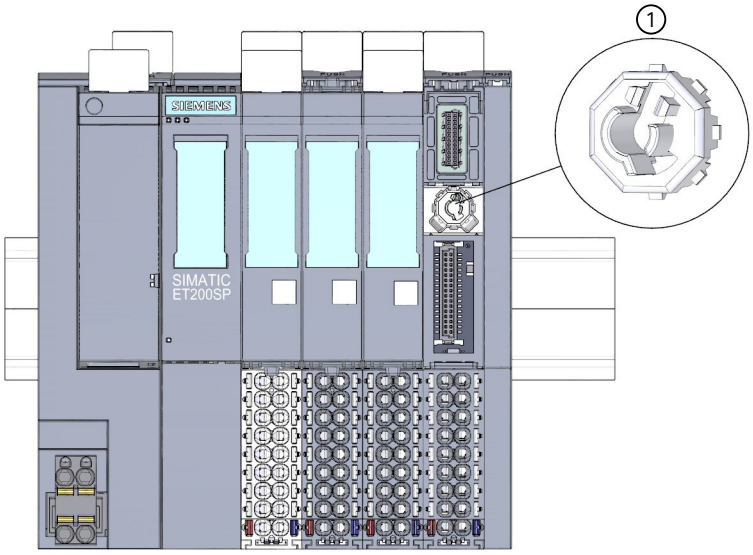

① Coding element

Figure 1-105 Changing the type of an I/O module

14.3 Replacing an I/O module

Introduction

When an I/O module is installed for the first time, a part of the coding element clicks into the BaseUnit. When you replace an I/O module with the same type of module, the correct coding element is already present in the BaseUnit.

Requirement

Refer to section Application planning (Page 88).

Replacing an I/O module

You have already removed the I/O module.

To replace an I/O module, follow these steps:

1. Remove the coding element (part) from the underside of the new I/O module.
2. Insert the new I/O module (same module type) into the BaseUnit until you hear it click into place.
3. Mark the new I/O module (labeling strip, equipment labeling plate).

14.4 Replacing a motor starter

The SIMATIC ET 200SP motor starter is wired.

To replace a SIMATIC ET 200SP motor starter, proceed as follows:

1. Turn the mechanical rotary interlock counter-clockwise to the assembly/disassembly position.

   NOTE
   Operating position/READY
   Turn the mechanical rotary interlock out of the READY position only in the current-free state (motor off).

2. Remove the SIMATIC ET 200SP motor starter from the BaseUnit.
3. Assemble the new motor starter as described.

   NOTE
   Mounting the motor starter
   You will find out how to mount the motor starter in chapter "Mounting/disassembly of motor starters (Page 186)".

WARNING

Risk of injury from automatic restart

When you replace the motor starter, the motor starter can restart again autonomously if an ON command is active. This can result in property damage or serious injury caused by connected devices that are automatically started up.

Revoke the ON commands on the motor starter before replacing the motor starter.

CAUTION

Protection against electrostatic charge

When handling and installing the SIMATIC ET 200SP motor starter, ensure protection against electrostatic charging of the components. Changes to the system configuration and wiring are only permissible after disconnection from the power supply.

14.5 Replacing the terminal box on the BaseUnit

Introduction

The terminal box is part of the BaseUnit. You can replace the terminal box if necessary. You do not need to dismantle the BaseUnit to do this.

The power and AUX buses of the potential group are not interrupted when you replace the terminal box.

Requirements

- The BaseUnit is mounted, wired and fitted with an I/O module.
- The terminal may only be replaced when the supply voltage is switched off.

Required tools

3 to 3.5 mm screwdriver

Procedure

Viewing the video sequence "Replacing the terminal box on the BaseUnit" (https://support.automation.siemens.com/WW/view/en/95886218)

Proceed as follows to replace the terminal box on a BaseUnit:

1. Switch off the supply voltage at the BaseUnit.
2. Simultaneously press the top and bottom release buttons of the I/O module and pull the module out of the BaseUnit.
3. Disconnect the wiring on the BaseUnit.
4. The release button of the terminal box is located on the underside of the BaseUnit. Use a screwdriver to push in the small opening at an angle from above.
5. Swivel the screwdriver slightly upwards to loosen the latching mechanism of the terminal box and lever the terminal box up out of the BaseUnit at the same time.
6. Remove the coding element (part) from the terminal box and press it onto the coding element (part) of the I/O module that you removed in step 2.
7. Insert the new terminal box into the BaseUnit at the top and swivel it downwards until it clips into the BaseUnit.
8. Wire the BaseUnit.
9. Insert the I/O module into the BaseUnit.
10. Switch on the supply voltage at the BaseUnit.

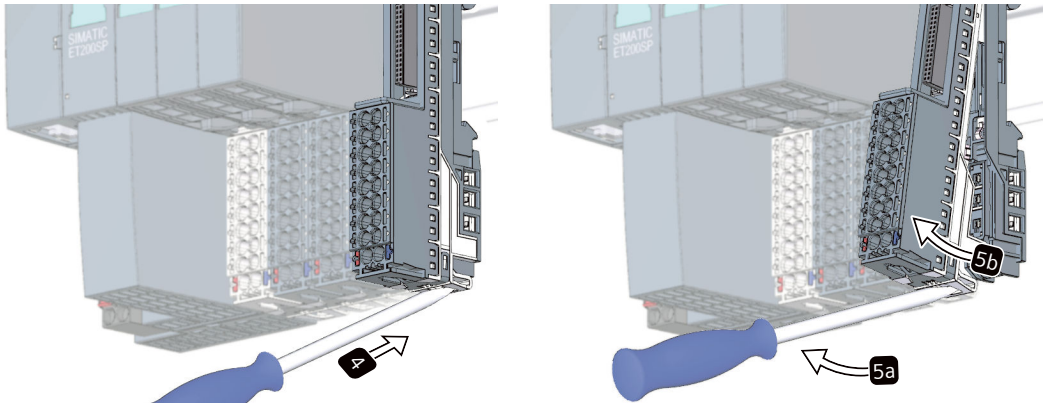

Figure 1-106 Replacing the terminal box on the BaseUnit

NOTE

When replacing the terminal box outside the control cabinet, make sure that you only mount light-colored terminal boxes on the matching BaseUnits with light-colored latch.

14.6 Firmware update

Introduction

During operation it may be necessary to update the firmware (e.g. to extend the available functions).

Update the firmware of the CPU/interface module and the I/O modules using firmware files. The retentive data is retained after the firmware has been updated.

We recommend that you always update to the latest firmware version available for the respective article number. The previous versions of the firmware are only intended as a backup to enable you to downgrade to the original version.

A firmware update has no effects on the user program of the CPU on which the update was performed. However, a downgrade can have effects on the user program if you use new functions in the user program which were not yet supported by the firmware of the CPU.

The following entry (https://support.industry.siemens.com/cs/ww/en/view/109804718) contains the current firmware statuses of the interface modules and modules of the ET 200SP.

The following entry (https://support.industry.siemens.com/cs/de/en/view/109478459) lists all firmware versions for the CPUs. You will also find a description of the new functions of the respective firmware versions.

Requirement

- You have downloaded the file(s) for the firmware update from the Product Support (https://support.industry.siemens.com/cs/ww/en/ps) web page.

  On this web page, select:

  – Automation Technology > Automation Systems > Industrial Automation Systems SIMATIC > SIMATIC ET 200 I/O Systems > ET 200 systems for the cabinet > ET 200SP.

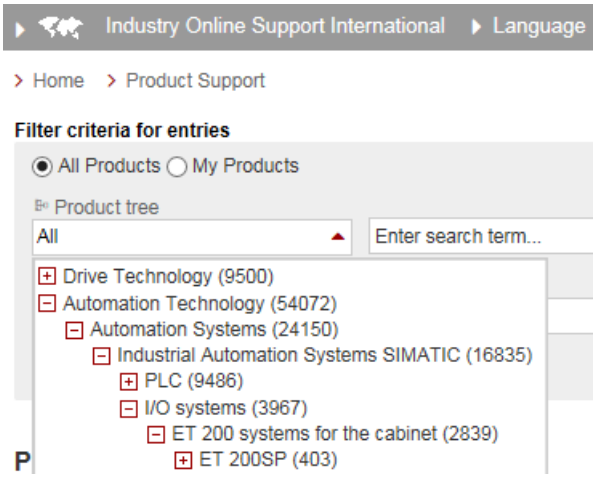

Figure 1-107 ET 200SP in the product tree

From this position, navigate to the specific type of module that you want to update. To continue, click on the "Software downloads" link under "Support". Save the desired firmware update files.

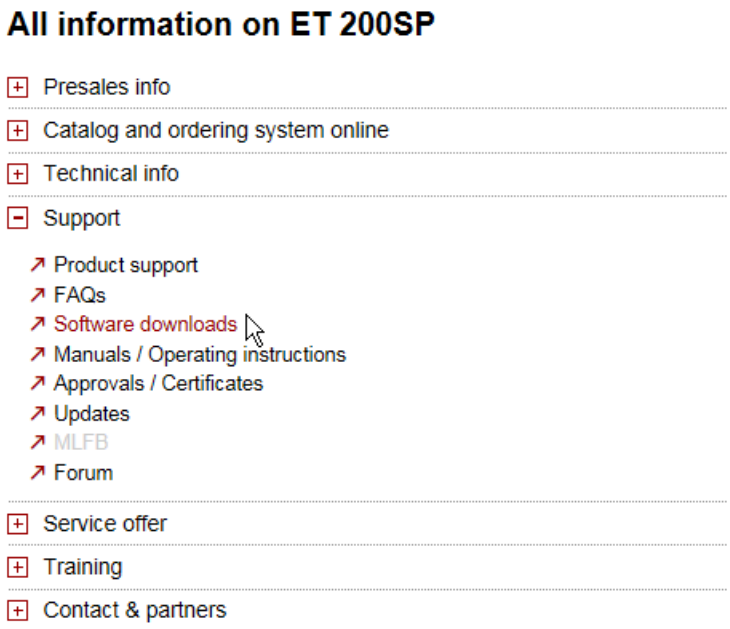

Figure 1-108 Selecting the software downloads

- Before installing the firmware update, make sure that the modules are not being used.
- Modules with firmware version V0.0.0 do not support the "firmware update" function.

NOTE

Firmware update of I/O modules

The L+ supply voltage must be present on the module at the start of and during the firmware update.

Additional requirement for fail-safe modules

⚠ WARNING

Check the firmware version for fail-safe approval

When using a new firmware version, always check that the version is approved for use in the module in question.

The attachments of the certificate (https://support.automation.siemens.com/WW/view/en/49368678/134200) for SIMATIC Safety specify the firmware version that is approved.

Options for the firmware update

The following options are available for updating firmware:

- Online in STEP 7 via Online & Diagnostics
- Online in STEP 7 via accessible devices (PROFINET)
- Online with the MultiFieldbus Configuration Tool (MFCT) (https://support.industry.siemens.com/cs/ww/en/view/109781837)
- Using a SIMATIC memory card (possible for CPU and central I/O modules)
- Via the integrated Web server (possible for CPU as well as centralized and distributed I/O modules)
- Online via the SIMATIC Automation Tool

NOTE

Firmware files of the CPU

If you perform a CPU update with STEP 7, you require STEP 7 (TIA Portal as of V13 Update 3).

The table below provides an overview of the media that can be used to update the firmware of a specific module.

Table 1-47 Overview of firmware update options

Firmware update	CPU	Interface module	I/O module
STEP 7 (TIA Portal)	✓ [1]	✓	✓
STEP 7 (V5.5 SP2 or higher) [2]	--	✓	✓
Accessible devices	✓	✓	✓
MFCT	--	✓	✓
SIMATIC memory card	✓	--	✓
Web server of the CPU	✓	--	✓
SIMATIC Automation Tool	✓	✓	✓

[1] V13 update 3 or higher

[2] If the firmware files are only available in this format, you can also install the files using STEP 7 (TIA Portal) but not the SIMATIC memory card or the Web server.

Firmware update for the motor starter

The following options are available for updating firmware for the motor starter.

- Online via PROFINET IO/PROFIBUS DP (with STEP 7)
- Via the integrated Web server (possible for CPU as well as centralized and distributed I/O modules)
- With the TIA Portal:
  - As of SIMATIC STEP 7 V13 SP1 with installed HSP for the ET 200SP motor starter
  - SIMATIC STEP 7 V14 and higher

  Over a SIMATIC memory card
- With SIMATIC STEP 7 version V5.5 SP4 and higher
- For fail-safe motor starters with the TIA Portal Version V14 SP1 or higher and installed HSP.

NOTE

The firmware update for fail-safe motor starters must take place in a separate ET 200SP system in which only the fail-safe motor starter that is to be updated is inserted.

Downtime during the firmware update

When you start a firmware update, for example online in STEP 7 via "Online & Diagnostics", the CPU goes into STOP mode and executes the firmware update. The time from start of the firmware update until RUN of the CPU with the new firmware takes a few minutes (typically < 3 minutes).

Installation of the firmware update

WARNING

Risk of impermissible system states

The CPU switches to STOP mode or the interface module to "station failure" as a result of the firmware update being installed. STOP or station failure can have an adverse effect on the operation of an online process or a machine.

Unexpected operation of a process or a machine can lead to fatal or severe injuries and/or to material damages.

Make sure that the CPU/interface module is not executing any active process before installing the firmware update.

Procedure online in STEP 7 via Online & Diagnostics

Requirements: There is an online connection between the CPU/module and PG/PC.

Proceed as follows to perform an online firmware update via STEP 7:

1. Select the module in the device view.
2. Select the "Online & diagnostics" command from the shortcut menu.
3. Select the "Firmware update" group in the "Functions" folder.
4. Click the "Browse" button to select the path to the firmware update files in the "Firmware update" area.
5. Select the suitable firmware file. The table in the firmware update area lists all modules for which an update is possible with the selected firmware file.
6. Click the "Run update" button. If the module can interpret the selected file, the file is downloaded to the module.

Updating the firmware

The "Run firmware after update" check box is always selected. When the loading process is complete, the CPU adopts the firmware and then operates with this new firmware.

If you have not selected the "Run firmware after update" check box, the previous firmware remains active until the module is reset (for example by power cycling). The new firmware only becomes active after the module has been reset.

You can find more information in the online help for STEP 7 under "General information on firmware update of a module".

NOTE

If a firmware update is interrupted, you need to remove and insert the module before starting the firmware update again.

Procedure online in STEP 7 via accessible devices

To perform a firmware update online via accessible devices, follow these steps:

1. From the "Online" menu, select the "Accessible devices" menu item.
2. In the "Accessible devices" dialog, search for the accessible devices for the selected PROFINET interface.
3. To go to a device in the project tree, select the desired device from the list of accessible devices and click the "Show" button.
4. In the project tree, select the "Online & diagnostics" option of the relevant device and perform the firmware update under the category "Functions/Firmware Update" (CPU, Local modules).

You can find information on how to perform a firmware update when your project has no connection to a CPU in the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/89257657).

Procedure using the SIMATIC memory card

To perform a firmware update using the SIMATIC memory card, follow these steps:

1. Insert a SIMATIC memory card into the SD card reader of your programming device/computer.
2. To store the update file on the SIMATIC memory card, select the SIMATIC memory card in the "Card Reader/USB memory" folder in the project tree.
3. Select the "Card Reader/USB memory > Create firmware update memory card" command in the "Project" menu.
4. Use a file selection dialog to navigate to the firmware update file. In a further step you can decide whether you want to delete the content of the SIMATIC memory card or whether you want to add the firmware update files to the SIMATIC memory card.
5. Insert the SIMATIC memory card with the firmware update files into the CPU.

Point to note when updating firmware for analog modules and the IO-Link Master CM 4xIO-Link communication module

If you want to update firmware for analog modules or the IO-Link Master CM 4xIO-Link communication module, you must supply a load current of 24 V DC to the modules through the infeed element.

Procedure

1. Remove any inserted SIMATIC memory card.
2. Insert the SIMATIC memory card with the firmware update files into the CPU.
3. The firmware update begins shortly after the SIMATIC memory card has been inserted.
4. Remove the SIMATIC memory card after the firmware update has been completed.
   The RUN LED on the CPU lights up yellow, the MAINT LED flashes yellow.

If you want to use the SIMATIC memory card later as a program card, delete the firmware update files manually.

NOTE

If your hardware configuration contains several modules, the CPU updates all affected modules in the slot sequence, which means in ascending order of the module position in the STEP 7 device configuration.

NOTE

Memory size of the SIMATIC memory card

If you perform a firmware update via the SIMATIC memory card, you must use a large enough card based on the CPU used and the associated I/O modules.

Note the specified file sizes of the update files when downloading them from Siemens Industry Online Support. The file size information is especially important when you perform the firmware update not only for the CPU but also for the associated I/O modules, communication modules, etc. The total size of the update files must not exceed the available memory size of your SIMATIC memory card.

You can find more information on the capacity of SIMATIC memory cards in the section Accessories/spare parts (Page 382)and in the function manual Structure and use of the CPU memory (https://support.industry.siemens.com/cs/de/en/view/59193101).

Procedure: via the integrated Web server

The procedure is described in the Web server (https://support.automation.siemens.com/WW/view/en/59193560) function manual.

Procedure: online via the SIMATIC Automation Tool

The procedure is described in the SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300) manual (included in the SIMATIC Automation Tool).

Behavior during the firmware update

Note the following behavior of the relevant I/O module when carrying out a firmware update:

- The DIAG LED display flashes red.
- The I/O module retains its current diagnostic status.
- Diagnostics alarm: Channel temporarily unavailable (error code $31_D/1F_H$)
- All outputs are in a current-free/voltage-free state

Note the following behavior when carrying out the firmware update of the motor starter:

- RN flashes green and ER flashes red.
- ST/OL flashes green and MAN flashes yellow.
- The motor starter powers up after completion of the firmware update. Diagnoses are reset. The firmware update does not affect the TMM and the cooling time.
- The sensor supply of the DI module remains active.

Behavior after the firmware update

After the firmware update, check the firmware version of the updated module.

Reference

You will find more information on these procedures in the STEP 7 online help.

14.7 Resetting the CPU/interface module (PROFINET IO) to factory settings

14.7.1 Resetting the CPU to factory settings

Introduction

The CPU can be reset to its delivery state using "Reset to factory settings". The function deletes all information saved internally on the CPU.

If you want to remove a PROFINET CPU and use it elsewhere with a different program, or put it into storage, we recommend that you reset the CPU to its factory settings. When restoring the factory settings, remember that you also delete the IP address parameters.

Recommendation

Put the CPU into its delivery state if:

- You remove a CPU and use it elsewhere with a different program
- You return the CPU to stock

When resetting to factory settings, remember that the IP address parameters are also deleted.

Options for resetting a CPU to factory settings

The following options are available for resetting the CPU to its factory settings:

- Using the mode selector
- Using STEP 7
- Using the SIMATIC Automation Tool

Procedure using the mode selector

Make sure that there is no SIMATIC memory card in the CPU and that the CPU is in STOP mode (the RUN/STOP LED is lit yellow).

NOTE

Reset to factory settings ↔ Memory reset

The procedure described below also corresponds to the procedure for a memory reset:

- Selector operation with inserted SIMATIC memory card: CPU executes a memory reset
- Selector operation without inserted SIMATIC memory card: CPU executes reset to factory settings

---

Perform a reset to factory settings when there is no SIMATIC memory card inserted as follows:

1. Set the mode selector to the STOP position.

   Result: The RUN/STOP LED lights up yellow.
2. Set the mode selector to the MRES position. Hold the mode selector in this position until the RUN/STOP LED lights up for the second time and remains lit (this takes 3 seconds). After this, release the switch.
3. Within the next three seconds, switch the mode selector back to the MRES position, and then back to STOP again.

Result: The CPU executes the "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, the CPU has been reset to factory settings and is in the STOP mode. The "Reset to factory settings" event is entered in the diagnostics buffer.

NOTE

The IP address of the CPU is also deleted when the CPU is reset to the factory settings through the mode selector.

For information on the memory reset of the CPU, refer to the section CPU memory reset (Page 303).

Procedure using STEP 7

Make sure that an online connection to the CPU exists.

To reset a CPU to factory settings using STEP 7, follow these steps:

1. Open the Online and Diagnostics view of the CPU.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. If you want to keep the IP address, select the "Retain IP address" option button. If you want to delete the IP address, select the "Reset IP address" option button.

   NOTE

   "Delete IP address" deletes all IP addresses, regardless of how you established the online connection.

   If there is a SIMATIC memory card inserted, selecting the "Delete IP address" option has the following effect:

   – The IP addresses are deleted and the CPU is reset to factory settings.
   – The configuration (including IP address) on the SIMATIC memory card is then downloaded to the CPU. If there is no saved configuration (because the SIMATIC memory card has been cleared or formatted, for example), no new IP address is assigned.

   ---
4. Click the "Reset" button.
5. Click "OK" in response to the confirmation prompts.

Result: The CPU executes the "Reset to factory settings", during which time the RUN/STOP LED flashes yellow. When the RUN/STOP LED lights up yellow, the CPU has been reset to factory

settings and is in the STOP mode. The "Reset to factory settings" event is entered in the diagnostics buffer.

Procedure using the SIMATIC Automation Tool

The procedure is described in the SIMATIC Automation Tool (https://support.industry.siemens.com/cs/ww/en/view/98161300) manual (included in the SIMATIC Automation Tool).

Result after resetting to factory settings

The following table provides an overview of the contents of the memory objects after the reset to factory settings.

Table 1-48 Result after resetting to factory settings

Memory object	Content
Actual values of the data blocks, instance data blocks	Initialized
Bit memory, timers and counters	Initialized
Certain retentive tags from technology objects (e.g. adjustment values of absolute encoders)	Initialized
Entries in the diagnostic buffer	Initialized, including a startup entry that informs about the reset to factory settings.
Entries in the syslog storage	Now only contains a startup entry that informs about the reset to factory settings.
IP address	Depends on the procedure: • Using mode switch: is deleted • Using STEP 7: Depending on the setting of the "Keep IP address"/"Delete IP address" option buttons
Device name	Is set to "CPU"
Counter readings of the runtime meters	Initialized
Time of day	Is set to "00:00:00, 01.01.2012"
Deleting passwords for protecting confidential PLC configuration data	Depends on the procedure: • Using mode switch: Retained • Using STEP 7: Depends on the setting of the "Delete password for the protection of confidential PLC configuration data" option button

If a SIMATIC memory card was inserted prior to the factory reset, the CPU downloads the configuration contained on the SIMATIC memory card (hardware and software). A configured IP address then becomes valid again.

NOTE

Password for protecting confidential configuration data after resetting the CPU to factory settings

- **Via the mode selector (SIMATIC Memory Card is not inserted):** The password for protection of confidential configuration data is retained.
- **Using STEP 7:** The password for protection of confidential configuration data is retained. The password is only deleted when the "Delete password for protection of confidential PLC configuration data" option is set.

You can find more information on the password for protection of confidential configuration data in the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) Function Manual.

Reference

Additional information on the topic "Resetting to factory settings" can be found in the Structure and use of the CPU memory (https://support.automation.siemens.com/WW/view/en/59193101) function manual, section on memory areas and retentivity, and in the STEP 7 online help.

14.7.2 Resetting interface module (PROFINET IO) to factory settings

Function

The "Reset to factory settings" function returns the interface module (PROFINET) to its delivery state.

Reset options

- Using STEP 7 (online via PROFINET IO)
- Using a reset button on the interface module (on rear). Exception: There is no reset button on the IM 155-6 PN BA and the IM 155-6 PN R1. See section Resetting the interface module (PROFINET IO) to factory settings with a RESET button (Page 344).

Procedure using STEP 7

To reset an interface module to factory settings using STEP 7, follow these steps:

Make sure that an online connection to the interface module exists.

1. Open the online and diagnostics view of the interface module.
2. In the "Functions" folder, select the "Reset to factory settings" group.
3. Click the "Reset" button.
4. Click "OK" in response to the confirmation prompt.

Result: The interface module then performs "Reset to factory settings".

Result after resetting to factory settings

The following table shows the values of the interface module properties after a factory reset:

Table 1-49 Properties of the interface module as shipped

Properties	Value
Parameters	Default setting
IP address	Not available
Device name	Not available
MAC address	Available
I&M data	Identification data (I&M0) available Maintenance data (I&M1, 2, 3, 4) reset *
Firmware version	Available

NOTE

Failure of downstream stations is possible

Downstream stations on a bus segment can fail when the factory settings are restored on an interface module.

NOTE

Behavior of the installed I/O modules during reset to factory settings

The I/O modules of the ET 200SP distributed I/O system assume the unconfigured state after a reset to factory settings. The interface module does not acquire any input data and does not output any output data.

Reference

You will find more information on the procedure in the STEP 7 online help.

14.7.3 Resetting the interface module (PROFINET IO) to factory settings with a RESET button

Requirement

The supply voltage to the interface module is turned on.

Required tools

3 to 3.5 mm screwdriver (for resetting with a RESET button)

Procedure

Proceed as follows to reset an interface module to factory settings by means of the RESET button:

1. Remove the interface module from the mounting rail (see Mounting the CPU/interface module (Page 126)) and swivel it downwards.
2. The RESET button is located on the rear of the interface module behind a small opening: Press a screwdriver into the small opening for at least 3 seconds to activate the RESET button.
3. Install the interface module back on the mounting rail (see Mounting the CPU/interface module (Page 126)).
4. Assign parameters to the interface module again.

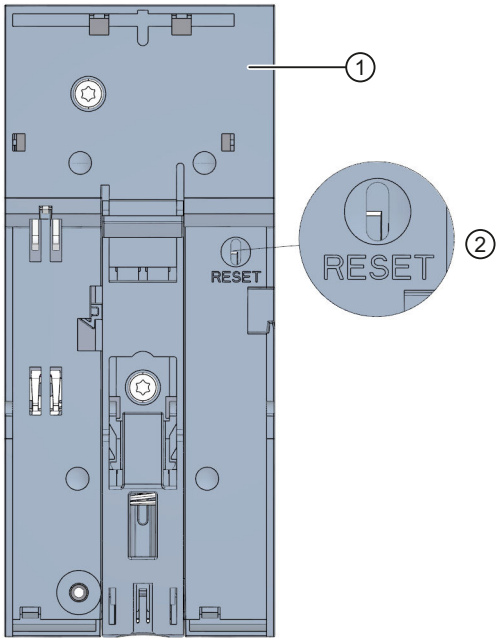

① Rear of the interface module

② RESET button

Figure 1-109 RESET button

14.8 Reaction to faults in fail-safe modules and fail-safe motor starters

Safe state (safety concept)

The basic principle behind the safety concept is the existence of a safe state for all process variables.

NOTE

For digital F-modules, this safe state is the value "0". This applies to both sensors and actuators. In the case of the fail-safe motor starters, the load is shut down in a fail-safe manner.

Fault reactions and startup of the F-system

The safety function means that fail-safe modules use substitute values (safe state) instead of process values (**passivation of the fail-safe module**) in the following situations:

- When the F-system is started up
- If errors are detected during safety-related communication between the F-CPU and the F-module via the PROFIsafe safety protocol (communication error)
- If F-I/O faults or channel faults are detected (e.g. crossover or discrepancy errors)

Detected faults are written to the diagnostic buffer of the F-CPU and communicated to the safety program in the F-CPU.

F-modules cannot save errors as retentive data. After a POWER OFF / POWER ON, any faults still existing are detected again during startup. However, you have the option of saving faults in your safety program.

⚠ WARNING

For channels that you set to "deactivated" in STEP 7, no diagnostic response or error handling is triggered when a channel fault occurs, not even when such a channel is affected indirectly by a channel group fault ("Channel activated/deactivated" parameter).

Remedying faults in the F-system

To remedy faults in your F-system, follow the procedure described in IEC 61508-1:2010 section 7.15.2.4 and IEC 61508-2:2010 section 7.6.2.1 e.

The following steps must be performed:

1. Diagnosing and repairing the fault
2. Revalidation of the safety function
3. Recording in the service report

Substitute value output for fail-safe modules

In the case of F-modules with inputs, if there is passivation, the F-system provides substitute values (0) for the safety program instead of the process data pending at the fail-safe inputs.

In the case of F-modules with outputs, if there is passivation, the F-system transfers substitute values (0) to the fail-safe outputs instead of the output values provided by the safety program. The output channels are de-energized. This also applies when the F-CPU goes to STOP mode. Assignment of substitute values is not possible.

Substitute values are used either for the relevant channel only or for all channels of the relevant failsafe module depending on:

- The F-system used
- The type of error that occurred (F-I/O, channel fault or communication error)
- The F-module parameter assignment

Reintegration of a fail-safe module

The system changes from fail-safe to process values (reintegration of an F-module) either automatically or only after user acknowledgment in the safety program. If channel faults occur, it may be necessary to remove and reinsert the F-module. A detailed listing of faults requiring removal and insertion of the F-module can be found in the section Diagnostic messages of the respective F-module.

After reintegration, the following occurs:

- In the case of an F-module with inputs, the process data pending at the fail-safe inputs is made available to the safety program again
- In the case of an F-module with outputs, the output values provided in the safety program are transferred to the fail-safe outputs again

Additional information on passivation and reintegration

For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety, Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126) manual.

Behavior of the fail-safe module with inputs in the event of a communication disruption

F-modules with inputs respond differently to communication errors compared to other errors.

If a communication error is detected, the current process values remain set at the inputs of the F-module. There is no passivation of the channels. The current process values are passivated in the F-CPU.

14.9 Maintenance and repair

The components of the ET 200SP distributed I/O system are maintenance-free.

NOTE

Repairs to a SIMATIC ET 200SP system may only be carried out by the manufacturer.

NOTE

Cleaning the ET 200SP

Requirement: All supply voltages on the ET 200SP distributed I/O system are switched off. Observe the five safety rules for working in and on electrical installations.

If you need to clean the devices, use dry ESD cleaning cloths (observing the ESD protective measures).

14.10 Warranty

To meet the conditions of the warranty, you must observe the safety and commissioning instructions.

Test and service functions 15

15.1 Test functions

Introduction

You can test the flow of your user program on the CPU. You monitor signal states and values of tags, and preassign tags with values so that you can simulate specific situations for the program flow.

NOTE

Using test functions

The use of test functions can influence the program execution time and thus the cycle and response times of the controller to a slight extent (a few milliseconds).

Requirements

- There is an online connection to the relevant CPU.
- An executable program is in the CPU.

Test options

- Testing with program status
- Testing with breakpoints
- Testing with a watch table
- Testing with a force table
- Testing with PLC tag table
- Testing with data block editor
- Testing with the LED flash test
- Testing with trace function

Testing with program status

The program status allows you to monitor the execution of the program. You can display the values of operands and the results of logic operations (RLO) allowing you to recognize and fix logical errors in your program.

NOTE

Restrictions for the "Program status" function

The monitoring of loops can significantly increase the cycle time. The increase in cycle time depends on the following factors:

- The number of tags to be monitored
- The actual number of loops run through

⚠ WARNING

Testing with program status

A test with the "Program status" function can produce serious property damage and personal injury in the event of malfunctions or program errors.

Make sure that you take appropriate measures to exclude the risk of hazardous conditions occurring before running a test with the "Program status" function.

Testing with breakpoints

With this test option, you set breakpoints in your program, establish an online connection, and enable the breakpoints on the CPU. You then execute a program from one breakpoint to another.

Requirements:

- Setting breakpoints is possible in the programming language SCL or STL.

Testing with breakpoints provides you with the following advantages:

- Localization of logic errors step by step
- Simple and quick analysis of complex programs prior to actual commissioning
- Recording of current values within individual executed loops
- Use of breakpoints for program validation also possible in SCL/STL networks within LAD/FBD blocks

NOTE

Restriction during testing with breakpoints

- When you test with breakpoints, there is a risk of overwriting the cycle time of the CPU.
- If you are using technology objects and test them with breakpoints, the CPU switches to STOP mode.

NOTE
F-System SIMATIC Safety
The setting of breakpoints in the standard user program results in errors in the safety program:

- Sequence of F cycle time monitoring
- Error in communication with the fail-safe I/O
- Error during safety-oriented CPU-CPU communication
- Internal CPU error

If you still wish to use breakpoints for testing, you must deactivate the safety mode beforehand. This will result in the following errors:

- Error in communication with the fail-safe I/O
- Error during safety-oriented CPU-CPU communication

Testing with watch tables

The following functions are available in the watch table:

- Monitoring of tags

  With watch tables, you can monitor the current values of individual tags of a user program or a CPU on the PG/PC and Web server. For the Web server to be able to display the value of tags, you must specify a symbolic name for each tag in the "Name" column of the watch table.

  You can monitor the following operand areas:

  – Inputs and outputs (process image) and bit memory
  – Contents of data blocks
  – Peripheral inputs and peripheral outputs
  – Timers and counters

- Modifying tags

  Use this function to assign fixed values to the individual tags of a user program or CPU. Modifying is also possible for testing with program status.

  You can control the following operand areas:

  – Inputs and outputs (process image) and bit memory
  – Contents of data blocks
  – Peripheral inputs and peripheral outputs (for example, %I0.0:P, %Q0.0:P)
  – Timers and counters

- "Enable peripheral outputs" and "Control immediately"

  These two functions enable you to assign fixed values to individual peripheral outputs of a CPU in the STOP mode. You can also use them to check your wiring.

Testing with the force table

The following functions are available in the force table.

- Monitoring of tags

  With force tables, you can display the current values of individual tags of a user program or a CPU on the PG/PC and Web server. You can monitor the table with or without a trigger condition. For the Web server to be able to display the value of tags, you must specify a symbolic name for each tag in the "Name" column of the force table.

  You can monitor the following tags:

  – Bit memory
  – Contents of data blocks
  – Peripheral inputs (e.g. %I0.0:P)

- Modifying tags

  With this function, you assign fixed values to the individual tags of a user program or a CPU on the PG/PC and Web server. Modifying is also possible for testing with program status.

  You can control the following tags:

  – Bit memories
  – Contents of data blocks
  – Peripheral inputs (e.g. %I0.0:P)

- Forcing of peripheral inputs and peripheral outputs

  You can force individual peripheral inputs or peripheral outputs.

  – Peripheral inputs: Forcing of peripheral inputs (for example %I0.0:P) represents the "bypassing" of sensors/inputs by specifying fixed values to the program. Instead of the actual input value (via process image or via direct access) the program receives the force value.
  – Peripheral outputs: Forcing of peripheral outputs (for example %Q0.0:P) represents the "bypassing" of the complete program by setting fixed values for the actuators.

You can use the force table to simulate different test environments and also overwrite tags in the CPU with a fixed value. This enables you to intervene in the running process to control it.

Difference between modifying and forcing

The fundamental difference between the modifying and forcing functions consists in the storage behavior:

- Modifying: Modifying of tags is an online function and is not stored in the CPU. You can end modifying of tags in the watch table or by disconnecting the online connection.
- Forcing: A force job is written to the SIMATIC memory card and is retained after a POWER OFF. You can only end the forcing of peripheral inputs and peripheral outputs in the force table.

Testing with PLC tag table

You can monitor the data values that tags currently assume in the CPU directly in the PLC tag table. To do this, open the PLC tag table and start monitoring.

Additionally, you have a possibility of copying PLC tags to a monitoring or force table and of monitoring, controlling or forcing them there.

Testing with data block editor

Various possibilities of monitoring and controlling tags are at your disposal in the data block editor. These functions directly access the current values of the tags in the online program. Current values are the values that the tags assume at the current time during program execution in the CPU's work memory. The following functions for monitoring and control are possible via the data block editor:

- Monitoring tags online
- Controlling individual actual values
- Creating a snapshot of the actual values
- Overwriting actual values with a snapshot

NOTE

Setting data values during commissioning

During commissioning of a system, data values often have to be adjusted to optimally adapt the program to the general conditions prevailing locally. To this end, the declaration table offers a few functions for data blocks.

Testing with the LED flash test

In many online dialogs, you can perform an LED flash test. This function is useful, for example, when you are not sure which device in the hardware configuration corresponds to the device currently selected in the software.

When you click the "Flash LED" button, an LED flashes on the currently selected device. In the case of the CPU, the RUN/STOP, ERROR and MAINT LEDs flash. They flash until you cancel the flashing test.

Testing with trace function

The trace function is used to record the CPU tags, depending on the settable trigger conditions. Tags are, for example, the drive parameters or system and user tags of a CPU. The CPU saves the recordings. You can display and evaluate the recordings with STEP 7, if necessary.

The trace function can be called from the CPU's folder in the project tree, under the name "Traces".

In connection with trace functions, also pay attention to the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/102781176).

Simulation

With STEP 7 you can run and test the hardware and software of the project in a simulated environment. Start the simulation using the menu command "Online" > "Simulation" > "Start".

Reference

You can find more information on test functions in the STEP 7 online help.

Further information about testing with trace and logic analyzer functions is available in the Function Manual Using the trace and logic analyzer function (https://support.automation.siemens.com/WW/view/en/64897128).

15.2 Reading out/saving service data

Service data

In addition to the contents of the diagnostics buffer, the service data contains a wide range of extra information about the internal status of the CPU. If a problem occurs with the CPU that cannot be solved with other methods, send the service data to Service & Support. The service data allows Service & Support to run fast analysis of the problems that have occurred.

NOTE

You cannot simultaneously execute a download to the device while reading out the service data of the CPU.

Methods of reading service data

You can read service data with:

- The Web server
- STEP 7
- the SIMATIC memory card
- MultiFieldbus Configuration Tool (MFCT)

Procedure using the Web server

To read service data using the Web server, follow these steps:

1. Open a Web browser that is suitable for communication with the CPU.
2. Enter the following address in the address bar of the web browser:
   https://<CPU IP address>/save_service_data, e.g. https://172.23.15.3/save_service_data

3. The service data page will appear on your screen, with a button for saving the service data.

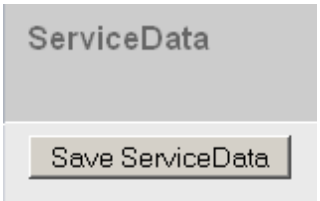

Figure 1-110 Reading out service data with the Web server

4. Save the service data locally on your PC/programming device, by clicking "Save ServiceData".

Result: The CPU stores the data in a .dmp file with the following naming convention: "<Article number> <Serial number> <Time stamp>.dmp". The file name cannot be changed.

NOTE

If you have defined your user page as the Web server's home page, direct access to the service data by entering the CPU's IP address is not possible. You will find more information on reading out service data via a user-defined page in the Web server (https://support.automation.siemens.com/WW/view/en/59193560) function manual.

Procedure using STEP 7

You can find more information on saving service data of the CPU (and interface module) in the STEP 7 online help using keyword "Saving service data".

Procedure via the SIMATIC memory card

If Ethernet communication with the CPU is not possible, use the

SIMATIC memory card to read out the service data. In all other cases, read the service data via the web server or STEP 7..

The procedure using the SIMATIC memory card is more time-consuming than the other options for reading out the service data. You must also ensure before reading out that there is sufficient memory space on the SIMATIC memory card.

To read service data using the SIMATIC memory card, follow these steps:

1. Insert the SIMATIC memory card into the card reader of your PC / programming device.
2. Open the job file S7_JOB.S7S in an editor.
3. Overwrite the entry PROGRAM with the string DUMP in the editor.
   Do not use any spaces/line breaks/quotation marks to ensure that the file size is exactly 4 bytes.
4. Save the file under the existing file name.
5. Ensure that the SIMATIC memory card is not write-protected and insert the SIMATIC memory card in the card slot of the CPU. Pay attention to the procedure described in Removing/inserting the SIMATIC memory card on the CPU (Page 296).

Result: The CPU writes the service data file DUMP.S7S to the SIMATIC memory card and remains in STOP mode.

Service data transfer is complete when the STOP LED stops flashing and is lit continuously. If the service data transfer was successful, only the STOP LED lights up.

In the event of errors during the transfer, the STOP LED is lit continuously and the ERROR LED flashes. The CPU also stores a text file with information on the error that occurred in the DUMP.S7S folder.

Technical specifications 16

16.1 Introduction

Introduction

This chapter lists the technical specifications of the system:

- The standards and test values that the ET 200SP distributed I/O system complies with and fulfills.
- The test criteria according to which the ET 200SP distributed I/O system was tested.

Technical specifications of the (F-)modules

The technical specifications of the individual (F-)modules can be found in the equipment manuals of the corresponding (F-)modules. In the event of deviations between the statements in this document and the manuals, the statements in the manuals take priority.

Technical specifications of the Ex modules

You can find the technical specifications of the Ex modules in the System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/en/view/109795533) and in the Ex I/O modules manuals.

Technical specifications of the motor starters

You can find the technical specifications of the motor starters in the ET 200SP Motor Starter (https://support.industry.siemens.com/cs/ww/en/view/109479973) Equipment Manual.

16.2 Safety information

Safety information

WARNING

Personal injury and damage to property may occur

In hazardous areas, personal injury and damage to property may occur if you disconnect plug-in connections during operation of an ET 200SP distributed I/O system.

Always switch off the power to the ET 200SP distributed I/O system when disconnecting plug-in connections in hazardous areas.

WARNING

Explosion hazard

If you replace components, compliance with Class I, Div. 2 or zone 2 may become invalid.

WARNING

Area of application

This device is only suitable for use in Class I, Div. 2, Group A, B, C, D; Class I, zone 2, Group IIC, or in non-hazardous areas.

Safety of the plant or the system

NOTICE

Safety is the responsibility of the assembler

The safety of any plant or system incorporating the equipment is the responsibility of the assembler of the plant or system.

16.3 Marks and approvals

Marks and approvals on the nameplate

The following overview provides information about the possible marks and approvals. Only the marks and approvals specified on the nameplate apply to the device.

You can find the associated certificates for download on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14031/cert).

CE marking

The ET 200SP distributed I/O system meets the requirements and protection targets of the following directives. The distributed I/O system complies with the harmonized European standards (EN) for programmable logic controllers published in the official journals of the European Union.

- Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits; OJ L 96, 29/03/2014, pp. 357-374
- 2014/30/EU "Electromagnetic Compatibility" (EMC Directive) Directive of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the member states relating to electromagnetic compatibility; Official Journal of the European Union L96, 29/03/2014, pp. 79-106
- 2014/34/EU "Equipment and protective systems intended for use in potentially explosive atmospheres" Directive of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast); Official Journal of the European Union L96, 29/03/2014, pp. 309–356
- 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)
  Directive of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, Official Journal of the European Union L174, 01/07/2011, pp 88-110
- 2006/42/EC "Machinery, and amending Directive 95/16/EC (Machinery directive) for F-modules" ET 200SP Directive of the European Parliament and of the Council of 17 May, 2006 on machinery, and amending Directive 95/16/EC (recast); official journal of the EU, L157, 09/06/2006, pp. 24–87

The EC Declarations of Conformity are available for the responsible authorities and are kept at the following address:

Siemens Aktiengesellschaft
Digital Industries
Factory Automation
DI FA DSP SYS
PO Box 1963
D-92209 Amberg

You can also find the EC Declarations of Conformity on the Internet (https://support.industry.siemens.com/cs/ww/es/ps/14031/cert?ct=444&ci=526).

UK Conformity Assessed marking

The ET 200SP distributed I/O system complies with the designated British standards (BS) for programmable logic controllers published in the official consolidated list of the British Government. The ET 200SP distributed I/O system meets the requirements and protection targets of the following regulations and associated supplements:

- The Electrical Equipment (Safety) Regulations 2016 (S.I. 2016 No. 1101), and related amendments
- Electromagnetic Compatibility Regulations 2016 (S.I. 2016 No. 1091), and related amendments
- Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016 (S.I. 2016 No. 1107), and related amendments
- Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (S.I. 2012 No. 3032), and related amendments
- Supply of Machinery (Safety) Regulations 2008 (S.I. 2008 No. 1597), and related amendments for ET 200SP safety components (fail-safe modules)

The UK Declarations of Conformity are available to the relevant authorities at the following address:

Siemens Aktiengesellschaft
Digital Industries
Factory Automation
DI FA DSP SYS
PO Box 1963
D-92209 Amberg

You can also find the UK Declarations of Conformity on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14031/cert?ct=444&ci=5596).

cULus approval

Underwriters Laboratories Inc.:

- UL 508 (Industrial Control Equipment) OR UL 61010-1 and UL 61010-2-201
- CAN/CSA C22.2 No. 142 (Process Control Equipment) OR CAN/CSA C22.2 No. 61010-1 and CAN/CSA C22.2 No. 61010-2-201

cULus HAZ. LOC. approval

HAZ. LOC.

Underwriters Laboratories Inc.:

- UL 508 (Industrial Control Equipment) OR UL 61010-1 and UL 61010-2-201
- CAN/CSA C22.2 No. 142 (Process Control Equipment) OR CAN/CSA C22.2 No. 61010-1 and CAN/CSA C22.2 No. 61010-2-201
- ANSI/ISA 12.12.01
- CAN/CSA C22.2 No. 213 (Hazardous Location)

APPROVED for use in
Class I, Division 2, Group A, B, C, D T4;
Class I, Zone 2, Group IIC T4

Installation Instructions for cULus haz.loc.

- WARNING – Explosion Hazard – Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

CSA

CSA C22.2 (Industrial Control Equipment Motor Controllers)

UL

UL 60947-4-2 Low-Voltage Switchgear and Controlgear

FM approval

Factory Mutual Research (FM):

- Approval Standard Class Number 3600, 3611, 3810
- ANSI/UL 121201
- ANSI/UL 61010-1
- CAN/CSA C22.2 No. 213
- CAN/CSA C22.2 No. 61010-1

APPROVED for use in Class I, Division 2, Group A, B, C, D T4;
Class I, Zone 2, Group IIC T4

Installation Instructions for FM

- WARNING – Explosion Hazard – Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

ATEX approval

According to EN 60079-15 (Electrical apparatus for potentially explosive atmospheres - Part 15: Type of protection "n") and EN 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements).

II 3 G Ex nA IIC T4 Gc
DEKRA 12ATEX0038 X

OR

According to EN 60079-7 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e") and EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements).

II 3 G Ex ec IIC T4 Gc
DEKRA 20ATEX0002 X

T-CPUs:

According to EN 60079-7 (Electrical apparatus for potentially explosive atmospheres - Part 7: Increased safety "e") and EN IEC 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General requirements).

II 3 G Ex ec IIC T4 Gc
DEKRA 23ATEX0006 X

Special conditions in hazardous areas:

1. The equipment shall only be used in an area of not more than pollution degree 2, as defined in EN 60664-1.
2. The equipment shall be installed in a suitable enclosure providing a degree of protection not less than IP54 in accordance with EN IEC 60079-0. The ambient conditions must be taken into consideration for use.
3. Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119V.

UKEX approval

According to EN 60079-7 (Explosive atmospheres – Part 7: Equipment protection by increased safety "e") and EN IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

II 3 G Ex ec IIC T4 Gc
DEKRA 21UKEX0009 X

T-CPUs:

According to EN 60079-7 (Explosive atmospheres – Part 7: Equipment protection by increased safety "e") and EN IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

II 3 G Ex ec IIC T4 Gc
DEKRA 23UKEX6001 X

Special conditions in explosive atmospheres:

1. The equipment shall only be used in an area of not more than degree of pollution 2, as defined in EN 60664-1.
2. The equipment shall be installed in a suitable enclosure providing a degree of protection not less than IP54 in accordance with EN IEC 60079-0. The ambient conditions must be taken into consideration for use.
3. Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119 V.

IECEx approval

According to IEC 60079-15 (Explosive atmospheres - Part 15: Equipment protection by type of protection "n") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

Ex nA IIC T4 Gc
IECEx DEK 13.0011X

OR

According to IEC 60079-7 (Explosive atmospheres - Part 7: Equipment protection by increased safety "e") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

Ex ec IIC T4 Gc
IECEx DEK 19.0086 X

T-CPUs:

According to IEC 60079-7 (Explosive atmospheres - Part 7: Equipment protection by increased safety "e") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements).

Ex ec IIC T4 Gc
IECEx DEK 23.0005 X

Special conditions in hazardous areas:

1. The equipment shall only be used in an area of not more than pollution degree 2, as defined in IEC 60664-1.
2. The equipment shall be installed in a suitable enclosure providing a degree of protection not less than IP54 in accordance with EN IEC 60079-0. The ambient conditions must be taken into consideration for use.
3. Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119V.

CCCEx approval

In accordance with GB/T 3836.3 (Explosive atmospheres - Part 3: Equipment protection by increased safety "e"), GB/T 3836.1 (Explosive atmospheres - Part 1: Equipment - General requirements).

Ex ec IIC T4 Gc

Special conditions in hazardous areas:

- The equipment shall only be used in an area of not more than pollution degree 2, as defined in GB/T 16935.1.
- The equipment must be installed in a suitable enclosure providing a degree of protection not less than IP54 in accordance with GB/T 3836.1. The ambient conditions must be taken into consideration for use.
- Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119V.

RCM Australia/New Zealand

The ET 200SP distributed I/O system meets the requirements of EN 61000-6-4 Generic standards – Emission standard for industrial environments.

Korea Certificate

Note that this device conforms to Limit Class A for emission of radio interference. This device is not intended to be used in residential areas.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

Mark for Eurasian Economic Union

The EAC (Eurasian Conformity) mark confirms conformity with the technical regulations (TR) of the Eurasian Economic Union.

16.4 Certificates

Shipbuilding certificates

The following shipbuilding certificates are planned:

- ABS (American Bureau of Shipping)
- BV (Bureau Veritas)
- DNV (Det Norske Veritas)
- LRS (Lloyds Register of Shipping)
- Class NK (Nippon Kaiji Kyokai)
- KR (Korean Register of Shipping)
- CCS (China Classification Society)
- RINA (Registro Italiano Navale)

Following approval, you will find the certificates with the certified article numbers on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14031/cert?ct=446).

16.5 Standards and requirements

The ET 200SP distributed I/O system meets the following standards and requirements.

IEC 61131-2

The ET 200SP distributed I/O system fulfills the requirements and criteria of IEC 61131-2 (Programmable controllers, Part 2: Equipment requirements and tests) and the EMC requirements for use in Zone B.

IEC 61010-2-201

The ET 200SP distributed I/O system fulfills the requirements and criteria of standard IEC 61010-2-201 (Safety requirements for electrical equipment for measurement, control, and laboratory use Part 2-201: Particular requirements for control equipment).

IEC 60695-11-10

The ET 200SP distributed I/O system fulfills the requirements and criteria of standard IEC 60695-11-10 (Fire hazard testing - Part 11-10: Test flames - 50 W horizontal and vertical flames test methods).

UL 94

The ET 200SP distributed I/O system fulfills the requirements and criteria of UL 94 (Tests for Flammability of Plastic Materials for Parts in Devices and Appliances).

IEC 60947

The motor starters belonging to the ET 200SP distributed I/O system meet the requirements and criteria of the IEC 60947 standard.

PROFINET

The PROFINET interfaces of the ET 200SP distributed I/O system are based on IEC 61158 Type 10.

PROFIBUS

The PROFIBUS interfaces of the ET 200SP distributed I/O system are based on IEC 61158 Type 3.

IO-Link

The ET 200SP distributed I/O system is based on IEC 61131-9.

Use in industrial environments

The ET 200SP distributed I/O system is suitable for use in industrial environments. It meets the following standards for this type of use:

- Requirements on interference emission EN 61000-6-4: 2007 + A1
- Requirements for immunity EN 61000-6-2

Use in mixed areas

Under specific prerequisites you can use the ET 200SP distributed I/O system in a mixed area. A mixed area is used for residential purposes and for commercial operations that do not significantly impact the residential purpose.

If you want to use the ET 200SP distributed I/O system in residential areas, you must ensure that its radio frequency interference emission complies with limit class B in accordance with EN 61000-6-3. Suitable measures for observing these limits for use in a mixed area are, for example:

- Installation of the ET 200SP distributed I/O system in grounded control cabinets
- Use of filters in the supply lines

An additional individual acceptance test is also required.

Use in residential areas

The ET 200SP distributed I/O system is **not** intended for use in residential areas. If you are using the ET 200SP distributed I/O system in residential areas, radio and TV reception may be affected.

Environmental Product Declaration (EPD)

Siemens is committed to the development and production of environmentally compatible and sustainably produced equipment.

With the help of an Environmental Product Declaration (EPD), you can obtain information on the "ecological footprint" of your Siemens product.

The EPD is based on the international ISO 14021 standard "Environmental labels and declarations – Self declared environmental claims – Type II".

EPDs are based on independently verified data from life cycle assessments, life cycle inventory analyses and information modules that comply with the ISO 14040 series of standards. The EPD contains comprehensive data relating to ingredients and substances (REACH, RoHS), fire load, energy consumption, packaging and disposal information for your Siemens product.

You can find the current Environmental Product Declarations (EPDs) for the ET 200SP distributed I/O system on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/14031/cert?ct=5669).

Importer addresses

In the following table, you can find the importer addresses for specific countries:

Countries	Address
United Kingdom (UK)	Siemens plc. Manchester M20 2UR
Türkiye (TR)	Siemens San. ve Tic. A.Ş. Yakacık Cad. No: 111 34870 Kartal/İstanbul

16.6 Electromagnetic compatibility

Definition

Electromagnetic compatibility (EMC) is the ability of an electrical installation to function satisfactorily in its electromagnetic environment without interfering with that environment.

The ET 200SP distributed I/O system meets the legal requirements for electromagnetic compatibility of equipment. The prerequisite is that the ET 200SP distributed I/O system complies with the requirements and guidelines relating to electrical equipment.

EMC in accordance with NE21

The ET 200SP distributed I/O system meets the EMC specifications of the NAMUR recommendation NE21.

Pulse-shaped disturbance variables of the ET 200SP system

The table below shows the electromagnetic compatibility of the ET 200SP distributed I/O system with regard to pulse-shaped disturbance variables.

Table 1-50 Pulse-shaped disturbance variables

Pulse-shaped disturbance variable	Tested with	Equivalent to severity
Electrostatic discharge in accordance with IEC 61000-4-2 *)	Air discharge ±8 kV Contact discharge: ±6 kV	3 3
Burst pulses (fast transient interference) in accordance with IEC 61000-4-4 *)	±2 kV (power supply line) ±2 kV (signal line >30 m) ±1 kV (signal cable <30 m)	3 4 3
High-energy single pulse (surge) in accordance with IEC 61000-4-5 **)		
• Asymmetric coupling (phase-ground) ***)	±1 kV (24 V DC supply cable)	2
	±1 kV (24 V DC signal/data line only > 30 m)	2
	2 kV (230 V AC supply cable)	3
• Symmetric coupling (phase-phase) ***)	±0.5 kV (24 V DC supply cable)	2
	±1 kV (230 V AC supply cable)	3

*) The maximum short-term influence of analog modules during the duration of the EMC tests can be ±10% of the full-scale value.
**) Analog value deviation beyond the limits of the nominal range and diagnostics possible.
***) If higher phase-ground or phase-phase values are required, you will need an additional external protective circuit (see Designing interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566) Function Manual).

Pulse-shaped disturbance variables of motor starters

The following table shows the electromagnetic compatibility of the ET 200SP motor starters with regard to pulse-shaped interference.

Table 1-51 Pulse-shaped disturbance variables

Pulse-shaped disturbance variable	Tested with	Equivalent to severity
Burst pulses (fast transients) in accordance with IEC 61000-4-4, tested with 5 kHz.	±2 kV (24 V supply cables) ±2 kV (500 V AC infeed*) ±1 kV (signal cable <30 m)	3
If you mount the motor starter to the right of a 15 mm or 20 mm I/O module or immediately next to a head module, use a dummy module. You will find more information in "Selecting a motor starter with suitable BaseUnit (Page 94)".		
High-energy single pulse (surge) in accordance with IEC 61000-4-5	500 V AC infeed: ±2 kV conducted interference - phase to ground ±1 kV conducted interference - phase to phase 24 V supply cable: ±1 kV conducted interference - phase to ground **) ±0.5 kV conducted interference - phase to phase **)	3
**) An RC circuit is not required for hybrid switching devices. If higher values 2 kV (phase-ground) or 1 kV (phase-phase) are required, you will need an additional external protective circuit (see Designing interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566) Function Manual).		

Sinusoidal disturbance variables

The tables below show the electromagnetic compatibility of the ET 200SP distributed I/O system with regard to sinusoidal disturbance variables.

- RF radiation

RF radiation in accordance with IEC 61000-4-3/NAMUR 21 Electromagnetic RF field, amplitude-modulated		Corresponds to degree of severity
80 MHz to 2.7 GHz	10 V/m	3
2.7 GHz to 6 GHz	3 V/m	2
80% AM (1 kHz)		

- RF coupling

RF coupling in accordance with IEC 61000-4-6	Corresponds to degree of severity
(10 kHz) 150 kHz to 80 MHz	3
10 V_{rms} unmodulated	
80% AM (1 kHz)	
150 Ω source impedance	

The maximum short-term influence of analog modules during the duration of the EMC tests can be ±1% of the full-scale value.

Emission of radio frequency interference

Interference emission of electromagnetic fields according to EN 55016.

Table 1-52 Interference emission of electromagnetic fields

Frequency	Interference emission	Measuring distance
30 MHz to 230 MHz	<40 dB (µV/m) Q	10 m
230 MHz to 1000 MHz	<47 dB (µV/m) Q	10 m
1 GHz to 3 GHz	<76 dB (µV/m) P	3 m
3 GHz to 6 GHz	<80 dB (µV/m) P	3 m

Interference emission via the AC power supply according to EN 55016.

Table 1-53 Interference emission via the AC power supply

Frequency	Interference emission
0.15 MHz to 0.5 MHz	<89 dB (µV) Q < 66 dB (µV/m) M
0.5 MHz to 30 MHz	< 73 dB (µV/m)Q < 60 dB (µV/m) M

16.7 Electromagnetic compatibility of fail-safe modules

Protecting ET 200SP with fail-safe modules against overvoltages

If your equipment requires protection from overvoltage, we recommend that you use an external protective circuit (surge filter) between the load voltage power supply and the load voltage input of the BaseUnits to ensure surge immunity for the ET 200SP with fail-safe modules.

NOTE

Overvoltage protection measures always require a case-by-case examination of the entire plant. Almost complete protection from overvoltages, however, can only be achieved if the entire building surroundings have been designed for overvoltage protection. In particular, this involves structural measures in the building design phase.

For detailed information regarding overvoltage protection, we recommend that you contact your Siemens representative or a company specializing in lightning protection.

The following figure shows an example configuration with fail-safe modules. Voltage is supplied by one power supply unit. Note, however, that the total current of the modules fed by the power supply unit must not exceed the permissible limits. You can also use multiple power supply units.

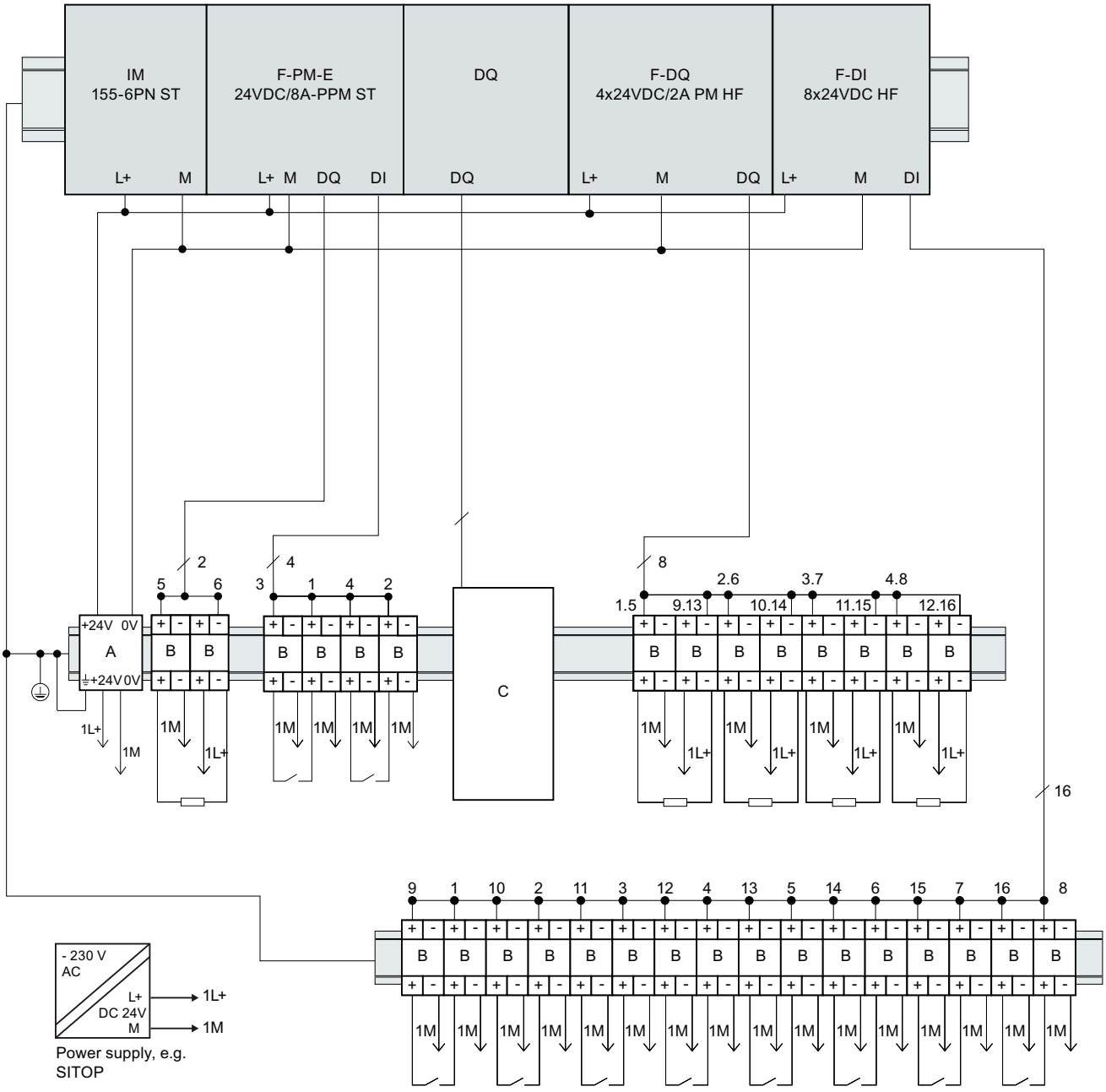

Figure 1-111 External protective circuit (surge filter) for ET 200SP with failsafe modules

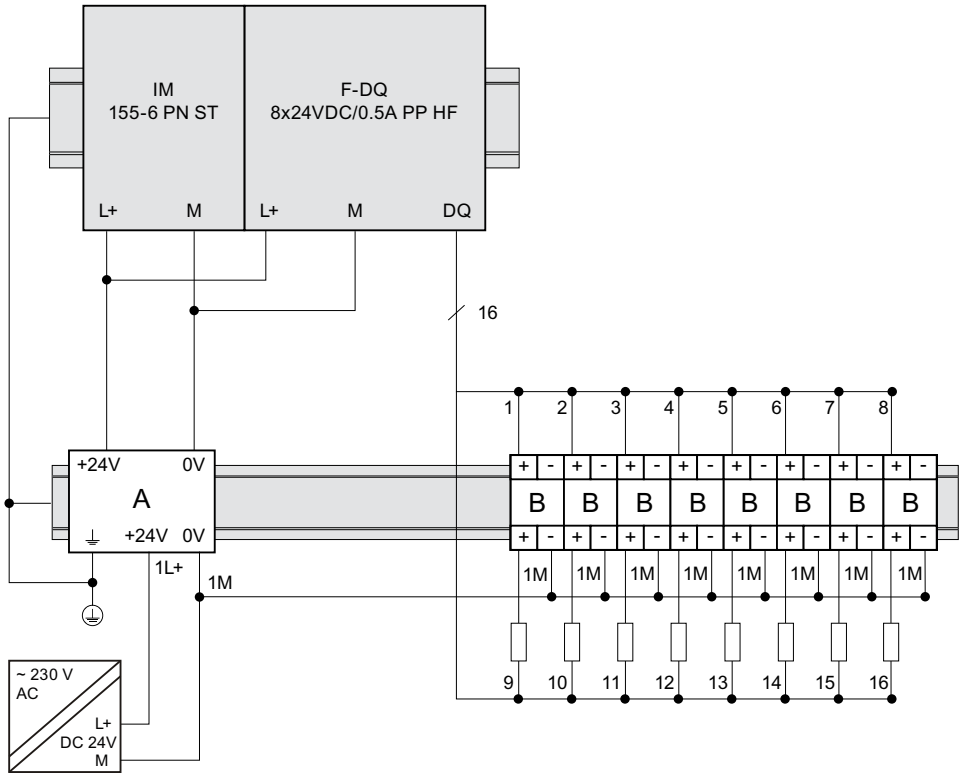

Figure 1-112 External protective circuit (surge filter) for ET 200SP with fail-safe modules

Name	Part number of Dehn Co.
A = BVT AVD 24	918 422
B = DCO RK D 5 24	919 986
C = The external protective circuit required at the outputs of the modules F-PM-E power module load group can be found in the Designing interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566) function manual.	

Electromagnetic compatibility of fail-safe motor starters

The safety versions of the motor starters are additionally tested according to the requirements of IEC 61000-6-7:2014 (taking into consideration the failure criteria for the STO safety function).

16.8 Shipping and storage conditions

Introduction

The ET 200SP distributed I/O system meets the requirements in terms of shipping and storage conditions according to IEC 61131-2. The following information applies to modules that are shipped and/or stored in their original packaging.

- Transport condition class: TTH4 (Minimum relative humidity 5%)
- Storage condition class: STH4 (Minimum ambient temperature -40 °C, minimum relative humidity 5%)

Table 1-54 Shipping and storage conditions for modules

Type of condition	Permissible range
Free fall (in shipping package)	≤1 m
Temperature	From -40 °C to +70 °C
Barometric pressure	from 1140 to 660 hPa (corresponds to an elevation of -1000 to 3500 m)
Relative humidity	5% to 95%, without condensation
Sinusoidal oscillations according to IEC 60068-2-6	5 - 8.4 Hz: 3.5 mm 8.4 - 500 Hz: 9.8 m/s^2
Impact acc. to IEC 60068-2-27[1)]	250 m/s^2, 6 ms, 1000 shocks

1) Not applicable to motor starters

16.9 Mechanical and climatic environmental conditions

Operating conditions

The ET 200SP distributed I/O system is suitable for use in weather-proof, fixed locations. The operating conditions are based on the requirements of IEC 61131-2.

- OTH4 (Minimum ambient temperature, see the Climatic ambient temperatures table)

You will find the permissible ambient conditions for the motor starter in the Technical data of the motor starter (https://support.industry.siemens.com/cs/ww/en/ps/21859/td).

Mechanical environmental conditions

The following table shows the mechanical environmental conditions in the form of sinusoidal vibrations.

Table 1-55 Mechanical environmental conditions

Frequency band	ET 200SP with IM 155-6 DP HF, BusAdapters BA 2×FC, BA 2xSCRJ, BA SCRJ/FC, BA 2xLC, BA LC/FC, BA 2xM12, BA 2xLC-LD and BA LC-LD/M12	ET 200SP with BusAdapters BA 2×RJ45, BA SCRJ/RJ45, BA LC/RJ45 and BA LC-LD/RJ45	ET 200SP with IM 155-6 PN BA and IM 155-6 PN R1	ET 200SP with digital output module F-RQ 1x24VDC/24..230V-AC/5A
5 ≤ f ≤ 8.4 Hz	3.5 mm amplitude			
8.4 ≤ f ≤ 150 Hz	1 g constant acceleration			
10 ≤ f ≤ 60 Hz	0.35 mm amplitude	---	---	---
60 ≤ f ≤ 1000 Hz	5 g constant acceleration			

Table 1-56 Mechanical environmental conditions for ET 200SP with CPU (from article number 6ES7xxx-xxx03-0AB0)

Frequency band	ET 200SP with CPU and BusAdapter BA 2×FC, BA 2xSCRJ, BA SCRJ/FC, BA 2xLC, BA LC/FC, BA 2xM12	ET 200SP with CPU and BusAdapter BA 2×RJ45, BA SCRJ/RJ45, BA LC/RJ45, BA 2×FC, BA 2xSCRJ, BA SCRJ/FC, BA 2xLC, BA LC/FC, BA 2xM12	ET 200SP with CPU and digital output module F-RQ 1x24VDC/24..230VAC/5A
5 ≤ f ≤ 8.4 Hz	3.5 mm amplitude		
8.4 ≤ f ≤ 150 Hz	1 g constant acceleration		
10 ≤ f ≤ 60 Hz	0.35 mm amplitude	---	---
60 ≤ f ≤ 1000 Hz	5 g constant acceleration[1)]		

[1)] Without using an RJ45 connector on the integrated PROFINET IO interface (RJ45 port) X1 Port 3 or X2 Port 1; the strain relief (6ES7193-6RA00-1AN0) must be mounted (for more information, refer to the ET 200SP BusAdapter Equipment Manual).

The mechanical ambient conditions for the Ex modules can be found in the system manual. T 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/en/view/109795533).

Tests of mechanical environmental conditions

The following table provides important information with respect to the type and scope of the tests of environmental mechanical conditions.

Table 1-57 Tests of mechanical environmental conditions

Condition tested	Test standard	Comment
Vibrations [2]	Vibration test according to IEC 60068-2-6 (sinusoidal)	Type of vibration: Frequency sweeps with a rate of change of 1 octave/minute. BA 2×RJ45, BA SCRJ/RJ45, BA LC/RJ45, BA LC-LD/RJ45, IM 155-6 PN BA, IM 155-6 PN R1, digital output module F-RQ 1x24VDC/24..230VAC/5A • 5 Hz ≤ f ≤ 8.4 Hz, 3.5 mm constant amplitude • 8.4 Hz ≤ f ≤ 150 Hz, 1 g constant acceleration IM 155-6 DP HF, BA 2×FC, BA 2xSCRJ, BA SCRJ/FC, BA 2xLC, BA LC/FC, BA 2xM12, BA 2xLC-LD, BA LC-LD/M12 • 10 Hz ≤ f ≤ 60 Hz, 0.35 mm constant amplitude • 60 Hz ≤ f ≤ 1000 Hz, 5 g constant acceleration Duration of vibration: 10 frequency sweeps per axis at each of three vertically aligned axes
Shock [2]	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 15 g peak value, 11 ms duration Direction of shock: 3 shocks in each direction (+/-) at each of three vertically aligned axes
Repetitive shock [1] [2]	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 25 g peak value, 6 ms duration Direction of shock: 1000 shocks in each direction (+/-) at each of three vertically aligned axes

[1] Not applicable in the case of the digital output module F-RQ 1x24VDC/24..230VAC/5A

[2] Not applicable for motor starters

The type and scope of the tests for mechanical ambient conditions for the Ex modules can be found in the system manual. ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/en/view/109795533).

Climatic environmental conditions

The following table shows the permissible climatic ambient conditions for the ET 200SP distributed I/O system during operation.

Table 1-58 Climatic environmental conditions

Environmental conditions	Permissible range	Comments
Temperature: horiz. mounting position: vertical mounting position:	 -30 °C to 60 °C -30 °C to 50 °C	The lower permissible ambient temperature was extended for the ET 200SP system to -30 °C. Differences may exist for specific modules and depending on the mounting position and, if applicable, load. Detailed information on this is described in the technical specifications of the respective equipment manual. The product data sheets with daily updated technical specifications can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/td) at Industry Online Sup-

Environmental conditions	Permissible range	Comments
		port. Enter the article number or the short description of the desired module on the website.
Permitted temperature change	10 K/h	-
Relative humidity	from 10 to 95%	Without condensation or icing.
Barometric pressure	from 1140 to 795 hPa	Corresponds to an altitude of -1000 to 2000 m. Note the following section "Using the distributed I/O system ET 200SP more than 2000 m above sea level".
Pollutant concentration	ANSI/ISA-71.04 severity level G1; G2; G3	-

SIPLUS products based on ET 200SP are offered for reliable operation under heavy to extreme operating conditions.

Using the distributed I/O system ET 200SP more than 2000 m above sea level

The maximum "operating height above sea level" depends on the module and is described in the technical specifications of the respective module. The product data sheets with daily updated technical specifications can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/td) at Industry Online Support. Enter the article number or the short description of the desired module on the website.

For altitudes > 2000 m, the following constraints apply to the maximum specified ambient temperature:

Restrictions of the specified maximum ambient temperature in reference to the installation altitude

Installation altitude	Derating factor for ambient temperature [1]
-1000 m to 2000 m	1.0
2000 m to 3000 m	0.9
3000 m to 4000 m	0.8
4000 m to 5000 m	0.7

[1] Base value for application of the derating factor is the maximum permissible ambient temperature in °C for 2000 m.

NOTE

- Linear interpolation between altitudes is permissible.
- The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.
- Note the mounting position of the respective module in the technical specifications. This is based on the IEC 61131-2 standard.
- Make sure that the power supplies you use are rated for altitudes > 2000 m.

Effects on the availability of modules

The higher cosmic radiation present during operation at altitudes above 2000 m will also start to have an effect on the failure rate of electronic components (the so-called soft error rate). In rare cases this can result in a transition of modules to the safe state, especially for fail-safe modules. However, the functional safety of the modules is fully retained.

NOTE

Fail-safe modules are certified for operation in safety mode up to the maximum altitude listed in the product data sheet.

All other markings and certifications are currently based on an altitude of up to 2000 m.

Information on PFDavg, PFH values for ET 200SP F

PFDavg and PFH values for F-CPUs at operating altitudes up to 5,000 m. Below you will find the probability of failure values (PFDavg and PFH values) for the F-CPUs with a service life of 20 years and with a repair time of 100 hours:

Operation in low demand mode low demand mode **According to IEC 61508:2010:** **PFDavg = Average probability of a dangerous failure on demand**	**Operation in high demand or continuous mode** high demand/continuous mode **According to IEC 61508:2010:** **PFH = Average frequency of a dangerous failure [h-1]**
< 2E-05	< 1E-09

NOTE

For fail-safe I/O modules, you can find the relevant details on PFDavg and PFH values on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109481784).

16.10 Insulation, protection class, degree of protection and rated voltage

Insulation

The isolation for the I/O modules is dimensioned according to the requirements of EN 61131-2 and EN 61010-2-201: The insulation for the motor starters is designed in accordance with the requirements of IEC 60947-1.

NOTE

In the case of modules with 24 V DC (SELV/PELV) supply voltage, galvanic isolations are tested with 707 V DC (type test).

Severity for voltage interruption according to IEC 61131-2

Interface modules, CPUs meet the severity class PS1 for voltage interruptions (1 ms).

Pollution degree/overvoltage category in accordance with IEC 61131 and IEC 61010-2-201

- Pollution degree: 2 (macro environment)
- Overvoltage category: II

Pollution degree/overvoltage category according to IEC 60947

- Pollution degree 2
- Overvoltage category: III

Protection class according to IEC 61131-2:2007 and IEC 61010-2-201

The ET 200SP distributed I/O system meets protection class I and includes parts of protection classes II and III.

The grounding of the mounting rail must meet the requirements for a functional earth FE.

Recommendation: For an interference-proof installation, the ground conductor should have a cross-section > 6 mm^2.

The installation location (e.g. enclosure, control cabinet) must have a protective conductor connection that meets the standard to maintain protection class I.

Degree of protection IP20

Degree of protection IP20 according to IEC 60529 for all modules of the ET 200SP distributed I/O system, which means:

- Protection against contact with standard probes
- Protection against foreign objects with diameters in excess of 12.5 mm
- No protection against water

NOTE

Use a BU cover

To meet the requirements of the degree of protection "IP20", fit a BU cover onto unfitted BaseUnits.

To ensure touch safety, fit a cover onto the opening of the infeed bus contacts belonging to the last plugged-in motor starter BaseUnit.

Rated voltage for operation

The ET 200SP distributed I/O system works with the rated voltage and corresponding tolerances listed in the following table.

Note the supply voltage of each module when selecting the rated voltage.

Table 1-59 Rated voltage for operation

Rated voltage	Tolerance range
24 V DC	19.2 to 28.8 V DC [1]
	18.5 to 30.2 V DC [2]
120 V AC (50/60 Hz)	93 to 132 V AC
230 V AC (50/60 Hz)	187 to 264 V AC
400 V AC (50/60 Hz) [3]	48 to 500 V AC

[1] Static value: Generation as protective extra low voltage with safe electrical separation in accordance with IEC 61131-2 or. IEC 61010-2-201.

[2] Dynamic value: Including ripple, e.g. as in the case of three-phase bridge power rectification

[3] Valid for the infeed bus of the modules and BaseUnits of motor starters only

16.11 Use of the ET 200SP distributed I/O system in zone 2 potentially explosive atmospheres

See product information "Use of subassemblies/modules in Zone 2 Hazardous Area" (https://support.automation.siemens.com/WW/view/en/19692172).

NOTE

Use of Ex modules

When you use Ex modules and the ET 200SP is located in a hazardous area of Zone 2, observe the notes in the System Manual ET 200SP HA Distributed I/O system / ET 200SP Modules for devices used in an explosion hazardous environment (https://support.industry.siemens.com/cs/ww/de/view/109795533/en).

NOTE

Zone 22: Observe standards and regulations, and individual acceptance test required

If you install, use and maintain the ET 200SP in hazardous area Zone 22, you must comply with the relevant standards, installation/setup regulations and country-specific regulations for Zone 22 (for example, the ET 200SP must be installed in an enclosure suitable for Zone 22). A individual acceptance test by a certification body (Ex) is also required.

Dimension drawings

A

A.1 SIMATIC system rail

SIMATIC system rail dimension drawing

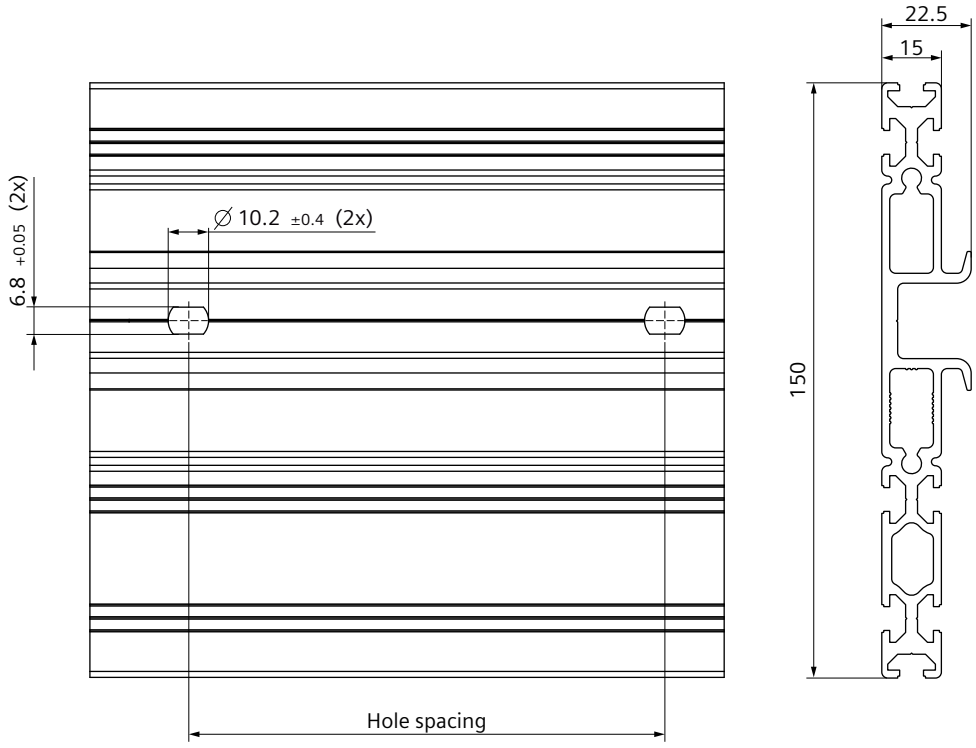

Figure 1-113 SIMATIC system rail dimension drawing

Article number	Hole spacing	Comment
6ES7193-6MR00-0AA0	466 ± 0.4 mm	With holes
6ES7193-6MR00-0BA0	500 ± 0.4 mm	With holes
6ES7193-6MR00-0CA0	800 ± 0.4 mm	With holes
6ES7193-6MR00-0DA0	-	Without holes

You can find additional dimensions of the SIMATIC system rail in section Accessories/Spare parts (Page 382).

A.2 Shield connector

Dimensional diagram of the shield connector

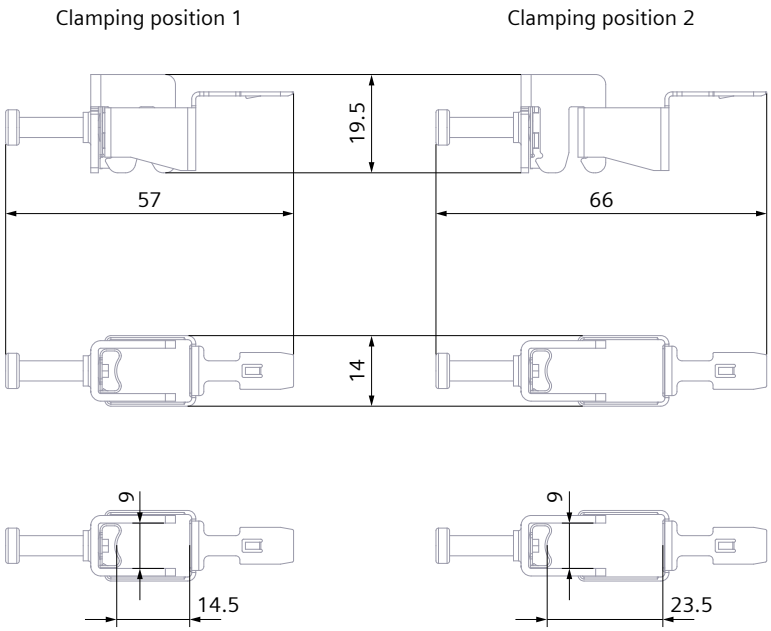

Figure 1-114 Dimensional diagram of the shield connector

A.3 Labeling strip

Dimension drawing of the labeling strips (roll)

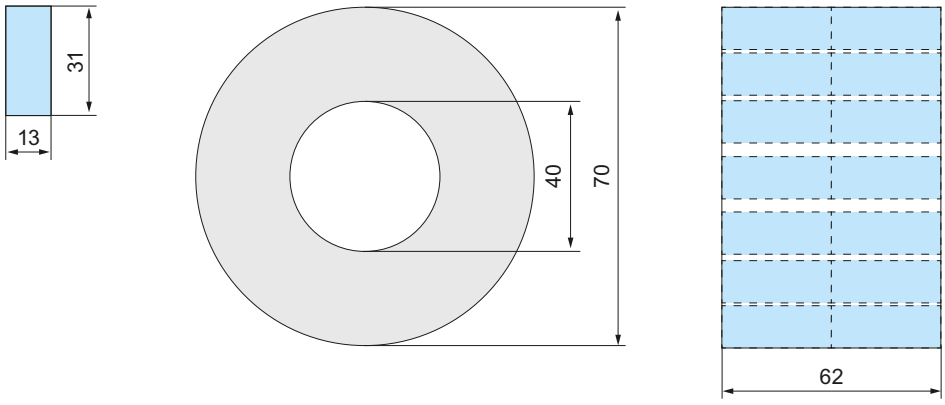

Figure 1-115 Dimension drawing of the labeling strips (roll)

Dimension drawing of the labeling strips (DIN A4 sheet)

The product information for the labeling strips (DIN A4 sheets) is available for download on the Internet (https://mall.industry.siemens.com/mall/en/de/Catalog/Product/6ES7193-6LA10-0AA0).

A.4 Reference identification labels

Dimensional diagram of reference identification label and sheet

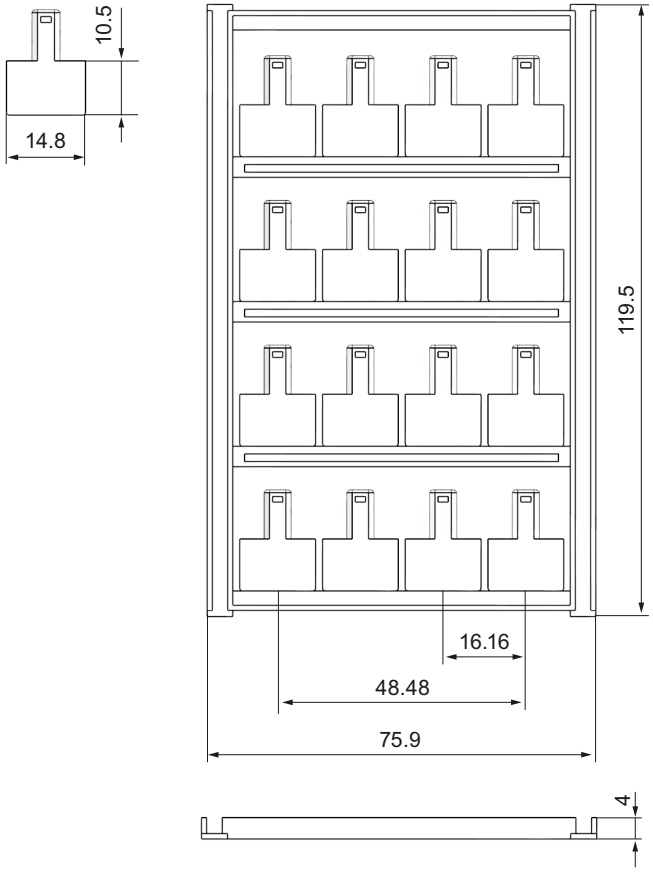

Figure 1-116 Dimensional diagram of reference identification label and sheet

Accessories/spare parts

B

Accessories for the ET 200SP distributed I/O system

Table 1-60 Accessories, general

Accessories, general	Packing unit	Article number
Strain relief units incl. screws	5 units	6ES7193-6RA00-1AN0
Cover for the BusAdapter interface	5 units	6ES7591-3AA00-0AA0
PROFIBUS FastConnect bus connector	1 unit	6ES7972-0BB70-0XA0
Server module (spare part)	1 unit	6ES7193-6PA00-0AA0
BU cover		
• 15 mm wide	5 units	6ES7133-6CV15-1AM0
• 20 mm wide	5 units	6ES7133-6CV20-1AM0
24 V DC connector (spare part)	10 units	6ES7193-4JB00-0AA0
Shield connection for BaseUnit (shield contacts and shield terminals)	5 units	6ES7193-6SC20-1AM0
Reference identification label, sheet with 16 labels	10 units	6ES7193-6LF30-0AW0
Labeling strips (for labeling the I/O modules)		
• Roll, light gray labeling strips (with a total of 500 strips), film, for labeling with thermal transfer roll printer	1 unit	6ES7193-6LR10-0AA0
• Roll, yellow labeling strips (with a total of 500 strips), film, for labeling with thermal transfer roll printer	1 unit	6ES7193-6LR10-0AG0
• DIN A4 sheets, light gray labeling strips (with a total of 1000 labels), paper, perforated, for labeling with laser printer	10 units	6ES7193-6LA10-0AA0
• DIN A4 sheets, yellow labeling strips (with a total of 1000 labels), paper, perforated, for labeling with laser printer	10 units	6ES7193-6LA10-0AG0
Mechanical coding element (spare part)[1)]		
• Coding element (type A)	20 units	6ES7193-6KA00-3AA0
• Coding element (type B)	20 units	6ES7193-6KB00-3AA0
• Coding element (type C)	20 units	6ES7193-6KC00-3AA0
• Coding element (type D)	20 units	6ES7193-6KD00-3AA0
Electronic coding element (spare part)[1)]		
• Coding element (type F, for fail-safe modules)	5 units	6ES7193-6EF00-1AA0
• Coding element (type H)	5 units	6ES7193-6EH00-1AA0
Mounting rails, tinned steel strip[2)]		
• Length: 483 mm	1 unit	6ES5710-8MA11
• Length: 530 mm	1 unit	6ES5710-8MA21

Accessories, general	Packing unit	Article number
• Length: 830 mm	1 unit	6ES5710-8MA31
• Length 2000 mm	1 unit	6ES5710-8MA41
SIMATIC system rails[2)]		
• Length 483 mm	1 unit	6ES7193-6MR00-0AA0
• Length 530 mm	1 unit	6ES7193-6MR00-0BA0
• Length 830 mm	1 unit	6ES7193-6MR00-0CA0
• Length 2000 mm	1 unit	6ES7193-6MR00-0DA0

[1)] For the I/O modules, mechanical or electronic coding elements are supplied ex works, depending on the module. Variants A, B, C, D, F and H are available as spare parts. The appropriate coding element can be found in the technical specifications of the respective I/O module. The procedure for changing the coding element is described in the section Changing the type of an I/O module (Page 328).

[2)] The length of the DIN rails and SIMATIC system rails can be shortened as required.

Table 1-61 Accessories, color identification labels (push-in terminals), 15 mm wide

Accessories, color identification labels (push-in terminals), 15 mm wide	Packing unit	Article number
16 process terminals (see I/O module manual)		
• Gray (terminals 1 to 16); color code CC00	10 units	6ES7193-6CP00-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 16); color code CC01	10 units	6ES7193-6CP01-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 16); color code CC01	50 units	6ES7193-6CP01-4MA0
• Gray (terminals 1 to 8), blue (terminals 9 to 16); color code CC02	10 units	6ES7193-6CP02-2MA0
• Gray (terminals 1 to 8), blue (terminals 9 to 16); color code CC02	50 units	6ES7193-6CP02-4MA0
• Gray (terminals 1 to 8), red (terminals 9 to 12), gray (terminals 13 to 16); color code CC03	10 units	6ES7193-6CP03-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 12), blue (terminals 13 to 16); color code CC04	10 units	6ES7193-6CP04-2MA0
• Gray (terminals 1 to 12), red (terminals 13 and 14), blue (terminals 15 and 16)	10 units	6ES7193-6CP05-2MA0
10 AUX terminals (for BU15-P16+**A10**+2D, BU15-P16+**A10**+2B)		
• Yellow-green (terminals 1 A to 10 A); color code CC71	10 units	6ES7193-6CP71-2AA0
• Red (terminals 1 A to 10 A); color code CC72	10 units	6ES7193-6CP72-2AA0
• Blue (terminals 1 A to 10 A); color code CC73	10 units	6ES7193-6CP73-2AA0
• Blue (terminals 1 A to 10 A); color code CC73	50 units	6ES7193-6CP73-4AA0
10 add-on terminals (for BU15-P16+A0+**12**D/T, BU15-P16+A0+**12**B/T)		
• Red (terminals 1B to 5B), blue (terminals 1 to 5C); color code CC74	10 units	6ES7193-6CP74-2AA0

Accessories, color identification labels (push-in terminals), 15 mm wide	Packing unit	Article number
16 potential terminals (for PotDis-BU-**P1**/x-R)		
• Red (terminals 1 to 16); color code CC62	10 units	6ES7193-6CP62-2MA0
16 potential terminals (for PotDis-BU-**P2**/x-B)		
• Blue (terminals 1 to 16); color code CC63	10 units	6ES7193-6CP63-2MA0
18 potential terminals (for PotDis-TB-**P1**-R)		
• Red (terminals 1 to 18); color code CC12	10 units	6ES7193-6CP12-2MT0
• Gray (terminals 1 to 18); color code CC10	10 units	6ES7193-6CP10-2MT0
18 potential terminals (for PotDis-TB-**P2**-B)		
• Blue (terminals 1 to 18); color code CC13	10 units	6ES7193-6CP13-2MT0
• Gray (terminals 1 to 18); color code CC10	10 units	6ES7193-6CP10-2MT0
18 potential terminals (for PotDis-TB-**BR**-W)		
• Yellow/green (terminals 1 to 18); color code CC11	10 units	6ES7193-6CP11-2MT0
• Red (terminals 1 to 18); color code CC12	10 units	6ES7193-6CP12-2MT0
• Blue (terminals 1 to 18); color code CC13	10 units	6ES7193-6CP13-2MT0
• Gray (terminals 1 to 18); color code CC10	10 units	6ES7193-6CP10-2MT0
18 potential terminals (for PotDis-TB-**n.c.**-G)		
• Gray (terminals 1 to 18); color code CC10	10 units	6ES7193-6CP10-2MT0

Table 1-62 Accessories, color identification labels (push-in terminals), 20 mm wide

Accessories, color identification labels (push-in terminals), 20 mm wide	Packing unit	Article number
12 process terminals (see I/O module manual)		
• Gray (terminals 1 to 4), red (terminals 5 to 8), blue (terminals 9 to 12); color code CC41	10 units	6ES7193-6CP41-2MB0
• Gray (terminals 1 to 8), red (terminals 9 and 10), blue (terminals 11 and 12), color code CC42	10 units	6ES7193-6CP42-2MB0
6 process terminals (see I/O module manual)		
• Gray (terminals 1 to 4), red (terminal 5), blue (terminal 6); color code CC51	10 units	6ES7193-6CP51-2MC0
• Gray (terminals 1, 2 and 5), red (terminals 3 and 4), blue (terminal 6); color code CC52	10 units	6ES7193-6CP52-2MC0
4 AUX terminals (for BU20-P12+**A4**+0B)		
• Yellow-green (terminals 1 A to 4 A); color code CC81	10 units	6ES7193-6CP81-2AB0
• Red (terminals 1 A to 4 A); color code CC82	10 units	6ES7193-6CP82-2AB0
• Blue (terminals 1 A to 4 A); color code CC83	10 units	6ES7193-6CP83-2AB0
2 AUX terminals (for BU20-P6+**A2**+4D, BU20-P6+**A2**+4B)		
• Yellow-green (terminals 1 A and 2 A); color code CC84	10 units	6ES7193-6CP84-2AC0
• Red (terminals 1 A and 2 A); color code CC85	10 units	6ES7193-6CP85-2AC0
• Blue (terminals 1 A and 2 A); color code CC86	10 units	6ES7193-6CP86-2AC0

Table 1-63 SIMATIC memory card accessories

Capacity	Packing unit	Article number
4 MB	1 unit	6ES7954-8LCxx-0AA0
12 MB	1 unit	6ES7954-8LExx-0AA0
24 MB	1 unit	6ES7954-8LFxx-0AA0
256 MB	1 unit	6ES7954-8LL02-0AA0
2 GB	1 unit	6ES7954-8LPxx-0AA0
32 GB	1 unit	6ES7954-8LTxx-0AA0

Table 1-64 Accessories for motor starters

Short designation	Packing unit	Article number
3DI/LC module (connecting terminal)	1 unit	3RK1908-1AA00-0BP0
Fan	1 unit	3RW4928-8VB00
BU cover 30	1 unit	3RK1908-1CA00-0BP0
Touch protection cover for the infeed bus	10 units	3RK1908-1DA00-2BP0
Mechanical bracket for BaseUnit	5 units	3RK1908-1EA00-1BP0

Components for lightning protection

If you need surge protection devices for lightning protection, you can find additional information in the function manual Designing interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566).

Online catalog

Additional article numbers for ET 200SP can be found on the Internet (https://mall.industry.siemens.com) in the online catalog and online ordering system.

See also

Firmware update (Page 332)

B.1 Lightning protection and overvoltage protection for fail-safe modules

Overvoltage arrestors for fail-safe modules

NOTE

This section only lists the overvoltage arrestors that may be used to protect the fail-safe modules.

Be sure to observe the detailed information on lightning protection and overvoltage protection of the ET 200SP distributed I/O system in Electromagnetic compatibility of fail-safe modules (Page 369).

Components for overvoltage protection of fail-safe modules (lightning protection zone transition 0_B to 1)

The overvoltage arrestors are only required for unshielded cables. The Configuring interference-free controllers (https://support.automation.siemens.com/WW/view/en/59193566) Function Manual lists the overvoltage arrestors which you may use for fail-safe modules.

Use over 2 000 m above sea level and extended temperature range

C

C.1 Ambient temperature and installation altitude

Extension of the temperature range and the installation altitude

The previously permissible range of ambient temperatures of **0 °C** to 60 °C for the horizontal mounting position has been extended for a large number of modules to a range of ambient temperatures of **-30 °C** to 60 °C or **-25 °C** to 60 °C (in each case without condensation or icing). Furthermore, the permissible installation altitude have been extended to installation altitudes of up to 5 000 m depending on the module.

The accessory components offered for ET 200SP (labeling strips, shield terminals, etc.) can also be used down to -30 °C and for altitudes up to 5 000 m.

The following tables show an overview of the current climatic ambient conditions for ambient temperature and installation altitude of modules of the ET 200SP product families.

For modules that are not listed, the current information in the "Technical specifications" section of the corresponding Equipment Manual applies.

Reference

The current status of the respective modules can be found in the online published technical specifications.

In general, the module-dependent extended climatic operating conditions are described in the "Technical specifications" section of the respective modules in the equipment manuals.

C.2 CPUs

CPUs

Standard CPU	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
CPU 1510SP-1 PN	6ES7510-1DJ01-0AB0	-25 to +60	FS 05	5 000
CPU 1510SP-1 PN	6ES7510-1DK03-0AB0	-30 to +60	FS 01	5 000
CPU 1512SP-1 PN	6ES7512-1DK01-0AB0	-25 to +60	FS 05	5 000
CPU 1512SP-1 PN	6ES7512-1DM03-0AB0	-30 to +60	FS 01	5 000
CPU 1514SP-2 PN	6ES7514-2DN03-0AB0	-30 to +60	FS 01	5 000

Fail-safe CPUs	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
CPU 1510SP F-1 PN	6ES7510-1SJ01-0AB0	-25 to +60	FS 01	5 000
CPU 1510SP F-1 PN	6ES7510-1SK03-0AB0	-30 to +60	FS 01	5 000
CPU 1512SP F-1 PN	6ES7512-1SK01-0AB0	-25 to +60	FS 01	5 000
CPU 1512SP F-1 PN	6ES7512-1SM03-0AB0	-30 to +60	FS 01	5 000
CPU 1514SP F-2 PN	6ES7514-2SN03-0AB0	-30 to +60	FS 01	5 000
CPU 1514SP TF-2 PN	6ES7514-2WN03-0AB0	-30 to +60	FS 01	5 000

PFDavg and PFH values for F-CPUs for operating altitudes up to 3 000 m or 5 000 m.

Below you will find the probability of failure values (PFDavg and PFH values) for the fail-safe CPUs mentioned in the table with a service life of 20 years and with a repair time of 100 hours:

Operation in low demand mode in accordance with IEC 61508:2010: PFDavg = Average probability of a dangerous failure on demand	Operation in high demand or continuous mode in accordance with IEC 61508:2010: PFH = Average frequency of a dangerous failure [h-1]
< 2E-05	< 1E-09 at an installation altitude ≤ 3 000 m < 2E-09 at an installation altitude > 3 000 m to 5 000 m

Technology CPUs	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
CPU 1514SP T-2 PN	6ES7514-2VN03-0AB0	-30 to +60	FS 01	5 000

Communications processor

Communications processor	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
CP 1542SP-1	6GK7542-6UX00-0XE0	-30 to +60	FS 01	2 000
CP 1542SP-1 IRC	6GK7542-6VX00-0XE0	-30 to +60	FS 01	2 000
CP 1543SP-1	6GK7543-6WX00-0XE0	-30 to +60	FS 01	2 000

Open Controller

Standard Open Controller	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
CPU 1515SP PC, 32-bit	6ES7677-2AA31-0EB0	0 to +60	FS 07	2 000
CPU 1515SP PC F, 32-bit	6ES7677-2FA31-0EB0	0 to +60	FS 03	2 000
CPU 1515SP PC, WES7P	6ES7677-2AA41-0FB0	0 to +60	FS 06	2 000

CPU 1515SP PC, WES7P + HMI (128PT)	6ES7677-2AA41-0FK0	0 to +60	FS 06	2 000
CPU 1515SP PC, WES7P + HMI (512PT)	6ES7677-2AA41-0FL0	0 to +60	FS 06	2 000
CPU 1515SP PC, WES7P + HMI (2kPT)	6ES7677-2AA41-0FM0	0 to +60	FS 06	2 000
CPU 1515SP PC2	6ES7677-2DB42-0GB0 6ES7677-2DB42-0GB1	-20 to +60	FS 04 FS 01	2 000
CPU 1515SP PC2 + HMI (128PT)	6ES7677-2DB42-0GK0	-20 to +60	FS 04	2 000
CPU 1515SP PC2 + HMI (512PT)	6ES7677-2DB42-0GL0	-20 to +60	FS 04	2 000
CPU 1515SP PC2 + HMI (2kPT)	6ES7677-2DB42-0GM0	-20 to +60	FS 04	2 000
CPU 1515SP PC2 IndOS	6ES7677-2DB43-0GB1	-20 to +60	FS 03	2 000

Fail-safe Open Controllers	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
CPU 1515SP PC F, WES7P	6ES7677-2FA41-0FB0	0 to +60	FS 03	2 000
CPU 1515SP PC F, WES7P + HMI (128PT)	6ES7677-2FA41-0FK0	0 to +60	FS 03	2 000
CPU 1515SP PC F, WES7P + HMI (512PT)	6ES7677-2FA41-0FL0	0 to +60	FS 03	2 000
CPU 1515SP PC F, WES7P + HMI (2kPT)	6ES7677-2FA41-0FM0	0 to +60	FS 03	2 000
CPU 1515SP PC2 F	6ES7677-2SB42-0GB0 6ES7677-2SB42-0GB1	-20 to +60	FS 04 FS 01	2 000
CPU 1515SP PC2 F + HMI (128PT)	6ES7677-2SB42-0GK0	-20 to +60	FS 04	2 000
CPU 1515SP PC2 F + HMI (512PT)	6ES7677-2SB42-0GL0	-20 to +60	FS 04	2 000
CPU 1515SP PC2 F + HMI (2kPT)	6ES7677-2SB42-0GM0	-20 to +60	FS 04	2 000
CPU 1515SP PC2 F IndOS	6ES7677-2SB43-0GB1	-20 to +60	FS 03	2 000
CPU 1515SP PC2 TF	6ES7677-2WB42-0GB0 6ES7677-2WB42-0GB1	-20 to +60	FS 04 FS 01	2 000
CPU 1515SP PC2 TF + HMI (128PT)	6ES7677-2WB42-0GK0	-20 to +60	FS 01	2 000
CPU 1515SP PC2 TF + HMI (512PT)	6ES7677-2WB42-0GL0	-20 to +60	FS 01	2 000
CPU 1515SP PC2 TF + HMI (2kPT)	6ES7677-2WB42-0GM0	-20 to +60	FS 01	2 000

PFDavg and PFH values for F-CPUs for operating altitudes up to 3 000 m or 5 000 m.

Below you will find the probability of failure values (PFDavg and PFH values) for the fail-safe CPUs mentioned in the table with a service life of 20 years and with a repair time of 100 hours:

Operation in low demand mode in accordance with IEC 61508:2010: PFDavg = Average probability of a dangerous failure on demand	Operation in high demand or continuous mode in accordance with IEC 61508:2010: PFH = Average frequency of a dangerous failure [h-1]
< 2E-05	< 1E-09 at an installation altitude ≤ 3 000 < 2E-09 at an installation altitude > 3 000 m to 5 000 m

Open Controller technology	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
CPU 1515SP PC2 T	6ES7677-2VB42-0GB0 6ES7677-2VB42-0GB1	-20 to +60	FS 04 FS 01	2 000
CPU 1515SP PC2 T + HMI (128PT)	6ES7677-2VB42-0GK0	-20 to +60	FS 01	2 000
CPU 1515SP PC2 T + HMI (512PT)	6ES7677-2VB42-0GL0	-20 to +60	FS 01	2 000
CPU 1515SP PC2 T + HMI (2kPT)	6ES7677-2VB42-0GM0	-20 to +60	FS 01	2 000

C.3 Interface modules

Interface module	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
IM 155-6 PN BA	6ES7155-6AR00-0AN0	-30 to +60	FS 04	5 000
IM 155-6 PN ST incl. BA 2xRJ45	6ES7155-6AA02-0BN0	0 to +60	FS 01	5 000
IM 155-6 PN ST	6ES7155-6AU02-0BN0	-30 to +60	FS 01	5 000
IM 155-6 PN/2 HF	6ES7155-6AU01-0CN0	-30 to +60	FS 02	5 000
IM 155-6 PN/3 HF 3-port	6ES7155-6AU30-0CN0	-30 to +60	FS 02	5 000
IM 155-6 PN R1	6ES7155-6AU00-0HM0	-30 to +60	FS 01	2 000
IM 155-6 MF HF	6ES7155-6MU00-0CN0	-30 to +60	FS 01	5 000
IM 155-6 MF HF	6ES7155-6MU01-0CN0	-30 to +60	FS 01	5 000
IM 155-6 PN HS	6ES7155-6AU00-0DN0	-25 to +60	FS 02	5 000
IM 155-6 DP HF - Bundle	6ES7155-6BA01-0CN0	0 to +60	FS 01	5 000
Server module (spare part)	6ES7193-6PA00-0AA0	-30 to +60	FS 07	5 000

C.4 BusAdapter

BusAdapter	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
BA 2x RJ45	6ES7193-6AR00-0AA0	-30 to +60	FS 06	5 000
BA 2x FC	6ES7193-6AF00-0AA0	-30 to +60	FS 04	5 000
BA 2x M12	6ES7193-6AM00-0AA0	-30 to +60	FS 01	5 000
BA 2x LC	6ES7193-6AG00-0AA0	-30 to +60	FS 05	5 000
BA LC/RJ45	6ES7193-6AG20-0AA0	-30 to +60	FS 04	5 000
BA LC/FC	6ES7193-6AG40-0AA0	-30 to +60	FS 04	5 000
BA 2x LC-LD	6ES7193-6AG50-0AA0	-30 to +60	FS 01	5 000
BA LC-LD/RJ45	6ES7193-6AG60-0AA0	-30 to +60	FS 01	5 000
BA LC-LD/M12	6ES7193-6AG70-0AA0	-30 to +60	FS 01	5 000
BA 2x SCRJ	6ES7193-6AP00-0AA0	-25 to +60	FS 04	5 000
BA SCRJ/RJ45	6ES7193-6AP20-0AA0	-25 to +60	FS 04	5 000
BA SCRJ/FC	6ES7193-6AP40-0AA0	-25 to +60	FS 04	5 000
DP connector	6ES7972-0BB70-0XA0	-25 to +60	FS 03	2 000
BA-SEND BA 1xFC	6ES7193-6AS00-0AA0	-30 to +60	FS 05	2 000

C.5 BaseUnits

BaseUnits

BaseUnit BU type P0	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
BU30-MS1	3RK1908-0AP00-0AP0	-25 to +60	FS 01	4 000
BU30-MS3	3RK1908-0AP00-0BP0	-25 to +60	FS 01	4 000
BU30-MS2	3RK1908-0AP00-0CP0	-25 to +60	FS 01	4 000
BU30-MS4	3RK1908-0AP00-0DP0	-25 to +60	FS 01	4 000
BU30-MS5	3RK1908-0AP00-0EP0	-25 to +60	FS 01	2 000
BU30-MS6	3RK1908-0AP00-0FP0	-25 to +60	FS 01	2 000
BU30-MS7	3RK1908-0AP00-0GP0	-25 to +60	FS 01	2 000
BU30-MS8	3RK1908-0AP00-0HP0	-25 to +60	FS 01	2 000
BU30-MS9	3RK1908-0AP00-0JP0	-25 to +60	FS 01	2 000
BU30-MS10	3RK1908-0AP00-0KP0	-25 to +60	FS 01	2 000

BaseUnits BU type A0 and A1	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	

BU15-P16+A0+2B	6ES7193-6BP00-0BA0	-30 to +60	FS 06	5 000
BU15-P16+A0+2D	6ES7193-6BP00-0DA0	-30 to +60	FS 06	5 000
BU15 double BU+2B	6ES7193-6BP60-0BA0	-30 to +60	FS 03	5 000
BU15 double BU+2DB	6ES7193-6BP60-0DA0	-30 to +60	FS 03	5 000
BU15-P16+A10+2B	6ES7193-6BP20-0BA0	-30 to +60	FS 06	5 000
BU15-P16+A10+2D	6ES7193-6BP20-0DA0	-30 to +60	FS 07	5 000
BU15-P16+A0+2B/T	6ES7193-6BP00-0BA1	-30 to +60	FS 06	5 000
BU15-P16+A0+2D/T	6ES7193-6BP00-0DA1	-30 to +60	FS 06	5 000
BU15-P16+A0+12B/T	6ES7193-6BP40-0BA1	-30 to +60	FS 06	5 000
BU15-P16+A0+12D/T	6ES7193-6BP40-0DA1	-30 to +60	FS 07	5 000

BaseUnits BU type B0 to U0	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
BU20-P12+A4+0B	6ES7193-6BP20-0BB0	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 V AC)
BU20-P12+A0+4B	6ES7193-6BP20-0BB1	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 V AC)
BU20-P6+A2+4D	6ES7193-6BP20-0DC0	-30 to +60	FS 03	5 000 (SELV/PELV supplied)
BU20-P6+A2+4B	6ES7193-6BP20-0BC1	-30 to +60	FS 03	5 000 (SELV/PELV supplied)
BU20-P12+A0+0B	6ES7193-6BP00-0BD0	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 V AC)
BaseUnit BU-SEND	6ES7193-6BN00-0NE0	-30 to +60	FS 04	2 000
BU20-P8+A4+0B	6ES7193-6BP20-0BF0	-30 to +60	FS 04	2 000
BU20-P16+A0+2B	6ES7193-6BP00-0BU0	-30 to +60	FS 03	5 000 (SELV/PELV supplied) 3 000 (277 V AC)
BU20-P16+A0+2D	6ES7193-6BP00-0DU0	-30 to +60	FS 03	5 000 (SELV/PELV supplied) 3 000 (277 V AC)

BaseUnit BU type M0	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
BU type M0	6ES7193-6BR00-0HM0	-30 to +60	FS 01	2 000

C.6 I/O modules

Information on PFDavg, PFH values for ET 200SP fail-safe I/O modules

The safety parameters specified in the Equipment Manual of the fail-safe I/O module ET 200SP (PFD_{avg}, PFH values) already reflect the influence of higher cosmic radiation (soft error rate) for operation up to 4 000 m above sea level.

I/O modules

Digital input modules	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
DI 4x120...230VAC ST	6ES7131-6FD01-0BB1	-30 to +60	FS 02	2 000
DI 8x24VDC BA	6ES7131-6BF01-0AA0	-30 to +60	FS 03	5 000
DI 8x24VDC SRC BA	6ES7131-6BF61-0AA0	-30 to +60	FS 02	2 000
DI 8x24VAC/48VUC BA	6ES7131-6CF00-0AU0	-30 to +60	FS 02	4 000 (48 V AC/48 V DC)
DI 8x24VDC ST	6ES7131-6BF01-0BA0	-30 to +60	FS 02	5 000
DI 8x24VDC HF	6ES7131-6BF00-0CA0	-30 to +60	FS 07	5 000
DI 8xNAMUR HF	6ES7131-6TF00-0CA0	-30 to +60	FS 04	5 000
DI 8x24VDC HS	6ES7131-6BF00-0DA0	-30 to +60	FS 04	5 000
DI 16x24VDC ST	6ES7131-6BH01-0BA0	-30 to +60	FS 02	5 000

Fail-safe digital input modules	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
F-DI 8x24VDC HF	6ES7136-6BA00-0CA0	0 to +60	FS 04	4 000 [1]
F-DI 8x24VDC HF	6ES7136-6BA01-0CA0	0 to +60	FS 01	4 000

[1] As of revision FS 04

Digital output modules	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0	-30 to +60	FS 08	5 000
	6ES7132-6BD21-0BA0	-30 to +60	FS 01	5 000
DQ 4x24VDC/2A HF	6ES7132-6BD20-0CA0	-30 to +60	FS 06	5 000
	6ES7132-6BD21-0CA0	-30 to +60	FS 01	5 000
DQ 4x24...230VAC/2A ST	6ES7132-6FD00-0BB1	-30 to +60	FS 05	3 000 (277 V AC)
DQ 4x24..230VAC/2A HF	6ES7132-6FD00-0CU0	-30 to +60	FS 04	3 000 (277 V AC)
DQ 4x24VDC/2A HS	6ES7132-6BD20-0DA0	-30 to +60	FS 05	5 000
DQ 8x24VDC/0.5A BA	6ES7132-6BF01-0AA0	-30 to +60	FS 02	5 000
DQ 8x24VDC/0.5A SNK BA	6ES7132-6BF61-0AA0	-25 to +60	FS 02	5 000

DQ 8x24VDC/0.5A ST	6ES7132-6BF01-0BA0	-30 to +60	FS 02	5 000
DQ 8x24VDC/0.5A HF	6ES7132-6BF00-0CA0	-30 to +60	FS 07	5 000
	6ES7132-6BF01-0CA0	-30 to +60	FS 01	5 000
DQ 16x24VDC/0.5A BA	6ES7132-6BH00-0AA0	-30 to +60	FS 03	5 000
DQ 16x24VDC/0.5A ST	6ES7132-6BH01-0BA0	-30 to +60	FS 03	5 000
DQ 16x24VDC/0.5A HF	6ES7132-6BH00-0CA0	-30 to +60	FS 01	5 000

Fail-safe digital output modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
F-DQ 4x24VDC/2A PM HF	6ES7136-6DB00-0CA0	0 to +60	FS 04	4 000 [1]
F-DQ 4x24VDC/2A PM HF	6ES7136-6DB01-0CA0	0 to +60	FS 01	4 000
F-DQ 8x24VDC/0.5A PP HF	6ES7136-6DC00-0CA0	0 to +60	FS 01	4 000

[1] As of revision FS 04

Digital input/output modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
DI 8x/DQ 8x24VDC/0.5A ST	6ES7133-6BH00-0BA0	-30 to +60	FS 01	5 000

Relay modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
RQ 4x24VUC/2A CO ST	6ES7132-6GD51-0BA0	-30 to +60	FS 02	2 000
RQ 4x120VDC-230VAC/5A NO ST	6ES7132-6HD01-0BB1	-30 to +60	FS 02	2 000
RQ 4x120VDC-230VAC/5A NO MA ST	6ES7132-6MD00-0BB1	-30 to +60	FS 03	2 000
RQ 3x120VDC-230VAC/5A CO ST	6ES7132-6HC50-0BU0	-30 to +60	FS 01	2 000
RQ 3x120VDC-230VAC/5A CO n.i. ST	6ES7132-6HC70-0BU0	-30 to +60	FS 01	2 000

Fail-safe relay modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
F-RQ 1x24VDC/24..230VAC/5A ST	6ES7136-6RA00-0BF0	0 to +60	FS 01	2 000

Analog input modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
AI 2xI 2/4-wire ST	6ES7134-6GB00-0BA1	-30 to +60	FS 04	5 000
AI 2xU ST	6ES7134-6FB00-0BA1	-30 to +60	FS 04	5 000

[2] Installation altitude higher than 2 000 m on request

AI 2xU/I 2/4-wire HF	6ES7134-6HB00-0CA1	-30 to +60	FS 06	5 000
AI 2xU/I 2-/4-wire HS	6ES7134-6HB00-0DA1	-30 to +60	FS 07	5 000
AI 2x SG 4-/6-wire HS	7MH4134-6LB00-0DA0	-25 to +60	FS 01	3 000
AI 4xI 2-wire 4...20mA HART HF	6ES7134-6TD00-0CA1	-30 to +60	FS 01	5 000
AI 4xI 2-/4-wire ST	6ES7134-6GD01-0BA1	-30 to +60	FS 02	5 000
AI 4xU/I 2-wire ST	6ES7134-6HD01-0BA1	-30 to +60	FS 02	5 000
AI 8xU BA	6ES7134-6FF00-0AA1	-30 to +60	FS 04	5 000
AI 4xTC HS	6ES7134-6JD00-0DA1	-30 to +60	FS 02	5 000
AI 4xRTD/TC 2-/3-/4-wire HF	6ES7134-6JD00-0CA1	-30 to +60	FS 08	5 000
AI 8xRTD/TC 2-wire HF	6ES7134-6JF00-0CA1	-30 to +60	FS 05	5 000
AI Energy Meter 480V ST	6ES7134-6PA20-0BD0	0 to +60	FS 01	3 000
AI Energy Meter HF CT	6ES7134-6PA00-0CU0	-30 to +60	FS 01	2 000 [2]
AI Energy Meter HF RC	6ES7134-6PA20-0CU0	-30 to +60	FS 01	2 000 [2]
AI Energy Meter CT ST	6ES7134-6PA01-0BU0	-30 to +60	FS 01	3 000
AI Energy Meter CT HF	6ES7134-6PA01-0CU0	-30 to +60	FS 01	3 000
AI Energy Meter RC ST	6ES7134-6PA21-0BU0	-30 to +60	FS 01	3 000
AI Energy Meter RC HF	6ES7134-6PA21-0CU0	-30 to +60	FS 01	3 000

[2] Installation altitude higher than 2 000 m on request

Fail-safe analog input modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
F-AI 4xI (0)4..20mA HF	6ES7136-6AA00-0CA1	0 to +60	FS 01	4 000
F-AI 4xU 0..10V HF	6ES7136-6AB00-0CA1	0 to +60	FS 01	4 000

Analog output modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
AQ 2xI ST	6ES7135-6GB00-0BA1	-30 to +60	FS 03	5 000
AQ 2xU ST	6ES7135-6FB00-0BA1	-30 to +60	FS 03	5 000
AQ 2xU/I HF	6ES7135-6HB00-0CA1	-30 to +60	FS 04	5 000
AQ 2xU/I HS	6ES7135-6HB00-0DA1	-30 to +60	FS 06	5 000
AQ 4xU/I ST	6ES7135-6HD00-0BA1	-30 to +60	FS 07	5 000
AQ 4xI HART HF	6ES7135-6TD00-0CA1	-30 to +60	FS 01	5 000

Technology modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
TM Count 1x24V	6ES7138-6AA01-0BA0	-30 bis +60	FS 03	5 000
TM Pulse 2x24V	6ES7138-6DB00-0BB1	-30 bis +60	FS 03	5 000
TM PTO 2x24V	6ES7138-6EB00-0BA0	-30 bis +60	FS 00	5 000

TM WP321 1x5VDC#1-4mV/V ST	7MH4138-6AA00-0BA0	-25 bis +60	FS 04	5 000
TM WP351 HF	7MH4138-6BA00-0CU0	-30 bis +60	FS 01	5 000
TM ECC PL ST	6FE1242-6TM20-0BB1	-30 bis +60	FS 00	2 000
TM ECC 2xPWM ST	6FE1242-6TM10-0BB1	-30 bis +60	FS 00	2 000
Pneumatic valve island Airline SP 8647	Bürkert	0 bis +55	-	2 000
TM StepDrive 1x24..48V/5A*	phytron 10020273	0 bis +60	-	2 000
TM SITRANS FCT070	7ME4138-6AA00-0BB1	-30 bis +60	FS 00	2 000

Fail-safe technology modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
F-TM ServoDrive 1x24..48V 5A ST	6BK1136-6AB00-0BU0	-30 bis +60	FS 00	3 000

Communications modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
CM PtP	6ES7137-6AA00-0BA0	-30 bis +60	FS 03	5 000
CM 1xDALI	6ES7137-6CA00-0BU0	-30 bis +60	FS 03	3 000
CM 4xIO-Link	6ES7137-6BD00-0BA0	-30 bis +60	FS 03	2 000
CM DP (für CPU)	6ES7545-5DA00-0AB0	-25 bis +60	FS 04	5 000
CM AS-I MASTER ST (AS-I V3.0)	3RK7137-6SA00-0BC1	-25 bis +60	FS 20	2 000
CM CAN	6ES7137-6EA00-0BA0	-30 bis +60	FS 03	5 000

Fail-safe communications modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
F-CM AS-I SAFETY ST	3RK7136-6SC00-0BC1	0 bis +60	FS 01	2 000

[1] As of revision FS 05

Fail-safe power modules	**Article number**	**Ambient temperature**		**Maximum installation altitude above sea level [m]**
		Temperature range [°C]	**As of version**	
F-PM-E 24VDC/8A PPM ST	6ES7136-6PA00-0BC0	0 bis +60	FS 05	4 000 [1]

[1] As of revision FS 05

C.7 Motor starter

Motor starter

Direct starter	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
DS 0.1 - 0.4A HF	3RK1308-0AA00-0CP0	-25 to +60	FS 01	4 000
DS 0.3 - 1 A HF	3RK1308-0AB00-0CP0	-25 to +60	FS 01	4 000
DS 0.9 - 3 A HF	3RK1308-0AC00-0CP0	-25 to +60	FS 01	4 000
DS 2.8 - 9 A HF	3RK1308-0AD00-0CP0	-25 to +60	FS 01	4 000
DS 4.0 - 12 A HF	3RK1308-0AE00-0CP0	-25 to +60	FS 01	4 000

Reversing starter	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
RS 0.1 - 0.4A HF	3RK1308-0BA00-0CP0	-25 to +60	FS 01	4 000
RS 0.3 - 1A HF	3RK1308-0BB00-0CP0	-25 to +60	FS 01	4 000
RS 0.9 - 3A HF	3RK1308-0BC00-0CP0	-25 to +60	FS 01	4 000
RS 2.8 - 9A HF	3RK1308-0BD00-0CP0	-25 to +60	FS 01	4 000
RS 4.0 - 12A HF	3RK1308-0BE00-0CP0	-25 to +60	FS 01	4 000

Fail-safe direct starter	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
F-DS 0.1 - 0.4A HF	3RK1308-0CA00-0CP0	-25 to +60	FS 01	4 000
F-DS 0.3 - 1 A HF	3RK1308-0CB00-0CP0	-25 to +60	FS 01	4 000
F-DS 0.9 - 3 A HF	3RK1308-0CC00-0CP0	-25 to +60	FS 01	4 000
F-DS 2.8 - 9 A HF	3RK1308-0CD00-0CP0	-25 to +60	FS 01	4 000
F-DS 4.0 - 12 A HF	3RK1308-0CE00-0CP0	-25 to +60	FS 01	4 000

Fail-safe reversing starter	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
F-RS 0.1 - 0.4A HF	3RK1308-0DA00-0CP0	-25 to +60	FS 01	4 000
F-RS 0.3 - 1 A HF	3RK1308-0DB00-0CP0	-25 to +60	FS 01	4 000
F-RS 0.9 - 3 A HF	3RK1308-0DC00-0CP0	-25 to +60	FS 01	4 000
F-RS 2.8 - 9 A HF	3RK1308-0DD00-0CP0	-25 to +60	FS 01	4 000
F-RS 4.0 - 12 A HF	3RK1308-0DE00-0CP0	-25 to +60	FS 01	4 000

C.8 Potential distributor

Potential distributor	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
		Temperature range [°C]	As of version	
PotDis-BU-P1/D-R	6ES7193-6UP00-0DP1	-30 to +60	FS 04	5 000
PotDis-BU-P1/B-R	6ES7193-6UP00-0BP1	-30 to +60	FS 04	5 000
PotDis-BU-P2/D-B	6ES7193-6UP00-0DP2	-30 to +60	FS 04	5 000
PotDis-BU-P2/B-B	6ES7193-6UP00-0BP2	-30 to +60	FS 04	5 000
PotDis TB P1-R	6ES7193-6TP00-0TP1	-30 to +60	FS 03	5 000
PotDis TB P2-B	6ES7193-6TP00-0TP2	-30 to +60	FS 03	5 000
PotDis TB BR-W	6ES7193-6TP00-0TP0	-30 to +60	FS 03	5 000
PotDis TB n.c.-G	6ES7193-6TP00-0TN0	-30 to +60	FS 03	5 000
BU cover - 15 mm (PU* 5) [1]	6ES7133-6CV15-1AM0	-40 to +60	FS 01	5 000
BU cover - 20 mm (PU* 5) [1]	6ES7133-6CV20-1AM0	-40 to +60	FS 01	5 000

[1] Packing unit: Pack of 5

C.9 Restrictions

Restrictions of the max. ambient temperature specified with regard to the installation altitude

Installation altitude	Derating factor for ambient temperature [1)]
-1 000 to 2 000 m	1.0
2 000 to 3 000 m	0.9
3 000 to 4 000 m	0.8
4 000 to 5 000 meters	0.7

1) Base value for the application of the derating factor is the maximum permissible ambient temperature in °C for 2 000 m

NOTE

- Linear interpolation between altitudes is permissible.
- The derating factors compensate for the decreasing cooling effect of air in higher altitudes due to lower density.
- Note the mounting position of the respective module in the technical specifications. The basis is the standard IEC 61131-2.
- Make sure that the power supplies you use are also rated for altitudes > 2 000 m.
- The "Safety-related shutdown of standard modules" function, as described on the Internet (https://support.industry.siemens.com/cs/ww/en/view/39198632), is only released up to a maximum of 2 000 m.

Effects on availability

The higher cosmic radiation present during operation at altitudes above 2 000 m will also start to have an effect on the failure rate of electronic components (referred to as the soft error rate). In rare cases this can result in a transition of the module into the safe state, especially for safety modules. However, the functional safety of the module is fully retained.

NOTE

Information on the components of the ET 200SP I/O system

The markings and approvals printed on the components of the ET 200SP I/O system are currently based on operation at an altitude of up to 2 000 m above sea level. The fail-safe components are certified for operation in safety mode up to the specified maximum altitudes (according to "Z10 067803 0020" certificate (https://support.industry.siemens.com/cs/ww/de/view/57141281/en)).

Reference

You can find more information in the Mechanical and climatic environmental conditions (Page 372) section.

Calculating the leakage resistance

D

Introduction

If you wish to protect the ET 200SP using a ground-fault detector or a residual current circuit breaker, then you need the leakage resistance to select the correct safety components.

Ohmic resistance

When determining the leakage resistance of the ET 200SP, you must take into account the ohmic resistance from the RC combination of the module in question:

Table 1-65 Ohmic resistance

Module	Ohmic resistance from RC network
CPU/interface module	10 MΩ (±5 %)
BaseUnit BU15...D	10 MΩ (±5 %)
BaseUnit BU30-MSx	10 MΩ (±5 %)

Formula

You can calculate the leakage resistance of the ET 200SP using the following formula if you protect all of the modules listed above with one ground-fault detector:

$R_{ET200SP}$ = R_{module} / N

$R_{ET200SP}$ = Leakage resistance of the ET 200SP

R_{module} = Leakage resistance of a module

N = Number of BaseUnits BU15...D and interface module in the ET 200SP

$R_{CPU/IM}$ = $R_{BU15...D}$ = R_{Module} = 9.5 MΩ

$R_{CPU/IM}$ = Leakage resistance of CP/interface module

$R_{BU15...D}$ = Leakage resistance of the BaseUnit BU15...D

If you protect the modules listed above within an ET 200SP with several ground-fault detectors, you must determine the leakage resistance for each individual ground-fault detector.

Example

The structure of an ET 200SP system consists of an IM 155-6 PN ST, two BaseUnits BU15...D and various input and output modules. The entire ET 200SP is protected with **one** ground-fault detector:

$$\text{RET 200SP} = \frac{9{,}5\ \text{M}\Omega}{3} = 3{,}17\ \text{M}\Omega$$

Figure 1-117 Calculation example for leakage resistance

SIMATIC ET 200SP data

E

E.1 Introduction

The EU Data Act, a key component of the European data strategy, went into effect on January 11, 2024.

The following information provides an overview of data that the ET 200SP automation system generates and that is accessible to you.

E.2 CPU data

Type, format, and estimated scope of data that the product is capable of generating

Type of data	Formats	Estimated scope
Process data (input and output data, states, alarms)	Numeric formats, binary formats	Cyclic processing Depending on application
Configuration and program data (upload to programming device/PC)	Binary formats, string formats	Depending on application
Diagnostics data, system and security events, service data	Time formats, string formats, CSV, binary formats	Depending on application Several hundred bytes per event
Operating data (runtimes, cycle times, CPU utilization)	Numeric formats, time formats, JSON	Depending on application
Log data	Time formats, string formats, CSV	Depending on application

Continuous and real-time data generation

The ET 200SP is able to generate data continuously and in real time. Data acquisition takes place continuously throughout the entire operation. The CPU operates with defined cycle times in which process data is acquired and processed.

Data storage and storage duration

Local data storage

The ET 200SP stores data in integrated memory areas of the CPU and on the SIMATIC Memory Card.

Local data storage	Storage capacity	Storage duration
Load memory (via SIMATIC Memory Card)	4 MB to 32 GB, depending on SIMATIC Memory Card	Permanent
Code work memory	100 kB to 900 kB, depending on CPU	During operation of the CPU
Data work memory	750 kB to 3.5 MB	During operation of the CPU
Retentive memory	Up to 512 KB, depending on CPU	Permanent

More information

You can find more information on memory areas, retentivity, and memory usage in the Structure and Use of the CPU Memory function manual (https://support.industry.siemens.com/cs/ww/en/view/59193101).

Remote data storage

Data can be transmitted to external systems via various communications interfaces of ET 200SP, such as PROFINET and Industrial Ethernet.

The ET 200SP can send data to various remote systems, including SCADA systems, SQL databases, cloud platforms (e.g. Insights Hub), and file servers.

The ET 200SP can send logging data to a SIEM system in the form of Syslog messages.

The storage duration on external systems depends on the configuration of the respective system.

The ET 200SP CPU can be integrated as a data source into the Siemens Industrial Edge concept.

Data access/retrieval, terms of use, and quality of service

Type of data	Access/retrieval via	Terms of use	Quality of service*
Process data (input and output data, states, alarms)	TIA Portal Web server OPC UA HMI/SCADA systems	User management Authentication Certificates	Prioritization of control tasks over data access Data throughputs up to 1 Gbps via PROFINET Encrypted data transmission available (HTTPS, TLS)
Configuration and program data	TIA Portal Web server SIMATIC Memory Card	User management Authentication Certificates	Encrypted data transmission available (HTTPS, TLS)

* "Quality of service" refers to the ability of ET 200SP to efficiently manage network resources and ensure that certain performance requirements relating to data transfer are fulfilled.

Type of data	Access/retrieval via	Terms of use	Quality of service*
Diagnostics data, system and security events, service data	TIA Portal SIMATIC Automation Tool Web server	User management Authentication Certificates	Encrypted data transmission available (HTTPS, TLS)
Operating data (runtimes, cycle times, CPU utilization)	TIA Portal Web server HMI/SCADA systems SIMATIC Controller Profiling	User management Authentication Certificates	Encrypted data transmission available (HTTPS, TLS)
Log data	TIA Portal Trace and logic analyzer function	User management Authentication	Encrypted data transmission available (HTTPS, TLS)

* "Quality of service" refers to the ability of ET 200SP to efficiently manage network resources and ensure that certain performance requirements relating to data transfer are fulfilled.

Deletion of data from CPUs

To delete all data from the data memories of the CPU, the "Reset to factory settings" function is available.

A reset of the CPU to factory settings can be implemented using any of the following:

- Mode selector keys/switches of the CPU
- TIA Portal
- SIMATIC Automation Tool

More information

You can find more information on deleting data in the System Manual ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293), in the sections “Securely removing data” and “Reset to factory settings”.

E.3 Data of the interface and I/O modules

Type, format, and estimated scope of data that the product is capable of generating

Type of data	Formats	Estimated scope
Process data (input and output data, states, alarms)	Numeric formats, binary formats	Cyclic processing Depending on application
Configuration and parameter data (upload to programming device/PC)	Binary formats, string formats	Depending on application
Diagnostics data, service data	Binary formats	Depending on application Less than 100 bytes per diagnostic event; several kilobytes of service data
Fieldbus* metadata: I&M data, log data, statistics data	Binary formats, string formats	Approximately 100 bytes per read-out data record

* PROFIBUS, PROFINET, EtherNet/IP, Modbus TCP (only for interface modules as MultiFieldbus devices)

Continuous and real-time data generation

The interface and I/O modules are able to generate data continuously and in real time. Data acquisition takes place continuously throughout the entire operation. The cycle time is specified by the CPU.

Data storage and storage duration

Local data storage

The interface and I/O modules store data in integrated memory areas.

Local data storage	Storage capacity	Storage duration
Retentive memory (for I&M data, configuration and parameter data*, service data, energy meters **)	Up to 16 MB for interface modules 1 To 6 MB for I/O modules	Permanent
Work memory (for process data, diagnostics data, fieldbus metadata, configuration and parameter data, service data)	Up to 1 MB for interface modules Several hundred KB for I/O modules	During operation of the module

* only interface modules as MultiFieldbus devices, IO-Link masters and CM 1xDALI

** only AI Energy Meter

Data access/retrieval, terms of use, and quality of service

Type of data	Access/retrieval via	Terms of use	Quality of service*
Process data (input and output data, states, alarms)	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT	Via fieldbus without authentication Via CPU (Page 402)	Prioritization of control tasks over data access Standard fieldbus transmission mechanisms Data throughputs up to 1 Gbps via PROFINET
Configuration and parameter data (upload to programming device/PC)	TIA Portal (via CPU) S7-PCT (for IO-Link masters) MFCT	Via fieldbus without authentication Via CPU (Page 402)	Standard fieldbus transmission mechanisms
Diagnostics data, service data	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT	Via fieldbus without authentication Via CPU (Page 402)	Standard fieldbus transmission mechanisms

* "Quality of service" refers to the ability of the interface and I/O modules to manage network resources efficiently and to ensure that specific performance requirements for data transmission are met.

Type of data	Access/retrieval via	Terms of use	Quality of service*
Fieldbus metadata: I&M data, log data, statistics data	CPU TIA Portal SIMATIC Automation Tool PRONETA S7-PCT (for IO-Link masters) MFCT	Via fieldbus without authentication Via CPU (Page 402)	Standard fieldbus transmission mechanisms

* "Quality of service" refers to the ability of the interface and I/O modules to manage network resources efficiently and to ensure that specific performance requirements for data transmission are met.

Deletion of data from interface and I/O modules

Interface modules

To delete all data from the data memories of the interface module, the "Reset to factory settings" function is available.

A reset of the IM to factory settings can be implemented using any of the following:

- TIA Portal
- SIMATIC Automation Tool
- MultiFieldbus Configuration Tool (MFCT)
- PRONETA
- STEP 7

I/O modules

The data of an IO-Link master can be deleted using S7-PCT by executing the "Reset to factory settings" function.

The data of a CM 1xDALI can be deleted via the CPU. For all other I/O modules, no delete function is available.

More information

You can find more information on deleting data in the System Manual ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293), in the sections “Securely removing data” and “Reset to factory settings”.

SIEMENS

SIMATIC
ET 200SP
Product information on the documentation of the ET 200SP distributed I/O system
Product Information

Module overview of ET 200SP

Module firmware corrected for R1 redundancy

A firmware update is required for some electronic modules to obtain the full compatibility for the ET 200SP R1 system. If an older firmware version of the module is used than the one specified below, a process data surge can occur during a redundancy switchover of the interface modules.

NOTE

All electronic modules not listed here do not require a firmware update to obtain full compatibility for the ET 200SP R1 system.

The following table shows which modules support a bumpless R1 switchover as of which firmware version:

Module	Article number	As of firmware version
F-CM AS-i Safety ST**	3RK7136-6SC00-0BC1	-
CM AS-i Master ST	3RK7137-6SA00-0BC1	V1.1.11
F-TM ServoDrive 1x24..48V ST	6BK1136-6AB00-0BU0	V1.3.0 or higher
F-TM ServoDrive 1x24..48V HF	6BK1136-6AB00-0CU0	V1.1.0 or higher
F-TM StepDrive 1x24..48V ST	6BK1136-6SB00-0BU0	V1.0.1 or higher
DI 8x24VDC BA*	6ES7131-6BF00-0AA0	-
DI 8x24VDC ST*	6ES7131-6BF00-0BA0	-
DI 8x24VDC SRC BA*	6ES7131-6BF60-0AA0	-
DI 16x24VDC ST*	6ES7131-6BH00-0BA0	-
DI 4x120..230VAC ST*	6ES7131-6FD00-0BB1	-
DI 8xNAMUR HF	6ES7131-6TF00-0CA0	V2.0 or higher
DQ 8x24VDC/0,5A BA*	6ES7132-6BF00-0AA0	-
DQ 8x24VDC/0,5A ST*	6ES7132-6BF00-0BA0	-
DQ 8x24VDC/0,5A SNK BA*	6ES7132-6BF60-0AA0	-
DQ 16x24VDC/0,5A ST*	6ES7132-6BH00-0BA0	-
RQ 4x24VUC/2A CO ST*	6ES7132-6GD50-0BA0	-
RQ 4x24VUC...230VUC/5A*	6ES7132-6HD00-0BB1	-
AI 4xI 2-/4-wire ST*	6ES7134-6GD00-0BA1	-
AI 2xU/I 2-/4-wire HF	6ES7134-6HB00-0CA1	V2.0.5

* No firmware update is offered for these modules since there are compatible successor products

** No firmware update with the error correction is currently offered for these modules

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Module	Article number	As of firmware version
AI 2xU/I 2-/4-wire HS	6ES7134-6HB00-0DA1	V2.0.3
AI 4xU/I 2-wire ST*	6ES7134-6HD00-0BA1	-
AI 4xRTD/TC 2-/3-/4-wire HF	6ES7134-6JD00-0CA1	V2.1.1
AI 4xTC HS	6ES7134-6JD00-0DA1	V1.0.3
AI 8xRTD/TC 2-wire HF	6ES7134-6JF00-0CA1	V2.1.1
AI Energy Meter*	6ES7134-6PA00-0BD0	-
AI Energy Meter 400VAC ST*	6ES7134-6PA01-0BD0	-
AI Energy Meter 480VAC ST*	6ES7134-6PA20-0BD0	-
AI Energy Meter 480VAC HF*	6ES7134-6PAx0-0CU0	-
AI4 x I HART	6ES7134-6TD00-0CA1	V1.1.1
AQ 2xU/I HF	6ES7135-6HB00-0CA1	V1.0.3
AQ 2xU/I HS	6ES7135-6HB00-0DA1	V2.0.4
AQ 4xU/I ST	6ES7135-6HD00-0BA1	V1.1.3
AQ 4xI HART	6ES7135-6TD00-0CA1	V1.0.1
F-AI 4xI	6ES7136-6AA00-0CA1	V1.0.2
F-AI 4xU	6ES7136-6AB00-0CA1	V1.0.1
F-DI 8X24VDC HF	6ES7136-6BA00-0CA0	V1.0.7
F-DI 8X24VDC HF	6ES7136-6BA01-0CA0	V1.0.0
F-TM Count sin/cos 1x1Vpp HF	6ES7136-6CB00-0CA0	V1.0.0
F-DQ 4XDC 24V/2A	6ES7136-6DB00-0CA0	V2.0.2
F-DQ 8X 24VDC/0.5A PP	6ES7136-6DC00-0CA0	V1.0.1
F-PM-E PPM, 24V DC	6ES7136-6PA00-0BC0	-
CM PtP*	6ES7137-6AA00-0BA0	-
CM PtP	6ES7137-6AA01-0BA0	V2.0.0
CM 4xIO-Link	6ES7137-6BD00-0BA0	V2.2.2
CM DALI	6ES7137-6CA00-0BU0	V1.0.1
CM 1xCAN	6ES7137-6EA00-0BA0	V1.2
TM Count 1x24V*	6ES7138-6AA00-0BA0	-
TM Count 1x24V	6ES7138-6AA01-0BA0	V2.0.2
TM PosInput 1*	6ES7138-6BA00-0BA0	-
TM PosInput 1	6ES7138-6BA01-0BA0	V2.0.1
TM Timer DIDQ 10x24V	6ES7138-6CG00-0BA0	V1.0.3
TM Pulse 2x24V	6ES7138-6DB00-0BB1	V1.0.2
TM ECC 2xPWM 12V ST*	6FE1242-6TM10-0BB1	-
AI 2x SG 4-/6-wire HS (DMS)	7MH4134-6LB00-0DA0	V1.0.2
SIWAREX WP321	7MH4138-6AA00-0BA0	V1.4.4

* No firmware update is offered for these modules since there are compatible successor products

** No firmware update with the error correction is currently offered for these modules

Module	Article number	As of firmware version
SIWAREX WP351	7MH4138-6BA00-0CU0	V1.1.0
Buerkert Ventile	AirLINE SP Typ 8647	V1.1.1
TM StepDrive 24-48V/5A**	PHYTRON 10020273	-

* No firmware update is offered for these modules since there are compatible successor products

** No firmware update with the error correction is currently offered for these modules

You can find the latest firmware versions for the modules on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109804718).

You can find a description of how to update the firmware of the modules in the "Firmware update" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Possible combinations of BaseUnits and I/O modules

Contents

This product information includes amendments and corrections to the documentation of the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Which I/O modules / motor starters fit on a BaseUnit?

The following table provides an overview of the I/O modules / motor starters that fit on the corresponding compatible BaseUnits:

Table 1 Possible combinations of BaseUnits and I/O modules

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
Digital I/O modules											
DI 16x24VDC ST	✓									CC00	
DI 8x24VDC ST	✓									CC01	
DI 8x24VDC HF	✓									CC01	

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
DI 8x24VDC HS	✓									CC01	
DI 8x24VDC BA	✓									CC01	
DI 8x24VDC SRC BA	✓									CC02	
DI 8xNAMUR HF	✓									CC01	
DI 4x120..230VAC ST				✓						CC41	
DQ 16x24VDC/0.5A ST	✓									CC00	
DQ 16x24VDC/0.5A HF	✓									CC00	
DQ 8x24VDC/0.5 ST	✓									CC02	
DQ 8x24VDC/0.5A HF	✓									CC02	
DQ 8x24VDC/0.5A BA	✓									CC02	

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
DQ 8x24VDC/0.5A SNK BA	✓									CC01	
DQ 4x24..230VAC/2A ST				✓						CC41	
DQ 4x24..230VAC/2A HF				✓						---	---
DQ 4x24VDC/2A ST	✓									CC02	
DQ 4x24VDC/2A HF	✓									CC02	
DQ 4x24VDC/2A HS	✓									CC00	
DI 8x/DQ 8x24VDC/-0.5A ST	✓									CC00	
RQ 4x24VUC/2A CO ST	✓									CC00	
RQ 4x120VDC-230VAC/5A NO ST			✓	✓						---	---
RQ 4x120VDC-230VAC/5A NO MA ST			✓	✓						---	---
RQ 3x120VDC-230VAC/5A CO ST									✓	---	---
RQ 3x120VDC-230VAC/5A CO n.i. ST									✓	---	---

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
Analog I/O modules											
AI 4xRTD/TC 2-/3-/4-wire HF	✓	✓								CC00	
AI 8xRTD/TC 2-wire HF	✓	✓								CC00	
AI 8xU BA	✓	✓								CC02	
AI 2xU ST	✓	✓								CC00	
AI 2xI 2-/4-wire ST	✓	✓								CC05	
AI 4xU/I 2-wire ST	✓	✓								CC03	
AI 4xTC HS	✓	✓								CC00	
AI 2xU/I 2-/4-wire HF	✓	✓								CC05	
AI 2xU/I 2-/4-wire HS	✓	✓								CC00	

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
AI 2xSG 4-/6-wire HS	✓									CC00	
AI 8xI 2-/4-wire BA	✓	✓								CC01	
AI 4xI 2-/4-wire ST	✓	✓								CC03	
AI 4xI 2-wire 4...20mA HART	✓	✓								CC03	
AQ 2xU ST	✓	✓								CC00	
AQ 2xI ST	✓	✓								CC00	
AQ 4xU/I ST	✓	✓								CC00	
AQ 4xI HART HF	✓	✓								CC00	
AQ 2xU/I HS	✓	✓								CC00	
AQ 2xU/I HF	✓	✓								CC00	

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
AI Energy Meter 400VAC ST							✓			CC20	Only systematic, but cannot be ordered
AI Energy Meter 480VAC ST							✓			CC20	
AI Energy Meter 480VAC/CT HF									✓	CC20	
AI Energy Meter 480VAC/RC HF									✓	CC20	
AI Energy Meter CT ST									✓	CC20	
AI Energy Meter RC ST									✓	CC20	
AI Energy Meter CT HF									✓	CC20	
AI Energy Meter RC HF									✓	CC20	
Fail-safe modules											
F-PM-E 24VDC/8A PPM ST					✓					CC52	
F-DI 8x24VDC HF	✓									CC01	
F-DQ 4x24VDC/2A PM HF	✓									CC02	
F-DQ 8x24VDC/0.-5A PP HF	✓									CC02	
F-RQ 1x24VDC/2-4..230VAC/5A								✓		CC42	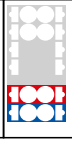

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
F-AI 4xI 0(4)..20mA 2-/4-wire HF	✓	✓								CC00	
F-AI 4xU 0..10V HF	✓	✓								CC00	
F-TM Count 1x1Vpp sin/cos HF	✓									CC01	
F-TM ServoDrive ST 1x24 ... 48 V									✓	---	---
F-TM StepDrive ST 1x24..48V 5A									✓	---	---
Communication modules											
CM 4xIO-Link	✓									CC04	
CM AS-i Master ST					✓					---	---
F-CM AS-i Safety ST					✓	✓				---	---
CM PtP	✓									---	---
CM 1xDALI									✓	---	---
CM 1xCAN ST	✓									---	---
Technology modules											
TM Count 1x24V	✓									---	---
TM PosInput 1	✓									---	---
TM Timer DIDQ 10x24V	✓									---	---
TM Pulse 2x24V				✓						---	---
SIWAREX WP321	✓									---	---

I/O module	BaseUnit BU15-		BaseUnit BU20-							Color-coded label for process terminals	
	BU type A0 P16+A1-0+2D P16+A0-+2D P16+A1-0+2B P16+A0-+2B	BU type A1 P16+A0-+12D/T P16+A0-+2D/T P16+A0-+12B/T P16+A0-+2B/T	BU type B0 P12+A4-+0B	BU type B1 P12+A0-+4B	BU type C0 P6+A2-+4D	BU type C1 P6+A2-+4B	BU type D0 P12+A-0+0B	BU type F0 P8+A4+-0B	BU type U0 P16+A0-+2D P16+A0-+2B		
SIWAREX WP351 HF									✓	CC00	
F-TM ServoDrive ST 1x24 ... 48 V									✓	---	---
F-TM StepDrive ST 1x24..48V 5A									✓	---	---
TM FCT070				✓						---	---
F-TM Count 1x1Vpp sin/cos HF	✓									CC01	

Table 2 Possible combinations of Ex BaseUnits and I/O modules

Ex I/O modules	BaseUnit	
	for Ex I/O modules	for Ex power module
Ex-DI 4xNAMUR	✓	
Ex-DQ 2x17.4VDC/27mA	✓	
Ex-DQ 2x23.1VDC/20mA	✓	
Ex-AQ 2xI HART	✓	
Ex-AI 2xI 2-wire HART	✓	
Ex-AI 4xTC/2xRTD 2-/3-/4-wire	✓	
Ex-PM E		✓

Table 3 Possible combinations of BaseUnits and motor starters

	Selecting the BaseUnit									
	BU-30--MS1	BU-30--MS2	BU-30--MS3	BU-30--MS4	BU-30--MS5	BU-30--MS6	BU-30--MS7	BU-30--MS8	BU-30--MS9	BU-30--MS10
24 V infeed	x		x							
500 V infeed	x	x			x		x	x		
F-DI terminals (no routing of the F-DI signal possible)					x	x				

* The F-DI terminals or F-DI infeed/routing have no function with this combination.

F-DI infeed								**x**			**x**
F-DI routing									**x**	**x**	
Motor starters											
DS 0.1 - 0.4 A HF	3RK1308-0A-A00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 0.3 - 1 A HF	3RK1308-0AB-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 0.9 - 3 A HF	3RK1308-0A-C00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 2.8 - 9 A HF	3RK1308-0A-D00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
DS 4.0 - 12 A HF	3RK1308-0AE-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 0.1 - 0.4 A HF	3RK1308-0BA-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 0.3 - 1 A HF	3RK1308-0BB-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 0.9 - 3 A HF	3RK1308-0BC-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 2.8 - 9 A HF	3RK1308-0BD-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
RS 4.0 - 12 A HF	3RK1308-0BE-00-0CP0	x	x	x	x	x*	x*	x*	x*	x*	x*
F-DS 0.1 - 0-.4 A HF	3RK1308-0C-A00-0CP0	x	x	x	x	x	x	x	x	x	x
F-DS 0.3 - 1 A HF	3RK1308-0CB-00-0CP0	x	x	x	x	x	x	x	x	x	x
F-DS 0.9 - 3 A HF	3RK1308-0CC-00-0CP0	x	x	x	x	x	x	x	x	x	x
F-DS 2.8 - 9 A HF	3RK1308-0C-D00-0CP0	x	x	x	x	x	x	x	x	x	x
F-DS 4.0 - 12 A HF	3RK1308-0CE-00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 0.1 - 0.4 A HF	3RK1308-0D-A00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 0.3 - 1 A HF	3RK1308-0DB-00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 0.9 - 3 A HF	3RK1308-0D-C00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 2.8 - 9 A HF	3RK1308-0D-D00-0CP0	x	x	x	x	x	x	x	x	x	x
F-RS 4.0 - 12 A HF	3RK1308-0DE-00-0CP0	x	x	x	x	x	x	x	x	x	x

* The F-DI terminals or F-DI infeed/routing have no function with this combination.

Table 4 Combination possibilities between potential distributor BaseUnit and potential distributor terminal block

Potential distributor terminal block	Potential distributor BaseUnit			
	PotDis-BU-P1/D-R	PotDis-BU-P1/B-R	PotDis-BU-P2/D-B	PotDis-BU-P2/B-B
PotDis-TB-P1-R	✓	✓	✓	✓
PotDis-TB-P2-B	✓	✓	✓	✓
PotDis-TB-n.c.-G	✓	✓	✓	✓
PotDis-TB-BR-W	✓	✓	✓	✓

CPUs

CPUs

CPU	Packing unit	Article number
CPU 1510SP-1 PN with server module	Pack of 1	6ES7510-1Dx0x-0AB0
CPU 1510SP F-1 PN with server module	Pack of 1	6ES7510-1Sx0x-0AB0
CPU 1512SP-1 PN with server module	Pack of 1	6ES7512-1Dx0x-0AB0
CPU 1512SP F-1 PN with server module	Pack of 1	6ES7512-1Sx0x-0AB0
CPU 1514SP-2 PN with server module	Pack of 1	6ES7514-2DN03-0AB0
CPU 1514SP F-2 PN with server module	Pack of 1	6ES7514-2SN03-0AB0
CPU 1514SP T-2 PN with server module	Pack of 1	6ES7514-2VN03-0AB0
CPU 1514SP TF-2 PN with server module	Pack of 1	6ES7514-2WN03-0AB0
CPU 1515SP PC with server module	Pack of 1	6ES7677-2AAxx-0xx0

Important differences between the CPUs...PN up to firmware version 2.9				
Features	**CPU 1510SP-1 PN**	**CPU 1510SP F-1 PN**	**CPU 1512SP-1 PN**	**CPU 1512SP F-1 PN**
Bus connection	PROFINET: BusAdapter (X1 Port 1, 2) • BA 2xRJ45 (as of firmware version 1.6) • BA 2xFC (as of firmware version V1.6) • BA 2xM12 (as of firmware V2.8)[1] RJ45, integrated (X1 Port 3)		PROFINET: BusAdapter (X1 Port 1, 2) • BA 2xRJ45 (as of firmware version 1.6) • BA 2xFC (as of firmware version V1.6) • BA 2xSCRJ (as of firmware V1.8)[2] • BA SCRJ/RJ45 (as of firmware V1.8)[2] • BA SCRJ/FC (as of firmware V1.8)[2] • BA 2xLC (as of firmware V2.0)[2] • BA LC/RJ45 (as of firmware V2.0)[2] • BA LC/FC (as of firmware V2.0)[2] • BA 2xM12 (as of firmware V2.8)[2] RJ45, integrated (X1 Port 3)	
	PROFIBUS: PROFIBUS DP connection socket via CM DP communications module			
Number of modules	64			
Data work memory	750 KB		1 MB	

[1] Only with article numbers 6ES7510-1DJ01-0AB0 and 6ES7510-1SJ01-0AB0

[2] Only with article numbers 6ES7512-1DK01-0AB0 and 6ES7512-1SK01-0AB0

[3] Only 6ES7510-1DJ01-0AB0, 6ES7512-1SJ01-0AB0, 6ES7512-1DK01-0AB0 and 6ES7512-1SK01-0AB0 with FW version V2.0

Important differences between the CPUs...PN up to firmware version 2.9				
Features	**CPU 1510SP-1 PN**	**CPU 1510SP F-1 PN**	**CPU 1512SP-1 PN**	**CPU 1512SP F-1 PN**
Code work memory	100 KB	150 KB	200 KB	300 KB
Address space	1280 bytes/2560 bytes[3]			
Multi hot-swapping	Yes			
Can be used for safety applications (supports PROFIsafe V2.0)	No	Yes	No	Yes

[1] Only with article numbers 6ES7510-1DJ01-0AB0 and 6ES7510-1SJ01-0AB0

[2] Only with article numbers 6ES7512-1DK01-0AB0 and 6ES7512-1SK01-0AB0

[3] Only 6ES7510-1DJ01-0AB0, 6ES7512-1SJ01-0AB0, 6ES7512-1DK01-0AB0 and 6ES7512-1SK01-0AB0 with FW version V2.0

Important differences between the CPUs...PN as of firmware version 3.0								
Features	**CPU 1510SP-1 PN**	**CPU 1510SP F-1 PN**	**CPU 1512SP-1 PN**	**CPU 1512SP F-1 PN**	**CPU 1514SP-2 PN**	**CPU 1514SP F-2 PN**	**CPU 1514SP T-2 PN**	**CPU 1514SP TF-2 PN**
Bus connection	PROFINET: BusAdapter (X1 Port 1, 2) • BA 2xRJ45 • BA 2xFC • BA 2xM12 RJ45, integrated (X1 Port 3 or X2 Port 1)							
	PROFIBUS: PROFIBUS DP connection socket via CM DP communications module							
Number of modules	64							
Data work memory	1 MB		2 MB		3.5 MB			
Code work memory	200 KB	300 KB	400 KB	600 KB	600 KB	900 KB		
Address space	2560 bytes							
Multi hot-swapping	Yes							
Can be used for safety applications (supports PROFIsafe V2.0)	No	Yes	No	Yes	No	Yes	No	Yes

Important differences between CPUs... PN from firmware version 3.1								
Features	**CPU 1510SP-1 PN**	**CPU 1510SP F-1 PN**	**CPU 1512SP-1 PN**	**CPU 1512SP F-1 PN**	**CPU 1514SP-2 PN**	**CPU 1514SP F-2 PN**	**CPU 1514SP T-2 PN**	**CPU 1514SP TF-2 PN**
Bus connection	PROFINET: BusAdapter (X1 Port 1, 2) • BA 2xRJ45 • BA 2xFC • BA 2xM12 • BA SCRJ/RJ45 • BA LC/RJ45 • BA 2xSCRJ • BA SCRJ/FC • BA 2xLC • BA LC/FC RJ45, integrated (X1 Port 3 or X2 Port 1)							
	PROFIBUS: PROFIBUS DP connection socket via CM DP communications module							
Number of modules	64							
Data work memory	1 MB		2 MB		3.5 MB			
Code work memory	200 KB	300 KB	400 KB	600 KB	600 KB	900 KB		
Address space	2560 bytes							
Multi hot-swapping	Yes							
Can be used for safety applications (supports PROFIsafe V2.0)	No	Yes	No	Yes	No	Yes	No	Yes

NOTE

The CM AS-i master ST and F-CM AS-i Safety ST communications modules are supported as of firmware V1.8 of the CPUs. Note the following additional requirements:

CM AS-i master ST:

- Firmware version of the CM AS-i master ST: V1.1
- STEP 7 (TIA Portal): V13 SP1 Update 4 or higher

F-CM AS-i Safety ST

- Firmware version of the CM AS-i Safety ST: V1.0
- STEP 7 (TIA Portal): as of V13 SP1 Update 4 and HSP0070 V3.0

Interface modules

Interface modules

Interface modules	Packing unit	Article number
Interface module IM 155-6 PN BA	Pack of 1	6ES7155-6AR00-0AN0
Interface module IM 155-6 PN ST		
• with BusAdapter BA 2xRJ45 and server module	Pack of 1	6ES7155-6AA02-0BN0
• with server module	Pack of 1	6ES7155-6AU02-0BN0
Interface module IM 155-6 PN/2 HF with server module	Pack of 1	6ES7155-6AU01-0CN0
Interface module IM 155-6 PN/3 HF with server module	Pack of 1	6ES7155-6AU30-0CN0
Interface module IM 155-6 PN R1 with server module	Pack of 1	6ES7155-6AU00-0HM0
Interface module IM 155-6 MF HF with server module	Pack of 1	6ES7155-6MU00-0CN0
Interface module IM 155-6 PN HS with server module	Pack of 1	6ES7155-6AU00-0DN0
Interface module IM 155-6 DP HF with PROFIBUS FastConnect bus connector (6ES7972-0BB70-0XA0) and server module	Pack of 1	6ES7155-6BA01-0CN0

Important differences between the interface modules						
Features	**IM 155-6 PN BA**	**IM 155-6 PN ST**	**IM 155-6 PN/2 HF IM 155-6 PN/3 HF**	**IM 155-6 MF HF**	**IM 155-6 PN HS**	**IM 155-6 DP HF**
Bus connection	PROFINET: 2xRJ45, integrated	PROFINET: BusAdapter • BA 2xRJ45 (as of firmware V1.0) • BA 2xFC (as of firmware V1.0) • BA 2xM12 (as of firmware V4.2)	PROFINET: BusAdapter • BA 2xRJ45 (as of firmware V2.0) • BA 2xFC (as of firmware V2.0) • BA 2xSCRJ (as of firmware V2.2) • BA SCRJ/RJ45 (as of firmware V3.1) • BA SCRJ/FC (as of firmware V3.1) • BA 2xLC (as of firmware V3.3) • BA LC/RJ45 (as of firmware V3.3) • BA LC/FC (as of firmware V3.3) • BA 2xM12 (as of firmware V4.2)	PROFINET, EtherNet/IP, Modbus TCP: BusAdapter • BA 2xRJ45 • BA 2xM12 (as of firmware V5.0) • BA 2xFC • BA 2xLC • BA 2xSCRJ • BA SCRJ/RJ45 • BA SCRJ/FC • BA LC/RJ45 • BA LC/FC	PROFINET: BusAdapter • BA 2xRJ45 (as of firmware V4.0) • BA 2xFC (as of firmware V4.0) • BA 2xSCRJ (as of firmware V4.0) • BA SCRJ/RJ45 (as of firmware V4.0) • BA SCRJ/FC (as of firmware V4.0) • BA 2xLC (as of firmware V4.0) • BA LC/RJ45 (as of firmware V4.0) • BA LC/FC (as of firmware V4.0)	PROFIBUS: PROFIBUS DP connection socket
Number of modules	12	32	64	64	30	32
RESET button	No	Yes	Yes	Yes	Yes	Not necessary
Address space (I/O data)	32 bytes	1440 bytes	1440 bytes	1440 bytes	968 bytes	244 bytes
Multi hot-swapping	No	Yes	Yes	Yes	Yes	Yes

Table 5 Station expansion via ET-Connection (mixed configuration ET 200SP/ET 200AL)

Modules	Packing unit	Article number
BU-Send	Pack of 1	6ES7193-6BN00-0NE0
BA-Send 1xFC	Pack of 1	6ES7193-6AS00-0AA0

BusAdapter

BusAdapter

BusAdapter	Packing unit	Article number
• BA 2×RJ45 (PROFINET BusAdapter with standard Ethernet socket)	Pack of 1	6ES7193-6AR00-0AA0
• BA 2×M12 (PROFINET BusAdapter with M12 Ethernet socket)	Pack of 1	6ES7193-6AM00-0AA0
• BA 2×FC (PROFINET BusAdapter with FastConnect Ethernet connection)	Pack of 1	6ES7193-6AF00-0AA0
• BA 2xSCRJ (PROFINET BusAdapter with POF/PCF fiber-optic cable connection)	Pack of 1	6ES7193-6AP00-0AA0
• BA SCRJ/RJ45 (media converter, PROFINET BusAdapter with fiber-optic cable FOC ⇔ standard RJ45 connector)	Pack of 1	6ES7193-6AP20-0AA0
• BA SCRJ/FC (media converter, PROFINET BusAdapter with fiber-optic cable FOC ⇔ direct connection of bus cable)	Pack of 1	6ES7193-6AP40-0AA0
• BA 2xLC (PROFINET BusAdapter with glass fiber-optic cable connection multi-mode)	Pack of 1	6ES7193-6AG00-0AA0
• BA LC/RJ45 (media converter, PROFINET BusAdapter with glass fiber-optic cable ⇔ standard RJ45 connector)	Pack of 1	6ES7193-6AG20-0AA0
• BA LC/FC (media converter, PROFINET BusAdapter with glass fiber-optic cable ⇔ direct connection of bus cable)	Pack of 1	6ES7193-6AG40-0AA0
• BA 2xLC-LD (PROFINET BusAdapter with single-mode glass fiber-optic cable connection, long distance)	Pack of 1	6ES7193-6AG50-0AA0
• BA LC-LD/RJ45 (media converter, PROFINET BusAdapter with single-mode glass fiber-optic connection, long distance ⇔ standard RJ45 connector)	Pack of 1	6ES7193-6AG60-0AA0
• BA LC-LD/M12 (media converter, PROFINET BusAdapter with single-mode glass fiber-optic connection, long distance ⇔ M12 Ethernet socket)	Pack of 1	6ES7193-6AG70-0AA0

BaseUnits

BaseUnits

Table 6 BaseUnits for I/O modules

BU type	BaseUnits (short name)	Color-coded labels*	Packing unit	Article number
A0	BU15-P16+A10+2D	**P16:** CC00 to CC05 **A10:** CC71 to CC73	Pack of 1	6ES7193-6BP20-0DA0
			Pack of 10	6ES7193-6BP20-2DA0
A0	BU15-P16+A0+2D	**P16:** CC00 to CC05	Pack of 1	6ES7193-6BP00-0DA0
			Pack of 10	6ES7193-6BP00-2DA0

* not included in the scope of delivery of the BaseUnit

BU type	BaseUnits (short name)	Color-coded labels*	Packing unit	Article number
A0	BU15-P16+A10+2B	**P16:** CC00 to CC05 **A10:** CC71 to CC73	Pack of 1	6ES7193-6BP20-0BA0
			Pack of 10	6ES7193-6BP20-2BA0
A0	BU15-P16+A0+2B	**P16:** CC00 to CC05	Pack of 1	6ES7193-6BP00-0BA0
			Pack of 10	6ES7193-6BP00-2BA0
A1	BU15-P16+A0+12D/T	**P16:** CC00 to CC05 **12D:** CC74	Pack of 1	6ES7193-6BP40-0DA1
A1	BU15-P16+A0+2D/T	**P16:** CC00 to CC05	Pack of 1	6ES7193-6BP00-0DA1
A1	BU15-P16+A0+12B/T	**P16:** CC00 to CC05 **12B:** CC74	Pack of 1	6ES7193-6BP40-0BA1
A1	BU15-P16+A0+2B/T	**P16:** CC00 to CC05	Pack of 1	6ES7193-6BP00-0BA1
B0	BU20-P12+A4+0B	**A4:** CC81 to CC83	Pack of 1	6ES7193-6BP20-0BB0
			Pack of 10	6ES7193-6BP20-2BB0
B1	BU20-P12+A0+4B	**P12:** CC41	Pack of 1	6ES7193-6BP20-0BB1
			Pack of 10	6ES7193-6BP20-2BB1
C0	BU20-P6+A2+4D	**P6:** CC51, CC52 **A2:** CC84 to CC86	Pack of 1	6ES7193-6BP20-0DC0
C1	BU20-P6+A2+4B	**P6:** CC51 **A2:** CC84 to CC86	Pack of 1	6ES7193-6BP20-0BC1
D0	BU20-P12+A0+0B	---	Pack of 1	6ES7193-6BP00-0BD0
F0	BU20-P8+A4+0B	**P8:** CC42	Pack of 1	6ES7193-6BP20-0BF0
U0	BU20-P16+A0+2D	**P16**: CC00 to CC05	Pack of 1	6ES7193-6BP00-0BU0
			Pack of 10	6ES7193-6BP00-2BU0
U0	BU20-P16+A0+2B	**P16**: CC00 to CC05	Pack of 1	6ES7193-6BP00-0DU0
			Pack of 10	6ES7193-6BP00-2DU0

* not included in the scope of delivery of the BaseUnit

Table 7 BaseUnit Ex I/O modules

BU type	Ex BaseUnits	Color-coded labels	Packing unit	Article number
W0	for Ex power module	-	Pack of 1	6DL1193-6BP00-0DW0
X1	for Ex I/O modules	-	Pack of 1	6DL1193-6BP00-0BX1

Table 8 BaseUnit PotDis

PotDis type	Potential distributor (short name)	Color-coded labels	Packing unit	Article number
P1	PotDis-BU-P1/D-R	CC62	Pack of 1	6ES7193-6UP00-0DP1
P1	PotDis-BU-P1/B-R	CC62	Pack of 1	6ES7193-6UP00-0BP1
P2	PotDis-BU-P2/D-B	CC63	Pack of 1	6ES7193-6UP00-0DP2
P2	PotDis-BU-P2/B-B	CC63	Pack of 1	6ES7193-6UP00-0BP2

Table 9 BaseUnit PotDis-TB

Terminal block type	Terminal block (short name)	Color-coded labels	Packing unit	Article number
P1	PotDis-TB-P1-R	CC12	Pack of 1	6ES7193-6TP00-0TP1
P2	PotDis-TB-P2-B	CC13	Pack of 1	6ES7193-6TP00-0TP2
N0	PotDis-TB-n.c.-G	CC10	Pack of 1	6ES7193-6TP00-0TN0
P0	PotDis-TB-BR-W	CC10 to CC13	Pack of 1	6ES7193-6TP00-0TP0

Table 10 BaseUnits for motor starters

BU type	BaseUnits (short name)	Color-coded labels	Packing unit	Article number
MS1	BU30-MS1	-	Pack of 1	3RK1908-0AP00-0AP0
MS2	BU30-MS2	-	Pack of 1	3RK1908-0AP00-0CP0
MS3	BU30-MS3	-	Pack of 1	3RK1908-0AP00-0BP0
MS4	BU30-MS4	-	Pack of 1	3RK1908-0AP00-0DP0
MS5	BU30-MS5	-	Pack of 1	3RK1908-0AP00-0EP0
MS6	BU30-MS6	-	Pack of 1	3RK1908-0AP00-0FP0
MS7	BU30-MS7	-	Pack of 1	3RK1908-0AP00-0GP0
MS8	BU30-MS8	-	Pack of 1	3RK1908-0AP00-0HP0
MS9	BU30-MS9	-	Pack of 1	3RK1908-0AP00-0JP0
MS10	BU30-MS10	-	Pack of 1	3RK1908-0AP00-0KP0

Table 11 BaseUnit interface module

BU type	Interface module	Color-coded labels	Packing unit	Article number
M0	IM 155-6 PN R1	-	Pack of 1	6ES7193-6BR00-0HM0

I/O modules

I/O modules

Digital I/O modules	Coding element type	Packing unit	Article number
DI 16x24VDC ST	A	Pack of 1	6ES7131-6BH01-0BA0
		Pack of 10	6ES7131-6BH01-2BA0
DI 8x24VDC ST	A	Pack of 1	6ES7131-6BF01-0BA0
		Pack of 10	6ES7131-6BF01-2BA0
DI 8x24VDC HF	A	Pack of 1	6ES7131-6BF00-0CA0
		Pack of 10	6ES7131-6BF00-2CA0
DI 8x24VDC HS	A	Pack of 1	6ES7131-6BF00-0DA0
DI 8xNAMUR HF	A	Pack of 1	6ES7131-6TF00-0CA0
DI 8x24VDC BA	A	Pack of 1	6ES7131-6BF01-0AA0
		Pack of 10	6ES7131-6BF01-2AA0
DI 8x24VDC SRC BA	B	Pack of 1	6ES7131-6BF61-0AA0

Digital I/O modules	Coding element type	Packing unit	Article number
DI 8x24VAC/48VUC BA	C	Pack of 1	6ES7131-6CF00-0AU0
DI 4x120..230VAC ST	C	Pack of 1	6ES7131-6FD01-0BB1
DQ 16x24VDC/0.5A ST	A	Pack of 1	6ES7132-6BH01-0BA0
		Pack of 10	6ES7132-6BH01-2BA0
DQ 16x24VDC/0.5A HF	A	Pack of 1	6ES7132-6BH00-0CA0
DQ 16x24VDC/0.5A BA	A	Pack of 1	6ES7132-6BH00-0AA0
		Pack of 10	6ES7132-6BH00-2AA0
DQ 8x24VDC/0.5A ST	A	Pack of 1	6ES7132-6BF01-0BA0
		Pack of 10	6ES7132-6BF01-2BA0
DQ 8x24VDC/0.5A HF	A	Pack of 1	6ES7132-6BF01-0CA0
		Pack of 10	6ES7132-6BF01-2CA0
DQ 8x24VDC/0.5A BA	A	Pack of 1	6ES7132-6BF01-0AA0
		Pack of 10	6ES7132-6BF01-2AA0
DQ 8x24VDC/0.5A SNK BA	B	Pack of 1	6ES7132-6BF61-0AA0
DQ 4x24VDC/2A ST	A	Pack of 1	6ES7132-6BD21-0BA0
		Pack of 10	6ES7132-6BD21-2BA0
DQ 4x24..230VAC/2A ST	C	Pack of 1	6ES7132-6FD00-0BB1
		Pack of 10	6ES7132-6FD00-2BB1
DQ 4x24..230VAC/2A HF	C	Pack of 1	6ES7132-6FD00-0CU0
DQ 4x24VDC/2A HF	A	Pack of 1	6ES7132-6BD21-0CA0
DQ 4x24VDC/2A HS	A	Pack of 1	6ES7132-6BD20-0DA0
DI 8x/DQ 8x24VDC/0.5A ST	A	Pack of 1	6ES7133-6BH00-0BA0
RQ 4x24VUC/2A CO ST	C	Pack of 1	6ES7132-6GD51-0BA0
RQ 4x120VDC-230VAC/5A NO ST	C	Pack of 1	6ES7132-6HD01-0BB1
		Pack of 10	6ES7132-6HD01-2BB1
RQ 4x120VDC-230VAC/5A NO MA ST	C	Pack of 1	6ES7132-6MD00-0BB1
RQ 3x120VDC-230VAC/5A CO ST	C	Pack of 1	6ES7132-6HC50-0BU0
RQ 3x120VDC-230VAC/5A CO n.i. ST	C	Pack of 1	6ES7132-6HC70-0BU0

Analog I/O modules	Coding element type	Packing unit	Article number
AI 8xU BA	B	Pack of 1	6ES7134-6FF00-0AA1
AI 2xU ST	A	Pack of 1	6ES7134-6FB00-0BA1
AI 4xU/I 2-wire ST	A	Pack of 1	6ES7134-6HD01-0BA1
		Pack of 10	6ES7134-6HD01-2BA1
AI 2xU/I 2-/4-wire HF	A	Pack of 1	6ES7134-6HB00-0CA1
AI 2xU/I 2-/4-wire HS	A	Pack of 1	6ES7134-6HB00-0DA1
AI 2xSG 4-/6-wire HS	A	Pack of 1	7MH4134-6LB00-0DA0
AI 8xI 2-/4-wire BA	A	Pack of 1	6ES7134-6GF00-0AA1
AI 2xI 2-/4-wire ST	A	Pack of 1	6ES7134-6GB00-0BA1

Analog I/O modules	Coding element type	Packing unit	Article number
AI 4xI 2-/4-wire ST	A	Pack of 1	6ES7134-6GD01-0BA1
		Pack of 10	6ES7134-6GD01-2BA1
AI 8xRTD/TC 2-wire HF	A	Pack of 1	6ES7134-6JF00-0CA1
		Pack of 10	6ES7134-6JF00-2CA1
AI 4xRTD/TC 2-/3-/4-wire HF	A	Pack of 1	6ES7134-6JD00-0CA1
		Pack of 10	6ES7134-6JD00-2CA1
AI 4xTC HS	A	Pack of 1	6ES7134-6JD00-0DA1
AI 4xI 2-wire 4...20mA HART	A	Pack of 1	6ES7134-6TD00-0CA1
AQ 2xU ST	A	Pack of 1	6ES7135-6FB00-0BA1
AQ 2xI ST	A	Pack of 1	6ES7135-6GB00-0BA1
AQ 4xU/I ST	A	Pack of 1	6ES7135-6HD00-0BA1
AQ 4xI HART HF	A	Pack of 1	6ES7135-6TD00-0CA1
AQ 2xU/I HF	A	Pack of 1	6ES7135-6HB00-0CA1
AQ 2xU/I HS	A	Pack of 1	6ES7135-6HB00-0DA1
AI Energy Meter CT HF	C	Pack of 1	6ES7134-6PA01-0CU0
AI Energy Meter RC HF	C	Pack of 1	6ES7134-6PA21-0CU0
AI Energy Meter CT ST	C	Pack of 1	6ES7134-6PA01-0BU0
AI Energy Meter RC ST	C	Pack of 1	6ES7134-6PA21-0BU0

Fail-safe modules	Coding element type	Packing unit	Article number
F-PM-E 24VDC/8A PPM ST	F	Pack of 1	6ES7136-6PA00-0BC0
F-DI 8x24VDC HF	F	Pack of 1	6ES7136-6BA01-0CA0
F-DQ 4x24VDC/2A PM HF	F	Pack of 1	6ES7136-6DB00-0CA0
F-DQ 8x24VDC/0.5A PP HF	F	Pack of 1	6ES7136-6DC00-0CA0
F-RQ 1x24VDC/24..230VAC/5A	C	Pack of 1	6ES7136-6RA00-0BF0
F-AI 4xI 0(4)..20mA 2-/4-wire HF	F	Pack of 1	6ES7136-6AA00-0CA1
F-AI 4xU 0..10V HF	H	Pack of 1	6ES7136-6AB00-0CA1
F-TM ServoDrive ST 1x24V..48V		Pack of 1	6BK1136-6AB00-0BU0
F-TM ServoDrive HF 1x24..48V 5A		Pack of 1	6BK1136-6AB00-0CU0
F-TM StepDrive ST 1x24..48V 5A		Pack of 1	6BK1136-6SB00-0BU0
F-TM Count 1x1Vpp sin/cos HF	H	Pack of 1	6ES7136-6CB00-0CA0
F-CM AS-i Safety ST	H	Pack of 1	3RK7136-6SC00-0BC1

Communications modules	Coding element type	Packing unit	Article number
CM 4xIO-Link	H	Pack of 1	6ES7137-6BD00-0BA0
CM AS-i Master ST	D	Pack of 1	3RK7137-6SA00-0BC1
F-CM AS-i Safety ST	H	Pack of 1	3RK7136-6SC00-0BC1
CM PtP	D	Pack of 1	6ES7137-6AA01-0BA0
		Pack of 10	6ES7137-6AA01-2BA0

Communications modules	Coding element type	Packing unit	Article number
CM DP (for CPU)		Pack of 1	6ES7545-5DA00-0AB0
CM 1xDALI	D	Pack of 1	6ES7137-6CA00-0BU0
CM 1xCAN ST	C	Pack of 1	6ES7137-6EA00-0BA0

Technology module	Coding element type	Packing unit	Article number
TM Count 1x24V	B	Pack of 1	6ES7138-6AA01-0BA0
		Pack of 10	6ES7138-6AA01-2BA0
TM PosInput 1	B	Pack of 1	6ES7138-6BA01-0BA0
		Pack of 10	6ES7138-6BA01-2BA0
TM PTO 2x24V		Pack of 1	6ES7138-6EB00-0BA0
TM Timer DIDQ 10x24V	B	Pack of 1	6ES7138-6CG00-0BA0
TM Pulse 2x24V	C	Pack of 1	6ES7138-6DB00-0BB1
SIWAREX WP321	B	Pack of 1	7MH4138-6AA00-0BA0
SIWAREX WP351 HF	B	Pack of 1	7MH4138-6BA00-0CU0
F-TM ServoDrive ST 1x24V..48V		Pack of 1	6BK1136-6AB00-0BU0
F-TM ServoDrive HF 1x24..48V 5A		Pack of 1	6BK1136-6AB00-0CU0
F-TM StepDrive ST 1x24..48V 5A		Pack of 1	6BK1136-6SB00-0BU0
TM SITRANS FCT070	D	Pack of 1	7ME4138-6AA00-0BB1
TM SITRANS FST070		Pack of 1	7ME3448-6AA00-0BB1
F-TM Count 1x1Vpp sin/cos HF	H	Pack of 1	6ES7136-6CB00-0CA0
TM ECC 2xPWM ST		Pack of 1	6FE1242-6TM20-0BB1
TM ECC PL ST		Pack of 1	6FE1242-6TM20-0BB1

Ex module	Packing unit	Article number
Ex-DI 4xNAMUR	Pack of 1	6DL1131-6TD00-0HX1
Ex-DQ 2x17.4VDC/27mA	Pack of 1	6DL1132-6CB00-0HX1
Ex-DQ 2x23.1VDC/20mA	Pack of 1	6DL1132-6EB00-0HX1
Ex-AQ 2xI HART	Pack of 1	6DL1135-6TB00-0HX1
Ex-AI 2xI 2-wire HART	Pack of 1	6DL1134-6TB00-0HX1
Ex-AI 4xTC/2xRTD 2-/3-/4-wire	Pack of 1	6DL1134-6JD00-0HX1
Ex-PM E	Pack of 1	6DL1133-6PX00-0HW0

Encoder modules for Module-to-Module Communication (MtM)

You can use the following modules as encoder modules for Module-to-Module Communication (MtM) with the module DQ 4x24VDC/2A HS in the "Cam control" operating mode:

Module	Article number	Firmware
DI 8x24VDC HS	6ES7131-6BF00-0DA0	V1.0 or higher
DI 8xNAMUR HF	6ES7131-6TF00-0CA0	V2.0 or higher

Module	Article number	Firmware
AI 2xSG 4-,6-Wire HS	7MH4134-6LB00-0DA0	V1.0 or higher
AI 2xU/I 2-/4-wire HS	6ES7134-6HB00-0DA1	V1.0 or higher
TM PosInput 1	6ES7138-6BA00-0BA0 6ES7138-6BA01-0BA0	V1.0 or higher V2.0 or higher
TM Count 1x24V	6ES7138-6AA00-0BA0 6ES7138-6AA01-0BA0	V1.0 or higher V2.0 or higher

See also

"Digital output module DQ 4x24VDC/2A HS" Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/109475185)
ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)

Motor starters

Motor starters

Direct starter	Packaging unit	Article number
DS 0.1 - 0.4 A HF	Pack of 1	3RK1308-0AA00-0CP0
DS 0.3 - 1 A HF	Pack of 1	3RK1308-0AB00-0CP0
DS 0.9 - 3 A HF	Pack of 1	3RK1308-0AC00-0CP0
DS 2.8 - 9 A HF	Pack of 1	3RK1308-0AD00-0CP0
DS 4.0 - 12 A HF	Pack of 1	3RK1308-0AE00-0CP0

Reversing starter	Packaging unit	Article number
RS 0.1 - 0.4 A HF	Pack of 1	3RK1308-0BA00-0CP0
RS 0.3 - 1 A HF	Pack of 1	3RK1308-0BB00-0CP0
RS 0.9 - 3 A HF	Pack of 1	3RK1308-0BC00-0CP0
RS 2.8 - 9 A HF	Pack of 1	3RK1308-0BD00-0CP0
RS 4.0 - 12 A HF	Pack of 1	3RK1308-0BE00-0CP0

Failsafe direct starter	Packaging unit	Article number
F-DS 0.1 - 0.4 A HF	Pack of 1	3RK1308-0CA00-0CP0
F-DS 0.3 - 1 A HF	Pack of 1	3RK1308-0CB00-0CP0
F-DS 0.9 - 3 A HF	Pack of 1	3RK1308-0CC00-0CP0
F-DS 2.8 - 9 A HF	Pack of 1	3RK1308-0CD00-0CP0
F-DS 4.0 - 12 A HF	Pack of 1	3RK1308-0CE00-0CP0

Fail-safe reversing starter	Packaging unit	Article number
F-RS 0.1 - 0.4 A HF	Pack of 1	3RK1308-0DA00-0CP0
F-RS 0.3 - 1 A HF	Pack of 1	3RK1308-0DB00-0CP0

Fail-safe reversing starter	Packaging unit	Article number
F-RS 0.9 - 3 A HF	Pack of 1	3RK1308-0DC00-0CP0
F-RS 2.8 - 9 A HF	Pack of 1	3RK1308-0DD00-0CP0
F-RS 4.0 - 12 A HF	Pack of 1	3RK1308-0DE00-0CP0

Accessories

Accessories

General accessories	Packing unit	Article number
Strain relief units incl. screws	Pack of 5	6ES7193-6RA00-1AN0
Cover for the BusAdapter interface	Pack of 5	6ES7591-3AA00-0AA0
PROFIBUS FastConnect bus connector	Pack of 1	6ES7972-0BB70-0XA0
Female connector, 2x2 pin	Pack of 1	6ES7193-4JB00-0AA0
Server module (spare part)	Pack of 1	6ES7193-6PA00-0AA0
BU cover		
• 15 mm wide	Pack of 5	6ES7133-6CV15-1AM0
• 20 mm wide	Pack of 5	6ES7133-6CV20-1AM0
24 V DC plug (spare part)	Pack of 10	6ES7193-4JB00-0AA0
Shield connector for BaseUnit (shield contacts and shield terminals)	Pack of 5	6ES7193-6SC20-1AM0
Reference identification label, sheet with 16 labels	Pack of 10	6ES7193-6LF30-0AW0
Labeling strips (for labeling the I/O modules)		
• Roll, light gray (with a total of 500 labeling strips)	Pack of 1	6ES7193-6LR10-0AA0
• Roll, yellow (with a total of 500 labeling strips)	Pack of 1	6ES7193-6LR10-0AG0
• DIN A4 sheets, light gray (with a total of 1000 labeling strips)	Pack of 10	6ES7193-6LA10-0AA0
• DIN A4 sheets, yellow (with a total of 1000 labeling strips)	Pack of 10	6ES7193-6LA10-0AG0
Electronic coding element (spare part)[1)]		
• Coding element (type A)	Pack of 20	6ES7193-6KA00-3AA0
• Coding element (type B)	Pack of 20	6ES7193-6KB00-3AA0
• Coding element (type C)	Pack of 20	6ES7193-6KC00-3AA0
• Coding element (type D)	Pack of 20	6ES7193-6KD00-3AA0
Electronic coding element (spare part)[1)]		
• Coding element (type F, for fail-safe modules)	Pack of 1	6ES7193-6EF00-1AA0
• Coding element (type H)	Pack of 1	6ES7193-6EH00-1AA0

1) For the I/O modules, mechanical or electronic coding elements are supplied ex works, depending on the module. Variants A, B, C, D, F and H are available as spare parts. The appropriate coding element can be found in the technical specifications of the respective I/O module. The procedure for changing the coding element is described in the section Changing the type of an I/O module.

2) You may shorten the length of the standard mounting rails and SIMATIC system rails as needed.

General accessories	Packing unit	Article number
Mounting rails, tin-plated steel strip[2)]		
• Length: 483 mm	Pack of 1	6ES5710-8MA11
• Length: 530 mm	Pack of 1	6ES5710-8MA21
• Length: 830 mm	Pack of 1	6ES5710-8MA31
• Length: 2000 mm	Pack of 1	6ES5710-8MA41
SIMATIC system rails[2)]		
• Length 483 mm	Pack of 1	6ES7193-6MR00-0AA0
• Length 530 mm	Pack of 1	6ES7193-6MR00-0BA0
• Length 830 mm	Pack of 1	6ES7193-6MR00-0CA0
• Length: 2000 mm	Pack of 1	6ES7193-6MR00-0DA0

1) For the I/O modules, mechanical or electronic coding elements are supplied ex works, depending on the module. Variants A, B, C, D, F and H are available as spare parts. The appropriate coding element can be found in the technical specifications of the respective I/O module. The procedure for changing the coding element is described in the section Changing the type of an I/O module.

2) You may shorten the length of the standard mounting rails and SIMATIC system rails as needed.

Accessories, color identification labels (push-in terminals), 15 mm wide	Packing unit		Article number
16 process terminals (you can find additional information in the I/O Module manual)			
• Gray (terminals 1 to 16); color code CC00	Pack of 10		6ES7193-6CP00-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 16); color code CC01	Pack of 10		6ES7193-6CP01-2MA0
• Gray (terminals 1 to 8), blue (terminals 9 to 16); color code CC02	Pack of 10		6ES7193-6CP02-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 12), gray (terminals 13 to 16); color code CC03	Pack of 10		6ES7193-6CP03-2MA0
• Gray (terminals 1 to 8), red (terminals 9 to 12), blue (terminals 13 to 16); color code CC04	Pack of 10		6ES7193-6CP04-2MA0
• Gray (terminals 1 to 12), red (terminals 13 and 14), blue (terminals 15 and 16); color code CC05	Pack of 10		6ES7193-6CP05-2MA0

Accessories, color identification labels (push-in terminals), 15 mm wide	Packing unit		Article number
10 AUX terminals (for BU15-P16+**A10**+2D, BU15-P16+**A10**+2B)			
• Yellow-green (terminals 1A to 10A); color code CC71	Pack of 10		6ES7193-6CP71-2AA0
• Red (terminals 1A to 10A); color code CC72	Pack of 10		6ES7193-6CP72-2AA0
• Blue (terminals 1A to 10A); color code CC73	Pack of 10		6ES7193-6CP73-2AA0
10 add-on terminals (for BU15-P16+A0+**12**D/T, BU15-P16+A0+**12**B/T)			
• Red (terminals 1B to 5B), blue (terminals 1 to 5C); color code CC74	Pack of 10		6ES7193-6CP74-2AA0

Accessories, color identification labels (push-in terminals), 20 mm wide	Packing unit		Article number
12 process terminals (you can find additional information in the I/O Module manual)			
• Gray (terminals 1 to 4), red (terminals 5 to 8), blue (terminals 9 to 12); color code CC41	Pack of 10		6ES7193-6CP41-2MB0
• Gray (terminals 1 to 8), red (terminals 9 and 10), blue (terminals 11 and 12), color code CC42	Pack of 10		6ES7193-6CP42-2MB0
6 process terminals (you can find additional information in the I/O Module manual)			
• Gray (terminals 1 to 4), red (terminal 5), blue (terminal 6); color code CC51	Pack of 10		6ES7193-6CP51-2MC0
• Gray (terminals 1, 2 and 5), red (terminals 3 and 4), blue (terminal 6); color code CC52	Pack of 10		6ES7193-6CP52-2MC0
4 AUX terminals (for BU20-P12+**A4**+0B)			
• Yellow-green (terminals 1A to 4A); color code CC81	Pack of 10		6ES7193-6CP81-2AB0
• Red (terminals 1A to 4A); color code CC82	Pack of 10		6ES7193-6CP82-2AB0
• Blue (terminals 1A to 4A); color code CC83	Pack of 10		6ES7193-6CP83-2AB0
2 AUX terminals (for BU20-P6+**A2**+4D, BU20-P6+**A2**+4B)			
• Yellow-green (terminals 1A and 2A); color code CC84	Pack of 10		6ES7193-6CP84-2AC0
• Red (terminals 1A and 2A); color code CC85	Pack of 10		6ES7193-6CP85-2AC0
• Blue (terminals 1A and 2A); color code CC86	Pack of 10		6ES7193-6CP86-2AC0

Accessories, color identification labels (push-in terminals) PotDis	Packing unit		Article number
PotDis-BU, 16 potential terminals			
• Red for PotDis-BU-P1/x-R (terminals 1 to 16); color code CC62	Pack of 10		6ES7193-6CP62-2MA0
• Blue for PotDis-BU-P2/x-B (terminals 1 to 16), color code CC63	Pack of 10		6ES7193-6CP63-2MA0
PotDis-TB-P1-R, 18 potential terminals			
• Red (terminals 1 to 18); color code CC12	Pack of 10		6ES7193-6CP12-2MT0
• Gray (terminals 1 to 18); color code CC10	Pack of 10		6ES7193-6CP10-2MT0
PotDis-TB-P2-B, 18 potential terminals			
• Blue (terminals 1 to 18); color code CC13	Pack of 10		6ES7193-6CP13-2MT0
• Gray (terminals 1 to 18); color code CC10	Pack of 10		6ES7193-6CP10-2MT0
PotDis-TB-BR-W, 18 potential terminals			
• Yellow/green (terminals 1 to 18); color code CC11	Pack of 10		6ES7193-6CP11-2MT0
• Red (terminals 1 to 18); color code CC12	Pack of 10		6ES7193-6CP12-2MT0
• Blue (terminals 1 to 18); color code CC13	Pack of 10		6ES7193-6CP13-2MT0

Accessories, color identification labels (push-in terminals) PotDis	Packing unit		Article number
• Gray (terminals 1 to 18); color code CC10	Pack of 10		6ES7193-6CP10-2MT0
PotDis-TB-n.c.-G, 18 potential terminals			
• Gray (terminals 1 to 18); color code CC10	Pack of 10		6ES7193-6CP10-2MT0

Accessories for motor starter	Packing unit	Article number
3DI / LC module	Pack of 1	3RK1908-1AA00-0BP0
Fan	Pack of 1	3RW4928-8VB00
Additional mechanical bracket for BaseUnit	Pack of 1	3RK1908-1EA00-1BP0
Cover for an empty BaseUnit	Pack of 1	3RK1908-1CA00-0BP0
Touch protection cover for infeed bus	Pack of 1	3RK1908-1DA00-2BP0

Technical specifications for BU cover

Article number	6ES7133-6CV20-1AM0
General information	
Product type designation	BU cover
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-40 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-40 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	20 mm
Height	73 mm
Depth	35.3 mm

Article number	6ES7133-6CV15-1AM0
General information	
Product type designation	BU cover

Article number	6ES7133-6CV15-1AM0
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-40 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-40 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	35.3 mm

Supplements to ET 200SP documentation

BaseUnits manual

Special consideration for BaseUnits with functional versions < 04

The following BaseUnits with functional version < 04 can only be used in potential groups with rated voltages ≤ 48 V DC or 24 V AC:

- BaseUnit BU20-P12+A0+4B (6ES7193-6BP20-0BB1).
- BaseUnit BU20-P12+A0+0B (6ES7193-6BP00-0BD0).

BusAdapter Equipment Manual

Strain relief

The strain relief 6ES7193-6RA00-1AN0 with FS01 is not suitable for the optical PROFINET cables of the BusAdapters.

BusAdapter BA 2xFC

A further cable has been added to the recommended types of Fast Connect Cable: IE FC TP Marine Cable (6XV1840-4AH10)

CPU manuals

CPU Equipment Manuals, Edition 11/2024

Section Product overview, New functions

New functions for FW version 4.1	Applications	Customer benefits
Backup and restore of the configuration of the CPU by a central user	As of FW version V4.1 of a CPU, a central user can also back up and restore the configuration.	Rules you need to follow for backup and restore. More information is available in the ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual, in the section Backing up and restoring the CPU configuration.
Integrated security		
Temporary account lockout for local user accounts	Starting from STEP 7 V21, you can set up a temporary account lockout for local user accounts in the case of CPUs as of FW version V4.1.	The temporary account lockout provides protection against brute force attacks.
SIMATIC ET 200SP data	This appendix provides you with an overview of the data that the CPU generates and makes available to you.	More information is available in the ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual, in the appendix SIMATIC ET 200SP data.
Communication of the CPU		
New function for OPC UA	Enables cross-vendor communication.	For more information, please refer to the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) Function Manual
Activating IP forwarding through a data record transfer	For CPUs as of FW version V4.1, you can also activate/deactivate the "IP forwarding" function for local interfaces of the CPU through data record transfer.	
Technology functions of the CPU		
General functions	Distribution of the processing of motion jobs across multiple cores Improved performance	S7-1500 Motion Control Overview (https://support.industry.siemens.com/cs/ww/en/view/109751049) Function Manual
Axis functions (only CPU 1514SP T-2 PN)	Specification of the motion setpoints of a superimposing axis in addition to the basic motion of the axis Extended range of functions	Axis functions (https://support.industry.siemens.com/cs/us/en/view/109817884) Function Manual
Synchronous operation functions (only CPU 1514SP T-2 PN)	Cam can be used as a time-based position profile Extended range of functions	Synchronous operation functions (https://support.industry.siemens.com/cs/us/en/view/109817888) Function Manual
	Area scaling at a cam before or during active camming Extended range of functions	
	Cross-PLC synchronous operation with communication via isochronous I-device Extended range of functions	

New functions for FW version 4.1	Applications	Customer benefits
Kinematics functions (only CPU 1514SP T-2 PN)	New predefined kinematics type "6-axis articulated arm with offset wrist" available Extended range of functions	Kinematics functions (https://support.industry.siemens.com/cs/us/en/view/109817886) Function Manual
Interpreter functions (only CPU 1514SP T-2 PN)	Value of a tag can be changed at a breakpoint in debug program mode Extended range of functions	Interpreter functions (https://support.industry.siemens.com/cs/us/en/view/109817891) Function Manual
Trace functionality of the CPU		
Creating a long-term trace configuration from a long-term trace measurement	Extended range of functions	Using the trace and logic analyzer function (https://support.industry.siemens.com/cs/us/en/view/64897128) Function Manual
Recording, display and analysis of events in TIA Portal	Diagnostics of Motion Control jobs Extended range of functions	S7-1500 Motion Control Overview (https://support.industry.siemens.com/cs/ww/en/view/109751049) Function Manual
PID control		
New version V2.0 of PID_Temp controller	Use for cooling-only applications	PID control (https://support.industry.siemens.com/cs/ww/en/view/108210036) Function Manual
	Temporary shutdown of the heating	
	Manual stopping of the integral-action component	
	Active limiting of the integral-action component and change of output value limits in automatic mode	
	Improved anti-windup behavior in the cascade	

Technical specifications section

Equipment Manual	Technical specifications for FW version V4.1
CPU 1510SP-1 PN (6ES7510-1DK03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7510-1DK03-0AB0/td?dl=en)
CPU 1512SP-1 PN (6ES7512-1DM03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7512-1DM03-0AB0/td?dl=en)
CPU 1514SP-2 PN (6ES7514-2DN03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7514-2DN03-0AB0/td?dl=en)
CPU 1514SP T-2 PN (6ES7514-2VN03-0AB0)	↓ (https://support.industry.siemens.com/cs/ww/en/pv/6ES7514-2VN03-0AB0/td?dl=en)

Interface module manuals

Compilation error up to STEP 7 V15.1 for IM 155-6 PN HF as of V2.1, IM 155-6 PN HS V4.0

Affected components:

- IM 155-6 PN HF as of V2.1
- IM 155-6 PN HS V4.0

A compilation error can occur in isochronous mode of the ET 200SP (IM 155-6 PN HF as of V2.1, IM 155-6 PN HS V4.0) with the setting "From OB" even if the settings are valid. The typical error message is: "The specific Ti value is invalid" or "The specific To value is invalid". But other error messages are possible as well.

Solution:

Upgrade the module description of the IM in this case. You can upgrade the module description of the IM in the network view or in the device view of the Inspector window using the "Update module description" function. The error can still occur with the current module description after the first compilation. If you have selected valid settings, the error will no longer occur with the subsequent compilation.

Equipment Manual IM 155-6 PN BA, Edition 03/2015

Status of the supply voltage

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules in the following table without a parameter assignment, the status of the supply voltage is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Order number
DI 8x24VDC ST	6ES7131-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7131-6BF00-0CA0
DQ 4x24VC/2A ST	6ES7132-6BD20-0BA0
DQ 8x24VDC/0,5A ST	6ES7132-6BF00-0BA0
DQ 16x24VDC/0,5A ST	6ES7132-6BH00-0BA0
DQ 8x24VDC/0,5A HF	6ES7132-6BF00-0CA0

Equipment Manual IM 155-6 PN ST, Edition 04/2017

Response times

The response time of the IM 155-6 PN ST is made up of:

- Backplane bus cycle time
- Operating system processing time.

NOTE

Validity of the formula

The following formula applies to the ET 200SP backplane bus.

The formula does not apply to the ET-Connection bus.

Backplane bus cycle time

The backplane bus cycle time is the time the interface module requires to output new output data, read new input data and then copy the data to the PROFINET send buffer.

The backplane bus cycle time is the result of the update time configured for the interface module as IO device and amounts to at least 1 ms.

- If the configured update time ≥ 1 ms, the backplane bus cycle time is equal to the configured update time.
- If the configured update time < 1 ms, the backplane bus cycle time is the product of an integer multiple of the configured update time.

Table 12 Example calculation

Configured update time	Backplane bus cycle time (integer multiple, minimum 1 ms)
250 µs	4 x 250 µs = 1000 µs
750 µs	2 x 750 µs = 1500 µs
1000 µs	1000 µs
2000 µs	2000 µs

Operating system processing time

The **operating system processing time** is calculated based on the following formula:

Operating system processing time output

Operating system processing time_output[µs] = 147 + 3.775 number_m + 0.275 bytes_out

Operating system processing time input

Operating system processing time_input[µs] = 158.3 + 2.325 number_m + 0.325 bytes_in

Explanation of the parameters:

Number_m: Total number of all modules (incl. server module)

Bytes_out: Sum of all output bytes

Bytes_in: Sum of all input bytes

Calculating the response time

Response time output

The response time output of the IM 155-6 PN ST is made up of:

- Backplane bus cycle time
- Operating system processing time_output.

Response time input

The response time input of the IM 155-6 PN ST is made up of:

- Backplane bus cycle time
- Operating system processing time_input.

Equipment Manual IM 155-6 PN ST, Edition 04/2017

You can perform a firmware update to V4.1 for IM 155-6 PN ST interface modules with the article number 6ES7155-6AU00-0BN0.

If you perform hardware detection of the IO device in the TIA Portal as of V15.0 after the firmware update to V4.1, the device name is displayed as not assigned in the "PROFINET device name" column in the "Topology comparison" tab of the interface module.

The reason is that the online combination of article number and firmware version of the IO device is not offered in the hardware catalog.

In this case, the hardware catalog for the interface module IM 155-6 PN ST offers the combination of article number 6ES7155-6AU00-0BN0 and FW up to V3.3.

Solution: In the "Topology comparison" tab, assign the device name offered from the selection list in the "PROFINET device name" column.

Equipment Manual IM 155-6 PN/2 HF, Edition 10/2018

Section 2.1 Properties

Maximum configuration

- 64 ET 200SP I/O modules + 16 ET 200AL modules
- 1 m backplane bus (without interface module)

Server module

The server module supports the identification data I&M 0 to 3.

Section 2.2 Functions

Module-to-Module Communication (MtM)

At a CPU STOP or failure of communication between the interface module and CPU, all modules of the ET 200SP output substitute values.

Equipment Manual IM 155-6 PN/3 HF, Edition 10/2018

Section 2.1 Properties

Maximum configuration

- 64 ET 200SP I/O modules + 16 ET 200AL modules
- 1 m backplane bus (without interface module)

Section 2.2 Functions

The "Interface-local coupling of IO data" function can also be used in addition to GSDML with STEP 7 (TIA Portal) as of V15.1 with HSP285.

Section 2.2.20 Interface-local coupling of I/O data

When using MSO local modules, make sure that you choose the same number of bytes in all shared configurations involved. Failure to do so will result in a parameterization error when establishing the connection.

Module-to-Module Communication (MtM)

At a CPU STOP or failure of communication between the interface module and CPU, all modules of the ET 200SP output substitute values.

Table 2-1 Version dependencies of the module functions

The "Interface-local coupling of IO data" function is possible with STEP 7 (TIA Portal) as of V15.1 with HSP285.

Section 3 Wiring

Notes

NOTE

To set up a ring topology, use only the P1 R and P2 R ports.

NOTE

Operation with only one BusAdapter

You can operate the interface module with only one BusAdapter on P1 R and P2 R. Disable the P3 port in the port options in STEP 7 for this. Cover the free BusAdapter port P3 with a BusAdapter interface cover (6ES7591-3AA00-0AA0).

NOTE

For IRT operation, both BusAdapters must be plugged in.

Section 5.3.4 Invalid configuration states of the ET 200SP on PROFINET IO

NOTE

Removal of the server module will trigger a station stop. All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) but the interface module continues to exchange data.

The virtual MSO Local modules are not affected by the failure.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

Section 6 Compatibility

Restoring the factory settings on the interface module via the RESET button

There is a special operation for interface module IM 155-6 PN/3 HF to reset it to the factory settings using the Reset button.

Requirements

The supply voltage to the interface module must be switched on.

Required tool

3 To 3.5 mm screwdriver (for resetting with a RESET button)

Procedure

1. Remove the interface module from the mounting rail and swivel it downwards.
2. The RESET button is located on the back of the interface module behind a small opening: Push a screwdriver into the small opening, thus pressing the RESET button.
3. Release the RESET button.
4. Press the RESET button for another 3 seconds.
5. Look at the LED display of the interface module to see whether the reset was successful: RUN LED flashes for 3 seconds, ERROR and MAINT LED are off.
6. Install the interface module back on the mounting rail.
7. Configure the interface module again.

Equipment Manual IM 155-6 PN HF, Edition 12/2015

Section 3.1 Pin assignment

PROFINET interface X1 Port 2:

If autonegotiation is disabled, the RJ-45 socket (X1 Port 2) has the switch assignment (MDI-X).

Equipment Manual IM 155-6 PN HS, Edition 09/2016

Section 3.1 Pin assignment

PROFINET interface X1 Port 2:

If autonegotiation is disabled, the RJ45 socket (X1 Port 2) has the switch assignment (MDI-X).

Section 7 Technical specifications

- The PROFINET certification of network Class 3 is in preparation.
- Technical specifications of the BusAdapters BA 2×SCRJ, BA SCRJ/RJ45, BA SCRJ/FC:
  The maximum length of the PCF-GI fiber-optic cable is 250 m.

Equipment Manual IM 155-6 DP HF, Edition 10/2018

Section 2.2.1 Requirements

Table 13 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file (https://support.industry.siemens.com/cs/ww/en/view/57138621)/third-party software [1]	STEP 7 as of V5.5 SP3 with HSP0242	STEP 7 (TIA Portal) as of V13
Interface module; article number: 6ES7155-6BA01-0CN0	1	V4.2	X	X [2]	X (as of V15.1)

[1] Systems of third-party manufacturers: dependent on the range of functions of the third-party system

[2] Configure the module as version 6ES7155-6BA00-0CN0 FW V3.1 (as of HSP0242 V3)

Compatibility with BusAdapter BA 2xM12

The following table shows the compatibility of the BusAdapter BA 2xM12 with the interface modules:

Interface module	BA 2xM12 is supported	Configurable with		
		PROFINET GSD	STEP 7	STEP 7 (TIA Portal)
IM155-6 PN HS (6ES7155-6AU00-0DN0)	No	-	-	-
IM155-6 PN ST (6ES7155-6AU01-0BN0)	Yes, as of FW V4.2	Yes	-	V16 or higher with HSP205
IM155-6 PN HF (6ES7155-6AU00-0CN0)			V5.5.4.0 or higher with HSP0250 V5.0	V16 or higher with HSP302
IM155-6 PN/2 PN HF (6ES7155-6AU01-0CN0)				
IM155-6 PN/3 PN HF (6ES7155-6AU30-0CN0)				
IM155-6 MF HF (6ES7155-6MU00-0CN0)	Yes, as of FW V5.0		V5.5.4.0 or higher with HSP0250 V5.0 configured as IM155-6 PN/2 PN HF V4.2	V16 or higher with HSP302 configured as IM155-6 PN/2 PN HF V4.2

Compatibility with BusAdapter BA 2xLC-LD, BA LC-LD/RJ45 and BA LC-LD/M12

The following table shows the compatibility of the BusAdapter BA 2xLC-LD, BA LC-LD/RJ45 and BA LC-LD/M12 with the interface modules:

<table>
<tr><th rowspan="2">Interface module</th><th rowspan="2">BA 2xLC-LD</th><th rowspan="2">BA LC-LD/RJ45</th><th rowspan="2">BA LC-LD/M12</th><th colspan="3">Configurable with</th></tr>
<tr><th>PROFINET GSD</th><th>STEP 7</th><th>STEP 7 (TIA Portal)</th></tr>
<tr><td>IM155-6 PN HS (6ES7155-6AU00-0DN0)</td><td colspan="3" rowspan="3">No</td><td rowspan="3">-</td><td rowspan="3">-</td><td rowspan="3">-</td></tr>
<tr><td>IM155-6 PN ST (6ES7155-6AU01-0BN0)</td></tr>
<tr><td>IM155-6 PN HF (6ES7155-6AU00-0CN0)</td></tr>
<tr><td>IM155-6 PN/2 PN HF (6ES7155-6AU01-0CN0)</td><td rowspan="2">Yes, as of FW V4.2 configured as BA 2xLC and monitor port disabled</td><td colspan="2" rowspan="2">Yes, as of FW V4.2 configured as BA LC/RJ45 and monitor port disabled</td><td rowspan="4">Yes</td><td rowspan="2">V5.5.4.0 or higher with HSP0250 V4 / HSP0255 V5.0</td><td rowspan="2">V15.1 or higher</td></tr>
<tr><td>IM155-6 PN/3 PN HF (6ES7155-6AU30-0CN0)</td></tr>
<tr><td>IM155-6 MF HF (6ES7155-6MU00-0CN0)</td><td>Yes, as of FW V5.1 configured as BA 2xLC and monitor port disabled</td><td colspan="2">Yes, as of FW V5.1 configured as BA LC/RJ45 and monitor port disabled; max. cable length 3 km</td><td>V5.5.4.0 or higher with HSP0250 V4 / HSP0255 V5.0 configured as IM155-6 PN2-/2 PN HF V4.2</td><td>V15.1 or higher, configured as IM155-6 PN/2 PN HF V4.2</td></tr>
<tr><td>IM155-6 R1 (6ES7155-6AU00-0HM0)</td><td colspan="3">Yes</td><td>-</td><td>V18 or higher</td></tr>
</table>

IM 155-6 MF HF FW 5.2

For IM 155-6 MF HF with FW 5.2, the following applies in Function Manual "MultiFieldbus", section 4.2.3.5 "Data record interface":

Record response (big-endian, read-only access)

Register Offset	Block	Field	Size	Description
0x0041		Processed Length	Unsigned16	Processed length of the PROFINET data record in bytes **Read:** Length of the PROFINET data record read **for Request Control == "Execute read" (0x0000 for "Continue read")** **Write:** Record length of the executed write job = Record Length (Zero in case of an error)

Equipment Manual IM 155-6 MF HF, Edition 01/2022

NOTE

Use in STEP 7 or STEP 7 TIA Portal

To use the interface module in STEP 7 or STEP 7 TIA Portal, install the GSD file. You can find the latest GSD file on the Internet (https://support.industry.siemens.com/cs/ww/en/view/57138621).

After installation, the interface module can be found under "Other field devices".

Data record interface for MF Shared Device

The MF device supports the simultaneous use of the data record interface for max. 2 fieldbuses.

Section 2.2 Functions

Module-to-Module Communication (MtM)

At a CPU STOP or failure of communication between the interface module and CPU, all modules of the ET 200SP output substitute values.

Section 3.1.11 Configuration control (option handling)

Configuration control is possible, but modules with submodules distributed on different ARs/fieldbuses may not be part of the AR for active configuration control.

Section 7.2.5 Connection hold time

After the hold time has elapsed, the outputs react as described in the section "Substitute value behavior".

Section 7.2.5 Hold time after connection reset

After the hold time has elapsed, the outputs react as described in the section "Substitute value behavior".

Equipment Manual IM 155-6 PN ST (6ES7155-6AU02-0BN0), Edition 11/2023

Enhanced by the following two features:

1. Media redundancy (MRP and MRPD)

Function for ensuring communication and plant availability. A ring topology ensures that an alternative communication path is made available if a transmission link fails.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12, in the PROFINET with STEP 7 (https://support.automation.siemens.com/WW/view/en/49948856) Function Manual.
- As of STEP 7 V5.5 in the PROFINET System Description (https://support.automation.siemens.com/WW/view/en/19292127) System Manual.

2. Interface-local coupling of I/O data

Module-internal shared output

In this example, IO data are transferred from one controller to other controllers over the PROFINET interface X1 by means of the module-internal shared output.

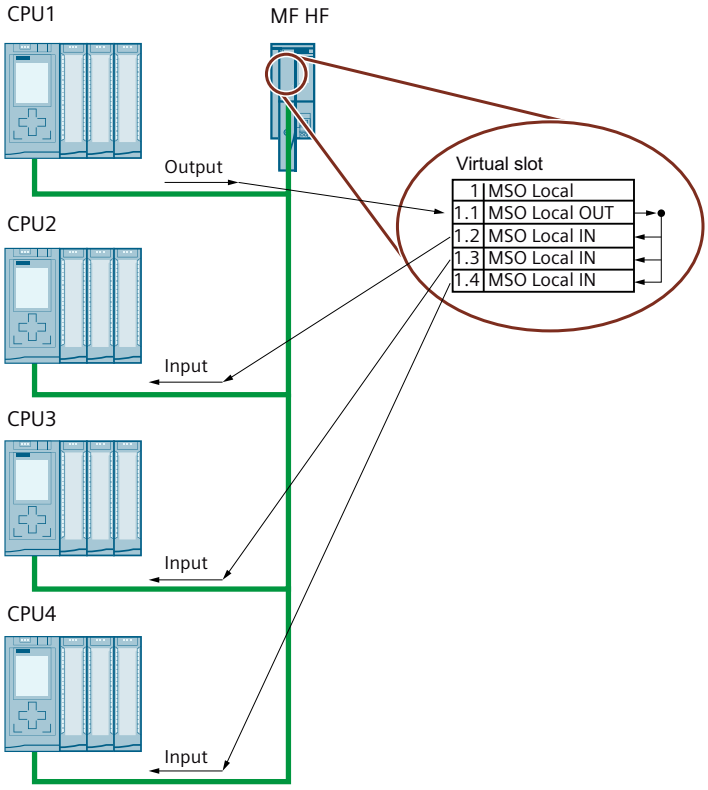

Figure 1 I/O data are transferred to other controllers in the same PROFINET network

Configuration

Table 14 Example configuration

Virtual slot	Type	I length	Q length	Access
1	MSO Local	-	-	-
1.1	MSO Local OUT	-	4 Bytes	CPU 1
1.2	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 2
1.3	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 3
1.4	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 4

Editing in the user program

The controller CPU 1 writes I/O data to the MSO Local OUT module with virtual slot 1.1 of the interface module. The data is available to CPUs 2 to 4 for reading with the remaining MSO Local IN modules. The validity of the provided user data is displayed by the data status byte (DS) of the MSO Local IN modules.

You can also use this example

- with fewer controllers and
- Configure it with other virtual modules.

NOTE

Virtual IO modules

Using virtual IO modules increases the communication load. This increases the data update time of all IO data accordingly.

I/O module manuals
Extended spare parts compatibility

Extended spare parts compatibility of DQ modules

The following table shows the modules you can replace without having to adapt the configuration.
If spare parts are installed, the functions of the configured module are retained.

You have configured and plugged in one of the following modules:	The following module is spare parts compatible:
• Digital output module DQ 16x24VDC/0.5A ST (6ES7132-6BH00-0BA0) • Digital output module DQ 16x24VDC/0.5A ST (6ES7132-6BH01-0BA0)	Digital output module DQ 16x24VDC/0.5A HF (6ES7132-6BH00-0CA0)
• Digital output module DQ 8x24VDC/0.5A BA (6ES7132-6BF00-0AA0) • Digital output module DQ 8x24VDC/0.5A BA (6ES7132-6BF01-0AA0)	Digital output module DQ 8x24VDC/0.5A HF (6ES7132-6BF01-0CA0) If you replace one of these modules with an HF module, you must observe the residual current at signal "0". More information can be found in the technical specifications of the respective modules.
• Digital output module DQ 8x24VDC/0.5A ST (6ES7132-6BF00-0BA0) • Digital output module DQ 8x24VDC/0.5A ST (6ES7132-6BF01-0BA0)	Digital output module DQ 8x24VDC/0.5A HF (6ES7132-6BF01-0CA0)
• Digital output module DQ 4x24VDC/2A ST (6ES7132-6BD20-0BA0) • Digital output module DQ 4x24VDC/2A ST (6ES7132-6BD21-0BA0)	Digital output module DQ 4x24VDC/2A HF (6ES7132-6BD21-0CA0)

Safety-related shutdown of standard modules

You can find the latest information on the standard modules that support safety-related shutdown, up to which SIL and Cat./PL and wiring examples, in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/39198632) and in the online version of the technical specifications.

Configuration notes on the I/O modules
(supplement to Product overview section in the manual)

I/O module		Article number	Firmware version	STEP 7 (TIA Portal)	STEP 7 V5.5 SP3
Digital input modules	DI 16x24VDC ST	6ES7131-6BH00-0BA0	V1.1.0	HSP0162 V13 SP1 or higher	HSP0229 V6.0
	DI 8x24VDC BA	6ES7131-6BF00-0AA0	V1.0.0	HSP0126	HSP0229 V5.0
	DI 8x24VDC ST	6ES7131-6BF00-0BA0	V1.1.0	V13 Update 3	HSP0229 V4.0
	DI 8x24VDC HF	6ES7131-6BF00-0CA0	V2.0.0	HSP0163 V13 SP1 Update 4 or higher	HSP0229 V6.0
	DI 8x24VDC HS	6ES7131-6BF00-0DA0	V1.0.2	Integrated as of V14	HSP0229 V5.0

I/O module		Article number	Firmware version	STEP 7 (TIA Portal)	STEP 7 V5.5 SP3
Digital output modules	DQ 8x24VDC/0.5A BA	6ES7132-6BF00-0AA1	V1.0.0	HSP0162 V13 SP1 or higher	HSP0230 V6.0
	DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0	V1.1.0	V13 Update 3	HSP0230 V4.0
	DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0	V1.1.0	V13 Update 3	HSP0230 V4.0
	DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0	V1.1.0	HSP0162 V13 SP1 or higher	HSP0230 V6.0
	DQ 8x24VDC/0.5A HF	6ES7132-6BF00-0CA0	V2.0.0	HSP0163 V13 SP1 Update 4 or higher	HSP0230 V6.0
	DQ 4x24VDC/2A HF	6ES7132-6BD20-0CA0	V2.0.0	HSP0163 V13 SP1 Update 4 or higher	HSP0230 V6.0
	DQ 4x24VDC/2A HS	6ES7132-6BD20-0DA0	V1.0.2	Integrated as of V14	HSP0230 V5.0
	DQ 4x24...230VAC/2A ST	6ES7132-6FD00-0BB1	V1.0	as of V13	HSP0230 V3.0
	DQ 4x24...230VAC/2A HF	6ES7132-6FD00-0CU0	V1.0.0	as of V14 with HSP0240	HSP 0230 as of V8.0
	RQ 4x120VDC-230VAC/-5A NO ST	6ES7132-6HD00-0BB1	V1.0.0	HSP0128	HSP0232 V5.0
	RQ 4x120VDC-230VAC/-5A NO MA ST	6ES7132-6MD00-0BB1	V1.0.0	HSP0162 V13 SP1 or higher	HSP0232 V6.0
Analog input modules	AI 8xU BA	6ES7134-6FF00-0AA1	V1.0.0	HSP0126	HSP0227 V5.0
	AI 2xU ST	6ES7134-6FB00-0BA1	V1.0.0	HSP0160 V13 SP1 or higher	HSP0227 V6.0
	AI 8xI 2-/4-wire BA	6ES7134-6GF000AA1	V1.0.0	HSP0126	HSP0227 V5.0
	AI 4xI 2-/4-wire ST	6ES7134-6GD00-0BA1	V1.1.0	V13 Update 3	HSP0227 V4.0
	AI 2xI 2-/4-wire ST	6ES7134-6GB00-0BA1	V1.0.0	HSP0160 V13 SP1 or higher	HSP0227 V6.0
	AI 4xU/I 2-wire ST	6ES7134-6HD00-0BA1	V1.1.0	V13 Update 3	HSP0227 V4.0
	AI 2xU/I 2-/4-wire HF	6ES7134-6HB00-0CA1	V2.0.0	HSP0161 V13 SP1 or higher	HSP0227 V6.0 V5.5 SP4 HF7 or higher
	AI 2xU/I 2-/4-wire HS	6ES7134-6HB00-0DA1	V2.0.1	Integrated as of V14	HSP0227 V5.0
	AI Energy Meter 400VAC ST	6ES7134-6PA01-0BD0	V3.0.0	V13 SP1 Update 4 HSP0159	HSP0227 V6.0
	AI Energy Meter 480VAC ST	6ES7134-6PA20-0BD0	V4.0.0	V13 SP1 Update 4 HSP0159	HSP0227 V6.0 V5.5 SP4 HF7 or higher

I/O module		Article number	Firmware version	STEP 7 (TIA Portal)	STEP 7 V5.5 SP3
Analog input modules	AI Energy Meter 480VAC/CT HF	6ES7134-6PA00-0CU0	V6.0.0	V15 or higher with HSP0253	V5.5 SP3 or higher
	AI Energy Meter 480VAC/RC HF	6ES7134-6PA20-0CU0	V6.0.0	V15 or higher with HSP0253	V5.5 SP3 or higher
Analog output modules	AQ 2xU ST	6ES7135-6FB00-0BA1	V1.0.0	HSP0160 V13 SP1 or higher	HSP0228 V6.0
	AQ 2xI ST	6ES7135-6GB00-0BA1	V1.0.0	HSP0160 V13 SP1 or higher	HSP0228 V6.0
	AQ 4xU/I ST	6ES7135-6HD00-0BA1	V1.1.0	V13 Update 3	HSP0228 V4.0
	AQ 2xU/I HS	6ES7135-6HB00-0DA1	V2.0.1	Integrated as of V14	HSP0228 V5.0

Digital module device manuals

I/O modules Equipment Manuals

LED DIAG

Table 15 LED DIAG fault display

LED DIAG	Meaning
Off	Backplane bus supply of the system is interrupted or switched off.
Flashes	Module parameters not assigned
On	Module parameters assigned and no module/channel diagnostics
Flashes	Module parameters assigned and module/channel diagnostics

Equipment Manuals for I/O modules ST, BA

When you have disabled all channels of the I/O module, a diagnostic message is still generated in the case of a fault if the "No supply voltage L+" diagnostics is enabled. For the following I/O modules, this behavior is corrected as of firmware version > V1.1.0:

- DI 16x24VDC ST
- DI 8x24VDC ST
- DQ 16x24VDC/0.5A ST
- DQ 8x24VDC/0.5 A ST
- DQ 4x24VDC/0.5A ST

Equipment Manuals for digital input modules with wire-break check

When wire-break check is configured the module requires a low quiescent current at the digital input in case of "0" signal for the monitoring. The parallel connection of a resistor with 25 kΩ to 45 kΩ is required in order that this quiescent current can flow when encoder contacts are open.

If wire-break check is disabled in the configuration, no parallel connection of the resistor is required.

If wire-break check is configured, connect a resistor with 25 kΩ to 45 kΩ parallel to each mechanical encoder contact.

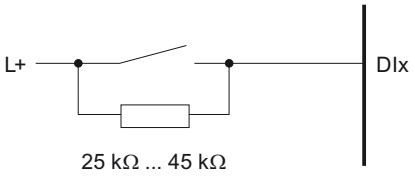

Figure 2 Connect mechanical encoder contact with resistor

Equipment Manual DI 8x24VDC HF, Edition 02/2014

Section 6.1 Technical specifications

- 24 V encoder supply
  - Output current, max.: 700 mA, total current

Equipment Manual DI 8xNAMUR HF, Edition 02/2014

Section A.2 Parameter assignment and structure of parameter data record

With data records 0 to 7, you can configure individual channels.

When the interface module IM 155-6 DP HF (PROFIBUS DP) is used and data records 0 and 1 are read, the module returns the diagnostics data records and not the parameter data records of the DI 8xNAMUR HF.

DQ Modules Equipment Manuals

Equipment Manual	Edition
DQ 8x24VDC/0.5A BA (6ES7132-6BF01-0AA0)	02/2019
DQ 8x24VDC/0.5A HF (6ES7132-6BF00-0CA0)	12/2017
DQ 8x24VDC/0.5A ST (6ES7132-6BF01-0BA0)	02/2019
DQ 8x24VDC/0.5A SNK BA (6ES7132-6BF61-0AA0)	02/2019

NOTICE

Current load of combined return conductors

When connecting in 2-wire connection, the static current load of the combined return conductor must not exceed 2A per terminal.

Equipment Manual DQ 4x24VDC/2A HS, Edition 09/2016

Section 6.1 Technical specifications

For this module, the marine approval for the bridge and deck zone is valid from a bus cycle time of at least 250 µs.

DQ 4x24VDC/2A HS Equipment Manual, Edition 05/2021
Section 6.4.1.3 Address space

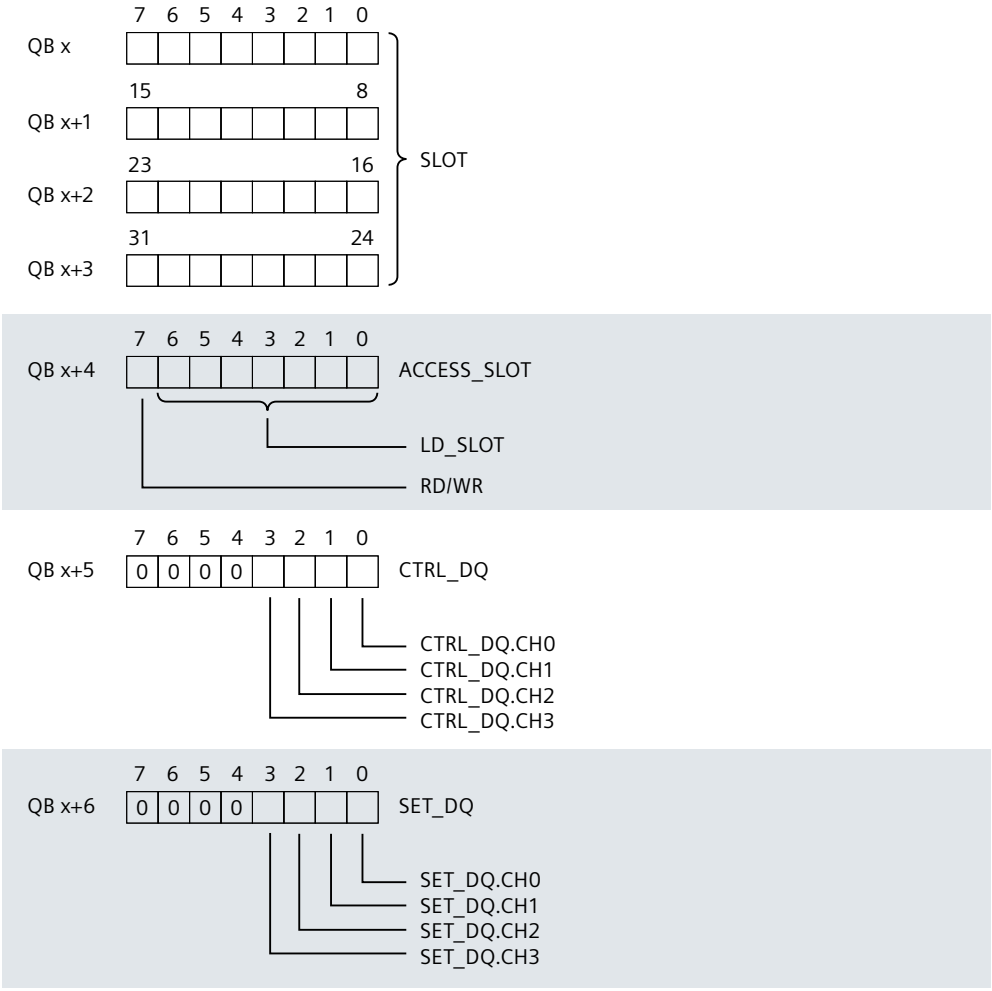

Figure 3 Assignment of the control interface

Equipment Manual Digital Output Module DQ 4x24..230VAC/2A ST, Edition 03/2015

Section 3.1 Wiring and block diagram

The following figure shows the block diagram and an example of the pin assignment of the digital output module DQ 4x24..230VAC/2A ST on the BaseUnit BU type B1.

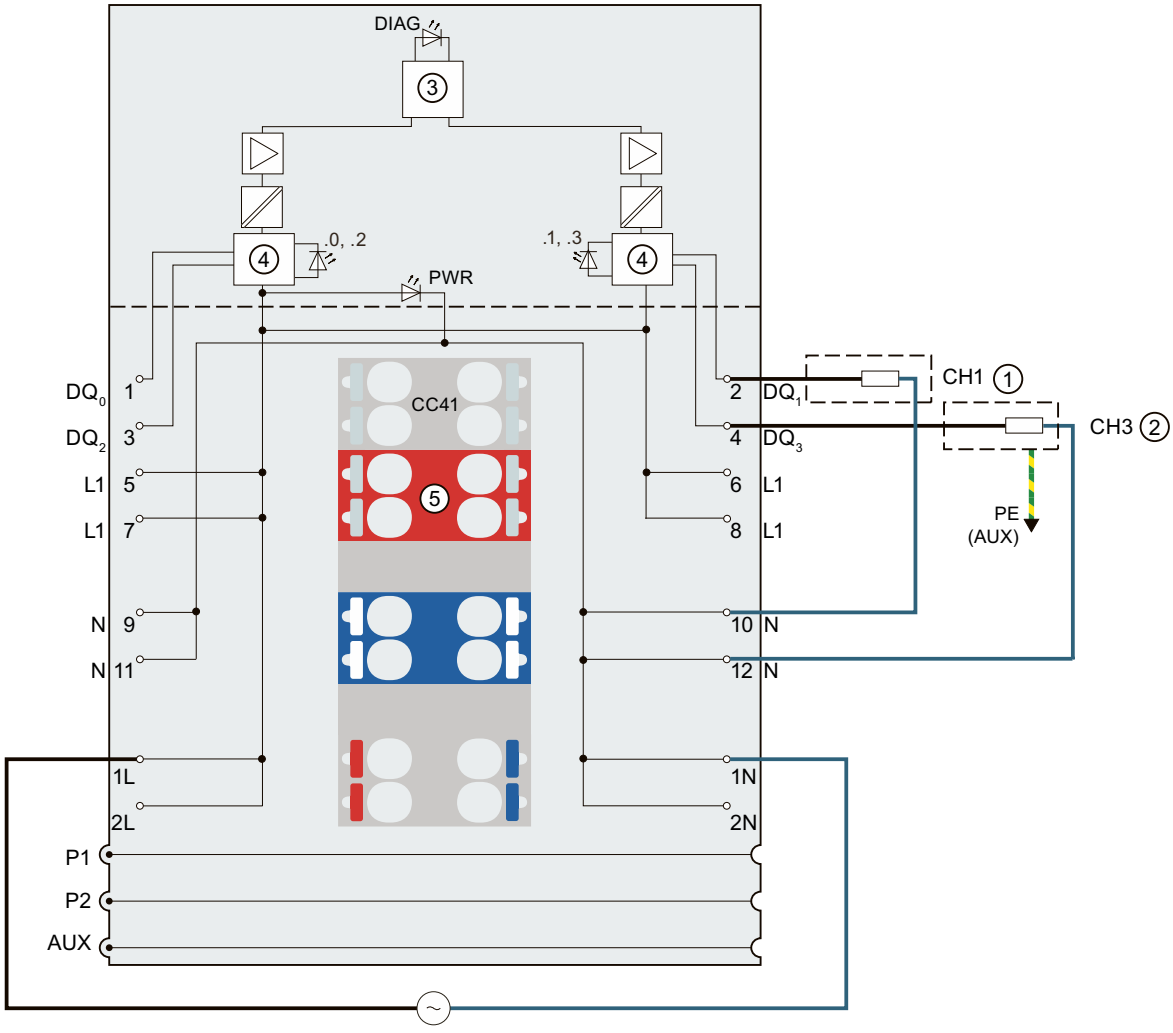

①	2-wire connection	N	Neutral conductor
②	3-wire connection	1L, 2L	Supply voltage 24 V AC to 230 V AC
③	Backplane bus interface	1N, 2N	Neutral conductor supply voltage
④	Output electronics	PE (AUX)	Protective conductor connection
⑤	Color-coded label CCxx (optional)	DIAG	Diagnostics LED (red/green)
DQ_n	Output signal, channel n	.0, .1, .2, .3	Channel status LED (green)
L1	Encoder supply	PWR	Power LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)		

Figure 4 Wiring and block diagram for 2-wire and 3-wire connection of actuators

Section 3.1 Pin assignment; Supply voltage fuse protection

The module has neither short-circuit protection nor overload protection. Protect the module from being destroyed by impermissible high current and install a fine fuse in the supply line. The maximum rated current of the fine fuse depends on the hardware function status (FS) of the module.

HW functional status of the module	Max. rated current of fuse	Tripping characteristic
FS ≤ 3	8 A	Quick response
FS ≥ 4	10 A	Quick response

Section 6.1 Technical specifications, Switching frequency with inductive load

The switching frequency of the outputs with inductive loads is max. 0.5 Hz.

Higher switching frequency is possible in spite of this, and depends on the alternating voltage and switched inductors or the power factor of the electric motor used.

Alternating voltage	Condition	Max. switching frequency
200 VAC or lower	---	10 Hz
200 VAC or higher	• Power factor of the electric motor cos φ > 0.35 • Electric motor must only be turned off after startup (no jogging mode). Electric motors which are turned off during startup could create inductive shutoff voltages > 600 V, which could destroy the output electronics (Triac).	10 Hz

Section 6.1 Technical specifications

Supply voltage	
Rated value (AC)	24 V to 230 V

Equipment Manual DQ 4x24..230VAC/2A HF, Edition 02/2018

Section 3.1.1. and 4.1.1 Wiring and block diagram

The following figure shows an example of the pin assignment of the digital output module DQ 4x24..230VAC/2A HF on BaseUnit BU type U0 (3-wire connection) in combination with a potential distribution module and terminal block.

For a 3-wire connection you connect the protective earth (PE) of the actuator to the terminal block.

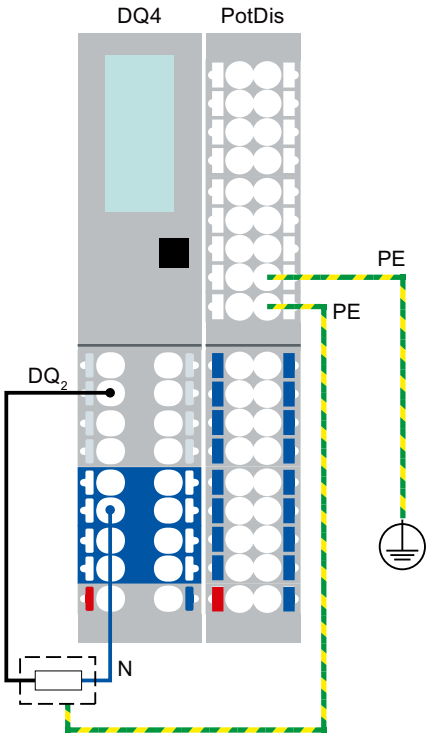

Figure 5 3-wire connection of actuators with potential distribution module at the digital output module DQ 4x24..230VAC/2A HF

Equipment Manuals DQ 16x24VDC/0.5A HF, Edition 01/2024; DQ 8x24VDC/0.5A HF, Edition 04/2024; DQ 4x24VDC/2A HF, Edition 04/2024

Section 7.1 Technical specifications

Module	Load resistance range (high limit, at nominal voltage)
DQ 16x24VDC/0.5A HF	2.4 kΩ
DQ 8x24VDC/0.5A HF	2.4 kΩ
DQ 4x24VDC/2A HF	1.6 kΩ

Equipment Manuals RQ 4x120VDC-230VAC/5A NO MA ST; Edition 06/2020, RQ 4x120VDC-230VAC/5A NO ST, Edition 06/2020

Section 3.1 Wiring and block diagram

NOTICE
The relay channels have no integrated short-circuit protection. Provide external short-circuit protection in the form of a miniature fuse with a maximum tripping current of 6.3 A and a fast tripping characteristic. A breaking capacity of at least 1500 A is required for mains voltages. For all other applications and for supply networks with a short-circuit current greater than 1500 A, you need to use a miniature fuse with an appropriately adapted breaking capacity.

⚠ WARNING
Do not connect exposed extra-low-voltage (SELV/PELV) and dangerous live voltages between channels at the same time! If you only use dangerously live voltages, keep a maximum voltage difference of 230 V between the channels.

Observe the information on the inductive DC loads in Section 6.1 "Technical specifications".

Section 6.1 Technical specifications

NOTICE
Required measures in the case of inductive DC loads and switching frequencies greater than 0.1 Hz Install an external freewheel in the form of a diode for switching frequencies greater than 0.1 Hz.

Equipment Manual RQ 4x24VUC/2A CO ST, Edition 02/2019

Switching capacity and service life of contacts

The list shows the switching capacity and lifetime of the relay contacts:

- Resistive DC load 24VDC/1.0A: 0.5 million switching cycles (typical)
- Resistive DC load 24VDC/2.0A: 0.1 million switching cycles (typical)
- Resistive AC load 24V: 0.1 million switching cycles (typical)
- Mechanical service life (free of load): 100 million switching cycles (typical)

The voltage specifications are nominal voltages.

Connection: 3-wire connection of actuators

The following figure shows the block diagram and an example of the pin assignment of the digital output module RQ 4x120VDC-230VAC/5A NO ST on the BaseUnit BU type B0.

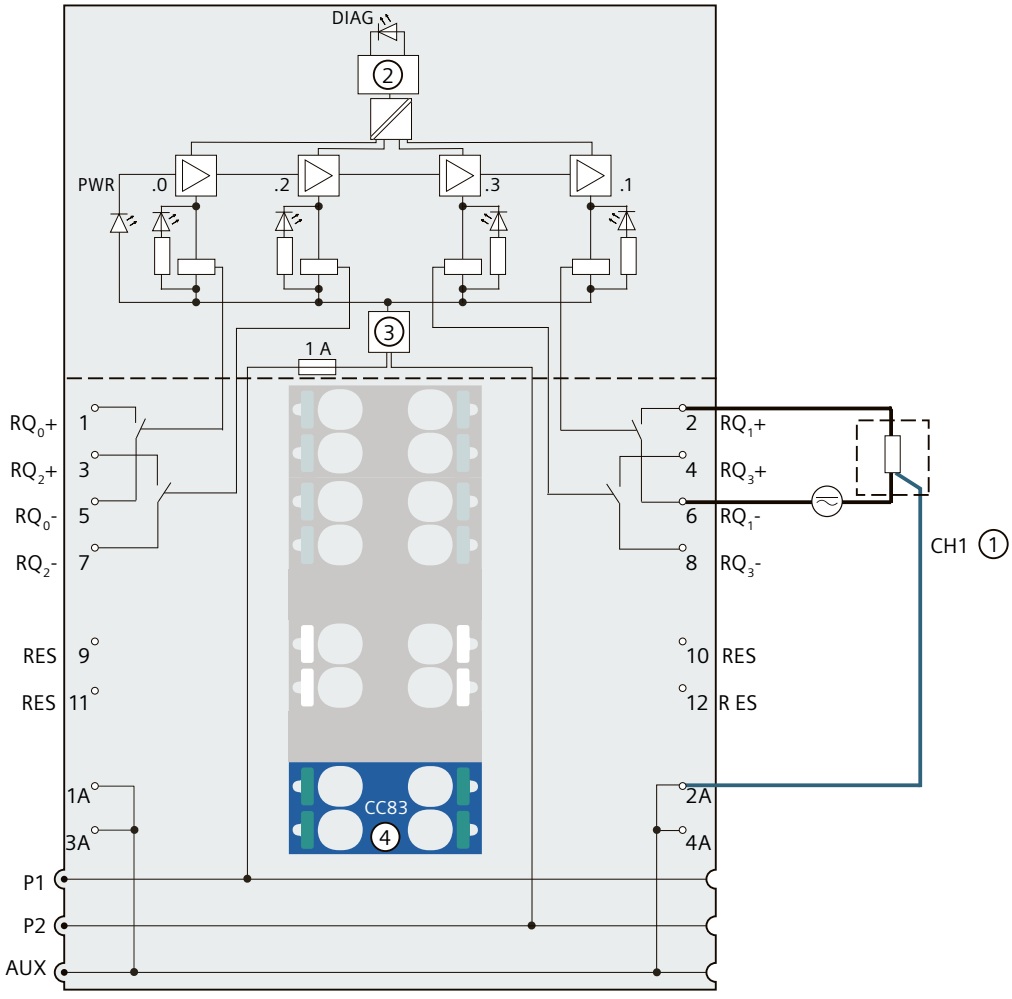

①	3-wire connection	RES	Reserve, must remain unused for future function extensions
②	Backplane bus interface	1 A to 4 A	AUX terminals
③	Polarity reversal protection	DIAG	Diagnostics LED (green, red)
④	Color identification label CCxx (optional)	.0, .1, .2, .3	Channel status LED (green)
RQ_n+, RQ_n-	Channel n	PWR	Power LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)		

Figure 6 Wiring and block diagram for 3-wire connection of actuators

Equipment Manual RQ 3x120VDC-230VAC/5A CO n.i. ST, Edition 01/2024

Section 4.3 Address space

Configuration options of the RQ 3x120VDC-230VAC/5A CO n.i. ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 16 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)		
		Integrated in hardware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 3-channel without value status	RQ 3x120VDC/230VAC/5A CO n.i. ST V0.0	V16 or higher with HSP 0321 *	X	X
1 x 3-channel with value status	RQ 3x120VDC/230VAC/5A CO n.i. ST V0.0, QI	V16 or higher with HSP 0321 *	X	---

* in compatibility mode of the RQ 3x120VDC-230VAC/5A CO ST (6ES7132-6HC50-0BU0)

RQ Modules Equipment Manuals

Equipment Manual	Edition
RQ 4x24VUC/2A CO ST (6ES7132-6GD51-0BA0)	10/2019
RQ 4x120VDC-230VAC/5A NO MA ST (6ES7132-6MD00-0BB1)	06/2020
RQ 4x120VDC-230VAC/5A NO ST (6ES7132-6HD01-0BB1)	06/2020
RQ 3x120VDC-230VAC/5A CO ST (6ES7132-6HC50-0BU0)	01/2024
RQ 3x120VDC-230VAC/5A CO n.i. ST (6ES7132-6HC70-0BU0)	01/2024

New Section 6.3 Mechanical environmental conditions

The mechanical ambient conditions are specified in the following table as sinusoidal oscillations.

Table 17 Test of mechanical environmental conditions

Condition tested	Test standard	Remarks
Vibrations	Vibration test according to IEC 60068-2-6 (Sinus)	Type of vibration: Frequency sweeps with a rate of change of 1 octave/minute. • 5 Hz ≤ f ≤ 8.4 Hz, 3.5 mm constant amplitude • 8.4 Hz ≤ f ≤ 150 Hz, 1 g constant acceleration Duration of oscillation: 10 frequency sweeps per axis, along each of the 3 mutually perpendicular axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 100 m/s^2 peak value, 11 ms duration Direction of shock: 3 shocks each in +/- direction, along each of the 3 perpendicular axes
Continuous shock	Shock, tested according to IEC 60068-2-27	Is not supported by the RQ module

Analog module device manuals

Equipment Manuals for analog input modules

Equipment Manual	Edition
AI 4xI 2-wire 4..20mA HART	11/2014

Section 5.2 "Parameters"

NOTE

Note that the settings in the "Interference frequency suppression" parameter have a direct effect on the cycle time of the module. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

Equipment Manuals for analog input modules

Equipment Manual	Edition
AI 4xTC HS (6ES7134-6JD00-0DA1)	03/2019

For user calibration with a calibration device, deactivate the "Wire-break check" parameter or function.

Equipment Manuals for analog input modules

Equipment Manual	Edition
AI 4xU/I 2-wire ST (6ES7134-6HD01-0BA1)	09/2019
AI 2xI 2/4-wire ST (6ES7134-6GB00-0BA1)	04/2018
AI 2xU/I 2/4-wire HF (6ES7134-6HB00-0CA1)	12/2015
AI 4xI 2/4-wire ST (6ES7134-6GD01-0BA1)	09/2018

New section in Appendix B: "Measured values for wire break"

Table 18 Measured values at a wire break depending on enabled diagnostics

Programmable diagnostics		Measured value		Explanation
Wire break	Underflow			
Enable	Enable	32767	$7FFF_H$	The "wire break" diagnostics is reported, because this has a higher priority.
Disable	Enable	-32768	8000_H	The "Lower limit violated" diagnostics is reported.
Disable	Disable	-32768	8000_H	No diagnostics reported.

Table 19 Using PTC resistors

Property	Technical specifications	Remarks
Switching points	**Behavior with rising temperature**	
	< 550 Ω	**Normal range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "0" (in the PII)
	550 Ω to 1650 Ω	**Prewarning range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "1" (in the PII)
	> 1650 Ω	**Response range:** • SIMATIC S7: Bit 0 = "1", Bit 2 = "0" (in the PII)
	Behavior with falling temperature	
	> 750 Ω	**Response range:** • SIMATIC S7: Bit 0 = "1", Bit 2 = "0" (in the PII)
	750 Ω to 540 Ω	**Prewarning range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "1" (in the PII)
	< 540 Ω	**Normal range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "0" (in the PII)
	Behavior after short-circuit	
	< 18 Ω	• SIMATIC S7: Bit 7 (IB x) = "1", Bit 0 = "0" and Bit 2 = "0"
(RRT-5) °C (RRT+5) °C (RRT+15) °C Measuring voltage/ voltage at the PTC	Max. 550 Ω Min. 1330 Ω Min. 4000 Ω Max. 7.5 V[1]	TNF = Rated response temperature of the sensor (according to DIN/VDE 0660)

[1] Below 23 kΩ

Equipment Manual AI 2xU/I 2-/4-wire HF analog input module, Edition 05/2021

Connection: Voltage and current measurement 3-wire connection

The following figure shows the block diagram and an example of the pin assignment of the analog input module AI 2xU/I 2-/4-wire HF on the BaseUnit BU type A0/A1.

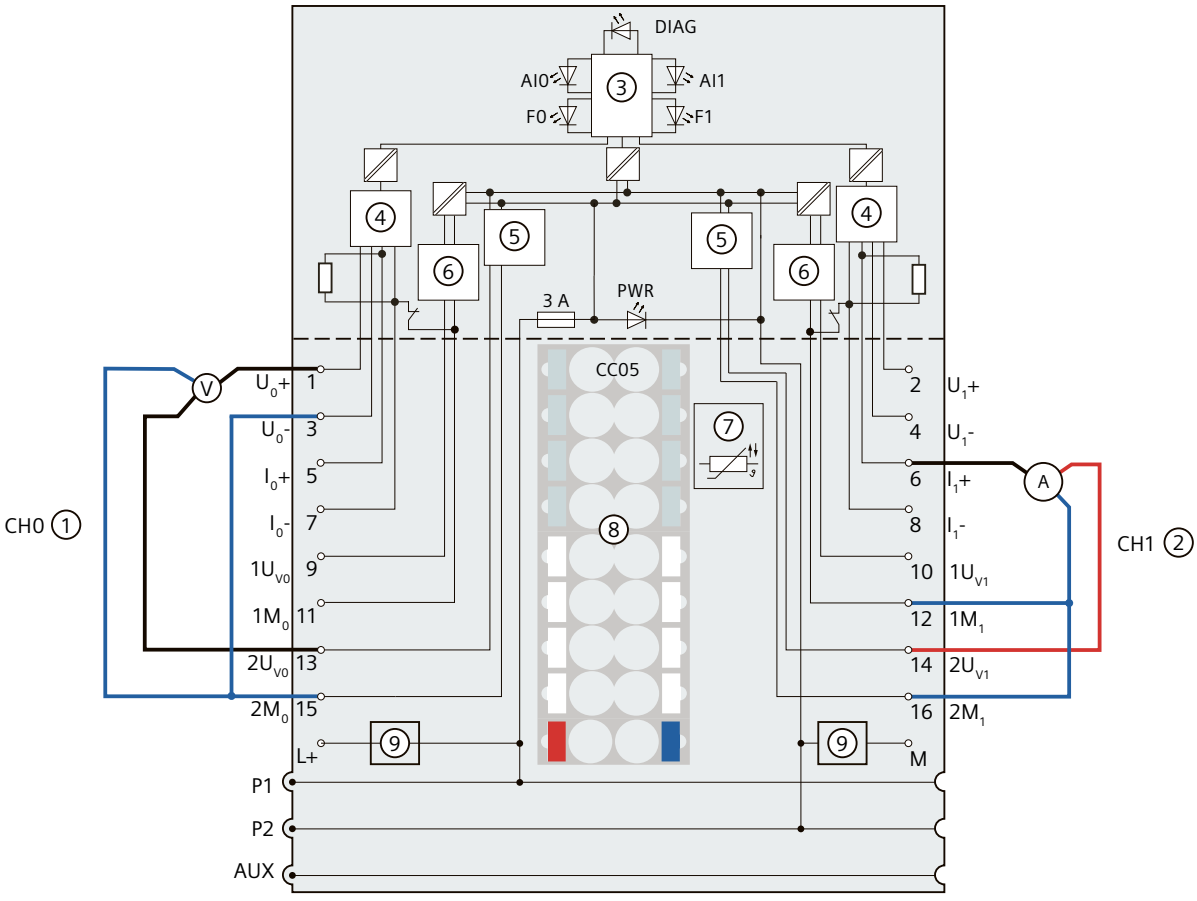

①	3-wire connection for voltage measurement	I_n+	Current input positive, channel n
②	3-wire connection for current measurement	I_n-	Current input negative, channel n
③	Backplane bus interface	U_{Vn}	Supply voltage, channel n
④	Analog-to-digital converter (ADC)	M_n	Reference ground to U_{Vn}, channel n
⑤	Current limitation (4-wire or 3-wire)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑥	Current limitation (2-wire)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑧	Color-coded label with color code CC05 (optional)	AI0, AI1	Channel status LED (green)

⑨	Supply voltage filter circuit (only when light-colored BaseUnit is present)	F0, F1	Channel fault LED (red)
U_n+	Voltage input positive, channel n	PWR	Power LED (green)
U_n-	Voltage input negative, channel n		

Figure 7 Wiring and schematic circuit diagram for voltage measurement 3-wire connection

Equipment Manual for Analog Input Module AI 2xI 2-/4-wire ST, Edition 04/2018

Connection: Current measurement 3-wire connection (3-wire transducer)

The following figure shows the block diagram and an example of the pin assignment of the analog input module AI 2xI 2-/4-wire ST on the BaseUnit BU type A0/A1.

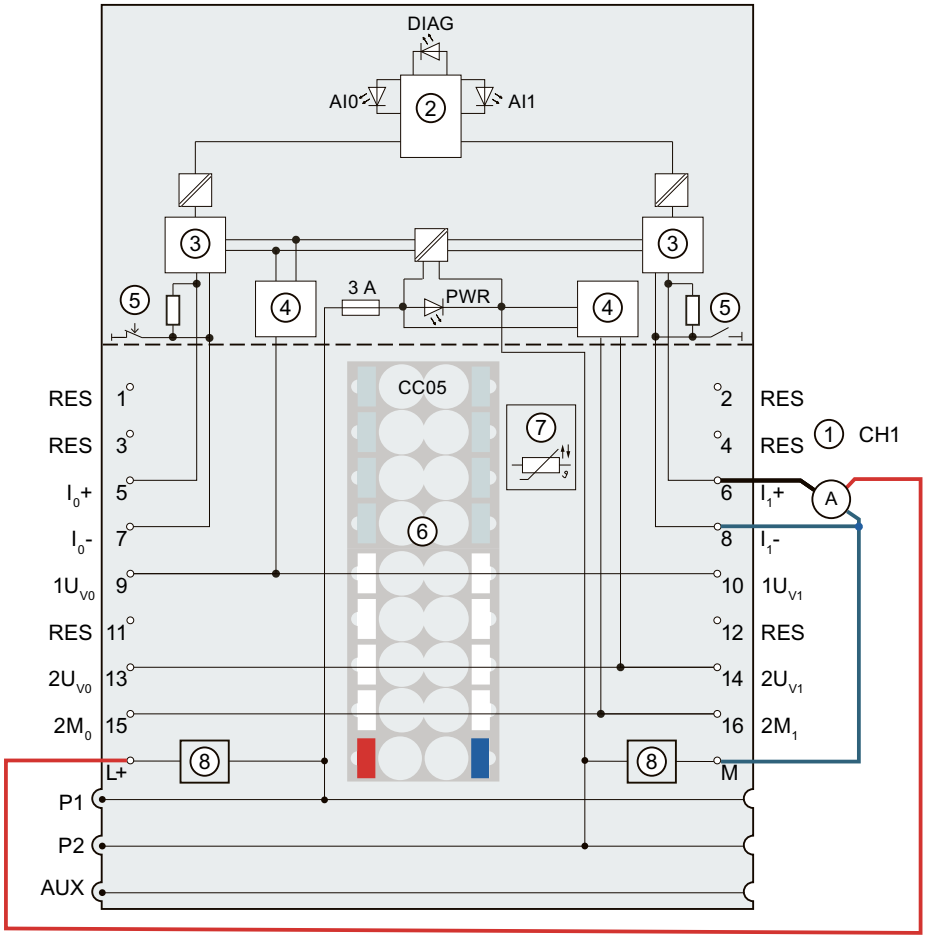

①	3-wire connection for current measurement (3-wire transducer)	$1U_{Vn}$	Supply voltage (2-wire transducer), channel n
②	Backplane bus interface	$2U_{Vn}$	Supply voltage (4-wire transducer), channel n
③	Analog-to-digital converter (ADC)	$2M_n$	Reference potential (4-wire transducer)
④	Current limitation	RES	Reserve, must remain unused for future function extensions
⑤	Switchover 2-wire / 4-wire	L+	24 V DC (infeed only with light-colored BaseUnit)

⑥	Color-coded label with color code CC05 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑧	Supply voltage filter circuit (only when light-colored BaseUnit is present)	AI0, AI1	Channel status LED (green)
I_n+	Current input positive, channel n	PWR	Power LED (green)
I_n-	Current input negative, channel n		

Figure 8 Wiring and block diagram for current measurement 3-wire connection (3-wire transducer)

NOTE

With this interconnection, the sensor supply is not limited. Up to a total current of 200 mA, you can use $2U_{Vn}$ to power the encoder.

NOTE

For 3-wire connection, configure the parameter "Measurement type/range" with "Current (4-wire transducer) 0..20 mA" or "Current (4-wire transducer) 4..20 mA".

"Parameters" section

You can only assign the parameters diagnostics on a module-by-module basis.

Equipment Manual AI 4xTC HS, Edition 03/2019

"Parameters" section

Table 20 Configurable parameters and their defaults (GSD file)

Parameters	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Fixed reference temperature	0 °C	0 °C	No	Channel	-

"Technical specifications" section

The abbreviation SFU stands for interference frequency suppression.

Equipment Manuals AI Energy Meter

Equipment Manual	Edition
AI Energy Meter CT HF (6ES7134-6PA01-0CU0)	04/2022
AI Energy Meter RC HF (6ES7134-6PA21-0CU0)	04/2022
AI Energy Meter CT ST (6ES7134-6PA01-0BU0)	04/2022
AI Energy Meter RC ST (6ES7134-6PA21-0BU0)	04/2022

Section 3.2 Connection examples

Any phase of the connected 3-phase system can be connected to the 4th measuring channel, not just the neutral conductor.

Section 3.1 Wiring and block diagram *and* section 3.2 Connection examples

Current transformer connection requirements

You must connect a current transformer to the infeed with K/P1 and to the ground/neutral point with L/P2.

The energy meter has the current transformer inputs ILx+ and ILx-. The current transformer on the secondary side via the outputs k/S1 and l/S2.

You must wire the k/S1 output of the current transformer to the ILx+ input of the energy meter. You must wire the output l/S2 of the current transformer to the input ILx- of the energy meter.

Chap. 4.2.1 Module versions at configuration with STEP 7

Module variants with fixed payload data assignment

Module version	Payload	Address space	Comment
2 I / 2 O	No cyclic payload. Access to measured values through "Read data record".	2-byte inputs 2-byte outputs	Information about the structure of the 2 I / 2 Q module version is available in the appendix "2 I / 2 Q" module version.
EE@Industry E0	Payload in accordance with EE@Industry measurement data profiles	12-byte inputs / 20-byte outputs	Information about the structure of the EE@Industry measured data profiles is available in the appendix Module version "EE@Industry measured data profile E0 / E1 / E2 / E3".
EE@Industry E1		4-byte inputs / 20-byte outputs	
EE@Industry E2		12-byte inputs / 20-byte outputs	

Section 7.2.4 Notes for the detection of wiring errors and incorrect rotating field

Based on the phase angle, you can recognize whether the flow direction of the current is correct and whether the voltage or current connections have been swapped. You cannot recognize, however, which phases are swapped and how. You can see whether the wiring is correct by referring to the figure "Quadrant in the quality bits" in section 7.2.3 "Operating quadrant".

Section 14.2 Explanation of parameters

Reactive power compensation

Reactive power Qtot Lx: Power of fundamental oscillation and the harmonic components

Reactive power Qn Lx: Power of harmonic components only

Fundamental reactive power Lx: Power of fundamental oscillation

Appendix E.11 Measured value data record for maximum values with time stamp (DS 154) *and* E.12 Measured value data record for minimum values with time stamp (DS 155)

The measured value IDs listed in the table refer only to the measured values and do not include the time stamps.

Appendix E.17 Information data record on available measured values (DS 170)

Measured variables of the module

Byte	Name	Data type	Unit	Value range
0	Version	BYTE	-	0
1	Reserved	BYTE	-	0
2…3	Number of IDs	UINT16	-	599
4…5	ID measured value 1	UINT16	-	-

Byte	Name	Data type	Unit	Value range
6...7	ID measured value 2	UINT16	-	-
...	...	...	-	-
1200 ... 1201	ID measured value 599	UINT16	-	-

Equipment Manual AI Energy Meter 480VAC/CT HF, Edition 03/2021

Wiring and block diagram

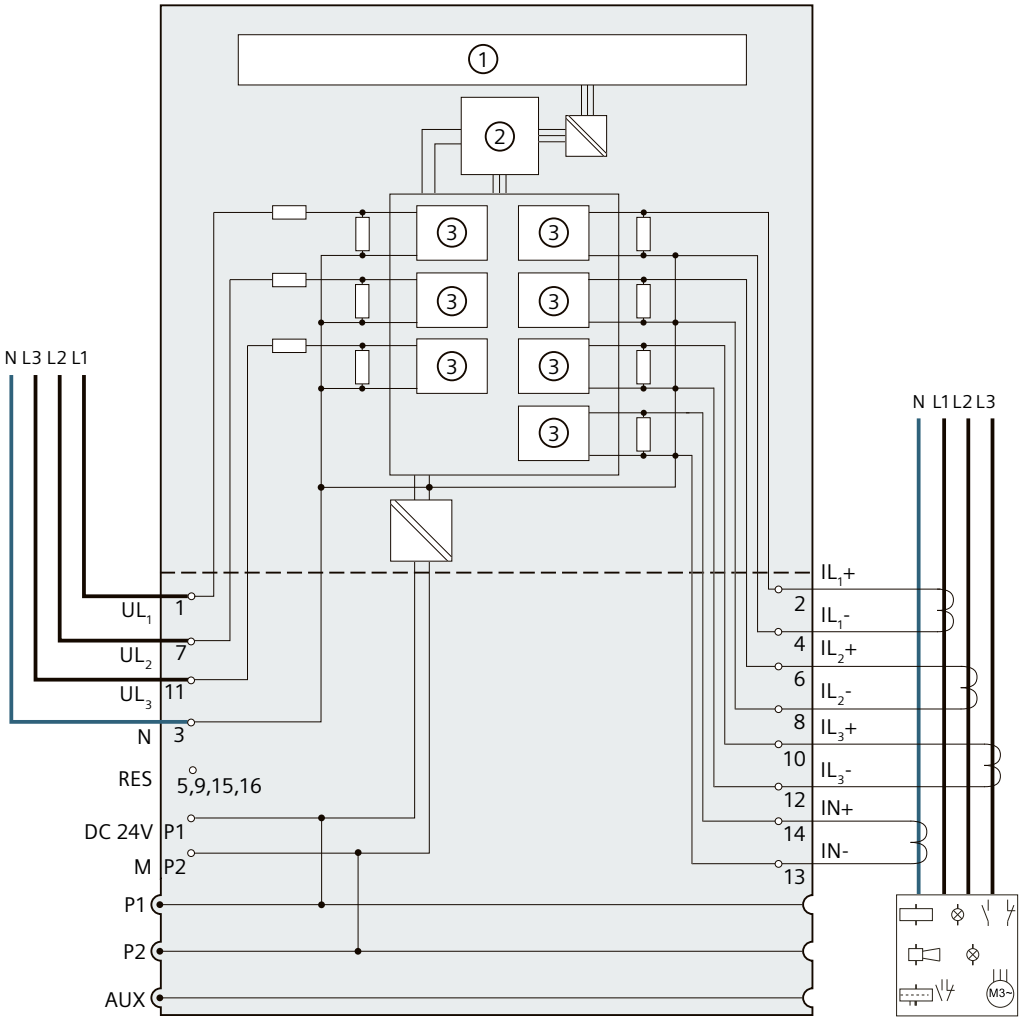

①	Backplane bus interface	UL_n	Connection voltage
②	Microcontroller	IL_n+ / IL_n-	Connection of current transformers
③	Analog-to-digital converter (ADC)	N, IN+ / IN-	Neutral conductor
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	RES	Reserve, must remain unused for future function extensions

Equipment Manual AI Energy Meter 480VAC/RC HF

Wiring and block diagram

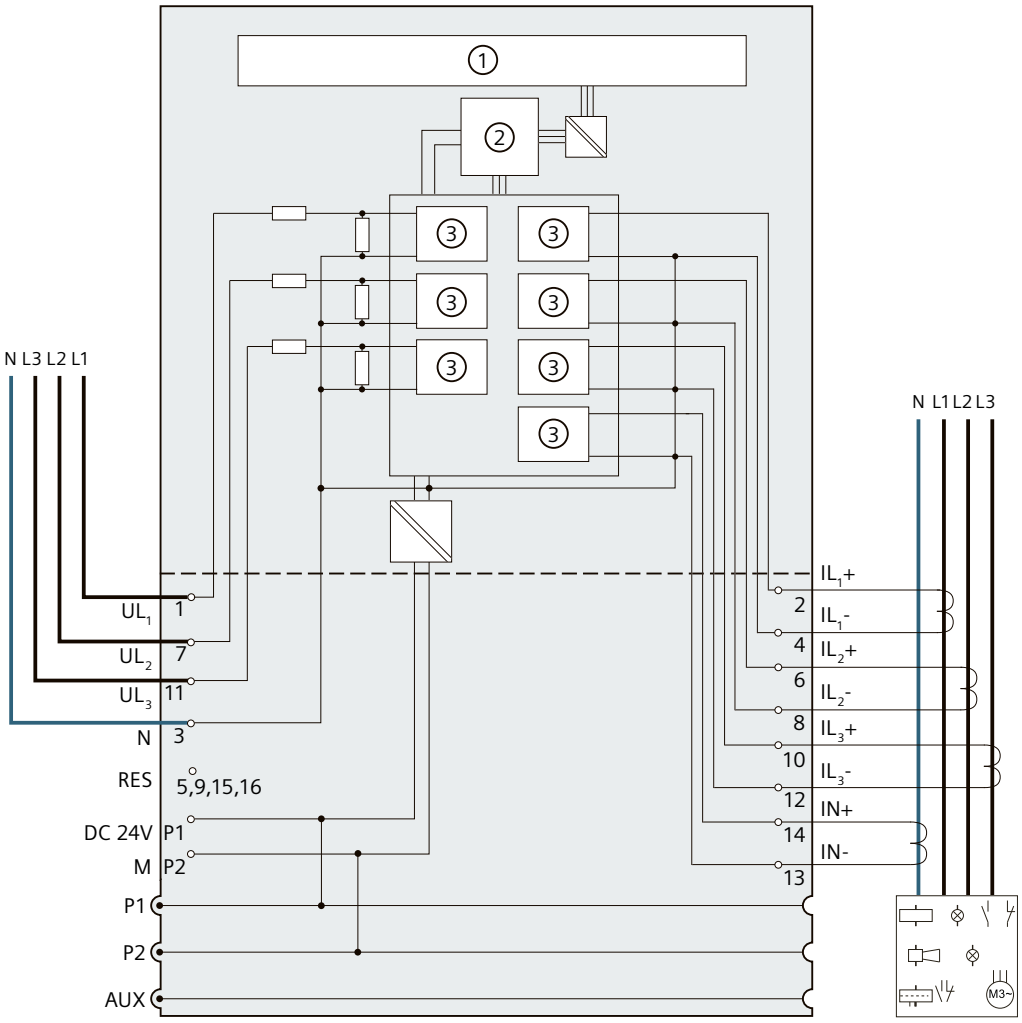

①	Microcontroller	UL_n	Connection voltage
②	Backplane bus interface	IL_n+ / IL_n-	Connection of current/voltage transformers and Rogowski coils
③	Analog-to-digital converter (ADC)	N, IN+ / IN-	Neutral conductor
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	RES	Reserve, must remain unused for future function extensions

Equipment Manual AI Energy Meter 480VAC ST, Edition 12/2015

For configuration with STEP 7 V13 or higher (TIA Portal), real values between $-7x10^{28}$ and $+7x10^{28}$ can be input. This is true for configuration via HSP and via GSD file (PROFINET).

For configuration with STEP 7 V5.5 SP4 as of HF7, configuration by means of GSD file (PROFINET) with REAL values of $-1.175x10^{38}$ to $+3.402x10^{38}$ is possible.

With STEP 7 SP4 to HF6, parameter assignment of REAL values is not possible. Functions that require REAL values are not available in this case.

Equipment Manuals AI Energy Meter 480VAC/CT HF, Edition 03/2021, and AI Energy Meter 480VAC/RC HF, Edition 03/2021

Below the "Measured variables for data records and user data" table in the section "Measured variables for connection type" it should correctly read in Italian:

[4] Valore medio aritmetico in virgola mobile calcolato su 10 s, disponibile se UL-N>3V

Equipment Manuals AI Energy Meter

Equipment Manual	Edition
AI Energy Meter 480VAC/CT HF	03/2021
AI Energy Meter 480VAC/RC HF	03/2021

Section 7.2.2 "Quality information with measured value IDs"

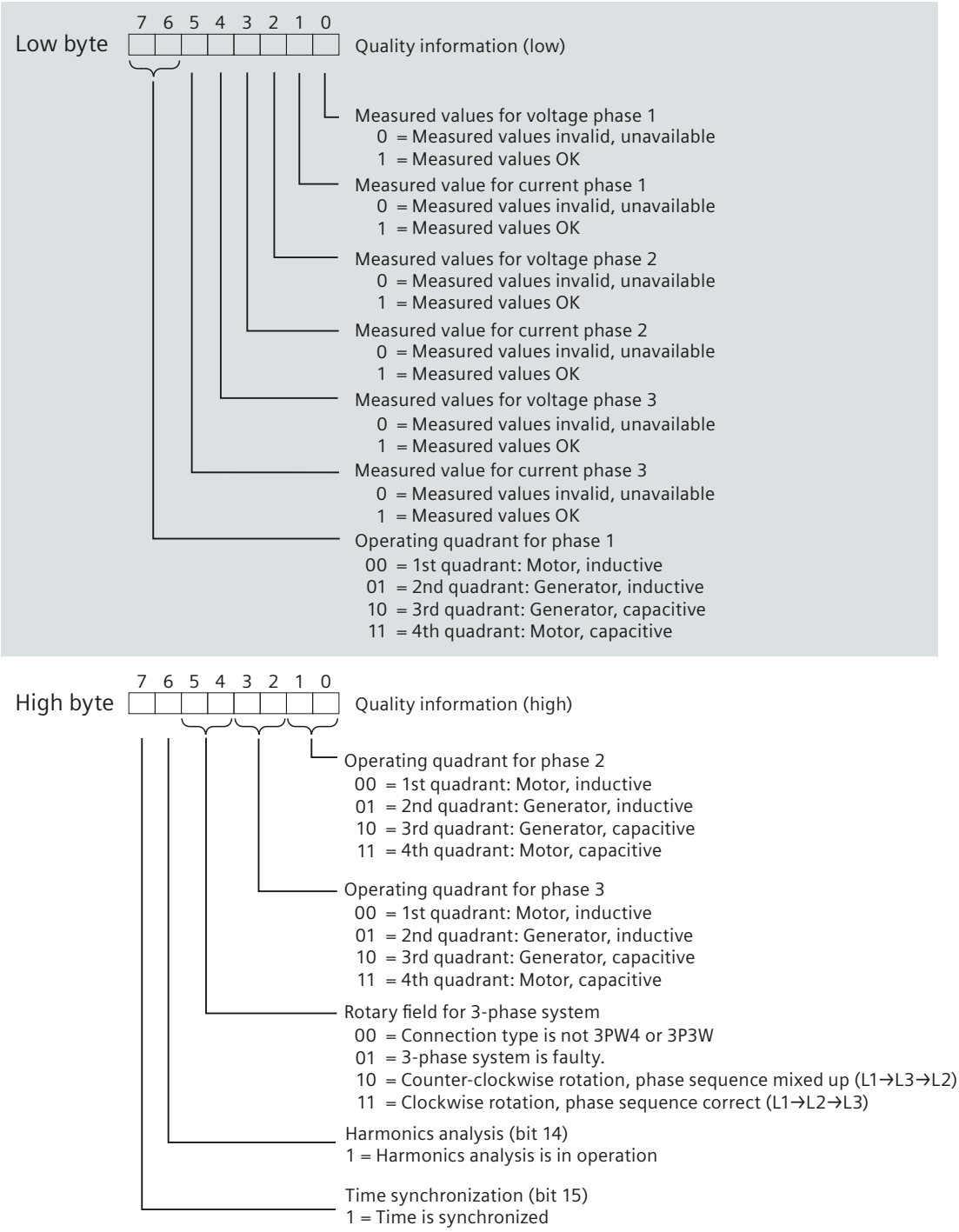

Figure 9 Quality information for low and high byte of the measured value ID 65503

Section "7.2.3 Operating quadrant"

The figure below shows the quality information of the operating quadrants.

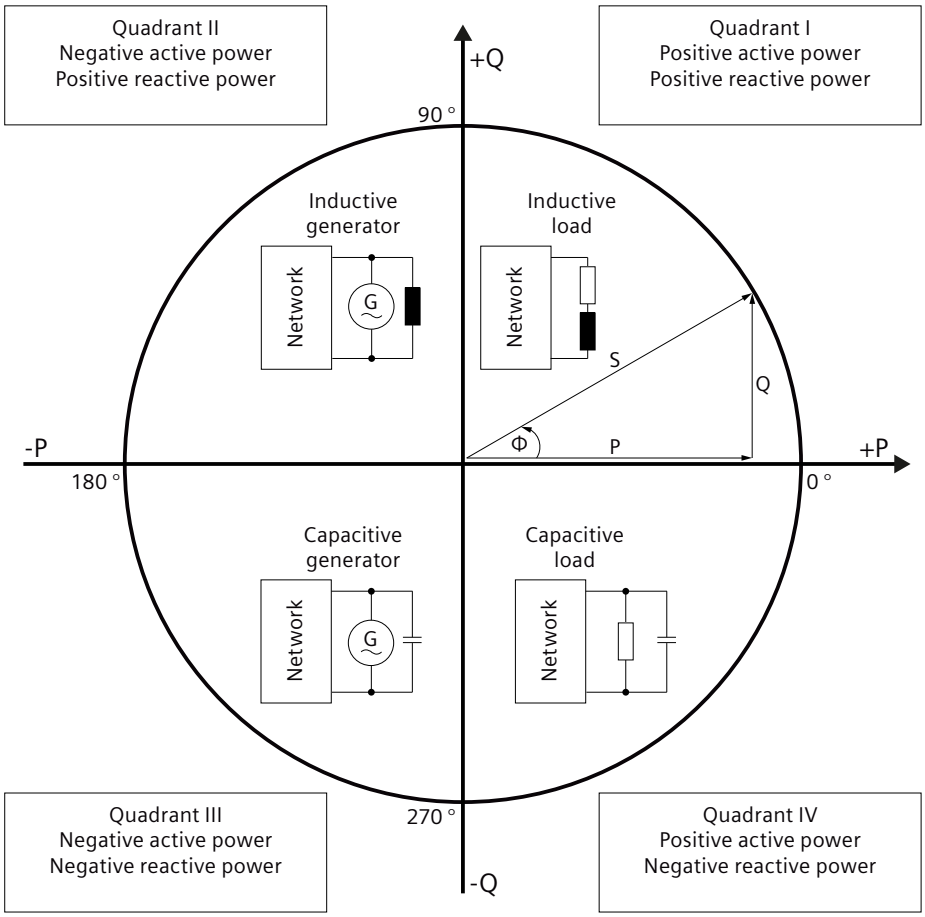

Figure 10 Quadrant in the quality bits

Section "7.2.4 Notes for the detection of wiring errors and incorrect rotating field"
Requirements
Detecting the rotating field requires 3-phase operation with 3P4W or 3P3W connection types.

The "See also" paragraph is omitted.

Section "8 Energy counter"
Introduction
"Outflow" describes the regenerative operation of the connected system.
"Inflow" describes the motor operation of the connected system.

Section 9.2.1 "Start values for operating hours counter"
Byte 158 ... byte 169: Start values for operating hours counter
The start values for operating hours counters in data record 143 are 32-bit floating point number. The format corresponds to the data type REAL in S7-1200 and in S7-1500.

Appendix F.1 "Tips and tricks"
Rotating field

To recognize wiring errors and evaluate the generated rotating field, use the combined measurement functions from the section "Notes for the detection of wiring errors and incorrect rotating field".

Equipment Manuals AI Energy Meter 400VAC ST, Edition 12/2015; AI Energy Meter 480VAC ST, Edition 12/2015
Requirements for the operation of the AI Energy Meter on slot 1 of the ET 200SP:

Interface module / CPU	AI Energy Meter 400VAC ST (6ES7134-6PA01-0BD0)	AI Energy Meter 480VAC ST (6ES7134-6PA20-0BD0)
IM 155-6 PN BA (6ES7155-6AR00-0AN0)	Can be operated on slot 1 for all IM 155-6 PN BA	
IM 155-6 PN ST (6ES7155-6AU00-0BN0)	Can be operated on slot 1 for IM 155-6 PN ST from firmware version V3.1 and higher and functional status FS 07	
IM 155-6 PN HF (6ES7155-6AU00-0CN0)	Can be operated on slot 1 for IM 155-6 PN HF from firmware version V3.0 and higher and functional status FS 05	
IM 155-6 DP HF (6ES7155-6BU00-0CN0)	Can be operated on slot 1 for IM 155-6 DP HF from firmware version V3.0 and higher	
CPU 1510SP-1 PN, CPU 1512SP-1 PN, CPU 1515SP PC	Can be operated on slot 1 for all CPUs	

Incorrect value range for information on power (INT variables)
Refers to the table of measured quantities in Appendix B and the tables of useful data variants in Appendix D.
Correct value range: -32768 to 32767

Product overview, Figure 2-1 Use of the AI Energy Meter
Display incorrect.
Replace figures as follows:

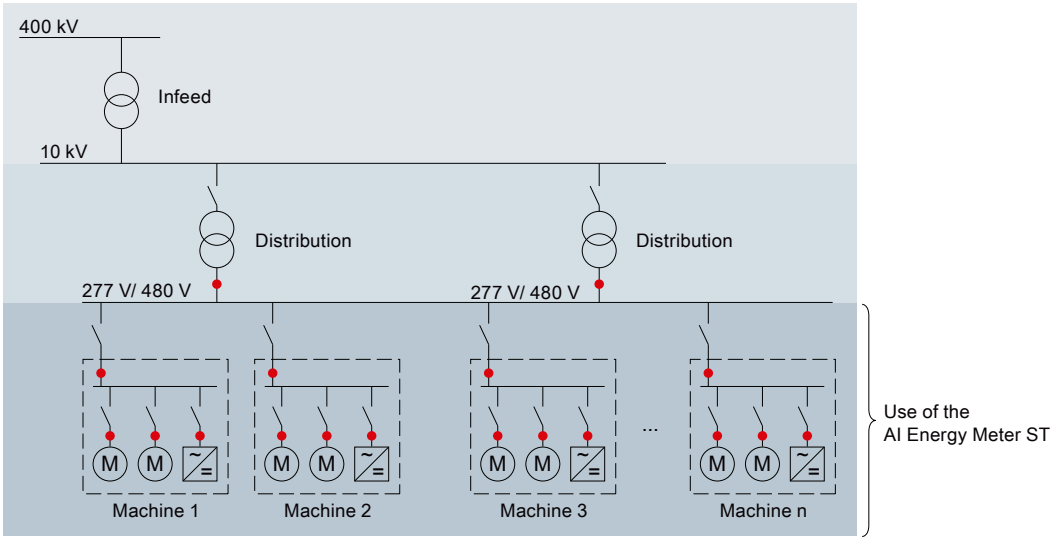

● Measuring points in the system

Figure 11 Use of the AI Energy Meter 480VAC ST

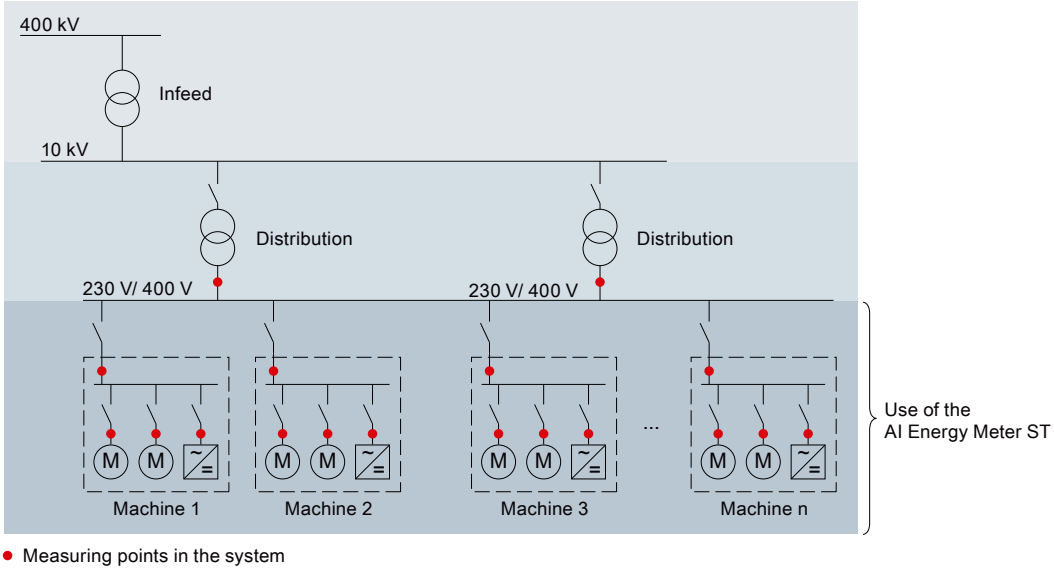

Figure 12 Use of the AI Energy Meter ST 400V

Section 3.1 Wiring and block diagram, paragraph on Fuse protection of the connection lines

AI Energy Meter 400VAC ST, replace set with:

If the cables are short-circuit proof according to IEC 61439-1:2009, e.g. in a conduit or on separate cable trays, separate line protection for the AI Energy Meter 400VAC ST can be omitted.

AI Energy Meter 480VAC ST, replace set with:

If the cables are short-circuit proof according to IEC 61439-1:2009, e.g. in a conduit or on separate cable trays, separate line protection for the AI Energy Meter 480VAC ST can be omitted.

Section 3.1 Wiring and block diagram, Figure 3-1

Replace wiring diagram, add note:

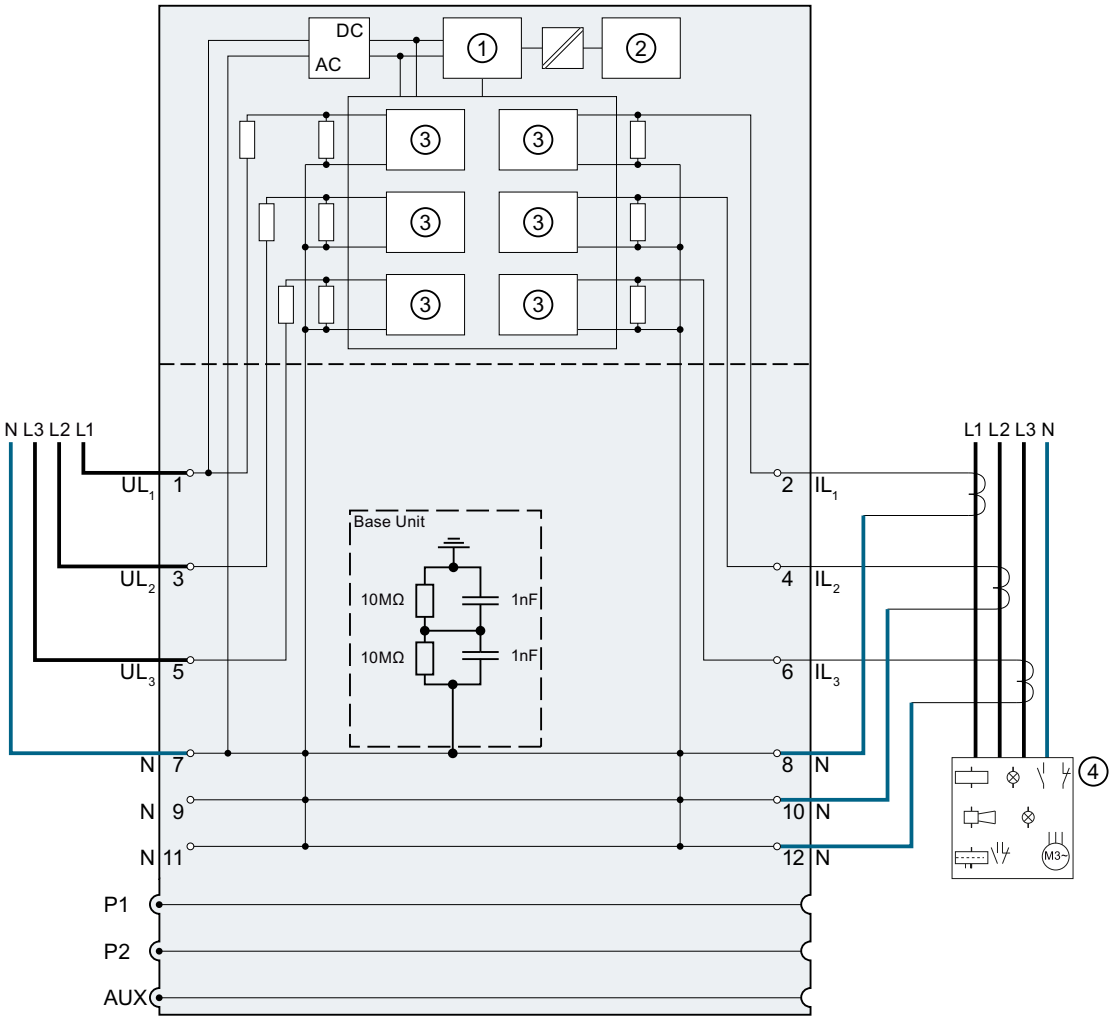

①	Microcontroller	UL_n	Voltage connection
②	Backplane bus interface	IL_n	Current connection
③	Analog-to-digital converter (ADC)	N	Neutral conductor
④	Power measurement		

Figure 13 Block diagram of the AI Energy Meter 480VAC ST

NOTE

The BaseUnit of the Energy Meter 400/480VAC, 6ES7193-6BP00-0BD0, BU20-P12+A0+0B, contains a connection from N to FE, or to the potential connected to the DIN rail. This connection consists of two Y2 capacitors in series, each with a capacitance of 1 nF, and two resistors in parallel, each with a resistance of 10 MOhm.

Equipment Manual for Energy Meter 480VAC ST, Edition 12/2015

In the Equipment Manual for Energy Meter 480VAC ST, the measured value ID and the associated measured variables for the complete performance are reversed. The correct association is shown in the table below:

Measured value ID	Measured variables	Unit
34	Total active power L1L2L3	W
35	Total reactive power L1L2L3	var
36	Total apparent power L1L2L3	VA
65	Max. total active power	W
66	Max. total reactive power	var
67	Max. total apparent power	VA
95	Min. total active power	W
96	Min. total reactive power	var
97	Min. total apparent power	VA

If you use the user-data mapping via data record DS 130, note that the texts for the measured variables are also displayed incorrectly during configuration.

During configuration of the measured variables for the total active, reactive, and apparent power, select the following texts:

Desired measured variable for the user-data mapping	Text to select during configuration
Total active power L1L2L3	Total apparent power L1L2L3 (ID00034)
Total reactive power L1L2L3	Total active power L1L2L3 (ID00035)
Total apparent power L1L2L3	Total reactive power L1L2L3 (ID00036)
Max. total active power	Max. total apparent power (ID00065)
Max. total reactive power	Max. total active power (ID00066)
Max. total apparent power	Max. total reactive power (ID00067)
Min. total active power	Min. total apparent power (ID00095)
Min. total reactive power	Min. total active power (ID00096)
Min. total apparent power	Min. total reactive power (ID00097)

The project configuration modification described above is no longer required if the following tools and GSD files are used:

- STEP 7 (TIA Portal) as of V14
- STEP 7 V5.5 SP4 or higher with HSP 0227
- GSD file GSDML-V2.32-ET200SP-20160706

Section 11.1 Phase-related measured values

Assignment of the user data variants swapped between L1 and L3.

Correct assignment:

- Phase-specific measurement Phase L1 with user data variants 158 ($9E_H$) and 159 ($9F_H$)
- Phase-specific measurement Phase L2 with payload variants 156 ($9C_H$) and 157 ($9D_H$)
- Phase-specific measurement Phase L3 with user data variants 154 ($9A_H$) and 155 ($9B_H$)

Appendix D User data variants

Table D-13 Basic energy counter measurement variables (periodic) Overflow counter (ID 239 or EFH).

Replace measured value IDs:

Table 21 Basic energy-counter-measurement variables (periodic) overflow counter

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	239 (EFH)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Overflow counter for active energy inflow L1	UINT	-	0 ... 65535	61190
4 ... 5	Overflow counter for active energy outflow L1	UINT	-	0 ... 65535	61191
6 ... 7	Overflow counter for reactive energy inflow L1	UINT	-	0 ... 65535	61192
8 ... 9	Overflow counter for reactive energy outflow L1	UINT	-	0 ... 65535	61193
10 ... 11	Overflow counter for apparent energy L1	UINT	-	0 ... 65535	61194
12 ... 13	Overflow counter for active energy inflow L2	UINT	-	0 ... 65535	61210
14 ... 15	Overflow counter for active energy outflow L2	UINT	-	0 ... 65535	61211
16 ... 17	Overflow counter for reactive energy inflow L2	UINT	-	0 ... 65535	61212
18 ... 19	Overflow counter for reactive energy outflow L2	UINT	-	0 ... 65535	61213
20 ... 21	Overflow counter for apparent energy L2	UINT	-	0 ... 65535	61214
22 ... 23	Overflow counter for active energy inflow L3	UINT	-	0 ... 65535	61230
24 ... 25	Overflow counter for active energy outflow L3	UINT	-	0 ... 65535	61231
26 ... 27	Overflow counter for reactive energy inflow L3	UINT	-	0 ... 65535	61232
28 ... 29	Overflow counter for reactive energy outflow L3	UINT	-	0 ... 65535	61233
30 ... 31	Overflow counter for apparent energy L3	UINT	-	0 ... 65535	61234

Equipment Manuals for analog output modules

Equipment Manual	Edition
Analog output module AQ 2xU/I HS	09/2016
Analog output module AQ 4xU/I ST	03/2016

"Representation of analog values in the current output ranges" section

Table 22 Current output ranges 4 to 20 mA

Values			Current output range	Range
	Dec.	**Hex.**	**4 to 20 mA**	
118.5149 %	32767	7FFF	21 mA	Overflow*
	29377	72C1		
106.25 %	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100 %	27648	6C00	20 mA	Rated range
75 %	20736	5100	16 mA	
0.003617 %	1	1	4 mA + 578.7 nA	
0 %	0	0	4 mA	
	-1	FFFF	3.9995 mA	Underrange

* Outputs positive maximum value or negative minimum value

Values			Current output range	Range
-2.5 %	-692	FD4C	3.6 mA	Underrange
	-693	FD4B	3.6 mA	Underflow*
-118.519 %	-32768	8000		

* Outputs positive maximum value or negative minimum value

Equipment Manuals for analog input modules

Equipment Manual	Edition
AI 4xU/I 2-wire ST (6ES7134-6HD01-0BA1)	09/2019
AI 2xI 2/4-wire ST (6ES7134-6GB00-0BA1)	04/2018
AI 4xI 2/4-wire ST (6ES7134-6GD01-0BA1)	09/2018
AI 4xTC HS (6ES7134-6JD00-0DA1)	03/2019

"Diagnostic messages" section

Diagnostic messages in the measured value of analog input modules

Each analog input module supplies the measured value $7FFF_H$ or 8000_H depending on the parameter assignment when an error is detected.

Equipment Manual AI 4xTC HS (6ES7134-6JD00-0DA1)

New section in Appendix B: "Measured values for wire break and reference channel mode"

Table 23 Measured values for a wire break depending on enabled diagnostics and parameters in TC operating mode

Parameters			Measured value		Explanation
Wire break check	Diagnostics wire break	Diagnostics underflow			
Enable	Enable	*	32767	$7FFF_H$	The "wire break" diagnostics is reported.
Enable	Disable	*	32767	$7FFF_H$	No diagnostics reported. A wire break check is carried out (i.e. test current flows).
Disable	Disable	*	Undefined		No "wire break" diagnostics is reported. No wire break check is carried out (i.e. no test current flows). This is required to calibrate thermocouples, since the test current necessary for a wire break check leads to measurement errors during calibration.

* Parameter assignment not relevant

Table 24 Measured values for a wire break in a TC measurement with enabled reference junction (reference channel) depending on enabled diagnostic information and parameters

Case	Parameters					Measured value			
	Reference channel		TC channel			Reference channel		TC channel	
	Diagnostics Wire break	Diagnostics underflow	Wire break check	Diagnostics wire break	Diagnostics underflow				
1	Enable[3]	*[3]	*	*	*[1]	32767[3]	$7FFF_H$[3]	32767[2]	$7FFF_H$[2]
2	Disable[3]	*[3]	*	*	*[1]	32767[3]	$7FFF_H$[3]	32767[2]	$7FFF_H$[2]
3	*	*	Enable[3]	Enable[3]	*[3]	Valid	Valid	32767[3]	$7FFF_H$[3]
4	*	*	Enable[3]	Disable[3]	*[3]	Valid	Valid	32767[3]	$7FFF_H$[3]
5	*	*	Disable[3]	Disable[3]	*[3]	Valid	Valid	Undefined[3]	

* Parameter assignment not relevant

1 Diagnostics is suppressed in the event of a reference channel error.

2 Measured value taken from the reference channel

3 Channel with line break

Explanations of the cases:

Case	Reference channel	TC channel
1	The "wire break" diagnostics is reported. This has a higher priority than the "Underflow" diagnostics.*	The "Reference channel error" diagnostics is reported if this is enabled. Where own pending diagnostic information ("overflow" or "underflow") is reported as outgoing. Wire break diagnostics is detected independently of the measured value and has the same priority as the "Reference channel error" diagnostics. Both items of diagnostic information can be pending simultaneously. The measured value of the reference channel (RTD channel) is adopted for the TC channel. The validity of the measured value of the TC channel is irrelevant.
2	No diagnostics reported. A wire break check is carried out (i.e. test current flows).*	*Behavior corresponds to case 1.*
3	*(Measured values are in the valid measuring range)*	The "wire break" diagnostics is reported.*
4	*(Measured values are in the valid measuring range)*	No diagnostics reported. A wire break check is carried out (i.e. test current flows).*
5	*(Measured values are in the valid measuring range)*	No "wire break" diagnostics is reported. No wire break check is carried out (i.e. no test current flows). This is required to calibrate thermocouples, since the test current necessary for a wire break check leads to measurement errors during calibration.*

* Channel with wire break

Communications module manuals

Communications module CM DP, Edition 12/2014

The communications module CM DP supports the PROFIsafe protocol V2.
Exception: Fail-safe modules that only support PROFIsafe V1 mode.

Communications module IO-Link Master CM 4xIO-Link, Edition 10/2017

Section "Connecting, Wiring and block diagram"

Connection: 2-wire and 3-wire connection in DQ operating mode:

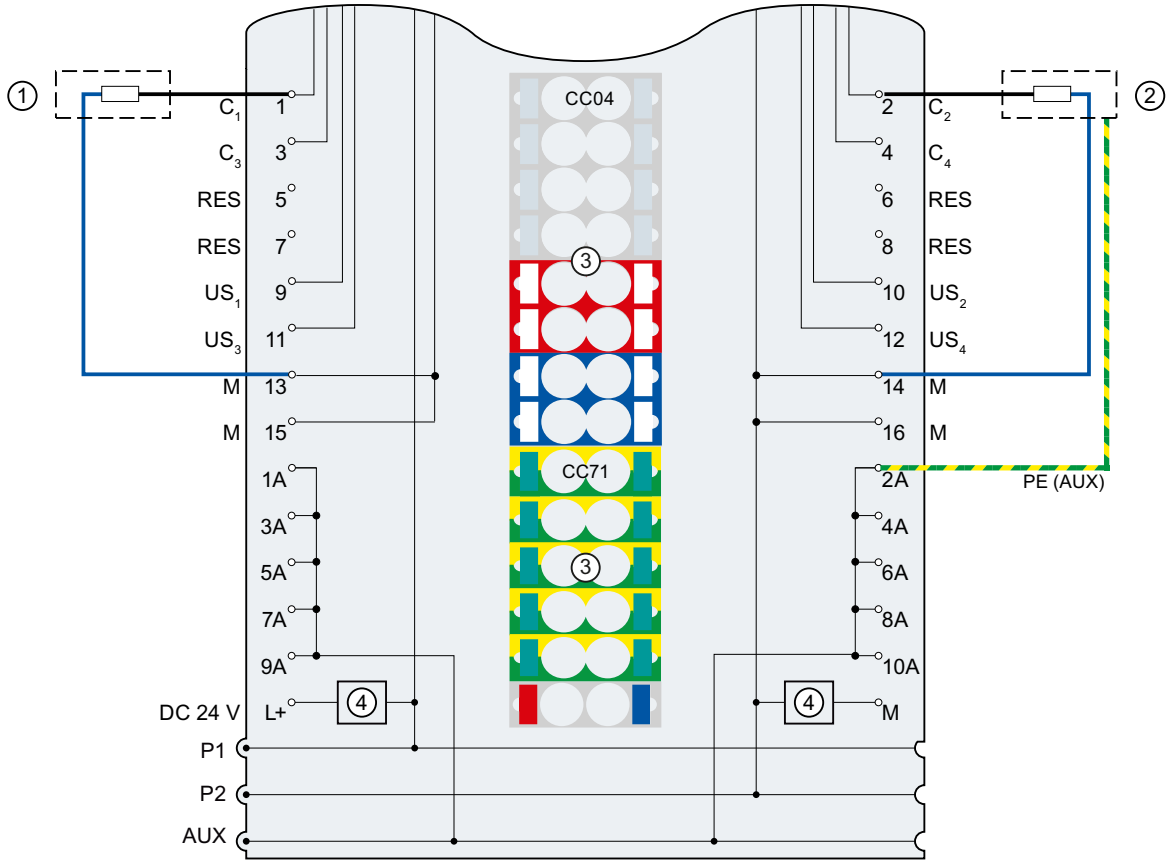

①	2-wire connection	1 A ... 10 A	AUX terminals
②	3-wire connection	PE (AUX)	Protective conductor connection
③	Color-coded labels with color code CC04 and CC71 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to the left (dark-colored BaseUnit) Connection to the left interrupted (light-colored BaseUnit)
④	Supply voltage filter circuit (only when light-colored BaseUnit is present)	C_n	Communication signal, DI, DQ
24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)	RES	Reserved, must not be assigned
M	Ground	US_n	Supply voltage (positive)

Figure 14 Terminal assignment for 2-wire and 3-wire connection in DQ operating mode

Section "Replacement of the IO-Link Master CM 4xIO-Link communication module with an electronic coding element type H"

The "IO_LINK_MASTER" function block is now called "LIOLink_Master".

Using ET 200SP higher than 2 000 m above sea level.

Ambient temperature and installation altitude

Extension of the temperature range and the installation altitude

The previously permissible ambient temperature range of **0 °C** to 60 °C has been extended for a large number of modules to an ambient temperature range of **-30 °C** to 60 °C or **-25 °C** to 60 °C (in each case without condensation or icing). In addition, depending on the module, the permitted installation altitudes has been extended to installation heights of up to 5 000 meters.

The accessory components offered for ET 200SP (labeling strips, shield terminals, mounting rails, front connectors, etc.) can also be used down to -30 °C and for altitudes up to 5 000 m.

The following tables show an overview of the current climatic ambient conditions for ambient temperature and installation altitude of modules of the ET 200SP product family. For modules that are not listed, the current information in the "Technical specifications" section of the corresponding Equipment Manual applies.

Reference

You can find the current status of the respective modules in the technical specifications published online.

In general, the module-dependent extended climatic operating conditions are described in the "Technical specifications" section of the respective modules in the Equipment Manuals.

Constraints on operating ET 200SP at altitudes > 2 000 m are described in SIMATIC ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Shipping and storage conditions for modules

ET 200SP meets the requirements of IEC 61131-2 regarding transport and storage conditions. The following information applies to modules that are shipped and/or stored in their original packaging.

Type of condition	Permitted range
Air pressure	1140 to 540 hPa (corresponds to an altitude of -1 000 to 5 000 m above sea level)

Listing of the modules

CPUs

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
CPU	CPU 1510 SP-1 PN	6ES7510-1DJ01-0AB0	-25 to +60	FS 05	5 000
CPU	CPU 1512 SP-1 PN	6ES7512-1DK01-0AB0	-25 to +60	FS 05	5 000
CPU	CPU 1510 SP F-1 PN	6ES7510-1SJ01-0AB0	-25 to +60	FS 03	5 000
CPU	CPU 1512 SP F-1 PN	6ES7512-1SK01-0AB0	-25 to +60	FS 03	5 000
CPU	CPU 1510 SP-1 PN	6ES7510-1DK03-0AB0	-30 to +60	FS 01	5 000
CPU	CPU 1512 SP-1 PN	6ES7512-1DM03-0AB0	-30 to +60	FS 01	5 000
CPU	CPU 1514SP-2 PN	6ES7514-2DN03-0AB0	-30 to +60	FS 01	5 000
CPU	CPU 1514SP T-2 PN	6ES7514-2VN03-0AB0	-30 to +60	FS 01	5 000
CPU	CPU 1510 SP F-1 PN	6ES7510-1SK03-0AB0	-30 to +60	FS 01	5 000

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
CPU	CPU 1512 SP F-1 PN	6ES7512-1SM03-0AB0	-30 to +60	FS 01	5 000
CPU	CPU 1514SP F-2 PN	6ES7514-2SN03-0AB0	-30 to +60	FS 01	5 000
CPU	CPU 1514SP TF-2 PN	6ES7514-2WN03-0AB0	-30 to +60	FS 01	5 000
CP	CP 1542SP-1	6GK7542-6UX00-0XE0	-30 to +60	FS 01	2 000
CP	CP 1542SP-1 IRC	6GK7542-6VX00-0XE0	-30 to +60	FS 01	2 000
CP	CP 1543SP-1	6GK7543-6WX00-0XE0	-30 to +60	FS 01	2 000
Open Controller	CPU 1515SP PC, 32-bit	6ES7677-2AA31-0EB0	0 to +60	FS 07	2 000
Open Controller	CPU 1515SP PC F, 32-bit	6ES7677-2FA31-0EB0	0 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC, WES7P	6ES7677-2AA41-0FB0	0 to +60	FS 06	2 000
Open Controller	CPU 1515SP PC, WES7P + HMI (128PT)	6ES7677-2AA41-0FK0	0 to +60	FS 06	2 000
Open Controller	CPU 1515SP PC, WES7P + HMI (512PT)	6ES7677-2AA41-0FL0	0 to +60	FS 06	2 000
Open Controller	CPU 1515SP PC, WES7P + HMI (2kPT)	6ES7677-2AA41-0FM0	0 to +60	FS 06	2 000
Open Controller	CPU 1515SP PC F, WES7P	6ES7677-2FA41-0FB0	0 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC F, WES7P + HMI (128PT)	6ES7677-2FA41-0FK0	0 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC F, WES7P + HMI (512PT)	6ES7677-2FA41-0FL0	0 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC F, WES7P + HMI (2kPT)	6ES7677-2FA41-0FM0	0 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC2	6ES7677-2DB42-0GB0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 + HMI (128PT)	6ES7677-2DB42-0GK0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 + HMI (512PT)	6ES7677-2DB42-0GL0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 + HMI (2kPT)	6ES7677-2DB42-0GM0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 F	6ES7677-2SB42-0GB0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 F + HMI (128PT)	6ES7677-2SB42-0GK0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 F + HMI (512PT)	6ES7677-2SB42-0GL0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 F + HMI (2kPT)	6ES7677-2SB42-0GM0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 (Ready4Linux)	6ES7677-2DB40-0GB0	-20 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC2 F (Ready4Linux)	6ES7677-2SB40-0GB0	-20 to +60	FS 03	2 000
Open Controller	CPU 1515SP PC2 T	6ES7677-2VB42-0GB0	-20 to +60	FS 04	2 000

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
Open Controller	CPU 1515SP PC2 T + HMI (128PT)	6ES7677-2VB42-0GK0	-20 to +60	FS 01	2 000
Open Controller	CPU 1515SP PC2 T + HMI (512PT)	6ES7677-2VB42-0GL0	-20 to +60	FS 01	2 000
Open Controller	CPU 1515SP PC2 T + HMI (2kPT)	6ES7677-2VB42-0GM0	-20 to +60	FS 01	2 000
Open Controller	CPU 1515SP PC2 TF	6ES7677-2WB42-0GB0	-20 to +60	FS 04	2 000
Open Controller	CPU 1515SP PC2 TF + HMI (128PT)	6ES7677-2WB42-0GK0	-20 to +60	FS 01	2 000
Open Controller	CPU 1515SP PC2 TF + HMI (512PT)	6ES7677-2WB42-0GL0	-20 to +60	FS 01	2 000
Open Controller	CPU 1515SP PC2 TF + HMI (2kPT)	6ES7677-2WB42-0GM0	-20 to +60	FS 01	2 000

PFDavg and PFH values for F-CPUs for operating altitudes up to 3 000 m or 5 000 m.

Below you will find the probability of failure values (PFDavg and PFH values) for the fail-safe CPUs mentioned in the table with a service life of 20 years and a repair time of 100 hours:

Operation in low demand mode in accordance with IEC 61508:2010: PFDavg = Average probability of a dangerous failure on demand	Operation in high demand/continuous mode in accordance with IEC 61508:2010: PFH = Average frequency of a dangerous failure [h-1]
< 2E-05	< 1E-09 at an installation altitude ≤ 3 000 < 2E-09 at an installation altitude > 3 000 m to 5 000 m

Interface modules

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
IM	IM 155-6 PN BA	6ES7155-6AR00-0AN0	-30 to +60	FS 04	5 000
IM	IM 155-6 PN ST incl. BA 2xRJ45	6ES7155-6AA01-0BN0	0 to +60	FS 01	5 000
IM	IM 155-6 PN ST	6ES7155-6AU02-0BN0	-30 to +60	FS 01	5 000
IM	IM 155-6 PN/2 HF	6ES7155-6AU01-0CN0	-30 to +60	FS 02	5 000
IM	IM 155-6 PN/3 HF 3-port	6ES7155-6AU30-0CN0	-30 to +60	FS 02	5 000
IM	IM 155-6 MF HF	6ES7155-6MU01-0CN0	-30 to +60	FS 01	5 000
IM	IM 155-6 PN HS	6ES7155-6AU00-0DN0	-25 to +60	FS 02	5 000
IM	IM 155-6 DP HF - Bundle	6ES7155-6BA01-0CN0	0 to +60	FS 01	5 000
IM	IM 155-6 DP HF	6ES7155-6BU01-0CN0	0 to +60	FS 01	5 000
IM	Server module (spare part)	6ES7193-6PA00-0AA0	-30 to +60	FS 07	5 000

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
BA	BA 2x RJ45	6ES7193-6AR00-0AA0	-30 to +60	FS 06	5 000
BA	BA 2x FC	6ES7193-6AF00-0AA0	-30 to +60	FS 04	5 000
BA	BA 2x M12	6ES7193-6AM00-0AA0	-30 to +60	FS 01	5 000
BA	BA 2x LC	6ES7193-6AG00-0AA0	-30 to +60	FS 05	5 000
BA	BA LC/RJ45	6ES7193-6AG20-0AA0	-30 to +60	FS 04	5 000
BA	BA LC/FC	6ES7193-6AG40-0AA0	-30 to +60	FS 04	5 000
BA	BA 2x LC-LD	6ES7193-6AG50-0AA0	-30 to +60	FS 01	5 000
BA	BA LC-LD/RJ45	6ES7193-6AG60-0AA0	-30 to +60	FS 01	5 000
BA	BA LC-LD/M12	6ES7193-6AG70-0AA0	-30 to +60	FS 01	5 000
BA	BA 2x SCRJ	6ES7193-6AP00-0AA0	-25 to +60	FS 04	5 000
BA	BA SCRJ/RJ45	6ES7193-6AP20-0AA0	-25 to +60	FS 04	5 000
BA	BA SCRJ/FC	6ES7193-6AP40-0AA0	-25 to +60	FS 04	5 000
BA	DP connector	6ES7972-0BB70-0XA0	-25 to +60	FS 03	2 000
BA	BA-SEND BA 1xFC	6ES7193-6AS00-0AA0	-30 to +60	FS 05	2 000

Digital input modules

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
DI	DI 4x120...230VAC ST	6ES7131-6FD01-0BB1	-30 to +60	FS 02	2 000
DI	DI 8x24VDC BA	6ES7131-6BF01-0AA0	-30 to +60	FS 03	5 000
DI	DI 8x24VDC BA (PU* 10) [1]	6ES7131-6BF01-2AA0	-30 to +60	FS 03	5 000
DI	DI 8x24VDC SRC BA	6ES7131-6BF61-0AA0	-30 to +60	FS 02	5 000
DI	DI 8x24VAC/48VUC BA	6ES7131-6CF00-0AU0	-30 to +60	FS 02	4 000 (48VAC/48VDC)
DI	DI 8x24VDC ST	6ES7131-6BF01-0BA0	-30 to +60	FS 02	5 000
DI	DI 8x24VDC ST (PU* 10) [1]	6ES7131-6BF01-2BA0	-30 to +60	FS 02	5 000
DI	DI 8x24VDC HF	6ES7131-6BF00-0CA0	-30 to +60	FS 07	5 000
DI	DI 8x24VDC HF (PU* 10) [1]	6ES7131-6BF00-2CA0	-30 to +60	FS 07	5 000
DI	DI 8xNAMUR HF	6ES7131-6TF00-0CA0	-30 to +60	FS 04	5 000
DI	DI 8x24VDC HS	6ES7131-6BF00-0DA0	-30 to +60	FS 04	5 000

[1] Packaging unit: Pack of 10

[2] As of revision FS 04

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
DI	DI 16x24VDC ST	6ES7131-6BH01-0BA0	-30 to +60	FS 02	5 000
DI	DI 16x24VDC ST (PU* 10) [1]	6ES7131-6BH01-2BA0	-30 to +60	FS 02	5 000
F-DI	F-DI 8x24VDC HF	6ES7136-6BA00-0CA0	0 to +60	FS 04	4 000 [2]
F-DI	F-DI 8x24VDC HF	6ES7136-6BA01-0CA0	0 to +60	FS 01	4 000

1 Packaging unit: Pack of 10

2 As of revision FS 04

Digital output modules

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
DQ	DQ 8x24VDC/0.5A BA	6ES7132-6BF01-0AA0	-30 to +60	FS 02	5 000
DQ	DQ 8x24VDC/0.5A BA (PU* 10) [1]	6ES7132-6BF01-2AA0	-30 to +60	FS 02	5 000
DQ	DQ 8x24VDC/0,5A SNK BA	6ES7132-6BF61-0AA0	-25 to +60	FS 02	5 000
DQ	DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0	-30 to +60	FS 08	5 000
DQ	DQ 4x24VDC/2A ST (PU* 10) [1]	6ES7132-6BD20-2BA0	-30 to +60	FS 08	5 000
DQ	DQ 4x24...230VAC/2A ST	6ES7132-6FD00-0BB1	-30 to +60	FS 05	3 000 (277 VAC)
DQ	DQ 4x24...230VAC/2A ST (PU* 10) [1]	6ES7132-6FD00-2BB1	-30 to +60	FS 05	3 000 (277 VAC)
DQ	DQ 4x24VDC/2A HF	6ES7132-6BD20-0CA0	-30 to +60	FS 06	5 000
DQ	DQ 4x24..230VAC/2A HF	6ES7132-6FD00-0CU0	-30 to +60	FS 04	3 000 (277 VAC)
DQ	DQ 4x24VDC/2A HS	6ES7132-6BD20-0DA0	-30 to +60	FS 05	5 000
DQ	DQ 16x24VDC/0.5A BA	6ES7132-6BH00-0AA0	-30 to +60	FS 03	5 000
DQ	DQ 16x24VDC/0.5A BA (PU* 10) [1]	6ES7132-6BH00-2AA0	-30 to +60	FS 03	5 000
DQ	DQ 8x24VDC/0.5A ST	6ES7132-6BF01-0BA0	-30 to +60	FS 02	5 000
DQ	DQ 8x24VDC/0.5A ST (PU* 10) [1]	6ES7132-6BF01-2BA0	-30 to +60	FS 02	5 000
DQ	DQ 8x24VDC/0.5A HF	6ES7132-6BF00-0CA0	-30 to +60	FS 07	5 000
DQ	DQ 8x24VDC/0.5A HF (PU* 10) [1]	6ES7132-6BF00-2CA0	-30 to +60	FS 07	5 000
DQ	DQ 16x24VDC/0.5A ST	6ES7132-6BH01-0BA0	-30 to +60	FS 03	5 000

1 Packaging unit: Pack of 10

2 As of revision FS 04

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
DQ	DQ 16x24VDC/0.5A ST (PU* 10) [1]	6ES7132-6BH01-2BA0	-30 to +60	FS 03	5 000
F-DQ	F-DQ 4x24VDC/2A PM HF	6ES7136-6DB00-0CA0	0 to +60	FS 04	4 000 [2]
F-DQ	F-DQ 8x24VDC/0.5A PP HF	6ES7136-6DC00-0CA0	0 to +60	FS 01	4 000
RQ	RQ 4x24VUC/2A CO ST	6ES7132-6GD51-0BA0	-30 to +60	FS 02	2 000
RQ	RQ 4x120VDC-230VAC/5A NO ST	6ES7132-6HD01-0BB1	-30 to +60	FS 02	2 000
RQ	RQ 4x120VDC-230VAC/5A NO ST (PU* 10)	6ES7132-6HD01-2BB1	-30 to +60	FS 02	2 000
RQ	RQ 4x120VDC-230VAC/5A NO MA ST	6ES7132-6MD00-0BB1	-30 to +60	FS 03	2 000
RQ	RQ 3x120VDC-230VAC/5A CO ST	6ES7132-6HC50-0BU0	-30 to +60	FS 01	2 000
RQ	RQ 3x120VDC-230VAC/5A CO n.i. ST	6ES7132-6HC70-0BU0	-30 to +60	FS 01	2 000
F-RQ	F-RQ 1x24VDC/24..230VAC/5A ST	6ES7136-6RA00-0BF0	0 to +60	FS 01	2 000

1 Packaging unit: Pack of 10

2 As of revision FS 04

Analog modules

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
AI	AI 2xI 2/4-wire ST	6ES7134-6GB00-0BA1	-30 to +60	FS 04	5 000
AI	AI 2xU ST	6ES7134-6FB00-0BA1	-30 to +60	FS 04	5 000
AI	AI 2xU/I 2/4-wire HF	6ES7134-6HB00-0CA1	-30 to +60	FS 06	5 000
AI	AI 2xU/I 2-/4-wire HS	6ES7134-6HB00-0DA1	-30 to +60	FS 07	5 000
AI	AI 2x SG 4-/6-wire HS	7MH4134-6LB00-0DA0	-25 to +60	FS 01	3 000
AI	AI 4xI 2-wire 4...20mA HART HF	6ES7134-6TD00-0CA1	-30 to +60	FS 01	5 000
AI	AI 4xI 2-/4-wire ST	6ES7134-6GD01-0BA1	-30 to +60	FS 02	5 000
AI	AI 4xI 2-/4-wire ST (PU* 10) [1]	6ES7134-6GD01-2BA1	-30 to +60	FS 02	5 000
AI	AI 4xU/I 2-wire ST	6ES7134-6HD01-0BA1	-30 to +60	FS 02	5 000
AI	AI 4xU/I 2-wire ST (PU* 10) [1]	6ES7134-6HD01-2BA1	-30 to +60	FS 02	5 000
AI	AI 8xI 2/4-wire BA	6ES7134-6GF00-0AA1	-30 to +60	FS 04	5 000

1 Packaging unit: Pack of 10

2 Installation altitude higher than 2 000 m on request

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
AI	AI 8xU BA	6ES7134-6FF00-0AA1	-30 to +60	FS 04	5 000
AI	AI 4xTC HS	6ES7134-6JD00-0DA1	-30 to +60	FS 02	5 000
AI	AI 4xRTD/TC 2-/3-/4-wire HF	6ES7134-6JD00-0CA1	-30 to +60	FS 08	5 000
AI	AI 4xRTD/TC 2-/3-/4-wire HF (PU* 10) [1]	6ES7134-6JD00-2CA1	-30 to +60	FS 08	5 000
AI	AI 8xRTD/TC 2-wire HF	6ES7134-6JF00-0CA1	-30 to +60	FS 05	5 000
AI	AI 8xRTD/TC 2-wire HF (PU* 10) [1]	6ES7134-6JF00-2CA1	-30 to +60	FS 05	5 000
AI	AI Energy Meter 400V ST	6ES7134-6PA01-0BD0	0 to +60	FS 01	3 000
AI	AI Energy Meter 480V ST	6ES7134-6PA20-0BD0	0 to +60	FS 01	3 000
AI	AI Energy Meter HF CT	6ES7134-6PA00-0CU0	-30 to +60	FS 01	2 000 [2]
AI	AI Energy Meter HF RC	6ES7134-6PA20-0CU0	-30 to +60	FS 01	2 000 [2]
F-AI	F-AI 4XI (0)4..20mA HF	6ES7136-6AA00-0CA1	0 to +60	FS 01	4 000
F-AI	F-AI 4xU 0..10V HF	6ES7136-6AB00-0CA1	0 to +60	FS 01	4 000
AQ	AQ 2xI ST	6ES7135-6GB00-0BA1	-30 to +60	FS 03	5 000
AQ	AQ 2xU ST	6ES7135-6FB00-0BA1	-30 to +60	FS 03	5 000
AQ	AQ 2xU/I HF	6ES7135-6HB00-0CA1	-30 to +60	FS 04	5 000
AQ	AQ 2xU/I HS	6ES7135-6HB00-0DA1	-30 to +60	FS 06	5 000
AQ	AQ 4xU/I ST	6ES7135-6HD00-0BA1	-30 to +60	FS 07	5 000
AQ	AQ 4xI HART HF	6ES7135-6TD00-0CA1	-30 to +60	FS 01	5 000

1 Packaging unit: Pack of 10

2 Installation altitude higher than 2 000 m on request

Technology modules and communication modules

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
TM	TM Count 1x24V	6ES7138-6AA01-0BA0	-30 to +60	FS 03	5 000
TM	TM Count 1x24V (PU* 10) [1]	6ES7138-6AA01-2BA0	-30 to +60	FS 03	5 000
TM	TM PosInput 1	6ES7138-6BA01-0BA0	-30 to +60	FS 03	5 000
TM	TM PosInput 1 (PU* 10) [1]	6ES7138-6BA01-2BA0	-30 to +60	FS 03	5 000
TM	TM Timer DIQ 10x24V	6ES7138-6CG00-0BA0	-30 to +60	FS 03	5 000
TM	TM Pulse 2x24V	6ES7138-6DB00-0BB1	-30 to +60	FS 03	5 000

1 Packaging unit: Pack of 10

2 As of revision FS 05

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
TM	TM PTO 2x24V	6ES7138-6EB00-0BA0	-30 to +60	FS 00	5 000
TM	TM WP321 1x5VDC#1-4mV/V ST	7MH4138-6AA00-0BA0	-25 to +60	FS 04	5 000
TM	TM WP351 HF	7MH4138-6BA00-0CU0	-30 to +60	FS 01	5 000
TM	TM ECC PL ST	6FE1242-6TM20-0BB1	-30 to +60	FS 00	2 000
TM	TM ECC 2xPWM ST	6FE1242-6TM10-0BB1	-30 to +60	FS 00	2 000
TM	Pneumatic valve island Airline SP 8647	Bürkert	0 to +55	-	2 000
TM	TM StepDrive 1x24..48V/5A*	phytron 10020273	0 to +60	-	2 000
TM	TM SITRANS FCT070	7ME4138-6AA00-0BB1	-30 to +60	FS 00	2 000
F-TM	F-TM ServoDrive 1x24..48V 5A ST	6BK1136-6AB00-0BU0	-30 to +60	FS 00	3 000
CM	CM PtP	6ES7137-6AA00-0BA0	-30 to +60	FS 03	5 000
CM	CM 1xDALI	6ES7137-6CA00-0BU0	-30 to +60	FS 03	3 000
CM	CM 4xIO-Link	6ES7137-6BD00-0BA0	-30 to +60	FS 03	2 000
CM	CM DP (für CPU)	6ES7545-5DA00-0AB0	-25 to +60	FS 04	5 000
CM	CM AS-I MASTER ST (AS-I V3.0)	3RK7137-6SA00-0BC1	-25 to +60	FS 20	2 000
CM	CM CAN	6ES7137-6EA00-0BA0	-30 to +60	FS 03	5 000
F-CM	F-CM AS-I SAFETY ST	3RK7136-6SC00-0BC1	0 to +60	FS 01	2 000
F-PM-E	F-PM-E 24VDC/8A PPM ST	6ES7136-6PA00-0BC0	0 to +60	FS 05	4 000 [2]

[1] Packaging unit: Pack of 10

[2] As of revision FS 05

Information on PFDavg, PFH values for ET 200SP fail-safe I/O modules

The safety parameters specified in the Equipment Manual of the fail-safe I/O module ET 200SP (PFD_{avg}, PFH values) already reflect the influence of higher cosmic radiation (soft error rate) for operation up to 4 000 m above sea level.

Motor starters and BaseUnits BU type P0

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
MS	DS 0.1 - 0.4A HF	3RK1308-0AA00-0CP0	-25 to +60	FS 01	4 000
MS	DS 0.3 - 1 A HF	3RK1308-0AB00-0CP0	-25 to +60	FS 01	4 000
MS	DS 0.9 - 3 A HF	3RK1308-0AC00-0CP0	-25 to +60	FS 01	4 000
MS	DS 2.8 - 9 A HF	3RK1308-0AD00-0CP0	-25 to +60	FS 01	4 000

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
MS	DS 4.0 - 12 A HF	3RK1308-0AE00-0CP0	-25 to +60	FS 01	4 000
MS	RS 0.1 - 0.4A HF	3RK1308-0BA00-0CP0	-25 to +60	FS 01	4 000
MS	RS 0.3 - 1 A HF	3RK1308-0BB00-0CP0	-25 to +60	FS 01	4 000
MS	RS 0.9 - 3 A HF	3RK1308-0BC00-0CP0	-25 to +60	FS 01	4 000
MS	RS 2.8 - 9 A HF	3RK1308-0BD00-0CP0	-25 to +60	FS 01	4 000
MS	RS 4.0 - 12 A HF	3RK1308-0BE00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-DS 0.1 - 0.4A HF	3RK1308-0CA00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-DS 0.3 - 1 A HF	3RK1308-0CB00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-DS 0.9 - 3 A HF	3RK1308-0CC00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-DS 2.8 - 9 A HF	3RK1308-0CD00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-DS 4.0 - 12 A HF	3RK1308-0CE00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-RS 0.1 - 0.4A HF	3RK1308-0DA00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-RS 0.3 - 1 A HF	3RK1308-0DB00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-RS 0.9 - 3 A HF	3RK1308-0DC00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-RS 2.8 - 9 A HF	3RK1308-0DD00-0CP0	-25 to +60	FS 01	4 000
F-MS	F-RS 4.0 - 12 A HF	3RK1308-0DE00-0CP0	-25 to +60	FS 01	4 000
BU type P0	BU30-MS1	3RK1908-0AP00-0AP0	-25 to +60	FS 01	4 000
BU type P0	BU30-MS3	3RK1908-0AP00-0BP0	-25 to +60	FS 01	4 000
BU type P0	BU30-MS2	3RK1908-0AP00-0CP0	-25 to +60	FS 01	4 000
BU type P0	BU30-MS4	3RK1908-0AP00-0DP0	-25 to +60	FS 01	4 000
BU type P0	BU30-MS5	3RK1908-0AP00-0EP0	-25 to +60	FS 01	2 000
BU type P0	BU30-MS6	3RK1908-0AP00-0FP0	-25 to +60	FS 01	2 000
BU type P0	BU30-MS7	3RK1908-0AP00-0GP0	-25 to +60	FS 01	2 000
BU type P0	BU30-MS8	3RK1908-0AP00-0HP0	-25 to +60	FS 01	2 000
BU type P0	BU30-MS9	3RK1908-0AP00-0JP0	-25 to +60	FS 01	2 000
BU type P0	BU30-MS10	3RK1908-0AP00-0KP0	-25 to +60	FS 01	2 000

BaseUnits BU type A0 and A1

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
BU type A0	BU15-P16+A0+2B	6ES7193-6BP00-0BA0	-30 to +60	FS 06	5 000
BU type A0	BU15-P16+A0+2B (PU* 10) [1]	6ES7193-6BP00-2BA0	-30 to +60	FS 06	5 000

[1] Packaging unit: Pack of 10

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
BU type A0	BU15-P16+A0+2D	6ES7193-6BP00-0DA0	-30 to +60	FS 06	5 000
BU type A0	BU15-P16+A0+2D (PU* 10) [1]	6ES7193-6BP00-2DA0	-30 to +60	FS 06	5 000
BU type A0	BU15 double BU+2B	6ES7193-6BP60-0BA0	-30 to +60	FS 03	5 000
BU type A0	BU15 double BU+2DB	6ES7193-6BP60-0DA0	-30 to +60	FS 03	5 000
BU type A0	BU15-P16+A10+2B	6ES7193-6BP20-0BA0	-30 to +60	FS 06	5 000
BU type A0	BU15-P16+A10+2B (PU* 10) [1]	6ES7193-6BP20-2BA0	-30 to +60	FS 06	5 000
BU type A0	BU15-P16+A10+2D	6ES7193-6BP20-0DA0	-30 to +60	FS 07	5 000
BU type A0	BU15-P16+A10+2D (PU* 10) [1]	6ES7193-6BP20-2DA0	-30 to +60	FS 07	5 000
BU type A1	BU15-P16+A0+2B/T	6ES7193-6BP00-0BA1	-30 to +60	FS 06	5 000
BU type A1	BU15-P16+A0+2D/T	6ES7193-6BP00-0DA1	-30 to +60	FS 06	5 000
BU type A1	BU15-P16+A0+12B/T	6ES7193-6BP40-0BA1	-30 to +60	FS 06	5 000
BU type A1	BU15-P16+A0+12D/T	6ES7193-6BP40-0DA1	-30 to +60	FS 07	5 000

[1] Packaging unit: Pack of 10

BaseUnits BU type B0 bis U0

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
BU type B0	BU20-P12+A4+0B	6ES7193-6BP20-0BB0	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type B0	BU20-P12+A4+0B (PU* 10) [1]	6ES7193-6BP20-2BB0	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type B1	BU20-P12+A0+4B	6ES7193-6BP20-0BB1	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type B1	BU20-P12+A0+4B (PU* 10) [1]	6ES7193-6BP20-2BB1	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 VAC)

[1] Packaging unit: Pack of 10

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
BU type C0	BU20-P6+A2+4D	6ES7193-6BP20-0DC0	-30 to +60	FS 03	5 000 (SELV/PELV supplied)
BU type C1	BU20-P6+A2+4B	6ES7193-6BP20-0BC1	-30 to +60	FS 03	5 000 (SELV/PELV supplied)
BU type D0	BU20-P12+A0+0B	6ES7193-6BP00-0BD0	-30 to +60	FS 04	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type E0	BaseUnit BU-SEND	6ES7193-6BN00-0NE0	-30 to +60	FS 04	2 000
BU type F0	BU20-P8+A4+0B	6ES7193-6BP20-0BF0	-30 to +60	FS 04	2 000
BU type U0	BU20-P16+A0+2B	6ES7193-6BP00-0BU0	-30 to +60	FS 03	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type U0	BU20-P16+A0+2B (PU* 10) [1]	6ES7193-6BP00-2BU0	-30 to +60	FS 03	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type U0	BU20-P16+A0+2D	6ES7193-6BP00-0DU0	-30 to +60	FS 03	5 000 (SELV/PELV supplied) 3 000 (277 VAC)
BU type U0	BU20-P16+A0+2D (PU* 10) [1]	6ES7193-6BP00-2DU0	-30 to +60	FS 03	5 000 (SELV/PELV supplied) 3 000 (277 VAC)

[1] Packaging unit: Pack of 10

Potential distributor

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
PotDis	PotDis-BU-P1/D-R	6ES7193-6UP00-0DP1	-30 to +60	FS 04	5 000
PotDis	PotDis-BU-P1/B-R	6ES7193-6UP00-0BP1	-30 to +60	FS 04	5 000

[1] Packaging unit: Pack of 5

Type	Name	Article number	Ambient temperature		Maximum installation altitude above sea level [m]
			Temperature range [°C]	As of revision	
PotDis	PotDis-BU-P2/D-B	6ES7193-6UP00-0DP2	-30 to +60	FS 04	5 000
PotDis	PotDis-BU-P2/B-B	6ES7193-6UP00-0BP2	-30 to +60	FS 04	5 000
PotDis	PotDis TB P1-R	6ES7193-6TP00-0TP1	-30 to +60	FS 03	5 000
PotDis	PotDis TB P2-B	6ES7193-6TP00-0TP2	-30 to +60	FS 03	5 000
PotDis	PotDis TB BR-W	6ES7193-6TP00-0TP0	-30 to +60	FS 03	5 000
PotDis	PotDis TB n.c.-G	6ES7193-6TP00-0TN0	-30 to +60	FS 03	5 000
BU cover	BU cover - 15 mm (PU* 5) [1]	6ES7133-6CV15-1AM0	-40 to +60	FS 01	5 000
BU cover	BU cover - 20 mm (PU* 5) [1]	6ES7133-6CV20-1AM0	-40 to +60	FS 01	5 000

[1] Packaging unit: Pack of 5

Restrictions

Restrictions of the max. ambient temperature specified with regard to the installation altitude

Installation altitude	Derating factor for ambient temperature [1)]
-1 000 to 2 000 m	1.0
2 000 to 3 000 m	0.9
3 000 to 4 000 m	0.8
4 000 to 5 000 m	0.7

[1)] Base value for the application of the derating factor is the maximum permissible ambient temperature in °C for 2 000 m

NOTE

- Linear interpolation between altitudes is permissible.
- The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.
- Note the mounting position of the respective module in the technical specifications. This is based on the IEC 61131-2 standard.
- Make sure that the power supplies you use are also rated for altitudes > 2 000 m.
- The "Safety-related shutdown of standard modules" function, as described in the Internet (https://support.industry.siemens.com/cs/ww/en/view/39198632), is only approved up to a maximum of 2 000 m.

Effects on availability

The higher cosmic radiation present during operation at altitudes over 2 000 m above sea level also starts to have an effect on the error rate of electronic components (referred to as the soft error rate). In rare cases, this can result in a transition of the module into the safe state, especially for Safety Modules. However, the functional safety of the module is fully retained.

NOTE

Information printed on the ET 200SP automation system components

The markings and approvals printed on the components of the ET 200SP automation system are currently based on operation at an altitude of up to 2 000 m above sea level. The fail-safe modules are certified for operation in safety mode up to the maximum altitudes indicated in the tables (As certified by the German Technical Inspectorate (https://support.industry.siemens.com/cs/us/en/view/109825198)).

SIEMENS
SIMATIC
ET 200SP
PROFIenergy product information
Product Information

PROFIenergy
Cybersecurity information

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Introduction

Introduction

PROFIenergy is a data interface based on PROFINET for switching off consumers centrally and in a coordinated manner during idle times, regardless of the manufacturer or device type. The goal is that the process is only provided with the energy that is absolutely required. The majority of the energy is saved by the process itself; the PROFINET device itself only contributes a few watts of saving potential. This operating mode is termed "pause" in PROFIenergy.

The PROFINET devices are turned off by special commands in the user program of the PROFINET IO controller. No additional hardware is required; the PROFIenergy commands are directly interpreted by the PROFINET devices.

The device which provides the PROFIenergy interface and supports the required control data record has the so-called PE-Entity, the access point for these control data records. This PE-Entity is located on the interface module as a substitute for I/O modules that do not have their own PE-Entity. I/O modules that have their own PE-Entity are always addressed directly.

Requirements

- Interface module IM 155-6 PN ST
- Interface module IM 155-6 PN HF
- ET 200SP I/O modules which support PROFIenergy
  - Digital input module DI 8x24VDC ST (6ES7131-6BF00-0BA0)
  - Digital input module DI 8x24VDC HF (6ES7131-6BF00-0CA0)
  - Digital input module DI 8xNAMUR HF (6ES7131-6TF00-0CA0)
  - Digital input module DI 8x24VDC HS (6ES7131-6BF00-0DA0)

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- Digital output module DQ 4x24VDC/2A ST (6ES7132-6BD20-0BA0)
- Digital output module DQ 4x24VDC/2A HF (6ES7132-6BD20-0CA0)
- Digital output module DQ 4x24VDC/2A HS (6ES7132-6BD20-0DA0)
- Digital output module DQ 8x24VDC/0,5A ST (6ES7132-6BF00-0BA0)
- Digital output module DQ 8x24VDC/0,5A HF (6ES7132-6BF00-0CA0)
- Digital output module DQ 16x24VDC/0,5A ST (6ES7132-6BH00-0BA0)
- Digital output module DQ 4x24..230VAC/2A ST (6ES7132-6FD00-0BB1)
- Digital output module RQ 4x24VUC/2A CO ST (6ES7132-6GD50-0BA0)
- Digital output module RQ 4x120VDC-230VAC/5A NO ST (6ES7132-6HD00-0BB0)
- Digital output module RQ 4x120VDC-230VAC/5A NO MA ST (6ES7132-6MD00-0BB1)
- Analog input module AI 2xU ST (6ES7134-6FB00-0BA1)
- Analog input module AI 2xI 2-/4-wire ST (6ES7134-6GB00-0BA1)
- Analog input module AI 4xI 2-/4-wire ST (6ES7134-6GD00-0BA1)
- Analog input module AI 2xU/I 2-/4-wire HF (6ES7134-6HB00-0CA1)
- Analog input module AI 4xU/I 2-wire ST (6ES7134-6HD00-0BA1)
- Analog input module AI 2xU/I 2-/4-wire HS (6ES7134-6HB00-0DA0)
- Analog output module AQ 2xU ST (6ES7135-6FB00-0BA1)
- Analog output module AQ 2xI ST (6ES7135-6GB00-0BA1)
- Analog output module AQ 4xU/I ST (6ES7135-6HD00-0BA1)
- Analog output module AQ 2xU/I HF (6ES7135-6HB00-0CA1)
- Analog output module AQ 2xU/I HS (6ES7135-6HB00-0DA1)
- Communication module IO-Link Master CM 4xIO-Link (6ES7137-6BD00-0BA0)

- User program for sending the parameter data record, index 3
- User program with the function blocks for controlling the PROFIenergy commands ("PE_START_END" - FB 815, "PE_CMD" - FB 816).

Procedure

1. Create the parameter data record, Index 3 in STEP 7
2. Transfer the parameter data record to the interface module with the instruction "WRREC" - SFB 53.
3. Create the user program with the FBs for controlling the PROFIenergy commands ("PE_START_END" - FB 815, "PE_CMD" - FB 816).
4. Transfer the user program to the CPU.

Additional information

- System manual ET 200SP Distributed I/O System
- Device manual Interface Module
- Device manuals Digital and Analog I/O Modules
- System manual PROFINET System Description
- You will find additional information on PROFIenergy services, parameters of the service IDs on the Internet under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order No: 3.802.
- Additional information on PROFIenergy FBs ("PE_START_END" - FB 815, "PE_CMD" - FB 816) is available in the online help for STEP 7 V5.5 as of SP2 "Help on System Functions/System Function Blocks".

Principle of operation

"Pause" control and "Pause" behavior

At the beginning and end of pauses, you enable or disable the pause function of the system; the IO controller then sends the PROFIenergy command "Start_Pause" or "End_Pause" to the PROFINET devices. The device then interprets the contents of the PROFIenergy command and switches on or off. The interface module is the PE-Entity for I/O modules with PROFIenergy capability of the ET 200SP.

Other PROFIenergy commands allow device information to be accessed during the pauses. You can use these commands to transfer the "Start_Pause" / "End_Pause" command in good time.

NOTE

A complete PROFIenergy sequence consists of the commands "Start_Pause" and "End_Pause". Always observe this sequence during programming.

LED displays

In general, PROFIenergy does not have an effect on the LED display. Please see the device manuals of the relevant I/O modules for exceptions.

Response to error detection

All channels whose pause mode is set to "PE_MODE_PROCEED" report errors as in productive operation.

The following rules apply to channels which switch to a pause mode other than "PE_MODE_PROCEED":

- All errors that are unrelated to the switch to "Pause" are reported.
- If error recognition is possible during "Pause", these errors continue to be reported.
- All error messages which are caused by the switch to "Pause" are suppressed.
- The following applies if error recognition is not possible during the "Pause":
  - The status of errors already pending before the "Pause" is retained.
  - Incoming and outgoing errors are reported once the "pause" has ended.

NOTE

Switching to "Pause" and out of "Pause" may cause an error to be reported.

Additional information

Additional information on diagnostics can be found in the I/O module device manuals.

Hardware interrupt

No hardware interrupts are triggered within the "pause". The hardware interrupts are re-evaluated when the "pause" ends.

"Pause" behavior under certain operating conditions

A "Pause" is ended in the following cases:

Table 1 Ending a "pause"

Ending a "pause"	Explanation
The supply voltage 1L+ of the interface module has failed	• The "pause" is exited. • The PROFIenergy parameter assignment is lost.
Firmware update	
Reset to factory settings	
The I/O module is pulled and plugged	
Controller stop[1]	• The "pause" is exited. • The PROFIenergy parameter assignment is retained.
Controller failure (connection interrupted)[1]	
Deactivation of the IO device[1]	
Station stop[1] • Removal of more than one I/O module (depending on the interface module used) • Dismounting of the server module	
Failure of the supply voltage L+ of the I/O module.	
Modification of the parameter settings of the I/O module during operation using data record 128	

[1] The substitute value behavior is activated.

Parameter assignment

Parameter assignment

- Parameter assignment of PROFIenergy takes place by means of the user program and parameter data record (version2), index 3. The interface module distributes the PROFIenergy parameters to the I/O modules.
- The parameter assignment of an additional pause behavior is possible immediately after the start of the previous "Pause". The required state for the following pause is activated with a new "Start_Pause" command.
- The parameter assignment can be written as often as necessary.
- The interface module checks the distribution of the parameters to the I/O modules and returns the result of the write job by means of return value. In the case of a negative return value, there are one or more I/O modules that have not accepted the parameter data record. In this case, the I/O modules respond according to their last valid PROFIenergy parameter assignment with an incoming "Start_Pause" command.
- Parameter assignment by means of the parameter data record has to be repeated in case of an I/O module failure or station failure.
- ET 200SP supports the setting for the behavior of **one** "Pause". If a different response is required for an additional "Pause", you will have to assign parameters again.

NOTE

Effect: The response (shutdown) of the I/O modules to PROFIenergy is related to the slot, which means that all channels of the slot show the same behavior.

Parameter data record

You specify which I/O modules (slots) are controlled with PROFIenergy commands in the parameter data record for PROFIenergy.

The content of the parameter data record for PROFIenergy, index 3 is described below; you can create it yourself and transmit it to the interface module.

Table 2 Parameter data record for PROFIenergy (version 2), index 3

Byte	Element		Coding	Explanation
0	Version		02_D	Cannot be modified
1	Number of blocks		01_D to n	Slots 1 to n depending • on the number of slots supported by the interface module and • the current configuration of the ET 200SP.
2	Block 1	Slot number	00_D	Unassigned
			01_D to n	I/O module slot with PROFIenergy
3		Mode	0_D: PE_MODE_PROCEED, proceed at "Pause" 1_D: PE_MODE_SHUTDOWN, shut down at "Pause" [1] 3_D: PE_MODE_LAST_VALUE, last output or measured value is retained 4_D: PE_MODE_SUBST_VALUE, substitute value "0" [2]	
:	:	:	:	
128	Block 64	Slot number	See Block 1	
129		Mode		

[1] The specific behavior depends on the used I/O module (with a digital input module, for example, the sensor supply is turned off or the outputs of an analog output module are de-energized)

[2] An analog output module (e. g. with the output range 0 mA to 20 mA, ± 20 mA) or a digital output module issues the value "0".

Error messages

The feedback data record returns the following error messages, if needed:

Table 3 Error messages

Error code	Meaning	
$80B1_H$	Impermissible length	Check the length of the data record
$80E0_H$	Error in header information	Check the data record header information
$80E1_H$	Parameter error • At least one I/O module does not support PROFIenergy • A parameter value has been incorrectly encoded	Check the content of the data record and correct the parameter assignment error before starting the "Pause". Parameter assignment errors which are not corrected can result in incorrect I/O module shutdown behavior.

PROFIenergy control data records

PROFIenergy control data records

The control data record for PROFIenergy, Index $80A0_H$, supports the following services of the Common Application Profile PROFIenergy V1.0 for the IM 155-6 PN ST, , IM 155-6 PN HF :

Table 4 Control data records for PROFIenergy

Service	Service ID	Meaning
Start pause [1]	01_H	Assuming the configured Pause behavior, suppressing all associated diagnostics data
End Pause	02_H	Leaving the pause
Query Modes	03_H	Reads the supported modes • Request List Energy Saving Modes • Request Get Mode (Energy Saving Mode Data)
PEM status	04_H	Reads the PROFIenergy status Status messages: • 00_H: PROFIenergy is ready for operation • 01_H: "Pause" is active • FF_H: "Pause" is not active
PE_Identify	05_H	Reads the supported PROFIenergy services

[1] The minimum (configurable) pause time for the ET 200SP is 10 s.

I/O modules

Digital input module

Requirements

- Digital input module DI 8x24VDC ST (6ES7131-6BF00-0BA0)
- Digital input module DI 8x24VDC HF (6ES7131-6BF00-0CA0)
- Digital input module DI 8xNAMUR HF (6ES7131-6TF00-0CA0)
- Digital input module DI 8x24VDC HS (6ES7131-6BF00-0DA0)

Display

DI 8x24VDC ST/ DI 8x24VDC HF/ DI 8x24VDC HS

- The channel LEDs are directly affected by the signal level at the terminal.
- Switching off the sensor supply also switches off the channel LED if an external sensor supply is connected.

DI 8xNAMUR

- The channel LEDs correspond to the signal state supplied by the I/O module.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is applied.

All channels which are set to "PE_MODE_PROCEED" in pause mode report errors as in productive operation.

The following applies for all channels which switch to a different pause mode:

- Sensor supply switch-off upon the start of "pause" does not result in the messages "Line break" or "Short circuit".
- "Line break" and "Short circuit" error recognition is not possible during the "pause":
  - Messages for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+
- Change in parameter assignment of I/O module with DS128
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 5 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Shut down at "Pause" [1] • Sensor supply switched off [2] • Pause substitute value: 0_B
	3_D: PE_MODE_LAST_VALUE	Last value at "pause" • Sensor supply switched off [2] • Pause substitute value: Last input value
	4_D: PE_MODE_SUBST_VALUE	Substitute value at "pause" • Sensor supply switched off [2] • Pause substitute value: Configured pause substitute value

[1] DI 8xNAMUR HF: A channel is set to "inverted". During the "pause", the PE substitute value is read in 1:1 (as in the parameter settings and not inverted again).

[2] DI 8x24VDC ST: As there is only one sensor supply for all channels, the supply can only be switched off at a "pause" if all channel parameters have been set to switch off.

Digital output modules

Requirements

- Digital output module DQ 4x24VDC/2A ST (6ES7132-6BD20-0BA0)
- Digital output module DQ 4x24VDC/2A HF (6ES7132-6BD20-0CA0)
- Digital output module DQ 4x24VDC/2A HS (6ES7132-6BD20-0DA0)
- Digital output module DQ 8x24VDC/0,5A ST (6ES7132-6BF00-0BA0)
- Digital output module DQ 8x24VDC/0,5A HF (6ES7132-6BF00-0CA0)
- Digital output module DQ 16x24VDC/0,5A ST (6ES7132-6BH00-0BA0)
- Digital output module DQ 4x24..230VAC/2A ST (6ES7132-6FD00-0BB1)
- Digital output module RQ 4x24VUC/2A CO ST (6ES7132-6GD50-0BA0)
- Digital output module RQ 4x120VDC-230VAC/5A NO ST (6ES7132-6HD00-0BB0)
- Digital output module RQ 4x120VDC-230VAC/5A NO MA ST (6ES7132-6MD00-0BB1)

Display

The channel LEDs are directly affected by the output value at the terminal.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is applied.

Line break and short circuit error recognition continues to be possible during the "pause". All channels therefore report errors as in productive operation, regardless of their pause mode.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+ (exception: The DQ 4x24..230VAC/2A ST remains in "Pause")
- Change in parameter assignment of I/O module with DS128
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 6 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Switch off at "pause" • Pause substitute value: 0_B
	3_D: PE_MODE_LAST_VALUE	Last value at "pause" • Pause substitute value: Last output value is maintained[1]
	4_D: PE_MODE_SUBST_VALUE	Substitute value at "pause" • Pause substitute value: Configured pause substitute value is output

[1] DQ 4x24VDC/2A HS: In the "Pulse width modulation" mode, the last value is output as frequency.

Analog input modules

Requirements

- Analog input module AI 2xU ST (6ES7134-6FB00-0BA1)
- Analog input module AI 2xI 2-/4-wire ST (6ES7134-6GB00-0BA1)
- Analog input module AI 4xI 2-/4-wire ST (6ES7134-6GD00-0BA1)
- Analog input module AI 2xU/I 2-/4-wire HF (6ES7134-6HB00-0CA1)
- Analog input module AI 4xU/I 2-wire ST (6ES7134-6HD00-0BA1)
- Analog input module AI 2xU/I 2-/4-wire HS (6ES7134-6HB00-0DA0)

Display

The channel LEDs are not affected by PROFIenergy.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is applied.

All channels which are set to "PE_MODE_PROCEED" in pause mode report errors as in productive operation.

The following applies for all channels which switch to a different pause mode:

- Sensor supply switch-off upon the start of "pause" does not result in the message "Line break".
- "Line break", "Short circuit", "High limit exceeded" and "Low limit exceeded" error recognition is not possible during the "pause":
  - Messages for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+
- Change in parameter assignment of I/O module with DS128
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 7 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Switch off at "pause" • Sensor supply switched off [1] • Pause substitute value: $7FFF_H$
	3_D: PE_MODE_LAST_VALUE	Last value at "pause" • Sensor supply switched off [1] • Pause substitute value: Last input value
	4_D: PE_MODE_SUBST_VALUE	Substitute value at "pause" • Sensor supply switched off [1] • Pause substitute value: Configured pause substitute value

[1] AI 2xI 2-/4-wire ST, AI 4xI 2-/4-wire ST, AI 4xU/I 2-wire ST, AI 2xU/I 2-/4-wire HS: As there is only one sensor supply for all channels, the supply can only be switched off at a "pause" if all channels have been configured to switch off.

Analog output module

Requirements

- Analog output module AQ 2xU ST (6ES7135-6FB00-0BA1)
- Analog output module AQ 2xI ST (6ES7135-6GB00-0BA1)
- Analog output module AQ 4xU/I ST (6ES7135-6HD00-0BA1)
- Analog output module AQ 2xU/I HF (6ES7135-6HB00-0CA1)
- Analog output module AQ 2xU/I HS (6ES7135-6HB00-0DA1)

Display

The channel LEDs are not affected by PROFIenergy.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is applied.

All channels which are set to "PE_MODE_PROCEED" in pause mode report errors as in productive operation.

The following applies to all channels which switch to the pause mode "PE_MODE_SHUTDOWN":

- "Line break" and "Short circuit" error recognition is not possible during the pause.
  - Messages for errors already pending before the "pause" are retained.
  - Incoming and outgoing errors are reported once the "pause" has ended.

The following applies for all channels which switch to a different pause mode:

- "Line break" and "Short circuit" error recognition continues to be possible during the pause. These errors are reported.
- The selection of an incorrect pause substitute value which does not correspond to the output range may result in the message "High limit exceeded" or "Low limit exceeded". The pause substitute output value effective at the terminal is limited to the high or low control limit for the output range.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+
- Change in parameter assignment of I/O module with DS128
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 8 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Switch off at "pause" • Outputs free from current and voltage
	3_D: PE_MODE_LAST_VALUE	Last value at "pause" • Pause substitute value: Last output value is maintained
	4_D: PE_MODE_SUBST_VALUE	Substitute value at "pause" • Pause substitute value: Configured pause substitute value is output

IO-Link Master

Requirements

Communication module IO-Link Master CM 4xIO-Link (6ES7137-6BD00-0BA0)

NOTE

The minimum pause time (10 s) must be observed. If it is undershot, problems may occur with the restart of IO-Link communication.

DI operating mode

Display

Switching off the supply voltage USn (port) also switches off the associated channel status LED Qn if an external supply voltage is connected.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is adopted.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+
- Re-assignment of the I/O module parameters
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 9 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Switch off at "pause" • Supply voltage USn (port) switched off • Pause substitute value: 0_B
	3_D: PE_MODE_LAST_VALUE	Last value at "pause" • Supply voltage USn (port) switched off • Pause substitute value: Last input value
	4_D: PE_MODE_SUBST_VALUE	Substitute value at "pause" • Supply voltage USn (port) switched off • Pause substitute value: Configured pause substitute value

DQ operating mode

Display

The channel status LEDs Qn show the output value.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is adopted.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+
- Re-assignment of the I/O module parameters
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 10 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Switch off at "pause" • Pause substitute value: 0_B
	3_D: PE_MODE_LAST_VALUE	Last value at "pause" • Pause substitute value: Last output value is maintained
	4_D: PE_MODE_SUBST_VALUE	Substitute value at "pause" • Pause substitute value: Configured pause substitute value is output

IO-Link operating mode

Display

When supply voltage USn (port) is switched off, the associated port status LED Cn and port error LED Fn are also switched off.

Response to error detection

The error "Missing supply voltage L+" is detected, reported and ends the "pause" regardless of whether the pause status is adopted.

All channels which are set to "PE_MODE_PROCEED" and "PE_MODE_LAST_VALUE" in pause mode report errors as in productive operation.

The following conditions apply to all channels (ports) which switch to a different pause mode ("PE_MODE_SHUTDOWN" and "PE_MODE_SUBST_VALUE"):

- Switching off the supply voltage USn (port) at the start of "pause" does not result in the messages "Line break" or "Short circuit".
- Error detection is not possible during the "pause" (no IO-Link device communication):
  - Messages for errors already pending before the "pause" are retained.
  - After the "pause" is over, the error status is updated and incoming/outgoing errors are reported correspondingly.

Ending a "pause"

The pause is ended in the following cases:

- Failure of the supply voltage L+
- Re-assignment of the I/O module parameters
- "End_Pause" command
- Controller failure
- Firmware update
- Station stop
- Restart of the interface module

Mode parameter

Only the "Mode" parameter is shown below. The complete configuration can be found in the "Parameter assignment" chapter.

Table 11 Mode parameter

Element	Coding	Explanation
Mode	0_D: PE_MODE_PROCEED	Proceed at "pause"
	1_D: PE_MODE_SHUTDOWN	Switch off at "pause" • Supply voltage USn (port) switched off[1] • Pause substitute value (input): 0_B
	3_D: PE_MODE_LAST_VALUE[2]	• Supply voltage USn (port) switched off • Last input and output value is maintained
	4_D: PE_MODE_SUBST_VALUE	see: 1_D: PE_MODE_SHUTDOWN

1 Supply voltage USn of the assigned port is switched off. Result: The IO-Link device fails.

2 With time-based IO, the IO-Link master behaves according to 1_D: PE_MODE_SHUTDOWN

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ET 200SP/ET 200AL Mixed configuration

Equipment Manual

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11/2020

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Preface

1

Purpose of the documentation

This manual supplements the system manuals ET 200SP distributed I/O system and ET 200AL distributed I/O system.

Functions that generally relate to the system are described in these system manuals.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP and ET 200AL distributed I/O systems.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

Documentation guide

2

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

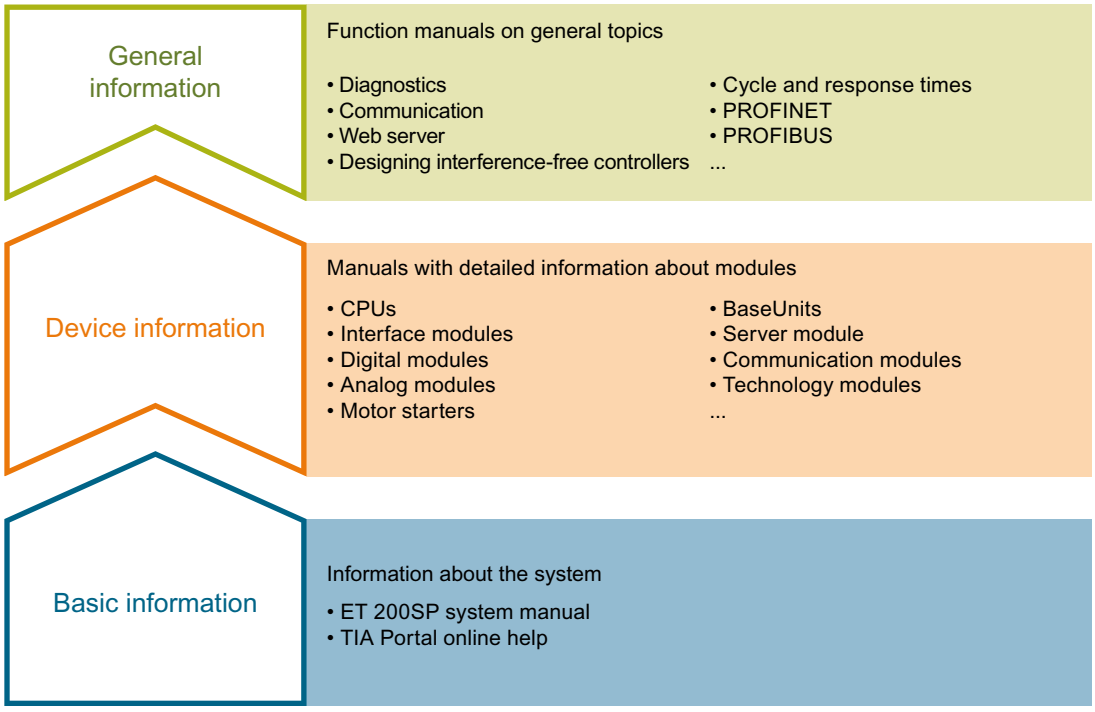

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet.

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet.

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet.

See also

My Documentation Manager
(http://support.industry.siemens.com/My/ww/en/documentation)

Product overview

3

3.1 BaseUnit BU-Send

3.1.1 Product overview

Article number

6ES7193-6BN00-0NE0

View

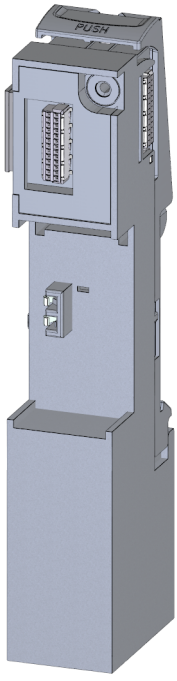

Figure 1-132 BaseUnit BU-Send

Properties

BaseUnit suitable for BusAdapter BA-Send 1xFC

Schematic circuit diagram

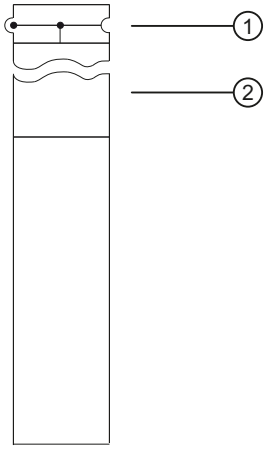

① Backplane bus

② BA-Send 1xFC expansion module

3.2 BusAdapter BA-Send 1xFC

3.2.1 Properties

Article number

6ES7193-6AS00-0AA0

View of the module

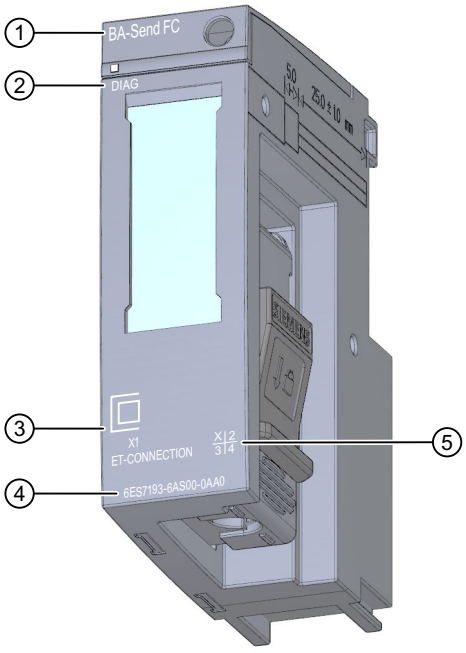

① Module type and name
② LED for diagnostics
③ Connection for ET-Connection
④ Article number
⑤ Functional version

Figure 1-133 View of the BusAdapter BA-Send 1xFC

Properties

The module has the following technical properties:

- BusAdapter for the direct connection of ET-Connection
- Connects the interface module via ET-Connection with the ET 200AL I/O modules
- Supports all ET 200AL I/O modules

The module supports the following functions:

- Identification data I&M 0 to 3. See system manual ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Maximum configuration

- 16 ET 200AL I/O modules
- 15 m bus cable between BusAdapter BA Send and the first ET 200AL I/O module and between two ET 200AL I/O modules.
- Supported functions:

Function	Mixed configuration		
	ET 200SP		ET 200AL I/O modules on ET-Connection
	IM	CPU	
Isochronous mode	⑥	--	--
Configuration control	⑥	⑥	⑥
Shared device	⑥	⑥	⑥
PROFIenergy	⑥	--	⑥
System redundancy S2	●[1]	--	●[1]

1) With IM 155-6 PN/3 HF and IM 155-6 PN/2 HF V4.2 or higher

Accessories

The following components must be ordered separately:

- Labeling strips
- Reference identification label
- Stripping tool for ET-Connection
- Bus cables for ET-Connection

See also

You will find additional information on accessories and the other components in the system manuals ET 200AL Distributed I/O System (http://support.automation.siemens.com/WW/view/en/89254965) and the Accessories/Spare parts section of the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

3.2.2 Wiring and schematic circuit diagram

ET-Connection with BusAdapter BA-Send 1xFC

The following table shows the signal names and the designations for the pin assignment of the BusAdapter BA-Send 1xFC.

Table 1-101 ET-Connection pin assignment with BusAdapter BA-Send 1xFC

View	Signal name		Description
Port 1 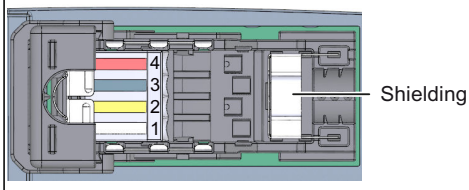 PROFINET IO with BusAdapter BA1xFC	1	TD	Transmit data +
	2	RD	Receive data +
	3	TD_N	Transmit data –
	4	RD_N	Receive data -

Schematic circuit diagram

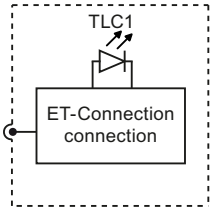

Figure 1-134 Circuit diagram BA-Send 1xFC

Additional information

You can find additional information on connecting the interface module and accessories in the *ET 200SP Distributed I/O System* system manual.

3.2.3 Diagnostics by means of LED display

LED display

The figure below shows the LED display (status and fault display) of the BusAdapter BA-Send 1xFC.

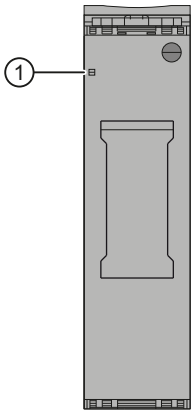

① DIAG (green/red)

Figure 1-135 LED display

Meaning of the LED display

The table below explains the meaning of the status and fault display.

DIAG LED

Table 1-102 Status and fault display DIAG

DIAG LED	Meaning	Remedy
□ Off	There is no connection between the ET-Connection interface of the BusAdapter BA-Send 1xFC and the ET 200AL.	Check whether the bus cable is interrupted.
	The CPU/interface module does not support the BA-Send 1xFC.	Run a firmware update.
■ On	There is a connection between the ET-Connection interface of the BusAdapter BA-Send 1xFC and the ET 200AL.	---
☼ Flashes	There is (at least) one diagnostics alarm of an ET-Connection device. Group error for all ET-Connection bus nodes.	Check the ET-Connection device.
	Set configuration does not match the actual configuration on the ET-Connection.	Check the configuration of the ET-Connection to see whether a module is missing or defective, or whether a non-configured module is wired.

Application planning

4

Mixed configuration ET 200SP and ET 200AL with ET-Connection

You have the option of integrating the I/O modules of the ET 200AL distributed I/O system (IP65/IP67) in a configuration of the ET 200SP distributed I/O system (IP20).

The figure below shows a combination of the modules of the ET 200AL and ET 200SP distributed I/O system.

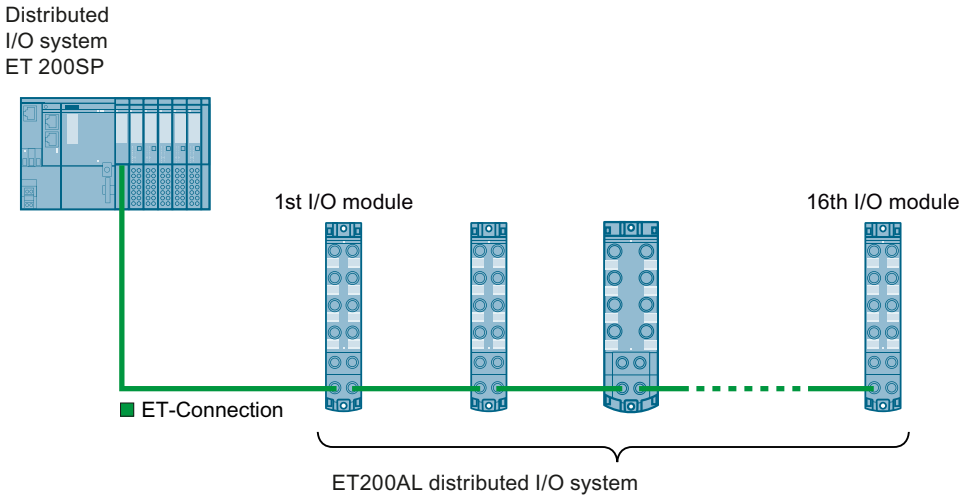

Figure 1-136 Mixed configuration ET 200SP and ET 200AL with ET-Connection

Requirement

The following components support mixed configuration:

- Interface module
  - IM 155-6 PN HF (V3.0 or higher)
  - IM 155-6 PN/2 HF
  - IM 155-6 PN/3 HF
  - IM 155-6 PN ST (V3.1 or higher)
  - IM 155-6 DP HF (V3.0 or higher)
  - IM 155-6 MF HF
- CPU
  - CPU 1510SP-1 PN (V2.0 or higher)
  - CPU 1510SP F-1 PN (V2.0 or higher)
  - CPU 1512SP-1 PN (V2.0 or higher)
  - CPU 1512SP F-1 PN (V2.0 or higher)

  - CPU 1515SP PC
  - CPU 1515SP PC F
  - CPU 1515SP PC T
  - CPU 1515SP PC2
  - CPU 1515SP PC2 F
  - CPU 1515SP PC2 T
  - CPU 1515SP PC2 TF
- BaseUnit BU-Send with BusAdapter BA-Send 1xFC
- ET-Connection cable
- Power cable

Rules

You must observe the following rules when assembling a mixed configuration:

- The bus length of the ET 200SP distributed I/O system must not exceed 1 m (without interface module, including BU-Send/BA-Send 1xFC and server module)
- A maximum of 16 ET 200AL I/O modules can be connected to ET-Connection
- The maximum length of the bus cable for ET-Connection between BA-Send and the first module or between two modules is 15 m

The following table shows which firmware versions of your IM or CPU support which maximum bus cable length.

IM/CPU	Up to 10 m	Up to 15 m
IM 155-6 PN HF	V3.0 or higher	V3.3 or higher
IM 155-6 PN ST	V3.1 or higher	V3.3 or higher
IM 155-6 DP HF	V3.0 or higher	--
CPU 1510SP-1 PN	V2.0 or higher	
CPU 1510SP F-1 PN		
CPU 1512SP-1 PN		
CPU 1512SP F-1 PN		

Procedure

To assemble a multi-tier configuration, follow these steps:

1. Switch off the supply voltage for the ET 200SP distributed I/O system.
2. Install the BaseUnit BU-Send to the immediate right of the ET 200SP CPU/interface module.
   When the BaseUnit BU-Send is used next to the ET 200SP CPU, a CM DP and an Ethernet CP or a maximum of two Ethernet CPs can be inserted between the CPU and BU-Send.

3. Then mount the additional BaseUnits / I/O modules for the ET 200SP distributed I/O system and the server module.
4. Connect the bus cable for ET-Connection to the BusAdapter BA-Send 1xFC and install it on the BaseUnit BU-Send.
5. Fasten the BusAdapter BA-Send 1xFC with the BaseUnit BU-Send (1 screw with tightening torque of 0.2 Nm). To do this, use a screwdriver with a 3 to 3.5 mm blade.
6. Connect the other end of the bus cable for ET-Connection (with M8 connector) to the first ET 200AL I/O module (X30 socket ET-Connection IN).
7. Connect the supply voltage (24 V DC) to the ET 200AL I/O modules (X80 connector).

NOTE

Firmware update of an ET 200AL I/O module

When you run a firmware update of an ET 200AL I/O module, ET-Connection is briefly interrupted by the restart of the module. All downstream ET 200AL I/O modules report a pull/plug interrupt.

NOTE

Insertion of theBusAdapter BA-Send 1xFC during operation leads to a restart of the interface module.

Mounting

5

Introduction

For the connection of the ET 200AL I/O module via ET-Connection to the ET 200SP, you require the BaseUnit BU-Send with the BusAdapter BA-Send 1xFC.

Requirement

- The mounting rail is mounted.
- The interface module is mounted.

Required tools

3 to 3.5 mm screwdriver (only for dismantling the BusAdapter)

Mounting BaseUnit BU-Send

To mount the BaseUnit BU-Send, follow these steps:

1. Mount the BaseUnit BU-Send to the right of the CPU/interface module.
2. Swivel the BaseUnit back until you hear the mounting rail release latch into place.
3. Move the BaseUnit to the left until you hear it latch into place on the CPU/interface module.

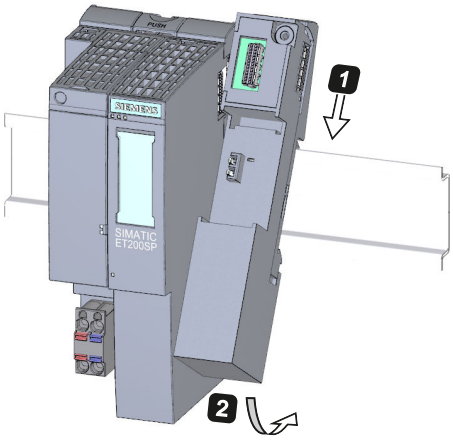

Figure 1-137 Mounting BU-Send

4. Mount the BusAdapter BA-Send 1xFC only after you have connected the bus cable for ET-Connection (see section Connecting).

Connecting

6

6.1 Connecting BaseUnit BU-Send

Pin assignment

The BaseUnit BU-Send only has one slot for an expansion module. No other connections are available.

Schematic circuit diagram

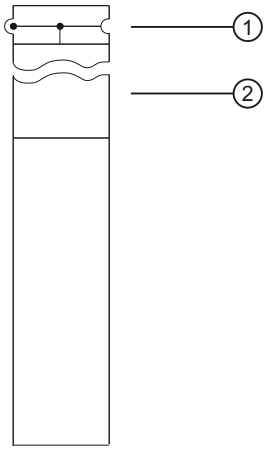

① Backplane bus

② BA-Send 1xFC expansion module

Figure 1-138 Schematic circuit diagram BU-Send

Introduction

You connect the ET 200AL I/O modules via the BusAdapter BA-Send 1xFC via ET-Connection.

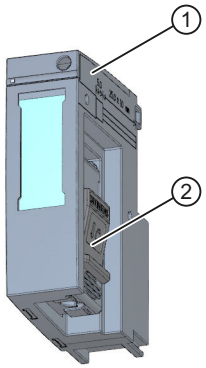

① BusAdapter BA-Send 1xFC

② Connection element for ET-Connection bus cable

Figure 1-139 BusAdapter BA-Send 1xFC

Required tools

Screwdriver with 3 to 3.5 mm blade

Required accessories

Use the bus cable for ET-Connection as connecting cable between the BusAdapter BA-Send 1xFC and the ET 200AL I/O modules.

We recommend using the Stripping Tool for ET-Connection (6ES7194-2KA00-0AA0) with blade cassette green (6GK1901-1B...). This guarantees fast and safe stripping.

The bus cable is available in the following versions:

Bus cable for ET-Connection M8, prefabricated on one side with 1x M8 connector, 4-pole, shielded

- Length 2 m: 6ES7194-2LH20-0AC0
- Length 5 m: 6ES7194-2LH50-0AC0
- Length 10 m: 6ES7194-2LN10-0AC0
- Length 15 m: 6ES7194-2LN15-0AC0

Bus cable for ET-Connection M8, PUR cable, prefabricated on one side with 1x M8 connector, 4-pole, shielded

- Length 2 m: 6ES7194-2MH20-0AC0
- Length 5 m: 6ES7194-2MH50-0AC0
- Length 10 m: 6ES7194-2MN10-0AC0
- Length 15 m: 6ES7194-2MN15-0AC0

Procedure

To connect the BusAdapter BA-Send 1xFC , follow these steps:

1. Strip the sheath of the bus cable at the open end as follows:

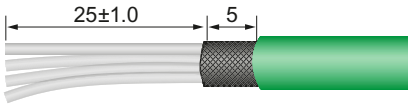

Figure 1-140 Connecting cable

Use the Stripping Tool for ET-Connection to do this. The relevant settings are shown on the tool.

2. Pull back the locking slide of the BusAdapter BA-Send 1xFC and open the cover of the connection element.
3. Lift the cable routing up as far as it will go.
4. Insert the unstripped single cores of the bus cable (according to the imprinted color coding) into the cable routing as far as they will go and press the cable routing down as far as it will go.
5. Close the cover of the connection element and push the locking slide forward.
6. Insert and fasten the BusAdapter BA-Send 1xFC with the BaseUnit BU-Send (1 screw with tightening torque of 0.2 Nm). To do this, use a screwdriver with a 3 to 3.5 mm blade.

7. Connect the M8 connector of the bus cable to the first ET 200AL I/O module (socket X30 ET-Connection IN). For more information about wiring the ET 200AL I/O modules, refer to the system manual of the ET 200AL distributed I/O system.

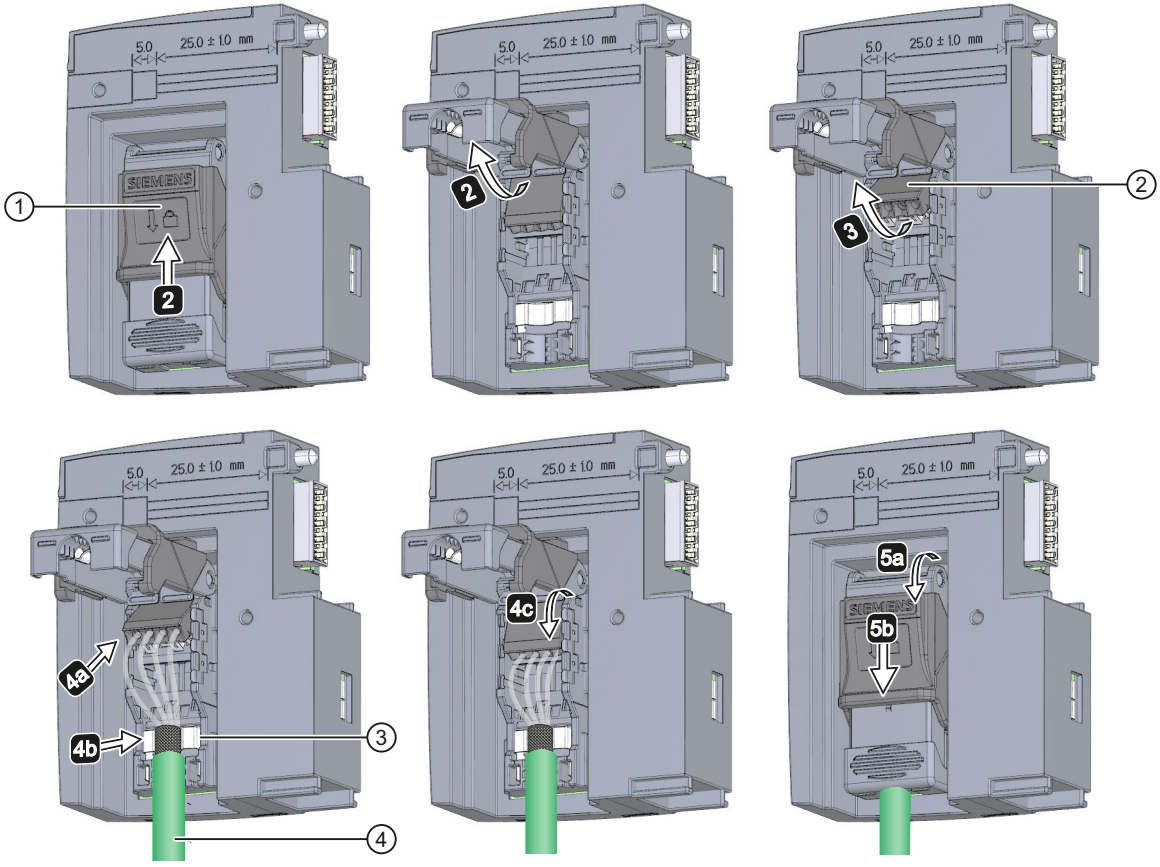

①	Locking slide	③	Shield contact
②	Cable routing	④	Bus cable for ET-Connection

Figure 1-141 Connection of the BusAdapeter BA-Send 1xFC

BusAdapter BA-Send 1xFC mounted

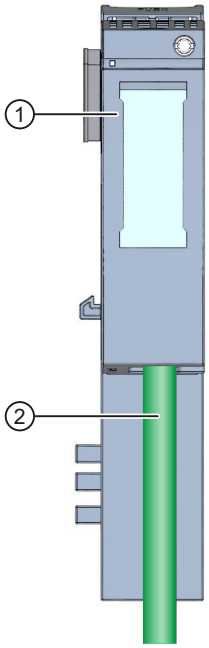

① BusAdapter BA-Send 1xFC

② Bus cable for ET-Connection

Figure 1-142 BusAdapter BA-Send 1xFC mounted

Configuring

7

Introduction

The mixed configuration allows the connection of up to 16 ET 200AL I/O modules to the ET 200SP via ET-Connection. The figure below shows the configuration of the ET-Connection and the assignment of the slots.

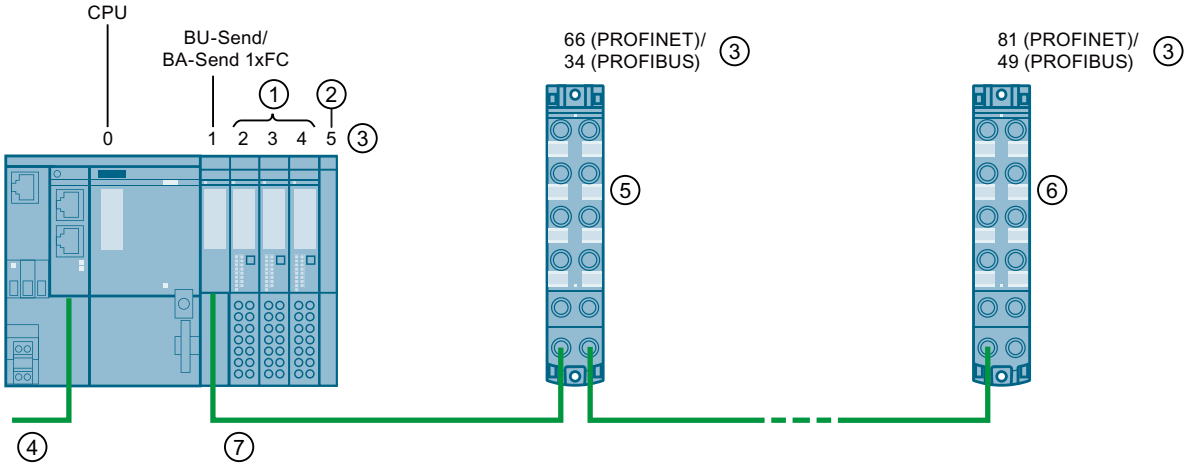

①	ET 200SP I/O modules	⑤	1st ET 200AL I/O module
②	ET 200SP server module	⑥	16th ET 200AL I/O module
③	Slots	⑦	ET-Connection
④	PROFINET IO		

Figure 1-143 Mixed configuration

For more information about connecting ET-Connection, supply voltages, actuators and sensors, refer to the ET 200AL system manual.

Configuration with a CPU

In a configuration with a CPU, a maximum of 2 slots can be used immediately to the right of the CPU with CM DP module or Ethernet CP. Combinations are also possible, i.e. CM DP module and one Ethernet CP or two Ethernet CPs.

BU-Send and BA-Send should always be inserted to the immediate right of the CM/CP.

Rules

Observe the following rules when configuring:

- With mixed configurations, the following maximum configuration is possible:
  - 31 slots for ET 200SP modules (IM 155-6 DP HF and IM 155-6 PN ST)
  - 63 slots for ET 200SP modules (IM 155-6 PN HF and CPUs)
  - 16 slots for ET 200AL I/O modules
  - 1 slot for BU-Send/BA-Send 1xFC
  - 1 slot for server module.
- The mixed configuration may contain a maximum of 31 (IM 155-6 DP HF and IM 155-6 PN ST)/63 (IM 155-6 PN HF and CPUs) ET 200SP I/O modules.
- The server module can also be mounted right next to the BU-Send/BA-Send 1xFC.
- Supported functions:

Function	Mixed configuration		
	ET 200SP		ET 200AL I/O modules on ET-Connection
	IM	CPU	
Isochronous mode	●	--	--
Configuration control	●	●	●
Shared device	●	●	●
PROFIenergy	●	--	●
System redundancy S2	●[1]	--	●[1]

1) With IM 155-6 PN/3 HF and IM 155-6 PN/2 HF V4.2 or higher

Configuring

Observe the following points when configuring:

- BU-Send/BA-Send 1xFC and server module must be configured. There are no parameters for BU-Send/BA-Send 1xFC.
- Arrangement of the modules in the configuration:
  - Configure the BU-Send/BA-Send 1xFC modules downstream from the interface module in slot 1. Position the ET 200SP modules behind it.
  - Configure the ET 200AL I/O modules from slot 66 (PROFINET)/67 (CPU)/34 (PROFIBUS).
- The layout of the modules represents a preset configuration and is independent of the configuration control.
- The system redundancy S2 function is not available in a mixed configuration.

Configuration example

An example of a mixed configuration is shown below:

Hardware configuration

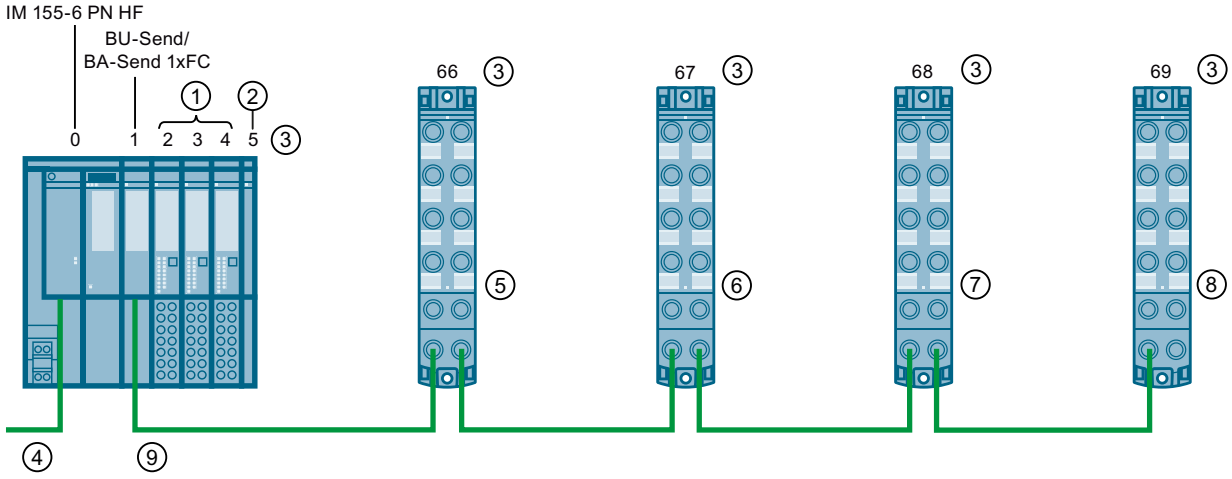

① ET 200SP I/O modules
② ET 200SP server module
③ Slots
④ PROFINET IO
⑤ 1st ET 200AL I/O module
⑥ 2nd ET 200AL I/O module
⑦ 3rd ET 200AL I/O module
⑧ 4th ET 200AL I/O module
⑨ ET-Connection

Figure 1-144 Mixed configuration

Configuring configuration example

Table 1-103 Overview

Mixed configuration	Module	Slot
ET 200SP	IM 155-6 PN HF	0
	BA-Send 1xFC	1
	DI 16x24VDC ST	2
	DI 16x24VDC ST	3
	DI 16x24VDC ST	4
	Server module	5
ET 200AL	DI 8x24VDC 8xM8	66
	DIQ 4+DQ 4x24VDC/0.5A 8xM8	67
	AI 4xU/I/RTD 4xM12	68
	CM 4xIO-Link 4xM12	69

NOTE

Configuration using PROFIBUS GSD file

When you use the PROFIBUS GSD file for the configuration, you must configure the gaps between the server module and the first ET 200AL I/O module with BU cover.

Technical specifications 8

8.1 Technical specifications BaseUnit BU-Send

Technical specifications of the BaseUnit BU-Send

Article number	6ES7193-6BN00-0NE0
General information	
HW functional status	from FS04
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	20 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	30 g

8.2 Technical specifications BusAdapter BA-Send 1xFC

Technical specifications of the BusAdapter BA-Send 1xFC

Article number	6ES7193-6AS00-0AA0
General information	
Product type designation	BA-Send 1xFC
HW functional status	From FS05
Interfaces	
Supports protocol for PROFINET IO	

Article number	6ES7193-6AS00-0AA0
Cable length	
– Cu conductors	15 m; from IM firmware V3.3: between BA-send and the first ET-CONNECTION bus node and between all other bus nodes
ET-Connection	
• Number of interfaces ET connection	1
• FC (FastConnect)	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	20 mm
Weights	
Weight, approx.	44 g

SIEMENS

SIMATIC
ET 200SP
User calibration of analog modules
Product Information

Security information

To ensure the secure operation of products and solutions from Siemens, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

Introduction

The characteristics of analog-digital/digital-analog converters in analog modules are usually offset and not uniform in their slope. This means you must calibrate the characteristics to the conditions of the analog module. A general distinction is made between factory calibration and user calibration.

Factory calibration

To ensure the accuracy of an analog module, it is calibrated during production in the factory. You cannot delete or change the factory calibration. You can only read the factory calibration values.

User calibration

You can start, delete and read back a user calibration for an analog module with error-free parameter assignment at any time. User calibration is used to increase the accuracy for specific use cases with deviations that can be compensated, for example, by sensors or wiring.

Zero-Scale/Offset calibration

Zero-Scale or Offset calibration is the calibration of the zero point. Usually "0" for bipolar ranges and the low limit of the nominal range for unipolar ranges. The characteristic of the converter is offset corrected and thus shifted into the zero point.

Full-Scale/Gain/Gain calibration

Full-Scale or Gain calibration is the calibration of the end point. It is usually the high limit of the nominal range. The slope of the converter characteristic is adjusted so that it also intersects the end point.

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A5E34352075-AA, 09/2014

Converter characteristic

The figure below shows the shift of the converter characteristic into the zero point on the left. The right part of the figure shows the change in the converter characteristic slope so that the converter characteristic intersects the end point.

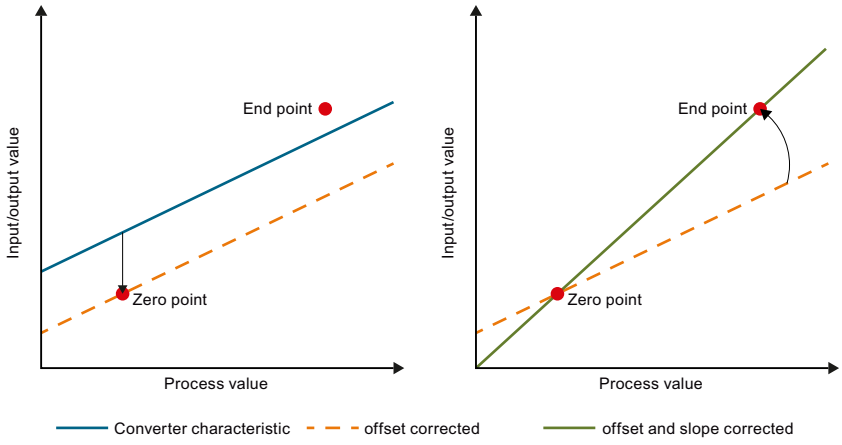

Figure 1 Correction of the converter characteristic

Requirement

The accuracy/quality of a user calibration depends on the following points:

- Stable temperature condition (e.g., 25 °C)
- The settling time of the used calibrator/measuring instrument and the analog module (e.g., for input or output modules with integrated measuring process → sigma-delta converter)
- Cables (if possible, short, shielded and grounded at one side)
- Accuracy of the used calibrator and/or measuring instrument

NOTE

Measuring accuracy

The measuring accuracy may deteriorate if the user calibration is not performed properly.

It is not immediately clear if a channel works with factory calibration values or user calibration values.

Mode of operation

You must perform the user calibration for each channel. To do so, always calibrate the selected channel in the set input/output range. You can start the user calibration at any time for a channel with error-free parameter assignment. After successful user calibration the newly calibrated channel works in the current input/output range with the newly determined calibration values.

Procedure

The user calibration is controlled by the data sets (DS). You must write a job data set for the analog module and receive instructions for further actions in the acknowledgment data set. This procedure is described in more detail in the section Performing user calibration (Page 10).

The figure below shows the steps required for the user calibration of an instruction to the analog module.

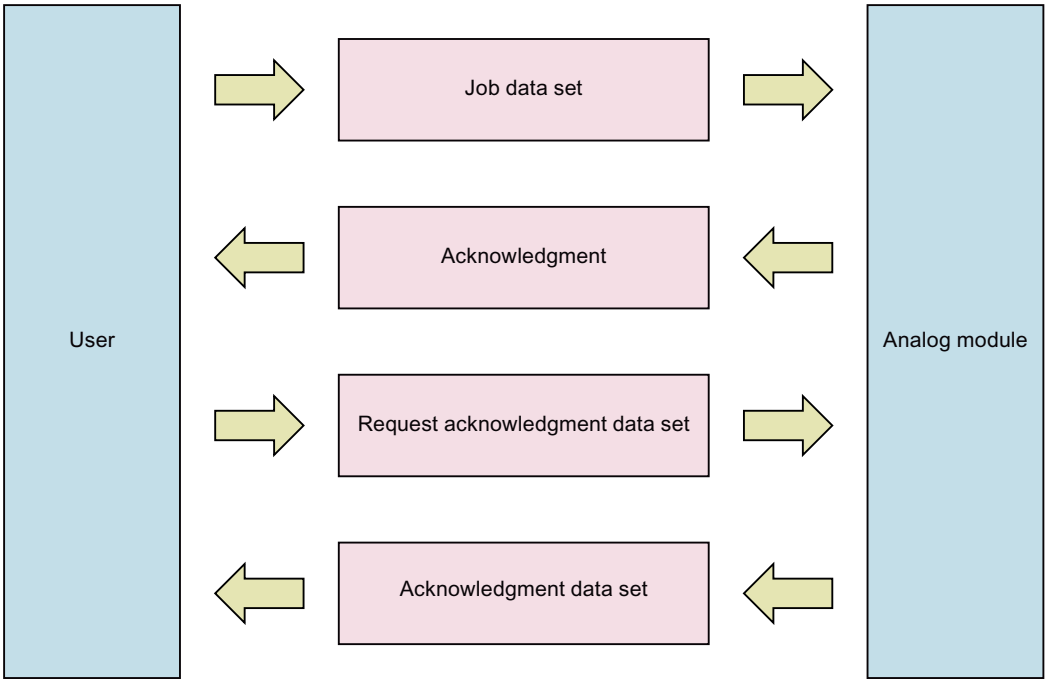

Figure 2 Steps in the user calibration for an instruction

The analog module saves the user calibration values. The values always apply only to the input/output range for which they were created. If the input/output range is re-parameterized, the factory calibration values are used once again. But the user calibration values still exist (see section Re-parameterization of the input/output range (Page 14)).

Each user calibration receives a time stamp (for each channel) which includes the date and time of the last user calibration of the channel. You must transfer the date and time to the analog module during calibration, because these values are not generated by the analog module.

The analog module controls the number of required calibration steps for a user calibration.

The actions which you must start or confirm during user calibration are also initiated by the analog module.

The set input/output range of a channel can only be calibrated completely during a user calibration (zero-scale and full-scale). Partial calibration is not possible (e.g., zero-scale only).

Data set structure

You can start a calibration process with the Write data set (job data set) and Read data set (acknowledgment data set) mechanisms, DS 237 for each.

The structure of the job data set and the acknowledgment data set is identical. This means the acknowledgment data set read last serves as the template for the next job data set.

Job data set and acknowledgment data set also apply to mixed modules with input and output channels. Mixed modules have an input channel and an output channel with channel number 0. To determine if you are calibrating an output channel or an input channel, the channel number for output channels generally has the offset value 40_H added to it.

Job data set

The following table shows the structure of the job data set.

Table 1 Structure of the job data set (18 bytes long)

Byte address	Element	Value range	Format
0	Command/job ID	1: Factory calibration 2: User calibration 3: Abort, normal channel processing 4: Read calibration values 5: Restore factory calibration 6: Reset	Byte
1	Identifier	0 1	Byte
2	Channel number	00_H ... $3F_H$ 40_H ... $7F_H$ FF_H	Byte
3	Calibration step	FF_H FE_H ... 00_H	Byte
4	Not relevant	-	Byte
5	Not relevant	-	Byte
6	Not relevant	-	Byte
7	Input/output size	0: Not relevant 1: mV 2: µA 3: - 4: Time/date 5: Ohm 6: Degrees 7: - 8: - 9: U~ (0.01 V) effective value AC 10: I~ (0.0001 A) effective value AC 11: Phi (0.01 degrees) (phase angle)	Byte
8	Substitute value behavior of inputs	0: retain last value 1: Overflow ($7FFF_H$) 2: Substitute value 3: continue to supply values*	Byte
9	Reserved	-	Byte
10 ... 17	Extended Record	See section below Extended Record	

* Only for analog modules AI 4xRTD/TC 2-/3-/4-wire HF and AI 8xRTD/TC 2-wire HF

The tables below show the value ranges of the elements and description of the job data set.

Command/job ID

Table 2 Command/job ID

Value range	Description
1: Factory calibration	Not relevant
2: User calibration	See section User calibration (mode = 2) (Page 15)

Value range	Description
3: Abort, normal channel processing	See section Abort (mode = 3) (Page 25)
4: Read calibration values	See section Read calibration values (mode = 4) (Page 27)
5: Restore factory calibration	See section Restore factory calibration (mode = 5) (Page 29)
6: Reset	See section Reset (mode = 6) (Page 30)

Identifier

Table 3 Identifier

Value range	Description
0	Not relevant
1	Execute

Channel number

Table 4 Channel number

Value range	Description
00_H ... $3F_H$	Input channels
40_H ... $7F_H$	Output channels
FF_H	All channels, only permitted for command = 6 (Reset)

Calibration step

Table 5 Calibration step

Value range	Description
FF_H	Start
FE_H ... 00_H	Apply from last acknowledgment data set

Input/output size

Table 6 Input/output size

Value range	Description
0: Not relevant	Specifies how to interpret the values as of byte 10.
1: mV	
2: µA	
3: -	
4: Time/date	
5: Ohm	
6: Degrees	
7: -	
8: -	

Value range	Description
9: U~ (0.01 V) effective value AC	Specifies how to interpret the values as of byte 10.
10: I~ (0.0001 A) effective value AC	
11: Phi (0.01 degrees) (phase angle)	

Substitute value behavior of inputs

Table 7 Substitute value behavior of inputs

Value range	Description
0: retain last value	Only relevant for analog input modules. Evaluated at start only.
1: Overflow ($7FFF_H$)	
2: Substitute value	
3: continue to supply values*	

* Only for analog modules AI 4xRTD/TC 2-/3-/4-wire HF and AI 8xRTD/TC 2-wire HF

Extended Record

Table 8 Extended Record for input/output size = 1 (mV), 2 (µA), 5 (Ohm), 6 (Degrees)

Byte address	Element	Format	Value range	Description
10	Date1	Word	-32768 ... 32767	Place before the decimal point
12	Date2	Word	-999 ... 999	Places after decimal point * 1000
14	Date3	Word	Not used	
16	Substitute value	Word	Not used	

Extended Record for input/output size = 4 (Date/Time), BCD coded: See section Time stamp, date/time (Page 13)

Table 9 Extended Record for input/output size = 9 (U~), 10 (I~), 11 (Phi)

Byte address	Element	Format	Value range	Description
10	Date1	Word	Not used	
12	Date2	Word	Not used	
14	Date3	Word	0 ... 65535	Setpoint for calibration operating point
16	Substitute value	Word	Not used	

Table 10 Extended Record for substitute value behavior of inputs = 2 (substitute value)

Byte address	Element	Format	Value range	Description
10	Date1	Word	0	Not relevant
12	Date2	Word	0	Not relevant
14	Date3	Word	0	Not relevant
16	Substitute value	Word	8000_H ... $7FFF_H$	Must be within parameterized measuring range

Acknowledgment data set

The following table shows the structure of the acknowledgment data set.

Table 11 Structure of the job or acknowledgment data set (18 bytes long)

Byte address	Element	Value range	Format
0	Command/mode	1: Factory calibration 2: User calibration 3: Abort, normal channel processing 4: Read calibration values	Byte
1	Status/error code	00_H: OK, Working 01_H: OK, Ready ≥ 10_H: Error	Byte
2	Channel number	00_H ... $3F_H$ 40_H ... $7F_H$ FF_H	Byte
3	Calibration step	FF_H ... 00_H	Byte
4	Input/output type	00_H ... $F9_H$	Byte
5	Input/output range	00_H ... $F9_H$	Byte
6	User action	0: None 1: Short-circuit 2: Feed, connection 3: Measurement 4: Remove connections	Byte
7	Input/output size	0: Not relevant 1: mV 2: µA 3: Calibration values 4: Time/date 5: Ohm 6: Degrees 7: - 8: - 9: U~ (0.01 V) effective value AC 10: I~ (0.0001 A) effective value AC 11: Phi (0.01 degrees) (phase angle)	Byte
8	Calibration counter	00_H ... FF_H	Byte
9	Reserved	-	Byte
10 ... 17	Extended Record	See section below Extended Record	

The tables below show the value ranges of the elements and description of the acknowledgment data set.

Command/mode

Is mirrored from the command with error-free processing of the job data set.

Table 12 Command/mode

Value range	Description
1: Factory calibration	Not relevant
2: User calibration	See section User calibration (mode = 2) (Page 15)
3: Abort, normal channel processing	See section Abort (mode = 3) (Page 25)
4: Read calibration values	See section Read calibration values (mode = 4) (Page 27)

Status/error code

Table 13 Status/error code

Value range	Description
00_H: OK, Working	Job processing still ongoing
01_H: OK, Ready	Job processing successfully completed
≥ 10_H: Error	See section Status and error codes (Page 12)

Channel number

Table 14 Channel number

Value range	Description
00_H ... $3F_H$	Input channels
40_H ... $7F_H$	Output channels
FF_H	All channels

Calibration step

Table 15 Calibration step

Value range	Description
FF_H ... 00_H	Number of calibration steps still required

Input/output type

Table 16 Input/output type

Value range	Description
00_H ... $F9_H$	Currently parameterized input/output type of the channel, see Parameter tables in the sections Format input type/range: Input channels (Page 31-32) and Format output type/range: Output channels (Page 34)

Input/output range

Table 17 Input/output range

Value range	Description
00_H ... $F9_H$	Currently parameterized input/output range of the channel, see Parameter tables in the sections Format input type/range: Input channels (Page 31-32) and Format output type/range: Output channels (Page 34)

User action

Table 18 User action

Value range	Description
0: None	Indicates how to wire the terminals specified under Terminal1/Terminal2.
1: Short-circuit	
2: Feed, connection	
3: Measurement	
4: Remove connections	

Input/output size

Table 19 Input/output size

Value range	Description
0: Not relevant	Specifies how to interpret the values as of byte 10. For user actions = 2 and 3 the corresponding unit is specified here.
1: mV	
2: µA	
3: Calibration values	
4: Time/date	
5: Ohm	
6: Degrees	
7: -	
8: -	
9: U~ (0.01 V) effective value AC	
10: I~ (0.0001 A) effective value AC	
11: Phi (0.01 degrees) (phase angle)	

Calibration counter

Table 20 Calibration counter

Value range	Description
00_H ... FF_H	Number of successful user calibrations 00_H = Factory calibration values

Extended Record

Table 21 Extended Record for input/output size = 1 (mV), 2 (µA), 5 (Ω), 6 (Degrees)

Byte address	Element	Format	Value range	Description
10	Date1	Word	-32768 ... 32767	Place before the decimal point
12	Date2	Word	-999 ... 999	Place after decimal point * 1000
14	Date3	Word	Not used	
16	Terminal1	Byte	0 ... x (0 = invalid)	Terminal at BaseUnit
17	Terminal2	Byte	0 ... x (0 = invalid)	Terminal at BaseUnit

Table 22 Extended Record for input/output size = 9 (U~), 10 (I~), 11 (Phi)

Byte address	Element	Format	Value range	Description
10	Date1	Double word	00_H ... $FFFFFFFF_H$	Calibration register content (last calibration step executed)
14	Date2	Word	0 ... 65535	Setpoint for next step
16	Terminal1	Byte	0 ... x (0 = invalid)	Terminal at BaseUnit
17	Terminal2	Byte	0 ... x (0 = invalid)	Terminal at BaseUnit

Extended Record for input/output size = 4 (Date/Time): See section Time stamp, date/time (Page 13)

Table 23 Extended Record for input/output size = 3 (calibration values)

Byte address	Element	Format	Value range	Description
10	Date1	Word	Format 1	Offset (converter units)
12	Date2	Word	Format 2	Gain
14	Date3	Word	Module-specific Format 1 or Format 2	Add1
16	Date4	Word		Add2

The values can be output in two formats:
Format 1 (identifier = 0):
WORD, value range -32767 ... +32768
Format 2 (identifier = 1):
Value range -31.999 to +31.999

Table 24 Extended Record: Places before and after the decimal point

2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
VZ	Places before the decimal point (0 ... 31)					Places after decimal point * 1000 (0 ... 999)									

Format Terminal1/Terminal2:
For user actions = 1, 2, 3, 4 the terminal number of the terminal at BaseUnit are displayed here (1 ... x).

Performing user calibration

Calibration start

You must start the user calibration using the job data set with command = 2 (user calibration) and calibration step = FF_H (Start).

An active/running calibration is displayed with Mode = 2 (user calibration) in the acknowledgment data set.

A diagnostic is also reported for analog modules with diagnostic capability:

- Analog modules with channel diagnostics signal error 31 (Channel temporarily unavailable) for the affected channel, channel fault LED lights up red, the module fault LED flashes.
- Analog modules which support the value status (QI) set QI to "BAD".

The user calibration can be started at any time. The start requires that the channel was parameterized without errors and that it is not already in another calibration mode which can be recognized by command 3 and status > 00_H in the acknowledgment data set:

- After starting the user calibration and until it is completed, only command = 2 is accepted and processed for this channel. All other commands result in the user calibration being aborted.
- The acknowledgment data set is generated immediately by mirroring it from the job data set and entering it in the status = 00_H (OK, Working).
- After completing the calibration step, the acknowledgment data set is updated and the status > 00_H is set:
  - The command was accepted with status = 01_H (OK, Ready). The number of steps that still have to executed is specified in the calibration step. The action that you need to execute next is specified in the user action.
  - For user action = 1 (Short-circuit), 2 (Infeed), 3 (Measuring) and 4 (Remove connections), the relevant terminals are specified in the Extended Record under Terminal1 and Terminal2 whereby Terminal1 is always the positive terminal.
  - For user action = 2 (Infeed) or 3 (Measuring) the unit is specified for measured variable (e.g., µA or mV).
  - For status > 10_H, an error was detected and calibration was aborted. In Command/Mode, "Abort, normal channel processing" is signaled. The analog module resumes the same status as before calibration was started.

Calibration sequence

Each calibration step is triggered by writing the job data set with calibration step = FF_H (for start) or FE_H ... 00_H, applied from the previously signaled acknowledgment data set and identifier = 01_H.

Next the analog module has to read and evaluate the acknowledgment data set.

- For status = 00_H (OK, Working), the calibration of the analog module initiated with the job data set is still in progress.
- For status = 01_H (OK, Ready), the calibration of the analog module initiated with the job data set is complete and was processed without errors.
- For status ≥ 10_H (Error), the calibration of the analog module initiated with the job data set was not processed successfully and was acknowledged with an error. The ongoing calibration is aborted and any determined calibration values are discarded.

NOTE

Non-relevant elements

Elements that are not relevant for a calibration step are not taken into consideration by the module. The user calibration is not aborted by these elements.

Calibration exit

You can exit the calibration in any calibration step by means of a job data set with command = 3 (Abort, normal channel processing). Any calibration values determined until then are lost. The analog module resumes the same status as before calibration was started. If user calibration values existed before the calibration, these will become effective again after the abort. If no user calibration values existed, the factory calibration values are still in effect.

Any calibration initiated previously can also be aborted with the following actions:

- POWER OFF/POWER ON of the supply voltage
- Pulling & plugging of the analog module
- Re-parameterization of the analog module
- Re-parameterization of the analog module
- Firmware update of the analog module

Calibration completion

The last calibration step is the confirmation of the calibration or of the determined calibration values. This calibration step is initialized by the analog module for a user calibration with calibration step = 1 in the acknowledgment data set. All calibration values of the current calibration process are determined and signaled back.

Confirm the calibration values with the job data set and calibration step = 1. With input/output size = 4 (Date/Time) a time stamp in S7 BCD format is entered starting with byte 10 (see section Time stamp, Date/Time (Page 13)).

As soon as the calibration values and the time stamp of the analog module have been checked and applied, mode = 3 (normal channel processing) and status = 01_H (OK, Ready) are signaled in the acknowledgment data set. The channel number, the input/output type and the input/
output range remain the same; the remaining data equals zero.

The newly determined calibration values are now valid and in effect.

The previous user calibration values are overwritten and cannot be restored.

In case of an error in the last calibration step (e.g., error in time stamp), the corresponding error code is signaled in the status. The new calibration values are discarded.

Status and error codes

Table 25 Status codes

Status code	Description
00_H	OK, Working; job in progress
01_H	OK, Ready; job executed without error
02_H ... $0F_H$	Reserved

Calibration is aborted with an error if an error occurs during calibration.

Table 26 Error codes

Error codes	Description	Remedy/Cause
General errors of the calibration process		
10_H	Invalid command	Correct job data set; table Command/job ID
11_H	Invalid channel number	Correct job data set; table Identification
12_H	Invalid identification	Correct job data set; table Channel number
13_H	Invalid calibration step	Correct job data set; table Calibration step
14_H	Error in input/output type or input/output range	Input/output type or input/output range cannot be scaled; see Analog Module Manual
15_H	Invalid module action	Irrelevant for user calibration

Error codes	Description	Remedy/Cause
16_H	Invalid input/output size information	Extended Record, invalid content; Correct job data set (Page 3)
17_H	Reserved	–
18_H	Time stamp error (year)	Invalid time stamp; correct job data set; section Time stamp, Date/Time (Page 13)
19_H	Time stamp error (month)	
$1A_H$	Time stamp error (day)	
$1B_H$	Time stamp error (hour)	
$1C_H$	Time stamp error (minute)	
$1D_H$	Time stamp error (day of the week)	
$1E_H$	Invalid substitute value behavior of inputs	Correct job data set; table Substitute value behavior of inputs
$1F_H$	Substitute value out of the measuring range	
Technology errors		
20_H	Value measured by user deviates too much from setpoint	Circuit, check measuring technique; correct job data set
21_H	Value supplied by user deviates too much from setpoint	Circuit, check infeed technique
22_H ... 23_H	Reserved	–
24_H	User calibration not supported	See Analog Module Manual
25_H ... $2F_H$	Reserved	–
System errors/general module errors		
30_H	Error writing to EEPROM/Flash	Replace analog module
31_H	Error in procedure	A job data set with a command other than the one active came in during the calibration process. Follow procedure; see section Example (Page 15)
32_H	Channel not parameterized	Correct configuration/parameter assignment
33_H	Reserved	–
34_H	Abort due to parameter assignment during ongoing calibration	See section Behavior with parameter assignment of analog modules during calibration (Page 15)
35_H ... $3F_H$	Reserved	–
Other faults/errors		
40_H	Reserved	–
41_H	No calibration values available	No calibration values available to delete; See section Prepare factory calibration (mode = 5) (Page 29) and Reset (mode = 6) (Page 30)
42_H ... FF_H	Reserved	–

Time stamp, Date/time

During user calibration, you transfer the date and time of the synchronization to the analog module in calibration step = 1 Date and time.

When reading the calibration values (command = 4), the date and time of the read calibration values are output in calibration step = 1.

Both take place with measured variable = 4 as time stamp in the acknowledgment data set as well as in the job data set as of byte 10 in S7 BCD format.

Byte address	Value	Format	Value range
10	Year	Byte	00_H = 2000, 99_H = 2099
11	Month	Byte	01_H ... 12_H
12	Tag	Byte	01_H ... 31_H
13	Hour	Byte	00_H ... 23_H
14	Minute	Byte	00_H ... 59_H
15	Second	Byte	00_H ... 59_H
16	ms	Byte	00_H ... 99_H
17.4 ... 17.7	ms	High nibble	0_H ... 9_H
17.0 ... 17.3	Day of the week	Low nibble	0 = undefined 1 = Sunday 2 = Monday 3 = Tuesday 4 = Wednesday 5 = Thursday 6 = Friday 7 = Saturday

Re-parameterization of the input/output range

If you have conducted a user calibration on a channel, the user calibration values are in effect for this channel. The user calibration values always apply only to the input/output range for which they were created. If the input/output range is re-parameterized to another input/output range, the factory calibration values are used once again for this range. The user calibration values still exist.

When you start a user calibration in the new input/output range, the new calibration values are saved for this new input/output range. The user calibration values of the previous input/output range are overwritten because only one user calibration can be saved per channel.

If you do not start user calibration and switch back to the previous input/output range, the previous user calibration values will be in effect once again.

Other channel parameters (e.g., interference frequency suppression) have no effect on the validity of the calibration values.

Calibration counter

Each error-free and complete user calibration of a channel is counted. More than 255 calibration processes do not increase the calibration counter.

The current counter status (including ongoing calibration) is displayed in calibration step = 1 together with the currently determined calibration values. When you acknowledge this calibration step with the job data set, the calibration counter is saved retentively with the determined user calibration values and will be in effect.

Each command = 5 (Restore factory calibration) or 6 (Reset) deletes the calibration counter.

A re-parameterization of the input/output ranges does not delete the calibration counter.

When you start a user calibration in the new input/output range, the calibration counter is reset and starts counting from 1 again.

If you do not start user calibration and switch back to the previous input/output range, the previous user calibration values will be in effect once again.

Behavior at CPU-STOP

Reading and writing of data sets is not possible in CPU STOP.

Behavior with parameter assignment of analog modules during calibration

Each parameter data set that comes in during an ongoing user calibration results in the calibration being aborted.
The acknowledgment data set is updated with a corresponding error message.

Example

User calibration (mode = 2)

All processes described below are based on the initial state of the acknowledgment data set.

Byte	Element	Value
0	Mode	3: normal channel processing
1	Status/error code	> 0
2	Channel number	X
3	Calibration step	FF_H*
4	Input/output type	0
5	Input/output range	0
6	User action	0: None
7	Input/output size	0
8	Calibration counter	0
9	Reserved	0
10	Date1	0
12	Date2	0
14	Date3	0
16	Terminal1	0
17	Terminal2	0

* The calibration step can only take place immediately after run-up FF_H. After completion/abort of a calibration step, "0 = no more steps" is signaled.

Only the data necessary for the current calibration step are entered in the job/
acknowledgment data set.

- The command and the channel number must remain the same for each job data set of a calibration sequence; otherwise, the calibration is aborted.
- The calibration step must be transferred to the analog module again in each job data set according to the last acknowledgment data set. The start is an exception.
- The channel must be parameterized.
- A job data set may only be transferred to the analog module with status > 00_H.
- The current calibration step is to be executed with identifier = 1 in the job data set.

Example: Analog input module RTD (resistance thermometer)

Step A: Start

Job data set:

Start the user calibration with channel X. The specified substitute value behavior of the inputs and the substitute value apply to the triggered calibration and are evaluated and applied by the analog module during the initial call only.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	
2	Channel number	X
3	Calibration step	FF_H: Start
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	0: retain last value
9	Reserved	
10	Date1	
12	Date2	
14	Datem3	
16	Substitute value	

Acknowledgment data set:

The analog module acknowledges the change to user calibration (mode = 2) with channel = X and status = 00_H (OK, Working). As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data. The input/output range currently set on this channel as well as the number of required calibration steps is signaled. The analog module requests channel X in the next calibration step; short-circuit at terminals Y and Z.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	FF_H		**4 more steps**
4	Input/output type			09_H: RTD, 2-wire
5	Input/output range			02_H: PT100, Std.
6	User action			1: Short-circuit
7	Input/output size			
8	Calibration counter			
9	Reserved			
10	Date1			
12	Date2			

Byte	Element	Value		Value
14	Date3			
16	Terminal1			Y
17	Terminal2			Z

Step B: Zero-Scale calibration

Job data set:
Acknowledge calibration step 4. The requested action (short-circuit terminals Y, Z) is finished.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute
2	Channel number	X
3	Calibration step	4
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:
As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data.
The number of necessary calibration steps is decremented. The analog module requests channel X in the next calibration step; infeed; remove connections.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	4		**3 more steps**
4	Input/output type			09_H: RTD, 2-wire

Byte	Element	Value		Value
5	Input/output range			02_H: PT100, Std.
6	User action			4: Remove connections
7	Input/output size			
8	Calibration counter			
9	Reserved			
10	Date1			
12	Date2			
14	Date3			
16	Terminal1			Y
17	Terminal2			Z

Step C: Intermediate step

Job data set:
Acknowledge calibration step 3. The requested action (remove connections at terminals Y, Z) is finished.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute
2	Channel number	X
3	Calibration step	3
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:
As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data.
The number of necessary calibration steps is decremented. The analog module requests channel X in the next calibration step; infeed 390.5 Ω at terminals Y and Z.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X

Byte	Element	Value		Value
3	Calibration step	3		**2 more steps**
4	Input/output type			09_H: RTD, 2-wire
5	Input/output range			02_H: PT100, Std.
6	User action			2: Infeed
7	Input/output size			5: Ohm
8	Calibration counter			
9	Reserved			
10	Date1			390
12	Date2			500
14	Date3			
16	Terminal1			Y
17	Terminal2			Z

Step D: Full-Scale calibration positive

Job data set:

Acknowledge calibration step 2. The requested action (infeed 390.5 Ω at terminals Y, Z) is finished.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute
2	Channel number	X
3	Calibration step	2
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data.

The number of necessary calibration steps is decremented. The calibration values determined by the analog module are signaled (identified by measured variable = 3). The offset is in Date1, the gain in Date2, Add1 in Date3 (if present) and Add2 in Date4 (if present).

The number of successful calibration processes is signaled for this input/output range in the calibration counter.

1 is not signaled back in calibration step, which means the last calibration step.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	2		**1 more step**
4	Input/output type			09_H: RTD, 2-wire
5	Input/output range			02_H: PT100, Std.
6	User action			0: None
7	Input/output size			3: Calibration values
8	Calibration counter			X: 1 ... 255
9	Reserved			
10	Date1			Offset
12	Date2			Gain
14	Date3			Add1
16	Date4			Add2

Step E: Closure

Job data set:

Acknowledge calibration step 1. The synchronization values signaled by the analog module are accepted. You must enter the date and the time with measured variable = 4 in S7 BCD format as of byte 10.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute
2	Channel number	X
3	Calibration step	1
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	4: Date/time
8	Substitute value behavior	
9	Reserved	
10	Date/time	Date and time in S7 BCD format

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready) and mode = 3 (normal channel processing), the determined calibration values and date/time are applied and saved.

0 is not signaled back in calibration step, which means no more calibration steps. Calibration complete.

Byte	Element	Value		Value
0	Mode	2: User calibration		3: normal channel processing

Byte	Element	Value		Value
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	1		**0 (ready now)**
4	Input/output type			09_H: RTD, 2-wire
5	Input/output range			02_H: PT100, Std.
6	User action			0
7	Input/output size			0
8	Calibration counter			0
9	Reserved			0
10	Date1			0
12	Date2			0
14	Date3			0
16	Terminal1			0
17	Terminal2			0

Example: Analog output module +/-10 V

Step A: Start

Job data set:
Start the user calibration with channel X.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	
2	Channel number	X
3	Calibration step	FF_H: Start
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:
The analog module acknowledges the change to user calibration (mode = 2) with channel = X and status = 00_H (OK, Working). As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data.

The input/output range currently set on this channel as well as the number of required calibration steps is signaled.
The analog module requests channel X in the first calibration step; measuring at terminals Y and Z.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	FF_H		**3 more steps**
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 ... 10 V
6	User action			3: Measurement
7	Input/output size			1: mV
8	Calibration counter			
9	Reserved			
10	Date1			
12	Date2			
14	Date3			
16	Terminal1			Y
17	Terminal2			Z

Step B: Zero-Scale calibration

Job data set:

Acknowledge calibration step 3. The requested action (voltage measuring at terminals Y, Z) is finished. The measured voltage is transferred to the analog module in Date1 in the unit specified under measured variable. The place in front of the decimal point of the voltage in mV is entered in Date1, and the value after the decimal point of the voltage in mV multiplied by 1000 is entered in Date2. Example: 15.6 mV.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute
2	Channel number	X
3	Calibration step	3
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	1: mV
8	Substitute value behavior	
9	Reserved	
10	Date1	15

Byte	Element	Value
12	Date2	600
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data.

The number of necessary calibration steps is decremented.

The analog module requests channel X in the next calibration step; measuring at terminals Y and Z.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	3		**2 more steps**
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 ... 10 V
6	User action			3: Measurement
7	Input/output size			1: mV
8	Calibration counter			
9	Reserved			
10	Date1			
12	Date2			
14	Date3			
16	Terminal1			Y
17	Terminal2			Z

Step C: Intermediate step

Job data set:

Acknowledge calibration step 2. The requested action (voltage measuring at terminals Y, Z) is finished. The measured voltage is transferred to the analog module in Date1 in the unit specified under measured variable. The place in front of the decimal point of the voltage in mV is entered in Date1, and the value after the decimal point of the voltage in mV multiplied by 1000 is entered in Date2. Example: 9986.3 mV.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute
2	Channel number	X
3	Calibration step	2
4	Not relevant	
5	Not relevant	

Byte	Element	Value
6	Not relevant	
7	Input/output size	1: mV
8	Substitute value behavior	
9	Reserved	
10	Date1	9986
12	Date2	300
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data.

The number of necessary calibration steps is decremented. The calibration values determined by the analog module are signaled (identified by measured variable = 3). The offset is in Date1, the gain in Date2, Add1 in Date3 (if present) and Add2 in Date4 (if present). The number of successful calibration processes is signaled for this input/output range in the calibration counter.

1 is not signaled back in calibration step, which means the last calibration step.

Byte	Element	Value		Value
0	Mode	2: User calibration		2: User calibration
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	2		**1 more step**
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 ... 10 V
6	User action			0: None
7	Input/output size			3: Calibration values
8	Calibration counter			X: 1 ... 255
9	Reserved			
10	Date1			Offset
12	Date2			Gain
14	Date3			Add1
16	Date4			Add2

Step D: Full-Scale calibration positive

Job data set:

Acknowledge calibration step 1. The synchronization values signaled by the analog module are accepted.

You must enter the date and the time with measured variable = 4 in S7 BCD format as of Date1.

Byte	Element	Value
0	Command	2: User calibration
1	Identifier	1: Execute

Byte	Element	Value
2	Channel number	X
3	Calibration step	1
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	4: Date/time
8	Substitute value behavior	
9	Reserved	
10	Date1	Date and time in S7 BCD format

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready) and mode = 3 (normal channel processing), the determined calibration values and date/time are applied and saved.

0 is not signaled back in calibration step, which means no more calibration steps. Calibration complete.

Byte	Element	Value		Value
0	Mode	2: User calibration		3: normal channel processing
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	1		**0 (ready now)**
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 ... 10 V
6	User action			0
7	Input/output size			0
8	Calibration counter			0
9	Reserved			0
10	Date1			0
12	Date2			0
14	Date3			0
16	Terminal1			0
17	Terminal2			0

Abort (mode = 3)

User abort

Job data set:

An ongoing calibration can be aborted in any calibration step and in any state, even with status = 00_H (OK, Working), with the command = 3 (Abort, channel processing).

Byte	Element	Value
0	Command	3: Abort, channel processing
1	Identifier	
2	Channel number	X
3	Calibration step	
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready) and mode = 3 (abort, normal channel processing), the calibration of channel X is aborted. The channel has the same state as before the calibration. The input/output range currently set on the channel is signaled.

Byte	Element	Value		Value
0	Mode	3: Abort, channel processing		3: Abort, channel processing
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step			0
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 ... 10 V
6	User action			0
7	Input/output size			0
8	Calibration counter			0
9	Reserved			
10	Date1			
12	Date2			

Byte	Element	Value		Value
14	Date3			
16	Terminal1			
17	Terminal2			

Module abort

If the analog module detects an error during a calibration process, this error aborts the calibration. The error code is signaled in the status.

See also

Calibration exit (Page 11)

Read calibration values (mode = 4)

All current calibration values of an analog module channel are read with command = 4 (Read calibration values); these are either the values from the factory calibration or the user calibration.

The command is only permitted in status > 00_H. The channel number must be specified and the calibration step must be set to FF_H (Start).

Step A: Start

Job data set:

Byte	Element	Value
0	Command	4: Read calibration values
1	Identifier	
2	Channel number	X
3	Calibration step	FF_H: Start
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data. Measured variable = 3 identifies the data as of Date1 as calibration values. Only the current calibration values of the specified channel are read with command = 4; these are the calibration values associated with the parameterized input/output range.

Byte	Element	Value		Value
0	Mode	4: Read calibration values		4: Read calibration values
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	FF_H		**1 more step**
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 ... 10 V
6	User action			0: None
7	Input/output size			3: Calibration values
8	Calibration counter			X: 0 ... 255
9	Reserved			0
10	Date1			Offset
12	Date2			Gain
14	Date3			Add1
16	Date4			Add2

The input/output range currently set on the channel is signaled.

The offset is in Date1, the gain in Date2, Add1 in Date3 (if present) and Add2 in Date4 (if present).

The calibration counter specifies if the values are factory calibration values (calibration counter = 0) or user calibration values (calibration counter > 0). For user calibration values, the value of the calibration counter is equal to the number of successful calibration processes for this input/output range (since the last user calibration of a different input/output range).

Calibration step = 1 indicates that one more step is necessary.

Step B: Closure

Job data set:

Acknowledge calibration step 1.

Byte	Element	Value
0	Command	4: Read calibration values
1	Identifier	
2	Channel number	X
3	Calibration step	1
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	

Byte	Element	Value
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready), the remaining data of the acknowledgment data set are valid and you can evaluate the data. Measured variable = 4 identifies the data as of Date1 Time stamp. A time stamp that matches the previously read calibration values is signaled.

Byte	Element	Value		Value
0	Mode	4: Read calibration values		3: normal channel processing
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	1		0
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 ... 10 V
6	User action			0: None
7	Input/output size			4: Date/time
8	Calibration counter			X: 0 ... 255
9	Reserved			
10	Date/time			Date and time in S7 BCD format

Restore factory calibration (mode = 5)

Use command = 5 (Restore factory calibration) to undo the executed user calibration of the specified channel for the set input/output range. The analog module applies the calibration values determined at the factory which will be in effect again. Delete saved user calibration values.

If user calibration values of the channel exist which do not belong to the set input/output range, these are not deleted.

The command is only permitted in status > 00_H.

Specify the channel number and set the calibration step to FF_H (Start).

The calibration counter is set to 0 again with this command.

Job data set:

Byte	Element	Value
0	Command	5: Restore factory calibration
1	Identifier	
2	Channel number	X
3	Calibration step	FF_H
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	

Byte	Element	Value
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:

As soon as the analog module signals in status = 01_H (OK, Ready) and mode = 3 (normal channel processing), restoration is complete. The user calibration was deleted and the channel continues operating in the previous state with factory calibration values.

Byte	Element	Value		Value
0	Mode	5: Restore factory calibration		3: normal channel processing
1	Status/error code	00: OK, Working		01: OK, Ready
2	Channel number	X		X
3	Calibration step	FF_H		**0 (ready now)**
4	Input/output type			01_H: Voltage
5	Input/output range			02_H: 0 ... 10 V
6	User action			
7	Input/output size			
8	Calibration counter			
9	Reserved			
10	Date1			
12	Date2			
14	Date3			
16	Terminal1			
17	Terminal2			

Reset (mode = 6)

Use the command = 6 (Reset) to restore the factory calibration for a channel or the entire analog module regardless of the parameter assignment of the channels.

The factory calibration of a channel is restored according to the channel number, and any saved user calibration values are deleted (even if the saved user calibration values do not belong to the currently set input/output range). With channel number FF_H, restoration takes place for all channels of the analog module.

The command is only permitted in status > 00_H. Set the calibration step to FF_H (Start). The channel or the analog module must not be parameterized.

The involved calibration counters are set to 0 again with this command.

Job data set:

Byte	Element	Value
0	Command	6: Reset
1	Identifier	
2	Channel number	X
3	Calibration step	FF_H
4	Not relevant	
5	Not relevant	
6	Not relevant	
7	Input/output size	
8	Substitute value behavior	
9	Reserved	
10	Date1	
12	Date2	
14	Date3	
16	Substitute value	

Acknowledgment data set:
As soon as the analog module signals in status = 01_H (OK, Ready) and mode = 3 (normal channel processing), reset is complete. The user calibration values were deleted. All channels involved continue operating in their previous state with factory calibration values.

Byte	Element	Value		Value
0	Mode	6: Reset		3: normal channel processing
1	Status/error code	00_H: OK, Working		01_H: OK, Ready
2	Channel number	X		X
3	Calibration step	FF_H		**0 (ready now)**
4	Input/output type			
5	Input/output range			
6	User action			
7	Input/output size			
8	Calibration counter			
9	Reserved			
10	Date1			
12	Date2			
14	Date3			
16	Terminal1			
17	Terminal2			

Appendix A

Input type/range format: Input channels

Input type format: Input channels

$Value_D$	Input type
00	Deactivated
01	Voltage
02	Current (4-wire transducer)
03	Current (2-wire transducer)
04	resistance (4-wire connection)
05	resistance (3-wire connection)
06	resistance (2-wire connection)
07	Thermal resistance (linear, 4-conductor connection)
08	Thermal resistance (linear, 3-conductor connection)
09	Thermal resistance (linear, 2-conductor connection)
10	Thermocouple

Input range format: Input channels

An input type that is not as listed in this table can also be used for specific modules. You must note, however, that the input type in the acknowledgment data set no longer matches the general definition.

$Value_D$	Input type
For input type = 01 (voltage)	
00	± 25 mV
01	± 50 mV
02	± 80 mV
03	± 250 mV
04	± 500 mV
05	± 1 V
06	± 1.25 V
07	± 2.5 V
08	± 5 V
09	± 10 V
10	1 ... 5 V
11	0 ... 10 V
For input type = 02, 03 (current)	
00	± 3.2 mA
01	± 10 mA
02	0 ... 20 mA
03	4 ... 20 mA

Value$_D$	Input type
04	± 20 mA
05	± 5 mA
For input type = 04, 05, 06 (resistor: 4-wire, 3-wire , 2-wire connection)	
00	48 Ω
01	150 Ω
02	300 Ω
03	600 Ω
04	3000 Ω
05	6000 Ω
06	10000 Ω
15	PTC (DIN VDE 0660 Part 303 Type A)
For input type = 07, 08, 09 (thermistor: 4-wire, 3-wire , 2-wire connection)	
00	Pt100 climatic range
01	Ni100 climatic range
02	Pt100 Standard range
03	Ni100 standard range
04	Pt500 standard range
05	Pt1000 standard range
06	Ni1000 standard range
07	Pt200 climatic range
08	Pt500 climatic range
09	Pt1000 climatic range
10	Ni1000 climatic range
11	Pt200 standard range
12	Ni120 standard range
13	Ni120 climatic range
14	Cu10 climatic range
15	Cu10 standard range
16	Ni200 standard range
17	Ni200 climatic range
18	Ni500 standard range
19	Ni500 climatic range
20	Pt10 standard range
21	Pt10 climatic range
22	Pt50 standard range
23	Pt50 climatic range
24	Cu50 standard range
25	Cu50 climatic range
26	Cu100 standard range

$Value_D$	Input type
27	Cu100 climatic range
28	LG Ni1000 standard range
29	LG Ni1000 climatic range
For input type = 10 (thermocouple)	
00	Type B [PtRh-PtRh]
01	Type N [NiCrSi-NiSi]
02	Type E [NiCr-CuNi]
03	Type R [PtRh-Pt]
04	Type S [PtRh-Pt]
05	Type J [Fe-CuNi]
06	Type L [Fe-CuNi] recalled since 1994 standard (DIN 43710)
07	Type T [Cu-CuNi]
08	Type K [NiCr-Ni]
09	Type U [Cu-CuNi] recalled since 1994 standard (DIN 43710)
10	Type C [W5Re-W26Re]
11	TXK/XK(L) [TXK/XK(L)]

Output type/range format: Output channels

Output type format: Output channels

An output type that is not as listed in this table can also be used for specific modules. You must note, however, that the output type in the acknowledgment data set no longer matches the general definition.

$Value_D$	Output type
00	Deactivated
01	Voltage
02	Current (4-wire transducer)
03	Current (2-wire transducer)

Output range format: Output channels

$Value_D$	Output range
For output type = 01 (voltage)	
00	± 10 V
01	± 5 V
02	0 ... 10 V
03	1 ... 5 V
04	± 2.5 V
05	± 1 V

$Value_D$	Output range
For output type = 02, 03 (current)	
00	± 20 mA
01	0 ... 20 mA
02	4 ... 20 mA

SIEMENS

SIMATIC
ET 200SP Open Controller
Product information on CPU 1515SP PC2 (F/T/TF)
Product Information

Documentation overview

This product information supplements the documentation for the ET 200SP Open Controller CPU 1515SP PC2 (F/T/TF), edition 03/2023.

The statements included in it take precedence over statements made elsewhere in case of doubt.

The described functional restrictions apply to the Open Controller CPU 1515SP PC2 (F/T/TF) V30.0 Windows and SIMATIC Industrial OS.

CPU 1515SP PC2 (F/T/TF) - Windows

Technical update - Windows

PROFIBUS support

Operation of the CM DP module with order number 6ES7 545-5DA00-0AB0 with CPU 1515SP PC2 (Windows LTSC 2021 variants) and Software Controller V30.0 is only possible as a DP master. Operation as a DP device (DP slave) is not possible.

With the coming software controller version V30.1 for the CPU 1515SP PC2, planned for March 2024, the CM DP module will be supported without restrictions.

The variants of the CPU 1515SP PC2 with software controller V21.9 and full support of the CM DP module still remain available.

Device warning of the "Intel(R) Serial IO GPIO Host Controller - INT3452" in the Device Manager

The Windows 10 LTSC 2019 Device Manager of the Open Controller image includes the following driver:

- Intel(R) Serial IO GPIO Host Controller - INT3452

This driver is marked by a yellow triangle with an exclamation mark.

To view the device status of this driver, do the following:

1. Select the driver "Intel(R) Serial IO GPIO Host Controller - INT3452".
2. Right-click on the driver.
3. Select the menu command "Properties".
   The "Properties of Intel(R) Serial IO GPIO Host Controller - INT3452" window opens.
4. The "General" tab contains the device status with the following error message: This device cannot find enough free resources that it can use. (Code 12)

This warning does **not** have a negative effect on the functionality of the system.

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A5E51390065-AB, 09/2023

Enabling the Wake-On-LAN functionality

To enable the Wake-On-LAN functionality, do the following:

1. In Windows, open the Device Manager with administrator privileges.
2. Look for the network adapter "Intel(R) I210 (Gigabit / Ethernet Server) Adapter".
3. Right-click on the adapter.
4. Select the menu command "Properties".
   The "Properties of Intel(R) Ethernet Server Adapter I210-T1" window opens.
5. Navigate to the "Advanced Settings" tab.
6. In the "Properties" area, enable the entries "Enable PME" and "Enable Magic Packet" by setting the value to "Enabled".
7. Restart Windows.

Result: The Wake-on-LAN functionality is enabled.

Restore partition is not assigned a drive letter

If the USB flash drive was not removed from the USB port after completing the restoration of the image, the drive letter of the restore partition remains unassigned.

In this case, you need to assign the drive letter of the partition manually.

This requires administrator privileges.

To manually assign the drive letter of the partition, follow these steps:

1. Go to the Windows Start menu and look for Windows Explorer.
2. Open Windows Explorer.
3. In the File Explorer, click on "This PC" and right-click on "Manage".
   The "Computer Management" window opens.
4. Click "Storage > Disk Management".
5. Right-click on the partition with the name "Restore" (the partition is highlighted) and select the following menu command: "Change Drive Letter and Paths".
   The "Change Drive Letter and Paths for Restore" window opens.
6. Click the "Add" button and select "Assign the following drive letter:".
   Use the drive letter "E".
7. Click "OK".
   If the assigned letter "E" is not displayed in the "Restore" partition, try clicking on another partition.
8. Close the "Computer Management" window.

Result: The partition was assigned to the drive letter.

Missing drivers in the device manager after initial setup

Not all drivers of the Intel® processor are pre-installed in the "Windows System Image Manager" of the Open Controller CPU1515 SP PC2. The drivers are not required for the operation of the Open Controller CPU1515 SP PC2 as a programmable controller. The exclamation marks in the Windows 10 Device Manager can be confirmed.

Acronis backup is not supported

The Acronis backup is not supported in the current version – use Image Partition Creator.

No activation of the Windows copy

If you do not have an Internet connection, you do **not** need to activate the Windows copy. There are no functional restrictions.

Display of processor temperature by SIMATIC IPC DiagBase

The **SIMATIC IPC DiagBase** software shows **only** the temperature of the CPU. The temperature of the motherboard and work memory are currently not displayed.

Changing the boot order

To change the boot sequence on the Open Controller CPU 1515SP PC2 ≥ V2.5, proceed as follows:

1. Connect a monitor and a keyboard to the CPU.
2. Switch on the power supply of the CPU.
   The Siemens logo, among others, appears on the screen of the connected monitor.
3. Press "Esc" to enter the boot menu. Wait briefly until the boot menu is displayed.
4. Press "F1" and wait until the computer loads the system information.
5. Select the digit of the desired boot media to set or change the boot drive.

   NOTE

   If no prepared boot medium is inserted in the selected boot drive, the system is automatically rebooted after 60 seconds. To select bootable media again in this case, repeat steps 3 to 5.

6. The system is reset after 5 seconds and automatically boots from the new boot drive.

Key combination <Ctrl+Alt+Del> during initial commissioning

To ensure that the initial initialization is complete, do **not** use the key combination <Ctrl+Alt+Del> during the initialization phase.

Operation with two monitors

Use only **one** monitor. If several monitors are used simultaneously, undefined states might occur in the system.
The following display and HDMI splitters are recommended for the CPU 1505S F:

- Display splitter: Multi Stream Transport (MST) Hub DisplayPort™ 1.2 Quad Monitor CSV-5400
- HDMI splitter: Delock Display Port 1.2 Splitter 87720

Cables for connecting the DisplayPorts

Use **only** the following cables to connect the DisplayPorts:

- DisplayPort cable, length: 5 m, E74020-C AWM Style 20276, 80°C, 30 V, VW-1 (with integrated ferrite cores at both ends)
- DisplayPort cable, length: 3 m, 6AV7860-0DH30-0AA0
- DisplayPort cable, length: 5 m, 6AV7860-0DH50-0AA0

Time-of-day synchronization cannot be used in the TIA Portal

The "Time-of-day synchronization" entry in the Inspector window > Properties > General cannot be used.

CPU 1515SP PC2 (F/T/TF) - SIMATIC Industrial OS

Technical update - SIMATC Industrial OS

PROFIBUS support

Usage of the CM DP module with software controller V30.0 with CPU 1515SP PC2 and SIMATIC Industrial OS is not released. With the coming software controller version V30.1 for the CPU 1515SP PC2, planned for March 2024, the CM DP module will be supported without restrictions.

See also

Getting Started IndOS (https://support.industry.siemens.com/cs/de/en/view/109795683)
Operating instructions (https://support.industry.siemens.com/cs/de/en/view/109808199)
Link to "Factory state" (https://support.industry.siemens.com/cs/ww/en/view/109817478)

SIEMENS

SIMATIC Distributed I/O System

ET 200SP HA / ET 200SP Modules for devices in a hazardous area

System Manual

6DL1193-6BP00-0DW0;6DL1133-6PX00-0HW0;6DL1-193-6BP00-0BX1;6ES7133-6CV20-1AM0

10/2024
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ET 200SP HA / ET 200SP Modules for devices in a hazardous area

System Manual

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Cybersecurity information 1

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Preface

2

Purpose of the documentation

This documentation supplements the system documentation of the following product series of distributed I/Os:

- SIMATIC ET 200SP HA distributed I/O
- SIMATIC ET 200SP distributed I/O

The I/O components described extend these distributed I/O systems with the option of integrating devices located in hazardous areas (intrinsically safe sensors, actuators and HART field devices) into the system. The associated I/O modules with device protection according to intrinsic safety "i" offer channel outputs in Zone 0 or 1. For setup, at least one special potential group must be integrated into the distributed I/O. Such a potential group is referred to as an Ex module group in the following.

You can find the following information on Ex module groups in this documentation:

- Deployment zones
- General information on components for use in hazardous areas
- System overview
- Installation
- Wiring
- Commissioning
- Service and maintenance

Area of application

The scalable design makes it possible to adapt the expansion to the respective requirements of the plant.

Knowledge required

A basic knowledge of automation technology is required to understand the documentation.

Knowledge of the system documentation of the distributed I/O used:

- SIMATIC ET 200SP HA distributed I/O
- SIMATIC ET 200SP distributed I/O

Configuration, use and programming of the basic system used for the distributed I/O.

If you use the components in a hazardous area, knowledge of the applicable international and local standards and guidelines for the design of components and systems in the specific hazardous area is required.

NOTE

Installation of components of the Ex module group

The statements made in this documentation take precedence over the system documentation of the distributed I/O used.

Rules for configuring the I/O station (Page 36)

Validity of the documentation

This documentation applies to the use of the distributed I/Os that are suitable for connecting devices in hazardous areas:

- SIMATIC ET 200SP HA distributed I/O
- SIMATIC ET 200SP distributed I/O

Conventions

The following terms are used synonymously in this documentation:

Term	Synonyms	Notes
I/O station	• IO device • DP master station	Unless otherwise specified, the following applies: • IO devices on a PROFINET IO • Stations of the distributed I/O (especially when integrating the Ex components at an ET 200SP station connected to a PROFIBUS DP)
I/O module	• I/O module • Module • Electronic module • PM	Unless otherwise specified, applies to the objects of the distributed I/O in which the electronics for detecting sensor signals and/or for outputting hardware control signals to actuators is implemented.
Basic assembly		Applies for the objects of the distributed I/O that do not belong to the components for devices located in the hazardous area.
Ex module group		Unless otherwise specified, applies to the special potential group with components for devices located in the hazardous area. Components of this potential group: • Ex BaseUnit with Ex power module • Ex BaseUnit(s) with Ex I/O module

Term	Synonyms	Notes
Ex I/O module	• Ex electronic module • Ex module	Unless otherwise specified, applies to I/O modules suitable for devices located in hazardous areas (intrinsically safe sensors, actuators and field devices). Note: Devices that are connected to these Ex I/O modules may be located in the Ex-i area up to Zone 0/1, provided that the devices and the associated components are also suitable.
Ex power module	• Ex-PM E • Power supply	Unless otherwise specified, applies to the components for power supply of the Ex module group
Ex BaseUnit	• BU • ExBU_PS • ExBU_PM	Components of the Ex module group: Unless otherwise specified, applies to the specific components for mounting the slots for the Ex power module or the Ex I/O modules. Note for ET 200SP HA: In contrast to the standard configuration of the ET 200SP HA, the slot of the Ex module group consists only of the Ex BaseUnit (no division into carrier module and terminal block).
Interface module	IM	Interface module or other head module
BU cover	Slot cover	Components of the Ex module group: Unless otherwise specified, applies for the specific component for covering a slot.

Also read the notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Special information

NOTE

Important note for maintaining operational safety of your plant

Plants with safety-related features are subject to special operational safety requirements on the part of the operator. Even suppliers are required to observe special measures during product monitoring. This is why we inform you about product developments and features that are or may become important for the operation of plants with regard to safety in a special newsletter.

You should subscribe to the corresponding newsletter in order to obtain the latest information and to allow you to modify your plant accordingly.

2.1 Recycling and disposal

Electrical and electronic products must be disposed of properly in accordance with the relevant regulations for waste electrical and electronic equipment. The product is low in pollutants and recyclable. Dispose of the product according to local regulations or contact a certified waste disposal service.

2.2 Documentation guide

The documentation for the ET 200SP HA and ET 200SP distributed I/Os for use in hazardous areas is divided into three sections.
The division offers you the possibility to access the specific content you need.

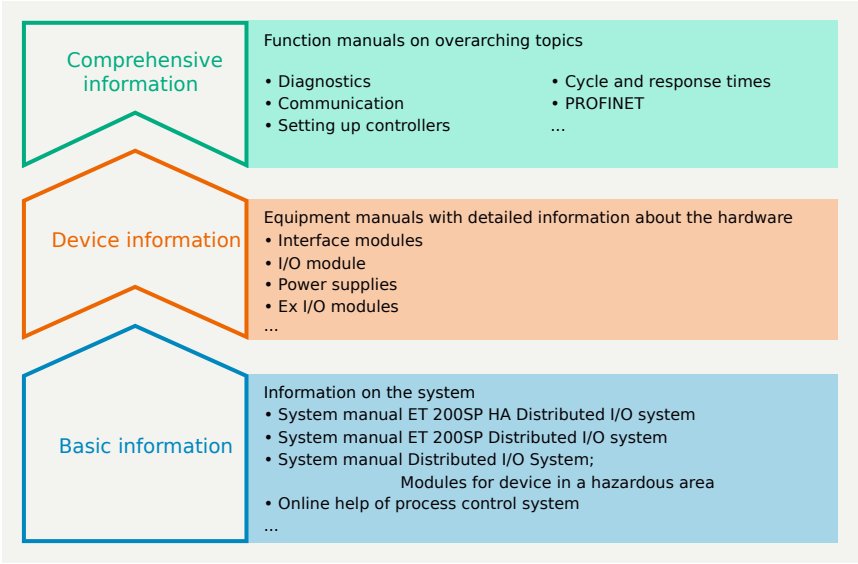

Basic information

The system manual describes in detail the installation and wiring of the components.

You can find information about the configuration of the components in the documentation of the process control system.

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

Comprehensive information

Function manuals provide you with detailed descriptions of comprehensive topics, e.g. diagnostics, communication, and interference-proof design of control systems.

Information on changes

Changes and additions to the manuals are documented in a product information file when necessary.

2.3 Notifications – Always up to date

Register for individual notifications (Newsletter)

1. Open the web page of the product support:
   https://support.industry.siemens.com/cs/ps
   (https://support.industry.siemens.com/cs/ww/en/ps)
2. Filter the products for which you want to receive notifications.
3. Click "Save filter".
4. Enter the filter name.
5. Click "Enable notification".
6. Click "Save filter".

Additional information on this:

- Quick start: Receive notifications (Newsletter) (https://support.industry.siemens.com/cs/): Individual notifications and filters (Newsletter)
- Helpful functions in Online Support (videos)
  (https://support.industry.siemens.com/cs/ww/es/sc/2063)

Always up to date with "mySupport"

In Industry Online Support, you can set "Filters" for various individual topics of interest (e.g. topics, configurations, products, etc.) or mark specific articles as "Favorites". To not have to check for yourself whether there is news or changes to these topics of interest, you can receive notifications from the Online Support, for example, by email.

- You access this service on the following pages on the Internet
  (https://support.industry.siemens.com/cs/my).
  You will find the following information in the header:
  - **Language**: Language selection for "mySupport" page
  - **Contact**: "Global and regional contacts"
  - **Help:** Help for "mySupport" page
  - **Support Request**: Requests submitted to technical specialists

2.4 Scannable code on the product

2.4.1 Scannable code on the product

This product can contain the ID-Link or the 2D matrix code. Please check by means of the following examples which type of code your product contains.

ID-Link:

2D matrix code:

2.4.2 2D Matrix code (QR code / EAN code)

The 2D matrix code on the product is a coded representation of the product-specific article number.

Access to product-related information

For reading the 2D matrix code, SIEMENS offers an app for mobile use.
Information about the app and the download can be found on the Internet: "Mobile use via app (https://support.industry.siemens.com/cs/ww/en/sc/2067)".

The app provides direct access to the technical forum and product-related posts, such as:

- FAQs
- Application examples
- Manuals
- Certificates
- Product notices

2.4.3 ID-Link

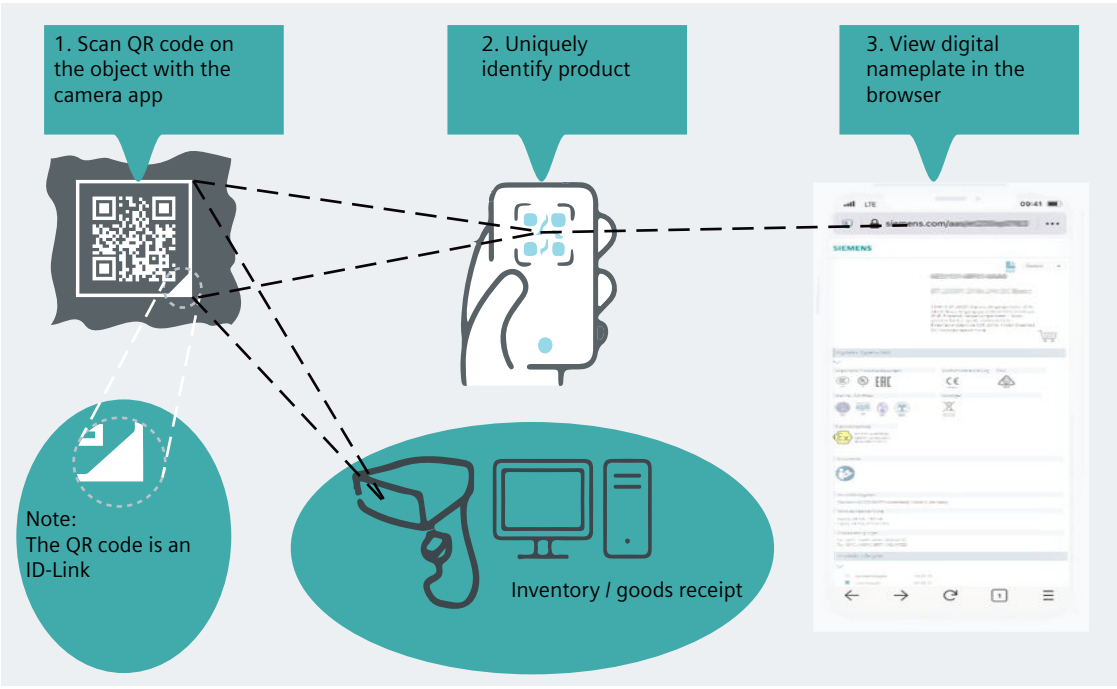

The ID-Link on the front of this product and on the packaging uniquely identifies the product.

The ID-Link corresponds to the standard IEC 61406-1.

If you scan the ID-Link (e.g. with a smartphone), you open the digital nameplate directly.

Digital nameplate

The digital nameplate is:

- A contribution from SIEMENS to reduce the CO_2 footprint and to conserve resources.
- The efficient way to access the product information provided on the Internet. This information remains up-to-date over the entire product life cycle.
  For your plant documentation, you have the option of linking the download or downloading the following information:
  - Technical specifications
  - Certifications and Declaration of Conformity
  - Manufacturer information
  - Product identification
  - User documentation
  - Replacement
  - Responsive web design
  - Other information

System overview

3

Definition

Accessory parts are not included in the Ex I/O components. The components can be ordered separately.

Accessories/spare parts (Page 110)

Description

An example use of the accessory components for Ex module groups is shown below:

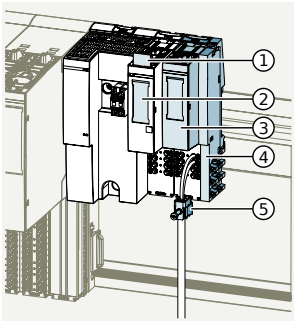

①	Reference identification labels (Page 24)	Used for slot identification.
②	Labeling strips (Page 25)	Used for identification of an Ex power module.
③	BU cover (slot cover) (Page 25)	Serves to protect the contacts when the slots are not occupied or reserved.
④	Server module	Part of the standard I/Os. Completes the station configuration of the distributed I/O.
⑤	Shield connector (Page 26)	Used to connect the shielding of process cables to the functional grounding.

3.1 Basic assembly of the I/O station

The following shows the basic assembly of an I/O station for connecting devices in the hazardous area.

Example:

Example configuration of the I/O station with Ex module group (Page 18)

Basic assembly of the I/O station

The basic assembly of the distributed I/O system provides the interface to the automation system.

Possible basic assembly:

- SIMATIC ET 200SP HA
- SIMATIC ET 200SP

Rules for configuring the I/O station (Page 36)

Requirement for connecting devices in the hazardous area

Devices in the hazardous area in Ex Zones 1 and 0 can be connected to the I/O station if these devices are connected to an Ex module group. Devices located in hazardous areas must be intrinsically safe (sensors, actuators and HART field devices).

Components of the Ex module group:

- Ex BaseUnits
- Ex power module
- Ex I/O module

Deployment zones (Page 35)

Additional information

- Notes on safe use (Page 34)
- You can find information on modules in the newsletter.
- You can find information about the existing product range in the current catalog.

3.2 Example configuration of the I/O station with Ex module group

The figure shows an example of the integration of an Ex module group in an I/O station based on the SIMATIC ET 200SP HA.

No I/O modules are required in the basic assembly of the I/O station for the integration of an Ex module group.

NOTE

I/O station on the basis of the SIMATIC ET 200SP

During the installation with SIMATIC ET 200SP, you can use the standard mounting rail of the ET 200SP as the basis of the I/O station.

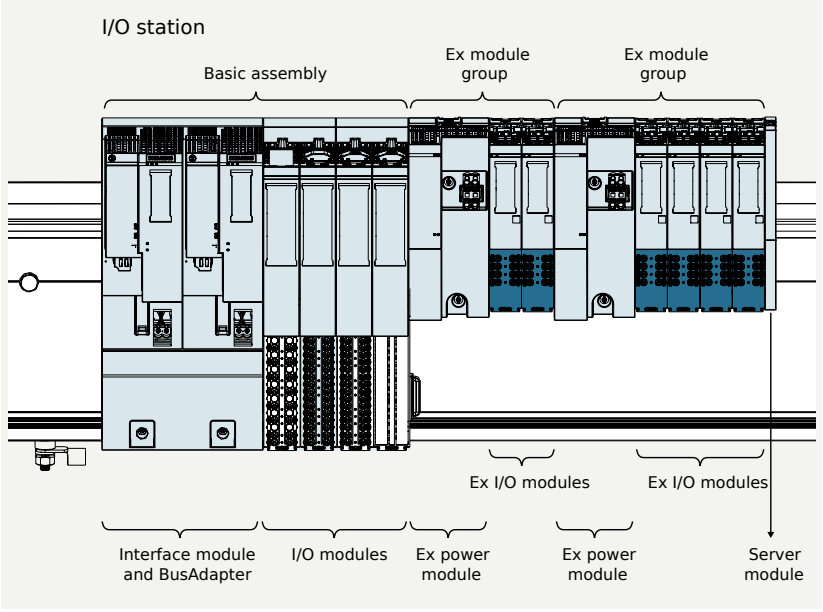

3.3 SIMATIC ET 200SP HA or SIMATIC ET 200SP distributed I/O system

Definition

The components described below enable connection of devices located in the hazardous area to the SIMATIC ET 200SP HA or SIMATIC ET 200SP distributed I/O systems.

Description

The following figure shows an example configuration of an IO device from the components of the distributed I/O system:

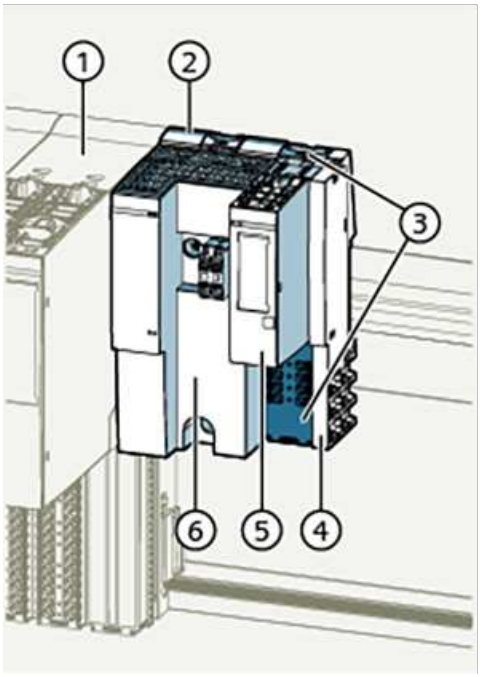

①	Standard I/O (including ⑥ server module)	Rules for configuring the I/O station (Page 36) The server module completes the configuration of the distributed I/O station Accessories for the Ex module groups (Page 16)
②	AUTOHOTSPOT	Slot for an Ex power module (with power supply plug)
③	Ex power module (Page 21)	Supply voltage for the Ex module group
④	Ex BaseUnit for Ex I/O module (Page 22)	Slot for an Ex I/O module (with terminal block for connection of sensors, actuators and other devices)

⑤	Ex I/O module (Page 23)	• Record the current process status via sensors connected to the terminal block of the Ex BaseUnit. • Trigger reactions in the process via the actuators connected to the terminal block of the Ex BaseUnit. The slot is coded by plugging in an Ex I/O module: Coding element (Page 24) If no Ex I/O module is plugged in, a slot cover can be inserted to protect the contacts. This is not shown in the example configuration:Accessories for the Ex module groups (Page 16)

3.4 Basic components of the Ex module group

3.4.1 Ex BaseUnit for Ex power module

Definition

The Ex BaseUnit for an Ex power module is a component of an Ex module group with electrical and mechanical functions.

Electrical functions:

- Isolation of the potential groups to the modules on the left-hand side.
- Routing the supply voltage of the Ex power module to the power bus.
- Routing the backplane bus to Ex BaseUnits plugged in at the right.

Mechanical functions:

- Specification of the slot on the mounting rail.
- Mounting and mechanical protection of an Ex power module.
- Mechanical connection with the module on the left (default I/O or Ex BaseUnit for an Ex I/O module).

Description

The Ex BaseUnit for Ex power module (type W0, article number 6DL1193-6BP00-0DW0) is structured as follows:

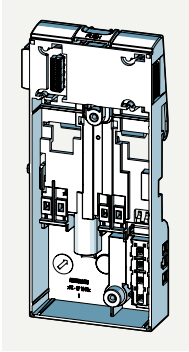

3.4.2 Ex power module

Definition

An Ex power module is a component of an Ex module group.

- The Ex power module restricts the voltage to the value permissible for the hazardous area.
- The output current is limited electronically and via a fuse.
- The supply voltage for the ex power module must be supplied from a SELV/PELV circuit.
- The Ex power module supplies the following Ex I/O modules via the power bus at the Ex BaseUnit of the Ex power module.
- A Ex BaseUnit is required for mounting the Ex power module.

Description

The Ex power module (article number: 6DL1133-6PX00-0HW0) is structured as follows:

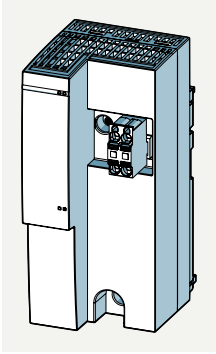

See also

Technical specifications - Ex power module (Page 103)

3.4.3 Ex BaseUnit for Ex I/O module

Definition

The Ex BaseUnit for an Ex I/O module is a component of an Ex module group with electrical and mechanical functions.

The Ex BaseUnits are used for the electrical and mechanical connection of the individual modules and provide the process terminals for the connection of sensors, actuators and other devices.

The Ex BaseUnit includes the following:

- Slot for an Ex I/O module
- Terminal block for the connection of sensors and actuators.

When assembling the Ex module group, you need an Ex BaseUnit for each slot of an Ex I/O module.

Electrical functions:

- Connecting the process signals of the sensors and actuators connected to the terminal block with the plugged in Ex I/O module.
- Routing the supply voltage and the backplane bus to the plugged in Ex I/O module.
- Routing the supply voltage and the backplane bus to an Ex BaseUnit for Ex I/O modules plugged in at the right.
- Routing the functional grounding from the mounting rail to the shield terminal.

Mechanical functions:

- Specification of the slot on the mounting rail
- Mounting and mechanical protection of an Ex I/O module
- Mechanical connection with the module on the left (Ex BaseUnit for an Ex I/O module or Ex BaseUnit for an Ex power module).

Description

The Ex BaseUnit for Ex I/O module (type X1, article number 6DL1193-6BP00-0BX1) is structured as follows:

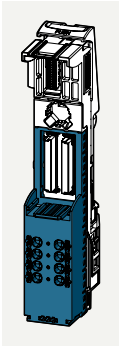

See also

Technical specifications - Ex BaseUnits (Page 105)

3.4.4 Ex I/O module

Definition

The I/O modules are connected to the process signals via the terminal block.

- I/O modules record the current process status via sensors connected to the terminal block of the Ex BaseUnit.
- I/O modules trigger reactions in the process via the actuators connected to the terminal block of the Ex BaseUnit.

Description

NOTE

For information on which Ex I/O modules can be ordered, refer to the online catalog under Information and support (Page 121).

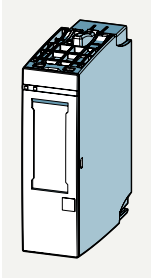

3.4.5 Coding element

Definition

The mechanical coding element is a component of the Ex I/O module.

This element encodes the type of the plugged Ex I/O module.

Acting as a mechanical lock, the coding element prevents incompatible Ex I/O modules from being connected to the Ex BaseUnit. A different type of Ex I/O module can only be plugged in after the coding element of the part latched in the Ex BaseUnit has been removed.

Description

NOTE

For more information on the function and handling of the coding elements, refer to the system documentation of the distributed I/O used:

- SIMATIC ET 200SP HA
- SIMATIC ET 200SP

Ex I/O modules have a mechanical, two-part coding element.

The coding element is located on the Ex I/O module at the factory.

The first time an Ex I/O module is plugged in, a part latches into the Ex BaseUnit. The second part of the coding element also remains on the Ex I/O module when the Ex I/O module is removed.

The part of the coding element that is latched onto the Ex BaseUnit encodes this slot to the type of the Ex I/O module.

The coding element (for Ex BaseUnit) has the following design:

3.5 Overview of the accessories

3.5.1 Reference identification labels

Definition

Reference identification labels are accessories for the Ex module group.

Equipment labeling plates enable the reference identification of the components of the Ex module group.

Description

The equipment labeling plates are used for the unique identification of the modules within the Ex module group.

The equipment labeling plates have the following structure:

Reference identification labels can be printed and can be ordered as accessories:

For thermal transfer and inkjet printers on a sheet

3.5.2 Labeling strips

Definition

Labeling strips are accessories for the Ex module group. Attach the labeling strips on the modules for plant-specific marking.

Description

The labeling strips are mostly used for unique identification of the component within the system.

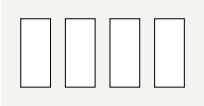

Labeling strips can be printed and can be ordered as accessories:

- Labeling strips for thermal transfer printer on a roll
- Labeling strips for laser printer as A4 sheets

3.5.3 BU cover (slot cover)

Definition

Slot covers are accessories for the Ex module group. A slot cover is inserted on Ex BaseUnits:

- When a slot is not equipped with an Ex I/O module.
- When a slot is reserved for future expansion (as an empty slot).

Description

A slot cover serves to protect an unused slot for an Ex I/O module.

The slot cover (BU cover 20 mm) is structured as follows:

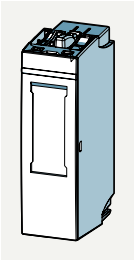

The BU covers have a holder for an equipment labeling plate on the inside.

If the I/O station is removed in the future, remove the equipment labeling plate from the holder and place it onto the final Ex I/O module.

3.5.4 Shield connector

Definition

You need the shield connection to apply cable shields (e.g. for analog modules).

The shield connection conducts interference currents on cable shields to ground via the mounting rail.

It enables the shield of process cables to be connected to the functional grounding. The mounting rail of the I/O station must be connected to functional grounding for this.

It is not necessary to contact the shield at the point where the cable enters the cabinet.

You fasten the shield connection to the Ex BaseUnit.

The shield connection is automatically connected to the functional grounding of the mounting rail after installation.

Description

The shield connection consists of a shield contact, a shield terminal and a support element.

The shield connection is a special clamping device which enables the low-impedance connection of cable shields with minimum assembly times.

The shield connection has the following structure:

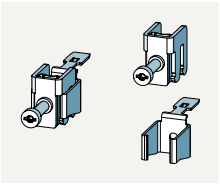

3.6 Factory markings

Definition

The markings support the installation of the modules and the configuration of the distributed I/O with existing modules.

Description

The following markings are applied in the delivery state:

- Module labeling (Page 28)
- Color coding of the I/O module classes (Page 29)
- Color coding of the spring releases (Page 31)

3.7 Labeling and coding

3.7.1 Module labeling

Definition

The module labeling provides information about properties of a specific module.

Description

The following module labeling is applied:

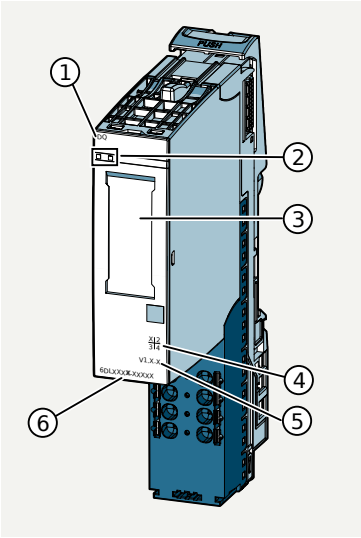

① Type of I/O module
② Labeling of the LED
③ Labeling strips (plant-specific labeling is possible)
④ Function version
⑤ Color code for selection of the color-coded labels
⑥ Serial number and article number

3.7.2 Color coding of the I/O module classes

Definition

The color coding of the I/O module classes indicates the basic type of the I/O module classes of the respective module.

Description

The color coding of the I/O module classes is displayed as follows:

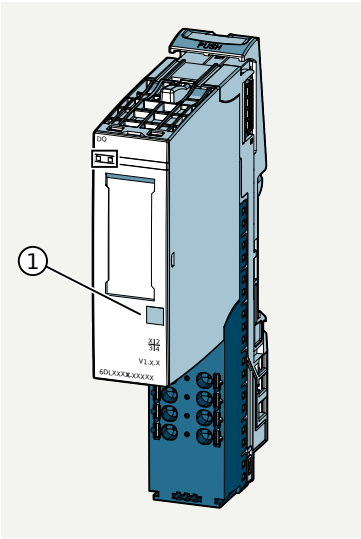

① Color coding of the I/O module classes (basic types)

The following basic types of I/O module classes are available:

Identifier for	Markings or colors	
Digital input module	white	
Digital output module	black	
Analog input module	light blue	
Analog output module	dark blue	

3.7.3 Color coding of the potential group

Definition

The color coding of the potential group indicates whether a potential group is opened or extended.

Description

The potential groups are displayed as follows:

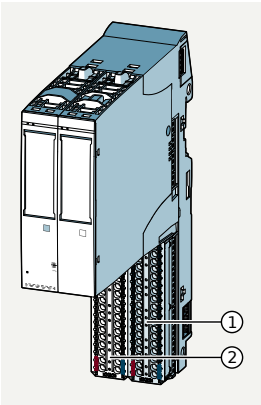

① Extending the potential group (dark gray terminal block)

② Opening the potential group (light gray terminal block)

NOTE

There are also terminal blocks with black cover. Black terminal blocks have no power bus function and cannot form potential groups with neighboring modules.

3.7.4 Color coding of the spring releases

Definition

The color coding of the spring releases provides information about the voltage to be connected.

Description

The color coding of the spring releases is displayed as follows:

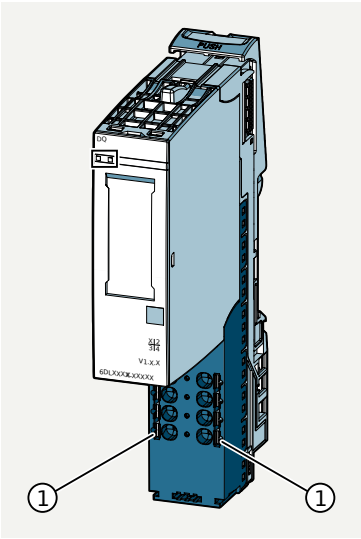

① Process terminals (white)

Plant planning

4

Maximum mechanical configuration

As soon as **one** of the following rules applies, the maximum configuration for an I/O station is reached:

Maximum configuration for ET 200SP HA mechanical

Properties	Rule
Number of modules	Maximum 56 slots for I/O modules, regardless of their use
Backplane bus length of the I/O station	Sum of the width of all carrier modules/BaseUnits and Ex BaseUnits + width of the server module <= 1.3 m

Maximum configuration for ET 200SP mechanical

Properties	Rule
Number of modules	Maximum 64 I/O modules (depending on the CPU/interface module used) Additional information on this: • CPU (https://support.industry.siemens.com/cs/ww/en/ps/13889/man) • Interface module (https://support.industry.siemens.com/cs/ww/en/ps/14034/man)
Backplane bus length of the I/O station[1)]	Sum of the width of all BaseUnits and Ex BaseUnits + width of the server module <= 1 m

[1)] Observe the required thermal decoupling (potential distributor or empty slot).

Configuration of an Ex module group

The following components are required for integrating an Ex module group into the I/O station:

NOTE

Permissible components of an Ex module group

Only the components listed in this table are permitted in Ex module groups!

Components	Quantity	Note
Ex BaseUnit for Ex power module	1	Mount the Ex module groups to the right of the standard I/Os. Note: • Rules for configuring the I/O station (Page 36) • Configuration examples (Page 38)

Components	Quantity	Note
Ex power module	1	An SELV/PELV power supply is required to supply the Ex power module. Power supply (SELV/PELV) (Page 40) The Ex power module generates the supply voltage for the Ex module group from this (safely separated extra-low voltage, voltage limited according to Ex ia). Technical specifications - Ex power module (Page 103)
Ex BaseUnit for Ex I/O module	1 per Ex I/O module	Mount the Ex BaseUnit for Ex I/O modules to the right of the Ex power module.
Ex I/O module	As required by the plant	Maximum number of modules depending on the current requirement and output current of the Ex power module.

Overload of the Ex power module

WARNING

Hazardous plant conditions

You must ensure that only approved components are operated on an Ex power module.

- A failure of the Ex power module and the connected I/O is possible.
- Undefined reactions can occur with an impermissible setup.

Termination of the Ex module group

NOTICE

Components permitted after an Ex module group

The Ex module group ends when one of the following modules is plugged in to the right of an Ex I/O module:

- Ex power module
- Server module

Only these modules are allowed to the right of an Ex module group!

See also

Useful information for use in hazardous areas (Page 34)

4.1 Useful information for use in hazardous areas

4.1.1 Notes on safe use

In accordance with the standards for electrical devices, all components of the distributed IO system are classified as open equipment.

NOTE

To operate the distributed I/O system, you have to ensure the following:

- Only authorized, trained or approved personnel have access to the distributed IO system (e.g. protection by enclosure, control cabinet or control room).
- The ambient conditions approved for the distributed I/O have been taken into account in the plant

Mechanical and climatic environmental conditions (Page 98)

Enclosure

The distributed I/O must be installed in a suitable enclosure.

For safe use, the following conditions must be guaranteed for the enclosure:

- The ambient conditions when using the distributed I/O system.
- The requirements according to the standards applicable in the area of application:

Area of application with validity of the standards	Requirement
EN / IEC 60529	Install the distributed I/O system in an enclosure with at least degree of protection IP 54.
UL 61010-1 und UL 61010-2-201	Installation of the distributed I/O system in a safety enclosure that meets the requirements regarding spread of fire and exhibits an appropriate strength.
IEC 61010-2-201	The distributed I/O system may only be used in an environment with no more than pollution degree 2.

NOTE

Observe the specific conditions of use in section "Explosion protection (Page 94)".

Use in hazardous area Zone 2

- A permissible installation location lies below the maximum permissible installation height of 2000 m above sea level.
- Observe the climatic ambient conditions: Mechanical and climatic environmental conditions (Page 98)
- The following applies to the suitability of the enclosure:

Area of application with validity of the standards	Requirement
EN/ISO 60079-0	At least manufacturer's certification for Zone 2

WARNING

Explosion hazard

If the electric circuit is live, the following must be observed:

- Do not disconnect the device in a flammable or combustible atmosphere.
- Do not open the housing in a flammable or combustible atmosphere.

WARNING

Area of application

This device is suitable for use in environments of Class 1, Division 2, Groups A, B, C, D; Class 1, Zone 2, Group IIC, or non-hazardous locations only.

NOTICE

Removal and replacement

When you replace components, compliance with Class 1, Division 2 might become invalid. Replacing components can affect the usability of the device.

4.1.2 Deployment zones

Deployment zones of intrinsically safe devices (intrinsically safe sensors, actuators and HART field devices)

The use of the Ex module groups enables the deployment of intrinsically safe devices in the following zones:

- Zone 0/ 20 (hazardous area)
- Zone 1/ 21 (hazardous area)
- Zone 2/ 22 (hazardous area)
- Safe area

Deployment zones of the I/O station

The use of the I/O station including the Ex module groups is permitted in the following zones:

- Zone 2 (hazardous area)
- Safe area

Configuration in the specific plant area

- Basic assembly of the I/O station (Page 17)

4.1.3 Rules for configuring the I/O station

Devices in the Zone 1 or Zone 0 hazardous area are connected to the I/O station if these devices are connected to an Ex module group.

Requirements in the I/O station

- The Ex module groups can be used with the associated interface module:
  Ensure that the interface modules of the base station can be used with the respective configuration tool.
- The configuration of the standard I/O is complete.
  At least the BaseUnit is mounted:
  - With ET 200SP HA: The carrier module for the interface module
  - With ET 200SP: The interface module
- You mount the Ex module groups with the power supply switched off.
- Only Ex I/O modules may be plugged into an Ex module group.
- On the right of an Ex module group, only the server module or further Ex module groups are permissible.
- If the server module has already been mounted, remove the server module.
  The configuration of the Ex module groups begins to the right of the standard I/Os.

Mixed use of I/O modules and Ex I/O modules

It is not allowed to mix I/O modules and Ex I/O modules within a potential group of an I/O station.

Measures

Pay special attention to the following when planning a plant with hazardous areas:

- Selection of the components
- Planning of the potentials
- Installation of the components

Due to the possible danger of explosion, ensure that the following components are suitable for use:

- Components that are located directly in a hazardous area
- Components with connection to the hazardous area

Planning the Ex module group

- Maximum mechanical configuration of the Ex module group (Page 32)
- Planning Ex I/O modules
  - Perform the planning based on the requirements of the plant.
  - If system expansions are foreseeable, consider reserve modules.
- Potential groups and Ex power modules (Page 43)

Plant specific conditions

- Notes on safe use (Page 34)
- Example for the configuration of distributed I/O on an ET 200SP HA (Page 38)
- Example for the configuration of the distributed I/O at an ET 200SP (Page 39)

4.1.4 Configuration examples

4.1.4.1 Example for the configuration of distributed I/O on an ET 200SP HA

You can find information about the Rules for configuring the I/O station (Page 36) in the system documentation of the SIMATIC ET 200SP HA.

Example

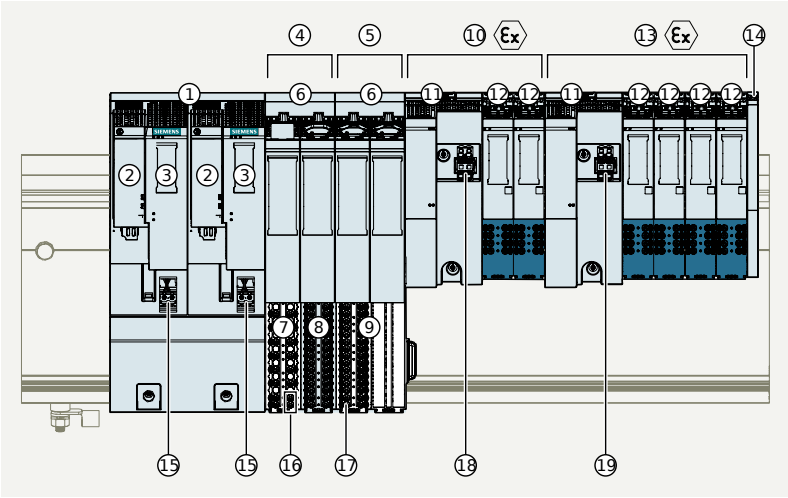

① Carrier module IM
② BusAdapter
③ Interface module (IM)

④ Potential group 1 (here ET 200SP HA)
- ⑥ Carrier module 2x
  - ⑦ Light terminal block with I/O module
  - ⑧ Dark terminal block with I/O module

⑤ Potential group 2 (here ET 200SP HA)
- ⑥ Carrier module 2x
  - ⑨ Light terminal block with I/O module

⑮ Supply voltage 1L+ for IM

⑯ Supply voltage 1L+ and 2L+ for potential group 1

⑰ Supply voltage 1L+ for potential group 2

⑭ Server module

⑩ Potential group 3 (Ex module group)
- ⑪ Ex BaseUnit with Ex power module
- ⑫ Ex BaseUnit with Ex I/O module

⑬ Potential group 4 (Ex module group)
- ⑪ Ex BaseUnit with Ex power module
- ⑫ Ex BaseUnit with Ex I/O module

⑱ Supply voltage 1L+ for Ex power module (potential group 3)

⑲ Supply voltage 1L+ for Ex power module (potential group 4)

4.1.4.2 Example for the configuration of the distributed I/O at an ET 200SP

You can find information on the Rules for configuring the I/O station (Page 36) in the system documentation for the SIMATIC ET 200SP.

Example

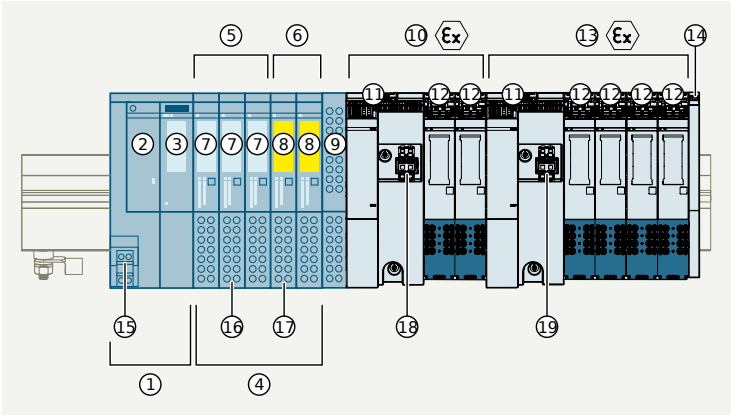

①	Carrier module IM	⑭	Server module
②	BusAdapter		
③	Head station / interface module (IM)		
④	BaseUnits for I/O modules		
⑤	Potential group 1 (here ET 200SP) • ⑦ I/O module	⑩	Potential group 3 (Ex module group) • ⑪ Ex BaseUnit with Ex power module • ⑫ Ex BaseUnit with Ex I/O module
⑥	Potential group 2 (here ET 200SP) • ⑧ Fail-safe I/O module	⑬	Potential group 4 (Ex module group) • ⑪ Ex BaseUnit with Ex power module • ⑫ Ex BaseUnit with Ex I/O module
⑨	Potential distributor Read the note "Thermal decoupling required".		
⑮	Supply voltage for IM	⑱	Supply voltage 1L+ for Ex power module (potential group 3)
⑯	Supply voltage for potential group 1	⑲	Supply voltage 1L+ for Ex power module (potential group 4)
⑰	Supply voltage for potential group 2		

Thermal decoupling required

For thermal decoupling of ET 200SP modules and Ex module groups, you install the following upstream from the first Ex power module (in the example between ⑥ and ⑩):

- An empty slot with a BU cover ⑨

  Or

- Recommendation: Potential distributor (PotDis terminal block PotDis-TB-P1-R on a PotDis BaseUnit PotDis-BU-P2/B-B)
  The potential distributor enables the supply voltage to be distributed for the next Ex power modules.

4.2 Power supply and potential ratios

4.2.1 Power supply (SELV/PELV)

Safe low voltage

Ensure that the supply and input voltages of the I/O system are generated safely separately U_{rated} = 24 V DC ±20% (⎓).

Power supply according to the following standards:

- EN / IEC /UL 61010-2-201
  This safe extra-low voltage with the required protection is called SELV (Safety Extra Low Voltage)/PELV (Protective Extra Low Voltage).

or

- NEC Class 2, as in the National Electrical Code (r) (ANSI / NFPA 70)

If the device is connected to a redundant power supply (two separate power supplies), both power supplies must meet these requirements.

All input voltages occurring on the I/O system must be limited to the maximum value of U_m = 60 V DC. This involves, for example, the following voltage sources:

- Power supply to the interface module of the basic design
- Supply voltage on all Ex power modules
- Supply voltage for sensors and actuators (e.g. on SP HA Standard modules)

See the assembly instruction in the respective documentation of the component used.

For compliance with Namur recommendation NE21, EN / IEC 61131-2, use power supplies/power packs with bridging of supply failures of at least 20 ms.

4.2.2 Power supply of the sensors and actuators

You must ensure that the supply of the sensors and the actuators at the base assembly is supplied with safe extra-low-voltage.

Power supply (SELV/PELV) (Page 40)

4.2.3 Electrical parameters for the safety concept

Rules for the configuration of intrinsically safe circuits

Ensure that the regulations and applicable standards for configuration, selection and installation of electrical systems are observed.

This way is the only way to prove the intrinsic safety for each field circuit.

The following table describes the conditions for checking the maximum safe values for a simple, intrinsically safe circuit:

Table 1-130 Rules for configuration

Underlying standard / conditions for electrical parameters		Applicable sensors and actuators
Standard: EN / IEC 60079-11; EN / IEC 60079-25 The following applies to the electrical parameters: • $U_0 \leq U_i$ • $I_0 \leq I_i$ • $P_0 \leq P_i$ • $C_0 \geq C_i + C_{line}$ • $L_0 \geq L_i + L_{line}$		The safety-related maximum values of the sensors and actuators must be adapted to the corresponding maximum values of the I/O modules. These maximum values can be found in the following documentation: • Ex certificate of the sensors and actuators • Documentation of the Ex I/O modules; Technical specifications • In the certificate of the components
Ex I/O module Sensors Actuators HART field devices	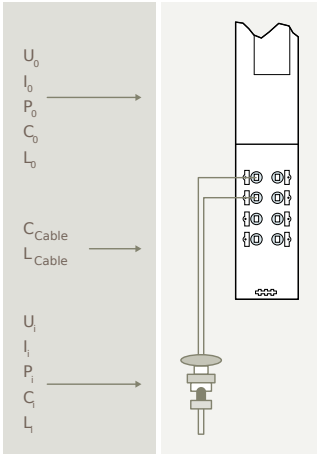	**Power sources:** • U_0 max. output voltage • I_0 max. output current • P_0 max. output power • C_0 max. external capacitance • L_0 max. external inductance C_{line} max. capacitance line/cable L_{line} max. inductance line/cable **Power receiver:** • U_i max. input voltage • I_i max. input current • P_i max. input power • C_i max. internal capacitance • L_i max. internal inductance

4.2.4 Intrinsically safe circuit

Safety

Observe the guidelines according to EN / IEC 60079-14 during configuration.

Basic realization

WARNING

Intrinsically safe electrical circuit

You must ensure that the connection of an intrinsically safe sensor, actuator or HART field device to the input/output of an I/O module results in an intrinsically safe circuit.

When you select sensors, actuators and HART field devices to an I/O module, you need to check the resulting safety-related values.

You can realize a simple, intrinsically safe circuit if you connect an intrinsically safe sensor, actuator or HART field instrument to an I/O module suitable for hazardous areas according to regulations.

Information on the assignment of the terminals on the Ex BaseUnit is provided in the documentation of the I/O module which is plugged/configured on a slot.

Electrical parameters for the safety concept (Page 41)

4.2.5 Grounding of the power supply

Power supply and potential equalization

Ensure that power is supplied to the Ex power module exclusively via an SELV/PELV power supply unit.

Connect the mounting rail of the station to your local equipotential bonding system.

To ensure intrinsic safety, no connection between the local equipotential bonding system and the equipotential bonding at the location of the connected field device is specified.
The fundamental requirements for equipotential bonding in explosion-protected areas according to EN / IEC 60079-14 remain valid to the full extent.

Introduction

The following figure shows the distributed I/O when integrating Ex module groups and power supply from the TN-S network:

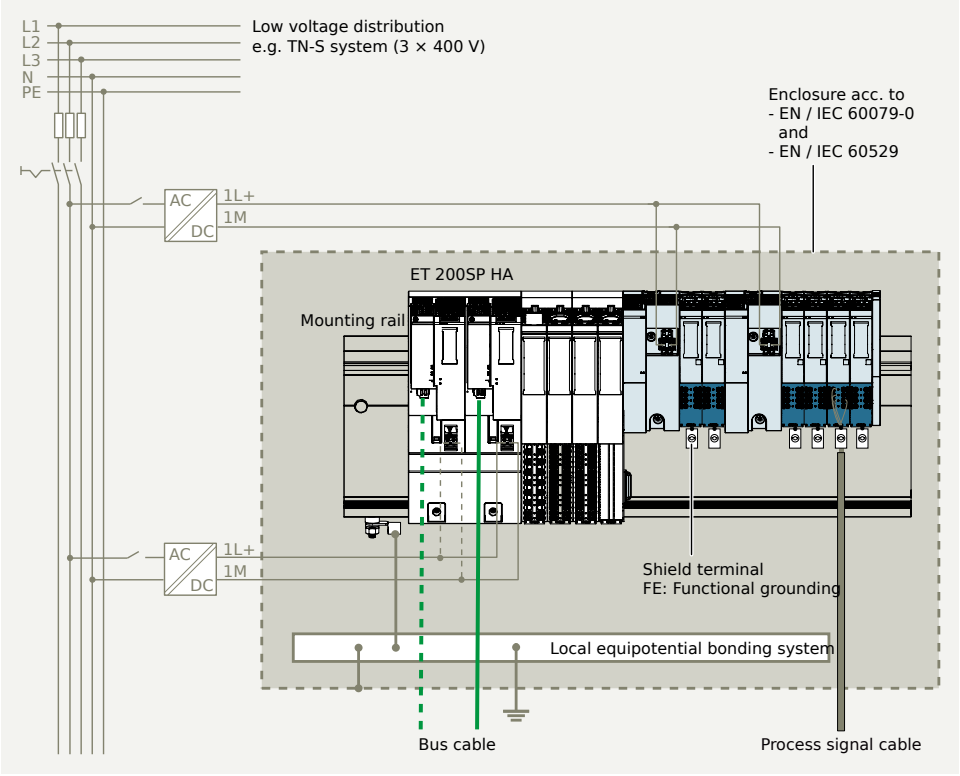

4.2.6 Potential groups and Ex power modules

You must ensure that the power supply is from safe extra-low-voltage.

Check the load on the Ex power modules

- Ensure that the current consumption of the Ex I/O modules of an Ex module group does not exceed the permissible output current of the Ex power module in any operating situation.
- Note the derating "Mechanical and climatic environmental conditions (Page 98)".
- The maximum current requirement of an Ex I/O module can be found in the documentation of the respective Ex I/O module.
- Note that **the permissible output current of the Ex power module is** > $\sum I_{max}$ of all I/O modules of the respective potential group.

4.2.7 Shielding and Measures to Counteract Interference Voltage

4.2.7.1 Shielding

Definition

Shielding is understood to mean all measures for the weakening (attenuation) of magnetic, electrical or electromagnetic interference fields by enclosing objects.

- Equipment Shielding (Page 44)
- Line Shielding (Page 44)

4.2.7.2 Equipment Shielding

General information

Particularly observe the following when cabinets and housings are incorporated in control system shielding:

- Cabinet covers such as side panels, rear panels, top and bottom panels, must make contact in an overlapping arrangement at adequate distances (e.g. 50 mm).
- Doors must be given additional contact with the cabinet ground. Use several grounding strips.
- Cables exiting the shielded housing should either be shielded or routed via filters.
- Where the cabinet contains sources of severe interference (transformers, cables to motors, etc.), they must be partitioned from sensitive electronic areas with metal plates. The metal plates must have several low-impedance bolted joints to the cabinet ground.

Any disturbance voltages connected to the automation device via non-Ex signal and supply cables are discharged to the mounting rail.

4.2.7.3 Line Shielding

Ex circuits

Take into account the guidelines according to EN / IEC 60079-14 when designing the shielding and grounding of the circuits to the field devices in hazardous areas.

Interference currents

A shielding terminal can be mounted on the terminal block of the Ex BaseUnit.

The shield terminal connects the cable shield to the mounting rail via the Ex BaseUnit.
You can find additional information on this in the section "Installing the shield contact (Page 112)".

Recommendation:
Application in an environment with interference:

- Use shielded cables for analog modules.
- Use shield terminals to connect the cable shield to functional grounding. Observe the required measures for explosion protection.

4.2.8 Voltage relationships in an Ex module group

The figure shows the potential relationships within the Ex module group.

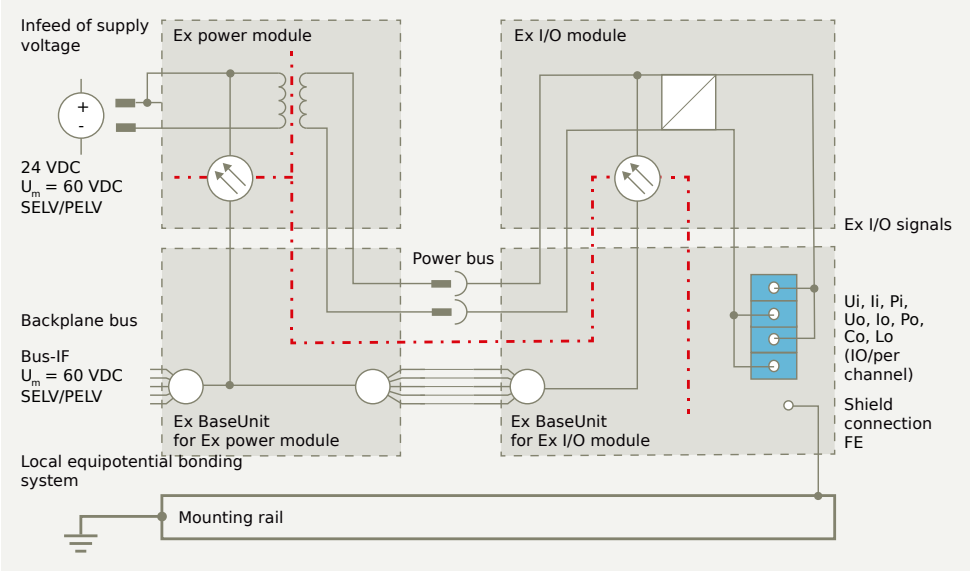

In the figure, the red dash-dotted line shows the separation of the potentials in the components of Ex I/O devices.

Potential separation by Ex BaseUnit for the Ex power module

The Ex BaseUnit for the Ex power module separates the power bus to the left.

There is electrical isolation between:

- Backplane bus and infeed of the supply voltage
- Backplane bus and the power bus
- Infeed of the supply voltage and the power bus
- Power bus and functional grounding

Galvanic isolation in an Ex module group

There is electrical isolation between:

- The electrical circuits of the standard I/O and the Ex module groups
- The backplane bus and the Ex I/O signals
- Ex I/O signals and functional grounding

Same potential in one Ex module group

There is the same potential for the supply voltages of the Ex I/O modules of an Ex module group.

Installation

5

5.1 Basics on mounting the Ex module group

5.1.1 Safety measures in hazardous areas

NOTE

Working on energized electrical installations and apparatus in hazardous industrial premises is prohibited. This also includes the disconnection of live control lines for test purposes.

Work on intrinsically safe electrical circuits is permitted as an exception, in special cases also work on other electrical systems, whereby the operator must have certified in writing that there is no risk of explosion for the duration of the work at the place of work.

If necessary, a fire permit must also be obtained.

Earthing and short-circuiting may only be performed in hazardous areas if there is no risk of explosion at the grounding and short-circuit point.

Use measuring instruments which are approved for the zones to test for no voltages.

NOTE

Module in Zone 2

In general, it is not allowed to pull or plug modules in Zone 2.

Before starting work, ensure that no explosive atmosphere is present and that the power supply is switched off.

5.1.2 Minimum clearances in the control cabinet

You need to ensure that heat dissipation is enabled when assembling the I/O station.

- Mechanical and climatic environmental conditions (Page 98)
- Mounting with ET 200SP - Mounting rule for ET 200SP: AUTOHOTSPOT

Minimum clearances

- Leave sufficient space for the wiring and the communication cable connection.
- Take the following into account when connecting the field devices:
  Minimum clearances and cable routing for use in hazardous areas (Page 49)

Minimum clearances for the installation of an I/O station with Ex module group in the control cabinet or to surrounding components

You must ensure the following clearances in millimeters when installing the mounting rail:

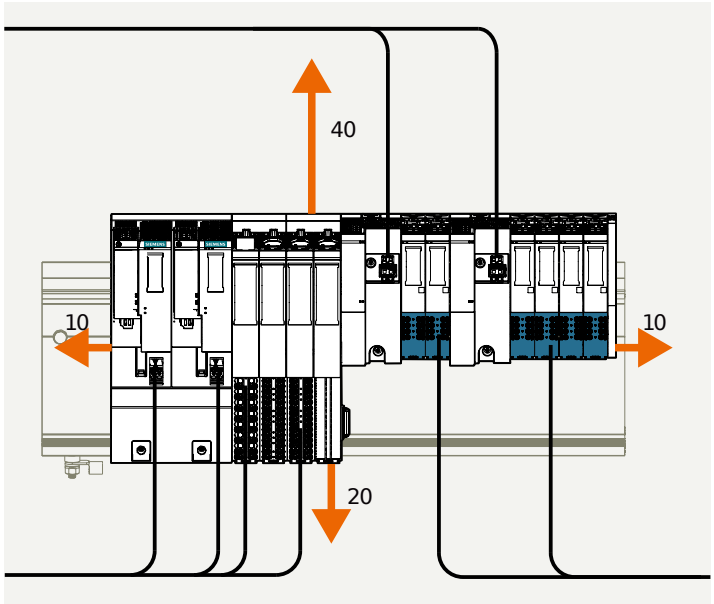

5.1.3 Minimum clearances and cable routing for use in hazardous areas

General information

Physical isolation of non-Ex signals from Ex signals corresponds to the requirements with regard to the configuration of explosion-protected automation technology.

Maintain safe distances - Minimum thread length

The distance between two points is called the thread length. These clearances are marked with arrows as an example in the following figure.

Due to the mechanical setup of the I/O station, a minimum thread length of 50 mm is maintained between connections with safe functional extra-low voltage and intrinsically safe connections.

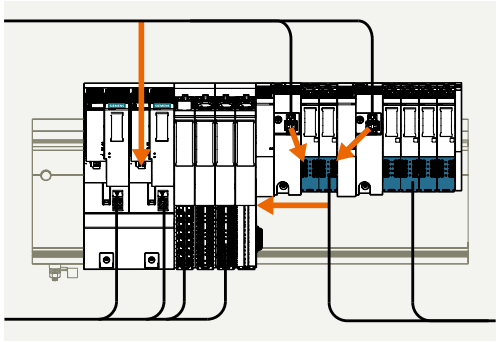

Ensure the following:

- The minimum thread length is maintained when wiring between intrinsically safe and non-intrinsically safe connections.
- The minimum thread length is maintained between conductive parts from Ex to non-Ex I/O modules.
- The intrinsically safe cables are laid separately from the non-intrinsically safe cables. Recommendation: Lay the cables in separate cable ducts. Routing in shared cable ducts is not recommended (observe thread length).

Wiring via connection elements

The following applies to the power supply:

- Voltage for the Ex module group is supplied by the Ex power module.
  For supply of the Ex power module, connect a power supply (SELV/PELV) to the X80 plug.
- Voltage for the Ex I/O Modules is supplied from the Ex power module via the power bus.

The Ex process lines can be led directly from the process terminals of the Ex BaseUnit to the equipment.

5.2 Overview of the mounting of an Ex module group

Mounting position

You can mount the I/O station with Ex module groups in horizontal or vertical mounting position. The preferred mounting position is horizontal mounting on a wall.

Requirement

The rules for configuring the I/O station are considered:

Rules for configuring the I/O station (Page 36)

Procedure

The following sequence is required for the mounting of the Ex module groups.

1. Mount the Ex BaseUnits.
   When installing an Ex module group always start with a Ex BaseUnit for an Ex power module.
   - Mounting the Ex BaseUnit for Ex I/O module (Page 51)
   - Mounting the Ex BaseUnit for Ex I/O module (Page 53)
2. Mount the modules belonging to the Ex module group (Ex power module and Ex I/O modules).
   The slots for the I/O modules are created by connecting the Ex BaseUnits.
   - Mounting the Ex power module (Page 52)
   - Inserting an Ex I/O module (Page 54)
3. Optional: Mount additional Ex module groups.
4. Mount the server module.
   - Installing the server module (Page 56)

Mounting components

- Fastening required for vibration and shock loads:
  If the system is subject to vibration and shock, you must install a mechanical fastening element on the mounting rail at both ends of the system.
  This measure prevents the distributed I/O system from slipping sideways.
  Use, for example, WAGO 249-117 or something comparable for fastening:
  https://www.wago.com/us/accessories/screwless-end-stop/p/249-117
- You can find information on securing components in the section "Mounting rules (Page 123)".

Additional information

Maximum mechanical configuration of the Ex module group (Page 32)

5.3 Installation

5.3.1 Mounting the Ex BaseUnit for Ex I/O module

Requirement

- The BaseUnit is mounted, at least:
  - With ET 200SP HA: The carrier module for the interface module
  - With ET 200SP: The interface module and thermal decoupling (see "AUTOHOTSPOT")
- The server module is not mounted.

NOTE
Module in Zone 2
In general, it is not allowed to pull or plug modules in Zone 2.
Ensure that the power supply is switched off before starting work.

Procedure

1. Hook the Ex BaseUnit (for mounting the Ex power module) into the mounting rail.
2. Swivel the Ex BaseUnit backwards until it snaps into place on the mounting rail.

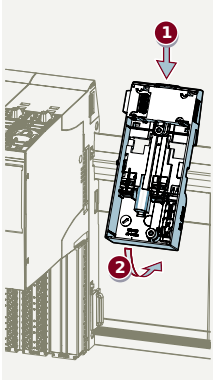

3. Move the Ex BaseUnit to the left until it snaps into the left component (e.g. BaseUnit/carrier module).

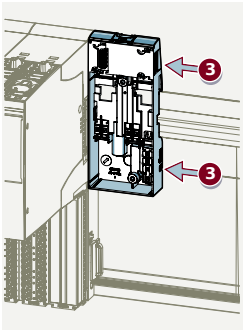

Result

The Ex BaseUnit for the Ex power module is mounted on the mounting rail.

5.3.2 Mounting the Ex power module

Requirement

The Ex BaseUnit for the Ex power module is mounted.

NOTE
Module in Zone 2
In general, it is not allowed to pull or plug modules in Zone 2.
Ensure that the power supply is switched off before starting work.

Procedure

1. Place the Ex power module parallel on the Ex BaseUnit of the Ex power module.

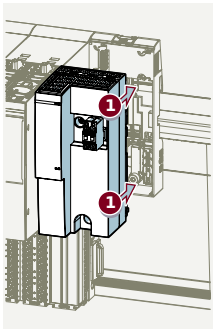

2. Mount the Ex power module with the Ex BaseUnit using the two screws.
   Observe the Mounting rules (Page 123).

NOTE
Plug in the connector for the supply voltage.

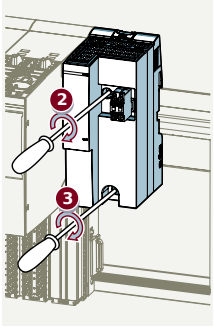

Result

The Ex power module is mounted.

5.3.3 Mounting the Ex BaseUnit for Ex I/O module

Requirement

The Ex BaseUnit for the Ex power module is mounted.
You can find information on this in the section "Mounting the Ex power module (Page 52)".

NOTE
Module in Zone 2
In general, it is not allowed to pull or plug modules in Zone 2.
Ensure that the power supply is switched off before starting work.

Procedure

1. Hook the Ex BaseUnit (for mounting the modular slots) into the mounting rail.

   Adhere to the maximum configuration length; section "Maximum mechanical configuration of the Ex module group (Page 32)".

2. Swivel the Ex BaseUnit backwards until it snaps into place on the mounting rail.

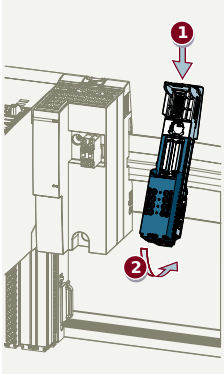

3. Move the Ex BaseUnit to the left until it snaps into place on the left component (Ex BaseUnit for the Ex power module or Ex BaseUnit for Ex I/O modules).

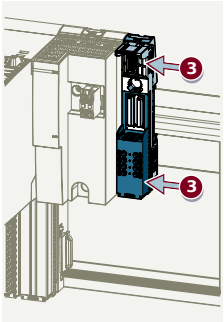

Result

The Ex BaseUnit for the Ex I/O module is mounted.

5.3.4 Inserting an Ex I/O module

The Ex I/O modules are assembled like standard I/O modules from left to right.

The Ex sensors and Ex actuators are connected directly to the Ex BaseUnit.

NOTE

Before you connect the sensors or actuators to an Ex I/O module, check the intrinsically safe circuits.

Requirement

The Ex BaseUnit for the Ex I/O module is mounted.

NOTE
Module in Zone 2
In general, it is not allowed to pull or plug modules in Zone 2.
Ensure that the power supply is switched off before starting work.

Mount all Ex BaseUnits **one after the other** before you start mounting the Ex I/O modules.

Procedure

Insert the Ex I/O module parallel into the slot until you hear both interlocks latch into place.

NOTE
Avoid inserting an Ex I/O module at an angle.

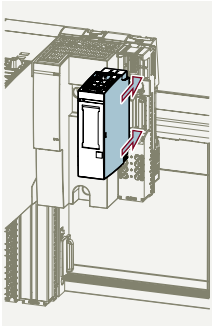

Result

The Ex I/O module has been inserted.

5.3.5 Inserting a BU cover

Requirement

Slots are not equipped with Ex I/O modules.

NOTE
Module in Zone 2
In general, it is not allowed to pull or plug modules in Zone 2.
Ensure that the power supply is switched off before starting work.

Procedure

Insert the BU cover parallel into the slot until you hear both interlocks latch into place.

NOTE
Avoid inserting a BU cover at an angle.

Result

The BU cover has been inserted.

5.3.6 Installing the server module

Requirement

The installation of the Ex I/O is completed.

NOTE
Module in Zone 2
In general, it is not allowed to pull or plug modules in Zone 2.
Ensure that the power supply is switched off before starting work.

NOTE
Scope of delivery (server module)
The following components are supplied with the standard I/Os (ET 200SP HA or ET 200SP):

- A server module
- A power bus cover (only for ET 200SP HA)

Procedure

1. Swivel the server module to the rear until the fastening elements click into place on the rail.

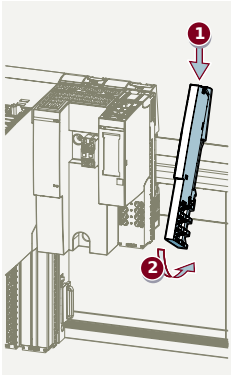

2. Slide the server module parallel to the left until it audibly snaps into the previous, last Ex BaseUnit.

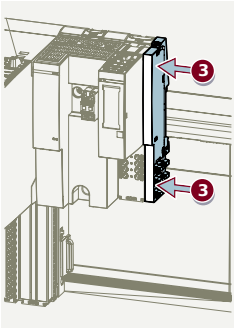

Result

The server module is mounted onto the mounting rail.

The server module completes the configuration or the line of the I/O station at the right end.

5.3.7 Identification possibilities of components of the Ex module group

5.3.7.1 Applying labeling strips

Requirement

The strip is labeled.

Procedure

Insert the labeling strip into the module.

Result

The labeling strip is mounted.

5.3.7.2 Applying reference identification labels

Requirement

The equipment labeling plates have been removed from the sheet.

Procedure

Insert the reference identification labels into the insert opening on the top of the modules:

- Interface module
- BusAdapter
- I/O module

- Slot cover

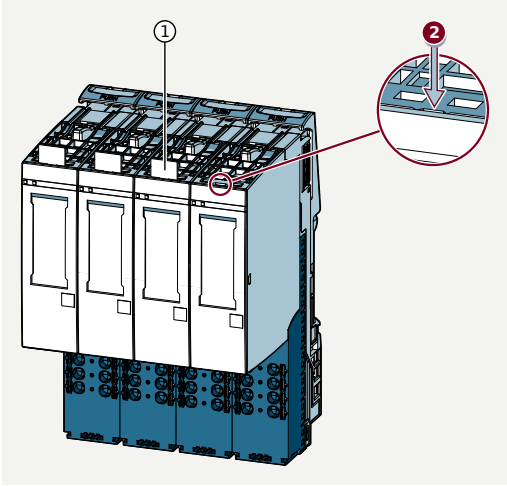

① Reference identification labels
② Opening for label

Result

The equipment labeling plate is mounted.

Wiring 6

6.1 Notes on operation

The integration of I/O systems in a plant or system demands that specific rules and regulations are observed, depending on the area of application.

NOTICE
Connecting a sensor or actuator to an Ex I/O module Before a sensor or actuator is connected to an Ex I/O module, an expert must perform a safety analysis of this intrinsically safe circuit, if necessary. • Intrinsically safe circuit (Page 42) • Electrical parameters for the safety concept (Page 41)

This section provides an overview of the most important rules that must be observed.

Specific application

Keep to the safety and accident prevention regulations applying to specific applications, for example machine protection guidelines.

EMERGENCY STOP devices

EMERGENCY STOP devices according to EN / IEC 60204 must remain active in all operating modes of the plant or system.

Excluding hazardous plant states

You need to implement suitable measures to ensure that dangerous operating conditions are excluded, also in the following situations:

- When the system restarts after a voltage dip or power failure.
- Bus communication starts automatically after a fault.

If necessary, EMERGENCY STOP must be forced!

An uncontrolled or undefined startup must not occur after the EMERGENCY STOP is unlocked.

Components for the supply voltage

You can find information on suitable components in "Interactive Catalog CA01; Automation and Drives (https://static.siemens.com/ca01/CA02_Install/Installer/CA01OnlineInstaller.zip)".

Degree of protection

The components for the Ex module groups are designed with IP 20 degree of protection and are foreseen for installation in a control cabinet.

Protection against outside electrical influences

Observe the following information on protection against electrical effects or faults:

- In plants with distributed I/O, ensure that the system is connected to a protective conductor with sufficient cross-section for discharge of electromagnetic interference.
- Ensure correct cable routing and installation of the supply, signal and bus cables.
- For signal and bus lines, you must ensure that a wire/cable breakage or a cross-circuit does not lead to undefined states of the plant or system.

Reference

You can find more information in the Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) function manual.

See also

Information on insulation, protection class, degree of protection and rated voltage (Page 101)

6.2 Communication link between basic assembly and Ex module group

Once correctly mounted, the Ex module group is automatically connected to the backplane bus of the I/O station.

The communication with the controller/automation system is performed via the interface module of the I/O station.

6.3 Supply of the terminal block

6.3.1 Connections on the Ex BaseUnit and the I/O module

Definition

The terminal block for connecting the I/O signals is part of the Ex BaseUnit for Ex I/O modules and cannot be mounted separately.

Description

The following figure shows the connections on the Ex BaseUnit and the I/O module.

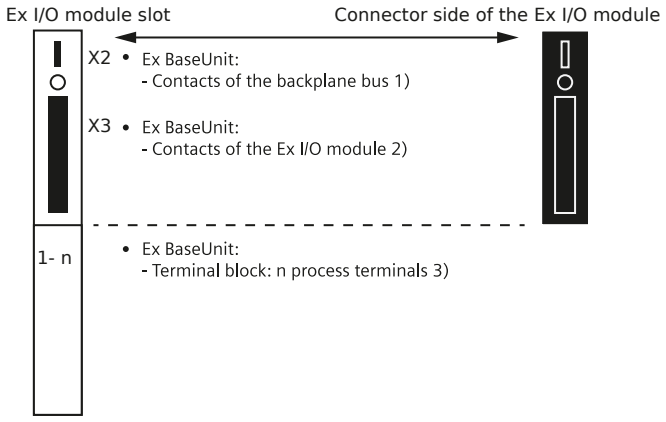

1) Ex BaseUnit contacts of the backplane bus (max. 50 mA; 3.3 V DC ⎓)

2) Ex BaseUnit contacts of the Ex I/O module for process signal transmission (for maximum voltages and currents, refer to the documentation of the respective I/O module)

3) Process terminals on the terminal block (number, maximum/permissible voltages and currents, refer to the documentation of the respective I/O module).

See also

Cable cross-sections and ferrules (Page 123)

6.3.2 Assignment of the terminals on the terminal block

The assignment of the terminal block of the Ex BaseUnit depends on the plugged Ex I/O module.

You can find information on the Ex I/O modules in the corresponding device manuals.

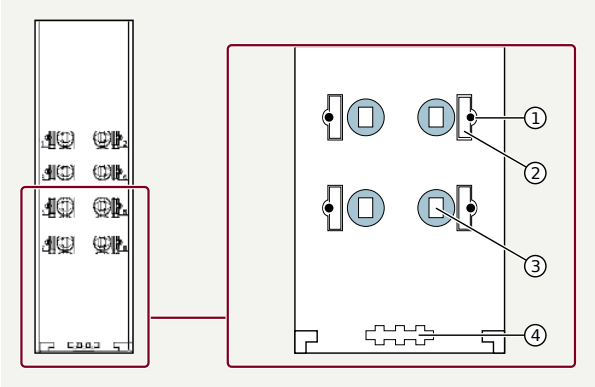

① Measuring tap
(suitable probes: Diameter 1.0 mm, cone height max 1.15 mm; length ≥ 10 mm in compliance with the approved voltage category)

② Spring release

③ Push-in terminal

④ Holder for shield support

Cable cross-sections and ferrules

You can find information on this in section "Cable cross-sections and ferrules (Page 123)".

Information on connecting the cables and tools

You can find information on this in the documentation of the SIMATIC ET 200SP or ET 200SP HA distributed I/O systems.

6.3.3 Supply voltage

Introduction

The supply voltage of the Ex power module is fed via a 4-pin plug, which is located on the front of the Ex power module.

Wiring of the Ex BaseUnit

When laying the cables and wiring, adhere to the installation and setup regulations according to DIN EN IEC 60079-14 as well as the country-specific regulations.

Ensure intrinsically safe and non-intrinsically safe cables are completely separate during wiring. They must be routed in separate cable ducts and must maintain a minimum distance of 50 mm from "non-intrinsically safe cables".

The shield connection is separated from the intrinsically safe circuits and is connected to the local equipotential bonding system.

Only Ex I/O modules of the ET 200SP HA and ET 200SP series may be connected to the Ex power module. Observe the maximum permissible output current of the Ex power module.

Power supply

Read the technical specifications and information on supply voltage in section "Notes on operation (Page 60)".

Connection for power supply (slot X80)

The module provides a connection plug on the front side for supplying the external SELV/PELV supply voltage.

The contacts on the connection plug are intended for the following connections:

Slot	Connection plug	Pin assignment		Verbunden
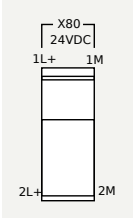	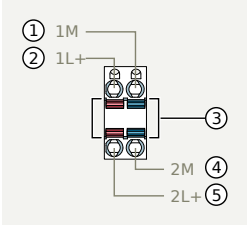	1	Supply voltage: Ground reference of the supply voltage (permissible current 10 A)	The following contacts are interconnected in the connection plug: • L+: 1L+ and 2L+ • M: 1M and 2M This enables the supply voltage to be looped through.
		2	Supply voltage: L+ 24 V DC (permitted current 10 A)	
		3	Spring release	
		4	Loop through supply voltage: Ground reference of the supply voltage (permissible current 10 A)	
		5	Loop through supply voltage: L+ 24 V DC (permitted current 10 A)	

[2] The maximum cross-section of the connection is 1.5 mm (including any ferrule). A strain relief is not present.

The wiring diagram is lasered onto the front panel of the Ex power module.

General terminal assignment

Table 1-131 **Terminal assignment for the Ex power module**

Terminal	Assignment	Terminal	Assignment	Description	Color coding label (terminals 1 to 4)
1L+	L+	**1M**	M	• L+: Supply voltage L+ 24 V DC • M: Ground reference of the supply voltage	---
2L+	L+	**2M**	M		

See also

Connections on the Ex BaseUnit and the I/O module (Page 62)

6.4 Connecting the supply voltage to the Ex power module

Requirement

The supply voltage is switched off.

Tools required

Depending on conductor type

- Single wire without ferrule: Toolless
- Multi-core (stranded wire) with ferrule or ultrasonic compacting: Suitable tool
- Multi-core (stranded wire) without ferrule, unprocessed: 3 to 3.5 mm screwdriver

Read the section "Connections on the Ex BaseUnit and the I/O module (Page 62)".

Procedure

Conductor (type)	**Solid**	**Multi-core (stranded wire)**	
Mounting	**Without ferrule**	**With ferrule or ultrasonic compression**	**Without ferrule, unprocessed**
Step 1	Strip 8 to 10 mm of the wires.		
Step 2	-	Compress or crimp the cable with ferrules	-
Step 3	-		Press the screwdriver into the spring release.
Step 4	Insert the wire into the push-in terminal as far as it will go.		
Step 5	-		Pull the screwdriver out of the spring release.
Step 6	Push the wired connection plug into the socket in the Ex power module.		

Result

The supply voltage is connected to the Ex power module.

Parameters for the Ex power module 7

7.1 Parameters of the Ex power module Ex-PM E

You use parameters to define the mode of operation of the Ex power module.

7.2 Module/channel parameters

Definition

Module/channel parameters are specific parameters whose configuration can affect the entire module or the channels.

Description

The following module/channel parameters are available:

Table 1-132 Parameters and their default settings

Parameters	Value range	Default	Changing parameter settings in RUN	Efficiency range
Diagnostics missing supply voltage L+	• Enabled • Disabled	Enabled	Yes	Module
Potential group	New intrinsically safe potential group	New intrinsically safe potential group	No	Module

7.3 Explanation of parameters

Diagnostics, Missing supply voltage L+

Defines whether a diagnostic interrupt is generated when the supply voltage L+ is missing or is too low.

Potential group

An Ex module group consists of the associated Ex power module and a group of Ex I/O modules placed directly adjacent to one another, which are supplied by the Ex power module via the power bus.

An Ex module group begins with an Ex power module, via which the required voltage for all Ex I/O modules of the potential group is supplied.

An Ex module group ends when an Ex power module or a server module in the station configuration follows an Ex BaseUnit.

Additional information

You can find information on the configuration of potential groups in the basic assembly of the I/O station in the respective system manual for the distributed I/O system.

Removal

8

8.1 Overview of the removal of an Ex module group

Requirement

Safety measures in hazardous areas (Page 47)

Recommendation:

Remove Ex module groups with the supply voltage switched off. Disconnect the supply voltage plug from the Ex power module:
See "Removing an Ex power module (Page 72)" Step 1

Removal of the Ex module groups:
If you want to remove the Ex module group or add or remove Ex BaseUnits, remove the server module.

- Removing a server module (Page 70)

Basic procedure

1. Remove modules that are not required (Ex power module and Ex I/O modules).
   It is not necessary to subsequently remove the Ex BaseUnits to change these modules.
   - Pull Ex I/O module (Page 71)
   - Removing an Ex power module (Page 72)
2. Remove signal cables that are not required.
   - Loosening signal cables (Page 73)
3. Remove Ex BaseUnits that are not required.
   - Removing the Ex BaseUnit for Ex I/O module (Page 74)
   - Removing the Ex BaseUnit for Ex power module (Page 75)

8.2 Removing a server module

Requirement

NOTE
Module in Zone 2
In general, it is not allowed to pull or plug modules in Zone 2.
Before starting work, ensure that no explosive atmosphere is present and that the power supply is switched off.

Procedure

1. Press the rail release on the server module and move the server module in parallel to the right (①+②).

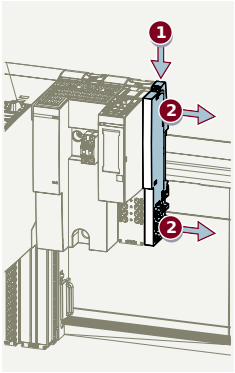

2. While pressing the rail release button, swivel the server module off the rail (③+④).

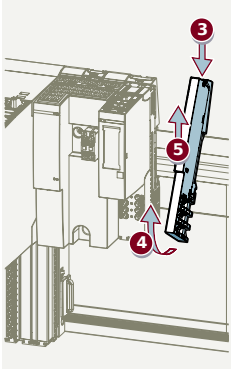

Result

The server module is removed.

8.3 Pull Ex I/O module

Requirement

NOTE
Module in Zone 2
In general, it is not allowed to pull or plug modules in Zone 2.
Before starting work, ensure that no explosive atmosphere is present and that the power supply is switched off.

Procedure

1. Simultaneously press the two release buttons ① on the top and bottom of the I/O module.
2. Hold down the release buttons and pull the I/O module parallel towards the front and out of the slot ②.

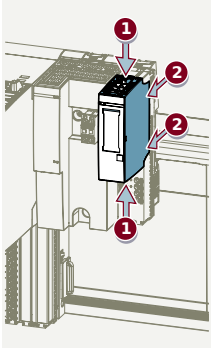

NOTE
Avoid pulling out an I/O module at a slanted angle.

Result

The Ex I/O module has been removed.

Additional information

- Inserting an Ex I/O module (Page 54)
- Replacing an Ex I/O module without changing the type (Page 78)
- Replacing an Ex I/O module and changing the type (Page 81)

8.4 Removing an Ex power module

Requirement

NOTE
Module in Zone 2
In general, it is not allowed to pull or plug modules in Zone 2.
Before starting work, ensure that no explosive atmosphere is present and that the power supply is switched off.

Tools required

Screwdriver 4.5 mm or TORX T15 (recommended): For loosening the fixing screws for the Ex BaseUnit.

Procedure

1. Disconnect the supply voltage plug from the Ex power module ①.
2. Loosen the two fixing screws on the Ex power module to the Ex BaseUnit ②.

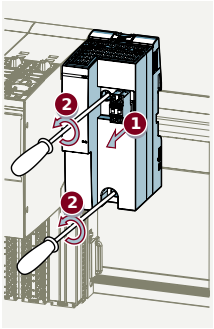

3. Pull the Ex power module parallel out of the Ex BaseUnit ③.

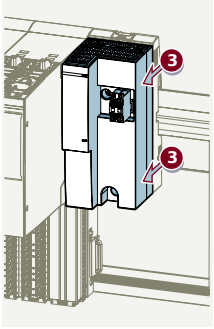

Result

The Ex power module has been removed.

8.5 Loosening signal cables

Requirement

The supply voltage is switched off.

Procedure

Adhere to the following sequence:

1. Press the screwdriver into the spring release of the terminal as far as it will go. The terminal opens.
   Leave the screwdriver in the spring release.

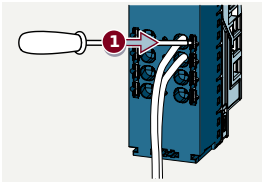

2. Pull out the cable.

NOTE
Avoid damaging the terminal
Never pull on the wire/cable while pressing the spring release.

Result

The signal cable has been removed.

8.6 Removing the Ex BaseUnit for Ex I/O module

Requirements

- The supply voltages for the Ex module group and any Ex module groups to the right of it are switched off.
- There are no Ex I/O modules on the Ex BaseUnits.

NOTE
Adjacent components
To remove a specific Ex BaseUnit, you need to remove adjacent components (Ex BaseUnit or server module) located on the right. If there is a clearance of approx. 8 mm to the adjacent components on the right, you can remove the Ex BaseUnit.

NOTE
Module in Zone 2
In general, it is not allowed to pull or plug modules in Zone 2.
Before starting work, ensure that no explosive atmosphere is present and that the power supply is switched off.

Procedure

1. Press the mounting rail release at the top of the Ex BaseUnit ① and move the Ex BaseUnit at least 8 mm to the right ②.

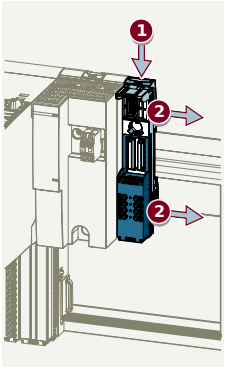

2. Keep the mounting rail release on the Ex BaseUnit pressed ③ and swing the Ex BaseUnit out of the mounting rail ④.

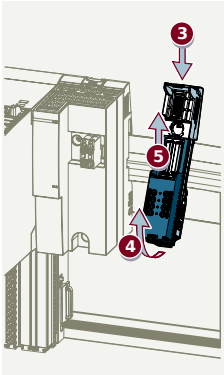

3. Lift the Ex BaseUnit upwards from the mounting rail ⑤.

Result

The Ex BaseUnit for the Ex I/O module has been removed.

8.7 Removing the Ex BaseUnit for Ex power module

Requirement

- All adjacent components on the right (Ex BaseUnit or server module) have been removed. You can find information on this in the following sections:
  - Section "Removing a server module (Page 70)"
  - Section "Pull Ex I/O module (Page 71)"
  - Section "Removing an Ex power module (Page 72)"
  - Section "Removing the Ex BaseUnit for Ex I/O module (Page 74)"
- There is a clearance of at least 8 mm to adjacent Ex BaseUnits.

NOTE
Adjacent components
To remove a specific Ex BaseUnit, you need to remove adjacent components (Ex BaseUnit or server module) located on the right. If there is a clearance of approx. 8 mm to the adjacent components on the right, you can remove the Ex BaseUnit.

NOTE
Module in Zone 2
In general, it is not allowed to pull or plug modules in Zone 2.
Before starting work, ensure that no explosive atmosphere is present and that the power supply is switched off.

Procedure

1. Press the mounting rail release at the top of the Ex BaseUnit ① and move the Ex BaseUnit at least 8 mm to the right ②.

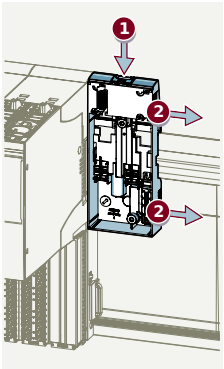

2. Keep the mounting rail release on the Ex BaseUnit pressed ③ and swing the Ex BaseUnit out of the mounting rail ④.

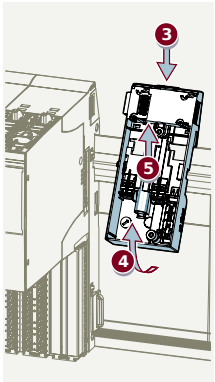

3. Lift the Ex BaseUnit upwards from the mounting rail ⑤.

Result

The Ex BaseUnit for Ex power module is removed.

Service and maintenance

9

9.1 Actions during operation - Overview

Notes on actions during operation

The following table describes the activities permitted during operation.
Notes on safe use (Page 34)

Permitted actions and actions permissible in Zone 2

Actions	Zone 2	See section ...
Maintenance during operation (visual inspections)	x	Servicing during operation (Page 77)
Disconnecting and terminating the cables to the encoders, actuators and HART field devices on the Ex BaseUnit		System manual of the respective I/O system
Re-configuration and diagnostics of the distributed I/O	x	System manual of the respective I/O system
Firmware update for Ex I/O module	x	Firmware update (Page 86)

9.2 Servicing during operation

Properties

Maintenance of the I/O station is essentially limited to visual inspections. The I/O station can be in running operation.

Requirements

Note the following:
Notes on safe use (Page 34)

Procedure

When the distributed I/O is installed in an enclosure:

- Check the tightness and the integrity of the enclosure's cable entries.
- Check whether water has penetrated. If there is, find out how it got there.

Check that the wiring is secure (connectors, cables).

9.3 Maintenance of the electrical equipment

Replacing equipment

Work on electrical systems or equipment can only be carried out if a "permit" has been granted. When replacing electrical equipment, the intended use with regard to temperature class, explosion group and the corresponding (Ex) Zone must be observed. Certificates of conformity, EU special test certificates, and design approval must be available.

Maintaining apparatus

Repaired electrical equipment may only be put back into operation if the following conditions are met:

- The equipment has been tested by a recognized expert (e.g. expert in accordance with Section 15 of the ElexV)
- The test has been certified.
  Exception:
  Explosion protection was not affected by the repair.
- If the repair affects explosion protection, only use spare parts that are original or certified for this maintenance.

If makeshift repairs are performed, they must guarantee explosion protection and ensure that no other hazards can occur.

9.4 Replacement of Ex module groups

9.4.1 Replacing an Ex I/O module without changing the type

Introduction

When an Ex I/O module is plugged in for the first time, part of the coding element snaps into the Ex BaseUnit.
If an I/O module is replaced, the coding element prevents confusion with another I/O module type. Another type of I/O module can only be plugged in after the coding element has been deliberately removed.

You can find information on the coding element in the section "Inserting an Ex I/O module (Page 54)".

Module identification - read and transfer data

If data for the identification of the components in the system is configured, you need to transfer this data again after the Ex I/O module has been plugged in.

- Data transmitted to the Ex I/O module for the module identification can be read back into the project.
  Configure the Ex I/O module in HW Config and select the menu command **CPU > Upload Module Identification to PG...** .
- Transfer any data for module identification in the configuration after plugging in the Ex I/O module.
  Configure the Ex I/O module in HW Config and select the menu command **CPU > Upload Module Identification...** .

Requirement

Read the section "Plant planning (Page 32)".

NOTE

Module in Zone 2

In general, it is not allowed to pull or plug modules in Zone 2.

Before starting work, ensure that no explosive atmosphere is present and that the power supply is switched off.

Procedure

NOTE

Please note if necessary: Replacing an Ex I/O module and changing the type (Page 81)

NOTE

Perform change in runtime: Read section "AUTOHOTSPOT".

---

1. Simultaneously press the two release buttons ① on the top and bottom of the Ex I/O module.
2. Hold down the release buttons and pull the Ex I/O module parallel towards the front and out of the slot ②.

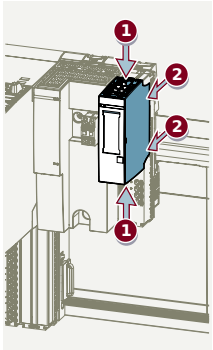

NOTE

Avoid pulling out an Ex I/O module at an angle.

3. Remove the **loose** part of the coding element from the new Ex I/O module at the rear.
4. Plug the loose part of the coding element onto the removed I/O module.

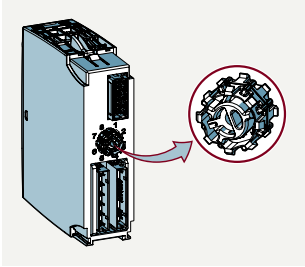

5. Plug the new Ex I/O module (same module type) into the Ex BaseUnit until it clicks into place.

NOTE

Avoid inserting an Ex I/O module at an angle.

6. Mark the new Ex I/O module (labeling strips and equipment labeling plate).

NOTE

Coding element

After replacing the I/O module, ensure that the coding plug of the replaced I/O module is completed again.

Result

The Ex I/O module without type change has been replaced.

9.4.2 Replacing an Ex I/O module and changing the type

Requirements

- The application planning is completed.
  See section Plant planning (Page 32).
- The Ex BaseUnit is suitable for accommodating the new I/O module.
- The wiring has been or will be adapted to the new I/O module.
- The configuration has been or will be adapted to the new I/O module.

NOTICE

Do not manipulate the coding element

Changes to the coding element can result in dangerous states in your plant and/or damage to the outputs of the I/O module.

To avoid physical damage, do not manipulate the coding.

You can find information on the coding element in the section "Inserting an Ex I/O module (Page 54)".

NOTE

Module in Zone 2

In general, it is not allowed to pull or plug modules in Zone 2.

Before starting work, ensure that no explosive atmosphere is present and that the power supply is switched off.

Procedure

NOTE

Please note if necessary:Replacing an Ex I/O module without changing the type (Page 78)

NOTE

Perform change in runtime: Read section "AUTOHOTSPOT".

1. Simultaneously press the two release buttons ① on the top and bottom of the Ex I/O module.
2. Hold down the release buttons and pull the Ex I/O module towards the front and out of the slot ②.

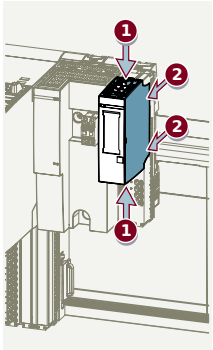

NOTE

Avoid pulling out an Ex I/O module at an angle.

3. Use a screwdriver to lift the coding element out of the Ex BaseUnit.

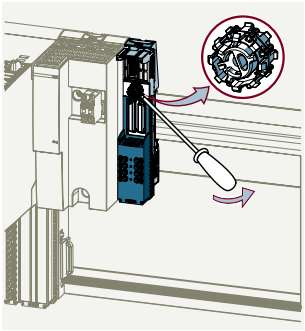

4. Insert the coding element into the removed I/O module.

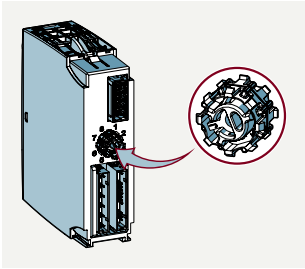

5. Insert the new Ex I/O module (different module type) into the Ex BaseUnit until it audibly clicks into place.

NOTE

Avoid inserting an Ex I/O module at an angle.

6. Label the new Ex I/O module.

NOTE
Coding element
After replacing the Ex I/O module, ensure that the coding plug of the replaced Ex I/O module is completed again.

Result

The Ex I/O module with type change has been replaced.

9.4.3 Replacing an Ex BaseUnit

Introduction

The process terminals are part of the Ex BaseUnit of the Ex I/O module. You can replace the Ex BaseUnit if needed. This requires the I/O module to be removed.

NOTICE
Power bus rails of the potential group and backplane bus are interrupted When a Ex BaseUnit is replaced, the power rails of the potential group and the backplane bus are interrupted.

Requirements

- The Ex BaseUnit is mounted, wired and equipped with an I/O module.
- Only replace the Ex BaseUnit when the supply voltage is switched off.

NOTE
Module in Zone 2
In general, it is not allowed to pull or plug modules in Zone 2.
Before starting work, ensure that no explosive atmosphere is present and that the power supply is switched off.

Tools required

3 to 3.5 mm screwdriver

Procedure

1. Remove the Ex I/O module.

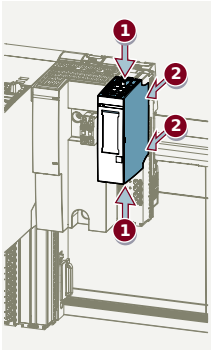

NOTE

Read section "Pull Ex I/O module (Page 71)".

2. Remove the coding element from the Ex BaseUnit.

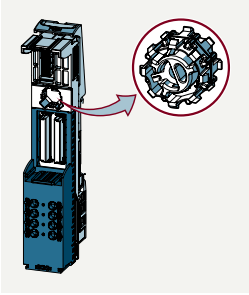

3. Press it onto the coding element of the Ex I/O module which you pulled in Step 1.
4. Disconnect the wiring on the Ex BaseUnit.

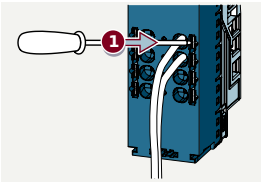

NOTE

You can find information on this in section "Loosening signal cables (Page 73)".

5. Remove the Ex BaseUnit.

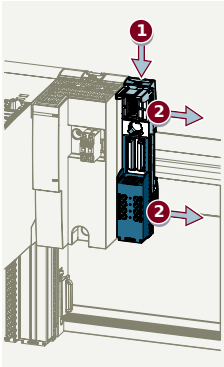

NOTE

You can find information on this in section "Removing the Ex BaseUnit for Ex I/O module (Page 74)".

6. Mount the new Ex BaseUnit.

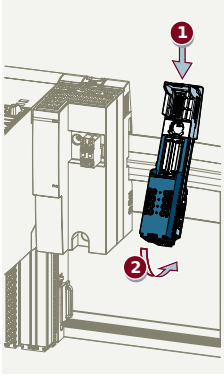

NOTE

You can find information on this in section "Mounting the Ex BaseUnit for Ex I/O module (Page 53)".

7. Wire the Ex BaseUnit.

NOTE

You can find information on this in section "Connections on the Ex BaseUnit and the I/O module (Page 62)".

8. Plug in the Ex I/O module.

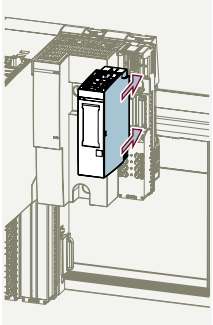

9. Switch on the supply voltage at the Ex power module.

Result

The Ex BaseUnit has been replaced.

9.5 Firmware update

This section describes the basic procedure for updating the firmware of the following modules:

- Ex power module
- Ex I/O module

Requirements

- A connection to the I/O station exists.
- The storage location of the file for the firmware update is known.

NOTE
Firmware update of Ex I/O modules
The L+ supply voltage must be applied to the module at startup and during the firmware update.

Procedure

1. Open the hardware configuration in the engineering system.
2. Perform the firmware update.

Additional information

- You can find specific information on firmware updates when using your engineering system in the online help of the engineering system.
- System documentation *SIMATIC Distributed I/O System: ET 200SP HA*
- System documentation *SIMATIC Distributed I/O System; ET 200SP*

Displays and interrupts

10

10.1 Status and error displays

Definition

The LED displays are status and fault indicators.

If Ex module groups are integrated in an I/O station based on the ET 200SP HA or ET 200SP, the error and status displays of the modules for use in hazardous areas are displayed on the respective module and at the interface module of the I/O station.

You can find information on the LED displays of the interface module in the documentation for the interface module.

Description

The following figure explains the LED displays of the Ex power module:

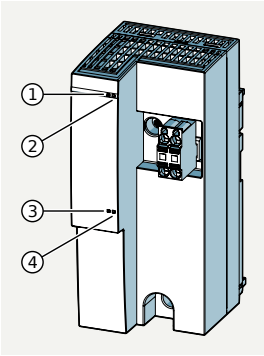

① DIAG LED (Page 89) (green/red)

② MT LED (Page 89) (yellow)

③ PWR LED (Page 90) (green)

④ Not used

Meaning of the LED displays

The tables below explain the meaning of the status, error and maintenance displays.

You can learn about corrective measures for messages as well as possible causes in the following section:

Diagnostic and maintenance messages (Page 117)

10.2 LEDs

10.2.1 DIAG LED

Definition

The DIAG LED provides you diagnostic information.

Description

The diagnostic display of the DIAG LED is as follows:

LED DIAG	Meaning
Off	Backplane bus supply of the system is disrupted or switched off.
flashes	Module is not configured.
On	Module parameters are assigned. No diagnostic message is pending.
flashes	Module parameters are assigned. At least one diagnostic message is pending.

10.2.2 MT LED

Definition

The MT LED provides maintenance information.

Description

The MT LED indicates the following maintenance status:

MT LED	Meaning
Off	No maintenance is required.
On	Maintenance is required. At least one maintenance event has occurred.

10.2.3 PWR LED

Definition

The PWR LED provides you status information about supply voltage L+.

Description

The PWR LED indicates the following status:

PWR LED	Meaning
▫ Off	Supply voltage L+ missing.
■ On	Supply voltage L+ available.

10.3 Interrupts

Definition

A diagnostic interrupt is an alarm that reports activated events of a device status to the system operator with the appropriate operator authorization (maintenance and service).

Description

The Ex power module supports diagnostic interrupts.

Diagnostic and maintenance messages are output via diagnostic interrupts.

NOTE

You can find more information on this in the appendix:
Diagnostic and maintenance messages (Page 117)

The following events cause the Ex power module to generate a diagnostic message:

- Parameter assignment error
- No supply voltage
- Channel/component temporarily unavailable
- The retentive memory in the BaseUnit is defective
- Invalid BaseUnit

If the following events occur, the Ex power module generates a maintenance message:

- The retentive memory in the BaseUnit is defective

Technical specifications 11

11.1 Standards and approvals

11.1.1 Currently valid markings and approvals

Introduction

This section contains the technical specifications of the system:

- The standards and test values which the distributed I/O system complies with and fulfills.
- The test criteria according to which the distributed I/O system was tested.

Technical specifications of the modules

The technical specifications of the individual modules are also provided in the manuals for the relevant modules. If there are deviations between the statements in this document and the equipment documentation, the statements in the equipment documentation take priority.

Validity of the information on the components

NOTICE
Markings and approvals In the manual you can find the markings and approvals which are generally possible or planned in the system. However, only the label or approval printed on the component of the distributed I/O system is valid!

Information on certificates and approvals

The following are delivered with the product:

- The product information in which all certificates and distributed approvals at the time of the delivery are listed.
- These certificates and registration certificates are available on the supplied USB stick.

The certificates for the markings and approvals can be found on the Internet under Service&Support (http://support.industry.siemens.com/cs/).

Safety information

⚠ WARNING

Personal injury and damage to property may occur

Personal injury and damage to property can occur in hazardous areas if you disconnect plug-in connections while the distributed I/O system is in operation.

In hazardous areas, always ensure that the distributed I/O system is de-energized before disconnecting plug-in connections.

⚠ WARNING

Explosion hazard

If you replace components, compliance with Class I, DIV 2 can become invalid.

⚠ WARNING

Area of application

This device is only suitable for use in Class I, Div. 2, Group A, B, C, D, or in non-hazardous areas.

11.1.2 CE approval

Introduction

CE

The distributed I/O system fulfills the requirements and protective goals of the following EC directives and complies with the harmonized standards (EN / IEC) that have been announced for programmable logic controllers in the official gazettes of the European Community:

- Low voltage directive
- EMC directive
- Explosion protection directive

You can find the EC declarations of conformity for download on the Internet (keyword "Declaration of conformity").

Low voltage directive

2014/35/EU "Elektrische Betriebsmittel zur Verwendung innerhalb bestimmter Spannungsgrenzen" (Niederspannungsrichtlinie)
The components of the distributed I/O system that fall under the Low Voltage Directive have been tested according to the requirements of EN 61010-2-201.

EMC directive

2014/30/EU "Elektromagnetische Verträglichkeit" (EMV-Richtlinie)

Use in industry

SIMATIC products are designed for operation in industrial fields.

Area of application	Interference emission requirements	Immunity requirements
Industry	EN 61000-6-4	EN 61000-6-2

Use in residential areas

If you use the distributed I/O system in residential areas, you must ensure that the emission of radio interference complies with EN 61000-6-3.

Suitable measures for achieving RF interference level Class B include, for example:

- Installation of the ET 200SP HA distributed I/O system in grounded control cabinets/boxes
- Use of filters in the supply lines

11.1.3 CCCEx approval

CCC approval

Certificate Number	2024322310005752
Classification	Ex ec [ia Ga] IIC T4 Gc
	Ex ec [ia IIIC Da] IIC T4 Gc
Marking	
The certificate is valid for the "https://support.industry.siemens.com/cs/ww/en/view/109963649 (https://support.industry.siemens.com/cs/document/109963648/explosion-protection-ccc-nepsi?dti=0&lc=en-WW)" products listed in the certificate.	

Certificate Number	2024322310005753
Classification	Ex ec ia IIC T4 Gc
Marking	
The certificate is valid for the "https://support.industry.siemens.com/cs/ww/en/view/109963648 (https://support.industry.siemens.com/cs/document/109963648/explosion-protection-ccc-nepsi?dti=0&lc=en-WW)" products listed in the certificate.	

11.1.4 UKCA marking for the United Kingdom

The modules meet "The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulation:
UKSI 2016 No. 1107".

UKCA

UK
CA

DEKRA 21UKEX0277X

DEKRA 21UKEX0280X

DEKRA 21UKEX0284X

DEKRA 21UKEX0283X

DEKRA 21UKEX0282X

DEKRA 21UKEX0278X

DEKRA 21UKEX0281X

DEKRA 21UKEX0279X

Importer UK:

Siemens plc

Manchester M20 2UR

11.1.5 Explosion protection

Certification

The approved Ex I/O modules may be installed in the following areas in compliance with the specific conditions of use:

- In the safe area
- In Zone 2 (category 3G)

The certificates of conformity and the explanations of the designations can be found on the Internet (https://support.industry.siemens.com/cs/products?dtp=Certificate&mfn=ps&lc=en-US).

ATEX Approval

Table 1-133 Certification according to the following standards:

Type Examination Certificate Number	Several certificates
Standards	EN 60079-0
	EN 60079-7

Type Examination Certificate Number	Several certificates
Standards	EN 60079-11
Marking for Ex-PM-E	II 3 G (1) Ex ec [ia] IIC T4 Gc
Marking for Ex I/O modules	II 3 G (1) G Ex ec [ia Ga] IIC T4 Gc II 3 G (1) D Ex ec [ia IIIC Da] IIC T4 Gc

The certificates for the products can be found on the Internet (https://support.industry.siemens.com/cs/products?dtp=Certificate&mfn=ps&lc=en-US).

NOTE

Specific conditions of use

1. This equipment shall be installed in an enclosure with an ingress protection of at least IP54 in accordance with EN 60079-0 and EN 60529. The installation shall also ensure Pollution Degree 2 (as defined in EN 60664-1) inside the enclosure. And all circuits shall be limited to Overvoltage category I or II. These requirements apply even when installed in a non-hazardous area.
2. The ground connection of the mounting rail shall be connected to the local equipotential bonding system according to the applicable installation standard.
3. Transient protection shall be provided that is set at a level not exceeding 140 % of the peak rated voltage value at all supply terminals to the equipment, or at most set at 119 V.

IECEx Approval

Table 1-134 Certification according to the following standards:

Certificate Number	Several certificates
Standards	IEC 60079-0
	IEC 60079-7
	IEC 60079-11
Marking for Ex-PM-E	Ex ec [ia] IIC T4 Gc
Marking for Ex I/O modules	Ex ec [ia Ga] IIC T4 Gc Ex ec [ia IIIC Da] IIC T4 Gc

The certificates for the products can be found on the Internet (https://support.industry.siemens.com/cs/products?dtp=Certificate&mfn=ps&lc=en-US).

NOTE

Specific conditions of use

1. This equipment shall be installed in an enclosure with an ingress protection of at least IP54 in accordance with IEC 60079-0 and IEC 60529. The installation shall also ensure Pollution Degree 2 (as defined in EN 60664-1) inside the enclosure. And all circuits shall be limited to Overvoltage category I or II. These requirements apply even when installed in a non-hazardous area.
2. The ground connection of the mounting rail shall be connected to the local equipotential bonding system according to the applicable installation standard.
3. Transient protection shall be provided that is set at a level not exceeding 140 % of the peak rated voltage value at all supply terminals to the equipment, or at most set at 119 V.

11.1.6 Marking for Australia and New Zealand

The distributed I/O system meets the requirements of the EN / IEC 61000-6-4 standard.

11.1.7 Korea Certificate

Note that this device corresponds to limit class A in terms of the emission of radio frequency interference. This device can be used in all areas, except residential areas.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

11.1.8 Marking for the Eurasian Customs Union

EAC (Eurasian Conformity)

Customs Union of Russia, Belarus and Kazakhstan

Declaration of conformity with the technical requirements of the Customs Union (TR CU).

11.2 Electromagnetic compatibility

The following information applies to components of the Ex module group. Ex module groups can only be used in conjunction with the basic assembly of the SIMATIC ET 200SP HA or SIMATIC ET 200SP. The EMC limits and specifications valid for the basic assembly therefore apply:

- Electromagnetic compatibility against pulse-shaped interference
- Electromagnetic compatibility against sinusoidal disturbances
- Emission of radio interferences

You can find information about this in the following documentation:

- System Manual ET 200SP HA (https://support.industry.siemens.com/cs/ww/en/view/109761547)
- Manual Collection ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)

Definition

Electromagnetic compatibility (EMC) is the capacity of an electrical installation to function in its electromagnetic environment without affecting that environment.

EMC requirements fulfilled

The design of the I/O station with integrated Ex module group also meets the requirements of the EMC directive for the internal European market.

Requirement:
It must be ensured that the design of the I/O station corresponds to the specifications and guidelines for the electrical design.

EMC in accordance with NE21

The I/O station meets the EMC requirements according to NAMUR directive NE21.

11.3 Shipping and storage conditions

The following information applies to components of the Ex module group. Ex module groups can only be used in conjunction with the basic assembly of the SIMATIC ET 200SP HA or SIMATIC ET 200SP. The transport and storage conditions valid for the basic assembly therefore apply.

Transport and storage conditions for components of the Ex module group

You can find information about this in the following documentation:

- System Manual ET 200SP HA (https://support.industry.siemens.com/cs/ww/en/view/109761547)
- Manual Collection ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)

11.4 Mechanical and climatic environmental conditions

Information on the documentation

NOTE
Higher-priority documentation
The information for the specific components takes precedence over the information in this documentation. The statements in the product information always takes precedence over all other information.

Operating conditions

Operating conditions in the safe area
The ET 200SP HA or ET 200SP distributed I/O system is designed for weather-protected, stationary use. The operating conditions of the components of the Ex module group exceed the requirements according to EN / IEC 60721-3-3:

- Class 3M3 (mechanical requirements)
- Class 3K3 (climatic requirements)

Use with additional measures
The described components may not be used without additional measures:

- At locations with a high degree of ionizing radiation
- In harsh operating environments caused, for example, by:
  - Accumulation of dust
  - Corrosive vapors or gases
  - Strong electrical or magnetic fields
- In installations requiring special monitoring, for example
  - Elevator systems

Electrical systems in potentially hazardous areas

An enclosure is required:

Notes on safe use (Page 34)

Mechanical environmental conditions

The following table shows the mechanical environmental conditions in the form of sinusoidal vibrations.

Table 1-135 Mechanical environmental conditions

Frequency range in Hz	
5 ≤ f ≤ 8.4	Amplitude 3.5 mm
8.4 ≤ f ≤ 150	constant acceleration 9.8 m/s^2

Reduction of vibration

If the described components are exposed to larger impacts or vibrations, the following applies:
Use suitable measures to ensure that the acceleration or amplitude is always reduced to the permissible level.

We recommend mounting the described components on damping materials (rubber-metal anti-vibration mountings, for example).

Tests of mechanical environmental conditions

The following table provides important information with respect to the type and scope of the tests of environmental mechanical conditions.

Table 1-136 Tests of mechanical environmental conditions

Condition tested	Test standard	Comment
Vibration	Vibration test to EN / IEC 60068-2-6 (sine)	Type of vibration: • Frequency sweeps with a rate of change of 1 octave/minute. – 5 Hz ≤ f ≤ 8.4 Hz, constant amplitude 3.5 mm – 8.4 Hz ≤ f ≤ 150 Hz, constant acceleration 9.8 m/s^2 Duration of vibration: • 10 frequency sweeps per axis at each of three vertically aligned axes
Shock	Shock, tested to EN / IEC 60068-2-27	Type of shock: • Half-sine Shock intensity: • Peak value 150 m/s^2 • Duration 11 ms Direction of shock: • 3 shocks in each direction (+/-) at each of three vertically aligned axes

Climatic environmental conditions

The following table shows the permissible climatic ambient conditions for the components of the Ex module group.

Table 1-137 Climatic environmental conditions

Ambient conditions	Permissible range	Comments
Temperature (Use with ET 200SP HA)	• Horizontal installation: from -40 °C to 70 °C • Vertical installation: from -40 °C to 60 °C	Observe the following "Derating" table and any load-dependent limitations. Refer to the documentation of the employed component.
Temperature (Use with ET 200SP)	• Horizontal installation: from -30 °C to 60 °C • Vertical installation: from -30 °C to 50 °C	
Air pressure	• From 1080 hPa (corresponds to a depth of approximately -1000 m) • Up to 795 hPa (corresponds to an elevation of approximately 2000 m)	The cooling effect of air depends on the density of the air. The locally occurring air pressure (operating altitude) might restrict the maximum permissible ambient temperature. The density of the air decreases with increasing altitude. Derating for the Ex power module (Page 105)
Relative humidity	From 10 to 95% Max. 95% at +25 °C	Without condensation, corresponds to relative humidity (RH) stress grade 2 in accordance with EN / IEC 61131 part 2
Concentration of pollutants	• SO_2: <0.5 ppm • RH: <60 %, no condensation • H_2S: <0.1 ppm • RH: <60 %, no condensation	Test: 10 ppm; 4 days Test: 1 ppm; 4 days
	ISA-S71.04 severity level G1; G2; G3	All assembled PCBs are treated with protective lacquer.

11.5 Information on insulation, protection class, degree of protection and rated voltage

The information for the specific components takes precedence over the information in this documentation. The statements in the product information always have priority over all other information.

Insulation

	Backplane bus	Supply voltage L+	Interface module	Power bus	Functional earth
Backplane bus	-	1500 V DC [1]	2100 V DC [2]	2100 V DC [2]	1500 V DC [1]
Supply voltage L+	-	-	2100 V DC [2]	2100 V DC [2]	1500 V DC [1]
Interface module	-	-	-	850 V DC [3]	707 V DC [4]
Power bus	-	-	-	-	1500 V DC [1]
Functional earth	-	-	-	-	-

[1] EN / IEC 60079-7, chapter 6.1 a): Insulation voltage specified by the basic system

[2] EN / IEC 60079-11, chapter 6.3.13 Insulation between intrinsically safe and non-intrinsically safe circuits: 1500 V x √2

[3] EN / IEC 60079-7, chapter 6.1 b) 1): 500 V x 170%

[4] EN / IEC 60079-11, chapter 6.3.13 Insulation between intrinsically safe and grounded parts: 500 V x √2

Degree of pollution / overvoltage category according to EN / IEC 61010-2-201

- Pollution degree 2
- Overvoltage category: II

Protection class according to EN / IEC 61010-2-201

The distributed I/O system complies with protection class III.
You can find additional information on this in the documentation of the I/O modules.

Degree of protection IP20

Degree of protection IP20 according to EN / IEC 60529 for all modules of the distributed I/O system, i.e.:

- Protection against contact with standard probe
- Protection against foreign objects with diameters in excess of 12.5 mm
- No protection against water

Rated voltage for operation

The distributed I/O system operates with the rated voltage shown in the following table.

- Observe the tolerance range of the nominal voltage.
- When selecting the nominal voltage, note the maximum permissible supply voltage of each module.

Table 1-138 Rated voltage for operation

Rated voltage	Tolerance range
24 V DC	19.2 to 28.8 V DC [1]
	18.5 to 30.2 V DC [2]

[1] Static value: Creation as functional extra-low voltage with safe electrical isolation according to EN / IEC 60364-4-41

[2] Dynamic value: Including ripple, e.g. as in the case of three-phase bridge power rectification

11.6 Use of the I/O station in hazardous area Zone 2

See product information "Use of subassemblies/modules in Zone 2 Hazardous Area" (http://support.automation.siemens.com/WW/view/en/19692172).

NOTE

Standards and regulations for use in Zone 22

- If you install, use and maintain the distributed I/Os in the hazardous area Zone 22, you must comply with the standards, installation/construction regulations and country-specific regulations applicable for Zone 22.
- A manufacturer's declaration of suitability for Zone 22 must be available for the enclosure.

11.7 Technical specifications of subcomponents of the Ex module group

11.7.1 Technical specifications of the Ex I/O modules

The technical specifications of the Ex I/O modules can be found in the device manuals of the according Ex I/O modules.

11.7.2 Technical specifications - Ex power module

Ex power module with intrinsically safe output voltage (Ex-PM E)

Note the potentially lower permissible operating temperature of all components contained in the basic design of the distributed I/O and any derating (see section "Derating for the Ex power module (Page 105)").

Article number	6DL1133-6PX00-0HW0
General information	
Product type designation	Ex-PM-E
usable BaseUnits	BU type W0
Product function	
• I&M data	Yes; Asset data
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	1.4 A
from load voltage L+ (without load), max.	50 mA
Output voltage	
Rated value (DC)	24 V
Overvoltage protection	Yes
Output current	
horizontal installation	
• up to 60 °C, max.	0.8 A
• up to 70 °C, max.	0.6 A
vertical installation	
• up to 50 °C, max.	0.8 A
• up to 60 °C, max.	0.6 A
Power	
Power available from the backplane bus	100 mW

Article number	6DL1133-6PX00-0HW0
Power loss	
Power loss, typ.	4.8 W
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Diagnoses	
• Diagnostic information readable	Yes
• missing load voltage	Yes
Diagnostics indication LED	
• MAINT LED	Yes; Yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• for module diagnostics	Yes; green/red DIAG LED
Ex(i) characteristics	
Module for Ex(i) protection	Yes
maximum values for connecting terminals for gas group IIC	
• Um (voltage at non-intrinsically safe connecting terminals), max.	60 V
Potential separation	
primary/secondary	Yes
Isolation	
Isolation tested with	further information on insulation can be found in the "ET 200SP HA / ET 200SP modules for devices in hazardous areas" System Manual
Ambient conditions	
Ambient temperature during operation	
• min.	-40 °C
• max.	70 °C; with derating
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m
Dimensions	
Width	50 mm
Height	114 mm
Depth	67.5 mm
Weights	
Weight, approx.	182 g

11.7.3 Derating for the Ex power module

Maximum permissible output current for the Ex power module depending on the mounting position and the ambient temperature.

Mounting position	Ambient temperature	Output current
Horizontal installation:	from -40 °C to 60 °C	0.8 A
	from -40 °C to 70 °C	0.6 A
Vertical installation:	from -40 °C to 50 °C	0.8 A
	from -40 °C to 60 °C	0.6 A

11.7.4 Technical specifications - Ex BaseUnits

Use

Table 1-139 Types

Article number	Use	Voltages	Potential group	Process terminals
6DL1193-6BP00-0DW0	For Ex power module		Start again	0
6DL1193-6BP00-0BX1	For Ex I/O module	Up to 24 V	Routing	8

Redundant configuration: No

Ex BaseUnit type W0 for Ex power module Ex-PM E

Article number	6DL1193-6BP00-0DW0
General information	
Product type designation	BU type W0
Product function	
• I&M data	Yes; Asset data
Current carrying capacity	
For P1 and P2 bus, max.	10 A
Hardware configuration	
Formation of potential groups	
• New potential group	Yes
• Potential group continued from the left	No
Slots	
• Number of slots	1
Potential separation	
between backplane bus and supply voltage	Yes
Isolation	
Isolation tested with	further information on insulation can be found in the "ET 200SP HA / ET 200SP modules for devices in hazardous areas" System Manual

Article number	6DL1193-6BP00-0DW0
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-40 °C
• horizontal installation, max.	70 °C
• vertical installation, min.	-40 °C
• vertical installation, max.	60 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m
Dimensions	
Width	50 mm
Height	117 mm
Depth	19 mm
Weights	
Weight, approx.	38 g

Ex BaseUnit type X1 for Ex I/O module

Article number	6DL1193-6BP00-0BX1
General information	
Product type designation	BU type X1
Product function	
• I&M data	Yes; Asset data
Current carrying capacity	
For P1 and P2 bus, max.	10 A
For process terminals, max.	0.5 A
Hardware configuration	
Temperature sensor	Yes; For internal reference junction with connecting thermocouple
Formation of potential groups	
• New potential group	No
• Potential group continued from the left	Yes
Slots	
• Number of slots	1
Potential separation	
between backplane bus and supply voltage	Yes
between process terminals and supply voltage	Yes
Isolation	
Isolation tested with	further information on insulation can be found in the "ET 200SP HA / ET 200SP modules for devices in hazardous areas" System Manual

Article number	6DL1193-6BP00-0BX1
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-40 °C
• horizontal installation, max.	70 °C
• vertical installation, min.	-40 °C
• vertical installation, max.	60 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²
• Conductor cross-section, max.	2.5 mm²
• Number of process terminals to I/O module	8
Dimensions	
Width	20 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	42 g

Dimension drawings

A

A.1 Dimension drawings of the rails

You can find information about this in the system documentation of the distributed I/O system:

- ET 200SP HA
  System Manual ET 200SP HA; Distributed I/O System ET 200SP HA
  (https://support.industry.siemens.com/cs/us/en/view/109761547)
- ET 200SP
  SIMATIC; ET 200SP; ET 200SP Distributed I/O System
  (https://support.industry.siemens.com/cs/us/en/view/58649293)

A.2 Shield connector

Dimensional diagram of the shield connector

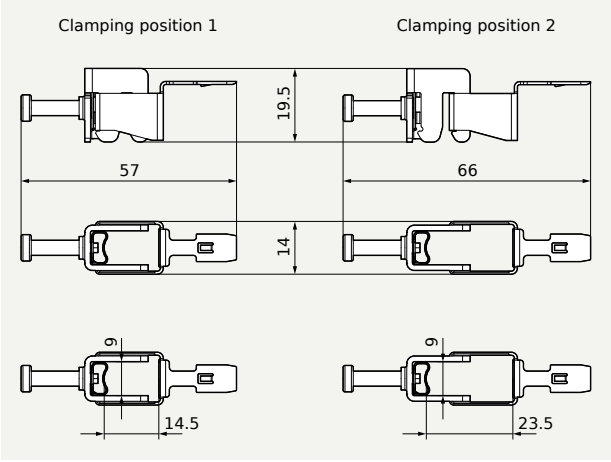

A.3 Labeling strip

Dimensional diagram of labeling strips and roll

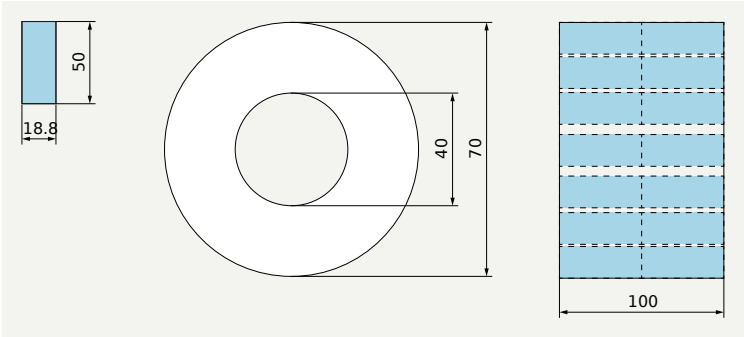

A.4 Reference identification labels

Dimensional diagram of reference identification label and sheet

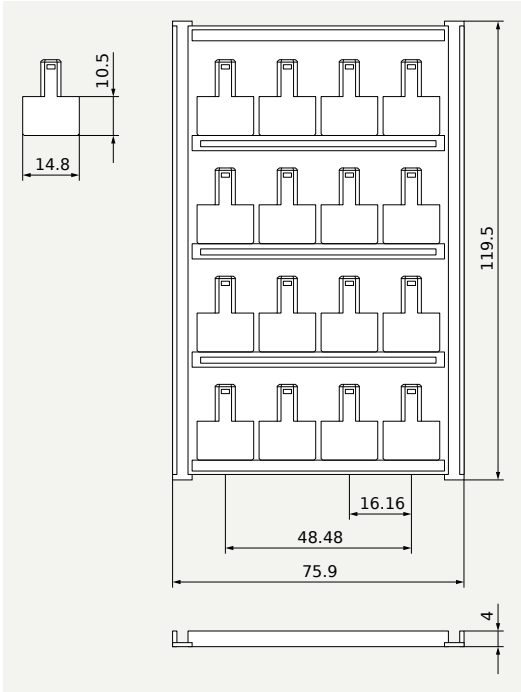

Accessories/spare parts

B

Accessories for Ex module group

Table 1-140 Accessories, general

Accessories section	Packing unit	Article number
Ex BaseUnit for Ex power module (Ex BaseUnit, type W0)	1 unit	6DL1193-6BP00-0DW0
Ex power module Ex PM E	1 unit	6DL1133-6PX00-0HW0
Ex BaseUnit for Ex I/O module (Ex BaseUnit, type X1)	1 unit	6DL1193-6BP00-0BX1
BU cover (slot cover 20 mm wide - for I/O module slots)	5 units	6ES7133-6CV20-1AM0
Shield connection for BaseUnit (shield contacts and shield terminals)	5 units	6ES7193-6SC20-1AM0
Reference identification label, white, sheet with 16 labels	10 units	6ES7193-6LF30-0AW0
Labeling strips (for labeling the I/O modules)		
• Roll, light gray (with a total of 500 labeling strips)	1 unit	6ES7193-6LR10-0AA0
• DIN A4 sheets, light gray (with a total of 1000 labeling strips)	10 units	6ES7193-6LA10-0AA0

Online catalog

Additional article numbers for the I/O stations can be found on the Internet (http://mall.industry.siemens.com) in the online catalog and online ordering system.

Leakage resistance of the I/O station

C

Introduction

If you want to protect the I/O station with ground fault monitoring or an RCD switch, you need the leakage resistor to select the right safety component.

NOTE

Additional leakage resistors from Ex system must be considered in the entire system setup (ET 200SP / ET 200SP HA). You can find the calculations for this in the respective system manual.

Ohmic resistance

When determining the leakage resistance of the I/O station, you additionally need to take into account the ohmic resistance from the RC combination of the Ex power module:

Module	Ohmic resistance from RC network
Ex power module for feeding the supply voltage	11 MΩ

Cables

D

D.1 Installing the shield contact

Requirements

- An Ex BaseUnit is mounted
- The cable has a diameter of max. Ø 7 mm each.

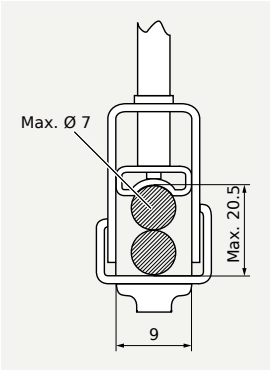

NOTE

Grounding

The shield connection of the Ex BaseUnit to the shield support is provided by the functional grounding.

Tools required

- Stripping tool
- Flat-bladed screwdriver with 3.5 to 4.5 mm blade width or Torx T10

Procedure

1. Press the shield support from above into the holder on the Ex BaseUnit until it snaps into place.

NOTE

If you use a 7.5 mm mounting rail, you must shorten the support element beforehand. To do this, unscrew the spacer of the support element.

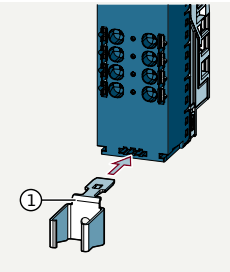

① Shield contact

2. Remove the cable insulation material around the shield terminal.
3. Connect the cable to the Ex BaseUnit and lay the cable in the shield support.

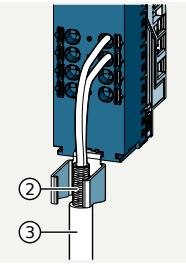

② Cable with removed insulation material (approx. 20 mm)

③ Cable to sensor/actuator

4. Insert the shield terminal into the shield contact.

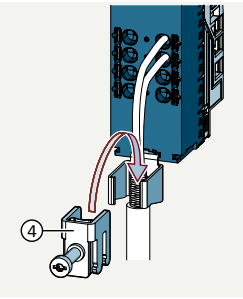

④ Shield terminal

5. Tighten the shield terminal with approximately 0.5 Nm until the terminal rests completely on the exposed braided shield.

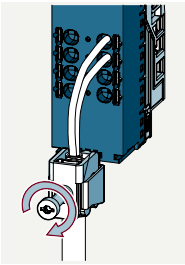

NOTE
Shield terminal does not have a zero clamping
Fix the shield terminal only at at least one inserted cable.

Result

The shield connection is mounted.
The cable shielding is connected to the functional grounding.

See also

Mounting rules (Page 123)
Shielding and Measures to Counteract Interference Voltage (Page 44)

Drivers, parameters, diagnostic messages and address space

E

E.1 Parameter assignment

Parameter assignment in the user program

You can re-configure the diagnostics of the Ex power module in RUN without affecting the system.

Changing parameters in RUN

The parameters are transferred to the Ex power module with the "WRREC" instruction via data record 128.

The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the Ex power module continues operation with the previous parameter assignment. The STATUS output parameter contains the corresponding error code.

The STATUS output parameter is 4 bytes long and is configured as followed:

- Byte1: Function_Num, general error code
- Byte2: Error_Decode, location of the error code
- Byte3: Error_Code_1, error code
- Byte4: Error_Code_2, manufacturer-specific extension of the error code

Module-specific errors of the Ex power module are displayed via Error_Decode = 0x80 and Error_Code_1 / Error_Code_2.

Error_ Code_1	Error_ Code_2	Cause	Remedy
0xB0	Variable	Number of the data record unknown (Error_Code_2 returns internal identifiers)	Enter valid number for data record.
0xB1	0x01	Length of the data record is incorrect	Enter valid value for data record length.
0xB2	Variable	Ex power module cannot be reached (Error_Code_2 returns internal identifiers)	• Check station - is the module plugged in correctly? • Check the parameters of the WRREC instruction.
0xE0	0x01	Header error (version or defined bits incorrect)	Correct the version number or defined bits.
0xE0	0x02	Header error (incorrect length or number of parameter blocks)	Correct the length and number of the parameter blocks.
0xE1	0x01	Reserved bit set	Write all reserved bits with a 0.

E.2 Assignment and form of the module/channel parameters

Structure of data record 128

Data record 128 contains the module parameters.

The data record consists of the following main components:

- Header information (module)
- Module parameters which enable diagnostics

Table 1-141 Structure of data record 128 in analog mode (12 bytes in length)

Byte	Length	Parameter	Efficiency range
0 ... 1	2 bytes	Header information (module)	Module
2	1 byte	Module parameters	Module parameters

NOTE

Legend for the following detailed screens

The following detailed screens show the assignment of the individual bytes in data record 128 based on the configuration.

- All unused bits, as well as the bits or bytes marked "reserved" must be set to "0".
- Activate a parameter by setting the corresponding bit to "1" or to the appropriate value.

Header information and module parameters

The following figure shows the configuration of the header information and module parameters.

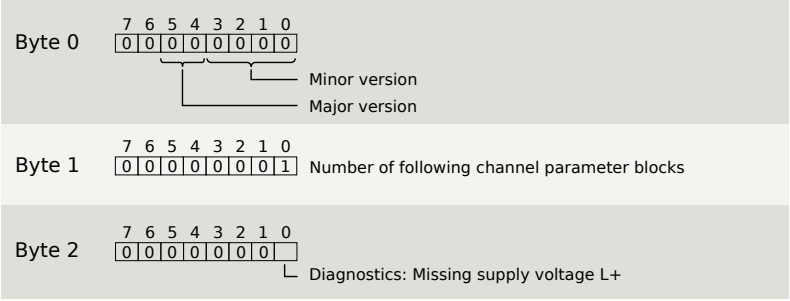

Figure 1-147 Header information and module parameters data record 128 of the Ex PM-E Ex power module

E.3 Diagnostic and maintenance messages

Diagnostic message

A diagnostic message is output for each diagnostic event, and the DIAG LED on the EX power module flashes red.

The diagnostic messages can be read in the diagnostic buffer of the CPU.

Table 1-142 Diagnostic messages, their meanings and remedy options

Diagnostic message	Error code	Assign-ment	Meaning	Remedy
Parameter assign-ment error	10_H	Module	Incorrect parameter assignment	Correct the parameter assignment
Supply voltage miss-ing	11_H	Module	Missing or insufficient supply voltage L+	Check supply voltage L+ and wiring on the Ex power module
Channel/component temporarily unavail-able	$1F_H$	Module	Firmware update is in progress or has been canceled during the update.	• Restart the firmware update • Wait for firmware update
Invalid BaseUnit	151_H	Module	The module was plugged into an impermissible Ex BaseUnit.	Replace Ex BaseUnit
The retentive memory in the BaseUnit is defective.	153_H	Module	A memory block error on the Ex BaseUnit was detected during startup.	Replace Ex BaseUnit

Maintenance message

Whenever it is detected that maintenance is required, a maintenance message is generated. The MT LED lights up on the module. The messages have no direct effect on the function of the module.

Table 1-143 Maintenance message, its meaning and remedies

Maintenance mes-sage	Error code	Assign-ment	Meaning	Remedy
The retentive memory in the BaseUnit is defective.	153_H	Module	A memory block error on the Ex BaseUnit was detected during opera-tion.	Replace Ex BaseUnit

E.4 Address space

The Ex power module does not use any data in the input or output data area.

Service & Support

F

Fastening/unfastening components

The components are maintenance-free.

Repairs on the components of the I/O system may only be made by the manufacturer.

Warranty

The warranty requires compliance with safety and commissioning information.

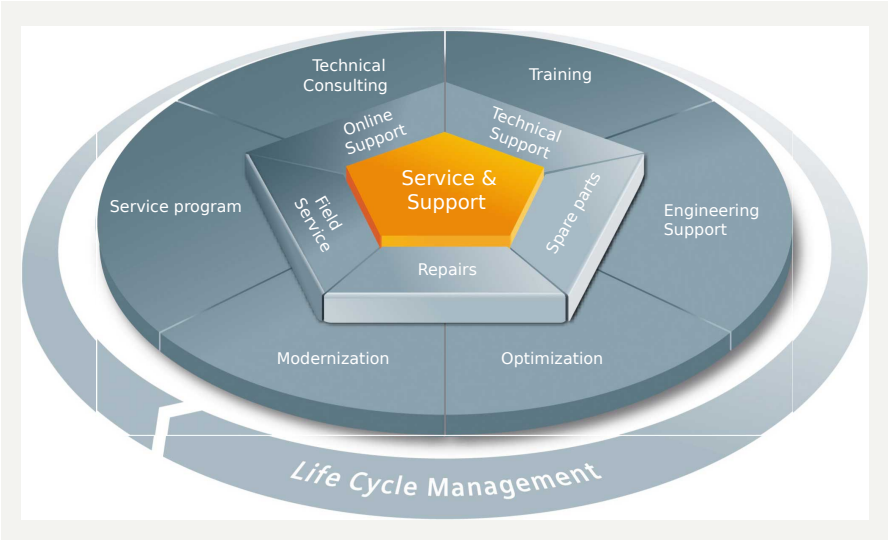

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You can find Online Support at the following address Internet (https://support.industry.siemens.com/cs/ww/en/).

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Support during project engineering and development with services fine-tuned to your requirements, from configuration through to implementation of an automation project.

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Our Field Service offers you services for commissioning and maintenance – to ensure that your machines and plants are always available.

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In every sector worldwide, plants and systems are required to operate with constantly increasing reliability. We will provide you with the support you need to prevent a standstill from occurring in the first place: with a worldwide network and optimum logistics chains.

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- Service contracts
- Plant IT Security Services
- Life Cycle Services for Drive Engineering
- SINUMERIK Manufacturing Excellence
- SIMATIC Remote Support Services

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- Costs that can be calculated and therefore planned
- Service reliability due to guaranteed response times and spare part delivery times
- Customer service personnel will be supported and relieved of additional tasks
- Comprehensive service from a single source, fewer interfaces and greater expertise

Contact

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You can find your personal contact in our contacts database on the Internet (https://support.industry.siemens.com/aspa_app).

F.1 Information and support

Downloads of the documentation

Complete versions of the documentation are available on the Internet (http://www.siemens.com/pcs7-documentation).

Documentation can be downloaded free of charge.

My Documentation Manager

- The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
  You can export the manual as PDF file or in a format that can be edited later.
- You can find the My Documentation Manager on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

Manual Collections

The Manual Collection contains the complete documentation of the respective distributed I/O summarized in a single file.

- Compile your personal Manual Collection in My Documentation Manager:
  Product support (https://support.industry.siemens.com/cs/ww/en/ps)
- Manual Collection ET 200SP
  (https://support.industry.siemens.com/cs/ww/en/view/84133942) and documentation of the I/O modules

Application examples

- Applications examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.
- You can find application examples on the Internet (http://support.industry.siemens.com/cs/ww/en/ps/ae).

Newsletter

You can find information on modules in the newsletter.
Notifications – Always up to date (Page 12)

Recommendation:
Register for notifications about the following products:

- SIMATIC S7-4xx
- SIMATIC S7-15xx
- PCS 7 as of V9.0 SP3
- SIMATIC S7 F Systems V6.3
- Distributed I/O
  - ET 200SP HA

    and/or
  - ET 200SP
- SIMATIC Industrial Software

Product assortment

- You can find information about the existing product range in the online catalog and the online order system:
  Mall (https://mall.industry.siemens.com)

CAx data

- You can use the CAx Download Manager to access current product information for your CAD or CAE system.
- You configure your own download package with a few clicks.
- In doing so you can select:
  - Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
  - Manuals, characteristics, operating manuals, certificates
  - Product master data
- You can find the CAx Download Manager on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

F.2 Mounting rules

Distances

Minimum clearances in the control cabinet (Page 48)

Fastening/unfastening components

Component	Fastening/unfastening	Tool	Tightening torque
Ex power module	Screw is located in the Ex power module	TORX T15 screwdriver or 4.5 mm blade width	1.5 Nm
Ex I/O module	Release buttons	None	None
Ex BaseUnit	Mounting rail release	None	None
Server module	Click mounting	None	None

See also

Cable cross-sections and ferrules (Page 123)

F.3 Cable cross-sections and ferrules

Cables with and without ferrule

The stripped part of the cable must be completely inserted into the terminal of the Ex BaseUnit.

NOTE
Cable cross-sections
The cable diameters must be approved for the required current.

Rule for ...		Ex power module (supply voltage)	Terminal block (push-in terminal of the Ex BaseUnit)
Permitted cable cross-sections for solid cables		1.0 to 2.5 mm^2	0.2 to 2.5 mm^2
		AWG*: 17 to 13	AWG*: 24 to 13
Permitted cable cross-sections for flexible cables	Without ferrule	1.0 to 2.5 mm^2	0.2 to 2.5 mm^2
		AWG*: 17 to 13	AWG*: 24 to 14
	With wire end sleeves (with plastic sleeve)***	1.0 to 1.5 mm^2 **	0.14 to 1.5 mm2
		AWG*: 17 to 16	AWG*: 26 to 16

* AWG: American Wire Gauge

** Ferrules without plastic sleeve: 1.0 mm^2 to 2.5 mm^2 /AWG: 17 to 13

*** See note on ferrules

Rule for ...		Ex power module (supply voltage)	Terminal block (push-in terminal of the Ex BaseUnit)
Permitted cable cross-sections for flexible cables	With TWIN end sleeve***	1 mm^2	
Stripped length of the cables		8 to 10 mm	
Wire end sleeves in accordance with DIN 46228 with plastic sleeve***		8 and 10 mm long	

* AWG: American Wire Gauge

** Ferrules without plastic sleeve: 1.0 mm^2 to 2.5 mm^2 /AWG: 17 to 13

*** See note on ferrules

NOTE

Ferrules

You can achieve optimal results with respect to a high-quality and durable electrical connection and maximum conductor extraction forces at the same time by using crimping dies preferably with smooth surfaces. Options include rectangular and trapezoidal crimping cross-sections.

Due to the large number of crimping dies used in the industry, we can recommend others on request. **Crimp forms with a pronounced wave profile are not permitted.**

SIEMENS

SIMATIC

ET 200SP
CPU 1510SP-1 PN
(6ES7510-1DK03-0AB0)

Equipment Manual

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Technical specifications 6

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11/2024
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Introduction

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Purpose of the documentation

This Equipment Manual supplements the ET 200SP Distributed I/O System (https://support.automation.siemens.com/WW/view/en/58649293) System Manual as well as the Function Manuals. This Equipment Manual contains a concise description of the module-specific information. The system-related functions are described in the System Manual. All system-spanning functions are described in the Function Manuals.

The information provided in this Equipment Manual and the System Manual allows you to commission the CPU.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe the notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

ID-Link for the digital nameplate

The ID-Link is a globally unique identifier according to IEC 61406-1, which you will find as a QR code on your product in the future.

The figure shows an example of an ID-Link for the CPU 1510SP-1 PN.

You can recognize the ID-Link by the frame with a black corner at the bottom right. The ID-Link takes you to the digital nameplate of your product.

Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call the ID-Link.

In the digital nameplate, you will find product data, manuals, declarations of conformity, certificates, and other helpful information about your product.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet. (https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293) for general information and measures regarding industrial cybersecurity.

This section provides an overview of security-related information pertaining to your SIEMENS device.

NOTE

Security-relevant changes to software or devices are documented in the section New functions.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

2.3 Cybersecurity-relevant information

Note all cybersecurity-relevant information.

Topics with cybersecurity-relevant information	Reference
Operational application environment and security assumptions	
Requirements for the operational application environment of the system and security assumptions	This section is found in the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Security properties of the product	
Access protection Physical protection: • You can protect the CPU against unauthorized access by locking the front flap. Password protection You can also protect the CPU with a password. Password categories: • Password to protect confidential configuration data • Passwords in the context of user management (UMAC) • Password for display	Information on locking and on password protection can be found in this Equipment Manual in the section Operator controls and display elements (Page 22). Also note the information on the topic of access protection in the Protection section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Integrated protection functions • The CPUs have integrated protection functions.	For information on the protection functions, refer to the "Overview of protection functions" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
PROFINET Security Class 1 • The device supports PROFINET Security Class 1. • With the introduction of PROFINET Security Class 1, additional security settings have been integrated into the PROFINET communication.	Detailed information about PROFINET Security Class 1 and the additional security settings can be found in the PROFINET with STEP 7 Function Manual (https://support.industry.siemens.com/cs/us/en/view/49948856).
Reading out and verifying signatures	You can find detailed information on reading and verifying signatures in the STEP 7 online help (TIA Portal).
Supported Ethernet services	Information about supported services can be found in the section Technical specifications (Page 31). You can find detailed information on the supported Ethernet services in the Communication Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192925).
Interfaces, ports, protocols and services	
Information on the following is security related: • Communications layer and communication role • Default states • Enabling/disabling ports and services	You can find detailed information on these topics in the Communication Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192925).
Secure operation	
Corrective measures for known risks	Corrective measures for known risks are announced on the Siemens ProductCERT (https://siemens.com/productcert) Web page. For more information on SIEMENS ProductCERT, refer to the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).

Topics with cybersecurity-relevant information	Reference
Security checks	Application-specific security measures such as cyclic checks of the configuration via checksums are described in the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Recording Security events	Information on recording security events can be found in the "Safe operation of CPUs" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Secure decommissioning Products that contain security-relevant data must be securely decommissioned before disposal or resale.	Information on secure decommissioning can be found in the "Safe operation of the system" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).

Product overview

3

3.1 New functions

In this chapter, you will find an overview of the most important new firmware features of the CPU compared to the predecessor CPU (V3.1).

New CPU features in firmware version V4.0

New functions	Applications	Customer benefits
Integrated safety		
Retentive memory area for syslog messages	The CPUs store syslog messages retentively as of FW version 4.0.	As a result, events in the syslog memory are retained even after the CPU is restarted.
Central user management	System-wide, central management of users and user groups outside the TIA Portal via the UMC server.	User management for comprehensive automation solutions with multiple projects, users, and user groups. Users and user groups can work in all projects in which they are activated and for which they have been assigned the appropriate rights. During operation, users can be added to or removed from a group or their passwords can be changed. These changes have no effect on the CPU configuration. It is not necessary to restart the CPU.
Programming of the CPU		
SIMATIC Controller Profiling	With SIMATIC Controller Profiling, you can analyze and evaluate the runtime behavior of your user program on a SIMATIC CPU.	With the new "Profiling" instruction, you can start or stop the profiling of a CPU from FW version V4.0. When starting the profiling, specify the configuration with which the profiling data is to be recorded.
Increasing the nesting depth	For CPUs as of FW version V4.0, the nesting depth has been extended for the following elements: • PLC data types • Tags of the STRUCT data type • Tags of the ARRAY of STRUCT/ARRAY of UDT data type	Previously, the maximum nesting depth was eight elements. You can now nest up to 26 elements inside each other. An ARRAY of STRUCT/UDT requires three hierarchy levels in each case. If you use these data types, the maximum nesting depth is reduced accordingly.
Communication of the CPU		
New function for OPC UA	Enables cross-vendor communication.	You can find more information in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

New functions	Applications	Customer benefits
Configuring SNMP and DCP	As of STEP 7 V20, you can centrally configure the SNMP settings for an entire PROFINET IO system. IO devices that support the SNMP automatically synchronize the SNMP settings of the PROFINET interface of your higher-lever IO controller. If IO controllers and IO devices support the DCP protocol, the write-protected mode is activated by default for DCP.	Easier configuration of the SNMP settings through central default at the CPU for the connected PROFINET IO system.
Web server of the CPU		
System web pages	Introduction of the system web pages with new design and functionality for: • Overview • Diagnostics • User program • Messages and DataLogs • Maintenance	• User interface with modern design • Intuitive and convenient operation • Flexible change management • Interaction with user-defined web applications with reference to Web API sessions
New Web API methods	The Web API has been expanded to include the following functions: • Reading out basic information from the CPU • Reading out API session information • Reading out technology objects and their values • Configuring the HTTP response header • Additional options for configuring web applications	The extended functional scope of the Web API offers more accessibility options. Furthermore, access to the web server via HMI Unified Panels is extended through the HTTP header configurations.
Technology functions of the CPU		
Axis functions	Defining the motion transition	Extended functional scope
	Stopping the basic motion	
Trace functionality of the CPU		
Named value data types in traces	"Named values" are values that are assigned a unique name. In the TIA Portal, you declare named values within "named value data types". They contain a set of values to which a unique set of names is assigned.	Named values are easily referenced throughout the program and enhance the readability and maintainability of the program. This makes it easy to monitor/analyze the named value data types in the trace, for example.
Recording as a binary file for long-term traces and long-term project traces	Recording as binary file instead of a CSV file and saving in a DAT file.	This makes it possible to monitor/analyze long-term traces and long-term project traces directly in the TIA Portal.
Acquiring events from technology objects in the trace recording	Detecting events in the trace recording which occur at a motion control technology object as of V9.0 during recording.	Monitoring/analyzing of the correct sequence and parameterization of motion control jobs in complex applications.
Cross-project trace	Recording of values from multiple projects with a PN/PN coupler.	Monitoring/analyzing of signals and events from multiple projects.

New functions of the CPU in firmware version V3.1

New functions	Applications	Customer benefits
Integrated safety		
Syslog messages	The CPU stores syslog messages in a local cache (temporary memory). The messages can be forwarded to a syslog server.	The syslog server saves all syslog messages from its connected devices. The messages can be displayed on the interface of the server and potential security risks can be identified.
Local user management	As of TIA Portal version V19 and FW version V3.1, the CPUs feature improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC). Starting with the above mentioned version, you can manage all project users with their rights (e.g. access rights) for all CPUs in the project. You can do this in the editor for users and roles in the TIA Portal.	Project users can be managed via the TIA Portal with their rights (for example, access rights) for all CPUs in the project in the editor for users and roles.
Communication of the CPU		
Implementation of PROFINET Security Class 1	As of V19, STEP 7 offers extended configuration options for the SNMP and DCP protocols in order to meet the requirements for PROFINET Security Class 1.	Additional protection of communication within your PROFINET network.
Project-internal shared device/shared I-device	As of STEP7 V19, a shared device/shared I-device together with a maximum of two IO controllers can be created in a single project. Previously, the second IO controller required its own project.	Simpler configuration.
Handling timeouts while exchanging data	When network loads are high, timeouts may occur in PROFINET IO devices during data record communication. Previously, the PROFINET IO communication was reduced by the CPU in this case. As of STEP 7 V19 and FW version V3.1, you can configure the behavior of the respective PROFINET interface.	PROFINET IO communication is maintained even under high grid loads
Web server of the CPU		
New Web API methods	Many new API methods extend your access options to the CPU via the Web API.	Additional applications for the web server
Technology functions of the CPU		
Axis functions	Measuring gearbox for positioning/synchronous axis	Advanced configuration options
	Torque feedforward control for positioning/synchronous axis: The torque feedforward control of the CPU controls the torque required to accelerate the axis, taking into account the motion profile.	Complex motion sequences can be executed faster and more precisely. This leads to a reduction of following errors in acceleration phases.
	Three drive stop modes can be configured for the alarm response "Remove enable".	You can choose between a deceleration ramp, coasting down, and rapid stop.
	Dynamic filter with floating mean value	The new "Floating mean value filter" mode is available for the dynamic filter.

New functions	Applications	Customer benefits
Axis functions	Standstill signal on external encoder	The standstill signal is also available for external encoders. The standstill signal is output when the encoder values are within the defined standstill window.
	Virtual axis	The axis is operated in the virtual mode with improved runtime behavior. The new mode replaces the existing behavior of the virtual axis.
Measuring input functions	Monitoring measuring input	With the "Measuring via monitoring" measuring input type, the measuring input can capture the measured signal of another configured measuring input.
	Cyclic measuring for central measuring input	Cyclic measuring possible without additional technology module
Trace functionality of the CPU		
Live monitoring for the long-term trace	With live monitoring for the long-term trace, you can: • Display and analyze values directly in the graph during recording • Use superimposed measurements for the long-term trace • Synchronize time bases	Improved display and analysis of long-term traces
Long-term project trace	With the long-term project trace, you can record signals of different S7-1500 CPUs simultaneously. The CPUs must be configured in a network. The recording is stored on a drive that you have configured.	Extended functional scope

Reference

You can find an overview of all new functions, improvements and revisions in the respective firmware versions on the Internet (https://support.industry.siemens.com/cs/ww/en/view/59192925).

See also

Internet (https://support.industry.siemens.com/cs/ww/en/view/109478459)

3.2 Hardware properties

Article number

6ES7510-1DK03-0AB0

View of the module

The figure below shows the CPU 1510SP-1PN.

Figure 2-1 CPU 1510SP-1 PN

Properties

The CPU 1510SP-1 PN has the following technical properties:

Property	Description	Additional information
Supply voltage	The 24 V DC supply voltage is fed via a 4-pin connection plug located at the bottom left on the front panel of the CPU.	• Section Connecting (Page 24) • ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649-293)
Standalone CPU	You can also use the CPU 1510SP-1 PN in the distributed I/O system ET 200SP as a "central system" without a higher-level controller.	

Property	Description	Additional information
PROFINET IO		
PROFINET interface (X1)	The interface has an integrated 3-port switch. Port 1 and port 2 are located on the optionally pluggable BusAdapter. Port 3 is integrated in the housing of the CPU. You can connect the PROFINET IO to the CPU via the BusAdapter. You will find information on the BusAdapters supported by the CPU in the Connecting (Page 24) section. In addition to PROFINET basic functionality, the interface also supports PROFINET IO RT (real-time) and IRT (isochronous real-time). PROFINET IO communication or real-time settings can be configured. The basic functionality of PROFINET supports HMI communication, communication with the configuration system, communication with a higher-level network (backbone, router, Internet) and communication with another machine or automation cell. Port 1 and port 2 can also be used as ring ports for the configuration of redundant ring structures in Ethernet.	• PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948-856) • ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649-293)
Operation of the CPU as • IO controller • I-device	• **IO controller:** As an IO controller, the CPU addresses the connected IO devices • **I-device:** As an I-device (intelligent IO device), the CPU is assigned to a higher-level IO controller and is used in the process as an intelligent pre-processing unit of sub-processes	
PROFIBUS DP		
DP master	To use the ET 200SP CPU as a DP master, you need the CPU and the optional communication module CM DP (PROFIBUS interface X2). When used as a DP master, the ET 200SP CPU exchanges data with the connected DP devices via PROFIBUS DP.	• PROFIBUS Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193-579) • Communication module CM DP Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/90156-526)
Intelligent DP device (I-DP device)	To use the ET 200SP CPU as an intelligent DP device (I-DP device), you need the CPU and the optional CM DP communications module (PROFIBUS interface X2). As an intelligent DP device, the ET 200SP CPU is connected via PROFIBUS DP to a higher-level DP master and exchanges data with it.	

Accessories

You can find information on the topic of "Accessories/spare parts" in the Distributed I/O system ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

NOTE

The CPU is delivered without a BusAdapter. You can find an overview of supported BusAdapters in the "Connecting (Page 24)" section. You can find the article numbers of the BusAdapters in the ET 200SP BusAdapter (https://support.industry.siemens.com/cs/us/en/view/109751716) Equipment Manual.

NOTE

You must provide covers for unused BusAdapter interfaces. You can find the article numbers of the covers in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual, in the "Accessories/spare parts" section.

3.3 Firmware functions

Functions

The CPU supports the following functions:

Function	Description	Additional information
Integrated system diagnostics	The system automatically generates the messages for the system diagnostics and outputs these messages via a programming device/PC, HMI device, the web server or the integrated display. System diagnostics information is also available when the CPU is in STOP mode.	Diagnostics Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192926)
Integrated web server	The web server lets you access the CPU data by means of a network. Evaluations, diagnostics, and modifications are thus possible over long distances. Monitoring and evaluation is possible without STEP 7; all you need is a web browser. Make sure that you take appropriate measures (e.g. limiting network access, using firewalls) to protect the CPU from being compromised.	• Web server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193560) • Security with SIMATIC S7 controllers System Manual (https://support.industry.siemens.com/cs/ww/en/view/90885010)
Integrated trace functionality	Trace functionality supports you in troubleshooting and/or optimizing the user program. You can record device tags and evaluate the recordings with the trace and logic analyzer function. Tags are, for example, drive parameters or system and user tags of a CPU. The device saves the recordings. You can read out and permanently save the recordings with the configuration system (ES), if required. The trace and logic analyzer function is therefore suitable for monitoring highly dynamic processes. The trace record can also be displayed through the web server.	Using the trace and logic analyzer function Function Manual (https://support.industry.siemens.com/cs/ww/en/view/64897128)

Function	Description	Additional information
	With the project trace, you can record the variables of multiple devices within a project, for example, a controller and a drive. With the long-term trace, you can record up to 64 different tags for each cycle in a .csv file over a long period (e.g. hours, days).	
OPC UA	With OPC UA, you can exchange data via an open and manufacturer-neutral communication protocol. The CPU can act as OPC UA server. The CPU acting as the OPC UA server can communicate with OPC UA clients. In turn, as an OPC UA client, the CPU can access an OPC UA server, allow the OPC UA server to run methods and read out information from the OPC UA server. The OPC UA Companion Specification allows methods to be specified uniformly and independently of the manufacturer. Using these specified methods, you can easily integrate devices from various manufacturers into your plants and production processes.	Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925)
Configuration control	You can use configuration control to operate different real hardware configurations with a configured maximum configuration of the hardware. Especially in series machine manufacturing, this means you have the option of operating/configuring different configuration variants of a machine with a single project.	ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)
PROFINET IO		
RT (real time)	RT prioritizes PROFINET IO telegrams over standard telegrams. This ensures the required determinism in the automation technology. In this process the data is transferred via prioritized Ethernet telegrams.	PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856)
IRT (isochronous real time)	A reserved bandwidth within the send clock is available for IRT data. The reserved bandwidth ensures that the IRT data can be transmitted in time-synchronized intervals, unaffected by other high network loading (e.g. TCP/IP communication or additional real time communication). Update times with maximum determinism can be realized through IRT. Isochronous applications are possible with IRT.	
Isochronous mode	The Isochronous mode system property acquires measured values and process data and processes the signals in a fixed system clock. Isochronous mode thus contributes to high control quality and hence to greater manufacturing precision. Isochronous mode reduces possible fluctuations of the process reaction times to a minimum. Time-assured processing makes higher machine cycles possible.	
MRP (Media Redundancy Protocol)	It is possible to establish redundant networks via the Media Redundancy Protocol. Redundant transmission links (ring topology) ensure that an alternative communication path is made available if a transmission link fails. The PROFINET devices that are part of this redundant network form an MRP domain. RT operation is possible with the use of MRP.	

Function	Description	Additional information
MRPD (Media Redundancy with Planned Duplication)	The advantage of the MRP extension MRPD is that, in the event of a failure of a device or a line in the ring, all other devices continue to be supplied with IO data without interruption and with short update times. MRPD is based on IRT and MRP. To realize media redundancy with short update times, the PROFINET devices participating in the ring send their data in both directions. The devices receive this data at both ring ports so that there is no reconfiguration time.	PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856)
Shared device	The "Shared device" function allows you to divide the modules or submodules of an IO device up among different IO controllers. Numerous IO controllers are often used in larger or widely distributed systems. Without the "Shared device" function, each I/O module of an IO device is assigned to the same IO controller. Therefore, if sensors in close proximity to each other need to provide data to different IO controllers, multiple IO devices are required. The "Shared device" function allows the modules or submodules of an IO device to be divided up among different IO controllers, thus allowing flexible automation concepts. You can, for example, combine I/O modules that are physically close to each other in one IO device.	
PROFIenergy	PROFIenergy is a PROFINET-based data interface for switching off consumers centrally and with full coordination during pause times regardless of the manufacturer or device type. The goal is that the process is only provided with the energy that is absolutely required. The majority of the energy is saved by the process; the PROFINET device itself only contributes a few watts of savings potential.	
Integrated technology		
Motion Control	The CPUs support the S7-1500 Motion Control functions via the technology objects speed axes, positioning axes, synchronized axes, external encoders, cams, cam tracks, and measuring inputs. • Speed-controlled axis for controlling a drive with speed specification • Positioning axis for position-controlled positioning of a drive • Synchronous axis to interconnect with a master value. The axis is synchronized to the master axis position. • External encoder for detecting the actual position of an encoder and its use as a master value for synchronous operation • Cams, cam track for position-dependent generation of switching signals • Measuring input for fast, accurate, and event-dependent sensing of actual positions You program the technology objects with Motion Control instructions according to PLCopen.	Motion Control topic page (https://support.industry.siemens.com/cs/ww/en/view/109751049)

Function	Description	Additional information
Integrated closed-loop control functionality	• PID Compact (continuous PID controller) • PID 3Step (step controller for integrating actuators) • PID Temp (temperature controller for heating and cooling with two separate actuators)	PID control Function Manual (https://support.industry.siemens.com/cs/ww/en/view/108210036)
Integrated safety		
Know-how protection	The know-how protection protects user blocks against unauthorized access and modifications.	ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)
Copy protection	Copy protection links user blocks to the serial number of the SIMATIC Memory Card or to the serial number of the CPU. User programs cannot run without the corresponding SIMATIC Memory Card or CPU.	
Local user management (as of FW version V3.1)	Improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC). You can used the local user management in the editor to manage all project users along with their rights (e.g. access rights) for users and roles of the project in the TIA Portal.	
Access protection (up to FW version V3.0)	You can use authorization levels to assign separate rights to different user groups.	
Integrity protection	The CPUs feature an integrity protection function by default. This helps to detect any manipulation of the engineering data on the SIMATIC Memory Card or during data transfer between the TIA Portal and the CPU, and to check communication from a SIMATIC HMI system to the CPU for possible manipulation of engineering data. The user receives a corresponding message about manipulation of engineering data detected by the integrity protection.	
Password provider	As an alternative to manual password input you can connect a password provider to STEP 7. A password provider offers the following advantages: • Convenient handling of passwords. STEP 7 reads the password automatically for the blocks. This saves you time. • Optimum block protection because the users do not know the password itself.	

3.4 Operating and display elements

3.4.1 Front view of the module

The figure shows the CPU 1510SP-1 PN.

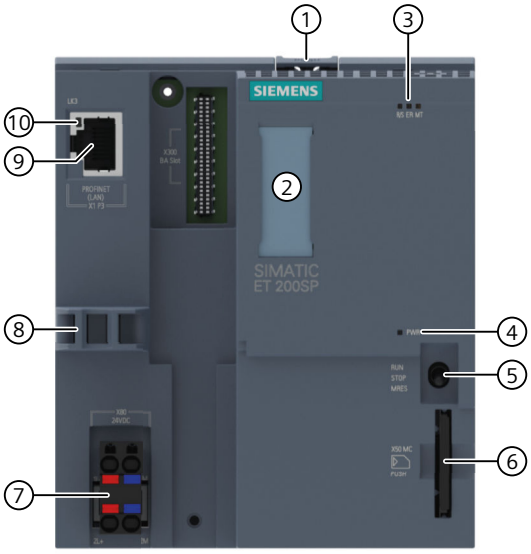

① Mounting rail release
② Labeling strips
③ LEDs for status and error displays
④ LED for display of the supply voltage
⑤ Mode switch
⑥ Slot for the SIMATIC Memory Card
⑦ Connection for supply voltage (included in scope of supply)
⑧ Cable support and attachment for port P3 of the PROFINET interface
⑨ Port P3 of the PROFINET interface X1
⑩ LEDs for status displays of the PROFINET interface X1

Figure 2-2 Front view without BusAdapter

Front view with BusAdapter

The figure on the left shows the CPU 1510SP-1 PN including a plugged BA 2xRJ45 BusAdapter. The BusAdapter is not included in the scope of supply. The figure on the right shows a separate view of the BA 2xRJ45 BusAdapter.

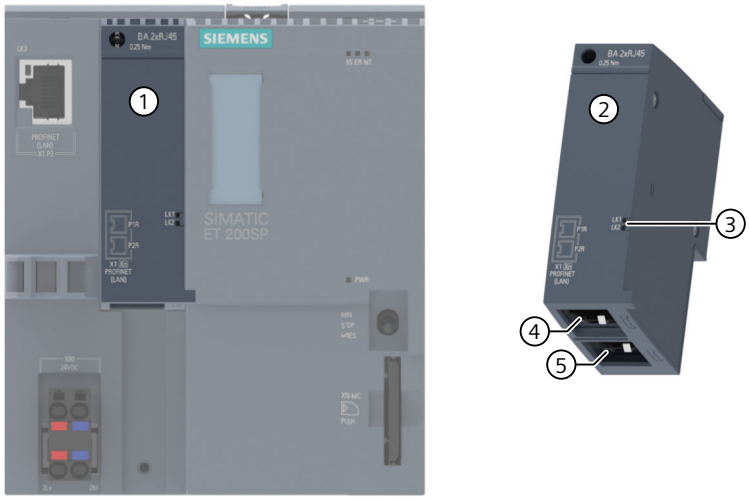

① BusAdapter BA 2×RJ45

② Separate view of the BusAdapter

③ LEDs for status displays of the PROFINET interface: LK1 and LK2 on BusAdapter

④ Port P1R of the PROFINET interface: RJ45 socket on BusAdapter BA 2×RJ45
R: Ring port for configuring a ring topology with media redundancy

⑤ Port P2R of the PROFINET interface: RJ45 socket on BusAdapter BA 2×RJ45
R: Ring port for configuring a ring topology with media redundancy

Figure 2-3 Front view of the CPU 1510SP-1 PN with BusAdapter

3.5 Mode switch

Use the mode switch to set the CPU operating mode.

The following table shows the position of the switch and the corresponding meaning.

Table 2-1 Mode switch settings

Position	Meaning	Explanation
RUN	RUN mode	The CPU can process the user program.
STOP	STOP mode	The user program is not being executed.
MRES	Memory reset	Position for CPU memory reset.

Wiring

4

This section provides information on the pin assignment of the individual interfaces and the block diagram of the CPU 1510SP-1 PN.

24 V DC supply voltage (X80)

The connector for the supply voltage is plugged in when the CPU ships from the factory.

The following table shows the signal names and the descriptions of the pin assignment of the 24 V DC supply voltage.

Table 2-2 Pin assignment 24 V DC supply voltage

View Connector	Signal name [1]		Description
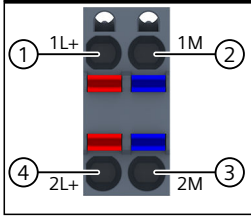	1	1L+	+ 24 V DC of the supply voltage
	2	1M	Ground of the supply voltage
	3	2M	Ground of the supply voltage for loop-through [2]
	4	2L+	+ 24 V DC of the supply voltage for loop-through [2]

[1] 1L+ and 2L+ as well as 1M and 2M are bridged internally

[2] Maximum 10 A permitted

PROFINET IO interface on the CPU (X1 P3)

The assignment corresponds to the Ethernet standard for an RJ45 connector.

- When autonegotiation is deactivated, the RJ45 socket is allocated as a switch (MDI-X).
- If autonegotiation is activated, then autocrossing is active and the RJ45 socket has either a device assignment (MDI) or switch assignment (MDI-X).

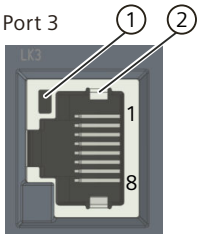

① LINK LED for port P3 (green LED on CPU)

② Shielding

BusAdapter

The following BusAdapters can be selected for use with the CPU 1510SP-1 PN :

- BusAdapter BA 2×RJ45
- BusAdapter BA SCRJ/RJ45
- BusAdapter BA LC/RJ45
- BusAdapter BA 2×FC
- BusAdapter BA 2xSCRJ
- BusAdapter BA SCRJ/FC
- BusAdapter BA 2xLC
- BusAdapter BA LC/FC
- BusAdapter BA 2xM12

For more information on the various BusAdapters, please refer to the SIMATIC ET 200SP BusAdapter (https://support.industry.siemens.com/cs/us/en/view/109751716) Equipment Manual.

Reference

You can find more information on the topics of "Connecting the CPU" and "Accessories/spare parts" in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) System Manual.

Assignment of the MAC addresses

The MAC address is a globally unique device identifier that is assigned to each PROFINET device in the factory. Its 6 bytes are divided into 3 bytes for the manufacturer ID and 3 bytes for the device ID (serial number). The front of the CPU 1510SP-1 PN is lasered with the MAC address of the PROFINET interface.

The PROFINET interface X1 of the CPU 1510SP-1 PN has three ports. Port 3 is located on the CPU. Ports 1 and 2 are located on the optional BusAdapter. In addition to the PROFINET interface, each PROFINET port also has a separate MAC address. There is therefore a total of four MAC addresses for the CPU 1510SP-1 PN.

The MAC addresses of the PROFINET ports are needed for the LLDP protocol, for example for the neighborhood discovery function.

The table below shows how the MAC addresses are assigned.

Table 2-3 Assignment of the MAC addresses

	Assignment
MAC address 1	PROFINET interface X1 • Visible in STEP 7 for accessible devices • Lasered on the front of the CPU (start of the number range)
MAC address 2	Port X1 P1R (required for LLDP, for example)
MAC address 3	Port X1 P2R (required for LLDP, for example)
MAC address 4	Port X1 P3 (required for LLDP, for example)

Block diagram

The following figure shows the block diagram of the CPU 1510SP-1 PN.

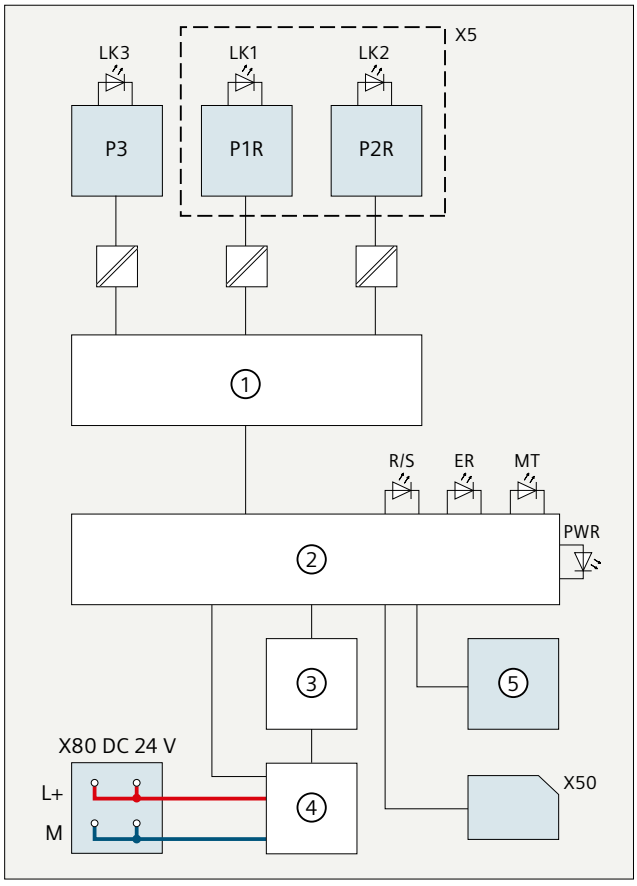

①	PROFINET switch	P1R	PROFINET interface X1 Port 1
②	Electronics	P2R	PROFINET interface X1 Port 2
③	Backplane bus interface	P3	PROFINET interface X1 Port 3
④	Internal supply voltage	L+	24 V DC supply voltage
⑤	RUN/STOP/MRES mode selector	M	Ground

X5	BusAdapter	LK1, 2, 3	LED Link TX/RX (green)
X50	SIMATIC Memory Card	R/S	RUN/STOP LED (green/yellow)
X80 24 V DC	Infeed of supply voltage	ER	ERROR LED (red)
		MT	MAINT LED (yellow)
		PWR	POWER LED (green)

Figure 2-4 Block diagram of the CPU 1510SP-1 PN

Interrupts, error messages, diagnostics and system alarms

5

The status and error displays of the CPU 1510SP-1 PN are described below.

You will find additional information on "Interrupts" in the STEP 7 online help.

You can find additional information on the topics of "Diagnostics" and "System alarms" in the Diagnostics (https://support.automation.siemens.com/WW/view/en/59192926) function manual.

5.1 Status and error display of the CPU

LED displays

The figure below shows the LED displays of the CPU 1510SP-1 PN and the BA 2xRJ45 BusAdapter.

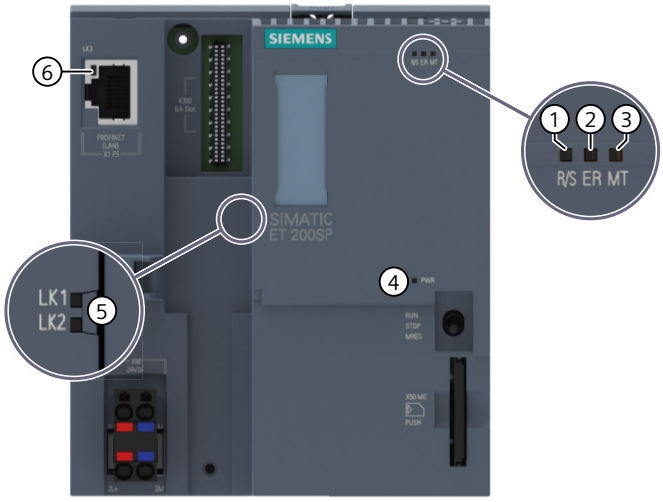

① RUN/STOP LED (green/yellow LED)

② ERROR LED (red LED)

③ MAINT LED (yellow LED)

④ POWER LED (green LED)

⑤ LINK LED for ports X1 P1 and X1 P2 (green LEDs on BusAdapter)

⑥ LINK LED for port X1 P3 (green LED on CPU)

Figure 2-5 LED displays on the CPU and BusAdapter

Meaning of the POWER, RUN/STOP, ERROR and MAINT LEDs

CPU 1510SP-1 PN features an LED for monitoring the supply voltage of the electronics (PWR) and three LEDs for displaying the current operating and diagnostics status. The following table shows the meaning of the various combinations of colors for the POWER, RUN/STOP, ERROR and MAINT LEDs.

Table 2-4 Meaning of the LEDs

POWER LED	RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	LED off	Missing or insufficient power supply on the CPU.
LED lit green	LED off	LED flashes red	LED off	An error has occurred.
LED lit green	LED lit green	LED off	LED off	CPU is in RUN mode.
LED lit green	LED lit green	LED off	LED lit yellow	Maintenance demanded for the plant. You need to check/replace the affected hardware within a short period of time.
				Active Force job
				OPC UA server of the CPU expects initial trust lists and CRLs via GDS Push function.
LED lit green	LED lit green	LED flashes red	LED off	A diagnostics event is pending. The CPU is in RUN mode.
LED lit green	LED lit yellow	LED flashes red	LED off	A diagnostics event is pending. The CPU is in STOP mode.
LED lit green	LED lit yellow	LED off	LED flashes yellow	Firmware update using SIMATIC Memory Card successfully completed.
LED lit green	LED lit yellow	LED off	LED off	CPU is in STOP mode.
				CPU runs a program with active break-points. The program is at a breakpoint.
LED lit green	LED lit yellow	LED flashes red	LED flashes yellow	The program on the SIMATIC Memory Card is causing an error.
				Firmware update via the SIMATIC Memory Card failed.
				The CPU has detected an error state. Additional information is available via the CPU diagnostic buffer.
LED lit green	LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. startup after STOP.
				Download of the user program from the SIMATIC Memory Card
				CPU runs a program with active break-points. The program is presently moving from one breakpoint to another.
				Firmware update is being performed.
LED lit green	LED flashes yellow/green	LED off	LED off	Startup (transition from STOP → RUN)

POWER LED	RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED lit green	LED flashes yellow/green	LED flashes red	LED flashes yellow	Startup (CPU booting)
				LED testing during startup.
				Flash LEDs

Meaning of the LINK LED

Each port has a LINK LED (LK1, LK2, LK3). The table below shows the various "LED scenarios" of the ports of the CPU 1510SP-1 PN.

Table 2-5 Meaning of the LEDs

LINK LED	Meaning
LED off	There is no Ethernet connection between the PROFINET interface of the PROFINET device and the communication partner. No data is currently being sent/received via the PROFINET interface. There is no LINK connection.
LED flashes green	The CPU is performing an "LED flash test".
LED lit green	There is an Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner.

NOTE

"LED" instruction

You can read the status (e.g. "On" or "Off") of LEDs of a CPU or a module using the "LED" instruction. Note, however, that it is not possible to read the LED status of the LINK RX/TX LEDs on all S7-1500 CPUs.

You can find additional information on the "LED" instruction in the STEP 7 online help.

Technical specifications

6

The following table shows the technical specifications as of 11/2024. You can find a data sheet with the latest technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7510-1DK03-0AB0/td?dl=en).

Article number	6ES7510-1DK03-0AB0
General information	
Product type designation	CPU 1510SP-1 PN
HW functional status	FS03
Firmware version	V4.0
• FW update possible	Yes
Product function	
• I&M data	Yes; I&M0 to I&M3
• Module swapping during operation (hot swapping)	Yes; Multi-hot swapping
• Isochronous mode	Yes; only with PROFINET; with minimum OB 6x cycle of 500 µs
• SysLog	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V20 (FW V4.0) / V18 (FW V3.0) or higher; configurable with older TIA Portal versions as 6ES7510-1DJ01-0AB0
Configuration control	
via dataset	Yes
Control elements	
Mode selector switch	1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	10 ms
Input current	
Current consumption (rated value)	0.48 A
Current consumption, max.	0.7 A
Inrush current, max.	1.34 A; Rated value
I^2t	0.3 $A^2 \cdot s$
Power	
Infeed power to the backplane bus	8.05 W

Article number	6ES7510-1DK03-0AB0
Power loss	
Power loss, typ.	3.5 W
Memory	
Number of slots for SIMATIC memory card	1
SIMATIC memory card required	Yes
Work memory	
• integrated (for program)	200 kbyte
• integrated (for data)	1 Mbyte
Load memory	
• Plug-in (SIMATIC Memory Card), max.	32 Gbyte
Backup	
• maintenance-free	Yes
CPU processing times	
for bit operations, typ.	6 ns
for word operations, typ.	7 ns
for fixed point arithmetic, typ.	9 ns
for floating point arithmetic, typ.	37 ns
CPU-blocks	
Number of elements (total)	4 000; Blocks (OB, FB, FC, DB) and UDTs
DB	
• Number range	1 ... 60 999; subdivided into: number range that can be used by the user: 1 ... 59 999, and number range of DBs created via SFC 86: 60 000 ... 60 999
• Size, max.	1 Mbyte; For DBs with absolute addressing, the max. size is 64 KB
FB	
• Number range	0 ... 65 535
• Size, max.	200 kbyte
FC	
• Number range	0 ... 65 535
• Size, max.	200 kbyte
OB	
• Size, max.	200 kbyte
• Number of free cycle OBs	100
• Number of time alarm OBs	20
• Number of delay alarm OBs	20
• Number of cyclic interrupt OBs	20; With minimum OB 3x cycle of 250 µs
• Number of process alarm OBs	50
• Number of DPV1 alarm OBs	3
• Number of isochronous mode OBs	1

Article number	6ES7510-1DK03-0AB0
• Number of technology synchronous alarm OBs	2
• Number of startup OBs	100
• Number of asynchronous error OBs	4
• Number of synchronous error OBs	2
• Number of diagnostic alarm OBs	1
Nesting depth	
• per priority class	24
Counters, timers and their retentivity	
S7 counter	
• Number	2 048
Retentivity	
– adjustable	Yes
IEC counter	
• Number	Any (only limited by the main memory)
Retentivity	
– adjustable	Yes
S7 times	
• Number	2 048
Retentivity	
– adjustable	Yes
IEC timer	
• Number	Any (only limited by the main memory)
Retentivity	
– adjustable	Yes
Data areas and their retentivity	
Retentive data area (incl. timers, counters, flags), max.	256 kbyte; in total; available retentive memory for bit memories, timers, counters, DBs, and technology data (axes): 216 KB
Flag	
• Size, max.	16 kbyte
• Number of clock memories	8; 8 clock memory bit, grouped into one clock memory byte
Data blocks	
• Retentivity adjustable	Yes
• Retentivity preset	No
Local data	
• per priority class, max.	64 kbyte; max. 16 KB per block
Address area	
Number of IO modules	2 048; max. number of modules / submodules

Article number	6ES7510-1DK03-0AB0
I/O address area	
• Inputs	32 kbyte; All inputs are in the process image
• Outputs	32 kbyte; All outputs are in the process image
per integrated IO subsystem	
– Inputs (volume)	8 kbyte
– Outputs (volume)	8 kbyte
per CM/CP	
– Inputs (volume)	8 kbyte
– Outputs (volume)	8 kbyte
Subprocess images	
• Number of subprocess images, max.	32
Address space per module	
• Address space per module, max.	288 byte; For input and output data respectively
Address space per station	
• Address space per station, max.	2 560 byte; for central inputs and outputs; depending on configuration; 2 048 bytes for ET 200SP modules + 512 bytes for ET 200AL modules
Hardware configuration	
Number of distributed IO systems	32; A distributed I/O system is characterized not only by the integration of distributed I/O via PROFINET or PROFIBUS communication modules, but also by the connection of I/O via AS-i master modules or links (e.g. IE/PB-Link)
Number of DP masters	
• Via CM	1
Number of IO Controllers	
• integrated	1
• Via CM	0
Rack	
• Modules per rack, max.	82; CPU + 64 modules + server module (mounting width max. 1 m) + 16 ET 200AL modules
• Quantity of operable ET 200SP modules, max.	64
• Quantity of operable ET 200AL modules, max.	16
• Number of lines, max.	1
PtP CM	
• Number of PtP CMs	the number of connectable PtP CMs is only limited by the number of available slots
Time of day	
Clock	
• Type	Hardware clock

Article number	6ES7510-1DK03-0AB0
• Backup time	6 wk; At 40 °C ambient temperature, typically
• Deviation per day, max.	10 s; Typ.: 2 s
Operating hours counter	
• Number	16
Clock synchronization	
• supported	Yes
• to DP, master	Yes; Via CM DP module
• on DP, device	Yes; Via CM DP module
• in AS, master	Yes
• in AS, device	Yes
• on Ethernet via NTP	Yes
Interfaces	
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1; Via CM DP module
Optical interface	No
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; X1 P3; opt. X1 P1 and X1 P2 via BusAdapter BA 2x RJ45
• Number of ports	3; 1. integr. + 2. via BusAdapter
• integrated switch	Yes
• BusAdapter (PROFINET)	Yes; compatible BusAdapters: BA 2x RJ45, BA 2x M12, BA 2x FC, BA 2x LC, BA LC/RJ45, BA LC/FC, BA 2x SCRJ, BA SCRJ/RJ45, BA SCRJ/FC
Protocols	
• IP protocol	Yes; IPv4
• PROFINET IO Controller	Yes
• PROFINET IO Device	Yes
• SIMATIC communication	Yes
• Open IE communication	Yes; Optionally also encrypted
• Web server	Yes
• Media redundancy	Yes
PROFINET IO Controller	
Services	
– Isochronous mode	Yes
– Direct data exchange	Yes; Requirement: IRT and isochronous mode (MRPD optional)
– IRT	Yes
– PROFIenergy	Yes; per user program
– Prioritized startup	Yes; Max. 32 PROFINET devices

Article number	6ES7510-1DK03-0AB0
– Number of connectable IO Devices, max.	128; In total, up to 512 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
– Of which IO devices with IRT, max.	64
– Number of connectable IO Devices for RT, max.	128
– of which in line, max.	128
– Number of IO Devices that can be simultaneously activated/deactivated, max.	8; in total across all interfaces
– Number of IO Devices per tool, max.	8
– Updating times	The minimum value of the update time also depends on communication share set for PROFINET IO, on the number of IO devices, and on the quantity of configured user data
– PROFINET Security Class	1
Update time for IRT	
– for send cycle of 250 µs	250 µs to 4 ms; Note: In the case of IRT with isochronous mode, the minimum update time of 500 µs of the isochronous OB is decisive
– for send cycle of 500 µs	500 µs to 8 ms
– for send cycle of 1 ms	1 ms to 16 ms
– for send cycle of 2 ms	2 ms to 32 ms
– for send cycle of 4 ms	4 ms to 64 ms
– With IRT and parameterization of "odd" send cycles	Update time = set "odd" send clock (any multiple of 125 µs: 375 µs, 625 µs ... 3 875 µs)
Update time for RT	
– for send cycle of 250 µs	250 µs to 128 ms
– for send cycle of 500 µs	500 µs to 256 ms
– for send cycle of 1 ms	1 ms to 512 ms
– for send cycle of 2 ms	2 ms to 512 ms
– for send cycle of 4 ms	4 ms to 512 ms
PROFINET IO Device	
Services	
– Isochronous mode	No
– IRT	Yes
– PROFIenergy	Yes; per user program
– Shared device	Yes
– Number of IO Controllers with shared device, max.	4
– activation/deactivation of I-devices	Yes; per user program
– Asset management record	Yes; per user program
– PROFINET Security Class	SNMP Configuration and DCP Read Only

Article number	6ES7510-1DK03-0AB0
2. Interface	
Interface types	
• RS 485	Yes; Via CM DP module
• Number of ports	1
Protocols	
• PROFIBUS DP master	Yes
• PROFIBUS DP device	Yes
• SIMATIC communication	Yes
PROFIBUS DP master	
• Number of connections, max.	48; Of which 4 each reserved for ES and HMI
• max. number of DP devices	125; In total, up to 512 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
Services	
– Equidistance	No
– Isochronous mode	No
– activation/deactivation of DP devices	Yes
Interface types	
RJ 45 (Ethernet)	
• 100 Mbps	Yes
• Autonegotiation	Yes
• Autocrossing	Yes
• Industrial Ethernet status LED	Yes
RS 485	
• Transmission rate, max.	12 Mbit/s
Protocols	
PROFIsafe	No
Number of connections	
• Number of connections, max.	128; via integrated interfaces of the CPU and connected CPs / CMs
• Number of connections reserved for ES/HMI/web	10
• Number of connections via integrated interfaces	88
• Number of connections per CP/CM	32
• Number of S7 routing paths	16
Redundancy mode	
• H-Sync forwarding	Yes
Media redundancy	
– Media redundancy	Yes; only via BusAdapter
– MRP	Yes; MRP Automanager according to IEC 62439-2 Edition 2.0, MRP Manager; MRP Client

Article number	6ES7510-1DK03-0AB0
– MRP interconnection, supported	Yes; as MRP ring node according to IEC 62439-2 Edition 3.0
– MRPD	Yes; Requirement: IRT
– Switchover time on line break, typ.	200 ms; For MRP, bumpless for MRPD
– Number of stations in the ring, max.	50
SIMATIC communication	
• PG/OP communication	Yes; encryption with TLS V1.3 pre-selected
• S7 routing	Yes
• Data record routing	Yes
• S7 communication, as server	Yes
• S7 communication, as client	Yes
• User data per job, max.	See online help (S7 communication, user data size)
Open IE communication	
• TCP/IP	Yes
– Data length, max.	64 kbyte
– several passive connections per port, supported	Yes
• ISO-on-TCP (RFC1006)	Yes
– Data length, max.	64 kbyte
• UDP	Yes
– Data length, max.	2 kbyte; 1 472 bytes for UDP broadcast
– UDP multicast	Yes; max. 78 multicast circuits
• DHCP	Yes
• DNS	Yes
• SNMP	Yes
• DCP	Yes
• LLDP	Yes
• Encryption	Yes; Optional
Web server	
• HTTP	Yes; Standard and user pages
• HTTPS	Yes; Standard and user pages
OPC UA	
• Runtime license required	Yes; "Small" license required
• OPC UA Client	Yes; Data Access (registered Read/Write), Method Call
– Application authentication	Yes
– Security policies	Available security policies: None, Basic128Rsa15, Basic256Rsa15, Basic256Sha256
– User authentication	"anonymous" or by user name & password

Article number	6ES7510-1DK03-0AB0
– Number of connections, max.	4
– Number of nodes of the client interfaces, recommended max.	1 000
– Number of elements for one call of OPC_UA_NodeGetHandleList/OPC_UA_ReadList/OPC_UA_WriteList, max.	300
– Number of elements for one call of OPC_UA_NameSpaceGetIndexList, max.	20
– Number of elements for one call of OPC_UA_MethodGetHandleList, max.	100
– Number of simultaneous calls of the client instructions for session management, per connection, max.	1
– Number of simultaneous calls of the client instructions for data access, per connection, max.	5
– Number of registerable nodes, max.	5 000
– Number of registerable method calls of OPC_UA_MethodCall, max.	100
– Number of inputs/outputs when calling OPC_UA_MethodCall, max.	20
• OPC UA Server	Yes
– Application authentication	Yes
– Security policies	available security policies: None, Basic128Rsa15, Basic256Rsa15, Basic256Sha256, Aes128Sha256RsaOaep, Aes256Sha256RsaPss
– User authentication	"anonymous" or by user name & password
– GDS support (certificate management)	Yes
– Number of sessions, max.	32
– Number of accessible variables, max.	50 000
– Number of registerable nodes, max.	10 000
– Number of subscriptions per session, max.	50
– Sampling interval, min.	100 ms
– Publishing interval, min.	200 ms
– Number of server methods, max.	20
– Number of inputs/outputs per server method, max.	20
– Number of monitored items, recommended max.	4 000; for 1 s sampling interval and 1 s send interval
– Number of server interfaces, max.	10 of each "Server interfaces" / "Companion specification" type and 20 of the type "Reference namespace"

Article number	6ES7510-1DK03-0AB0
– Number of nodes for user-defined server interfaces, max.	15 000
• Alarms and Conditions	Yes
– Number of program alarms	100
– Number of alarms for system diagnostics	50
Further protocols	
• MODBUS	Yes; MODBUS TCP
S7 message functions	
Number of login stations for message functions, max.	32
number of subscriptions, max.	250
number of tags/attributes for subscriptions, max.	2 000
Program alarms	Yes
Number of configurable program messages, max.	5 000; Program messages are generated by the "Program_Alarm" block, ProDiag or GRAPH
Number of loadable program messages in RUN, max.	5 000
Test commissioning functions	
Joint commission (Team Engineering)	Yes; Parallel online access possible for up to 5 engineering systems
Status block	Yes; Up to 8 simultaneously (in total across all ES clients)
Single step	Yes
Number of breakpoints	8
Profiling	Yes
Status/control	
• Status/control variable	Yes
• Variables	Inputs/outputs, memory bits, DBs, distributed I/Os, timers, counters
• Number of variables, max.	
– of which status variables, max.	200; per job
– of which control variables, max.	200; per job
Forcing	
• Forcing	Yes
• Forcing, variables	Peripheral inputs/outputs
• Number of variables, max.	200
Diagnostic buffer	
• present	Yes
• Number of entries, max.	1 000
– of which powerfail-proof	500

Article number	6ES7510-1DK03-0AB0
Traces	
• Number of configurable Traces	4
• Memory size per trace, max.	512 kbyte
Interrupts/diagnostics/status information	
Diagnostics indication LED	
• RUN/STOP LED	Yes
• ERROR LED	Yes
• MAINT LED	Yes
• Monitoring of the supply voltage (PWR-LED)	Yes
• Connection display LINK TX/RX	Yes
Supported technology objects	
Motion Control	Yes; Note: The number of technology objects affects the cycle time of the PLC program; selection guide via the TIA Selection Tool
• Number of available Motion Control resources for technology objects	1 120
• Required Motion Control resources	
– per speed-controlled axis	40
– per positioning axis	80
– per synchronous axis	160
– per external encoder	80
– per output cam	20
– per cam track	160
– per probe	40
• Positioning axis	
– Number of positioning axes at motion control cycle of 4 ms (typical value)	11
– Number of positioning axes at motion control cycle of 8 ms (typical value)	14
Controller	
• PID_Compact	Yes; Universal PID controller with integrated optimization
• PID_3Step	Yes; PID controller with integrated optimization for valves
• PID-Temp	Yes; PID controller with integrated optimization for temperature
Counting and measuring	
• High-speed counter	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation

Article number	6ES7510-1DK03-0AB0
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; No condensation
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
configuration / header	
configuration / programming / header	
Programming language	
– LAD	Yes
– FBD	Yes
– STL	Yes
– SCL	Yes
– CFC	Yes
– GRAPH	Yes
Know-how protection	
• User program protection/password protection	Yes
• Copy protection	Yes
• Block protection	Yes
Access protection	
• protection of confidential configuration data	Yes
• Protection level: Write protection	Yes
• Protection level: Read/write protection	Yes
• Protection level: Write protection for Failsafe	No
• Protection level: Complete protection	Yes
• User administration	Yes; device-wide and centralized
• Number of users	100
programming / cycle time monitoring / header	
• lower limit	adjustable minimum cycle time
• upper limit	adjustable maximum cycle time
Dimensions	
Width	100 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	265 g

General technical specifications

You can find information on the general technical specifications, such as standards and approvals, electromagnetic compatibility, protection class, etc. in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) System Manual.

Dimension drawing

A

This section contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

Dimension drawing of the CPU 1510SP-1 PN

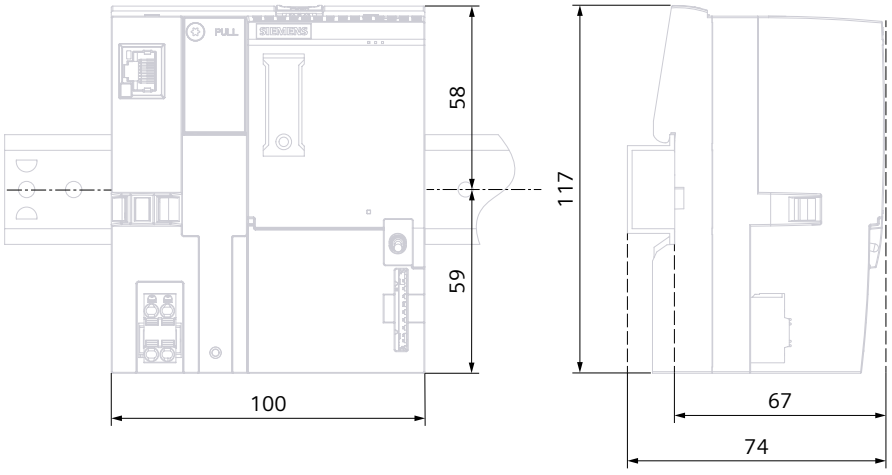

Figure 2-6 Dimensional drawing CPU 1510SP-1 PN

SIEMENS

SIMATIC

ET 200SP
CPU 1512SP-1 PN
(6ES7512-1DM03-0AB0)

Equipment Manual

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Dimension drawing A

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Introduction 1

1.1 Introduction

Purpose of the documentation

This Equipment Manual supplements the ET 200SP Distributed I/O System (https://support.automation.siemens.com/WW/view/en/58649293) System Manual as well as the Function Manuals. This Equipment Manual contains a concise description of the module-specific information. The system-related functions are described in the System Manual. All system-spanning functions are described in the Function Manuals.

The information provided in this Equipment Manual and the System Manual allows you to commission the CPU.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe the notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

ID-Link for the digital nameplate

The ID-Link is a globally unique identifier according to IEC 61406-1, which you will find as a QR code on your product in the future.

The figure shows an example of an ID-Link for the CPU 1512SP-1 PN.

You can recognize the ID-Link by the frame with a black corner at the bottom right. The ID-Link takes you to the digital nameplate of your product.

Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call the ID-Link.

In the digital nameplate, you will find product data, manuals, declarations of conformity, certificates, and other helpful information about your product.

1.2 ET 200SP Documentation Guide

1.2.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet. (https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.2.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293) for general information and measures regarding industrial cybersecurity.

This section provides an overview of security-related information pertaining to your SIEMENS device.

NOTE

Security-relevant changes to software or devices are documented in the section New functions.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

2.3 Cybersecurity-relevant information

Note all cybersecurity-relevant information.

Topics with cybersecurity-relevant information	Reference
Operational application environment and security assumptions	
Requirements for the operational application environment of the system and security assumptions	This section is found in the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Security properties of the product	
Access protection Physical protection: • You can protect the CPU against unauthorized access by locking the front flap. Password protection You can also protect the CPU with a password. Password categories: • Password to protect confidential configuration data • Passwords in the context of user management (UMAC) • Password for display	Information on locking and on password protection can be found in this Equipment Manual in the section Operator controls and display elements (Page 22). Also note the information on the topic of access protection in the Protection section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Integrated protection functions • The CPUs have integrated protection functions.	For information on the protection functions, refer to the "Overview of protection functions" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
PROFINET Security Class 1 • The device supports PROFINET Security Class 1. • With the introduction of PROFINET Security Class 1, additional security settings have been integrated into the PROFINET communication.	Detailed information about PROFINET Security Class 1 and the additional security settings can be found in the PROFINET with STEP 7 Function Manual (https://support.industry.siemens.com/cs/us/en/view/49948856).
Reading out and verifying signatures	You can find detailed information on reading and verifying signatures in the STEP 7 online help (TIA Portal).
Supported Ethernet services	Information about supported services can be found in the section Technical specifications (Page 31). You can find detailed information on the supported Ethernet services in the Communication Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192925).
Interfaces, ports, protocols and services	
Information on the following is security related: • Communications layer and communication role • Default states • Enabling/disabling ports and services	You can find detailed information on these topics in the Communication Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192925).
Secure operation	
Corrective measures for known risks	Corrective measures for known risks are announced on the Siemens ProductCERT (https://siemens.com/productcert) Web page. For more information on SIEMENS ProductCERT, refer to the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).

Topics with cybersecurity-relevant information	Reference
Security checks	Application-specific security measures such as cyclic checks of the configuration via checksums are described in the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Recording Security events	Information on recording security events can be found in the "Safe operation of CPUs" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Secure decommissioning Products that contain security-relevant data must be securely decommissioned before disposal or resale.	Information on secure decommissioning can be found in the "Safe operation of the system" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).

Product overview

3

3.1 New functions

In this chapter, you will find an overview of the most important new firmware features of the CPU compared to the predecessor CPU (V3.1).

New CPU features in firmware version V4.0

New functions	Applications	Customer benefits
Integrated safety		
Retentive memory area for syslog messages	The CPUs store syslog messages retentively as of FW version 4.0.	As a result, events in the syslog memory are retained even after the CPU is restarted.
Central user management	System-wide, central management of users and user groups outside the TIA Portal via the UMC server.	User management for comprehensive automation solutions with multiple projects, users, and user groups. Users and user groups can work in all projects in which they are activated and for which they have been assigned the appropriate rights. During operation, users can be added to or removed from a group or their passwords can be changed. These changes have no effect on the CPU configuration. It is not necessary to restart the CPU.
Programming of the CPU		
SIMATIC Controller Profiling	With SIMATIC Controller Profiling, you can analyze and evaluate the runtime behavior of your user program on a SIMATIC CPU.	With the new "Profiling" instruction, you can start or stop the profiling of a CPU from FW version V4.0. When starting the profiling, specify the configuration with which the profiling data is to be recorded.
Increasing the nesting depth	For CPUs as of FW version V4.0, the nesting depth has been extended for the following elements: • PLC data types • Tags of the STRUCT data type • Tags of the ARRAY of STRUCT/ARRAY of UDT data type	Previously, the maximum nesting depth was eight elements. You can now nest up to 26 elements inside each other. An ARRAY of STRUCT/UDT requires three hierarchy levels in each case. If you use these data types, the maximum nesting depth is reduced accordingly.
Communication of the CPU		
New function for OPC UA	Enables cross-vendor communication.	You can find more information in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

New functions	Applications	Customer benefits
Configuring SNMP and DCP	As of STEP 7 V20, you can centrally configure the SNMP settings for an entire PROFINET IO system. IO devices that support the SNMP automatically synchronize the SNMP settings of the PROFINET interface of your higher-lever IO controller. If IO controllers and IO devices support the DCP protocol, the write-protected mode is activated by default for DCP.	Easier configuration of the SNMP settings through central default at the CPU for the connected PROFINET IO system.
Web server of the CPU		
System web pages	Introduction of the system web pages with new design and functionality for: • Overview • Diagnostics • User program • Messages and DataLogs • Maintenance	• User interface with modern design • Intuitive and convenient operation • Flexible change management • Interaction with user-defined web applications with reference to Web API sessions
New Web API methods	The Web API has been expanded to include the following functions: • Reading out basic information from the CPU • Reading out API session information • Reading out technology objects and their values • Configuring the HTTP response header • Additional options for configuring web applications	The extended functional scope of the Web API offers more accessibility options. Furthermore, access to the web server via HMI Unified Panels is extended through the HTTP header configurations.
Technology functions of the CPU		
Axis functions	Defining the motion transition	Extended functional scope
	Stopping the basic motion	
Trace functionality of the CPU		
Named value data types in traces	"Named values" are values that are assigned a unique name. In the TIA Portal, you declare named values within "named value data types". They contain a set of values to which a unique set of names is assigned.	Named values are easily referenced throughout the program and enhance the readability and maintainability of the program. This makes it easy to monitor/analyze the named value data types in the trace, for example.
Recording as a binary file for long-term traces and long-term project traces	Recording as binary file instead of a CSV file and saving in a DAT file.	This makes it possible to monitor/analyze long-term traces and long-term project traces directly in the TIA Portal.
Acquiring events from technology objects in the trace recording	Detecting events in the trace recording which occur at a motion control technology object as of V9.0 during recording.	Monitoring/analyzing of the correct sequence and parameterization of motion control jobs in complex applications.
Cross-project trace	Recording of values from multiple projects with a PN/PN coupler.	Monitoring/analyzing of signals and events from multiple projects.

New functions of the CPU in firmware version V3.1

New functions	Applications	Customer benefits
Integrated safety		
Syslog messages	The CPU stores syslog messages in a local cache (temporary memory). The messages can be forwarded to a syslog server.	The syslog server saves all syslog messages from its connected devices. The messages can be displayed on the interface of the server and potential security risks can be identified.
Local user management	As of TIA Portal version V19 and FW version V3.1, the CPUs feature improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC). Starting with the above mentioned version, you can manage all project users with their rights (e.g. access rights) for all CPUs in the project. You can do this in the editor for users and roles in the TIA Portal.	Project users can be managed via the TIA Portal with their rights (for example, access rights) for all CPUs in the project in the editor for users and roles.
Communication of the CPU		
Implementation of PROFINET Security Class 1	As of V19, STEP 7 offers extended configuration options for the SNMP and DCP protocols in order to meet the requirements for PROFINET Security Class 1.	Additional protection of communication within your PROFINET network.
Project-internal shared device/shared I-device	As of STEP7 V19, a shared device/shared I-device together with a maximum of two IO controllers can be created in a single project. Previously, the second IO controller required its own project.	Simpler configuration.
Handling timeouts while exchanging data	When network loads are high, timeouts may occur in PROFINET IO devices during data record communication. Previously, the PROFINET IO communication was reduced by the CPU in this case. As of STEP 7 V19 and FW version V3.1, you can configure the behavior of the respective PROFINET interface.	PROFINET IO communication is maintained even under high grid loads
Web server of the CPU		
New Web API methods	Many new API methods extend your access options to the CPU via the Web API.	Additional applications for the web server
Technology functions of the CPU		
Axis functions	Measuring gearbox for positioning/synchronous axis	Advanced configuration options
	Torque feedforward control for positioning/synchronous axis: The torque feedforward control of the CPU controls the torque required to accelerate the axis, taking into account the motion profile.	Complex motion sequences can be executed faster and more precisely. This leads to a reduction of following errors in acceleration phases.
	Three drive stop modes can be configured for the alarm response "Remove enable".	You can choose between a deceleration ramp, coasting down, and rapid stop.
	Dynamic filter with floating mean value	The new "Floating mean value filter" mode is available for the dynamic filter.

New functions	Applications	Customer benefits
Axis functions	Standstill signal on external encoder	The standstill signal is also available for external encoders. The standstill signal is output when the encoder values are within the defined standstill window.
	Virtual axis	The axis is operated in the virtual mode with improved runtime behavior. The new mode replaces the existing behavior of the virtual axis.
Measuring input functions	Monitoring measuring input	With the "Measuring via monitoring" measuring input type, the measuring input can capture the measured signal of another configured measuring input.
	Cyclic measuring for central measuring input	Cyclic measuring possible without additional technology module
Trace functionality of the CPU		
Live monitoring for the long-term trace	With live monitoring for the long-term trace, you can: • Display and analyze values directly in the graph during recording • Use superimposed measurements for the long-term trace • Synchronize time bases	Improved display and analysis of long-term traces
Long-term project trace	With the long-term project trace, you can record signals of different S7-1500 CPUs simultaneously. The CPUs must be configured in a network. The recording is stored on a drive that you have configured.	Extended functional scope

Reference

You can find an overview of all new functions, improvements and revisions in the respective firmware versions on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109478459).

3.2 Hardware properties

Article number

6ES7512-1DM03-0AB0

View of the module

The figure below shows the CPU 1512SP-1PN.

Figure 2-7 CPU 1512SP-1 PN

Properties

The CPU 1512SP-1 PN has the following technical properties:

Property	Description	Additional information
Supply voltage	The 24 V DC supply voltage is fed via a 4-pin connection plug located at the bottom left on the front panel of the CPU.	• Section Connecting (Page 24) • ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649-293)
Standalone CPU	You can also use the CPU 1512SP-1 PN in the distributed I/O system ET 200SP as a "central system" without a higher-level controller.	

Property	Description	Additional information
PROFINET IO		
PROFINET interface (X1)	The interface has an integrated 3-port switch. Port 1 and port 2 are located on the optionally pluggable BusAdapter. Port 3 is integrated in the housing of the CPU. You can connect the PROFINET IO to the CPU via the BusAdapter. You will find information on the BusAdapters supported by the CPU in the Connecting (Page 24) section. In addition to PROFINET basic functionality, the interface also supports PROFINET IO RT (real-time) and IRT (isochronous real-time). PROFINET IO communication or real-time settings can be configured. The basic functionality of PROFINET supports HMI communication, communication with the configuration system, communication with a higher-level network (backbone, router, Internet) and communication with another machine or automation cell. Port 1 and port 2 can also be used as ring ports for the configuration of redundant ring structures in Ethernet.	• PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948-856) • ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649-293)
Operation of the CPU as • IO controller • I-device	• **IO controller:** As an IO controller, the CPU addresses the connected IO devices • **I-device:** As an I-device (intelligent IO device), the CPU is assigned to a higher-level IO controller and is used in the process as an intelligent pre-processing unit of sub-processes	
PROFIBUS DP		
DP master	To use the ET 200SP CPU as a DP master, you need the CPU and the optional communication module CM DP (PROFIBUS interface X2). When used as a DP master, the ET 200SP CPU exchanges data with the connected DP devices via PROFIBUS DP.	• PROFIBUS Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193-579) • Communication module CM DP Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/90156-526)
Intelligent DP device (I-DP device)	To use the ET 200SP CPU as an intelligent DP device (I-DP device), you need the CPU and the optional CM DP communications module (PROFIBUS interface X2). As an intelligent DP device, the ET 200SP CPU is connected via PROFIBUS DP to a higher-level DP master and exchanges data with it.	

Accessories

You can find information on the topic of "Accessories/spare parts" in the Distributed I/O system ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

NOTE

The CPU is delivered without a BusAdapter. You can find an overview of supported BusAdapters in the "Connecting (Page 24)" section. You can find the article numbers of the BusAdapters in the ET 200SP BusAdapter (https://support.industry.siemens.com/cs/us/en/view/109751716) Equipment Manual.

NOTE

You must provide covers for unused BusAdapter interfaces. You can find the article numbers of the covers in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual, in the "Accessories/spare parts" section.

3.3 Firmware functions

Functions

The CPU supports the following functions:

Function	Description	Additional information
Integrated system diagnostics	The system automatically generates the messages for the system diagnostics and outputs these messages via a programming device/PC, HMI device, the web server or the integrated display. System diagnostics information is also available when the CPU is in STOP mode.	Diagnostics Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192926)
Integrated web server	The web server lets you access the CPU data by means of a network. Evaluations, diagnostics, and modifications are thus possible over long distances. Monitoring and evaluation is possible without STEP 7; all you need is a web browser. Make sure that you take appropriate measures (e.g. limiting network access, using firewalls) to protect the CPU from being compromised.	• Web server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193560) • Security with SIMATIC S7 controllers System Manual (https://support.industry.siemens.com/cs/ww/en/view/90885010)
Integrated trace functionality	Trace functionality supports you in troubleshooting and/or optimizing the user program. You can record device tags and evaluate the recordings with the trace and logic analyzer function. Tags are, for example, drive parameters or system and user tags of a CPU. The device saves the recordings. You can read out and permanently save the recordings with the configuration system (ES), if required. The trace and logic analyzer function is therefore suitable for monitoring highly dynamic processes. The trace record can also be displayed through the web server.	Using the trace and logic analyzer function Function Manual (https://support.industry.siemens.com/cs/ww/en/view/64897128)

Function	Description	Additional information
	With the project trace, you can record the variables of multiple devices within a project, for example, a controller and a drive. With the long-term trace, you can record up to 64 different tags for each cycle in a .csv file over a long period (e.g. hours, days).	
OPC UA	With OPC UA, you can exchange data via an open and manufacturer-neutral communication protocol. The CPU can act as OPC UA server. The CPU acting as the OPC UA server can communicate with OPC UA clients. In turn, as an OPC UA client, the CPU can access an OPC UA server, allow the OPC UA server to run methods and read out information from the OPC UA server. The OPC UA Companion Specification allows methods to be specified uniformly and independently of the manufacturer. Using these specified methods, you can easily integrate devices from various manufacturers into your plants and production processes.	Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925)
Configuration control	You can use configuration control to operate different real hardware configurations with a configured maximum configuration of the hardware. Especially in series machine manufacturing, this means you have the option of operating/configuring different configuration variants of a machine with a single project.	ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)
PROFINET IO		
RT (real time)	RT prioritizes PROFINET IO telegrams over standard telegrams. This ensures the required determinism in the automation technology. In this process the data is transferred via prioritized Ethernet telegrams.	PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856)
IRT (isochronous real time)	A reserved bandwidth within the send clock is available for IRT data. The reserved bandwidth ensures that the IRT data can be transmitted in time-synchronized intervals, unaffected by other high network loading (e.g. TCP/IP communication or additional real time communication). Update times with maximum determinism can be realized through IRT. Isochronous applications are possible with IRT.	
Isochronous mode	The Isochronous mode system property acquires measured values and process data and processes the signals in a fixed system clock. Isochronous mode thus contributes to high control quality and hence to greater manufacturing precision. Isochronous mode reduces possible fluctuations of the process reaction times to a minimum. Time-assured processing makes higher machine cycles possible.	
MRP (Media Redundancy Protocol)	It is possible to establish redundant networks via the Media Redundancy Protocol. Redundant transmission links (ring topology) ensure that an alternative communication path is made available if a transmission link fails. The PROFINET devices that are part of this redundant network form an MRP domain. RT operation is possible with the use of MRP.	

Function	Description	Additional information
MRPD (Media Redundancy with Planned Duplication)	The advantage of the MRP extension MRPD is that, in the event of a failure of a device or a line in the ring, all other devices continue to be supplied with IO data without interruption and with short update times. MRPD is based on IRT and MRP. To realize media redundancy with short update times, the PROFINET devices participating in the ring send their data in both directions. The devices receive this data at both ring ports so that there is no reconfiguration time.	PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856)
Shared device	The "Shared device" function allows you to divide the modules or submodules of an IO device up among different IO controllers. Numerous IO controllers are often used in larger or widely distributed systems. Without the "Shared device" function, each I/O module of an IO device is assigned to the same IO controller. Therefore, if sensors in close proximity to each other need to provide data to different IO controllers, multiple IO devices are required. The "Shared device" function allows the modules or submodules of an IO device to be divided up among different IO controllers, thus allowing flexible automation concepts. You can, for example, combine I/O modules that are physically close to each other in one IO device.	
PROFIenergy	PROFIenergy is a PROFINET-based data interface for switching off consumers centrally and with full coordination during pause times regardless of the manufacturer or device type. The goal is that the process is only provided with the energy that is absolutely required. The majority of the energy is saved by the process; the PROFINET device itself only contributes a few watts of savings potential.	
Integrated technology		
Motion Control	The CPUs support the S7-1500 Motion Control functions via the technology objects speed axes, positioning axes, synchronized axes, external encoders, cams, cam tracks, and measuring inputs. • Speed-controlled axis for controlling a drive with speed specification • Positioning axis for position-controlled positioning of a drive • Synchronous axis to interconnect with a master value. The axis is synchronized to the master axis position. • External encoder for detecting the actual position of an encoder and its use as a master value for synchronous operation • Cams, cam track for position-dependent generation of switching signals • Measuring input for fast, accurate, and event-dependent sensing of actual positions You program the technology objects with Motion Control instructions according to PLCopen.	Motion Control topic page (https://support.industry.siemens.com/cs/ww/en/view/109751049)

Function	Description	Additional information
Integrated closed-loop control functionality	• PID Compact (continuous PID controller) • PID 3Step (step controller for integrating actuators) • PID Temp (temperature controller for heating and cooling with two separate actuators)	PID control Function Manual (https://support.industry.siemens.com/cs/ww/en/view/108210036)
Integrated safety		
Know-how protection	The know-how protection protects user blocks against unauthorized access and modifications.	ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)
Copy protection	Copy protection links user blocks to the serial number of the SIMATIC Memory Card or to the serial number of the CPU. User programs cannot run without the corresponding SIMATIC Memory Card or CPU.	
Local user management (as of FW version V3.1)	Improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC). You can used the local user management in the editor to manage all project users along with their rights (e.g. access rights) for users and roles of the project in the TIA Portal.	
Access protection (up to FW version V3.0)	You can use authorization levels to assign separate rights to different user groups.	
Integrity protection	The CPUs feature an integrity protection function by default. This helps to detect any manipulation of the engineering data on the SIMATIC Memory Card or during data transfer between the TIA Portal and the CPU, and to check communication from a SIMATIC HMI system to the CPU for possible manipulation of engineering data. The user receives a corresponding message about manipulation of engineering data detected by the integrity protection.	
Password provider	As an alternative to manual password input you can connect a password provider to STEP 7. A password provider offers the following advantages: • Convenient handling of passwords. STEP 7 reads the password automatically for the blocks. This saves you time. • Optimum block protection because the users do not know the password itself.	

3.4 Operating and display elements

3.4.1 Front view of the module

The figure shows the CPU 1512SP-1 PN.

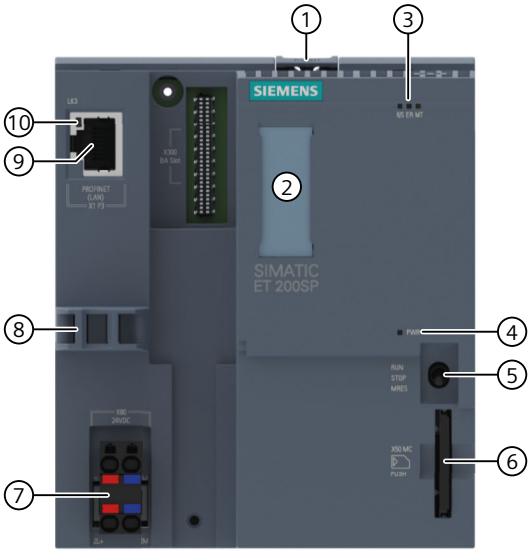

① Mounting rail release
② Labeling strips
③ LEDs for status and error displays
④ LED for display of the supply voltage
⑤ Mode switch
⑥ Slot for the SIMATIC Memory Card
⑦ Connection for supply voltage (included in scope of supply)
⑧ Cable support and attachment for port P3 of the PROFINET interface
⑨ Port P3 of the PROFINET interface X1
⑩ LEDs for status displays of the PROFINET interface X1

Figure 2-8 Front view without BusAdapter

Front view with BusAdapter

The figure on the left shows the CPU 1512SP-1 PN including a plugged BA 2xRJ45 BusAdapter. The BusAdapter is not included in scope of supply. The figure on the right shows a separate view of the BA 2xRJ45 BusAdapter.

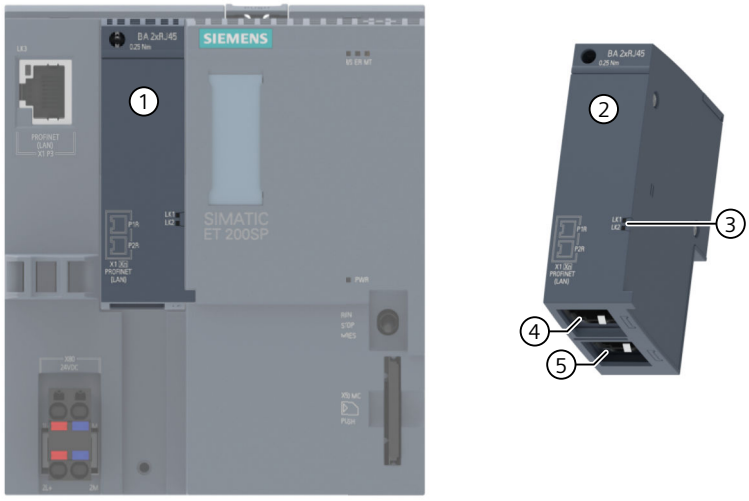

① BusAdapter BA 2xRJ45

② Separate view of the BusAdapter

③ LEDs for status displays of the PROFINET interface: LK1 and LK2 on BusAdapter

④ Port P1R of the PROFINET interface: RJ45 socket on BusAdapter BA 2×RJ45
R: Ring port for configuring a ring topology with media redundancy

⑤ Port P2R of the PROFINET interface: RJ45 socket on BusAdapter BA 2×RJ45
R: Ring port for configuring a ring topology with media redundancy

Figure 2-9 Front view of the CPU 1512SP-1 PN with BA 2xRJ45 BusAdapter

3.5 Mode switch

Use the mode switch to set the CPU operating mode.

The following table shows the position of the switch and the corresponding meaning.

Table 2-6 Mode switch settings

Position	Meaning	Explanation
RUN	RUN mode	The CPU can process the user program.
STOP	STOP mode	The user program is not being executed.
MRES	Memory reset	Position for CPU memory reset.

Wiring

4

This section provides information on the pin assignment of the individual interfaces and the block diagram of the CPU 1512SP-1 PN.

24 V DC supply voltage (X80)

The connector for the supply voltage is plugged in when the CPU ships from the factory.

The following table shows the signal names and the descriptions of the pin assignment of the 24 V DC supply voltage.

Table 2-7 Pin assignment 24 V DC supply voltage

View Connector	Signal name [1]		Description
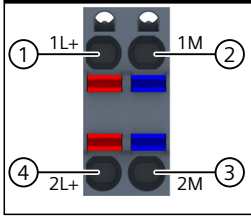	1	1L+	+ 24 V DC of the supply voltage
	2	1M	Ground of the supply voltage
	3	2M	Ground of the supply voltage for loop-through [2]
	4	2L+	+ 24 V DC of the supply voltage for loop-through [2]

[1] 1L+ and 2L+ as well as 1M and 2M are bridged internally

[2] Maximum 10 A permitted

PROFINET IO interface on the CPU (X1 P3)

The assignment corresponds to the Ethernet standard for an RJ45 connector.

- When autonegotiation is deactivated, the RJ45 socket is allocated as a switch (MDI-X).
- If autonegotiation is activated, then autocrossing is active and the RJ45 socket has either a device assignment (MDI) or switch assignment (MDI-X).

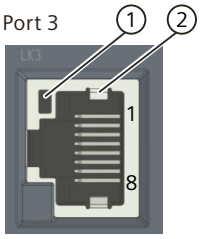

① LINK LED for port P3 (green LED on CPU)

② Shielding

BusAdapter

The following BusAdapters can be selected for use with the CPU 1512SP-1 PN :

- BusAdapter BA 2×RJ45
- BusAdapter BA SCRJ/RJ45
- BusAdapter BA LC/RJ45
- BusAdapter BA 2×FC
- BusAdapter BA 2xSCRJ
- BusAdapter BA SCRJ/FC
- BusAdapter BA 2xLC
- BusAdapter BA LC/FC
- BusAdapter BA 2xM12

For more information on the various BusAdapters, please refer to the SIMATIC ET 200SP BusAdapter (https://support.industry.siemens.com/cs/us/en/view/109751716) Equipment Manual.

Reference

You can find more information on the topics of "Connecting the CPU" and "Accessories/spare parts" in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) System Manual.

Assignment of the MAC addresses

The MAC address is a globally unique device identifier that is assigned to each PROFINET device in the factory. Its 6 bytes are divided into 3 bytes for the manufacturer ID and 3 bytes for the device ID (serial number). The front of the CPU 1512SP-1 PN is lasered with the MAC address of the PROFINET interface.

The PROFINET interface X1 of the CPU 1512SP-1 PN has three ports. Port 3 is located on the CPU. Ports 1 and 2 are located on the optional BusAdapter. In addition to the PROFINET interface, each PROFINET port also has a separate MAC address. There is therefore a total of four MAC addresses for the CPU 1512SP-1 PN.

The MAC addresses of the PROFINET ports are needed for the LLDP protocol, for example for the neighborhood discovery function.

The table below shows how the MAC addresses are assigned.

Table 2-8 Assignment of the MAC addresses

	Assignment
MAC address 1	PROFINET interface X1 • Visible in STEP 7 for accessible devices • Lasered on the front of the CPU (start of the number range)
MAC address 2	Port X1 P1R (required for LLDP, for example)
MAC address 3	Port X1 P2R (required for LLDP, for example)
MAC address 4	Port X1 P3 (required for LLDP, for example)

Block diagram

The following figure shows the block diagram of the CPU 1512SP-1 PN.

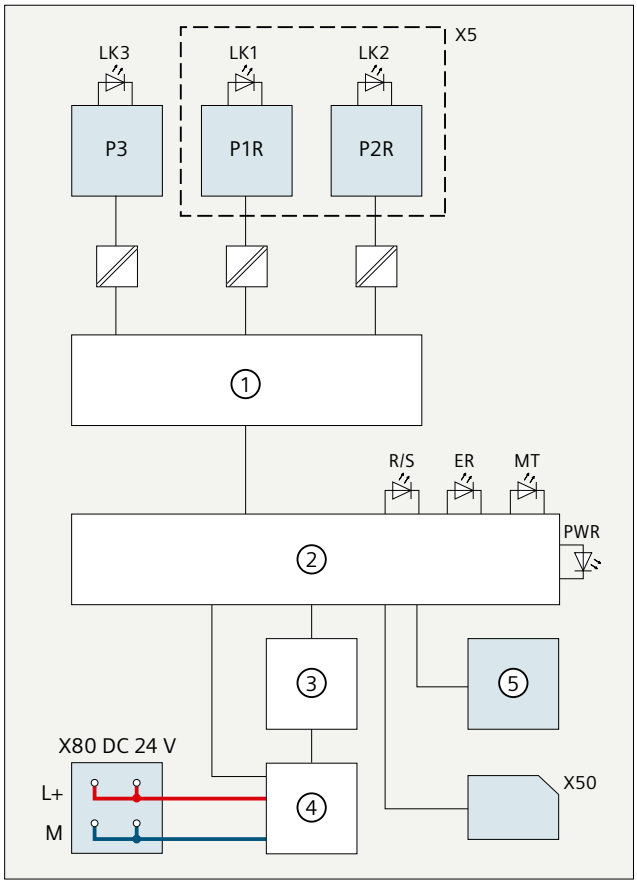

①	PROFINET switch	P1R	PROFINET interface X1 Port 1
②	Electronics	P2R	PROFINET interface X1 Port 2
③	Backplane bus interface	P3	PROFINET interface X1 Port 3
④	Internal supply voltage	L+	24 V DC supply voltage
⑤	RUN/STOP/MRES mode selector	M	Ground

X5	BusAdapter	LK1, 2, 3	LED Link TX/RX (green)
X50	SIMATIC Memory Card	R/S	RUN/STOP LED (green/yellow)
X80 24 V DC	Infeed of supply voltage	ER	ERROR LED (red)
		MT	MAINT LED (yellow)
		PWR	POWER LED (green)

Figure 2-10 Block diagram of the CPU 1512SP-1 PN

Interrupts, error messages, diagnostics and system alarms

5

The status and error displays of the CPU 1512SP-1 PN are described below.

You will find additional information on "Interrupts" in the STEP 7 online help.

You can find additional information on the topics of "Diagnostics" and "System alarms" in the Diagnostics (https://support.automation.siemens.com/WW/view/en/59192926) function manual.

5.1 Status and error display of the CPU

LED displays

The figure below shows the LED displays of the CPU 1512SP-1 PN and the BA 2xRJ45 BusAdapter.

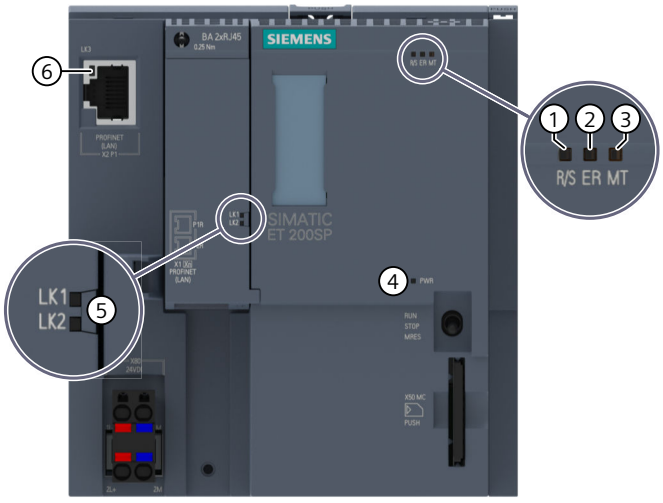

① RUN/STOP LED (green/yellow LED)

② ERROR LED (red LED)

③ MAINT LED (yellow LED)

④ POWER LED (green LED)

⑤ LINK RX/TX-LED for the ports X1 P1 and X1 P2 (green LEDs on the BusAdapter)

⑥ LINK RX/TX LED for port X1 P3 (green LED on the CPU)

Figure 2-11 LED displays on the CPU and BusAdapter

Meaning of the POWER, RUN/STOP, ERROR and MAINT LEDs

CPU 1512SP-1 PN features an LED for monitoring the supply voltage of the electronics (PWR) and three LEDs for displaying the current operating and diagnostics status. The following table shows the meaning of the various combinations of colors for the POWER, RUN/STOP, ERROR and MAINT LEDs.

Table 2-9 Meaning of the LEDs

POWER LED	RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	LED off	Missing or insufficient supply voltage on the CPU.
LED lit green	LED off	LED flashes red	LED off	An error has occurred.
LED lit green	LED lit green	LED off	LED off	CPU is in RUN mode.
LED lit green	LED lit green	LED off	LED lit yellow	Maintenance demanded for the plant. You need to check/replace the affected hardware within a short period of time.
				Active Force job.
				OPC UA server of the CPU expects initial trust lists and CRLs via GDS Push function.
LED lit green	LED lit green	LED flashes red	LED off	A diagnostics event is pending. The CPU is in RUN mode.
LED lit green	LED lit yellow	LED flashes red	LED off	A diagnostics event is pending. The CPU is in STOP mode.
LED lit green	LED lit yellow	LED off	LED flashes yellow	Firmware update using SIMATIC Memory Card successfully completed.
LED lit green	LED lit yellow	LED off	LED off	CPU is in STOP mode.
				CPU runs a program with active breakpoints. The program is at a breakpoint.
LED lit green	LED lit yellow	LED flashes red	LED flashes yellow	The program on the SIMATIC Memory Card is causing an error.
				Firmware update using SIMATIC Memory Card failed.
				The CPU has detected an error state. Additional information is available via the CPU diagnostic buffer.
LED lit green	LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. startup after STOP.
				Download of the user program from the SIMATIC Memory Card
				CPU carries out a program with active breakpoint. The program is presently moving from one breakpoint to another.
				Firmware update is being performed.
LED lit green	LED flashes yellow/green	LED off	LED off	Startup (transition from STOP → RUN)

POWER LED	RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED lit green	LED flashes yellow/green	LED flashes red	LED flashes yellow	Startup (CPU booting)
				LED testing during startup.
				Flash LEDs

Meaning of the LINK LED

Each port has a LINK LED (LK1, LK2, LK3). The table below shows the various "LED scenarios" of ports for the CPU 1512SP-1 PN.

Table 2-10 Meaning of the LEDs

LINK LED	Meaning
LED off	There is no Ethernet connection between the PROFINET interface of the PROFINET device and the communication partner. No data is currently being sent/received via the PROFINET interface. There is no LINK connection.
LED flashes green	The CPU is performing an "LED flash test".
LED lit green	There is an Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner.

NOTE

"LED" instruction

You can read the status (e.g. "On" or "Off") of LEDs of a CPU or a module using the "LED" instruction. Note, however, that it is not possible to read the LED status of the LINK RX/TX LEDs on all S7-1500 CPUs.

You can find additional information on the "LED" instruction in the STEP 7 online help.

Technical specifications

6

The following table shows the technical specifications as of 11/2024. You can find a data sheet with the latest technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7512-1DM03-0AB0/td?dl=en).

Article number	6ES7512-1DM03-0AB0
General information	
Product type designation	CPU 1512SP-1 PN
HW functional status	FS03
Firmware version	V4.0
• FW update possible	Yes
Product function	
• I&M data	Yes; I&M0 to I&M3
• Module swapping during operation (hot swapping)	Yes; Multi-hot swapping
• Isochronous mode	Yes; only with PROFINET; with minimum OB 6x cycle of 500 µs
• SysLog	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V20 (FW V4.0) / V18 (FW V3.0) or higher; configurable with older TIA Portal versions as 6ES7 512-1DK01-0AB0
Configuration control	
via dataset	Yes
Control elements	
Mode selector switch	1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	10 ms
Input current	
Current consumption (rated value)	0.48 A
Current consumption, max.	0.7 A
Inrush current, max.	1.34 A; Rated value
I^2t	0.3 $A^2 \cdot s$
Power	
Infeed power to the backplane bus	8.05 W

Article number	6ES7512-1DM03-0AB0
Power loss	
Power loss, typ.	3.5 W
Memory	
Number of slots for SIMATIC memory card	1
SIMATIC memory card required	Yes
Work memory	
• integrated (for program)	400 kbyte
• integrated (for data)	2 Mbyte
Load memory	
• Plug-in (SIMATIC Memory Card), max.	32 Gbyte
Backup	
• maintenance-free	Yes
CPU processing times	
for bit operations, typ.	6 ns
for word operations, typ.	7 ns
for fixed point arithmetic, typ.	9 ns
for floating point arithmetic, typ.	37 ns
CPU-blocks	
Number of elements (total)	4 000; Blocks (OB, FB, FC, DB) and UDTs
DB	
• Number range	1 ... 60 999; subdivided into: number range that can be used by the user: 1 ... 59 999, and number range of DBs created via SFC 86: 60 000 ... 60 999
• Size, max.	1 Mbyte; For DBs with absolute addressing, the max. size is 64 KB
FB	
• Number range	0 ... 65 535
• Size, max.	400 kbyte
FC	
• Number range	0 ... 65 535
• Size, max.	400 kbyte
OB	
• Size, max.	400 kbyte
• Number of free cycle OBs	100
• Number of time alarm OBs	20
• Number of delay alarm OBs	20
• Number of cyclic interrupt OBs	20; With minimum OB 3x cycle of 250 µs
• Number of process alarm OBs	50
• Number of DPV1 alarm OBs	3
• Number of isochronous mode OBs	1

Article number	6ES7512-1DM03-0AB0
• Number of technology synchronous alarm OBs	2
• Number of startup OBs	100
• Number of asynchronous error OBs	4
• Number of synchronous error OBs	2
• Number of diagnostic alarm OBs	1
Nesting depth	
• per priority class	24
Counters, timers and their retentivity	
S7 counter	
• Number	2 048
Retentivity	
– adjustable	Yes
IEC counter	
• Number	Any (only limited by the main memory)
Retentivity	
– adjustable	Yes
S7 times	
• Number	2 048
Retentivity	
– adjustable	Yes
IEC timer	
• Number	Any (only limited by the main memory)
Retentivity	
– adjustable	Yes
Data areas and their retentivity	
Retentive data area (incl. timers, counters, flags), max.	256 kbyte; in total; available retentive memory for bit memories, timers, counters, DBs, and technology data (axes): 216 KB
Flag	
• Size, max.	16 kbyte
• Number of clock memories	8; 8 clock memory bit, grouped into one clock memory byte
Data blocks	
• Retentivity adjustable	Yes
• Retentivity preset	No
Local data	
• per priority class, max.	64 kbyte; max. 16 KB per block
Address area	
Number of IO modules	2 048; max. number of modules / submodules

Article number	6ES7512-1DM03-0AB0
I/O address area	
• Inputs	32 kbyte; All inputs are in the process image
• Outputs	32 kbyte; All outputs are in the process image
per integrated IO subsystem	
– Inputs (volume)	8 kbyte
– Outputs (volume)	8 kbyte
per CM/CP	
– Inputs (volume)	8 kbyte
– Outputs (volume)	8 kbyte
Subprocess images	
• Number of subprocess images, max.	32
Address space per module	
• Address space per module, max.	288 byte; For input and output data respectively
Address space per station	
• Address space per station, max.	2 560 byte; for central inputs and outputs; depending on configuration; 2 048 bytes for ET 200SP modules + 512 bytes for ET 200AL modules
Hardware configuration	
Number of distributed IO systems	32; A distributed I/O system is characterized not only by the integration of distributed I/O via PROFINET or PROFIBUS communication modules, but also by the connection of I/O via AS-i master modules or links (e.g. IE/PB-Link)
Number of DP masters	
• Via CM	1
Number of IO Controllers	
• integrated	1
• Via CM	0
Rack	
• Modules per rack, max.	82; CPU + 64 modules + server module (mounting width max. 1 m) + 16 ET 200AL modules
• Quantity of operable ET 200SP modules, max.	64
• Quantity of operable ET 200AL modules, max.	16
• Number of lines, max.	1
PtP CM	
• Number of PtP CMs	the number of connectable PtP CMs is only limited by the number of available slots
Time of day	
Clock	
• Type	Hardware clock

Article number	6ES7512-1DM03-0AB0
• Backup time	6 wk; At 40 °C ambient temperature, typically
• Deviation per day, max.	10 s; Typ.: 2 s
Operating hours counter	
• Number	16
Clock synchronization	
• supported	Yes
• to DP, master	Yes; Via CM DP module
• on DP, device	Yes; Via CM DP module
• in AS, master	Yes
• in AS, device	Yes
• on Ethernet via NTP	Yes
Interfaces	
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1; Via CM DP module
Optical interface	No
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; X1 P3; opt. X1 P1 and X1 P2 via BusAdapter BA 2x RJ45
• Number of ports	3; 1. integr. + 2. via BusAdapter
• integrated switch	Yes
• BusAdapter (PROFINET)	Yes; compatible BusAdapters: BA 2x RJ45, BA 2x M12, BA 2x FC, BA 2x LC, BA LC/RJ45, BA LC/FC, BA 2x SCRJ, BA SCRJ/RJ45, BA SCRJ/FC
Protocols	
• IP protocol	Yes; IPv4
• PROFINET IO Controller	Yes
• PROFINET IO Device	Yes
• SIMATIC communication	Yes
• Open IE communication	Yes; Optionally also encrypted
• Web server	Yes
• Media redundancy	Yes
PROFINET IO Controller	
Services	
– Isochronous mode	Yes
– Direct data exchange	Yes; Requirement: IRT and isochronous mode (MRPD optional)
– IRT	Yes
– PROFIenergy	Yes; per user program
– Prioritized startup	Yes; Max. 32 PROFINET devices

Article number	6ES7512-1DM03-0AB0
– Number of connectable IO Devices, max.	128; In total, up to 512 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
– Of which IO devices with IRT, max.	64
– Number of connectable IO Devices for RT, max.	128
– of which in line, max.	128
– Number of IO Devices that can be simultaneously activated/deactivated, max.	8; in total across all interfaces
– Number of IO Devices per tool, max.	8
– Updating times	The minimum value of the update time also depends on communication share set for PROFINET IO, on the number of IO devices, and on the quantity of configured user data
– PROFINET Security Class	1
Update time for IRT	
– for send cycle of 250 µs	250 µs to 4 ms; Note: In the case of IRT with isochronous mode, the minimum update time of 500 µs of the isochronous OB is decisive
– for send cycle of 500 µs	500 µs to 8 ms
– for send cycle of 1 ms	1 ms to 16 ms
– for send cycle of 2 ms	2 ms to 32 ms
– for send cycle of 4 ms	4 ms to 64 ms
– With IRT and parameterization of "odd" send cycles	Update time = set "odd" send clock (any multiple of 125 µs: 375 µs, 625 µs ... 3 875 µs)
Update time for RT	
– for send cycle of 250 µs	250 µs to 128 ms
– for send cycle of 500 µs	500 µs to 256 ms
– for send cycle of 1 ms	1 ms to 512 ms
– for send cycle of 2 ms	2 ms to 512 ms
– for send cycle of 4 ms	4 ms to 512 ms
PROFINET IO Device	
Services	
– Isochronous mode	No
– IRT	Yes
– PROFIenergy	Yes; per user program
– Shared device	Yes
– Number of IO Controllers with shared device, max.	4
– activation/deactivation of I-devices	Yes; per user program
– Asset management record	Yes; per user program
– PROFINET Security Class	SNMP Configuration and DCP Read Only

Article number	6ES7512-1DM03-0AB0
2. Interface	
Interface types	
• RS 485	Yes; Via CM DP module
• Number of ports	1
Protocols	
• PROFIBUS DP master	Yes
• PROFIBUS DP device	Yes
• SIMATIC communication	Yes
PROFIBUS DP master	
• Number of connections, max.	48; Of which 4 each reserved for ES and HMI
• max. number of DP devices	125; In total, up to 512 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
Services	
– Equidistance	No
– Isochronous mode	No
– activation/deactivation of DP devices	Yes
Interface types	
RJ 45 (Ethernet)	
• 100 Mbps	Yes
• Autonegotiation	Yes
• Autocrossing	Yes
• Industrial Ethernet status LED	Yes
RS 485	
• Transmission rate, max.	12 Mbit/s
Protocols	
PROFIsafe	No
Number of connections	
• Number of connections, max.	128; via integrated interfaces of the CPU and connected CPs / CMs
• Number of connections reserved for ES/HMI/web	10
• Number of connections via integrated interfaces	88
• Number of connections per CP/CM	32
• Number of S7 routing paths	16
Redundancy mode	
• H-Sync forwarding	Yes
Media redundancy	
– Media redundancy	Yes; only via BusAdapter
– MRP	Yes; MRP Automanager according to IEC 62439-2 Edition 2.0, MRP Manager; MRP Client

Article number	6ES7512-1DM03-0AB0
– MRP interconnection, supported	Yes; as MRP ring node according to IEC 62439-2 Edition 3.0
– MRPD	Yes; Requirement: IRT
– Switchover time on line break, typ.	200 ms; For MRP, bumpless for MRPD
– Number of stations in the ring, max.	50
SIMATIC communication	
• PG/OP communication	Yes; encryption with TLS V1.3 pre-selected
• S7 routing	Yes
• Data record routing	Yes
• S7 communication, as server	Yes
• S7 communication, as client	Yes
• User data per job, max.	See online help (S7 communication, user data size)
Open IE communication	
• TCP/IP	Yes
– Data length, max.	64 kbyte
– several passive connections per port, supported	Yes
• ISO-on-TCP (RFC1006)	Yes
– Data length, max.	64 kbyte
• UDP	Yes
– Data length, max.	2 kbyte; 1 472 bytes for UDP broadcast
– UDP multicast	Yes; max. 78 multicast circuits
• DHCP	Yes
• DNS	Yes
• SNMP	Yes
• DCP	Yes
• LLDP	Yes
• Encryption	Yes; Optional
Web server	
• HTTP	Yes; Standard and user pages
• HTTPS	Yes; Standard and user pages
OPC UA	
• Runtime license required	Yes; "Small" license required
• OPC UA Client	Yes; Data Access (registered Read/Write), Method Call
– Application authentication	Yes
– Security policies	Available security policies: None, Basic128Rsa15, Basic256Rsa15, Basic256Sha256
– User authentication	"anonymous" or by user name & password

Article number	6ES7512-1DM03-0AB0
– Number of connections, max.	4
– Number of nodes of the client interfaces, recommended max.	1 000
– Number of elements for one call of OPC_UA_NodeGetHandleList/OPC_UA_ReadList/OPC_UA_WriteList, max.	300
– Number of elements for one call of OPC_UA_NameSpaceGetIndexList, max.	20
– Number of elements for one call of OPC_UA_MethodGetHandleList, max.	100
– Number of simultaneous calls of the client instructions for session management, per connection, max.	1
– Number of simultaneous calls of the client instructions for data access, per connection, max.	5
– Number of registerable nodes, max.	5 000
– Number of registerable method calls of OPC_UA_MethodCall, max.	100
– Number of inputs/outputs when calling OPC_UA_MethodCall, max.	20
• OPC UA Server	Yes
– Application authentication	Yes
– Security policies	available security policies: None, Basic128Rsa15, Basic256Rsa15, Basic256Sha256, Aes128Sha256RsaOaep, Aes256Sha256RsaPss
– User authentication	"anonymous" or by user name & password
– GDS support (certificate management)	Yes
– Number of sessions, max.	32
– Number of accessible variables, max.	50 000
– Number of registerable nodes, max.	10 000
– Number of subscriptions per session, max.	50
– Sampling interval, min.	100 ms
– Publishing interval, min.	200 ms
– Number of server methods, max.	20
– Number of inputs/outputs per server method, max.	20
– Number of monitored items, recommended max.	4 000; for 1 s sampling interval and 1 s send interval
– Number of server interfaces, max.	10 of each "Server interfaces" / "Companion specification" type and 20 of the type "Reference namespace"

Article number	6ES7512-1DM03-0AB0
– Number of nodes for user-defined server interfaces, max.	15 000
• Alarms and Conditions	Yes
– Number of program alarms	100
– Number of alarms for system diagnostics	50
Further protocols	
• MODBUS	Yes; MODBUS TCP
S7 message functions	
Number of login stations for message functions, max.	32
number of subscriptions, max.	250
number of tags/attributes for subscriptions, max.	2 000
Program alarms	Yes
Number of configurable program messages, max.	5 000; Program messages are generated by the "Program_Alarm" block, ProDiag or GRAPH
Number of loadable program messages in RUN, max.	5 000
Test commissioning functions	
Joint commission (Team Engineering)	Yes; Parallel online access possible for up to 5 engineering systems
Status block	Yes; Up to 8 simultaneously (in total across all ES clients)
Single step	Yes
Number of breakpoints	8
Profiling	Yes
Status/control	
• Status/control variable	Yes
• Variables	Inputs/outputs, memory bits, DBs, distributed I/Os, timers, counters
• Number of variables, max.	
– of which status variables, max.	200; per job
– of which control variables, max.	200; per job
Forcing	
• Forcing	Yes
• Forcing, variables	Peripheral inputs/outputs
• Number of variables, max.	200
Diagnostic buffer	
• present	Yes
• Number of entries, max.	1 000
– of which powerfail-proof	500

Article number	6ES7512-1DM03-0AB0
Traces	
• Number of configurable Traces	4
• Memory size per trace, max.	512 kbyte
Interrupts/diagnostics/status information	
Diagnostics indication LED	
• RUN/STOP LED	Yes
• ERROR LED	Yes
• MAINT LED	Yes
• Monitoring of the supply voltage (PWR-LED)	Yes
• Connection display LINK TX/RX	Yes
Supported technology objects	
Motion Control	Yes; Note: The number of technology objects affects the cycle time of the PLC program; selection guide via the TIA Selection Tool
• Number of available Motion Control resources for technology objects	1 120
• Required Motion Control resources	
– per speed-controlled axis	40
– per positioning axis	80
– per synchronous axis	160
– per external encoder	80
– per output cam	20
– per cam track	160
– per probe	40
• Positioning axis	
– Number of positioning axes at motion control cycle of 4 ms (typical value)	11
– Number of positioning axes at motion control cycle of 8 ms (typical value)	14
Controller	
• PID_Compact	Yes; Universal PID controller with integrated optimization
• PID_3Step	Yes; PID controller with integrated optimization for valves
• PID-Temp	Yes; PID controller with integrated optimization for temperature
Counting and measuring	
• High-speed counter	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation

Article number	6ES7512-1DM03-0AB0
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; No condensation
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
configuration / header	
configuration / programming / header	
Programming language	
– LAD	Yes
– FBD	Yes
– STL	Yes
– SCL	Yes
– CFC	Yes
– GRAPH	Yes
Know-how protection	
• User program protection/password protection	Yes
• Copy protection	Yes
• Block protection	Yes
Access protection	
• protection of confidential configuration data	Yes
• Protection level: Write protection	Yes
• Protection level: Read/write protection	Yes
• Protection level: Write protection for Failsafe	No
• Protection level: Complete protection	Yes
• User administration	Yes; device-wide and centralized
• Number of users	100
programming / cycle time monitoring / header	
• lower limit	adjustable minimum cycle time
• upper limit	adjustable maximum cycle time
Dimensions	
Width	100 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	265 g

General technical specifications

You can find information on the general technical specifications, such as standards and approvals, electromagnetic compatibility, protection class, etc. in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) System Manual.

Dimension drawing

A

This section contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

Dimension drawing of the CPU 1512SP-1 PN

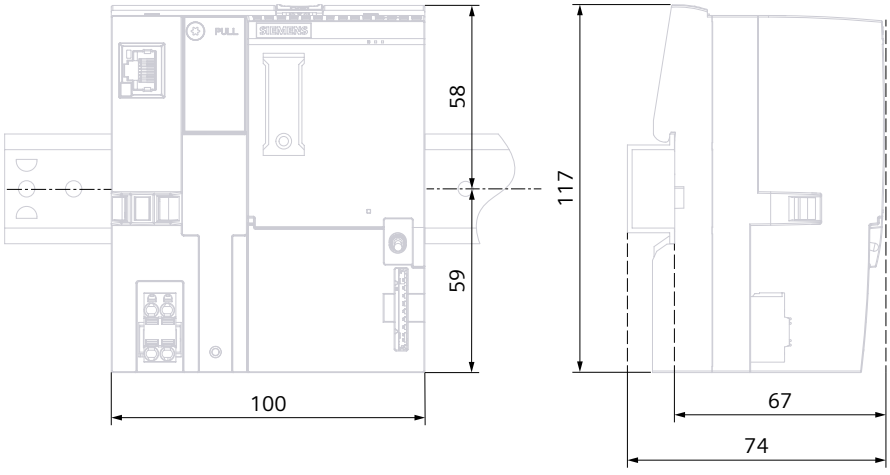

Figure 2-12 Dimension drawing CPU 1512SP-1 PN

SIEMENS

SIMATIC

ET 200SP
CPU 1514SP-2 PN
(6ES7514-2DN03-0AB0)

Equipment Manual

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Interrupts, error messages, diagnostics and system alarms 5

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Dimension drawing A

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Introduction 1

1.1 Introduction

Purpose of the documentation

This Equipment Manual supplements the ET 200SP Distributed I/O System (https://support.automation.siemens.com/WW/view/en/58649293) System Manual as well as the Function Manuals. This Equipment Manual contains a concise description of the module-specific information. The system-related functions are described in the System Manual. All system-spanning functions are described in the Function Manuals.

The information provided in this Equipment Manual and the System Manual allows you to commission the CPU.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe the notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

ID-Link for the digital nameplate

The ID-Link is a globally unique identifier according to IEC 61406-1, which you will find as a QR code on your product in the future.

The figure shows an example of an ID-Link for the CPU 1514SP-2 PN.

You can recognize the ID-Link by the frame with a black corner at the bottom right. The ID-Link takes you to the digital nameplate of your product.

Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call the ID-Link.

In the digital nameplate, you will find product data, manuals, declarations of conformity, certificates, and other helpful information about your product.

1.2 ET 200SP Documentation Guide

1.2.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet. (https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.2.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293) for general information and measures regarding industrial cybersecurity.

This section provides an overview of security-related information pertaining to your SIEMENS device.

NOTE

Security-relevant changes to software or devices are documented in the section New functions.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

2.3 Cybersecurity-relevant information

Note all cybersecurity-relevant information.

Topics with cybersecurity-relevant information	Reference
Operational application environment and security assumptions	
Requirements for the operational application environment of the system and security assumptions	This section is found in the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Security properties of the product	
Access protection Physical protection: • You can protect the CPU against unauthorized access by locking the front flap. Password protection You can also protect the CPU with a password. Password categories: • Password to protect confidential configuration data • Passwords in the context of user management (UMAC) • Password for display	Information on locking and on password protection can be found in this Equipment Manual in the section Operator controls and display elements (Page 22). Also note the information on the topic of access protection in the Protection section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Integrated protection functions • The CPUs have integrated protection functions.	For information on the protection functions, refer to the "Overview of protection functions" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
PROFINET Security Class 1 • The device supports PROFINET Security Class 1. • With the introduction of PROFINET Security Class 1, additional security settings have been integrated into the PROFINET communication.	Detailed information about PROFINET Security Class 1 and the additional security settings can be found in the PROFINET with STEP 7 Function Manual (https://support.industry.siemens.com/cs/us/en/view/49948856).
Reading out and verifying signatures	You can find detailed information on reading and verifying signatures in the STEP 7 online help (TIA Portal).
Supported Ethernet services	Information about supported services can be found in the section Technical specifications (Page 31). You can find detailed information on the supported Ethernet services in the Communication Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192925).
Interfaces, ports, protocols and services	
Information on the following is security related: • Communications layer and communication role • Default states • Enabling/disabling ports and services	You can find detailed information on these topics in the Communication Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192925).
Secure operation	
Corrective measures for known risks	Corrective measures for known risks are announced on the Siemens ProductCERT (https://siemens.com/productcert) Web page. For more information on SIEMENS ProductCERT, refer to the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).

Topics with cybersecurity-relevant information	Reference
Security checks	Application-specific security measures such as cyclic checks of the configuration via checksums are described in the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Recording Security events	Information on recording security events can be found in the "Safe operation of CPUs" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Secure decommissioning Products that contain security-relevant data must be securely decommissioned before disposal or resale.	Information on secure decommissioning can be found in the "Safe operation of the system" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).

Product overview

3

3.1 New functions

In this chapter, you will find an overview of the most important new firmware features of the CPU compared to the predecessor CPU (V3.1).

New CPU features in firmware version V4.0

New functions	Applications	Customer benefits
Integrated safety		
Retentive memory area for syslog messages	The CPUs store syslog messages retentively as of FW version 4.0.	As a result, events in the syslog memory are retained even after the CPU is restarted.
Central user management	System-wide, central management of users and user groups outside the TIA Portal via the UMC server.	User management for comprehensive automation solutions with multiple projects, users, and user groups. Users and user groups can work in all projects in which they are activated and for which they have been assigned the appropriate rights. During operation, users can be added to or removed from a group or their passwords can be changed. These changes have no effect on the CPU configuration. It is not necessary to restart the CPU.
Programming of the CPU		
SIMATIC Controller Profiling	With SIMATIC Controller Profiling, you can analyze and evaluate the runtime behavior of your user program on a SIMATIC CPU.	With the new "Profiling" instruction, you can start or stop the profiling of a CPU from FW version V4.0. When starting the profiling, specify the configuration with which the profiling data is to be recorded.
Increasing the nesting depth	For CPUs as of FW version V4.0, the nesting depth has been extended for the following elements: • PLC data types • Tags of the STRUCT data type • Tags of the ARRAY of STRUCT/ARRAY of UDT data type	Previously, the maximum nesting depth was eight elements. You can now nest up to 26 elements inside each other. An ARRAY of STRUCT/UDT requires three hierarchy levels in each case. If you use these data types, the maximum nesting depth is reduced accordingly.
Communication of the CPU		
New function for OPC UA	Enables cross-vendor communication.	You can find more information in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

New functions	Applications	Customer benefits
Configuring SNMP and DCP	As of STEP 7 V20, you can centrally configure the SNMP settings for an entire PROFINET IO system. IO devices that support the SNMP automatically synchronize the SNMP settings of the PROFINET interface of your higher-lever IO controller. If IO controllers and IO devices support the DCP protocol, the write-protected mode is activated by default for DCP.	Easier configuration of the SNMP settings through central default at the CPU for the connected PROFINET IO system.
Web server of the CPU		
System web pages	Introduction of the system web pages with new design and functionality for: • Overview • Diagnostics • User program • Messages and DataLogs • Maintenance	• User interface with modern design • Intuitive and convenient operation • Flexible change management • Interaction with user-defined web applications with reference to Web API sessions
New Web API methods	The Web API has been expanded to include the following functions: • Reading out basic information from the CPU • Reading out API session information • Reading out technology objects and their values • Configuring the HTTP response header • Additional options for configuring web applications	The extended functional scope of the Web API offers more accessibility options. Furthermore, access to the web server via HMI Unified Panels is extended through the HTTP header configurations.
Technology functions of the CPU		
Axis functions	Defining the motion transition	Extended functional scope
	Stopping the basic motion	
Trace functionality of the CPU		
Named value data types in traces	"Named values" are values that are assigned a unique name. In the TIA Portal, you declare named values within "named value data types". They contain a set of values to which a unique set of names is assigned.	Named values are easily referenced throughout the program and enhance the readability and maintainability of the program. This makes it easy to monitor/analyze the named value data types in the trace, for example.
Recording as a binary file for long-term traces and long-term project traces	Recording as binary file instead of a CSV file and saving in a DAT file.	This makes it possible to monitor/analyze long-term traces and long-term project traces directly in the TIA Portal.
Acquiring events from technology objects in the trace recording	Detecting events in the trace recording which occur at a motion control technology object as of V9.0 during recording.	Monitoring/analyzing of the correct sequence and parameterization of motion control jobs in complex applications.
Cross-project trace	Recording of values from multiple projects with a PN/PN coupler.	Monitoring/analyzing of signals and events from multiple projects.

New functions of the CPU in firmware version V3.1

New functions	Applications	Customer benefits
Integrated safety		
Syslog messages	The CPU stores syslog messages in a local cache (temporary memory). The messages can be forwarded to a syslog server.	The syslog server saves all syslog messages from its connected devices. The messages can be displayed on the interface of the server and potential security risks can be identified.
Local user management	As of TIA Portal version V19 and FW version V3.1, the CPUs feature improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC). Starting with the above mentioned version, you can manage all project users with their rights (e.g. access rights) for all CPUs in the project. You can do this in the editor for users and roles in the TIA Portal.	Project users can be managed via the TIA Portal with their rights (for example, access rights) for all CPUs in the project in the editor for users and roles.
Communication of the CPU		
Implementation of PROFINET Security Class 1	As of V19, STEP 7 offers extended configuration options for the SNMP and DCP protocols in order to meet the requirements for PROFINET Security Class 1.	Additional protection of communication within your PROFINET network.
Project-internal shared device/shared I-device	As of STEP7 V19, a shared device/shared I-device together with a maximum of two IO controllers can be created in a single project. Previously, the second IO controller required its own project.	Simpler configuration.
Handling timeouts while exchanging data	When network loads are high, timeouts may occur in PROFINET IO devices during data record communication. Previously, the PROFINET IO communication was reduced by the CPU in this case. As of STEP 7 V19 and FW version V3.1, you can configure the behavior of the respective PROFINET interface.	PROFINET IO communication is maintained even under high grid loads
Web server of the CPU		
New Web API methods	Many new API methods extend your access options to the CPU via the Web API.	Additional applications for the web server
Technology functions of the CPU		
Axis functions	Measuring gearbox for positioning/synchronous axis	Advanced configuration options
	Torque feedforward control for positioning/synchronous axis: The torque feedforward control of the CPU controls the torque required to accelerate the axis, taking into account the motion profile.	Complex motion sequences can be executed faster and more precisely. This leads to a reduction of following errors in acceleration phases.
	Three drive stop modes can be configured for the alarm response "Remove enable".	You can choose between a deceleration ramp, coasting down, and rapid stop.
	Dynamic filter with floating mean value	The new "Floating mean value filter" mode is available for the dynamic filter.

New functions	Applications	Customer benefits
Axis functions	Standstill signal on external encoder	The standstill signal is also available for external encoders. The standstill signal is output when the encoder values are within the defined standstill window.
	Virtual axis	The axis is operated in the virtual mode with improved runtime behavior. The new mode replaces the existing behavior of the virtual axis.
Measuring input functions	Monitoring measuring input	With the "Measuring via monitoring" measuring input type, the measuring input can capture the measured signal of another configured measuring input.
	Cyclic measuring for central measuring input	Cyclic measuring possible without additional technology module
Trace functionality of the CPU		
Live monitoring for the long-term trace	With live monitoring for the long-term trace, you can: • Display and analyze values directly in the graph during recording • Use superimposed measurements for the long-term trace • Synchronize time bases	Improved display and analysis of long-term traces
Long-term project trace	With the long-term project trace, you can record signals of different S7-1500 CPUs simultaneously. The CPUs must be configured in a network. The recording is stored on a drive that you have configured.	Extended functional scope

Reference

You can find an overview of all new functions, improvements and revisions in the respective firmware versions on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109478459).

3.2 Hardware properties

Article number

6ES7514-2DN03-0AB0

View of the module

The figure below shows the CPU 1514SP-2PN.

Figure 2-13 CPU 1514SP-2 PN

Properties

The CPU 1514SP-2 PN has the following technical properties:

Property	Description	Additional information
Supply voltage	The 24 V DC supply voltage is fed via a 4-pin connection plug located at the bottom left on the front panel of the CPU.	• Section Connecting (Page 24) • ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649-293)
Standalone CPU	You can use the CPU in the distributed I/O system ET 200SP as a "central system" even without a higher-level controller.	

Property	Description	Additional information
PROFINET IO		
Interface X1	PROFINET IO (IRT) interface with 2 ports via bus adapter	• PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948-856) • ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649-293)
Interface X2	Additional PROFINET IO interface (only RT) with an RJ45 port	
Operation of the CPU as • IO controller • I-device	• **IO controller:** As an IO controller, the CPU addresses the connected IO devices • **I-device:** As an I-device (intelligent IO device), the CPU is assigned to a higher-level IO controller and is used in the process as an intelligent pre-processing unit of sub-processes.	
PROFIBUS DP		
DP master	To use the ET 200SP CPU as a DP master, you need the CPU and the optional communication module CM DP (PROFIBUS interface X2). When used as a DP master, the ET 200SP CPU exchanges data with the connected DP devices via PROFIBUS DP.	• PROFIBUS Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193-579) • Communication module CM DP Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/90156-526)
Intelligent DP device (I-DP device)	To use the ET 200SP CPU as an intelligent DP device (I-DP device), you need the CPU and the optional CM DP communications module (PROFIBUS interface X2). As an intelligent DP device, the ET 200SP CPU is connected via PROFIBUS DP to a higher-level DP master and exchanges data with it.	

Accessories

You can find information on the topic of "Accessories/spare parts" in the Distributed I/O system ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

NOTE

The CPU is delivered without a BusAdapter. You can find an overview of supported BusAdapters in the"Connecting (Page 24)" section. You can find the article numbers of the BusAdapters in the ET 200SP BusAdapter (https://support.industry.siemens.com/cs/us/en/view/109751716) Equipment Manual.

NOTE

You must provide covers for unused BusAdapter interfaces. You can find the article numbers of the covers in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual, in the "Accessories/spare parts" section.

3.3 Firmware functions

Functions

The CPU supports the following functions:

Function	Description	Additional information
Integrated system diagnostics	The system automatically generates the messages for the system diagnostics and outputs these messages via a programming device/PC, HMI device, the web server or the integrated display. System diagnostics information is also available when the CPU is in STOP mode.	Diagnostics Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192926)
Integrated web server	The web server lets you access the CPU data by means of a network. Evaluations, diagnostics, and modifications are thus possible over long distances. Monitoring and evaluation is possible without STEP 7; all you need is a web browser. Make sure that you take appropriate measures (e.g. limiting network access, using firewalls) to protect the CPU from being compromised.	• Web server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193560) • Security with SIMATIC S7 controllers System Manual (https://support.industry.siemens.com/cs/ww/en/view/90885010)
Integrated trace functionality	Trace functionality supports you in troubleshooting and/or optimizing the user program. You can record device tags and evaluate the recordings with the trace and logic analyzer function. Tags are, for example, drive parameters or system and user tags of a CPU. The device saves the recordings. You can read out and permanently save the recordings with the configuration system (ES), if required. The trace and logic analyzer function is therefore suitable for monitoring highly dynamic processes. The trace record can also be displayed through the web server. With the project trace, you can record the variables of multiple devices within a project, for example, a controller and a drive. With the long-term trace, you can record up to 64 different tags for each cycle in a .csv file over a long period (e.g. hours, days).	Using the trace and logic analyzer function Function Manual (https://support.industry.siemens.com/cs/ww/en/view/64897128)
OPC UA	With OPC UA, you can exchange data via an open and manufacturer-neutral communication protocol. The CPU can act as OPC UA server. The CPU acting as the OPC UA server can communicate with OPC UA clients. In turn, as an OPC UA client, the CPU can access an OPC UA server, allow the OPC UA server to run methods and read out information from the OPC UA server. The OPC UA Companion Specification allows methods to be specified uniformly and independently of the manufacturer. Using these specified methods, you can easily integrate devices from various manufacturers into your plants and production processes.	Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925)

Function	Description	Additional information
Configuration control	You can use configuration control to operate different real hardware configurations with a configured maximum configuration of the hardware. Especially in series machine manufacturing, this means you have the option of operating/configuring different configuration variants of a machine with a single project.	ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)
PROFINET IO		
RT (real time)	RT prioritizes PROFINET IO telegrams over standard telegrams. This ensures the required determinism in the automation technology. In this process the data is transferred via prioritized Ethernet telegrams.	PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856)
IRT (isochronous real time)	A reserved bandwidth within the send clock is available for IRT data. The reserved bandwidth ensures that the IRT data can be transmitted in time-synchronized intervals, unaffected by other high network loading (e.g. TCP/IP communication or additional real time communication). Update times with maximum determinism can be realized through IRT. Isochronous applications are possible with IRT.	
Isochronous mode	The Isochronous mode system property acquires measured values and process data and processes the signals in a fixed system clock. Isochronous mode thus contributes to high control quality and hence to greater manufacturing precision. Isochronous mode reduces possible fluctuations of the process reaction times to a minimum. Time-assured processing makes higher machine cycles possible.	
MRP (Media Redundancy Protocol)	It is possible to establish redundant networks via the Media Redundancy Protocol. Redundant transmission links (ring topology) ensure that an alternative communication path is made available if a transmission link fails. The PROFINET devices that are part of this redundant network form an MRP domain. RT operation is possible with the use of MRP.	
MRPD (Media Redundancy with Planned Duplication)	The advantage of the MRP extension MRPD is that, in the event of a failure of a device or a line in the ring, all other devices continue to be supplied with IO data without interruption and with short update times. MRPD is based on IRT and MRP. To realize media redundancy with short update times, the PROFINET devices participating in the ring send their data in both directions. The devices receive this data at both ring ports so that there is no reconfiguration time.	
Shared device	The "Shared device" function allows you to divide the modules or submodules of an IO device up among different IO controllers. Numerous IO controllers are often used in larger or widely distributed systems. Without the "Shared device" function, each I/O module of an IO device is assigned to the same IO controller. Therefore, if sensors in close proximity to each other need to provide data to different IO controllers, multiple IO devices are required. The "Shared device" function allows the modules or submodules of an IO device to be divided up among different IO controllers, thus allowing flexible	

Function	Description	Additional information
	automation concepts. You can, for example, combine I/O modules that are physically close to each other in one IO device.	PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856)
PROFIenergy	PROFIenergy is a PROFINET-based data interface for switching off consumers centrally and with full coordination during pause times regardless of the manufacturer or device type. The goal is that the process is only provided with the energy that is absolutely required. The majority of the energy is saved by the process; the PROFINET device itself only contributes a few watts of savings potential.	
Integrated technology		
Motion Control	The CPUs support the S7-1500 Motion Control functions via the technology objects speed axes, positioning axes, synchronized axes, external encoders, cams, cam tracks, and measuring inputs. • Speed-controlled axis for controlling a drive with speed specification • Positioning axis for position-controlled positioning of a drive • Synchronous axis to interconnect with a master value. The axis is synchronized to the master axis position. • External encoder for detecting the actual position of an encoder and its use as a master value for synchronous operation • Cams, cam track for position-dependent generation of switching signals • Measuring input for fast, accurate, and event-dependent sensing of actual positions You program the technology objects with Motion Control instructions according to PLCopen.	Motion Control topic page (https://support.industry.siemens.com/cs/ww/en/view/109751049)
Integrated closed-loop control functionality	• PID Compact (continuous PID controller) • PID 3Step (step controller for integrating actuators) • PID Temp (temperature controller for heating and cooling with two separate actuators)	PID control Function Manual (https://support.industry.siemens.com/cs/ww/en/view/108210036)
Integrated safety		
Know-how protection	The know-how protection protects user blocks against unauthorized access and modifications.	ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)
Copy protection	Copy protection links user blocks to the serial number of the SIMATIC Memory Card or to the serial number of the CPU. User programs cannot run without the corresponding SIMATIC Memory Card or CPU.	
Local user management (as of FW version V3.1)	Improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC). You can used the local user management in the editor to manage all project users along with their rights (e.g. access rights) for users and roles of the project in the TIA Portal.	

Function	Description	Additional information
Access protection (up to FW version V3.0)	You can use authorization levels to assign separate rights to different user groups.	ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)
Integrity protection	The CPUs feature an integrity protection function by default. This helps to detect any manipulation of the engineering data on the SIMATIC Memory Card or during data transfer between the TIA Portal and the CPU, and to check communication from a SIMATIC HMI system to the CPU for possible manipulation of engineering data. The user receives a corresponding message about manipulation of engineering data detected by the integrity protection.	
Password provider	As an alternative to manual password input you can connect a password provider to STEP 7. A password provider offers the following advantages: • Convenient handling of passwords. STEP 7 reads the password automatically for the blocks. This saves you time. • Optimum block protection because the users do not know the password itself.	

3.4 Operating and display elements

3.4.1 Front view of the module

The figure shows the CPU 1514SP-2 PN.

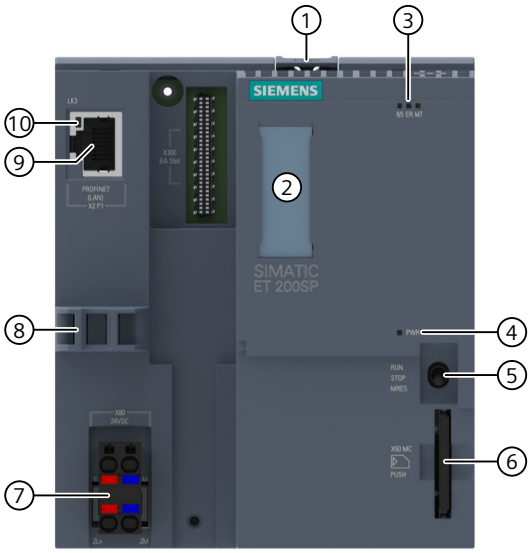

① Mounting rail release
② Labeling strips
③ LEDs for status and error displays
④ LED for display of the supply voltage
⑤ Mode switch
⑥ Slot for the SIMATIC memory card
⑦ Connection for supply voltage (included in product package)
⑧ Cable support and attachment for port P3 of the PROFINET interface
⑨ Port P1 of the PROFINET interface X2
⑩ LEDs for status displays of the PROFINET interface X2

Figure 2-14 Front view without BusAdapter

Front view with BusAdapter

The figure on the left shows the CPU 1514SP-2 PN including a plugged BA 2xRJ45 BusAdapter. The BusAdapter is not included in the scope of supply. The figure on the right shows a separate view of the BA 2xRJ45 BusAdapter.

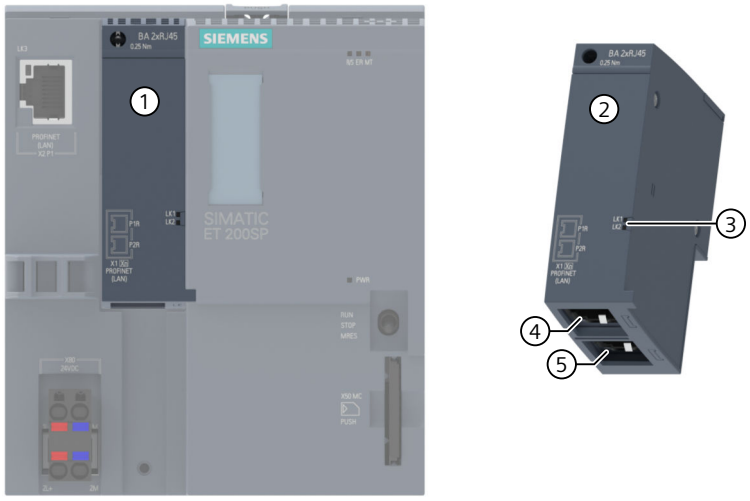

① BusAdapter BA 2xRJ45

② Separate view of the BusAdapter

③ LEDs for status displays of the PROFINET interface: LK1 and LK2 on BusAdapter

④ Port P1R of the PROFINET interface: RJ45 socket on BusAdapter BA 2×RJ45
R: Ring port for configuring a ring topology with media redundancy

⑤ Port P2R of the PROFINET interface: RJ45 socket on BusAdapter BA 2×RJ45
R: Ring port for configuring a ring topology with media redundancy

Figure 2-15 Front view of the CPU 1514SP-2 PN with BusAdapter BA 2xRJ45

3.5 Mode switch

Use the mode switch to set the CPU operating mode.

The following table shows the position of the switch and the corresponding meaning.

Table 2-11 Mode switch settings

Position	Meaning	Explanation
RUN	RUN mode	The CPU can process the user program.
STOP	STOP mode	The user program is not being executed.
MRES	Memory reset	Position for CPU memory reset.

Wiring

4

This section provides information on the pin assignment of the individual interfaces and the block diagram of the CPU.

24 V DC supply voltage (X80)

The connector for the supply voltage is plugged in when the CPU ships from the factory.

The following table shows the signal names and the descriptions of the pin assignment of the 24 V DC supply voltage.

Table 2-12 Pin assignment 24 V DC supply voltage

View Connector	Signal name [1]		Description
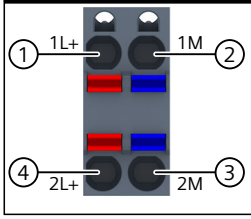	1	1L+	+ 24 V DC of the supply voltage
	2	1M	Ground of the supply voltage
	3	2M	Ground of the supply voltage for loop-through [2]
	4	2L+	+ 24 V DC of the supply voltage for loop-through [2]

[1] 1L+ and 2L+ as well as 1M and 2M are bridged internally

[2] Maximum 10 A permitted

PROFINET IO interface on the CPU (X2 P1)

The assignment corresponds to the Ethernet standard for an RJ45 connector.

- When autonegotiation is deactivated, the RJ45 socket is allocated as a switch (MDI-X).
- If autonegotiation is activated, then autocrossing is active and the RJ45 socket has either a device assignment (MDI) or switch assignment (MDI-X).

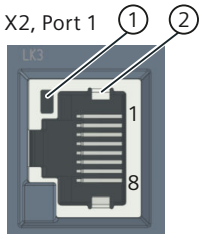

① LINK LED for port X2 P1 (green LED on CPU)

② Shielding

BusAdapter

The following BusAdapters can be selected for use with the CPU :

- BusAdapter BA 2×RJ45
- BusAdapter BA SCRJ/RJ45
- BusAdapter BA LC/RJ45
- BusAdapter BA 2×FC
- BusAdapter BA 2xSCRJ
- BusAdapter BA SCRJ/FC
- BusAdapter BA 2xLC
- BusAdapter BA LC/FC
- BusAdapter BA 2xM12

For more information on the various BusAdapters, please refer to the SIMATIC ET 200SP BusAdapter (https://support.industry.siemens.com/cs/us/en/view/109751716) Equipment Manual.

Reference

You can find more information on the topics of "Connecting the CPU" and "Accessories/spare parts" in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) System Manual.

Assignment of the MAC addresses

The MAC address is a globally unique device identifier that is assigned to each PROFINET device in the factory. Its 6 bytes are divided into 3 bytes for the manufacturer ID and 3 bytes for the device ID (serial number). The front panel of the CPU is lasered with the MAC address of the PROFINET interface.

The PROFINET interface X1 of the CPU has two ports. Ports 1 and 2 are located on the optional BusAdapter. Port 1 of the PROFINET interface X2 is located on the CPU.
In addition to the PROFINET interface, each PROFINET port also has a separate MAC address. There is therefore a total of five MAC addresses for the CPU.

The MAC addresses of the PROFINET ports are needed for the LLDP protocol, for example for the neighborhood discovery function.

The table below shows how the MAC addresses are assigned.

Table 2-13 Assignment of the MAC addresses

	Assignment
MAC address 1	PROFINET interface X1 • Visible in STEP 7 for accessible devices • Lasered on the front of the CPU (start of the number range)
MAC address 2	Port X1 P1R (required for LLDP, for example)

	Assignment
MAC address 3	Port X1 P2R (required for LLDP, for example)
MAC address 4	PROFINET interface X2 • Visible in STEP 7 for accessible devices • lasered on the front of the CPU
MAC address 5	Port X2 P1 (required for LLDP, for example)

Block diagram

The following figure shows the block diagram of the CPU.

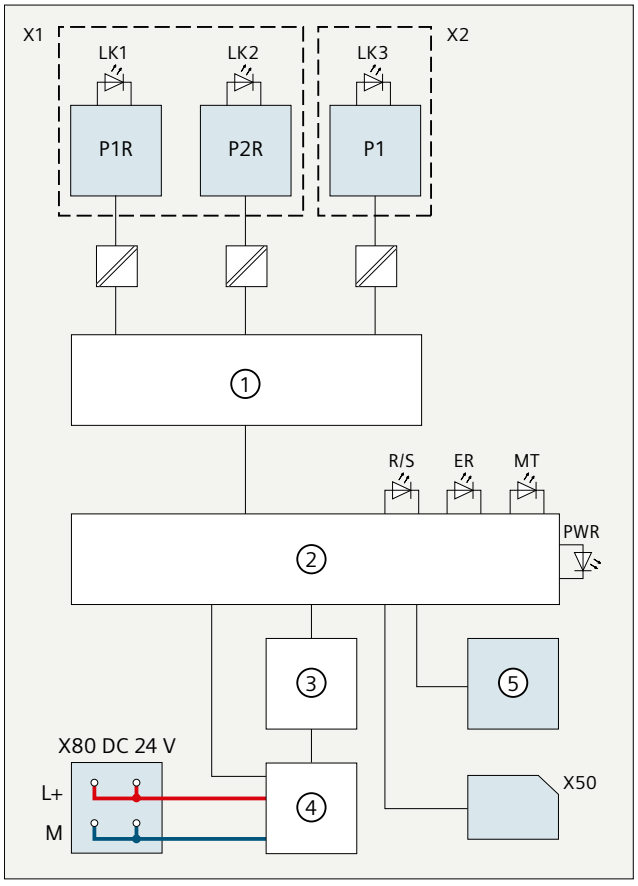

①	PROFINET switch	P1R	PROFINET interface X1 Port 1
②	Electronics	P2R	PROFINET interface X1 Port 2
③	Backplane bus interface	P1	PROFINET interface X2 port 1
④	Internal supply voltage	L+	24 V DC supply voltage
⑤	RUN/STOP/MRES mode selector	M	Ground
X1	BusAdapter	LK1, 2, 3	LED Link TX/RX (green)
X50	SIMATIC Memory Card	R/S	RUN/STOP LED (green/yellow)
X80 24 V DC	Infeed of supply voltage	ER	ERROR LED (red)
		MT	MAINT LED (yellow)
		PWR	POWER LED (green)

Figure 2-16 Block diagram of the CPU

Interrupts, error messages, diagnostics and system alarms

5

The status and error displays of the CPU are described below.

You will find additional information on "Interrupts" in the STEP 7 online help.

You can find additional information on the topics of "Diagnostics" and "System alarms" in the Diagnostics (https://support.automation.siemens.com/WW/view/en/59192926) function manual.

5.1 Status and error display of the CPU

LED displays

The figure below shows the LED displays of the CPU and the BA 2xRJ45 BusAdapter.

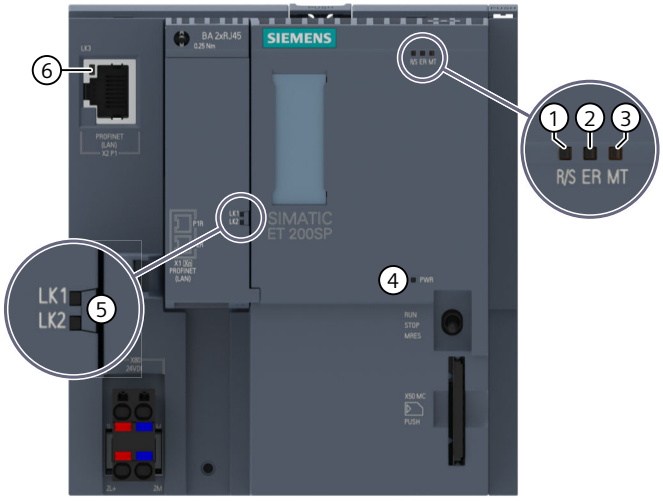

① RUN/STOP LED (green/yellow LED)

② ERROR LED (red LED)

③ MAINT LED (yellow LED)

④ POWER LED (green LED)

⑤ LINK LED for ports X1 P1 and X1 P2 (green LEDs on BusAdapter)

⑥ LINK LED for port X2 P1 (green LED on CPU)

Figure 2-17 LED displays on the CPU and BusAdapter

Meaning of the POWER, RUN/STOP, ERROR and MAINT LEDs

CPU features an LED for monitoring the supply voltage of the electronics (PWR) and three LEDs for displaying the current operating and diagnostics status. The following table shows the meaning of the various combinations of colors for the POWER, RUN/STOP, ERROR and MAINT LEDs.

Table 2-14 Meaning of the LEDs

POWER LED	RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	LED off	Missing or insufficient supply voltage on the CPU.
LED lit green	LED off	LED flashes red	LED off	An error has occurred.
LED lit green	LED lit green	LED off	LED off	CPU is in RUN mode.
LED lit green	LED lit green	LED off	LED lit yellow	Maintenance demanded for the plant. You need to check/replace the affected hardware within a short period of time.
				Active Force job.
				OPC UA server of the CPU expects initial trust lists and CRLs via GDS Push function.
LED lit green	LED lit green	LED flashes red	LED off	A diagnostics event is pending. The CPU is in RUN mode.
LED lit green	LED lit yellow	LED flashes red	LED off	A diagnostics event is pending. The CPU is in STOP mode.
LED lit green	LED lit yellow	LED off	LED flashes yellow	Firmware update using SIMATIC Memory Card successfully completed.
LED lit green	LED lit yellow	LED off	LED off	CPU is in STOP mode.
				CPU runs a program with active breakpoints. The program is at a breakpoint.
LED lit green	LED lit yellow	LED flashes red	LED flashes yellow	The program on the SIMATIC Memory Card is causing an error.
				Firmware update using SIMATIC Memory Card failed.
				The CPU has detected an error state. Additional information is available via the CPU diagnostic buffer.
LED lit green	LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. startup after STOP.
				Download of the user program from the SIMATIC Memory Card
				CPU carries out a program with active breakpoint. The program is presently moving from one breakpoint to another.
				Firmware update is being performed.
LED lit green	LED flashes yellow/green	LED off	LED off	Startup (transition from STOP → RUN)

POWER LED	RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED lit green	LED flashes yellow/green	LED flashes red	LED flashes yellow	Startup (CPU booting)
				LED testing during startup.
				Flash LEDs

Meaning of the LINK LED

Each port has a LINK LED (LK1, LK2, LK3). The table below shows the various "LED scenarios" of ports for the CPU.

Table 2-15 Meaning of the LEDs

LINK LED	Meaning
LED off	There is no Ethernet connection between the PROFINET interface of the PROFINET device and the communication partner. No data is currently being sent/received via the PROFINET interface. There is no LINK connection.
LED flashes green	The CPU is performing an "LED flash test".
LED lit green	There is an Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner.

NOTE

"LED" instruction

You can read the status (e.g. "On" or "Off") of LEDs of a CPU or a module using the "LED" instruction. Note, however, that it is not possible to read the LED status of the LINK RX/TX LEDs on all S7-1500 CPUs.

You can find additional information on the "LED" instruction in the STEP 7 online help.

Technical specifications

6

The following table shows the technical specifications as of 11/2024. You can find a data sheet with the latest technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7514-2DN03-0AB0/td?dl=en).

Article number	6ES7514-2DN03-0AB0
General information	
Product type designation	CPU 1514SP-2 PN
HW functional status	FS03
Firmware version	V4.0
• FW update possible	Yes
Product function	
• I&M data	Yes; I&M0 to I&M3
• Module swapping during operation (hot swapping)	Yes; Multi-hot swapping
• Isochronous mode	Yes; only with PROFINET; with minimum OB 6x cycle of 375 µs
• SysLog	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V20 (FW V4.0) / V18 (FW V3.0) or higher
Configuration control	
via dataset	Yes
Control elements	
Mode selector switch	1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	10 ms
Input current	
Current consumption (rated value)	0.48 A
Current consumption, max.	0.7 A
Inrush current, max.	1.34 A; Rated value
I^2t	0.3 $A^2 \cdot s$
Power	
Infeed power to the backplane bus	8.05 W

Article number	6ES7514-2DN03-0AB0
Power loss	
Power loss, typ.	3.5 W
Memory	
Number of slots for SIMATIC memory card	1
SIMATIC memory card required	Yes
Work memory	
• integrated (for program)	600 kbyte
• integrated (for data)	3.5 Mbyte
Load memory	
• Plug-in (SIMATIC Memory Card), max.	32 Gbyte
Backup	
• maintenance-free	Yes
CPU processing times	
for bit operations, typ.	6 ns
for word operations, typ.	7 ns
for fixed point arithmetic, typ.	9 ns
for floating point arithmetic, typ.	37 ns
CPU-blocks	
Number of elements (total)	4 000; Blocks (OB, FB, FC, DB) and UDTs
DB	
• Number range	1 ... 60 999; subdivided into: number range that can be used by the user: 1 ... 59 999, and number range of DBs created via SFC 86: 60 000 ... 60 999
• Size, max.	3.5 Mbyte; For DBs with absolute addressing, the max. size is 64 KB
FB	
• Number range	0 ... 65 535
• Size, max.	600 kbyte
FC	
• Number range	0 ... 65 535
• Size, max.	600 kbyte
OB	
• Size, max.	600 kbyte
• Number of free cycle OBs	100
• Number of time alarm OBs	20
• Number of delay alarm OBs	20
• Number of cyclic interrupt OBs	20; With minimum OB 3x cycle of 250 µs
• Number of process alarm OBs	50
• Number of DPV1 alarm OBs	3
• Number of isochronous mode OBs	1

Article number	6ES7514-2DN03-0AB0
• Number of technology synchronous alarm OBs	2
• Number of startup OBs	100
• Number of asynchronous error OBs	4
• Number of synchronous error OBs	2
• Number of diagnostic alarm OBs	1
Nesting depth	
• per priority class	24
Counters, timers and their retentivity	
S7 counter	
• Number	2 048
Retentivity	
– adjustable	Yes
IEC counter	
• Number	Any (only limited by the main memory)
Retentivity	
– adjustable	Yes
S7 times	
• Number	2 048
Retentivity	
– adjustable	Yes
IEC timer	
• Number	Any (only limited by the main memory)
Retentivity	
– adjustable	Yes
Data areas and their retentivity	
Retentive data area (incl. timers, counters, flags), max.	512 kbyte; In total; available retentive memory for bit memories, timers, counters, DBs, and technology data (axes): 472 KB
Flag	
• Size, max.	16 kbyte
• Number of clock memories	8; 8 clock memory bit, grouped into one clock memory byte
Data blocks	
• Retentivity adjustable	Yes
• Retentivity preset	No
Local data	
• per priority class, max.	64 kbyte; max. 16 KB per block
Address area	
Number of IO modules	8 192; max. number of modules / submodules

Article number	6ES7514-2DN03-0AB0
I/O address area	
• Inputs	32 kbyte; All inputs are in the process image
• Outputs	32 kbyte; All outputs are in the process image
per integrated IO subsystem	
– Inputs (volume)	8 kbyte
– Outputs (volume)	8 kbyte
per CM/CP	
– Inputs (volume)	8 kbyte
– Outputs (volume)	8 kbyte
Subprocess images	
• Number of subprocess images, max.	32
Address space per module	
• Address space per module, max.	288 byte; For input and output data respectively
Address space per station	
• Address space per station, max.	2 560 byte; for central inputs and outputs; depending on configuration; 2 048 bytes for ET 200SP modules + 512 bytes for ET 200AL modules
Hardware configuration	
Number of distributed IO systems	64; A distributed I/O system is characterized not only by the integration of distributed I/O via PROFINET or PROFIBUS communication modules, but also by the connection of I/O via AS-i master modules or links (e.g. IE/PB-Link)
Number of DP masters	
• Via CM	1
Number of IO Controllers	
• integrated	2
• Via CM	0
Rack	
• Modules per rack, max.	82; CPU + 64 modules + server module (mounting width max. 1 m) + 16 ET 200AL modules
• Quantity of operable ET 200SP modules, max.	64
• Quantity of operable ET 200AL modules, max.	16
• Number of lines, max.	1
PtP CM	
• Number of PtP CMs	the number of connectable PtP CMs is only limited by the number of available slots
Time of day	
Clock	
• Type	Hardware clock

Article number	6ES7514-2DN03-0AB0
• Backup time	6 wk; At 40 °C ambient temperature, typically
• Deviation per day, max.	10 s; Typ.: 2 s
Operating hours counter	
• Number	16
Clock synchronization	
• supported	Yes
• to DP, master	Yes; Via CM DP module
• on DP, device	Yes; Via CM DP module
• in AS, master	Yes
• in AS, device	Yes
• on Ethernet via NTP	Yes
Interfaces	
Number of PROFINET interfaces	2
Number of PROFIBUS interfaces	1; Via CM DP module
Optical interface	No
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; X1 P1 and X1 P2 via BusAdapter BA 2x RJ45
• Number of ports	2; via BusAdapter
• integrated switch	Yes
• BusAdapter (PROFINET)	Yes; compatible BusAdapters: BA 2x RJ45, BA 2x M12, BA 2x FC, BA 2x LC, BA LC/RJ45, BA LC/FC, BA 2x SCRJ, BA SCRJ/RJ45, BA SCRJ/FC
Protocols	
• IP protocol	Yes; IPv4
• PROFINET IO Controller	Yes
• PROFINET IO Device	Yes
• SIMATIC communication	Yes
• Open IE communication	Yes; Optionally also encrypted
• Web server	Yes
• Media redundancy	Yes
PROFINET IO Controller	
Services	
– Isochronous mode	Yes
– Direct data exchange	Yes; Requirement: IRT and isochronous mode (MRPD optional)
– IRT	Yes
– PROFIenergy	Yes; per user program
– Prioritized startup	Yes; Max. 32 PROFINET devices

Article number	6ES7514-2DN03-0AB0
– Number of connectable IO Devices, max.	256; in total, up to 1024 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
– Of which IO devices with IRT, max.	64
– Number of connectable IO Devices for RT, max.	256
– of which in line, max.	256
– Number of IO Devices that can be simultaneously activated/deactivated, max.	8; in total across all interfaces
– Number of IO Devices per tool, max.	8
– Updating times	The minimum value of the update time also depends on communication share set for PROFINET IO, on the number of IO devices, and on the quantity of configured user data
– PROFINET Security Class	1
Update time for IRT	
– for send cycle of 250 µs	250 µs to 4 ms; Note: In the case of IRT with isochronous mode, the minimum update time of 375 µs of the isochronous OB is decisive
– for send cycle of 500 µs	500 µs to 8 ms
– for send cycle of 1 ms	1 ms to 16 ms
– for send cycle of 2 ms	2 ms to 32 ms
– for send cycle of 4 ms	4 ms to 64 ms
– With IRT and parameterization of "odd" send cycles	Update time = set "odd" send clock (any multiple of 125 µs: 375 µs, 625 µs ... 3 875 µs)
Update time for RT	
– for send cycle of 250 µs	250 µs to 128 ms
– for send cycle of 500 µs	500 µs to 256 ms
– for send cycle of 1 ms	1 ms to 512 ms
– for send cycle of 2 ms	2 ms to 512 ms
– for send cycle of 4 ms	4 ms to 512 ms
PROFINET IO Device	
Services	
– Isochronous mode	No
– IRT	Yes
– PROFIenergy	Yes; per user program
– Shared device	Yes
– Number of IO Controllers with shared device, max.	4
– activation/deactivation of I-devices	Yes; per user program
– Asset management record	Yes; per user program
– PROFINET Security Class	SNMP Configuration and DCP Read Only

Article number	6ES7514-2DN03-0AB0
2. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; X2
• Number of ports	1
• integrated switch	No
Protocols	
• IP protocol	Yes; IPv4
• PROFINET IO Controller	Yes
• PROFINET IO Device	Yes
• SIMATIC communication	Yes
• Open IE communication	Yes; Optionally also encrypted
• Web server	Yes
• Media redundancy	No
PROFINET IO Controller	
Services	
– Isochronous mode	No
– Direct data exchange	No
– IRT	No
– PROFIenergy	Yes; per user program
– Prioritized startup	No
– Number of connectable IO Devices, max.	32; in total, up to 1024 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
– Number of connectable IO Devices for RT, max.	32
– of which in line, max.	32
– Number of IO Devices that can be simultaneously activated/deactivated, max.	8; in total across all interfaces
– Number of IO Devices per tool, max.	8
– Updating times	The minimum value of the update time also depends on communication share set for PROFINET IO, on the number of IO devices, and on the quantity of configured user data
– PROFINET Security Class	1
Update time for RT	
– for send cycle of 1 ms	1 ms to 512 ms
PROFINET IO Device	
Services	
– Isochronous mode	No
– IRT	No
– PROFIenergy	Yes; per user program

Article number	6ES7514-2DN03-0AB0
– Prioritized startup	No
– Shared device	Yes
– Number of IO Controllers with shared device, max.	4
– activation/deactivation of I-devices	Yes; per user program
– Asset management record	Yes; per user program
– PROFINET Security Class	SNMP Configuration and DCP Read Only
3. Interface	
Interface types	
• RS 485	Yes; Via CM DP module
• Number of ports	1
Protocols	
• PROFIBUS DP master	Yes
• PROFIBUS DP device	Yes
• SIMATIC communication	Yes
PROFIBUS DP master	
• Number of connections, max.	48; Of which 4 each reserved for ES and HMI
• max. number of DP devices	125; in total, up to 1024 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
Services	
– Equidistance	No
– Isochronous mode	No
– activation/deactivation of DP devices	Yes
Interface types	
RJ 45 (Ethernet)	
• 100 Mbps	Yes
• Autonegotiation	Yes
• Autocrossing	Yes
• Industrial Ethernet status LED	Yes
RS 485	
• Transmission rate, max.	12 Mbit/s
Protocols	
PROFIsafe	No
Number of connections	
• Number of connections, max.	192; via integrated interfaces of the CPU and connected CPs / CMs
• Number of connections reserved for ES/HMI/web	10
• Number of connections via integrated interfaces	128
• Number of connections per CP/CM	32

Article number	6ES7514-2DN03-0AB0
• Number of S7 routing paths	16
Redundancy mode	
• H-Sync forwarding	Yes
Media redundancy	
– Media redundancy	Yes; only via BusAdapter
– MRP	Yes; MRP Automanager according to IEC 62439-2 Edition 2.0, MRP Manager; MRP Client
– MRP interconnection, supported	Yes; as MRP ring node according to IEC 62439-2 Edition 3.0
– MRPD	Yes; Requirement: IRT
– Switchover time on line break, typ.	200 ms; For MRP, bumpless for MRPD
– Number of stations in the ring, max.	50
SIMATIC communication	
• PG/OP communication	Yes; encryption with TLS V1.3 pre-selected
• S7 routing	Yes
• Data record routing	Yes
• S7 communication, as server	Yes
• S7 communication, as client	Yes
• User data per job, max.	See online help (S7 communication, user data size)
Open IE communication	
• TCP/IP	Yes
– Data length, max.	64 kbyte
– several passive connections per port, supported	Yes
• ISO-on-TCP (RFC1006)	Yes
– Data length, max.	64 kbyte
• UDP	Yes
– Data length, max.	2 kbyte; 1 472 bytes for UDP broadcast
– UDP multicast	Yes; max. 118 multicast circuits
• DHCP	Yes
• DNS	Yes
• SNMP	Yes
• DCP	Yes
• LLDP	Yes
• Encryption	Yes; Optional
Web server	
• HTTP	Yes; Standard and user pages
• HTTPS	Yes; Standard and user pages

Article number	6ES7514-2DN03-0AB0
OPC UA	
• Runtime license required	Yes; "Medium" license required
• OPC UA Client	Yes; Data Access (registered Read/Write), Method Call
– Application authentication	Yes
– Security policies	Available security policies: None, Basic128Rsa15, Basic256Rsa15, Basic256Sha256
– User authentication	"anonymous" or by user name & password
– Number of connections, max.	10
– Number of nodes of the client interfaces, recommended max.	2 000
– Number of elements for one call of OPC_UA_NodeGetHandleList/OPC_UA_ReadList/OPC_UA_WriteList, max.	300
– Number of elements for one call of OPC_UA_NameSpaceGetIndexList, max.	20
– Number of elements for one call of OPC_UA_MethodGetHandleList, max.	100
– Number of simultaneous calls of the client instructions for session management, per connection, max.	1
– Number of simultaneous calls of the client instructions for data access, per connection, max.	5
– Number of registerable nodes, max.	5 000
– Number of registerable method calls of OPC_UA_MethodCall, max.	100
– Number of inputs/outputs when calling OPC_UA_MethodCall, max.	20
• OPC UA Server	Yes
– Application authentication	Yes
– Security policies	available security policies: None, Basic128Rsa15, Basic256Rsa15, Basic256Sha256, Aes128Sha256RsaOaep, Aes256Sha256RsaPss
– User authentication	"anonymous" or by user name & password
– GDS support (certificate management)	Yes
– Number of sessions, max.	48
– Number of accessible variables, max.	100 000
– Number of registerable nodes, max.	20 000
– Number of subscriptions per session, max.	50
– Sampling interval, min.	100 ms
– Publishing interval, min.	100 ms

Article number	6ES7514-2DN03-0AB0
– Number of server methods, max.	50
– Number of inputs/outputs per server method, max.	20
– Number of monitored items, recommended max.	4 000; for 1 s sampling interval and 1 s send interval
– Number of server interfaces, max.	10 of each "Server interfaces" / "Companion specification" type and 20 of the type "Reference namespace"
– Number of nodes for user-defined server interfaces, max.	30 000
• Alarms and Conditions	Yes
– Number of program alarms	200
– Number of alarms for system diagnostics	100
Further protocols	
• MODBUS	Yes; MODBUS TCP
S7 message functions	
Number of login stations for message functions, max.	64
number of subscriptions, max.	500
number of tags/attributes for subscriptions, max.	8 000
Program alarms	Yes
Number of configurable program messages, max.	10 000; Program messages are generated by the "Program_Alarm" block, ProDiag or GRAPH
Number of loadable program messages in RUN, max.	10 000
Test commissioning functions	
Joint commission (Team Engineering)	Yes; Parallel online access possible for up to 8 engineering systems
Status block	Yes; Up to 8 simultaneously (in total across all ES clients)
Single step	Yes
Number of breakpoints	8
Profiling	Yes
Status/control	
• Status/control variable	Yes
• Variables	Inputs/outputs, memory bits, DBs, distributed I/Os, timers, counters
• Number of variables, max.	
– of which status variables, max.	200; per job
– of which control variables, max.	200; per job
Forcing	
• Forcing	Yes

Article number	6ES7514-2DN03-0AB0
• Forcing, variables	Peripheral inputs/outputs
• Number of variables, max.	200
Diagnostic buffer	
• present	Yes
• Number of entries, max.	3 200
– of which powerfail-proof	500
Traces	
• Number of configurable Traces	4
• Memory size per trace, max.	512 kbyte
Interrupts/diagnostics/status information	
Diagnostics indication LED	
• RUN/STOP LED	Yes
• ERROR LED	Yes
• MAINT LED	Yes
• Monitoring of the supply voltage (PWR-LED)	Yes
• Connection display LINK TX/RX	Yes
Supported technology objects	
Motion Control	Yes; Note: The number of technology objects affects the cycle time of the PLC program; selection guide via the TIA Selection Tool
• Number of available Motion Control resources for technology objects	2 400
• Required Motion Control resources	
– per speed-controlled axis	40
– per positioning axis	80
– per synchronous axis	160
– per external encoder	80
– per output cam	20
– per cam track	160
– per probe	40
• Positioning axis	
– Number of positioning axes at motion control cycle of 4 ms (typical value)	11
– Number of positioning axes at motion control cycle of 8 ms (typical value)	20
Controller	
• PID_Compact	Yes; Universal PID controller with integrated optimization
• PID_3Step	Yes; PID controller with integrated optimization for valves

Article number	6ES7514-2DN03-0AB0
• PID-Temp	Yes; PID controller with integrated optimization for temperature
Counting and measuring	
• High-speed counter	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; No condensation
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
configuration / header	
configuration / programming / header	
Programming language	
– LAD	Yes
– FBD	Yes
– STL	Yes
– SCL	Yes
– CFC	Yes
– GRAPH	Yes
Know-how protection	
• User program protection/password protection	Yes
• Copy protection	Yes
• Block protection	Yes
Access protection	
• protection of confidential configuration data	Yes
• Protection level: Write protection	Yes
• Protection level: Read/write protection	Yes
• Protection level: Write protection for Failsafe	No
• Protection level: Complete protection	Yes
• User administration	Yes; device-wide and centralized
• Number of users	100
programming / cycle time monitoring / header	
• lower limit	adjustable minimum cycle time
• upper limit	adjustable maximum cycle time

Article number	6ES7514-2DN03-0AB0
Dimensions	
Width	100 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	265 g

General technical specifications

You can find information on the general technical specifications, such as standards and approvals, electromagnetic compatibility, protection class, etc. in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) System Manual.

Dimension drawing

A

This section contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

Dimension drawing of the CPU

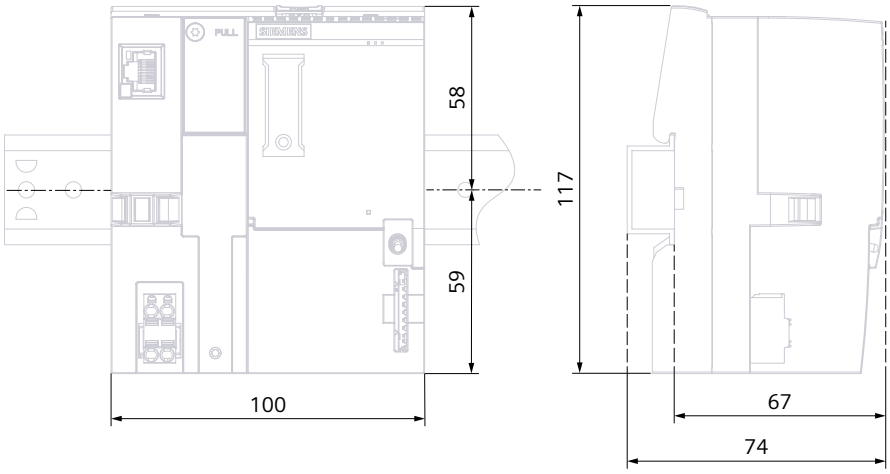

Figure 2-18 Dimension drawing of the CPU

SIEMENS

SIMATIC

ET 200SP
CPU 1514SPT-2 PN
(6ES7514-2VN03-0AB0)

Equipment Manual

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Industrial cybersecurity 2

Product overview 3

Connecting 4

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Dimensional drawing A

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Introduction 1

1.1 Introduction

Purpose of the documentation

This Equipment Manual supplements the ET 200SP Distributed I/O System (https://support.automation.siemens.com/WW/view/en/58649293) System Manual as well as the Function Manuals. This Equipment Manual contains a concise description of the module-specific information. The system-related functions are described in the System Manual. All system-spanning functions are described in the Function Manuals.

The information provided in this Equipment Manual and the System Manual allows you to commission the CPU.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe the notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

ID-Link for the digital nameplate

The ID-Link is a globally unique identifier according to IEC 61406-1, which you will find as a QR code on your product in the future.

The figure shows an example of an ID-Link for the CPU 1514SPT-2 PN.

You can recognize the ID-Link by the frame with a black corner at the bottom right. The ID-Link takes you to the digital nameplate of your product.

Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call the ID-Link.

In the digital nameplate, you will find product data, manuals, declarations of conformity, certificates, and other helpful information about your product.

1.2 S7-1500/ET 200MP documentation guide

1.2.1 Information classes S7-1500/ET 200MP

The documentation for the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require. Changes and supplements to the manuals are documented in a Product Information.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742691).

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- S7-1500/ET 200MP System Manual
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules
- Equipment Manuals Power Supply Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC S7-1500 and ET 200MPsystems.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manual Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the S7-1500 and ET 200MP systems on the Internet (https://support.industry.siemens.com/cs/de/en/view/68052815).

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/86140384)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109806400)

SIMATIC S7-1500 comparison list for programming languages

The comparison list contains an overview of which instructions and functions you can use for which controller families.

You can find the comparison list on the Internet
(https://support.industry.siemens.com/cs/ww/en/view/86630375).

1.2.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293) for general information and measures regarding industrial cybersecurity.

This section provides an overview of security-related information pertaining to your SIEMENS device.

NOTE

Security-relevant changes to software or devices are documented in the section New functions.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

2.3 Cybersecurity-relevant information

Note all cybersecurity-relevant information.

Topics with cybersecurity-relevant information	Reference
Operational application environment and security assumptions	
Requirements for the operational application environment of the system and security assumptions	This section is found in the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Security properties of the product	
Access protection Physical protection: • You can protect the CPU against unauthorized access by locking the front flap. Password protection You can also protect the CPU with a password. Password categories: • Password to protect confidential configuration data • Passwords in the context of user management (UMAC) • Password for display	Information on locking and on password protection can be found in this Equipment Manual in the section Operator controls and display elements (Page 23). Also note the information on the topic of access protection in the Protection section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Integrated protection functions • The CPUs have integrated protection functions.	For information on the protection functions, refer to the "Overview of protection functions" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
PROFINET Security Class 1 • The device supports PROFINET Security Class 1. • With the introduction of PROFINET Security Class 1, additional security settings have been integrated into the PROFINET communication.	Detailed information about PROFINET Security Class 1 and the additional security settings can be found in the PROFINET with STEP 7 Function Manual (https://support.industry.siemens.com/cs/us/en/view/49948856).
Reading out and verifying signatures	You can find detailed information on reading and verifying signatures in the STEP 7 online help (TIA Portal).
Supported Ethernet services	Information about supported services can be found in the section Technical specifications (Page 32). You can find detailed information on the supported Ethernet services in the Communication Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192925).
Interfaces, ports, protocols and services	
Information on the following is security related: • Communications layer and communication role • Default states • Enabling/disabling ports and services	You can find detailed information on these topics in the Communication Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192925).
Secure operation	
Corrective measures for known risks	Corrective measures for known risks are announced on the Siemens ProductCERT (https://siemens.com/productcert) Web page. For more information on SIEMENS ProductCERT, refer to the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).

Topics with cybersecurity-relevant information	Reference
Security checks	Application-specific security measures such as cyclic checks of the configuration via checksums are described in the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Recording Security events	Information on recording security events can be found in the "Safe operation of CPUs" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Secure decommissioning Products that contain security-relevant data must be securely decommissioned before disposal or resale.	Information on secure decommissioning can be found in the "Safe operation of the system" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).

Product overview

3

3.1 New functions

This section contains an overview of the most important new firmware functions of the CPU compared with the predecessor version CPU (V3.1).

New CPU features in firmware version V4.0

New functions	Applications	Customer benefits
Integrated safety		
Retentive memory area for syslog messages	The CPUs store syslog messages retentively as of FW version 4.0.	As a result, events are retained in the syslog memory even after a CPU restart.
Central user management	System-wide, central management of users and user groups outside TIA Portal via UMC server.	User management for comprehensive automation solutions with multiple projects, users, and user groups. Users and user groups can work in all projects in which they are activated and for which they have been assigned the appropriate rights. During operation, users can be added to or removed from a group, or their passwords can be changed. The changes have no effect on the CPU configuration. It is not necessary to restart the CPU.
Programming the CPU		
SIMATIC Controller Profiling	SIMATIC Controller Profiling allows you to analyze and evaluate the runtime behavior of your user program on a SIMATIC CPU.	Using the new instruction "Profiling", you can start or stop the profiling of a CPU with firmware version V4.0 or higher. When starting the profiling, specify the configuration with which the profiling data is to be recorded.
Increasing the nesting depth	For the CPUs of firmware version V4.0 or higher, the nesting depth has been extended for the following elements: • PLC data types • Tags of the STRUCT data type • Tags of the ARRAY of STRUCT / ARRAY of UDT data type	Previously, the maximum nesting depth was 8 elements. You can now nest up to 26 elements inside each other. An ARRAY of STRUCT/UDT requires three hierarchy levels in each case. If you use these data types, the maximum nesting depth is reduced accordingly.
Communication of the CPU		
New functions for OPC UA	Enables cross-vendor communication.	For more information, please refer to the Communication Function Manual.

New functions	Applications	Customer benefits
Configuring SNMP and DCP	As of STEP 7 V20, you can centrally configure the SNMP settings for an entire PROFINET IO system. IO devices that support the SNMP automatically synchronize the SNMP settings of the PROFINET interface of your higher-lever IO controller. If IO controllers and IO devices support the DCP protocol, the write-protected mode is activated by default for DCP.	Easier configuration of the SNMP settings through central default at the CPU for the connected PROFINET IO system.
Web server of the CPU		
System web pages	Introduction of system web pages with new design and functionality for: • Overview • Diagnostics • User program • Messages and DataLogs • Maintenance	• Modern design of the user interface • Intuitive and convenient operation • Flexible change management • Interaction with user-defined web applications with reference to Web API sessions
New Web API methods	The Web API has been expanded to include the following functions: • Reading out basic information of the CPU • Reading API session information • Technology objects and reading their values • Configuring the HTTP response header • Additional options for configuring web applications	The extended scope of functions of the Web API offers additional access options. Moreover, through the configurations of the HTTP header, access to the web server is extended via HMI Unified Panels.
Technology functions of the CPU		
Axis functions	Defining the motion transition	Extended scope of functions
	Stopping the basic motion	
Synchronous operation functions	New cyclic cam types with larger definition ranges	Extended scope of functions
	Directly setting a following axis synchronously in the camming at a specified master value position. New synchronization mode of the following axis in the camming: • Direct synchronous setting at a specified master value position	
	New synchronization modes of the following axis in the gearing: • Subsequent synchronization using master value distance starting from current master value position with calculated synchronous position • Subsequent synchronization using master value distance with calculated synchronous position	
	Reverse tolerance of the master value in the gearing or camming is adjustable.	Synchronizing and desynchronizing are not aborted if the master value is fluctuating.
	Cross-PLC synchronous operation with communications via PN/PN coupler	Extended scope of functions

New functions	Applications	Customer benefits
Synchronous operation functions	Cross-PLC synchronous operation across several projects	Use of externally supplied projects possible.
Kinematics functions	Extension of the kinematics control panel	Improved commissioning
	Display of effective dynamic limits	Improved diagnostics options
Interpreter functions	"Debug" program mode	Testing the execution of the Interpreter program is possible.
Trace functionality of the CPU		
Named value data types in Traces	"Named values" are values that are assigned a unique name. In TIA Portal, you declare named values within "named value data types". They contain a set of values to which a unique set of names is assigned.	Named values are easily referenced throughout the program and increase the readability and maintainability of the program. This makes it easy to monitor/analyze the named value data types in the trace.
Recording as binary file for long-term trace and long-term project trace	Recording as binary file instead of a CSV file and saving in a DAT file.	This makes it possible to monitor/analyze long-term traces and long-term project traces directly in TIA Portal.
Acquiring events from technology objects in the Trace recording	Detecting events in the Trace recording, which occur at a Motion Control technology object from version V9.0 or higher during recording.	Monitoring/analyzing of the correct sequence and parameterization of Motion Control jobs in complex applications.
Cross-project Trace	Recording of values from multiple projects with a PN/PN coupler.	Monitoring/analyzing of signals and events from multiple projects.

New functions of the CPU in firmware version V3.1

New functions	Applications	Customer benefits
Integrated safety		
Syslog messages	The CPU stores syslog messages in a local cache (temporary memory). The messages can be forwarded to a syslog server.	The syslog server saves all syslog messages from its connected devices. The messages can be displayed on the interface of the server and potential security risks can be identified.
Local user management	As of TIA Portal version V19 and FW version V3.1, the CPUs feature improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC). Starting with the above mentioned version, you can manage all project users with their rights (e.g. access rights) for all CPUs in the project. Management is performed in the editor for users and roles in the TIA Portal.	Project users can be managed via the TIA Portal with their rights (for example, access rights) for all CPUs in the project in the editor for users and roles.
Communication of the CPU		
Implementation of PROFINET Security Class 1	As of V19, STEP 7 offers extended configuration options for the SNMP and DCP protocols in order to meet the requirements for PROFINET Security Class 1.	Additional protection of communication within your PROFINET network.

New functions	Applications	Customer benefits
Project-internal Shared Device/Shared I-Device	As of STEP7 V19, a Shared Device/Shared I-Device can be created together with a maximum of two IO controllers in a project. Previously, the 2nd IO controller required a separate project.	Simple configuration
Handling timeouts while exchanging data	High network load timeouts may occur during data record communication with PROFINET IO devices. Up to now, PROFINET IO communication was terminated by the CPU in this case. As of STEP 7 V19 and FW version V3.1, you can configure the behavior of the respective PROFINET interface.	PROFINET IO communication is maintained even under high grid loads
Web server of the CPU		
New Web API methods	Many new API methods extend your access options to the CPU via the Web API.	Additional applications for the web server
Technology functions of the CPU		
Axis functions	Measuring gearbox for positioning/synchronous axis	Advanced configuration options
	Torque feedforward control for positioning/synchronous axis: The torque feedforward control of the CPU controls the required torque for acceleration of the axis while taking the motion profile into consideration.	Complex motion sequences can be executed faster and more precisely. This leads to a reduction of the following error in acceleration phases.
	Three drive stop modes can be configured for the "Remove enable" alarm response.	You can choose between a deceleration ramp, coasting down, and rapid stop.
	Dynamic filter with floating mean value	A new "floating mean value filter" mode is available for the dynamic filter.
	Standstill signal on external encoder	The standstill signal is also available for external encoders. The standstill signal is output when the encoder values are within the defined standstill window.
	Virtual axis	The axis is operated in virtual mode with improved runtime behavior. The new mode replaces the already existing virtual axis behavior.
Measuring input functions	Monitoring measuring input	Using the measuring input type "Measuring via monitoring", the measuring input can capture the measured signal of another configured measuring input.
	Cyclic measuring for central measuring input	Cyclic measuring possible without additional technology module.
Interpreter functions	The following technology objects are provided with the SIMATIC Motion Interpreter: • Interpreter • Interpreter program • Interpreter mapping Motion Control Language (MCL) is supported.	• Sequential programming of technology and motion tasks takes place separately and independently of the cyclic user program of the CPU • Integrated extensions for technological tasks, e.g. path-synchronous actions. • Fast, simple programming through parameterization dialogs

New functions	Applications	Customer benefits
Synchronous operation function	Cyclic readout of the following value in cam-ming	Extended scope of functions
Kinematics functions	Improved blending behavior during conveyor tracking	Blending is possible in more motion phases.
Trace functionality of the CPU		
Live monitoring for the long-term trace	With live monitoring for the long-term trace you can: • Display and analyze values directly in the graph during recording • Use combined measurements for the long-term trace • Synchronize time bases	Improved display and analysis of long-term traces.
Long-term project trace	With the long-term project trace, you can record signals from different CPUs S7-1500 simultaneously. The CPUs must be configured in a network. The recording is stored on a drive that you have configured.	Extended scope of functions

Reference

You can find an overview of all new functions, improvements and revisions in the respective firmware versions on the Internet.

See also

Internet (https://support.industry.siemens.com/cs/ww/en/view/109478459)

Communication function manual (https://support.industry.siemens.com/cs/ww/en/view/59192925)

3.2 Hardware properties

Article number

6ES7514-2VN03-0AB0

View of the module

The figure below shows the CPU 1514SP T-2PN.

Figure 2-19 CPU 1514SP T-2 PN

Properties

The CPU 1514SP T-2 PN has the following technical properties:

Property	Description	Additional information
Supply voltage	The 24 V DC supply voltage is fed via a 4-pin connection plug located at the bottom left on the front panel of the CPU.	• Section Connecting (Page 25) • ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649-293)
Standalone CPU	You can use the CPU in the distributed I/O system ET 200SP as a "central system" even without a higher-level controller.	

Property	Description	Additional information
PROFINET IO		
Interface X1	PROFINET IO (IRT) interface with 2 ports via bus adapter	• PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948-856) • ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649-293)
Interface X2	Additional PROFINET IO interface (only RT) with an RJ45 port	
Operation of the CPU as • IO controller • I-device	• **IO controller:** As an IO controller, the CPU addresses the connected IO devices • **I-device:** As an I-device (intelligent IO device), the CPU is assigned to a higher-level IO controller and is used in the process as an intelligent pre-processing unit of sub-processes.	
PROFIBUS DP		
DP master	To use the ET 200SP CPU as a DP master, you need the CPU and the optional communication module CM DP (PROFIBUS interface X2). When used as a DP master, the ET 200SP CPU exchanges data with the connected DP devices via PROFIBUS DP.	• PROFIBUS Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193-579) • Communication module CM DP Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/90156-526)
Intelligent DP device (I-DP device)	To use the ET 200SP CPU as an intelligent DP device, you need the CPU and the optional CM DP communications module (PROFIBUS interface X2). As an intelligent DP device, the ET 200SP CPU is connected via PROFIBUS DP to a higher-level DP master and exchanges data with it.	

Accessories

You can find information on the topic of "Accessories/spare parts" in the Distributed I/O system ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

NOTE

The CPU is delivered without a BusAdapter. You can find an overview of supported BusAdapters in the "Connecting (Page 25)" section. You can find the article numbers of the BusAdapters in the ET 200SP BusAdapter (https://support.industry.siemens.com/cs/us/en/view/109751716) Equipment Manual.

NOTE

You must provide covers for unused BusAdapter interfaces. You can find the article numbers of the covers in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual, in the "Accessories/spare parts" section.

3.3 Firmware functions

Functions

The CPU supports the following functions:

Function	Description	Additional information
Integrated system diagnostics	The system automatically generates the messages for the system diagnostics and outputs these messages via a programming device/PC, HMI device, the web server or the integrated display. System diagnostics information is also available when the CPU is in STOP mode.	Diagnostics Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192926)
Integrated web server	The web server lets you access the CPU data by means of a network. Evaluations, diagnostics, and modifications are thus possible over long distances. Monitoring and evaluation is possible without STEP 7, only a web browser is required. Note that you must take appropriate measures to protect the CPU from compromise (such as restricting network access, using firewalls).	• Web server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193560) • Security with SIMATIC S7 controllers System Manual (https://support.industry.siemens.com/cs/ww/en/view/90885010)
Integrated trace functionality	Trace functionality supports you in troubleshooting and/or optimizing the user program. You can record device tags and evaluate the recordings with the trace and logic analyzer function. Tags are, for example, drive parameters or system and user tags of a CPU. The device saves the recordings. You can read out and permanently save the recordings with the configuration system (ES), if required. The trace and logic analyzer function is therefore suitable for monitoring highly dynamic processes. The trace record can also be displayed through the web server. With the project trace, you can record the variables of multiple devices within a project, for example, a controller and a drive. With the long-term trace, you can record up to 64 different tags for each cycle in a .csv file over a long period (e.g. hours, days).	Using the trace and logic analyzer function Function Manual (https://support.industry.siemens.com/cs/ww/en/view/64897128)
OPC UA	With OPC UA, you can exchange data via an open and manufacturer-neutral communication protocol. The CPU can act as OPC UA server. The CPU acting as the OPC UA server can communicate with OPC UA clients. In turn, as an OPC UA client, the CPU can access an OPC UA server, allow the OPC UA server to run methods and read out information from the OPC UA server. Through OPC UA Companion Specification, methods can be specified in a uniform and vendor-neutral way. Using these specified methods, you can easily integrate devices from various manufacturers into your plants and production processes.	Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925)

Function	Description	Additional information
Configuration control	You can use configuration control to operate different real hardware configurations with a configured maximum configuration of the hardware. This means especially in series machine manufacturing you have the option of operating/configuring different configuration variants of a machine with a single project.	ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)
PROFINET IO		
RT (real time)	RT prioritizes PROFINET IO telegrams over standard telegrams. This ensures the required determinism in the automation technology. In this process the data is transferred via prioritized Ethernet telegrams.	PROFINET Function Manual (https://support.automation.siemens.com/WW/view/en/49948856)
IRT (isochronous real time)	A reserved bandwidth within the send clock is available for IRT data. The reserved bandwidth ensures that the IRT data can be transmitted in time-synchronized intervals, unaffected by other high network loading (e.g. TCP/IP communication or additional real time communication). Update times with maximum determinism can be realized through IRT. Isochronous applications are possible with IRT.	
Isochronous mode	The Isochronous mode system property acquires measured values and process data and processes the signals in a fixed system clock. Isochronous mode thus contributes to high control quality and hence to greater manufacturing precision. Isochronous mode reduces possible fluctuations of the process reaction times to a minimum. Time-assured processing makes higher machine cycles possible.	
MRP (Media Redundancy Protocol)	It is possible to establish redundant networks via the Media Redundancy Protocol. Redundant transmission links (ring topology) ensure that an alternative communication path is made available if a transmission link fails. The PROFINET devices that are part of this redundant network form an MRP domain. RT operation is possible with the use of MRP.	
MRPD (Media Redundancy with Planned Duplication)	The advantage of the MRP extension MRPD is that, in the event of a failure of a device or a line in the ring, all other devices continue to be supplied with IO data without interruption and with short update times. MRPD is based on IRT and MRP. To realize media redundancy with short update times, the PROFINET devices participating in the ring send their data in both directions. The devices receive this data at both ring ports so that there is no reconfiguration time.	
Shared device	The "Shared device" function allows you to divide the modules or submodules of an IO device up among different IO controllers. Numerous IO controllers are often used in larger or widely distributed systems. Without the "Shared device" function, each I/O module of an IO device is assigned to the same IO controller. If sensors that are physically close to each other must provide data to different IO controllers, several IO devices are required. The "Shared device" function allows the modules or submodules of an IO device to be divided up among different IO controllers, thus allowing flexible	

Function	Description	Additional information
	automation concepts. You can, for example, combine I/O modules that are physically close to each other in one IO device.	PROFINET Function Manual (https://support.automation.siemens.com/WW/view/en/49948856)
PROFIenergy	PROFIenergy is a PROFINET-based data interface for switching off consumers centrally and with full coordination during pause times regardless of the manufacturer or device type. The goal is that the process is only provided with the energy that is absolutely required. The majority of the energy is saved by the process; the PROFINET device itself only contributes a few watts of savings potential.	
Integrated technology		
Motion Control	The CPUs support the S7-1500 Motion Control functions via the technology objects speed axes, positioning axes, synchronized axes, external encoders, cams, cam tracks, and measuring inputs. • Speed-controlled axis for controlling a drive with speed specification • Positioning axis for position-controlled positioning of a drive • Synchronous axis to interconnect with a master value. The axis is synchronized to the master axis position. • External encoder for detecting the actual position of an encoder and its use as a master value for synchronous operation • Cams, cam track for position-dependent generation of switching signals • Measuring input for fast, accurate, and event-dependent sensing of actual positions You program the technology objects with Motion Control instructions according to PLCopen.	Motion Control topic page (https://support.industry.siemens.com/cs/ww/en/view/109751049)
Extended Motion Control functions	**The technology CPUs** of the SIMATIC S7-1500 also support extended Motion Control functions with the additional technology objects cam, leading axis proxy and kinematics: • Extended synchronous operation functions – Synchronization with specification of the synchronous position – Actual value coupling – Leading value or following value shift in gearing or camming – Camming – Synchronization to specified positions – Cross-PLC synchronous operation – Velocity gearing • Up to 4 encoders or measuring systems as actual position for position control	Motion Control topic page (https://support.industry.siemens.com/cs/ww/en/view/109751049)

Function	Description	Additional information
	• Controlling of kinematics, such as – Cartesian portals – Roller pickers – Delta pickers – SCARA • SIMATIC Motion Interpreter allows the sequential programming of technology and motion tasks. In the process, individual axes and kinematics are programmed separately and independently of cyclic user program.	
Integrated closed-loop control functionality	• PID Compact (continuous PID controller) • PID 3Step (step controller for integrating actuators) • PID Temp (temperature controller for heating and cooling with two separate actuators)	PID control Function Manual (https://support.industry.siemens.com/cs/ww/en/view/108210036)
Integrated safety		
Know-how protection	The know-how protection protects user blocks against unauthorized access and modifications.	ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)
Copy protection	Copy protection links user blocks to the serial number of the SIMATIC Memory Card or to the serial number of the CPU. User programs cannot run without the corresponding SIMATIC Memory Card or CPU.	
Local user management (as of FW version V3.1)	Improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC). You can used the local user management in the editor to manage all project users along with their rights (e.g. access rights) for users and roles of the project in the TIA Portal.	
Access protection (up to FW version V3.0)	You can use authorization levels to assign separate rights to different user groups.	
Integrity protection	The CPUs feature an integrity protection function by default. This helps to detect any manipulation of the engineering data on the SIMATIC Memory Card or during data transfer between the TIA Portal and the CPU, and to check communication from a SIMATIC HMI system to the CPU for possible manipulation of engineering data. The user receives a corresponding message about manipulation of engineering data detected by the integrity protection.	
Password provider	As an alternative to manual password input you can connect a password provider to STEP 7. A password provider offers the following advantages: • Convenient handling of passwords. STEP 7 reads the password automatically for the blocks. This saves you time. • Optimum block protection because the users do not know the password itself.	

3.4 Operator controls and display elements

3.4.1 Front view of the module

The figure shows the CPU 1514SP T-2 PN.

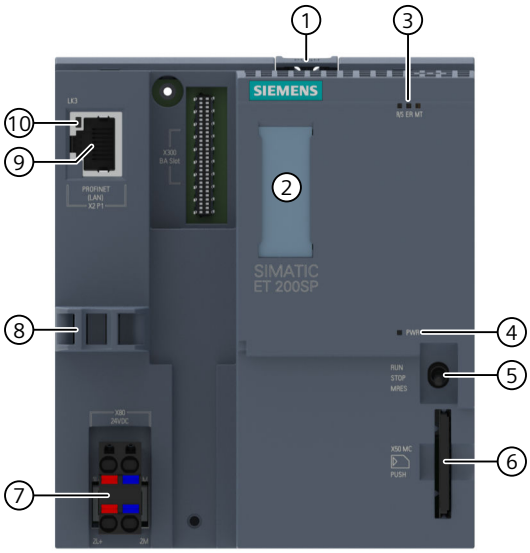

① Mounting rail release
② Labeling strips
③ LEDs for status and error displays
④ LED for display of the supply voltage
⑤ Mode switch
⑥ Slot for the SIMATIC memory card
⑦ Connection for supply voltage (included in product package)
⑧ Cable support and attachment for port P3 of the PROFINET interface
⑨ Port P1 of the PROFINET interface X2
⑩ LEDs for status displays of the PROFINET interface X2

Figure 2-20 Front view without BusAdapter

Front view with BusAdapter

The figure on the left shows the CPU 1514SP T-2 PN including a plugged BA 2xRJ45 BusAdapter. The BusAdapter is not included in the scope of supply. The figure on the right shows a separate view of the BA 2xRJ45 BusAdapter.

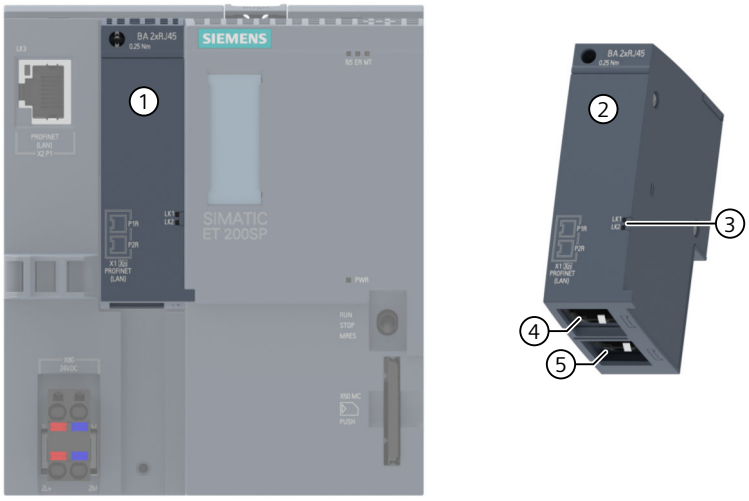

① BusAdapter BA 2xRJ45

② Separate view of the BusAdapter

③ LEDs for status displays of the PROFINET interface: LK1 and LK2 on BusAdapter

④ Port P1R of the PROFINET interface: RJ45 socket on BusAdapter BA 2×RJ45
R: Ring port for configuring a ring topology with media redundancy

⑤ Port P2R of the PROFINET interface: RJ45 socket on BusAdapter BA 2×RJ45
R: Ring port for configuring a ring topology with media redundancy

Figure 2-21 Front view of the CPU 1514SP T-2 PN with BusAdapter BA 2xRJ45

3.5 Mode switch

Use the mode switch to set the CPU operating mode.

The following table shows the position of the switch and the corresponding meaning.

Table 2-16 Mode switch settings

Position	Meaning	Explanation
RUN	RUN mode	The CPU can process the user program.
STOP	STOP mode	The user program is not being executed.
MRES	Memory reset	Position for CPU memory reset.

Connecting

4

This section provides information on the pin assignment of the individual interfaces and the block diagram of the CPU.

24 V DC supply voltage (X80)

The connector for the supply voltage is plugged in when the CPU ships from the factory.

The following table shows the signal names and the descriptions of the pin assignment of the 24 V DC supply voltage.

Table 2-17 Pin assignment 24 V DC supply voltage

View Connector	Signal name [1]		Description
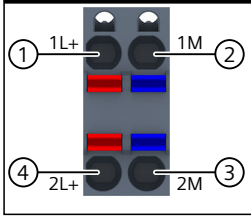	1	1L+	+ 24 V DC of the supply voltage
	2	1M	Ground of the supply voltage
	3	2M	Ground of the supply voltage for loop-through [2]
	4	2L+	+ 24 V DC of the supply voltage for loop-through [2]

[1] 1L+ and 2L+ as well as 1M and 2M are bridged internally

[2] Maximum 10 A permitted

PROFINET IO interface on the CPU (X2 P1)

The assignment corresponds to the Ethernet standard for an RJ45 connector.

- When autonegotiation is deactivated, the RJ45 socket is allocated as a switch (MDI-X).
- If autonegotiation is activated, then autocrossing is active and the RJ45 socket has either a device assignment (MDI) or switch assignment (MDI-X).

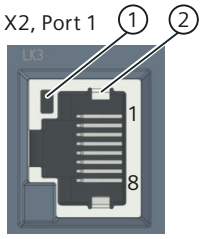

① LINK LED for port X2 P1 (green LED on CPU)

② Shielding

BusAdapter

The following BusAdapters can be selected for use with the CPU :

- BusAdapter BA 2×RJ45
- BusAdapter BA SCRJ/RJ45
- BusAdapter BA LC/RJ45
- BusAdapter BA 2×FC
- BusAdapter BA 2xSCRJ
- BusAdapter BA SCRJ/FC
- BusAdapter BA 2xLC
- BusAdapter BA LC/FC
- BusAdapter BA 2xM12

For more information on the various BusAdapters, please refer to the SIMATIC ET 200SP BusAdapter (https://support.industry.siemens.com/cs/us/en/view/109751716) Equipment Manual.

Reference

You can find more information on the topics of "Connecting the CPU" and "Accessories/spare parts" in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) System Manual.

Assignment of the MAC addresses

The MAC address is a globally unique device identifier that is assigned to each PROFINET device in the factory. Its 6 bytes are divided into 3 bytes for the manufacturer ID and 3 bytes for the device ID (serial number). The front panel of the CPU is lasered with the MAC address of the PROFINET interface.

The PROFINET interface X1 of the CPU has two ports. Ports 1 and 2 are located on the optional BusAdapter. Port 1 of the PROFINET interface X2 is located on the CPU.
In addition to the PROFINET interface, each PROFINET port also has a separate MAC address. There is therefore a total of five MAC addresses for the CPU.

The MAC addresses of the PROFINET ports are needed for the LLDP protocol, for example for the neighborhood discovery function.

The table below shows how the MAC addresses are assigned.

Table 2-18 Assignment of the MAC addresses

	Assignment
MAC address 1	PROFINET interface X1 • Visible in STEP 7 for accessible devices • Lasered on the front of the CPU (start of the number range)
MAC address 2	Port X1 P1R (required for LLDP, for example)

	Assignment
MAC address 3	Port X1 P2R (required for LLDP, for example)
MAC address 4	PROFINET interface X2 • Visible in STEP 7 for accessible devices • lasered on the front of the CPU
MAC address 5	Port X2 P1 (required for LLDP, for example)

Block diagram

The following figure shows the block diagram of the CPU.

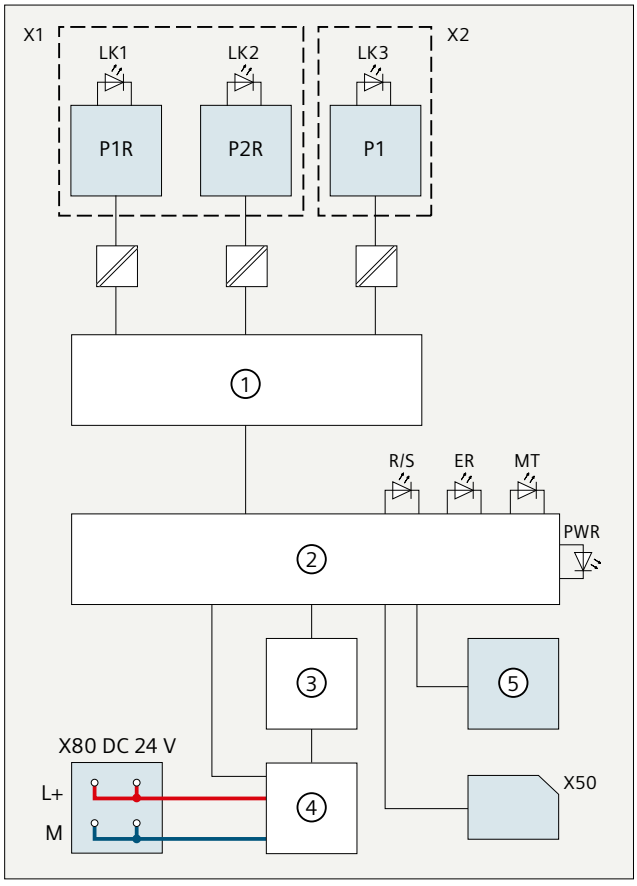

①	PROFINET switch	P1R	PROFINET interface X1 Port 1
②	Electronics	P2R	PROFINET interface X1 Port 2
③	Backplane bus interface	P1	PROFINET interface X2 port 1
④	Internal supply voltage	L+	24 V DC supply voltage
⑤	RUN/STOP/MRES mode selector	M	Ground
X1	BusAdapter	LK1, 2, 3	LED Link TX/RX (green)
X50	SIMATIC Memory Card	R/S	RUN/STOP LED (green/yellow)
X80 24 V DC	Infeed of supply voltage	ER	ERROR LED (red)
		MT	MAINT LED (yellow)
		PWR	POWER LED (green)

Figure 2-22 Block diagram of the CPU

Interrupts, error messages and diagnostics and system alarms

5

5.1 Status and error display of the CPU_Introduction

The status and error displays of the CPU are described below.

You will find additional information on "Interrupts" in the STEP 7 online help.

You can find additional information on the topics of "Diagnostics" and "System alarms" in the Diagnostics (https://support.automation.siemens.com/WW/view/en/59191792) function manual.

5.2 Status and error display of the CPU

LED displays

The figure below shows the LED displays of the CPU and the BA 2xRJ45 BusAdapter.

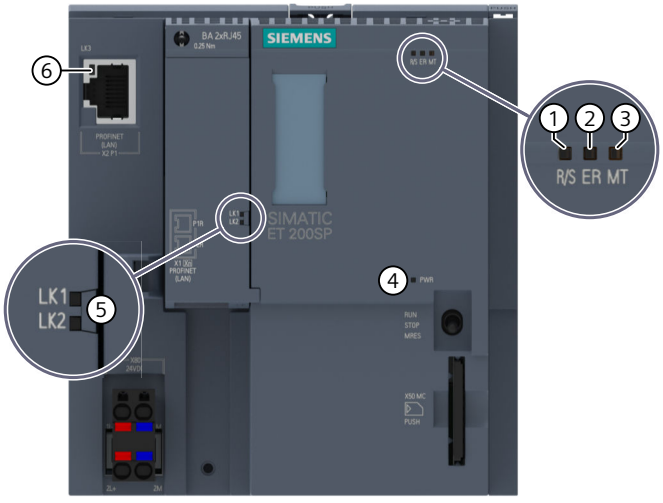

① RUN/STOP LED (green/yellow LED)

② ERROR LED (red LED)

③ MAINT LED (yellow LED)

④ POWER LED (green LED)

⑤ LINK LED for ports X1 P1 and X1 P2 (green LEDs on BusAdapter)

⑥ LINK LED for port X2 P1 (green LED on CPU)

Figure 2-23 LED displays on the CPU and BusAdapter

Meaning of the POWER, RUN/STOP, ERROR and MAINT LEDs

CPU features an LED for monitoring the supply voltage of the electronics (PWR) and three LEDs for displaying the current operating and diagnostics status. The following table shows the meaning of the various combinations of colors for the POWER, RUN/STOP, ERROR and MAINT LEDs.

Table 2-19 Meaning of the LEDs

POWER LED	RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	LED off	Missing or insufficient supply voltage on the CPU.
LED lit green	LED off	LED flashes red	LED off	An error has occurred.
LED lit green	LED lit green	LED off	LED off	CPU is in RUN mode.
LED lit green	LED lit green	LED off	LED lit yellow	Maintenance demanded for the plant. You need to check/replace the affected hardware within a short period of time.
				Active Force job.
				OPC UA server of the CPU expects initial trust lists and CRLs via GDS Push function.
LED lit green	LED lit green	LED flashes red	LED off	A diagnostics event is pending. The CPU is in RUN mode.
LED lit green	LED lit yellow	LED flashes red	LED off	A diagnostics event is pending. The CPU is in STOP mode.
LED lit green	LED lit yellow	LED off	LED flashes yellow	Firmware update using SIMATIC Memory Card successfully completed.
LED lit green	LED lit yellow	LED off	LED off	CPU is in STOP mode.
				CPU runs a program with active breakpoints. The program is at a breakpoint.
LED lit green	LED lit yellow	LED flashes red	LED flashes yellow	The program on the SIMATIC Memory Card is causing an error.
				Firmware update using SIMATIC Memory Card failed.
				The CPU has detected an error state. Additional information is available via the CPU diagnostic buffer.
LED lit green	LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. startup after STOP.
				Download of the user program from the SIMATIC Memory Card
				CPU carries out a program with active breakpoint. The program is presently moving from one breakpoint to another.
				Firmware update is being performed.
LED lit green	LED flashes yellow/green	LED off	LED off	Startup (transition from STOP → RUN)

POWER LED	RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED lit green	LED flashes yellow/green	LED flashes red	LED flashes yellow	Startup (CPU booting)
				LED testing during startup.
				Flash LEDs

Meaning of the LINK LED

Each port has a LINK LED (LK1, LK2, LK3). The table below shows the various "LED scenarios" of ports for the CPU.

Table 2-20 Meaning of the LEDs

LINK LED	Meaning
LED off	There is no Ethernet connection between the PROFINET interface of the PROFINET device and the communication partner. No data is currently being sent/received via the PROFINET interface. There is no LINK connection.
LED flashes green	The CPU is performing an "LED flash test".
LED lit green	There is an Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner.

NOTE

"LED" instruction

You can read the status (e.g. "On" or "Off") of LEDs of a CPU or a module using the "LED" instruction. Note, however, that it is not possible to read the LED status of the LINK RX/TX LEDs on all S7-1500 CPUs.

You can find additional information on the "LED" instruction in the STEP 7 online help.

Technical specifications

6

The following table shows the technical specifications as of 11/2024. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7514-2VN033-0AB0/td?dl=en).

Article number	6ES7514-2VN03-0AB0
General information	
Product type designation	CPU 1514SP T-2 PN
HW functional status	FS04
Firmware version	V4.0
• FW update possible	Yes
Product function	
• I&M data	Yes; I&M0 to I&M3
• Module swapping during operation (hot swapping)	Yes; Multi-hot swapping
• Isochronous mode	Yes; only with PROFINET; with minimum OB 6x cycle of 375 µs
• SysLog	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V20 (FW V4.0) / V18 (FW V3.0) or higher
Configuration control	
via dataset	Yes
Control elements	
Mode selector switch	1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	10 ms
Input current	
Current consumption (rated value)	0.48 A
Current consumption, max.	0.7 A
Inrush current, max.	1.34 A; Rated value
I^2t	0.3 $A^2 \cdot s$
Power	
Infeed power to the backplane bus	8.05 W

Article number	6ES7514-2VN03-0AB0
Power loss	
Power loss, typ.	3.5 W
Memory	
Number of slots for SIMATIC memory card	1
SIMATIC memory card required	Yes
Work memory	
• integrated (for program)	900 kbyte
• integrated (for data)	3.5 Mbyte
Load memory	
• Plug-in (SIMATIC Memory Card), max.	32 Gbyte
Backup	
• maintenance-free	Yes
CPU processing times	
for bit operations, typ.	6 ns
for word operations, typ.	7 ns
for fixed point arithmetic, typ.	9 ns
for floating point arithmetic, typ.	37 ns
CPU-blocks	
Number of elements (total)	8 000; Blocks (OB, FB, FC, DB) and UDTs
DB	
• Number range	1 ... 60 999; subdivided into: number range that can be used by the user: 1 ... 59 999, and number range of DBs created via SFC 86: 60 000 ... 60 999
• Size, max.	3.5 Mbyte; For DBs with absolute addressing, the max. size is 64 KB
FB	
• Number range	0 ... 65 535
• Size, max.	900 kbyte
FC	
• Number range	0 ... 65 535
• Size, max.	900 kbyte
OB	
• Size, max.	900 kbyte
• Number of free cycle OBs	100
• Number of time alarm OBs	20
• Number of delay alarm OBs	20
• Number of cyclic interrupt OBs	20; With minimum OB 3x cycle of 250 µs
• Number of process alarm OBs	50
• Number of DPV1 alarm OBs	3
• Number of isochronous mode OBs	1

Article number	6ES7514-2VN03-0AB0
• Number of technology synchronous alarm OBs	2
• Number of startup OBs	100
• Number of asynchronous error OBs	4
• Number of synchronous error OBs	2
• Number of diagnostic alarm OBs	1
Nesting depth	
• per priority class	24
Counters, timers and their retentivity	
S7 counter	
• Number	2 048
Retentivity	
– adjustable	Yes
IEC counter	
• Number	Any (only limited by the main memory)
Retentivity	
– adjustable	Yes
S7 times	
• Number	2 048
Retentivity	
– adjustable	Yes
IEC timer	
• Number	Any (only limited by the main memory)
Retentivity	
– adjustable	Yes
Data areas and their retentivity	
Retentive data area (incl. timers, counters, flags), max.	512 kbyte; In total; available retentive memory for bit memories, timers, counters, DBs, and technology data (axes): 472 KB
Flag	
• Size, max.	16 kbyte
• Number of clock memories	8; 8 clock memory bit, grouped into one clock memory byte
Data blocks	
• Retentivity adjustable	Yes
• Retentivity preset	No
Local data	
• per priority class, max.	64 kbyte; max. 16 KB per block
Address area	
Number of IO modules	8 192; max. number of modules / submodules

Article number	6ES7514-2VN03-0AB0
I/O address area	
• Inputs	32 kbyte; All inputs are in the process image
• Outputs	32 kbyte; All outputs are in the process image
per integrated IO subsystem	
– Inputs (volume)	8 kbyte
– Outputs (volume)	8 kbyte
per CM/CP	
– Inputs (volume)	8 kbyte
– Outputs (volume)	8 kbyte
Subprocess images	
• Number of subprocess images, max.	32
Address space per module	
• Address space per module, max.	288 byte; For input and output data respectively
Address space per station	
• Address space per station, max.	2 560 byte; for central inputs and outputs; depending on configuration; 2 048 bytes for ET 200SP modules + 512 bytes for ET 200AL modules
Hardware configuration	
Number of distributed IO systems	64; A distributed I/O system is characterized not only by the integration of distributed I/O via PROFINET or PROFIBUS communication modules, but also by the connection of I/O via AS-i master modules or links (e.g. IE/PB-Link)
Number of DP masters	
• Via CM	1
Number of IO Controllers	
• integrated	2
• Via CM	0
Rack	
• Modules per rack, max.	82; CPU + 64 modules + server module (mounting width max. 1 m) + 16 ET 200AL modules
• Quantity of operable ET 200SP modules, max.	64
• Quantity of operable ET 200AL modules, max.	16
• Number of lines, max.	1
PtP CM	
• Number of PtP CMs	the number of connectable PtP CMs is only limited by the number of available slots
Time of day	
Clock	
• Type	Hardware clock

Article number	6ES7514-2VN03-0AB0
• Backup time	6 wk; At 40 °C ambient temperature, typically
• Deviation per day, max.	10 s; Typ.: 2 s
Operating hours counter	
• Number	16
Clock synchronization	
• supported	Yes
• to DP, master	Yes; Via CM DP module
• on DP, device	Yes; Via CM DP module
• in AS, master	Yes
• in AS, device	Yes
• on Ethernet via NTP	Yes
Interfaces	
Number of PROFINET interfaces	2
Number of PROFIBUS interfaces	1; Via CM DP module
Optical interface	No
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; X1 P1 and X1 P2 via BusAdapter BA 2x RJ45
• Number of ports	2; via BusAdapter
• integrated switch	Yes
• BusAdapter (PROFINET)	Yes; compatible BusAdapters: BA 2x RJ45, BA 2x M12, BA 2x FC, BA 2x LC, BA LC/RJ45, BA LC/FC, BA 2x SCRJ, BA SCRJ/RJ45, BA SCRJ/FC
Protocols	
• IP protocol	Yes; IPv4
• PROFINET IO Controller	Yes
• PROFINET IO Device	Yes
• SIMATIC communication	Yes
• Open IE communication	Yes; Optionally also encrypted
• Web server	Yes
• Media redundancy	Yes
PROFINET IO Controller	
Services	
– Isochronous mode	Yes
– Direct data exchange	Yes; Requirement: IRT and isochronous mode (MRPD optional)
– IRT	Yes
– PROFIenergy	Yes; per user program
– Prioritized startup	Yes; Max. 32 PROFINET devices

Article number	6ES7514-2VN03-0AB0
– Number of connectable IO Devices, max.	256; in total, up to 1024 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
– Of which IO devices with IRT, max.	64
– Number of connectable IO Devices for RT, max.	256
– of which in line, max.	256
– Number of IO Devices that can be simultaneously activated/deactivated, max.	8; in total across all interfaces
– Number of IO Devices per tool, max.	8
– Updating times	The minimum value of the update time also depends on communication share set for PROFINET IO, on the number of IO devices, and on the quantity of configured user data
– PROFINET Security Class	1
Update time for IRT	
– for send cycle of 250 µs	250 µs to 4 ms; Note: In the case of IRT with isochronous mode, the minimum update time of 375 µs of the isochronous OB is decisive
– for send cycle of 500 µs	500 µs to 8 ms
– for send cycle of 1 ms	1 ms to 16 ms
– for send cycle of 2 ms	2 ms to 32 ms
– for send cycle of 4 ms	4 ms to 64 ms
– With IRT and parameterization of "odd" send cycles	Update time = set "odd" send clock (any multiple of 125 µs: 375 µs, 625 µs ... 3 875 µs)
Update time for RT	
– for send cycle of 250 µs	250 µs to 128 ms
– for send cycle of 500 µs	500 µs to 256 ms
– for send cycle of 1 ms	1 ms to 512 ms
– for send cycle of 2 ms	2 ms to 512 ms
– for send cycle of 4 ms	4 ms to 512 ms
PROFINET IO Device	
Services	
– Isochronous mode	No
– IRT	Yes
– PROFIenergy	Yes; per user program
– Shared device	Yes
– Number of IO Controllers with shared device, max.	4
– activation/deactivation of I-devices	Yes; per user program
– Asset management record	Yes; per user program
– PROFINET Security Class	SNMP Configuration and DCP Read Only

Article number	6ES7514-2VN03-0AB0
2. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; X2
• Number of ports	1
• integrated switch	No
Protocols	
• IP protocol	Yes; IPv4
• PROFINET IO Controller	Yes
• PROFINET IO Device	Yes
• SIMATIC communication	Yes
• Open IE communication	Yes; Optionally also encrypted
• Web server	Yes
• Media redundancy	No
PROFINET IO Controller	
Services	
– Isochronous mode	No
– Direct data exchange	No
– IRT	No
– PROFIenergy	Yes; per user program
– Prioritized startup	No
– Number of connectable IO Devices, max.	32; in total, up to 1024 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
– Number of connectable IO Devices for RT, max.	32
– of which in line, max.	32
– Number of IO Devices that can be simultaneously activated/deactivated, max.	8; in total across all interfaces
– Number of IO Devices per tool, max.	8
– Updating times	The minimum value of the update time also depends on communication share set for PROFINET IO, on the number of IO devices, and on the quantity of configured user data
– PROFINET Security Class	1
Update time for RT	
– for send cycle of 1 ms	1 ms to 512 ms
PROFINET IO Device	
Services	
– Isochronous mode	No
– IRT	No
– PROFIenergy	Yes; per user program

Article number	6ES7514-2VN03-0AB0
– Prioritized startup	No
– Shared device	Yes
– Number of IO Controllers with shared device, max.	4
– activation/deactivation of I-devices	Yes; per user program
– Asset management record	Yes; per user program
– PROFINET Security Class	SNMP Configuration and DCP Read Only
3. Interface	
Interface types	
• RS 485	Yes; Via CM DP module
• Number of ports	1
Protocols	
• PROFIBUS DP master	Yes
• PROFIBUS DP device	Yes
• SIMATIC communication	Yes
PROFIBUS DP master	
• Number of connections, max.	48; Of which 4 each reserved for ES and HMI
• max. number of DP devices	125; in total, up to 1024 distributed I/O devices can be connected via AS-i, PROFIBUS or PROFINET
Services	
– Equidistance	No
– Isochronous mode	No
– activation/deactivation of DP devices	Yes
Interface types	
RJ 45 (Ethernet)	
• 100 Mbps	Yes
• Autonegotiation	Yes
• Autocrossing	Yes
• Industrial Ethernet status LED	Yes
RS 485	
• Transmission rate, max.	12 Mbit/s
Protocols	
PROFIsafe	No
Number of connections	
• Number of connections, max.	192; via integrated interfaces of the CPU and connected CPs / CMs
• Number of connections reserved for ES/HMI/web	10
• Number of connections via integrated interfaces	128
• Number of connections per CP/CM	32

Article number	6ES7514-2VN03-0AB0
• Number of S7 routing paths	16
Redundancy mode	
• H-Sync forwarding	Yes
Media redundancy	
– Media redundancy	Yes; only via BusAdapter
– MRP	Yes; MRP Automanager according to IEC 62439-2 Edition 2.0, MRP Manager; MRP Client
– MRP interconnection, supported	Yes; as MRP ring node according to IEC 62439-2 Edition 3.0
– MRPD	Yes; Requirement: IRT
– Switchover time on line break, typ.	200 ms; For MRP, bumpless for MRPD
– Number of stations in the ring, max.	50
SIMATIC communication	
• PG/OP communication	Yes; encryption with TLS V1.3 pre-selected
• S7 routing	Yes
• Data record routing	Yes
• S7 communication, as server	Yes
• S7 communication, as client	Yes
• User data per job, max.	See online help (S7 communication, user data size)
Open IE communication	
• TCP/IP	Yes
– Data length, max.	64 kbyte
– several passive connections per port, supported	Yes
• ISO-on-TCP (RFC1006)	Yes
– Data length, max.	64 kbyte
• UDP	Yes
– Data length, max.	2 kbyte; 1 472 bytes for UDP broadcast
– UDP multicast	Yes; max. 118 multicast circuits
• DHCP	Yes
• DNS	Yes
• SNMP	Yes
• DCP	Yes
• LLDP	Yes
• Encryption	Yes; Optional
Web server	
• HTTP	Yes; Standard and user pages
• HTTPS	Yes; Standard and user pages

Article number	6ES7514-2VN03-0AB0
OPC UA	
• Runtime license required	Yes; "Medium" license required
• OPC UA Client	Yes; Data Access (registered Read/Write), Method Call
– Application authentication	Yes
– Security policies	Available security policies: None, Basic128Rsa15, Basic256Rsa15, Basic256Sha256
– User authentication	"anonymous" or by user name & password
– Number of connections, max.	10
– Number of nodes of the client interfaces, recommended max.	2 000
– Number of elements for one call of OPC_UA_NodeGetHandleList/OPC_UA_ReadList/OPC_UA_WriteList, max.	300
– Number of elements for one call of OPC_UA_NameSpaceGetIndexList, max.	20
– Number of elements for one call of OPC_UA_MethodGetHandleList, max.	100
– Number of simultaneous calls of the client instructions for session management, per connection, max.	1
– Number of simultaneous calls of the client instructions for data access, per connection, max.	5
– Number of registerable nodes, max.	5 000
– Number of registerable method calls of OPC_UA_MethodCall, max.	100
– Number of inputs/outputs when calling OPC_UA_MethodCall, max.	20
• OPC UA Server	Yes
– Application authentication	Yes
– Security policies	available security policies: None, Basic128Rsa15, Basic256Rsa15, Basic256Sha256, Aes128Sha256RsaOaep, Aes256Sha256RsaPss
– User authentication	"anonymous" or by user name & password
– GDS support (certificate management)	Yes
– Number of sessions, max.	48
– Number of accessible variables, max.	100 000
– Number of registerable nodes, max.	20 000
– Number of subscriptions per session, max.	50
– Sampling interval, min.	100 ms
– Publishing interval, min.	100 ms

Article number	6ES7514-2VN03-0AB0
– Number of server methods, max.	50
– Number of inputs/outputs per server method, max.	20
– Number of monitored items, recommended max.	4 000; for 1 s sampling interval and 1 s send interval
– Number of server interfaces, max.	10 of each "Server interfaces" / "Companion specification" type and 20 of the type "Reference namespace"
– Number of nodes for user-defined server interfaces, max.	30 000
• Alarms and Conditions	Yes
– Number of program alarms	200
– Number of alarms for system diagnostics	100
Further protocols	
• MODBUS	Yes; MODBUS TCP
S7 message functions	
Number of login stations for message functions, max.	64
number of subscriptions, max.	500
number of tags/attributes for subscriptions, max.	8 000
Program alarms	Yes
Number of configurable program messages, max.	10 000; Program messages are generated by the "Program_Alarm" block, ProDiag or GRAPH
Number of loadable program messages in RUN, max.	10 000
Test commissioning functions	
Joint commission (Team Engineering)	Yes; Parallel online access possible for up to 8 engineering systems
Status block	Yes; Up to 8 simultaneously (in total across all ES clients)
Single step	Yes
Number of breakpoints	8
Profiling	Yes
Status/control	
• Status/control variable	Yes
• Variables	Inputs/outputs, memory bits, DBs, distributed I/Os, timers, counters
• Number of variables, max.	
– of which status variables, max.	200; per job
– of which control variables, max.	200; per job
Forcing	
• Forcing	Yes

Article number	6ES7514-2VN03-0AB0
• Forcing, variables	Peripheral inputs/outputs
• Number of variables, max.	200
Diagnostic buffer	
• present	Yes
• Number of entries, max.	3 200
– of which powerfail-proof	500
Traces	
• Number of configurable Traces	4
• Memory size per trace, max.	512 kbyte
Interrupts/diagnostics/status information	
Diagnostics indication LED	
• RUN/STOP LED	Yes
• ERROR LED	Yes
• MAINT LED	Yes
• Monitoring of the supply voltage (PWR-LED)	Yes
• Connection display LINK TX/RX	Yes
Supported technology objects	
Motion Control	Yes; Note: The number of technology objects affects the cycle time of the PLC program; selection guide via the TIA Selection Tool
• Number of available Motion Control resources for technology objects	2 400
• Required Motion Control resources	
– per speed-controlled axis	40
– per positioning axis	80
– per synchronous axis	160
– per external encoder	80
– per output cam	20
– per cam track	160
– per probe	40
• Number of available Extended Motion Control resources for technology objects	120
• Required Extended Motion Control resources	
– per cam (1 000 points and 50 segments)	2
– per cam (10 000 points and 50 segments)	20
– per cam (50 points and 600 segments)	2
– per cam (50 points and 6 000 segments)	20

Article number	6ES7514-2VN03-0AB0
– for each set of kinematics	30
– per Interpreter	60
– Per leading axis proxy	3
• kinematics functions	
– kinematics with up to 4 interpolating axes	Yes; max. 3D + orientation
– kinematics with 5 or more interpolating axes	No
– user-defined kinematics	No
– SIMATIC Safe Kinematics	No
• Positioning axis	
– Number of positioning axes at motion control cycle of 4 ms (typical value)	11
– Number of positioning axes at motion control cycle of 8 ms (typical value)	20
Controller	
• PID_Compact	Yes; Universal PID controller with integrated optimization
• PID_3Step	Yes; PID controller with integrated optimization for valves
• PID-Temp	Yes; PID controller with integrated optimization for temperature
Counting and measuring	
• High-speed counter	Yes
product functions / security / header	
PROFINET Security Class	1
signed firmware update	Yes
Secure Boot	Yes
safely removing data	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; No condensation
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
configuration / header	
configuration / programming / header	
Programming language	
– LAD	Yes

Article number	6ES7514-2VN03-0AB0
– FBD	Yes
– STL	Yes
– SCL	Yes
– CFC	Yes
– GRAPH	Yes
Know-how protection	
• User program protection/password protection	Yes
• Copy protection	Yes
• Block protection	Yes
Access protection	
• protection of confidential configuration data	Yes
• Protection level: Write protection	Yes
• Protection level: Read/write protection	Yes
• Protection level: Write protection for Failsafe	No
• Protection level: Complete protection	Yes
• User administration	Yes; device-wide and centralized
• Number of users	100
• Number of groups	100
• Number of roles	50
programming / cycle time monitoring / header	
• lower limit	adjustable minimum cycle time
• upper limit	adjustable maximum cycle time
Dimensions	
Width	100 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	265 g

General technical specifications

You can find information on the general technical specifications, such as standards and approvals, electromagnetic compatibility, protection class, etc. in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Dimensional drawing

A

This section contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

Dimension drawing of the CPU

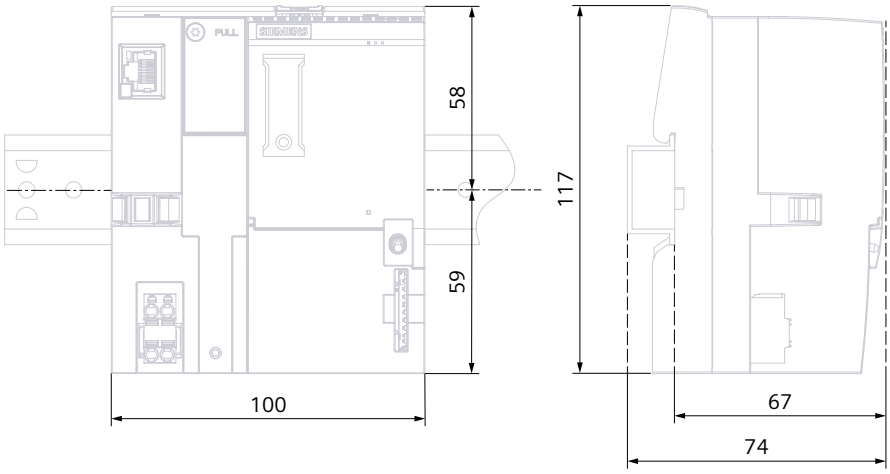

Figure 2-24 Dimension drawing of the CPU

SIEMENS

SIMATIC

ET 200SP Open Controller CPU 1515SP PC (F)

Equipment Manual

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05/2017

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Preface

Purpose of the documentation

This manual supplements the system manual for the ET 200SP distributed I/O system. Functions that generally relate to the system are described in this manual.

The information contained in this product manual and the system / function manuals enable you put the CPU 1515SP PC (F) into operation.

Basic knowledge required

The system must be operated and used by qualified staff only.
The following knowledge is required:

- Installation guideline for SIMATIC ET 200SP
- Programming with STEP 7
- PC based automation with an S7-1500 software controller and with WinCC Runtime Advanced
- Basic knowledge of PC technology
- Windows Embedded Standard 7 operating system

Scope of validity of the documentation

This documentation is valid for the following devices:

ET 200SP Open Controller	Article number	
	System version WES7 E 32Bit 4GB RAM	System version WES7 P 64Bit 4GB RAM
CPU 1515SP PC	6ES7677-2AA31-0EB0	6ES7677-2AA41-0FB0
CPU 1515SP PC + HMI 128PT	--	6ES7677-2AA41-0FK0
CPU 1515SP PC + HMI 512PT	--	6ES7677-2AA41-0FL0
CPU 1515SP PC + HMI 2048PT	--	6ES7677-2AA41-0FM0
CPU 1515SP PC F	6ES7677-2FA31-0EB0	6ES7677-2FA41-0FB0
CPU 1515SP PC F + HMI 128PT	--	6ES7677-2FA41-0FK0
CPU 1515SP PC F + HMI 512PT	--	6ES7677-2FA41-0FL0
CPU 1515SP PC F + HMI 2048PT	--	6ES7677-2FA41-0FM0
CPU 1515SP PC, spare part, without CFast card, without software	6ES7677-2AA40-0AA0	

Conventions

Conventions STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.
- **Forums**

  For answers and solutions concerning automation technology.
- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (http://www.siemens.com/automation/service&support).

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all the products in automation and drives are available on the Internet (https://mall.industry.siemens.com).

Information about third-party software updates

This product contains third-party software. Siemens accepts liability with respect to updates/patches for the third-party software only when these are distributed by Siemens in the context of a Software Update Service contract or officially approved by Siemens. Otherwise, updates/patches are installed at the user's own risk. You can find more information about our software update service offer under (http://w3.siemens.com/mcms/topics/en/simatic/licenses/software-update-service/Pages/Default.aspx).

Notes on protecting administrator accounts

A user with administrator rights has extensive access and manipulation possibilities.

Therefore, make sure that the administrator account is adequately protected to prevent unauthorized changes. To do this, set secure passwords and use a standard user account for regular operation. Other measures, such as the use of security policies, should be applied as required.

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

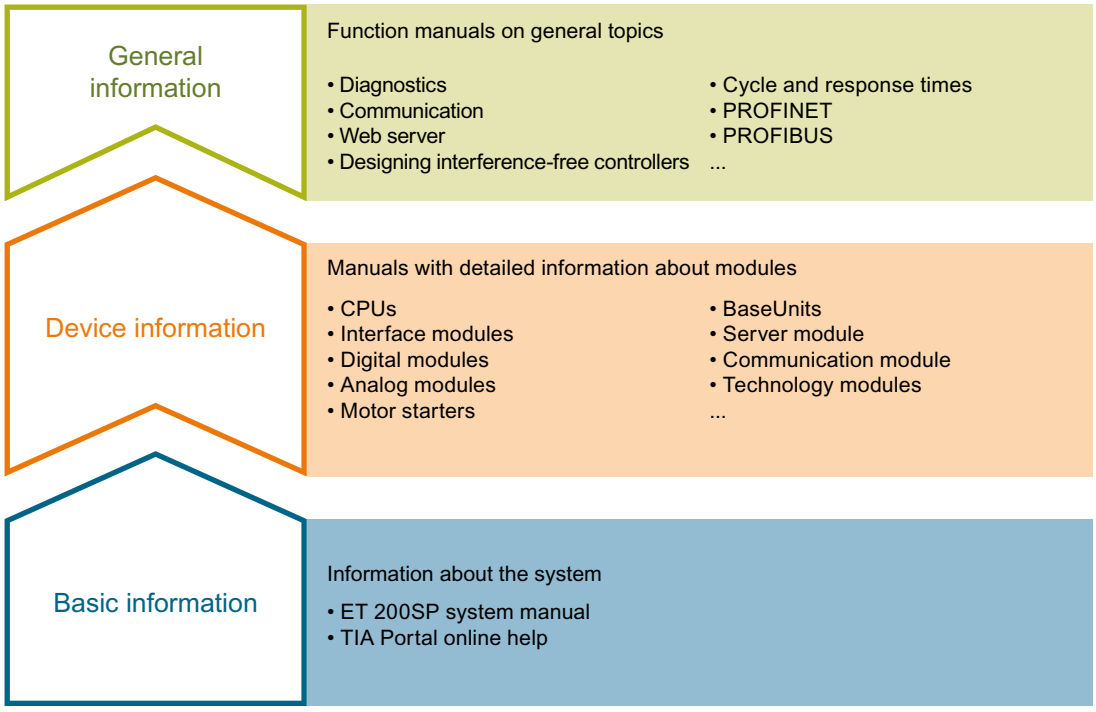

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

1.1 Documentation on CPU 1515SP PC (F)

The following additional documentation is required for using the CPU 1515SP PC (F):

- Operating manual S7-1500 software controller (http://support.automation.siemens.com/WW/view/en/109249299)
- System manual WinCC Advanced V14 (http://support.automation.siemens.com/WW/view/en/109742297)
- System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)
- Manual Server module (http://support.automation.siemens.com/WW/view/en/63257531)

Safety notes 2

WARNING

Life-endangering voltage when control cabinet is open

If the device is installed in a control cabinet, areas or components can be under life-endangering voltage when the control cabinet is open.

Contact with these areas or components may lead to death through electric shock.

Switch off the power before opening the control cabinet.

If the device is operated in a machine in accordance with the machinery directive, the provisions of the guideline 2006/42/EC apply.

Safe operation of a plant

WARNING

Risk of fire

The device is classified for use in the area of Industrial Control Equipment as "Open Type" according to UL508. If overheating occurs, burning material may leak and cause a fire.

For this reason, observe the following information:

- For approval and operation in accordance with UL508, the device must be installed in a housing complying with UL508.
- Install the device in an enclosure that meets the requirements of sections 4.6 and 4.7.3 of the standards EN 60950-1:2006 and IEC/UL/EN/DIN-EN 60950-1.

If you have questions about the validity of installation in the planned environment, please contact our service representatives.

NOTICE

Protective measures

To ensure safe operation of a plant, you have to take suitable IT security measures, for example, network segmentation.

Seal the cover with lead to protect the CFast card with the operating system of the CPU 1515SP PC (F) against unauthorized access.

For more information on Industrial Security, refer to the Internet (http://www.siemens.com/industrialsecurity).

Repairs

⚠ WARNING

Damage caused by opening the device

Unauthorized opening of and improper repairs to the device may result in substantial damage to equipment or endanger the user.

Only authorized personnel are permitted to repair the device.

For additional information on repairs, see section Sending the device to customer service (Page 88).

ESD guidelines

Modules containing electrostatic sensitive devices (ESDs) can be identified by the following label:

Strictly follow the guidelines mentioned below when handling modules which are sensitive to ESD:

- Before working with modules with ESD, you need to ensure that you are free of electrostatic charge (e.g. by touching a grounded object).
- All devices and tools must be free of static charge.
- Always pull the mains connector and disconnect the battery before installing or removing modules which are sensitive to ESD.
- Handle modules fitted with ESDs only by their edges.
- Do not touch any connector pins or conductors on modules containing ESDs.

See also

Electromagnetic compatibility (Page 94)

2.1 Notes on use

WARNING

Hazards at an unprotected machine or plant

According to the results of a risk analysis, hazards can occur at an unprotected machine. The hazards may lead to personal injury.

According to the risk analysis, the risk of injury to persons can be countered with the following measures:

- Additional protective equipment at the machine or plant. In this case, the programming, parameter assignment and wiring of the I/O used, in particular, must be performed in accordance with the safety criteria (SIL, PL or Cat.) ascertained by means of an appropriate risk analysis.
- Use of the device for its intended purpose, which can be established by performing a functional test on the plant. This allows errors in programming, parameter assignment and wiring to be detected.
- Documentation of the test results which can be entered, if required, into the relevant safety certificates.

NOTICE

Ambient conditions

Ambient conditions for which the device is not suitable can lead to faults or damage the device.

Note the following:

- Only operate the device in enclosed areas. If you do not comply with this instruction, the warranty becomes void.
- Only operate the device in accordance with the ambient conditions given in the technical specifications.
- Protect the device from dust, moisture and heat.
- Do not expose the device to direct sunlight or other strong sources of light.
- The device must not be used in places with more difficult operating conditions through corrosive vapors or gases without taking additional protective measures, for example, supply of clean air.

Product overview

3

3.1 Fail-safe option

Areas of application

F-CPUs are mainly designed for personal and machine protection. In addition to the safety program, you can also program standard applications. You can operate the F-CPUs in safety mode or in standard mode.

Reference

Information on the use of F-CPUs in safety mode is available in the programming and operating manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).

You can find information on using the CPU 1505SP (F) software controller in the corresponding product manual (https://support.industry.siemens.com/cs/ww/en/view/109740725) and in the F product information (https://support.industry.siemens.com/cs/ww/en/view/109478599).

3.2 Properties

Article number

6ES7677-2xAxx-0xx0

The complete article number depends on the system version and the ordering option.

View of the module

The figure below shows the CPU 1515SP PC.

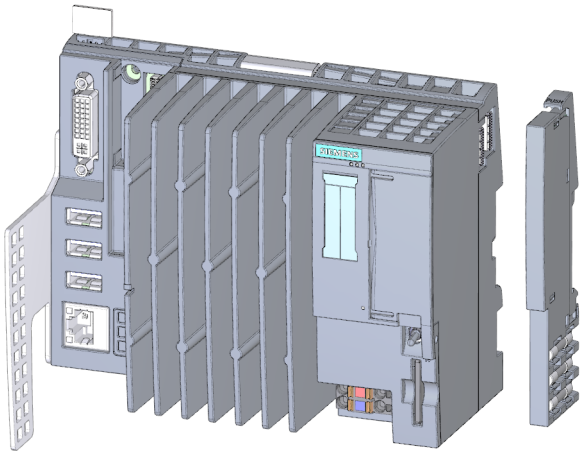

Figure 2-25 CPU 1515SP PC with supplied accessories

Properties

CPU 1515SP PC (F) is a PC based automation device in the design of the ET 200SP. It is used for control and visualization purposes. The supplied IPC DiagBase software provides basic diagnostics functions and supports you in handling the BIOS.

CPU 1515SP PC (F) has the following technical properties:

- A removable CFast card with the following pre-installations is used as storage medium:
  - Windows Embedded Standard 7 operating system
  - S7-1500 Software Controller CPU 1505SP (F)
  - Optionally with HMI: WinCC Runtime Advanced as of V14 SP1
- Interfaces
  - An interface for the exchangeable ET 200SP BusAdapters for connection of PROFINET IO (2 ports)
  - An interface for connecting devices using Industrial Ethernet (Gigabit Ethernet)
  - 3 interfaces for USB devices
  - One DVI-I interface for a monitor
  - A sealable slot for the CFast card
  - A slot for an SD/MMC card as additional optional drive
- Supply voltage 1L+ 24 V DC (SELV/PELV). The connection plug is included in the scope of delivery.
- CPU 1515SP PC (F) is designed for use in industrial environment:
  - Compact design
  - Fan-less operation
  - High robustness
- The CPU 1515SP PC (F) is approved for the degree of protection IP20 and for the installation in a control cabinet.

System versions and ordering options

System version	SIMATIC software	CFast card	Article number
WES7 E 32Bit	CPU 1505SP V2.1	30 GB	6ES7677-2AA31-0EB0
WES7 P 64Bit (multitouch functionality)	CPU 1505SP V2.1	30 GB	6ES7677-2AA41-0FB0
	CPU 1505SP V2.1 & WinCC Runtime Adv. V14 SP1 128PT	30 GB	6ES7677-2AA41-0FK0
	CPU 1505SP V2.1 & WinCC Runtime Adv. V14 SP1 512PT	30 GB	6ES7677-2AA41-0FL0
	CPU 1505SP V2.1 & WinCC Runtime Adv. V14 SP1 2048PT	30 GB	6ES7677-2AA41-0FM0
WES7 E 32Bit	CPU 1505SP F V2.1	30 GB	6ES7677-2FA31-0EB0
WES7 P 64Bit (multitouch functionality)	CPU 1505SP F V2.1	30 GB	6ES7677-2FA41-0FB0
	CPU 1505SP F V2.1 & WinCC Runtime Adv. V14 SP1 128PT	30 GB	6ES7677-2FA41-0FK0

System version	SIMATIC software	CFast card	Article number
WES7 P 64Bit (multitouch functionality)	CPU 1505SP F V2.1 & WinCC Runtime Adv. V14 SP1 512PT	30 GB	6ES7677-2FA41-0FL0
	CPU 1505SP F V2.1 & WinCC Runtime Adv. V14 SP1 2048PT	30 GB	6ES7677-2FA41-0FM0
CPU 1515SP PC, spare part, without CFast card, without software			6ES7677-2AA40-0AA0

3.3 Sample configuration

Configuration

CPU 1515SP PC (F) is mounted on the mounting rail according to EN 60715. A modular system is formed with ET 200SP modules in the central rack.

You can use the CPU 1515SP PC (F) as PROFINET IO controller. The PROFINET IO devices are connected with the SIMATIC BusAdapter BA 2xRJ45 via the ports of the interface X1 PN (LAN).

Devices can be connected via Industrial Ethernet using the integrated interface X2 PN/IE (LAN).

The connection to PROFIBUS can be made using the DP master module.

Sample configuration

The figure below shows an example configuration with CPU 1515SP PC (F).

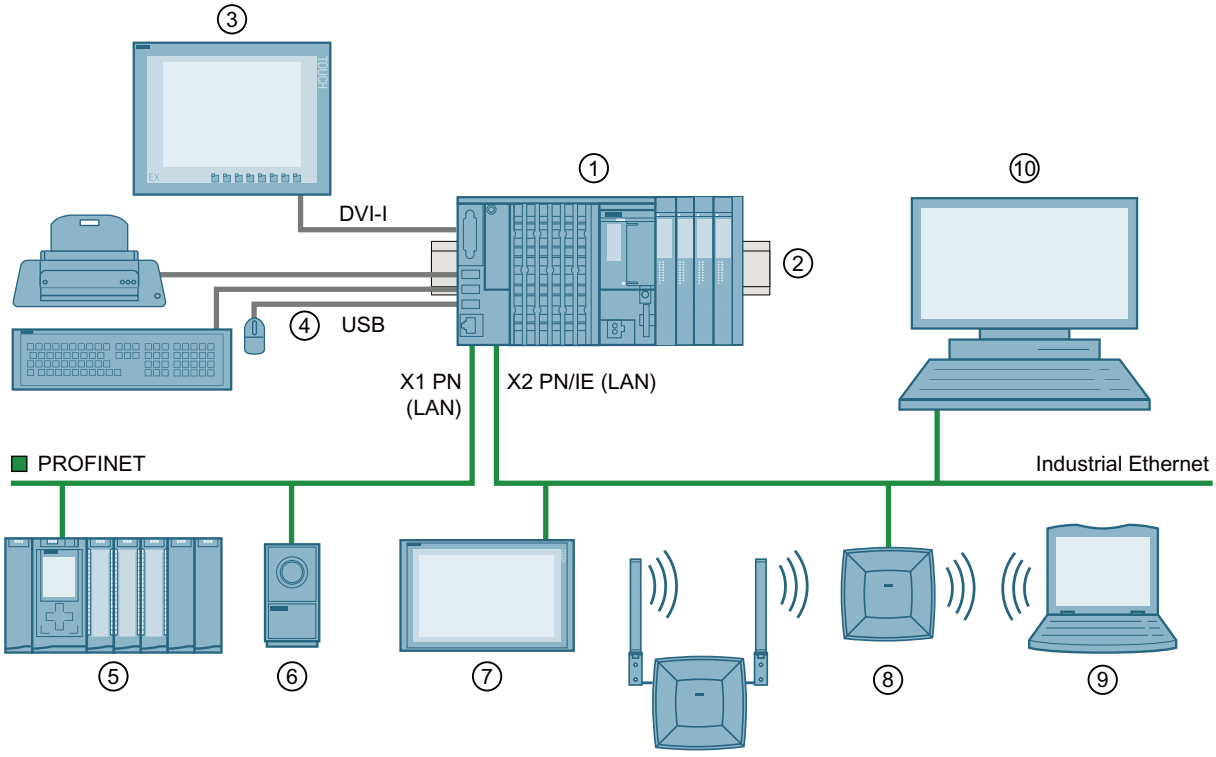

Figure 2-26 Example configuration with the CPU 1515SP PC (F)

① CPU 1515SP PC (F), I/O module, server module

② Mounting rail

③ Flat Panel - Wide Screen Display

④ USB devices: Keyboard, mouse, printer ...

⑤ PROFINET IO device

⑥ Camera

⑦ Industrial Thin Client ITC

⑧ SCALANCE W786

⑨ Field programming device

⑩ PC/Programming device

3.4 Components

Components of the CPU 1515SP PC (F)

The table below contains an overview of the components of the CPU 1515SP PC (F):

Table 2-21 Components of the CPU 1515SP PC

Component	Function	Figure
Mounting rail in accordance with EN 60715	The mounting rail is the module carrier for the CPU 1515SP PC (F).	
CPU 1515SP PC (F)	CPU with strain relief and white reference labels	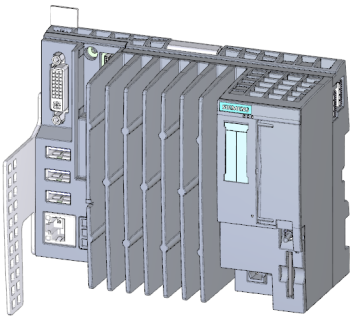
BusAdapter	The BusAdapter allows free selection of the connection technology for PROFINET IO. The following versions are available for CPU 1515SP PC (F): • For standard RJ45 plug (BA 2×RJ45) ① • For direct connection of the bus cable (BA 2×FC) ②	① ② 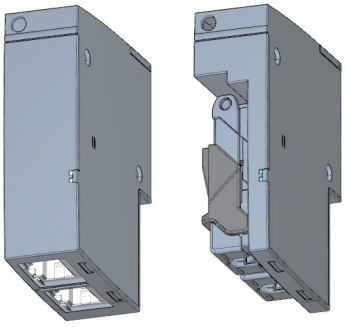
Server module	The server module completes the configuration of the CPU 1515SP PC (F) with I/O modules. The server module is included in the CPU's scope of delivery.	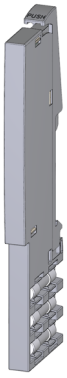

3.5 Configuration of the devices

Front view

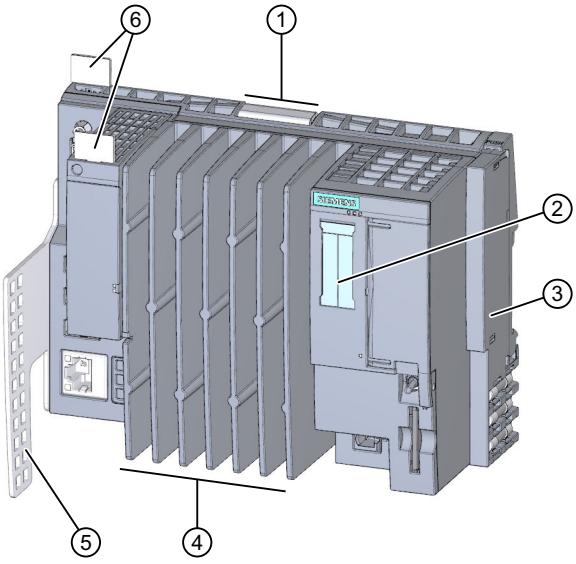

Figure 2-27 Front view CPU 1515SP PC (F)

① Mounting rail release mechanism

② Labeling strips

③ Server module

④ Cooling fins

⑤ Strain relief

⑥ Reference labels

3.6 Operator controls and display elements

Front view of the module

The figure below shows the operator control and connection elements of the CPU 1515SP PC (F).

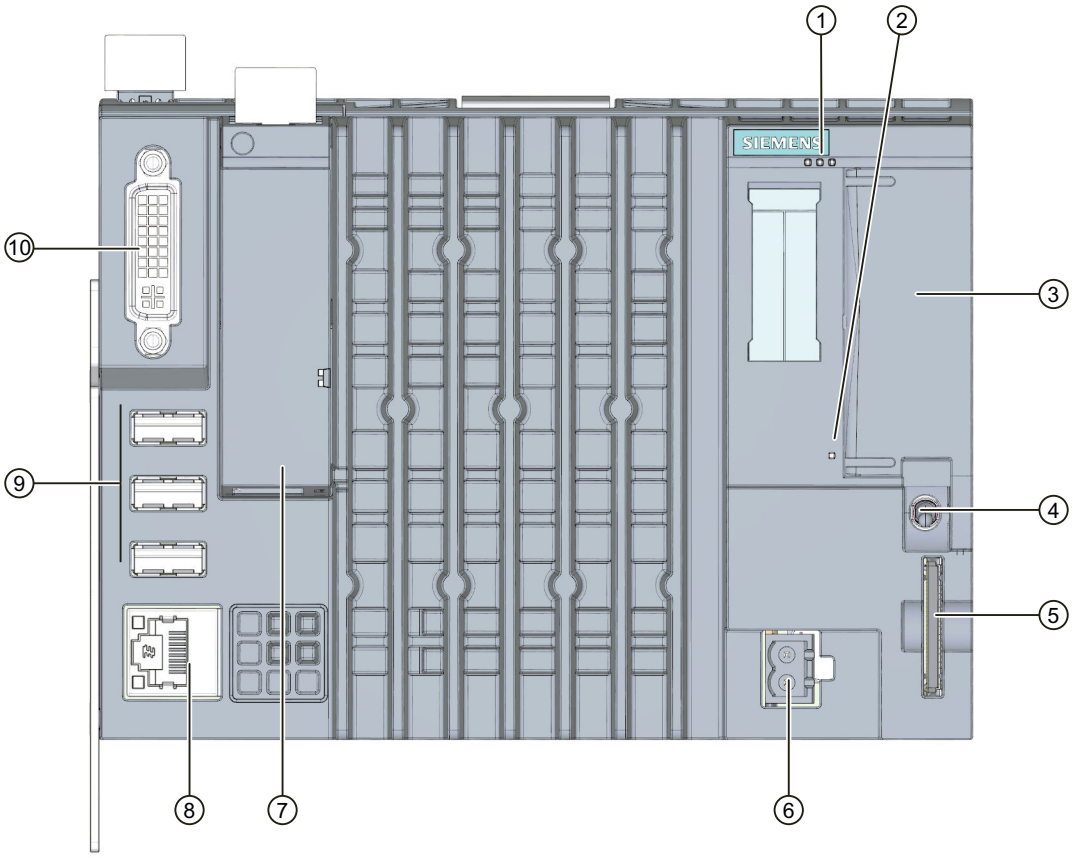

Figure 2-28 View of the CPU 1515SP PC (F)

1	LED displays for the current operating mode and diagnostic status of the CPU	
2	Power LED	
3	**X50:**	Slot for the CFast card (flash memory), sealable
4	Mode selector	
5	**X51:**	Slot for an optional SD/MMC card
6	**X80:**	Connector for 24 V DC supply voltage
7	**X1 PROFINET (LAN):**	Slot for BusAdapter for connection of PROFINET IO; status display for PROFINET

⑧ **X2 PN/IE (LAN):** GbE Ethernet connection with integrated display

⑨ **X60, X61, X62:** 3 USB connections

⑩ **X70 DVI-I:** Connection for monitor

Slot for CFast card

The operating system, Runtime software and project are installed on the supplied SIMATIC CFast card. The CFast card is the only mass storage device of the CPU 1515SP PC (F).

NOTE

Unauthorized access

Seal the cover of the shaft with lead to protect the CFast card with the operating system of the CPU 1515SP PC (F) against unauthorized access and manipulation.

Slot for SD/MMC card

You can use a SIMATIC SD or MMC card as additional storage drive. This drive can be used to store data via Windows, for example a backup, but not the operating system, the Runtime software or the project.

Permitted SD cards: SDHC up to 32 GB, SDXC up to 2 TB.

USB connections

Two USB high-current (500 mA) interfaces and one low-current (100 mA) interface can be used at the same time.

MAC addresses

The MAC address consists of a 3-byte manufacturer ID and a 3-byte device ID (consecutive number).

Each device is already assigned four MAC addresses in the factory. The front of the CPU 1515SP PC (F) is lasered with the MAC addresses 1 and 4. With the MAC addresses 2 and 3, the consecutive numbers are incremented. If, for example, the first MAC address is 08-00-06-6B-80-C0, the second MAC address is 08-00-06-6B-80-C1.

Table 2-22 Assignment of the MAC addresses

	Assignment
MAC address 1	X2 PN/IE (LAN) • Visible in STEP 7 for accessible devices • Lasered on the front of the CPU (start of the number range)
MAC address 2	X1 PROFINET (LAN) • Visible in STEP 7 for accessible devices
MAC address 3	Port X1 P1 (required for LLDP, for example)
MAC address 4	Port X1 P2 R (required for LLDP, for example) • Lasered on the front of the CPU (end of the number range)

Connector for supply voltage

CPU 1515SP PC (F) has a 2-pole terminal for the power supply.

The connection plug for the supply voltage is plugged in when the CPU is shipped from the factory.

Mode selector

Use the mode selector to set the CPU operating mode.

Table 2-23 Mode selector positions

Position	Meaning	Description
RUN	Operating mode RUN[1]	The CPU is processing the user program.
STOP	Operating mode STOP[1]	The CPU is not processing the user program. The outputs are set to a "safe" state.
MRES	Memory reset	**For active S7-1500 software controller**[2] only: CPU memory reset

1 RUN and STOP indicate the **selected** operating state. The LED displays RUN and STOP display the **actual** operating state of the CPU 1515SP PC (F).

2 See the S7-1500 software controller manual

3.7 Scope of delivery

3.7.1 Unpacking the device

When unpacking

When unpacking, make sure to check the following:

- Check packaging and contents for visible damage from transport.
- Check the delivery for completeness.
  Please inform your Siemens contact partner should you determine damages from transport or any irregularities.
- Keep the supplied documentation and licenses. They belong to the device and are the proof that you have purchased the software preinstalled on the CFast card.
  Documentation and licenses are required for initial commissioning and for any questions that arise.
- Keep the original packaging in case the device needs to be transported again.

NOTICE
Damage to the device during transport and storage If a device is transported or stored without packaging, it is unprotected from shocks, vibrations, pressure and moisture. Damaged packaging indicates that environmental conditions have already had a significant impact on the device. The device might be damaged. Do not dispose of the original packaging. Pack the device for transport and storage.

NOTICE
Damage to the device caused by condensation If the device was exposed to low temperatures or extreme variations in temperature during transport, this may cause moisture to build up on or in the device (condensation). Moisture can cause short-circuits in the electrical circuits and damage the device. Proceed as follows to avoid damage: • Store the device in dry conditions. • Make sure it adapts to room temperature before commissioning. • Do not expose the device to direct heat radiation from a heater. • If condensation has developed, wait for approximately 12 hours or until the device is completely dry before you switch it on.

WARNING

Electric shock and fire hazard from damaged device

A damaged device can carry dangerous voltage and trigger a fire in the machine or plant. A damaged device has unpredictable properties and states.

Death or severe injury could occur.

Make sure that the damaged device is not installed and commissioned accidentally. Label the damaged device correspondingly and keep it locked up. Have the device repaired without delay.

Identification data

The identification data can be used to clearly identify the device when a repair is necessary.

Make a note of the following data for your devices:

- The article number of the CPU 1515SP PC (F) is located on the order form.
- Depending on the scope of delivery, the "Certificate-of-License" is included in the license verification for the S7-1500 software controller and for WinCC Runtime Advanced V14 SP1.
- The "Microsoft Windows Product Key" can be found on the "Certificate of Authenticity" label.
- The first and the last MAC addresses are located on the device.

3.7.2 Scope of delivery - System version WES7 E 32Bit 4GB RAM

NOTE

The designation **CPU 1515SP PC** with the article number 6ES7677-**2AA40-0AA0** is always on the device regardless of the order option.

The following components are included in the scope of delivery of the CPU 1515SP PC:

Order option	**CPU 1515SP PC**	**CPU 1515SP PC (spare part)**
Article number	6ES7677-2AA31-0EB0	6ES7677-2AA40-0AA0
CPU	X	X
Strain relief with fixing screws	X	X
Server module	X	X
30 GB CFast card with the following pre-installations:		
• Windows Embedded Standard 7 E operating system	X	–
• S7-1500 Software Controller CPU 1505SP	X	–
• WinCC RT Advanced as of V14 SP1	–	–

Order option	CPU 1515SP PC	CPU 1515SP PC (spare part)
Restore DVD for image restore	X	–
"Documentation and Drivers" DVD	X	–
Windows-Certificate of Authenticity (CoA)	X	–
Certificate of License (COL)	X	–
USB stick with SIMATIC license keys	X	–
Product information	X	–

The following components are contained in the scope of delivery of the CPU 1515SP PC F:

Order option	CPU 1515SP PC F
Article number	6ES7677-2FA31-0EB0
CPU	X
Strain relief with fixing screws	X
Server module	X
30 GB CFast card with the following pre-installations:	
• Windows Embedded Standard 7 E operating system	X
• S7-1500 Software Controller CPU 1505SP F	X
• WinCC RT Advanced as of V14 SP1	–
Restore DVD for image restore	X
"Documentation and Drivers" DVD	X
Windows-Certificate of Authenticity (CoA)	X
Certificate of License (COL)	X
USB stick with SIMATIC license keys	X
Product information	X

3.7.3 Scope of delivery - System version WES7 P 64Bit 4GB RAM

NOTE

The designation **CPU 1515SP PC** with the article number 6ES7677-**2AA40-0AA0** is always on the device regardless of the order option.

The following components are included in the scope of delivery of the CPU 1515SP PC:

Order option	CPU 1515SP PC	CPU 1515SP PC + HMI	CPU 1515SP PC (spare part)
Article number	6ES7677-2AA41-0FB0	6ES7677-2AA41-0FK0 HMI 128PT 6ES7677-2AA41-0FL0 HMI 512PT 6ES7677-2AA41-0FM0 HMI 2048PT	6ES7677-2AA40-0AA0
CPU	X	X	X

Order option	CPU 1515SP PC	CPU 1515SP PC + HMI	CPU 1515SP PC (spare part)
Strain relief with fixing screws	X	X	X
Server module	X	X	X
30 GB CFast card with the following pre-installations:			
• Windows Embedded Standard 7 P operating system	X	X	–
• S7-1500 Software Controller CPU 1505SP	X	X	–
• WinCC RT Advanced as of V14 SP1	–	X	–
Restore DVD for image restore	X	X	–
"Documentation and Drivers" DVD	X	X	–
Windows Certificate of Authenticity (CoA)	X	X	–
Certificate of License (CoL)	X	X	–
USB stick with SIMATIC license keys	X	X	–
Product information	X	X	–

The following components are contained in the scope of delivery of the CPU 1515SP PC F:

Order option	CPU 1515SP PC F	CPU 1515SP PC F + HMI
Article number	6ES7677-2FA41-0FB0	6ES7677-2FA41- • 0FK0 HMI 128PT • 0FL0 HMI 512PT • 0FM0 HMI 2048PT
CPU	X	X
Strain relief with fixing screws	X	X
Server module	X	X
30 GB CFast card with the following pre-installations:		
• Windows Embedded Standard 7 P operating system	X	X
• S7-1500 Software Controller CPU 1505SP F	X	X
• WinCC RT Advanced as of V14 SP1	–	X
Restore DVD for image restore	X	X
"Documentation and Drivers" DVD	X	X
Windows Certificate of Authenticity (CoA)	X	X

Order option	CPU 1515SP PC F	CPU 1515SP PC F + HMI
Certificate of License (CoL)	X	X
USB stick with SIMATIC license keys	X	X
Product Information	X	X

Installing

4

4.1 Basics

Introduction

The CPU 1515SP PC (F) is an open operation resource. This means that you may only install it in enclosures, cabinets or electrical operating areas. These housings, cabinets or electrical operating areas must only be accessible with a key or tool. Access may only be possible for instructed or authorized personnel.

Installation location

CPU 1515SP PC (F) must be installed in a suitable enclosure or suitable control cabinet with at least IP54 degree of protection according to EN 60529 and the ambient conditions for the operation of the equipment must be taken into consideration.

Installation position

You can install the ET 200SP distributed I/O system in any position. The preferred mounting position is horizontal mounting on a vertical wall.

The restrictions regarding ambient temperature and maximum configuration apply to the CPU 1515SP PC (F) depending on the mounting position.

NOTICE
Damage to the modules Modules can be damaged if exposed to ambient temperatures higher than permitted. The following ambient temperatures must not be exceeded during operation: • Horizontal mounting – 60 °C for an installation with up to 32 I/O modules. – 55 °C for an installation with up to 64 I/O modules. • Vertical mounting – 50 °C for an installation with up to 32 I/O modules.

For more detailed information, refer to section Mechanical and climatic ambient conditions (Page 97)

Mounting rail

CPU 1515SP PC (F) is mounted on a mounting rail according to EN 60715 (35 × 7.5 mm and/or 35 × 15 mm).

You must ground the mounting rail separately in the control cabinet. Exception: If you install the rail on grounded, zinc-plated mounting plates, there is no need to ground the rail separately.

NOTE

If the ET 200SP distributed I/O system is exposed to vibration and shock loads, both ends of the ET 200SP system assembly must be mechanically fixed to the mounting rail (e.g using 8WA1010-1PH01 ground terminals). This measure prevents the ET 200SP from shifting to the side.

NOTE

If the ET 200SP distributed I/O system is exposed to high vibration and shock load, we recommend that you screw the mounting rail to the mounting surface at intervals of approx. 200 mm.

Suitable surface finishes are:

- Steel strip in accordance with Appendix A of EN 60715 or
- Tinned steel strip. We recommend the use of the mounting rails in section Accessories/spare parts (Page 120).

NOTE

Mounting rails of other manufacturers

If you use mounting rails from other manufacturers, ensure that they have the properties required for your climatic and mechanical ambient conditions.

Check whether the mounting rails meet the requirements for a protective conductor.

Minimum clearances

Maintain the following minimum clearances when installing or dismantling the CPU 1515SP PC (F).

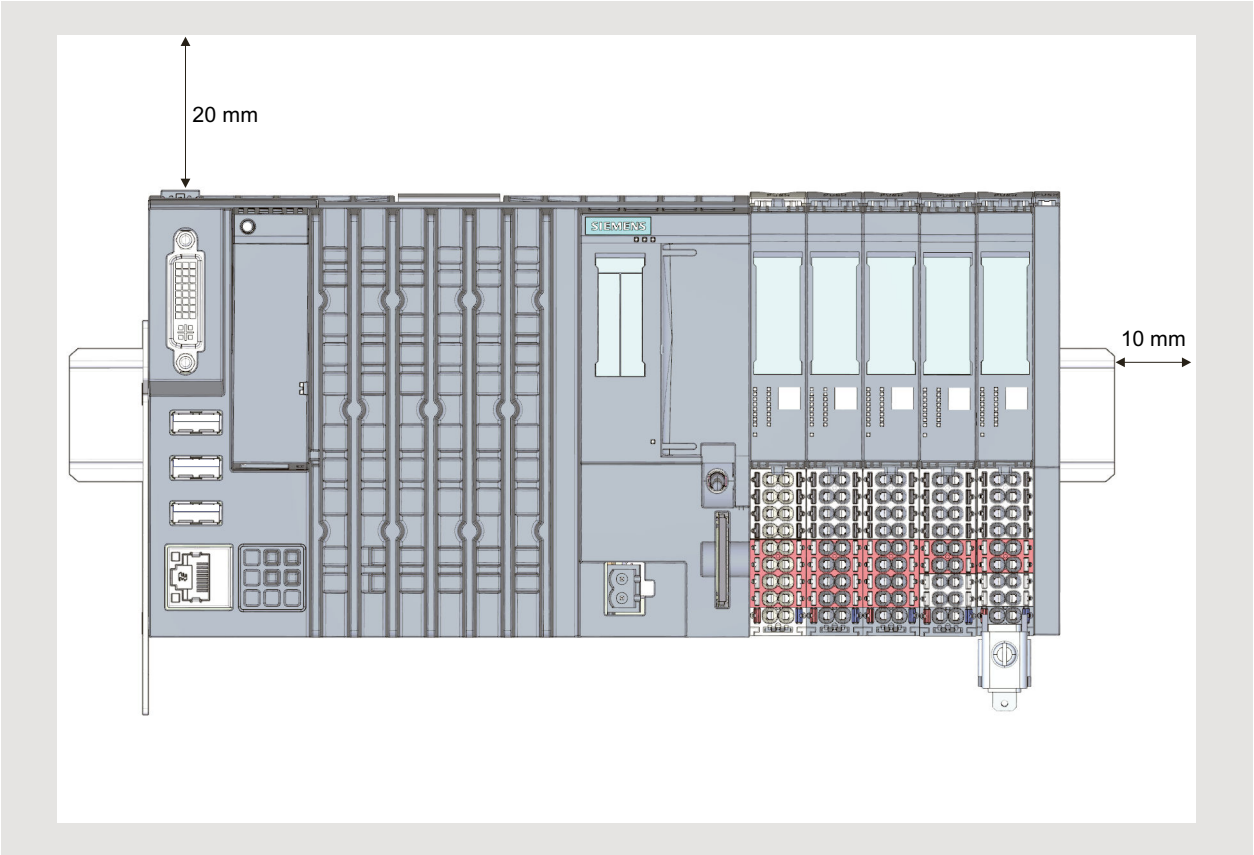

Figure 2-29 Minimum clearances

Installation rules

- After the CPU 1515SP PC (F) there is a BaseUnit BU..D with incoming supply voltage L+ (light terminal box).
- This is followed by BaseUnits BU..B (with dark-colored terminal box).
- The respective corresponding I/O modules can be connected to the BaseUnits. Suitable combinations of BaseUnits and I/O modules can be found in the ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/84133942).
- The server module completes the installation.

NOTE

Only install the CPU 1515SP PC (F) when the power supply is switched off.

4.2 Hardware configuration

Maximum mechanical configuration

As soon as one of the following rules applies, the maximum configuration has been reached:

Table 2-24 Maximum mechanical configuration

Properties	Rule
Number of modules	• Horizontal mounting – 0 to 60 °C ambient temperature: a maximum of 32 I/O modules **and** USB load – 0 to 55 °C ambient temperature: a maximum of 64 I/O modules **and** USB load • Vertical mounting – 0 to 50 °C ambient temperature: a maximum of 32 I/O modules **and** USB load
Backplane bus length	Maximum 1 m mounting width (without CPU 1515SP PC (F), including server module)

Electrical maximum configuration

The number of operable I/O modules of a potential group is limited by the

- Power consumption of the I/O modules
- Power consumption of the components supplied via these I/O modules

The maximum current-carrying capability of the terminals on the BaseUnit L+/ground is 10 A.

USB load

In case of maximum configuration with the CPU 1515SP PC (F), the USB load must also be taken into consideration:

- Horizontal mounting
  - Ambient temperature of 0 to 60 °C with maximum 32 I/O modules **and** 3 x 100 mA USB load
  - Ambient temperature of 0 to 55 °C with maximum 64 I/O modules **and** 2 x 500 mA + 1 x 100 mA USB load
- Vertical mounting
  - Ambient temperature of 0 to 50 °C with maximum 32 I/O modules **and** 3 x 100 mA USB load

Address space

The address space is predefined. However, you can adjust the address space in the user program.

4.3 Installing CPU 1515SP PC (F)

Requirements

The mounting rail is fitted.

Required tools

3 to 3.5 mm screwdriver (only to fix the strain relief and dismantle the BusAdapter)

Fixing strain relief

Fasten the strain relief at the upper and lower left side of the CPU 1515SP PC (F) with the supplied screws.

Installing CPU 1515SP PC (F)

1. Install the CPU on the mounting rail.
2. Swivel the CPU back until you hear the mounting rail release click into place
3. To check that the CPU has correctly clicked into place, pull on the underside of the enclosure.

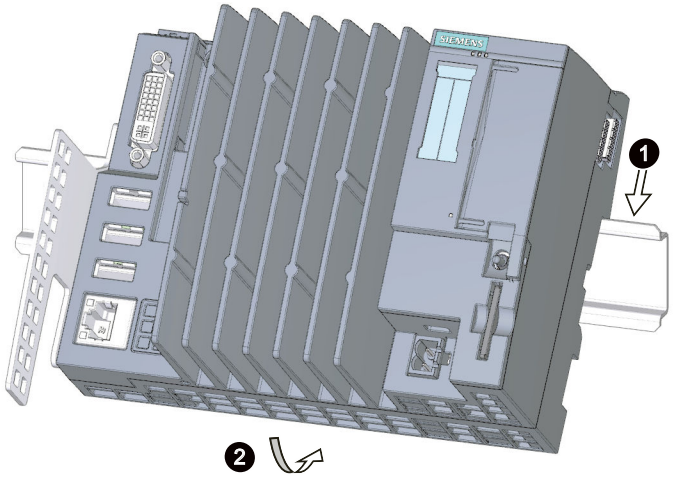

Figure 2-30 Installing CPU 1515SP PC (F)

Disassemble CPU 1515SP PC (F)

The BaseUnits with the I/O modules are located to the left of the CPU 1515SP PC (F):

1. Switch off the supply voltage on the CPU.
2. Press the mounting rail release button on the first BaseUnit and, at the same time, move the CPU in parallel to the left until it comes off the remaining the module group.

   Note: The mounting rail release button is located above the CPU.
3. While pressing the mounting rail release button on the CPU, swivel the CPU out of the mounting rail.

NOTE

It is not necessary to remove the BusAdapter from the CPU 1515SP PC (F).

Connection 5

5.1 Notes on connection

NOTE

Rules and regulations for operation

Observe the information contained in the *Wiring* section in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) and in the function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566).

NOTICE

Fault caused by I/O devices

The connection of I/O devices can lead to faults on the device.

Injury to persons and damage to the machine or plant could result.

Note the following when connecting I/O devices:

- Read the documentation related to the I/O devices. Follow all instructions given in the documentation.
- Only connect I/O devices which are suitable for use in industrial environments according to EN 61000-6-2/EC 61000-6-2.
- You may only connect hot-plug capable I/O devices when the power supply is switched off.

NOTE

Feedback through USB devices

If USB devices are connected which - contrary to the USB 2.0 specification - feed voltage back to the host interface, the startup of the CPU 1515SP PC (F) is not ensured upon power-up.

Regenerative feedback is generally not permitted.

5.2 Terminal and block diagram

Block diagram

The figure below shows the block diagram of the CPU 1515SP PC (F).

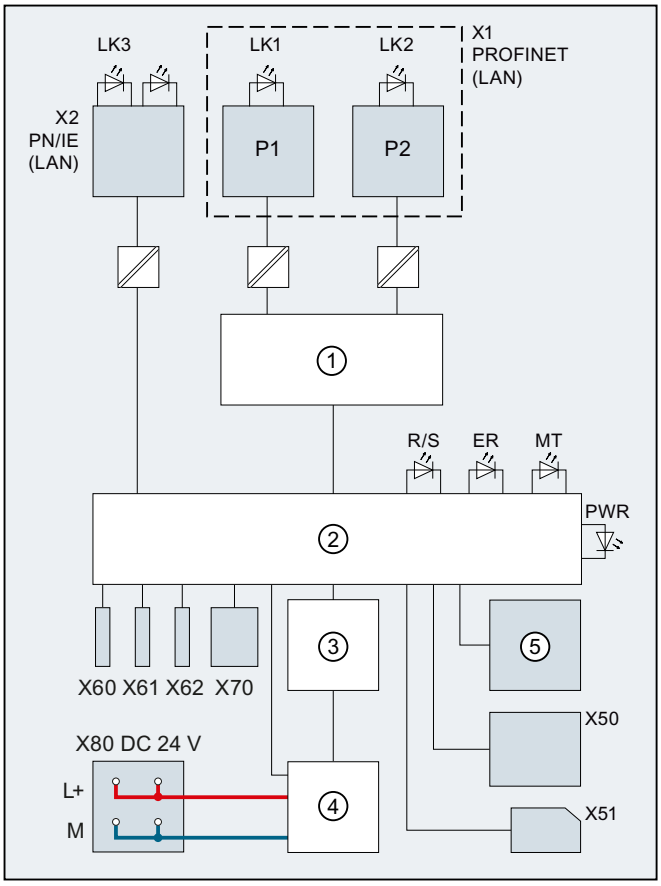

①	Switch	X1 PN (LAN)	PROFINET interface X1
②	Electronics	P1	PROFINET interface X1 Port 1
③	Backplane bus interface	P2	PROFINET interface X1 Port 2
④	Internal supply voltage	L+	24 V DC supply voltage
⑤	Mode selector	M	Ground
X50	CFast card	LK1, LK2	LED Link TX/RX
X51	SD/MMC card	LK3	LED Link
X60	USB interface 2.0, 0.5 A	R/S	RUN/STOP LED (yellow/green)
X61, X62	USB interface 2.0, 0.5 A	ER	ERROR LED (red)
X70	DVI-I interface	MT	MAINT LED (yellow)
X80 24 V DC	Infeed of supply voltage	PWR	POWER LED (yellow/green)
X2 PN/IE (LAN)	Ethernet interface X2		

Figure 2-31 Block diagram for CPU 1515SP PC (F)

5.3 Electrical configuration

Non-isolated configuration

NOTE

Unlike the distribution I/O system ET 200SP, only a non-isolated configuration is possible the CPU 1515SP PC (F).

The figure below shows a CPU 1515SP PC (F) in the overall configuration with infeed from a TN-S system. The power supply supplies the CPU 1515SP PC (F) and the load circuits for the 24 V DC modules.

With the CPU 1515SP PC (F) there is a fixed connection between the ground infeed terminal and the contact springs to the mounting rail. You must ground the mounting rail separately in the control cabinet.

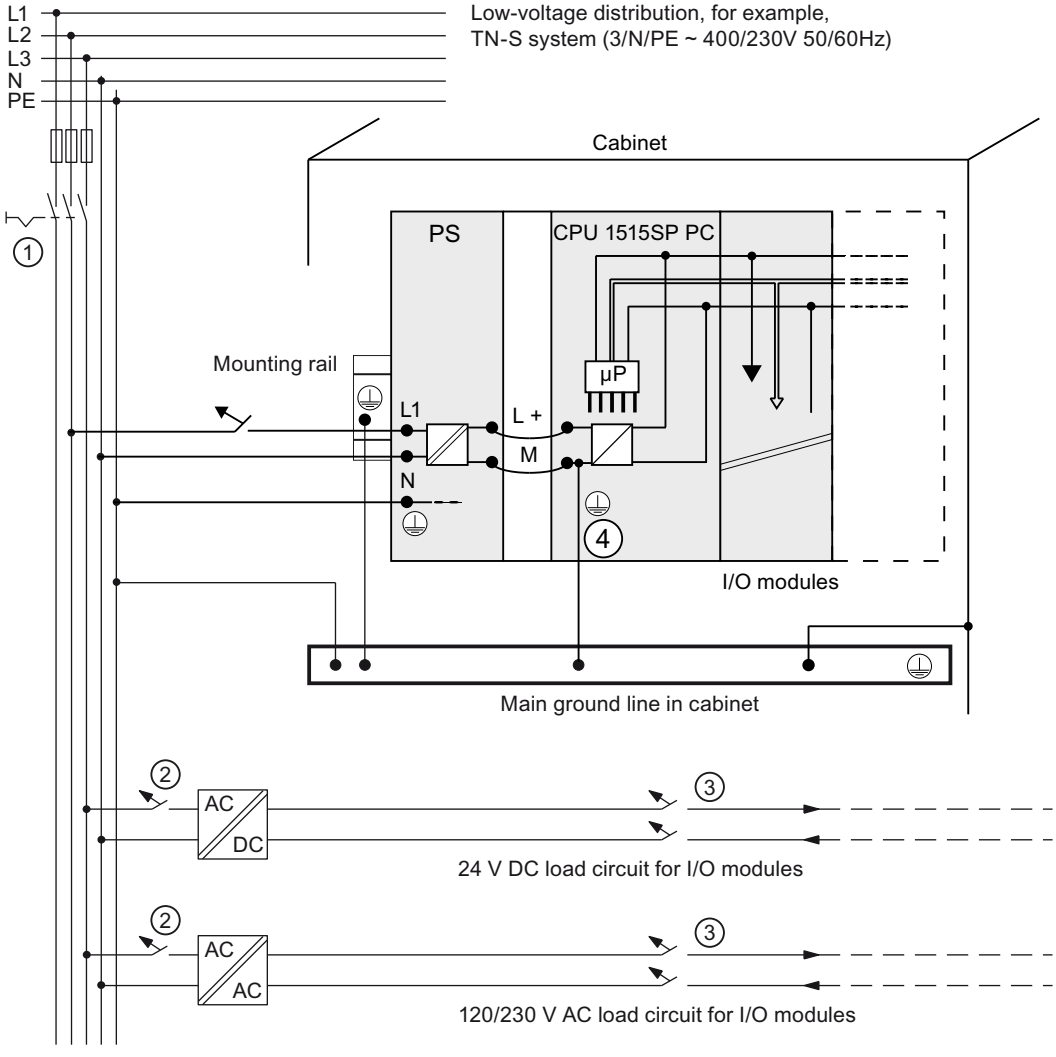

① Master switch
② Short-circuit and overload protection
③ Load current supply (galvanic isolation)
④ In the CPU 1515SP PC (F), this connection is automatically established.

The represented layout of the power connections does not correspond to the actual layout; it was chosen for demonstration purposes only.

Figure 2-32 Connecting the load voltage reference potential

5.4 Connecting devices to networks

The following options are available for integrating devices into existing or planned system environments and networks.

Ethernet

You can use the integrated Ethernet interface X2 PN/IE (LAN) (10/100/1000 Mbps) for communication and data exchange with automation devices, for example, SIMATIC S7. Only ASCII characters are permitted in the name of the interface X2 PN/IE (LAN) in the TIA Portal, e.g. PROFINET_2.

You need suitable software to do this: STEP 7, WinCC, SIMATIC NET.

NOTE

Use a Category 5e Ethernet cable (Cat-5e cable) for operation with 1000 Mbps.

PROFINET

PROFINET operation is possible via the X1 PN (LAN) interface and the approved BusAdapter.

PROFIBUS

The connection to PROFIBUS can be made using the DP master module.

5.5 Securing cables

The strain relief for connection lines prevents the USB and the PROFINET connector coming loose from the CPU 1515SP PC (F). The strain relief is included in the scope of delivery.

WARNING

Flying sparks due to loose cables

Risk of explosion in hazardous areas.

USB cables and PROFINET connectors may detach from the device in the case of strong oscillation and high vibrating loads.

Attach these cables to the strain relief of the device using cable ties.

Requirements

- The strain relief is fixed to the CPU.
- The CPU is installed.

Procedure

Secure the USB and PROFINET cables to the strain relief using cable ties.

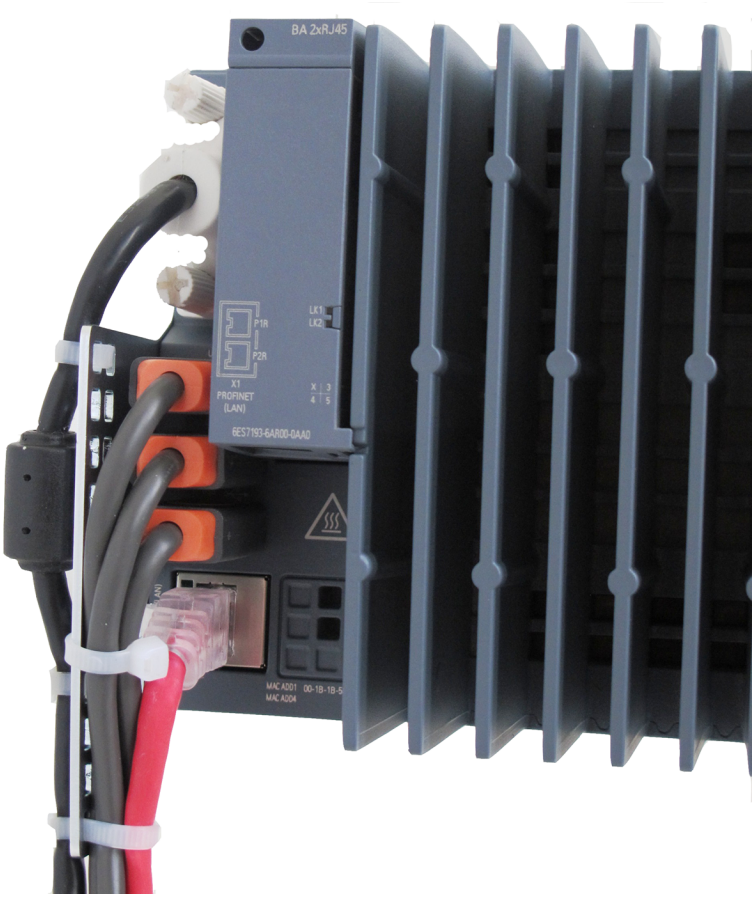

Figure 2-33 Secured cables

Diagnostics, error and system alarm

6

6.1 Status and error display

LED display

The figure below shows the LED displays of the CPU 1515SP PC (F).

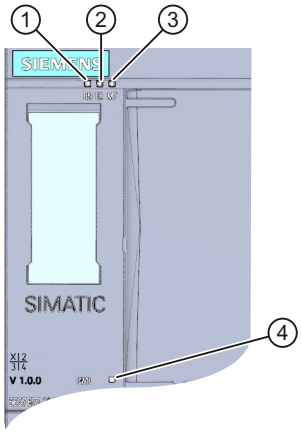

① RUN/STOP LED (yellow/green LED)

② ERROR LED (red LED)

③ MAINT LED (yellow LED)

④ POWER LED (yellow/green LED)

Figure 2-34 LED displays of the CPU 1515SP PC (F).

Meaning of the LED displays with active software controller

CPU 1515SP PC (F) has a display of the current operating state and of the diagnostics status (three LEDs).

The following table shows the meaning of the color combinations of the LED displays in connection with the software controller.

Table 2-25 Meaning of the LED displays

RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	POWER OFF Starting of the CPU 1515SP PC (F) in the "Windows only" mode No power supply. The software controller of the CPU 1515SP PC (F) has not been down-loaded or the software controller of the CPU 1515SP PC (F) is in the operating state Power OFF.
LED off	LED flashes red	LED off	An error has occurred.
LED green	LED off	LED off	Software controller of the CPU 1515SP PC (F) is in RUN mode.
LED green	LED flashes red	LED off	A diagnostics event is pending.
LED green	LED off	LED lights up yel-low	Maintenance demanded for the plant. The affected hardware must be exchanged within a short period.
LED green	LED off	LED flashes yellow	Maintenance required for the plant. You must exchange the affected hardware within a foreseeable period.
			Firmware update successfully completed
LED lights up yel-low	LED off	LED off	Software controller of the CPU is in the operating state STOP.
LED lights up yel-low	LED flashes red	LED flashes yellow	The user program is causing an error.
			CPU defective
LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. ramp-up after STOP.
			Loading the user program
LED flashes yellow/green	LED off	LED off	Startup (transition from RUN → STOP)
LED flashes yellow/green	LED flashes red	LED flashes yellow	Startup (CPU booting)
			Test of LEDs during startup, inserting a module.
			LED flashing test

POWER LED

Table 2-26 POWER LED

POWER LED	Meaning
LED off	No supply voltage or supply voltage too low
LED lights up yellow	Supply voltage present; running through BIOS phase; operating system is shut down
LED green	Supply voltage present; Booting or operation of the operating system

Commissioning 7

7.1 Notes on commissioning

WARNING

Improper commissioning in hazardous areas

Device failure or risk of explosion in hazardous areas.

- Do not commission the device unless it is fully mounted and connected according to the specifications in the section Enhanced Write Filter (EWF) (Page 70).
- Before commissioning, please consider the effects on other devices in the plant.

CAUTION

Hot surfaces

Risk of burns due to hot surfaces.

During operation, only touch the device with appropriate protective gloves.

NOTICE

Condensation in the device

Damage to the device due to condensation if the temperature between transport or storage and the installation site differs by more than 20 °C (36 °F).

Before commissioning the device, leave it to stand for several hours in the new environment.

NOTICE

Data loss

Data loss may occur if write filters are used incorrectly.

Therefore, note the information on write filters.

Two write filters are available for configuration under Windows Embedded:

- Enhanced Write Filter (Page 70)
- File Based Write Filter (Page 73)

7.2 Initial commissioning

Requirements

The following conditions must be met before you commission the open controller for the first time.

- CPU 1515SP PC (F) is mounted.
- The CFast card is inserted.
- No data carriers are connected via USB.
- The following hardware is available: A monitor, a USB keyboard, a USB mouse

Procedure

1. Connect a monitor via a DVI-I cable.
2. Connect a keyboard and a mouse to the CPU via USB.
3. Connect the power supply.
   → The PWR LED lights up yellow first, then green.
   → The device carries out the hardware initialization.
4. Wait until the Siemens logo disappears from the screen.
5. Follow the instructions on the screen to configure the device

NOTICE
Faulty installation If you change the default values in the BIOS Setup or switch off the device during the installation, the installation will be disrupted and the operating system will not be installed correctly. The operational reliability of the device and the plant is endangered. Do not switch of the device during the entire installation process. Do not change the default values in the BIOS Setup.

Result

- The WES7 operating system is installed.
- WES7 P: The Multitouch functions are available.
- The operating system's start screen is displayed after each startup.
- A login window appears if a password was entered during the initial commissioning.

Initial commissioning an open controller

The basic settings, user name, administrator password and IP address are prompted for during initial power-up of your CPU 1515SP PC (F). The device is then automatically set up for the operating system that is installed on the CFast card. Restart the device after the operating system has been set up.

NOTE

The initial commissioning is not possible with a Multitouch panel, as the Multitouch driver is only available after the installation of the operating system.

User name, computer name, password

When you enter a "User name", this is suffixed with "-PC" under "Computer name". The computer name must not exceed 15 characters.

NOTE

This user has administrator rights!

For security reasons, enter a password for this user (administrator).

IP address

The IP address (192.168.1.1) and the subnet mask (255.255.255.0) for the X2 interface are pre-set in the logon dialog.

You use the buttons to make your changes or to retain the pre-set values.

NOTE

The initial TIA Portal download must be performed using set IP address via the GB Ethernet interface X2 in order that the PROFINET interface X1 and the hardware configuration are correctly assigned.

User "Operator"

A user "Operator" with standard user rights is already created on the Windows system.

The user is in a user group "SIEMENS TIA Engineer". This grants the user the rights to use the installed SIMATIC software products.

To be able to use the CPU 1515SP PC (F) directly, the Windows "Autologon" is activated for the user "Operator". No password is preset.

NOTE

When you assign a password, change the entry for the Windows "Autologon" function accordingly in order that the function remains activated.

Administrator rights

You need administrator rights for the following actions:

- Back up the data in the root directory of the C partition.
- Installing the language pack

Screen resolution

In Windows Embedded Standard 7, the values that are determined for the monitor via the DVI-I interface are set for the screen resolution.

7.3 Initial configuration of an Open Controller

Creating the configuration

You have created a new project in the TIA Portal.

To create the configuration in the TIA Portal, follow these steps:

1. Double-click "Add new device" in the project tree.
2. In "PC-Systeme > SIMATIC S7 Open Controller > ET 200SP Open Controller >", select the "CPU 1515SP PC (F) (+HMI)".
3. Select the appropriate version.

   The configured Open Controller is displayed in the device view.
4. The following components can be seen in the Open Controller:
   - Onboard interface X2 (GB Ethernet Windows interface) that is assigned directly to the PC station (1 port)
   - Replaceable BusAdapter X1, which is directly assigned to the software controller (2 ports)
   - On the right side (behind the plugged modules in the rack): the configured software controller CPU 1505SP (F) and WinCC Runtime Advanced.
5. Insert the server module.
   The server module at the right end of the configuration forms the termination of the CPU with the I/O modules.

Setting the IP addresses:

In the Inspector window under "Properties":

- Onboard interface X2: the configured, specified IP address is identical with the Windows IP address that is set during the first commissioning on the open controller.
- BusAdapter X1: the configured, specified IP address is identical with the IP address that is set during the first commissioning in the panel of the software controller (display application).

Important properties of the Software Controller

Change the properties in the Inspector window under "Properties" if required:

- Selecting startup type
- System diagnostics
- Setting the storage location for retentive data
- Setting up copy protection
- Using the LEDs of the hardware
- Configuring the Web server
- Assigning interfaces for the communication

Establish HMI connection

1. Right-click the WinCC RT Advanced in the device view.
2. Start the HMI device wizard.
3. Apply all default settings.
   The wizard creates system images for you with the corresponding navigation.
4. Switch to the connection view in the network view.
5. Click on WinCC RT Advanced.
6. Drag (with mouse button pressed) from the WinCC RT Advanced software to the S7-1500 software controller (for example, CPU 1505SP).
   A network connection is established between the two devices.

Downloading the project to the target system

The complete PC station is downloaded the first time you download the configuration.

1. Select the complete PC system in the device view.
2. Click the "Download to device" button.
3. Make the following settings:
   - Type of connection
   - Specify the interface of the programming device
   - Specify the X2 interface on the Open Controller

NOTE

The first TIA Portal download **must** be via the "X2" interface.

Only ASCII characters are permitted in the name of the interface X2 PN/IE (LAN) in the TIA Portal, e.g. PROFINET_2.

Download and compile the project. The hardware configuration and the first download are now completed.

WinCC RT Advanced

WinCC Runtime Advanced contains all the essential functions for operator control and monitoring of machinery or plants.

Reference

For more information on WinCC RT Advanced, refer to the WinCC Advanced V14 (http://support.automation.siemens.com/WW/view/en/109742297) system manual.

7.4 Installing license keys

Licensing the software

A license key is not required to operate the S7-1500 software controller CPU 1505SP (F) V2.x. The software controller is permanently coupled to your CPU 1515SP PC (F). It is not necessary to input the key via the Automation License Manager!

WinCC RT Advanced requires a product-specific license key. This is located on the supplied USB stick.

Prior to commissioning, you must install the license key for the HMI powertags using the *Automation License Manager (ALM)*.

Perform the licensing directly via the CPU 1515SP PC (F).

Requirements

- Initial commissioning was successfully completed.
- Windows Embedded Standard 7 has started.
- The enhanced write filter **EWF** must be disabled on the CPU 1515SP PC (F).

Installing License keys with local configuration

The *Automation License Manager* is preinstalled on the CPU 1515SP PC (F).

Open the software using the icon on the desktop or a menu command.

1. In the Windows start bar, select **Start > All Programms > Siemens Automation > Automation License Manager**.
2. Follow the instructions of the *Automation License Manager*.

Using a programming device/PC to install the license keys

The *Automation License Manager* is pre-installed on a programming device / PC with STEP 7 and the CPU 1515SP PC (F).

1. Connect the CPU 1515SP PC (F) to a programming device / PC.
2. Connect the supplied USB stick to the programming device/PC.
3. Select the menu command **Start >SIMATIC >License Management > Automation License Manager**.
4. Select the menu command **Bearbeiten > Rechner verbinden** and enter the IP address of the CPU 1515SP PC (F) (default 192.168.1.1).
5. Drag the license keys from the USB stick to the system partition C: of the CPU 1515SP PC (F).

Saving and securing license keys in the case of restore and repair

NOTE

Loss of license keys

A SIMATIC license key cannot be copied or duplicated. If you drag the license keys from your USB-Stick to your CPU 1515SP PC (F), no copies are then left on the USB stick.

Secure your purchased license keys **before** restoring the delivery state (Restore) or in the case of repair. To do this, move the license keys to a USB stick and keep this stick in a safe place.

If a fault occurs with your license keys on the CPU 1515SP PC (F), contact your local Siemens representative. Make sure to have the "Certificate of License" (CoL) to hand.

NOTE

The EWF (Page 70) write filter serves to protect your license keys and your configuration.

Reference

For additional information on licenses, refer to the *Automation License Manager* manual. You can find the manual for the CPU 1515SP PC (F) under **Start > All Programs > Siemens Automation > Documentation** and in the Internet (http://support.automation.siemens.com/WW/view/en/56956174).

7.5 Windows Security Center

Warning from the Windows Security Center

A warning from the Windows Security Center appears when you first switch on your device. The Security Center check the status of the device with regard to the main security aspects listed below. If the Security Center finds a problem during this check, it gives recommendations on how to better protect the device.

- Firewall: The Windows firewall contributes to protecting the device by preventing the access of unauthorized users via a network or the Internet. Windows checks whether the device is protected by a software firewall.
  As delivered, the firewall is enabled.
- Antivirus software: Antivirus programs contribute to protecting the device against viruses and other security threats. Windows checks whether a comprehensive up-to-date program is used on the device.
  No antivirus software is installed as delivered.
- Automatic updates: With the help of automatic updates, Windows can routinely check for the latest major updates for the device and install these automatically. In the delivery state, this option is disabled.

NOTE

To keep Windows up-to-date, enable either the automatic update function of Windows or install updates manually. Before the installation, check the size of the package to be installed and decide if you need the update and if there is sufficient storage space available.

Some updates may make it necessary to use a larger CFast card or to change the partitioning. You can find information on changing the partition size in the Change partitioning (Page 76) chapter.

Configure the Security Center to suit your requirements.

7.6 Switching CPU 1515SP PC (F) on/off

Requirements

Initial commissioning was successfully completed.

Switching on the CPU 1515SP PC

1. Switch on the power supply of the CPU.

   The Boot Manager GRUB4DOS opens.
2. Select the mode in which the CPU 1515SP PC (F) should start:
   - Only with the Windows operating system.
   - With the Windows operating system and the S7-1500 software controller (default).

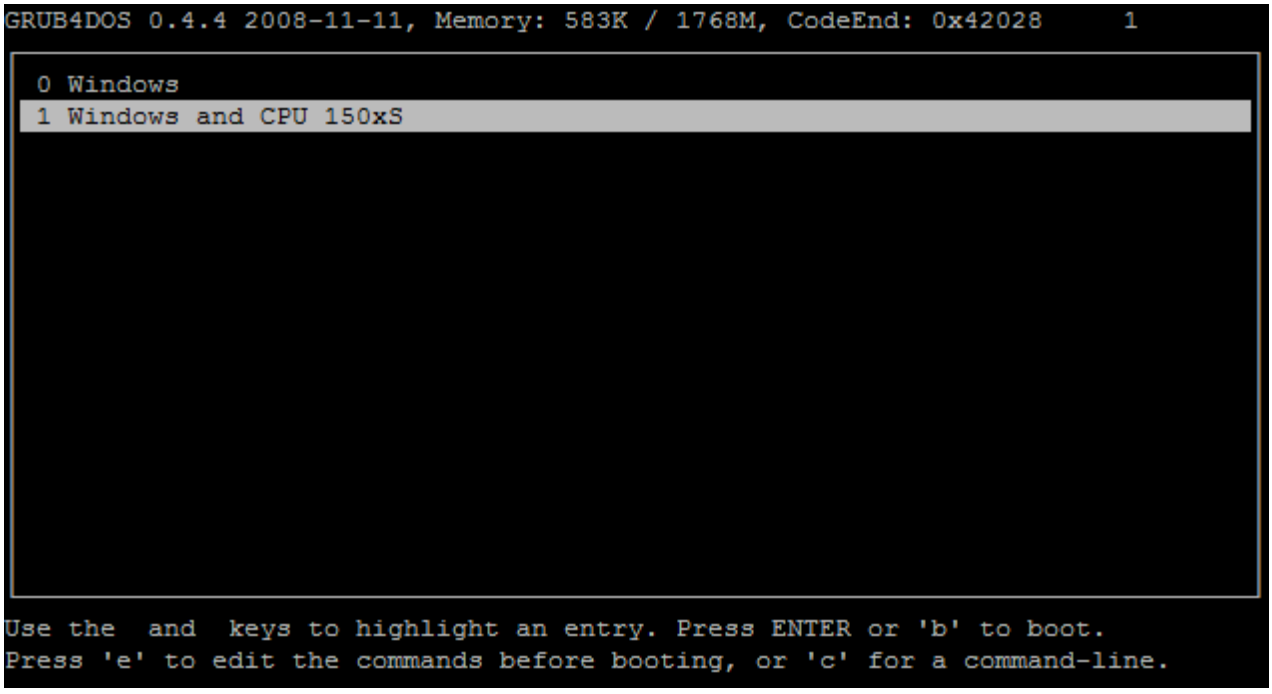

Figure 2-35 Boot Manager GRUB4DOS

Switch off CPU 1515SP PC (F)

1. To switch off the Windows function, use **StartShut down**.

   The PWR LED changes from green to yellow.

   The Windows function shuts down the Windows operating system and the S7-1500 software controller.

If the device will not be used for a longer period after the shutdown, de-energize the device.

Functions

8

8.1 Monitoring functions

Introduction

CPU 1515SP PC (F) has monitoring functions that you can use with the corresponding software. The following display, monitoring and control functions are available.

- Temperature monitoring
- Monitoring of drives with SMART functionality
- Operating hours counter (information on the total runtime)

SIMATIC IPC DiagBase

The SIMATIC IPC DiagBase software is contained in the scope of delivery of the CPU 1515SP PC (F).

With the SIMATIC IPC DiagBase software, you use the functions for local monitoring. Use the DiagBase Management Explorer application to obtain a clearer overview for monitoring. The DiagBase Alarm Manager notifies you of individual alarms.

NOTE

For additional information, refer to the online help for the SIMATIC IPC DiagBase software.

SIMATIC IPC DiagMonitor

The SIMATIC IPC DiagMonitor software is provided on a CD.

Potential system failures are detected and reported in good time with the diagnostics and alerting software. The software is also used for remote diagnostics.

The software contains:

- The software for the stations to be monitored
- A library for creating your own applications

Temperature monitoring

Three thermistors monitor the temperature at multiple locations of the CPU 1515SP PC (F):

- Processor temperature
- Temperature in the vicinity of the RAM ICs/blocks
- Temperature of the basic module

If one of the temperature values exceeds the set temperature threshold, the temperature monitoring triggers a temperature error. The temperature error activates the IPC DiagBase and/or IPC DiagMonitor software.

The temperature error remains stored until the temperatures fall below the temperature threshold again and it is reset using one of the following measures:

- Acknowledgment of the error message by the monitoring software
- Restart of the device

8.2 Retentive memory NVRAM

Retentive memory is non-volatile memory for saving a limited quantity of data in the event of power failure.

The data defined as retentive is stored in retentive memory. This data is retained beyond a power-off or power failure.

A corresponding function is implemented in the S7-1500 software controller to allow NVRAM to be used there. Up to 410 KB of data is backed up to non-volatile data memeory by this in the event of power failure. This function can be set on the engineering station in the TIA Portal.

8.3 BIOS description

8.3.1 Introduction

BIOS setup

The BIOS setup is located in the BIOS ROM. The information is stored to the memory of the CPU 1515SP PC (F) via the system configuration.

You can set the following using the Setup:

- The hardware configuration, for example, drive type
- The system properties
- time and date

NOTE

The American keyboard layout applies in the BIOS.

Changing the device configuration

The device configuration is preset for working with the supplied software.

Only change the set values if you have made technical changes to your device.

8.3.2 Starting BIOS setup

Start the setup program as follows:

1. Disconnect the device from the power supply and switch it on again (cold restart).

   The following screen appears in the default setting of the CPU 1515SP PC (F) after it is switched on:

Figure 2-36 BIOS setup

After completion of the startup test, you have the option of starting the SETUP program.

The following BIOS message appears:

```
Press F2 go to Setup Utility
Press F12 go to Boot Manager
```

2. Press the <F2> button while the message is on the screen.

8.3.3 BIOS setup menus

Overview of BIOS setup

The menus and submenus are shown on the following pages.

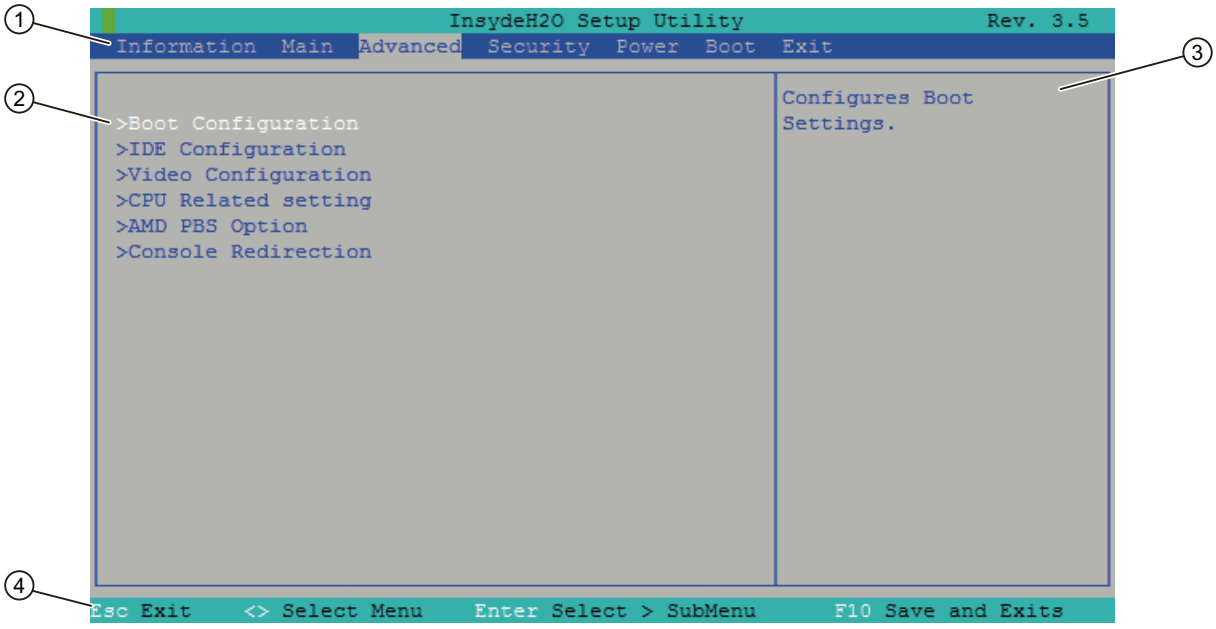

① Menu bar

② Selectable submenu

③ Help window

④ Operating line

Figure 2-37 Structure of the BIOS setup menus

Menu structure

In the menu bar ①, you can select between the following menu forms:
[Information] [Main] [Advanced] [Security] [Power] [Boot] [Exit].

In the main window ②, various settings are displayed or submenus selected.

In the Help window ③ of the respective menu, you can find information on the selected setup entry.

The operating line ④ contains notes on operation.

You can use the cursor keys [←] left and [→] right to switch between the menu forms.

Menu	Meaning
Information	Device-specific information, for example, product version
Main	Setting system functions
Advanced	Advanced system configuration

Menu	Meaning
Security	Safety functions, for example, setting a password
Power	Determining the switch-on behavior of the device
Boot	Determining boot options, such as boot priority
Exit	Exiting and saving

8.3.3.1 Information menu

This menu shows the versions of the device-specific functions.

Keep this information at hand for Customer Support when you have technical questions regarding your system.

Example

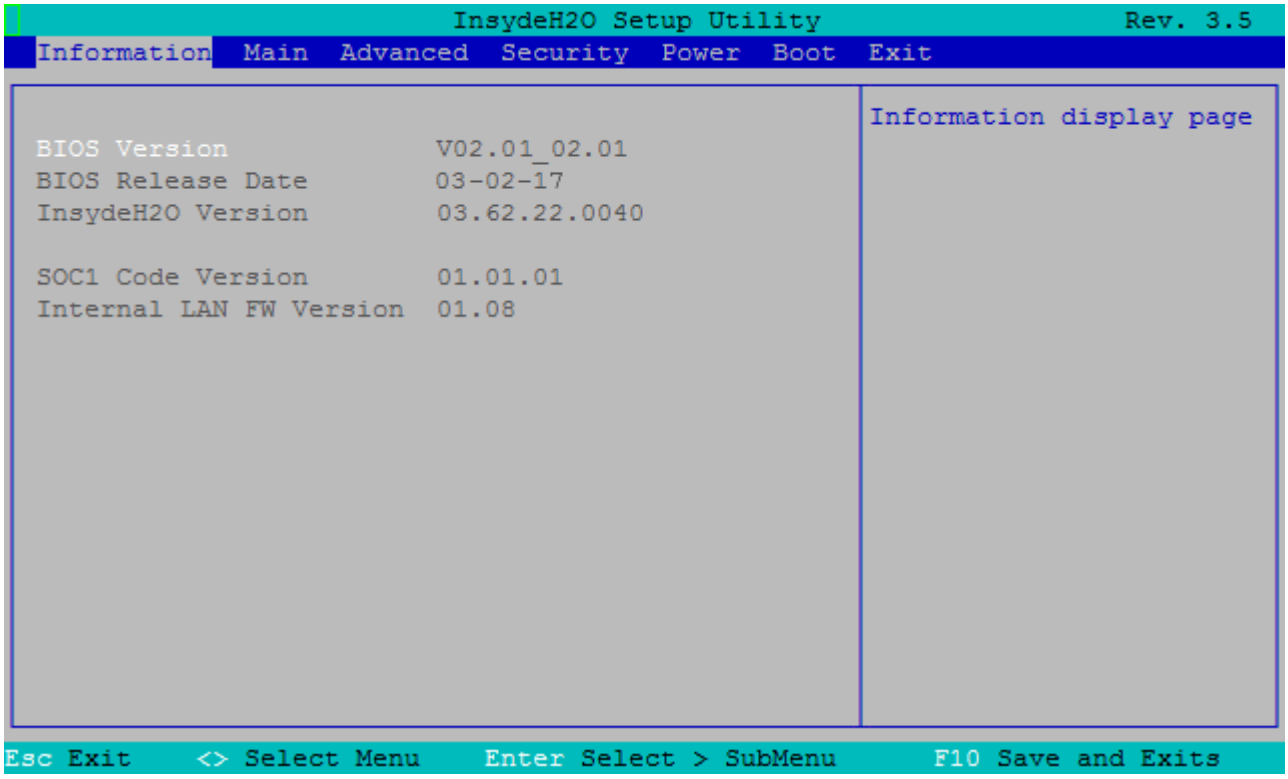

Figure 2-38 Information menu

8.3.3.2 Main menu

Settings in the Main menu

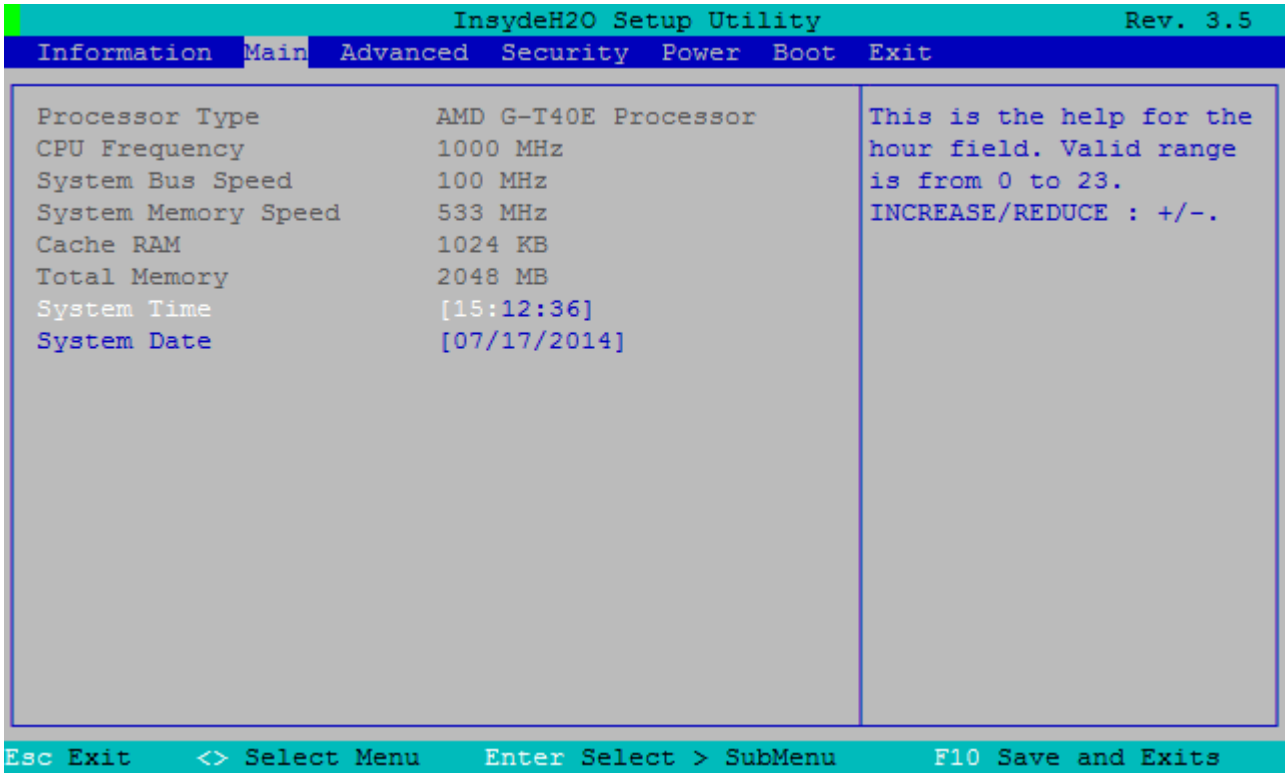

Figure 2-39 Main menu

In the Main menu, you can use the [↑] up and [↓] down arrow keys to select between the following system setting fields:

Array	Meaning
System Time	Displaying and setting the current time
System Date	Displaying and setting the current calendar date

System Time and System Date

System Time and System Date show the current values. After you have selected the corresponding field, you can change the following settings, one after the other, using the [+] and [–] keys:

- For the time of day: Hour: Minute: Second
- For the date: Month/day/year.

You can use the <ENTER> key to switch between the entries within the Date and Time fields (e.g., from hour to minute).

8.3.3.3 Advanced menu

Settings in the Advanced menu

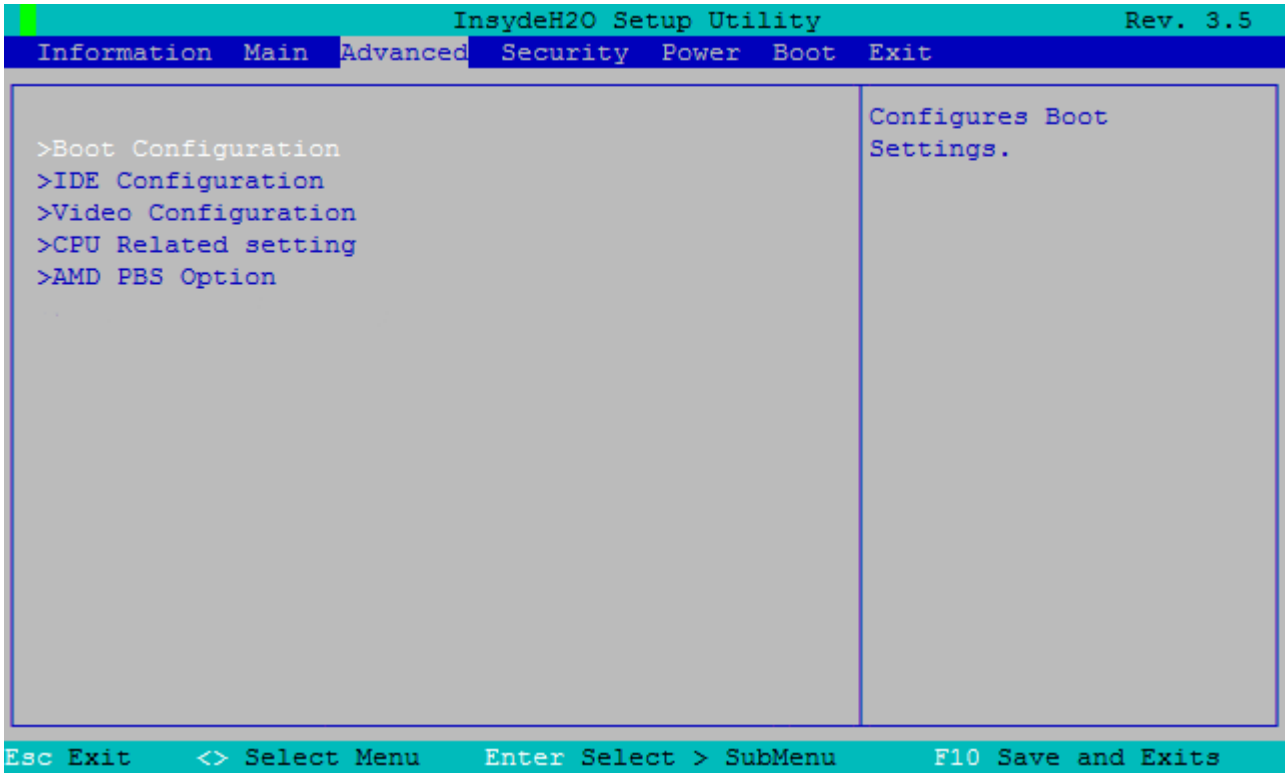

Figure 2-40 Advanced menu

Entry	Meaning
Boot Configuration	Configuring the boot settings
IDE Configuration	Configuring the devices
Video Configuration	Configuring the graphics parameters
CPU Related setting	Configuring CPU parameters
AMD PBS Option	Configuring interfaces

"IDE Configuration" submenu

Entry	Meaning
SATA configure as	Setting the SATA configuration type: IDE, LEGACY IDE, AHCI
Serial ATA Port 0	Serial ATA Port 0 device configuration

"Video Configuration" submenu

Entry	Meaning
UMA Sharing Memory Size (256 MB)	Setting the size of the work memory for the graphics processor. (Unified Memory Architecture; also Shared Memory)

"CPU Related setting" submenu

Entry	Meaning
SVM support	Enabling (Enabled) or disabling (Disabled) Secure Virtual Machine functionality .

"AMD PBS Option" submenu

Entry	Meaning
Internal LAN Controller	Integrated Ethernet interface (10/100/1000 Mbps) X2 PN/IE (LAN)
PXE Boot to INT_LAN	Enabling (Enabled) or disabling (Disabled) internal Southbridge Network Controller.

8.3.3.4 Security menu

Settings in the Security menu

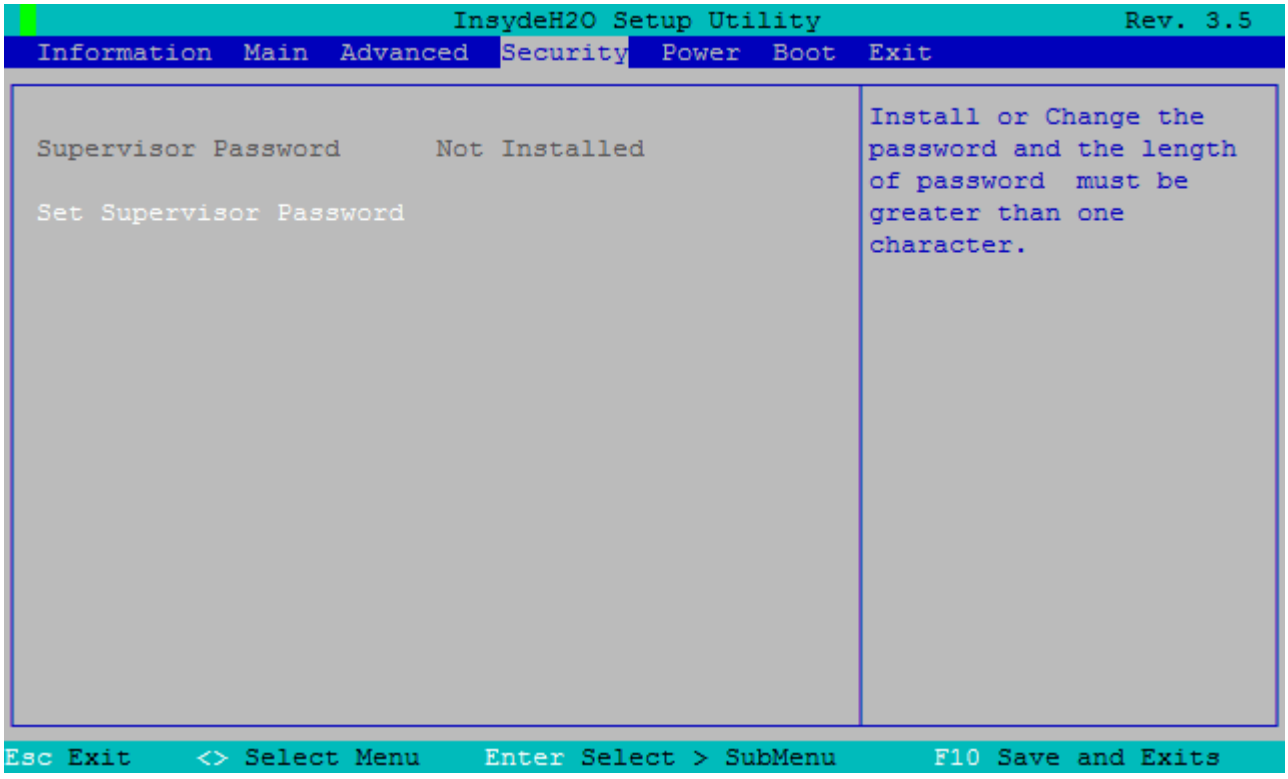

Figure 2-41 Security menu

To protect the CPU 1515SP PC (F) against unauthorized access, assign a password.

Supervisor Password	Installed	Specific setup fields, including the Supervisor password, can be modified by the user.
	Not installed	Password is disabled.
Set Supervisor Pass-word	This field opens a dialog for assigning or changing the password.	

NOTE

Overwriting of the Supervisor password during a BIOS update

A BIOS update overwrites the password.

After a BIOS update, set up the password again.

8.3.3.5 Power menu

Settings in the Power menu

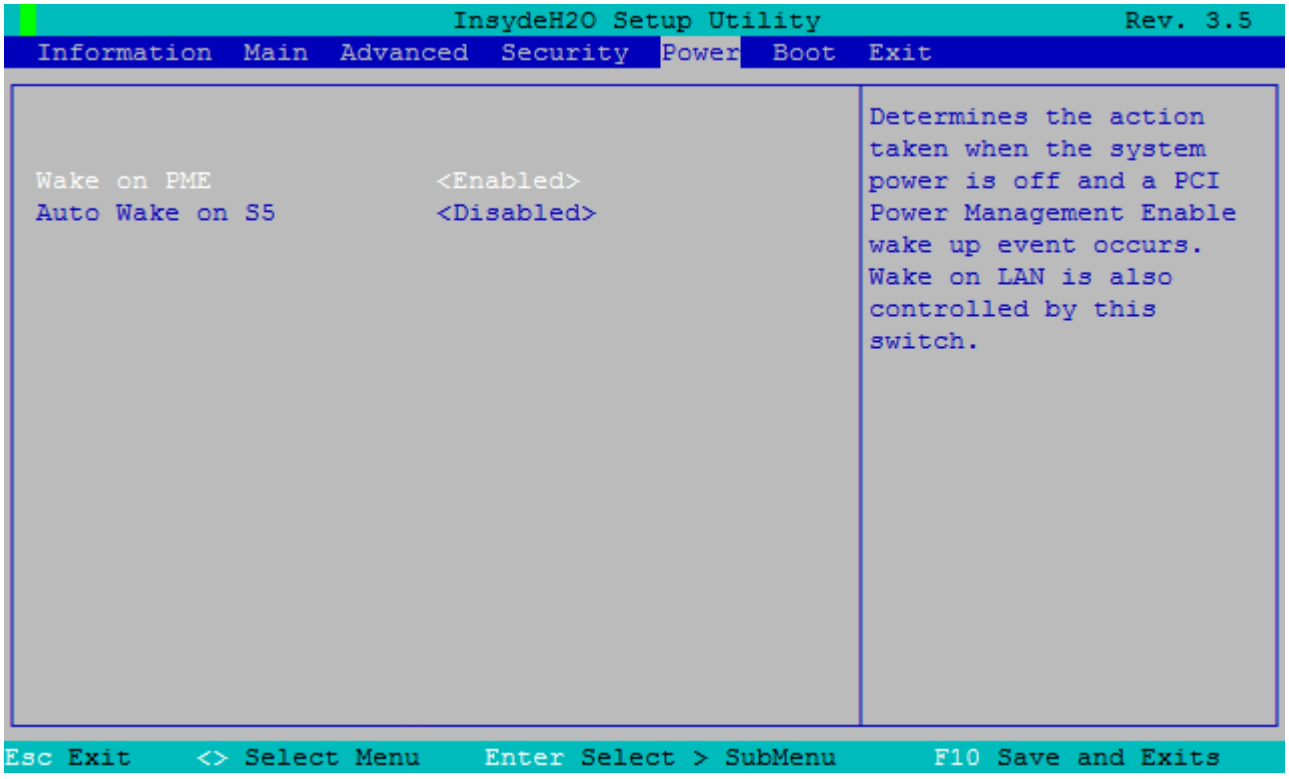

Figure 2-42 Power menu

In the Power menu, you specify the device reaction to a power failure and a Wake Event.

Entry	Meaning
Wake on PME	When activated (Enabled), the device switches itself on when a Power Management Event occurs. Otherwise, the device remains switched off.
Auto Wake on S5	When activated (Enabled), the device switches itself on when a Wake Event occurs. Otherwise, the device remains switched off.

8.3.3.6 Boot menu

Entries in the Boot menu

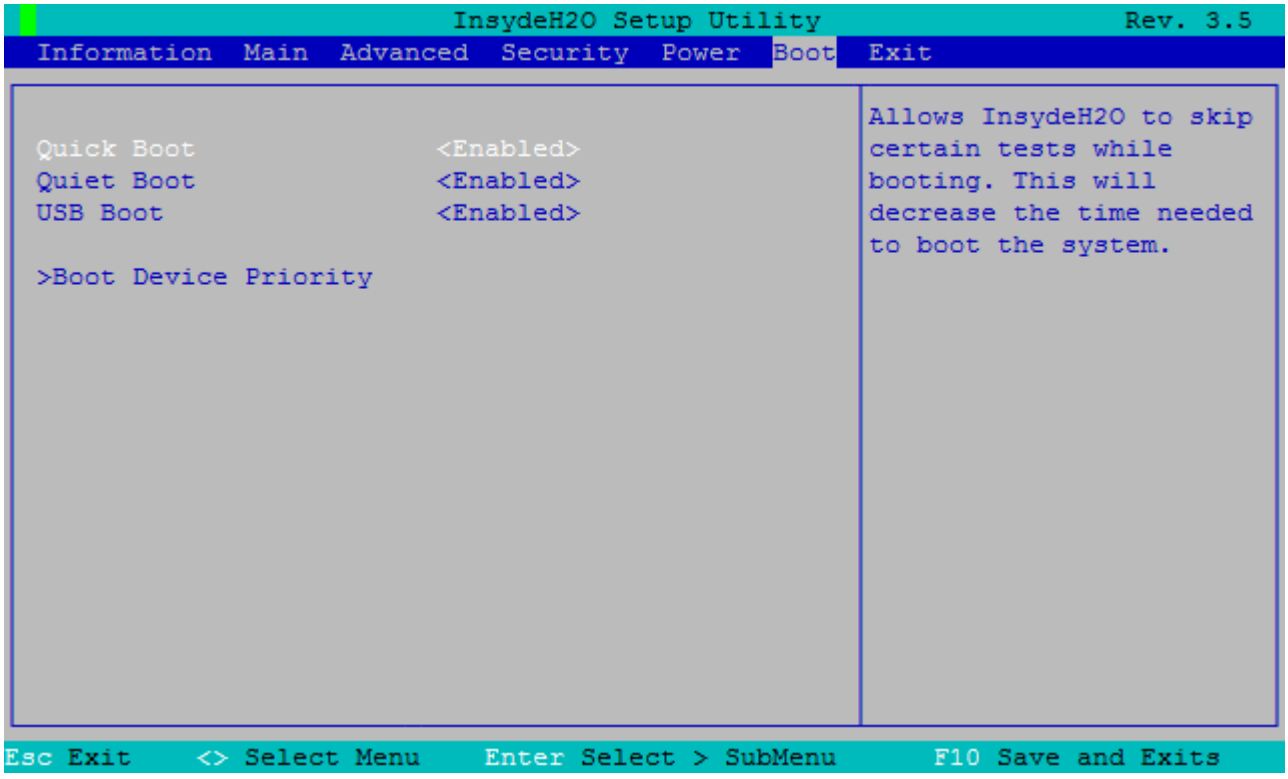

Figure 2-43 Boot menu

In this menu, you define the boot behavior of the device.

Entry	Meaning
Quick Boot	Enabling (Enabled) or disabling (Disabled). The device starts up faster when this option is enabled, because various hardware function tests are skipped.
Quiet Boot	When this option is disabled, the device boots in text mode. When it is enabled, a start screen with logo appears.
USB Boot	Booting from connected USB devices permitted/not permitted.

Boot menu > submenu "Boot Device Priority"

In this menu, you define the sequence of the boot media.

Entry	Meaning
Normal Boot Menu	Normal = boot sequence by component type Advance = individual boot sequence of all components

Boot Device Priority > submenu "Boot Type Order"

Entry	Meaning
Hard Disk Drive	Setting the boot sequence of the group of drives
USB	Setting the boot sequence of the group of USB drives
Others	Setting the boot sequence of the group Others,, e.g. Remote Boot Device

All connected boot-capable components and their boot position are displayed in this menu. The boot position of the components can be moved freely.

The component at the top (highest boot priority) is used for booting. If the component is not available, the system boots from the next component in the list.

You change the boot sequence as follows:

- Select the boot components using the keys <↑>, <↓>
- Move to the required position using the keys <+>, <–>

NOTE

You can start the Boot Manager by pressing the <F12> key during the boot process.
The Boot Manager shows all available boot components and boots from the device selected by the user.

"Normal Boot Menu > Advance" setting

Boot capable components which were disconnected and reconnected to the CPU 1515SP PC (F) during the boot processes, appear in first place in the BIOS in the "Advance" setting.

Boot Device Priority > submenu "Hard Disk Drive"

The size of the CFast card is displayed in this menu.

8.3.3.7 Exit menu

Settings in the Exit menu

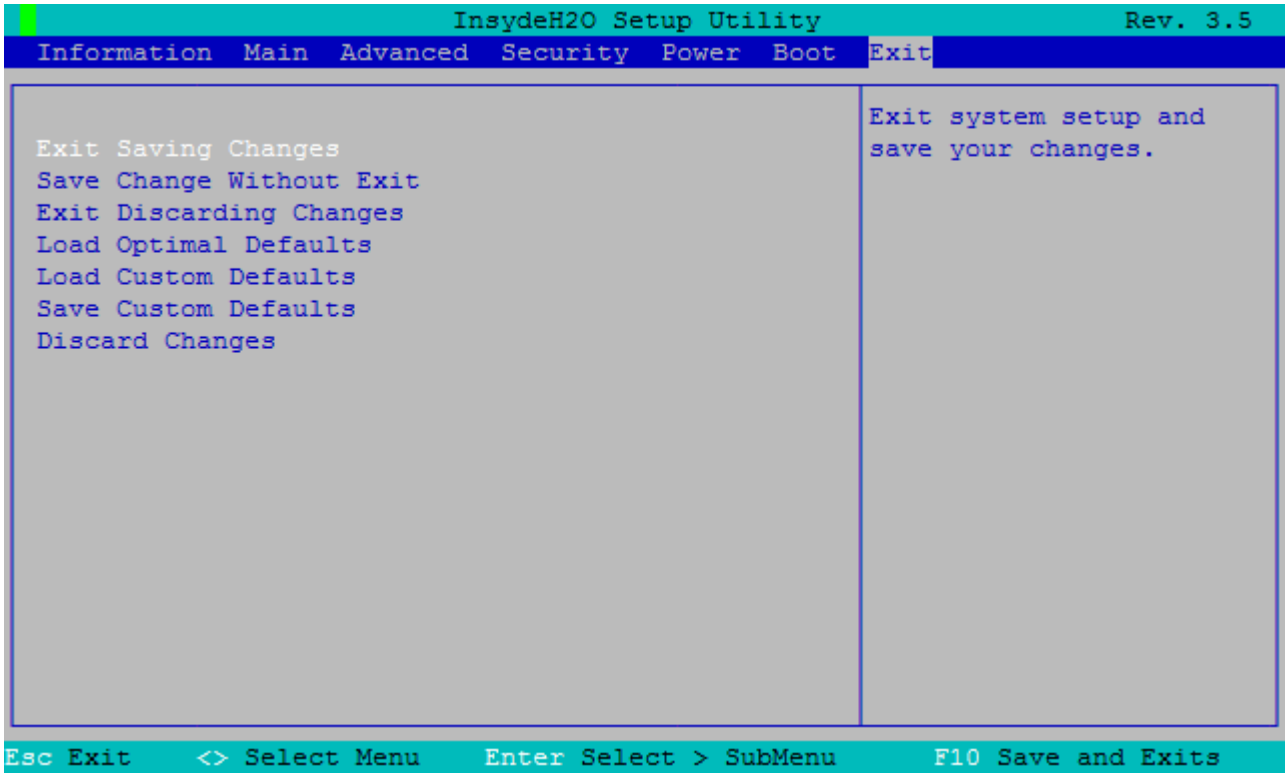

Figure 2-44 Exit menu

The setup program is always terminated via the Exit menu.

The menu is used to save or discard the changes made.

Entry	Meaning
Exit Saving Changes	Saves all changes and then starts the system with the new parameters.
Save Change Without Exit	Saves all changes
Exit Discarding Changes	Discards all changes and then restarts the system with the old parameters.
Load Optimal Defaults	Loads the optimum default values
Load Custom Defaults	Loads the default values
Safe Custom Defaults	Saves the default values
Discard Changes	Discards all changes

8.3.4 BIOS setup default settings

Documenting the device configuration

If you change the default setting of the BIOS Setup, then enter this in the following table. This will ensure that values you set will be readily available if hardware changes are made later.

We recommend that you print out the table below and keep it in a safe place after you have made your entries.

NOTE

The default settings in the BIOS setup depend on the ordered device configuration.

BIOS setup default settings

Menu	System parameters	Default settings	User settings
Main	System Time	hh:mm:ss	
	System Date	MM/TT/JJJJ	
Advanced > IDE Configuration	SATA configure as	LEGACY IDE	
	Serial ATA Port 0	SIMATIC IPC CFast 30	
Advanced > Video Configuration	UMA Sharing Memory Size	256 MB	
Advanced > CPU Related setting	SVM Support	Enabled	
Advanced > AMD PBS Option	Internal LAN Controller	Auto	
	PXE Boot to INT_LAN	Disabled	
Security	Supervisor Password	Not installed	
	Set Supervisor Password	Inactive (no password assigned)	
Power	Wake on PME	Enabled	
	Auto Wake on S5	Disabled	
Boot	Quick Boot	Enabled	
	Quiet Boot	Disabled	
	USB Boot	Disabled	
Boot > Boot Device Priority > Normal Boot Menu	Normal Advance	Normal	
Boot > Boot Device Priority	Boot Type Order	Hard Disk Drive	
		USB	
		Others	
	Hard Disk Drive	SIMATIC IPC CFast 8/16/30 GByte	
Exit	Exit Saving Change	Standard	
	Save Change Without Exit		

Menu	System parameters	Default settings	User settings
Exit	Exit Discarding Changes		
	Load Optimal Defaults		
	Load Custom Defaults		
	Safe Custom Defaults		
	Discard Changes		

8.3.5 BIOS update

With the SIMATIC IPC DiagBase software (included in scope of delivery), you can perform the following actions:

- Perform a BIOS update.
- Saving and updating the current BIOS version.
- Saving the BIOS settings or loading them from another backup.

For additional information, refer to the online help for the SIMATIC IPC DiagBase software.

Requirements

- The S7-1500 software controller CPU 1505SP (F) must be in STOP mode.
- CPU 1515SP PC (F) must be started in Windows mode.

NOTICE
Malfunctions in the software controllers due to critical actions If you perform a BIOS update during the operation of the S7-1500 software controller CPU 1505SP (F), software controller malfunctions can occur that lead to interruptions in communications and downtimes. Do not perform BIOS updates or other actions that strongly utilize the hardware resources during the operation of the CPU 1505SP (F). **Prior** to a BIOS update, switch the CPU 1505SP (F) to STOP.

Performing a BIOS update

1. Start the CPU 1515SP PC (F) in the GRUB menu in **Windows mode** (see figure).
   → The PWR LED lights up yellow first, then green.
   → The device carries out the hardware initialization.
2. Follow the BIOS update steps described in the help for SIMATIC IPC DiagBase.
   → The update is performed.
   → You are prompted to restart the device.

3. Us thee Windows function **Start > Shut down** to shut down the CPU 1515SP PC (F).
   → The PWR LED lights up green first, then yellow.
   → The Windows function closes the Windows operating system and the software controller.
4. Switch off the power supply at the CPU 1515SP PC (F).
5. Connect the power supply.
6. Wait until the Siemens logo disappears.
   → The CPU 1515SP PC (F) restarts.

NOTICE
Overwriting of the Supervisor password during a BIOS update A BIOS update overwrites the password. After a BIOS update, set up the password again in the Security menu under "Set Supervisor Password".

8.4 Power options

An energy diagram with the name SIMATIC on the CPU 1515SP PC (F). This ensures that the CPU does not deviate from its maximum clock rate in order not to endanger the real-time capability of the software controller.

8.5 Protective functions for data carriers

NOTICE
Data loss The number of write cycles on CFast cards is limited due to technical reasons. To prevent data loss, the CFast card must therefore be provided with special protection. Use a write filter to lengthen of service life of the CFast card and avoid the CPU 1515SP PC (F).

Write filters

Two write filters are available for Windows Embedded:

- To protect an entire partition of the CFast card, use the Enhanced Write Filter EWF (Page 70).
  Unlike FBWF, you can also use EWF with compressed NTFS data systems.
- Use the File-Based Write Filter FBWF (Page 73), to update specific files dynamically.
  The FBWF can be configured more flexibly and enables direct write access without restart.

NOTICE
Data loss If both write filters are activated, the EWF blocks direct write access of the FBWF. Data get lost after a restart of CPU 1515SP PC (F). Activate **only one** of the two write filters per partition.

8.5.1 Enhanced Write Filter (EWF)

Purpose and function

The Enhanced Write Filter (EWF) allows you to write-protect individual partitions.

EWF is disabled by default on the CPU 1515SP PC (F).

The EWF is activated by means of the pre-installed SIMATIC IPC EWF Manager or the Windows console application ewfmgr.exe.

SIMATIC IPC EWF Manager

Start the software via **Start > All Programs > Siemens Automation > SIMATIC > EWF Manager**.

In the status bar, you can use the SIMATIC IPC EWF Manager icon to check whether the EWF is active.

Table 2-27 Meaning of the icons

Icons	Meaning
	The partition is protected by the EWF.
	EWF is disabled for this partition.
	The EWF is currently switched off, but is activated after the restart.
	The EWF is currently active, but will be deactivated after the restart.
	The filter is active. A Commit command is executed before the next reboot.
	The filter is currently active, but is deactivated after the restart. A Commit command will also be executed before the next reboot.

The operating instructions for the SIMATIC Industrial PC: IPC EWF Manager (http://support.automation.siemens.com/WW/view/en/50867677) is available on the CPU 1515SP PC (F) under **Start > All Programs > Siemens Automation > Documents > Manuals.**

Console application ewfmgr.exe

The application is called via the Windows command line (Command Prompt).

The following functions are available, among others, for setting, switching on and switching off the EWF:

Table 2-28 Enhanced Write Filter functions

Function	Command
Write-protect drive C: Switching on	`ewfmgr c: -enable`
Write-protect drive C: disable (modified data is accepted)	`ewfmgr c: -commitanddisable`
Modified files on drive C: Accept	`ewfmgr c: -commit`
Display information about the EWF drive	`ewfmgr c:`
Display help	`ewfmgr /h`

NOTE

The EWF commands for write protection become effective only after a restart.

NOTE

The EWF command `ewfmgr c: -commitanddisable` must not be used with the option `-Live`.

Special features when using the EWF

NOTICE

Data loss upon power failure and upon shutdown/restart

If the EWF is active, all changes made on the C drive are lost after power failure and on shutdown/restart.

Use an UPS to prevent data losses after power failure.

Back up the data in the EWF-RAM overlay to the CFast card before shutting down the CPU 1515SP PC (F). In the command line, enter the following commands:

```
ewfmgr c: -commit
```

Restart the device

Or

`ewfmgr c: -commitanddisable`

Restart the device

`ewfmgr c: -enable`

Restart the device

NOTE

Data loss

If EWF is active and you decline a restart after having set the `-commitanddisable` or `-commit` option, your data is lost after a power failure!

NOTE

Disabling automatic daylight saving changes

In systems without central time management and with activated EWF, the time is advanced or set back by one hour in the daylight saving time or standard time period each time the system performs a cold or warm restart, due to the system-specific function for automatic daylight saving changes.

Reason for this behavior: Windows Embedded Standard 7 sets a flag in a registry entry that indicates completion of the conversion to daylight saving time. Since this file is also protected against modification by the EWF, the marker is lost during the boot sequence and the adjustment is made again.

We therefore recommend that you deactivate the automatic adjustment and change the clock manually.

Proceed as follows:

1. Disable the EWF filter (`ewfmgr c: -commitanddisable`) and reboot the system.
2. Deactivate the automatic switchover in the Control Panel:
   Start > Control Panel > Date and Time > in the tab "Time Zone" clear the check mark for "Automatically adjust clock for daylight saving changes".
3. Save the change (`ewfmgr c: -commit`).
4. Switch on the EWF again (`ewfmgr c: -commitanddisable`) and reboot the system.

8.5.2 File-Based Write Filter (FBWF)

Purpose and function

The FBWF allows you to write-protect specific files and folders of a partition.

FBWF is enabled by default on the CPU 1515SP PC (F).

The FBWF is activated by means of the Windows console application fbwfmgr.exe.

NOTICE
Data loss If both write filters are activated, the EWF blocks direct write access of the FBWF. Data get lost after a restart of CPU 1515SP PC (F). Activate **only one** of the two write filters.

Console application fbwfmgr.exe

The application is called via the Windows command line (Command Prompt).

The following functions, among others, are available for setting, switching on and switching off the FBWF:

Table 2-29 File-Based Write Filter

Function	Command
Show FBWF status	`fbwfmgr /displayconfig`
Activate FBWF after the next restart	`fbwfmgr /enable`
Write to protected files	`fbwfmgr /commit c: \<Path>\<File Name>`
Display help	`fbwfmgr /?`
Defining exclusions:	
• Add file	`fbwfmgr /addexclusion c: \<Path>\<FileName.ext>`
• Add folder	`fbwfmgr /addexclusion c: \<Path>`
• Remove file	`fbwfmgr /removeexclusion c: \<Path>\<FileName.ext>`
• Remove folder	`fbwfmgr /removeexclusion c: \<Path>`

NOTE

Note:

- The correct notation is as follows:
  Drive letter: space character "\" relative file path
- The write protection commands become effective only after a restart.

Rule for exclusion list

The following sequence applies if you define exclusions for files and folders that do not yet exist:

- Defining exclusions
- Restart CPU 1515SP PC (F)
- Create file/folder

Display of the partition size with activated FBWF

The partition size displayed in the Explorer does not correspond with the actual size when the FBWF is active. The size displayed is derived from the amount of memory occupied on the partition and from memory released by the FBWF. After the maximum size of the overlay was reached, a message is output warning of insufficient space on the partition.

Reference

Additional information on FBWF is available on the Internet (http://msdn.microsoft.com/en-us/library/ff794219(v=winembedded.60).aspx).
Additional information on the topic of partitions is available in the Change partitioning (Page 76) chapter.

Maintenance 9

9.1 Backing up and restoring data

Introduction

The operating system and the Runtime software are located on the supplied Restore DVD. You can use this to restore the original software of the CPU 1515SP PC (F).

If you use functions from the Restore menu, you must acknowledge a security message. For the functions, 72 hours are available in each case. If the functions are no completed within this period, the CPU 1515SP PC (F) is automatically restarted.

Save your project to partition D: of the CFast card.

SIMATIC IPC Image & Partition Creator

You can also create your own image of your CFast card. This contains the operating system, the Runtime software and the complete project loaded from the TIA Portal.

To back up data in Windows Embedded Standard 7, we recommend the software tool SIMATIC IPC Image & Partition Creator (V3.3 or later). It provides for easy backup and fast restore of the contents of the CFAST card and of individual partitions (images).

NOTE

The SIMATIC Image & Partition Creator supports the X2 PN/IE (LAN) interface.

You can procure the SIMATIC IPC Image & Partition Creator:

- via the Siemens online ordering system (http://www.siemens.com/automation/mall).
- Pre-installed on the SIMATIC IPC Service USB flash drives.

For additional information, please refer to the corresponding product documentation.

SIMATIC IPC Service USB flash drive

You can use the SIMATIC IPC Service USB flash drives for data backup and restore.

You obtain these through the Siemens online ordering system (http://www.siemens.com/automation/mall).

9.2 Change partitioning

9.2.1 Partitions in the delivery state

Partitioning the CFast card

The following partitions are set up on the CFast card by default:

Partition	Name	30 GB CFast card (WES7 E 32Bit/WES7 P 64Bit)	File system
C:	SYSTEM	19.5 GB	NTFS
D:	DATA	8 GB	NTFS
-	-	0.4 GB	RAW
-	WinCCMB	0.04 GB	NTFS

NOTE
Partitions in Windows Embedded Standard 7
The partitions need to be set again if they are faulty or if the partitioning is to be changed.

NOTICE
CPU volume for software controller (0.4 GB RAW)
Do not change the CPU volume for software controllers.
This is the only way to ensure that the software controller continues to operate without error.

9.2.2 Change partitioning

If the capacities of the partitions are insufficient, you have the option with Windows 7 to change the size of the partitions (for example, drive C: extend and drive D: reduce).

Free space must be available in order to extend the partition. You can recognize free space by the designation "Unallocated". You may have the reduce or delete other partitions to create space.

NOTE
Deleting partitions
When partitions are deleted on the data on them are destroyed.

Possible reasons for an expansion of the partition size to drive C:

- Loading security updates for Windows drive C:
- Option of installing large software packages on C, if their size exceeds the available storage space.

Expand/shrink partition

To expand, for example, Partition C: at the cost of Partition D: follow these steps:

In the Windows start bar, select **Start > Control Panel > System and Security > Administrative Tools > Computer Management > Disk Management**. The "Computer Management" window opens.

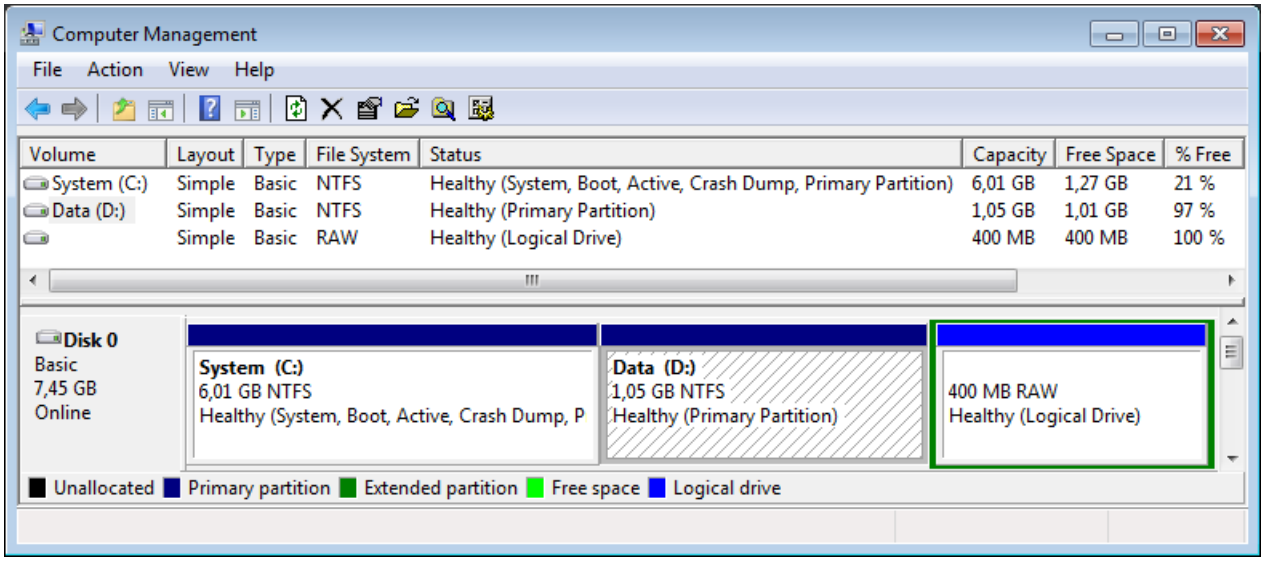

Figure 2-45 Computer Management

To expand Partition C: you must delete Partition D: first. Right-click on Partition D: and select "Delete Volume..."

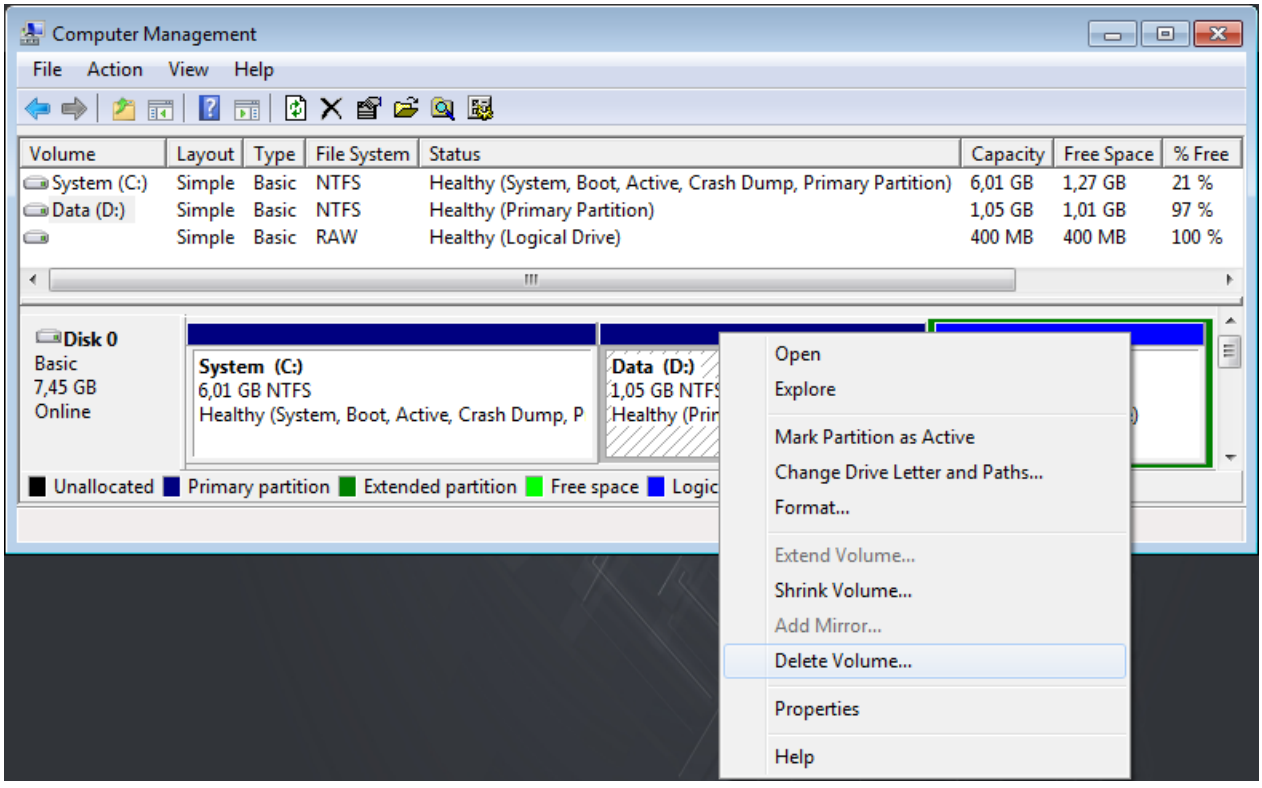

Figure 2-46 Partition D: Delete

The space which was occupied by Partition D: is now available for Partition C: .

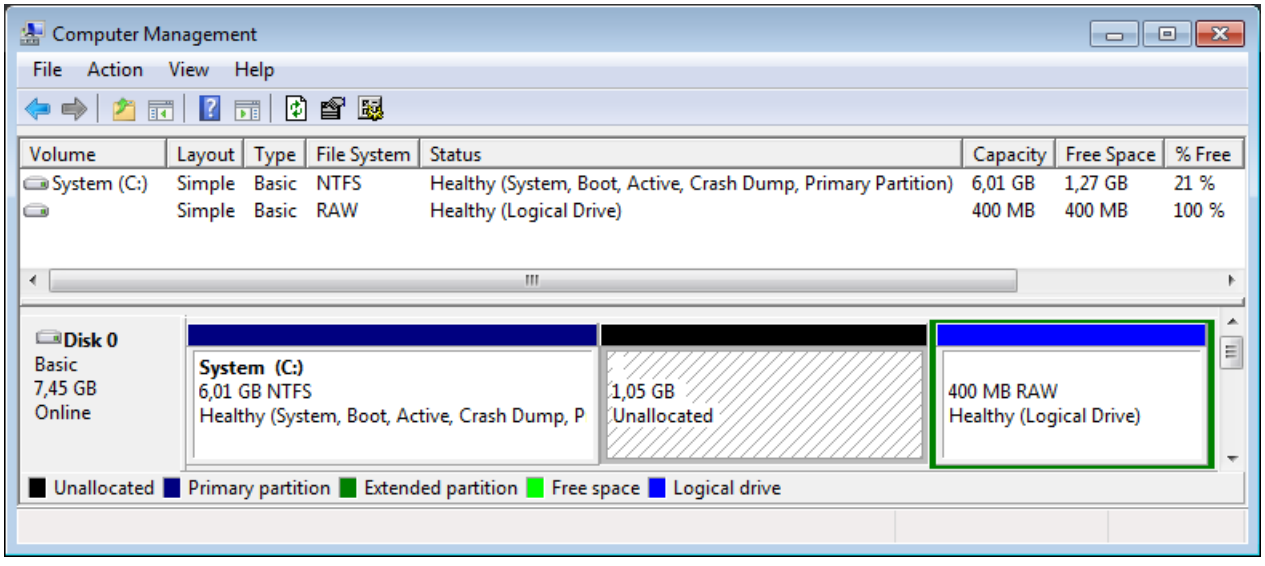

Figure 2-47 Partition D: cleared

Now right-click on Partition C: and select "Extend Volume...".

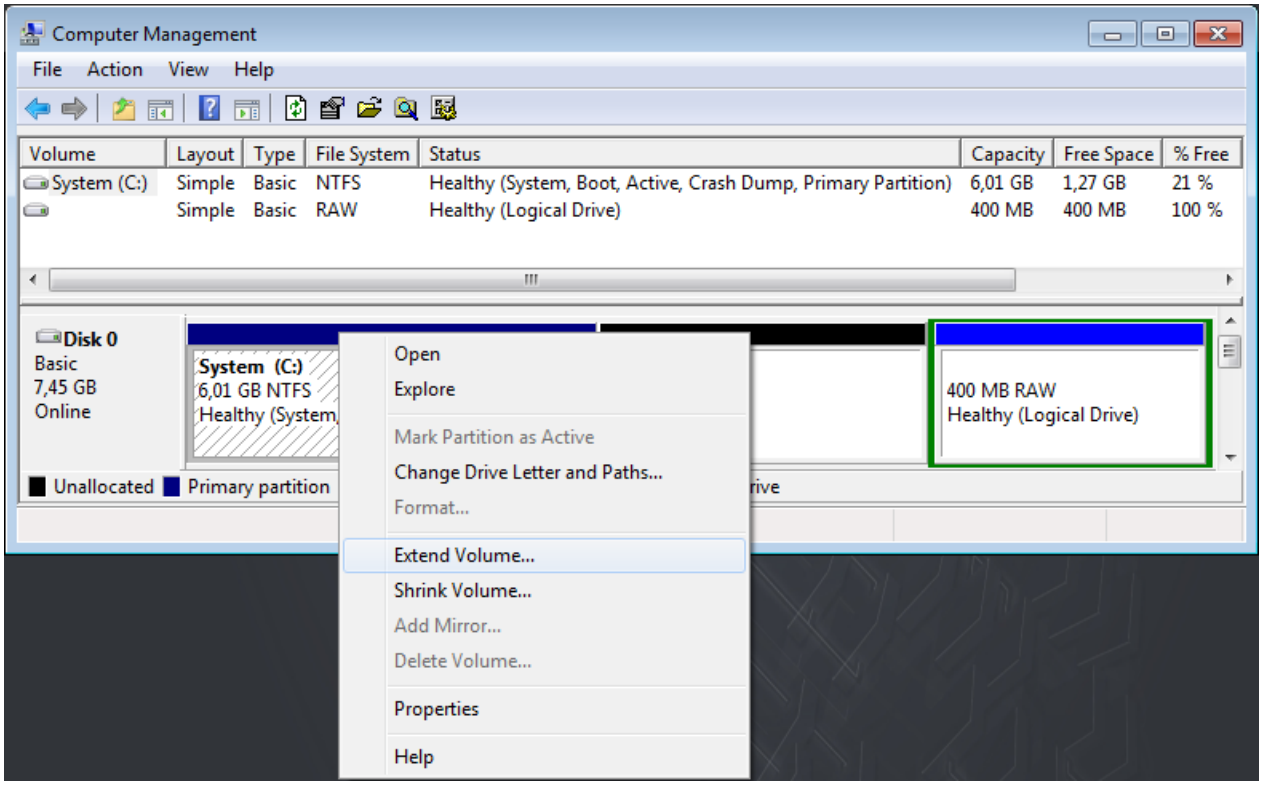

Figure 2-48 Partition C: expand

After selecting the option "Extend Volume...", the "Extend Volume Wizard" appears.

Figure 2-49 Extend Volume Wizard

In the following window you have the option to expand Partition C: by all or part of the available memory. In our example we expand Partition C: by 500 MB.

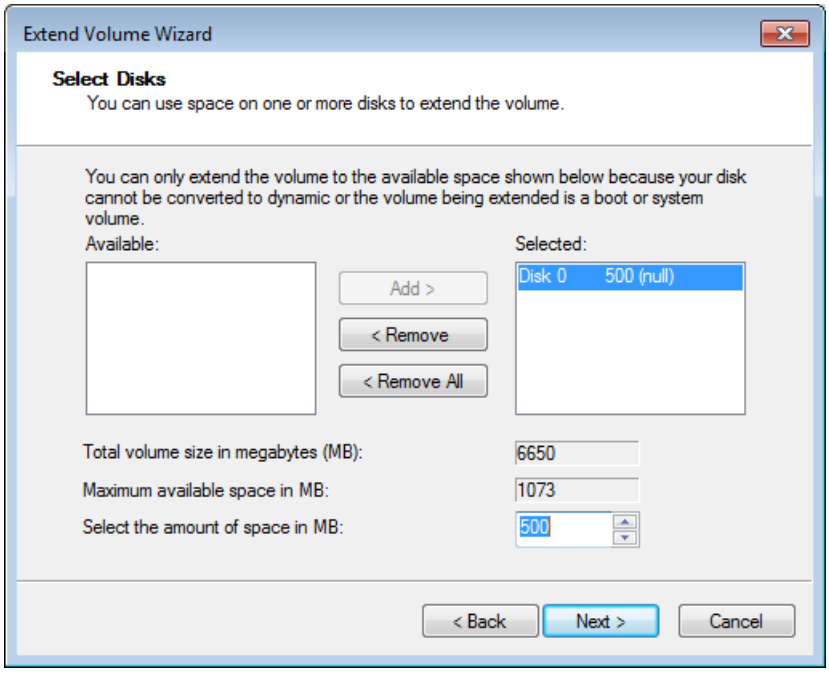

Figure 2-50 Select memory size

When you have completed the steps of the wizard, the Computer Management window shows you the new division of the partition sizes.

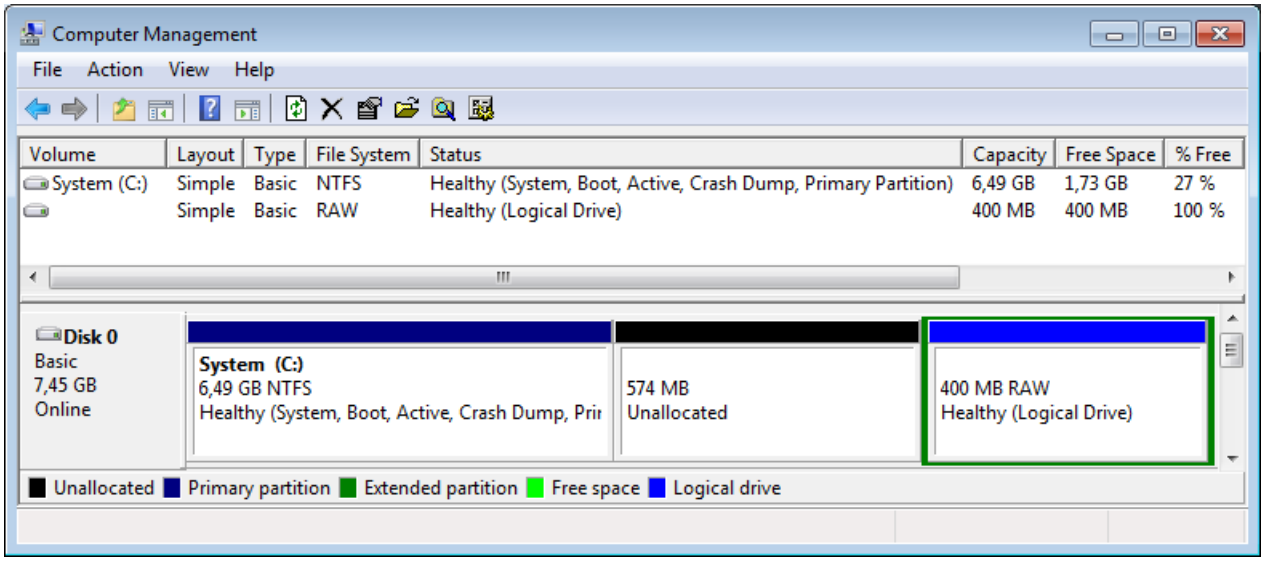

Figure 2-51 Result of the repartitioning

To reassign the unassigned memory to Partition D: right-click on the unassigned memory and select "New Simple Volume..."

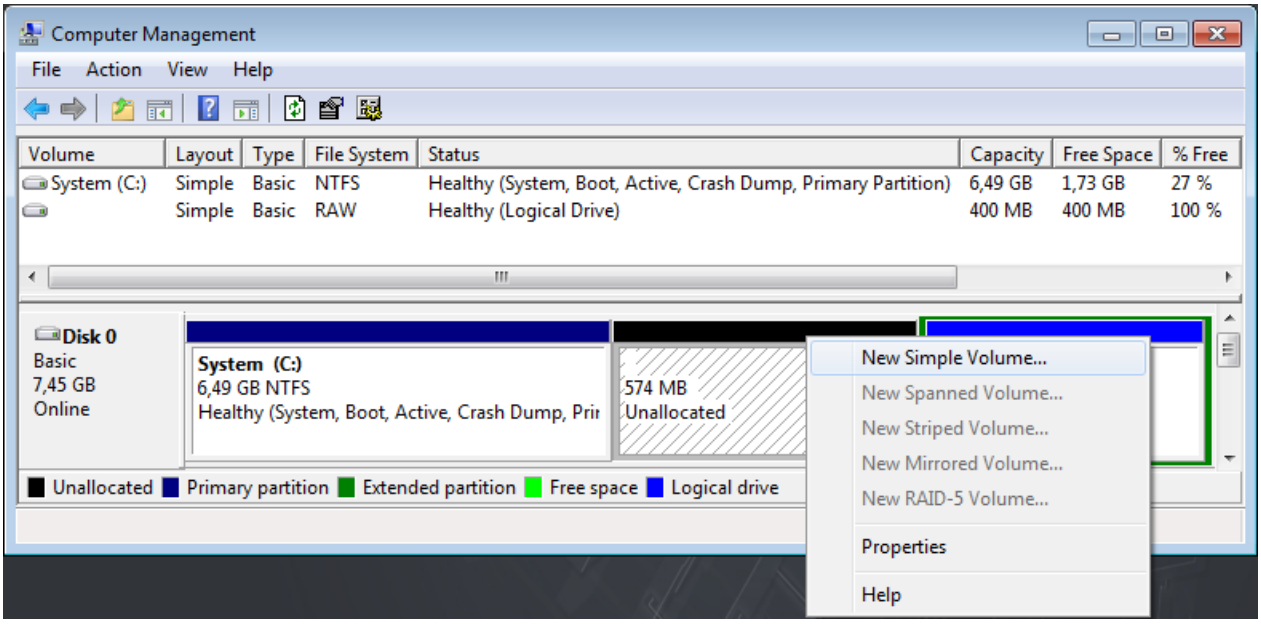

Figure 2-52 Recreate partition

After selecting the option "New Simple Volume...", the "New Simple Volume Wizard" appears. Set the required memory size there.

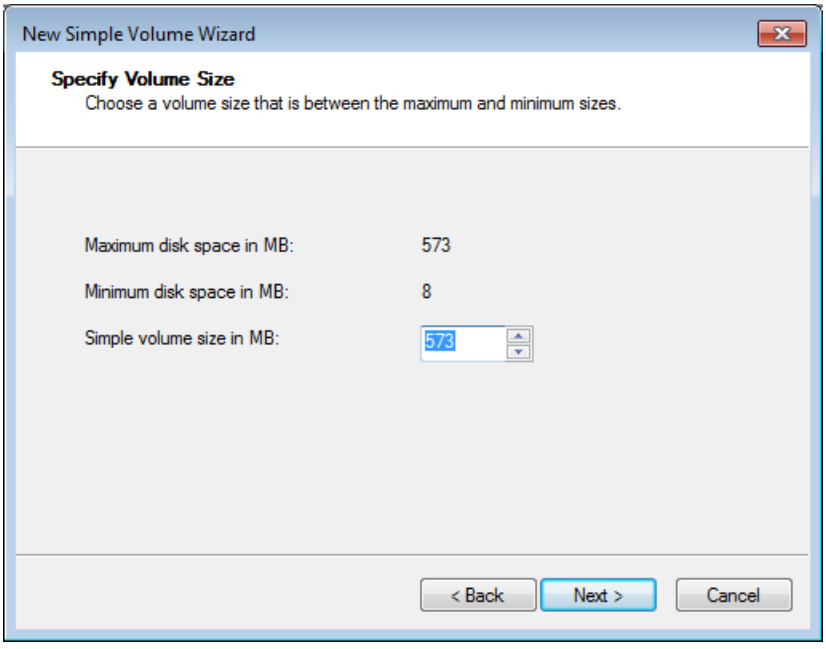

Figure 2-53 Select memory size

In the following window, select Drive D:

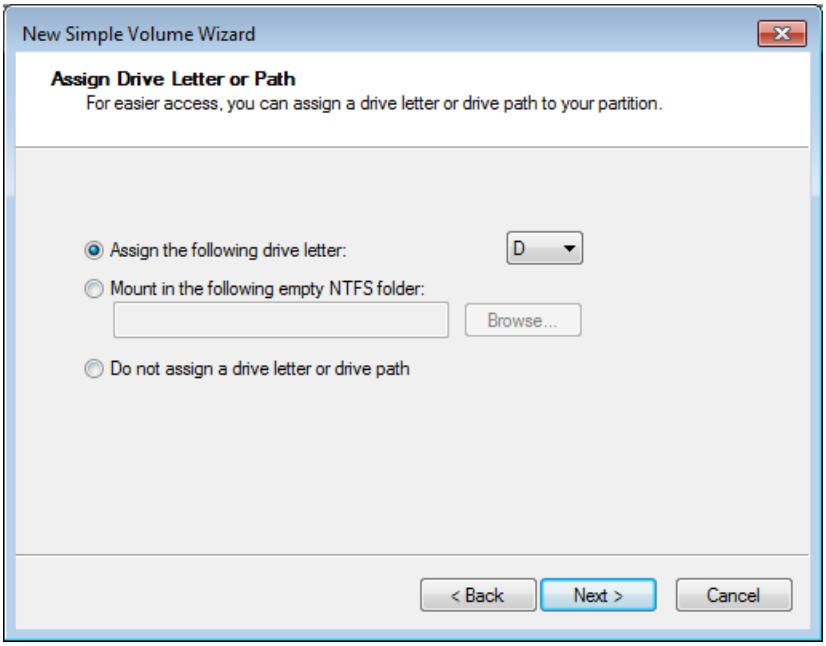

Figure 2-54 Assign drive letter

Specify the formatting for storing data on the partition.

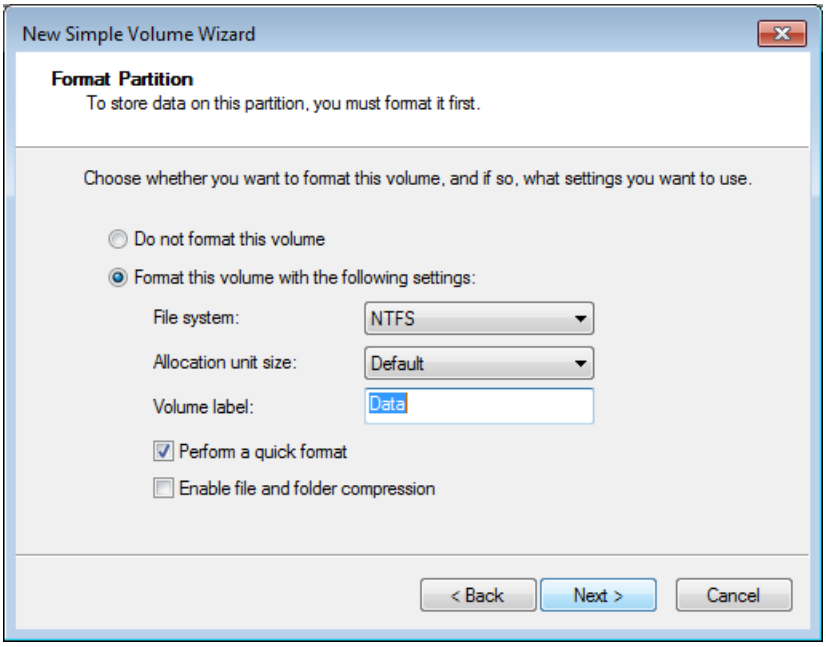

Figure 2-55 Specify formatting

Once you have defined the formatting, an overview of your selected settings appears. Then click "Finish" to complete the process.

The "Computer Management" window now shows the new partition sizes.

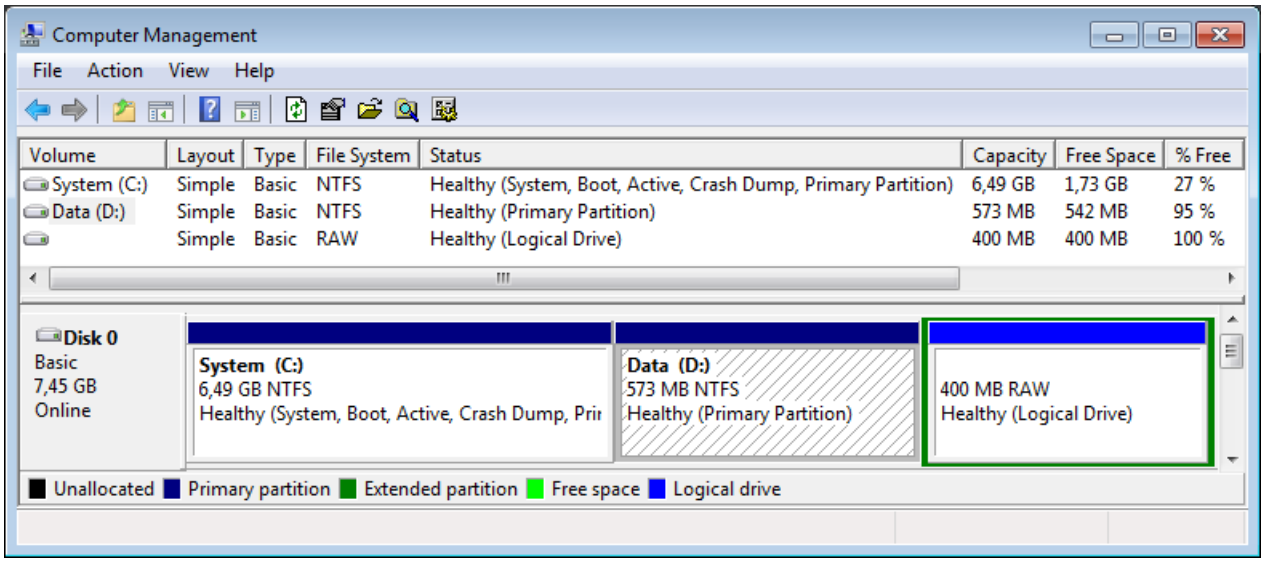

9.3 Restoring the delivery state

Introduction

The entire image of your operating system and your Runtime software are located on the supplied Restore DVD. You can use the SIMATIC Restore menu to restore the original CPU 1515SP PC (F) software.

Alternatively, you can use the Restore menu to create a boot-capable USB stick to restore the original software without a DVD-ROM drive (see chapter Restoring delivery state using USB stick (Page 85)).

NOTE

Restoring existing system partition

If your projects are stored on partition D: you can then use the option "Restore existing system partition" to restore Partition C: with the operating system and the Runtime software, without your project data being affected.

NOTE

Using Multitouch panels

The restoration of the original software is not possible with a Multitouch panel, because the Multitouch driver is not available until after the installation of the operating system.

Requirements

To restore the original software of the CPU 1515SP PC (F), the following is required:

- A CFast card. Minimum size of the CFast card for the CPU 1515SP PC (F):
  - WES7 E 32Bit 4GB RAM: 8 GB
  - WES7 P 64Bit 4GB RAM: 16 GB
- A DVD drive with external power supply
- The supplied Restore DVD. Alternatively, a bootable USB stick
- A data backup

NOTICE
Data loss During restoration of the system to delivery state, the CFast card is completely erased and re-formatted, and is then loaded with the original software. All subsequently modified or added data, programs, license keys and partitions on the CFast card will be lost. Back up the data of the CPU 1515SP PC (F), after you have assigned parameters to the module and if you have made changes to the configuration.

NOTICE
Loss of license keys Back up the license keys before the restore by dragging these to your USB stick via *Automation License Manager*. After the restart of the CPU 1515SP PC (F), re-install the license keys on the device via the *Automation License Manager*.

Restore delivery state of the CPU 1515SP PC (F) with the Restore DVD

Before the restore

1. Switch off the power supply of the CPU.
2. Remove all USB devices from the CPU.
3. Connect a DVD drive with restore DVD to a USB interface of the CPU.
4. Switch on the power supply of the CPU.
   → The CPU is started.
5. Press <F12> to start the Boot Manager.
6. Select the list entry for the DVD drive in the Boot Manager.

7. After the prompt, confirm the start by pressing any key.
   → The loading process is displayed (Windows logo).
   → The SIMATIC Restore menu opens.
   – Select a language.
   – Select "CPU1515SP PC (F)" or "CPU1515SP PC (F) + HMI".
   – Select the option "Completely restore system drive".
     → The original software is restored on Partition C:, Partition D: is deleted.

After the restore

1. Exit the Restore menu.
2. Remove all USB devices.
3. Proceed as described in Initial commissioning (Page 46).

Further procedure

- Reconnect the USB devices.
- Install the license keys.

9.4 Restoring delivery state using USB stick

Introduction

You can use the Restore menu to create a bootable USB stick in order to restore the original software of the CPU 1515SP PC (F).

Use the SIMATIC IPC Service USB FlashDrive (6AV7672-8JD02-0AA0) for the creation.

Preparing bootable USB stick using PC

NOTICE
Data loss If you transfer the data from the Restore-DVD to the USB stick, all existing data on the USB stick is deleted. You should back up the data on the USB stick before you create the Restore USB stick.

Transferring Restore DVD data to the USB stick

1. Place the Restore DVD into the DVD drive of a PC.
2. Double-click the CD_Menu.exe file in the root directory of the DVD.
3. Select the option " Create USB flash drive".
4. When all the data has been transferred, remove the Restore USB stick safely from the PC.

NOTE

If you disturb the User-Interface window during the process (for example, by a mouse click in the window), the process continues unchanged even if no reaction is recognizable within the tool interface.

Restoring delivery state using USB stick

Before the restore

1. Switch off the power supply of the CPU.
2. Remove all USB devices from the CPU.
3. Connect the Restore USB stick directly to the CPU.
4. Switch on the power supply of the CPU.
   The CPU is started.
   The restore process starts.
5. Press <F12> to start the Boot Manager.
6. Select the list entry for the USB stick as boot medium in the Boot Manager.
7. After the prompt, confirm the start by pressing any key.
   The loading process is displayed (Windows logo).
   The SIMATIC Restore menu opens.
8. Select a language.
9. Select "CPU 1515SP PC (F)" or "CPU 1515SP PC (F) + HMI".
10. Select the option "Restore delivery state".
    The original software is restored.

After the restore

1. Exit the Restore menu.
2. Remove all USB devices.
3. Proceed as described in Initial commissioning.

9.5 Updating software

NOTE

If you update the software, then always start the CPU 1515SP PC (F) in the GRUB menu in Windows mode (see Figure).

Information on updating software can be found on the Internet (https://support.industry.siemens.com/cs/ww/en).

HMI devices

During the installation, make sure that you always use the latest drivers for the HMI devices used (SIMATIC Flat Panels).
Before you install a new driver version, you must uninstall the old driver version in order to ensure proper operation.

You can download the current driver software from SIMATIC Product Support.

9.6 Windows Embedded Standard 7

The Windows Embedded Standard 7 operating system is pre-installed on the CPU 1515SP PC (F). WES7 E 32Bit or WES7 P 64Bit are available depending on the order option.

The WES7 P version supports multi-touch functionality (gesture control).

Windows language packs

English is available as the basic language for the installation of the Windows operating system.

With the system version **WES7 P 64Bit 4GB RAM** of the CPU 1515SP PC (F), other operating system languages can be installed after the first commissioning. Note that you need administrator rights to install language packages.

The following language packages are contained on the Restore DVD in \Packages\x64\LanguagePack:

- Traditional Chinese
- Simplified Chinese
- German
- English
- French
- Italian
- Japanese
- Korean
- Russian
- Spanish

Installing languages

Use the Windows function "Start > Control Panel > Region and Language" to install a language pack. The installation takes around 45 minutes.

Updates

You can install additional updates at a later time. You can find current information on the operating system at Widows (http://www.windows.com).

9.7 Sending the device to customer service

Before sending

NOTE

Back up data and remove memory cards

Before you send in the CPU 1515SP PC (F) for repair:

- Create a backup of your data.
- Back up your SIMATIC license keys on a USB stick.
- Remove your SD/MMC cards.
- Remove your **CFast card**.

9.8 Removing and inserting the CFast card

Introduction

CPU 1515SP PC (F) has one slot for a CFast card. On this card, you will find the operating system, your Runtime software and, after configuration, the project.

Seal the cover for the CFast card to protect the system against unauthorized access.

You must remove the CFast card before you send in the CPU, for example, for repair.

Requirements

- CPU 1515SP PC (F) is de-energized.

Procedure – Removing the CFast card

1. Remove the seal.
2. Open the cover, using a screwdriver if necessary.
3. Press onto the CFast card.
   The card is pressed out of the slot.
4. Pull the card out of the slot.
   To do this, grip the rib on the underside of the memory card.

Procedure – Inserting the CFast card

1. Open the cover of the slot, using a screwdriver if necessary.
2. Insert the CFast card into the slot.
3. Press the CFast card into the slot.

   The CFast card is properly inserted if the cover can be closed without any resistance.
4. Close the cover.

NOTICE
Unauthorized access Seal the cover with lead to protect the CFast card with the operating system of the CPU 1515SP PC (F) against unauthorized access.

Technical data 10

10.1 Standards and approvals

Introduction

The general technical specifications cover the following:

- The standards and test values which the CPU 1515SP PC (F) complies with and fulfils.
- The test criteria according to which the CPU 1515SP PC (F) was tested.

Currently valid markings and approvals

NOTE

The currently valid markings and approvals are printed on the CPU 1515SP PC (F).

Safety information

WARNING

Risk of personal injury and damage to property.

In potentially explosive atmospheres, injury to persons and material damage may occur if you disconnect plug-in connections during operation of an ET 200SP.

Always switch off the power to the ET 200SP when disconnecting plug-in connections in potentially explosive atmospheres.

WARNING

Flying sparks due to loose cables

Risk of explosion in hazardous areas.

USB cables and PROFINET connectors may detach from the device in the case of strong oscillation and high vibrating loads.

Attach these cables to the strain relief of the device using cable ties.

⚠ WARNING
Explosion hazard If you replace components, compliance with Class I, DIV. 2 can become invalid.

⚠ WARNING
Area of application This device is only suitable for use in Class I, Div. 2, Group A, B, C, D, or in non-hazardous areas.

CE marking

The CPU 1515SP PC (F) meets the requirements and protection targets of the following EC guidelines and complies with the harmonized European standards (EN) for programmable logic controllers published in the official gazettes of the European Community:

- 2006/95/EC "Electrical equipment designed for use within certain voltage limits" (Low-Voltage Directive)
- 2004/108/EC "Electromagnetic Compatibility" (EMC Directive)
- 94/9/EC "Equipment and protective systems intended for use in potentially explosive atmospheres" (Explosion Protection Directive)

The EC declarations of conformity are available for the responsible authorities at:

Siemens AG
Digital Factory
Factory Automation
DF FA AS DH AMB
Postfach 1963
D-92209 Amberg

These are also available for download on the Customer Support Internet pages, keyword "Declaration of Conformity".

cULus approval

Underwriters Laboratories Inc., complying with

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)

OR

cULus HAZ. LOC. approval

Underwriters Laboratories Inc., complying with

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)
- ANSI/ISA 12.12.01
- CSA C22.2 No. 213 (Hazardous Location)

APPROVED for use in
Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

Installation Instructions for cULus haz.loc.

- WARNING - Explosion Hazard - Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

FM approval

Factory Mutual Research (FM) according to
Approval Standard Class Number 3611, 3600, 3810 (ANSI/ISA 82.02.01)
CSA C22.2 No. 213
CSA C22.2 No. 61010-1
APPROVED for use in Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

ATEX approval

in accordance with EN 60079-15 (Electrical apparatus for potentially explosive atmospheres; Type of protection "n") and EN 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements)

II 3 G Ex nA IIC Tx Gc
DEKRA 12ATEX0038X

IECEx approval

According to IEC 60079-15 (Explosive atmospheres - Part 15: Equipment protection by type of protection "n") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements)

Ex nA IIC Tx Gc
IECEx DEK 13.0011X

Marking for Australia and New Zealand

or

The ET 200SP distributed I/O system meets the requirements of the standard AS/NZS CISPR 16.

Korea Certificate KCC-REM-S49-ET200SP

Note that this device corresponds to limit class A in terms of the emission of radio frequency interference. This device can be used in all areas, except residential areas.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

IEC 61131

The CPU 1515SP PC (F) with the S7-1500 software controller CPU 1505SP (F) meets the requirements and criteria of the standard IEC 61131-2 (programmable logic controllers, part 2: Equipment requirements and tests).

PROFINET standard

The ET 200SP distributed I/O system is based on the standard IEC 61158 Type 10.

PROFIBUS standard

The ET 200SP distributed I/O system is based on the standard IEC 61158 Type 3.

IO-Link standard

The ET 200SP distributed I/O system is based on the standard IEC 61131-9.

Use in industrial environments

SIMATIC products are designed for use in industry.

Table 2-30 Use in industrial environments

Area of application	Interference emission requirements	Interference immunity requirements
Industry	EN 61000-6-4: 2011	EN 61000-6-2: 2005

Use in residential areas

NOTE

The ET 200SP is intended for use in industrial areas; use in residential areas may have an impact on radio/TV reception.

If you want to use the ET 200SP in residential areas, you must ensure that its radio frequency interference emission complies with limit class B in accordance with EN 55011.

Suitable measures for achieving RF interference level Class B include, for example:

- Installation of the CPU 1515SP PC (F). in grounded control/switch cabinets
- Use of filters in the supply lines

Reference

The certificates for the markings and approvals can be found on the Internet under Service&Support (http://www.siemens.com/automation/service&support).

10.2 Electromagnetic compatibility

Definition

Electromagnetic compatibility (EMC) is the ability of an electrical installation to function satisfactorily in its electromagnetic environment without interfering with that environment.

Among other things, CPU 1515SP PC (F) also meets the requirements of the EMC legislation for the European single market. The prerequisite for this is that the CPU 1515SP PC (F) complies with the requirements and guidelines relating to electrical equipment.

EMC according to NE 21

The CPU 1515SP PC does not meet the EMC specifications of the NAMUR guideline NE21.

The CPU 1515SP PC meets the EMC specifications according to IEC 61131-2 and IEC 61000-6-2.

Pulse-shaped disturbance

The following table shows the electromagnetic compatibility of the CPU 1515SP PC (F) with regard to pulse-shaped interference.

Table 2-31 Pulse-shaped disturbance

Pulse-shaped disturbance	Test voltage	corresponds to degree of severity
Electrostatic discharge according to IEC 61000-4-2.	Air discharge: ±8 kV Contact discharge ± 4 kV	3 3
Burst pulses (high-speed transient disturbance) according to IEC 61000-4-4.	2 kV (power supply cable) 2 kV (signal cable > 30 m) 1 kV (signal cable < 30 m)	3 3
High-energy single pulse (surge) according to IEC 61000-4-5 External protective circuit required (see function manual Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566))		3
• asymmetric coupling	2 kV (power supply cable) DC with protective elements 2 kV (signal cable/data cable only > 30 m), possibly with protective elements	
• symmetric coupling	1 kV (power supply cables) DC with protective elements 1 kV (signal cable/data cable only > 30 m), possibly with protective elements	

Sinusoidal disturbance

The following table shows the electromagnetic compatibility of the CPU 1515SP PC (F) with regard to sinusoidal interference.

- RF radiation

Table 2-32 Sinusoidal disturbance variables with RF radiation

RF radiation according to IEC 61000-4-3/NAMUR 21 Electromagnetic RF field, amplitude-modulated		corresponds to degree of severity
80 to 1000 MHz; 1.0 to 2.0 GHz	2.0 GHz to 2.7 GHz	3
10 V/m	3 V/m	
80% AM (1 kHz)		

- RF coupling

Table 2-33 Sinusoidal disturbance variables with RF coupling

RF coupling according to IEC 61000-4-6	corresponds to degree of severity
(10 kHz) 150 kHz to 80 MHz	3
10 V_{rms} unmodulated	
80% AM (1 kHz)	
150 Ω source impedance	

Emission of radio interference

Interference emission of electromagnetic fields according to EN 55016: Limit class A, group 1 (measured at a distance of 10 m).

Table 2-34 Interference emission of electromagnetic fields according to EN 55016

Frequency	Emitted interference
30 MHz to 230 MHz	< 40 dB (µV/m)Q
230 MHz to 1000 MHz	< 47 dB (µV/m)Q

Interference emission via the AC power supply according to EN 55016: Limit value class A, Group 1.

Table 2-35 Interference emission via the AC power supply according to EN 55016

Frequency	Emitted interference
0.15 to 0.5 MHz	<79 dB (µV) Q <66 dB (µV) M
0.5 to 30 MHz	<73 dB (µV) Q <60 dB (µV) M

10.3 Shipping and storage conditions

Introduction

The CPU 1515SP PC (F) exceeds requirements in terms of shipping and storage conditions according to IEC 61131-2. The following information applies to modules that are shipped and/or stored in their original packaging.

Table 2-36 Shipping and storage conditions for modules

Type of condition	Permissible range
Free fall (in shipping package)	≤1 m
Temperature	From -40 °C to +70 °C
Barometric pressure	1080 hPa to 660 hPa (corresponds to an altitude of -1000 m to 3500 m)

Type of condition	Permissible range
Relative humidity	5% to 95%, without condensation
Sinusoidal vibrations according to IEC 60068-2-6	5 - 8.4 Hz: 3.5 mm 8.4 - 500 Hz: 9.8 m/s^2
Shock according to IEC 60068-2-27	250 m/s^2, 6 ms, 1000 shocks

10.4 Mechanical and climatic ambient conditions

NOTE

Restrictions

Deviating from the ambient conditions for the ET 200SP distributed I/O system, the following restrictions apply to the CPU 1515SP PC (F):

- Mechanical ambient conditions:
  - 2 g constant acceleration when using the BusAdapter BA 2×FC
- Ambient temperature:
  - 0 to 60 °C for horizontal installation with maximum 32 I/O modules
  - 0 to 55 °C for horizontal installation with maximum 64 I/O modules
  - 0 to 50 °C for vertical installation with maximum 32 I/O modules

Operating conditions

CPU 1515SP PC (F) is designed for stationary use in weather-proof locations. The operating conditions exceed the requirements according to DIN IEC 60721-3-3:

- Class 3M3 (mechanical requirements)
- Class 3K3 (climatic requirements)

Mechanical ambient conditions

The table below shows the mechanical ambient conditions in the form of sinusoidal oscillations.

Table 2-37 Mechanical ambient conditions

Frequency band	CPU 1515SP PC (F)
5 ≤ f ≤ 8.4 Hz	3.5 mm amplitude
8.4 ≤ f ≤ 150 Hz	1 g constant acceleration
10 ≤ f ≤ 60 Hz	0.35 mm amplitude
60 ≤ f ≤ 1000 Hz	• 1 g constant acceleration (with BusAdapter BA 2×RJ45) • 2 g constant acceleration (with BusAdapter BA 2×FC)

Test of mechanical ambient conditions

The table below provides important information with respect to the type and scope of the test of ambient mechanical conditions.

Table 2-38 Test of mechanical ambient conditions

Condition tested	Test Standard	Comment
Vibration	Vibration test according to IEC 60068-2-6 (sine)	Type of oscillation: Frequency sweeps with a rate of change of 1 octave/minute. BA 2×RJ45 • 5 Hz ≤ f ≤ 8.4 Hz, 3.5 mm constant amplitude • 8.4 Hz ≤ f ≤ 150 Hz, 1 g constant acceleration BA 2×FC • 10 Hz ≤ f ≤ 60 Hz, 0.35 mm constant amplitude • 60 Hz ≤ f ≤ 1000 Hz, 2 g constant acceleration Duration of vibration: 10 frequency sweeps per axis in each of 3 vertically aligned axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 150 m/s^2 peak value, 11 ms duration Direction of shock: 3 shocks in each direction (+/-) at each of 3 vertically aligned axes

Climatic ambient conditions

You may use the CPU 1515SP PC (F) under the following climatic, ambient conditions.

Table 2-39 Climatic ambient conditions

Ambient conditions	Permissible range	Comments
Temperature: Horizontal mounting position:	• from 0 to 60 °C	For configuration with 32 I/O modules and 3 x 100 mA USB load
	• from 0 to 55 °C	For configuration with 64 I/O modules and 2 x 500 mA + 1 x 100 mA USB load
Vertical installation:	• 0 to 50 °C	For configuration with 32 I/O modules and 3 x 100 mA USB load
Permitted temperature change	10 K/h	-
Relative humidity	from 10 to 95%	Without condensation, corresponds to relative humidity (RH) class 2 according to IEC 61131 part 2
Barometric pressure	1080 hPa to 795 hPa	Corresponds to an altitude of -1000 m to 2000 m
Concentration of pollutants	SO_2: <0.5 ppm; RH <60 %, no condensation H_2S: <0.1 ppm; RH <60 %, no condensation	-
	ISA-S71.04 severity level G1; G2; G3	-

10.5 Information on insulation, protection class, degree of protection and rated voltage

Insulation

The insulation is designed according to the requirements of EN 61131-2: 2007.

NOTE

For modules with 24 V DC supply voltage, the electrical isolation is designed for max. 60 V AC / 75 V DC and basic insulation is designed according to EN 61131-2: 2007.

Pollution degree/overvoltage category according to IEC 61131

- Pollution degree 2
- Overvoltage category: II

Protection class according to IEC 61131-2:2007

CPU 1515SP PC (F) fulfils the protection class I and contains parts of protection class II and III.

The grounding of the mounting rail must meet the requirements for functional earth FE.

The installation location (e.g. enclosure, control cabinet) must have a protective conductor connection that meets the standard to maintain protection class I.

Degree of protection IP20

Degree of protection IP20 according to IEC 60529, i.e.:

- Protection against contact with standard probe
- Protection against foreign objects with diameters in excess of 12.5 mm
- No protection against water

Rated voltage for operation

CPU 1515SP PC (F) works with the rated voltage and corresponding tolerances listed in the following table.

Table 2-40 Rated voltage for operation

Rated voltage	Tolerance range
24 V	19.2 to 28.8 V DC [1]
	18.5 to 30.2 V DC [2]

[1] Static value: Creation as functional extra-low voltage with safe electrical isolation in accordance with IEC 60364-4-41

[2] Dynamic value: including ripple, for example, with three-phase bridge rectification

10.6 Use of the ET 200SP in zone 2 potentially explosive atmospheres

See product information Use of subassemblies/modules in a Zone 2 Hazardous Area (http://support.automation.siemens.com/WW/view/en/19692172).

10.7 Module data

10.7.1 CPU 1515SP PC, system version WES7 E 32Bit 4GB RAM

CPU 1515SP PC, system version WES7 E 32Bit 4GB RAM

	6ES7677-2AA31-0EB0
General information	
Product type designation	CPU 1515SP PC
HW release number	FS06
Firmware version	V2.1
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V14 SP1
PC configuration	
Processor	Dual-Core 1 GHz, AMD G Series APU T40E
Main memory	4 GB RAM
Flash disk	30 GB
Operating systems	Windows Embedded Standard 7 E 32 bit
Installed SW	
Visualization	No
Controller	S7-1500 Software Controller CPU 1505SP V2.1
Operator controls	
Mode selector	1
Supply voltage	
Type of supply voltage	24 V DC

	6ES7677-2AA31-0EB0
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	
Current consumption (rated value)	1.5 A; full processor load, incl. ET 200SP modules and USB use
Current consumption (in no-load operation), typ.	0.6 A
Inrush current, max.	4.7 A; rated value
Power	
Power consumption, max.	36 W; incl. ET 200SP modules and USB use
Incoming power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	15 W; without ET 200SP modules and without USB use
Memory	
Type of memory	DDR3-SDRAM
CFast memory card	Yes; 30 GB flash memory
SIMATIC memory card required	No
Work memory	
Integrated (for program)	1 MB
Integrated (for data)	5 MB
Integrated (for ODK application)	10 MB
Load memory	
Integrated (on PC mass storage medium)	320 MB
Buffering	
with UPS	Yes; all retentive declared memory areas
with non-volatile memory	Yes
Hardware configuration	
integrated power supply	Yes
Number of DP masters	
Via CM	1
Racks	
Modules per rack, max.	64; CPU 1515SP PC + 64 module + server module
Number of rows, max.	1
Time-of-day	
Clock	
Type	Hardware clock
Buffering time	6 wk; at 40 °C ambient temperature, typ.
Deviation per day, max.	10 s; typ.: 2 s
Interfaces	
Number of Industrial Ethernet interfaces	2

	6ES7677-2AA31-0EB0
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1
Number of interfaces RS 485	1; via CM DP module
Number of USB interfaces	3; 3x USB 2.0 front, 500 mA each – of which 2 x 500 mA and 1 x 100 mA simultaneously
Number of SD card slots	1
Video interfaces	
Graphic interface	1x DVI-I
1st interface	
Interface hardware	
Number of ports	2
Integrated switch	Yes
RJ 45 (Ethernet)	Yes; via BusAdapter BA 2x RJ45
Transmission rate, max.	100 Mbps
Industrial Ethernet status LED	Yes
2nd interface	
Interface hardware	
Number of ports	1
RJ 45 (Ethernet)	Yes; integrated
Transmission rate, max.	1000 Mbps
Industrial Ethernet status LED	No
3rd interface	
Interface hardware	
RS 485	Yes
Interface hardware	
RJ 45 (Ethernet)	
100 Mbps	Yes; for 1st Interface X1
1000 Mbps	Yes; for 2nd Interface X2
Autonegotiation	Yes
Autocrossing	Yes
RS 485	
Transmission rate, max.	12 Mbps
Interrupts/diagnostics/status information	
LED diagnostics display	
RUN/STOP LED	Yes
ERROR LED	Yes
MAINT LED	Yes
Ambient conditions	
Ambient temperature in operation	
Min.	0 °C
Max.	Up to 60 °C with max. 32 ET 200SP modules and 3x 100 mA USB load; up to 55 °C with max 64 ET 200SP modules and 2x max. 500 mA and 1x max. 100 mA USB load

	6ES7677-2AA31-0EB0
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C; with max. 32 ET 200SP modules and 3x 100 mA USB load
Ambient temperature during storage / transport	
Min.	-40 °C
Max.	70 °C
I/O / Options	
I/O	
SD card	Optional for additional mass storage
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

10.7.2 CPU 1515SP PC F, system version WES7 E 32Bit 4GB RAM

CPU 1515SP PC F, system version WES7 E 32Bit 4GB RAM

	6ES7677-2FA31-0EB0
General information	
Product type designation	CPU 1515SP PC F
Firmware version	V2.1
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V14 SP1
PC configuration	
Processor	Dual-Core 1 GHz, AMD G Series APU T40E
Main memory	4 GB RAM
Flash disk	30 GB
Operating systems	Windows Embedded Standard 7 E 32 bit
Installed SW	
Visualization	No
Controller	S7-1500 Software Controller CPU 1505SP F
Operator controls	
Mode selector	1
Supply voltage	
Type of supply voltage	24 V DC
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V

	6ES7677-2FA31-0EB0
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	
Current consumption (rated value)	1.5 A; full processor load, incl. ET 200SP modules and USB use
Current consumption (in no-load operation), typ.	0.6 A
Inrush current, max.	4.7 A; rated value
Power	
Power consumption, max.	36 W; incl. ET 200SP modules and USB use
Incoming power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	15 W; without ET 200SP modules and without USB use
Memory	
Type of memory	DDR3-SDRAM
CFast memory card	Yes; 30 GB flash memory
SIMATIC memory card required	No
Work memory	
Integrated (for program)	1.5 MB
Integrated (for data)	5 MB
Integrated (for ODK application)	10 MB
Load memory	
Integrated (on PC mass storage medium)	320 MB
Buffering	
with UPS	Yes; all retentive declared memory areas
with non-volatile memory	Yes
Hardware configuration	
integrated power supply	Yes
Number of DP masters	
Via CM	1
Racks	
Modules per rack, max.	64; CPU 1515SP PC + 64 module + server module
Number of rows, max.	1
Time-of-day	
Clock	
Type	Hardware clock
Buffering time	6 wk; at 40 °C ambient temperature, typ.
Deviation per day, max.	10 s; typ.: 2 s
Interfaces	
Number of Industrial Ethernet interfaces	2
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1

	6ES7677-2FA31-0EB0
Number of interfaces RS 485	1; via CM DP module
Number of USB interfaces	3; 3x USB 2.0 front, 500 mA each – of which 2 x 500 mA and 1 x 100 mA simultaneously
Number of SD card slots	1
Video interfaces	
Graphics interface	1x DVI-I
1st interface	
Interface hardware	
Number of ports	2
integrated switch	Yes
RJ 45 (Ethernet)	Yes; via BusAdapter BA 2x RJ45
Transmission rate, max.	100 Mbps
Industrial Ethernet status LED	Yes
2nd interface	
Interface hardware	
Number of ports	1
RJ 45 (Ethernet)	Yes; integrated
Transmission rate, max.	1000 Mbps
Industrial Ethernet status LED	No
3rd interface	
Interface hardware	
RS 485	Yes
Interface hardware	
RJ 45 (Ethernet)	
100 Mbps	Yes; for 1st Interface X1
1000 Mbps	Yes; for 2nd Interface X2
Autonegotiation	Yes
Autocrossing	Yes
RS 485	
Transmission rate, max.	12 Mbps
Interrupts/diagnostics/status information	
LED diagnostics display	
RUN/STOP LED	Yes
ERROR LED	Yes
MAINT LED	Yes
Ambient conditions	
Ambient temperature in operation	
Min.	0 °C
Max.	Up to 60 °C with max. 32 ET 200SP modules and 3x 100 mA USB load; up to 55 °C with max 64 ET 200SP modules and 2x max. 500 mA and 1x max. 100 mA USB load
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C

	6ES7677-2FA31-0EB0
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C; with max. 32 ET 200SP modules and 3x 100 mA USB load
Ambient temperature during storage / transport	
Min.	-40 °C
Max.	70 °C
I/O / Options	
I/O	
SD card	optional for additional mass storage
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

10.7.3 CPU 1515SP PC, system version WES7 E 32Bit 4GB RAM - spare part

CPU 1515SP PC, system version WES7 E 32Bit 4GB RAM - spare part

	6ES7677-2AA40-0AA0
General information	
Product type designation	CPU 1515SP PC
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	as of STEP 7 V14
PC configuration	
Processor	Dual-Core 1 GHz, AMD G Series APU T40E
Main memory	4 GB RAM
Installed SW	
Visualization	No
Controller	No
Operator controls	
Mode selector	1
Supply voltage	
Type of supply voltage	24 V DC
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	

	6ES7677-2AA40-0AA0
Current consumption (rated value)	1.5 A; full processor load, incl. ET 200SP modules and USB use
Current consumption (in no-load operation), typ.	0.6 A
Inrush current, max.	4.7 A; rated value
Power	
Power consumption, max.	36 W; incl. ET 200SP modules and USB use
Incoming power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	15 W; without ET 200SP modules and without USB use
Memory	
Type of memory	DDR3-SDRAM
CFast memory card	No
Work memory	
Integrated	4 GB
Hardware configuration	
integrated power supply	Yes
Number of DP masters	
Via CM	1
Racks	
Modules per rack, max.	64; CPU + 64 Module + server module (mounting width max. 1 m)
Number of rows, max.	1
Time-of-day	
Clock	
Type	Hardware clock
Buffering time	6 wk; at 40 °C ambient temperature, typ.
Deviation per day, max.	10 s; typ.: 2 s
Interfaces	
Number of Industrial Ethernet interfaces	2
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1; via CM DP module
Number of interfaces RS 485	1; via CM DP module
Number of USB interfaces	3; 3x USB 2.0 front, 500 mA each – of which 2 x 500 mA and 1 x 100 mA simultaneously
Number of SD card slots	1
Video interfaces	
Graphics interface	1x DVI-I
1st interface	
Interface hardware	
Number of ports	2
integrated switch	Yes
RJ 45 (Ethernet)	Yes; via BusAdapter BA 2x RJ45
Transmission rate, max.	100 Mbps

	6ES7677-2AA40-0AA0
Industrial Ethernet status LED	Yes
2nd interface	
Interface hardware	
Number of ports	1
RJ 45 (Ethernet)	Yes; integrated
Transmission rate, max.	1000 Mbps
Industrial Ethernet status LED	No
3rd interface	
Interface hardware	
RS 485	Yes; via CM DP module
Interface hardware	
RJ 45 (Ethernet)	
100 Mbps	Yes; for 1st Interface X1
1000 Mbps	Yes; for 2nd Interface X2
Autonegotiation	Yes
Autocrossing	Yes
RS 485	
Transmission rate, max.	12 Mbps
Ambient conditions	
Ambient temperature in operation	
Min.	0 °C
Max.	Up to 60 °C with max. 32 ET 200SP modules and 3x 100 mA USB load; up to 55 °C with max 64 ET 200SP modules and 2x max. 500 mA and 1x max. 100 mA USB load
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C; with max. 32 ET 200SP modules and 3x 100 mA USB load
Ambient temperature during storage / transport	
Min.	-40 °C
Max.	70 °C
I/O / Options	
I/O	
SD card	optional for additional mass storage
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

10.7.4 CPU 1515SP PC, system version WES7 P 64Bit 4GB RAM

CPU 1515SP PC, system version WES7 P 64Bit 4GB RAM

	6ES7677-2AA41-0FB0
General information	
Product type designation	CPU 1515SP PC
HW release number	FS05
Firmware version	V2.1
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V14 SP1
PC configuration	
Processor	Dual-Core 1 GHz, AMD G Series APU T40E
Main memory	4 GB RAM
Flash disk	30 GB
Operating systems	Windows Embedded Standard 7 P 64 bit
Installed SW	
Visualization	No
Controller	S7-1500 Software Controller CPU 1505SP V2.1
Operator controls	
Mode selector	1
Supply voltage	
Type of supply voltage	24 V DC
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	
Current consumption (rated value)	1.5 A; full processor load, incl. ET 200SP modules and USB use
Current consumption (in no-load operation), typ.	0.6 A
Inrush current, max.	4.7 A; rated value
Power	
Power consumption, max.	36 W; incl. ET 200SP modules and USB use
Incoming power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	15 W; without ET 200SP modules and without USB use
Memory	
Type of memory	DDR3-SDRAM
CFast memory card	Yes; 30 GB flash memory
SIMATIC memory card required	No
Work memory	
Integrated (for program)	1 MB

	6ES7677-2AA41-0FB0
Integrated (for data)	5 MB
Integrated (for ODK application)	10 MB
Load memory	
Integrated (on PC mass storage medium)	320 MB
Buffering	
with UPS	Yes; all retentive declared memory areas
with non-volatile memory	Yes
Hardware configuration	
integrated power supply	Yes
Number of DP masters	
Via CM	1
Racks	
Modules per rack, max.	64; CPU 1515SP PC + 64 module + server module
Number of rows, max.	1
Time-of-day	
Clock	
Type	Hardware clock
Buffering time	6 wk; at 40 °C ambient temperature, typ.
Deviation per day, max.	10 s; typ.: 2 s
Interfaces	
Number of Industrial Ethernet interfaces	2
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1
Number of interfaces RS 485	1; via CM DP module
Number of USB interfaces	3; 3x USB 2.0 front, 500 mA each – of which 2 x 500 mA and 1 x 100 mA simultaneously
Number of SD card slots	1
Video interfaces	
Graphics interface	1x DVI-I
1st interface	
Interface hardware	
Number of ports	2
integrated switch	Yes
RJ 45 (Ethernet)	Yes; via BusAdapter BA 2x RJ45
Transmission rate, max.	100 Mbps
Industrial Ethernet status LED	Yes
2nd interface	
Interface hardware	
Number of ports	1
RJ 45 (Ethernet)	Yes; integrated
Transmission rate, max.	1000 Mbps
Industrial Ethernet status LED	No

	6ES7677-2AA41-0FB0
3rd interface	
Interface hardware	
RS 485	Yes
Interface hardware	
RJ 45 (Ethernet)	
100 Mbps	Yes; for 1st Interface X1
1000 Mbps	Yes; for 2nd Interface X2
Autonegotiation	Yes
Autocrossing	Yes
RS 485	
Transmission rate, max.	12 Mbps
Interrupts/diagnostics/status information	
LED diagnostics display	
RUN/STOP LED	Yes
ERROR LED	Yes
MAINT LED	Yes
Ambient conditions	
Ambient temperature in operation	
Min.	0 °C
Max.	Up to 60 °C with max. 32 ET 200SP modules and 3x 100 mA USB load; up to 55 °C with max 64 ET 200SP modules and 2x max. 500 mA and 1x max. 100 mA USB load
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C; with max. 32 ET 200SP modules and 3x 100 mA USB load
Ambient temperature during storage / transport	
Min.	-40 °C
Max.	70 °C
I/O / Options	
I/O	
SD card	optional for additional mass storage
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

10.7.5 CPU 1515SP PC F, system version WES7 P 64Bit 4GB RAM

CPU 1515SP PC F, system version WES7 P 64Bit 4GB RAM

	6ES7677-2FA41-0FB0
General information	
Product type designation	CPU 1515SP PC
HW release number	FS02
Firmware version	V2.1
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V14 SP1
PC configuration	
Processor	Dual-Core 1 GHz, AMD G Series APU T40E
Main memory	4 GB RAM
Flash disk	30 GB
Operating systems	Windows Embedded Standard 7 P 64 bit
Installed SW	
Visualization	No
Controller	S7-1500 Software Controller CPU 1505SP F
Operator controls	
Mode selector	1
Supply voltage	
Type of supply voltage	24 V DC
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	
Current consumption (rated value)	1.5 A; full processor load, incl. ET 200SP modules and USB use
Current consumption (in no-load operation), typ.	0.6 A
Inrush current, max.	4.7 A; rated value
Power	
Power consumption, max.	36 W; incl. ET 200SP modules and USB use
Incoming power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	15 W; without ET 200SP modules and without USB use
Memory	
Type of memory	DDR3-SDRAM
CFast memory card	Yes; 30 GB flash memory
SIMATIC memory card required	No
Work memory	
Integrated (for program)	1.5 MB

	6ES7677-2FA41-0FB0
Integrated (for data)	5 MB
Integrated (for ODK application)	10 MB
Load memory	
Integrated (on PC mass storage medium)	320 MB
Buffering	
with UPS	Yes; all retentive declared memory areas
with non-volatile memory	Yes
Hardware configuration	
integrated power supply	Yes
Number of DP masters	
Via CM	1
Racks	
Modules per rack, max.	64; CPU 1515SP PC + 64 module + server module
Number of rows, max.	1
Time-of-day	
Clock	
Type	Hardware clock
Buffering time	6 wk; at 40 °C ambient temperature, typ.
Deviation per day, max.	10 s; typ.: 2 s
Interfaces	
Number of Industrial Ethernet interfaces	2
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1
Number of interfaces RS 485	1; via CM DP module
Number of USB interfaces	3; 3x USB 2.0 front, 500 mA each – of which 2 x 500 mA and 1 x 100 mA simultaneously
Number of SD card slots	1
Video interfaces	
Graphics interface	1x DVI-I
1st interface	
Interface hardware	
Number of ports	2
integrated switch	Yes
RJ 45 (Ethernet)	Yes; via BusAdapter BA 2x RJ45
Transmission rate, max.	100 Mbps
Industrial Ethernet status LED	Yes
2nd interface	
Interface hardware	
Number of ports	1
RJ 45 (Ethernet)	Yes; integrated
Transmission rate, max.	1000 Mbps
Industrial Ethernet status LED	No

	6ES7677-2FA41-0FB0
3rd interface	
Interface hardware	
RS 485	Yes
Interface hardware	
RJ 45 (Ethernet)	
100 Mbps	Yes; for 1st Interface X1
1000 Mbps	Yes; for 2nd Interface X2
Autonegotiation	Yes
Autocrossing	Yes
RS 485	
Transmission rate, max.	12 Mbps
Interrupts/diagnostics/status information	
LED diagnostics display	
RUN/STOP LED	Yes
ERROR LED	Yes
MAINT LED	Yes
Ambient conditions	
Ambient temperature in operation	
Min.	0 °C
Max.	Up to 60 °C with max. 32 ET 200SP modules and 3x 100 mA USB load; up to 55 °C with max 64 ET 200SP modules and 2x max. 500 mA and 1x max. 100 mA USB load
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C; with max. 32 ET 200SP modules and 3x 100 mA USB load
Ambient temperature during storage / transport	
Min.	-40 °C
Max.	70 °C
I/O / Options	
I/O	
SD card	optional for additional mass storage
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

10.7.6 CPU 1515SP PC, system version WES7 E 64Bit 4GB RAM - spare part

CPU 1515SP PC, system version WES7 E 64Bit 4GB RAM - spare part

	6ES7677-2AA40-0AA0
General information	
Product type designation	CPU 1515SP PC
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	as of STEP 7 V14
PC configuration	
Processor	Dual-Core 1 GHz, AMD G Series APU T40E
Main memory	4 GB RAM
Installed SW	
Visualization	No
Controller	No
Operator controls	
Mode selector	1
Supply voltage	
Type of supply voltage	24 V DC
Low limit of permitted range (DC)	19.2 V
High limit of permitted range (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	
Current consumption (rated value)	1.5 A; full processor load, incl. ET 200SP modules and USB use
Current consumption (in no-load operation), typ.	0.6 A
Inrush current, max.	4.7 A; rated value
Power	
Power consumption, max.	36 W; incl. ET 200SP modules and USB use
Incoming power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	15 W; without ET 200SP modules and without USB use
Memory	
Type of memory	DDR3-SDRAM
CFast memory card	No
Work memory	
Integrated	4 GB
Hardware configuration	
integrated power supply	Yes
Number of DP masters	
Via CM	1
Racks	

	6ES7677-2AA40-0AA0
Modules per rack, max.	64; CPU + 64 Module + server module (mounting width max. 1 m)
Number of rows, max.	1
Time-of-day	
Clock	
Type	Hardware clock
Buffering time	6 wk; at 40 °C ambient temperature, typ.
Deviation per day, max.	10 s; typ.: 2 s
Interfaces	
Number of Industrial Ethernet interfaces	2
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1; via CM DP module
Number of interfaces RS 485	1; via CM DP module
Number of USB interfaces	3; 3x USB 2.0 front, 500 mA each – of which 2 x 500 mA and 1 x 100 mA simultaneously
Number of SD card slots	1
Video interfaces	
Graphics interface	1x DVI-I
1st interface	
Interface hardware	
Number of ports	2
integrated switch	Yes
RJ 45 (Ethernet)	Yes; via BusAdapter BA 2x RJ45
Transmission rate, max.	100 Mbps
Industrial Ethernet status LED	Yes
2nd interface	
Interface hardware	
Number of ports	1
RJ 45 (Ethernet)	Yes; integrated
Transmission rate, max.	1000 Mbps
Industrial Ethernet status LED	No
3rd interface	
Interface hardware	
RS 485	Yes; via CM DP module
Interface hardware	
RJ 45 (Ethernet)	
100 Mbps	Yes; for 1st Interface X1
1000 Mbps	Yes; for 2nd Interface X2
Autonegotiation	Yes
Autocrossing	Yes
RS 485	
Transmission rate, max.	12 Mbps
Ambient conditions	

	6ES7677-2AA40-0AA0
Ambient temperature in operation	
Min.	0 °C
Max.	Up to 60 °C with max. 32 ET 200SP modules and 3x 100 mA USB load; up to 55 °C with max 64 ET 200SP modules and 2x max. 500 mA and 1x max. 100 mA USB load
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C; with max. 32 ET 200SP modules and 3x 100 mA USB load
Ambient temperature during storage / transport	
Min.	-40 °C
Max.	70 °C
I/O / Options	
I/O	
SD card	optional for additional mass storage
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

10.7.7 CPU 1515SP PC (F) + HMI

The technical specifications of the following devices modules can be found in the product information under (http://support.automation.siemens.com/WW/view/en/104117388).

ET 200SP Open Controller System version WES7 P 64Bit 4GB RAM	Article number
CPU 1515SP PC	
CPU 1515SP PC + HMI 128PT	6ES7677-2AA41-0FK0
CPU 1515SP PC + HMI 512PT	6ES7677-2AA41-0FL0
CPU 1515SP PC + HMI 2048PT	6ES7677-2AA41-0FM0
CPU 1515SP PC F	
CPU 1515SP PC F + HMI 128PT	6ES7677-2FA41-0FK0
CPU 1515SP PC F + HMI 512PT	6ES7677-2FA41-0FL0
CPU 1515SP PC F + HMI 2048PT	6ES7677-2FA41-0FM0

10.7.8 S7-1500 Software Controller CPU 1505SP (F)

CPU 1505SP (F) is a PC-based controller of the SIMATIC S7-1500 Software Controller family. For more information about the CPU 1505SP (F), refer to the corresponding manual at (https://support.industry.siemens.com/cs/ww/en/view/109740725). For the CPU 1505SP F, also note the information in the F product information at (https://support.industry.siemens.com/cs/ww/en/view/109478599).

Technical specifications

You can find all technical specifications on CPU 1505SP with the article number 6ES7672-5DC01-0YA0 under (https://support.industry.siemens.com/cs/ww/en/pv/6ES7672-5DC01-0YA0/td). You can find all technical specifications on CPU 1505SP F with the article number 6ES7672-5SC01-0YA0 under (https://support.industry.siemens.com/cs/ww/en/pv/6ES7672-5SC01-0YA0/td).

10.8 Dimension drawings

10.8.1 CPU 1515SP PC (F)

This section contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets.

Dimension drawings of the CPU 1515SP PC (F).

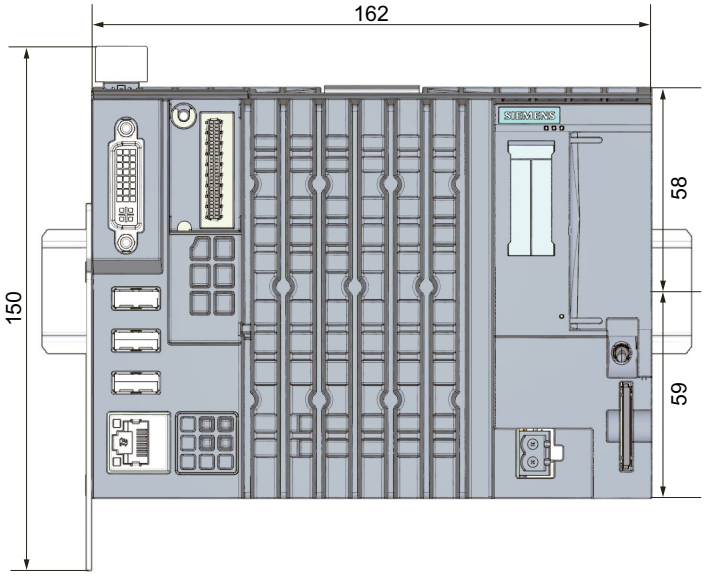

Figure 2-56 Dimension drawing of CPU 1515SP PC, front view

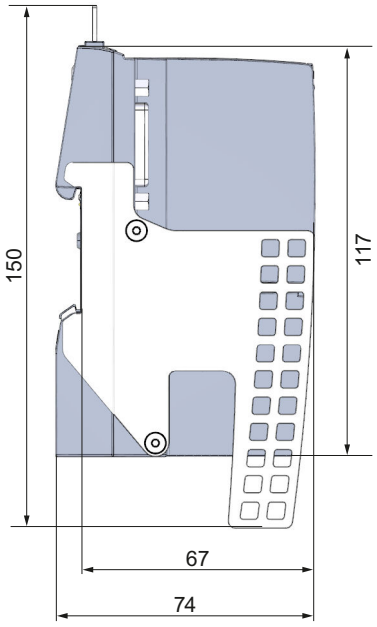

Figure 2-57 Dimension drawing of CPU 1515SP PC, side view

Accessories/spare parts

A

Ordering options and accessories for CPU 1515SP PC (F)

Table 2-41 Order options for CPU 1515SP PC

Description	Article number
System version **WES7 E 32Bit 4GB RAM** [1]	
CPU 1515SP PC, 30 GB CFast card with pre-installed S7-1500 Software Controller CPU 1505SP	6ES7677-2AA31-0EB0
CPU 1515SP PC, 30 GB CFast card with pre-installed S7-1500 Software Controller CPU 1505SP F	6ES7677-2FA31-0EB0
CPU 1515SP PC 4 GB, spare part (without CFast card, without software)	6ES7677-2AA40-0AA0
System version **WES7 P 64Bit 4GB RAM** [1]	
CPU 1515SP PC, 30 GB CFast card with pre-installed S7-1500 Software Controller CPU 1505SP	6ES7677-2AA41-0FB0
CPU 1515SP PC, 30 GB CFast card with pre-installed S7-1500 Software Controller CPU 1505SP and WinCC Runtime Advanced as of V14	
• CPU 1515SP PC + HMI 128PT	6ES7677-2AA41-0FK0
• CPU 1515SP PC + HMI 512PT	6ES7677-2AA41-0FL0
• CPU 1515SP PC + HMI 2048PT	6ES7677-2AA41-0FM0
CPU 1515SP PC F, 30 GB CFast card with pre-installed S7-1500 Software Controller CPU 1505SP	6ES7677-2FA41-0FB0
CPU 1515SP PC, 30 GB CFast card with pre-installed S7-1500 Software Controller CPU 1505SP F and WinCC Runtime Advanced as of V14	
• CPU 1515SP PC F + HMI 128PT	6ES7677-2FA41-0FK0
• CPU 1515SP PC F + HMI 512PT	6ES7677-2FA41-0FL0
• CPU 1515SP PC F + HMI 2048PT	6ES7677-2FA41-0FM0

[1] Windows Embedded Standard 7

Table 2-42 Accessories for CPU 1515SP PC (F)

Description	Article number
BusAdapter, 1 unit	
• BA 2×RJ45 (PROFINET BusAdapter with standard Ethernet socket)	6ES7193-6AR00-0AA0
• BA 2×FC (PROFINET BusAdapter with Fast Connect Ethernet connection)	6ES7193-6AF00-0AA0
Server module; 1 unit	6ES7193-6PA00-0AA0
Strain relief for CPU 1515SP PC (F)	A5E32291462
SIMATIC IPC Service USB flash drive 8 GB (SLC), pre-installed BIOS-MANAGER V3.3, Image/Partition Creator V3.3 and installation CD	6AV7672-8JD01-0AA0

Description	Article number
SIMATIC IPC Service USB Flashdrive 16 GB, USB3.0, pre-installed BIOS-MANAGER V3.3, Image/Partition Creator V3.4 and installation CD	6AV7672-8JD02-0AA0
SIMATIC IPC DiagMonitor Software V4.4	6ES7648-6CA04-4YX0
SIMATIC PC, adapter cable, DVI-I compliant with VGA, 250 mm long	6ES7648-3AB00-0XA0
Reference identification label, sheet with 16 labels, 10 units	6ES7193-6LF30-0AW0
Mounting rails, tin-plated steel strip	
• Length: 483 mm	6ES5710-8MA11
• Length: 430 mm	6ES5710-8MA21
• Length: 830 mm	6ES5710-8MA31
• Length: 2000 mm	6ES5710-8MA41
SIMATIC IPC CFast cards	
• CFast 4 GB Industrial Grade	6ES7648-2BF10-0XG10
• CFast 8 GB Industrial Grade	6ES7648-2BF10-0XH10
• CFast 16 GB Industrial Grade	6ES7648-2BF10-0XJ10
• CFast 30 GB Industrial Grade	6ES7648-2BF10-0XK10

Online catalog

Additional article numbers can be found on the Internet in the online catalog and online ordering system (http://www.siemens.com/automation/mall).

Abbreviations

B

Abbreviation	Term	Meaning
AC	Alternating current	Alternating current
ALM	Automation License Manager	Tool for managing license keys in STEP 7
BIOS	Basic Input Output System	Basic Input Output System. A set of important software routines used after the startup of the CPU to load the operating system and to provide the routines for data exchange between hardware components.
CE	Communauté Européenne	CE label
CFast	CompactFlash ATA Serial Transfer	Memory card
CoA	Certificate of Authenticity	Certificate of Authenticity, label with Microsoft Windows "Product Key"
CoL	Certificate of License	Certificate of License for the SIMATIC software loaded
DC	Direct Current	DC current
DVD	Digital Versatile Disc	Digital storage medium with high memory capacity.
DVI-I	Digital Visual Interface	Interface for transfer of image and video data for DVI-I monitors.
ESD	Components sensitive to electrostatic charge	
EN	European standard	
EWF	Enhanced Write Filter	Enhanced write filter
FBWF	File Based Write Filter	File based write filter
GbE	Gigabit Ethernet	
GRUB / GRUB4DOS	GRand Unified Bootloader	Boot Manager
HMI	Human Machine Interface	User interface
IEC	International Electronical Commission	
IM	Interface module	The interface module connects the ET 200SP distributed I/O system with the IO controller and exchanges data with the I/O modules via the backplane bus.
LAN	Local Area Network	Computer network that is limited to a local area.
LED	Light Emitting Diode	Light emitting diode
LLDP	Link Layer Discovery Protocol	Protocol that enables the exchange of information between adjacent devices.
MMC	Multi Media Card	Memory card
NTFS	New Technology File System	File system that offers targeted access protection at the file level.
NVRAM	Non-Volatile Random-Access Memory	Non-volatile data memory that is RAM-based, the data content of which is retained without external power supply.
PC	Personal Computer	

Abbreviation	Term	Meaning
PELV	Protective Extra Low Voltage	PELV, previously called "extra low voltage with safe isolation", is a protective measure against electrical shock. See EN 50178.
PN	PROFINET	
PG	Programming device	Compact programming device which meets the special requirements of industry. The PG is fully equipped for programming SIMATIC PLCs.
PS	Power supply	Power supply
PT	Power Tags	Process tags; tags enable data exchange between the components of an automation process, for example, between the HMI device and the controller.
RAM	Random Access Memory	Main or work memory of a computer with direct access, allowing read access to data and editing.
RT	Runtime	
SD	Secure Digital card	Memory card
SELV	Safety Extra Low Voltage	Safety extra-low voltage; protective measure in which circuits with a rated voltage of up to 50 V AC or 120 V DC are operated ungrounded and feeds from circuits with a higher voltage are separated from these by, for example, a safety transformer.
UL	Underwriters Laboratories Inc.	
USB	Universal Serial Bus	Serial bus system for connecting a computer to external devices.

Troubleshooting

C

Problem	Possible cause	Remedy
CPU 1515SP PC (F) is not working.	CPU 1515SP PC (F) is not supplied with current.	Check the power supply.
CPU 1515SP PC (F) does not start.	Feedback through USB devices.	Use USB devices that comply with the USB 2.0 specification.
Windows no longer boots.	Settings in the BIOS setup are not correct. Windows clock is set incorrectly.	Check the settings in the BIOS setup menu Boot.
Time and/or date of the CPU 1515SP PC (F) do not match.	CPU 1515SP PC (F) was not connected for more than 6 weeks.	Correct the settings in the BIOS setup menu Main or in Windows.
USB device is not working.	USB power supply is overloaded.	Use an external power supply for the USB device (see section Application planning (Page 33).

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ET 200SP Open Controller CPU 1515SP PC2 (F/T/TF)

Operating Instructions

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Appendix A

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ET 200SP Open Controller CPU 1515SP PC2 (F/T/TF)

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Introduction 1

Purpose of the documentation

These operating instructions supplement the system manual ET 200SP distributed I/O system. Functions that generally relate to the system are described in this system manual.

The information provided in these operating instructions and in the system/function manuals supports you in commissioning the CPU 1515SP PC2.

Basic knowledge required

The system must be operated and used by qualified staff only.
The following knowledge is required:

- Installation guideline for SIMATIC ET 200SP
- Totally Integrated Automation Portal, in particular:
  - Hardware configuration with *hardware and network editor*
  - Communication between CPUs
- PC-based automation with an S7-1500 Software Controller
- Basic knowledge of fail-safe automation systems
- Basic knowledge of PC technology
- Operating system Windows 10 IoT Enterprise (64-bit LTSC 2021) or SIMATIC Industrial OS (operating system based on Debian GNU/Linux)

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

"CPU 1515SP PC2 T" means that the respective section applies **only** to the "CPU 1515SP PC2 T".

"CPU 1515SP PC2 F" means that the respective section applies **only** to the "CPU 1515SP PC2 F".

"CPU 1515SP PC2 TF" means that the respective section applies **only** to the "CPU 1515SP PC2 TF".

"CPU 1515SP PC2" also includes "CPU 1515SP PC2 F", "CPU 1515SP PC2 T" and "CPU 1515SP PC2 TF".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Scope of validity of the documentation

This documentation is valid for the following products:

ET 200SP Open Controller	Article number
Standard CPU	
• CPU 1515SP PC2 basic device	6ES7677-2DB40-0AA0
• CPU 1515SP PC2 (Win 10)	6ES7677-2DB42-0GB1
• CPU 1515SP PC2 (IndOS)	6ES7677-2DB43-0GB1
Fail-safe CPUs	
• CPU 1515SP PC2 F (Win 10)	6ES7677-2SB42-0GB1
• CPU 1515SP PC2 F (IndOS)	6ES7677-2SB43-0GB1
Technology CPUs	
• CPU 1515SP PC2 T (Win 10)	6ES7677-2VB42-0GB1
Fail-safe technology CPUs	
• CPU 1515SP PC2 TF (Win 10)	6ES7677-2WB42-0GB1

1.1 Documentation on CPU 1515SP PC2

The following additional documentation is required to use the CPU 1515SP PC2:

- Operating Instructions CPU 1505SP (F/T/TF), CPU 1507S (F), CPU 1508S (F/T/TF) (https://support.industry.siemens.com/cs/ww/en/view/109825803)
- Operating Instructions CPU1505SP (F), CPU 1507S (F), CPU 1508S (F) SIMATIC Industrial OS (https://support.industry.siemens.com/cs/ww/en/view/109808199)
- STEP 7 online help (TIA Portal)
- ET 200SP distributed I/O system manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)
- ET 200SP server module manual (https://support.industry.siemens.com/cs/ww/en/view/63257531)
- Programming and Operating Manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126)
- Product Information SIMATIC S7-1200/S7-1500 F-CPUs (https://support.industry.siemens.com/cs/ww/en/view/109478599)

1.2 ET 200SP Documentation Guide

1.2.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/84133942)

1.2.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
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Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.2.3 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

See also

PRONETA Professional (https://support.industry.siemens.com/cs/ww/en/view/109781283)

1.3 Information about third-party software updates

This product contains third-party software. Siemens accepts liability with respect to updates/patches for the third-party software only when these are distributed by Siemens in the context of a Software Update Service contract or officially approved by Siemens. Otherwise, updates/patches are performed at your own risk. You can find more information about our software update service offer on the Internet (https://www.siemens.com/sus).

1.4 Notes on protecting administrator accounts

A user with administrator rights has extensive access and manipulation possibilities.

Therefore, make sure that the administrator account is adequately protected to prevent unauthorized changes. To do this, set secure passwords and use a standard user account for regular operation. Other measures, such as the use of security policies, should be applied as required.

Safety information 2

2.1 General safety instructions

You can find a detailed description of the safety instructions in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

2.2 Notes on use

WARNING

Hazards at an unprotected machine or plant

According to the results of a risk analysis, hazards can occur at an unprotected machine. The hazards may lead to personal injury.

According to the risk analysis, the risk of injury to persons can be countered with the following measures:

- Additional protective equipment at the machine or plant. In this case, the programming, parameter assignment and wiring of the I/O used, in particular, must be performed in accordance with the safety criteria (SIL, PL or Cat.) ascertained by means of an appropriate risk analysis.
- Use of the device for its intended purpose, which can be established by performing a functional test on the plant. This allows errors in programming, parameter assignment and wiring to be detected.
- Documentation of the test results which can be entered, if required, into the relevant safety certificates.

NOTICE
Ambient conditions Ambient conditions for which the device is not suitable can lead to faults or damage the device. Note the following: • Only operate the device in enclosed areas. If you do not comply with this instruction, the warranty becomes void. • Only operate the device in accordance with the ambient conditions given in the technical specifications. • Protect the device from dust, moisture and heat. • Do not expose the device to direct sunlight or other strong sources of light. • The device must not be used in places with more difficult operating conditions through corrosive vapors or gases without taking additional protective measures, for example, supply of clean air.

Industrial Cybersecurity 3

3.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293) for general information and measures regarding industrial cybersecurity.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

3.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

3.3 Cybersecurity-relevant information

Observe all cybersecurity-relevant information.

Topics with relevant cybersecurity information	Reference
Operational application environment and security assumptions	
Requirements for the operational application environment of the system and security assumptions	You can find this section in the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Security properties of the product	
Access protection Physical protection: • You can protect the CPU from unauthorized access by sealing the card slot of the CFast card. Password protection You can also protect the CPU with a password. Password categories: • Password to protect confidential configuration data • Password in the context of user management (UMAC)	Also read the information on access protection in the Protection section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Integrated protection functions • The CPUs have integrated protection functions.	You can find information on the protection functions in the "Overview of protection functions" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
PROFINET Security Class 1 • The device supports PROFINET Security Class 1. • With the introduction of PROFINET Security Class 1, additional security settings have been integrated into the PROFINET communication.	You can find detailed information about PROFINET Security Class 1 and the additional security settings in the PROFINET with STEP 7 Function Manual (https://support.industry.siemens.com/cs/us/en/view/49948856).
Reading out and verifying signatures	You can find detailed information on reading and verifying signatures in the STEP 7 online help (TIA Portal).
Supported Ethernet services	Information on supported services can be found in section Technical specifications (Page 81). You can find detailed information about supported Ethernet services in the Communication Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192925).
Interfaces, ports, protocols and services	
Information on the following is security related: • Communications layer and communication role • Default states • Enabling/disabling ports and services	You can find detailed information on these topics in the Communication Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192925).
Secure operation	
Corrective measures for known risks	Corrective measures for known risks are described on the Siemens ProductCERT (https://siemens.com/productcert) Web page. You can find additional information on SIEMENS ProductCERT in the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).

Topics with relevant cybersecurity information	Reference
Security checks	Application-specific security measures such as cyclic checks of the configuration via checksums are described in the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Recording Security events	You can find information on recording security events in the "Safe operation of CPUs" section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).
Secure decommissioning Products that contain security-relevant data must be safely decommissioned before disposal or resale.	You can find information on safe decommissioning in the Safe operation of the system section of the System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293).

Areas of application

4

4.1 Areas of application of fail-safe CPUs

Areas of application

F-CPUs are mainly designed for personal and machine protection. In addition to the safety program, you can also program standard applications. You can operate the F-CPUs in safety mode or in standard mode.

Reference

Information on the use of F-CPUs in safety mode is available in the programming and operating manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

You can find information on using the CPU 1505SP (F) Software Controller in the following manuals:

- Software Controller CPU 1505SP (F) with Windows (https://support.industry.siemens.com/cs/ww/en/view/109825803)
- Software Controllers CPU 1505SP (F) with SIMATIC Industrial OS (https://support.industry.siemens.com/cs/ww/en/view/109808199)
- F product information (https://support.industry.siemens.com/cs/ww/en/view/109478599)

4.2 Areas of application of technology CPUs

Areas of application

Areas of application of T-CPUs are motion control applications such as gearing and camming as well as control of kinematics. Due to the supported technology functions, the S7-1500T CPUs are suitable for controlling packaging machines, conversion applications, assembly automation, etc.

You can operate the TF-CPUs in safety mode or in standard mode.

Reference

You can find information on using the T-CPUs in the function manual SIMATIC S7-1500T Motion Control (https://support.industry.siemens.com/cs/ww/en/view/109817884).

You can find information on using the T-CPUs in the function manual SIMATIC S7-1500T kinematics functions (https://support.industry.siemens.com/cs/ww/en/view/109817886).

You can find information on using the F-CPUs and TF-CPUs in safety mode in the product information for SIMATIC S7-1200/S7-1500 F-CPUs (https://support.industry.siemens.com/cs/ww/en/view/109478599).

Product overview

5

5.1 Field of application

Article number

The article number depends on the pre-installed S7-1500 Software Controller and HMI Runtime.

You can find an overview of the article numbers in the section Scope of validity of the documentation (Page 7).

View of the module

The following figure shows the CPU 1515SP PC2:

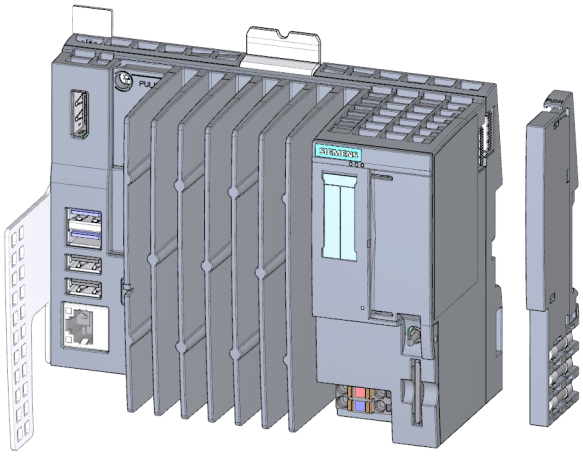

Figure 2-58 CPU 1515SP PC2 with supplied accessories

5.2 Characteristics

The CPU 1515SP PC2 is a PC-based automation device in the design of the ET 200SP. It is used for control and visualization purposes. The supplied IPC DiagBase software provides basic diagnostics functions and supports you in handling the BIOS.

General characteristics

- A removable CFast card with the following pre-installations is used as storage medium:
  - Operating system Windows 10 IoT Enterprise (64-bit LTSC 2021) or SIMATIC Industrial OS V3.4.2 (based on Debian 11)
  - S7-1500 Software Controller: CPU 1505SP, CPU 1505SP F, CPU 1505SP T, CPU 1505SP TF
- Interfaces:
  - An interface for the exchangeable ET 200SP BusAdapters for connection of PROFINET IO (2 ports) Accessories/spare parts (Page 115)
  - An interface for connecting devices using Industrial Ethernet (Gigabit Ethernet)
  - 4 interfaces for USB devices (2 x USB 3.0 and 2 x USB 2.0)

    NOTE
    USB 2.0 support
    Note that the wireless HID devices are not supported in BIOS for USB 2.0. Some wireless devices do not work during setup.

  - A DisplayPort interface (DPP) for a monitor
  - A sealable slot for the CFast card
  - A slot for an SD/MMC card as additional optional drive
- Supply voltage 1L+ 24 V DC (SELV/PELV). The connection plug is included in the scope of delivery.
- The CPU 1515SP PC2 is suitable for use in industrial environments:
  - Compact design
  - Fan-less operation
  - High robustness
- The CPU 1515SP PC2 complies with IP 20 degree of protection and is intended for installation in a control cabinet.

Additional information

You can find more information on the system versions and ordering options in the section Scope of validity of the documentation (Page 7).

5.3 Sample configuration

Configuration

The CPU 1515SP PC2 is mounted on a mounting rail according to EN 60715. A modular system is formed with ET 200SP modules in the central rack. You can also expand the CPU 1515SP PC2 with fail-safe I/O modules.

You can use the CPU 1515SP PC2 as PROFINET IO controller. The PROFINET IO devices are connected via the ports of the X1 PN(LAN) interface using a SIMATIC BusAdapter.

Devices can be connected via Industrial Ethernet using the integrated interface X2 PN/IE(LAN).

The connection to PROFIBUS can be made using the DP master module.

Sample configuration

The following figure shows a sample configuration with the CPU 1515SP PC2:

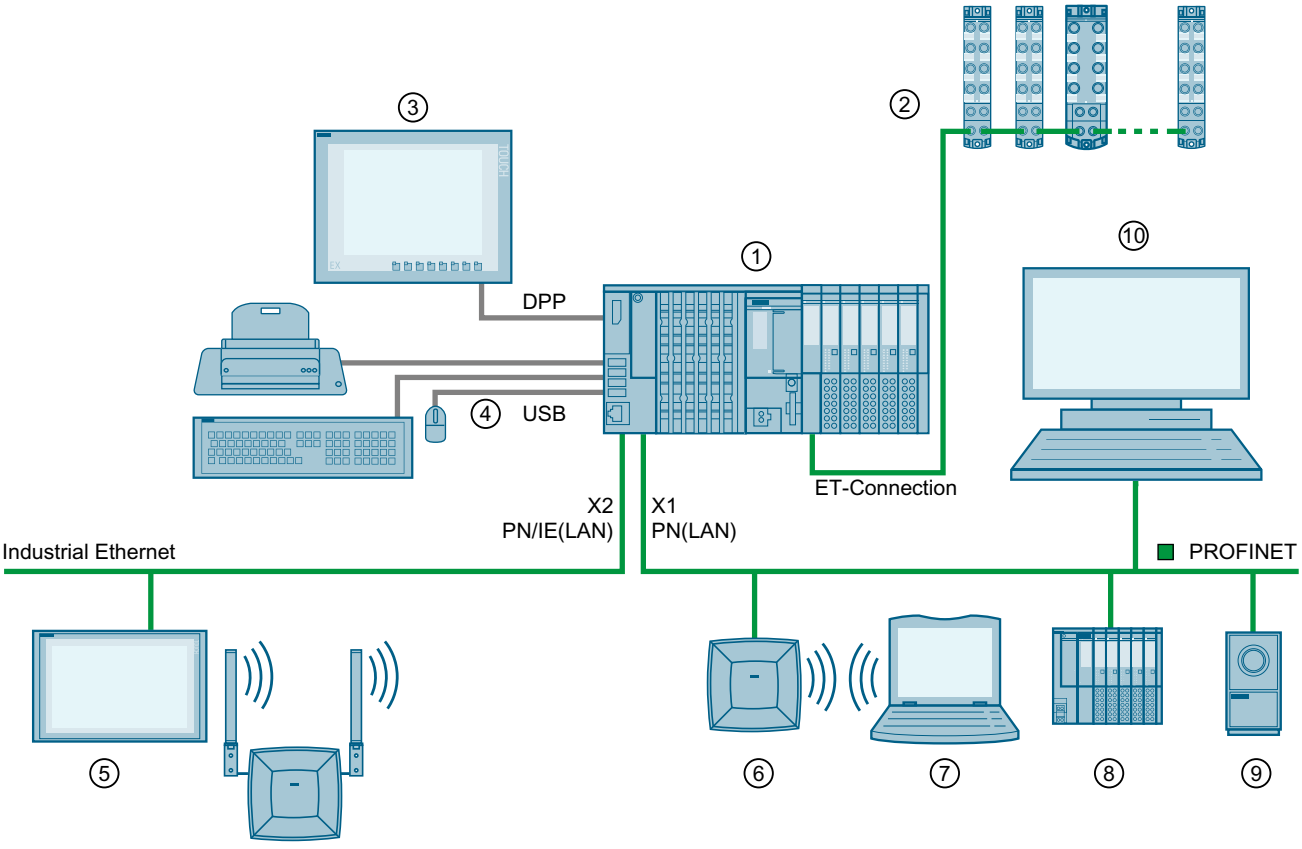

① CPU 1515SP PC2, I/O modules, server module, BusAdapter

② ET 200AL modules with ET-Connection

③ Flat Panel - Wide Screen Display

④ USB devices: Keyboard, mouse, printer ...

⑤ Industrial Thin Client ITC

⑥ SCALANCE W786
⑦ Field PG
⑧ PROFINET IO device
⑨ Camera
⑩ PC/Programming device

Figure 2-59 Configuration example with the CPU 1515SP PC2

Reference

You can find more information about configuring the ET 200AL modules in the system manual ET 200AL distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/89254965).

5.4 Components

Components of the CPU 1515SP PC2

The following table provides an overview of the components of the CPU 1515SP PC2:

Table 2-43 Components of the CPU 1515SP PC2

Component	Function	Figure
Mounting rail in accordance with EN 60715	The mounting rail is the rack for the CPU 1515SP PC2.	
CPU 1515SP PC2	CPU with strain relief and white reference labels	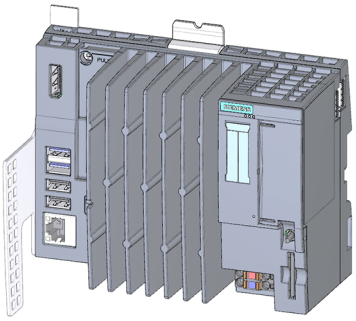

Component	Function	Figure
BusAdapter	The BusAdapter allows free selection of the connection technology for PROFINET IO. The following versions are available for CPU 1515SP PC2: • For standard RJ45 connector (BA 2×RJ45) ① • For direct connection of the bus cable (BA 2×FC) ② • For standard M12 connector (D-coded) with screw-type terminal or plug-in push-pull version (BA 2xM12) ③ • For POF/PCF fiber-optic cable (BA 2xSCRJ) ④ • As media converter for POF/PCF fiber-optic cable ⇔ standard RJ45 plug (BA SCRJ/RJ45) ⑤ • As media converter for POF/PCF fiber-optic cable ⇔ direct connection of the bus cable (BA SCRJ/FC) ⑥ • For glass fiber-optic cable (BA 2xLC) ⑦ • As media converter for glass fiber-optic cable ⇔ standard RJ45 plug (BA LC/RJ45) ⑧ • As media converter for glass fiber-optic cable ⇔ direct connection of the bus cable (BA LC/FC) ⑨	① ② ③ 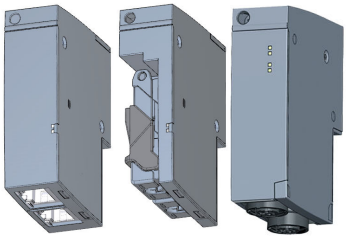 ④ ⑤ ⑥ 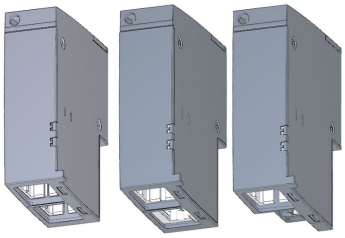 ⑦ ⑧ ⑨ 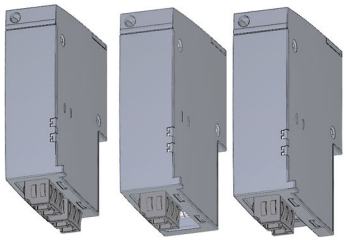
	For mixed configuration with an ET 200AL , you require the BusAdapter BA-Send 1xFC ① (plugged into the BaseUnit BU-Send). Connect the bus cable for ET-Connection to the BusAdapter BA-Send 1xFC.	① 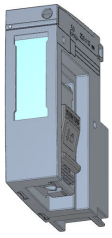

Component	Function	Figure
Server module	The server module completes the configuration of the CPU 1515SP PC2 with I/O modules. The server module is included in the CPU's scope of delivery.	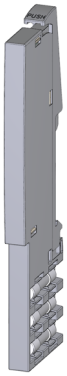

5.5 Operator controls and connection elements

View of the module

The following figure shows the operator controls and connection elements of the CPU 1515SP PC2:

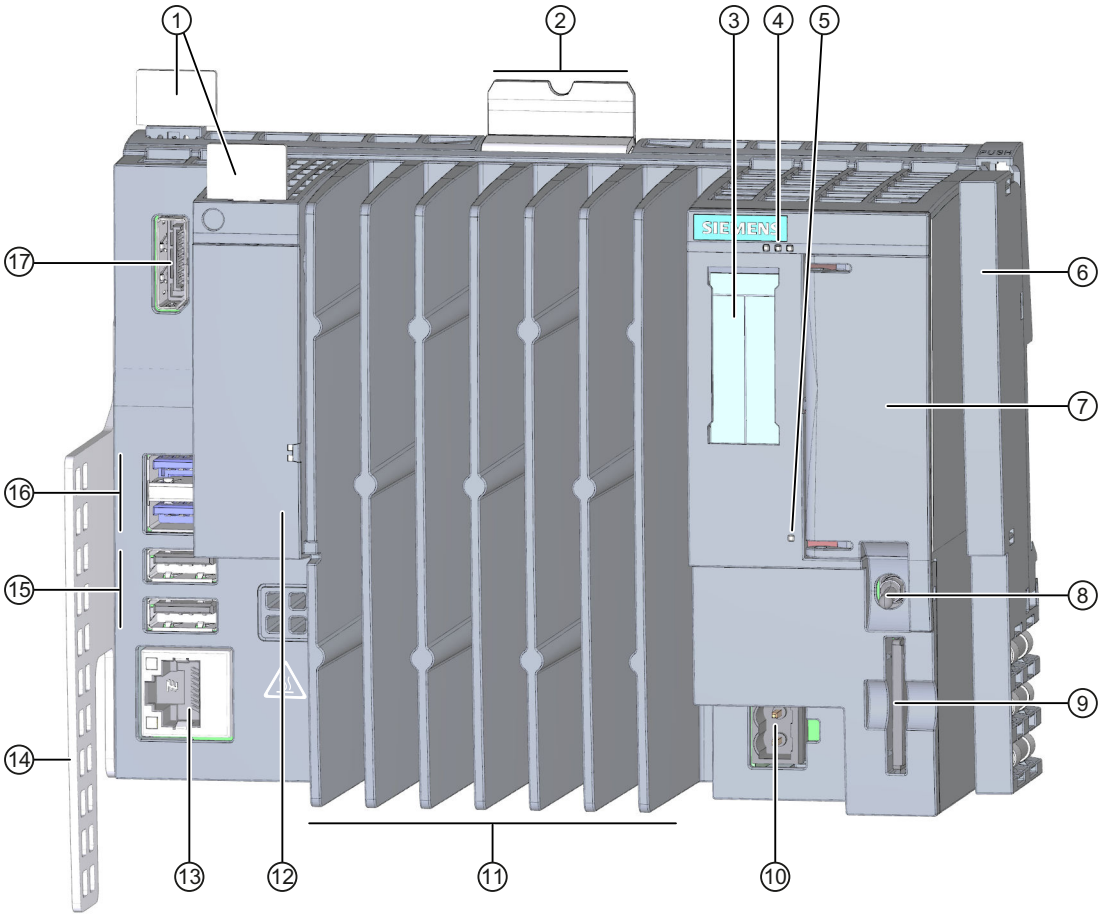

① Reference identification labels
② Mounting rail release
③ Labeling strips
④ LEDs for the current operating state and diagnostic status of the CPU 1505SP
⑤ Power LED
⑥ Server module
⑦ **X50:** Slot for the CFast card (flash memory), sealable
⑧ Mode selector
⑨ **X51:** Slot for an optional SD/MMC card
⑩ **X80:** Connector for 24 V DC supply voltage
⑪ Cooling fins
⑫ **X1 PROFINET (LAN):** Slot for BusAdapter for connection of PROFINET IO; Status display for PROFINET

⑬	**X2 PN/IE(LAN):**	GbE Ethernet connection with integrated display
⑭	Strain relief	
⑮	**X62, X63:**	2 x USB 2.0 ports
⑯	**X60, X61:**	2 x USB 3.0 ports
⑰	**X70:**	DisplayPort interface (DPP)

Figure 2-60 View of the CPU 1515SP PC2

Slot for CFast card

The operating system, Runtime software and project are installed on the supplied SIMATIC CFast card. The CFast card is the only mass storage device of the CPU 1515SP PC2.

NOTE
Unauthorized access
Seal the cover of the slot to protect the CFast card with the operating system of the CPU 1515SP PC2 from unauthorized access and manipulation.

Slot for SD/MMC card

You can use a SIMATIC SD or MMC card as additional storage drive. This drive can be used to store data via Windows/IndOS page, for example a backup, but not the operating system, the Runtime software or the project.

Permitted SD cards: SDHC up to 32 GB, SDXC up to 2 TB.

USB connections

- 2 x USB 3.0 with I_{max} = 1 A per interface
- 2 x USB 2.0 with I_{max} = 0.5 A per interface

MAC addresses

The MAC address consists of a 3-byte manufacturer ID and a 3-byte device ID (consecutive number).

Each device is already assigned four MAC addresses in the factory. The front of the CPU 1515SP PC2 is lasered with the MAC address 1 and 4. With the MAC addresses 2 and 3, the consecutive numbers are incremented. If, for example, the first MAC address is 08-00-06-6B-80-C0, the second MAC address is 08-00-06-6B-80-C1.

Table 2-44 Assignment of the MAC addresses

	Assignment
MAC address 1	X2 PN/IE(LAN) • Visible in STEP 7 for accessible devices • Lasered on the front of the CPU (start of the number range)
MAC address 2	X1 PROFINET (LAN) • Visible in STEP 7 for accessible devices
MAC address 3	Port X1 P1 (required for LLDP, for example)
MAC address 4	Port X1 P2 R (required for LLDP, for example) • Lasered on the front of the CPU (end of the number range)

Connector for supply voltage

The CPU 1515SP PC2 is equipped with a 2-pin connection terminal for the power supply.

The connection plug for the supply voltage is plugged in when the CPU is shipped from the factory.

Mode selector

Use the mode selector to set the CPU operating mode.

Table 2-45 Mode selector positions

Position	Meaning	Description
RUN	Operating mode RUN[1]	The CPU is processing the user program.
STOP	Operating mode STOP[1]	The CPU is not processing the user program. The outputs are set to a "safe" state.
MRES	Memory reset	**For active S7-1500 Software Controller**[2] only: CPU memory reset

1 RUN and STOP indicate the **selected** operating state. The RUN and STOP LEDs indicate the **actual** operating mode of the CPU 1515SP PC2.

2 See operating instructions for CPU 1505SP (F/T/TF), CPU 1507S (F), CPU 1508S (F/T/TF) Version 30.1

5.6 Scope of delivery

When ordering the hardware with the article number "6ES7677-2DB40-0AA0", you will only receive the basic unit = hardware of the CPU 1515SP PC2 Open Controller, **without** any software.

The hardware **always** has the article number "6ES7677-2DB40-0AA0" and **always** has the designation "CPU 1515SP PC2".

The bundles that can be ordered have their own article numbers. You can find this article number on the CFast card. The following figure shows, based on an example, where to find the article number on the CFast card:

NOTE

To order the different bundles, please use the article number provided in the Introduction (Page 7) and Spare parts/accessories (Page 115) sections.

The hardware is always the CPU 1515SP PC2 basic unit. The bundles differ with respect to the software contained on the CFast card.

The scope of delivery of the CPU 1515SP PC2 Open Controller does not include a BusAdapter; you must order it separately.

The ET 200SP Open Controller is delivered with the following accessories:

- CPU 1515SP PC2 basic device
- Server module; 6ES7193-6PA00-0AA0
- Strain relief with fixing screws
- Plug, 24 V DC, 2x2-pin

- CFast card with 128 GB memory and with the following pre-installations:
  - Operating system Windows 10 IoT Enterprise (64-bit LTSC 2021) or SIMATIC Industrial OS (IndOS)
  - S7-1500 Software Controller CPU 1505SP (F/T/TF)
- "Certificate of Authenticity" label
- "Certificate of License" (CoL)
- Product information

NOTE

The scope of delivery no longer includes a USB restore stick

We therefore highly recommend that you create your own USB restore stick (Page 70) before using the CPU 1515SP PC2 Open Controller.

See also

Product announcement for ET 200SP PC2
(https://support.industry.siemens.com/cs/ww/en/view/109760163)

Application planning 6

6.1 Basics

Introduction

The CPU 1515SP PC2 is open equipment. This means you may only set up the CPU in enclosures, cabinets or electrical equipment rooms and in a dry environment (IP20 degree of protection). The housings, cabinets and electrical operating rooms must guarantee protection against electric shock and spread of fire. The requirements regarding mechanical strength must also be observed. The housings, cabinets, and electrical operating rooms must not be accessible without a key or tool. Access may only be possible for instructed or authorized personnel.

Installation location

Install the CPU 1515SP PC2 in a suitable enclosure/control cabinet with at least IP54 degree of protection according to EN 60529 and take into consideration the ambient conditions for operating the devices.

Installation position

You can install the ET 200SP distributed I/O system in any position. The preferred mounting position is horizontal mounting on a vertical wall.

Depending on the mounting position, restrictions on ambient temperature and maximum configuration apply to the CPU 1515SP PC2.

NOTICE
Damage to the modules Modules can be damaged if exposed to ambient temperatures higher than permitted. Additional **important information** on the permissible ambient temperatures can be found in section Mechanical and climatic ambient conditions (Page 88).

6.2 Unpacking the device

When unpacking

When unpacking, make sure to check the following:

- Check packaging and contents for visible damage from transport. Damaged or incomplete devices should never be commissioned.
- Check the delivery for correctness and completeness.
  Please inform your Siemens contact partner should you notice any irregularities.
- Keep the supplied documentation and licenses. They belong to the device and are the proof that you have purchased the software preinstalled on the CFast card.
  Documentation and licenses are required for initial commissioning and for any questions that arise.
- Keep the original packaging in case the device needs to be transported again.
- Note the identification data (Page 34) of the device.

NOTICE

Damage to the device during transport and storage

If a device is transported or stored without packaging, it is unprotected from shocks, vibrations, pressure and moisture. Damaged packaging indicates that environmental conditions have already had a significant impact on the device.

The device might be damaged.

Do not dispose of the original packaging. Pack the device for transport and storage.

NOTICE

Damage to the device caused by condensation

If the device was exposed to low temperatures or extreme variations in temperature during transport, this may cause moisture to build up on or in the device (condensation). Please note the specified mechanical and climatic ambient conditions (Page 88).

Moisture can cause short-circuits in the electrical circuits and damage the device.

Proceed as follows to avoid damage:

- Store the device in dry conditions.
- Make sure it adapts to room temperature before commissioning.
- Do not expose the device to direct heat radiation from a heater.
- If condensation has developed, wait until the device is completely dry before you switch it on.

WARNING

Electric shock and fire hazard from damaged device

A damaged device can carry dangerous voltage and trigger a fire in the machine or plant. A damaged device has unpredictable properties and states.

Death or severe injury could occur.

Make sure that the damaged device is not installed and commissioned accidentally. Label the damaged device correspondingly and keep it locked up. Have the device repaired without delay.

6.3 Identification data

The identification data can be used to clearly identify the device when a repair is necessary.

The activation code for Windows is already integrated in the supplied image.

Note the following data:

- Printed on the nameplate of the device, please find the following information:
  - Article number
  - Serial number
  - The first and the last MAC address
- Depending on the scope of delivery, the "Certificate-of-License" is provided as proof of license.
  Valid for the following products:
  - S7-1500 Software Controller CPU 1505SP
  - S7-1500 Software Controller CPU 1505SP F/T/TF
- The "Microsoft Windows Product Key" can be found on the "Certificate of Authenticity" label.

6.4 Installation location

Introduction

Install the CPU 1515SP PC2 in a suitable housing/control cabinet with sufficient mechanical strength, fire protection and at least IP54 degree of protection according to EN 60529, and take into consideration the ambient conditions for operating the devices.

Mounting rail

You must ground the mounting rail separately in the control cabinet. Exception: If you install the rail on grounded, zinc-plated mounting plates, there is no need to ground the rail separately.

NOTE

If the ET 200SP distributed I/O system is exposed to vibration and shock loads, both ends of the ET 200SP system assembly must be mechanically fixed to the mounting rail (e.g using 8WA1010-1PH01 ground terminals). This measure prevents the ET 200SP from shifting to the side.

NOTE

If the ET 200SP distributed I/O system is exposed to high vibration and shock load, we recommend that you screw the mounting rail to the mounting surface at intervals of approx. 200 mm.

Suitable surface finishes are:

- Steel strip in accordance with Appendix A of EN 60715 or
- Tinned steel strip. We recommend the use of the mounting rails in section (Page 115).

NOTE

Mounting rails of other manufacturers

If you use mounting rails from other manufacturers, ensure that they have the properties required for your climatic and mechanical ambient conditions.

Minimum clearances

Make sure to maintain the following minimum clearances when installing the CPU 1515SP PC2.

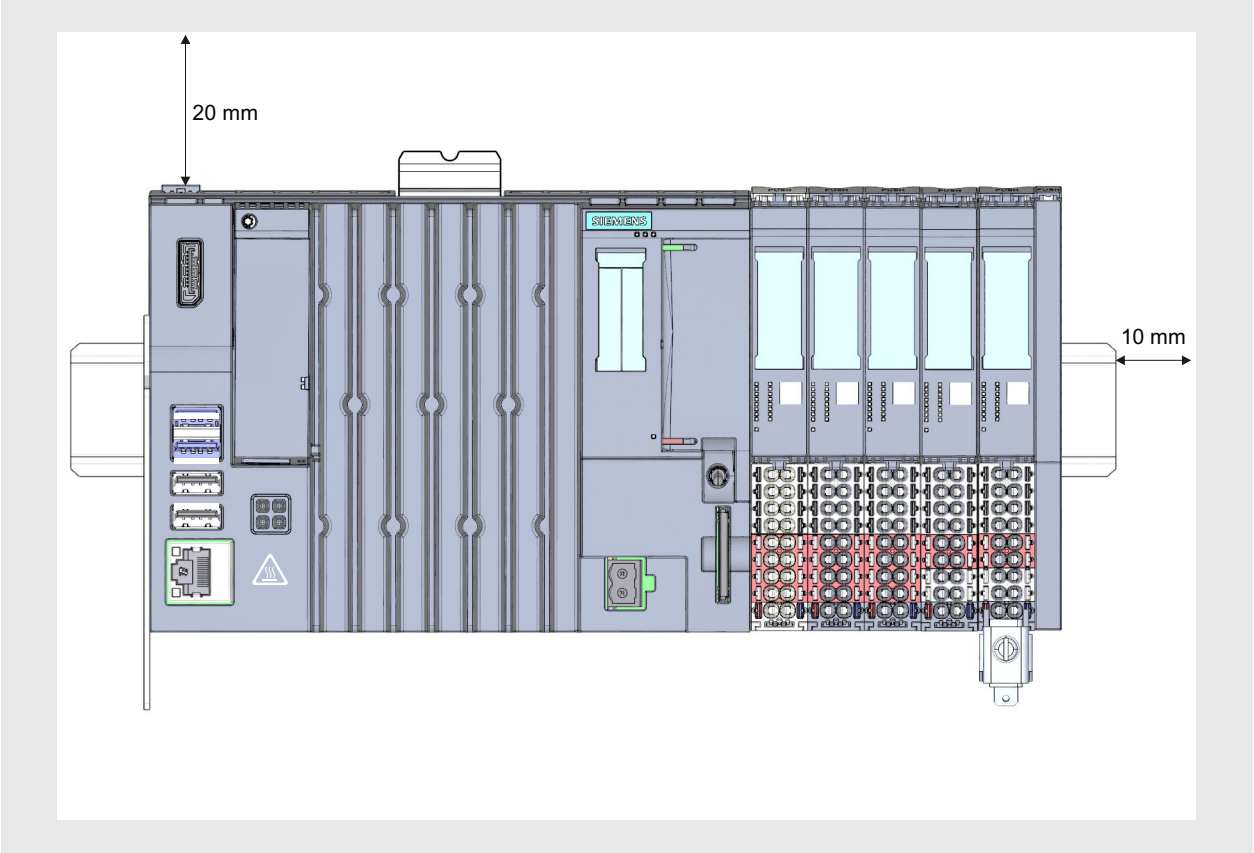

Figure 2-61 Minimum clearances

Installation rules

- After the CPU 1515SP PC2, there is a BaseUnit BU..D with incoming supply voltage L+ (light-colored terminal box).
- This is followed by BaseUnits BU..B (with dark-colored terminal box).
- The respective corresponding I/O modules can be connected to the BaseUnits. Suitable combinations of BaseUnits and I/O modules can be found in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/84133942).
- The server module completes the installation.

NOTE

Install the CPU 1515SP PC2 only with disconnected supply voltage.

6.5 Hardware configuration

As soon as one of the following rules applies, the maximum configuration has been reached.

Maximum mechanical configuration

Backplane bus length: Maximum 1 m mounting width (without CPU 1515SP PC2, including server module)

Electrical maximum configuration

The number of operable I/O modules of a potential group is limited by the

- Power consumption of the I/O modules
- Power consumption of the components supplied via these I/O modules

The maximum current-carrying capability of the terminals on the BaseUnit L+/ground is 10 A.

USB load

When using the CPU 1515SP PC2 with the maximum configuration, the USB load must also be considered:

- **Horizontal mounting:**
  - Ambient temperature of 55 °C or higher with max. 32 ET 200SP modules:
    4 x 0.3 A USB load; CFAST memory card max. 10% load; SD card not used
- **Vertical mounting:**
  - Ambient temperature of 45 °C or higher with max. 32 ET 200SP modules:
    4x 0.3 A USB load; CFAST memory card and SD card max. 10% load

Address space

The address space is predefined. However, you can adjust the address space in the user program.

Installation 7

7.1 Installing the device

Requirements

The mounting rail is fitted.

Required tools

3 to 3.5 mm screwdriver (only to fix the strain relief and dismantle the BusAdapter)

Fixing strain relief

Fix the strain relief to the top and bottom of the left-hand side of the CPU 1515SP PC2 with the supplied screws.

Installing the CPU 1515SP PC2

1. Install the CPU on the mounting rail.
2. Swivel the CPU back until you hear the mounting rail release click into place
3. To check that the CPU has correctly clicked into place, pull on the underside of the enclosure.

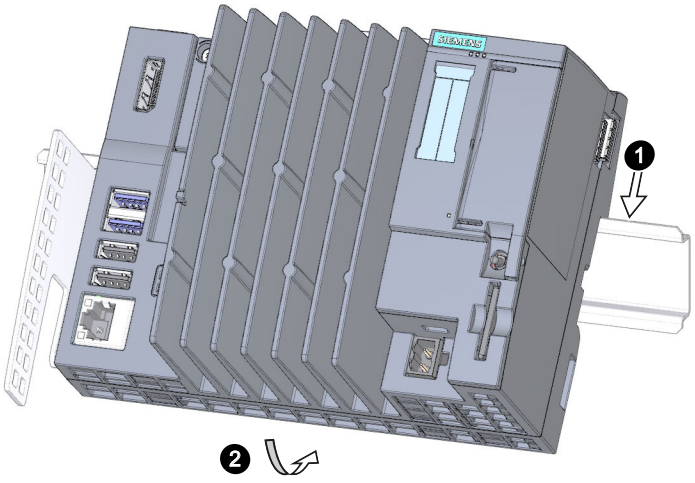

Figure 2-62 Installing the CPU 1515SP PC2

Uninstalling the CPU 1515SP PC2

The BaseUnits with the I/O modules are located to the right of the CPU 1515SP PC2:

1. Switch off the supply voltage on the CPU.
2. Press the mounting rail release button on the first BaseUnit and, at the same time, move the CPU parallel to the left until it comes off the rest of the module group.

   Note: The mounting rail release button is located above the CPU.
3. While pressing the mounting rail release button on the CPU, swivel the CPU out of the mounting rail.

NOTE

It is not necessary to remove the BusAdapter from the CPU 1515SP PC2.

Wiring 8

8.1 Notes on connection

NOTE

Rules and regulations for operation

Observe the information contained in the *Wiring* section in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/84133942) and in the function manual Designing interference-free controllers function manual (https://support.industry.siemens.com/cs/ww/en/view/59193566).

NOTICE

Risk of hazardous system states

If you remove and insert I/O devices with the supply voltage switched on, this can result in hazardous system states.

Injury to persons and damage to the machine or plant could result.

Therefore, I/O devices can only be inserted and removed when the supply voltage is switched off.

Only connect I/O devices which are suitable for use in industrial environments according to EN 61000-6-2 / IEC 61000-6-2.

8.2 Terminal and block diagram

Block diagram

The following figure shows the block diagram for the CPU 1515SP PC2.

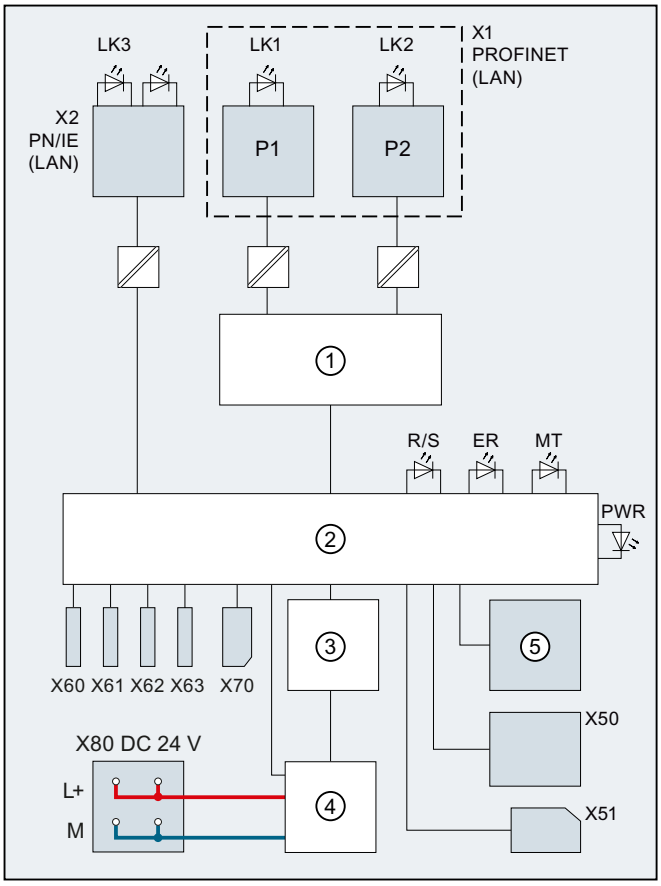

①	Switch	X1 PN(LAN)	PROFINET interface X1
②	Electronics	P1	PROFINET interface X1 Port 1
③	Backplane bus interface	P2	PROFINET interface X1 Port 2
④	Internal supply voltage	L+	24 V DC supply voltage
⑤	Mode selector	M	Ground
X50	CFast card	LK1, LK2	LED Link TX/RX
X51	SD/MMC card	LK3	LED Link
X60, X61	USB 3.0 interfaces, max. 0.9 A	R/S	RUN/STOP LED (yellow/green)
X62, X63	USB 2.0 interfaces, max. 0.5 A	ER	ERROR LED (red)
X70	DPP interface	MT	MAINT LED (yellow)
X80 24 V DC	Infeed of supply voltage	PWR	POWER LED (yellow/green)
X2 PN/IE(LAN)	Ethernet interface X2		

Figure 2-63 Block diagram for the CPU 1515SP PC2

8.3 Electrical configuration

Non-isolated configuration

NOTE

Unlike the ET 200SP distributed I/O system, the CPU 1515SP PC2 can only be operated with a non-isolated configuration.

The following figure shows the overall configuration of a CPU 1515SP PC2 with power supply from a TN-S system. The power supply supplies the CPU 1515SP PC2 and the load circuit for the 24 V DC modules.

For the CPU 1515SP PC2, there is a fixed connection between the ground infeed terminal and the contact springs to the mounting rail. You must ground the mounting rail separately in the control cabinet.

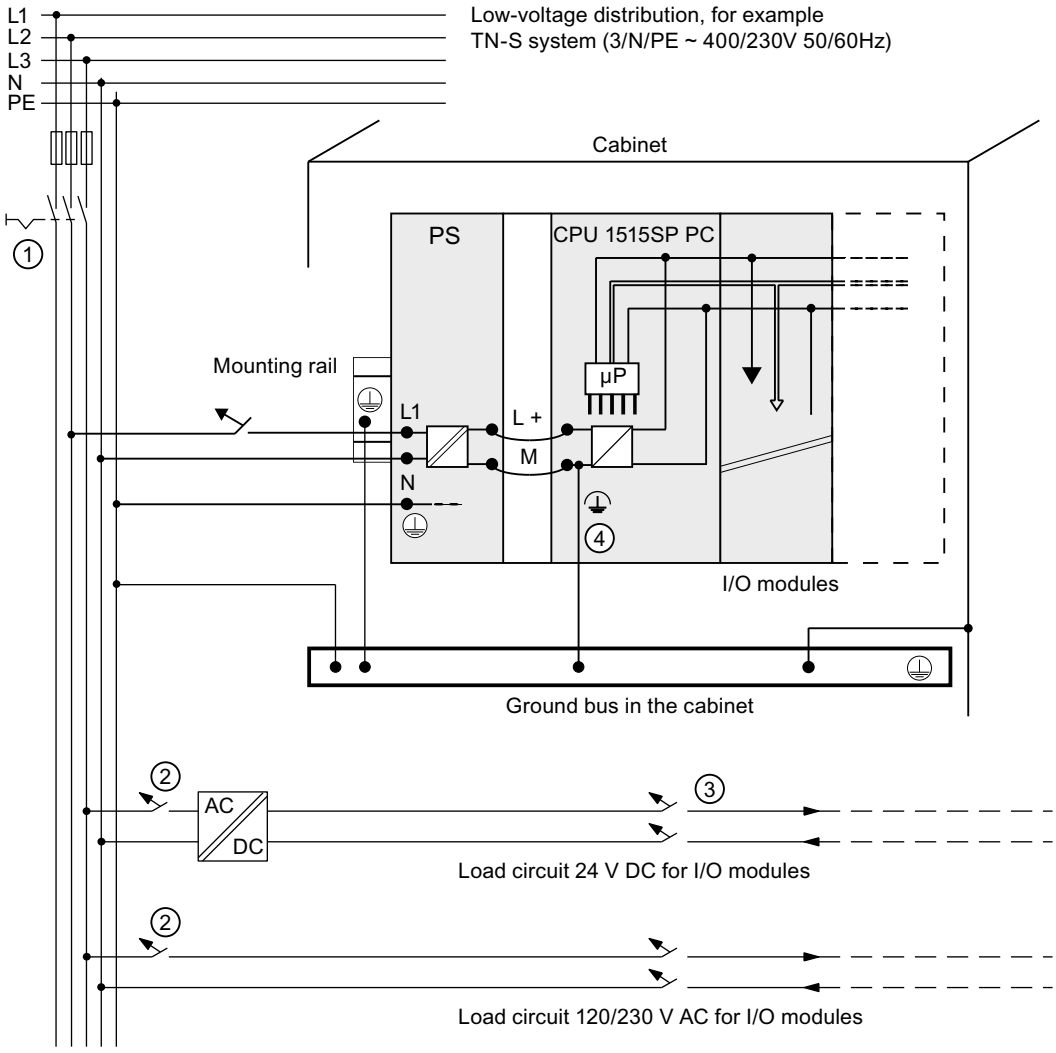

① Master switch
② Short-circuit and overload protection
③ Load current supply (galvanic isolation)
④ This connection is established automatically with the CPU 1515SP PC2.

The represented layout of the power connections does not correspond to the actual layout; it was chosen for demonstration purposes only.

Figure 2-64 Connecting the load voltage reference potential

8.4 Connecting devices to networks

The following options are available for integrating devices into existing or planned system environments and networks.

Ethernet

You can use the integrated Ethernet interface X2 PN/IE(LAN) (10/100/1000 Mbps) for communication and data exchange with automation devices, for example, SIMATIC S7. Only ASCII characters are permitted in the name of the X2 PN/IE(LAN) interface in the TIA Portal, e.g. PROFINET_2.

You need suitable software to do this: STEP 7, WinCC, SIMATIC NET.

NOTE

Use a Category 5e Ethernet cable (Cat-5e cable) for operation with 1000 Mbps.

PROFINET

PROFINET operation is possible via the X1 PN(LAN) interface and the approved BusAdapter.

PROFIBUS

The connection to PROFIBUS can be made using the DP master module.

8.5 Securing cables

The strain relief for connecting cables prevents the USB cables and PROFINET connectors detaching from the CPU 1515SP PC2. The strain relief is included in the scope of delivery.

WARNING

Flying sparks due to loose cables

Risk of explosion in hazardous areas.

USB cables and PROFINET connectors may detach from the device in the case of strong oscillation and high vibrating loads.

Attach these cables to the strain relief of the device using cable ties.

Requirements

- The strain relief is fixed to the CPU.
- The CPU is installed.

Procedure

Secure the USB and PROFINET cables to the strain relief using cable ties.

Figure 2-65 Secured cables

Commissioning 9

9.1 Notes on commissioning

WARNING

Improper commissioning in hazardous areas

Device failure or risk of explosion in hazardous areas.

- Do not commission the device unless it is fully mounted and connected according to the specifications in the section Wiring (Page 40).
- Before commissioning, please consider the effects on other devices in the plant.

NOTICE

Condensation in the device

Damage to the device due to condensation if the temperature between transport or storage and the installation point differs.

Before commissioning the device, leave it to stand until it is dry.

NOTICE

Data loss

Data loss may occur if write filters are used incorrectly.

Therefore, note the information on write filters.

The following configurable write filter is available under Windows 10:

- Unified Write Filter (UWF) (Page 61)

9.2 Basic commissioning procedure

The following sections provide an overview of the general commissioning procedure.

Step 1: Commissioning requirements (Page 46)

Step 2: Preparing commissioning (Page 46)

Step 3: Commissioning procedure (Page 47)

9.2.1 Requirements

The following requirements must be met before you commission the Open Controller for the first time:

- The CPU 1515SP PC2 is mounted.
- The supplied CFast card is inserted.
- No data carriers are connected via USB.

9.2.2 Preparing commissioning

Procedure

If the requirements are met, proceed with commissioning as follows:

1. Connect a monitor using a DisplayPort cable.
2. Connect a keyboard and a mouse to the CPU via USB.

Result

The Open Controller is prepared for commissioning.

Operation with two monitors

Use only one monitor. If several monitors are used simultaneously, undefined states might occur in the system.

The following display and HDMI splitters are recommended for the CPU 1505S F:

- Display splitter: Multi Stream Transport (MST) Hub DisplayPort™ 1.2 Quad Monitor CSV-5400
- HDMI splitter: Delock Display Port 1.2 Splitter 87720

DisplayPort connection cable

Use **only** the following connection cables for the DisplayPort:

- DisplayPort cable, length: 5 m, E74020-C AWM Style 20276, 80 °C, 30 V, VW-1 (with integrated ferrite cores at both ends)
- DisplayPort cable, length: 3 m, 6AV7860-0DH30-0AA0
- DisplayPort cable, length: 5 m, 6AV7860-0DH50-0AA0

9.2.3 Commissioning procedure

When you start up your CPU 1515SP PC2 for the first time, basic settings and the administrator password are queried. The device is then automatically set up for the operating system that is installed on the CFast card. Restart the device after the operating system has been set up.

NOTE

The initial commissioning is not possible with a Multitouch panel, as the Multitouch driver is only available after the installation of the operating system.

Procedure

When the requirements (Page 46) are met and the preparations for commissioning (Page 46) are complete, proceed as follows with the commissioning:

1. Connect the power supply.
   → The PWR LED lights up yellow first, then green.
   → The device carries out the hardware initialization.
2. Wait until the Siemens logo disappears from the screen.
3. Follow the instructions on the screen to configure the device:
   – Set <Language>, <Country/region>, <App language>, <Keyboard layout>, <Time zone for>
   – Accept license conditions
   – Setting the account
4. Finally, you will be prompted to restart the device.

NOTICE
Faulty installation when shutting down the CPU If you shut down the CPU during installation, the installation is disrupted, and the operating system is not installed correctly. The operational reliability of the device and the plant is endangered. Do **not** shut down the CPU during the entire installation process.

Information on users/user groups in Windows

A user "Operator" with standard user rights is already created on the Windows system.

The user is in a user group "SIEMENS TIA Engineer". This grants the user the rights to use the installed SIMATIC software products.

To use the CPU 1515SP PC2 directly, the Windows "Autologon" function is enabled for the "Operator" user. No password is preset.

NOTE

When you assign a password, change the entry for the "Autologon" function accordingly using the Windows user administration.

For security reasons, some functions of the CPU 1505SP (F/T/TF) Software Controller installed on the CPU 1515SP PC2 are not enabled under Windows without additional user groups. For example, these are: Controlling the Software Controller CPU 1505SP (F/T/TF) via command line tool, or loading a PC station using a configuration file import.

The user groups "Software Controller Operators" and/or "Failsafe Operators" (only applies to fail-safe CPUs) are not available as standard and must be created by the user.

With standard versions of the CPU 1515SP PC2, users of the user group "Software Controller Operators" have the right to control the CPU 1505SP (T) Software Controller with the command line tool and to load a PC station using the configuration file import.

With fail-safe versions of the CPU 1515SP PC2, users of the user group "Failsafe Operators" have the right to control the CPU 1505SP (F/TF) Software Controller with the command line tool and to load a PC station using the configuration file import.

Result

- The Windows 10 IoT Enterprise operating system (64-bit LTSC) is installed.
- The "Operator" user is logged on automatically.
- The Software Controller is ready to use.
- For administrative purposes, the "Operator" user can be logged off and the administrator created during commissioning can be logged on.
- The operating system's start screen is displayed after each startup.

9.3 Initial commissioning an open controller

The following sections provide an overview of the first commissioning of an Open Controller.

Step 1: Creating the configuration of the Open Controller (Page 49)

Step 2: Setting the IP address (Page 50)

Step 3: Changing the properties of the Software Controller (Page 50)

Step 5: Downloading a project to the target system (Page 50)

Step 6: Transferring the license key (Page 51)

Step 7: Switching the Open Controller on/off (Page 53)

Key combination <Ctrl+Alt+Del> during initial commissioning
To ensure that the initial initialization is complete, do **not** use the key combination <Ctrl+Alt+Del> during the initialization phase.

9.3.1 Creating the configuration of the Open Controller

Requirements

The following requirements must be met before you can create the configuration of the Open Controller:

- The TIA Portal ≥ V19 must be installed.
- You have started the TIA Portal and created a new project.

Creating the configuration

To create the configuration in the TIA Portal, follow these steps:

1. Double-click "Add new device" in the project tree.
2. Select "PC systems > SIMATIC S7 Open Controller > ET 200SP Open Controller >".
3. Select the required device.
4. Select the desired version and click "OK".
   The configured Open Controller is displayed in the device view.
5. The following interfaces can be seen in the Open Controller:
   – Onboard interface X2 (GB Ethernet Windows interface) that is assigned directly to the PC station (1 port)
   – Exchangeable BusAdapter that is assigned directly to the Software Controller (2 ports)
6. The following preconfigured components can be seen in the device view:
   – **CPU 1515SP PC2 / CPU 1515SP PC2 F/T/TF:** CPU 1505SP (F/T/TF) Software Controller
7. Insert the server module from the hardware catalog.
   The server module forms the termination of the CPU with the I/O modules. If no server module is configured, the server module is added automatically during compiling.

NOTE

If you created a TIA Portal V19 project for OC2 T/TF V30.1 before installing Update 1 for TIA Portal V30.1, you must recreate the project after installing Update 1 for TIA Portal V19 or migrate it from the previous version.

9.3.2 Setting the IP address

Set the IP address as follows:

- BusAdapter [X1]: The configured IP address becomes effective on the Open Controller after a download. To go online via the [X1] interface, the configured address must match the [X1] address entered in the panel of the software controller.
- Onboard interface [X2]: The configured IP address should be identical to the Windows IP address of the Open Controller.

9.3.3 Changing the properties of the S7-1500 Software Controller

Information on the property of the CPU is available in the Inspector window under "Properties". You can change these properties if required.

9.3.4 Downloading a project to the target system

To set up your automation system, you need to download the project data you generated offline to the connected devices. This project data is generated, for example when configuring hardware, networks, and connections or when programming the user program or when creating recipes. The first time you download, the entire project data is downloaded. During later download operations, only changes are downloaded.

Downloading a project

Proceed as follows to download the configuration:

1. Select the complete PC system in the device view.
2. For Open Controller up to V21.9: Right-click on the PC system.

   For Open Controller V30.0 and higher: Right-click on the PLC software under the PC system.
3. Select the option you require in the "Download to device" menu command.

NOTE

Note that the options available to you always depend on the selected device.

4. Select the interfaces with which you want to establish the online connection to the device. You have the option of showing all compatible devices by selecting the corresponding option and clicking the "Start search" command.

NOTE

For the Open Controller V30.0 or higher, the TIA Portal download must be carried out via the "X1" interface.

For older versions (the last supported version is V21.9), the TIA Portal download must be carried out via the "X2" interface.

Only ASCII characters are permitted in the name of the X1 or X2 PN/IE(LAN) interface in the TIA Portal, e.g. PROFINET_2.

5. Download and compile the project.

Reference

Additional information on the possible options for downloading is available in the online help of the TIA Portal.

9.3.5 Transferring license keys

Licensing the software

For the following products, you need to transfer the product-specific license key with the *Automation License Manager (ALM)* before commissioning:

- WinCC RT Advanced incl. PowerTag
- CPU 1505SP T/TF

NOTE

No license key is required to operate the S7-1500 Software Controller CPU 1505SP (F).

Requirements

- Initial commissioning was successfully completed.
- Windows 10 IoT Enterprise (64-bit LTSC 2021) is started.
- The extended write filter **UWF must be deactivated** on the CPU 1515SP PC2.

Transferring license keys with local configuration

The *Automation License Manager* is pre-installed on the CPU 1515SP PC2.

Open the software using the icon on the desktop or a menu command.

1. In the Windows start bar, select **Start > Siemens Automation > Automation License Manager**.
2. Follow the instructions of the *Automation License Manager*.

Transferring license keys via programming device/PC

The *Automation License Manager* is pre-installed on a programming device/PC with STEP 7 and the CPU 1515SP PC2.

1. Connect the CPU 1515SP PC2 to a programming device/PC.
2. Connect the supplied USB stick to the programming device/PC.
3. Select the menu command **Start > Siemens Automation > Automation License Manager**.
4. Select the menu command **Edit > Connect computer** and enter the IP address of the CPU 1515SP PC2.
5. if the option "Forbid license keys transfer from local computer" is disabled on the source computer, drag the license keys from the USB stick to the system partition C: of the CPU 1515SP PC2.

Backing up license keys for restore and repair

NOTE

Loss of license keys

A SIMATIC license key cannot be copied or duplicated. No more license key copies exist on the USB stick once you have dragged the license keys from the USB stick to your CPU 1515SP PC2.

Secure your purchased license keys **before** restoring the delivery state (Restore) or in the case of repair. To do this, move the license keys to a USB stick and keep this stick in a safe place.

If an error occurs on your license keys on the CPU 1515SP PC2, please contact your Siemens representative. Make sure to have the "Certificate of License" (CoL) to hand.

Reference

For additional information on licenses, refer to the *Automation License Manager* manual. You can find the manual on the CPU 1515SP PC2 under **Start > All Programs > Siemens Automation > Documentation** and on the Internet (https://support.industry.siemens.com/cs/ww/en/view/56956174).

You can find additional information on the UWF write filter in the section Data loss in the event of unexpected shutdown (Page 61).

9.3.6 Switching the Open Controller on/off

Requirements

Initial commissioning was successfully completed.

Switching on the CPU 1515SP PC2

Proceed as follows to switch on the CPU 1515SP PC2:

1. Switch on the power supply of the CPU.

   The Boot Manager GRUB2DOS starts.
2. Select the mode in which the CPU 1515SP PC2 should start:
   - Default: with the Windows operating system and the S7-1500 Software Controller
   - Only with the Windows operating system (e.g. with updates)

Switching off the CPU 1515SP PC2

Proceed as follows to switch off the CPU 1515SP PC2:

1. Use the Windows function **Start > Power > Shut down** to switch off.

   The PWR LED changes from green to yellow.

   The Windows function shuts down the Windows operating system and the S7-1500 Software Controller.

If the device will not be used for a longer period after the shutdown, de-energize the device.

Backing up the data of the Open Controller

NOTE

You can create a backup image of your CFast card. This contains the operating system, the Runtime software and the complete project loaded from the TIA Portal. To back up data under Windows, we recommend the SIMATIC IPC Image & Partition Creator software tool (≥ V3.5).
For more information on the Image & Partition Creator, refer to section: Backing up and restoring data (Page 69).

9.4 Activating the Wake On LAN functionality

To enable the Wake On LAN functionality, follow these steps:

1. In Windows, open the Device Manager with administrator privileges.
2. Look for the network adapter "Intel(R) I210 (Gigabit / Ethernet Server) Adapter".
3. Right-click on the adapter.
4. Select the menu command "Properties".
   The "Properties of Intel(R) Ethernet Server Adapter I210-T1" window opens.
5. Navigate to the "Advanced Settings" tab.
6. In the "Properties" area, enable the entries "Enable PME" and "Enable Magic Packet" by setting the value to "Enabled".
7. Restart Windows.

The Wake On LAN functionality is activated.

Interrupt, error and system messages 10

10.1 Status and error display

LED display

The following figure shows the LED displays of the CPU 1515SP PC2.

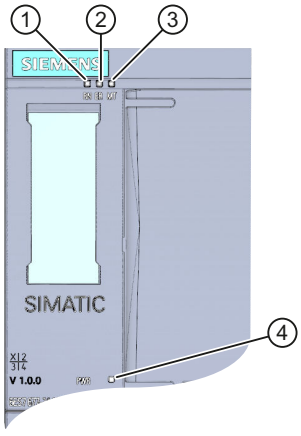

① RUN/STOP LED (yellow/green LED)

② ERROR LED (red LED)

③ MAINT LED (yellow LED)

④ POWER LED (yellow/green LED)

Figure 2-66 LEDs of the CPU 1515SP PC2

Meaning of the LED displays with active S7-1500 Software Controller

The CPU 1515SP PC2 has three LEDs to indicate the current operating state and diagnostics status.

The following table shows the meaning of the color combinations of the LED displays in connection with the S7-1500 Software Controller.

Table 2-46 Meaning of the LED displays

RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED off	LED off	LED off	POWER OFF Starting CPU 1515 SP PC2 in "Windows-only" mode. No power supply. Software Controller of the CPU 1515SP PC2: • is not downloaded • is in the operating state Power OFF Use of the hardware LEDs was disabled (configuration via TIA Portal).
LED off	LED flashes red	LED off	An error has occurred.
LED green	LED off	LED off	Software Controller of the CPU 1515SP PC2 is in RUN mode.
LED green	LED flashes red	LED off	A diagnostics event is pending.
LED green	LED off	LED lights up yellow	Maintenance demanded for the plant. The affected hardware must be exchanged within a short period.
LED green	LED off	LED flashes yellow	Maintenance required for the plant. You must exchange the affected hardware within a foreseeable period.
			Firmware update successfully completed.
LED lights up yellow	LED off	LED off	Software Controller of the CPU is in the operating state STOP.
LED lights up yellow	LED flashes red	LED flashes yellow	The user program is causing an error.
LED flashes yellow	LED off	LED off	CPU is performing internal activities during STOP, e.g. ramp-up after STOP.
			Loading the user program.
LED flashes yellow/green	LED off	LED off	Startup (transition from STOP → RUN)
			Startup (CPU booting)

RUN/STOP LED	ERROR LED	MAINT LED	Meaning
LED flashes yellow/green	LED flashes red	LED flashes yellow	Test of LEDs during startup, inserting a module.
			LED flashing test
LED flashes green	LED flashes red	LED flashes red	CPU defective

POWER LED

Table 2-47 POWER LED

POWER LED	Meaning
LED off	No supply voltage or supply voltage too low; operating system is shut down
LED lights up yellow	Supply voltage present; running through BIOS phase
LED green	Supply voltage present; Booting or operation of the operating system

Functions 11

11.1 Monitoring functions

11.1.1 Requirements

Introduction

The CPU 1515SP PC2 has monitoring functions that you can use with the corresponding monitoring software.
The following display, monitoring and control functions are available:

- Temperature monitoring (only possible with the Windows version)
- Monitoring the CFast card with the S.M.A.R.T. function
- Operating hours counter (information on the total runtime)
- HW LED status display (RUN/STOP, ERROR, MAINT)

Monitoring software

- **SIMATIC IPC DiagBase**

  The SIMATIC DiagBase software is included in the scope of delivery of the CPU 1515SP PC2.

  Use the DiagBase Management Explorer application to obtain a clearer overview for monitoring. The DiagBase Alarm Manager notifies you of individual alarms.

  NOTE

  For additional information, refer to the online help for the SIMATIC IPC DiagBase software.

- **SIMATIC IPC DiagMonitor**

  The SIMATIC DiagMonitor software is provided on a CD. You can find the order number of the license in the section Accessories/Spare parts (Page 115).

  Potential system failures are detected and reported in good time with the diagnostics and alerting software. The software is also used for remote diagnostics.

  The software contains:

  – The software for the stations to be monitored
  – A library for creating your own applications

11.1.2 Temperature monitoring

Temperature monitoring is only possible with the Windows version.

Three temperature sensors monitor the temperature at different locations of the CPU 1515SP PC2:

- Processor temperature
- Temperature in the vicinity of the RAM ICs/blocks
- Temperature of the basic module

NOTE

The **SIMATIC IPC DiagBase** software shows **only** the temperature of the CPU. The temperature of the main memory and basic module is currently not displayed.

If one of the temperature values exceeds the set temperature threshold, the temperature monitoring triggers a temperature error. The temperature error activates the IPC DiagBase and/or IPC DiagMonitor software.

The temperature error remains stored until the temperatures fall below the temperature threshold again and it is reset using one of the following measures:

- Acknowledgment of the error message by the monitoring software
- Restart of the device

11.1.3 Monitoring the CFast card with the S.M.A.R.T function

The CFast card supports the **S.M.A.R.T function** (**S**elf-**M**onitoring, **A**nalysis and **R**eporting Technology). This function helps avoid data loss.

Using special routines, SIMATIC IPC DiagBase requests a status report for the hard drive. The SMART hard drive keeps a list of errors that occurred while reading or writing sectors. When the number of errors exceeds a certain threshold, this is often an early warning of an impending defect of the drive.

At the latest, this is also the time when you should create a backup of the drive and replace the hard drive.

In this case, SMART would notice the rapid increase in the error rate and trigger an alarm.

Errors that originate, for example, in the electronics and lead to an immediate failure of the hard drive, but cannot be recognized by SMART.

11.1.4 Operating hours counter

You can use an operating hours counter for a variety of applications:

- For calculating the operating time of the CPU
- For calculating the operating time of controlled equipment

You can find more information about the operating hours counter in the "Operating hours counter" group in the "Diagnostics" folder of the Online and Diagnostics view in the TIA Portal.

11.2 Retentive memory NVRAM

Retentive memory is non-volatile memory for saving a limited quantity of data in the event of power failure.

The data defined as retentive is stored in retentive memory. This data is retained beyond a power-off or power failure.

A corresponding function is implemented in the S7-1500 software controller to allow NVRAM to be used there. This saves up to 410 KB of data in non-volatile data memory in the case of power failure. This function can be set on the engineering station in the TIA Portal.

11.3 BIOS setup

BIOS setup

The boot sequence can be set using the BIOS Setup.

To change the boot sequence on the Open Controller CPU 1515SP PC2 ≥ V2.5, proceed as follows:

1. Connect a monitor and a keyboard to the CPU.
2. Switch on the power supply to the CPU.
   The Siemens logo, among others, appears on the screen of the connected monitor.
3. Press "Esc" to enter the boot menu. Wait briefly until the boot menu is displayed.
4. Press "F1" and wait until the computer loads the system information.
5. Select the digit of the desired boot media to set or change the boot drive.

   NOTE

   If no prepared boot medium is inserted in the selected boot drive, the system automatically reboots after 60 seconds. To select bootable media again in this case, repeat steps 3 to 5.

6. The system is reset after 5 seconds and automatically boots from the new boot drive.

Changing the device configuration

The device configuration is preset for working with the supplied software.

Only change the set values if you have made technical changes to your device.

11.4 Power options

A power plan with the name SIMATIC S7 is set as default on the CPU 1515SP PC2. This ensures that the CPU does not deviate from its maximum clock rate in order not to endanger the real-time capability of the software controller.

11.5 Benefits of the function: Sleep mode

Under Windows 10, sleep mode reduces the power consumption of PCs and laptops during ongoing operation. By default, Windows 10 puts the computer into standby mode after 15 or 30 minutes of inactivity.

To change the default settings of the mode, follow these steps:

1. Open the Control Panel on your PC.
2. Select the "Hardware and Sounds" category.
3. Click "Power options".
   A new window opens.
4. On the left side, click on "Change when the PC sleeps".
   A new window opens with two columns for On battery (for notebooks) and Plugged in (for notebooks and PCs).
5. To specify switching to sleep mode after a specific period of time, select "Put the computer to sleep:" Your desired time.
6. Save your new settings with "Apply changes".

NOTE

The Software Controller does **not** work when power save mode is **enabled**.

11.6 Data loss in the event of unexpected shutdown

Various options are available to prevent data loss in the event of forced shutdown (line side switch) or unexpected shutdown (power failure), such as using UWF (Unified Write Filter) in conjunction with the ET200SP Open Controller.

By restricting write access to the file system, UWF increases the stability and security of Windows devices. Write attempts to a protected drive are redirected by the UWF to a virtual overlay, which protects the contents of a drive from unwanted changes or data loss.

11.6.1 Options for preventing data loss

For Microsoft Windows 10 on SIMATIC IPCs and ET200SP Open Controllers, there are various options for protecting the operating system against data loss or damage in the event of an unexpected shutdown. Microsoft recommends always shutting down the operating system properly. If a proper shutdown is not guaranteed, select one of the following options:

- Using an uninterruptible power supply (UPS)
- Using the Unified Write Filter (UWF) function

11.6.2 General information on the write filter

The common abbreviation for the "Unified Write Filter" is "UWF" (Unified Write Filter). Enabling the filter ensures that data is no longer saved retentively on the system. All write access operations are swapped out to the work memory (RAM) and are available until system restart. As soon as the computer is restarted, it loses its memory and goes back to the state that it was in before the filter was enabled.

NOTICE
Risk of data loss when "UWF" is activated When the device is shut down, all changes made after the boot process may be lost due to the write-protected data storage medium. To prevent this from happening, make changes to data storage media only with disabled write protection.

The "UWF" is disabled in the delivery state!

The filter does not support external removable data storage media, such as USB sticks and other flash drives, that are recognized as removable data storage media by the operating system.

NOTE

Note that the work memory is reduced when "UWF" is enabled.

NOTICE
Loss of data due to frequent write cycles. The number of write cycles on CFast cards is limited due to technical reasons. To prevent data loss, the CFast card must be provided with special protection. To protect the CFast card, enable the "UWF". This feature extends the service life of the CFast card and prevents a possible failure of the CPU 1515SP PC2.

Reference

You can find additional information on the "UWF" write filter on the Internet in the online help for Microsoft® Windows® 10.

11.6.3 Functional principle of the UWF

The Unified Write Filter (UWF) protects the content of a volume by redirecting all write attempts to a protected volume on a virtual overlay. By default, the overlay is located in the work memory with a size of 1024 MB.

Depending on the Windows version, the behavior may vary with a full overlay:

- Microsoft Windows 10 LTSB 2016 / Windows 10 LTSC 2019: - System no longer responds as write accesses can no longer be made
- Microsoft Windows 10 LTSC 2021: - System restarts automatically to clear overlay

NOTE

The use of Unified Write Filters on systems with 24/7 availability is not planned by Microsoft.

11.6.4 Using UWF with WinCC Unified PC Runtime

When downloading the WinCC Unified PC Runtime project (up to and including V18), it is not possible to set the project path to a partition other than the system partition (usually drive "C:"). A project download to a partition protected with UWF leads to project loss after a restart.

UWF provides the option of excluding specific paths from protection. Changes to the excluded paths are persistent even after a restart. Changes are kept in the overlay until the restart and only take effect on the hard disk after the restart.

The overlay area grows with every download of the WinCC Unified project.

If the project size exceeds the free overlay area on the Industrial Workstation/Open Controller, downloading the Runtime project will cause irreversible damage to the device.

Licenses that are managed by the Automation License Manager are lost after a restart if they are transferred to the protected UWF volume.

11.6.5 Options for using UWF with WinCC Unified PC Runtime

There are various ways of using UWF in conjunction with WinCC Unified PC Runtime to prevent data loss in the event of a forced shutdown (line side switch) or unexpected shutdown (power failure).

The following options are available:

- Using an uninterruptible power supply (UPS) instead of the UWF
- Use of UWF with the following conditions:
- Protecting the system partition "C:\"
- Exclusion of the following paths
  - "C:\ProgramData\SCADAProjects"
  - "C:\ProgramData\Siemens"
- Ensure that sufficient memory is available in the overlay.
- Restart the operating system before downloading the project or generally at regular intervals

- Optional: Place overlay on hard disk and enlarge → increases the time until the overlay is filled.
- Protect system partition with UWF and disable UWF for project download and then enable it again.
- No protection of the system partition with the following conditions
  - Store SIMATIC product licenses on a separate partition (see note)
  - Protect separate partition with product licenses using UWF.
  - Avoid frequent write operations to minimize the risk of damage to the system due to forced or unexpected shutdowns.

NOTE

No additional partitions can be created with the ET200SP Open Controller. We recommend using the restore partition "E:\" for the licenses and authorizations of SIMATIC products and for protecting this partition when using UWF.

As of WinCC Unified PC Runtime V19, you can customize the file path for the WinCC Unified project folder. This makes it possible to protect the system partition "C:\" using UWF in conjunction with the WinCC Unified PC Runtime without affecting the download of the Runtime.

11.6.6 Enabling write protection

To enable the "Unified Write Filter = UWF" under Windows, follow these steps:

1. Control Panel > Programs > Programs and Features > Turn Windows features on or off > Device Lockdown > Uniform Write Filter

To activate the UWF and protect the system partition "C:\", perform the following steps:

1. Open CMD Terminal with admin rights.
2. `uwfmgr filter enable`
3. `uwfmgr volume protect C:`
4. Add exclusions for SCADAProjects and Siemens folders.
5. `uwfmgr file add-exclusion C:\ProgramData\SCADAProjects`
6. `uwfmgr file add-exclusion C:\ProgramData\Siemens`
7. Restart IPC and check the configuration.
8. Open CMD Terminal with admin rights.
9. `uwfmgr get-config`

You can find an overview of the available commands for UWF here: UWF Manager (https://learn.microsoft.com/en-us/windows/iot/iot-enterprise/customize/uwfmgrexe).

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12.1 Display resolution

The table below shows the resolutions available with the DisplayPort V1.2 standard:

DisplayPort V1.2 standard	Resolution	Refresh rate
720p	1280 x 720	30 Hz
720p	1280 x 720	60 Hz
1080p	1920 x 1080	30 Hz
1080p	1920 x 1080	60 Hz
1440p (2K)	2560 x 1440	30 Hz
1440p (2K)	2560 x 1440	60 Hz
4K	3840 x 2160	30 Hz / 60 Hz

12.2 Partitions in the delivery state

12.2.1 Partitions for the Windows version

Partitioning the CFast card

The following partitions are set up on the CFast card by default:

Partition	Name	128 GB CFast card	File system
C:	System	60 GB	NTFS
D:	Data	44 GB	NTFS
E:	Restore	16 GB	NTFS
-	-	560 MB	RAW

NOTE

Partitions under Windows 10 IoT Enterprise (64-bit LTSC 2021)

The partitions need to be set again if they are faulty or if the partitioning is to be changed.

NOTE

Restoring existing system partition

If your projects are stored on partition D: you can use the "Restore existing system partition" option to restore partition C: with the operating system and the Runtime software, without your project data being affected.

NOTICE
CPU volume for S7-1500 Software Controller (560 MB RAW) Do not change the CPU volume for Software Controllers. This is the only way to ensure that the Software Controller continues to operate without error.

12.2.2 Partitions for the IndOS version

Partitioning the CFast card

The following partitions are set up on the CFast card by default:

Partition	Name	128 GB CFast card	File system
SDA1	EFI	256 MB	VFAT
SDA2	BIOS_GRUB	1 MB	
SDA3	boot	1 GB	BTRFS
SDA4	VMM	1 GB	EXT4
SDA5	SWCPU Raw	1.7 GB	
SDA6	root	115.3 GB	CRYPTO_LUKS

NOTICE
CPU volume for S7-1500 Software Controller (1.7 GB RAW) Do not change the CPU volume for Software Controllers. This is the only way to ensure that the Software Controller continues to operate without error.

12.3 BIOS update

You can perform a BIOS update with the SIMATIC IPC DiagBase software. The SIMATIC IPC DiagBase software is included in the scope of delivery of the CPU 1515SP PC2.

NOTICE
Irreparable damage to the BIOS An incorrectly executed BIOS update can irreparably damage the BIOS. The device is then no longer operational and must be sent in for repair. You may only start a BIOS update when it is absolutely necessary. The following applies here: • Do not disconnect the power supply during an update. • The update process must be completed before you shut down the device. • Perform BIOS update only in "Windows-only" mode. • Do not perform a BIOS "downgrade".

NOTE

BIOS update while the Software Controller is running

If you perform a BIOS update while the software controller is running, the DiagBase Management Explorer displays the following error message: Error while loading the BIOS file.

Procedure

To perform a BIOS update, follow these steps:

1. Check whether an up-to-date BIOS is available for the CPU 1515 SP PC2. You can find additional information in the "BIOS version" table on the Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/109743969) page.

   NOTICE

   BIOS versions for the Open Controller CPU 1515SP PC2

   When you accidentally use a BIOS version for the CPU 1515SP PC Open Controller, it may happen that the device can no longer be operated and needs to be sent in for repair.

   Therefore, when selecting the BIOS version, make sure that you use files that are intended for the Open Controller CPU 1515SP PC2. You will recognize these files by the name of the zip file: CPU_1515SP_**PC2**_xxxx_xxxx.zip

2. Start the Open Controller in "**Windows-only**" mode.
3. Start the DiagBase Management Explorer.
4. In the "Tools" menu bar, select "Local Bios".
5. Select the "Update" tab.
6. Click the "Load" button in the "BIOS Image" field.
7. Select the folder with the .rom BIOS file for the update.
8. Start the update.
9. After a successful update, you will see the note "Needs reboot".
10. Restart the Open Controller.

Starting make take some time after the update. Moreover, the PWR LED provides you with information about which phase the Open Controller is in:
Yellow = BIOS phase
Green = Operational

NOTICE

BIOS downgrade

Do not downgrade from BIOS V02.08_01.00 to an earlier version, e.g. to BIOS V02.05_16.02.

After a downgrade, the Open Controller is **unusable**!

Please send the device in its original packaging to your Siemens representative.

NOTE

IP address of the Siemens RT-VMM network adapter

After completing the update to V30.1, the IP address of the SIEMENS RT-VMM Network Adapter is lost. After the upgrade, set up the SIEMENS RT-VMM Network Adapter again.

Setting the IP address for the SIEMENS RT-VMM Network Adapter

NOTE

IP address of the SIEMENS RT-VMM Network Adapter after starting in "Windows-only" mode

If you start Windows in "Windows-only" mode, the assigned IP address of the SIEMENS RT-VMM Network Adapter will be lost. After starting in "Windows and Software Controller" mode, reset the IP address for the SIEMENS RT-VMM Network Adapter.

You can use the "set_vnic_ip.bat" script to set the IP address. The script accepts IP addresses and subnet masks as arguments. The script also reads IP addresses and subnet masks from a default input file, e.g. "ip_configuration.txt".

Use the following command: set_vnic_ip.bat <IP_address> <Subnet_Mask_Address>

NOTE

You can find additional information on the Internet (https://support.industry.siemens.com/cs/document/109826746).

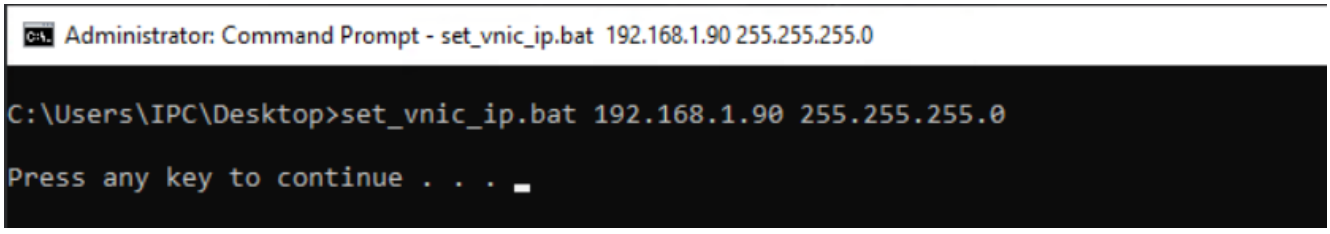

Figure 2-67 Example for setting the IP address

Use the following command to read and set IP addresses and subnet masks from a standard input file:

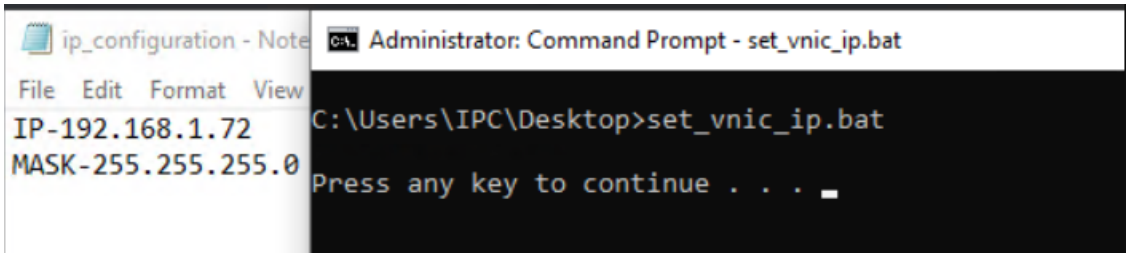

Figure 2-68 Reading and setting the file configuration

A file, e.g. "ip_configuration.txt" with the .bat file, is required for this scenario. The following script is available for creating the "ip_configuration.txt" file: "create_ip_config.bat"

This script creates the "ip_configuration.txt" file for the user, reads the current RT-VMM IP configuration and writes it to the file.

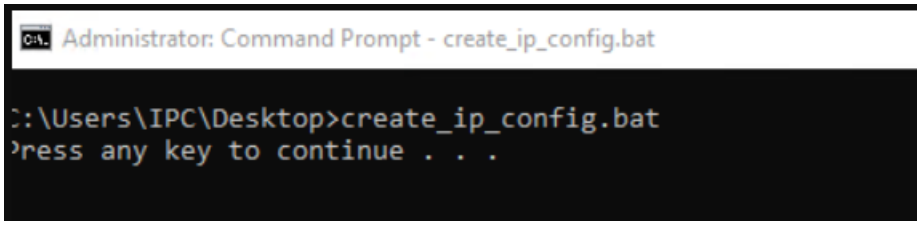

Figure 2-69 Creating the IP configuration

Reference

You can find additional information in the SIMATIC IPC DiagBase Operating Manual (https://support.industry.siemens.com/cs/ww/en/view/109749690).

12.4 Backing up and restoring data

Introduction

The CFast card (included in the scope of delivery) contains the operating system, the runtime software and the restore area.

To prevent loss of data and be able to restore the contents of the CFast card at any time, create a USB restore stick (Page 70).

If you use functions from the Restore menu, you must acknowledge a security message. For the functions, 72 hours are available in each case. If the functions are not completed within this time period, CPU 1515SP PC2 is automatically restarted without a further prompt.

If you want to back up your projects, save them to the D: partition of the CFast card.

SIMATIC IPC Image & Partition Creator

You can also create your own image of your CFast card. This contains the operating system, the Runtime software and the complete project loaded from the TIA Portal.

We recommend the SIMATIC IPC Image & Partition Creator (≥ V3.5) software tool to back up data under Windows. It provides for easy backup and fast restore of the contents of the CFAST card and of individual partitions (images).

NOTE

Data can only be backed up to a network drive with the SIMATIC IPC Image & Partition Creator software using the X2 PN/IE(LAN) interface.

You can procure the SIMATIC IPC Image & Partition Creator:

- Via the Siemens online ordering system.
- Pre-installed on the SIMATIC IPC Service USB flash drives.

For additional information, please refer to the corresponding product documentation.

SIMATIC IPC Service USB flash drive

You can use the SIMATIC IPC Service USB flash drives for data backup and restore.

You obtain these through the Siemens online ordering system.

12.5 Creating a bootable Restore USB stick

As **no** restore USB stick is included in the scope of delivery, we recommend creating a USB restore stick to restore the CFast card after commissioning the Open Controller.

You will also find the restore image on the CFast card in partition E:.

Business logic for the creation of the Restore USB stick

The following requirements must be met:

- You need a USB stick with at least 16 GB free memory.

  To create the USB stick use, for example, the SIMATIC IPC Service USB FlashDrive (6ES7648-6XA11-0YA0). Alternatively, you can also use other bootable USB sticks with a minimum size of 16 GB.
- Make sure that PowerShell (version number 3.0 - 5.1) is installed in Windows.
- To create the stick you need administrator rights under Windows.
- If you create the USB stick on another Windows 10 PC, connect a CFast card reader to record the 128 GB CFast card.

Creating a bootable Restore USB stick

The Restore USB stick is used to restore the delivery state of the CFast card:

- Restoring the delivery state is only possible on the Open Controller CPU 1515SP PC2.

  When creating on a Windows PC, the user must use a CFast card reader and insert the supplied CFast card.

  If the "System" partition on the CFast card is error-free, use the Open Controller CPU 1515SP PC2 directly.
- If the "System" partition on the CFast card is damaged, use a Windows 10 PC with Windows 10 Build 1607 or later for restoring.

Use the following steps to ensure that you can restore the system if an error occurs:

NOTICE
Data loss All existing data on the USB stick is deleted when you create the USB restore stick. Back up the data on the USB stick before you create the USB restore stick.

1. The "Restore" partition of the CFast card contains the file "E:\Create-RestoreUsb.lnk". Open this file.

   NOTE

   When you create the USB restore stick on a different Windows 10 PC, the drive name might be different from "E".

2. To obtain the full administrator access token, confirm the UAC (User Account Control) through administrator logon information. Enter an administrator password. The script in the Powershell is started.
3. Insert the USB restore stick into the PC.
   Please note that the script will be ended if a USB stick is not inserted within 60 seconds after the prompt.
4. Confirm the deletion of all data on the USB stick by entering "Y" (without quotation marks).
5. Confirm by entering "Y" to copy the restoration data from the restore partition to the USB stick.
6. When the copy is complete, press the "Enter" key to exit the script.

The USB restore stick for restoring the delivery state is ready. The process is logged in a log file in the directory "E:\TOOLS\CreateRestoreUsb\Logs".

Check bootable Restore USB stick

Check whether the restore process can be started with the Restore USB stick.

1. Switch off the power supply of the CPU 1515SP PC2.
2. Remove all USB drives from the CPU 1515SP PC2.
3. Connect the Restore USB stick directly to the CPU 1515SP PC2.
4. Switch on the power supply of the CPU 1515SP PC2.
5. Press <ESC> to start the Boot Manager.
6. Select the list entry for the USB stick in the Boot Manager.
7. When the loading process is indicated (Windows logo) and the "SIMATIC Restore" menu can be opened, a check is made to determine if the "Restore" USB stick is bootable and was created properly.

   NOTE

   To check the functionality it is sufficient to test the start of the SIMATIC IPC Restore application. The application can be aborted before the recovery process starts.

12.6 Restoring the delivery state

NOTE

Using Multitouch Panels

The restoration of the original software is not possible with a Multitouch panel, because the Multitouch driver is not available until after the installation of the operating system.

NOTICE

Data loss

During restoration of the system to delivery state, the CFast card is completely erased and reformatted, and is then loaded with the original software. All subsequently modified or added data, programs, license keys and partitions on the CFast card will be lost.

Back up the data of the CPU 1515SP PC2 after you have assigned parameters to the module and if you have made changes to the configuration.

NOTICE

Loss of license keys

Back up the license keys before the restore by dragging these to your USB restore stick via the *Automation License Manager*.

After the restart of the CPU 1515SP PC2, transfer the license keys back to the device via the *Automation License Manager*.

Procedure to restore the delivery state

To restore the state saved on the CFast card using the USB restore stick, follow these steps.

1. Switch off the power supply to the CPU 1515SP PC2.
2. Remove all USB drives from the CPU 1515SP PC2.
3. Connect the USB restore stick directly to the CPU 1515SP PC2.
4. Insert the CFast card into the designated slot of the CPU 1515SP PC2.
5. Switch on the power supply to the CPU 1515SP PC2.

   The CPU is started.
6. To start the Boot Manager, press <Esc> while the Siemens logo is being displayed.
7. Select the list entry for the USB stick as boot medium in the Boot Manager.
8. Follow the instructions of the SIMATIC IPC Restore application. Select the "CPU 1515SP PC2" option to restore the system.
   The original software is restored.
9. Copy the restore data from the USB flash drive to the restore partition. To do this, select the "Fill restore partition" option in the SIMATIC IPC Restore application.

NOTE

The restore process writes **all** the data stored on the USB stick to the restore partition.

In case you skip step 9 from the above instruction, the restore partition will remain empty.

12.7 Updating software

NOTE

When you update software (such as Windows, drivers, BIOS, etc.), always start the CPU 1515SP PC2 in the GRUB menu in Windows mode.

Information on updating software for the respective product can be found on the Internet (https://support.industry.siemens.com/cs/ww/en).

HMI devices

During the installation, make sure that you always use the latest drivers for the HMI devices used (SIMATIC Flat Panels).

Before you install a new driver version, you must uninstall the old driver version in order to ensure proper operation.

You can download the current driver software from SIMATIC Product Support.

Missing drivers in the device manager after initial setup

Not all drivers of the Intel® processor are pre-installed in the "Windows System Image Manager" of the Open Controller CPU1515 SP PC2. The drivers are not required for the operation of the Open Controller CPU1515 SP PC2 as a programmable controller. The exclamation marks in the Windows 10 Device Manager are accepted.

Device warning of the "Intel(R) Serial IO GPIO Host Controller - INT3452" in the Device Manager

The following driver is located in the Windows 10 LTSC Device Manager of the Open Controller image:

- Intel(R) Serial IO GPIO Host Controller - INT3452

This driver is marked by a yellow triangle with an exclamation mark.

To view the device status of this driver, do the following:

1. Select the driver "Intel(R) Serial IO GPIO Host Controller - INT3452".
2. Right-click on the driver.
3. Select the menu command "Properties".
   The "Properties of Intel(R) Serial IO GPIO Host Controller - INT3452" window opens.
4. The "General" tab shows the device status with the following error message:
   This device cannot find enough free resources that it can use. (Code 12)

NOTE

This warning does not have a negative effect on the functionality of the system.

Reference

You can find additional information about updating in the BIOS update (Page 66).

12.8 Windows 10 IoT Enterprise (64-bit LTSC 2021)

The Windows 10 IoT Enterprise (64-bit LTSC 2021) operating system is pre-installed on the CPU 1515SP PC2.

Windows language packs

After first commissioning of the CPU 1515SP PC2, you can install additional operating system languages. You need administrator rights to install language packages.

The following language packages are available on the restore partition E: under \LanguagesPackages\..

- Chinese (simplified)
- German
- English
- French
- Italian
- Spanish

Installing the Windows language packs

To install the Windows language packages, follow these steps:

1. To start a console session, open the "Run" dialog, for example, with the keyboard shortcut: <Windows key+R>.
2. Enter the following command: lpksetup.exe
3. Click "OK" to confirm.
4. The "Install or uninstall display languages" window opens.
5. Click on "Install display languages".
6. Select the display language to be installed by clicking on "Browse".
7. Navigate to the folder containing the display languages and confirm with "OK".
8. The selected language pack is displayed in the "Install or uninstall display languages" window.
9. Click on "Next" and follow the instructions of the installation wizard.

Updates

You can install additional updates at a later time. You can find current information on the operating system at Widows (http://www.windows.com).

NOTE

In the delivery state, partitions are set up on drive C: and D: on the CFast card with free memory. You can find additional information in the section Partitions for the Windows version (Page 65).

Make sure that sufficient free memory space is available on your CFast card for the installation of updates.

12.9 Sending the device to customer service

Before sending

Before you send in the CPU 1515SP PC2 for repair:

- Create a backup of your data.
- Back up your SIMATIC license keys on a USB stick.
- Remove your SD/MMC cards.
- Remove your **CFast card**.

NOTE

The Acronis Backup is not supported in the current version – use Image Partition Creator.

Sending in the device

- Pack the device in its original packaging.
- Enclose identification data (Page 34).
- Send to your Siemens contact partner.

12.10 Removing and inserting the CFast card

Introduction

The CPU 1515SP PC2 has a slot for a CFast card. On this card, you will find the operating system, your runtime software, the restore area and, after configuration, the project.

Seal the cover for the CFast card to protect the system against unauthorized access.

You must remove the CFast card before you send in the CPU, for example, for repair.

Requirements

- The CPU 1515SP PC2 is disconnected from the power supply.

Procedure – Removing the CFast card

NOTICE
Removing the CFast card during operation Do **not** remove the CFast card while the CPU 1515SP PC2 Open Controller is running.

1. Remove the seal.
2. Open the cover, using a screwdriver if necessary.
3. Press onto the CFast card.
   The card is pressed out of the slot.
4. Pull the card out of the slot.
   To do this, grip the rib on the underside of the memory card.

Procedure – Inserting the CFast card

1. Open the cover of the slot, using a screwdriver if necessary.
2. Insert the CFast card into the slot.
3. Press the CFast card into the slot until it clicks into place.

   The CFast card is properly inserted if the cover can be closed without any resistance.
4. Close the cover.

NOTICE
Unauthorized access Seal the cover to protect the CFast card with the operating system of the CPU 1515SP PC2 from unauthorized access.

12.11 Recycling and disposal

For ecologically sustainable recycling and disposal of your old device, contact a certificated disposal service for electronic scrap or dispose of the device in accordance with the regulations in your country.

Industrial OS 13

The functions described in the following section apply **only** to the Open Controller CPU 1515SP PC2 (F) V30.1 SIMATIC Industrial OS.

13.1 Updating BIOS

A physical access to the CPU 1515SP PC2 is not required. An SSH connection is sufficient.

Procedure

Proceed as follows to update the BIOS:

1. Download the BIOS update file from Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/109743969).
2. Transfer the BIOS update file to the CPU 1515SP PC2.

   You can transfer the file to the Linux device in several ways.

   For example:

   Check the code for the device after the response of the `lsblk` command:

   ```
   sudo mkdir /mnt/usb
   lsblk
   ```

   Activate the selected device. Replace `/dev/sdd1` with your device.

   ```
   mount /dev/sdd1 /mnt/usb
   cd /mnt/usb
   ```

3. Run the following command as root: `bios-update File.tar.gz`

   The CPU 1515SP PC2 is automatically restarted twice.

   A log file is created in the home directory of the root. The file contains complete information about the BIOS update process. If an error is detected, a service data dump is added to this log file.
4. Check the log file after the required number of restarts. If it says "All done" at the end, then the BIOS update was successful.

   Otherwise, check the error message and contact Siemens Industry Online Support if necessary. Provide the log file to the Siemens Industry Online Support.

You can now check the BIOS version with the `dmidecode -s bios-version` command.

NOTE

It is recommended to run the BIOS update in native Linux mode.

13.2 Commissioning procedure

When you start the Open Controller CPU 1515SP PC2 for the first time, you must enter the basic settings and the administrator password. The device is then automatically set up for the operating system installed on the CFast card.

Procedure:

1. Connect the power supply.
   - The PWR LED lights up yellow first, then green.
   - The device carries out the hardware initialization.
2. Wait until the Siemens logo disappears from the screen.
3. Accept the license conditions (license conditions, security information and OSS information).
4. Follow the instructions on the screen to configure the device:
   - Set <Language>, <Country/region>, <App language>, <Keyboard layout>, <Time zone for>.
   - You can find the detailed description of the configuration of SIMATIC Industrial OS in Industrial OS - Getting Started, section 2.4. (https://support.industry.siemens.com/cs/ww/en/view/109795683)

The system restarts.

You can log in and use the system.

More information about installation and operation of the software controller can be found in the Operating Instructions Software Controller CPU 1505SP (F), CPU 1507S (F) and CPU 1508S (F) SIMATIC Industrial OS.
(https://support.industry.siemens.com/cs/de/en/view/109808199)

13.2.1 Configuration loss of the SWCPU after commissioning

There is a time window (approx. 30 seconds) in which the SWCPU loses its configuration if the power supply to the device is interrupted directly after the first start of IndOS (the moment in which the first login screen appears and the device is already usable).

This is because the configuration of the SWCPU is stored temporarily but has not yet been saved in the permanent system memory.

NOTICE
Do not interrupt the power supply to the Open Controller after initial commissioning, otherwise the SWCPU will lose its configuration.

Procedure when configuration is lost

Run swcpu-configure.sh in the command line to restore the configuration of the SWCPU to its original state.

13.3 System backup and restoring to factory state

For system backups and restoring to factory state, we recommend the open-source tool "Clonezilla".

The recovery image to be used with "Clonezilla" for download and more information on system backups and restoring can be found on the Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/109825700) page.

13.4 Changing system time and date

To change the system time and date, use the following Linux command: "date -s"

Synchronization via NTP server is described in Industrial OS - Getting Started, chapter 2.4.7 (https://support.industry.siemens.com/cs/de/en/view/109795683).

13.5 Time and date synchronization

NOTE

When changing the time in SIMATIC Industrial OS, it is necessary to manually synchronize the system time and date with the real-time clock. To do this, use the following Linux command: "hwclock --systohc".

NOTE

Time-of-day synchronization cannot be used in the TIA Portal.

The "Time-of-day synchronization" entry in the Inspector window > Properties > General cannot be used.

13.6 Security updates

For updates of the software packages available in the Industrial OS, we recommend setting a regular interval for installing security updates in the "Apt Update" dialog.

The "Apt Update" function is described in Industrial OS - Getting Started, Section 2.4.12 (https://support.industry.siemens.com/cs/de/en/view/109795683). The call of the setup settings with the "mel-setup" command is described in section 2.6.

Current security instructions for the installed packages can be found at https://www.debian.org/security/ (https://www.debian.org/security/)

Current security instructions for the Linux kernel and BIOS used can be found at https://new.siemens.com/global/en/products/services/cert (https://www.siemens.com/global/en/products/services/cert.html).

NOTICE
Only install kernel updates provided by Siemens For updates of the Linux kernel, **only** use SIMATIC Industrial OS versions provided by SIEMENS. Updates that are not provided by Siemens can result in security, stability and compatibility problems. Ensure the consistency and integrity of the downloaded files.

Technical specifications 14

14.1 Standards and approvals

Introduction

The general technical specifications cover the following:

- The standards and test values that the CPU 1515SP PC2 complies with and fulfills.
- The test criteria according to which the CPU 1515SP PC2 was tested.

Currently valid markings and approvals

NOTE
Information for CPU 1515SP PC2
The currently valid markings and approvals are printed on the CPU 1515SP PC2.

Safety information

WARNING
Risk of personal injury and damage to property.
In hazardous areas, there is a risk of injury or damage if you disconnect any connectors while the CPU 1515SP PC2 is in operation.
Always de-energize the CPU 1515SP PC2 operated in such areas before you disconnect the connectors.

WARNING
Flying sparks due to loose cables
Risk of explosion in hazardous areas.
USB cables and PROFINET connectors may detach from the device in the case of strong oscillation and high vibrating loads.
Attach these cables to the strain relief of the device using cable ties.

WARNING

Explosion hazard

If you replace components, compliance with Class I, DIV. 2 can become invalid.

WARNING

Area of application

This device is only suitable for use in Class I, Div. 2, Group A, B, C, D, or in non-hazardous areas.

CE marking

The CPU 1515SP PC2 meets the requirements and safety objectives of the following guidelines and complies with the harmonized European standards (EN) for programmable logic controllers published in the official journals of the European Community:

- 2014/30/EU "Electromagnetic Compatibility" (EMC Directive)
- 2014/34/EU "Equipment and protective systems intended for use in potentially explosive atmospheres" (Explosion Protection Directive)
- 2011/65/EU "Restriction of the use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)
- 2006/42/EC "Machinery Directive" for fail-safe modules

The conformity declaration certificates are available for the responsible authorities and are kept at the following address:

Siemens AG
Digital Factory
Factory Automation
DF FA TI COS TT
Postfach 1963
D-92209 Amberg

They are also available for download on the Siemens Industry Online Support (https://support.industry.siemens.com/cs/de/en/) web pages, keyword "Declaration of Conformity".

cULus approval

Underwriters Laboratories Inc., complying with

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)

OR

cULus HAZ. LOC. approval

Underwriters Laboratories Inc., complying with

- UL 508 (Industrial Control Equipment)
- CSA C22.2 No. 142 (Process Control Equipment)
- ANSI/ISA 12.12.01
- CSA C22.2 No. 213 (Hazardous Location)

APPROVED for use in
Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

Installation Instructions for cULus haz.loc.

- WARNING - Explosion Hazard - Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAY.

FM approval

Factory Mutual Research (FM) according to
Approval Standard Class Number 3611, 3600, 3810

(ANSI/ISA 82.02.01)
CSA C22.2 No. 213
CSA C22.2 No. 61010-1
APPROVED for use in Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

Installation Instructions for FM

- WARNING - Explosion Hazard - Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

OR

ATEX approval

In accordance with EN 60079-15 (Electrical apparatus for potentially explosive atmospheres; Type of protection "n") and EN 60079-0 (Electrical apparatus for potentially explosive gas atmospheres - Part 0: General Requirements)

II 3 G Ex nA IIC Tx Gc
DEKRA 12ATEX0038X

OR

IECEx approval

According to IEC 60079-15 (Explosive atmospheres - Part 15: Equipment protection by type of protection "n") and IEC 60079-0 (Explosive atmospheres - Part 0: Equipment - General requirements)

Ex nA IIC Tx Gc
IECEx DEK 13.0011X

RCM (C-Tick) Declaration of conformity for Australia/New Zealand

CPU 1515SP PC2 meets the requirements of the standard EN 61000-6-4:2007 + A1:2011.

Korea Certificate KCC-REM-S49-ET200SP

Note that this device corresponds to limit class A in terms of the emission of radio frequency interference. This device can be used in all areas, except residential areas.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

IEC 61131

The CPU 1515SP PC2 with the S7-1500 Software Controller CPU 1505SP (F/T/TF) fulfills the requirements and criteria of the IEC 61131-2 standard (programmable logic controllers, Part 2: Equipment requirements and tests).

PROFINET standard

CPU 1515SP PC2 is based on standard IEC 61158 Type 10.

PROFIBUS standard

CPU 1515SP PC2 is based on standard IEC 61158 Type 3.

IO-Link standard

CPU 1515SP PC2 is based on standard IEC 61131-9.

Use in industrial environments

CPU 1515SP PC2 is designed for use in industrial environments. It meets the following standards for this type of use:

- Requirements on interference emission EN 61000-6-4: 2007 + A1: 2011
- Requirements on immunity EN 61000-6-2: 2005

Use in mixed areas

Under certain circumstances, you can use the CPU 1515SP PC2 in a mixed area. A mixed area is used for residential purposes and for commercial operations that do not significantly impact on residents.

If you want to use the CPU 1515SP PC2 in mixed areas, you must ensure that its radio frequency interference emission complies with the limit classes of the EN 61000-6-3 generic standard. Suitable measures for observing these limits for use in a mixed area are, for example:

- Installation of the CPU 1515SP PC2 in grounded control cabinets
- Use of noise filters in the supply cables

An individual acceptance test is also required.

Use in residential areas

NOTE

CPU 1515SP PC2 not intended for use in residential areas

CPU 1515SP PC2 is not intended for use in residential areas. Using the CPU 1515SP PC2 in residential areas can affect radio and television reception.

Reference

The certificates for the markings and approvals can be found on the Internet under Siemens Industry Online Support (https://support.industry.siemens.com/cs/de/en/).

14.2 Electromagnetic compatibility

Definition

Electromagnetic compatibility (EMC) is the ability of an electrical installation to function satisfactorily in its electromagnetic environment without interfering with that environment.

The CPU 1515SP PC2 meets the requirements of the EMC legislation for the European single market, among other requirements. The prerequisite for this is that the CPU 1515SP PC2 complies with the specifications and guidelines relating to electrical configuration.

EMC according to NE 21

The CPU 1515SP PC2 meets the EMC specifications of NAMUR guideline NE 21.

Pulse-shaped disturbance

The following table shows the electromagnetic compatibility of the CPU 1515SP PC2 with regard to pulse-shaped disturbances.

Table 2-48 Pulse-shaped disturbance

Pulse-shaped disturbance	Test voltage	corresponds to degree of severity
Electrostatic discharge according to IEC 61000-4-2.	Air discharge: ±8 kV Contact discharge ± 4 kV	3 3
Burst pulses (high-speed transient disturbance) according to IEC 61000-4-4.	±2 kV (power supply lines) ±2 kV (signal lines > 30 m) ±1 kV (signal lines < 30 m)	3 3
High-energy single pulse (surge) according to IEC 61000-4-5 External protective circuit required (see function manual Designing interference-free controllers (https://support.industry.siemens.com/cs/ww/en/view/59193566))		3
• asymmetric coupling	±2 kV (power supply lines) DC with protective elements ±2 kV (signal/data line only > 30 m), with protective elements	
• symmetric coupling	±1 kV (power supply lines) DC with protective elements ±1 kV (signal/data line only > 30 m), with protective elements	

Sinusoidal disturbance

The following table shows the electromagnetic compatibility of the CPU 1515SP PC2 with regard to sinusoidal disturbances.

- RF radiation

Table 2-49 Sinusoidal disturbance variables with RF radiation

RF radiation according to IEC 61000-4-3/NAMUR 21 Electromagnetic RF field, amplitude-modulated		**corresponds to degree of severity**
80 to 1000 MHz; 1.0 to 2.0 GHz	2.0 GHz to 6.0 GHz	3
10 V/m	3 V/m	
80% AM (1 kHz)		

- RF coupling

Table 2-50 Sinusoidal disturbance variables with RF coupling

RF coupling according to IEC 61000-4-6	**corresponds to degree of severity**
(10 kHz) 150 kHz to 80 MHz	3
10 V_{rms} unmodulated	
80% AM (1 kHz)	
150 Ω source impedance	

Emission of radio interference

Interference emission of electromagnetic fields in accordance with IEC61000-6-4 (measured at a distance of 10 m).

Table 2-51 Interference emission of electromagnetic fields

Frequency	**Emitted interference**
30 MHz to 230 MHz	< 40 dB (µV/m)Q
230 MHz to 1000 MHz	< 47 dB (µV/m)Q

Emission of interference via AC supply voltage in accordance with EN 55016.

Table 2-52 Interference emission via the AC power supply

Frequency	**Emitted interference**
0.15 to 0.5 MHz	<79 dB (µV) Q <66 dB (µV) M
0.5 to 30 MHz	<73 dB (µV) Q <60 dB (µV) M

14.3 Shipping and storage conditions

Introduction

The CPU 1515SP PC2 exceeds the requirements of IEC 61131-2 in terms of shipping and storage conditions. The following information applies to modules that are shipped and/or stored in their original packaging.

Table 2-53 Shipping and storage conditions for modules

Type of condition	Permissible range
Free fall (in shipping package)	≤1 m
Temperature	From -40 °C to +70 °C
Barometric pressure	from 1140 hPa to 660 hPa (corresponds to an altitude of -1000 m to 3500 m)
Relative humidity	5% to 95%, without condensation
Sinusoidal vibrations according to IEC 60068-2-6	5 - 8.4 Hz: 3.5 mm 8.4 - 500 Hz: 9.8 m/s^2
Shock according to IEC 60068-2-27	250 m/s^2, 6 ms, 1000 shocks

14.4 Mechanical and climatic ambient conditions

Operating conditions

The CPU 1515SP PC2 is suitable for use in weather-proof, fixed locations. The operating conditions are based on the requirements of DIN IEC 60721-3-3:

- Class 3M3 (mechanical requirements)
- Class 3K3 (climatic requirements)

Mechanical ambient conditions

The table below shows the mechanical ambient conditions in the form of sinusoidal oscillations.

Table 2-54 Mechanical environmental conditions for BA 2×RJ45

Frequency band	
5 Hz ≤ f ≤ 8.4 Hz	3.5 mm amplitude
8.4 Hz ≤ f ≤ 150 Hz	1 g constant acceleration

Table 2-55 Mechanical environmental conditions for BA 2×FC

Frequency band	CPU 1515SP PC2
5 Hz ≤ f ≤ 8.2 Hz	7.5 mm amplitude
8.2 Hz ≤ f ≤ 500 Hz	2 g constant acceleration

Test of mechanical ambient conditions

The table below provides important information with respect to the type and scope of the test of ambient mechanical conditions.

Table 2-56 Test of mechanical ambient conditions

Condition tested	Test Standard	Comment
Vibration	Vibration test according to IEC 60068-2-6 (sine)	Type of oscillation: Frequency sweeps with a rate of change of 1 octave/minute. BA 2×RJ45 • 5 Hz ≤ f ≤ 8.4 Hz, 3.5 mm constant amplitude • 8.4 Hz ≤ f ≤ 150 Hz, 1 g constant acceleration BA 2×FC • 5 Hz ≤ f ≤ 8.2 Hz, 7.5 mm constant amplitude • 8.2 Hz ≤ f ≤ 500 Hz, 2 g constant acceleration Duration of vibration: 10 frequency sweeps per axis in each of 3 vertically aligned axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half-sine Shock intensity: 150 m/s^2 peak value, 11 ms duration Direction of shock: 3 shocks in each direction (+/-) at each of 3 vertically aligned axes

Climatic ambient conditions

You can use the CPU 1515SP PC2 under the following climatic ambient conditions:

Table 2-57 Climatic ambient conditions

Ambient conditions	Permissible range	Comments
Temperature: Horizontal mounting position	• 55 °C or higher	When expanding with 32 ET 200SP modules: 4 x 0.3 A USB load; CFAST memory card max. 10% load; SD card not used
Temperature: Vertical mounting position	• 45 °C or higher	When expanding with 32 ET 200SP modules: 4x 0.3 A USB load; CFast memory card and SD card max. 10% load
Permitted temperature change	10 K/h	-
Relative humidity	from 10 to 95%	Without condensation
Barometric pressure	From 1140 to 795 hPa	Corresponds to an altitude of -1000 m to 2000 m
Concentration of pollutants	ANSI/ISA-71.04 severity level G1; G2; G3	-

14.5 Information on insulation, protection class, degree of protection and rated voltage

Insulation

The insulation is designed according to the requirements of EN 61131-2: 2007.

NOTE

In the case of modules with 24 V DC (SELV/PELV) supply voltage, galvanic isolations are tested with 707 V DC (type test).

NOTE

The ground/minus pole of the 24 V DC power supply is connected via the device with functional ground (FE).

Pollution degree / overvoltage category according to IEC 61131

- Pollution degree 2
- Overvoltage category: II

Protection class in accordance with IEC 61131-2:2007

The distributed I/O system ET 200SP fulfills protection class I and includes parts of protection class II and III. The CPU 1515SP PC2 is a part of protection class III.

The grounding of the mounting rail must meet the requirements for functional earth FE.

The installation location (e.g. enclosure, control cabinet) must have a protective conductor connection that meets the standard to maintain protection class I.

Degree of protection IP20

Degree of protection IP20 according to IEC 60529, i.e.:

- Protection against contact with standard probe
- Protection against foreign objects with diameters in excess of 12.5 mm
- No protection against water

Rated voltage for operation

The CPU 1515SP PC2 works with the rated voltage and corresponding tolerances listed in the following table.

Table 2-58 Rated voltage for operation

Rated voltage	Tolerance range
24 V DC	19.2 to 28.8 V DC [1]

[1] Static value: Creation as functional extra-low voltage with safe electrical isolation in accordance with IEC 60364-4-41

14.6 Use of the ET 200SP in zone 2 potentially explosive atmospheres

See product information Use of subassemblies/modules in a Zone 2 Hazardous Area (https://support.industry.siemens.com/cs/ww/en/view/19692172).

14.7 Module data

14.7.1 Technical specifications CPU 1515SP PC2

Technical specifications

The following table shows the technical specifications as of 02/2024. You will find a data sheet including daily updated technical specifications on the Internet (https://sieportal.siemens.com/en-ww/home). Enter the current article number of your product in the search field.

Article number	6ES7677-2DB42-0GB1
General information	
Product type designation	CPU 1515SP PC2
Firmware version	V30.1
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes; only with PROFINET; with minimum OB 6x cycle of 500 µs
• SysLog	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V19
Installed software	
• Visualization	No
• Control	S7-1500 Software Controller CPU 1505SP
Control elements	
Mode selector switch	1

Article number	6ES7677-2DB42-0GB1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	5 ms
Input current	
Current consumption (rated value)	1.8 A; Full processor load, incl. ET 200SP modules and using USB
Current consumption (in no-load operation), typ.	0.5 A
Current consumption, max.	2.9 A
I^2t	0.426 A^2·s; with starting current inrush
Power	
Active power input, max.	43 W; incl. ET 200SP modules and using USB
Infeed power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	16 W
Processor	
Processor type	Intel Atom E3940, 1.6 GHz, 4 cores
Memory	
Type of memory	DDR3L
Main memory	8 GB RAM
CFast memory card	Yes; 128 GB flash memory
SIMATIC memory card required	No
Work memory	
• integrated (for program)	2 Mbyte
• integrated (for data)	7.5 Mbyte
• integrated (for CPU function library of CPU Runtime)	20 Mbyte
Load memory	
• integrated (on PC mass storage)	320 Mbyte
Backup	
• with UPS	Yes; all memory areas declared retentive
• with non-volatile memory	Yes
Hardware configuration	
Integrated power supply	Yes
Number of DP masters	
• Via CM	1
Number of IO Controllers	
• via PC interfaces	1

Article number	6ES7677-2DB42-0GB1
Rack	
• Modules per rack, max.	82; CPU + 64 modules + server module (mounting width max. 1 m) + 16 ET 200AL modules
• Quantity of operable ET 200SP modules, max.	64
• Quantity of operable ET 200AL modules, max.	16
• Number of lines, max.	1
Time of day	
Clock	
• Type	Hardware clock
• Backup time	6 wk; At 40 °C ambient temperature, typically
• Deviation per day, max.	10 s; Typ.: 2 s
Interfaces	
Number of industrial Ethernet interfaces	2
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1; Via CM DP module
Number of RS 485 interfaces	1; Via CM DP module
Number of USB interfaces	4; 2x USB 2.0, 2x USB 3.0 on front side
Number of SD card slots	1
Video interfaces	
• Graphics interface	1x DisplayPort
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; Via BusAdapter BA 2x RJ45
– Transmission rate, max.	100 Mbit/s
– Industrial Ethernet status LED	Yes
• Number of ports	2
• integrated switch	Yes
2. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; Integrated
– Transmission rate, max.	1 000 Mbit/s
– Industrial Ethernet status LED	No
• Number of ports	1
3. Interface	
Interface types	
• RS 485	Yes
Interface types	
RS 485	
• Transmission rate, max.	12 Mbit/s

Article number	6ES7677-2DB42-0GB1
Interrupts/diagnostics/status information	
Diagnostics indication LED	
• RUN/STOP LED	Yes
• ERROR LED	Yes
• MAINT LED	Yes
Ambient conditions	
Ambient temperature during operation	
• min.	-20 °C
• horizontal installation, min.	-20 °C
• horizontal installation, max.	60 °C; from 55°C: with max. 32 ET 200SP modules; 4x 0.3 A USB load; CFast memory card max. 10% load; SD card not used
• vertical installation, min.	-20 °C
• vertical installation, max.	50 °C; from 45°C: with max. 32 ET 200SP modules; 4x 0.3 A USB load; CFast memory card and SD card; max. 10% load
Ambient temperature during storage/transportation	
• min.	-40 °C
• max.	70 °C
Operating systems	
pre-installed operating system	Windows 10 IoT Enterprise 2021 LTSC
Peripherals/Options	
SD card	Optionally for additional mass storage
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

14.7.2 Technical specifications of CPU 1515SP PC2 F

Technical specifications

The following table shows the technical specifications as of 02/2024. You will find a data sheet including daily updated technical specifications on the Internet (https://sieportal.siemens.com/en-ww/home). Enter the current article number of your product in the search field.

Article number	6ES7677-2SB42-0GB1
General information	
Product type designation	CPU 1515SP PC2 F

Article number	6ES7677-2SB42-0GB1
Firmware version	V30.1
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes; only with PROFINET; with minimum OB 6x cycle of 500 µs
• SysLog	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V19
Installed software	
• Visualization	No
• Control	S7-1500 Software Controller CPU 1505SP F
Control elements	
Mode selector switch	1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	5 ms
Input current	
Current consumption (rated value)	1.8 A; Full processor load, incl. ET 200SP modules and using USB
Current consumption (in no-load operation), typ.	0.5 A
Current consumption, max.	2.9 A
I^2t	0.426 A^2·s; with starting current inrush
Power	
Active power input, max.	43 W; incl. ET 200SP modules and using USB
Infeed power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	16 W
Processor	
Processor type	Intel Atom E3940, 1.6 GHz, 4 cores
Memory	
Type of memory	DDR3L
Main memory	8 GB RAM
CFast memory card	Yes; 128 GB flash memory
SIMATIC memory card required	No
Work memory	
• integrated (for program)	3 Mbyte

Article number	6ES7677-2SB42-0GB1
• integrated (for data)	7.5 Mbyte
• integrated (for CPU function library of CPU Runtime)	20 Mbyte
Load memory	
• integrated (on PC mass storage)	320 Mbyte
Backup	
• with UPS	Yes; all memory areas declared retentive
• with non-volatile memory	Yes
Hardware configuration	
Integrated power supply	Yes
Number of DP masters	
• Via CM	1
Number of IO Controllers	
• via PC interfaces	1
Rack	
• Modules per rack, max.	82; CPU + 64 modules + server module (mounting width max. 1 m) + 16 ET 200AL modules
• Quantity of operable ET 200SP modules, max.	64
• Quantity of operable ET 200AL modules, max.	16
• Number of lines, max.	1
Time of day	
Clock	
• Type	Hardware clock
• Backup time	6 wk; At 40 °C ambient temperature, typically
• Deviation per day, max.	10 s; Typ.: 2 s
Interfaces	
Number of industrial Ethernet interfaces	2
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1; Via CM DP module
Number of RS 485 interfaces	1; Via CM DP module
Number of USB interfaces	4; 2x USB 2.0, 2x USB 3.0 on front side
Number of SD card slots	1
Video interfaces	
• Graphics interface	1x DisplayPort
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; Via BusAdapter BA 2x RJ45
– Transmission rate, max.	100 Mbit/s
– Industrial Ethernet status LED	Yes

Article number	6ES7677-2SB42-0GB1
• Number of ports	2
• integrated switch	Yes
2. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; Integrated
– Transmission rate, max.	1 000 Mbit/s
– Industrial Ethernet status LED	No
• Number of ports	1
3. Interface	
Interface types	
• RS 485	Yes
Interface types	
RS 485	
• Transmission rate, max.	12 Mbit/s
Interrupts/diagnostics/status information	
Diagnostics indication LED	
• RUN/STOP LED	Yes
• ERROR LED	Yes
• MAINT LED	Yes
Ambient conditions	
Ambient temperature during operation	
• min.	-20 °C
• horizontal installation, min.	-20 °C
• horizontal installation, max.	60 °C; from 55°C: with max. 32 ET 200SP modules; 4x 0.3 A USB load; CFast memory card max. 10% load; SD card not used
• vertical installation, min.	-20 °C
• vertical installation, max.	50 °C; from 45°C: with max. 32 ET 200SP modules; 4x 0.3 A USB load; CFast memory card and SD card; max. 10% load
Ambient temperature during storage/transportation	
• min.	-40 °C
• max.	70 °C
Operating systems	
pre-installed operating system	Windows 10 IoT Enterprise 2021 LTSC
Peripherals/Options	
SD card	Optionally for additional mass storage

Article number	6ES7677-2SB42-0GB1
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

14.7.3 Technical specifications of CPU 1515SP PC2 T

Technical specifications

The following table shows the technical specifications as of 02/2024. You will find a data sheet including daily updated technical specifications on the Internet (https://sieportal.siemens.com/en-ww/home). Enter the current article number of your product in the search field.

Article number	6ES7677-2VB42-0GB1
General information	
Product type designation	CPU 1515SP PC2 T
Firmware version	V30.1
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes; only with PROFINET; with minimum OB 6x cycle of 500 µs
• SysLog	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V19
Installed software	
• Visualization	No
• Control	S7-1500 Software Controller CPU 1505SP T
Control elements	
Mode selector switch	1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	5 ms

Article number	6ES7677-2VB42-0GB1
Input current	
Current consumption (rated value)	1.8 A; Full processor load, incl. ET 200SP modules and using USB
Current consumption (in no-load operation), typ.	0.5 A
Current consumption, max.	2.9 A
I^2t	0.426 A^2·s; with starting current inrush
Power	
Active power input, max.	43 W; incl. ET 200SP modules and using USB
Infeed power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	16 W
Processor	
Processor type	Intel Atom E3940, 1.6 GHz, 4 cores
Memory	
Type of memory	DDR3L
Main memory	8 GB RAM
CFast memory card	Yes; 128 GB flash memory
SIMATIC memory card required	No
Work memory	
• integrated (for program)	3 Mbyte
• integrated (for data)	7.5 Mbyte
• integrated (for CPU function library of CPU Runtime)	20 Mbyte
Load memory	
• integrated (on PC mass storage)	320 Mbyte
Backup	
• with UPS	Yes; all memory areas declared retentive
• with non-volatile memory	Yes
Hardware configuration	
Integrated power supply	Yes
Number of DP masters	
• Via CM	1
Number of IO Controllers	
• via PC interfaces	1
Rack	
• Modules per rack, max.	82; CPU + 64 modules + server module (mounting width max. 1 m) + 16 ET 200AL modules
• Quantity of operable ET 200SP modules, max.	64
• Quantity of operable ET 200AL modules, max.	16
• Number of lines, max.	1

Article number	6ES7677-2VB42-0GB1
Time of day	
Clock	
• Type	Hardware clock
• Backup time	6 wk; At 40 °C ambient temperature, typically
• Deviation per day, max.	10 s; Typ.: 2 s
Interfaces	
Number of industrial Ethernet interfaces	2
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1; Via CM DP module
Number of RS 485 interfaces	1; Via CM DP module
Number of USB interfaces	4; 2x USB 2.0, 2x USB 3.0 on front side
Number of SD card slots	1
Video interfaces	
• Graphics interface	1x DisplayPort
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; Via BusAdapter BA 2x RJ45
– Transmission rate, max.	100 Mbit/s
– Industrial Ethernet status LED	Yes
• Number of ports	2
• integrated switch	Yes
2. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; Integrated
– Transmission rate, max.	1 000 Mbit/s
– Industrial Ethernet status LED	No
• Number of ports	1
3. Interface	
Interface types	
• RS 485	Yes
Interface types	
RS 485	
• Transmission rate, max.	12 Mbit/s
Interrupts/diagnostics/status information	
Diagnostics indication LED	
• RUN/STOP LED	Yes
• ERROR LED	Yes
• MAINT LED	Yes

Article number	6ES7677-2VB42-0GB1
Ambient conditions	
Ambient temperature during operation	
• min.	-20 °C
• horizontal installation, min.	-20 °C
• horizontal installation, max.	60 °C; from 55°C: with max. 32 ET 200SP modules; 4x 0.3 A USB load; CFast memory card max. 10% load; SD card not used
• vertical installation, min.	-20 °C
• vertical installation, max.	50 °C; from 45°C: with max. 32 ET 200SP modules; 4x 0.3 A USB load; CFast memory card and SD card; max. 10% load
Ambient temperature during storage/transportation	
• min.	-40 °C
• max.	70 °C
Operating systems	
pre-installed operating system	Windows 10 IoT Enterprise 2021 LTSC
Peripherals/Options	
SD card	Optionally for additional mass storage
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

14.7.4 Technical specifications of CPU 1515SP PC2 TF

Technical specifications

The following table shows the technical specifications as of 02/2024. You will find a data sheet including daily updated technical specifications on the Internet (https://sieportal.siemens.com/en-ww/home). Enter the current article number of your product in the search field.

Article number	6ES7677-2WB42-0GB1
General information	
Product type designation	CPU 1515SP PC2 TF
Firmware version	V30.1
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes; only with PROFINET; with minimum OB 6x cycle of 500 µs

Article number	6ES7677-2WB42-0GB1
• SysLog	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V19
Installed software	
• Visualization	No
• Control	S7-1500 Software Controller CPU 1505SP TF
Control elements	
Mode selector switch	1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	5 ms
Input current	
Current consumption (rated value)	1.8 A; Full processor load, incl. ET 200SP modules and using USB
Current consumption (in no-load operation), typ.	0.5 A
Current consumption, max.	2.9 A
I^2t	0.426 $A^2 \cdot s$; with starting current inrush
Power	
Active power input, max.	43 W; incl. ET 200SP modules and using USB
Infeed power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	16 W
Processor	
Processor type	Intel Atom E3940, 1.6 GHz, 4 cores
Memory	
Type of memory	DDR3L
Main memory	8 GB RAM
CFast memory card	Yes; 128 GB flash memory
SIMATIC memory card required	No
Work memory	
• integrated (for program)	3 Mbyte
• integrated (for data)	7.5 Mbyte
• integrated (for CPU function library of CPU Runtime)	20 Mbyte
Load memory	
• integrated (on PC mass storage)	320 Mbyte

Article number	6ES7677-2WB42-0GB1
Backup	
• with UPS	Yes; all memory areas declared retentive
• with non-volatile memory	Yes
Hardware configuration	
Integrated power supply	Yes
Number of DP masters	
• Via CM	1
Number of IO Controllers	
• via PC interfaces	1
Rack	
• Modules per rack, max.	82; CPU + 64 modules + server module (mounting width max. 1 m) + 16 ET 200AL modules
• Quantity of operable ET 200SP modules, max.	64
• Quantity of operable ET 200AL modules, max.	16
• Number of lines, max.	1
Time of day	
Clock	
• Type	Hardware clock
• Backup time	6 wk; At 40 °C ambient temperature, typically
• Deviation per day, max.	10 s; Typ.: 2 s
Interfaces	
Number of industrial Ethernet interfaces	2
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1; Via CM DP module
Number of RS 485 interfaces	1; Via CM DP module
Number of USB interfaces	4; 2x USB 2.0, 2x USB 3.0 on front side
Number of SD card slots	1
Video interfaces	
• Graphics interface	1x DisplayPort
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; Via BusAdapter BA 2x RJ45
– Transmission rate, max.	100 Mbit/s
– Industrial Ethernet status LED	Yes
• Number of ports	2
• integrated switch	Yes

Article number	6ES7677-2WB42-0GB1
2. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; Integrated
– Transmission rate, max.	1 000 Mbit/s
– Industrial Ethernet status LED	No
• Number of ports	1
3. Interface	
Interface types	
• RS 485	Yes
Interface types	
RS 485	
• Transmission rate, max.	12 Mbit/s
Interrupts/diagnostics/status information	
Diagnostics indication LED	
• RUN/STOP LED	Yes
• ERROR LED	Yes
• MAINT LED	Yes
Ambient conditions	
Ambient temperature during operation	
• min.	-20 °C
• horizontal installation, min.	-20 °C
• horizontal installation, max.	60 °C; from 55°C: with max. 32 ET 200SP modules; 4x 0.3 A USB load; CFast memory card max. 10% load; SD card not used
• vertical installation, min.	-20 °C
• vertical installation, max.	50 °C; from 45°C: with max. 32 ET 200SP modules; 4x 0.3 A USB load; CFast memory card and SD card; max. 10% load
Ambient temperature during storage/transportation	
• min.	-40 °C
• max.	70 °C
Operating systems	
pre-installed operating system	Windows 10 Enterprise 2021 LTSC
Peripherals/Options	
SD card	Optionally for additional mass storage
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

14.7.5 Technical specifications CPU 1515SP PC2 - IndOS

Technical specifications

The following table shows the technical specifications as of 02/2024. You will find a data sheet including daily updated technical specifications on the Internet (https://sieportal.siemens.com/en-ww/home). Enter the current article number of your product in the search field.

Article number	6ES7677-2DB43-0GB1
General information	
Product type designation	CPU1515SP PC2 - IndOS
Firmware version	V30.1
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes; only with PROFINET; with minimum OB 6x cycle of 500 µs
• SysLog	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V19
Installed software	
• Visualization	No
• Control	S7-1500 Software Controller CPU 1505SP
Control elements	
Mode selector switch	1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	5 ms
Input current	
Current consumption (rated value)	1.8 A; Full processor load, incl. ET 200SP modules and using USB
Current consumption (in no-load operation), typ.	0.5 A
Current consumption, max.	2.9 A
I^2t	0.426 $A^2 \cdot s$; with starting current inrush
Power	
Active power input, max.	43 W; incl. ET 200SP modules and using USB
Infeed power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	16 W

Article number	6ES7677-2DB43-0GB1
Processor	
Processor type	Intel Atom E3940, 1.6 GHz, 4 cores
Memory	
Type of memory	DDR3L
Main memory	8 GB RAM
CFast memory card	Yes; 128 GB flash memory
SIMATIC memory card required	No
Work memory	
• integrated (for program)	2 Mbyte
• integrated (for data)	7.5 Mbyte
• integrated (for CPU function library of CPU Runtime)	20 Mbyte
Load memory	
• integrated (on PC mass storage)	320 Mbyte
Backup	
• with UPS	Yes; all memory areas declared retentive
• with non-volatile memory	Yes
Hardware configuration	
Integrated power supply	Yes
Number of DP masters	
• Via CM	1
Number of IO Controllers	
• via PC interfaces	1
Rack	
• Modules per rack, max.	82; CPU + 64 modules + server module (mounting width max. 1 m) + 16 ET 200AL modules
• Quantity of operable ET 200SP modules, max.	64
• Quantity of operable ET 200AL modules, max.	16
• Number of lines, max.	1
Time of day	
Clock	
• Type	Hardware clock
• Backup time	6 wk; At 40 °C ambient temperature, typically
• Deviation per day, max.	10 s; Typ.: 2 s
Interfaces	
Number of industrial Ethernet interfaces	2
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1; Via CM DP module
Number of RS 485 interfaces	1; Via CM DP module
Number of USB interfaces	4; 2x USB 2.0, 2x USB 3.0 on front side

Article number	6ES7677-2DB43-0GB1
Number of SD card slots	1
Video interfaces	
• Graphics interface	1x DisplayPort
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; Via BusAdapter BA 2x RJ45
– Transmission rate, max.	100 Mbit/s
– Industrial Ethernet status LED	Yes
• Number of ports	2
• integrated switch	Yes
2. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; Integrated
– Transmission rate, max.	1 000 Mbit/s
– Industrial Ethernet status LED	No
• Number of ports	1
3. Interface	
Interface types	
• RS 485	Yes
Interface types	
RS 485	
• Transmission rate, max.	12 Mbit/s
Interrupts/diagnostics/status information	
Diagnostics indication LED	
• RUN/STOP LED	Yes
• ERROR LED	Yes
• MAINT LED	Yes
Ambient conditions	
Ambient temperature during operation	
• min.	-20 °C
• horizontal installation, min.	-20 °C
• horizontal installation, max.	60 °C; from 55°C: with max. 32 ET 200SP modules; 4x 0.3 A USB load; CFast memory card max. 10% load; SD card not used
• vertical installation, min.	-20 °C
• vertical installation, max.	50 °C; from 45°C: with max. 32 ET 200SP modules; 4x 0.3 A USB load; CFast memory card and SD card; max. 10% load
Ambient temperature during storage/transportation	
• min.	-40 °C

Article number	6ES7677-2DB43-0GB1
• max.	70 °C
Operating systems	
pre-installed operating system	SIMATIC Industrial OS
Peripherals/Options	
SD card	Optionally for additional mass storage
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

14.7.6 Technical specifications of CPU 1515SP PC2 F -IndOS

Technical specifications

The following table shows the technical specifications as of 02/2024. You will find a data sheet including daily updated technical specifications on the Internet (https://sieportal.siemens.com/en-ww/home). Enter the current article number of your product in the search field.

Article number	6ES7677-2SB43-0GB1
General information	
Product type designation	CPU1515SP PC2 F - IndOS
Firmware version	V30.1
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes; only with PROFINET; with minimum OB 6x cycle of 500 µs
• SysLog	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V19
Installed software	
• Visualization	No
• Control	S7-1500 Software Controller CPU 1505SP F
Control elements	
Mode selector switch	1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes

Article number	6ES7677-2SB43-0GB1
Mains buffering	
• Mains/voltage failure stored energy time	5 ms
Input current	
Current consumption (rated value)	1.8 A; Full processor load, incl. ET 200SP modules and using USB
Current consumption (in no-load operation), typ.	0.5 A
Current consumption, max.	2.9 A
I^2t	0.426 A^2·s; with starting current inrush
Power	
Active power input, max.	43 W; incl. ET 200SP modules and using USB
Infeed power to the backplane bus	8.75 W
Power loss	
Power loss, typ.	16 W
Processor	
Processor type	Intel Atom E3940, 1.6 GHz, 4 cores
Memory	
Type of memory	DDR3L
Main memory	8 GB RAM
CFast memory card	Yes; 128 GB flash memory
SIMATIC memory card required	No
Work memory	
• integrated (for program)	3 Mbyte
• integrated (for data)	7.5 Mbyte
• integrated (for CPU function library of CPU Runtime)	20 Mbyte
Load memory	
• integrated (on PC mass storage)	320 Mbyte
Backup	
• with UPS	Yes; all memory areas declared retentive
• with non-volatile memory	Yes
Hardware configuration	
Integrated power supply	Yes
Number of DP masters	
• Via CM	1
Number of IO Controllers	
• via PC interfaces	1
Rack	
• Modules per rack, max.	82; CPU + 64 modules + server module (mounting width max. 1 m) + 16 ET 200AL modules
• Quantity of operable ET 200SP modules, max.	64

Article number	6ES7677-2SB43-0GB1
• Quantity of operable ET 200AL modules, max.	16
• Number of lines, max.	1
Time of day	
Clock	
• Type	Hardware clock
• Backup time	6 wk; At 40 °C ambient temperature, typically
• Deviation per day, max.	10 s; Typ.: 2 s
Interfaces	
Number of industrial Ethernet interfaces	2
Number of PROFINET interfaces	1
Number of PROFIBUS interfaces	1; Via CM DP module
Number of RS 485 interfaces	1; Via CM DP module
Number of USB interfaces	4; 2x USB 2.0, 2x USB 3.0 on front side
Number of SD card slots	1
Video interfaces	
• Graphics interface	1x DisplayPort
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; Via BusAdapter BA 2x RJ45
– Transmission rate, max.	100 Mbit/s
– Industrial Ethernet status LED	Yes
• Number of ports	2
• integrated switch	Yes
2. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; Integrated
– Transmission rate, max.	1 000 Mbit/s
– Industrial Ethernet status LED	No
• Number of ports	1
3. Interface	
Interface types	
• RS 485	Yes
Interface types	
RS 485	
• Transmission rate, max.	12 Mbit/s

Article number	6ES7677-2SB43-0GB1
Interrupts/diagnostics/status information	
Diagnostics indication LED	
• RUN/STOP LED	Yes
• ERROR LED	Yes
• MAINT LED	Yes
Ambient conditions	
Ambient temperature during operation	
• min.	-20 °C
• horizontal installation, min.	-20 °C
• horizontal installation, max.	60 °C; from 55°C: with max. 32 ET 200SP modules; 4x 0.3 A USB load; CFast memory card max. 10% load; SD card not used
• vertical installation, min.	-20 °C
• vertical installation, max.	50 °C; from 45°C: with max. 32 ET 200SP modules; 4x 0.3 A USB load; CFast memory card and SD card; max. 10% load
Ambient temperature during storage/transportation	
• min.	-40 °C
• max.	70 °C
Operating systems	
pre-installed operating system	SIMATIC Industrial OS
Peripherals/Options	
SD card	Optionally for additional mass storage
Dimensions	
Width	160 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	0.83 kg

14.7.7 S7-1500 Software Controller CPU 1505SP (F/T/TF)

The CPU 1505SP (F/T/TF) is a PC-based controller of the SIMATIC S7-1500 Software Controller family.

You can find additional information about the CPU 1505SP (F/T/TF) in the relevant manual (https://support.industry.siemens.com/cs/ww/en/view/109825803).

You can find additional information about the CPU 1505SP (F/T/TF) with the operating system SIMATIC Industrial OS in the relevant manual (https://support.industry.siemens.com/cs/ww/en/view/109808199).

For the CPU 1505SP (F/T/TF), please also note the information in the F product information (https://support.industry.siemens.com/cs/ww/en/view/109478599).

Technical specifications

You can find all technical specifications for the CPU 1505SP (F/T/TF) on the Internet. Enter the current article number of your product in the search field.

Dimension drawings

15

15.1 CPU 1515SP PC2

This section contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets.

Dimension drawings of the CPU 1515SP PC2

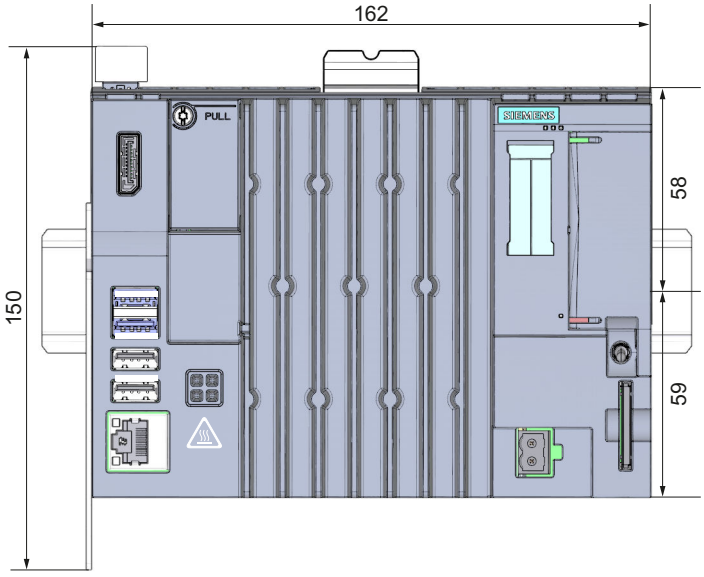

Figure 2-70 Dimension drawing CPU 1515SP PC2, front view

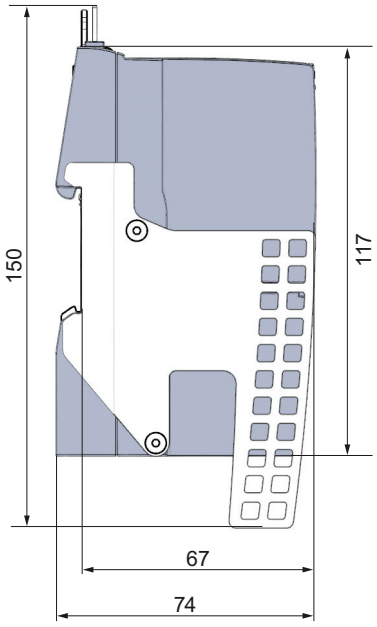

Figure 2-71 Dimension drawing CPU 1515SP PC2, side view

Spare parts/accessories 16

16.1 Accessories/spare parts

Accessories for CPU 1515SP PC2

Table 2-59 Accessories for CPU 1515SP PC2

Description	Article number
BusAdapter/media converter; 1 unit	
• BA 2×FC (PROFINET BusAdapter with FastConnect Ethernet connection)	6ES7193-6AF00-0AA0
• BA 2xLC (BusAdapter 2x LC glass fiber-optic connectors, for PROFINET)	6ES7193-6AG00-0AA0
• BA LC/RJ45 (media converter glass fiber-optic/CU 1x LC FO connector 1x RJ45 connector for PROFINET)	6ES7193-6AG20-0AA0
• BA LC/FC (media converter glass fiber-optic/CU 1x LC FO connector and 1x FastConnect (FC) connector for PROFINET)	6ES7193-6AG40-0AA0
• BA 2xSCRJ (BusAdapter 2 SCRJ FO connectors, for PROFINET)	6ES7193-6AP00-0AA0
• BA SCRJ/RJ45 (media converter fiber-optic CU 1x SCRJ FO connector and 1x RJ45 connector for PROFINET)	6ES7193-6AP20-0AA0
• BA SCRJ/FC (media converter fiber-optic CU 1x SCRJ FO connector and 1x FastConnect (FC) connector for PROFINET)	6ES7193-6AP40-0AA0
• BA 2×RJ45 (PROFINET BusAdapter with standard Ethernet socket)	6ES7193-6AR00-0AA0
• BA-Send 1xFC (1x FastConnect connector for ET-Connection)	6ES7193-6AS00-0AA0
• BA 2xM12 (2 x M12 push-pull sockets, D coding, also suitable for M12 standard, for PROFINET)	6ES7193-6AM00-0AA0
Server module; 1 unit	6ES7193-6PA00-0AA0
Strain relief for CPU 1515SP PC2	A5E32291462
SIMATIC IPC Service USB flash drive 8 GB (SLC), pre-installed BIOS-MANAGER V3.3, Image/Partition Creator V3.3 and installation CD	6AV7672-8JD01-0AA0
SIMATIC IPC Service USB flash drive 16 GB, USB3.0, pre-installed BIOS-MANAGER V3.3, Image/Partition Creator V3.4 and installation CD	6AV7672-8JD02-0AA0
SIMATIC IPC DiagMonitor software	6ES7648-6CA05-0YX0
SIMATIC IPC accessories DisplayPort cable, length: 3 m	6AV7860-0DH30-0AA0
SIMATIC IPC accessories DisplayPort cable, length: 5 m	6AV7860-0DH50-0AA0
DisplayPort cable, length: 5 m, E74020-C AWM Style 20276, 80°C, 30 V, VW-1 (with integrated ferrite cores at both ends)	-
SIMATIC PC, DisplayPort according to DVI-I for onboard graphics	6ES7648-3AF00-0XA0
Reference identification label, sheet with 16 labels, 10 units	6ES7193-6LF30-0AW0
Mounting rails, tin-plated steel strip	
• Length: 483 mm	6ES5710-8MA11

Description	Article number
• Length: 430 mm	6ES5710-8MA21
• Length: 830 mm	6ES5710-8MA31
• Length: 2000 mm	6ES5710-8MA41

Online catalog

Additional article numbers can be found on the Internet in the online catalog and online ordering system (https://mall.industry.siemens.com).

Appendix A

A.1 Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.
- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.
- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.
- **Forums**

  For answers and solutions concerning automation technology.
- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (https://support.industry.siemens.com/cs/de/en/).

A.2 Troubleshooting

Problem	Possible cause	Remedy
CPU 1515SP PC2 does not work.	CPU 1515SP PC2 is not supplied with power.	Check the power supply.
Time and/or date of the CPU 1515SP PC2 not correct.	CPU 1515SP PC2 was not connected for more than 6 weeks.	Check the settings in Windows.
USB device is not working.	USB power supply is overloaded.	Use an external power supply for the USB device (see section Application planning (Page 37)).

List of abbreviations

B

B.1 Abbreviations

Abbreviation	Term	Meaning
AC	Alternating current	Alternating current
ALM	Automation License Manager	Tool for managing license keys in STEP 7
BIOS	Basic Input Output System	Basic Input Output System. A set of important software routines used after the startup of the CPU to load the operating system and to provide the routines for data exchange between hardware components.
CE	Communauté Européenne	CE label
CFast	CompactFlash ATA Serial Transfer	Memory card
CoA	Certificate of Authenticity	Certificate of Authenticity, label with Microsoft Windows "Product Key"
CoL	Certificate of License	Certificate of License for the SIMATIC software loaded
DC	Direct current	DC current
DPP	Dual-mode DisplayPort	Interface for transfer of image and video data for monitors
ESD	Components sensitive to electrostatic charge	
EN	European standard	
GbE	Gigabit Ethernet	
GRUB / GRUB2DOS	GRand Unified Bootloader	Boot Manager
HMI	Human Machine Interface	User interface
IEC	International Electrotechnical Commission	
IM	Interface module	The interface module connects the ET 200SP distributed I/O system with the IO controller and exchanges data with the I/O modules via the backplane bus.
LAN	Local Area Network	Computer network that is limited to a local area.
LED	Light Emitting Diode	Light emitting diode
LLDP	Link Layer Discovery Protocol	Protocol that enables the exchange of information between adjacent devices.
MMC	Multi Media Card	Memory card
NTFS	New Technology File System	File system that offers targeted access protection at the file level.
NVRAM	Non-Volatile Random-Access Memory	Non-volatile data memory that is RAM-based, the data content of which is retained without external power supply.
PC	Personal computer	
PELV	Protective Extra Low Voltage	PELV, previously called "extra low voltage with safe isolation", is a protective measure against electrical shock. See EN 50178.

Abbreviation	Term	Meaning
PN	PROFINET	
PG	Programming device	Compact programming device which meets the special requirements of industry. The PG is fully equipped for programming SIMATIC PLCs.
PS	Power supply	Power supply
PT	Power Tags	Process tags; tags enable data exchange between the components of an automation process, for example, between the HMI device and the controller.
RAM	Random Access Memory	Main or work memory of a computer with direct access, allowing read access to data and editing.
RT	Runtime	
SD	Secure Digital card	Memory card
SELV	Safety Extra Low Voltage	Safety Extra Low Voltage; electrical circuit in which the voltage cannot exceed 30 V AC (RMS), 42.4 V AC peak or 60 V DC under NORMAL CONDITIONS and CONDITIONS OF A SINGLE FAULT, including ground faults in other circuits.
UL	Underwriters Laboratories Inc.	
UWF	Unified Write Filter	Configurable write protection under Windows 10, for protection of data storage media (for example, CFast card, internal USB drives, etc.) seeData loss in the event of unexpected shutdown (Page 61)
USB	Universal Serial Bus	Serial bus system for connecting a computer to external devices.

SIEMENS

SIMATIC
S7-1200/S7-1500
F-CPUs
Product Information

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under https://www.siemens.com/cert.

Content

Introduction

This Product Information contains important information on the F-CPUs specified in the section "Scope of validity". The Product Information is part of the product supplied. The information in this Product Information should be considered more up-to-date than other documentation if uncertainties arise.

Scope of validity

The statements in this Product Information apply to the F-CPUs listed below:

S7-1200 F-CPUs	
S7-1200 F-CPUs G1	**S7-1200 F-CPUs G2**
• CPU 1212FC DC/DC/DC • CPU 1212FC DC/DC/Rly • CPU 1214FC DC/DC/DC • CPU 1214FC DC/DC/Rly • CPU 1215FC DC/DC/DC • CPU 1215FC DC/DC/Rly	• CPU 1212FC DC/DC/DC • CPU 1212FC DC/DC/Rly • CPU 1214FC DC/DC/DC • CPU 1214FC DC/DC/Rly

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S7-1500 F-CPUs		
• CPU 1511(T)F-1 PN • CPU 1511VF-1 PN • CPU 1513F-1 PN • CPU 1515(T)F-2 PN • CPU 1516TF-3 PN • CPU 1516(T)F-3 PN/DP • CPU 1517(T)F-3 PN • CPU 1517(T)F-3 PN/DP • CPU 1517VF-1 PN • CPU 1518(T)F-3 PN • CPU 1518(T)F-4 PN/DP (MFP/ODK) • CPU 1518HF-4 PN	• CPU 1510SP F-1 PN • CPU 1512SP F-1 PN • CPU 1514SP (T)F-2 PN • CPU 1513proF-2 PN • CPU 1516proF-2 PN	S7-1500 F-Software Controller • CPU 1505SP (T)F • CPU 1507S F • CPU 1508S (T)F

Areas of application

Main areas of application of the S7-1200/1500 F-CPUs are personal and machine safety and burner controls. In addition to the safety program, you can also program standard applications.

You can operate the S7-1200/1500 F-CPUs in safety or standard mode. In standard mode, S7-1200/1500 F-CPUs behave like standard S7-1200/1500 CPUs.

For S7-1500 F-CPUs, an installed license for *STEP 7 Safety* is required for safety mode. Without an installed license for *STEP 7 Safety*, you can use the S7-1500 F-CPUs in standard mode.

An installed license for *STEP 7 Safety* is not required for S7-1200 F-CPUs for safety mode.

Additional information on using the S7-1200/1500 F-CPUs in safety mode is available in the programming and operating manual "SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)".

Information on using the S7-1200 F-CPUs in standard mode is available in the relevant system manuals for the S7-1200 standard CPUs at the following links:

- CPUs 121x G1 (https://support.industry.siemens.com/cs/ww/en/view/109772940)
- CPUs 121x G2 (https://support.industry.siemens.com/cs/ww/en/ps/30069/man)

Additional information on using the S7-1500 F-CPUs in standard mode is available in the relevant manuals for the S7-1500 and the standard-T-CPUs S7-1500 at the following links:

- CPUs 151x (http://support.automation.siemens.com/WW/view/en/67295862/133300)
- CPU 1518HF-4 PN (https://support.industry.siemens.com/cs/ww/en/view/109784207)
- CPUs 151xT (https://support.industry.siemens.com/cs/ww/en/ps/22057/man)
- CPUs 151xSP (http://support.automation.siemens.com/WW/view/en/90466439/133300)
- CPU 151xpro-2 PN (https://support.industry.siemens.com/cs/ww/en/ps/13906/man)
- CPU 151xV-1 PN (https://support.industry.siemens.com/cs/ww/en/view/109996319)
- S7-1500 Software Controller (https://support.industry.siemens.com/cs/ww/en/ps/13911/man)

You can find the latest firmware for the relevant F-CPU by searching for downloads with the respective article number in the Industry Online Support (https://support.industry.siemens.com).

NOTE

Observe any application-specific requirements, for example on mains buffering for power supplies/power packs.

PFD_{avg} and PFH values for F-CPUs

Below are the probability of failure on demand values (PFD_{avg}, PFH values) for the above-named F-CPUs with a mission time of 20 years and an MTTR of 100 hours:

Low demand mode **low demand mode** **According to IEC 61508:2010:** **PFD_{avg} = Average probability of dangerous failure on demand**	**High demand or continuous mode** **high demand/continuous mode** **According to IEC 61508:2010:** **PFH = Average frequency of a dangerous failure [h^{-1}]**
< 2E-05	< 1E-09 up to an operational altitude of 3 000 m or < 2E-09 at an operating altitude greater than 3 000 m up to 5 000 m

S7-1200/1500 F-CPUs for permissible ambient temperature and max. permissible installation height and work memory as compared to the standard CPUs

CPU	Article number	Ambient temperature		Installation altitude		Work memory (Std.-/F-CPU)
		Temperature range [°C]	From revision level	Max. altitude [m]	From revision level	
S7-1200 F G1						
CPU 1212FC DC/DC/DC	6ES7212-1AF40-0XB0	0 to +55	FS 05	5 000	FS 10	100 KB/150 KB
CPU 1212FC DC/DC/RLY	6ES7212-1HF40-0XB0	0 to +55	FS 05	2 000	FS 05	100 KB/150 KB
CPU 1214FC DC/DC/DC	6ES7214-1AF40-0XB0	0 to +55	FS 01	5 000	FS 10	150 KB/200 KB
CPU 1214FC DC/DC/RLY	6ES7214-1HF40-0XB0	0 to +55	FS 01	2 000	FS 01	150 KB/200 KB
CPU 1215FC DC/DC/DC	6ES7215-1AF40-0XB0	0 to +55	FS 01	5 000	FS 10	200 KB/250 KB
CPU 1215FC DC/DC/RLY	6ES7215-1HF40-0XB0	0 to +55	FS 01	2 000	FS 01	200 KB/250 KB
S7-1200 F G2						
CPU 1212FC DC/DC/DC	6ES7212-1AF50-0XB0	0 to +55	FS 01	5 000	FS 01	150 KB/200 KB
CPU 1212FC DC/DC/RLY	6ES7212-1HF50-0XB0	0 to +55	FS 01	2 000	FS 01	150 KB/200 KB
CPU 1214FC DC/DC/DC	6ES7214-1AF50-0XB0	0 to +55	FS 01	5 000	FS 01	250 KB/300 KB
CPU 1214FC DC/DC/RLY	6ES7214-1HF50-0XB0	0 to +55	FS 01	2 000	FS 01	250 KB/300 KB
S7-1500 F						
CPU 1510SP F-1 PN	6ES7510-1SJ01-0AB0	-25 to +60	FS 01	5 000	FS 03	100 KB/150 KB
CPU 1510SP F-1 PN	6ES7510-1SK03-0AB0	-30 to +60	FS 01	5 000	FS 01	200 KB/300 KB
CPU 1512SP F-1 PN	6ES7512-1SK01-0AB0	-25 to +60	FS 01	5 000	FS 03	200 KB/300 KB
CPU 1512SP F-1 PN	6ES7512-1SM03-0AB0	-30 to +60	FS 01	5 000	FS 01	400 KB/600 KB
CPU 1514SP F-2 PN	6ES7514-2SN03-0AB0	-30 to +60	FS 01	5 000	FS 01	600 KB/900 KB
CPU 1514SP TF-2 PN	6ES7514-2WN03-0AB0	-30 to +60	FS 01	5 000	FS 01	900 KB/900 KB
CPU 1511F-1 PN	6ES7511-1FK01-0AB0	0 to +60	FS 01	5 000	FS 03	150 KB/225 KB
CPU 1511F-1 PN	6ES7511-1FK02-0AB0	-25 to +60	FS 01	5 000	FS 01	150 KB/225 KB
CPU 1511F-1 PN	6ES7511-1FL03-0AB0	-30 to +60	FS 01	5 000	FS 01	300 KB/450 KB
CPU 1511TF-1 PN	6ES7511-1UK01-0AB0	0 to +60	FS 03	5 000	FS 03	225 KB/225 KB

* with condensation

CPU	Article number	Ambient temperature		Installation altitude		Work memory (Std.-/F-CPU)
		Temperature range [°C]	From revision level	Max. altitude [m]	From revision level	
CPU 1511TF-1 PN	6ES7511-1UL03-0AB0	-30 to +60	FS 01	5 000	FS 01	450 KB/450 KB
CPU 1513F-1 PN	6ES7513-1FL01-0AB0	0 to +60	FS 01	5 000	FS 03	300 KB/450 KB
CPU 1513F-1 PN	6ES7513-1FL02-0AB0	-25 to +60	FS 01	5 000	FS 01	300 KB/450 KB
CPU 1513F-1 PN	6ES7513-1FM03-0AB0	-30 to +60	FS 01	5 000	FS 01	600 KB/900 KB
CPU 1515F-2 PN	6ES7515-2FM01-0AB0	0 to +60	FS 01	5 000	FS 03	500 KB/750 KB
CPU 1515F-2 PN	6ES7515-2FM02-0AB0	-25 to +60	FS 01	5 000	FS 01	500 KB/750 KB
CPU 1515F-2 PN	6ES7515-2FN03-0AB0	-30 to +60	FS 01	5 000	FS 01	1 MB/1.5 MB
CPU 1515TF-2 PN	6ES7515-2UM01-0AB0	0 to +60	FS 03	5 000	FS 03	750 KB/750 KB
CPU 1515TF-2 PN	6ES7515-2UN03-0AB0	-30 to +60	FS 01	5 000	FS 01	1.5 MB/1.5 MB
CPU 1516F-3 PN/DP	6ES7516-3FN01-0AB0	0 to +60	FS 01	5 000	FS 03	1 MB/1.5 MB
CPU 1516F-3 PN/DP	6ES7516-3FN02-0AB0	-25 to +60	FS 01	5 000	FS 01	1 MB/1.5 MB
CPU 1516F-3 PN/DP	6ES7516-3FP03-0AB0	-30 to +60	FS 01	5 000	FS 01	2 MB/3 MB
CPU 1513proF-2 PN*	6ES7513-2GL00-0AB0	-25 to +55	FS 01	5 000	FS 01	300 KB/450 KB
CPU 1516proF-2 PN*	6ES7516-2GN00-0AB0	-25 to +55	FS 01	5 000	FS 02	1 MB/1.5 MB
CPU 1513proF-2 PN*	6ES7513-2GM03-0AB0	-25 to +55	FS 01	5 000	FS 01	600 KB/900 KB
CPU 1516proF-2 PN*	6ES7516-2GP03-0AB0	-25 to +55	FS 01	5 000	FS 01	2 MB/3 MB
CPU 1516TF-3 PN/DP	6ES7516-3UN00-0AB0	0 to +60	FS 05	5 000	FS 05	3 MB/3 MB
CPU 1516TF-3 PN	6ES7 516-3UP10-0AB0	0 to +60	FS 01	5 000	FS 01	3 MB/3 MB
CPU 1517F-3 PN/DP	6ES7517-3FP00-0AB0	0 to +60	FS 01	5 000	FS 05	2 MB/3 MB
CPU 1517F-3 PN/DP	6ES7517-3FP01-0AB0	0 to +60	FS 01	5 000	FS 01	2 MB/3 MB
CPU 1517F-3 PN	6ES7 517-3FQ10-0AB0	0 to +60	FS 01	5 000	FS 01	4 MB/6 MB
CPU 1517TF-3 PN/DP	6ES7517-3UP00-0AB0	0 to +60	FS 04	5 000	FS 05	3 MB/3 MB
CPU 1517TF-3 PN	6ES7 517-3UQ10-0AB0	0 to +60	FS 01	5 000	FS 01	6 MB/6 MB
CPU 1518F-4 PN/DP	6ES7518-4FP00-0AB0	0 to +60	FS 01	5 000	FS 05	6 MB/9 MB
CPU 1518F-3 PN	6ES7 518-3FT10-0AB0	0 to +60	FS 01	5 000	FS 01	12 MB/18 MB
CPU 1518F-4 PN/DP ODK	6ES7518-4FP00-3AB0	0 to +60	FS 04	5 000	FS 05	6 MB/9 MB
CPU 1518F-4 PN/DP MFP	6ES7518-4FX00-1AB0	0 to +60	FS 01	5 000	FS 01	6 MB/9 MB
CPU 1518HF-4 PN	6ES7518-4JP00-0AB0	0 to +60	FS 01	5 000	FS 01	-- /9 MB
CPU 1518HF-4 PN	6ES7 518-4JT10-0AB0	0 to +60	FS 01	5 000	FS 01	-- /18 MB
CPU 1518TF-4 PN/DP	6ES7518-4UP00-0AB0	0 to +60	FS 10	5 000	FS 10	9 MB/9 MB
CPU 1518TF-3 PN	6ES7 518-3UT10-0AB0	0 to +60	FS 01	5 000	FS 01	18 MB/18 MB

* with condensation

NOTE

Operation of an (F-)CPU is permitted only up to 100% of the indicated CPU work memory in the TIA Portal.

Restrictions on the maximum specified ambient air temperature with reference to the installation altitude

Installation altitude	Derating factor for ambient air temperature [1]
-1 000 to 2 000 m	1.0
2 000 to 3 000 m	0.9
3 000 to 4 000 m	0.8
4 000 to 5 000 m	0.7

[1] The basic value for the application of the derating factor is the maximum permissible ambient temperature in °C for 2 000 m

NOTE

- Linear interpolation between altitudes is permissible.
- The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.
- Pay attention to the mounting position of the respective module in the technical data. Based on the IEC 61131-2 standard.
- Ensure that the power supply units used are also adequate for altitudes > 2 000 m.
- The displays of the S7-1500 CPUs are designed for an altitude of ≤ 3 000 m. If used at > 3 000 m, in rare cases, there can be problems in the representation of the CPU display; however, these do not have an effect on the functional safety of the F-CPU.
- The "Safety-oriented tripping of standard modules" function, as described on the SIEMENS Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/39198632) pages, is only approved up to max. 2 000 m.

Effects on the availability

The higher cosmic radiation present during operation at altitudes above 2 000 m will also start to have an effect on the failure rate of electronic components (the so-called soft error rate). In rare cases, this can result in a transition of the F-CPU into the safe state. However, the functional safety of the F-CPU is fully retained.

Currently valid markings and approvals

NOTE

Information on the components of the S7-1200/S7-1500

The currently valid markings and approvals are printed on the components of the S7-1500.

The F-CPUs are certified for use in safety mode up to 3 000 m or 5 000 m. All other markings and approvals are currently based on a height of up to 2 000 m.

Shipping and storage conditions

The S7-1200/S7-1500 fulfills the requirements according to IEC 61131-2 with regard to the shipping and storage conditions. The following information applies to modules shipped or stored in their original packaging.

Type of condition	Permissible range
Air pressure	from 1 140 to 540 hPa (corresponds to an altitude of -1 000 m to 5 000 m)

Equipment manual for CPU 1517F-3 PN/DP (6ES7517-3FP01-0AB0)

You can find the technical specifications in the equipment manual for the CPU 1517-3 PN/DP (6ES7517-3AP00-0AB0) (https://support.industry.siemens.com/cs/ww/en/view/90471765).
The following values differ with the CPU 1517F-3 PN/DP (6ES7517-3FP01-0AB0):

- Current consumption (nominal value) is 1.7 A
- The current consumption (max.) and inrush current (max.) amounts to 2.2 A
- I^2t is 0.5 A^2s
- The power loss is 29 W

Overview of the behavior of the F-CPUs regarding communication network disconnectors according to IEC 61784-3-3 (PROFIsafe standard)

F-CPU	Network disconnector according to IEC 61784-3-3	Remark
S7-1200 G1	• Network disconnection between Ethernet X1 and CP/CM on the backplane bus.	See [1] and [2]
CPU 1212FC DC/DC/DC CPU 1212FC DC/DC/Rly		
CPU 1214FC DC/DC/DC CPU 1214FC DC/DC/Rly		
CPU 1215FC DC/DC/DC CPU 1215FC DC/DC/Rly		
S7-1200 G2	• Network disconnection between Ethernet X1 and CP/CM on the backplane bus.	See [1] and [2]
CPU 1212FC DC/DC/DC CPU 1212FC DC/DC/Rly		
CPU 1214FC DC/DC/DC CPU 1214FC DC/DC/Rly		

[1] Absolute network disconnector between socket A and B:

a) If A and B belong to different local Ethernet interfaces (for example, X1 and X2) and no bridging is implemented at communication level 2 for these interfaces.

a) If either A or B are part of a local Ethernet interface and the other is part of a backplane bus module with an Ethernet interface (CP, CM), and no bridging is implemented at communication level 2 for these interfaces.

[2] No network disconnector between socket A and B:

a) If A and B belong to the same local Ethernet interface (for example, X1).

b) If A and B both belong to a backplane bus module (CP, CM).

[3] As of firmware V3.0, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

[4] As of firmware V3.1, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

[5] As of firmware V4.0, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

[6] With firmware higher than V40.0.0 with configured CP1625-2 (in TIA Portal and Resource Configurator), the F-CPU is only a network disconnector between the two interfaces of the CP1625-2 if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

S7-1500	• Network disconnection between Ethernet X1 and CP/CM on the backplane bus.	See [1] and [2]
CPU 1511(T)F-1 PN		
CPU 1513F-1 PN		
CPU 1510SP F-1 PN		
CPU 1512SP F-1 PN		
CPU 1514SP (T)F-2 PN [3]	• Network disconnection between Ethernet X1 and X2. • Network disconnection between Ethernet X1 and CP/CM on the backplane bus. • Network disconnection between Ethernet X2 and CP/CM on the backplane bus.	
CPU 1515(T)F-2 PN [3]		
CPU 1516F-3 PN/DP [3]		
CPU 1516TF-3 PN/DP		
CPU 1517(T)F-3 PN/DP		
CPU 1513proF-2 PN [4]		
CPU 1516proF-2 PN [4]		
CPU 1516TF-3 PN [5] CPU 1517(T)F-3 PN [5] CPU 1518(T)F-3 PN [5] CPU 1518(T)F-4 PN/DP (ODK) CPU 1518HF-4 PN [5]	• Network disconnection between Ethernet X1, X2 and X3. • Network disconnection between Ethernet X1 and CP/CM on the backplane bus. • Network disconnection between Ethernet X2 and CP/CM on the backplane bus. • Network disconnection between Ethernet X3 and CP/CM on the backplane bus.	
CPU 1511VF-1 PN CPU 1517VF-1 PN	**No**	-
CPU 1518F-4 PN/DP MFP		

1 Absolute network disconnector between socket A and B:

a) If A and B belong to different local Ethernet interfaces (for example, X1 and X2) and no bridging is implemented at communication level 2 for these interfaces.

a) If either A or B are part of a local Ethernet interface and the other is part of a backplane bus module with an Ethernet interface (CP, CM), and no bridging is implemented at communication level 2 for these interfaces.

2 No network disconnector between socket A and B:

a) If A and B belong to the same local Ethernet interface (for example, X1).

b) If A and B both belong to a backplane bus module (CP, CM).

3 As of firmware V3.0, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

4 As of firmware V3.1, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

5 As of firmware V4.0, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

6 With firmware higher than V40.0.0 with configured CP1625-2 (in TIA Portal and Resource Configurator), the F-CPU is only a network disconnector between the two interfaces of the CP1625-2 if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

CPU 1505SP (T)F	• With Open Controller CPU 1515SP PC1 and PC2: **No** • With Open Controller CPU 1515SP PC3: Network disconnection between Ethernet X1 and X10.	See [1] and [2]
CPU 1507S F [6]	• With firmware lower than V40.0.0: **No** • With firmware V40.0.0: Network disconnection between local Ethernet interface X2 and CP. Note: There is no network disconnection between multiple local Ethernet interfaces and between multiple Ethernet interfaces on a CP. • With firmware higher than V40.0.0: Network separation between local and external Ethernet interfaces, between different external Ethernet interfaces and between the two interfaces of the CP1625-2.	
CPU 1508S (T)F [6]		

[1] Absolute network disconnector between socket A and B:

a) If A and B belong to different local Ethernet interfaces (for example, X1 and X2) and no bridging is implemented at communication level 2 for these interfaces.

a) If either A or B are part of a local Ethernet interface and the other is part of a backplane bus module with an Ethernet interface (CP, CM), and no bridging is implemented at communication level 2 for these interfaces.

[2] No network disconnector between socket A and B:

a) If A and B belong to the same local Ethernet interface (for example, X1).

b) If A and B both belong to a backplane bus module (CP, CM).

[3] As of firmware V3.0, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

[4] As of firmware V3.1, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

[5] As of firmware V4.0, the F-CPU is only a network disconnector if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

[6] With firmware higher than V40.0.0 with configured CP1625-2 (in TIA Portal and Resource Configurator), the F-CPU is only a network disconnector between the two interfaces of the CP1625-2 if it contains a safety program with an F-communication partner (e.g.: fail-safe I/O or F-CPU).

Even when using a communication network disconnector according to IEC 61784-3-3 (PROFIsafe standard), you must still ensure that the individual isolated networks are not connected by other standard components. See also this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).
Standard CPUs are generally not network disconnectors according to IEC 61784-3-3 (PROFIsafe standard).

Support of PROFIsafe V2 for PROFINET IO

Interfaces that support PROFINET IO also support PROFIsafe V2.

Support of PROFIsafe V2.4 for PROFIBUS DP

Interfaces that support PROFIBUS DP also support PROFIsafe V2.4 but not PROFIsafe V2.6.

Restriction with "CREAT_DB" and "DELETE_DB" instructions

F-DBs can neither be created nor deleted.

Restriction with "READ_DBL" and "WRIT_DBL" instructions

The destination address must not point to an F-DB.

Restrictions when configuring the retentive behavior of data blocks

The configuration of the retentive behavior of data blocks is not supported for F-DBs. This means that the actual values of the F-DBs will not be retentive in the event of POWER OFF/POWER ON and restart (STOP-RUN) of the F-CPU. The F-DBs retain the initial values from the load memory.

The "Retain" check box is grayed-out for all tags in F-DBs.

Configuration control (option handling) on an S7-1200 F-CPU G1

Configuration control (option handling) on an S7-1200 F-CPU G1 is possible with central modules subject to the following limitation:

- The fail-safe S7-1200 G1 modules cannot be swapped and must also always be physically inserted into their configured slot.

Position the fail-safe S7-1200 G1 modules directly next to the F-CPU. Position the standard modules on the right next to the fail-safe S7-1200 G1 modules.

Fail-safe runtime rights when using the user management (UMAC)

When using the user management (UMAC), you can assign the following fail-safe runtime rights:

- "Full access incl. fail-safe access" for use in the TIA Portal
- "Change parameter of the F-System (F-Admin)" for use in the web server environment

Procedure for loading a configuration for firmware < V2.0 for S7-1500 F-CPUs

If you have loaded an S7-1500 F-CPU with a configuration for firmware as of V2.0 with configured protection level "Full access incl. fail-safe (no protection)" and you now want to load a configuration for firmware <= V1.8 to this F-CPU, you must observe the following:

When the configuration with firmware <= V1.8 is loaded to the F-CPU, you will be prompted to enter the password and the entered password will be identified as invalid.

As a remedy, format the SIMATIC Memory Card as described in the online help for STEP 7 under "Formatting an S7-1500 memory card". You can then load the configuration for firmware <= V1.8 to the F-CPU.

Procedure for loading a configuration for firmware V4.1 S7-1200 F-CPUs G1

If you have loaded an S7-1200 F-CPU G1 with a configuration for firmware as of V4.5 with configured protection level "Full access incl. fail-safe (no protection)" and you now want to load a configuration for firmware 4.1 to this F-CPU, you must observe the following:

When the configuration with firmware V4.1 is loaded onto the F-CPU, you are prompted to enter the password and the entered password will be identified as invalid.

As a remedy, format the SIMATIC Memory Card if you are working with an external load memory (SIMATIC Memory Card). If you are working with the internal load memory, proceed as you would for a lost password. You can then load the configuration for firmware V4.1 to the F-CPU.

Migrating or upgrading to TIA Portal V17 or higher

When migrating or upgrading to TIA Portal V17 or higher and current firmware (S7-1500F V2.9/S7-1200F G1 V4.5), we recommend that you create a new backup file.

If the existing backup file is still used, an access authorization for the F-CPU may be required when restoring the software and hardware configuration of the F-CPU.

Use of isochronous mode interrupt (F-)OBs

The number of isochronous mode interrupt (F-)OBs depends on the F-CPU used. You can obtain information in the technical specification of the F-CPU.

If the sum of the isochronous mode interrupt OBs and the isochronous mode interrupt F-OBs exceeds the number specified in the technical specifications of the F-CPU, it is no longer possible to load the standard user program in RUN.

Supplement to syslog messages for F-CPUs

For F-CPUs S7-1500/S7-1200 G2 as of V4.1, at the event "SE_USER_PROGRAM_CHANGED" the collective F signature is entered in the syslog message. If the change is rejected, the previous collective F signature is entered.

For more information about the "Syslog messages" function, see:

- SIMATIC S7-1500/ET 200MP Automation System system manual (https://support.industry.siemens.com/cs/ww/en/view/59191792) in the section "Syslog messages"
- Syslog messages product information (https://support.industry.siemens.com/cs/ww/en/view/109823696)

F-diagnostic messages with an S7-1500 HF CPU

NOTE

On a redundant system S7-1500HF, F-diagnostic messages are entered duplicated on both HF-CPUs (primary and backup CPU).

If one of the two HF CPUs is not available (e.g. STOP, POWER OFF, etc.), then the F-diagnostics is simply entered on the accessible HF CPU only. When the redundant HF-CPU returns, the diagnostics is duplicated again.

Download in Multiuser Commissioning mode

NOTE

When downloading in the Multiuser Commissioning mode, the serial number is read exclusively from the server project and compared to the linked F-CPU.

In the same manner the transferred serial number of the linked F-CPU is written back solely to the server project. The serial number from the local session is not used.

TIA Portal with CFC

STEP 7 Safety and F-CPUs with active F-functionality are not supported. You can use either CFC or the F-capability on an F-CPU.

Resetting a (T)F-CPU to factory settings

If you want to reset a (T)F-CPU online to factory settings including formatting of the SIMATIC Memory Card and are logged in with the password for "Full access (no protection)", the message "The device could not be reset" may be displayed.

Follow these steps:

1. Go to "Online und diagnostics".
2. Format the SIMATIC Memory Card under "Functions" with "Format memory card".
3. Enter the password for "Full access incl. fail-safe (no protection)".

Alternatively, follow these steps:

1. Go to the "Online" menu command. Select "Delete access rights".
2. Go to "Online und diagnostics".
3. Under "Functions", go to "Reset to factory settings".
4. Select "Format memory card".
5. Click on "Reset PLC".
6. Enter the password for "Full access incl. fail-safe (no protection)".

Requirements for power supplies in the event of voltage interruption

NOTE

To ensure adherence to IEC 61131-2 and NAMUR Recommendation NE 21, only use power packs/power supply units (230 V AC → 24 V DC) with a mains buffering time of at least 20 ms. Observe the relevant requirements in your product standards (e.g. 30 ms for "burners" pursuant to EN 298) as regards possible voltage interruptions. The latest up-to-date information on PS components is available on the Internet (https://mall.industry.siemens.com).

These requirements, of course, also apply to power packs/power supply units not constructed using ET 200SP or S7-300-/400-/1500 technology.

Display (for S7-1500 F-CPUs with display)

S7-1500 F-CPUs with display show you the following in the "Overview" menu under "Fail-safe":

- Safety mode activated/deactivated
- Collective F-signature
- Last fail-safe change
- Version of *STEP 7 Safety* with which the safety program was compiled.
- Remaining runtime in deactivated safety mode (for F-CPUs FW V4.0 or higher)
- F-BaseID (for F-CPUs FW 4.1 or higher)
- Information on the F-runtime groups
  - Name of F-runtime group
  - F-runtime groups signature
  - Current cycle time
  - Max. cycle time
  - Current runtime
  - Max. runtime
  - For F-CPUs from FW V3.0 to <V4.0 (valid from CPU 1511SP F-1 PN to CPU 1516F-3 PN/DP), "Remaining runtime in deactivated safety mode" is also displayed here.

The following is displayed for each F-I/O under "Fail-safe parameters":

- F-parameter signature (with addresses)
- safety mode (for F-CPUs with FW <V4.0)
- F-monitoring time
- F-source address
- F-destination address

The following additional menu command is displayed in the "Settings" menu under "Protection":

- Enable/disable F-password

Write access to F-blocks is not permitted.

NOTE

Controlling fail-safe inputs/outputs can result set the F-CPU to STOP.

NOTE

With the display firmware V2.5, the display is not refreshed and cannot be operated for a few minutes after loading program changes. Afterwards, the display restarts.

NOTE

In the case of a redundant S7-1500HF system, the display of the "Last fail-safe change" in the display and web server is only synchronized in the RUN-Redundant mode.

Web server/Web API

The F-CPUs S7-1200/1500 show you the following on the previous web pages (except S7-1200 G2) or the system web pages (except S7-1200 G1) of the web server and via the Web API:

- Safety mode activated/deactivated
- Collective F-signature
- Last fail-safe change
- Version of *STEP 7 Safety* with which the safety program was compiled. (Not supported by Web API).
- Remaining runtime in deactivated safety mode (not on the existing web pages)
- F-BaseID (not on the existing web pages)
- Information on the F-runtime groups
  - Name of F-runtime group
  - Remaining runtime in deactivated safety mode (only on existing web pages; in the case of Web API, the smaller of the two F-runtime groups is always returned.)
  - F-runtime groups signature
  - Current cycle time
  - Max. cycle time
  - Current runtime
  - Max. runtime

The following is displayed for each F-I/O on the "Module Information" web page in the "Fail-safe" tab:

- F-parameter signature (with addresses)
- Safety mode (only on existing web pages; not supported by Web API).
- F-monitoring time
- F-source address
- F-destination address

Write access to F-blocks is not permitted.

NOTE

Controlling fail-safe inputs/outputs can result set the F-CPU to STOP.

The new system web pages on the F-CPUs S7-1200G2/S7-1500 only show information on the safety-related project data from FW V4.1 onwards.

To use a program card as external load memory with an S7-1200F G2, the following warning must be observed, contrary to the information in the "SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)" programming and operating manual:

WARNING

You must observe the following procedure to ensure that there is no "old" safety-related project data in the internal load memory of the F-CPU when you insert a program card into an S7-1200 F-CPU G2:

1. Check whether **the STOP/RUN LED (yellow) and the maintenance LED flash for 3 seconds during startup when the card slot is empty.**

   If this is the case, the internal load memory of the F-CPU has already been deleted (for example, when the F-CPU has already been operated with a program card as an external load memory), step 3 is skipped (except with FW V4.1.x) and you can skip step 5.
2. Insert the program card into the F-CPU.

   The F-CPU then performs an automatic restart, regardless of whether it is in RUN or STOP.
3. **After the restart, the STOP/RUN LED (yellow) and the maintenance LED must be flashing**. In this case, the internal load memory of the F-CPU is deleted (therefore no longer contains any "old" safety-related project data) and step 5 can be skipped.

   Use one of the following variants to evaluate the program card:
   - Turn the F-CPU off and back on.
   - Remove and insert the program card.
   - Execute the "Memory reset" (MRES) function.
4. After the restart, the program card is evaluated. The F-CPU then enters the startup mode (RUN or STOP) that was set up for the F-CPU (variant 1 of step 3) or remains in STOP (variant 2 or 3 of step 3 or if step 3 was skipped because the internal load memory was empty).
5. Perform a program identification. *(S106)*

Application UI with API (for F-CPUs S7-1500V)

S7-1500V F-CPUs as of V2.1 show you the following in the menu "PLC" under "Failsafe" (the language of the S7-1500V UI is English):

- Safety mode activated/deactivated ("Safety mode")
- Collective F signature ("F-Signature")
- Last fail-safe change ("Last modification")
- Redundancy of the available Virtual Timeservices ("Virt. Timeservice redundant")
- ID of the last active Virtual Timeservice ("Last active Virt. Timeservice")

NOTE

The "Last modification" parameter in the UI or API of the S7-1500VF corresponds with the PLC time. Note that the PLC time in the virtualized environment does generally not correspond with the IE(V)D time. If you use the "Cyclic Retentive Backup" functionality, note that "Last modification" will be overwritten with the current timestamp when restoring the S7-1500VF.

NOTE

The "Virt. Timeservice redundant" parameter is returned in STOP of the S7-1500VF in the API as the Boolean value "false" and displayed in the WebUI as "-".

The following points relate to the S7-1500 F Virtual Controller

Information on the type tests

Edge-enabled devices are approved for use with the S7-1500 F Virtual Controller. With STEP 7 Safety, these are fail-safe even in the case of elevated electromagnetic interference. Special type tests for functional safety are therefore not required for these devices – unlike for F-I/O. With regard to availability, however, you must observe the application-specific requirements, especially the standards for burner control.

The following points relate to the S7-1500 F-Software Controller

The S7-1500 F Software Controller is a fail-safe software CPU that is used on the following devices and is also only approved for these devices:

S7-1500 F-Software Controller	Device as of V30.0 and below V40.0	Device with V40.0	Device as of V40.1
CPU 1505SP F	• CPU 1515SP PC(2)[1]	• CPU 1515SP PC(3)[1]	• CPU 1515SP PC(3)[1]
CPU 1505SP TF	• CPU 1515SP PC(2)[1]	---	• CPU 1515SP PC(3)[1]
CPU 1507S F	• IPC 427E[2] and IPC 477E[2] • IPC 627E[2], IPC 647E[2] and IPC 677E[2] • IPC 847E[2] • IPC 227G and IPC 277G[3] • IPC BX-39A[2] and IPC PX-39A (PRO)[2]	• IPC BX-59A[1]	• IPC BX-39A[1] • IPC BX-59A[1]
CPU 1508S F	• IPC 427E[2] and IPC 477E[2] • IPC 627E[2], IPC 647E[2] and IPC 677E[2] • IPC 847E[2] • IPC BX-39A[2] and IPC PX-39A (PRO)[2]	• IPC BX-59A[1]	• IPC BX-39A[1] • IPC BX-59A[1]
CPU 1508S TF	• IPC 627E[3] and IPC 677E[3]	---	• IPC BX-59A[1]

1 These devices support Fast Commissioning mode.

2 Can be used even without NVRAM memory, but Fast Commissioning mode is then not supported. If NVRAM is present and assigned to the SW Controller via the Resource Configurator Tool, then Fast Commissioning mode is supported.

3 Can be used even without NVRAM memory. Fast Commissioning mode is not supported.

The devices specified in the table above react in a fail-safe manner when the S7-1500 F-Software Controller and *STEP 7 Safety* are used, even in the case of elevated electromagnetic interference. Special type tests for functional safety are therefore not required for these devices – unlike for F-I/O. With regard to availability, however, you must observe the application-specific requirements, especially the standards for burner control.

The yellow adhesive label with the TÜV SÜD test mark for functional safety included in the scope of delivery is exclusively intended for use in connection with S7-1500 F-Software Controllers (not included in the download version of the product package). You can use the adhesive label to mark the hardware on which the S7-1500 F-Software Controller is installed. You must remove the adhesive label when you uninstall the S7-1500 F-Software Controller.

Backup and restore

Backup and restoration of project data is not supported.

NOTE

The Windows user "Everyone" is not taken into consideration if it is in the "Failsafe Operators" Windows user group.

TPM functionality

The TPM functionality cannot be used for S7-1500 F-Software Controllers because it could result in a STOP.

Using EWF or UWF and the EWF or UWF Manager

You cannot select EWF or UWF and the EWF or UWF Manager for the CPU volume.

Other particularities

NOTE

The NVRAM must inserted in an IPC before installation of an S7-1500 F Software Controller. If the NVRAM is inserted subsequently, the S7-1500 F Software Controller must be uninstalled and then reinstalled.

NOTE

No NVRAM is required for the operation of an S7-1500 F Software Controller as of firmware V40.0.

NOTE

If you want to start the import of the configuration file of an S7-1500 F Software Controller, the user performing the import must be in the "Failsafe Operators" (Windows) or "failsafe_operators" (Linux) user group.

NOTE

The lock symbol is only set in the panel if you have set up a standard password.

NOTE

For an S7-1500 F Software Controller on an IPC 627E, IPC 647E, IPC 677E or IPC 847E, you must use at least the BIOS version V25.02.10.

NOTE

The CPU clock must not be changed in RUN because this would result in a STOP. You can prevent this by disabling the energy-saving function.

SIEMENS

SIMATIC

ET 200SP
Interface module IM 155-6 DP HF (6ES7155-6BA01-0CN0)

Equipment Manual

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (https://www.siemens.com/industrialsecurity).

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Guide to documentation

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

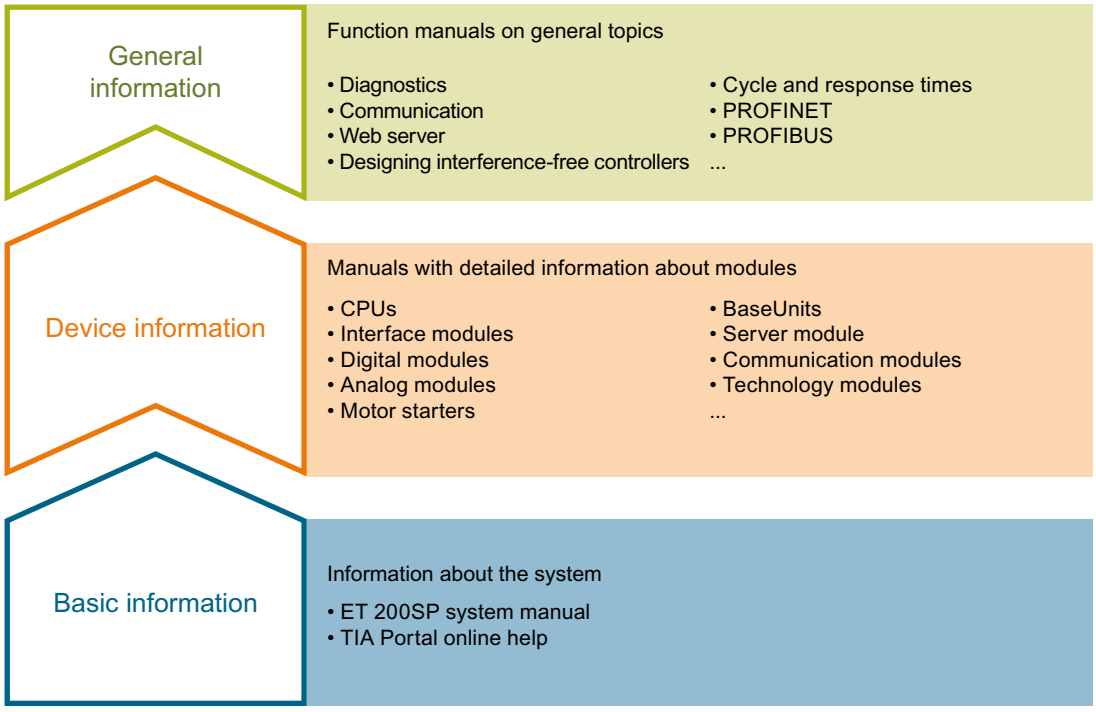

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7155-6BA01-0CN0

Article number 6ES7155-6BA01-0CN0 contains the following components:

- Interface module IM 155-6 DP HF (6ES7155-6BU01-0CN0)
- Server module (6ES7193-6PA00-0AA0)
- PROFIBUS FastConnect bus connector (6ES7972-0BB70-0XA0)

View of the module

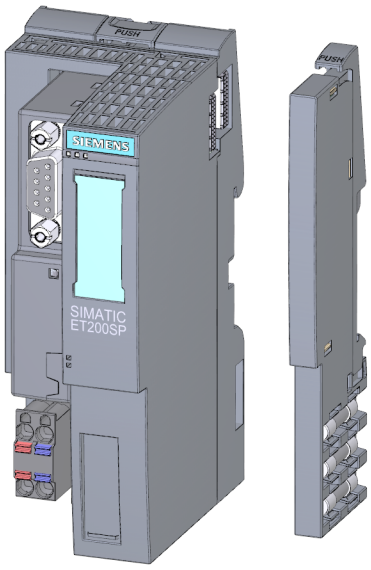

Figure 2-72 View of the 155-6 DP HF interface module with supplied accessories

Properties

The module has the following technical properties:

- Connects the ET 200SP distributed I/O system with PROFIBUS DP
- Power supply 1 L+ 24 V DC (SELV/PELV)
- Bus connection via RS485 interface

The module supports the following functions (Page 12):

Maximum configuration

- 244 bytes I/O data
- 32 I/O modules and 16 ET 200AL modules

Accessories

You order the following accessories separately:

- Labeling strips
- Reference identification label

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Server module

The server module is included in the product package of the interface module and available separately as an accessory.

The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system
- Features a support for 3 spare fuses (5 × 20 mm)
- Provides station functions, e.g., status bytes
- Identification data I&M 0 to 3

NOTE

You need to configure the server module in the configuration software.

To do so, place the server module with the required length of status bytes at the last slot of the configuration. When there are 32 I/O modules, the server module is inserted at slot 33.

PROFIBUS FastConnect bus connector

The PROFIBUS FastConnect bus connector is included in the product package of the interface module and also available separately as an accessory.

You can find additional information on the PROFIBUS FastConnect bus connector in the corresponding product information on the Internet (http://support.automation.siemens.com/WW/view/en/58648998).

Configuration with more than 244 bytes of parameter data

With a configuration as of STEP 7 V5.5 SP 3 with HSP 242, you have the option of operating the IM 155-6 DP HF interface module as of 6ES7155-6BA00-0CN0 in DPV1 mode with more than 244 bytes of parameter data. Configuration with the GSD file does not offer this option.

Reference

You can find additional information on identification data in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2 Functions

2.2.1 Functions

Introduction

The interface module supports the following functions:

- Identification data I&M 0 to 3
- PROFIBUS DP
- Firmware update via PROFIBUS DP
- Configuration control by means of the user program
- Operation as DPV1 slave
- Operation after Y-link (not with F-modules)
- Station extension via ET-Connection
- F-direct data exchange

Requirements

The table below shows the software requirements for a configuration with the IM 155-6 DP HF interface module:

Table 2-60 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130-000) / software from a third-party manufacturer[1]	STEP 7 as of V5.5 SP3 with HSP0242	STEP 7 (TIA Portal) as of V13
Operation after Y-link (not with F-modules)	1	V1.1.0	X	-	-
Hot-swapping	1	V1.0.0	X	X	X

1 Systems of third-party manufacturers: Depending on the range of functions of the third-party system

2 Configure the module as version 6ES7155-6BA00-0CN0 FW V3.1 (as of HSP0242 V3)

Function	Product version of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130-000) / software from a third-party manufacturer[1]	STEP 7 as of V5.5 SP3 with HSP0242	STEP 7 (TIA Portal) as of V13
Station extension via ET-Connection	1	V3.0.0	X	X (as of HSP0242 V2)	-
F-direct data exchange	1	V3.1.0	-	X (as of HSP0242 V3)	-
Interface module; article number: 6ES7155-6BA01-0CN0	1	V4.2	-	X [2]	X (as of V15.1)

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

[2] Configure the module as version 6ES7155-6BA00-0CN0 FW V3.1 (as of HSP0242 V3)

2.2.2 Configuration control

Properties

Configuration control allows you to prepare your distributed I/O system for future extensions or options. Configuration control means that you can configure the planned maximum configuration of your distributed I/O system in advance and vary it later in a flexible manner by means of the user program.

Reference

You can find more information on configuration control

- in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual
- on the Internet under the following link: Application collection (http://support.automation.siemens.com/WW/view/en/29430270)
- in the STEP 7 online help.

Connecting

3

3.1 Terminal assignment

24 V DC supply voltage

The table below shows the signal names and descriptions of the pin assignment of the 24 V DC supply voltage.

Table 2-61 Pin assignment 24 V DC supply voltage

View		Signal name[1)]	Description
Connector	IM connection		
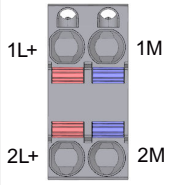	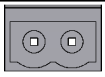	1L+	24 V DC
		2L+	24 V DC (for looping through)[2]
		1M	Ground
		2M	Ground (for looping through)[2]

1 1L+ and 2L+ as well as 1M and 2M are internally bridged.

2 Maximum 10 A permitted.

PROFIBUS DP with RS485 interface

The following table shows the signal names and descriptions of the terminal assignment of the PROFIBUS DP interface.

Table 2-62 Terminal assignment PROFIBUS DP with RS485 interface

View	Signal name		Description
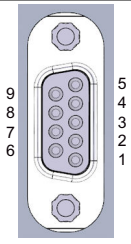	1	-	-
	2	-	-
	3	RxD/TxD-P	Data line B
	4	RTS	Request To Send
	5	M5V2	DP data reference potential (from station)
	6	P5V2	Supply plus (from station)
	7	-	-
	8	RxD/TxD-N	Data line A
	9	-	-

Reference

You can find additional information on connecting the interface module and on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Block diagram

The following figure show the block diagram of the IM 155-6 DP HF interface module.

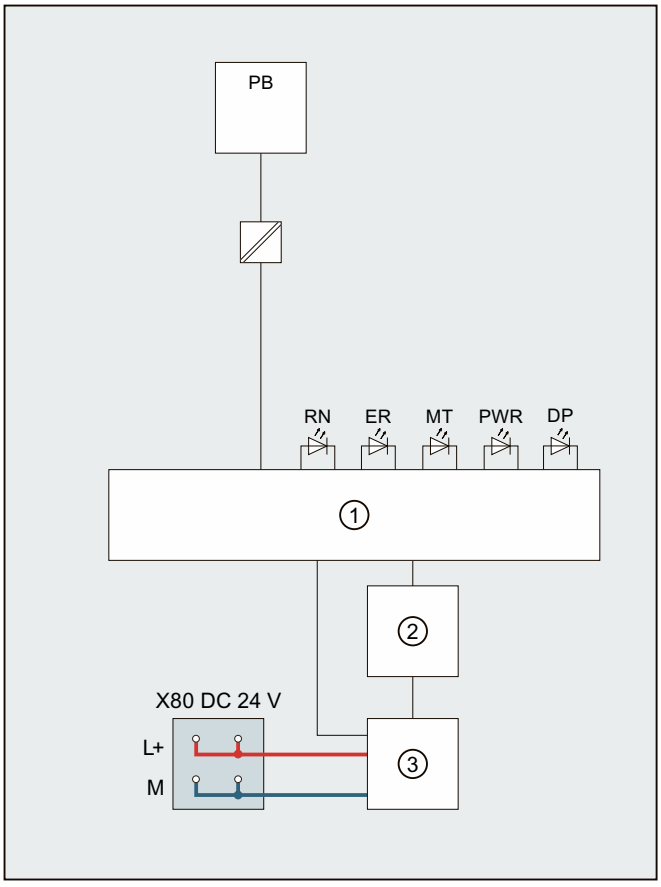

①	ET 200SP backplane bus interface and electronics	L+	24 V DC supply voltage
②	Backplane bus	M	Ground
③	Internal power supply	RN	RUN/STOP LED (green)
X80 24 V DC	Feed supply voltage	ER	ERROR LED (red)
PB	PROFIBUS interface	MT	MAINT LED (yellow)
		PWR	POWER LED (green)
		DP	PROFIBUS DP LED (green)

Figure 2-73 Block diagram of the IM 155-6 DP HF interface module

3.3 Setting the PROFIBUS DP address

Introduction

On the interface module (PROFIBUS), set the PROFIBUS DP address for PROFIBUS DP using the DIP switch. By setting the PROFIBUS DP address, you specify where the ET 200SP is to be addressed on the PROFIBUS DP.

Requirements

- Each PROFIBUS DP address may be assigned only once on the PROFIBUS DP.
- Valid PROFIBUS DP addresses are 1 to 125.
- The set PROFIBUS DP address must match the PROFIBUS DP address specified for the ET 200SP in the configuration software.

Required tools

Screwdriver 3 - 3.5 mm

Setting the PROFIBUS DP address

1. Slide the window of the interface module upwards.
2. Use a screwdriver to set the required PROFIBUS address via the DIP switch.
3. Close the window.

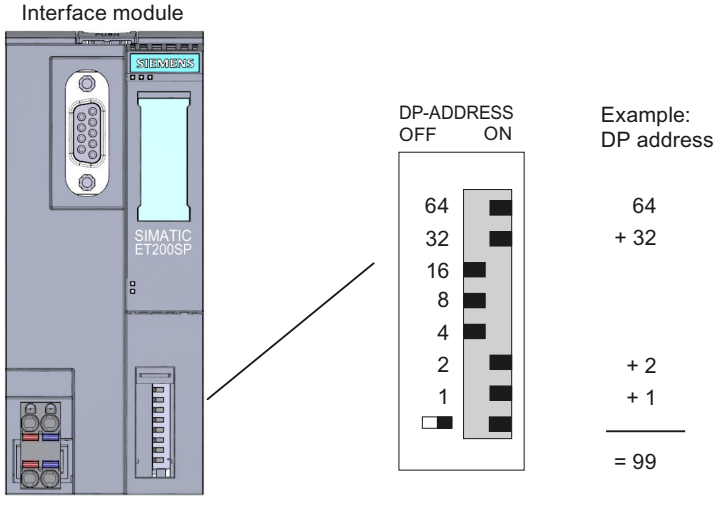

Figure 2-74 Setting the PROFIBUS DP address

Changing the PROFIBUS DP address

You can change the PROFIBUS DP address in exactly the same way as you set it. **A change in the PROFIBUS DP address only becomes valid for the ET 200SP** after a POWER ON of the interface module**.**

Parameters/address space

4

4.1 Parameters

Parameters for IM 155-6 DP HF interface module

The following table shows the parameters for the IM 155-6 DP HF interface module.

Table 2-63 Parameters for IM 155-6 DP HF interface module (GSD file)

Parameters	Value range	Default[3]	Effective range
Configuration control [1]	Disable/enable	Disable	ET 200SP
Startup when preset/actual configuration differ	Yes/No	No	ET 200SP
Diagnostics interrupt	Yes/No	Yes	ET 200SP
Hardware interrupt	Yes/No	Yes	ET 200SP
Pull/plug module interrupt[2]	Yes/No	No	ET 200SP

1 Note that the "Startup if preset configuration does not match actual configuration" parameter is always activated when you use configuration control.

2 The “Pull/plug” parameter is always activated in the GSD file.

3 The defaults apply to the default startup. If no other parameters are specified by the DP master, the IM 155-6 DP HF starts up with these parameters.

NOTE

Only for configuration using the PROFIBUS GSD file, does not affect configuration with STEP 7 via HSP:

Not all parameters of an I/O module are provided by the GSD file with GSD configuration, because the PROFIBUS standard limits the number of parameters to 244 bytes per ET 200SP. These parameters can be configured later using data record 128, if necessary. The description is available in the respective manual of the employed I/O module.

NOTE

PROFIBUS GSD configuration as of STEP 7 V5.5 SP3

The universal module must not be configured.

4.2 Description of parameters

4.2.1 Configuration control

You can use this parameter to enable the configuration control function in the ET 200SP distributed I/O system.

NOTE
Configuration control
The "Configuration control" function can only be used if you set the parameter "Startup if preset configuration does not match actual configuration" to yes at the same time.

NOTE
Configuring the enable
If you configure the enable, the ET 200SP distributed I/O system requires control data record 196 from the user program so that the ET 200SP distributed I/O system can operate the I/O modules.

Reference

You can find additional information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the STEP 7 online help.

4.2.2 Startup when expected/actual config differ

If the parameter is enabled and

- modules are removed and inserted during operation, this does not lead to a station failure of the ET 200SP distributed I/O system.
- If the preset configuration does not match the actual configuration, the ET 200SP distributed I/O system continues to exchange data with the DP master.

If the parameter is disabled and

- modules are removed and inserted during operation, this leads to a station failure of the ET 200SP distributed I/O system.
- If the preset configuration does not match the actual configuration, data exchange does not take place between the DP master and the ET 200SP distributed I/O system.

4.2.3 Diagnostic interrupt

You can use this parameter to enable or disable diagnostic interrupts.

4.2.4 Hardware interrupt

You can use this parameter to enable or disable hardware interrupts.

4.2.5 Insert/remove module interrupt

You can use this parameter to enable or disable insert/remove module interrupts.

4.3 Substitute value behavior

The substitute value behavior is implemented by the DP master per slot in the ET 200SP distributed I/O system.

The respective output reacts according to its configured substitute value behavior:

- Current-free/voltage-free
- Keep last value
- Output substitute value

The substitute value behavior is triggered in the following cases:

- STOP DP master
- DP master failure (connection interruption)
- Firmware update
- Station stop, for example, due to:
  - No server module
  - At least one I/O module installed on an incorrect BaseUnit
- Deactivate DP slave

NOTE

Reducing a configuration

If you reduce the configuration of the ET 200SP distributed I/O system and download the new configuration to the CPU, the modules no longer configured but still present retain their original substitute value behavior. This applies until the supply voltage on the BaseUnit BU...D or on the interface module is switched off.

The "current-free/voltage-free" behavior takes effect in the following cases:

- Firmware update
- Configuration control: receipt of a new control data record
- Incorrectly configured module
- Module with incorrect parameter assignment

Interrupts, error messages, diagnostics and system alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED display on the interface module:

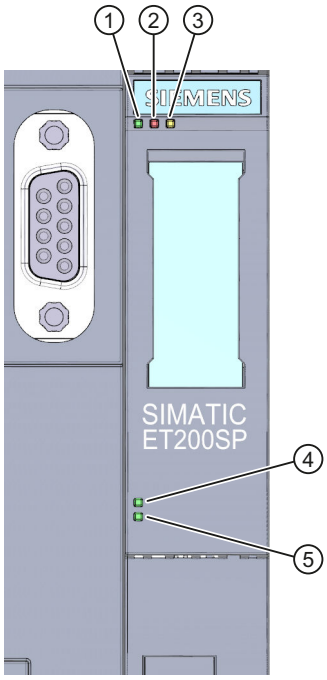

① RN (green)
② ER (red)
③ MT (yellow)
④ DP (green)
⑤ PWR (green)

Figure 2-75 LED displays on the interface module

Meaning of the LED displays

The following tables contain the meaning of the status and error displays.

RN/ER/MT LEDs on the interface module

Table 2-64 Status and error displays of RN/ER/MT LEDs

LEDs			Meaning	Remedy
RN (RUN)	ER (ERROR)	MT (MAINT)		
Off	Off	Off	No or too little supply voltage at interface module	Check the supply voltage or switch it on at the interface module.[1]
On	On	On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	-
Flashes	Off	Off	Interface module is deactivated.	Activate the interface module with the configuration software or the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP starts up.	-
			ET 200SP is being assigned parameters.	
On	Not relevant	Not relevant	ET 200SP is currently exchanging data with the DP master.	-
Not relevant	Flashes	Not relevant	Group error and group error channels	Evaluate the diagnostics and eliminate the error.
			The preset configuration does not match the actual configuration of the ET 200SP.	Check the configuration of the ET 200SP to see whether a module is missing or faulty, or whether a non-configured module is inserted.
			Invalid configuration states	See the Invalid configuration states of the ET 200SP on PROFINET DP (Page 41) section.
			Parameter assignment error in the I/O module	Evaluate the display of the module status in STEP 7 and correct the error in the corresponding I/O module.
Not relevant	Not relevant	On	Maintenance is demanded.	Perform maintenance
Flashes	Flashes	Flashes	Hardware or firmware faulty.[2]	Run a firmware update. If the error persists, contact Siemens Industry Online Support. Replace the interface module.

1 PWR LED On (on interface module): Check the backplane bus for a short-circuit.

2 DP LED Off

PWR LED on the interface module

Table 2-65 Status display of the PWR LED

PWR LED	Meaning	Remedy
□ Off	No or too little supply voltage	Check the supply voltage.
■ On	Supply voltage present	-

LED DP on the RS485 interface

Table 2-66 Status display of the DP LED

LED DP	Meaning	Remedy
□ Off	There is no connection between the PROFIBUS interface of your PROFIBUS device and a communication partner (for example, DP master).	Check whether the bus cable to the DP master is broken.
■ On	There is a connection between the PROFIBUS interface of your PROFIBUS device and a communication partner (for example, DP master).	-

LED display of configuration errors

Configuration errors of the ET 200SP distributed I/O system are output on the interface module by the ERROR (red) and MAINT (yellow) LEDs.

The following configuration errors are signaled by the LEDs:

- No server module
- Interruptions or short-circuit on the backplane bus

Operating principle

The LED error display provides information on the cause of the error. After a notification by means of a flashing signal, the error type and then the error location/error code are displayed in each case.

The LED error display:

- Is activated during POWER ON and during operation
- Has priority over all other states that are displayed by means of the ERROR- and MAINT-LED
- Remains on until the cause of the error has been eliminated

Table 2-67 Display of error type and error location

Sequence		Description
1	ERROR- and MAINT-LED flash 3x with 0.5 Hz	Indication of the error type
2	MAINT-LED flashes with 1 Hz	Display of error type (decimal)

Sequence		Description
3	ERROR- and MAINT-LED flash 3x with 2 Hz	Indication of error location/error code
4	ERROR-LED flashes with 1 Hz	Display of the tens position (decimal) of the error location/error code
5	MAINT-LED flashes with 1 Hz	Display of the units position (decimal) of the error location/error code
6	Repetition of 1 to 5 until the cause of the error has been eliminated.	

Error display

The following table shows the possible causes of error that can occur.

Table 2-68 Error display

Error type (MAINT)	Error location (ERROR/MAINT)	Cause of error	Solution
1	33*	• No server module • Interruptions on the backplane bus • Short-circuit on the backplane bus	Check the configuration of the ET 200SP.

* Slot

NOTE

The following LEDs indicate a short-circuit in the backplane bus supply or in the bus connection supply:

- PWR-LED: On
- RN-, ER- and MT-LED: Off

5.2 Interrupts

5.2.1 Introduction

Definition

The interrupt section of the slave diagnostics indicates the interrupt type and the event that led to an interrupt being triggered. The interrupt section comprises 62 bytes including an interrupt header.

Position in the diagnostics frame

The interrupt section is located after the channel diagnostics.

Data record

The diagnostic data of a module are located in the data records 0 and 1:

- Data record 0 contains 4 bytes of diagnostics data that describe the current status of the distributed I/O system. DS0 is part of the header information of OB 82 (local data bytes 8 to 11).
- Data record 1 contains 4 bytes of diagnostics data that are also available in data record 0.

The figure below shows the structure of data record 1:

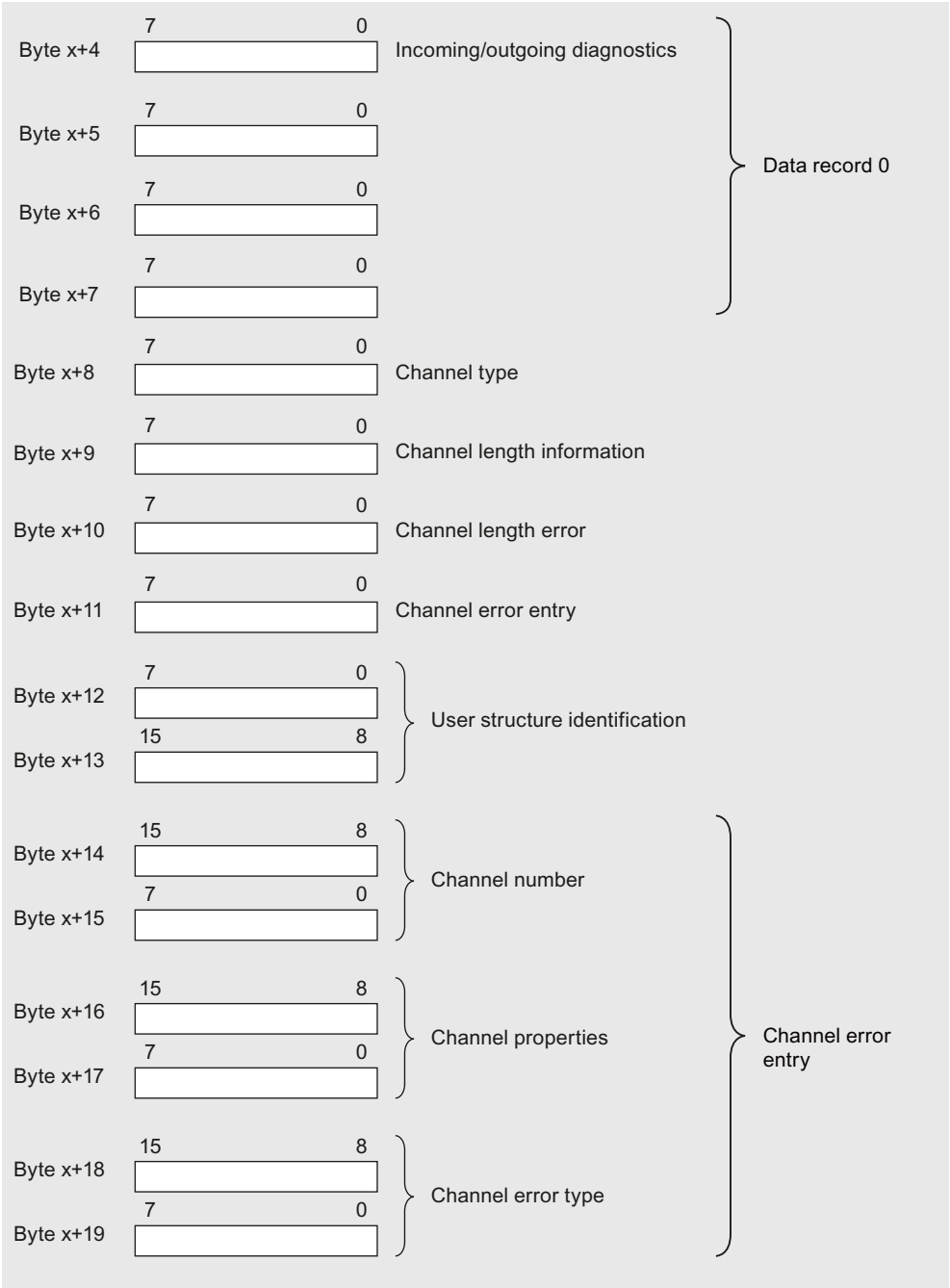

Figure 2-76 Structure of data record 1

Reading data records

DS0 and DS1 can be read with SFC 59 (RD_REC) or SFB 52 (RDREC). The data length of DS 1 can be up to 240 bytes. In this case, DS1 includes up to 38 channel error entries.

Note the figures below in this section.

Content

The contents of the interrupt information depend on the interrupt type:

- In the case of diagnostic interrupts, diagnostic data record 1 (up to 58 bytes) is sent as interrupt status information (starting from byte x+4).
- The length of the interrupt status information for hardware interrupts is 4 bytes.

Structure of interrupts

The figure below shows the structure of the interrupt section for the ET 200SP distributed I/O system:

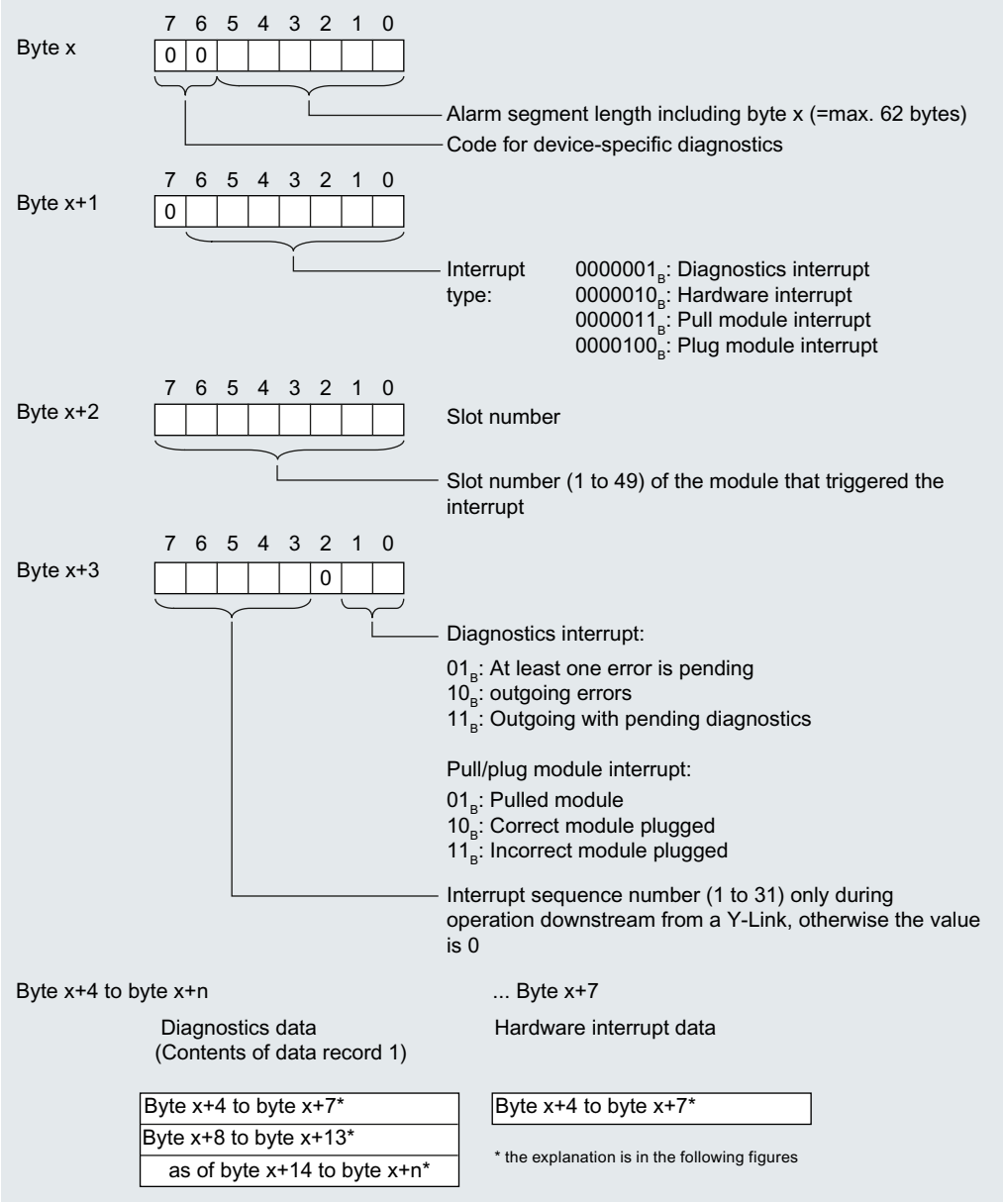

Figure 2-77 Structure of the interrupt status of the interrupt section

Diagnostic interrupt, byte x+4 to x+7

The figure below shows the structure starting at byte x+4 to x+7 for diagnostic interrupt:

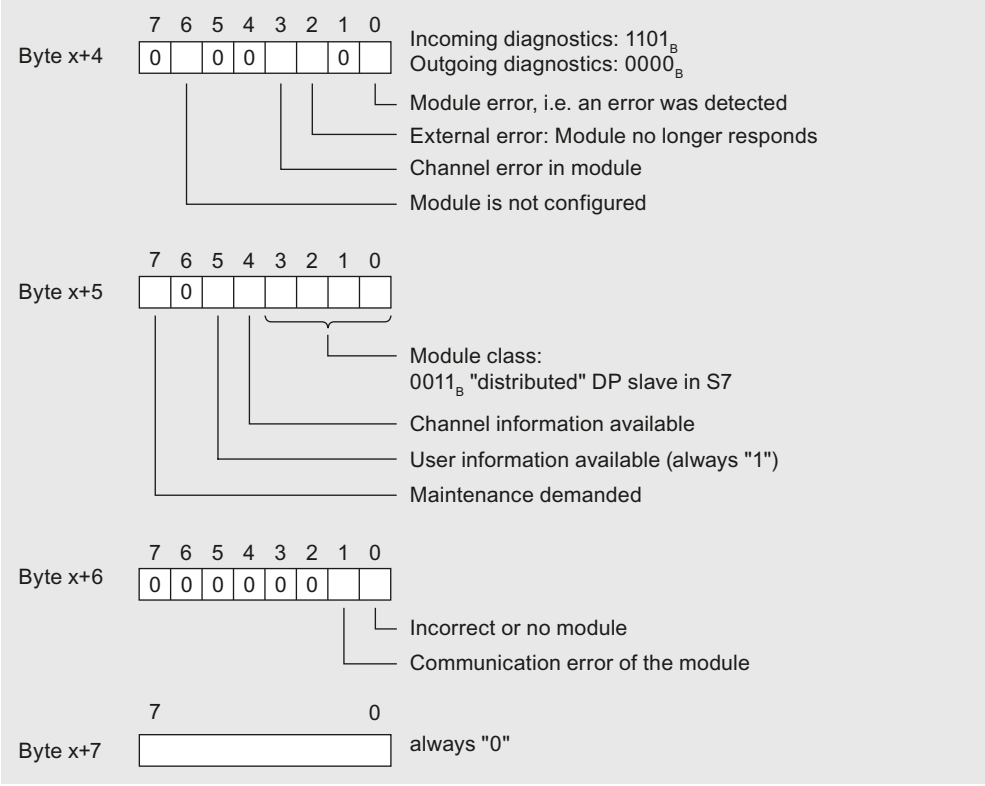

Figure 2-78 Structure of bytes x+4 to x+7 for diagnostic interrupt

Diagnostic interrupt from the modules, starting at byte x+8

The figure below shows the structure starting at byte x+8:

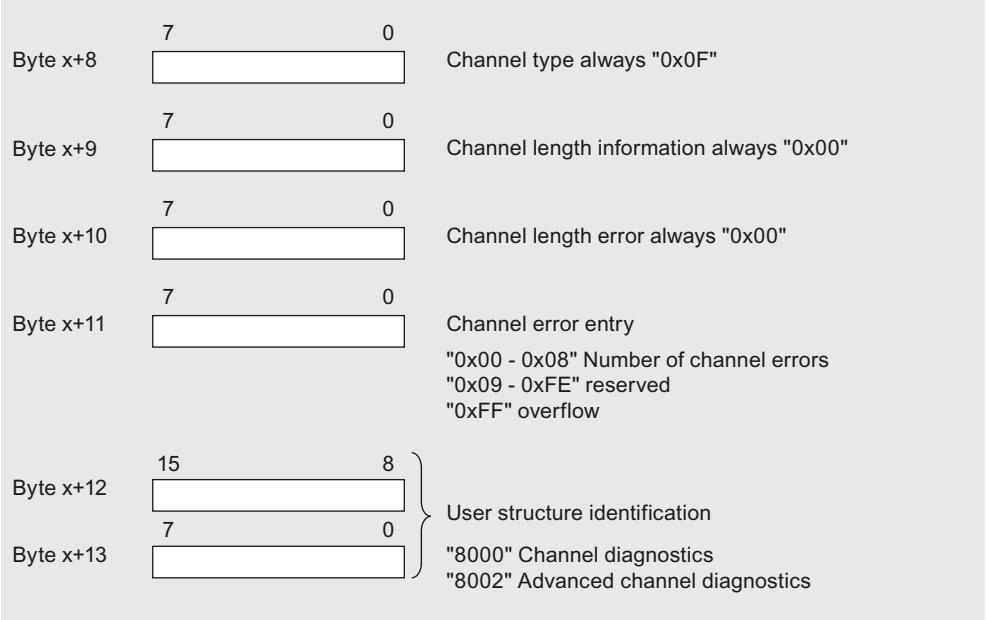

Figure 2-79 Structure starting at byte x+8

Diagnostic interrupt from the modules, starting at byte x+14

The channel error entries start from byte x+14. A channel error entry is 6 bytes long and can follow 8 times starting from byte x+14.

If you read the channel error entries using an SFB or SFC, 38 channel diagnostics are possible.

The figure below shows the structure starting at byte x+14:

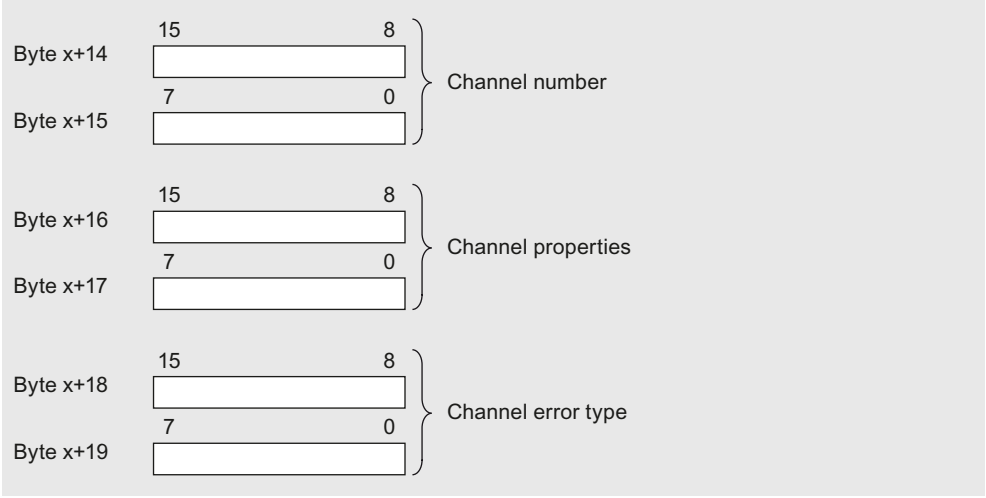

Figure 2-80 Structure starting from byte x+14

The following table is used to explain the channel error entries:

	Description	
Channel number	0 to 63: Channel number for channel error 0x8000: Entire submodule	
Channel properties	Bit 0 to 7	00_H: Free data type 01_H: bit 02_H: 2 bit 03_H: 4 bit 04_H: byte 05_H: word 06_H: Double word 07_H bis FF_H: Reserve
	Bit 8	0: Channel 1: Channel group
	Bit 9, 10	00_H: Diagnostics 01_H: Maintenance demanded 02_H: Maintenance required 03_H: Reserve
	Bit 11, 12	00_H: Channel error-free 01_H: Incoming diagnostics 02_H: Outgoing diagnostics 03_H: Outgoing diagnostics, but other diagnostics are also pending on this channel
	Bit 13 to 15	00_H: Reserve 01_H: Input channel 02_H: Output channel 03_H: Input/output channel
Channel error type	Refer to respective manual for explanation.	

Example of a diagnostic interrupt

The figure below shows an example of a diagnostic interrupt (part 1):

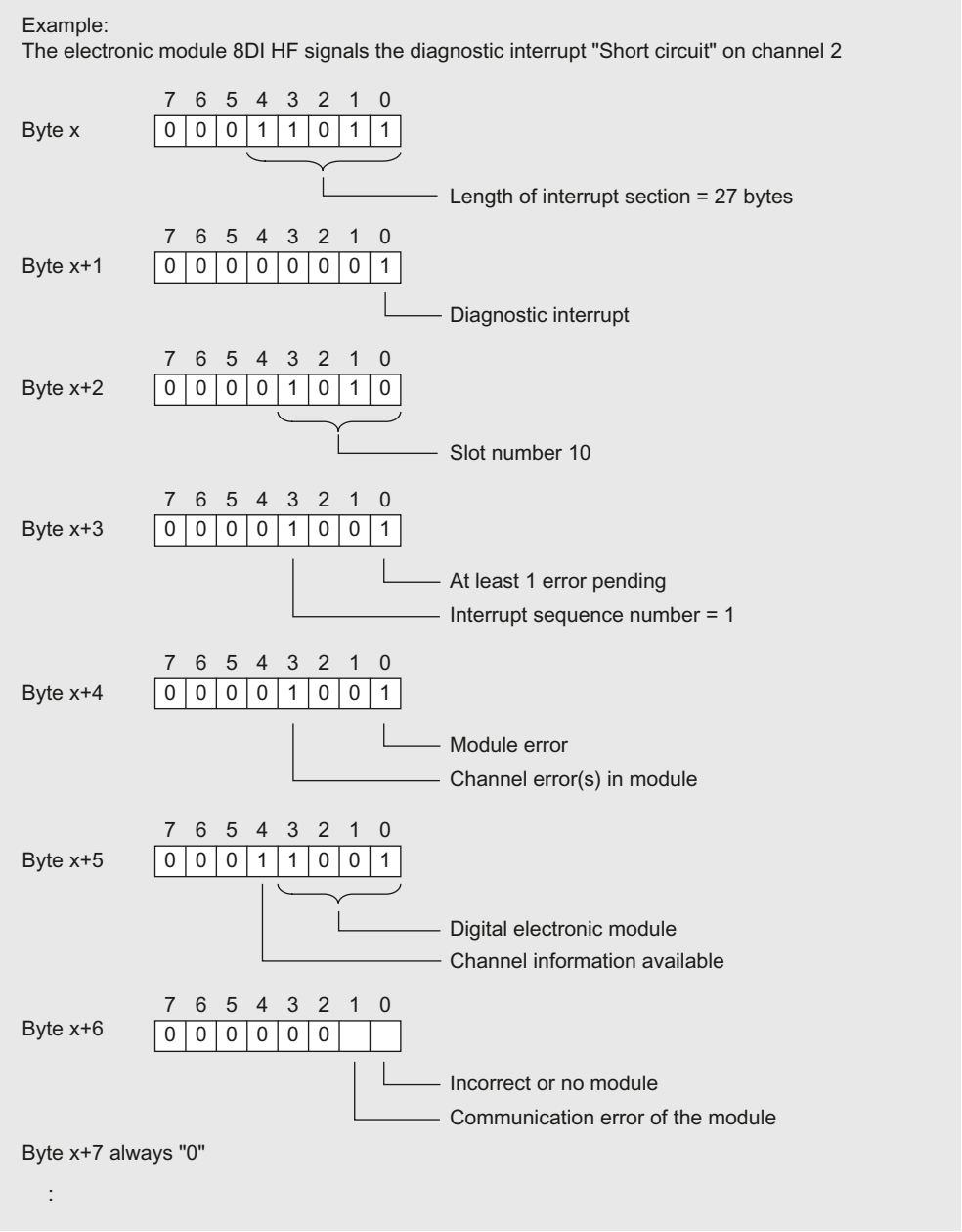

Figure 2-81 Example of a diagnostic interrupt (part 1)

The figure below shows an example of a diagnostic interrupt (part 2):

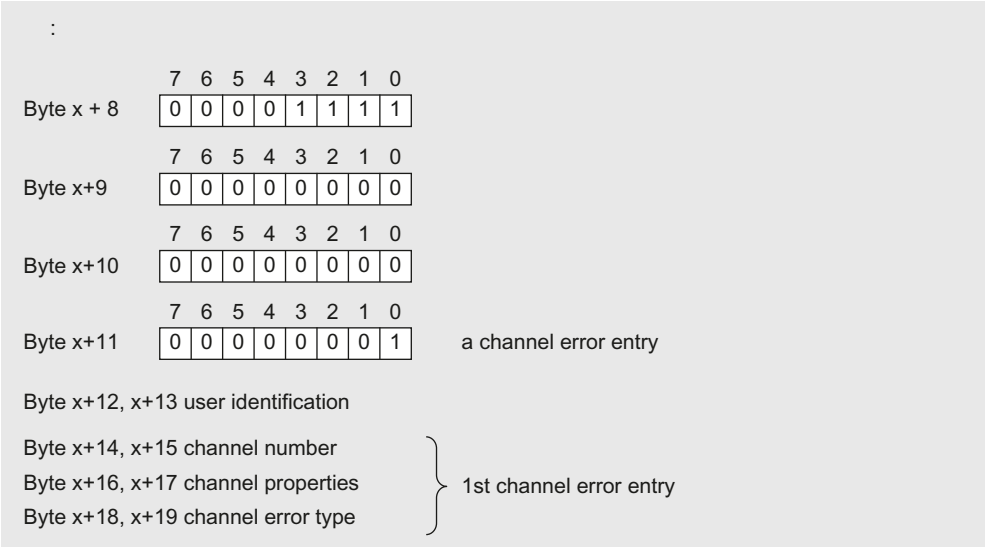

Figure 2-82 Example of a diagnostic interrupt (part 2)

Hardware interrupt of digital and analog input modules

The figure below shows the structure starting at byte x+4 for the hardware interrupt:

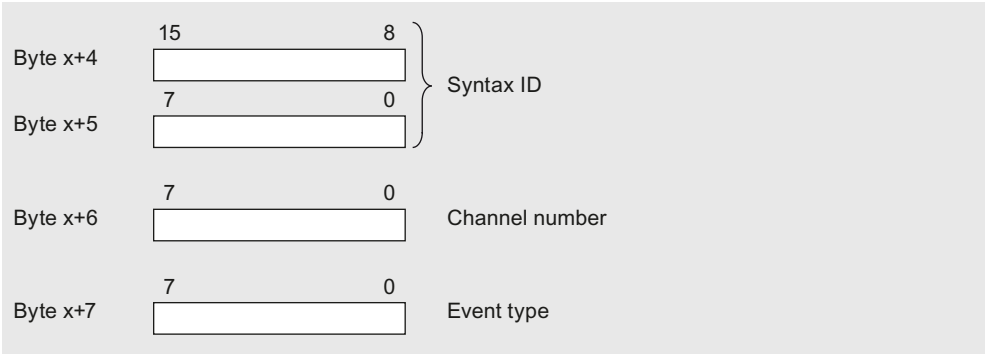

Figure 2-83 Structure starting at byte x+4 for hardware interrupt

5.2.2 Evaluating interrupts of ET 200SP

Introduction

With certain process statuses/errors, the DP slave in each case creates an interrupt block with the corresponding information in the diagnostics frame (DPV1 interrupt mechanism). Regardless of this, the diagnostic status of the DP slave is displayed in the identifier-related diagnostics, in the module status, and in the channel diagnostics.

Interrupts in DPV1 mode

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostic interrupts
- Hardware interrupts
- Insert/remove module interrupts

5.2.3 Triggering of a diagnostics interrupt

When an event comes or goes (e.g. wire break on a channel of an I/O module), the module triggers a diagnostics interrupt if "Enable: diagnostic interrupt" is set.

The CPU interrupts user program execution and processes the diagnostic interrupt OB (OB 82). The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.

5.2.4 Triggering a hardware interrupt

When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the hardware interrupt OB, for example OB 40. The event that triggered the interrupt is entered in the start information of the hardware interrupt OB.

NOTE

Diagnostics "Hardware interrupt lost" (from I/O module)

Do not use hardware interrupts for technological purposes (e.g., cyclical generation of hardware interrupts).

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

5.2.5 Triggering an insert/remove module interrupt

When an insert/remove module interrupt occurs, the CPU interrupts execution of the user program and processes the insert/remove module interrupt OB (OB 83). The event that triggered the interrupt is entered in the start information of the insert/remove module interrupt OB.

5.3 Alarms

Actions after a diagnostics alarm in DPV1 mode

The error is entered in the channel diagnostics in the diagnostics frame:

- In DPV1 mode, diagnostics can be reported as diagnostic interrupts.
- After a diagnostics alarm, this is
  - entered in the diagnostics frame as diagnostic interrupt block (always for one interrupt only).
  - Stored in the diagnostics buffer of the CPU.
- The ERROR LED of the interface module flashes.
- OB 82 is called. If OB 82 does not exist, the CPU changes to STOP mode.
- Acknowledgment of diagnostic interrupt (a new interrupt is then possible)

Length of the diagnostics frame

- The maximum frame length for the ET 200SP distributed I/O system with IM155-6 DP HF interface module (DPV1 mode) is 244 bytes.
- The minimum frame length is 6 bytes.

Reading out the diagnostics data

Table 2-69 Reading out the diagnostics data with STEP 7

Automation system with DP master	Application	See...
SIMATIC S7/M7	Slave diagnostics data as plain text in the "DP slave diagnostics" tab in the STEP 7 user interface	"Diagnosing hardware" in the STEP 7 online help
	Instruction "DP NRM_DG" (SFC 13) Reading out slave diagnostics (store in the data area of the user program)	SFC, see STEP 7 online help
	Instruction "RD_REC" (SFC 59) Reading out data records of the S7 diagnostics data (store in the data area of the user program)	See System and Standard Functions reference manual
	Instruction "RDREC" (SFB 52) Reading data records from the DP slave	SFB, see STEP 7 online help (system functions/function blocks)
	Instruction "RALRM" (SFB 54) Receiving interrupts from the interrupt OBs	SFB, see STEP 7 online help (system functions/function blocks)

5.3.1 Slave diagnostics

The figure below shows the structure of the slave diagnostics.

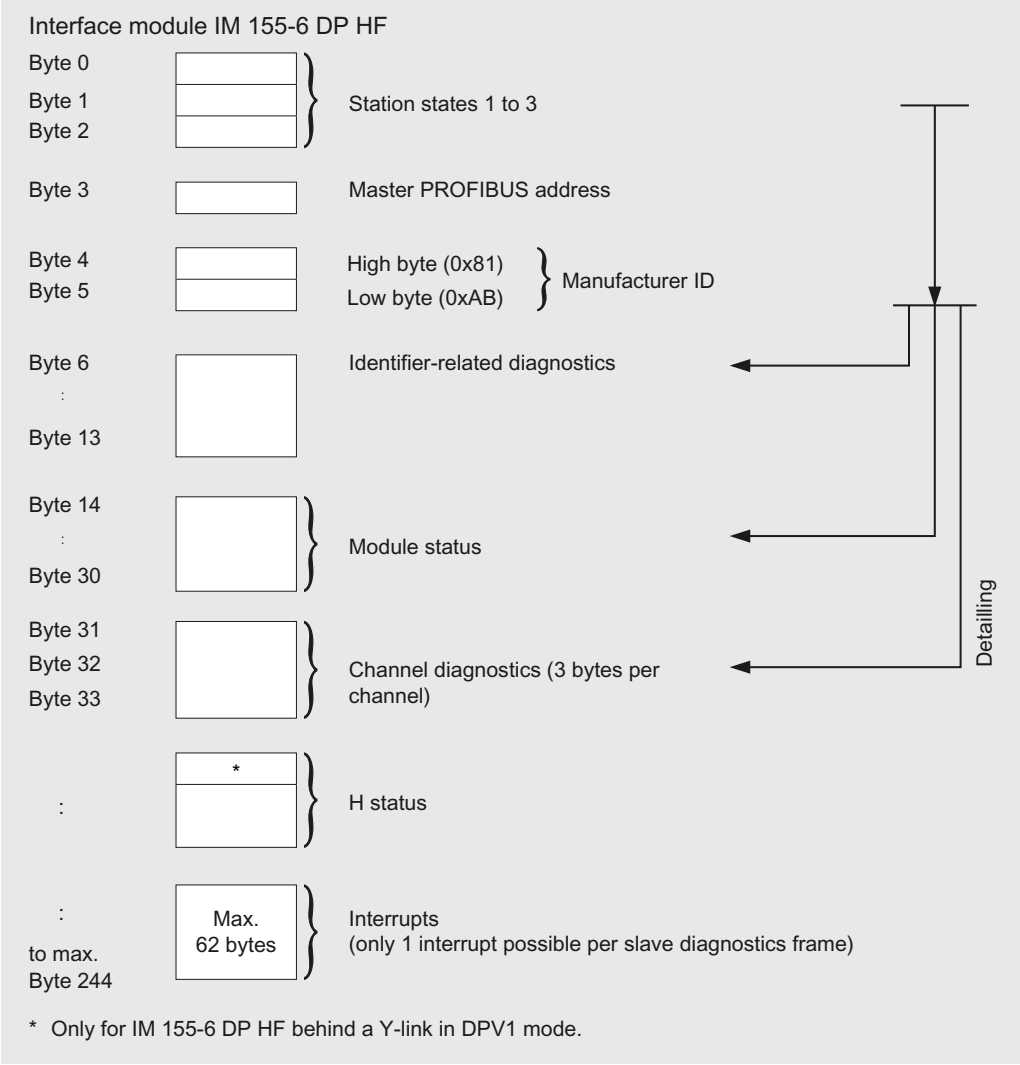

Figure 2-84 Structure of the slave diagnostics

NOTE

The length of the diagnostics frame varies with the IM 155-6 DP HF (depending on parameter assignment) between 6 and 244 bytes in DPV1 mode.

You can identify the length of the last received diagnostics frame in STEP 7 from the RET_VAL parameter of the SFC 13.

5.3.2 Station statuses 1 to 3

Station statuses 1 to 3 provide an overview of the status of a DP slave.

Structure of station status 1 (byte 0)

Table 2-70 Structure of station status 1 (byte 0)

Bit	Meaning	Cause/Remedy
0	1: The DP slave is not responding to the DP master.	• Is the correct PROFIBUS address set on the DP slave? • Is the bus connector plugged in? • Is the DP slave connected to the voltage supply? • Is the RS485 repeater properly configured?
1	1: The DP slave is not yet ready to exchange data.	• Wait; the DP slave is currently starting up.
2	1: The configuration data transferred from the DP master to the DP slave does not match the DP slave configuration.	• Has the correct station type or the correct DP slave configuration been entered in the configuration software?
3	1: External diagnostics is available. (Group diagnostics display)	• Evaluate the ID-specific diagnostics, the module status, and/or the channel diagnostics. As soon as all errors have been eliminated, bit 3 is reset. The bit is set again when there is a new diagnostics alarm in the bytes of the aforementioned diagnostics.
4	1: The required function is not supported by the DP slave (for example, changing the PROFIBUS address by means of software).	• Check the configuration.
5	1: The DP master cannot interpret the response of the DP slave.	• Check the bus configuration.
6	1: The DP slave type does not match the software configuration.	• Has the correct station type been entered in the configuration software?
7	1: Parameters have been assigned to the DP slave by a different DP master (not the one that currently has access to the DP slave).	• The bit is always 1, for example, if you access the DP slave with the programming device or another DP master. • The PROFIBUS address of the DP master that assigned parameters to the DP slave is located in the "Master PROFIBUS address" diagnostics byte.

Structure of station status 2 (byte 1)

Table 2-71 Structure of station status 2 (byte 1)

Bit	Meaning	
0	1:	The DP slave parameters need to be reassigned.
1	1:	A diagnostics alarm is present. The DP slave will not operate until the problem is eliminated (static diagnostics alarm).
2	1:	The bit on the DP slave is always "1".
3	1:	The watchdog is activated for this DP slave.
4	1:	The DP slave has received the "FREEZE" control command.[1]
5	1:	The DP slave has received the "SYNC" control command.[1]
6	0:	Bit is always "0".
7	1:	The DP slave is disabled, that is, it has been removed from the processing in progress.
[1] The bit is updated only if another diagnostics alarm also changes.		

Structure of station status 3 (byte 2)

Table 2-72 Structure of station status 3 (byte 2)

Bit	Meaning	
0 to 6	0:	Bits are always set to "0".
7	1:	• There are more diagnostic alarms pending than the DP slave is able to store. • The DP master cannot enter all the diagnostics alarms sent by the DP slave in its (channel) diagnostics buffer.

5.3.3 Master PROFIBUS address

The master PROFIBUS address diagnostics byte contains the PROFIBUS address of the DP master:

- That assigned parameters to the DP slave
- That has read and write access to the DP slave

The master PROFIBUS address is located in byte 3 of the slave diagnostics.

5.3.4 Identifier-related diagnostics

The identifier-related diagnostics indicates whether modules of the ET 200SP distributed I/O system have errors or not. Identifier-related diagnostics start at byte 6 and comprise 8 bytes.

The figure below shows how the identifier-related diagnostics for the ET 200SP distributed I/O system is structured with the IM 155-6 DP HF interface module:

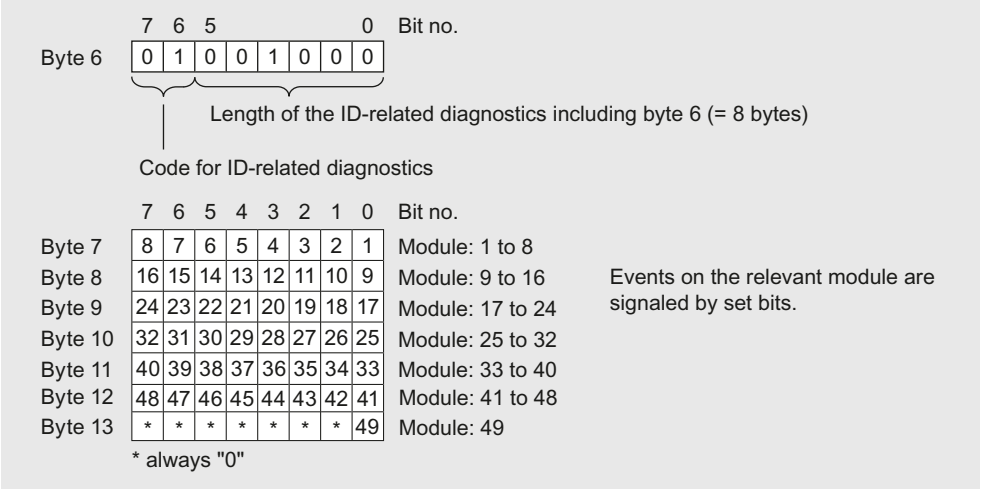

Figure 2-85 Structure of the identifier-related diagnostics

5.3.5 Module status

The module status indicates the status of the configured modules and provides more information on the identifier-related diagnostics with respect to the configuration. The module status begins after the identifier-related diagnostics and comprises 17 bytes.

The following figure shows how the module status for the ET 200SP distributed I/O system is structured with the IM 155-6 DP HF interface module:

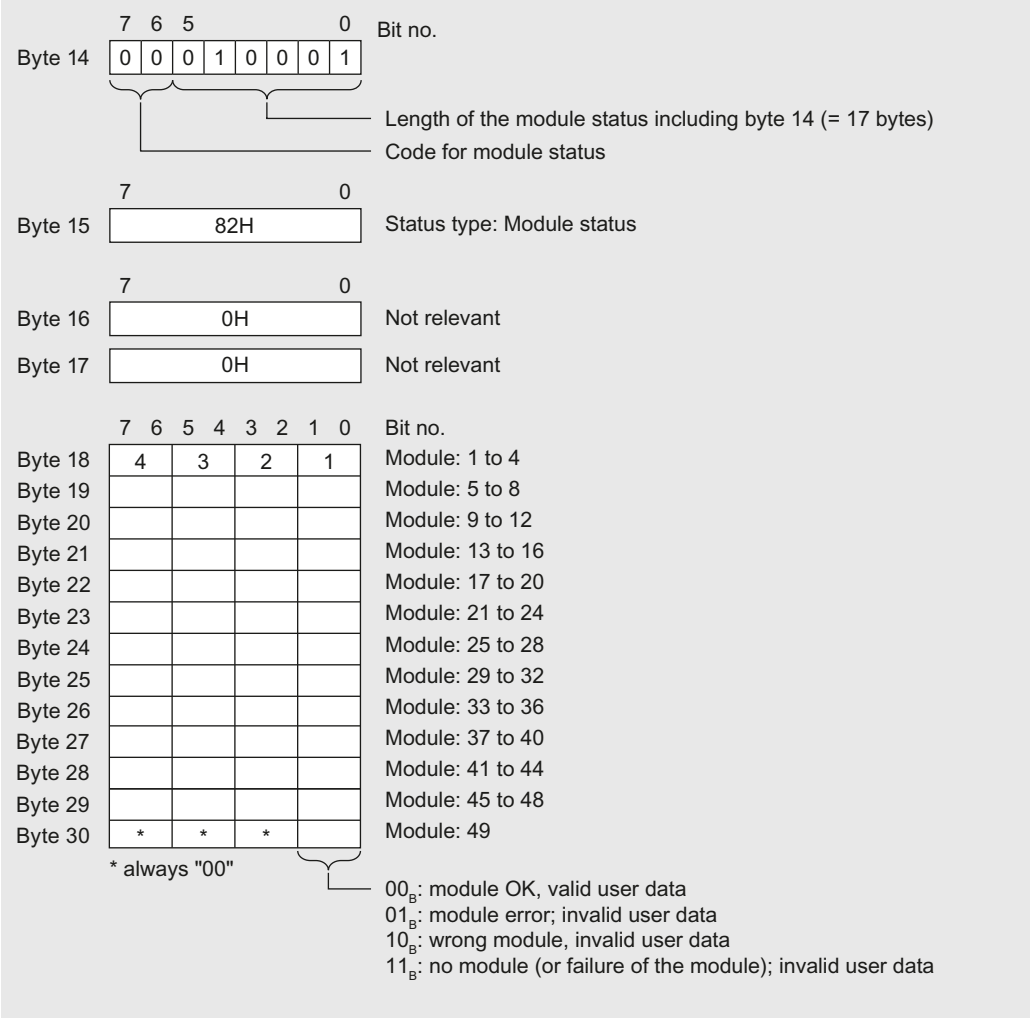

Figure 2-86 Module status structure

5.3.6 Channel diagnostics

Channel diagnostics provides information about channel errors in modules and details of the identifier-related diagnostics. Channel diagnostics begins after the module status. Channel diagnostics does not affect the module status.

The following figure shows how the channel diagnostics for the ET 200SP distributed I/O system is structured with the IM 155-6 DP HF interface module:

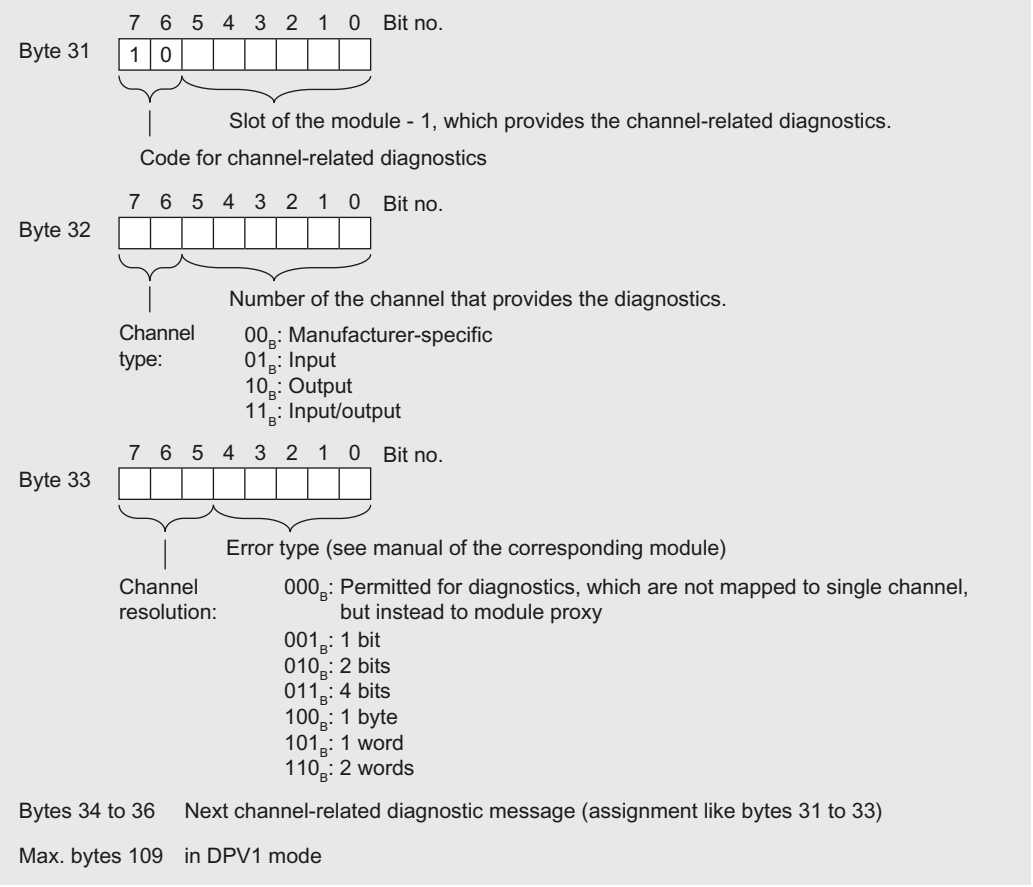

Figure 2-87 Structure of channel diagnostics

When a BaseUnit is incorrectly configured, mapping is made to channel diagnostics. The slot is then apparent from the first byte. In this case, the error type is coded with 0x10 - parameter error. All other fields are set to "0".

5.3.7 H status

Requirements

The H status in the diagnostics frame supplies the IM 155-6 DP HF interface module only when operated behind a Y link (e.g. IM 157) in DPV1 mode. This block can be passed over during the evaluation of the diagnostics frame. The configuration is described in the following section.

Structure of the H status

The following figure shows the structure of the H status of the IM 155-6 DP HF interface module.

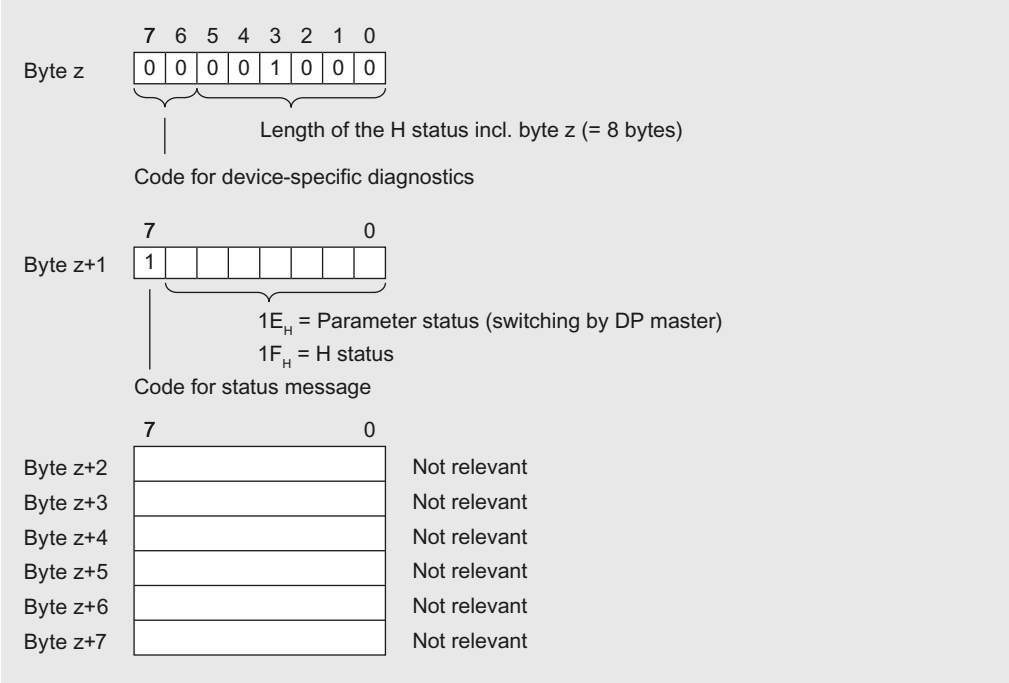

Figure 2-88 Structure of the H status

5.3.8 Invalid configuration states of the ET 200SP on PROFIBUS DP

Incorrect configuration states

The following incorrect configuration states of the ET 200SP distributed I/O system lead to a failure of the DP slave or prevent the start of data exchange.

- Number of modules exceeds maximum configuration.
- Faulty backplane bus (e.g., defective BaseUnit). No interrupt is generated when the ET 200SP backplane bus is interrupted
- No server module
- Configuration exceeds maximum length of 1 m
- Configuration of an incorrect BaseUnit

NOTE

All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) at a station stop. However, the interface module will continue to exchange data.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

Diagnostics

The table below shows the incorrect configurations and their diagnostics:

Table 2-73 Diagnostics

Identifier-related diagnostics	Module status	Cause	Response
Slot 33 set, remaining slots not relevant	Slot 33 with 11_B: ""No module; invalid user data" set	• No server module • More than 32 I/O modules • Defective backplane bus	All I/O modules and interface modules fail
All 33 bits set	01_B: "Module error; invalid user data" for all modules	• Configuration > 1 m	All I/O modules and interface modules fail

If the BaseUnit is configured incorrectly, the channel diagnostics "Parameter assignment error" is signaled for the respective slot. Check the parameter "Potential group" in the parameters of the I/O module.

5.3.9 Load voltage failure on the BaseUnit BU...D

Load voltage failure

If supply voltage fails on the BaseUnit BU...D, the I/O modules react as follows:

- A remove module interrupt is generated if an I/O module is removed during the failure of the supply voltage.
- An insert module interrupt is generated if an I/O module is inserted during the failure of the supply voltage.

Compatibility 6

6.1 Compatibility of modules

Valid firmware versions

The table below lists the valid firmware versions and their field of application for the I/O modules.

I/O modules	Firmware version	Comment
DI 8x24VDC ST	V1.0.1	As of this version, you have the option to operate I/O modules after an IM 155-6 DP HF (6ES7155-6BA00-0CN0) interface module.
DI 16x24VDC ST		
DQ 4x24VDC/2A ST		
DQ 8x24VDC/0.5A ST		
DQ 16x24VDC/0.5A ST		
AI 4xI 2-,4-wire ST		
AI 4xU/I 2-wire ST		
AI 4xRTD/TC 2-,3-,4-wire HF		
AQ 4xU/I ST		

Status of the supply voltage

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules without parameter assignment in the following table, the status of the supply voltage (status byte of the server module) is always signaled as "1" regardless of the actual status of the supply voltage.
- When a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Article number
DI 8x24VDC ST	6ES7131-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7131-6BF00-0CA0
DQ 4x24VC/2A ST	6ES7132-6BD20-0BA0
DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0
DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0
DQ 8x24VDC/0.5A HF	6ES7132-6BF00-0CA0

Plugging and pulling (hot-swapping) of ET 200SP I/O modules

NOTICE

Pulling and plugging (hot swapping) of ET 200SP I/O modules during operation on S7-300 via PROFIBUS DP

ET 200SP I/O modules can be pulled and plugged:

- As of STEP7 V5.5 SP3 HSP 242 and
- If "Operation if preset configuration <> actual configuration" parameter is enabled.

Note the following when operating the ET 200SP with S7-300 via PROFIBUS DP: Plugging of ET 200SP I/O modules results in a brief station failure of the ET 200SP.

NOTE

ET 200SP I/O modules can be pulled and plugged without restrictions for all other DP master systems if you enable the "Pull/plug module (OB83)" parameter.

Communication module IO-Link Master CM 4xIO-Link

NOTE

Communication module IO-Link Master CM 4xIO-Link

Operation of the CM 4xIO-Link IO-Link Master communication module with the IM 155--6 DP HF interface module is supported as of S7-PCT V3.1 and an updated module firmware version/GSD file.

Reaction times for fail-safe modules

The following maximum reaction time of the interface module must be taken into account when calculating the reaction times of fail-safe modules: **Maximum reaction time = 2.3 ms**

First BaseUnit of an ET 200SP in the configuration

The interface modules support plugging a dark-colored BaseUnit in slot 1. This means that modules without a connection to the integrated voltage buses P1 and P2 can now also be configured starting with slot 1. Currently, this applies to the following modules:

- AI EnergyMeter ST (6ES7134-6PA00-0BD0)
- DI 4x120 ... 230VAC ST (6ES7131-6FD00-0BB1)
- DQ 4x24 ... 230VAC/2A ST (6ES7132-6FD00-0BB1)

NOTE

First BaseUnit of an ET 200SP in the configuration

Please note the information on limiting the overvoltage and power rating in the AC I/O module manuals.

The 24 V DC supply voltage is fed in via an external fuse.

The 24 V DC supply voltage is provided by a light-colored BaseUnit.

Requirement for configuration of these modules in slot 1:

- Configuration via GSD or GSDML
- Configuration as of STEP7 V5.5 SP4 as of
  - HSP0242 V2.0 for IM155-6 DP HF
- Configuration as of STEP7 V13 SP1

See also: Functions (Page 12)

Technical specifications 7

7.1 Technical specifications

Technical specifications of the IM 155-6 DP HF

The following table shows the technical specifications as of 08/2018. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7155-6BA01-0CN0/td?dl=de).

Article number	6ES7155-6BA01-0CN0
General information	
Product type designation	IM 155-6DP HF with PROFIBUS connector and server module
Firmware version	V4.2
Product function	
• I&M data	Yes; I&M0 to I&M3
• Module swapping during operation (hot swapping)	Yes; Multi-hot swapping
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V15 SP1
• STEP 7 configurable/integrated as of version	As of V5.5 SP4, only up to FW V3.1
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
Configuration control	
via dataset	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	10 ms
Input current	
Current consumption, max.	335 mA
Inrush current, max.	1.6 A
I^2t	0.038 $A^2 \cdot s$
Power loss	
Power loss, typ.	1.5 W

Article number	6ES7155-6BA01-0CN0
Address area	
Address space per module	
• Address space per module, max.	32 byte; per input / output
Address space per station	
• Address space per station, max.	244 byte; per input / output
Hardware configuration	
Rack	
• Modules per rack, max.	32; + 16 ET 200AL modules
Interfaces	
Number of PROFIBUS interfaces	1
1. Interface	
Interface types	
• RS 485	Yes
• Output current of the interface, max.	90 mA
Protocols	
• PROFIBUS DP slave	Yes
RS 485	
• Transmission rate, max.	12 Mbit/s
PROFIBUS DP	
Services	
– SYNC capability	Yes
– FREEZE capability	Yes
– DPV0	Yes
– DPV1	Yes
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Status indicator	Yes
Alarms	Yes
Diagnostics function	Yes
Diagnostics indication LED	
• RUN LED	Yes; Green LED
• ERROR LED	Yes; Red LED
• MAINT LED	Yes; yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Connection display DP	Yes; Green DP LED

Article number	6ES7155-6BA01-0CN0
Potential separation	
between backplane bus and electronics	No
between PROFIBUS DP and all other circuit components	Yes
between supply and all other circuits	No
Permissible potential difference	
between different circuits	Safety extra low voltage SELV
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Connection method	
ET-Connection	
• via BU/BA Send	Yes; + 16 ET 200AL modules
Dimensions	
Width	50 mm
Height	117 mm
Depth	74 mm
Weights	
Weight, approx.	150 g

Dimension drawing

A

This appendix contains a dimension drawing of the module installed on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

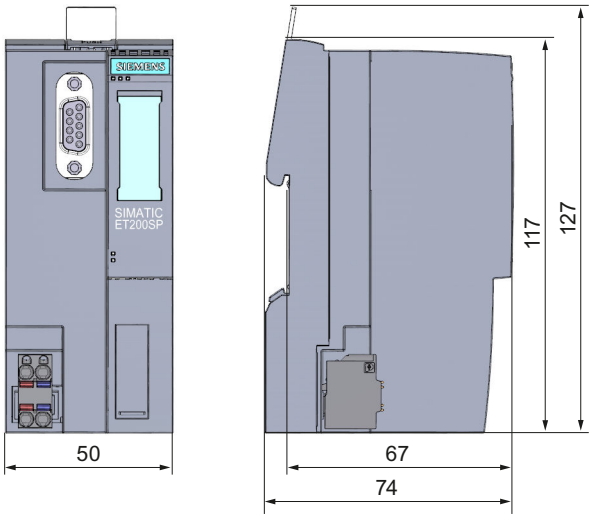

Figure 2-89 Dimension drawing of the IM 155-6 DP HF interface module (front and side view)

SIEMENS

SIMATIC

ET 200SP
Interface module IM 155-6 MF HF (6ES7155-6MU01-0CN0)

Equipment Manual

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Introduction 1

1.1 Introduction

Purpose of the documentation

This equipment manual supplements the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in the system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used hereinafter, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.2 ET 200SP Documentation Guide

1.2.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/84133942)

1.2.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.2.3 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

See also

PRONETA Professional (https://support.industry.siemens.com/cs/ww/en/view/109781283)

1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is PC-based software and supports the configuration of MultiFieldbus-Devices and DALI-modules. In addition, the MFCT offers convenient options for bulk firmware updating of ET 200 devices with MultiFieldbus-support and reading of service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI modules.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- CM PtP:
  Analysis of serial communication, event logs and reading of the current configuration.

- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109773881)

Industrial Cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

You can find more general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-related information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

2.3 Cybersecurity-relevant information

Observe all cybersecurity-relevant information.

Topics with cybersecurity-relevant information	Reference
Operational application environment and security assumptions	
Requirements for the operational application environment of the system and security assumptions	You can find this section in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Security properties of the product	
Access protection	Note the information on access protection in the Protection chapter of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Data integrity	The topic of data integrity is described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Signed firmware update	The topic of signed firmware updates is described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
PROFINET Security Class 1 • The device supports PROFINET Security Class 1. • With the introduction of PROFINET Security Class 1, additional security settings have been integrated into the PROFINET communication.	Detailed information about PROFINET Security Class 1 and the additional security settings can be found in the PROFINET with STEP 7 Function Manual (https://support.automation.siemens.com/WW/view/en/49948856)
Supported Ethernet services	You can find information on supported services in the Technical specifications (Page 93) section. You can find detailed information about supported Ethernet services in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
Interfaces, ports, protocols and services	
Information on the following is security-relevant: • Communication layer and communication role • Default states • Enabling/disabling of ports and services	You can find detailed information on these topics in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
Secure operation	
Recommendations for safe operation	You can find cross-system information on the safe operation of interface modules in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Corrective measures for known risks	Corrective measures for known risks are announced on the Siemens ProductCERT and Siemens CERT (https://siemens.com/productcert) web page. You can find more information on SIEMENS ProductCERT in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Topics with cybersecurity-relevant information	Reference
Security checks	You can find descriptions of specific security measures, such as cyclic checks of the configuration via checksums, in the Industrial cybersecurity section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Secure decommissioning Products that contain security-relevant data must be securely decommissioned before disposal or resale.	You can find information on secure decommissioning in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293), Secure operation of the system section

Product overview

3

3.1 Properties

Article number

6ES7155-6MU01-0CN0 (IM 155-6 MF HF interface module and server module)

View of the module

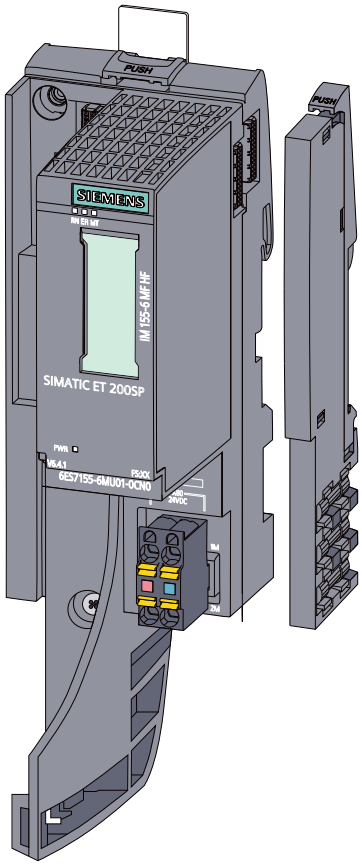

Figure 2-90 View of the 155-6 MF HF interface module with included accessories (24 V DC connector and server module) and optional accessories (labeling strips, cable grip and equipment labeling plate)

Properties

The module has the following technical properties:

- Using the MultiFieldbus function, it connects the ET 200SP distributed I/O system with
  - PROFINET IO
  - EtherNet/IP
  - Modbus TCP
- Compatible with the 155-6 PN/2 HF interface module (except for isochronous mode, topology, prioritized startup and BusAdapter with fiber-optic cable connection)
- The system benefits of the ET 200SP distributed I/O system can also be used with the fieldbus protocols EtherNet/IP and Modbus TCP:
  - MF Shared Device: The fieldbus can be selected for each submodule.
  - Low space requirements
  - Extensive range of modules (section "Modules that can be used with EtherNet/IP (Page 55)" and section "Modules that can be used with Modbus TCP (Page 71)")
  - Multi hot swapping
  - Dynamic reconfiguration of the modules via the user program
- No system change or replacement of the interface module of the I/O is required when using different controllers.

  (series machine manufacturers with end customers in various regions around the world)
- Use of different fieldbus protocols is possible depending on the region and application.
- Power supply 1 L+ 24 V DC (SELV/PELV). The connection plug is included in the scope of delivery of the interface module.
- Supported topologies
  - Linear bus topology
  - Star topology
  - Tree topology
- Use of fail-safe modules

Bit-flip robustness

Natural radiation can affect electronics, especially at broad wavelengths. This could result in unwanted changes to the bits in the electronic memory and damage to the system. The hardware and software of the interface modules are therefore tested in a laboratory radiation environment (neutron particle accelerators) to check their susceptibility to bit flipping. In addition, automatic error code correction is implemented on both the firmware and hardware level. All measures taken result in an increase in the radiation resistance of the interface module, which is particularly important for critical applications.

Maximum configuration

- 64 ET 200SP I/O modules +16 ET 200AL modules
- 1 440 bytes I/O data
- 1 m backplane bus (without interface module)

Maximum amount of I/O data (PROFINET IO)

Gross data length (for input data and output data):
Without system redundancy S2:

- 1 440 bytes
- 1 440 bytes for shared device with 2 IO controllers (in total for both IO controllers)
- 360 bytes for shared device with more than 2 IOC (per IO controller)

With system redundancy S2:

- 1 440 bytes
- 360 bytes for system redundancy S2 and shared device with min. 1 additional IOC (per IO controller)

The number of maximum net data lengths for input and output data depends on the number and type of I/O modules used, including the ET 200AL modules.

Net data length (for input data and output data):
The following minimum lengths can be applied without shared device and without explicit calculation of the maximum net data length.

- 933 bytes without and with system redundancy S2

Calculation of the max. net data length:
Max. net data length = "Max. gross data length" - "Total number of I/O submodules (no user data, input or output data)" - "Number of I/O mixed submodules (input and output data)" - "5 bytes for interface module and server module without ET connection (6 bytes for interface module with ET connection)"

The result of the calculation of the maximum net data length applies equally to input and output data.

NOTE

The maximum usable I/O data for EtherNet/IP and Modbus TCP is available in the "Technical specifications (Page 93)" section.

Accessories

You order the following accessories separately:

- BA 2×RJ45 BusAdapter for RJ45 bus cable connector
- BA 2xM12 BusAdapter for bus cable with M12 plug
- BA 2×FC BusAdapter for direct connection of the bus cable
- 24 V DC connector
- Labeling strips
- Equipment labeling plate
- Cable grip
- M12 unlatching straps
- SIMATIC system rail
- S5 rails

Information on the BusAdapters is available in the BusAdapter (https://support.industry.siemens.com/cs/ww/en/view/109751716) manual.

You can find more information on accessories in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Server module

The server module as of V1.2 (TIA Portal as of V19 with HSP0065, STEP7 Classic V5.6 with HSP0236 V4.0) is included in the scope of delivery of the interface module and is available separately as a spare part.

The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system
- Includes a holder for 3 spare fuses (5 × 20 mm).
- Provides station functions, e.g., group diagnostics: No supply voltage L+, status bytes.
- Supports I&M identification data
- Required for device replacement without a programming device if you are using an MF connection

NOTE

You need to configure and assign parameters to the server module in the configuration software.

To do this, place the server module in the last configuration slot and enable the parameter Group diagnostics: missing supply voltage L+. If there are 64 I/O modules, the server module is plugged in slot 65.

You can find more information in the Server module (https://support.automation.siemens.com/WW/view/en/63257531) manual.

First BaseUnit of an ET 200SP in the configuration

NOTE

First BaseUnit of an ET 200SP in the configuration

When an AC I/O module or AI Energy Meter ST is plugged, the first BaseUnit in an ET 200SP station may be a dark one. Note the information on limiting the overvoltage and power rating in the AC I/O module manuals.

To route the 24 V DC supply voltage via a fuse, a light BaseUnit must be plugged into the slot of the first 24 V DC I/O module.

Pay attention to the type of the BaseUnits during configuration.

See also

PROFINET IO functions (Page 21)

EtherNet/IP functions (Page %getreference)

Modbus TCP functions (Page %getreference)

3.2 MultiFieldbus engineering

MultiFieldbus Configuration Tool (MFCT)

The configuration and parameter assignment of the IM 155-6 MF HF interface module is created and downloaded with MFCT, and stored retentively in the interface module.

MFCT creates the following files and makes them available:

- User Defined Data Types (UDT) file (file extension *.l5x), enables structured access to I/O data with Ethernet/IP.
- Electronic Data Sheet (EDS) according to CIP specification Vol.1 for integration into EtherNet/IP configuration systems (the EDA file is also available for download (https://support.industry.siemens.com/cs/ww/en/ps/27993))
- Comma Separated Values (CSV), contains the I/O data mapping of your configuration

You can find additional information on MFCT in the "MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209)" function manual.

3.3 Detect active fieldbus

For exclusive operation on a fieldbus (not MF Shared Device) you can recognize the active fieldbus by the number of green LEDs on the MF device.

This requires that there are no errors and that the MF device is in cyclic data exchange with a controller.

LED schematic:	RN/NS	ER/MS	MT/IO
PROFINET	■ Green	□ Off	□ Off
Modbus TCP	■ Green	■ Green	□ Off
EtherNet/IP	■ Green	■ Green	■ Green

PROFINET IO

4

4.1 PROFINET IO functions

Introduction

The interface module supports the following PROFINET IO functions:

- Integrated switch with 2 ports
- Supported Ethernet services: ICMP, ARP, SNMP, LLDP
- Port diagnostics
- Deactivating ports
- Isochronous real-time communication
- Minimum update time 250 µs
- Prioritized startup
- Isochronous mode
- Device replacement without programming device (PG) and without topological configuration
- Reset to factory settings via PROFINET IO or RESET button (station-wide)
- Reset to factory settings via PROFINET IO (Factory Mode 8)
- Identification data I&M 0 to I&M 4
- Firmware update via PROFINET IO
- Performance upgrade PROFINET (DFP, FFT, fragmentation)
- Media redundancy (MRP and MRPD)
- Shared device
- Distribution of module channels to submodules
- Support of 17 submodules
- Module-internal or submodule-internal Shared Input/Shared Output (MSI/MSO)
- S2 system redundancy
- Station extension via ET-Connection
- Supports BusAdapter for different connection systems to PROFINET IO:
  - BA 2×RJ45 for RJ45 bus connection connector
  - BA 2xM12 for bus cable with M12 plug
  - BA 2×FC for direct connection of the bus cable
- Value status (quality information, QI) of I/O modules
- PROFIenergy

- Removal/insertion of multiple I/O modules during operation (multi hot swap)
- Module-to-Module Communication (MtM)
- Configuration control (option handling)
- Setting the time
- Time distribution
- Use of fail-safe modules
- Use of technology modules
- Maximum user data length per module: 288 bytes
- Reading out service data
- Reference temperature distribution
- Diagnostic interrupts
- Hardware interrupts
- Maintenance events
- Interface-local coupling of IO data
- Alternating IO devices during operation ("docking systems")

Requirements

The table below shows the software requirements for a configuration with the IM 155-6 MF HF interface module:

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software [2]		
			Configuration with GSD file (https://support.automation.siemens.com/WW/view/en/19698639/130000)/software from a third-party manufacturer [1]	STEP 7 Classic	STEP 7 (TIA Portal)
Integrated switch with 2 ports	1	V6.2.1	X	X	X
Supported Ethernet services: ICMP, ARP, SNMP, LLDP	1	V6.2.1	X	X	X
Port diagnostics	1	V6.2.1	X	X	X
Deactivating ports	1	V6.2.1	X	X	X
Isochronous real-time communication	1	V6.2.1	X	X	X
Minimum update time 250 µs	1	V6.2.1	X	X	X
Prioritized startup	1	V6.2.1	X	X	X
Isochronous mode	1	V6.2.1	-	X	X

1 Systems of third-party manufacturers: Depending on the range of functions of the third-party system

2 Replacement parts scenario

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software [2]		
			Configuration with GSD file (https://support.automation.siemens.com/WW/view/en/19698639/130000)/software from a third-party manufacturer [1]	STEP 7 Classic	STEP 7 (TIA Portal)
Device replacement without programming device (PG) and without topological configuration	1	V6.2.1	X	X	X
Reset to factory settings via PROFINET IO or RESET button	1	V6.2.1	X	X	X
Reset to factory settings via PROFINET IO (Factory Mode 8)	1	V6.4.1	X	X	X
Identification data I&M 0 to I&M 4	1	V6.2.1	X	X	X
Firmware update via PROFINET IO	1	V6.2.1	X	X	X
Performance upgrade PROFINET (DFP, FFT, fragmentation)	1	V6.3.1	X	X	X
Media redundancy (MRP and MRPD)	1	V6.2.1	X	X	X
Shared device	1	V6.2.1	X	X	X
Distribution of module channels to submodules	1	V6.2.1	X	X	X
Support of 17 submodules	1	V6.4.1	X	X	X
Module-internal or submodule-internal Shared Input/Shared Output (MSI/MSO)	1	V6.2.1	X	X	X
S2 system redundancy	1	V6.2.1	X	X	X
Station extension via ET-Connection	1	V6.2.1	X	X	X
Supports BusAdapter for different connection systems to PROFINET IO	1	V6.2.1	X	X	X
Value status (quality information, QI) of I/O modules	1	V6.2.1	X	X	X
PROFIenergy	1	V6.2.1	X	X	X
Removal/insertion of multiple I/O modules during operation (multi hot swap)	1	V6.2.1	X	X	X
Module-to-Module Communication (MtM)	1	V6.2.1	X	X	X

1 Systems of third-party manufacturers: Depending on the range of functions of the third-party system

2 Replacement parts scenario

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software [2]		
			Configuration with GSD file (https://support.automation.siemens.com/WW/view/en/19698639/130000)/software from a third-party manufacturer [1]	STEP 7 Classic	STEP 7 (TIA Portal)
Configuration control (option handling)	1	V6.2.1	X	X	X
Setting the time	1	V6.2.1	X	X	X
Time distribution	1	V6.2.1	X	X	X
Use of fail-safe modules	1	V6.2.1	X	X	X
Use of technology modules	1	V6.2.1	X	X	X
Maximum user data length per module: 288 bytes	1	V6.2.1	X	X	X
Reading out service data	1	V6.2.1	X	X	X
Reference temperature distribution	1	V6.2.1	X	X	X
Diagnostic interrupts	1	V6.2.1	X	X	X
Hardware interrupts	1	V6.2.1	X	X	X
Maintenance events	1	V6.2.1	X	X	X
Interface-local coupling of IO data	1	V6.2.1	X	X	X
Alternating IO devices during operation ("docking systems")	1	V6.2.1	X	X	X

1 Systems of third-party manufacturers: Depending on the range of functions of the third-party system

2 Replacement parts scenario

The following table shows the appropriate version of the configuration software depending on the functional status of the module.

Table 2-74 Version of the configuration software depending on the functional status of the module

Firmware version of the module	STEP 7 Classic	STEP 7 (TIA Portal)
As of V6.1	As of STEP 7 V5.5 SP4 with HSP0329 V1.0	As of V18 with HSP0415 V1.0
As of V6.2	As of STEP 7 V5.6 with HSP0329 V2.0	As of V19 with HSP0415 V1.0
As of V6.3	As of STEP 7 V5.7 SP3 HF3 with HSP0342 V1.0	As of V19 with HSP0415 V2.0
As of V6.4	As of STEP 7 V5.7 SP3 HF3 with HSP0342 V2.0	As of V20 with HSP0415 V2.0

Cabling with fixed connection setting

If you set a fixed connection setting of the port in STEP 7, you must also disable "Autonegotiation/Autocrossover".

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 (TIA Portal) V12, in the PROFINET with STEP 7 (https://support.automation.siemens.com/WW/view/en/49948856) function manual.
- As of STEP 7 V5.5, in the PROFINET System Description (https://support.automation.siemens.com/WW/view/en/19292127) system manual.

See also

Compatibility of modules (Page 89)
ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293)
PROFINET with STEP 7 (https://support.automation.siemens.com/WW/view/en/49948856)

4.1.1 Supported Ethernet services: ICMP, ARP, SNMP, LLDP

The module supports the following standardized Ethernet services:

- **ICMP - Internet Control Message Protocol (RFC 792)**

ICMP is a protocol used to transmit informational and error messages over the Internet protocol.

- **ARP - Address Resolution Protocol (RFC 826)**

ARP is a protocol used to determine the hardware address (MAC) of an associated Internet protocol (IP) address.

- **SNMP - Simple Network Monitoring Protocol (RFC 1157, RFC 3410)**

SNMP is a protocol for transmitting management information across networks.

- **LLDP – Link Layer Discovery Protocol (IEEE 802.1AB)**

LLDP is a protocol for identifying neighboring devices.

4.1.2 Port diagnostics

Depending on the BusAdapter used, the device supports special diagnostic alarms that signal the quality of data transfer on the medium used.

4.1.3 Disabling of ports

The device supports the deactivation of the port by parameter assignment, so that all communication on this port is prevented.

4.1.4 Isochronous real-time communication

Synchronized transmission method for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth within the send clock is available for IRT data. The reserved bandwidth ensures that the IRT data is also transmitted in time-synchronized intervals, unaffected by other high network loading (e.g. TCP/IP communication or additional real time communication).

A topological configuration is required for IRT.

NOTE

IO controller as sync master with IRT communication

Operation of the IO controller as a sync master is recommended when configuring the IRT communication.

Otherwise, IRT- and RT-configured IO devices may fail if the sync master fails.

You can find more information on the configuration of synchronized PROFINET devices in sync domains in the STEP 7 online help and:

- As of STEP 7 V12 in the PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5 in the PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

4.1.5 Minimum update time 250 µs

The shortest update cycle of IO data for this device is 250 µs. To achieve this value, the controller used must also support this time.

4.1.6 Prioritized startup

Prioritized startup is a PROFINET IO function in a PROFINET IO system with IRT and RT communication. It reduces the time needed for correspondingly configured IO devices to return to cyclic user data exchange.

This function accelerates the startup of IO devices in the following cases:

- After recovery of supply voltage
- After station recovery
- After activation of IO devices

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.
- As of STEP 7 V5.5 in the PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127) system manual.

4.1.7 Isochronous mode

An isochronous system acquires measured values and process data within a fixed system cycle, processes the signals and outputs them synchronously to the process.

You can find more information on isochronous mode in the PROFINET with STEP7 (https://support.automation.siemens.com/WW/view/en/49948856) function manual.

4.1.8 Device replacement without programming device (PG) and without topological configuration

Device replacement without topological configuration

The configuration and parameter assignment data of the MF device is also saved on the server module in addition to the interface module. The MF configuration and parameter assignment data stored on the server module are required for device replacement without a programming device.

Replacing the interface module then results in different possible uses for the MF configuration and parameter assignment data.

Table 2-75 Scenarios for using the MF configuration and parameter assignment data

	Interface module empty	**Interface module with CFG and PRM data**
Server module without CFG and PRM data	No CFG and PRM data	The CFG and PRM data from the interface module is used and copied to the server module.
Server module with CFG and PRM data	The CFG and PRM data from the server module is used and copied to the interface module.	The CFG and PRM data from the server module is used and copied to the interface module if it contains other CFG and PRM data.

Be aware of the following constraints:

- Restoring the factory settings deletes the CFG and PRM data in both the interface module and the server module. To prevent the CFG and PRM data from being deleted in the server module, you can remove the server module from the interface module before restoring the factory settings.
- When a server module is replaced, the CFG and PRM data stored in the server module is transferred to the interface module with POWER ON.
- Use server module as of V1.2.0.

The device name is also stored on the BusAdapter in addition to the interface module. A device name saved on the BusAdapter is the requirement for device replacement without topological configuration.

Replacing the interface module produces a range of scenarios for using the device name.

Table 2-76 Scenarios for using the device name

	Interface module empty	**Interface module with device name**
BusAdapter without device name	No device name available	The device name from the interface module is used and copied to the BusAdapter.
BusAdapter with device name	The device name from the BusAdapter is used and copied to the interface module.	The device name from the BusAdapter is used and copied to the interface module if this has a different device name.

Be aware of the following constraints:

- Resetting to factory settings deletes the device name in both the interface module and the BusAdapter. To prevent the device name from being deleted in the BusAdapter, you can remove the BusAdapter from the interface module before resetting to factory settings.
- When a BusAdapter is replaced, a device name stored in the BusAdapter is applied to the interface module after a POWER ON.
- Do not pull/plug the BusAdapter while under voltage.

Device replacement with topological configuration

IO devices with this function can be replaced in a simple manner:

- The device name does not have to be assigned with the programming device.

The replacement IO device is assigned the device name by the IO controller and not by the programming device. The IO controller uses the configured topology and the neighboring relationships determined by the IO devices for this purpose. All involved devices must support the LLDP protocol (Link Layer Discovery Protocol). The configured target topology must match the actual topology.

If the IO devices were already used in another configuration, reset them to factory settings before reusing them. You can find more information in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 (TIA Portal) V12, in the PROFINET with STEP 7 (https://support.automation.siemens.com/WW/view/en/49948856) function manual.
- As of STEP 7 V5.5 in the PROFINET system description (https://support.automation.siemens.com/WW/view/en/19292127) system manual.

4.1.9 Reset to factory settings

There are two modes for resetting to factory settings:

- Resetting to factory settings via PROFINET IO or the RESET button deletes the device name, IP address, service data and I&M data 1-4 both in the selected interface module and in the corresponding BusAdapter and server module.
- Resetting via PROFINET IO using Factory Mode 8 deletes the IP address, service data and I&M data 1-4 in the device and all associated modules that support resetting to factory settings.

4.1.10 Identification data I&M 0 to I&M 4

Identification and maintenance data (I&M data) is information saved on the module. The data is:

- Read-only (I-data) or
- Readable/writable (M-data)

Identification data (I&M0): Manufacturer information about the module that can only be read. Some identification data is also printed on the housing of the module, for example article number and serial number.
Maintenance data (I&M1, 2, 3): Plant-dependent information, e.g. installation location.

Maintenance data is created during configuration and downloaded to the module.
All modules of the ET 200SP distributed I/O system support identification data (I&M0 to I&M3).

Checksums CRC (I&M4): The interface module calculates checksums based on its used data and the supplied data from the associated modules, such as parameter settings, IP address, device name, MAC address and I&M data. The interface module stores the checksums in the I&M4 data area.

The I&M identification data supports you in the following activities:

- Checking the system configuration
- Locating hardware changes in a plant
- Correcting faults in a plant
- Inspection of safe operation of a plant

Modules can be clearly identified online using the I&M identification data.

With TIA Portal, you can read out the identification data I&M (see online help of the TIA Portal).

IM4 is write-protected due to information integrity. You can find more information on the identification data I&M0 to I&M3 in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

NOTE

I&M4 can be read by an application in the PLC.

4.1.11 Firmware update via PROFINET IO

You can find information on how to perform a firmware update in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

4.1.12 Performance upgrade PROFINET (DFP, FFT, fragmentation)

Dynamic Frame Packing (DFP)

Dynamic Frame Packing (DFP) optimizes the PROFINET communication by combining multiple small frames into larger packets.

- Reduces network overhead and improves bandwidth utilization
- Helps reduce network load and improves real-time performance
- Particularly effective when many small data packets have to be transmitted.

Fast Forwarding Technology (FFT)

Fast Forwarding Technology (FFT) is an advanced switching technology that accelerates frame forwarding in PROFINET networks.

- Reduces latency through frame processing at hardware level.
- Enables cut-through switching instead of store-and-forward
- Particularly important for time-critical applications

Frame fragmentation

Frame fragmentation enables large data packets to be split into smaller fragments.

- Enables better coexistence of real-time and non-real-time data traffic.
- Prevents time-critical frames from being blocked by large data packets.
- Improves the overall network determinism.

Preamble shortening

Preamble shortening is a PROFINET optimization method that reduces the standard Ethernet frame preamble length to improve network performance.

4.1.13 Media redundancy (MRP and MRPD)

Function for safeguarding communication and plant availability. A ring topology ensures that an alternative communication path is made available if a transmission route fails.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12, in the PROFINET with STEP 7 (https://support.automation.siemens.com/WW/view/en/49948856) function manual.
- As of STEP 7 V5.5 in the PROFINET system description (https://support.automation.siemens.com/WW/view/en/19292127) system manual.

4.1.14 Shared device

IO device that makes its data available to up to four IO controllers.

The interface module supports shared device at submodule level.

If **there is no validity check of the shared device projects by the Engineering System**, note the following:

- Make sure the configurations are consistent. Assign each module or submodule to only one IO controller. Multiple assignment will result in an error as the module or submodule will only be available in the first controller.
- If you reconfigure the shared device configurations without the validity check mentioned above, you must commission ET 200SP again. This means you must download the projects of all involved IO controllers to the respective CPU again after reconfiguration. If necessary, perform a POWER OFF/POWER ON of the interface module.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12, in the PROFINET with STEP 7 (https://support.automation.siemens.com/WW/view/en/49948856) function manual.
- As of STEP 7 V5.5 in the PROFINET system description (https://support.automation.siemens.com/WW/view/en/19292127) system manual.

NOTE

In the case of a shared device application, make sure that all controllers work with the same send clock. If the controller does not have the same send clock, this results in communication relationships not being set up.

If you set up all controllers in one project, the same send clock is ensured. Set the same send clock for engineering in separate projects.

4.1.15 Distribution of module channels to submodules

Support of submodules on suitable I/O modules

The IM 155-6 MF HF interface module supports the division of I/O modules into up to 17 submodules. This allows parts of an I/O module to be separately configured and parameterized.

A maximum of 256 submodules are supported. Of these, four submodules are used for the interface module, one submodule for the server module, and one submodule for each unused slot.

You can assign each of these submodules to different IO controllers.

The following functions are only executed if you have configured submodule 1 during configuration:

- Firmware update
- Write I&M data
- Calibration
- PROFIenergy

4.1.16 Module-internal or submodule-internal Shared Input/Shared Output (MSI/MSO)

The Module-internal Shared Input function allows an input module to make its input data available to up to four IO controllers. Each controller has read access to the same channels.

The Module-internal Shared Output function allows an output module to be operated by up to four IO controllers. One IO controller has write access. Up to three additional IO controllers can have read access to the same channels.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the PROFINET with STEP 7 (https://support.automation.siemens.com/WW/view/en/49948856) function manual.
- As of STEP 7 V5.5, in the PROFINET system description (https://support.automation.siemens.com/WW/view/en/19292127) system manual.

4.1.17 Interface-local coupling of IO data (MSO)

Module-internal shared output

In this example, IO data is transferred from one controller to other controllers via the PROFINET interface X1 using module-internal shared output.

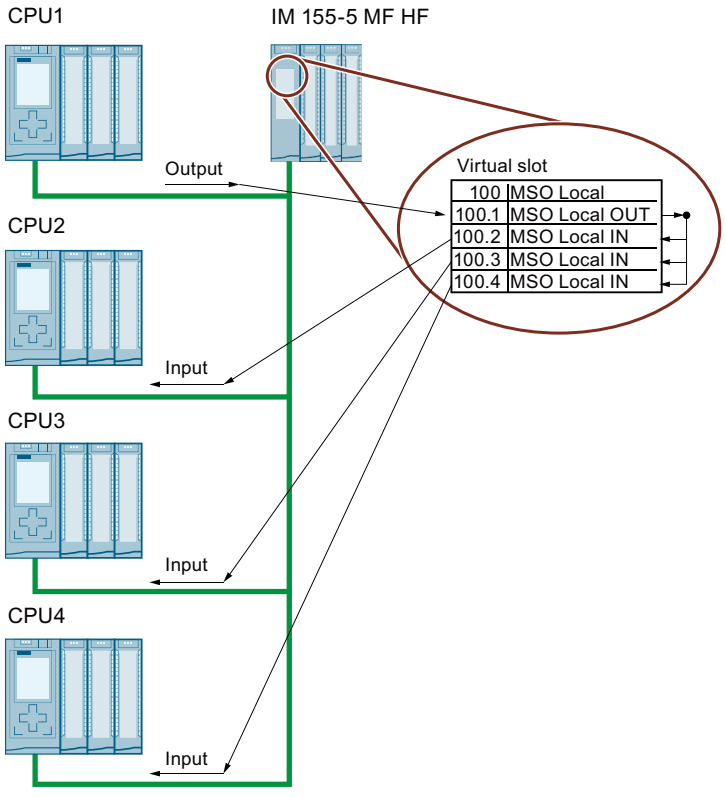

Figure 2-91 IO data is transferred to other controllers in the same PROFINET network

Configuration

Table 2-77 Configuration example

Virtual slot	Type	I length	Q length	Access
100	MSO Local	-	-	-
100.1	MSO Local OUT	-	4 bytes	CPU 1
100.2	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 2
100.3	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 3
100.4	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 4

Editing in the user program

The controller CPU 1 writes IO data to the MSO Local OUT module with virtual slot 100.1 of the interface module. The data is available to CPUs 2 to 4 for reading with the remaining MSO Local IN modules. The validity of the provided user data is displayed by the data status byte (DS) of the MSO Local IN modules.

This example can also:

- Be used with fewer controllers
- Be configured with other virtual modules

NOTE
Virtual IO modules
The use of virtual IO modules increases the communication load. This increases the data update time of all IO data accordingly.

4.1.18 System redundancy S2

An IO device with S2 system redundancy supports redundant ARs.

In a redundant system, an IO device with system redundancy S2 has a redundant AR for each of the two CPUs (IO controllers). If one CPU fails, the IO device with S2 system redundancy remains accessible to the remaining IO controller via the AR.

The interface module supports system redundancy S2 on S7-400H CPUs and on S7-1500R/H CPUs.

You can find more information in the STEP 7 online help and

- As of STEP 7 V12, in the PROFINET with STEP 7 (https://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET system description (https://support.automation.siemens.com/WW/view/en/19292127) system manual

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NOTE

Restrictions in operation with activated system redundancy S2

You cannot use the following functions during operation of the IM155-6 MF HF, firmware version V6.2 with activated system redundancy S2:

- Configuration control (option handling)
- Module-to-Module Communication (MtM)

4.1.19 Station extension via ET connection

Station expansion via ETConnection enables the flexible addition of further stations to an existing automation system. The Ethernet-based connection (ETConnection) allows additional I/O modules or stations to be seamlessly integrated into the plant structure without requiring major changes to the existing configuration.

4.1.20 Value status (quality information, QI) of I/O modules

The IM 155-6 MF HF interface module supports I/O modules with value status. The value status provides information about the validity of the individual process values.

You can find more information on the value status in the system manual (https://support.automation.siemens.com/WW/view/en/58649293) and in the I/O module manuals.

4.1.21 PROFIenergy

Properties

PROFIenergy (for PROFINET) reduces the energy consumption by using PROFIenergy commands during production-free periods.

Reference

You will find additional information on PROFIenergy in the following manuals:

- Manual I/O modules (https://support.automation.siemens.com/WW/view/en/55679691/133300)
- Function manual PROFINET as of STEP 7 V12 (https://support.automation.siemens.com/WW/view/en/49948856)
- System manual PROFINET System Description (https://support.automation.siemens.com/WW/view/en/19292127)
- PROFIenergy (https://support.automation.siemens.com/WW/view/en/66928686) product information
- Internet (https://www.profibus.com) under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order No: 3.802

4.1.22 Removal/insertion of multiple I/O modules during operation (Multi Hot Swap)

Properties

You can remove and insert any number of I/O modules during operation. The interface module and the inserted I/O modules remain in operation.

NOTE

The IM 155-6 MF HF interface module does not support pulling or plugging the server module, interface module and BusAdapter during operation.

Reference

You can find more information on the removal/insertion of modules in the system manual ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293).

4.1.23 Module-to-Module Communication (MtM)

Introduction

Module-to-Module Communication (MtM) offers the following advantages for operation via PROFINET IO:

- Improved performance during data transfer by bypassing the IO controller.
- Deterministic cycle times
- Cost-effective, high-performance solutions for applications where the performance of a specific technology module is not required.

Module-to-Module Communication (MtM)

Module-to-Module Communication (MtM) enables direct exchange of data between specific IO modules within a station via the interface module. This enables you to move small and/or time-critical tasks to the IO module. You achieve better performance while reducing the load on the CPU.

With Module-to-Module Communication (MtM), the interface module copies the input data of an IO module directly to a different IO module via the ET 200SP backplane bus. The IO module (data sink) carries out application-specific processing of the data.

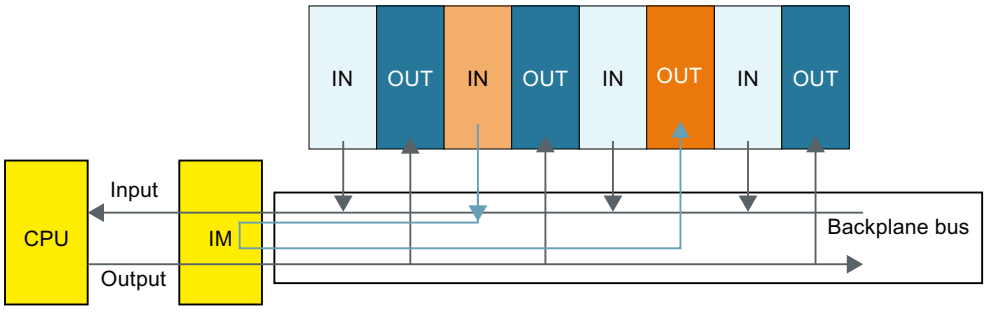

You configure the data source and data sink for Module-to-Module Communication (MtM) in the hardware configuration of the respective output module. Programming of the user program is **not** required in the variant for Module-to-Module Communication (MtM).

NOTE

The preparation of the input data in the output module (mapping) and the output of the data to the outputs are application- and technology-specific.
Example: The DQ 4x24VDC/2A HS digital output module supports

- the application cam control with Module-to-Module Communication (MtM) under the designation DQ 4x24VDC/2A HS **MCC MtM**

Additional information can be found in the manuals of the corresponding IO modules.

4.1.24 Configuration control (option handling)

Properties

Configuration control allows you to prepare your automation system for future expansions or changes. Configuration control means you can configure the planned maximum expansion of your automation system in advance and flexibly vary it later by means of the user program.

Reference

You can find more information on configuration control:

- In the system manual ET 200SP distributed I/O system. (https://support.automation.siemens.com/WW/view/en/58649293)
- On the Internet under the following link: Application collection (https://support.automation.siemens.com/WW/view/en/29430270).
- In the STEP 7 online help.

4.1.25 Setting the time

The interface module supports time setting, for example, with AI Energy Meter CT HF (6ES7134-6PA01-0CU0).

We show you how to set the time in an application example (https://support.automation.siemens.com/WW/view/en/109754890).

4.1.26 Time distribution

For example, if there is an AI Energy Meter CT HF (6ES7134-6PA01-0CU0), the time is automatically distributed within the ET 200SP station. You can find more information in the section Setting the time.

4.1.27 Use of fail-safe modules

Properties

The IM 155-6 MF HF interface module supports the use of fail-safe modules with PROFIsafe.

Reaction times for fail-safe modules

The following maximum reaction time of the interface module must be taken into account when calculating the reaction times of fail-safe modules: **Maximum reaction time = configured update time + 400 µs (but at least 1.5 ms)**

Reference

You can find more information in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

4.1.28 Use of technology modules

The IM 155-6 MF HF interface module supports the "Position detection for Motion Control" mode of the technology modules TM Count 1x24V (6ES7138-6AA00-0BA0) and TM PosInput 1 (6ES7138-6BA00-0BA0).

4.1.29 Reading out service data

The function makes it possible to read out diagnostic and service information from the interface module.

In the case of a pending maintenance alarm, you can read out the service data and make it available to SIEMENS support for queries and product improvement.

Methods of reading service data

- TIA V19
- Multi Fieldbus Configuration Tool (MFCT), V1.4.1 or higher

The tool download and more information, as well as documentation on the individual functions of the MFCT, can be found on the Internet (https://support.industry.siemens.com/cs/de/de/view/109773881/en).

4.1.30 Reference temperature distribution

Specific I/O modules require a reference temperature to compensate for temperature dependence. This device supports the function of distributing this temperature on the backplane bus. Up to 4 reference temperatures can be distributed.

4.1.31 Diagnostic interrupts

A diagnostic interrupt is a display of an error state.

If a module with diagnostic capability in which the diagnostic interrupt is released detects a change in its diagnostic state, it sends a diagnostics interrupt request to the CPU.
The CPU then interrupts the processing of the user program and processes the diagnostic interrupt OB (OB 82).

You can find more information in the Interrupts (Page 45) and Alarms (Page 47) sections.

4.1.32 Hardware interrupts

According to the configuration, the I/O modules or the interface module trigger a hardware interrupt for certain events/states. When a hardware interrupt occurs, the CPU interrupts the execution of the user program and runs the assigned hardware interrupt OB. The event that triggered the interrupt is entered in the start information of the assigned hardware interrupt OB by the CPU.

4.1.33 Maintenance events

A maintenance event indicates an identified maintenance requirement that has no direct influence on the function of the module. The maintenance event indicates that a check or replacement of plant components is required.

When a module with maintenance capability detects a change in its diagnostic state, it sends a maintenance request to the CPU. The CPU then interrupts the processing of the user program and processes the diagnostic interrupt OB (OB 82).

You can find more information in the Interrupts and Alarms sections.

4.1.34 Alternating IO devices during operation ("docking systems")

Alternating IO devices during operation ("docking systems")

- Docking station
- Docking unit

You can find additional information in the STEP 7 online help and

- As of STEP 7 V12, in the PROFINET with STEP 7 (https://support.automation.siemens.com/WW/view/en/49948856) function manual

4.2 Interrupts, error messages, diagnostics and system alarms

4.2.1 Status and error displays

LED displays

The following figure shows the LED displays on the interface module and BusAdapter:

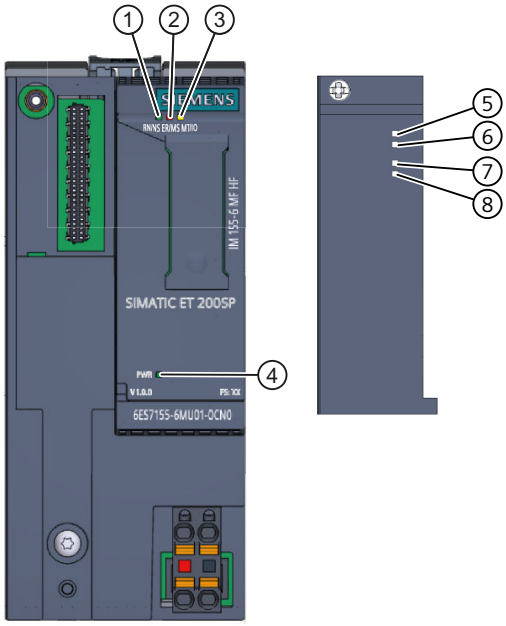

① RN/NS (red/green)
② ER/MS (red/green)
③ MT/IO (green/yellow)
④ PWR (green)
⑤ LK1 (green)
⑥ MT1 (yellow), SCRJ port
⑦ LK2 (green)
⑧ MT12 (yellow), SCRJ port

Figure 2-92 LED displays on the interface module and BusAdapter

Meaning of the LEDs

The following tables show the meaning of the status and error displays.

The meaning of the NS/MS/IO LEDs for operation with EtherNet/IP can be found in section "Status and error displays for EtherNet/IP (Page 66)" and for Modbus TCP in the section "Status and error displays for Modbus TCP (Page 80)".

RN/NS, ER/MS, MT/IO LEDs on the interface module during operation with PROFINET IO

The LEDs display the status with the highest priority if there are different LED states due to overlaid events. (0 = off, 1 = green flashing, 2 = green, 3 = yellow, 4 = red flashing, 5 = red)

Table 2-78 Status and error displays of the LEDs RN/NS, ER/MS, MT/IO

LEDs			Meaning	Solution
RN/NS (RUN)	ER/MS (ERROR)	MT/IO (MAINT)		
Off	Off	Off	Missing or insufficient supply voltage on interface module.	Check the supply voltage or turn it on at the interface module.*
On	On	On	RN/NS, ER/MS and MT/IO LEDs are permanently on: Hardware or firmware defective. Error information will be determined and stored retentively on the Flash memory.	Do not disconnect the interface module from the supply voltage while the LEDs are permanently lit up. This may take a few minutes.
Flashes	Not relevant	Not relevant	Interface module is deactivated.	Activate the interface module with the configuration software or via the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP starts up.	-
			ET 200SP is being assigned parameters.	
			ET 200SP is reset to factory settings.	
On	Not relevant	Not relevant	ET 200SP is currently exchanging data with the IO controller.	-
Not relevant	Flashes	Not relevant	Group errors and group error channels.	Evaluate the diagnostics data and remedy the error.
			The preset configuration does not match the actual configuration of the ET 200SP.	Check the configuration of the ET 200SP to see whether a module is missing, faulty or not configured.
			Invalid configuration states.	You can find more information in the section Invalid configuration states of the ET 200SP system (Page 51)
			Parameter assignment error in the I/O module.	Evaluate the display of the module status in STEP 7. Eliminate the error in the corresponding I/O module.
Not relevant	Not relevant	On	Maintenance required is present; that is, at least one maintenance event has occurred.	See section Maintenance alarms (Page 49)
On	Flashes	Flashes	The server module was removed or more than one server module is inserted in the station.	Re-insert the server module or check the number of inserted server modules.
Flashes	Flashes	Flashes	Hardware or firmware defective (LK1 and LK2 LEDs of the PROFINET interface do not flash).	Restart the device by disconnecting and reconnecting the supply voltage. Run a firmware update. If the error persists, contact Siemens Industry Online Support. Replace the interface module. You can read out service data with MFCT and TIA Portal as of V19.

* PWR LED on (on the interface module): Check the backplane bus for a short-circuit.

LEDs			Meaning	Solution
RN/NS (RUN)	ER/MS (ERROR)	MT/IO (MAINT)		
Flashes	Flashes	Flashes	The "Node flash test" is run (the LK1 and LK2 LEDs of the PROFINET interface also flash).	-
On *and then* On	On *and then* On	On *and then* On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s in red. Then for approximately 0.25 s in green.	-

* PWR LED on (on the interface module): Check the backplane bus for a short-circuit.

PWR LED on the interface module

Table 2-79 Status display of the PWR LED

PWR LED	Meaning	Solution
Off	Missing or insufficient supply voltage.	Check the supply voltage.
On	Supply voltage present If the MT/IO LED is lit, observe the maintenance alarms.	-

LED display of configuration errors

Configuration errors of the ET 200SP distributed I/O system are indicated on the interface module via the red LED ER/MS and the yellow LED MT/IO.

The following configuration errors are indicated by the LEDs:

- No server module
- Interruptions or short-circuit on the backplane bus

Operating principle

The LED error display provides information on the cause of the error. After notification by the flashing signal, the error type is displayed followed by the error location/error code.

The LED error display

- Is activated during POWER ON and during operation.
- Has priority over all other states that are displayed by means of the LEDs ER/MS and MT/IO.
- Remains on until the cause of the error has been eliminated.

Table 2-80 Display of error type and error location

Sequence		Description
1	LEDs ER/MS and MT/IO flashes 3x with 0.5 Hz	Signaling of error type
2	LED MT/IO flashes with 1 Hz	Display of error type (decimal)
3	LEDs ER/MS and MT/IO flashes 3x with 2 Hz	Signaling of error location/error code
4	LED ER/MS flashes with 1 Hz	Display of tens digit (decimal) of the error location/error code
5	LED MT/IO flashes 1 Hz	Display of ones digit (decimal) of the error location/error code
6	Repetition of 1 to 5 until the cause of the error has been eliminated.	

Error display

Table 2-81 Error display

Error type (MAINT)	Error location (ERROR/ MAINT)	Cause of error	Solution
1	65	• No server module • More than one server module plugged in • Interruptions on the backplane bus • Short circuit of communication on the backplane bus	Check the configuration of the ET 200SP.

NOTE

A short circuit in the backplane bus supply or the bus connection supply is indicated by the following LEDs:

- PWR LED: on
- RN/NS, ER/MS and MT/IO LED: Off

4.2.2 Interrupts

Introduction

The I/O device triggers interrupts as a reaction to specific errors. The evaluation of the interrupt is dependent on the PROFINET IO controller used.

Evaluating interrupts with PROFINET IO controllers

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostic error interrupts
- Hardware interrupts
- Pull/plug interrupts
- Maintenance events

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

System diagnostics

In STEP 7 (TIA Portal), the innovated system diagnostics is available for the devices of the S7-1500 automation system (IO controller S7-1500 CPU) and ET 200SP (IO device). Independent of the cyclic user program, alarms are made available on the display of the S7-1500 CPU, the CPU web server and the HMI device.

You will find more information on system diagnostics in the Diagnostics (https://support.industry.siemens.com/cs/ww/en/view/59192926) function manual.

4.2.2.1 Triggering of a diagnostics interrupt

For an incoming or outgoing event (e.g. wire break on a channel of an I/O module), the module triggers a diagnostic error interrupt if this is configured accordingly.

The CPU interrupts processing of the user program and processes the diagnostic error interrupt OB (OB 82). The event that triggered the interrupt is entered in the start information of the diagnostic error interrupt OB.

4.2.2.2 Triggering a hardware interrupt

In the event of a hardware interrupt, the CPU interrupts the processing of the user program and processes the hardware interrupt OB, e.g. OB 40. The event that triggered the interrupt is entered in the start information of the hardware interrupt OB.

NOTE

Diagnostics "Hardware interrupt lost" (from I/O module)

Do not use hardware interrupts for functional purposes (e.g. the cyclic generation of hardware interrupts).

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

4.2.2.3 Triggering of a remove/insert module interrupt

In the event of a remove/insert module interrupt, the CPU interrupts processing of the user program and processes the remove/insert module OB, e.g. OB 83. The event that triggered the interrupt is entered in the start information of the remove/insert module OB.

NOTE

Parameter assignment error after removal/insertion

If you write data records from the user program to the modules of the distributed I/O, make sure that these modules actually exist and are available. You can do this by evaluating OB 83. After inserting a module, OB 83 is not called until the module has started up and its parameters are assigned. This ensures that data record operations can be executed without errors.

4.2.2.4 Triggering of a maintenance event

The PROFINET IO interfaces of the interface module support the diagnostics concept and maintenance concept in PROFINET IO according to the IEC 61158 Type 10 standard. The goal is to detect and remove potential problems as early as possible.

For the interface module, maintenance events signal to the user when a plant component must be checked or replaced.

The CPU interrupts the processing of the user program and processes the diagnostic error interrupt OB (OB 82). The event that triggered the maintenance event is entered in the start information of the diagnostic error interrupt OB.

4.2.3 Alarms

Introduction

The ET 200SP distributed I/O system generates the following alarms:

- Diagnostic messages
- Maintenance alarms

4.2.3.1 Diagnostics alarms

Actions after a diagnostics alarm

There can be more than one diagnostics alarm at the same time. Each diagnostics alarm initiates the following actions:

- The ER/MS LED of the interface module flashes red.
- Diagnostics data is reported as diagnostic interrupts to the CPU of the PROFINET IO controller and can be read via data records.
- Incoming diagnostic messages are saved to the diagnostic buffer of the PROFINET IO controller.
- (S7-300/400) The diagnostic interrupt OB is called. If the diagnostic interrupt OB (OB 82) is not available, the IO controller goes into STOP mode.

You can find more information on using PROFINET IO in the STEP 7 online help.

Table 2-82 Diagnostics alarms, their meaning and possible remedies

Diagnostics alarm	Channel Error Type (CET)	Extended Channel Error Type (ECET)	Associated value AddValue	Meaning / Cause	Solution
Configuration error: Module parameter (potential group) incorrect or wrong BaseUnit/terminal block in real slot <slot>	0x0602	0x0691	Slot	The configured BaseUnit or the terminal block does not match the real configuration.	Check for suitable BaseUnit or terminal block.
Configuration error: Station stop - missing or wrong server module	0x0602	0x0693	0x00	During the startup of an ET 200SP station, no server module was plugged in or the server module was removed during operation.	Check that the server module is installed correctly in the rack.
Configuration error: Station stop - too many server modules	0x0602	0x068C	-	More than one server module is plugged into the station.	Ensure that only one server module is plugged into the station.
Configuration error: Permitted size of backplane bus exceeded	0x0602	0x0698	0x00	The total width of the installed modules exceeds the permitted configuration length of 1 000 mm.	Check that the configuration of the backplane bus does not exceed the permitted size.

Diagnostics alarm	Channel Error Type (CET)	Extended Channel Error Type (ECET)	Associated value AddValue	Meaning / Cause	Solution
Configuration error: Incorrect backplane bus configuration in slot <slot>	0x0602	0x0699	Slot	The maximum power requirement of all installed modules exceeds 2 100 mA in total. The associated value <slot> indicates the faulty slot.	Check backplane bus mounting.
Configuration error: Invalid BusAdapter on the interface module	0x0602	0x069C	0x00	The installed BusAdapter does not correspond to the configuration.	Check project planning and mounting of the right BusAdapter.
Network configuration error: Shared Device conflict, invalid submodule assignment at slot	0x0603	0x06A5	Slot	There is an invalid submodule assignment.	Check the submodule assignment.
Load voltage error: Missing voltage in load voltage group at slot according channel number	0x0610	0x06B0	0x00	No supply voltage to the load group.	Check the load supply voltage of the modules.

The scope of the diagnostics alarms displayed depends on the configuration and the parameter assignment.

If required, the standard can be downloaded from the Internet (http://www.profibus.com).

Reading the diagnostics

Table 2-83 Reading the diagnostics with STEP 7

Automation system with IO controller	Application	See ...
SIMATIC S7	Diagnostics as plain text in STEP 7 using Online and Diagnostics view	STEP 7 online help • as of STEP 7 V12, Function Manual PROFINET with STEP 7 as of V12 (https://support.automation.siemens.com/WW/view/en/49948856) • as of STEP 7 V5.5, System Manual PROFINET System Description (https://support.automation.siemens.com/WW/view/en/19292127)
	Instruction "RDREC" (SFB 52) Read data records from the IO device	
	Instruction "RALRM" (SFB 54) Receive interrupts from the IO device	

More information on the data records for PROFINET IO

You will find the structure of the diagnostics data records and examples for programming in the Programming Manual, From PROFIBUS DP to PROFINET IO (https://support.automation.siemens.com/WW/view/en/19289930) in the sections "Structure of diagnostic data records" and "Examples of diagnostic data records" and in Example application (https://support.automation.siemens.com/WW/view/en/24000238).

Causes of error and troubleshooting

The causes of error and remedies for the diagnostics alarms are described in the manuals for I/O modules (https://support.automation.siemens.com/WW/view/en/55679691/133300) in the section, "Interrupts, error messages, and system events".

PROFINET IO

Another source of diagnostics events is the PROFINET base used. This generates diagnostics alarms whose coding is already defined in the PROFINET IO - Application Layer Service Definition V2.2 standard.

The actual scope of diagnostics used is dependent on the configuration and parameter assignment.

If required, the standard is available for download on the Internet (http://www.profibus.com) from the PROFIBUS User Organization home page.

See also

PROFINET with STEP 7 V11 (http://support.automation.siemens.com/WW/view/en/49948856)

4.2.3.2 Maintenance alarms

The PROFINET IO interfaces of the interface module support the diagnostics concept and maintenance concept in PROFINET IO according to the IEC 61158 Type 10 standard. The goal is to detect and remove potential problems as early as possible.

For the interface module, maintenance events signal to the user when a plant component must be checked or replaced.

The CPU interrupts user program execution and executes the diagnostic interrupt OB. The event that triggered the maintenance event is entered in the start information of the diagnostic interrupt OB.

NOTE

Maintenance alarms have no direct influence on the function of the module.

Maintenance demanded alarms

A maintenance event is generated each time *maintenance demanded* is detected. The maintenance LED (MT/IO LED) on the interface module lights up in yellow.

Table 2-84 Maintenance demanded alarms, their meaning and possible remedies

Maintenance demanded alarm	Channel Error Type (CET)	Extended Channel Error Type (ECET)	Associated value AddValue	Meaning / Cause	Solution
Configuration error: Firmware of interface module incompatible with backup on storage medium	0x0602	0x068D	-	The version of the backup on the server module is higher than expected.	Update the firmware of the interface module to restore backed up data.
Configuration error: Saved multi-fieldbus configuration is incompatible	0x0602	0x068E	-	The retentively saved configuration is incompatible with the firmware used.	Update the multi-fieldbus configuration using MFCT, or perform a firmware update with the newest version available.
Load voltage error: Power supply undervoltage	0x0610	0x06B4	-	The supply voltage of the interface module is below the tolerance limit.	Check the power supply.

Maintenance required alarms

A maintenance event is generated each time *maintenance required* is detected. However, it has no influence on the ER/MS LED or MT/IO LED on the interface module.

Table 2-85 Maintenance demanded alarms, their meaning and possible remedies

Maintenance required alarm	Channel Error Type (CET)	Extended Channel Error Type (ECET)	Associated value AddValue	Meaning / Cause	Solution
Security event: Firmware successfully downloaded and activated for use after a reset (New firmware version <FW version>)	0x0190	0x012C	Signed firmware version	The firmware has been successfully loaded into the module. This firmware update takes effect after the interface module is restarted.	-
Security event: The firmware integrity checks failed. The new firmware version <FW version> was rejected.	0x0190	0x0193	Signed firmware version	The firmware was not successfully loaded into the module. This can have many different reasons, e.g. corrupted binary files or an incorrect signature.	Verify if the firmware update file you are using comes from a secure source. Download the firmware again from the Siemens support website and repeat the firmware update.

NOTE

Detailed information on other maintenance alarms can be found in TIA Portal.

System alarms in STEP 7 (TIA Portal)

The maintenance information is generated in STEP 7 (TIA Portal) with the following system events:

- Maintenance demanded - indicated for each port by a wrench with a yellow background in the device view or in the hardware configuration.
- Maintenance required - indicated for each port by a wrench with a green background in the device view or in the hardware configuration.

You can find more information in the STEP 7 online help.

4.2.3.3 Invalid configuration states of the ET 200SP system

Invalid configuration states

The following invalid configuration states of the ET 200SP distributed I/O system lead to the failure of the IO device or prevent data exchange:

- Number of modules exceeds maximum configuration.
- Faulty backplane bus (e.g. defective BaseUnit). ET 200SP backplane bus interruptions do not trigger an interrupt.
- At least one I/O module is plugged into a different BaseUnit as the one configured in the parameters.
- No server module.
- Invalid or incorrectly configured BusAdapter

NOTE

Removal of the server module will trigger a station stop. All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) but the interface module continues to exchange data.

The virtual MSO Local modules are not affected by the failure.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

4.2.3.4 Failure of supply voltage L+ at BaseUnit BU...D

Failure of the supply voltage L+

The I/O modules react as follows to failure of the supply voltage L+ on the BaseUnit BU...D:

- If an I/O module is removed during failure of the supply voltage, a pull interrupt is generated for PROFINET IO.
- If an I/O module is installed during failure of the supply voltage, a plug interrupt is generated for PROFINET IO.

4.2.3.5 STOP of the IO controller and recovery of the IO device

STOP of the PROFINET IO controller

Diagnostics received from the IO device while the IO controller is in STOP do not initiate a call of any corresponding OBs when the IO controller goes into RUN. Read the $E00C_H$ data record in startup OB using the instruction "RDREC". This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Recovery of the PROFINET IO device

If you want to read the occurring diagnostics in the STOP state of the IO controller, you have to read the $E00C_H$ data record with the "RDREC" instruction. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

EtherNet/IP

5

5.1 EtherNet/IP functions

The interface module supports the following EtherNet/IP functions:

- I/O communication with scanner
- Configuring from the user program
- Read diagnostics (interrupts are not supported)
- Normative CIP objects
- Resetting interface module to factory setting
- Diagnostics bit in data status of cyclic I/O data per submodule
- Integrated switch with 2 ports
- Supported Ethernet services: PING, ARP, SNMP, LLDP
- Minimum RPI 2 ms
- Firmware update via MFCT
- Supports BusAdapter for different connection technologies
- Shared device
- Distribution of module channels to submodules
- Module-internal or submodule-internal Shared Input/Shared Output (MSI/MSO)
- Station extension via ET-Connection
- Identification data I&M 0 to I&M 4
- PROFIenergy
- Removal/insertion of multiple I/O modules during operation (multi hot swap)
- Module-to-Module Communication (MtM)
- Setting the time

Requirements

The following table shows the software requirements of the EtherNet/IP functions:

Table 2-86 Version dependencies of the EtherNet/IP functions

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software MFCT
			As of V1.0 Update 2
I/O communication with scanner	1	V6.2.1	X
Configuring from the user program	1	V6.2.1	X

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software MFCT
			As of V1.0 Update 2
Reading diagnostics	1	V6.2.1	X
Normative CIP objects	1	V6.2.1	X
Resetting interface module to factory setting	1	V6.2.1	X
Diagnostics bit in data status of cyclic I/O data per submodule	1	V6.2.1	X
Integrated switch with 2 ports	1	V6.2.1	X
Supported Ethernet services: PING, ARP, SNMP, LLDP	1	V6.2.1	X
Minimum RPI 2 ms	1	V6.2.1	X
Reset to factory settings via RESET button	1	V6.2.1	X
Firmware update via MFCT	1	V6.2.1	X
BA 2xRJ45 BusAdapter	1	V6.2.1	---
BA 2xFC BusAdapter	1	V6.2.1	---
BA 2xM12 BusAdapter	1	V6.2.1	---
Shared device	1	V6.2.1	As of V1.3 Update 1
Distribution of module channels to submodules	1	V6.2.1	As of V1.3 Update 1
Module-internal or submodule-internal Shared Input/Shared Output (MSI/MSO)	1	V6.2.1	As of V1.3 Update 1
Station extension via ET connection	1	V6.2.1	X
Interface-local coupling of I/O data	1	V6.2.1	As of V1.3 Update 1
Identification data I&M 0 to I&M 4	1	V6.2.1	X
PROFIenergy	1	V6.2.1	X
Removal/insertion of multiple I/O modules during operation (multi hot swap)	1	V6.2.1	X
Module-to-Module Communication (MtM)	1	V6.2.1	As of V1.3 Update 1
Setting the time	1	V6.2.1	X

NOTE

You can find a more detailed description of the functions in the section PROFINET IO functions (Page 21) or in the function manual SIMATIC MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209).

5.1.1 Applicable modules with EtherNet/IP

With EtherNet/IP the following modules cannot be used or can be used only with limitations.

These modules are divided into 4 categories:

Category	Description
1	Module can be used without functional restrictions. The module needs simple parameter reassignment. Records/interface are described in the Equipment Manual.
2	A function block must be created for the module for the target control. The module operates with a non-locked function block. The function block can be reimplemented.
3	Subfunctions of the module are not supported by the selected fieldbus. Subfunctions are only possible using blocks or additional interfaces.
4	The module is not supported by the selected fieldbus. The module needs a protected function block (e.g. for F-modules).

NOTE

Module operating modes based on isochronous operation (e.g. oversampling or time stamping) are not supported.

F-modules

Module	Article number	Category	Note
F-DI 8x24VDC HF	6ES7136-6BA00-0CA0	4	-
	6ES7136-6BA01-0CA0	4	-
F-DQ 4x24VDC/2A PM HF	6ES7136-6DB00-0CA0	4	-
F-DQ 8x24VDC/0.5A PP HF	6ES7136-6DC00-0CA0	4	-
F-RQ 1x24VDC/24..230VAC/5A	6ES7136-6RA00-0BF0	4	-
F-PM-E 24VDC/8A PPM ST	6ES7136-6PA00-0BC0	4	-
F-AI 4xI 0(4)..20mA 2-/4-wire HF	6ES7136-6AA00-0CA1	4	-
F-AI 4xU 0..10V HF	6ES7136-6AB00-0CA1	4	-
F-TM Count 1x1Vpp sin/cos HF	6ES7136-6CB00-0CA0	4	-

Technology modules

Module	Article number	Category	Note
TM ECC 2xPWM 12V ST	6FE1242-6TM10-0BB1	2	The control interface is described.
SIWAREX WP321	7MH4138-6AA00-0BA0	3	Only for DR data records (calibrating) The description of the blocks is available on request. Alternatively, commissioning with SIWATOOL V7 is possible.
TM SIWAREX WP351 HF	7MH4138-6BA00-0CU0	3	Commissioning is possible with the integrated web browser.
F-TM ServoDrive 1x24..48V ST	6BK1136-6AB00-0BU0	3	Comprehensive support of controller calculation and diagnostics is currently only available in the TIA Portal.

Communication modules

Module	Article number	Category	Note
CM PtP	6ES7137-6AA01-0BA0	3	PRM, DataEx is described in the Function Manual
CM 4xIO-Link	6ES7137-6BD00-0BA0	3	Time-based IO blocks (isochronous mode)
CM DALI	6ES7137-6CA00-0BU0	2	See the "ET 200SP, CM 1xDALI – Communication Model Description (https://support.industry.siemens.com/cs/ww/en/view/109774228)" Programming Manual

5.1.2 Update time of the I/O data

You can estimate the typical update time for an I/O cycle as follows:

RPI time (can be set starting at 2 ms)

+ I/O processing (typically 1.4 ms, +/- 1 ms jitter due to free-running cycles)

+ EM conversion (dependent on cycle time and parameter assignment of the module)

If necessary, you must take into account other influences caused by the EIP scanner and network components by adding them.

NOTE

When using ET 200AL I/O modules, the search for nodes at the ET connection can take up to 5 seconds. The user data is temporarily invalid during this period (IDS/ODS = 0x40).

5.1.3 Examples for I/O data mapping

5.1.3.1 I/O Data Mapping Introduction EtherNet/IP

I/O data mapping

During parameter assignment of the MF device, you can choose between three formats for the I/O data mapping:

- With the "Byte" format, the input or output data of the modules of an I/O connection are lined up by increasing slot address (Slot.Subslot).
- With the "Word" format, the input or output data of the modules of an I/O connection are lined up by increasing slot address (Slot.Subslot). If the submodule has an odd data length, a fill byte (content 0x00) is inserted after the submodule. This aligns the following data status bytes (IDS, ODS) to word limits. A padding byte (content 0x00) is also inserted after the data status byte (IDS, ODS). Subsequent submodules will then also start at an even byte offset.
- With the "Flexible" format, the input or output data of the modules of an I/O connection are lined up by increasing slot address (Slot.Subslot). The alignment depends on the data length of the submodule and follows the alignment rules described in the Rockwell specification "Type Encoding of Logix Structures in CIP Data Table R/W". According to these rules, submodule data with a length of X bytes should begin at X-byte boundaries, which means that 1-byte data is bound to 1-byte address boundaries, which is the same as in the "Byte" format, 2-byte data starts at 2-byte address boundaries, which is the same as in the "Word" format, 4-byte data starts at 4-byte address boundaries, and so on. Padding bytes (content 0x00) are inserted as needed to ensure that all submodule data starts at the correct boundaries. Additionally, the format provides the option to swap the byte order of the submodule data.

The image of the outputs contains only the output data (with padding bytes if necessary), while the input image also supplies additional status bytes together with the input data (with padding bytes if necessary).

An Output Data Status Byte (ODS) is available for each output submodule in the image of the inputs.

There is an Input Data Status Byte (IDS) for each input submodule that follows the respective input data of the submodule in the input image.

Submodules with a data length of 0 for input and output data are treated as input submodules. Only an Input Data Status Byte (IDS) is entered in the input image.

NOTE

You can find the I/O data mapping for your configuration in the exported CSV file.

NOTE

For information about data mapping, see the system and equipment manuals.

I/O data status

The following table shows the coding of the status bytes for IDS and ODS:

Field	Bit number	Bit mask	Default	Bit value = '0'	Bit value = '1'
IOValid	7	0x80	0	I/O data invalid	I/O data valid*
Problem	6	0x40	0	Initial status	Module problem: • Module not plugged • Incorrect module plugged • Module with incorrect parameter assignment • I/O data temporarily invalid after station startup
NoCoupling	5	0x20	0	Initial status	No I/O data from PN coupler (MSO Local)
Reserved	4...2	0x1E	000	-	
ProcessEvent	1	0x02	0	No process event	Process event available
Diagnosis	0	0x01	0	No diagnostics	Diagnostics available

NOTE

For MSI and MSO submodules, the IDS.Diagnosis bit is 0. Comparable to the diagnostic error interrupt of PROFINET, the diagnostics for MSI and MSO are only signaled in the IDS.Diagnosis bit for the default submodule (subslot = 1).

5.1.3.2 Example of I/O data mapping for I/O data alignment Byte

Example configuration

The following figure shows the configuration for this example:

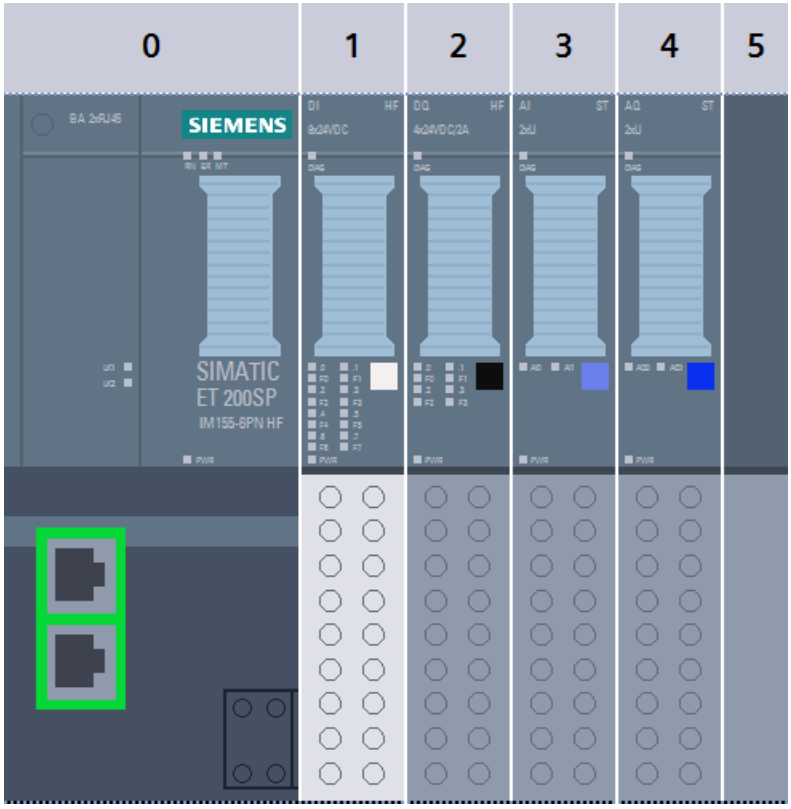

The example uses the following modules:

Slot	Module
0	IM 155-6 MF
1	DI 8 HF
2	DQ 4 HF, QI
3	AI 2 ST
4	AQ 2 ST
5	Server module

Input buffer

The following table shows the input buffer for the example configuration for the I/O data alignment Byte:

Slot	Name*	Data type	Byte off-set	Description
0	Slot0_1_IDS	Byte	0	Input Data State for the interface module
1	Slot1_1_I_channel_0_0	Byte	1	1 byte input data for the DI 8 HF module
	Slot1_1_IDS	Byte	2	Input Data State for the DI 8 HF module
2	Slot2_1_QI	Byte	3	Value status for the DQ 4 HF module
	Slot2_1_IDS	Byte	4	Input Data State for the value status of the DQ 4 HF module
3	Slot3_1_I_channel_0_0	Byte	5	2 bytes input data for channel 0 of the AI 2 ST module
	Slot3_1_I_channel_0_1	Byte	6	
	Slot3_1_I_channel_1_0	Byte	7	2 bytes input data for channel 1 of the AI 2 ST module
	Slot3_1_I_channel_1_1	Byte	8	
	Slot3_1_IDS	Byte	9	Input Data State for the AI 2 ST module
5	Slot5_1_IDS	Byte	10	Input Data State for the server module
2	Slot2_1_ODS	Byte	11	Output Data State for the DQ 4 HF module
4	Slot4_1_ODS	Byte	12	Output Data State for the AQ 2 ST module

* The name is formed according to the following scheme: Slot<Slot#>_<Subslot#>_<DataItem-TextId>[_<Index>]

The sum of the input data is 13 bytes.

Output buffer

The following table shows the output buffer for the example configuration for the I/O data alignment Byte:

Slot	Name*	Data type	Byte off-set	Description
2	Slot2_1_O_channel_0_0	Byte	0	1 byte output data for the DQ4 HF module
4	Slot4_1_O_channel_0_0	Byte	1	2 bytes output data for channel 0 of the AQ 2 ST module
	Slot4_1_O_channel_0_1	Byte	2	
	Slot4_1_O_channel_1_0	Byte	3	2 bytes output data for channel 1 of the AQ 2 ST module
	Slot4_1_O_channel_1_1	Byte	4	

* The name is formed according to the following scheme: Slot<Slot#>_<Subslot#>_<DataItem-TextId>[_<Index>]

The sum of the output data is 5 bytes.

5.1.3.3 Example of I/O data mapping for I/O data alignment Word

Example configuration

The following figure shows the configuration for this example:

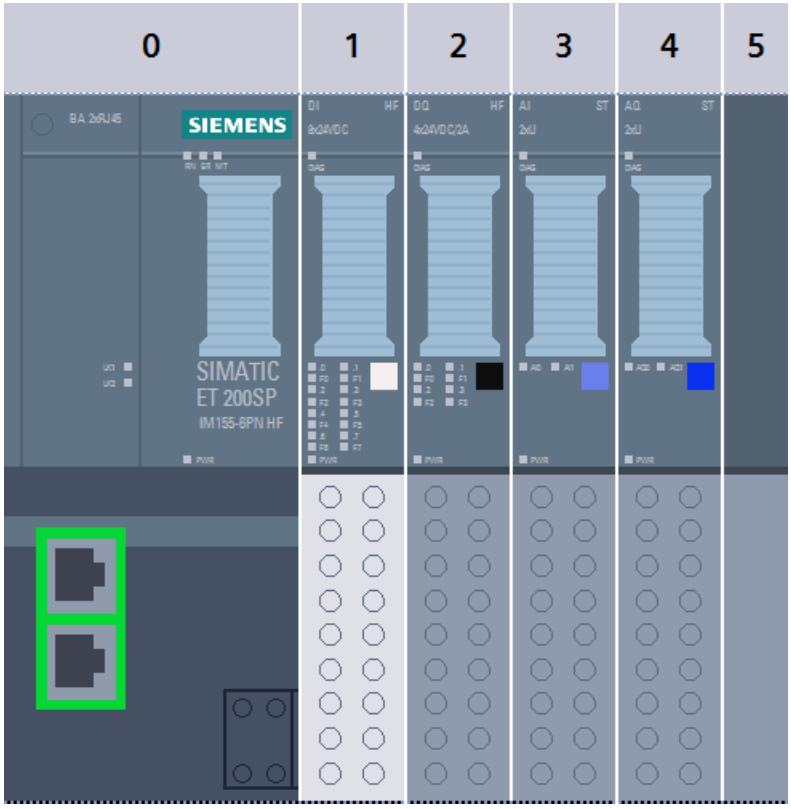

The example uses the following modules:

Slot	Module
0	IM 155-6 MF
1	DI 8 HF
2	DQ 4 HF, QI
3	AI 2 ST
4	AQ 2 ST
5	Server module

Input buffer

The following table shows the input buffer for the example configuration for the I/O data alignment Word:

Slot	Name*	Data type	Byte off-set	Description
0	Slot0_1_IDS	Byte	0	Input Data State for the interface module
	0x00	Byte	1	*Padding byte*
1	Slot1_1_I_channel_0_0	Byte	2	1 byte input data for the DI 8 HF module
	0x00	Byte	3	*Padding byte*
	Slot1_1_IDS	Byte	4	Input Data State for the DI 8 HF module
	0x00	Byte	5	*Padding byte*
2	Slot2_1_QI	Byte	6	Value status for the DQ 4 HF module
	0x00	Byte	7	*Padding byte*
	Slot2_1_IDS	Byte	8	Input Data State for the value status of the DQ 4 HF module
	0x00	Byte	9	*Padding byte*
3	Slot3_1_I_channel_0_0	Byte	10	2 bytes input data for channel 0 of the AI 2 ST module
	Slot3_1_I_channel_0_1	Byte	11	
	Slot3_1_I_channel_1_0	Byte	12	2 bytes input data for channel 1 of the AI 2 ST module
	Slot3_1_I_channel_1_1	Byte	13	
	Slot3_1_IDS	Byte	14	Input Data State for the AI 2 ST module
	0x00	Byte	15	*Padding byte*
5	Slot5_1_IDS	Byte	16	Input Data State for the server module
	0x00	Byte	17	*Padding byte*
2	Slot2_1_ODS	Byte	18	Output Data State for the DQ 4 HF module
	0x00	Byte	19	*Padding byte*
4	Slot4_1_ODS	Byte	20	Output Data State for the AQ 2 ST module
	0x00	Byte	21	*Padding byte*

* The name is formed according to the following scheme: Slot<Slot#>_<Subslot#>_<DataItem-TextId>[_<Index>]

The sum of the input data is 22 bytes.

Output buffer

The following table shows the output buffer for the example configuration for the I/O data alignment Word:

Slot	Name*	Data type	Byte off-set	Description
2	Slot2_1_O_channel_0_0	Byte	0	1 byte output data for the DQ4 HF module
	0x00	Byte	1	*Padding byte*
4	Slot4_1_O_channel_0_0	Byte	2	2 bytes output data for channel 0 of the AQ 2 ST module

* The name is formed according to the following scheme: Slot<Slot#>_<Subslot#>_<DataItem-TextId>[_<Index>]

Slot	Name*	Data type	Byte offset	Description
4	Slot4_1_O_channel_0_1	Byte	3	2 bytes output data for channel 0 of the AQ 2 ST module
	Slot4_1_O_channel_1_0	Byte	4	2 bytes output data for channel 1 of the AQ 2 ST module
	Slot4_1_O_channel_1_1	Byte	5	

* The name is formed according to the following scheme: Slot<Slot#>_<Subslot#>_<DataItem-TextId>[_<Index>]

The sum of the output data is 6 bytes.

5.1.3.4 Example of I/O data mapping for flexible data alignment

Example configuration

The following figure shows the configuration for this example:

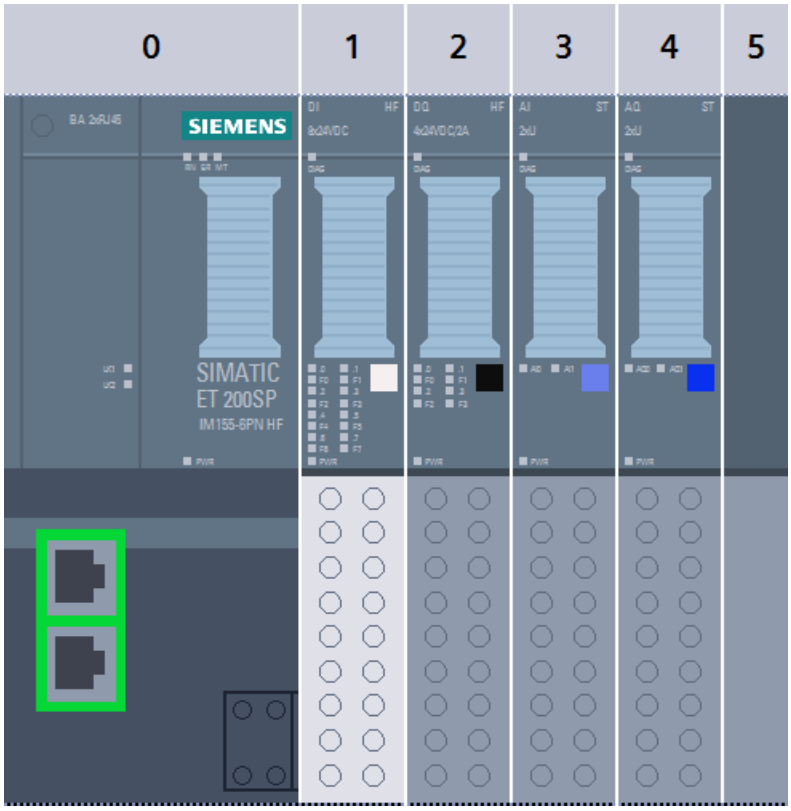

The example uses the following modules:

Slot	Module/IO module
0	IM 155-6 MF
1	DI 8 HF
2	DQ 4 HF, QI
3	AI 2 ST
4	AQ 2 ST
5	Server module

Input buffer

The following table shows the input buffer for the example configuration for flexible data alignment (big-endian):

Slot	Name*	Data type	Byte off-set	submodule
0	Slot0_1_IDS	Byte	0	IM 155-6 MF HF V5.2 / Input Data State
1	Slot1_1_I_channel_0_0	Byte	1	DI 8x24VDC HF V2.0
	Slot1_1_IDS	Byte	2	DI 8x24VDC HF V2.0 / Input Data State
2	Slot2_1_QI	Byte	3	DQ 4x24VDC/2A HF V2.0, QI
	Slot2_1_IDS	Byte	4	DQ 4x24VDC/2A HF V2.0, QI / Input Data State
-	0x0	Byte	5	Reserved
3	Slot3_1_I_channel_0_1	Byte	6	AI 2xU ST V1.0
	Slot3_1_I_channel_0_0	Byte	7	AI 2xU ST V1.0
	Slot3_1_I_channel_1_1	Byte	8	AI 2xU ST V1.0
	Slot3_1_I_channel_1_0	Byte	9	AI 2xU ST V1.0
	Slot3_1_IDS	Byte	10	AI 2xU ST V1.0 / Input Data State
5	Slot5_1_IDS	Byte	11	Server module V1.1 (0 bytes) / Input Data State
2	Slot2_1_ODS	Byte	12	DQ 4x24VDC/2A HF V2.0, QI / Output Data State
4	Slot4_1_ODS	Byte	13	AQ 2xU ST V1.0 / Output Data State

The sum of the input data is 14 bytes.

Output buffer

The following table shows the output buffer for the example configuration for the flexible data alignment:

Slot	Name*	Data type	Byte off-set	submodule
2	Slot2_1_O_channel_0_0	Byte	0	DQ 4x24VDC/2A HF V2.0, QI
	0x00	Byte	1	Reserved
4	Slot4_1_O_channel_0_1	Byte	2	AQ 2xU ST V1.0
	Slot4_1_O_channel_0_0	Byte	3	AQ 2xU ST V1.0
	Slot4_1_O_channel_1_1	Byte	4	AQ 2xU ST V1.0
	Slot4_1_O_channel_1_0	Byte	5	AQ 2xU ST V1.0

* The name is formed according to the following scheme: Slot<Slot#>_<Subslot#>_Id_<Id#>_<DataItem-TextId>

The sum of the input data is 6 bytes.

5.1.4 Shared device

Four ARs are available; these are shared by the fieldbuses. For EtherNet/IP and Modbus TCP, only one AR is reserved in each case, regardless of the number of controller connections used.

The maximum amount of I/O data must comply with the rules of the following table:

Number of fieldbus connections			Maximum I/O data per connection[1]		Max. download size with MFCT [1]	
PROFINET	**EtherNet /IP**	**Modbus TCP**	**Inputs**	**Outputs**	**Inputs**	**Outputs**
1	1 to 2	0	EtherNet/IP **or** Modbus TCP: 500 PROFINET: 1440	EtherNet/IP **or** Modbus TCP: 246 PROFINET: 1440	Download size[2]: 1440	Download size[2]: 1440
1	0	1 to 10				
0	1 to 2	1 to 10	500	246	1440	1440
1	1 to 2	1 to 10	360	246	360	360
2	1 to 2	0				
2	0	1 to 10				
2	1 to 2	1 to 10				

1 Including PROFINET payload qualifier or data status byte for signaling the data validity

2 PROFINET data + download size as displayed in MFCT ≤ 1440

The download size contains the I/O data of all EtherNet/IP and Modbus TCP connections as well as additional bytes for controlling the download.

NOTE

To avoid temporarily exceeding the I/O quantity structure, you must proceed as follows in case of a reconfiguration that results in changed I/O lengths:

1. Reduce the amount of I/O data in one configuration and download it to the MF device/CPU.
2. Increase the amount of I/O data in another configuration and download it to the MF device/CPU.

5.2 Diagnostics

5.2.1 Status and error displays for EtherNet/IP

RN/NS, ER/MS, MT/IO LEDs on the MF device

The LEDs display the status with the **highest priority** if there are different LED states due to overlaid events. (0 = off, 1 = green flashing, 2 = green, 3 = yellow, 4 = red flashing, 5 = red)

The following table shows the meaning of the RN/NS, ER/MS LEDs and MT/IO LEDs for EtherNet/IP:

Table 2-87 Status and error displays of the RN/NS LED

LED RN/NS (NET STATUS)	Meaning	Solution
Flashes	The MF device is not exchanging data.	• Check the correctness of the download with MFCT and for a valid IP address. • Establish the cyclic communication with the EtherNet/IP scanner.
On	The MF device is exchanging data via at least one connection.	---
Flashes	Timeout	• Check the accessibility of the device via the network from the perspective of the EtherNet/IP scanner.

Table 2-88 Status and error displays of the ER/MS LED

LED ER/MS (MODUL STATUS)	Meaning	Solution
Off	There is no MultiFieldbus project in the MF device.	• Create a project with MFCT and transfer it to the MF device.
Flashes	The MF device is not exchanging data. There is a MultiFieldbus project in the MF device.	• Establish the cyclic communication with the EtherNet/IP scanner.
On	The MF device is exchanging data via a connection.	---
Flashes	• Diagnostics are present. • Errors in the configuration or parameter assignment.	• Check for diagnostics information and, if necessary, eliminate the error. • Check the configuration of the MF station and, if necessary, correct the configuration and parameter assignment of the MF device in the MFCT and download them to the MF device again.

Table 2-89 Status and error displays of the MT/IO LED

LED MT/IO (IO STATUS)	Meaning	Solution
□ Off	There is no MultiFieldbus project in the MF device, or I/O that is used by EtherNet/IP is in STOP. There is no error.	• Switch the EtherNet/IP scanner to RUN mode.
■ On	I/O used by EtherNet/IP is in RUN mode.	---
■ On	There is a maintenance event	• You can find more information in the section "Maintenance alarms (Page 49)."

Combinations of the RN/NS, ER/MS, MT/IO LEDs on the MF device

Combinations of the three LEDs are possible. The following table shows the possible combinations:

Table 2-90 Status and error displays of the RN/NS, ER/MS, MT/IO LEDs

LEDs			Meaning	Notes
RN/NS (NET STATUS)	ER/MS (MODUL STATUS)	MT/IO (IO STATUS)		
□ Off	□ Off	□ Off	Missing or insufficient supply voltage on the MF device.	• Check the supply voltage or switch on the supply voltage on the MF device. *
☼ Flashes	□ Off	□ Off	The MF device is not exchanging data. There is no MultiFieldbus project in the MF device.	• Create a project with MFCT and transfer it to the MF device. Then establish the cyclic I/O communication with the MF device.
■ On	□ Off	□ Off	The MF device is exchanging data via PROFINET IO. There is no MultiFieldbus project in the MF device.	• Exclusive PROFINET use
☼ Flashes	☼ Flashes	□ Off	The MF device is not exchanging data. There is a MultiFieldbus project in the MF device.	• Establish the cyclic communication via EtherNet/IP.
■ On	■ On	□ Off	The MF device is exchanging data error-free via a connection (EtherNet/IP). I/Os used by EtherNet/IP are in STOP.	• If a data exchange was configured for EtherNet/IP, the assigned EtherNet/IP scanner is in STOP mode.
■ On	■ On	■ On	The MF device is exchanging data error-free via a connection (EtherNet/IP). I/O used by EtherNet/IP is in RUN mode.	---

* PWR LED on (on the MF device): Check the backplane bus for a short-circuit.

LEDs			Meaning	Notes
RN/NS (NET STATUS)	**ER/MS (MODUL STATUS)**	**MT/IO (IO STATUS)**		
■ On	☼ Flashes	■ On *or* □ Off	The MF device is exchanging data via at least one connection. Errors in the configuration or parameter assignment.	• At least one module is configured incorrectly, there is no missing module or I/O diagnostics information. • Check the station configuration and, if necessary, correct the configuration and parameter assignment of the MF device in the MFCT and download them to the MF device again. • Check the device status in the Device-Info area and, if necessary, eliminate the diagnostics error.
☼ Flashes	☼ Flashes	□ Off	The MF device is not exchanging data. The MF device has an error.	• Establish the cyclic communication via the I/O register area of the MF device or via EtherNet/IP. • Check the station configuration and eliminate configuration and parameter assignment errors via MFCT and eliminate diagnostics errors.
☼ Flashes	☼ Flashes	Not relevant	At least one connection existed (EtherNet/IP). A connection has been terminated by timeout.	• Reduce the cycle time. • Check the accessibility of the MF device via the network from the perspective of the EtherNet/IP scanner.
☼ Flashes	☼ Flashes	Not relevant	At least one connection existed (EtherNet/IP or Modbus TCP). A connection has been terminated by timeout. Error in the configuration or parameter assignment, or diagnostics present.	• Check the accessibility of the MF device via the network from the perspective of the EtherNet/IP scanner. • Check the station configuration and eliminate configuration and parameter assignment errors via MFCT and eliminate diagnostics errors.
■ On	☼ Flashes	☼ Flashes	The server module was removed or more than one server module is inserted in the station.	Re-insert the server module or check the number of inserted server modules.
☼ Flashes	☼ Flashes	☼ Flashes	The "Node flash test" is running.	• The LK1 and LK2 LEDs of the Ethernet interface are also flashing.
☼ Flashes	☼ Flashes	☼ Flashes	Hardware or firmware defective.	• You can read out the service data with TIA Portal as of V19.
■ On *and then* ■ On	■ On *and then* ■ On	■ On *and then* ■ On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s in red. Then for approximately 0.25 s in green.	---
■ On	■ On	■ On	RN/NS-, ER/MS-, MT/IO-LEDs are permanently on: Hardware or firmware defective. Error information will be determined and stored retentively on the Flash memory.	Do not disconnect the interface module from the supply voltage while the LEDs are permanently lit up. This may take a few minutes.

* PWR LED on (on the MF device): Check the backplane bus for a short-circuit.

Modbus TCP

6

6.1 Modbus TCP functions

The interface module supports the following MODBUS TCP functions:

- I/O communication with Modbus client
  - Register access
  - Bit by bit access via FC1, FC2, FC4, FC5, FC6, FC15, FC23 functions
  - Hold time after connection reset for soft redundancy
- Free user registers (e.g. for coordination of the redundancy)
- Device status register
- Config status register
- Diagnostics bit in data status of cyclic I/O data per submodule (interrupts are not supported)
- Data record interface
- Integrated switch with 2 ports
- Supported Ethernet services: PING, ARP, SNMP, LLDP
- Minimum repetition rate 2 ms
- Firmware update via MFCT
- Shared device
- Distribution of module channels to submodules
- Module-internal or submodule-internal Shared Input/Shared Output (MSI/MSO)
- Station extension via ET-Connection
- Module status
- Supports BusAdapter for different connection technologies
- Interface-local coupling of IO data
- Identification data I&M0 to I&M4
- PROFIenergy
- Removal/insertion of multiple I/O modules during operation (multi hot swap)
- Module-to-Module Communication (MtM)
- Setting the time
- TCP reset hold time for soft redundancy
- Reset to factory settings via RESET button

Requirements

The following table shows the software requirements of the Modbus TCP functions:

Table 2-91 Version dependencies of the Modbus TCP functions

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software MFCT	RegLayoutVersion
			As of V1.0 Update 2	
I/O communication with Modbus client	1	V6.2.1	X	V1.0
Bit by bit access via FC1 FC2 FC5 FC15 functions	1	V6.2.1	As of V1.3 Update 1	≥ V1.1
Bit by bit access via F4, F6 and F23	1	V6.3.1	X	≥ V1.1
Free user registers (e.g. for coordination of the redundancy)	1	V6.2.1	X	V1.0
Device status register	1	V6.2.1	X	V1.0
Config status register				
Diagnostics bit in data status of cyclic I/O data per submodule	1	V6.2.1	X	V1.0
Data record interface	1	V6.2.1	X	≥ V1.1
Integrated switch with 2 ports	1	V6.2.1	As of V1.3 Update 1	---
Supported Ethernet services: PING, ARP, SNMP, LLDP	1	V6.2.1	As of V1.3 Update 1	---
Minimum repetition rate 2 ms	1	V6.2.1	As of V1.3 Update 1	---
Firmware update via MFCT	1	V6.2.1	As of V1.3 Update 1	---
Shared device	1	V6.2.1	As of V1.3 Update 1	---
Distribution of module channels to submodules	1	V6.2.1	As of V1.3 Update 1	---
Module-internal or submodule-internal Shared Input/Shared Output (MSI/MSO)	1	V6.2.1	As of V1.3 Update 1	---
Station extension via ET connection	1	V6.2.1	X	---
Module status	1	V6.2.1	X	≥ V1.1
BA 2xRJ45 BusAdapter	1	V6.2.1	---	---
BA 2xFC BusAdapter	1	V6.2.1	---	---
BA 2xM12 BusAdapter	1	V6.2.1	---	---
Interface-local coupling of IO data	1	V6.2.1	As of V1.3 Update 1	---
Identification data I&M0 to I&M4	1	V6.2.1	As of V1.3 Update 1	---
PROFIenergy	1	V6.2.1	As of V1.3 Update 1	---
Removal/insertion of multiple I/O modules during operation (multi hot swap)	1	V6.2.1	As of V1.3 Update 1	---
Module-to-Module Communication (MtM)	1	V6.2.1	As of V1.3 Update 1	---

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software MFCT	RegLayoutVersion
			As of V1.0 Update 2	
Setting the time	1	V6.2.1	As of V1.3 Update 1	---
TCP reset hold time for soft redundancy	1	V6.2.1	As of V1.3 Update 1	≥ V1.1
Reset to factory settings via RESET button	1	V6.2.1	As of V1.3 Update 1	---

NOTE

You can find a more detailed description of the functions in the section PROFINET IO functions (Page 21) or in the function manual SIMATIC MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209).

6.1.1 Applicable modules with Modbus TCP

With Modbus TCP, the following modules cannot be used or can be used only with limitations.

These modules are divided into 4 categories:

Category	Description
1	This category is not relevant for Modbus TCP.
2	A function block for the target control must be created for the module. The module operates with a non-locked function block. The function block can be reimplemented.
3	Subfunctions of the module are not supported by the selected fieldbus. Subfunctions are only possible using blocks or additional interfaces.
4	The module is not supported by the selected fieldbus. The module needs a protected function block (e.g. for F-modules).

NOTE

Module operating modes based on isochronous operation (e.g. oversampling or time stamping) are not supported.

F-modules

Module	Article number	Category	Note
F-DI 8x24VDC HF	6ES7136-6BA00-0CA0	4	-
	6ES7136-6BA01-0CA0	4	-
F-DQ 4x24VDC/2A PM HF	6ES7136-6DB00-0CA0	4	-
F-DQ 8x24VDC/0.5A PP HF	6ES7136-6DC00-0CA0	4	-
F-RQ 1x24VDC/24..230VAC/5A	6ES7136-6RA00-0BF0	4	-
F-PM-E 24VDC/8A PPM ST	6ES7136-6PA00-0BC0	4	-
F-AI 4xI 0(4)..20mA 2-/4-wire HF	6ES7136-6AA00-0CA1	4	-
F-AI 4xU 0..10V HF	6ES7136-6AB00-0CA1	4	-
F-TM Count 1x1Vpp sin/cos HF	6ES7136-6CB00-0CA0	4	-

Technology modules

Module	Article number	Category	Note
TM ECC 2xPWM 12V ST	6FE1242-6TM10-0BB1	2	The control interface is described.
SIWAREX WP321	7MH4138-6AA00-0BA0	3	Commissioning is possible with SIWATOOL V7.
TM SIWAREX WP351 HF	7MH4138-6BA00-0CU0	3	Commissioning is possible with SIWATOOL V7 or the integrated web browser.
F-TM ServoDrive 1x24..48V ST	6BK1136-6AB00-0BU0	3	Comprehensive support of controller calculation and diagnostics is currently only available in the TIA Portal.

Communication modules

Module	Article number	Category	Note
CM PtP	6ES7137-6AA01-0BA0	3	See the "**CM PtP operation with PROFINET controller** (https://support.industry.siemens.com/cs/ww/en/view/59062563)" Programming and Operating Manual
CM 4xIO-Link	6ES7137-6BD00-0BA0	3	Time-based IO blocks (isochronous mode)
CM DALI	6ES7137-6CA00-0BU0	2	See the "ET 200SP, CM 1xDALI – Communication Model Description (https://support.industry.siemens.com/cs/ww/en/view/109774228)" Programming Manual

6.1.2 Update time of the I/O data

You can estimate the typical update time for an I/O cycle as follows:

RPI time (can be set starting at 2 ms)

+ I/O processing (typically 1.4 ms, +/- 1 ms jitter due to free-running cycles)

+ EM conversion (dependent on cycle time and parameter assignment of the module)

If necessary, you must take into account other influences caused by the EIP scanner and network components by adding them.

NOTE

When using ET 200AL I/O modules, the search for nodes at the ET connection can take up to 5 seconds. The user data is temporarily invalid during this period (IDS/ODS = 0x40).

6.1.3 Examples for I/O data mapping

6.1.3.1 I/O Data Mapping Introduction Modbus

I/O data mapping

During parameter assignment of the MF device, you can choose between three formats for the I/O data mapping:

- With the "Byte" format, the input or output data of the modules of an I/O connection are lined up by increasing slot address (Slot.Subslot).
- With the "Word" format, the input or output data of the modules of an I/O connection are lined up by increasing slot address (Slot.Subslot). If the submodule has an odd data length, a fill byte (content 0x00) is inserted after the submodule. This aligns the following data status bytes (IDS, ODS) to word limits. A padding byte (content 0x00) is also inserted after the data status byte (IDS, ODS). Subsequent submodules will then also start at an even byte offset.

The image of the outputs contains only the output data (with padding bytes if necessary), while the input image also supplies additional status bytes together with the input data (with padding bytes if necessary).

An Output Data Status Byte (ODS) is available for each output submodule in the image of the inputs.

There is an Input Data Status Byte (IDS) for each input submodule that follows the respective input data of the submodule in the input image.

Submodules with a data length of 0 for input and output data are treated as input submodules. Only an Input Data Status Byte (IDS) is entered in the input image.

NOTE

You can find the I/O data mapping for your configuration in the exported CSV file.

NOTE

For information about data mapping, see the system and equipment manuals.

I/O data status

The following table shows the coding of the status bytes for IDS and ODS:

Field	Bit number	Bit mask	Default	Bit value = '0'	Bit value = '1'
IOValid	7	0x80	0	I/O data invalid	I/O data valid*
Problem	6	0x40	0	Initial status	Module problem: • Module not plugged • Incorrect module plugged • Module with incorrect parameter assignment • I/O data temporarily invalid after station startup
NoCoupling	5	0x20	0	Initial status	No I/O data from PN coupler (MSO Local)
Reserved	4...2	0x1E	000	-	
ProcessEvent	1	0x02	0	No process event	Process event available
Diagnosis	0	0x01	0	No diagnostics	Diagnostics available

NOTE

For MSI and MSO submodules, the IDS.Diagnosis bit is 0. Comparable to the diagnostic error interrupt of PROFINET, the diagnostics for MSI and MSO are only signaled in the IDS.Diagnosis bit for the default submodule (subslot = 1).

6.1.3.2 Example of I/O data mapping for I/O data alignment Byte

Configuration example

The following figure shows the configuration for this example:

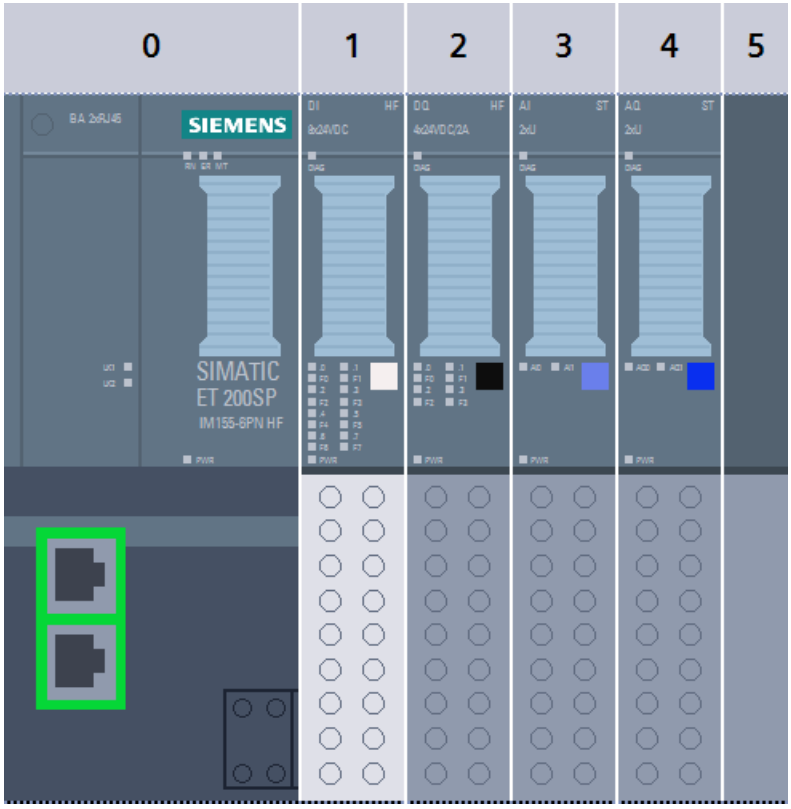

The example uses the following modules:

Slot	Module
0	IM 155-6 MF
1	DI 8 HF
2	DQ 4 HF, QI
3	AI 2 ST
4	AQ 2 ST
5	Server module

Input buffer

The following table shows the input buffer for the example configuration for the I/O data alignment Byte:

Slot	Name*	Data type	Access	Register offset	Description
0	Slot0_1_IDS	Word	LSB	0	Input Data State for the interface module
1	Slot1_1_I_channel_0_0		MSB	0	1 byte input data for the DI 8 HF module
	Slot1_1_IDS	Word	LSB	1	Input Data State for the DI 8 HF module
2	Slot2_1_QI		MSB	1	Value status for the DQ 4 HF module
	Slot2_1_IDS	Word	LSB	2	Input Data State for the value status of the DQ 4 HF module
3	Slot3_1_I_channel_0_0		MSB	2	2 bytes input data for channel 0 of the AI 2 ST module
	Slot3_1_I_channel_0_1	Word	LSB	3	
	Slot3_1_I_channel_1_0		MSB	3	2 bytes input data for channel 1 of the AI 2 ST module
	Slot3_1_I_channel_1_1	Word	LSB	4	
	Slot3_1_IDS		MSB	4	Input Data State for the AI 2 ST module
5	Slot5_1_IDS	Word	LSB	5	Input Data State for the server module
2	Slot2_1_ODS		MSB	5	Output Data State for the DQ 4 HF module
4	Slot4_1_ODS	Word	LSB	6	Output Data State for the AQ 2 ST module
x	Reserved		MSB	6	Reserved (0x00)

The sum of the input data is 7 registers.

Output buffer

The following table shows the output buffer for the example configuration for the I/O data alignment Byte:

Slot	Name*	Data type	Access	Register offset	Description
2	Slot2_1_O_channel_0_0	Word	LSB	0	1 byte output data for the DQ4 HF module
4	Slot4_1_O_channel_0_0		MSB	0	2 bytes output data for channel 0 of the AQ 2 ST module
	Slot4_1_O_channel_0_1	Word	LSB	1	
	Slot4_1_O_channel_1_0		MSB	1	2 bytes output data for channel 1 of the AQ 2 ST module
	Slot4_1_O_channel_1_1	Word	LSB	2	
x	Reserved		MSB	2	Reserved (0x00)

* The name is formed according to the following scheme: Slot<Slot#>_<Subslot#>_<DataItem-TextId>[_<Index>]

The sum of the output data is 3 registers.

6.1.3.3 Example of I/O data mapping for I/O data alignment Word

Configuration example

The following figure shows the configuration for this example:

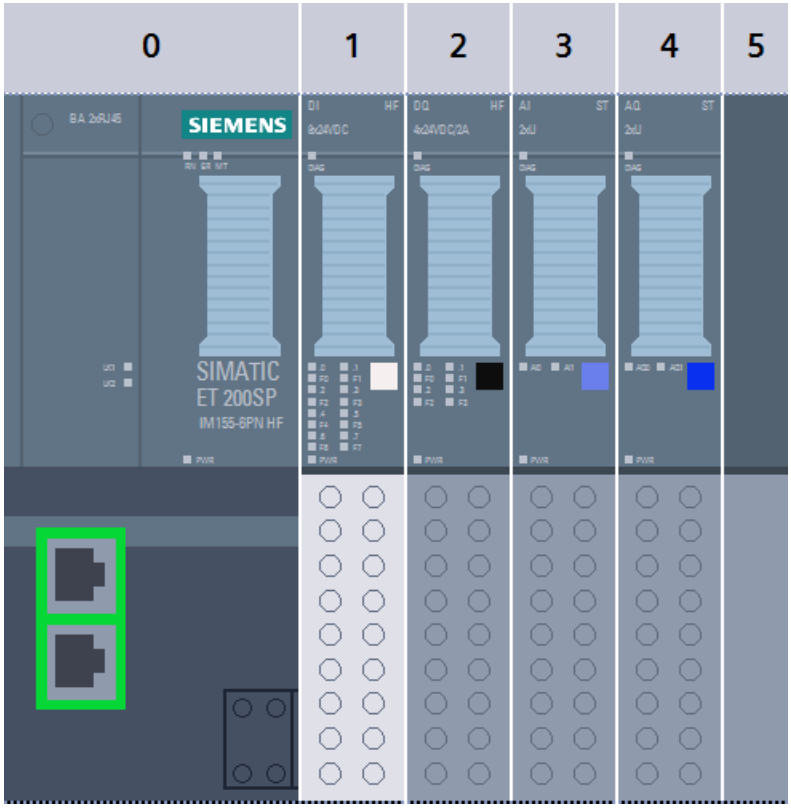

The example uses the following modules:

Slot	Module
0	IM 155-6 MF
1	DI 8 HF
2	DQ 4 HF, QI
3	AI 2 ST
4	AQ 2 ST
5	Server module

Input buffer

The following table shows the input buffer for the example configuration of the I/O data alignment Word:

Slot	Name*	Data type	Access	Register offset	Description
0	Slot0_1_IDS	Word	LSB	0	Input Data State for the interface module
	0x00		MSB	0	*Padding byte*
1	Slot1_1_I_channel_0_0	Word	LSB	1	1 byte input data for the DI 8 HF module
	0x00		MSB	1	*Padding byte*
	Slot1_1_IDS	Word	LSB	2	Input Data State for the DI 8 HF module
	0x00		MSB	2	*Padding byte*
2	Slot2_1_QI	Word	LSB	3	Value status for the DQ 4 HF module
	0x00		MSB	3	*Padding byte*
	Slot2_1_IDS	Word	LSB	4	Input Data State for the value status of the DQ 4 HF module
	0x00		MSB	4	*Padding byte*
3	Slot3_1_I_channel_0_0	Word	LSB	5	2 bytes input data for channel 0 of the AI 2 ST module
	Slot3_1_I_channel_0_1		MSB	5	
	Slot3_1_I_channel_1_0	Word	LSB	6	2 bytes input data for channel 1 of the AI 2 ST module
	Slot3_1_I_channel_1_1		MSB	6	
	Slot3_1_IDS	Word	LSB	7	Input Data State for the AI 2 ST module
	0x00		MSB	7	*Padding byte*
5	Slot5_1_IDS	Word	LSB	8	Input Data State for the server module
	0x00		MSB	8	*Padding byte*
2	Slot2_1_ODS	Word	LSB	9	Output Data State for the DQ 4 HF module
	0x00		MSB	9	*Padding byte*
4	Slot4_1_ODS	Word	LSB	10	Output Data State for the AQ 2 ST module
	0x00		MSB	10	*Padding byte*

The sum of the input data is 11 registers.

Output buffer

The following table shows the output buffer for the example configuration for the I/O data alignment Word:

Slot	Name*	Data type	Access	Register offset	Description
2	Slot2_1_O_channel_0_0	Word	LSB	0	1 byte output data for the DQ4 HF module
	0x00		MSB	0	*Padding byte*
4	Slot4_1_O_channel_0_0	Word	LSB	1	2 bytes output data for channel 0 of the AQ 2 ST module

* The name is formed according to the following scheme: Slot<Slot#>_<Subslot#>_<DataItem-TextId>[_<Index>]

Slot	Name*	Data type	Access	Register offset	Description
4	Slot4_1_O_channel_0_1	Word	MSB	1	2 bytes output data for channel 0 of the AQ 2 ST module
	Slot4_1_O_channel_1_0	Word	LSB	2	2 bytes output data for channel 1 of the AQ 2 ST module
	Slot4_1_O_channel_1_1		MSB	2	

* The name is formed according to the following scheme: Slot<Slot#>_<Subslot#>_<DataItem-TextId>[_<Index>]

The sum of the output data is 3 registers.

6.1.4 Shared device

Four ARs are available; these are shared by the fieldbuses. For EtherNet/IP and Modbus TCP, only one AR is reserved in each case, regardless of the number of controller connections used.

The maximum amount of I/O data must comply with the rules of the following table:

Number of fieldbus connections			Maximum I/O data per connection[1]		Max. download size with MFCT [1]	
PROFINET	EtherNet /IP	Modbus TCP	Inputs	Outputs	Inputs	Outputs
1	1 to 2	0	EtherNet/IP **or** Modbus TCP: 500 PROFINET: 1440	EtherNet/IP **or** Modbus TCP: 246 PROFINET: 1440	Download size[2]: 1440	Download size[2]: 1440
1	0	1 to 10				
0	1 to 2	1 to 10	500	246	1440	1440
1	1 to 2	1 to 10	360	246	360	360
2	1 to 2	0				
2	0	1 to 10				
2	1 to 2	1 to 10				

1 Including PROFINET payload qualifier or data status byte for signaling the data validity

2 PROFINET data + download size as displayed in MFCT ≤ 1440

The download size contains the I/O data of all EtherNet/IP and Modbus TCP connections as well as additional bytes for controlling the download.

NOTE

To avoid temporarily exceeding the I/O quantity structure, you must proceed as follows in case of a reconfiguration that results in changed I/O lengths:

1. Reduce the amount of I/O data in one configuration and download it to the MF device/CPU.
2. Increase the amount of I/O data in another configuration and download it to the MF device/CPU.

6.2 Diagnostics

6.2.1 Status and error displays for Modbus TCP

RN/NS, ER/MS LEDs on the MF device

The LEDs display the status with the **highest priority** if there are different LED states due to overlaid events. (0 = off, 1 = green flashing, 2 = green, 3 = yellow, 4 = red flashing, 5 = red)

The following table shows the meaning of the RN/NS LEDs and ER/MS LEDs for Modbus TCP:

Table 2-92 Status and error displays of the RN/NS LED

LED RN/NS (NET STATUS)	Meaning	Solution
Flashes	The MF device is not exchanging data.	• Check the correctness of the download with MFCT and for a valid IP address. • Establish the cyclic communication via the I/O register area of the MF device.
On	The MF device is exchanging data via at least one connection.	---
Flashes	Timeout	• Write the Modbus TCP output register within the configured time for the Modbus hold time. • Increase the value for the Modbus hold time in the parameter assignment of the MF device in the MFCT. • Check the accessibility of the MF device via the network from the perspective of the Modbus TCP controller.

Table 2-93 Status and error displays of the ER/MS LED

LED ER/MS (MODUL STATUS)	Meaning	Solution
Off	There is no MultiFieldbus project in the MF device.	• Create a project with MFCT and transfer it to the MF device.
Flashes	The MF device is not exchanging data. There is a MultiFieldbus project in the MF device.	• Establish the cyclic communication via the I/O register area of the MF device.
On	The MF device is exchanging data via a connection.	---
Flashes	Errors in the configuration or parameter assignment.	• Check the configuration of the MF station and, if necessary, correct the configuration and parameter assignment of the MF device in the MFCT and download them to the MF device again. • Check the device status in the Device-Info area and, if necessary, eliminate the error.
On	There is a maintenance event	• You can find more information in the section "Maintenance alarms".

Combinations of the RN/NS, ER/MS, MT/IO LEDs on the MF device

Combinations of the three LEDs are possible. The following table shows the possible combinations:

Table 2-94 Status and error displays of the RN/NS, ER/MS, MT/IO LEDs

LEDs			Meaning	Notes
RN/NS (NET STATUS)	ER/MS (MODUL STATUS)	MT/IO (IO STATUS)		
□ Off	□ Off	□ Off	Missing or insufficient supply voltage on the MF device.	• Check the supply voltage or switch on the supply voltage on the MF device. *
☼ Flashes	□ Off	□ Off	The MF device is not exchanging data. There is no MultiFieldbus project in the MF device.	• Create a project with MFCT and transfer it to the MF device. Then establish the cyclic I/O communication with the MF device.
■ On	□ Off	□ Off	The MF device is exchanging data via PROFINET IO. There is no MultiFieldbus project in the MF device.	• Exclusive PROFINET use
☼ Flashes	☼ Flashes	□ Off	The MF device is not exchanging data. There is a MultiFieldbus project in the MF device.	• Establish the cyclic communication via Modbus TCP I/O register area for configured modules.
■ On	☼ Flashes	□ Off	The MF device is exchanging data via PROFINET IO. There is a MultiFieldbus project in the MF device.	• Establish the cyclic I/O communication with a Modbus TCP controller. The corresponding fieldbus must have been selected via MFCT and downloaded to the MF device in advance. • Select "PROFINET" as the fieldbus in the MFCT for exclusive operation with PROFINET controllers.
■ On	■ On	□ Off	The MF device is exchanging data error-free via a connection (Modbus TCP).	---
■ On	☼ Flashes	□ Off	The MF device is exchanging data. The MF device has an error.	• Check the station configuration and, if necessary, correct the configuration and parameter assignment of the MF device in the MFCT and download them to the MF device again. • Check the device status in the Device-Info area and, if necessary, eliminate the diagnostics error.
☼ Flashes	☼ Flashes	□ Off	The MF device is not exchanging data. The MF device has an error.	• Establish the cyclic communication via the I/O register area of the MF device. • Check the station configuration and eliminate configuration and parameter assignment errors via MFCT and eliminate diagnostics errors.

* PWR LED on (on the MF device): Check the backplane bus for a short-circuit.

LEDs			Meaning	Notes
RN/NS (NET STATUS)	**ER/MS (MODUL STATUS)**	**MT/IO (IO STATUS)**		
Flashes	Flashes	Off	At least one connection existed (Modbus TCP). A connection has been terminated by timeout.	• Reduce the cycle time for writing the output registers in the Modbus TCP controller to less than the time for the Modbus hold time configured via the MFCT. • Check the accessibility of the MF device via the network from the perspective of the Modbus TCP controller.
Flashes	Flashes	Off	At least one connection existed (Modbus TCP). A connection has been terminated by timeout. Errors in the configuration or parameter assignment.	• Reduce the cycle time for writing the output registers in the Modbus TCP controller to less than the time for the Modbus hold time configured via the MFCT. • Check the accessibility of the MF device via the network from the perspective of the Modbus TCP controller. • Check the station configuration and eliminate configuration and parameter assignment errors via MFCT and eliminate diagnostics errors.
On	Flashes	Flashes	The server module was removed or more than one server module is inserted in the station.	Re-insert the server module or check the number of inserted server modules.
Flashes	Flashes	Flashes	The "Node flash test" is running.	• The LK1 and LK2 LEDs of the Ethernet interface are also flashing.
Flashes	Flashes	Flashes	Hardware or firmware defective.	• You can read out the service data with TIA Portal as of V19.
On *and then* On	On *and then* On	On *and then* On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s in red. Then for approximately 0.25 s in green.	-
On	On	On	RN/NS-, ER/MS-, MT/IO-LEDs are permanently on: Hardware or firmware defective. Error information will be determined and stored retentively on the Flash memory.	Do not disconnect the interface module from the supply voltage while the LEDs are permanently lit up. This may take a few minutes.

* PWR LED on (on the MF device): Check the backplane bus for a short-circuit.

Wiring

7

7.1 Pin assignment

24 V DC supply voltage (X80)

View		Signal name [1]	Description
Connector	IM connection		
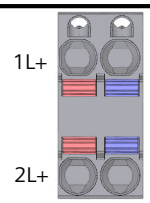	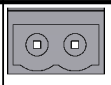	1L+	24 V DC
		2L+	24 V DC (for loop-through)[2]
		1M	Ground
		2M	Ground (for loop-through)[2]

[1] 1L+ and 2L+ as well as 1M and 2M are bridged internally

[2] Maximum 10 A permitted

Reference

You can find more information on accessories and how to connect the interface module in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

BusAdapter pin assignment

You can find information on the pin assignment of the BusAdapter at:

PROFINET IO BusAdapter (https://support.industry.siemens.com/cs/ww/en/view/109773801/de)

7.2 Block diagram

Block diagram

The following figure shows the block diagram of the IM 155-6 MF HF interface module.

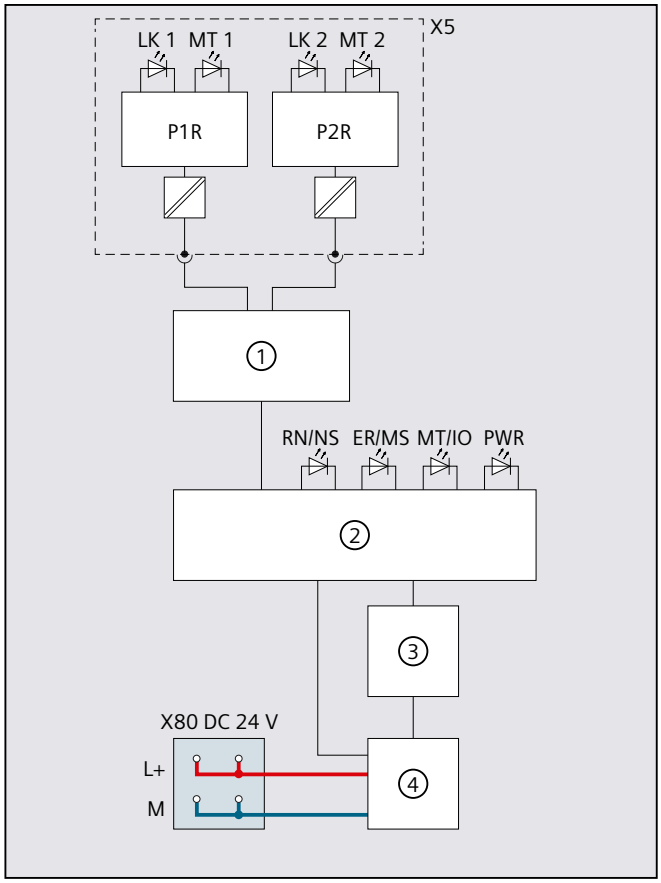

①	Switch	L+	24 V DC supply voltage
②	ET 200SP backplane bus interface and electronics	M	Ground
③	Backplane bus	LK 1,2	Link TX/RX LED (green)
④	Internal power supply	MT 1,2	MAINTENANCE FiberOptic LED (SCRJ port, yellow)
X80 24 - V DC	Feed supply voltage	RN/NS	RUN LED (green)/Network status (red)
X5	BusAdapter (For BusAdapters with RJ45 interface, the shielding is connected to functional ground)	ER/MS	ERROR LED (red)/Module status (green)
P1R	PROFINET interface X1 Port 1	MT/IO	LED MAINTENANCE (yellow)/ I/O status (green)
P2R	PROFINET interface X1 Port 2	PWR	POWER LED (green)

Figure 2-93 Block diagram of the IM 155-6 MF HF interface module

Parameters/address space 8

8.1 Parameters

Parameters for IM 155-6 MF HF interface module

The following table shows the parameters for the IM 155-6 MF HF interface module.

Table 2-95 Configurable parameters and their defaults
for IM 155-6 MF HF interface module (GSD file)

Parameters	Value range	Default	Scope
Diagnostics: Undervoltage [1]	• Disable • Enable	Disable	ET 200SP
Configuration control [2]	• Disable • Enable	Disable	ET 200SP
I/O data alignment [4]	• Byte • Word • Flexible/User-defined	Byte	ET 200SP
Connection hold time [3]	0 .. 30,000 ms	5,000 ms	ET 200SP
Hold time after connection reset [3]	0 .. 30,000 ms	0 ms	ET 200SP
Type of fieldbus	• PROFINET • EtherNet/IP #0 (0x301, 0x300) • EtherNet/IP #1 (0x309, 0x308) • ModbusTCP #0 (0x000, 0x2D0) • ModbusTCP #1 (0x5A0, 0x870) • ModbusTCP #2 (0x0B40, 0x0E10) • ModbusTCP #3 (0x10E0, 0x13B0) • ModbusTCP #4 (0x1680, 0x1950) • ModbusTCP #5 (0x1C20, 0x1EF0) • ModbusTCP #6 (0x21C0, 0x2490) • ModbusTCP #7 (0x2760, 0x2A30) • ModbusTCP #8 (0x2D00, 0x2FD0) • ModbusTCP #9 (0x32A0, 0x3570)	PROFINET	ET 200SP

1 Maintenance

2 only for PROFINET IO

3 only for Modbus TCP

4 only for EtherNet/IP and Modbus TCP

8.2 Explanation of parameters

8.2.1 Diagnostics: Undervoltage

Diagnostics: Undervoltage

Diagnostics (maintenance) undervoltage is triggered if the supply voltage falls below the value 19.2 V DC. When the supply voltage then exceeds 20.4 V DC, the diagnostics alarm is reported as outgoing.

See also

Diagnostics alarms (Page 47)

8.2.2 Configuration control

Configuration control

You use this parameter to enable the PROFINET configuration control function in the ET 200SP distributed I/O system.

NOTE

If you configure the enable, the ET 200SP distributed I/O system requires a control data record 196 from the user program in order for the ET 200SP distributed I/O system to operate the I/O modules.

Reference

You can find more information on the control data record in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual and in the STEP 7 online help.

8.2.3 I/O data alignment

I/O data alignment

For information on the "I/O data alignment" parameter, refer to the "MultiFieldbus" Function Manual.

8.2.4 Connection hold time

Connection hold time

You use the "Connection hold time" parameter to define the hold time of the outputs after the last valid write access with Modbus TCP to output register.

NOTE

The GSD file allows you to set the "Connection hold time" parameter to 0 ms. When you set the parameter "Connection hold time" to 0 ms, you deactivate monitoring of the communication via Modbus TCP.

NOTICE
"Connection hold time" parameter set to 0 ms When you set the parameter "Connection hold time" to 0 ms, you yourself are responsible for monitoring the communication via Modbus TCP.

8.2.5 Hold time after connection reset

Hold time after connection reset

You use the parameter "Hold time after connection reset" to define the hold time of the outputs after a reset of the connection via Modbus TCP.

8.2.6 Type of fieldbus

Type of fieldbus

Select the desired fieldbus with the parameter "Type of fieldbus":

- PROFINET
- EtherNet/IP
- Modbus TCP

You can find more information in the SIMATIC MultiFieldbus Function Manual (https://support.industry.siemens.com/cs/ww/en/view/109773209).

8.3 Substitute value behavior

You can find more information on substitute value behavior in the system manual ET 200SP Distributed I/O System (https://support.automation.siemens.com/WW/view/en/58649293).

8.4 Status of supply voltage L+ and feedback voltage of I/O modules

The "Status of supply voltage L+ and the feedback voltage of I/O modules" is configured on the server module. The input data can then be read out on the server module. You will find the relevant description in the Server module (https://support.automation.siemens.com/WW/view/en/63257531) equipment manual.

Compatibility

9

9.1 Compatibility of modules

Compatibility with the IM 155-6 MF HF interface module

If you exchange or replace an interface module, the following table shows the compatibility between the interface modules and different firmware versions:

		IM 155-6 MF HF V6.2 plugged	IM 155-6 MF HF V6.3 plugged	IM 155-6 MF HF V6.4 plugged
Interface module configured		**Compatibility**	**Compatibility**	**Compatibility**
IM 155-6 PN ST V1.0		-	-	-
IM 155-6 PN ST V1.1, V3.1, V3.3, V4.1 or V4.2		X	X	X
IM 155-6 PN HF V2.0, V2.1, V2.2, V3.0, V3.1, V3.3 or V4.2		X*	X*	X*
		*Compatibility subject to the following restrictions: • Operation with a BusAdapter via fiber-optic cable connection (LC, LC-LD, SCRJ) is not supported. • Operation in isochronous mode requires reconfiguration. • Applications that use topological planning **and** have changed the default cable length value from 100 m to 20 m. With adjusted cable length, compatible exchange is ensured. However, a maintenance message: "Remote mismatch / Cable delay mismatch" may be displayed. This behavior can be corrected by reconfiguring or by deactivating the cable length diagnostics.		
IM 155-6 MF HF V5.0, V5.1 or V5.2		X**	X**	X**
		Compatibility subject to the following restrictions: • Operation with a BusAdapter via fiber-optic cable connection (LC, LC-LD, SCRJ) is not supported. • Applications that use topological planning **and have changed the default cable length value from 100 m to 20 m. With adjusted cable length, compatible exchange is ensured. However, a maintenance message: "Remote mismatch / Cable delay mismatch" may be displayed. This behavior can be corrected by reconfiguring or by deactivating the cable length diagnostics.		
IM 155-6 PN ST	V6.1	X	X	X
	V6.2	X	X	X
	V6.3	-	X	X
	V6.4	-	-	X
IM 155-6 MF HF	V6.2	X	X	X
	V6.3	-	X	X
	V6.4	-	-	X

Station configuration with more than 32 I/O modules

Certain older I/O modules with functional status 001 and 002 do not support a station configuration with more than 32 I/O modules.

The table below shows all modules that do not support a station configuration with more than 32 I/O modules:

Table 2-96 Incompatible modules with functional status

Modules	Article number	Up to functional status
Analog modules		
AI 4xI 2-/4-wire ST	6ES7134-6GD00-0BA1	002
AI 4xU/I 2-wire ST	6ES7134-6HD00-0BA1	002
AI 4xRTD/TC 2-/3-/4-wire HF	6ES7134-6JD00-0CA1	002
AI 4xU/I ST	6ES7135-6HD00-0BA1	002
Digital modules		
DI 16x24VDC ST	6ES7131-6BH00-0BA0	002
DI 8x24VDC ST	6ES7131-6BF00-0BA0	002
DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0	002
DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0	002
DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0	002

Status of the supply voltage

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules without parameter assignment in the following table, the status of the supply voltage (status byte of the server module) is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Article number
DI 8x24VDC ST	6ES7131-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7131-6BF00-0CA0
DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0
DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0
DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0
DQ 8x24VDC/0.5A HF	6ES7132-6BF00-0CA0

Analog output module AQ 4xU/I ST

NOTE

For operation of the AQ 4xU/I ST analog output module, firmware version V1.0 (6ES7135-6HD00-0BA1) with the interface module, you need to set the "Reaction to CPU STOP" parameter to "Turn off" with a PROFINET send clock < 1 ms.

Reaction times for fail-safe modules

The following maximum reaction time of the interface module must be taken into account when calculating the reaction times of fail-safe modules: **T_{Slave} = configured update time + 400 µs (but at least 1.4 ms)**

Interface module IM 155-6 PN HF (6ES7155-6AU00-0CN0) with firmware version V4.2

NOTE

You cannot use the following functions during operation of the IM 155-6 PN HF (6ES7155-6AU00-0CN0) with firmware version V4.2:

- Module-to-Module Communication (MtM)
- Setting the time
- Diagnostics (maintenance) undervoltage

Operation and maintenance 10

10.1 Resetting interface module with MFCT to factory settings

You can also reset the interface module with MFCT to factory settings.

Information on this is available in section "Resetting the MF device" of the "MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209)" function manual.

10.2 Firmware update

You can perform firmware updates for modules and interface modules:

- With TIA Portal as of V19.
- With MFCT. Information on this is available in the "MultiFieldbus" function manual in the section "Firmware update with MFCT".

See also

MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209)

Technical specifications 11

Technical specifications of the IM 155-6 MF HF

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7155-6MU01-0CN0/td?dl=en).

Article number	6ES7155-6MU01-0CN0
General information	
Product type designation	IM 155-6 MF HF
Firmware version	V6.4.1
• FW update possible	Yes
Vendor identification (VendorID)	002AH
Device identifier (DeviceID)	0313H
Manufacturer ID according to ODVA (VendorID)	0x04E3
Device ID according to ODVA (Product code)	0FA2H
Product function	
• I&M data	Yes; I&M0 to I&M4
• Module swapping during operation (hot swapping)	Yes; Multi-hot swapping
• Isochronous mode	Yes
• IRT	Yes
• Tool changer	Yes; Docking station and docking unit
• Local coupling, IO data	Yes
– Number of coupling modules	6; 1x output + max. 5x input
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V20
• STEP 7 configurable/integrated from version	V5.7 SP3
• PROFINET from GSD version/GSD revision	GSDML V2.45
• Multi Fieldbus Configuration Tool (MFCT)	V1.5.2.0 or higher
Configuration control	
via dataset	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes

Article number	6ES7155-6MU01-0CN0
Short-circuit protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	10 ms
Input current	
Current consumption (rated value)	550 mA
Current consumption, max.	650 mA
Inrush current, max.	1 A
I^2t	0.05 $A^2 \cdot s$
Power loss	
Power loss, typ.	2 W
Address area	
Address space per module	
• Address space per module, max.	288 byte; For input and output data respectively
Address space per station	
• Address space per station, max.	1 440 byte
Hardware configuration	
Rack	
• Quantity of operable ET 200SP modules, max.	64
• Quantity of operable ET 200AL modules, max.	16
Submodules	
• Number of submodules per station, max.	256
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch)
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; with BusAdapter
• Number of ports	2; with BusAdapter
• integrated switch	Yes
• BusAdapter (PROFINET)	Yes; BA 2x RJ45, BA 2x M12, BA 2x FC
Protocols	
• PROFINET IO Device	Yes
• Open IE communication	Yes
• Media redundancy	Yes; PROFINET MRP client
PROFINET IO Device	
Services	
– IRT	Yes; 250 µs to 4 ms in 125 µs frame
– Dynamic Frame Packing (DFP)	Yes
– Fast Forwarding	Yes
– Fragmentation	Yes

Article number	6ES7155-6MU01-0CN0
– PROFIenergy	Yes
– Prioritized startup	Yes
– Shared device	Yes
– Number of IO Controllers with shared device, max.	14; 2x PN controller + 2x EtherNet/IP scanner + 10x Modbus TCP master
Interface types	
RJ 45 (Ethernet)	
• Transmission procedure	PROFINET with 100 Mbit/s full duplex (100BASE-TX)
• 100 Mbps	Yes
• Autonegotiation	Yes
• Autocrossing	Yes
Protocols	
Supports protocol for PROFINET IO	Yes
PROFIsafe	Yes
PROFIBUS	No
EtherNet/IP	Yes
Modbus TCP	Yes
Number of connections	
• Number of MtM communication relationships/connections, max.	16
Redundancy mode	
• PROFINET system redundancy (S2)	Yes; NAP S2
• H-Sync forwarding	Yes
Media redundancy	
– MRP	Yes
– MRPD	Yes
EtherNet/IP	
Services	
– CIP Implicit Messaging	Yes
– CIP Explicit Messaging	Yes
– CIP Safety	No
– Configuration control via Explicit Messaging	No
– Shared device	Yes; 2x PN controller + 2x EtherNet/IP scanner + 10x Modbus TCP master
– Number of scanners with shared device, max.	2
Updating times	
– Requested Packet Interval (RPI)	2 ms
Address area	
– Address space per module, max.	288 byte; (246 byte outputs / 288 byte inputs)

Article number	6ES7155-6MU01-0CN0
– ForwardOpen (Class1 & 32 bit Header)	500 byte; (246 byte outputs / 500 byte inputs)
– LargeForwardOpen (Class3)	4 002 byte
Connections	
– Number of rack connections	2
Modbus TCP	
Services	
– read coils (code=1)	Yes
– read discrete inputs (code=2)	Yes
– Read Holding Registers (Code=3)	Yes
– Read Input Register (Code=4)	Yes
– write single coil (code=5)	Yes
– Write Single Register (Code=6)	Yes
– write multiple coils (code=15)	Yes
– Write Multiple Registers (Code=16)	Yes
– Read/Write Multiple Registers (Code=23)	Yes
– Parameter change by master	Yes
– Modbus TCP Security Protocol	No
Address space per station	
– Address space per station, max.	500 byte; (246 byte outputs / 500 byte inputs)
– Access-consistent address space	250 byte; (246 byte outputs / 250 byte inputs)
Updating time	
– I/O request interval	2 ms
Connections	
– number of connections per device	9; (1x inputs / 2x outputs / 4x volatile registers / 2x Device Info)
Open IE communication	
• TCP/IP	Yes
• UDP	Yes
• SNMP	Yes
• LLDP	Yes
• ARP	Yes
• IGMP	Yes
• Multicast	Yes
• Broadcast	Yes
• IPv4	Yes
• IPv6	No

Article number	6ES7155-6MU01-0CN0
Isochronous mode	
Equidistance	Yes
shortest clock pulse	250 µs
max. cycle	4 ms
Bus cycle time (TDP), min.	250 µs
Jitter, max.	1 µs
Interrupts/diagnostics/status information	
Status indicator	Yes
Alarms	Yes
Diagnostics function	Yes
Diagnostics indication LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• MAINT LED	Yes; Yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• NS LED	Yes; green/red LED
• MS LED	Yes; green/red LED
• IO LED	Yes; red-green-yellow LED
• Connection display LINK TX/RX	Yes; 2x green link LEDs on BusAdapter
Potential separation	
between backplane bus and electronics	No
between PROFINET and all other circuits	Yes; 1500 V AC (type test)
between supply and all other circuits	No
Permissible potential difference	
between different circuits	Safety extra low voltage SELV
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Network loading class	3
Security	
PROFINET Security Class	1
signed firmware update	Yes
Secure Boot	No
safely removing data	Yes
data integrity	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; No condensation

Article number	6ES7155-6MU01-0CN0
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Connection method	
ET-Connection	
• via BU/BA Send	Yes; + 16 ET 200AL modules
Mechanics/material	
Strain relief	Yes; Optional
Dimensions	
Width	50 mm
Height	117 mm
Depth	74 mm
Weights	
Weight, approx.	120 g; without BusAdapter

Dimension drawing

A

This appendix contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

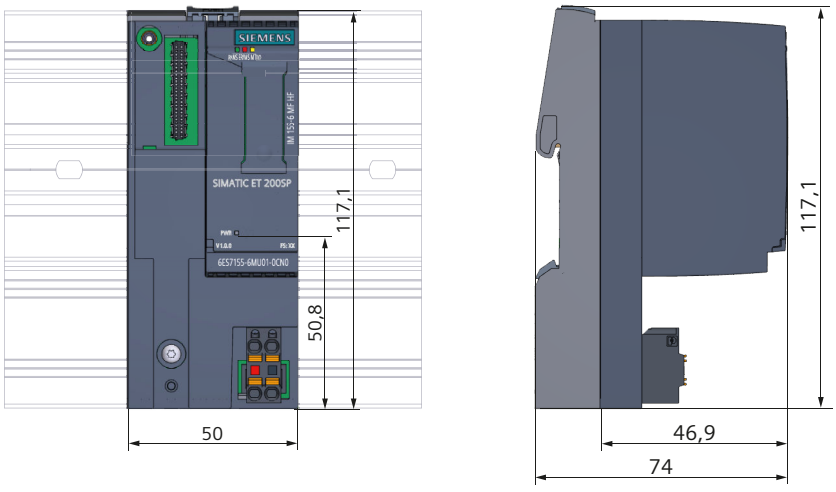

Figure 2-94 Dimension drawing of the IM 155-6 MF HF interface module (front and side view)

SIEMENS

SIMATIC

ET 200SP
Interface module IM 155-6 PN BA (6ES7155-6AR01-0AN0)

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Introduction 1

1.1 Introduction

Purpose of the documentation

This equipment manual supplements the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in the system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used hereinafter, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.2 ET 200SP Documentation Guide

1.2.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/84133942)

1.2.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.2.3 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

See also

PRONETA Professional (https://support.industry.siemens.com/cs/ww/en/view/109781283)

1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is PC-based software and supports the configuration of MultiFieldbus-Devices and DALI-modules. In addition, the MFCT offers convenient options for bulk firmware updating of ET 200 devices with MultiFieldbus-support and reading of service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI modules.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- CM PtP:
  Analysis of serial communication, event logs and reading of the current configuration.

- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109773881)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

You can find more general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-related information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://www.siemens.com/cert.

2.3 Cybersecurity-relevant information

Observe all cybersecurity-relevant information.

Topics with cybersecurity-relevant information	Reference
Operational application environment and security assumptions	
Requirements for the operational application environment of the system and security assumptions	You can find this section in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Security properties of the product	
Access protection	Note the information on access protection in the Protection chapter of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Data integrity	The topic of data integrity is described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Signed firmware update	The topic of signed firmware updates is described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
PROFINET Security Class 1 • The device supports PROFINET Security Class 1. • With the introduction of PROFINET Security Class 1, additional security settings have been integrated into the PROFINET communication.	Detailed information about PROFINET Security Class 1 and the additional security settings can be found in the PROFINET with STEP 7 Function Manual (https://support.automation.siemens.com/WW/view/en/49948856)
Supported Ethernet services	You can find information on supported services in the Technical specifications section. You can find detailed information about supported Ethernet services in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
Interfaces, ports, protocols and services	
Information on the following is security-relevant: • Communication layer and communication role • Default states • Enabling/disabling of ports and services	You can find detailed information on these topics in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
Secure operation	
Recommendations for safe operation	You can find cross-system information on the safe operation of interface modules in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Corrective measures for known risks	Corrective measures for known risks are announced on the Siemens ProductCERT and Siemens CERT (https://siemens.com/productcert) web page. You can find more information on SIEMENS ProductCERT in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Topics with cybersecurity-relevant information	Reference
Security checks	You can find descriptions of specific security measures, such as cyclic checks of the configuration via checksums, in the Industrial cybersecurity section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Secure decommissioning Products that contain security-relevant data must be securely decommissioned before disposal or resale.	You can find information on secure decommissioning in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293), Secure operation of the system section

Product overview

3

3.1 Properties

Article number

6ES7155-6AR01-0AN0 (interface module IM 155-6 PN BA and server module)

View of the module

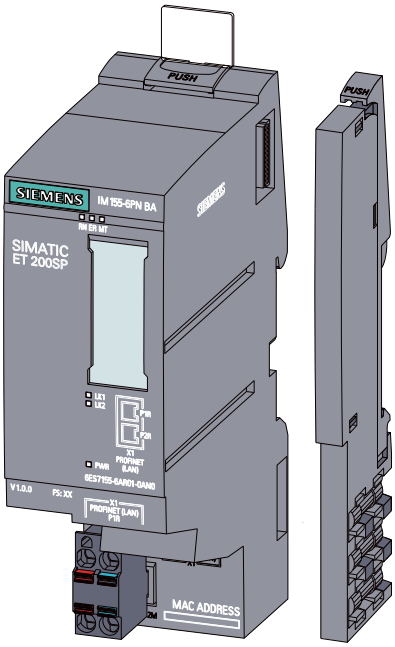

Figure 2-95 View of the IM 155-6 PN BA interface module with included accessories (24 V DC connector and server module) and optional accessories (the labeling strips and equipment labeling plate)

Properties

The module has the following technical properties:

- Connects the ET 200SP distributed I/O system with PROFINET IO
- Power supply 1 L+ 24 V DC (SELV/PELV). The connection plug is included in the scope of delivery of the interface module.

Supported topologies

- Linear bus topology
- Star topology
- Tree topology

The module supports the following functions (Page 16):

Maximum configuration

- 16 ET 200SP I/O modules
- 128 bytes I/O data

Accessories

The following accessories can be ordered separately:

- 24 V DC connector
- Labeling strips
- Equipment labeling plate
- SIMATIC system rail

A detailed list of the available accessories can be found in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Server module

The server module is included in scope of delivery of the interface module and is also available separately.

The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system
- Features a support for 3 spare fuses (5 × 20 mm)
- Provides station functions, e.g. group diagnostics: No supply voltage L+, status bytes.
- I&M identification data
- Retentive storage of the device name for device replacement without topological configuration

NOTE

You need to configure and assign parameters to the server module in the configuration software.

To do this, place the server module in the last configuration slot and enable the parameter Group diagnostics: missing supply voltage L+. When there are 16 I/O modules, the server module is inserted in slot 17.

You can find more information in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

First BaseUnit of an ET 200SP in the configuration

NOTE

First BaseUnit of an ET 200SP in the configuration

When an AC I/O module or AI Energy Meter ST is plugged, the first BaseUnit in an ET 200SP station may be a dark one. Note the information on limiting the overvoltage and power rating in the AC I/O module manuals.

In order to route the 24 V DC supply voltage via a fuse, a light BaseUnit must be plugged into the slot of the first 24 V DC I/O module.

Pay attention to the type of the BaseUnits during configuration.

3.2 Functions

Introduction

The interface module supports the following PROFINET IO functions:

- Integrated switch with 2 ports
- Supported Ethernet services: ICMP, ARP, SNMP, LLDP
- Port diagnostics
- Deactivating ports
- Real-time communication
- Isochronous real-time communication
- Minimum update time 1 ms
- Media redundancy (MRP and MRPD)
- Device replacement without programming device (PG) and without topological configuration
- Reset to factory settings via PROFINET IO or RESET button (station-wide)
- Reset to factory settings via PROFINET IO (Factory Mode 8)
- Firmware update via PROFINET IO
- Performance upgrade PROFINET (DFP, FFT, fragmentation)
- Identification data I&M 0 to I&M 4
- PROFIenergy
- Configuration control (option handling)
- Value status (quality information, QI) of I/O modules
- Reading out service data
- Reference temperature distribution

- Setting the time
- Time distribution
- Diagnostic interrupts
- Hardware interrupts
- Removal/insertion of multiple I/O modules during operation (multi hot swap)
- Maintenance events

Requirements

The table below shows the software requirements for a configuration with the IM 155-6 PN BA interface module:

Table 2-97 Version dependencies of other module functions

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130000)/software from a third-party manufacturer [1]	STEP 7 Classic	STEP 7 (TIA Portal)
Integrated switch with 2 ports	1	V6.2.1	X	X	X
Supported Ethernet services: ICMP, ARP, SNMP, LLDP	1	V6.3.0	X	X	X
Port diagnostics	1	V6.3.0	X	X	X
Deactivating ports	1	V6.3.0	X	X	X
Real-time communication	1	V6.3.0	X	X	X
Isochronous real-time communication	1	V6.4.0	X	X	X
Minimum update time 1 ms	1	V6.3.0	X	X	X
Media redundancy (MRP)	1	V6.3.0	X	X	X
Media redundancy (MRPD)	1	V6.4.0	X	X	X
Device replacement without programming device (PG) and without topological configuration	1	V6.3.0	X	X	X
Reset to factory settings via PROFINET IO or RESET button	1	V6.2.1	X	X	X
Reset to factory settings via PROFINET IO (Factory Mode 8)	1	V6.4.0	X	X	X
Firmware update via PROFINET IO	1	V6.3.0	X	X	X

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130-000)/software from a third-party manufacturer [1]	STEP 7 Classic	STEP 7 (TIA Portal)
Performance upgrade PROFINET (DFP, FFT, fragmentation)	1	V6.4.0	X	X	X
Identification data I&M 0 to I&M 4	1	V6.3.0	X	X	X
PROFIenergy	1	V6.3.0	---	X	X
Configuration control (option handling)	1	V6.3.0	X	X	X
Value status (quality information, QI) of I/O modules	1	V6.3.0	X	X	X
Reading out service data	1	V6.3.0	-	X	X
Reference temperature distribution	1	V6.3.0	X	X	X
Setting the time	1	V6.3.0	X	X	X
Time distribution	1	V6.3.0	X	X	X
Diagnostic interrupts	1	V6.3.0	X	X	X
Hardware interrupts	1	V6.3.0	X	X	X
Removal/insertion of multiple I/O modules during operation (multi hot swap)	1	V6.3.0	X	X	X
Maintenance events	1	V6.3.0	X	X	X
User data • MaxApplicationInputLength 128 bytes • MaxApplicationOutput-Length 128 bytes	1	V6.3.0	X	X	X

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

The following table shows the appropriate version of the configuration software depending on the functional status of the module.

Table 2-98 Version of the configuration software depending on the functional status of the module

Firmware version of the module	STEP 7 Classic	STEP 7 (TIA Portal)
As of V6.1	As of STEP 7 V5.5 SP4 with HSP0329 V1.0	As of V18 with HSP0415 V1.0
As of V6.2	As of STEP 7 V5.6 with HSP0329 V2.0	As of V19 with HSP0415 V1.0
As of V6.3	As of STEP 7 V5.7 SP3 HF3 with HSP0342 V1.0	As of V19 with HSP0415 V2.0
As of V6.4	As of STEP 7 V5.7 SP3 HF3 with HSP0342 V2.0	As of V20 with HSP0415 V2.0

Cabling with fixed connection setting

If you set a fixed connection setting of the port in STEP 7, you must also disable "Autonegotiation/Autocrossover".

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12 in the PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5 in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Replacement of an IM 155-6 PN BA

In a replacement scenario, you reset an IO device that is already in operation to the as-delivered state using "Reset to factory settings". You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

GSD file

An additional GSD file based on the schema version V2.25 is available for the previous PROFINET GSD files. This is only to be used when the engineering tool used does not support GSD files of the current schema version.

3.2.1 Supported Ethernet services: ICMP, ARP, SNMP, LLDP

The module supports the following standardized Ethernet services:

- **ICMP - Internet Control Message Protocol (RFC 792)**

ICMP is a protocol used to transmit informational and error messages over the Internet protocol.

- **ARP - Address Resolution Protocol (RFC 826)**

ARP is a protocol used to determine the hardware address (MAC) of an associated Internet Protocol (IP) address.

- **SNMP - Simple Network Monitoring Protocol (RFC 1157, RFC 3410)**

SNMP is a protocol for transmitting management information across networks.

- **LLDP – Link Layer Discovery Protocol (IEEE 802.1AB)**

LLDP is a protocol for identifying neighboring devices.

3.2.2 Port diagnostics

The device supports special diagnostics alarms that signal the quality of data transfer on the medium used.

3.2.3 Disabling of ports

The device supports the deactivation of the port by parameter assignment, so that all communication on this port is prevented.

3.2.4 Real-time communication

A transmission method for PROFINET IO based on cyclic data exchange with a provider-consumer model.

3.2.5 Isochronous real-time communication

Synchronized transmission method for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth within the send clock is available for IRT data. The reserved bandwidth ensures that the IRT data is also transmitted in time-synchronized intervals, unaffected by other high network loading (e.g. TCP/IP communication or additional real time communication).

A topological configuration is required for IRT.

NOTE

IO controller as sync master with IRT communication

Operation of the IO controller as a sync master is recommended when configuring the IRT communication.

Otherwise, IRT- and RT-configured IO devices may fail if the sync master fails.

You can find more information on the configuration of synchronized PROFINET devices in sync domains in the STEP 7 online help and:

- As of STEP 7 V12 in the PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5 in the PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

3.2.6 Minimum update time 1 ms

The shortest update cycle of IO data for this device is 1 ms. To achieve this value, the controller used must also support this time.

3.2.7 Media redundancy (MRP and MRPD)

MRP is a function for ensuring communication and plant availability. A ring topology ensures that an alternative communication path is made available if a transmission route fails.

You can find more information in the STEP 7 online help and as of STEP 7 (TIA Portal) V12 in the PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

3.2.8 Device replacement without programming device (PG) and without topological configuration

Device replacement without topological configuration

The device name is stored on the server module (as of V1.1.1) as well as on the interface module. A device name stored in the server module is required for device replacement without topology configuration.

When the interface module is replaced, there is range of scenarios in which the device name is used.

Table 2-99 Scenarios for using the device name

	Interface module empty	Interface module with device name
Server module empty	No device name available.	The device name from the interface module is used and copied to the server module.
Server module with device name	The device name from the server module is used and copied to the interface module.	The device name from the server module is used and copied to the interface module if this has a different device name.

Note the following constraints:

- Resetting to factory settings deletes the device name in both the interface module and the server module. To prevent the device name from being deleted in the server module, you can remove the server module from the interface module before resetting to factory settings.
- When a server module is replaced, a device name stored in the server module is applied to the interface module after a POWER ON.

- Removal/insertion of the server module under voltage is not permitted. If you pull/plug the server module while under voltage, the interface module restarts.
- If you use a server module with an invalid firmware version (< V1.1.1), channel-specific diagnostics is generated with the error number 27 (general error). To correct this error, you need to replace the server module or update the server module firmware.

Device replacement with topology configuration

IO devices with this function can be replaced in a simple manner:

- The device name does not need to be assigned with the programming device (PG).

The replaced IO device is assigned the device name by the IO controller, not by the programming device (PG). The IO controller uses the configured topology and the neighborhood relationships determined by the IO devices for this purpose. All involved devices must support the LLDP protocol (Link Layer Discovery Protocol). The configured topology must match the actual topology.

If the IO devices were already used in another configuration, reset them to factory settings before reusing them. You can find more information in the ET 200SP distributed I/O system system manual.

You can find more information in the STEP 7 online help and as of STEP 7 (TIA Portal) V12 in the PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

Device replacement without programming device (PG) and without topological configuration

Device replacement without topological configuration

The device name is stored on the server module (as of V1.1.1) as well as on the interface module. A device name stored in the server module is required for device replacement without topology configuration.

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Table 2-100 Scenarios for using the device name

	Interface module empty	Interface module with device name
Server module empty	No device name available.	The device name from the interface module is used and copied to the server module.
Server module with device name	The device name from the server module is used and copied to the interface module.	The device name from the server module is used and copied to the interface module if this has a different device name.

Note the following constraints:

- Resetting to factory settings deletes the device name in both the interface module and the server module. To prevent the device name from being deleted in the server module, you can remove the server module from the interface module before resetting to factory settings.
- When a server module is replaced, a device name stored in the server module is applied to the interface module after a POWER ON.

- Removal/insertion of the server module under voltage is not permitted. If you pull/plug the server module while under voltage, the interface module restarts.
- If you use a server module with an invalid firmware version (< V1.1.1), channel-specific diagnostics is generated with the error number 27 (general error). To correct this error, you need to replace the server module or update the server module firmware.

See also

Distributed I/O system ET 200SP
(https://support.industry.siemens.com/cs/ww/en/view/58649293)

3.2.9 Reset to factory settings via PROFINET IO

There are two modes for resetting to factory settings:

- Resetting to factory settings via PROFINET IO or the RESET button deletes the device name, IP address, service data and I&M data 1-4 both in the selected interface module and in the corresponding BusAdapter and server module.
- Resetting via PROFINET IO using Factory Mode 8 deletes the IP address, service data and I&M data 1-4 in the device and all associated modules that support resetting to factory settings.

3.2.10 Firmware update via PROFINET IO

You can find information on how to perform a firmware update in the ET 200SP Distributed I/O System system manual.

See also

Distributed I/O system ET 200SP
(https://support.industry.siemens.com/cs/ww/en/view/58649293)

3.2.11 Performance upgrade PROFINET (DFP, FFT, fragmentation)

Dynamic Frame Packing (DFP)

Dynamic Frame Packing (DFP) optimizes the PROFINET communication by combining multiple small frames into larger packets.

- Reduces network overhead and improves bandwidth utilization
- Helps reduce network load and improves real-time performance
- Particularly effective when many small data packets have to be transmitted.

Fast Forwarding Technology (FFT)

Fast Forwarding Technology (FFT) is an advanced switching technology that accelerates frame forwarding in PROFINET networks.

- Reduces latency through frame processing at hardware level.
- Enables cut-through switching instead of store-and-forward
- Particularly important for time-critical applications

Frame fragmentation

Frame fragmentation enables large data packets to be split into smaller fragments.

- Enables better coexistence of real-time and non-real-time data traffic.
- Prevents time-critical frames from being blocked by large data packets.
- Improves the overall network determinism.

Preamble shortening

Preamble shortening is a PROFINET optimization method that reduces the standard Ethernet frame preamble length to improve network performance.

3.2.12 Identification data I&M 0 to I&M 4

Identification and maintenance data (I&M data) is information saved on the module. The data is:

- Read-only (I-data) or
- Readable/writable (M-data)

Identification data (I&M0): Manufacturer information about the module that can only be read. Some identification data is also printed on the housing of the module, for example article number and serial number.
Maintenance data (I&M1, 2, 3): Plant-dependent information, e.g. installation location. Maintenance data is created during configuration and downloaded to the module.
All modules of the ET 200SP distributed I/O system support identification data (I&M0 to I&M3).

Checksums CRC (I&M4): The interface module calculates checksums based on its used data and the supplied data from the associated modules, such as parameter settings, IP address, device name, MAC address and I&M data. The interface module stores the checksums in the I&M4 data area.

The I&M identification data supports you in the following activities:

- Checking the system configuration
- Locating hardware changes in a plant
- Correcting faults in a plant
- Inspection of safe operation of a plant

Modules can be clearly identified online using the I&M identification data.

With TIA Portal, you can read out the identification data I&M (see online help of the TIA Portal).

IM4 is write-protected due to information integrity. You can find more information on the identification data I&M 0 to I&M 3 in the ET 200SP distributed I/O system system manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

3.2.13 PROFIenergy

Properties

PROFIenergy (for PROFINET) reduces the energy consumption by using PROFIenergy commands during production-free periods.

Reference

You can find more information on PROFIenergy in the:

- Product manual I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300)
- PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) function manual.
- System manual PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127)
- PROFIenergy (http://support.automation.siemens.com/WW/view/en/66928686) product information.
- Internet (http://www.profibus.com) under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order No: 3.802.

3.2.14 Configuration control (option handling)

Properties

Configuration control allows you to prepare your distributed I/O system for future extensions or changes. Configuration control means that you can configure the planned maximum configuration of your distributed I/O system in advance and vary it later in a flexible manner by means of the user program.

Reference

You can find more information on configuration control

- in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual
- on the Internet under the following link: Application collection (http://support.automation.siemens.com/WW/view/en/29430270)
- in the STEP 7 online help.

3.2.15 Value status (quality information, QI) of I/O modules

The IM 155-6 PN BA interface module supports I/O modules with value status. The value status provides information about the validity of the individual process values.

You can find more information on the value status in the system manual (https://support.industry.siemens.com/cs/ww/en/view/58649293) and in the I/O module manuals.

3.2.16 Reading out service data

The function makes it possible to read out diagnostic and service information from the interface module.

In the case of a pending maintenance alarm, you can read out the service data and make it available to SIEMENS support for queries and product improvement.

The service data is read out using the TCP protocol. A connection on port 102 is opened for this.

Methods of reading service data

- TIA V19
- Multi Fieldbus Configuration Tool (MFCT), V1.4.1 or higher

The tool download and more information, as well as documentation on the individual functions of the MFCT, can be found on the Internet (https://support.industry.siemens.com/cs/de/de/view/109773881/en).

3.2.17 Reference temperature distribution

Specific I/O modules require a reference temperature to compensate for temperature dependence. This device supports the function of distributing this temperature on the backplane bus. Up to 4 reference temperatures can be distributed.

3.2.18 Setting the time

The interface module supports time setting, for example, with AI Energy Meter CT HF (6ES7134-6PA01-0CU0).

We show you how to set the time in an application example (https://support.industry.siemens.com/cs/ww/en/view/109754890).

3.2.19 Time distribution

For example, if there is an AI Energy Meter CT HF (6ES7134-6PA01-0CU0), the time is automatically distributed within the ET 200SP station. You can find more information in the section Setting the time.

3.2.20 Diagnostic interrupts

A diagnostic interrupt is a display of an error state.

If a module with diagnostic capability in which the diagnostic interrupt is released detects a change in its diagnostic state, it sends a diagnostics interrupt request to the CPU.
The CPU then interrupts the processing of the user program and processes the diagnostic interrupt OB (OB 82).

You can find more information in the Interrupts and Alarms sections.

3.2.21 Hardware interrupts

According to the configuration, the I/O modules or the interface module trigger a hardware interrupt for certain events/states. When a hardware interrupt occurs, the CPU interrupts the execution of the user program and runs the assigned hardware interrupt OB. The event that triggered the interrupt is entered in the start information of the assigned hardware interrupt OB by the CPU.

3.2.22 Removal/insertion of multiple I/O modules during operation (Multi Hot Swap)

Properties

You can remove and insert any number of I/O modules during operation. The interface module and the inserted I/O modules remain in operation.

NOTE

The interface module IM 155-6 PN BA does not support the removal and insertion of the server module and the interface module during operation.

Reference

You can find more information on the removal/insertion of modules in the system manual ET 200SP distributed I/O system
(https://support.automation.siemens.com/WW/view/en/58649293).

3.2.23 Maintenance events

A maintenance event indicates an identified maintenance requirement that has no direct influence on the function of the module. The maintenance event indicates that a check or replacement of plant components is required.

When a module with maintenance capability detects a change in its diagnostic state, it sends a maintenance request to the CPU. The CPU then interrupts the processing of the user program and processes the diagnostic interrupt OB (OB 82).

You can find more information in the Interrupts and Alarms sections.

Wiring

4

4.1 Pin assignment

24 V DC supply voltage (X80)

Table 2-101 Pin assignment 24 V DC supply voltage

View		Signal name [1]	Description
Connector	IM connection		
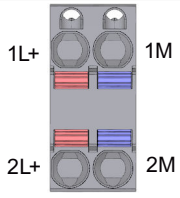	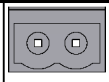	1L+	24 V DC
		2L+	24 V DC (for looping through)[2]
		1M	Ground
		2M	Ground (for looping through)[2]

[1] 1L+ and 2L+ as well as 1M and 2M are bridged internally

[2] Maximum 10 A permitted

Reference

You can find more information on accessories and how to connect the interface module in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

4.2 Schematic circuit diagram

The following figure shows the block diagram of the IM 155-6 PN BA interface module.

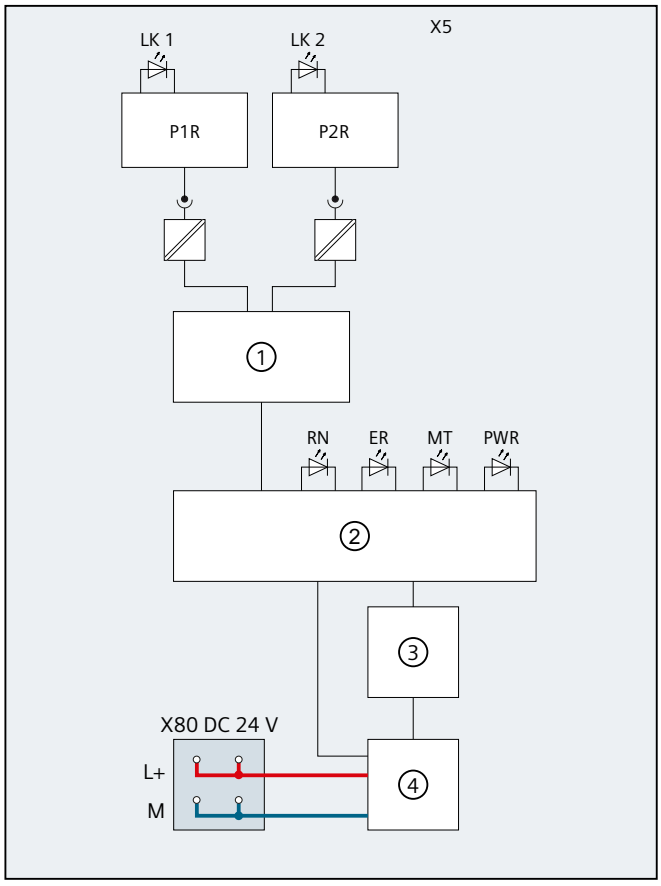

①	Switch	L+	24 V DC supply voltage
②	ET 200SP backplane bus interface and electronics	M	Mass
③	Backplane bus	LK 1,2	Link TX/RX LED (green)
④	Internal power supply	RN	RUN LED (green)
X80 24 V DC	Supply voltage infeed	ER	ERROR LED (red)
P1R	PROFINET interface X1 port 1	MT	MAINTENANCE LED (yellow)
P2R	PROFINET interface X1 port 2	PWR	POWER LED (green)

Figure 2-96 Schematic circuit diagram of the IM 155-6 PN BA interface module

Parameters/address space 5

5.1 Parameters

Parameters for IM 155-6 PN BA interface module

The following table shows the parameters for the IM 155-6 PN BA interface module.

Table 2-102 Configurable parameters and their defaults for IM 155-6 PN BA interface module (GSD file)

Parameters	Value range	Default	Efficiency range
Configuration control	Disable/enable	Disable	ET 200SP

5.2 Explanation of parameters

5.2.1 Configuration control

You can use this parameter to enable the configuration control function in the ET 200SP distributed I/O system.

NOTE

If you configure the enable, the ET 200SP distributed I/O system requires a control data record 196 from the user program in order for the ET 200SP distributed I/O system to operate the I/O modules.

Reference

You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the STEP 7 online help.

5.3 Substitute value behavior

You can find more information on substitute value behavior in the system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

5.4 Status of supply voltage L+ and feedback voltage of I/O modules

Configurations

The "Status of supply voltage L+ and the feedback voltage of I/O modules" is configured on the server module. The input data can then be read out on the server module. You will find the relevant description in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) equipment manual.

Interrupts, diagnostics, error, and system messages 6

6.1 Status and error displays

LED display

The figure below shows the LED display on the interface module.

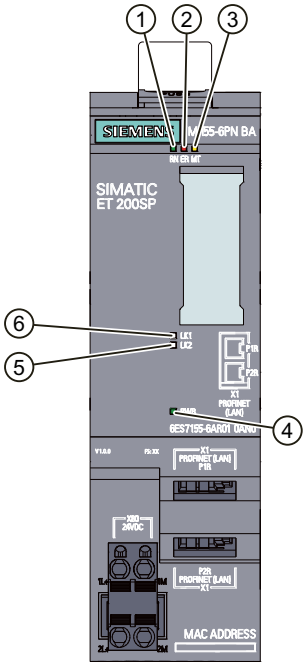

① RN (green)

② ER (red)

③ MT (yellow)

④ PWR (green)

⑤ LK1 (green)

⑥ LK2 (green)

Figure 2-97 LED display on the interface module

Meaning of the LEDs

The following tables show the meaning of the status and error displays.

RN/ER/MT LEDs on the interface module

Table 2-103 Status and error displays of the RN/ER/MT LEDs

LEDs			Meaning	Solution
RN (RUN)	ER (ERROR)	MT (MAINT)		
Off	Off	Off	Missing or insufficient supply voltage on interface module.	Check the supply voltage or switch it on at the interface module. *
On	On	On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	-
On	On	On	RN/ER/MT LEDs are permanently on: Hardware or firmware defective. Error information will be determined and stored retentively on the Flash memory.	Do not disconnect the interface module from the supply voltage while the LEDs are permanently lit up. This may take a few minutes.
Flashes	Not relevant	Not relevant	Interface module is deactivated.	Activate the interface module with the configuration software or the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP starts up.	-
			ET 200SP is being assigned parameters.	
			ET 200SP is reset to factory settings.	
On	Not relevant	Not relevant	ET 200SP is currently exchanging data with the IO controller.	
Not relevant	Flashes	Not relevant	Group errors and group error channels.	Evaluate the diagnostics data and remedy the error.
			The configured structure does not correspond to the actual structure of the ET 200SP .	Check the structure of the ET 200SP to see whether a module is missing or defective, or whether a non-configured module is plugged.
			Invalid configuration states.	See section Invalid configuration states of the ET 200SP on PROFINET IO (Page 43)
			Parameter assignment error in the I/O module.	Evaluate the display of the module status in STEP 7 and eliminate the error in the respective I/O module.
Not relevant	Not relevant	On	Maintenance required is present; that is, at least one maintenance event has occurred.	See section AUTOHOTSPOT

* PWR LED on (on the interface module): Check the backplane bus for a short-circuit.

LEDs			Meaning	Solution
RN (RUN)	ER (ERROR)	MT (MAINT)		
■ On	☼ Flashes	☼ Flashes	The server module was removed or more than one server module is inserted in the station.	Re-insert the server module or check the number of inserted server modules.
☼ Flashes	☼ Flashes	☼ Flashes	The "Node flash test" is run (the LK1 and LK2 LEDs of the PROFINET interface also flash).	-
			Hardware or firmware defective (LK1 and LK2 LEDs of the PROFINET interface do not flash).	Restart the device by disconnecting and reconnecting the supply voltage. Perform a firmware update. If the error persists, contact Siemens Industry Online Support. Replace the interface module. You can read out the service data with TIA Portal as of V18 and MFCT.

* PWR LED on (on the interface module): Check the backplane bus for a short-circuit.

PWR LED on the interface module

Table 2-104 PWR status display on the interface module

PWR LED	Meaning	Solution
□ Off	Missing or insufficient supply voltage on interface module.	Check the supply voltage.
■ On	Supply voltage L+ is available.	-

LK1/LK2 LED on the interface module

Table 2-105 LK1/LK2 Status display on the interface module

LEDs LK1/LK2	Meaning	Solution
□ Off	There is no Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	Check whether the bus cable to the switch/IO controller is interrupted or whether the port is disabled.
■ On	There is an Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	-
☼ Flashes	The "Node flash test" is run (the RN/ER/MT LEDs also flash).	-

LED display of configuration errors

Configuration errors of the ET 200SP distributed I/O system are indicated on the interface module via the red ERROR LED and the yellow MAINT LED.

The following configuration errors are indicated by the LEDs:

- No server module
- Interruptions or short-circuit on the backplane bus

Operating principle

The LED error display provides information on the cause of the error. After notification by the flashing signal, the error type is displayed followed by the error location/error code.

The LED error display

- is active during POWER ON as well as during operation.
- Takes precedence over all other states indicated by the ERROR LED (ER) and MAINT LED (MT).
- remains turned on until the cause of the error has been corrected.

Table 2-106 Display of error type and error location

Sequence		Description
1	The ERROR and MAINT LEDs flash 3x at 0.5 Hz	Signaling of error type
2	MAINT LED flashes at 1 Hz	Display of error type (decimal)
3	The ERROR and MAINT LEDs flash 3x at 2 Hz	Signaling of error location/error code
4	The ERROR LED flashes at 1 Hz	Display of tens digit (decimal) of the error location/error code
5	The MAINT LED flashes at 1 Hz	Display of ones digit (decimal) of the error location/error code
6	Repeat steps 1 to 5 until the cause of the error has been corrected.	

Error display

The following table shows the possible causes of error that can occur.

Table 2-107 Error display

Error type (MAINT)	Error location (ERROR/MAINT)	Cause of error	Solution
1	65*	• No server module • More than one server module plugged in • Interruptions on the backplane bus • Short circuit of communication on the backplane bus	Check the configuration of the ET 200SP.

* Slot

NOTE

A short circuit in the backplane bus supply or the bus connection supply is indicated by the following LEDs:

- PWR LED: On
- RN, ER and MT LED: Off

6.2 Interrupts

Introduction

The I/O device generates interrupts as a reaction to specific error events. Interrupts are evaluated based on the I/O controller used.

Evaluating interrupts with I/O controllers

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostics interrupts
- Hardware interrupts
- Swapping interrupts
- Maintenance events

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

System diagnostics

In STEP 7 (TIA Portal), the updated system diagnostics is available for the devices of the S7-1500 automation system (IO controller S7-1500 CPU) and ET 200SP (IO device). Independent of the cyclic user program, messages are made available on the display of the CPU S7-1500, the CPU web server and the HMI device.

You will find more information on system diagnostics in the Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

6.2.1 Triggering of a diagnostics interrupt

For an incoming or outgoing event (e.g. wire break on a channel of an I/O module), the module triggers a diagnostics interrupt if this is configured accordingly.

The CPU interrupts processing of the user program and processes the diagnostics block OB 82. The event which led to the interrupt is entered in the start information of the OB 82.

6.2.2 Triggering a hardware interrupt

During a hardware interrupt, the CPU interrupts the processing of the user program and processes the hardware interrupt block, e.g. OB 40. The event that triggered the interrupt is entered in the start information of the hardware interrupt block.

NOTE

Diagnostics "Hardware interrupt lost" (from I/O module)

Do not use hardware interrupts for functional purposes (e.g. cyclic generation of hardware interrupts).

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

6.2.3 Triggering a swapping interrupt

In the event of a pull/plug interrupt, the CPU interrupts processing of the user program and processes the pull/plug OB (OB 83). The event which led to the interrupt is entered in the start information of the OB 83.

NOTE

Parameter assignment error after removal/insertion

If you write data records from the user program to the modules of the distributed I/O, make sure that these modules actually exist and are available. You can do this by evaluating OB83. After inserting a module, OB83 is not called until the module has started up and its parameters are assigned. This ensures that data record operations can be executed without errors.

6.2.4 Triggering of a maintenance event

The PROFINET IO interfaces of the interface module support the diagnostic concept and maintenance concept in PROFINET IO according to the IEC 61158 Type 10 standard. The goal is to detect and remove potential problems as early as possible.

For the interface module, maintenance events signal to the user when a plant component must be checked or replaced.

The CPU interrupts the processing of the user program and processes the diagnostic interrupt OB (OB 82). The event that triggered the maintenance event is entered in the start information of the diagnostic interrupt OB.

6.3 Alarms

Introduction

The ET 200SP distributed I/O system generates the following alarms:

- Diagnostic alarms
- Maintenance alarms

6.3.1 Diagnostics alarms

Actions after a diagnostics alarm

There can be more than one diagnostics alarm at the same time. Each diagnostics alarm initiates the following actions:

- The ER LED on the interface module flashes red.
- Diagnostics are reported as diagnostic interrupts to the CPU of the IO controller and can be read via data records.
- Incoming diagnostics alarms are saved to the diagnostics buffer of the I/O controller.
- (S7-300/400) The diagnostic interrupt OB is called. If the diagnostic interrupt OB (OB 82) is not available, the IO controller goes into STOP mode.

You can find more information on using PROFINET IO in the STEP 7 online help.

Table 2-108 Diagnostics alarms, their meaning and possible remedies

Diagnostics alarm	Channel Error Type (CET)	Extended Channel Error Type (ECET)	Associated value AddValue	Meaning / Cause	Solution
Configuration error: Module parameter (potential group) incorrect or wrong BaseUnit/terminal block in real slot <slot>	0x0602	0x0691	Slot	The configured BaseUnit or the terminal block does not match the real configuration.	Check for suitable BaseUnit or terminal block.
Configuration error: Station stop - missing or wrong server module	0x0602	0x0693	0x00	During the startup of an ET 200SP station, no server module was plugged in or the server module was removed during operation.	Check that the server module is installed correctly in the rack.
Configuration error: Station stop - too many server modules	0x0602	0x068C	-	More than one server module is plugged into the station.	Ensure that only one server module is plugged into the station.
Configuration error: Permitted size of backplane bus exceeded	0x0602	0x0698	0x00	The total width of the installed modules exceeds the permitted configuration length of 1 000 mm.	Check that the configuration of the backplane bus does not exceed the permitted size.
Configuration error: Incorrect backplane bus configuration in slot <slot>	0x0602	0x0699	Slot	The maximum power requirement of all installed modules exceeds 2 100 mA in total. The associated value <slot> indicates the faulty slot.	Check backplane bus mounting.
Network configuration error: Shared Device conflict, invalid submodule assignment at slot <slot>	0x0603	0x06A5	Slot	There is an invalid submodule assignment.	Check the submodule assignment.

The scope of the diagnostics alarms displayed depends on the configuration and the parameter assignment.

If required, the standard can be downloaded from the Internet (http://www.profibus.com).

Reading the diagnostics

Table 2-109 Reading the diagnostics with STEP 7

Automation system with IO controller	Application	See ...
SIMATIC S7	Diagnostics as plain text in STEP 7 using Online and Diagnostics view	STEP 7 online help • as of STEP 7 V12, Function Manual PROFINET with STEP 7 as of V12 (http://support.automation.siemens.com/WW/view/en/19289930) • as of STEP 7 V5.5, System Manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)
	Instruction "RDREC" (SFB 52) Read data records from the IO device	
	Instruction "RALRM" (SFB 54) Receive interrupts from the IO device	

More information on the data records for PROFINET IO

You will find the structure of the diagnostics data records and examples for programming in the Programming Manual, From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) in the sections "Structure of diagnostic data records" and "Examples of diagnostic data records" and in Example application (http://support.automation.siemens.com/WW/view/en/24000238).

Causes of error and troubleshooting

The causes of error and remedies for the diagnostics alarms are described in the manuals for I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300) in the section, "Interrupts, error messages, and system events".

PROFINET IO

Another source of diagnostics events is the PROFINET base used. This generates diagnostics alarms whose coding is already defined in the PROFINET IO - Application Layer Service Definition V2.2 standard.

The actual scope of diagnostics used is dependent on the configuration and parameter assignment.

If required, the standard is available for download on the Internet (http://www.profibus.com) from the PROFIBUS User Organization home page.

See also

PROFINET with STEP 7 V11 (http://support.automation.siemens.com/WW/view/en/49948856)

6.3.2 Maintenance alarms

Triggering of a maintenance event

The PROFINET IO interfaces of the interface module support the diagnostics concept and maintenance concept in PROFINET IO according to the IEC 61158 Type 10 standard. The goal is to detect and remove potential problems as early as possible.

For the interface module, maintenance events signal to the user when a plant component must be checked or replaced.

The CPU interrupts user program execution and executes the diagnostic interrupt OB. The event that triggered the maintenance event is entered in the start information of the diagnostic interrupt OB.

NOTE

Detailed information on other maintenance alarms can be found in TIA Portal.

Maintenance required alarms

A maintenance event is generated each time maintenance required is detected. However, it has no influence on the ER LED or MT LED on the interface module.

NOTE

Maintenance alarms have no direct influence on the function of the module.

Table 2-110 Maintenance required alarms, their meaning and possible remedies

Maintenance required alarm	Channel Error Type (CET)	Extended Channel Error Type (ECET)	Associated value AddValue	Meaning / Cause	Solution
Security event: Firmware successfully downloaded and activated for use after a reset (New firmware version <FW version>)	0x0190	0x012C	Signed firmware version	The firmware has been successfully loaded into the module. This firmware update takes effect after the interface module is restarted.	-
Security event: The firmware integrity checks failed. The new firmware version <FW version> was rejected.	0x0190	0x0193	Signed firmware version	The firmware was not successfully loaded into the module. This can have many different reasons, e.g. corrupted binary files or an incorrect signature.	Verify if the firmware update file you are using comes from a secure source. Download the firmware again from the Siemens support website and repeat the firmware update.

System alarms in STEP 7 (TIA Portal)

The maintenance information is generated in STEP 7 (TIA Portal) with the following system events:

- Maintenance required - indicated for each port by a wrench with a green background in the device view or in the hardware configuration.

You can find more information in the STEP 7 online help.

6.3.3 Invalid configuration states of the ET 200SP on PROFINET IO

Invalid configuration states

The following invalid configuration states of the ET 200SP distributed I/O system lead to the failure of the IO device or prevent data exchange.

- Number of modules exceeds maximum configuration.
- Faulty backplane bus (e.g. defective BaseUnit). ET 200SP backplane bus interruptions do not trigger an interrupt.
- At least one I/O module is installed in a different BaseUnit than the one configured in the parameters.
- Missing server module

NOTE

Removal of the server module will trigger a station stop. All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) but the interface module is still exchanging data.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

6.3.4 Failure of supply voltage L+ at BaseUnit BU...D

Failure of the supply voltage L+

The I/O modules react as follows to failure of the supply voltage L+ on the BaseUnit BU...D:

- If an I/O module is removed during failure of the supply voltage, a pull alarm is generated.
- If an I/O module is installed during failure of the supply voltage, an insert alarm is generated.

6.3.5 STOP of the IO controller and recovery of the IO device

STOP of the SIMATIC IO controller

Diagnostics frames received from the IO device while the IO controller is in STOP do not initiate a call of any corresponding OBs when the IO controller goes into RUN. You must read the data record $E00C_H$ with the "RDREC" instruction in OB 100. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Recovery of the SIMATIC IO devices

If you want to read the diagnostics of a station after its return, you have to read the $E00C_H$ data record with the "RDREC" instruction in OB 86. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Compatibility 7

Compatibility between the versions of the IM 155-6 PN BA

The table below describes which version you can use in the configuration for which actually plugged version of the IM 155-6 PN ST BA interface module.

Interface modules plugged		Interface modules configured		
		155-6AR00-0AN0	**155-6AR01-0AN0**	**155-6AR01-0AN0**
		IM155-6 PN BA V3.2	**IM155-6 PN BA V6.3**	**IM155-6 PN BA V6.4**
155-6AR00-0AN0	IM155-6 PN BA, V3.2	X	-	-
155-6AR01-0AN0	IM155-6 PN BA, V6.3	X	X	-
155-6AR01-0AN0	IM155-6 PN BA, V6.4	X	X	X

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules in the following table without a parameter assignment, the status of the supply voltage is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Article number
DI 8x24VDC ST	6ES7131-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7131-6BF00-0CA0
DQ 4x24VC/2A ST	6ES7132-6BD20-0BA0
DQ 8x24VDC/0,5A ST	6ES7132-6BF00-0BA0
DQ 16x24VDC/0,5A ST	6ES7132-6BH00-0BA0
DQ 8x24VDC/0,5A HF	6ES7132-6BF00-0CA0

Operation and maintenance 8

8.1 Resetting interface module to factory settings with MFCT

You can also reset the interface module to factory settings with MFCT.

Information on this is available in the "Resetting the MF device" section of the "MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209)" function manual.

8.2 Firmware update with MFCT

With MFCT, you can perform firmware updates for modules and interface modules.

Information on this is available in the "MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209)" function manual in the section "Firmware update with MFCT".

Technical specifications 9

Technical specifications of the IM 155-6 PN BA

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7155-6AR01-0AN0/td?dl=de).

Article number	6ES7155-6AR01-0AN0
General information	
Product type designation	IM 155-6 PN BA
Firmware version	V6.4.0
• FW update possible	Yes
Vendor identification (VendorID)	0x002A
Device identifier (DeviceID)	0x0313
Product function	
• I&M data	Yes; I&M0 to I&M4
• Module swapping during operation (hot swapping)	Yes; Multi-hot swapping
• Isochronous mode	Yes
• IRT	Yes
• Local coupling, IO data	Yes
– Number of coupling modules	6; 1x output + max. 5x input
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V20
• STEP 7 configurable/integrated from version	V5.7 SP3
• PROFINET from GSD version/GSD revision	GSDML V2.45
Configuration control	
via dataset	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Short-circuit protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	5 ms

Article number	6ES7155-6AR01-0AN0
Input current	
Current consumption (rated value)	200 mA
Current consumption, max.	300 mA
Inrush current, max.	1 A
I^2t	0.05 $A^2 \cdot s$
Power loss	
Power loss, typ.	1.8 W
Address area	
Address space per module	
• Address space per module, max.	128 byte; For input and output data respectively
Address space per station	
• Address space per station, max.	128 byte
Hardware configuration	
Rack	
• Quantity of operable ET 200SP modules, max.	16
• Quantity of operable ET 200AL modules, max.	0
Submodules	
• Number of submodules per station, max.	256
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch)
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; 2 integrated RJ45 ports
• Number of ports	2; integrated RJ45 ports
• integrated switch	Yes
• BusAdapter (PROFINET)	No
Protocols	
• PROFINET IO Device	Yes
• Open IE communication	Yes
• Media redundancy	Yes; PROFINET MRP client
PROFINET IO Device	
Services	
– IRT	Yes; 1 ms to 4 ms at an interval of 125 µs
– Dynamic Frame Packing (DFP)	Yes
– Fast Forwarding	Yes
– Fragmentation	Yes
– PROFIenergy	Yes
– Prioritized startup	Yes

Article number	6ES7155-6AR01-0AN0
– Shared device	No
Interface types	
RJ 45 (Ethernet)	
• Transmission procedure	PROFINET with 100 Mbit/s full duplex (100BASE-TX)
• 100 Mbps	Yes
• Autonegotiation	Yes
• Autocrossing	Yes
Protocols	
Supports protocol for PROFINET IO	Yes
PROFIsafe	No
PROFIBUS	No
EtherNet/IP	No
Modbus TCP	No
Redundancy mode	
• PROFINET system redundancy (S2)	No
Media redundancy	
– MRP	Yes
– MRPD	Yes
Open IE communication	
• TCP/IP	Yes
• UDP	Yes
• SNMP	Yes
• LLDP	Yes
• ARP	Yes
• IGMP	Yes
• Multicast	Yes
• Broadcast	Yes
• IPv4	Yes
• IPv6	No
Interrupts/diagnostics/status information	
Status indicator	Yes
Alarms	Yes
Diagnostics function	Yes
Diagnostics indication LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• MAINT LED	Yes; Yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED

Article number	6ES7155-6AR01-0AN0
• Connection display LINK TX/RX	Yes; 2x green LED
Potential separation	
between backplane bus and electronics	No
between PROFINET and all other circuits	Yes; 1500 V AC (type test)
between supply and all other circuits	No
Permissible potential difference	
between different circuits	Safety extra low voltage SELV
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Network loading class	3
Security	
PROFINET Security Class	1
signed firmware update	Yes
Secure Boot	No
safely removing data	Yes
data integrity	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; No condensation
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Connection method	
ET-Connection	
• via BU/BA Send	No
Mechanics/material	
Strain relief	No
Dimensions	
Width	35 mm
Height	117 mm
Depth	74 mm
Weights	
Weight, approx.	125 g

Dimension drawing

A

This appendix contains a dimension drawing of the module installed on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

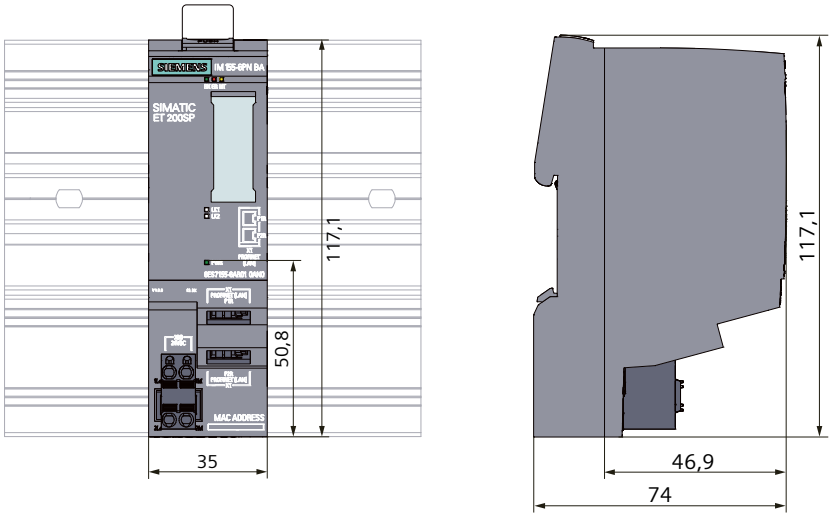

Figure 2-98 Dimension drawing of the IM 155-6 PN BA interface module (front and side view)

SIEMENS

SIMATIC

ET 200SP
IM 155-6 PN ST Interface Module (6ES7155-6AU02-0BN0)

Equipment Manual

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Introduction 1

1.1 Introduction

Purpose of the documentation

This equipment manual supplements the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in the system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used hereinafter, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.2 ET 200SP Documentation Guide

1.2.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/84133942)

1.2.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.2.3 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

See also

PRONETA Professional (https://support.industry.siemens.com/cs/ww/en/view/109781283)

1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is PC-based software and supports the configuration of MultiFieldbus-Devices and DALI-modules. In addition, the MFCT offers convenient options for bulk firmware updating of ET 200 devices with MultiFieldbus-support and reading of service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI modules.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- CM PtP:
  Analysis of serial communication, event logs and reading of the current configuration.

- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109773881)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

You can find more general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-related information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://www.siemens.com/cert.

2.3 Cybersecurity-relevant information

Observe all cybersecurity-relevant information.

Topics with cybersecurity-relevant information	Reference
Operational application environment and security assumptions	
Requirements for the operational application environment of the system and security assumptions	You can find this section in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Security properties of the product	
Access protection	Note the information on access protection in the Protection chapter of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Data integrity	The topic of data integrity is described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Signed firmware update	The topic of signed firmware updates is described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
PROFINET Security Class 1 • The device supports PROFINET Security Class 1. • With the introduction of PROFINET Security Class 1, additional security settings have been integrated into the PROFINET communication.	Detailed information about PROFINET Security Class 1 and the additional security settings can be found in the PROFINET with STEP 7 Function Manual (https://support.automation.siemens.com/WW/view/en/49948856)
Supported Ethernet services	You can find information on supported services in the Technical specifications section. You can find detailed information about supported Ethernet services in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
Interfaces, ports, protocols and services	
Information on the following is security-relevant: • Communication layer and communication role • Default states • Enabling/disabling of ports and services	You can find detailed information on these topics in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
Secure operation	
Recommendations for safe operation	You can find cross-system information on the safe operation of interface modules in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Corrective measures for known risks	Corrective measures for known risks are announced on the Siemens ProductCERT and Siemens CERT (https://siemens.com/productcert) web page. You can find more information on SIEMENS ProductCERT in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Topics with cybersecurity-relevant information	Reference
Security checks	You can find descriptions of specific security measures, such as cyclic checks of the configuration via checksums, in the Industrial cybersecurity section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Secure decommissioning Products that contain security-relevant data must be securely decommissioned before disposal or resale.	You can find information on secure decommissioning in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293), Secure operation of the system section

Product overview

3

3.1 Properties

Article number

6ES7155-6AU02-0BN0 (IM 155-6 PN ST interface module and server module)

6ES7155-6AA02-0BN0 (IM 155-6 PN ST interface module with BusAdapter BA 2×RJ45 and server module)

View of the module

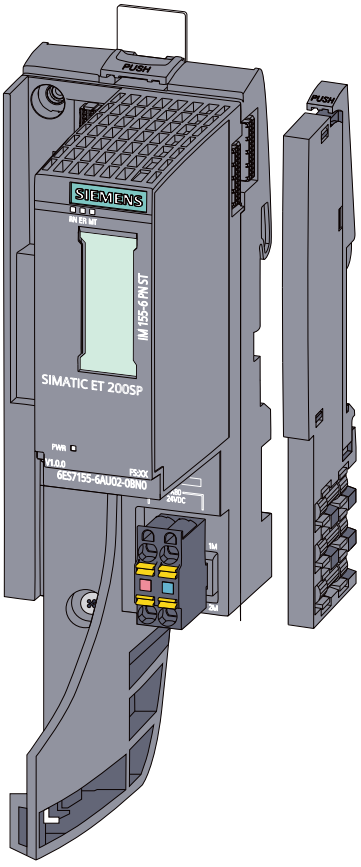

Figure 2-99 View of the IM 155-6 PN ST interface module with included accessories (24 V DC connector and server module) and optional accessories (the labeling strips, cable grip and equipment labeling plate)

Properties

The module has the following technical properties:

- Connects the ET 200SP distributed I/O system with PROFINET IO
- Power supply 1 L+ 24 V DC (SELV/PELV). The connection plug is included in the scope of delivery of the interface module.
- PROFINET IO connection via selectable BusAdapter for RJ45 bus connector (BA 2×RJ45), for standard M12 connector or push-pull connector (BA 2xM12) or for direct connection of the bus cable (BA 2×FC)
- Supported topologies
  - Linear bus topology
  - Star topology
  - Tree topology
- Use of fail-safe modules

The module supports the following functions (Page 16):

Maximum configuration

- 32 ET 200SP I/O modules + 16 ET 200AL modules
- 1440 bytes I/O data
- 1 m backplane bus (without interface module)

Accessories

The following accessories can be ordered separately:

- BA 2×RJ45 BusAdapter for RJ45 bus cable connector
- BA 2×FC BusAdapter for direct connection of the bus cable
- BA 2xM12 BusAdapter for bus cable with standard M12 connector
- 24 V DC connector
- Labeling strips
- Reference identification label
- Strain relief
- M12 unlatching straps
- SIMATIC system rail

NOTE

The interface module is also available as a bundle with the BusAdapter BA 2xRJ45 (and the server module). The article number is 6ES7155-6AA02-0BN0.

A detailed list of the available accessories can be found in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Server module

The server module is included in the scope of delivery of the interface module and available separately as an accessory.

The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system
- Features a support for 3 spare fuses (5 × 20 mm)
- Provides station functions, e.g. group diagnostics: No supply voltage L+, status bytes.
- I&M identification data

NOTE

You need to configure and assign parameters to the server module in the configuration software.

To do this, place the server module in the last configuration slot and enable the parameter Group diagnostics: missing supply voltage L+. When there are 32 I/O modules, the server module is inserted in slot 33.

You can find more information in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

First BaseUnit of an ET 200SP in the configuration

NOTE

First BaseUnit of an ET 200SP in the configuration

When an AC I/O module or AI Energy Meter ST is plugged, the first BaseUnit in an ET 200SP station may be a dark one. Please note the information on limiting the overvoltage and power rating in the AC I/O module manuals.

In order to route the 24 V DC supply voltage via a fuse, a light BaseUnit must be plugged into the slot of the first 24 V DC I/O module.

Pay attention to the type of the BaseUnits during the configuration.

3.2 Functions

Introduction

The interface module supports the following PROFINET IO functions:

- Integrated switch with 2 ports
- Supported Ethernet services: ICMP, ARP, SNMP, LLDP
- Port diagnostics
- Deactivating ports
- Real-time communication

- Isochronous real-time communication
- Minimum update time 1 ms
- Prioritized startup
- Media redundancy (MRP and MRPD)
- Shared device
- Distribution of module channels to submodules
- Support of 17 submodules
- Device replacement without programming device (PG) and without topological configuration
- Firmware update via PROFINET IO
- Station extension via ET-Connection
- Identification data I&M 0 to 4
- PROFIenergy
- Use of fail-safe modules
- Configuration control (option handling)
- Value status (quality information, QI) of I/O modules
- Reading out service data
- Reference temperature distribution
- Setting the time
- Time distribution
- Diagnostic interrupts
- Hardware interrupts
- Removal/insertion of multiple I/O modules during operation (multi hot swap)
- Maintenance events
- Module-internal Shared Input/Shared Output (MSI/MSO)
- Reset to factory settings via PROFINET IO or RESET button (station-wide)
- Reset to factory settings via PROFINET IO (Factory Mode 8)
- Performance upgrade PROFINET (DFP, FFT, fragmentation)
- The BusAdapter provides the connection system for PROFINET IO. The following versions are available for the IM 155-6 PN ST interface module:
  - For standard RJ45 connector: BA 2×RJ45
  - For direct connection of the bus cable: BA 2×FC
  - For standard M12 connector or push-pull connector BA 2xM12

Requirements

The table below shows the software requirements for a configuration with the IM 155-6 PN ST interface module:

Table 2-111 Version dependencies of other module functions

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130-000)/software from a third-party manufacturer [1]	STEP 7 Classic	STEP 7 (TIA Portal)
Integrated switch with 2 ports	1	V6.2.1	X	X	X
Supported Ethernet services: ICMP, ARP, SNMP, LLDP	1	V6.1.0	X	X	X
Port diagnostics	1	V6.1.0	X	X	X
Deactivating ports	1	V6.1.0	X	X	X
Real-time communication	1	V6.1.0	X	X	X
Isochronous real-time communication	1	V6.4.0	X	X	X
Minimum update time 1 ms	1	V6.1.0	X	X	X
Prioritized startup	1	V6.1.0	X	X	X
Media redundancy (MRP)	1	V6.3.0	X	X	X
Media redundancy (MRPD)	1	V6.2.1	X	X	X
Shared device	1	V6.1.0	X	X	X
Distribution of module channels to submodules	1	V6.2.1	X	X	X
Support of 17 submodules	1	V6.4.0	X	X	X
Device replacement without programming device (PG) and without topological configuration	1	V6.1.0	X	X	X
Firmware update via PROFINET IO	1	V6.1.0	X	X	X
Station extension via ET-Connection	1	V6.1.0	X	X	X
Identification data I&M 0 to I&M 4	1	V6.1.0	X	X	X
PROFIenergy	1	V6.1.0	-	X	X
Use of fail-safe modules	1	V6.1.0	X	X	X
Configuration control (option handling)	1	V6.1.0	X	X	X

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130-000)/software from a third-party manufacturer [1]	STEP 7 Classic	STEP 7 (TIA Portal)
Value status (quality information, QI) of I/O modules	1	V6.1.0	X	X	X
Reading out service data	1	V6.1.0	-	X	X
Reference temperature distribution	1	V6.1.0	X	X	X
Setting the time	1	V6.1.0	X	X	X
Time distribution	1	V6.1.0	X	X	X
Diagnostic interrupts	1	V6.1.0	X	X	X
Hardware interrupts	1	V6.1.0	X	X	X
Removal/insertion of multiple I/O modules during operation (multi hot swap)	1	V6.1.0	X	X	X
Maintenance events	1	V6.1.0	X	X	X
Module-internal Shared Input/Shared Output (MSI/MSO)	1	V6.1.0	X	X	X
Reset to factory settings via PROFINET IO or RESET button	1	V6.2.1	X	X	X
Reset to factory settings via PROFINET IO (Factory Mode 8)	1	V6.4.0	X	X	X
User data • MaxApplicationInputLength 1440 bytes • MaxApplicationOutput-Length 1440 bytes	1	V6.1.0	X	X	X
Performance upgrade PROFINET (DFP, FFT, fragmentation)	1	V6.3.0	X	X	X
Supports BusAdapter for different connection systems to PROFINET IO	1	V6.2.1	X	X	X

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

The following table shows the appropriate version of the configuration software depending on the functional status of the module.

Table 2-112 Version of the configuration software depending on the functional status of the module

Firmware version of the module	STEP 7 Classic	STEP 7 (TIA Portal)
As of V6.1	As of STEP 7 V5.5 SP4 with HSP0329 V1.0	As of V18 with HSP0415 V1.0
As of V6.2	As of STEP 7 V5.6 with HSP0329 V2.0	As of V19 with HSP0415 V1.0
As of V6.3	As of STEP 7 V5.7 SP3 HF3 with HSP0342 V1.0	As of V19 with HSP0415 V2.0
As of V6.4	As of STEP 7 V5.7 SP3 HF3 with HSP0342 V2.0	As of V20 with HSP0415 V2.0

Cabling with fixed connection setting

If you set a fixed connection setting of the port in STEP 7, you must also disable "Autonegotiation/Autocrossover".

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12 in the PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5 in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Replacement of an IM 155-6 PN ST

In a replacement scenario, you reset an IO device that is already in operation to the as-delivered state using "Reset to factory settings". You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

GSD file

An additional GSD file based on the schema version V2.25 is available for the previous PROFINET GSD files. This is only to be used when the engineering tool used does not support GSD files of the current schema version.

3.2.1 Supported Ethernet services: ICMP, ARP, SNMP, LLDP

The module supports the following standardized Ethernet services:

- **ICMP - Internet Control Message Protocol (RFC 792)**

ICMP is a protocol used to transmit informational and error messages over the Internet protocol.

- **ARP - Address Resolution Protocol (RFC 826)**

ARP is a protocol used to determine the hardware address (MAC) of an associated Internet protocol (IP) address.

- **SNMP - Simple Network Monitoring Protocol (RFC 1157, RFC 3410)**

SNMP is a protocol for transmitting management information across networks.

- **LLDP – Link Layer Discovery Protocol (IEEE 802.1AB)**

LLDP is a protocol for identifying neighboring devices.

3.2.2 Port diagnostics

Depending on the BusAdapter used, the device supports special diagnostic alarms that signal the quality of data transfer on the medium used.

3.2.3 Disabling of ports

The device supports the deactivation of the port by parameter assignment, so that all communication on this port is prevented.

3.2.4 Real-time communication

A transmission method for PROFINET IO based on cyclic data exchange with a provider-consumer model.

3.2.5 Isochronous real-time communication

Synchronized transmission method for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth within the send clock is available for IRT data. The reserved bandwidth ensures that the IRT data is also transmitted in time-synchronized intervals, unaffected by other high network loading (e.g. TCP/IP communication or additional real time communication).

A topological configuration is required for IRT.

NOTE

IO controller as sync master with IRT communication

Operation of the IO controller as a sync master is recommended when configuring the IRT communication.

Otherwise, IRT- and RT-configured IO devices may fail if the sync master fails.

You can find more information on the configuration of synchronized PROFINET devices in sync domains in the STEP 7 online help and:

- As of STEP 7 V12 in the PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5 in the PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

3.2.6 Minimum update time 250 µs

The shortest update cycle of IO data for this device is 250 µs. To achieve this value, the controller used must also support this time.

3.2.7 Prioritized startup

Prioritized startup is a PROFINET IO function in a PROFINET IO system with IRT and RT communication. It reduces the time needed for correspondingly configured IO devices to return to cyclic user data exchange.

This function accelerates the startup of IO devices in the following cases:

- After recovery of supply voltage
- After station recovery
- After activation of IO devices

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.
- As of STEP 7 V5.5 in the PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127) system manual.

3.2.8 Media redundancy (MRP and MRPD)

Function for safeguarding communication and plant availability. A ring topology ensures that an alternative communication path is made available if a transmission route fails.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12, in the PROFINET with STEP 7 (https://support.automation.siemens.com/WW/view/en/49948856) function manual.
- As of STEP 7 V5.5 in the PROFINET system description (https://support.automation.siemens.com/WW/view/en/19292127) system manual.

3.2.9 Shared device

IO device which makes its data available to multiple IO controllers.

The interface module supports shared device at submodule level.

If **there is no validity check of the shared device projects by the Engineering System**, note the following:

- Make sure the configurations are consistent. Assign each module or submodule to only one IO controller. Multiple assignment causes errors because the module or submodule is only available in the first controller.
- If you reconfigure the shared device configurations without the validity check mentioned above, you must commission ET 200SP again. This means you must download the projects of all involved IO controllers to the respective CPU again after reconfiguration. If necessary, perform a POWER OFF/POWER ON of the interface module.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12 in the PROFINET with STEP 7 V13 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual
- As of STEP 7 V5.5 in the PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

NOTE

In the case of a shared device application, make sure that all controllers work with the same send clock. If the controller does not have the same send clock, this results in communication relationships not being set up.

If you set up all controllers in one project, the same send clock is ensured. Set the same send clock for engineering in separate projects.

3.2.10 Device replacement without programming device (PG) and without topological configuration

Device replacement without topological configuration

In addition to both interface modules, the device name is also stored on the BusAdapter plugged into the interface module. A stored device name in each of the two BusAdapters is a prerequisite for a device exchange without topological configuration.

Replacing the interface module produces a range of scenarios for using the device name.

Table 2-113 Scenarios for using the device name

	Interface module empty	Interface module with device name
BusAdapter without device name	No device name available	The device name from the interface module is used and copied to the BusAdapter.
BusAdapter with device name	The device name from the BusAdapter is used and copied to the interface module.	The device name from the BusAdapter is used and copied to the interface module if this has a different device name.

Note the following constraints:

- When a BusAdapter is replaced, a device name stored in the BusAdapter is applied to the interface module after a POWER ON.
- Removal/insertion of the BusAdapter under voltage is not permitted.

Device replacement with topology configuration

IO devices with this function can be replaced in a simple manner:

- The device name does not need to be assigned with the programming device (PG).

The replaced IO device is assigned the device name by the IO controller, not by the programming device (PG). The IO controller uses the configured topology and the neighborhood relationships determined by the IO devices for this purpose. All involved devices must support the LLDP protocol (Link Layer Discovery Protocol). The configured topology must match the actual topology.

If the IO devices were already used in another configuration, reset them to factory settings before reusing them. You can find more information in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

You can find more information in the STEP 7 online help and as of STEP 7 (TIA Portal) V12 in the PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

3.2.11 Distribution of module channels to submodules

Support of submodules on suitable I/O modules

The IM 155-6 PN ST interface module supports the division of I/O modules into up to 17 submodules. This allows parts of an I/O module to be separately configured and parameterized.

You can assign each of these submodules to different IO controllers.

The following functions are only executed if you have configured submodule 1 during configuration:

- Firmware update
- Write I&M data
- Calibration
- PROFIenergy

3.2.12 Firmware update via PROFINET IO

You can find information on how to perform a firmware update in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

3.2.13 Station extension via ET connection

Station expansion via ETConnection enables the flexible addition of further stations to an existing automation system. The Ethernet-based connection (ETConnection) allows additional I/O modules or stations to be seamlessly integrated into the plant structure without requiring major changes to the existing configuration.

3.2.14 Identification data I&M 0 to I&M 4

Identification and maintenance data (I&M data) is information saved on the module. The data is:

- Read-only (I-data) or
- Readable/writable (M-data)

Identification data (I&M0): Manufacturer information about the module that can only be read. Some identification data is also printed on the housing of the module, for example article number and serial number.
Maintenance data (I&M1, 2, 3): Plant-dependent information, e.g. installation location. Maintenance data is created during configuration and downloaded to the module.
All modules of the ET 200SP distributed I/O system support identification data (I&M0 to I&M3).

Checksums CRC (I&M4): The interface module calculates checksums based on its used data and the supplied data from the associated modules, such as parameter settings, IP address, device name, MAC address and I&M data. The interface module stores the checksums in the I&M4 data area.

The I&M identification data supports you in the following activities:

- Checking the system configuration
- Locating hardware changes in a plant
- Correcting faults in a plant
- Inspection of safe operation of a plant

Modules can be clearly identified online using the I&M identification data.

With TIA Portal, you can read out the identification data I&M (see online help of the TIA Portal).

IM4 is write-protected due to information integrity. You can find more information on the identification data I&M 0 to I&M 3 in the ET 200SP distributed I/O system system manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

3.2.15 PROFIenergy

Properties

PROFIenergy (for PROFINET) reduces the energy consumption by using PROFIenergy commands during production-free periods.

Reference

You can find more information on PROFIenergy in the:

- Product manual I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300)
- PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) function manual.
- System manual PROFINET system description (http://support.automation.siemens.com/WW/view/en/19292127)
- PROFIenergy (http://support.automation.siemens.com/WW/view/en/66928686) product information.
- Internet (http://www.profibus.com) under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order No: 3.802.

3.2.16 Use of fail-safe modules

Properties

The IM 155-6 PN ST interface module supports the use of fail-safe modules.

Reference

You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2.17 Use of technology modules

Technology modules

The IM 155-6 PN ST interface module supports the "Position input for Motion Control" mode of the technology modules TM Count 1x24V (6ES7138-6AA00-0BA0) and TM PosInput 1 (6ES7138-6BA00-0BA0).

3.2.18 Configuration control (option handling)

Properties

Configuration control allows you to prepare your distributed I/O system for future extensions or changes. Configuration control means that you can configure the planned maximum configuration of your distributed I/O system in advance and vary it later in a flexible manner by means of the user program.

Reference

You can find more information on configuration control

- in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual
- on the Internet under the following link: Application collection (http://support.automation.siemens.com/WW/view/en/29430270)
- in the STEP 7 online help.

3.2.19 Value status (quality information, QI) of I/O modules

Value status

The IM 155-6 PN ST interface module supports I/O modules with value status. The value status provides information about the validity of the individual process values.

You can find more information on the value status in the system manual (http://support.automation.siemens.com/WW/view/en/58649293) and in the I/O module manuals.

3.2.20 Reading out service data

The function makes it possible to read out diagnostic and service information from the interface module.

In the case of a pending maintenance alarm, you can read out the service data and make it available to SIEMENS support for queries and product improvement.

Methods of reading service data

- TIA V19
- Multi Fieldbus Configuration Tool (MFCT), V1.4.1 or higher

The tool download and more information, as well as documentation on the individual functions of the MFCT, can be found on the Internet (https://support.industry.siemens.com/cs/de/de/view/109773881/en).

3.2.21 Reference temperature distribution

Specific I/O modules require a reference temperature to compensate for temperature dependence. This device supports the function of distributing this temperature on the backplane bus. Up to 4 reference temperatures can be distributed.

3.2.22 Setting the time

The interface module supports time setting, for example, with AI Energy Meter CT HF (6ES7134-6PA01-0CU0).

We show you how to set the time in an application example (https://support.industry.siemens.com/cs/ww/en/view/109754890).

3.2.23 Time distribution

For example, if there is an AI Energy Meter CT HF (6ES7134-6PA01-0CU0), the time is automatically distributed within the ET 200SP station. You can find more information in the section Setting the time (Page 28).

3.2.24 Diagnostic interrupts

A diagnostic interrupt is a display of an error state.

If a module with diagnostic capability in which the diagnostic interrupt is released detects a change in its diagnostic state, it sends a diagnostics interrupt request to the CPU.
The CPU then interrupts the processing of the user program and processes the diagnostic interrupt OB (OB 82).

You can find more information in the Interrupts and Alarms sections.

3.2.25 Hardware interrupts

According to the configuration, the I/O modules or the interface module trigger a hardware interrupt for certain events/states. When a hardware interrupt occurs, the CPU interrupts the execution of the user program and runs the assigned hardware interrupt OB. The event that triggered the interrupt is entered in the start information of the assigned hardware interrupt OB by the CPU.

3.2.26 Removal/insertion of multiple I/O modules during operation (Multi Hot Swap)

Properties

You can remove and insert any number of I/O modules during operation. The interface module and the inserted I/O modules remain in operation.

NOTE

The IM 155-6 MF HF interface module does not support pulling or plugging the server module, interface module and BusAdapter during operation.

Reference

You can find more information on the removal/insertion of modules in the system manual ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293).

3.2.27 Maintenance events

A maintenance event indicates an identified maintenance requirement that has no direct influence on the function of the module. The maintenance event indicates that a check or replacement of plant components is required.

When a module with maintenance capability detects a change in its diagnostic state, it sends a maintenance request to the CPU. The CPU then interrupts the processing of the user program and processes the diagnostic interrupt OB (OB 82).

You can find more information in the Interrupts and Alarms sections.

3.2.28 Module-internal Shared Input/Shared Output (MSI/MSO)

The Module-internal Shared Input function allows an input module to make its input data available to up to four IO controllers (for ET 200SP PN ST). Each controller has read access to the same channels.

The module-internal Shared Output function allows an output module to make its output data available to up to four IO controllers. One IO controller has write access, while the other IO controllers can have read access to the same channels.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the PROFINET with STEP 7 V13 (http://support.automation.siemens.com/WW/view/en/49948856) function manual

3.2.29 Interface-local coupling of IO data (MSO)

Module-internal shared output

In this example, IO data is transferred from one controller to other controllers via the PROFINET interface X1 using module-internal shared output.

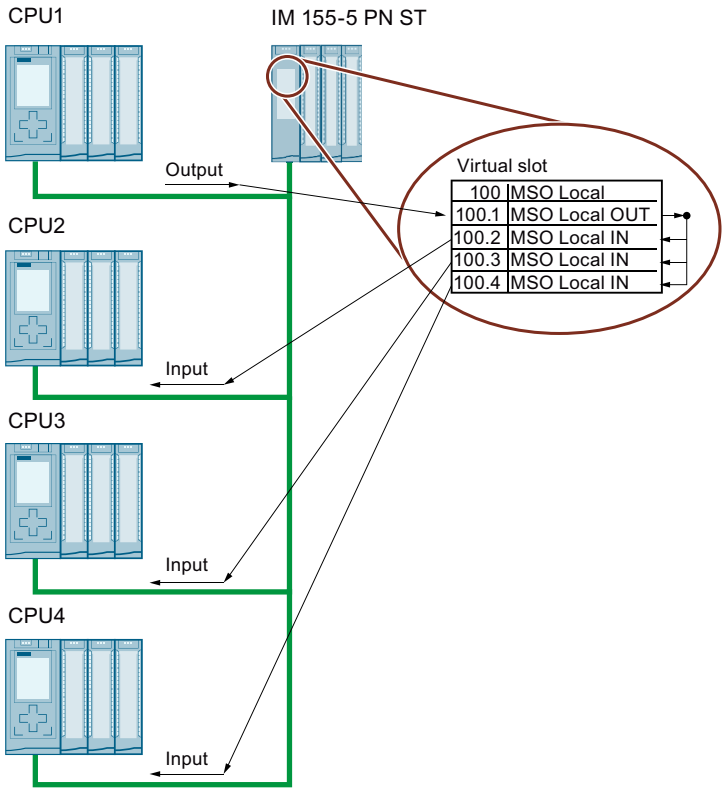

Figure 2-100 IO data is transferred to other controllers in the same PROFINET network

Configuration

Table 2-114 Configuration example

Virtual slot	Type	I length	Q length	Access
100	MSO Local	-	-	-
100.1	MSO Local OUT	-	4 bytes	CPU 1
100.2	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 2
100.3	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 3
100.4	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 4

Editing in the user program

The controller CPU 1 writes IO data to the MSO Local OUT module with virtual slot 100.1 of the interface module. The data is available to CPUs 2 to 4 for reading with the remaining MSO Local IN modules. The validity of the provided user data is displayed by the data status byte (DS) of the MSO Local IN modules.

This example can also:

- Be used with fewer controllers
- Be configured with other virtual modules

NOTE
Virtual IO modules
The use of virtual IO modules increases the communication load. This increases the data update time of all IO data accordingly.

3.2.30 Reset to factory settings

There are two modes for resetting to factory settings:

- Resetting to factory settings via PROFINET IO or the RESET button deletes the device name, IP address, service data and I&M data 1-4 both in the selected interface module and in the corresponding BusAdapter and server module.
- Resetting via PROFINET IO using Factory Mode 8 deletes the IP address, service data and I&M data 1-4 in the device and all associated modules that support resetting to factory settings.

3.2.31 Performance upgrade PROFINET (DFP, FFT, fragmentation)

Dynamic Frame Packing (DFP)

Dynamic Frame Packing (DFP) optimizes the PROFINET communication by combining multiple small frames into larger packets.

- Reduces network overhead and improves bandwidth utilization
- Helps reduce network load and improves real-time performance
- Particularly effective when many small data packets have to be transmitted.

Fast Forwarding Technology (FFT)

Fast Forwarding Technology (FFT) is an advanced switching technology that accelerates frame forwarding in PROFINET networks.

- Reduces latency through frame processing at hardware level.
- Enables cut-through switching instead of store-and-forward
- Particularly important for time-critical applications

Frame fragmentation

Frame fragmentation enables large data packets to be split into smaller fragments.

- Enables better coexistence of real-time and non-real-time data traffic.
- Prevents time-critical frames from being blocked by large data packets.
- Improves the overall network determinism.

Preamble shortening

Preamble shortening is a PROFINET optimization method that reduces the standard Ethernet frame preamble length to improve network performance.

Wiring

4

4.1 Pin assignment

24 V DC supply voltage (X80)

Table 2-115 Pin assignment 24 V DC supply voltage

View		Signal name [1]	Description
Connector	IM connection		
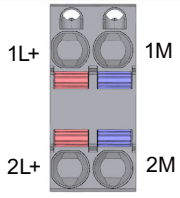	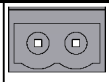	1L+	24 V DC
		2L+	24 V DC (for looping through)[2]
		1M	Ground
		2M	Ground (for looping through)[2]

[1] 1L+ and 2L+ as well as 1M and 2M are bridged internally

[2] Maximum 10 A permitted

Reference

You can find more information on accessories and how to connect the interface module in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

4.2 Schematic circuit diagram

The following figure shows a block diagram of the IM 155-6 PN ST interface module.

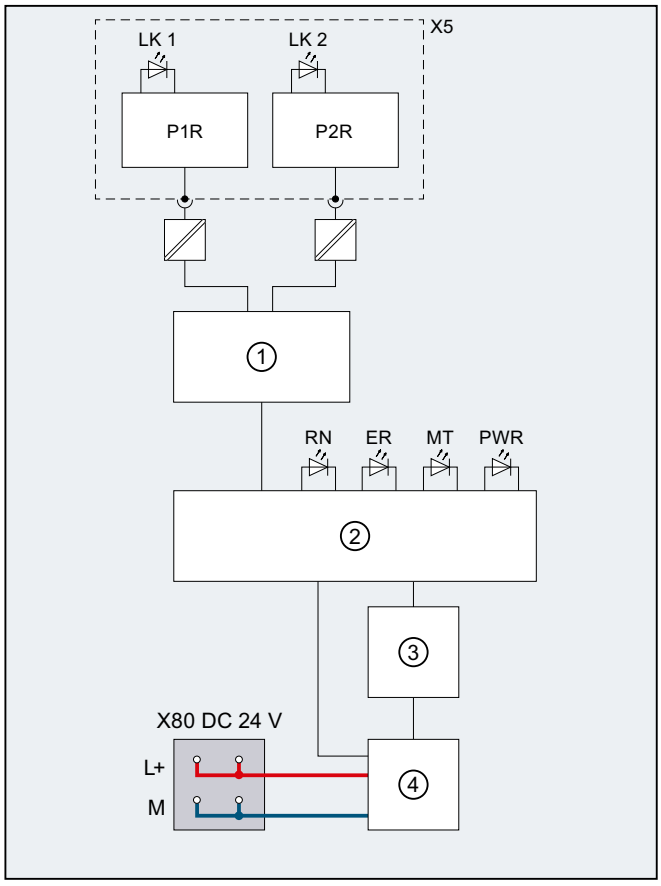

①	Switch	L+	24 V DC supply voltage
②	ET 200SP backplane bus interface and electronics	M	Mass
③	Backplane bus	LK 1,2	Link TX/RX LED (green)
④	Internal power supply	RN	RUN LED (green)
X80 24 V DC	Supply voltage infeed	ER	ERROR LED (red)
X5	BusAdapter	MT	MAINTENANCE LED (yellow)
P1R	PROFINET interface X1 Port 1	PWR	POWER LED (green)
P2R	PROFINET interface X1 Port 2		

Figure 2-101 Block diagram of the IM 155-6 PN ST interface module

Parameters/address space 5

5.1 Parameters

Parameters for IM 155-6 PN ST interface module

The following table shows the parameters for the IM 155-6 PN ST interface module.

Table 2-116 Parameters for interface module IM 155-6 PN ST (GSD file)

Parameters	Value range	Default	Efficiency range
Configuration control	Disable/enable	Disable	ET 200SP

5.2 Explanation of parameters

5.2.1 Configuration control

You can use this parameter to enable the configuration control function in the ET 200SP distributed I/O system.

NOTE

If you configure the enable, the ET 200SP distributed I/O system requires a control data record 196 from the user program in order for the ET 200SP distributed I/O system to operate the I/O modules.

Reference

You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the STEP 7 online help.

5.3 Substitute value behavior

You can find more information on substitute value behavior in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

5.4 Status of supply voltage L+ and feedback voltage of I/O modules

Configurations

The "Status of supply voltage L+ and the feedback voltage of I/O modules" is configured on the server module. The input data can then be read out on the server module. You will find the relevant description in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

Interrupts, diagnostics, error, and system messages 6

6.1 Status and error displays

LED displays

The following figure shows the LED displays on the interface module and BusAdapter:

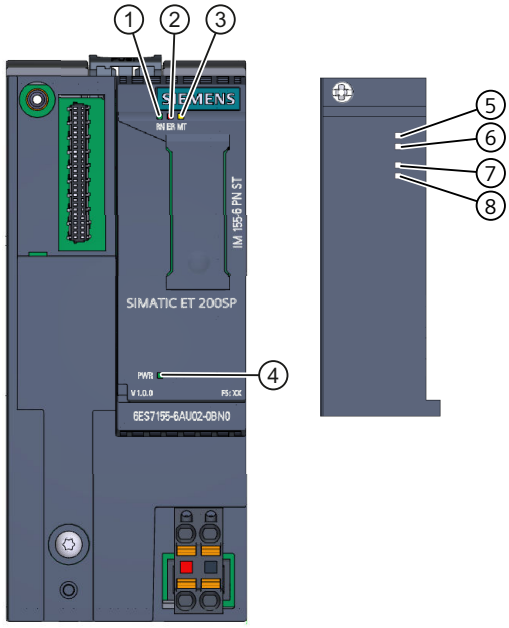

① RN (green)
② ER (red)
③ MT (yellow)
④ PWR (green)
⑤ LK1 (green)
⑥ MT1 (yellow), SCRJ port
⑦ LK2 (green)
⑧ MT12 (yellow), SCRJ port

Figure 2-102 LED display on the interface module and BusAdapter

Meaning of the LEDs

The following tables show the meaning of the status and error displays.

RN/ER/MT LEDs on the interface module

Table 2-117 Status and error displays of RN/ER/MT LEDs

LEDs			Meaning	Solution
RN (RUN)	**ER (ERROR)**	**MT (MAINT)**		
□ Off	□ Off	□ Off	Missing or insufficient supply voltage on interface module.	Check the supply voltage or switch it on at the interface module. *
■ On	■ On	■ On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	-
■ On	■ On	■ On	RN/ER/MT LEDs are permanently on: Hardware or firmware defective. Error information will be determined and stored retentively on the Flash memory.	Do not disconnect the interface module from the supply voltage while the LEDs are permanently lit up. This may take a few minutes.
☼ Flashes	Not relevant	Not relevant	Interface module is deactivated.	Activate the interface module with the configuration software or the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP starts up.	-
			ET 200SP is being assigned parameters.	
			ET 200SP is reset to factory settings.	
■ On	Not relevant	Not relevant	ET 200SP is currently exchanging data with the IO controller.	
Not relevant	☼ Flashes	Not relevant	Group errors and group error channels.	Evaluate the diagnostics data and remedy the error.
			The configured structure does not correspond to the actual structure of the ET 200SP .	Check the structure of the ET 200SP to see whether a module is missing or defective, or whether a non-configured module is plugged.
			Invalid configuration states.	See section Invalid configuration states of the ET 200SP on PROFINET IO (Page 47)
			Parameter assignment error in the I/O module.	Evaluate the display of the module status in STEP 7 and eliminate the error in the respective I/O module.
Not relevant	Not relevant	■ On	Maintenance required is present; that is, at least one maintenance event has occurred.	See Maintenance alarms (Page 46) section

* PWR LED on (on the interface module): Check the backplane bus for a short-circuit.

LEDs			Meaning	Solution
RN (RUN)	ER (ERROR)	MT (MAINT)		
■ On	Flashes	Flashes	The server module was removed or more than one server module is inserted in the station.	Re-insert the server module or check the number of inserted server modules.
Flashes	Flashes	Flashes	The "Node flash test" is run (the LK1 and LK2 LEDs of the PROFINET interface also flash).	-
			Hardware or firmware defective (LK1 and LK2 LEDs of the PROFINET interface do not flash).	Restart the device by disconnecting and reconnecting the supply voltage. Perform a firmware update. If the error persists, contact Siemens Industry Online Support. Replace the interface module. You can read out the service data with TIA Portal as of V18 and MFCT.

* PWR LED on (on the interface module): Check the backplane bus for a short-circuit.

PWR LED on the interface module

Table 2-118 PWR status display on the interface module

PWR LED	Meaning	Solution
□ Off	Supply voltage not present or too small	Check the supply voltage.
■ On	Supply voltage present	-

LK1/LK2 LED on the BusAdapter

Table 2-119 LK1/LK2status display on the BusAdapter

LEDs LK1/LK2	Meaning	Solution
□ Off	There is no Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	Check whether the bus cable to the switch/IO controller is interrupted or whether the port is disabled.
■ On	There is an Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	-
Flashes	The "Node flash test" is run (the RN/ER/MT LEDs also flash).	-

LED display of configuration errors

Configuration errors of the ET 200SP distributed I/O system are indicated on the interface module via the red ERROR LED and the yellow MAINT LED.

The following configuration errors are indicated by the LEDs:

- No server module
- Interruptions or short-circuit on the backplane bus

Operating principle

The LED error display provides information on the cause of the error. After notification by the flashing signal, the error type is displayed followed by the error location/error code.

The LED error display

- is active during POWER ON as well as during operation.
- Takes precedence over all other states indicated by the ERROR LED (ER) and MAINT LED (MT).
- remains turned on until the cause of the error has been corrected.

Table 2-120 Display of error type and error location

Sequence		Description
1	The ERROR and MAINT LEDs flash 3x at 0.5 Hz	Signaling of error type
2	MAINT LED flashes at 1 Hz	Display of error type (decimal)
3	The ERROR and MAINT LEDs flash 3x at 2 Hz	Signaling of error location/error code
4	The ERROR LED flashes at 1 Hz	Display of tens digit (decimal) of the error location/error code
5	The MAINT LED flashes at 1 Hz	Display of ones digit (decimal) of the error location/error code
6	Repeat steps 1 to 5 until the cause of the error has been corrected.	

Error display

The following table shows the possible causes of error that can occur.

Table 2-121 Error display

Error type (MAINT)	Error location (ERROR/MAINT)	Cause of error	Solution
1	65*	• No server module • More than one server module plugged in • Interruptions on the backplane bus • Short circuit of communication on the backplane bus	Check the configuration of the ET 200SP.

* Slot

NOTE

A short circuit in the backplane bus supply or the bus connection supply is indicated by the following LEDs:

- PWR LED: On
- RN, ER and MT LED: Off

6.2 Interrupts

Introduction

The I/O device generates interrupts as a reaction to specific error events. Interrupts are evaluated based on the I/O controller used.

Evaluating interrupts with I/O controllers

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostic interrupts
- Hardware interrupts
- Swapping interrupts
- Maintenance events

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB (organization block) using the instruction "RALRM" (read additional interrupt information).

System diagnostics

In STEP 7 (TIA Portal), the updated system diagnostics is available for the devices of the S7-1500 automation system (IO controller S7-1500 CPU) and ET 200SP (IO device). Independent of the cyclic user program, messages are made available on the display of the CPU S7-1500, the CPU web server and the HMI device.

You will find more information on system diagnostics in the Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

6.2.1 Triggering of a diagnostics interrupt

For an incoming or outgoing event (e.g. wire break on a channel of an I/O module), the module triggers a diagnostics interrupt if this is configured accordingly.

The CPU interrupts processing of the user program and processes the diagnostics block OB 82. The event which led to the interrupt is entered in the start information of the OB 82.

6.2.2 Triggering a hardware interrupt

During a hardware interrupt, the CPU interrupts the processing of the user program and processes the hardware interrupt block, e.g. OB 40. The event that triggered the interrupt is entered in the start information of the hardware interrupt block.

NOTE

Diagnostics "Hardware interrupt lost" (from I/O module)

Do not use hardware interrupts for functional purposes (e.g. cyclic generation of hardware interrupts).

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

6.2.3 Triggering a swapping interrupt

In the event of a pull/plug interrupt, the CPU interrupts processing of the user program and processes the pull/plug OB (OB 83). The event that triggered the interrupt is entered in the start information of the remove/insert module OB.

NOTE

Parameter assignment error after removal/insertion

If you write data records from the user program to the modules of the distributed I/O, make sure that these modules actually exist and are available. You can do this by evaluating OB83. After inserting a module, OB83 is not called until the module has started up and its parameters are assigned. This ensures that data record operations can be executed without errors.

6.2.4 Triggering of a maintenance event

The PROFINET IO interfaces of the interface module support the diagnostic concept and maintenance concept in PROFINET IO according to the IEC 61158 Type 10 standard. The goal is to detect and remove potential problems as early as possible.

For the interface module, maintenance events signal to the user when a plant component must be checked or replaced.

The CPU interrupts the processing of the user program and processes the diagnostic interrupt OB (OB 82). The event that triggered the maintenance event is entered in the start information of the diagnostic interrupt OB.

6.3 Alarms

Introduction

The ET 200SP distributed I/O system generates the following alarms:

- Diagnostic alarms
- Maintenance alarms

6.3.1 Diagnostics alarms

Actions after a diagnostics alarm

There can be more than one diagnostics alarm at the same time. Each diagnostics alarm initiates the following actions:

- The ER LED on the interface module flashes red.
- Diagnostics are reported as diagnostic interrupts to the CPU of the IO controller and can be read via data records.
- Incoming diagnostics alarms are saved to the diagnostics buffer of the I/O controller.
- (S7-300/400) The diagnostic interrupt OB is called. If the diagnostic interrupt OB (OB 82) is not available, the IO controller goes into STOP mode.

You can find more information on using PROFINET IO in the STEP 7 online help.

Table 2-122 Diagnostics alarms, their meaning and possible remedies

Diagnostics alarm	Channel Error Type (CET)	Extended Channel Error Type (ECET)	Associated value AddValue	Meaning / Cause	Solution
Configuration error: Module parameter (potential group) incorrect or wrong BaseUnit/terminal block in real slot <slot>	0x0602	0x0691	Slot	The configured BaseUnit or the terminal block does not match the real configuration.	Check for suitable BaseUnit or terminal block.
Configuration error: Station stop - missing or wrong server module	0x0602	0x0693	-	During the startup of an ET 200SP station, no server module was plugged in or the server module was removed during operation.	Check that the server module is installed correctly in the rack.
Configuration error: Station stop - too many server modules	0x0602	0x068C	-	More than one server module is plugged into the station.	Ensure that only one server module is plugged into the station.
Configuration error: Permitted size of backplane bus exceeded	0x0602	0x0698	-	The total width of the installed modules exceeds the permitted configuration length of 1 000 mm.	Check that the configuration of the backplane bus does not exceed the permitted size.
Configuration error: Incorrect backplane bus configuration in slot <slot>	0x0602	0x0699	Slot	The maximum power requirement of all installed modules exceeds 2 100 mA in total. The associated value <slot> indicates the faulty slot.	Check backplane bus mounting.
Configuration error: Invalid BusAdapter on the interface module	0x0602	0x069C	-	The installed BusAdapter does not correspond to the configuration.	Check project planning and mounting of the right BusAdapter.
Network configuration error: Shared Device conflict, invalid submodule assignment at slot <slot>	0x0603	0x06A5	Slot	There is an invalid submodule assignment.	Check the submodule assignment.

The scope of the diagnostics alarms displayed depends on the configuration and the parameter assignment.

If required, the standard can be downloaded from the Internet (http://www.profibus.com).

Reading the diagnostics

Table 2-123 Reading the diagnostics with STEP 7

Automation system with IO controller	Application	See ...
SIMATIC S7	Diagnostics as plain text in STEP 7 using Online and Diagnostics view	STEP 7 online help • as of STEP 7 V12, Function Manual PROFINET with STEP 7 as of V12 (https://support.automation.siemens.com/WW/view/en/49948856) • as of STEP 7 V5.5, System Manual PROFINET system description (https://support.automation.siemens.com/WW/view/en/19292127)
	Instruction "RDREC" (SFB 52) Read data records from the IO device	
	Instruction "RALRM" (SFB 54) Receive interrupts from the IO device	

More information on the data records for PROFINET IO

You will find the structure of the diagnostics data records and examples for programming in the From PROFIBUS DP to PROFINET IO (https://support.automation.siemens.com/WW/view/en/19289930) Programming Manual, in the sections "Structure of diagnostics data records" and "Examples of diagnostics data records" and in the application example (https://support.automation.siemens.com/WW/view/en/24000238).

Causes of error and troubleshooting

The causes of error and remedies for the diagnostics alarms are described in the manuals for the I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300) in the section "Interrupts, error messages, and system events".

PROFINET IO

Another source of diagnostics events is the PROFINET base used. This generates diagnostics alarms whose coding is already defined in the PROFINET IO - Application Layer Service Definition V2.2 standard.

The actual scope of diagnostics used is dependent on the configuration and parameter assignment.

If required, the standard is available for download on the Internet (http://www.profibus.com) from the PROFIBUS User Organization home page.

See also

PROFINET with STEP 7 V11 (http://support.automation.siemens.com/WW/view/en/49948856)

6.3.2 Maintenance alarms

Triggering of a maintenance event

The PROFINET IO interfaces of the interface module support the diagnostics concept and maintenance concept in PROFINET IO according to the IEC 61158 Type 10 standard. The goal is to detect and remove potential problems as early as possible.

For the interface module, maintenance events signal to the user when a plant component must be checked or replaced.

The CPU interrupts user program execution and executes the diagnostic interrupt OB. The event that triggered the maintenance event is entered in the start information of the diagnostic interrupt OB.

NOTE

Detailed information on other maintenance alarms can be found in TIA Portal.

Maintenance required alarms

A maintenance event is generated each time maintenance required is detected. However, it has no influence on the ER LED or MT LED on the interface module.

NOTE

Maintenance alarms have no direct influence on the function of the module.

Table 2-124 Maintenance demanded alarms, their meaning and possible remedies

Maintenance required alarm	Channel Error Type (CET)	Extended Channel Error Type (ECET)	Associated value AddValue	Meaning / Cause	Solution
Security event: Firmware successfully downloaded and activated for use after a reset (New firmware version <FW version>)	0x0190	0x012C	Signed firmware version	The firmware has been successfully loaded into the module. This firmware update takes effect after the interface module is restarted.	-
Security event: The firmware integrity checks failed. The new firmware version <FW version> was rejected.	0x0190	0x0193	Signed firmware version	The firmware was not successfully loaded into the module. This can have many different reasons, e.g. corrupted binary files or an incorrect signature.	Verify if the firmware update file you are using comes from a secure source. Download the firmware again from the Siemens support website and repeat the firmware update.

System alarms in STEP 7 (TIA Portal)

The maintenance information is generated in STEP 7 (TIA Portal) with the following system events:

- Maintenance required - indicated for each port by a wrench with a green background in the device view or in the hardware configuration.

You can find more information in the STEP 7 online help.

6.3.3 Invalid configuration states of the ET 200SP on PROFINET IO

Invalid configuration states

The following invalid configuration states of the ET 200SP distributed I/O system lead to the failure of the IO device or prevent the exchange of user data with the I/O modules.

- Number of modules exceeds maximum configuration
- Faulty backplane bus (e.g. defective BaseUnit). ET 200SP backplane bus interruptions do not trigger an interrupt.
- At least one I/O module is installed in a different BaseUnit than the one configured in the parameters.
- Missing server module
- Invalid or incorrectly configured BusAdapter

NOTE

Removal of the server module will trigger a station stop. All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) but the interface module is still exchanging data.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

6.3.4 Failure of supply voltage L+ at BaseUnit BU...D

Failure of the supply voltage L+

The I/O modules react as follows to failure of the supply voltage L+ on the BaseUnit BU...D:

- If an I/O module is removed during failure of the supply voltage, a pull alarm is generated.
- If an I/O module is installed during failure of the supply voltage, an insert alarm is generated.

6.3.5 STOP of the IO controller and recovery of the IO device

STOP of the SIMATIC IO controller

Diagnostics frames received from the IO device while the IO controller is in STOP do not initiate a call of any corresponding OBs when the IO controller goes into RUN. You must read the data record $E00C_H$ with the "RDREC" instruction in OB 100. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Recovery of the SIMATIC IO devices

If you want to read the diagnostics of a station after its return, you have to read the $E00C_H$ data record with the "RDREC" instruction in OB 86. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Compatibility

7

Compatibility between the versions of the IM 155-6 PN ST

The table below describes which version you can use in the configuration for which actually plugged version of the IM 155-6 PN ST interface module.

Interface modules plugged	Interface modules configured									
	IM155--6 PN ST V1.0	IM155--6 PN ST V1.1	IM155--6PN ST V3.1	IM 155-6 PN ST V3.3	IM155--6 PN ST V4.1	IM155--6 PN ST V4.2	IM155--6 PN ST V6.1	IM155--6 PN ST V6.2	IM155--6 PN ST V6.3	IM155--6 PN ST V6.4
IM 155-6 PN ST, V1.0	X	-	-	-	-	-	-	-	-	-
IM 155-6 PN ST, V1.1	X	X	-	-	-	-	-	-	-	-
IM 155-6 PN ST, V3.1	X	X	X	-	-	-	-	-	-	-
IM 155-6 PN ST, V3.3	X	X	X	X	-	-	-	-	-	-
IM 155-6 PN ST, V4.1	X	X	X	X	X	-	-	-	-	-
IM 155-6 PN ST, V4.2	X	X	X	X	X	X	-	-	-	-
IM 155-6 PN ST, V6.1	-	X	X	X	X	X	X	-	-	-
IM 155-6 PN ST, V6.2	-	X	X	X	X	X	X	X	-	-
IM 155-6 PN ST, V6.3	-	X	X	X	X	X	X	X	X	-
IM 155-6 PN ST, V6.4	-	X	X	X	X	X	X	X	X	X
IM 155-6 MF HF, V6.2	-	X	X	X	X	X	X	X	-	-
IM 155-6 MF HF, V6.3	-	X	X	X	X	X	X	X	X	-
IM 155-6 MF HF, V6.4	-	X	X	X	X	X	X	X	X	X

Status of the supply voltage

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules in the following table without a parameter assignment, the status of the supply voltage is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Article number
DI 8x24VDC ST	6ES7131-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7131-6BF00-0CA0
DQ 4x24VC/2A ST	6ES7132-6BD20-0BA0
DQ 8x24VDC/0,5A ST	6ES7132-6BF00-0BA0
DQ 16x24VDC/0,5A ST	6ES7132-6BH00-0BA0
DQ 8x24VDC/0,5A HF	6ES7132-6BF00-0CA0

Reaction times for fail-safe modules

The following maximum reaction time of the interface module must be taken into account when calculating the reaction times of fail-safe modules:
T_{Slave} = configured update time + 400 µs (but at least 1.4 ms)

Operation and maintenance 8

8.1 Resetting interface module to factory settings with MFCT

You can also reset the interface module to factory settings with MFCT.

Information on this is available in the "Resetting the MF device" section of the "MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209)" function manual.

8.2 Firmware update with MFCT

With MFCT, you can perform firmware updates for modules and interface modules.

Information on this is available in the "MultiFieldbus (https://support.industry.siemens.com/cs/ww/en/view/109773209)" function manual in the section "Firmware update with MFCT".

Technical specifications 9

Technical specifications of the IM 155-6 PN ST

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7155-6AU02-0BN0/td?dl=de).

Article number	6ES7155-6AU02-0BN0
General information	
Product type designation	IM 155-6 PN ST
Firmware version	V6.4.0
• FW update possible	Yes
Vendor identification (VendorID)	002AH
Device identifier (DeviceID)	0313H
Manufacturer ID according to ODVA (VendorID)	04E3H
Device ID according to ODVA (Product code)	0FA2H
Product function	
• I&M data	Yes; I&M0 to I&M4
• Module swapping during operation (hot swapping)	Yes; Multi-hot swapping
• Isochronous mode	Yes
• IRT	Yes
• Local coupling, IO data	Yes
– Number of coupling modules	6; 1x output + max. 5x input
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V20
• STEP 7 configurable/integrated from version	V5.7 SP3
• PROFINET from GSD version/GSD revision	GSDML V2.45
Configuration control	
via dataset	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Short-circuit protection	Yes

Article number	6ES7155-6AU02-0BN0
Mains buffering	
• Mains/voltage failure stored energy time	10 ms
Input current	
Current consumption (rated value)	350 mA
Current consumption, max.	450 mA
Inrush current, max.	1 A
I^2t	0.05 $A^2 \cdot s$
Power loss	
Power loss, typ.	1.8 W
Address area	
Address space per module	
• Address space per module, max.	288 byte; For input and output data respectively
Address space per station	
• Address space per station, max.	1 440 byte
Hardware configuration	
Rack	
• Quantity of operable ET 200SP modules, max.	32
• Quantity of operable ET 200AL modules, max.	16
Submodules	
• Number of submodules per station, max.	256
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch)
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; with BusAdapter
• Number of ports	2; with BusAdapter
• integrated switch	Yes
• BusAdapter (PROFINET)	Yes; BA 2x RJ45, BA 2x FC, BA 2x M12
Protocols	
• PROFINET IO Device	Yes
• Open IE communication	Yes
• Media redundancy	Yes; PROFINET MRP client
PROFINET IO Device	
Services	
– IRT	Yes; 1 ms to 4 ms at an interval of 125 µs
– Dynamic Frame Packing (DFP)	Yes
– Fast Forwarding	Yes
– Fragmentation	Yes
– PROFIenergy	Yes

Article number	6ES7155-6AU02-0BN0
– Prioritized startup	Yes
– Shared device	Yes
– Number of IO Controllers with shared device, max.	4
Interface types	
RJ 45 (Ethernet)	
• Transmission procedure	PROFINET with 100 Mbit/s full duplex (100BASE-TX)
• 100 Mbps	Yes
• Autonegotiation	Yes
• Autocrossing	Yes
Protocols	
Supports protocol for PROFINET IO	Yes
PROFIsafe	Yes
PROFIBUS	No
EtherNet/IP	No
Modbus TCP	No
Redundancy mode	
• PROFINET system redundancy (S2)	No
Media redundancy	
– MRP	Yes
– MRPD	Yes
Open IE communication	
• TCP/IP	Yes
• UDP	Yes
• SNMP	Yes
• LLDP	Yes
• ARP	Yes
• IGMP	Yes
• Multicast	Yes
• Broadcast	Yes
• IPv4	Yes
• IPv6	No
Interrupts/diagnostics/status information	
Status indicator	Yes
Alarms	Yes
Diagnostics function	Yes
Diagnostics indication LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED

Article number	6ES7155-6AU02-0BN0
• MAINT LED	Yes; Yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Connection display LINK TX/RX	Yes; 2x green link LEDs on BusAdapter
Potential separation	
between backplane bus and electronics	No
between PROFINET and all other circuits	Yes; 1500 V AC (type test)
between supply and all other circuits	No
Permissible potential difference	
between different circuits	Safety extra low voltage SELV
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Network loading class	3
Security	
PROFINET Security Class	1
signed firmware update	Yes
Secure Boot	No
safely removing data	Yes
data integrity	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; No condensation
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Connection method	
ET-Connection	
• via BU/BA Send	Yes; + 16 ET 200AL modules
Mechanics/material	
Strain relief	Yes; Optional
Dimensions	
Width	50 mm
Height	117 mm
Depth	74 mm
Weights	
Weight, approx.	120 g; without BusAdapter

Dimension drawing

A

This appendix contains a dimension drawing of the module installed on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

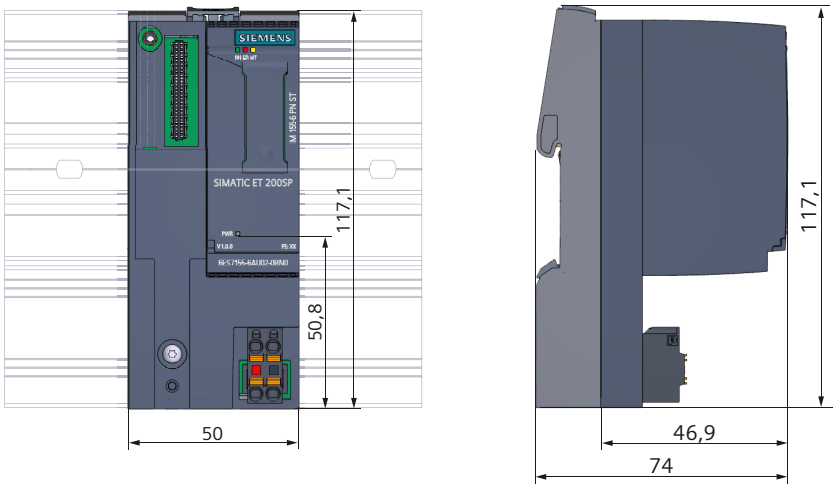

Figure 2-103 Dimension drawing of the IM 155-6 PN ST interface module (front and side view)

SIEMENS

SIMATIC

ET 200SP
Interface module IM 155-6 PN/2 HF (6ES7155-6AU01-0CN0)

Equipment Manual

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10/2018
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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes labeled as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (https://www.siemens.com/industrialsecurity).

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Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

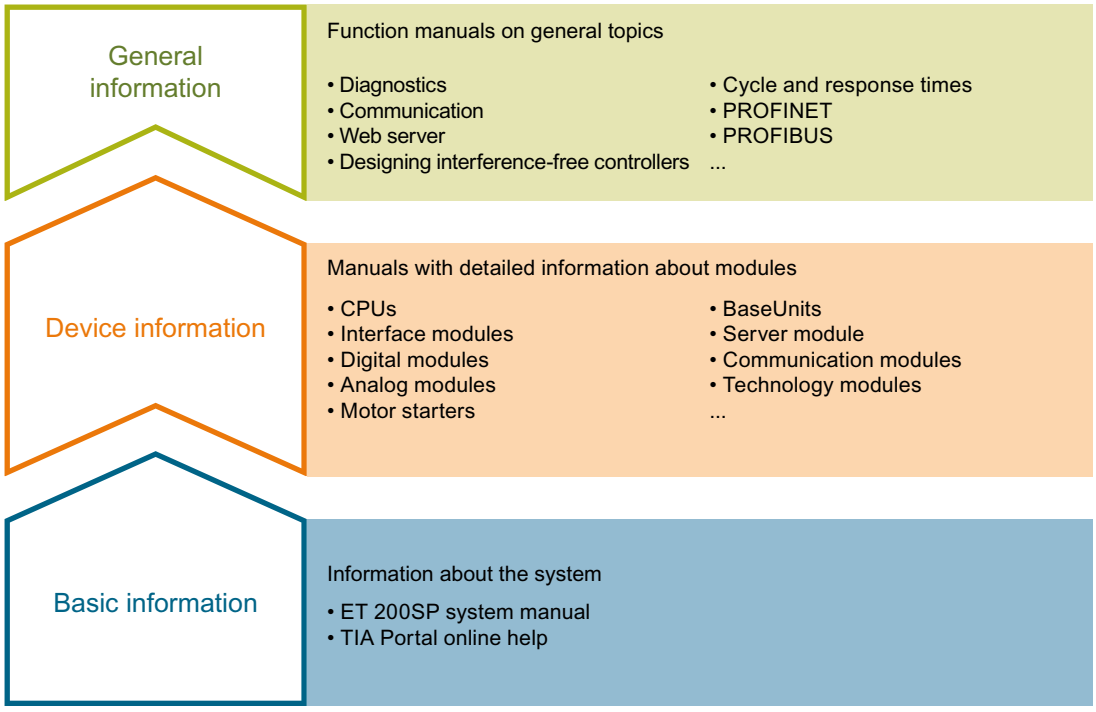

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7155-6AU01-0CN0

View of the module

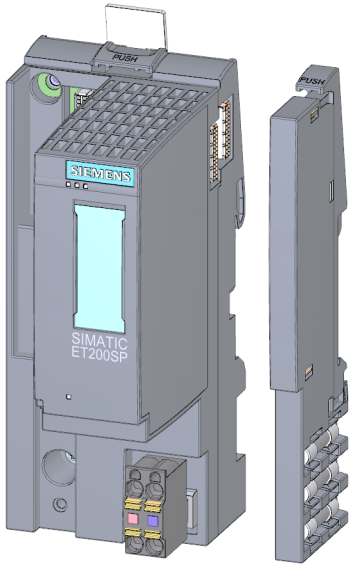

Figure 2-104 View of the AS interface module 155-6 PN/2 HF with included accessory (24 V DC connector and server module) and optional accessories (labeling strips and reference identification label)

Properties

The module has the following technical properties:

- Connects the ET 200SP distributed I/O system with PROFINET IO.
- Power supply 1 L+ 24 V DC (SELV/PELV). The connection plug is included in the scope of delivery of the interface module and is available as replacement part.
- PROFINET IO connection via selectable BusAdapters
  - BA 2×RJ45 for RJ45 bus connector
  - BA 2×FC for direct connection of the bus cable
  - BA 2xLC for glass fiber-optic cable

- BA 2xSCRJ for POF/PCF fiber-optic cable
- BA SCRJ/RJ45 as media converter for POF/PCF fiber-optic cable ⇔ standard RJ45 connector
- BA SCRJ/FC as media converter for POF/PCF fiber-optic cable ⇔ direct connection of the bus cable
- BA LC/RJ45 as media converter for glass fiber-optic cable ⇔ standard RJ45 connector
- BA LC/FC as media converter for glass fiber-optic cable ⇔ direct connection of the bus cable

Maximum configuration

- 64 ET 200SP I/O modules + 16 ET 200AL modules
- 1 m backplane bus (without interface and server module)

Maximum amount of I/O data

Gross data length (for input data and output data):
Without system redundancy S2:

- 1440 bytes
- 1440 bytes for shared device with 2 IOC (in total for both IOC)
- 360 bytes for shared device with more than 2 IOC (per IOC)

With system redundancy S2:

- 1000 bytes
- 360 bytes for system redundancy S2 and shared device with min. 1 additional IOC (per IOC)

The number of maximum net data length for input data and output data depends on the number and type of I/O modules used including ET 200AL modules.

Net data length (for input data and output data):
The following minimum lengths can be applied without shared device and without explicit calculation of the maximum net data length.

- 933 bytes without system redundancy S2
- 493 bytes with system redundancy S2

Calculation of the max. net data length:
Max. net data length = Max. gross length - number of I/O submodules (no user data, input or output data) - number of I/O mixed modules (input and output data) - 5 bytes for interface module and server module without ET-Connection (6 bytes for interface module with ET-Connection)

The result of the calculation of the maximum net data length applies equally to input and output data.

Accessories

You order the following accessories separately:

- BA 2×RJ45 BusAdapter
- BA 2×FC BusAdapter
- BA 2×LC BusAdapter
- BA 2xSCRJ BusAdapter
- BA SCRJ/RJ45 BusAdapter
- BA SCRJ/FC BusAdapter
- BA LC/RJ45 BusAdapter
- BA LC/FC BusAdapter
- Strain relief for PROFINET cable
- 24 V DC connector (one included in the scope of delivery)
- Labeling strips
- Reference identification label

Information on the BusAdapters is available in the BusAdapter (https://support.industry.siemens.com/cs/ww/en/view/109751716) manual.

You can find more information on accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Server module

The server module is included in the scope of delivery of the interface module and available separately as an accessory.

The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system
- Includes a holder for 3 spare fuses (5 × 20 mm).
- Provides station functions, e.g., group diagnostics: No supply voltage L+, status bytes.
- Identification data I&M 0 to 4

NOTE

You need to configure and assign parameters to the server module in the configuration software.

Place the server module in the last slot of the configuration. If there are 64 I/O modules, the server module is plugged in slot 65.

You can find more information in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

First BaseUnit of an ET 200SP in the configuration

The interface modules support plugging a dark-colored BaseUnit in slot 1. This means that modules without a connection to the integrated voltage buses P1 and P2 can now also be configured starting with slot 1. Currently, this applies to the following modules:

- AI Energy Meter ST
- DI 4 x 120...230 V AC ST (6ES7131-6FD00-0BB1)
- DQ 4 x 24...230 V AC/2 A ST (6ES7132-6FD00-0BB1)

NOTE

First BaseUnit of an ET 200SP in the configuration

Please note the information on limiting the overvoltage and power rating in the AC I/O module manuals.

You route the infeed of the 24 V DC supply voltage over an external fuse.

The 24 V DC supply voltage is provided by a light-colored BaseUnit.

Requirement for configuration of these modules in slot 1:

- Configuration via GSD or GSDML
- Configuration as of STEP 7 V5.5 SP4 with
  - HSP0255 V3.0 for IM155-6 PN HF
- Configuration as of STEP 7 V13 SP1

See also

Functions (Page 13)

2.2 Functions

Introduction

The interface module supports the following PROFINET IO functions:

- Integrated switch with 2 ports
- Supported Ethernet services: PING, ARP, SNMP, LLDP
- Port diagnostics
- Disabling ports
- Minimum update time 250 µs
- Device replacement without programming device, also without topological configuration
- Reset to factory settings via PROFINET IO or RESET button
- Firmware update via PROFINET IO
- Isochronous real-time communication
- Prioritized startup
- Media redundancy (MRP)

- Shared device
- Distribution of module channels to a maximum of 4 submodules
- Module-internal or submodule-internal Shared Input/Shared Output (MSI/MSO)
- Isochronous mode
- System redundancy S2
- Station extension via ET-Connection
- Alternating IO devices during operation ("docking systems")
  - Docking station
  - Docking unit
- Supports BusAdapter for different connection technologies to PROFINET IO.

The interface module supports additional functions:

- Identification data I&M 0 to I&M 4
- PROFIenergy
- Configuration control (option handling)
- Use of fail-safe modules
- Removal/insertion of multiple I/O modules during operation (Multi Hot Swap)
- Module-to-Module Communication (MtM)

Requirements

The table below shows the software requirements for a configuration with the IM 155-6 PN/2 HF interface module:

Table 2-125 Version dependencies of the module functions

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software			
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130000)/-software from a third-party manufacturer [1]	STEP 7 as of V5.5 SP3 with HSP 233	STEP 7 as of V5.5 SP4 with HSP 250/255	STEP 7 (TIA Portal) as of V12.0.1 with HSP 0058
Real-time communication	1	V2.0.0	X	X	X	X
Isochronous real-time communication	1	V2.0.0	X	X	X	X
Prioritized startup	1	V2.0.0	X	X	X	X
Device replacement without programming device	1	V2.0.0	X	X	X	X
Media redundancy (MRP)	1	V2.0.0	X	X	X	X

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software			
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130000)/-software from a third-party manufacturer [1]	STEP 7 as of V5.5 SP3 with HSP 233	STEP 7 as of V5.5 SP4 with HSP 250/255	STEP 7 (TIA Portal) as of V12.0.1 with HSP 0058
Shared device	1	V2.0.0	X	X	X	X
Value status	1	V2.0.0	X	X	X	X
PROFIenergy	1	V2.0.0	X	X	X	X
Multi Hot Swap	1	V2.0.0	X	X	X	X
Use of fail-safe modules	1	V2.0.0	---	X	X	X
Oversampling	1	V2.1.0	X	X	X	X
Isochronous mode	1	V2.1.0	---	X	X	X
Module-internal Shared Input/Shared Output (MSI/MSO)	1	V2.2.0	X	---	X	X
BusAdapter for fiber-optic cable FOC: BA 2xSCRJ	3	V2.2.0	X	---	X	X (as of V13 SP1)
System redundancy S2 to S7-400H	1	V3.0.0	X	---	X	---
System redundancy S2 IEC-compliant	1	V4.2.0	X	---	---	---
System redundancy S2 to S7-1500R/H	1	V4.2.0	X	---	---	X (as of V15.1)
Station extension via ET-Connection	1	V3.0.0	X	---	X (as of V5.5 SP4)	X (as of V13 SP1)
Maximum user data length per module: 288 bytes	1	V3.1.0	X	X (as of V5.5 SP4)	X (as of V5.5 SP4)	X (as of V13 SP1)
BA SCRJ/RJ45 BusAdapter	3	V3.1.0	X	---	X (as of V5.5 SP4, HSP0250 V3)	X (as of V13 SP1, HSP0129 V1.0)
BA SCRJ/FC BusAdapter	3	V3.1.0	X	---	X (as of V5.5 SP4, HSP0250 V3)	X (as of V13 SP1, HSP0129 V1.0)
BA 2xLC BusAdapter	3	V3.3.0	X	---	X (as of V5.5 SP4, HSP0250/255 V4)	X (as of V13 SP1, Update 6)
BA LC/RJ45 BusAdapter	3	V3.3.0	X	---	X (as of V5.5 SP4, HSP0250/255 V4)	X (as of V13 SP1, Update 6)

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

Function	Functional status of the module as of	Firmware version of the module as of	Configuration software			
			Configuration with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130000)/-software from a third-party manufacturer [1]	STEP 7 as of V5.5 SP3 with HSP 233	STEP 7 as of V5.5 SP4 with HSP 250/255	STEP 7 (TIA Portal) as of V12.0.1 with HSP 0058
BA LC/FC BusAdapter	3	V3.3.0	X	---	X (as of V5.5 SP4, HSP0250/255 V4)	X (as of V13 SP1, Update 6)
Distribution of module channels to multiple sub-modules	3	V3.3.0	X	---	X (as of V5.5 SP4, HSP0255 V4)	X (as of V13 SP1, Update 6)
Maintenance interrupts of I/O modules	3	V3.3.0	X	---	X (as of V5.5 SP4, HSP0255 V4)	X (as of V13 SP1, Update 6)
Extended Channel Diagnostics	3	V3.3.0	X	---	X (as of V5.5 SP4, HSP0255 V4)	X (as of V13 SP1, Update 6)
Module-to-Module Communication (MtM)	1	V4.2.0	X	---	---	X (as of V15.1)

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

Cabling with fixed connection setting

If you set a fixed connection setting of the port in STEP 7, you must also disable "Autonegotiation/Autocrossover".

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 (TIA Portal) V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

Compatibility with the IM 155-6 PN interface module

In an existing plant, the IM 155-6 PN/2 HF replaces the IM 155-6 PN ST without reconfiguration. When the IM 155-6 PN/2 HF replaces the IM 155-6 PN ST, it is possible to insert and remove several I/O modules during operation.

For more information on compatibility, refer to section: Compatibility (Page 44)

See also

ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)

PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856)

2.2.1 Device replacement

Device replacement

Device replacement without topological configuration

The device name is also stored on the BusAdapter in addition to the interface module. A device name saved on the BusAdapter is the requirement for device replacement without topological configuration.

Replacing the interface module produces a range of scenarios for using the device name.

Table 2-126 Scenarios for using the device name

	Interface module empty	Interface module with device name
BusAdapter without device name	No device name available	The device name from the interface module is used and copied to the BusAdapter.
BusAdapter with device name	The device name from the BusAdapter is used and copied to the interface module.	The device name from the BusAdapter is used and copied to the interface module if this has a different device name.

Be aware of the following constraints:

- Resetting to factory settings deletes the device name in both the interface module and the BusAdapter. To prevent the device name from being deleted in the BusAdapter, you can remove the BusAdapter from the interface module before resetting to factory settings.
- When a BusAdapter is replaced, a device name stored in the BusAdapter is applied to the interface module after a POWER ON.
- Do not pull/plug the BusAdapter while under voltage.

Device replacement with topological configuration

IO devices with this function can be replaced in a simple manner:

- The device name does not have to be assigned with the programming device.

The replacement IO device is assigned the device name by the IO controller and not by the programming device. The IO controller uses the configured topology and the neighboring relationships determined by the IO devices for this purpose. All involved devices must support the LLDP protocol (Link Layer Discovery Protocol). The configured target topology must match the actual topology.

If the IO devices were already used in another configuration, reset them to factory settings before reusing them. You can find information on this in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 (TIA Portal) V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

2.2.2 Real-time communication

Real-time communication

A transmission method for PROFINET IO based on cyclic data exchange with a provider-consumer model.

2.2.3 Isochronous real-time communication

Isochronous real-time communication

A synchronized transmission method for cyclic exchange of IO data between PROFINET devices. A reserved bandwidth within the send clock is available for the transmission. The reserved bandwidth ensures that the IRT data is also transmitted in reserved, time-synchronized intervals, unaffected by other high network load (e.g. TCP/IP communication or additional real time communication).

A topology configuration is required for IRT.

NOTE

IO controller as sync master with IRT communication

We recommend operating the IO controller also as a sync master when configuring the IRT communication. Otherwise, IRT- and RT-configured IO devices may fail if the sync master fails.

You can find more information on the configuration of synchronized PROFINET devices in sync domains in the STEP 7 online help and

- As of STEP 7 (TIA Portal) V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

2.2.4 Prioritized startup

Prioritized startup

Prioritized startup is a PROFINET IO function in a PROFINET IO system with IRT and RT communication. It reduces the time needed for correspondingly configured IO devices to return to cyclic user data exchange.

The function accelerates the startup of IO devices in the following cases:

- After recovery of supply voltage
- After station recovery
- After activation of IO devices

NOTE

Dependency of the startup time

The interface module permits startup times from 0.5 s.

The startup time depends on the number and type of modules.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 (TIA Portal) V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

2.2.5 Submodules

Submodules

The IM 155-6 PN/2 HF interface module supports the division of I/O modules into up to 4 submodules. This allows parts of an I/O module to be separately configured and parameterized.

A maximum of 256 submodules is supported, whereby 4 submodules are used for the interface module and one submodule for the server module.

You can assign each of these submodules to different IO controllers.

The following functions are only executed if you have configured submodule 1 during configuration:

- Firmware update
- Write I&M data
- Calibration
- PROFIenergy

2.2.6 Media redundancy (MRP)

Media redundancy (MRP)

Function for safeguarding communication and plant availability. A ring topology ensures that an alternative communication path is made available if a transmission route fails.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

2.2.7 Shared device

Shared device

IO device that makes its data available to up to four IO controllers.

The interface module supports shared device at submodule level.

If **there is no validity check of the shared device projects by the Engineering System**, note the following:

- Make sure the configurations are consistent. Assign each module or submodule to only one IO controller. Multiple assignment will result in an error as the module or submodule will only be available in the first controller.
- If you reconfigure the shared device configurations without the validity check mentioned above, you must commission ET 200SP again. This means you must download the projects of all involved IO controllers to the respective CPU again after reconfiguration. If necessary, perform a POWER OFF/POWER ON of the interface module.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

NOTE

In the case of a shared device application, make sure that all controllers work with the same send clock. If the controller does not have the same send clock, this results in communication relationships not being set up.

If you set up all controllers in one project, the same send clock is ensured. Set the same send clock for engineering in separate projects.

2.2.8 Isochronous mode

Isochronous mode

The input and output data of distributed I/O modules in the system is simultaneously acquired and simultaneously output. For this purpose, the I/O data, the transmission cycle via PROFINET IO, and the user program are synchronized. The constant PROFINET IO cycle forms the corresponding clock generator. The interface module supports isochronous mode of I/O data for the modules starting at 250 µs. The IO device can exchange isochronous process data with a maximum of one IO controller.

NOTE

When the module is pulled or no written control data record has been written with activated configuration control, the IO controller cannot access a module. In this case, cycle time violations may occur with activated isochronous mode in the synchronous cycle interrupt OB (OB61). The time error OB (OB80) is called in the event of a cycle time violation.

This behavior is associated with updating the process image by means of the "SYNC_PI" (SFC126) and "SYNC_PO" (SFC127) instructions. It depends on the set cycle time and the configuration limits.

You can find additional information in the STEP 7 online help and

- As of STEP 7 V12, in the PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856) function manual.
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

2.2.9 Module-internal Shared Input/Shared Output (MSI/MSO)

Module-internal Shared Input/Shared Output (MSI/MSO)

The Module-internal Shared Input function allows an input module to make its input data available to up to four IO controllers. Each controller has read access to the same channels.

The Module-internal Shared Output function allows an output module to be operated by up to four IO controllers. One IO controller has write access. Up to three additional IO controllers can have read access to the same channels.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

2.2.10 System redundancy S2

System redundancy S2

An IO device with S2 system redundancy supports redundant ARs.

In a redundant system, an IO device with system redundancy S2 has a redundant AR for each of the two CPUs (IO controllers). If one CPU fails, the IO device with S2 system redundancy remains accessible to the remaining IO controller via the AR.

The interface module supports system redundancy S2 on CPUs S7-400H (from firmware version V3.0) and on CPUs S7-1500R/H (from firmware version V4.2).

You can find additional information in the STEP 7 online help and

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856)
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)

2.2.11 Alternating IO devices during operation ("docking systems")

Alternating IO devices during operation ("docking systems")

- Docking station
- Docking unit

You can find additional information in the STEP 7 online help and

- As of STEP 7 V12, in the PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856) function manual

2.2.12 Oversampling

Oversampling

The IM 155-6 PN/2 HF interface module supports the oversampling mode of HS modules. With oversampling, the modules reduce the respective PROFINET send clocks in isochronous mode.

Additional information on oversampling can be found in the manuals for the I/O modules.

2.2.13 Value status

Value status

The IM 155-6 PN/2 HF interface module supports I/O modules with value status.

Additional information on the value status can be found in the manuals for the I/O modules.

2.2.14 PROFIenergy

Properties

PROFIenergy (for PROFINET) reduces the energy consumption by using PROFIenergy commands during production-free periods.

Reference

You will find additional information on PROFIenergy in the following manuals:

- Manual I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300)
- Function manual PROFINET as of STEP 7 V12 (http://support.automation.siemens.com/WW/view/en/49948856)
- System manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)
- PROFIenergy (http://support.automation.siemens.com/WW/view/en/66928686) product information
- Internet (http://www.profibus.com) under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order No: 3.802

2.2.15 Configuration control (option handling)

Properties

Configuration control allows you to prepare your automation system for future expansions or changes. Configuration control means you can configure the planned maximum expansion of your automation system in advance and flexibly vary it later by means of the user program.

Reference

You can find more information on configuration control:

- In the system manual ET 200SP distributed I/O system. (http://support.automation.siemens.com/WW/view/en/58649293)
- On the Internet under the following link: Application collection (http://support.automation.siemens.com/WW/view/en/29430270).
- In the STEP 7 online help.

2.2.16 Use of fail-safe modules

Properties

The IM 155-6 PN/2 HF interface module supports the use of fail-safe modules.

Reference

You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2.17 Multi Hot Swap

Properties

You can remove and insert any number of I/O modules during operation. The interface module and the inserted I/O modules remain in operation.

NOTE

The IM 155-6 PN/2 HF interface module does not support removal and insertion of the server module, interface module and BusAdapter during operation.

Reference

You can find more information on the removal/insertion of modules in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

2.2.18 Module-to-Module Communication (MtM)

Introduction

Module-to-Module Communication (MtM) offers the following advantages:

- Improved performance during transmission of data by bypassing the IO controller.
- Deterministic cycle times
- Cost-effective, high-performance solutions for applications where the performance of a specific technology module is not required.

Module-to-Module Communication (MtM)

Module-to-Module Communication (MtM) enables direct exchange of data between specific IO modules within a station via the interface module. This enables you to move small and/or time-critical tasks to the IO module. You achieve better performance while reducing the load on the CPU.

With Module-to-Module Communication (MtM), the interface module copies the input data of an IO module directly to a different IO module via the ET 200SP backplane bus. The IO module (data sink) carries out application-specific processing of the data.

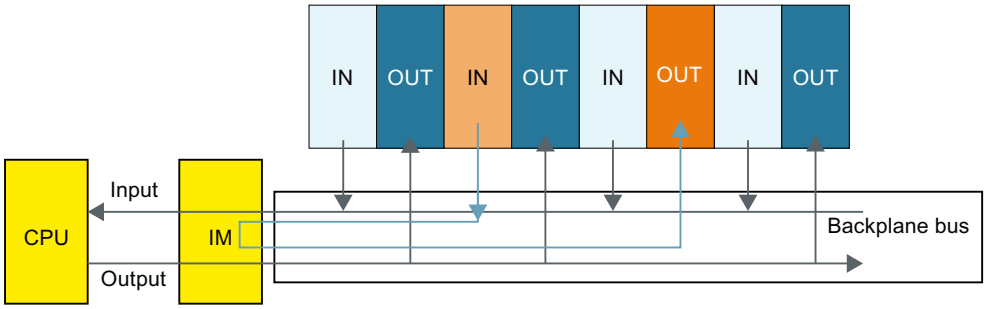

You configure the data source and data sink for Module-to-Module Communication (MtM) in the hardware configuration of the respective output module. Programming of the user program is **not** required in the variant for Module-to-Module Communication (MtM).

NOTE

The preparation of the input data in the output module (mapping) and the output of the data to the outputs are application- and technology-specific.
Example: The DQ 4x24VDC/2A HS digital output module supports

- the application cam control with Module-to-Module Communication (MtM) under the designation DQ 4x24VDC/2A HS **MCC MtM**

Additional information can be found in the manuals of the corresponding IO modules.

2.2.19 Setting the time

The interface module supports time setting, for example with AI Energy Meter 480VAC/CT HF (6ES7134-6PA00-0CU0).

We show you how to set the time in an application example (https://support.automation.siemens.com/WW/view/en/109754890).

Wiring

3

3.1 Pin assignment

24 V DC supply voltage

The following table shows the signal names and the descriptions of the pin assignment for a 24 V DC supply voltage.

Table 2-127 Pin assignment 24 V DC supply voltage

View		Signal name[1]	Description
Connector	IM connection		
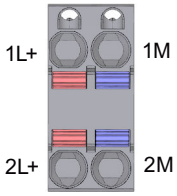	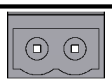	1L+	24 V DC (SELV/PELV)
		2L+	24 V DC (for looping through)[2]
		1M	Ground
		2M	Ground (for looping through)[2]

1 1L+ and 2L+ as well as 1M and 2M are bridged internally.

2 Maximum 10 A permitted.

Reference

You can find more information on accessories and how to connect the interface module in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Block diagram

Block diagram

The following figure shows the block diagram of the IM 155-6 PN/2 HF interface module.

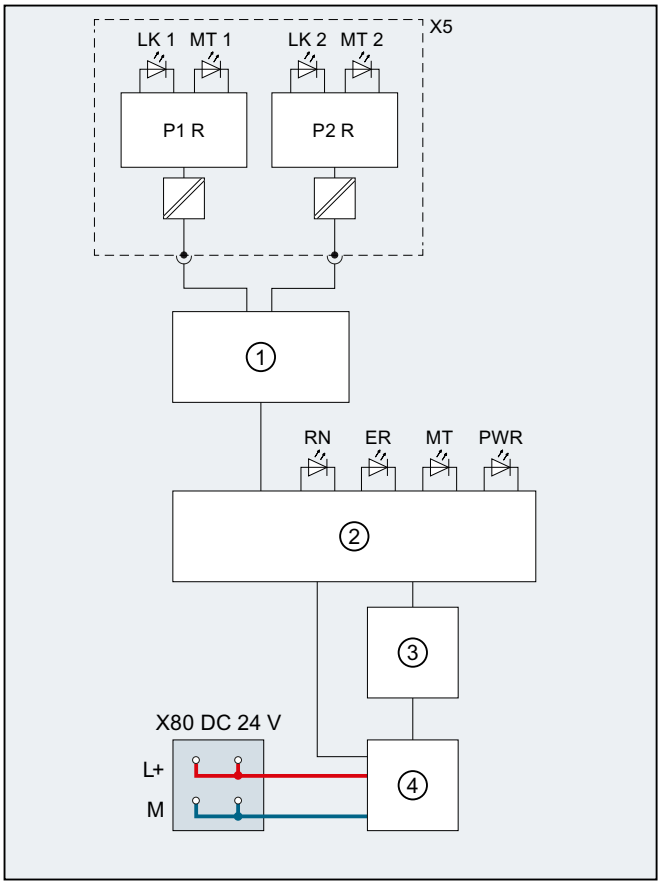

①	Switch	L+	24 V DC supply voltage
②	ET 200SP backplane bus interface and electronics	M	Ground
③	Backplane bus	LK 1,2	Link TX/RX LED (green)
④	Internal power supply	MT 1,2	MAINTENANCE FiberOptic LED (SCRJ port, yellow)
X80 24 V DC	Feed supply voltage	RN	RUN LED (green)
X5	BusAdapter	ER	ERROR LED (red)
P1 R	PROFINET interface X1 Port 1	MT	MAINTENANCE LED (yellow)
P2 R	PROFINET interface X1 Port 2	PWR	POWER LED (green)

Figure 2-105 Block diagram of the IM 155-6 PN/2 HF interface module

Parameters/address space

4

4.1 Parameters

Parameters for IM 155-6 PN/2 HF interface module

The following table shows the parameters for the interface module IM 155-6 PN/2 HF.

Table 2-128 Parameters for IM 155-6 PN/2 HF interface module (GSD file)

Parameters	Value range	Default	Effective range
Enable configuration control	Yes/No	No	ET 200SP
Diagnostics (maintenance) under-voltage	Yes/No	No	ET 200SP

4.2 Explanation of parameters

4.2.1 Enable configuration control

Enable configuration control

You use this parameter to enable the configuration control function in the ET 200SP distributed I/O system.

NOTE

If you configure the enable, the ET 200SP distributed I/O system requires a control data record 196 from the user program in order for the ET 200SP distributed I/O system to operate the I/O modules.

Reference

You can find more information on the control data record in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the STEP 7 online help.

4.2.2 Diagnostics (maintenance) undervoltage

Diagnostics (maintenance) undervoltage

Diagnostics (maintenance) undervoltage is triggered if the supply voltage falls below the value 19.2 V DC. When the supply voltage then exceeds 20.4 V DC, the diagnostics alarm is reported as outgoing.

See also

Channel diagnostics (Page 38)

4.3 Substitute value behavior

Substitute value behavior

The respective output behaves according to its configured substitute value behavior:

- Zero current or zero voltage
- Output substitute value
- Keep last value

The substitute value behavior is triggered in the following cases:

- STOP controller
- Controller failure (connection interrupted)
- Parameter assignment phase during startup
- Deactivating the IO device
- Station stop
  - Missing server module
  - Insertion of invalid I/O modules
  - At least one I/O module is installed on an incorrect BaseUnit

NOTE
Reducing a configuration
If you reduce the configuration of the ET 200SP distributed I/O system and download the configuration to the CPU, the modules which are no longer configured but still present retain their original substitute value behavior. This applies until the supply voltage is switched off at the interface module.

The "current-free/voltage-free" behavior becomes effective in the following cases:

- Firmware update
- Reset to factory settings
- Configuration control: The IM has not received a valid control data record 196 yet
- Incorrectly configured module
- Module with incorrect parameter assignment

Substitute value behavior for module-internal Shared Output (MSO) and module-internal Shared Input (MSI)

Substitute value behavior for module-internal Shared Output (MSO) and module-internal Shared Input (MSI) corresponds to the behavior described above.

4.4 Status of the supply voltage L+ of the I/O modules

The status of the supply voltage L+ of the ET 200SP I/O modules can be mapped to the server module with the interface module IM 155-6 PN/2 HF.

You can find information on the status of the supply voltage L+ of the I/O modules in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

Interrupts, error messages, diagnostics and system alarms

5

5.1 Status and error displays

LED displays

The following figure shows the LED displays on the interface module and BusAdapter.

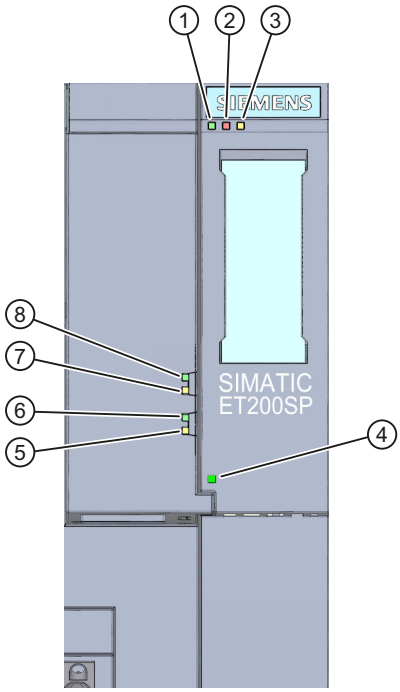

① RN (green)
② ER (red)
③ MT (yellow)
④ PWR (green)
⑤ MT2 (yellow), SCRJ port
⑥ LK2 (green)
⑦ MT1 (yellow), SCRJ port
⑧ LK1 (green)

Figure 2-106 LED displays on the interface module and BusAdapter

Meaning of the LED displays

The following tables contain the meaning of the status and error displays.

RN/ER/MT LEDs on the interface module

Table 2-129 Status and error displays of RN/ER/MT LEDs

LEDs			Meaning	Solution
RN (RUN)	ER (ERROR)	MT (MAINT)		
Off	Off	Off	Missing or insufficient supply voltage on interface module.	Check the supply voltage or turn it on at the interface module.*
On	On	On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	-
Flashes	Not relevant	Not relevant	Interface module is deactivated.	Activate the interface module with the configuration software or via the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP starts up.	-
			ET 200SP is being assigned parameters.	
			ET 200SP is being reset to factory settings.	
On	Not relevant	Not relevant	ET 200SP is currently exchanging data with the IO controller.	-
Not relevant	Flashes	Not relevant	Group errors and group error channels.	Evaluate the diagnostics and eliminate the error.
			The preset configuration does not match the actual configuration of the ET 200SP.	Check the configuration of the ET 200SP to see whether a module is missing, faulty or not configured.
			Invalid configuration states.	For additional information, see section Invalid configuration states of the ET 200SP on PROFINET IO (Page 42)
			Parameter assignment error in the I/O module.	Evaluate the display of the module status in STEP 7. Eliminate the error in the corresponding I/O module.
Not relevant	Not relevant	On	Maintenance	For additional information, see section Maintenance events (Page 37)
Flashes	Flashes	Flashes	The "Node flash test" is run (LEDs LK1 and LK2 of the PROFINET interface also flash).	-
			Hardware or firmware defective (LEDs LK1 and LK2 of the PROFINET interface do not flash).	Run a firmware update. If the error persists, contact Siemens Industry Online Support. Replace the interface module.

* PWR LED on (on the interface module): Check the backplane bus for a short-circuit.

PWR LED on the interface module

Table 2-130 Status display of the PWR LED

PWR LED	Meaning	Solution
□ Off	Supply voltage not present or too small.	Check the supply voltage.
■ On	Supply voltage present. Observe the maintenance messages if the MAIN LED is lit	-

LED display of configuration errors

Configuration errors of the ET 200SP distributed IO system are indicated on the interface module via the red ERROR LED and the yellow MAINT LED.

The following configuration errors are signaled by the LEDs:

- No server module
- Interruptions or short-circuit on the backplane bus

Operating principle

The LED error display provides information on the cause of the error. After notification by the flash signal, the error type is displayed followed by the error location/error code.

The LED error display:

- Is activated during POWER ON and during operation.
- Has priority over all other states that are displayed by means of the ERROR and MAINT LED.
- Remains on until the cause of the error has been eliminated.

Table 2-131 Display of error type and error location

Sequence		Description
1	The ERROR and MAINT LEDs flash 3x at 0.5 Hz	Indication of the error type
2	The MAINT LED flashes at 1 Hz	Display of error type (decimal)
3	The ERROR and MAINT LEDs flash 3x at 2 Hz	Signaling of error location/error code
4	The ERROR LED flashes at 1 Hz	Display of tens digit (decimal) of the error location/error code
5	The MAINT LED flashes at 1 Hz	Display of ones digit (decimal) of the error location/error code
6	Repetition of 1 to 5 until the cause of the error has been eliminated.	

Error display

Table 2-132 Error display

Error type (MAINT)	Error location (ERROR/ MAINT)	Cause of error	Solution
1	65	• No server module • Interruptions on the backplane bus • Short circuit of communication on the backplane bus	Check the configuration of the ET 200SP.

NOTE

A short circuit in the backplane bus supply or the bus connection supply is indicated by the following LEDs:

- PWR LED: On
- RN, ER and MT LED: Off

5.2 Interrupts

Introduction

The I/O device triggers interrupts as a reaction to specific errors. Interrupts are evaluated based on the I/O controller used.

Evaluating interrupts with I/O controllers

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostic error interrupts
- Hardware interrupts
- Pull/plug interrupts
- Maintenance events

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

System diagnostics

In STEP 7 (TIA Portal), the innovated system diagnostics is available for the devices of the S7-1500 automation system (IO controller S7-1500 CPU) and ET 200SP (IO device). Independent of the cyclic user program, alarms are made available on the display of the S7-1500 CPU, the CPU web server and the HMI device.

You will find more information on system diagnostics in the Diagnostics (https://support.industry.siemens.com/cs/ww/en/view/59192926) function manual.

5.2.1 Triggering of a diagnostics interrupt

Triggering of a diagnostics interrupt

For an incoming or outgoing event (e.g. wire break on a channel of an I/O module), the module triggers a diagnostic error interrupt if this is configured accordingly.

The CPU interrupts processing of the user program and processes the diagnostic error interrupt OB (OB 82). The event that triggered the interrupt is entered in the start information of the diagnostic error interrupt OB.

5.2.2 Triggering a hardware interrupt

Triggering a hardware interrupt

If there is a hardware interrupt, the CPU interrupts user program execution and processes the hardware interrupt block OB, e.g., OB 40. The result that triggered the interrupt is added to the start information of the hardware interrupt OB.

NOTE

Diagnostics "Hardware interrupt lost" (from I/O module)

Do not use hardware interrupts for functional purposes (e.g. the cyclic generation of hardware interrupts).

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

5.2.3 Triggering of a remove/insert module interrupt

Triggering of a remove/insert module interrupt

In the event of a remove/insert module interrupt, the CPU interrupts processing of the user program and processes the remove/insert module OB, e.g. OB 83. The event that triggered the interrupt is entered in the start information of the remove/insert module OB.

NOTE

Parameter assignment error after removal/insertion

If you write data records from the user program to the modules of the distributed I/O, make sure that these modules actually exist and are available. You can do this by evaluating OB83. After inserting a module, OB83 is not called until the module has started up and its parameters are assigned. This ensures that data record operations can be executed without errors.

5.3 Alarms

5.3.1 Diagnostics alarms

Actions after a diagnostics alarm

There can be more than one diagnostics alarm at the same time. Each diagnostics alarm initiates the following actions:

- The ERROR LED of the interface module flashes.
- Diagnostics are reported as diagnostic error interrupts to the CPU of the IO controller and can be read via data records.
- Incoming diagnostics alarms are saved to the diagnostics buffer of the I/O controller.
- (S7-300/400) The diagnostic interrupt OB is called. If the diagnostics interrupt OB (OB 82) is not available, the IO controller goes into STOP mode.

You can find more information in the STEP 7 online help.

Reading the diagnostics

Table 2-133 Reading the diagnostics with STEP 7

Automation system with IO controller	Application	See...
SIMATIC S7	Diagnostics as plain text in STEP 7 using Online and Diagnostics view	STEP 7 online help • as of STEP 7 V12, function manual PROFINET with STEP 7 as of V12 (http://support.automation.siemens.com/WW/view/en/49948856) • as of STEP 7 V5.5, system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)
	Instruction "RDREC" (SFB 52) Read data records from the IO device	
	Instruction "RALRM" (SFB 54) Receive interrupts from the IO device	

Additional information on the data records for PROFINET IO

The structure of the diagnostic data records and programming examples are available in the programming manual From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) and in Example application (http://support.automation.siemens.com/WW/view/en/24000238).

Causes of error and troubleshooting

The causes of error and remedies for the diagnostic alarms are described in the manuals for I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300) in the section, "Interrupts, error messages, and system events".

See also

Channel diagnostics (Page 38)

5.3.2 Maintenance events

Triggering of a maintenance event

The PROFINET IO interfaces of the interface module support the diagnostic concept and maintenance concept in PROFINET IO according to the IEC 61158 Type 10 standard. The goal is to detect and remove potential problems as soon as possible.

For the interface module, maintenance events signal to the user when a plant component must be checked or replaced.

The CPU interrupts user program execution and executes the diagnostic error interrupt OB. The event that triggered the maintenance event is entered in the start information of the diagnostic error interrupt OB.

The interface module signals a maintenance event to the higher-level diagnostic system in the case of the following event:

Table 2-134 Triggering of a maintenance event

Maintenance alarm	Event	Alarm/Meaning
Maintenance demanded LED MAINT is lit.	Synchronization loss	• No synchronization frame received. No synchronization frame was received by the sync master within the timeout period after parameter assignment or during operation. • Successive synchronization frames are located outside permitted limits (jitter).
	Undervoltage	• Diagnostics Undervoltage If the supply voltage of the interface falls below the value 19.2 V DC, this diagnostics is reported as incoming Maintenance demanded.

System alarms in STEP 7 (TIA Portal)

The maintenance information is generated in STEP 7 (TIA Portal) with the following system alarms:

- Maintenance demanded - indicated for each port by a yellow wrench icon in the device view or in the hardware configuration.

You can find more information in the STEP 7 online help.

5.3.3 Channel diagnostics

Function

Channel-related diagnostics provides information about channel faults in modules.

Channel faults are mapped as channel diagnostics data in IO diagnostics data records.

The data record is read using the instruction "RDREC".

Structure of the diagnostics data records

The data records supported by the ET 200SP distributed I/O system are based on the standard PROFINET IO - Application Layer Service Definition V2.2.

If required, you can find the standard on the Internet (http://www.profibus.com) on the PROFIBUS user organization home page.

Codes of the extended channel diagnostics

With the IM 155-6 PN/2 HF interface module, the following extended channel diagnostics are reported:

ChannelErrorType (CET)	ExtendedChannelError-Type (ECET)	Associated value AddValue	Diagnostics
0x0602	0x0691	Slot	Station stop - module parameter "Potential group" faulty or incorrect BaseUnit in actual slot (AddValue)
0x0602	0x0693	0x00	Diagnostics with missing server module
0x0602	0x0698	0x00	Diagnostics backplane bus too large
0x0602	0x0699	Slot	Diagnostics with incorrect bus configuration
0x0602	0x069C	0x00	Diagnostics with incorrectly plugged BusAdapter
0x0610	0x06B0	0x00	Group diagnostics: Missing supply voltage L+ for the potential groups Note: The slot in which the light-colored BaseUnit of the respective load module is located is coded in the "ChannelNumber" element.
0x0610	0x06B4	0x00	Diagnostics "Undervoltage power supply" Note: This diagnostics is not supported by the hard-ware IM 155-6 PN HF (6ES7155-6AU00-0CN0). If the supply voltage of the interface falls below the value 19.2 V DC, this diagnostics is reported as incoming Maintenance demanded.

Structure of the manufacturer-specific diagnostics data records (IM 155-6 PN HF Version < V3.3)

The structure of the diagnostics data records is differentiated by the BlockVersion. The following BlockVersion applies to the IM 155-6 PN HF interface modules:

Table 2-135 Structure of the manufacturer-specific diagnostics data records

IM 155-6 PN HF interface module	BlockVersion
6ES7155-6AU00-0CN0	W#16#0101

NOTE

Manufacturer-specific diagnostics are not reported as of version V3.3 for the interface module IM 155-6 PN HF.

Manufacturer-specific diagnostics in the User Structure Identifier (USI)

The following manufacturer-specific diagnostics are signaled in the USI with the IM 155-6 PN HF interface module:

Table 2-136 Manufacturer-specific diagnostics in the USI

USI no. W#16#...	Diagnostics
0003	Group diagnostics: Missing supply voltage L+ for the potential groups
0004	Diagnostics with missing server module
0006	Diagnostics with incorrect BaseUnit
0007	Diagnostics with incorrect bus configuration

USI structure = W#16#0003

Table 2-137 USI structure = W#16#0003

Data block name		Content	Comment	Bytes
USI		W#16#0003	Manufacturer-specific diagnostics with failure of supply voltage L+ as of slot x of the ET 200SP module	2
Followed by the slot as of which the supply voltage L+ has failed.				
	Slot	W#16#0001 to W#16#0040	Bit 8 to 15	1
			Bit 0 to 7	1
Followed by 2 reserved bytes:				
	Reserved			1
	Reserved			1

USI structure = W#16#0004

Table 2-138 USI structure = W#16#0004

Data block name		Content	Comment	Bytes
USI		W#16#0004	Manufacturer-specific diagnostics with missing server module Result: Station stop • The I/O modules fail → substitute value behavior • The interface module continues to exchange data with the IO controller	2
Followed by 4 reserved bytes:				
	Reserved			1
	Reserved			1
	Reserved			1
	Reserved			1

USI structure = W#16#0006

Table 2-139 USI structure = W#16#0006

Data block name		Content	Comment	Bytes
USI		W#16#0006	Manufacturer-specific diagnostics if an ET 200SP I/O module is installed on an incorrect BaseUnit. Result: Station stop • The I/O modules fail → substitute value behavior • The interface module continues to exchange data with the IO controller	2
Followed by the slot for the I/O module:				
	Slot	W#16#0001 to W#16#0040	Bit 8 to 15	1
			Bit 0 to 7	1
Followed by 2 reserved bytes:				
	Reserved			1
	Reserved			1

USI structure = W#16#0007

Table 2-140 USI structure = W#16#0007

Data block name		Content	Comment	Bytes
USI		W#16#0007	Manufacturer-specific diagnostics if operation is not possible with existing bus configuration Result: Station stop • The I/O modules fail → substitute value behavior • The interface module continues to exchange data with the IO controller	2
Followed by the slot for the I/O module:				
	Slot	W#16#0001 to W#16#0040	Bit 8 to 15	1
			Bit 0 to 7	1
If slot 0 is specified, check the width of the station configuration (maximum 1 m).				
Followed by 2 reserved bytes:				
	Reserved			1
	Reserved			1

5.3.4 Invalid configuration states of the ET 200SP on PROFINET IO

Invalid configuration states

The following invalid configuration states of the ET 200SP distributed I/O system lead to the failure of the IO device or prevent data exchange:

- Number of modules exceeds maximum configuration.
- Faulty backplane bus (e.g. defective BaseUnit). ET 200SP backplane bus interruptions do not trigger an interrupt.
- At least one I/O module is plugged into a different BaseUnit as the one configured in the parameters.
- No server module.
- Invalid or incorrectly configured BusAdapter.

NOTE

Removal of the server module will trigger a station stop. All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) but the interface module continues to exchange data.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

See also

Status and error displays (Page 31)
Channel diagnostics (Page 38)

5.3.5 Failure of supply voltage L+ at BaseUnit BU...D

Failure of the supply voltage L+

The I/O modules react as follows to failure of the supply voltage L+ on the BaseUnit BU...D:

- If an I/O module is removed during failure of the supply voltage, a pull interrupt is generated.
- If an I/O module is installed during failure of the supply voltage, a plug interrupt is generated.

5.3.6 STOP of the IO controller and recovery of the IO device

STOP of the SIMATIC IO controller

Diagnostics received from the IO device while the IO controller is in STOP do not initiate a call of any corresponding OBs when the IO controller goes into RUN. Read the $E00C_H$ data record in startup OB using the instruction "RDREC". This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Recovery of the SIMATIC IO devices

If you want to read the occurring diagnostics in the STOP state of the IO controller, you have to read the $E00C_H$ data record with the "RDREC" instruction. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Compatibility

6

6.1 Compatibility of modules

Compatibility with the IM 155-6 PN/2 HF interface module

If you exchange or replace an interface module, the following table shows the compatibilities:

- Between the interface modules IM 155-6 PN/2 HF and IM 155-6 PN ST
- Between the various firmware versions

	Interface module configured											
Interface module plugged	**IM 155-6 PN ST V1.0**	**IM 155-6 PN ST V1.1**	**IM 155-6 PN ST V3.1**	**IM 155-6 PN ST V3.3**	**IM 155-6 PN ST V4.1**	**IM 155-6 PN HF V2.0**	**IM 155-6 PN HF V2.1**	**IM 155-6 PN HF V2.2**	**IM 155-6 PN HF V3.0**	**IM 155-6 PN HF V3.1**	**IM 155-6 PN HF V3.3**	**IM 155-6 PN HF V4.2**
IM 155-6 PN HF V2.0	Yes*	---	---	---	---	Yes	---	---	---	---	---	---
IM 155-6 PN HF V2.1	Yes*	Yes*	---	---	---	Yes	Yes	---	---	---	---	---
IM 155-6 PN HF V2.2	Yes*	Yes*	---	---	---	Yes	Yes	Yes	---	---	---	---
IM 155-6 PN HF V3.0	Yes*	Yes*	---	---	---	Yes	Yes	Yes	Yes	---	---	---
IM 155-6 PN HF V3.1	Yes*	Yes*	Yes*	---	---	Yes	Yes	Yes	Yes	Yes	---	---
IM 155-6 PN HF V3.3	Yes*	Yes*	Yes*	Yes*	---	Yes	Yes	Yes	Yes	Yes	Yes	---
IM 155-6 PN/2 HF V4.2	Yes*	Yes*	Yes*	Yes*	Yes*	Yes	Yes	Yes	Yes	Yes	Yes	Yes

* The interface module IM 155-6 PN HF only supports the transmission rate 100 Mbps for Ethernet services.

Station configuration with more than 32 I/O modules

Certain I/O modules with functional status 001 and 002 do not support a station configuration with more than 32 I/O modules.

The table below shows all modules that do not support a station configuration with more than 32 I/O modules:

Table 2-141 Incompatible modules with functional status

Modules	Article number	Up to functional status
Analog modules		
AI 4xI 2-/4-wire ST	6ES7134-6GD00-0BA1	002
AI 4xU/I 2-wire ST	6ES7134-6HD00-0BA1	002
AI 4xRTD/TC 2-/3-/4-wire HF	6ES7134-6JD00-0CA1	002
AI 4xU/I ST	6ES7135-6HD00-0BA1	002
Digital modules		
DI 16x24VDC ST	6ES7131-6BH00-0BA0	002
DI 8x24VDC ST	6ES7131-6BF00-0BA0	002
DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0	002
DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0	002
DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0	002

Status of the supply voltage

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules without parameter assignment in the following table, the status of the supply voltage (status byte of the server module) is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Article number
DI 8x24VDC ST	6ES7131-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7131-6BF00-0CA0
DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0
DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0
DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0
DQ 8x24VDC/0.5A HF	6ES7132-6BF00-0CA0

Resetting an interface module to factory settings via the RESET button

There is a special operation for interface module IM 155-6 PN/2 HF to reset it to the factory settings using the Reset button.

Requirements

The supply voltage to the interface module must be switched on.

Required tools

3 to 3.5 mm screwdriver (for resetting via the RESET button)

Procedure

1. Remove the interface module from the mounting rail and swivel it downwards.
2. The RESET button is located on the back of the interface module behind a small opening: Push a screwdriver into the small opening, thus pressing the RESET button.
3. Release the RESET button.
4. Press the RESET button for another 3 seconds.
5. Look at the LED display of the interface module to see whether the reset was successful: RUN LED flashes for 3 seconds, ERROR and MAINT LED are off.
6. Install the interface module back on the mounting rail.
7. Assign parameters to the interface module again.

AQ 4xU/I ST analog output module

NOTE

For operation of the AQ 4xU/I ST analog output module, firmware version V1.0 (6ES7135-6HD00-0BA1) with the interface module, you need to set the "Reaction to CPU STOP" parameter to "Turn off" with a PROFINET send clock < 1 ms.

Reaction times for fail-safe modules

The following maximum reaction time of the interface module must be taken into account when calculating the reaction times of fail-safe modules: **Maximum reaction time = configured update time + 400 µs (but at least 1.4 ms)**

Operation with activated system redundancy S2

NOTE

Restrictions in operation with activated system redundancy S2

You cannot use the following functions during operation of the IM155-6 PN/2 HF, firmware version V4.2 with activated system redundancy S2:

- Configuration control (option handling)
- Module-to-Module Communication (MtM)

Interface module IM 155-6 PPN HF (6ES7155-6AU00-0CN0) with version V4.2

NOTE

You cannot use the following functions during operation of the IM 155-6 PN HF (6ES7155-6AU00-0CN0) with firmware version V4.2:

- Module-to-Module Communication (MtM)
- Setting the time
- Diagnostics (maintenance) undervoltage

Technical specifications 7

Technical specifications of the IM 155-6 PN/2 HF

The following table shows the technical specifications as of 08/2018. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7155-6AU01-0CN0/td?dl=en).

Article number	6ES7155-6AU01-0CN0
General information	
Product type designation	IM 155-6 PN/2 HF with server module
Firmware version	V4.2
• FW update possible	Yes
Number of MtM communication relationships/connections, max.	16
Product function	
• I&M data	Yes; I&M0 to I&M3
• Module swapping during operation (hot swapping)	Yes; Multi-hot swapping
• Tool changer	Yes; Docking station and docking unit
• Local coupling, IO data	No
• Local coupling, data records	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	STEP 7 V15.1 or higher
• STEP 7 configurable/integrated as of version	Configurable via GSD file
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Configuration control	
via dataset	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	10 ms
Input current	
Current consumption, max.	700 mA
Inrush current, max.	4.5 A
I^2t	0.25 $A^2 \cdot s$

Article number	6ES7155-6AU01-0CN0
Power loss	
Power loss, typ.	2.4 W
Address area	
Address space per module	
• Address space per module, max.	288 byte; For input and output data respectively
Address space per station	
• Address space per station, max.	1 440 byte; Dependent on configuration
Hardware configuration	
Rack	
• Modules per rack, max.	64; + 16 ET 200AL modules
Submodules	
• Number of submodules per station, max.	256
Time stamping	
Accuracy	10 ms
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch)
1. Interface	
Interface types	
• Number of ports	2; via BusAdapter
• integrated switch	Yes
• BusAdapter (PROFINET)	Yes; Compatible BusAdapter: BA 2x RJ45, BA 2x FC, BA 2x SCRJ, BA SCRJ / RJ45, BA SCRJ / FC, BA 2x LC, BA LC / RJ45, BA LC / FC
Protocols	
• PROFINET IO Device	Yes
• Open IE communication	Yes
• Media redundancy	Yes; PROFINET MRP
Interface types	
RJ 45 (Ethernet)	
• Transmission procedure	PROFINET with 100 Mbit/s full duplex (100BASE-TX)
• 10 Mbps	No
• 100 Mbps	Yes; PROFINET with 100 Mbit/s full duplex (100BASE-TX)
• Autonegotiation	Yes
• Autocrossing	Yes
Protocols	
PROFINET IO Device	
Services	
– Isochronous mode	Yes; Bus cycle time: min. 250 µs
– Open IE communication	Yes

Article number	6ES7155-6AU01-0CN0
– IRT	Yes; 250 µs, 500 µs, 1 ms, 2 ms, 4 ms additionally with IRT with high performance: 250 µs to 4 ms in 125 µs frame
– PROFIenergy	Yes
– Prioritized startup	Yes
– Shared device	Yes
– Number of IO Controllers with shared device, max.	4
Redundancy mode	
– MRP	Yes
– MRPD	No
– PROFINET system redundancy (S2)	Yes; NAP S2
– Redundant PROFINET configuration (R1)	No
– H-Sync forwarding	Yes
Open IE communication	
• TCP/IP	Yes
• SNMP	Yes
• LLDP	Yes
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	Yes
Equidistance	Yes
shortest clock pulse	250 µs
max. cycle	4 ms
Bus cycle time (TDP), min.	250 µs
Jitter, max.	1 µs
Interrupts/diagnostics/status information	
Status indicator	Yes
Alarms	Yes
Diagnostics function	Yes
Diagnostics indication LED	
• RUN LED	Yes; Green LED
• ERROR LED	Yes; Red LED
• MAINT LED	Yes; yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Connection to network LINK (green)	Yes; 2x green link LEDs on BusAdapter
Potential separation	
between backplane bus and electronics	No
between PROFINET and all other circuits	Yes
between supply and all other circuits	No

Article number	6ES7155-6AU01-0CN0
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Network loading class	3
Security level	According to Security Level 1 Test Cases V1.1.1
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; No condensation
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Connection method	
ET-Connection	
• via BU/BA Send	Yes; + 16 ET 200AL modules
Mechanics/material	
Strain relief	Yes; Optional
Dimensions	
Width	50 mm
Height	117 mm
Depth	74 mm
Weights	
Weight, approx.	120 g; without BusAdapter

Dimension drawing

A

This appendix contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

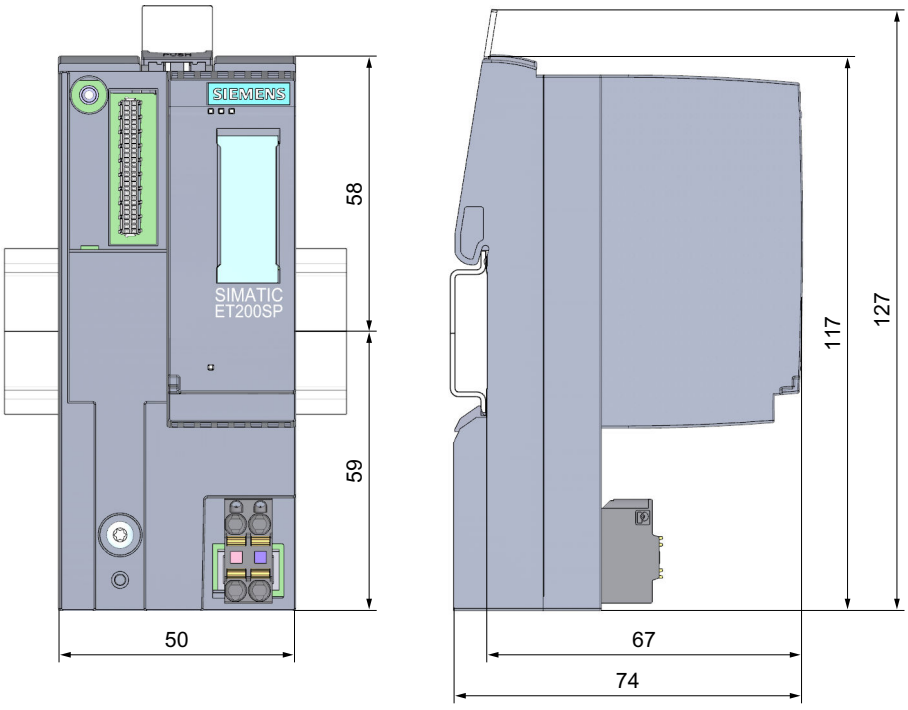

Figure 2-107 Dimension drawing of the IM 155-6 PN/2 HF interface module, front and side views

SIEMENS

SIMATIC

ET 200SP
Interface module IM 155-6 PN/3 HF (6ES7155-6AU30-0CN0)

Equipment Manual

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10/2018
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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes labeled as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (https://www.siemens.com/industrialsecurity).

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Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

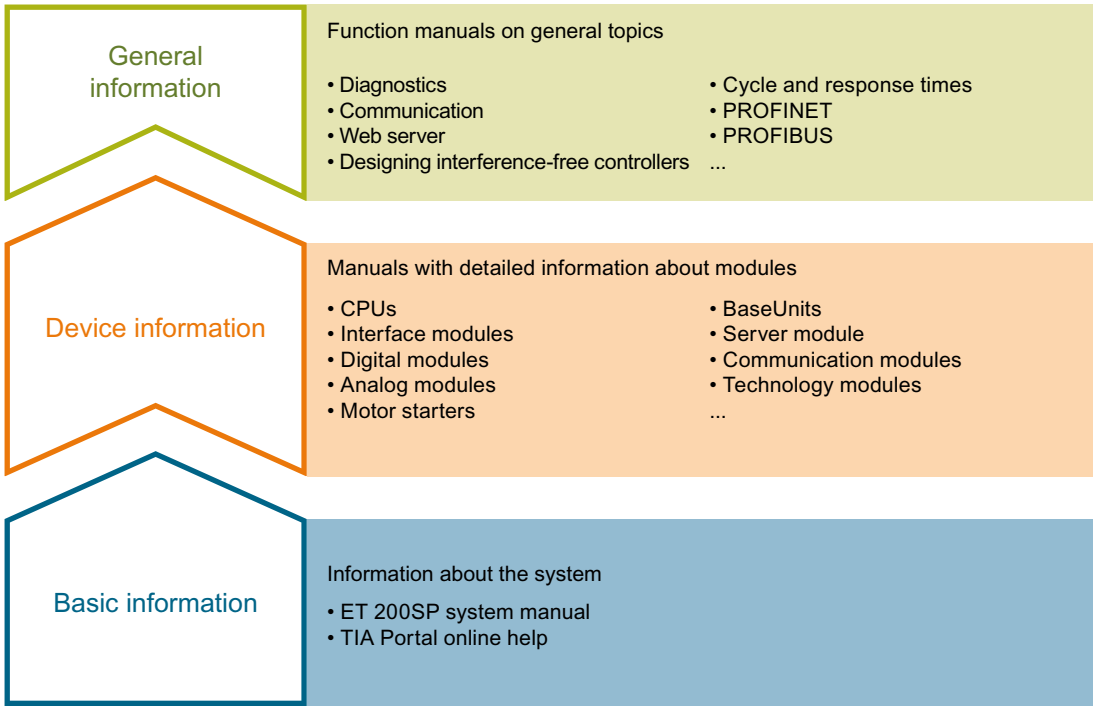

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

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In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7155-6AU30-0CN0 (interface module 155-6 PN/3 HF and server module)

View of the module

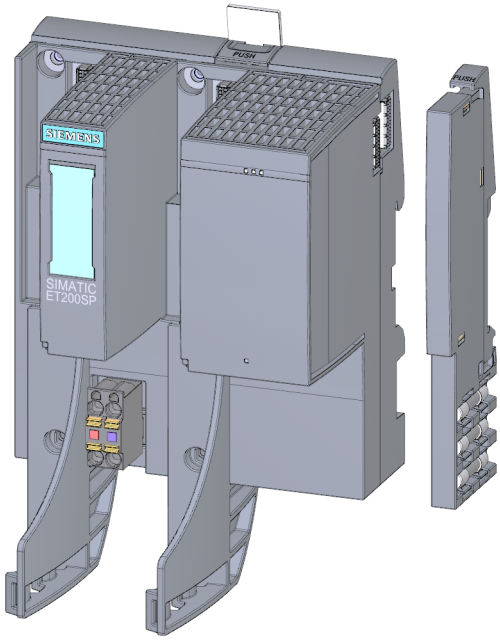

Figure 2-108 View AS interface module 155-6 PN/3 HF with included accessory (24 V DC connector and server module) and optional accessories (strain-relief for PROFINET cable, labeling strips and reference identification label)

Properties

The module has the following technical properties:

- Integrated switch with 3 ports
- Connects the ET 200SP distributed I/O system with PROFINET IO.
- Supply voltage 1 L+ DC 24 V (SELV/PELV). The connection plug is included in the scope of delivery of the interface module and available as replacement part.

- PROFINET IO connection via selectable BusAdapters
  - BA 2×RJ45 for RJ45 bus connector
  - BA 2×FC for direct connection of the bus cable
  - BA 2xSCRJ for POF/PCF fiber-optic cable
  - BA SCRJ/RJ45 as media converter for POF/PCF fiber-optic cable ⇔ standard RJ45 connector
  - BA SCRJ/FC as media converter for POF/PCF fiber-optic cable ⇔ direct connection of the bus cable
  - BA 2xLC for glass fiber-optic cable
  - BA LC/RJ45 as media converter for glass fiber-optic cable ⇔ standard RJ45 connector
  - BA LC/FC as media converter for fiber-optic cable ⇔ direct connection of the bus cable

Maximum configuration

- 64 ET 200SP I/O modules + 16 ET 200AL modules
- 1 m backplane bus (without interface module and server module)

Maximum amount of I/O data

Gross data length (for input and output data):
Without system redundancy S2:

- 1440 bytes
- 1440 bytes for shared device with 2 IOCs (in total for both IOCs)
- 360 bytes for shared device with more than 2 IOCs (per IOC)

With system redundancy S2:

- 1000 bytes
- 360 bytes with system redundancy S2 and shared device with at least 1 additional IOC (per IOC)

The number of the max. net data length for input and output data depends on the number and type of I/O modules used, including ET 200AL modules and virtual modules.

Net data length (for input and output data):
Without explicit calculation of the maximum net data length, the following minimum lengths can be used without shared device.

- 933 bytes (without system redundancy S2)
- 493 bytes (with system redundancy S2)

Calculation of the max. net data length:
Max. length net data = max. gross length - number of I/O submodules (input or output data, without user data) - number of mixed I/O modules (input and output data) - 5 bytes for

interface module and server module without ET connection (6 bytes for interface module with ET connection)

The result of the calculation of the maximum net data length applies equally to input and output data.

Accessories

You order the following accessories separately:

- BA 2×RJ45 BusAdapter
- BA 2×FC BusAdapter
- BA 2×LC BusAdapter
- BA 2xSCRJ BusAdapter
- BA SCRJ/RJ45 BusAdapter
- BA SCRJ/FC BusAdapter
- BA LC/RJ45 BusAdapter
- BA LC/FC BusAdapter
- Strain relief for PROFINET cables
- Labeling strips
- Reference identification label

Information on the BusAdapters is available in the BusAdapter (https://support.industry.siemens.com/cs/ww/en/view/109751716) manual.

You can find more information on accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Server module

The server module is included in the scope of delivery of the interface module and available separately as an accessory.

The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system
- Includes a holder for 3 spare fuses (5 × 20 mm).
- Provides station functions, e.g., group diagnostics: No supply voltage L+, status bytes.
- Identification data I&M 0 to 3

NOTE

You need to configure and assign parameters to the server module in the configuration software.

Place the server module in the last slot of the configuration. If there are 64 I/O modules, the server module is plugged in slot 65.

You can find more information in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

First BaseUnit of an ET 200SP in the configuration

The interface modules support plugging dark-colored BaseUnits in slot 1. This means that modules without a connection to the integrated voltage buses P1 and P2 can now also be configured starting with slot 1. Currently, this applies to the following modules:

- AI Energy Meter ST
- DI 4 x 120..230V AC ST (6ES7131-6FD00-0BB1)
- DQ 4 x 24..230V AC/2A ST (6ES7132-6FD00-0BB1)

NOTE
First BaseUnit of an ET 200SP in the configuration
Please note the information on limiting the overvoltage and power rating in the AC I/O module manuals.
The 24 V DC supply voltage is fed in via an external fuse.
The DC 24 V supply voltage is supplied via a light-colored BaseUnit.

See also

Functions (Page 13)

2.2 Functions

Introduction

The interface module supports the following PROFINET IO functions:

- Integrated switch with 3 ports
- Supported Ethernet services: PING, ARP, SNMP, LLDP
- Port diagnostics
- Disabling ports
- Minimum update time 250 µs
- Device replacement without programming device, also without topological configuration
- Reset to factory settings via PROFINET IO
- Firmware update via PROFINET IO
- Isochronous real-time communication
- Prioritized startup
- Media redundancy (MRP)
- Shared device
- Distribution of module channels to a maximum of 4 submodules

- Module-internal or submodule-internal Shared Input/Shared Output (MSI/MSO)
- Isochronous mode
- System redundancy S2
- Station extension via ET-Connection
- Alternating IO devices during operation ("docking systems")
  - Docking station
  - Docking unit
- Supports BusAdapter for different connection technologies to PROFINET IO.

The interface module supports additional functions:

- Interface local coupling of IO data (configuration only via GSDML)
- Module-to-Module Communication (MtM)
- Identification data I&M 0 to I&M 3
- PROFIenergy
- Configuration control (option handling)
- Use of fail-safe modules
- Removal/insertion of multiple I/O modules during operation (Multi Hot Swap)

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 (TIA Portal), in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).

Requirements

The table below shows the software requirements for a configuration with the IM 155-6 PN/3 HF interface module:

Table 2-142 Version dependencies of the module functions

Function	Functional status of the module as of	Firmware version of the module as of	Configuring with GSD file (http://support.automation.siemens.com/WW/view/en/196-98639/130000)[1]	Configuration software	
				STEP 7 as of V5.5 SP4	STEP 7 (TIA Portal) as of V15.1
Real-time communication	1	V4.2.0	X	---	X
Isochronous real-time communication	1	V4.2.0	X	---	X
Prioritized startup	1	V4.2.0	X	---	X
Device replacement without programming device	1	V4.2.0	X	---	X
Media redundancy (MRP)	1	V4.2.0	X	---	X
Shared device	1	V4.2.0	X	---	X
Value status	1	V4.2.0	X	---	X

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

Function	Functional status of the module as of	Firmware version of the module as of	Configuring with GSD file (http://support.automation.siemens.com/WW/view/en/19698639/130000)[1]	Configuration software	
				STEP 7 as of V5.5 SP4	STEP 7 (TIA Portal) as of V15.1
PROFIenergy	1	V4.2.0	X	---	X
Multi Hot Swap	1	V4.2.0	X	---	X
Use of fail-safe modules	1	V4.2.0	---	---	X
Oversampling	1	V4.2.0	X	---	X
Isochronous mode	1	V4.2.0	---	---	X
Module-internal Shared Input/Shared Output (MSI/MSO)	1	V4.2.0	X	---	X
BusAdapter for fiber-optic cable FOC: BA 2xSCRJ	1	V4.2.0	X	---	X
System redundancy S2 to S7-400H	1	V4.2.0	X	---	---
System redundancy S2 IEC compliant	1	V4.2.0	X	---	---
System redundancy S2 on S7-1500R/H	1	V4.2.0	X	---	X
Station extension via ET-Connection	1	V4.2.0	X	---	X
Maximum user data length per module: 288 bytes	1	V4.2.0	X	---	X
BA SCRJ/RJ45 BusAdapter	1	V4.2.0	X	---	X
BA SCRJ/FC BusAdapter	1	V4.2.0	X	---	X
BA 2xLC BusAdapter	1	V4.2.0	X	---	X
BusAdapter BA LC/RJ45	1	V4.2.0	X	---	X
BA LC/FC BusAdapter	1	V4.2.0	X	---	X
Distribution of module channels to multiple submodules	1	V4.2.0	X	---	X
Maintenance interrupts of I/O modules	1	V4.2.0	X	---	X
Extended Channel Diagnostics	1	V4.2.0	X	---	X
Module-to-Module Communication (MtM)	1	V4.2.0	X	---	X
Interface local coupling of IO data	1	V4.2.0	X	---	---

[1] Systems of third-party manufacturers: Depending on the range of functions of the third-party system

Cabling with fixed connection setting

If you set a fixed connection setting of the port in STEP 7, you must also disable "Autonegotiation/Autocrossover".

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

See also

Compatibility of modules (Page 43)
ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)
PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856)

2.2.1 Device replacement

Device replacement

Device replacement without topological configuration

The device name is also stored on both BusAdapters in addition to the interface module. A device name stored in both BusAdapters is required for device replacement without topology configuration.

Replacing the interface module produces a range of scenarios for using the device name.

- The interface module generally starts with the device name of the left BusAdapter. In the case of different device names, the device name is distributed (stored) from the left BusAdapter to the right Bus Adapter and to the interface module.
- If the left BusAdapter is missing or does not yet have a device name, the device name is taken from the right BusAdapter and, if there are differences, distributed (stored) accordingly.
- If only BusAdapters without device names are connected, the device name is taken from the interface module and stored on both BusAdapters.

Be aware of the following constraints:

- Resetting to factory settings deletes the device name in both the interface module and the BusAdapter. To prevent the device name from being deleted in the BusAdapter, you can remove the BusAdapter from the interface module before resetting to factory settings.
- When a BusAdapter is replaced, a device name stored in the BusAdapter is applied to the interface module after a POWER ON.
- Do not pull/plug the BusAdapter while under voltage.

Device replacement with topological configuration

IO devices with this function can be replaced in a simple manner:

- The device name does not have to be assigned with the programming device.

The replacement IO device is assigned the device name by the IO controller and not by the programming device. The IO controller uses the configured topology and the neighboring relationships determined by the IO devices for this purpose. All involved devices must support

the LLDP protocol (Link Layer Discovery Protocol). The configured target topology must match the actual topology.

If the IO devices were already used in another configuration, reset them to factory settings before reusing them. You can find information on this in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 (TIA Portal) V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

2.2.2 Real-time communication

Real-time communication

A transmission method for PROFINET IO based on cyclic data exchange with a provider-consumer model.

2.2.3 Isochronous real-time communication

Isochronous real-time communication

Is a synchronized communication protocol for cyclic exchange of data between PROFINET devices. A reserved bandwidth within the send clock is available for the transfer. The reserved bandwidth ensures that the IRT data is also transmitted in time-synchronized intervals, unaffected by other high network loading (e.g. TCP/IP communication or additional real time communication).

A topology configuration is required for IRT.

NOTE

For IRT, both BusAdapters must be plugged in.

NOTE

IO controller as sync master with IRT communication

We recommend operating the IO controller also as a sync master when configuring the IRT communication.

Otherwise, IRT and RT configured IO devices may fail if the sync master fails.

You can find more information on the configuration of synchronized PROFINET devices in sync domains in the STEP 7 online help and

- As of STEP 7 (TIA Portal) V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

2.2.4 Prioritized startup

Prioritized startup

Prioritized startup is a PROFINET IO function in a PROFINET IO system with IRT and RT communication. It reduces the time needed for correspondingly configured IO devices to return to cyclic user data exchange.

The function accelerates the start-up of IO devices in the following cases:

- After recovery of supply voltage
- After station recovery
- After activation of IO devices

NOTE

Dependency of the startup time

The interface module permits startup times from 1.2 s.

The startup time depends on the number and type of modules.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 (TIA Portal) V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

2.2.5 Submodules

Submodules

The IM 155-6 PN/3 HF interface module supports the division of I/O modules into up to 4 submodules. This allows parts of an I/O module to be separately configured and parameterized.

A maximum of 256 submodules is supported, whereby 4 submodules are used for the interface module and one submodule for the server module.

You can assign each of these submodules to different IO controllers.

The following functions are only executed if you have configured submodule 1 during configuration:

- Firmware update
- Write I&M data
- Calibration
- PROFIenergy

2.2.6 Media redundancy (MRP)

Media redundancy (MRP)

Function for safeguarding communication and plant availability. A ring topology ensures that an alternative communication path is made available if a transmission route fails.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

2.2.7 Shared device

Shared device

IO device that makes its data available to up to four IO controllers.

The interface module supports shared device at submodule level.

If **there is no validity check of the shared device projects by the Engineering System**, note the following:

- Make sure the configurations are consistent. Assign each module or submodule to only one IO controller. Multiple assignment will result in an error as the module or submodule will only be available in the first controller.
- If you reconfigure the shared device configurations without the validity check mentioned above, you must commission ET 200SP again. This means you must download the projects of all involved IO controllers to the respective CPU again after reconfiguration. If necessary, perform a POWER OFF/POWER ON of the interface module.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

NOTE

In the case of a shared device application, make sure that all controllers work with the same send clock. If the controller does not have the same send clock, this results in communication relationships not being set up.

If you set up all controllers in one project, the same send clock is ensured. Set the same send clock for engineering in separate projects.

2.2.8 Isochronous mode

Isochronous mode

The input and output data of distributed I/O modules in the system is simultaneously acquired and simultaneously output. The I/O data, the transmission cycle via PROFINET IO, and the user program are synchronized for this purpose. The constant PROFINET IO cycle forms the corresponding clock generator. The interface module supports isochronous mode of I/O data for the modules starting at 250 µs. The IO device can exchange isochronous process data with a maximum of one IO controller.

NOTE

If the module is pulled or if no control data record was written with activated configuration control, then the IO controller cannot access a module. In this case, cycle time violations may occur with activated isochronous mode in the synchronous cycle interrupt OB (OB61). The time error OB (OB80) is called in the event of a cycle time violation.

This behavior is associated with updating the process image by means of the "SYNC_PI" (SFC126) and "SYNC_PO" (SFC127) instructions. It depends on the set cycle time and the configuration limits.

You can find additional information in the STEP 7 online help and

- As of STEP 7 V12, in the PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856) function manual.
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

2.2.9 Module-internal Shared Input/Shared Output (MSI/MSO)

Module-internal Shared Input/Shared Output (MSI/MSO)

The Module-internal Shared Input function allows an input module to make its input data available to up to four IO controllers. Each controller has read access to the same channels.

The Module-internal Shared Output function allows an output module to be operated by up to four IO controllers. One IO controller has write access. Up to three additional IO controllers can have read access to the same channels.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856).
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127).

2.2.10 System redundancy S2

System redundancy S2

An IO device with S2 system redundancy supports redundant ARs.

In a redundant system, an IO device with system redundancy S2 has a redundant AR for each of the two CPUs (IO controllers). If one CPU fails, the IO device with S2 system redundancy remains accessible to the remaining IO controller via the AR.

The interface module supports system redundancy S2 on S7-400H CPUs and on S7-1500R/H CPUs.

You can find additional information in the STEP 7 online help and

- As of STEP 7 V12, in the function manual PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856)
- As of STEP 7 V5.5, in the system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)

2.2.11 Alternating IO devices during operation ("docking systems")

Alternating IO devices during operation ("docking systems")

- Docking station
- Docking unit

You can find additional information in the STEP 7 online help and

- As of STEP 7 V12, in the PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856) function manual

2.2.12 Oversampling

Oversampling

The IM 155-6 PN/3 HF interface module supports the oversampling mode of HS modules. With oversampling, the modules reduce the respective PROFINET send clocks in isochronous mode.

Additional information on oversampling can be found in the manuals for the I/O modules.

2.2.13 Value status

Value status

The IM 155-6 PN/3 HF interface module supports I/O modules with value status.

Additional information on the value status can be found in the manuals for the I/O modules.

2.2.14 PROFIenergy

Properties

PROFIenergy (for PROFINET) reduces the energy consumption by using PROFIenergy commands during production-free periods.

Reference

You will find additional information on PROFIenergy in the following manuals:

- Manual I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300)
- Function manual PROFINET with STEP 7 V12 and higher (http://support.automation.siemens.com/WW/view/en/49948856)
- System manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)
- PROFIenergy (http://support.automation.siemens.com/WW/view/en/66928686) product information
- Internet (http://www.profibus.com) under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order No: 3.802

2.2.15 Configuration control (option handling)

Properties

Configuration control allows you to prepare your automation system for future expansions or changes. Configuration control means you can configure the planned maximum expansion of your automation system in advance and flexibly vary it later by means of the user program.

Reference

You can find more information on configuration control:

- In the system manual ET 200SP distributed I/O system. (http://support.automation.siemens.com/WW/view/en/58649293)
- On the Internet under the following link: Application collection (http://support.automation.siemens.com/WW/view/en/29430270).
- In the STEP 7 online help.

2.2.16 Use of fail-safe modules

Properties

The IM 155-6 PN/3 HF interface module supports the use of fail-safe modules.

Reference

You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2.17 Multi Hot Swap

Properties

You can remove and insert any number of I/O modules during operation. The interface module and the inserted I/O modules remain in operation.

NOTE

The IM 155-6 PN/3 HF interface module does not support the removal and insertion of the server module, the interface module and BusAdapter during operation.

Reference

You can find more information on the removal/insertion of modules in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

2.2.18 Module-to-Module Communication (MtM)

Introduction

Module-to-Module Communication (MtM) offers the following advantages:

- Improved performance during transmission of data by bypassing the IO controller.
- Deterministic cycle times
- Cost-effective, high-performance solutions for applications where the performance of a specific technology module is not required.

Module-to-Module Communication (MtM)

Module-to-Module Communication (MtM) enables direct exchange of data between specific IO modules within a station via the interface module. This enables you to move small and/or time-critical tasks to the IO module. You achieve better performance while reducing the load on the CPU.

With Module-to-Module Communication (MtM), the interface module copies the input data of an IO module directly to a different IO module via the ET 200SP backplane bus. The IO module (data sink) carries out application-specific processing of the data.

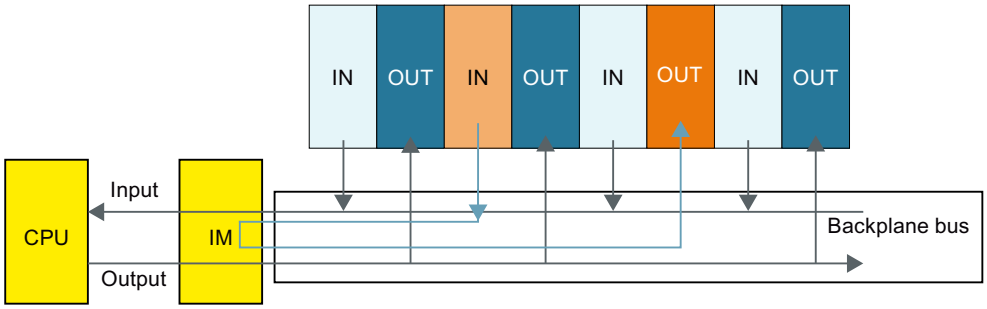

For Module-to-Module Communication (MtM), configure the data source and the data sink in the hardware configuration of the respective output module. Programming of the user program is **not** required in the variant for Module-to-Module Communication (MtM).

NOTE

The preparation of the input data in the output module (mapping) and the output of the data to the outputs are application- and technology-specific.
Example: The DQ 4x24VDC/2A HS digital output module supports

- the application cam control with Module-to-Module Communication (MtM) under the designation DQ 4x24VDC/2A HS **MCC MtM**

Additional information can be found in the manuals of the corresponding IO modules.

2.2.19 Setting the time

The interface module supports time-setting, for example with AI Energy Meter 480VAC/CT HF (6ES7134-6PA00-0CU0).

In an Application example (https://support.automation.siemens.com/WW/view/en/109754890) we show you how to set the time of day.

2.2.20 Interface local coupling of IO data

Module-internal Shared Output is transferred to other controllers

In this example, IO data are transferred from one controller to other controllers over the PROFINET interface X1 by means of the Module-internal Shared Output.

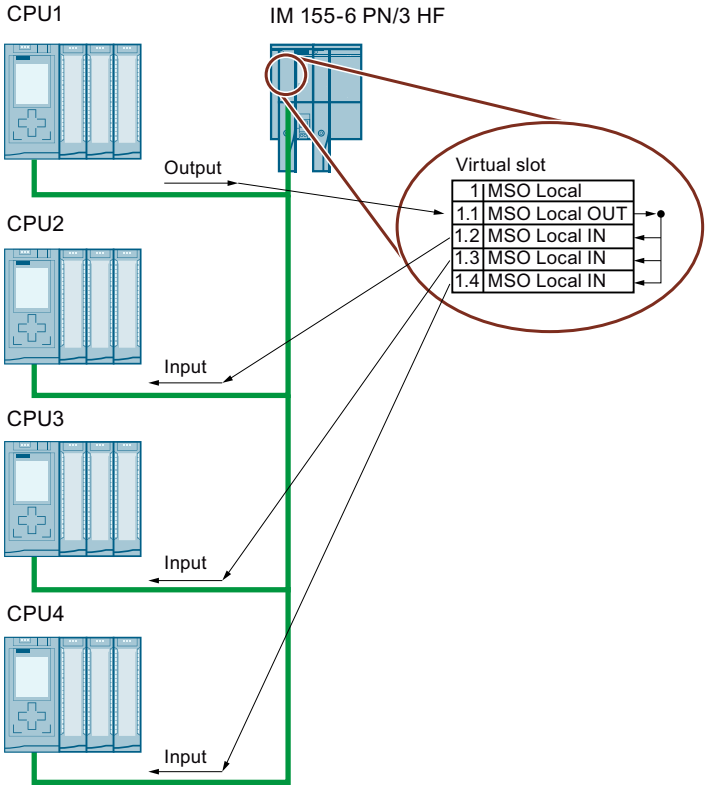

Figure 2-109 I/O data are transferred to other controllers in the same PROFINET network

Configuration

Table 2-143 Example of the configuration

Virtual slot	Type	I-length	Q-length	Access
1	MSO Local	-	-	-
1.1	MSO Local OUT	-	4 bytes	CPU 1
1.2	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 2
1.3	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 3
1.4	MSO Local IN	5 bytes incl. 1 byte DS	-	CPU 4

Editing in the user program

The controller CPU 1 writes I/O data to the MSO Local OUT module with the virtual slot 1.1 of the interface module. The data is available to CPUs 2 to 4 for reading with the remaining MSO Local IN modules. The validity of the provided user data is displayed by the data status byte (DS) of the MSO Local IN modules.

You can also use this example:

- with fewer controllers and
- configure it with other virtual modules.

NOTE

Virtual IO modules

The use of virtual IO modules increases the communication load. This increases the data update time of all IO data accordingly.

Wiring

3

3.1 Pin assignment

24 V DC supply voltage

The following table shows the signal names and the descriptions of the pin assignment for a 24 V DC supply voltage.

Table 2-144 Pin assignment 24 V DC supply voltage

View		Signal name[1]	Description
Connector	IM connection		
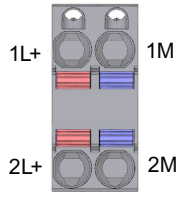	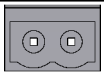	1L+	24 V DC
		2L+	24 V DC (for looping through)[2]
		1M	Ground
		2M	Ground (for looping through)[2]

1 1L+ and 2L+ as well as 1M and 2M are bridged internally.

2 Maximum 10 A permitted.

Reference

You can find more information on accessories and how to connect the interface module in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Block diagram

Block diagram

The following figure shows a block diagram of the IM 155-6 PN/3 HF interface module.

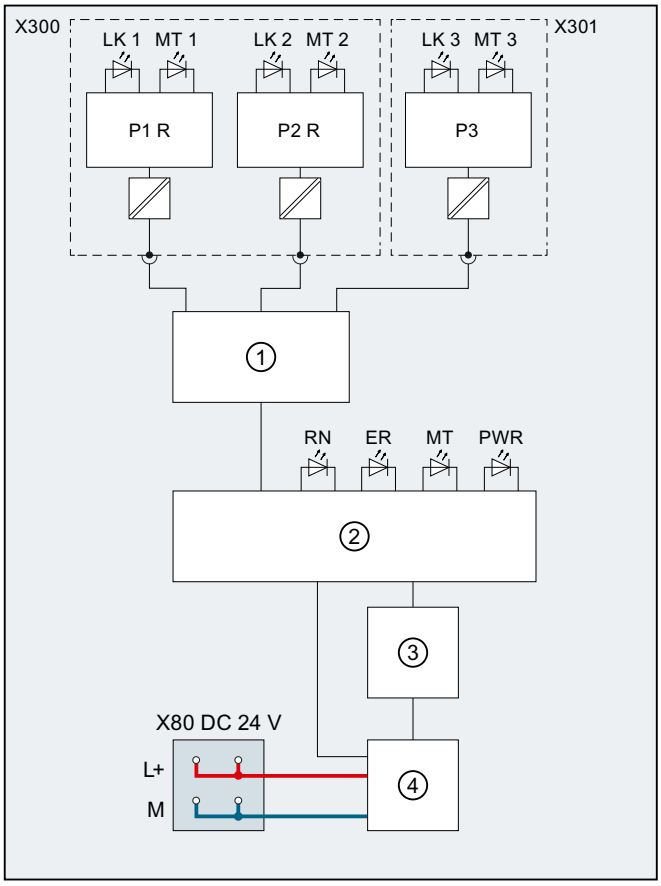

①	Switch	L+	24 V DC supply voltage
②	ET 200SP backplane bus interface and electronics	M	Ground
③	Backplane bus	LK 1, 2, 3	Link TX/RX LED (green)
④	Internal power supply	MT 1,2,3	MAINTENANCE FiberOptic LED (SCRJ port, yellow)
X80 24 V DC	Feed supply voltage	RN	RUN LED (green)
X300, X301	BusAdapter	ER	ERROR LED (red)
P1 R	PROFINET interface X1 Port 1	MT	LED MAINTENANCE (yellow)
P2 R	PROFINET interface X1 Port 2	PWR	POWER LED (green)
P3	PROFINET interface X1 Port 3		

Figure 2-110 Block diagram of the IM 155-6 PN/3 HF interface module

NOTE

To set up a ring topology, use only the P1 R and P2 R ports.

NOTE

Operation with only one BusAdapter

If you operate the interface module with only one BusAdapter, then provide the free bus adapter interface with a cover for the BusAdapter interface.

NOTE

For IRT operation, both bus adapters must be plugged in.

Parameters/address space

4

4.1 Parameters

Parameters for IM 155-6 PN/3 HF interface module

The following table shows the parameters for the interface module IM 155-6 PN/3 HF.

Table 2-145 Parameters for IM 155-6 PN/3 HF interface module (GSD file)

Parameters	Value range	Default	Effective range
Enable configuration control	Yes/No	No	ET 200SP
Diagnostics (maintenance) under-voltage	Yes/No	No	ET 200SP

4.2 Explanation of parameters

4.2.1 Enable configuration control

Enable configuration control

You use this parameter to enable the configuration control function in the ET 200SP distributed I/O system.

NOTE

If you configure the enable, the ET 200SP distributed I/O system requires a control data record 196 from the user program in order for the ET 200SP distributed I/O system to operate the I/O modules.

Reference

You can find more information on the control data record in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the STEP 7 online help.

4.2.2 Diagnostics (maintenance) undervoltage

Diagnostics (maintenance) undervoltage

The diagnostics alarm (maintenance) for undervoltage is triggered (incoming) if the supply voltage falls below the value 19.2 V DC. When the supply voltage then exceeds 20.4 V DC, the diagnostics alarm is reported as outgoing.

4.3 Substitute value behavior

Substitute value behavior

The respective output behaves according to its configured substitute value behavior:

- Zero current or zero voltage
- Output substitute value
- Keep last value

The substitute value behavior is triggered in the following cases:

- STOP controller
- Controller failure (connection interrupted)
- Parameter assignment phase during startup
- Deactivating the IO device
- Station stop
  - Missing server module
  - Insertion of invalid I/O modules
  - At least one I/O module is installed on an incorrect BaseUnit

NOTE
Reducing a configuration
If you reduce the configuration of the ET 200SP distributed I/O system and download the configuration to the CPU, the modules which are no longer configured but still present retain their original substitute value behavior. This applies until the supply voltage is switched off at the interface module.

The "current-free/voltage-free" behavior becomes effective in the following cases:

- Firmware update
- Reset to factory settings
- Configuration control: The IM has not received a valid control data record 196 yet
- Incorrectly configured module
- Module with incorrect parameter assignment

Substitute value behavior for module-internal Shared Output (MSO) and module-internal Shared Input (MSI)

Substitute value behavior for module-internal Shared Output (MSO) and module-internal Shared Input (MSI) corresponds to the behavior described above.

4.4 Status of the supply voltage L+ of the I/O modules

You can find information on the status of the supply voltage L+ of the I/O modules in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

Interrupts, error messages, diagnostics and system alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays on the interface module and on the BusAdapters:

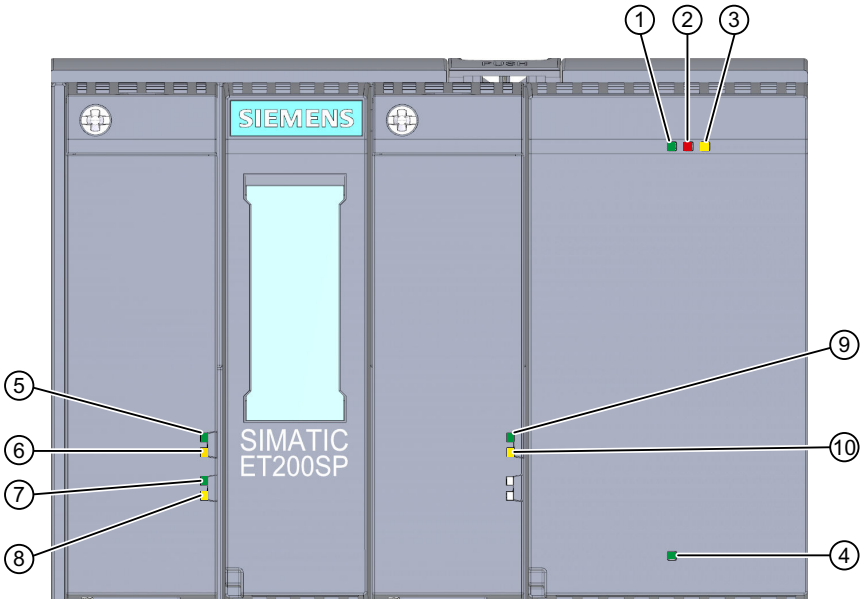

① RN (green)
② ER (red)
③ MT (yellow)
④ PWR (green)
⑤ LK1 (green)
⑥ MT1 (yellow), SCRJ port
⑦ LK2 (green)
⑧ MT2 (yellow), SCRJ port
⑨ LK3 (green)
⑩ MT3 (yellow), SCRJ port

Figure 2-111 LED displays on the interface module and BusAdapter 2xSCRJ

Meaning of the LED displays

The following tables contain the meaning of the status and error displays.

RN/ER/MT LEDs on the interface module

Table 2-146 Status and error displays of RN/ER/MT LEDs

LEDs			Meaning	Solution
RN (RUN)	ER (ERROR)	MT (MAINT)		
Off	Off	Off	Missing or insufficient supply voltage on interface module.	Check the supply voltage or turn it on at the interface module.*
On	On	On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	-
Flashes	Not relevant	Not relevant	Interface module is deactivated.	Activate the interface module with the configuration software or the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP starts up.	-
			ET 200SP is being assigned parameters.	
			ET 200SP is being reset to factory settings.	
On	Not relevant	Not relevant	ET 200SP is currently exchanging data with the IO controller.	-
Not relevant	Flashes	Not relevant	Group errors and group error channels.	Evaluate the diagnostics and eliminate the error.
			The preset configuration does not match the actual configuration of the ET 200SP.	Check the configuration of the ET 200SP to see whether a module is missing, faulty or not configured.
			Invalid configuration states.	For additional information, see section Invalid configuration states of the ET 200SP on PROFINET IO (Page 41)
			Parameter assignment error in the I/O module.	Evaluate the display of the module status in STEP 7. Eliminate the error in the corresponding I/O module.
Not relevant	Not relevant	On	Maintenance	For additional information, see section Maintenance events (Page 39)
Flashes	Flashes	Flashes	The "Node flash test" is run (LEDs LK1 and LK2 of the PROFINET interface also flash).	-
			Hardware or firmware defective (LEDs LK1 and LK2 of the PROFINET interface do not flash).	Run a firmware update. If the error persists, contact Siemens Industry Online Support. Replace the interface module.

* PWR LED on (on the interface module): Check the backplane bus for a short-circuit.

PWR LED on the interface module

Table 2-147 Status display of the PWR LED

PWR LED	Meaning	Solution
□ Off	Supply voltage not present or too small.	Check the supply voltage.
■ On	Supply voltage present. Observe the maintenance messages if the MAIN LED is lit	-

LED display of configuration errors

Configuration errors of the distributed IO system ET 200SP are indicated on the interface module via the red LED ERROR and the yellow LED MAINT.

The following configuration errors are signaled by the LEDs:

- No server module
- Interruptions or short-circuit on the backplane bus

Operating principle

The LED error display provides information on the cause of the error. After notification by the flash signal, the error type is displayed followed by the error location/error code.

The LED error display:

- Is activated during POWER ON and during operation.
- Has priority over all other states that are displayed by means of the ERROR and MAINT LED.
- Remains on until the cause of the error has been eliminated.

Table 2-148 Display of error type and error location

Sequence		Description
1	The ERROR and MAINT LEDs flash 3x at 0.5 Hz	Indication of the error type
2	The MAINT LED flashes at 1 Hz	Display of error type (decimal)
3	The ERROR and MAINT LEDs flash 3x at 2 Hz	Signaling of error location/error code
4	The ERROR LED flashes at 1 Hz	Display of tens digit (decimal) of the error location/error code
5	The MAINT LED flashes at 1 Hz	Display of ones digit (decimal) of the error location/error code
6	Repetition of 1 to 5 until the cause of the error has been eliminated.	

Error display

Table 2-149 Error display

Error type (MAINT)	Error location (ERROR/ MAINT)	Cause of error	Solution
1	65	• No server module • Interruptions on the backplane bus • Short circuit of communication on the backplane bus	Check the configuration of the ET 200SP.

NOTE

A short circuit in the backplane bus supply or the bus connection supply is indicated by the following LEDs:

- PWR LED: On
- RN, ER and MT LED: Off

5.2 Interrupts

Introduction

The I/O device triggers interrupts as a reaction to specific errors. Interrupts are evaluated based on the I/O controller used.

Evaluating interrupts with I/O controllers

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostic error interrupts
- Hardware interrupts
- Pull/plug interrupts
- Maintenance events

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

System diagnostics

In STEP 7 (TIA Portal), the innovated system diagnostics is available for the devices of the S7-1500 automation system (IO controller S7-1500 CPU) and ET 200SP (IO device). Independent of the cyclic user program, alarms are made available on the display of the S7-1500 CPU, the CPU web server and the HMI device.

You will find more information on system diagnostics in the Diagnostics (https://support.industry.siemens.com/cs/ww/en/view/59192926) function manual.

5.2.1 Triggering of a diagnostics interrupt

Triggering of a diagnostics interrupt

For an incoming or outgoing event (e.g. wire break on a channel of an I/O module), the module triggers a diagnostic error interrupt if this is configured accordingly.

The CPU interrupts processing of the user program and processes the diagnostic error interrupt OB (OB 82). The event that triggered the interrupt is entered in the start information of the diagnostic error interrupt OB.

5.2.2 Triggering a hardware interrupt

Triggering a hardware interrupt

If there is a hardware interrupt, the CPU interrupts user program execution and processes the hardware interrupt block OB, e.g., OB 40. The result that triggered the interrupt is added to the start information of the hardware interrupt OB.

NOTE

Diagnostics "Hardware interrupt lost" (from I/O module)

Do not use hardware interrupts for functional purposes (e.g. the cyclic generation of hardware interrupts).

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

5.2.3 Triggering of a remove/insert module interrupt

Triggering of a remove/insert module interrupt

In the event of a remove/insert module interrupt, the CPU interrupts processing of the user program and processes the remove/insert module OB, e.g. OB 83. The event that triggered the interrupt is entered in the start information of the remove/insert module OB.

NOTE

Parameter assignment error after removal/insertion

If you write data records from the user program to the modules of the distributed I/O, make sure that these modules actually exist and are available. You can do this by evaluating OB83. After inserting a module, OB83 is not called until the module has started up and its parameters are assigned. This ensures that data record operations can be executed without errors.

5.3 Alarms

5.3.1 Diagnostics alarms

Actions after a diagnostics alarm

There can be more than one diagnostics alarm at the same time. Each diagnostics alarm initiates the following actions:

- The ERROR LED of the interface module flashes.
- Diagnostics are reported as diagnostic error interrupts to the CPU of the IO controller and can be read via data records.
- Incoming diagnostics alarms are saved to the diagnostics buffer of the I/O controller.
- (S7-300/400) The diagnostic interrupt OB is called. If the diagnostics interrupt OB (OB 82) is not available, the IO controller goes into STOP mode.

You can find more information in the STEP 7 online help.

Reading the diagnostics

Table 2-150 Reading the diagnostics with STEP 7

Automation system with IO controller	Application	See...
SIMATIC S7	Diagnostics as plain text in STEP 7 using Online and Diagnostics view	STEP 7 online help • as of STEP 7 V12 function manual PROFINET with STEP 7 as of V12 (http://support.automation.siemens.com/WW/view/en/49948856) • as of STEP 7 V5.5, system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)
	Instruction "RDREC" (SFB 52) Read data records from the IO device	
	Instruction "RALRM" (SFB 54) Receive interrupts from the IO device	

Additional information on the data records for PROFINET IO

The structure of the diagnostic data records and programming examples are available in the programming manual From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) and in Example application (http://support.automation.siemens.com/WW/view/en/24000238).

Causes of error and troubleshooting

The causes of error and remedies for the diagnostic alarms are described in the manuals for I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300) in the section, "Interrupts, error messages, and system events".

See also

Channel diagnostics (Page 40)

5.3.2 Maintenance events

Triggering of a maintenance event

The PROFINET IO interfaces of the interface module support the diagnostic concept and maintenance concept in PROFINET IO according to the IEC 61158 Type 10 standard. The goal is to detect and remove potential problems as soon as possible.

For the interface module, maintenance events signal to the user when a plant component must be checked or replaced.

The CPU interrupts user program execution and executes the diagnostic error interrupt OB. The event that triggered the maintenance event is entered in the start information of the diagnostic error interrupt OB.

The interface module signals a maintenance event to the higher-level diagnostic system in the case of the following event:

Table 2-151 Triggering of a maintenance event

Maintenance alarm	Event	Alarm/Meaning
Maintenance demanded LED MAINT is lit.	Synchronization loss	• No synchronization frame received. No synchronization frame was received by the sync master within the timeout period after parameter assignment or during operation. • Successive synchronization frames are located outside permitted limits (jitter).
	Undervoltage	• Diagnostics Undervoltage If the supply voltage of the interface falls below the value 19.2 V DC, these diagnostics are reported as incoming Maintenance demanded.

System alarms in STEP 7 (TIA Portal)

The maintenance information is generated in STEP 7 (TIA Portal) with the following system alarms:

- Maintenance demanded - indicated for each port by a yellow wrench icon in the device view or in the hardware configuration.

You can find more information in the STEP 7 online help.

5.3.3 Channel diagnostics

Function

Channel-related diagnostics provides information about channel faults in modules.

Channel faults are mapped as channel diagnostics data in IO diagnostics data records.

The data record is read using the instruction "RDREC".

Structure of the diagnostics data records

The data records supported by the ET 200SP distributed I/O system are based on the standard PROFINET IO - Application Layer Service Definition V2.2.

If required, you can find the standard on the Internet (http://www.profibus.com) at the home page of the PROFIBUS user organization.

Codes of the extended channel diagnostics

With the IM 155-6 PN/3 HF interface module, the following extended channel diagnostics are reported:

ChannelErrorType (CET)	ExtendedChannelError-Type (ECET)	Associated value AddValue	Diagnostics
0x0602	0x0691	Slot	Station stop - module parameter "Potential group" faulty or incorrect BaseUnit in actual slot (AddValue)
0x0602	0x0693	0x00	Diagnostics with missing server module
0x0602	0x0698	0x00	Diagnostics backplane bus too large
0x0602	0x0699	Slot	Diagnostics with incorrect bus configuration
0x0610	0x06B0	0x00	Group diagnostics: Missing supply voltage L+ for the potential groups Note: The slot in which the light-colored BaseUnit of the respective load module is located is coded in the "ChannelNumber" element.
0x0610	0x06B4	0x00	Diagnostics "Undervoltage power supply" If the supply voltage of the interface falls below the value 19.2 V DC, these diagnostics are reported as incoming Maintenance demanded.

5.3.4 Invalid configuration states of the ET 200SP on PROFINET IO

Invalid configuration states

The following invalid configuration states of the ET 200SP distributed I/O system lead to the failure of the IO device or prevent data exchange:

- Number of modules exceeds maximum configuration.
- Faulty backplane bus (e.g. defective BaseUnit). ET 200SP backplane bus interruptions do not trigger an interrupt.
- At least one I/O module is plugged into a different BaseUnit as the one configured in the parameters.
- No server module.
- Invalid or incorrectly configured BusAdapter.

NOTE

Removal of the server module will trigger a station stop. All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) but the interface module continues to exchange data.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

See also

Status and error displays (Page 33)
Channel diagnostics (Page 40)

5.3.5 Failure of supply voltage L+ at BaseUnit BU...D

Failure of the supply voltage L+

The I/O modules react as follows to failure of the supply voltage L+ on the BaseUnit BU...D:

- If an I/O module is removed during failure of the supply voltage, a pull interrupt is generated.
- If an I/O module is installed during failure of the supply voltage, a plug interrupt is generated.

5.3.6 STOP of the IO controller and recovery of the IO device

STOP of the SIMATIC IO controller

Diagnostics received from the IO device while the IO controller is in STOP do not initiate a call of any corresponding OBs when the IO controller goes into RUN. Read the $E00C_H$ data record in startup OB using the instruction "RDREC". This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Recovery of the SIMATIC IO devices

If you want to read the occurring diagnostics in the STOP state of the IO controller, you have to read the $E00C_H$ data record with the "RDREC" instruction. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Compatibility 6

6.1 Compatibility of modules

Station configuration with more than 32 I/O modules

Certain I/O modules with functional status 001 and 002 do not support a station configuration with more than 32 I/O modules.

The table below shows all modules that do not support a station configuration with more than 32 I/O modules:

Table 2-152 Incompatible modules with functional versions

Modules	Article number	up to functional status
Analog modules		
AI 4xI 2-/4-wire ST	6ES7134-6GD00-0BA1	002
AI 4xU/I 2-wire ST	6ES7134-6HD00-0BA1	002
AI 4xRTD/TC 2-/3-/4-wire HF	6ES7134-6JD00-0CA1	002
AI 4xU/I ST	6ES7135-6HD00-0BA1	002
Digital modules		
DI 16x24VDC ST	6ES7131-6BH00-0BA0	002
DI 8x24VDC ST	6ES7131-6BF00-0BA0	002
DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0	002
DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0	002
DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0	002

Status of the supply voltage

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules without parameter assignment in the following table, the status of the supply voltage (status byte of the server module) is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Article number
DI 8x24VDC ST	6ES7131-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0

Modules	Article number
DI 8x24VDC HF	6ES7131-6BF00-0CA0
DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0
DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0
DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0
DQ 8x24VDC/0.5A HF	6ES7132-6BF00-0CA0

AQ 4xU/I ST analog output module

NOTE

For operation of the AQ 4xU/I ST analog output module, firmware version V1.0 (6ES7135-6HD00-0BA1) with the interface module, you need to set the "Reaction to CPU STOP" parameter to "Turn off" with a PROFINET send clock < 1 ms.

Reaction times for fail-safe modules

The following maximum reaction time of the interface module must be taken into account when calculating the reaction times of fail-safe modules: **Maximum reaction time = configured update time + 400 µs (but at least 1.4 ms)**

Operation with activated system redundancy S2

NOTE

Restrictions in operation with activated system redundancy S2

You cannot use the following functions during operation of the IM155-6 PN/3 HF, firmware version V4.2 with activated system redundancy S2:

- Configuration control (option handling)
- Module-to-Module Communication (MtM)
- Interface local coupling of IO data

Technical specifications 7

Technical specifications of IM 155-6 PN/3 HF

The following table shows the technical specifications as of 08/2018. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7155-6AU30-0CN0/td?dl=en).

Article number	6ES7155-6AU30-0CN0
General information	
Product type designation	IM 155-6 PN/3 HF with server module
Firmware version	V4.2
• FW update possible	Yes
Number of MtM communication relationships/connections, max.	16
Product function	
• I&M data	Yes; I&M0 to I&M3
• Module swapping during operation (hot swapping)	Yes; Multi-hot swapping
• Tool changer	Yes; Docking station and docking unit
• Local coupling, IO data	Yes
– Number of coupling modules	16
– Number of coupling submodules per module	4
• Local coupling, data records	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V15.1
• STEP 7 configurable/integrated as of version	Configurable via GSD file
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Configuration control	
via dataset	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	10 ms

Article number	6ES7155-6AU30-0CN0
Input current	
Current consumption (rated value)	175 mA; At 24 V, 2 slots 2x RJ45 BusAdapter, no I/O modules
Current consumption, max.	950 mA
Inrush current, max.	9 A
I^2t	0.34 $A^2 \cdot s$
Power loss	
Power loss, typ.	4.9 W
Address area	
Address space per module	
• Address space per module, max.	288 byte; For input and output data respectively
Address space per station	
• Address space per station, max.	1 440 byte; Dependent on configuration
Hardware configuration	
Rack	
• Modules per rack, max.	64; + 16 ET 200AL modules
Submodules	
• Number of submodules per station, max.	256
Interfaces	
Number of PROFINET interfaces	1; 3 ports (switch)
1. Interface	
Interface types	
• Number of ports	3; Via 2 BusAdapter slots
• integrated switch	Yes
• BusAdapter (PROFINET)	Yes; Compatible BusAdapter: BA 2x RJ45, BA 2x FC, BA 2x SCRJ, BA SCRJ / RJ45, BA SCRJ / FC, BA 2x LC, BA LC / RJ45, BA LC / FC
Protocols	
• PROFINET IO Device	Yes
• Open IE communication	Yes
• Media redundancy	Yes; PROFINET MRP
Interface types	
RJ 45 (Ethernet)	
• Transmission procedure	PROFINET with 100 Mbit/s full duplex (100BASE-TX)
• 10 Mbps	No
• 100 Mbps	Yes; PROFINET with 100 Mbit/s full duplex (100BASE-TX)
• Autonegotiation	Yes
• Autocrossing	Yes
Protocols	
PROFINET IO Device	

Article number	6ES7155-6AU30-0CN0
Services	
– Isochronous mode	Yes; Bus cycle time: min. 250 µs
– Open IE communication	Yes
– IRT	Yes; 250 µs, 500 µs, 1 ms, 2 ms, 4 ms additionally with IRT with high performance: 250 µs to 4 ms in 125 µs frame
– PROFIenergy	Yes
– Prioritized startup	Yes
– Shared device	Yes
– Number of IO Controllers with shared device, max.	4
Redundancy mode	
– MRP	Yes
– MRPD	No
– PROFINET system redundancy (S2)	Yes; NAP S2
– Redundant PROFINET configuration (R1)	No
– H-Sync forwarding	Yes
Open IE communication	
• TCP/IP	Yes
• SNMP	Yes
• LLDP	Yes
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	Yes
Equidistance	Yes
shortest clock pulse	250 µs
max. cycle	4 ms
Bus cycle time (TDP), min.	250 µs
Jitter, max.	1 µs
Interrupts/diagnostics/status information	
Status indicator	Yes
Alarms	Yes
Diagnostics function	Yes
Diagnostics indication LED	
• RUN LED	Yes; Green LED
• ERROR LED	Yes; Red LED
• MAINT LED	Yes; yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Connection to network LINK (green)	Yes; 2x green link LEDs on BusAdapter

Article number	6ES7155-6AU30-0CN0
Potential separation	
between backplane bus and electronics	No
between PROFINET and all other circuits	Yes
between supply and all other circuits	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Network loading class	3
Security level	According to Security Level 1 Test Cases V1.1.1
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; No condensation
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Connection method	
ET-Connection	
• via BU/BA Send	Yes; + 16 ET 200AL modules
Mechanics/material	
Strain relief	Yes; Optional
Dimensions	
Width	100 mm
Height	117 mm
Depth	74 mm
Weights	
Weight, approx.	220 g; without BusAdapter

Dimension drawing

A

This appendix contains a dimension drawing of the module mounted on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

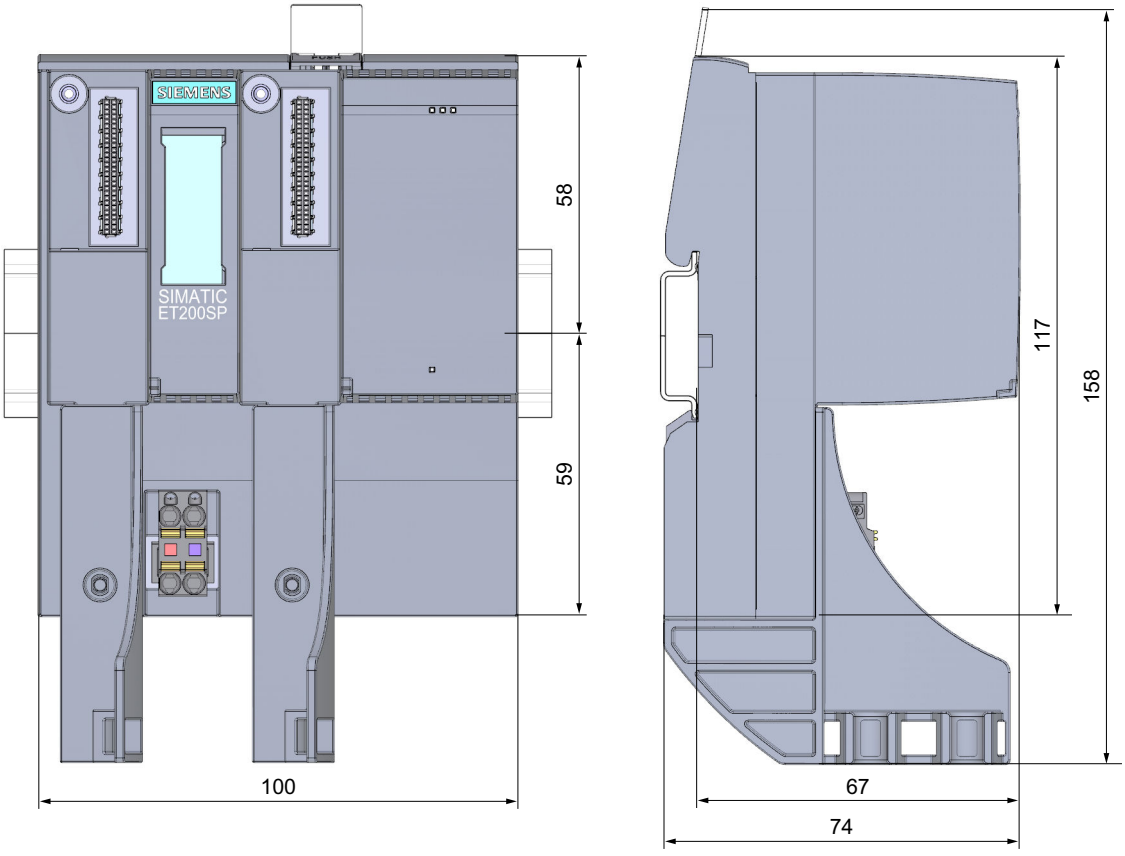

Figure 2-112 Dimension drawing of the IM 155-6 PN/3 HF interface module, front and side views

SIEMENS

SIMATIC

ET 200SP
IM 155-6 PN HS interface module (6ES7155-6AU00-0DN0)

Equipment Manual

Documentation guide 1

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Dimensional drawing A

09/2016
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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes labeled as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

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- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.

- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (http://www.siemens.com/automation/service&support).

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all the products in automation and drives are available on the Internet (https://mall.industry.siemens.com).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

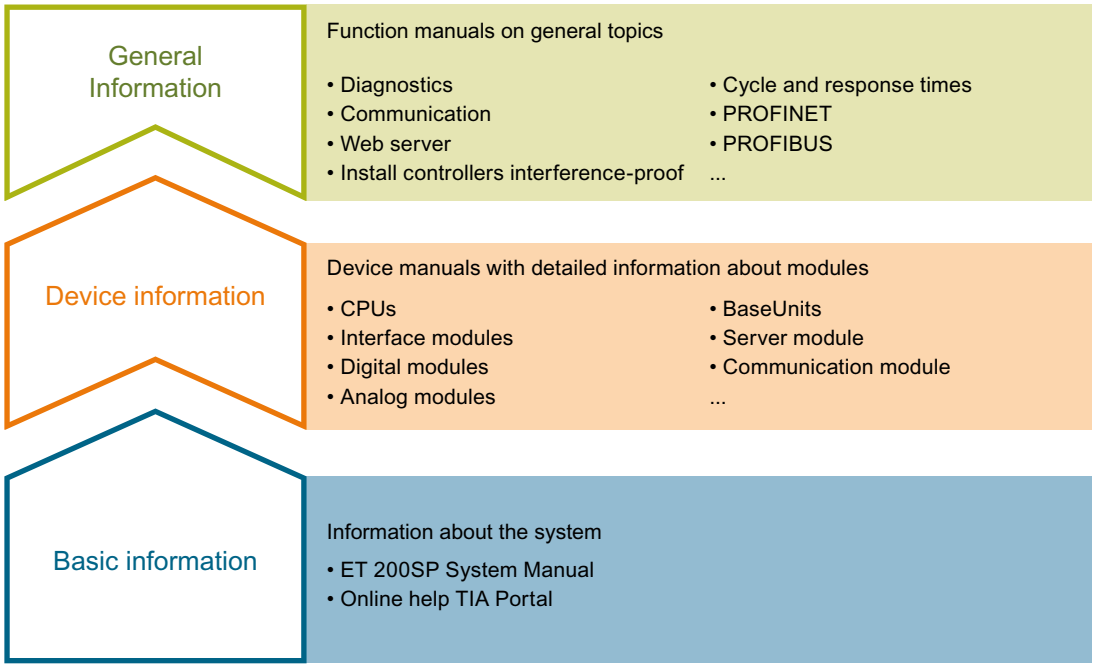

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

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With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

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You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Product overview

2

2.1 Properties

Article number

6ES7155-6AU00-0DN0 (interface module IM 155-6 PN HS and server module)

View of the module

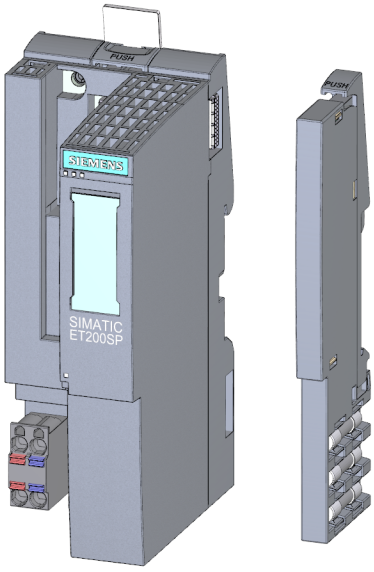

Figure 2-113 View of the IM 155-6 PN HS interface module and the server module

Properties

The module has the following properties:

- Connects the ET 200SP distributed I/O system with PROFINET IO
- High-speed applications as of 125 µs
- Isochronous mode according to PROFINET V2.3
- Supply voltage 1L+ 24 V DC (SELV/PELV).
- The connection plugs for the 24 V DC supply voltage and the server module are included in the scope of delivery of the interface module.

- PROFINET IO connection via selectable BusAdapters
  - For RJ45 bus connection plug (BA 2×RJ45)
  - For direct connection of the bus cable (BA 2×FC)
  - For POF/PCF fiber-optic cable (BA 2xSCRJ)
  - As media converter for POF/PCF fiber-optic cable ⇔ standard RJ45 plug (BA SCRJ/RJ45)
  - As media converter for POF/PCF fiber-optic cable ⇔ direct connection of the bus cable (BA SCRJ/FC)
  - For glass fiber-optic cable (BA 2xLC)
  - As media converter for glass fiber-optic cable ⇔ standard RJ45 plug (BA LC/RJ45)
  - As media converter for glass fiber-optic cable ⇔ direct connection of the bus cable (BA LC/FC)

The module supports the following PROFINET IO functions (see (Page 11))

Maximum configuration

- 30 I/O modules
- 0.5 m backplane bus (without interface module but with server module)

Maximum amount of I/O data

The maximum amount of I/O data without user data qualifier is 968 bytes.

NOTE

- In the case of a shared device configuration, the 968 bytes apply to the total I/O data of all controllers that share the device.
- If more than two (max. four) controllers share the device, the maximum amount of I/O data including user data qualifier is limited to 360 bytes per controller.

Accessories

You order the following accessories separately:

- BA 2×RJ45 BusAdapter
- BA 2×FC BusAdapter
- BA 2×SCRJ BusAdapter
- BA SCRJ/RJ45 BusAdapter
- BA SCRJ/FC BusAdapter
- BA 2×LC BusAdapter
- BA LC/RJ45 BusAdapter
- BA LC/FC BusAdapter

- Labeling strips
- Reference identification label

A detailed list of the available accessories can be found in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Server module

The server module is included in the scope of delivery of the interface module and is available separately as a spare part. The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system
- Features a support for 3 spare fuses (5 × 20 mm)
- Provides station functions, for example, group load diagnostics, status bytes.
- Identification data I&M 0 to 3

NOTE

You need to configure and assign parameters to the server module in the configuration software.

To do this, place the server module in the last configuration slot and enable the parameter Group diagnostics: Missing supply voltage L+. When there are 30 I/O modules, the server module is inserted in slot 31.

You can find more information in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

First BaseUnit of an ET 200SP in the configuration

The interface modules support dark-colored BaseUnits in slot 1. This means that modules without a connection to the integrated voltage buses P1 and P2 can be configured starting with slot 1. Currently, this applies to the following modules:

- AI EnergyMeter
- DI 4x120..230VAC ST (6ES7131-6FD00-0BB1)
- DQ 4x24..230VAC/2A ST (6ES7132-6FD00-0BB1)
- RQ 4x120VDC-230VAC/5A NO ST (6ES7132-6HD00-0BB1)
- RQ 4x120VDC-230VAC/5A NO MA ST (6ES7132-6MD00-0BB1)

NOTE

First BaseUnit of an ET 200SP in the configuration

The first BaseUnit of an ET 200SP station may be a dark-colored one if an AC I/O module or AI Energy Meter is plugged. Please observe the information on limiting the overvoltage and power rating in the AC I/O module manuals.

A light-colored BaseUnit must be plugged into the slot of the first 24 V DC I/O module to supply the 24 V DC supply voltage.

Pay attention to the type of the BaseUnits during the configuration.

2.2 Functions

PROFINET IO

The interface module supports the following PROFINET IO functions:

- Integrated switch with 2 ports
- Supported Ethernet services: ping, arp, network diagnostics (SNMP)/MIB-2, LLDP-MIB and MRP-MIB
- Port diagnostics
- Disabling ports
- Minimum update time 125 µs
- Device replacement without programming device, also without topological configuration
- Reset to factory settings via PROFINET IO
- Firmware update via PROFINET IO
- Isochronous real-time communication
- Prioritized startup
- Media redundancy (MRP)
- Media redundancy with planned duplication (MRPD)
- Shared device
- Module division of I/O modules (submodules)
- Module-internal Shared Input/Shared Output (MSI/MSO)

- Isochronous mode as of 125 µs
- Performance upgrade PROFINET V2.3
- Freely selectable connection method and connection technology over SIMATIC BusAdapter for PROFINET copper, POF, PCF or fiber-optic cables.

The interface module supports additional functions:

- Identification data I&M 0 to 3
- Oversampling
- PROFIenergy
- Configuration control (option handling)
- Value status of I/O modules
- Use of fail-safe modules
- Multi Hot Swap (removal/insertion of multiple I/O modules during operation)
- Reset to factory settings via RESET button

NOTE
Docking unit
The use of the IM155-6 PN HS interface module as a docking unit (function: IO device changing in operation) in a docking system is not supported.

Requirements

The table below shows the software requirements for a configuration with the IM 155-6 PN HS interface module:

Table 2-153 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file/software from a third-party manufacturer [1]	STEP 7 as of V5.5 SP4 with HSP0238	STEP 7 (TIA Portal) as of V14
Real-time communication	1	V4.0.0	X	X	X
Isochronous real-time communication according to PROFINET	1	V4.0.0	X	X	X
Prioritized startup	1	V4.0.0	X	X	X
Media redundancy (MRP)	1	V4.0.0	X	X	X
Shared device	1	V4.0.0	X	X	X
Multi Hot Swap	1	V4.0.0	X	X	X
Media redundancy with planned duplication (MRPD)	1	V4.0.0	X	X	X

[1] systems of third-party manufacturers: Depending on the range of functions of the third-party system

Function	Product version of the module as of	Firmware version of the module as of	Configuration software		
			Configuration with GSD file/software from a third-party manufacturer [1]	STEP 7 as of V5.5 SP4 with HSP0238	STEP 7 (TIA Portal) as of V14
Isochronous mode ≥ 250 µs	1	V4.0.0	---	X	X
Isochronous mode ≥ 125 µs/187.5 µs	1	V4.0.0	---	---	X
Device replacement without programming device	1	V4.0.0	X	X	X
Module-internal Shared Input/Shared Output (MSI/MSO)	1	V4.0.0	X	X	X
Module division of I/O modules (submodules)	1	V4.0.0	X	X	X
PROFIenergy	1	V4.0.0	X	X	X
Value status	1	V4.0.0	X	X	X
Use of fail-safe modules	1	V4.0.0	---	X	X
Oversampling	1	V4.0.0	---	X	X
BA 2xRJ45 BusAdapter	1	V4.0.0	X	X	X
BA 2xFC BusAdapter	1	V4.0.0	X	X	X
BA 2xSCRJ BusAdapter	1	V4.0.0	X	X	X
BA SCRJ/RJ45 BusAdapter	1	V4.0.0	X	X	X
BA SCRJ/FC BusAdapter	1	V4.0.0	X	X	X
BA 2xLC BusAdapter	1	V4.0.0	X	X	X
BA LC/RJ45 BusAdapter	1	V4.0.0	X	X	X
BA LC/FC BusAdapter	1	V4.0.0	X	X	X

[1] systems of third-party manufacturers: Depending on the range of functions of the third-party system

Cabling with fixed connection setting

If you set a fixed connection setting of the port in STEP 7, you should also disable "Autonegotiation/Autocrossover".

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Real-time communication

A transmission method for PROFINET IO based on cyclic data exchange with a provider-consumer model.

Isochronous real-time communication

Synchronized communication protocol for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth is available in the send cycle for IRT data. The reserved bandwidth ensures that the IRT data can also be transferred with another high network load (e.g. TCP/IP communication or additional real time communication) at reserved, chronologically synchronized intervals.

A topological configuration is required for IRT.

NOTE

IO controller as sync master with IRT communication

We recommend also operating the IO controller as a sync master when configuring the IRT communication.

Otherwise, IO devices with IRT and RT configuration could fail as a result of sync master failure.

You can find more information on the configuration of synchronized PROFINET devices in sync domains in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Isochronous mode of I/O data

I/O data, transmission cycle via PROFINET IO, and the user program are synchronized to achieve maximum deterministics. The input and output data of distributed I/O modules in the system is simultaneously collected and simultaneously output. The constant PROFINET IO cycle forms the corresponding clock generator. The interface module supports isochronous mode of I/O data for the modules starting at 125 µs. The IO device can exchange isochronous process data with a maximum of one IO controller.

NOTE

If the IO controller cannot access a module (for example, module pulled, activated configuration control without written control data record), cycle time violations may occur with activated isochronous mode in the synchronous cycle interrupt OB (OB61). The time error OB (OB80) is called in the event of a cycle time violation.

This behavior is associated with updating the process image by means of the "SYNC_PI" (SFC126) and "SYNC_PO" (SFC127) instructions and depends, among other things, on the set cycle time and the configuration limits.

NOTE

Isochronous mode restrictions with IM 155-6 PN HS

Isochronous mode of I/O data in combination with the following functions is not possible with the interface module IM 155-6 PN HS:

- PROFIenergy

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Prioritized startup

Prioritized startup describes the PROFINET IO functionality for accelerating the startup of IO devices in a PROFINET IO system with IRT and RT communication.

The function reduces the time that the appropriately configured IO devices require in order to return to cyclic user data exchange in the following cases:

- After the supply voltage has returned
- After a station has returned
- After IO devices have been activated

NOTE

Dependency on the startup time

The startup time depends on the number and type of modules.

The interface module permits startup times from 0.5 s.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Device replacement

Device replacement without topological configuration

The device name is also stored on the BusAdapter in addition to the interface module. A device name saved on the BusAdapter is the requirement for device replacement without topological configuration.

Storing the name on the BusAdapter and the interface module produces a range of scenarios for using the device name when the interface module is replaced.

Table 2-154 Scenarios for using the device name

	Interface module empty	Interface module with device name
BusAdapter empty	No device name available	The device name from the interface module is used and copied to the BusAdapter.
BusAdapter with device name	The device name from the BusAdapter is used and copied to the interface module.	The device name from the BusAdapter is used and copied to the interface module if this has a different device name.

Be aware of the following constraints:

- Resetting to factory settings via the RESET button deletes the device name in both the interface module and the BusAdapter. To prevent the device name from being deleted in the BusAdapter, you can remove the BusAdapter from the interface module before resetting to factory settings.
- When a BusAdapter is replaced, a device name stored in the BusAdapter is applied to the interface module after a POWER ON.
- Do not pull/plug the BusAdapter while under voltage. If you pull/plug the BusAdapter while under voltage, the interface module restarts.

Device replacement with topological configuration

IO devices having this function can be replaced in a simple manner:

- The device name does not have to be assigned with the programming device.

The replaced IO device is assigned the device name by the IO controller and not by the programming device. The IO controller uses the configured topology and the neighboring relationships determined by the IO devices for this purpose. All involved devices must support the LLDP protocol (Link Layer Discovery Protocol). The configured target topology must match the actual topology.

IO devices that were already operated in a different configuration should be reset to their factory settings before reuse (see system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)).

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Replacement scenario of an IM 155-6 PN HS or of a BusAdapter

In a replacement scenario, any IO device or BusAdapter in operation must be reset to its delivery state via "Reset to factory settings" (see the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

Media redundancy (MRP)

Function for safeguarding communication and system availability. A ring topology ensures that an alternative communication path is made available if a transmission route fails.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Media redundancy with planned duplication (MRPD)

If bumpless media redundancy is to be reached with short update times (together with IRT), you must use the MRP extension "Media redundancy with planned duplication (MRPD)".

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Shared device

IO device which makes its data available to multiple IO controllers.

The interface module supports shared device at submodule level.

Notes on configuring:

- Always load hardware changes to all affected IO controllers.
- Set the same send clocks in the projects.
- Limit the I/O data including user data qualifier to 360 bytes per IO controller.
- Use the same station name and the same IP address for each shared configuration.
- Assign each module or submodule to only one IO controller.
- In the case of an incorrect configuration, you may need to perform a power OFF/ON on the interface module.

You can find more information on this topic in the STEP 7 online help and

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- As of STEP 7 V5.5, in the PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual

Submodules

The IM 155-6 PN HS interface module supports the module division of I/O modules into up to 4 submodules. This allows parts of an I/O module to be separately configured and assigned parameters.

It is possible to assign each of these submodules to different IO controllers.

The functions

- Firmware update
- Write I&M data
- Calibration
- PROFIenergy

can only be executed if you have configured submodule 1 during configuration.

Module-internal Shared Input/Shared Output (MSI/MSO)

The module-internal Shared Input function allows an input module to make its input data available to up to three additional IO controllers. Each controller has read access to the same channels.

The module-internal Shared Output function allows an output module to make the status of its output data available to up to three additional IO controllers. These additional IO controllers can read the status of the channels as input data.

You can find more information on this topic in the STEP 7 online help and:

- As of STEP 7 V14, in the PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual

Value status

The IM 155-6 PN HS interface module supports I/O modules with value status.

You can find more information on the value status in the manuals for the I/O modules.

Oversampling

The IM 155-6 PN HS interface module supports the oversampling mode of HS modules. With oversampling, the modules reduce the respective PROFINET send clocks in isochronous mode.

You can find more information on oversampling in the manuals for the I/O modules.

2.2.1 PROFIenergy

Properties

PROFIenergy (for PROFINET) reduces the energy consumption by using PROFIenergy commands during production-free periods.

Reference

You can find more information on PROFIenergy in the

- I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual
- PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) function manual
- PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127) system manual
- PROFIenergy (http://support.automation.siemens.com/WW/view/en/66928686) product information.
- Internet (http://www.profibus.com) under Common Application Profile PROFIenergy; Technical Specification for PROFINET; Version 1.0; January 2010; Order No: 3.802.

2.2.2 Configuration control (option handling)

Properties

Configuration control allows you to prepare your distributed I/O system for future extensions or changes. Configuration control means that you can configure the planned maximum configuration of your distributed I/O system in advance and vary it later in a flexible manner by means of the user program.

Reference

You can find more information on configuration control

- in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual
- on the Internet under the following link Application collection (http://support.automation.siemens.com/WW/view/en/29430270)
- in the STEP 7 online help.

2.2.3 Use of fail-safe modules

Properties

The interface module IM 155-6 PN HS supports the use of fail-safe modules.

Reference

You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2.4 Multi Hot Swap

Properties

You can remove and insert any number of I/O modules during operation. The interface module and the inserted I/O modules remain in operation.

NOTE

The IM 155-6 PN HS interface module does not support the removal and insertion of the server module, the interface module and BusAdapter during operation.

Reference

You can find more information on the removal/insertion of modules in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Connecting

3

3.1 Terminal assignment

24 V DC supply voltage

The table below shows the signal names and descriptions of the pin assignment of the 24 V DC supply voltage.

Table 2-155 Pin assignment 24 V DC supply voltage

View		Signal name[1]	Description
Connector	IM connection		
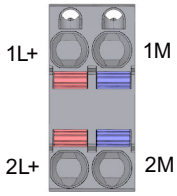	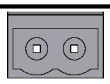	1L+	24 V DC
		2L+	24 V DC (for looping through)[2]
		1M	Ground
		2M	Ground (for looping through)[2]

1 1L+ and 2L+ as well as 1M and 2M are bridged internally.

2 Maximum 10 A permitted.

PROFINET IO with BusAdapter BA 2×RJ45

The following table shows the signal name and description of the pin assignment of the BusAdapter BA 2×RJ45.

Table 2-156 PROFINET IO pin assignment with BusAdapter BA 2×RJ45

View	Signal name		Description
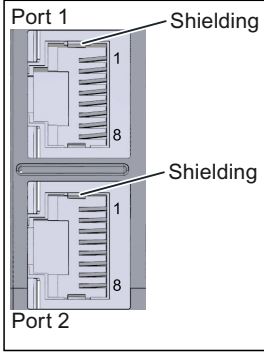	1	TD	Transmit data +
	2	TD_N	Transmit data -
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data -
	7	GND	Ground
	8	GND	Ground

PROFINET IO with BusAdapter BA 2×FC

The following table shows the signal name and description of the pin assignment of the BusAdapter BA 2×FC.

Table 2-157 PROFINET IO pin assignment with BusAdapter BA 2×FC

View	Signal name		Description
Port 1 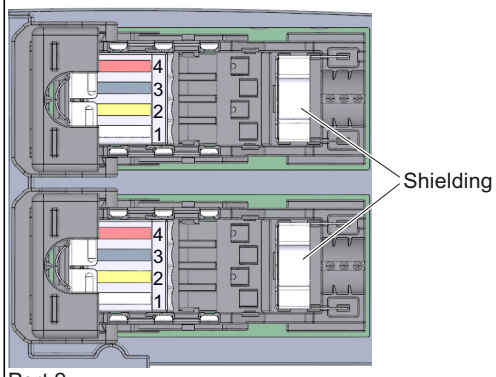 Port 2	1	TD	Transmit data +
	2	TD_N	Transmit data -
	3	RD	Receive data +
	4	RD_N	Receive data -

PROFINET IO with BusAdapter BA 2×SCRJ

The following table shows the signal names and description of the pin assignment for the BA 2×SCRJ BusAdapter.

Table 2-158 PROFINET IO pin assignment with BusAdapter BA 2×SCRJ

View	Signal name	Description
Port 1 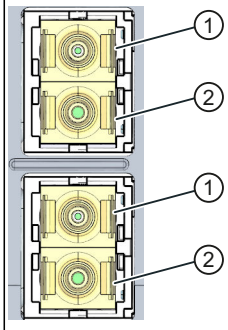 Port 2	1	Receiver/Receive data
	2	Sender/Transmit data

PROFINET IO with BusAdapter BA 2×LC

The following table shows the signal names and description of the pin assignment for the BA 2×LC BusAdapter.

Table 2-159 PROFINET IO pin assignment with BusAdapter BA 2×LC

View	Signal name	Description
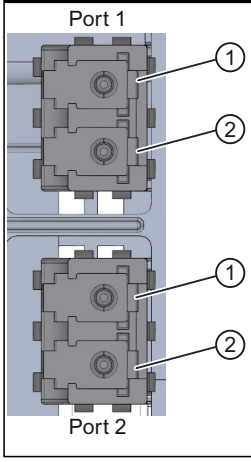	1	Receiver/Receive data
	2	Sender/Transmit data

PROFINET IO with BusAdapter BA SCRJ/RJ45

The following table shows the signal names and description of the pin assignment for the BA SCRJ/RJ45 BusAdapter.

Table 2-160 PROFINET IO pin assignment with BusAdapter BA SCRJ/RJ45

View	Signal name		Description
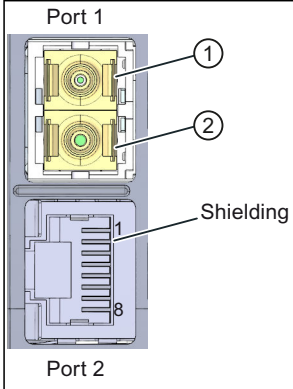	1		Receiver/Receive data
	2		Sender/Transmit data
	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data –
	7	GND	Ground
	8	GND	Ground

PROFINET IO with BusAdapter BA SCRJ/FC

The following table shows the signal names and description of the pin assignment for the BA SCRJ/FC BusAdapter.

The pin assignment for the BA SCRJ/FC BusAdapter is shown individually for a clearer overview.

Table 2-161 PROFINET IO pin assignment with BusAdapter BA SCRJ/FC

View	Signal name		Description
Port 1 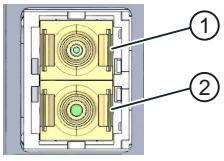	①		Receiver/Receive data
	②		Sender/Transmit data
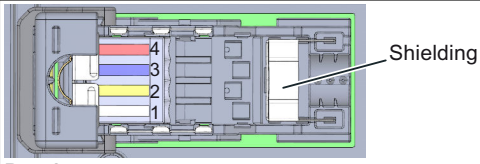 Port 2	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	RD_N	Receive data -

PROFINET IO with BusAdapter BA LC/RJ45

The following table shows the signal names and description of the pin assignment for the BA LC/RJ45 BusAdapter.

Table 2-162 PROFINET IO pin assignment with BusAdapter BA LC/RJ45

View	Signal name		Description
Port 1 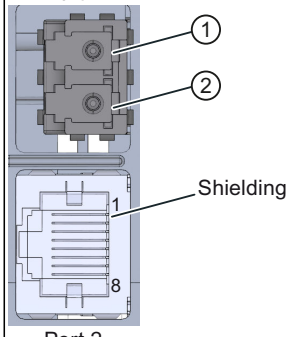 Port 2	①		Receiver/Receive data
	②		Sender/Transmit data
	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive data –
	7	GND	Ground
	8	GND	Ground

PROFINET IO with BusAdapter BA LC/FC

The following table shows the signal names and description of the pin assignment for the BA LC/FC BusAdapter.

The pin assignment for the BA LC/FC BusAdapter is shown individually for a clearer overview.

Table 2-163 PROFINET IO pin assignment with BusAdapter BA LC/FC

View	Signal name		Description
Port 1 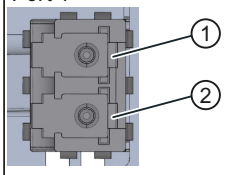	①		Receiver/Receive data
	②		Sender/Transmit data
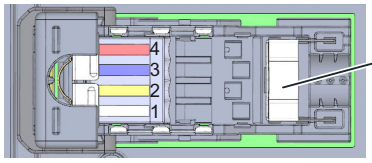 Port 2	1	TD	Transmit data +
	2	TD_N	Transmit data –
	3	RD	Receive data +
	4	RD_N	Receive data -

Reference

You can find more information on accessories and how to connect the interface module in the System Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

3.2 Schematic circuit diagram

The following figure shows the block diagram of the interface module IM 155-6 PN HS.

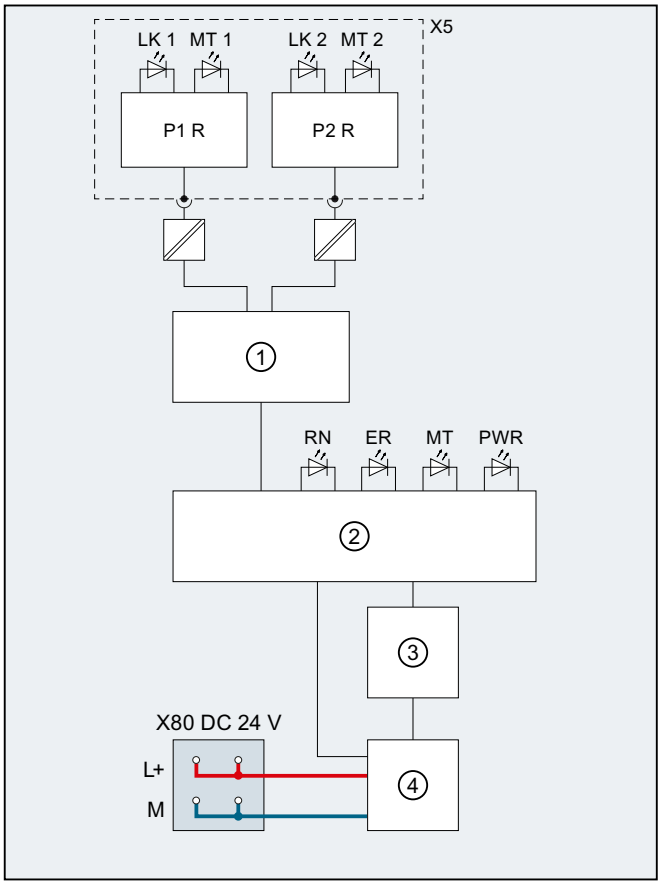

①	Switch	L+	24 V DC supply voltage
②	ET 200SP backplane bus interface and electronics	M	Ground
③	Backplane bus	LK 1,2	Link TX/RX LED (green)
④	Internal power supply	MT 1,2	MAINT FiberOptic LED (SCRJ port) (yellow)
X80 24 V DC	Feed supply voltage	RN	RUN/STOP LED (green/yellow)
X5	BusAdapter	ER	ERROR LED (red)
P1 R	PROFINET interface X1 Port 1	MT	MAINT LED (yellow)
P2 R	PROFINET interface X1 Port 2	PWR	POWER LED (green)

Figure 2-114 Block diagram of the IM 155-6 PN HS interface module

Parameters/address space

4

4.1 Parameters

Parameters for IM 155-6 PN HS interface module

The following table shows the parameters for the IM 155-6 PN HS interface module.

Table 2-164 Parameters for IM 155-6 PN HS interface module (GSD file)

Parameters	Value range	Default	Efficiency range
Configuration control	Disable/enable	Disable	ET 200SP

4.2 Explanation of parameters

4.2.1 Configuration control

You can use this parameter to enable the configuration control function in the ET 200SP distributed I/O system.

NOTE

If you configure the enable, the ET 200SP distributed I/O system requires a control data record 196 from the user program in order for the ET 200SP distributed I/O system to operate the I/O modules.

Reference

You can find more information in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the STEP 7 online help.

4.3 Substitute value behavior

Substitute value behavior

The substitute value behavior in the ET 200SP distributed I/O system is defined through the configuration.

The respective output behaves according to its configured substitute value behavior:

- Current-free/voltage-free
- Output substitute value
- Keep last value

The substitute value behavior is triggered in the following cases:

- STOP controller
- Controller failure (connection interrupted)
- Parameter assignment phase during startup
- Deactivating the IO device
- Station stop:
  - Missing server module
  - At least one I/O module installed on an incorrect BaseUnit

NOTE

Reducing a configuration

If you reduce the configuration of the ET 200SP distributed I/O system and download the configuration to the CPU, the modules which are no longer configured but still present retain their original substitute value behavior. This applies until the supply voltage is switched off at the interface module.

The "current-free/voltage-free" behavior becomes effective in the following cases:

- Firmware update
- Reset to factory settings
- Configuration control: The IM has not received a valid control data record 196 yet.
- Incorrectly configured module
- Module with incorrect parameter assignment

4.4 Status of the supply voltage L+ of the I/O modules

The status of the supply voltage L+ of the ET 200SP I/O modules is mapped to the server module with the interface module IM 155-6 PN HS.

You can find information on the status of the supply voltage L+ of the I/O modules in the Server module (http://support.automation.siemens.com/WW/view/en/63257531) manual.

Interrupts, diagnostics, error, and system messages 5

5.1 Status and error displays

LED displays

The following figure shows the LED displays on the interface module and BusAdapter.

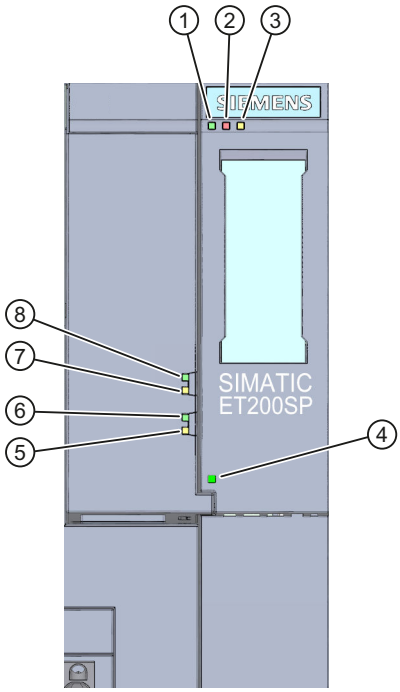

① RN (green)
② ER (red)
③ MT (yellow)
④ PWR (green)
⑤ MT2 (yellow) (SCRJ port)
⑥ LK2 (green)
⑦ MT1 (yellow) (SCRJ port)
⑧ LK1 (green)

Figure 2-115 LED displays on the interface module and BusAdapter

Meaning of the LEDs

The following tables contain the meaning of the status and error displays.

RN/ER/MT LEDs on the interface module

Table 2-165 Status and error displays of RN/ER/MT LEDs

LEDs			Meaning	Remedy
RN (RUN)	**ER (ERROR)**	**MT (MAINT)**		
Off	Off	Off	Missing or insufficient supply voltage on interface module.	Check the supply voltage or turn it on at the interface module.*
On	On	On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	---
Flashes	Not relevant	Not relevant	Interface module is deactivated.	Activate the interface module with the configuration software or the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP starts up.	---
			ET 200SP is being assigned parameters.	
On	Not relevant	Not relevant	ET 200SP is currently exchanging data with the IO controller.	---
Not relevant	Flashes	Not relevant	Group errors and group error channels.	Evaluate the diagnostics data and remedy the error.
			The configured structure does not correspond to the actual structure of the ET 200SP .	Check the structure of the ET 200SP to see whether a module is missing or defective, or whether a non-configured module is plugged.
			Invalid configuration states.	See section Invalid configuration states of the ET 200SP on PROFINET IO (Page 37)
			Parameter error in the I/O module.	Evaluate the display of the module status in STEP 7 and eliminate the error in the respective I/O module.
Not relevant	Not relevant	On	Maintenance	See section Maintenance events (Page 35)
Flashes	Flashes	Not relevant	Invalid BusAdapter	Check the BusAdapter.
Flashes	Flashes	Flashes	The "Node flash test" is run (the LEDs LK1 and LK2 of the PROFINET interface also flash).	---
			Hardware or firmware defective (the LEDs LK1 and LK2 of the PROFINET interface do not flash).	Run a firmware update. If the error persists, contact Siemens Industry Online Support. Replace the interface module.
Not relevant	Flashes	Flashes	Configuration error on backplane bus	Insert the server module as bus termination or check the number of inserted modules.

* PWR LED on (on the interface module): Check the backplane bus for a short circuit.

PWR LED on the interface module

Table 2-166 Status display of the PWR LED

PWR LED	Meaning	Remedy
□ Off	Supply voltage not present or too small	Check the supply voltage.
■ On	Supply voltage present	---

LK1/LK2 and MT1/MT2 LEDs on the BusAdapter

Table 2-167 Status and error displays of LK1/LK2 and MT1/MT2 LEDs

LED		Meaning	Remedy
LK1/LK2	MT1/MT2*		
□ Off	Not relevant	There is no Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	Check whether the bus cable to the switch/IO controller is interrupted.
■ On	Not relevant	There is an Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	---
☼ Flashes	Not relevant	The "Node flash test" is run (the RN/ER/MT LEDs also flash).	---
Not relevant	□ Off	No error	---
Not relevant	■ On	• Fiber-optic error • Maintenance demanded: Attenuation through the fiber-optic cable is so high that operation will soon no longer be possible.	Causes and measures for the transmission route: • Replacement of fiber-optic cable if damaged or aged • Correct installation of the PROFINET connector/PROFINET connections • Adherence to maximum length of 50 m for POF cable or 100 m for PCF cable. • Secure fit of the FOC connector

* Available only on BA 2×SCRJ, BA SCRJ/RJ45 and BA SCRJ/FC BusAdapters

LED display of configuration errors

Configuration errors of the ET 200SP distributed I/O system are output on the interface module by the ER (red) and MT (yellow) LEDs.

The following configuration errors are indicated by the LEDs:

- Missing server module
- Interruptions or short circuit on the backplane bus

Principle of operation

You determine the information for cause of the error with the LED error display. After notification by the flash signal, the error type is displayed followed by the error location/error code.

The LED error display

- is active during POWER ON as well as during operation.
- Has priority over all other states that are displayed by means of the ER and MT LEDs.
- remains turned on until the cause of the error has been corrected.

Table 2-168 Display of error type and error location

Sequence		Description
1	ER and MT LEDs flash 3x with 0.5 Hz	Signaling of error type
2	MT LED flashes with 1 Hz	Display of the error type (decimal)
3	ER and MT LEDs flash 3x with 2 Hz	Signaling of error location/error code
4	ER LED flashes with 1 Hz	Display of tens digit (decimal) of the error location/error code
5	MT LED flashes with 1 Hz	Display of ones digit (decimal) of the error location/error code
6	Repeat steps 1 to 5 until the cause of the error has been corrected.	

Error display

The following table shows the possible causes of error that can occur.

Table 2-169 Error display

Error type (MT)	Error location (ER/MT)	Cause of error	Remedy
1	65*	• Missing server module • Interruptions at the backplane bus • Short circuit of communication on the backplane bus	Check the configuration of the ET 200SP.

* Slot

NOTE

A short circuit in the backplane bus supply or the bus connection supply is indicated by the following LEDs:

- PWR LED: On
- RN-, ER and MT LED: Off

5.2 Interrupts

Introduction

The I/O device generates interrupts as a reaction to specific error events. Interrupts are evaluated based on the I/O controller used.

Evaluating interrupts with I/O controllers

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostics interrupts
- Hardware interrupts
- Swapping interrupts
- Maintenance events

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

System diagnostics

STEP 7 (TIA Portal) offers innovative system diagnostics for the devices of the S7-1500 (IO controller CPU S7-1500) and the ET 200SP (IO device) automation system. Independent of the cyclic user program, messages are made available on the display of the CPU S7-1500, the CPU web server and the HMI device.

For more information on system diagnostics, refer to the System Diagnostics function manual. (http://support.automation.siemens.com/WW/view/en/59192926).

5.2.1 Triggering of a diagnostics interrupt

Triggering of a diagnostics interrupt

For an incoming or outgoing event (e.g. wire break on a channel of an I/O module), the module triggers a diagnostics interrupt if this is configured accordingly.

The CPU interrupts the processing of the user program and processes the diagnostics interrupt (OB 82). The event which led to the interrupt is entered in the start information of the diagnostics interrupt (OB 82).

5.2.2 Triggering a hardware interrupt

Triggering a hardware interrupt

During a hardware interrupt, the CPU interrupts the processing of the user program and processes the hardware interrupt block (e.g., OB 40). The event that triggered the interrupt is entered in the start information of the hardware interrupt block.

NOTE

Diagnostics "Hardware interrupt lost" (from I/O module)

Avoid creating hardware interrupts cyclically.

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

5.2.3 Triggering a swapping interrupt

Triggering a remove/insert interrupt

In the event of a remove/insert interrupt, the CPU interrupts processing of the user program and processes the remove/insert interrupt (OB 83). The event which led to the interrupt is entered in the start information of the remove/insert interrupt (OB 83).

NOTE

Parameter assignment error after removal/insertion

If you write data records from the user program to the modules of the distributed I/O, make sure that these modules actually exist and are available. You can do this by evaluating the remove/insert interrupt (OB83). After inserting a module, the remove/insert interrupt (OB83) is not called until the module has started up and its parameters are assigned. This ensures that data record operations can be executed without errors.

5.3 Alarms

Actions after a diagnostics alarm

There can be more than one diagnostic alarm at a given time. Actions initiated by diagnostics alarms:

- The ER LED on the interface module flashes.
- Diagnostic data is reported as diagnostic interrupts to the CPU of the IO controller and can be read via data records.
- Incoming diagnostics alarms are saved to the diagnostics buffer of the I/O controller.
- The diagnostics interrupt (OB 82) is called. If the diagnostics interrupt (OB 82) is not available, the I/O controller goes into STOP mode.

You can find more information on this topic in the STEP 7 online help.

Reading out the diagnostics data

Table 2-170 Reading the diagnostics with STEP 7

Automation system with IO controller	Application	See...
SIMATIC S7	Diagnostics as plain text in STEP 7 in online and diagnostics view	STEP 7 online help • As of STEP 7 V14, function manual PROFINET with STEP 7 V14 (http://support.automation.siemens.com/WW/view/en/49948856) • As of STEP 7 V5.5, system manual PROFINET System Description (http://support.automation.siemens.com/WW/view/en/19292127)
	Instruction "RDREC" (SFB 52) Read data records from the IO device	
	Instruction "RALRM" (SFB 54) Receive interrupts from the IO device	

Additional information on the data records for PROFINET IO

The structure of the diagnostic data records and programming examples are available in the Programming Manual From PROFIBUS DP to PROFINET IO (http://support.automation.siemens.com/WW/view/en/19289930) and in Example application (http://support.automation.siemens.com/WW/view/en/24000238).

Causes of error and troubleshooting

The causes of error and remedies for the diagnostics alarms are described in the product manuals for I/O modules (http://support.automation.siemens.com/WW/view/en/55679691/133300) in the section "Interrupts/diagnostics alarms".

See also

Channel diagnostics (Page 36)

5.3.1 Maintenance events

Triggering of a maintenance event

The PROFINET IO interfaces of the interface module support the diagnostic concept and maintenance concept in PROFINET IO according to the IEC 61158-6-10 standard. The goal is to detect and remove potential problems as soon as possible.

For the interface module, maintenance events signal to the user when a network component must be checked or replaced.

The CPU interrupts the processing of the user program and processes the diagnostics interrupt (OB 82). The event that triggered the maintenance event is entered in the start information of the diagnostics interrupt (OB 82).

At the following events:

- The interface module signals a maintenance event to the higher-level diagnostic system
- The I/O module signals a maintenance event.

Table 2-171 Triggering of a maintenance event

Maintenance alarm	Event	Meaning
Maintenance demanded (*maintenance demanded*) MT LED is lit	Synchronization loss	• No synchronization telegram received No synchronization telegram was received by the sync master within the timeout period after parameter assignment or during operation. • Successive synchronization telegrams are located outside permitted limits (jitter)
	Critical FOC attenuation	The received light intensity at the FOC port is critical. The FOC should be replaced.
	Maintenance request from I/O module	An I/O module signals a maintenance event that is sent and displayed by the interface module

System alarms in STEP 7 (TIA Portal)

The maintenance information is generated in STEP 7 with the following system alarms:

- Maintenance demanded - indicated for each port by a yellow wrench icon in the device view or in the hardware configuration.

You can find more information in the STEP 7 online help.

5.3.2 Channel diagnostics

Function

Channel-related diagnostics provides information about channel faults in modules.

Channel faults are mapped as channel diagnostics data in IO diagnostics data records.

The data record is read using the instruction "RDREC".

Structure of the diagnostics data records

The data records supported by the ET 200SP distributed I/O system are based on the standard PROFINET IO - Application Layer Service Definition V2.3.

You can download the standard PROFIBUS user organization (http://www.profibus.com) from the homepage of the PROFIBUS User Organization.

Codes of the extended channel diagnostics

With the IM 155-6 PN HS interface module, the following extended channel diagnostics are reported:

Slot number	ChannelError-Type (CET)	ExtendedChannelEr-rorType (ECET)	Associated value AddValue	Diagnostics
Module slot	0x0602	0x0691	Slot	Station stop - module parameter "Potential group" faulty or incorrect BaseUnit in actual slot (AddValue)
Slot 0	0x0602	0x0693	0x00	Diagnostics with missing server module
	0x0602	0x0698	0x00	Diagnostics backplane bus too long
	0x0602	0x0699	Slot	Diagnostics with incorrect bus configura-tion
	0x0602	0x069C	0x00	Diagnostics with incorrectly plugged BusAdapter
Server module slot	0x0610	0x06B0	0x00	Group diagnostics: Missing supply voltage L+ for the potential groups Note: The slot in which the light-colored BaseUnit of the respective load module is located is coded in the "ChannelNumber" element.

5.3.3 Invalid configuration states of the ET 200SP on PROFINET IO

Invalid configuration states

The following invalid configuration states of the ET 200SP distributed I/O system lead to the failure of the IO device or prevent the exchange of user data with the I/O modules.

- Number of modules exceeds maximum configuration
- Faulty backplane bus (e.g. defective BaseUnit). ET 200SP backplane bus interruptions do not trigger an interrupt.
- At least one I/O module is installed in a different BaseUnit than the one configured in the parameters.
- Missing server module
- Invalid or incorrectly configured BusAdapter.

NOTE

Removal of the server module will trigger a station stop. All I/O modules of the ET 200SP distributed I/O system fail (substitute value behavior) but the interface module is still exchanging data.

Revoking the station stop (by correcting the invalid configuration state) leads to a brief failure of the ET 200SP distributed I/O system and automatic restart.

See also

Status and error displays (Page 29)
Channel diagnostics (Page 36)

5.3.4 Failure of supply voltage L+ at BaseUnit BU...D

Failure of the supply voltage L+

The I/O modules react as follows to failure of the supply voltage L+ on the BaseUnit BU...D:

- If an I/O module is removed during failure of the supply voltage, a pull alarm is generated.
- If an I/O module is installed during failure of the supply voltage, an insert alarm is generated.

5.3.5 STOP of the IO controller and recovery of the IO device

STOP of the SIMATIC IO controller

Diagnostics frames received from the IO device while the IO controller is in STOP do not initiate a call of any corresponding OBs when the IO controller goes into RUN. You must read the data record $E00C_H$ with the "RDREC" instruction in OB 100. This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Recovery of the SIMATIC IO devices

If you want to read the diagnostics of a station after its return, you have to read the $E00C_H$ data record with the "RDREC" instruction in the rack interrupt (OB 86). This record contains all diagnostics for the slots assigned to an IO controller in an IO device.

Compatibility

6

Status of the supply voltage

Load voltage diagnostics are only valid if the station started up with a valid and complete configuration.

- For modules in the following table without a parameter assignment, the status of the supply voltage is always signaled as "1" regardless of the actual status of the supply voltage.
- If a potential group is exclusively made up of modules without parameter assignment from the table below, no group diagnostics "Missing supply voltage L+" is signaled for this potential group.

Modules	Order number
DI 8x24VDC ST	6ES7131-6BF00-0BA0
DI 16x24VDC ST	6ES7131-6BH00-0BA0
DI 8x24VDC HF	6ES7131-6BF00-0CA0
DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0
DQ 4x24VDC/2A HF	6ES7132-6BD20-0CA0
DQ 8x24VDC/0,5A ST	6ES7132-6BF00-0BA0
DQ 8x24VDC/0,5A HF	6ES7132-6BF00-0CA0
DQ 16x24VDC/0,5A ST	6ES7132-6BH00-0BA0

Reaction times for fail-safe modules

The following maximum reaction time of the interface module must be taken into account when calculating the reaction times of fail-safe modules:
maximum reaction time = configured update time + 400 µs (but at least 1.4 ms)

Technical specifications 7

Technical specifications of the IM 155-6 PN HS

	6ES7155-6AU00-0DN0
General information	
Product type designation	ET 200SP, IM 155-6 PN HS with server module
Firmware version	V4.0
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	As of STEP 7 V14
STEP 7 can be configured/integrated as of version	V5.5 SP4 or higher
PROFINET as of GSD version/GSD revision	- / V2.3
Configuration control	
Via data record	Yes
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Reverse polarity protection	Yes
Power and voltage failure backup	
Power/voltage failure backup time	5 ms
Input current	
Current consumption, max.	700 mA
Inrush current, max.	3.7 A
I^2t	0.09 A^2s
Power loss	
Power loss, typ.	2.4 W
Address area	
Address space per module	
Address space per module, max.	32 bytes; for both input and output data
Address space per station	
Address space per station, max.	968 bytes each for input data and output data
Hardware configuration	
Racks	
Modules per rack, max.	30
Submodules	

	6ES7155-6AU00-0DN0
Number of submodules per station, max.	125
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch)
1st interface	
Interface hardware	
Number of ports	2
Integrated switch	Yes
BusAdapter (PROFINET)	Yes; usable BusAdapters: BA 2x RJ45, BA 2x FC, BA 2x SCRJ, BA SCRJ / RJ45, BA SCRJ / FC, BA 2x LC, BA LC / RJ45, BA LC / FC
Protocols	
PROFINET IO device	Yes
Open IE communication	Yes
Media redundancy	Yes; as MRP or MRPD client, max. 50 or 30 devices in the ring
Interface hardware	
RJ 45 (Ethernet)	
Transmission method	PROFINET with 100 Mbps full duplex (100BASE-TX)
10 Mbps	Yes; for Ethernet services
100 Mbps	Yes; PROFINET with 100 Mbps full duplex (100BASE-TX)
Autonegotiation	Yes
Autocrossing	Yes
Protocols	
PROFINET IO device	
Services	
S7 communication	Yes
Isochronous mode	Yes; bus cycle time min. 125 µs
IRT	Yes; 125 µs, 250 µs, 500 µs, 1 ms, 2 ms, 4 ms additionally with IRT with high performance: 250 µs to 4 ms in 125 µs intervals
MRP	Yes
MRPD	Yes
PROFINET system redundancy	No
PROFIenergy	Yes
Prioritized startup	Yes
Shared device	Yes
Number of IO controllers with shared device, max.	4
Open IE communication	
TCP/IP	Yes
SNMP	Yes
LLDP	Yes
Isochronous mode	

	6ES7155-6AU00-0DN0
Isochronous mode (application synchronized up to terminal)	Yes
Constant bus cycle time	Yes
Shortest clock pulse	125 µs
Longest clock pulse	4 ms
Bus cycle time (TDP), min.	125 µs
Jitter, max.	0.25 µs
Interrupts/diagnostics/status information	
Status display	Yes
Interrupts	Yes
Diagnostic functions	Yes
Diagnostic indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
MAINT LED	Yes; yellow LED
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Connection display LINK TX/RX	Yes; 2x green Link LED on BusAdapter
Electrical isolation	
Between backplane bus and electronics	No
between PROFINET and all other circuits	Yes
Standards, approvals, certificates	
Network loading class	3
Security level	According to Security Level 1 Test Cases V1.1.1
Ambient conditions	
Ambient temperature during operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Dimensions	
Width	50 mm
Height	117 mm
Depth	74 mm
Weights	
Weight, approx.	147 g; without BusAdapter

Technical specifications of the BusAdapter BA 2×RJ45

Table 2-172 Technical specifications of the BusAdapter BA 2×RJ45

	6ES7193-6AR00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1
RJ45	Yes; 2 x
FC (FastConnect)	No
SCRJ	0
LC	0
Cable length	
Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	46 g

Technical specifications of the BusAdapter BA 2×FC

Table 2-173 Technical specifications of the BusAdapter BA 2×FC

	6ES7193-6AF00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1
FC (FastConnect)	Yes; 2 x
Cable length	
Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	53 g

Technical specifications of the BusAdapter BA 2×SCRJ

Table 2-174 Technical specifications of the BusAdapter BA 2×SCRJ

	6ES7193-6AP00-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (switch) SCRJ FO
RJ45	No
FC (FastConnect)	No
SCRJ	2
LC	0
Cable length	
PCF	100 m
Plastic FOC (POF)	50 m
PCF-GI	300 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Technical specifications of the BusAdapter BA SCRJ/RJ45

Table 2-175 Technical specifications of the BusAdapter BA SCRJ/RJ45

	6ES7193-6AP20-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (SCRJ + RJ45)
RJ45	Yes; 1x
FC (FastConnect)	No
SCRJ	1
LC	0
Cable length	
PCF	100 m
Plastic FOC (POF)	50 m
PCF-GI	300 m
Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm

	6ES7193-6AP20-0AA0
Depth	59 mm
Weights	
Weight, approx.	50 g

Technical specifications of the BusAdapter BA SCRJ/FC

Table 2-176 Technical specifications of the BusAdapter BA SCRJ/FC

	6ES7193-6AP40-0AA0
Interfaces	
PROFINET IO	
Number of PROFINET interfaces	1; 2 ports (SCRJ + FC)
RJ45	No
FC (FastConnect)	Yes; 1x
SCRJ	1
LC	0
Cable length	
PCF	100 m
Plastic FOC (POF)	50 m
PCF-GI	300 m
Copper cables	100 m
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Technical specifications of the BusAdapter BA 2×LC

Table 2-177 Technical specifications of the BusAdapter BA 2×LC

	6ES7193-6AG00-0AA0
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch) LC multimode glass-fiber
PROFINET IO	
RJ45	No
FC (FastConnect)	No
SCRJ	0
LC	2
Cable length	
Multimode gradient-index fiber 50/125 µm	3 km

	6ES7193-6AG00-0AA0
Multimode gradient-index fiber 62.5/125 µm	3 km
Ambient conditions	
Ambient temperature during operation	
Min.	0 °C
Max.	60 °C
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	40 g

Technical specifications of the BusAdapter BA LC/RJ45

Table 2-178 Technical specifications of the BusAdapter BA LC/RJ45

	6ES7193-6AG20-0AA0
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch) LC / RJ45
PROFINET IO	
RJ45	Yes; 1x
FC (FastConnect)	No
SCRJ	0
LC	1
Cable length	
Copper cables	100 m
Multimode gradient-index fiber 50/125 µm	3 km
Multimode gradient-index fiber 62.5/125 µm	3 km
Ambient conditions	
Ambient temperature during operation	
Min.	0 °C
Max.	60 °C
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	32 g

Technical specifications of the BusAdapter BA LC/FC

Table 2-179 Technical specifications of the BusAdapter BA LC/FC

	6ES7193-6AG40-0AA0
Interfaces	
Number of PROFINET interfaces	1
PROFINET IO	
RJ45	No
FC (FastConnect)	Yes; 1x
SCRJ	0
LC	1
Cable length	
Copper cables	100 m
Multimode gradient-index fiber 50/125 µm	3 km
Multimode gradient-index fiber 62.5/125 µm	3 km
Ambient conditions	
Ambient temperature during operation	
Min.	0 °C
Max.	60 °C
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

Dimensional drawing

A

This appendix contains a dimension drawing of the module installed on a mounting rail. Always observe the specified dimensions for installation in cabinets, control rooms, etc.

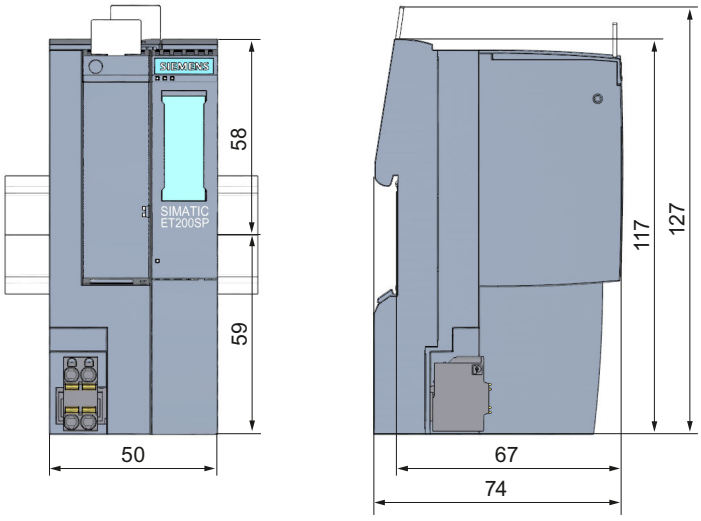

Figure 2-116 Dimension drawing of the IM 155-6 PN HS interface module (front and side view)

SIEMENS

SIMATIC

ET 200SP
Interface Module IM 155-6 PN R1 (6ES7155-6AU00-0HM0)

Equipment Manual

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Introduction 1

Purpose of the documentation

This equipment manual supplements the ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual. Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes labeled as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

ID link for the digital nameplate

The ID link is a globally unique identifier according to IEC 61406-1, which you will find in the future as a QR code on your product.

The figure shows an example of an ID link for the IM 155-6 PN R1 interface module.

You can recognize the ID link by the frame with a black corner at the bottom right. The ID link takes you to the digital nameplate of your product.

Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call the ID link (https://i.siemens.com/1P6ES7155-6AU00-0HM0+S123ABC).

In the digital nameplate, you will find product data, manuals, declarations of conformity, certificates, and other helpful information about your product.

1.1 ET 200SP Documentation Guide

1.1.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/84133942)

1.1.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.1.3 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

See also

PRONETA Professional (https://support.industry.siemens.com/cs/ww/en/view/109781283)

Industrial cybersecurity 2

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

For general information and measures regarding industrial cybersecurity, refer to the ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://www.siemens.com/cert.

2.2 Cybersecurity-relevant information

Observe all cybersecurity-relevant information.

Topics with cybersecurity-relevant information	Reference
Operational application environment and security assumptions	
Requirements for the operational application environment of the system and security assumptions	This section is found in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Topics with cybersecurity-relevant information	Reference
Security properties of the product	
Access protection	Note the information on the topic of access protection in the "Protection" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Data integrity	The topic of data integrity is described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Signed firmware update	The topic of signed firmware updates is described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Secure Boot	The topic of secure boot is described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
PROFINET Security Class 1 • The device supports PROFINET Security Class 1. • With the introduction of PROFINET Security Class 1, additional security settings have been integrated into the PROFINET communication.	Detailed information about PROFINET Security Class 1 and the additional security settings can be found in the PROFINET with STEP 7 Function Manual (https://support.industry.siemens.com/cs/us/en/view/49948856)
Supported Ethernet services	You can find information on supported services in the Technical specifications section. You can find detailed information on supported Ethernet services in the Communication Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192925).
Interfaces, ports, protocols and services	
Information on the following is security-relevant: • Communication layer and communication role • Default states • Enabling/disabling of ports and services	You can find detailed information on these topics in the Communication Function Manual (https://support.industry.siemens.com/cs/us/en/view/59192925).
Secure operation	
Recommendations for safe operation	Cross-system information on the safe operation of interface modules can be found in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Corrective measures for known risks	Corrective measures for known risks are announced on the Siemens ProductCERT and Siemens CERT (https://siemens.com/productcert) web page. For more information on SIEMENS ProductCERT, refer to the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Topics with cybersecurity-relevant information	Reference
Security checks	Application-specific security measures such as cyclic checks of the configuration via checksums are described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Secure decommissioning Products that contain security-relevant data must be securely decommissioned before disposal or resale.	Information on secure decommissioning can be found in the "Safe operation of the system" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Product overview

3

3.1 Properties

Article number

2x 6ES7155-6AU00-0HM0 (interface module IM 155-6 PN R1)

1x 6ES7193-6BR00-0HM0 (BaseUnit BU type M0 and server module)

6ES7193-6MR00-0AA0 (SIMATIC system rail, length 483 mm)

6ES7193-6MR00-0BA0 (SIMATIC system rail, length 530 mm)

6ES7193-6MR00-0CA0 (SIMATIC system rail, length 830 mm)

6ES7193-6MR00-0DA0 (SIMATIC system rail, length 2000 mm)

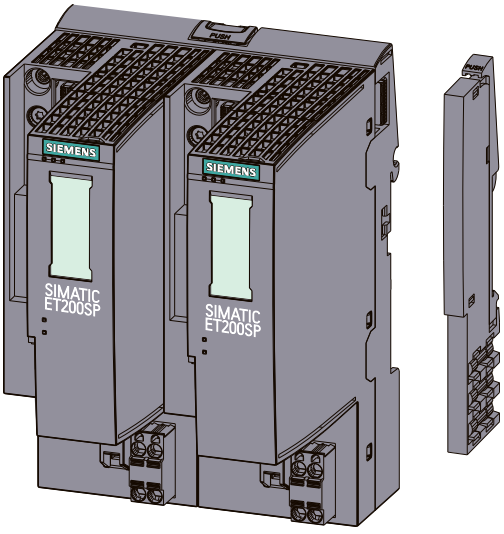

Figure 2-117 View of the ET 200SP R1 and the server module

Properties

The special feature of the ET 200SP R1 system is the high availability due to redundant PROFINET connections.

The two IM 155-6 PN R1 with the corresponding BusAdapters, together with the BaseUnit and the SIMATIC system rail, form the interface of the ET 200SP R1.

The module has the following technical properties:

- Connects the ET 200SP distributed I/O system with PROFINET IO
- Supply voltage 1L+ 24 V DC (SELV/PELV). Two connection plugs are included in the scope of delivery of the BaseUnit.
  The supply voltage is fed in via the BaseUnit.
- PROFINET IO connection via selectable BusAdapters

NOTE

The IM 155-6 PN R1 cannot be pulled/plugged when the corresponding supply voltage plug is plugged in.

NOTE

BusAdapter of the same type

Note that only BusAdapters of the same type are supported on both interface modules.

Accessories

The following accessories can be ordered separately:

- BusAdapter
  - BA 2×RJ45 for RJ45 bus connector
  - BA 2×FC for direct connection of the bus cable
  - BA 2xSCRJ for POF/PCF fiber-optic cable
  - BA 2xLC for glass fiber-optic cable
  - BA 2xM12 for bus cable with standard M12 plug
  - BA 2xLC-LD (Long Distance) for single-mode fiber-optic cables with a maximum length of 20 km
  - BA SCRJ/RJ45 as media converter for POF/PCF fiber-optic cable ⇔ standard RJ45 connector
  - BA SCRJ/FC as media converter for POF/PCF fiber-optic cable ⇔ direct connection of the bus cable
  - BA LC/RJ45 as media converter for glass fiber-optic cable ⇔ standard RJ45 connector
  - BA LC/FC as media converter for glass fiber-optic cable ⇔ direct connection of the bus cable
  - BA LC-LD/RJ45 as media converter for glass fiber-optic cable with an LC plug connector ⇔ standard RJ45 connector
  - BA LC-LD/M12 as media converter for glass fiber-optic cable with an LC plug connector ⇔ standard M12 plug or M12 push-pull connector

Information on the BusAdapters is available in the BusAdapter (https://support.industry.siemens.com/cs/ww/en/view/109751716) manual.

- BaseUnits
  - BaseUnit BU type M0 for two IM 155-6 PN R1 incl. server module and two 24 V DC connectors

Information on the BaseUnits is available in the BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) equipment manual.

- SIMATIC system rail
- Labeling strips
- Reference identification label

You can find more information on the accessories in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Configuration limits for IO devices

Maximum number of connections to IO controllers

A connection to a redundant S7-1500H system is permitted for the ET 200SP R1.

Maximum configuration

- 64 ET 200SP I/O modules
- 1 m backplane bus (without interface module)

Maximum amount of I/O data

Gross data length (for input data and output data):

- 1440 bytes

The number of maximum net data lengths for input and output data depends on the number and type of I/O modules used.

Calculation of the max. net data length:

The max. net data length is calculated according to the following formula:

Max. net data length = "Max. gross length" – "Total number of I/O submodules" – "Number of mixed I/O modules (input and output data)" – "9 bytes for interface module and server module"

The result of the calculation of the maximum net data length applies equally to input and output data.

Server module

The server module is included in the scope of delivery of the BaseUnit in a bundle and is available separately as an accessory.

The server module has the following properties:

- Terminates the backplane bus of the ET 200SP distributed I/O system.
- Features a support for 3 spare fuses (5 × 20 mm).
- Provides station functions, e.g. "Group diagnostics: No supply voltage L+", status bytes.
- I&M identification data
- Representation of the statuses of supply voltage L+ and the feedback voltage per slot.

NOTE

You need to configure and assign parameters to the server module in the configuration software.

To do this, place the server module on the last slot of the configuration and set the parameter "Group diagnostics: No supply voltage L+". For example, when there are 64 I/O modules, the server module is inserted on slot 66.

NOTE

Immediately after a redundancy switchover, the status of the regenerative voltage can be displayed as not present (= 0) for a maximum of 30 ms if:

- You are using the server module with the "Status of the feedback voltage" enabled, and
- There is no supply voltage L+ to least one digital output module and
- Feedback voltage is present

You can find more information in the server module (https://support.industry.siemens.com/cs/ww/en/view/63257531) manual.

First I/O BaseUnit of an ET 200SP in the configuration

NOTE

First I/O BaseUnit of an ET 200SP in the configuration

To route the 24 V DC supply voltage via a fuse, a light BaseUnit must be plugged into the slot of the first 24 V DC I/O module.

When an AC I/O module or AI Energy Meter ST is plugged, the first BaseUnit in an ET 200SP station may be a dark one. Note the information on limiting the overvoltage and power rating in the AC I/O module manuals.

Pay attention to the type of the BaseUnits during configuration.

3.2 Functions

Introduction

The interface module supports the following PROFINET IO functions:

- Supported Ethernet services: ICMP, ARP, SNMP, LLDP
- Port diagnostics
- Disabling of ports
- Minimum update time 1 ms
- Device replacement without programming device (PG) and without topological configuration
- Media redundancy protocol (MRP)
- Distribution of module channels to a maximum of 4 submodules
- Real-time communication
- Use of fail-safe modules
- System modifications during ongoing operation on S7-1500R/H (CiR)
- System redundancy R1
- Value status of I/O modules
- Reading out service data
- Reference temperature distribution
- H-Sync forwarding
- Setting the time
- Time distribution
- Diagnostic interrupts
- Hardware interrupts
- Removal/insertion of multiple I/O modules during operation (Multi Hot Swap)
- Maintenance events
- Reset to factory settings via PROFINET IO
- Firmware update via PROFINET IO
- Identification data I&M 0 to I&M 3

You can find more information on the system functions in the ET 200SP Distributed I/O System system manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

NOTE

Redundant firmware update

You can only perform a redundant firmware update via MFCT.

Requirements

The table below shows the software requirements for a configuration with the IM 155-6 PN R1 interface module:

Table 2-180 Version dependencies of the module functions

Function	Functional status of the module as of	Firmware version of the module as of	Configuring with GSD file (https://support.industry.siemens.com/cs/ww/en/view/57138621)	Configuring with TIA Portal V18 and higher
Supported Ethernet services: ICMP, ARP, SNMP, LLDP	1	V6.0.0	X	X
Port diagnostics	1	V6.0.0	X	X
Disabling of ports	1	V6.0.0	X	X
Minimum update time 1 ms	1	V6.0.0	X	X
Device replacement without programming device (PG) and without topological configuration	1	V6.0.0	X	X
Media redundancy protocol (MRP)	1	V6.0.0	X	X
Distribution of module channels to a maximum of 4 submodules	1	V6.0.0	X	X
Real-time communication	1	V6.0.0	X	X
Use of fail-safe modules	1	V6.0.0	---	X
System modifications during ongoing operation on S7-1500R/H (CiR)	1	V6.1.0	---	V21 or higher
System redundancy R1	1	V6.0.0	X	X
Value status of I/O modules	1	V6.0.0	X	X
Reading out service data	1	V6.0.0	X	X
Reference temperature distribution	1	V6.0.0	X	X
H-Sync forwarding	1	V6.0.0	X	X
Setting the time	1	V6.0.0	X	X
Time distribution	1	V6.0.0	X	X
Diagnostic interrupts	1	V6.0.0	X	X
Hardware interrupts	1	V6.0.0	X	X
Removal/insertion of multiple I/O modules during operation (Multi Hot Swap)	1	V6.0.0	X	X
Maintenance events	1	V6.0.0	X	X
Reset to factory settings via PROFINET IO	1	V6.0.0	X	X
Firmware update via PROFINET IO	1	V6.0.0	X	X
Identification data I&M 0 to I&M 3	1	V6.0.0	X	X

X = possible

3.2.1 Supported Ethernet services: ICMP, ARP, SNMP, LLDP

Supported Ethernet services: ICMP, ARP, SNMP, LLDP

The module supports the following standardized Ethernet services:

- **ICMP - Internet Control Message Protocol (RFC 792)**

ICMP is a protocol used to transmit informational and error messages over the Internet protocol.

- **ARP - Address Resolution Protocol (RFC 826)**

ARP is a protocol used to determine the hardware address (MAC) of an associated Internet Protocol (IP) address.

- **SNMP - Simple Network Monitoring Protocol (RFC 1157, RFC 3410)**

SNMP is a protocol for transmitting management information across networks.

- **LLDP – Link Layer Discovery Protocol (IEEE 802.1AB)**

LLDP is a protocol for identifying neighboring devices.

3.2.2 Port diagnostics

Port diagnostics

Depending on the BusAdapter used, the device supports special diagnostic alarms that signal the quality of data transfer on the medium used.

3.2.3 Disabling of ports

Disabling of ports

The device supports the deactivation of the port by parameter assignment, so that all communication on this port is prevented.

3.2.4 Minimum update time 1 ms

Minimum update time 1 ms

The shortest update cycle of IO data for this device is 1 ms. To achieve this value, the controller used must also support this time.

3.2.5 Device replacement without programming device (PG) and without topological configuration

Device replacement without topological configuration

In addition to both interface modules, the device name is also stored on the BusAdapter plugged into the interface module. A stored device name in each of the two BusAdapters is a prerequisite for a device exchange without topological configuration.

Replacing the interface module produces a range of scenarios for using the device name.

Table 2-181 Scenarios for using the device name

	Interface module empty	**Interface module with device name**
BusAdapter without device name	No device name available	The device name from the interface module is used and copied to the BusAdapter.
BusAdapter with device name	The device name from the BusAdapter is used and copied to the interface module.	The device name from the BusAdapter is used and copied to the interface module if this has a different device name.

Note the following constraints:

- When a BusAdapter is replaced, a device name stored in the BusAdapter is applied to the interface module after a POWER ON.
- Removal/insertion of the BusAdapter under voltage is not permitted.

Device replacement with topology configuration

IO devices with this function can be replaced in a simple manner:

- The device name does not need to be assigned with the programming device (PG).

The replaced IO device is assigned the device name by the IO controller, not by the programming device (PG). The IO controller uses the configured topology and the neighborhood relationships determined by the IO devices for this purpose. All involved devices must support the LLDP protocol (Link Layer Discovery Protocol). The configured topology must match the actual topology.

If the IO devices were already used in another configuration, reset them to factory settings before reusing them. You can find more information in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

You can find more information in the STEP 7 online help and as of STEP 7 (TIA Portal) V12 in the PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

3.2.6 Media redundancy protocol (MRP)

Media redundancy protocol (MRP)

MRP is a function for ensuring communication and plant availability. A ring topology ensures that an alternative communication path is made available if a transmission route fails.

You can find additional information in the STEP 7 online help and as of STEP 7 (TIA Portal) V12 in the PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

3.2.7 Distribution of module channels to a maximum of 4 submodules

Distribution of module channels to a maximum of 4 submodules

The IM 155-6 PN R1 interface module supports the distribution of channels of selected I/O modules over up to 4 submodules. This allows parts of an I/O module to be separately configured and parameterized.

A maximum of 256 submodules is supported, whereby 4 submodules are used for each interface module and one submodule for the server module.

The following functions are only executed if you have configured submodule 1 during configuration:

- Firmware update
- Write I&M data
- Calibration

3.2.8 Real-time communication

Real-time communication

A transmission method for PROFINET IO based on cyclic data exchange with a provider-consumer model.

3.2.9 Use of fail-safe modules

3.2.9.1 Redundancy switchover times for the fail-safe modules

Definition

In redundancy mode of the ET 200SP interface module, you can expect a changeover time to the active communication channel of up to 500 ms. During this time, the input and output values may be frozen during a redundancy switchover.

WARNING

Loss of the safety function

Take into account the changeover time of 500 ms for the PROFIsafe timeout time. If you choose a timeout time that is too small, the fail-safe IO modules are depassivated and the safety function may be lost.

3.2.10 System redundancy R1

System redundancy R1

An R1 redundancy mode represents a cyclic data exchange with PROFINET controllers in operating mode R1.

In a redundant R1 system, an interface module of the redundant IO device is connected to one of the redundant CPUs via system redundancy. Both the redundant CPUs and the redundant interface modules are synchronized with each other. The failure of only one connection ensures bumpless continuation of the I/O handling. See section Compatibility of modules (Page 41). Only the failure of both connections results in a station failure.

R1 mode is possible in both line and ring topology (MRP) and any other topologies.

You can find more information on individual topologies in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

3.2.11 System modifications during ongoing operation on S7-1500R/H (CiR)

Certain configuration changes in the RUN-Redundant system state can be carried out without interruption with system modifications during ongoing, redundant operation (Configuration in RUN, CiR).

The following configuration changes are possible:

- Add IO device
- Reconfigure I/O module

You can find more information on CiR in the S7-1500 RH system manual (https://support.industry.siemens.com/cs/us/en/view/109754833).

3.2.12 Value status of I/O modules

Value status

The IM 155-6 PN R1 interface module supports I/O modules with value status. The value status provides information about the validity of the individual process values.

Additional information on the value status can be found in the manuals for the I/O modules.

3.2.13 Reading out service data

Reading out service data

The function makes it possible to read out diagnostic and service information from the interface module.

In the case of a pending maintenance alarm, you can read out the service data and make it available to SIEMENS support for queries and product improvement.

The service data is read out using the TCP protocol. A connection on port 102 is opened for this.

Methods of reading service data

- Multi Fieldbus Configuration Tool (MFCT), V1.4.1 or higher

The download of the tool and additional information as well as documentation on the individual functions of the MFCT can be found on the Internet (https://support.industry.siemens.com/cs/de/de/view/109773881/en).

3.2.14 Reference temperature distribution

Reference temperature distribution

Specific I/O modules require a reference temperature to compensate for temperature dependence. This device supports the function of distributing this temperature on the backplane bus. Up to 4 reference temperatures can be distributed.

3.2.15 H-Sync forwarding

H-Sync forwarding

H-Sync forwarding enables a PROFINET device with MRP to forward synchronization data (synchronization frames) of a redundant S7-1500R system only within the PROFINET ring.

In addition, H-Sync Forwarding forwards the synchronization data even during reconfiguration of the PROFINET ring. H-Sync Forwarding avoids a cycle time increase if the PROFINET ring is interrupted.

3.2.16 Setting the time

The interface module supports time setting, for example, with AI Energy Meter 480VAC/CT HF (6ES7134-6PA00-0CU0).

In an application example (https://support.industry.siemens.com/cs/ww/en/view/109754890) we show you how to set the time of day.

Note that you call the block "Sync_Time_ET200SP" in the user program for each hardware identifier of the two IM 155-6 interface modules of a redundant ET 200SP R1 station. If there is a loss of redundancy on the ET 200SP R1 involved, one of the two calls of the block "Sync_Time_ET200SP" can be acknowledged with an error. If the call of one of the two blocks is successful, the time has been set in the ET 200SP R1 device.

3.2.17 Time distribution

Time distribution

For example, if there is an AI Energy Meter 480VAC/CT HF (6ES7134-6PA00-0CU0), the time is automatically distributed within the ET 200SP station. You can find more information in the section Setting the time (Page 24).

3.2.18 Diagnostic interrupts

Diagnostic interrupts

A diagnostic interrupt is a display of an error state.

If a module with diagnostic capability in which the diagnostic interrupt is released detects a change in its diagnostic state, it sends a diagnostics interrupt request to the CPU.
The CPU then interrupts the processing of the user program and processes the diagnostic interrupt OB (OB 82).

For additional information, refer to the sections Interrupts (Page 31) and Alarms (Page 33).

3.2.19 Hardware interrupts

Hardware interrupts

According to the configuration, the I/O modules or the interface module trigger a hardware interrupt for certain events/states. When a hardware interrupt occurs, the CPU interrupts the execution of the user program and runs the assigned hardware interrupt OB. The event that triggered the interrupt is entered in the start information of the assigned hardware interrupt OB by the CPU.

3.2.20 Removal/insertion of multiple I/O modules during operation (Multi Hot Swap)

Removal/insertion of multiple I/O modules during operation (Multi Hot Swap)

You can remove and insert any number of I/O modules during operation. The interface module and the inserted I/O modules remain in operation.

Reference

You can find more information on the removal/insertion of modules in the system manual Distributed I/O system ET 200SP
(https://support.industry.siemens.com/cs/ww/en/view/58649293).

3.2.21 Maintenance events

Maintenance events

A maintenance event indicates an identified maintenance requirement that has no direct influence on the function of the module. The maintenance event indicates that a check or replacement of plant components is required.

When a module with maintenance capability detects a change in its diagnostic state, it sends a maintenance request to the CPU. The CPU then interrupts the processing of the user program and processes the diagnostic interrupt OB (OB 82).

For additional information, refer to the sections Interrupts (Page 31) and Alarms (Page 33).

3.2.22 Reset to factory settings

There are two modes for resetting to factory settings:

- Resetting to factory settings via PROFINET IO or the RESET button deletes the device name, IP address, service data and I&M data 1-4 both in the selected interface module and in the corresponding BusAdapter and server module.
- Resetting via PROFINET IO using Factory Mode 8 deletes the IP address, service data and I&M data 1-4 in the device and all associated modules that support resetting to factory settings.

3.2.23 Firmware update via PROFINET IO

Firmware update via PROFINET IO

You can find information on how to perform a firmware update in the ET 200SP Distributed I/O System system manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

3.2.24 Identification data I&M 0 to I&M 3

Identification data I&M 0 to I&M 3

Identification and maintenance data (I&M data) is information saved on the module. The data is:

- Read-only (I-data) or
- Readable/writable (M-data)

Identification data (I&M0): Manufacturer information about the module that can only be read. Some identification data is also printed on the housing of the module, for example article number and serial number.
Maintenance data (I&M1, 2, 3): Plant-dependent information, e.g. installation location. Maintenance data is created during configuration and downloaded to the module.
All modules of the ET 200SP distributed I/O system support identification data (I&M0 to I&M3).

The I&M identification data supports you in the following activities:

- Checking the system configuration
- Locating hardware changes in a plant
- Correcting faults in a plant

Modules can be clearly identified online using the I&M identification data.

With TIA Portal, you can read out the identification data I&M (see online help of the TIA Portal).

You can find additional information on the identification data I&M 0 to I&M 3 in the ET 200SP distributed I/O system System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Interrupts, error messages, diagnostics and system alarms

4

4.1 Status and error displays

LED displays

The figure below shows the LED indicators on the interface modules and on the BusAdapters:

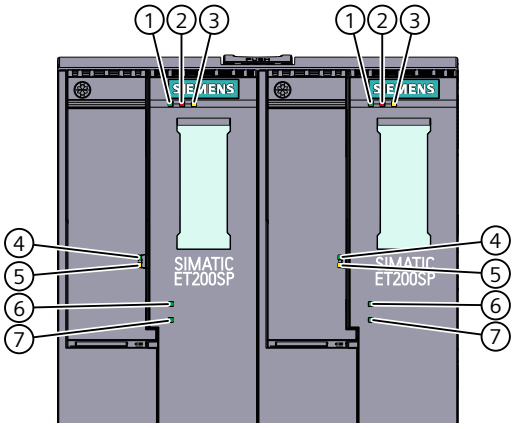

① RN (green)

② ER (red)

③ MT (yellow)

④ LK1 (green)

⑤ LK2 (green)

⑥ ACT (green)

⑦ PWR (green)

Figure 2-118 LED displays on the interface module and BusAdapter 2xRJ45

Meaning of the LEDs

The following tables contain the meaning of the status and error displays.

RN/ER/MT LEDs on the interface module

Table 2-182 Status and error displays of RN/ER/MT LEDs

LEDs			Meaning	Remedy
RN (RUN)	ER (ERROR)	MT (MAINT)		
Off	Off	Off	Missing or insufficient supply voltage on interface module.	Check the supply voltage or turn it on at the interface module.*
On	On	On	Test of LEDs during startup: The three LEDs light up simultaneously for approximately 0.25 s.	-
On	On	On	RN/ER/MT LEDs are permanently on: Hardware or firmware defective. Error information will be determined and stored retentively on the Flash memory.	Do not disconnect the interface module from the supply voltage while the LEDs are permanently lit up. This process takes between 20 s and 6 min.
Flashes	Not relevant	Not relevant	Interface module is deactivated.	Activate the interface module with the configuration software or via the user program.
			Interface module is not configured.	Configure the interface module with the configuration software.
			ET 200SP is starting up.	-
			ET 200SP is being assigned parameters.	
On	Not relevant	Not relevant	ET 200SP is currently exchanging data with an IO controller.	-
Not relevant	Flashes	Not relevant	Group error and group error channels	Evaluate the diagnostics and eliminate the error.
			The preset configuration does not match the actual configuration of the ET 200SP.	Check the design of the ET 200SP R1 to see whether a module is missing or defective, or whether a non-configured module is inserted.
			Invalid configuration states	You can find information on the hardware configuration of the ET 200SP R1 in the ET 200SP Distributed I/O System system manual; section Application planning, Hardware configuration.
			Parameter assignment error in the I/O module	Evaluate the display of the module status in HW Config and eliminate the error in the respective I/O module.
Not relevant	Not relevant	On	A maintenance required is present, that is, at least one maintenance event has occurred.	You can find more information in the section Maintenance alarms (Page 35).
Flashes	Flashes	Flashes	The "Node flash test" is run (the LEDs LK1 and LK2 of the PROFINET interface also flash).	Restart the device by disconnecting and reconnecting the supply voltage and read out the service data as described in the manual. Replace the interface module.
			Hardware or firmware defective (the LEDs LK1 and LK2 of the PROFINET interface do not flash).	-

* PWR LED on (on the interface module): Check the backplane bus for short-circuit.

ACT LED on the interface module

Status display of the ACT LED

ACT LED	Meaning
Off	There is no active data exchange with the I/O modules via this interface module.
On	Active data exchange with the I/O modules is taking place via this interface module. The partner interface module is ready for operation and can take over the data exchange in the event of a switchover.
Flashes	Active data exchange with the I/O modules is taking place via this interface module. The partner interface module is not operational and **cannot** take over the data exchange during a switchover.

PWR LED on the interface module

Status display of the PWR LED

PWR LED	Meaning	Remedy
Off	Missing or insufficient supply voltage at the interface module.	Check the supply voltage.
On	Supply voltage L+ is available.	-

LK1/LK2 LEDs on the BusAdapter

Status display of the LK LED

LK1/LK2 LEDs	Meaning	Remedy
Off	There is no Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	Check whether the bus cable to the switch/IO controller is interrupted or whether the port is disabled.
On	There is an Ethernet connection between the PROFINET IO interface of your PROFINET device and a communication partner (e.g. IO controller).	-
Flashes	The "Node flash test" is run (the RN/ER/MT LEDs also flash).	-

LED display of configuration errors

Configuration errors of the ET 200SP distributed IO system are indicated on the interface module via the red ERROR LED and the yellow MAINT LED.

The following configuration errors are indicated by the LEDs:

- Server module missing during startup of station
- Interruptions or short circuit on the backplane bus

Principle of operation

You determine the information on the cause of the error with the LED error display. After notification by the flash signal, the error type is displayed followed by the error location/error code.

The LED error display:

- Is activated during POWER ON and during operation.
- Takes precedence over all other states indicated by the ERROR LED (ER) and MAINT LED (MT).
- Remains on until the cause of the error has been eliminated.

Table 2-183 Display of error type and error location

Sequence		Description
1	The ERROR and MAINT LEDs flash 3x at 0.5 Hz	Signaling of error type
2	MAINT LED flashes at 1 Hz	Display of the error type (decimal)
3	The ERROR and MAINT LEDs flash 3x at 2 Hz	Signaling of error location/error code
4	The ERROR LED flashes at 1 Hz	Display of tens digit (decimal) of the error location/error code
5	The MAINT LED flashes at 1 Hz	Display of ones digit (decimal) of the error location/error code
6	Repetition of 1 to 5 until the cause of the error has been eliminated.	

Error display

Table 2-184 Error display

Error type (MAINT)	Error location (ERROR/ MAINT)	Cause of error	Remedy
1	65	• No server module • Interruptions at the backplane bus • Short circuit of communication on the backplane bus	Check the configuration of the ET 200SP.

NOTE

A short circuit in the backplane bus supply or the bus connection supply is indicated by the following LEDs:

- PWR LED: On
- RN, ER and MT LED: Off

More information on the BusAdapters and their status and error displays is available in the BusAdapter (https://support.industry.siemens.com/cs/ww/en/view/109751716) manual.

Show not supported BusAdapter

The LEDs RN (flashes), ER (flashes) and MT (off) on the interface module indicate that no supported BusAdapter has been inserted.

See also

Diagnostics alarms (Page 33)

Reading out service data (Page 23)

4.2 Interrupts

Introduction

The I/O device generates interrupts as a reaction to specific error events. Interrupts are evaluated based on the I/O controller used.

Evaluating interrupts with I/O controllers

The ET 200SP distributed I/O system supports the following interrupts:

- Diagnostics interrupts
- Hardware interrupts
- Pull/plug interrupts
- Maintenance events

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

System diagnostics

In STEP 7 (TIA Portal), the innovated system diagnostics is available for the devices of the S7-1500 automation system (IO controller S7-1500 CPU) and ET 200SP (IO device). Independent of the cyclic user program, alarms are made available on the display of the S7-1500 CPU, the CPU web server and the HMI device.

You will find more information on system diagnostics in the Diagnostics (https://support.industry.siemens.com/cs/ww/en/view/59192926) function manual.

4.2.1 Triggering of a diagnostics interrupt

Triggering of a diagnostics interrupt

For an incoming or outgoing event (e.g. wire break on a channel of an I/O module), the module triggers a diagnostics interrupt if this is configured accordingly.

The CPU interrupts the processing of the user program and processes the diagnostics interrupt OB (OB 82). The event that triggered the interrupt is entered in the start information of the diagnostics interrupt OB.

4.2.2 Triggering a hardware interrupt

Triggering a hardware interrupt

In the event of a hardware interrupt, the CPU interrupts processing of the user program and processes the process interrupt OB, e.g. OB 40. The event that triggered the interrupt is entered in the start information of the hardware interrupt OB.

NOTE

Diagnostics "Hardware interrupt lost" (from I/O module)

Do not use hardware interrupts for functional purposes (e.g. cyclic generation of hardware interrupts).

If the hardware interrupt load is too high, hardware interrupts can get lost depending on the number of I/O modules and the communication load.

4.2.3 Triggering of a pull/plug interrupt

Triggering of a pull/plug interrupt

In the event of a pull/plug interrupt, the CPU interrupts processing of the user program and processes the pull/plug OB (OB 83). The event that triggered the interrupt is entered in the start information of the pull/plug OB.

NOTE

Parameter assignment error after removal/insertion

If you write data records from the user program to the modules of the distributed I/O, make sure that these modules actually exist and are available. You can do this by evaluating OB83. After inserting a module, OB83 is not called until the module has started up and its parameters are assigned. This ensures that data record operations can be executed without errors.

4.2.4 Triggering of a maintenance event

Triggering of a maintenance event

The PROFINET IO interfaces of the interface module support the diagnostic concept and maintenance concept in PROFINET IO according to the IEC 61158 Type 10 standard. The goal is to detect and remove potential problems as early as possible.

For the interface module, maintenance events signal to the user when a plant component must be checked or replaced.

The CPU interrupts the processing of the user program and processes the diagnostic interrupt OB (OB 82). The event that triggered the maintenance event is entered in the start information of the diagnostic interrupt OB.

4.3 Alarms

Introduction

The ET 200SP distributed I/O system generates the following alarms:

- Diagnostic alarms
- Maintenance alarms

4.3.1 Diagnostics alarms

Actions after a diagnostic alarm

There can be more than one diagnostics alarm at the same time. Each diagnostic alarm initiates the following actions:

- The ERROR LED of the interface module flashes red.
- Diagnostic data is reported as diagnostic interrupts to the CPU of the IO controller and can be read via data records.
- Incoming diagnostic alarms are saved to the diagnostic buffer of the IO controller.

Table 2-185 Diagnostic alarms, their meaning and possible remedies

Diagnostic alarm	Channel error type (CET)	Extended Channel Error Type (ECET)	Associated value AddValue	Meaning / Cause	Remedy
Configuration error: Station stop - missing or wrong server module	0x0602	0x0693	-	No server module was plugged in during startup of an ET 200SP station.	Check that the server module is installed correctly in the rack.
Configuration error: Permitted size of backplane exceeded	0x0602	0x0698	-	The total width of the installed modules exceeds the permitted configuration length of 1 000 mm.	Check that the configuration of the backplane bus does not exceed the permitted size.
Configuration error: Incorrect backplane bus configuration in slot <slot>	0x0602	0x0699	Slot	The maximum power requirement of all installed modules exceeds 2 100 mA in total. The associated value <slot> indicates the faulty slot.	Check backplane mounting.
Configuration error: Invalid BusAdapter on the interface module	0x0602	0x069C	-	The installed BusAdapter does not correspond to the configuration.	Check project planning and mounting of the right BusAdapter.
Configuration error: Module parameter 'potential group' incorrect or wrong BaseUnit/TerminalBlock on real configuration slot <slot>	0x0602	0x069F	Slot	The configured BaseUnit or the terminal block does not match the real configuration.	Check for suitable base unit or terminal block.
Load voltage error: Missing voltage in load group at slot according channel number	0x0610	0x6B0	-	No supply voltage to the load group.	Check the load supply voltage of the modules.
Redundancy error: Maintenance demanded <internal error code>	0x0630	0x06D0	ErrorCode	There is a problem which may lead to redundancy loss.	Perform the operating instructions described in the manual. The interface modules and the BaseUnit should be replaced at the next opportunity.*)
Redundancy error: Failure in BusAdapter of partner module	0x0630	0x06D2	-	The BusAdapter of the redundancy partner module is not installed or is not supported.	Replace BusAdapter of partner module.

*) Read the service data according to the description in the manual and send them to the SIEMENS Customer Support for root cause analysis.

PROFINET IO

Another source of diagnostic events is the PROFINET basic technology in use. It generates diagnostics messages containing coding that is already defined in the PROFINET IO Standard - Application Layer Service Definition V2.2.

The actual scope of diagnostics used is dependent on the configuration and parameter assignment.

You can download the standard if needed on the Internet (https://www.profibus.com) from the home page of the PROFIBUS user organization.

4.3.2 Maintenance alarms

Maintenance alarms

A maintenance event is generated each time a maintenance requirement is identified. The maintenance LED on the interface module lights up in yellow.

NOTE

Maintenance messages have no direct effect on the module function.

Table 2-186 Maintenance messages, their meaning and possible remedies

Maintenance message	Channel error type (CET)	Extended Channel Error Type (ECET)	Associated value AddValue	Meaning / Cause	Remedy
Configuration error: Missing or wrong server module	0x0602	0x069E	-	When operating an ET 200SP station, the server module is pulled.	Check that the server module is installed correctly in the rack.
Redundancy error: Maintenance demanded <internal error code>	0x0630	0x06D0	ErrorCode	There is a problem which may lead to redundancy loss.	Perform the operating instructions described in the manual. The interface modules and the BaseUnit should be replaced at the next opportunity.*)
Redundancy error: Power supply malfunctioning	0x0630	0x06D1	-	There is a problem with the power supply which may lead to redundancy loss.	Perform a maintenance cycle as described in the manual. **)
Redundancy error: Redundancy partner with different hardware or software version	0x0630	0x06D3	-	The hardware/firmware versions of the redundancy partners are not identical.	Replace the module with one with the same MLFB of the redundancy partner, or perform a firmware update with the identical version of the redundancy partner.
Hardware error: Failure on access of flash memory in base unit or in carrier module	0x0640	0x06E0	Slot	An error in the memory block on the BaseUnit was detected during operation.	Check if the base unit or the carrier module is mounted correctly into the rack or replace base unit or the carrier module.

*) Read the service data according to the description in the manual and send them to the SIEMENS Customer Support for root cause analysis.

**) As described in the ET 200SP Distributed I/O System system manual

Maintenance message	Channel error type (CET)	Extended Channel Error Type (ECET)	Associated value AddValue	Meaning / Cause	Remedy
Hardware error: Failure on access of flash memory in BusAdapter	0x0640	0x06E1	Slot	An error of the memory block of the BusAdapter was detected during operation.	Check if the BusAdapter is mounted correctly into the module or replace the BusAdapter.
Hardware error: Module resource limit has been reached	0x0640	0x06E2	Error code	The internal memory block was overloaded. Example: Increased memory requirements caused by extreme overload over PROFINET (denial of service).	Read the service data according to the description in the manual and send them to the SIEMENS Customer Support for root cause analysis.
Hardware error: Increased disturbances detected	0x0640	0x06E4	Error code	For more detailed information, see the following section Compatibility (Page 41).	Check the operational environment of your rack with regard to external impacts (e.g. high voltage pulses, EMC, radiation). To reset the diagnosis, read the service data according to the description in the manual and send them to the SIEMENS Customer Support for root cause analysis.

*) Read the service data according to the description in the manual and send them to the SIEMENS Customer Support for root cause analysis.

**) As described in the ET 200SP Distributed I/O System system manual

4.3.2.1 Automatic restart of the interface module in case of error

Automatic restart of the interface module in case of error

In the following situations, the interface module is restarted automatically:

- Detected code distortions, for example due to radiation exposure (cosmic rays or a radioactively contaminated environment)
- Firmware error

It can take 20 s to 6 minutes between detecting such an error and restarting. For this time, there is a loss of redundancy.

If the error leads to a maintenance alarm "Hardware error: Increased disturbances detected", read out the service data from the device and make it available to SIEMENS support for queries and product improvement. Only reading out service data leads to the reset of the Maintenance LED display.

You can find more information on reading out the service data in section Reading out service data (Page 23).

4.3.2.2 Invalid configuration states of the ET 200SP on PROFINET IO

Invalid configuration states

The following invalid configuration states prevent data exchange:

- Number of modules exceeds maximum configuration. You can find additional information on the maximum configuration in the section Properties (Page 13).
- Faulty backplane bus (e.g. defective BaseUnit). An interruption of the ET 200SP backplane bus does not trigger an interrupt.
- Server module missing during startup of station
- Invalid or incorrectly configured BusAdapter

Wiring

5

5.1 Pin assignment

Definition

Each interface module has its own 24 V connection.

24 V DC supply voltage

The following table shows the signal names and the descriptions of the pin assignment of the 24 V DC supply voltage.

Table 2-187 Pin assignment 24 V DC supply voltage

View		Signal name [1]	Description
Connector	IM connection		
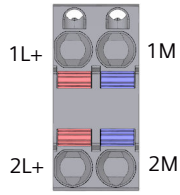	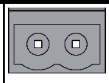	1L+	24 V DC
		2L+	24 V DC (for looping through)[2]
		1M	Ground
		2M	Ground (for looping through)[2]

[1] 1L+ and 2L+ as well as 1M and 2M are bridged internally

[2] Maximum 10 A permitted

Reference

You can find more information on connecting the interface module and on the accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

You can find more information on the pin assignment of the BusAdapter under PROFINET IO BusAdapter (https://support.industry.siemens.com/cs/ww/en/view/109773801).

5.2 Schematic circuit diagram

Schematic circuit diagram

The following figure shows the block diagram of the IM 155-6 PN R1 interface module.

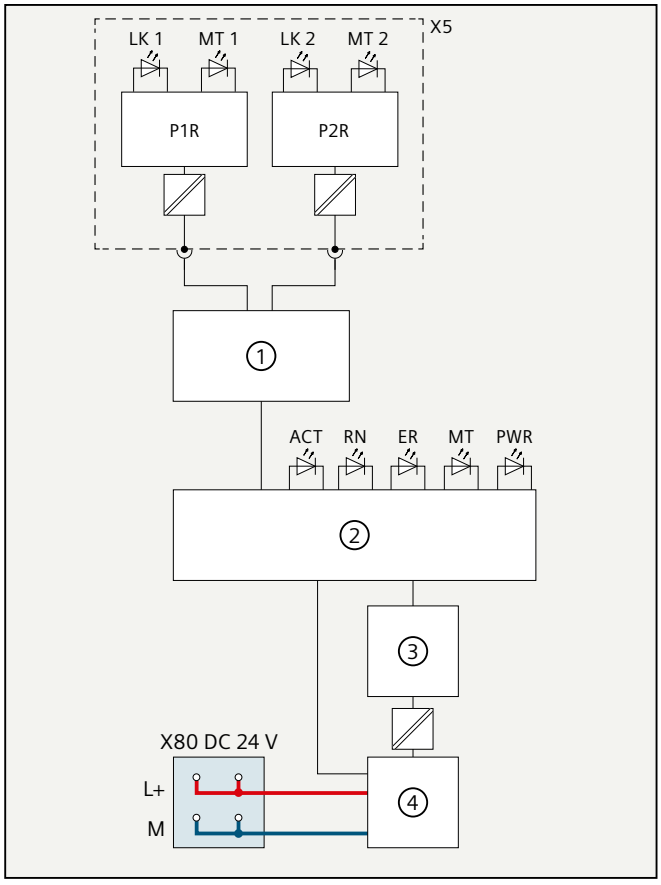

①	Switch	L+	24 V DC supply voltage
②	ET 200SP backplane bus interface and electronics	M	Ground
③	Backplane bus	LK 1,2	Link TX/RX LED (green)
④	Internal voltage distribution	MT 1,2	MAINTENANCE FiberOptic LED (optional, yellow)
X80	24 V DC supply voltage infeed	ACT	ACTIVE LED (green)
X5	BusAdapter	RN	RUN LED (green)
P1R	PROFINET interface X1 port 1	ER	ERROR LED (red)
P2R	PROFINET interface X1 port 2	MT	MAINTENANCE LED (yellow)
		PWR	Power LED (green)

Figure 2-119 Schematic circuit diagram of the IM 155-6 PN R1 interface module

Parameter 6

Description

You configure the ET 200SP R1 on a redundant S7-1500H system.

6.1 Status of the supply voltage L+ of the I/O modules

You can find information on the status of the supply voltage L+ of the I/O modules in the Server module (https://support.industry.siemens.com/cs/ww/en/view/63257531) equipment manual.

6.2 Substitute value behavior

The substitute value behavior in the ET 200SP distributed I/O system is executed by the IO controller for each slot.

The respective output behaves according to its configured substitute value behavior:

- Current-free/voltage-free
- Output substitute value
- Keep last value

The substitute value behavior is triggered in the following cases:

- STOP of H-system (both controllers are in STOP state at the same time)
- H-system failure (connection interruption on both controllers at the same time)
- Stop of station, e.g. due to missing server module during startup of the ET 200SP R1 station
- Deactivating the IO device

NOTE

Reducing a configuration

If you reduce the configuration of the ET 200SP distributed I/O system and download the configuration to the CPU, the modules which are no longer configured but still present retain their original substitute value behavior. This applies until the supply voltage is switched off at the interface module or the modules are removed.

The "current-free/voltage-free" behavior takes effect in the following cases:

- Incorrectly configured module
- Module with incorrect parameter assignment

Compatibility 7

7.1 Compatibility of modules

Station configuration with more than 32 I/O modules

Certain I/O modules with functional status 001 and 002 do not support a station configuration with more than 32 I/O modules.

The following table shows all modules that do not support a station configuration with more than 32 I/O modules.

Table 2-188 Incompatible modules with functional status

Modules	Article number	Up to and including functional status
Analog modules		
AI 4xI 2-/4-wire ST	6ES7134-6GD00-0BA1	002
AI 4xU/I 2-wire ST	6ES7134-6HD00-0BA1	002
AI 4xRTD/TC 2-/3-/4-wire HF	6ES7134-6JD00-0CA1	002
AI 4xU/I ST	6ES7135-6HD00-0BA1	002
Digital modules		
DI 16x24VDC ST	6ES7131-6BH00-0BA0	002
DI 8x24VDC ST	6ES7131-6BF00-0BA0	002
DQ 16x24VDC/0.5A ST	6ES7132-6BH00-0BA0	002
DQ 4x24VDC/2A ST	6ES7132-6BD20-0BA0	002
DQ 8x24VDC/0.5A ST	6ES7132-6BF00-0BA0	002

Bumpless changeover of modules

You can find additional information on the bumpless changeover of modules in the Product Information on the Internet (https://support.industry.siemens.com/cs/ww/en/view/73021864).

Operation of modules in isochronous mode

Since the ET 200SP R1 system does not support isochronous mode, there is a corresponding functional limitation with modules (e.g. TM Timer DIDQ 10x24) that require isochronous mode for full functionality.

Data record repetition on redundancy switchovers

During a redundancy switchover, it may happen that a data record addressed to the module does not reach the recipient or the data record response cannot be delivered. In these cases, there is an automatic repetition of data records.

For some modules, this behavior may result in error messages or state errors in related instructions. Therefore, you must evaluate the error messages for these instructions and react to them in an application-specific manner.

The following table shows affected modules and instructions.

Table 2-189 Modules and instructions that require an application-specific error response

Modules	Instruction	Article number
ET 200SP, CM PTP		6ES7137-6AA00-0BA0
ET 200SP, CM PTP	• PtP communication • USS communication • MODBUS (RTU) • ET200S serial interface • SIMATIC NET CP	6ES7137-6AA01-0BA0

Technical specifications

8

Technical specifications of IM 155-6 PN R1

The following table shows the technical specifications as of 11/2022. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7155-6AU00-0HM0/td?dl=en).

Article number	6ES7155-6AU00-0HM0
General information	
Product type designation	IM 155-6 PN R1
HW functional status	From FS03
Firmware version	V6.1
• FW update possible	Yes
Product function	
• I&M data	Yes; I&M0 to I&M4
• Module swapping during operation (hot swapping)	Yes; Multi-hot swapping
• Isochronous mode	No
• IRT	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V19
• STEP 7 configurable/integrated from version	use GSD file
• PROFINET from GSD version/GSD revision	GSDML V2.45
Configuration control	
via dataset	No
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
reconfiguration possible in RUN	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Short-circuit protection	Yes
Mains buffering	
• Mains/voltage failure stored energy time	10 ms
Input current	
Current consumption, max.	700 mA
Inrush current, max.	5 A
I^2t	0.36 $A^2 \cdot s$

Article number	6ES7155-6AU00-0HM0
Power loss	
Power loss, typ.	2.4 W
Address area	
Address space per module	
• Address space per module, max.	288 byte; For input and output data respectively
Address space per station	
• Address space per station, max.	1 440 byte
Hardware configuration	
Rack	
• Quantity of operable ET 200SP modules, max.	64
• Quantity of operable ET 200AL modules, max.	0
Submodules	
• Number of submodules per station, max.	256
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch)
1. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; with BusAdapter
• Number of ports	2; with BusAdapter
• integrated switch	Yes
• BusAdapter (PROFINET)	Yes; BA 2x RJ45, BA 2x M12, BA 2x FC, BA 2x SCRJ, BA SCRJ/RJ45, BA SCRJ/FC, BA 2x LC, BA LC/RJ45, BA LC/FC, BA 2x LC-LD, BA LC-LD/RJ45, BA LC-LD/M12
Protocols	
• PROFINET IO Device	Yes
• Open IE communication	Yes
• Media redundancy	Yes; PROFINET MRP client
PROFINET IO Device	
Services	
– IRT	No
– PROFIenergy	No
– Prioritized startup	No
– Shared device	No

Article number	6ES7155-6AU00-0HM0
Interface types	
RJ 45 (Ethernet)	
• Transmission procedure	PROFINET with 100 Mbit/s full duplex (100BASE-TX)
• 100 Mbps	Yes
• Autonegotiation	Yes
• Autocrossing	Yes
Protocols	
Supports protocol for PROFINET IO	Yes
PROFIsafe	Yes
PROFIBUS	No
EtherNet/IP	No
Modbus TCP	No
Redundancy mode	
• PROFINET system redundancy (S2)	No
• PROFINET system redundancy (R1)	Yes
• H-Sync forwarding	Yes
Media redundancy	
– MRP	Yes
– MRPD	No
Open IE communication	
• TCP/IP	Yes
• SNMP	Yes
• LLDP	Yes
Interrupts/diagnostics/status information	
Status indicator	Yes
Alarms	Yes
Diagnostics function	Yes
Diagnostics indication LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• MAINT LED	Yes; Yellow LED
• ACT LED	Yes; green LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Connection display LINK TX/RX	Yes; 2x green link LEDs on BusAdapter
Potential separation	
between backplane bus and electronics	No
between PROFINET and all other circuits	Yes; 1500 V AC (type test)
between supply and all other circuits	Yes

Article number	6ES7155-6AU00-0HM0
Permissible potential difference	
between different circuits	Safety extra low voltage SELV
Isolation	
Isolation tested with	707 V DC (type test)
Security	
PROFINET Security Class	1
signed firmware update	Yes
Secure Boot	No
safely removing data	No
data integrity	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; No condensation
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m
Connection method	
ET-Connection	
• via BU/BA Send	No
Dimensions	
Width	50 mm
Height	138 mm
Depth	89 mm
Weights	
Weight, approx.	192 g; without BusAdapter

Dimension drawing

A

This appendix contains the dimension drawing of the ET 200SP R1 including its BaseUnit, mounted on a SIMATIC system rail. You must take into account the dimensions for installation in cabinets, control rooms, etc.

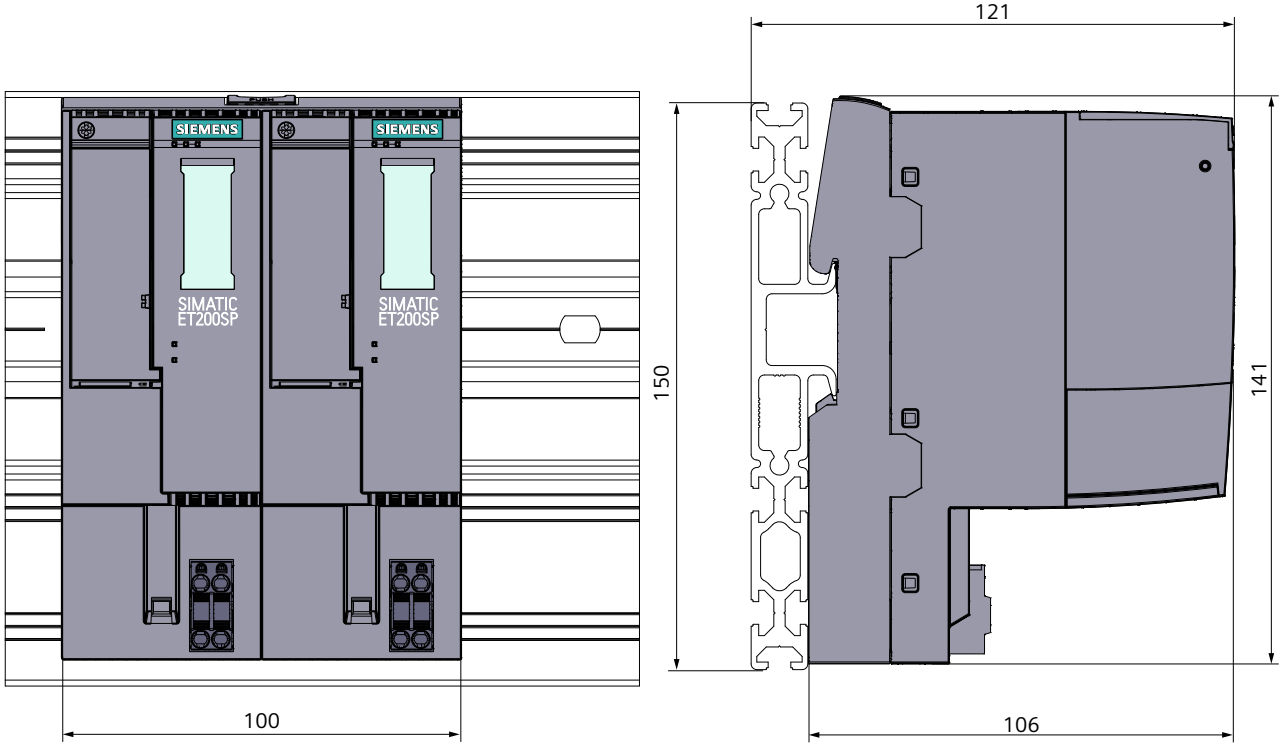

Figure 2-120 Dimension drawing for ET 200SP R1 (front and side view)

SIEMENS

SIMATIC

ET 200SP
Server module
(6ES7193-6PA00-0AA0)

Equipment Manual

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Diagnostics alarms 4

Technical specifications 5

Parameter data record 6

Dimensional drawing A

03/2015
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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes labeled as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

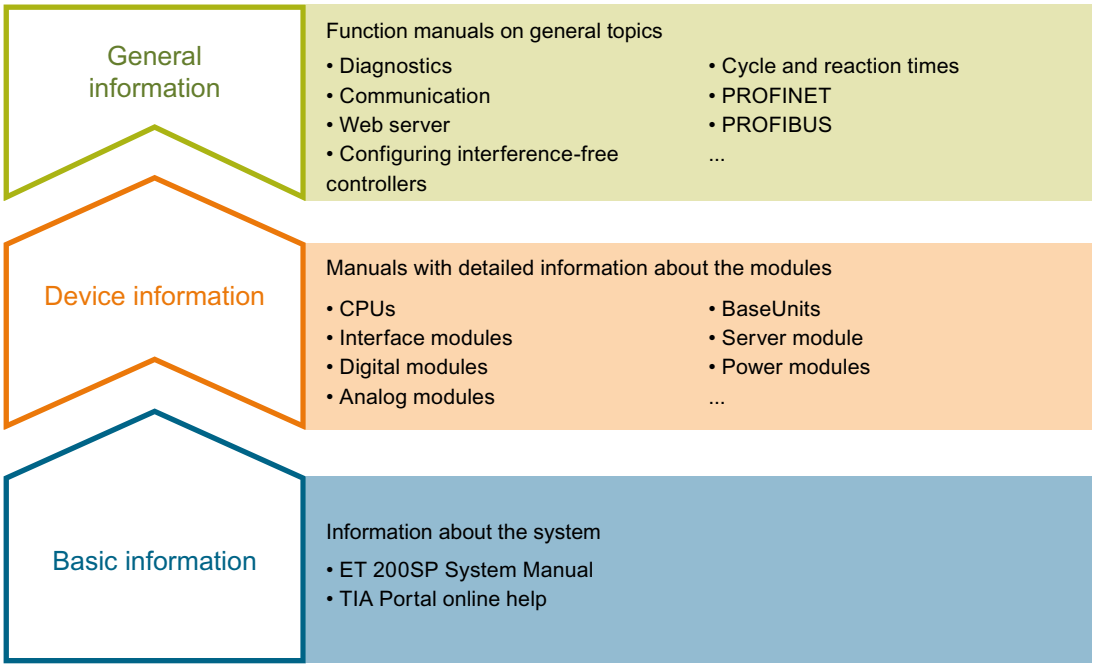

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

Application examples

Applications examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

2.1 Properties

Article number

6ES7193-6PA00-0AA0

View of the module

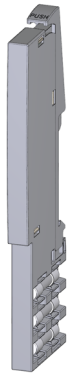

Figure 2-121 View of the server module

Properties

The module has the following technical properties:

- Closes off the backplane bus of the ET 200SP
- Contains a support for 3 spare fuses (5 × 20 mm)

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- Representation of the statuses of supply voltage L+ and the feedback voltage (Page 15) per slot.
- Retentive storage of device name for device replacement without topological configuration of the IM 155-6 PN BA.

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Function and properties	Product version of the module as of	Firmware version of the module as of
Support of the IM 155-6 PN BA	1	V1.1.1

Parameters/address space 3

3.1 Parameters

Parameters for the server module

The effective range of the configurable parameter depends on the type of configuration. Possible configuration: Distributed operation on PROFINET IO in an ET 200SP system.

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameter to the module by means of data records, see section Parameter assignment and structure of parameter data record (Page 19).

The following parameter settings are possible:

Table 2-190 Configurable parameter and its default (GSD file)

Parameters	Range of values	Default	Reconfiguration in RUN	Effective range with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Group diagnostics: No supply voltage L+	• Disable • Enable	No	Yes	ET 200SP	---

3.2 Explanation of the parameters

Group diagnostics: No supply voltage L+

When you enable this parameter, the ET 200SP generates one diagnostic per potential group (as group information) when the supply voltage L+ fails.

This function does not depend on enabling the parameter "Diagnostics: No supply voltage L+" of the I/O modules.

The diagnostics is formed from the states of the supply voltage of the installed I/O modules within the potential group.

Requirements

- All I/O modules must be inserted, i.e. the current configuration must not have any empty slots.
- If no I/O modules are inserted on light-colored BaseUnits BU..D, the beginning of this potential group is not recognized. The I/O modules of this potential group are therefore part of the previous potential group.
  If the I/O module is installed on the light-colored BaseUnit, the potential group is detected, the diagnostics is reevaluated according to the potential group arrangement and new diagnostics may be reported. The position of the light-colored BaseUnit remains stored in the structure until the supply voltage 1L+ of the CPU/interface module is turned off.

3.3 Address space

Introduction

You can read out the status of the supply voltage L+ and the feedback voltage of I/O modules via the address space of the server module:

- All I/O modules:
  No supply voltage L+ or no I/O module available
- Additional digital output module HF:
  feedback voltage present

Requirements

- The I/O module used must support monitoring of the supply voltage.
- The I/O module used must support monitoring of a feedback voltage.

Length of input data

The length of the input data depends on the CPU/interface module:

- Interface module with 12 I/O modules maximum configuration: 2/4 bytes
- Interface module with 32 I/O modules maximum configuration: 4/8 bytes
- CPU/interface module with 64 I/O modules maximum configuration: 8/16 bytes

Configurations

In the configuration software, you can select 3 configurations for the server module for operation on the CPU/interface module:

- Configuration with disabled "Status of the supply voltage L+" and disabled "Status of the feedback voltage":
  - The server module only has one diagnostics address.
- Configuration with enabled "Status of the supply voltage L+" and disabled "Status of the feedback voltage":
  - The server module has 2/4/8 bytes of input data for the display of the status of the supply voltage L+ of the inserted I/O modules.
  - Display in the input data of the server module:

    Supply voltage L+ present/missing or I/O module available/not available

- Configuration with enabled "Status of the supply voltage L+" and enabled "Status of the feedback voltage":
  - The server module has 4/8/16 bytes of input data for the display of the status of the supply voltage L+ and the status of the feedback voltage of the inserted I/O modules.
  - Display in the input data of the server module:

    Supply voltage L+ present/missing or I/O module available/not available

    Feedback voltage present/missing

Table 2-191 Data length depending on configuration and maximum configuration

Maximum configuration	"Status supply voltage" deactivated	Activated	Activated
	"Status feedback voltage" deactivated	Deactivated	Activated
12 slots	0	2	4
32 slots	0	4	8
64 slots	0	8	16

3.3.1 Input data for interface modules with maximum 12 I/O modules

Configuration with enabled status detection of the supply voltage L+ (2 bytes of input data)

You can read out the following status for each I/O module of the ET 200SP in the input data (byte 0 to 1):

- Supply voltage L+ present/missing or I/O module available/not available (2 bytes)

	7	6	5	4	3	2	1	0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	x	x	x	x	12	11	10	9

Slots of the I/O modules
Bit = 1:
Supply voltage L+ available and I/O module available
Bit = 0:
Missing supply voltage L+ or no I/O module available
X = 0

Figure 2-122 Configuration with enabled status detection of the supply voltage L+ (2 bytes)

Configuration with enabled status detection of the supply voltage L+ and enabled status detection of the feedback voltage (4 bytes of input data)

You can read out the following status for each I/O module of the ET 200SP in the input data (byte 0 to 3).

- Supply voltage L+ present/missing or I/O module available/not available (2 bytes)
- Feedback voltage present/missing (2 bytes)

	7	6	5	4	3	2	1	0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	x	x	x	x	12	11	10	9

Slots of the I/O modules
Bit = 1:
Supply voltage L+ available and I/O module available
Bit = 0:
Missing supply voltage L+ or I/O module not available
x = 0

Byte 2	8	7	6	5	4	3	2	1
Byte 3	x	x	x	x	12	11	10	9

Bit = 1:
Feedback voltage present
Bit = 0:
Feedback voltage missing
x = 0

Figure 2-123 Configuration with enabled status detection of the supply voltage L+ and enabled status detection of the feedback voltage (4 bytes of input data)

NOTE

- An inserted or missing server module always signals bit=0 for the slot.
- If the server module is missing, the input data is invalid.
- For I/O modules without feedback voltage monitoring, the bit for the feedback voltage is the same as the bit for the missing supply voltage L+.

3.3.2 Input data for interface modules with maximum 32 I/O modules

Configuration with enabled status detection of the supply voltage L+ (4 bytes of input data)

You can read out the following status for each I/O module of the ET 200SP in the input data (byte 0 to 3):

- Supply voltage L+ present/missing or I/O module available/not available (4 bytes)

	7	6	5	4	3	2	1	0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	16	15	14	13	12	11	10	9
Byte 2	24	23	22	21	20	19	18	17
Byte 3	32	31	30	29	28	27	26	25

Slots of the I/O modules
Bit = 1:
Supply voltage L+ available and I/O module available
Bit = 0:
Missing supply voltage L+ or no I/O module available

Figure 2-124 Supply voltage L+ missing or I/O module not available (4 bytes); feedback voltage not available

Configuration with enabled status detection of the supply voltage L+ and enabled status detection of the feedback voltage (8 bytes of input data)

You can read out the following status for each I/O module of the ET 200SP in the input data (byte 0 to 7).

- Supply voltage L+ present/missing or I/O module available/not available (4 bytes)
- Feedback voltage present/missing (4 bytes)

	7	6	5	4	3	2	1	0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	16	15	14	13	12	11	10	9
Byte 2	24	23	22	21	20	19	18	17
Byte 3	32	31	30	29	28	27	26	25

Slots of the I/O modules
Bit = 1:
Supply voltage L+ available and I/O module available
Bit = 0:
Missing supply voltage L+ or I/O module not available

Byte 4	8	7	6	5	4	3	2	1
Byte 5	16	15	14	13	12	11	10	9
Byte 6	24	23	22	21	20	19	18	17
Byte 7	32	31	30	29	28	27	26	25

Bit = 1:
Feedback voltage present
Bit = 0:
Feedback voltage missing

Figure 2-125 Configuration with enabled status detection of the supply voltage L+ and enabled status detection of the feedback voltage (8 bytes of input data)

NOTE

- An inserted or missing server module always signals bit=0 for the slot.
- If the server module is missing, the input data is invalid.
- For I/O modules without feedback voltage monitoring, the bit for the feedback voltage is the same as the bit for the missing supply voltage L+.

3.3.3 Input data for CPU/interface modules with maximum 64 I/O modules

Configuration with enabled status detection of the supply voltage L+ (8 bytes of input data)

You can read out the following status for each I/O module of the ET 200SP in the input data (byte 0 to 7):

- Supply voltage L+ present/missing or I/O module available/not available (8 bytes)

	7	6	5	4	3	2	1	0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	16	15	14	13	12	11	10	9
Byte 2	24	23	22	21	20	19	18	17
Byte 3	32	31	30	29	28	27	26	25
Byte 4	40	39	38	37	36	35	34	33
Byte 5	48	47	46	45	44	43	42	41
Byte 6	56	55	54	53	52	51	50	49
Byte 7	64	63	62	61	60	59	58	57

Slots of I/O modules
Bit = 1:
Supply voltage L+ present and I/O module available
Bit = 0:
Missing supply voltage L+ or no I/O module available

Figure 2-126 Configuration with enabled status detection of the supply voltage L+ (8 bytes)

Configuration with enabled status detection of the supply voltage L+ and enabled status detection of the feedback voltage (16 bytes of input data)

You can read out the following status for each I/O module of the ET 200SP in the input data (byte 0 to 15):

- Supply voltage L+ present/missing or I/O module available/not available (8 bytes)
- Feedback voltage present/missing (8 bytes)

	7	6	5	4	3	2	1	0
Byte 0	8	7	6	5	4	3	2	1
Byte 1	16	15	14	13	12	11	10	9
Byte 2	24	23	22	21	20	19	18	17
Byte 3	32	31	30	29	28	27	26	25
Byte 4	40	39	38	37	36	35	34	33
Byte 5	48	47	46	45	44	43	42	41
Byte 6	56	55	54	53	52	51	50	49
Byte 7	64	63	62	61	60	59	58	57

Slots of I/O modules

Bit = 1:
Supply voltage L+ present and I/O module available

Bit = 0:
Missing supply voltage L+ or no I/O module available

Byte 8	8	7	6	5	4	3	2	1
Byte 9	16	15	14	13	12	11	10	9
Byte 10	24	23	22	21	20	19	18	17
Byte 11	32	31	30	29	28	27	26	25
Byte 12	40	39	38	37	36	35	34	33
Byte 13	48	47	46	45	44	43	42	41
Byte 14	56	55	54	53	52	51	50	49
Byte 15	64	63	62	61	60	59	58	57

Bit = 1:
Feedback voltage available

Bit = 0:
Feedback voltage not available

Figure 2-127 Configuration with enabled status detection of the supply voltage L+ and enabled status detection of the feedback voltage (16 bytes of input data)

NOTE

- An inserted or missing server module always signals bit=0 for the slot.
- If the server module is missing, the input data is invalid.
- For I/O modules without feedback voltage monitoring, the bit for the feedback voltage is the same as the bit for the missing supply voltage L+.

3.3.4 Evaluating feedback voltage

Ranges of error

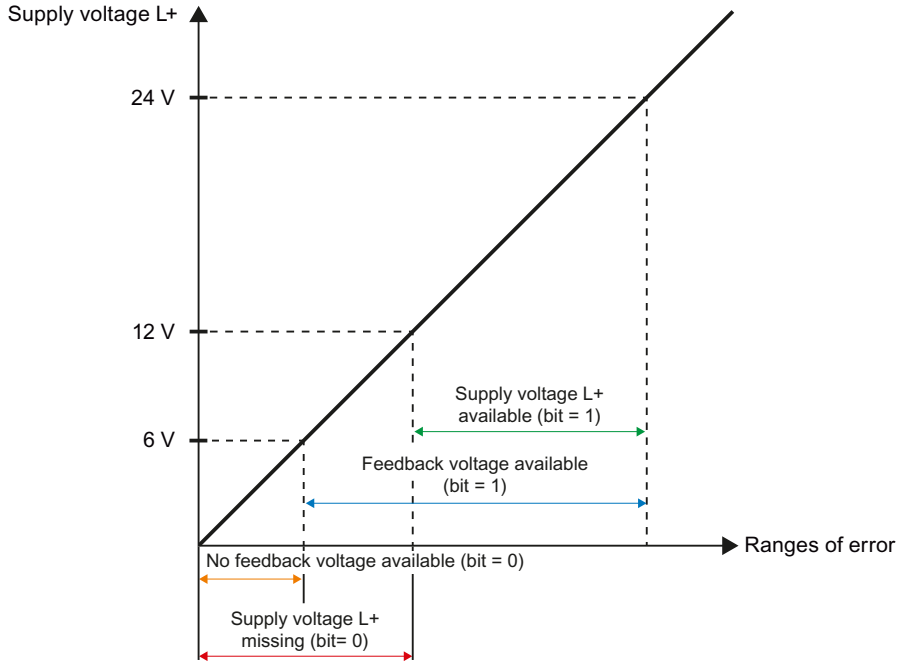

Figure 2-128 Ranges of error of the supply voltage L+ and the feedback voltage

Feedback voltage

A feedback may occur, for example, due to a crossover in a cable of a digital output module and depends on the target status of the supply voltage L+:

If the supply voltage L+ of the I/O module is greater than 6 V, this is entered in the input data in the respective bit.

- Byte 2 and 3 (for 12 I/O modules and 4 bytes of input data)
- Byte 4 to 7 (for 32 I/O modules and 8 bytes of input data)
- Byte 8 to 15 (for 64 I/O modules and 16 bytes of input data)

The feedback voltage can be evaluated via the user program in the following cases:

Table 2-192 Under what circumstances can the feedback voltage be evaluated via the user program?

Supply voltage L+ safely disconnected[1]	Status detection of supply voltage L+ (input data)	Status detection of feedback voltage (input data)	Explanation
Yes	Not available: Bit = 0	Available: Bit = 1	The feedback voltage detected is in the range 6 to 12 V (e.g. in the event of a fault in the system)
Yes	Available: Bit = 1	Available: Bit = 1	The feedback voltage detected is > 12 V (e.g. in the event of a fault in the system)

[1] This does not refer to the supply voltage applied to the BaseUnit, but, for example, to the status information of a safety relay.

Diagnostics alarms

4

A diagnostics alarm is output for each diagnostics event. The diagnostics alarms can, for example, be read out in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-193 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Server module with invalid firmware version (< V1.1.1)	$1B_H$	General error	• Replace the server module. • Firmware update of the server module.

Technical specifications

5

5.1 Technical specifications

Technical specifications of the server module

	6ES7193-6PA00-0AA0
Dimensions	
Width	7 mm
Height	117 mm
Depth	36 mm
Weights	
Weight, approx.	19 g

Parameter data record

6

6.1 Parameter assignment and structure of parameter data record

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The WRREC instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

STATUS output parameter

The module ignores errors that occurred during the transfer of parameters with the WRREC instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

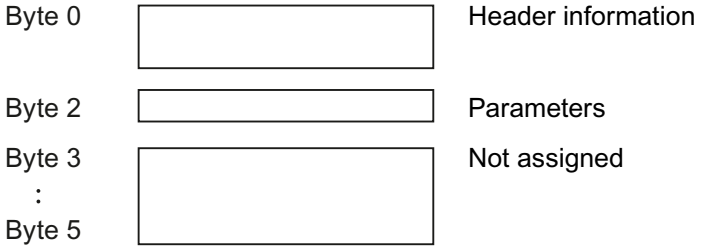

Figure 2-129 Structure of data record 128

Header information

The following diagram shows the structure of the header information.

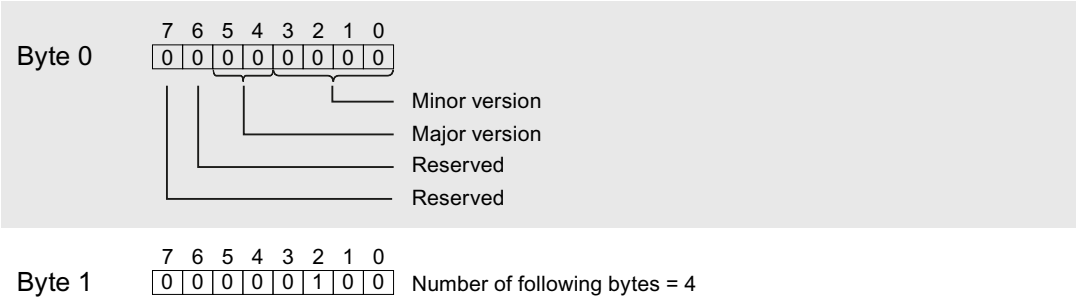

Figure 2-130 Header information

Parameters

The following diagram shows the structure of the parameter in byte 2.

Enable the parameter by setting the corresponding bit to "1".

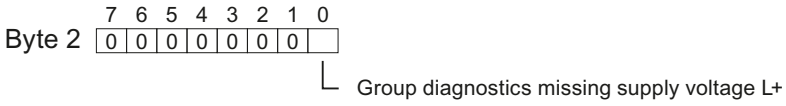

Figure 2-131 Structure of byte 2

Dimensional drawing

A

A.1 Server module

Dimensional drawing of the server module

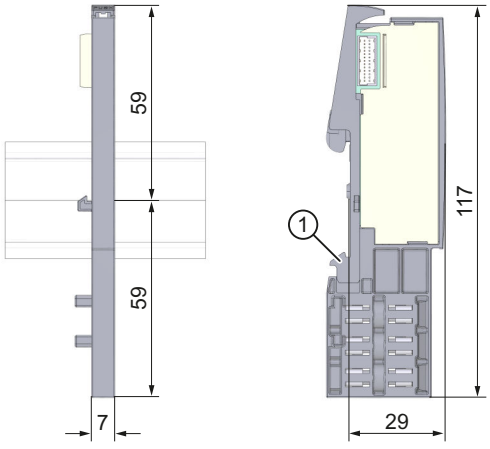

① Contact plating of mounting rail

Figure 2-132 Dimensional drawing of the server module

SIEMENS

SIMATIC

ET 200SP
Digital input module DI 4x120..230VAC ST (6ES7131-6FD01-0BB1)

Equipment Manual

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Parameter data record A

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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

Due to the change in hardware, the article number of the module has been changed from 6ES7131-6FD00-0BB1 to 6ES7131-6FD0**1**-0BB1. Both modules are compatible, except for the firmware-update function.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

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Guide to documentation

1

The documentation for the SIMATIC S7-1500 automation system and the SIMATIC ET 200MP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

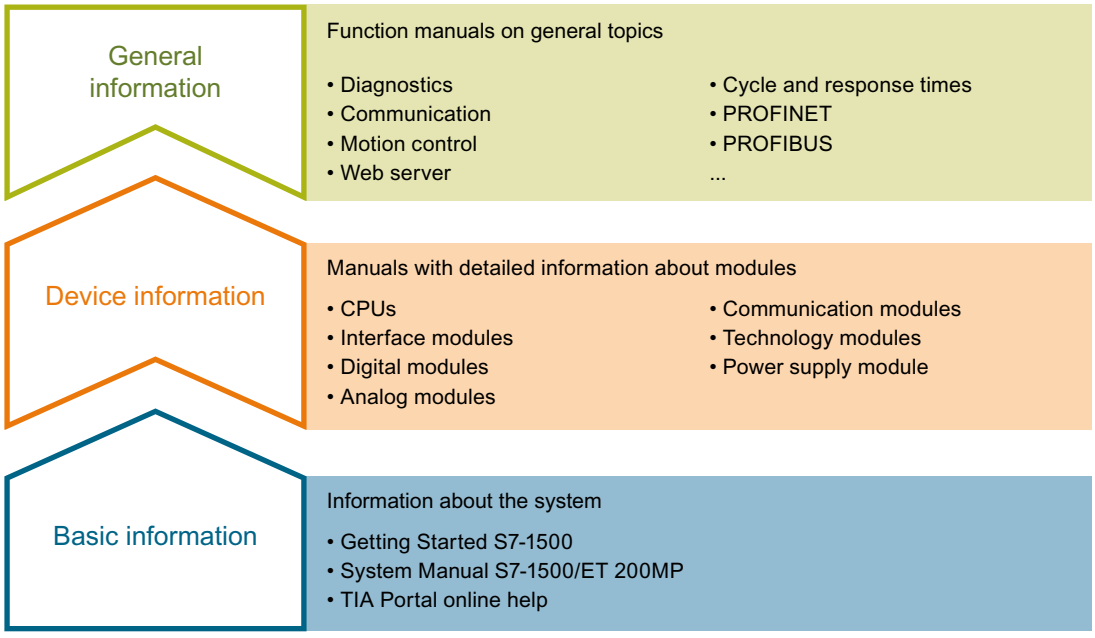

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC S7-1500 and ET 200MP systems, e.g. diagnostics, communication, motion control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/68052815).

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86140384).

SIMATIC S7-1500 comparison list for programming languages

The comparison list contains an overview of which instructions and functions you can use for which controller families.

You can find the comparison list on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86630375).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of the TIA Portal.

General function overview:

- Network browsing and creation of a table showing the accessible devices in the network.
- Flashing of device LEDs or HMI display to locate a device
- Downloading of addresses (IP, subnet, gateway) to a device
- Downloading the PROFINET name (station name) to a device
- Placing a CPU in RUN or STOP mode
- Setting the time in a CPU to the current time of your PG/PC
- Downloading a new program to a CPU or an HMI device
- Downloading from CPU, downloading to CPU or deleting recipe data from a CPU
- Downloading from CPU or deleting data log data from a CPU
- Backup/restore of data from/to a backup file for CPUs and HMI devices
- Downloading service data from a CPU
- Reading the diagnostics buffer of a CPU
- Performing a CPU memory reset
- Resetting devices to factory settings
- Downloading a firmware update to a device

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the PROFINET network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET network and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Order number

6ES7131-6FD01-0BB1

View of the module

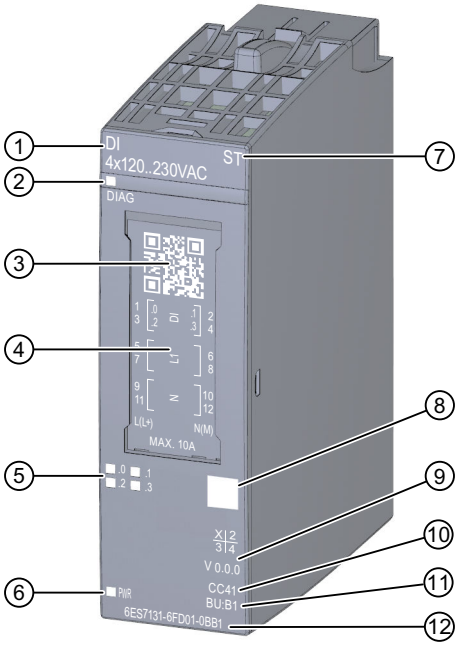

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-133 View of the module DI 4x120..230VAC ST

Properties

The module has the following technical properties:

- 4 digital inputs
- Supply voltage L+
- Suitable for connection of switches and 2-wire sensors in accordance with IEC 61131, type 3

The module supports the following functions:

Table 2-194 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X
Configuration in RUN	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X
Value status	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the DI 4x120..230VAC ST module with the terminal assignments for a 2-wire, 3-wire and 4-wire connection.

Information about wiring of the BaseUnit is available in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

You may use and combine the different wiring options for all channels.

NOTICE
Hazardous voltage, risk of fatal or serious injury Always disconnect the system and module from the power supply before commencing work.

NOTE

Limiting overvoltage

You must ensure overvoltage is limited to 1 kV for the encoder supply.

NOTE

Power limitation

To limit power, each input voltage must have a fuse with a maximum rating of 10 A tripping current. The fuse must be a quick-acting microfuse.

Connection: 2-wire and 3-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the digital input module DI 4x120..230VAC ST on the BaseUnit BU type B1 without AUX terminals (2-wire and 3-wire connection).

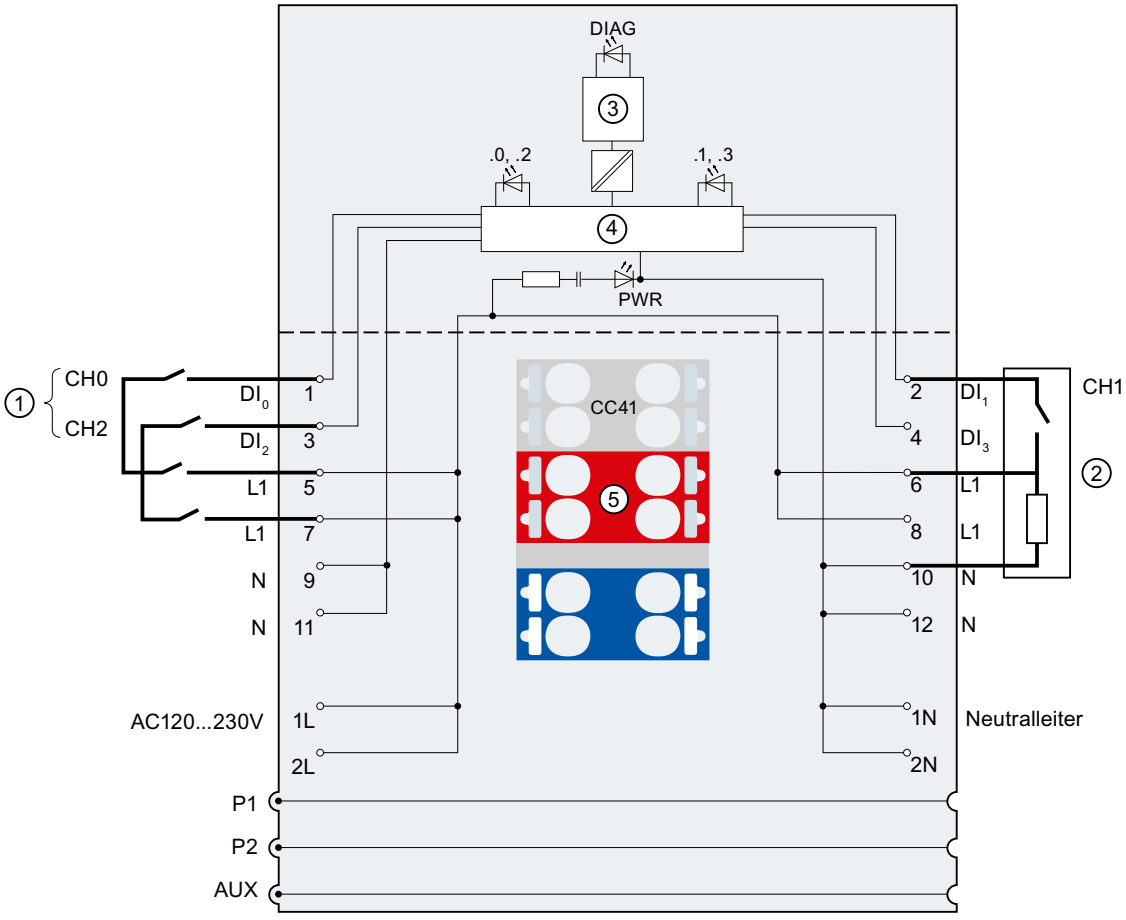

①	2-wire connection	DI_n	Input signal, channel n
②	3-wire connection	L1	Encoder supply, channel n
③	Backplane bus interface	1L / 2L	Infeed 120 ... 230 V AC
④	Input electronics	1N / 2N	N-conductor connection
⑤	Color identification label CCxx (optional)	DIAG	Error or Diagnostics LED (green, red)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	PWR	Power LED (green)
.0 to .3	Channel status LED (green)		

Figure 2-134 Wiring and block diagram for 1-wire and 2-wire connection of encoders

Connection: 4-wire connection:

The following figure shows the block diagram and an example of the terminal assignment of the digital input DI 4x120..230VAC ST on the BaseUnit BU type B1 with AUX terminals (4-wire connection).

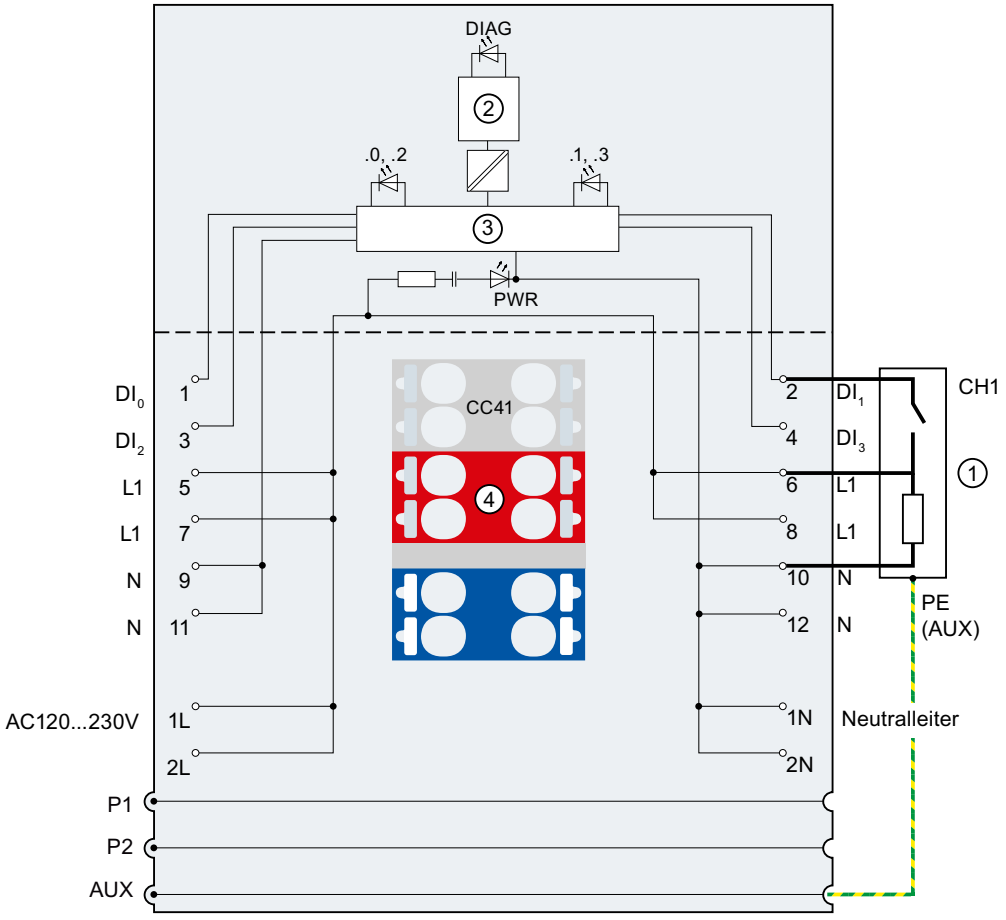

①	4-wire connection	DI_n	Input signal, channel n
②	Backplane bus interface	L1	Encoder supply, channel n
③	Input electronics	1L / 2L	Infeed 120 ... 230 V AC
④	Color identification label CCxx (optional)	1N / 2N	N-conductor connection
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	DIAG	Error or diagnostics LED (green, red)
.0 to .3	Channel status LED (green)	PWR	Power LED (green)

Figure 2-135 Wiring and block diagram for 4-wire connection of encoders.

Parameters/address space

4

4.1 Parameters

Parameters of the DI 4x120..230VAC ST

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When performing the configuration in the user program, use the "WRREC" instruction to transfer the parameters to the module using data records (refer to the section Parameter assignment and structure of parameter data record (Page 23)).

The following parameter settings are possible:

Table 2-195 Configurable parameters and their defaults (GSD file)

Parameters	Value range	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel

4.2 Explanation of parameters

Channel activated

Determines whether a channel is enabled or disabled.

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of DI 4x120..230VAC ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module using a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-196 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in hard-ware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel without value status	DI 4x120..230VAC ST V0.0	V14, SP1 or higher with HSP 0222	X	X
1 x 4-channel with value status	DI 4x120..230VAC ST V0.0, QI	V14, SP1 or higher with HSP 0222	X	---

Evaluating the value status

An additional two bytes are allocated in the input address space if you enable the value status for the digital module. Bits 0 to 3 in these bytes are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space of the digital input module DI 4x120..230VAC ST

The following figure shows the assignment of the address space for the DI 4x120..230VAC ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

Assignment in the process image of the inputs (PII)

	7	6	5	4	3	2	1	0	
IB x	0	0	0	0					Input values at channels 0 to 3
	7	6	5	4	3	2	1	0	
IB x+1	0	0	0	0					Value status (QI) at channels 0 to 3

0: value read in at channel is faulty

Figure 2-136 Address space of the DI 4x120..230VAC ST digital input module with value status

NOTE

Value status

The value status is independent of the connected supply voltage 120 ... 230 V AC.

Interrupts/diagnostics alarms

5

5.1 Status and fault displays

LED displays

The figure below shows the LED displays (status and fault displays) of the DI 4x120..230VAC ST.

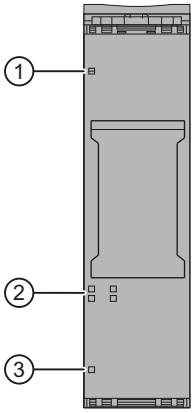

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-137 LED display

Meaning of the LEDs

The tables below explain the meaning of the Status and fault displays.

LED DIAG

Table 2-197 LED DIAG fault display

LED DIAG	Meaning
☐ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashing	Module parameters not assigned
■ On	Module parameters assigned
☼ Flashing	Module diagnostics is available

LED channel status

Table 2-198 Channel status LED status and fault display

LED channel status	Meaning
☐ Off	Process signal = 0
■ On	Process signal = 1

LED PWR

Table 2-199 LED PWR status display

LED PWR	Meaning
☐ Off	Supply voltage L+ missing
■ On	Supply voltage L+ present

5.2 Diagnostics alarms

Diagnostics alarms

A diagnostic alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostic alarm, for example, in the diagnostics buffer of the CPU. You can analyze the error code with the user program.

Table 2-200 Diagnostic alarm, meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment

5.3 Load voltage status

Load voltage status

The firmware of the module cannot detect the status of the load voltage.

If the "Load voltage status" function tied to the server module is used, a "1" is always displayed in the status bit for a slot with the DI 4×120..230VAC ST. Even when the load voltage is not applied.

Technical specifications

6

6.1 Technical specifications

DI 4×120..230VAC ST technical specifications

Article number	6ES7131-6FD01-0BB1
General information	
Product type designation	DI 4x120 ... 230 V AC ST
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type B1
Color code for module-specific color identification plate	CC41
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V14
• STEP 7 configurable/integrated as of version	V5.5 SP3
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DI	Yes
• Counter	No
• Oversampling	No
• MSI	No
Supply voltage	
Rated value (AC)	230 V
Reverse polarity protection	No
Input current	
Current consumption (rated value)	10 mA
Encoder supply	
Number of outputs	4
Short-circuit protection	No; when using BU type B1, a fuse with 10 A tripping current must be provided
Output current	
• up to 60 °C, max.	10 A

Article number	6ES7131-6FD01-0BB1
Power loss	
Power loss, typ.	1 W; Active power, load voltage 230 V, all inputs connected with 230 V, 50 Hz
Address area	
Address space per module	
• Inputs	1 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type B1
• 2-wire connection	BU type B1
• 3-wire connection	BU type B1
• 4-wire connection	BU type B1 + potential distributor module
Digital inputs	
Number of digital inputs	4
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Input voltage	
• Type of input voltage	120/230V AC (47 Hz to 63 Hz)
• Rated value (AC)	230 V
• for signal "0"	0V AC to 40V AC
• for signal "1"	74 V AC to 264 V AC
Input current	
• for signal "1", typ.	10.8 mA
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	No
– at "0" to "1", min.	1.5 ms
– at "0" to "1", max.	4 ms
– at "1" to "0", min.	10 ms
– at "1" to "0", max.	10 ms
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Encoder	
Connectable encoders	
• 2-wire sensor	Yes

Article number	6ES7131-6FD01-0BB1
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	No
• Hardware interrupt	No
Diagnostic messages	
• Monitoring the supply voltage	No
• Wire-break	No
• Short-circuit	No
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	2 545 V DC/2 s (routine test)
Altitude during operation based on sea level	
• Ambient air temperature-barometric pressure-altitude	On request: Ambient temperatures lower than 0 °C (without condensation) and/or installation altitudes greater than 2 000 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	36 g

Dimensional drawing

See the manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

The module parameters can be reassigned in RUN without affecting the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

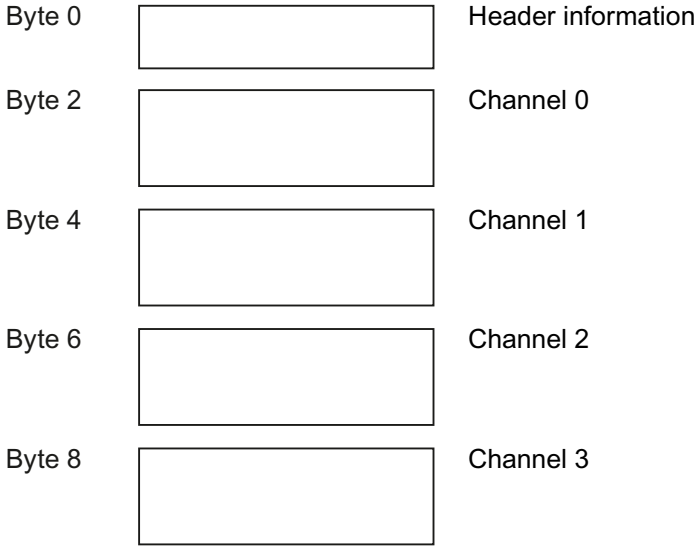

Figure 2-138 Structure of data record 128

Header information

The figure below shows the structure of the header information.

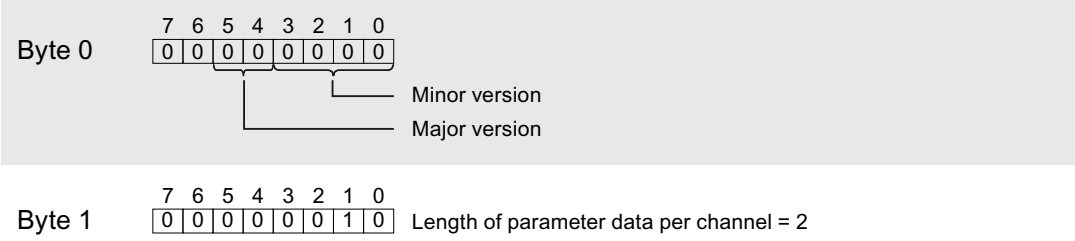

Figure 2-139 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You enable a parameter by setting the corresponding bit to "1".

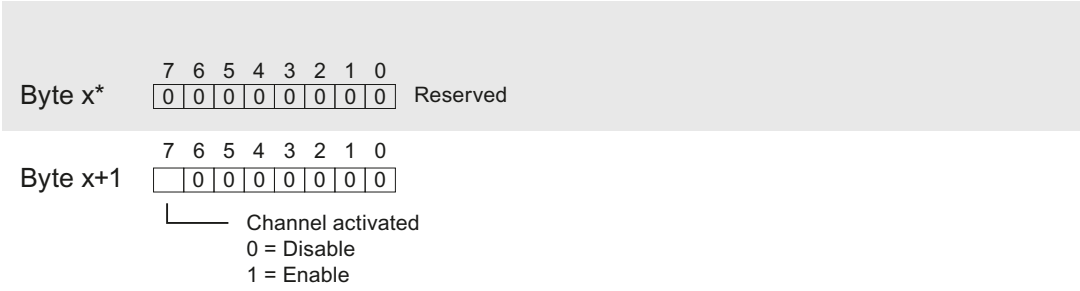

* x = 2 + (channel number × 2); channel number = 0 to 3

Figure 2-140 Structure byte x to x+1 for the channels 0 to 3

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	07	Invalid coding for input filter time.	Check the parameters of the module.

SIEMENS

SIMATIC

ET 200SP
Digital input module DI 8x24VDC
BA (6ES7131-6BF01-0AA0)

Equipment Manual

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Product overview 2

Wiring 3

Parameters/address space 4

Interrupts/diagnostics alarms 5

Technical specifications 6

Parameter data record A

02/2019
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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

Technical specifications: Ambient temperature in horizontal and vertical mounting position, extended to min. -30 °C.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

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ET 200SP Documentation Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

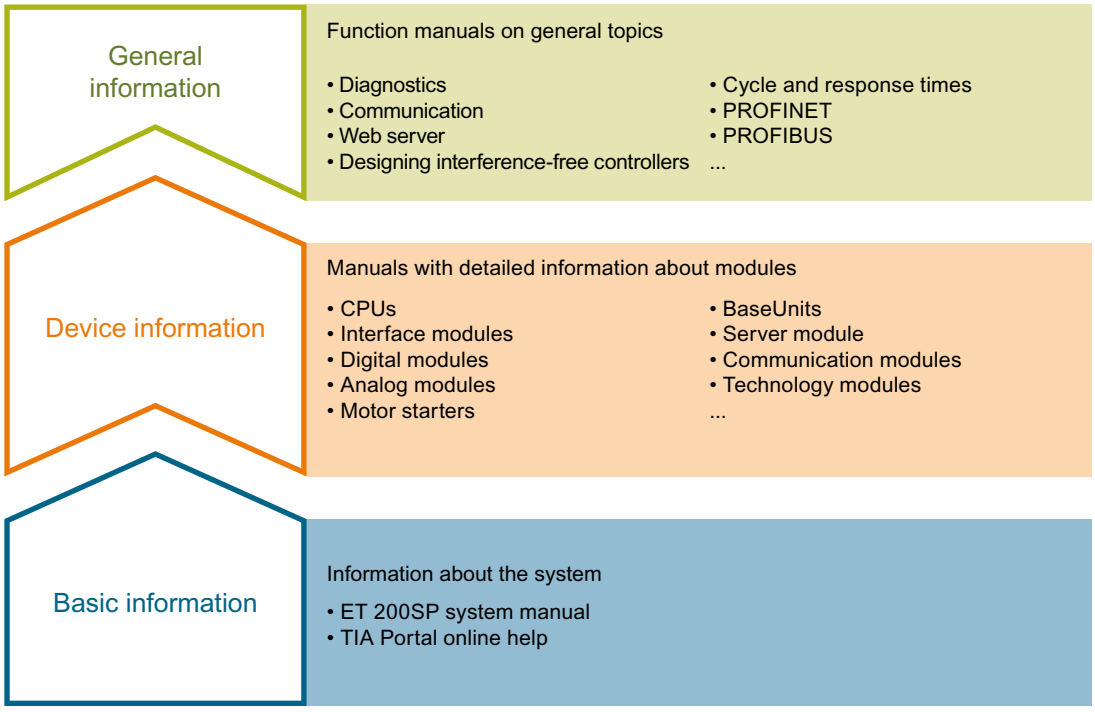

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

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You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

Product overview

2

2.1 Properties

Article number

6ES7131-6BF01-0AA0 (Number in package unit: 1 unit)

6ES7131-6BF01-2AA0 (Number in package unit: 10 units)

View of the module

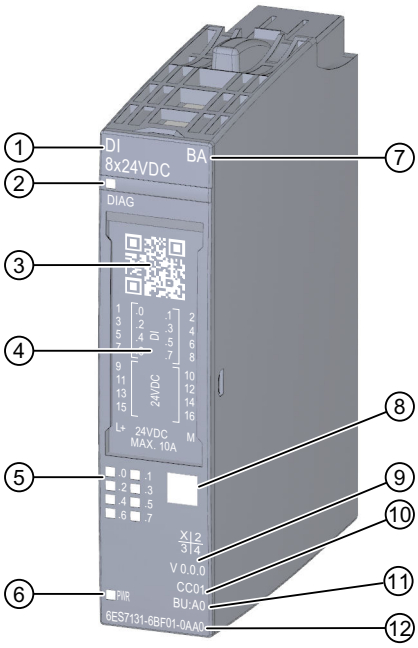

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-141 View of the DI 8×24VDC BA module

Properties

The module has the following technical properties:

- Digital input module with 8 inputs
- Supply voltage L+
- Sink input (PNP, sinking input)
- Configurable input delay 0.05 ms to 20 ms (per channel)
- Suitable for connection of switches and 2-wire sensors according to IEC 61131, type 1, 2 and 3

The module supports the following functions:

Table 2-201 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X
Reconfiguration in RUN	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X

You can configure the module with STEP 7 and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring 3

3.1 Wiring and block diagram

This section includes the block diagram of the DI 8x24VDC BA module with the terminal assignments for a 1-wire, 2-wire and 3-wire connection.

Information about wiring of the BaseUnit is available in the system manual ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293).

NOTE

You may use and combine the different wiring options for all channels.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

NOTE

The input channels provide values even without connected supply voltage L+. The characteristic type 2 is only maintained with connected supply voltage L+.

Connection: 1-wire and 2-wire connection

The figure below shows the block diagram and an example of the terminal assignment of the digital input module DI 8x24VDC BA on the BaseUnit BU type A0 without AUX terminals (1-wire and 2-wire connection).

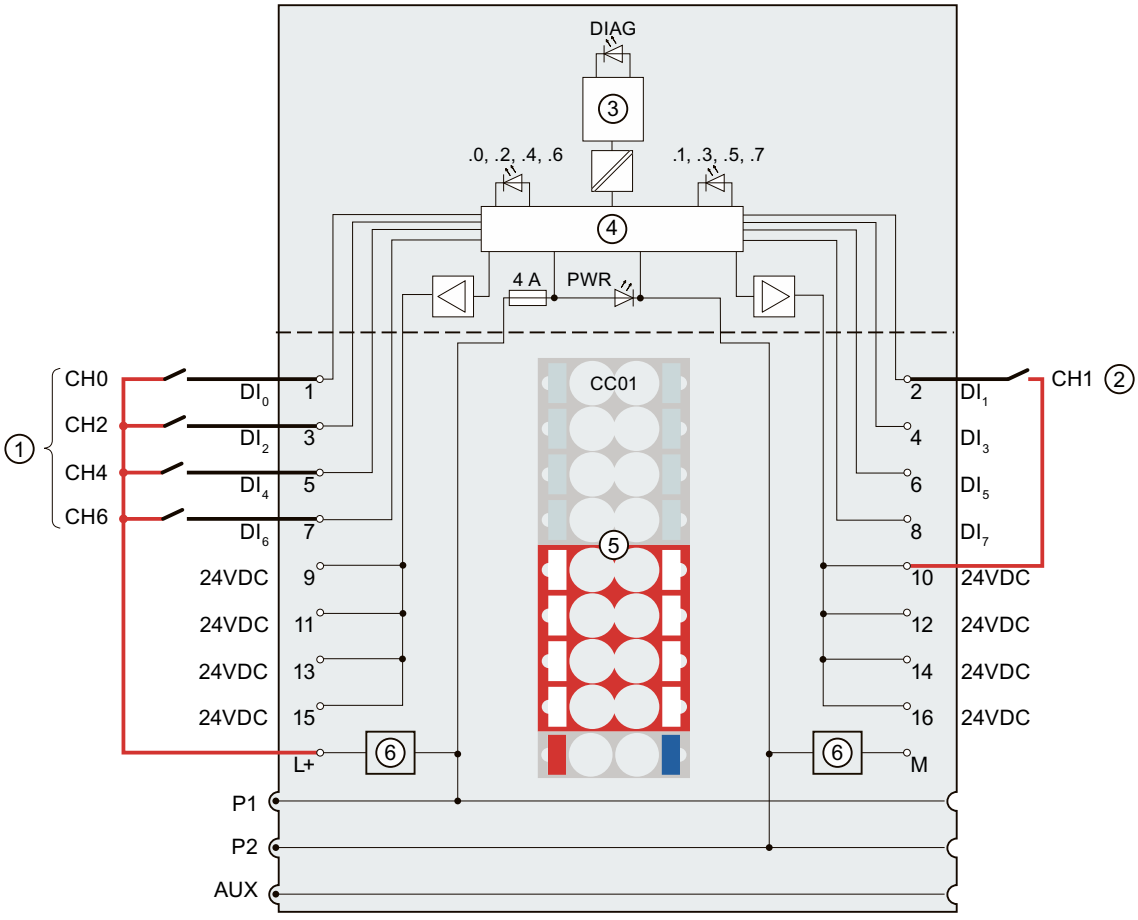

①	1-wire connection	DI_n	Input signal, channel n
②	2-wire connection	24 V DC	Encoder supply, channel n
③	Backplane bus interface	L+	24 V DC (feed for light-colored BaseUnit only)
④	Input electronics	M	Ground
⑤	Color identification label CCxx (optional)	DIAG	Error or Diagnostics LED (green, red)
⑥	Filter connection supply voltage (only when light-colored BaseUnit is present)	.0 to .7	Channel status LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	PWR	Power LED (green)

Figure 2-142 Wiring and block diagram for 1-wire and 2-wire connection of encoders

Connection: 3-wire connection

The figure below shows the block diagram and an example of the terminal assignment of the digital input module DI 8x24VDC BA on the BaseUnit BU type A0 with AUX terminals (3-wire connection).

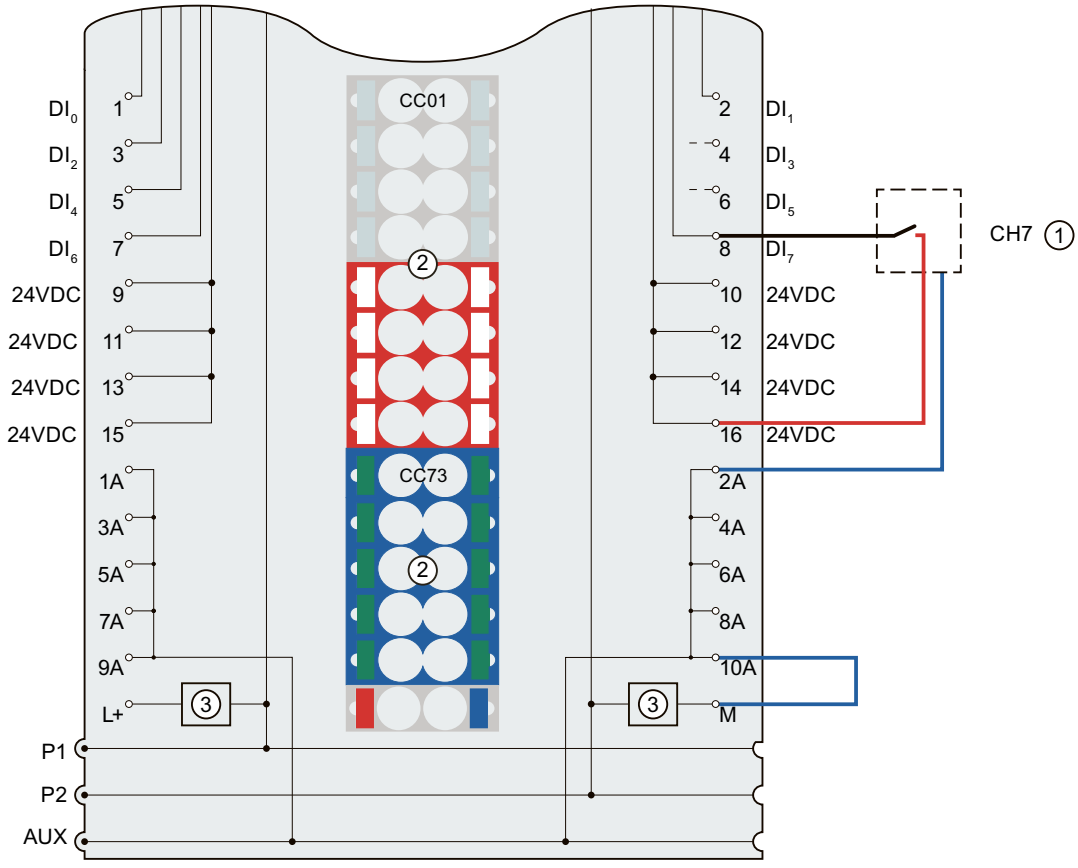

①	3-wire connection
②	Color identification labels CCxx (optional)
③	Filter connection supply voltage (only when light-colored BaseUnit is present)
DI_n	Input signal, channel n
24 V DC	Encoder supply, channel n
L+	24 V DC (feed for light-colored BaseUnit only)
M	Ground
1 A to 10 A	AUX terminals
P1, P2, AUX	Internal self-configuring voltage buses Connection to left (dark BaseUnit) Connection to left interrupted (light BaseUnit)

Figure 2-143 Wiring and block diagram for 3-wire connection of encoders

Parameters/address space

4

4.1 Parameters

DI 8x24VDC BA parameters

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records; see section Parameter assignment and structure of the parameter data record (Page 22).

The following parameter settings are possible:

Table 2-202 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel
Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	Yes	Channel	Module [1]

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 3 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter data record".

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 3 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter data record".

4.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Channel activated

Determines whether a channel is activated or deactivated.

Input delay

This parameter can be used to suppress signal interference. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of DI 8x24VDC BA

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module using a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-203 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in hardware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DI 8x24VDC BA V0.0	V14, SP1 or higher with HSP 0222	X	X

Address space

The figure below shows the assignment of the address space for DI 8x24VDC BA.

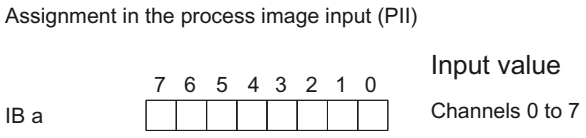

Figure 2-144 Address space of DI 8x24VDC BA

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the DI 8x24VDC BA.

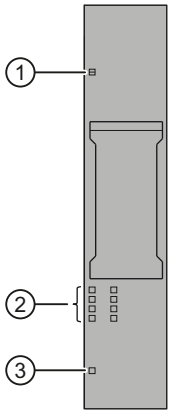

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-145 LED displays

Meaning of the LEDs

The following tables contain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 17).

DIAG LED

Table 2-204 Error display of the DIAG LED

DIAG LED	Meaning
□ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned
☼ Flashes	Module diagnostics is available

Channel status LED

Table 2-205 Status display of the channel status LED

Channel status LED	Meaning
□ Off	Process signal = 0
■ On	Process signal = 1

PWR LED

Table 2-206 Status display of the PWR LED

PWR LED	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ present

5.2 Interrupts

The DI 8×24VDC BA digital input module supports diagnostic interrupts.

Diagnostic interrupts

The module generates a diagnostic interrupt at the following events:

- Parameter assignment error
- No supply voltage

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostic alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-207 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L+.	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DI 8×24VDC BA

The following table shows the technical specifications as of 02/2019. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7131-6BF01-0AA0/td?dl=en).

Article number	6ES7131-6BF01-0AA0
General information	
Product type designation	DI 8x 24 V DC BA, PU 1
HW functional status	FS03
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC01
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V14
• STEP 7 configurable/integrated as of version	V5.5 SP3 / -
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DI	Yes
• Counter	No
• Oversampling	No
• MSI	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes

Article number	6ES7131-6BF01-0AA0
Input current	
Current consumption, max.	70 mA; All channels are supplied from the encoder supply
Encoder supply	
Number of outputs	8
Output voltage encoder supply, min.	19.2 V
Short-circuit protection	Yes; per module
24 V encoder supply	
• 24 V	Yes
• Short-circuit protection	Yes
Power loss	
Power loss, typ.	1.6 W; 24 V, 8 inputs supplied via encoder supply
Address area	
Address space per module	
• Inputs	1 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0
• 3-wire connection	BU type A0 with AUX terminals or potential distributor module
• 4-wire connection	BU type A0 + Potential isolation module
Digital inputs	
Number of digital inputs	8
Digital inputs, parameterizable	Yes
Input characteristic curve in accordance with IEC 61131, type 1	Yes
Input characteristic curve in accordance with IEC 61131, type 2	Yes
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Input voltage	
• Type of input voltage	DC
• Rated value (DC)	24 V
• for signal "0"	-30 to +5V
• for signal "1"	+11 to +30V
Input current	
• for signal "1", typ.	6.8 mA

Article number	6ES7131-6BF01-0AA0
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes; 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms (in each case + delay of 30 to 500 µs, depending on line length)
– at "0" to "1", min.	0.05 ms
– at "0" to "1", max.	20 ms
– at "1" to "0", min.	0.05 ms
– at "1" to "0", max.	20 ms
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Encoder	
Connectable encoders	
• 2-wire sensor	Yes
– permissible quiescent current (2-wire sensor), max.	2 mA
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Monitoring of encoder power supply	No
• Wire-break	No
• Short-circuit	No
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED

Article number	6ES7131-6BF01-0AA0
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm

Dimension drawing

See the manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

The module parameters can be re-assigned in RUN (for example, the input delay of selected channels can be edited in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid again after a restart.

STATUS output parameter

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

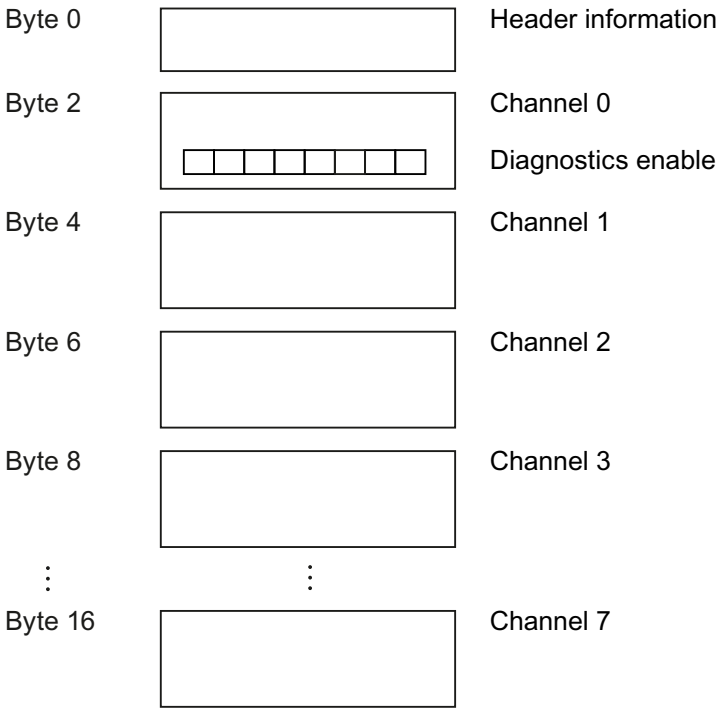

Figure 2-146 Structure of data record 128

Header information

The figure below shows the structure of the header information.

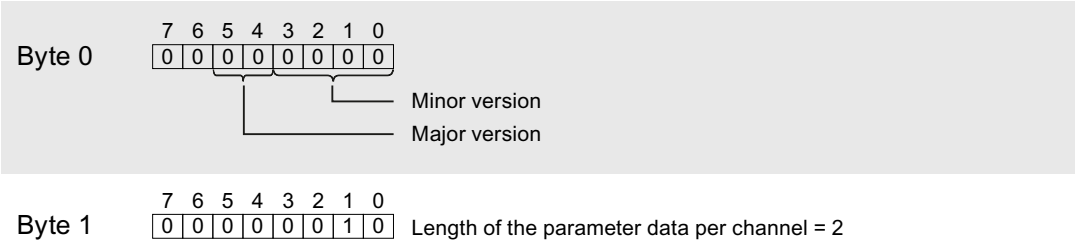

Figure 2-147 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

Enable a parameter by setting the corresponding bit to "1".

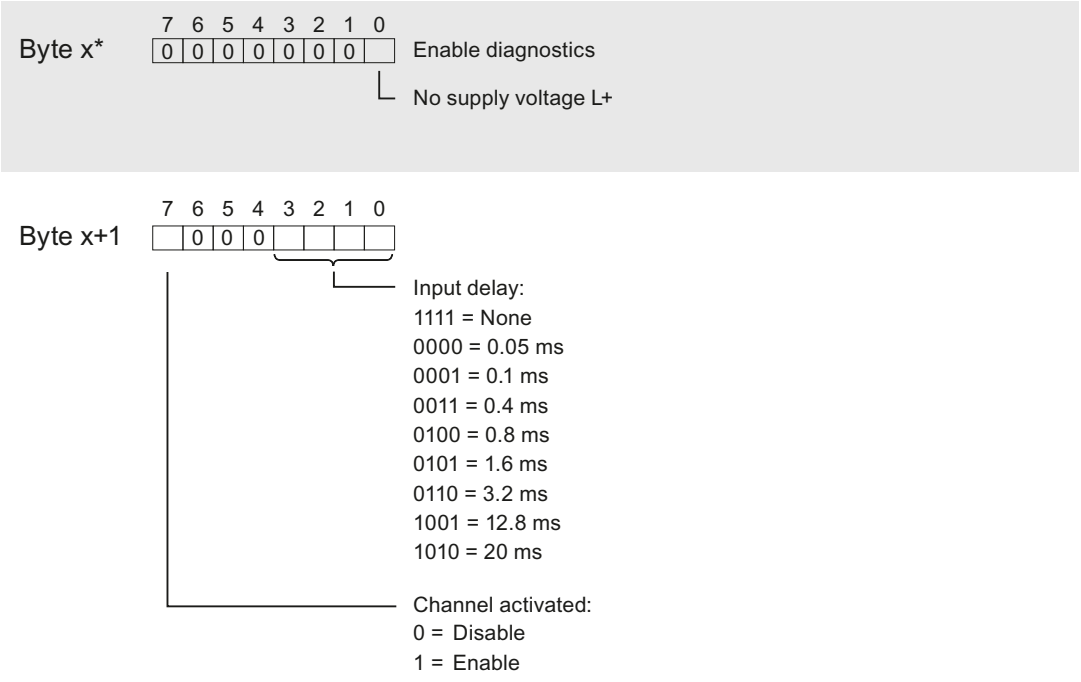

* x = 2 + (channel number × 2); channel number = 0 to 7

Figure 2-148 Structure byte x to x+1 for the channels 0 to 7

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	07	Invalid coding for input filter time.	Check the parameters of the module.

SIEMENS

SIMATIC

ET 200SP
Digital input module DI 8x24VDC ST (6ES7131-6BF01-0BA0)

Equipment Manual

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Parameters/address space 4

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Technical specifications 6

Parameter data record A

02/2019
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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

Technical specifications: Ambient temperature in horizontal and vertical mounting position, extended to min. -30 °C.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that can be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

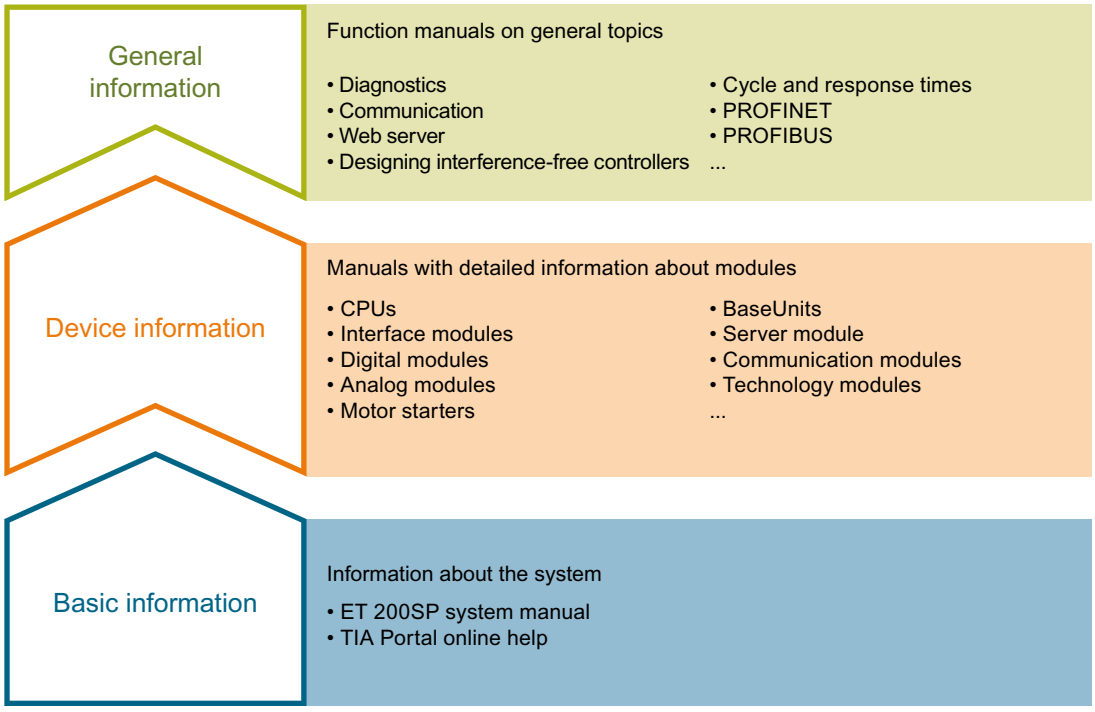

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

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In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7131-6BF01-0BA0 (number in package unit: 1 unit)
6ES7131-6BF01-2BA0 (number in package unit: 10 units)

View of the module

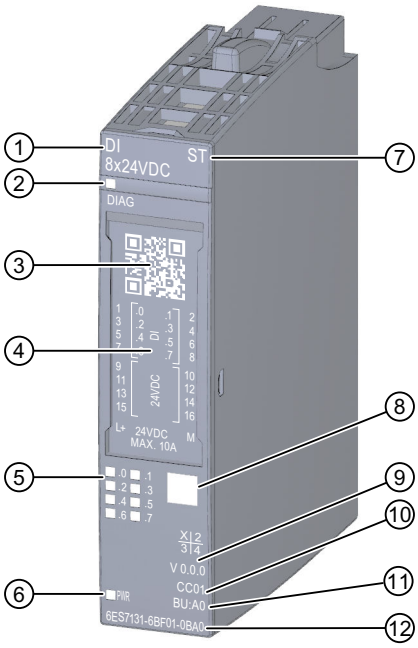

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-149 View of the module DI 8×24VDC ST

Properties

The module has the following technical properties:

- Digital input module with 8 inputs
- Supply voltage L+
- Sink input (PNP)
- Configurable input delay 0.05 ms to 20 ms (per channel)
- Configurable diagnostics (per module)
- Suitable for connection of switches and 2-wire sensors in accordance with IEC 61131, type 1 and 3

The module supports the following functions:

Table 2-208 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X
Configuration in RUN	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X
PROFIenergy	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X
Value status	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You will find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring up

3

3.1 Wiring and block diagram

This section includes the block diagram of the DI 8x24VDC ST module with the terminal assignments for a 1-wire, 2-wire and 3-wire connection.

Information about wiring of the BaseUnit is available in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

You may use and combine the different wiring options for all channels.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Connection: 1-wire and 2-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the digital input module DI 8x24VDC ST on the BaseUnit BU type A0 without AUX terminals (1-wire and 2-wire connection).

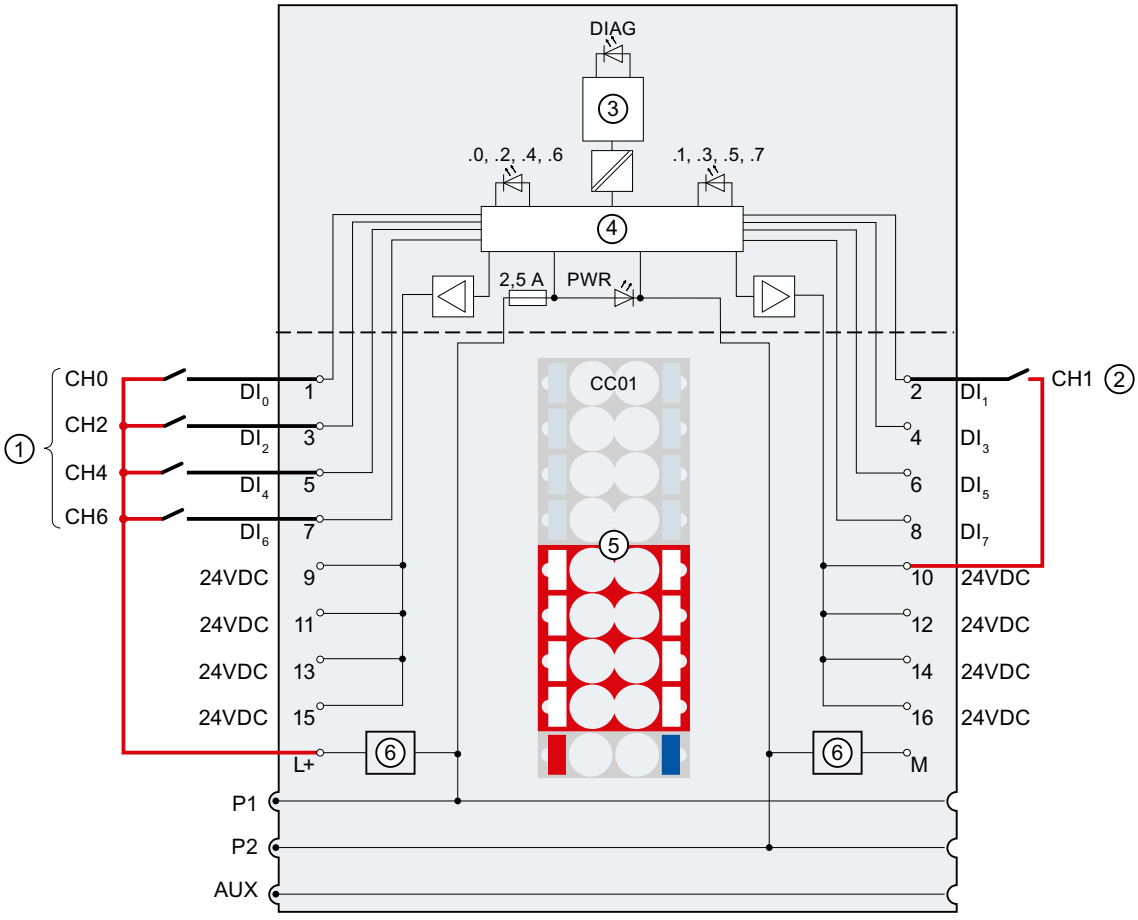

①	1-wire connection	DI_n	Input signal, channel n
②	2-wire connection	24 V DC	Transducer supply, channel n
③	Backplane bus interface	L+	24 V DC (feed for light-colored BaseUnit only)
④	Input electronics	M	Ground
⑤	Color identification label CCxx (optional)	DIAG	Error or Diagnostics LED (green, red)
⑥	Filter connection supply voltage (only when light-colored BaseUnit is present)	.0 to .7	Channel status LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	PWR	Power LED (green)

Figure 2-150 Wiring and block diagram for 1-wire and 2-wire connection of transducers

Connection: 3-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the digital input DI 8x24VDC ST on the BaseUnit BU type A0 with AUX terminals (3-wire connection).

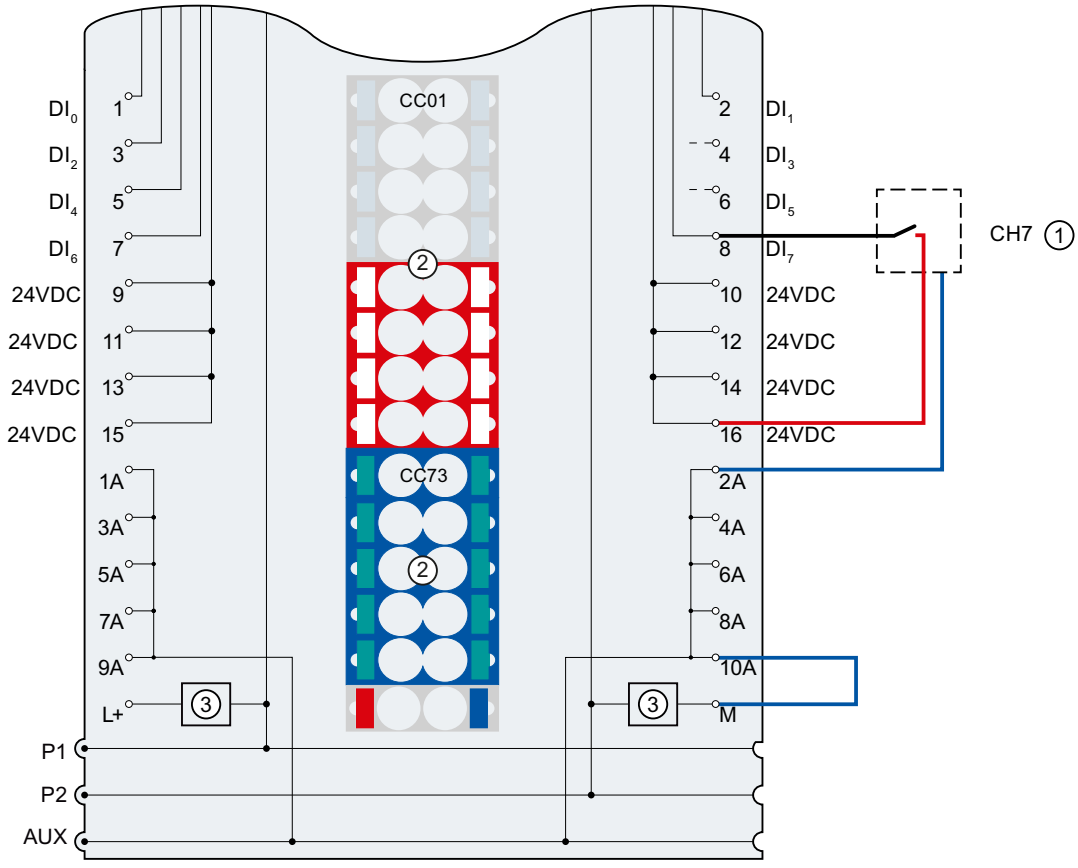

①	3-wire connection
②	Color identification labels CCxx (optional)
③	Filter connection supply voltage (only when light-colored BaseUnit is present)
DI_n	Input signal, channel n
L+	24 V DC (feed for light-colored BaseUnit only)
M	Ground
1 A to 10 A	AUX terminals
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)

Figure 2-151 Wiring and block diagram for 3-wire connection of transducers

Wire-break detection

When wire-break detection is configured the module requires a low quiescent current at the digital input in case of "0" signal for the monitoring. The parallel connection of a resistor with 25 kΩ to 45 kΩ is required in order that this quiescent current can flow when mechanical transducer contacts are open.

If wire-break detection is disabled in the configuration, no parallel connection of the resistor is required.

If wire-break detection is configured, connect a resistor with 25 kΩ to 45 kΩ parallel to each mechanical transducer contact.

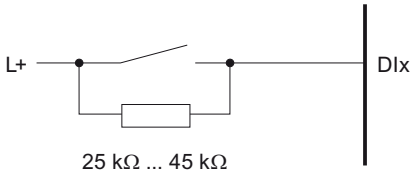

Figure 2-152 Connect mechanical transducer contact with resistor

Parameters/address space

4

4.1 Parameters

Parameters for DI 8x24VDC ST

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 26).

The following parameter settings are possible:

Table 2-209 Settable parameters and their defaults (GSD file)

Parameters	Value range	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Wire break	• Disable • Enable	Disable	yes	Module	Module
Channel enabled	• Disable • Enable	Enable	yes	Channel	Channel

[2] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 3 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

Parameters	Value range	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Input delay	• none • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	yes	Channel	Module [1]
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	no	Module	Module

[2] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 3 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

4.2 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics short-circuit to ground

Enabling of the diagnostics if a short-circuit of the encoder supply to ground occurs.

Diagnostics wire break

Enabling of the diagnostics if the module has no current flow or the current is too weak to be measured at the relevant input.

Channel activated

Determines whether a channel is enabled or disabled.

Input delay

This parameter can be used to avoid signal faults. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of DI 8x24VDC ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module using a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-210 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in hard-ware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DI 8x24VDC ST V0.0	V14, SP1 or higher with HSP 0222	X	X
1 x 8-channel with value status	DI 8x24VDC ST V0.0, QI	V14, SP1 or higher with HSP 0222	X	---

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 7 in this byte are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the DI 8×24VDC ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

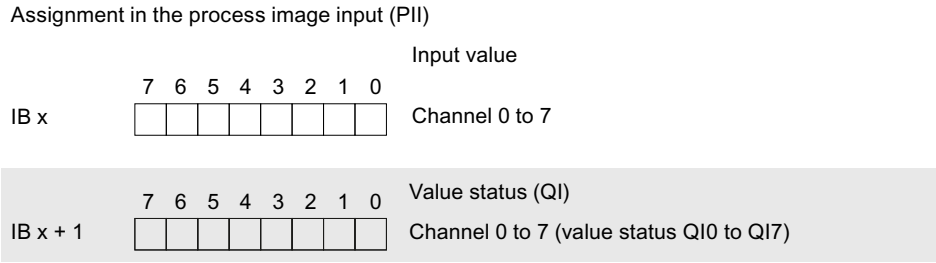

Figure 2-153 Address space of the DI 8×24VDC ST with value status

Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays (status and error displays) of the DI 8x24VDC ST.

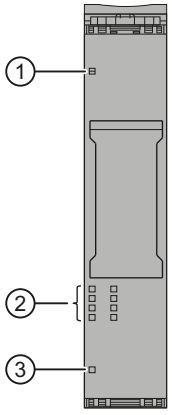

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-154 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 21).

DIAG LED

Table 2-211 DIAG LED fault/error display

DIAG LED	Meaning
☐ off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ on	Module parameters assigned
☼ Flashes	Module diagnostics is available

Channel status LED

Table 2-212 Status display of the channel status LED

Channel status LED	Meaning
☐ off	Process signal = 0
■ on	Process signal = 1

PWR LED

Table 2-213 Status display of the PWR LED

PWR LED	Meaning
☐ off	No supply voltage L+
■ on	Supply voltage L+ present

5.2 Interrupts

The DI 8×24VDC ST digital input module supports diagnostic interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Short-circuit
- Wire break
- Parameter assignment error
- No supply voltage

5.3 Diagnostics alarms

A diagnostic alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-214 Diagnostics alarms, their meaning and how to deal with them

Diagnostics alarm	Error code	Meaning	Remedy
Short-circuit	1_H	Short-circuit to ground at transducer supply	Correct the process wiring
Wire break	6_H	Impedance of transducer circuit too high.	Use a different transducer type or modify the wiring, for example, use cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor of 25 kiloohms to 45 kiloohms to the transducer contacts
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DI 8x24VDC ST

The following table shows the technical specifications as of 02/2019. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7131-6BF01-0BA0/td?dl=en).

Article number	6ES7131-6BF01-0BA0
General information	
Product type designation	DI 8x24 VDC ST
HW functional status	From FS02
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC01
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V14
• STEP 7 configurable/integrated as of version	V5.5 SP3 or higher
• PCS 7 configurable/integrated as of version	V8.1 SP1
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DI	Yes
• Counter	No
• Oversampling	No
• MSI	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes

Article number	6ES7131-6BF01-0BA0
Input current	
Current consumption, max.	50 mA; All channels are supplied from the encoder supply
Encoder supply	
Number of outputs	8
Output voltage encoder supply, min.	19.2 V
Short-circuit protection	Yes; per module
24 V encoder supply	
• 24 V	Yes
• Short-circuit protection	Yes
• Output current per channel, max.	700 mA
• Output current per module, max.	700 mA
Power loss	
Power loss, typ.	1 W; 24 V, 8 inputs supplied via encoder supply
Address area	
Address space per module	
• Inputs	1 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0
• 3-wire connection	BU type A0 with AUX terminals or potential distributor module
• 4-wire connection	BU type A0 + Potential isolation module
Digital inputs	
Number of digital inputs	8
Digital inputs, parameterizable	Yes
Source/sink input	P-reading
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Input voltage	
• Rated value (DC)	24 V
• for signal "0"	-30 to +5V
• for signal "1"	+11 to +30V
Input current	
• for signal "1", typ.	2.5 mA

Article number	6ES7131-6BF01-0BA0
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes; 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms (in each case + delay of 30 to 500 µs, depending on line length)
– at "0" to "1", min.	0.05 ms
– at "0" to "1", max.	20 ms
– at "1" to "0", min.	0.05 ms
– at "1" to "0", max.	20 ms
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Encoder	
Connectable encoders	
• 2-wire sensor	Yes
– permissible quiescent current (2-wire sensor), max.	1.5 mA
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Monitoring of encoder power supply	Yes; Module-by-module, optional protective circuit for preventing wire-break diagnostics in the case of simple encoder contacts: 25 kOhm to 45 kOhm
• Wire-break	Yes; Module-wise
• Short-circuit	Yes; Module-wise
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED

Article number	6ES7131-6BF01-0BA0
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	28 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

The module parameters can be re-assigned in RUN (for example, the input delay of selected channels can be edited in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 contains the diagnostics for the entire module.

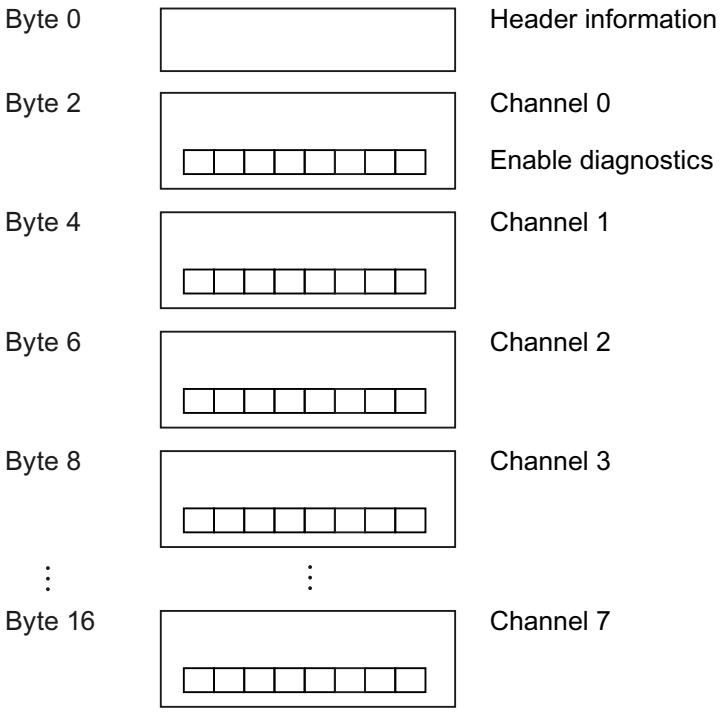

Figure 2-155 Structure of data record 128

Header information

The figure below shows the structure of the header information.

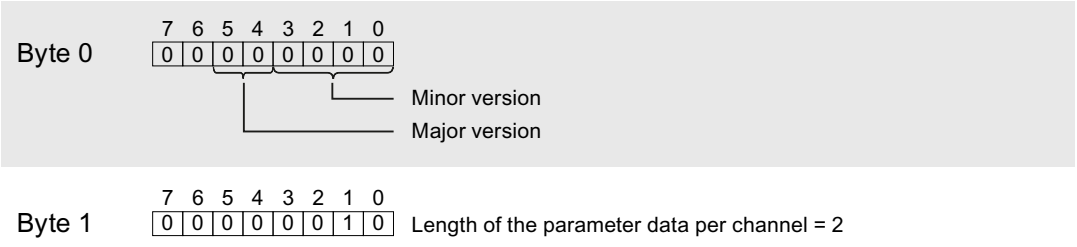

Figure 2-156 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

You enable a parameter by setting the corresponding bit to "1".

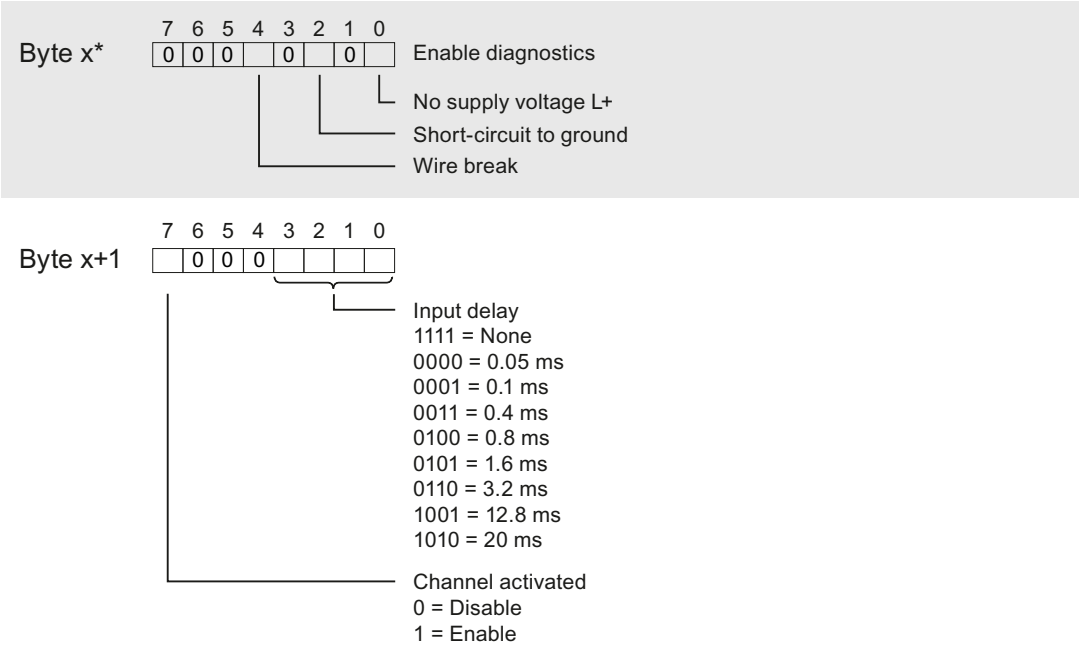

* x = 2 + (channel number × 2); channel number = 0 to 7

Figure 2-157 Structure byte x to x+1 for the channels 0 to 7

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	07	Invalid coding for input filter time.	Check the parameters of the module.

SIEMENS

SIMATIC

ET 200SP
Digital input module DI 8x24VDC HF (6ES7131-6BF00-0CA0)

Equipment Manual

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Product overview 2

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Parameter data record A

12/2017
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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

Number in pack: 10 units (6ES7131-BF00-2CA0)

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected

to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (https://www.siemens.com/industrialsecurity).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

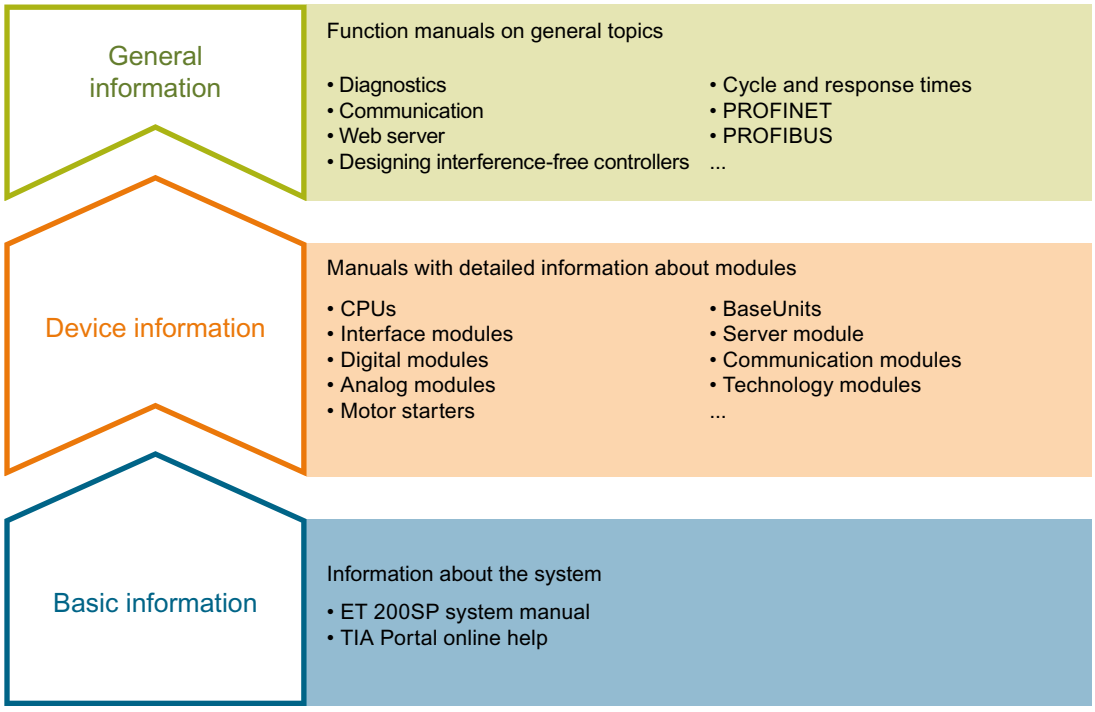

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

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In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7131-6BF00-0CA0 (number in pack: 1 unit)

6ES7131-6BF00-2CA0 (number in pack: 10 units)

View of the module

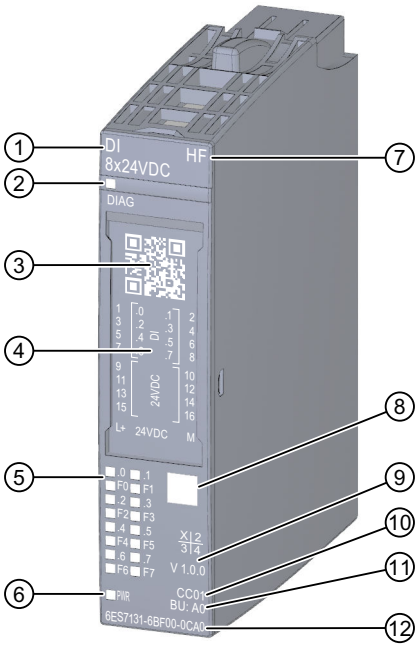

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-158 View of the DI 8x24VDC HF module

Properties

The module has the following technical properties:

- Digital input module with 8 inputs
- Sink input (PNP, active high)
- Supply voltage L+
- Configurable input delay 0.05 ms to 20 ms (per channel)
- Configurable diagnostics (per channel)
- Configurable hardware interrupts (per channel)
- Suitable for connection of switches and 2-wire sensors according to IEC 61131, type 1 and 3

The module supports the following functions:

Table 2-215 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Pulse stretching	FS01	V1.0.0 or higher	V12 or higher	V5.5 SP3 or higher with HSP 0229 V1.0 or higher	X	X
Firmware update	FS01	V1.0.0 or higher	V12 or higher	V5.5 SP3 or higher with HSP 0229 V1.0 or higher	X	X
Identification data I&M0 to I&M3	FS01	V1.0.0 or higher	V12 or higher	V5.5 SP3 or higher with HSP 0229 V1.0 or higher	X	X
Reconfiguration in RUN	FS01	V1.0.0 or higher	V12 or higher	V5.5 SP3 or higher with HSP 0229 V1.0 or higher	X	X
Value status	FS01	V1.1.0 or higher	V12, SP1 or higher with HSP 0057	V5.5 SP3 or higher with HSP 0229 V2.0 or higher	X	X
Isochronous mode	FS01	V1.1.0 or higher	V12, SP1 or higher with HSP 0057	V5.5 SP3 or higher with HSP 0229 V2.0 or higher	X	X
Module-internal shared input (MSI)	FS01	V1.2..0 or higher	V13 or higher	V5.5 SP3 or higher with HSP 0229 V3.1 or higher	X	X
Configurable submodule/submodules for shared device	FS01	V2.0.0 or higher	V13 SP1 Update 4 or higher with HSP 0163	V5.5 SP3 or higher with HSP 0229 V6.0 or higher	X	X

Accessories

The following accessories are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connector

See also

You can find additional information on the accessories in the system manual Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Wiring 3

3.1 Wiring and block diagrams

This section includes the block diagram of the DI 8x24VDC HF module with the terminal assignments for a 1-wire, 2-wire and 3-wire connection in the DI operating mode. You can use and combine the different wiring options for all channels.

You can find information on wiring the BaseUnit in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/91696622).

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Wiring: 1 and 2-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the digital input module DI 8×24VDC HF on the BaseUnit BU type A0 without AUX terminals (1- and 2-wire connection).

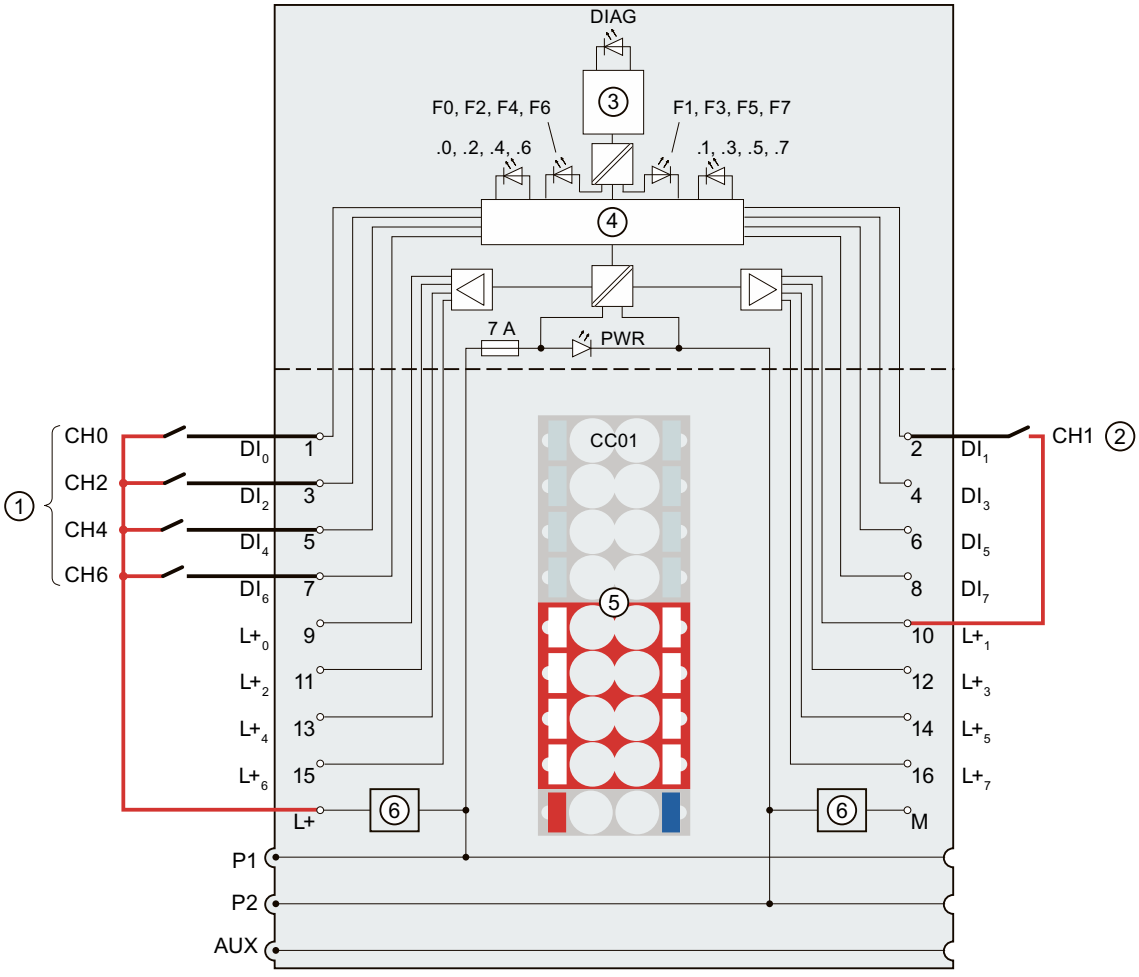

①	1-wire connection	$L+_n$	Encoder supply, channel n
②	2-wire connection	L+	24 V DC (infeed only with light BaseUnit)
③	Backplane bus interface	DIAG	Error or diagnostics LED (green, red)
④	Input electronics	.0 to .7	Channel status LED (green)
⑤	Color-coded label with color code CC01 (optional)	PWR	Power LED (green)
⑥	Supply voltage filter circuit (only available with light BaseUnit)	F0 to F7	Channel fault LED (red)
M	Ground	P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)
DI_n	Input signal, channel n		

Figure 2-159 Pinout and block diagram for 1 and 2-wire connection of encoders

Wiring: 3-wire connection

The following figure shows an example of the terminal assignment of the digital input module DI 8×24VDC HF on the BaseUnit BU type A0 with AUX terminals (3-wire connection).

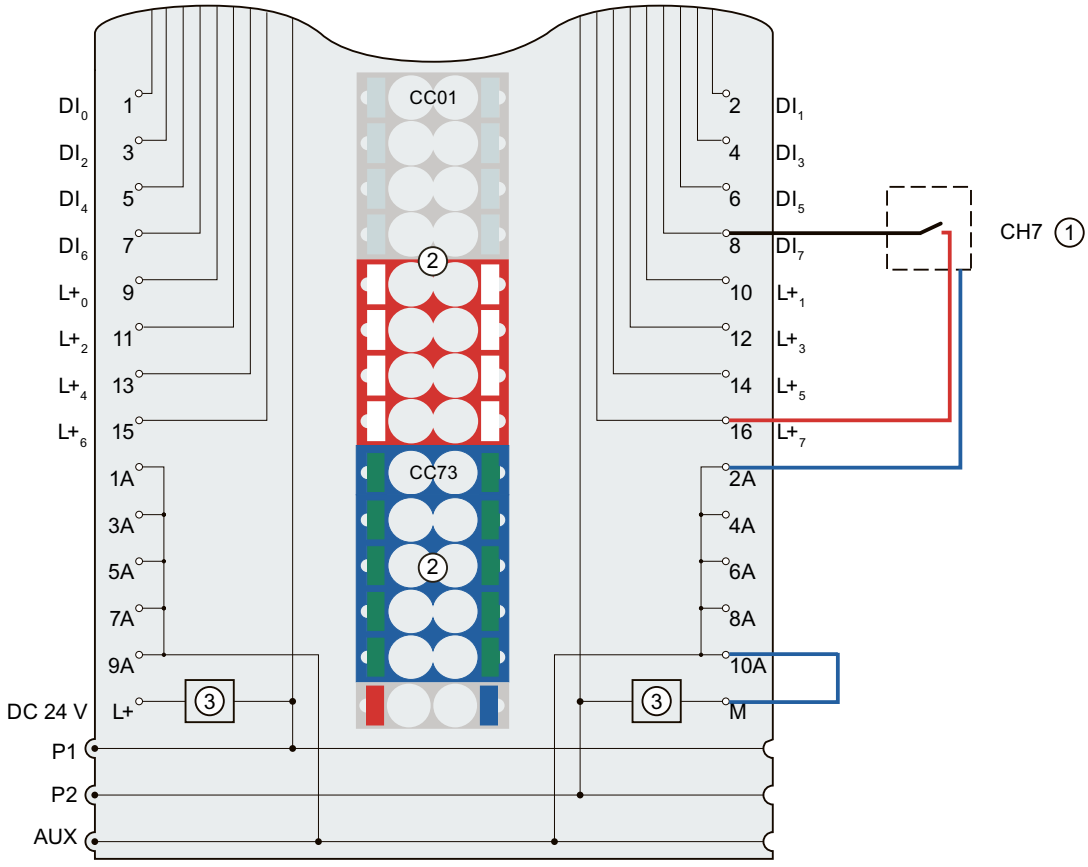

①	3-wire connection
②	Color-coded labels with color code CC01 and CC73 (optional)
③	Supply voltage filter circuit (only available with light BaseUnit)
DI_n	Input signal, channel n
$L+_n$	Encoder supply, channel n
DC 24 V	Supply voltage L+ (infeed only with light BaseUnit)
M	Ground
1A ... 10A	AUX terminals
P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)

Figure 2-160 Pinout and block diagram for 3-wire connection of encoders

Parameters/address space

4

4.1 Parameters

Parameters of the DI 8x24VDC HF

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records (see chapter Parameter assignment and structure of the parameter data record (Page 33)).

Table 2-216 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Configuration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics wire break[1]	• Disable • Enable	Disable	Yes	Channel	Channel
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel

1 If you use a floating switch, you need to connect a resistor in parallel so that the wire break diagnostics is enabled in the open state (sensor resistance for the wire break diagnostics: 25 kΩ to 45 kΩ).

2 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 6 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter, however, with data records 0 to 7 or data record 128, see Appendix "Parameter data record".

Parameter	Value range	Default	Configuration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	Yes	Channel	Module [2]
Pulse stretching	• None • -0.05 s • 0.1 s • 0.2 s • 0.5 s • 1 s • 2 s	None	Yes	Channel	[2]
Hardware interrupt rising edge	• Disable • Enable	Disable	Yes	Channel	[2]
Hardware interrupt falling edge	• Disable • Enable	Disable	Yes	Channel	[2]
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

1 If you use a floating switch, you need to connect a resistor in parallel so that the wire break diagnostics is enabled in the open state (sensor resistance for the wire break diagnostics: 25 kΩ to 45 kΩ).

2 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 6 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter, however, with data records 0 to 7 or data record 128, see Appendix "Parameter data record".

4.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Diagnostics: Wire break

Enabling diagnostics if the line to the encoder is interrupted.

Channel activated

Determines whether a channel is activated or deactivated.

Input delay

This parameter can be used to suppress signal interference. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

In isochronous mode, the terminal signal is read in at the time T_i (time for reading the input data). The read-in time T_i refers to the channel for which no input delay time was configured.

For input channels with longer input delays, the read-in time is moved accordingly. This means individual channels can be assigned input delays, if necessary, without having a negative impact on the possible cycle time.

Isochronous configuration is only possible if there is no input delay configured for at least one channel.

Pulse stretching

Pulse stretching is a function used to change a digital input signal. A pulse on a digital input is stretched to at least the configured length. If the input pulse is already longer than the configured length, the pulse is not changed.

In isochronous mode, the terminal signal is read in at time T_i (time for reading in the input data), i.e. smaller pulses than T_DC (data cycle) are not recognized in certain cases.

Principle of pulse stretching

The figure below uses examples to show whether and how input pulses are changed.

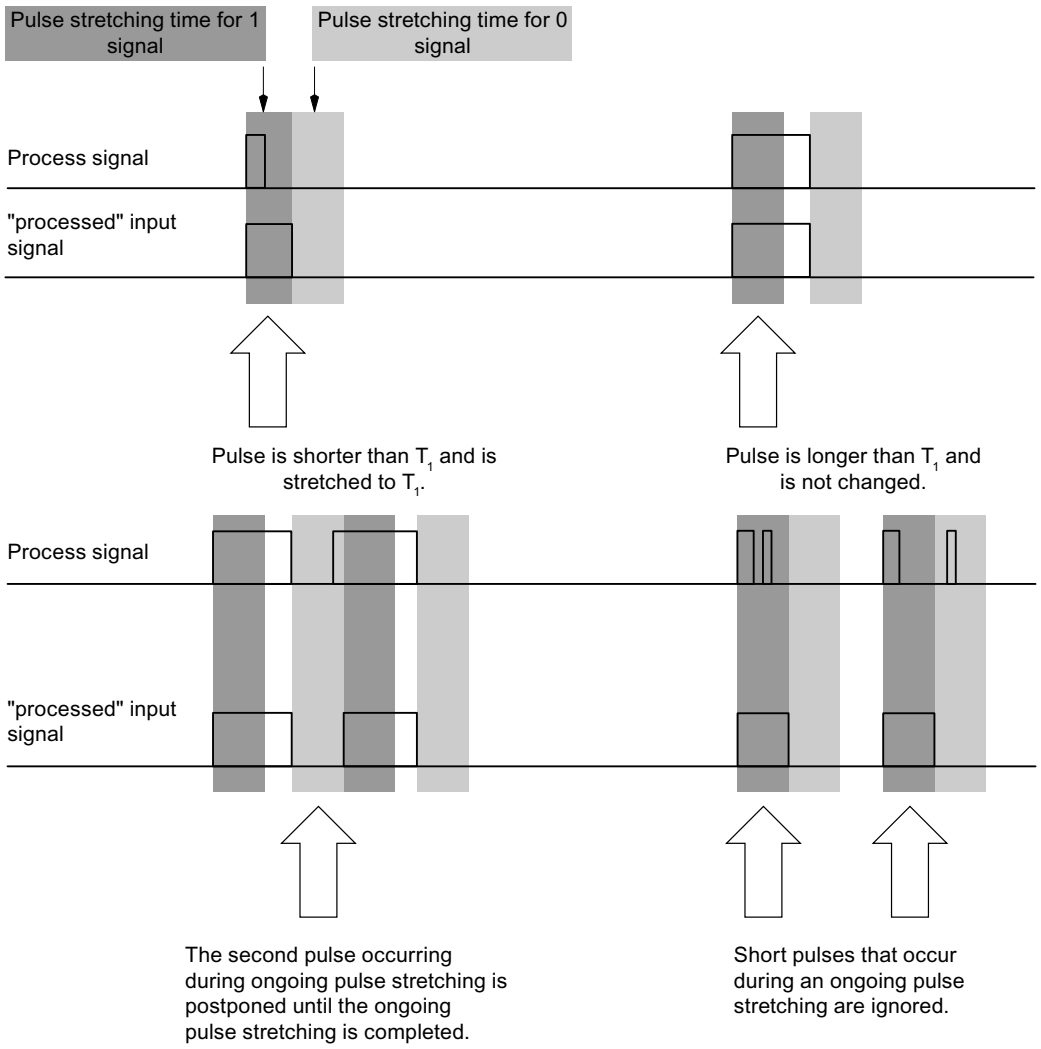

T_1 Pulse stretching parameter

Figure 2-161 Principle of pulse stretching

Hardware interrupt, rising edge

Specifies whether a hardware interrupt is generated by a rising edge.

Hardware interrupt, falling edge

Specifies whether a hardware interrupt is generated by a falling edge.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/91696622).

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image input.

Configuration options of DI 8x24VDC HF

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-217 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, as of V13, SP1	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DI 8x24VDC HF V1.0	X	X	X
1 x 8-channel without value status	DI 8x24VDC HF V1.1	X	X	X
1 x 8-channel with value status	DI 8x24VDC HF V1.1, QI	X	X	---
1 x 8-channel without value status	DI 8x24VDC HF V1.2	X	X	X
1 x 8-channel with value status for module-internal Shared Input with up to 4 submodules	DI 8x24VDC HF V1.2, MSI	X	X	---
1 x 8-channel with value status	DI 8x24VDC HF V1.2, QI	X	X	---
1 x 8-channel without value status	DI 8x24VDC HF V2.0	---	X	X

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, as of V13, SP1	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel with value status for module-internal Shared Input with up to 4 submodules	DI 8x24VDC HF V2.0, MSI	---	X	---
1 x 8-channel with value status	DI 8x24VDC HF V2.0, QI	---	X	---
2 x 4-channel without value status	DI 8x24VDC HF V2.0, S.2	---	X	---
2 x 4-channel with value status	DI 8x24VDC HF V2.0, S.2 QI	---	X	---
4 x 2-channel without value status	DI 8x24VDC HF V2.0, S.4	---	X	---
4 x 2-channel with value status	DI 8x24VDC HF V2.0, S.4 QI	---	X	---

NOTE

The following functions are only fully available when the submodule X.1 is configured and the IO controller to which submodule X.1 is assigned has established a connection to the IO device.

- Firmware update
- I&M identification data
- PROFIenergy

2 x 4- / 4 x 2-channel configuration

For the configuration, the channels of the module are divided into submodules. The submodules can be assigned to different IO controllers when the module is used in a shared device.

The number of usable submodules is dependent on the interface module used. Read the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- DI 8x24VDC HF QI,
- DI 8x24VDC HF MSI

An additional bit is assigned to each channel for the value status. The value status bit indicates if the read in digital value is valid. (0 = value is incorrect).

Address space for configuration as 1 x 8-channel DI 8x24VDC HF

The figure below shows the address space assignment for configuration as a 8-channel module without value status.

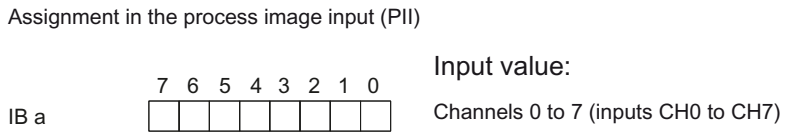

Figure 2-162 Address space for configuration as 1 x 8-channel DI 8x24VDC HF without value status

Address space for configuration as 1 x 8-channel DI 8x24VDC HF, QI

The following figure shows the assignment of the address space for the configuration as a 8-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address.

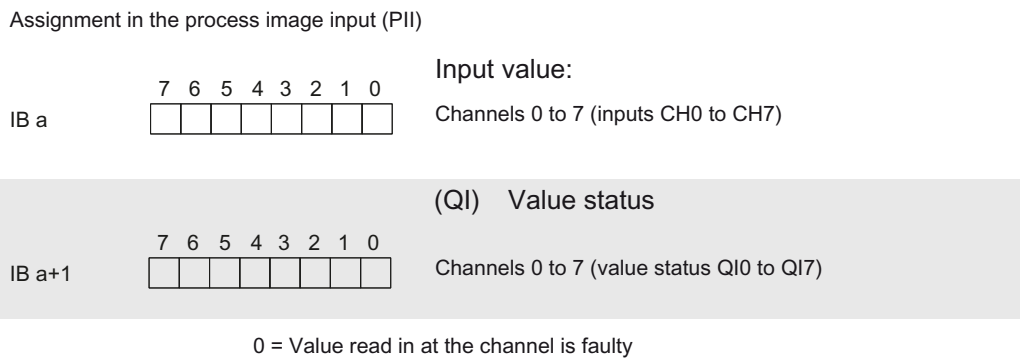

Figure 2-163 Address space for configuration as 1 x 8-channel DI 8x24VDC HF QI with value status

Address space for configuration as 1 x 8-channel DI 8x24VDC HF MSI

The channels 0 to 7 of the module are copied in up to four submodules with configuration 1 x 8-channel module (Module-internal shared input, MSI). Channels 0 to 7 are then available with identical input values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information,QI)

The meaning of the value status depends on the submodule on which it occurs.

For the 1st submodule (=basic submodule), the value status 0 indicates that the value is incorrect.

For the 2nd to 4th submodule (=MSI submodule), the value status 0 indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

The following figure shows the assignment of the address space with submodule 1, 2, 3 and 4 and the value status.

Assignment in the process image input (PII) for 1st submodule

1st submodule (basic submodule):

	7	6	5	4	3	2	1	0	
IB a									Channels 0 to 7 (inputs CH0 to CH7)
IB a+1									(QI) Value status Channels 0 to 7 (value status QI0 to QI7)

Assignment in the process image input (PII) for 2nd submodule

2nd submodule (MSI submodule):

	7	6	5	4	3	2	1	0	
IB b									Channels 0 to 7 (inputs CH0 to CH7)
IB b+1									(QI) Value status Channels 0 to 7 (value status QI0 to QI7)

Assignment in the process image input (PII) for 3rd submodule

3rd submodule (MSI submodule):

	7	6	5	4	3	2	1	0	
IB c									Channels 0 to 7 (inputs CH0 to CH7)
IB c+1									(QI) Value status Channels 0 to 7 (value status QI0 to QI7)

Assignment in the process image input (PII) for 4th submodule

4th submodule (MSI submodule):

	7	6	5	4	3	2	1	0	
IB d									Channels 0 to 7 (inputs CH0 to CH7)
IB d+1									(QI) Value status Channels 0 to 7 (value status QI0 to QI7)

0 = Value read in at the channel is faulty

Figure 2-164 Address space for configuration as 1 x 8-channel DI 8x24VDC HF MSI with value status

Address space for configuration as 2 x 4-channel DI 8x24VDC HF V2.0, S.2

The figure below shows the address space assignment for configuration as a 2 x 4-channel module without value status.

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	Input value:	
IB a	0	0	0	0					Channel 0 to 3 (input CH0 to CH3)	1st submodule
IB b	0	0	0	0					Channel 4 to 7 (input CH4 to CH7)	2nd submodule

Figure 2-165 Address space for configuration as 2 x 4-channel DI 8x24VDC HF V2.0, S.2 without value status

Address space for configuration as 2 x 4-channel DI 8x24VDC HF V2.0, S.2 QI

Each of the two submodules has a freely assignable start address.

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	Input value:	
IB a	0	0	0	0					Channel 0 to 3 (input CH0 to CH3)	1st submodule
IB b	0	0	0	0					Channel 4 to 7 (input CH4 to CH7)	2nd submodule
									(QI) Value status	
IB a+1	0	0	0	0					Channel 0 to 3 (value status QI0 to QI3)	1st submodule
IB b+1	0	0	0	0					Channel 4 to 7 (value status QI4 to QI7)	2nd submodule

0 = Value read in at the channel is faulty

Figure 2-166 Address space for configuration as 2 x 4-channel DI 8x24VDC HF V2.0, S.2 QI with value status

Address space for configuration as 4 x 2-channel DI 8x24VDC HF V2.0, S.4

The figure below shows the address space assignment for configuration as a 4 x 2-channel module without value status.

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	Input value:	
IB a	0	0	0	0	0	0			Channels 0 and 1 (inputs CH0 and CH1)	1st submodule
IB b	0	0	0	0	0	0			Channel 2 and 3 (input CH2 and CH3)	2nd submodule
IB c	0	0	0	0	0	0			Channel 4 and 5 (input CH4 and CH5)	3rd submodule
IB d	0	0	0	0	0	0			Channel 6 and 7 (input CH6 and CH7)	4th submodule

Figure 2-167 Address space for configuration as 4 x 2-channel DI 8x24VDC HF V2.0, S.4 without value status

Address space for configuration as 4 x 2-channel DI 8x24VDC HF V2.0, S.4 QI

Each of the four submodules has a freely assignable start address.

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	Input value:	
IB a	0	0	0	0	0	0			Channels 0 and 1 (inputs CH0 and CH1)	1st submodule
IB b	0	0	0	0	0	0			Channel 2 and 3 (input CH2 and CH3)	2nd submodule
IB c	0	0	0	0	0	0			Channel 4 and 5 (input CH4 and CH5)	3rd submodule
IB d	0	0	0	0	0	0			Channel 6 and 7 (input CH6 and CH7)	4th submodule
									(QI) Value status	
IB a+1	0	0	0	0	0	0			Channels 0 and 1 (value status QI0 and QI1)	1st submodule
IB b+1	0	0	0	0	0	0			Channel 2 and 3 (value status QI2 and QI3)	2nd submodule
IB c+1	0	0	0	0	0	0			Channel 4 and 5 (value status QI4 and QI5)	3rd submodule
IB d+1	0	0	0	0	0	0			Channel 6 and 7 (value status QI6 and QI7)	4th submodule

0 = Value read in at the channel is faulty

Figure 2-168 Address space for configuration as 4 x 2-channel DI 8x24VDC HF V2.0, S.4 QI with value status

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the DI 8x24VDC HF.

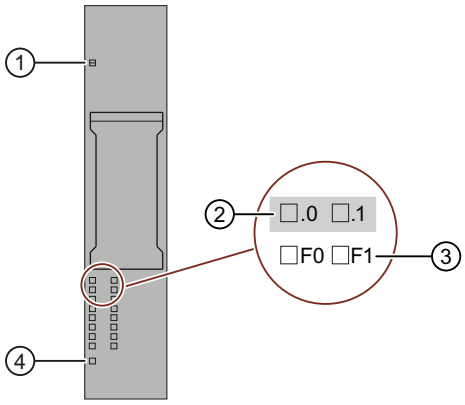

① DIAG (green/red)

② Channel status (green)

③ Channel error (red)

④ PWR (green)

Figure 2-169 LED display

Meaning of the LEDs

The tables below explain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 28).

DIAG LED

Table 2-218 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module not ready for operation (no parameters assigned)
On	Module parameters assigned and no module/channel diagnostics
Flashes	Module parameters assigned and module/channel diagnostics

LED channel status/channel error

Table 2-219 Status / error display of the LED channel status / channel error

LED channel status	LED channel error	Meaning
□ Off	□ Off	Channel deactivated or process signal = 0
■ On	□ Off	• No supply voltage present or • Process voltage > 11 V is present regardless of whether or not the channel is activated and regardless of whether diagnostics was detected
□ Off	■ On	Supply voltage is available and process voltage < 11V is present regardless of whether or not the channel is activated and regardless of whether diagnostics was detected
■ On	■ On	Channel activated and diagnostics enable was recognized

PWR LED

Table 2-220 Status display of the PWR LED

PWR LED	Meaning
□ Off	Missing supply voltage L+
■ On	Supply voltage L+ present

5.2 Interrupts

The digital input module DI 8×24VDC HF supports hardware and diagnostics alarms.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit
- Wire break
- Parameter assignment error
- Supply voltage missing
- Hardware interrupt lost
- Channel temporarily unavailable

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- At positive edge (signal change from 0 to 1)
- At negative edge (signal change from 1 to 0)

In the event of an interrupt, interrupt OBs are automatically executed in the CPU of the IO controller.

You can obtain detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

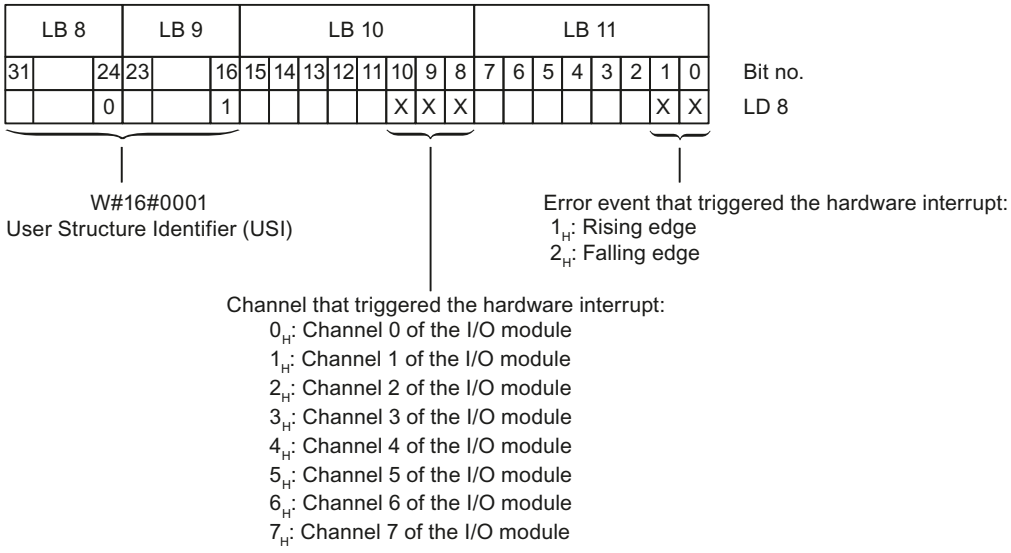

Figure 2-170 Start information of the organization block

Structure of the additional interrupt information

Table 2-221 Structure of USI = W#16#0001

Data block name		Content	Comment	Bytes
USI		W#16#0001	User Structure Identifier: Additional interrupt information for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#07	Channel 0 to 7 of the I/O module	1
It follows the error event that triggered the hardware interrupt.				
	Error event	B#16#01	Positive edge	1
		B#16#02	Negative edge	

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-222 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit	1_H	Short-circuit to ground at sensor supply	Correct the process wiring
Wire break	6_H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, for example, use cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect in parallel a resistor of 25 kOhm to 45 kOhm to the encoder contacts
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Hardware interrupt lost	16_H	The module cannot trigger an interrupt because the previous interrupt was not acknowledged; possible configuration error	• Change interrupt processing in the CPU and, if necessary, edit the module parameters. • The error persists until the module is assigned new parameters
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not read in process values in this state.	• Wait for firmware update. • Restart the firmware update.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DI 8×24VDC HF

Article number	6ES7131-6BF00-0CA0
General information	
Product type designation	DI 8x24 V DC HF
Firmware version	V2.0
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC01
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V13 SP1 / -
• STEP 7 configurable/integrated as of version	V5.5 / -
• PCS 7 configurable/integrated as of version	V8.1 SP1
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DI	Yes
• Counter	No
• Oversampling	No
• MSI	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Encoder supply	
Number of outputs	8
Output voltage encoder supply, min.	19.2 V
Short-circuit protection	Yes

Article number	6ES7131-6BF00-0CA0
24 V encoder supply	
• 24 V	Yes
• Short-circuit protection	Yes; per channel, electronic
Power loss	
Power loss, typ.	1.5 W; 24 V, 8 inputs supplied via encoder supply
Address area	
Address space per module	
• Inputs	1 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Submodules	
• Number of configurable submodules, max.	4
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0
• 3-wire connection	BU type A0 with AUX terminals
• 4-wire connection	BU type A0 + Potential isolation module
Digital inputs	
Number of digital inputs	8
Digital inputs, parameterizable	Yes
Source/sink input	P-reading
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Pulse extension	Yes; Pulse duration from 4 µs
• Length	2 s; 50 ms, 100 ms, 200 ms, 500 ms, 1 s, 2 s
Edge evaluation	Yes; rising edge, falling edge, edge change
Input voltage	
• Type of input voltage	DC
• Rated value (DC)	24 V
• for signal "0"	-30 to +5V
• for signal "1"	+11 to +30V
Input current	
• for signal "1", typ.	2.5 mA
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes; 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms (in each case + delay of 30 to 500 µs, depending on line length)
– at "0" to "1", min.	0.05 ms

Article number	6ES7131-6BF00-0CA0
– at "0" to "1", max.	20 ms
– at "1" to "0", min.	0.05 ms
– at "1" to "0", max.	20 ms
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Encoder	
Connectable encoders	
• 2-wire sensor	Yes
– permissible quiescent current (2-wire sensor), max.	1.5 mA
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	Yes
Filtering and processing time (TCI), min.	420 µs
Bus cycle time (TDP), min.	500 µs
Jitter, max.	8 µs
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes; channel by channel
• Hardware interrupt	Yes; Parameterizable, channels 0 to 7
Diagnostic messages	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Monitoring of encoder power supply	Yes; channel by channel
• Wire-break	Yes; Channel by channel, optional protective circuit for preventing wire-break diagnostics in the case of simple encoder contacts: 25 kOhm to 45 kOhm
• Short-circuit	Yes; channel by channel
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	Yes; Red LED
• for module diagnostics	Yes; green/red DIAG LED

Article number	6ES7131-6BF00-0CA0
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Ambient air temperature-barometric pressure-altitude	On request: Negative ambient temperature down to -30 °C (without condensation), installation altitudes between 2 000 m and 5 000 m
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	28 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

With data records 0 to 7, you can reconfigure individual channels.

Operation of the module behind a PROFIBUS DP interface module

If the module is operated behind a PROFIBUS DP interface module, the parameter data records 0 and 1 cannot be read back. You obtain the diagnostics data records 0 and 1 with the read back parameter data records 0 and 1. You can find additional information in the Interrupts section of the PROFIBUS DP interface module manual on the Internet (http://support.automation.siemens.com/WW/view/en/78324181).

Parameter assignment in the user program

The module parameters can be re-assigned in RUN (for example, the input delay of selected channels can be edited in RUN without having an effect on the other channels).

Changing parameters in RUN

The WRREC instruction is used to transfer the parameters to the module using data record 128 or data records 0 to 7. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

If you reconfigure a module and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Data record structure

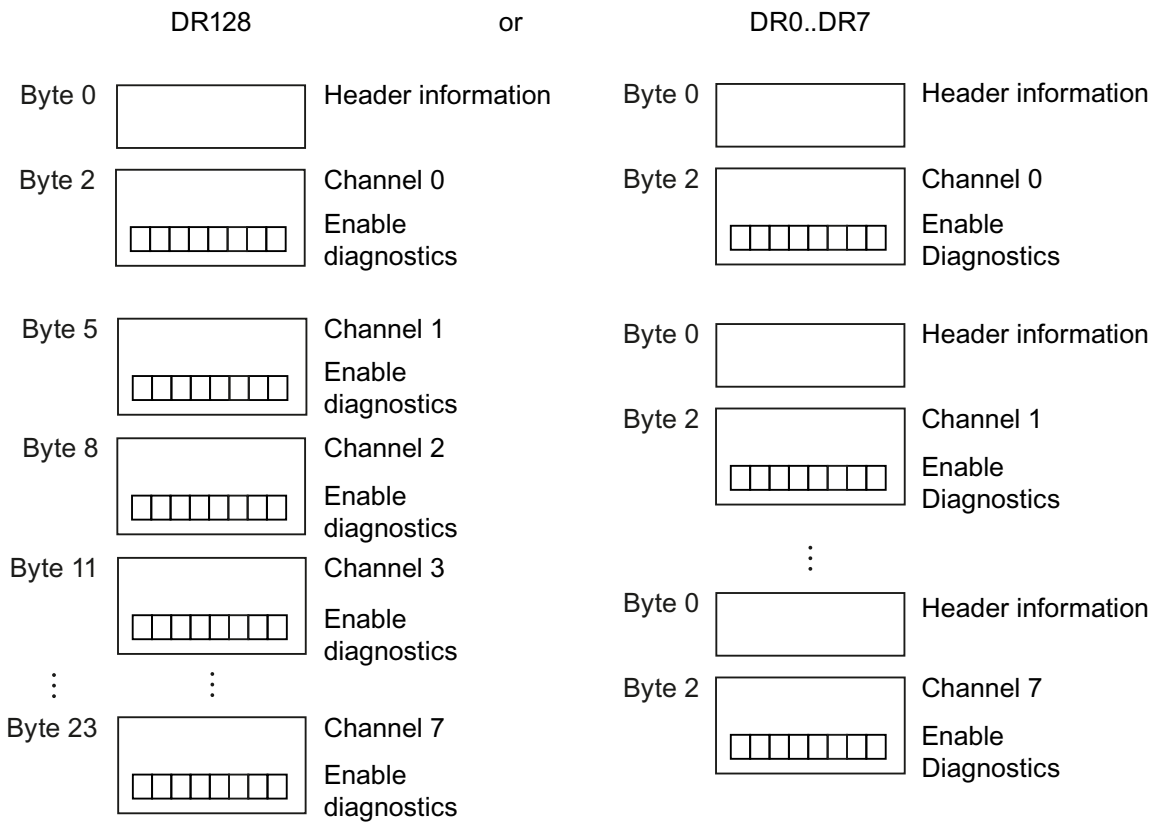

Figure 2-171 Structure of data record 128 and data records 0 to 7

Header information

The figure below shows the structure of the header information.

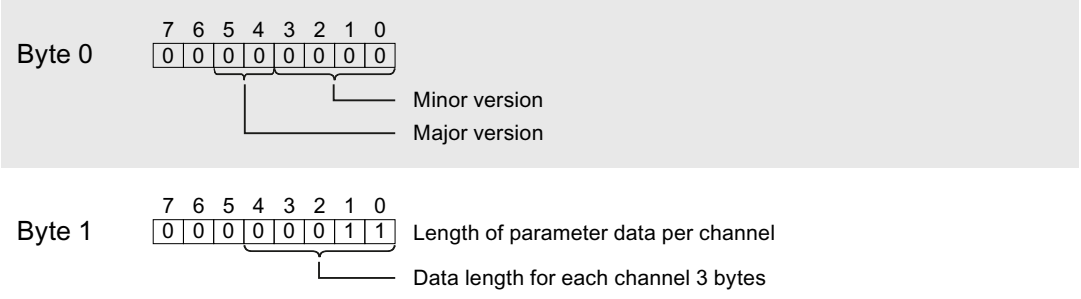

Figure 2-172 Header information

Parameter

The figure below shows the structure of the parameters for channels 0 to 7.

You enable a parameter by setting the corresponding bit to "1".

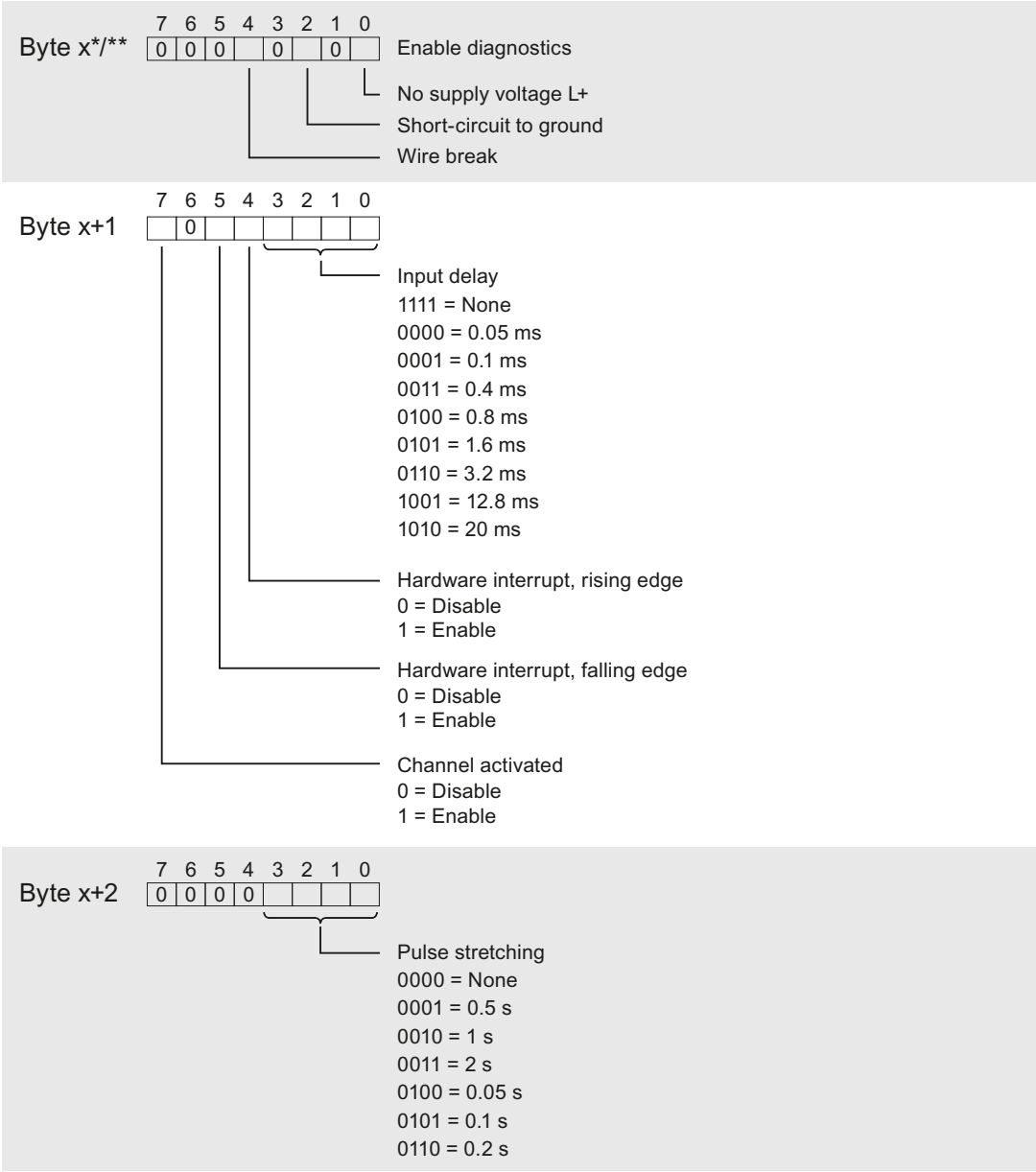

* x = 2 + (channel number × 3); channel number = 0 to 7 for DR 128
** x = 2 for DR 0 to DR 7

Figure 2-173 Structure of byte x to x+2 for channels 0 to 7

Error transmitting the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine whether the module is plugged or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	E0	xx	Wrong version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module

SIEMENS

SIMATIC

ET 200SP
Digital input module DI 8x24VDC HS (6ES7131-6BF00-0DA0)

Equipment Manual

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Oversampling (OVS) operating mode 5

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11/2019
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Preface

Purpose of the documentation

This device manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that relate generally to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you when commissioning the ET 200SP distributed I/O system.

Changes compared to the previous version

Compared to the previous version, this manual contains the following change:

Parameters and value range are harmonized in "Counting" mode (GSD file and TIA Portal).

Conventions

Please pay particular attention to notes highlighted as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

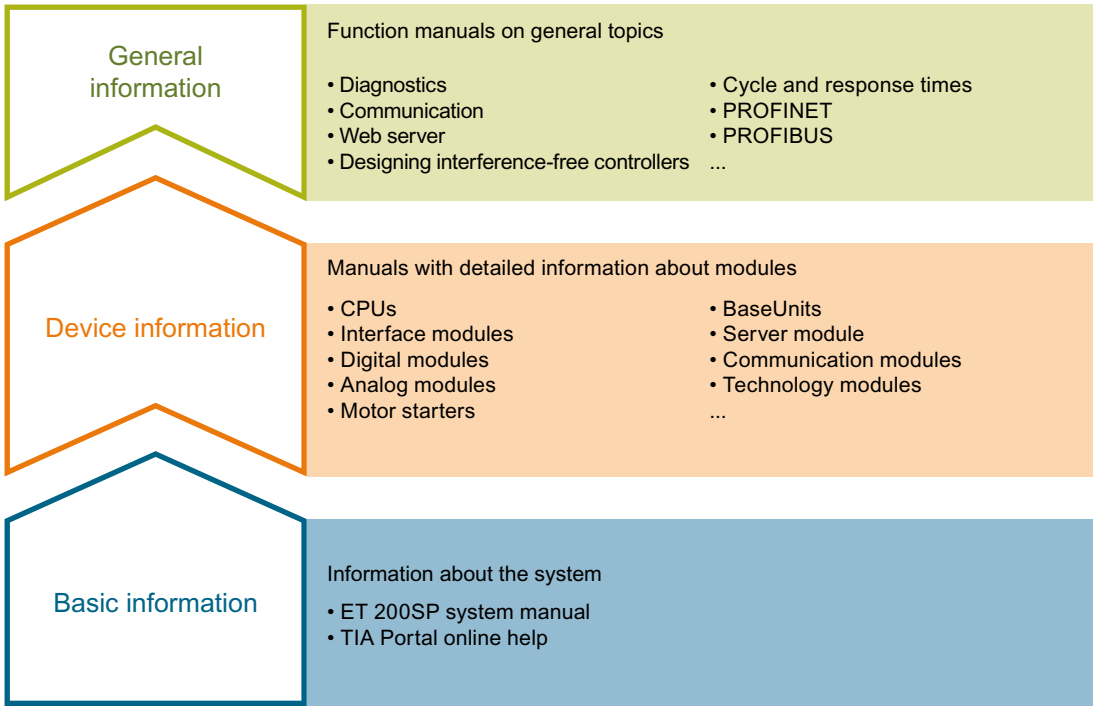

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

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You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7131-6BF00-0DA0

View of the module

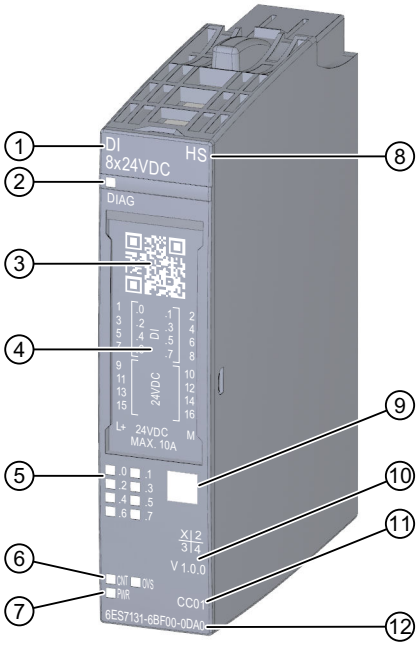

① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LEDs for operating mode
⑦ LED for supply voltage
⑧ Function class
⑨ Color coding module type
⑩ Function and firmware version
⑪ Color code for selecting the color identification labels
⑫ Article number

Figure 2-174 View of the DI 8×24VDC HS module

Properties

The module has the following technical properties:

- Digital input module with 8 high-speed inputs
- Supply voltage L+
- Sink input (PNP)
- Module-specific configurable diagnostics for supply voltage and short-circuit to M
- Suitable for connection of switches and 2-wire sensors in accordance with IEC 61131, type 1 and 3
- Three operating modes:

Table 2-223 Operating modes of the DI 8×24VDC HS

Property		Operating mode			
		DI (Page 13)		Counting (CNT) (Page 26)	Oversampling (OVS) (Page 45)
		Without value status (QI)	With value status (QI)		
Number of channels		8	8	4	8
Isochronous mode		Yes, optional	Yes, optional	Yes, optional	Yes, required
• Shortest send clock		125 µs	125 µs	125 µs	250 µs
Oversampling		No	No	No	Yes
• Number of oversampling levels (sampling rate)		—	—	—	2 ... 32
• Shortest sub-cycle (= shortest sampling time)		—	—	—	7.8125 µs
Counter length, max. counting frequency		—	—	32-bit, 10 kHz *	—
Configurable input delay		0 ms ... 20 ms	0 ms ... 20 ms	0.05 ms - 20 ms	0 ms ... 20 ms
Configurable hardware interrupts; rising edge and/or falling edge (per channel)		×	×	—	—
Data length	Inputs	1 byte	2 bytes	25 bytes	32 bytes
	Outputs	0 bytes	0 bytes	20 bytes	0 bytes

* If a diagnostic event occurs, the maximum counting frequency is reduced to 9 kHz.

The module supports the following functions:

- Isochronous mode
- Firmware update
- I&M identification data
- Reconfiguration in RUN
- PROFIenergy

The module can be configured with HSP or a GSD file. The configurations for the operating modes can be found under various codes / module names:

Table 2-224 Codes / module names for the configuration options

Operating mode		Configuration software			
		HSP0127 for STEP 7 (TIA Portal)	HSP0229 for STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
DI	Without QI	DI 8×24VDC HS	DI 8×24VDC HS DI/OVS	DI 8×24VDC HS	DI 8×24VDC HS
	With QI			DI 8×24VDC HS QI	—
Counting (CNT)			DI 8×24VDC HS CNT	DI 8×24VDC HS CNT	DI 8×24VDC HS CNT
Oversampling (OVS) *			DI 8×24VDC HS DI/OVS	—	—

* The interface module or CPU with which the module is used must support isochronous mode.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Operating mode DI

3

3.1 Wiring up

3.1.1 Wiring and block diagrams

This section contains the block diagram for the DI 8x24VDC HS with the pin assignments for 1, 2 and 3-wire connection in DI operating mode. You may use and combine the different wiring options for all channels.

Information on wiring the BaseUnit can be found in the system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

The module's load group must start with a light BaseUnit. Keep this in mind also during the configuration.

Wiring: 1 and 2-wire connection

The figure below shows the block diagram and an example of pin assignment for the DI 8×24VDC HS digital input module on the BaseUnit BU type A0 without AUX terminals (1 and 2-wire connection).

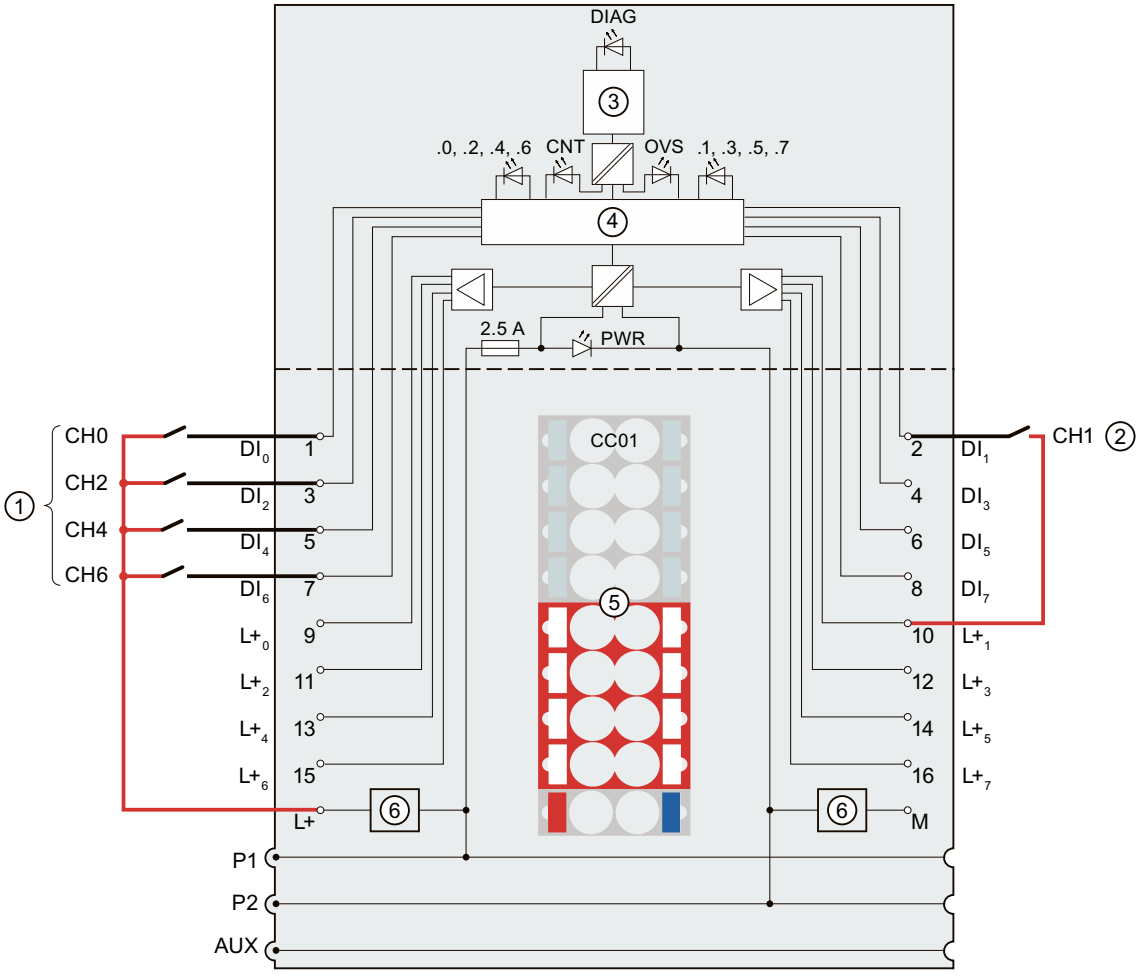

①	1-wire connection	$L+_n$	Encoder supply, channel n
②	2-wire connection	L+	24 V DC (infeed only with light BaseUnit)
③	Backplane bus interface	DIAG	LED error or diagnostics (green, red)
④	Input electronics	.0 to .7	LED channel status (green)
⑤	Color-coded label CCxx (optional)	PWR	LED power (green)
⑥	Supply voltage filter circuit (only available with light BaseUnit)	CNT	LED operating mode Count (green)
M	Ground	OVS	LED operating mode Oversampling (green)
DI_n	Input signal, channel n	P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)

Figure 2-175 Pinout and block diagram for 1 and 2-wire connection of encoders

Wiring: 3-wire connection

The figure below shows an example of pin assignment for the DI 8×24VDC HS digital input module on the BaseUnit BU type A0 with AUX terminals (3-wire connection).

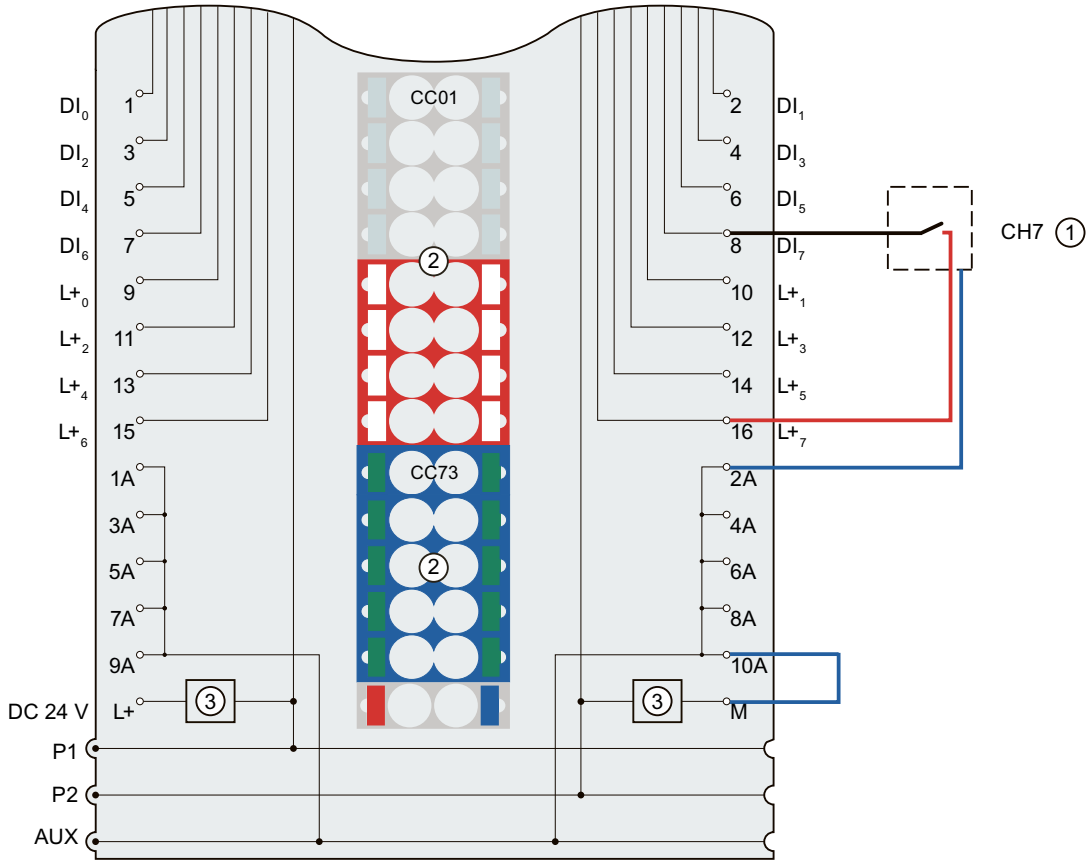

①	3-wire connection
②	Color-coded labels CCxx (optional)
③	Supply voltage filter circuit (only available with light BaseUnit)
DI_n	Input signal, channel n
$L+_n$	Encoder supply, channel n
DC 24 V	Supply voltage L+ (infeed only with light BaseUnit)
M	Ground
1A ... 10A	AUX terminals
P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)

Figure 2-176 Pinout and block diagram for 3-wire connection of encoders

3.2 Parameters/address space

3.2.1 High-speed inputs

Function

In operating mode DI, use all eight channels as digital high-speed inputs. High-speed inputs make sense when rapid reactions to input signals are needed (reaction time < 2 ms).

Requirement

Low reaction times require a cycle time of less than 750 µs.

3.2.2 Parameters

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation on an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

In addition to configuration via the configuration software, you can also configure parameters in RUN mode (dynamic) via the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of parameter data record for DI operating mode (Page 60).

The following parameter settings are possible for each operating mode:

Table 2-225 Configurable parameters in DI operating mode

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software	
				HSP0127 for STEP 7 (TIA Portal); HSP0229 for STEP 7; PROFINET IO GSD file	GSD file PROFIBUS DP
Operating mode[1]	• DI / Oversampling • Counting	—	no	Module	Module
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module	Module

1 When configuring with HSP0229 for STEP 7 or with a GSD file, the operating mode is specified by selecting the module name.

2 Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter via data record 128.

3 If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter for each channel via data record 128.

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software	
				HSP0127 for STEP 7 (TIA Portal); HSP0229 for STEP 7; PROFINET IO GSD file	GSD file PROFIBUS DP
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	yes	Module	Module
Channel activated	• Disable • Enable	Enable	yes	Channel	Channel
Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	yes	Channel	Module [2]
Pulse stretching	• None • 0.05 s • 0.1 s • 0.2 s • 0.5 s • 1 s • 2 s	None	yes	Channel	— [3]
Hardware interrupt: rising edge	• Disable • Enable	Disable	yes	Channel	— [3]
Hardware interrupt: falling edge	• Disable • Enable	Disable	yes	Channel	— [3]
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module	Module

1 When configuring with HSP0229 for STEP 7 or with a GSD file, the operating mode is specified by selecting the module name.

2 Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter via data record 128.

3 If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter for each channel via data record 128.

3.2.3 Explanation of parameters

Operating mode

At the module level, specifies the operating mode in which the module's channels are operated:

- DI / Oversampling (Page 45)
- Counting (Page 26)

When configuring with HSP0229 for STEP 7 or with a GSD file, the operating mode is specified by selecting the module name.

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Channel activated

Determines whether a channel is enabled or disabled. If a digital input is disabled, the module ignores its signals.

Pulse stretching

Pulse stretching is a function used to change a digital input signal. A pulse on a digital input is stretched to at least the configured length. If the input pulse is already longer than the configured length, the pulse is not changed. With Pulse stretching, you can reliably detect very short input signals without having to use a correspondingly short cycle time.

In isochronous mode, the terminal signal is read in at the time T_i (time for reading the input data). In some cases, pulses that are shorter than the cycle time (send clock) are not detected.

If you want to detect short signals isochronously, the Oversampling operating mode is recommended. Oversampling also provides more precise information about the time at which a signal occurs.

Principle of pulse stretching

The figure below uses examples to show whether and how input pulses are changed.

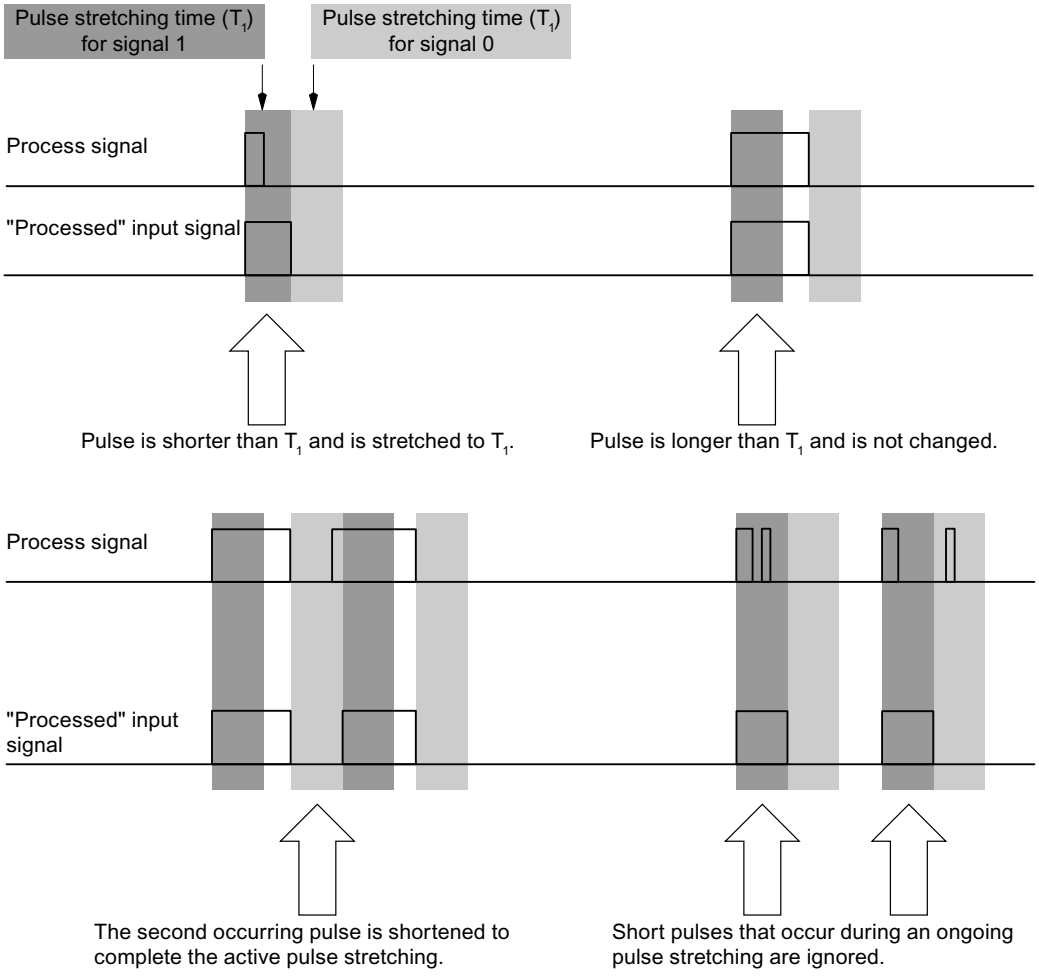

Figure 2-177 Principle of pulse stretching

Input delay

This parameter can be used to avoid signal faults. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

Isochronous configuration is only possible if there is no input delay configured for at least one channel. In isochronous mode, the terminal signal is read in at the time T_i (time for reading the input data). The read time T_i refers to the channel for which no input delay time was configured.

For input channels with longer input delays, the read time is moved accordingly. This means individual channels can be assigned input delays, if necessary, without having a negative impact on the possible cycle time.

NOTE

If you select the "None" or "0.05 ms" option for the input delay, you have to use shielded cables for connection of the digital inputs.

Hardware interrupt: rising edge

Specifies whether a hardware interrupt is generated for a rising edge.

Hardware interrupt: falling edge

Specifies whether a hardware interrupt is generated for a falling edge.

Potential group

Specifies whether a light-colored BaseUnit with incoming supply voltage is located on this slot (see ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual).

3.2.4 Address space

Address space with value status (Quality Information, QI)

The figure below shows the assignment of the address space with value status (Quality Information (QI)). "IB x" represents the start address of input byte x.

The addresses for the value status are only available if the value status is enabled.

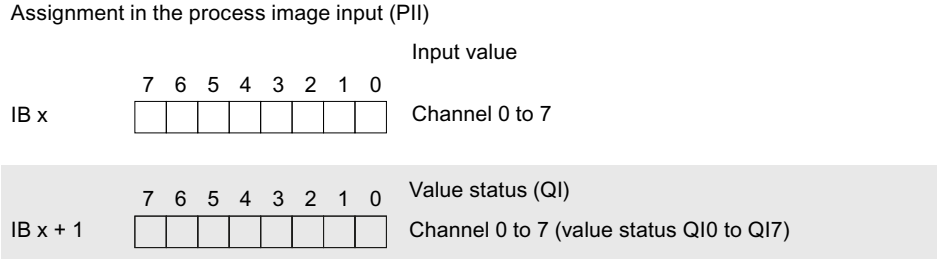

Figure 2-178 Address space with value status

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 7 in this byte are each assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

3.3 Interrupts/diagnostics alarms

3.3.1 Status and error display

LED display

The figure below shows the LED display of the DI 8×24VDC HS.

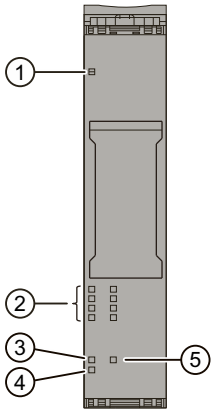

① DIAG (green/red)
② Channel status (green)
③ CNT (green)
④ PWR (green)
⑤ OVS (green)

Figure 2-179 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Remedial measures for dealing with diagnostic interrupts can be found in the section Diagnostics alarms (Page 25).

DIAG LED

Table 2-226 DIAG LED fault/error display

DIAG LED	Meaning
☐ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-227 Status display of the channel status LED

Channel status LED	Meaning
☐ Off	Process signal = 0
■ On	Process signal = 1

CNT LED

Table 2-228 Status display of the CNT LED

CNT LED	Meaning
☐ Off	Counting operating mode disabled
■ On	Counting operating mode enabled

OVS LED

Table 2-229 Status display of the OVS LED

OVS LED	Meaning
☐ Off	Oversampling operating mode disabled
■ On	Oversampling operating mode enabled

PWR LED

Table 2-230 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

3.3.2 Interrupts

The digital input module DI 8×24VDC HS supports hardware and diagnostics alarms in the DI mode.

Diagnostic interrupts

The module generates a diagnostics interrupt at the following events:

- Channel temporarily unavailable
- Short-circuit
- Parameter assignment error
- No load voltage
- Hardware interrupt lost

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- At rising edge (signal change from 0 to 1)
- At falling edge (signal change from 1 to 0)

If an interrupt occurs, a corresponding interrupt OB is called in the CPU of the IO controller.

S7-1500

Detailed information on the event is available in the STEP 7 online help.

The block interface is shown here with optimized block access, which is set in the TIA Portal by default.

Name	Data type	Comment
LADDR	HW_IO	Hardware identifier of the module triggering the interrupt
USI	WORD	USI (High/Low)
IChannel	USInt	Channel that triggered the hardware interrupt
EventType	Byte	Error event

S7-300/400 or a different CPU

The module generates a hardware interrupt at the following events:

- At rising edge (signal change from 0 to 1)
- At falling edge (signal change from 1 to 0)

If an interrupt occurs, a corresponding interrupt OB is called in the CPU of the IO controller.

You will find detailed information on the event in the hardware interrupt organization block with the "RALRM" (read additional interrupt information) instruction and in the STEP 7 online help.

The channel of the module that triggered the hardware interrupt is entered in the start information of OB40 in the OB40_POINT_ADDR tag. The following figure shows the assignment to the bits of double word 8 in local data.

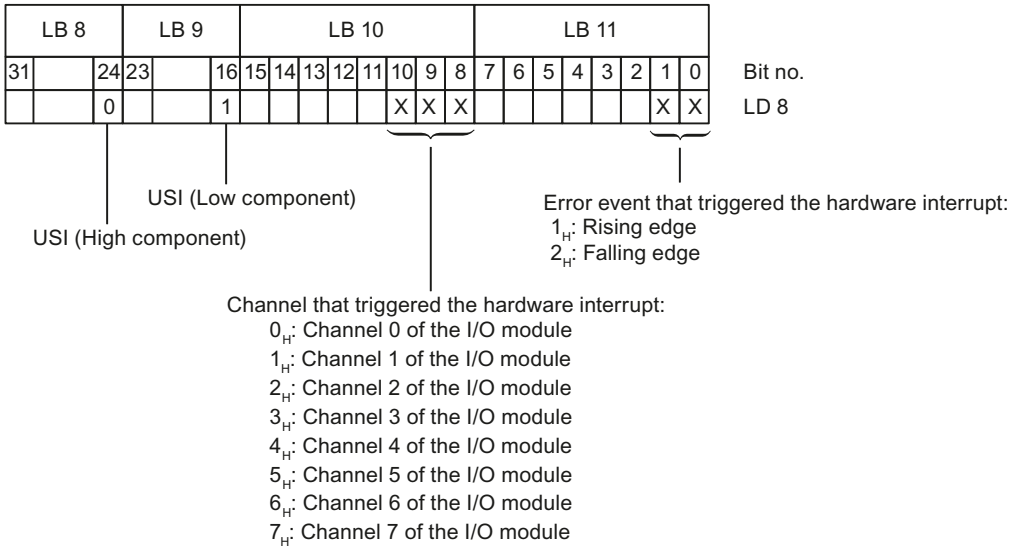

Figure 2-180 OB40_POINT_ADDR tag

Structure of the additional interrupt information

Table 2-231 Structure of USI = W#16#0001

Data block name		Content	Comment	Bytes
USI		W#16#0001	User Structure Identifier: Additional interrupt info for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#07	Channel 0 to 7 of the I/O module	1
It follows the error event that triggered the hardware interrupt.				
	Error event	B#16#01	Rising edge	1
		B#16#02	Falling edge	

3.3.3 Diagnostics alarms

A diagnostic interrupt is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostic interrupts can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-232 Diagnostic interrupts, their meaning and how to deal with them

Diagnostic interrupt	Error code	Meaning	Remedy
Short-circuit	1_H	Short-circuit to ground at encoder supply	Correct process wiring
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel/module. • Incorrect parameter assignment.	Correct parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Hardware interrupt lost	16_H	• Module cannot send an interrupt because a previous interrupt has not been processed • Possible cause: Too many hardware interrupts in too short a time	Change interrupt processing in the CPU and re-assign module parameters correspondingly
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module reads no process values in this state.	• Wait for firmware update. • Restart the firmware update.

Counting operating mode (CNT) 4

4.1 Connecting

4.1.1 Wiring and block diagrams

This section contains the block diagram for the DI 8×24VDC HS module with the pin assignments for 1, 2 and 3-wire connection in counting operating mode. You may use and combine the different wiring options for all channels.

Information on wiring the BaseUnit can be found in the system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

The module's load group must start with a light BaseUnit. Keep this in mind also during the configuration.

Wiring: 1 and 2-wire connection

The figure below shows the block diagram and an example of pin assignment for the DI 8×24VDC HS digital input module on the BaseUnit BU type A0 without AUX terminals (1 and 2-wire connection).

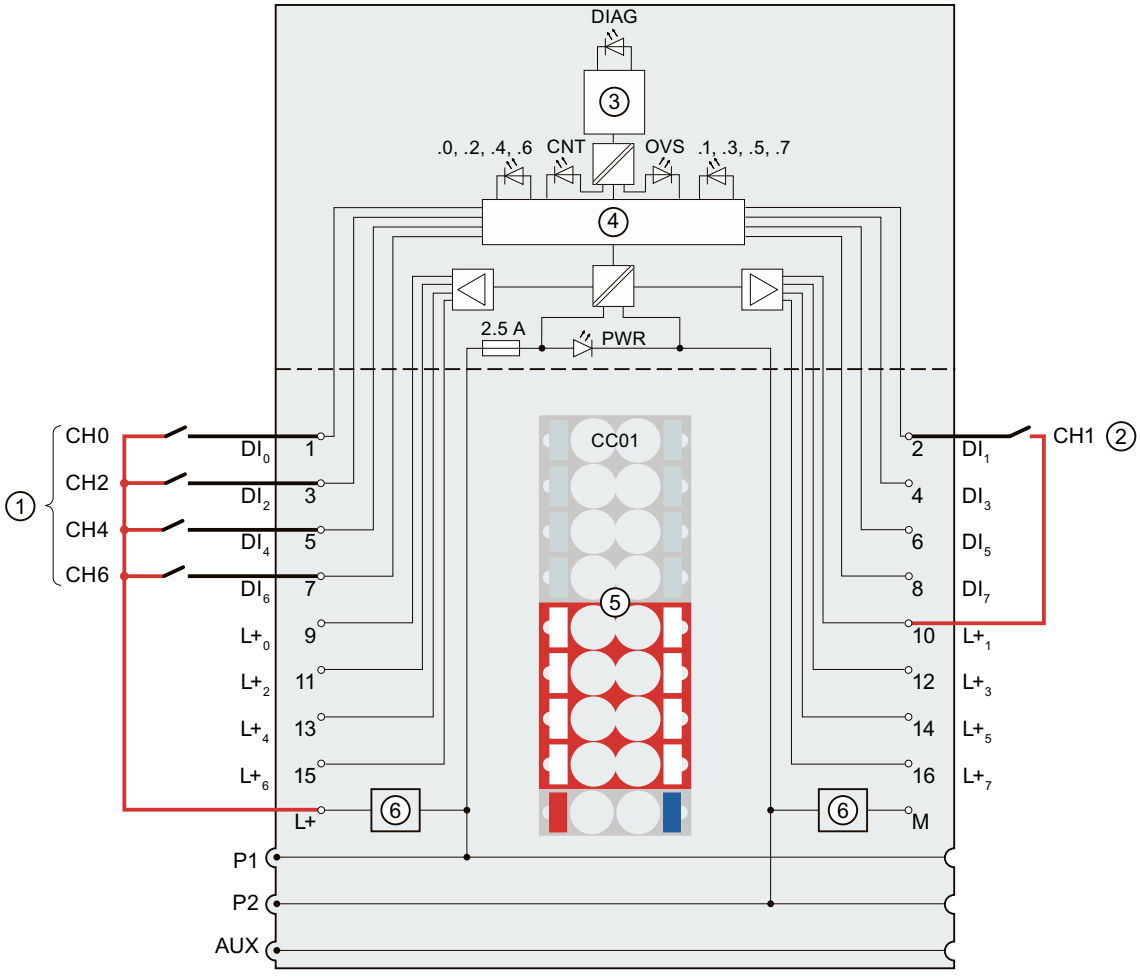

①	1-wire connection	DIAG	LED error or diagnostics (green, red)
②	2-wire connection	.0 to .7	LED channel status (green)
③	Backplane bus interface	PWR	LED power (green)
④	Input electronics	CNT	LED operating mode Count (green)
⑤	Color-coded label CCxx (optional)	OVS	LED operating mode Oversampling (green)
⑥	Supply voltage filter circuit (only available with light BaseUnit)	DI_0 - DI_3	Counter input, channels 0-3
M	Ground	DI_4	Direction input or gate input for DI_0, channel 4
$L+_n$	Encoder supply, channel n	DI_5	Direction input or gate input for DI_1, channel 5
L+	24 V DC (infeed only with light BaseUnit)	DI_6	Direction input or gate input for DI_2, channel 6
P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)	DI_7	Direction input or gate input for DI_3, channel 7

Figure 2-181 Pinout and block diagram for 1 and 2-wire connection of encoders

Wiring: 3-wire connection

The figure below shows an example of pin assignment for the DI 8×24VDC HS digital input module on the BaseUnit BU type A0 with AUX terminals (3-wire connection).

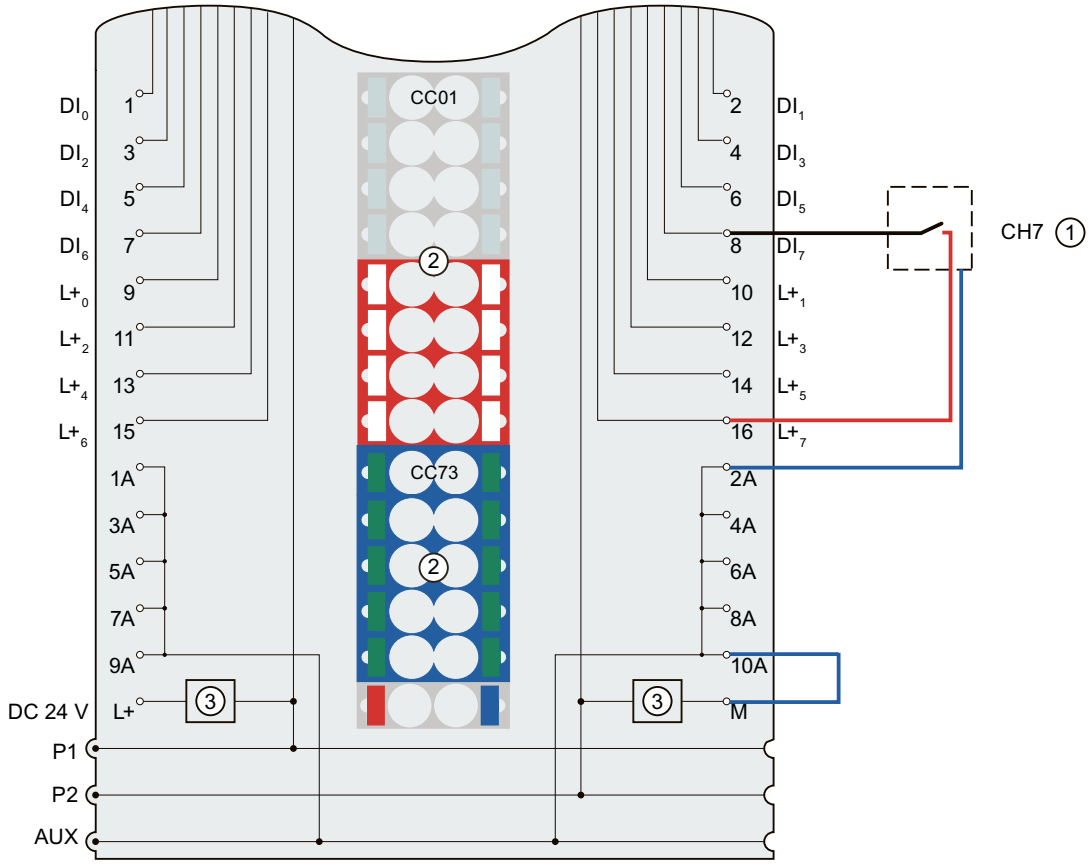

①	3-wire connection
②	Color-coded labels CCxx (optional)
③	Supply voltage filter circuit (only available with light BaseUnit)
DI_n	Input signal, channel n
$L+_n$	Encoder supply, channel n
DC 24 V	Supply voltage L+ (infeed only with light BaseUnit)
M	Ground
1A ... 10A	AUX terminals
P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)

Figure 2-182 Pinout and block diagram for 3-wire connection of encoders

4.2 Parameters/address space

4.2.1 Counting

Function

Counting refers to the detection and summation of events. The respective counters of the module detect encoder signals and pulses and evaluate them accordingly, for example:

- For counting general piece goods up to a maximum limit
- For applications with recurring counting processes

You can count with DI_0 through DI_3. You can specify each counter's characteristics using the functions described below.

Counter limits

The counting limits define the counter value range used. The counter limits are configurable and can be modified during runtime using the user program.

The maximum possible counting limit is 2147483647 (2^{31}–1). The minimum possible counting limit is –2147483648 (–2^{31}).

You can continue or stop counting upon violation of a counting limit (automatic gate stop) Upon high and low limit violations of the counter value, an event bit is set in the feedback interface (Page 38) in each case.

Start value

You can configure a start value within the counter limits. The start value can be modified during runtime with the user program.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are recordd.

The control of the hardware gate takes place externally via the digital inputs DI_4 through DI_7. The software gate is controlled via the user program. Use of the hardware gate can be enabled through parameter assignment.

Count direction

The counting direction is specified either via suitable external pulse signals at the each counter's control input or via the configuration.

Comparison values

You define two comparison values that can control the STS_DQ feedback bit, independent of the user program. If the current counter value meets the configured comparison condition, the STS_DQ reset bit is set. You can use the STS_DQ reset bit in order to control a digital output module's digital output.

The comparison values are configurable and can be modified during runtime with the user program. When a comparison event occurs, in each case an event bit is set in the feedback interface (Page 38).

4.2.2 Parameters

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation on an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

In addition to configuration via the configuration software, you can also configure parameters in RUN mode (dynamic) via the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of parameter data record for Counting operating mode (Page 64).

The following parameter settings are possible for each operating mode:

Table 2-233 Configurable parameters in Counting operating mode

Parameters	Value range	Default	Reconfig-uration in RUN	Effective range with configuration software	
				HSP0127 for STEP 7 (TIA Portal); HSP0229 for STEP 7; PROFINET IO GSD file	GSD file PROFIBUS DP
Operating mode[1]	• DI / Oversampling • Counting	—	No	Module	Module
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Module	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel

1 When configuring with HSP0229 for STEP 7 or with a GSD file, the operating mode is specified by selecting the module name.

2 If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter for each channel via data record 128.

3 Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter via data record 128.

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software	
				HSP0127 for STEP 7 (TIA Portal); HSP0229 for STEP 7; PROFINET IO GSD file	GSD file PROFIBUS DP
Input delay	• 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	Yes	Channel	Module [2]
Reaction to violation of a counting limit	• Stop counting • Continue counting	Stop counting	Yes	Channel	Channel
Edge selection	• At rising edge • At falling edge	At rising edge	Yes	Channel	Channel
Count direction	• Up • Down	Up	Yes	Channel	Channel
Set output	• Off (DQ = 0) • Off (DQ = 1) • Between comparison value 0 and 1 • Not between comparison value 0 and 1	Off (DQ = 0)	Yes	Channel	Channel
Set function of DI	• Digital input • Gate start/stop • Count direction	Digital input	Yes	Channel	Channel
High counting limit	-2147483648...2147483647	2147483647	Yes	Channel	Channel
Low counting limit	-2147483648...2147483647	0	Yes	Channel	— [3]
Start value	-2147483648...2147483647	0	Yes	Channel	— [3]
Comparison value 1	-2147483648...2147483647	10	Yes	Channel	Channel
Comparison value 0	-2147483648...2147483647	0	Yes	Channel	— [3]
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module	Module

1 When configuring with HSP0229 for STEP 7 or with a GSD file, the operating mode is specified by selecting the module name.

2 If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter for each channel via data record 128.

3 Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter via data record 128.

4.2.3 Explanation of parameters

Operating mode

Selection of the operating mode in which all of the module's channels are operated.

- DI (Page 13) / Oversampling (Page 45)
- Counting

When configuring with HSP0229 for STEP 7 or with a GSD file, the operating mode is specified by selecting the module name.

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Channel activated

Determines whether a channel is enabled or disabled. If a digital input is disabled, the module ignores its signals.

Input delay

You use this parameter to suppress signal interferences. The module only detects changes to the signal if the changed signal is constantly pending longer than the set input delay time.

NOTE

If you select the "0.05 ms" value range for the input delay, you have to use shielded cables for connection of the digital inputs.

Reaction to violation of a counting limit

Selection of the reaction to violation of the counter high limit in the upward direction or the counter low limit in the downward direction:

- Stop counting:
  After a counting limit is violated, the internal gate is closed. This stops the counting process. The counter value is set to the opposite counting limit. To restart counting, you must close and reopen the software/hardware gate.
- Continue counting:
  After a counting limit is violated, the counter value is set to the opposite counting limit and counting continues.

Edge selection

Selects the edge that is counted:

- At rising edge:
  The respective counter counts all rising edges at the digital input.
- At falling edge:
  The respective counter counts all falling edges at the digital input.

NOTE

If the "Reverse direction" option is selected in "Set function of DI" and the counting direction in the process changes, the counting edge is automatically adjusted (opposite edges).

Count direction

Count direction selection:

- Up:
  The respective counter counts up.
- Down:
  The respective counter counts down.

NOTE

This parameter has no effect if the "Reverse direction" option is selected in "Set function of DI".

Set output

Selects the function that controls the response of the STS_DQ feedback bit (Page 38): You use the feedback bit STS_DQ to control a digital output of a digital output module.

- Off (DQ = 0):
  STS_DQ is independent of the counter value and permanently not set.
- Off (DQ = 1):
  STS_DQ is independent of the counter value and permanently set.
- Between comparison value 0 and 1:
  STS_DQ is set if counter value ≥ comparison value 0 and counter value ≤ comparison value 1.
- Not between comparison value 0 and 1:
  STS_DQ is set if counter value < comparison value 0 or counter value > comparison value 1.

Set function of DI

Selects the function of DI_{n+4}, which controls the assigned counter input DI_n:

- Digital input:
  No function is assigned to DI_{n+4}. The signal status of DI_{n+4} is read by the CPU using the feedback interface (Page 38).
- Gate start/stop:
  Setting DI_{n+4} opens the hardware gate for DI_n. Resetting DI_{n+4} closes the hardware gate for DI_n.
- Count direction:
  DI_{n+4} reverses the counting direction at DI_n, in order to adjust it to the process. If DI_{n+4} is not set, DI_n counts up. If DI_{n+4} is set, DI_n counts down.

Counter high limit

Sets counter high limit.

The following applies:

- Counter high limit > counter low limit
- Counter high limit ≤ 2147483647 (2^{31} - 1)

Counter low limit

Sets the counter low limit.

The following applies:

- Counter low limit < counter high limit
- Counter low limit ≥ -2147483648 (-2^{31})

Start value

Sets the start value.

The following applies:

- Start value ≥ counter low limit
- Start value ≤ counter high limit

Comparison value 1

Sets the second comparison value.

The following applies:

- Comparison value 1 > comparison value 0
- Comparison value 1 ≤ counter high limit

Comparison value 0

Sets the first comparison value.

The following applies:

- Comparison value 0 < comparison value 1
- Comparison value 0 ≥ counter low limit

Potential group

Specifies whether a light-colored BaseUnit with incoming supply voltage is located on this slot (see ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual).

4.2.4 Address space

4.2.4.1 Assignment of the control interface

Control interface

The user program uses the control interface to influence the behavior of the module's counter. The figure below shows the address space allocation for the control interface in the process image of the outputs.

The following table shows the offset of the control interface for the channels of the module:

Channel	Offset x
0	0
1	5
2	10
3	15

Enter the offset from the table for x in the following screen.

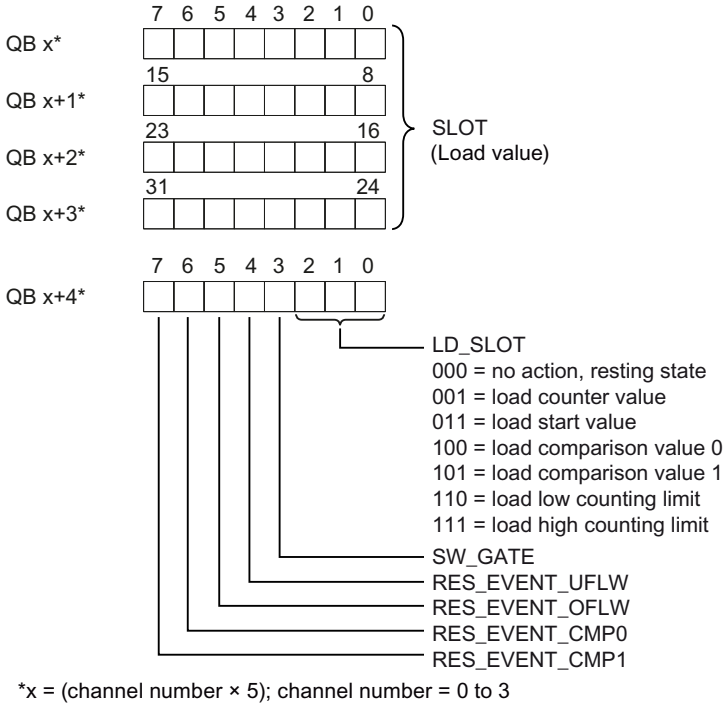

Figure 2-183 Assignment of the control interface

Notes on the control bits

Control bit	Notes
SLOT	This value is used to specify the loaded value for each channel. Use the LD_SLOT load request to evaluate the loaded value.
LD_SLOT	This load request is used to specify the meaning of the SLOT (loaded value) value for each channel. The user program performs the respective action, as soon as LD_SLOT changes. When the loading request LD_SLOT = 011_B is entered and the software gate is opened, each counting operation begins with the start value. If another load request is entered and the software gate is opened, counting continues with the current count at each start of the counting operation. These two situations are also in effect when the hardware gate is configured and the software gate is closed.
SW_GATE	With this bit, you open and close the software gate of the respective channel. Together, the software gate and the hardware gate form the internal gate. The module only counts if the internal gate is open. 0 means: Software gate closed 1 means: Software gate open
RES_EVENT_UFLW	Use this bit to initiate the resetting of the saved event in the EVENT_UFLW feedback bit for the respective channel.
RES_EVENT_OFLW	Use this bit to initiate the resetting of the saved event in the EVENT_OFLW feedback bit for the respective channel.
RES_EVENT_CMP0	Use this bit to initiate the resetting of the saved event in the EVENT_CMP0 feedback bit for the respective channel.
RES_EVENT_CMP1	Use this bit to initiate the resetting of the saved event in the EVENT_CMP1 feedback bit for the respective channel.

4.2.4.2 Assignment of the feedback interface

Feedback interface

The user program receives current values and status information from the module via the feedback interface. The figure below shows the address space allocation for the feedback interface in the process image of the inputs.

NOTE

In isochronous mode, current values and the status information in the feedback interface is updated at the time T_i (time for reading the input data).

The following table shows the offset of the feedback interface for the channels of the module:

Channel	Offset x
0	1
1	7
2	13
3	19

Enter the offset from the table for x in the following screen.

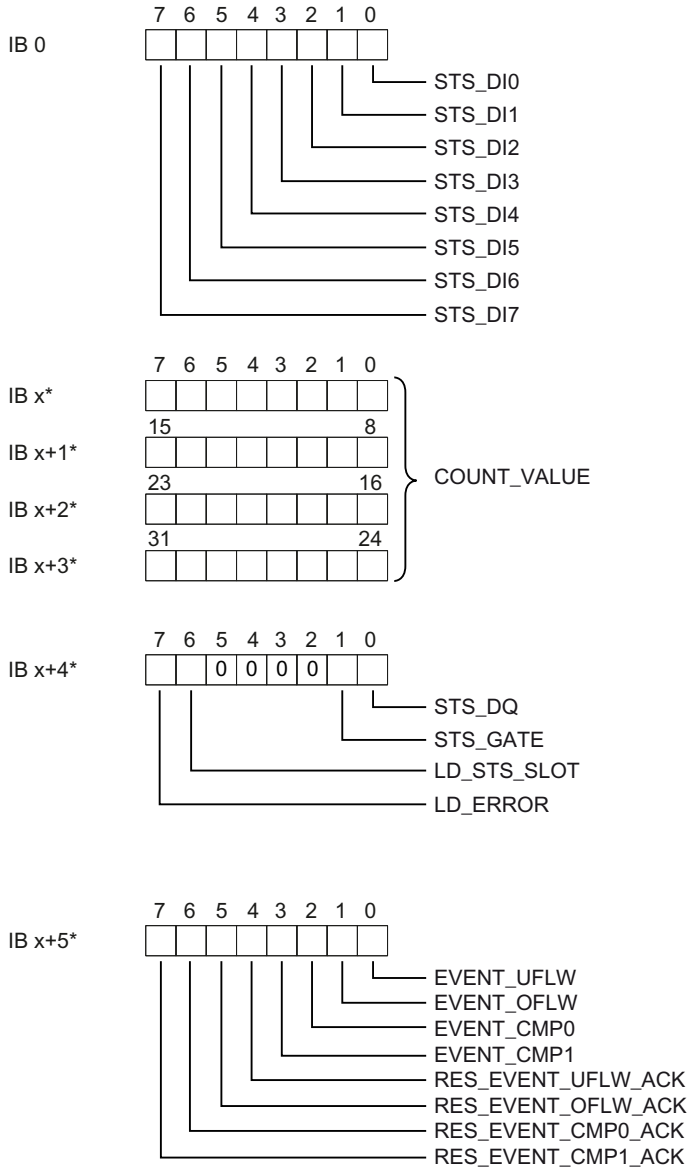

*x = (channel number × 6); channel number = 0 to 3

Figure 2-184 Assignment of the feedback interface

Notes on the feedback bits

Feedback bit	Notes
STS_DIn	This bit indicates the status of the respective digital input DI_n.
COUNT_VALUE	This value returns the current counter value for the respective channel.
STS_DQ	This bit depends on the "Set output" parameter of the respective channel. You can use STS_DQ in each case, in order to control a digital output module's digital output.

Feedback bit	Notes
STS_GATE	Together, the software gate and the hardware gate form the internal gate. This bit indicates the status of the internal gate for the respective channel. The module only counts if the internal gate is open. 0 means: Gate closed 1 means: Gate open Note: If you change a channel parameter in RUN mode via data record 128, all of the changed channel's values are retransferred to the module. In doing so, the internal gate of the respective channel is closed and the counter value is set to the start value. To restart counting, you need to close and reopen the software gate in each case.
LD_STS_SLOT	This bit indicates for the respective channel, by mean of a status change (toggling), that the load request for SLOT (LD_SLOT) has been detected and executed.
LD_ERROR	This bit indicates for the respective channel that an error occurred (latching) during loading via the control interface. The loaded value was not applied. One of the following conditions has not been met: • Counter low limit ≤ counter value (If this condition is not met, the start value is loaded as the current counter value.) • Counter low limit ≤ start value • Counter low limit ≤ comparison value 0/1 • Counter high limit ≥ counter value (If this condition is not met, the start value is loaded as the current counter value.) • Counter high limit ≥ start value • Counter high limit ≥ comparison value 0/1 • Counter low limit < counter high limit • Comparison value 0 < comparison value 1 • Do not write a reserved load request in LD_SLOT
EVENT_UFLW	For the respective channel, this bit indicates the saved state which shows that there was a counter value underflow (a violation of the counter low limit). You reset the status by acknowledgment with RES_EVENT_UFLW.
EVENT_OFLW	For the respective channel, this bit indicates the saved state which shows that there was a counter value overflow (a violation of the counter high limit). You reset the status by acknowledgment with RES_EVENT_OFLW.
EVENT_CMP0	For the respective channel, this bit indicates the saved status which shows that a comparison event with comparison value 0 has occurred. You reset the status by acknowledgment with RES_EVENT_CMP0. The EVENT_CMP0 bit is not set when you set the counter value to the start value.
EVENT_CMP1	For the respective channel, this bit indicates the saved status which shows that a comparison event with comparison value 1 has occurred. You reset the status by acknowledgment with RES_EVENT_CMP1. The EVENT_CMP1 bit is not set when you set the counter value to the start value.
RES_EVENT_UFLW_ACK	This bit indicates for the respective channel that the reset of event bit EVENT_UFLW is active.
RES_EVENT_OFLW_ACK	This bit indicates for the respective channel that the reset of event bit EVENT_OFLW is active.
RES_EVENT_CMP0_ACK	This bit indicates for the respective channel that the reset of event bit EVENT_CMP0 is active.
RES_EVENT_CMP1_ACK	This bit indicates for the respective channel that the reset of event bit EVENT_CMP1 is active.

Complete acknowledgment principle

Saving bits are acknowledged according to the complete acknowledgment principle.

The figure below shows an example of the sequence of the complete acknowledgment principle in the event of an overflow:

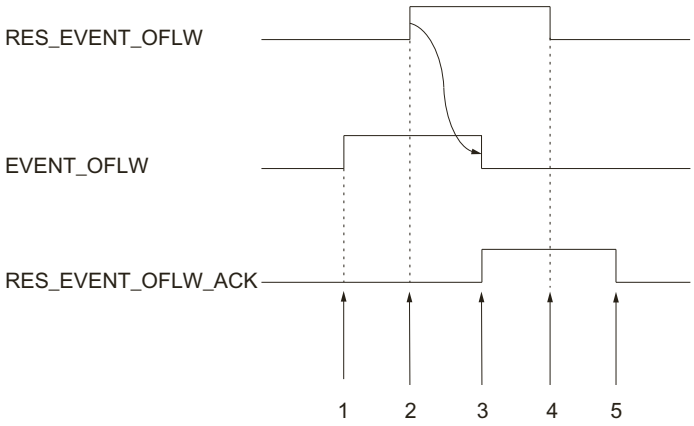

① The EVENT_OFLW feedback bit is set as a saving event upon overflow.

② You set the RES_EVENT_OFLW control bit to trigger EVENT_OFLW reset.

③ The RES_EVENT_OFLW_ACK feedback bit is set when reset of EVENT_OFLW is detected.

④ You then rest the control bit RES_EVENT_OFLW .

⑤ The RES_EVENT_OFLW_ACK feedback bit is reset.

Figure 2-185 Acknowledgment principle

NOTE

If you have initiated the reset of an event bit, you must wait for the respective feedback bit. Then you can initiate another reset.

NOTE

Opening the software gate or hardware gate (0-1 transition) resets all event bits.

4.3 Interrupts/diagnostic messages

4.3.1 Status and error display

LED display

The figure below shows the LED display of the DI 8×24VDC HS.

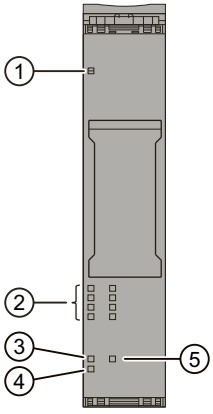

① DIAG (green/red)
② Channel status (green)
③ CNT (green)
④ PWR (green)
⑤ OVS (green)

Figure 2-186 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Remedial measures for dealing with diagnostic interrupts can be found in the section Diagnostics alarms (Page 44).

DIAG LED

Table 2-234 DIAG LED fault/error display

DIAG LED	Meaning
□ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-235 Status display of the channel status LED

Channel status LED	Meaning
□ Off	Process signal = 0
■ On	Process signal = 1

CNT LED

Table 2-236 Status display of the CNT LED

CNT LED	Meaning
□ Off	Counting operating mode disabled
■ On	Counting operating mode enabled

OVS LED

Table 2-237 Status display of the OVS LED

OVS LED	Meaning
□ Off	Oversampling operating mode disabled
■ On	Oversampling operating mode enabled

PWR LED

Table 2-238 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

4.3.2 Interrupts

The digital input module DI 8×24VDC HS supports diagnostics alarms in the Counting mode.

Diagnostic interrupts

The module generates a diagnostics interrupt at the following events:

- Channel temporarily unavailable
- Short-circuit
- Parameter assignment error
- No load voltage

4.3.3 Diagnostics alarms

A diagnostic interrupt is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostic interrupts can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-239 Diagnostic interrupts, their meaning and how to deal with them

Diagnostic interrupt	Error code	Meaning	Remedy
Short-circuit	1_H	Short-circuit to ground at encoder supply	Correct process wiring
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module reads no process values in this state.	• Wait for firmware update. • Restart the firmware update.

Oversampling (OVS) operating mode 5

5.1 Connecting

5.1.1 Wiring and block diagrams

This section contains the block diagram for the DI 8×24VDC HS module with the pin assignments for 1, 2 and 3-wire connection in Oversampling operating mode. You may use and combine the different wiring options for all channels.

Information on wiring the BaseUnit can be found in the system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

The module's load group must start with a light BaseUnit. Keep this in mind also during the configuration.

Wiring: 1 and 2-wire connection

The figure below shows the block diagram and an example of pin assignment for the DI 8×24VDC HS digital input module on the BaseUnit BU type A0 without AUX terminals (1 and 2-wire connection).

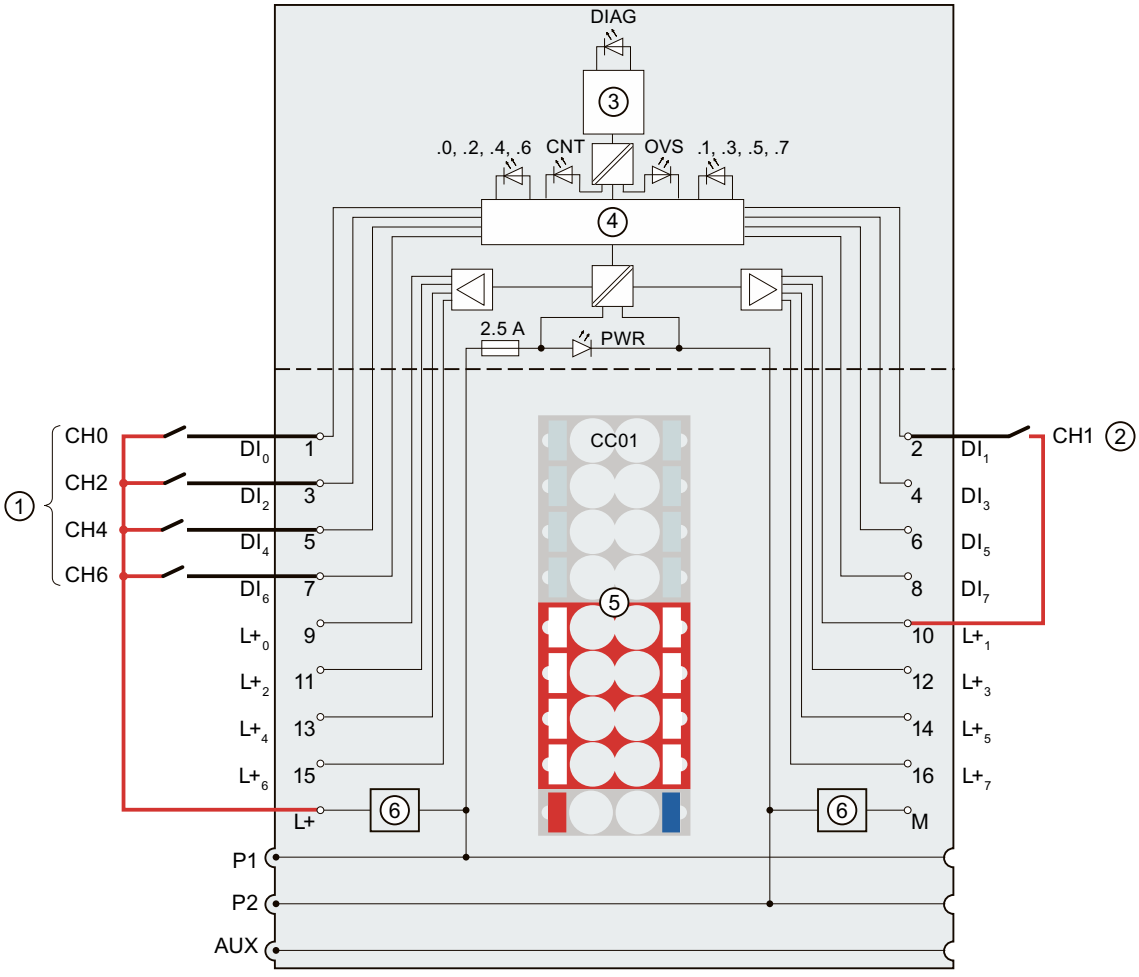

①	1-wire connection	$L+_n$	Encoder supply, channel n
②	2-wire connection	L+	24 V DC (infeed only with light BaseUnit)
③	Backplane bus interface	DIAG	LED error or diagnostics (green, red)
④	Input electronics	.0 to .7	LED channel status (green)
⑤	Color-coded label CCxx (optional)	PWR	LED power (green)
⑥	Supply voltage filter circuit (only available with light BaseUnit)	CNT	LED operating mode Count (green)
M	Ground	OVS	LED operating mode Oversampling (green)
DI_n	Input signal, channel n	P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)

Figure 2-187 Pinout and block diagram for 1 and 2-wire connection of encoders

Wiring: 3-wire connection

The figure below shows an example of pin assignment for the DI 8×24VDC HS digital input module on the BaseUnit BU type A0 with AUX terminals (3-wire connection).

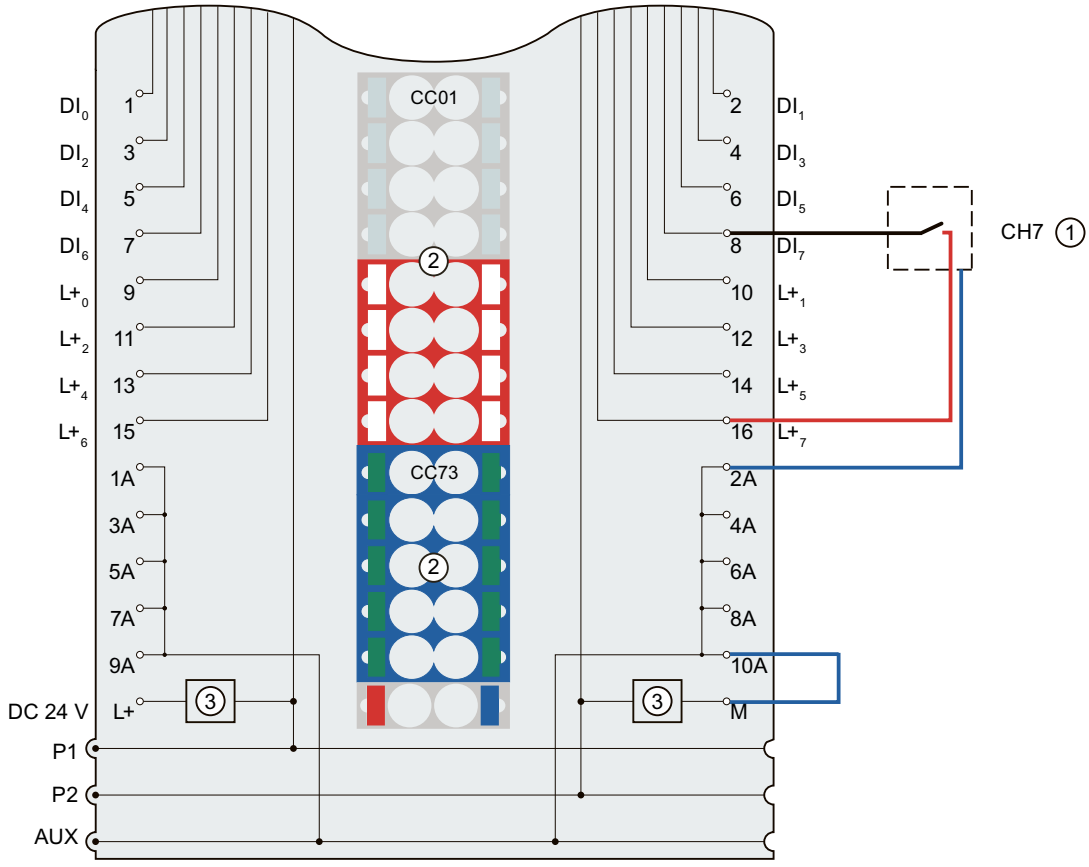

①	3-wire connection
②	Color-coded labels CCxx (optional)
③	Supply voltage filter circuit (only available with light BaseUnit)
DI_n	Input signal, channel n
$L+_n$	Encoder supply, channel n
DC 24 V	Supply voltage L+ (infeed only with light BaseUnit)
M	Ground
1A ... 10A	AUX terminals
P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)

Figure 2-188 Pinout and block diagram for 3-wire connection of encoders

5.2 Parameters/address space

5.2.1 Oversampling

Function

Oversampling is the acquisition of data in constant bus cycle segments (sub-cycles), whereby n sub-cycles correspond to one PROFINET bus cycle.

Oversampling is useful whenever you require acquisition of data with high time resolution but without using an extremely short PROFINET bus cycle and thus fast CPU cycles.

With the oversampling function, a PROFINET bus cycle is divided into constant bus sub-cycles:

- Each subcycle detects an 8-bit value.
- A subcycle is at least 7.8125 µs in length.
- Subcycles are possible in steps from 2 to 32 (sampling rate).

Requirement

Oversampling is only possible when isochronous mode is set.

Configuration

You configure oversampling with the following parameter:

- Sampling rate

NOTE

Do not use a reduction ratio for blocks in the case of configuration with oversampling in the runtime groups of your user program. This will ensure that the data processing in the user program of the CPU is synchronized with the acquisition on the module.

Sampling interval

The duration of a subcycle is the sampling interval. The cycle time T (send clock) for isochronous mode is specified in the configuration software. This time, divided by the configured sampling rate n_{Sample}, yields the sampling interval t_{Sample} of the module.

Example calculation:

$$t_{Sample} = \frac{T}{n_{Sample}} = \frac{1\ \text{ms}}{16} = 62{,}5\ \mu\text{s}$$

Figure 2-189 Example of calculating the sampling interval

Chronological sequence

The figure below shows the chronological sequence for oversampling. The detected input data of a data cycle (send clock) is copied to the interface module in the next cycle data and are available to the CPU in the data cycle after the next one.

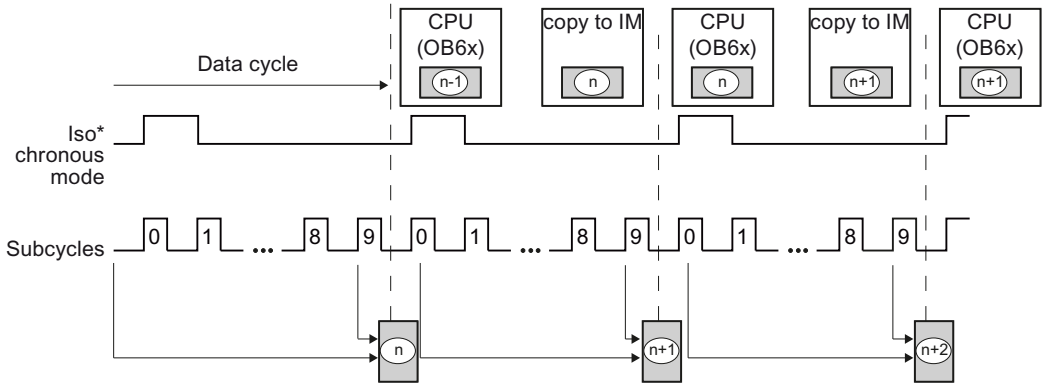

n Detected value from cycle n

Subcycle 8 bits apiece x 32 (max.) = max. 32 bytes of input data per data cycle

Figure 2-190 Oversampling

NOTE

Do not use a reduction ratio for the send clock in this operating mode for blocks in your user program (for example, OB61). This will ensure that the data processing in the user program of the CPU is synchronized with the acquisition on the module.

5.2.2 Parameters

In distributed mode, you can use the Oversampling operating mode on the PROFINET IO in an ET 200SP system.

In addition to configuration via the configuration software, you can also configure parameters in RUN mode (dynamic) via the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of parameter data record for Oversampling operating mode (Page 69).

The following parameter settings are possible:

Table 2-240 Configurable parameters in the Oversampling operating mode

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software
				HSP0127 for STEP 7 (TIA Portal); HSP0229 for STEP 7
Operating mode[1]	• DI / Oversampling • Counting	—	no	Module
Sampling rate	• 2 values / cycle • 3 values / cycle • ... • 32 values / cycle	—	yes	Module
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	yes	Module
Channel activated	• Disable • Enable	Enable	yes	Channel
Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	None	yes	Channel
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module

[1] When configuring with HSP0229 for STEP 7, the operating mode is specified by selecting the module name.

5.2.3 Explanation of parameters

Operating mode

At the module level, specifies the operating mode in which the module's channels are operated.

- DI (Page 13) / Oversampling
- Counting (Page 26)

When configuring with HSP0229 for STEP 7, the operating mode is specified by selecting the module name.

Sampling rate

Specifies the number of subcycles per isochronous data cycle.

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Channel activated

Determines whether a channel is enabled or disabled. If a digital input is disabled, the module ignores its signals.

Input delay

This parameter can be used to avoid signal faults. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

Isochronous configuration is only possible if there is no input delay configured for at least one channel. In isochronous mode, the terminal signal is read in at the time T_i (time for reading the input data). The read time T_i refers to the channel for which no input delay time was configured.

For input channels with longer input delays, the read time is moved accordingly. This means individual channels can be assigned input delays, if necessary, without having a negative impact on the possible cycle time.

NOTE

If you select the "None" or "0.05 ms" option for the input delay, you have to use shielded cables for connection of the digital inputs.

Potential group

Specifies whether a light-colored BaseUnit with incoming supply voltage is located on this slot (see ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual).

5.2.4 Address space

Address space

The figure below shows the assignment of the address space. "IB x" represents the start address of input byte x.

In the respective bit, the subcycles are counted from left to right. Up to 32 subcycles are possible. If fewer than 32 subcycles are configured, the bits that are consequently unused are set to 0.

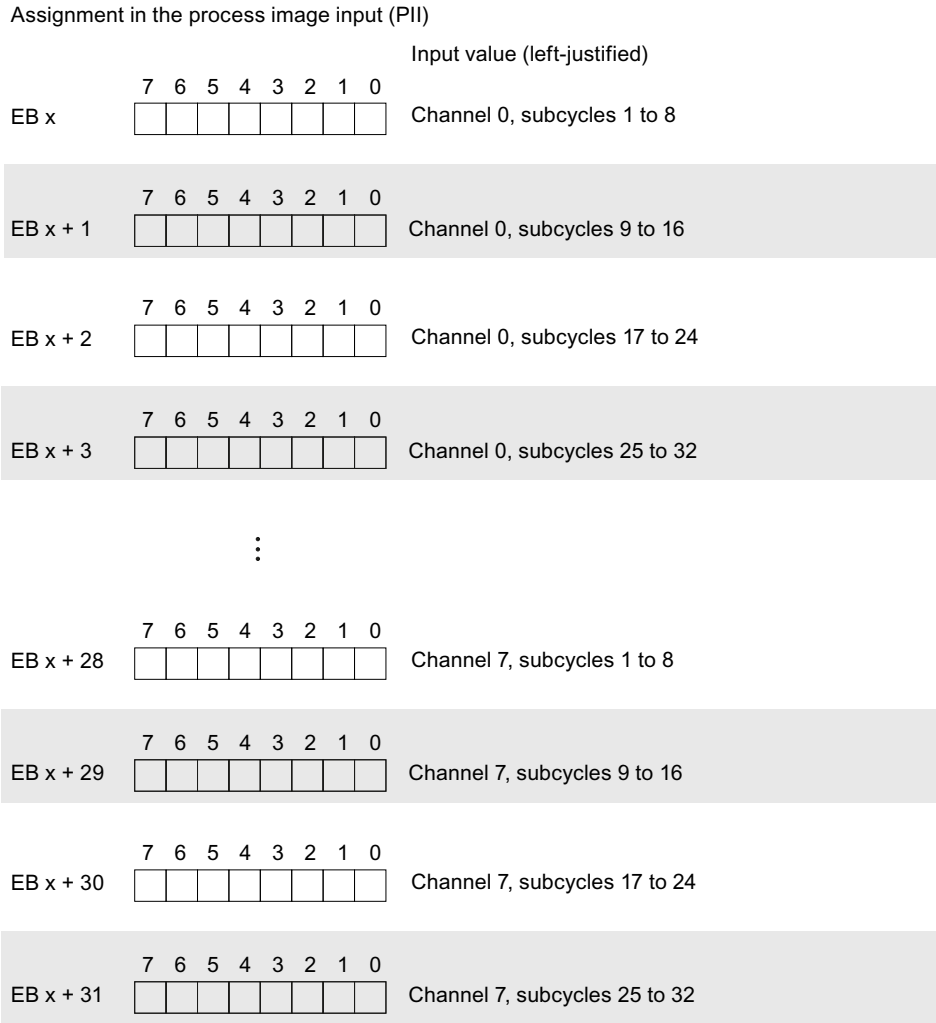

Figure 2-191 Address space for oversampling

NOTE

While you are changing parameters in RUN mode, corruption of input data can occur.

5.3 Interrupts/diagnostic messages

5.3.1 Status and error display

LED display

The figure below shows the LED display of the DI 8×24VDC HS.

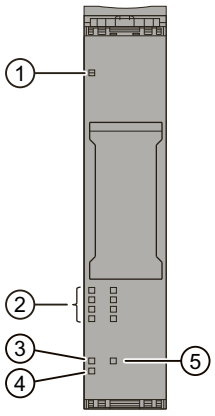

① DIAG (green/red)
② Channel status (green)
③ CNT (green)
④ PWR (green)
⑤ OVS (green)

Figure 2-192 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Remedial measures for dealing with diagnostic interrupts can be found in the section Diagnostics alarms (Page 55).

DIAG LED

Table 2-241 DIAG LED fault/error display

DIAG LED	Meaning
□ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-242 Status display of the channel status LED

Channel status LED	Meaning
□ Off	Process signal = 0
■ On	Process signal = 1

CNT LED

Table 2-243 Status display of the CNT LED

CNT LED	Meaning
□ Off	Counting operating mode disabled
■ On	Counting operating mode enabled

OVS LED

Table 2-244 Status display of the OVS LED

OVS LED	Meaning
□ Off	Oversampling operating mode disabled
■ On	Oversampling operating mode enabled

PWR LED

Table 2-245 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

5.3.2 Interrupts

The digital input module DI 8×24VDC HS supports diagnostics alarms in the Oversampling mode.

Diagnostic interrupts

The module generates a diagnostics interrupt at the following events:

- Short-circuit
- Parameter assignment error
- No load voltage
- Channel temporarily unavailable

5.3.3 Diagnostics alarms

A diagnostic interrupt is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostic interrupts can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-246 Diagnostic interrupts, their meaning and how to deal with them

Diagnostic interrupt	Error code	Meaning	Remedy
Short-circuit	1_H	Short-circuit to ground at encoder supply	Correct process wiring
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module reads no process values in this state.	• Wait for firmware update. • Restart the firmware update.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DI 8x24VDC HS

The following table shows the technical specifications as of 09/2019. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7131-6BF00-0DA0/td?dl=en)

Article number	6ES7131-6BF00-0DA0
General information	
Product type designation	DI 8x24 V DC HS
HW functional status	from FS04
Firmware version	V1.0.2
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC01
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V13 SP1
• STEP 7 configurable/integrated as of version	V5.5 SP3 / -
• PROFIBUS as of GSD version/GSD revision	GSD Revision 5
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DI	Yes
• Counter	Yes
• Oversampling	Yes
• MSI	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	70 mA; without sensor supply

Article number	6ES7131-6BF00-0DA0
24 V encoder supply	
• 24 V	Yes
• Short-circuit protection	Yes; per module, electronic
• Output current, max.	700 mA
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
• Address space per module, max.	45 byte
• Inputs	32 byte; 1 byte + 1 byte for QI information in DI mode; 32 bytes in Oversampling mode; 25 bytes in Counter mode
• Outputs	20 byte; In count mode
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0
• 3-wire connection	BU type A0 with AUX terminals
• 4-wire connection	BU type A0 + external terminals
Digital inputs	
Number of digital inputs	8
Source/sink input	P-reading
Pulse extension	Yes
• Length	2 s; 50 ms, 100 ms, 200 ms, 500 ms, 1 s, 2 s
Digital input functions, parameterizable	
• Gate start/stop	Yes
• Freely usable digital input	Yes
• Counter	Yes
– Number, max.	4
– Counting frequency, max.	10 kHz
– Counting width	32 bit
– Counting direction up/down	Yes
• Digital input with oversampling	Yes
– Number, max.	8
– Values per cycle, max.	32
– Resolution, min.	7.8125 µs
Input voltage	
• Type of input voltage	DC
• Rated value (DC)	24 V
• for signal "0"	-30 to +5V

Article number	6ES7131-6BF00-0DA0
• for signal "1"	+11 to +30V
Input current	
• for signal "1", typ.	6 mA
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms
for interrupt inputs	
– parameterizable	Yes
for technological functions	
– parameterizable	Yes
Cable length	
• shielded, max.	50 m
• unshielded, max.	50 m
Encoder	
Connectable encoders	
• 2-wire sensor	Yes
– permissible quiescent current (2-wire sensor), max.	1.5 mA
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	Yes
Bus cycle time (TDP), min.	125 µs
Jitter, max.	5 µs
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	Yes
Diagnostic messages	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Monitoring of encoder power supply	Yes; Module-wise
• Wire-break	No
• Short-circuit	Yes; Module-wise
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; Green PWR LED
• Channel status display	Yes; Green LED

Article number	6ES7131-6BF00-0DA0
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	28 g

Dimension drawing

See manual ET 200SP BaseUnits
(ttps://support.industry.siemens.com/cs/ww/en/view/59753521)

Parameter data records

A

A.1 Parameter assignment and structure of parameter data record for DI operating mode

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

NOTE

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment can result in a brief exit from clocked mode and renewed synchronization with the fieldbus cycle.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You can find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128 for the complete module

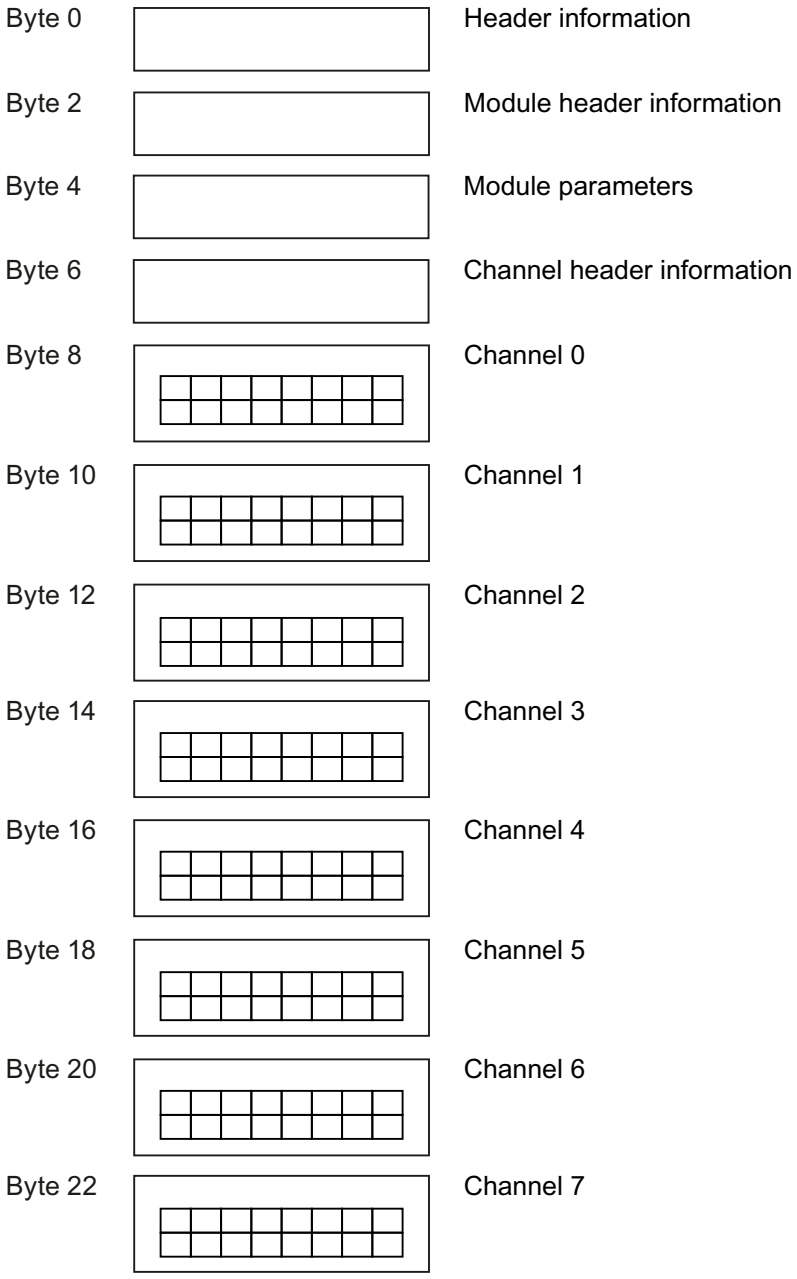

Figure 2-193 Structure of data record 128 for the complete module

Header information

The figure below shows the structure of the header information.

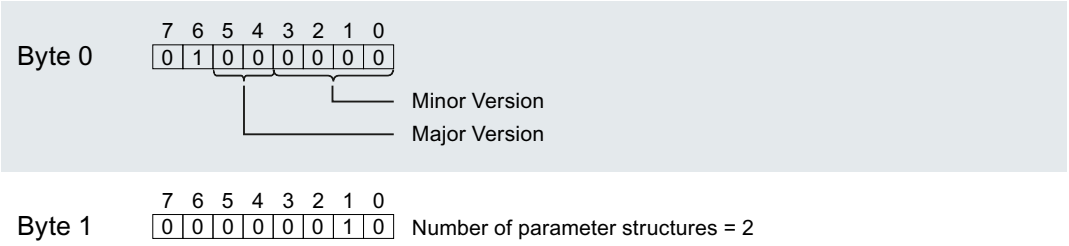

Figure 2-194 Structure of the header information

Module header information

The figure below shows the structure of the module header information.

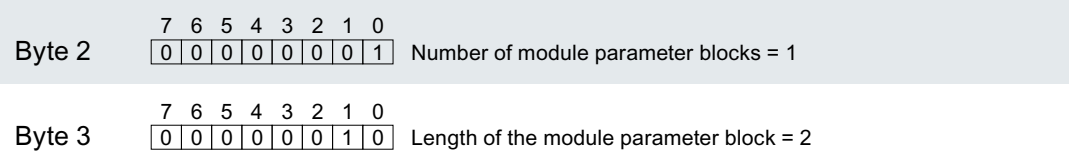

Figure 2-195 Module header information

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 to 7. You enable a parameter by setting the corresponding bit to "1".

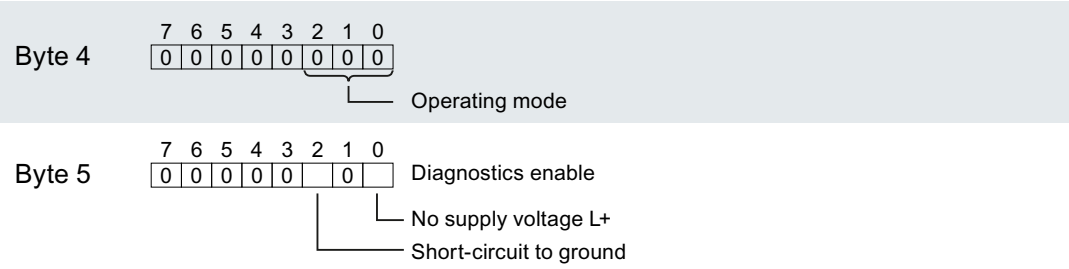

Figure 2-196 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

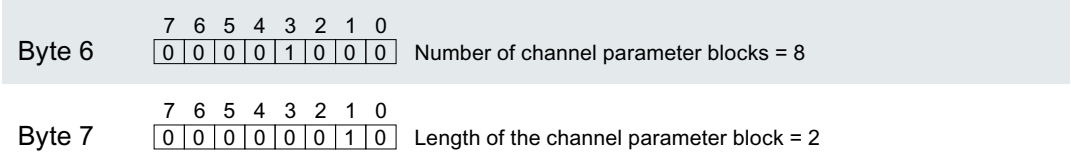

Figure 2-197 Channel header information

Channel parameter block

The figure below shows the structure of the channel parameter block. You enable a parameter by setting the corresponding bit to "1".

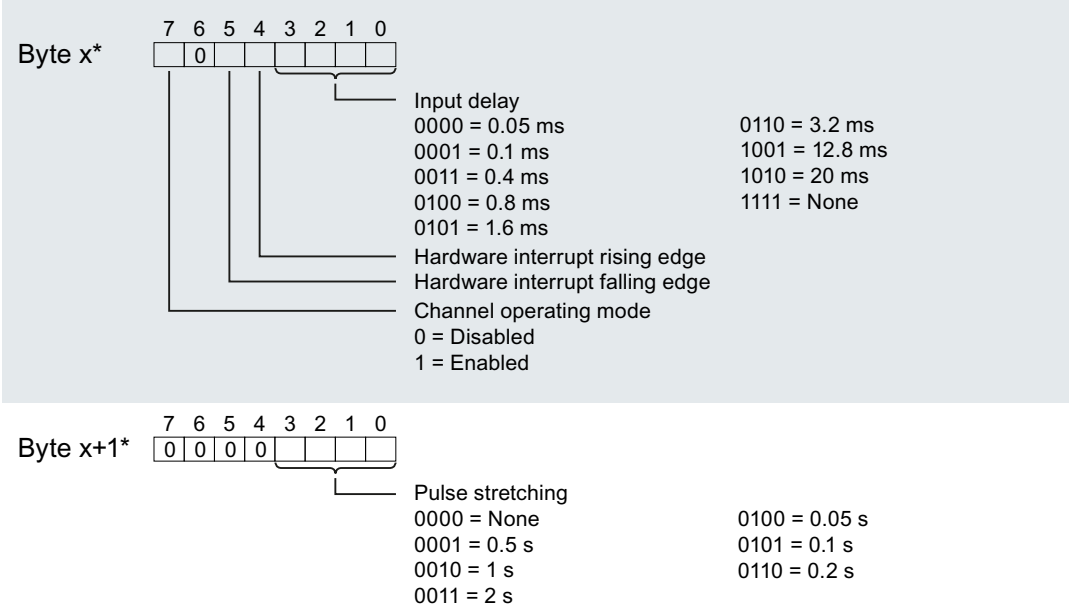

*x = 8 + (channel number × 2); channel number = 0 to 7

Figure 2-198 Structure byte x to x+1 for the channels 0 to 7

A.2 Parameter assignment and structure of parameter data record for Counting operating mode

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

NOTE

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment can result in a brief exit from clocked mode and renewed synchronization with the fieldbus cycle.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You can find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128 for the complete module

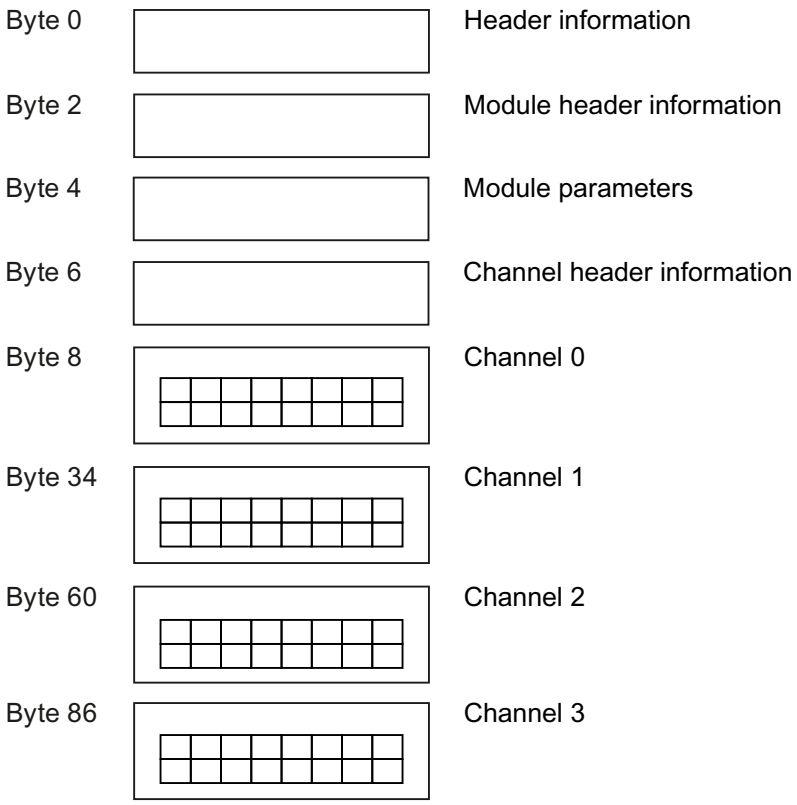

Figure 2-199 Structure of data record 128 for the complete module

Header information

The figure below shows the structure of the header information.

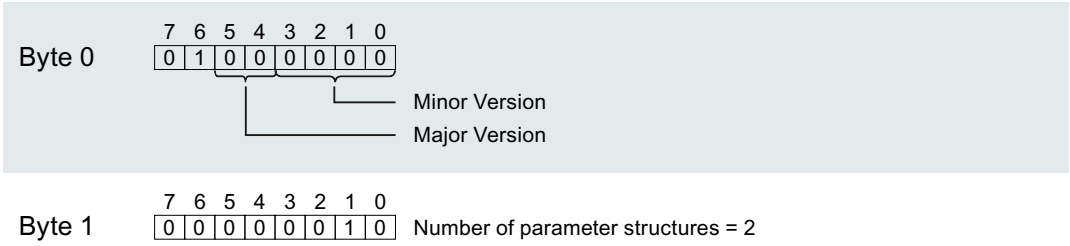

Figure 2-200 Structure of the header information

Module header information

The figure below shows the structure of the module header information.

	7	6	5	4	3	2	1	0	
Byte 2	0	0	0	0	0	0	0	1	Number of module parameter blocks = 1
Byte 3	0	0	0	0	0	0	1	0	Length of the module parameter block = 2

Figure 2-201 Module header information

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 to 3. You enable a parameter by setting the corresponding bit to "1".

	7	6	5	4	3	2	1	0	
Byte 4	0	0	0	0	0	0	0	1	Operating mode
Byte 5	0	0	0	0	0		0		Diagnostics enable No supply voltage L+ Short-circuit to ground

Figure 2-202 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

	7	6	5	4	3	2	1	0	
Byte 6	0	0	0	0	0	1	0	0	Number of channel parameter blocks = 4
Byte 7	0	0	0	1	1	0	1	0	Length of the channel parameter block = 26

Figure 2-203 Channel header information

Channel parameter block

The figure below shows the structure of the parameters for channels 0 to 3. You enable a parameter by setting the corresponding bit to "1".

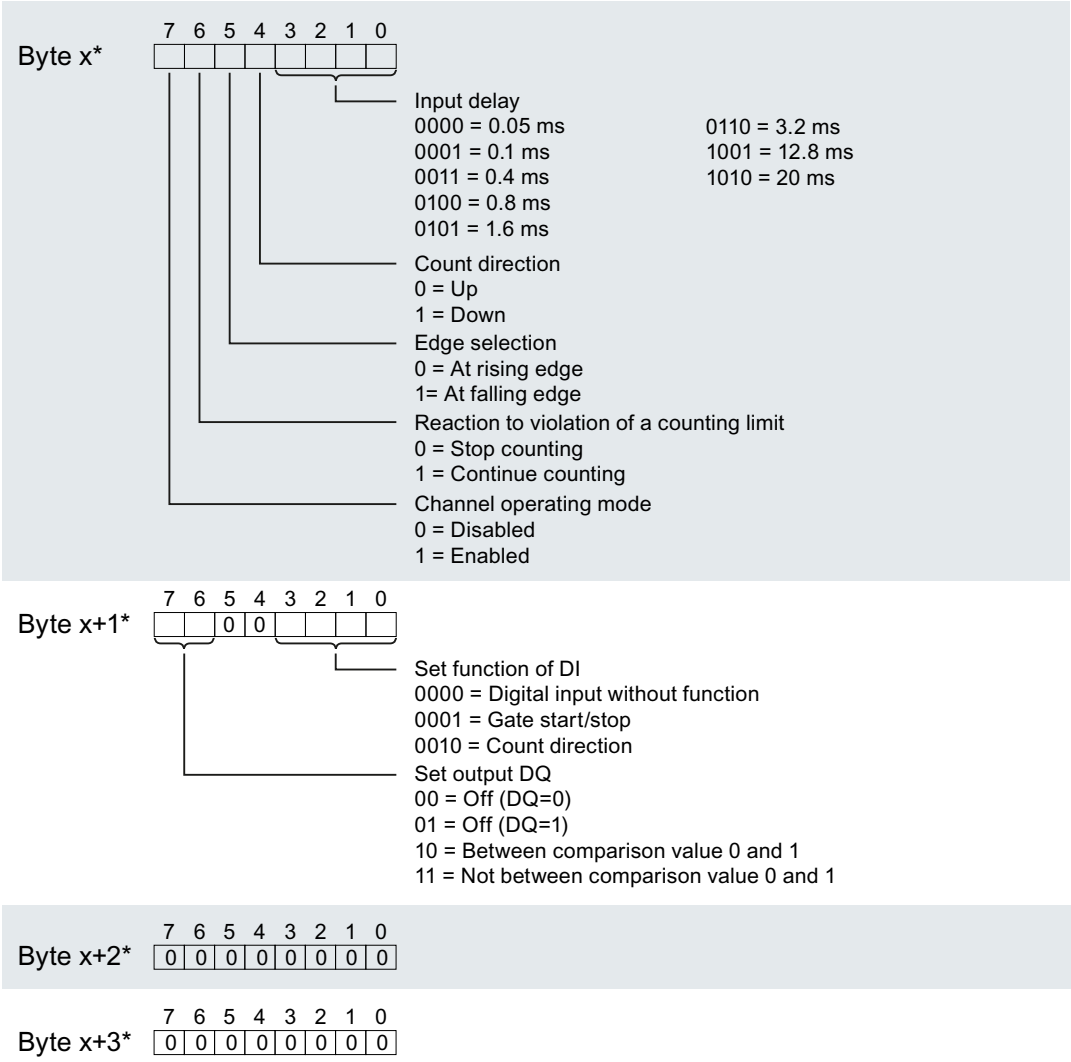

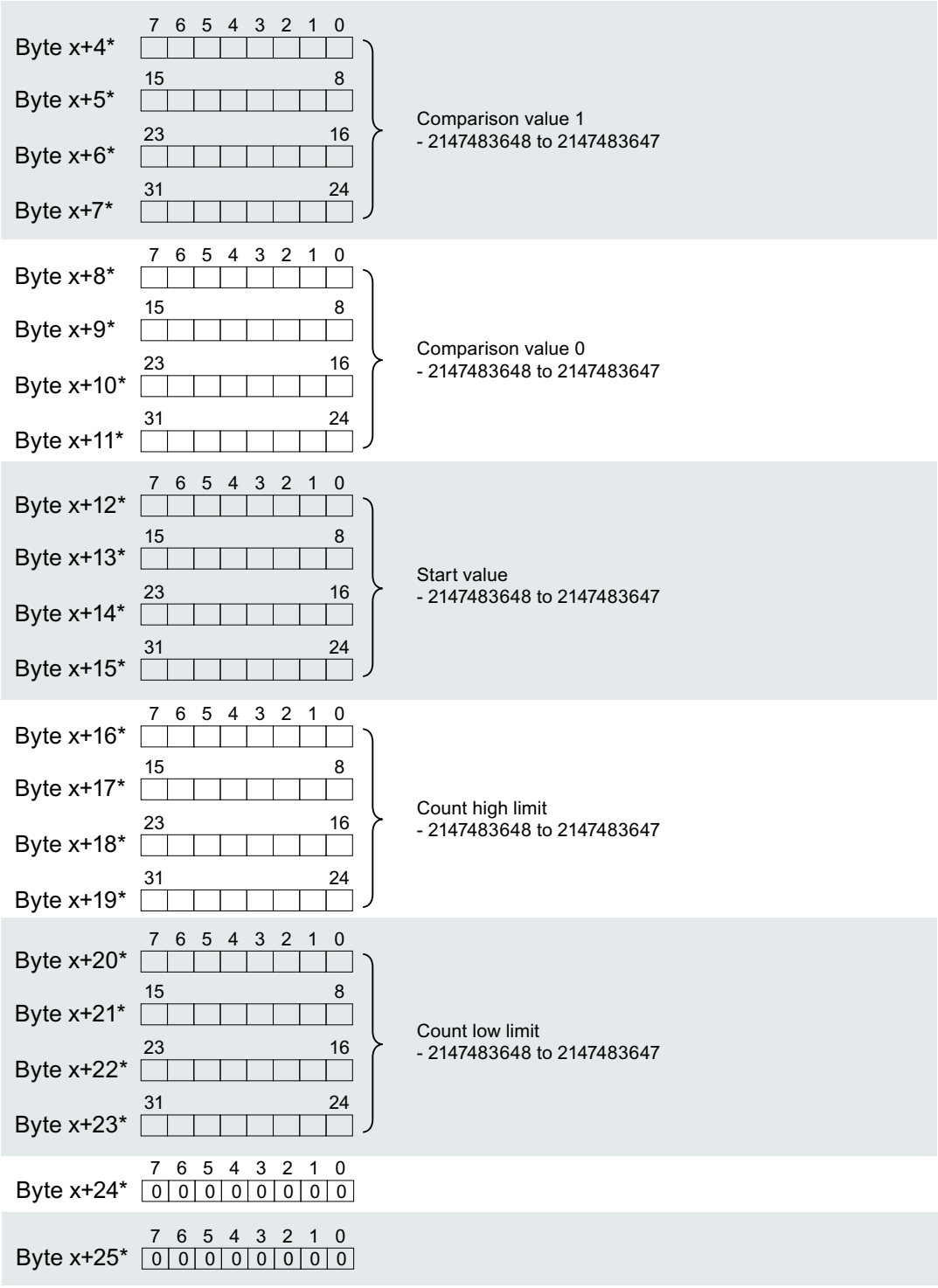

*x = 8 + (channel number × 26); channel number = 0 to 3

Figure 2-204 Structure byte x to x+25 for the channels 0 to 3

A.3 Parameter assignment and structure of parameter data record for Oversampling operating mode

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

NOTE

Changing parameters in RUN

If you change parameters in RUN mode, falsifications can occur in the input data.

A parameter data record that has content different from the startup parameter assignment can result in a brief exit from clocked mode and renewed synchronization with the fieldbus cycle.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You can find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128 for the complete module

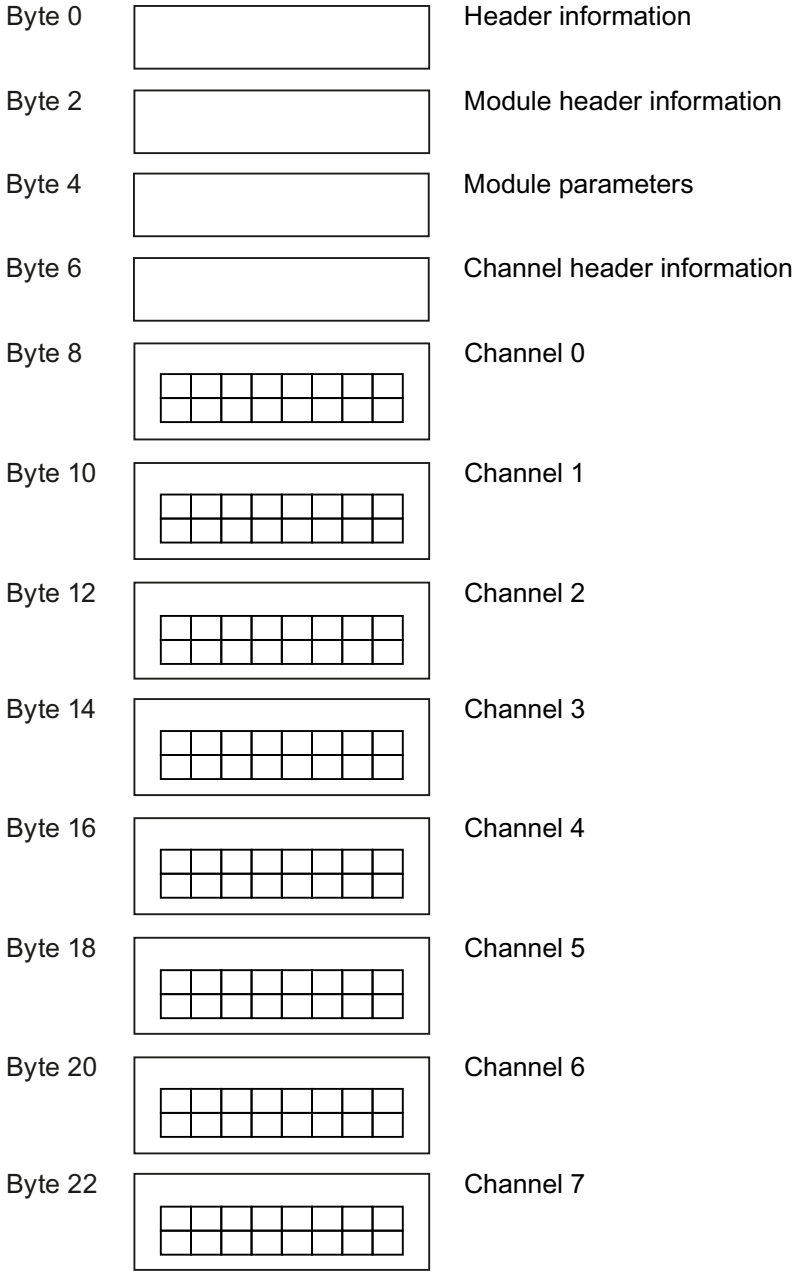

Figure 2-205 Structure of data record 128 for the complete module

Header information

The figure below shows the structure of the header information.

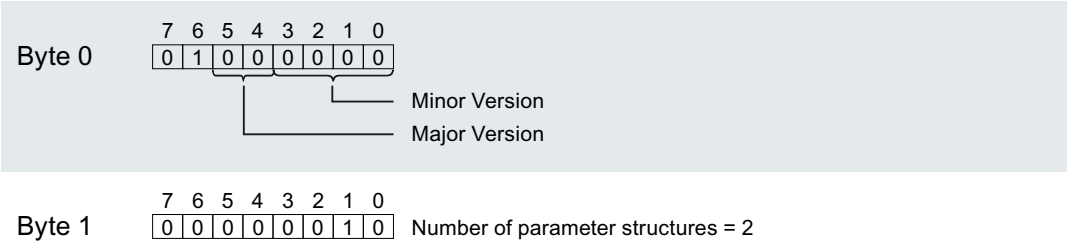

Figure 2-206 Structure of the header information

Module header information

The figure below shows the structure of the module header information.

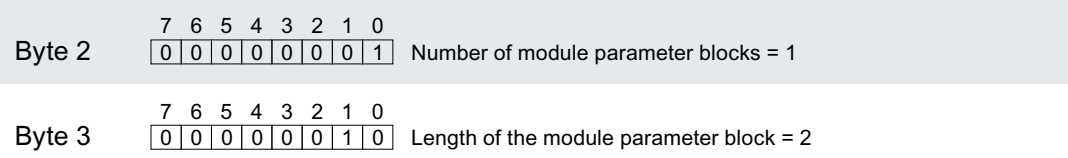

Figure 2-207 Module header information

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 to 7. You enable a parameter by setting the corresponding bit to "1".

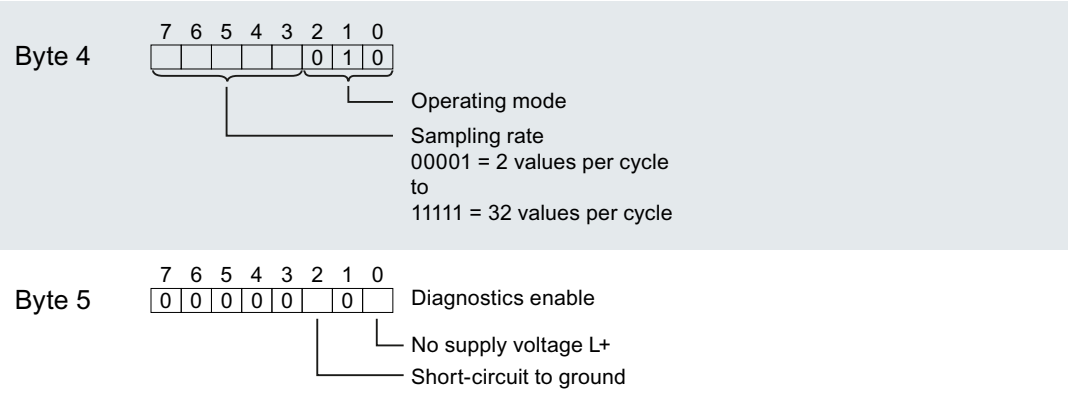

Figure 2-208 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

	7	6	5	4	3	2	1	0	
Byte 6	0	0	0	0	1	0	0	0	Number of channel parameter blocks = 8
Byte 7	0	0	0	0	0	0	1	0	Length of the channel parameter block = 2

Figure 2-209 Channel header information

Channel parameter block

The figure below shows the structure of the parameters for channels 0 to 7. You enable a parameter by setting the corresponding bit to "1".

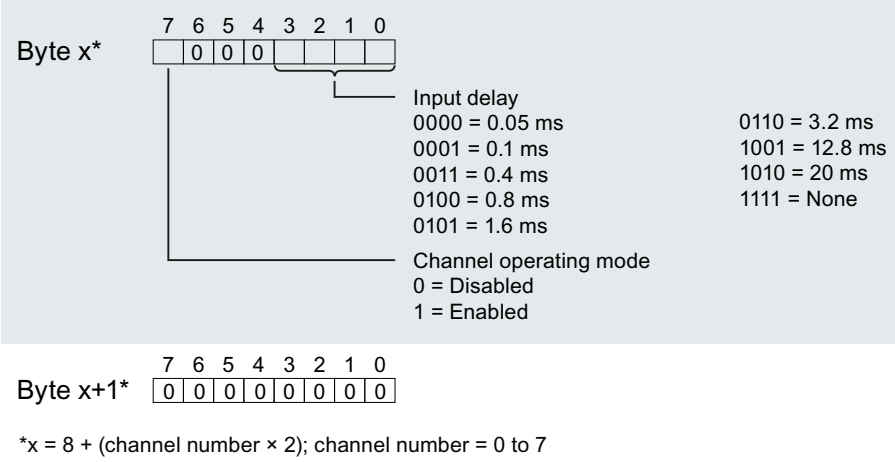

*x = 8 + (channel number × 2); channel number = 0 to 7

Figure 2-210 Structure byte x to x+1 for the channels 0 to 7

SIEMENS

SIMATIC

ET 200SP
Digital output module DI 8x24VDC SRC BA (6ES7131-6BF61-0AA0)

Equipment Manual

Documentation guide 1

Product overview 2

Wiring 3

Parameters/address space 4

Interrupts/diagnostics alarms 5

Technical specifications 6

Parameter data record A

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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

Technical specifications: Ambient temperature in horizontal and vertical mounting position, extended to min. -30 °C.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that can be implemented, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (http://www.siemens.com/industrialsecurity).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

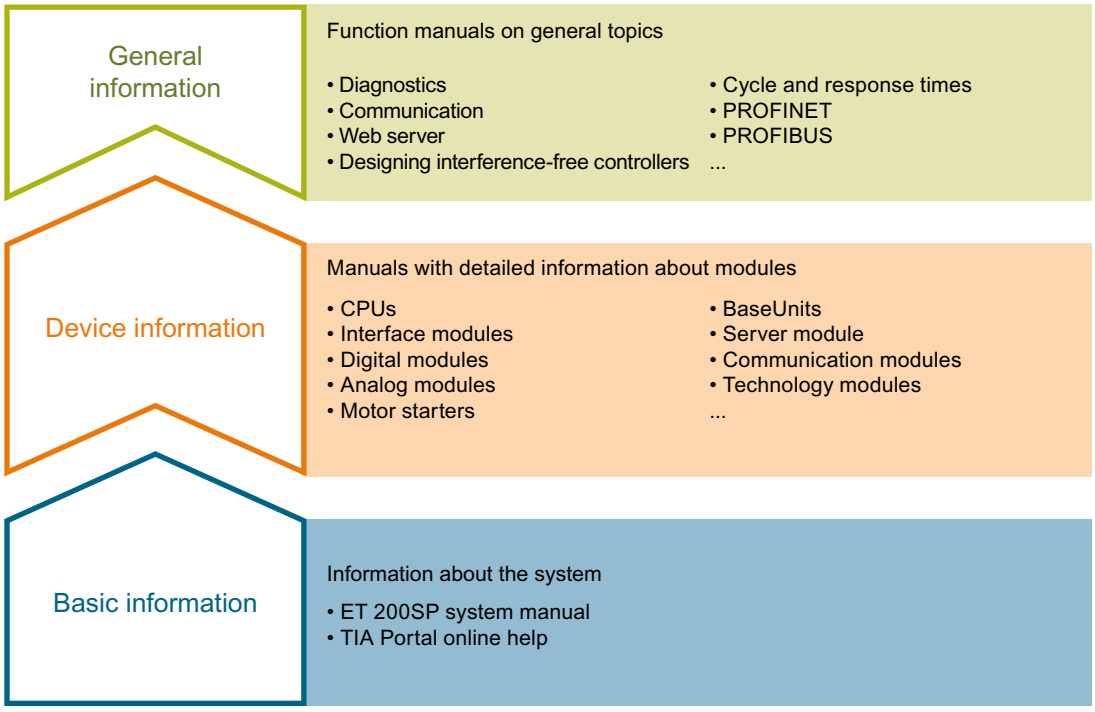

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Part number

6ES7131-6BF61-0AA0

View of the module

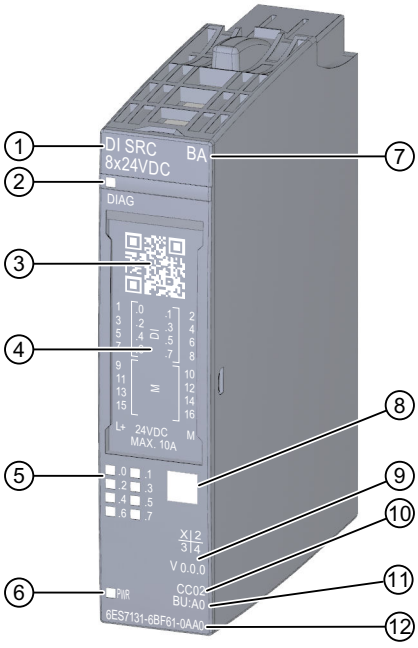

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-211 View of the DI 8×24VDC SRC BA module

Properties

The module has the following technical properties:

- 8 digital inputs
- Source input (NPN, M reading)
- Supply voltage L+
- Configurable input delay 0.05 ms to 20 ms (per channel)
- Configurable diagnostics (per module)
- Suitable for connection of switches and 2-wire sensors according to IEC 61131, type 1 and 3

The module supports the following functions:

Table 2-247 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X
Configuration in RUN	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X

Accessories

The following accessories are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring 3

3.1 Wiring and block diagram

This section includes the block diagram of the DI 8x24VDC SRC BA module with the terminal assignments for a 1-wire, 2-wire and 3-wire connection.

Information about wiring of the BaseUnit is available in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

You may use and combine the different wiring options for all channels.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

NOTE

The input channels provide values even without connected supply voltage L+. The characteristic type 2 is only maintained with connected supply voltage L+.

Connection: 1-wire and 2-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the digital input module DI 8x24VDC SRC BA on the BaseUnit BU type A0 without AUX terminals (1-wire and 2-wire connection).

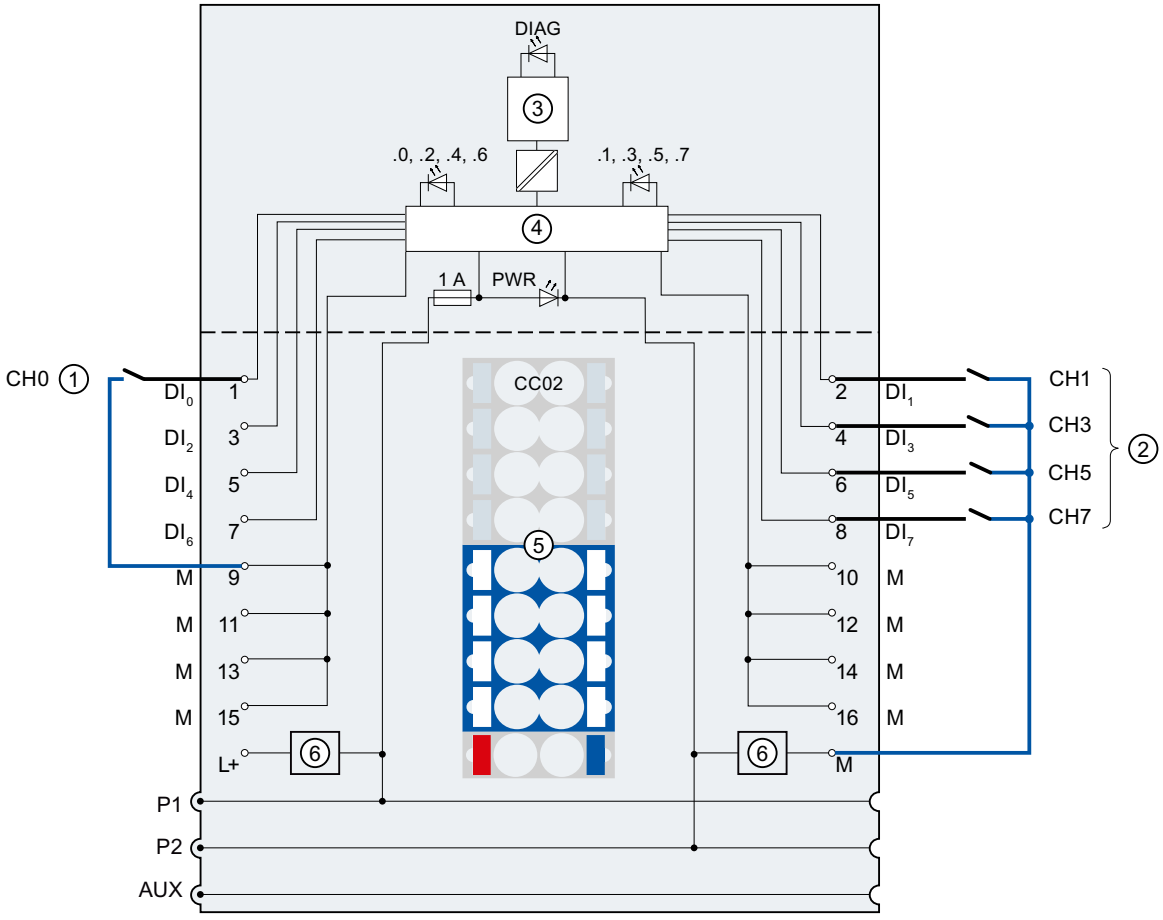

①	1-wire connection	DI_n	Input signal, channel n
②	2-wire connection	24 V DC	Encoder supply, channel n
③	Backplane bus interface	L+	24 V DC (feed for light-colored BaseUnit only)
④	Input electronics	M	Ground
⑤	Color identification label CCxx (optional)	DIAG	Error or Diagnostics LED (green, red)
⑥	Filter connection supply voltage (only when light-colored BaseUnit is present)	.0 to .7	Channel status LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	PWR	Power LED (green)

Figure 2-212 Wiring and block diagram for 1-wire and 2-wire connection of encoders

Connection: 3-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the digital input DI 8x24VDC SRC BA on the BaseUnit BU type A0 with AUX terminals (3-wire connection).

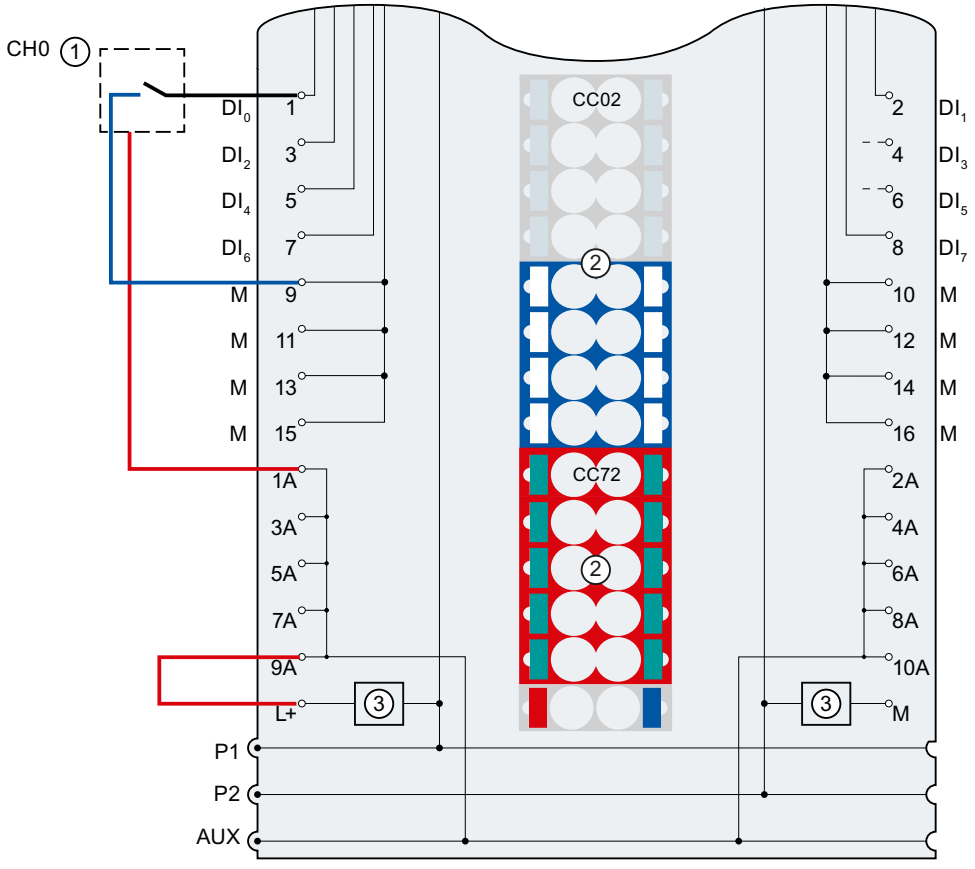

①	3-wire connection
②	Color identification labels CCxx (optional)
③	Filter connection supply voltage (only when light-colored BaseUnit is present)
DI_n	Input signal, channel n
24 V DC	Encoder supply, channel n
L+	24 V DC (feed for light-colored BaseUnit only)
M	Ground
1 A to 10 A	AUX terminals
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)

Figure 2-213 Wiring and block diagram for 3-wire connection of encoders

Parameters/address space

4

4.1 Parameters

DI 8×24VDC SRC BA parameters

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records (see chapter Parameter assignment and structure of the parameter data record (Page 24)).

Table 2-248 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel
Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	Yes	Channel	Module [1]

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 3 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 3 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

4.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Channel activated

Determines whether a channel is activated or deactivated.

Input delay

This parameter can be used to suppress signal interference. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of DI 8x24VDC SRC BA

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module using a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-249 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in hard-ware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DI 8x24VDC SRC BA V0.0	V14, SP1 or higher with HSP 0222	X	X

Address space of the digital input module DI 8x24VDC SRC BA

The figure below shows the assignment of the address space for DI 8x24VDC SRC BA.

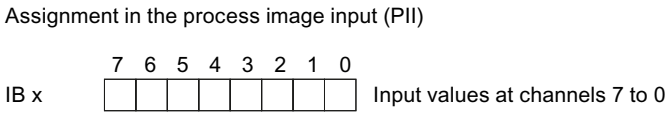

Figure 2-214 Address space of the digital input module DI 8x24VDC SRC BA

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the DI 8x24VDC SRC BA.

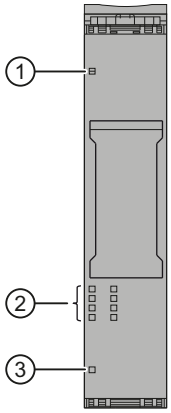

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-215 LED display

Meaning of the LED displays

The tables below explain the meaning of the Status and error displays. Remedial measures for diagnostics alarms can be found in section Diagnostics alarms (Page 19).

LED DIAG

Table 2-250 Error display of the LED DIAG

LED DIAG	Meaning
□ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned
☼ Flashes	Module diagnostics is available

LED channel status

Table 2-251 Status display of the LED channel status

LED channel status	Meaning
□ Off	Process signal = 0
■ On	Process signal = 1

LED PWR

Table 2-252 Status display of the LED PWR

LED PWR	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

5.2 Interrupts

The DI 8×24VDC SRC BA digital input module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following event:

- Parameter assignment error
- No supply voltage

Detailed information on the event is available in the STEP 7 online help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostic alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-253 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Remedy
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications

6

6.1 Technical specifications

Technical specifications of DI 8x24VDC SRC BA

The following table shows the technical specifications as of 02/2019. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7131-6BF61-0AA0/td?dl=en).

Article number	6ES7131-6BF61-0AA0
General information	
Product type designation	DI 8x24 VDC SRC BA
HW functional status	From FS02
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC02
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V14
• STEP 7 configurable/integrated as of version	V5.5 SP3 / -
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DI	Yes
• Counter	No
• Oversampling	No
• MSI	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Encoder supply	
Short-circuit protection	No

Article number	6ES7131-6BF61-0AA0
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
• Inputs	1 byte
Hardware configuration	
Automatic encoding	Yes
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0
• 3-wire connection	BU type A0 with AUX terminals or potential distributor module
• 4-wire connection	BU type A0 + Potential isolation module
Digital inputs	
Number of digital inputs	8
Digital inputs, parameterizable	Yes
Source/sink input	m-reading
Input characteristic curve in accordance with IEC 61131, type 1	Yes
Input voltage	
• Rated value (DC)	24 V
• for signal "0"	30 V to -5 V (reference potential is L+)
• for signal "1"	-11 V to -30 V (reference potential is L+)
Input current	
• for signal "1", typ.	6 mA
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes; 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms (in each case + delay of 30 to 500 µs, depending on line length)
– at "0" to "1", min.	0.05 ms
– at "0" to "1", max.	20 ms
– at "1" to "0", min.	0.05 ms
– at "1" to "0", max.	20 ms
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	200 m

Article number	6ES7131-6BF61-0AA0
Encoder	
Connectable encoders	
• 2-wire sensor	Yes
– permissible quiescent current (2-wire sensor), max.	1.5 mA
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Monitoring of encoder power supply	No
• Wire-break	No
• Short-circuit	No
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C

Article number	6ES7131-6BF61-0AA0
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	28 g

Dimensional drawing

See the manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

The module parameters can be re-assigned in RUN (for example, the input delay of selected channels can be edited in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics for the entire module.

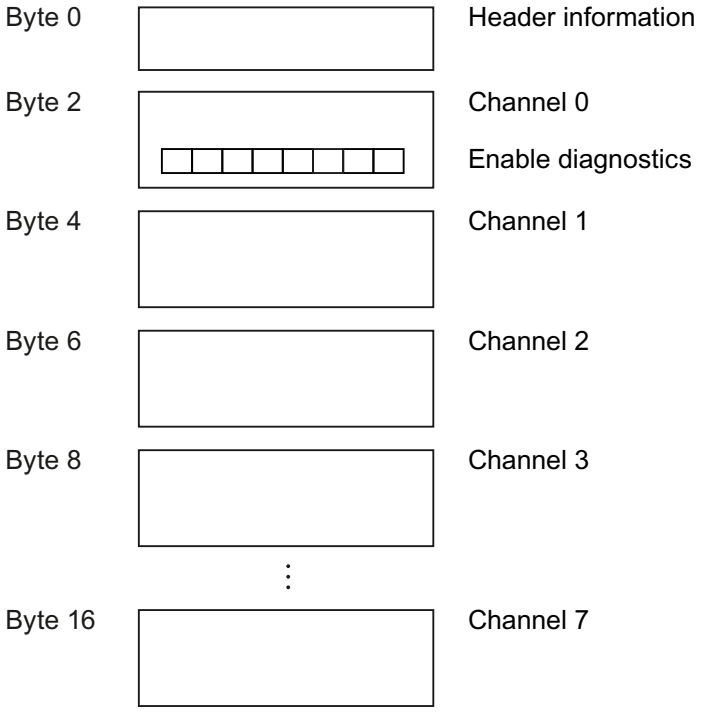

Figure 2-216 Structure of data record 128

Header information

The figure below shows the structure of the header information.

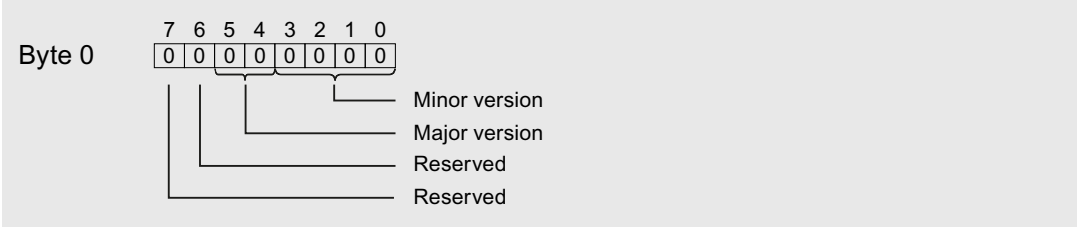

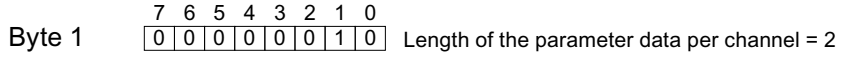

Figure 2-217 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

Enable a parameter by setting the corresponding bit to "1".

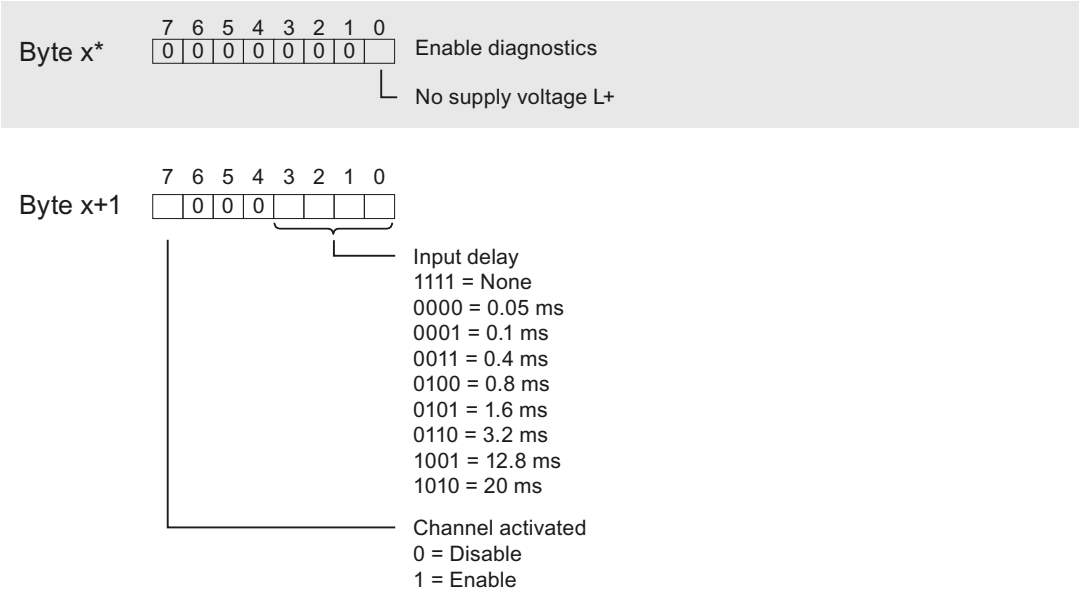

* x = 2 + (channel number × 2); channel number = 0 to 7

Figure 2-218 Structure byte x to x+1 for the channels 0 to 7

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	07	Invalid coding for input filter time.	Check the parameters of the module.

SIEMENS

SIMATIC

ET 200SP
Digital input module DI 8x24VAC/48VUC BA (6ES7131-6CF00-0AU0)

Equipment Manual

Guide to documentation 1

Product overview 2

Wiring 3

Parameter assignment/addressing 4

Interrupts/diagnostics alarms 5

Technical specifications 6

Parameter data record A

07/2018
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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (https://www.siemens.com/industrialsecurity).

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A.1 Parameter assignment and structure of parameter data record 23

Guide to documentation

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

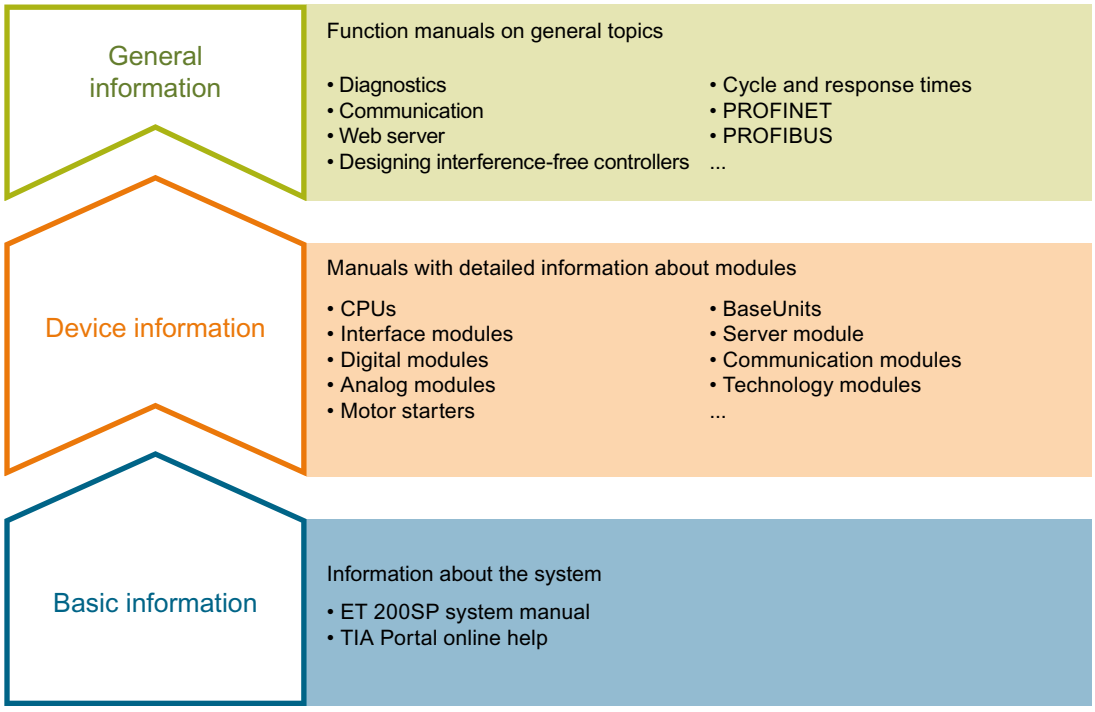

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview 2

2.1 Properties

Article number

6ES7131-6CF00-0AU0

View of the module

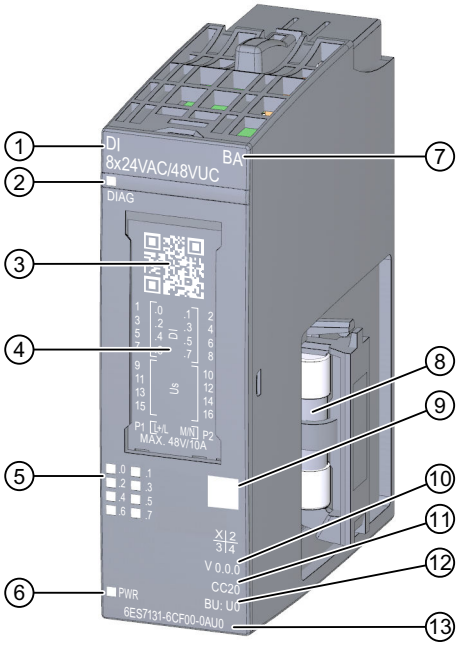

①	Module type and name	⑧	Replaceable fuse
②	LED for diagnostics	⑨	Color coding module type
③	2D matrix code	⑩	Function and firmware version
④	Wiring diagram	⑪	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑫	BU type
⑥	LED for supply voltage	⑬	Article number
⑦	Function class		

Figure 2-219 View of the module DI 8x24VAC/48VUC BA

NOTE

Replace the fuse

1. Remove the module from the station.
2. Insert a screwdriver into the slotted top face of the fuse holder.
3. Lift out the fuse holder.
4. Replace the fuse.
5. Slide the fuse holder back into the module.

Properties

The module has the following technical properties:

- 8 digital inputs
- Suitable for connection of switches and 2-wire sensors in accordance with IEC 61131, type 1

The module supports the following functions:

Table 2-254 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	as of V15 with HSP 0254	as of V5.5 SP3 with HSP 0229 V8.0	X	X
Configuration in RUN	FS01	V0.0.0 and higher	as of V15 with HSP 0254	as of V5.5 SP3 with HSP 0229 V8.0	X	X

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

You can find additional information on the accessories in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Wiring 3

3.1 Wiring and block diagram

This section includes the block diagram of the DI 8x24VAC/48VUC BA module with the terminal assignments for a 1-wire and 2-wire connection.

Information about wiring of the BaseUnit is available in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

You may use and combine the different wiring options for all channels.

NOTE

Hazardous voltage, risk of fatal or serious injury

Always disconnect the system and module from the power supply before commencing work.

NOTE

Limiting overvoltage

You must ensure overvoltage is limited to 1 kV for the encoder supply.

NOTE

Power limitation

To limit power, each input voltage must have a fuse with a maximum rating of 10 A tripping current. The fuse must be a quick-acting microfuse.

Connection: 1-wire and 2-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the digital output module DI 8x24VAC/48VUC BA on the BaseUnit BU type U0 (1-wire and 2-wire connection).

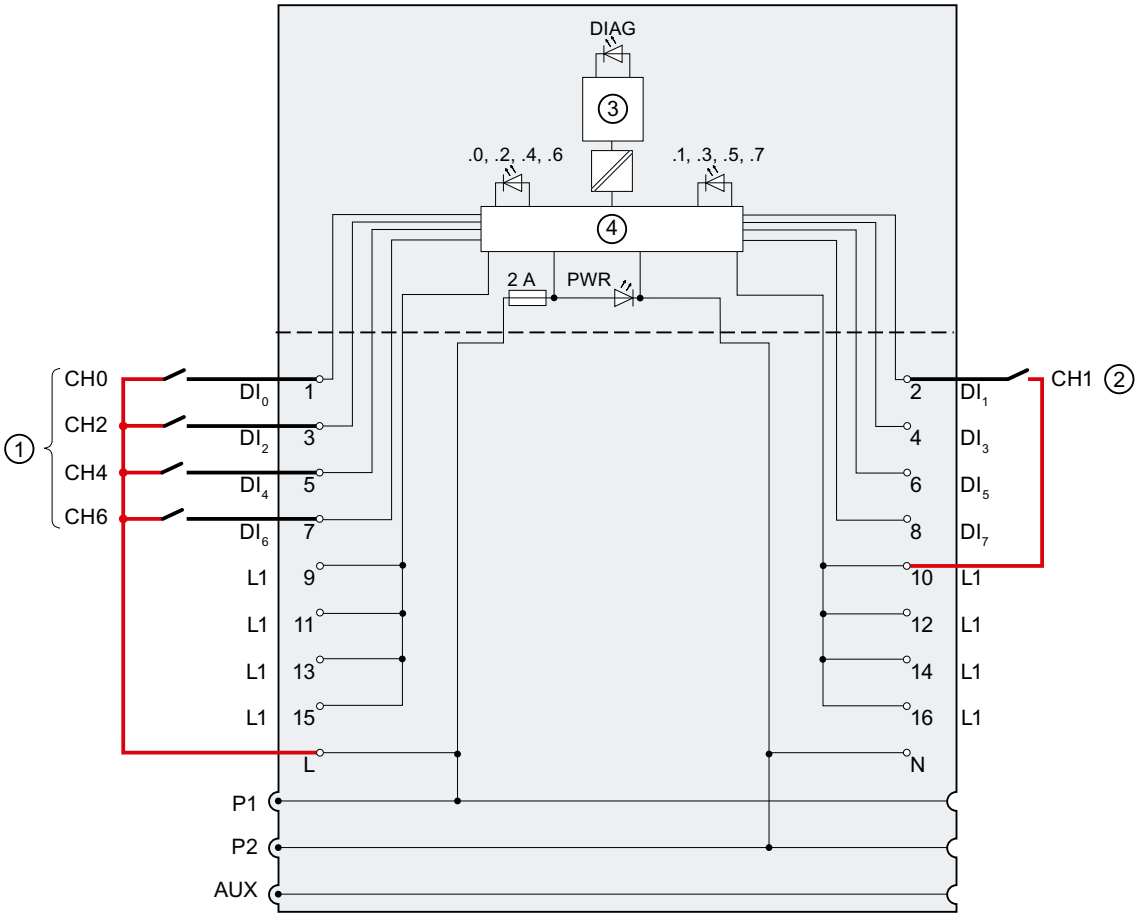

①	1-wire connection	DI_n	Input signal, channel n
②	2-wire connection	L1	Encoder supply, channel n
③	Backplane bus interface	L	Supply 24 V AC / 48 V UC
④	Input electronics	N	N-conductor connection
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	DIAG	Error or diagnostics LED (green, red)
.0 to .7	Channel status LED (green)	PWR	Power LED (green)

Figure 2-220 Wiring and block diagram for 1-wire and 2-wire connection of encoders

Parameter assignment/addressing 4

4.1 Parameters

Parameters of DI 8x24VAC/48VUC BA

During configuration of the module with STEP 7, define the properties of the module via various parameters. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When performing the configuration in the user program, use the "WRREC" instruction to transfer the parameters to the module using data records (refer to the section Parameter assignment and structure of parameter data record (Page 23)).

The following parameter settings are possible:

Table 2-255 Configurable parameters and their defaults (GSD file)

Parameters	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics, No supply voltage L	• Disable • Enable	Disable	Yes	Module	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] The parameter length of the I/O module is 3 bytes.

4.2 Explanation of parameters

Diagnostics No supply voltage L

Enabling of the diagnostics for no or insufficient supply voltage L.

Channel activated

Determines whether a channel is enabled or disabled.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which is followed by a light-colored BaseUnit or server module in the station configuration.

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image input.

Configuration options of DI 8x24VAC/48VUC BA

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module using a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-256 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in hard-ware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DI 8x24VAC/48VUC BA	as of V15 with HSP 0254	X	X

Address space of the digital input module DI 8x24VAC/48VUC BA

The figure below shows the assignment of the address space for DI 8x24VAC/48VUC BA.

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	
IB x									Input values at channels 0 to 7

Figure 2-221 Address space of the digital input module DI 8x24VAC/48VUC BA

Interrupts/diagnostics alarms

5

5.1 Status and fault displays

LED displays

The figure below shows the LED displays (status and error displays) of the DI 8x24VAC/48VUC BA.

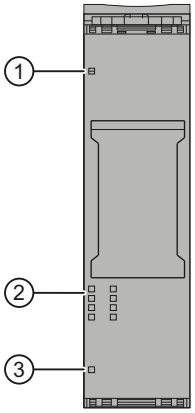

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-222 LED display

Meaning of the LEDs

The tables below explain the meaning of the Status and fault displays.

LED DIAG

Table 2-257 LED DIAG fault display

LED DIAG	Meaning
☐ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashing	Module parameters not assigned
■ On	Module parameters assigned
☼ Flashing	Module diagnostics is available

LED channel status

Table 2-258 Channel status LED status and fault display

LED channel status	Meaning
☐ Off	Process signal = 0
■ On	Process signal = 1

LED PWR

Table 2-259 LED PWR status display

LED PWR	Meaning
☐ Off	No supply voltage L
■ On	Supply voltage L present

5.2 Interrupts

The DI 8x24VAC/48VUC BA digital input module supports diagnostics interrupts.

Diagnostic interrupts

The module generates a diagnostic interrupt at the following events:

- Parameter assignment error
- No supply voltage

5.3 Diagnostics alarms

A diagnostic alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-260 Diagnostics alarms, their meaning and how to deal with them

Diagnostics alarm	Error code	Meaning	Remedy
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L	• Check supply voltage L at the BaseUnit • Check BaseUnit type

Technical specifications

6

Technical specifications of the DI 8x24VAC ... 48VUC BA

Article number	6ES7131-6CF00-0AU0
General information	
Product type designation	DI 8x24VAC/48VUC BA
Firmware version	
• FW update possible	No
usable BaseUnits	BU type U0
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V15
• STEP 7 configurable/integrated as of version	Configurable via GSD file
• PROFIBUS as of GSD version/GSD revision	GSD Revision 5
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DI	Yes
• Counter	No
• Oversampling	No
• MSI	No
Supply voltage	
Rated value (DC)	48 V
permissible range, lower limit (DC)	40.8 V
permissible range, upper limit (DC)	57.6 V
Rated value (AC)	48 V; 24 V/48 V; 50 Hz/60 Hz
Reverse polarity protection	Yes
Input current	
Current consumption, max.	70 mA; without sensor supply
Encoder supply	
Number of outputs	8
Short-circuit protection	Yes; Per module, 5x 20 mm fuse, 2 A/250 V, quick-response, replaceable
Output current	
• up to 60 °C, max.	1 A
24 V encoder supply	
• 24 V	No

Article number	6ES7131-6CF00-0AU0
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
• Address space per module, max.	1 byte
Hardware configuration	
Automatic encoding	
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type U0
• 2-wire connection	BU type U0
• 3-wire connection	BU type U0 + Potential isolation module
• 4-wire connection	BU type U0 + Potential isolation module
Digital inputs	
Number of digital inputs	8
Source/sink input	P-reading
Input characteristic curve in accordance with IEC 61131, type 1	Yes
Input characteristic curve in accordance with IEC 61131, type 2	No
Input characteristic curve in accordance with IEC 61131, type 3	No
Pulse extension	No
Input voltage	
• Type of input voltage	AC/DC
• for signal "0"	AC/DC < 10 V
• for signal "1"	AC > 14 V, DC > 34 V
Input current	
• for signal "1", typ.	3.5 mA
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	No
– at "0" to "1", max.	15 ms
– at "1" to "0", max.	20 ms
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Encoder	
Connectable encoders	
• 2-wire sensor	Yes

Article number	6ES7131-6CF00-0AU0
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
• Monitoring of encoder power supply	Yes
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	1 200 V DC between supply voltage and backplane bus
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	40 g

Dimensional drawing

See the manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

The module parameters can be reassigned in RUN without affecting the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

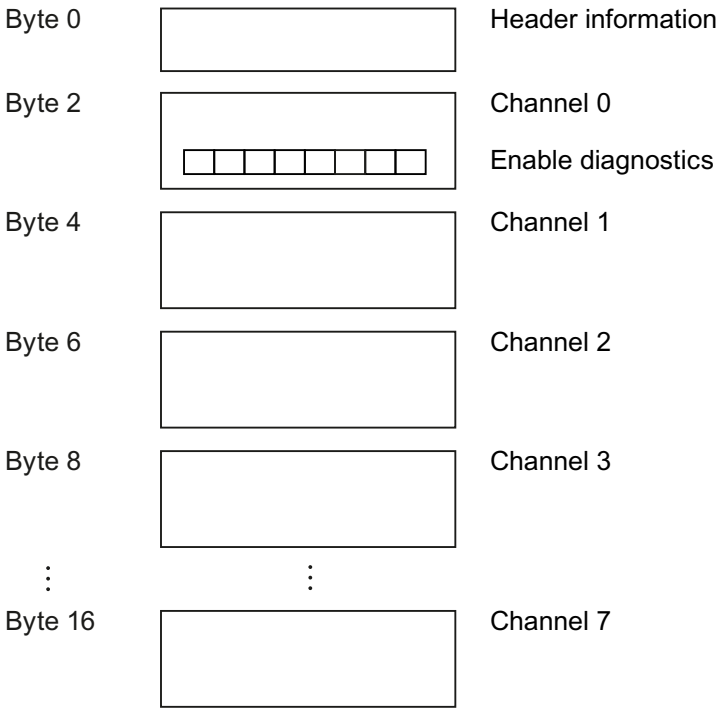

Figure 2-223 Structure of data record 128

Header information

The figure below shows the structure of the header information.

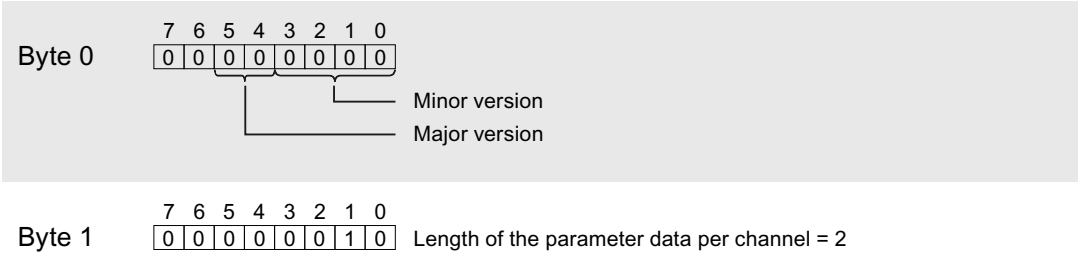

Figure 2-224 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

You enable a parameter by setting the corresponding bit to "1".

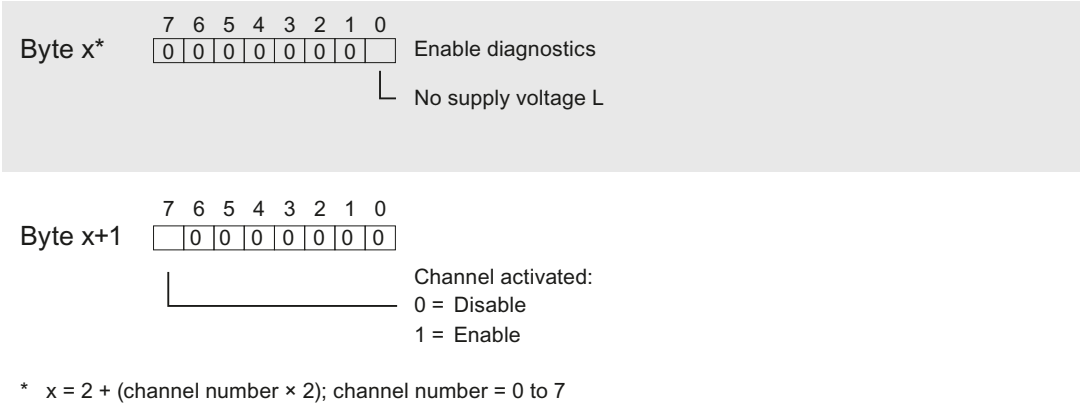

Figure 2-225 Structure byte x to x+1 for the channels 0 to 7

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	07	Invalid coding for input filter time.	Check the parameters of the module.

SIEMENS

SIMATIC

ET 200SP
DI 8xNAMUR HF digital input module (6ES7131-6TF00-0CA0)

Equipment Manual

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Introduction 1

Purpose of the documentation

This equipment manual supplements the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

- Wiring and block diagrams have been revised.
- The technical specifications have been updated.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

You can find more general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-related information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

2.3 Cybersecurity-relevant information

Observe all cybersecurity-relevant information.

Topics with relevant cybersecurity information	Reference
Operational application environment and security assumptions	
Requirements for the operational application environment of the system and security assumptions	You can find this section in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Security properties of the product	
Access protection	Also note the information on access protection in the Protection chapter of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Data integrity	The topic of data integrity is described in the Industrial cybersecurity section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Signed firmware update	The topic of signed firmware updates is described in the Industrial cybersecurity section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
PROFINET Security Class 1 • The device supports PROFINET Security Class 1. • With the introduction of PROFINET Security Class 1, additional security settings have been integrated into the PROFINET communication.	You can find detailed information about PROFINET Security Class 1 and additional security settings in the PROFINET with STEP 7 Function Manual (https://support.automation.siemens.com/WW/view/en/49948856).
Supported Ethernet services	You can find information on supported services in the Technical specifications section. You can find detailed information about supported Ethernet services in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
Interfaces, ports, protocols and services	
Information on the following is security related: • Communications layer and communication role • Default states • Enabling/disabling of ports and services	You can find detailed information on these topics in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
Secure operation	
Recommendations for safe operation	You can find cross-system information on the safe operation of interface modules in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Corrective measures for known risks	Corrective measures for known risks are announced on the Siemens ProductCERT and Siemens CERT (https://siemens.com/productcert) web page. For more information on SIEMENS ProductCERT, refer to the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Topics with relevant cybersecurity information	Reference
Security checks	You can find descriptions of specific security measures, such as cyclic checks of the configuration via checksums, in the Industrial cybersecurity section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Secure decommissioning Products that contain security-relevant data must be safely decommissioned before disposal or resale.	You can find information on safe decommissioning in the Safe operation of the system section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Product overview

3

3.1 Properties

Article number

6ES7131-6TF00-0CA0

View of the module

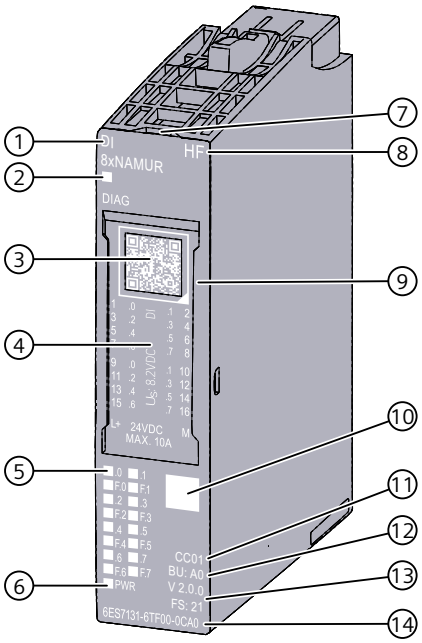

①	Module type and name	⑧	Function class
②	LED for diagnostics	⑨	Insertion option for optional labeling strip
③	QR code for identification link	⑩	Color coding module type
④	Wiring diagram	⑪	Color code for selecting the color-coded labels
⑤	LEDs for channel status and channel fault	⑫	BU type
⑥	LED for supply voltage	⑬	Firmware and functional version
⑦	Slot for optional equipment labeling plate	⑭	Article number

Figure 2-226 DI 8xNAMUR HF view of the module

Properties

The module has the following technical properties:

- Digital input module with 8 inputs
- Value status (quality information) (per channel)
- Sensor supply 8.2 V DC (PROFIenergy) that can be switched off individually (per channel)
- Supply voltage L+
- Selectable diagnostics (per channel)
- Suitable for connecting NAMUR sensors and connected and unconnected mechanical contacts

NOTE

The module can be used as an encoder module for the digital output module DQ 4x24VDC/2A HS.

Table 2-261 Operating modes of DI 8xNAMUR HF

Property		**Operating mode DI**	**Counter mode**			
		DI	CNT1	CNT2	CNT3	CNT4
Number of channels		8xDI	1xCNT 1XDI or control channel 6xDI	2xCNT 2xDI or control channel 4xDI	3xCNT 3xDI or control channel 2xDI	4xCNT 4xDI or control channel
Isochronous mode		No				
Counter width, max. counting frequency		-	32 bits, 5 kHz max.*			
Configurable input delay		100 µs - 20 ms	100 µs - 20 ms			
Configurable hardware interrupts; rising edge and/or falling edge (per channel)		x	For DI inputs or control channels only.			
Data length	Inputs	2 bytes	12 bytes	22 bytes	32 bytes	42 bytes
	Outputs	0 bytes	5 bytes	10 bytes	15 bytes	20 bytes

*If the gate/dir functionality is used with a frequency of more than 2 kHz:

- The minimum pulse length is 500 µs

- Response time is 500 µs

The module supports the following functions:

Table 2-262 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	As of FS01	As of V1.0.0	Integrated as of V13	• As of V5.5 SP3 with HSP 0229 V3.0 • Integrated as of V5.5 SP4	X	X
Identification data I&M0 to I&M3	As of FS01	As of V1.0.0	Integrated as of V13	• As of V5.5 SP3 with HSP 0229 V3.0 • Integrated as of V5.5 SP4	X	X
Reconfiguration in RUN	As of FS01	As of V1.0.0	Integrated as of V13	• As of V5.5 SP3 with HSP 0229 V3.0 • Integrated as of V5.5 SP4	X	X
Hardware interrupts	As of FS01	As of V1.0.0	Integrated as of V13	• As of V5.5 SP3 with HSP 0229 V3.0 • Integrated as of V5.5 SP4	X	X
Diagnostics alarms	As of FS01	As of V1.0.0	Integrated as of V13	• As of V5.5 SP3 with HSP 0229 V3.0 • Integrated as of V5.5 SP4	X	X
Power failure detection	As of FS01	As of V1.0.0	Integrated as of V13	• As of V5.5 SP3 with HSP 0229 V3.0 • Integrated as of V5.5 SP4	X	X
Pulse stretching	As of FS01	As of V1.0.0	Integrated as of V13	• As of V5.5 SP3 with HSP 0229 V3.0 • Integrated as of V5.5 SP4	X	X
PROFIenergy	As of FS01	As of V1.0.0	Integrated as of V13	• As of V5.5 SP3 with HSP 0229 V3.0 • Integrated as of V5.5 SP4	X	X
Pulse stretching	As of FS01	As of V1.0.0	Integrated as of V13	• As of V5.5 SP3 with HSP 0229 V3.0 • Integrated as of V5.5 SP4	X	X
Chatter monitoring	As of FS01	As of V1.0.0	Integrated as of V13	• As of V5.5 SP3 with HSP 0229 V3.0 • Integrated as of V5.5 SP4	X	X

[1] Measuring functions and counters with scaling of measured values are not supported for PROFIBUS DP.

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Diagnostics for changeover contact sensor type	As of FS01	As of V1.0.0	Integrated as of V13	• As of V5.5 SP3 with HSP 0229 V3.0 • Integrated as of V5.5 SP4	X	X
Counter functionality	As of FS21	As of V2.0.0	• V18 Update 3 with HSP0400 • Integrated as of V19	• As of V5.5 SP3 with HSP 0229 V9.0 • Integrated as of V5.7 SP3	X	X[1]
Input delay	As of FS21	As of V2.0.0	• V18 Update 3 with HSP0400 • Integrated as of V19	• As of V5.5 SP3 with HSP 0229 V9.0 • Integrated as of V5.7 SP3	X	X

[1] Measuring functions and counters with scaling of measured values are not supported for PROFIBUS DP.

You can configure the module with STEP 7 (TIA Portal) and with a GSD file. The configurations for the operating modes can be found under various codes / module names:

Table 2-263 Codes / module names for the configuration options

Operating mode (all with QI)	Configuration software			
	HSP0400 for STEP 7 (TIA Portal)	HSP0229 V9.0 for STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
DI NAMUR	DI 8xNAMUR HF *FW version: V1.0*	DI 8xNAMUR HF	DI 8xNAMUR HF V1.0, QI	DI 8xNAMUR HF V1.0, QI
DI NAMUR	DI 8xNAMUR HF *FW version: V2.0*	DI 8xNAMUR HF	DI 8xNAMUR HF V2.0, QI	DI 8xNAMUR HF V2.0, QI
4-channel pulse counter	DI 8xNAMUR HF *FW version: V2.0*	DI 8xNAMUR HF	DI 8xNAMUR HF V2.0, QI, CNT 4	-
3-channel pulse counter	DI 8xNAMUR HF *FW version: V2.0*	DI 8xNAMUR HF	DI 8xNAMUR HF V2.0, QI, CNT 3	DI 8xNAMUR HF V2.0, QI, CNT3
2-channel pulse counter	DI 8xNAMUR HF *FW version: V2.0*	DI 8xNAMUR HF	DI 8xNAMUR HF V2.0, QI, CNT 2	-
1-channel pulse counter	DI 8xNAMUR HF *FW version: V2.0*	DI 8xNAMUR HF	DI 8xNAMUR HF V2.0, QI, CNT 1	DI 8xNAMUR HF V2.0, QI, CNT1
4-channel pulse counter, scaling of measured values	DI 8xNAMUR HF *FW version: V2.0*	DI 8xNAMUR HF	DI 8xNAMUR HF V2.0, QI, CNT 4, SCALE	-
3-channel pulse counter, scaling of measured values	DI 8xNAMUR HF *FW version: V2.0*	DI 8xNAMUR HF	DI 8xNAMUR HF V2.0, QI, CNT 3, SCALE	-
2-channel pulse counter, scaling of measured values	DI 8xNAMUR HF *FW version: V2.0*	DI 8xNAMUR HF	DI 8xNAMUR HF V2.0, QI, CNT 2, SCALE	-
1-channel pulse counter, scaling of measured values	DI 8xNAMUR HF *FW version: V2.0*	DI 8xNAMUR HF	DI 8xNAMUR HF V2.0, QI, CNT 1, SCALE	-

The following table shows the configuration options for ET 200SP DI NAMUR:

Table 2-264 Engineering with

STEP 7 TIA Portal, configurable/integrated as of version	V18 Update 3 with HSP0400 / V19
STEP 7, configurable/integrated as of version	HSP0229 V9.0 as of STEP 7 V5.5 SP3 / STEP 7 V5.7.3
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.42

Accessories

The following accessories can be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connection

You can find more information on accessories in the System Manual ET 200SP Distributed I/O System (https://support.automation.siemens.com/WW/view/en/58649293).

See also

ET 200SP Product information
(https://support.industry.siemens.com/cs/ww/en/view/73021864)

Operating mode DI

4

4.1 Wiring

4.1.1 Pin assignment

General pin assignment

Table 2-265 Pin assignment for DI 8×NAMUR HF (6ES7131-6TF00-0CA0)

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Digital input, channel 0	DI_0	1	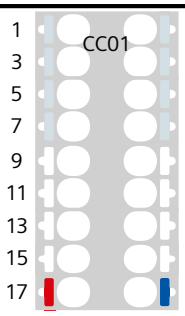	2	DI_1	Digital input, channel 1
Digital input, channel 2	DI_2	3		4	DI_3	Digital input, channel 3
Digital input, channel 4	DI_4	5		6	DI_5	Digital input, channel 5
Digital input, channel 6	DI_6	7		8	DI_7	Digital input, channel 7
Sensor supply, channel 0	Us_0	9		10	Us_1	Sensor supply, channel 1
Sensor supply, channel 2	Us_2	11		12	Us_3	Sensor supply, channel 3
Sensor supply, channel 4	Us_4	13		14	Us_5	Sensor supply, channel 5
Sensor supply, channel 6	Us_6	15		16	Us_7	Sensor supply, channel 7
24 V DC supply voltage	L+	17		18	M	Ground

The figures below show the connections for input signal DI_0 for all sensor types.		
NAMUR sensors / IEC 60947-5-6 sensors 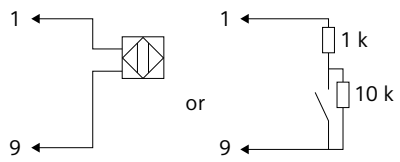 	NAMUR changeover contacts / IEC 60947-5-6 changeover contacts 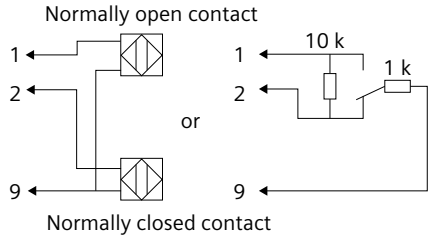 	Single contact connected with 10 kΩ (mechanical normally open contact) 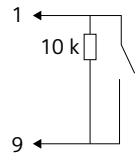
Changeover contact connected with 10 kΩ (mechanical changeover contact) 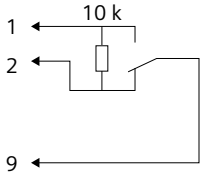 	Single contact, unconnected (mechanical normally open contact with single contact) 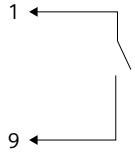 	Changeover contact, unconnected (mechanical changeover contact) 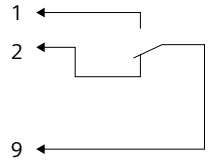

[1] Usable BaseUnit types, can be identified by the last two digits of the order number. See also system manual ET 200SP Distributed I/O System.

NOTE

The load group of the module must begin with a light BaseUnit. Also keep this in mind during configuration.

Firmware update

When updating the firmware, the L+ supply voltage must be applied to the module at the start and during the firmware update.

4.1.2 Block diagram

This section contains the schematic circuit diagram of the module.

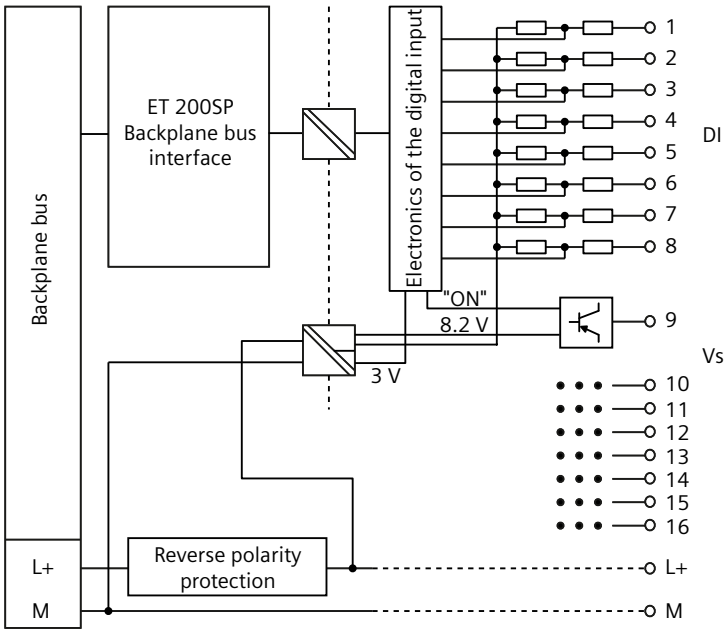

Figure 2-227 Block diagram DI 8×NAMUR HF

4.2 Parameters/address space

4.2.1 Parameters

DI 8xNAMUR HF parameters

You can specify the module properties with various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation on an ET 200SP-CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system
- Distributed operation on EtherNet/IP in an ET 200SP system
- Distributed operation on Modbus TCP in an ET 200SP system

In addition to parameter assignment via the configuration software, you can also configure parameters in RUN mode (dynamic) via the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records (see chapter Parameter assignment and structure of the parameter data record for operating mode DI (Page 74)).

The following parameter settings are possible:

Table 2-266 Settable parameters and their defaults in the DI mode (GSD file)

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Chatter error	• Disable • Enable	Disable	Yes	Channel	-
Diagnostics: Changeover error	• Disable • Enable	Disable	Yes	Channel	Channel[1]
Sensor type	• Deactivated • NAMUR sensor • Single contact, unconnected • Single contact with 10 kΩ • NAMUR changeover contact[1] • Changeover contact, unconnected[1] • Changeover contact with 10 kΩ[1]	NAMUR sensor	Yes	Channel	Channel
Pulse stretching	• None • 0.5 s • 1 s • 2 s	None	Yes	Channel	-
Digital input	• Normal • Inverted	Normal	Yes	Channel	Channel
Chatter monitoring	• Deactivated • 2 ... 32 signal changes	Deactivated	Yes	Channel	-
Monitoring window	• 0.5 s • 1 s ... 100 s	0.5 s	Yes	Channel	-

1 Can only be parameterized for even channels

2 "Input delay" for channels 0-3 and 4-7 can only be set identically.

3 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 10 bytes with a PROFIBUS GSD configuration. If necessary, you can set this parameter, however, with data records 0 to 7 or data record 128, see Appendix "Parameter data record".

4 As of firmware version V2.0.0

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Input delay[4]	• None • 0.1 ms • 0.2 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 10 ms • 12.8 ms • 20 ms	0.1 ms	Yes	Channel	Channel[2]
Hardware interrupt rising edge	• Disable • Enable	Disable	Yes	Channel	- [3]
Hardware interrupt falling edge	• Disable • Enable	Disable	Yes	Channel	- [3]
Potential group	• Use the potential group of the left module (module plugged into a dark BaseUnit) • Enable new potential group (module plugged into a light BaseUnit)	Use potential group of the left module	No	Module	Module

1 Can only be parameterized for even channels

2 "Input delay" for channels 0-3 and 4-7 can only be set identically.

3 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 10 bytes with a PROFIBUS GSD configuration. If necessary, you can set this parameter, however, with data records 0 to 7 or data record 128, see Appendix "Parameter data record".

4 As of firmware version V2.0.0

Technology functions

All technology functions, such as

- Pulse stretching
- Chatter monitoring
- Changeover errors
- Hardware interrupts

are executed only when there is an fault-free signal (QI = 1). This means that there is no diagnostics information on the channel (see also chapter Address space (Page 31)).

Changing parameter settings and effects on the technology functions

Reconfiguring a technology function starts its processing again. Reconfiguring one technology function has no effect on other technology functions. Exception: Signal inversion and chatter monitoring, because an additional edge change is generated when signal inversion is disabled/enabled.

4.2.2 Explanation of parameters

Diagnostics: No supply voltage L+

The diagnostics alarm is enabled for missing or insufficient supply voltage L+.

This diagnostic message is also set if another problem occurs with the supply voltage of the sensor (e.g. if a fault occurs in the supply voltage of the module for the sensors). Another example is when both problems occur together: L+ problems (usually external reasons) and problems with the sensor supply (internal reasons).

Tip: To avoid a diagnostics overload, you should only enable "Diagnostics: Missing supply voltage" for an active channel.

Diagnostics: Short-circuit to ground

The diagnostics alarm is enabled if there is a short-circuit of the sensor supply to ground.

"Short-circuit to ground" diagnostics is available with the following sensor setting:

- NAMUR sensor
- NAMUR changeover contact

Diagnostics: Wire break

The diagnostics alarm is enabled if the line to the sensor is interrupted.

"Wire break" diagnostics is available with the following sensor setting:

- NAMUR sensor
- Single contact with 10 kΩ
- NAMUR changeover contact
- Changeover contact with 10 kΩ

Diagnostics: Chatter error

The diagnostic message is enabled when a chatter error occurs.

Chatter monitoring is a process control function for digital input signals. It detects and reports signal changes that are unexpected in process engineering, for example when an input signal fluctuates too often between "0" and "1". If signal characteristics like these occur, it is a sign that the sensors are faulty or that there are instabilities from a process engineering viewpoint.

Diagnostics: Changeover error

The diagnostics alarm is enabled when a changeover error occurs.

"Changeover error" diagnostics is available with the following sensor setting:

- NAMUR changeover contact
- Changeover contact, unconnected
- Changeover contact with 10 kΩ

Sensor type

Specifies which sensor type is connected (see Pin assignment (Page 20) chapter for DI NAMUR HF).

For the sensor types

- NAMUR changeover contact
- Changeover contact, unconnected
- Changeover contact with 10 kΩ

the following applies: The normally open contact channel must be set according to the sensor type. The normally closed contact channel must be deactivated.

If "Channel deactivated" is shown, this means that the channel is not activated.

Pulse stretching

Sets whether and for how long pulse stretching is to take place.

Pulse stretching is a function for changing a digital input signal. A pulse at a digital input is extended to at least the configured length. If the input pulse is already longer than the configured length, then the pulse will not be changed.

Digital input

Specifies whether or not the input signal is to be inverted. You can use the parameter for the following encoder types:

- NAMUR sensor
- Single contact, unconnected
- Single contact with 10 kΩ

Chatter monitoring

Chatter monitoring: Setting of the signal change

Settings for the tolerated number of signal changes during chatter monitoring within the monitoring window.

Number of signal changes = 0 deactivates the chatter monitoring function.

Monitoring window

Chatter monitoring: Setting of the monitoring window

Each input channel has a configurable monitoring window. The monitoring window is started the first time the input signal changes. If the input signal changes within the monitoring window more often than the configured number of signal changes, this is recognized as a chatter error. If no chatter error is detected within the monitoring window, the window is restarted at the next signal change.

Input delay

This parameter can be used to suppress signal interference. Changes to the signal are only detected if they are present consistently for longer than the set input delay time.

For input channels with longer input delays, the read-in time is moved accordingly. This means individual channels can be assigned input delays, if necessary, without having a retroactive negative impact on the possible cycle time.

Hardware interrupt rising edge

Specifies whether a hardware interrupt is generated for a rising edge.

Hardware interrupt falling edge

Specifies whether a hardware interrupt is generated for a falling edge.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light BaseUnit through which the required voltage is supplied for all modules of the potential group. The light BaseUnit interrupts the three self-assembling voltage buses P1, P2, and AUX to the left neighbor.

Specify on which slot a light BaseUnit with supply voltage feed or a dark BaseUnit is located (see ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual).

All additional I/O modules of this potential group are plugged into dark BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

The station configuration must be completed with a server module.

4.2.3 Pulse stretching

Description

Pulse stretching is a function for changing a digital input signal. A pulse at a digital input is extended to at least the configured length. If the input pulse is already longer than the configured length, then the pulse will not be changed.

A pulse-stretched signal is the input signal for the hardware interrupts.

Principle of pulse stretching

The following figure uses examples to show if and how input pulses are changed.

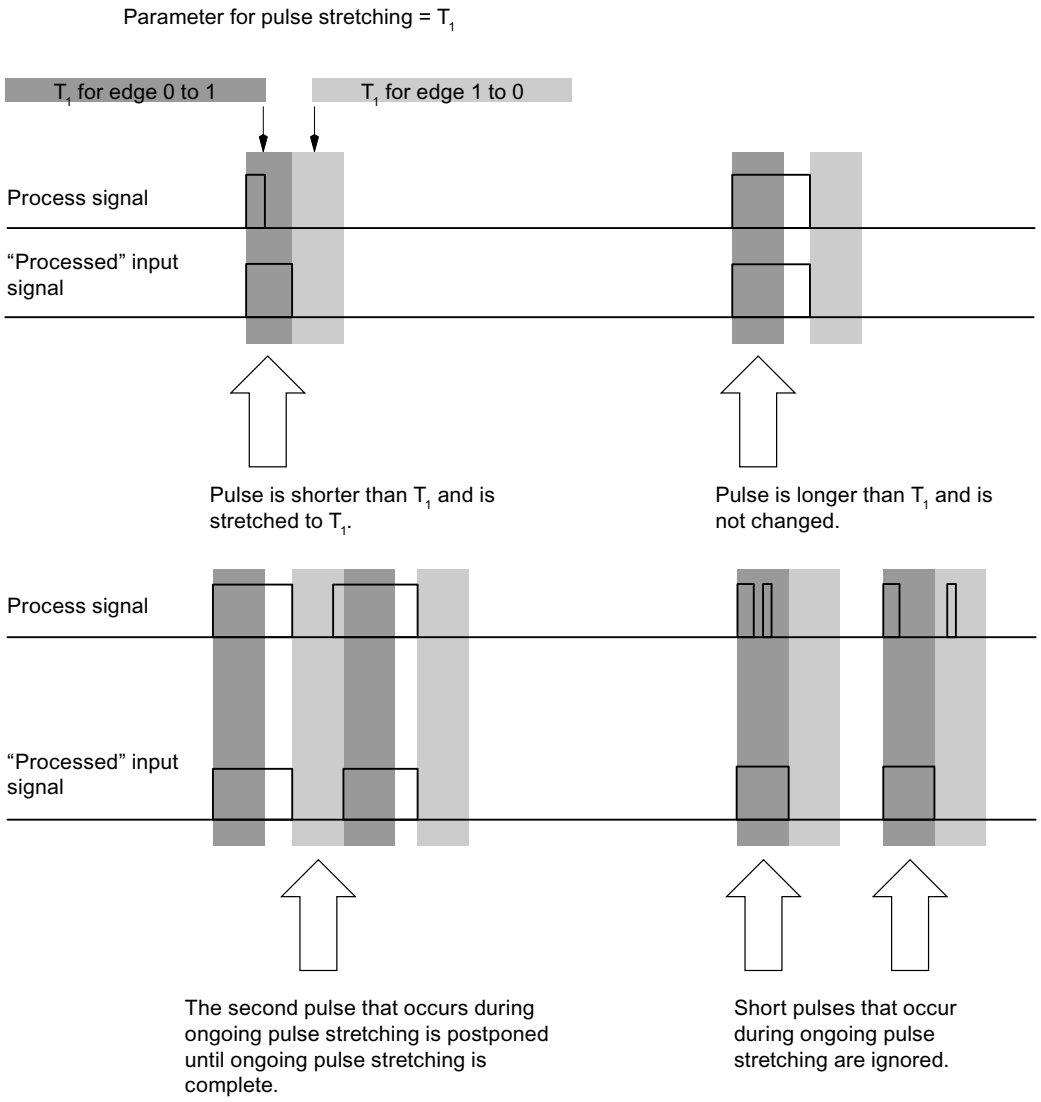

Figure 2-228 Principle of pulse stretching

NOTE

If you set pulse stretching for an input channel, this will also affect the chatter monitoring that is enabled for this channel. The "pulse-stretched" signal is the input signal for the chatter monitoring. You should therefore match the parameter settings for pulse stretching and chatter monitoring to one another. By selecting the appropriate values for the parameters you can adjust the functions optimally to your process.

NOTE

Pulse stretching in progress is reset in the event of an error in the value status (QI = 0, e.g. wire break).

4.2.4 Chatter monitoring

Description

Chatter monitoring is a process control function for digital input signals. It detects and reports signal changes that are unexpected in process engineering, for example when an input signal fluctuates too often between the states "0" and "1". This period is known as the "monitoring window". If signal characteristics like these occur, it is a sign that the sensors are faulty or that there are instabilities from a process engineering viewpoint.

Activating chatter monitoring

You activate chatter monitoring by specifying a permitted number of input signal changes between the states "0" and "1" within the monitoring window. The number 0 disables the chatter monitoring function.

A chatter error detected by the chatter monitoring has a direct effect on the value status (QI).

Detecting a chatter error

Each input channel has a monitoring window specified by parameters. The monitoring window is started the first time the input signal changes. If the input signal changes within the monitoring window more often than the configured number of signal changes, this is recognized as a chatter error. If no chatter error is detected within the monitoring window, the window is restarted at the next signal change.

Reporting a chatter error

If a chatter error occurs, the current signal status is entered in the process image and the value status of the signal is set to "invalid" (QI = 0). If "Chatter error" diagnostics is enabled, "Chatter error" is also entered as diagnostic information, triggering an incoming diagnostics interrupt.

You can evaluate and process the value status (QI) and the diagnostics information in the user program.

Resetting a chatter error

If no further chattering of the input signal is detected within three monitoring windows, an outgoing diagnostics interrupt is triggered. The status of the value of the current signal in the process image is set to "valid".

NOTE

Active chatter monitoring is reset if there is an error in the input signal (value status QI = 0).

Principle

The following figure gives you another graphic illustration of the principle of chatter monitoring.

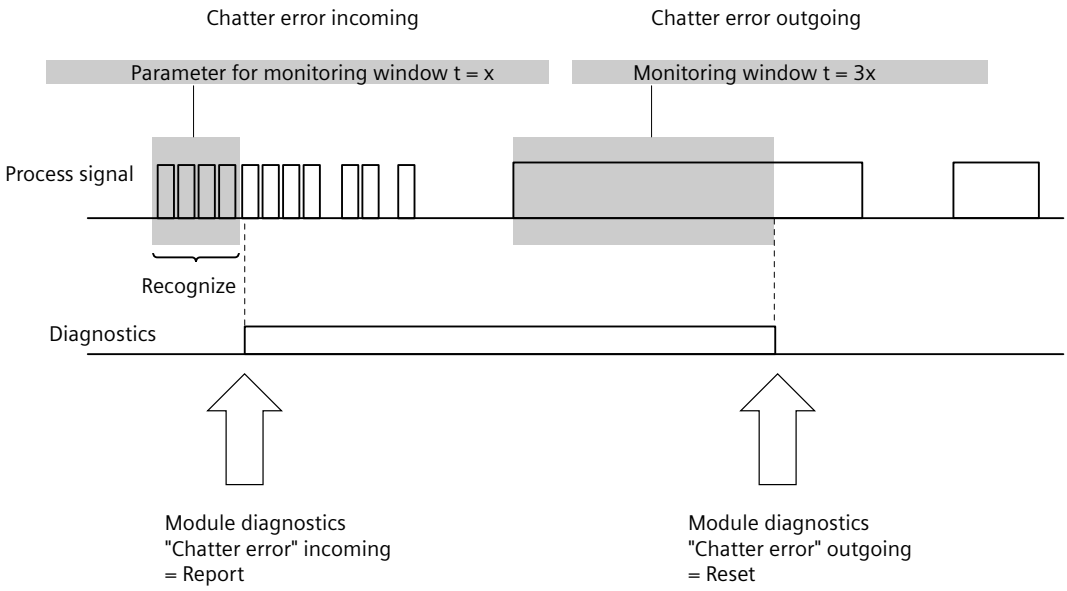

Figure 2-229 The principle of chatter monitoring

4.2.5 Address space

Configuration options of the DI 8×NAMUR HF

Configuration with value status:

- DI 8×NAMUR HF QI

Evaluating the value status

As a result of configuration with value status (QI), an additional byte is allocated in the input address space. Each bit in this byte is assigned to a channel and returns information about the validity of the digital value.

Deactivated channels or channels that are not operating correctly return a value status of QI = 0.

With changeover contacts, the value status of a normally closed channel is always QI = 0. The validity of the signal must be checked on the normally open channel.

You can find more information on evaluating the value status in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Address space of the digital input module DI 8×NAMUR HF

The following figure shows the assignment of address space for the DI 8×NAMUR HF with value status (Quality Information (QI)).

Assignment in the process image input (PII)

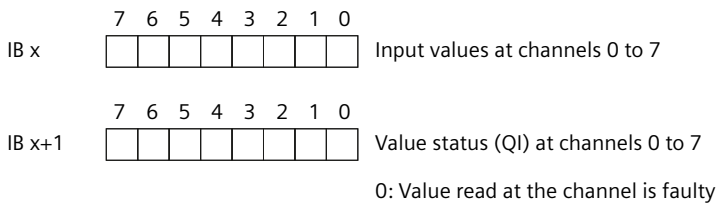

Figure 2-230 Address space of the DI 8×NAMUR HF digital input module with value status

Technology functions

All technology functions, such as

- Pulse stretching
- Chatter monitoring
- Changeover error
- Hardware interrupt

require a valid input signal that returns QI = 1 (no diagnostics detected). Otherwise, they will not run.

4.3 Interrupts/diagnostics alarms

4.3.1 Status and fault displays

LED displays

The figure below shows the LED displays (status and error displays) of the module.

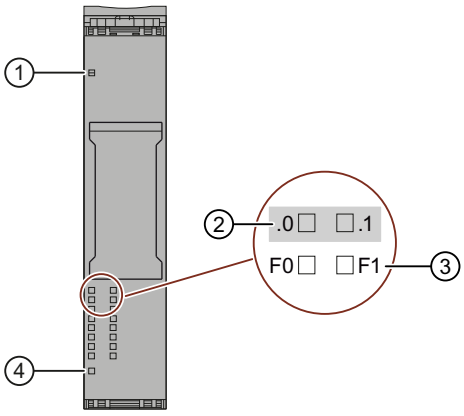

① DIAG (green/red)
② Channel status (green)
③ Channel fault (red)
④ PWR (green)

Figure 2-231 LED display

Meaning of the LEDs

The following tables describe the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the chapter Diagnostics alarms (Page 36).

LED DIAG

Table 2-267 LED DIAG fault display

LED DIAG	Meaning
Off	Backplane bus supply of the system is interrupted or switched off.
Flashing	Module parameters not assigned
On	Module parameters assigned and no module/channel diagnostics available
Flashing	Module parameters assigned and module/channel diagnostics available

LED channel status/channel fault

The channel status LED shows the signal status of the user data of an input. If inversion is enabled, the channel status LED shows the inverted status of the signal applied to the terminal.

If there is a diagnostics event on the channel, the channel status LED is always off if diagnostics is enabled and therefore does not indicate the signal status of the user data of the input.

Table 2-268 Channel status/channel fault LED status and fault display

LED		Meaning
Channel status	Channel fault	
□ Off	□ Off	Input returns "0" signal and no channel diagnostics available or channel deactivated
■ On	□ Off	Input returns "1" signal and no channel diagnostics available
□ Off	■ On	Channel activated and channel diagnostics available
■ On	■ On	Not permitted (fault)

LED PWR

Table 2-269 LED PWR status display

LED PWR	Meaning
□ Off	Supply voltage L+ is missing, is too low or polarity reversed
■ On	Supply voltage L+ present

4.3.2 Interrupts

Digital input module DI 8×NAMUR HF supports diagnostics and hardware interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt at the following events:

- Short-circuit to ground
- Wire break
- Supply voltage missing
- Changeover error
- Chatter error
- Parameterization error
- Hardware interrupt lost
- Channel/component temporarily unavailable

Detailed information on the event is available in the STEP 7 online help.

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- At rising edge (signal change from "0" to "1")
- At falling edge (signal change from "1" to "0")

In the event of an interrupt, interrupt OBs run automatically in the CPU of the IO controller.

You will find detailed information on the event in the hardware interrupt organization block with the "RALRM" instruction (read additional interrupt info) and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of the local data double word 8.

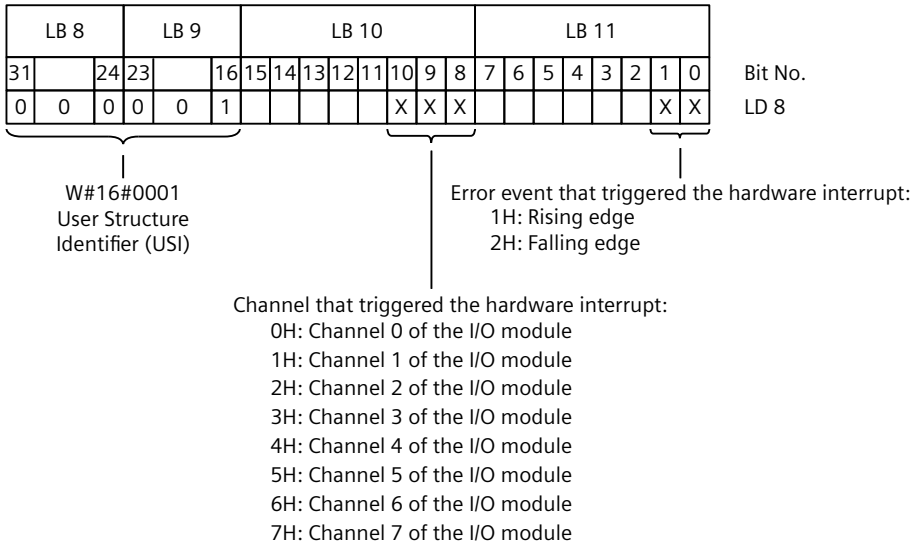

Figure 2-232 Organization block start information

If a hardware interrupt could not be signaled because there are too many hardware interrupts pending, the module generates the diagnostic interrupt "Hardware interrupt lost". You can find more information in the chapter Diagnostics of the inputs (Page 36).

The order of events on the individual channels within the 500-microsecond interval is not maintained. The events are reported to the PLC in groups in the order of the channels.

Structure of the additional interrupt information

Table 2-270 Structure of USI = W#16#0001

Data block name		Contents	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	Additional interrupt information for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#07	Channel 0 to 7 of the I/O module	1
The error event that triggered the hardware interrupt follows.				
	Error event	B#16#01	Rising edge	1
		B#16#02	Falling edge	

4.3.3 Diagnostics alarms

Diagnostics alarms

A diagnostic message is generated and the DIAG-LED flashes red on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostic buffer of the CPU. You can evaluate the fault codes with the user program.

Table 2-271 Diagnostics alarms, meaning and corrective measures

Diagnostics alarm	Fault code	Meaning	Remedy
Short-circuit (NAMUR changeover contact and NAMUR sensor only) Tip: Check the normally open and normally closed contact channels of the NAMUR changeover contact.	1_H	Short-circuit in the signal line to the sensor	Correct the process wiring
		Sensor defective	Replace the sensor
		Wrong sensor type configured	Correct the parameter assignment
		Load impedance too low	Use a sensor with a higher impedance
Wire break (only NAMUR changeover contact, NAMUR sensor, sensor connected with 10 kΩ and single contact connected with 10 kΩ) Tip: Check the normally open and normally closed contact channels of the NAMUR changeover contact	6_H	Signal line to a sensor interrupted	Correct the process wiring
		Sensor defective	Replace the sensor
		Wrong sensor type configured	Correct the parameter assignment
		Load impedance too high	Use a different sensor type or modify the wiring, for example, using cables with a larger cross-section
		Channel not connected (open)	Disable diagnostics, connect sensor contacts
Error	9_H	Sensor supply defective	Replace the module
		Hardware failure	
		This fault cannot be deactivated by parameter assignment, it is always active.	
Parameterization error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct parameter assignment
Supply voltage missing	11_H	Supply voltage L+ missing or too low	Check the supply voltage L+ on the BaseUnit Check BaseUnit type
		Is reported in the event of a power failure (24 V or 8.2 V power supply). This fault replaces all other faults (i.e. if there is a power failure, only this fault is reported, regardless of other faults currently present).	
Hardware interrupt lost	16_H	• Module cannot trigger an interrupt because a preceding interrupt was not processed completely • Possible cause: Too many hardware interrupts in too short a time	Change interrupt processing in the CPU and re-parameterize the module accordingly

Diagnostics alarm	Fault code	Meaning	Remedy
External fault (changeover sensors only)	$1A_H$	Changeover error: Validity check between normally closed and normally open contact channel negative	Check process wiring, change sensor
Error1 in actuator/encoder = Signal flutters	$1D_H$	Chatter error: Signal chatters: too many signal changes within the monitoring window If no further chattering of the input signal is detected within three monitoring windows, an outgoing diagnostics alarm is triggered. The status of the value of the current signal in the process image is set to "valid".	Verify the chatter monitoring parameters Check process wiring, if necessary change sensor
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled while running. The module does not read in process values in this state.	• Connecting the supply voltage • Wait for firmware update • Restart the firmware update

The diagnostics events occur at an interval of 2 kHz (every 500 µs), but the actual time of reporting to the CPU depends on several factors (the actual system load, duration of the ET 200SP backplane cycle, etc.).

4.3.4 Diagnostics for changeover contact sensor type

Diagnostics for changeover contact sensor type

With the changeover error diagnostics, the switchover between two input channels is checked. If there is a signal change in a changeover contact channel and there is no signal change at the other contact changeover channel after the tolerated switchover time, the diagnostics module returns a changeover error.

The tolerated switchover time between the two channels is set to the fixed value of 300 ms.

Changeover sensors are always assigned to two adjacent channels: The normally open contact channel should be set in accordance with the sensor type to channel 0, 2, 4, 6, and the respective corresponding normally closed contact channel 1, 3, 5, 7 deactivated.

Principle of changeover contact diagnostics

If the digital inputs of a channel group are configured as "changeover contacts", the module for this channel group carries out diagnostics for the changeover contact sensor type.

The digital input signal and the value status are only updated for the normally open contact channel (channels 0, 2, 4, 6). The digital input signal is "0" and the value status is "invalid" (QI = 0) for the normally closed contact channel (channels 1, 3, 5, 7). This channel is only used for a validity check of the sensor.

If the validity check is negative, the following applies:

- The module identifies the value status of the normally open contact channel as "invalid" (QI = 0)
- The module creates a diagnostics entry for the normally open contact channel and
- A diagnostics interrupt is triggered if changeover error diagnostics is enabled.

Please note the following special features for changeover contact diagnostics:

- If the normally open and normally closed contact signals are not plausible after 300 ms, (e.g. if there is no L/H or H/L combination of the channel pairs), a changeover error is output as diagnostics information.
- A time interval of 300 ms from the last change on each of the two channels is measured (change from/to L, H or a fault state). If another change occurs during the 300 ms time interval, the check is restarted for another 300 ms.
- If a fault has already occurred (QI = 0, e.g. a wire break), the module no longer performs diagnostics for changeover errors.
- Depending on the type of changeover contact, the are different diagnostic options (Dependencies for configuration with GSD files (Page 73)). Depending on the sensor type, a changeover error can have different causes.
  - In the case of connected changeover contacts, a changeover error may also be the result of a short-circuit (sensor is not defective; there is a short-circuit).
  - In the case of unconnected changeover contacts, a changeover error may also be the result of a wire break.
  - If a wire break or short-circuit can be detected with the particular sensor type but its diagnostics is not enabled, instead of the wire break or short-circuit diagnostics information, the changeover error diagnostics information is displayed if this is enabled.
  - During the time interval of 300 ms determined for the check (with possible repeated extension), the changeover contact channel reports a diagnostics that was valid before the first change. As soon as the 300 ms time interval passes without further changes, this diagnostics is updated.

Example:

- The changeover contact is configured on the first channel (index 0).
- Index 1 is automatically configured as its "odd" partner.
- Channel 0 measures the L state and channel 1 measures the wire break state.
- For channel 0, both diagnostic bits 6 and 26 are set (there is a wire break at the odd input).
- Nothing is reported for channel 1 (odd channel is automatically configured and reports DI = 0, QI = 0 to the CPU).

Tip: Data records 0 to 7 and changeover sensor

Using the data records 1, 3, 5 and 7, you can configure a changeover sensor on an even channel (normally closed contact channel).

The corresponding normally open contact channel can be configured with the data records 0, 2, 4 and 6.

An even changeover contact channel must be followed by an odd, deactivated channel. Otherwise:

- you receive a parameter assignment error or
- the parameter assignment is rejected and the current parameter assignment retained.

Remedy: First, send data records 1, 3, 5 and 7 with "deactivated", and then send data records 0, 2, 4 and 6 with changeover contact sensor.

Counter mode (CNT) 5

5.1 Counter

Numerator frequency

The maximum counting frequency is 5 kHz. This means that the counter is able to count all edges correctly if the signal on the counting channel does not change faster than 5 kHz.

5.1.1 Counters and changeover contacts

Counters and changeover contacts

Changeover contacts are not supported in the counter mode.

PROFIBUS restrictions

If PROFIBUS is used with the GSD configuration, only the CNT1 and CNT3 pulse counter configurations are available. The reason for this is that the size of the input data of CNT4 is more than 32 bytes, which makes its use with PROFIBUS impossible.

Counter and DI functionality

The counter function can be deactivated for a specific counting channel by setting it to digital input mode. In this mode the counting channel works as a DI channel.

The control channel has 3 possible states - DI, gate control, direction control. In the DI operating mode, the control channel behaves as a DI channel, i.e. its control function is deactivated. If the control channel is configured in either gate or direction control operating mode, beyond the control function of that channel, its entire DI function will still be available.

5.1.2 Restrictions of the control channel

Delay in setting the control channel

The signals are processed with a frequency of 2 kHz by the control channel. This means that there can be a delay of up to 500 µs in setting the control channel.

Delay in setting the control channel

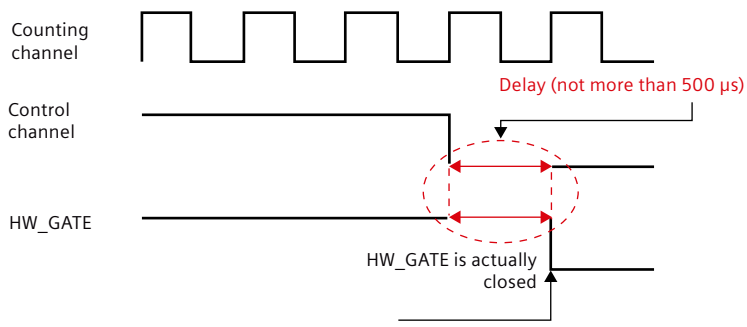

The figure shows the delay when the HW_GATE is turned off by switching the control channel from HIGH to LOW. The actual HW_GATE value is only changed after a certain delay.

5.2 Wiring

5.2.1 Pin assignment

This chapter includes the block diagram of the DI 8xNAMUR HF module with the terminal assignments for a 1-wire, 2-wire and 3-wire connection in the counter mode. You may use and combine the different wiring options for all channels.

You can find information on wiring the BaseUnit in the System Manual Distributed I/O system ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293).

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Pin assignment

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Digital input, channel 0	DI_0	1		2	DI_1	Digital input, channel 1
Digital input, channel 2	DI_2	3		4	DI_3	Digital input, channel 3
Digital input, channel 4	DI_4	5		6	DI_5	Digital input, channel 5
Digital input, channel 6	DI_6	7		8	DI_7	Digital input, channel 7
Sensor supply, channel 0	Us_0	9		10	Us_1	Sensor supply, channel 1
Sensor supply, channel 2	Us_2	11		12	Us_3	Sensor supply, channel 3

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Sensor supply, channel 4	Us_4	13	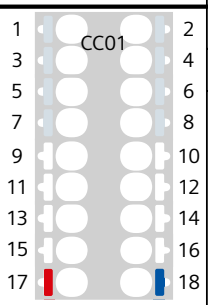	14	Us_5	Sensor supply, channel 5
Sensor supply, channel 6	Us_6	15		16	Us_7	Sensor supply, channel 7
24 V DC supply voltage	L+	17		18	M	Ground

The figures below show the connections for input signal DI0 for all sensor types.		
NAMUR sensors / IEC 60947-5-6 sensors 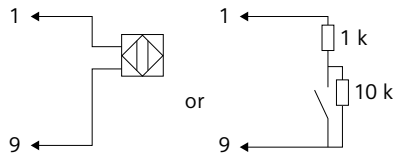	Single contact, unconnected (mechanical normally open contact with single contact) 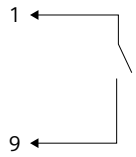	Single contact connected with 10 kΩ (mechanical normally open contact) 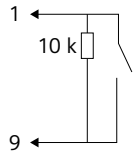

[1] Usable BaseUnit types, can be identified by the last two digits of the order number. See also system manual ET 200SP Distributed I/O System.

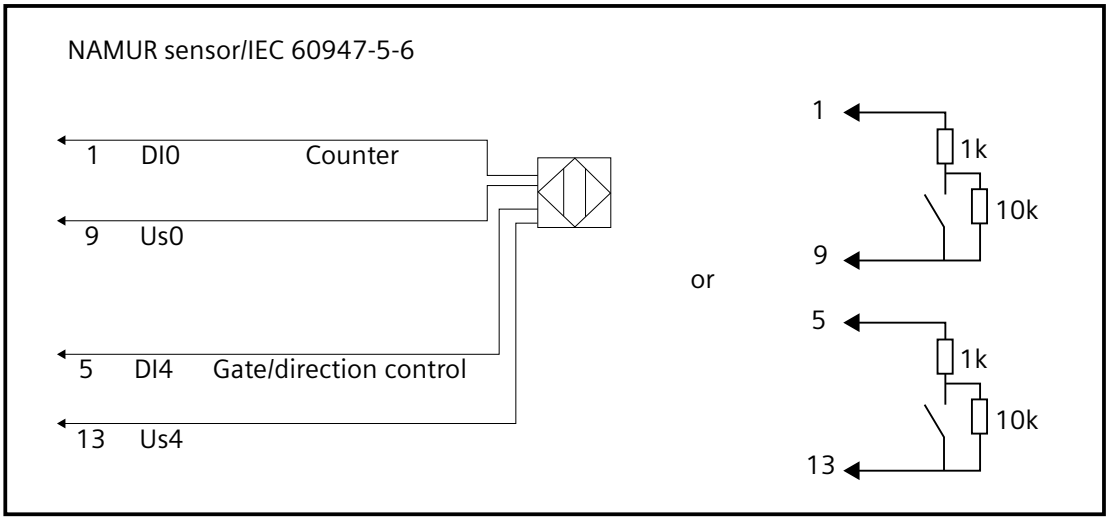

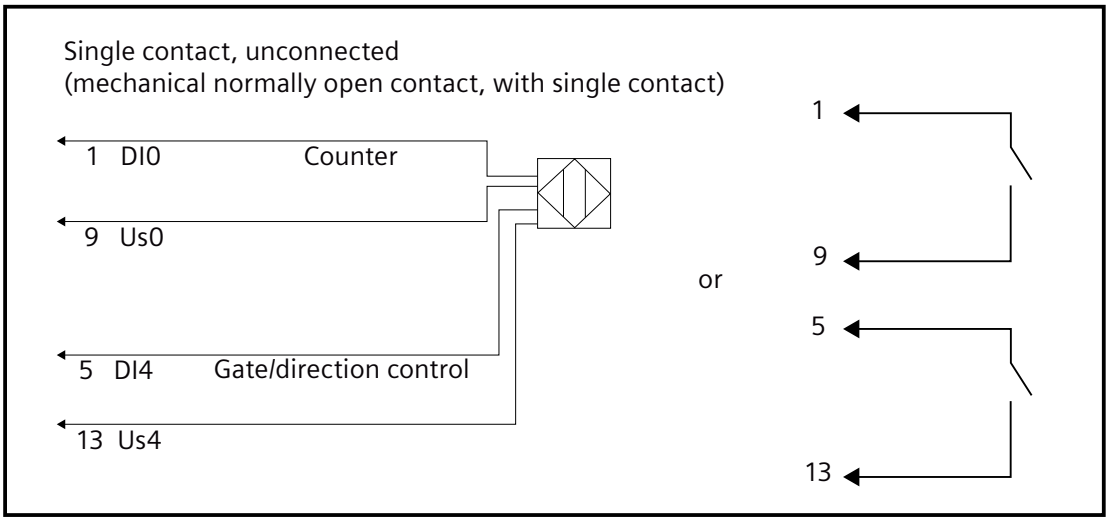
Single contact, unconnected
(mechanical normally open contact, with single contact)
1 DI0
Counter
9 Us0
5 DI4
Gate/direction control
13 Us4
or
1
9
5
13

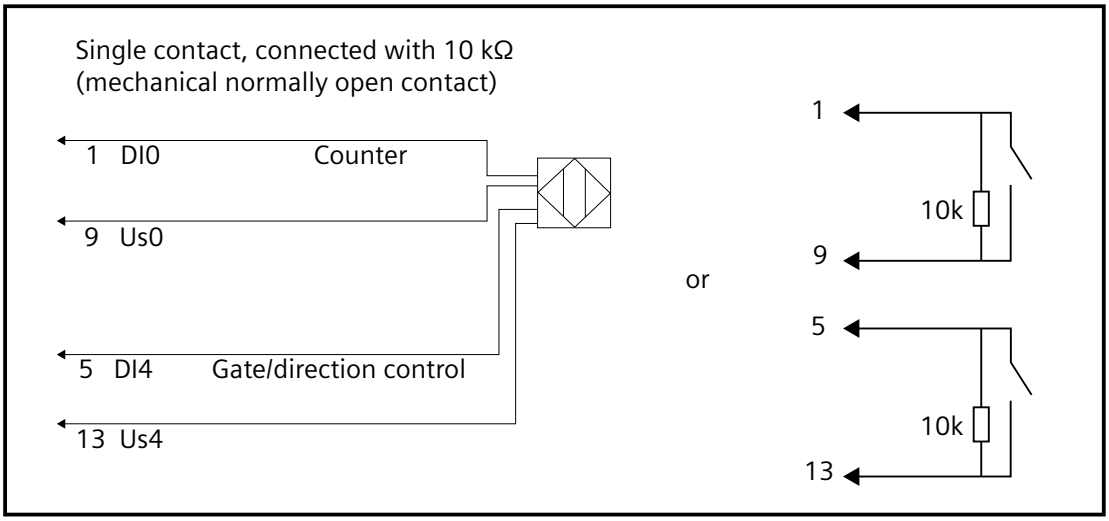
Single contact, connected with 10 kΩ
(mechanical normally open contact)
1 DI0
Counter
9 Us0
5 DI4
Gate/direction control
13 Us4
or
1
10k
9
5
10k
13

5.2.2 Schematic circuit diagram

This section contains the schematic circuit diagram of the module.

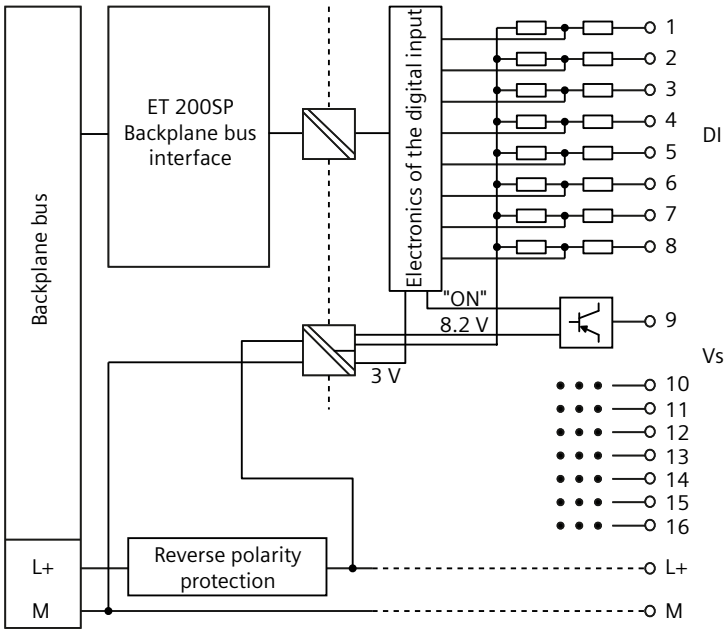

Figure 2-233 Block diagram DI 8xNAMUR HF

5.3 Parameters/address space

5.3.1 Counting

Function

Counting refers to the detection and summation of events. The respective counters of the module detect encoder signals and pulses and evaluate them accordingly, for example:

- For counting general piece goods up to a maximum limit
- For applications with recurring counting processes

You can count with DI_0 through DI_3. You can specify each counter's characteristics using the functions described below.

Counter limits

The counting limits define the counter value range used. The counter limits are configurable and can be modified during runtime using the user program.

The maximum possible counting limit is 2147483647 (2^{31}–1). The minimum possible counting limit is –2147483648 (–2^{31}).

You can continue or stop counting upon violation of a counting limit (automatic gate stop) Upon high and low limit violations of the counter value, an event bit is set in the feedback interface (Page 62) in each case.

Start value

You can configure a start value within the counter limits. The start value can be modified during runtime with the user program.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are recordd.

The control of the hardware gate takes place externally via the digital inputs DI_4 through DI_7. The software gate is controlled via the user program. Use of the hardware gate can be enabled through parameter assignment.

Count direction

The counting direction is specified either via suitable external pulse signals at the each counter's control input or via the configuration.

Comparison values

You define two comparison values that can control the STS_DQ feedback bit, independent of the user program. If the current counter value meets the configured comparison condition, the STS_DQ reset bit is set. You can use the STS_DQ reset bit in order to control a digital output module's digital output.

The comparison values are configurable and can be modified during runtime with the user program. When a comparison event occurs, in each case an event bit is set in the feedback interface (Page 62).

5.3.2 Scaling

The property of the scaling is similar to the scaling of the measured values in the Analog input module AI 2xU/I 2-/4-wire HF (https://support.industry.siemens.com/cs/de/en/view/89116945).

Function

NOTE

Effects of inversion

It is possible to set the "Scaled high nominal range limit" parameter lower than the "Scaled low nominal range limit" parameter, whereby the representation of the measuring range will be inverted compared to the terminal value.

NOTE

When the Parameter "Scaled high nominal range limit" and "Scaled low nominal range limit" parameters are too close together, resolution may be lost, which means it may no longer be possible to show every value.

Process image (I/0 data structure)

The output data has the same format as the counters, only SLOT is in FLOAT32 format here.

Table 2-272 Address space in the configuration digital operation with "Count" operating mode without QI

Byte offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Data type
QB x	*SLOT (load value)*								*Float32*
QB x + 1									
QB x + 2									
QB x + 3									
QB x + 4	RESET_ EVENT_ CMP1	RESET_ EVENT_ CMP0	RESET_ EVENT_ OFLW	RESET_ EVENT_ UFLW	SW_GATE	LD_SLOT (meaning of the load value)			Unsigned8 (bit granu-lar)

Notes:

"QB" stands for output byte

x = channel number × 5

The input data has the same format as the counters, but now instead of the "Count value", (formerly INTEGER32), a new scaled "Count value" in FLOAT32 format is reported to the CPU.

Table 2-273 Address space in the configuration digital operation with "Count" operating mode without QI

Byte offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Data type
IB x + 2	COUNT_VALUE								*Float32*
IB x + 3									
IB x + 4									
IB x + 5									
IB x + 6	**MEASURED_VALUE**								Float32
IB x + 7									
IB x + 8									

Notes:

"IB" stands for input byte

x = channel number × 10

The data marked in italics represent the changes presented for SCLx submodules compared to CNTx submodules.

The data marked in bold means that the parameter is used for measuring.

Byte offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Data type
IB x + 9	**MEASURED_VALUE**								Float32
IB x + 10	LD_ERROR	LD_STS_SL-OT	0	0	**STS_M_ INTERVAL**	QI	STS_GATE	STS_DQ	Unsigned8 (bit granu-lar)
IB x + 11	RESET_ EVENT_ CMP1_ ACK	RESET_ EVENT_ CMP0_ ACK	RESET_ EVENT_ UFLW_ ACK	RESET_ EVENT_ OFLW_ ACK	EVENT_ CMP1	EVENT_ CMP0	EVENT_ OFLW	EVENT_ UFLW	Unsigned8 (bit granu-lar)

Notes:

"IB" stands for input byte

x = channel number × 10

The data marked in italics represent the changes presented for SCLx submodules compared to CNTx submodules.

The data marked in bold means that the parameter is used for measuring.

Parameter data record DS129

The representation of the measuring range is defined by the following parameters:

- The "Scaled high nominal range limit" parameter sets the desired display value (in REAL) for the high nominal range limit of the measuring range.
- The "Scaled low nominal range limit" parameter sets the desired display value (in REAL) for the low nominal range limit of the measuring range.

The "Start value", "Comparison value 0" and "Comparison value 1" are now in the FLOAT32 format. The reason for this is that these values are represented in the scaling mode in the range [*low_scaling_limit, high_scaling_limit*] instead of [low_cnt_limit, high_cnt_limit] as with the usual counters.

Changing the scaling configuration during operation

The scaling parameters

- "Scaled high nominal range limit" and
- "Scaled low nominal range limit"

can be changed to any valid values during the operation.

Commands (LD_SLOT)

In the chapter Process image (I/0 data structure) it has already been described that LD_SLOT is in FLOAT32 format. It applies to the scaled range [*low_scaling_limit, high_scaling_limit*]. The table below shows the commands and their meaning.

Command (in binary 3-bit format)	Meaning	Response
000	NOP (no action)	No action
001	Load the scaled counter value (Float32)	The Integer32 count value is calculated and set.
011	Load the scaled start value (Float32)	The Integer32 start value is calculated and set.
100	Load the scaled comparison value 0 (Float32)	The Float32 comparison value 0 is set.
101	Load the scaled comparison value 1 (Float32)	The Float32 comparison value 1 is set.
110	Load the scaled low nominal range limit (Float32)	The Float32-scaled low nominal range limit is set. The Integer32 lower count limit is calculated and set.
111	Load the scaled high nominal range limit (Float32)	The Float32-scaled high nominal range limit is set. The Integer32 higher count limit is calculated and set.

Use of commands "110" and "111"

To properly use the commands "110" and "111" in scaling mode, take the gain into account.

Gain

If, for example, count limits are set to [0; 100] and scaled nominal range limits are set to [0.0; 1.0], this means that one pulse (one count) represents the value 1.0 / 100 = 0.01 in the scaled nominal range. This value is known as gain. If, for example, 100 counts corresponds to a distance of 1.0 m, this ratio is represented by the gain 0.01 m/number of counts.

The gain is calculated only once during parameter assignment of the module (e.g. during initial configuration from TIA Portal or by writing DS 129). The gain is viewed as physically significant (e.g. property of a sensor) and its value must therefore be retained. The gain must not be changed after processing of the commands "110" (set low scaled limit) and "111" (set high scaled limit).

NOTE

If you use commands "110" and "111" in scaling mode, the resulting length of the new scaled nominal range must equal the gain multiplied by the integer number.

Example

"Low nominal range limit" is 3, "High nominal range limit" is 113, "Scaled low nominal range limit" is 6.5 and "Scaled high nominal range limit" is 17.5.

Gain = (17.5 - 6.5) / (113 - 3) = 0.1

The new value for the high scaled limit (command "111") can only be 6.5 + n * 0.1. For example, the values 9.501, 13.75 and 17.193 are rejected (LD_ERROR bit is defined in the input data), but the values 9.5, 13.7 and 17.2 are accepted as the scaled high nominal range limit.

Additional examples

- If the scaled range is to be doubled (increased by 100%), the "Scaled high nominal range limit" can be calculated with 17.5 + (17.5 - 6.5) * 1 = 28.5.
- An increase of 20% can be achieved by changing the scaled high nominal range limit to 17.5 + (17.5 - 6.5) * 0.2 = 19.7.

For rounding tolerance, values that are close enough to the permissible values (within approximately 5%) are also accepted and adapted in the module.

5.3.3 Parameters

You can specify the module properties with various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation on an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system
- Distributed operation on EtherNet/IP in an ET 200SP system
- Distributed operation on Modbus TCP in an ET 200SP system

In addition to configuration via the configuration software, you can also configure parameters in RUN mode (dynamic) via the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records, see chapter Parameter assignment and structure of parameter data record for counter mode (Page 79).

The following parameter settings are possible for each operating mode:

Table 2-274 Settable parameters and their defaults in the Counting mode (GSD file)

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software	
				HSP0400 for STEP 7 (TIA Portal); HSP0229 for STEP 7; PROFINET IO GSD file	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics Wire break	• Disable • Enable	Disable	Yes	Channel	Channel

1 "Input delay" for channels 0-3 and 4-7 can only be set identically. If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter for each channel via data record 128.

2 Because the number of parameters is limited to 244 bytes per ET 200SP station in a PROFIBUS GSD configuration, the parameter assignment options are limited. The parameter length of the I/O module is up to 37 bytes with a PROFIBUS GSD configuration. If your PROFIBUS Master supports the "Read/write data record" function, you can set these parameters via data records 128 and 129.

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software	
				HSP0400 for STEP 7 (TIA Portal); HSP0229 for STEP 7; PROFINET IO GSD file	GSD file PROFIBUS DP
Diagnostics: Chatter error	• Disable • Enable	Disable	Yes	Channel	-
Sensor type	• Channel deactivated • NAMUR sensor • Single contact unconnected • Single contact, connected with 10 kΩ • NAMUR changeover contact • Changeover contact, unconnected • Changeover contact, connected with 10 kΩ	NAMUR sensor	Yes	Channel	Channel
Pulse stretching	• None • 0.5 s • 1 s • 2 s	None	Yes	Channel	-
Digital input	• Normal • Inverted	Normal	Yes	Channel	Channel
Chatter monitoring	• Deactivated • 2 to 32 signal changes	Deactivated	Yes	Channel	-
Monitoring window	• 0.5 s • 1 s ... 100 s	0.5 s	Yes	Channel	-
Input delay	• None • 0.1 ms • 0.2 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 10 ms • 12.8 ms • 20 ms	0.1 ms	Yes	Channel	Channel[1]
Hardware interrupt rising edge	• Disable • Enable	Disable	Yes	Channel	Channel
Hardware interrupt falling edge	• Disable • Enable	Disable	Yes	Channel	Channel

1 "Input delay" for channels 0-3 and 4-7 can only be set identically. If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter for each channel via data record 128.

2 Because the number of parameters is limited to 244 bytes per ET 200SP station in a PROFIBUS GSD configuration, the parameter assignment options are limited. The parameter length of the I/O module is up to 37 bytes with a PROFIBUS GSD configuration. If your PROFIBUS Master supports the "Read/write data record" function, you can set these parameters via data records 128 and 129.

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software	
				HSP0400 for STEP 7 (TIA Portal); HSP0229 for STEP 7; PROFINET IO GSD file	GSD file PROFIBUS DP
Potential group	• Use the potential group of the left module (module plugged into a dark BaseUnit) • Enable new potential group (module plugged into a light BaseUnit)	Use potential group of the left module	No	Module	Module
Edge selection	• At rising edge • At falling edge	At rising edge	Yes	Channel	Channel
Reaction to violation of a counting limit	• Stop counting • Continue counting	Stop counting	Yes	Channel	Channel
Set function of DI	• Digital input • Gate start/stop • Count direction	Digital input	Yes	Channel	Channel
Count direction	• Up • Down	Up	Yes	Channel	Channel
Set output DQ	• Off (DQ = 0) • Off (DQ = 1) • Between comparison value 0 and 1 • Not between comparison value 0 and 1	Off (DQ = 0)	Yes	Channel	Channel
Comparison value 1	-2147483647 ... 2147483647	10	Yes	Channel	Channel
Comparison value 0	-2147483648 ... 2147483646	0	Yes	Channel	— [2]
Start value	-2147483648 ... 2147483647	0	Yes	Channel	— [2]
Counter high limit	-2147483647 ... 2147483647	2147483647	Yes	Channel	Channel
Counter low limit	-2147483648 ... 2147483646	0	Yes	Channel	— [2]
Update time [µs]	0 ... 25000000 µs	10000	Yes	Channel	Channel
Increments per unit	1 ... 65535	1	Yes	Channel	Channel
Measured value	• No measurement • Frequency • Period duration • Velocity	No measurement	Yes	Channel	Channel

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software	
				HSP0400 for STEP 7 (TIA Portal); HSP0229 for STEP 7; PROFINET IO GSD file	GSD file PROFIBUS DP
Time base for velocity measurement	• 1 ms • 10 ms • 100 ms • 1 s • 1 min	1 min	Yes	Channel	Channel

1 "Input delay" for channels 0-3 and 4-7 can only be set identically. If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter for each channel via data record 128.

2 Because the number of parameters is limited to 244 bytes per ET 200SP station in a PROFIBUS GSD configuration, the parameter assignment options are limited. The parameter length of the I/O module is up to 37 bytes with a PROFIBUS GSD configuration. If your PROFIBUS Master supports the "Read/write data record" function, you can set these parameters via data records 128 and 129.

5.3.4 Explanation of parameters

Diagnostics: No supply voltage L+

The diagnostics alarm is enabled for missing or insufficient supply voltage L+.

This diagnostic message is also set if another problem occurs with the supply voltage of the sensor (e.g. if a fault occurs in the supply voltage of the module for the sensors). Another example is when both problems occur together: L+ problems (usually external reasons) and problems with the sensor supply (internal reasons).

Tip: To avoid a diagnostics overload, you should only enable "Diagnostics: Missing supply voltage" for an active channel.

Diagnostics: Short-circuit to ground

The diagnostics alarm is enabled if there is a short-circuit of the sensor supply to ground.

"Short-circuit to ground" diagnostics is available with the following sensor setting:

- NAMUR sensor
- NAMUR changeover contact

Diagnostics: Wire break

The diagnostics alarm is enabled if the line to the sensor is interrupted.

"Wire break" diagnostics is available with the following sensor setting:

- NAMUR sensor
- Single contact with 10 kΩ
- NAMUR changeover contact
- Changeover contact with 10 kΩ

Diagnostics: Chatter error

The diagnostic message is enabled when a chatter error occurs.

Chatter monitoring is a process control function for digital input signals. It detects and reports signal changes that are unexpected in process engineering, for example when an input signal fluctuates too often between "0" and "1". If signal characteristics like these occur, it is a sign that the sensors are faulty or that there are instabilities from a process engineering viewpoint.

Sensor type

Specifies which sensor type is connected (see section Pin assignment (Page 41) for DI NAMUR HF).

For the sensor types

- NAMUR changeover contact
- Changeover contact, unconnected
- Changeover contact with 10 kΩ

the following applies: The normally open contact channel must be set according to the sensor type. The normally closed contact channel must be deactivated.

If "Channel deactivated" is shown, this means that the channel is not activated.

Pulse stretching

Sets whether and for how long pulse stretching is to take place.

Pulse stretching is a function for changing a digital input signal. A pulse at a digital input is extended to at least the configured length. If the input pulse is already longer than the configured length, then the pulse will not be changed.

Digital input

Specifies whether or not the input signal is to be inverted. You can use the parameter for the following encoder types:

- NAMUR sensor
- Single contact, unconnected
- Single contact with 10 kΩ

Chatter monitoring

Chatter monitoring: Setting of the signal change

Settings for the tolerated number of signal changes during chatter monitoring within the monitoring window.

Number of signal changes = 0 deactivates the chatter monitoring function.

Monitoring window

Chatter monitoring: Setting of the monitoring window

Each input channel has a configurable monitoring window. The monitoring window is started the first time the input signal changes. If the input signal changes within the monitoring window more often than the configured number of signal changes, this is recognized as a chatter error. If no chatter error is detected within the monitoring window, the window is restarted at the next signal change.

Input delay

This parameter can be used to suppress signal interference. Changes to the signal are only detected if they are present consistently for longer than the set input delay time.

For input channels with longer input delays, the read-in time is moved accordingly. This means individual channels can be assigned input delays, if necessary, without having a retroactive negative impact on the possible cycle time.

Hardware interrupt rising edge

Specifies whether a hardware interrupt is generated for a rising edge.

Hardware interrupt falling edge

Specifies whether a hardware interrupt is generated for a falling edge.

Potential group

Specifies whether a light-colored BaseUnit with infeed of the supply voltage is located in this slot (see the System Manual SIMATIC ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293)).

Edge selection

Selects the edge that is counted:

- At rising edge:
  The respective counter counts all rising edges at the digital input.
- At falling edge:
  The respective counter counts all falling edges at the digital input.

NOTE

If the "Reverse direction" option is selected in "Set function of DI" and the counting direction in the process changes, the counting edge is automatically adjusted (opposite edges).

Reaction to violation of a counting limit

Selection of the reaction to violation of the counter high limit in the upward direction or the counter low limit in the downward direction:

- Stop counting:
  After a counting limit is violated, the internal gate is closed. This stops the counting process. The counter value is set to the opposite counting limit. To restart counting, you must close and reopen the software/hardware gate.
- Continue counting:
  After a counting limit is violated, the counter value is set to the opposite counting limit and counting continues.

Set function of DI

Selects the function of DI_{n+4}, which controls the assigned counter input DI_n:

- Digital input:
  No function is assigned to DI_{n+4}. The signal status of DI_{n+4} is read by the CPU using the feedback interface (Page 58).
- Gate start/stop:
  Setting DI_{n+4} opens the hardware gate for DI_n. Resetting DI_{n+4} closes the hardware gate for DI_n.
- Count direction:
  DI_{n+4} reverses the counting direction at DI_n, in order to adjust it to the process. If DI_{n+4} is not set, DI_n counts up. If DI_{n+4} is set, DI_n counts down.

In "Count direction" mode, the edge is changed when the counting direction is changed. For this reason, the "Count direction" parameter is ignored in this mode. In this case, the actual

type of the counting edges depends on the value of the "Edge selection" parameter. The table below shows a summary of the counter behavior.

Edge selection/count direction	Up	Down
At rising edge	Counting of rising edges	Counting of falling edges
At falling edge	Counting of falling edges	Counting of rising edges

Count direction

Count direction selection:

- Up:
  The respective counter counts up.
- Down:
  The respective counter counts down.

NOTE

This parameter has no effect if the "Reverse direction" option is selected in "Set function of DI".

If, for example, the "Edge selection" via DS129 was initially set to "At rising edge", then the rising edges are counted upward by setting the control channel to 0 (up). The falling edges, on the other hand, are counted downwards by setting the control channel to 1 (down).

Set output DQ

Selects the function that controls the response of the STS_DQ feedback bit (Page 59): You use the feedback bit STS_DQ to control a digital output of a digital output module.

- Off (DQ = 0):
  STS_DQ is independent of the counter value and permanently not set.
- Off (DQ = 1):
  STS_DQ is independent of the counter value and permanently set.
- Between comparison value 0 and 1:
  STS_DQ is set if counter value ≥ comparison value 0 and counter value ≤ comparison value 1.
- Not between comparison value 0 and 1:
  STS_DQ is set if counter value < comparison value 0 or counter value > comparison value 1.

Comparison value 1

Sets the second comparison value.

The following applies:

- Comparison value 1 > comparison value 0
- Comparison value 1 ≤ counter high limit

Comparison value 0

Sets the first comparison value.

The following applies:

- Comparison value 0 < comparison value 1
- Comparison value 0 ≥ counter low limit

Start value

Sets the start value.

The following applies:

- Start value ≥ counter low limit
- Start value ≤ counter high limit

Counter high limit

Sets counter high limit.

The following applies:

- Counter high limit > counter low limit
- Counter high limit ≤ 2147483647 (2^{31} - 1)

Counter low limit

Sets the counter low limit.

The following applies:

- Counter low limit < counter high limit
- Counter low limit ≥ -2147483648 (-2^{31})

Update time [µs]

By configuring the update time in microseconds, you define the interval between two measured value updates.

Increments per unit

With this parameter, you define the number of count pulses per relevant unit that the incremental or pulse encoder supplies for the velocity measurement.

Measured value

Used to select the measurement type, i.e. frequency, period and velocity measurement.

Time base for velocity measurement

With this parameter, you specify the time base with which the velocity should be provided.

You can select from the following options:

- 1 ms
- 10 ms
- 100 ms
- 1 s
- 1 min

The default setting is "1 min".

5.3.5 Address space

5.3.5.1 Assignment of the control interface

Control interface

The user program uses the control interface to influence the behavior of the module's counter.

The table below shows the structure of the control interface for individual channels.

Byte offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Data type
QB x	SLOT (load value)								Integer32/Float32[1]
QB x + 1									
QB x + 2									
QB x + 3									
QB x + 4	RESET_ EVENT_ CMP1	RESET_ EVENT_ CMP0	RESET_ EVENT_ OFLW	RESET_ EVENT_ UFLW	SW_GATE	LD_SLOT (meaning of the load value)			Unsigned8 (bit granular)

Notes:

"QB" stands for output byte

x = channel number × 5

[1] The data type depends on the mode used. The Integer32 data type is supported in count mode and the Float32 data type in scaling mode.

5.3.5.2 Notes on the control interface

Notes on the control bits

Control bit	Notes
SLOT	With this value you specify the load value for the respective channel. Use the LD_SLOT load request to evaluate the loaded value.
LD_SLOT	With this load request you specify the meaning of the value in SLOT (load value) for the respective channel. The user program performs the respective action, as soon as LD_SLOT changes. When the loading request LD_SLOT = 011_B is entered and the software gate is opened, each counting operation begins with the start value. If another load request is entered and the software gate is opened, counting continues with the current count at each start of the counting operation. These two situations are also in effect when the hardware gate is configured and the software gate is closed.
SW_GATE	With this bit, you open and close the software gate of the respective channel. Together, the software gate and the hardware gate form the internal gate. The module only carries out the counting process when the internal gate is open. 0 means: Software gate closed 1 means: Software gate open
RES_EVENT_UFLW	Use this bit to initiate the resetting of the saved event in the EVENT_UFLW feedback bit for the respective channel.
RES_EVENT_OFLW	Use this bit to initiate the resetting of the saved event in the EVENT_OFLW feedback bit for the respective channel.
RES_EVENT_CMP0	Use this bit to initiate the resetting of the saved event in the EVENT_CMP0 feedback bit for the respective channel.
RES_EVENT_CMP1	Use this bit to initiate the resetting of the saved event in the EVENT_CMP1 feedback bit for the respective channel.

Table 2-275 Detailed display of SW_GATE and LD_SLOT

Control interface SW_GATE.LD_SLOT	Conversion to LD_SLOT command	Action (LD_SLOT)	Load value (SLOT)	Response to GATE start
x.000 (NOP)	1.xxx 0.000	Deactivate counter	-	-
	0.xxx 1.000	Activate counter	-	Counting from the current value
	1.xxx 1.000	The counter remains activated	-	Maintaining the previous behavior
	0.xxx 0.000	The counter remains deactivated	-	-
x.001 (CNT = LW)	1.xxx 0.001	Deactivate counter	In the counter value	-
	0.xxx 1.001	Activate counter	In the counter value	Counting from the current value
	1.xxx 1.001	The counter remains activated	In the counter value	Maintaining the previous behavior
	0.xxx 0.001	The counter remains deactivated	In the counter value	-
	1.xxx 0.010	Deactivate counter	-	-

Control interface SW_GATE.LD_SLOT	Conversion to LD_SLOT command	Action (LD_SLOT)	Load value (SLOT)	Response to GATE start
x.010 (reserved)	0.010 1.010	Activate counter (only the SW_GATE change)	-	Counting from the current value
	0.xxx 1.010 xxx ≠ 010	(LD_ERROR=1) reserved	-	Maintaining the previous behavior
	1.xxx 1.010 0.xxx 0.010	(LD_ERROR =1) counter remains activated or deactivated	-	Maintaining the previous behavior
x.011 (SW = LW / CNT = SW)	1.xxx 0.011	Deactivate counter	In start value	-
	0.xxx 1.011	Activate counter	-	Counting from the start value
	1.xxx 1.011	The counter remains activated	In start value	Maintaining the previous behavior
	0.xxx 0.011	The counter remains deactivated	In start value	-
x.100 (V0 = LW)	1.xxx 0.100	Deactivate counter	In V0	-
	0.xxx 1.100	Activate counter	In V0	Counting from the current value
	1.xxx 1.100	The counter remains activated	In V0	Maintaining the previous behavior
	0.xxx 0.100	The counter remains deactivated	In V0	-
x.101 (V1 = LW)	1.xxx 0.101	Deactivate counter	In V1	-
	0.xxx 1.101	Activate counter	In V1	Counting from the current value
	1.xxx 1.101	The counter remains activated	In V1	Maintaining the previous behavior
	0.xxx 0.101	The counter remains deactivated	In V1	-
x.110 (UZG = LW)	1.xxx 0.110	Deactivate counter	In the UZG	-
	0.xxx 1.110	Activate counter	In the UZG	Counting from the current value
	1.xxx 1.110	The counter remains activated	In the UZG	Maintaining the previous behavior
	0.xxx 0.110	The counter remains deactivated	In the UZG	-
x.111 (OZG = LW)	1.xxx 0.111	Deactivate counter	In the OZG	-
	0.xxx 1.111	Activate counter	In the OZG	Counting from the current value
	1.xxx 1.111	The counter remains activated	In the OZG	Maintaining the previous behavior
	0.xxx 0.111	The counter remains deactivated	In the OZG	-

HW GATE is configured as follows:

No command is executed after the edge change 0 → 1 of the HW gate. Instead, the counter reacts to the last setting "Behavior at GATE start", provided that SW_GATE = 1 has remained stable.

Abbreviations:

NOP = No operation

CNT = Count value

V0 = Comparison limit 0

UZG = Lower count limit

LW = Load value (SLOT)

V1 = Comparison limit 1

OZG = Higher count limit

SW = Start value

5.3.5.3 Assignment of the feedback interface

Feedback interface

The user program receives current values and status information from the module via the feedback interface. The figure below shows the address space allocation for the feedback interface in the process image of the inputs.

The first two bytes represent the DI and QI information for all channels.

Byte offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Data type
IB 0	DI7	DI6	DI5	DI4	DI3	DI2	DI1	DI0	Unsigned8 (bit granular)
IB 1	QI7	QI6	QI5	QI4	QI3	QI2	QI1	QI0	Unsigned8 (bit granular)

Below you can find the meaning of the values:

Name	Meaning
DI<n> [n=0..7]	Digital input for channel <n>, i.e. DI0 is the digital input for channel 0, DI1 is the digital input for channel 1, etc.
QI<n> [n=0..7]	Quality information for the channel <n>.

The following structure is used for every channel. It consists of 10 bytes. For example, for 4 counter channels, this information uses 10 * 4 = 40 bytes. The fields used only for the measurements are marked in bold.

Byte offset	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Data type
IB x + 2	COUNT_VALUE								Integer32/Float32[1]
IB x + 3									
IB x + 4									
IB x + 5									
IB x + 6	**MEASURED_VALUE**								Float32
IB x + 7									
IB x + 8									
IB x + 9									
IB x + 10	LD_ERROR	LD_STS_S-LOT	0	0	**STS_M_I-NTERVAL**	QI	STS_GATE	STS_DQ	Unsigned8 (bit granu-lar)
IB x + 11	RESET_ EVENT_ CMP1_AC-K	RESET_ EVENT_ CMP0_AC-K	RESET_ EVENT_ UFLW_AC-K	RESET_ EVENT_ OFLW_AC-K	EVENT_ CMP1	EVENT_ CMP0	EVENT_ OFLW	EVENT_ UFLW	Unsigned8 (bit granu-lar)

Notes:

"IB" stands for input byte

x = channel number × 10

[1] The data type depends on the mode used. The Integer32 data type is supported in count mode and the Float32 data type in scaling mode.

5.3.5.4 Notes on the feedback interface

Notes on the feedback bits

Feedback bit	Notes
COUNT_VALUE	This value returns the current counter value for the respective channel.
MEASURED_VALUE	**If measurements are activated, frequency, velocity and current velocity are included in the value in Float32 format. Otherwise, this field contains 0 if measurements are dis-abled.** This value shows the current measured value with REAL data type: • Frequency: Based on the time sequence of the count pulses or position value changes, the average frequency within a measuring interval is calculated and returned as a float-ing-point number in units of hertz. • Period duration: Based on the time sequence of the count pulses or position value changes, the average period within a measuring interval is calculated and returned as a floating-point number in units of seconds. • Velocity: Based on the time sequence of the count pulses or position value changes and additional parameters, the average velocity within a measuring interval is calculated and returned in the configured unit. The measured values are returned as signed values. The sign indicates whether the counter value increased or decreased during the relevant time interval. The update time is asyn-chronous to the opening of the internal gate, which means that the update time is not star-

Feedback bit	Notes
	ted when the gate is opened. After the internal gate is closed, the last measured value calculated is still returned.
STS_DQ	This bit depends on the "Set output" parameter of the respective channel. You can use STS_DQ in each case, in order to control a digital output module's digital output.
STS_GATE	Together, the software gate and the hardware gate form the internal gate. This bit indicates the status of the internal gate for the respective channel. The module only counts if the internal gate is open. 0 means: Gate closed 1 means: Gate open Note: If you change a channel parameter in RUN via data record 128 or 129, all values of the changed channel are transferred to the module again. In doing so, the internal gate of the respective channel is closed and the counter value is set to the start value. To restart counting, you need to close and reopen the software gate in each case.
QI	Quality information for the counter channel.
STS_M_INTERVAL	**This bit is used only for the additional "Measurement" property and not for the counter functionality itself. You can find more information in the function manual Counting, measurement and position detection.**
LD_STS_SLOT	This bit indicates for the respective channel, by mean of a status change (toggling), that the load request for SLOT (LD_SLOT) has been detected and executed.
LD_ERROR	This bit indicates for the respective channel that an error occurred (latching) during loading via the control interface. The loaded value was not applied. One of the following conditions has not been met: • Count low limit ≤ count value (If this condition is not met, the start value is loaded as the current count value.) • Counter low limit ≤ start value • Counter low limit ≤ comparison value 0/1 • Count high limit ≥ count value (If this condition is not met, the start value is loaded as the current count value.) • Counter high limit ≥ start value • Counter high limit ≥ comparison value 0/1 • Counter low limit < counter high limit • Comparison value 0 < comparison value 1 • Do not write a reserved load request in LD_SLOT
EVENT_UFLW	For the respective channel, this bit indicates the saved state which shows that there was a counter value underflow (a violation of the counter low limit). You reset the status by acknowledgment with RES_EVENT_UFLW.
EVENT_OFLW	For the respective channel, this bit indicates the saved state which shows that there was a counter value overflow (a violation of the counter high limit). You reset the status by acknowledgment with RES_EVENT_OFLW.
EVENT_CMP0	For the respective channel, this bit indicates the saved status which shows that a comparison event with comparison value 0 has occurred. You reset the status by acknowledgment with RES_EVENT_CMP0. The EVENT_CMP0 bit is not set when you set the counter value to the start value.
EVENT_CMP1	For the respective channel, this bit indicates the saved status which shows that a comparison event with comparison value 1 has occurred. You reset the status by acknowledgment with RES_EVENT_CMP1. The EVENT_CMP1 bit is not set when you set the counter value to the start value.
RES_EVENT_UFLW_ACK	This bit indicates for the respective channel that the reset of event bit EVENT_UFLW is active.

Feedback bit	Notes
RES_EVENT_OFLW_ACK	This bit indicates for the respective channel that the reset of event bit EVENT_OFLW is active.
RES_EVENT_CMP0_ACK	This bit indicates for the respective channel that the reset of event bit EVENT_CMP0 is active.
RES_EVENT_CMP1_ACK	This bit indicates for the respective channel that the reset of event bit EVENT_CMP1 is active.

Complete acknowledgment principle

Saving bits are acknowledged according to the complete acknowledgment principle.

The figure below shows an example of the sequence of the complete acknowledgment principle in the event of an overflow:

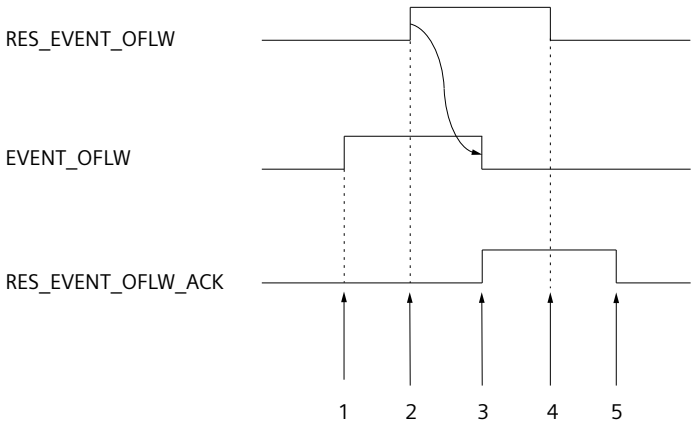

① The EVENT_OFLW feedback bit is set as a saving event upon overflow.

② You set the RES_EVENT_OFLW control bit to trigger EVENT_OFLW reset.

③ The RES_EVENT_OFLW_ACK feedback bit is set when reset of EVENT_OFLW is detected.

④ You then rest the control bit RES_EVENT_OFLW .

⑤ The RES_EVENT_OFLW_ACK feedback bit is reset.

Figure 2-234 Acknowledgment principle

NOTE

If you have initiated the reset of an event bit, you must wait for the respective feedback bit. Then you can initiate another reset.

NOTE

Opening the software gate or hardware gate (0-1 transition) resets all event bits.

See also

Counting, measuring and position detection
(https://support.industry.siemens.com/cs/ww/en/view/59709820)

5.4 Interrupts/diagnostic messages

5.4.1 Status and fault displays

LED display

For detailed information on the LED displays, refer to the chapter Status and fault displays (Page 32) of the operating mode DI.

5.4.2 Interrupts

Digital input module DI 8×NAMUR HF supports diagnostics and hardware interrupts.

Diagnostics and hardware interrupts

In general, all diagnostic and hardware interrupts are supported and reported in the same way in the counter mode as in the operating mode DI.

The counter channels do not offer some properties of the operating mode DI, therefore 0x1A (external fault) and 0x1D (actuator fault) are not available. 0x1A is used for the changeover errors and 0x1D for the chatter errors.

You can find more information on the diagnostic and hardware interrupts in the section Diagnostic messages (Page 36).

5.5 Measurement

The measuring functions are largely described in the Function Manual Counting, measuring and position detection (https://support.industry.siemens.com/cs/ww/en/view/59709820), especially in chapter 2.2.9.1 "Overview of measuring functions", (only the declared accuracy up to 100 ppm is not relevant), as well as 2.2.9.2 "Measured value determination with incremental or pulse encoder" (only the chapters "Measuring principle", "Frequency measurement", "Period measurement" and "Velocity measurement" are relevant).

Measuring ranges

The measuring functions have the following measuring range limits:

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0.04 Hz	5 kHz
Period measurement	200 µs	25 s
Velocity measurement	Depending on the configured number of "Increments per unit" and the "Time base for velocity measurement"	

All measured values are returned as signed values. The sign indicates whether the counter value increased or decreased during the relevant time interval.

Parameter data record DS129

There are 4 values in DS129 that are used to perform measurements.

- **Measured value**

  Used to select the measurement type, i.e. frequency, period and velocity measurement.
- **Update time**

  You will find the description of this value in the Function Manual Counting, measuring and position detection (https://support.industry.siemens.com/cs/ww/en/view/59709820), chapter 2.2.9.1 "Overview of measuring functions".
- **Time base for velocity measurement and Increments per unit**

  The description of these two values can be found in the above Function Manual, chapter 2.2.9.2 "Measured value determination with incremental or pulse encoder", "Velocity measurement" chapter.

Changing the measurement parameters during the run

All 4 parameters described above in "Parameter data record DS129" can be changed to any valid values during the run.

Process image (I/O data structure)

A measured value (frequency, period duration or velocity) is supplied via MEASURED_VALUE in the feedback interface.

The feedback bit STS_M_INTERVAL shows whether a counting pulse occurred in the previous measuring interval. This enables a distinction to be made between an assumed and an actual counting pulse.

More information can be found in the Function Manual Counting, measuring and position detection (https://support.industry.siemens.com/cs/ww/en/view/59709820) as well as in the Process image (I/O data structure) chapter for the counter mode.

Technical specifications

6

6.1 Technical specifications

DI 8×NAMUR HF technical specifications

The following table shows the technical specifications as of 03/2024. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7131-6TF00-0CA0/td?dl=en).

Article number	6ES7131-6TF00-0CA0
General information	
Product type designation	DI 8xNAMUR HF
HW functional status	from FS21
Firmware version	V2.0 or higher
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC01
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• suitable for operation on PROFINET R1 IMs	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V19
• STEP 7 configurable/integrated from version	V5.5 SP3 / -
• PROFIBUS from GSD version/GSD revision	GSD Revision 5
• PROFINET from GSD version/GSD revision	GSDML V2.42
Operating mode	
• DI	Yes
• Counter	Yes
• Oversampling	No
• MSI	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	70 mA

Article number	6ES7131-6TF00-0CA0
Encoder supply	
Number of outputs	8
Short-circuit protection	Yes
24 V encoder supply	
• 24 V	No
• Short-circuit protection	No
NAMUR encoder supply	
• 8.2 V	Yes
• Short-circuit protection	Yes
• Output current per channel, max.	8 mA
• Output current per module, max.	64 mA
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
• Address space per module, max.	1 byte
• Inputs	42 byte; 1 byte + 1 byte for QI information in DI mode; 42 bytes in Counter mode
• Outputs	20 byte; 0 in DI mode; 20 bytes in Counter mode
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Submodules	
• Number of configurable submodules, max.	1
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type A0
• 3-wire connection	BU type A0
Digital inputs	
Number of digital inputs	8; NAMUR
Digital inputs, parameterizable	Yes
Pulse extension	Yes; 0.5 s, 1 s, 2 s
Edge evaluation	Yes; rising edge, falling edge, edge change
Signal change flutter	Yes; 2 to 32 signal changes
Flutter observation window	Yes; 0.5 s, 1 s to 100 s in 1-s steps
Digital input functions, parameterizable	
• Gate start/stop	Yes
• Freely usable digital input	Yes
• Counter	Yes
– Number, max.	4; See manual for details

Article number	6ES7131-6TF00-0CA0
– Counting frequency, max.	5 kHz
– Counting width	32 bit
– Counting direction up/down	Yes
Input voltage	
• Rated value (DC)	8.2 V
Input current	
for 10 k switched contact	
– for signal "0", min.	0.35 mA
– for signal "0", max.	1.2 mA
– for signal "1", min.	2.1 mA
– for signal "1", max.	7 mA
for unswitched contact	
– for signal "0", max. (permissible quiescent current)	0.5 mA
– for signal "1", typ.	8 mA
for NAMUR encoders	
– for signal "0", min.	0.35 mA
– for signal "0", max.	1.2 mA
– for signal "1", min.	2.1 mA
– for signal "1", max.	7 mA
Input delay (for rated value of input voltage)	
• tolerated changeover time for changeover contacts	300 ms
for standard inputs	
– parameterizable	No
for NAMUR inputs	
– at "0" to "1", max.	20 ms; See manual for details
– at "1" to "0", max.	20 ms; See manual for details
Cable length	
• shielded, max.	200 m; 50 m for Counter mode
Encoder	
Connectable encoders	
• NAMUR encoder/changeover contact according to EN 60947	Yes
• Single contact / changeover contact unconnected	Yes
• Single contact / changeover contact connected with 10 kΩ	Yes
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes; channel by channel
• Hardware interrupt	Yes; Parameterizable, channels 0 to 7

Article number	6ES7131-6TF00-0CA0
Diagnoses	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Monitoring of encoder power supply	No
• Wire-break	Yes; channel by channel
• Short-circuit	Yes; channel by channel
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• Between the channels and load voltage L+	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	32 g

NAMUR sensors and connected contacts

Monitoring for short-circuit and wire break only for NAMUR changeover contacts. The response ranges of the diagnostics correspond to IEC 60947-5-6.

Dimension drawing

See manual BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD files

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other, see the tables below.

Configuring with a PROFINET GSD file

The table lists the diagnostics information and its dependencies on the sensor types for PROFINET.

Sensor type	Diagnostics information					
	Missing supply voltage L+	Short-circuit to ground	Wire break	Chatter error	Changeover error	Inversion
NAMUR sensor	×	×	×	×	-	×
Single contact, unconnected	×	-	-	×	-	×
Single contact, connected with 10 kΩ	×	-	×	×	-	×
NAMUR changeover contact	×	×	×	×	×	-
Changeover contact, unconnected	×	-	-	×	×	-
Changeover contact, connected with 10 kΩ	×	-	×	×	×	-

Configuring with a PROFIBUS GSD file

The table lists the diagnostics information and its dependencies on the sensor types for PROFIBUS.

Sensor type	Diagnostics information				
	Missing supply voltage L+	Short-circuit to ground	Wire break	Changeover error	Inversion
NAMUR sensor	×	×	×	-	×
Single contact, unconnected	×	-	-	-	×
Single contact, connected with 10 kΩ	×	-	×	-	×
NAMUR changeover contact	×	×	×	×	-
Changeover contact, unconnected	×	-	-	×	-
Changeover contact, connected with 10 kΩ	×	-	×	×	-

A.2 Parameter assignment and structure of the parameter data record 128 for operating mode DI

Data record 128 of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can change the parameter assignment of the module in your user program regardless of its configuration. This means that you can use all the functions of the module even if you configured it using PROFIBUS GSD.

With data records 0 to 7, you can configure the individual channels.

When the interface module IM 155-6 DP HF (PROFIBUS DP) is used and data records 0 and 1 are read, the module returns the diagnostics data records and not the parameter data records of the DI 8xNAMUR HF.

Parameter assignment in the user program

You can change the parameters of the module in RUN (e.g. "Switch diagnostics on" can be changed in RUN).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128 or data records 0 to 7. The parameters set with STEP 7 are not changed on the CPU, which means that the parameters set in STEP 7 are valid again after a restart.

If you reconfigure a module and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128 and data records 0 to 7

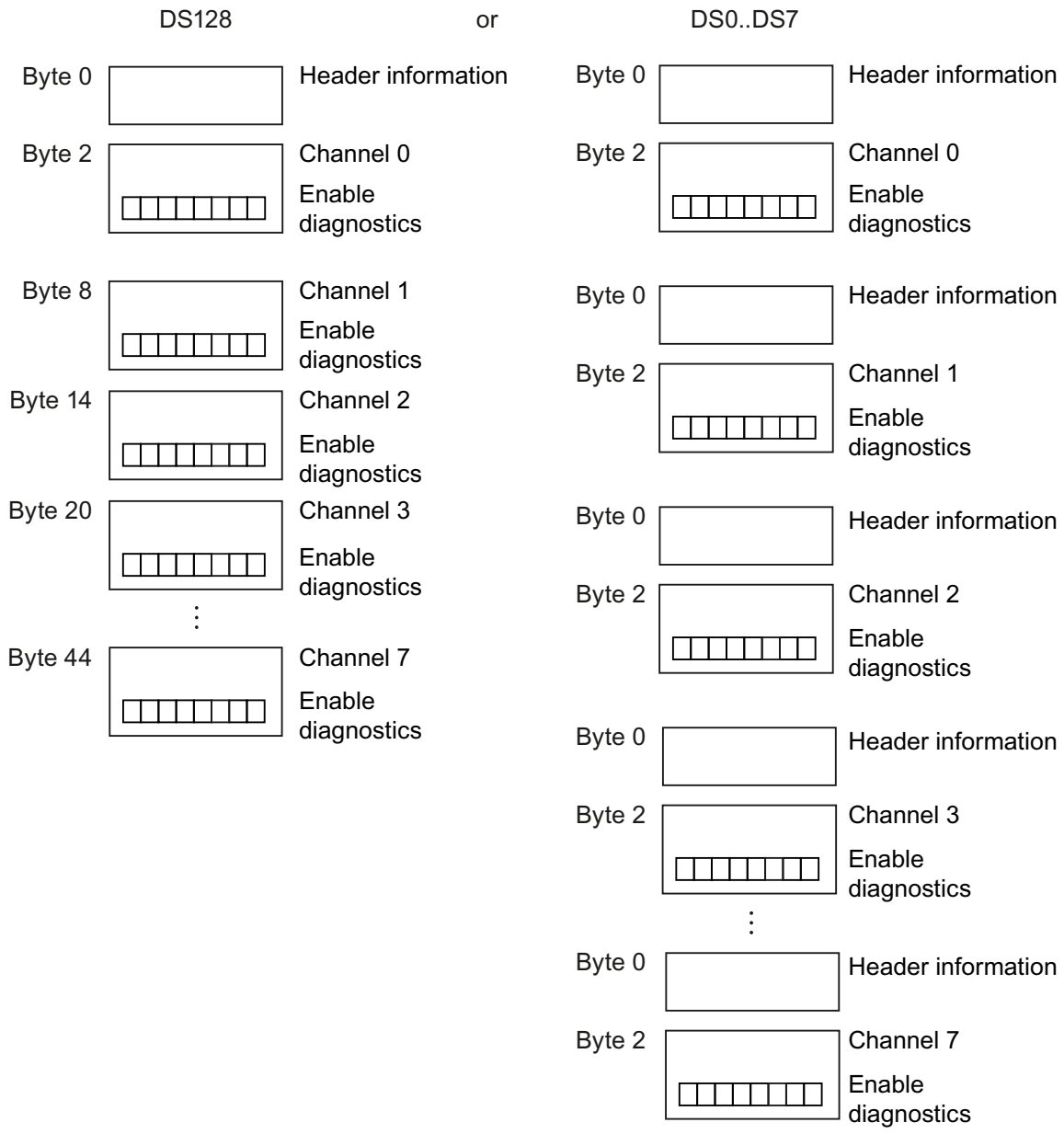

Figure 2-235 Structure of data record 128 and data records 0 to 7

Header information

The figure below shows the structure of the header information (NAMUR V1.0).

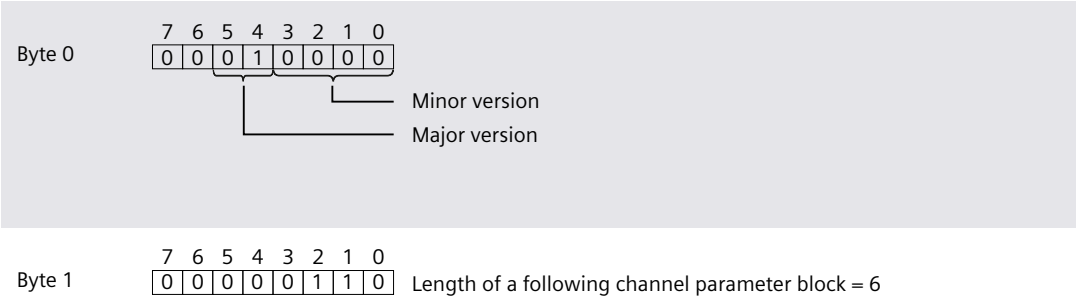

Figure 2-236 DS 128 or DS 0 to 7: Bytes 0 and 1; header information (structure version 1.0)

The figure below shows the structure of the header information (NAMUR V2.0).

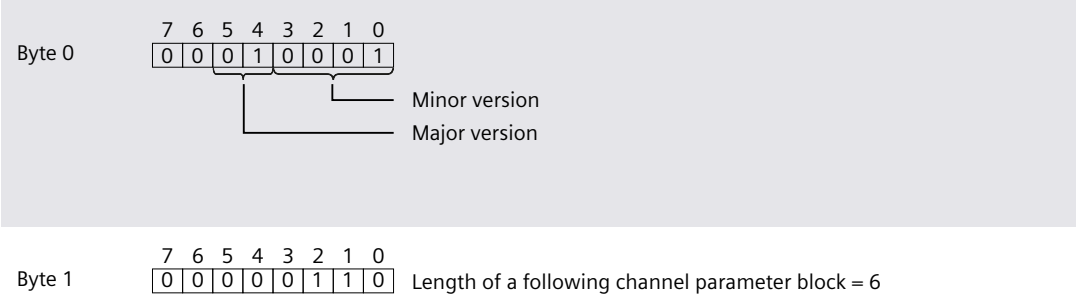

Figure 2-237 DS 128 or DS 0 to 7: Bytes 0 and 1; header information (structure version 1.1)

Parameters

The figure below shows the structure of the parameters for channels 0 to 7. You enable a parameter by setting the corresponding bit to "1".

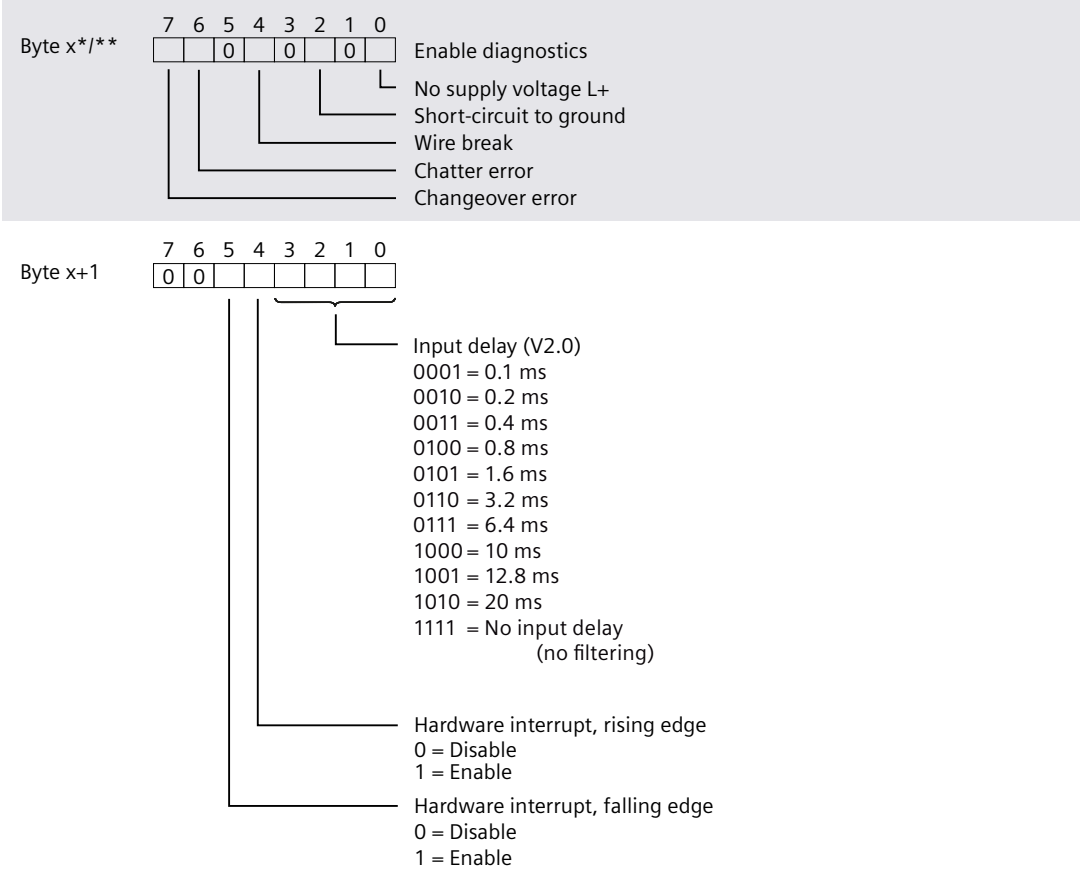

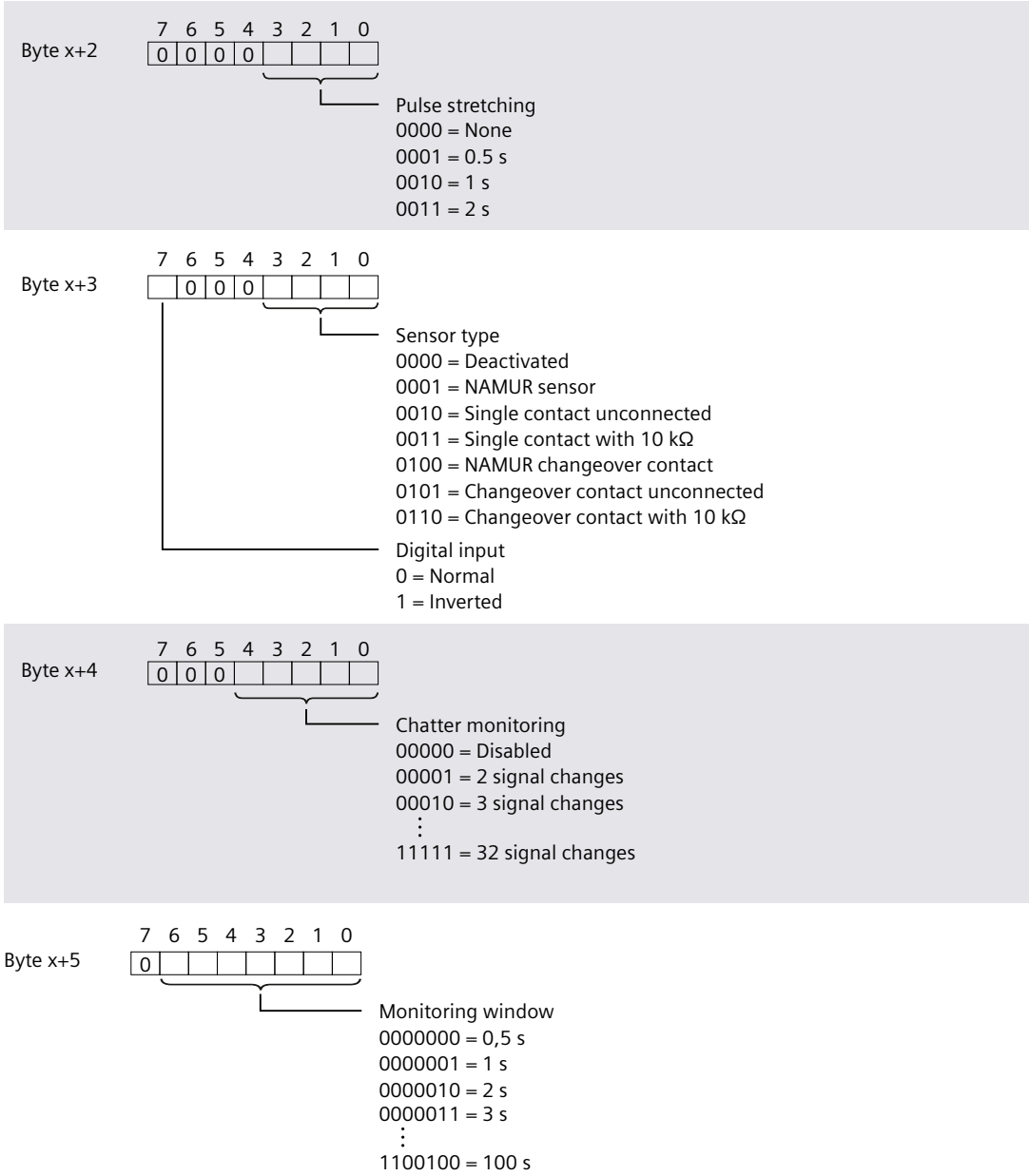

* x = 2 + (channel number × 6); channel number = 0 to 7 for DS 128
**x = 2 for DS 0 to DS 7

Figure 2-238 DS 128 or DS 0 to 7: Byte x to x+5: Structure for channels 0 to 7

When the DI NAMUR V1.0 is configured, the parameter Input delay 0000 = reserved.

A.3 Assignment and structure of parameter data record 128 for counting operating mode

Data record 128 of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can change the parameter assignment of the module in your user program regardless of its configuration. This means that you can use all the functions of the module even if you configured it using PROFIBUS GSD.

With data records 0 to 7, you can configure the individual channels.

When the interface module IM 155-6 DP HF (PROFIBUS DP) is used and data records 0 and 1 are read, the module returns the diagnostics data records and not the parameter data records of the DI 8xNAMUR HF.

Parameter assignment in the user program

You can change the parameters of the module in RUN (e.g. "Switch diagnostics on" can be changed in RUN).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128 or data records 0 to 7. The parameters set with STEP 7 are not changed on the CPU, which means that the parameters set in STEP 7 are valid again after a restart.

If you reconfigure a module and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

STATUS output parameter

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128 and data records 0 to 7

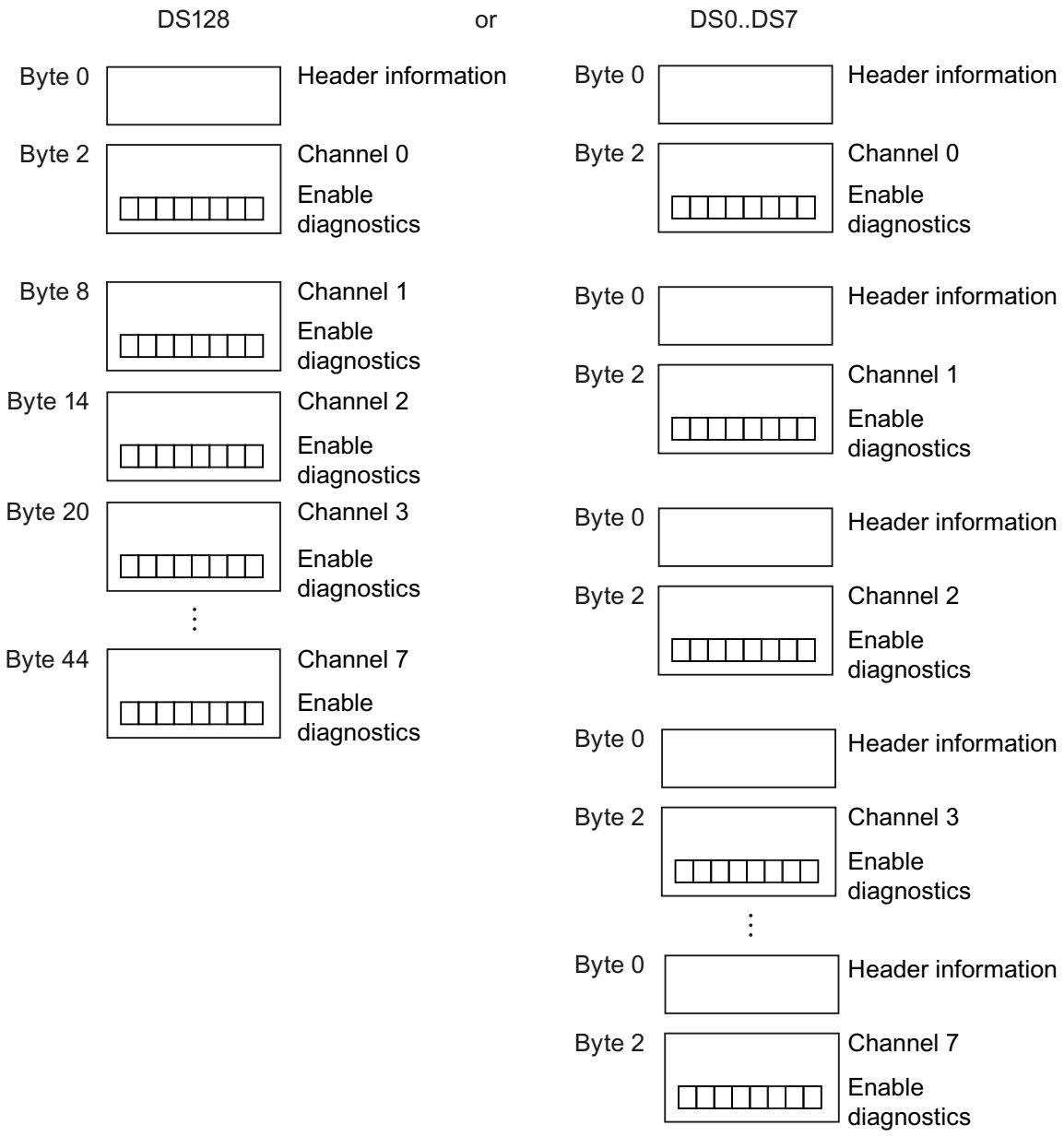

Figure 2-239 Structure of data record 128 and data records 0 to 7

Header information

The figure below shows the structure of the header information.

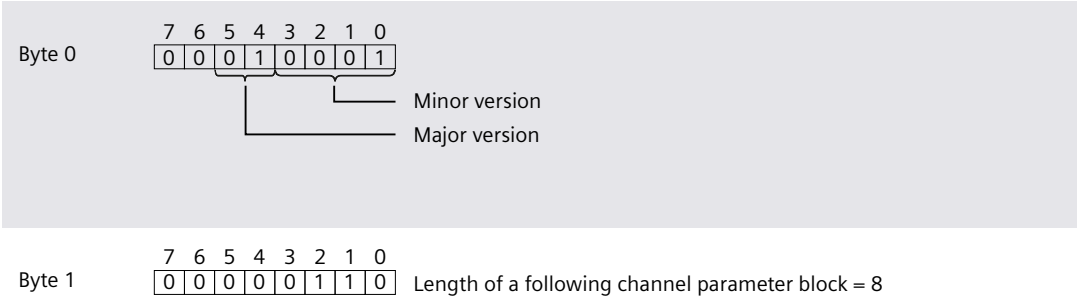

Figure 2-240 DS 128 or DS 0 to 7: Bytes 0 and 1; header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7. You enable a parameter by setting the corresponding bit to "1".

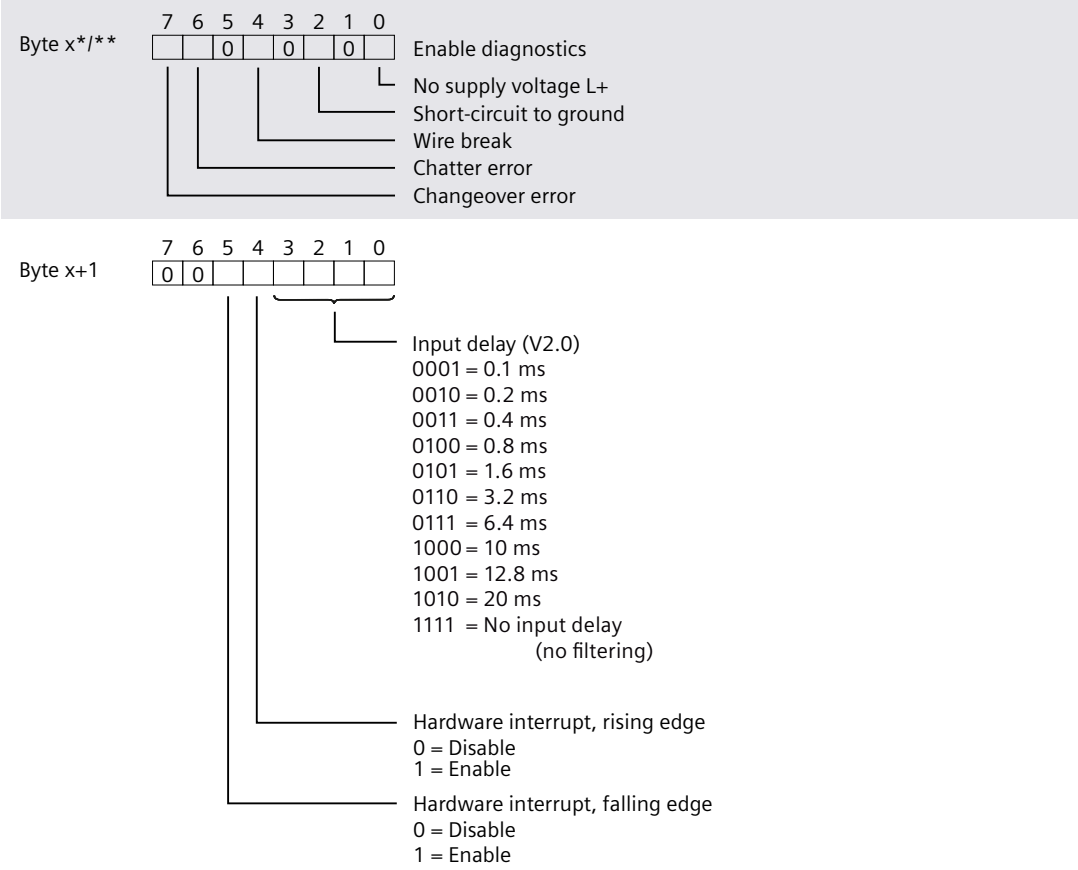

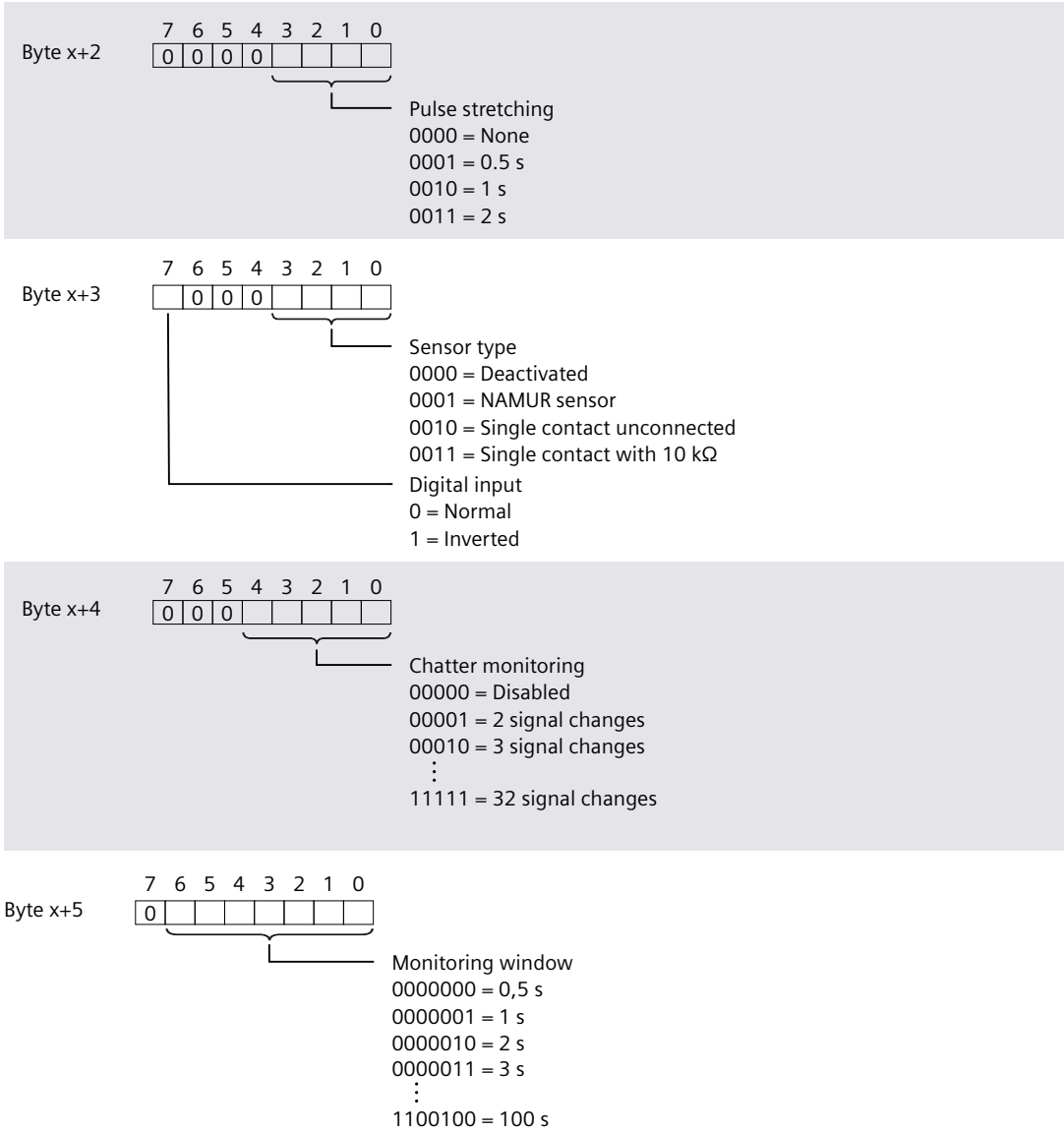

* x = 2 + (channel number × 6); channel number = 0 to 7 for DS 128
**x = 2 for DS 0 to DS 7

Figure 2-241 DR 128 or DR 0 to 7: Byte x to x+5: Structure for channels 0 to 7

A.4 Assignment and structure of parameter data record 129 for Counting operating mode

You can configure the counting channels via data record 129. The meaning of some parameters, such as "Scaled high counting limit" and "Scaled low counting limit" depends on whether scaling is enabled. Data record 129 has a variable length depending on how many counting channels were selected, but the length and structure of the parameter block per channel is fixed and the same regardless of the selected submodule.

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 129. The parameters set with STEP 7 are not changed in the CPU, which means that the parameters set with STEP 7 are valid again after a restart.

NOTE

A parameter data record that has content different from the startup parameter assignment can result in a brief exit from clocked mode and renewed synchronization with the fieldbus cycle.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You can find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 129 for the submodule with 4 counting channels (CNT4)

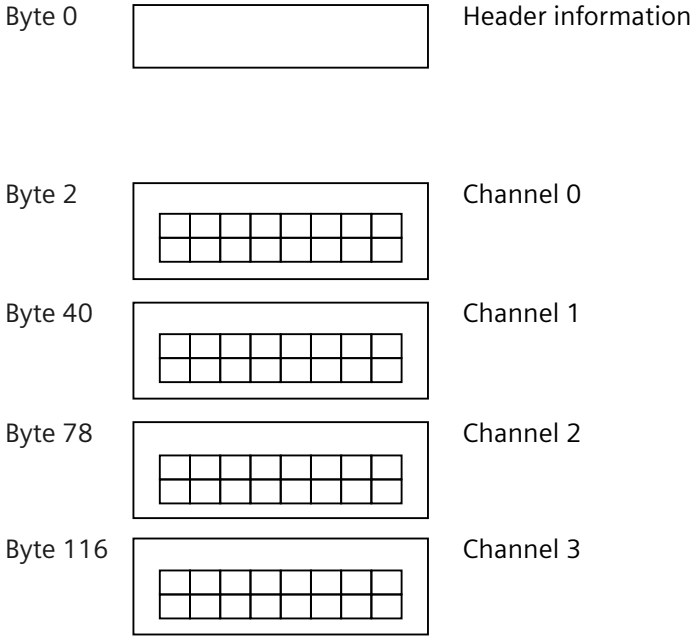

Figure 2-242 Structure of data record 129 for the submodule CNT4

NOTE

The length of data record 129 depends on the number of counting channels. The figure shows an example for 4 counting channels. If there are fewer counting channels (1, 2 or 3), only the corresponding number of blocks per channel are used.

Header information

The figure below shows the structure of the header information.

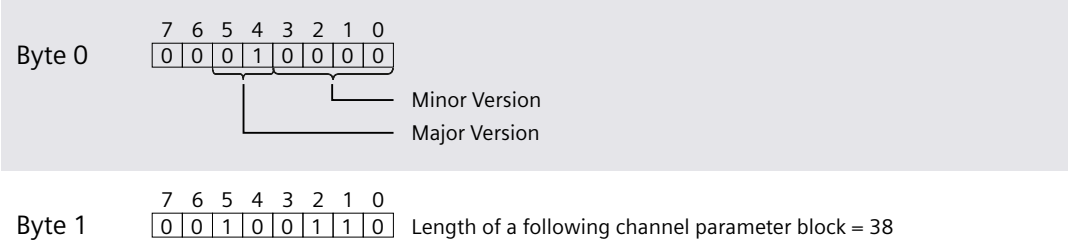

Figure 2-243 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3. You enable a parameter by setting the corresponding bit to "1".

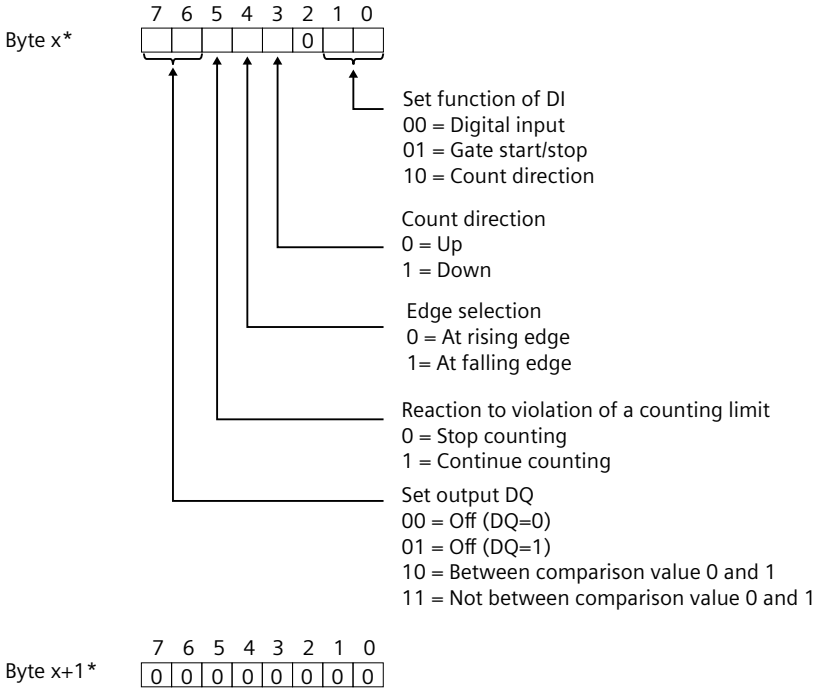

Byte x+2*	7 6 5 4 3 2 1 0	Comparison value 1 - 2147483647 to 2147483647
Byte x+3*	15 8	
Byte x+4*	23 16	
Byte x+5*	31 24	
Byte x+6*	7 6 5 4 3 2 1 0	Comparison value 0 - 2147483648 to 2147483646
Byte x+7*	15 8	
Byte x+8*	23 16	
Byte x+9*	31 24	
Byte x+10*	7 6 5 4 3 2 1 0	Start value - 2147483648 to 2147483647
Byte x+11*	15 8	
Byte x+12*	23 16	
Byte x+13*	31 24	
Byte x+14*	7 6 5 4 3 2 1 0	High count limit - 2147483647 to 2147483647
Byte x+15*	15 8	
Byte x+16*	23 16	
Byte x+17*	31 24	
Byte x+18*	7 6 5 4 3 2 1 0	Low count limit - 2147483648 to 2147483646
Byte x+19*	15 8	
Byte x+20*	23 16	
Byte x+21*	31 24	

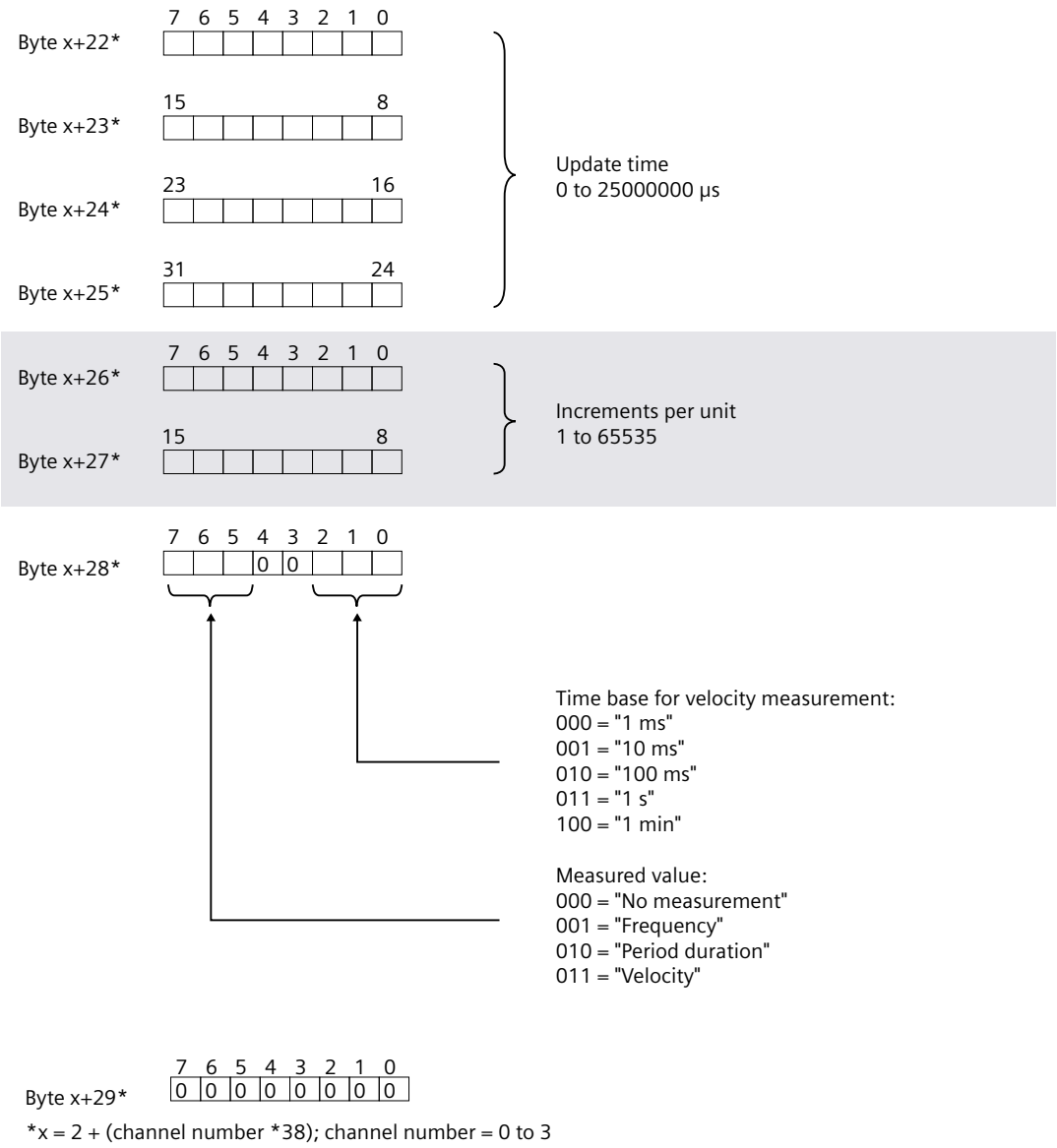

*x = 2 + (channel number *38); channel number = 0 to 3

Figure 2-244 Structure byte x to x+29 for channels 0 to 3

The meaning of the next bytes x+30* - x+37* depends on whether a configuration with "SCALE" is used.

Bytes x+30* - x+37* for counter submodules WITHOUT scaling

	7	6	5	4	3	2	1	0	
	0	0	0	0	0	0	0	0	Byte x+30*
	0	0	0	0	0	0	0	0	Byte x+31*
	0	0	0	0	0	0	0	0	Byte x+32*
	0	0	0	0	0	0	0	0	Byte x+33*
	0	0	0	0	0	0	0	0	Byte x+34*
	0	0	0	0	0	0	0	0	Byte x+35*
	0	0	0	0	0	0	0	0	Byte x+36*
	0	0	0	0	0	0	0	0	Byte x+37*

*x = 2 + (channel number *38); channel number = 0 to 3

Figure 2-245 Structure byte x+30 to x+37, without scaling

Bytes x+30* - x+37* for counter submodules WITH scaling

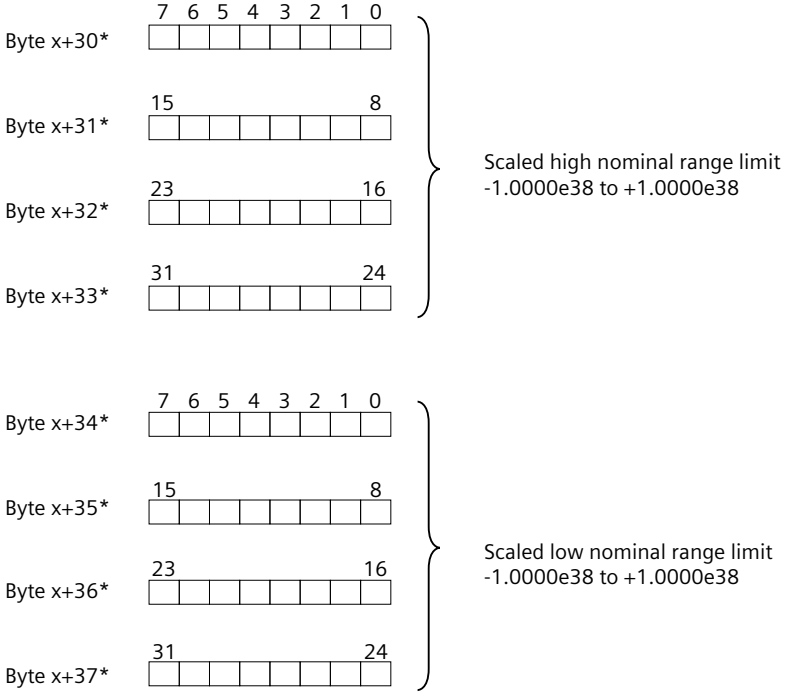

*x = 2 + (channel number *38); channel number = 0 to 3

Figure 2-246 Structure byte x+30 to x+37, with scaling

A.5 Error codes

Error when transferring the data record

The module always checks all values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data records 128 and 129

Table 2-276 Error messages, their meaning and remedial measures

Error code in STATUS parameter (hexadecimal)				Meaning	Remedy
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$B0_H$	00_H	Number of the data record unknown	Enter a valid number for the data record.
DF_H	80_H	$B1_H$	01_H	Length of the data record incorrect	Enter a valid value for the data record length.
DF_H	80_H	$B2_H$	00_H	Module not accessible	• Check station. • Plug the module in correctly. • Check parameters of the WRREC block.
DF_H	80_H	$E0_H$	01_H	Header error (version or specified bits incorrect).	Correct version number or fixed bits, see DS 128 or DS 0 to 7: Bytes 0 and 1; header information (structure version 1.0).
DF_H	80_H	$E0_H$	02_H	Header error (number or length of parameter structures or parameter blocks incorrect)	Correct the number and length of the parameter structures or parameter blocks, see DS 128 or DS 0 to 7: Bytes 0 and 1; header information (structure version 1.0).
DF_H	80_H	$E1_H$	01_H	Reserved bit set	Write 0 to all reserved bits.
DF_H	80_H	$E1_H$	02_H	Invalid diagnostics enable bit set for operating mode	Correct the diagnostics enables to correspond to the operating mode.
DF_H	80_H	$E1_H$	20_H	Number of changes for chatter monitoring not correct	Use valid coding for parameter "Chatter monitoring".
DF_H	80_H	$E1_H$	21_H	Changeover contact sensor type cannot be set for this channel	User changeover contact sensor type only for even-numbered channel indexes (0, 2, 4, 6).
DF_H	80_H	$E1_H$	22_H	Channel with changeover contact must not be inverted	Do not use inversion on channels with changeover contact.
DF_H	80_H	$E1_H$	23_H	Channel next to the changeover contact (odd-numbered channel index) must be deactivated.	When using a changeover contact, set the sensor type to an even-numbered channel index (0, 2, 4, 6) and deactivate the channel on the corresponding odd-numbered index (1, 3, 5, 7).
DF_H	80_H	$E1_H$	24_H	Wrong sensor type (unknown)	Use correct sensor type.
DF_H	80_H	$E1_H$	25_H	Invalid coding for pulse stretching	Use valid coding for parameter "Pulse stretching", see Parameter assignment and structure of the parameter data record 128 for operating mode DI (Page 74).

Error code in STATUS parameter (hexadecimal)				Meaning	Remedy
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$E1_H$	26_H	Version of the data record (DS) is not correct	Use the correct version number in the data record header, corresponding to the current operating mode.
DF_H	80_H	$E1_H$	27_H	Length of data record (DS) is not correct	Use the correct data record length, corresponding to the operating mode, data record number and its version.
DF_H	80_H	$E1_H$	28_H	Invalid coding for input delay.	Use valid coding for parameter "Input delay", see Parameter assignment and structure of the parameter data record 128 for operating mode DI (Page 74).
DF_H	80_H	$E1_H$	$2A_H$	DI mode is not correct	Use only the permissible mode (DI/GATE/DIR) for the DI channel that is assigned to the CNT channel.
DF_H	80_H	$E1_H$	$2C_H$	Control input cannot be deactivated	Put the channel into non-counting mode before deactivating.
DF_H	80_H	$E1_H$	$2E_H$	Invalid coding for parameter "Measured value"	Use valid coding for parameter "Measured value", see Structure byte x to x+29 for channels 0 to 3.
DF_H	80_H	$E1_H$	$2F_H$	Use a valid coding for the time base of the speed measurement	Use valid coding for parameter "Time base for velocity measurement"; see Structure byte x to x+29 for channels 0 to 3.
DF_H	80_H	$E1_H$	30_H	Comparison values are not correct	Ensure that the comparison values lie within the limits and are in the right order.
DF_H	80_H	$E1_H$	31_H	Count limits are not correct	Use valid count values for scaled values.
DF_H	80_H	$E1_H$	32_H	Update time for the measurement is not correct	Use update time ≤ 25 s.
DF_H	80_H	$E1_H$	33_H	The value of "Increments per unit" is not correct	Use an increment value not equal to zero.

See also

Assignment and structure of parameter data record 129 for Counting operating mode (Page 83)

Compatibility

B

Principle of operation

This mode provides basic properties with technological functions, emulating the behavior of the previous module.

- The input data consists of two bytes, 8 bits for the status of the digital input and 8 bits for the value status.
- Hardware interrupts and diagnostics are captured using samples taken at 3 ms sampling intervals.
- Technological functions are processed in intervals of 3 ms.
- The input data for the CPU is set every 500 µs.

Input filtering

There are two basic modes of input filtering operation:

1. Compatible filtering (with the mode compatible with FS lower than 21)
2. Filtering based on input delay (with the mode compatible with FS higher than 21)

Compatible input filtering

With compatible input filtering (when the module is configured in the compatible mode), all fault states (wire break, short-circuit) must persist for at least the time of 3 samples in order to be confirmed. In the worst case, a fault state that lasts slightly longer than 2 sampling intervals (i.e. 6+ ms) is confirmed (results in a diagnostics event).

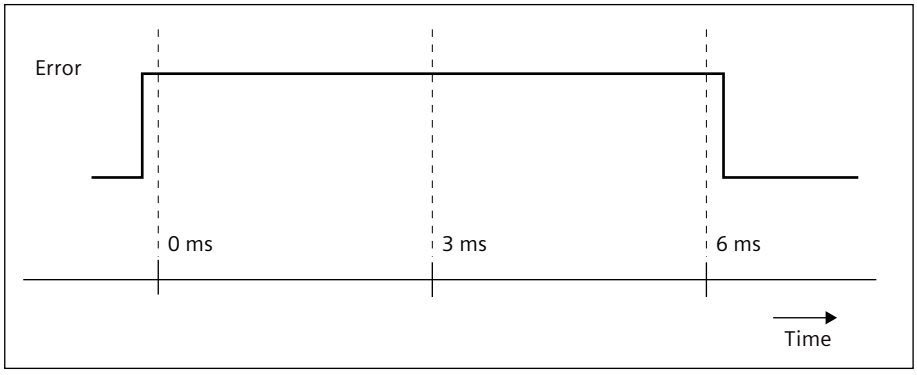

Figure 2-247 Duration of the input event = 6+ ms

The fault-free states (L and H) are considered as a common logical "fault-free state". A fault-free state must take 6+ ms to be confirmed. As soon as this state is confirmed, there is no filtering between the L and H states (i.e. even a short L/H pulse - e.g. an EMI event - can be sent to the PLC).

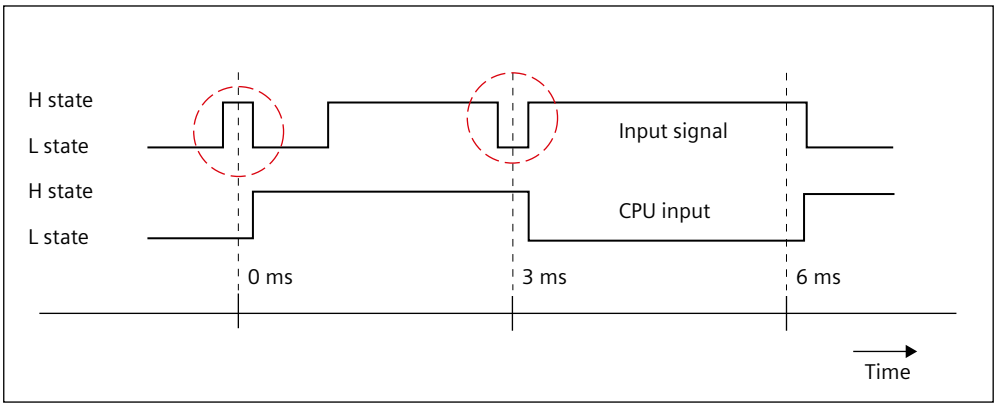

Figure 2-248 Short non-filtered L and H states

The events marked in the dashed circles are considered to be valid samples and are sent to the CPU. Even a very short pulse can be sampled and evaluated as a 3 ms pulse in the CPU.

Functions of the operating mode DI

C

Function of the filtering dependent on the input delay

The filter algorithm works with two input states:

1. The "currently valid state" and
2. The "new state" waiting for confirmation.

The filter samples the input signal. If the logic input state changes, this is only output by the filter when it has completed a specific number of samples without the value changing. Even with a short pulse that is sampled at least once, the algorithm is reset and sampling of the changed input signal begins again.

The following figure shows an example of the input and output square waveforms of a signal filtered depending on the input delay. The two states are designated L (LOW) and H (HIGH), the input delay of which is set to five samples. The filter does not output the change in signal after pulse ① because the input state changes again within the input delay time (after three samplings). The same applies to pulse ② (change after three samples) and to pulse ③ (change after four samples).

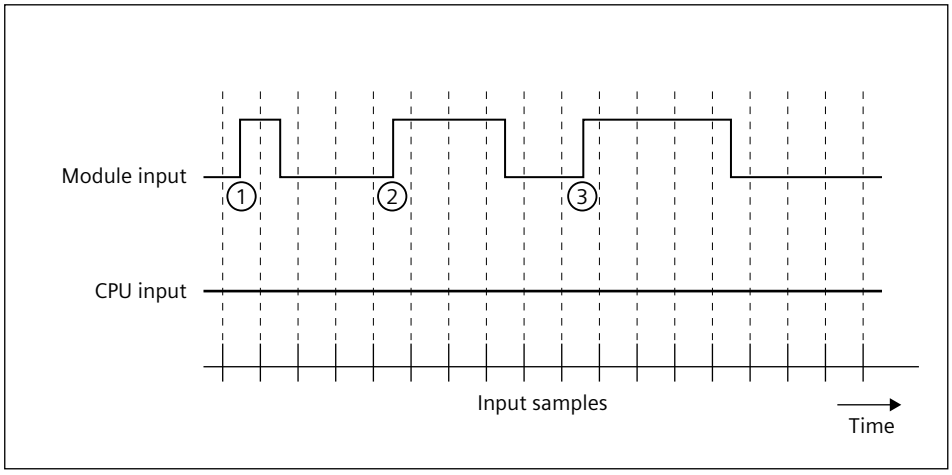

Figure 2-249 A short input pulse will not pass the filter (input delay set to 5 samples)

The next example shows that a pulse that lasts long enough passes the filter and the input signal is thus accepted. By contrast, a pulse that is too short is filtered out. In this scenario, the input delay is 3 samples.

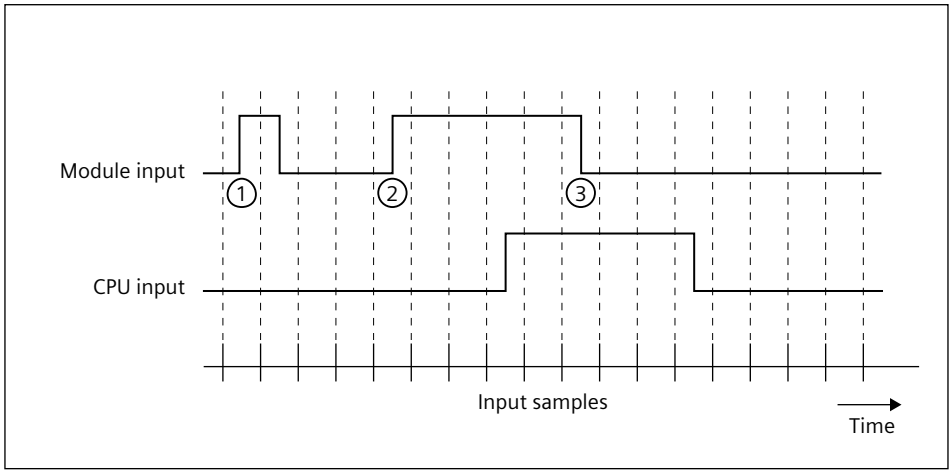

Figure 2-250 A sufficiently long pulse will pass the filter (input delay set to 3 samples)

The pulse ① is filtered out. The rising edge ② passes the filter with a delay of 3 samples, the same applies to the falling edge ③. The long pulse is copied to the output in each case and delayed by the input delay.

The last example shows how the input switches between several states. For sake of simplicity, the input delay is set to the same value (three sample cycles) for all states.

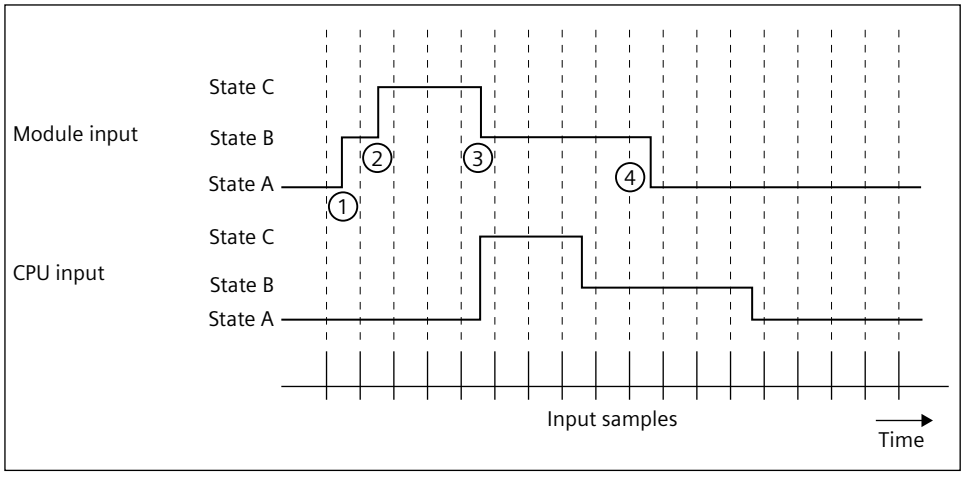

Figure 2-251 Switching between several states (input delay set to 3 samples)

The first pulse ① is filtered out because the state B (log. L) is sampled only once. The change to state C (log. H) ② passes the filter after 3 samples and is transferred to the CPU. The change back to state B ③ passes the filter after another 3 samples. The last change to state A (wire break) ④ is also output after three sample values.

Input delay and samples

The module inputs are sampled at 32 kHz, which corresponds to a period of 31.25 µs. The input delay constants can be expressed as multiples of 100 µs. This means that the input delay achieved differs slightly from the set delay.

For each possible input delay setting, a specific number of samples is selected for confirmation. The number is chosen to minimize the difference between the required and the achieved input delay. For shorter input delays, the difference is larger, in the worst case it is 6.25%.

In addition, the input signal passes a low-pass EMC filter that slightly changes the curve in the time domain. The step response of the input signal is symmetrical for the H to L and L to H transitions, but the threshold between H and L is not symmetrical. The result is that more H states are sampled for a signal with a 50% duty cycle. For this reason, the number of samples of the H states is one larger than that of the L states.

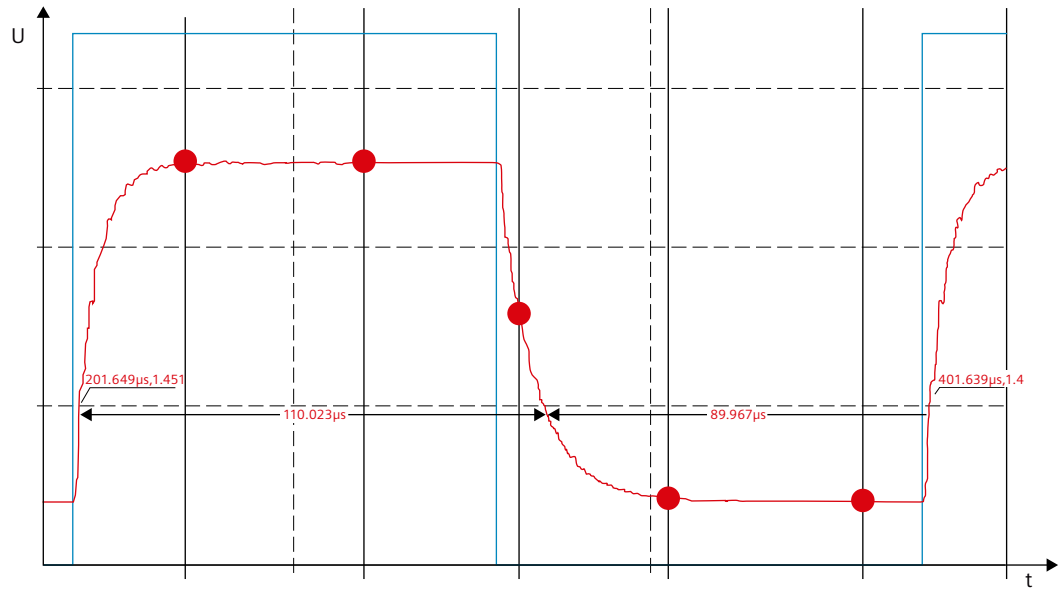

Figure 2-252 Filtered step response (red) of the input signal (blue): At a duty cycle of 50%, more H samples are measured.

Example:

With an input delay of 100 µs, the selected number of samples is 3 (because 3 x 31.25 µs = 93.75 µs), which yields a difference of 6.25%. The number of samples to confirm the H state is 3, and the number of samples to confirm the L state is only 2.

Table 2-277 Settings for the individual input delays

Setting the input delay	Exact number of samples	Number of samples H state	Number of samples L state	Difference for the H state
100 µs	3.2	3	2	-6.25%
200 µs	6.4	6	5	-6.25%
400 µs	12.8	13	12	+1.56%
800 µs	25.6	26	25	+1.56%
1.6 ms	51.2	51	50	-0.39%

Setting the input delay	Exact number of samples	Number of samples H state	Number of samples L state	Difference for the H state
3.2 ms	102.4	102	101	-0.39%
6.4 ms	204.8	205	204	+0.10%
10 ms	320	320	319	0%
12.8 ms	409.6	410	409	+0.10%
20 ms	640	640	639	0%

SIEMENS

SIMATIC

ET 200SP
Digital input module DI 16x24VDC ST (6ES7131-6BH01-0BA0)

Equipment Manual

Documentation guide 1

Product overview 2

Connecting 3

Parameters/address space 4

Interrupts/diagnostic alarms 5

Technical specifications 6

Parameter data record A

02/2019
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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

Technical specifications: Ambient temperature in horizontal and vertical mounting position, extended to min. -30 °C.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that can be implemented, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (http://www.siemens.com/industrialsecurity).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

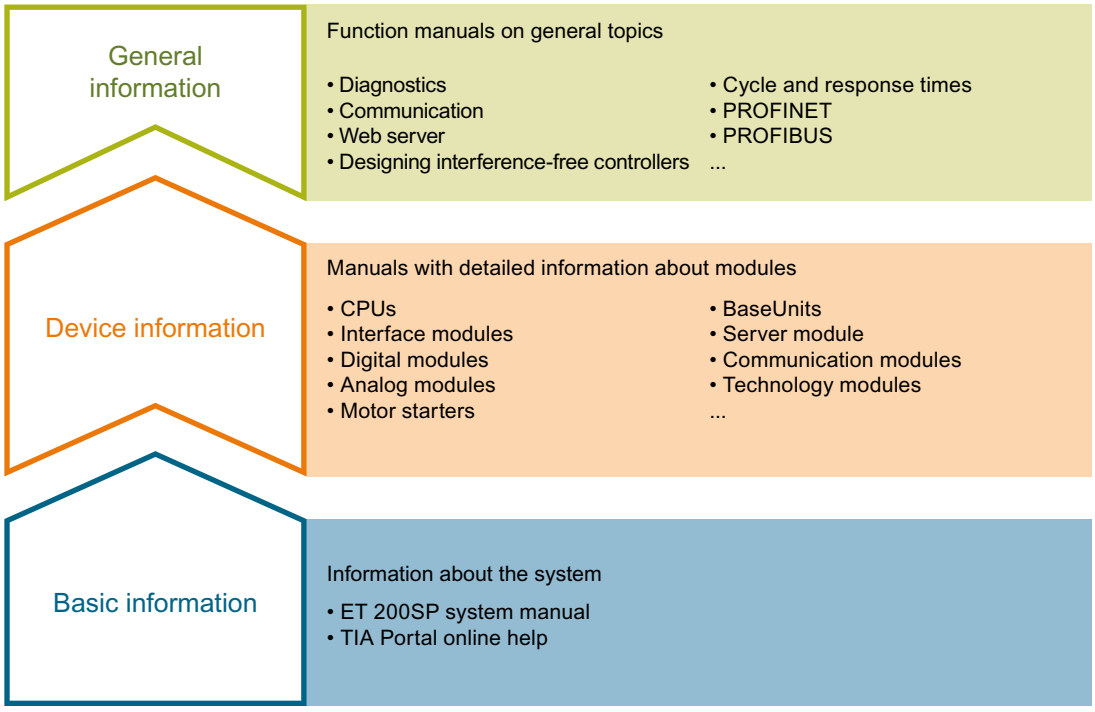

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7131-6BH01-0BA0 (number in package unit: 1 unit)
6ES7131-6BH01-2BA0 (number in package unit: 10 units)

View of the module

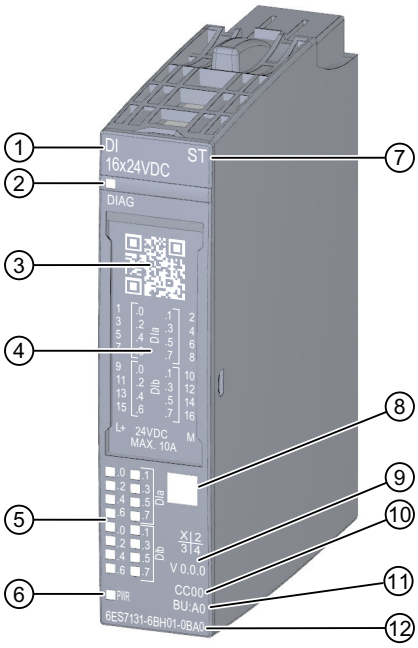

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-253 View of the module DI 16×24VDC ST

Properties

The module has the following technical properties:

- Digital input module with 16 inputs
- Sink input, (PNP, P-reading)
- Supply voltage L+
- Configurable input delay 0.05 to 20 ms (per channel)
- Configurable diagnostics (per module)
- Suitable for connection of switches and 2-wire sensors in accordance with IEC 61131, type 3

The module supports the following functions:

Table 2-278 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X
Configuration in RUN	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X
Value status	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0229 V7.0	X	X

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Connecting

3

3.1 Wiring and block diagram

This section includes the block diagram of the DI 16x24VDC ST module with the terminal assignments for a 1-wire connection.

Information on wiring the BaseUnit can be found in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

NOTE

Make sure that you only use digital modules with BaseUnit type A0 during commissioning.

Wiring: 1-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the digital input module DI 16x24VDC ST on the BaseUnit BU type A0 without AUX terminals (1-wire connection).

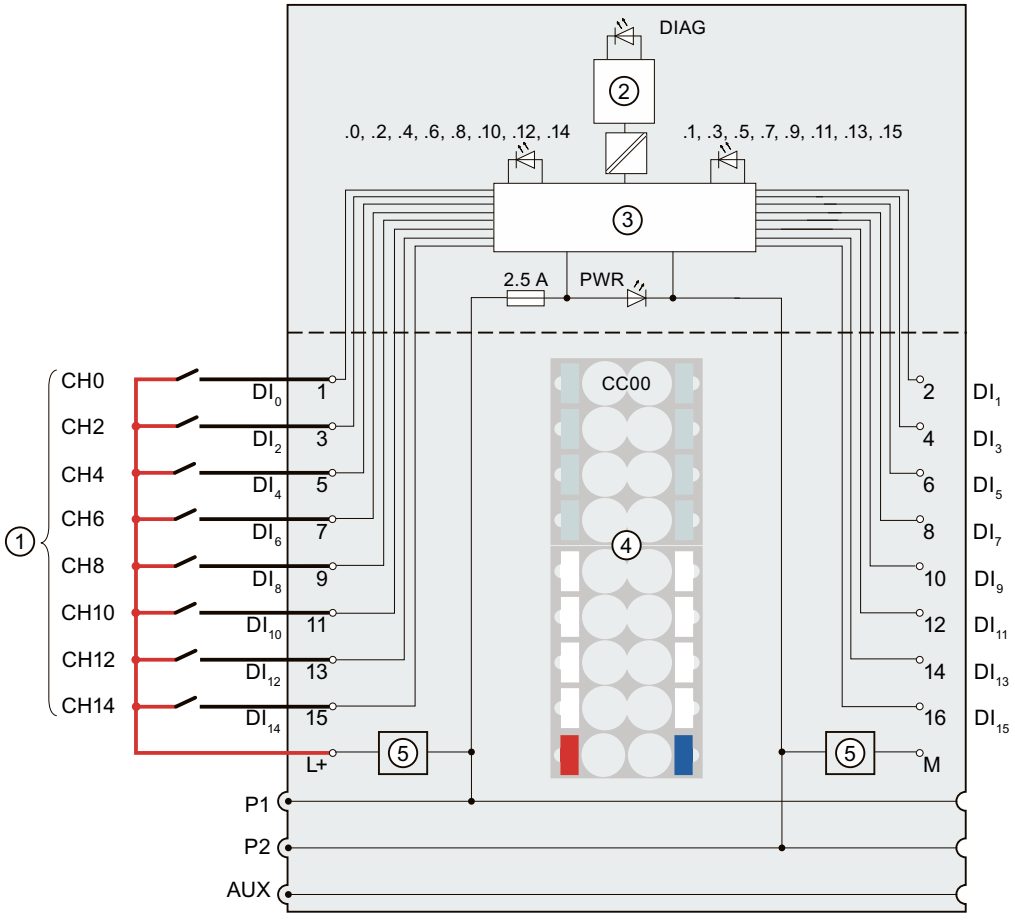

①	1-wire connection	DI_n	Input signal, channel n
②	Backplane bus interface	L+	24 V DC (infeed only with light-colored BaseUnit)
③	Input electronics	M	Ground
④	Color-coded label with color code CC00 (optional)	DIAG	Error or diagnostics LED (green, red)
⑤	Filter connection supply voltage (only when light-colored BaseUnit is present)	.0 to .15	Channel status LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	PWR	Power LED (green)

Figure 2-254 Wiring and block diagram for 1-wire connection of transducers

Wire-break detection

When wire-break detection is configured the module requires a low quiescent current at the digital input in case of "0" signal for the monitoring. The parallel connection of a resistor with 25 kΩ to 45 kΩ is required in order that this quiescent current can flow when mechanical transducer contacts are open.

If wire-break detection is disabled in the configuration, no parallel connection of the resistor is required.

If wire-break detection is configured, connect a resistor with 25 kΩ to 45 kΩ parallel to each mechanical transducer contact.

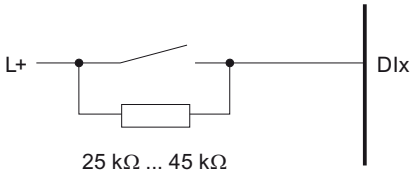

Figure 2-255 Connect mechanical transducer contact with resistor

Parameters/address space

4

4.1 Parameters

Parameters for DI 16x24VDC ST

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of parameter data record (Page 25).

The following parameter settings are possible:

Table 2-279 Configurable parameters and their defaults (GSD file)

Parameters	Range of values	Default	Parameter reassignment in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics Wire break	• Disable • Enable	Disable	Yes	Module	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel
Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	Yes	Channel	Module [1]

[2] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 4 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

Parameters	Range of values	Default	Parameter reassignment in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[2] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 4 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

4.2 Declaration of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Wire break

Enabling diagnostics if the line to the encoder is interrupted.

Channel activated

Determines whether a channel is activated or deactivated.

Input delay

This parameter can be used to suppress signal interference. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image input.

Configuration options of DI 16x24VDC ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-280 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in hard-ware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 16-channel without value status	DI 16x24VDC ST V0.0	V14, SP1 or higher with HSP 0222	X	X
1 x 16-channel with value status	DI 16x24VDC ST V0.0, QI	V14, SP1 or higher with HSP 0222	X	---

Evaluating the value status

An additional two bytes are allocated in the input address space if you enable the value status for the digital module. Bits 0 to 15 in these bytes are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the DI 16x24VDC ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

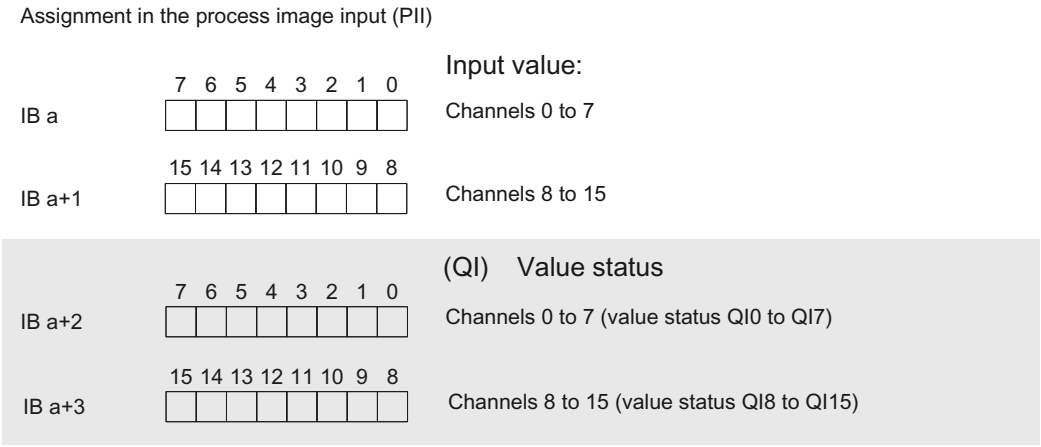

Figure 2-256 Address space of the DI 16×24VDC ST with value status

Interrupts/diagnostic alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays (status and error displays) of the DI 16x24VDC ST.

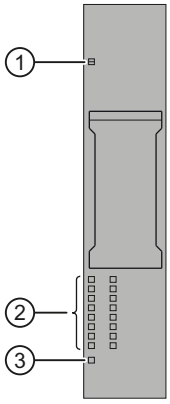

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-257 LED display

Meaning of the LEDs

The following tables show the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostic messages (Page 20).

DIAG LED

Table 2-281 Error display of the DIAG LED

DIAG LED	Meaning
□ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned
☼ Flashes	Module diagnostics is available

Channel status LED

Table 2-282 Status display of the channel status LED

Channel status LED	Meaning
□ Off	Process signal = 0
■ On	Process signal = 1

PWR LED

Table 2-283 Status display of the PWR LED

PWR LED	Meaning
□ Off	Missing supply voltage L+
■ On	Supply voltage L+ present

5.2 Interrupts

The DI 16×24VDC ST digital input module supports diagnostic interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Wire break
- Parameter assignment error
- Supply voltage missing

5.3 Diagnostic messages

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-284 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Wire break	6_H	Impedance of transducer circuit too high.	Use a different transducer type or modify the wiring, for example, use cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor of 25 kiloohms to 45 kiloohms to the transducer contacts
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DI 16×24VDC ST

The following table shows the technical specifications as of 02/2019. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7131-6BH01-0BA0/td?dl=en).

Article number	6ES7131-6BH01-0BA0
General information	
Product type designation	DI 16x24VDC ST
HW functional status	From FS02
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V14
• STEP 7 configurable/integrated as of version	V5.5 SP3
• PCS 7 configurable/integrated as of version	V8.1 SP1
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DI	Yes
• Counter	No
• Oversampling	No
• MSI	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes

Article number	6ES7131-6BH01-0BA0
Input current	
Current consumption, max.	90 mA
24 V encoder supply	
• 24 V	No
Power loss	
Power loss, typ.	1.7 W
Address area	
Address space per module	
• Inputs	2 byte; + 2 bytes for QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0 + Potential isolation module
• 3-wire connection	BU type A0 + Potential isolation module
• 4-wire connection	BU type A0 + Potential isolation module
Digital inputs	
Number of digital inputs	16
Digital inputs, parameterizable	Yes
Source/sink input	P-reading
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Input voltage	
• Rated value (DC)	24 V
• for signal "0"	-30 to +5V
• for signal "1"	+11 to +30V
Input current	
• for signal "1", typ.	2.5 mA
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes; 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms (in each case + delay of 30 to 500 µs, depending on line length)
– at "0" to "1", min.	0.05 ms
– at "0" to "1", max.	20 ms
– at "1" to "0", min.	0.05 ms
– at "1" to "0", max.	20 ms
Cable length	
• shielded, max.	1 000 m

Article number	6ES7131-6BH01-0BA0
• unshielded, max.	600 m
Encoder	
Connectable encoders	
• 2-wire sensor	Yes
– permissible quiescent current (2-wire sensor), max.	1.5 mA
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Monitoring of encoder power supply	No
• Wire-break	Yes; Module-by-module, optional protective circuit for preventing wire-break diagnostics in the case of simple encoder contacts: 25 kOhm to 45 kOhm
• Short-circuit	No
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C

Article number	6ES7131-6BH01-0BA0
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	28 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

The module parameters can be re-assigned in RUN (for example, the input delay of selected channels can be edited in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

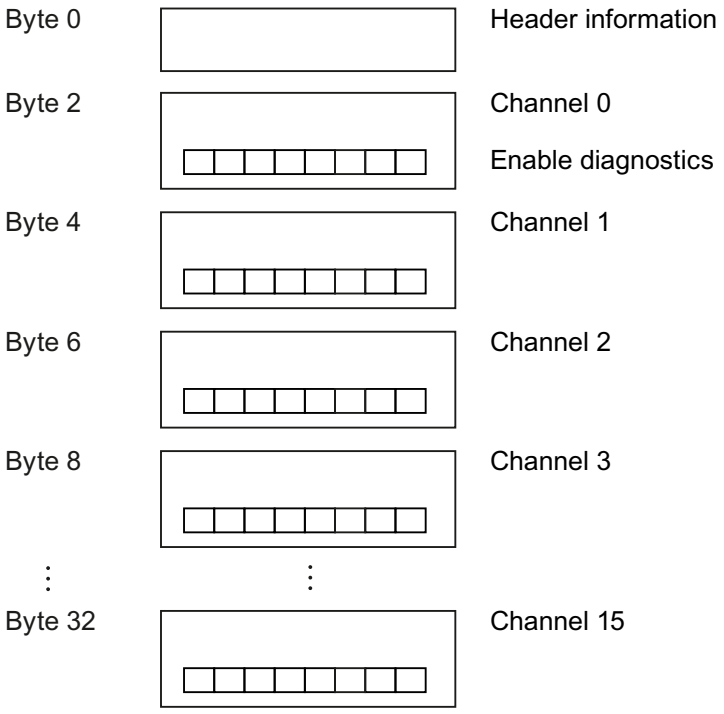

Figure 2-258 Structure of data record 128

Header information

The figure below shows the structure of the header information.

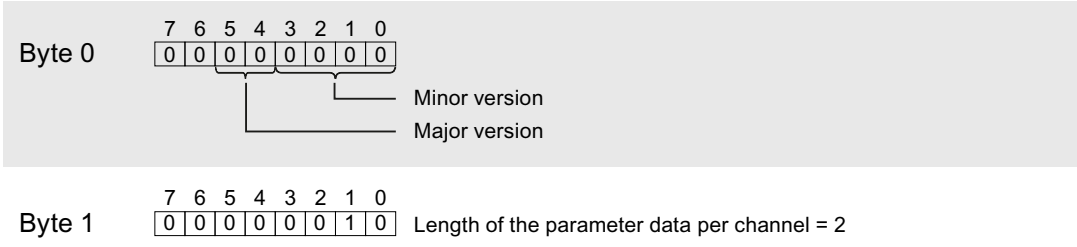

Figure 2-259 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 15.

You enable a parameter by setting the corresponding bit to "1".

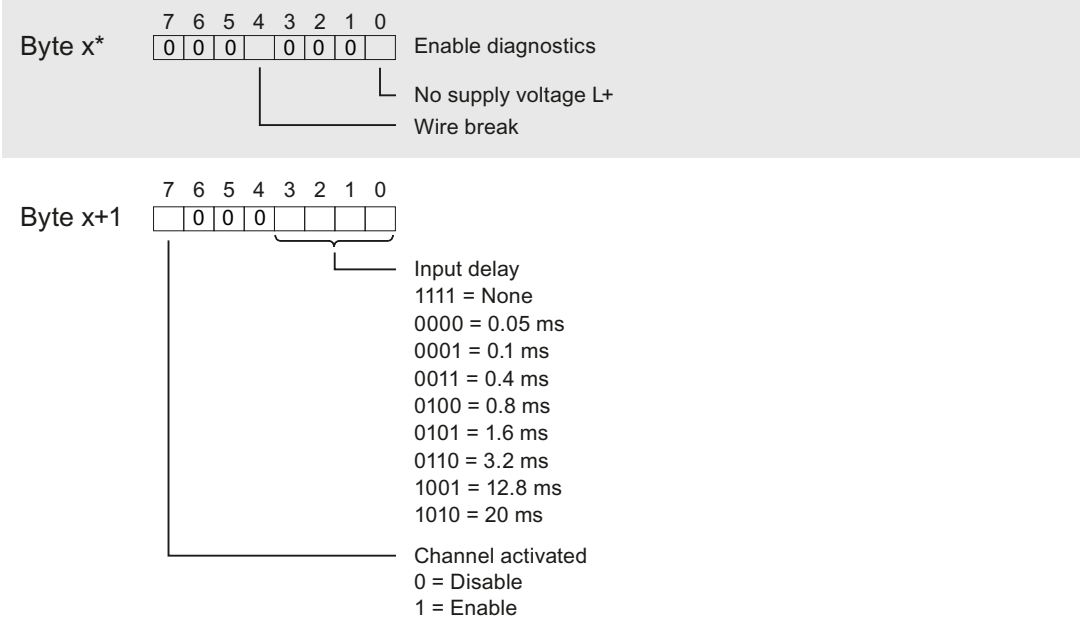

* x = 2 + (channel number × 2); channel number = 0 to 15

Figure 2-260 Structure byte x to x+1 for the channels 0 to 15

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	07	Invalid coding for input filter time.	Check the parameters of the module.

SIEMENS

SIMATIC

ET 200SP
Digital output module DQ 4x24VDC/2A ST (6ES7132-6BD21-0BA0)

Equipment Manual

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Parameters/address space 5

Interrupts/diagnostics alarms 6

Technical specifications 7

Parameter data record A

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Introduction

1

Purpose of the documentation

This manual supplements the System Manual ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in the system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

Product overview

3

3.1 Properties

Article number

6ES7132-6BD21-0BA0 (packing unit: 1 unit)

6ES7132-6BD21-2BA0 (packing unit: 10 units)

View of the module

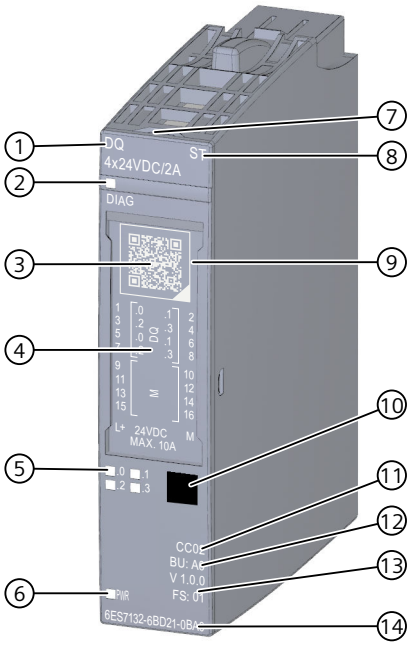

①	Module type and name	⑧	Function class
②	LED for diagnostics	⑨	Insertion option for optional labeling strip
③	QR code for identification link	⑩	Color coding module type
④	Wiring diagram	⑪	Color code for selecting the color-coded labels
⑤	LEDs for channel status	⑫	BU type
⑥	LED for supply voltage	⑬	Firmware and function versions
⑦	Slot for optional equipment labeling plate	⑭	Article number

Figure 2-261 View of the module DQ 4×24VDC/2A ST

Properties

The module has the following technical properties:

- Digital output module with 4 outputs
- Source output (PNP, P-switching)
- Supply voltage L+
- Output current 2 A (per channel)
- Total current 8 A (per module)

  See derating: Technical specifications (Page 28)
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Extended spare parts compatibility (see product information (https://support.industry.siemens.com/cs/ww/en/view/73021864))

The module supports the following functions:

Table 2-285 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V1.0.0 or higher	V19 or higher with HSP0425	V5.5 SP3 or higher with HSP 0230 from V11.0	X	X
I&M0 to I&M3 identification data	FS01	V1.0.0 or higher	V19 or higher with HSP0425	V5.5 SP3 or higher with HSP 0230 from V11.0	X	X
Parameter reassignment in RUN	FS01	V1.0.0 or higher	V19 or higher with HSP0425	V5.5 SP3 or higher with HSP 0230 from V11.0	X	X
PROFIenergy	FS01	V1.0.0 or higher	V19 or higher with HSP0425	V5.5 SP3 or higher with HSP 0230 from V11.0	X	-
Value status	FS01	V1.0.0 or higher	V19 or higher with HSP0425	V5.5 SP3 or higher with HSP 0230 from V11.0	X	X

Accessories

The following accessories are available optionally:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Wiring up

4

4.1 Wiring diagram

This section contains the pin assignment for the module.

You can find information on wiring the BaseUnit in the system manual ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293).

NOTE

The load group of the module must begin with a light-colored BaseUnit. Also keep this in mind during configuration.

NOTICE

You may only use the digital output module with a BaseUnit type A0.

With the BaseUnit type A1, the integrated fuse can be triggered, rendering the terminals unusable.

NOTE

Cross-circuit at output

Note that a voltage applied at the output due to a cross-circuit can lead to the modules being supplied with L+.

Pin assignment: 1 and 2-wire connection of actuators

The following table shows an example of the pin assignment of digital output module DQ 4×24VDC/2A ST on the BaseUnit BU type A0 without AUX terminals:

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Digital output, channel 0	DQ_0	1		2	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	3		4	DQ_3	Digital output, channel 3
Digital output, channel 0	DQ_0	5		6	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	7		8	DQ_3	Digital output, channel 3
Ground	M	9		10	M	Ground
Ground	M	11		12	M	Ground

1) Infeed only with light-colored BaseUnit

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Ground	M	13	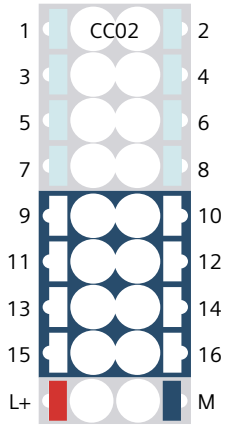	14	M	Ground
Ground	M	15		16	M	Ground
24 V DC supply voltage[1)]	L+	L+		M	M	Ground

1) Infeed only with light-colored BaseUnit

NOTICE
Current load of combined return conductors For 2-wire connection, the static current load of the combined return conductor must not exceed 2A per terminal.

Pin assignment: 3-wire connection of actuators

The following table shows an example of the pin assignment of the digital output module DQ 4×24VDC/2A ST on the BaseUnit BU type A0 with AUX terminals.

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Digital output, channel 0	DQ_0	1		2	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	3		4	DQ_3	Digital output, channel 3
Digital output, channel 0	DQ_0	5		6	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	7		8	DQ_3	Digital output, channel 3
Ground	M	9		10	M	Ground
Ground	M	11		12	M	Ground
Ground	M	13		14	M	Ground
Ground	M	15		16	M	Ground
AUX terminal	AUX	1A		2A	AUX	AUX terminal
AUX terminal	AUX	3A		4A	AUX	AUX terminal
AUX terminal	AUX	5A		6A	AUX	AUX terminal

1) Infeed only with light-colored BaseUnit

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
AUX terminal	AUX	7A		8A	AUX	AUX terminal
AUX terminal	AUX	9A		10A	AUX	AUX terminal
24 V DC supply voltage[1]	L+	L+		M	M	Ground

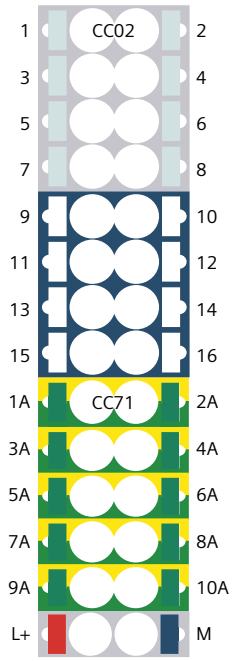

[1] Infeed only with light-colored BaseUnit

Output connection types

1-wire connection of actuators	2-wire connection of actuators	3-wire connection of actuators
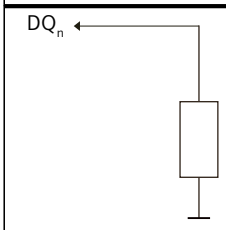	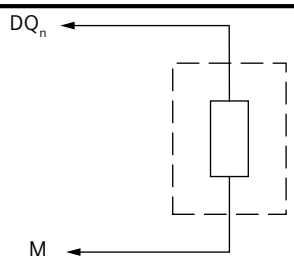	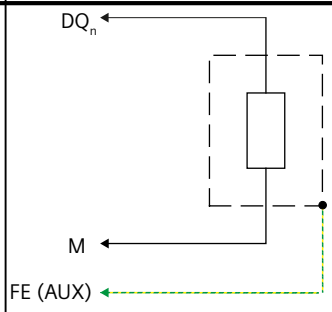

You can also connect the ground and functional grounding via a potential distribution module (PotDis module) or AUX terminals. More information on the potential distributor modules is available in the BaseUnits Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/59753521).

NOTE

You can use and combine the different connection options for all channels.

4.2 Schematic circuit diagram

This section contains the schematic circuit diagram of the module.

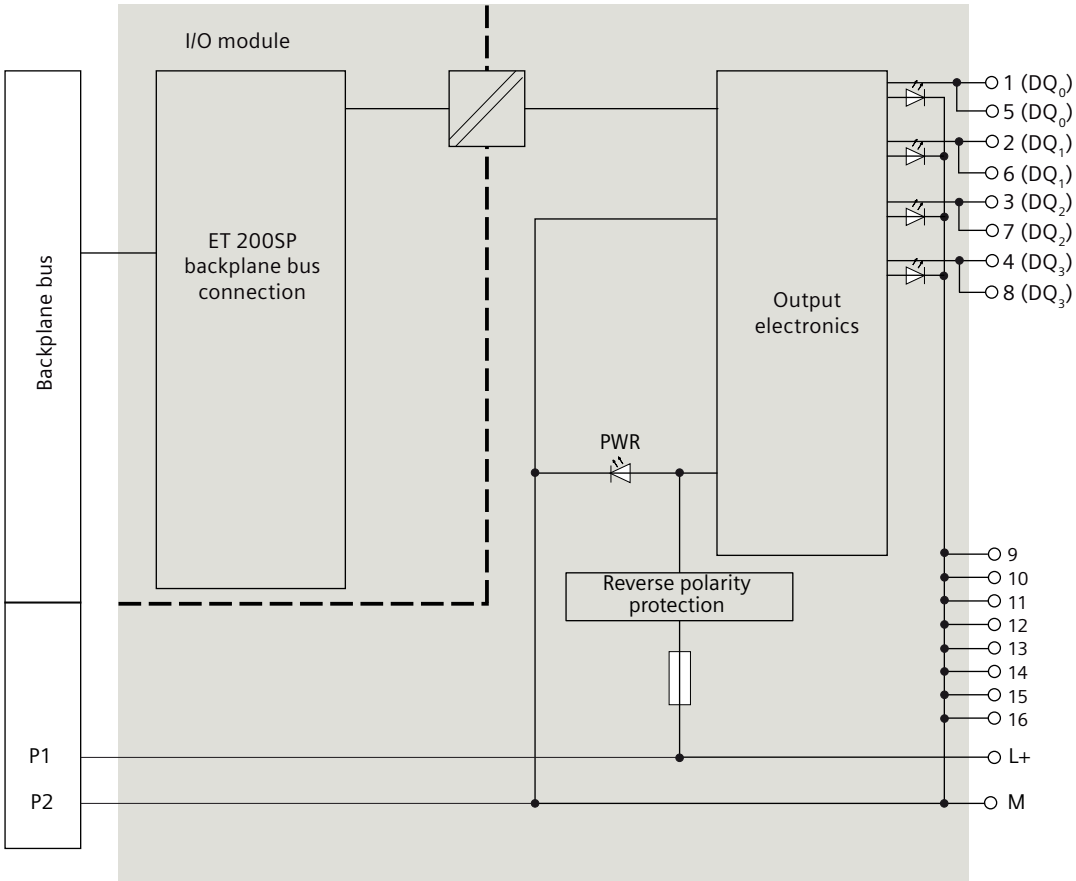

Figure 2-262 Schematic circuit diagram

Parameters/address space

5

5.1 Parameters

Parameters for DQ 4x24VDC/2A ST

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation on an ET 200SP-CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition to parameter assignment via the configuration software, you can also configure parameters in RUN mode (dynamically) via the user program. When assigning the parameters in the user program, the "WRREC" instruction transfers the parameters to the module using data records; see section Parameter assignment and structure of the parameter data record (Page 34).

The following parameter settings are possible:

Table 2-286 Configurable parameters and their defaults (GSD file)

Parameters	Value range	Default	Reconfiguration during RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Short-circuit to L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the possible parameter settings are restricted. The parameter length of the I/O module is 4 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter Data Record".

Parameters	Value range	Default	Reconfiguration during RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Channel enabled	• Disable • Enable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Potential group	• Use the potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into a light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the possible parameter settings are restricted. The parameter length of the I/O module is 4 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter Data Record".

NOTE

- If both parameters "Diagnostics: Short-circuit to L+" and "Diagnostics: Wire break" are enabled and one of these diagnostic events occurs, the affected channel is switched off. This prevents undefined load switching and the corresponding diagnostics alarm is triggered.
- If the parameter "Diagnostics: Wire break" is enabled and "Diagnostics: Short circuit to L+" is disabled and a "Diagnostics: Wire break" is present, the affected channel is switched off. This prevents undefined load switching and the corresponding diagnostics alarm is triggered.
- If the parameter "Diagnostics: Short-circuit to L+" is enabled and "Diagnostics: Wire break" is disabled, the signal state is retained at the affected channel when "Diagnostics: Short-circuit to L+" occurs. A diagnostics alarm is triggered only for 0 signal.

5.2 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Diagnostics: Short-circuit to L+

Enabling of the diagnostics if a short-circuit of the actuator supply to L+ occurs.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Channel enabled

Determines whether a channel is enabled or disabled.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group starts with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

Specify the slot in which a light-colored BaseUnit with supply voltage feed or a dark-colored BaseUnit is to be located (see ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) System Manual).

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

The station configuration must be completed with a server module.

5.3 Address space

The module can be configured differently in STEP 7; see the table below. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of DQ 4x24VDC/2A ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-287 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the STEP 7 hardware catalog from V19 with HSP0425	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel without value status	DQ 4x24VDC/2A ST V1.0	X	X	X
1 x 4-channel with value status	DQ 4x24VDC/2A ST V1.0, QI	X	X	X

NOTE

The following functions are only fully available when the submodule X.1 is configured and the IO controller to which submodule X.1 is assigned has established a connection to the IO device.

- Firmware update
- I&M identification data
- PROFIenergy

Value status (quality information, QI)

The value status is always activated for the following configurations:

- DQ 4×24VDC/2A ST V1.0, QI

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

You can find more information on evaluating the value status in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A ST V1.0

The figure below shows the address space assignment for configuration as a 1x4-channel module without value status. "QB" stands for output byte.

Assignment in the process image output (PIQ)

	7	6	5	4	3	2	1	0	Output value:
AB a	0	0	0	0					Channels 0 to 3 (outputs CH0 to CH3)

Figure 2-263 Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A ST V1.0

Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A ST V1.0, QI

The figure below shows the address space assignment for configuration as a 1x4-channel module with value status. The addresses for the value status are only available if the value status is enabled. "IB" stands for input byte. "QB" stands for output byte.

Assignment in the process image output (PIQ)

	7	6	5	4	3	2	1	0	Output value:
QB x	0	0	0	0					Channels 0 to 3 (outputs CH0 to CH3)

Assignment in the process image of the inputs (PII)

	7	6	5	4	3	2	1	0	(QI) Value status
IB x	0	0	0	0					Channels 0 to 3 (value status QI0 to QI3)

Figure 2-264 Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A ST V1.0, QI

Interrupts/diagnostics alarms

6

6.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the module:

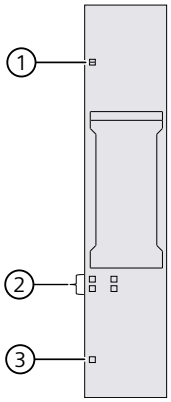

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-265 LED displays

Meaning of the LEDs

The following tables explain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 26).

DIAG LED

Table 2-288 Error display of the DIAG LED

DIAG LED	Meaning
Off	The system's backplane bus supply is faulty or switched off
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics available
Flashes	Module parameters assigned and module diagnostics available

Channel status LED

Table 2-289 Status display of the channel status LED

Channel status LED	Meaning
□ Off	Channel disabled or enabled and process signal = 0
■ On	Channel enabled and process signal = 1

PWR LED

Table 2-290 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

6.2 Interrupts

The DQ 4×24VDC/2A ST digital output module supports diagnostic interrupts.

Diagnostic interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit
- Wire break
- Parameter assignment error
- No supply voltage
- Channel/component temporarily unavailable

Detailed information on the event is available in the STEP 7 online help.

6.3 Diagnostics alarms

A diagnostic message is generated and the DIAG-LED flashes red on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

NOTE
You can connect 2 actuators per output
The diagnostics of the two actuators influenced each other in the case of duplicate wiring.
This means:
- a wire break is only signaled if both actuators are affected
- a single short-circuit affects both actuators

NOTE
Wiring 2 outputs in parallel
When connecting 2 outputs in parallel for redundant control of a load, the channel diagnoses "Short circuit to L+" and "Wire break" must be disabled, otherwise erroneous diagnostic messages may occur.

Table 2-291 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit	1_H	• Short-circuit of actuator supply to ground [1] • Short-circuit of actuator supply to L+ [2]	Correct the process wiring
Wire break	6_H	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, e.g. use cables with a larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor to the actuat- or contacts in the load resist- ance range
Parameter assign- ment error	10_H	• Module cannot evaluate parameters for this channel • Incorrect parameter assignment	Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L+	• Check the supply voltage L+ at the BaseUnit • Check BaseUnit type
Channel/component temporarily unavail- able	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update • Restart the firmware update

1 Only in switched state (output value 1)

2 Only in non-switched state (output value 0)

NOTE

In case of a short-circuit of the actuator supply to L+ at the enabled channel, load distributions can occur which result in wire break diagnostics.

Technical specifications 7

7.1 Technical specifications

Technical specifications of the DQ 4×24VDC/2A ST

The following table lists the technical specifications as of the issue date. You can find a data sheet including the latest technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/de/pv/6ES7132-6BD21-0BA0/td?dl=en).

Article number	6ES7132-6BD21-0BA0
General information	
Product type designation	DQ 4x24VDC/2A ST
HW functional status	01
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC02
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V19 or higher with HSP0425 / integrated as of TIA Portal V20
• STEP 7 configurable/integrated from version	as of STEP 7 V5.5 SP3 with HSP0230 V11.0 / integrated as of STEP 7 V5.7 SP3
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.43
Operating mode	
• DQ	Yes
• DQ with energy-saving function	No
• PWM	No
• Oversampling	No
• MSO	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes

Article number	6ES7132-6BD21-0BA0
Input current	
Current consumption, max.	20 mA; without load
output voltage / header	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1 W
Address area	
Address space per module	
• Address space per module, max.	1 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0
• 3-wire connection	BU type A0 with AUX terminals or potential distributor module
Digital outputs	
Type of digital output	Source output (PNP, current-sourcing)
Number of digital outputs	4
Current-sinking	No
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
output characteristic acc. to IEC 61131, type 2	Yes
Short-circuit protection	Yes; Electronic
• Response threshold, typ.	2.8 to 5.2 A
Open-circuit detection	Yes
Limitation of inductive shutdown voltage to	Typ. L+ (-50 V)
Controlling a digital input	Yes; supports input type 3 according to IEC 61131-2
Switching capacity of the outputs	
• with resistive load, max.	2 A
• with inductive load, max.	2 A
• on lamp load, max.	10 W
Load resistance range	
• lower limit	12 Ω
• upper limit	3 400 Ω
Output current	
• for signal "1" rated value	2 A
• for signal "1" permissible range, max.	2 A

Article number	6ES7132-6BD21-0BA0
• for signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
• "0" to "1", typ.	50 µs
• "1" to "0", typ.	100 µs
Parallel switching of two outputs	
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	100 Hz
• with inductive load, max.	0.1 Hz; higher frequencies are possible, see Equipment Manual "Maximum permitted switching frequency of inductive loads"
• on lamp load, max.	10 Hz
Total current of the outputs	
• Current per channel, max.	2 A
• Current per module, max.	8 A; see Equipment Manual "Derating curve"
Total current of the outputs (per module)	
horizontal installation	
– up to 30 °C, max.	8 A
– up to 40 °C, max.	8 A
– up to 50 °C, max.	6 A
– up to 60 °C, max.	4 A
vertical installation	
– up to 30 °C, max.	8 A
– up to 40 °C, max.	6 A
– up to 50 °C, max.	4 A
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnoses	
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Wire-break	Yes; Module-wise
• Short-circuit to M	Yes; Module-wise
• Short-circuit to L+	Yes; Module-wise

Article number	6ES7132-6BD21-0BA0
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• Between the channels and load voltage L+	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

Residual current for signal state "0"

NOTE

Residual current for signal state "0"

Due to the Diagnostics: Wire break function, there is a low level of residual current in the "0" signal state at the output, which may cause the display diodes to flicker.

This residual current does not depend on the setting for the Diagnostics: Wire break parameter.

Derating trend

The following figure shows the load current derating with horizontal and vertical mounting positions. You use this diagram to determine the maximum total current of the module as a function of ambient temperature.

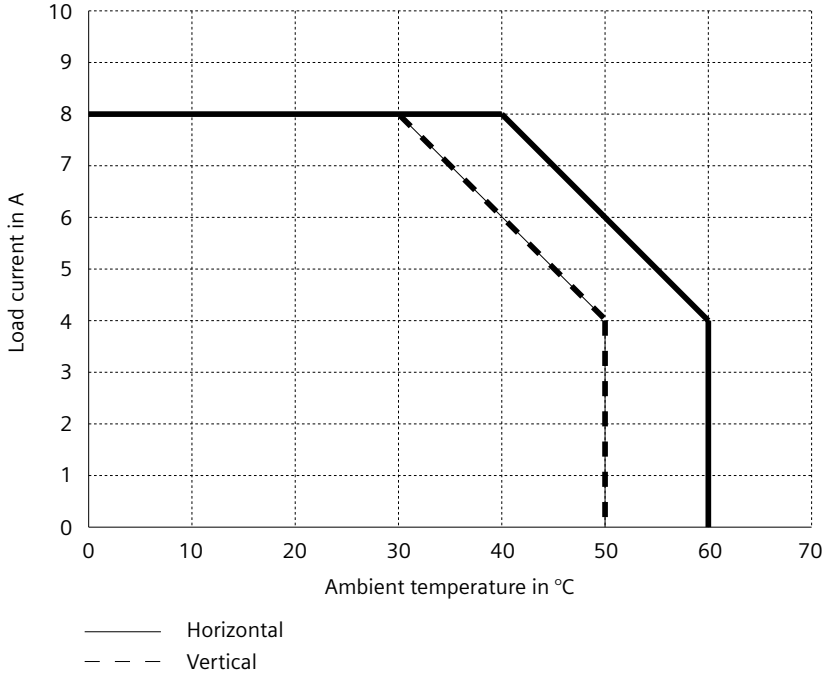

Figure 2-266 Load current to temperature in different installation positions

If a channel drives a cyclically switched inductive load, this channel contributes 2 A to the total current.

Maximum permitted switching frequency of inductive loads

The following trends show the maximum permissible switching frequency of inductive loads as a function of inductance and channel current. The maximum switching frequency applies to a pulse-pause ratio of 50%. The channel contributes 2 mA to the total current of the module, even if the actual channel current is smaller.

If you do not know the inductance of the actuator, assume a maximum inductance of 1.152 H for DC-13 loads (IEC 60947-5-1).

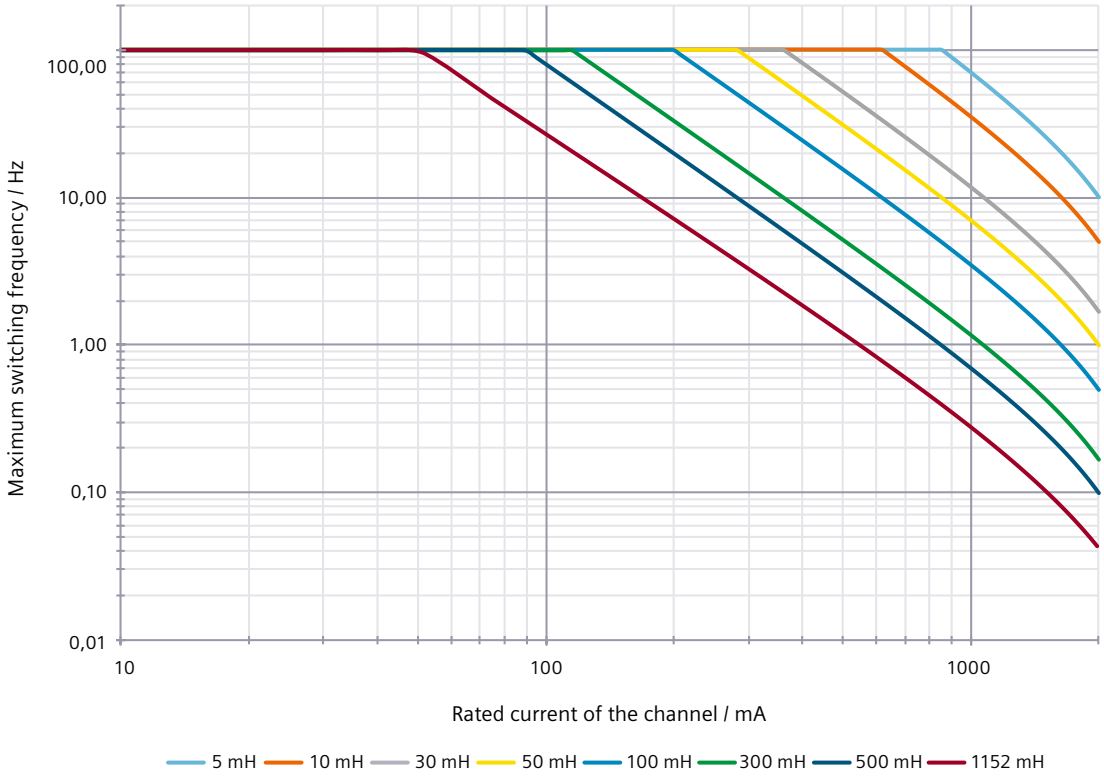

Figure 2-267 Maximum switching frequency

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You have the option to reassign the module parameters in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

If you reconfigure a module and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. However, the STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

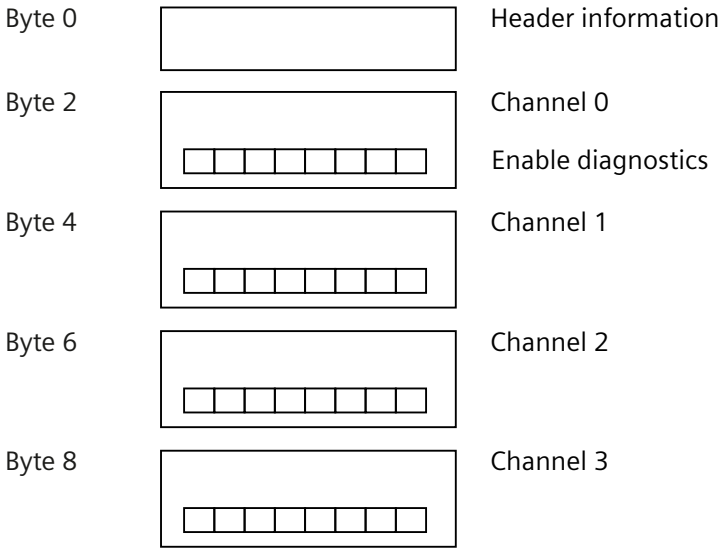

Figure 2-268 Structure of data record 128

Header information

The figure below shows the structure of the header information.

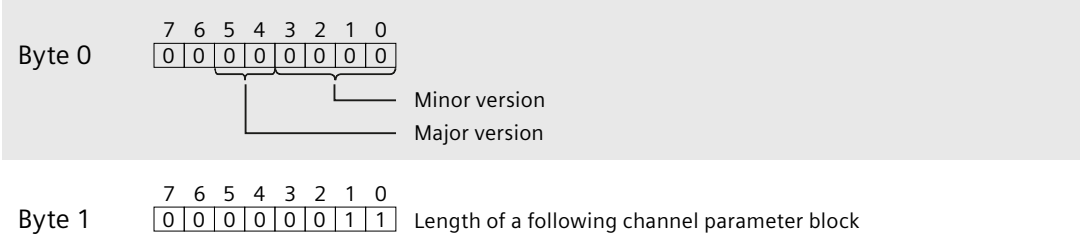

Figure 2-269 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You enable a parameter by setting the corresponding bit to "1".

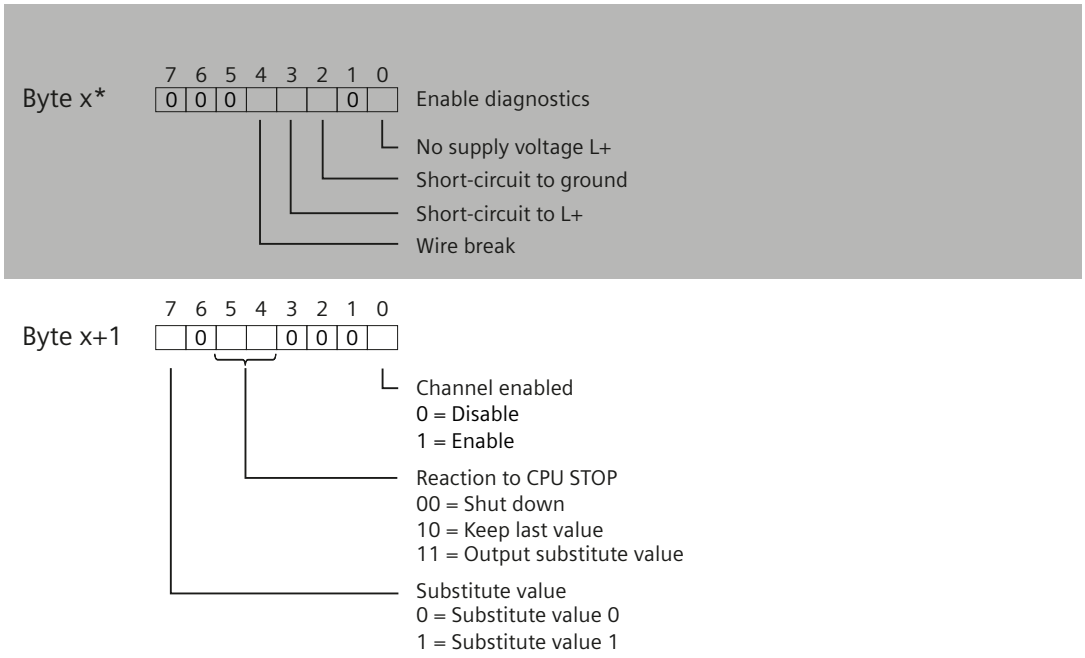

* x = 2 + (channel number × 2); channel number = 0 to 3

Figure 2-270 Structure byte x to x+1 for the channels 0 to 3

A.2 Error codes

Error transmitting the data record

The module always checks all the values of the transferred data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Table 2-292 Error messages, their meaning, and remedial measures

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$B0_H$	00_H	Number of the data record unknown	Enter a valid number for the data record.
DF_H	80_H	$B1_H$	01_H	Length of the data record incorrect	Enter a valid value for the data record length.
DF_H	80_H	$B2_H$	00_H	Module not accessible	• Check station. • Plug the module in correctly. • Check parameters of the WRREC block.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF_H	80_H	$E0_H$	01_H	Header error (version or specified bits incorrect)	Correct version number or specified bits, see Header information (Page 34).
DF_H	80_H	$E0_H$	02_H	Header error (number or length of parameter structures or parameter blocks incorrect)	Correct the number and length of the parameter structures or parameter blocks, see Header information (Page 34).
DF_H	80_H	$E1_H$	01_H	Reserved bit set	Write 0 to all reserved bits.
DF_H	80_H	$E1_H$	06_H	Invalid coding for substitute value behavior	Use valid coding for "Reaction to CPU STOP" parameter, see Structure of byte x to x+1 for channels 0 to 3 (Page 34).

SIEMENS

SIMATIC

ET 200SP
DQ 4x24..230VAC/2A ST digital output module (6ES7132-6FD00-0BB1)

Equipment Manual

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Parameter data record A

03/2015
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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Guide to documentation

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

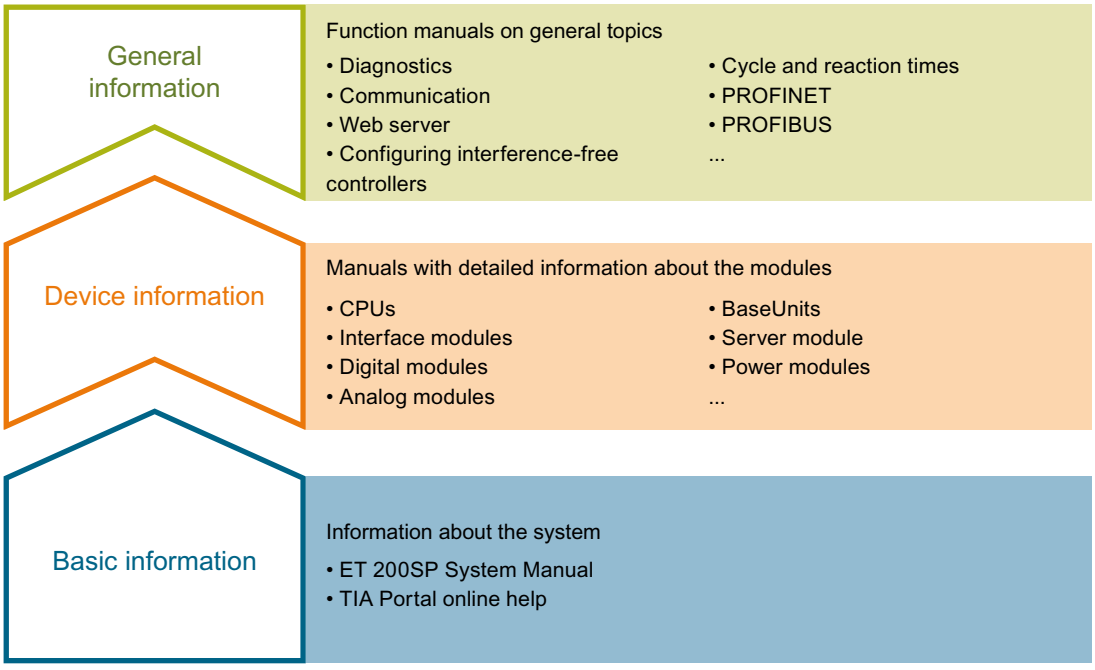

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

Application examples

Applications examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find application examples on the Internet (http://support.industry.siemens.com/cs/ww/en/ps/ae).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

2.1 Properties

Article number

6ES7132-6FD00-0BB1

View of the module

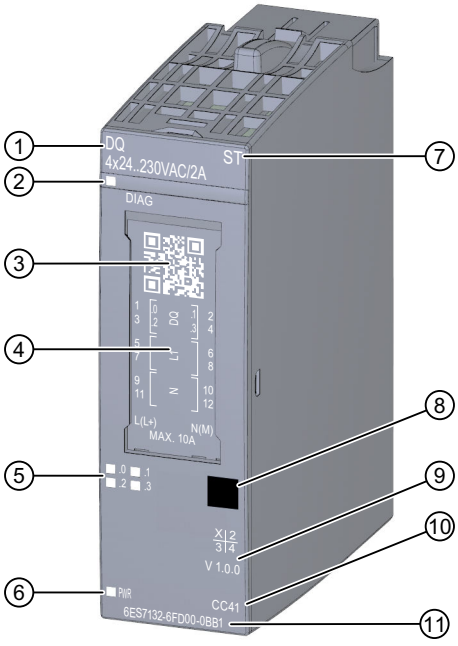

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	Article number
⑥	LED for supply voltage		

Figure 2-271 View of the DQ 4×24..230VAC/2A ST module

Properties

The module has the following technical properties:

- 4 digital outputs each with a value status (quality information)
- Supply voltage L+
- Switches in zero point
- Output current 2 A per channel
- Total current 8 A (per module)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, AC contactors, and indicator lights

The module supports the following functions:

- Firmware update
- Identification data I&M0 to I&M3
- Reconfiguration in RUN
- PROFIenergy

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label

You can find more information on accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the DQ 4x24..230VAC/2A ST module with the terminal assignments for 2-wire and 3-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system system manual.

NOTICE
Dangerous voltage. Risk of death or serious injury. Always disconnect the system and module from the power supply before commencing work.

NOTE

Limiting overvoltage

You must ensure overvoltage is limited to 1 kV for the encoder supply.

NOTE

Power limitation

To limit power, each input voltage must have a fuse with a maximum rating of 10 A tripping current. The fuse must be a quick-acting microfuse.

NOTE

You may use and combine the different wiring options for all channels.

Connection: 2-wire and 3-wire connection of actuators

The following figure shows the block diagram and an example for the terminal assignment of the digital input module DQ 4x24..230VAC/2A ST on the BaseUnit BU type B1.

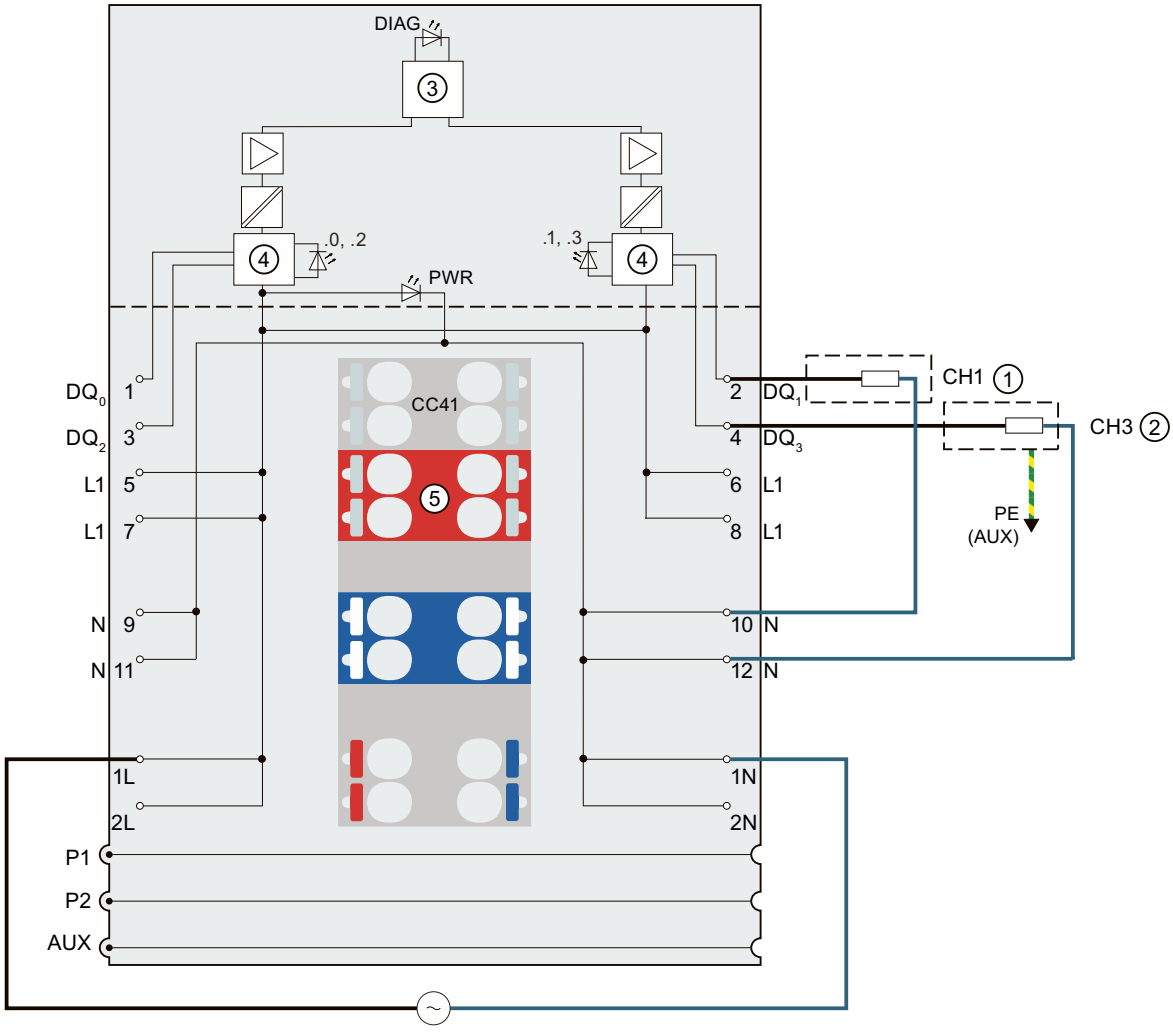

①	2-wire connection	N	Neutral
②	3-wire connection	1L, 2L	Supply voltage 120 V AC to 230 V AC
③	Backplane bus interface	1N, 2N	Neutral conductor supply voltage
④	Output electronics	PE (AUX)	Protective conductor connection
⑤	Color identification label CCxx (optional)	DIAG	Diagnostics LED (red/green)
DQ_n	Output signal, channel n	.0, .1, .2, .3	Channel status LED (green)
L1	Encoder supply	PWR	Power LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)		

Figure 2-272 Wiring and block diagram for 2-wire and 3-wire connection of actuators

No connection for three-phase loads

The digital output is not suitable for three-phase loads.

Parameter assignment/addressing 4

4.1 Parameters

DQ 4×24..230VAC/2A ST parameters

The table below lists the parameters that can be set. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When performing the configuration in the user program, use the "WRREC" instruction to transfer the parameters to the module using data records (refer to the section Parameter assignment and structure of parameter data record (Page 21)).

The following parameter settings are possible:

Table 2-293 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP[1]
Operating mode	• Channel activated • Channel deactivated	Channel activ-ated	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module

[1] Only for configuration using the PROFIBUS GSD file; does not affect configuration with STEP 7 using HSP: As the number of parameters with PROFIBUS GSD configuration is limited to a maximum of 244 bytes per ET 200SP station, the configuration options are limited. If required, however, you can still set this parameter using data record 128 as described in the column "GSD file PROFINET IO" (see the table above). The parameter length of the I/O module is 3 bytes.

4.2 Explanation of parameters

Operating mode

Determines whether a channel is enabled or disabled.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

4.3 Address space

Configuration options of DQ 4×24..230VAC/2A ST

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 3 in this byte are assigned to a channel. They provide information about the validity of the digital value.

Bit =1: No fault is present on the channel.

Bit =0: Channel is deactivated or there is an error on the module.

If an error on a channel occurs with this module, the value status for all channels is 0.

Address space of the digital output module DQ 4×24..230VAC/2A ST

The following figure shows the assignment of the address space for the DQ 4×24..230VAC/2A ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

Assignment in the process image of the outputs (PIQ)

	7	6	5	4	3	2	1	0	
QB x	0	0	0	0					Output values at channels 0 to 3

Assignment in the process image of the inputs (PII)

	7	6	5	4	3	2	1	0	
IB x	0	0	0	0					Value status (QI) at channels 0 to 3
									0: value output at channel is faulty

Figure 2-273 Address space of the DQ 4×24..230VAC/2A ST digital output module with value status

Interrupts/diagnostics alarms

5

5.1 Status and fault displays

LED display

The figure below shows the LED displays of the DQ 4×24..230VAC/2A ST.

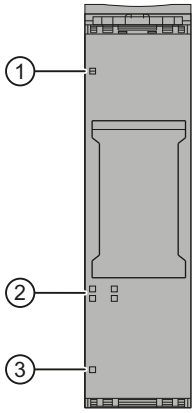

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-274 LED displays

Meaning of the LEDs

The following tables explain the meaning of the status and error displays.

DIAG LED

Table 2-294 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-295 Status display of the channel status LED

Channel status LED	Meaning
□ Off	Channel deactivated or activated and process signal = 0
■ On	Channel activated and process signal = 1

PWR LED

Table 2-296 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

5.2 Load voltage status

Load voltage status

The firmware of the module cannot detect the status of the load voltage.

If the "Load voltage status" function tied to the server module is used, a "1" is always displayed in the status bit for a slot with the DQ 4×24..230VAC/2A ST. Even when the load voltage is not applied.

The state of the load voltage at the terminal does not impact the PROFIenegy behavior.

5.3 Interrupts

The DQ 4x24...230VAC/2A ST digital output module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Channel temporarily unavailable
- Parameter assignment error

5.4 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-297 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not read in process values in this state.	• Wait for firmware update • Restart the firmware update

Technical specifications 6

6.1 Technical specifications

Technical specifications of the DQ 4×24...230VAC/2A ST

	6ES7132-6FD00-0BB1
Product type designation	DQ 4x24 ... 230VAC/2A
General information	
Firmware version	V1.0
FW update possible	Yes
Usable BaseUnits	BU type B1
Color code for module-specific color identification label	CC41
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD as of revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
DQ	Yes
DQ with energy-saving function	No
PWM	No
Oversampling	No
MSO	No
Supply voltage	
Rated value (AC)	230 V
Input current	
Current consumption (rated value)	11.5 mA
Power loss	
Power loss, typ.	9 W; active power, load voltage 230 V, all outputs loaded with 2 A, 50 Hz
Address area	
Address space per module	
Address space per module, max.	1 byte; + 1 byte for QI information
Input	1 byte; with QI
Output	1 bytes

	6ES7132-6FD00-0BB1
Digital outputs	
Number of outputs	4
Sinking output	No
Sourcing output	Yes
Short-circuit protection	No; install a fuse with 10A trigger current when using a type B1 BU
Switching capacity of outputs	
With resistive load, max.	2 A
With lamp load, max.	100 W
Output voltage	
For signal "1", min.	20.4 V
Output current	
For signal "1" rated value	2 A
For signal "1" permitted range, min.	10 mA
For signal "1" permitted range, max.	2 A
For signal "0" residual current, max.	460 µA
Output delay with resistive load	
"0" to "1", max.	10 ms
"1" to "0", max.	10 ms
Parallel switching of 2 outputs	
For logic operations	No
For increased performance	No
For redundant control of a load	Yes
Switching frequency	
With resistive load, max.	10 Hz
With inductive load, max.	0.5 Hz
With lamp load, max.	1 Hz
Total current of outputs	
Current per channel, max.	2 A
Current per module, max.	8 A
Total current of outputs (per module)	
Horizontal installation	
up to 40 °C, max.	8 A
up to 50 °C, max.	6 A
up to 60 °C, max.	4 A
Vertical installation	
up to 30 °C, max.	8 A
up to 40 °C, max.	6 A
up to 50 °C, max.	4 A
Output current per channel	
Horizontal installation	
up to 60 °C, max.	2 A
Vertical installation	

	6ES7132-6FD00-0BB1
up to 50 °C, max.	2 A
Triac outputs	
Size of motor starter according to NEMA, max.	5
Cable length	
Shielded, max.	1000 m
Unshielded, max.	600 m
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	No
Diagnostics alarms	
Diagnostics	No
Monitoring of supply voltage	No
Diagnostics indicator LED	
Monitoring of the supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	No
Insulation	
Insulation tested with	DC 2545 V 2 s (routine test)
Dimensions	
Width	20 mm
Weights	
Weight, approx.	50 g

Dimension drawing

See the manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

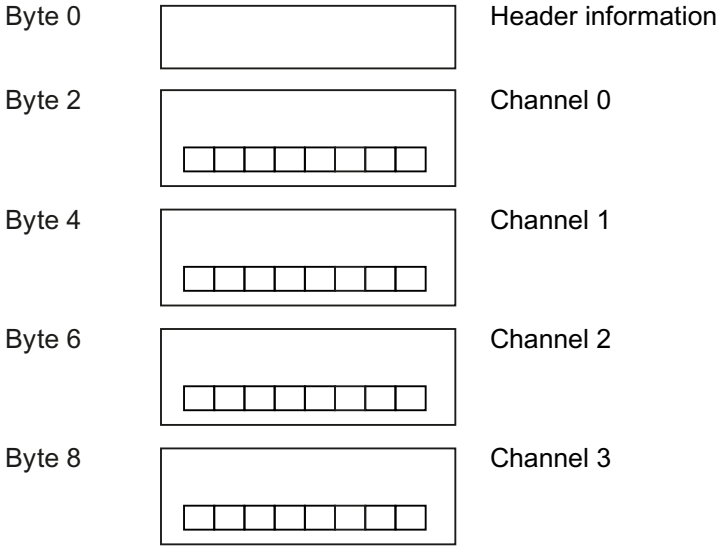

Figure 2-275 Structure of data record 128

Header information

The figure below shows the structure of the header information.

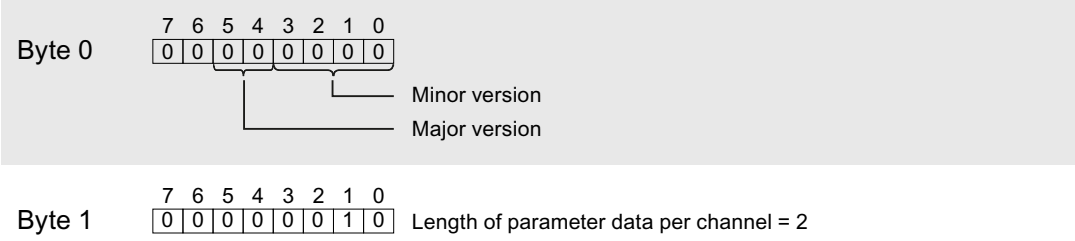

Figure 2-276 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You enable a parameter by setting the corresponding bit to "1".

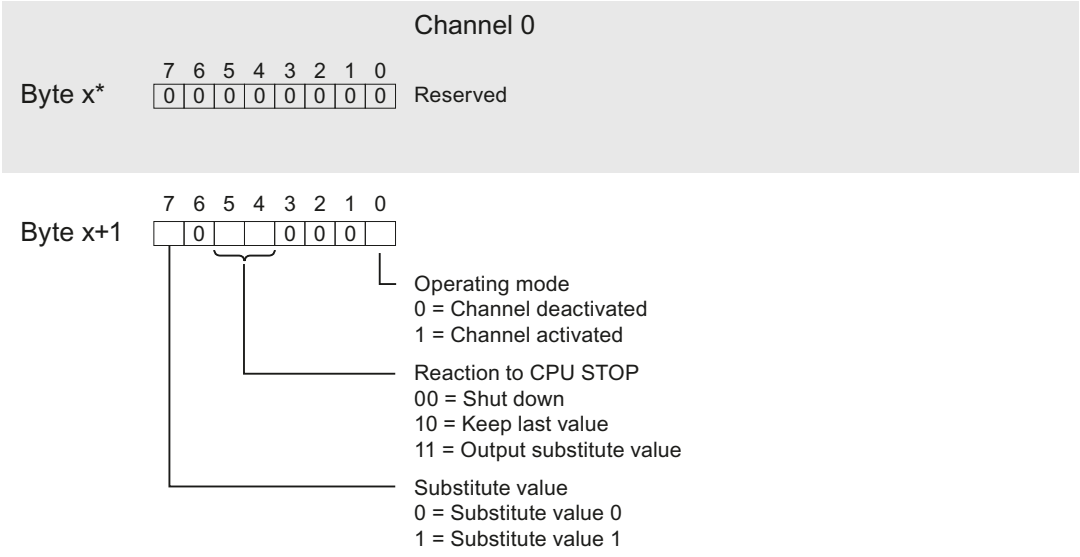

* x = 2 + (channel number x 2); channel number = 0 to 3

Figure 2-277 Structure byte x to x+1 for the channels 0 to 3

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ET 200SP DQ 4x24..230VAC/2A HF digital output module (6ES7132-6FD00-0CU0)

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02/2018

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Preface

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In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (https://www.siemens.com/industrialsecurity).

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Guide to documentation

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

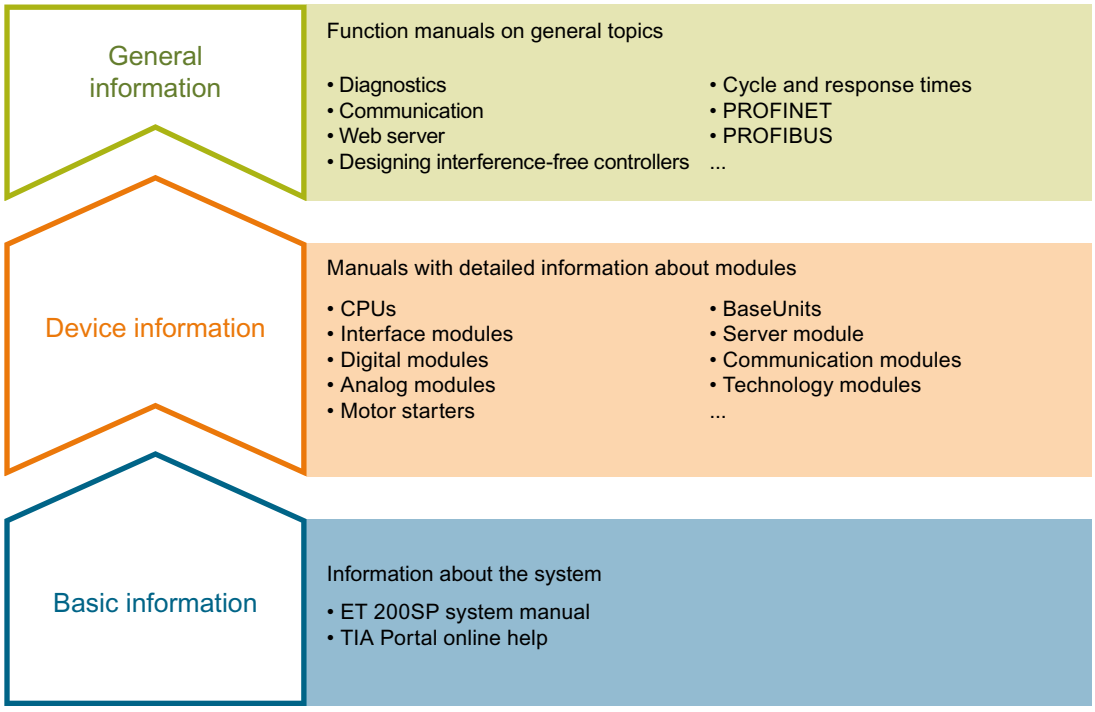

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7132-6FD00-0CU0

View of the module

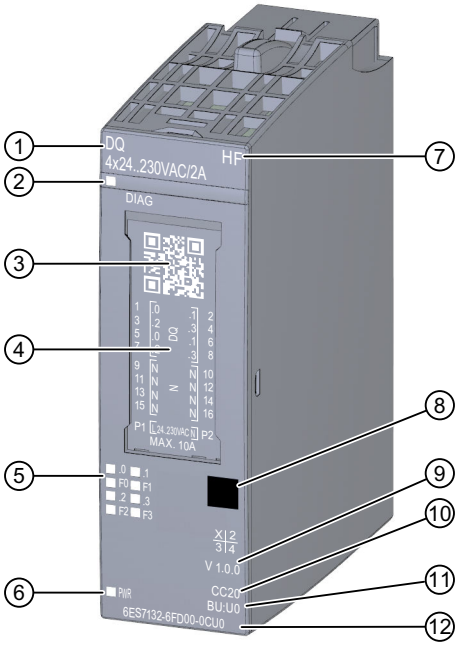

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-278 View of the module DQ 4×24..230VAC/2A HF

Properties

The module has the following technical properties:

- Digital output module with 4 outputs (TRIAC)
- Output current 2 A per channel (max. 4 A), total current max. 8 A
  (see derating: Technical specifications (Page 40))
- Power rating max. 900 W
- Configurable diagnostics (per channel)
- Configurable substitute values (per channel)
- Suitable for power control of heating systems or infrared sources in drying processes
- Wave packet control to prevent harmonic components
- Startup delay per channel to reduce system loads
- Output filter per channel for soft start or soft stop
- Two operating modes:
  - DQ
  - PC (PowerControl)
- with one of four control types each:
  - Phase control - phase-angle proportional (default)
  - Phase control - power-proportional
  - Wave packet control - half waves
  - Wave packet control - full waves

Table 2-298 Operating modes of the DQ 4×24..230VAC/2A HF

Property		**Operating mode**			
		DQ		**PC (PowerControl)**	
		Without value status (QI)	**With value status (QI)**	**Without value status (QI)**	**With value status (QI)**
Number of channels		4			
Control type selection		Yes			
Configurable temperature shut-down		Yes			
Configurable startup delay		0 ms ... 10 s			
Configurable output filter down/up		0 ms ... 60 s			
Data length	Inputs	0 bytes	1 byte	0 bytes	1 byte
	Outputs	1 byte	1 byte	8 bytes	8 bytes

The module supports the following functions:

Table 2-299 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V1.0.0 or higher	V14 or higher with HSP 0240	V5.5 SP3 or higher with HSP 0230 V8.0 or higher	X	X
Identification data I&M0 to I&M3	FS01	V1.0.0 or higher	V14 or higher with HSP 0240	V5.5 SP3 or higher with HSP 0230 V8.0 or higher	X	X
Reconfiguration in RUN	FS01	V1.0.0 or higher	V14 or higher with HSP 0240	V5.5 SP3 or higher with HSP 0230 V8.0 or higher	X	X
PROFIenergy	FS01	V1.0.0 or higher	V14 or higher with HSP 0240	V5.5 SP3 or higher with HSP 0230 V8.0 or higher	X	X
Value status	FS01	V1.0.0 or higher	V14 or higher with HSP 0240	V5.5 SP3 or higher with HSP 0230 V8.0 or higher	X	X

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label

You can find more information on accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

2.2 Functions

Introduction

Two operating mode are available for the module DQ 4×24..230VAC/2A HF:

- DQ mode
- PC mode (PowerControl)

In PC mode, control of the module outputs is analog. The value range is $0..1000_D$ (= 0.1% increments). The resolution of the process value is 16 bits per channel.

In DQ mode, output control is binary.

You configure the channels with the functions described below.

Control types

In PC mode, you can assign one of four control types to all channels of the module; you use these control types to control different processes in your plant.

The control the power in the control types:

- Phase control - power-proportional
- Wave packet control (half waves)
- Wave packet control (full waves)

You can use these control types, for example, for power control of heating systems or infrared sources in drying processes.

You control the average switch-on duration in the control type:

- Phase control - phase-angle proportional

You can use this control type, for example, to dim lamps that offer this feature.

You also assign the control types in DQ mode. The resolution of the process value here is only 1 bit per channel.

PC mode (PowerControl) operating principles

Phase control

The load voltage is reduced through phase control and raised from the starting voltage up to mains voltage in the zero crossing.
Depending on the application, phase control offers advantages compared to wave packet control, such as even heating or prevention of radiation source flickering in case of low setpoints.

You can configure the following during each half wave:

- For phase control - phase-angle proportional: The switch-on duration in proportion to the process value.
- For phase control - power-proportional: The output power.

The following graphic schematically shows the principle of phase control:

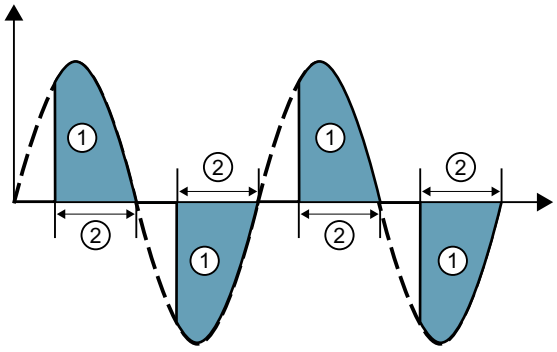

① Average power 80%, corresponds to a process value of 800 (power proportional)

② Average switch-on duration 67%, corresponds to a process value of 670 (phase angle proportional)

Figure 2-279 Principle of phase control

NOTE

Use of filters

To observe the EMC guidelines, you must filter the faults caused by phase control in the plant. A suitable filter, for example, is EPCOS SIFI-C B84113C.

For additional information about electromagnetic compatibility of the module, see the section Technical specifications (Page 40).

Phase control - power-proportional

This control type enables you to control the output power in the phase control in proportion to the maximum power.
This means, for example, that a 500 W heating element ideally consumes about 50 W of its maximum power at a process value of 10.0%.

Note that infrared sources may consume more power. The deviation from the setpoint is at its lowest in case of a linear and purely ohmic load.

Wave packet control

In case of wave packet control, the module connects the load voltage through to the load for entire half or full waves starting at the zero crossing.
The wave packets to be output are calculated dynamically. Unlike with fixed wave packet patterns, the changes of the output value are taken into consideration faster while ensuring the absence of direct voltage in the output voltage at the same time. This allows for the implementation of controllers with shorter dead times.

The process value hereby refers to the average switch-on duration over multiple alternating voltage periods of the load voltage.
The graphics below show you how basic wave packet control for half waves or full waves works.

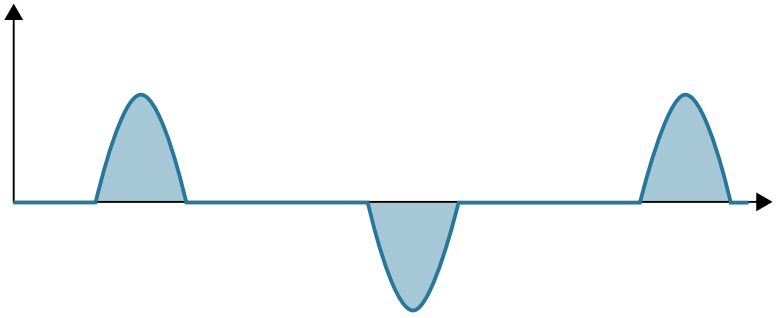

Figure 2-280 Principle of wave packet control - half waves

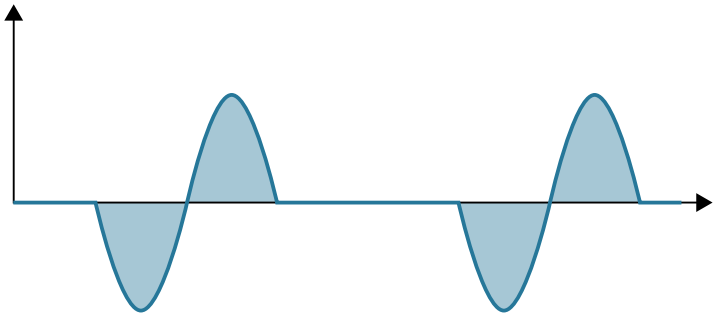

Figure 2-281 Principle of wave packet control - full waves

DQ mode

3

3.1 Wiring

3.1.1 Wiring and block diagram

This section includes the block diagram of the DQ 4x24..230VAC/2A HF module with the terminal assignments for a 1-wire and 2-wire connection.
You can use the different connection options for all channels and combine them at random.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

DANGER

Dangerous voltage. Risk of death or serious injury.

You must always disconnect the system and module from the power supply before commencing work.

NOTE

Limiting overvoltage

You must ensure overvoltage of the encoder supply is limited to 1 kV.

NOTE

Power limitation

To limit power, each input voltage must have a fuse with a maximum rating of 10 A tripping current. The fuse must be a quick-acting microfuse.

NOTE

Three-phase loads

Do not connect any three-phase loads to the module. The digital output is not suitable for three-phase loads.

Connection: 1-wire and 2-wire connection of actuators

The following figure shows the block diagram and an example of the terminal assignment of the digital output module DQ 4x24..230VAC/2A HF on the BaseUnit BU type U0.

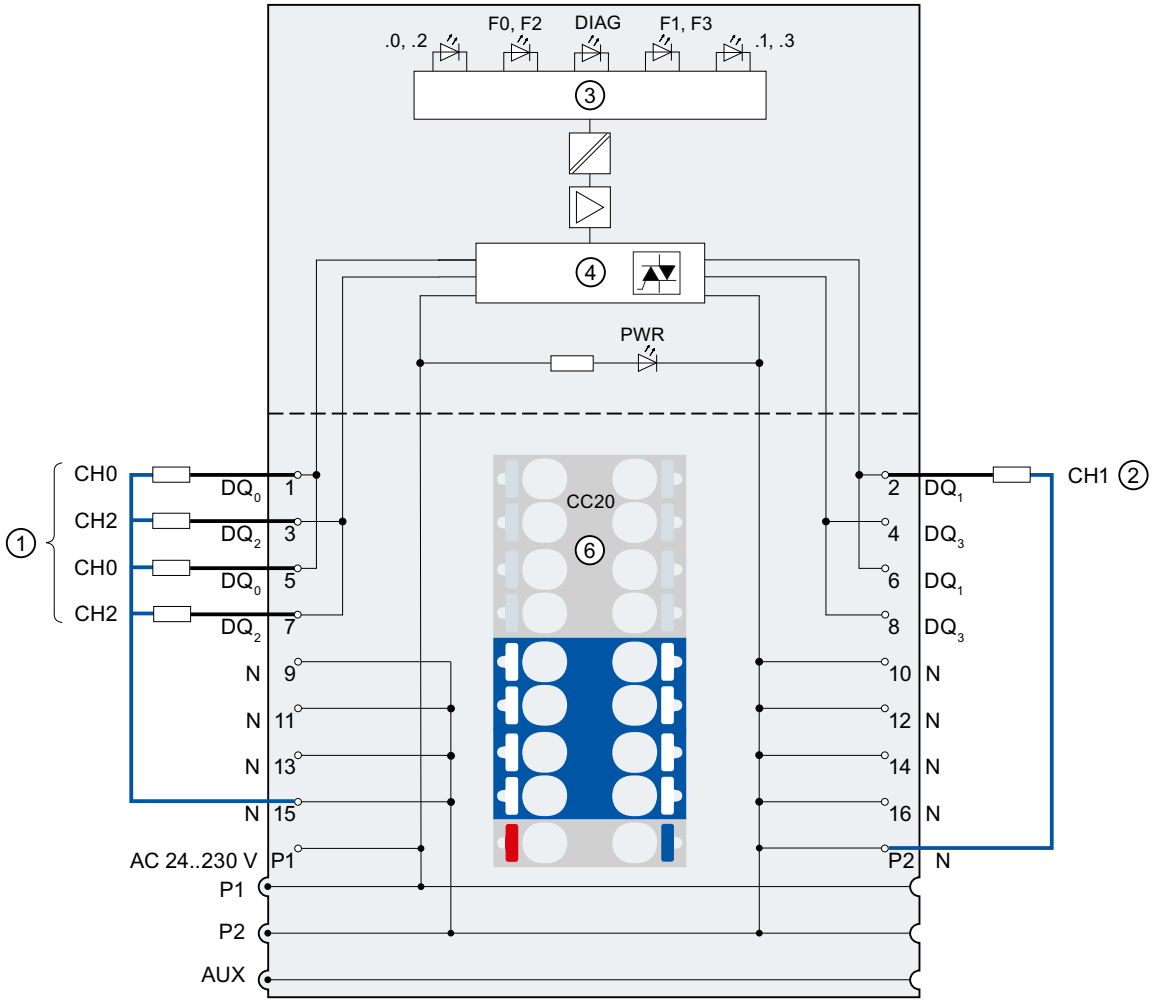

①	1-wire connection	24..230 V AC	Supply voltage L (infeed for light-colored BaseUnit only)
②	2-wire connection	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Backplane bus interface	N	Neutral
④	Output electronics	DIAG	Error or diagnostics LED (green, red)
⑤	Polarity reversal protection	.0 to .3	Channel status LED (green)
⑥	Color-coded label CC20 (optional)	F0 to F3	Channel fault LED (red)
DQ_n	Output signal, channel n	PWR	Power LED (green)

Figure 2-282 Wiring and block diagram for 1-wire and 2-wire connection of actuators.

3.2 Parameters/address space

3.2.1 Parameters

Parameters of the DQ 4×24..230VAC/2A HF

The following table lists the configurable parameters in DQ mode.

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When performing the configuration in the user program, use the "WRREC" instruction to transfer the parameters to the module using data records (refer to the section Parameter assignment and structure of parameter data record (Page 47)).

The following parameter settings are possible:

Table 2-300 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP[1]
Module parameters					
Control type	• Phase control - phase-angle proportional • Phase control - power-proportional • Wave packet control - half waves • Wave packet control - full waves	Phase control - phase-angle proportional	Yes	Module	Module
Channel parameters					
Diagnostics No supply voltage L	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics Overtemperature	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics Wire break[2]	• Disable • Enable	Disable	Yes	Channel	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel

1 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 7 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data set".

2 For physical reasons, a wire break cannot be detected for actuators with two inputs and shared reference point. In this case, deactivate the diagnostics.

Parameter	Range of values	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP[1]
Temperature shut-down	• Output active even under overtemperat-ure conditions • Output disabled under overtemperat-ure conditions	Output active even under overtemperat-ure conditions	Yes	Channel	Module
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Channel startup delay	• No delay • 100 ms • 1 s • 2 s • 3 s • 4 s • 5 s • 10 s	No delay	Yes	Channel	-
Channel output filter down	• No filter • 500 ms • 1 s • 5 s • 10 s • 30 s • 60 s	No filter	Yes	Channel	-
Channel output filter up	• No filter • 500 ms • 1 s • 5 s • 10 s • 30 s • 60 s	No filter	Yes	Channel	-
Potential group					
Potential group	• Use potential group of the left module (module plugged into a dark BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

1 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 7 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data set".

2 For physical reasons, a wire break cannot be detected for actuators with two inputs and shared reference point. In this case, deactivate the diagnostics.

3.2.2 Explanation of parameters

Control type

At the module level, specifies the control type in which the module's channels are operated.

- Phase control - phase-angle proportional (default)
- Phase control - power-proportional
- Wave packet control - half waves
- Wave packet control - full waves

Diagnostics No supply voltage L

Enabling of the diagnostics for no or insufficient supply voltage L.

Diagnostics Overtemperature

Diagnostics enabled when overtemperature occurs in the module.

When you enable the Overtemperature diagnostics and the module detects that the maximum permissible module temperature is exceeded, the Overtemperature diagnostics is output.

Diagnostics Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Channel activated

Determines whether a channel is enabled or disabled.

Temperature shutdown

Determines whether a channel remains activate or is deactivated in case of overtemperature.

When the module has detected that the maximum permissible module temperature has been exceeded, the channel is either deactivated or remains active depending on the configuration.
To prevent damage to the module, the channel is automatically deactivated when temperature shutdown is configured.

You cannot control the channel until the temperature is once again in the valid range.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Channel startup delay

Specifies the duration of the startup delay of a channel.

You can set startup delays with values ranging from 100 ms to 10 s. This means the channels cannot be controlled before the set startup delay has expired.
Configure different startup delays for each channel to decouple the starting currents and thus reduce the network load.
Startup delays are also in effect when the module is to output substitute values. The startup delay starts after the module was started and when the load voltage returns.
This means that depending on your process, the initial switch on of lamps is always delayed by the configured time.

Channel output filter down/up

Specifies the down or up output filter of a channel.

For smooth operation or to increase the interference immunity of your application, use down or up output filters with values from 500 ms to 60 s.
Quick changes of the filter input values are converted into smoother signal changes at the filter output. This means, for example, that extreme currents in the heating phase of infrared sources are limited.

In addition, you can also use output filters to reduce shifts in the zero crossings of the power supply that can occur in isolating transformers.
This increases the accuracy of the module.

When you have configured a startup delay, the output filter is held at the reset state during this delay.
Once the startup delay has expired, the output filter starts its linear ramp directly at the value that was held during the startup delay.

Note that the configured filter times always refer to the process value jumps from 0% to 100% or from 100% to 0%.
This means the settling time of the filter is shorter for smaller jumps.

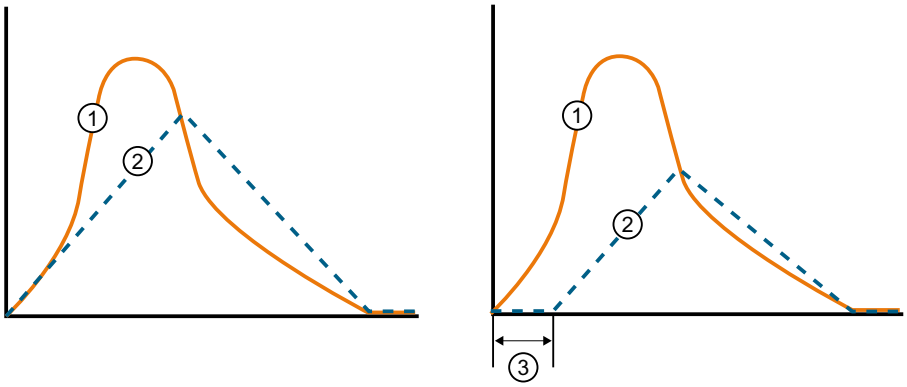

① Power without output filter

② Power with output filter (max. slope according to Output filters parameter)

③ Startup delay

Figure 2-283 Power trend or average switch-on duration in case of phase control phase-angle proportional with and without output filter

Each channel has its own output filters. These output filters always work with maximum resolution.

Output filters are also in effect when the module is to output substitute values, for example, after CPU STOP or in case of a communication failure.
This means all transitions are still smooth and infrared sources for hot gluing spots do not fail immediately, for example, but are shut down slowly to ensure that the surface of the gluing spots does not tear due to sudden cooling.

If you do not want to use output filters, use the parameter setting "No filter".

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

3.2.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of the DQ 4×24..230VAC/2A HF in DQ mode

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. When you configure the module by means of the GSD file, the configuration is available under different short designations/module names. The following configurations are possible:

Table 2-301 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, V14 or higher	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel without value status	DQ 4×24..230VAC/2A HF V1.0	X	X	X
1 x 4-channel with value status	DQ 4×24..230VAC/2A HF V1.0, QI	X	X	---

NOTE

The following functions are only fully available when the submodule X.1 is configured and the IO controller to which submodule X.1 is assigned has established a connection to the IO device.

- Firmware update
- I&M identification data
- PROFIenergy

Value status (quality information, QI)

The value status is always activated for the following module names:

- DQ 4×24..230VAC/2A HF V1.0, QI

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

Address space for configuration as 1 x 4-channel DQ 4×24..230VAC/2A HF V1.0

The figure below shows the address space allocation for the configuration **without** value status in DQ mode (DQ 4×24..230VAC/2A HF V1.0).

Assignment in the process image of the outputs (PIQ)

	7	6	5	4	3	2	1	0	
QB x	0	0	0	0					Output values at channels 0 to 3

Figure 2-284 Address space for configuration as 1 x 4-channel DQ 4×24..230VAC/2A HF V1.0 without value status

Address space for configuration as 1 x 4-channel DQ 4×24..230VAC/2A HF V1.0, QI

The figure below shows the address space allocation for the configuration **with** value status in DQ mode (DQ 4×24..230VAC/2A HF V1.0, QI).

Assignment in the process image of the outputs (PIQ)

	7	6	5	4	3	2	1	0	
QB x	0	0	0	0					Output values at channels 0 to 3

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	
IB x	0	0	0	0					Value status (QI) at channels 0 to 3

0: Value output at channel is incorrect

Figure 2-285 Address space for configuration as 1 x 4-channel DQ 4×24..230VAC/2A HF V1.0 with value status

3.3 Interrupts/diagnostics alarms

3.3.1 Status and fault displays

LED display

The following figure shows you the LED display of the DQ 4×24..230VAC/2A HF.

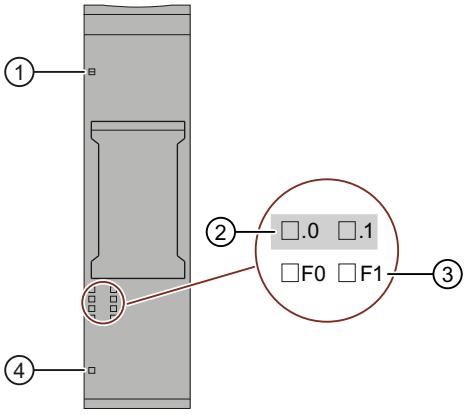

① DIAG (green/red)
② Channel status (green)
③ Channel error (red)
④ PWR (green)

Figure 2-286 LED displays

Meaning of the LEDs

The following tables explain the meaning of the status and error displays.

DIAG LED

Table 2-302 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module/channel diagnostics
Flashes	Module parameters assigned and module/channel diagnostics

LED channel status/channel error

Table 2-303 Status / error display of the LED channel status / channel error

Channel status LED	LED channel error	Meaning
□ Off	□ Off	Channel deactivated or process signal = 0 and no channel diagnostics
■ On	□ Off	Channel activated and process signal = 1 and no channel diagnostics
□ Off	■ On	Channel activated and channel diagnostics

PWR LED

Table 2-304 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L
■ On	Supply voltage L present

3.3.2 Interrupts

The digital output module DQ 4x24...230VAC/2A HF supports diagnostic interrupts.

Diagnostics interrupts

In DQ mode, the module generates a diagnostics interrupt for the following events:

- Overtemperature
- Wire break
- Parameter assignment error
- Supply voltage missing
- Channel/component temporarily unavailable

Detailed information on the event is available in the STEP 7 online help.

3.3.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.
In DQ mode, the module outputs the following diagnostic alarms:

Table 2-305 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarms	Error code	Meaning	Solution
Overtemperature	5_H	Possible causes: • Short-circuit or overload at the digital outputs • Ambient temperature outside the specification	• Correct the process wiring • Improve cooling • Check controlled loads
Wire break	6_H	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, for example, use cables with larger cross-section
		Wirebreak between the module and actuator	Connect the cable
		Channel not connected (open)	Disable diagnostics
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	No or insufficient supply voltage L	• Check supply voltage L at the BaseUnit • Check BaseUnit type
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

PC mode

4

4.1 Wiring

4.1.1 Wiring and block diagram

This section includes the block diagram of the DQ 4x24..230VAC/2A HF module with the terminal assignments for a 1-wire and 2-wire connection.
You can use the different connection options for all channels and combine them at random.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

DANGER

Dangerous voltage. Risk of death or serious injury.

You must always disconnect the system and module from the power supply before commencing work.

NOTE

Limiting overvoltage

You must ensure overvoltage of the encoder supply is limited to 1 kV.

NOTE

Power limitation

To limit power, each input voltage must have a fuse with a maximum rating of 10 A tripping current. The fuse must be a quick-acting microfuse.

NOTE

Three-phase loads

Do not connect any three-phase loads to the module. The digital output is not suitable for three-phase loads.

Connection: 1-wire and 2-wire connection of actuators

The following figure shows the block diagram and an example of the terminal assignment of the digital output module DQ 4x24..230VAC/2A HF on the BaseUnit BU type U0.

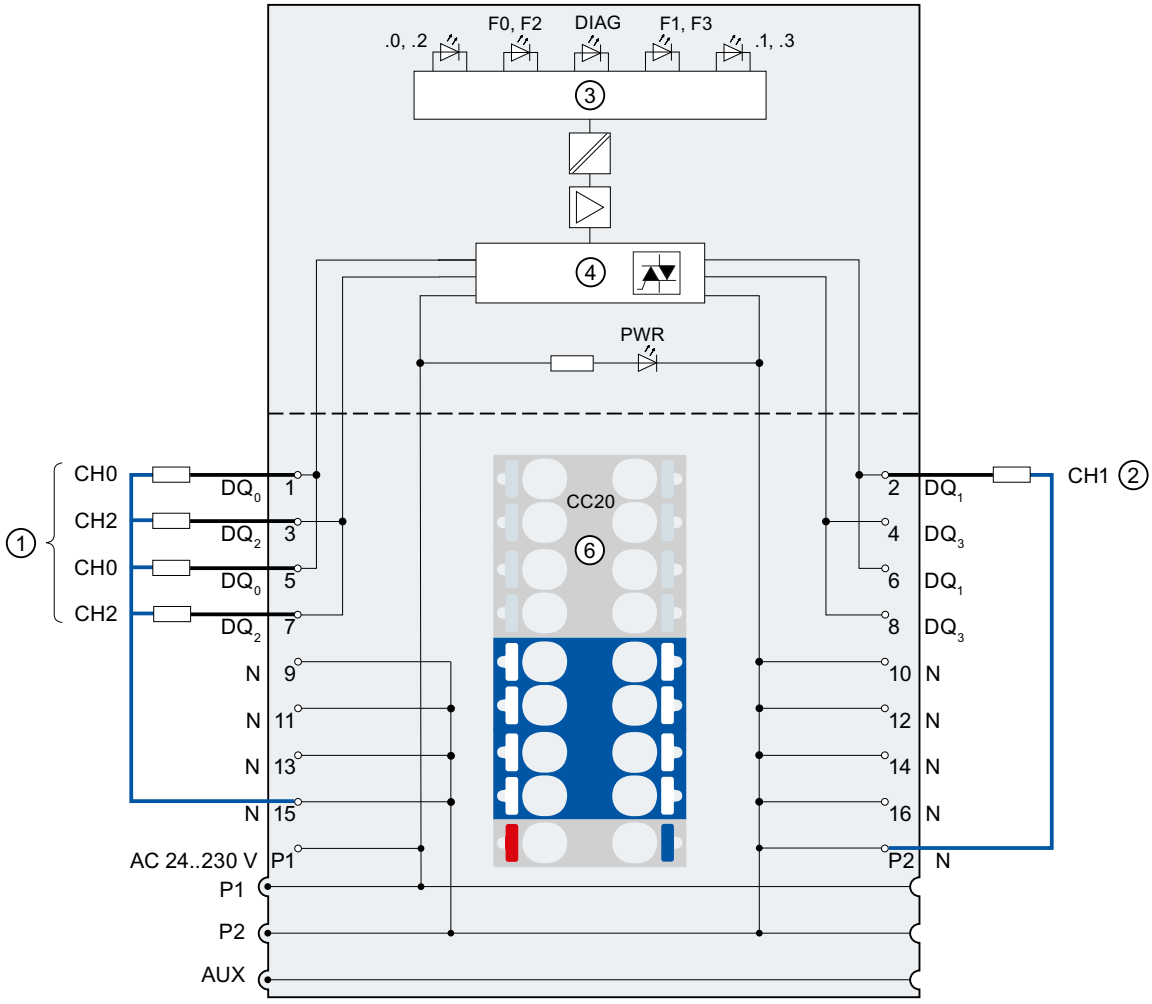

①	1-wire connection	24..230 V AC	Supply voltage L (infeed for light-colored BaseUnit only)
②	2-wire connection	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Backplane bus interface	N	Neutral
④	Output electronics	DIAG	Error or diagnostics LED (green, red)
⑤	Polarity reversal protection	.0 to .3	Channel status LED (green)
⑥	Color-coded label CC20 (optional)	F0 to F3	Channel fault LED (red)
DQ_n	Output signal, channel n	PWR	Power LED (green)

Figure 2-287 Wiring and block diagram for 1-wire and 2-wire connection of actuators.

4.2 Parameters/address space

4.2.1 Parameters

Parameters of the DQ 4×24..230VAC/2A HF

The following table lists the configurable parameters in PC mode.

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When performing the configuration in the user program, use the "WRREC" instruction to transfer the parameters to the module using data records (refer to the section Parameter assignment and structure of parameter data record (Page 47)).

The following parameter settings are possible:

Table 2-306 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP[1]
Module parameters					
Control type	• Phase control - phase-angle proportional • Phase control - power-proportional • Wave packet control - half waves • Wave packet control - full waves	Phase control - phase-angle proportional	Yes	Module	Module
Channel parameters					
Diagnostics No supply voltage L	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics Overtemperature	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics Wire break[2]	• Disable • Enable	Disable	Yes	Channel	Module

1 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 7 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data set".

2 For physical reasons, a wire break cannot be detected for actuators with two inputs and shared reference point. In this case, deactivate the diagnostics.

3 The Overflow and Channel substitute value [0.1%] diagnostics are only available if you configured the module in PC mode.

Parameter	Range of values	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP[1]
Diagnostics Overflow [3]	• Disable • Enable	Disable	Yes	Channel	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel
Temperature shut-down	• Output active even under overtemperat-ure conditions • Output disabled under overtemperat-ure conditions	Output active even under overtemperat-ure conditions	Yes	Channel	Module
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value	Turn off	Yes	Channel	Module
Channel startup delay	• No delay • 100 ms • 1 s • 2 s • 3 s • 4 s • 5 s • 10 s	No delay	Yes	Channel	-
Channel output filter down	• No filter • 500 ms • 1 s • 5 s • 10 s • 30 s • 60 s	No filter	Yes	Channel	-
Channel output filter up	• No filter • 500 ms • 1 s • 5 s • 10 s • 30 s • 60 s	No filter	Yes	Channel	-

1 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 7 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data set".

2 For physical reasons, a wire break cannot be detected for actuators with two inputs and shared reference point. In this case, deactivate the diagnostics.

3 The Overflow and Channel substitute value [0.1%] diagnostics are only available if you configured the module in PC mode.

Parameter	Range of values	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP[1]
Channel substitute value [0.1%] [2]	0...1000	0	Yes	Channel	Channel
Potential group					
Potential group	• Use potential group of the left module (module plugged into a dark BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

1 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 7 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data set".

2 For physical reasons, a wire break cannot be detected for actuators with two inputs and shared reference point. In this case, deactivate the diagnostics.

3 The Overflow and Channel substitute value [0.1%] diagnostics are only available if you configured the module in PC mode.

4.2.2 Explanation of parameters

Control type

At the module level, specifies the control type in which the module's channels are operated.

- Phase control - phase-angle proportional (default)
- Phase control - power-proportional
- Wave packet control - half waves
- Wave packet control - full waves

Diagnostics No supply voltage L

Enabling of the diagnostics for no or insufficient supply voltage L.

Diagnostics Overtemperature

Diagnostics enabled when overtemperature occurs in the module.

When you enable the Overtemperature diagnostics and the module detects that the maximum permissible module temperature is exceeded, the Overtemperature diagnostics is output.

Diagnostics Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Diagnostics overflow

Enabling of the diagnostics when the permitted value range of the process value is exceeded.

Channel activated

Determines whether a channel is enabled or disabled.

Temperature shutdown

Determines whether a channel remains activate or is deactivated in case of overtemperature.

When the module has detected that the maximum permissible module temperature has been exceeded, the channel is either deactivated or remains active depending on the configuration.
To prevent damage to the module, the channel is automatically deactivated when temperature shutdown is configured.

You cannot control the channel until the temperature is once again in the valid range.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Channel startup delay

Specifies the duration of the startup delay of a channel.

You can set startup delays with values ranging from 100 ms to 10 s. This means the channels cannot be controlled before the set startup delay has expired.
Configure different startup delays for each channel to decouple the starting currents and thus reduce the network load.
Startup delays are also in effect when the module is to output substitute values. The startup delay starts after the module was started and when the load voltage returns.
This means that depending on your process, the initial switch on of lamps is always delayed by the configured time.

Channel output filter down/up

Specifies the down or up output filter of a channel.

To increase the interference immunity of your application, use down or up output filters with values from 500 ms to 60 s.
Quick changes of the filter input values are converted into smoother signal changes at the

filter output. This means, for example, that extreme currents in the heating phase of infrared sources are limited.

In addition, you can also use output filters to reduce shifts in the zero crossings of the power supply that can occur in isolating transformers.
This increases the accuracy of the module.

When you have configured a startup delay, the output filter is held at the reset state during this delay.
Once the startup delay has expired, the output filter starts its linear ramp directly at the value that was held during the startup delay.

Note that the configured filter times always refer to the process value jumps from 0% to 100% or from 100% to 0%.
This means the settling time of the filter is shorter for smaller jumps.

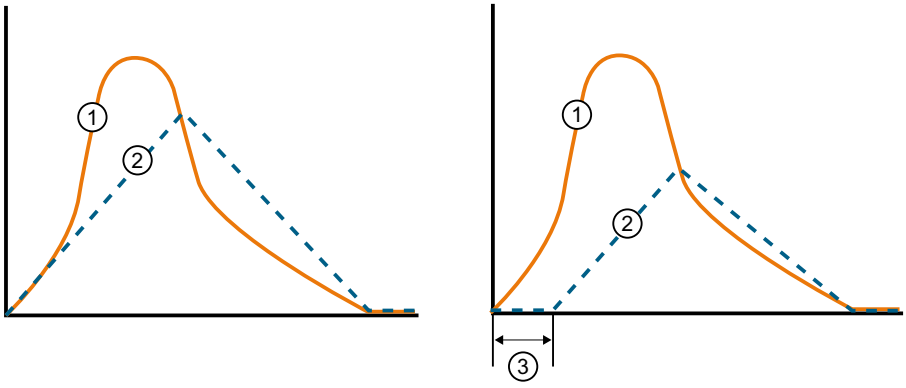

① Power without output filter

② Power with output filter (max. slope according to Output filters parameter)

③ Startup delay

Figure 2-288 Power trend or average switch-on duration in case of phase control phase-angle proportional with and without output filter

Each channel has its own output filters. These output filters always work with maximum resolution.

Output filters are also in effect when the module is to output substitute values, for example, after CPU STOP or in case of a communication failure.
This means all transitions are still smooth and infrared sources for hot gluing spots do not fail immediately, for example, but are shut down slowly to ensure that the surface of the gluing spots does not tear due to sudden cooling.

If you do not want to use output filters, use the parameter setting "No filter".

Channel substitute value [0.1%]

Defines the substitute value that is output when a CPU STOP occurs and the setting "Output substitute value" is selected in the "Reaction to CPU STOP" parameter.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

4.2.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of the DQ 4×24..230VAC/2A HF in PC mode

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. When you configure the module by means of the GSD file, the configuration is available under different short designations/module names. The following configurations are possible:

Table 2-307 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, V14 or higher	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel without value status	DQ 4×24..230VAC/2A HF PC V1.0	X	X	X
1 x 4-channel with value status	DQ 4×24..230VAC/2A HF PC V1.0, QI	X	X	---

NOTE

The following functions are only fully available when the submodule X.1 is configured and the IO controller to which submodule X.1 is assigned has established a connection to the IO device.

- Firmware update
- I&M identification data
- PROFIenergy

Value status (quality information, QI)

The value status is always activated for the following module names:

- DQ 4×24..230VAC/2A HF PC V1.0, QI

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

Address space for configuration as 1 x 4-channel DQ 4×24..230VAC/2A HF PC V1.0

The figure below shows the address space allocation for the configuration **without** value status in PC mode (DQ 4×24..230VAC/2A HF PC V1.0).

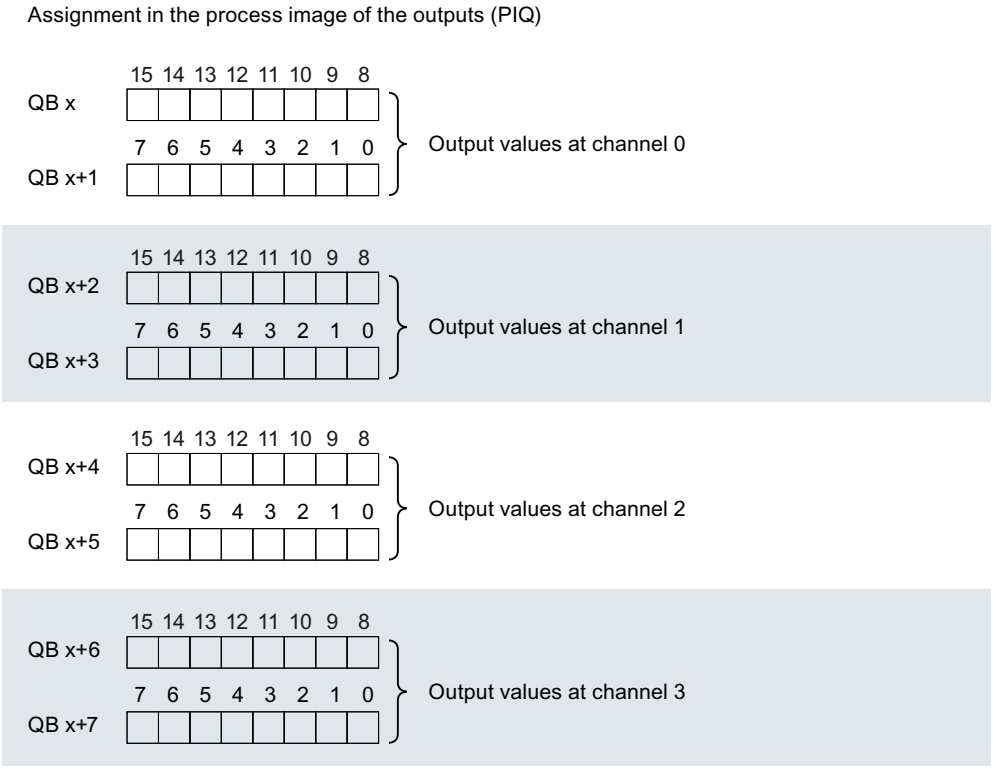

Figure 2-289 Address space for configuration as 1 x 4-channel DQ 4×24..230VAC/2A HF PC V1.0 without value status

Address space for configuration as 1 x 4-channel DQ 4×24..230VAC/2A HF PC V1.0, QI

The figure below shows the address space allocation for the configuration **with** value status in PC mode (DQ 4×24..230VAC/2A HF PC V1.0, QI).

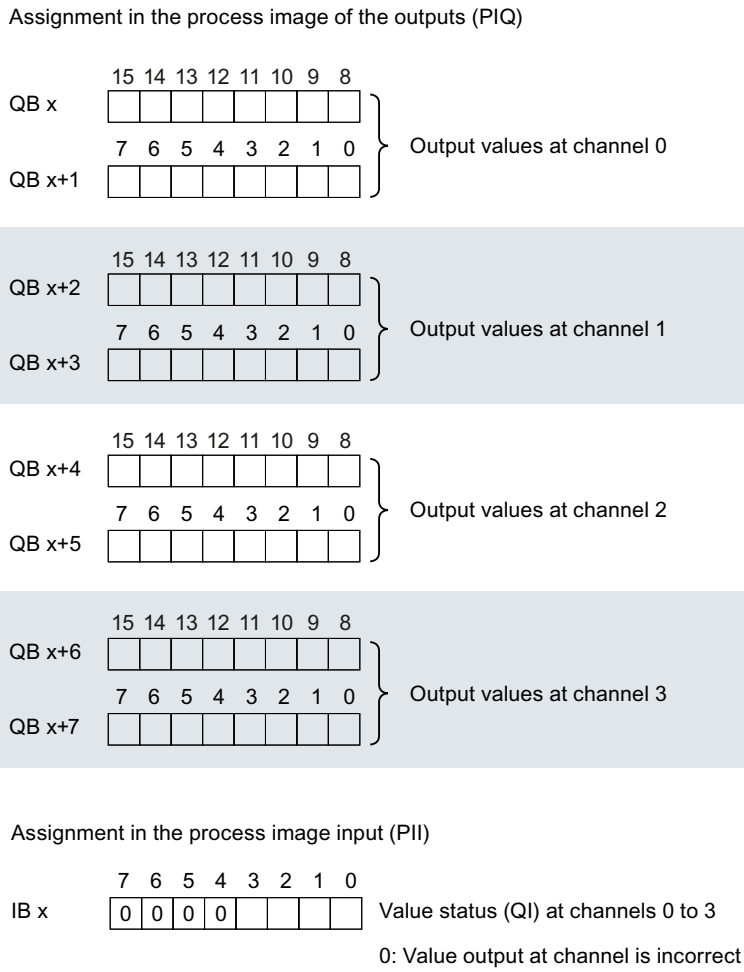

Figure 2-290 Address space for configuration as 1 x 4-channel DQ 4×24..230VAC/2A HF PC V1.0 with value status

4.3 Interrupts/diagnostics alarms

4.3.1 Status and fault displays

LED display

The following figure shows you the LED display of the DQ 4×24..230VAC/2A HF.

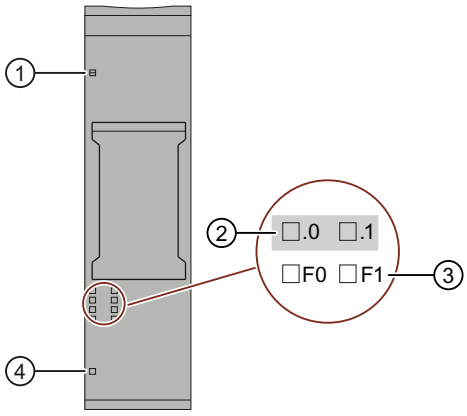

① DIAG (green/red)
② Channel status (green)
③ Channel error (red)
④ PWR (green)

Figure 2-291 LED displays

Meaning of the LEDs

The following tables explain the meaning of the status and error displays.

DIAG LED

Table 2-308 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module/channel diagnostics
Flashes	Module parameters assigned and module/channel diagnostics

LED channel status/channel error

Table 2-309 Status / error display of the LED channel status / channel error

Channel status LED	LED channel error	Meaning
□ Off	□ Off	Channel deactivated or process signal = 0 and no channel diagnostics
■ On	□ Off	Channel activated and process signal = 1 and no channel diagnostics
□ Off	■ On	Channel activated and channel diagnostics

PWR LED

Table 2-310 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L
■ On	Supply voltage L present

4.3.2 Interrupts

The digital output module DQ 4x24...230VAC/2A HF supports diagnostic interrupts.

Diagnostics interrupts

In PC mode, the module generates a diagnostic interrupt for the following events:

- Overtemperature
- Wire break
- High limit violated
- Parameter assignment error
- Supply voltage missing
- Channel/component temporarily unavailable

Detailed information on the event is available in the STEP 7 online help.

4.3.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.
In PC mode, the module outputs the following diagnostic alarms:

Table 2-311 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarms	Error code	Meaning	Solution
Overtemperature	5_H	• Short-circuit or overload at the digital outputs • Ambient temperature outside the specification	• Correct the process wiring • Improve cooling • Check controlled loads
Wire break	6_H	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, for example, use cables with larger cross-section
		Wirebreak between the module and actuator	Connect the cable
		Channel not connected (open)	Disable diagnostics
High limit violated	7_H	The permitted value range of the process value is exceeded.	Correct the output value (0 to 1000)
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	No or insufficient supply voltage L	• Check supply voltage L at the BaseUnit • Check BaseUnit type
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

Technical specifications

5

Technical specifications of the DQ 4×24...230VAC/2A HF

Article number	6ES7132-6FD00-0CU0
General information	
Product type designation	DQ 4x24 ... 230 V AC/2 A HF, PU 1
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type U0
Color code for module-specific color identification plate	CC20
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V14
• STEP 7 configurable/integrated as of version	STEP 7 V5.5 or higher
• PROFIBUS as of GSD version/GSD revision	GSD as of Revision 5
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DQ	Yes
• DQ with energy-saving function	Yes
• PWM	No
• Oversampling	No
• MSO	No
• Phase control	Yes; Control area: 8.5 ... 100% of the phase angle
• Trailing-edge phase	No
• Half-wave	Yes
• Full-wave	Yes
Supply voltage	
Rated value (AC)	230 V; 47 ... 63 Hz, max. rate of change of frequency 1 mHz/s
Input current	
Current consumption (rated value)	8 mA; without load
Output voltage	
Rated value (AC)	230 V; 24V AC to 230V AC

Article number	6ES7132-6FD00-0CU0
Power loss	
Power loss, typ.	9 W; Active power, load voltage 230 V, all outputs loaded with 2 A, 50 Hz
Address area	
Address space per module	
• Inputs	+ 1 byte for QI information
• Outputs	8 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type U0
• 2-wire connection	BU type U0
• 3-wire connection	BU type U0 + Potential isolation module
Digital outputs	
Number of digital outputs	4
Current-sinking	No
Current-sourcing	Yes
Short-circuit protection	No; external fusing necessary
Open-circuit detection	Yes; channel by channel
• Response threshold, typ.	1 mA; 40 V AC or more
Overload protection	No; A miniature fuse with 10 tripping current and tripping characteristic "quick response" must be provided in the module supply
Controlling a digital input	Yes
Switching capacity of the outputs	
• with resistive load, max.	2 A; Max. 4 A, see additional description in manual
• with inductive load, max.	2 A
• on lamp load, max.	100 W; Tungsten rating in accordance with UL; for thermistors with higher power ratings, see the notes in the manual
Output voltage	
• for signal "1", min.	20.4 V
Output current	
• for signal "1" rated value	2 A
• for signal "1" permissible range, min.	10 mA
• for signal "1" permissible range, max.	4 A; Note derating data in the manual
• for signal "0" residual current, max.	3 mA
Output delay with resistive load	
• "0" to "1", max.	40 ms; 2 AC cycles
• "1" to "0", max.	20 ms; 1 AC cycle

Article number	6ES7132-6FD00-0CU0
Parallel switching of two outputs	
• for logic links	No
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	10 Hz; Applies to DQ mode; limited by line frequency in PC mode
• with inductive load (acc. to IEC 60947-5-1, AC15), max.	10 Hz; Applies to DQ mode; limited by line frequency in PC mode
• on lamp load, max.	1 Hz; Applies to DQ mode; limited by line frequency in PC mode
Total current of the outputs	
• Current per channel, max.	2 A; Max. 4 A, see additional description in manual
• Current per module, max.	8 A
Total current of the outputs (per module)	
horizontal installation	
– up to 40 °C, max.	8 A; Applicable for current channels up to 2 A. For current channels between 2 A and 4 A, note derating data in the manual
– up to 50 °C, max.	8 A; Applicable for current channels up to 2 A. For current channels between 2 A and 4 A, note derating data in the manual
– up to 60 °C, max.	8 A; Applicable for current channels up to 2 A. For current channels between 2 A and 4 A, note derating data in the manual
vertical installation	
– up to 30 °C, max.	8 A; Applicable for current channels up to 2 A. For current channels between 2 A and 4 A, note derating data in the manual
– up to 40 °C, max.	8 A; Applicable for current channels up to 2 A. For current channels between 2 A and 4 A, note derating data in the manual
– up to 50 °C, max.	8 A; Applicable for current channels up to 2 A. For current channels between 2 A and 4 A, note derating data in the manual
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes

Article number	6ES7132-6FD00-0CU0
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
• Wire-break	Yes; channel by channel
• Short-circuit	No
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	Yes; red Fn LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	2 545 V DC/2 s (routine test)
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	50 g

Derating

The figures below show the maximum permissible total current for the derating, depending on the ambient temperature for horizontal and vertical mounting position, with channel currents of 2 A or 4 A.
The following values apply to channel currents up to 2 A for the utilization category AC-15 (IEC 60947-5-1).

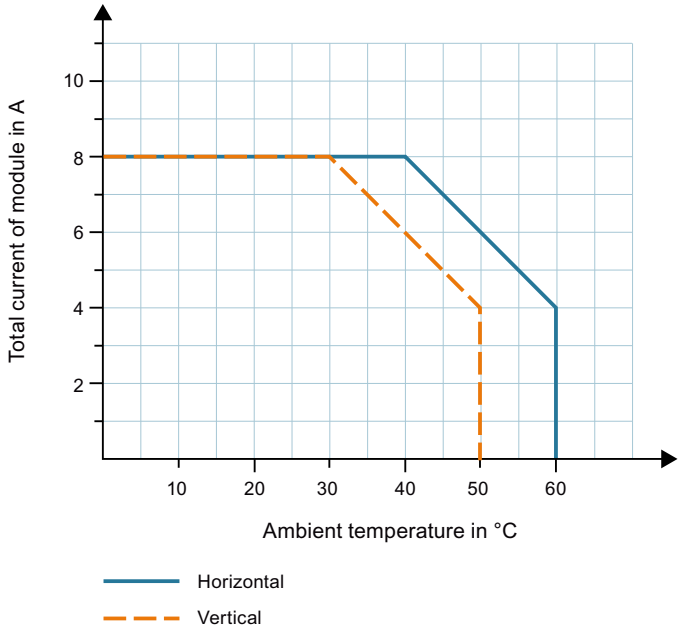

Figure 2-292 Derating depending on ambient temperature - channel current 2 A

The following values apply to channel currents of 2 A to 4 A for the utilization category AC-12 (IEC 60947-5-1):

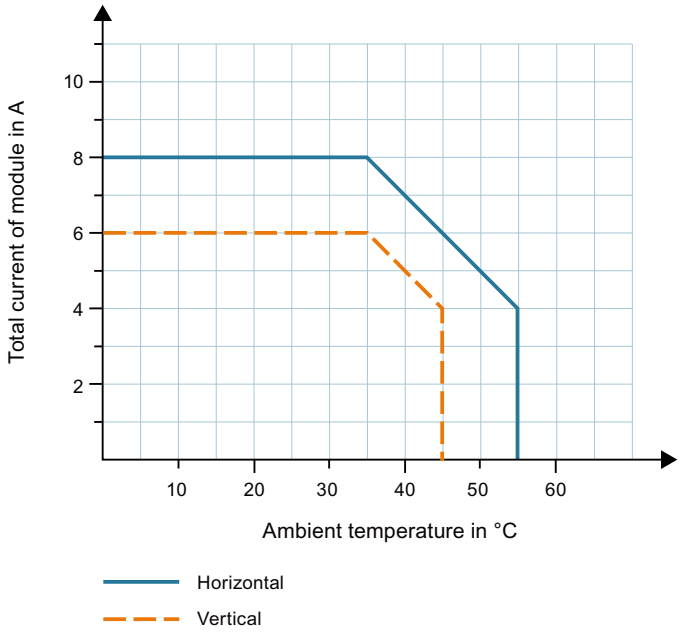

Figure 2-293 Derating depending on ambient temperature - channel current 4 A

Note that the rms values are in effect for the channel and total currents.

NOTE

Loads with PTC thermistor properties

For PTC thermistors up to 4 A continuous current and power ratings above 100 W (e.g. infrared sources), you must observe the significantly higher inrush current.

Ensure that the switch-on peak current does not exceed 15 A.

To reduce the inrush current, preheat the load or use the function "Output filter with phase control".
This slowly increases the switch-on duration of the load and the inrush current of the load being heated is limited.
Use an output filter time of 5 s or a preheating with 25 ° phase control, for example, for a PTC thermistor with a power rating of 900 W and an estimated factor 10 of the inrush current overshoot.

If you want to connect multiple PTC thermistors per module at the same time, use the "Startup delay" function.
By doing so, you connect the channels at different times so that the inrush current overshoots do not overlap and the fuse is not overloaded.

Electromagnetic compatibility

The control of loads in the control types phase control power-proportional or phase-angle proportional results in strong electromagnetic effects on the power supply network.
To observe the limits in accordance with EMC Directives, you must filter the load supply of the module with phase control in PC mode or when using the function "Output filter with phase control" in DQ mode.
Conformity was measured with filters of the type "EPCOS SIFI-C B84113C". Use this type of filter or a filter with the same characteristic curve or with a characteristic curve with greater damping.
You must ensure conformity with the values in the tables below.

Interference emission in accordance with EN 61000-6-4:2007 + A1:2011 and IEC 61131-2:

Table 2-312 Interference emission of electromagnetic fields

Frequency	Interference emission
Test environment OATS or SAC (measured at a distance of 10 m) • 30 MHz to 230 MHz • 230 MHz to 1000 MHz	 • <40 dB (µV/m) Q • <47 dB (µV/m) Q
Test environment FAR (measured at a distance of 3 m) • 30 MHz to 230 MHz • 230 MHz to 1000 MHz	 • 45 to 52 dB (µV/m) Q • <52 dB (µV/m) Q
Test environment OATS, SAC or FAR (measured at a distance of 3 m) • 1 GHz to 3 GHz • 3 GHz to 6 GHz	 • <76 dB (µV/m) P / <56 dB (µV/m) M • <80 dB (µV/m) P / <60 dB (µV/m) M

Table 2-313 Interference emission via the AC power supply

Frequency	Interference emission
0.15 MHz to 0.5 MHz	<79 dB (µV/m) Q <66 dB (µV/m) M
0.5 MHz to 30 MHz	<73 dB (µV/m) Q <60 dB (µV/m) M

Dimension drawing

See the manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You have the option to re-configure the module in RUN (e.g. the response of selected channels to the CPU STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

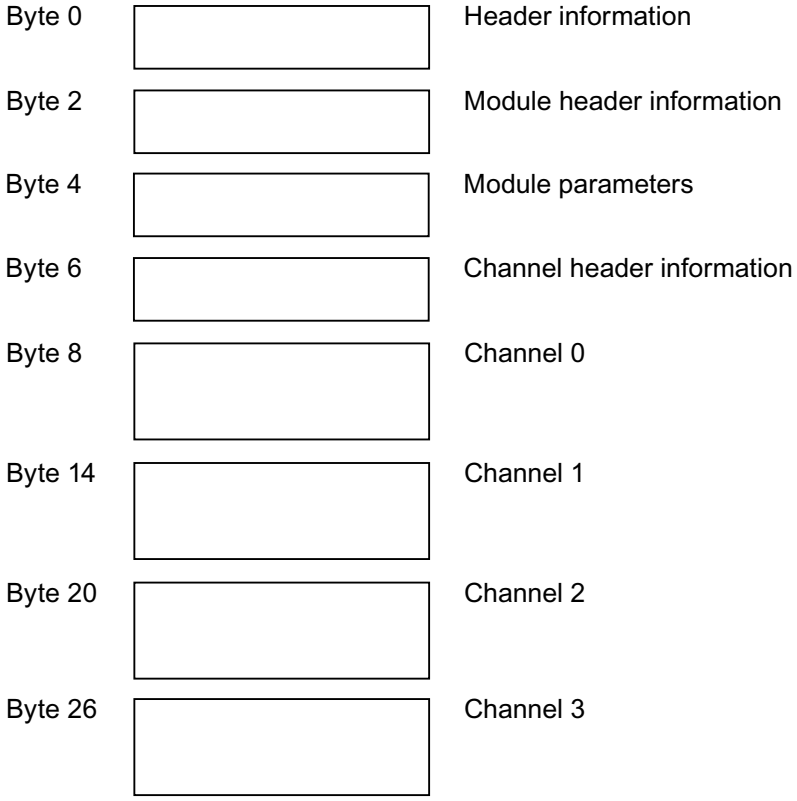

Figure 2-294 Structure of data record 128

Header information

The figure below shows the structure of the header information.

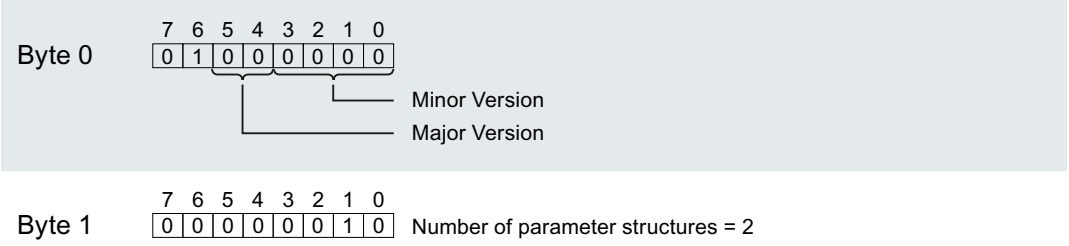

Figure 2-295 Header information

Module header information

The figure below shows the structure of the module header information.

	7	6	5	4	3	2	1	0	
Byte 2	0	0	0	0	0	0	0	1	Number of module parameter blocks = 1
Byte 3	0	0	0	0	0	0	1	0	Length of the module parameter block = 2

Figure 2-296 Module header information

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 to 7. You enable a parameter by setting the corresponding bit to "1".

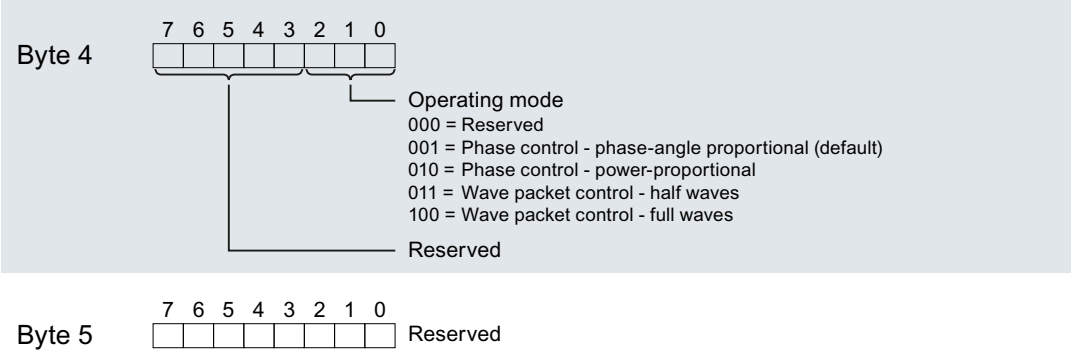

Figure 2-297 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

	7	6	5	4	3	2	1	0	
Byte 6	0	0	0	0	0	1	0	0	Number of channel parameter blocks = 4
Byte 7	0	0	0	0	0	1	1	0	Length of the channel parameter block = 6

Figure 2-298 Channel header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You enable a parameter by setting the corresponding bit to "1".

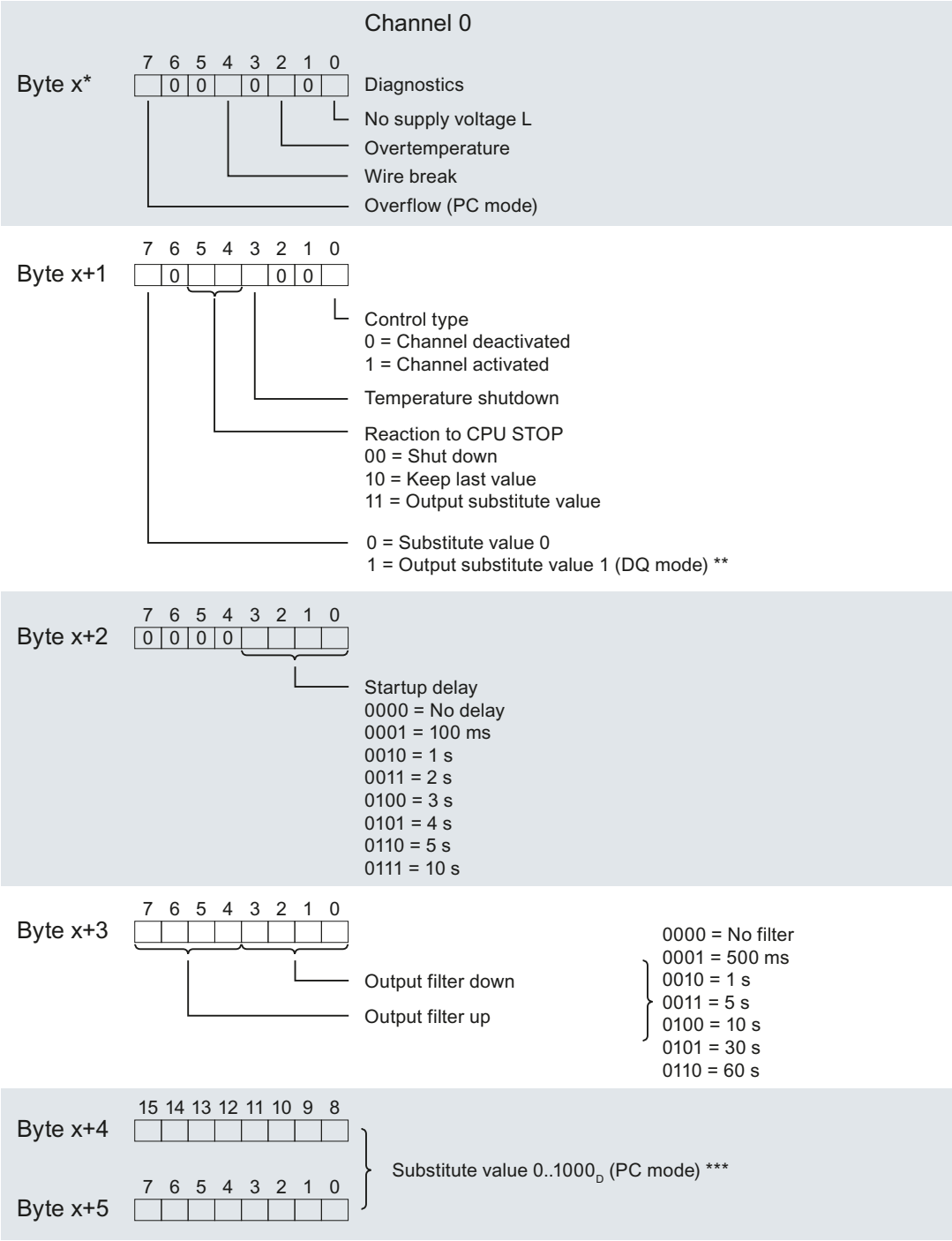

* x = 8 + (channel number × 6); channel number = 0 to 3
** is ignored in PC mode
*** is ignored in DQ mode

Figure 2-299 Structure byte x up to x+5 for the channel 0 to 3

A.2 Error transferring the data record DQ

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter. (See also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	01	At least one reserved bit is set to "1".	Set all reserved bits to "0".
DF	80	E1	02	Overflow diagnostics is enabled even though DQ mode is active.	Block all Overflow diagnostics or switch to PC mode.
DF	80	E1	05	Invalid coding for operating mode.	Check module parameters.
DF	80	E1	06	Invalid coding for substitute value behavior.	Check all channel parameters.
DF	80	E1	20	Invalid coding for startup delay.	Check all channel parameters.
DF	80	E1	21	Invalid coding for output filter up or down.	Check all channel parameters.

SIEMENS

SIMATIC

ET 200SP
Digital output module DQ 8x24VDC/0.5A BA (6ES7132-6BF01-0AA0)

Equipment Manual

ET 200SP Documentation Guide 1

Product overview 2

Wiring 3

Parameters/address space 4

Interrupts/diagnostics alarms 5

Technical specifications 6

Parameter data record A

02/2019
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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

Technical specifications: Ambient temperature in horizontal and vertical mounting position, extended to min. -30 °C.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

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To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit.

See also

IndustrialSecurity (http://www.siemens.com/industrialsecurity)

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A.1 Parameter assignment and structure of the parameter data record 23

ET 200SP Documentation Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

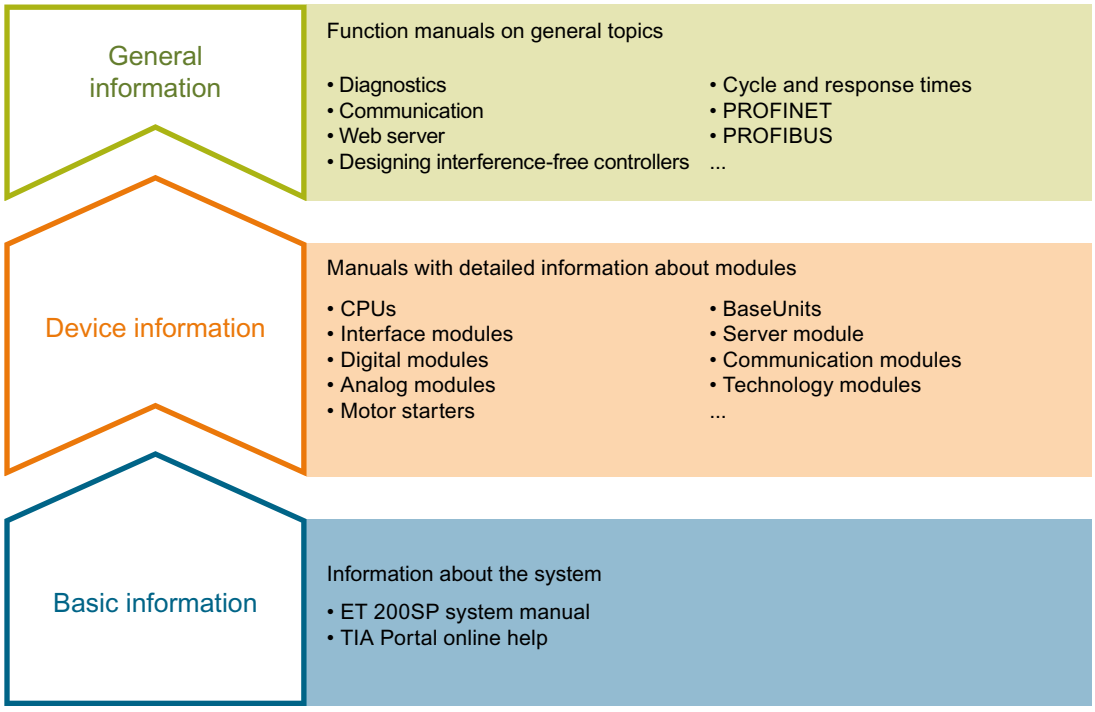

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

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You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

Product overview

2

2.1 Properties

Article number

6ES7132-6BF01-0AA0 (number in package unit: 1 unit)
6ES7132-6BF01-2AA0 (number in package unit: 10 units)

View of the module

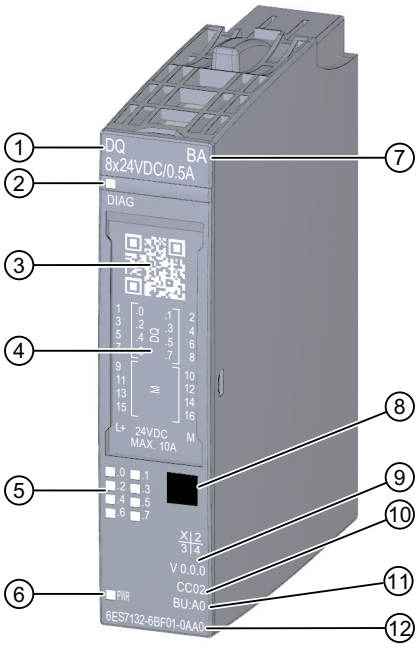

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-300 View of the module DQ 8×24VDC/0.5A BA

Properties

The module has the following technical properties:

- Digital output module with 8 outputs
- Supply voltage L+
- Output current 0.5 A (per channel)
- Source output (PNP, P-switching)
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Safety-related shutdown

The module supports the following functions:

Table 2-314 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0230 V7.0	X	X
Configuration in RUN	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0230 V7.0	X	X

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the system manual Distributed I/O System ET 200SP (https://support.automation.siemens.com/WW/view/en/58649293).

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the DQ 8x24VDC/0.5A BA module with the terminal assignments for a 1-wire, 2-wire and 3-wire connection.

You can use and combine the different wiring options for all channels.

You can find information on wiring the BaseUnit in the system manual Distributed I/O System ET 200SP (https://support.automation.siemens.com/WW/view/en/58649293).

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

NOTE

Cross circuit at output

Be aware that voltage from a cross-circuit at the output can feed L+ to modules.

Wiring: 1 and 2-wire connection of actuators

The following figure shows an example of the terminal assignment of the digital output module DQ 8×24VDC/0.5A BA on the BaseUnit BU type A0 without AUX terminals (1- and 2-wire connection).

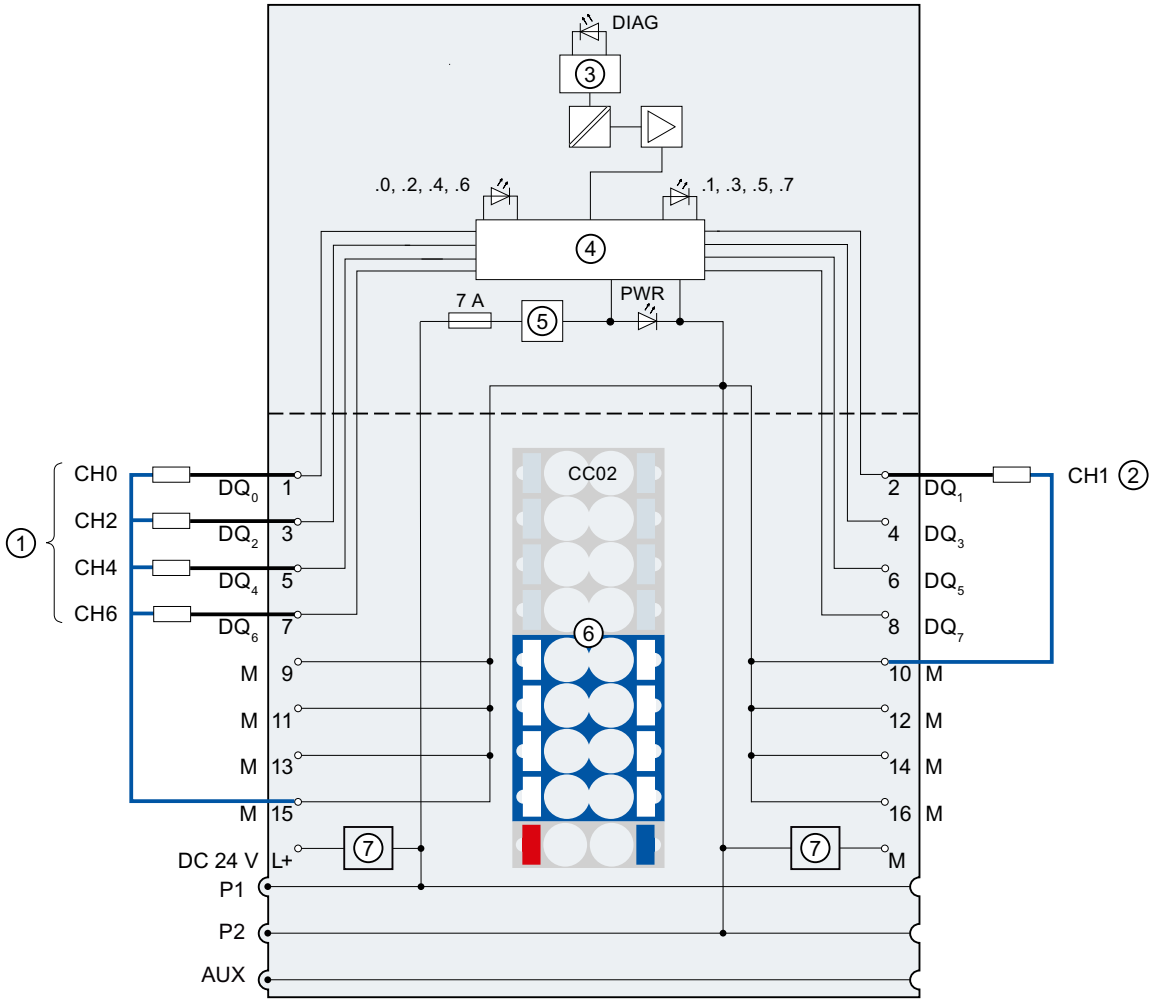

①	1-wire connection	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
②	2-wire connection	M	Ground
③	Backplane bus interface	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
④	Output electronics	DQ_n	Output signal, channel n
⑤	Polarity reversal protection	DIAG	Error or diagnostics LED (green, red)
⑥	Color-coded label with color code CC02 (optional)	.0 to .7	Channel status LED (green)
⑦	Filter connection supply voltage (only when light-colored BaseUnit is present)	PWR	Power LED (green)

Figure 2-301 Block diagram and terminal assignment for 1- and 2-wire connection of actuators

Wiring: 3-wire connection of actuators

The following figure shows an example of the terminal assignment of the digital output module DQ 8×24VDC/0.5A BA on the BaseUnit BU type A0 with AUX terminals (3-wire connection).

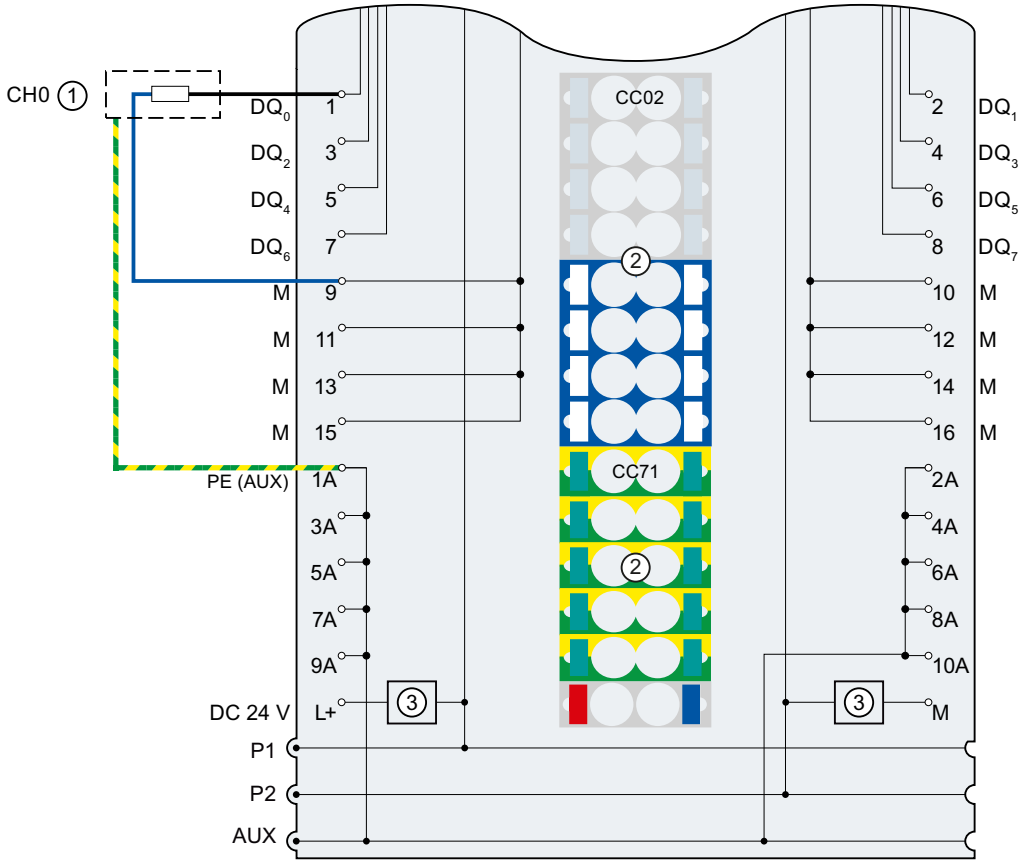

①	3-wire connection	1 A to 10 A	AUX terminals
②	Color-coded labels with color codes CC02 and CC71 (optional)	PE (AUX)	Protective conductor connection
③	Filter connection supply voltage (only when light-colored BaseUnit is present)	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
DQ_n	Output signal, channel n	M	Ground
		P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)

Figure 2-302 Terminal assignment for 3-wire connection of actuators

Parameters/address space 4

4.1 Parameters

Parameters for DQ 8x24VDC/0.5A BA

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records, see section Parameter assignment and structure of parameter data record (Page 23).

The following parameter settings are possible:

Table 2-315 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 4 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter data record".

4.2 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Channel activated

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

ET 200SP distributed I/O system
(https://support.automation.siemens.com/WW/view/en/58649293)

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of DQ 8x24VDC 0.5A BA

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module using a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-316 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in hard-ware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DQ 8x24VDC 0.5A BA V0.0	V14, SP1 or higher with HSP 0222	X	X

Address space of the digital output module DQ 8x24VDC 0.5A BA

The figure below shows the assignment of the address space for DQ 8x24VDC/0.5A BA

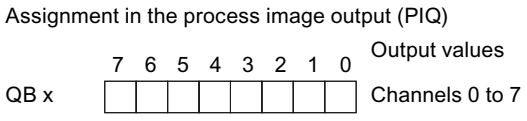

Figure 2-303 Address space of DQ 8x24VDC/0.5A BA

Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

DQ 8x24VDC/0.5A BA.

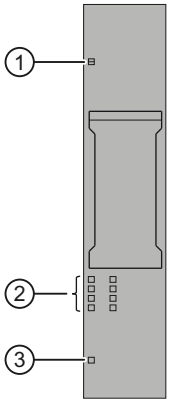

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-304 LED display

Meaning of the LEDs

The following tables show the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 17).

DIAG LED

Table 2-317 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module diagnostics is available

Channel status LED

Table 2-318 Status display of the channel status LED

Channel status LED	Meaning
Off	Channel deactivated or activated and process signal = 0
On	Channel activated and process signal = 1

PWR LED

Table 2-319 Status display of the PWR LED

PWR LED	Meaning
Off	Missing supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The DQ 8×24VDC/0.5A BA digital output module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Parameter assignment error
- Supply voltage missing

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-320 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications 6

6.1 Technical specifications

Technical specifications of the DQ 8x24VDC/0.5A BA

The following table shows the technical specifications as of 02/2019. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7132-6BF01-0AA0/td?dl=en).

Article number	6ES7132-6BF01-0AA0
General information	
Product type designation	DQ 8x 24 V DC/0.5 A BA, PU 1
HW functional status	From FS02
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC02
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V14
• STEP 7 configurable/integrated as of version	V5.5 SP3
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DQ	Yes
• DQ with energy-saving function	No
• PWM	No
• Oversampling	No
• MSO	No
Redundancy	
• Redundancy capability	Yes

Article number	6ES7132-6BF01-0AA0
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	45 mA; without load
Output voltage	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1 W
Address area	
Address space per module	
• Address space per module, max.	1 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0
• 3-wire connection	BU type A0 with AUX terminals or potential distributor module
• 4-wire connection	BU type A0 + Potential isolation module
Digital outputs	
Type of digital output	Source output (PNP, current-sourcing)
Number of digital outputs	8
Current-sourcing	Yes
Short-circuit protection	Yes; per channel, electronic
• Response threshold, typ.	1 A
Limitation of inductive shutdown voltage to	Typ. L+ (-50 V)
Controlling a digital input	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A
• on lamp load, max.	5 W
Load resistance range	
• lower limit	48 Ω
• upper limit	100 kΩ
Output current	
• for signal "1" rated value	0.5 A
• for signal "1" permissible range, max.	0.5 A
• for signal "0" residual current, max.	10 µA

Article number	6ES7132-6BF01-0AA0
Output delay with resistive load	
• "0" to "1", max.	100 µs; at rated load
• "1" to "0", max.	150 µs; at rated load
Parallel switching of two outputs	
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	100 Hz
• with inductive load, max.	2 Hz
• on lamp load, max.	10 Hz
Total current of the outputs	
• Current per channel, max.	0.5 A
• Current per module, max.	4 A
Total current of the outputs (per module)	
horizontal installation	
– up to 30 °C, max.	4 A
– up to 40 °C, max.	4 A
– up to 50 °C, max.	4 A
– up to 60 °C, max.	4 A
vertical installation	
– up to 30 °C, max.	4 A
– up to 40 °C, max.	4 A
– up to 50 °C, max.	4 A
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	No
• Short-circuit	No
• Group error	Yes

Article number	6ES7132-6BF01-0AA0
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety-related tripping of standard modules	Yes; From FS01
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PL d
• SIL acc. to IEC 61508	SIL 2
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

Safety-related shutdown

NOTE

The digital output module DQ 8x24VDC/0.5A BA supports safety-related shutdown in connection with a fail-safe power module F-PM-E 24VDC/8A PPM ST:

- SIL according to IEC 61508: 2
- Highest attainable safety class in safety mode, performance level according to EN ISO 13849-1: d

Dimension drawing

See the manual ET 200SP BaseUnits (https://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You have the option to reconfigure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

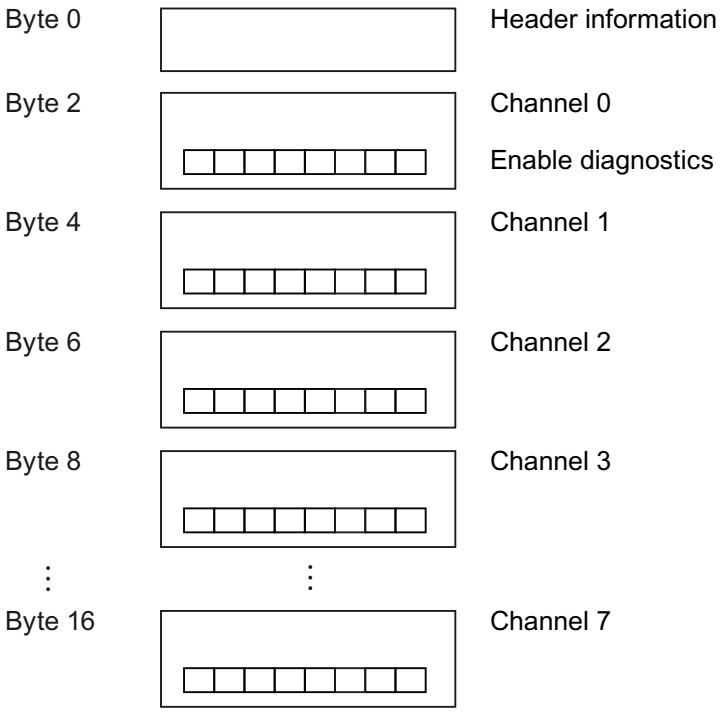

Figure 2-305 Structure of data record 128

Header information

The figure below shows the structure of the header information.

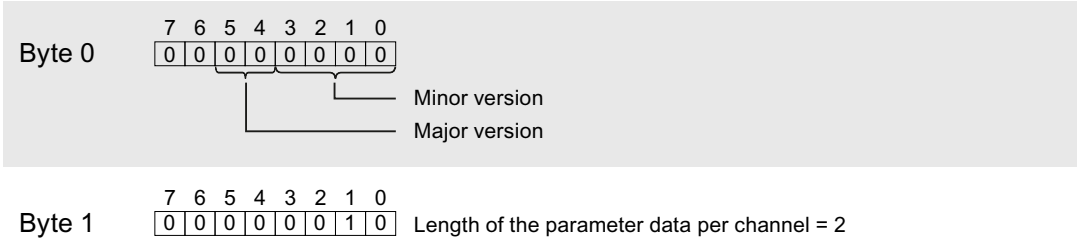

Figure 2-306 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

You enable a parameter by setting the corresponding bit to "1".

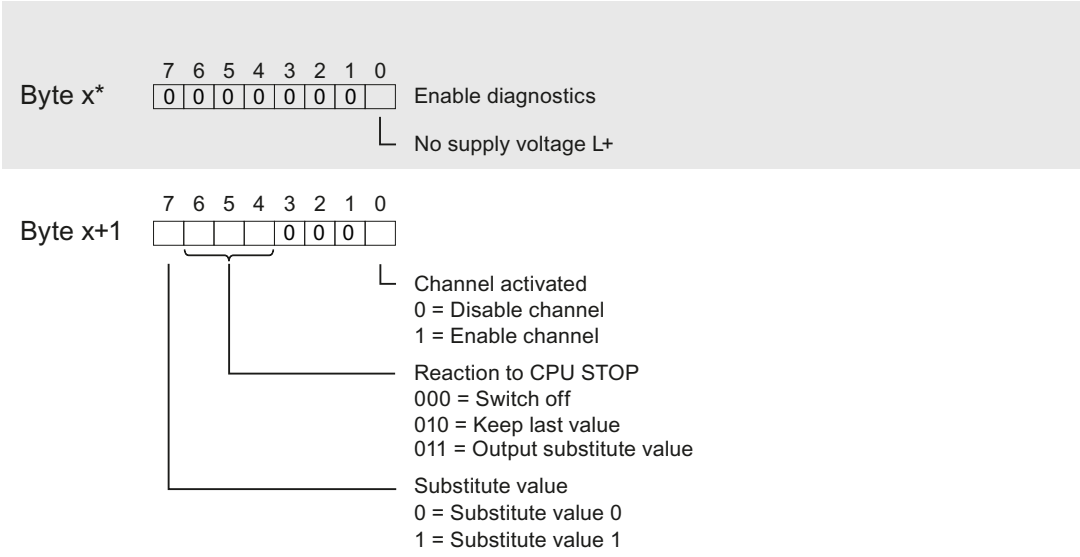

* x = 2 + (channel number × 2); channel number = 0 to 7

Figure 2-307 Structure byte x to x+1 for the channels 0 to 7

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter. (See also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	06	Invalid coding for substitute value behavior.	Check the parameters of the module.

SIEMENS

SIMATIC

ET 200SP
Digital output module DQ 8x24VDC/0.5A ST (6ES7132-6BF01-0BA0)

Equipment Manual

Documentation guide 1

Product overview 2

Wiring up 3

Parameters/address space 4

Interrupts/diagnostics alarms 5

Technical specifications 6

Parameter data record A

02/2019
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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

Technical specifications: Ambient temperature in horizontal and vertical mounting position, extended to min. -30 °C.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

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Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (http://www.siemens.com/industrialsecurity).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

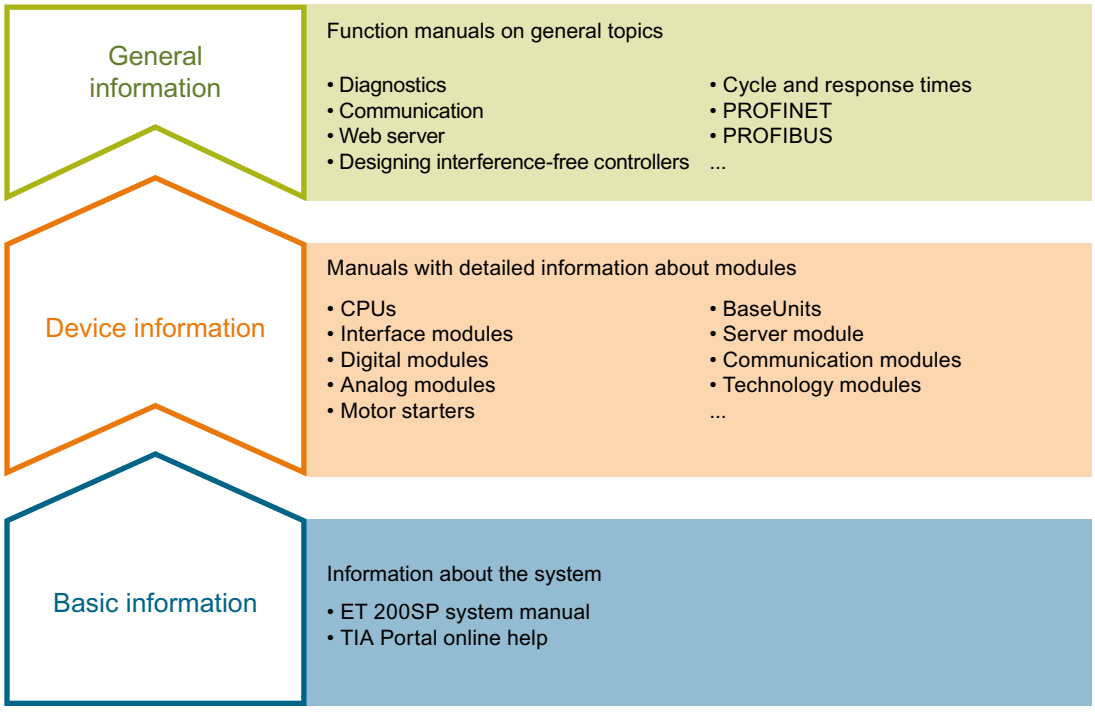

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7132-6BF01-0BA0 (number in package unit: 1 unit)
6ES7132-6BF01-2BA0 (number in package unit: 10 units)

View of the module

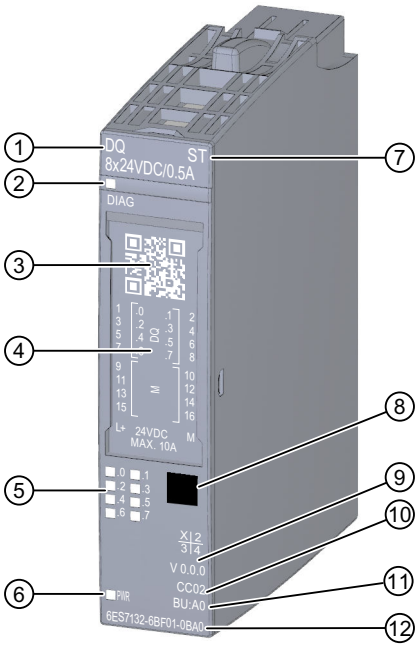

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-308 View of the module DQ 8×24VDC/0.5A ST

Properties

The module has the following technical properties:

- Digital output module with 8 outputs
- Supply voltage L+
- Output current 0.5 A per channel
- Source output (PNP)
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Safety-related shutdown

The module supports the following functions:

Table 2-321 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0230 V7.0	X	X
Configuration in RUN	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0230 V7.0	X	X
PROFIenergy	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0230 V7.0	X	X
Value status	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0230 V7.0	X	X

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring up

3

3.1 Wiring and block diagram

This section includes the block diagram of the DQ 8x24VDC/0.5A ST module with the terminal assignments for a 1-wire, 2-wire and 3-wire connection.

You can use and combine the different wiring options for all channels.

You can find information on wiring the BaseUnit in the system manual Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

NOTE

Cross circuit at output

Be aware that voltage from a cross-circuit at the output can feed L+ to modules.

Wiring: 1 and 2-wire connection of actuators

The following figure shows an example of the terminal assignment of the digital output module DQ 8×24VDC/0.5A ST on the BaseUnit BU type A0 without AUX terminals (1-wire and 2-wire connection).

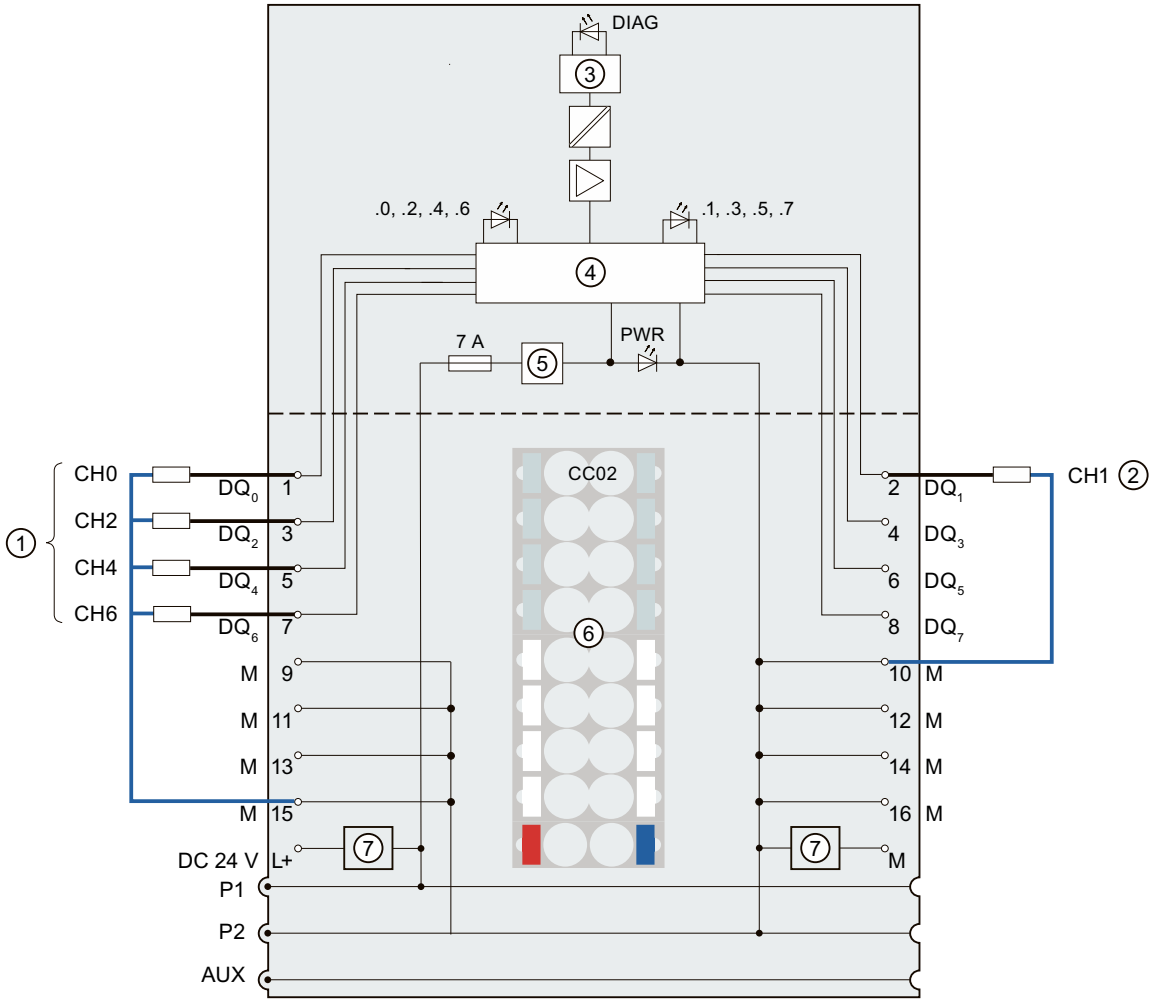

①	1-wire connection	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
②	2-wire connection	M	Ground
③	Backplane bus interface	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
④	Output electronics	DQ_n	Output signal, channel n
⑤	Polarity reversal protection	DIAG	Error or diagnostics LED (green, red)
⑥	Color-coded label with color code CC02 (optional)	.0 to .7	Channel status LED (green)
⑦	Filter connection supply voltage (only when light-colored BaseUnit is present)	PWR	Power LED (green)

Figure 2-309 Block diagram and terminal assignment for 1- and 2-wire connection of actuators

Wiring: 3-wire connection of actuators

The following figure shows an example of the terminal assignment of the digital output module DQ 8×24VDC/0.5A ST on the BaseUnit BU type A0 with AUX terminals (3-wire connection).

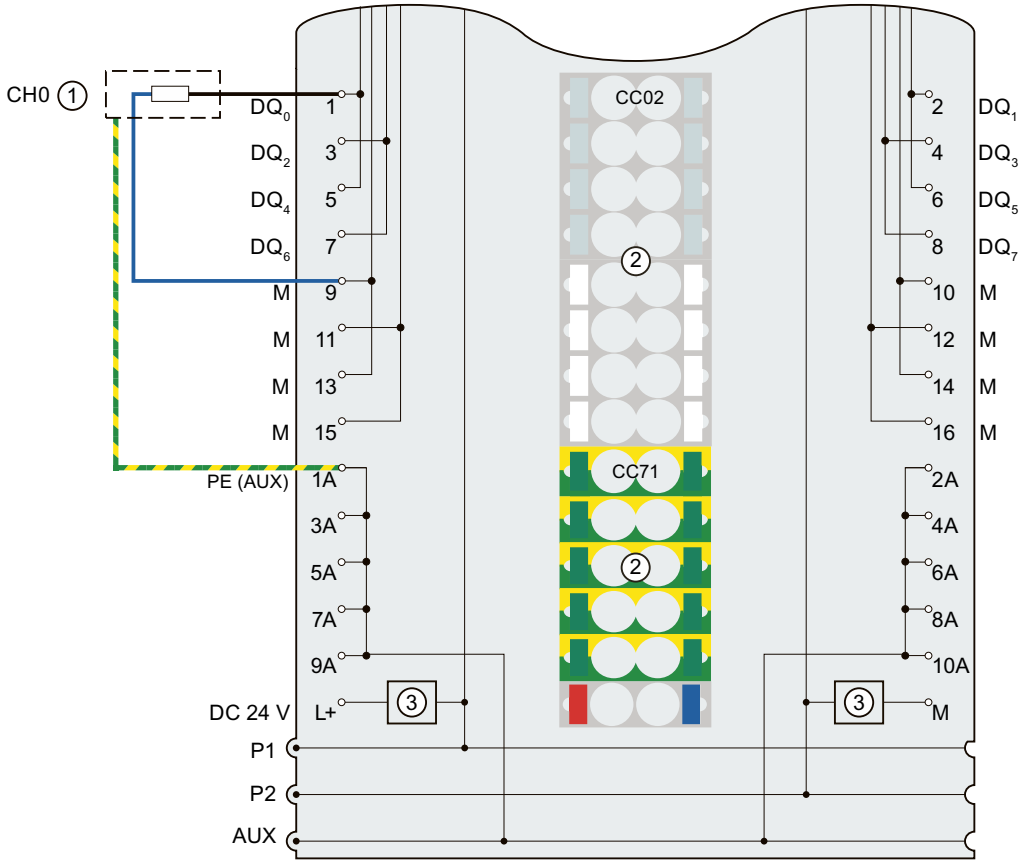

①	3-wire connection	1 A to 10 A	AUX terminals
②	Color-coded labels with color codes CC02 and CC71 (optional)	PE (AUX)	Protective conductor connection
③	Filter connection supply voltage (only when light-colored BaseUnit is present)	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
DQ_n	Output signal, channel n	M	Ground
		P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)

Figure 2-310 Terminal assignment for 3-wire connection of actuators

Parameters/address space 4

4.1 Parameters

Parameters for DQ 8x24VDC/0.5A ST

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records, see section Parameter assignment and structure of parameter data record (Page 26).

The following parameter settings are possible:

Table 2-322 Settable parameters and their defaults (GSD file)

Parameters	Value range	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Short-circuit to L+	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Wire break	• Disable • Enable	Disable	yes	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 4 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

Parameters	Value range	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Channel activated	• Disable • Enable	Enable	yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	no	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 4 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

NOTE

If both parameters "Diagnostics: short-circuit to L+" and "Diagnostics: wire break" are enabled and one of these diagnostic events occurs, the affected channel is switched off to avoid triggering an undefined load and the corresponding diagnostic alarm.

If both parameters "Diagnostics: short-circuit to L+" and "Diagnostics: wire break" are enabled and one of these diagnostic events occurs, the affected channel is switched off to avoid triggering an undefined load and the corresponding diagnostic alarm.

If the parameter "Diagnostics: short-circuit to L+" is enabled and "Diagnostics: wire break" is disabled, the signal status is retained at the affected channel when "Diagnostics: short-circuit to L+" occurs. A diagnostic alarm is triggered only for 0 signal.

4.2 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Diagnostics short-circuit to L+

Enabling of the diagnostics if a short-circuit of the actuator supply to L+ occurs.

Diagnostics wire break

Enabling of the diagnostics if the line to the actuator is broken.

The module responds to a wire break as follows:

- Disabled
  - Channel status LED lit green.
  - Output voltage present at channel.
- Enabled
  - Channel status LED is off.
  - Output is switched off.
  - In addition, the "Diagnostics: Wire break" is signaled and the DIAG LED on the module flashes.

NOTE

If one of the two parameters "Diagnostics: Short-circuit to L+" or "Diagnostics: Wire break" is enabled and one of these diagnostics occurs, the affected channel is switched off. This prevents undefined load switching and supports detection of a faulty channel for module diagnostics.

Channel activated

Determines whether a channel is enabled or disabled.

Reaction to CPU STOP

Specifies the behavior of the module if the CPU changes to STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of DQ 8x24VDC 0.5A ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module using a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-323 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in hardware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DQ 8x24VDC 0.5A ST V0.0	V14, SP1 or higher with HSP 0222	X	X
1 x 8-channel with value status	DQ 8x24VDC 0.5A ST V0.0, QI	V14, SP1 or higher with HSP 0222	X	---

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 7 in this byte are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the DQ 8×24VDC/0.5A ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

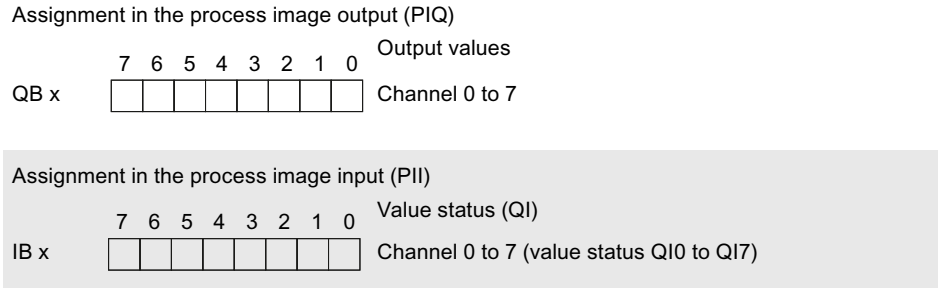

Figure 2-311 Address space of the DQ 8×24VDC/0.5A ST with value status

Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

DQ 8x24VDC/0.5A ST.

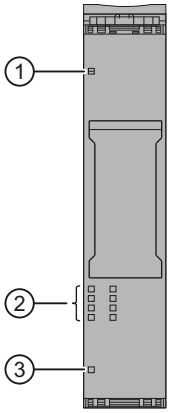

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-312 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 20).

DIAG LED

Table 2-324 DIAG LED fault/error display

DIAG LED	Meaning
☐ off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ on	Module parameters assigned
☼ Flashes	Module diagnostics is available

Channel status LED

Table 2-325 Status display of the channel status LED

Channel status LED	Meaning
☐ off	Channel deactivated or activated and process signal = 0
■ on	Channel activated and process signal = 1

PWR LED

Table 2-326 Status display of the PWR LED

PWR LED	Meaning
☐ off	No supply voltage L+
■ on	Supply voltage L+ present

5.2 Interrupts

The digital output module DQ 8x24...24VDC/0.5A ST supports diagnostic interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Short-circuit
- Wire break
- Parameter assignment error
- No supply voltage

5.3 Diagnostics alarms

A diagnostic alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-327 Diagnostics alarms, their meaning and how to deal with them

Diagnostics alarm	Error code	Meaning	Remedy
Short-circuit	1_H	• Short-circuit of actuator supply to ground • Short-circuit of actuator supply to L+	Correct the process wiring
Wire break	6_H	Actuator circuit impedance too high.	Use a different actuator type or wire differently, e.g. use cables with a larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor to the actuator contacts in the load resistance range
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications

6

6.1 Technical specifications

Technical specifications of the DQ 8x24VDC/0.5A ST

The following table shows the technical specifications as of 02/2019. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7132-6BF01-0BA0/td?dl=en).

Article number	6ES7132-6BF01-0BA0
General information	
Product type designation	DQ 8x24VDC/0.5A ST
HW functional status	From FS02
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC02
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V14
• STEP 7 configurable/integrated as of version	V5.5 SP3 or higher
• PCS 7 configurable/integrated as of version	V8.1 SP1
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DQ	Yes
• DQ with energy-saving function	No
• PWM	No
• Oversampling	No
• MSO	No
Redundancy	
• Redundancy capability	Yes

Article number	6ES7132-6BF01-0BA0
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	35 mA; without load
Output voltage	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1 W
Address area	
Address space per module	
• Address space per module, max.	1 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0
• 3-wire connection	BU type A0 with AUX terminals or potential distributor module
• 4-wire connection	BU type A0 + Potential isolation module
Digital outputs	
Type of digital output	Source output (PNP, current-sourcing)
Number of digital outputs	8
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes
• Response threshold, typ.	1 A
Limitation of inductive shutdown voltage to	Typ. L+ (-50 V)
Controlling a digital input	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A
• on lamp load, max.	5 W
Load resistance range	
• lower limit	48 Ω
• upper limit	12 kΩ
Output voltage	
• for signal "1", min.	L+ (-0.8 V)

Article number	6ES7132-6BF01-0BA0
Output current	
• for signal "1" rated value	0.5 A
• for signal "1" permissible range, max.	0.5 A
• for signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
• "0" to "1", max.	50 µs; at rated load
• "1" to "0", max.	100 µs; at rated load
Parallel switching of two outputs	
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	100 Hz
• with inductive load, max.	2 Hz
• on lamp load, max.	10 Hz
Total current of the outputs	
• Current per channel, max.	0.5 A
• Current per module, max.	4 A
Total current of the outputs (per module)	
horizontal installation	
– up to 30 °C, max.	4 A
– up to 40 °C, max.	4 A
– up to 50 °C, max.	4 A
– up to 60 °C, max.	4 A
vertical installation	
– up to 30 °C, max.	4 A
– up to 40 °C, max.	4 A
– up to 50 °C, max.	4 A
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes

Article number	6ES7132-6BF01-0BA0
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; Module-wise
• Short-circuit to M	Yes; Module-wise
• Short-circuit to L+	Yes; Module-wise
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Suitable for safety-related tripping of standard modules	Yes; From FS01
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PL d
• SIL acc. to IEC 61508	SIL 2
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m

Article number	6ES7132-6BF01-0BA0
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

Safety-related shutdown

NOTE

The digital output module DQ 8x24VDC/0.5A ST supports safety-related shutdown in connection with a fail-safe power module F-PM-E 24VDC/8A PPM ST:

- SIL according to IEC 61508: 2
- Highest attainable safety class in safety mode, performance level according to EN ISO 13849-1: d

Residual current for signal state "0"

NOTE

Residual current for signal state "0"

Due to the Diagnostics: Wire break function, there is a low level of residual current in the "0" signal state at the output, which may cause the display diodes to flicker.

This residual current does not depend on the setting for the Diagnostics: Wire break parameter.

Dimension drawing

See manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You have the option to reconfigure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 contains the diagnostics for the entire module.

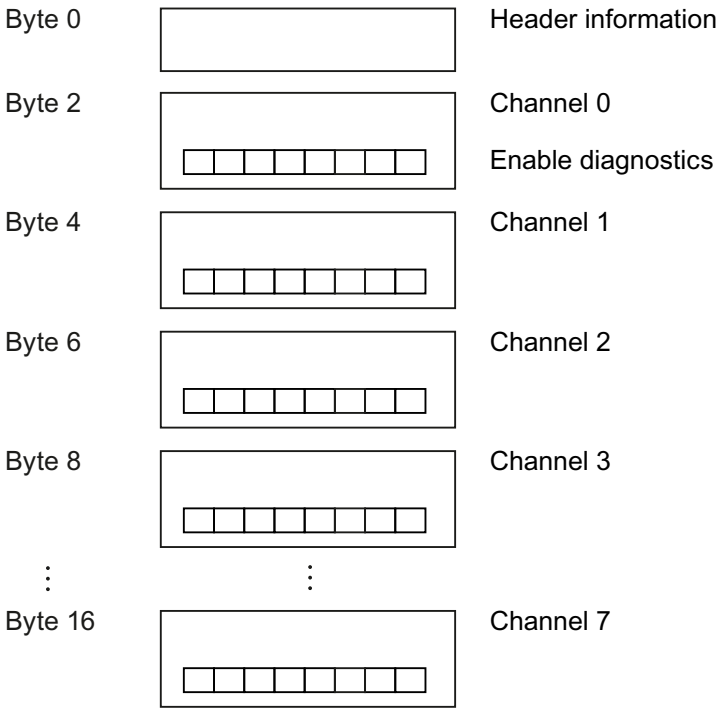

Figure 2-313 Structure of data record 128

Header information

The figure below shows the structure of the header information.

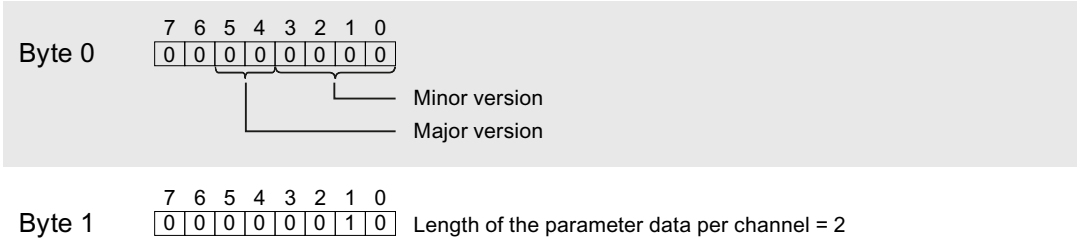

Figure 2-314 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

You enable a parameter by setting the corresponding bit to "1".

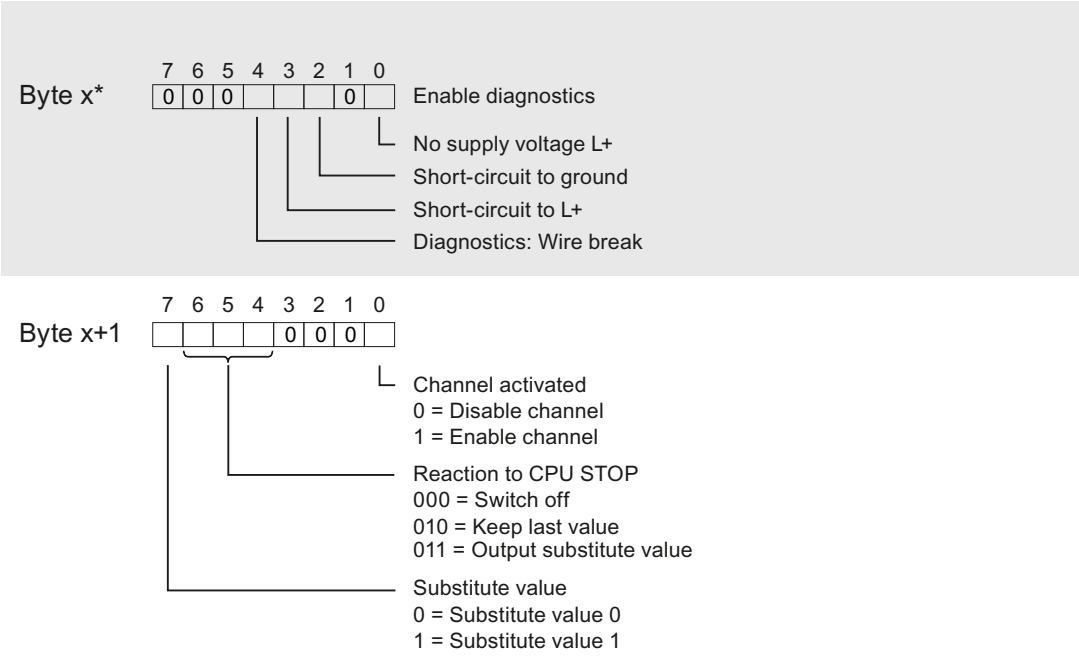

* x = 2 + (channel number × 2); channel number = 0 to 7

Figure 2-315 Structure byte x to x+1 for the channels 0 to 7

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter. (See also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	06	Invalid coding for substitute value behavior.	Check the parameters of the module.

SIEMENS

SIMATIC

ET 200SP
Digital output module DQ 8x24VDC/0.5A HF (6ES7132-6BF01-0CA0)

Equipment Manual

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Parameter data record A

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Introduction

1

Purpose of the documentation

This manual supplements the System Manual ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in the system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

Product overview

3

3.1 Properties

Article number

6ES7132-6BF01-0CA0 (packing unit: 1 unit)

6ES7132-6BF01-2CA0 (packing unit: 10 units)

View of the module

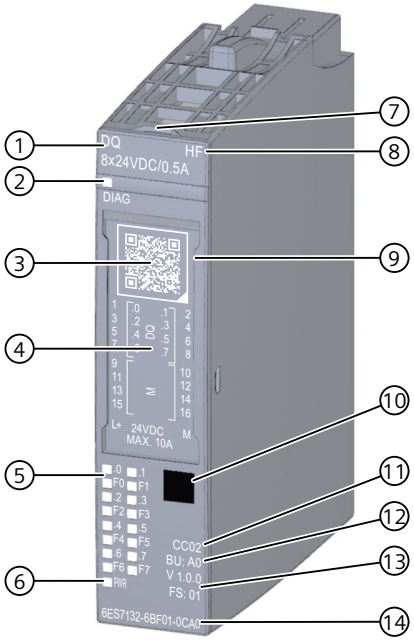

①	Module type and name	⑧	Function class
②	LED for diagnostics	⑨	Insertion option for optional labeling strip
③	QR code for identification link	⑩	Color coding module type
④	Wiring diagram	⑪	Color code for selecting the color-coded labels
⑤	LEDs for channel status and channel fault	⑫	BU type
⑥	LED for supply voltage	⑬	Firmware and function version
⑦	Slot for optional equipment labeling plate	⑭	Article number

Figure 2-316 View of module DQ 8×24VDC/0.5A HF

Properties

The module has the following technical properties:

- Digital output module with 8 outputs
- Source output (PNP, P-switching)
- Supply voltage L+
- Output current 0.5 A (per channel)
- Total current maximum 4 A

  See Technical specifications (Page 32)
- Configurable diagnostics (per channel)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Suitable for safety-related shutdown of standard modules
- Extended spare parts compatibility (see product information (https://support.industry.siemens.com/cs/ww/en/view/73021864))

The module supports the following functions:

Table 2-328 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V1.0.0 or higher	V19 or higher with HSP0428	V5.5 SP3 or higher with HSP 0230 from V11.0	X	X
Identification data I&M0 to I&M3	FS01	V1.0.0 or higher	V19 or higher with HSP0428	V5.5 SP3 or higher with HSP 0230 from V11.0	X	X
Parameter reassignment in RUN	FS01	V1.0.0 or higher	V19 or higher with HSP0428	V5.5 SP3 or higher with HSP 0230 from V11.0	X	X
PROFIenergy	FS01	V1.0.0 or higher	V19 or higher with HSP0428	V5.5 SP3 or higher with HSP 0230 from V11.0	X	-
Value status	FS01	V1.0.0 or higher	V19 or higher with HSP0428	V5.5 SP3 or higher with HSP 0230 from V11.0	X	X
Isochronous mode	FS01	V1.0.0 or higher	V19 or higher with HSP0428	V5.5 SP3 or higher with HSP 0230 from V11.0	X	-
Module-internal shared output (MSO)	FS01	V1.0.0 or higher	V19 or higher with HSP0428	V5.5 SP3 or higher with HSP 0230 from V11.0	X	-
Configurable submodules/submodules for shared devices	FS01	V1.0.0 or higher	V19 or higher with HSP0428	V5.5 SP3 or higher with HSP 0230 from V11.0	X	-

Accessories

The following accessories are available optionally:

- Labeling strips
- Color-coded labels
- Reference identification label
- Shield connection

See also

You can find more information on accessories in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Wiring

4

4.1 Wiring diagram

This section contains the pin assignment for the module.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) System Manual.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

NOTICE

You may only use the digital output module with a BaseUnit type A0.

With the BaseUnit type A1, the integrated fuse can be triggered, rendering the terminals unusable.

NOTE

Cross-circuit at output

Note that a voltage applied at the output due to a cross-circuit can lead to the modules being supplied with L+.

Pin assignment: 1 and 2-wire connection of actuators

The following table shows an example of the pin assignment of digital output module DQ 8×24VDC/0.5A HF on the BaseUnit BU type A0 without AUX terminals:

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Digital output, channel 0	DQ_0	1		2	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	3		4	DQ_3	Digital output, channel 3
Digital output, channel 4	DQ_4	5		6	DQ_5	Digital output, channel 5
Digital output, channel 6	DQ_6	7		8	DQ_7	Digital output, channel 7
Ground	M	9		10	M	Ground
Ground	M	11		12	M	Ground

1) Infeed only with light BaseUnit

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Ground	M	13	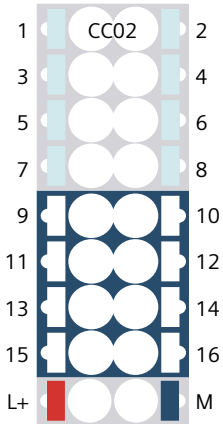	14	M	Ground
Ground	M	15		16	M	Ground
24 V DC supply voltage[1]	L+	17		18	M	Ground

[1] Infeed only with light BaseUnit

NOTICE
Current load of combined return conductors When connecting in 2-wire connection, the static current load of the combined return conductor must not exceed 2A per terminal.

Pin assignment: 3-wire connection of actuators

The following table shows an example of the pin assignment of digital output module DQ 8×24VDC/0.5A HF on the BaseUnit BU type A0 with AUX terminals.

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Digital output, channel 0	DQ_0	1		2	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	3		4	DQ_3	Digital output, channel 3
Digital output, channel 4	DQ_4	5		6	DQ_5	Digital output, channel 5
Digital output, channel 6	DQ_6	7		8	DQ_7	Digital output, channel 7
Ground	M	9		10	M	Ground
Ground	M	11		12	M	Ground
Ground	M	13		14	M	Ground
Ground	M	15		16	M	Ground
AUX terminal	AUX	1A		2A	AUX	AUX terminal
AUX terminal	AUX	3A		4A	AUX	AUX terminal
AUX terminal	AUX	5A		6A	AUX	AUX terminal

[1] Infeed only with light BaseUnit

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
AUX terminal	AUX	7A		8A	AUX	AUX terminal
AUX terminal	AUX	9A		10A	AUX	AUX terminal
24 V DC supply voltage[1]	L+	L+		M	M	Ground

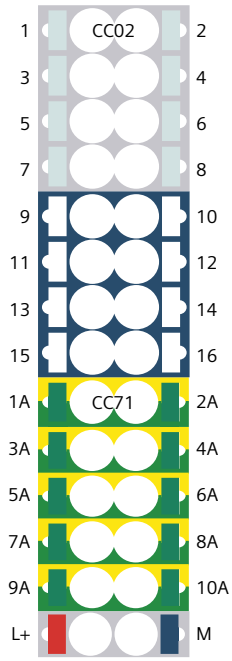

[1] Infeed only with light BaseUnit

Output connection types

1-wire connection of actuators	2-wire connection of actuators	3-wire connection of actuators
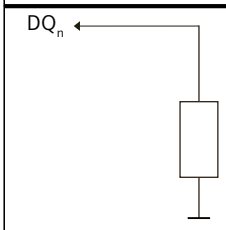	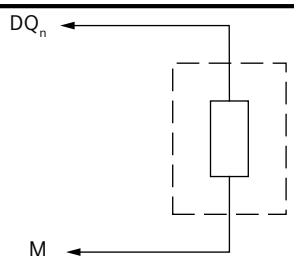	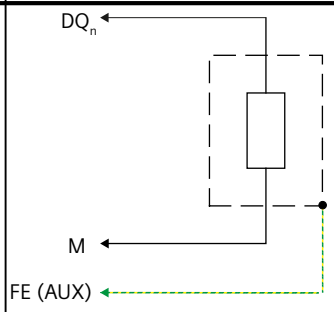

You can also connect the ground and functional grounding via a potential distribution module (PotDis module) or AUX terminals. More information on potential distribution modules is available in the BaseUnits Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/59753521).

NOTE

You can use and combine the different wiring options for all channels.

4.2 Block diagram

This section contains the schematic circuit diagram of the module.

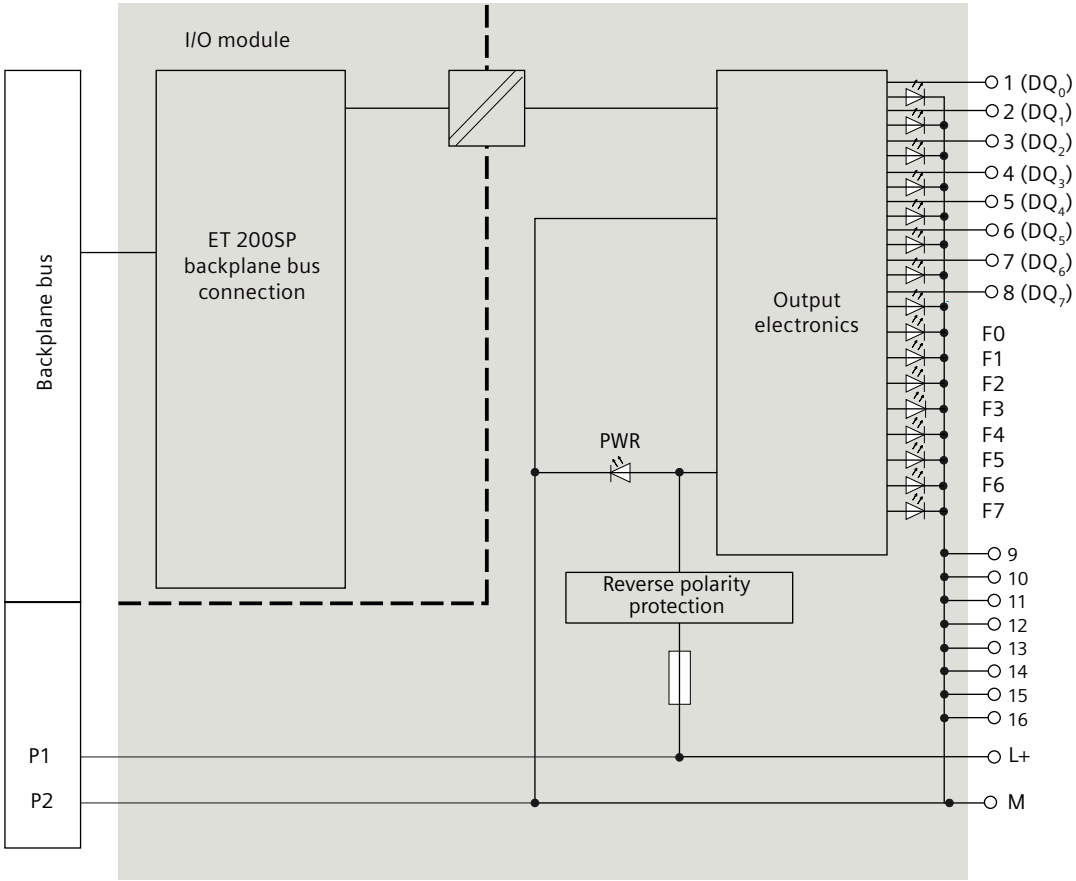

Figure 2-317 Schematic circuit diagram

Parameters/address space

5

5.1 Parameters

Parameters for DQ 8x24VDC/0.5A HF

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation on an ET 200SP-CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition to parameter assignment via the configuration software, you can also configure parameters in RUN mode (dynamically) via the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records. See the Parameter assignment and structure of the parameter data record (Page 38) section.

The following parameter settings are possible:

Table 2-329 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Parameter reassignment during RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel [1]
Diagnostics: Short-circuit to L+	• Disable • Enable	Disable	Yes	Channel	
Check for wire break	• Disable • Enable	Enable	Yes	Channel	Channel
Diagnostics Wire break	• Disable • Enable	Disable	Yes	Channel	Channel

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the possible parameter settings are restricted. The parameter length of the I/O module is 8 bytes for PROFIBUS GSD configuration. However, if necessary you can set these parameters using data records 64 to 71 or data record 128, see "Parameter data record" appendix.

Parameter	Value range	Default	Parameter reassignment during RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Channel enabled	• Disable • Enable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module [1]
Potential group	• Use the potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into a light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the possible parameter settings are restricted. The parameter length of the I/O module is 8 bytes for PROFIBUS GSD configuration. However, if necessary you can set these parameters using data records 64 to 71 or data record 128, see "Parameter data record" appendix.

NOTE

- If both parameters "Diagnostics: Short-circuit to L+" and "Diagnostics: Wire break" are enabled and one of these diagnostic events occurs, the affected channel is switched off. This prevents undefined load switching and the corresponding diagnostics alarm is triggered.
- If the parameter "Diagnostics: Wire break" is enabled and "Diagnostics: Short-circuit to L+" is disabled and a "Diagnostics: Wire break" is present, the affected channel is switched off. This prevents undefined load switching and the corresponding diagnostics alarm is triggered.
- If the parameter "Diagnostics: Short-circuit to L+" is enabled and "Diagnostics: Wire break" is disabled, the signal state is retained at the affected channel when "Diagnostics: Short-circuit to L+" occurs. A diagnostics alarm is triggered only for 0 signal.

5.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Diagnostics: Short-circuit to L+

Enabling of the diagnostics if a short-circuit of the actuator supply to L+ occurs.

Check for wire break

Specifies whether a check for wire break is carried out for the channel. Diagnostics: Wire break can only be reported if the check for wire break is enabled. If the check for wire break is disabled, the measuring current for the channel is also disabled.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken. If Diagnostics: Wire break is enabled, the "Check for wire break" parameter must also be enabled for the channel.

Channel enabled

Determines whether a channel is enabled or disabled.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group starts with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

Specify on which slot a light-colored BaseUnit with supply voltage feed or a dark-colored BaseUnit is located (see ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual).

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

The station setup must be completed with a server module.

5.3 Address space

The module can be configured differently in STEP 7; see the table below. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of DQ 8x24VDC/0.5A HF

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-330 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the STEP 7 hardware catalog from V19 with HSP0428	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DQ 8x24VDC/0.5A HF V1.0	X	X	X
1 x 8-channel with value status	DQ 8x24VDC/0.5A HF V1.0, QI	X	X	X
1 x 8-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 8x24VDC/0.5A HF V1.0, MSO	X	X	-
2 x 4-channel without value status	DQ 8x24VDC/0.5A HF V1.0, S.2	X	X	-
2 x 4-channel with value status	DQ 8x24VDC/0.5A HF V1.0, S.2 QI	X	X	-
4 x 2-channel without value status	DQ 8x24VDC/0.5A HF V1.0, S.4	X	X	-
4 x 2-channel with value status	DQ 8x24VDC/0.5A HF V1.0, S.4 QI	X	X	-

NOTE

The following functions are only fully available when the submodule X.1 is configured and the IO controller to which submodule X.1 is assigned has established a connection to the IO device.

- Firmware update
- I&M identification data
- PROFIenergy

2 x 4- / 4 x 2-channel configuration

For the configuration, the channels of the module are divided into multiple submodules. These submodules can be assigned to different IO controllers when the module is used in a Shared Device.

The number of usable submodules is dependent on the interface module used. Read the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The value status is always activated for the following configurations:

- DQ 8x24VDC/0.5A HF V1.0, QI
- DQ 8x24VDC/0.5A HF V1.0, MSO
- DQ 8x24VDC/0.5A HF V1.0, S.2 QI
- DQ 8x24VDC/0.5A HF V1.0, S.4 QI

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

You can find more information on evaluating the value status in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Address space for configuration as 1 x 8-channel DQ 8x24VDC/0.5A HF V1.0

The following figure shows the assignment of the address space for the configuration as 1 x 8-channel module without value status. "QB" stands for output byte.

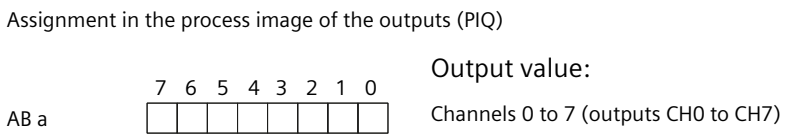

Figure 2-318 Address space for configuration as 1 x 8-channel DQ 8x24VDC/0.5A HF V1.0

Address space for configuration as 1 x 8-channel DQ 8x24VDC/0.5A HF V1.0, QI

The following figure shows the assignment of the address space for the configuration as 1 x 8-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address. "IB" stands for input byte. "QB" stands for output byte.

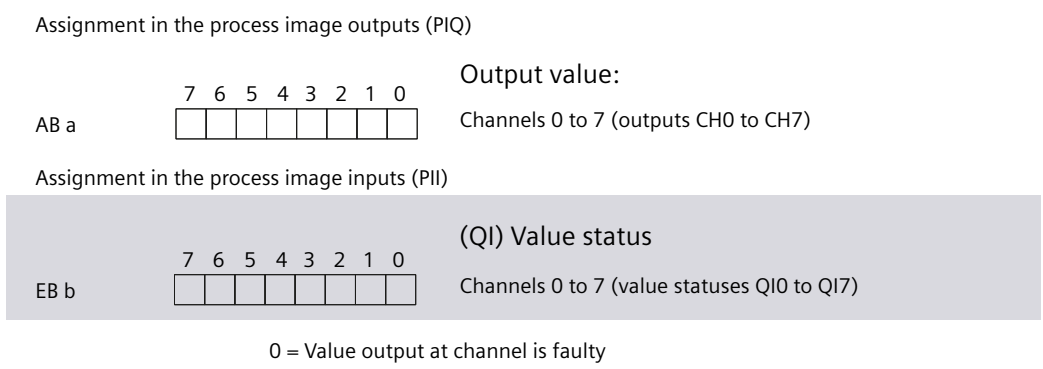

Figure 2-319 Address space for configuration as 1 x 8-channel DQ 8x24VDC/0.5A HF V1.0, QI

Address space for configuration as 1 x 8-channel DQ 8x24VDC/0.5A HF V1.0, MSO

For the configuration as a 1 x 8-channel module (module-internal Shared Output, MSO), channels 0 to 7 of the module are copied to up to four submodules. Channels 0 to 7 are then available with identical values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device:

- The IO controller to which submodule 1 is assigned has write access to outputs 0 to 7.
- The IO controllers to which submodule 2, 3, or 4 is assigned have read access to outputs 0 to 7.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

In the 1st submodule (= basic submodule), the value status 0 indicates that the value is incorrect or that the IO controller of the basic submodule is in STOP state.

For the 2nd to 4th submodule (= MSO submodule), the value status 0 indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule is not yet configured (not ready).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

The following figure shows the assignment of the address space for submodules 1, 2, 3, and 4 and the value status. "IB" stands for input byte. "QB" stands for output byte.

Assignment in the process image outputs (PIQ) for the 1st submodule

	7 6 5 4 3 2 1 0	1st submodule (basic submodule):
AB a		Channels 0 to 7 (outputs CH0 to CH7)
	7 6 5 4 3 2 1 0	(QI) Value status
EB b		Channels 0 to 7 (value statuses QI0 to QI7)

Assignment in the process image inputs (PII) for the 2nd submodule

	7 6 5 4 3 2 1 0	2nd submodule (MSO submodule): Read-back output values
EB c		Channels 0 to 7 (outputs CH0 to CH7)
	7 6 5 4 3 2 1 0	(QI) Value status
EB c+1		Channels 0 to 7 (value statuses QI0 to QI7)

Assignment in the process image inputs (PII) for the 3rd submodule

	7 6 5 4 3 2 1 0	3rd submodule (MSO submodule): Read-back output values
EB d		Channels 0 to 7 (outputs CH0 to CH7)
	7 6 5 4 3 2 1 0	(QI) Value status
EB d+1		Channels 0 to 7 (value statuses QI0 to QI7)

Assignment in the process image inputs (PII) for the 4th submodule

	7 6 5 4 3 2 1 0	4th submodule (MSO submodule): Read-back output values
EB e		Channels 0 to 7 (outputs CH0 to CH7)
	7 6 5 4 3 2 1 0	(QI) Value status
EB e+1		Channels 0 to 7 (value statuses QI0 to QI7)

0 = Value output at channel is faulty

Figure 2-320 Address space for configuration as 1 x 8-channel DQ 8x24VDC/0.5A HF V1.0, MSO

Address space for configuration as 2 x 4-channel DQ 8x24VDC/0.5A HF V1.0, S.2

The figure below shows the address space assignment for configuration as a 2 x 4-channel module without value status.

Each of the two submodules has a freely assignable start address. "QB" stands for output byte.

Assignment in the process image outputs (PIQ)

	7	6	5	4	3	2	1	0	Output value:	
AB a	0	0	0	0					Channels 0 to 3 (outputs CH0 to CH3)	1st submodule
AB b	0	0	0	0					Channels 4 to 7 (outputs CH4 to CH7)	2nd submodule

Figure 2-321 Address space for configuration as 2 x 4-channel DQ 8x24VDC/0.5A HF V1.0, S.2

Address space for configuration as 2 x 4-channel DQ 8x24VDC/0.5A HF V1.0, S.2 QI

The figure below shows the address space assignment for configuration as a 2 x 4-channel module with value status.

Each of the two submodules has a freely assignable start address. "IB" stands for input byte. "QB" stands for output byte.

Assignment in the process image outputs (PIQ)

	7	6	5	4	3	2	1	0	Output value:	
AB a	0	0	0	0					Channels 0 to 3 (outputs CH0 to CH3)	1st submodule
AB b	0	0	0	0					Channels 4 to 7 (outputs CH4 to CH7)	2nd submodule

Assignment in the process image inputs (PII)

	7	6	5	4	3	2	1	0	(QI) Value status	
EB c	0	0	0	0					Channels 0 to 3 (value statuses QI0 to QI3)	1st submodule
EB d	0	0	0	0					Channels 4 to 7 (value statuses QI4 to QI7)	2nd submodule

0 = Value output at channel is faulty

Figure 2-322 Address space for configuration as 2 x 4-channel DQ 8x24VDC/0.5A HF V1.0, S.2 QI

Address space for configuration as 4 x 2-channel DQ 8x24VDC/0.5A HF V1.0, S.4

The following figure shows the assignment of the address space for the configuration as a 4 x 2-channel module without value status.

Each of the four submodules has a freely assignable start address. "QB" stands for output byte.

Assignment in the process image of the outputs (PIQ)

	7	6	5	4	3	2	1	0	Output value:	
AB a	0	0	0	0	0	0			Channels 0 and 1 (outputs CH0 and CH1)	1st submodule
AB b	0	0	0	0	0	0			Channels 2 and 3 (outputs CH2 and CH3)	2nd submodule
AB c	0	0	0	0	0	0			Channels 4 and 5 (outputs CH4 and CH5)	3rd submodule
AB d	0	0	0	0	0	0			Channels 6 and 7 (outputs CH6 and CH7)	4th submodule

Figure 2-323 Address space for configuration as 4 x 2-channel DQ 8x24VDC/0.5A HF V1.0, S.4

Address space for configuration as 4 x 2-channel DQ 8x24VDC/0.5A HF V1.0, S.4 QI

The following figure shows the assignment of the address space for the configuration as a 4 x 2-channel module with value status.

Each of the four submodules has a freely assignable start address. "IB" stands for input byte. "QB" stands for output byte.

Assignment in the process image outputs (PIQ)

	7	6	5	4	3	2	1	0	Output value:	
AB a	0	0	0	0	0	0			Channels 0 and 1 (outputs CH0 and CH1)	1st submodule
AB b	0	0	0	0	0	0			Channels 2 and 3 (outputs CH2 and CH3)	2nd submodule
AB c	0	0	0	0	0	0			Channels 4 and 5 (outputs CH4 and CH5)	3rd submodule
AB d	0	0	0	0	0	0			Channels 6 and 7 (outputs CH6 and CH7)	4th submodule

Assignment in the process image inputs (PII)

	7	6	5	4	3	2	1	0	(QI) Value status	
EB e	0	0	0	0	0	0			Channels 0 and 1 (value statuses QI0 and QI1)	1st submodule
EB f	0	0	0	0	0	0			Channels 2 and 3 (value statuses QI2 and QI3)	2nd submodule
EB g	0	0	0	0	0	0			Channels 4 and 5 (value statuses QI4 and QI5)	3rd submodule
EB h	0	0	0	0	0	0			Channels 6 and 7 (value statuses QI6 and QI7)	4th submodule

0 = Value output at channel is faulty

Figure 2-324 Address space for configuration as 4 x 2-channel DQ 8x24VDC/0.5A HF V1.0, S.4 QI

Interrupts/diagnostics alarms

6

6.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the module:

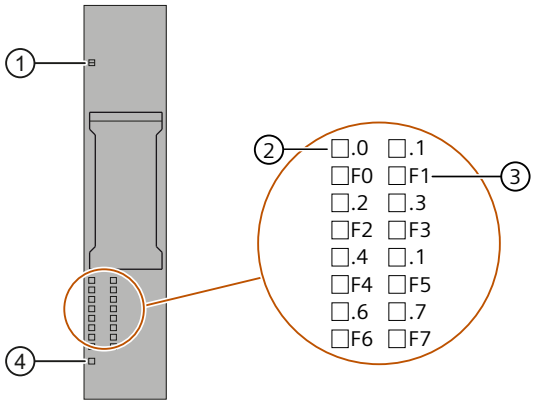

① DIAG (green/red)

② Channel status (green)

③ Channel error (red)

④ PWR (green)

Figure 2-325 LED displays

Meaning of the LEDs

The following tables explain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 31).

DIAG LED

Table 2-331 Error display of the DIAG LED

DIAG LED	Meaning
Off	The system's backplane bus supply is faulty or switched off
Flashes	Module parameters not assigned
On	Module parameters assigned and no module/channel diagnosis data available
Flashes	Module parameters assigned with module/channel diagnosis data available

Channel status and channel diagnosis LEDs

Table 2-332 Status display of the channel status/channel error LED

Channel status LED	Channel error LED	Meaning
□ Off	□ Off	Channel disabled or enabled and process signal = 0 and no channel diagnosis data available
■ On	□ Off	Channel enabled and process signal = 1 and no channel diagnosis data available
□ Off	■ On	Channel enabled and channel diagnosis data available

PWR LED

Table 2-333 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

6.2 Interrupts

The DQ 8×24VDC/0.5A HF digital output module supports diagnostic interrupts.

Diagnostic interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit
- Wire break
- Parameter assignment error
- Supply voltage missing
- Channel/component temporarily unavailable

Detailed information on the event is available in the STEP 7 online help.

6.3 Diagnostics alarms

A diagnostic message is generated and the DIAG-LED flashes red on the module for each diagnostics event. You can read out the diagnostic messages, for example, in the diagnostic buffer of the CPU. You can evaluate the error codes with the user program.

NOTE

Wiring 2 outputs in parallel

When connecting 2 outputs in parallel for redundant control of a load, the channel diagnoses "Short-circuit to L+" and "Wire break" must be disabled, otherwise erroneous diagnostic messages may occur.

Table 2-334 Diagnostic messages, their meaning, and remedial measures

Diagnostic message	Error code	Meaning	Solution
Short-circuit	1_H	• Short-circuit of actuator supply to ground [1] • Short-circuit of actuator supply to L+ [2]	Correct the process wiring
Wire break	6_H	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, e.g. use cables with a larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor to the actuator contacts in the load resistance range
Parameter assignment error	10_H	• Module cannot evaluate parameters for this channel • Incorrect parameter assignment	Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L+	• Check the supply voltage L+ at the BaseUnit • Check BaseUnit type
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update • Restart the firmware update

1 Only in switched state (output value 1)

2 Only in non-switched state (output value 0)

NOTE

In case of a short-circuit of the actuator supply to L+ at the activated channel, load distributions can occur which result in wire break diagnoses.

Technical specifications 7

7.1 Technical specifications

Technical specifications of the DQ 8x24VDC/0.5A HF

The following table lists the technical specifications as of the issue date. You can find a data sheet including the latest technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7132-6BF01-0CA0/td?dl=de).

Article number	6ES7132-6BF01-0CA0
General information	
Product type designation	DQ 8x24VDC/0.5A HF
HW functional status	01
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC02
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	as of TIA Portal V19 with HSP0428 / integrated as of TIA Portal V20
• STEP 7 configurable/integrated from version	as of STEP 7 V5.5 SP3 with HSP0230 V11.0 / integrated as of STEP 7 V5.7 SP3
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.43
Operating mode	
• DQ	Yes
• DQ with energy-saving function	No
• PWM	No
• Oversampling	No
• MSO	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes

Article number	6ES7132-6BF01-0CA0
Input current	
Current consumption, max.	20 mA; without load
output voltage / header	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1 W
Address area	
Address space per module	
• Address space per module, max.	8 byte; 2 channels per submodule + QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Submodules	
• Number of configurable submodules, max.	4
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0
• 3-wire connection	BU type A0 with AUX terminals or potential distributor module
Digital outputs	
Type of digital output	Source output (PNP, current-sourcing)
Number of digital outputs	8
Current-sinking	No
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
output characteristic acc. to IEC 61131, type 0.5	Yes
Short-circuit protection	Yes; Electronic
• Response threshold, typ.	0.7 to 1.3 A
Open-circuit detection	Yes
Limitation of inductive shutdown voltage to	Typ. L+ (-50 V)
Controlling a digital input	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A
• with inductive load, max.	0.5 A
• on lamp load, max.	5 W
Load resistance range	
• lower limit	48 Ω
• upper limit	12 kΩ

Article number	6ES7132-6BF01-0CA0
Output current	
• for signal "1" rated value	0.5 A
• for signal "1" permissible range, max.	0.5 A
• for signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
• "0" to "1", typ.	50 µs
• "1" to "0", typ.	100 µs
Parallel switching of two outputs	
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	100 Hz
• with inductive load, max.	0.1 Hz; higher frequencies are possible, see Equipment Manual "Maximum permitted switching frequency of inductive loads"
• on lamp load, max.	10 Hz
Total current of the outputs	
• Current per channel, max.	0.5 A
• Current per module, max.	4 A
Total current of the outputs (per module)	
horizontal installation	
– up to 60 °C, max.	4 A
vertical installation	
– up to 50 °C, max.	4 A
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Isochronous mode	
Execution and activation time (TCO), min.	48 µs
Bus cycle time (TDP), min.	500 µs
Jitter, max.	8 µs
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnoses	
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Wire-break	Yes; channel by channel

Article number	6ES7132-6BF01-0CA0
• Short-circuit to M	Yes; channel by channel
• Short-circuit to L+	Yes; channel by channel
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• Between the channels and load voltage L+	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Suitable for safety-related tripping of standard modules	Yes; see FAQ Entry ID: 39198632
Highest safety class achievable for safety-related tripping of standard modules	
• Performance level according to ISO 13849-1	PL d
• Category according to ISO 13849-1	Cat. 3
• SIL acc. to IEC 62061	SIL 2
• remark on safety-oriented shutdown	https://support.industry.siemens.com/cs/de/en/view/39198-632
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual

Article number	6ES7132-6BF01-0CA0
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

Residual current for signal state "0"

NOTE

Residual current for signal state "0"

Due to the Diagnostics: Wire break function, a small residual current flows in signal state "0" of the output when the check for wire break is enabled. This may cause the display diodes to flicker.

You can minimize this residual current with the "Check for wire break" parameter.

Maximum permitted switching frequency of inductive loads

The following trends show the maximum permissible switching frequency of inductive loads as a function of inductance and channel current. The maximum switching frequency applies to a pulse-pause ratio of 50%. The channel contributes 500 mA to the total current of the module, even if the actual channel current is smaller.

If you do not know the inductance of the actuator, assume a maximum inductance of 1.152 H for DC-13 loads (IEC 60947-5-1).

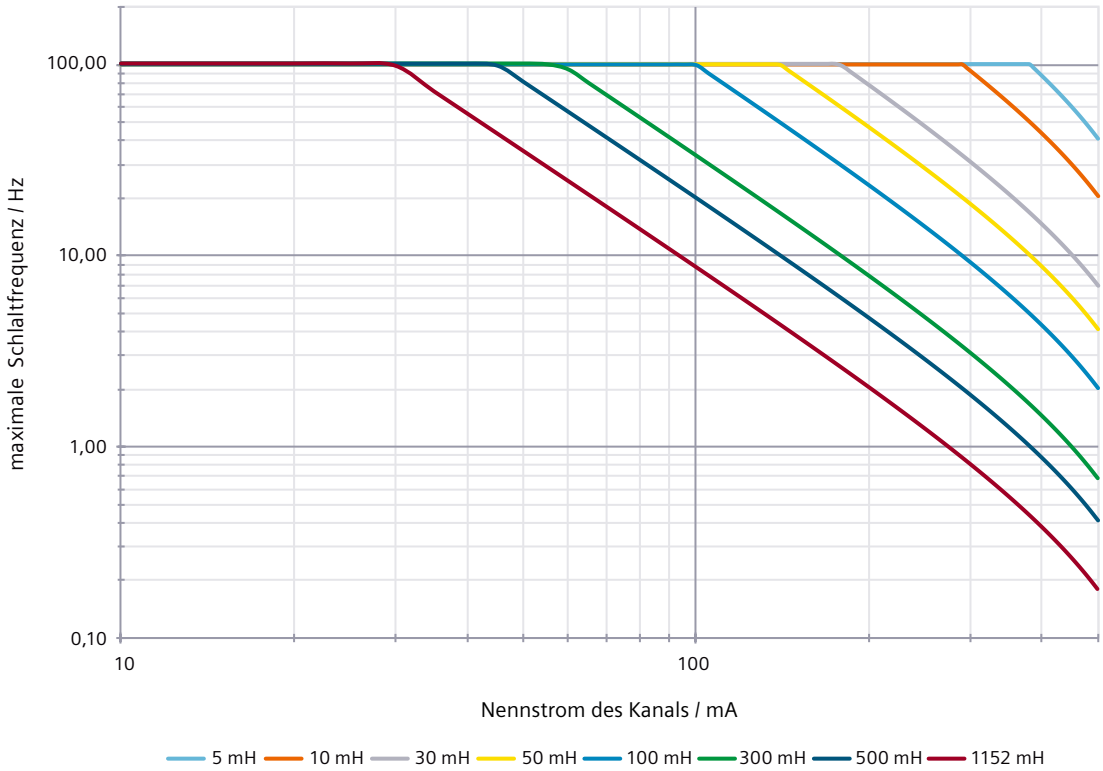

Figure 2-326 Maximum switching frequency

Dimension drawing

See manual ET 200SP BaseUnits
(https://support.industry.siemens.com/cs/ww/en/view/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reassign the module parameters in your user program, regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

With data records 64 to 71, you can configure individual channels.

Parameter assignment in the user program

You have the option to reassign the module parameters in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Reassigning parameters in RUN

The WRREC instruction is used to transfer the parameters to the module using data record 128 or data records 64 to 71. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

If you reconfigure a module and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, the STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Data record structure

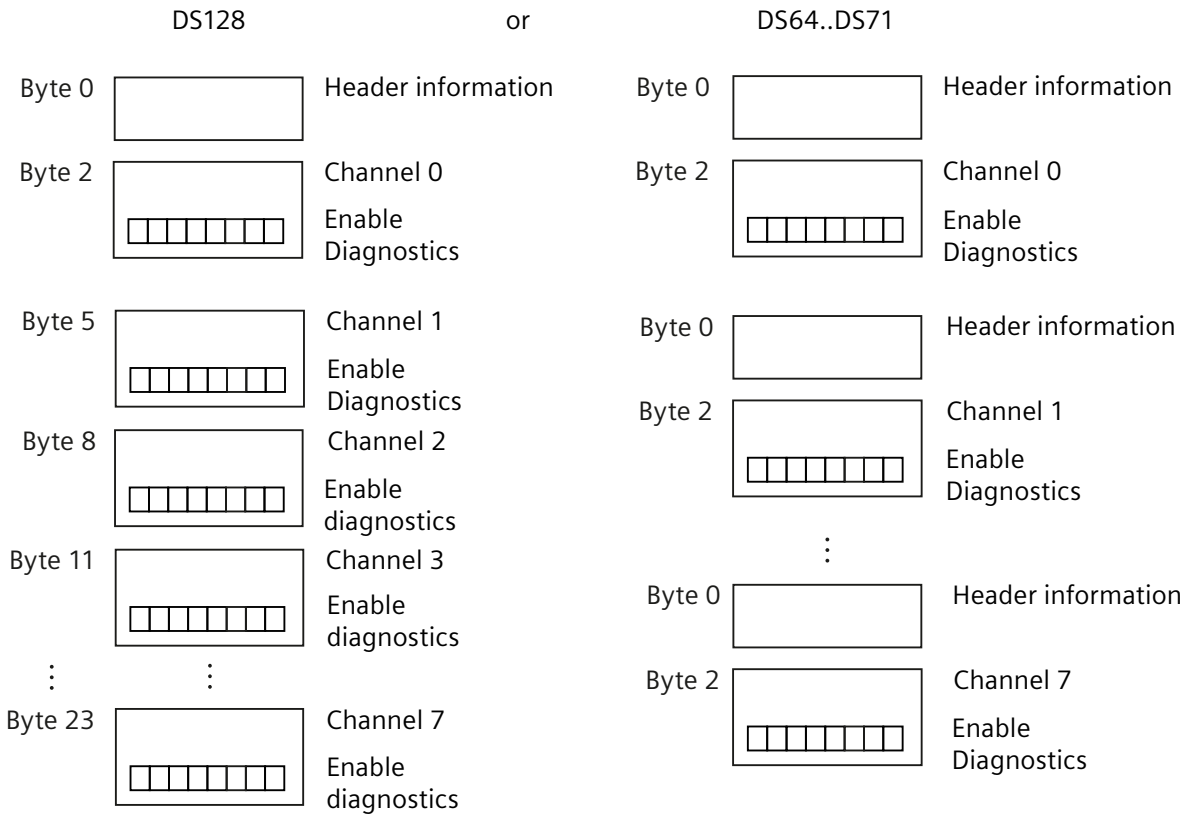

Figure 2-327 Structure of data record 128 and data record 64 to 71

Header information

The figure below shows the structure of the header information.

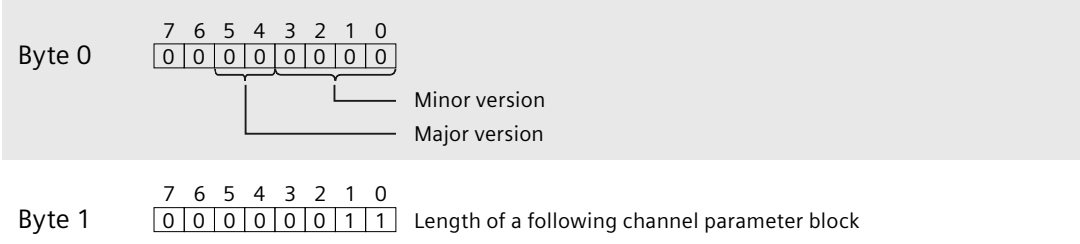

Figure 2-328 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

You can enable a parameter by setting the corresponding bit to "1".

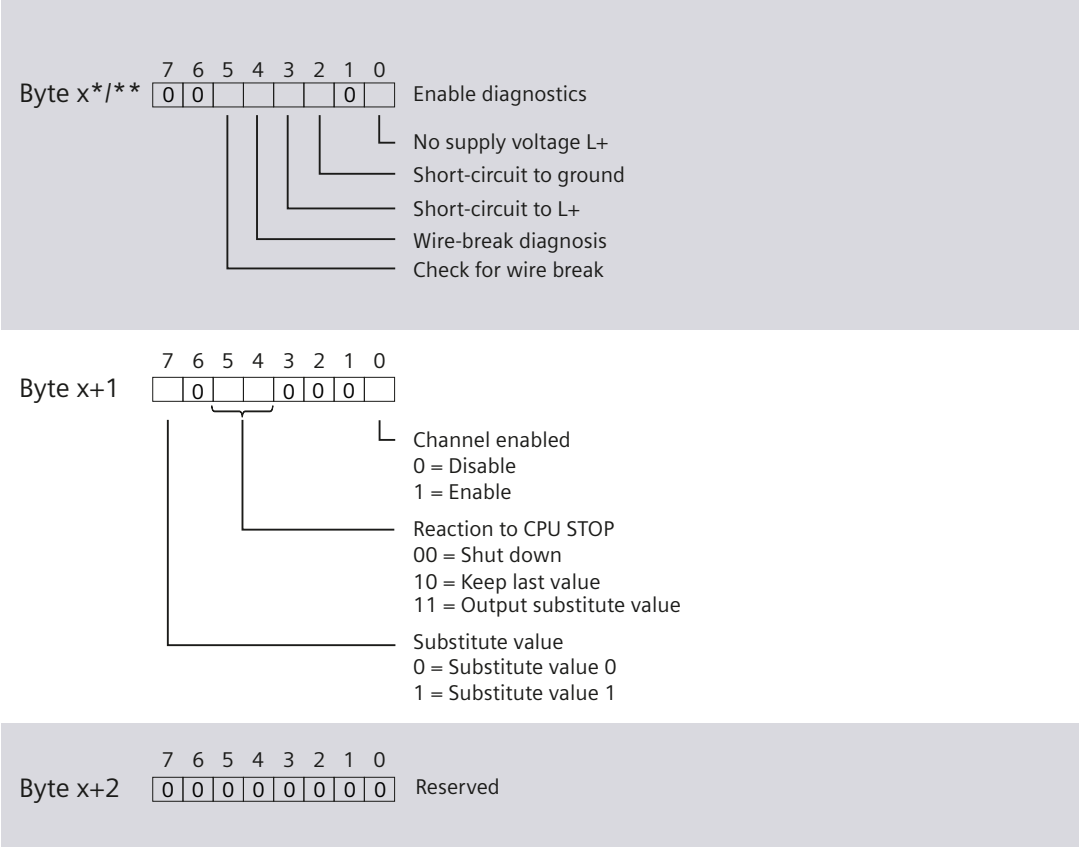

* x = 2 + (channel number × 3); Channel number = 0 to 7 for DS 128
** x = 2 for DS 64 to DS 71

Figure 2-329 Structure of byte x to x+2 for channels 0 to 7

A.2 Error codes

Error transmitting the data record

The module always checks all the values of the transferred data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Table 2-335 Error messages, their meaning, and remedial measures

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF_H	80_H	$B0_H$	00_H	Number of the data record unknown	Enter a valid number for the data record.
DF_H	80_H	$B1_H$	01_H	Length of the data record incorrect	Enter a valid value for the data record length.
DF_H	80_H	$B2_H$	00_H	Module not accessible	• Check station. • Plug the module in correctly. • Check parameters of the WRREC block.
DF_H	80_H	$E0_H$	01_H	Header error (version or specified bits incorrect)	Correct version number or specified bits, see Header information (Page 38).
DF_H	80_H	$E0_H$	02_H	Header error (number or length of parameter structures or parameter blocks incorrect)	Correct the number and length of the parameter structures or parameter blocks, see Header information (Page 38).
DF_H	80_H	$E1_H$	01_H	Reserved bit set	Write 0 to all reserved bits.
DF_H	80_H	$E1_H$	02_H	Invalid diagnostics enable bit set for operating mode	Correct diagnostics enables. For dependence on "Check for wire break" parameter, see Structure Byte x to x+2 for channels 0 to 7 (Page 38)
DF_H	80_H	$E1_H$	06_H	Invalid coding for substitute value behavior	Use valid coding for "Reaction to CPU STOP" parameter, see Structure of byte x to x+2 for channels 0 to 7 (Page 38).

SIEMENS

SIMATIC

ET 200SP
Digital output module DQ 4x24VDC/2A HF (6ES7132-6BD21-0CA0)

Equipment Manual

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Parameter data record A

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Introduction

1

Purpose of the documentation

This manual supplements the System Manual ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in the system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).

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To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

Product overview

3

3.1 Properties

Article number

6ES7132-6BD21-0CA0 (number in pack: 1 unit)

View of the module

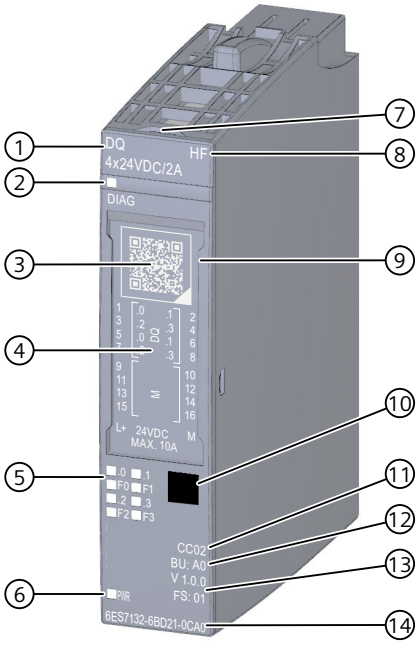

①	Module type and name	⑧	Function class
②	LED for diagnostics	⑨	Insertion option for optional labeling strip
③	QR code for identification link	⑩	Color coding module type
④	Wiring diagram	⑪	Color code for selecting the color-coded labels
⑤	LEDs for channel status and channel fault	⑫	BU type
⑥	LED for supply voltage	⑬	Firmware and function version
⑦	Slot for optional equipment labeling plate	⑭	Article number

Figure 2-330 View of the module DQ 4×24VDC/2A HF

Properties

The module has the following technical properties:

- Digital output module with 4 outputs
- Source output (PNP, P-switching)
- Supply voltage L+
- Output current 2 A (per channel)
- Total current 8 A (per module)

  See derating: Technical specifications (Page 31)
- Configurable diagnostics (per channel)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Suitable for safety-related shutdown of standard modules
- Extended spare parts compatibility (see product information (https://support.industry.siemens.com/cs/ww/en/view/73021864))

The module supports the following functions:

Table 2-336 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V1.0.0 or higher	V19 or higher with HSP0426	V5.5 SP3 or higher with HSP 0230 from V11.0	X	X
Identification data I&M0 to I&M3	FS01	V1.0.0 or higher	V19 or higher with HSP0426	V5.5 SP3 or higher with HSP 0230 from V11.0	X	X
Parameter reassignment in RUN	FS01	V1.0.0 or higher	V19 or higher with HSP0426	V5.5 SP3 or higher with HSP 0230 from V11.0	X	X
PROFIenergy	FS01	V1.0.0 or higher	V19 or higher with HSP0426	V5.5 SP3 or higher with HSP 0230 from V11.0	X	-
Value status	FS01	V1.0.0 or higher	V19 or higher with HSP0426	V5.5 SP3 or higher with HSP 0230 from V11.0	X	X
Isochronous mode	FS01	V1.0.0 or higher	V19 or higher with HSP0426	V5.5 SP3 or higher with HSP 0230 from V11.0	X	-
Module-internal shared output (MSO)	FS01	V1.0.0 or higher	V19 or higher with HSP0426	V5.5 SP3 or higher with HSP 0230 from V11.0	X	-
Configurable submodules/submodules for shared devices	FS01	V1.0.0 or higher	V19 or higher with HSP0426	V5.5 SP3 or higher with HSP 0230 from V11.0	X	-

Accessories

The following accessories are available optionally:

- Labeling strips
- Color-coded labels
- Reference identification label
- Shield connection

See also

You can find more information on accessories in the ET 200SP Distributed I/O System (https://support.automation.siemens.com/WW/view/en/58649293) System Manual.

Wiring

4

4.1 Wiring diagram

This section contains the pin assignment for the module.

You can find information on wiring the BaseUnit in the system manual ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293).

NOTE

The load group of the module must begin with a light-colored BaseUnit. Also keep this in mind during configuration.

NOTICE

You may only use the digital output module with a BaseUnit type A0.

With the BaseUnit type A1, the integrated fuse can be triggered, rendering the terminals unusable.

NOTE

Cross-circuit at output

Note that a voltage applied at the output due to a cross-circuit can lead to the modules being supplied with L+.

Pin assignment: 1 and 2-wire connection of actuators

The following table shows an example of the pin assignment of digital output module DQ 4×24VDC/2A HF on the BaseUnit BU type A0 without AUX terminals:

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Digital output, channel 0	DQ_0	1		2	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	3		4	DQ_3	Digital output, channel 3
Digital output, channel 0	DQ_0	5		6	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	7		8	DQ_3	Digital output, channel 3
Ground	M	9		10	M	Ground
Ground	M	11		12	M	Ground

1) Infeed only with light-colored BaseUnit

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Ground	M	13	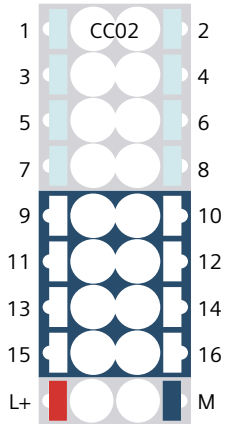	14	M	Ground
Ground	M	15		16	M	Ground
24 V DC supply voltage[1)]	L+	L+		M	M	Ground

1) Infeed only with light-colored BaseUnit

NOTICE
Current load of combined return conductors For 2-wire connection, the static current load of the combined return conductor must not exceed 2A per terminal.

Pin assignment: 3-wire connection of actuators

The following table shows an example of the pin assignment of the digital output module DQ 4×24VDC/2A HF on the BaseUnit BU type A0 with AUX terminals.

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Digital output, channel 0	DQ_0	1		2	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	3		4	DQ_3	Digital output, channel 3
Digital output, channel 0	DQ_0	5		6	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	7		8	DQ_3	Digital output, channel 3
Ground	M	9		10	M	Ground
Ground	M	11		12	M	Ground
Ground	M	13		14	M	Ground
Ground	M	15		16	M	Ground
AUX terminal	AUX	1A		2A	AUX	AUX terminal
AUX terminal	AUX	3A		4A	AUX	AUX terminal
AUX terminal	AUX	5A		6A	AUX	AUX terminal

1) Infeed only with light-colored BaseUnit

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
AUX terminal	AUX	7A		8A	AUX	AUX terminal
AUX terminal	AUX	9A		10A	AUX	AUX terminal
24 V DC supply voltage[1]	L+	L+		M	M	Ground

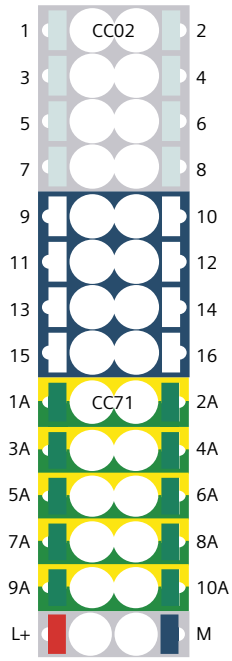

[1] Infeed only with light-colored BaseUnit

Output connection types

1-wire connection of actuators	2-wire connection of actuators	3-wire connection of actuators
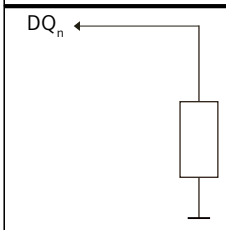	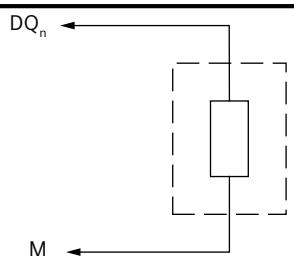	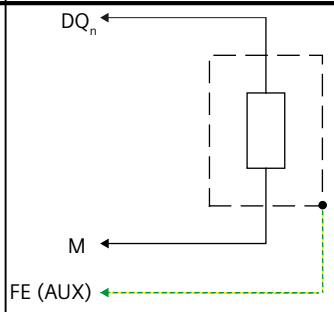

You can also connect the ground and functional grounding via a potential distribution module (PotDis module) or AUX terminals. More information on potential distribution modules is available in the BaseUnits Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/59753521).

NOTE

You can use and combine the different connection options for all channels.

4.2 Schematic circuit diagram

This section contains the schematic circuit diagram of the module.

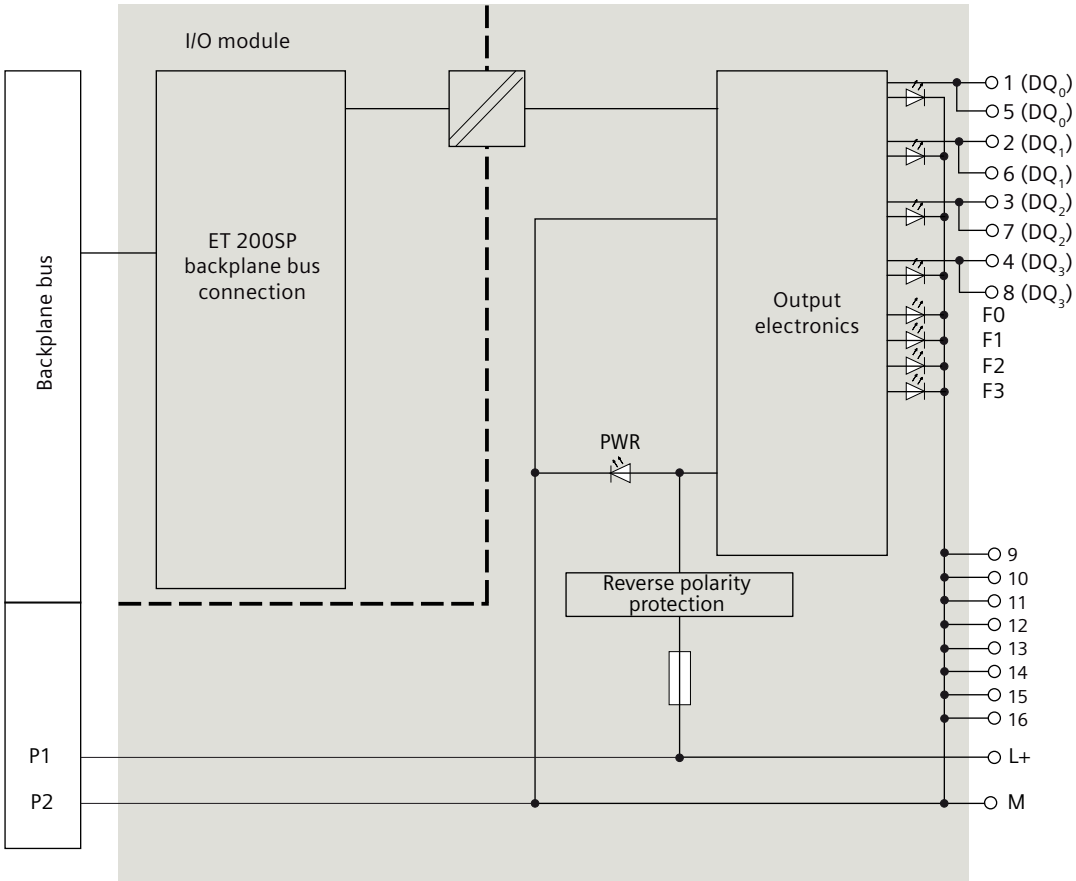

Figure 2-331 Schematic circuit diagram

Parameters/address space

5

5.1 Parameters

Parameters for DQ 4x24VDC/2A HF

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation on an ET 200SP-CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition to parameter assignment via the configuration software, you can also configure parameters in RUN mode (dynamically) via the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records. See the Parameter assignment and structure of the parameter data record (Page 38) section.

The following parameter settings are possible:

Table 2-337 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration during RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP[1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel[1]
Diagnostics: Short-circuit to L+	• Disable • Enable	Disable	Yes	Channel	
Check for wire break	• Disable • Enable	Enable	Yes	Channel	Channel
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the possible parameter settings are restricted. The parameter length of the I/O module is 5 bytes for PROFIBUS GSD configuration. However, if necessary you can set these parameters using data records 64 to 67 or data record 128, see "Parameter data record" appendix.

Parameter	Value range	Default	Reconfiguration during RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP[1]
Channel enabled	• Disable • Enable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module[1]
Potential group	• Use the potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the possible parameter settings are restricted. The parameter length of the I/O module is 5 bytes for PROFIBUS GSD configuration. However, if necessary you can set these parameters using data records 64 to 67 or data record 128, see "Parameter data record" appendix.

NOTE

- If both parameters "Diagnostics: Short-circuit to L+" and "Diagnostics: Wire break" are enabled and one of these diagnostic events occurs, the affected channel is switched off. This prevents undefined load switching and the corresponding diagnostics alarm is triggered.
- If the parameter "Diagnostics: Wire break" is enabled and "Diagnostics: Short circuit to L+" is disabled and a "Diagnostics: Wire break" is present, the affected channel is switched off. This prevents undefined load switching and the corresponding diagnostics alarm is triggered.
- If the parameter "Diagnostics: Short-circuit to L+" is enabled and "Diagnostics: Wire break" is disabled, the signal state is retained at the affected channel when "Diagnostics: Short-circuit to L+" occurs. A diagnostics alarm is triggered only for 0 signal.

5.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs.

Diagnostics: Short-circuit to L+

Enabling of the diagnostics if a short-circuit of the actuator supply to L+ occurs.

Check for wire break

Specifies whether a wire-break check is carried out for the channel. A wire-break diagnosis can only be reported if the wire-break check is enabled. If the wire-break check is disabled, the measuring current for the channel is also disabled.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken. If the wire break diagnostics is enabled, the parameter "Check for wire break" must also be enabled for the channel.

Channel enabled

Determines whether a channel is enabled or disabled.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group starts with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

Specify the slot in which a light-colored BaseUnit with supply voltage feed or a dark-colored BaseUnit is to be located (see ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) System Manual).

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

The station setup must be completed with a server module.

5.3 Address space

The module can be configured differently in STEP 7; see the table below. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of DQ 4×24VDC/2A HF

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-338 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. STEP 7 (TIA Portal)		
		Integrated in the STEP 7 hardware catalog from V19 with HSP0426	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel without value status	DQ 4×24VDC/2A HF V1.0	X	X	X
1 x 4-channel with value status	DQ 4×24VDC/2A HF V1.0, QI	X	X	X
1 x 4-channel with value status for module-internal Shared Output with up to 4 submodules	DQ 4×24VDC/2A HF V1.0, MSO	X	X	-
2 x 2-channel without value status	DQ 4×24VDC/2A HF V1.0, S.2	X	X	-
2 x 2-channel with value status	DQ 4×24VDC/2A HF V1.0, S.2 QI	X	X	-

NOTE

The following functions are only fully available when the submodule X.1 is configured and the IO controller to which submodule X.1 is assigned has established a connection to the IO device.

- Firmware update
- I&M identification data
- PROFIenergy

2 x 2-channel configuration

For the configuration, the channels of the module are divided into multiple submodules. These submodules can be assigned to different IO controllers when the module is used in a Shared Device.

The number of usable submodules is dependent on the interface module used. Read the information in the manual for the particular interface module.

Value status (quality information, QI)

The value status is always activated for the following configurations:

- DQ 4×24VDC/2A HF V1.0, QI
- DQ 4×24VDC/2A HF V1.0, MSO
- DQ 4×24VDC/2A HF V1.0, S.2 QI

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

You can find more information on evaluating the value status in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A HF V1.0

The figure below shows the address space assignment for configuration as a 1x4-channel module without value status. "QB" stands for output byte.

Assignment in the process image output (PIQ)

	7	6	5	4	3	2	1	0	Output value:
AB a	0	0	0	0					Channels 0 to 3 (outputs CH0 to CH3)

Figure 2-332 Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A HF V1.0

Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A HF V1.0, QI

The figure below shows the address space assignment for configuration as a 1x4-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address. "IB" stands for input byte. "QB" stands for output byte.

Assignment in the process image output (PIQ)

	7	6	5	4	3	2	1	0	Output value:
AB a	0	0	0	0					Channels 0 to 3 (outputs CH0 to CH3)

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	(QI) Value status:
EB a	0	0	0	0					Channels 0 to 3 (value statuses QI0 to QI3)

0 = Error in the value output at the channel

Figure 2-333 Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A HF V1.0, QI

Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A HF V1.0, MSO

For the configuration as a 1 x 4-channel module (module-internal shared output, MSO), channels 0 to 3 of the module are copied to up to four submodules. Channels 0 to 3 are then available with identical values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device:

- The IO controller to which submodule 1 is assigned has write access to outputs 0 to 3.
- The IO controllers to which submodule 2, 3, or 4 is assigned have read access to outputs 0 to 3.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

In the 1st submodule (= basic submodule), the value status 0 indicates that the value is incorrect or that the IO controller of the basic submodule is in STOP state.

For the 2nd to 4th submodule (= MSO submodule), the value status 0 indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule is not yet configured (not ready).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

The following figure shows the assignment of the address space for submodules 1, 2, 3, and 4 and the value status. "IB" stands for input byte. "QB" stands for output byte.

Assignment in the process image output (PIQ) for 1st submodule

	7	6	5	4	3	2	1	0	
AB a	0	0	0	0					1st submodule (basic submodule): Channels 0 to 3 (outputs CH0 to CH3)
EB b	0	0	0	0					(QI) Value status Channels 0 to 3 (value statuses QI0 to QI3)

Assignment in the process image input (PII) for 2nd submodule

	7	6	5	4	3	2	1	0	
EB c	0	0	0	0					2nd submodule (MSO submodule): Read-back output values Channels 0 to 3 (outputs CH0 to CH3)
EB c+1	0	0	0	0					(QI) Value status Channels 0 to 3 (value statuses QI0 to QI3)

Assignment in the process image input (PII) for 3rd submodule

	7	6	5	4	3	2	1	0	
EB d	0	0	0	0					3rd submodule (MSO submodule): Read-back output values Channels 0 to 3 (outputs CH0 to CH3)
EB d+1	0	0	0	0					(QI) Value status Channels 0 to 3 (value statuses QI0 to QI3)

Assignment in the process image input (PII) for 4th submodule

	7	6	5	4	3	2	1	0	
EB e	0	0	0	0					4th submodule (MSO submodule): Read-back output values Channels 0 to 3 (outputs CH0 to CH3)
EB e+1	0	0	0	0					(QI) Value status Channels 0 to 3 (value statuses QI0 to QI3)

0 = Error in the value output at the channel

Figure 2-334 Address space for configuration as 1 x 4-channel DQ 4×24VDC/2A HF V1.0, MSO

Address space for configuration as 2 x 2-channel DQ 4×24VDC/2A HF V1.0, S.2

The figure below shows the address space assignment for configuration as a 2 x 2-channel module without value status.

Each of the two submodules has a freely assignable start address. "QB" stands for output byte.

Assignment in the process image output (PIQ)

	7	6	5	4	3	2	1	0	Output value:	
AB a	0	0	0	0	0	0			Channels 0 and 1 (outputs CH0 and CH1)	1st submodule
AB b	0	0	0	0	0	0			Channels 2 and 3 (outputs CH2 and CH3)	2nd submodule

Figure 2-335 Address space for configuration as 2 x 2-channel DQ 4×24VDC/2A HF V1.0, S.2

Address space for configuration as 2 x 2-channel DQ 4×24VDC/2A HF V1.0, S.2 QI

The figure below shows the address space assignment for configuration as a 2 x 2-channel module with value status.

Each of the two submodules has a freely assignable start address. "IB" stands for input byte. "QB" stands for output byte.

Assignment in the process image output (PIQ)

	7	6	5	4	3	2	1	0	Output value:	
AB a	0	0	0	0	0	0			Channels 0 and 1 (outputs CH0 and CH1)	1st submodule
AB b	0	0	0	0	0	0			Channels 2 and 3 (outputs CH2 and CH3)	2nd submodule

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	(QI) Value status	
EB a	0	0	0	0	0	0			Channels 0 and 1 (value statuses QI0 and QI1)	1st submodule
EB b	0	0	0	0	0	0			Channels 2 and 3 (value statuses QI2 and QI3)	2nd submodule

0 = Error in the value output at the channel

Figure 2-336 Address space for configuration as 2 x 2-channel DQ 4×24VDC/2A HF V1.0, S.2 QI

Interrupts/diagnostics alarms

6

6.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the module:

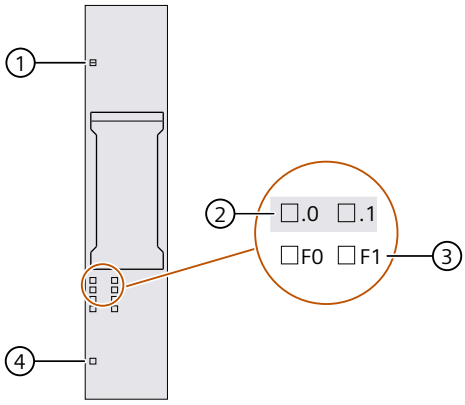

① DIAG (green/red)

② Channel status (green)

③ Channel error (red)

④ PWR (green)

Figure 2-337 LED displays

Meaning of the LEDs

The following tables explain the meaning of the status and error displays. Corrective measures for diagnostic messages can be found in section Diagnostic messages (Page 29).

DIAG LED

Table 2-339 Error display of the DIAG LED

DIAG LED	Meaning
Off	The system's backplane bus supply is faulty or switched off
Flashes	Module parameters not assigned
On	Module parameters assigned and no module/channel diagnosis data available
Flashes	Module parameters assigned with module/channel diagnosis data available

Channel status and channel diagnosis LEDs

Table 2-340 Status display of the channel status/channel error LED

Channel status LED	Channel error LED	Meaning
□ Off	□ Off	Channel disabled or enabled and process signal = 0 and no channel diagnosis data available
■ On	□ Off	Channel enabled and process signal = 1 and no channel diagnosis data available
□ Off	■ On	Channel enabled and channel diagnosis data available

PWR LED

Table 2-341 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

6.2 Interrupts

The DQ 4×24VDC/2A HF digital output module supports diagnostic interrupts.

Diagnostic interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit
- Wire break
- Parameter assignment error
- Supply voltage missing
- Channel/component temporarily unavailable

Detailed information on the event is available in the STEP 7 online help.

6.3 Diagnostics alarms

A diagnostic message is generated and the DIAG-LED flashes red on the module for each diagnostics event. You can read out the diagnostic messages, for example, in the diagnostic buffer of the CPU. You can evaluate the error codes with the user program.

NOTE

You can connect 2 actuators per output

The diagnostics of the two actuators influenced each other in the case of duplicate wiring.

This means:

- a wire break is only signaled if both actuators are affected
- a single short-circuit affects both actuators

NOTE

Wiring 2 outputs in parallel

When connecting 2 outputs in parallel for redundant control of a load, the channel diagnoses "Short circuit to L+" and "Wire break" must be disabled, otherwise erroneous diagnostic messages may occur.

Table 2-342 Diagnostic messages, their meaning and corrective measures

Diagnostic message	Error code	Meaning	Solution
Short-circuit	1_H	• Short-circuit of actuator supply to ground [1] • Short-circuit of actuator supply to L+ [2]	Correct the process wiring
Wire break	6_H	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, e.g. use cables with a larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor to the actuator contacts in the load resistance range
Parameter assignment error	10_H	• Module cannot evaluate parameters for this channel • Incorrect parameter assignment	Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L+	• Check the supply voltage L+ at the BaseUnit • Check BaseUnit type
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update • Restart the firmware update

1 Only in switched state (output value 1)

2 Only in non-switched state (output value 0)

NOTE

In case of a short-circuit of the actuator supply to L+ at the activated channel, load distributions can occur which result in wire break diagnostics.

Technical specifications 7

7.1 Technical specifications

Technical specifications of the DQ 4×24VDC/2A HF

The following table lists the technical specifications as of the issue date. You can find a data sheet including the latest technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/de/pv/6ES7132-6BD21-0CA0/td?dl=en).

Article number	6ES7132-6BD21-0CA0
General information	
Product type designation	DQ 4x24VDC/2A HF
HW functional status	01
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC02
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	as of TIA Portal V19 with HSP0426 / integrated as of TIA Portal V20
• STEP 7 configurable/integrated from version	as of STEP 7 V5.5 SP3 with HSP0230 V11.0 / integrated as of STEP 7 V5.7 SP3
• PROFIBUS from GSD version/GSD revision	GSD Revision 5
• PROFINET from GSD version/GSD revision	GSDML V2.43
Operating mode	
• DQ	Yes
• DQ with energy-saving function	No
• PWM	No
• Oversampling	No
• MSO	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes

Article number	6ES7132-6BD21-0CA0
Input current	
Current consumption, max.	20 mA; without load
output voltage / header	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1 W
Address area	
Address space per module	
• Address space per module, max.	4 byte; 2 channels per submodule + QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Submodules	
• Number of configurable submodules, max.	2
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0
• 3-wire connection	BU type A0 with AUX terminals or potential distributor module
Digital outputs	
Type of digital output	Source output (PNP, current-sourcing)
Number of digital outputs	4
Current-sinking	No
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
output characteristic acc. to IEC 61131, type 2	Yes
Short-circuit protection	Yes; Electronic
• Response threshold, typ.	2.8 to 5.2 A
Open-circuit detection	Yes
Limitation of inductive shutdown voltage to	Typ. L+ (-50 V)
Controlling a digital input	Yes
Switching capacity of the outputs	
• with resistive load, max.	2 A
• with inductive load, max.	2 A
• on lamp load, max.	10 W
Load resistance range	
• lower limit	12 Ω
• upper limit	3 400 Ω

Article number	6ES7132-6BD21-0CA0
Output current	
• for signal "1" rated value	2 A
• for signal "1" permissible range, max.	2 A
• for signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
• "0" to "1", typ.	50 µs
• "1" to "0", typ.	100 µs
Parallel switching of two outputs	
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	100 Hz
• with inductive load, max.	0.1 Hz; higher frequencies are possible, see Equipment Manual "Maximum permitted switching frequency of inductive loads"
• on lamp load, max.	10 Hz
Total current of the outputs	
• Current per channel, max.	2 A
• Current per module, max.	8 A; see Equipment Manual "Derating curve"
Total current of the outputs (per module)	
horizontal installation	
– up to 30 °C, max.	8 A
– up to 40 °C, max.	8 A
– up to 50 °C, max.	6 A
– up to 60 °C, max.	4 A
vertical installation	
– up to 30 °C, max.	8 A
– up to 40 °C, max.	6 A
– up to 50 °C, max.	4 A
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Isochronous mode	
Execution and activation time (TCO), min.	75 µs
Bus cycle time (TDP), min.	500 µs
Jitter, max.	8 µs
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes

Article number	6ES7132-6BD21-0CA0
Alarms	
• Diagnostic alarm	Yes
Diagnoses	
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Wire-break	Yes; channel by channel
• Short-circuit to M	Yes; channel by channel
• Short-circuit to L+	Yes; channel by channel
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• Between the channels and load voltage L+	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Suitable for safety-related tripping of standard modules	Yes; see FAQ Entry ID: 39198632
Highest safety class achievable for safety-related tripping of standard modules	
• Performance level according to ISO 13849-1	PL d
• Category according to ISO 13849-1	Cat. 3
• SIL acc. to IEC 62061	SIL 2
• remark on safety-oriented shutdown	https://support.industry.siemens.com/cs/de/en/view/39198-632
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C

Article number	6ES7132-6BD21-0CA0
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

Residual current for signal state "0"

NOTE

Residual current for signal state "0"

Due to the Diagnostics: Wire break function, a small residual current flows in signal state "0" of the output when the wire-break check is enabled. This may cause the display diodes to flicker.

You can minimize this residual current with the "Check for wire break" parameter.

Derating trend

The figure below shows the load current derating for the module in horizontal and vertical mounting position. You use this diagram to determine the maximum total current of the module as a function of ambient temperature.

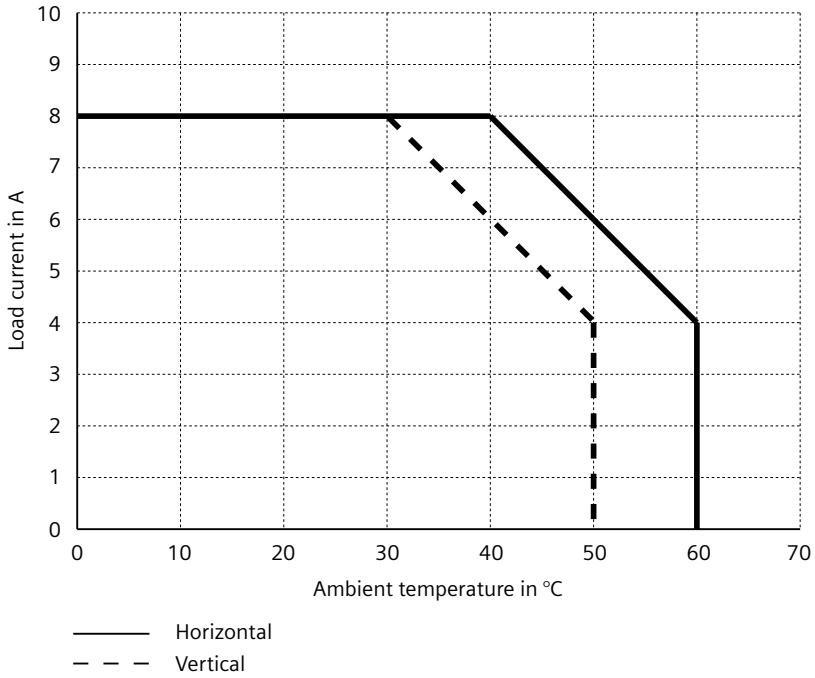

Figure 2-338 Load current vs. temperature in different mounting positions

If a channel drives a cyclically switched inductive load, this channel contributes 2 A to the total current.

Maximum permitted switching frequency of inductive loads

The following trends show the maximum permissible switching frequency of inductive loads as a function of inductance and channel current. The maximum switching frequency applies to a pulse-pause ratio of 50%. The channel contributes 2 mA to the total current of the module, even if the actual channel current is smaller.

If you do not know the inductance of the actuator, assume a maximum inductance of 1.152 H for DC-13 loads (IEC 60947-5-1).

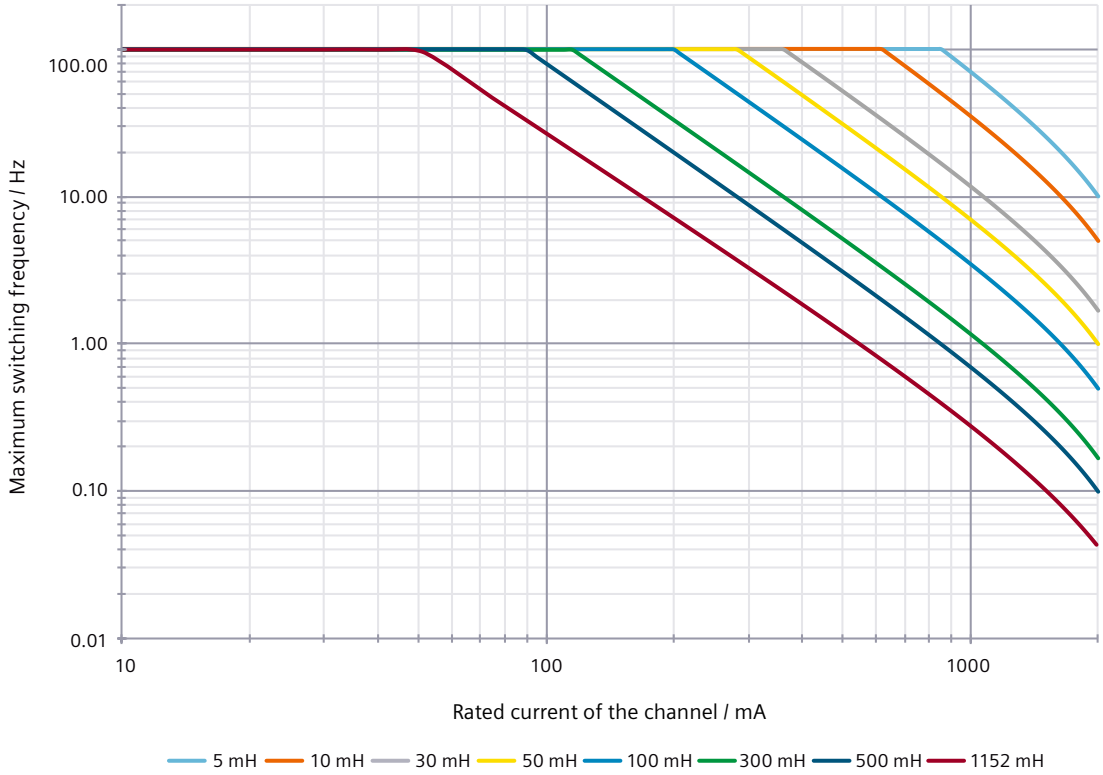

Figure 2-339 Maximum switching frequency

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

You can configure the individual channels with data records 64 to 67.

Parameter assignment in the user program

You have the option to reassign the module parameters in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The WRREC instruction is used to transfer the parameters to the module using data record 128 or data records 64 to 67. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

If you reconfigure a module and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, the STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Data record structure

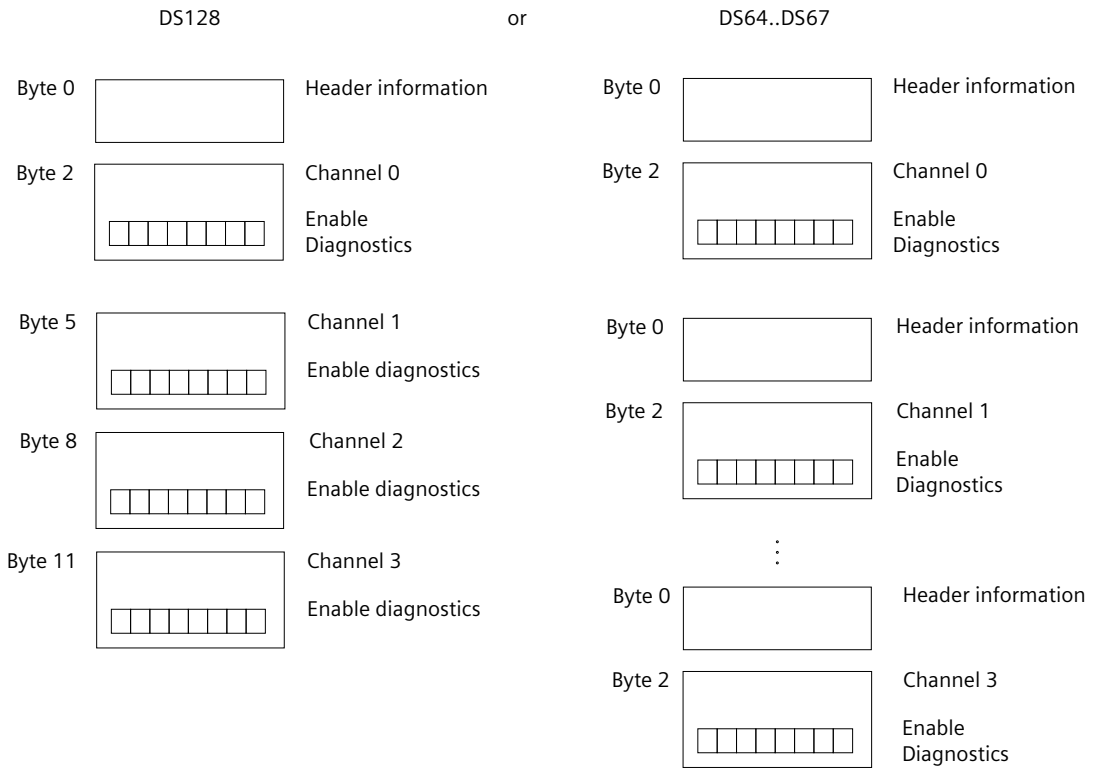

Figure 2-340 Structure of data record 128 or data records 64 to 67

Header information

The figure below shows the structure of the header information.

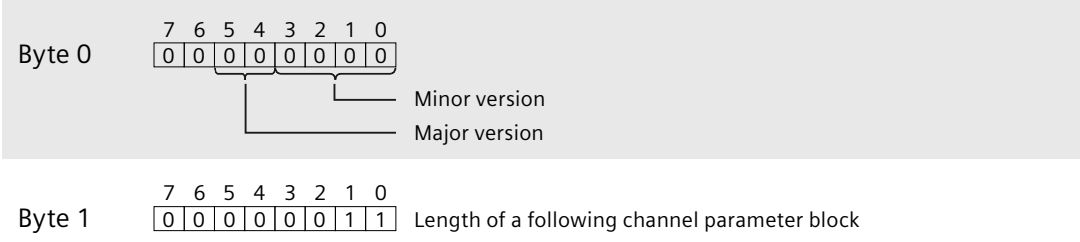

Figure 2-341 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You can enable a parameter by setting the corresponding bit to "1".

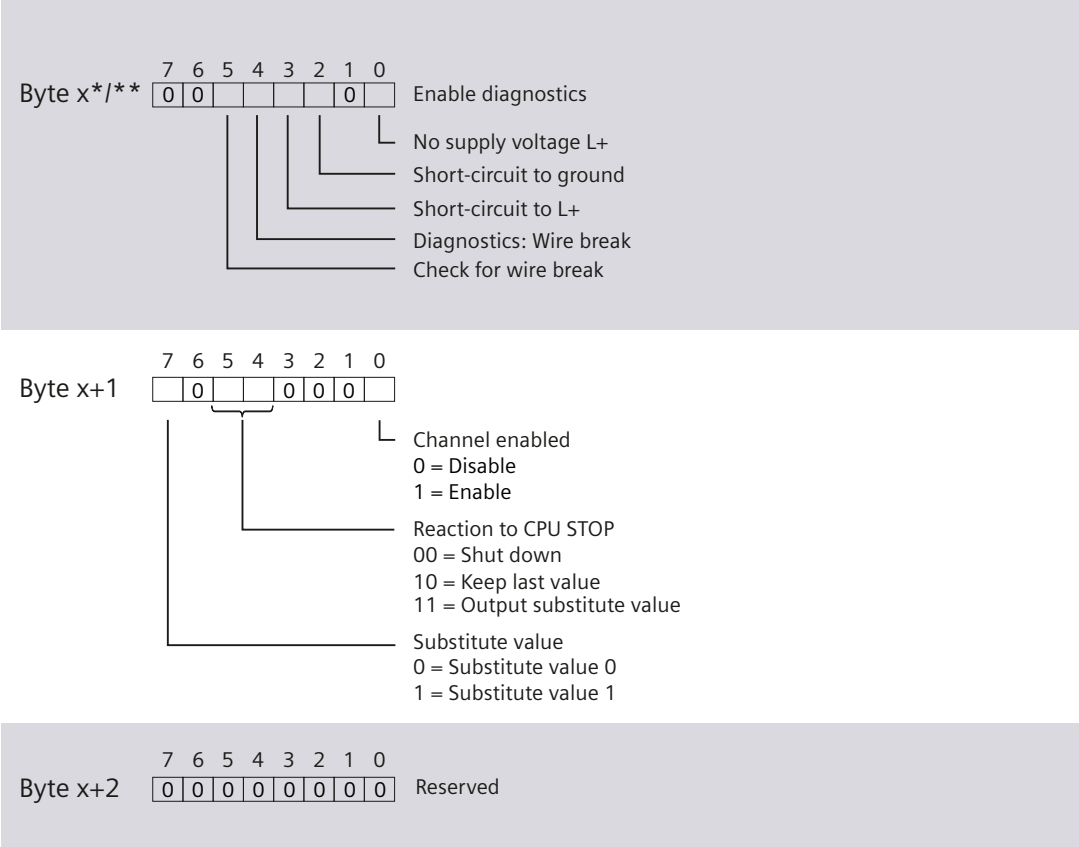

* x = 2 + (channel number × 3); channel number = 0 to 3 for DS 128**
x = 2 for DS 64 to DS 67

Figure 2-342 Structure of byte x to x+2 for channels 0 to 3

A.2 Error codes

Error transmitting the data record

The module always checks all the values of the transferred data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Table 2-343 Error messages, their meaning, and remedial measures

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF_H	80_H	$B0_H$	00_H	Number of the data record unknown	Enter a valid number for the data record.
DF_H	80_H	$B1_H$	01_H	Length of the data record incorrect	Enter a valid value for the data record length.
DF_H	80_H	$B2_H$	00_H	Module not accessible	• Check station. • Plug the module in correctly. • Check parameters of the WRREC block.
DF_H	80_H	$E0_H$	01_H	Header error (version or specified bits incorrect)	Correct version number or specified bits, see Header information (Page 38).
DF_H	80_H	$E0_H$	02_H	Header error (number or length of parameter structures or parameter blocks incorrect)	Correct the number and length of the parameter structures or parameter blocks, see Header information (Page 38).
DF_H	80_H	$E1_H$	01_H	Reserved bit set	Write 0 to all reserved bits.
DF_H	80_H	$E1_H$	02_H	Invalid diagnostics enable bit set for operating mode	Correct diagnostics enables. For dependence on wire-break check parameter, see Structure Byte x to x+2 for channels 0 to 7 (Page 38).
DF_H	80_H	$E1_H$	06_H	Invalid coding for substitute value behavior	Use valid coding for "Reaction to CPU STOP" parameter, see Structure of byte x to x+2 for channels 0 to 3 (Page 38).

SIEMENS

SIMATIC

ET 200SP
Digital output module DQ 4x24VDC/2A HS (6ES7132-6BD20-0DA0)

Equipment Manual

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05/2021
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Preface

Purpose of the documentation

This manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in the system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the central processing units of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: To designate the configuring and programming software, we use "STEP 7" in this documentation as a synonym for all versions of "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For ecologically sustainable recycling and disposal of your old device, contact a certified disposal service for electronic scrap and dispose of the device in accordance with the regulations in your country.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

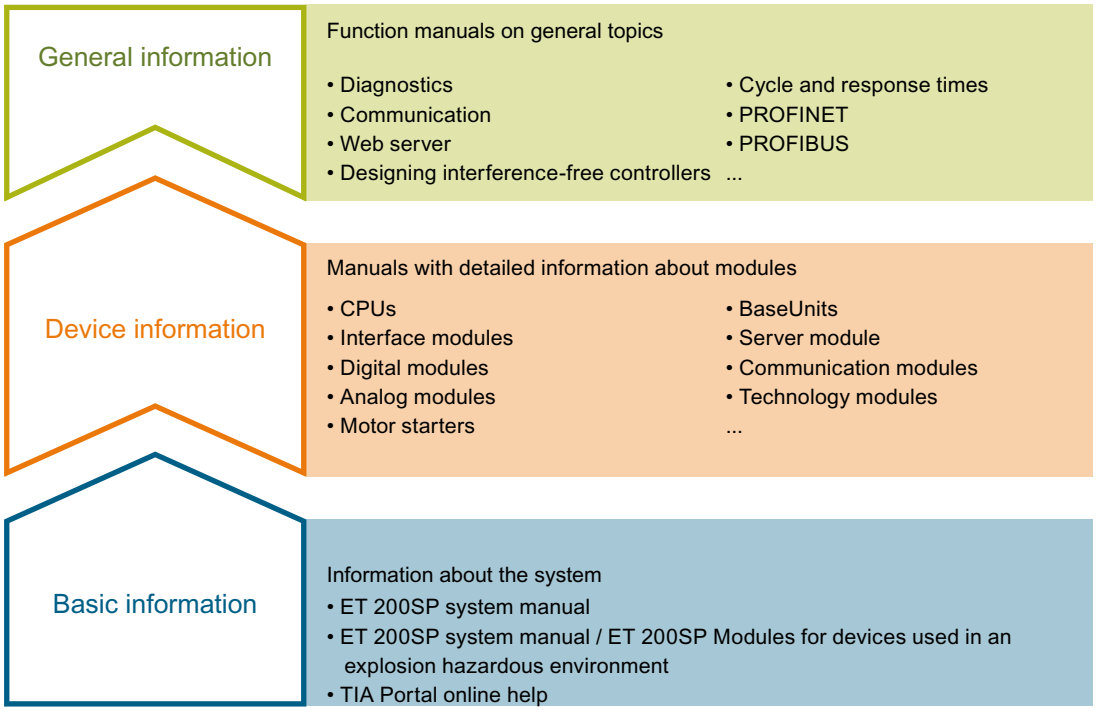

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

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You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/ae).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109767888).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant, incl. fail-safe inputs and outputs.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7132-6BD20-0DA0

View of the module

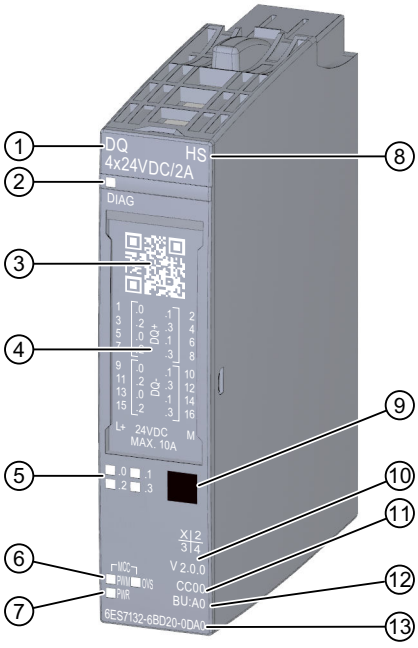

①	Module type and name	⑧	Function class
②	LED for diagnostics	⑨	Color coding of module type
③	2D matrix code	⑩	Function and firmware version
④	Terminal diagram	⑪	Color code for selection of the color coding labels
⑤	LEDs for channel status	⑫	BU type
⑥	LEDs for operating mode	⑬	Article number
⑦	LED for supply voltage		

Figure 2-343 View of the DQ 4×24VDC/2A HS module

Properties

The module has the following technical properties:

- Digital output module with 4 outputs (push-pull)
- Source output (PNP, sourcing output)
- Supply voltage L+
- Output current 2 A (per channel)
- Configurable substitute values (per channel)
- Configurable diagnostics (per module)
- Suitable for solenoid valves, DC contactors, and indicator lights

The module supports the following functions:

Table 2-344 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	FS01 or higher	V1.0.0 or higher	V13 SP1 or higher with HSP 0127	V5.5 SP3 or higher with HSP 0230 V5.0	X	X
Identification data I&M	FS01 or higher	V1.0.0 or higher	V13 SP1 or higher with HSP 0127	V5.5 SP3 or higher with HSP 0230 V5.0	X	X
Configuration in RUN	FS01 or higher	V1.0.0 or higher	V13 SP1 or higher with HSP 0127	V5.5 SP3 or higher with HSP 0230 V5.0	X	X
PROFIenergy	FS01 or higher	V1.0.0 or higher	V13 SP1 or higher with HSP 0127	V5.5 SP3 or higher with HSP 0230 V5.0	X	-
Value status	FS01 or higher	V1.0.0 or higher	V13 SP1 or higher with HSP 0127	V5.5 SP3 or higher with HSP 0230 V5.0	X	-
Isochronous mode	FS01 or higher	V1.0.0 or higher	V13 SP1 or higher with HSP 0127	V5.5 SP3 or higher with HSP 0230 V5.0	-	-
Oversampling	FS01 or higher	V1.0.0 or higher	V13 SP1 or higher with HSP 0127	V5.5 SP3 or higher with HSP 0230 V5.0	-	-
Valve control	FS01 or higher	V1.0.0 or higher	V13 SP1 or higher with HSP 0127	V5.5 SP3 or higher with HSP 0230 V5.0	X	X
Pulse width modulation (PWM)	FS01 or higher	V1.0.0 or higher	V13 SP1 or higher with HSP 0127	V5.5 SP3 or higher with HSP 0230 V5.0	X	X
Cam control (MCC - Modular CAM Controller)	FS01 or higher	V2.0.0 or higher	V15.1 or higher	V5.5 SP3 or higher with HSP 0230 V9.0	V5.6 HF4 / V15 or higher	-
Module-to-module communication (MtM)	FS01 or higher	V2.0.0 or higher	V15.1 or higher	V5.5 SP3 or higher with HSP 0230 V9.0	V5.6 HF4 / V15 or higher	-
Configuration and control via technology object	FS01 or higher	V2.0.0 or higher	V17.0 or higher	-	-	-

Overview of operating modes, functions and parameters

The table below provides an overview of:

- The dependencies between the operating modes of the module and associated technical functions
- The required parameter assignment for the respective operating mode

Table 2-345 Operating modes, functions and parameters of the DQ 4×24VDC/2A HS

Function/Parameter assignment	Operating mode				
	Normal operation	**Valve control in normal operation**	**Pulse width modulation**	**Oversampling**	**Cam control**
Function					
Isochronous mode [1]	Yes, optional	Yes, optional	No	Yes, required	Yes
• Shortest send clock	125 µs	125 µs	-	250 µs	-
Oversampling	No	No	No	Yes	No
• Number of oversampling levels (output rate)	-	-	-	2 to 32	-
• Shortest sub-cycle (= shortest sample time)	-	-	-	100 µs	-
Cam control	-	-	-	-	Yes
• Maximum number of cam tracks	-	-	-	-	4
• Maximum number of cams per track	-	-	-	-	16
Value status (QI)	x	x	-	-	x
Data length • via MtM communication	1 byte	1 byte	8 bytes	16 bytes	14 bytes input data 7 bytes output data
• via CPU					14 bytes of input data, 13 or 23 bytes of output data
Parameter assignment					
Holding time valve control	-	x	-	-	-
Pulse width modulation duty cycle	-	x	-	-	-
Pulse width modulation time period	-	x	x	-	-
Substitute value duty cycle	-	-	x	-	-
Pulsed cam output duty cycle	-	-	-	-	x
Pulsed cam output period	-	-	-	-	x
Modulo activated	-	-	-	-	x

[1] Isochronous mode is not configurable using a GSD file.

Function/Parameter assignment	Operating mode				
	Normal operation	Valve control in normal operation	Pulse width modulation	Oversampling	Cam control
Hysteresis	-	-	-	-	x
Axis reference position	-	-	-	-	x
Encoder value minimum/maximum	-	-	-	-	x
Cam start position/end position	-	-	-	-	x
Cam effective direction	-	-	-	-	x
Cam channel assignment	-	-	-	-	x

[1] Isochronous mode is not configurable using a GSD file.

Configuration options

You can configure the module with STEP 7 or with a GSD file. When you configure the module using a GSD file, you can find the configuration under various short designations/module names. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

The following configurations are possible:

Table 2-346 Configuration options with GSD file of the DQ 4×24VDC/2A HS

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. STEP 7			
		Can be integrated in the hardware catalog of STEP 7 (TIA Portal) V13 SP1 or higher	Can be integrated into hardware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel normal operation without value status	DQ 4×24VDC/2A HS	x	-	x	x
1 x 4-channel normal operation with value status	DQ 4×24VDC/2A HS QI	x	-	x	-
1 x 4-channel with pulse width modulation	DQ 4×24VDC/2A HS PWM	x	-	x	x
1 x 4-channel with oversampling	-	x	-	-	-
1 x 4-channel with cam control and MtM	DQ 4×24VDC/2A HS MCC /6 Byte) MtM	V15 or higher	V5.6 HF4 or higher	x	-
	DQ 4×24VDC/2A HS MCC (16 Byte) MtM	V15 or higher	V5.6 HF4 or higher	x	-

Value status (quality information, QI)

The value status is always activated for the following module names in the GSD file:

- DQ 4×24VDC/2A HS **QI** (...)
- DQ 4×24VDC/2A HS MCC MtM (...)

Evaluating the value status

If you enable the value status function for the digital module, a byte in the input address space is additionally assigned. Bits 0 to 3 of this byte are each assigned to one channel. They provide information about the validity of the digital value.

- Bit = 1: No error is present on the channel.
- Bit = 0: Channel is disabled or there is an error in the module.

If an error occurs on a channel of this module, the value status for all channels is 0.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

See also

Technical specifications (Page 111)

DQ operating mode DQ (valve control) 3

3.1 Wiring

3.1.1 Wiring and block diagram

In this section, you can find the block diagram of the DQ 4x24VDC/2A HS module showing the terminal assignments for a 2-wire and 3-wire connection in DQ operating mode.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

NOTE

You can connect 2 actuators per output.

NOTE

Cross circuit at output

Be aware that voltage from a cross circuit at the output can feed L+ to modules.

NOTE

- The load group of the module must begin with a light BaseUnit. Keep this in mind also during the configuration.
- The connection of actuators with 1-wire connection is not permitted.

NOTE

You may use and combine the different wiring options for all channels.

NOTE

Outputs DQ_n- must not be connected with ground.

Connection: 2-wire connection of actuators

The figure below shows an example for the terminal assignment of the digital output module DQ 4×24VDC/2A HS on the BaseUnit BU type A0 without AUX terminals (2-wire connection).

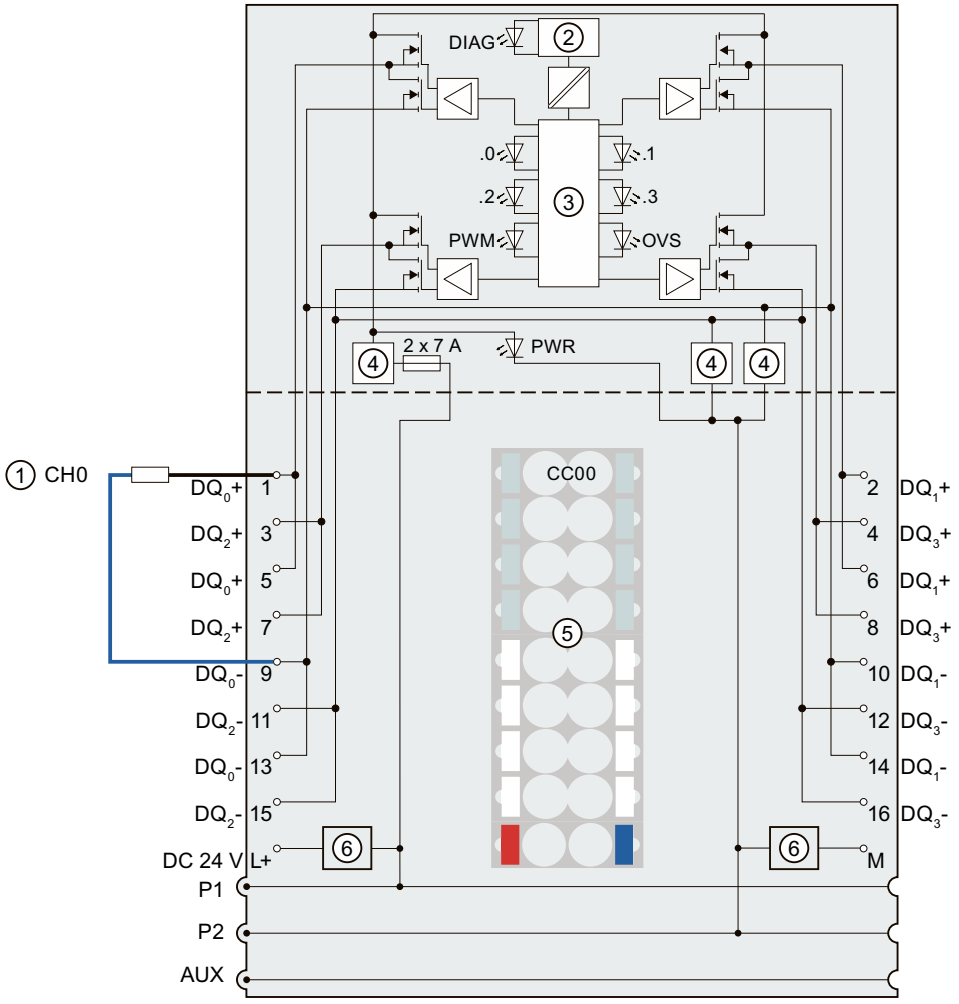

①	2-wire connection	24 V DC	Supply voltage L+ (infeed for light BaseUnit only)
②	Backplane bus interface	M	Ground
③	Control unit	P1, P2, AUX	Internal self-configuring voltage buses Connection to left (dark BaseUnit) Connection to left interrupted (light BaseUnit)
④	Polarity reversal protection	DIAG	Error or Diagnostics LED (green, red)
⑤	Color-coded label CCxx (optional)	.0, .1, .2, .3	Channel status LED (green)
⑥	Supply voltage filter circuit (only when light BaseUnit is present)	PWM	Pulse width modulation LED (green)
DQ_n+	Output signal, channel n	OVS	Oversampling LED (green)
DQ_n-	Reference output signal, channel n	PWR	Power LED (green)

Figure 2-344 Block diagram and terminal assignment for 2-wire connection of actuators

Connection: 3-wire connection of actuators

The figure below shows an example for the terminal assignment of the digital output module DQ 4×24VDC/2A HS on the BaseUnit BU type A0 with AUX terminals (3-wire connection).

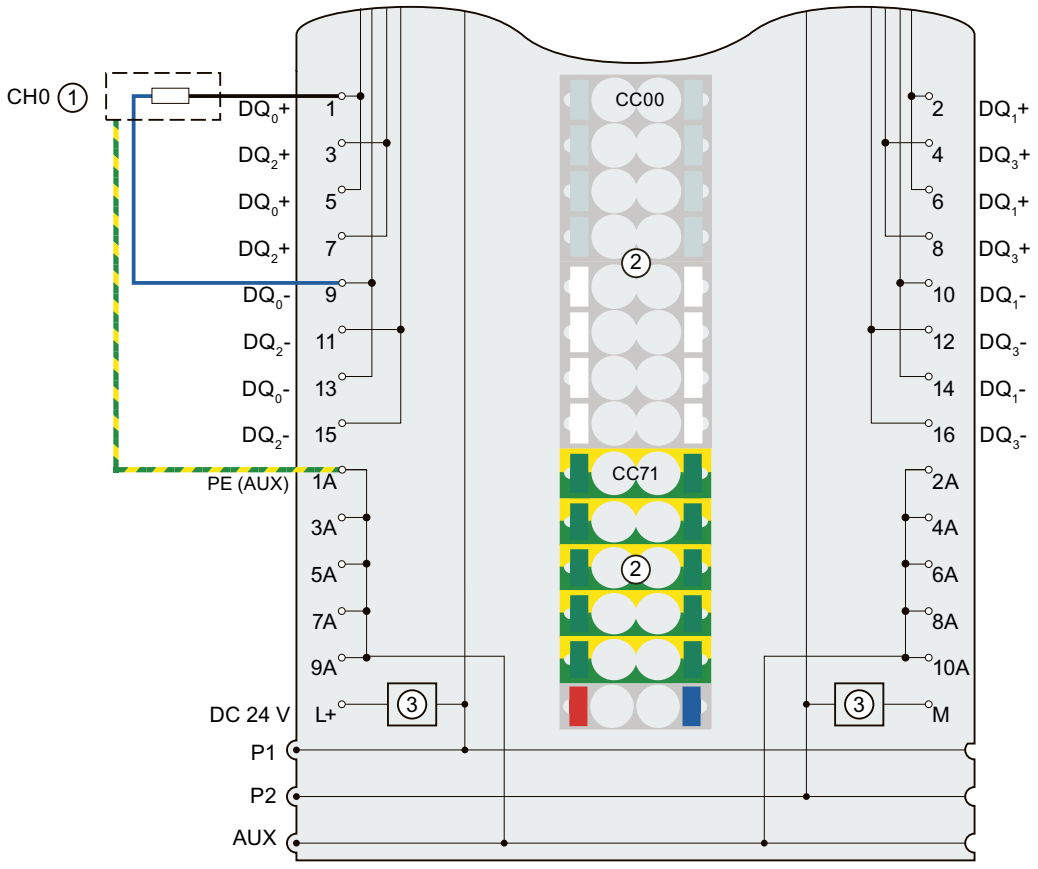

①	3-wire connection	1 A ... 10 A	AUX terminals
②	Color-coded labels CCxx (optional)	PE (AUX)	Protective conductor connection
③	Supply voltage filter circuit (only when light BaseUnit is present)	24 V DC	Supply voltage L+ (infeed for light BaseUnit only)
DQ_n+	Output signal, channel n	M	Ground
DQ_n-	Reference output signal, channel n	P1, P2, AUX	Internal self-configuring voltage buses Connection to left (dark BaseUnit) Connection to left interrupted (light BaseUnit)

Figure 2-345 Terminal assignment for 3-wire connection of actuators

3.2 Parameters/address space

3.2.1 Normal operation/Valve control

Normal operation

"Normal operation" refers to the function of the DQ 4×24VDC/2A HS as digital output module.

Valve control is a special function of normal operation.

Valve control function

You can use the valve control function to switch to a lower "holding current" after operating the valve (inrush current). You do this by activating a pulse width modulation (see section Pulse width modulation (Page 44)).

At a 0 → 1 change of the digital channel, the configured hold time is started. After the hold time elapses, the pulse duty cycle becomes "modulated upon" in the form of a pulse width modulation. The actuating signal is output digitally as a pulse train of on and off pulses.

Configuration

You configure valve control with the following parameters:

- "Normal operation" operating mode
- Holding time valve control
- Pulse width modulation duty cycle
- Pulse width modulation time period

Chronological sequence

The figure below shows the chronological sequence for valve control. The pulse width modulation is activated in the next possible data cycle.

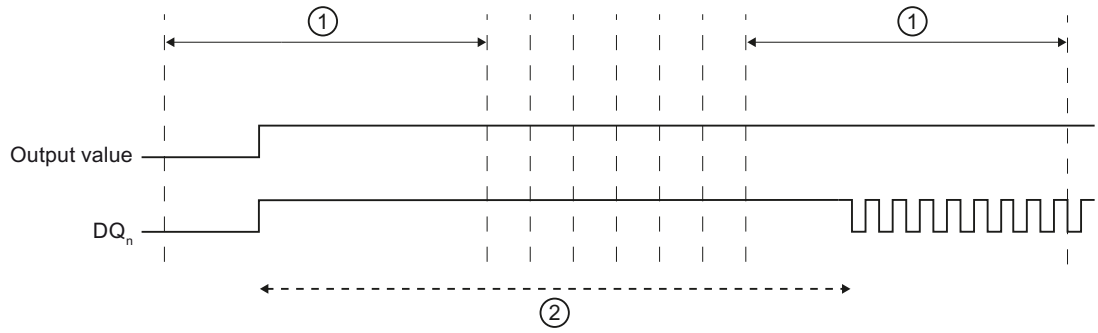

① Data cycle

② Holding time valve control

Figure 2-346 Valve control

"Pulse width modulation time period" parameter

You use the "Pulse width modulation time period" parameter to specify the frequency of the pulse width modulation "modulated upon" for the valve control (see section Pulse width modulation (Page 44)).

Note: When this is parameter is set to "Off", the DQ 4×24VDC/2A HS is in normal operation without valve control.

"Pulse width modulation duty cycle" parameter

You use the "Pulse width modulation duty cycle" parameter (0 ... 1000) to specify the pulse duty cycle of the "modulated upon" pulse width modulation within the configured period.

Note: Unlike in the "Pulse width modulation" operating mode, the duty factor cannot be updated cyclically as a function of an output value from the user program in normal operation with valve control.

Derating

Read the information on derating of the module in section Derating of the DQ 4x24VDC/2A HS (Page 116).

3.2.2 Parameters

DQ 4×24VDC/2A HS parameters

The effective range of the assignable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation on an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition to assigning parameters with the configuration software, you can also set the parameters in RUN mode (dynamically) using the user program. When assigning the parameters in the user program, the "WRREC" instruction transfers the parameters to the module using data records; see section Parameter assignment and structure of the parameter data record for DQ operating mode (Page 119).

The following parameter settings are possible:

Table 2-347 Assignable parameters in DQ operating mode (valve control) (GSD file) [3]

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software	
				HSP0127 for STEP 7 (TIA Portal); HSP0230 for STEP 7; GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Operating mode [4]	• Normal operation DQ (valve control) [2] • Oversampling • Pulse width modulation • Cam control		No	Module	Module [1]
Output rate	• 1 value/cycle	1 value/cycle	No	Module	Module[1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module [1]
Diagnostics Short circuit to L+/G	• Disable • Enable	Disable	Yes	Module	Module [1]
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel [1]
Reaction to CPU STOP	• Shutdown • Keep last value • Output substitute value 1	Shutdown	Yes	Channel	Module [1]
Holding time valve control	• 10 ms • 20 ms • ... • 10 s	500 ms	Yes	Channel	Channel [1]
Pulse width modulation duty cycle	• 0% • 0.1% • 0.2% • ... • 100%	50%	Yes	Channel	Channel [1]
Pulse width modulation time period	• Off • 0.20 ms • 0.40 ms • 0.93 ms • 1.33 ms • 4.27 ms • 10.67 ms • 21.33 ms • 34.13 ms • 59.73 ms	Off	Yes	Channel	Channel [1]

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software	
				HSP0127 for STEP 7 (TIA Portal); HSP0230 for STEP 7; GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Potential group	• Use potential group of the left module (dark BaseUnit) • Enable new potential group (light BaseUnit)	Use potential group of the left module	No	Module	Module [1]

1 Because the number of parameters is limited to a maximum of 244 bytes per ET 200SP station when configuring with a PROFIBUS GSD, the possible parameter assignments are restricted. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 15 bytes.

2 Valve control is a special function of normal operation.

3 Oversampling is not supported with GSD files.

4 When configuring with HSP0230 for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

3.2.3 Explanation of parameters

Operating mode

At the module level, specifies the operating mode in which the module's channels are operated. When configuring with HSP0230 for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

- Normal operation as digital output module
  - Valve control is a special function of normal operation, see section Normal operation/Valve control (Page 19).
- Pulse width modulation, see section Pulse width modulation (Page 44)
- Oversampling, see section Oversampling (Page 32)
- Cam control, see section Cam control operating mode (Page 55)

Output rate

Specifies the number of subcycles per isochronous data cycle.
See section Oversampling (Page 32).

Diagnostics No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics Short circuit to L+/G

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Channel activated

Specifies whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Holding time valve control

Specifies the time which must expire before the pulse width modulated output signal is output in the next possible data cycle.
See section Normal operation/Valve control (Page 19).

Pulse width modulation duty cycle

Specifies the pulse duty cycle for the "modulated upon" pulse width modulation for the valve control.
See section Normal operation/Valve control (Page 19).

Pulse width modulation time period

Specifies the frequency of the pulse width modulation.
See section Normal operation/Valve control (Page 19) and section Pulse width modulation (Page 44).

Potential group

With the "Potential group" parameter, you specify whether the module is plugged into a light or dark BaseUnit.

A potential group always begins with an I/O module that is plugged into a light BaseUnit. All modules inserted to the right of this that are plugged into dark BaseUnits belong to the same potential group, because the dark BaseUnits are supplied via the light BaseUnits.

The potential group ends at a new light BaseUnit or the end of the station.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

3.2.4 Address space

Address space for configuration as a 4-channel DQ 4×24VDC/2A HS

The figure below shows the assignment of the address space for the configuration as a 4-channel module with value status (normal operation without/with valve control). The addresses for the value status are only available if the value status was enabled.

Assignment in the process image output (PIQ) with normal operation

	7	6	5	4	3	2	1	0	Output value
QB x	0	0	0	0					Channel 0 to 3

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	Value status (QI)
IB x	0	0	0	0					Channel 0 to 3 (value status QI0 to QI3)

Figure 2-347 Address space for configuration as a 4-channel DQ 4×24VDC/2A HS with value status

Evaluating the value status

If you enable the value status for the digital module, a byte in the input address space is additionally assigned. Bits 0 to 3 of this byte are each assigned to one channel. They provide information about the validity of the digital value.

Bit = 1: No error is present on the channel.

Bit = 0: Channel is disabled or there is an error in the module.

If an error occurs on a channel of this module, the value status for all channels is 0.

3.3 Interrupts/diagnostics alarms

3.3.1 Status and error displays

LED displays

The figure below shows the location of the LED displays of the DQ 4×24VDC/2A HS.

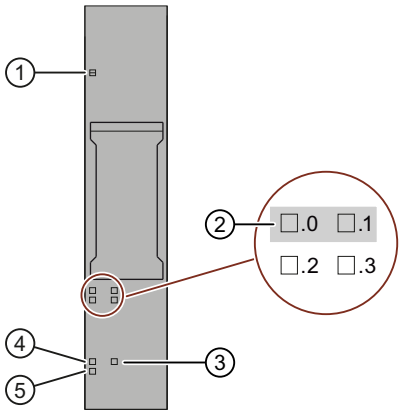

① DIAG (green/red)
② Channel status (green)
③ OVS (green)
④ PWM (green)
⑤ PWR (green)

Figure 2-348 LED displays

Meaning of the LEDs

The following tables contain the meaning of the Status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms.

DIAG LED

Table 2-348 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-349 Status display of the channel status LED

Channel status LED	Meaning
□ Off	Channel deactivated or process signal = 0
■ On	Channel activated and process signal = 1

OVS LED and PWM LED

Table 2-350 Status display of the oversampling LED

OVS LED	PWM LED	Meaning
□ Off	□ Off	DQ operating mode (valve control) active
■ On	□ Off	Oversampling operating mode active
□ Off	■ On	Pulse width modulation operating mode active
■ On	■ On	Cam control (MCC) operating mode active

PWR LED

Table 2-351 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

3.3.2 Interrupts

The DQ 4×24VDC/2A HS digital output module supports diagnostic interrupts.

Diagnostic interrupts

The module generates a diagnostic interrupt at the following events:

- Short circuit
- Excess temperature
- Parameter assignment error
- No supply voltage
- Communication error
- Channel temporarily not available

Detailed information on the event is available in the STEP 7 online help.

3.3.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output and the DIAG LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

NOTE

You can connect 2 actuators per output.

The diagnostics of the two actuators influence each other in the case of duplicate wiring. This means that a single short-circuit affects both actuators.

Table 2-352 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarms	Error code	Meaning	Solution
Short circuit [1] [2]	1_H	Short-circuit of the actuator supply	Correct the process wiring
Excess temperature	5_H	The module has detected that the maximum permitted module temperature has been exceeded. All channels of the module are switched to high resistance. The module is then restarted.	Correct the process wiring
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment

1 The channels 0 and 1 or 2 and 3 each form a load group. Within a load group, a short-circuit can have an effect on the adjacent channel. The load groups do not have an effect on each other in the case of a short-circuit.

2 If the short-circuit persists, the module heats up. This may trigger temperature monitoring with excess temperature diagnostic interrupt.

Diagnostics alarms	Error code	Meaning	Solution
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Communication error	13_H	Module is defective.	Replace the module.
Channel temporarily not available	$1F_H$	Firmware update is currently in progress or was canceled. The module does not output any process values or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

1 The channels 0 and 1 or 2 and 3 each form a load group. Within a load group, a short-circuit can have an effect on the adjacent channel. The load groups do not have an effect on each other in the case of a short-circuit.

2 If the short-circuit persists, the module heats up. This may trigger temperature monitoring with excess temperature diagnostic interrupt.

Oversampling operating mode

4

4.1 Connecting

4.1.1 Wiring and block diagram

In this section, you can find the block diagram of the DQ 4x24VDC/2A HS module showing the terminal assignments for a 2-wire and 3-wire connection in oversampling operating mode.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

NOTE

You can connect 2 actuators per output.

NOTE

Cross circuit at output

Be aware that voltage from a cross circuit at the output can feed L+ to modules.

NOTE

- The load group of the module must begin with a light BaseUnit. Keep this in mind also during the configuration.
- The connection of actuators with 1-wire connection is not permitted.

NOTE

You may use and combine the different wiring options for all channels.

NOTE

Outputs DQ_n- must not be connected with ground.

Connection: 2-wire connection of actuators

The figure below shows an example for the terminal assignment of the digital output module DQ 4×24VDC/2A HS on the BaseUnit BU type A0 without AUX terminals (2-wire connection).

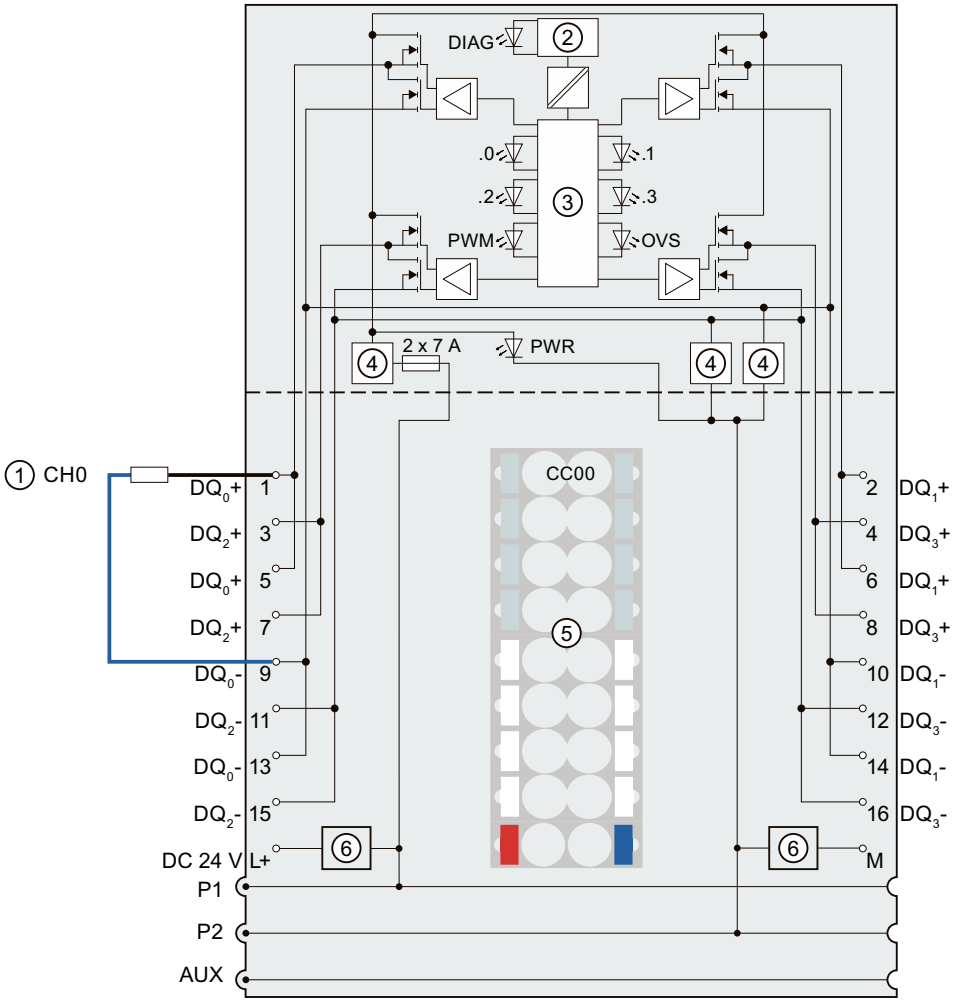

①	2-wire connection	24 V DC	Supply voltage L+ (infeed for light BaseUnit only)
②	Backplane bus interface	M	Ground
③	Control unit	P1, P2, AUX	Internal self-configuring voltage buses Connection to left (dark BaseUnit) Connection to left interrupted (light BaseUnit)
④	Polarity reversal protection	DIAG	Error or Diagnostics LED (green, red)
⑤	Color-coded label CCxx (optional)	.0, .1, .2, .3	Channel status LED (green)
⑥	Supply voltage filter circuit (only when light BaseUnit is present)	PWM	Pulse width modulation LED (green)
DQ_n+	Output signal oversampling, channel n	OVS	Oversampling LED (green)
DQ_n-	Reference output signal, channel n	PWR	Power LED (green)

Figure 2-349 Block diagram and terminal assignment for 2-wire connection of actuators

Connection: 3-wire connection of actuators

The figure below shows an example for the terminal assignment of the digital output module DQ 4×24VDC/2A HS on the BaseUnit BU type A0 with AUX terminals (3-wire connection).

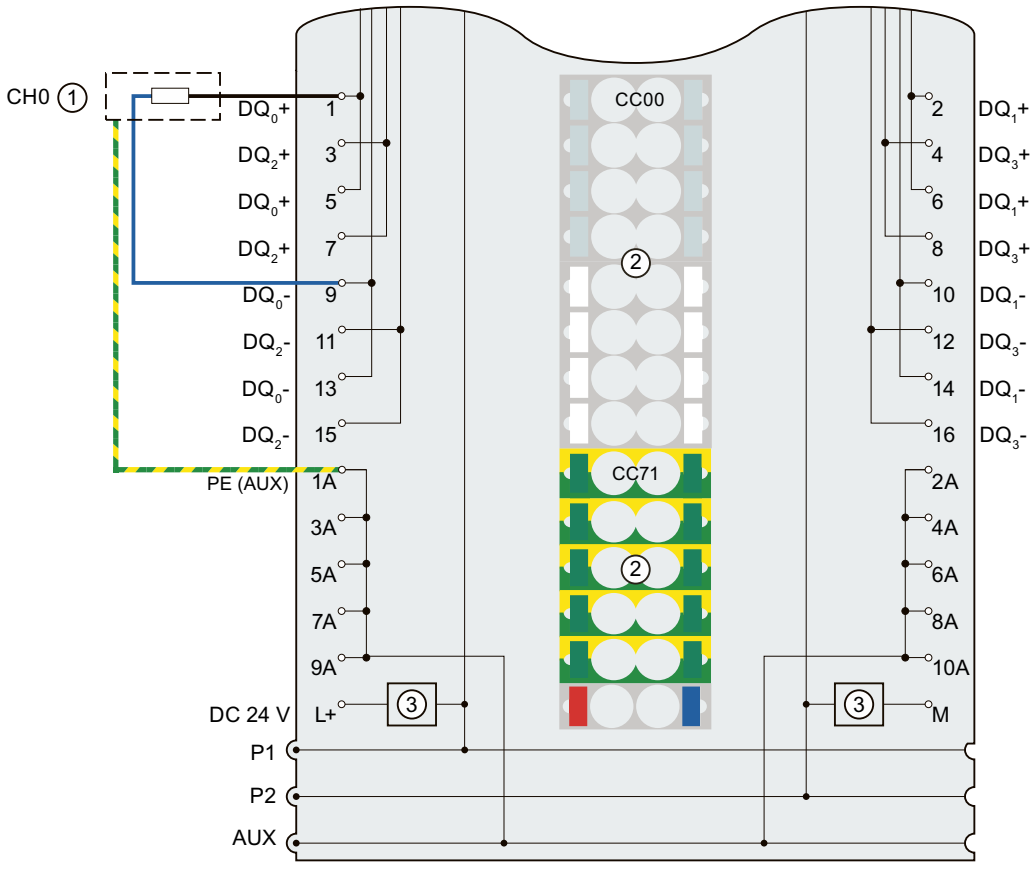

①	3-wire connection	1 A ... 10 A	AUX terminals
②	Color-coded labels CCxx (optional)	PE (AUX)	Protective conductor connection
③	Supply voltage filter circuit (only when light BaseUnit is present)	24 V DC	Supply voltage L+ (infeed for light BaseUnit only)
DQ_n+	Output signal oversampling, channel n	M	Ground
DQ_n-	Reference output signal, channel n	P1, P2, AUX	Internal self-configuring voltage buses Connection to left (dark BaseUnit) Connection to left interrupted (light BaseUnit)

Figure 2-350 Terminal assignment for 3-wire connection of actuators

4.2 Parameters/address space

4.2.1 Oversampling

Function

Oversampling is the output of data in constant bus cycle segments (sub-cycles), whereby n sub-cycles correspond to one PROFINET bus cycle. A data packet is transmitted from the controller to the module, which outputs the packet in n constant bus sub-cycles.

Oversampling is useful whenever you require output of data with high time resolution but without using an extremely short PROFINET bus cycle and thus fast CPU cycles.

With oversampling, a PROFINET bus cycle is divided into constant bus sub-cycles:

- Each sub-cycle returns a 4-bit output value.
- A sub-cycle is at least 100 µs long.
- Sub-cycles are possible in increments of 2 to 32 (only even numbers). The following applies here: Isochronous data cycle / number of sub-cycles ≥ permitted sub-cycle duration (100 µs).

Requirement

Oversampling is only possible when isochronous mode is set.

Configuration

You configure oversampling with the following parameters:

- "Oversampling" operating mode
- Output rate

NOTE

When oversampling is configured, do not use any reduction ratio of blocks in the runtime groups of your user program. Make sure that the output of data in the module is synchronized with the user program of the CPU.

Chronological sequence

The figure below shows the chronological sequence for oversampling. The output data present in the CPU is output in the data cycle after the next one, distributed across the sub-cycles which are generated on the actual module.

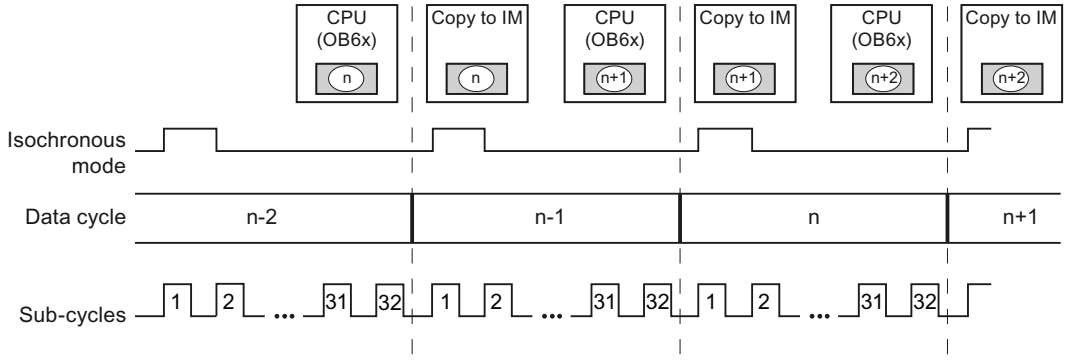

n Output values from bus cycle n

Sub-cycle 4 bit x 32 (max) each = max. 16 bytes output data per data cycle

Figure 2-351 Oversampling

Derating

Read the information on derating of the module in section Derating of the DQ 4x24VDC/2A HS (Page 116).

4.2.2 Parameters

DQ 4×24VDC/2A HS parameters

The effective range of the assignable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation on an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system

In addition to assigning parameters with the configuration software, you can also set the parameters in RUN mode (dynamically) using the user program. When assigning the parameters in the user program, the "WRREC" instruction transfers the parameters to the module using data records; see section Parameter assignment and structure of the parameter data record for oversampling operating mode (Page 124).

The following parameter settings are possible:

Table 2-353 Assignable parameters in oversampling operating mode

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software
				HSP0127 for STEP 7 (TIA Portal); HSP0230 for STEP 7
Operating mode [1]	• Normal operation DQ (valve control) [2] • Oversampling • Pulse width modulation • Cam control		No	Module
Output rate	• 2 values/cycle • 4 values/cycle • ... • 32 values/cycle		No	Module
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module
Diagnostics Short circuit to L+/G	• Disable • Enable	Disable	Yes	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel
Reaction to CPU STOP	• Shutdown • Keep last value • Output substitute value 1	Shutdown	Yes	Channel
Potential group	• Use potential group of the left module (dark BaseUnit) • Enable new potential group (light BaseUnit)	Use potential group of the left module	No	Module

1 When configuring with HSP0230 for STEP 7, you determine the operating mode when you select the module name.

2 Valve control is a special function of normal operation.

4.2.3 Explanation of parameters

Operating mode

At the module level, specifies the operating mode in which the module's channels are operated. When configuring with HSP0230 for STEP 7, you determine the operating mode when you select the module name.

- Normal operation as digital output module
  - Valve control is a special function of normal operation, see section Normal operation/Valve control (Page 19).
- Pulse width modulation, see section Pulse width modulation (Page 44)
- Oversampling, see section Oversampling (Page 32)
- Cam control, see section Cam control operating mode (Page 55)

Output rate

Specifies the number of subcycles per isochronous data cycle.
See section Oversampling (Page 32).

Diagnostics No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics Short circuit to L+/G

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Channel activated

Specifies whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

With the "Potential group" parameter, you specify whether the module is plugged into a light or dark BaseUnit.

A potential group always begins with an I/O module that is plugged into a light BaseUnit. All modules inserted to the right of this that are plugged into dark BaseUnits belong to the same potential group, because the dark BaseUnits are supplied via the light BaseUnits.

The potential group ends at a new light BaseUnit or the end of the station.

See also

Distributed I/O System ET 200SP
(https://support.industry.siemens.com/cs/ww/en/view/58649293)

4.2.4 Address space

Address space for configuration with oversampling

The figure below shows the address space allocation for the configuration with oversampling.

Assignment in the process image output (PIQ) with oversampling

	7	6	5	4	3	2	1	0	Output value (left-justified)
QB x									Channel 0, sub-cycles 1 to 8
QB x + 1									Channel 0, sub-cycles 9 to 16
QB x + 2									Channel 0, sub-cycles 17 to 24
QB x + 3									Channel 0, sub-cycles 25 to 32
					⋮				
QB x + 12									Channel 3, sub-cycles 1 to 8
QB x + 13									Channel 3, sub-cycles 9 to 16
QB x + 14									Channel 3, sub-cycles 17 to 24
QB x + 15									Channel 3, sub-cycles 25 to 32

Figure 2-352 Address space of the DQ 4×24VDC/2A HS with oversampling

4.3 Interrupts/diagnostics alarms

4.3.1 Status and error displays

LED displays

The figure below shows the location of the LED displays of the DQ 4×24VDC/2A HS.

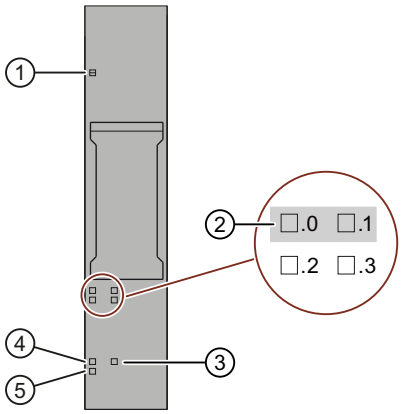

① DIAG (green/red)
② Channel status (green)
③ OVS (green)
④ PWM (green)
⑤ PWR (green)

Figure 2-353 LED displays

Meaning of the LEDs

The following tables contain the meaning of the Status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms.

DIAG LED

Table 2-354 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-355 Status display of the channel status LED

Channel status LED	Meaning
□ Off	Channel deactivated or process signal = 0
■ On	Channel activated and process signal = 1

OVS LED and PWM LED

Table 2-356 Status display of the oversampling LED

OVS LED	PWM LED	Meaning
□ Off	□ Off	DQ operating mode (valve control) active
■ On	□ Off	Oversampling operating mode active
□ Off	■ On	Pulse width modulation operating mode active
■ On	■ On	Cam control (MCC) operating mode active

PWR LED

Table 2-357 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

4.3.2 Interrupts

The DQ 4×24VDC/2A HS digital output module supports diagnostic interrupts.

Diagnostic interrupts

The module generates a diagnostic interrupt at the following events:

- Short circuit
- Excess temperature
- Parameter assignment error
- No supply voltage
- Communication error
- Channel temporarily not available

Detailed information on the event is available in the STEP 7 online help.

4.3.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output and the DIAG LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

NOTE

You can connect 2 actuators per output.

The diagnostics of the two actuators influence each other in the case of duplicate wiring. This means that a single short-circuit affects both actuators.

Table 2-358 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarms	Error code	Meaning	Solution
Short circuit [1] [2]	1_H	Short-circuit of the actuator supply	Correct the process wiring
Excess temperature	5_H	The module has detected that the maximum permitted module temperature has been exceeded. All channels of the module are switched to high resistance. The module is then restarted.	Correct the process wiring
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment

[1] The channels 0 and 1 or 2 and 3 each form a load group. Within a load group, a short-circuit can have an effect on the adjacent channel. The load groups do not have an effect on each other in the case of a short-circuit.

[2] If the short-circuit persists, the module heats up. This may trigger temperature monitoring with excess temperature diagnostic interrupt.

Diagnostics alarms	Error code	Meaning	Solution
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Communication error	13_H	Module is defective.	Replace the module.
Channel temporarily not available	$1F_H$	Firmware update is currently in progress or was canceled. The module does not output any process values or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

1 The channels 0 and 1 or 2 and 3 each form a load group. Within a load group, a short-circuit can have an effect on the adjacent channel. The load groups do not have an effect on each other in the case of a short-circuit.

2 If the short-circuit persists, the module heats up. This may trigger temperature monitoring with excess temperature diagnostic interrupt.

Pulse width modulation operating mode 5

5.1 Connecting

5.1.1 Wiring and block diagram

In this section, you can find the block diagram of the DQ 4x24VDC/2A HS module showing the terminal assignments for a 2-wire and 3-wire connection in pulse width modulation operating mode.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

NOTE

You can connect 2 actuators per output.

NOTE

Cross circuit at output

Be aware that voltage from a cross circuit at the output can feed L+ to modules.

NOTE

- The load group of the module must begin with a light BaseUnit. Keep this in mind also during the configuration.
- The connection of actuators with 1-wire connection is not permitted.

NOTE

You may use and combine the different wiring options for all channels.

NOTE

Outputs DQ_n- must not be connected with ground.

Connection: 2-wire connection of actuators

The figure below shows an example for the terminal assignment of the digital output module DQ 4×24VDC/2A HS on the BaseUnit BU type A0 without AUX terminals (2-wire connection).

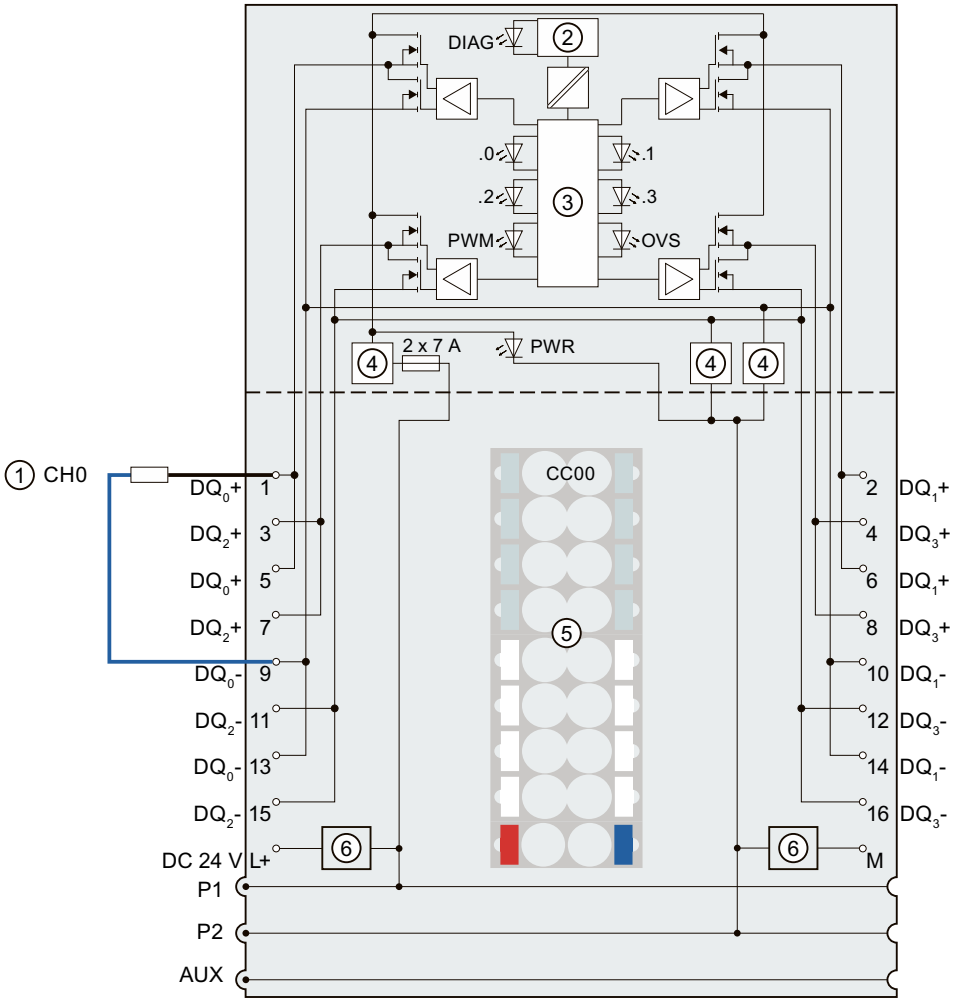

①	2-wire connection	24 V DC	Supply voltage L+ (infeed for light BaseUnit only)
②	Backplane bus interface	M	Ground
③	Control unit	P1, P2, AUX	Internal self-configuring voltage buses Connection to left (dark BaseUnit) Connection to left interrupted (light BaseUnit)
④	Polarity reversal protection	DIAG	Error or Diagnostics LED (green, red)
⑤	Color-coded label CCxx (optional)	.0, .1, .2, .3	Channel status LED (green)
⑥	Supply voltage filter circuit (only when light BaseUnit is present)	PWM	Pulse width modulation LED (green)
DQ_n+	Output signal pulse width modulation, channel n	OVS	Oversampling LED (green)
DQ_n-	Reference output signal, channel n	PWR	Power LED (green)

Figure 2-354 Block diagram and terminal assignment for 2-wire connection of actuators

Connection: 3-wire connection of actuators

The figure below shows an example for the terminal assignment of the digital output module DQ 4×24VDC/2A HS on the BaseUnit BU type A0 with AUX terminals (3-wire connection).

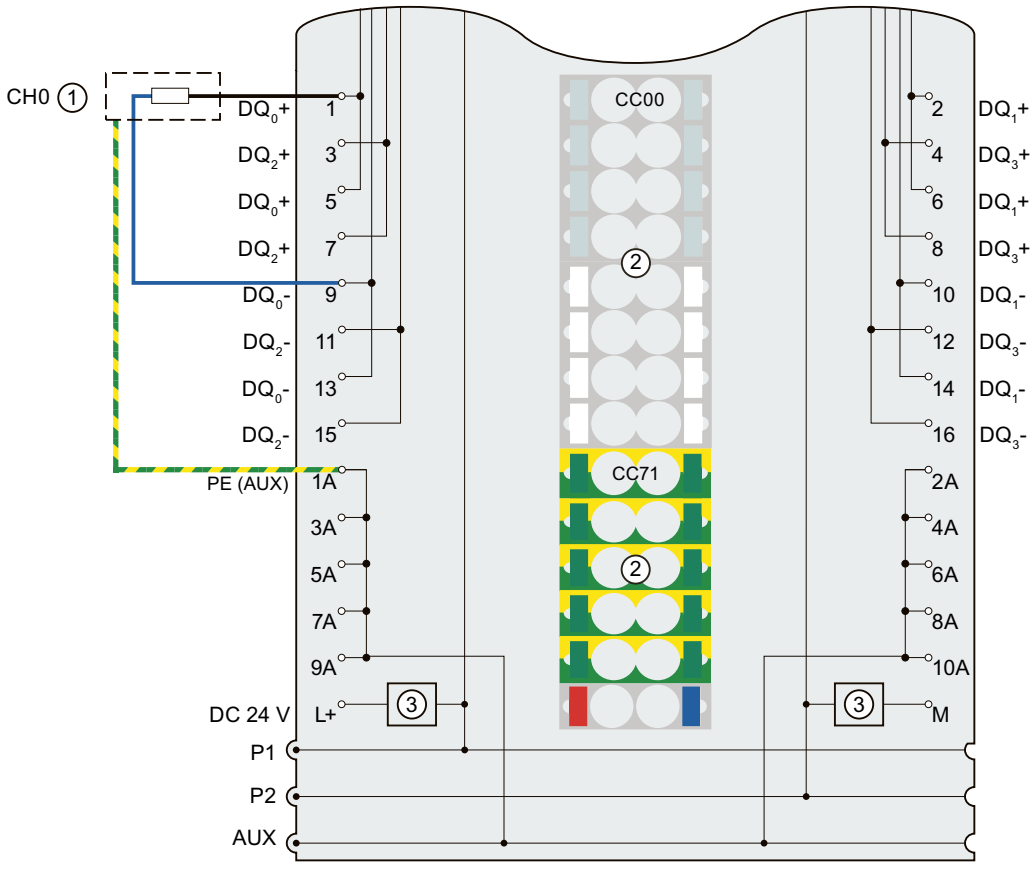

①	3-wire connection	1 A ... 10 A	AUX terminals
②	Color-coded labels CCxx (optional)	PE (AUX)	Protective conductor connection
③	Supply voltage filter circuit (only when light BaseUnit is present)	24 V DC	Supply voltage L+ (infeed for light BaseUnit only)
DQ_n+	Output signal pulse width modulation, channel n	M	Ground
DQ_n-	Reference output signal, channel n	P1, P2, AUX	Internal self-configuring voltage buses Connection to left (dark BaseUnit) Connection to left interrupted (light BaseUnit)

Figure 2-355 Terminal assignment for 3-wire connection of actuators

5.2 Parameters/address space

5.2.1 Pulse width modulation

Function

In the "pulse width modulation" operating mode, the four outputs only provide a pulse width modulated output signal.

The digital channel is activated with a pulse duty cycle that is updated cyclically as a function of the output value from the user program. The actuating signal is output digitally as a pulse train of on and off pulses.

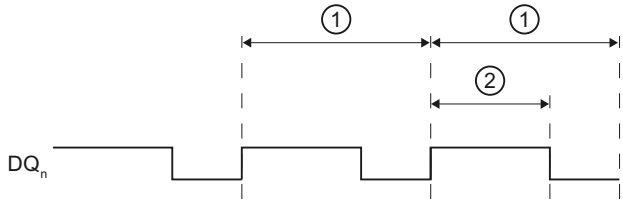

① Time period T; frequency of the pulse width modulation: f = 1/T

② Pulse duration (duty factor)

Figure 2-356 Pulse width modulation

Configuration

You configure the pulse width modulation with the following parameters:

- "Pulse width modulation" operating mode
- Pulse width modulation time period
- Substitute value duty cycle

Chronological sequence

The output value (0 ... 1000) is written from the user program to the output word of the channel. The module maps this value by means of the output characteristic and the values for minimum pulse duration and minimum pulse pause to the configured time period and thus determines the pulse duty cycle (the pulse duration) of the pulse width modulation.

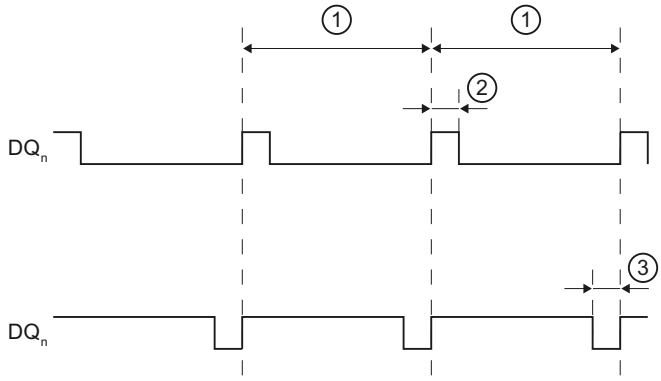

① Time period T

② Minimum pulse duration

③ Minimum pulse pause

Figure 2-357 Minimum pulse duration and minimum pulse pause

The minimum pulse duration and the minimum pulse pause are at least 2 µs each, which means:

- Any pulse duration that is shorter than the minimum pulse duration will be suppressed
- Any pulse duration that is longer than the time period minus minimum pulse duration is reduced to 100% (≙ output value 1000)

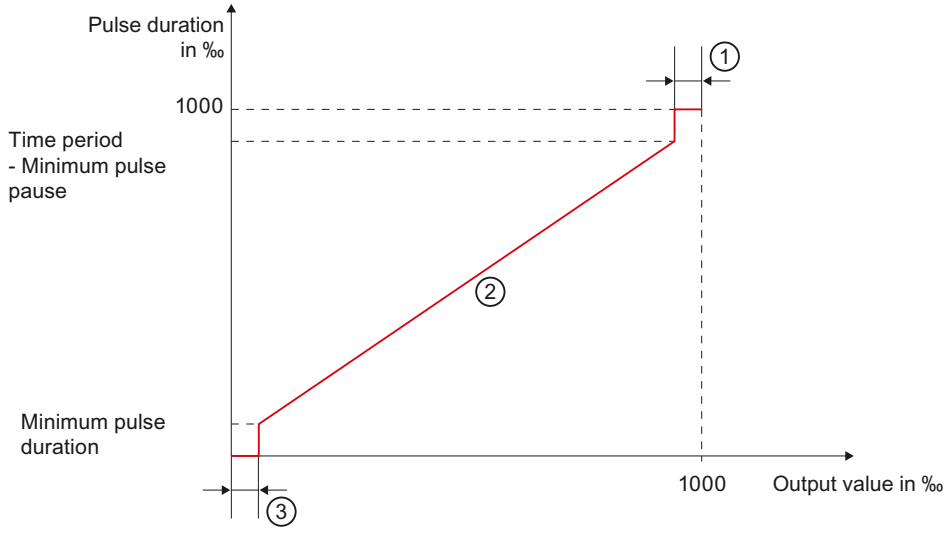

① Minimum pulse pause

② Output characteristic

③ Minimum pulse duration

Figure 2-358 Output characteristic of the pulse duration

The following values apply when determining the pulse duty cycle of the pulse width modulation:

Table 2-359 Determining the pulse duty cycle of the pulse width modulation

Time period parameter	Frequency	Output value in the user program (‰)	Pulse duty cycle at output terminal DQ_n (‰)
0.20 ms	5000 Hz	0...9	0
		10...990	10...990
		991...1000	1000
0.40 ms	2500 Hz	0...4	0
		5...995	5...995
		996...1000	1000
0.93 ms	1071 Hz	0...2	0
		3...997	3...997
		998...1000	1000
1.33 ms	750 Hz	0, 1	0
		2...998	2...998
		999, 1000	1000
4.27 ms	234 Hz	0...1000	0...1000
10.67 ms	94 Hz	0...1000	0...1000
21.33 ms	47 Hz	0...1000	0...1000
34.13 ms	29 Hz	0...1000	0...1000
59.73 ms	17 Hz	0...1000	0...1000

Example

When you configure a channel with 5000 Hz (≙ 200 µs) and the user program writes the value 3 to the output word of the channel, this value is converted to 0 by the module: The channel is permanently 0.

"Diagnostics Overflow" parameter

You use the "Diagnostics Overflow" parameter to enable the diagnostics for the case that the permitted value range of the duty factor is exceeded, i.e. an output value > 1000 from the user program is written to the output word of the channel.

"Substitute value duty cycle" parameter

You use the "Substitute value duty cycle" parameter (0 ... 1000) to specify the pulse duty cycle of the pulse width modulation in the case of a CPU STOP.

Derating

Read the information on derating of the module in section Derating of the DQ 4x24VDC/2A HS (Page 116).

5.2.2 Parameters

Parameters

The effective range of the assignable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation on an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition to assigning parameters with the configuration software, you can also set the parameters in RUN mode (dynamically) using the user program. When assigning the parameters in the user program, the "WRREC" instruction transfers the parameters to the module using data records; see section Parameter assignment and structure of the parameter data record for pulse width modulation operating mode (Page 129).

The following parameter settings are possible for the respective operating mode:

Table 2-360 Assignable parameters in pulse width modulation operating mode (GSD file) [3]

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software	
				HSP0127 for STEP 7 (TIA Portal); HSP0230 for STEP 7; GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Operating mode [4]	• Normal operation DQ (valve control) [2] • Oversampling • Pulse width modulation • Cam control		No	Module	Module [1]
Output rate	• 1 value/cycle	1 value/cycle	No	Module	Module[1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module [1]
Diagnostics Short circuit to L+/G	• Disable • Enable	Disable	Yes	Module	Module [1]
Diagnostics Overflow	• Disable • Enable	Disable	Yes	Module	Module [1]
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel [1]

1 Because the number of parameters is limited to a maximum of 244 bytes per ET 200SP station when configuring with a PROFIBUS GSD, the possible parameter assignments are restricted. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 15 bytes.

2 Valve control is a special function of normal operation.

3 Oversampling is not supported with GSD files.

4 When configuring with HSP0230 for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software	
				HSP0127 for STEP 7 (TIA Portal); HSP0230 for STEP 7; GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Reaction to CPU STOP	• Shutdown • Keep last value • Output substitute value	Shutdown	Yes	Channel	Module [1]
Substitute value duty cycle	• 0% • 0.1% • 0.2% • ... • 100%	0%	Yes	Channel	Channel [1]
Pulse width modulation time period	• Off • 0.20 ms • 0.40 ms • 0.93 ms • 1.33 ms • 4.27 ms • 10.67 ms • 21.33 ms • 34.13 ms • 59.73 ms	0.93 ms	Yes	Channel	Channel [1]
Potential group	• Use potential group of the left module (dark BaseUnit) • Enable new potential group (light BaseUnit)	Use potential group of the left module	No	Module	Module [1]

1 Because the number of parameters is limited to a maximum of 244 bytes per ET 200SP station when configuring with a PROFIBUS GSD, the possible parameter assignments are restricted. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 15 bytes.

2 Valve control is a special function of normal operation.

3 Oversampling is not supported with GSD files.

4 When configuring with HSP0230 for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

5.2.3 Explanation of parameters

Operating mode

At the module level, specifies the operating mode in which the module's channels are operated. When configuring with HSP0230 for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

- Normal operation as digital output module
  - Valve control is a special function of normal operation, see section Normal operation/Valve control (Page 19).
- Pulse width modulation, see section Pulse width modulation (Page 44)
- Oversampling, see section Oversampling (Page 32)
- Cam control, see section Cam control operating mode (Page 55)

Output rate

Specifies the number of subcycles per isochronous data cycle.
See section Oversampling (Page 32).

Diagnostics No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics Short circuit to L+/G

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Diagnostics Overflow

You use the "Diagnostics Overflow" parameter to enable the diagnostics for the case that the permitted value range of the duty factor is exceeded, i.e. an output value > 1000 from the user program is written to the output word of the channel. See section Pulse width modulation (Page 44).

Channel activated

Specifies whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Substitute value duty cycle

You use the "Substitute value duty cycle" parameter (0 ... 1000) to specify the pulse duty cycle of the pulse width modulation in the case of a CPU STOP. See section Pulse width modulation (Page 44).

Pulse width modulation time period

Specifies the frequency of the pulse width modulation.
See section Normal operation/Valve control (Page 19) and section Pulse width modulation (Page 44).

Potential group

With the "Potential group" parameter, you specify whether the module is plugged into a light or dark BaseUnit.

A potential group always begins with an I/O module that is plugged into a light BaseUnit. All modules inserted to the right of this that are plugged into dark BaseUnits belong to the same potential group, because the dark BaseUnits are supplied via the light BaseUnits.

The potential group ends at a new light BaseUnit or the end of the station.

Derating

Read the information on derating of the module in section Derating of the DQ 4x24VDC/2A HS (Page 116).

See also

Distributed I/O System ET 200SP
(https://support.industry.siemens.com/cs/ww/en/view/58649293)

5.2.4 Address space

Address space for configuration with pulse width modulation

The figure below shows the address space allocation for the configuration with pulse width modulation.

Assignment in the process image output (PIQ) with pulse width modulation

	7	6	5	4	3	2	1	0	Output value
QB x									Channel 0
QB x + 1									
QB x + 2									Channel 1
QB x + 3									
QB x + 4									Channel 2
QB x + 5									
QB x + 6									Channel 3
QB x + 7									

Figure 2-359 Address space of the DQ 4×24VDC/2A HS with pulse width modulation

5.3 Interrupts/diagnostics alarms

5.3.1 Status and error displays

LED displays

The figure below shows the location of the LED displays of the DQ 4×24VDC/2A HS.

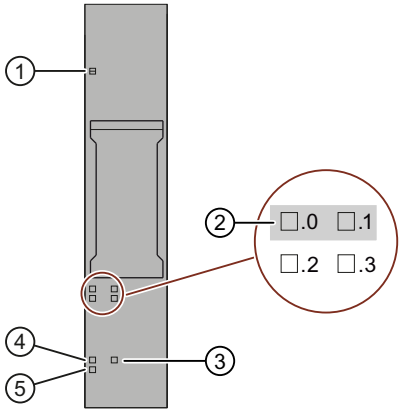

① DIAG (green/red)
② Channel status (green)
③ OVS (green)
④ PWM (green)
⑤ PWR (green)

Figure 2-360 LED displays

Meaning of the LEDs

The following tables contain the meaning of the Status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms.

DIAG LED

Table 2-361 Error display of the DIAG LED

DIAG LED	Meaning
□ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-362 Status display of the channel status LED

Channel status LED	Meaning
□ Off	Channel deactivated or process signal = 0
■ On	Channel activated and process signal = 1

OVS LED and PWM LED

Table 2-363 Status display of the oversampling LED

OVS LED	PWM LED	Meaning
□ Off	□ Off	DQ operating mode (valve control) active
■ On	□ Off	Oversampling operating mode active
□ Off	■ On	Pulse width modulation operating mode active
■ On	■ On	Cam control (MCC) operating mode active

PWR LED

Table 2-364 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

5.3.2 Interrupts

The DQ 4×24VDC/2A HS digital output module supports diagnostic interrupts.

Diagnostic interrupts

The module generates a diagnostic interrupt at the following events:

- Short circuit
- Excess temperature
- High limit violated
- Parameter assignment error
- No supply voltage
- Communication error
- Channel temporarily not available

Detailed information on the event is available in the STEP 7 online help.

5.3.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output and the DIAG LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

NOTE

You can connect 2 actuators per output.

The diagnostics of the two actuators influence each other in the case of duplicate wiring. This means that a single short-circuit affects both actuators.

Table 2-365 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarms	Error code	Meaning	Solution
Short circuit [1] [2]	1_H	Short-circuit of the actuator supply	Correct the process wiring
Excess temperature	5_H	The module has detected that the maximum permitted module temperature has been exceeded. All channels of the module are switched to high resistance. The module is then restarted.	Correct the process wiring
High limit violated	7_H	The permitted value range of the duty factor has been exceeded.	Correct the output value (0 to 1000)
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Communication error	13_H	Module is defective.	Replace the module.
Channel temporarily not available	$1F_H$	Firmware update is currently in progress or was canceled. The module does not output any process values or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

1 The channels 0 and 1 or 2 and 3 each form a load group. Within a load group, a short-circuit can have an effect on the adjacent channel. The load groups do not have an effect on each other in the case of a short-circuit.

2 If the short-circuit persists, the module heats up. This may trigger temperature monitoring with excess temperature diagnostic interrupt.

Cam control operating mode 6

6.1 Overview of the possible applications

6.1.1 Parameterization and control options

You configure and parameterize the output module DQ 4x24VDC/2A HS using STEP 7 (TIA Portal).

You have two alternative options for parameterizing and controlling the functions of the output module:

- Configuration using the technology object and control with the corresponding instruction
  The technology module control and feedback interface is accessed with the technology object.
  The encoder data is transferred either with the technology object (user program) or via Module to Module Communication (MtM) to the output module and processed there.
- Parameter settings via hardware configuration
  Access to the control and feedback interface of the output module takes place through direct access of the user program to the I/O data.
  The encoder data are transferred via Module to Module Communication (MtM) and processed by the output module.

6.1.2 Configuration via technology object

For central and distributed use, we recommend the convenient, graphics-assisted configuration using a technology object. A detailed description of this configuration can be found starting from section Technology object DQ4_CAM (Page 85).

For the device configuration of the output module, specify "Cam control" mode and "Use "DQ4_CAM" technology object" control mode.

When assigning the parameters of the Hardware interface (Page 90) in the technology object, you decide the assignment to the encoder module and to the output module and specify the type of data transmission.

Data transmission via the CPU

Here you parameterize as Data transmission "by controller".

NOTE

Encoder module and output modules may be located in different stations or in the same station. This applies to centralized as well as distributed operation.

The following figure shows the data exchange process when using the technology object without MtM communication.

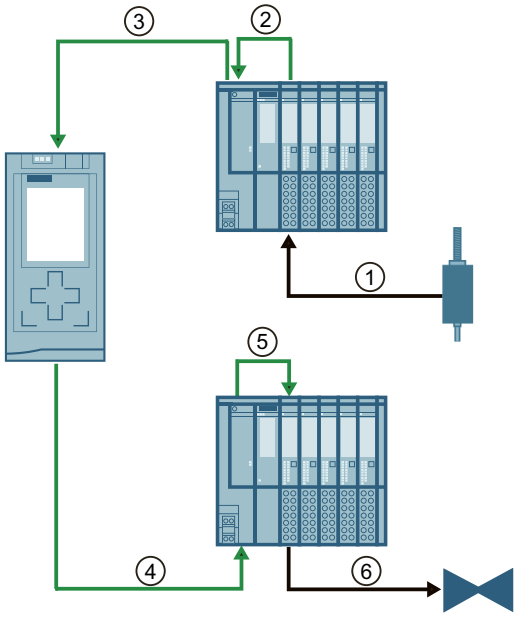

① Read encoder signals into encoder module
② Transfer encoder signals to interface module
③ Transfer encoder signals to technology object
④ Transfer encoder signals to interface module
⑤ Transfer encoder signals to output module
⑥ Process encoder signals in the output module and output signals

The scope of the input and output addresses of the output module for data transmission via the CPU is:

	Inputs	Outputs
Range	14 bytes	13 bytes or 23 bytes, depending on the encoder module used

Data transmission via MtM communication

Here you parameterize as Data transmission "via Module to Module Communication".

NOTE

Data transmission via MtM communication can only be used in conjunction with an interface module that supports Module to Module Communication (MtM). In addition, the encoder module and output module must be in the same station.

The figure below shows the data exchange process when using the technology object with MtM communication.

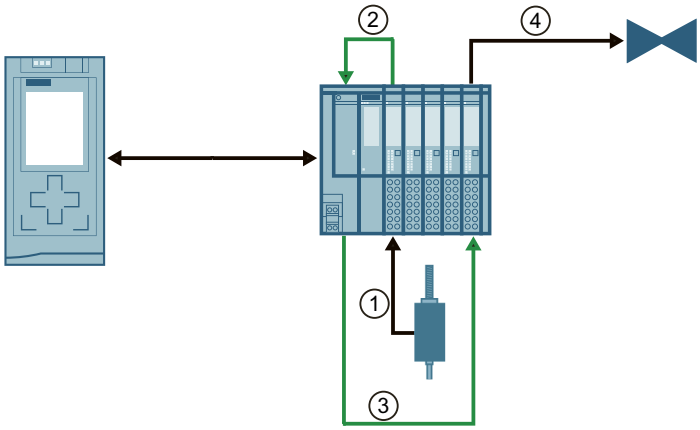

① Read encoder signals into encoder module

② Transfer encoder signals to interface module

③ Transfer encoder signals to output module

④ Process encoder signals in the output module and output signals

The scope of the input and output addresses of the output module for data transmission via MtM communication is:

	Inputs	Outputs
Range	14 bytes	7 bytes

When using Module to Module Communication (MtM), the reaction time of the cam controller is reduced to the duration of a backplane bus cycle. A backplane bus cycle typically corresponds to one PROFINET cycle.

You can find more information on Module-to-Module Communication (MtM) in the FAQ with entry ID 109767618 (https://support.industry.siemens.com/cs/ww/en/view/109767618) in Siemens Industry Online Support.

6.1.3 Parameter setting via hardware configuration with MtM communication

For the device configuration of the output module, specify "Cam control" mode and "Use MtM without technology object" control mode. Additional support on setting parameters via the hardware configuration and a description of the control and feedback interface is available in the section Address space (Page 76).

NOTE

Data transmission via MtM communication can only be used in conjunction with an interface module that supports Module to Module Communication (MtM). In addition, the encoder module and output module must be in the same station.

The figure below shows the data exchange process when using MtM communication (without technology object).

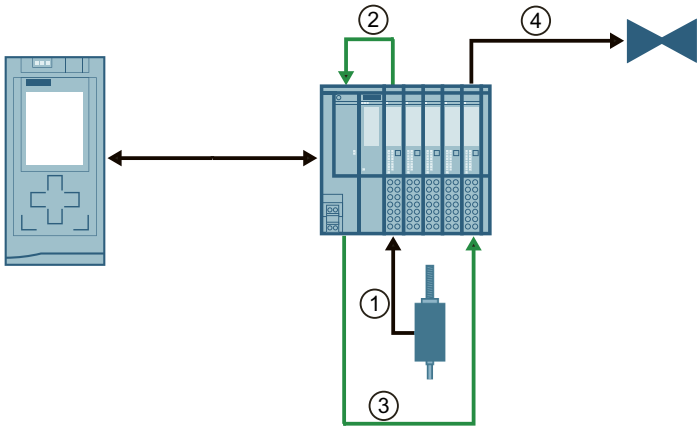

① Read encoder signals into encoder module

② Transfer encoder signals to interface module

③ Transfer encoder signals to output module

④ Process encoder signals in the output module and output signals

The scope of the input and output addresses of the output module for data transmission via MtM communication is:

	Inputs	Outputs
Range	14 bytes	7 bytes

When using Module to Module Communication (MtM), the reaction time of the cam controller is reduced to the duration of a backplane bus cycle. A backplane bus cycle typically corresponds to one PROFINET cycle.

You can find more information on Module-to-Module Communication (MtM) in the FAQ with entry ID 109767618 (https://support.industry.siemens.com/cs/ww/en/view/109767618) in Siemens Industry Online Support.

6.2 Connecting

6.2.1 Wiring and block diagram

In this section, you can find the block diagram of the DQ 4x24VDC/2A HS module showing the terminal assignments for a 2-wire and 3-wire connection in cam control operating mode.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

NOTE

You can connect 2 actuators per output.

NOTE

Cross circuit at output

Be aware that voltage from a cross circuit at the output can feed L+ to modules.

NOTE

- The load group of the module must begin with a light BaseUnit. Keep this in mind also during the configuration.
- The connection of actuators with 1-wire connection is not permitted.

NOTE

You may use and combine the different wiring options for all channels.

NOTE

Outputs DQ_n- must not be connected with ground.

Connection: 2-wire connection of actuators

The figure below shows an example for the terminal assignment of the digital output module DQ 4×24VDC/2A HS on the BaseUnit BU type A0 without AUX terminals (2-wire connection).

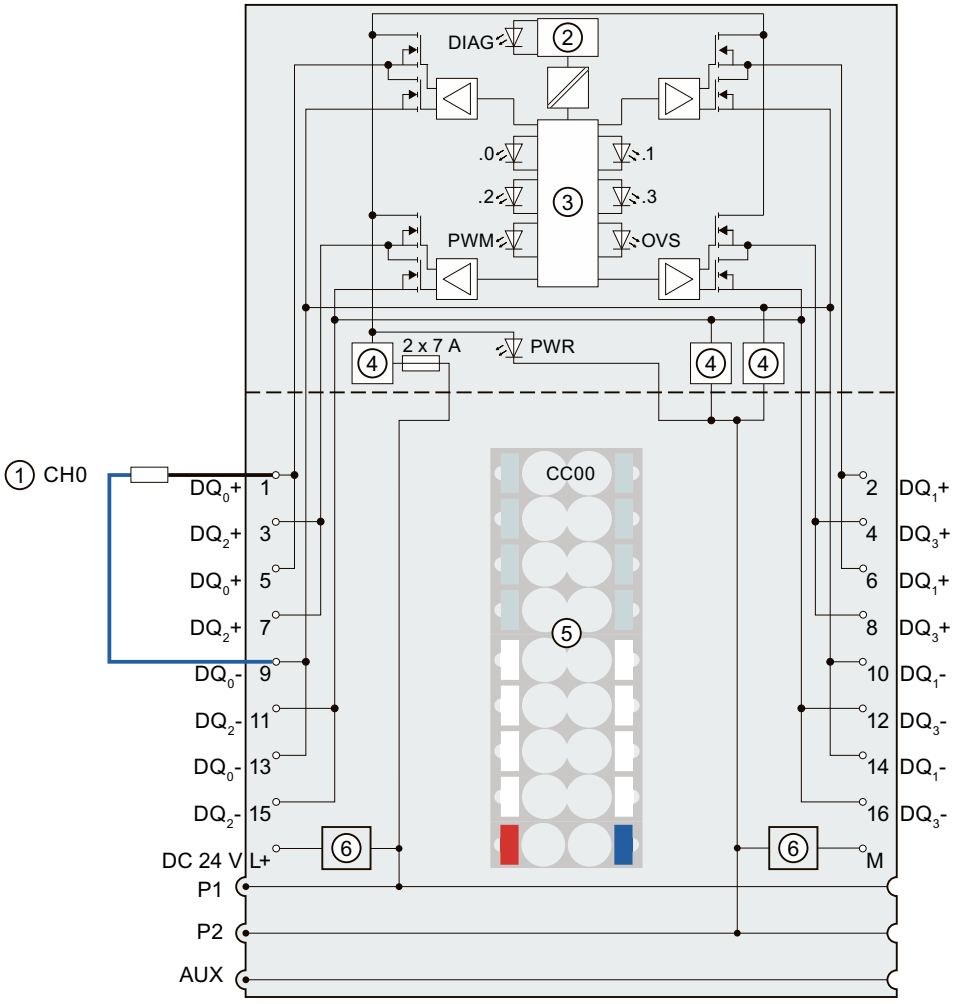

①	2-wire connection	24 V DC	Supply voltage L+ (infeed for light BaseUnit only)
②	Backplane bus interface	M	Ground
③	Control unit	P1, P2, AUX	Internal self-configuring voltage buses Connection to left (dark BaseUnit) Connection to left interrupted (light BaseUnit)
④	Polarity reversal protection	DIAG	Error or Diagnostics LED (green, red)
⑤	Color-coded label CCxx (optional)	.0, .1, .2, .3	Channel status LED (green)
⑥	Supply voltage filter circuit (only when light BaseUnit is present)	PWM	Pulse width modulation LED (green)
DQ_n+	Output signal cam control, channel n	OVS	Oversampling LED (green)
DQ_n-	Reference output signal, channel n	PWR	Power LED (green)
		MCC	Oversampling LED (green) and Power LED (green)

Figure 2-361 Block diagram and terminal assignment for 2-wire connection of actuators

Connection: 3-wire connection of actuators

The figure below shows an example for the terminal assignment of the digital output module DQ 4×24VDC/2A HS on the BaseUnit BU type A0 with AUX terminals (3-wire connection).

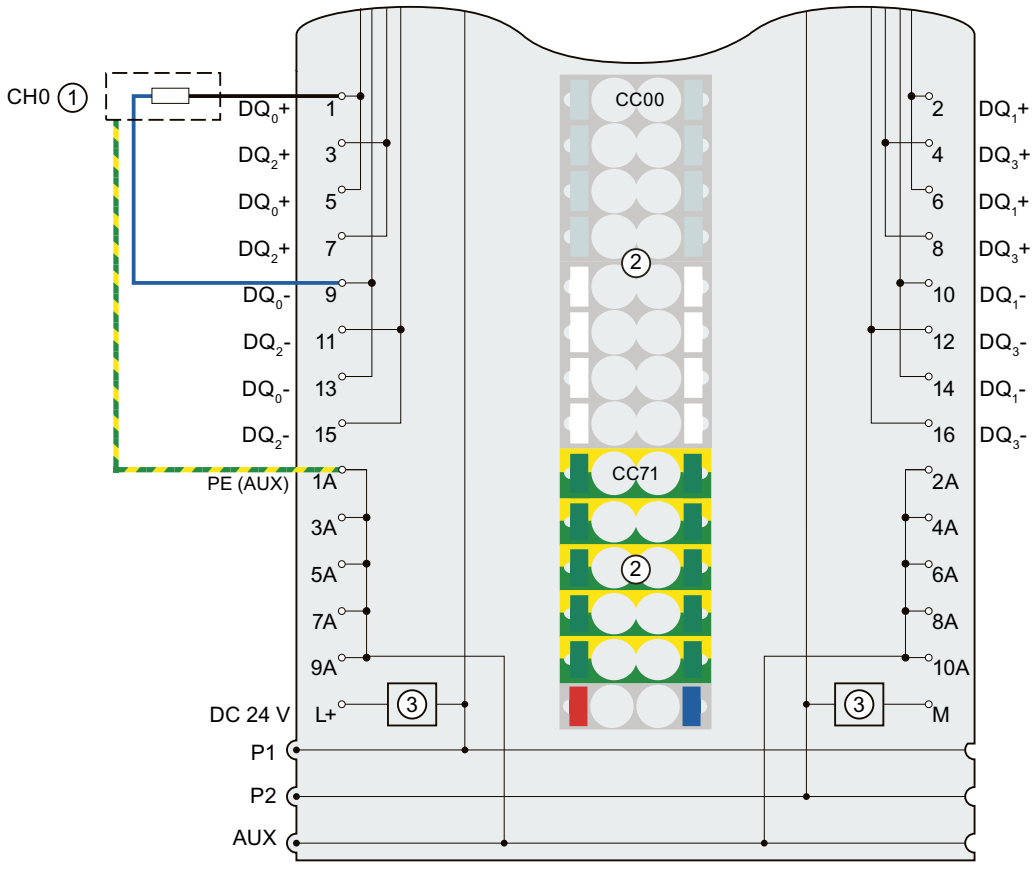

①	3-wire connection	1 A ... 10 A	AUX terminals
②	Color-coded labels CCxx (optional)	PE (AUX)	Protective conductor connection
③	Supply voltage filter circuit (only when light BaseUnit is present)	24 V DC	Supply voltage L+ (infeed for light BaseUnit only)
DQ_n+	Output signal cam control, channel n	M	Ground
DQ_n-	Reference output signal, channel n	P1, P2, AUX	Internal self-configuring voltage buses Connection to left (dark BaseUnit) Connection to left interrupted (light BaseUnit)

Figure 2-362 Terminal assignment for 3-wire connection of actuators

6.3 Basics of cam control

6.3.1 Cam control

With cam control, switching signals are generated depending on an encoder value. Encoder values can, for example, originate from a linear axis, from a rotary axis with modulo function, or from analog values.

The current actual position value of the axis is determined by an encoder to which an encoder module is connected. The encoder signals are hereby evaluated, e.g. the pulses counted that are proportional to the distance moved. The parameterized switch-on ranges of the cams are compared with the actual position value (encoder value). The digital outputs of the output module switch on or off depending on the switching status of the cams.

You can realize up to four cam tracks with one output module. A cam control with more than four cam tracks can be implemented with several output modules. All output modules of this cam controller can be supplied with the same encoder module. Each output module has its own control/feedback interface and can work independently of the other output modules in the cam controller.

NOTE

Incremental jumps

Incremental jumps may occur if, due to the system, an encoder value is not transmitted to the output module for every increment of the sensor. This impairs the switching accuracy of the output.

If incremental jumps occur in your system and the cams switch depending on the direction, ensure that the maximum incremental jump is significantly less than 1/2 x (maximum encoder value – minimum encoder value).

NOTE

Direction detection

Some of the encoder modules that can be used do not return explicit direction information. If no direction information is included in the encoder data, two different valid encoder values are needed for the direction detection. The two values allow a subtraction to be performed and the direction to be derived from the result.

Make sure that the maximum incremental jump is significantly smaller than 1/2 x (maximum encoder value – minimum encoder value).

6.3.2 Start and end position

Start and end position of a cam

The switch-on range of cams is basically defined by a start position and end position.

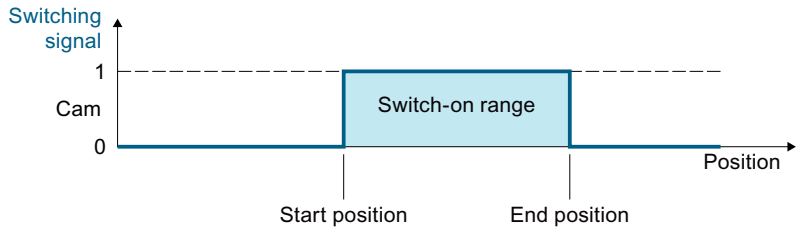

NOTE

If several cams are assigned to the same digital output, their switch-on ranges must not overlap.

Effective direction

A cam can be switched as a function of the motion direction.

The following effective directions are possible for the cams:

None:
The cam is switched off.

Positive:
The following figure shows an example of the switching behavior with "Positive" effective direction:

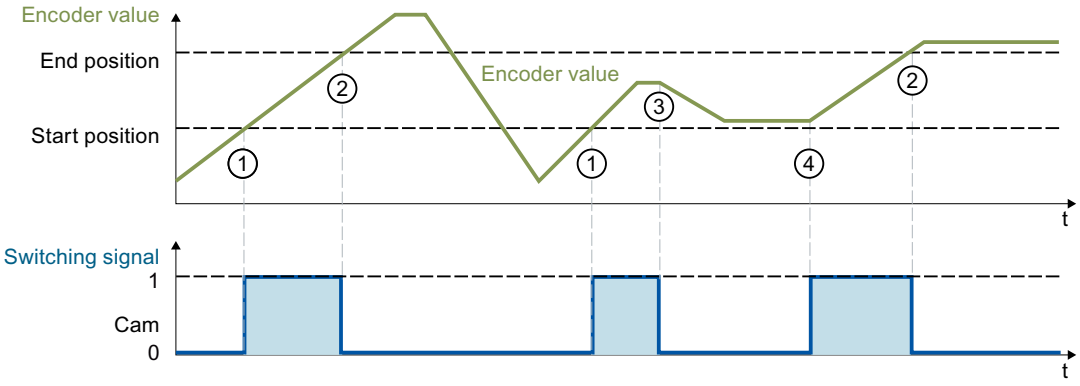

① The cam switches on when the start position in positive direction of movement is reached.

② The cam switches off when the end position is exceeded in positive direction of motion.

③ If the direction is reversed in the switch-on range from positive to negative effective direction, the cam is switched off.

④ If the direction is reversed in the switch-on range from a negative to a positive effective direction, the cam is switched on.

Negative:

The following figure shows an example of the switching behavior with "Negative" effective direction:

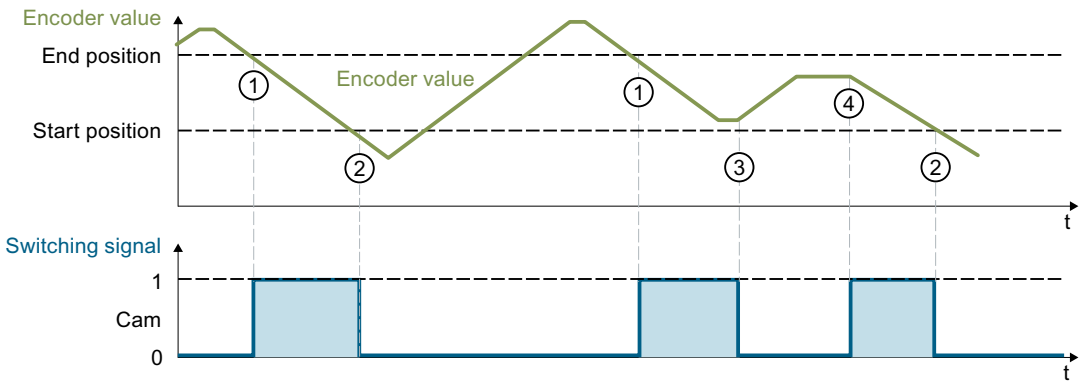

① The cam switches on when the end position in the negative direction of movement is reached.

② The cam switches off when the value falls below the start position in the negative direction of motion.

③ If the direction is reversed in the switch-on range from negative to positive effective direction, the cam switches off.

④ If the direction is reversed in the switch-on range from positive to negative effective direction, the cam switches on.

Both:

The following figure shows an example of the switching behavior with "Both" effective direction:

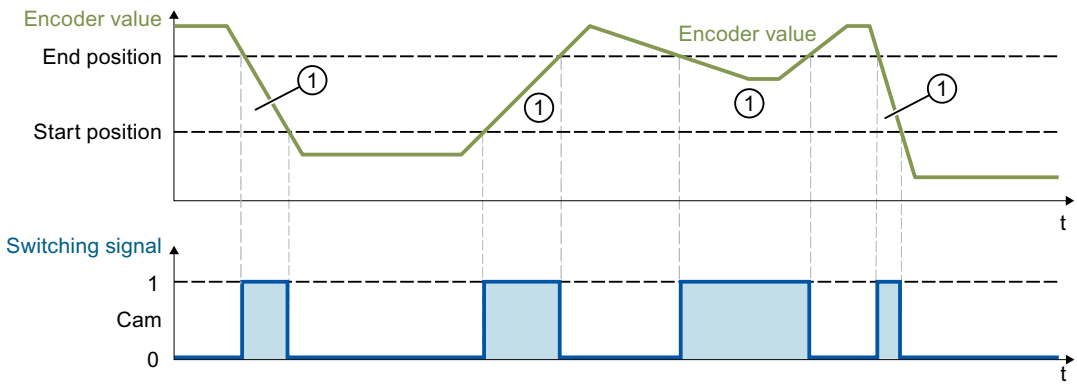

① The cam switches on when the encoder value is in the switch-on range.

Channel assignment

You assign each cam to the digital output on which the cam is to be output.

If several cams are assigned to the same digital output, their switch-on ranges must not overlap.

6.3.3 Hysteresis

Hysteresis

Slight movements of the encoder can result in the position value fluctuating around a certain position. If a start or end position is within the fluctuation range, the corresponding cam and the digital output are switched on and off correspondingly often without using a hysteresis, depending on the effective direction of the cam. The hysteresis prevents these unwanted switching operations.

The hysteresis is a position tolerance within which the position values may vary without changing the switching state of the cam.

Behavior when hysteresis is activated:

- The configured hysteresis width is in effect for all cams.
- The hysteresis range extends in the positive and negative directions around the detected direction reversal point. The hysteresis range thus extends over double the configured hysteresis. The hysteresis limit points represent the hysteresis range spanned by the firmware.
- Changes in direction recognized within the hysteresis are ignored and the switching status of cams is not changed.
- After the hysteresis range is exited, the output is set according to the cam settings.

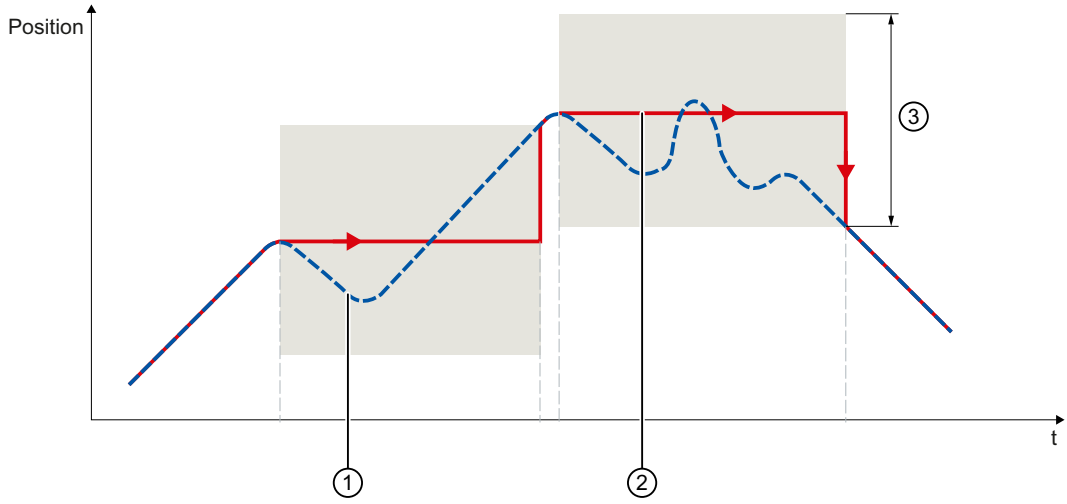

① Actual position
② Effective position
③ Effective hysteresis

The following example shows the effects of the hysteresis on the switching behavior of the cam with positive effective direction. The hysteresis keeps the output stable when the encoder value signals a small direction reversal.

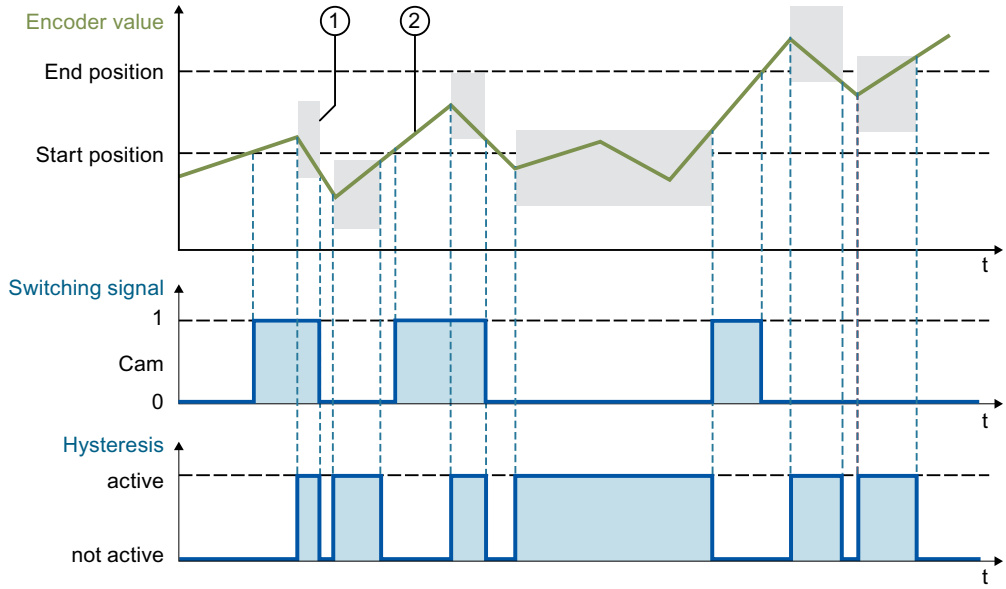

① Hysteresis range

② Encoder value

6.3.4 Pulsed cam output

It is possible to pulse the cams in order to save energy for the respective actuator. This function works while a cam has status 1. You configure the pulsed cam output with the "Pulsed cam output duty cycle" and "Pulsed cam output period" parameters.

The duty cycle is used to specify the pulse-period ratio of the pulsed output signal within the configured cycle duration.

NOTE

The edges of the pulsed output cam are not synchronized with the cam start or end.

The following figure shows an example of the pulsed cam output:

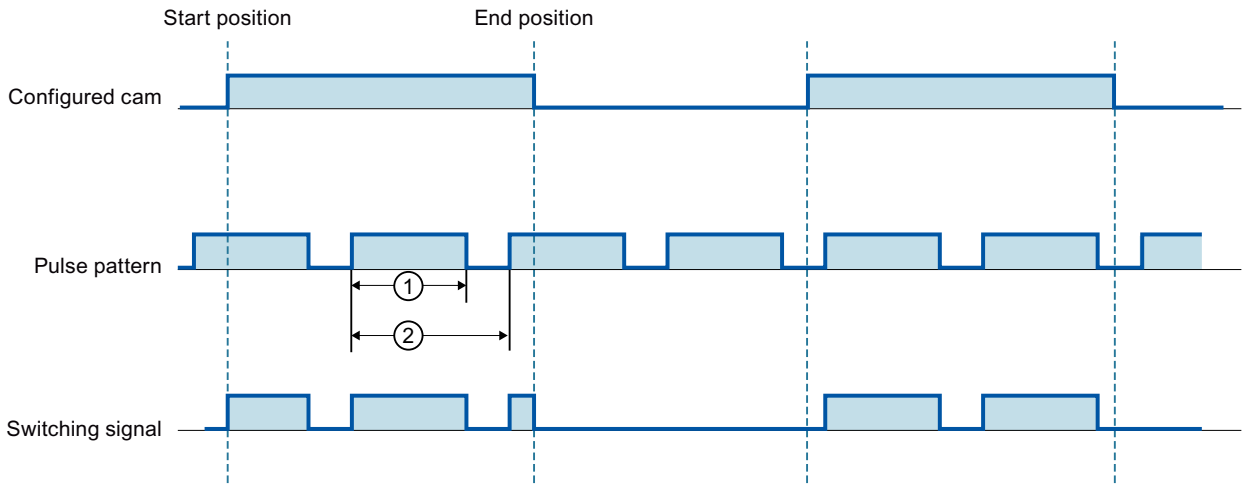

① T_{ON}

② Period duration

Duty cycle = T_{ON} / Period * 100%

6.4 Manual mode (MtM)

6.4.1 Parameters/address space

6.4.1.1 Parameters

Parameters

The effective range of the assignable parameters depends on the type of configuration.

This configuration variant is linked to the distributed operation on PROFINET IO in an ET 200SP system. The DQ 4x24VC/2A HS output module and the assigned encoder module must be located in the same distributed station.

In addition to assigning parameters with the configuration software, you can also set the parameters in RUN mode (dynamically) using the user program. When assigning the parameters in the user program, the "WRREC" instruction transfers the parameters to the module using data records; see section Parameter assignment and structure of the parameter data record for cam control operating mode (Page 134).

The module to module communication (MtM) must also be configured for the cam control operating mode. You can find additional information regarding module to module communication (MtM), e.g. in manual Interface Module IM 155-6 PN/2 HF (https://support.industry.siemens.com/cs/ww/de/).

The following parameter settings are possible:

Table 2-366 Assignable parameters in cam control operating mode (GSD file) [2]

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software
				GSD file PROFINET IO
Operating mode [3]	• Normal operation DQ (valve control) [1] • Oversampling • Pulse width modulation • Cam control		No	Module
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module
Diagnostics Short circuit to L+/G	• Disable • Enable	Disable	Yes	Module
Encoder source diagnostics	• Disable • Enable	Disable	Yes	Module
Modulo activated	• Disable • Enable	Disable	Yes	Module
Encoder module	• DI 8x24VDC HS, Count, Ch.0 • DI 8x24VDC HS, Count, Ch.1 • DI 8x24VDC HS, Count, Ch.2 • DI 8x24VDC HS, Count, Ch.3 • AI 2xU/I 2-/4-wire HS, Ch.0 • AI 2xU/I 2-/4-wire HS, Ch.1 • AI 2xU/I 2-/4-wire HS, QI, Ch.0 • AI 2xU/I 2-/4-wire HS, QI, Ch.1 • TM Count 1x24V, Ch.0 [4] • TM Count 1x24V Fastmode, Ch.0 • TM PosInput 1, Ch.0 [4] • TM PosInput 1 Fastmode, Ch.0 • AI 2xSG 4-/6-wire HS, Ch.0 [4] • AI 2xSG 4-/6-wire HS, Ch.1 [4]	DI 8x24VDC HS, Count, Ch.0	No	Module
Hysteresis	• 0 = Not activated • 1 to 65535	0 = Not activated	Yes	Module
Axis reference position	• -2,147,483,648 to 2,147,483,647	0	Yes	Module
Minimum encoder value	• -2,147,483,648 to 2,147,483,647	0	Yes	Module
Maximum encoder value	• -2,147,483,648 to 2,147,483,647	2,147,483,646	Yes	Module
Cam 0 start position to Cam 15 start position	• -2,147,483,648 to 2,147,483,647	0	Yes	Module

1 Valve control is a special function of normal operation.

2 Oversampling is not supported with GSD files.

3 When configuring with a GSD file, you determine the operating mode when you select the module name.

4 Only available in the configuration variant "DQ 4x24VDC/2A HS V2.0, MCC (16 Byte) MtM".

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software
				GSD file PROFINET IO
Cam 0 end position to Cam 15 end position	• -2,147,483,648 to 2,147,483,647	0	Yes	Module
Cam 0 effective direction to Cam 15 effective direction	• None • Positive • Negative • Both	None	Yes	Module
Cam 0 channel assignment to Cam 15 channel assignment	• Channel 0 • Channel 1 • Channel 2 • Channel 3	Channel 0	Yes	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel
Reaction to CPU STOP	• Shutdown • Keep last value • Output substitute value 1	Shutdown	Yes	Channel
Pulsed cam output duty cycle	• 0% • 0.1% • 0.2% • ... • 100%	50%	Yes	Channel
Pulsed cam output period	• Off • 0.20 ms • 0.40 ms • 0.93 ms • 1.33 ms • 4.27 ms • 10.67 ms • 21.33 ms • 34.13 ms • 59.73 ms	0.93 ms	Yes	Channel
Potential group	• Use potential group of the left module (dark BaseUnit) • Enable new potential group (light BaseUnit)	Use potential group of the left module	No	Module

1 Valve control is a special function of normal operation.

2 Oversampling is not supported with GSD files.

3 When configuring with a GSD file, you determine the operating mode when you select the module name.

4 Only available in the configuration variant "DQ 4x24VDC/2A HS V2.0, MCC (16 Byte) MtM".

The following parameters are possible for the module to module communication (MtM)

Table 2-367 Assignable parameters for module to module communication (MtM)

Parameters	Value range	Default	Configuration in RUN	Effective range with configuration software
				GSD file PROFINET IO
Slot of encoder module	1 to 64	1	No	Module
Subslot of encoder module	1	1	No	Module
Encoder module [1]	• DI 8x24VDC HS, Count, Ch.0 • DI 8x24VDC HS, Count, Ch.1 • DI 8x24VDC HS, Count, Ch.2 • DI 8x24VDC HS, Count, Ch.3 • AI 2xU/I 2-/4-wire HS, Ch.0 • AI 2xU/I 2-/4-wire HS, Ch.1 • AI 2xU/I 2-/4-wire HS, QI, Ch.0 • AI 2xU/I 2-/4-wire HS, QI, Ch.1 • TM Count 1x24V, Ch.0 [2] • TM Count 1x24V Fastmode, Ch.0 • TM PosInput 1, Ch.0 [2] • TM PosInput 1 Fastmode, Ch.0 • AI 2xSG 4-/6-wire HS, Ch.0 [2] • AI 2xSG 4-/6-wire HS, Ch.1 [2]	DI 8x24VDC HS, Count, Ch.0	No	Module

[1] The parameter must be assigned identical with the "Encoder module" parameter under "Parameters in cam control operating mode".

[2] Only available in the configuration variant "DQ 4x24VDC/2A HS V2.0, MCC (16 Byte) MtM".

6.4.1.2 Explanation of parameters

Parameters in cam control operating mode

Operating mode

At the module level, specifies the operating mode in which the module's channels are operated. When configuring using a GSD file, you determine the operating mode when you select the module name.

- Normal operation as digital output module
  - Valve control is a special function of normal operation, see section Normal operation/Valve control (Page 19).
- Pulse width modulation, see section Pulse width modulation (Page 44)
- Oversampling, see section Oversampling (Page 32)
- Cam control, see section Cam control (Page 63)

Diagnostics No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics Short circuit to L+/G

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Encoder source diagnostics

Enabling of the diagnostics for the following events:

- Invalid encoder value when modulo is deactivated (outside minimum encoder value/maximum encoder value)
- Value status of the encoder module = 0
- Encoder module removed

Modulo activated

When "Modulo" is activated (value = 1), the encoder value is mapped onto a recurring modulo range. The modulo range is defined by the start value and the length. The start value corresponds to the "Minimum encoder value" parameter.

The length is calculated using the following formula:

Length = ABS (maximum encoder value - minimum encoder value) +1

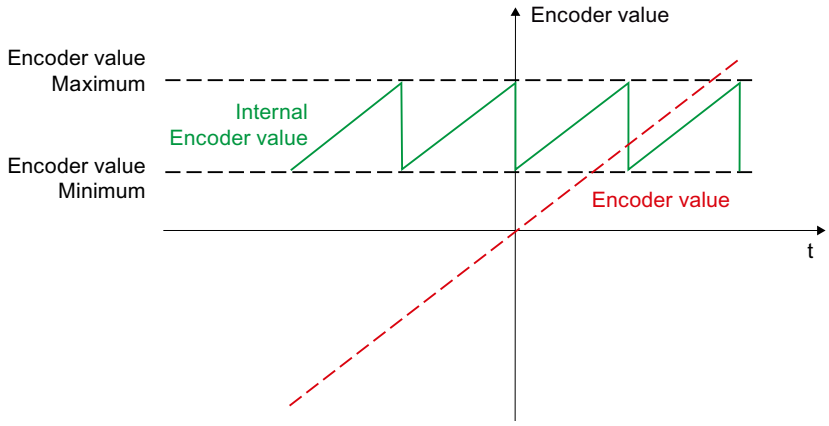

Figure 2-363 Modulo calculation

Encoder module

With the help of the "Encoder module" parameter, you specify how the encoder data that is transferred to the DQ4HS module via module to module communication (MtM) is interpreted. The selected encoder module/encoder channel must be identical with the configured encoder module that supplies the encoder data.

Depending on which encoder module is being used, not only the encoder value but also the value status of the encoder module and/or the direction of the encoder is included in the supplied encoder data and processed in the cam control.

The following table shows the availability of value status and direction of the encoder module:

Table 2-368 Availability of value status and direction of the encoder module:

Encoder module	Value status	Direction
DI 8x24VDC HS	-	-
AI 2xU/I 2-/4-wire HS	x [1]	-
TM Count 1x24V	x	x
TM PosInput 1	x	x
AI 2xSG 4-/6-wire HS	x	-

[1] In the configuration variant with QI.

The value status of the encoder module affects the value status of the DQ4HS module. If the value status of the encoder module is invalid, the value status of the DQ4HS module is set to 0.

For encoder modules that do not provide a direction in the encoder data, it must be kept in mind that only 2 valid different encoder values have to be available in the cam control before the internal direction detection can evaluate the encoder value and the associated configured cam. With the first valid encoder value, INP_OK = 1 is set, and with the second valid value, SYNC = 1 is additionally set.

Hysteresis

With the help of a hysteresis, fluctuations (minimal direction reversal in the encoder value) that affect the encoder value can be compensated.

The hysteresis setting must satisfy the following conditions:

- Hysteresis < ABS ((maximum encoder value - minimum encoder value) / 4)
- Hysteresis < Cam_i end position - Cam_i start position [i = 0 to 15]

Axis reference position

With the help of the axis reference position, the encoder value can be adapted or corrected, e.g. for taking the zero position of the sensor into account. The axis reference position is subtracted from the encoder value before further processing of the encoder value.

Encoder value minimum/maximum

- "Minimum encoder value" is the low value of the valid encoder range. When "Modulo" is activated, this value is the start value for the modulo operation.
- "Maximum encoder value" is the high value of the valid encoder range. When "Modulo" is activated, this value is used for calculating the length for the modulo operation.

The difference of "Maximum encoder value" and "Minimum encoder value" must be at least 2.

When "Modulo" is deactivated, a check is made to determine whether the encoder value is less than "Minimum encoder value" and greater than "Maximum encoder value".

When "Modulo" is activated, the result of "Maximum encoder value" - "Maximum encoder value" must not exceed the value 2,147,483,646.

Cam 0 start position/end position to Cam 15 start position/end position

The position values are used to specify the switching range of the cam that, in combination with the effective direction and channel assignment, leads to the switching action at the output.

When modulo is deactivated, the following applies:

- Minimum encoder value <= Cam start position < Cam end position <= Maximum encoder value

When modulo is activated, the following applies:

- Minimum encoder value < Maximum encoder value
- Minimum encoder value <= Cam start position <= Maximum encoder value
- Minimum encoder value <= Cam end position <= Maximum encoder value
- Cam start position <> Cam end position

See section Cam control (Page 63).

Cam 0 effective direction to Cam 15 effective direction

With this parameter, you specify the effective direction of the cam.

See section Cam control (Page 63).

Cam 0 channel assignment to Cam 15 channel assignment

With this parameter, you specify the assignment of the output channel for a cam. You can assign an output channel to each cam.

Channel activated

Specifies whether a channel is activated or deactivated.

Reaction to CPU STOP

Specifies the behavior of the module in the event of a CPU STOP and for all channels in the cam control in the event of invalid encoder values.

NOTE

With "Output substitute value 1" or "Keep last value", a pulsed cam output continues to act.

Pulsed cam output duty cycle

This parameter indicates the percentage of switching state "1" for the time specified in the "Pulsed cam output period" parameter.

Pulsed cam output period

This parameter specifies the period of the pulsed cam output.

Potential group

With the "Potential group" parameter, you specify whether the module is plugged into a light or dark BaseUnit.

A potential group always begins with an I/O module that is plugged into a light BaseUnit. All modules inserted to the right of this that are plugged into dark BaseUnits belong to the same potential group, because the dark BaseUnits are supplied via the light BaseUnits.

The potential group ends at a new light BaseUnit or the end of the station.

See also

Distributed I/O System ET 200SP
(https://support.industry.siemens.com/cs/ww/en/view/58649293)

Parameters for module to module communication (MtM)

Slot of encoder module

Specifies the slot of the encoder module for the module to module communication (MtM)

Subslot of encoder module

This value is permanently preset to 1.

Encoder module

Specifies the module that is used as an encoder module for the module to module communication (MtM)

NOTE

Parameter assignment of the encoder module

The parameter must be assigned identical with the "Encoder module" parameter under Parameters in cam control operating mode (Page 71).

6.4.1.3 Address space

Assignment of the control interface

Control interface

The user program uses the control interface to influence the behavior of the cam control. The figure below shows the address space allocation for the control interface in the process image output.

"QB x" represents the start address of output byte x.

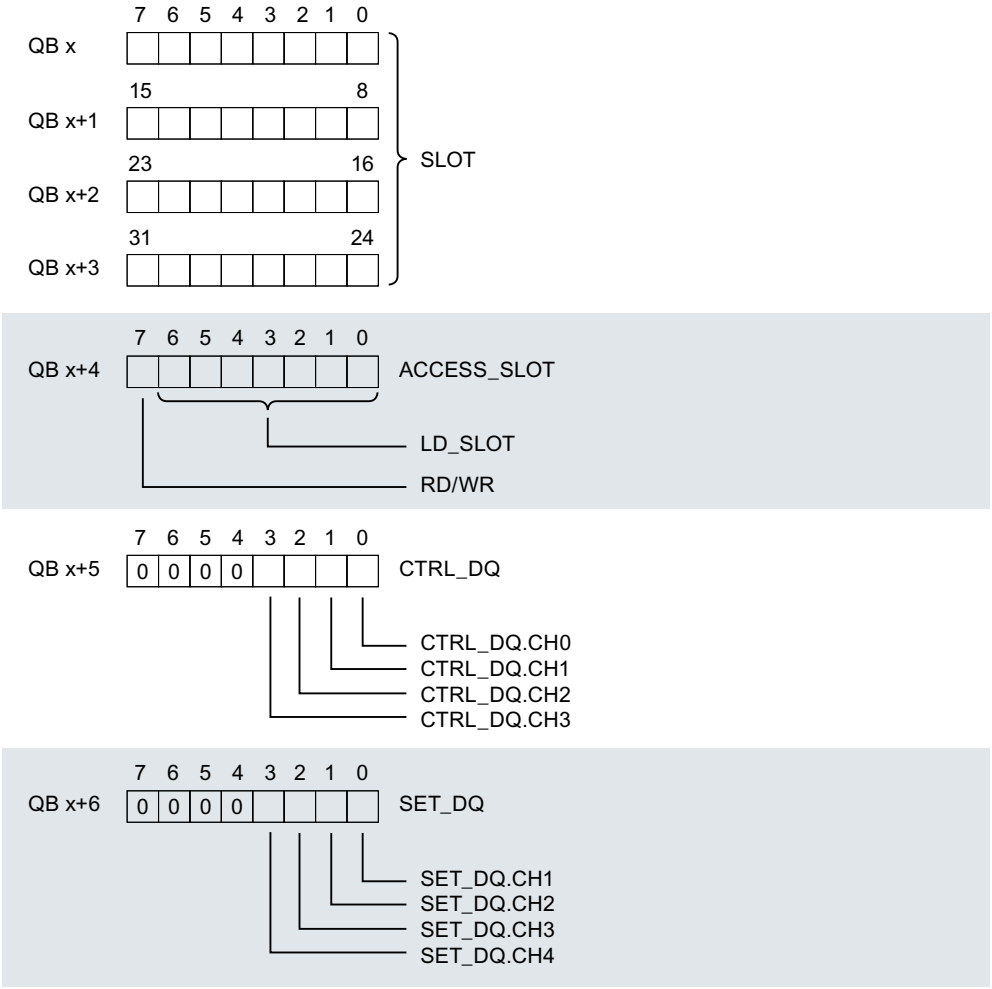

Figure 2-364 Assignment of the control interface

Notes on the control interface

Notes on the control bits

Table 2-369 Details for the control interface

Control bit	Notes
SLOT	You use this value to specify the write accesses for the registers addressable with LD_SLOT.
ACCESS_SLOT	• RD/WR = 0: Read access to the addressed register. • RD/WR = 0 --> 1: Writing is enabled at a transition from "0" to "1". Note: After a successful write operation, the addressed register is read. • LD_SLOT You use this value to select the register, see Notes on the control interface (Page 77).
CTRL_DQ.CHx	You use this bit to specify how channel X is controlled. • 0 = Direct channel writing by the CPU. • 1 = Take channel value from the cam track.
SET_DQ.CHx	Values for the direct channel writing by the CPU. The bit is processed in combination with bit CTRL_DQ.x = 0. • 0 = Channel X outputs the value 0. • 1 = Channel X outputs the value 1.

Table 2-370 Addressable register in LD_SLOT

Value of LD_SLOT	Register	Notes
0x00	CAM_Ctrl-Version	Version of the software module and the user ID • Bits 0 to 7: Version-Low of SW module CAM_Ctrl • Bits 8 to 15: Version-High of SW module CAM_Ctrl • Bits 16 to 31: User ID
0x01	CAM_Ctrl-Config	Static module configuration • Bits 0 to 7: Number of channels • Bits 8 to 15: Number of cams • Bits 16 to 23: Number of internal registers • Bits 24 to 31: Reserved
0x02	ENC_RAW	Raw copied encoder value
0x03	HYS_START	When hysteresis is active (STS_REG.HYS = 1), the HYS_START and HYS_END registers contain the boundary points of the hysteresis.
0x04	HYS_END	
0x05	ENC_ERRORS	Read: Number of detected errors in the encoder data (change from 1 to 0 of bit INP_OK in byte STS_REG of the feedback interface). Write: Resetting the counter
0x06	DIFF_MEDIAN [1]	Read: Averaged difference value of the incoming encoder values (indicator for update rate) The evaluation is directly coupled to the raw value (encoder data). • Only the differences between the encoder values as a moving average are evaluated. Write: Resetting the counter

Value of LD_SLOT	Register	Notes
0x07	PWM_WRITE	Read: Status of the currently activated pulsed cam output Write: Activation/deactivation of the pulsed cam output • Deactivate pulsed cam output for channel X: SLOT.Bitx = 0 • Activate pulsed cam output for channel X: SLOT.Bitx = 1
0x08	CAM_ON-INFO	Bit string with the switching state of the 16 cams of the cam pool

[1] You can use the DIFF_MEDIAN value, for example, to evaluate the increment jumps occurring in the application during the commissioning phase.

Assignment of the feedback interface

Feedback interface

The user program receives current values and status information from the module via the feedback interface. The figure below shows the address space allocation for the feedback interface in the process image input.

"IB x" represents the start address of input byte x.

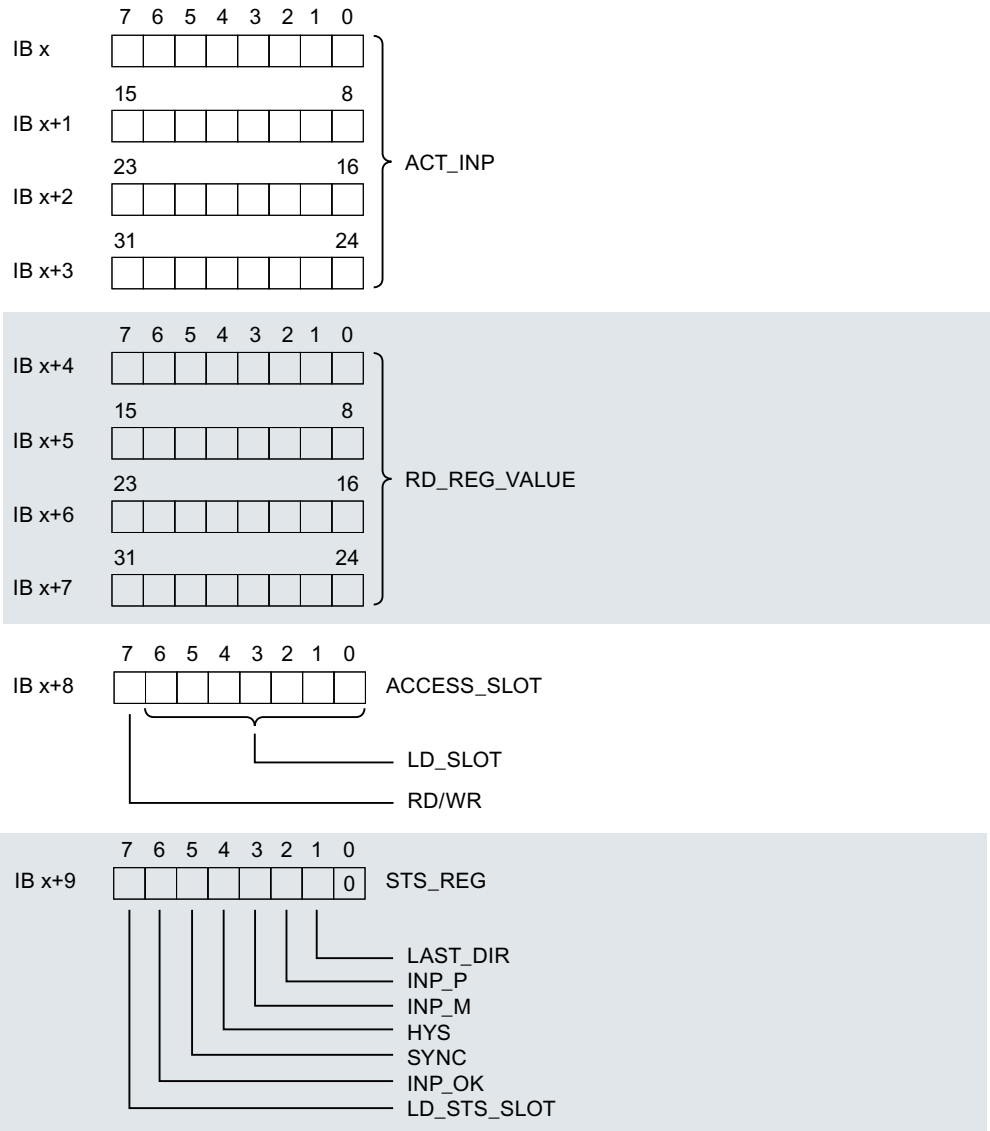

Figure 2-365 Assignment of the feedback interface, part 1

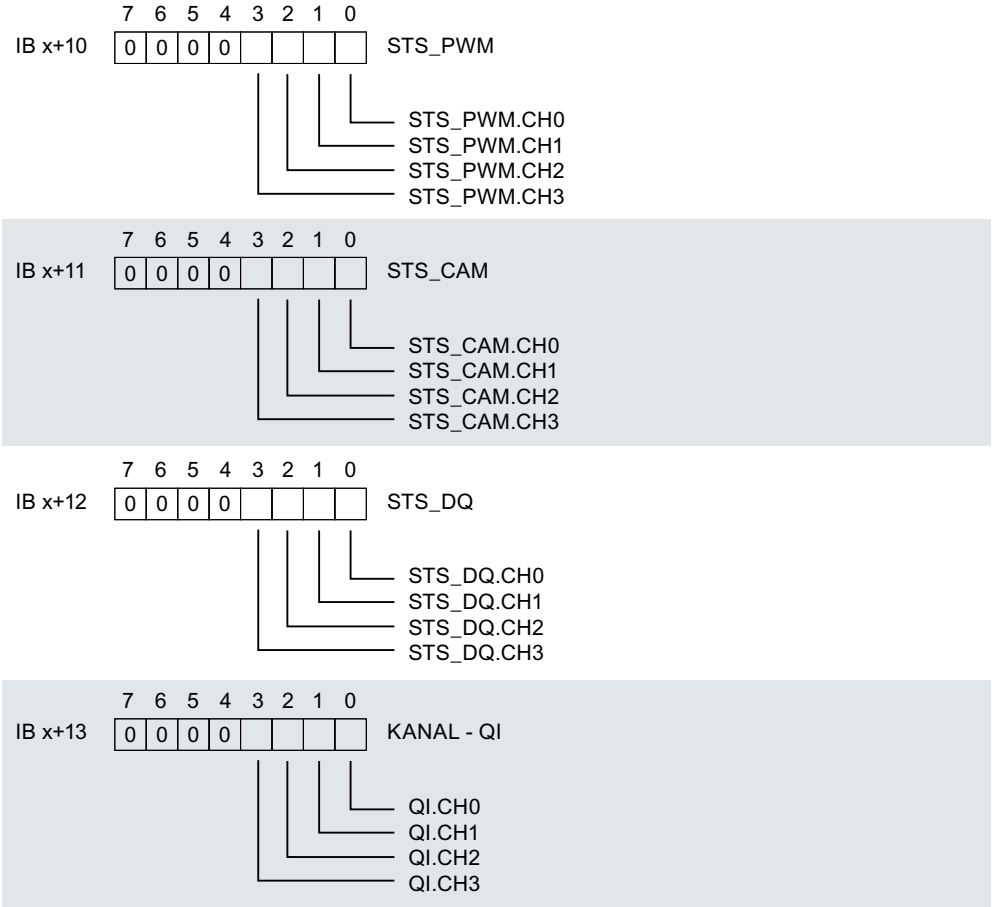

Figure 2-366 Assignment of the feedback interface, part 2

Notes on the feedback interface

Notes on the feedback bits

Table 2-371 Details for the feedback interface

Feedback bit	Notes
ACT_INP	Internal encoder value This value is used by the cam control unit of the digital output module for evaluating the configured cams.
RD_REG_VALUE	Register value that was requested via the control interface, see table "Addressable registers in LD_SLOT".
ACCESS_SLOT	Feedback in response to the SLOT request via the control interface.
LAST_DIR	• 0 = Backward motion of last motion • 1 = Forward motion of last motion
INP_P	• 0 = No forward motion • 1 = Forward motion (current encoder value)
INP_M	• 0 = No backward motion • 1 = Backward motion (current encoder value)

Feedback bit	Notes
HYS	• 0 = Hysteresis is not active • 1 = Hysteresis is active
SYNC	• 0 = No encoder direction available Note: If no encoder direction is available, the configured substitute values are output for all channels that operate as a cam track (CTRL_DQ.CHx = 1). • 1 = Encoder data can be used for cam output
INP_OK	• 0 = Encoder data is invalid Note: When the encoder data is invalid, the value status is set to 0. • 1 = Encoder data detected as invalid
LD_STS_SLOT	This bit changes its value following a successful write operation.
STS_PWM	Status for pulsed cam output of channels 0 to 3 • Bit 0 for channel 0: 0 = No pulsed cam output, 1 = Pulsed cam output activated • Bit 1 for channel 1: 0 = No pulsed cam output, 1 = Pulsed cam output activated • Bit 2 for channel 2: 0 = No pulsed cam output, 1 = Pulsed cam output activated • Bit 3 for channel 3: 0 = No pulsed cam output, 1 = Pulsed cam output activated • Bits 4 to 7: Reserved
STS_CAM	Signal status of the cam tracks • Bit 0 for channel 0: 0 = Cam track off, 1 = Cam track on • Bit 1 for channel 1: 0 = Cam track off, 1 = Cam track on • Bit 2 for channel 2: 0 = Cam track off, 1 = Cam track on • Bit 3 for channel 3: 0 = Cam track off, 1 = Cam track on • Bits 4 to 7: Reserved
STS_DQ	Signal status of the digital outputs • Bit 0 for channel 0: 0 = DQ channel off, 1 = DQ channel on (pulse output is possible) • Bit 1 for channel 1: 0 = DQ channel off, 1 = DQ channel on (pulse output is possible) • Bit 2 for channel 2: 0 = DQ channel off, 1 = DQ channel on (pulse output is possible) • Bit 3 for channel 3: 0 = DQ channel off, 1 = DQ channel on (pulse output is possible) • Bits 4 to 7: Reserved

6.4.2 Interrupts/diagnostics alarms

6.4.2.1 Status and error displays

LED displays

The figure below shows the location of the LED displays of the DQ 4×24VDC/2A HS.

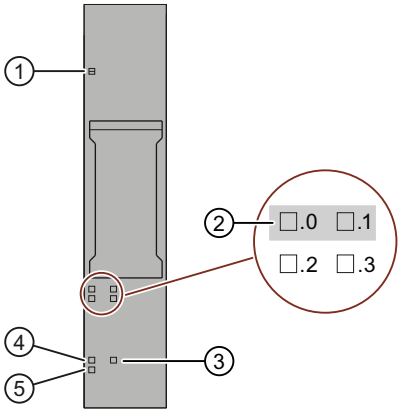

① DIAG (green/red)
② Channel status (green)
③ OVS (green)
④ PWM (green)
⑤ PWR (green)

Figure 2-367 LED displays

Meaning of the LEDs

The following tables contain the meaning of the Status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms.

DIAG LED

Table 2-372 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-373 Status display of the channel status LED

Channel status LED	Meaning
□ Off	Channel deactivated or process signal = 0
■ On	Channel activated and process signal = 1

OVS LED and PWM LED

Table 2-374 Status display of the oversampling LED

OVS LED	PWM LED	Meaning
□ Off	□ Off	DQ operating mode (valve control) active
■ On	□ Off	Oversampling operating mode active
□ Off	■ On	Pulse width modulation operating mode active
■ On	■ On	Cam control (MCC) operating mode active

PWR LED

Table 2-375 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

6.4.2.2 Interrupts

The DQ 4×24VDC/2A HS digital output module supports diagnostic interrupts.

Diagnostic interrupts

The module generates a diagnostic interrupt at the following events:

- Short circuit
- Excess temperature
- Parameter assignment error
- No supply voltage
- Communication error
- Invalid encoder data
- Encoder module removed or not ready to operate
- Channel temporarily not available

Detailed information on the event is available in the STEP 7 online help.

6.4.2.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output and the DIAG LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

NOTE

You can connect 2 actuators per output.

The diagnostics of the two actuators influence each other in the case of duplicate wiring. This means that a single short-circuit affects both actuators.

Table 2-376 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarms	Error code	Meaning	Solution
Short circuit [1] [2]	1_H	Short-circuit of the actuator supply	Correct the process wiring
Excess temperature	5_H	The module has detected that the maximum permitted module temperature has been exceeded. All channels of the module are switched to high resistance. The module is then restarted.	Correct the process wiring
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment

[1] The channels 0 and 1 or 2 and 3 each form a load group. Within a load group, a short-circuit can have an effect on the adjacent channel. The load groups do not have an effect on each other in the case of a short-circuit.

[2] If the short-circuit persists, the module heats up. This may trigger temperature monitoring with excess temperature diagnostic interrupt.

Diagnostics alarms	Error code	Meaning	Solution
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Communication error	13_H	Module is defective.	Replace the module.
Error 1 in actuat-or/sensor	$1D_H$	The encoder data is invalid.	• Check encoder module and connected sensor. • Check messages about encoder mod-ules and eliminate any errors.
Error 2 in actuat-or/sensor	$1E_H$	The encoder module is removed or not ready to operate	• Insert encoder module • Insert server module • Check connection to the controller
Channel temporarily not available	$1F_H$	Firmware update is currently in progress or was canceled. The module does not output any process values or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

[1] The channels 0 and 1 or 2 and 3 each form a load group. Within a load group, a short-circuit can have an effect on the adjacent channel. The load groups do not have an effect on each other in the case of a short-circuit.

[2] If the short-circuit persists, the module heats up. This may trigger temperature monitoring with excess temperature diagnostic interrupt.

6.5 Operation with technology object

6.5.1 Technology object DQ4_CAM

During the configuration, commissioning and diagnosis of the cam control functions for the DQ 4x24VDC/2A HS output module in combination with an encoder module, STEP 7 (TIA Portal) supports you with the "Technology objects" function:

- In STEP 7 (TIA Portal) you configure the DQ4_CAM technology object by entering the encoder parameters.
- The corresponding DQ4_CAM instruction is programmed in the user program. This instruction takes over the supply of the control and feedback interface of the output module. The encoder data are hereby transferred to the output module and processed there.

The DQ4_CAM technology object corresponds to the instance DB of the instruction DQ4_CAM. The configuration of the cam control functions is saved in the technology object. The technology object is located in the folder "PLC > Technology objects".

Operating mode

To parameterize a DQ 4x24VDC/2A HS via the technology object, specify the operating mode "Cam control" and the control mode "Use technology object "DQ4_CAM"" in the hardware configuration of the DQ 4x24VDC/2A HS.

6.5.2 Overview of the configuration steps

Introduction

The following overview shows the basic procedure for configuring the cam control functions of the DQ 4x24VDC/2A HS output module via the technology object DQ4_CAM.

Requirement

To use the technology object DQ4_CAM, a project must be created in STEP 7 (TIA Portal) with an S7-1500 CPU. The output module DQ 4x24VDC/2A HS and the encoder module must be added, but not necessarily in the same station.

NOTE

The interface module used must support the value status function.

Procedure

Proceed in the recommended sequence outlined below:

Step	Description
1	Configure output module and encoder module
2	Add technology object (Page 86)
3	Configure a technology object according to your application (Page 88)
4	Call instruction in the user program (Page 96)
5	Load to CPU
6	Commissioning the technology object (Page 107)
7	Diagnostics of the technology object (Page 108)

6.5.3 Add technology object

Adding a technology object in the project navigation

When a technology object is added, an instance DB is created for the instruction of this technology object. The configuration of the technology object is stored in this instance DB.

Requirement

A project with a CPU S7-1500 has been created.

Procedure

To add a technology object, proceed as follows:

1. Open the CPU folder in the project tree.
2. Open the "Technology objects" folder.
3. Double-click on "Add new object".
   The "Add new object" dialog opens.
4. Select the technology "Counting, measurement, cams".
5. Select the "DQ4_CAM" object.
6. Enter an individual name for the technology object in the "Name" text box.
7. Click "Additional information" if you want to add your own information to the technology object.
8. Confirm with "OK".

Result

The new technology object has now been created and stored in the project tree in the "Technology objects" folder.

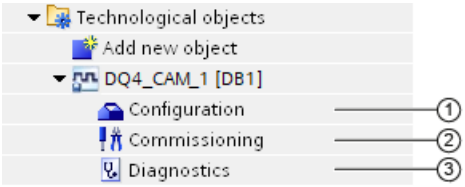

	Object	Description
1	Configuration (Page 88)	In the configuration dialog: • Mapping of the encoder module, the encoder module channel and the output module • Setting the parameters of the technology object for the cam control functions When you change the configuration of the technology object, you must download the technology object **and** the hardware configuration to the CPU.
2	Commissioning (Page 107)	Commissioning and function test of the technology object: Controlling parameters of the DQ4_CAM instruction and monitoring the effects
3	Diagnostics (Page 108)	Monitoring of the cam control functions

6.5.4 Configuring DQ4_CAM

6.5.4.1 Working with the configuration dialog

You configure the properties of the technology object in the configuration window. Proceed as follows to open the configuration window of the technology object:

1. Open the "Technology objects" folder in the project tree.
2. Open the technology object in the project tree.
3. Double-click on the "Configuration" object.

The configuration is divided into the following categories:

- **Hardware interface**
  Connection between technology object and encoder module/output module
- **General parameters**
  Parameters for setting the encoder value range.
- **Cam parameters**
  Parameters for setting the behavior of the output module cams.
- **Output parameters**
  Parameters for setting the behavior of the digital outputs of the output module.

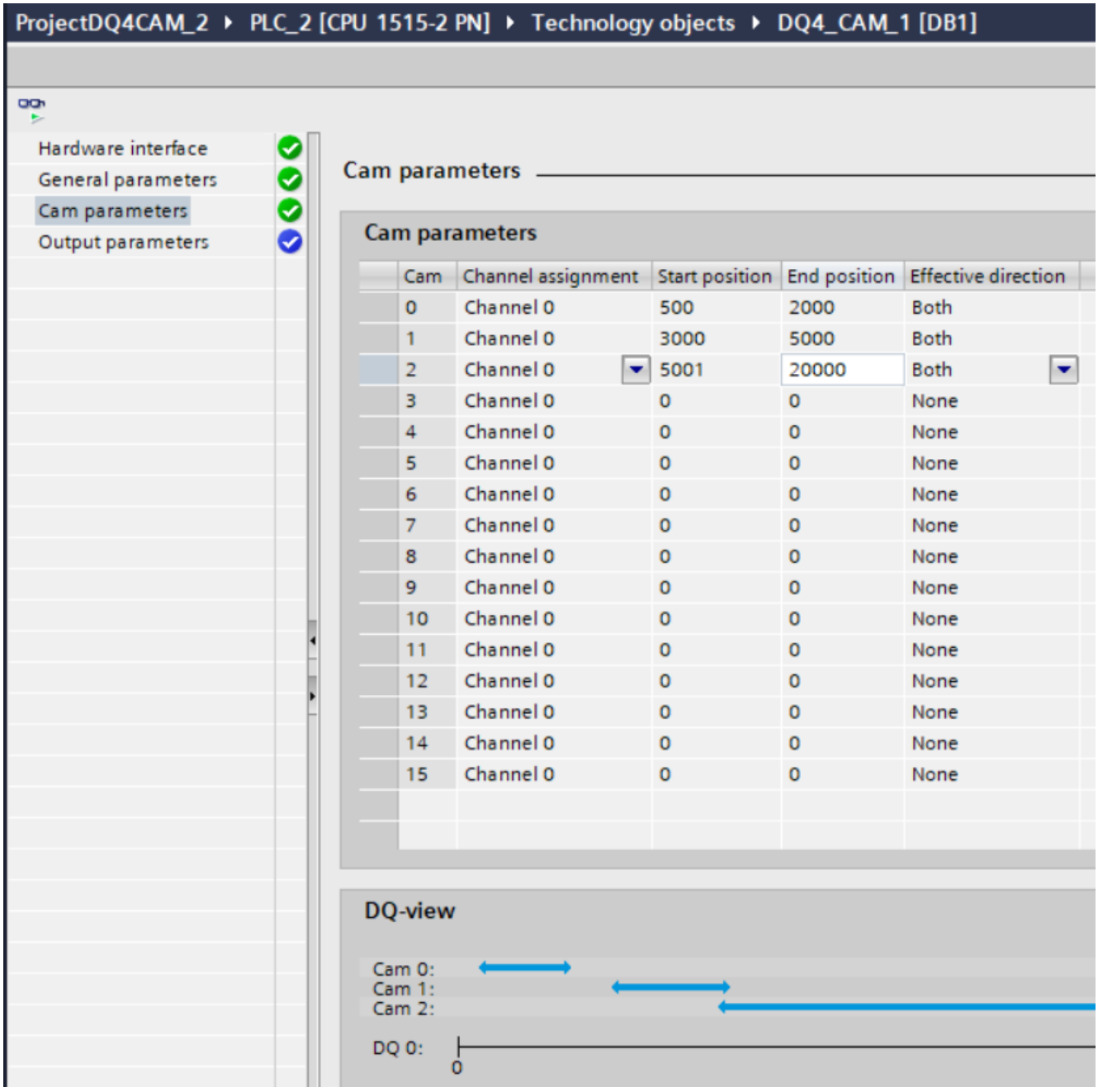

Cam	Channel assignment	Start position	End position	Effective direction
0	Channel 0	500	2000	Both
1	Channel 0	3000	5000	Both
2	Channel 0	5001	20000	Both
3	Channel 0	0	0	None
4	Channel 0	0	0	None
5	Channel 0	0	0	None
6	Channel 0	0	0	None
7	Channel 0	0	0	None
8	Channel 0	0	0	None
9	Channel 0	0	0	None
10	Channel 0	0	0	None
11	Channel 0	0	0	None
12	Channel 0	0	0	None
13	Channel 0	0	0	None
14	Channel 0	0	0	None
15	Channel 0	0	0	None

Configuration window icons

Icons in the area navigation of the configuration show additional details about the status of the configuration:

	The configuration contains default values and is complete. The configuration contains only default values. With these default values, you can use the technology object without additional changes.
	The configuration contains values set by the user or automatically adapted values and is complete All text boxes of the configuration contain valid values and at least one default value was changed.
	The configuration is incomplete or incorrect At least one text box or drop-down list contains an invalid value. The corresponding field or the drop-down list is displayed on a red background. Click the roll-out error message to indicate the cause of error.

Synchronization of the parameter values

When you change the configuration of the technology object, you must download the technology object and the hardware configuration to the CPU.

Within STEP 7 (TIA Portal), the parameter values in the property dialog of the assigned module are overwritten by the parameter values of the technology object. The current parameter values of the technology object are displayed in the property dialog of the module (read-only).

6.5.4.2 Hardware interface

Under "Hardware interface" you establish the connection between the technology object DQ4_CAM, the encoder module and the output module DQ 4x24VDC/2A HS.

Encoder module

In a follow-up dialog box, select the module to which the encoder you want to use is connected. If you do not use an MtM, the encoder module does not necessarily have to be in the same station as the output module. Depending on the encoder module, the value status of the encoder module and the direction of the encoder are supplied in the encoder data in addition to the encoder value, and processed in the cam control.

The following table lists the "encoder modules" that you can use under the S7-1500 CPU or ET 200SP CPU.

Encoder module	Operating mode	Value status	Direction
DI 8x24VDC HS	Counting	–	–
AI 2xU/I 2-/4-wire HS	–	x[1]	–
AI 2xSG 4-/6-wire HS	–	x	–
TM Count 1x24V	• Operating with technology object "Counting and measurement" • Manual operation (without technology object) • Fast Mode	x	x
TM PosInput 1		x	x

[1] In the configuration variant with QI

The value status of the encoder module affects the value status of the output module. If the value status of the encoder module is invalid, the value status of the output module (static tag QI_CHn) is set to 0.

For encoder modules that do not provide a direction in the encoder data, it must be ensured that two valid, different encoder values are available before the direction is recognized.

After selecting the encoder module, you can click the "Device configuration" button to open the device configuration belonging to the module.

NOTE

You can assign an encoder module to several technology objects if necessary.

Channel

In the case of an encoder module with several channels, select the number of the channel that is to be used as encoder value.

Output module

In a follow-up dialog box, select the output module DQ 4x24VDC/2A HS.

After selecting the output module, you can click the "Device configuration" button to open the device configuration associated with the output module. The parameter settings of the output module required for using the technology object are made via the parameters of the technology object.

NOTE

An output module can be assigned to only *one* technology object. An output module that is already assigned to a technology object can no longer be selected.

Data transmission

Use this parameter to define how the encoder data is transferred to the output module.

You can select from the following options:

Data transmission	Meaning
Via CPU (default)	The encoder data is transferred to the output module with the user program.
Via Module to Module Communication	The encoder data is transferred to the output module via Module to Module Communication (MtM). The reaction time of the cam controller is thereby reduced to the duration of a backplane bus cycle. A backplane bus cycle typically corresponds to one PROFINET cycle.

Synchronization of the parameter values

If, after assigning the output module to the technology object, there is an inconsistency between the parameter values in the properties dialog of the output module and in the technology object, a button appears with a message indicating this. When you click the button, the parameter values in the property dialog of the assigned module are overwritten by the parameter values of the technology object within STEP 7 (TIA Portal). The current parameter values of the technology object are displayed in the property dialog of the module (read-only).

NOTE

If you change parameter values of the technology object, the corresponding parameter values are also overwritten without prompt in the properties dialog of the hardware configuration. As after every change in hardware configuration, the next time the project is loaded in the CPU, a prompt appears asking whether the CPU should go to STOP mode.

6.5.4.3 General parameters

Enable modulo

With this parameter you map the encoder value to a repeating modulo range. The modulo range is determined by "Minimum encoder value" and "Maximum encoder value".

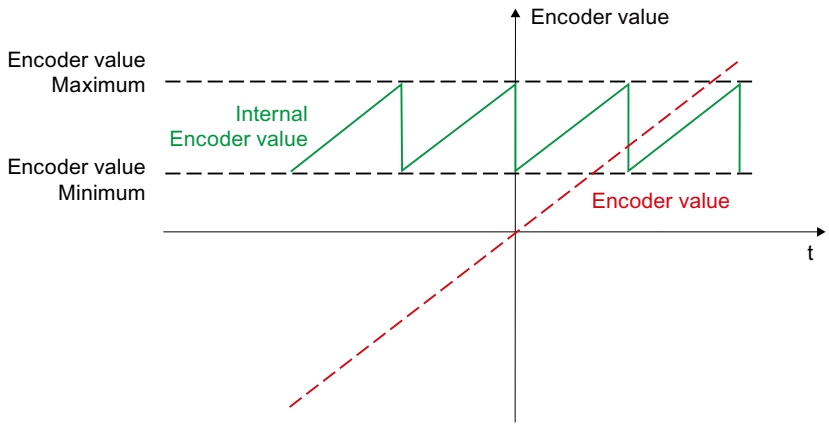

This parameter is deactivated in the default setting.

Hysteresis (in increments)

With the parameterization of the hysteresis (Page 66) you specify a range around the encoder value that is activated after a change of direction. In the hysteresis range, the cams cannot switch again before the encoder value has left this range.

The hysteresis setting must satisfy the following conditions:

- Hysteresis < (Maximum encoder value – Minimum encoder value) / 4
- Hysteresis < End position – Start position

If you enter "0", the hysteresis is switched off. You can enter a value between 0 and 65535. The default setting is "0".

Axis reference position

With the parameter assignment of the axis reference position you adapt the encoder value, for example, to take into account the zero position of the sensor. The axis reference position is subtracted from the encoder value before further processing of the encoder value.

You can enter a value between –2147483648 and 2147483647. The default setting is "0".

Maximum encoder value

With this parameter you specify the upper value of the valid encoder range.

"Maximum encoder value" must be at least 2 greater than "Minimum encoder value".

If you have activated the "Modulo" parameter, the following applies:

- Maximum encoder value – Minimum encoder value <= 2147483646
- Maximum encoder value forms the upper limit of the modulo range.

You can enter a value between –2147483646 and 2147483647. The default setting is "2147483646".

Minimum encoder value

With this parameter you specify the lower value of the valid encoder range.

"Minimum encoder value" must be at least 2 less than "Maximum encoder value".

If you have activated the "Modulo" parameter, the following applies:

- Maximum encoder value – Minimum encoder value <= 2147483646
- Minimum encoder value forms the lower limit of the modulo range.

You can enter a value between –2147483648 and 2147483645. The default setting is "0".

6.5.4.4 Cam parameters

Channel assignment

With the parameter assignment of the channel, you specify the digital output on which the cam is output.

If several cams are assigned to the same digital output, their switch-on ranges must not overlap.

The default setting is "Channel 0".

"Start position / end position"

With the parameter assignment of the two position values, you define the lower and upper value of the switch-on range of the cam (Page 64).

If the modulo is disabled:

- Minimum encoder value <= Cam start position < Cam end position <= Maximum encoder value

When modulo is enabled, the following applies:

- Minimum encoder value <= Cam start position <= Maximum encoder value
- Minimum encoder value <= Cam end position <= Maximum encoder value

The default setting is "0" in each case.

NOTE

If several cams are assigned to the same digital output, their switch-on ranges must not overlap.

Effective direction

With this parameter you specify the direction of movement (Page 64) in which the respective cam acts.

You can select from the following options:

Effective direction	Meaning
None (default)	The cam is switched off.
Positive	The cam only switches between the two position values when motion is forwards.
Negative	The cam only switches between the two position values when motion is backwards.
Both	The cam switches between the two position values regardless of the direction of movement.

6.5.4.5 Output parameters

Channel activated

With this parameter you specify whether the respective channel of the digital output module is used.

This parameter is activated in the default setting.

Pulsed cam output period

With this parameter to specify the period duration for the pulsed output of the cam signal (Page 67).

The "None" option leads to a continuous cam signal.

The default setting is "0.93 ms" in each case.

Pulsed cam output duty cycle

This parameter is used to specify the pulse-period ratio (also called switch-on duration or duty cycle) of the pulsed output signal (Page 67) on the respective channel as a percentage.

The default setting is "50.0" in each case.

Reaction to CPU STOP

This parameter is used to specify the reaction of the digital output of the respective channel in case of a CPU STOP and in case of invalid encoder values.

You can select from the following options:

Reaction to CPU STOP	Meaning
Shutdown (default)	The channel outputs value "0" at the digital output until the next STOP-RUN transition of the CPU or the next valid encoder values.
Keep last value	Until the next STOP-RUN transition of the CPU or the next valid encoder values, the channel outputs at the digital output the value that was valid at the time of the transition to STOP. A pulsed cam output continues to be effective.
Output substitute value 1	The channel outputs value "1" at the digital output until the next STOP-RUN transition of the CPU or the next valid encoder values. A pulsed cam output continues to be effective.

6.5.5 Programming DQ4_CAM

6.5.5.1 Instruction DQ4_CAM

DQ4_CAM

The instruction DQ4_CAM belongs to the technology object DQ4_CAM and supplies the control and feedback interface of the output module DQ 4x24VDC/2A HS.

The DQ4_CAM instruction thus forms the software interface between the user program and the output module. It must be called cyclically from the user program in order to synchronize the input and output data.

The output module can be used centrally or in distributed operation. The instruction applies in each case to the channel of the encoder module and the output module, both of which are assigned to the associated technology object.

Additional information

Description DQ4_CAM (Page 97)

Input parameters DQ4_CAM (Page 98)

Output parameters DQ4_CAM (Page 99)

Static tags DQ4_CAM (Page 100)

UDT DQ4_CAM_Parameters (Page 103)

Error codes of parameter Status (Page 105)

Reaction to encoder errors (Page 105)

6.5.5.2 Call instruction in the user program

The DQ4_CAM instruction can be called once for each output module in the cycle or, alternatively, in a time-controlled program. The call is not permitted in an event-controlled interrupt program.

Requirements

- Encoder and output module are assigned to a common process image partition.
- The instruction is called in the OB to which the process image partition is assigned.

Procedure

Proceed as follows to call the instruction in the user program:

1. Open the CPU folder in the project tree.
2. Open the "Program blocks" folder.
3. Double-click the OB for cyclic program execution.
   The block is opened in the work area.

4. In the "Instructions" window, open the "Technology" group and the "Counting, measurement, cams" folder.
   The folder contains the instruction.
5. Select the instruction and drag it to your OB.
   The "Call options" dialog opens.
6. Select a technology object from the "Name" list or enter the name for a new technology object.
7. Confirm with "OK".

Result

If the technology object does not exist yet, it is added. The instruction is added in the OB. The technology object is assigned to this call of the instruction.

NOTE

If you click one of the buttons "Configuration", "Commissioning" or "Diagnostics" in the user interface of the instruction, the respective editor opens.

6.5.5.3 Description DQ4_CAM

Description

The DQ4_CAM instruction is used to control the cam control functions of the output module via the user program.

Call

The instruction must be called once per output module, either cyclically or in a time-controlled program. The call is not permitted in an event-controlled interrupt program.

Operating principle

Encoder value: The encoder value is available at the output parameter (Page 99) EncoderValue. The encoder value is updated at every call of the instruction.

Register value: You can read parameters from the output module or change parameters in the module via a register mechanism. The static tag WriteRegister (Page 100) controls the function of reading or changing parameters. With the static tag RegisterSelect you select the parameters to be edited. Reading is carried out cyclically. Writing is carried out once after a positive edge at WriteRegister. A read parameter value is available in the static RegisterValueRd. During writing, the value of the selected parameter is overwritten with the value of the static tag RegisterValueWr.

Parameter changes via the user program

You can re-parameterize the output module via the user program while the CPU is in RUN mode. The structure "Configuration" is available for this in the static area of the technology object instance. Write the parameter values (Page 103) to this structure and apply the parameter assignment with a rising edge at the static tag WriteConfiguration. After a successful adoption of the parameters, WriteConfiguration is automatically reset.

Using the output parameter Error, check whether an error has occurred. If no errors have occurred the parameter change was successful.

Status of the digital outputs

You get the status of a digital output via the respective output parameter StatusDQn. The digital output depends on the parameters CtrlDQn, SetDQn and StatusCamn.

Using digital outputs with user program

You can use the input parameters CtrlDQn and SetDQn to control the digital outputs of released channels using the instruction:

Input parameters	Reaction of the digital output DQ_n
$CtrlDQ_n = 0$	$DQ_n = SetDQ_n$
$CtrlDQ_n = 1$	$DQ_n = StatusCam_n$ (respective cam result)

n = 0...3

Reaction to error

If an error has occurred during the call of the instruction or in the output module, the output parameter Error is set. More detailed error information can be read at the output parameter Status (Page 105).

Remove the cause of the error and reset the static tag WriteConfiguration.

You can find detailed information on the subject of encoder errors under Reaction to encoder errors (Page 105).

6.5.5.4 Input parameters DQ4_CAM

Parameter	Declaration	Data type	Default	Description
CtrlDQ0	INPUT	BOOL	TRUE	Specify what is output at digital output DQ0. TRUE: The cam result is output at DQ0. FALSE: The value of SetDQ0 is output at DQ0. 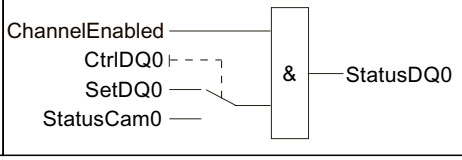

Parameter	Declaration	Data type	Default	Description
CtrlDQ1	INPUT	BOOL	TRUE	Specify what is output at digital output DQ1. TRUE: The cam result is output at DQ1. FALSE: The value of SetDQ1 is output at DQ1.
CtrlDQ2	INPUT	BOOL	TRUE	Specify what is output at digital output DQ2. TRUE: The cam result is output at DQ2. FALSE: The value of SetDQ2 is output at DQ2.
CtrlDQ3	INPUT	BOOL	TRUE	Specify what is output at digital output DQ3. TRUE: The cam result is output at DQ3. FALSE: The value of SetDQ3 is output at DQ3.
SetDQ0	INPUT	BOOL	FALSE	Set digital output DQ0. The output DQ0 is only switched if CtrlDQ0 = FALSE.
SetDQ1	INPUT	BOOL	FALSE	Set digital output DQ1. The output DQ1 is only switched if CtrlDQ1 = FALSE.
SetDQ2	INPUT	BOOL	FALSE	Set digital output DQ2. The output DQ2 is only switched if CtrlDQ2 = FALSE.
SetDQ3	INPUT	BOOL	FALSE	Set digital output DQ3. The output DQ3 is only switched if CtrlDQ3 = FALSE.

6.5.5.5 Output parameters DQ4_CAM

Parameter	Declaration	Data type	Default	Description
StatusCam0	OUTPUT	BOOL	FALSE	Current status of the cams parameterized for channel 0. The status is only output at digital output DQ0 if CtrlDQ0 = 1 and channel 0 is enabled.
StatusCam1	OUTPUT	BOOL	FALSE	Current status of the cams parameterized for channel 1. The status is only output at digital output DQ1 if CtrlDQ1 = 1 and channel 1 is enabled.
StatusCam2	OUTPUT	BOOL	FALSE	Current status of the cams parameterized for channel 2. The status is only output at digital output DQ2 if CtrlDQ2 = 1 and channel2 is enabled.
StatusCam3	OUTPUT	BOOL	FALSE	Current status of the cams parameterized for channel 3. The status is only output at digital output DQ3 if CtrlDQ3 = 1 and channel 3 is enabled.
StatusDQ0	OUTPUT	BOOL	FALSE	Current status digital output DQ0. The digital output depends on the parameters CtrlDQ0, SetDQ0 and StatusCam0 (Page 97). The status is only output if channel 0 is enabled.
StatusDQ1	OUTPUT	BOOL	FALSE	Current status digital output DQ1. The digital output depends on the parameters CtrlDQ1, SetDQ1 and StatusCam1 (Page 97). The status is only output if channel 1 is enabled.
StatusDQ2	OUTPUT	BOOL	FALSE	Current status digital output DQ2. The digital output depends on the parameters CtrlDQ2, SetDQ2 and StatusCam2 (Page 97). The status is only output if channel 2 is enabled.

Parameter	Declaration	Data type	Default	Description
StatusDQ3	OUTPUT	BOOL	FALSE	Current status digital output DQ3. The digital output depends on the parameters CtrlDQ3, SetDQ3 and StatusCam3 (Page 97). The status is only output if channel 3 is enabled.
HysteresisActive	OUTPUT	BOOL	FALSE	The current encoder value is in the hysteresis range.
EncoderSync	OUTPUT	BOOL	FALSE	TRUE: Encoder direction present. Current encoder data can be used for cam output. FALSE: No encoder direction available. If no direction information is supplied, it is calculated from two valid different encoder values. With the first valid encoder value EncoderDataValid is set to TRUE and with the second valid value EncoderSync is also set to TRUE.
Encoder-DataValid	OUTPUT	BOOL	FALSE	TRUE: Current encoder data recognized as valid. FALSE: Current encoder data are invalid. Note: If the encoder data is invalid, the value status is set to FALSE. You can find additional information under Reaction to encoder errors (Page 105).
EncoderValue	OUTPUT	DINT	0	Current internal encoder value that is used to evaluate the parameterized cams.
Error	OUTPUT	BOOL	FALSE	An error has occurred. The cause of the error can be found in the output parameter Status.
Status	OUTPUT	WORD	0	The Status (Page 105) parameter displays the number of the error message. Status = 0000_H: There is no error.

6.5.5.6 Static tags DQ4_CAM

Tag	Data type	Default	Access	Description
Initialized	BOOL	FALSE	Write	Instruction is initialized and ready for operation. Resetting to FALSE leads to the reinitialization of the technology object.
StatusPWM0	BOOL	FALSE	Read	TRUE: Pulsed cam output for channel 0 switched on FALSE: No pulsed cam output
StatusPWM1	BOOL	FALSE	Read	TRUE: Pulsed cam output for channel 1 switched on FALSE: No pulsed cam output
StatusPWM2	BOOL	FALSE	Read	TRUE: Pulsed cam output for channel 2 switched on FALSE: No pulsed cam output
StatusPWM3	BOOL	FALSE	Read	TRUE: Pulsed cam output for channel 3 switched on FALSE: No pulsed cam output
QI_CH0	BOOL	FALSE	Read	Value status for digital output DQ0. TRUE: Supply voltage is present and OK FALSE: Invalid encoder value or short circuit or temperature rise

Tag	Data type	Default	Access	Description
QI_CH1	BOOL	FALSE	Read	Value status for digital output DQ1. TRUE: Supply voltage is present and OK FALSE: Invalid encoder value or short circuit or temperature rise
QI_CH2	BOOL	FALSE	Read	Value status for digital output DQ2. TRUE: Supply voltage is present and OK FALSE: Invalid encoder value or short circuit or temperature rise
QI_CH3	BOOL	FALSE	Read	Value status for digital output DQ3. TRUE: Supply voltage is present and OK FALSE: Invalid encoder value or short circuit or temperature rise
LastMotionDirection	BOOL	FALSE	Read	Direction of the last change of the encoder value. TRUE: Up FALSE: Down
MotionForward	BOOL	FALSE	Read	TRUE: Motion forwards FALSE: No motion forwards
MotionBackward	BOOL	FALSE	Read	TRUE: Motion backwards FALSE: No motion backwards
RegisterSelect	BYTE	0	Writing	Specification of the register to be read/written. See the table below.
WriteRegister	BOOL	FALSE	Writing	FALSE: Read access to the addressed register. FALSE -> TRUE: Writing is activated with a rising edge. Is automatically reset after successful writing.
RegisterValueRd	DWORD	0	Read	Register value that was requested via RegisterSelect
RegisterValueWr	DWORD	0	Writing	Register value to be written. Only relevant for RegisterSelect = 7.
AdditionalErrorId	DWORD	0	Read	Further error information of an internal instruction, e.g. from STATUS parameter of WRREC.
Configuration	"DQ4_CAM_Parameters"	–		Parameters for output module. See section UDT DQ4_CAM_Parameters (Page 103)
WriteConfiguration	BOOL	FALSE	Writing	With a positive edge, the writing of the parameters (Page 103) belonging to the static tag Configuration is activated. Is automatically reset after successful writing. If the parameter values are incorrect, WriteConfiguration is not reset; instead Error is set and Status and AdditionalErrorId contain the error information.

RegisterSelect tag	Register	Description
0_D	CAM_Ctrl-Version	Read: Version of the firmware component CAM_Ctrl: • Bits 0 to 7: Low version of the software component • Bits 8 to 15: High version of the software component • Bits 16 to 31: Reserved
1_D	CAM_Ctrl-Config	Read: Static module configuration: • Bits 0 to 7: Number of channels • Bits 8 to 15: Number of cams • Bits 16 to 23: Number of internal registers • Bits 24 to 31: Reserved
2_D	ENC_RAW	Read: Raw copied encoder value
3_D	HYS_START	Read: Start position of the hysteresis (with active hysteresis, HysteresisActive = TRUE)
4_D	HYS_END	Read: End position of the hysteresis (with active hysteresis, HysteresisActive = TRUE)
5_D	ENC_ERRORS	Read: Number of recognized errors in the encoder data (falling edge of the output parameter EncoderDataValid)
		Write: Resetting the counter
6_D	DIFF_MEDIAN	Read: Average differential value of the incoming encoder values (indicator for update rate). The evaluation is coupled directly to the raw value of the encoder data. Only the differences between the encoder values are evaluated as moving average. With the value you can, for example, evaluate the incremental jumps occurring in the application during the commissioning phase.
		Write: Reset the value
7_D	PWM_WRITE	Read: Status of the pulsed cam output of the 4 channels: • Bit n = 0: Output cam for channel n deactivated • Bit n = 1: Cam output for channel n activated
		Write: Activation/deactivation of the pulsed cam output: • Deactivate cam output for channel n: Bit n = 0 in RegisterValueWr • Activate cam output for channel n: Bit n = 1 in RegisterValueWr
8_D	CAM_ON-INFO	Read: States of the 16 cams: • Bit n = 0: Cam n is reset • Bit n = 1: Cam n is set

Direction detection

Depending on the encoder module, there are two possibilities for direction detection:

- The encoder module provides explicit direction information with the encoder data.

  or

- The encoder module provides no explicit direction information with the encoder data. The output module forms the difference from two valid, different position values of the encoder data and derives the direction from this.

The static variable LastMotionDirection permanently shows the direction of the last position change. The static variables MotionForward and MotionBackward, on the other hand, indicates whether a forward or backward movement has been detected in the last cycle of the output module.

NOTE

Non-synchronous operation can have a negative effect on the reliability of MotionForward and MotionBackward if the output module operates in cycles shorter than the encoder module or technology object. If the rate of change in the actual value is low, two cycles may possibly contain the same encoder value and thus no direction is detected.

6.5.5.7 UDT DQ4_CAM_Parameters

Description

You can reassign output module parameters with the user program while the CPU is in RUN. The structure "Configuration" as data type UDT DQ4_CAM_Parameters is available for this in the static area of the technology object instance. Write the parameter values to this structure and apply the parameter assignment with a rising edge at the static tag WriteConfiguration. After a successful adoption of the parameters, WriteConfiguration is automatically reset.

The parameters are transferred via the data record 128 to the module using the instruction WRREC. No parameters are hereby changed in the CPU. After a CPU startup, the parameters set in the offline parameter settings via technology object are valid again.

If errors occur during the transfer or validation of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. A corresponding error code (Page 105) is then written to the AdditionalErrorId static tag.

NOTE

Direction detection

Direction detection is restarted after each writing of data record 128 (EncoderDataValid = FALSE, EncoderSync = FALSE).

If no direction information is not supplied with the encoder data, two valid, different encoder values are required for direction detection (EncoderSync = TRUE). The two values allow a subtraction to be performed and the direction to be derived from the result.

Until the direction information is available (EncoderSync = TRUE), the channels used for cam output output the parameterized "Reaction to CPU STOP".

Parameter

Tag	Data type	Default	Access	Description
DiagNoSupplyVoltage	BOOL	FALSE	Writing	Activate/deactivate the diagnostics for no or insufficient supply voltage L+
DiagShortCircuit	BOOL	FALSE	Writing	Activate/deactivate the diagnostics short circuit to L+/M

Tag	Data type	Default	Access	Description
DiagEncoderSource	BOOL	FALSE	Writing	Activate/deactivate of the encoder source diagnostics
Modulo	BOOL	FALSE	Writing	Activate/deactivate modulo
Hysteresis	UINT	0	Writing	Set hysteresis: 0_D: Hysteresis deactivated 1 ... 65535_D: Hysteresis activated
AxisReferencePosition	DINT	0	Writing	Set axis reference position: –2147483648 ... 2147483647_D
MinimumEncoderValue	DINT	0	Writing	Set the minimum encoder value range: –2147483648 ... 2147483645_D
MaximumEncoderValue	DINT	2147483646	Writing	Set the maximum encoder value: –2147483646 ... 2147483647_D
CamStartPosition	DINT-Array [0...15]	0	Writing	Set the start position of the cams: –2147483648 ... 2147483647_D
CamEndPosition	DINT-Array [0...15]	0	Writing	Setting the end position of the cams: –2147483648 ... 2147483647_D
CamEffectiveDirection	BYTE-Array [0...15]	0	Writing	Set the effective direction of the cams: 0_D: None 1: Positive 2: Negative 3: Both
CamChannelAssignment	BYTE-Array [0...15]	0	Writing	Setting the channel assignment of the cams: 0 ... 3
ChannelEnabled	BOOL-Array [0...3]	TRUE	Writing	Activate/deactivate channels: 0 ... 3
ReactionToCpuStop	BYTE-Array [0...3]	0	Writing	Set the behavior of the channels at CPU-STOP: 0_D: Shutdown 1: Invalid 2: Keep last value 3 to 10: Invalid 11: Output substitute value 1 12 to 255: Invalid
PulsedCamOutputDuty-Cycle	UINT-Array [0...3]	500	Writing	Set duty cycle for pulsed cam output: 0_D: 0.0 % 1: 0.1 % ... 500: 50.0 % ... 1000: 100.0 %
PulsedCamOutputPeriod	BYTE-Array [0...3]	12	Writing	Set the period duration for pulsed cam output: 0_D: None 4: 0.20 ms 7: 0.40 ms 12: 0.93 ms 14: 1.33 ms 21: 4.27 ms 26: 10.67 ms 30: 21.33 ms 33: 34.13 ms 36: 59.73 ms

6.5.5.8 Error codes of parameter Status

Error code (W#16#...)	Description
0000	No error
8001	Instruction was called multiple times with the same instance (DB)
8002	Wrong OB. Call the instruction only in the OB that is assigned to the PIP to which the output module belongs.
8003	Invalid address of the encoder module. Check the configuration of the encoder module in the technology object.
8004	The selected encoder module is not permitted. Check the configuration of the encoder module in the technology object.
8005	Invalid address of the output module. Check the configuration of the output module in the technology object.
8006	The selected output module is not permitted. Check the configuration of the output module in the technology object. Permissible module type: DQ 4x24VDC/2A HS
8007	Communication with the output module failed (read data records): Error information of internal instruction RDREC saved in static tag AdditionalErrorID
8008	Communication with output module failed (write data records): Error information of internal instruction WRREC saved in static tag AdditionalErrorID
8009	Incorrect encoder signal
800A	Invalid register address. Check the static tag RegisterSelect.
800B	The register addressed via RegisterSelect can be read, but does not support any write operation. Confirm the error by resetting the WriteRegister static tag or correct the error by addressing a register that supports a write operation.

6.5.5.9 Reaction to encoder errors

The following table shows the behavior of the technology object and the output module in case of encoder errors depending on the control mode and the type of data transmission.

Control mode	Data transmission via	Reaction from	Reaction to		
			Invalid encoder values		Missing encoder module
			Without QI	With QI	
Use MtM without technology object	MtM	DQ 4x24VDC/-2A HS	• No error detection • Encoder value of the encoder module is used as valid value	• Diagnostic interrupt 29 ($1D_H$) • See the list 1 below	• Diagnostic interrupt 30 ($1E_H$) • See the list 1 below
	CPU	Data transmission via controller is not available.			

[1] If "Shutdown" or "Output substitute value 1" is configured, it is possible that the states of the control bits are not displayed correctly in the diagnostics of the technology object.

Control mode	Data transmission via	Reaction from	Reaction to		
			Invalid encoder values		Missing encoder module
			Without QI	With QI	
Using the "DQ4_CAM" technology object	MtM	DQ 4x24VDC/-2A HS	• No error detection • Encoder value of the encoder module is used as valid value	• Diagnostic interrupt 29 ($1D_H$) • See the list 1 below	• Diagnostic interrupt 30 ($1E_H$) • See the list 1 below
		Technology object		• Error 8009_H • See the list 2 below	• Error 8009_H • See the list 2 below
	CPU	DQ 4x24VDC/-2A HS	• No error detection • Encoder value of the encoder module is used as valid value	• Diagnostic interrupt 29 ($1D_H$) • See the list 1 below	No error detection. The input parameters are internally overridden depending on the "Reaction to CPU STOP" parameter: • Shutdown: CtrlDQ = 0, SetDQ = 0 • Keep last value: No internal override; input parameters are transferred to output module • Output substitute value 1: CtrlDQ = 0, SetDQ = 1
		Technology object		• Error 8009_H • See the list 2 below	• Error 8009_H • See the list 2 below

[1] If "Shutdown" or "Output substitute value 1" is configured, it is possible that the states of the control bits are not displayed correctly in the diagnostics of the technology object.

List 1: Behavior of the digital outputs and feedback data of the output module DQ 4x24VDC/2A HS	List 2: Behavior of the status values of the technology object DQ4_CAM
• Last valid encoder value is kept (ACT_INP) • Encoder data recognition is set to invalid (INP_OK = 0) • Direction information is reset (SYNC = 0) • States of all cams are reset (STS_CAM = 0) • Value status is set to BAD (QI_0) • Configured "Reaction to CPU STOP" is output for channels that are activated for cam output (CTRL_DQ = 1)	• Keep last valid encoder value (EncoderValue) • Encoder data recognition is set to invalid (EncoderDataValid = FALSE) • Direction information is reset (EncoderSync = FALSE) • States of all cams are reset (StatusCamn = FALSE) • Value status is set to BAD (QI_CHn = FALSE)

6.5.6 Commissioning the technology object

A graphic display of an operating diagram for the digital output signals in the commissioning editor helps you with commissioning and the function test for the technology object. You can change specific parameters of the DQ4_CAM instruction in CPU online mode and monitor their effects.

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.
- The corresponding DQ4_CAM instruction is called cyclically from the user program.
- The input parameters of the technology object are not overwritten by the user program.

NOTE

Input parameters in the DQ4_CAM instruction that are connected in the user program can no longer be operated in the commissioning editor.

Procedure

To open the commissioning editor of a technology object and to control a parameter value change, follow these steps:

1. Open the "Technology objects" folder in the project tree.
2. Open the DQ4_CAM technology object in the project tree.
3. Double-click on the "Commissioning" object.
   The functions for commissioning the DQ4_CAM technology object are displayed.
4. In the commissioning dialog box, click the button "Monitor all".
   The parameters (online values) of the technology object DQ4_CAM are loaded and displayed.
5. If you want to change a parameter, select the check box of the parameter.
   The parameter value is changed.

Online mode

In online mode, you can modify the following parameters to test the technology object function:

- CtrlDQn (Page 98)
- SetDQn (Page 98)

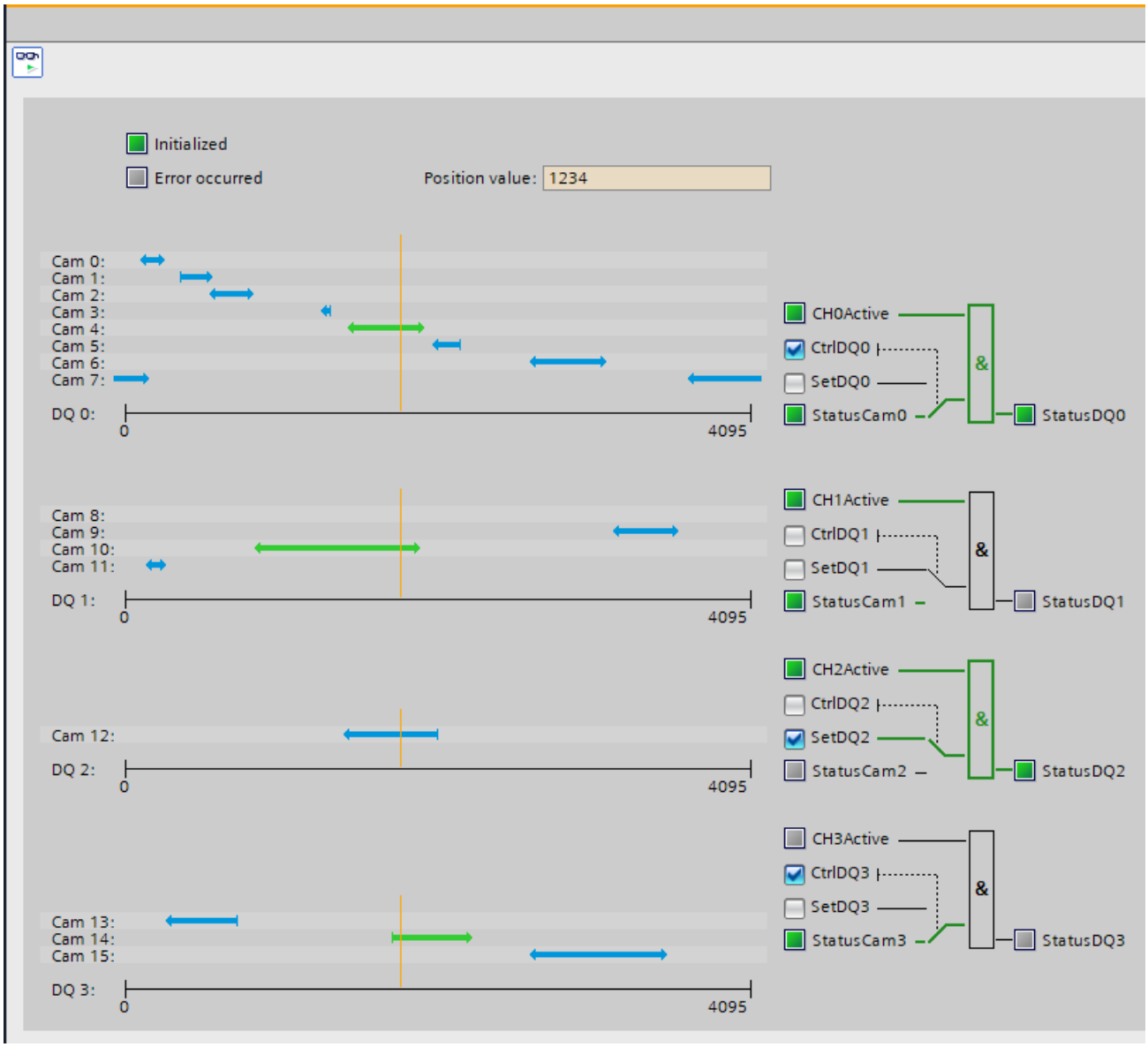

6.5.7 DQ4_CAM diagnostics

The diagnostics functions is used to monitor the encoder values and the cam functions.

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.
- The associated instruction DQ4_CAM is called cyclically from the user program.

Procedure

To open the display editor for the diagnostic functions, follow these steps:

1. Open the "Technology objects" folder in the project tree.
2. Open the DQ4_CAM technology object in the project tree.
3. Double-click on the "Diagnostics" object.
4. Click the "Monitor all" button.

Display

The following values are read by the technology object from the feedback interface of the output module and displayed:

- Event display/diagnostics information
- Signal states of the digital outputs
- Encoder value
- Read register value:

Additional information on status displays is available in the context-sensitive help for each event in STEP 7 (TIA Portal). When the CPU is in STOP, the status display is not updated.

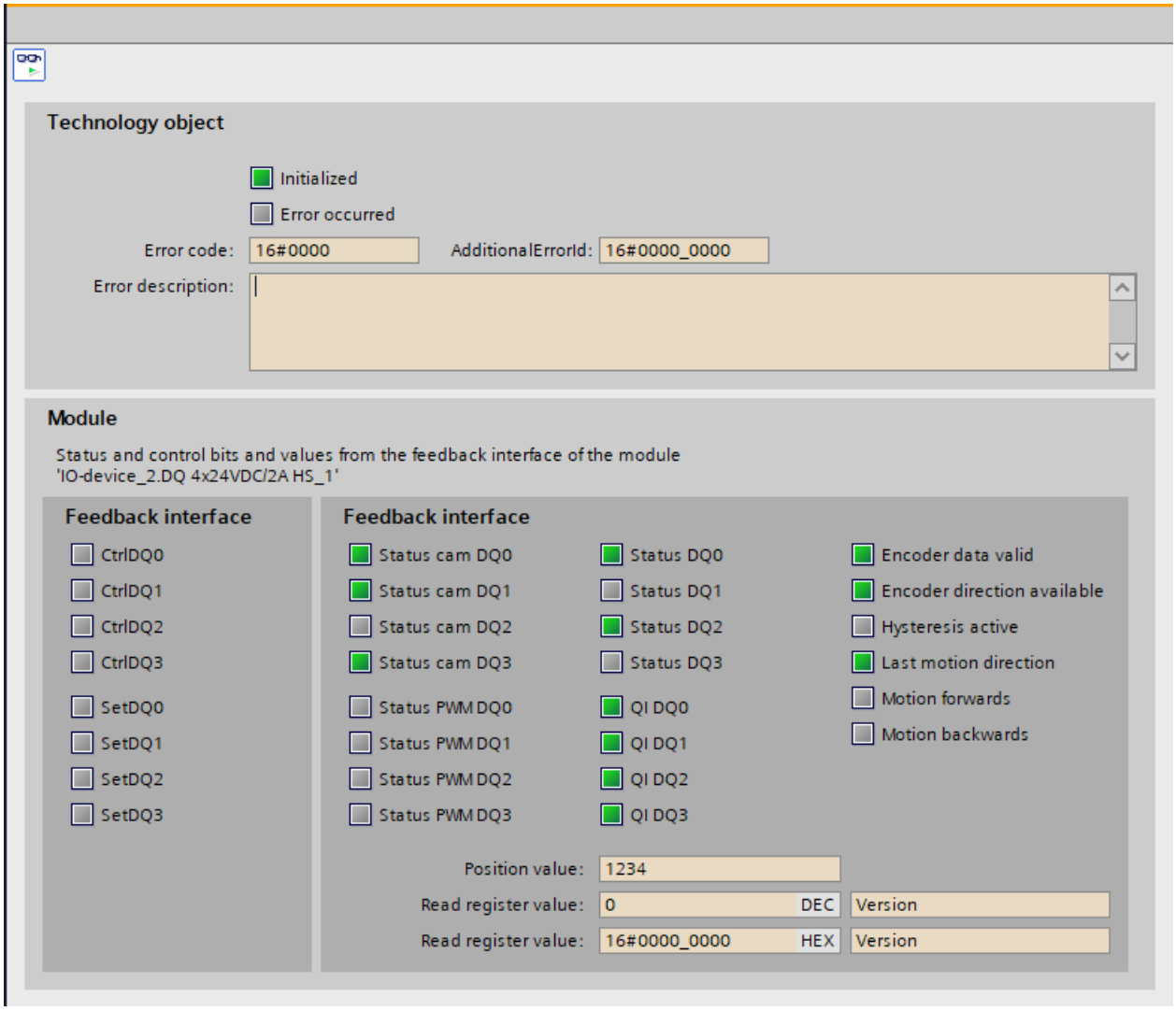

Technical specifications 7

7.1 Technical specifications

Technical specifications of the DQ 4×24VDC/2A HS

The following table shows the technical specifications as of 02/2021. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7132-6BD20-0DA0/td?dl=en).

Article number	6ES7132-6BD20-0DA0
General information	
Product type designation	DQ 4x24 V DC/2 A HS
HW functional status	From FS05
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes; Operating modes DQ and OVS only
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V15.1 or higher
• STEP 7 configurable/integrated from version	via GSD as of V5.6 HF4
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.33
Operating mode	
• DQ	Yes
• DQ with energy-saving function	Yes; Valve control
• PWM	Yes
• Cam control (switching at comparison values)	Yes; Via MtM (module-to-module communication)
• Oversampling	Yes
• MSO	No

Article number	6ES7132-6BD20-0DA0
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	50 mA; without load
Output voltage	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	2.5 W; at 24 V, 25 °C, DQ mode, 2 A per channel
Address area	
Address space per module	
• Inputs	1 byte; Max. 14 bytes in the cam control operating mode
• Outputs	1 byte; Max. 16 bytes in the oversampling operating mode
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0
• 3-wire connection	BU type A0 with AUX terminals or potential distributor module
• 4-wire connection	BU type A0 + Potential distributor module
Digital outputs	
Type of digital output	Source output (PNP, current-sourcing)
Number of digital outputs	4
Current-sinking	No
Current-sourcing	Yes; Push-pull output
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes
• Response threshold, typ.	6 A
Limitation of inductive shutdown voltage to	M (-1 V)
Controlling a digital input	No
Digital output functions, parameterizable	
• Switching tripped by comparison values	Yes
– Number of cam tracks, max.	4
– Number of cams per module, max.	16
– Number of cams per track, max.	16
– Supported axis types	Linear axes and rotary axes with modulo function

Article number	6ES7132-6BD20-0DA0
– Hysteresis	Yes
– Pulsed cam output	Yes
– Range of values for comparison values, max.	-2,147,483,648 to 2,147,483,647 (user-specific within this range)
• Freely usable digital output	Yes
• PWM output	Yes
– Number, max.	4
– Cycle duration, parameterizable	Yes; 0 ms, 0.2 ms, 0.4 ms, 0.93 ms, 1.33 ms, 4.27 ms, 10.67 ms, 21.33 ms, 34.13 ms, 59.73 ms
– Resolution of the duty cycle	0.1 %
• Digital output with oversampling	Yes
– Number, max.	4
– Values per cycle, max.	32
– Resolution, min.	100 µs
Switching capacity of the outputs	
• with resistive load, max.	2 A
• on lamp load, max.	10 W
Load resistance range	
• lower limit	12 Ω
• upper limit	3 400 Ω
Output current	
• for signal "1" rated value	2 A
• for signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
• "0" to "1", max.	1 µs
• "1" to "0", max.	1 µs
Parallel switching of two outputs	
• for uprating	No
Switching frequency	
• with resistive load, max.	5 kHz
• with inductive load, max.	5 kHz
• on lamp load, max.	5 kHz
Total current of the outputs	
• Current per channel, max.	2 A
• Current per module, max.	8 A
Total current of the outputs (per module) horizontal installation	
– up to 30 °C, max.	8 A; DQ mode

Article number	6ES7132-6BD20-0DA0
– up to 40 °C, max.	6.9 A; DQ mode
– up to 50 °C, max.	4.7 A; DQ mode
– up to 60 °C, max.	2.5 A; DQ mode
vertical installation	
– up to 30 °C, max.	7.2 A; DQ mode
– up to 40 °C, max.	5.6 A; DQ mode
– up to 50 °C, max.	4 A; DQ mode
Cable length	
• shielded, max.	50 m
• unshielded, max.	50 m
Isochronous mode	
Execution and activation time (TCO), min.	40 µs
Bus cycle time (TDP), min.	125 µs
Jitter, max.	1 µs
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnoses	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
• Wire-break	No
• Short-circuit	Yes; Module-wise
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
Isolation	
Isolation tested with	707 V DC (type test)

Article number	6ES7132-6BD20-0DA0
Standards, approvals, certificates	
Suitable for safety functions	No
Suitable for safety-related tripping of standard modules	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)

7.2 Derating of the DQ 4x24VDC/2A HS

Maximum permitted output current depending on the frequency

The figure below shows the maximum permitted output current per channel depending on the frequency.

You must take this characteristic into consideration for all operating modes of the module.

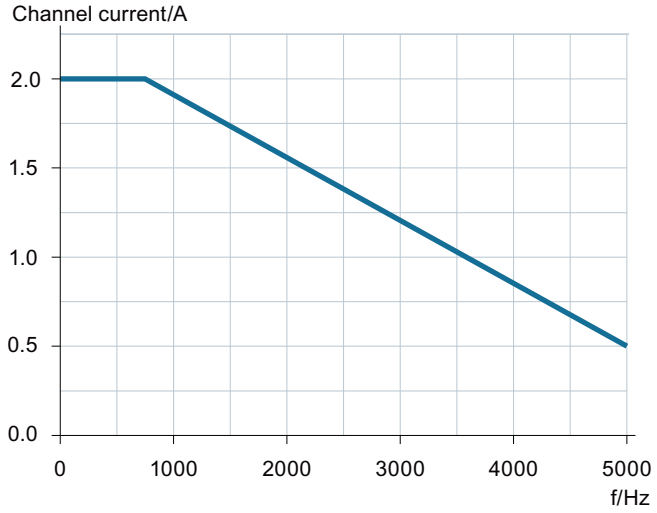

Figure 2-368 Derating of the DQ 4×24VDC/2A HS depending on the frequency

Maximum permitted output current depending on the ambient temperature

In addition to the dependency of the maximum permitted output current on the frequency, you also have to take into consideration the dependency on the ambient temperature. Depending on the configured operating mode, there is an additional "DQ" or "PWM" derating. The table below shows the dependencies of derating version and module operating mode:

Table 2-377 Additional derating versions of the DQ 4×24VDC/2A HS

Derating version	Operating mode				
	Normal operation	Valve control in normal operation	Pulse width modulation	Oversampling	Cam control
DQ derating	x	-	-	x	-
PWM derating	-	x	x	-	x

DQ derating

The figure below shows the maximum permitted total current depending on the ambient temperature for the DQ derating.

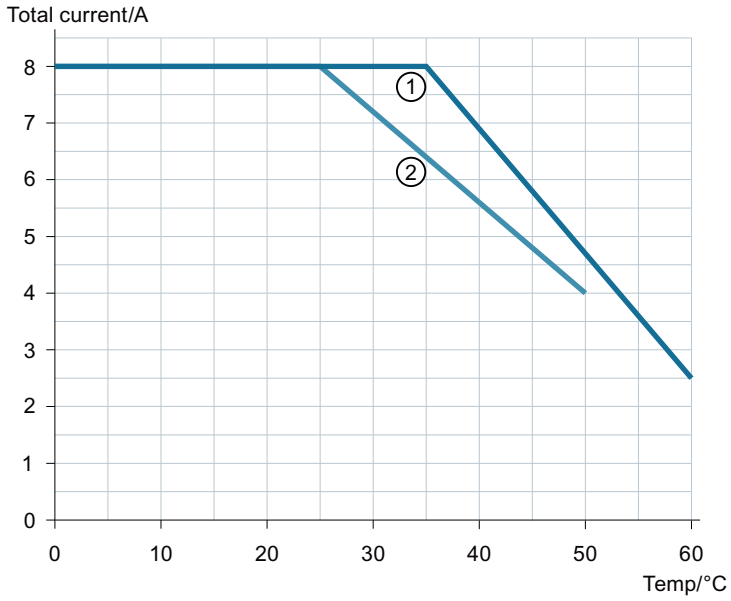

① Horizontal installation position

② Vertical installation position

Figure 2-369 Additional DQ derating depending on the ambient temperature

PWM derating

The figure below shows the maximum permitted total current depending on the ambient temperature for the PWM derating.

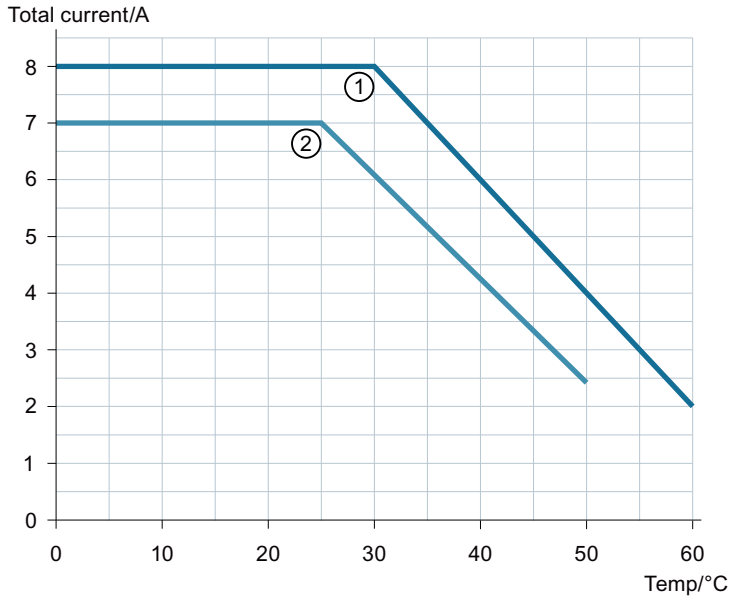

① Horizontal installation position

② Vertical installation position

Figure 2-370 Additional PWM derating depending on the ambient temperature

Parameter data records

A

A.1 Parameter assignment and structure of the parameter data record for DQ operating mode

Parameter assignment in the user program

You can reassign the parameters of the module in RUN. For example, the reaction to CPU STOP of individual channels can be changed in RUN without this having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

NOTE

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment can result in a brief exit from clocked mode and renewed synchronization with the fieldbus cycle.

NOTE

Changing parameters in RUN

When parameters are reassigned in RUN, a brief signal failure can occur at the output. For this reason, reassignment of parameters in RUN should be done when a 0 is being output at the output.

STATUS output parameter

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128 for entire module

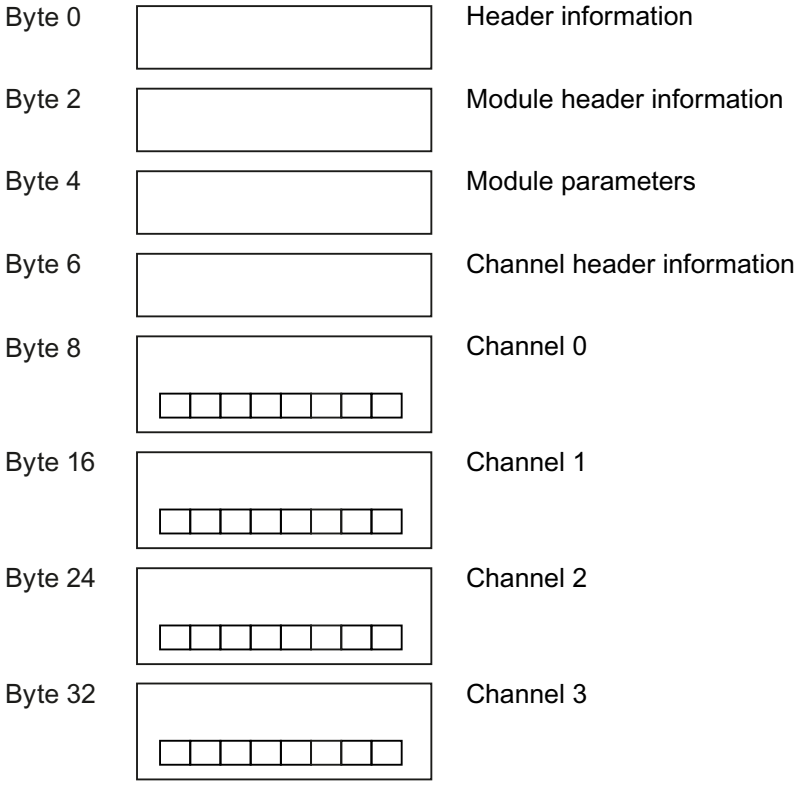

Figure 2-371 Structure of data record 128 for entire module

Header information

The figure below shows the structure of the header information.

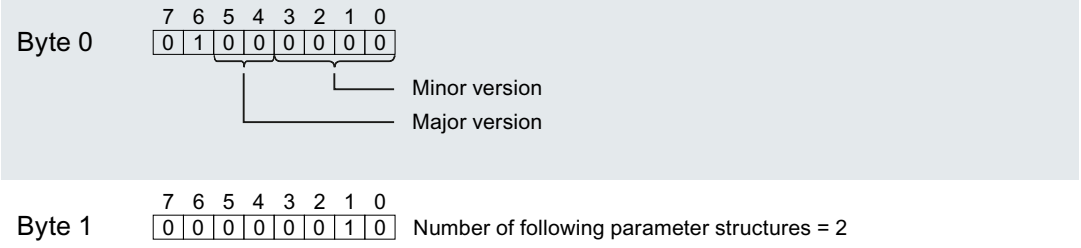

Figure 2-372 Header information

Module header information

The figure below shows the structure of the module header information.

	7	6	5	4	3	2	1	0	
Byte 2	0	0	0	0	0	0	0	1	Number of the following module parameter blocks = 1
Byte 3	0	0	0	0	0	0	1	0	Length of the following module parameter block = 2

Figure 2-373 Module header information

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 to 3. Enable a parameter by setting the corresponding bit to "1".

	7	6	5	4	3	2	1	0	
Byte 4	0	0	0	0	0	0	0	0	Operating mode 00 = DQ (normal mode) Output rate 0 = 1 value/cycle
Byte 5	0	0	0	0			0		Enable diagnostics No supply voltage L+ 00 = Short-circuit disabled 11 = Short-circuit enabled

Figure 2-374 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

	7	6	5	4	3	2	1	0	
Byte 6	0	0	0	0	0	1	0	0	Number of the following channel parameter blocks = 4
Byte 7	0	0	0	0	1	0	0	0	Length of the following channel parameter block = 8

Figure 2-375 Channel header information

Channel parameter block

The figure below shows the structure of the channel parameter block.

Enable a parameter by setting the corresponding bit to "1".

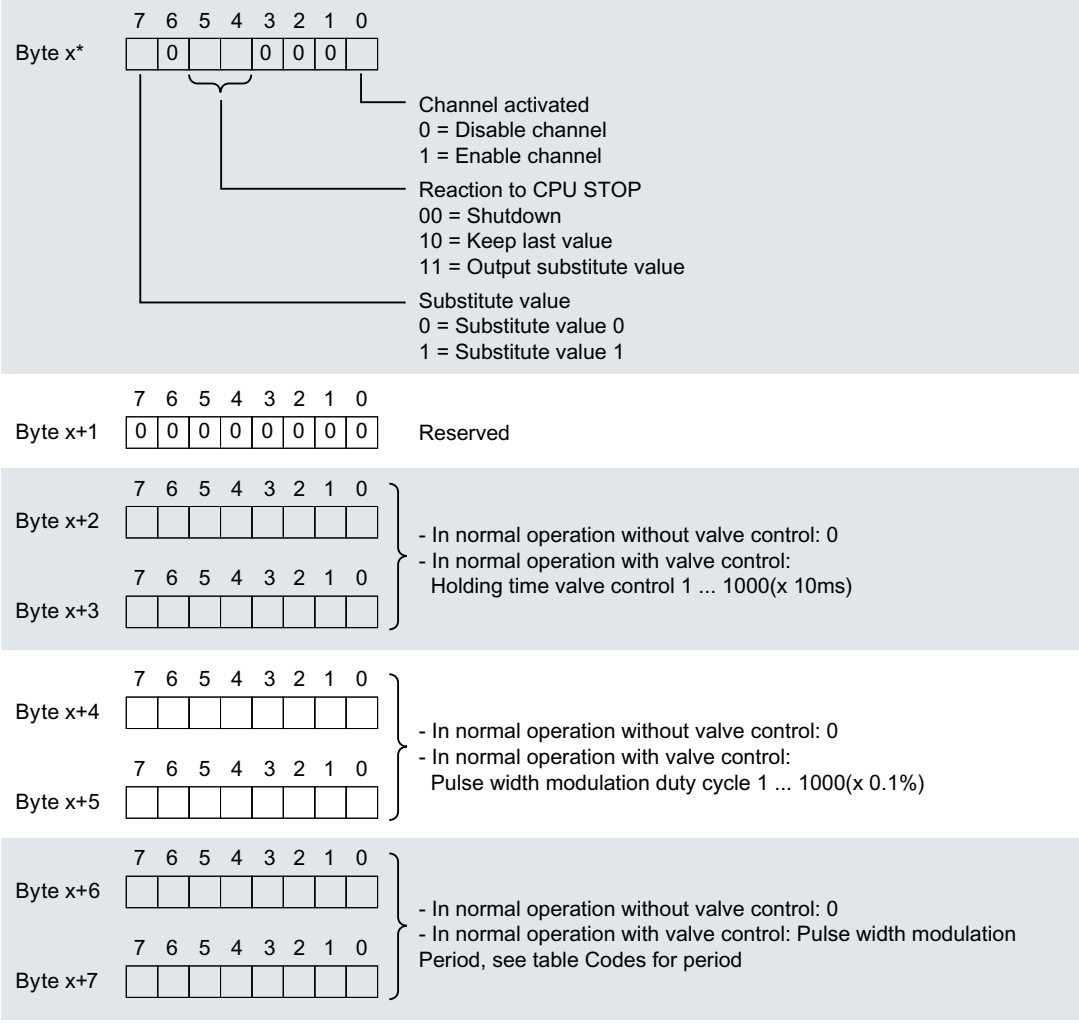

Figure 2-376 Structure of byte x to x+7 for channels 0 to 3

Codes for time period of the pulse width modulation

The following table contains the codes for the time period of the pulse width modulation of the digital output module. You must enter these codes in bytes x+6 and x+7 of the channel parameter block of data record 128 (see previous figure).

Table 2-378 Codes for the period

Value	Time period	Code
0	Off	0000 0000
4	0.20 ms	0000 0100
7	0.40 ms	0000 0111
12	0.93 ms	0000 1100
14	1.33 ms	0000 1110
21	4.27 ms	0001 0101
26	10.67 ms	0001 1010
30	21.33 ms	0001 1110
33	34.13 ms	0010 0001
36	59.73 ms	0010 0100

Errors when transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module take over the values from the data record.

In case of errors, the WRREC instruction for writing data records returns corresponding error codes in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help.

The following table shows the module-specific error codes and their meaning for data record 128. The error codes are supported starting from firmware version V2.0.0.

Table 2-379 Error messages, their meaning and corrective measures

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$B0_H$	00_H	Number of the data record unknown	Enter a valid number for the data record.
DF_H	80_H	$B1_H$	01_H	Length of the data record incorrect	Enter a valid value for the data record length.
DF_H	80_H	$B2_H$	00_H	Module not accessible	• Check station. • Plug the module in correctly. • Check parameters of the WRREC block.
DF_H	80_H	$E0_H$	01_H	Incorrect version in header	Correct the version number of the parameter block, see Header information.
DF_H	80_H	$E0_H$	02_H	Error in the header, length or number of parameter blocks	Correct the length and number of parameter blocks, see Header information and Module header information.
DF_H	80_H	$E1_H$	01_H	Reserved bit set	Write 0 to all reserved bits.
DF_H	80_H	$E1_H$	02_H	Invalid diagnostics enable bit set for operating mode	Correct the diagnostics enables according to the operating mode, see Module parameter block.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$E1_H$	06_H	Code for behavior with substitute value invalid	Use valid code for reaction to CPU STOP, see Structure of byte x to x+7 for channels 0 to 3.
DF_H	80_H	$E1_H$	$0D_H$	Code for output rate invalid	Use valid code for output rate, see Module parameter block.
DF_H	80_H	$E1_H$	21_H	Set operating mode invalid	Adapt operating mode according to the configuration, see Module parameter block.
DF_H	80_H	$E1_H$	22_H	Value for holding time valve control invalid	Adapt holding time valve control to valid value, see Structure of byte x to x+7 for channels 0 to 3.
DF_H	80_H	$E1_H$	23_H	Value for pulse width modulation duty cycle invalid	Adapt pulse width modulation duty cycle to valid value, see Structure of byte x to x+7 for channels 0 to 3.
DF_H	80_H	$E1_H$	24_H	Code for pulse width modulation time period invalid	Use valid code for pulse width modulation time period, see Structure of byte x to x+7 for channels 0 to 3.

A.2 Parameter assignment and structure of the parameter data record for oversampling operating mode

Parameter assignment in the user program

You can reassign the parameters of the module in RUN. For example, the reaction to CPU STOP of individual channels can be changed in RUN without this having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

NOTE

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment can result in a brief exit from clocked mode and renewed synchronization with the fieldbus cycle.

STATUS output parameter

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128 for entire module

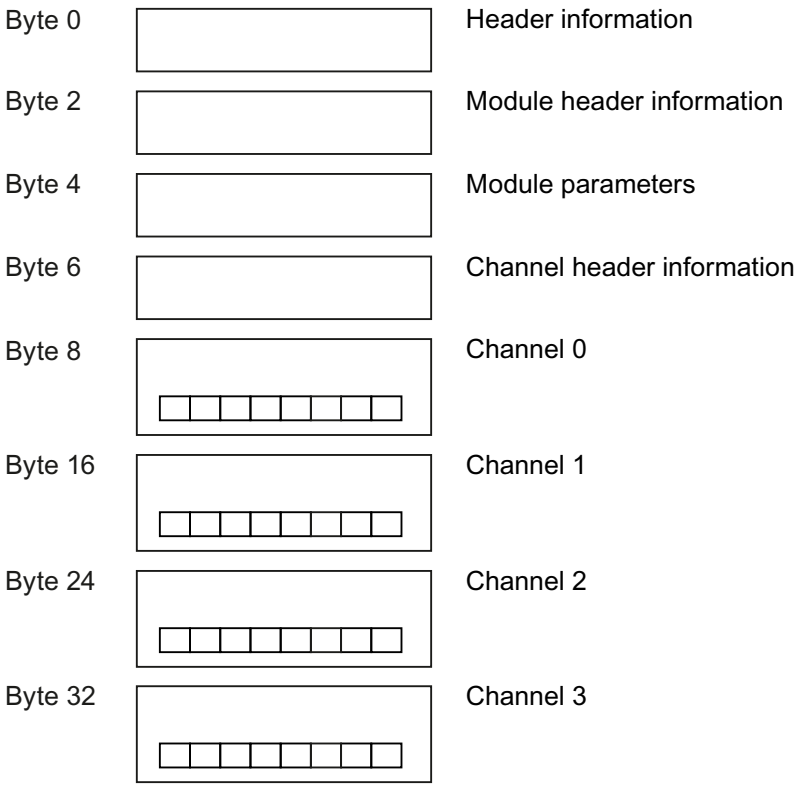

Figure 2-377 Structure of data record 128 for entire module

Header information

The figure below shows the structure of the header information.

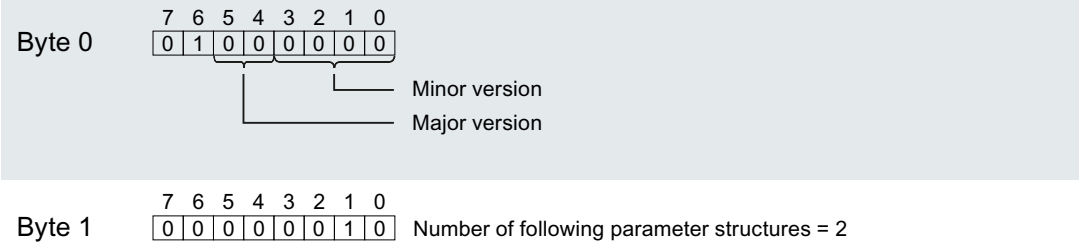

Figure 2-378 Header information

Module header information

The figure below shows the structure of the module header information.

	7	6	5	4	3	2	1	0	
Byte 2	0	0	0	0	0	0	0	1	Number of the following module parameter blocks = 1
Byte 3	0	0	0	0	0	0	1	0	Length of the following module parameter block = 2

Figure 2-379 Module header information

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 to 3. Enable a parameter by setting the corresponding bit to "1".

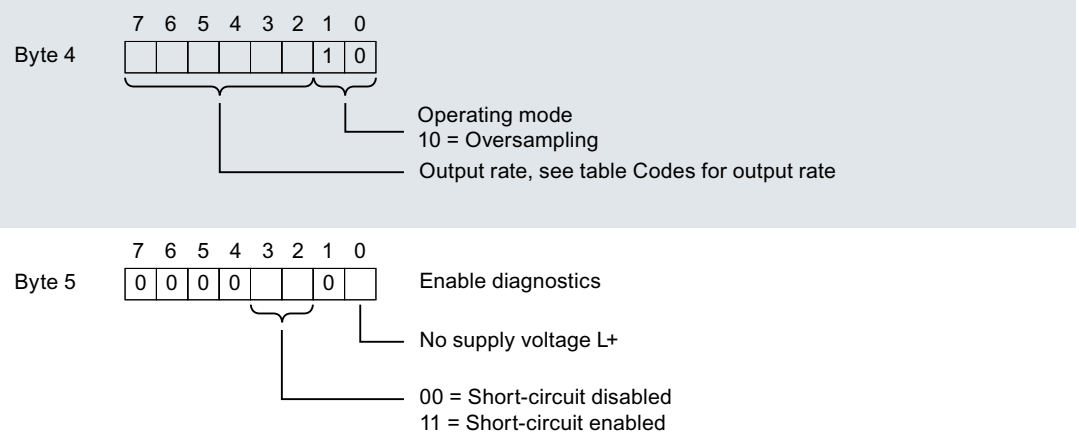

Figure 2-380 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

	7	6	5	4	3	2	1	0	
Byte 6	0	0	0	0	0	1	0	0	Number of the following channel parameter blocks = 4
Byte 7	0	0	0	0	1	0	0	0	Length of the following channel parameter block = 8

Figure 2-381 Channel header information

Channel parameter block

The figure below shows the structure of the channel parameter block.

Enable a parameter by setting the corresponding bit to "1".

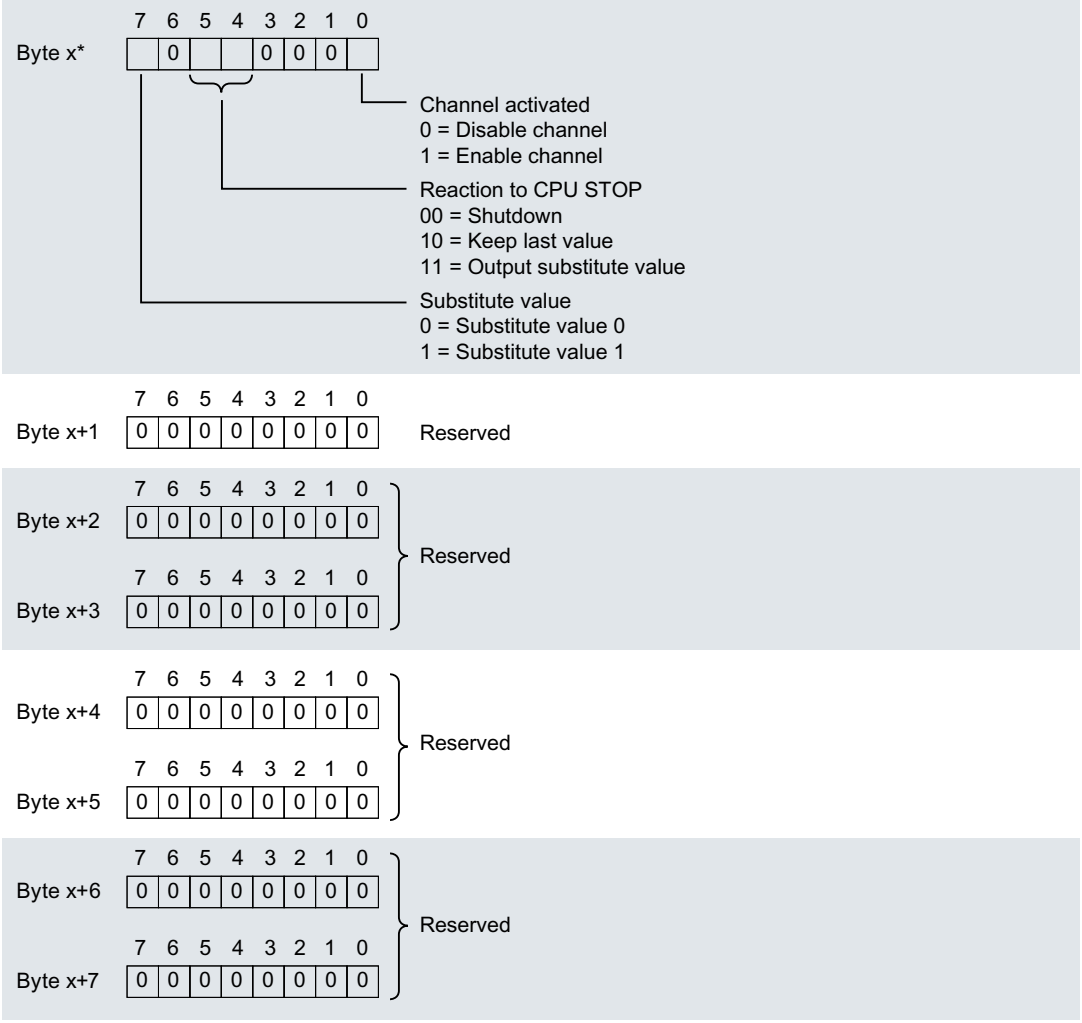

*x = 8 + (channel number × 8); channel number = 0 to 3

Figure 2-382 Structure of byte x to x+7 for channels 0 to 3

Codes for the output rate

The table below contains the codes for the output rate of the digital output module. You must enter these codes in byte 4 of the module parameter block of data record 128 (see figure).

Table 2-380 Codes for the output rate

Value	Output rate	Code
1	2 values/cycle	000001
3	4 values/cycle	000011
5	6 values/cycle	000101
7	8 values/cycle	000111
9	10 values/cycle	001001
11	12 values/cycle	001011
13	14 values/cycle	001101
15	16 values/cycle	001111
17	18 values/cycle	010001
19	20 values/cycle	010011
21	22 values/cycle	010101
23	24 values/cycle	010111
25	26 values/cycle	011001
27	28 values/cycle	011011
29	30 values/cycle	011101
31	32 values/cycle	011111

Errors when transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module take over the values from the data record.

In case of errors, the WRREC instruction for writing data records returns corresponding error codes in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help.

The following table shows the module-specific error codes and their meaning for data record 128. The error codes are supported starting from firmware version V2.0.0.

Table 2-381 Error messages, their meaning and corrective measures

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$B0_H$	00_H	Number of the data record unknown	Enter a valid number for the data record.
DF_H	80_H	$B1_H$	01_H	Length of the data record incorrect	Enter a valid value for the data record length.
DF_H	80_H	$B2_H$	00_H	Module not accessible	• Check station. • Plug the module in correctly. • Check parameters of the WRREC block.
DF_H	80_H	$E0_H$	01_H	Incorrect version in header	Correct the version number of the parameter block, see Header information.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$E0_H$	02_H	Error in the header, length or number of parameter blocks	Correct the length and number of parameter blocks, see Header information, figure Module header information and Channel header information.
DF_H	80_H	$E1_H$	01_H	Reserved bit set	Write 0 to all reserved bits.
DF_H	80_H	$E1_H$	02_H	Invalid diagnostics enable bit set for operating mode	Correct the diagnostics enables according to the operating mode, see Module parameter block.
DF_H	80_H	$E1_H$	06_H	Code for behavior with substitute value invalid	Use valid code for reaction to CPU STOP, see Structure of byte x to x+7 for channels 0 to 3.
DF_H	80_H	$E1_H$	$0D_H$	Code for output rate invalid	Use valid code for output rate, see Module parameter block.
DF_H	80_H	$E1_H$	21_H	Set operating mode invalid	Adapt operating mode according to the configuration, see Module parameter block.

See also

Parameter assignment and structure of the parameter data record for oversampling operating mode (Page 124)

A.3 Parameter assignment and structure of the parameter data record for pulse width modulation operating mode

Parameter assignment in the user program

You can reassign the parameters of the module in RUN. For example, you can change the period of individual channels in "Pulse width modulation" operating mode in RUN without this having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

NOTE

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment can result in a brief exit from clocked mode and renewed synchronization with the fieldbus cycle.

STATUS output parameter

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128 for entire module

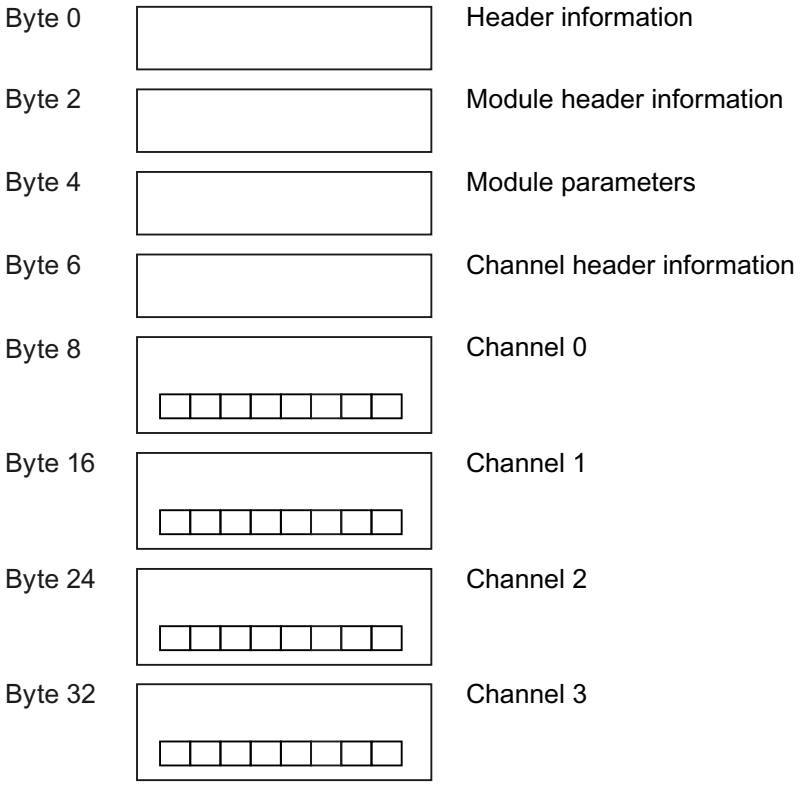

Figure 2-383 Structure of data record 128 for entire module

Header information

The figure below shows the structure of the header information.

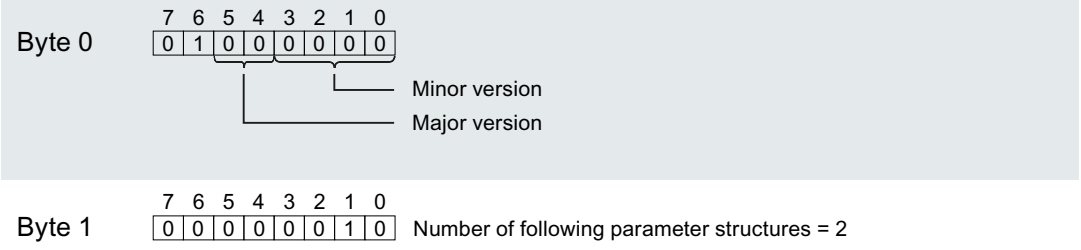

Figure 2-384 Header information

Module header information

The figure below shows the structure of the module header information.

	7	6	5	4	3	2	1	0	
Byte 2	0	0	0	0	0	0	0	1	Number of the following module parameter blocks = 1
Byte 3	0	0	0	0	0	0	1	0	Length of the following module parameter block = 2

Figure 2-385 Module header information

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 to 3.

Enable a parameter by setting the corresponding bit to "1".

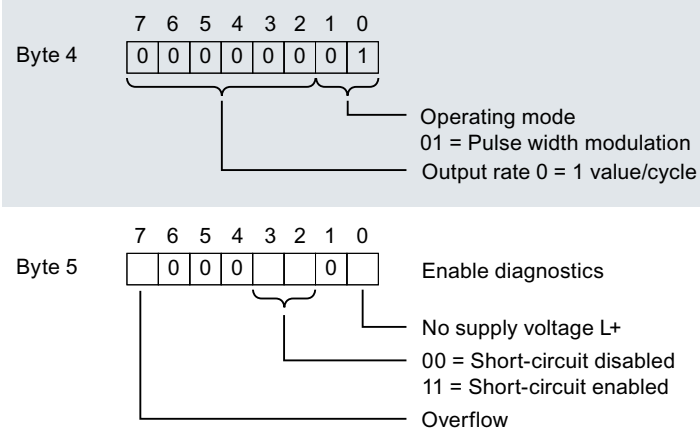

Figure 2-386 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

	7	6	5	4	3	2	1	0	
Byte 6	0	0	0	0	0	1	0	0	Number of the following channel parameter blocks = 4
Byte 7	0	0	0	0	1	0	0	0	Length of the following channel parameter block = 8

Figure 2-387 Channel header information

Channel parameter block

The figure below shows the structure of the channel parameter block.

Enable a parameter by setting the corresponding bit to "1".

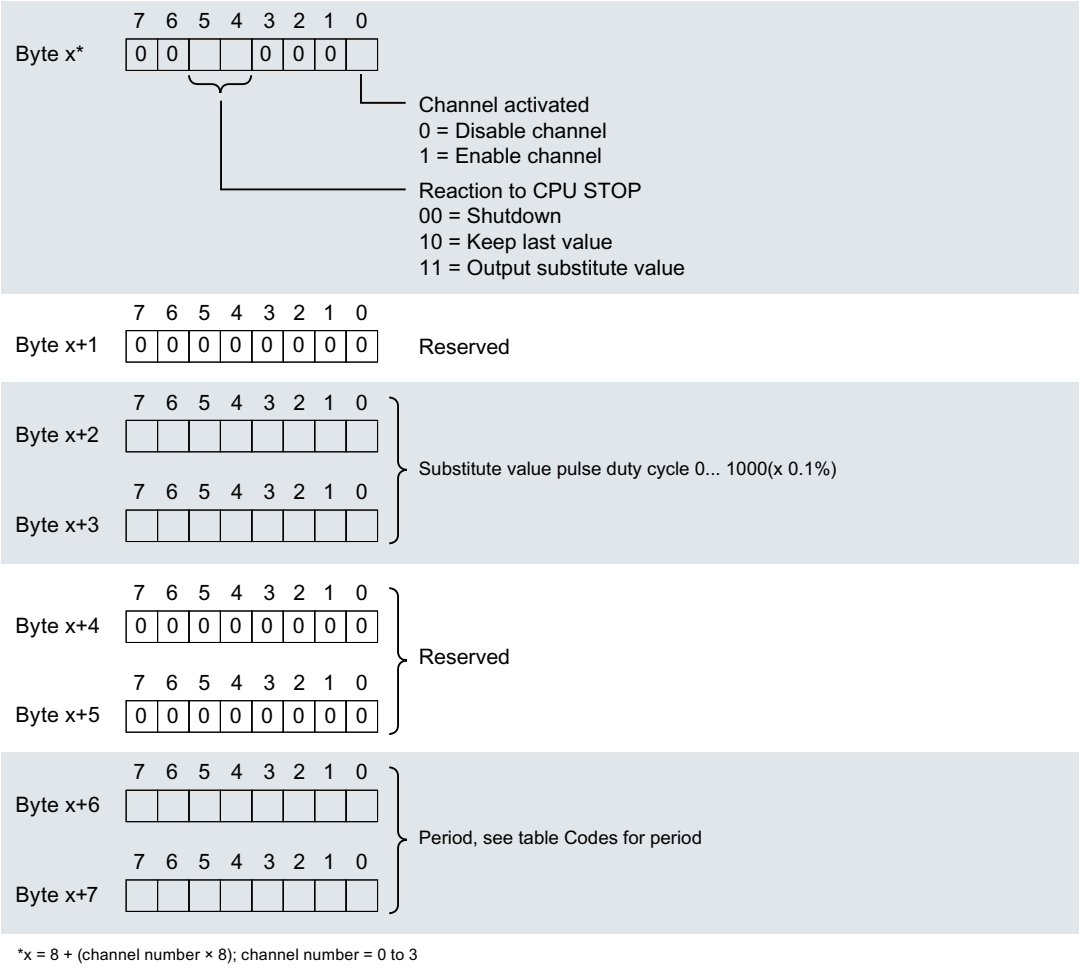

Figure 2-388 Structure of byte x to x+7 for channels 0 to 3

Codes for time period of the pulse width modulation

The following table contains the codes for the time period of the pulse width modulation of the digital output module. You must enter these codes in bytes x+6 and x+7 of the channel parameter block of data record 128 (see previous figure).

Table 2-382 Codes for the period

Value	Time period	Code
0	Off	0000 0000
4	0.20 ms	0000 0100
7	0.40 ms	0000 0111
12	0.93 ms	0000 1100
14	1.33 ms	0000 1110
21	4.27 ms	0001 0101
26	10.67 ms	0001 1010
30	21.33 ms	0001 1110
33	34.13 ms	0010 0001
36	59.73 ms	0010 0100

Errors when transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module take over the values from the data record.

In case of errors, the WRREC instruction for writing data records returns corresponding error codes in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help.

The following table shows the module-specific error codes and their meaning for data record 128. The error codes are supported starting from firmware version V2.0.0.

Table 2-383 Error messages, their meaning and corrective measures

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$B0_H$	00_H	Number of the data record unknown	Enter a valid number for the data record.
DF_H	80_H	$B1_H$	01_H	Length of the data record incorrect	Enter a valid value for the data record length.
DF_H	80_H	$B2_H$	00_H	Module not accessible	• Check station. • Plug the module in correctly. • Check parameters of the WRREC block.
DF_H	80_H	$E0_H$	01_H	Incorrect version in header	Correct the version number of the parameter block, see Header information.
DF_H	80_H	$E0_H$	02_H	Error in the header, length or number of parameter blocks	Correct the length and number of parameter blocks, see Header information and Channel header information.
DF_H	80_H	$E1_H$	01_H	Reserved bit set	Write 0 to all reserved bits.
DF_H	80_H	$E1_H$	02_H	Invalid diagnostics enable bit set for operating mode	Correct the diagnostics enables according to the operating mode, see Module parameter block.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$E1_H$	06_H	Code for behavior with substitute value invalid	Use valid code for reaction to CPU STOP, see Structure of byte x to x+7 for channels 0 to 3.
DF_H	80_H	$E1_H$	$0A_H$	Value for substitute value invalid	Adapt substitute value to valid value, see Structure of byte x to x+7 for channels 0 to 3.
DF_H	80_H	$E1_H$	$0D_H$	Code for output rate invalid	Use valid code for output rate, see Module parameter block.
DF_H	80_H	$E1_H$	21_H	Set operating mode invalid	Adapt operating mode according to the configuration, see Module parameter block.
DF_H	80_H	$E1_H$	24_H	Code for pulse width modulation time period invalid	Use valid code for pulse width modulation time period, see Structure of byte x to x+7 for channels 0 to 3.

See also

Parameter assignment and structure of the parameter data record for pulse width modulation operating mode (Page 129)

A.4 Parameter assignment and structure of the parameter data record for cam control operating mode

Parameter assignment in the user program

You can reassign the parameters of the module in RUN. For example, you can change the period of individual channels in RUN without this having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

If a parameter is changed in the module parameter block or in the internal cam control block, the direction information is nullified (SYNC = 0) until it can be detected again. As long as no direction information is available, the configured substitute values are output for the cam control channels.

NOTE
Direction detection
If no direction information is included with the supplied encoder data, two valid different encoder values are needed for the direction detection (SYNC = 1). The two values allow a subtraction to be performed and the direction to be derived from the result.

STATUS output parameter

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128 for entire module

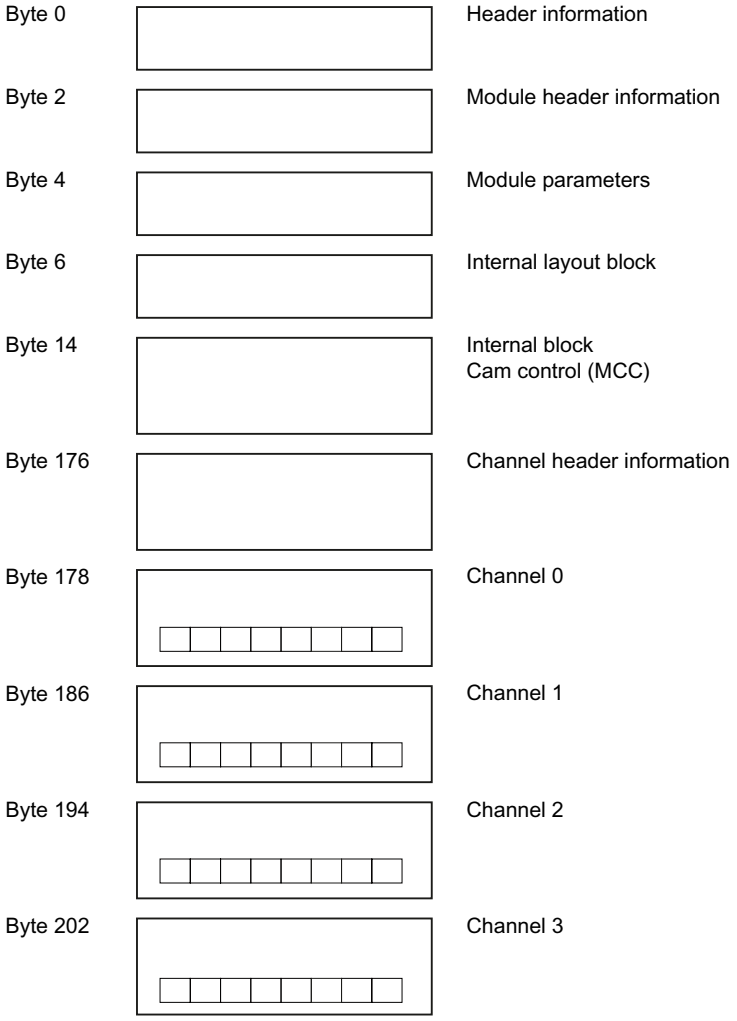

Figure 2-389 Structure of data record 128 for entire module with cam control operating mode

Header information

The figure below shows the structure of the header information.

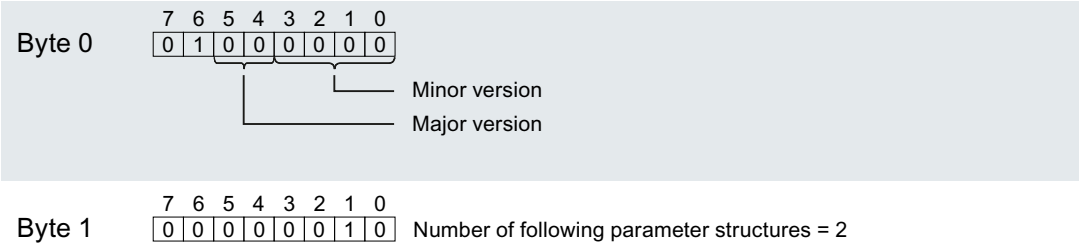

Figure 2-390 Header information

Module header information

The figure below shows the structure of the module header information.

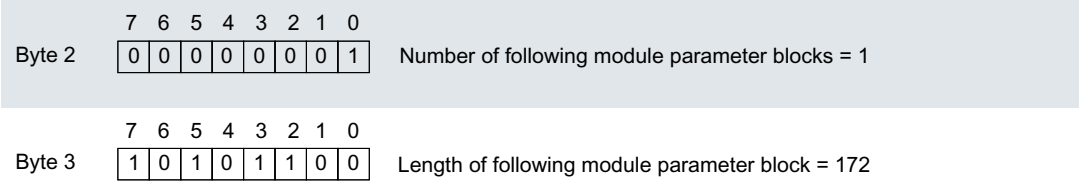

Figure 2-391 Module header information in cam control operating mode

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 to 3.

Enable a parameter by setting the corresponding bit to "1".

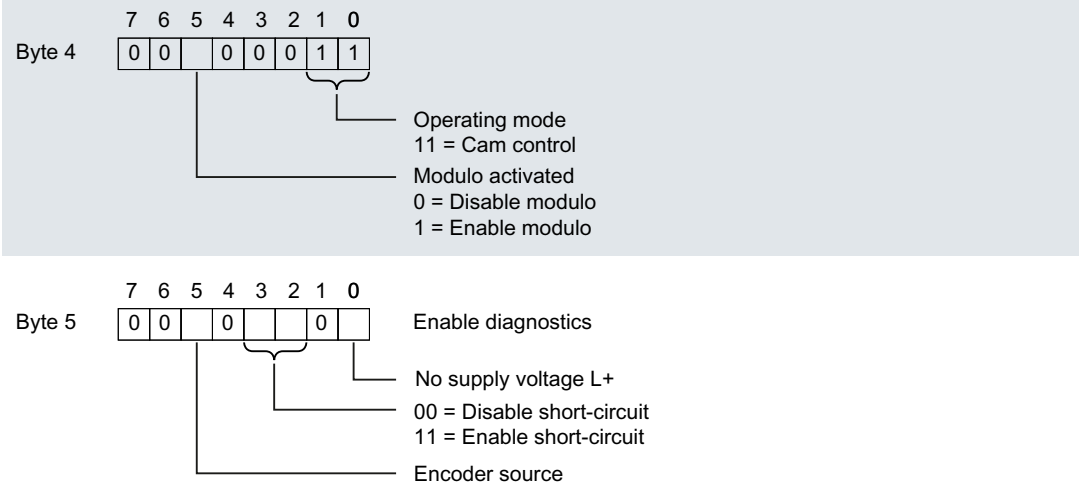

Figure 2-392 Module parameter block in cam control operating mode

Internal layout block

The figure below shows the structure of the internal layout block.

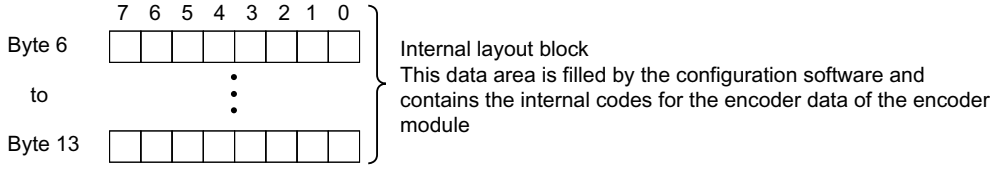

Figure 2-393 Internal layout block in cam control operating mode

Internal block cam control (Modular CAM Controller)

The figure below shows the structure of the internal block cam control (Modular CAM Controller).

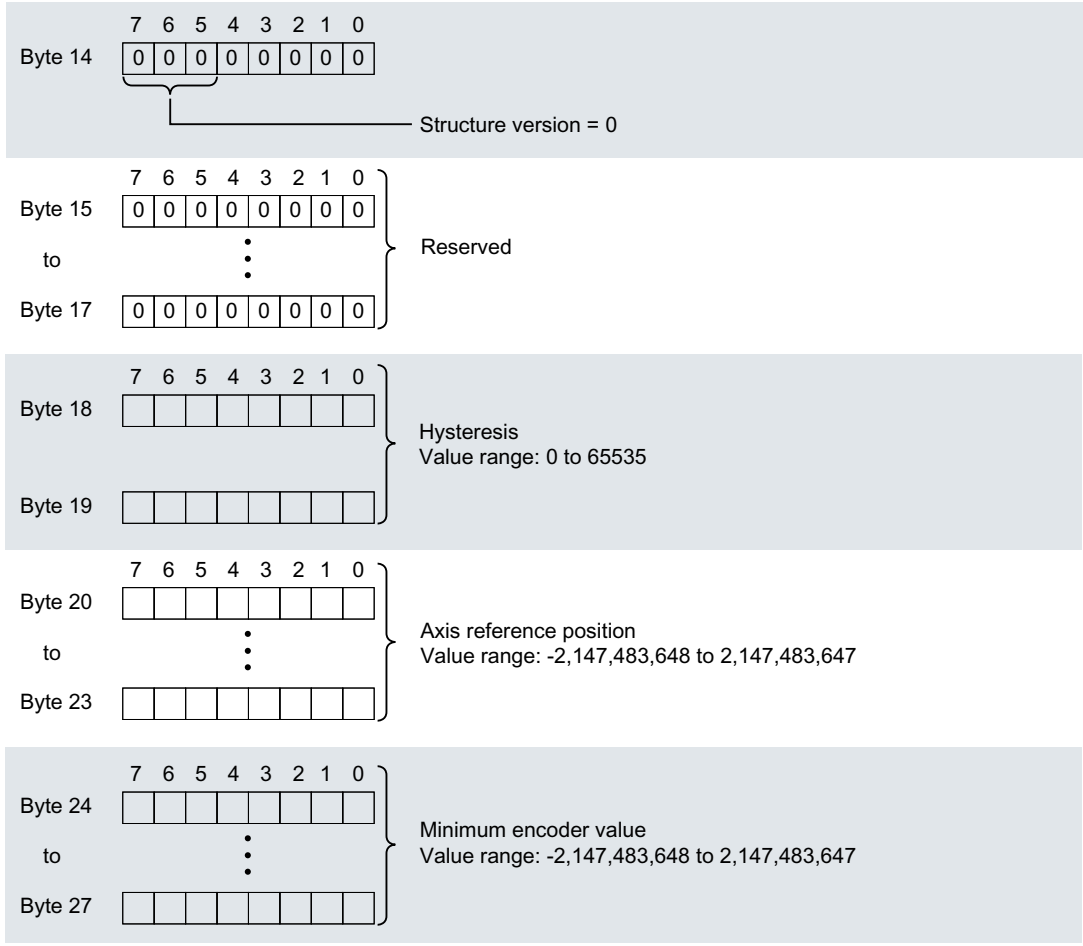

Figure 2-394 Internal block cam control (Modular CAM Controller), part 1

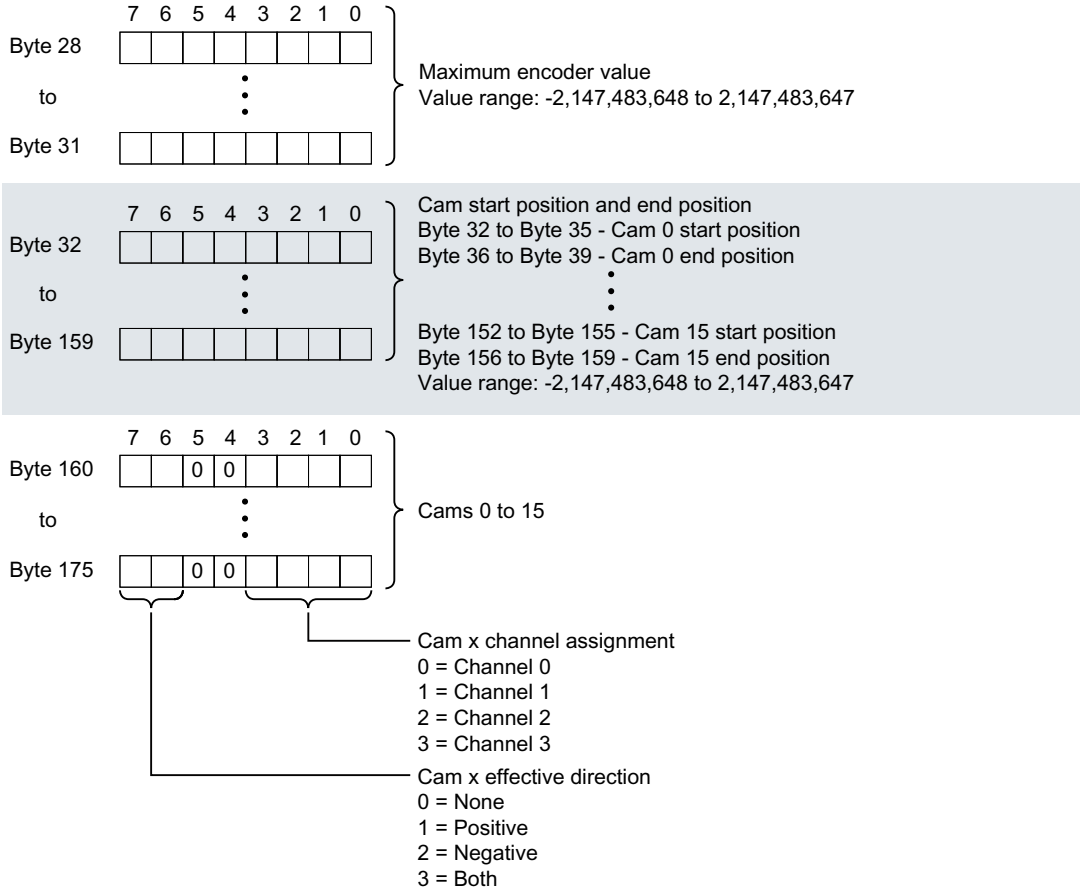

Figure 2-395 Internal block cam control (Modular CAM Controller), part 2

Channel header information

The figure below shows the structure of the channel header information.

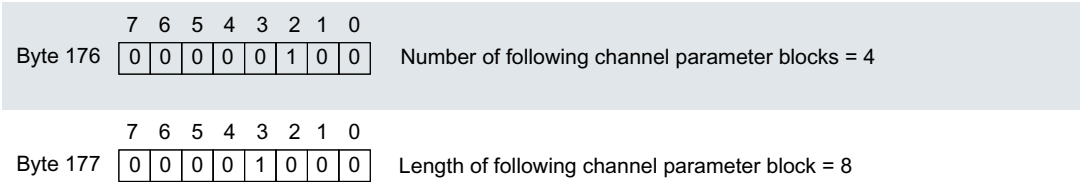

Figure 2-396 Channel header information in cam control operating mode

Channel parameter block

The figure below shows the structure of the channel parameter block.

Enable a parameter by setting the corresponding bit to "1".

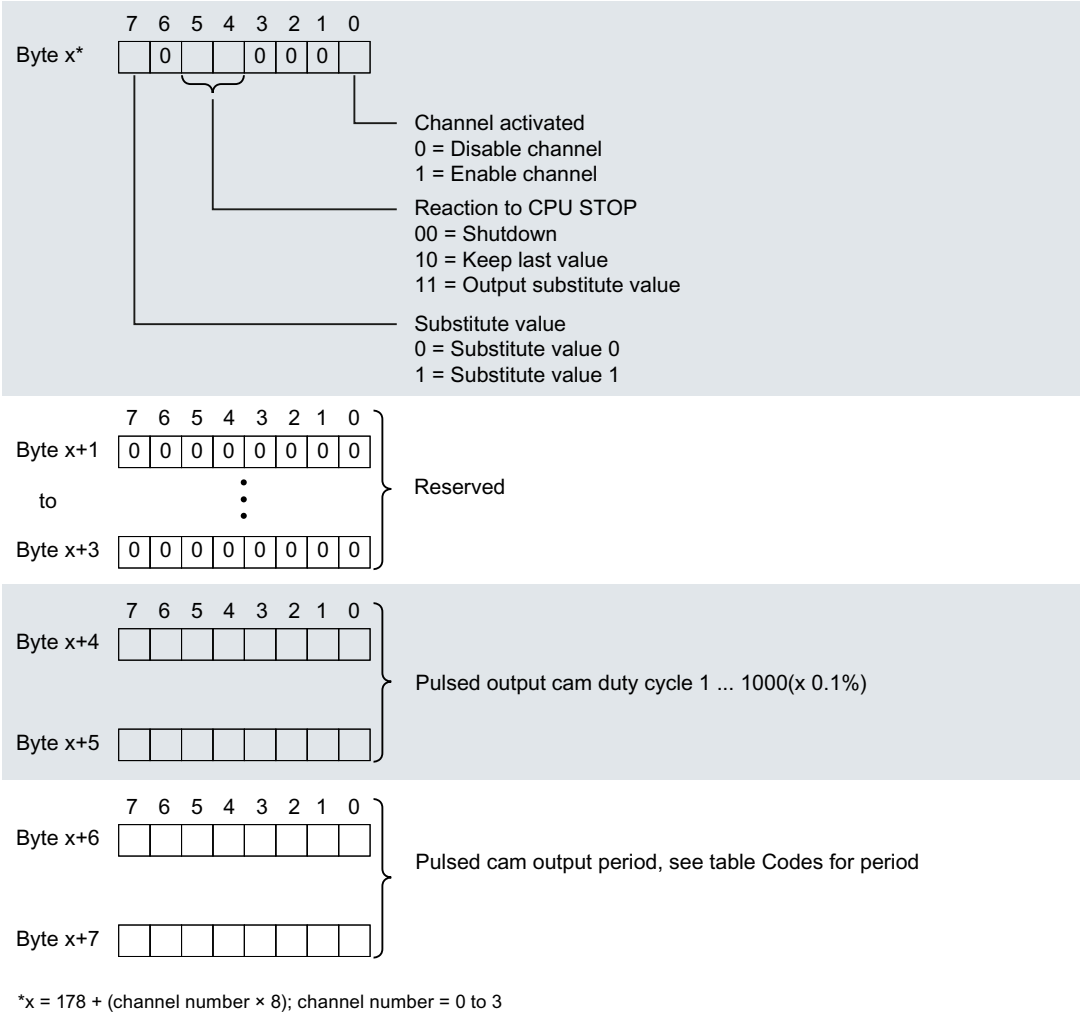

Figure 2-397 Structure of byte x to x+7 for channels 0 to 3 in cam control operating mode

Codes for pulsed cam output period

The table below contains the codes for the pulsed cam output period of the digital output module. You must enter these codes in bytes x+6 and x+7 of the channel parameter block of data record 128 (see previous figure).

Table 2-384 Codes for the period

Value	Time period	Code
0	Off	0000 0000
4	0.20 ms	0000 0100
7	0.40 ms	0000 0111
12	0.93 ms	0000 1100
14	1.33 ms	0000 1110
21	4.27 ms	0001 0101
26	10.67 ms	0001 1010
30	21.33 ms	0001 1110
33	34.13 ms	0010 0001
36	59.73 ms	0010 0100

Errors when transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module take over the values from the data record.

In case of errors, the WRREC instruction for writing data records returns corresponding error codes in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help.

The following table shows the module-specific error codes and their meaning for data record 128. The error codes are supported starting from firmware version V2.0.0.

Table 2-385 Error messages, their meaning and corrective measures

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$B0_H$	00_H	Number of the data record unknown	Enter a valid number for the data record.
DF_H	80_H	$B1_H$	01_H	Length of the data record incorrect	Enter a valid value for the data record length.
DF_H	80_H	$B2_H$	00_H	Module not accessible	• Check station. • Plug the module in correctly. • Check parameters of the WRREC block.
DF_H	80_H	$E0_H$	01_H	Incorrect version in header	Correct the version number of the parameter block, see Header information.
DF_H	80_H	$E0_H$	02_H	Error in the header, length or number of parameter blocks	Correct the length and number of parameter blocks, see Header information and Module header information in cam control operating mode.
DF_H	80_H	$E1_H$	01_H	Reserved bit set	Write 0 to all reserved bits.
DF_H	80_H	$E1_H$	02_H	Invalid diagnostics enable bit set for operating mode	Correct the diagnostics enables according to the operating mode, see Module parameter block in cam control operating mode.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$E1_H$	06_H	Code for behavior with substitute value invalid	Use valid code for reaction to CPU STOP, see Structure of byte x to x+7 for channels 0 to 3 in cam control operating mode.
DF_H	80_H	$E1_H$	21_H	Set operating mode invalid	Adapt operating mode according to the configuration, see Module parameter block in cam control operating mode.
DF_H	80_H	$E1_H$	23_H	Value for pulsed cam output duty cycle invalid	Adapt pulsed cam output duty cycle to valid value, see Structure of byte x to x+7 for channels 0 to 3 in cam control operating mode.
DF_H	80_H	$E1_H$	24_H	Code for pulsed cam output period invalid	Use valid code for pulsed cam output period, see Structure of byte x to x+7 for channels 0 to 3 in cam control operating mode.
DF_H	80_H	$E1_H$	42_H	Difference of maximum encoder value and minimum encoder value invalid	Difference of maximum encoder value and minimum encoder value invalid must not exceed 2,147,483,646.
DF_H	80_H	$E1_H$	43_H	Format of encoder value invalid	Read back data record 128 and apply the values/codes of the internal layout block unchanged.
DF_H	80_H	$E1_H$	44_H	Difference of maximum encoder value and minimum encoder value invalid	The difference of maximum encoder value and minimum encoder value must be at least 2.
DF_H	80_H	$E1_H$	45_H	Specifications in the layout of encoder data invalid	Read back data record 128 and apply the values/codes of the internal layout block unchanged.
DF_H	80_H	$E1_H$	46_H	Value of hysteresis invalid	The hysteresis setting must satisfy the following conditions: • Hysteresis < ABS ((maximum encoder value - minimum encoder value) / 4)
DF_H	80_H	$E1_H$	47_H	Value for channel assignment of a cam invalid	For the channel assignment of a cam, only values 0 to 3 may be used, see Internal block cam control (Modular CAM Controller), part 1.
DF_H	80_H	$E1_H$	48_H	Difference of cam end position and cam start position invalid	The hysteresis setting must satisfy the following conditions: • Hysteresis < Cam_i end position - Cam_i start position [i = 0 to 15] or Cam end position and cam start position must satisfy the following conditions: When modulo is deactivated: • Cam end position > Cam start position When modulo is activated: • Cam end position <> Cam start position
DF_H	80_H	$E1_H$	49_H	Overlapping of cams	The switch-on range of all cams that are assigned to a cam track must not overlap.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF_H	80_H	$E1_H$	$4A_H$	Cam start position or cam end position invalid or outside of encoder range	Cam end position and cam start position must satisfy the following conditions: When modulo is deactivated: • Minimum encoder value <= Cam start position < Cam end position <= Maximum encoder value When modulo is activated: • Minimum encoder value <= Cam start position <= Maximum encoder value • Minimum encoder value <= Cam end position <= Maximum encoder value
DF_H	80_H	$E1_H$	$4B_H$	Structure version invalid	Write 0 to structure version, see Internal block cam control (Modular CAM Controller), part 1.

SIEMENS

SIMATIC

ET 200SP
Digital output module DQ 8x24VDC/0.5A SNK BA (6ES7132-6BF61-0AA0)

Equipment Manual

Documentation guide 1

Product overview 2

Wiring 3

Parameters/address space 4

Interrupts/diagnostics alarms 5

Technical specifications 6

Parameter data record A

02/2019

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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

Technical specifications: Ambient temperature in horizontal and vertical mounting position, extended to min. -25 °C.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that can be implemented, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (http://www.siemens.com/industrialsecurity).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

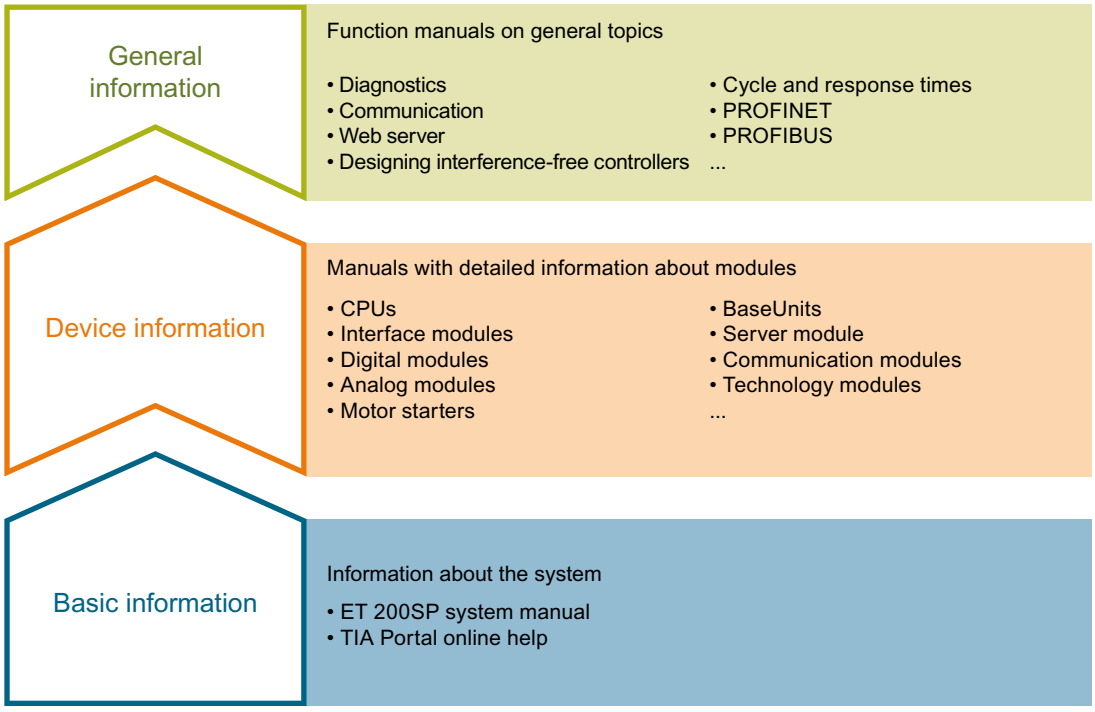

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Part number

6ES7132-6BF61-0AA0

View of the module

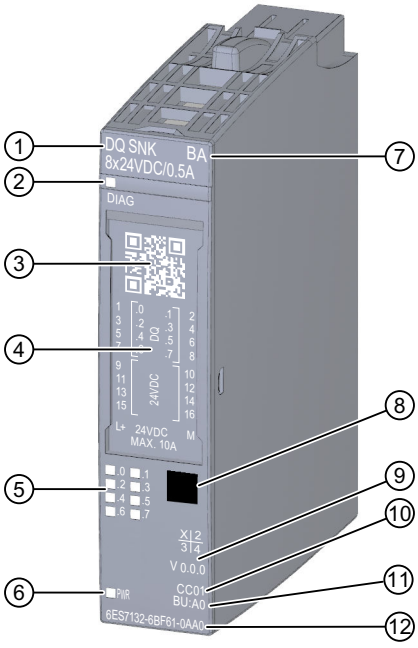

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-398 View of the DQ 8×24VDC/0,5A SNK BA module

Properties

The module has the following technical properties:

- Digital output module with 8 outputs
- Sink output (NPN, M switching)
- Supply voltage L+
- Output current 0.5 A (per channel)
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights

The module supports the following functions:

Table 2-386 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0230 V7.0	X	X
Configuration in RUN	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0230 V7.0	X	X

Accessories

The following accessories are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the DQ 8x24VDC/0.5A SNK BA module with the terminal assignments for a 1-wire and 2-wire connection.

Information about wiring of the BaseUnit is available in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

You may use and combine the different wiring options for all channels.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Connection: 1-wire and 2-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the digital input module DQ 8x24VDC/0.5A SNK BA on the BaseUnit BU type A0 without AUX terminals (1-wire and 2-wire connection).

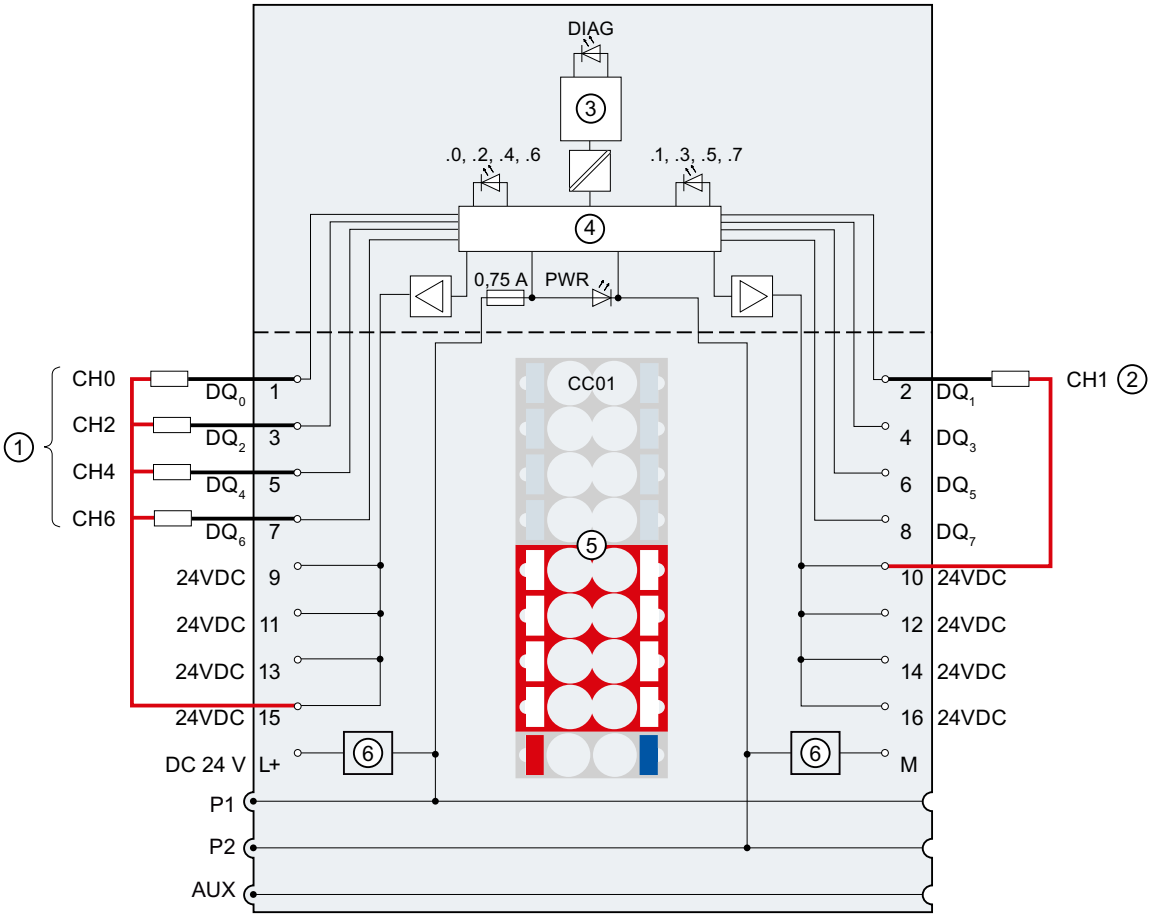

①	1-wire connection	DQ_n	Output signal, channel n
②	2-wire connection	24 V DC	Encoder supply, channel n
③	Backplane bus interface	L+	24 V DC (feed for light-colored BaseUnit only)
④	Output electronics	M	Ground
⑤	Color identification label CCxx (optional)	DIAG	Error or Diagnostics LED (green, red)
⑥	Filter connection supply voltage (only when light-colored BaseUnit is present)	.0 to .7	Channel status LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	PWR	Power LED (green)

Figure 2-399 Wiring and block diagram for 1-wire and 2-wire connection of actuators.

Parameters/address space

4

4.1 Parameters

DQ 8x24VDC/0,5A SNK BA parameters

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records (see chapter Parameter assignment and structure of the parameter data record (Page 22)).

Table 2-387 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 4 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

4.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Channel activated

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of DQ 8x24VDC 0.5A SNK BA

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module using a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-388 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in hard-ware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	DQ 8x24VDC/0,5A SNK BA V0.0	V14, SP1 or higher with HSP 0222	X	X

Address space of the digital output module DQ 8x24VDC/0,5A SNK BA

The figure below shows the assignment of the address space for DQ 8x24VDC/0,5A SNK BA

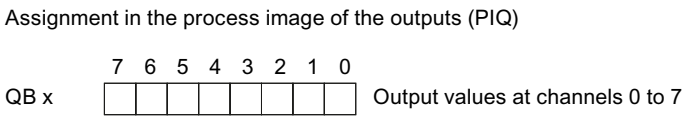

Figure 2-400 Address space of the digital output module DQ 8x24VDC/0,5A SNK BA

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the DQ 8x24VDC/0,5A SNK BA.

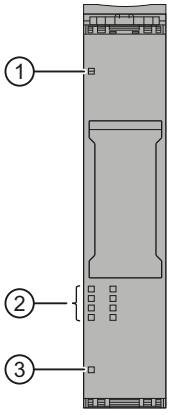

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-401 LED displays

Meaning of the LED displays

The tables below explain the meaning of the Status and error displays. Remedial measures for diagnostics alarms can be found in section Diagnostics alarms (Page 17).

LED DIAG

Table 2-389 Error display of the LED DIAG

LED DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned
Flashes	Module diagnostics is available

LED channel status

Table 2-390 Status display of the LED channel status

LED channel status	Meaning
□ Off	Channel deactivated or activated and process signal = 0
■ On	Channel activated and process signal = 1

LED PWR

Table 2-391 Status display of the LED PWR

LED PWR	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

5.2 Interrupts

The DQ 8×24VDC/0,5A SNK BA digital output module supports diagnostics alarms.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following event:

- Parameter assignment error
- No supply voltage

Detailed information on the event is available in the STEP 7 online help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostic alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-392 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Remedy
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications

6

6.1 Technical specifications

Technical specifications of DQ 8x24VDC/0,5A SNK BA

The following table shows the technical specifications as of 02/2019. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7132-6BF61-0AA0/td?dl=en).

Article number	6ES7132-6BF61-0AA0
General information	
Product type designation	DQ 8x24VDC/0,5A SNK BA
HW functional status	From FS02
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC01
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V14
• STEP 7 configurable/integrated as of version	V5.5 SP3
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DQ	Yes
• DQ with energy-saving function	No
• PWM	No
• Oversampling	No
• MSO	No
Redundancy	
• Redundancy capability	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V

Article number	6ES7132-6BF61-0AA0
Output voltage	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
• Outputs	1 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Digital outputs	
Type of digital output	Sink output (NPN)
Number of digital outputs	8
Current-sinking	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes
• Response threshold, typ.	1.5 A
Limitation of inductive shutdown voltage to	Typ. 47 V
Controlling a digital input	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A
• on lamp load, max.	5 W
Load resistance range	
• lower limit	48 Ω
• upper limit	3 400 Ω
Output current	
• for signal "1" rated value	0.5 A
• for signal "1" permissible range, max.	0.5 A
• for signal "0" residual current, max.	5 µA
Output delay with resistive load	
• "0" to "1", max.	300 µs
• "1" to "0", max.	600 µs
Parallel switching of two outputs	
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	100 Hz
• with inductive load, max.	0.5 Hz
• on lamp load, max.	10 Hz

Article number	6ES7132-6BF61-0AA0
Total current of the outputs	
• Current per channel, max.	0.5 A
• Current per module, max.	4 A
Total current of the outputs (per module)	
horizontal installation	
– up to 60 °C, max.	4 A
vertical installation	
– up to 50 °C, max.	4 A
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	No
• Short-circuit	No
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No

Article number	6ES7132-6BF61-0AA0
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-25 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-25 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

Dimensional drawing

See the manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You have the option to re-configure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics for the entire module.

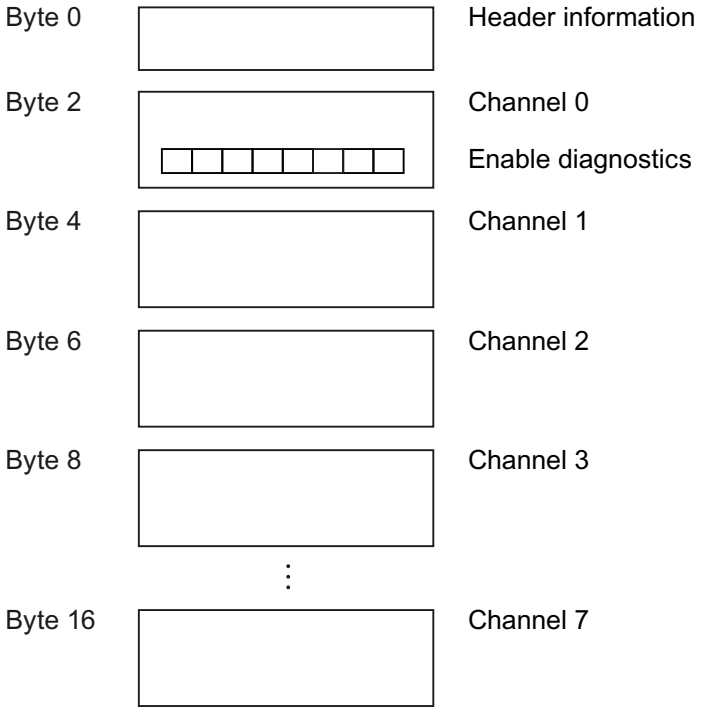

Figure 2-402 Structure of data record 128

Header information

The figure below shows the structure of the header information.

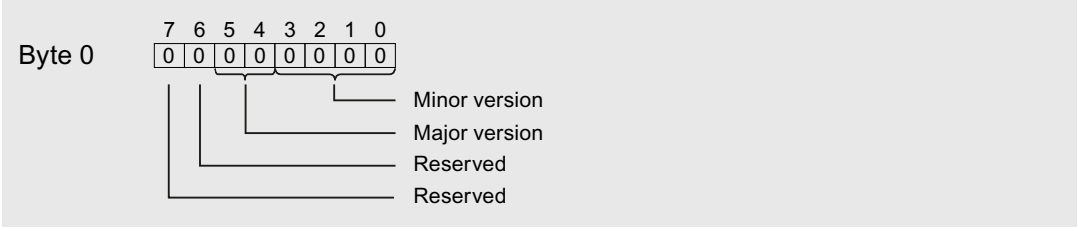

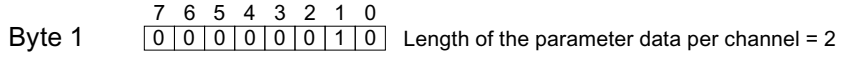

Figure 2-403 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

Enable a parameter by setting the corresponding bit to "1".

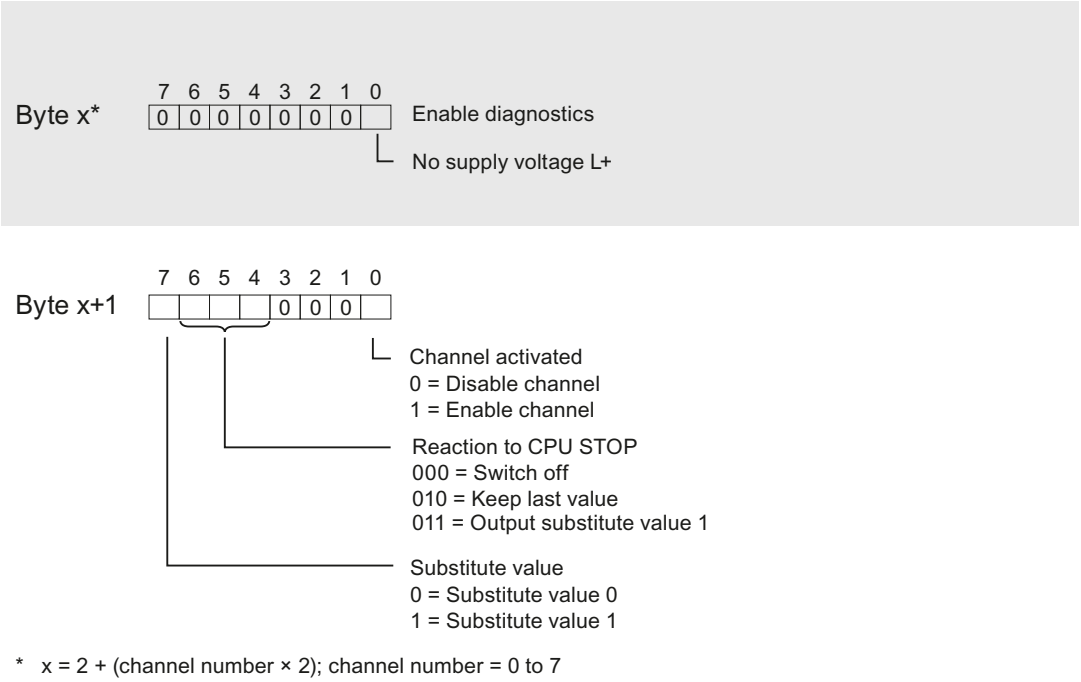

* x = 2 + (channel number × 2); channel number = 0 to 7

Figure 2-404 Structure byte x to x+1 for the channels 0 to 7

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter. (See also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	06	Invalid coding for substitute value behavior.	Check the parameters of the module.

SIEMENS

SIMATIC

ET 200SP DQ 16x24VDC/0.5A BA digital output module (6ES7132-6BH00-0AA0)

Equipment Manual

Documentation guide 1

Product overview 2

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Parameters/address space 4

Interrupts/diagnostic alarms 5

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Parameter data record A

02/2018

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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For ecologically sustainable recycling and disposal of your old device, contact a certified disposal service for electronic scrap and dispose of the device in accordance with the regulations in your country.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (https://www.siemens.com/industrialsecurity).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

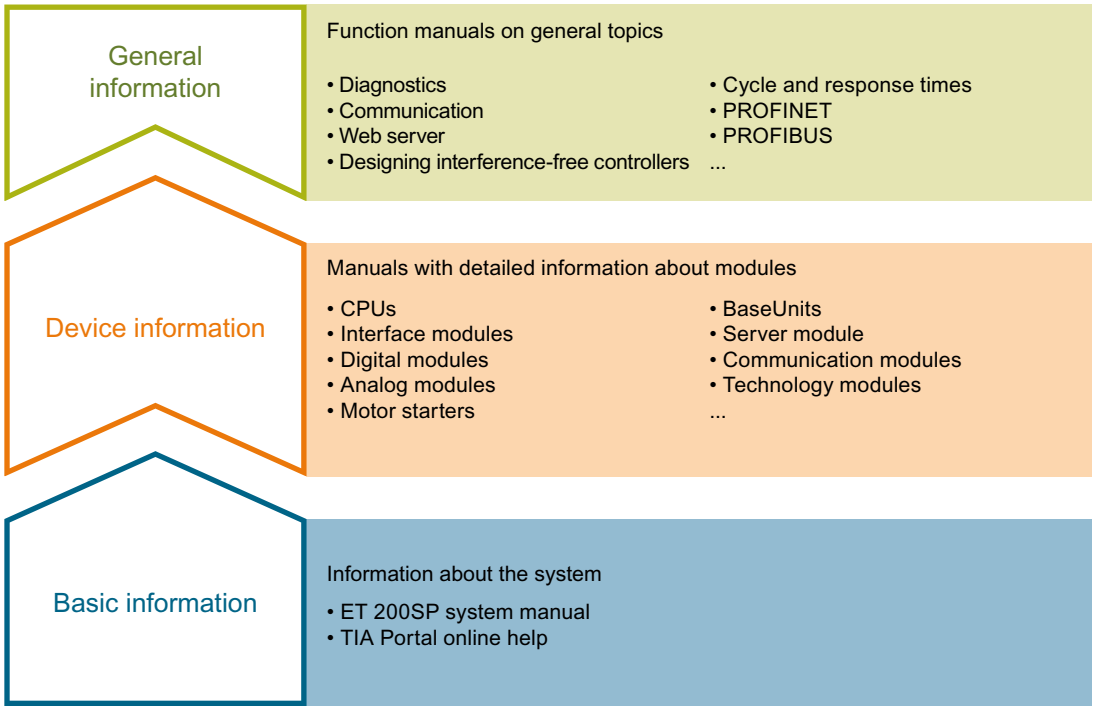

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7132-6BH00-0AA0

View of the module

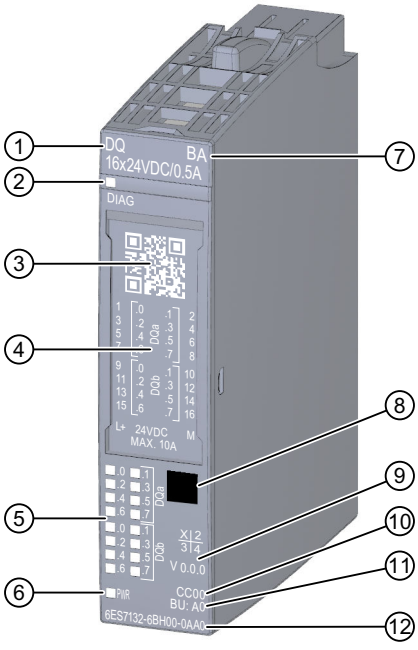

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-405 View of the module DQ 16×24VDC/0.5A BA

Properties

The module has the following technical properties:

- Digital output module with 16 outputs
- Supply voltage L+
- Output current 0.5 A (per channel), total current max. 8 A
- Source output (PNP, P-switching)
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights

The module supports the following functions:

Table 2-393 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V14 or higher with HSP 0240	V5.5 SP3 or higher with HSP 0230 V8.0 or higher	X	X
Configuration in RUN	FS01	V0.0.0 and higher	V14 or higher with HSP 0240	V5.5 SP3 or higher with HSP 0230 V8.0 or higher	X	X

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the system manualET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Connecting

3

3.1 Wiring and block diagram

This section includes the block diagram of the DQ 16×24VDC/0.5A BA module with the terminal assignments for a 1-wire and 2-wire connection.

You can find information on wiring the BaseUnit as well as information on wiring your system with potential distribution modules in the system manual Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293).

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

NOTE

The fuse integrated in BaseUnit type A1 may be triggered in the digital output module, rendering the terminals unusable.
Make sure that you only use digital output modules with BaseUnit type A0 during commissioning.

Wiring: 1-wire connection of actuators

The following figure shows the block diagram and an example for the terminal assignment of the digital output module DQ 16×24VDC/0.5A BA on the BaseUnit BU type A0 (1-wire connection).

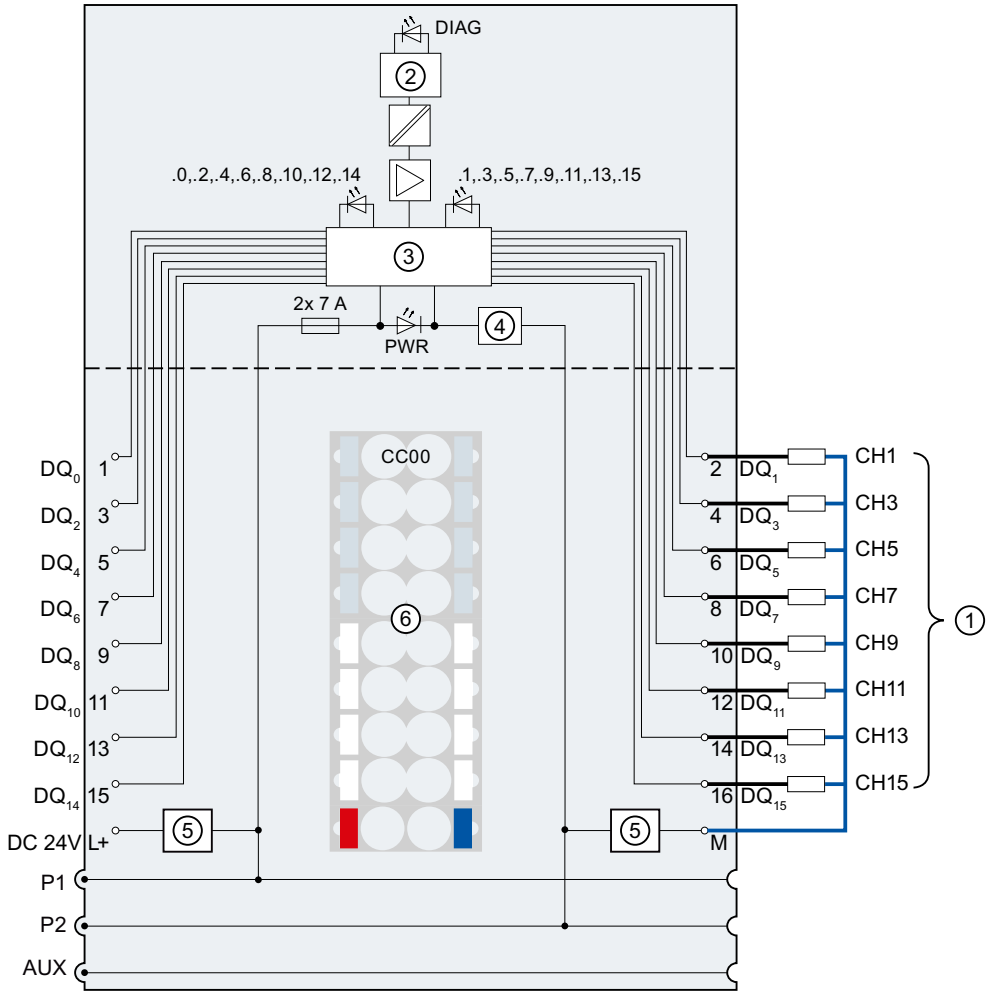

①	1-wire connection	DQ_n	Output signal, channel n
②	Backplane bus interface	24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)
③	Output electronics	M	Ground
④	Polarity reversal protection	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Supply voltage filter circuit (only available with light BaseUnit)	DIAG	Diagnostics LED (green, red)
⑥	Color-coded label with color code CC00 (optional)	.0 to .15	Channel status LED (green)
		PWR	Power LED (green)

Figure 2-406 Wiring and block diagram for 1-wire connection of actuators

Example: 2-wire connection of actuators with potential distribution module

The following figure shows an example for the terminal assignment of the digital output module DQ 16×24VDC/0.5A BA on the BaseUnit BU type A0 (2-wire connection) in combination with a potential distribution module.

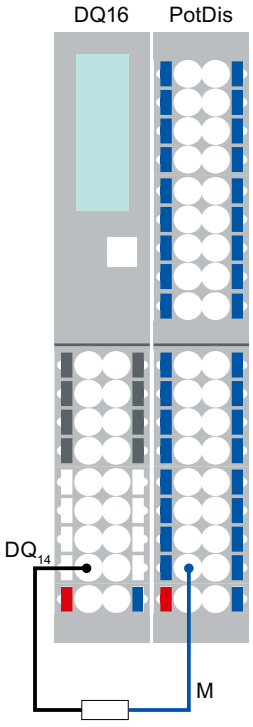

Figure 2-407 Example: 2-wire connection of actuators with potential distribution module

Parameters/address space 4

4.1 Parameters

Parameters for DQ 16x24VDC/0.5A BA

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of parameter data record (Page 24).

The following parameter settings are possible:

Table 2-394 Configurable parameters and their defaults (GSD file)

Parameters	Range of values	Default	Parameter reassign-ment in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 6 bytes.

4.2 Declaration of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Channel activated

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of DQ 16x24VDC/0.5A BA

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-395 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)		
		Integrated in hardware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 16-channel without value status	DQ 16x24VDC/0.5A BA V0.0	V14 or higher with HSP 0230	X	X

Address space

The figure below shows the assignment of the address space for DQ 16x24VDC/0.5A BA.

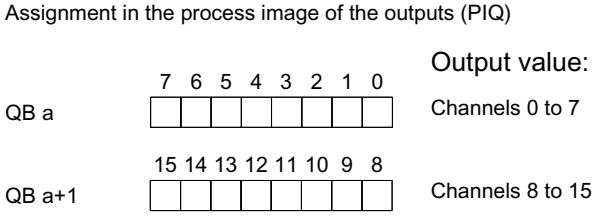

Figure 2-408 Address space DQ 16×24VDC/0.5A BA

Interrupts/diagnostic alarms

5

5.1 Status and error display

LED display

DQ 16x24VDC/0.5A BA

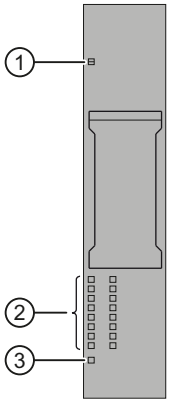

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-409 LED display

Meaning of the LEDs

The following tables contain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in chapter Diagnostic messages (Page 19).

DIAG LED

Table 2-396 DIAG LED fault display

DIAG LED	Meaning
□ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashing	Module not configured
■ On	Module parameters assigned
☼ Flashing	Module diagnostics is available

LED channel status

Table 2-397 LED channel status display

LED channel status	Meaning
□ Off	Channel deactivated or activated and process signal = 0
■ On	Channel activated and process signal = 1

PWR LED

Table 2-398 Status display of the PWR LED

PWR LED	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ present

5.2 Interrupts

The DQ 16×24VDC/0.5A BA digital output module supports diagnostic interrupts.

Diagnostic interrupts

The module generates a diagnostic interrupt at the following events:

- Parameter assignment error
- Supply voltage missing

5.3 Diagnostic messages

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-399 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	• Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications

6

Technical specifications of the DQ 16×24VDC/0.5A BA

Article number	6ES7132-6BH00-0AA0
General information	
Product type designation	DQ 16x 24 V DC/0.5 A BA, PU 1
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V14
• STEP 7 configurable/integrated as of version	STEP 7 V5.5 or higher
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DQ	Yes
• DQ with energy-saving function	No
• PWM	No
• Oversampling	No
• MSO	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	55 mA; without load
Output voltage	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1 W

Article number	6ES7132-6BH00-0AA0
Address area	
Address space per module	
• Outputs	2 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0 + Potential isolation module
• 3-wire connection	BU type A0 + Potential isolation module
• 4-wire connection	BU type A0 + Potential isolation module
Digital outputs	
Type of digital output	Source output (PNP, current-sourcing)
Number of digital outputs	16
Current-sinking	No
Current-sourcing	Yes
Short-circuit protection	Yes
• Response threshold, typ.	1.4 A; 0.7 to 1.9 A
Open-circuit detection	No
Limitation of inductive shutdown voltage to	Typ. L+ (-53 V)
Controlling a digital input	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A
• on lamp load, max.	5 W
Load resistance range	
• lower limit	48 Ω
• upper limit	100 kΩ
Output current	
• for signal "1" rated value	0.5 A
• for signal "0" residual current, max.	30 µA
Output delay with resistive load	
• "0" to "1", typ.	80 µs; at rated load
• "0" to "1", max.	150 µs; at rated load
• "1" to "0", typ.	100 µs; at rated load
• "1" to "0", max.	200 µs; at rated load
Parallel switching of two outputs	
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	100 Hz

Article number	6ES7132-6BH00-0AA0
• with inductive load, max.	2 Hz
• on lamp load, max.	10 Hz
Total current of the outputs	
• Current per channel, max.	0.5 A
• Current per module, max.	8 A
Total current of the outputs (per module)	
horizontal installation	
– up to 60 °C, max.	8 A
vertical installation	
– up to 50 °C, max.	8 A
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	No
• Short-circuit	No
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
Isolation	
Isolation tested with	707 V DC (type test)

Article number	6ES7132-6BH00-0AA0
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Ambient air temperature-barometric pressure-altitude	On request: Ambient temperatures lower than 0 °C (without condensation) and/or installation altitudes greater than 2 000 m
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You have the option to reconfigure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

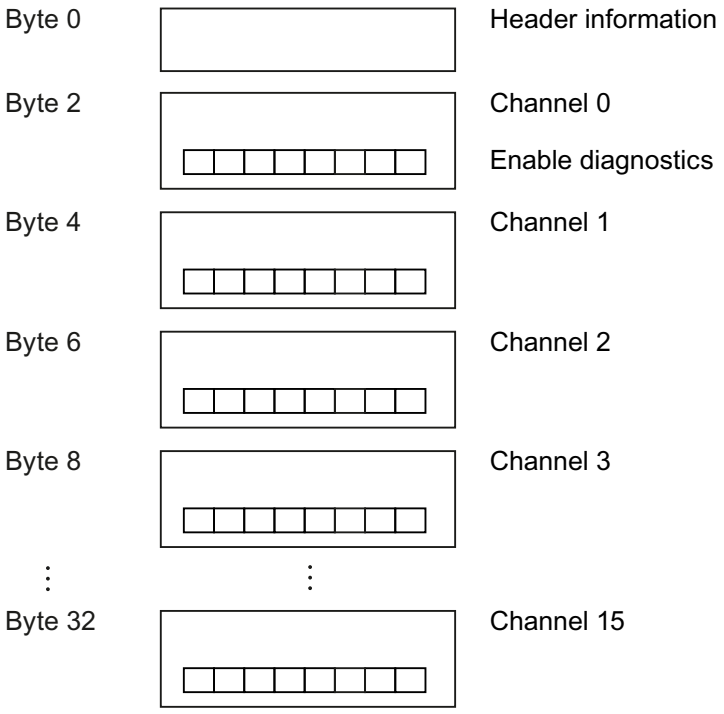

Figure 2-410 Structure of data record 128

Header information

The figure below shows the structure of the header information.

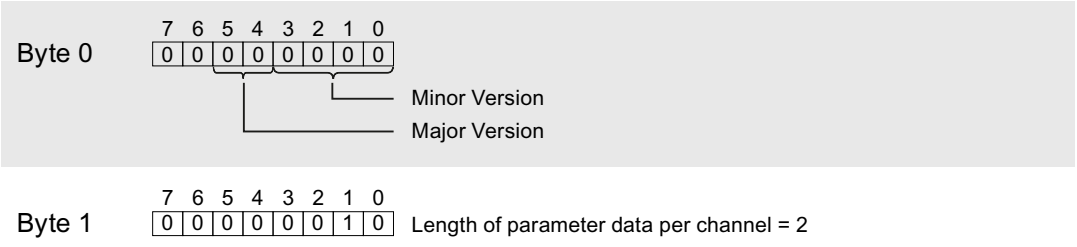

Figure 2-411 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 15.

You enable a parameter by setting the corresponding bit to "1".

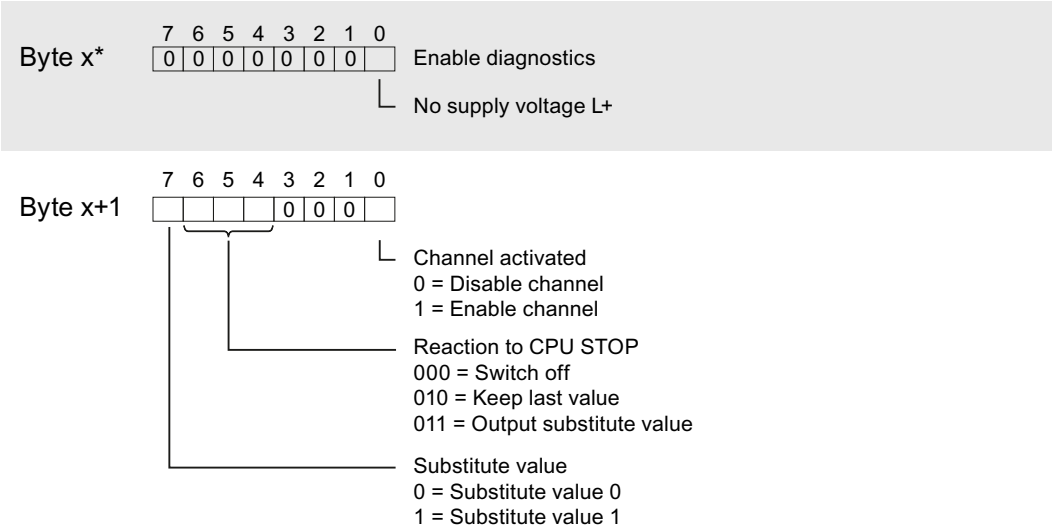

* x = 2 + (channel number × 2); channel number = 0 to 15

Figure 2-412 Structure byte x to x+1 for the channels 0 to 15

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter. (See also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E0	06	Invalid coding for substitute value behavior.	Check the parameters of the module.

SIEMENS

SIMATIC

ET 200SP
Digital output module DQ 16x24VDC/0.5A ST (6ES7132-6BH01-0BA0)

Equipment Manual

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Connecting 4

Parameters/address space 5

Interrupts/diagnostic alarms 6

Technical specifications 7

Parameter data record A

01/2025
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Introduction

1

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and waste disposal

For environmentally sustainable recycling and waste disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

3

3.1 Properties

Article number

6ES7132-6BH01-0BA0 (number in package unit: 1 unit)

6ES7132-6BH01-2BA0 (number in package unit: 10 units)

View of the module

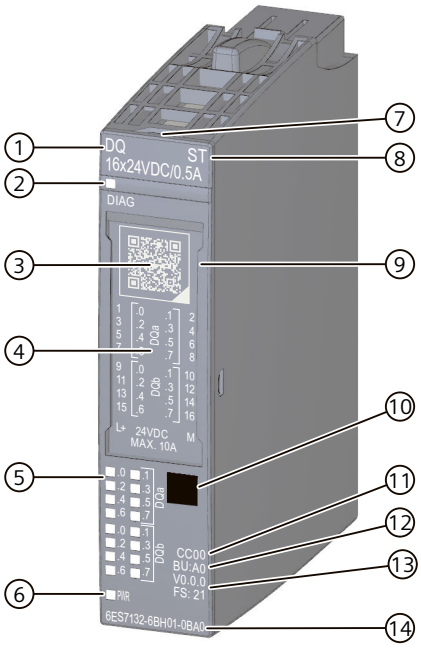

①	Module type and name	⑧	Function class
②	LED for diagnostics	⑨	Insertion option for optional labeling strip
③	QR code for identification link	⑩	Color coding module type
④	Wiring diagram	⑪	Color code for selecting the color-coded labels
⑤	LEDs for channel status	⑫	BU type
⑥	LED for supply voltage	⑬	Firmware and functional version
⑦	Slot for optional equipment labeling plate	⑭	Article number

Figure 2-413 View of the module DQ 16×24VDC/0.5A ST

Properties

The module has the following technical properties:

- Digital output module with 16 outputs
- Source output (PNP, P-switching)
- Supply voltage L+
- Output current 0.5 A (per channel)
- Total current max. 8 A
  (see derating: Technical specifications (Page 26))
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Extended spare parts compatibility (see product information (https://support.industry.siemens.com/cs/ww/en/view/73021864))

The module supports the following functions:

Table 2-400 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0230 V7.0	X	X
Reparameterizing in RUN	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0230 V7.0	X	X
PROFIenergy	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0230 V7.0	X	-
Value status	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0230 V7.0	X	X

Accessories

The following accessories are available optionally:

- Labeling strips
- Color-coded labels
- Reference identification label
- Shield connection

See also

You can find more information on accessories in the ET 200SP Distributed I/O System (https://support.automation.siemens.com/WW/view/en/58649293) System Manual.

Connecting

4

4.1 Wiring diagram

This section contains the pin assignment for the module.

You can find information on wiring the BaseUnit in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) System Manual.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Also keep this in mind during configuration.

NOTICE

You may only use the digital output module with a type A0 BaseUnit.

With the type A1 BaseUnit, the integrated fuse can be triggered, rendering the terminals unusable.

NOTE

Cross-circuit at output

Note that a voltage applied at the output due to a cross-circuit can lead to the modules being supplied with L+.

Pin assignment: 1-wire connection of actuators

The following table shows an example of the pin assignment of the digital output module DQ 16x24VDC/0.5A ST on the BaseUnit BU type A0 without AUX terminals:

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Digital output, channel 0	DQ_0	1	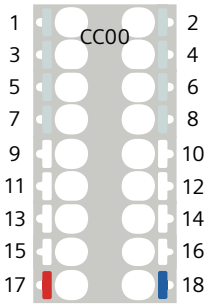	2	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	3		4	DQ_3	Digital output, channel 3
Digital output, channel 4	DQ_4	5		6	DQ_5	Digital output, channel 5
Digital output, channel 6	DQ_6	7		8	DQ_7	Digital output, channel 7
Digital output, channel 8	DQ_8	9		10	DQ_9	Digital output, channel 9
Digital output, channel 10	DQ_{10}	11		12	DQ_{11}	Digital output, channel 11
Digital output, channel 12	DQ_{12}	13		14	DQ_{13}	Digital output, channel 13
Digital output, channel 14	DQ_{14}	15		16	DQ_{15}	Digital output, channel 15
24 V DC supply voltage	L+	17		18	M	Ground

Pin assignment: 2-wire connection of actuators

The following table shows an example of the pin assignment of the digital output module DQ 16x24VDC/0.5A ST on the BaseUnit BU type A0 with AUX terminals:

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Digital output, channel 0	DQ_0	1	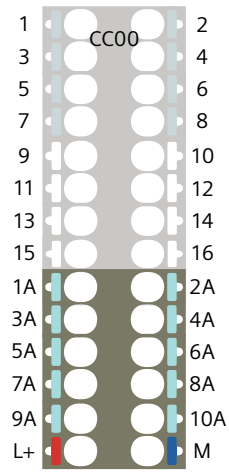	2	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	3		4	DQ_3	Digital output, channel 3
Digital output, channel 4	DQ_4	5		6	DQ_5	Digital output, channel 5
Digital output, channel 6	DQ_6	7		8	DQ_7	Digital output, channel 7
Digital output, channel 8	DQ_8	9		10	DQ_9	Digital output, channel 9
Digital output, channel 10	DQ_{10}	11		12	DQ_{11}	Digital output, channel 11
Digital output, channel 12	DQ_{12}	13		14	DQ_{13}	Digital output, channel 13
Digital output, channel 14	DQ_{14}	15		16	DQ_{15}	Digital output, channel 15
AUX terminal	AUX	1A		2A	AUX	AUX terminal
AUX terminal	AUX	3A		4A	AUX	AUX terminal
AUX terminal	AUX	5A		6A	AUX	AUX terminal
AUX terminal	AUX	7A		8A	AUX	AUX terminal
AUX terminal	AUX	9A		10A	AUX	AUX terminal
24 V DC supply voltage[1)]	L+	L+		M	M	Ground

[1)] Infeed only with light BaseUnit

Output connection types

1-wire connection for channel n	2-wire connection for channel n	3-wire connection for channel n
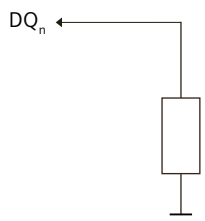	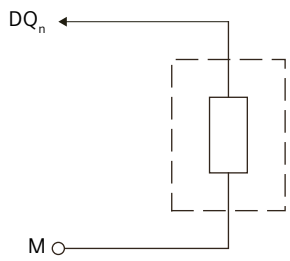	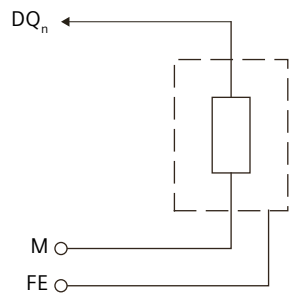

You can also connect the ground and functional grounding via a potential distribution module (PotDis module) or AUX terminals. More information on potential distribution modules is available in the BaseUnits Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/59753521).

NOTE

You can use and combine the different connection options for all channels.

4.2 Block diagram

This section contains the schematic circuit diagram of the module.

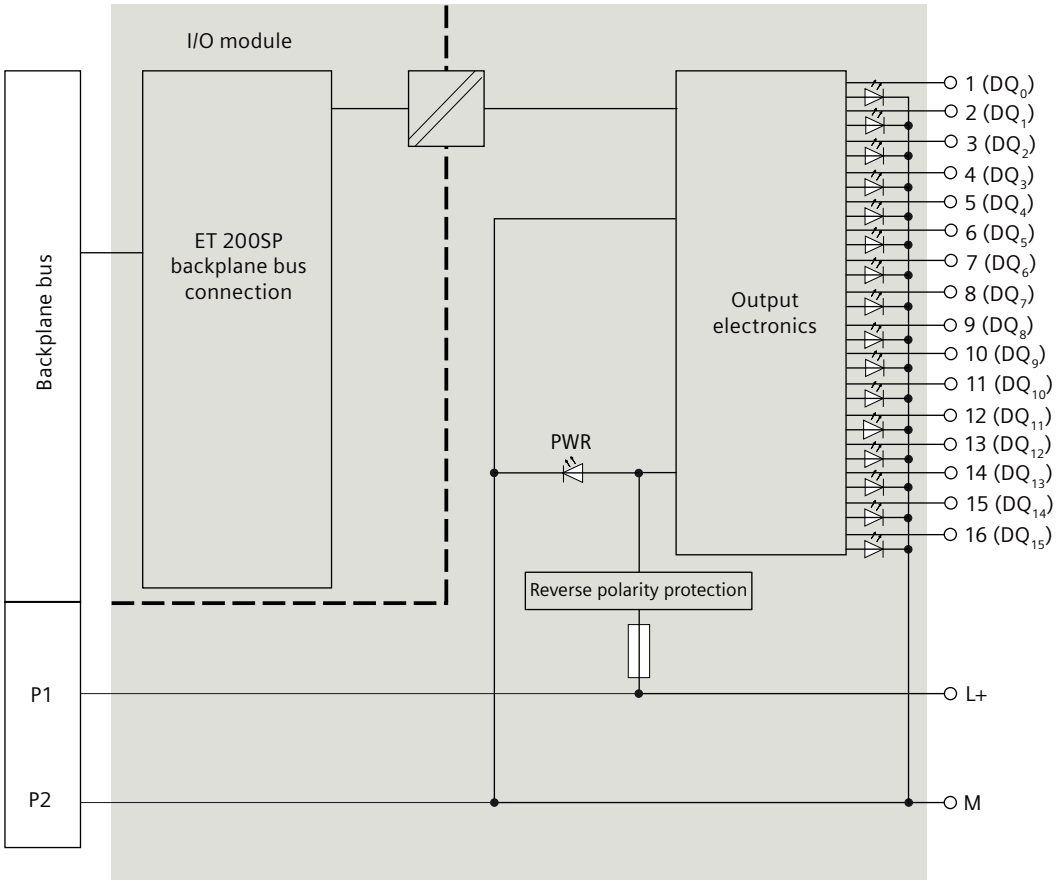

Figure 2-414 Schematic circuit diagram

Parameters/address space 5

5.1 Parameters

Parameters for DQ 16x24VDC/0.5A ST

You can specify the module properties with various parameters in the course of your STEP 7 configuration. The table below lists the configurable parameters. The efficiency range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP-CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition to parameter assignment via the configuration software, you can also configure parameters in RUN mode (dynamically) via the user program. When assigning the parameters in the user program, the "WRREC" instruction transfers the parameters to the module using data records; see section Parameter assignment and structure of parameter data record (Page 32).

The following parameter settings are possible:

Table 2-401 Configurable parameters and their defaults (GSD file)

Parameters	Range of values	Default	Parameter reassignment in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Short circuit to ground	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Short circuit to L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter setting options are restricted. The parameter length of the I/O module is 6 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

Parameters	Range of values	Default	Parameter reassignment in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Potential group	• Use the potential group of the left module (module plugged into a dark BaseUnit) • Enable new potential group (module plugged into a light BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter setting options are restricted. The parameter length of the I/O module is 6 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

NOTE

- If both parameters "Diagnostics: Short circuit to L+" and "Diagnostics: Wire break" are enabled and one of these diagnostic events occurs, the affected channel is switched off. This prevents undefined load switching and the corresponding diagnostics alarm is triggered.
- If the parameter "Diagnostics: Wire break" is enabled and the parameter "Diagnostics: Short circuit to L+" is disabled and a "Diagnostics: wire break" is pending, the affected channel is switched off. This prevents undefined load switching and the corresponding diagnostics alarm is triggered.
- If the parameter "Diagnostics: Short circuit to L+" is enabled and "Diagnostics: Wire break" is disabled, the signal status is retained at the affected channel when "Diagnostics: Short circuit to L+" occurs. A diagnostics alarm is triggered only for 0 signal.

5.2 Declaration of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short circuit to ground

Enabling of the diagnostics if a short circuit of the actuator supply to ground occurs.

Diagnostics: Short circuit to L+

Enabling of the diagnostics if a short circuit of the actuator supply to L+ occurs.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Channel activated

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2, and AUX to the left neighbor.

Specify on which slot a light-colored BaseUnit with supply voltage feed or a dark BaseUnit is located (see ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual).

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

The station configuration must be completed with a server module.

5.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of DQ 16x24VDC/0.5A ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-402 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the STEP 7 hardware catalog, as of V14 with HSP 0222	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 16-channel without value status	DQ 16x24VDC/0.5A ST V0.0	X	X	X
1 x 16-channel with value status	DQ 16x24VDC/0.5A ST V0.0, QI	X	X	X

Value status (quality information, QI)

The value status is always activated for the following configurations:

- DQ 16x24VDC/0.5A ST V0.0, QI

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

You can find more information on evaluating the value status in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Address space for configuration as 1 x 16-channel DQ 16x24VDC/0.5A ST V0.0

The figure below shows the address space assignment for configuration as a 1 x 16-channel module without value status. You can freely assign the start address for the module. "QB" stands for output byte.

Assignment in the process image output (PIQ)

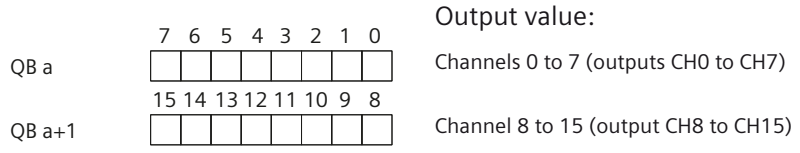

Figure 2-415 Address space for configuration as 16-channel DQ 16x24VDC/0.5A ST V0.0

Address space for configuration as 1 x 16-channel DQ 16x24VDC/0.5A ST V0.0, QI

The figure below shows the address space assignment for configuration as a 1 x 16-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address. "IB" stands for input byte. "QB" stands for output byte.

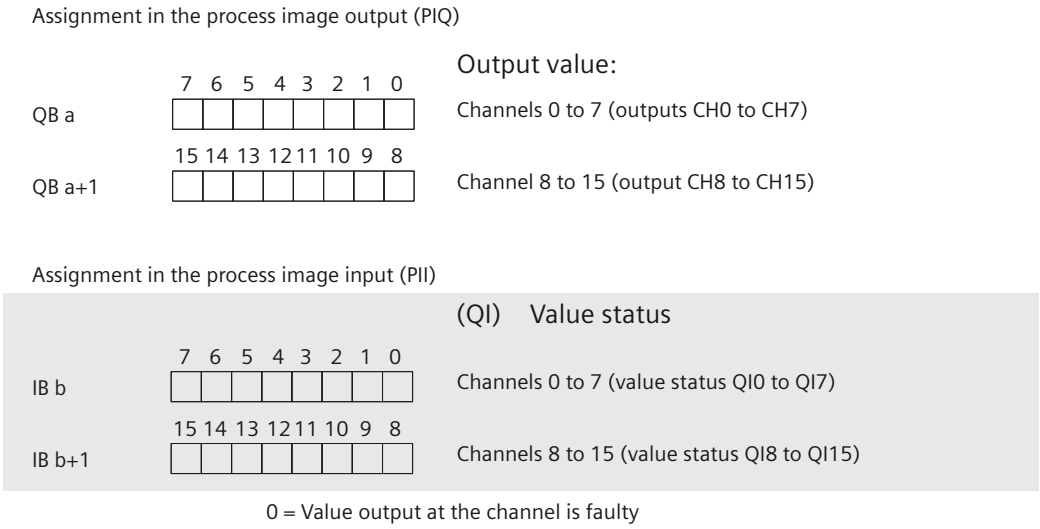

Figure 2-416 Address space for configuration as 16-channel DQ 16x24VDC/0.5A ST V0.0, QI

Interrupts/diagnostic alarms

6

6.1 Status and error display

LED display

The figure below shows the LED displays (status and error displays) of the module:

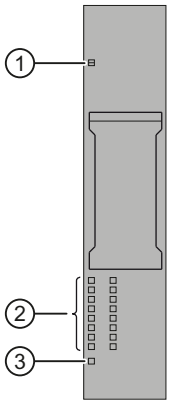

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-417 LED display

Meaning of the LEDs

The meaning of the status and error messages is described in the following tables. You will find remedial measures for diagnostics alarms in the Diagnostic messages (Page 24) section.

DIAG LED

Table 2-403 DIAG LED fault display

DIAG LED	Meaning
□ Off	Backplane bus supply of the system is interrupted or switched off.
☼ Flashes	Module not configured
■ On	Module parameters assigned and no module diagnostics available
☼ Flashes	Module parameters assigned and module diagnostics available

LED channel status

Table 2-404 LED channel status display

LED channel status	Meaning
□ Off	Channel deactivated or channel activated and process signal = 0
■ On	Channel activated and process signal = 1

PWR LED

Table 2-405 Status display of the PWR LED

PWR LED	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ present

6.2 Interrupts

The digital output module DQ 16×24VDC/0.5A ST supports diagnostic interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt for the following events:

- Short circuit
- Wire break
- Parameter assignment error
- Supply voltage missing

You can find detailed information on events in the STEP 7 online help.

6.3 Diagnostic messages

A diagnostic message is generated and the DIAG-LED flashes red on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

NOTE

Wiring two outputs in parallel

When connecting two outputs in parallel for redundant control of a load, the channel diagnostics "Short circuit to L+" and "Wire break" must be disabled, otherwise faulty diagnostics alarms may occur.

Table 2-406 Diagnostics alarms, their meaning, and remedial measures

Diagnostics alarm	Error code	Meaning	Solution
Short circuit	1_H	• Short circuit of actuator supply to ground [1] • Short circuit of actuator supply to L+ [2]	Correct the process wiring
Wire break	6_H	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, e.g. use cables with larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor to the actuator contacts in the load resistance range
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel • Incorrect parameter assignment	Correct the parameter assignment
Supply voltage missing	11_H	No or insufficient supply voltage L+	• Check the supply voltage L+ at the BaseUnit • Check BaseUnit type

[1] Only in switched state (output value 1)

[2] Only in non-switched state (output value 0)

NOTE

In case of a short circuit of the actuator supply to L+ at the activated channel, load distributions can occur which result in broken wire diagnostics.

Technical specifications 7

7.1 Technical specifications

Technical specifications of the DQ 16x24VDC/0.5A ST

The following table lists the technical specifications on the issue date. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7132-6BH01-0BA0/td?dl=en).

Article number	6ES7132-6BH01-0BA0
General information	
Product type designation	DQ 16x24VDC/0.5 ST
HW functional status	from FS21
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 TIA V14 with HSP0222 / integrated as of TIA V15
• STEP 7 configurable/integrated from version	V5.5 SP3 with HSP0230 V7.0 / integrated as of V5.6 SP1
• PCS 7 configurable/integrated from version	V8.1 SP1
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.3
Operating mode	
• DQ	Yes
• DQ with energy-saving function	No
• PWM	No
• Oversampling	No
• MSO	No

Article number	6ES7132-6BH01-0BA0
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	30 mA; without load
output voltage / header	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1 W
Address area	
Address space per module	
• Address space per module, max.	2 byte; + 2 bytes for QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0 with AUX terminals or potential distributor module
• 3-wire connection	BU type A0 with AUX terminals or potential distributor module
Digital outputs	
Type of digital output	Source output (PNP, current-sourcing)
Number of digital outputs	16
Current-sinking	No
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
output characteristic acc. to IEC 61131, type 0.5	Yes
Short-circuit protection	Yes; Electronic
• Response threshold, typ.	1 A; 0.7 to 1.3 A
Open-circuit detection	Yes
Limitation of inductive shutdown voltage to	Typ. L+ (-50 V)
Controlling a digital input	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A
• with inductive load, max.	0.5 A
• on lamp load, max.	5 W

Article number	6ES7132-6BH01-0BA0
Load resistance range	
• lower limit	48 Ω
• upper limit	12 kΩ
Output current	
• for signal "1" rated value	0.5 A
• for signal "1" permissible range, max.	0.5 A
• for signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
• "0" to "1", typ.	50 µs
• "1" to "0", typ.	100 µs
Parallel switching of two outputs	
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	100 Hz
• with inductive load, max.	0.1 Hz; higher frequencies are possible, see Equipment Manual "Maximum permitted switching frequency of inductive loads"
• on lamp load, max.	10 Hz
Total current of the outputs	
• Current per channel, max.	0.5 A
• Current per module, max.	8 A; see Equipment Manual "Derating curve"
Total current of the outputs (per module)	
horizontal installation	
– up to 40 °C, max.	8 A
– up to 50 °C, max.	6 A
– up to 60 °C, max.	4 A
vertical installation	
– up to 30 °C, max.	8 A
– up to 40 °C, max.	6 A
– up to 50 °C, max.	4 A
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes

Article number	6ES7132-6BH01-0BA0
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; Module-wise
• Short-circuit to M	Yes; Module-wise
• Short-circuit to L+	Yes; Module-wise
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• Between the channels and load voltage L+	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Suitable for safety-related tripping of standard modules	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; < 0 °C as of FS03
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; < 0 °C as of FS03
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

Residual current for signal state "0"

NOTE

Residual current for signal state "0"

Due to the "Diagnostics: Wire break" function, there is a low level of residual current in the "0" signal state at the output, which may cause the display diodes to flicker.

This residual current does not depend on the setting for the "Diagnostics: Wire break" parameter.

Derating trend

The figure below shows the load current derating with horizontal and vertical mounting positions. You use this diagram to determine the maximum total current of the module as a function of ambient temperature.

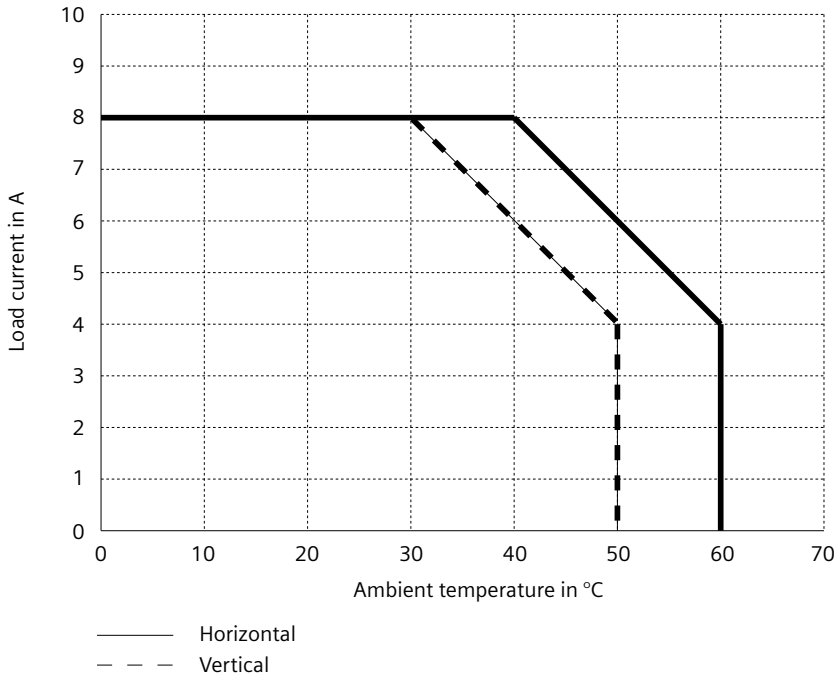

Figure 2-418 Load current vs. ambient temperature in different mounting positions

If one channel drives a cyclically switched inductive load, this channel contributes 500 mA to the total current.

Maximum permitted switching frequency of inductive loads

The following trends show the maximum permissible switching frequency of inductive loads as a function of inductance and channel current. The maximum switching frequency applies to a pulse-pause ratio of 50%. The channel contributes 500 mA to the total current of the module, even if the actual channel current is smaller.

If you do not know the inductance of the actuator, assume a maximum inductance of 1.152 H for DC-13 loads (IEC 60947-5-1).

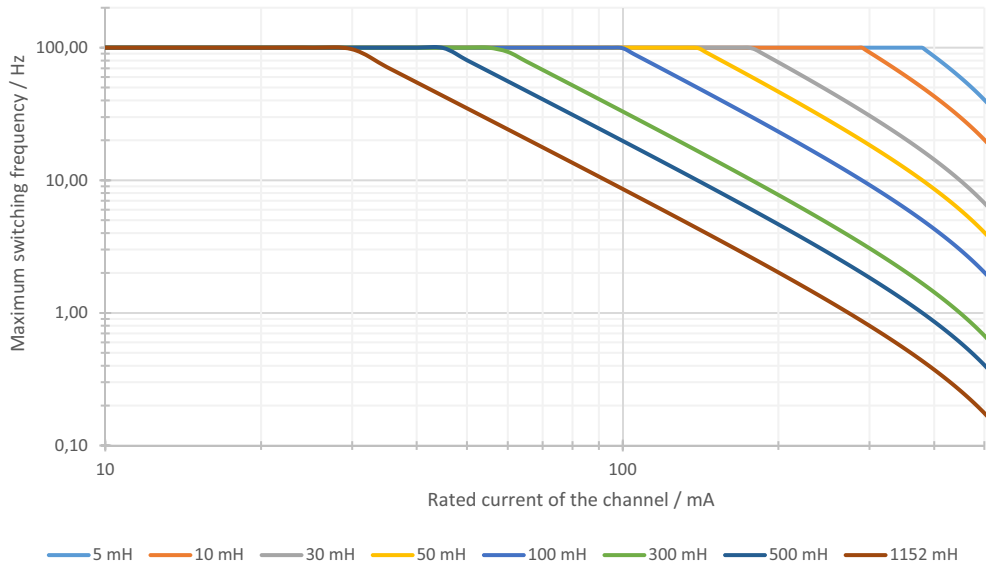

Figure 2-419 Maximum switching frequency

Dimension drawing

See Equipment Manual ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reparameterize the module in your user program, regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can reassign the parameters of the module in RUN. For example, the reaction to CPU STOP of individual channels can be changed in RUN without this having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 are not changed on the CPU, which means that the parameters set in STEP 7 are valid again after a restart.

If you reconfigure a module and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

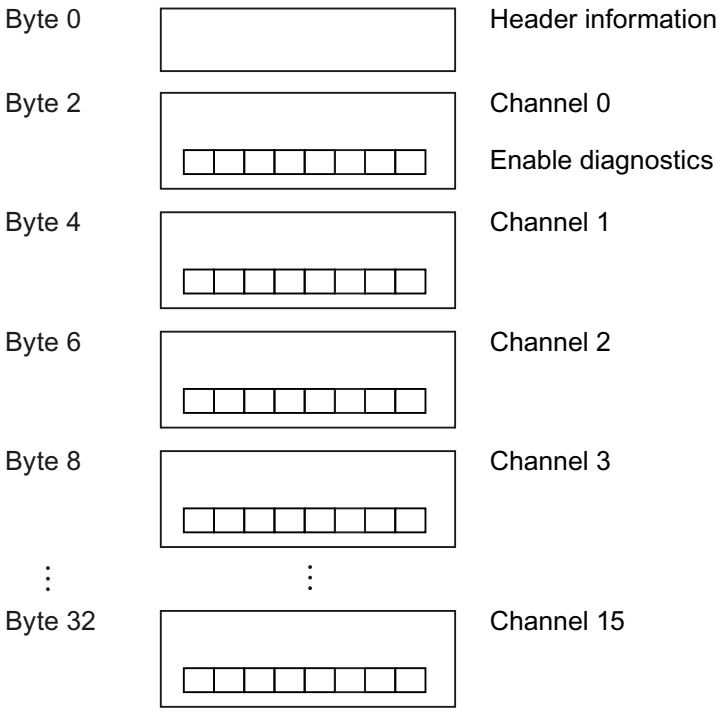

Figure 2-420 Structure of data record 128

Header information

The figure below shows the structure of the header information.

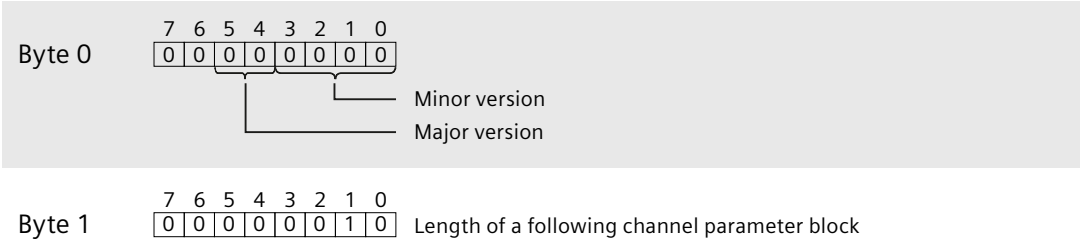

Figure 2-421 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 15.

You enable a parameter by setting the corresponding bit to "1".

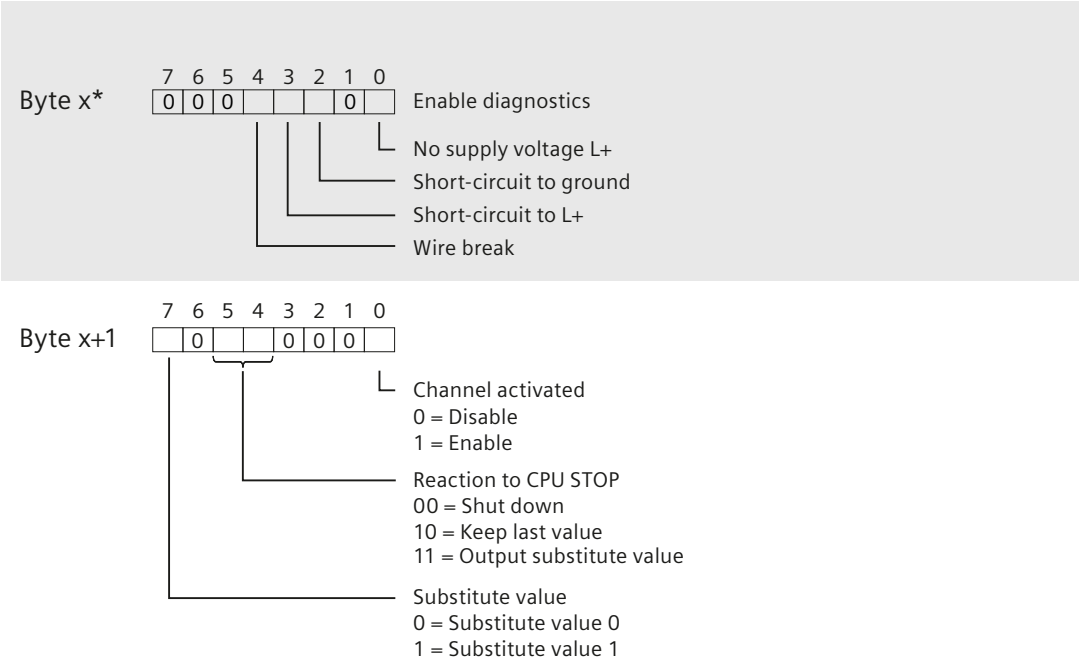

* x = 2 + (channel number × 2); channel number = 0 to 15

Figure 2-422 Structure byte x to x+1 for the channels 0 to 15

A.2 Error codes

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The table below shows the module-specific error codes and their meaning for parameter data record 128.

Table 2-407 Error messages, their meaning, and remedial measures

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$B0_H$	00_H	Number of the data record unknown	Enter a valid number for the data record.
DF_H	80_H	$B1_H$	02_H	Length of the data record incorrect	Enter a valid value for the data record length.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF_H	80_H	$B2_H$	00_H	Module not accessible	• Check station. • Plug the module in correctly. • Check parameters of the WRREC block.
DF_H	80_H	$E0_H$	01_H	Header error (version or specified bits incorrect).	Correct version number or fixed bits, see Header information.
DF_H	80_H	$E0_H$	02_H	Header error (number or length of parameter structures or parameter blocks incorrect)	Correct the number and length of the parameter structures or parameter blocks, see Header information.
DF_H	80_H	$E1_H$	01_H	Reserved bit set	Write 0 to all reserved bits.
DF_H	80_H	$E1_H$	06_H	Invalid coding for substitute value behavior.	Use valid code for "Reaction to CPU STOP" parameter, see Structure byte x to x+1 for the channels 0 to 15.

SIEMENS

SIMATIC

ET 200SP
Digital output module DQ 16x24VDC/0.5A HF (6ES7132-6BH00-0CA0)

Equipment Manual

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Parameter data record A

08/2024
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Introduction

1

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200clean Distributed I/O System (https://support.industry.siemens.com/cs/en/en/view/65949252) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

3

3.1 Properties

Article number

6ES7132-6BH00-0CA0 (packing unit: 1 unit)

View of the module

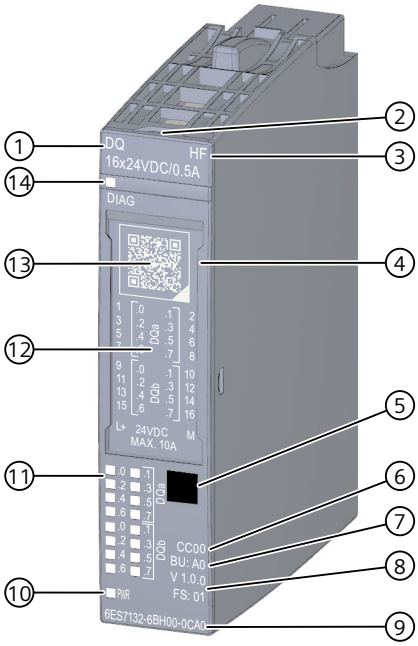

①	Module type and name	⑧	Function class
②	LED for diagnostics	⑨	Insertion option for optional labeling strip
③	QR code for identification link	⑩	Color coding module type
④	Wiring diagram	⑪	Color code for selecting the color-coded labels
⑤	LEDs for channel status and channel fault	⑫	BU type
⑥	LED for supply voltage	⑬	Firmware and function version
⑦	Slot for optional equipment labeling plate	⑭	Article number

Figure 2-423 View of the module DQ 16x24VDC/0.5A HF

Properties

The module has the following technical properties:

- Digital output module with 16 outputs
- Source output (PNP, P-switching)
- Supply voltage L+
- Output current 0.5 A (per channel)
- Total current maximum 8 A

  See derating: Technical specifications
- Configurable diagnostics (per channel)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Suitable for safety-related shutdown of standard modules

The module supports the following functions:

Table 2-408 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V1.0.0 or higher	As of V18 with HSP0416	As of V5.5 SP3 with HSP 0230 as of V10.0	X	X
Identification data I&M0 to I&M3	FS01	V1.0.0 or higher	As of V18 with HSP0416	As of V5.5 SP3 with HSP 0230 as of V10.0	X	X
Parameter reassignment in RUN	FS01	V1.0.0 or higher	As of V18 with HSP0416	As of V5.5 SP3 with HSP 0230 as of V10.0	X	X
PROFIenergy	FS01	V1.0.0 or higher	As of V18 with HSP0416	As of V5.5 SP3 with HSP 0230 as of V10.0	X	X
Value status	FS01	V1.0.0 or higher	As of V18 with HSP0416	As of V5.5 SP3 with HSP 0230 as of V10.0	X	X
Isochronous mode	FS01	V1.0.0 or higher	As of V18 with HSP0416	As of V5.5 SP3 with HSP 0230 as of V10.0	X	-
Module-internal shared output (MSO)	FS01	V1.0.0 or higher	As of V18 with HSP0416	As of V5.5 SP3 with HSP 0230 as of V10.0	X	-
Configurable submodules/ submodules for shared device	FS01	V1.0.0 or higher	As of V18 with HSP0416	As of V5.5 SP3 with HSP 0230 as of V10.0	X	-

Accessories

The following accessories are available optionally:

- Labeling strips
- Color-coded labels
- Reference identification label
- Shield connection

See also

You can find more information on accessories in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Wiring

4

4.1 Wiring diagram

This section contains the pin assignment for the module.

You can find information on wiring the BaseUnit in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) System Manual.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Also keep this in mind during configuration.

NOTICE

You may only use the digital output module with a type A0 BaseUnit.

With the type A1 BaseUnit, the integrated fuse can be triggered, rendering the terminals unusable.

NOTE

Cross circuit at output

Be aware that voltage from a cross circuit at the output can feed L+ to modules.

Pin assignment: 1-wire connection of actuators

The following table shows an example of the pin assignment of the digital output module DQ 16x24VDC/0.5A HF on the BaseUnit BU type A0 without AUX terminals:

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Digital output, channel 0	DQ_0	1	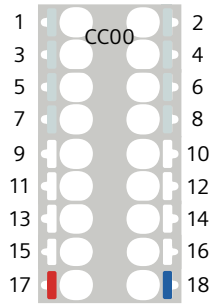	2	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	3		4	DQ_3	Digital output, channel 3
Digital output, channel 4	DQ_4	5		6	DQ_5	Digital output, channel 5
Digital output, channel 6	DQ_6	7		8	DQ_7	Digital output, channel 7
Digital output, channel 8	DQ_8	9		10	DQ_9	Digital output, channel 9
Digital output, channel 10	DQ_{10}	11		12	DQ_{11}	Digital output, channel 11
Digital output, channel 12	DQ_{12}	13		14	DQ_{13}	Digital output, channel 13
Digital output, channel 14	DQ_{14}	15		16	DQ_{15}	Digital output, channel 15
24 V DC supply voltage	L+	17		18	M	Ground

Pin assignment: 2-wire connection of actuators

The following table shows an example of the pin assignment of the digital output module DQ 16x24VDC/0.5A HF on the BaseUnit BU type A0 with AUX terminals:

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Digital output, channel 0	DQ_0	1		2	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	3		4	DQ_3	Digital output, channel 3
Digital output, channel 4	DQ_4	5		6	DQ_5	Digital output, channel 5
Digital output, channel 6	DQ_6	7		8	DQ_7	Digital output, channel 7
Digital output, channel 8	DQ_8	9		10	DQ_9	Digital output, channel 9
Digital output, channel 10	DQ_{10}	11		12	DQ_{11}	Digital output, channel 11
Digital output, channel 12	DQ_{12}	13		14	DQ_{13}	Digital output, channel 13
Digital output, channel 14	DQ_{14}	15		16	DQ_{15}	Digital output, channel 15
AUX terminal	AUX	1A		2A	AUX	AUX terminal
AUX terminal	AUX	3A		4A	AUX	AUX terminal
AUX terminal	AUX	5A		6A	AUX	AUX terminal
AUX terminal	AUX	7A		8A	AUX	AUX terminal
AUX terminal	AUX	9A		10A	AUX	AUX terminal
24 V DC supply voltage[1)]	L+	L+		M	M	Ground

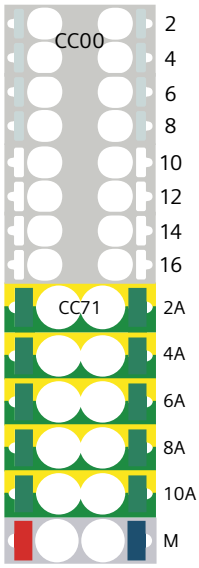

[1)] Infeed only with light BaseUnit

Output connection types

1-wire connection for channel n	2-wire connection for channel n	3-wire connection for channel n
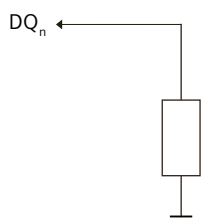	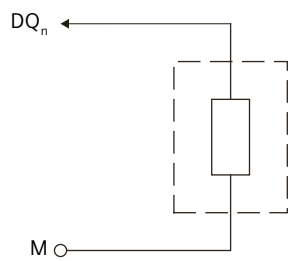	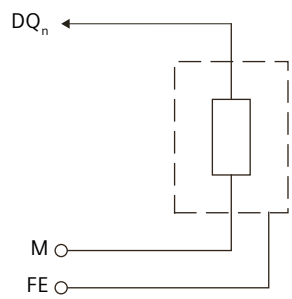

You can also connect the ground and functional grounding via a potential distribution module (PotDis module) or AUX terminals. More information on potential distribution modules is available in the BaseUnits Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/59753521).

NOTE

You can use and combine the different connection options for all channels.

4.2 Block diagram

This section contains the schematic circuit diagram of the module.

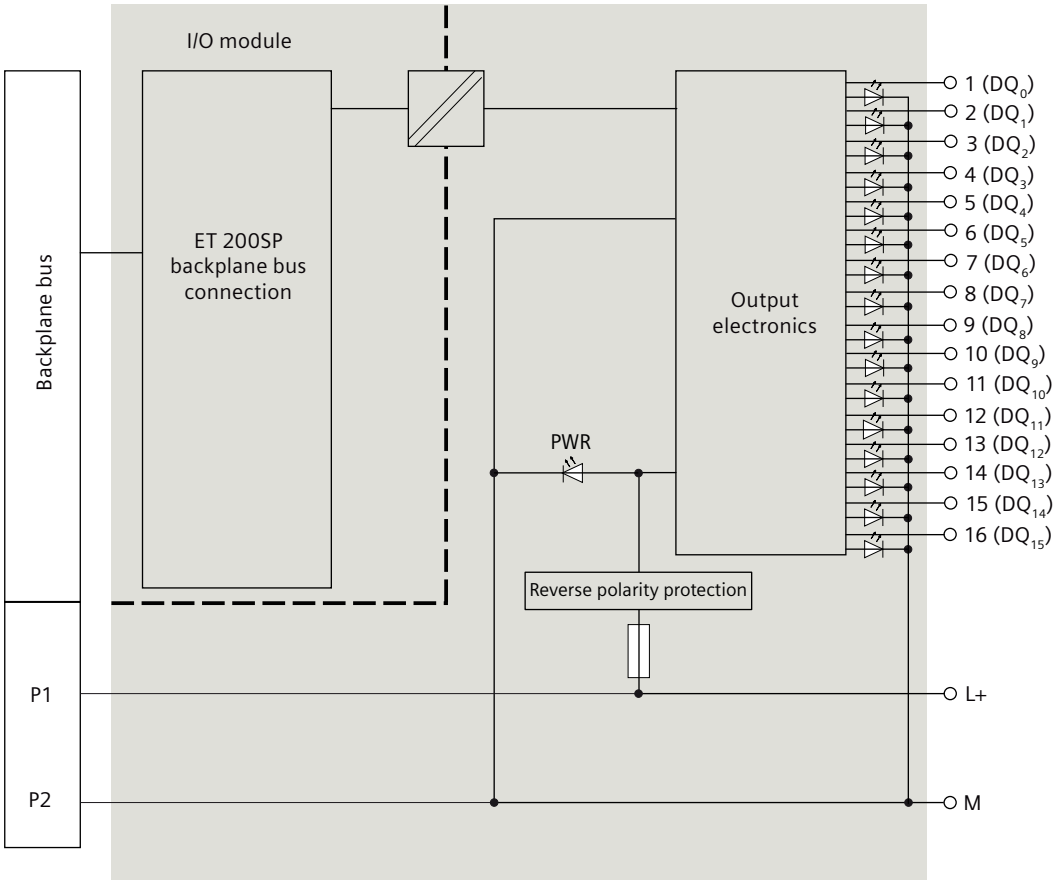

Figure 2-424 Schematic circuit diagram

Parameters/address space 5

5.1 Parameters

Parameters for DQ 16x24VDC/0.5A HF

You can specify the module properties with various parameters in the course of your STEP 7 configuration. The table below lists the configurable parameters. The efficiency range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation on an ET 200SP-CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition to configuration via the configuration software, you can also configure parameters in RUN mode (dynamically) via the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records. See the Parameter assignment and structure of the parameter data record (Page 40) section.

The following parameter settings are possible:

Table 2-409 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel [1]
Diagnostics: Short circuit to L+	• Disable • Enable	Disable	Yes	Channel	
Check for wire break	• Disable • Enable	Enable	Yes	Channel	Channel
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter setting options are restricted. The parameter length of the I/O module is 14 bytes with a PROFIBUS GSD configuration. However, if necessary you can set these parameters using data records 64 to 71 or data record 128, see "Parameter data record" appendix.

Parameter	Value range	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module [1]
Potential group	• Use the potential group of the left module (module plugged into a dark BaseUnit) • Enable new potential group (module plugged into a light BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter setting options are restricted. The parameter length of the I/O module is 14 bytes with a PROFIBUS GSD configuration. However, if necessary you can set these parameters using data records 64 to 71 or data record 128, see "Parameter data record" appendix.

NOTE

- If both parameters "Diagnostics: Short circuit to L+" and "Diagnostics: Wire break" are enabled and one of these diagnostic events occurs, the affected channel is switched off. This prevents undefined load switching and the corresponding diagnostics alarm is triggered.
- If the parameter "Diagnostics: Wire break" is enabled and the parameter "Diagnostics: Short circuit to L+" is disabled and a "Diagnostics: wire break" is pending, the affected channel is switched off. This prevents undefined load switching and the corresponding diagnostics alarm is triggered.
- If the parameter "Diagnostics: Short circuit to L+" is enabled and "Diagnostics: Wire break" is disabled, the signal status is retained at the affected channel when "Diagnostics: Short circuit to L+" occurs. A diagnostics alarm is triggered only for 0 signal.

5.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short circuit to ground

Enabling of the diagnostics if a short circuit of the actuator supply to ground occurs.

Diagnostics: Short circuit to L+

Enabling of the diagnostics if a short circuit of the actuator supply to L+ occurs.

Check for wire break

Determines whether a check for wire break is carried out for the channel. The wire break diagnostics for the channel can only be reported with activated check for wire break. The measuring current for the channel is disabled with deactivated check for wire break.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken. If the wire break diagnostics is enabled, the parameter "Check for wire break" must also be activated for the channel.

Channel activated

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2, and AUX to the left neighbor.

Specify on which slot a light-colored BaseUnit with supply voltage feed or a dark BaseUnit is located (see ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual).

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

The station configuration must be completed with a server module.

5.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of DQ 16x24VDC/0.5A HF

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-410 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the STEP 7 hardware catalog, as of V18 with HSP0416	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 16-channel with value status	DQ 16x24VDC/0.5A HF V1.0, QI	X	X	X
1 x 16-channel without value status	DQ 16x24VDC/0.5A HF V1.0	X	X	X
1 x 16-channel with value status for module-internal shared output with up to 4 submodules	DQ 16x24VDC/0.5A HF V1.0, MSO	X	X	-
2 x 8-channel with value status	DQ 16x24VDC/0.5A HF V1.0, S.2 QI	X	X	-
2 x 8-channel without value status	DQ 16x24VDC/0.5A HF V1.0, S.2	X	X	-
4 x 4-channel with value status	DQ 16x24VDC/0.5A HF V1.0, S.4, QI	X	X	-
4 x 4-channel without value status	DQ 16x24VDC/0.5A HF V1.0, S.4	X	X	-

NOTE

The following functions are only fully available when the submodule X.1 is configured and the IO controller to which submodule X.1 is assigned has established a connection to the IO device.

- Firmware update
- I&M identification data
- PROFIenergy

2 x 8- / 4 x 4-channel configuration

For the configuration, the channels of the module are divided into multiple submodules. These submodules can be assigned to different IO controllers when the module is used in a Shared Device.

The number of usable submodules is dependent on the interface module used. Read the information in the Equipment Manual for the respective interface module.

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- DQ 16x24VDC/0.5A HF V1.0, QI
- DQ 16x24VDC/0.5A HF V1.0, MSO
- DQ 16x24VDC/0.5A HF V1.0, S.2 QI
- DQ 16x24VDC/0.5A HF V1.0, S.4 QI

An additional bit is assigned to each channel for the value status. The bit for the value status indicates if the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

You can find more information on evaluating the value status in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Address space for configuration as 1 x 16-channel DQ 16x24VDC/0.5A HF

The figure below shows the address space assignment for configuration as a 1 x 16-channel module without value status. "QB" stands for output byte.

Assignment in the process image output (PIQ)

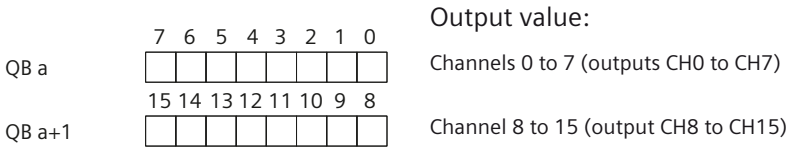

Figure 2-425 Address space for configuration as 16-channel DQ 16x24VDC/0.5A HF without value status

Address space for configuration as 1 x 16-channel DQ 16x24VDC/0.5A HF, QI

The figure below shows the address space assignment for configuration as a 1 x 16-channel module with value status. You can freely assign the start address for the module. The addresses of the channels are derived from the start address. "IB" stands for input byte. "QB" stands for output byte.

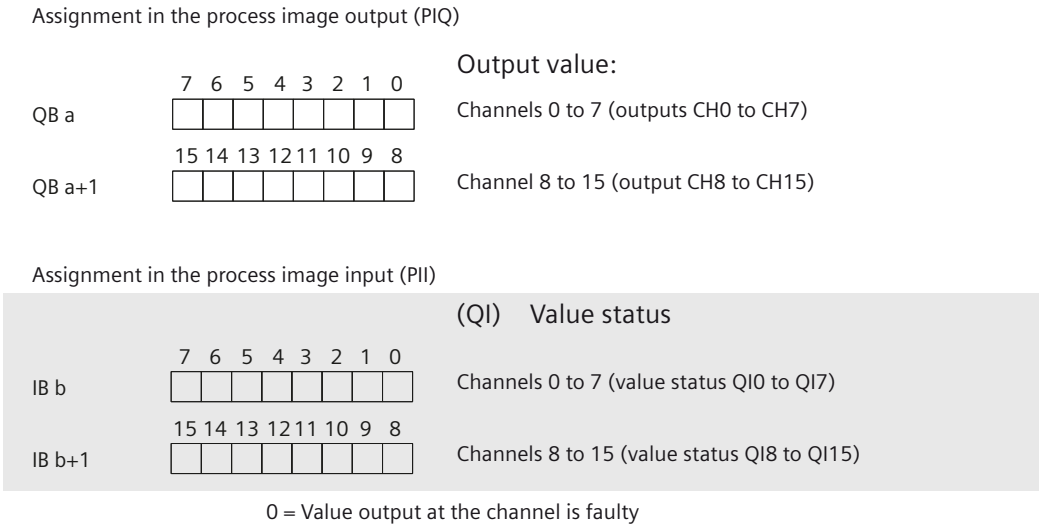

Figure 2-426 Address space for configuration as 16-channel DQ 16x24VDC/0.5A HF, QI with value status

Address space for configuration as 1 x 16-channel DQ 16x24VDC/0.5A HF, MSO

For the configuration as a 1 x 16-channel module (module-internal Shared Output, MSO), channels 0 to 15 of the module are copied to up to four submodules. Channels 0 to 15 are then available with identical values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device:

- The IO controller to which submodule 1 is assigned has write access to outputs 0 to 15.
- The IO controllers to which submodule 2, 3, or 4 is assigned have read access to outputs 0 to 15.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

With the 1st submodule (= basic submodule), the value status 0 indicates that the value is incorrect or that the IO controller of the basic submodule is in STOP mode.

For the 2nd to 4th submodule (=MSO submodule), the value status 0 indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule is not yet configured (not ready).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller of the basic submodule is in STOP or POWER OFF state.

The figure below shows the assignment of the address space for submodules 1, 2, 3, and 4 and the value status. "IB" stands for input byte. "QB" stands for output byte.

Assignment in the process image of the outputs (PIQ) for the 1st submodule

		1st submodule (basic submodule):
	7 6 5 4 3 2 1 0	
QB a		Channels 0 to 7 (outputs CH0 to CH7)
	15 14 13 12 11 10 9 8	
QB a+1		Channels 8 to 15 (output CH8 to CH15)
	7 6 5 4 3 2 1 0	(QI) Value status
IB b		Channels 0 to 7 (value status QI0 to QI7)
	15 14 13 12 11 10 9 8	
IB b+1		Channels 8 to 15 (value status QI8 to QI15)

Assignment in the process image of the inputs (PII) for the 2nd submodule

		2nd submodule (MSO submodule): Read-back output values
	7 6 5 4 3 2 1 0	
IB c		Channels 0 to 7 (outputs CH0 to CH7)
	15 14 13 12 11 10 9 8	
IB c+1		Channels 8 to 15 (output CH8 to CH15)
	7 6 5 4 3 2 1 0	(QI) Value status
IB c+2		Channels 0 to 7 (value status QI0 to QI7)
	15 14 13 12 11 10 9 8	
IB c+3		Channels 8 to 15 (value status QI8 to QI15)

Assignment in the process image of the inputs (PII) for the 3rd submodule

		3rd submodule (MSO submodule): Read-back output values
	7 6 5 4 3 2 1 0	
IB d		Channels 0 to 7 (outputs CH0 to CH7)
	15 14 13 12 11 10 9 8	
IB d+1		Channels 8 to 15 (output CH8 to CH15)
	7 6 5 4 3 2 1 0	(QI) Value status
IB d+2		Channels 0 to 7 (value status QI0 to QI7)
	15 14 13 12 11 10 9 8	
IB d+3		Channels 8 to 15 (value status QI8 to QI15)

Assignment in the process image of the inputs (PII) for the 4th submodule

		4th submodule (MSO submodule): Read-back output values
	7 6 5 4 3 2 1 0	
IB e		Channels 0 to 7 (outputs CH0 to CH7)
	15 14 13 12 11 10 9 8	
IB e+1		Channels 8 to 15 (output CH8 to CH15)
	7 6 5 4 3 2 1 0	(QI) Value status
IB e+2		Channels 0 to 7 (value status QI0 to QI7)
	15 14 13 12 11 10 9 8	
IB e+3		Channels 8 to 15 (value status QI8 to QI15)

0 = Value output at the channel is faulty

Figure 2-427 Address space for configuration as 1 x 16-channel DQ 16x24VDC/0.5A HF, MSO with value status

Address space for configuration as 2 x 8-channel DQ 16x24VDC/0.5A HF V1.0, S.2

The figure below shows the assignment of the address space for configuration as a 2 x 8-channel module without value status.

Each of the two submodules has a freely assignable start address. "QB" stands for output byte.

Assignment in the process image of the outputs (PIQ)

	7 6 5 4 3 2 1 0	Output value:	
QB a		Channels 0 to 7 (outputs CH0 to CH7)	1st submodule
QB b		Channels 8 to 15 (output CH8 to CH15)	2nd submodule

Figure 2-428 Address space for configuration as 2 x 8-channel DQ 16x24VDC/0.5A HF V1.0, S.2 without value status

Address space for configuration as 2 x 8-channel DQ 16x24VDC/0.5A HF V1.0, S.2 QI

The figure below shows the assignment of the address space for configuration as a 2 x 8-channel module with value status.

Each of the two submodules has a freely assignable start address. "IB" stands for input byte. "QB" stands for output byte.

Assignment in the process image output (PIQ)

	7 6 5 4 3 2 1 0	Output value:	
QB a		Channels 0 to 7 (outputs CH0 to CH7)	1st submodule
QB b		Channel 8 to 15 (output CH8 to CH15)	2nd submodule

Assignment in the process image input (PII)

	7 6 5 4 3 2 1 0	(QI) Value status	
IB c		Channels 0 to 7 (value status QI0 to QI7)	1st submodule
IB d		Channels 8 to 15 (value status QI8 to QI15)	2nd submodule

0 = Value output at the channel is faulty

Figure 2-429 Address space for configuration as 2 x 8-channel DQ 16x24VDC/0.5A HF V1.0, S.2 QI with value status

Address space for configuration as 4 x 4-channel DQ 16x24VDC/0.5A HF V1.0, S.4

The figure below shows the address space assignment for configuration as a 4 x 4-channel module without value status.

Each of the four submodules has a freely assignable start address. "QB" stands for output byte.

Assignment in the process image output (PIQ)

	7	6	5	4	3	2	1	0	Output value:	
QB a	0	0	0	0					Channels 0 to 3 (output CH0 to CH3)	1st submodule
QB b	0	0	0	0					Channels 4 to 7 (output CH4 to CH7)	2nd submodule
QB c	0	0	0	0					Channels 8 to 11 (output CH8 to CH11)	3rd submodule
QB d	0	0	0	0					Channels 12 to 15 (output CH12 to CH15)	4th submodule

Figure 2-430 Address space for configuration as 4 x 4-channel DQ 16x24VDC/0.5A HF V2.0, S.4 without value status

Address space for configuration as 4 x 4-channel DQ 16x24VDC/0.5A HF V1.0, S.4 QI

The figure below shows the address space assignment for configuration as a 4 x 4-channel module with value status.

Each of the four submodules has a freely assignable start address. "IB" stands for input byte. "QB" stands for output byte.

Assignment in the process image output (PIQ)

	7 6 5 4 3 2 1 0	Output value:	
QB a	0 0 0 0	Channels 0 to 3 (output CH0 to CH3)	1st submodule
QB b	0 0 0 0	Channels 4 to 7 (output CH4 to CH7)	2nd submodule
QB c	0 0 0 0	Channels 8 to 11 (output CH8 to CH11)	3rd submodule
QB d	0 0 0 0	Channels 12 to 15 (output CH12 to CH15)	4th submodule

Assignment in the process image input (PII)

	7 6 5 4 3 2 1 0	(QI) Value status	
IB e	0 0 0 0	Channels 0 to 3 (value status QI0 to QI3)	1st submodule
IB f	0 0 0 0	Channels 4 to 7 (value status QI4 to QI7)	2nd submodule
IB g	0 0 0 0	Channels 8 to 11 (value status QI8 to QI11)	3rd submodule
IB h	0 0 0 0	Channels 12 to 15 (value status QI12 to QI15)	4th submodule

0 = Value output at the channel is faulty

Figure 2-431 Address space for configuration as 4 x 4-channel DQ 16x24VDC/0.5A HF V1.0, S.4 QI with value status

Interrupts/diagnostics alarms

6

6.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the module:

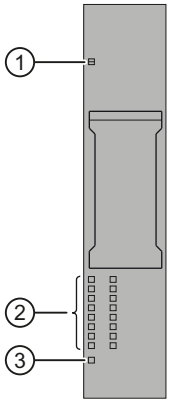

① DIAG (green/red)

② Channel status and channel error (green)

③ PWR (green)

Figure 2-432 LED displays

Meaning of the LEDs

The meaning of the status and error messages is described in the following tables. You will find remedial measures for diagnostics alarms in the Diagnostics alarms (Page 31) section.

DIAG LED

Table 2-411 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the system is interrupted or switched off.
Flashes	Module not configured
On	Module parameters assigned and no module/channel diagnostics available
Flashes	Module parameters assigned and module/channel diagnostics available

Channel status and channel error LEDs

One LED per channel is available for displaying channel status and channel errors. The LED display is divided into two phases:

- In the channel status phase, the status of the process signal of the associated channel is visualized.
- In the channel error phase, the status of the diagnostics of the associated channel is visualized.

If no diagnostics are pending at any channel, all LED displays are in the channel status phase. If a diagnostics is pending on at least one channel, the channel status phase (5 seconds) and channel error phase (2 seconds) alternate cyclically for all LED displays. The switchover between the two phases is represented by a high-frequency flashing pattern (0.5 seconds) on all channels.

Incoming or outgoing channel diagnostics are displayed as follows:

- If a channel diagnostics occurs while the LED displays are in the channel error phase, this will only be displayed in the subsequent channel error phase.
- If a channel diagnostics goes while the LED displays are in the channel status phase and if it has already been displayed once, it will not be displayed in the subsequent channel error phase.
- If a channel diagnostics comes and goes while the LED indicators are in the channel status phase, it will only be displayed for one channel error phase. Each incoming channel diagnostics is thus shown for at least one channel error phase.

The figure below shows an example of a cycle (8 seconds) consisting of a sequence of channel status phase, transition, channel error phase, and renewed transition.

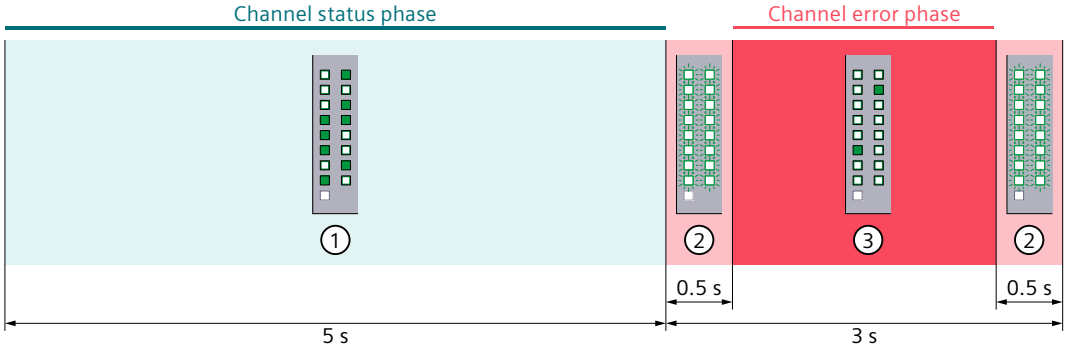

① Status display

② Transition indicated by high-frequency flashing of all LEDs

③ Diagnostics display

Figure 2-433 Status/error display of the channel status and channel error LEDs

Table 2-412 LED in the channel status phase

Channel status phase LED	Meaning
□ Off	Channel deactivated or activated and process signal = 0
■ On	Channel activated and process signal = 1

Table 2-413 LED in the channel error phase

Channel error phase LED	Meaning
□ Off	No channel diagnostics available
■ On	Channel diagnostics available

PWR LED

Table 2-414 Status display of the PWR LED

PWR LED	Meaning
□ Off	Missing supply voltage L+
■ On	Supply voltage L+ present

6.2 Interrupts

The DQ 16×24VDC/0.5A HF digital output module supports diagnostic interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt for the following events:

- Short circuit
- Wire break
- Parameter assignment error
- Supply voltage missing
- Channel/component temporarily unavailable

Detailed information on the event is available in the STEP 7 online help.

6.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes red on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

NOTE

Wiring two outputs in parallel

When connecting two outputs in parallel for redundant control of a load, the channel diagnostics "Short circuit to L+" and "Wire break" must be disabled, otherwise faulty diagnostics alarms may occur.

Table 2-415 Diagnostics alarms, their meaning, and remedial measures

Diagnostics alarm	Error code	Meaning	Solution
Short circuit	1_H	• Short circuit of actuator supply to ground [1] • Short circuit of actuator supply to L+ [2]	Correct the process wiring
Wire break	6_H	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, e.g. use cables with larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect a resistor to the actuator contacts in the load resistance range

[1] Only in switched state (output value 1)

[2] Only in non-switched state (output value 0)

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel • Incorrect parameter assignment	Correct the parameter assignment
Supply voltage missing	11_H	No or insufficient supply voltage L+	• Check the supply voltage L+ at the BaseUnit • Check BaseUnit type
Channel/component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update • Restart the firmware update

[1] Only in switched state (output value 1)

[2] Only in non-switched state (output value 0)

NOTE

In case of a short circuit of the actuator supply to L+ at the activated channel, load distributions can occur which result in broken wire diagnostics.

Technical specifications 7

7.1 Technical specifications

Technical specifications of the DQ 16x24VDC/0.5A HF

The following table lists the technical specifications as of the issue date. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7132-6BH00-0CA0/td?dl=en).

Article number	6ES7132-6BH00-0CA0
General information	
Product type designation	DQ 16x24VDC/0.5A HF
HW functional status	01
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V18 or higher with HSP 0416
• STEP 7 configurable/integrated from version	V5.5 SP3 or higher
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.43
Operating mode	
• DQ	Yes
• DQ with energy-saving function	No
• PWM	No
• Cam control (switching at comparison values)	No
• Oversampling	No
• MSO	Yes

Article number	6ES7132-6BH00-0CA0
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	20 mA; without load
output voltage / header	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1 W
Address area	
Address space per module	
• Address space per module, max.	8 byte; 4 channels per submodule + QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Submodules	
• Number of configurable submodules, max.	4
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0 with AUX terminals or potential distributor module
• 3-wire connection	BU type A0 with AUX terminals or potential distributor module
Digital outputs	
Type of digital output	Source output (PNP, current-sourcing)
Number of digital outputs	16
Current-sinking	No
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
output characteristic acc. to IEC 61131, type 0.5	Yes
Short-circuit protection	Yes; Electronic
• Response threshold, typ.	0.7 to 1.3 A
Open-circuit detection	Yes
Limitation of inductive shutdown voltage to	Typ. L+ (-50 V)
Controlling a digital input	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A

Article number	6ES7132-6BH00-0CA0
• with inductive load, max.	0.5 A
• on lamp load, max.	5 W
Load resistance range	
• lower limit	48 Ω
• upper limit	12 kΩ
Output current	
• for signal "1" rated value	0.5 A
• for signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
• "0" to "1", typ.	50 µs
• "1" to "0", typ.	100 µs
Parallel switching of two outputs	
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	100 Hz
• with inductive load, max.	0.1 Hz; higher frequencies are possible, see Equipment Manual "Maximum permitted switching frequency of inductive loads"
• on lamp load, max.	10 Hz
Total current of the outputs	
• Current per channel, max.	0.5 A
• Current per module, max.	8 A
Total current of the outputs (per module)	
horizontal installation	
– up to 40 °C, max.	8 A
– up to 50 °C, max.	6 A
– up to 60 °C, max.	4 A
vertical installation	
– up to 30 °C, max.	8 A
– up to 40 °C, max.	6 A
– up to 50 °C, max.	4 A
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Isochronous mode	
Execution and activation time (TCO), min.	48 µs
Bus cycle time (TDP), min.	500 µs
Jitter, max.	8 µs

Article number	6ES7132-6BH00-0CA0
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; channel by channel
• Short-circuit to M	Yes; channel by channel
• Short-circuit to L+	Yes; channel by channel
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; green LED, see Alarms/diagnostics
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• Between the channels and load voltage L+	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Suitable for safety-related tripping of standard modules	Yes; see FAQ Entry ID: 39198632
Highest safety class achievable for safety-related tripping of standard modules	
• Performance level according to ISO 13849-1	PL d
• Category according to ISO 13849-1	Cat. 3
• SIL acc. to IEC 62061	SIL 2
• remark on safety-oriented shutdown	https://support.industry.siemens.com/cs/de/en/view/39198-632
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C

Article number	6ES7132-6BH00-0CA0
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	26 g

Residual current for signal state "0"

NOTE

Residual current for signal state "0"

Due to the Diagnostics: Wire break function, there is a low level of residual current at an activated check for wire break in the "0" signal state at the output. This may cause the display diodes to flicker.

You can minimize this residual current with the "Check for wire break" parameter.

Derating trend

The figure below shows the load current derating with horizontal and vertical mounting positions. You can use this diagram to determine the maximum total current of the module.

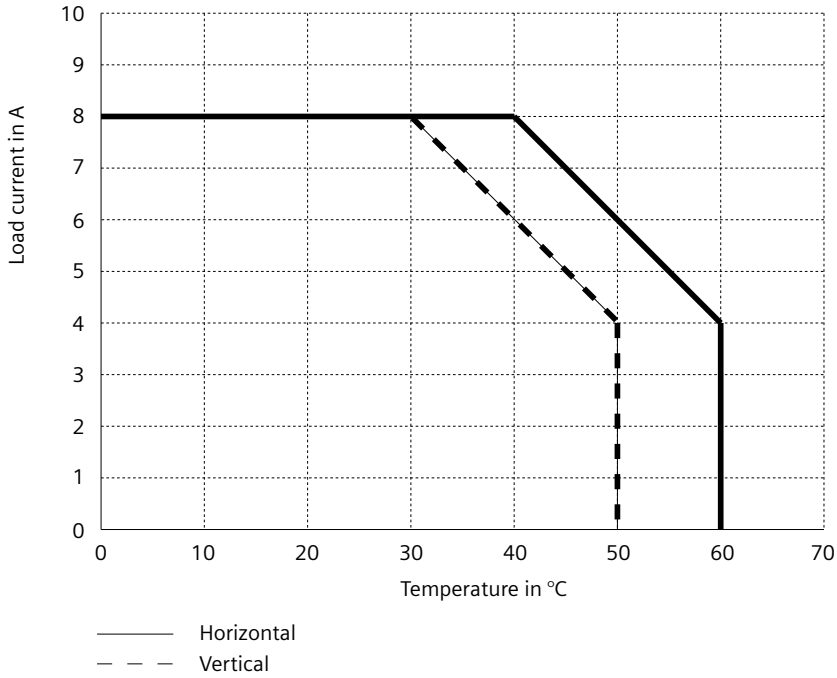

Figure 2-434 Load current to temperature in different mounting positions

If one channel drives a cyclically switched inductive load, this channel contributes 500 mA to the total current.

Maximum permitted switching frequency of inductive loads

The following trends show the maximum permissible switching frequency of inductive loads as a function of inductance and channel current. The maximum switching frequency applies to a pulse-pause ratio of 50%. The channel contributes 500 mA to the total current of the module, even if the actual channel current is smaller.

If you do not know the inductance of the actuator, assume a maximum inductance of 1.152 H for DC-13 loads (IEC 60947-5-1).

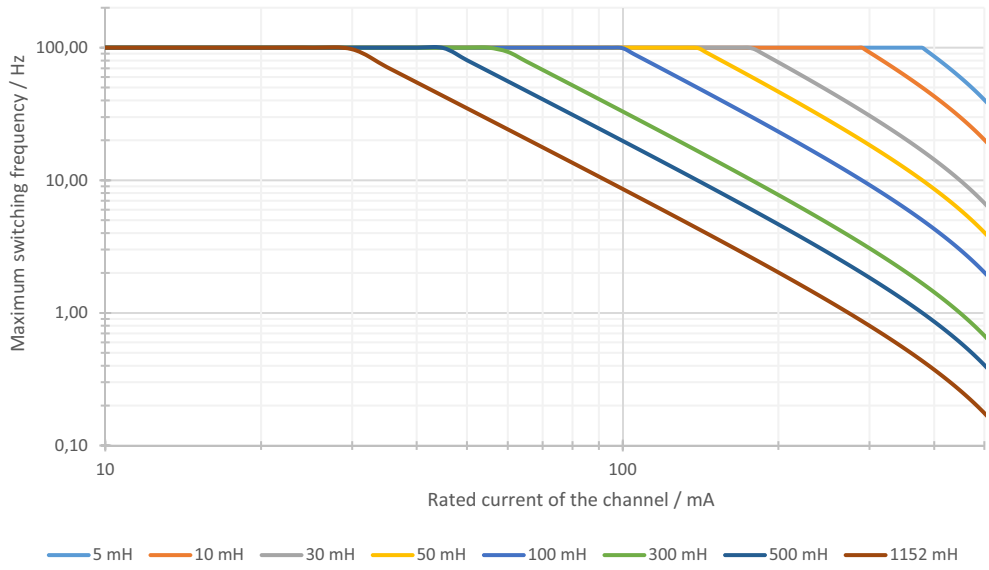

Figure 2-435 Maximum switching frequency

Dimension drawing

See Equipment Manual ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reparameterize the module in your user program, regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

With data records 64 to 79, you can configure individual channels.

Parameter assignment in the user program

You have the option to reconfigure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128 or data records 64 to 79. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

If you reconfigure a module and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing".

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, the STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Data record structure

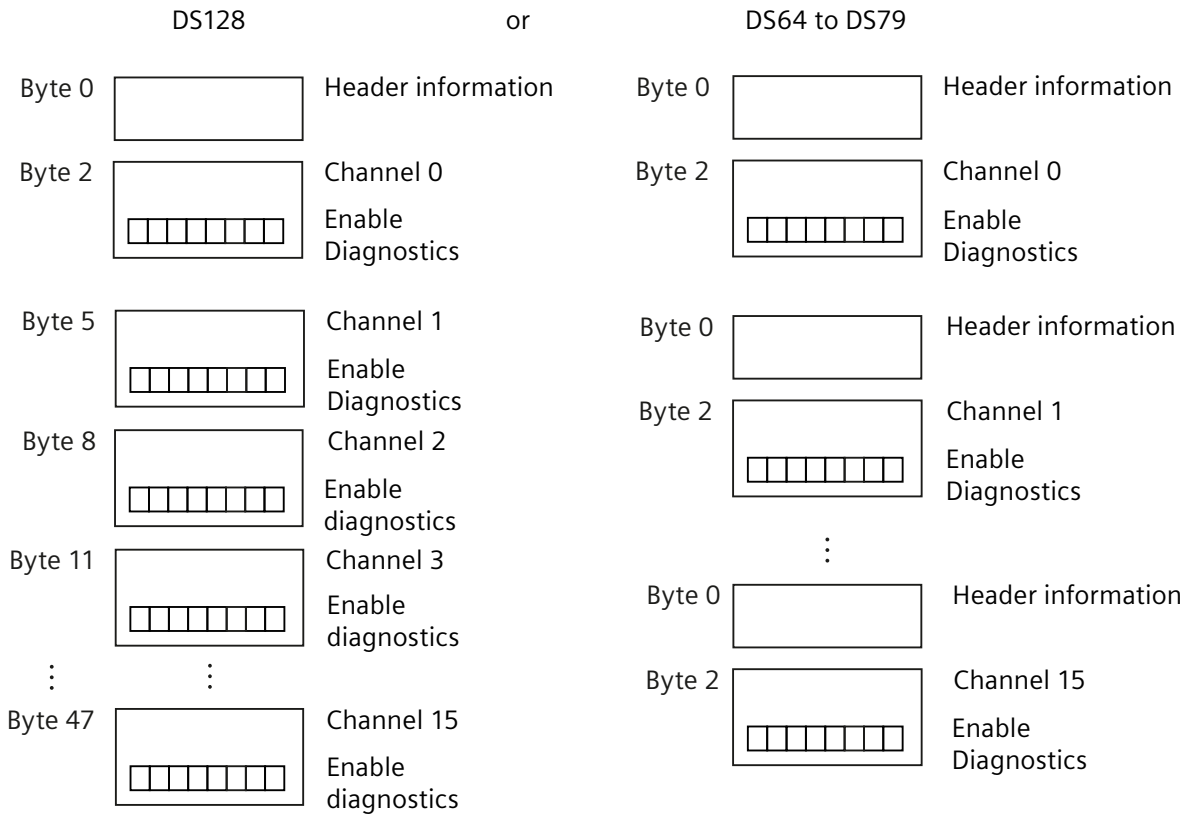

Figure 2-436 Structure of data record 128 or data records 64 to 79

Header information

The figure below shows the structure of the header information.

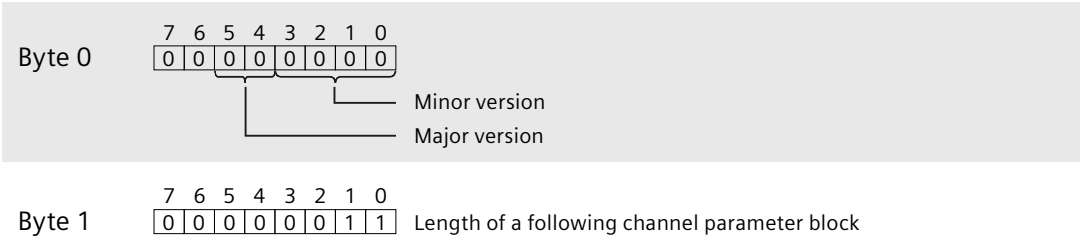

Figure 2-437 Header information

Parameter

The figure below shows the structure of the parameters for channels 0 to 15.

You enable a parameter by setting the corresponding bit to "1".

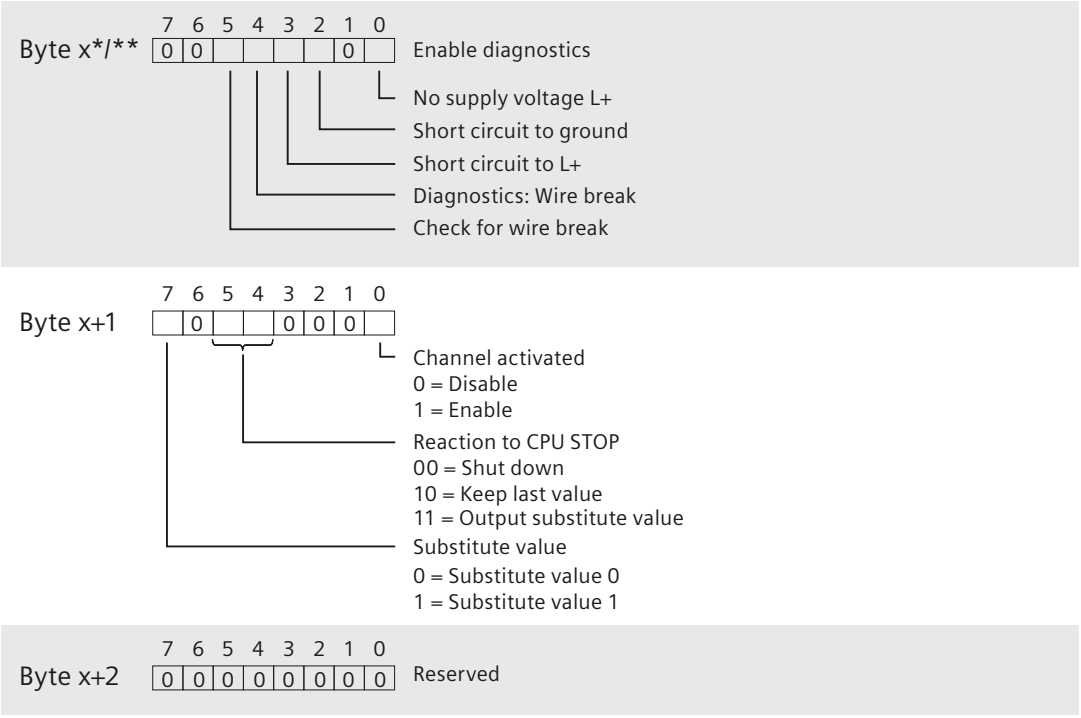

* x = 2 + (channel number × 3); channel number = 0 to 15 for DS 128
** x = 2 for DS 64 to DS 79

Figure 2-438 Structure of byte x to x+2 for channels 0 to 15

A.2 Error codes

Errors when transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module take over the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The table below shows the module-specific error codes and their meaning for parameter data record 128.

Table 2-416 Error messages, their meaning, and remedial measures

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF_H	80_H	$B0_H$	00_H	Number of the data record unknown.	Enter a valid number for the data record.
DF_H	80_H	$B1_H$	01_H	Length of the data record incorrect.	Enter a valid value for the data record length.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF_H	80_H	$B2_H$	00_H	Module not accessible.	• Check station. • Plug the module in correctly. • Check parameters of the WRREC block.
DF_H	80_H	$E0_H$	01_H	Header error (version or specified bits incorrect).	Correct version number or fixed bits, see Header information.
DF_H	80_H	$E0_H$	02_H	Header error (number or length of parameter structures or parameter blocks incorrect)	Correct the number and length of the parameter structures or parameter blocks, see Header information.
DF_H	80_H	$E1_H$	01_H	Reserved bit set.	Describe all reserved bits with 0.
DF_H	80_H	$E1_H$	02_H	Invalid diagnostics enable bit set for operating mode.	Correct diagnostics enables. Dependence on check for wire break parameter, see Structure of byte x to x+2 for channels 0 to 15.
DF_H	80_H	$E1_H$	06_H	Invalid coding for substitute value behavior.	Use valid code for "Reaction to CPU STOP" parameter, see Structure of byte x to x+2 for channels 0 to 15.

SIEMENS

SIMATIC

ET 200SP
Digital Output Module RQ 3x120VDC-230VAC/5A CO ST (6ES7132-6HC50-0BU0)

Equipment Manual

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Parameter data record A

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Introduction

1

Purpose of the documentation

This manual supplements the system manual ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old device, contact a company certified for the disposal of electronic waste and dispose of the device in accordance with the regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/84133942)

1.1.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.1.3 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

See also

PRONETA Professional (https://support.industry.siemens.com/cs/ww/en/view/109781283)

1.2 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109773881)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

Product overview

3

3.1 Properties

Article number

6ES7132-6HC50-0BU0

View of the module

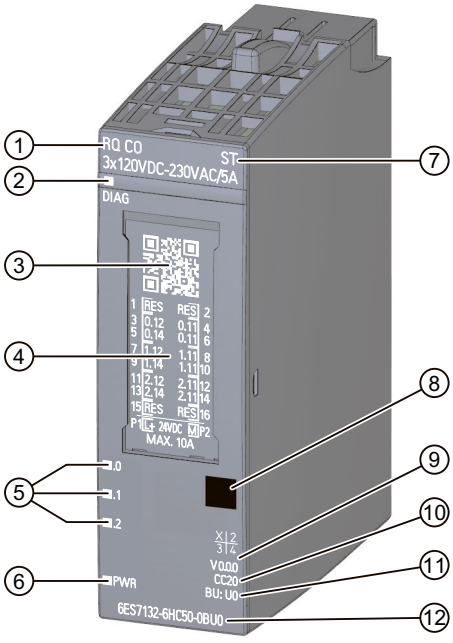

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-439 View of the module RQ 3x120VDC-230VAC/5A CO ST

Properties

The module has the following technical properties:

- Digital output module with 3 floating relay outputs
- Supply voltage L+
- Output current per output 5 A
- Changeover contact (CO: change-over) consisting of one normally closed contact and one normally open contact
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights

The module supports the following functions:

Table 2-417 Version dependencies of the functions

Function	HW version	FW version	STEP 7	GSD file	
			TIA Portal	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V16 or higher with HSP 0321	X	X
Reconfiguration in RUN	FS01	V0.0.0 and higher	V16 or higher with HSP 0321	X	X
PROFIenergy	FS01	V0.0.0 and higher	V16 or higher with HSP 0321	X	X
Value status	FS01	V0.0.0 and higher	V16 or higher with HSP 0321	X	-

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring up

4

4.1 Wiring and block diagram

This section includes the block diagram of the RQ 3x120VDC-230VAC/5A CO ST module with the terminal assignments for a 2-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

NOTE

You can use and combine the different wiring options for all channels.

NOTICE

The relay channels have no integrated short-circuit protection. Provide external short-circuit protection in the form of a miniature fuse with a maximum tripping current of 6.3 A and a fast tripping characteristic. A breaking capacity of at least 1500 A is required for mains voltages. For all other applications and for supply networks with a short-circuit current greater than 1500 A, you need to use a miniature fuse with an appropriately adapted breaking capacity.

⚠ WARNING

Do not connect exposed extra-low-voltage (SELV/PELV) and dangerous live voltages between channels at the same time!

If you only use dangerously live voltages, keep a maximum voltage difference of 300 V between the channels.

Connection: 2-wire connection of actuators

The following figure shows the block diagram and an example of the terminal assignment of the digital output module RQ 3x120VDC-230VAC/5A CO ST on the BaseUnit BU type U0.

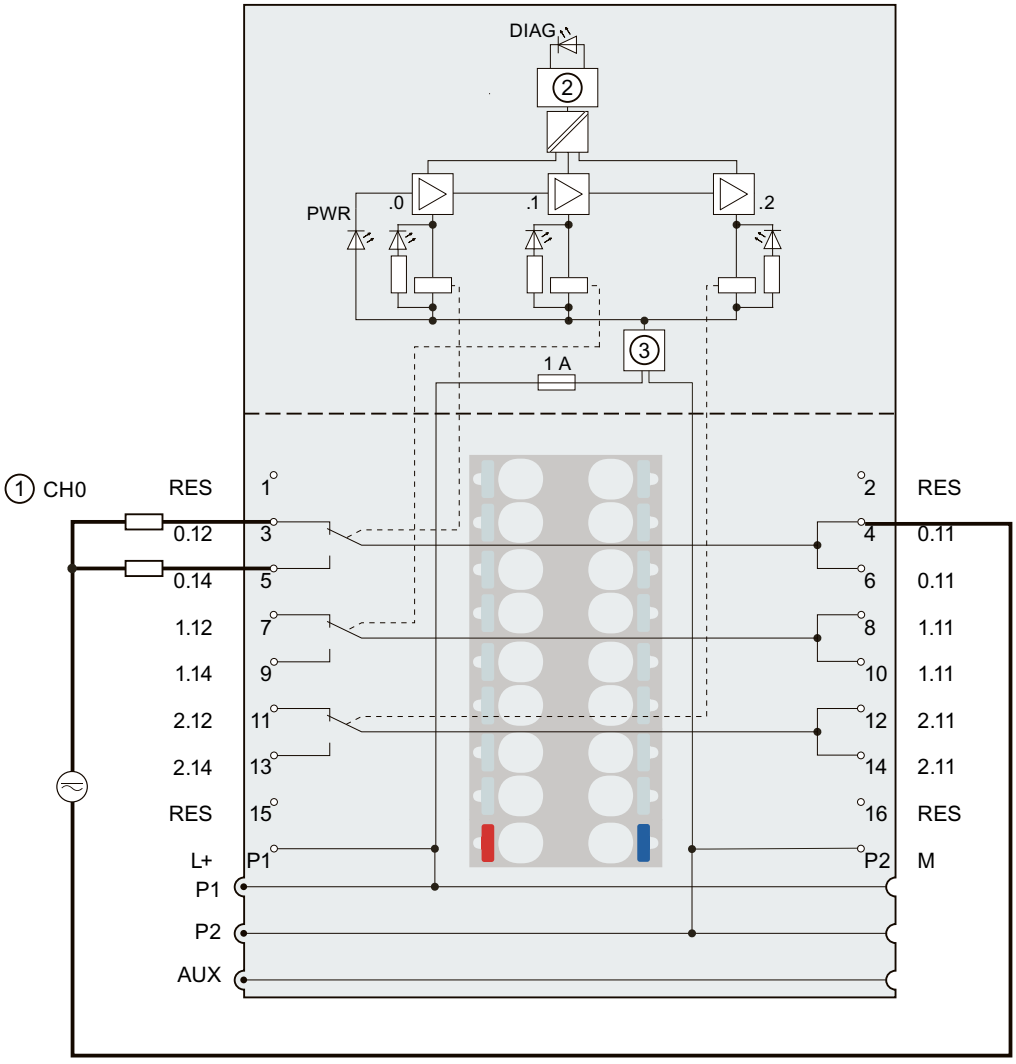

①	2-wire connection	RES	Reserve, must remain unused for future function extensions
②	Backplane bus interface	L+	24 V DC supply voltage
③	Polarity reversal protection	M	Ground
n.11	Common contact	DIAG	Diagnostics LED (green, red)
n.12	Normally closed contact	.0, .1, .2	Channel status LED (green)
n.14	Normally open contact	PWR	Power LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)		

Figure 2-440 Wiring and block diagram for 2-wire connection of actuators

Parameters/address space

5

5.1 Parameters

Parameter for RQ 3x120VDC-230VAC/5A CO ST

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU and an Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 28).

The following parameter settings are possible:

Table 2-418 Settable parameters and their defaults (GSD file)

Parameter	Value range	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module	Module
Channel enabled	• Disable • Enable	Enable	yes	Channel	Channel
Reaction to CPU STOP	• Shutdown • Keep last value • Output substitute value 1	Shutdown	yes	Channel	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the possible parameter settings are restricted. The parameter length of the I/O module is 4 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

5.2 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Channel activated

Determines whether a channel is enabled or disabled.

Reaction to CPU STOP

Specifies the behavior of the module if the CPU changes to STOP.

5.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of RQ 3x120VDC-230VAC/5A CO ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module using a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-419 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)		
		Integrated in hardware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 3-channel without value status	RQ 3x120VDC/230VAC/5A CO ST V0.0	V16 or higher with HSP 0321	X	X
1 x 3-channel with value status	RQ 3x120VDC/230VAC/5A CO ST V0.0, QI	V16 or higher with HSP 0321	X	---

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 2 in this byte are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

Assignment in the process image output (PIQ)

	7	6	5	4	3	2	1	0	Output value
QB x	0	0	0	0	0				Channels 0 to 2

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	Value status (QI)
IB x	0	0	0	0	0				Channels 0 to 2 (value status QI0 to QI2)

Figure 2-441 Address space of RQ 3x120VDC-230VAC/5A CO ST with value status

Interrupts/diagnostics alarms

6

6.1 Status and error display

LED display

The figure below shows the LED displays (status and error displays) of the RQ 3x120VDC-230VAC/5A CO ST.

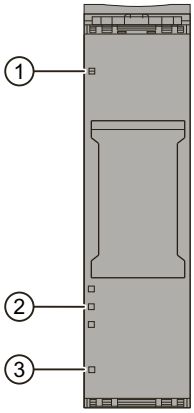

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-442 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 20).

DIAG LED

Table 2-420 DIAG LED fault/error display

DIAG LED	Meaning
☐ off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module not ready for operation (no parameters assigned)
■ on	Module parameters assigned
☼ Flashes	Module diagnostics is available

Channel status LED

Table 2-421 Status display of the channel status LED

Channel status LED	Meaning
☐ off	Channel deactivated or activated and process signal = 0
■ on	Channel activated and process signal = 1

PWR LED

Table 2-422 Status display of the PWR LED

PWR LED	Meaning
☐ off	No supply voltage L+
■ on	Supply voltage L+ present

6.2 Interrupts

The digital output module RQ 3x120VDC-230VAC/5A CO ST supports diagnostics interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Parameter assignment error
- No supply voltage

6.3 Diagnostics alarms

A diagnostic alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-423 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications 7

7.1 Technical specifications

Technical specifications of the RQ 3x120VDC-230VAC/5A CO ST

The following table shows the technical specifications as of 01/2024. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7132-6HC50-0BU0/td?dl=en).

Article number	6ES7132-6HC50-0BU0
General information	
Product type designation	RQ 3x120VDC-230VAC/5A CO ST
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type U0
Color code for module-specific color identification plate	CC20
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V16 or higher
• STEP 7 configurable/integrated from version	Configurable via GSD file
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.34
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	40 mA; without load
Current consumption, max.	55 mA
output voltage / header	
Rated value (AC)	230 V
Power loss	
Power loss, typ.	1.6 W

Article number	6ES7132-6HC50-0BU0
Address area	
Address space per module	
• Inputs	+ 1 byte for QI information
• Outputs	1 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	type C
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type U0
• 3-wire connection	BU type U0
Digital outputs	
Type of digital output	Relays
Number of digital outputs	3
Current-sinking	Yes
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	No
Switching capacity of the outputs	
• with resistive load, max.	5 A; for an additional description, see the Technical Data in the Equipment Manual
• with inductive load, max.	2 A; for an additional description, see the Technical Data in the Equipment Manual
Parallel switching of two outputs	
• for logic links	Yes
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	2 Hz
• with inductive load, max.	0.5 Hz
• on lamp load, max.	2 Hz
Total current of the outputs	
• Current per channel, max.	5 A
• Current per module, max.	15 A
Total current of the outputs (per module)	
horizontal installation	
– up to 50 °C, max.	15 A
– up to 60 °C, max.	12 A; maximum channel current 4A
vertical installation	
– up to 40 °C, max.	15 A

Article number	6ES7132-6HC50-0BU0
– up to 50 °C, max.	12 A; maximum channel current 4A
Relay outputs	
• Number of relay outputs	3; changeover contact, isolated
• Rated supply voltage of relay coil L+ (DC)	24 V
• Current consumption of relays (coil current of all relays), max.	30 mA
• external protection for relay outputs	yes, with miniature fuse max. 6.3 A tripping current, quick-response tripping characteristic and 1 500 A breaking capacity
• Number of operating cycles, max.	1 000 000; see additional description in the manual
Switching capacity of contacts	
– with inductive load, max.	2 A; see additional description in the manual
– with resistive load, max.	5 A; see additional description in the manual
– Thermal continuous current, max.	5 A; Max. 1 385 VA, 150 W
– Switching current, min.	10 mA; 5 V DC
– Rated switching voltage (DC)	24 V DC to 120 V DC
– Rated switching voltage (AC)	24V AC to 230V AC
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	200 m
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	No
• Short-circuit	No
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED

Article number	6ES7132-6HC50-0BU0
Potential separation	
Potential separation channels	
• between the channels	Yes
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Isolation	
Isolation tested with	2 000 V DC (routine test)
tested with	
• between channels and backplane bus/supply voltage	2 000 V DC (routine test)
• between backplane bus and supply voltage	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	40 g

Derating trend

The following figure show the load current derating with horizontal and vertical mounting positions.

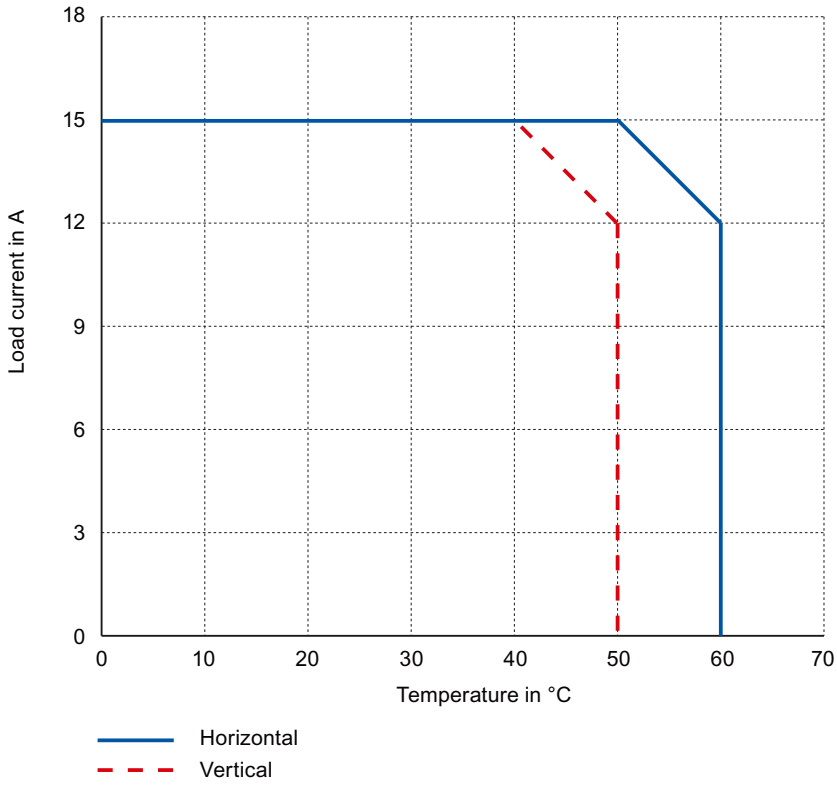

Figure 2-443 Load current and mounting position

Dimension drawing

See the manual ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521)

7.2 Switching cycles

Switching capacity and lifetime of the contacts

With an external protective circuit, the contacts will last longer than specified in the table. This table shows the switching capacity and lifetime of the relay contacts:

Table 2-424 Switching capacity and lifetime of the relay contacts

Resistive load	Voltage	Current	Switching cycles (typical)
For resistive load	24 V DC	5.0 A	0.1 million
		3.0 A	0.2 million
		2.0 A	0.3 million
		1.0 A	0.5 million
		0.5 A	0.8 million
		0.1 A	1 million
	48 V DC	2.0 A	0.3 million
		1.0 A	0.5 million
		0.5 A	0.8 million
		0.1 A	1 million
	60 V DC	1.0 A	0.5 million
		0.5 A	0.8 million
		0.1 A	1 million
	120 V DC	0.1 A	1 million
For resistive load	48 V AC to 230 V AC	5.0 A	0.1 million
		3.0 A	0.2 million
		2.0 A	0.3 million
		1.0 A	0.5 million
		0.5 A	0.8 million
		0.1 A	1 million
With inductive load Utilization category DC-13, R300 according to IEC/UL 60947-5-1	24 V DC	2.0 A	0.1 million
		1.0 A	0.3 million
		0.5 A	0.5 million
		0.1 A	1 million
	48 V DC	1.0 A	0.3 million
		0.5 A	0.5 million
		0.1 A	1 million
	60 V DC	0.5 A	0.5 million
		0.1 A	1 million
	120 V DC	0.22 A	0.8 million
		0.1 A	1 million

* B300/UL certification only up to 1.5 A load current

Resistive load	Voltage	Current	Switching cycles (typical)
With inductive load Utilization category AC-15, B300 according to IEC/UL 60947-5-1	48 V AC to 230 V AC	2.0 A*	0.1 million
		1.0 A	0.3 million
		0.5 A	0.5 million
		0.1 A	1 million

* B300/UL certification only up to 1.5 A load current

NOTE

Tests of mechanical environmental conditions

Shock tested according to IEC 60068-2-27. Shock intensity: 100 m/s^2 peak value, 11 ms duration

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You have the option to reconfigure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

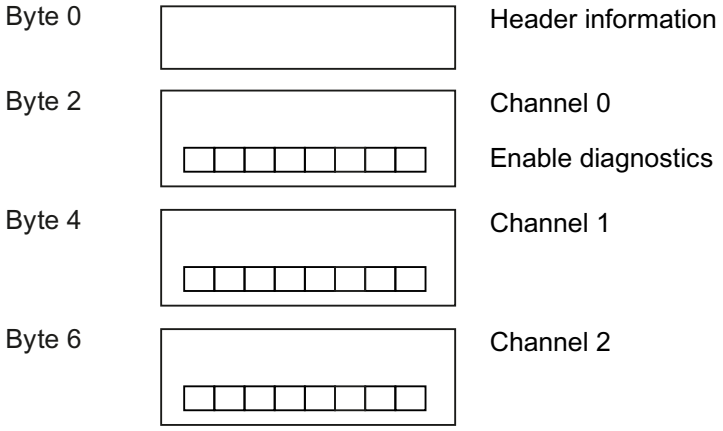

Figure 2-444 Structure of data record 128

Header information

The figure below shows the structure of the header information.

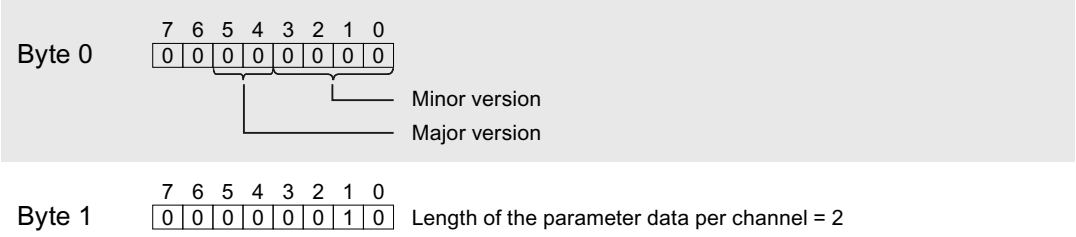

Figure 2-445 Header information

Parameters

The figure below shows the structure of the parameters in data record 128.

You enable a parameter by setting the corresponding bit to "1".

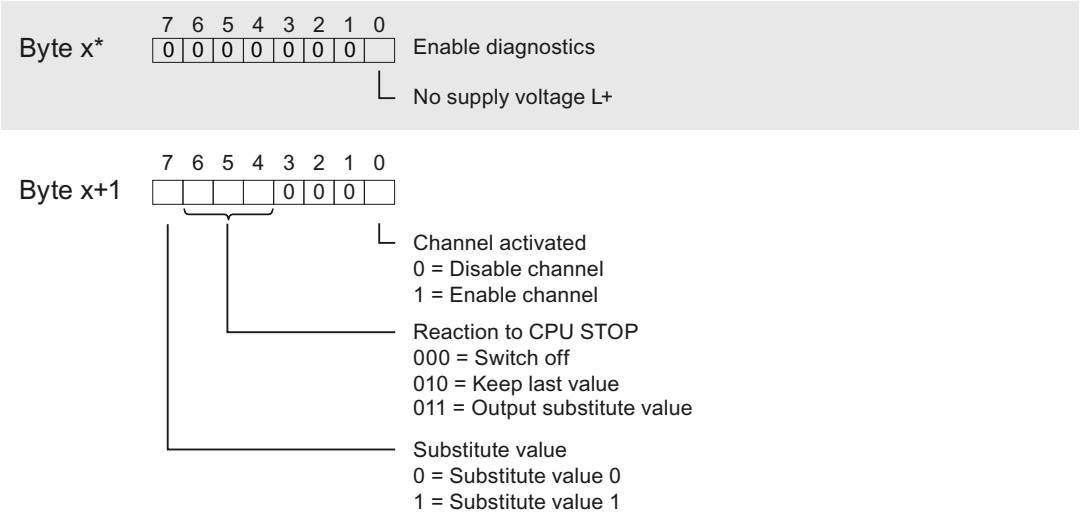

* x = 2 + (channel number × 2); channel number = 0 to 2

Figure 2-446 Structure byte x to x+1 for the channels 0 to 2

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter. (See also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	06	Invalid coding for substitute value behavior.	Check the parameters of the module.

SIEMENS

SIMATIC

ET 200SP
Digital Output Module RQ 3x120VDC-230VAC/5A CO n.i. ST (6ES7132-6HC70-0BU0)

Equipment Manual

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Parameter data record A

01/2024
A5E50097118-AB

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Introduction

1

Purpose of the documentation

This manual supplements the system manual ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old device, contact a company certified for the disposal of electronic waste and dispose of the device in accordance with the regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/84133942)

1.1.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.1.3 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

See also

PRONETA Professional (https://support.industry.siemens.com/cs/ww/en/view/109781283)

1.2 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109773881)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

Product overview

3

3.1 Properties

Article number

6ES7132-6HC70-0BU0

View of the module

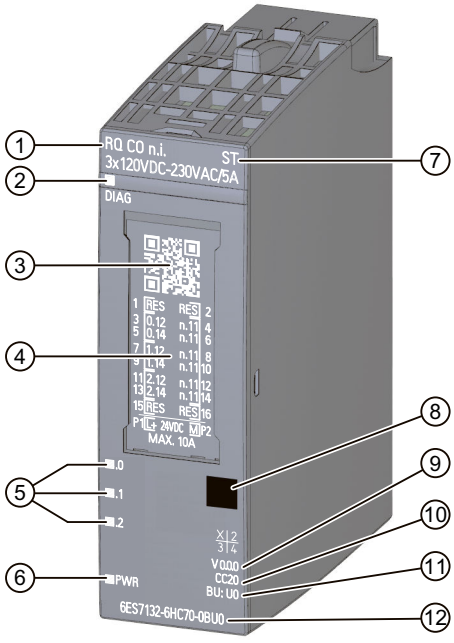

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-447 View of the module RQ 3x120VDC-230VAC/5A CO n.i. ST

Properties

The module has the following technical properties:

- Digital output module with 3 relay outputs with shared infeed to simplify wiring
- Supply voltage L+
- Output current per output 5 A
- Changeover contact (CO: change-over) consisting of one normally closed contact and one normally open contact
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights

The module supports the following functions:

Table 2-425 Version dependencies of the functions

Function	HW version	FW version	STEP 7	GSD file *	
			TIA Portal	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V16 or higher with HSP 0321*	X	X
Reconfiguration in RUN	FS01	V0.0.0 and higher	V16 or higher with HSP 0321*	X	X
PROFIenergy	FS01	V0.0.0 and higher	V16 or higher with HSP 0321*	X	X
Value status	FS01	V0.0.0 and higher	V16 or higher with HSP 0321*	X	-

* in compatibility mode of the RQ 3x120VDC-230VAC/5A CO ST (6ES7132-6HC50-0BU0)

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring up

4

4.1 Wiring and block diagram

This section includes the block diagram of the RQ 3x120VDC-230VAC/5A CO n.i. ST module with the terminal assignments for a 2-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

NOTE

You can use and combine the different wiring options for all channels.

NOTICE

The relay channels have no integrated short-circuit protection. Provide external short-circuit protection in the form of a miniature fuse with a maximum tripping current of 6.3 A and a fast tripping characteristic. A breaking capacity of at least 1500 A is required for mains voltages. For all other applications and for supply networks with a short-circuit current greater than 1500 A, you need to use a miniature fuse with an appropriately adapted breaking capacity.

WARNING

Do not connect exposed extra-low-voltage (SELV/PELV) and dangerous live voltages between channels at the same time!

If you only use dangerously live voltages, keep a maximum voltage difference of 300 V between the channels.

Connection: 2-wire connection of actuators

The following figure shows the block diagram and an example of the terminal assignment of the digital output module RQ 3x120VDC-230VAC/5A CO n.i. ST on the BaseUnit BU type U0.

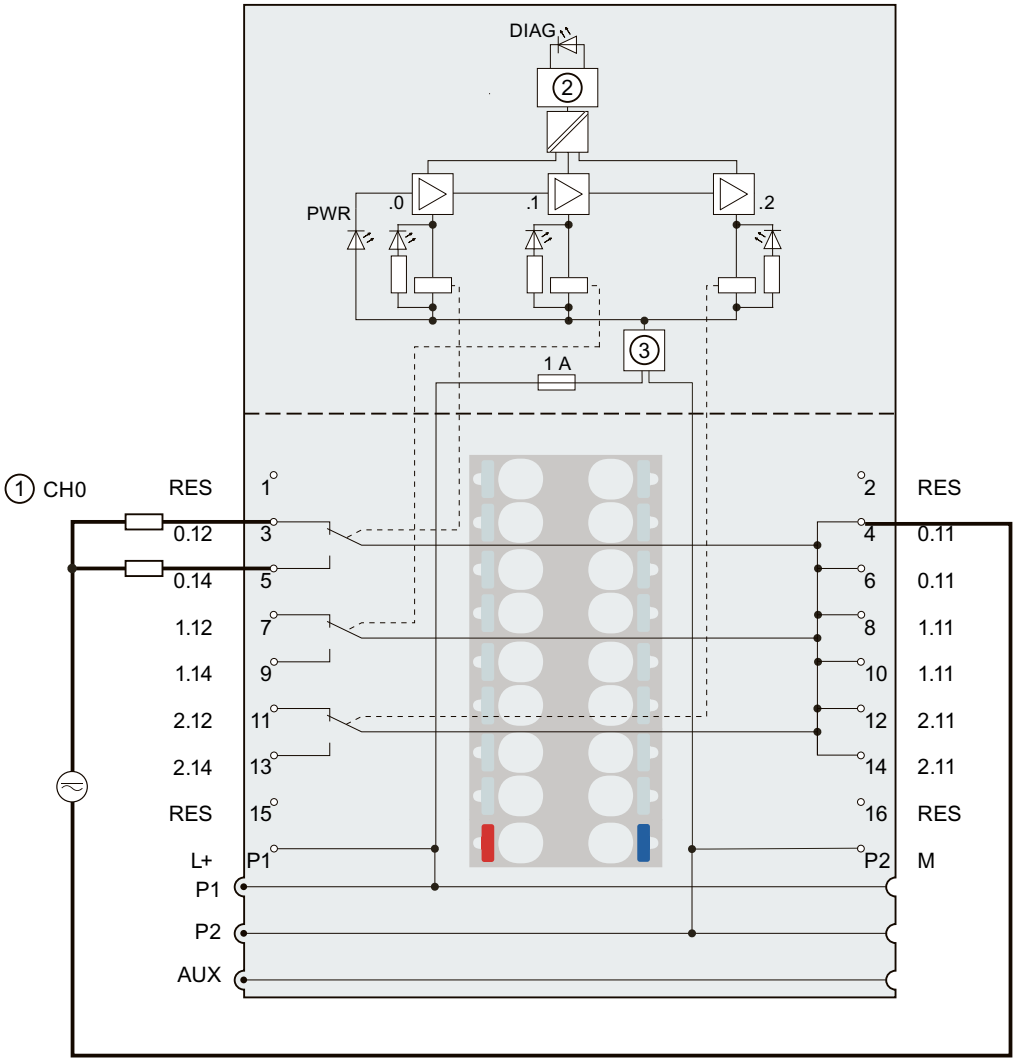

①	2-wire connection	RES	Reserve, must remain unused for future function extensions
②	Backplane bus interface	L+	24 V DC supply voltage
③	Polarity reversal protection	M	Ground
n.11	Common contact	DIAG	Diagnostics LED (green, red)
n.12	Normally closed contact	.0, .1, .2	Channel status LED (green)
n.14	Normally open contact	PWR	Power LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)		

Figure 2-448 Wiring and block diagram for 2-wire connection of actuators

Parameters/address space

5

5.1 Parameters

Parameter for RQ 3x120VDC-230VAC/5A CO n.i. ST

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU and an Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 26).

The following parameter settings are possible:

Table 2-426 Settable parameters and their defaults (GSD file)

Parameter	Value range	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal) [1]	
				GSD file PROFINET IO	GSD file PROFIBUS DP [2]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Channel enabled	• Disable • Enable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Shutdown • Keep last value • Output substitute value 1	Shutdown	Yes	Channel	Module

1 in compatibility mode of the RQ 3x120VDC-230VAC/5A CO ST (6ES7132-6HC50-0BU0)

2 Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the possible parameter settings are restricted. The parameter length of the I/O module is 4 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

5.2 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Channel activated

Determines whether a channel is enabled or disabled.

Reaction to CPU STOP

Specifies the behavior of the module if the CPU changes to STOP.

5.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of RQ 3x120VDC-230VAC/5A CO n.i. ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module using a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-427 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g., with STEP 7 (TIA Portal)		
		Integrated in hardware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 3-channel without value status	RQ 3x120VDC/230VAC/5A CO n.i. ST V0.0	V16 or higher with HSP 0321	X	X
1 x 3-channel with value status	RQ 3x120VDC/230VAC/5A CO n.i. ST V0.0, QI	V16 or higher with HSP 0321	X	---

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 2 in this byte are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

Assignment in the process image output (PIQ)

	7	6	5	4	3	2	1	0	Output value
QB x	0	0	0	0	0				Channels 0 to 2

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	Value status (QI)
IB x	0	0	0	0	0				Channels 0 to 2 (value status QI0 to QI2)

Figure 2-449 Address space of RQ 3x120VDC-230VAC/5A CO n.i. ST with value status

Interrupts/diagnostics alarms

6

6.1 Status and error display

LED display

The figure below shows the LED displays (status and error displays) of the RQ 3x120VDC-230VAC/5A CO n.i. ST.

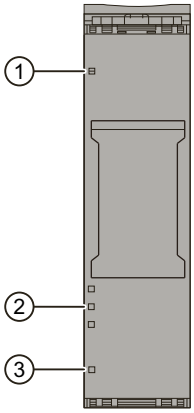

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-450 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 20).

DIAG LED

Table 2-428 DIAG LED fault/error display

DIAG LED	Meaning
☐ off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module not ready for operation (no parameters assigned)
■ on	Module parameters assigned
☼ Flashes	Module diagnostics is available

Channel status LED

Table 2-429 Status display of the channel status LED

Channel status LED	Meaning
☐ off	Channel deactivated or activated and process signal = 0
■ on	Channel activated and process signal = 1

PWR LED

Table 2-430 Status display of the PWR LED

PWR LED	Meaning
☐ off	No supply voltage L+
■ on	Supply voltage L+ present

6.2 Interrupts

The digital output module RQ 3x120VDC-230VAC/5A CO n.i. ST supports diagnostics interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Parameter assignment error
- No supply voltage

6.3 Diagnostics alarms

A diagnostic alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-431 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications 7

7.1 Technical specifications

Technical specifications of the RQ 3x120VDC-230VAC/5A CO n.i. ST

The following table shows the technical specifications as of 01/2024. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7132-6HC70-0BU0/td?dl=en).

Article number	6ES7132-6HC70-0BU0
General information	
Product type designation	RQ 3x120VDC-230VAC/5A CO n.i. ST
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type U0
Color code for module-specific color identification plate	CC20
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	40 mA; without load
Current consumption, max.	55 mA
output voltage / header	
Rated value (AC)	230 V
Power loss	
Power loss, typ.	1.4 W
Address area	
Address space per module	
• Inputs	+ 1 byte for QI information
• Outputs	1 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes

Article number	6ES7132-6HC70-0BU0
• Type of mechanical coding element	type C
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type U0
• 3-wire connection	BU type U0
Digital outputs	
Type of digital output	Relays
Number of digital outputs	3
Current-sinking	Yes
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	No
Switching capacity of the outputs	
• with resistive load, max.	5 A; for an additional description, see the Technical Data in the Equipment Manual
• with inductive load, max.	2 A; for an additional description, see the Technical Data in the Equipment Manual
Parallel switching of two outputs	
• for logic links	Yes
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	2 Hz
• with inductive load, max.	0.5 Hz
• on lamp load, max.	2 Hz
Total current of the outputs	
• Current per channel, max.	5 A
• Current per module, max.	5 A
Total current of the outputs (per module)	
horizontal installation	
– up to 50 °C, max.	5 A
– up to 60 °C, max.	5 A
vertical installation	
– up to 40 °C, max.	5 A
– up to 50 °C, max.	5 A
Relay outputs	
• Number of relay outputs	3; Changeover contact, non-floating
• Rated supply voltage of relay coil L+ (DC)	24 V
• Current consumption of relays (coil current of all relays), max.	40 mA

Article number	6ES7132-6HC70-0BU0
• external protection for relay outputs	yes, with miniature fuse max. 6.3 A tripping current, quick-response tripping characteristic and 1 500 A breaking capacity
• Number of operating cycles, max.	1 000 000; see additional description in the manual
Switching capacity of contacts	
– with inductive load, max.	2 A; see additional description in the manual
– with resistive load, max.	5 A; see additional description in the manual
– Thermal continuous current, max.	5 A; Max. 1 385 VA, 150 W
– Switching current, min.	10 mA; 5 V DC
– Rated switching voltage (DC)	24 V DC to 120 V DC
– Rated switching voltage (AC)	24V AC to 230V AC
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	200 m
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	No
• Short-circuit	No
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Isolation	
Isolation tested with	2 000 V DC (routine test)

Article number	6ES7132-6HC70-0BU0
tested with	
• between channels and backplane bus/supply voltage	2 000 V DC (routine test)
• between backplane bus and supply voltage	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	40 g

Dimension drawing

See the manual ET 200SP BaseUnits
(https://support.industry.siemens.com/cs/ww/en/view/59753521)

7.2 Switching cycles

Switching capacity and lifetime of the contacts

With an external protective circuit, the contacts will last longer than specified in the table. This table shows the switching capacity and lifetime of the relay contacts:

Table 2-432 Switching capacity and lifetime of the relay contacts

Resistive load	Voltage	Current	Switching cycles (typical)
For resistive load	24 V DC	5.0 A	0.1 million
		3.0 A	0.2 million
		2.0 A	0.3 million
		1.0 A	0.5 million

* B300/UL certification only up to 1.5 A load current

Resistive load	Voltage	Current	Switching cycles (typical)
For resistive load	24 V DC	0.5 A	0.8 million
		0.1 A	1 million
	48 V DC	2.0 A	0.3 million
		1.0 A	0.5 million
		0.5 A	0.8 million
		0.1 A	1 million
	60 V DC	1.0 A	0.5 million
		0.5 A	0.8 million
		0.1 A	1 million
	120 V DC	0.1 A	1 million
For resistive load	48 V AC to 230 V AC	5.0 A	0.1 million
		3.0 A	0.2 million
		2.0 A	0.3 million
		1.0 A	0.5 million
		0.5 A	0.8 million
		0.1 A	1 million
With inductive load Utilization category DC-13, R300 according to IEC/UL 60947-5-1	24 V DC	2.0 A	0.1 million
		1.0 A	0.3 million
		0.5 A	0.5 million
		0.1 A	1 million
	48 V DC	1.0 A	0.3 million
		0.5 A	0.5 million
		0.1 A	1 million
	60 V DC	0.5 A	0.5 million
		0.1 A	1 million
	120 V DC	0.22 A	0.8 million
		0.1 A	1 million
With inductive load Utilization category AC-15, B300 according to IEC/UL 60947-5-1	48 V AC to 230 V AC	2.0 A*	0.1 million
		1.0 A	0.3 million
		0.5 A	0.5 million
		0.1 A	1 million

* B300/UL certification only up to 1.5 A load current

NOTE

Tests of mechanical environmental conditions

Shock tested according to IEC 60068-2-27. Shock intensity: 100 m/s^2 peak value, 11 ms duration

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You have the option to reconfigure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

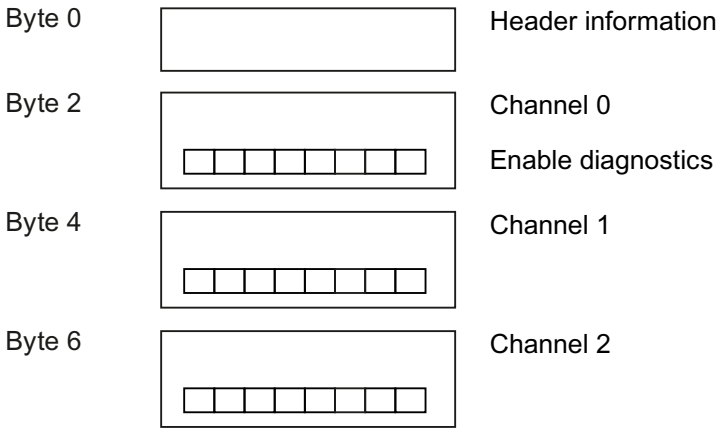

Figure 2-451 Structure of data record 128

Header information

The figure below shows the structure of the header information.

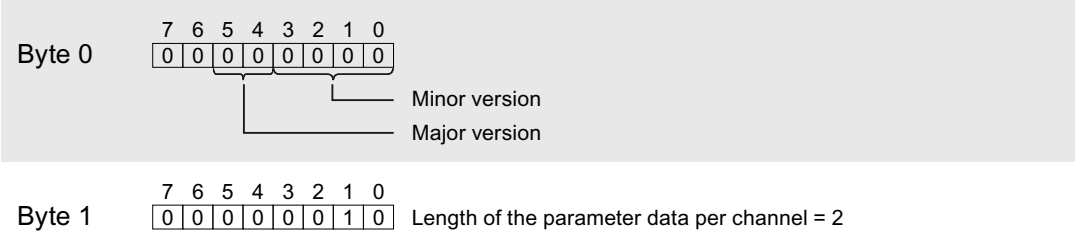

Figure 2-452 Header information

Parameters

The figure below shows the structure of the parameters in data record 128.

You enable a parameter by setting the corresponding bit to "1".

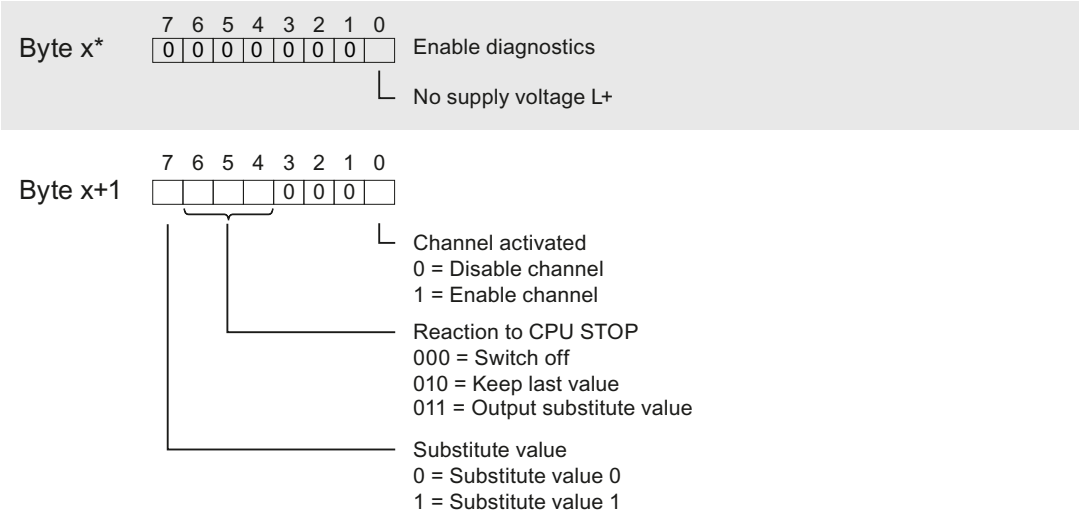

* x = 2 + (channel number × 2); channel number = 0 to 2

Figure 2-453 Structure byte x to x+1 for the channels 0 to 2

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter. (See also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	06	Invalid coding for substitute value behavior.	Check the parameters of the module.

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SIMATIC

ET 200SP
Digital output module RQ 4x24VUC/2A CO ST (6ES7132-6GD51-0BA0)

Equipment Manual

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Interrupts/diagnostics alarms 5

Technical specifications 6

Parameter data record A

02/2019

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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

Technical specifications: Ambient temperature in horizontal and vertical mounting position, extended to min. -30 °C.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

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ET 200SP Documentation Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

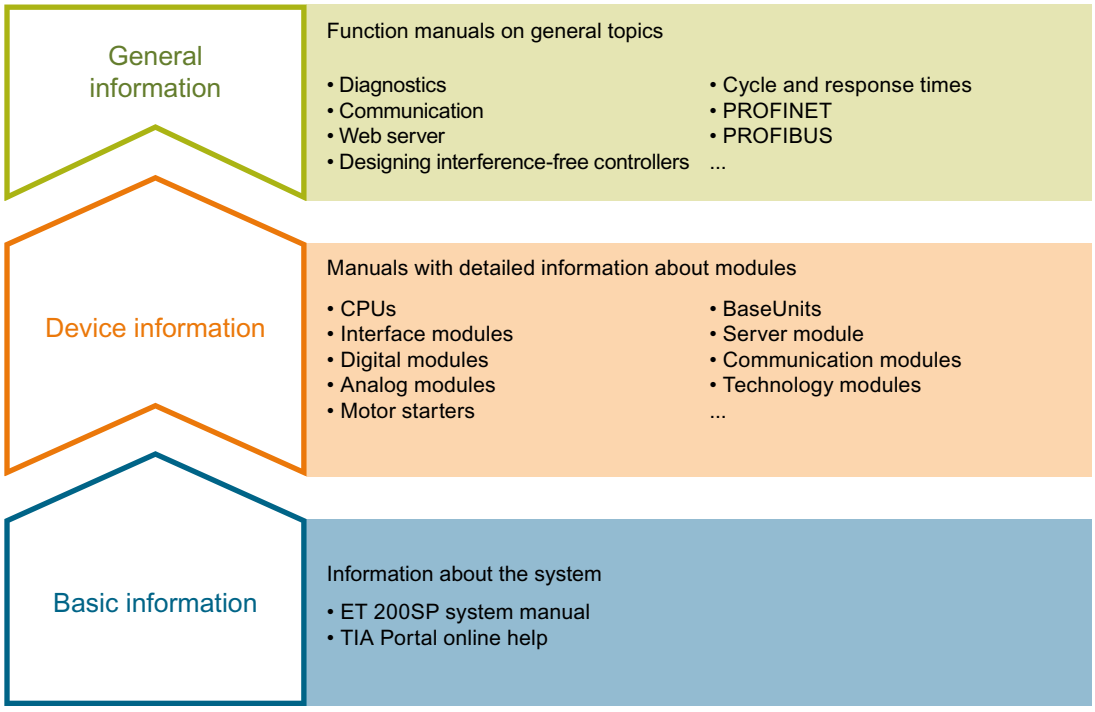

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

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Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

Product overview

2

2.1 Properties

Part number

6ES7132-6GD51-0BA0

View of the module

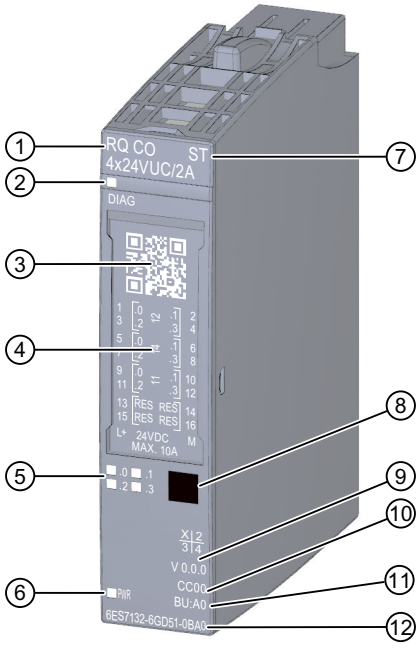

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-454 View of the RQ 4×24VUC/2A CO ST module

Properties

The module has the following technical properties:

- 4 digital outputs with floating relay changeover contacts
- Supply voltage L+
- Output current per output 2 A
- Normally open contact (NO: normally open) and normally closed contact (NC: normally closed)
- Assignable substitute values (per channel)
- Configurable diagnostics (per module)
- Suitable for resistive load

The module supports the following functions:

Table 2-433 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0232 V7.0	X	X
Configuration in RUN	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0232 V7.0	X	X
PROFIenergy	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0232 V7.0	X	X
Value status	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0232 V7.0	X	X

Accessories

The following accessories are supplied with the module and can also be ordered separately as spare parts:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP Distributed I/O System (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the RQ 4x24VUC/2A CO ST module with the terminal assignments for a 3-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

NOTE

You may use and combine the different wiring options for all channels.

Connection: 2-wire connection of actuators

The following figure shows the block diagram and an example of the terminal assignment of the digital output module RQ 4x24VUC/2A CO ST on the BaseUnit BU type A0.

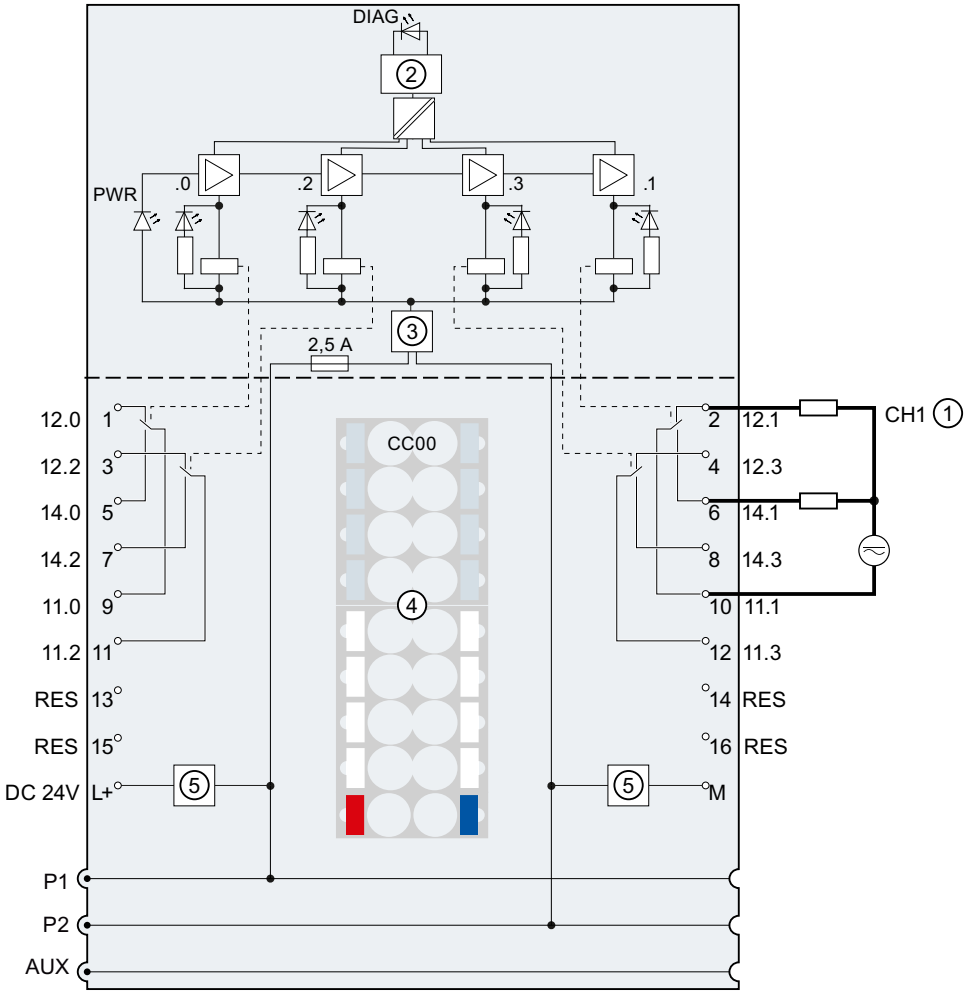

①	2-wire connection	11.n	Common contact
②	Backplane bus interface	12.n	Normally closed contact
③	Reverse polarity protection	14.n	Normally open contact
④	Color-coded label CCxx (optional)	n	Channel
⑤	Filter connection supply voltage (only when light-colored BaseUnit is present)	DIAG	Diagnostics LED (green, red)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)	L+	24 V DC (infeed only with light-colored BaseUnit)
.0, .1, .2, .3	Channel status LED (green)	PWR	Power LED (green)
		M	Ground

Figure 2-455 Wiring and block diagram for 2-wire connection of actuators

Parameters/address space

4

4.1 Parameters

RQ 4x24VUC/2A CO ST parameters

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records (see chapter Parameter assignment and structure of the parameter data record (Page 22)).

Table 2-434 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP[1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Channel activated	• Disable • Enable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

1 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 4 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter, however, with data record 128, see appendix "Parameter data record".

4.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Channel activated

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of RQ 4x24VUC/2A CO ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module using a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-435 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in hardware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel without value status	RQ 4x24VUC/2A CO ST V0.0	V14, SP1 or higher with HSP 0222	X	X
1 x 4-channel with value status	RQ 4x24VUC/2A CO ST V0.0, QI	V14, SP1 or higher with HSP 0222	X	---

Evaluating the value status

An additional two bytes are allocated in the input address space if you enable the value status for the digital module. Bits 0 to 3 in these bytes are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the RQ 4x24VUC/2A CO ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

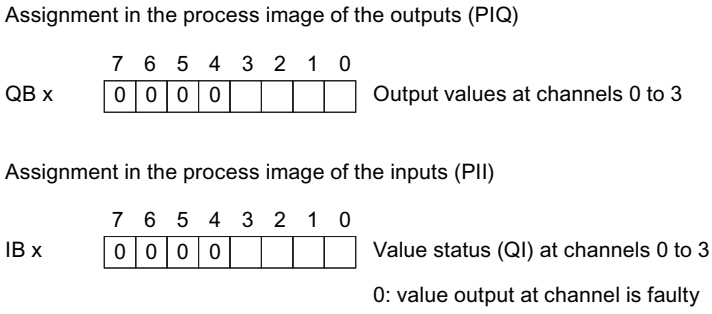

Figure 2-456 Address space of the digital output module RQ 4x24VUC/2A CO ST

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the RQ 4x24VUC/2A CO ST.

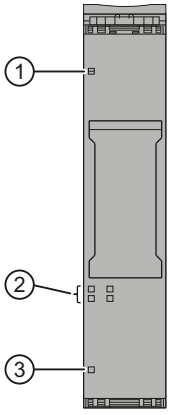

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-457 LED display

Meaning of the LED displays

The tables below explain the meaning of the status and error displays. Remedial measures for diagnostics alarms can be found in section Diagnostics alarms (Page 16).

LED DIAG

Table 2-436 Error display of the LED DIAG

LED DIAG	Meaning
☐ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module not ready for operation (no parameters assigned)
■ On	Module parameters assigned
☼ Flashes	Module diagnostics is available

LED channel status

Table 2-437 Status display of the LED channel status

LED channel status	Meaning
☐ Off	Channel deactivated or activated and process signal = 0
■ On	Channel activated

LED PWR

Table 2-438 Status display of the LED PWR

LED PWR	Meaning
☐ Off	No supply voltage L+
■ On	Supply voltage L+ present

5.2 Interrupts

The RQ 4×24VUC/2A CO ST digital output module supports diagnostics alarms.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following event:

- Parameter assignment error
- No supply voltage

Detailed information on the event is available in the STEP 7 online help.

5.3 Diagnostics alarms

Diagnostics alarms

A diagnostic alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-439 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Remedy
Parameter assignment error	10_H	The module cannot evaluate parameters for the channel	• Incorrect parameter assignment • Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the potential group • Check BaseUnit

Technical specifications 6

Technical specifications of the RQ 4x24VUC/2A CO ST

The following table shows the technical specifications as of 02/2019. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7132-6GD51-0BA0/td?dl=en).

Article number	6ES7132-6GD51-0BA0
General information	
Product type designation	RQ CO 4x24VDC/2A ST
HW functional status	From FS02
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V14
• STEP 7 configurable/integrated as of version	V5.5 SP3
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• DQ	Yes
• DQ with energy-saving function	No
• PWM	No
• Oversampling	No
• MSO	No
Redundancy	
• Redundancy capability	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	50 mA

Article number	6ES7132-6GD51-0BA0
Power loss	
Power loss, typ.	1.2 W
Address area	
Address space per module	
• Inputs	+ 1 byte for QI information
• Outputs	1 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Digital outputs	
Type of digital output	Relays
Number of digital outputs	4
Current-sinking	Yes
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	No
Parallel switching of two outputs	
• for logic links	Yes
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	2 Hz
Total current of the outputs	
• Current per channel, max.	2 A
• Current per module, max.	8 A
Total current of the outputs (per module)	
horizontal installation	
– up to 40 °C, max.	8 A
– up to 50 °C, max.	6 A
– up to 60 °C, max.	4 A
vertical installation	
– up to 30 °C, max.	8 A
– up to 40 °C, max.	6 A
– up to 50 °C, max.	4 A
Relay outputs	
• Number of relay outputs	4
• Rated supply voltage of relay coil L+ (DC)	24 V
• Current consumption of relays (coil current of all relays), max.	40 mA

Article number	6ES7132-6GD51-0BA0
Switching capacity of contacts	
– with resistive load, max.	2 A
– Thermal continuous current, max.	2 A
– Switching current, min.	1 mA; 5 V DC
– Rated switching voltage (DC)	24 V
– Rated switching voltage (AC)	24 V
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	200 m
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	No
• Short-circuit	No
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	Yes
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C

Article number	6ES7132-6GD51-0BA0
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

Derating trend

The following figure show the load current derating with horizontal and vertical mounting positions.

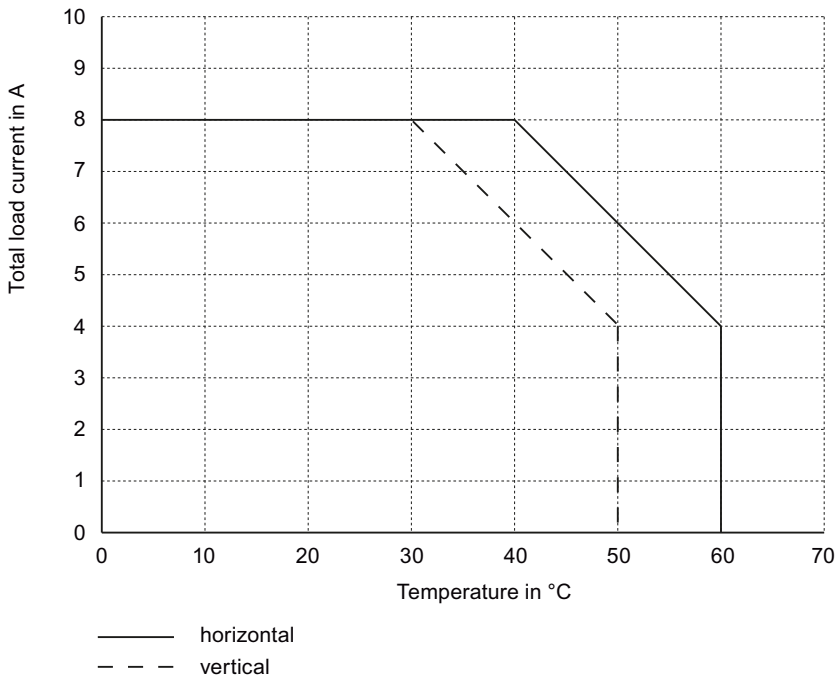

Figure 2-458 Load current for mounting position

Dimension drawing

See the manual ET 200SP BaseUnits
(https://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record A

A.1 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You have the option to re-configure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

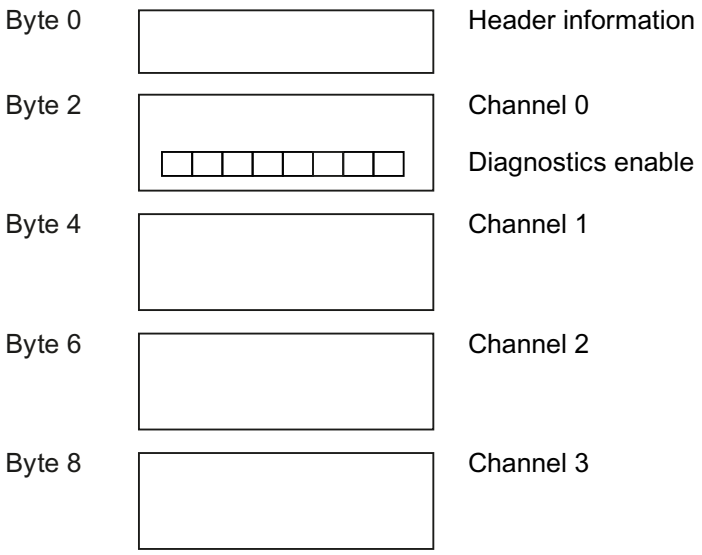

Figure 2-459 Structure of data record 128

Header information

The figure below shows the structure of the header information.

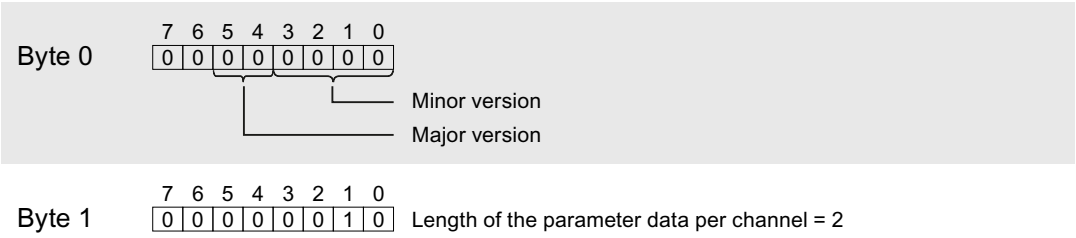

Figure 2-460 Header information

Parameters

The figure below shows the structure of the parameters in data record 128.

Enable a parameter by setting the corresponding bit to "1".

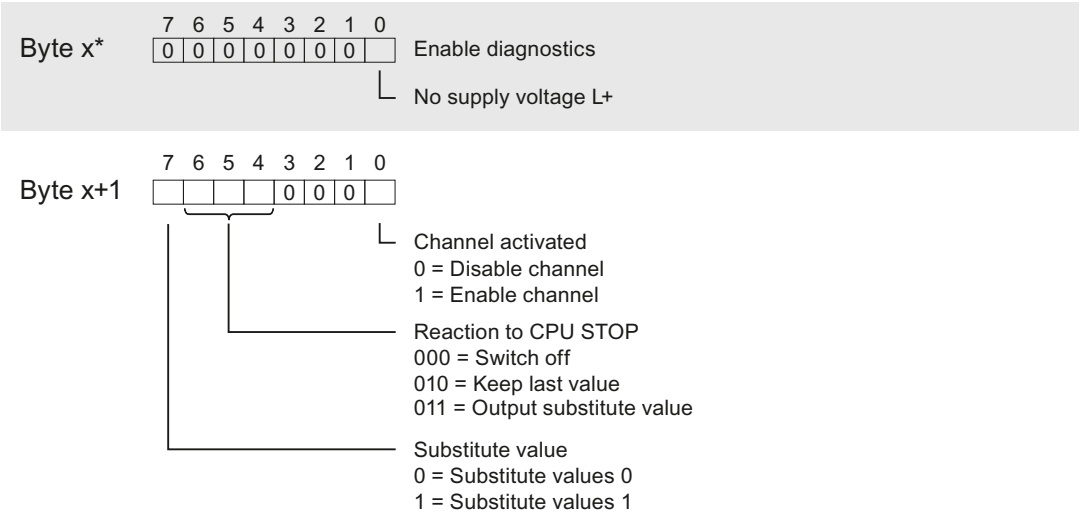

* x = 2 + (channel number × 2); channel number = 0 to 3

Figure 2-461 Structure byte x to x+1 for the channels 0 to 3

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter. (See also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	06	Invalid coding for substitute value behavior.	Check the parameters of the module.

SIEMENS

SIMATIC

ET 200SP
Digital output module RQ 4x120VDC-230VAC/5A NO ST (6ES7132-6HD01-0BB1)

Equipment Manual

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Parameter data record A

06/2020
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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

- Wiring and block diagram for current measurement 2-wire and 4-wire connection has been changed.
- The technical specifications have been updated.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

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ET 200SP Documentation Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

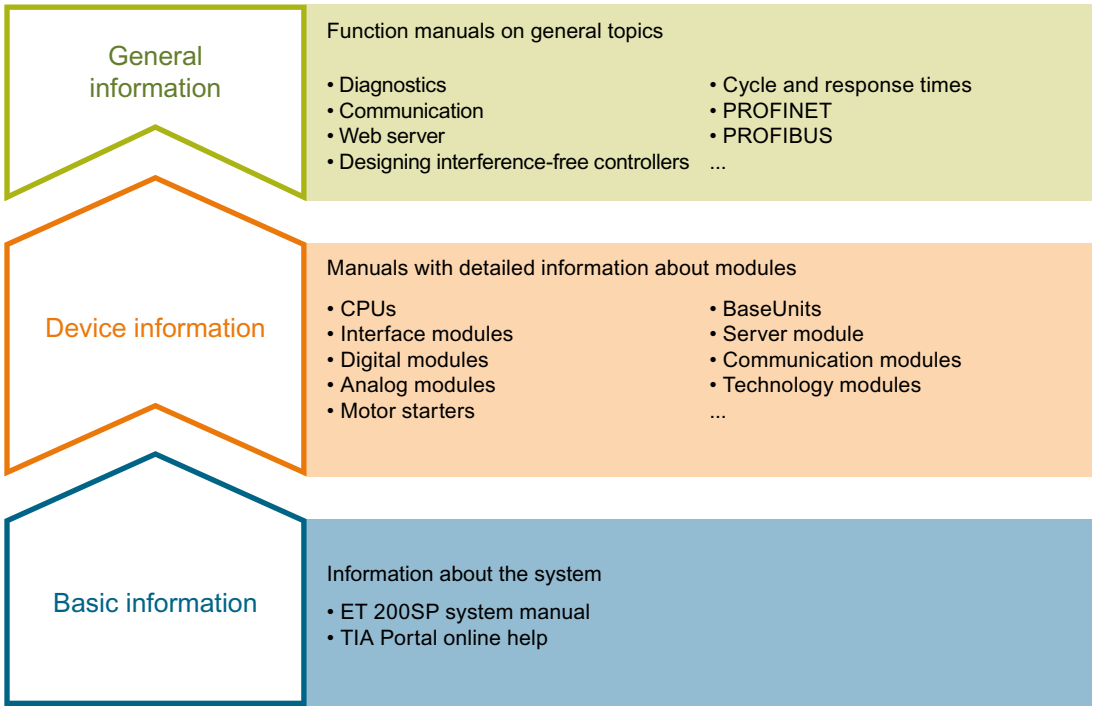

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

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You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

Product overview

2

2.1 Properties

Article number

6ES7132-6HD01-0BB1 (number in package unit: 1 unit)
6ES7132-6HD01-2BB1 (number in package unit: 10 units)

View of the module

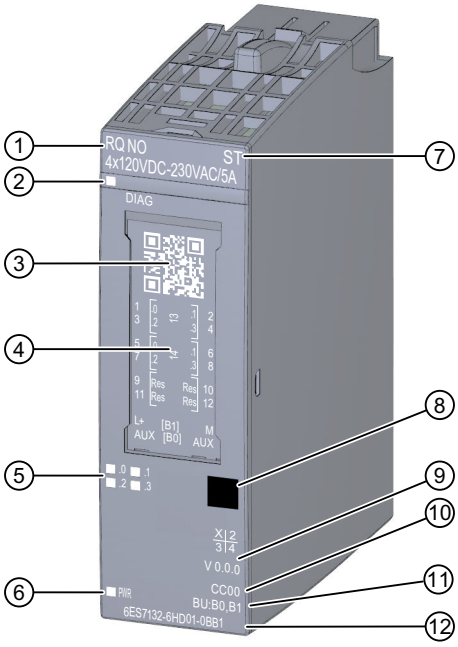

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-462 View of the RQ 4×120VDC-230VAC/5A NO ST module

Properties

The module has the following technical properties:

- Digital output module with 4 floating relay outputs
- Supply voltage L+
- Output current per output 5 A
- Normally open contact (NO: normally open)
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- Suitable for solenoid valves, DC contactors, and indicator lights

The module supports the following functions:

Table 2-440 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Identification data I&M0 to I&M3	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0232 V7.0	X	X
Configuration in RUN	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0232 V7.0	X	X
PROFIenergy	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0232 V7.0	X	X
Value status	FS01	V0.0.0 and higher	V14 or higher with HSP 0222	V5.5 SP3 or higher with HSP 0232 V7.0	X	X

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring up

3

3.1 Wiring and block diagram

This section includes the block diagram of the RQ 4x120VDC-230VAC/5A NO ST module with the terminal assignments for 2-wire and 3-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

NOTE

You may use and combine the different wiring options for all channels.

NOTE

- The relay contacts of the module can only switch identical voltage potential.
- The AUX terminals of the self-assembling voltage bus can be used for the connection of the protective conductor (PE) or for the same voltages up to a maximum of 24 V DC.

Connection: 3-wire connection of actuators

The following figure shows the block diagram and an example for the terminal assignment of the digital output module RQ 4x120VDC-230VAC/5A NO ST on the BaseUnit BU type B0.

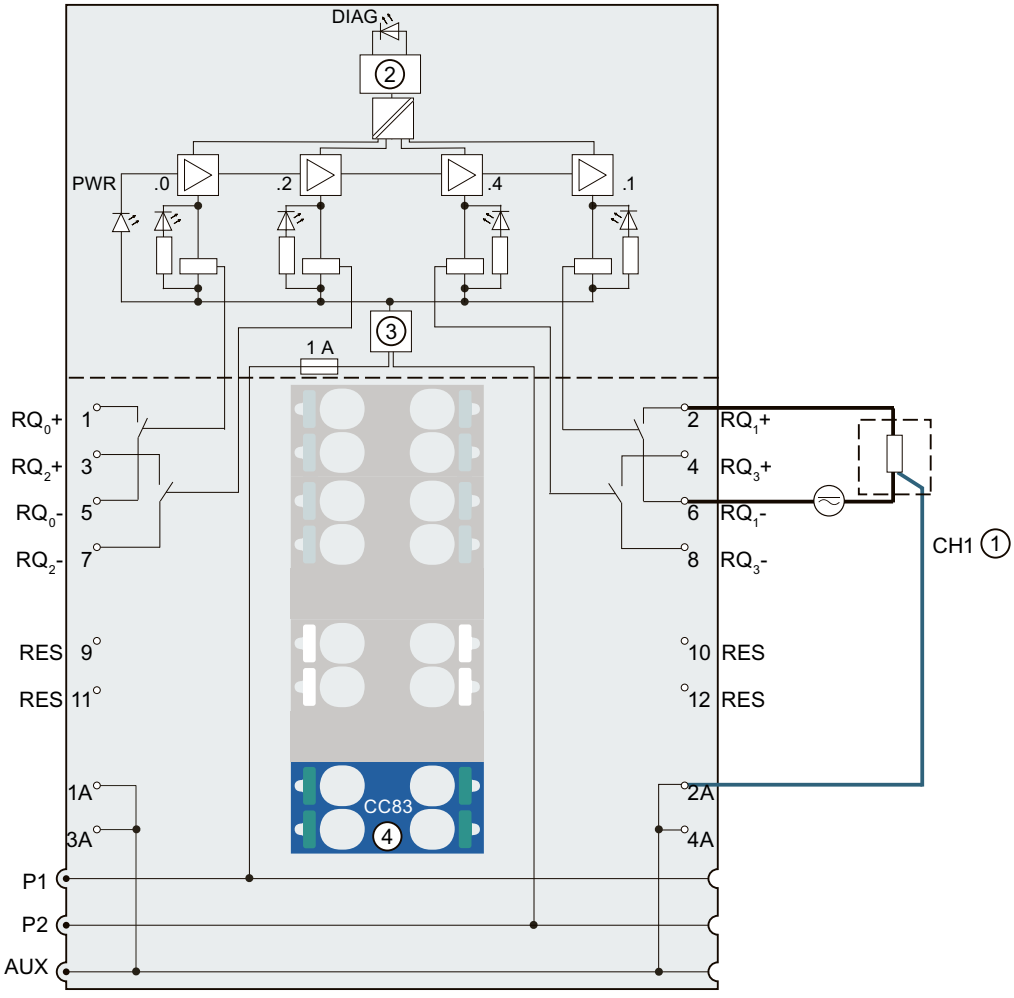

①	3-wire connection	RES	Reserve, must remain unused for future function extensions
②	Backplane bus interface	1A to 4A	AUX terminals
③	Polarity reversal protection	DIAG	Diagnostics LED (green, red)
④	Color identification label CCxx (optional)	.0, .1, .2, .3	Channel status LED (green)
RQ_n+, RQ_n-	Channel n	PWR	Power LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)		

Figure 2-463 Wiring and block diagram for 3-wire connection of actuators

Connection: 2-wire connection of actuators

The following figure shows the block diagram and an example for the terminal assignment of the digital output module RQ 4x120VDC-230VAC/5A NO ST on the BaseUnit BU type B1.

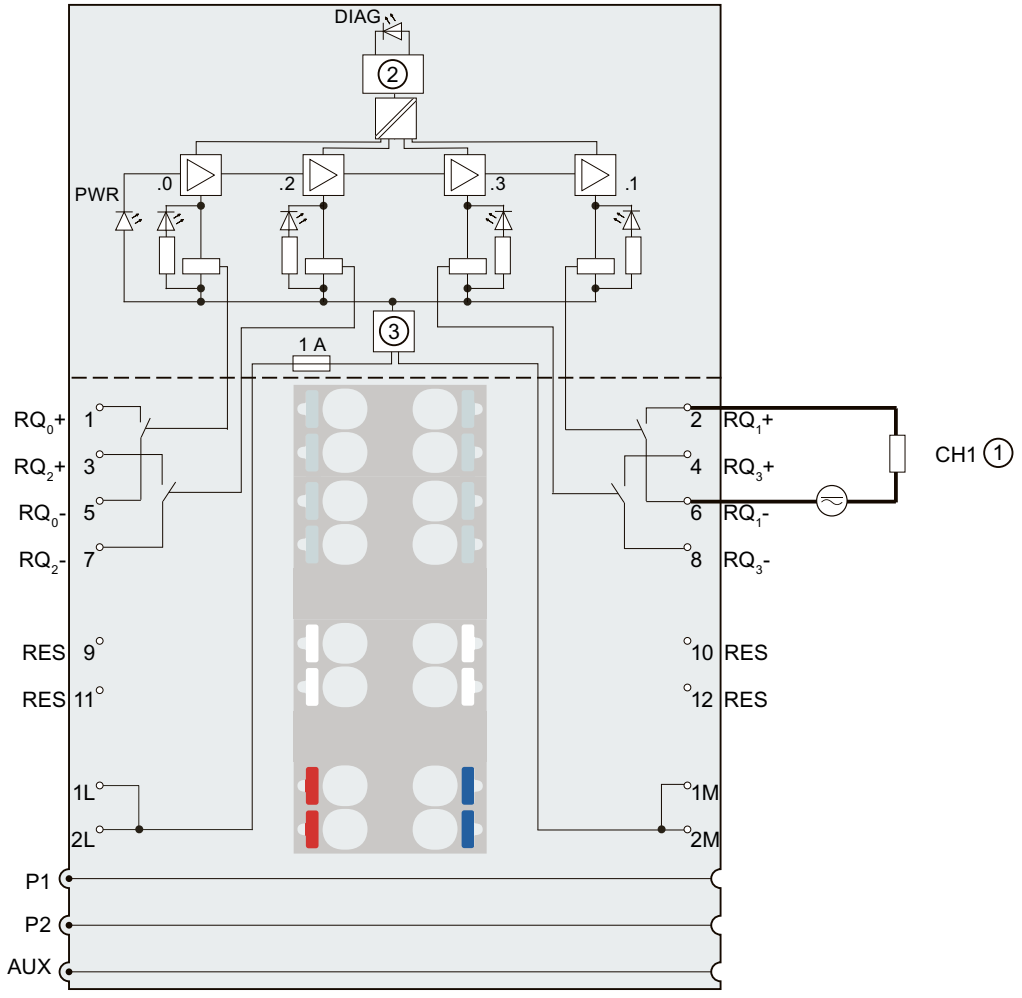

①	2-wire connection	1L, 2L	24 V DC supply voltage
②	Backplane bus interface	1M, 2M	Ground
③	Polarity reversal protection	DIAG	Diagnostics LED (green, red)
RQ_n+, RQ_n-	Channel n	.0, .1, .2, .3	Channel status LED (green)
RES	Reserve, must remain unused for future function extensions	PWR	Power LED (green)
		P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)

Figure 2-464 Wiring and block diagram for 2-wire connection of actuators

Parameters/address space

4

4.1 Parameters

Parameters for RQ 4x120VDC-230VAC/5A NO ST

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the parameters depends on the type of configuration.

The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 25).

The following parameter settings are possible:

Table 2-441 Settable parameters and their defaults (GSD file)

Parameter	Value range	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module	Module
Channel enabled	• Disable • Enable	Enable	yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	yes	Channel	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 4 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

4.2 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Channel activated

Determines whether a channel is enabled or disabled.

Reaction to CPU STOP

Specifies the behavior of the module if the CPU changes to STOP.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of RQ 4x120VDC-230VAC/5A NO ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module using a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-442 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in hard-ware catalog STEP 7	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel without value status	RQ 4x120VDC-230VAC/5A NO ST V0.0	V14, SP1 or higher with HSP 0222	X	X
1 x 4-channel with value status	RQ 4x120VDC-230VAC/5A NO ST V0.0, QI	V14, SP1 or higher with HSP 0222	X	---

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 3 in this byte are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the RQ 4x120VDC-230VAC/5A NO ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

Assignment in the process image output (PIQ)

	7	6	5	4	3	2	1	0	Output value
QB x	0	0	0	0					Channel 0 to 3

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	Value status (QI)
IB x	0	0	0	0					Channel 0 to 3 (value status QI0 to QI3)

Figure 2-465 Address space of RQ 4×120VDC-230VAC/5A NO ST with value status

Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays (status and error displays) of the RQ 4x120VDC-230VAC/5A NO ST.

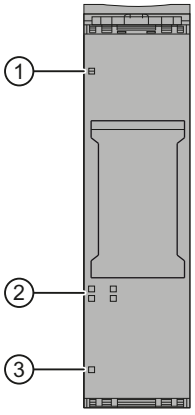

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-466 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 17).

DIAG LED

Table 2-443 DIAG LED fault/error display

DIAG LED	Meaning
☐ off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module not ready for operation (no parameters assigned)
■ on	Module parameters assigned
☼ Flashes	Module diagnostics is available

Channel status LED

Table 2-444 Status display of the channel status LED

Channel status LED	Meaning
☐ off	Channel deactivated or activated and process signal = 0
■ on	Channel activated and process signal = 1

PWR LED

Table 2-445 Status display of the PWR LED

PWR LED	Meaning
☐ off	No supply voltage L+
■ on	Supply voltage L+ present

5.2 Interrupts

The RQ 4×120VDC-230VAC/5A NO ST digital output module supports diagnostic interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Parameter assignment error
- No supply voltage

5.3 Diagnostics alarms

A diagnostic alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-446 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No supply voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications 6

6.1 Technical specifications

Technical specifications of RQ 4x120VDC-230VAC/5A NO ST

The following table shows the technical specifications as of 06/2020. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7132-6HD01-0BB1/td?dl=en).

Article number	6ES7132-6HD01-0BB1
General information	
Product type designation	RQ 4x120 VDC ... 230 VAC/5 A NO ST
HW functional status	From FS02
Firmware version	V0.0
• FW update possible	No
usable BaseUnits	BU type B0, B1
Color code for module-specific color identification plate	CC40
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V14
• STEP 7 configurable/integrated from version	V5.5 SP3
• PCS 7 configurable/integrated from version	V8.1 SP1
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.3
Operating mode	
• DQ	Yes
• DQ with energy-saving function	No
• PWM	No
• Oversampling	No
• MSO	No
Redundancy	
• Redundancy capability	Yes

Article number	6ES7132-6HD01-0BB1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	55 mA; without load
Output voltage	
Rated value (AC)	230 V
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
• Inputs	+ 1 byte for QI information
• Outputs	1 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	type C
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type B1
• 3-wire connection	BU type B0
Digital outputs	
Type of digital output	Relays
Number of digital outputs	4
Current-sinking	Yes
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	No
Parallel switching of two outputs	
• for logic links	Yes
• for uprating	No
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	2 Hz
• with inductive load, max.	0.5 Hz
• on lamp load, max.	2 Hz
Total current of the outputs	
• Current per channel, max.	5 A
• Current per module, max.	20 A

Article number	6ES7132-6HD01-0BB1
Total current of the outputs (per module)	
horizontal installation	
– up to 50 °C, max.	20 A
– up to 60 °C, max.	16 A
vertical installation	
– up to 40 °C, max.	20 A
– up to 50 °C, max.	16 A
Relay outputs	
• Number of relay outputs	4
• Rated supply voltage of relay coil L+ (DC)	24 V
• Current consumption of relays (coil current of all relays), max.	40 mA
• external protection for relay outputs	Yes, with miniature fuse max. 6 A tripping current and quick-response tripping characteristic
• Number of operating cycles, max.	7 000 000; see additional description in the manual
Switching capacity of contacts	
– with inductive load, max.	2 A; see additional description in the manual
– with resistive load, max.	5 A; see additional description in the manual
– Thermal continuous current, max.	5 A; Max. 1 385 VA, 150 W
– Switching current, min.	100 mA; 5 V DC
– Rated switching voltage (DC)	24 V DC to 120 V DC
– Rated switching voltage (AC)	24V AC to 230V AC
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	200 m
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	No
• Short-circuit	No
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	No

Article number	6ES7132-6HD01-0BB1
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	Yes
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Permissible potential difference	
between channels and backplane bus/supply voltage	240 V AC
Isolation	
Isolation tested with	2 500 V DC (type test)
tested with	
• between channels and backplane bus/supply voltage	2 500 V DC
• between backplane bus and supply voltage	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	40 g

Derating trend

The following figure show the load current derating with horizontal and vertical mounting positions.

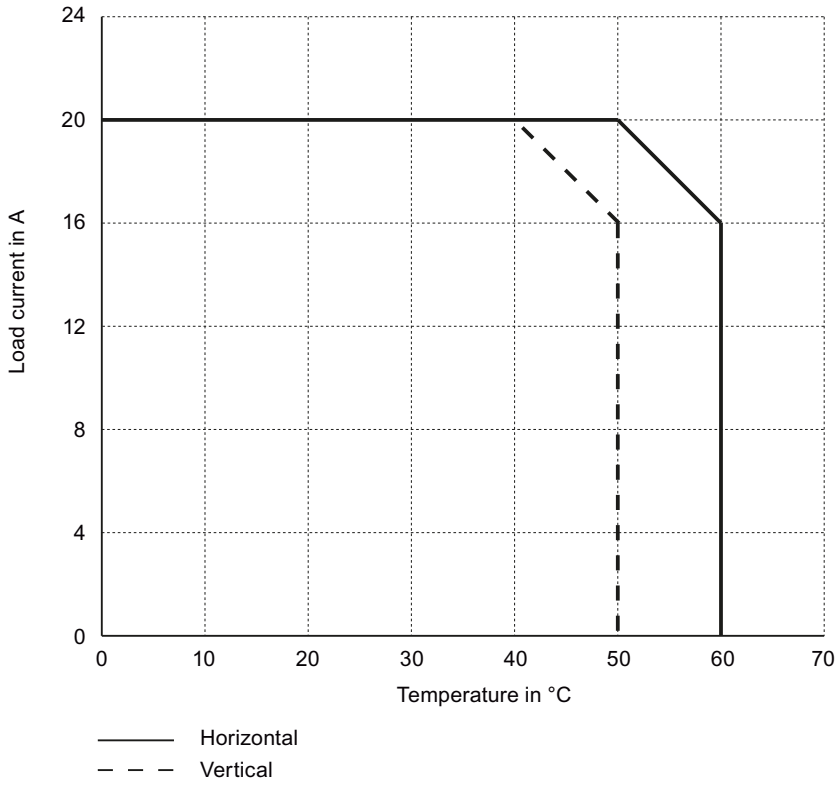

Figure 2-467 Load current and mounting position

Dimension drawing

See the manual ET 200SP BaseUnits (https://support.automation.siemens.com/WW/view/en/58532597/133300)

6.2 Switching cycles

Switching capacity and lifetime of the contacts

With an external protective circuit, the contacts will last longer than specified in the table. This table shows the switching capacity and lifetime of the relay contacts:

Table 2-447 Switching capacity and lifetime of the relay contacts

Resistive load	Voltage	Current	Switching cycles (typical)
For resistive load	24 VDC	5.0 A	0.1 million
		4.0 A	0.2 million
		2.0 A	0.5 million
		1.0 A	1.6 million
		0.5 A	4 million
		0.1 A	7 million
	60 VDC	0.5 A	1.6 million
	120 VDC	0.2 A	1.6 million
	48 VAC	2.0 A	1.6 million
	60 VAC	2.0 A	1.2 million
	120 VAC	5.0 A	0.1 million
		3.0 A	0.2 million
		2.0 A	0.4 million
		1.0 A	0.8 million
		0.5 A	1.5 million
	230 VAC	5.0 A	0.1 million
		3.0 A	0.2 million
		2.0 A	0.4 million
		1.0 A	0.8 million
		0.5 A	1.5 million
For inductive load in accordance with IEC 947-5-1 DC 13/ AC15	24 VDC	2.0 A	0.1 million
		1.0 A	0.2 million
		0.5 A	0.5 million
	60 VDC	0.5 A	0.2 million
	120 VDC	0.2 A	0.5 million
	48 VAC	1.0 A	0.7 million
	60 VAC	1.0 A	0.5 million
	120 VAC	2.0 A	0.1 million
		1.0 A	0.3 million
		0.5 A	1 million
		0.1 A	2 million

Resistive load	Voltage	Current	Switching cycles (typical)
For inductive load in accordance with IEC 947-5-1 DC 13/ AC15	230 VAC	2.0 A	0.1 million
		1.0 A	0.3 million
		0.5 A	1 million

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You have the option to reconfigure the module in RUN (e.g. the response of selected channels to the CPU-STOP state can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

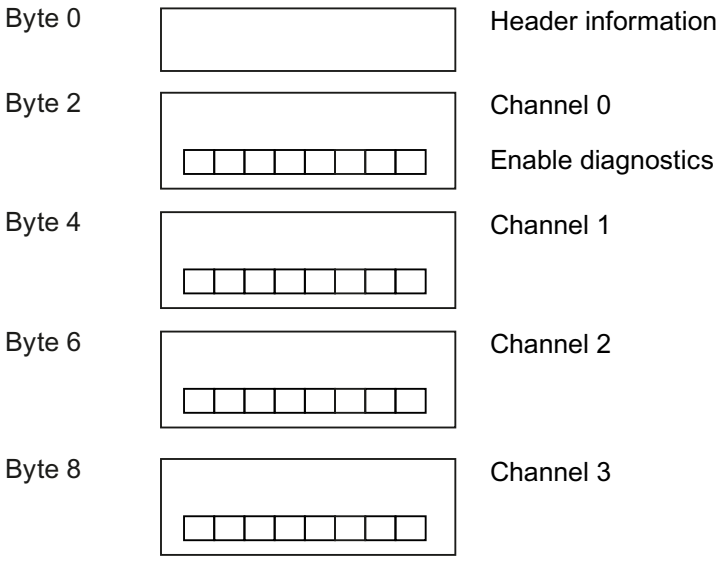

Figure 2-468 Structure of data record 128

Header information

The figure below shows the structure of the header information.

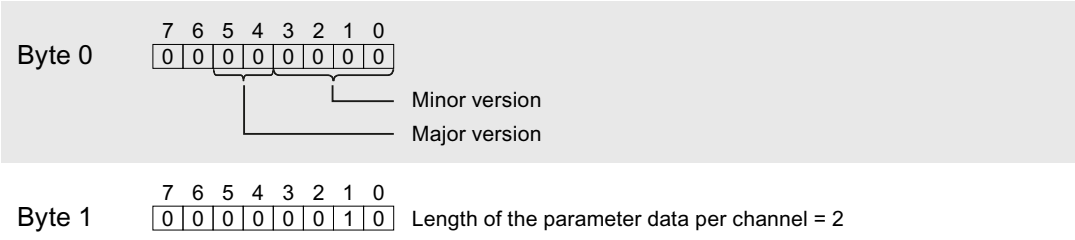

Figure 2-469 Header information

Parameters

The figure below shows the structure of the parameters in data record 128.

You enable a parameter by setting the corresponding bit to "1".

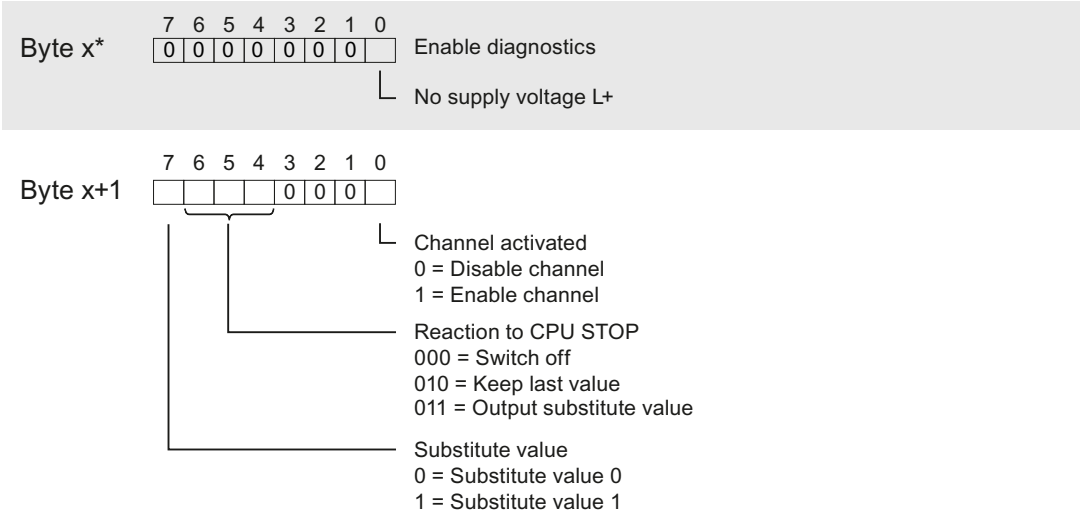

* x = 2 + (channel number × 2); channel number = 0 to 3

Figure 2-470 Structure byte x to x+1 for the channels 0 to 3

Error transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter. (See also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station whether the module is plugged or drawn. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	06	Invalid coding for substitute value behavior.	Check the parameters of the module.

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SIMATIC

ET 200SP
Digital output module RQ 4x120VDC-230VAC/5A NO MA ST (6ES7132-6MD00-0BB1)

Equipment Manual

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Interrupts/diagnostics alarms 5

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Parameter data record A

06/2020

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

- Wiring and block diagram for 2-wire and 3-wire connection has been changed.
- The technical specifications have been updated.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

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Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

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A.1 Parameter assignment and structure of the parameter data record 27

ET 200SP Documentation Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

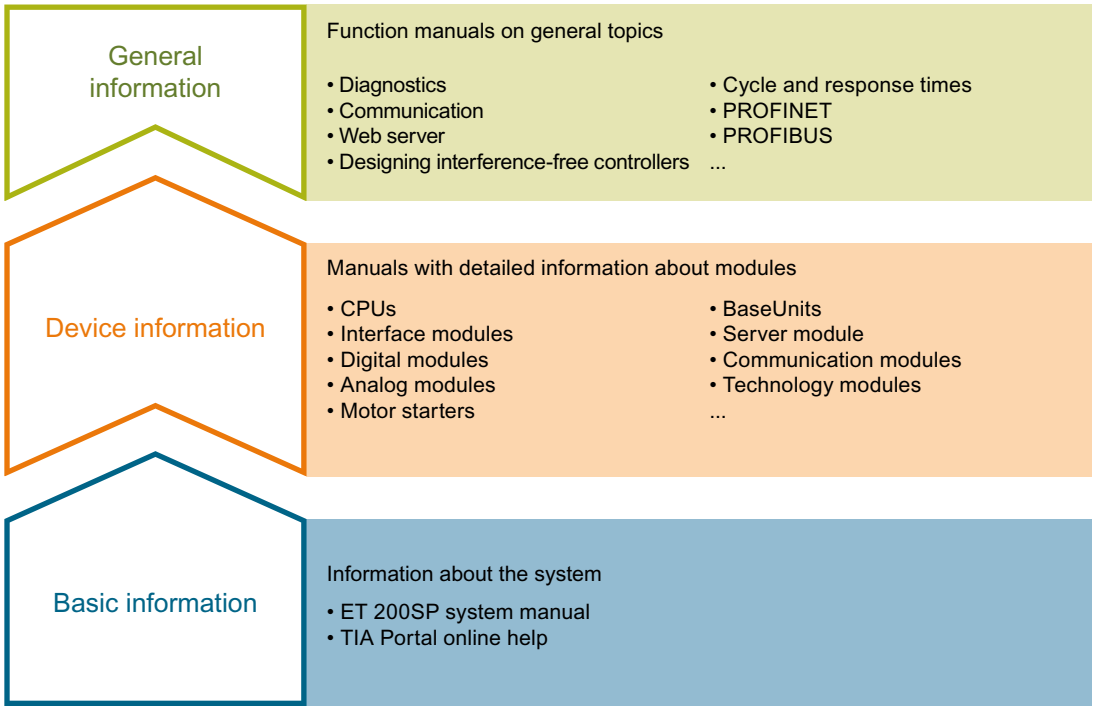

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

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Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

Product overview

2

2.1 Properties

Article number

6ES7132-6MD00-0BB1

View of the module

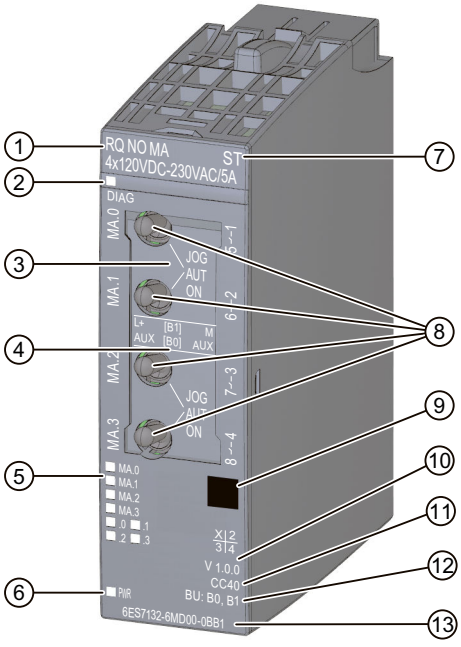

①	Module type and name	⑧	Toggle/jog switch for manually controlling the relay
②	LED for diagnostics	⑨	Color coding of module type
③	JOG (switch position up: jog) AUT (switch position "middle": Automatic mode ON (switch position down: Manual mode (MANUAL ON))	⑩	Function and firmware version
④	Wiring diagram	⑪	Color code for selection of the color coding labels
⑤	LEDs for channel status and manual mode	⑫	BU type
⑥	LED for supply voltage	⑬	Article number
⑦	Function class		

Figure 2-471 View of the module RQ 4×120VDC-230VAC/5A NO MA ST

Properties

The module has the following technical properties:

- Digital output module with 4 floating relay outputs
- Supply voltage L+
- Output current 5 A (per output)
- Normally open contact (NO: normally open)
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)
- 4 toggle/jog switches (jog, automatic or manual mode (MANUAL ON)) for controlling the relay
- Suitable for solenoid valves, DC contactors, and indicator lights

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy
- Value status

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

NOTE

When load voltage is present, the relays of the RQ 4x120VDC-230VAC/5A NO MA ST can also be activated via a manual switch even when they are in a non-configured state.

When an output is set to manual control, the relay remains active during a firmware update.

Accessories

The following accessories must be ordered separately:

- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Wiring

3

3.1 Wiring and block diagram

This section includes the block diagram of the RQ 4x120VDC-230VAC/5A NO MA ST module with the terminal assignments for a 2-wire and 3-wire connection.

You can find information on wiring the BaseUnit in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

You can use and combine the different wiring options for all channels.

NOTE

- The relay contacts of the module can only switch identical voltage potential.
- The AUX terminals of the self-assembling voltage bus can be used for the connection of the protective conductor (PE) or for the same voltages up to a maximum of 24 V DC.
- The switch position of the toggle/jog switch is stored in the process image input (PII) and can be read there.

Wiring: 3-wire connection of actuators

The following figure shows the block diagram and an example of the terminal assignment of the digital output module RQ 4x120VDC-230VAC/5A NO MA ST on the BaseUnit BU type B0.

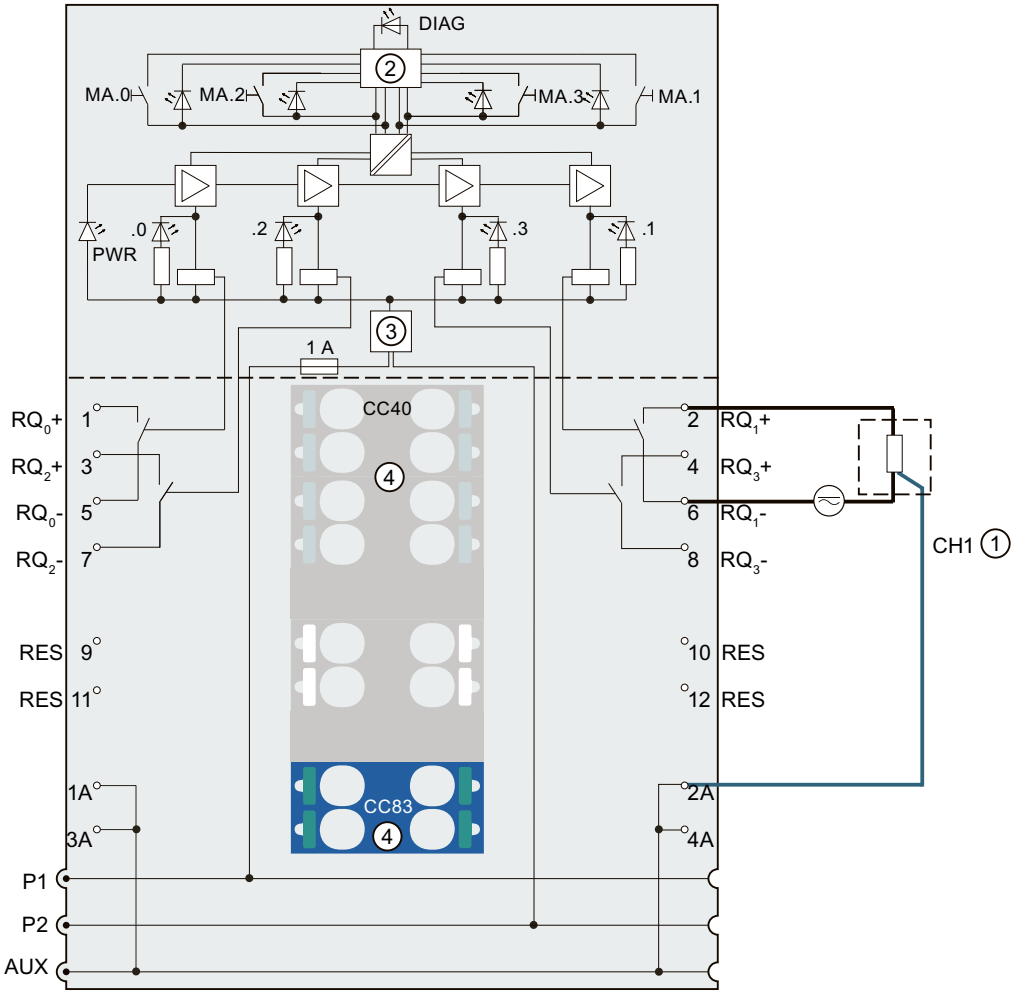

①	3-wire connection	RES	Reserve, must remain unused for future function extensions
②	Backplane bus interface	1A to 4A	AUX terminals
③	Polarity reversal protection	DIAG	Diagnostics LED (green, red)
④	Color-coded label with color codes CC40 and CC83 (optional)	MA .0 .. .3	LED MANUAL ON and automatic
RQ_n+, RQ_n-	Channel n	.0, .1, .2, .3	Channel status LED (green)
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)	PWR	Power LED (green)

Figure 2-472 Wiring and block diagram for 3-wire connection of actuators

Wiring: 2-wire connection of actuators

The following figure shows the block diagram and an example of the terminal assignment of the digital output module RQ 4x120VDC-230VAC/5A NO MA ST on the BaseUnit BU type B1.

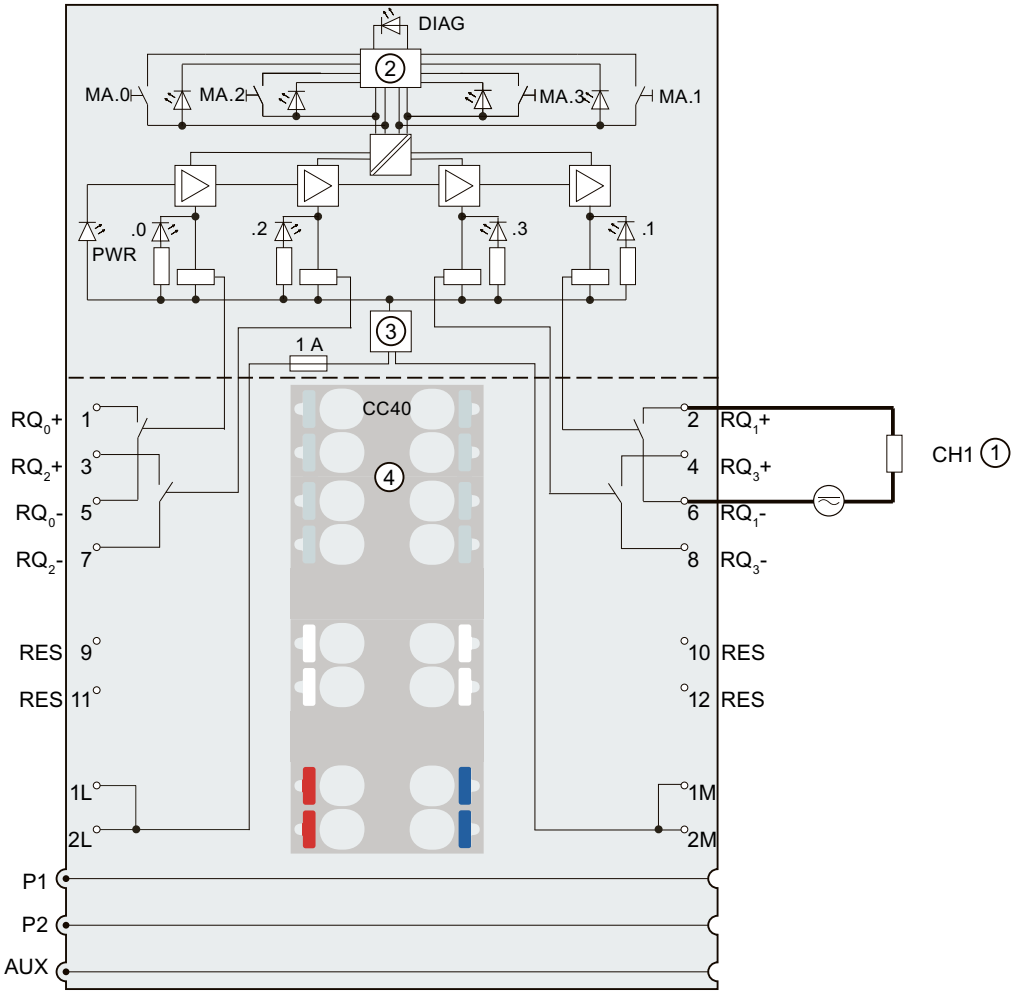

①	2-wire connection	1M, 2M	Ground
②	Backplane bus interface	DIAG	Diagnostics LED (green, red)
③	Polarity reversal protection	MA .0 .. .3	LED MANUAL ON and automatic
④	Color-coded label with color code CC40 (optional)	.0, .1, .2, .3	Channel status LED (green)
RQ_n+, RQ_n-	Channel n	PWR	Power LED (green)
RES	Reserve, must remain unused for future function extensions	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit)
1L, 2L	24 V DC supply voltage		

Figure 2-473 Wiring and block diagram for 2-wire connection of actuators

Toggle/jog switch for controlling the relay

You can switch the relay using the toggle/jog switch to jog, MANUAL ON (manual mode) or automatic mode for each channel. In manual mode, the state set by the output data is ignored.

The 4 toggle/jog switches are located on the front of the electronic module.

- JOG (switch position "up": job mode): Short-term manual operation (MANUAL ON), while jogged.
- AUT (switch position "middle" or "not activated": Automatic mode): Each channel is activated via the user program (normal operation).
- ON (switch position "down": Manual mode (MANUAL ON) permanently): Each channel is switched on ("1" signal) independent of the activation of the user program (and substitute values).

Parameters/address space

4

4.1 Parameters

Parameters for RQ 4x120VDC-230VAC/5A NO MA ST

The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of the parameter data record (Page 27).

The following parameter settings are possible:

Table 2-448 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [1]
Diagnostics: No supply voltage L+	• Enable • Disable	Disable	Yes	Module	Module
Channel activated	• Enable • Disable	Enable	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value 1	Turn off	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 4 bytes.

4.2 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Channel activated

Determines whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module in the event of a CPU STOP.

Potential group

The load or supply voltage is fed module by module. The voltage buses P1, P2 and AUX are looped through the module from the left to the right neighboring module without tap.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

4.3 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image output/input.

Configuration options of RQ 4×120VDC-230VAC/5A NO MA ST

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-449 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, as of V13, SP1	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel without value status	RQ 4×120VDC-230VAC/5A NO MA ST	X	X	X
1 x 4-channel with value status	RQ 4×120VDC-230VAC/5A NO MA ST, QI	X	X	-

Evaluating the value status

An additional byte is allocated in the input address space if you enable the value status for the digital module. Bits 0 to 3 in this byte are assigned to a channel. They provide information about the validity of the digital value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the RQ 4×120VDC-230VAC/5A NO MA ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

Assignment in the process image output (PIQ)

	7	6	5	4	3	2	1	0	Output value
QB x	0	0	0	0					Channels 0 to 3

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	Toggle/jog switch
IB x	0	0	0	0					Channels 0 to 3 (manual ON)

	7	6	5	4	3	2	1	0	Value status (QI)
IB x+1	0	0	0	0					Channel 0 to 3 (value status QI0 to QI3)

Figure 2-474 Address space of RQ 4×120VDC-230VAC/5A NO MA ST with value status

Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The following figure shows you the LED display of the RQ 4x120VDC-230VAC/5A NO MA ST.

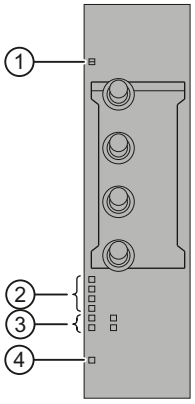

① DIAG (green/red)

② MA .0 .. .3 (yellow)

③ Channel status (green)

④ PWR (green)

Figure 2-475 LED display

Meaning of the LEDs

The following tables show the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 19).

DIAG LED

Table 2-450 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module not ready for operation (no parameters assigned)
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

LED MA 1..4

Table 2-451 Status display of the LED MA .0 .. .3 (manual mode)

Channel status LED	Meaning
Off	Automatic
On	Manual ON (toggle/jog switch) = Manual mode Output enabled at specific channel

Channel status LED

Table 2-452 Status display of the channel status LED

Channel status LED	Meaning
Off	Channel deactivated or activated and process signal = 0
On	Channel activated and process signal = 1

PWR LED

Table 2-453 Status display of the PWR LED

PWR LED	Meaning
Off	Missing supply voltage L+
On	Supply voltage L+ present

5.2 Interrupts

The digital output module RQ 4×120VDC-230VAC/5A NO MA ST supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-454 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update • Restart the firmware update

Technical specifications 6

6.1 Technical specifications

Technical specifications of the RQ 4×120VDC-230VAC/5A NO MA ST

The following table shows the technical specifications as of 06/2020. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7132-6MD00-0BB1/td?dl=en).

Article number	6ES7132-6MD00-0BB1
General information	
Product type designation	RQ 4x120 V DC ... 230 V AC/5 A NO MA ST
HW functional status	From FS03
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type B0, B1
Color code for module-specific color identification plate	CC40
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V13 SP1
• STEP 7 configurable/integrated from version	V5.5 SP3 / -
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.3
Operating mode	
• DQ	Yes
• DQ with energy-saving function	No
• PWM	No
• Oversampling	No
• MSO	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes

Article number	6ES7132-6MD00-0BB1
Input current	
Current consumption, max.	100 mA; without load
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
• Inputs	1 byte; With QI
• Outputs	1 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	type C
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type B1
• 3-wire connection	BU type B0
Digital outputs	
Type of digital output	Relays
Number of digital outputs	4
Short-circuit protection	No
Switching frequency	
• with resistive load, max.	2 Hz
• with inductive load, max.	0.5 Hz
• on lamp load, max.	2 Hz
Total current of the outputs	
• Current per channel, max.	5 A
• Current per module, max.	20 A
Total current of the outputs (per module)	
horizontal installation	
– up to 50 °C, max.	20 A
– up to 60 °C, max.	16 A
vertical installation	
– up to 40 °C, max.	20 A
– up to 50 °C, max.	16 A
Relay outputs	
• Number of relay outputs	4
• Rated supply voltage of relay coil L+ (DC)	24 V
• Current consumption of relays (coil current of all relays), max.	40 mA
• external protection for relay outputs	Yes, with miniature fuse max. 6 A tripping current and quick-response tripping characteristic

Article number	6ES7132-6MD00-0BB1
• Number of operating cycles, max.	7 000 000; see additional description in the manual
Switching capacity of contacts	
– with inductive load, max.	2 A; see additional description in the manual
– with resistive load, max.	5 A; see additional description in the manual
– Thermal continuous current, max.	5 A
– Switching current, min.	100 mA; 5 V DC
– Rated switching voltage (DC)	24 V DC to 120 V DC
– Rated switching voltage (AC)	24V AC to 230V AC
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	200 m
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	No
• Short-circuit	No
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	Yes
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Permissible potential difference	
between channels and backplane bus/supply voltage	240 V AC
Isolation	
Isolation tested with	2 500 V DC (type test)

Article number	6ES7132-6MD00-0BB1
tested with	
• between channels and backplane bus/supply voltage	2 500 V DC
• between backplane bus and supply voltage	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	45 g

NOTE

External fuse for relay outputs

The outputs have to be protected by an external fuse.

When installed in a danger area according to the National Electric Code (NEC), the fuse must only be removed with the correct tool when the module is not in an explosion-proof zone.

Derating trend

The following figure show the load current derating with horizontal and vertical mounting positions.

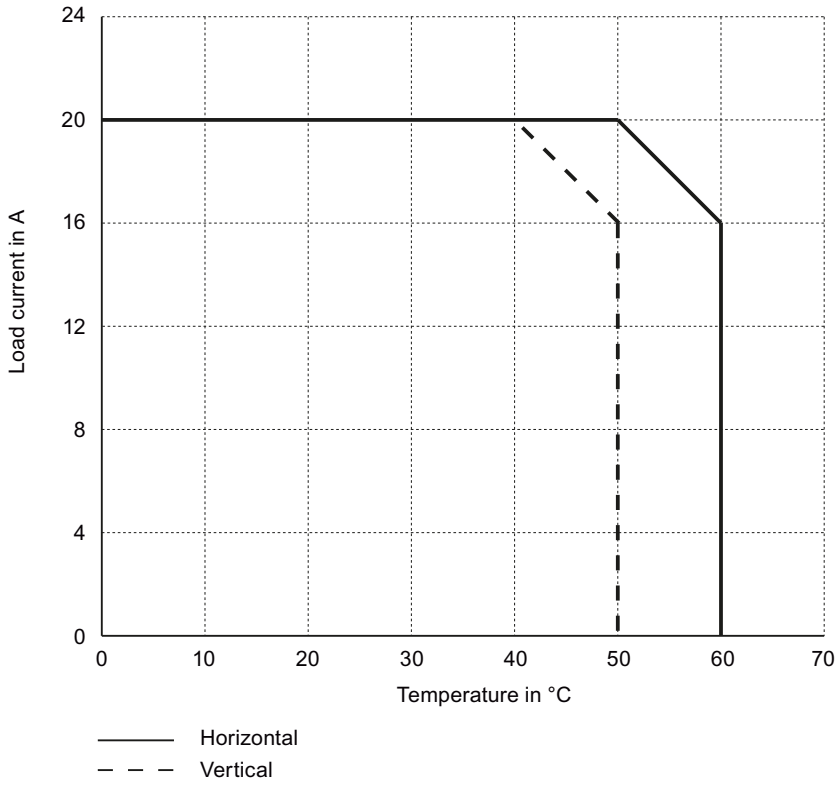

Figure 2-476 Load current for mounting position

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

6.2 Switching cycles

Switching capacity and lifetime of the contacts

With an external protective circuit, the contacts will last longer than specified in the table. This table shows the switching capacity and lifetime of the relay contacts:

Table 2-455 Switching capacity and lifetime of the relay contacts

Resistive load	Voltage	Current	Switching cycles (typical)
For resistive load	24 V DC	5.0 A	0.1 million
		4.0 A	0.2 million
		2.0 A	0.5 million
		1.0 A	1.6 million
		0.5 A	4 million
		0.1 A	7 million
	60 VDC	0.5 A	1.6 million
	120 VDC	0.2 A	1.6 million
	48 VAC	2.0 A	1.6 million
	60 VAC	2.0 A	1.2 million
	120 VAC	5.0 A	0.1 million
		3.0 A	0.2 million
		2.0 A	0.4 million
		1.0 A	0.8 million
		0.5 A	1.5 million
	230 VAC	5.0 A	0.1 million
		3.0 A	0.2 million
		2.0 A	0.4 million
		1.0 A	0.8 million
		0.5 A	1.5 million
For inductive load in accordance with IEC 947-5-1 DC 13/ AC15	24 V DC	2.0 A	0.1 million
		1.0 A	0.2 million
		0.5 A	0.5 million
	60 VDC	0.5 A	0.2 million
	120 VDC	0.2 A	0.5 million
	48 VAC	1.0 A	0.7 million
	60 VAC	1.0 A	0.5 million
	120 VAC	2.0 A	0.1 million
		1.0 A	0.3 million
		0.5 A	1 million
		0.1 A	2 million

Resistive load	Voltage	Current	Switching cycles (typical)
For inductive load in accordance with IEC 947-5-1 DC 13/ AC15	230 VAC	2.0 A	0.1 million
		1.0 A	0.3 million
		0.5 A	1 million

NOTE

Tests of mechanical environmental conditions

Shock tested according to IEC 60068-2-27. Shock intensity: 100 m/s^2 peak value, 11 ms duration

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

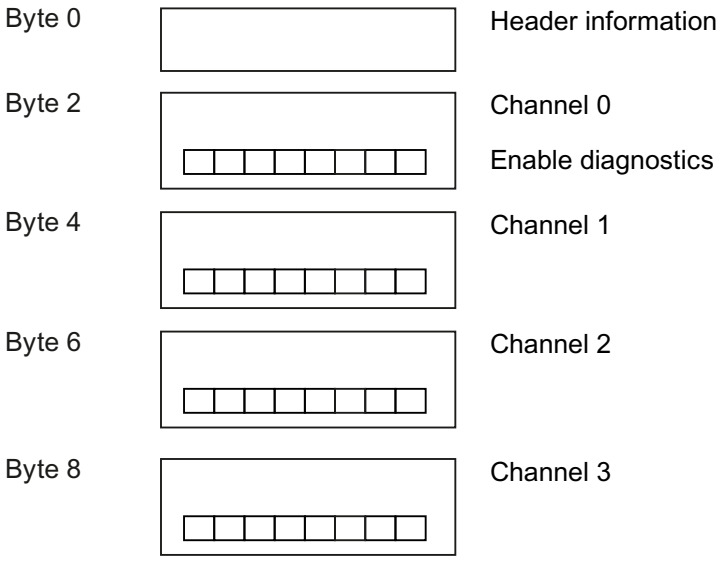

Figure 2-477 Structure of data record 128

Header information

The figure below shows the structure of the header information.

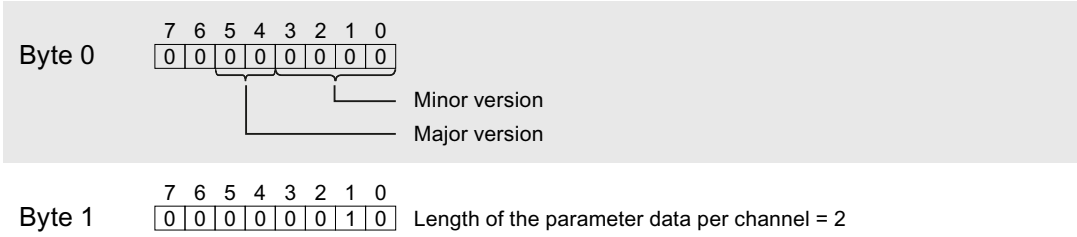

Figure 2-478 Header information

Parameters

The figure below shows the structure of the parameters in data record 128.

You enable a parameter by setting the corresponding bit to "1".

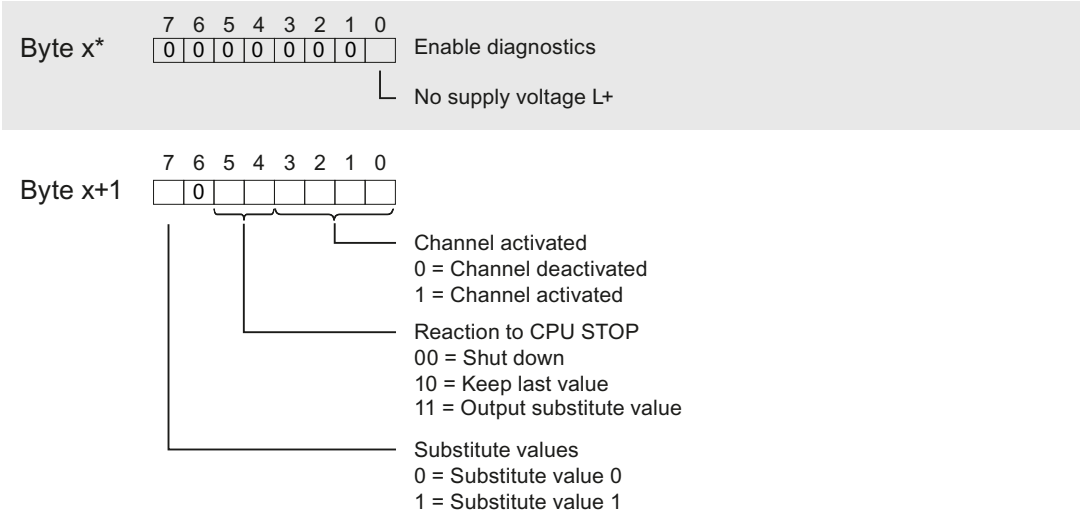

* x = 2 + (channel number × 2); channel number = 0 to 3

Figure 2-479 Structure byte x to x+1 for the channels 0 to 3

Error transmitting the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine whether the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	E0	xx	Wrong version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module

SIEMENS

SIMATIC

ET 200SP
Digital input/output module
DI 8x/DQ 8x24VDC/0.5A ST
(6ES7133-6BH00-0BA0)

Equipment Manual

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Introduction

1

Purpose of the documentation

This manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in the system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the central processing units of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: To designate the configuring and programming software, we use "STEP 7" in this documentation as a synonym for all versions of "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For ecologically sustainable recycling and disposal of your old device, contact a certified disposal service for electronic scrap and dispose of the device in accordance with the regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

Product overview

3

3.1 Properties

Article number

6ES7133-6BH00-0BA0

View of the module

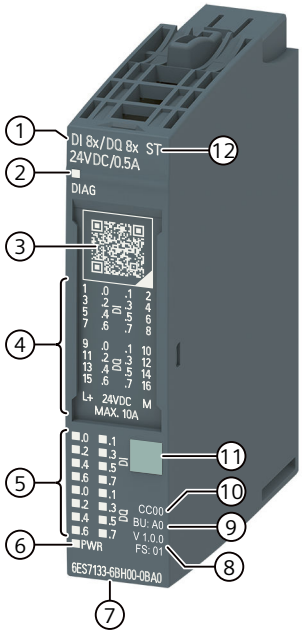

①	Module type and name	⑦	Article number
②	LED for diagnostics	⑧	Function and firmware version
③	QR code for identification link	⑨	BU type
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	Color coding module type
⑥	LED for supply voltage	⑫	Function class

Figure 2-480 View of the module DI 8x/DQ 8x24VDC/0.5A ST

Properties

The module has the following technical properties:

- Digital inputs
  - 8 digital inputs
  - Sink input (PNP)
  - Configurable input delay 0.05 ms to 20 ms (per channel)
  - Configurable diagnostics (per module)
  - Suitable for connection of switches and 2-wire sensors in accordance with IEC 61131, type 1 and 3
- Digital outputs
  - 8 digital outputs
  - Supply voltage L+
  - Source output (PNP, P-switching)
  - Output current 0.5 A (per channel)
  - Configurable diagnostics (per module)
  - Configurable substitute values (per channel)
  - Suitable for solenoid valves, DC contactors, and indicator lights

The module supports the following functions:

Table 2-456 Version dependencies of the functions

Function	HW version	FW version	STEP 7	GSD file	
			TIA Portal	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V1.0.0 or higher	V18 or higher with HSP 0401	X	X
Identification data I&M0 to I&M3	FS01	V1.0.0 or higher	V18 or higher with HSP 0401	X	X
Reconfiguration in RUN	FS01	V1.0.0 or higher	V18 or higher with HSP 0401	X	X
PROFIenergy	FS01	V1.0.0 or higher	V18 or higher with HSP 0401	X	-
Value status	FS01	V1.0.0 or higher	V18 or higher with HSP 0401	X	X

The module can be configured with HSP or a GSD file with TIA V18 or later. The configurations for the operating modes can be found under various codes / module names:

Table 2-457 Codes / module names for the configuration options

Function	Configuration software	
	GSD file PROFINET IO	GSD file PROFIBUS DP
Without QI	DI 8x/DQ 8x24VDC/0.5A ST V1.0	DI 8x/DQ 8x24VDC/0.5A ST V1.0
With QI	DI 8x/DQ 8x24VDC/0.5A ST V1.0, QI	DI 8x/DQ 8x24VDC/0.5A ST V1.0, QI

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Connection

4

4.1 Wiring diagram

This section contains the pin assignment for the module.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Terminal assignment

Description	Signal	Terminal	BaseUnit BU type A0	Terminal	Signal	Description
Digital input, channel 0	DI_0	1	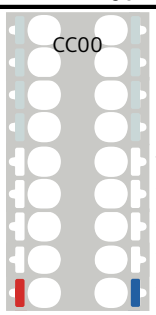	2	DI_1	Digital input, channel 1
Digital input, channel 2	DI_2	3		4	DI_3	Digital input, channel 3
Digital input, channel 4	DI_4	5		6	DI_5	Digital input, channel 5
Digital input, channel 6	DI_6	7		8	DI_7	Digital input, channel 7
Digital output, channel 0	DQ_0	9		10	DQ_1	Digital output, channel 1
Digital output, channel 2	DQ_2	11		12	DQ_3	Digital output, channel 3
Digital output, channel 4	DQ_4	13		14	DQ_5	Digital output, channel 5
Digital output, channel 6	DQ_6	15		16	DQ_7	Digital output, channel 7
24 V DC supply voltage	L+	17		18	M	Ground

Input connection types

1-wire connection for channel n	1-wire connection with common supply for several channels	3-wire connection for channel n
	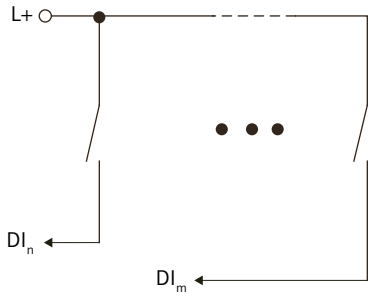	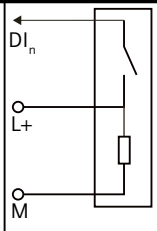

You can also connect the power supply via a potential distribution module (PotDis module).

NOTE

You can use and combine the different wiring options for all channels.

Output connection types

1-wire connection for channel n	3-wire connection for channel n
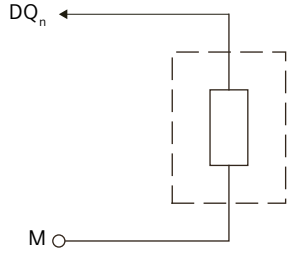	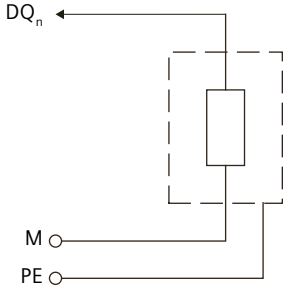

You can also connect the ground via a potential distribution module (PotDis module).

NOTE

You can use and combine the different wiring options for all channels.

4.2 Block diagram

This section contains the block diagram of the module-

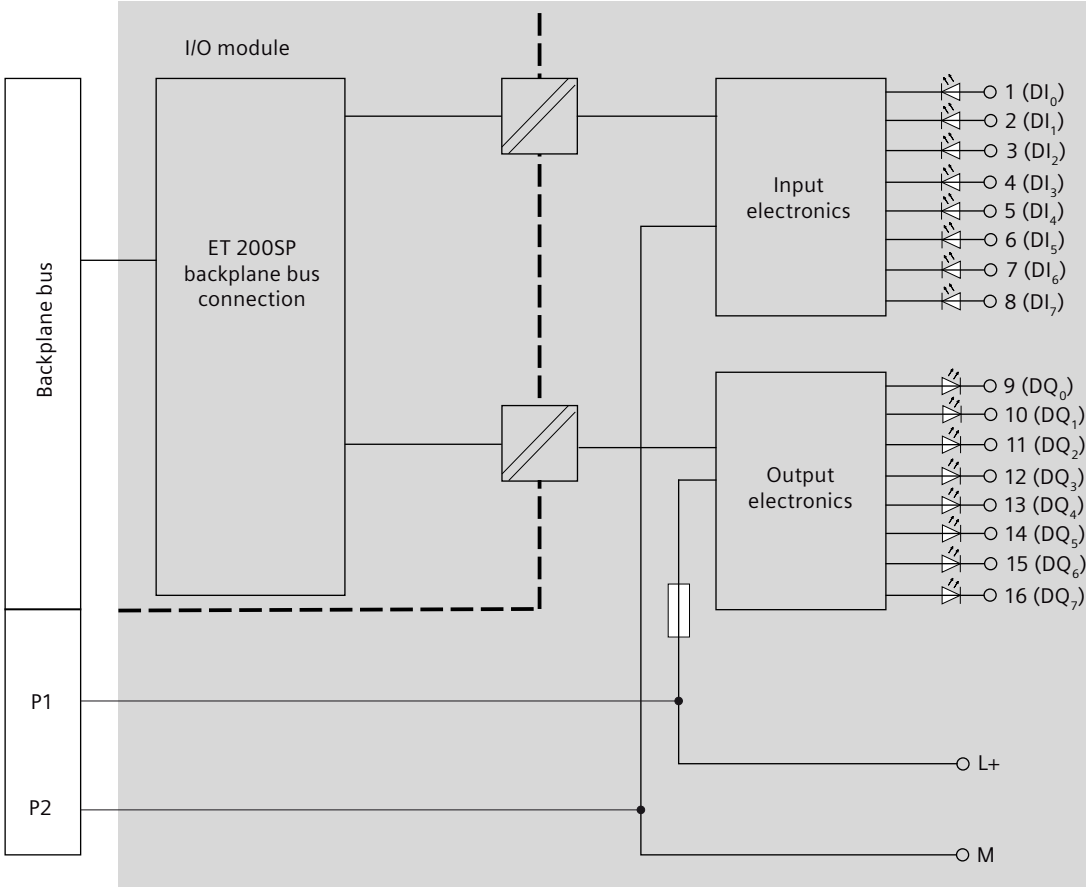

Figure 2-481 Block diagram for I/O module and BaseUnit

Wire-break detection

When wire-break detection is configured the module requires a low quiescent current at the digital input in case of "0" signal for the monitoring. The parallel connection of a resistor with 25 kΩ to 45 kΩ is required in order that this quiescent current can flow when mechanical transducer contacts are open.

If wire-break detection is disabled in the configuration, no parallel connection of the resistor is required.

If wire-break detection is configured, connect a resistor with 25 kΩ to 45 kΩ parallel to each mechanical transducer contact.

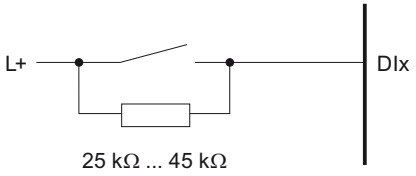

Figure 2-482 Connect mechanical transducer contact with resistor

Parameters/address space 5

5.1 Parameters

Specify the module properties with the various parameters in the course of the parameter assignment of the module with STEP 7. The following table lists the configurable parameters. The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation on an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

In addition to configuration via the configuration software, you can also configure parameters in RUN mode (dynamic) via the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 33).

The following parameter settings are possible:

Table 2-458 Configurable parameters and their defaults (GSD file)

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software	
				GSD file PROFINET I-O	GSD file PROFIBUS DP [1]
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics DI: Wire break	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics DQ: Short-circuit to ground	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics DQ: Short-circuit to L+	• Disable • Enable	Disable	yes	Module	Module
Diagnostics DQ: Wire break	• Disable • Enable	Disable	yes	Module	Module
Channel activated DI	• Disable • Enable	Enable	yes	Channel	Channel

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter via data record 128, see Appendix "Parameter data set".

Parameters	Value range	Default	Reconfiguration in RUN	Effective range with configuration software	
				GSD file PROFINET I-O	GSD file PROFIBUS DP [1]
Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	3.2 ms	yes	Channel	Module
Channel activated DQ	• Disable • Enable	Enable	yes	Channel	Channel
Reaction to CPU STOP	• Shutdown • Keep last value • Output substitute value 1 (for PROFINET IO) • Output substitute value (for PROFIBUS DP)	Shutdown	yes	Channel	Module
Substitute value	• 0 • 1	0	yes	-	Channel
Potential group	• Use potential group of the left module (module plugged into a dark BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If your PROFIBUS Master supports the "Read / write data record" function, you can set this parameter via data record 128, see Appendix "Parameter data set".

5.2 Explanation of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics DI: Wire break

Enabling of the diagnostics if the module has no current flow or the current is too weak to be measured at the relevant input.

Diagnostics DQ: Short-circuit to ground

Enable "Short-circuit" diagnostics when a short-circuit occurs between output and ground.

Diagnostics DQ: Short-circuit to L+

Enable "Short-circuit" diagnostics when a short-circuit occurs between output and L+.

Diagnostics DQ: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

NOTE

Wire break diagnostics in problematic electromagnetic conditions

To avoid faulty wire break diagnostics, deactivate the diagnostics or increase the current to at least 10 mA.

NOTE

Glowing of LEDs due to wire break test current

Permanently active wire break test current of approx. 20 µA can cause connected LEDs to glow in the "0" signal state.

Channel activated DI

Determines whether a channel is enabled or disabled. If a digital input is disabled, its input signals at the terminal are not processed by the module.

Input delay

This parameter can be used to avoid signal faults. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

For input channels with longer input delays, the read time is moved accordingly. This means individual channels can be assigned input delays, if necessary, without having a negative impact on the possible cycle time.

NOTE

If you select the "None" or "0.05 ms" option for the input delay, you have to use shielded cables for connection of the digital inputs.

Channel activated DQ

Specifies whether a channel is activated or deactivated.

Reaction to CPU STOP

Determines the behavior of the module at CPU STOP.

Substitute value

Defines the substitute value that is output when a CPU STOP occurs and the setting "Output substitute value" is selected in the "Reaction to CPU STOP" parameter.

Potential group

Specify whether a light-colored BaseUnit with incoming supply voltage or a dark-colored BaseUnit is located in this slot (see ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual).

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with a dark-colored BaseUnit, which is followed by a light-colored BaseUnit or server module in the station configuration.

5.3 Address space

Address space for configuration as DI 8x/DQ 8x24VDC/0.5A ST

The following figures show the assignment of the address space without value status. "EB x" stands for the start address input byte x. "AB x" stands for the address output byte x.

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	Input value
IB x									Channels 0 to 7

Assignment in the process image output (PIQ)

	7	6	5	4	3	2	1	0	Output value
AB x									Channels 0 to 7

Address space for configuration as DI 8x/DQ 8x24VDC/0.5A ST, QI

The following figures show the assignment of the address space with value status (Quality Information (QI)). "IB x" represents the start address of input byte x. "AB x" stands for the address output byte x.

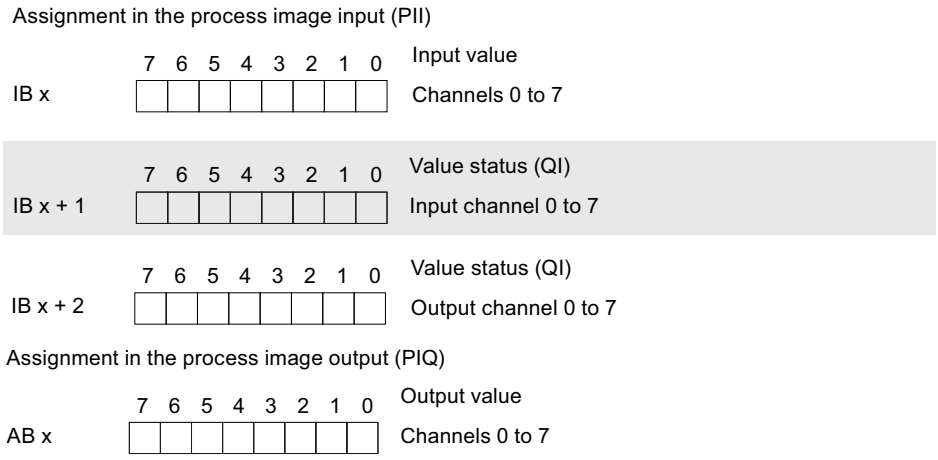

Evaluating the value status

An additional bit is assigned to each channel for the value status. The bit for the value status indicates whether the output value specified by the user program is actually pending at the module terminal (0 = value is incorrect).

You can find more information on evaluating the value status in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Interrupts/diagnostic messages

6

6.1 Status and error display

LED display

The following figure shows you the LED display of the DI 8x/DQ 8x24VDC/0.5A ST.

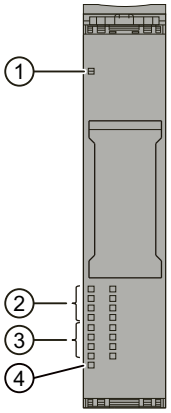

① DIAG (green/red)

② Input channel status (green)

③ Output channel status (green)

④ PWR (green)

Figure 2-483 LED display

Meaning of the LED display

The following tables show the meaning of the status and error displays. Remedial measures for dealing with diagnostic interrupts can be found in the section Diagnostics alarms (Page 25).

DIAG LED

Table 2-459 DIAG LED fault/error display

DIAG LED	Meaning
□ Off	Backplane bus supply of the system is interrupted or switched off.
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

LED channel status inputs

Table 2-460 LED channel status display inputs

Channel status LED	Meaning
□ Off	Process signal = 0
■ On	Process signal = 1

LED channel status outputs

Table 2-461 LED channel status display outputs

LED channel status	Meaning
□ Off	• Channel deactivated • Channel activated and process signal = 0 • Diagnostics pending
■ On	Channel activated and process signal = 1

PWR LED

Table 2-462 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

6.2 Interrupts

The DI 8x/DQ 8x24VDC/0.5A ST digital input/output module supports diagnostic interrupts.

Diagnostic interrupts

The module generates a diagnostics interrupt at the following events:

- Short-circuit
- Wire break
- Parameter assignment error
- Supply voltage missing
- Channel / component temporarily not available

Detailed information on the event is available in the STEP 7 online help.

6.3 Diagnostics alarms

A diagnostic message is generated and the DIAG-LED flashes red on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostic buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-463 Diagnostic interrupts, their meaning and how to deal with them

Diagnostic interrupt	Error code	Meaning		Remedy
Short-circuit	1_H	• Short-circuit between output and ground • Short-circuit between output and L+		Correct the process wiring
Wire break	6_H	DI	Impedance of transducer circuit too high.	• Use a different encoder type or modify the wiring, for example, using cables with larger cross-section • Connect a resistor of 25 kiloohms to 45 kiloohms to the transducer contacts
			Wire break between the module and sensor	Connect the cable
			Channel not connected (open)	Deactivate diagnostics
		DQ	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, e.g. use cables with larger cross-section
			Wire break between the module and actuator	Connect the cable
			Channel not connected (open)	• Deactivate diagnostics • Connect a resistor of 48 kiloohms to 12 kiloohms to the actuator contacts See Connect mechanical transducer contact with resistor

Diagnostic interrupt	Error code	Meaning	Remedy
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel/module. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	No or insufficient supply voltage L+	• Check the supply voltage L+ at the BaseUnit • Check BaseUnit type
Channel / component temporarily not available	$1F_H$	Firmware update is currently in progress or was canceled. The module does not output any process values or substitute values in this state, or does not read in any process values.	• Wait for firmware update. • Restart the firmware update.

Technical specifications 7

7.1 Technical specifications

Technical specifications of the DI 8x/DQ 8x24VDC/0.5A ST

The following table shows the technical specifications as of 02/2024. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7133-6BH00-0BA0/td?dl=en).

Article number	6ES7133-6BH00-0BA0
General information	
Product type designation	DI 8x/DQ 8x24VDC/0,5A ST
HW functional status	FS01
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V18 or higher with HSP 0401
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.42
Operating mode	
• DI	Yes
• DQ	Yes
• DQ with energy-saving function	No
• PWM	No
• Oversampling	No
• MSO	No
Redundancy	
• Redundancy capability	No

Article number	6ES7133-6BH00-0BA0
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	35 mA; without load
output voltage / header	
Rated value (DC)	24 V
Power loss	
Power loss, typ.	1 W
Address area	
Address space per module	
• Inputs	1 byte; + 1 byte for QI information
• Outputs	1 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0
• 2-wire connection	BU type A0 with AUX terminals or potential distributor module
• 3-wire connection	BU type A0 with AUX terminals or potential distributor module
Digital inputs	
Number of digital inputs	8
Digital inputs, parameterizable	Yes
Source/sink input	P-reading
Input characteristic curve in accordance with IEC 61131, type 1	Yes
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Input voltage	
• Rated value (DC)	24 V
• for signal "0"	-30 to +5 V
• for signal "1"	+11 to +30V
Input current	
• for signal "1", typ.	2.5 mA

Article number	6ES7133-6BH00-0BA0
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes; 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms
– at "0" to "1", min.	0.05 ms
– at "0" to "1", max.	20 ms
– at "1" to "0", min.	0.05 ms
– at "1" to "0", max.	20 ms
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Digital outputs	
Type of digital output	Source output (PNP, current-sourcing)
Number of digital outputs	8
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
output characteristic acc. to IEC 61131, type 0.5	Yes
Short-circuit protection	Yes; Electronic
• Response threshold, typ.	1 A
Limitation of inductive shutdown voltage to	Typ. L+ (-50 V)
Controlling a digital input	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A
• with inductive load, max.	0.5 A; max. 1 H inductance
• on lamp load, max.	5 W
Load resistance range	
• lower limit	48 Ω
• upper limit	12 kΩ
Output voltage	
• for signal "1", min.	L+ (-0.8 V)
Output current	
• for signal "1" rated value	0.5 A
• for signal "1" permissible range, max.	0.5 A
• for signal "0" residual current, max.	0.1 mA
Output delay with resistive load	
• "0" to "1", max.	50 µs
• "1" to "0", max.	100 µs
Parallel switching of two outputs	
• for uprating	No

Article number	6ES7133-6BH00-0BA0
• for redundant control of a load	Yes
Switching frequency	
• with resistive load, max.	100 Hz
• with inductive load (acc. to IEC 60947-5-1, DC13), max.	0.1 Hz; higher frequencies are possible, see Equipment Manual "Maximum permitted switching frequency of inductive loads"
• on lamp load, max.	10 Hz
Total current of the outputs	
• Current per channel, max.	0.5 A
• Current per module, max.	4 A
Total current of the outputs (per module)	
horizontal installation	
– up to 60 °C, max.	4 A
vertical installation	
– up to 50 °C, max.	4 A
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Encoder	
Connectable encoders	
• 2-wire sensor	Yes
– permissible quiescent current (2-wire sensor), max.	1.5 mA
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; module-by-module, for DI: optional protective circuit for preventing wire-break diagnostics in the case of simple encoder contacts: 25 kOhm to 45 kOhm
• Short-circuit to M	Yes; module-by-module for DQ
• Short-circuit to L+	Yes; module-by-module for DQ
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	No

Article number	6ES7133-6BH00-0BA0
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

Maximum permitted switching frequency of inductive loads

The following trends show the maximum permissible switching frequency of inductive loads as a function of inductance and channel current. The maximum switching frequency applies to a pulse-pause ratio of 50%. The channel contributes 500 mA to the total current of the module, even if the actual channel current is smaller.

If you do not know the inductance of the actuator, assume a maximum inductance of 1.152 H for DC-13 loads (IEC 60947-5-1).

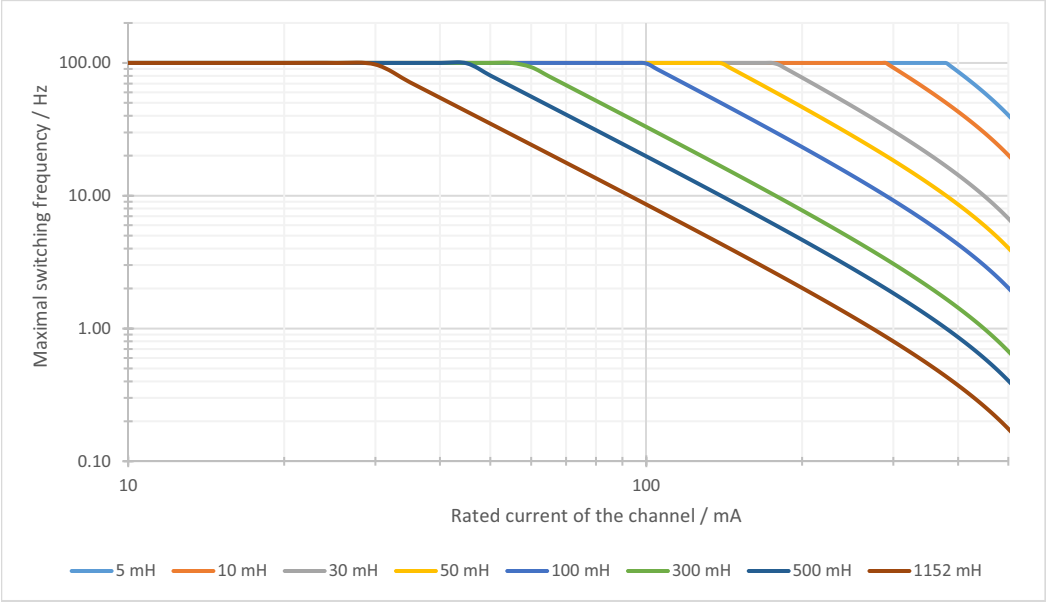

Figure 2-484 Maximum switching frequency

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can change the parameters of the module in RUN.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You can find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128 for the complete module

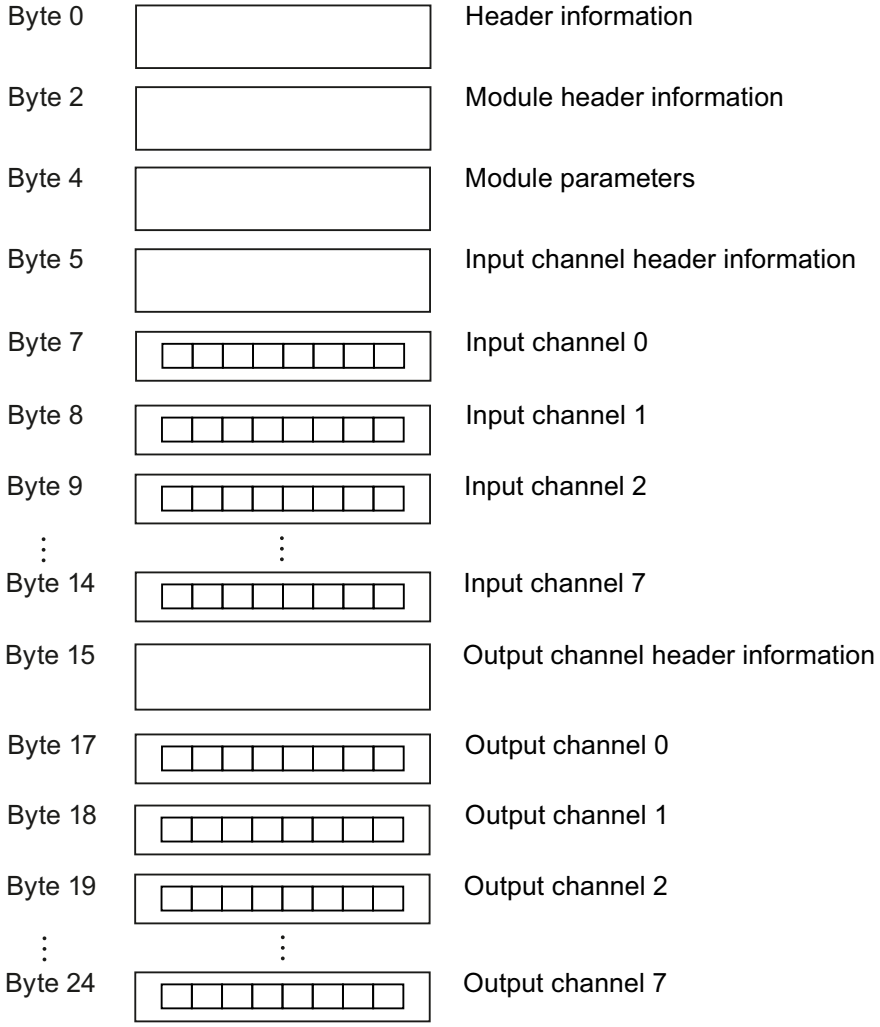

Figure 2-485 Structure of data record 128 for the complete module

Header information

The figure below shows the structure of the header information.

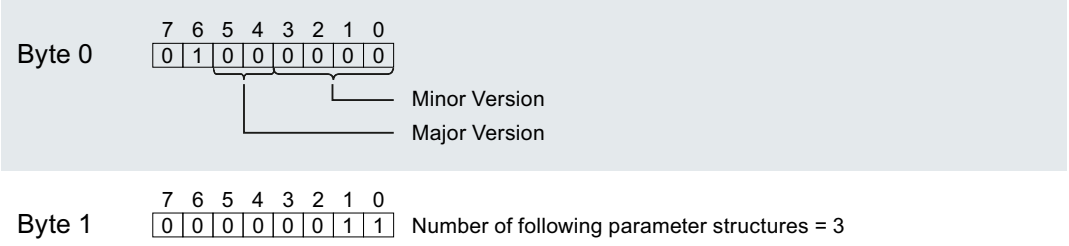

Figure 2-486 Header information

Module header information

The figure below shows the structure of the module header information.

	7	6	5	4	3	2	1	0	
Byte 2	0	0	0	0	0	0	0	1	Number of the following module parameter blocks = 1
Byte 3	0	0	0	0	0	0	0	1	Length of the following module parameter block = 1

Figure 2-487 Module header information

Module parameter block

The figure below shows the structure of the module parameter block. You enable a parameter by setting the corresponding bit to "1".

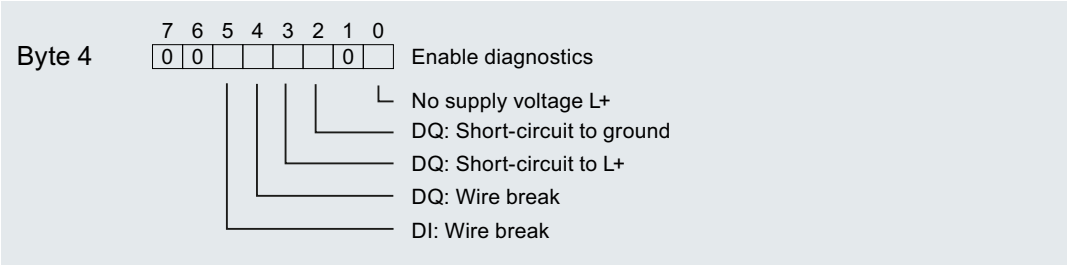

Figure 2-488 Module parameter block

Input channel header information

The figure below shows the structure of the input channel header information.

	7	6	5	4	3	2	1	0	
Byte 5	0	0	0	0	1	0	0	0	Number of following channel parameter blocks = 8
Byte 6	0	0	0	0	0	0	0	1	Length of the following channel parameter block = 1

Figure 2-489 Input channel header information

Channel parameter block input channel

The figure below shows the structure of the input channel parameter block. You enable a parameter by setting the corresponding bit to "1".

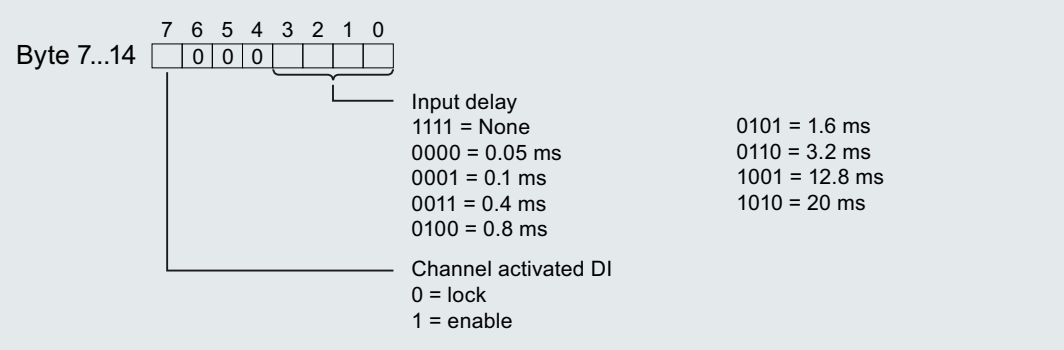

Figure 2-490 Structure bytes 7 to 14 for input channels 0 to 7

Output channel header information

The figure below shows the structure of the output channel header information.

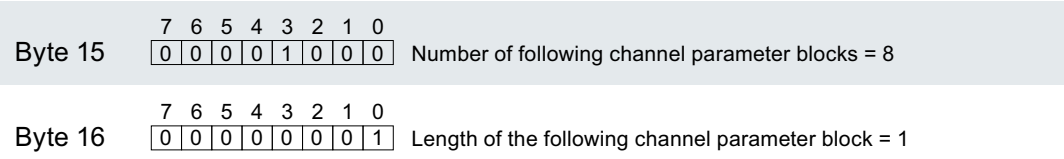

Figure 2-491 Output channel header information

Channel parameter block output channel

The figure below shows the structure of the output channel parameter block. Enable a parameter by setting the corresponding bit to "1".

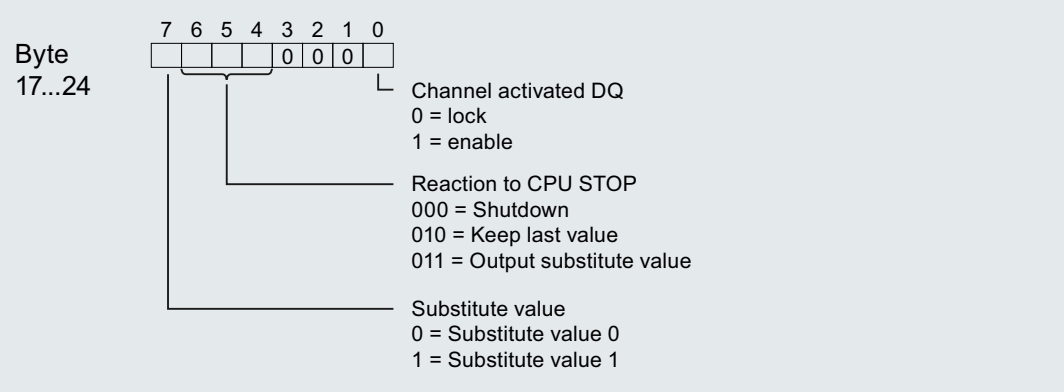

Figure 2-492 Structure bytes 17 to 24 for output channels 0 to 7

A.2 Error codes

Errors when transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module take over the values from the data record.

In case of errors, the WRREC instruction for writing data records returns corresponding error codes in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help.

The following table shows the module-specific error codes and their meaning for data record 128.

Table 2-464 Error messages, their meaning and corrective measures

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF_H	80_H	$B0_H$	00_H	Number of the data record unknown	Enter a valid number for the data record.
DF_H	80_H	$B1_H$	01_H	Length of the data record incorrect	Enter a valid value for the data record length.
DF_H	80_H	$B2_H$	00_H	Module not accessible	• Check station. • Plug the module in correctly. • Check parameters of the WRREC block.
DF_H	80_H	$E0_H$	01_H	Header error (version or specified bits incorrect)	Correct version number or fixed bits, see Header information
DF_H	80_H	$E0_H$	02_H	Header error (number or length of parameter structures or parameter blocks incorrect)	Correct the number and length of the parameter structures or parameter blocks, see Header information.
DF_H	80_H	$E1_H$	01_H	Reserved bit set	Describe all reserved bits with 0.
DF_H	80_H	$E1_H$	06_H	Invalid coding for substitute value reaction	Use valid code for "Reaction to CPU STOP" parameter, see Structure bytes 17 to 24 for output channels 0 to 7.
DF_H	80_H	$E1_H$	07_H	Invalid coding for input filter time	Use valid coding for parameter "Input delay", see Structure bytes 7 to 14 for input channels 0 to 7.

SIEMENS

SIMATIC

ET 200SP
Analog input module AI 8xU BA (6ES7134-6FF00-0AA1)

Equipment Manual

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Introduction 1

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

- Wiring and block diagrams have been revised.
- The technical specifications have been updated.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

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Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

3

3.1 Properties

Article number

6ES7134-6FF00-0AA1

View of the module

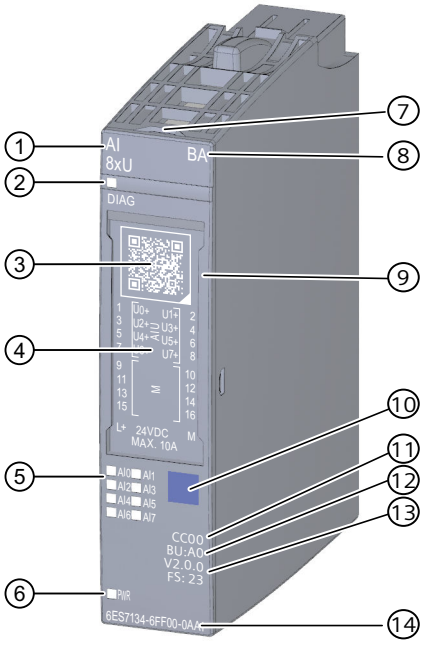

① Module type and name
② LED for diagnostics
③ QR code for identification link
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Slot for optional reference identification label
⑧ Function class
⑨ Insertion option for optional labeling strips
⑩ Color coding module type
⑪ Color code for selecting the color identification labels
⑫ BU type
⑬ Firmware revision level and release number
⑭ Article number

Figure 2-493 View of the AI 8×U BA module

Properties

The module has the following technical properties:

- Analog input module with 8 inputs (single-ended)
- Input ranges for voltage measurement:
  - ±10 V, resolution 16 bits including sign
  - 0 to 10 V, resolution 15 bits
- Cycle time of the module (all channels) 10 ms
- Configurable diagnostics (per module)

The module supports the following functions:

Table 2-465 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V1.0.0 or higher	As of V13 SP1 with HSP0126	As of V5.5 SP3 with HSP0227 V5.0	X	X
Identification data I&M0 to I&M3	FS01	V1.0.0 or higher	As of V13 SP1 with HSP0126	As of V5.5 SP3 with HSP0227 V5.0	X	X
Parameter reassignment in RUN mode	FS01	V1.0.0 or higher	As of V13 SP1 with HSP0126	As of V5.5 SP3 with HSP0227 V5.0	X	X

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Wiring up

4

4.1 Connection diagram

This section shows the connection diagram of the module with the terminal assignment for a 2-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Pin assignment

The following table shows an example of the pin assignment of the analog input module on the BaseUnit BU type A0/A1:

Description	Signal	Terminal	BaseUnit BU type A0/A1	Terminal	Signal	Description
Analog input voltage positive, channel 0	U_0+	1	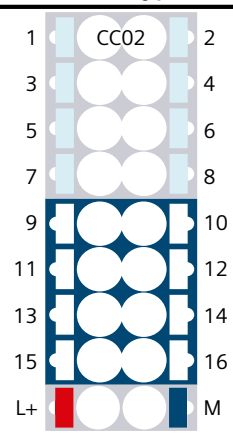	2	U_1+	Analog input voltage positive, channel 1
Analog input voltage positive, channel 2	U_2+	3		4	U_3+	Analog input voltage positive, channel 3
Analog input voltage positive, channel 4	U_4+	5		6	U_5+	Analog input voltage positive, channel 5
Analog input voltage positive, channel 6	U_6+	7		8	U_7+	Analog input voltage positive, channel 7
Ground of the analog inputs	M_{ANA}	9		10	M_{ANA}	Ground of the analog inputs
Ground of the analog inputs	M_{ANA}	11		12	M_{ANA}	Ground of the analog inputs
Ground of the analog inputs	M_{ANA}	13		14	M_{ANA}	Ground of the analog inputs
Ground of the analog inputs	M_{ANA}	15		16	M_{ANA}	Ground of the analog inputs
24 V DC supply voltage[1)]	L+	L+		M	M	Ground

[1)] Infeed only with light-colored BaseUnit

Connection types

2-wire connection for voltage measurement

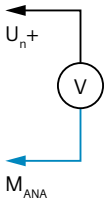

4.2 System structure with BaseCarrier

The figure below shows the pinning of the PCB connector of the BaseCarrier in top view.

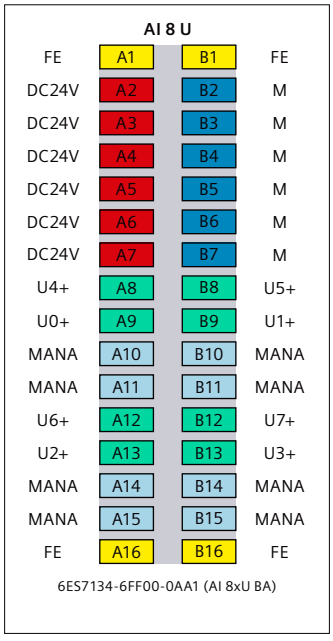

Figure 2-494 **Pinning AI 8xU BA**

You can find more information in the ET 200SP System Structure with BaseCarrier (https://support.industry.siemens.com/cs/ww/en/view/109988377) function manual

4.3 Schematic circuit diagram

This section contains the schematic circuit diagram of the analog input module.

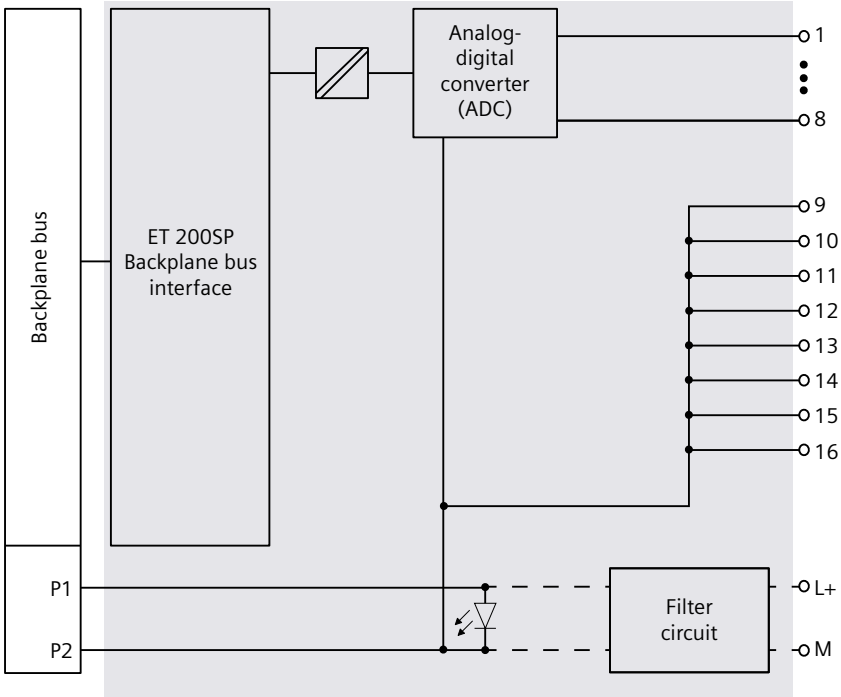

Figure 2-495 Schematic circuit diagram

Parameters/address space

5

5.1 Measuring types and ranges

The analog input module AI 8xU BA has the following measuring ranges:

Table 2-466 Measuring ranges

Measurement type	Measuring range	Resolution
Voltage	0 to 10 V ± 10 V	15 bits 16 bits including sign

You will find the tables of the measuring ranges as well as overflow, overrange, etc., in the section Representation of analog values (Page 39).

5.2 Parameters

AI 8xU BA parameters

Specify the module properties with the various parameters during parameter assignment of the module with STEP 7. The following table lists the configurable parameters. The efficiency range of the configurable parameters depends on the type of configuration.
The following configurations are possible:

- Central operation with an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

In addition to assigning parameters with the configuration software, you can also set the parameters in RUN mode (dynamically) using the user program.

When assigning the parameters in the user program, the "WRREC" instruction transfers the parameters to the module using data records; see section Parameter assignment and structure of the parameter data record (Page 34).

The following parameter settings are possible:

Table 2-467 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Reconfiguration in RUN	Scope with configuration software e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Module	Module [1]
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Module	
Type/range of measurement	• Deactivated • Voltage +/- 10 V • Voltage 0 V to 10 V	Voltage (+/- 10 V)	Yes	Channel	Channel
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel
Interference frequency suppression	• 60 Hz (50 ms) • 50 Hz (60 ms) [2] • 16.6 Hz (180 ms) • 4800 Hz (0.625 ms) • 60 Hz (18.75 ms) [3] • 50 Hz (22.5 ms) [2 3] • 16.6 Hz (67.5 ms) [3]	50 Hz (60 ms)	Yes	Channel	Module
Potential group	• Use the potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into a light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

1 Only when configuring using a PROFIBUS GSD file; does not apply to configuration with STEP 7 via HSP: The parameter assignment options are limited because PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes for each ET 200SP station. The parameter length of the I/O module is 8 bytes for PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128; see appendix "Parameter data record".

2 Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

3 By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical specifications).

NOTE

Unused channels

Disable unused channels in the parameter assignment to improve the cycle time of the module.

A deactivated channel always returns the value $7FFF_H$.

NOTE

Note that the settings in the "Interference frequency suppression" parameter have a direct effect on the cycle time of the module. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

NOTE

Note that the settings in the "Interference frequency suppression" parameter have a direct effect on the temporary deviations of the analog values.

When setting the interference frequency suppression to 4.8 kHz, the temporary deviation of the analog values reaches up to ±30% of the full-scale value in the burst of 100 Hz, in accordance with IEC 61000-4-4 "Burst-Impulse (fast transient interferences)". See the ET 200SP Distributed I/O System (https://support.automation.siemens.com/WW/view/en/58649293) system manual, section "Pulse-shaped disturbance variables of the ET 200SP system".

5.3 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Type/range of measurement

See the section Measurement types and measuring ranges (Page 18).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) × cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This is valid for all signal changes at the analog input.

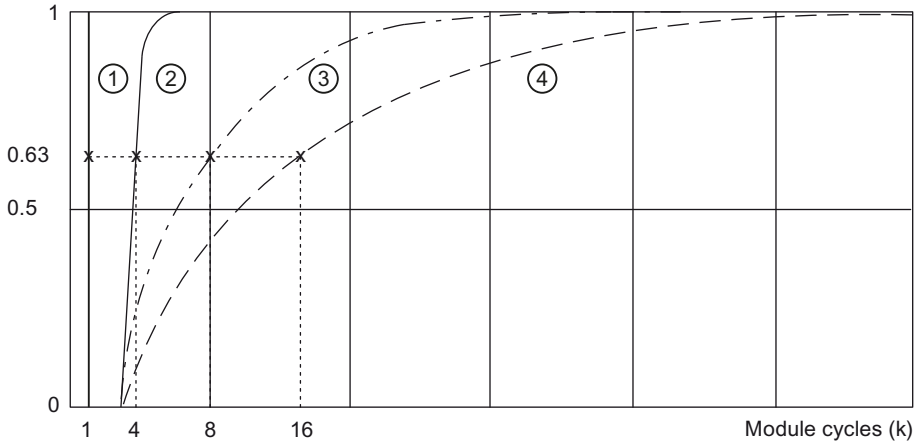

① No smoothing (k = 1)

② Weak (k = 4)

③ Medium (k = 8)

④ Strong (k = 16)

Figure 2-496 Smoothing for AI 8xU BA

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the alternating voltage network may negatively affect the measured value, in particular when measuring in the low voltage range. With this parameter, the user specifies the line frequency that is predominant in the plant.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2, and AUX to the left neighbor.

Specify the slot in which a light-colored BaseUnit with supply voltage infeed or a dark-colored BaseUnit is to be located (see ET 200SP Distributed I/O System (https://support.automation.siemens.com/WW/view/en/58649293) system manual). All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You

take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

The station configuration must be completed with a server module.

See also

You can find more information in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

5.4 Address space

The module can be configured in various ways in STEP 7; see the following table. Depending on the configuration, additional/different addresses are assigned in the process image input.

Configuration options of AI 8×U BA

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. When you configure the module by means of the GSD file, the configurations are available under different short designations/module names; see following table. The following configurations are possible:

Table 2-468 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software e.g., with STEP 7 (TIA Portal)		
		FW version V2.0: Integrated in the hardware catalog STEP 7 as of V21*	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	AI 8xU BA V1.0	X	X	X
1 x 8-channel without value status	AI 8xU BA V2.0	X	X	X

* If the firmware version V2.0 is not available in the catalog, V1.0 can also be configured.

Address space for configuration as 1 x 8-channel AI 8×U BA V1.0

The following figure shows the assignment of the address space for the configuration as 1 x 8-channel module without value status. "IB" stands for input byte.

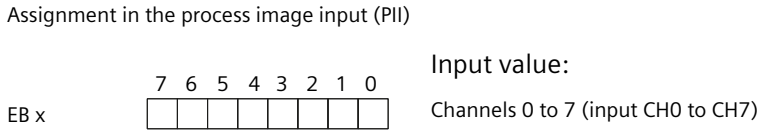

Figure 2-497 Address space for configuration as 1 x 8-channel AI 8×U BA V1.0

Address space for configuration as 1 x 8-channel AI 8×U BA V2.0

The following figure shows the assignment of the address space for the configuration as 1 x 8-channel module without value status. "IB" stands for input byte.

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	Input value:
EB x									Channels 0 to 7 (input CH0 to CH7)

Figure 2-498 Address space for configuration as 1 x 8-channel AI 8×U BA V2.0

See also

ET 200SP Distributed I/O System
(http://support.automation.siemens.com/WW/view/en/58649293)

Interrupts/diagnostics alarms

6

6.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the module.

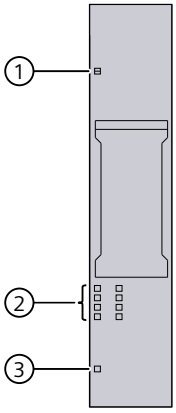

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-499 LED displays

Meaning of the LEDs

The meaning of the status and error messages is described in the following tables. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 27).

DIAG LED

Table 2-469 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the system is interrupted or switched off.
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics available
Flashes	Module parameters assigned and module diagnostics available

Channel status LED

Table 2-470 Status display of the channel status LED

Channel status LED	Meaning
Off	Channel deactivated
On	Channel activated

PWR LED

Table 2-471 Status display of the PWR LED

PWR LED	Meaning
Off	No supply voltage L+
On	Supply voltage L+ present

6.2 Interrupts

Introduction

The I/O device generates interrupts as a reaction to specific error events. Interrupts are evaluated based on the I/O controller used.

Evaluating interrupts with I/O controllers

The module supports the following interrupts

- Diagnostic interrupts
- Maintenance events

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

6.2.1 Triggering of a diagnostics interrupt

Triggering of a diagnostics interrupt

For an incoming or outgoing event (e.g. wire break on a channel of an I/O module), the module triggers a diagnostics interrupt if this is configured accordingly.

The CPU interrupts processing of the user program and processes the diagnostics block OB 82. The event which led to the interrupt is entered in the start information of the OB 82.

6.2.2 Triggering of a maintenance event

Triggering of a maintenance event

For the module, maintenance events signal to the user when a plant component needs to be checked or replaced.

The CPU interrupts the processing of the user program and processes the diagnostic error interrupt OB (OB 82). The event that triggered the maintenance event is entered in the start information of the diagnostic error interrupt OB.

6.3 Alarms

6.3.1 Alarms

Introduction

The module generates the following alarms:

- Diagnostics alarms
- Maintenance alarms

6.3.2 Diagnostics alarms

A diagnostics alarm is generated and the DIAG LED flashes red on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostic buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-472 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
High limit violated	7_H	Value is above overrange.	Correct interplay between module and encoder
Low limit violated	8_H	Value is below underrange.	Correct interplay between module and encoder
Error	9_H	Internal module error occurred.	Replace module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	No or insufficient supply voltage L+	• Check the supply voltage L+ on the BaseUnit • Check BaseUnit type

Diagnostics alarms in the measured value of analog input modules

Each analog input module supplies the measured value $7FFF_H$ or 8000_H depending on the parameter assignment for when an error is detected.

6.3.3 Maintenance alarms

For the module, maintenance events signal to the user when a plant component needs to be checked or replaced.

The CPU interrupts the processing of the user program and processes the diagnostic error interrupt OB (OB 82). The event that triggered the maintenance event is entered in the start information of the diagnostic error interrupt OB.

Maintenance required alarms

Every time maintenance required is detected, a maintenance event is generated. However, it has no influence on the LED DIAG on the module.

NOTE

Maintenance alarms have no direct influence on the function of the module.

Table 2-473 Maintenance required alarms, their meaning and possible remedies

Maintenance required alarm	Error code	Meaning / Cause	Solution
Security event: Firmware successfully downloaded and activated for use after a reset	0191_H	The firmware was successfully loaded into the module. This firmware update takes effect after the module is restarted.	-
Security event: Firmware integrity checks failed.	0192_H	The firmware was not successfully loaded into the module. This can have many different reasons, e.g. corrupted binary files or an incorrect signature.	Verify if the firmware update file you are using comes from a secure source. Download the firmware again from the Siemens support website and repeat the firmware update.

System events in STEP 7 (TIA Portal)

The maintenance information is generated in STEP 7 (TIA Portal) with the following system events:

- Maintenance required - indicated for each port by a wrench with a green background in the device view or in the hardware configuration.

You can find more information in the STEP 7 online help.

Technical specifications 7

7.1 Technical specifications

Technical specifications of the AI 8×U BA

The following table lists the technical specifications as of the issue date. A data sheet including daily updated technical specifications is available on the Internet (https://support.industry.siemens.com/cs/ww/de/pv/6ES7134-6FF00-0AA1/td?dl=en).

Article number	6ES7134-6FF00-0AA1
General information	
Product type designation	AI 8xU BA
HW functional status	FS23 or higher
Firmware version	V2.0.0
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC02
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Measuring range scalable	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	TIA Portal V21
• STEP 7 configurable/integrated from version	V5.7 SP3
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.45
Operating mode	
• Oversampling	No
• MSI	No
CiR - Configuration in RUN	
Reparameterization possible in RUN	No
Calibration possible in RUN	No

Article number	6ES7134-6FF00-0AA1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	25 mA; rated voltage, all channels active, no load
Current consumption, max.	25 mA; worst case voltage, all channels active, max. load, no derating
Power loss	
Power loss, typ.	0.7 W; rated voltage, 50 % active channels, 50 % of range
Power loss, max.	0.7 W; max. voltage, full load, all channels active, no derating
Address area	
Address space per module	
• Address space per module, max.	16 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	type B
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0, A1
• 2-wire connection	BU type A0, A1
Analog inputs	
Number of analog inputs	8; Single-ended
• For voltage measurement	8
permissible input voltage for voltage input (destruction limit), max.	30 V
Cycle time (all channels), min.	1 ms; per channel
Input ranges (rated values), voltages	
• 0 to +10 V	Yes; 15 bit
– Input resistance (0 to 10 V)	100 kΩ
• -10 V to +10 V	Yes; 16 bit incl. sign
– Input resistance (-10 V to +10 V)	100 kΩ
Cable length	
• shielded, max.	200 m
Analog value generation for the inputs	
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit

Article number	6ES7134-6FF00-0AA1
• Integration time, parameterizable	Yes
• Interference voltage suppression for interference frequency f1 in Hz	16.67 / 50 / 60 / 4 800 (16.67 / 50 / 60)
• Conversion time (per channel)	180 / 60 / 50 / 0.625 (67.5 / 22.5 / 18.75) ms
Smoothing of measured values	
• Number of smoothing levels	4
• parameterizable	Yes
• Step: None	Yes
• Step: low	Yes; 4x smoothing
• Step: Medium	Yes; 8x smoothing
• Step: High	Yes; 16x smoothing
Encoder	
Connection of signal encoders	
• for voltage measurement	Yes
• for current measurement as 4-wire transducer	No
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %
Temperature error (relative to input range), (+/-)	0.005 %/K
Crosstalk between the inputs, min.	-50 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Voltage, relative to input range, (+/-)	0.5 %
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to input range, (+/-)	0.3 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	70 dB; With conversion time 67.5 / 22.5 / 18.75 ms: 40 dB
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	No
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	No
• Short-circuit	No

Article number	6ES7134-6FF00-0AA1
• Group error	Yes
• Overflow/underflow	Yes; Module-wise
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
product functions / security / header	
signed firmware update	Yes; firmware V2.0.0 or higher
safely removing data	Yes; firmware V2.0.0 or higher
data integrity	Yes; firmware V2.0.0 or higher
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; < 0 °C as of FS04
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; < 0 °C as of FS04
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See the manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Measurement type	Measuring range	Diagnostics		
		No supply voltage L+	Overflow	Underflow
Deactivated		*	*	*
Voltage	±10 V	x	x	x
	0 V to 10 V	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Diagnostics	
		No supply voltage L+	Overflow/underflow
Deactivated		*	*
Voltage	±10 V	x	x
	0 V to 10 V	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reassign the module parameters in your user program, regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can reassign the parameters of the module in RUN. For example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 are not changed on the CPU, which means that the parameters set in STEP 7 are valid again after a restart.

STATUS output parameter

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 contains the diagnostics for the entire module.

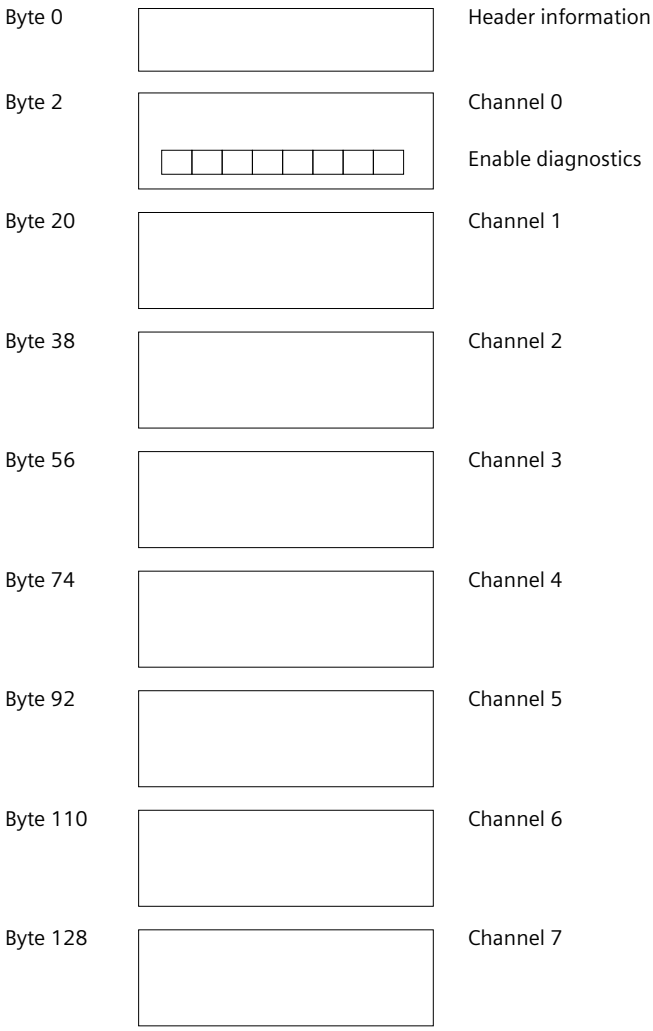

Figure 2-500 Structure of data record 128

Header information

The figure below shows the structure of the header information.

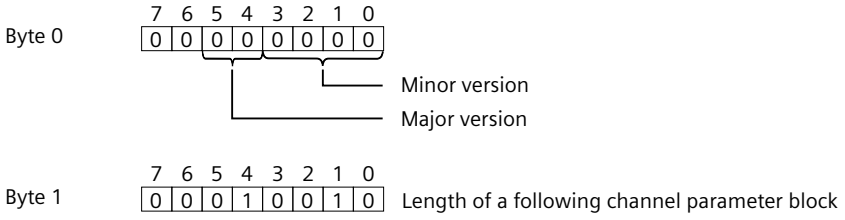

Figure 2-501 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

Enable a parameter by setting the corresponding bit to "1".

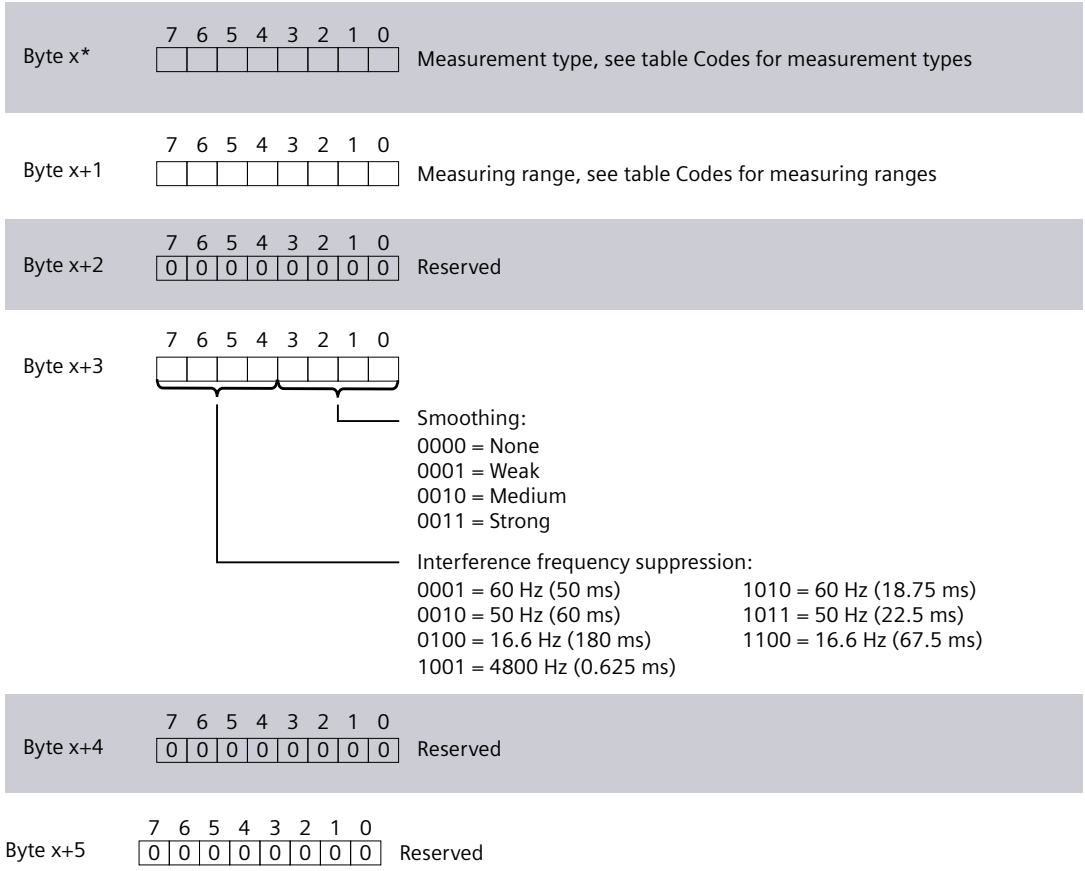

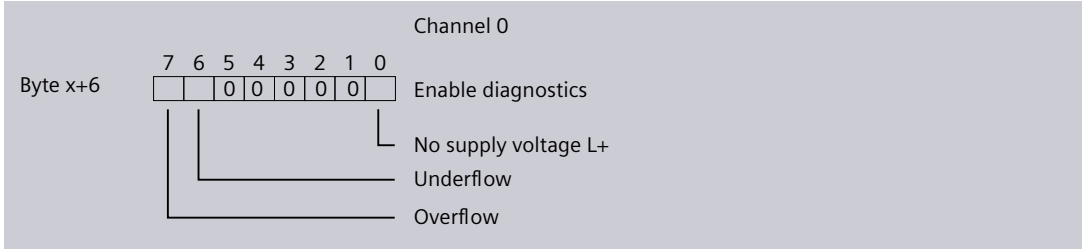

Byte x+7 | 7 6 5 4 3 2 1 0 | 0 0 0 0 0 0 0 0 | Reserved

Byte x+17 | 0 0 0 0 0 0 0 0 | Reserved

* x = 2 + (channel number × 18); channel number = 0 to 7

Figure 2-502 Structure of byte x to x+17 for channels 0 to 7

Codes for measurement types

The following table contains the codes for the measurement types of the analog input module. You must enter these codes at byte x (see previous figure).

Table 2-474 Codes for measurement types

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001

Codes for measuring ranges

The following table contains the codes for the measuring ranges of the analog input module. You enter these codes at byte x+1 (see previous figure).

Table 2-475 Codes for measuring ranges

Measuring range	Code
±10 V 0 to 10 V	0000 1001 0000 1011

Error while transferring the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	xx	Module cannot be reached.	• Check station. • Plug the module in correctly. • Check parameters of the WRREC block.
DF	80	E0	xx	Wrong version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module

Representation of analog values

B

Measured value resolution

The resolution of the analog values differs depending on the analog module and its parameter assignment.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table 2-476 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	**Hexadecimal**	**High byte**	**Low byte**
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table 2-477 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 2-478 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	

Dec. value	Measured value in %	Data word																Range
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table 2-479 Voltage measuring range ±10 V

Values		Voltage measuring range	Range
Dec.	**Hex.**	**±10 V**	
32767	7FFF	>11.759 V	Overflow
32511	7EFF	11.759 V	Overrange
27649	6C01		
27648	6C00	10 V	Nominal range
20736	5100	7.5 V	
1	1	361.7 µV	
0	0	0 V	
-1	FFFF		
-20736	AF00	-7.5 V	
-27648	9400	-10 V	
-27649	93FF		Underrange
-32512	8100	-11.759 V	
-32768	8000	<-11.759 V	Underflow

Table 2-480 Voltage measuring range 0 V to 10 V

Values		Voltage measuring range	Range
Dec.	**Hex.**	**0 to 10 V**	
32767	7FFF	>11.759 V	Overflow
32511	7EFF	11.759 V	Overrange
27649	6C01		
27648	6C00	10 V	Nominal range
20736	5100	7.5 V	
1	1	0 V + 361.7 µV	

Values		Voltage measuring range	Range
0	0	0 V	Nominal range
-1	FFFF		Underrange
-4864	ED00	-1.759 V	
-32768	8000	< -1.759 V	Underflow

SIEMENS

SIMATIC

ET 200SP
Analog input module AI 8xI 2-/4-wire BA (6ES7134-6GF00-0AA1)

Equipment Manual

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Introduction

1

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

- Wiring and block diagrams have been revised.
- The technical specifications have been updated.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

3

3.1 Properties

Article number

6ES7134-6GF00-0AA1

View of the module

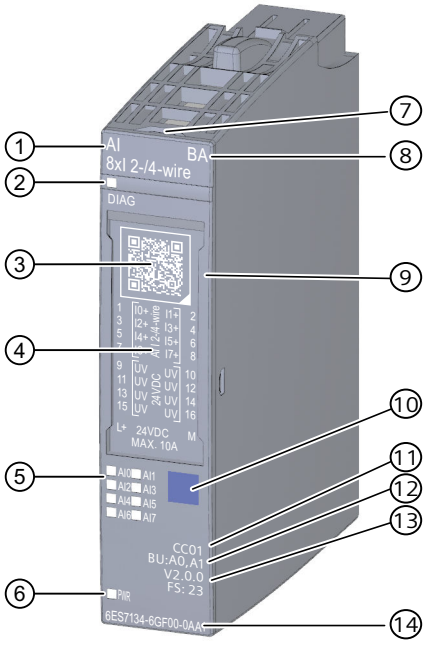

①	Module type and name	⑧	Function class
②	LED for diagnostics	⑨	Insertion option for optional labeling strips
③	QR code for identification link	⑩	Color coding module type
④	Wiring diagram	⑪	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑫	BU type
⑥	LED for supply voltage	⑬	Firmware revision level and release number
⑦	Slot for optional reference identification label	⑭	Article number

Figure 2-503 View of the AI 8×I 2-/4-wire BA module

Properties

The module has the following technical properties:

- Analog input module with 8 inputs (single-ended)
- For 2-wire and 4-wire transducers
- Input ranges for current measurement:
  - 4 mA to 20 mA, resolution 15 bits
  - 0 mA to 20 mA, resolution 15 bits
  - ±20 mA, resolution 16 bit including sign
- Cycle time of the module (all channels) 10 ms
- Configurable diagnostics (per module)

The module supports the following functions:

Table 2-481 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V1.0.0 or higher	As of V13 SP1 with HSP0126	As of V5.5 SP3 with HSP0227 V5.0	X	X
Identification data I&M0 to I&M3	FS01	V1.0.0 or higher	As of V13 SP1 with HSP0126	As of V5.5 SP3 with HSP0227 V5.0	X	X
Parameter reassignment in RUN mode	FS01	V1.0.0 or higher	As of V13 SP1 with HSP0126	As of V5.5 SP3 with HSP0227 V5.0	X	X

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Wiring up

4

4.1 Connection diagram

This section shows the connection diagram of the module with the terminal assignments for a 2-wire and 4-wire connection (2- and 4-wire transducer).

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

NOTE

You may use and combine the different wiring options for all channels.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Connector pin assignment: Current measurement 2-wire connection (2-wire transducer)

The following table shows an example of the pin assignment of the analog input module AI 8xI 2-/4-wire BA on the BaseUnit BU type A0/A1:

Description	Signal	Terminal	BaseUnit BU type A0/A1	Terminal	Signal	Description
Analog input current positive, channel 0	I_0+	1	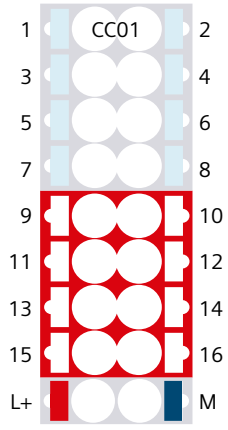	2	I_1+	Analog input current positive, channel 1
Analog input current positive, channel 2	I_2+	3		4	I_3+	Analog input current positive, channel 3
Analog input current positive, channel 4	I_4+	5		6	I_5+	Analog input current positive, channel 5
Analog input current positive, channel 6	I_6+	7		8	I_7+	Analog input current positive, channel 7
Infeed voltage	U_V	9		10	U_V	Infeed voltage
Infeed voltage	U_V	11		12	U_V	Infeed voltage
Infeed voltage	U_V	13		14	U_V	Infeed voltage
Infeed voltage	U_V	15		16	U_V	Infeed voltage
24 V DC supply voltage[1)]	L+	L+		M	M	Ground

[1)] Infeed only with light-colored BaseUnit

Pin assignment: Current measurement 4-wire connection (4-wire transducer)

The following table shows an example of the pin assignment of the analog input module AI 8xI 2-/4-wire BA on the BaseUnit BU type A0 with AUX terminals:

Description	Signal	Terminal	BaseUnit BU type A0/A1	Terminal	Signal	Description
Analog input current positive, channel 0	I_0+	1	1 CC01 2	2	I_1+	Analog input current positive, channel 1
Analog input current positive, channel 2	I_2+	3	3 4	4	I_3+	Analog input current positive, channel 3
Analog input current positive, channel 4	I_4+	5	5 6	6	I_5+	Analog input current positive, channel 5
Analog input current positive, channel 6	I_6+	7	7 8	8	I_7+	Analog input current positive, channel 7
Infeed voltage	U_V	9	9 10	10	U_V	Infeed voltage
Infeed voltage	U_V	11	11 12	12	U_V	Infeed voltage
Infeed voltage	U_V	13	13 14	14	U_V	Infeed voltage
Infeed voltage	U_V	15	15 16	16	U_V	Infeed voltage
AUX terminal	AUX	1 A	1A CC73 2A	2 A	AUX	AUX terminal
AUX terminal	AUX	3 A	3A 4A	4 A	AUX	AUX terminal
AUX terminal	AUX	5 A	5A 6A	6 A	AUX	AUX terminal
AUX terminal	AUX	7 A	7A 8A	8 A	AUX	AUX terminal
AUX terminal	AUX	9 A	9A 10A	10 A	AUX	AUX terminal
24 V DC supply voltage[1)]	L+	L+	L+ M	M	M	Ground

1) Infeed only with light-colored BaseUnit

Connection types

2-wire connection for current measurement	4-wire connection for current measurement
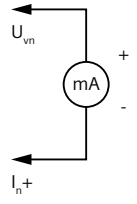	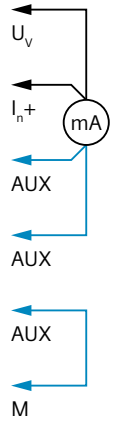

4.2 System structure with BaseCarrier

The figure below shows the pinning of the PCB connector of the BaseCarrier in top view.

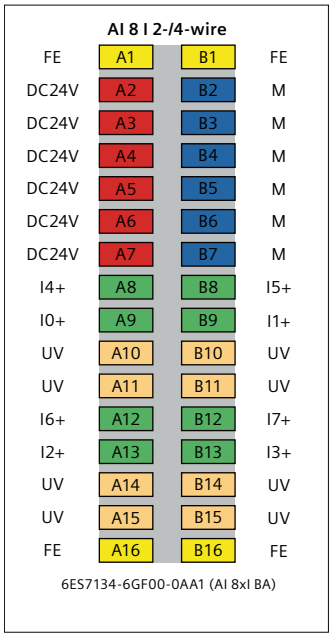

Figure 2-504 **Pinning AI 8xI 2-/4-wire BA**

You can find more information in the ET 200SP System Structure with BaseCarrier (https://support.industry.siemens.com/cs/ww/en/view/109988377) function manual

4.3 Schematic circuit diagram

This section contains the schematic circuit diagram of the analog input module.

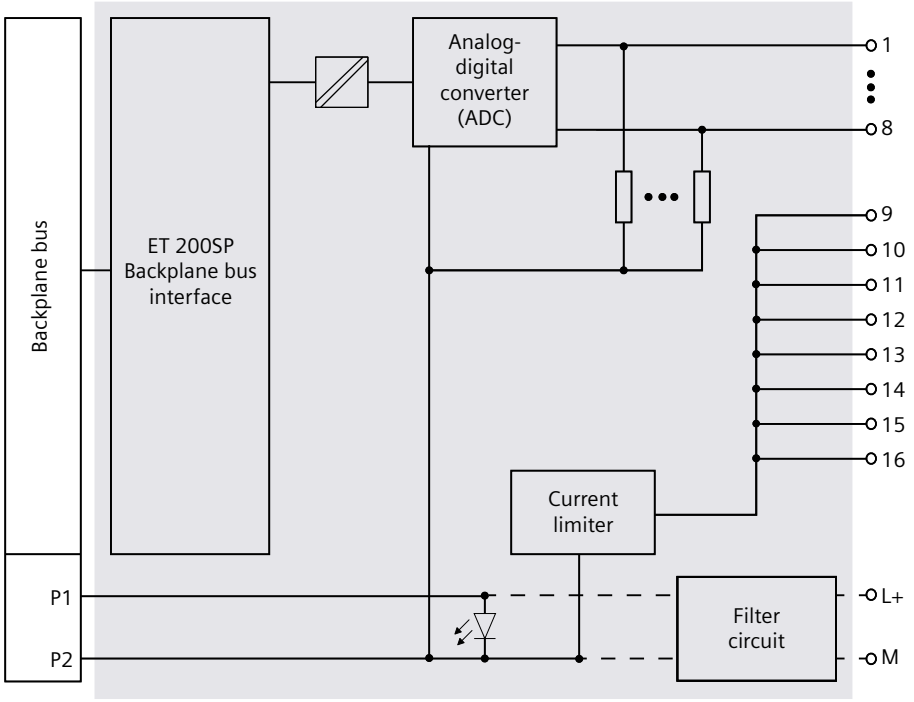

Figure 2-505 Schematic circuit diagram analog input module

Parameters/address space

5

5.1 Measuring types and ranges

The analog input module AI 8xI 2-/4-wire BA has the following measuring ranges:

Table 2-482 Measuring ranges

Measurement type	Measuring range	Resolution
Current (2-wire and 4-wire transducers)	0 mA to 20 mA 4 mA to 20 mA	15 bits 15 bits
Current (4-wire transducer)	± 20 mA	16 bits including sign

You will find the tables of the measuring ranges as well as overflow, overrange, etc., in the section Representation of analog values (Page 42).

5.2 Parameters

AI 8xI 2-/4-wire BA parameters

Specify the module properties with the various parameters during parameter assignment of the module with STEP 7. The following table lists the configurable parameters. The efficiency range of the configurable parameters depends on the type of configuration.
The following configurations are possible:

- Central operation with an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

In addition to assigning parameters with the configuration software, you can also set the parameters in RUN mode (dynamically) using the user program.

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 37).

The following parameter settings are possible:

Table 2-483 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Reconfiguration in RUN	Scope with configuration software e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Module	Module [1]
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Module	
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Module	Module
Type/range of measurement	• Deactivated • Current (4-wire transducer) 0 to 20 mA • Current (4-wire transducer) 4 to 20 mA • Current (4-wire transducer) +/-20 mA • Current (2-wire transducer) 0 to 20 mA • Current (2-wire transducer) 4 to 20 mA	Current (4-wire transducer) 4 to 20 mA	Yes	Channel	Channel
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel
Interference frequency suppression	• 60 Hz (50 ms) • 50 Hz (60 ms) [2] • 16.6 Hz (180 ms) • 4800 Hz (0.625 ms) • 60 Hz (18.75 ms) [3] • 50 Hz (22.5 ms) [2 3] • 16.6 Hz (67.5 ms) [3]	50 Hz (60 ms)	Yes	Channel	Module

1 Only when configuring using a PROFIBUS GSD file; does not apply to configuration with STEP 7 via HSP: The parameter assignment options are limited because PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes for each ET 200SP station. The parameter length of the I/O module is 8 bytes for PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128; see appendix "Parameter data record".

2 Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

3 By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical specifications).

Parameter	Range of values	Default	Reconfiguration in RUN	Scope with configuration software e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Potential group	• Use the potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into a light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

1 Only when configuring using a PROFIBUS GSD file; does not apply to configuration with STEP 7 via HSP: The parameter assignment options are limited because PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes for each ET 200SP station. The parameter length of the I/O module is 8 bytes for PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128; see appendix "Parameter data record".

2 Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

3 By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical specifications).

NOTE

Unused channels

"Deactivate" unused channels in the parameter assignment to improve the cycle time of the module.

A deactivated channel always returns the value $7FFF_H$.

NOTE

Note that the settings in the "Interference frequency suppression" parameter have a direct effect on the cycle time of the module. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

NOTE

Note that the settings in the "Interference frequency suppression" parameter have a direct effect on the temporary deviations of the analog values.

When setting the interference frequency suppression to 4.8 kHz, the temporary deviation of the analog values reaches up to ±30% of the full-scale value in the burst of 100 kHz, in accordance with IEC 61000-4-4 "Burst-Impulse (fast transient interferences)". See the ET 200SP Distributed I/O System (https://support.automation.siemens.com/WW/view/en/58649293) system manual, section "Pulse-shaped disturbance variables of the ET 200SP system".

5.3 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the encoder supply to ground occurs.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics: Wire break

Enabling of the diagnostics if the module has no current flow or the current is too weak to be measured at the relevant input.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the Diagnostics: Wire break is output.

Measurement type/measuring ranges

See the section Measurement types and measuring ranges (Page 19).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) × cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This is valid for all signal changes at the analog input.

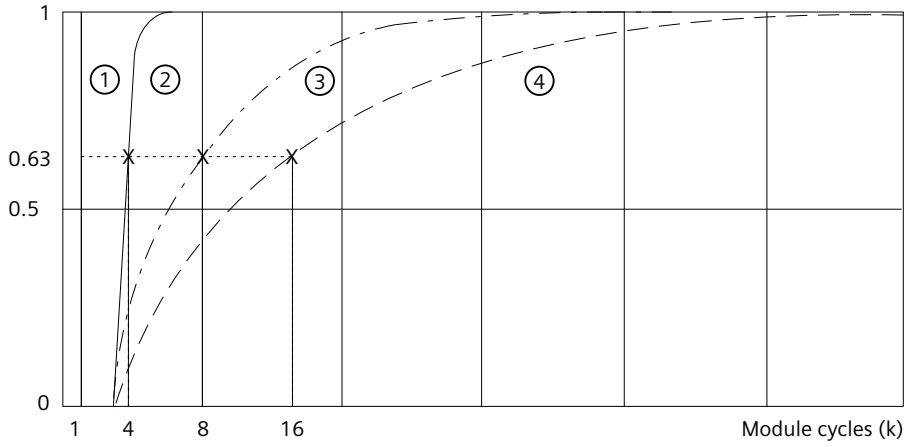

① No smoothing (k = 1)

② Weak (k = 4)

③ Medium (k = 8)

④ Strong (k = 16)

Figure 2-506 Smoothing with AI 8xI 2-/4-wire BA

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the alternating voltage network may negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2, and AUX to the left neighbor.

Specify the slot in which a light-colored BaseUnit with supply voltage infeed or a dark-colored BaseUnit is to be located (see ET 200SP Distributed I/O System (https://support.automation.siemens.com/WW/view/en/58649293) system manual). All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You

take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

The station configuration must be completed with a server module.

See also

You can find more information in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

5.4 Address space

The module can be configured in various ways in STEP 7; see the following table. Depending on the configuration, additional/different addresses are assigned in the process image input.

Configuration options of AI 8xI 2-/4-wire BA

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. When you configure the module by means of the GSD file, the configurations are available under different short designations/module names; see following table. The following configurations are possible:

Table 2-484 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software e.g., with STEP 7 (TIA Portal)		
		FW version V2.0: Integrated in the hardware catalog STEP 7 as of V21*	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 8-channel without value status	AI 8xI 2-/4-wire BA V1.0	X	X	X
1 x 8-channel without value status	AI 8xI 2-/4-wire BA V2.0	X	X	X

* If the firmware version V2.0 is not available in the catalog, V1.0 can also be configured.

Address space for configuration as 1 x 8-channel AI 8xI 2-/4-wire BA V1.0

The following figure shows the assignment of the address space for the configuration as 1 x 8-channel module without value status. "IB" stands for input byte.

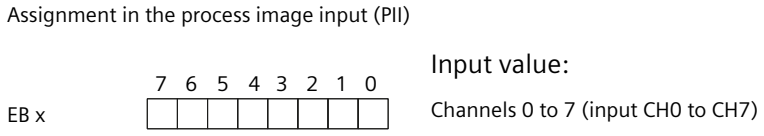

Figure 2-507 Address space for configuration as 1x8-channel AI 8xI 2-/4-wire BA V1.0

Address space for configuration as 1 x 8-channel AI 8xI 2-/4-wire BA V2.0

The following figure shows the assignment of the address space for the configuration as 1 x 8-channel module without value status. "IB" stands for input byte.

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	Input value:
EB x									Channels 0 to 7 (input CH0 to CH7)

Figure 2-508 Address space for configuration as 1x8-channel AI 8xI 2-/4-wire BA V2.0

See also

ET 200SP Distributed I/O System
(http://support.automation.siemens.com/WW/view/en/58649293)

Interrupts/diagnostics alarms

6

6.1 Status and error displays

LED displays

The figure below shows the LED displays (status and error displays) of the module.

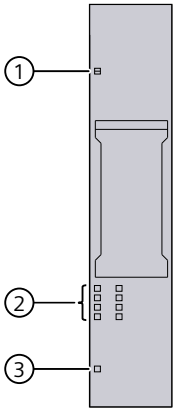

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-509 LED displays

Meaning of the LEDs

The meaning of the status and error messages is described in the following tables. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 29).

DIAG LED

Table 2-485 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the system is interrupted or switched off.
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics available
Flashes	Module parameters assigned and module diagnostics available

Channel status LED

Table 2-486 Status display of the channel status LED

Channel status LED	Meaning
Off	Channel deactivated
On	Channel activated

PWR LED

Table 2-487 Status display of the PWR LED

PWR LED	Meaning
Off	No supply voltage L+
On	Supply voltage L+ present

6.2 Interrupts

Introduction

The I/O device generates interrupts as a reaction to specific error events. Interrupts are evaluated based on the I/O controller used.

Evaluating interrupts with I/O controllers

The module supports the following interrupts

- Diagnostic interrupts
- Maintenance events

In the event of an interrupt, interrupt OBs are automatically called in the CPU of the IO controller.

Information on the cause and class of the error is already available, based on the OB number and start information.

Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

6.2.1 Triggering of a diagnostics interrupt

Triggering of a diagnostics interrupt

For an incoming or outgoing event (e.g. wire break on a channel of an I/O module), the module triggers a diagnostics interrupt if this is configured accordingly.

The CPU interrupts processing of the user program and processes the diagnostics block OB 82. The event which led to the interrupt is entered in the start information of the OB 82.

6.2.2 Triggering of a maintenance event

Triggering of a maintenance event

For the module, maintenance events signal to the user when a plant component needs to be checked or replaced.

The CPU interrupts the processing of the user program and processes the diagnostic error interrupt OB (OB 82). The event that triggered the maintenance event is entered in the start information of the diagnostic error interrupt OB.

6.3 Alarms

Introduction

The module generates the following alarms:

- Diagnostics alarms
- Maintenance alarms

6.3.1 Diagnostics alarms

A diagnostics alarm is generated and the DIAG LED flashes red on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostic buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-488 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit *	1_H	Encoder supply to ground	Correct interplay between module and encoder
Wire break	6_H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, for example, using cables with a larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate channel • Connect the encoder contacts
High limit violated	7_H	Value is above overrange.	Correct interplay between module and encoder
Low limit violated	8_H	Value is below underrange.	Correct interplay between module and encoder
Error	9_H	Internal module error occurred.	Replace module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment (diagnostics wire break set only with the permitted measuring ranges).
Supply voltage missing	11_H	No or insufficient supply voltage L+	• Check the supply voltage L+ on the BaseUnit • Check BaseUnit type

* Short-circuit of the encoder supply to ground has an effect on all channels

Diagnostics alarms in the measured value of analog input modules

Each analog input module supplies the measured value $7FFF_H$ or 8000_H depending on the parameter assignment for when an error is detected.

6.3.2 Maintenance alarms

For the module, maintenance events signal to the user when a plant component needs to be checked or replaced.

The CPU interrupts the processing of the user program and processes the diagnostic error interrupt OB (OB 82). The event that triggered the maintenance event is entered in the start information of the diagnostic error interrupt OB.

Maintenance required alarms

Every time maintenance required is detected, a maintenance event is generated. However, it has no influence on the LED DIAG on the module.

NOTE

Maintenance alarms have no direct influence on the function of the module.

Table 2-489 Maintenance required alarms, their meaning and possible remedies

Maintenance required alarm	Error code	Meaning / Cause	Solution
Security event: Firmware successfully downloaded and activated for use after a reset	0191_H	The firmware was successfully loaded into the module. This firmware update takes effect after the module is restarted.	-
Security event: Firmware integrity checks failed.	0192_H	The firmware was not successfully loaded into the module. This can have many different reasons, e.g. corrupted binary files or an incorrect signature.	Verify if the firmware update file you are using comes from a secure source. Download the firmware again from the Siemens support website and repeat the firmware update.

System events in STEP 7 (TIA Portal)

The maintenance information is generated in STEP 7 (TIA Portal) with the following system events:

- Maintenance required - indicated by a wrench with a green background in the device view or in the hardware configuration.

You can find more information in the STEP 7 online help.

Technical specifications 7

7.1 Technical specifications

Technical specifications of the AI 8×I 2-/4-wire BA

The following table lists the technical specifications as of the issue date. A data sheet including daily updated technical specifications is available on the Internet (https://support.industry.siemens.com/cs/ww/de/pv/6ES7134-6GF00-0AA1/td?dl=en).

Article number	6ES7134-6GF00-0AA1
General information	
Product type designation	AI 8xI 2-/4-wire BA
HW functional status	FS23 or higher
Firmware version	V2.0.0
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC01
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Measuring range scalable	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	TIA Portal V21
• STEP 7 configurable/integrated from version	V5.7 SP3
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.45
Operating mode	
• Oversampling	No
• MSI	No
CiR - Configuration in RUN	
Reparameterization possible in RUN	No
Calibration possible in RUN	No

Article number	6ES7134-6GF00-0AA1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	25 mA; rated voltage, all channels active, no load
Current consumption, max.	725 mA; worst case voltage, all channels active, max. load, no derating
Encoder supply	
24 V encoder supply	
• 24 V	Yes
• Short-circuit protection	Yes
• Output current, max.	0.7 A; total current of all encoders/channels
Power loss	
Power loss, typ.	0.7 W; rated voltage, 50 % active channels, 50 % of range
Power loss, max.	1.5 W; max. voltage, full load, all channels active, no derating
Address area	
Address space per module	
• Address space per module, max.	16 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0, A1
• 2-wire connection	BU type A0, A1
• 4-wire connection	BU type A0, A1 + potential distributor module
Analog inputs	
Number of analog inputs	8; Single-ended
• For current measurement	8
permissible input current for current input (destruction limit), max.	50 mA
Cycle time (all channels), min.	1 ms; per channel
Input ranges (rated values), currents	
• 0 to 20 mA	Yes
– Input resistance (0 to 20 mA)	100 Ω; 15 bit
• -20 mA to +20 mA	Yes
– Input resistance (-20 mA to +20 mA)	100 Ω; 16 bit incl. sign

Article number	6ES7134-6GF00-0AA1
• 4 mA to 20 mA	Yes
– Input resistance (4 mA to 20 mA)	100 Ω; 15 bit
Cable length	
• shielded, max.	200 m
Analog value generation for the inputs	
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Interference voltage suppression for interference frequency f1 in Hz	16.67 / 50 / 60 / 4 800 (16.67 / 50 / 60)
• Conversion time (per channel)	180 / 60 / 50 / 0.625 (67.5 / 22.5 / 18.75) ms
Smoothing of measured values	
• Number of smoothing levels	4
• parameterizable	Yes
• Step: None	Yes
• Step: low	Yes; 4x smoothing
• Step: Medium	Yes; 8x smoothing
• Step: High	Yes; 16x smoothing
Encoder	
Connection of signal encoders	
• for voltage measurement	No
• for current measurement as 2-wire transducer	Yes
– Burden of 2-wire transmitter, max.	650 Ω
• for current measurement as 4-wire transducer	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %
Temperature error (relative to input range), (+/-)	0.005 %/K
Crosstalk between the inputs, min.	50 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Current, relative to input range, (+/-)	0.5 %
Basic error limit (operational limit at 25 °C)	
• Current, relative to input range, (+/-)	0.3 %

Article number	6ES7134-6GF00-0AA1
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	70 dB; With conversion time 67.5 / 22.5 / 18.75 ms: 40 dB
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	No
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; at 4 to 20 mA
• Short-circuit	Yes; Sensor supply to M; module by module
• Group error	Yes
• Overflow/underflow	Yes; Module-wise
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green LED
• Channel status display	Yes; green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
product functions / security / header	
signed firmware update	Yes; firmware V2.0.0 or higher
safely removing data	Yes; firmware V2.0.0 or higher
data integrity	Yes; firmware V2.0.0 or higher
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; < 0 °C as of FS04
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; < 0 °C as of FS04
• vertical installation, max.	50 °C

Article number	6ES7134-6GF00-0AA1
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See the manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, note that the settings of some parameters are interdependent.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range with PROFINET.

Measurement type	**Measuring range**	**Diagnostics**				
		No supply voltage L+	**Short-circuit to ground**	**Overflow**	**Underflow**	**Wire break**
Deactivated		*	*	*	*	*
Current (4-wire transducer)	0 mA to 20 mA	x	x	x	x	-
	4 mA to 20 mA	x	x	x	x	x
	±20 mA	x	x	x	x	-
Current (2-wire transducer)	0 mA to 20 mA	x	x	x	-	-
	4 mA to 20 mA	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range with PROFIBUS.

Measurement type	**Measuring range**	**Diagnostics**			
		No supply voltage L+	**Short-circuit to ground**	**Overflow/underflow**	**Wire break**
Deactivated		*	*	*	*
Current (4-wire transducer)	0 mA to 20 mA	x	x	x	-
	4 mA to 20 mA	x	x	x	x
	±20 mA	x	x	x	-
Current (2-wire transducer)	0 mA to 20 mA	x	x	x	-
	4 mA to 20 mA	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reassign the module parameters in your user program, regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can reassign the parameters of the module in RUN. For example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

STATUS output parameter

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 contains the diagnostics for the entire module.

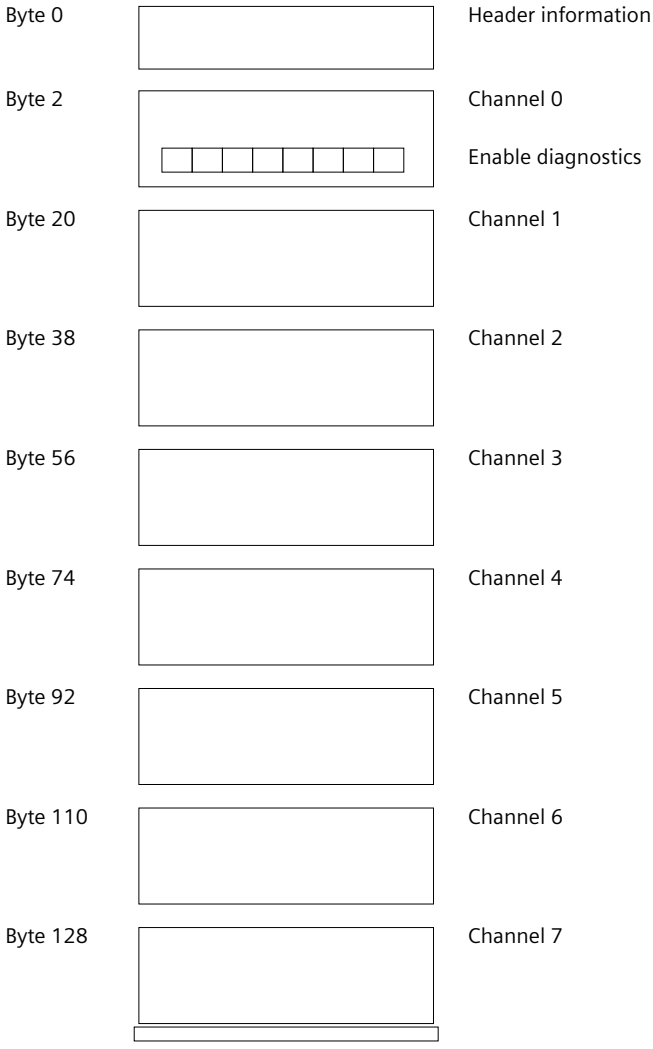

Figure 2-510 Structure of data record 128

Header information

The figure below shows the structure of the header information.

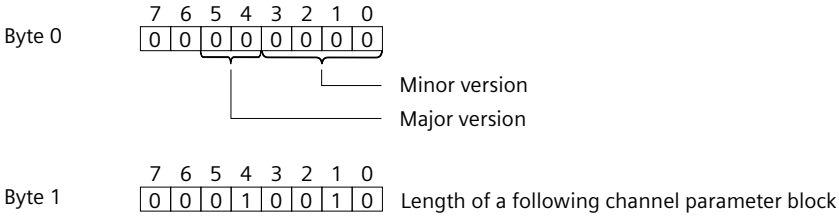

Figure 2-511 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

Enable a parameter by setting the corresponding bit to "1".

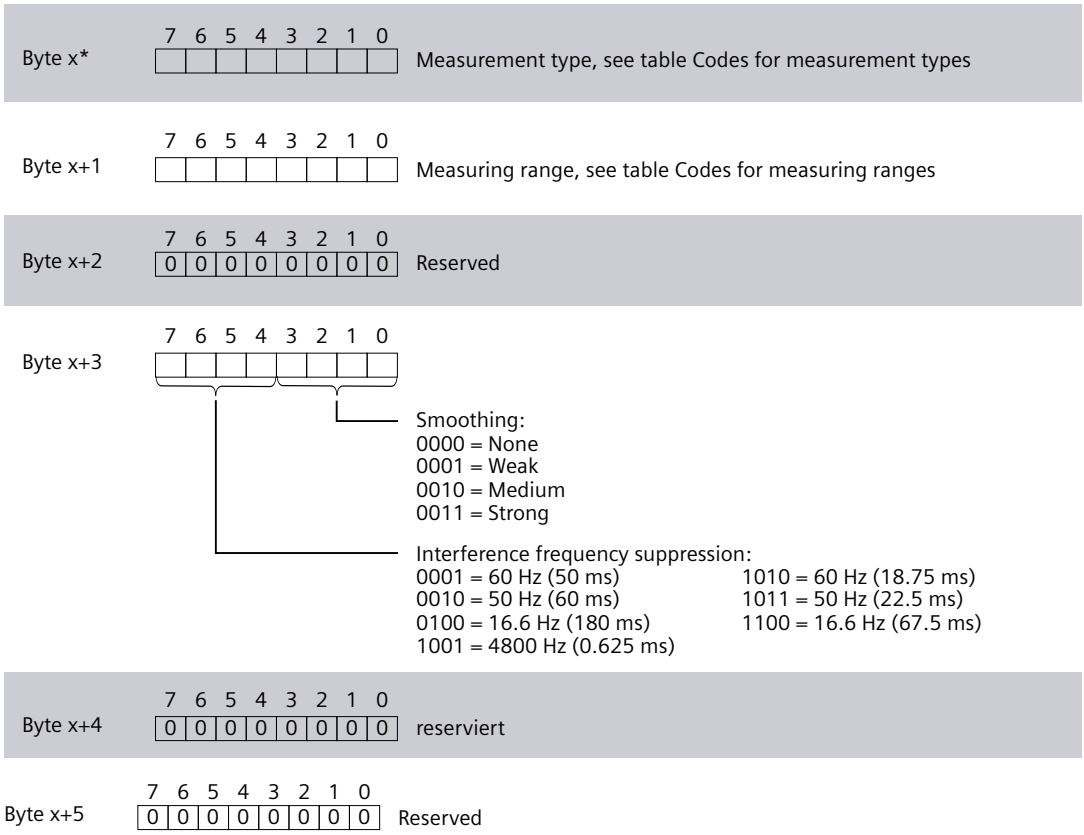

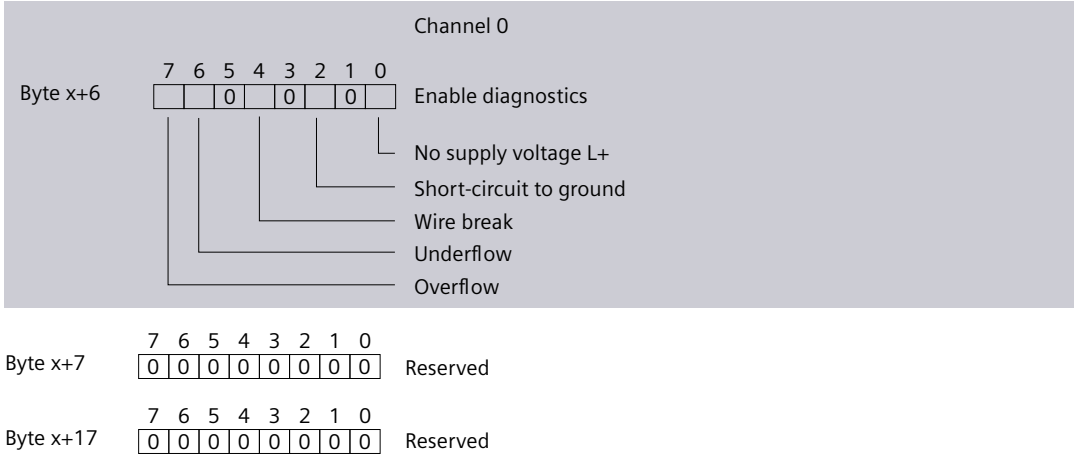

* x = 2 + (channel number × 18); channel number = 0 to 7

Figure 2-512 Structure of byte x to x+17 for channels 0 to 7

Codes for measurement types

The following table contains the codes for the measurement types of the analog input module. You must enter these codes at byte x (see previous figure).

Table 2-490 Codes for measurement types

Measurement type	Code
Deactivated	0000 0000
Current, 4-wire transducer	0000 0010
Current, 2-wire transducer	0000 0011

Codes for measuring ranges

The following table contains the codes for the measuring ranges of the analog input module. You enter these codes at byte x+1 (see previous figure).

Table 2-491 Codes for measuring ranges

Measuring range	Code
0 to 20 mA	0000 0010
4 mA to 20 mA	0000 0011
±20 mA	0000 0100

Error while transferring the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	xx	Module cannot be reached.	• Check station. • Plug the module in correctly. • Check parameters of the WRREC block.
DF	80	E0	xx	Wrong version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module

Representation of analog values

B

Measured value resolution

The resolution of the analog values differs depending on the analog module and its parameter assignment.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table 2-492 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	**Hexadecimal**	**High byte**	**Low byte**
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table 2-493 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 2-494 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	

Dec. value	Measured value in %	Data word																Range
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table 2-495 Current measuring range ±20 mA

Values		Current measuring range	Range
Dec.	**Hex.**	**±20 mA**	
32767	7FFF	>23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	<-23.52 mA	Underflow

Table 2-496 Current measuring ranges 0 mA to 20 mA and 4 mA to 20 mA

Values		Current measuring range		Range
Dec.	**Hex.**	**0 mA to 20 mA***	**4 mA to 20 mA**	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range

* For measurement type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

Values		Current measuring range		Range
20736	5100	15 mA	16 mA	Nominal range
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<-3.52 mA	< 1.185 mA	Underflow

* For measurement type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

B.3 Measured values for wire break

The following table contains the measured values at a wire break depending on enabled diagnostics.

Table 2-497 Measured values at a wire break depending on enabled diagnostics

Programmable diagnostics		Measured value		Explanation
Wire break	Underflow			
Enable	Enable	32767	$7FFF_H$	The "wire break" diagnostics is reported, because this has a higher priority.
Disable	Enable	-32768	8000_H	The "Lower limit violated" diagnostics is reported.
Disable	Disable	-32768	8000_H	No diagnostics reported.

SIEMENS

SIMATIC

ET 200SP
Analog Input Module AI 4xU/I 2-wire ST (6ES7134-6HD01-0BA1)

Equipment Manual

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Technical specifications 6

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06/2020
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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

Wiring and block diagram has been modified.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

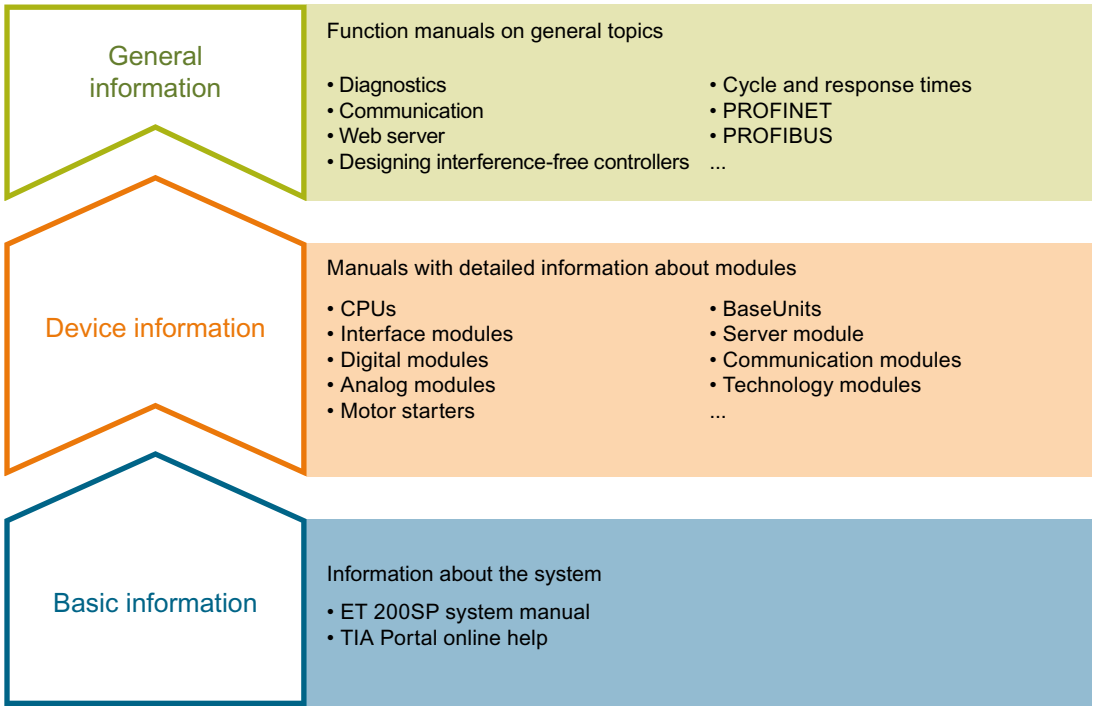

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

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"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://new.siemens.com/global/en/productservices/automation/topics/tia/tia-selection-tool.html).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7134-6HD01-0BA1 (number in pack: 1 unit)

6ES7134-6HD01-2BA1 (number in pack: 10 units)

View of the module

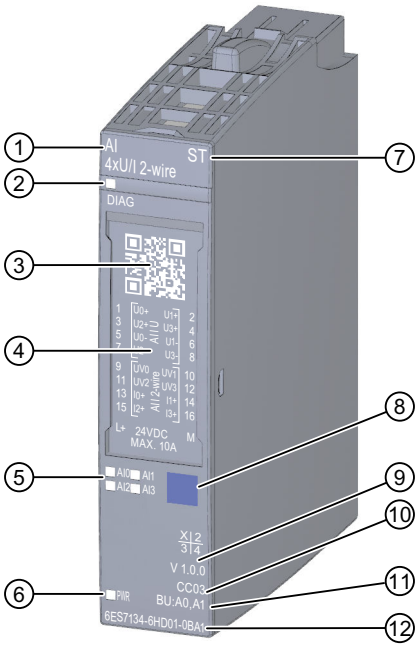

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-513 View of the module AI 4×U/I 2-wire ST

Properties

The module has the following technical properties:

- Analog input module with 4 inputs
- Measuring type voltage and current for 2-wire transducer (can be set for each channel)
- Input ranges for voltage measurement:
  - ±10 V, resolution 16 bits including sign
  - ±5 V, resolution 16 bits including sign
  - 1 to 5 V, resolution 15 bits
  - 0 to 10 V, resolution 15 bits
- Input ranges for current measurement:
  - 4 to 20 mA, resolution 15 bits
  - 0 to 20 mA, resolution 15 bits
- Electrically isolated from the supply voltage L+ (only for voltage measuring type)
- Permitted common mode voltage: 10 V_{ss}
- Configurable diagnostics per module

The module supports the following functions:

Table 2-498 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V2.0.0 or higher	V14 or higher with HSP 0239	V5.5 SP3 or higher with HSP 0227 V7.0 or higher	X	X
Identification data I&M0 to I&M3	FS01	V2.0.0 or higher	V14 or higher with HSP 0239	V5.5 SP3 or higher with HSP 0227 V7.0 or higher	X	X
Reconfiguration in RUN	FS01	V2.0.0 or higher	V14 or higher with HSP 0239	V5.5 SP3 or higher with HSP 0227 V7.0 or higher	X	X
PROFIenergy	FS01	V2.0.0 or higher	V14 or higher with HSP 0239	V5.5 SP3 or higher with HSP 0227 V7.0 or higher	X	X
Value status	FS01	V2.0.0 or higher	V14 or higher with HSP 0239	V5.5 SP3 or higher with HSP 0227 V7.0 or higher	X	X

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You will find additional information on the accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Wiring up

3

3.1 Wiring and block diagram

This section includes the block diagram of the AI 4xU/I 2-wire ST module with the terminal assignments.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

NOTE

You can use and combine the different wiring options for all channels.

NOTE

The load group of the module must begin with a light BaseUnit. Keep this in mind also during the configuration.

Wiring: Voltage and current measurement 2-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the analog input module AI 4xU/I 2-wire ST on the BaseUnit BU type A0/A1.

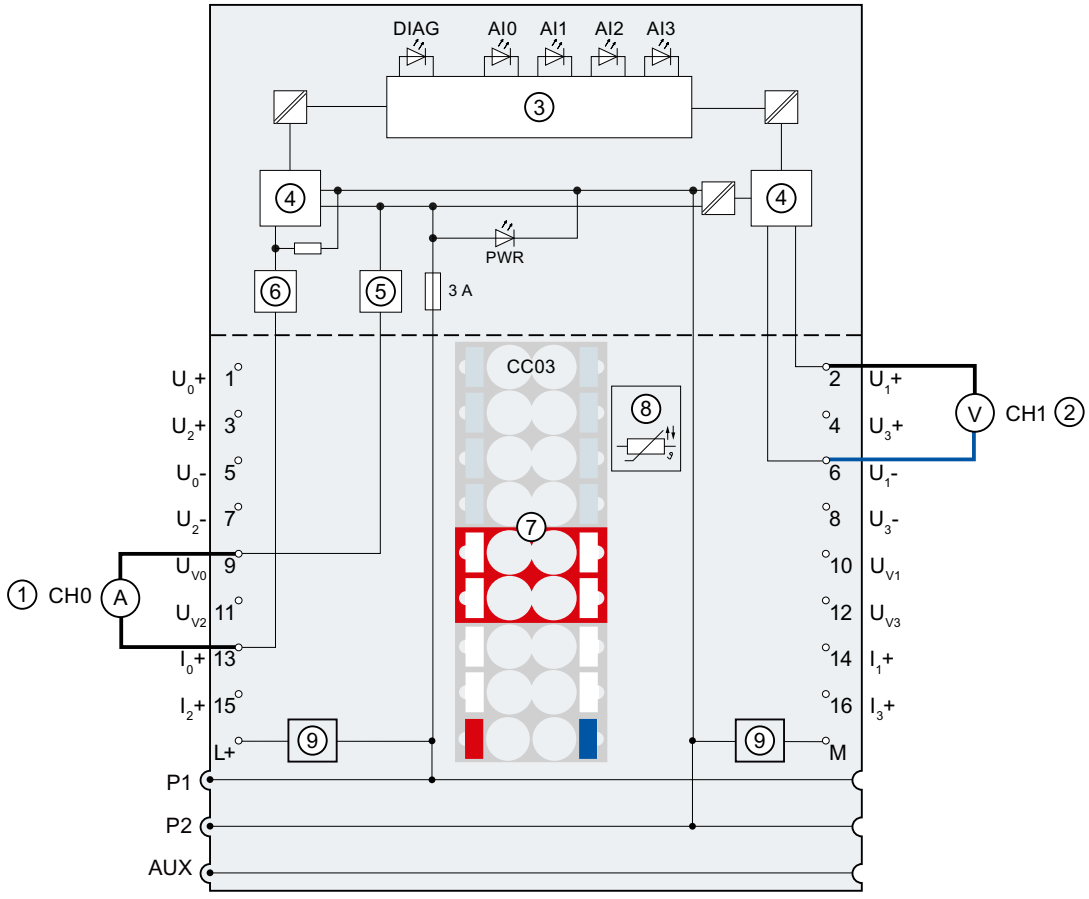

①	2-wire connection for current measurement (2-wire transducer)	U_n+	Voltage input positive, channel n
②	2-wire connection for voltage measurement	U_n-	Voltage input negative, channel n
③	Backplane bus interface	U_{vn}	Supply voltage, channel n
④	Analog-to-digital converter (ADC)	I_n+	Current input positive, channel n
⑤	Short-circuit protection	L+	24 V DC (infeed only with light BaseUnit)
⑥	Current limitation	M	Ground
⑦	Color-coded label with color code CC03 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark BaseUnit) Connection to left interrupted (light BaseUnit)
⑧	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑨	Supply voltage filter circuit (only when light BaseUnit is present)	AI0, AI1, AI2, AI3	Channel status LED (green)
		PWR	Power LED (green)

Figure 2-514 Wiring and block diagram for voltage and current measurement

Parameters/address space

4

4.1 Measuring types and ranges

The analog input module AI 4×U/I 2-wire ST has the following measuring ranges:

Table 2-499 Measuring ranges

Measuring type	Measuring range	Resolution
Voltage	± 5 V ±10 V 1 to 5 V 0 to 10 V	16 bits including sign 16 bits including sign 15 bits 15 bits
Current (2-wire transducer)	0 mA to 20 mA 4 to 20 mA	15 bits 15 bits

You will find the tables of the measuring ranges as well as overflow, overrange, etc., in the section Representation of analog values (Page 34).

4.2 Parameters

Parameters of the AI 4xU/I 2-wire ST

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 29).

The following parameter settings are possible:

Table 2-500 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics Overflow	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics Underflow	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics Wire break	• Disable • Enable	Disable	Yes	Module	Module
Measuring type/range	• deactivated • Voltage +/- 5 V • Voltage +/- 10 V • Voltage 1..5 V • Voltage 0..10 V • Current (2-wire transducer) 0..20 mA • Current (2-wire transducer) 4..20 mA	Current (2-wire transducer) 4..20 mA	Yes	Channel	Channel
Smoothing	• None • weak • medium • strong	None	Yes	Channel	Channel
Interference frequency suppression [2]	• 60 Hz • 50 Hz[1] • 16.6 Hz	50 Hz	Yes	Channel	Module [3]
Potential group	• Use potential group of the left module (module plugged into a dark BaseUnit) • Enable new potential group (module plugged into light BaseUnit)	Use potential group of the left module	No	Module	Module

1 ...Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

2 The settings in the "Interference frequency suppression" parameter have a direct effect on the conversion time of the channel. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

2 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 5 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data set".

NOTE

Unused channels

Disable unused channels in the parameter assignment to improve the cycle time of the module.

A disabled channel always returns the value $7FFF_H$.

4.3 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics Short-circuit to ground

Enabling of the diagnostics in the event of a short-circuit of the encoder supply to ground or of an input to the encoder supply. Short-circuit is also detected in the range 1 to 5 V, when both input signals are short-circuited.

The short-circuit and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, however, the short-circuit diagnostics suppresses the underflow diagnostics. Short-circuit is output as the diagnostics event.

Diagnostics overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics Wire break

Enabling of the diagnostics if the module has no current flow or the current is too weak to be measured at the relevant input.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the wire break diagnostics info is output.

Type/range of measurement

Refer to the section Measuring types and ranges (Page 14).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This applies to every signal change at the analog input.

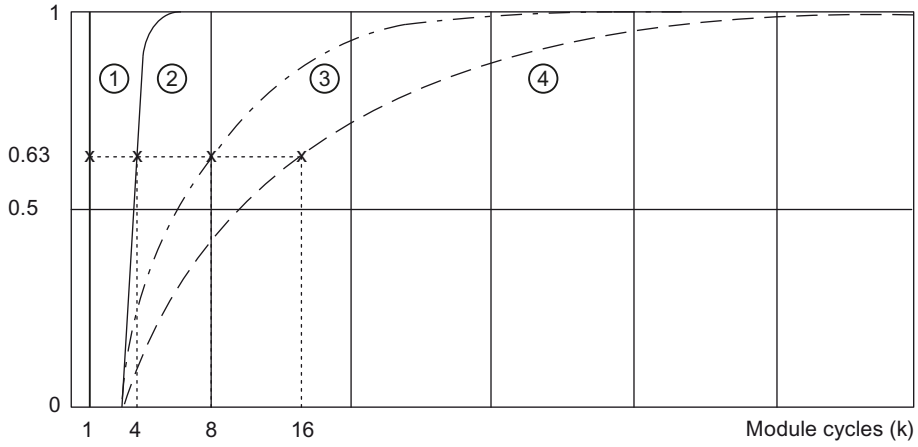

① No smoothing (k = 1)

② Weak (k = 4)

③ Medium (k = 8)

④ Strong (k = 16)

Figure 2-515 Smoothing with AI 4xU/I 2-wire ST

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network can negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the supply frequency that is predominant in the plant.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

4.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 to 3 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AI 4×U/I 2-wire ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

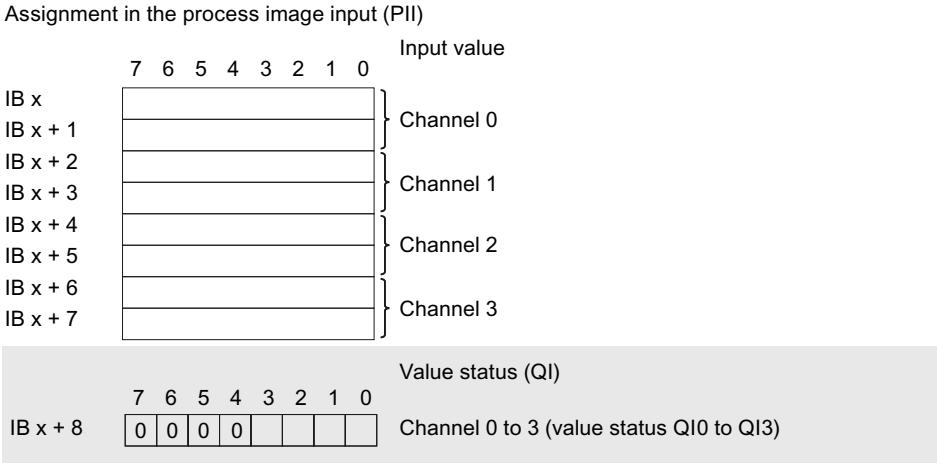

Figure 2-516 Address space of the AI 4×U/I 2-wire ST with value status

Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays (status and error displays) of the AI 4xU/I 2-wire ST.

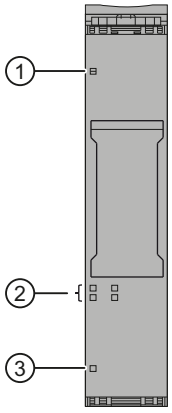

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-517 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 21).

DIAG LED

Table 2-501 DIAG LED fault/error display

DIAG LED	Meaning
☐ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-502 Status display of the channel status LED

Channel status LED	Meaning
☐ Off	Channel disabled
■ On	Channel activated

PWR LED

Table 2-503 Status display of the PWR LED

PWR LED	Meaning
☐ Off	No supply voltage L+
■ On	Supply voltage L+ present

5.2 Interrupts

The analog input module AI 4×U/I 2-wire ST supports diagnostics interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Channel temporarily unavailable
- Short-circuit (current, voltage 1..5 V)
- Wire break (current 4 to 20 mA)
- Low limit violated
- High limit violated
- Error
- Parameter assignment error
- Supply voltage missing

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-504 Diagnostics alarms, their meaning and how to deal with them

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit (current)*	1_H	Sensor supply to ground	Correct the module/encoder tuning
		Input to sensor supply	
Short-circuit (1 to 5 V) **	1_H	Short-circuit of input signal	Correct the module/encoder tuning
		Open input	Connect input
Wire break (current) **	6_H	Impedance of encoder circuit too high.	Use a different encoder type or modify the wiring, for example, using cables with a larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect the sensor contacts
High limit violated	7_H	Value is above the overrange.	Correct the module/encoder tuning
Low limit violated	8_H	Value is below the underrange.	Correct the module/encoder tuning
Error	9_H	Internal module error occurred.	Replace module

* Short-circuit of the encoder supply to ground and/or of the input signal to the encoder supply of a channel can have a temporary effect on other channels (duration < 0.5 s). This means the short-circuit diagnostics can also be reported for unaffected channels and/or the measured value can be affected temporarily.

** In case of activated smoothing the module calculates the measured values across several module cycles. The module only generates the short circuit or wire break diagnosis if the smoothed measured value is stable. After the short-circuit or wire break has been eliminated, the module supplies stable measured values again depending on the set smoothing level.

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module does not read any process values in this state.	• Wait for firmware update. • Restart the firmware update.

* Short-circuit of the encoder supply to ground and/or of the input signal to the encoder supply of a channel can have a temporary effect on other channels (duration < 0.5 s). This means the short-circuit diagnostics can also be reported for unaffected channels and/or the measured value can be affected temporarily.

** In case of activated smoothing the module calculates the measured values across several module cycles. The module only generates the short circuit or wire break diagnosis if the smoothed measured value is stable. After the short-circuit or wire break has been eliminated, the module supplies stable measured values again depending on the set smoothing level.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the AI 4×U/I 2-wire ST

The following table shows the technical specifications as of 06/2020. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7134-6HD01-0BA1/td?dl=en).

Article number	6ES7134-6HD01-0BA1
General information	
HW functional status	From FS02
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC03
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Measuring range scalable	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V14 / -
• STEP 7 configurable/integrated as of version	V5.6 and higher
• PCS 7 configurable/integrated as of version	V8.1 SP1
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• Oversampling	No
• MSI	No
CiR – Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	No

Article number	6ES7134-6HD01-0BA1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	37 mA; without sensor supply
24 V encoder supply	
• 24 V	Yes
• Short-circuit protection	Yes
• Output current, max.	20 mA; max. 50 mA per channel for a duration < 10 s
Power loss	
Power loss, typ.	0.85 W; Without encoder supply voltage
Address area	
Address space per module	
• Address space per module, max.	8 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type A0, A1
Analog inputs	
Number of analog inputs	4; Differential inputs
permissible input voltage for voltage input (destruction limit), max.	30 V
permissible input current for current input (destruction limit), max.	50 mA
Cycle time (all channels), min.	Sum of the basic conversion times and additional processing times (depending on the parameterization of the active channels)
Input ranges (rated values), voltages	
• 0 to +10 V	Yes; 15 bit
– Input resistance (0 to 10 V)	120 kΩ
• 1 V to 5 V	Yes; 15 bit
– Input resistance (1 V to 5 V)	120 kΩ
• -10 V to +10 V	Yes; 16 bit incl. sign
– Input resistance (-10 V to +10 V)	120 kΩ
• -5 V to +5 V	Yes; 16 bit incl. sign
– Input resistance (-5 V to +5 V)	120 kΩ

Article number	6ES7134-6HD01-0BA1
Input ranges (rated values), currents	
• 0 to 20 mA	Yes; 15 bit
– Input resistance (0 to 20 mA)	100 Ω; + approx. 0.7 V diode forward voltage
• 4 mA to 20 mA	Yes; 15 bit
– Input resistance (4 mA to 20 mA)	100 Ω; + approx. 0.7 V diode forward voltage
Cable length	
• shielded, max.	1 000 m; 200 m for voltage measurement
Analog value generation for the inputs	
Measurement principle	integrating (Sigma-Delta)
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz
• Conversion time (per channel)	180 / 60 / 50 ms
Smoothing of measured values	
• Number of smoothing levels	4; None; 4/8/16 times
• parameterizable	Yes
Encoder	
Connection of signal encoders	
• for voltage measurement	Yes
• for current measurement as 2-wire transducer	Yes
– Burden of 2-wire transmitter, max.	650 Ω
• for current measurement as 4-wire transducer	No
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %
Temperature error (relative to input range), (+/-)	0.005 %/K
Crosstalk between the inputs, min.	50 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Voltage, relative to input range, (+/-)	0.5 %
• Current, relative to input range, (+/-)	0.5 %
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to input range, (+/-)	0.3 %
• Current, relative to input range, (+/-)	0.3 %

Article number	6ES7134-6HD01-0BA1
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	70 dB
• Common mode voltage, max.	10 V
• Common mode interference, min.	90 dB
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	No
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; at 4 to 20 mA
• Short-circuit	Yes; with 1 to 5 V or 2-wire mode: Short-circuit of the encoder supply to ground or of an input to the encoder supply
• Group error	Yes
• Overflow/underflow	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green LED
• Channel status display	Yes; green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red LED
Potential separation	
Potential separation channels	
• between the channels	Yes; channel group-specific between 2-wire current input group and voltage input group
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes; only for voltage inputs
Permissible potential difference	
between the inputs (UCM)	10 V DC
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for applications according to AMS 2750	Yes; Declaration of Conformity, see online support entry 109757262
Suitable for applications according to CQI-9	Yes

Article number	6ES7134-6HD01-0BA1
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measuring type and measuring range for PROFINET.

Measuring type	Measuring range	Diagnostics				
		No supply voltage L+	Short-circuit to M	Overflow	Underflow	Wire break
deactivated		*	*	*	*	*
Voltage	±5 V	x	-	x	x	-
	±10 V	x	-	x	x	-
	1..5 V	x	x	x	x	-
	0..10 V	x	-	x	x	-
Current (2-wire transducer)	0..20 mA	x	x	x	x	-
	4..20 mA	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measuring type and measuring range for PROFIBUS.

Measuring type	Measuring range	Diagnostics			
		No supply voltage L+	Short-circuit to M	Overflow/ Underflow	Wire break
deactivated		*	*	*	*
Voltage	±5 V	x	-	x	-
	±10 V	x	-	x	-
	1..5 V	x	x	x	-
	0..10 V	x	-	x	-
Current (2-wire transducer)	0..20 mA	x	x	x	-
	4..20 mA	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can reassign the parameters of the module in RUN. For example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 contains the diagnostics for the entire module.

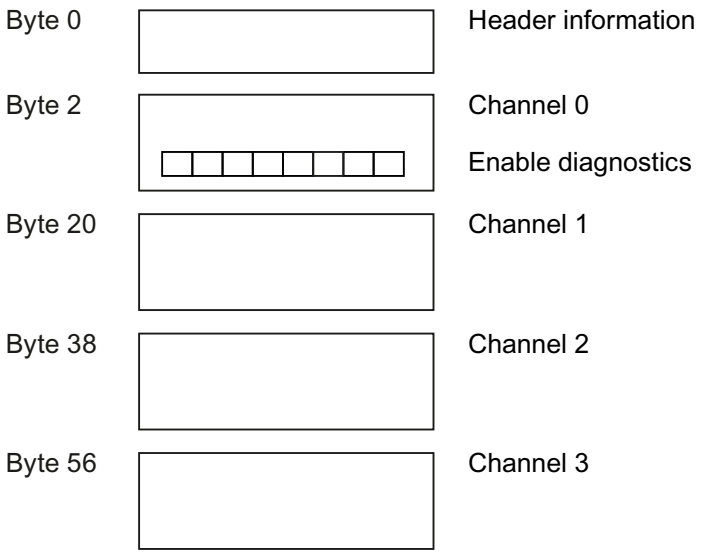

Figure 2-518 Structure of data record 128

Header information

The figure below shows the structure of the header information.

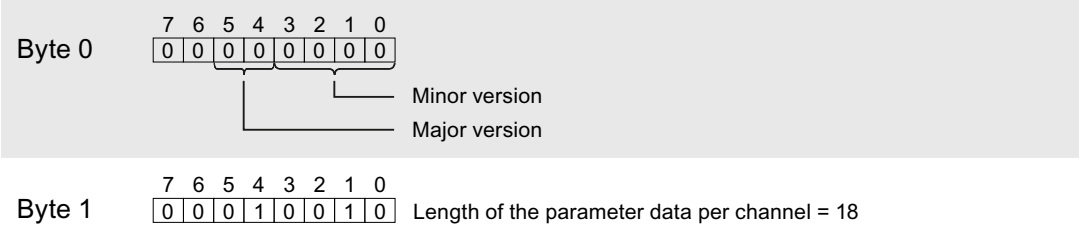

Figure 2-519 Header information

Parameter

The figure below shows the structure of the parameters for channels 0 to 3.
You enable a parameter by setting the corresponding bit to "1".

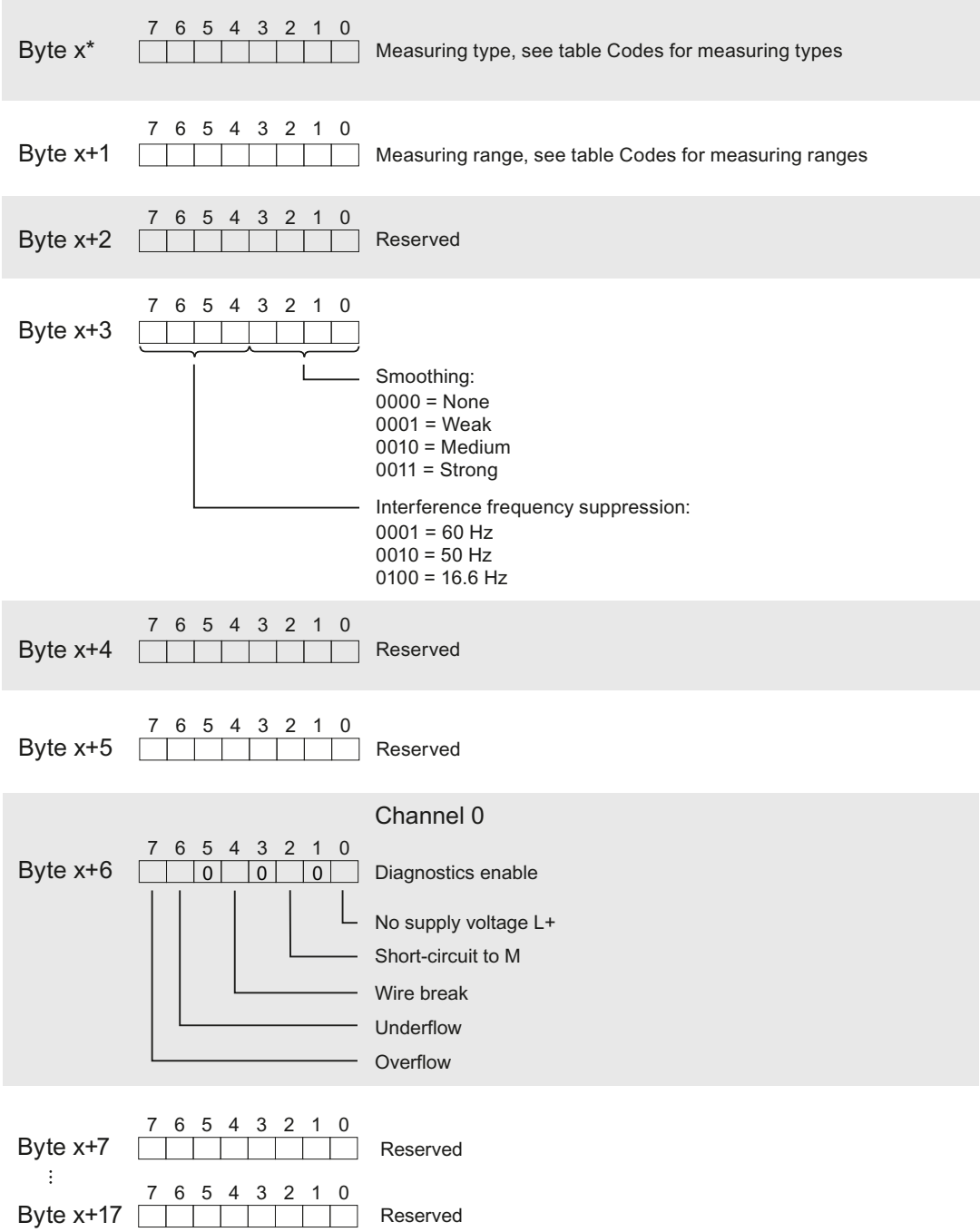

* x = 2 + (channel number × 18); channel number= 0 to 3

Figure 2-520 Structure of byte x to x+17 for channels 0 to 3

Codes for the measuring type

The following table contains the codes for the measuring types of the analog input module. You must enter these codes at byte x (see previous figure).

Table 2-505 Codes for the measuring type

Measuring type	Coding
Deactivated	0000 0000
Voltage	0000 0001
Current, 2-wire transducer	0000 0011

Codes for the measuring range

The following table contains the codes for the measuring ranges of the analog input module. You enter these codes at byte x+1 (see previous figure).

Table 2-506 Codes for the measuring range

Measuring type	Coding
Voltage	
±5 V	0000 1000
±10 V	0000 1001
1 to 5 V	0000 1010
0 to 10 V	0000 1011
Current	
0 to 20 mA	0000 0010
4 to 20 mA	0000 0011

A.3 Error in transferring the data record analog input

Error transferring the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station to determine whether the module is plugged or pulled. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	01	Reserved bit set	Check the parameters of the module.
DF	80	E1	02	Invalid diagnostics enable bit set for operating mode.	Check the parameters of the module.
DF	80	E1	05	Invalid coding set for measuring range / measurement type.	Check the parameters of the module.
DF	80	E1	08	Invalid coding set for interference frequency suppression / integration time.	Check the parameters of the module.
DF	80	E1	09	Invalid coding for smoothing.	Check the parameters of the module.

Representation of analog values

B

This appendix shows the analog values for all measuring ranges that you can use with the analog module.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its assigned parameters.

The table below shows the representation of binary analog values and of the associated decimal and hexadecimal units of the analog values.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table 2-507 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	**Hexadecimal**	**High byte**	**Low byte**
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table 2-508 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 2-509 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table 2-510 Voltage measuring range ±10 V and ±5 V

Values		Voltage measuring range		Range
Dec.	**Hex.**	**±10 V**	**±5 V**	
32767	7FFF	>11.759 V	>5.879 V	Overflow
32511	7EFF	11.759 V	5.879 V	Overrange
27649	6C01			
27648	6C00	10 V	5 V	Nominal range
20736	5100	7.5 V	3.75 V	
1	1	361.7 µV	180.8 µV	
0	0	0 V	0 V	
-1	FFFF			
-20736	AF00	-7.5 V	-3.75 V	
-27648	9400	-10 V	-5 V	
-27649	93FF			Underrange
-32512	8100	-11.759 V	-5.879 V	
-32768	8000	<-11.759 V	<-5.879 V	Underflow

Table 2-511 Voltage measuring range 1 to 5 V and 0 to 10 V

Values		Voltage measuring range		Range
Dec.	**Hex.**	**1 to 5 V**	**0 to 10 V**	
32767	7FFF	>5.704 V	>11.759 V	Overflow
32511	7EFF	5.704 V	11.759 V	Overrange
27649	6C01			
27648	6C00	5 V	10 V	Nominal range
20736	5100	4 V	7.5 V	
1	1	1 V + 144.7 µV	0 V + 361.7 µV	
0	0	1 V	0 V	
-1	FFFF			Underrange **
-4864	ED00	0.296 V	-1.759 V *	
-32768	8000	<0.296 V	<-1.759 V *	Underflow **

* negative values are only possible if the module (6ES7134-6GD**01**-0BA1) with FW version V2.0.0 and higher is configured.
** no underrange/underflow if the predecessor module (6ES7134-6GD**00**-0BA1) is configured.

B.3 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table 2-512 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		Range
Dec.	**Hex.**	**0 to 20 mA ***	**4 to 20 mA**	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<-3.52 mA	<1.185 mA	Underflow

* For measuring type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

SIEMENS

SIMATIC

ET 200SP
Analog input module AI 2xU ST (6ES7134-6FB00-0BA1)

Equipment Manual

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Introduction 1

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

- Wiring and block diagrams have been revised.
- The technical specifications have been updated.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

3

3.1 Properties

Article number

6ES7134-6FB00-0BA1

View of the module

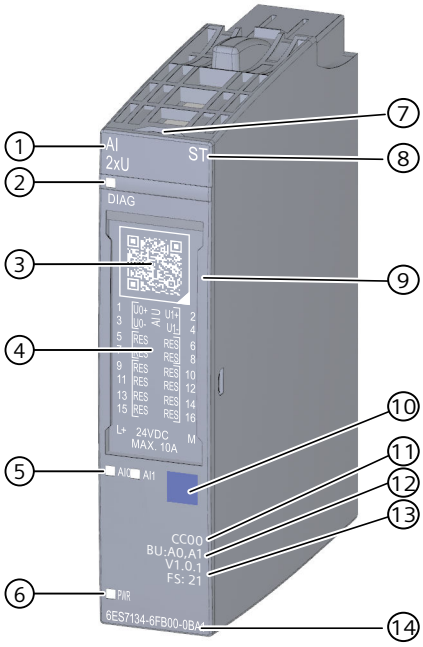

① Module type and name
② LED for diagnostics
③ QR code for identification link
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Slot for optional reference identification label
⑧ Function class
⑨ Insertion option for optional labeling strips
⑩ Color coding module type
⑪ Color code for selecting the color identification labels
⑫ BU type
⑬ Firmware revision level and release number
⑭ Article number

Figure 2-521 View of the module AI 2×U ST

Properties

The module has the following technical properties:

- Analog input module with 2 inputs
- Voltage measurement type (can be set per channel)
- Input ranges for voltage measurement:
  - ±5 V, resolution 16 bits including sign
  - ±10 V, resolution 16 bits including sign
  - 1 to 5 V, resolution 15 bits
  - 0 to 10 V, resolution 15 bits
- Electrically isolated from supply voltage L+
- Permitted common mode voltage: 10 V_{ss}
- Configurable diagnostics (per module)

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy
- Value status

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

4

4.1 Connection diagram

This section shows the connection diagram of the AI 2xU ST module with the terminal assignments for a 2-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) System Manual.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Pin assignment

The following table shows an example of the pin assignment of the analog input module AI 2xU ST on the BaseUnit BU type A0/A1:

Description	Signal	Terminal	BaseUnit BU type A0/A1	Terminal	Signal	Description
Analog input voltage positive, channel 0	U_0+	1	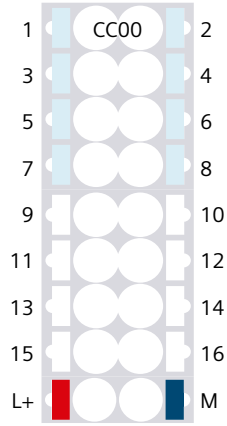	2	U_1+	Analog input voltage positive, channel 1
Analog input voltage negative, channel 0	U_0-	3		4	U_1-	Analog input voltage negative, channel 1
-	RES[1)]	5		6	RES[1)]	-
-	RES[1)]	7		8	RES[1)]	-
-	RES[1)]	9		10	RES[1)]	-
-	RES[1)]	11		12	RES[1)]	-
-	RES[1)]	13		14	RES[1)]	-
-	RES[1)]	15		16	RES[1)]	-
24 V DC supply voltage[2)]	L+	L+		M	M	Ground

1) Reserve, must remain unused for future function extensions

2) Infeed only with light-colored BaseUnit

Connection types

2-wire connection for voltage output

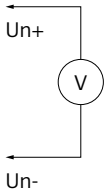

4.2 Schematic circuit diagram

This section contains the schematic circuit diagram of the AI 2×U ST analog output module.

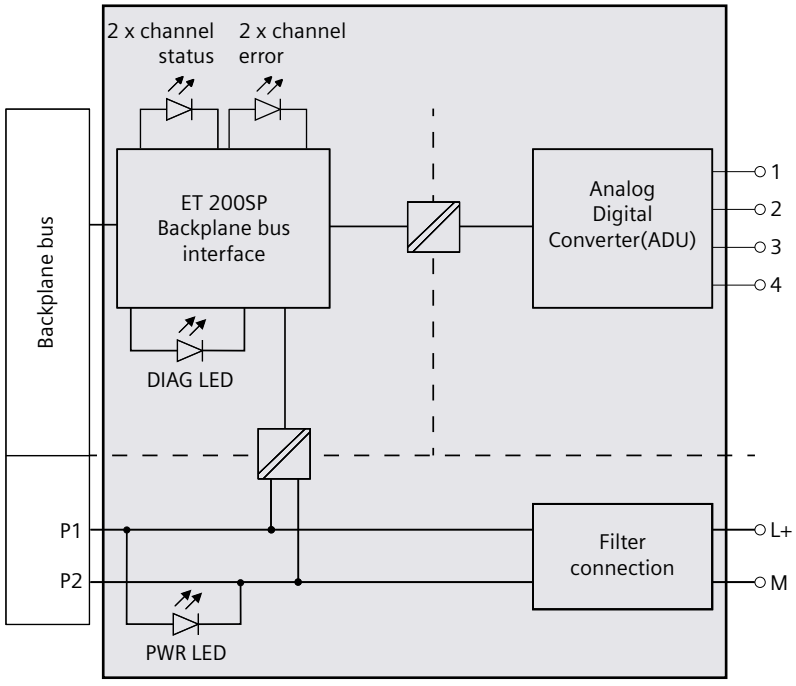

Figure 2-522 Schematic circuit diagram AI 2xU ST analog output module

Parameters/address space

5

5.1 Measuring types and ranges

The analog input module AI 2×U ST has the following measuring ranges:

Table 2-513 Measuring ranges

Measurement type	Measuring range	Resolution
Voltage	± 5 V ± 10 V 1 to 5 V 0 to 10 V	16 bits incl. sign 16 bits incl. sign 15 bits 15 bits

You will find the tables of the measuring ranges as well as overflow, overrange, etc., in the section Representation of analog values (Page 35).

5.2 Parameters

Parameters of the AI 2xU ST

Specify the module properties with the various parameters during parameter assignment of the module with STEP 7. The following table lists the configurable parameters. The efficiency range of the configurable parameters depends on the type of configuration.
The following configurations are possible:

- Central operation with an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

In addition to assigning parameters with the configuration software, you can also set the parameters in RUN mode (dynamically) using the user program.

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of the parameter data record (Page 31).

The following parameter settings are possible:

Table 2-514 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Overflow [1]	• Disable • Enable	Disable	Yes	Module	Module [1]
Diagnostics: Underflow [1]	• Disable • Enable	Disable	Yes	Module	
Measurement type/measuring range	• Deactivated • Voltage +/- 5 V • Voltage +/- 10 V • Voltage 0..10 V • Voltage 1..5 V	Voltage +/- 10 V	Yes	Channel	Channel
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel
Interference frequency suppression	• 60 Hz (50 ms) • 50 Hz (60 ms) [2] • 16.6 Hz (180 ms) • None	50 Hz (60 ms)	Yes	Channel	Module
Potential group	• Use potential group of the use the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into a light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 4 bytes.

[2] Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

NOTE

Unused channels

Disable the unused channels in the parameter assignment.

A deactivated channel always returns the value $7FFF_H$.

NOTE

Note that the settings in the "Interference frequency suppression" parameter have a direct effect on the cycle time of the module. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

5.3 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Diagnostics are enabled when both input signals are short-circuited in the range 1 to 5 V.

The short-circuit and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, however, the short-circuit diagnostics suppresses the underflow diagnostics. Short-circuit is output as the diagnostics event.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Measurement type/measuring range

Refer to the section Measuring types and ranges (Page 17).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) × cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This applies to every signal change at the analog input.

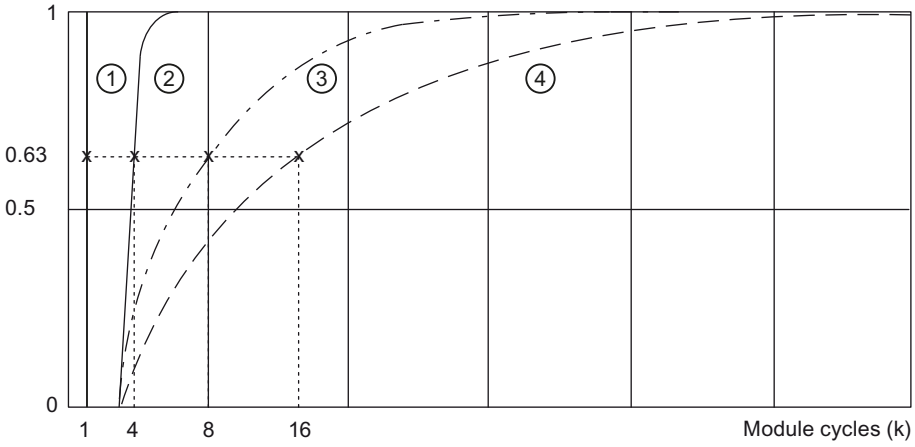

① No smoothing (k = 1)

② Weak (k = 4)

③ Medium (k = 8)

④ Strong (k = 16)

Figure 2-523 Smoothing for AI 2xU ST

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network can negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2, and AUX to the left neighbor.

Specify the slot in which a light-colored BaseUnit with
supply voltage infeed or a dark-colored BaseUnit is to be located (see ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) System Manual).

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

5.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 and 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: No fault is present on the channel.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AI 2×U ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

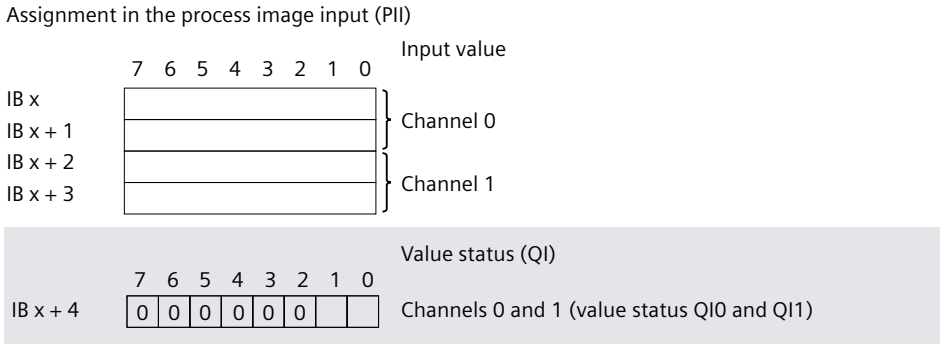

Figure 2-524 Address space of the AI 2×U ST with value status

Interrupts/diagnostics alarms

6

6.1 Status and error display

LED display

The following figure shows you the LED display of the AI 2xU ST.

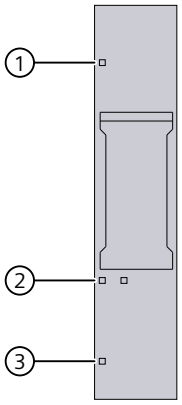

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-525 LED display

Meaning of the LEDs

The meaning of the status and error messages is described in the following tables.
Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 24).

DIAG LED

Table 2-515 Error display of the DIAG LED

DIAG LED	Meaning
Off	The system's backplane bus supply is faulty or switched off
Flashes	Module parameters not assigned
On	Module parameters assigned and no module/channel diagnostics data available
Flashes	Module parameters assigned and module/channel diagnostics available

Channel status LED

Table 2-516 Status display of the channel status LED

Channel status LED	Meaning
Off	Channel disabled
On	Channel activated

PWR LED

Table 2-517 Status display of the PWR LED

PWR LED	Meaning
Off	Missing supply voltage L+
On	Supply voltage L+ present

6.2 Interrupts

The AI 2×U ST analog input module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit (voltage 1 V to 5 V)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- Supply voltage missing
- Channel/component temporarily not available

6.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG LED flashes red on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-518 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit (1 to 5 V)	1_H	Short-circuit of input signal	Correct interplay between module and encoder
		Open input	Connect input
High limit violated	7_H	Value is above the overrange	Correct interplay between module and encoder
Low limit violated	8_H	Value is below the underrange	Correct interplay between module and encoder
Error	9_H	Internal module error has occurred	Replace module
Parameter assignment error	10_H	• Module cannot evaluate parameters for the channel • Incorrect parameter assignment	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check the supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel/component temporarily not available	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not read process values in this state.	• Wait for firmware update • Restart the firmware update

Technical specifications 7

7.1 Technical specifications

Technical specifications of the AI 2×U ST

The following table lists the technical specifications on the issue date. A data sheet including daily updated technical specifications is available on the Internet (https://support.industry.siemens.com/cs/ww/de/pv/6ES7134-6FB00-0BA1/td?dl=en).

Article number	6ES7134-6FB00-0BA1
General information	
Product type designation	AI 2xU ST
HW functional status	from FS21
Firmware version	V1.0.1
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Measuring range scalable	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V13 SP1
• STEP 7 configurable/integrated from version	V5.5 SP3 / -
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.3
Operating mode	
• Oversampling	No
• MSI	No
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	No

Article number	6ES7134-6FB00-0BA1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	37 mA
Encoder supply	
24 V encoder supply	
• 24 V	No
Additional 24 V encoder supply	
• 24 V	No
Power loss	
Power loss, typ.	0.9 W
Address area	
Address space per module	
• Address space per module, max.	4 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Selection of BaseUnit for connection variants	
• 1-wire connection	BU type A0, A1
• 2-wire connection	BU type A0, A1
Analog inputs	
Number of analog inputs	2
• For voltage measurement	2
permissible input voltage for voltage input (destruction limit), max.	30 V
Cycle time (all channels), min.	500 µs
Input ranges (rated values), voltages	
• 0 to +10 V	Yes; 15 bit
– Input resistance (0 to 10 V)	180 kΩ
• 1 V to 5 V	Yes; 15 bit
– Input resistance (1 V to 5 V)	180 kΩ
• -10 V to +10 V	Yes; 16 bit incl. sign
– Input resistance (-10 V to +10 V)	180 kΩ
• -5 V to +5 V	Yes; 16 bit incl. sign
– Input resistance (-5 V to +5 V)	180 kΩ

Article number	6ES7134-6FB00-0BA1
Cable length	
• shielded, max.	200 m
Analog value generation for the inputs	
Measurement principle	Sigma Delta
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz / off
• Conversion time (per channel)	50 ms @ 60 Hz, 60 ms @ 50 Hz, 180 ms @ 16.6 Hz, 250 µs without filter
Smoothing of measured values	
• Number of smoothing levels	4
• parameterizable	Yes
• Step: None	Yes
• Step: low	Yes; 4x smoothing
• Step: Medium	Yes; 8x smoothing
• Step: High	Yes; 16x smoothing
Encoder	
Connection of signal encoders	
• for voltage measurement	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %
Temperature error (relative to input range), (+/-)	0.005 %/K
Crosstalk between the inputs, min.	-50 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Voltage, relative to input range, (+/-)	0.5 %
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to input range, (+/-)	0.3 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	70 dB
• Common mode voltage, max.	10 V
• Common mode interference, min.	90 dB

Article number	6ES7134-6FB00-0BA1
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	No
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	No
• Short-circuit	Yes; at 1 to 5 V
• Group error	Yes
• Overflow/underflow	Yes; Module-wise
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Permissible potential difference	
between the inputs (UCM)	10 Vpp
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; < 0 °C as of FS04
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; < 0 °C as of FS04
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual

Article number	6ES7134-6FB00-0BA1
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Measurement type	Measuring range	Diagnostics			
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow
Deactivated		*	*	*	*
Voltage	±5 V	x	-	x	x
	±10 V	x	-	x	x
	1 V to 5 V	x	x	x	x
	0 V to 10 V	x	-	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Diagnostics			
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow
Deactivated		*	*	*	*
Voltage	±5 V	x	-	x	x
	±10 V	x	-	x	x
	1 V to 5 V	x	x	x	x
	0 V to 10 V	x	-	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reassign the module parameters in your user program, regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can reassign the module parameters in RUN. For example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

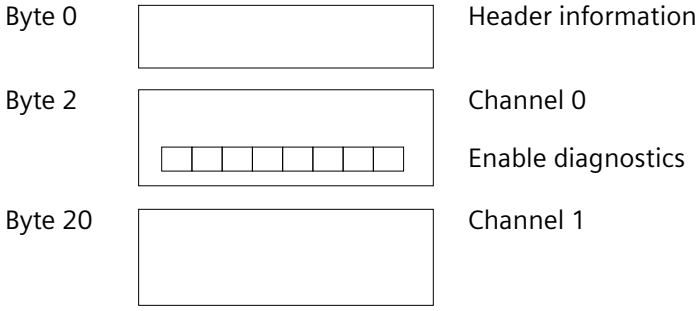

Figure 2-526 Structure of data record 128

Header information

The figure below shows the structure of the header information.

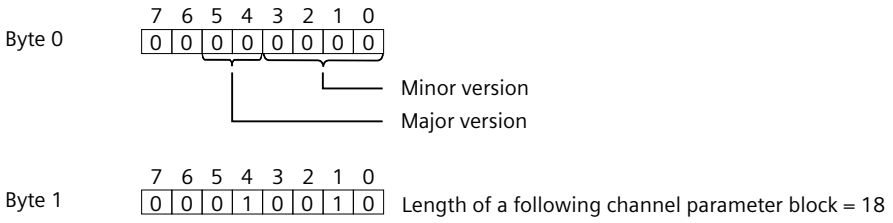

Figure 2-527 Header information

Parameters

The following figure shows the structure of the parameters for channels 0 and 1.
You enable a parameter by setting the corresponding bit to "1".

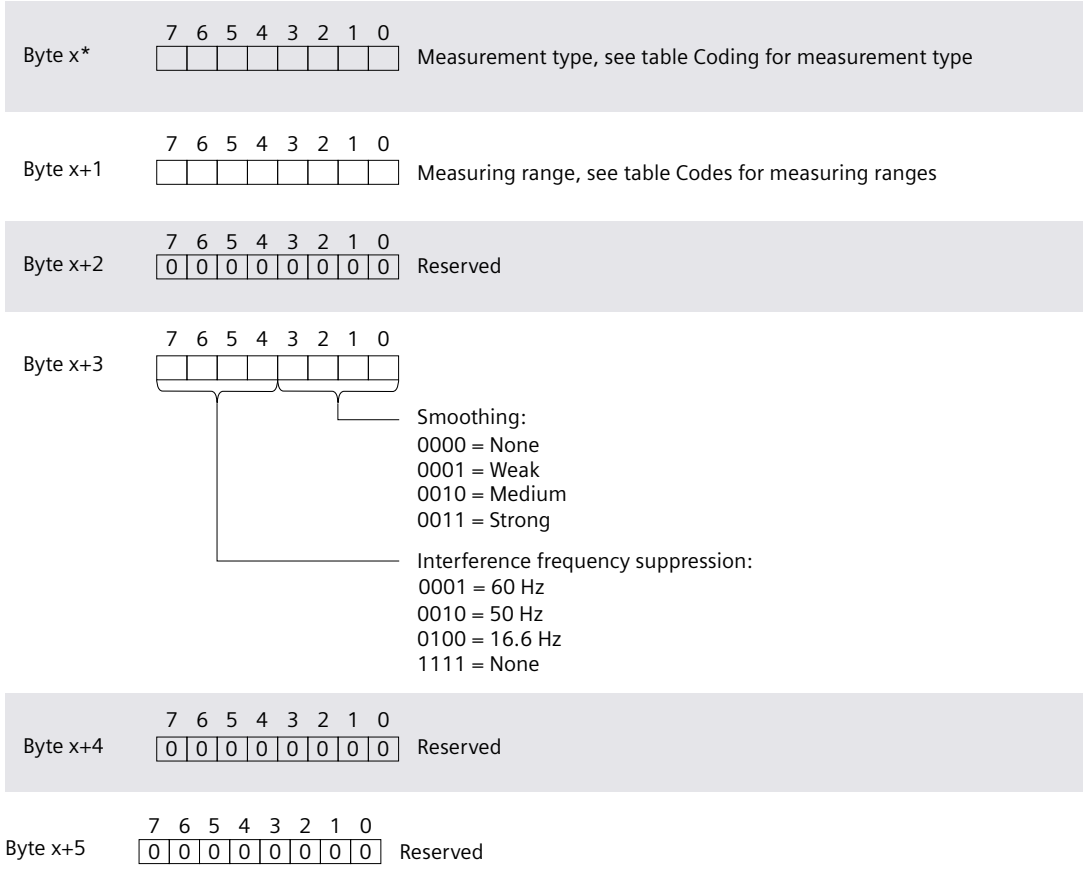

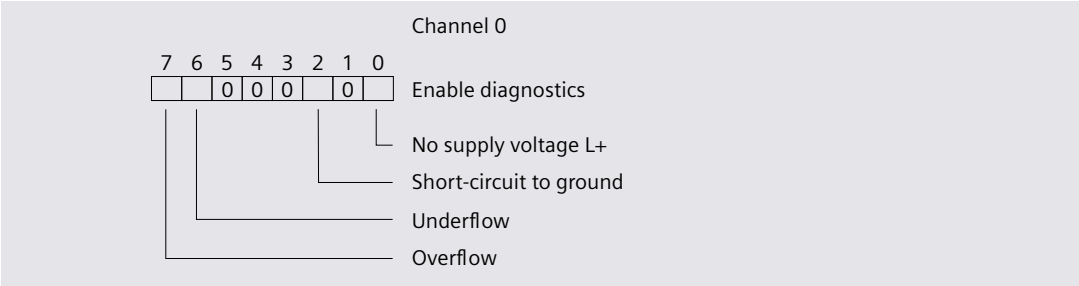

	7	6	5	4	3	2	1	0	
Byte x+7	0	0	0	0	0	0	0	0	Reserved
⋮									
Byte x+17	0	0	0	0	0	0	0	0	Reserved

* x = 2 + (channel number × 18); channel number = 0 and 1

Figure 2-528 Structure of bytes x to x+17 for channels 0 and 1

Codes for measurement types

The following table contains the codes for the measuring types of the analog input module. You must enter these codes at byte x (see previous figure).

Table 2-519 Codes for measurement types

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001

Codes for measuring ranges

The following table contains the codes for the measuring ranges of the analog input module. You enter these codes at byte x+1 (see previous figure).

Table 2-520 Codes for measuring ranges

Measurement type	Code
Voltage	
±5 V	0000 1000
±10 V	0000 1001
1 to 5 V	0000 1010
0 to 10 V	0000 1011

A.3 Error codes

Error transmitting the data record

The module always checks all the values of the transferred data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error codes if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Module not accessible	• Check the station to determine if the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	I0	xx	Incorrect version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	I1	xx	Parameter error	Check the parameters of the module.

Representation of analog values

B

B.1 Representation of analog values

This appendix shows the analog values for all measuring ranges that you can use with the analog input module.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its assigned parameters.

The table below shows the representation of binary analog values and of the associated decimal and hexadecimal units of the analog values.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table 2-521 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	**Hexadecimal**	**High byte**	**Low byte**
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.2 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table 2-522 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	

Dec. value	Measured value in %	Data word																Range
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 2-523 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.3 Representation of analog values in voltage measuring ranges

Voltage measuring range ±10 V to ±5 V

Table 2-524 Voltage measuring range ±10 V to ±5 V

System		Voltage measuring range		Range
dec	**hex**	**±10 V**	**±5 V**	
32767	7FFF	>11.759 V	>5.879 V	Overflow
32511	7EFF	11.759 V	5.879 V	Overrange
27649	6C01			
27648	6C00	10 V	5 V	Nominal range
20736	5100	7.5 V	3.75 V	
1	1	361.7 µV	180.8 µV	
0	0	0 V	0 V	
-1	FFFF			
-20736	AF00	-7.5 V	-3.75 V	
-27648	9400	-10 V	-5 V	
-27649	93FF			Underrange
-32512	8100	-11.759 V	-5.879 V	
-32768	8000	<-11.759 V	<-5.879 V	Underflow

Voltage measuring ranges 1 V to 5 V and 0 V to 10 V

Table 2-525 Voltage measuring ranges 1 V to 5 V and 0 V to 10 V

System		Voltage measuring range		Range
dec	**hex**	**1 V to 5 V**	**0 V to 10 V**	
32767	7FFF	>5.704 V	>11.759 V	Overflow
32511	7EFF	5.704 V	11.759 V	Overrange
27649	6C01			
27648	6C00	5 V	10 V	Nominal range
20736	5100	4 V	7.5 V	
1	1	1 V + 144.7 µV	0 V + 361.7 µV	
0	0	1 V	0 V	
-1	FFFF			Underrange
-4864	ED00	0.296 V	-1.759 V	
-32768	8000	<0.296 V	<-1.759 V	Underflow

SIEMENS

SIMATIC

ET 200SP
Analog input module AI 2xI 2/4-wire ST
(6ES7134-6GB00-0BA1)

Equipment Manual

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Product overview 2

Wiring 3

Parameters/address space 4

Interrupts/diagnostics alarms 5

Technical specifications 6

Parameter data record A

Representation of analog values B

04/2018
A5E36104399-AB

Preface

Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to the previous version

Compared to the previous version, this manual contains the following changes:

- Connection diagram has been updated
- Technical specifications have been updated:
- Comments on the previous version of this manual were included in the current edition.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

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To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

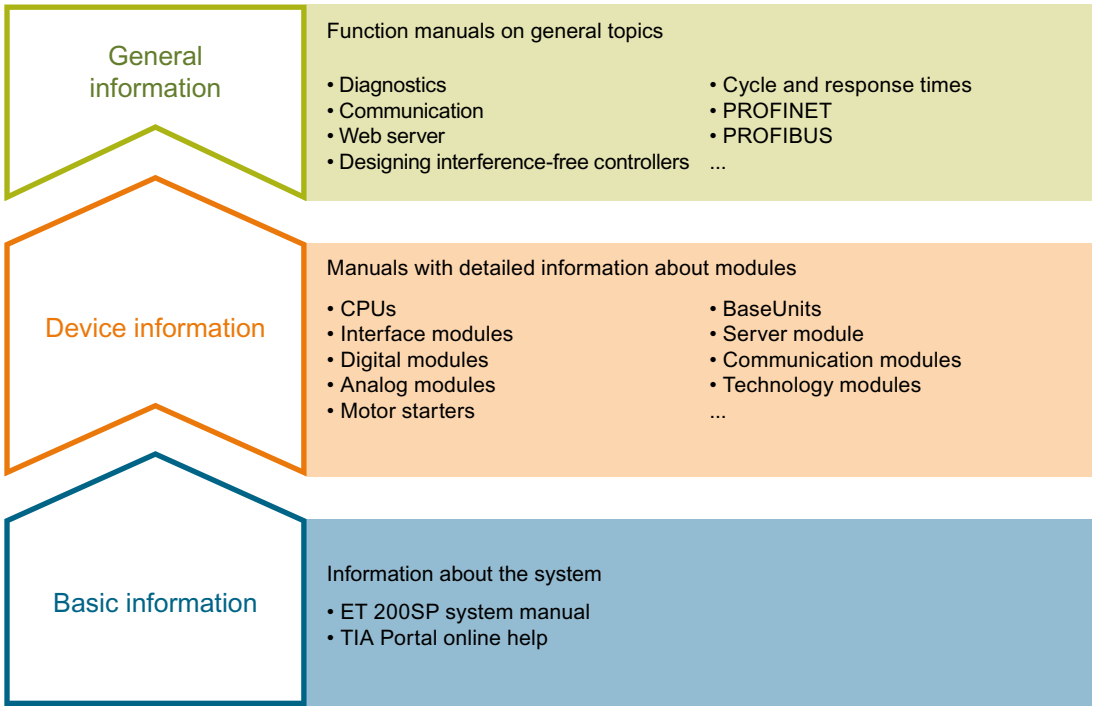

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7134-6GB00-0BA1

View of the module

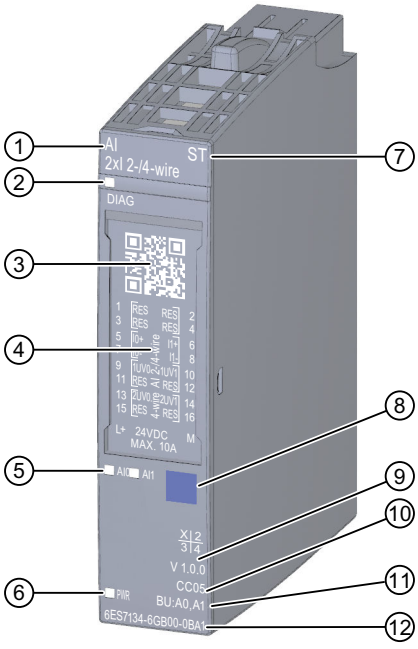

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-529 View of the module AI 2×I 2-/4-wire ST

Properties

The module has the following technical properties:

- Analog input module with 2 inputs
- Measuring type current for 2- and 4-wire transducers
- Input ranges for current measurement:
  - 0 mA to 20 mA, resolution 15 bits
  - 4 to 20 mA, resolution 15 bits
  - ± 20 mA, resolution 16 bit incl. sign
- Electrically isolated from supply voltage L+
- Permitted common mode voltage: 10 V_{pp}/3.5 V_{rms}
- Configurable diagnostics (per module)
- Constant cycle time for processing measured values
  - 500 µs, regardless of the number of channels used and the configuration

The module supports the following functions:

Table 2-526 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V1.0.0 or higher	V13 SP1 or higher	as of V5.5 SP4 with HSP 0227 V6.0 or higher	X	X
Identification data I&M0 to I&M3	FS01	V1.0.0 or higher	V13 SP1 or higher	as of V5.5 SP4 with HSP 0227 V6.0 or higher	X	X
Configuration in RUN	FS01	V1.0.0 or higher	V13 SP1 or higher	as of V5.5 SP4 with HSP 0227 V6.0 or higher	X	X
Value status	FS01	V1.0.0 or higher	V13 SP1 or higher	as of V5.5 SP4 with HSP 0227 V6.0 or higher	X	
PROFIenergy	FS01	V1.0.0 or higher	V13 SP1 or higher	as of V5.5 SP4 with HSP 0227 V6.0 or higher	X	X

You can configure the module with STEP 7 and with GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring 3

3.1 Wiring and block diagram

This section includes the block diagram of the AI 2xI 2-/4-wire ST module with the various terminal assignments for a 2- und 4-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

NOTE

You can use and combine the different wiring options for all channels.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Wiring: Current measurement 2-wire and 4-wire connection (2-wire and 4-wire transducer)

The following figure shows the block diagram and an example of the terminal assignment of the analog input module AI 2xI 2-/4-wire ST on the BaseUnit BU type A0/A1.

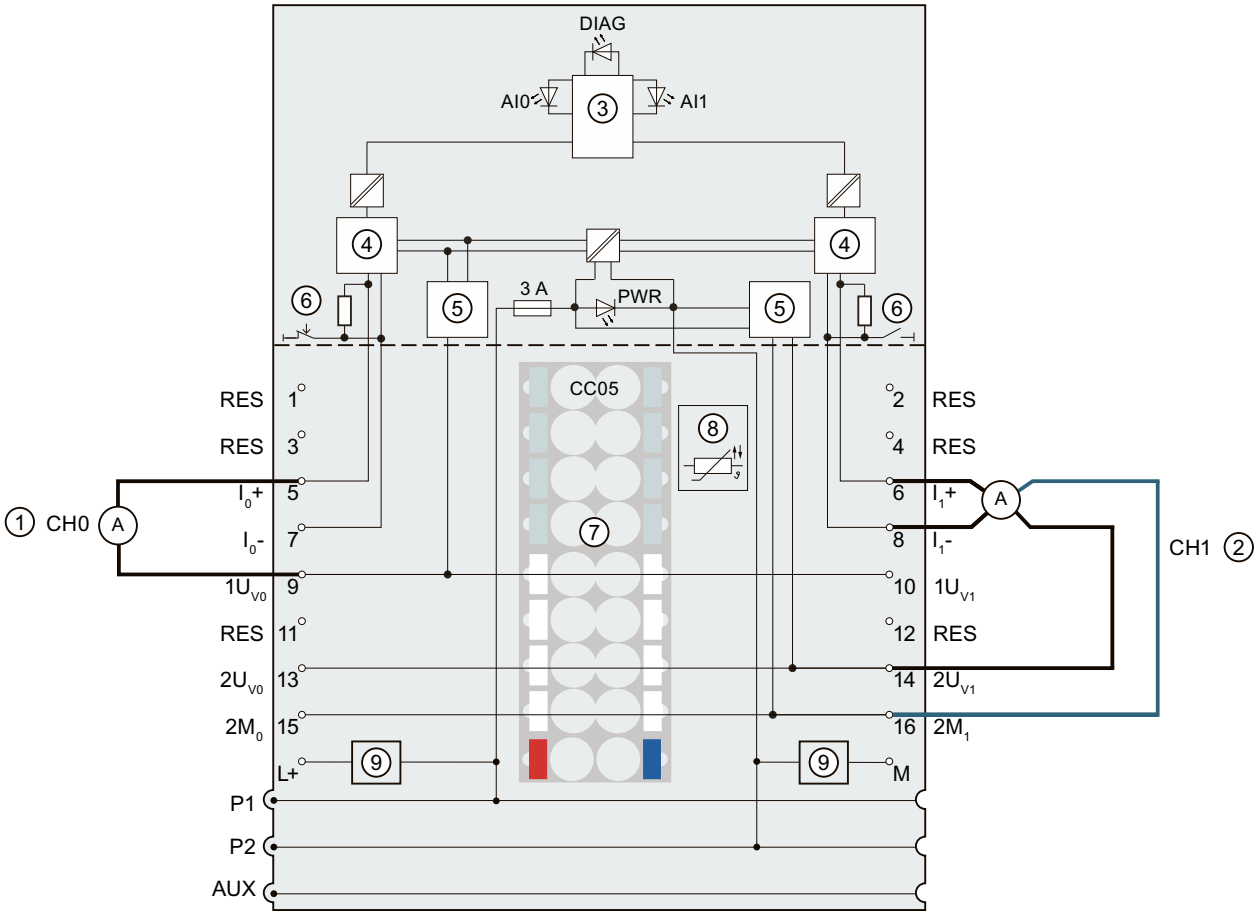

①	2-wire connection for current measurement (2-wire transducer)	I_n+	Current input positive, channel n
②	4-wire connection for current measurement (4-wire transducer)	I_n-	Current input negative, channel n
③	Backplane bus interface	$1U_{Vn}$	Supply voltage (2-wire transducer), channel n
④	Analog-to-digital converter (ADC)	$2U_{Vn}$	Supply voltage (4-wire transducer), channel n
⑤	Current limitation	$2M_n$	Reference potential (4-wire transducer)
⑥	Switchover 2-wire / 4-wire	RES	Reserve, must remain unused for future function extensions
⑦	Color-coded label with color code CC05 (optional)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑧	Temperature recording for BU type A1 only (function cannot be used for this module)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)

⑨	Filter connection supply voltage (only when light-colored BaseUnit is present)	DIAG	Diagnostics LED (green, red)
		AI0, AI1	Channel status LED (green)
		PWR	Power LED (green)

Figure 2-530 Wiring and block diagram for current measurement 2-wire and 4-wire connection (2-wire and 4-wire transducer)

Parameters/address space

4

4.1 Measurement types and measuring ranges

The analog input module AI 2×I 2-/4-wire ST has the following measuring ranges:

Table 2-527 Measuring ranges

Measurement type	Measuring range	Resolution
Current (2-wire transducer)	0 to 20 mA 4 mA to 20 mA	15 bits 15 bits
Current (4-wire transducer)	0 mA to 20 mA 4 mA to 20 mA ± 20 mA	15 bit 15 bits 16 bits incl. sign

You can find the tables of measuring ranges and overflow, overrange, etc. in the section Representation of analog values in the current measuring ranges (Page 35) and the "Analog value processing" function manual.

4.2 Parameters

Parameters of AI 2xI 2-/4-wire ST

During configuration of the module with STEP 7, define the properties of the module via various parameters. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of the parameter data record (Page 30).

The following parameter settings are possible:

Table 2-528 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Overflow [1]	• Disable • Enable	Disable	Yes	Channel	Channel [1]
Diagnostics: Underflow [1]	• Disable • Enable	Disable	Yes	Channel	
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel
Measurement type/measuring range	• Deactivated • Current (4-wire transducer) 0 to 20 mA • Current (4-wire transducer) 4 to 20 mA • Current (4-wire transducer) +/- 20 mA • Current (2-wire transducer) 0 to 20 mA • Current (2-wire transducer) 4 to 20 mA	Current (4-wire transducer) 4 to 20 mA	Yes	Channel	Channel
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel
Interference frequency suppression [2]	• 60 Hz (50 ms) • 50 Hz (60 ms) [3] • 16.6 Hz (180 ms) • None	• 50 Hz (60 ms)	Yes	Channel	Module
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 4 bytes for PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data record".

[2] The settings in the "Interference frequency suppression" parameter have a direct effect on the conversion time of the channel. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

[3] Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

NOTE
Unused channels
"Deactivate" the unused channels in the parameter assignment.
A deactivated channel always returns the value $7FFF_H$.

4.3 Description of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics alarm for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics in the event of a short-circuit of the encoder supply to ground or of an input to the encoder supply.

The short-circuit and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the short-circuit diagnostics is output.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics: Wire break

Enabling of the diagnostics if the module has no current flow or has too little current for the measurement in the range of 4 mA to 20 mA.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the wire break diagnostics is output.

Measurement type/measuring range

See the section Measurement types and measuring ranges (Page 15).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels.

Smoothing time = Number of conversion cycles (k) x conversion time (≙ of the integration time set in the "Interference frequency suppression" parameter) of the channel.

The following figure shows how many conversion cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This applies to every signal change at the analog input.

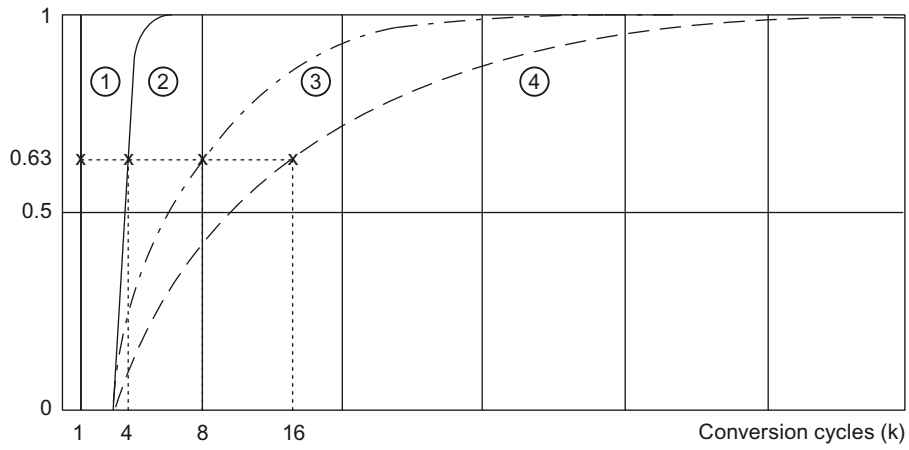

① No smoothing

② Weak (k = 4)

③ Medium (k = 8)

④ Strong (k = 16)

Figure 2-531 Smoothing for AI 2×I 2-/4-wire ST

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network can negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Note:

The interference frequency suppression works parallel to the sampling of channels 0 and 1. The cycle time of the module is 500 µs regardless of the number of channels used and the configured interference frequency suppression.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

4.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 to 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: There are no errors on the module.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AI 2xI 2-/4-wire ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

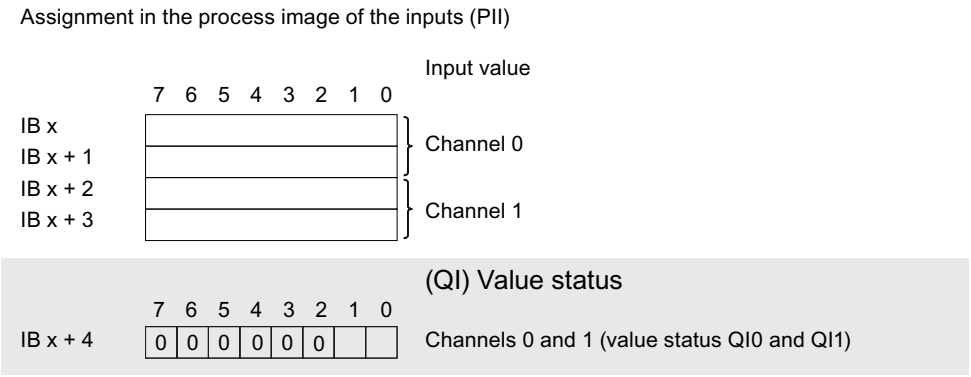

Figure 2-532 Address space of the AI 2xI 2-/4-wire ST with value status

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED displays

The following figure shows you the LED display of the AI 2×I 2-/4-wire ST.

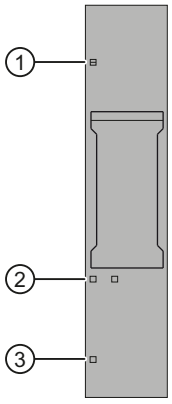

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-533 LED displays

Meaning of the LEDs

The following tables show the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 23).

DIAG LED

Table 2-529 Error display of the DIAG LED

DIAG	Meaning
☐ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-530 Status display of the channel status LED

Channel status	Meaning
☐ Off	Channel disabled
■ On	Channel activated

PWR LED

Table 2-531 Status display of the PWR LED

PWR	Meaning
☐ Off	Missing supply voltage L+
■ On	Supply voltage L+ present

5.2 Interrupts

The AI 2×I 2-/4-wire ST analog input module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit (encoder supply)
- Wire break (current 4 to 20 mA)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-532 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit (encoder supply) [1]	1_H	Encoder supply to ground	Correct interplay between module and encoder
		Input after encoder supply	
Wire break (current 4 to 20 mA)	6_H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, e.g. use cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate channel • Connect the encoder contacts
High limit violated	7_H	Value is above the overrange.	Correct interplay between module and encoder
Low limit violated	8_H	Value is below the underrange.	Correct interplay between module and encoder
Error	9_H	Internal module error has occurred (diagnostics alarm on channel 0 applies for the entire module).	Replace the module

[1] Since the module has no encoder supply for separate channels, a short-circuit in a channel has a permanent effect on the other channel.

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment (wire break diagnostics set only with the permitted measuring ranges).
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module does not read any process values in this state.	• Wait for firmware update. • Restart the firmware update.

[1] Since the module has no encoder supply for separate channels, a short-circuit in a channel has a permanent effect on the other channel.

Technical specifications

6

6.1 Technical specifications

Technical specifications of AI 2xI 2-/4-wire ST

Article number	6ES7134-6GB00-0BA1
General information	
Product type designation	AI 2xI 2-/4-wire ST
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC05
Product function	
• I&M data	Yes; I&M0 to I&M3
• Measuring range scalable	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V13 SP1
• STEP 7 configurable/integrated as of version	V5.5 SP3
• PROFIBUS as of GSD version/GSD revision	GSD Revision 5
• PROFINET as of GSD version/GSD revision	V2.3 / -
Operating mode	
• Oversampling	No
• MSI	No
CiR – Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	45 mA; without sensor supply
24 V encoder supply	
• 24 V	Yes

Article number	6ES7134-6GB00-0BA1
• Short-circuit protection	Yes
• Output current, max.	50 mA; Total current for both channels (two-wire)
Additional 24 V encoder supply	
• 24 V	Yes
• Short-circuit protection	Yes; Module-wise
• Output current, max.	200 mA; Total current for both channels (four-wire)
Power loss	
Power loss, typ.	1.1 W
Address area	
Address space per module	
• Address space per module, max.	4 byte; + 1 byte for QI information
Analog inputs	
Number of analog inputs	2
• For current measurement	2
permissible input current for current input (destruction limit), max.	50 mA
Cycle time (all channels), min.	500 µs
Input ranges (rated values), currents	
• 0 to 20 mA	Yes; 15 bit
• Input resistance (0 to 20 mA)	130 Ω; 90 ohms with two wires
• -20 mA to +20 mA	Yes; 16 bit incl. sign
• Input resistance (-20 mA to +20 mA)	130 Ω
• 4 mA to 20 mA	Yes; 15 bit
• Input resistance (4 mA to 20 mA)	130 Ω; 90 ohms with two wires
Cable length	
• shielded, max.	1 000 m
Analog value generation for the inputs	
Measurement principle	Sigma Delta
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz / off
• Conversion time (per channel)	50 ms @ 60 Hz, 60 ms @ 50 Hz, 180 ms @ 16.6 Hz, 500 µs without filter
Smoothing of measured values	
• Number of smoothing levels	4
• parameterizable	Yes

Article number	6ES7134-6GB00-0BA1
• Step: None	Yes; 1x conversion time
• Step: low	Yes; 4x conversion time
• Step: Medium	Yes; 8x conversion time
• Step: High	Yes; 16x conversion time
Encoder	
Connection of signal encoders	
• for current measurement as 2-wire transducer	Yes
– Burden of 2-wire transmitter, max.	650 Ω
• for current measurement as 4-wire transducer	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %
Temperature error (relative to input range), (+/-)	0.005 %/K
Crosstalk between the inputs, min.	-50 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Current, relative to input range, (+/-)	0.5 %
Basic error limit (operational limit at 25 °C)	
• Current, relative to input range, (+/-)	0.3 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	70 dB
• Common mode voltage, max.	10 V
• Common mode interference, min.	90 dB
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	No
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; at 4 to 20 mA
• Short-circuit	Yes; Short-circuit of the encoder supply

Article number	6ES7134-6GB00-0BA1
• Group error	Yes
• Overflow/underflow	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Permissible potential difference	
between the inputs (UCM)	10 Vpp
Isolation	
Isolation tested with	707 V DC (type test)
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	32 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Measurement type	Measuring range	Diagnostics				
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow	Wire break
Deactivated		*	*	*	*	*
Current (4-wire transducer)	0 mA to 20 mA	x	x	x	x	-
	4 mA to 20 mA	x	x	x	x	x
	±20 mA	x	x	x	x	-
Current (2-wire transducer)	0 mA to 20 mA	x	x	x	-	-
	4 mA to 20 mA	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Diagnostics			
		No supply voltage L+	Short-circuit to ground	Overflow/under-flow	Wire break
Deactivated		*	*	*	*
Current (4-wire transducer)	0 mA to 20 mA	x	x	x	-
	4 mA to 20 mA	x	x	x	x
	+/- 20 mA	x	x	x	-
Current (2-wire transducer)	0 mA to 20 mA	x	x	x	-
	4 mA to 20 mA	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

You can reassign the module parameters in RUN. For example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128 for entire module

NOTE

Channel 0 includes the diagnostics enable for the entire module.

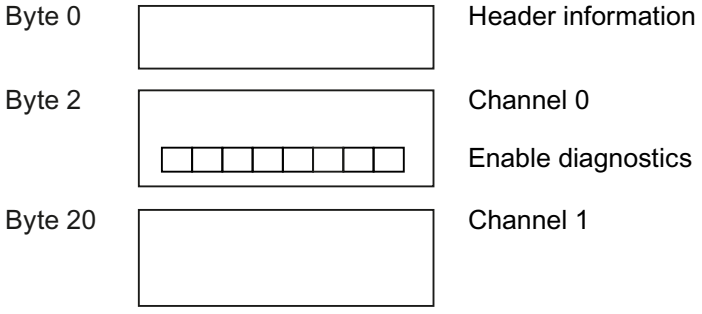

Figure 2-534 Structure of data record 128 for entire module

Header information

The figure below shows the structure of the header information.

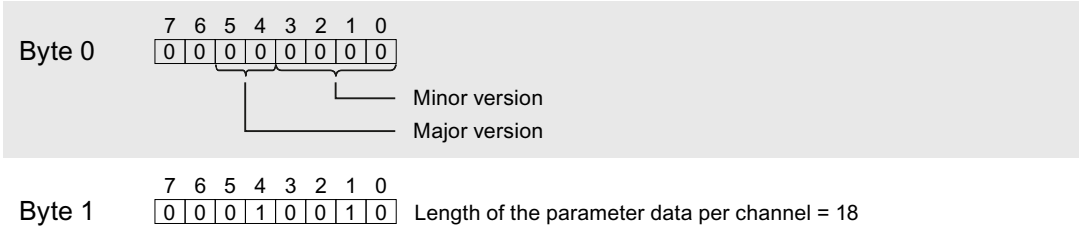

Figure 2-535 Header information

Parameters

The following figure shows the structure of the parameters for channels 0 and 1.
You enable a parameter by setting the corresponding bit to "1".

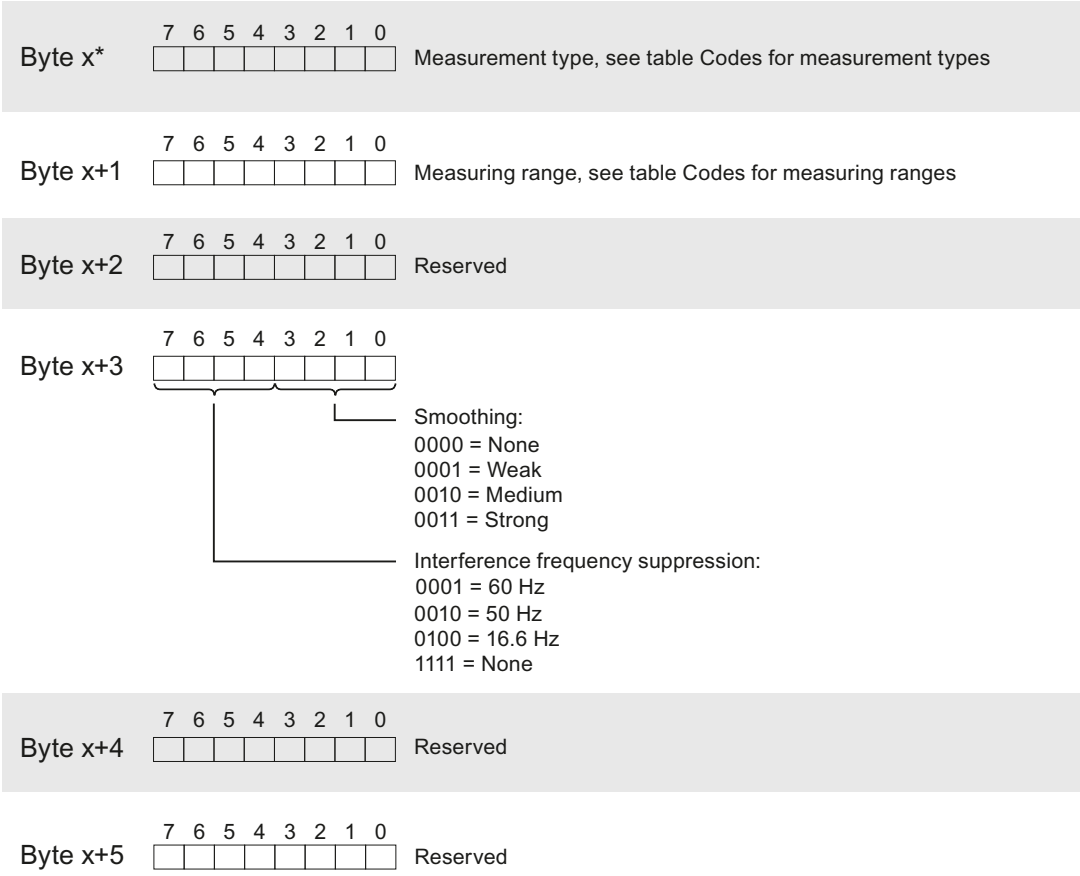

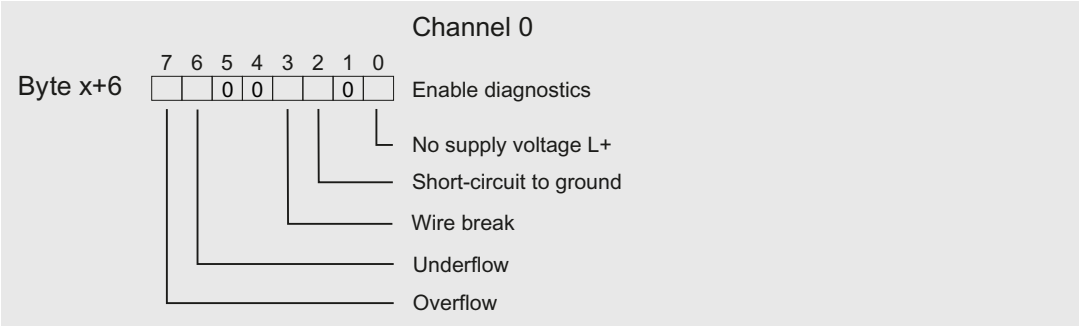

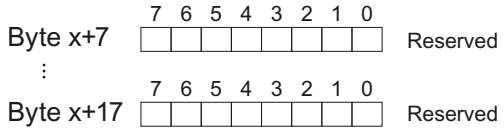

* x = 2 + (channel number × 18); channel number = 0 and 1

Figure 2-536 Structure of bytes x to x+17 for channels 0 and 1

Codes for measurement types

The following table contains the codes for the measuring types of the analog input module. You must enter these codes in byte x (see channel parameter block figure).

Table 2-533 Codes for measurement types

Measurement type	Code
Deactivated	0000 0000
Current, 4-wire transducer	0000 0010
Current, 2-wire transducer	0000 0011

Codes for measuring ranges

The following table contains the codes for the measuring ranges of the analog input module. You must enter these codes in byte x+1 (see channel parameter block figure).

Table 2-534 Codes for measuring ranges

Measuring range	Coding
Current	
0 mA to 20 mA 4 mA to 20 mA ±20 mA	0000 0010 0000 0011 0000 0100

Error transmitting the data record

The module always checks all values of the transmitted data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error codes if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine if the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	I0	xx	Incorrect version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	I1	xx	Parameter error	Check the parameters of the module.

Representation of analog values

B

B.1 Representation of analog values for analog inputs

This appendix shows the analog values for all measuring ranges that you can use with the analog module.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its parameter assignment.

The table below shows the representation of binary analog values and of the associated decimal and hexadecimal units of the analog values.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table 2-535 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.2 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table 2-536 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	

Dec. value	Measured value in %	Data word																Range
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 2-537 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.3 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table 2-538 Current measuring range ±20 mA

Values		Current measuring range	Range
Dec.	**Hex.**	**±20 mA**	
32767	7FFF	> 23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	< -23.52 mA	Underflow

Table 2-539 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		Range
Dec.	**Hex.**	**0 to 20 mA***	**4 to 20 mA**	
32767	7FFF	> 23.52 mA	> 22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	< -3.52 mA	< 1.185 mA	Underflow

* For measurement type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

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SIMATIC

ET 200SP
Analog input module AI 2xU/I 2-/4-wire HS (6ES7134-6HB00-0DA1)

Equipment Manual

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Introduction 1

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

- Wiring and block diagrams have been revised.
- The technical specifications have been updated.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

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You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

3

3.1 Properties

Article number

6ES7134-6HB00-0DA1

View of the module

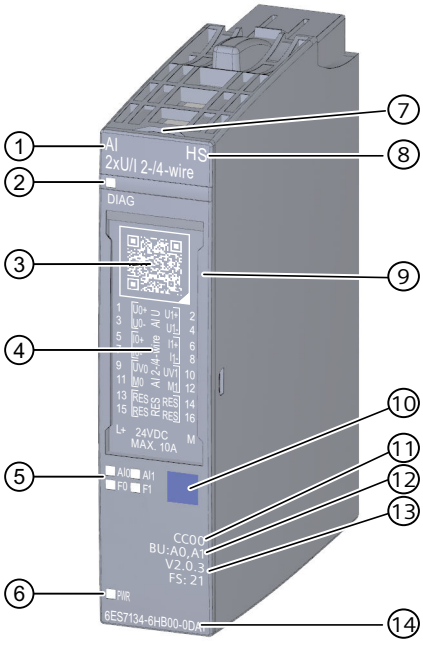

①	Module type and name	⑧	Function class
②	LED for diagnostics	⑨	Insertion option for optional labeling strips
③	QR code for identification link	⑩	Color coding module type
④	Wiring diagram	⑪	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑫	BU type
⑥	LED for supply voltage	⑬	Firmware revision level and release number
⑦	Slot for optional reference identification label	⑭	Article number

Figure 2-537 View of the AI 2×U/I 2-/4-wire HS module

Properties

The module has the following technical properties:

- Analog input module with 2 inputs
- Measurement types voltage and current for 2-/4-wire transducers
- Input ranges for voltage measurement:
  - ±10 V, resolution 16 bit including sign
  - ±5 V, resolution 15 bit incl. sign
  - 1 to 5 V, resolution 13 bit
  - 0 to 10 V, resolution 15 bit
- Input ranges for current measurement:
  - ±20 mA, resolution 16 bit incl. sign
  - 4 to 20 mA, resolution 14 bit
  - 0 to 20 mA, resolution 15 bit
- Electrically isolated between the channels
- Electrically isolated from supply voltage L+
- Permitted common mode voltage: 100 V_{pp}/35 V_{rms}
- Configurable diagnostics (per channel)
- Hardware interrupt on limit violation can be set per channel (two high and two low limits per channel)

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- PROFIenergy

Table 2-540 Version dependencies of other module functions

Function	Release number of the module as of	Firmware version of the module as of
Basic version	1	V1.0.0
Isochronous mode with send clock up to 250 µs	2	V1.1.0
Value status	2	V1.1.0
Oversampling channel 0	2	V1.1.0
Oversampling channel 0 and 1	2	V2.0.0
Isochronous mode with send clock up to 125 µs	2	V2.0.1

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color-coded labels
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Connecting

4

4.1 Connection diagram

This section shows the connection diagram of the AI 2xU/I 2-/4-wire HS module with the various terminal assignments for a 2-wire and 4-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) System Manual.

NOTE

You can use and combine the different wiring options for all channels.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Pin assignment

The following table shows an example of the pin assignment of the analog input module AI 2xU/I 2-/4-wire HS on the BaseUnit BU type A0/A1:

Description	Signal	Terminal	BaseUnit BU type A0/A1	Terminal	Signal	Description
Analog input voltage positive, channel 0	U_0+	1	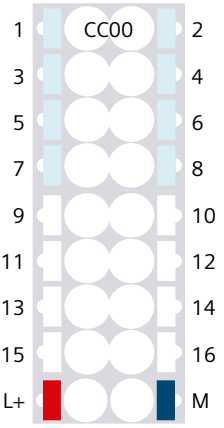	2	U_1+	Analog input voltage positive, channel 1
Analog input voltage negative, channel 0	U_0-	3		4	U_1-	Analog input voltage negative, channel 1
Analog input current positive, channel 0	I_0+	5		6	I_1+	Analog input current positive, channel 1
Analog input current negative, channel 0	I_0-	7		8	I_1-	Analog input current negative, channel 1
Supply voltage, channel 0	U_{V0}	9		10	U_{V1}	Supply voltage, channel 1
Reference ground to U_{Vn}, channel 0	M_0	11		12	M_1	Reference ground to U_{Vn}, channel 1
-	RES[1]	13		14	RES[1]	-
-	RES[1]	15		16	RES[1]	-
24 V DC supply voltage[2]	L+	L+		M	M	Ground

[1] Reserve, must remain unused for future function extensions

[2] Infeed only with light-colored BaseUnit

Connection types

2-wire connection for voltage measurement	2-wire connection for current measurement	3-wire connection for current measurement	4-wire connection for current measurement
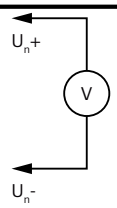	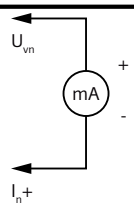	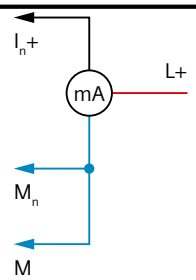	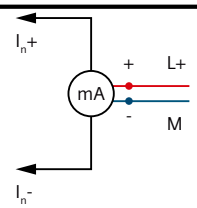

AT a 3-wire connection, there is no galvanic isolation of the channel to the supply voltage or among the channels.

4.2 Schematic circuit diagram

This section contains the schematic circuit diagram of the AI 2xU/I 2-/4-wire HS analog input module.

NOTE

A connection between the current inputs I_n and the reference ground M_n is not allowed and leads to malfunctions of the module.

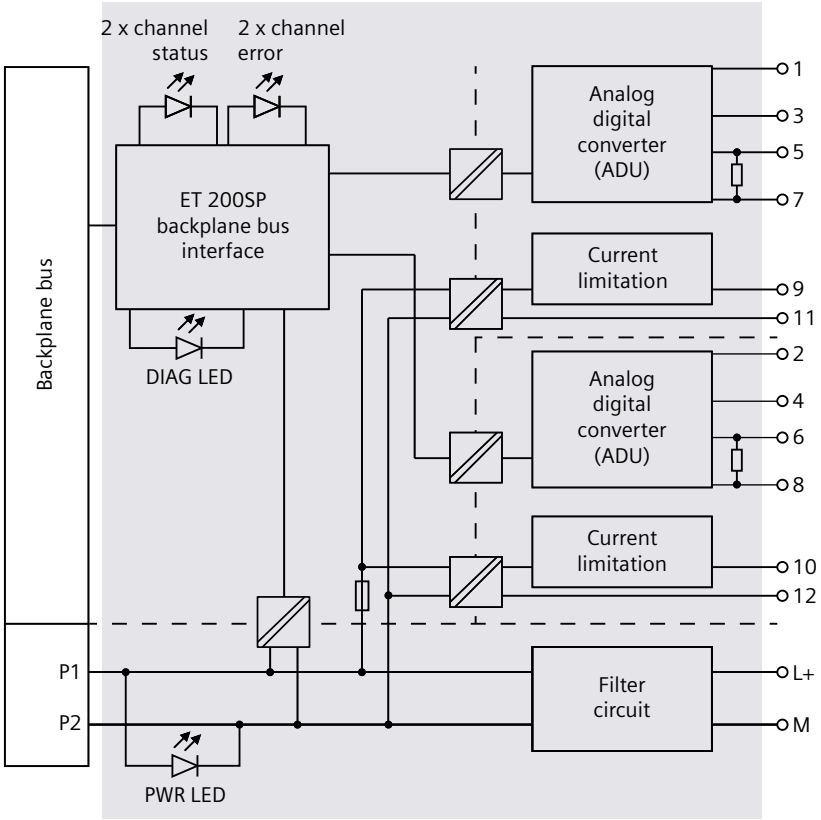

Figure 2-538 Schematic circuit diagram AI 2xU/I 2-/4-wire HS analog input module

Parameters/address space

5

5.1 Measurement types and measuring ranges

The analog input module AI 2×U/I 2/4-wire HSF has the following measuring ranges:

Table 2-541 Measuring ranges

Measurement type	Measuring range	Resolution
Voltage	±10 V ±5 V 0 to 10 V 1 to 5 V	16 bit incl. sign 15 bit incl. sign 15 bit 13 bit
Current (2-/4-wire transducers)	±20 mA [1] 0 to 20 mA 4 to 20 mA	16 bit incl. sign 15 bit 14 bit

You can find the tables of measuring ranges and overflow, overrange, etc. in the section Representation of analog values (Page 47) and the "Analog Value Processing" function manual.

[1] Measuring range "+/-20 mA" is only possible with the measurement type "Current (4-wire transducer)".

5.2 Parameters

Parameters of the AI 2xU/I 2/4-wire HS

Specify the module properties with the various parameters during parameter assignment of the module with STEP 7. The following table lists the configurable parameters. The efficiency range of the configurable parameters depends on the type of configuration.
The following configurations are possible:

- Central operation on an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

In addition to assigning parameters with the configuration software, you can also set the parameters in RUN mode (dynamically) using the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records; see section Parameter assignment and structure of parameter data record (Page 41).

The following parameter settings are possible:

Table 2-542 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Sampling rate	1 value/cycle	1 value/cycle	No	Module	Module
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Channel	Channel [1]
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Channel	
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel
Type/range of measurement	• Deactivated • Voltage 1 to 5 V • Voltage +/- 5 V • Voltage +/- 10 V • Voltage 0 to 10 V • Current (4-wire transducer) 0 to 20 mA • Current (4-wire transducer) +/- 20 mA • Current (4-wire transducer) 4 to 20 mA • Current (2-wire transducer) 0 to 20 mA • Current (2-wire transducer) 4 to 20 mA	Current (4-wire transducer) 4 to 20 mA	Yes	Channel	Channel
Smoothing	• None • 2 times • 4 times • 8 times • 16 times • 32 times • 64 times	None	Yes	Channel	Channel
Hardware interrupt high limit 1	• Disable • Enable	Disable	Yes	Channel	- [1]
Hardware interrupt low limit 1	• Disable • Enable	Disable	Yes	Channel	

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 5 bytes.

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Hardware interrupt high limit 2	• Disable • Enable	Disable	Yes	Channel	- [1]
Hardware interrupt low limit 2	• Disable • Enable	Disable	Yes	Channel	
High limit 1	• Value	27648	Yes	Channel	Channel [1]
Low limit 1	• Value	0	Yes	Channel	
High limit 2	• Value	27648	Yes	Channel	
Low limit 2	• Value	0	Yes	Channel	
Potential group	• Use the potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into a light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 5 bytes.

NOTE
Unused channels
"Deactivate" the unused channels in the parameter assignment.
A deactivated channel always returns the value $7FFF_H$.

5.3 Description of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics alarm for missing or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics in the event of a short-circuit of the encoder supply to ground or of an input to the encoder supply. A short-circuit is also detected in the range of 1 to 5 V if the input signal is short-circuited or the input is not connected.

The short-circuit and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the short-circuit diagnostics is output.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics: Wire break

Enabling of the diagnostics if the module has no current flow or has too little current for the measurement in the range of 4 mA to 20 mA.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the wire break diagnostics is output.

Measurement type/measuring range

See the section Measurement types and measuring ranges (Page 19).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 7 levels.

Smoothing time = number of module cycles (k) × cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This is valid for all signal changes at the analog input.

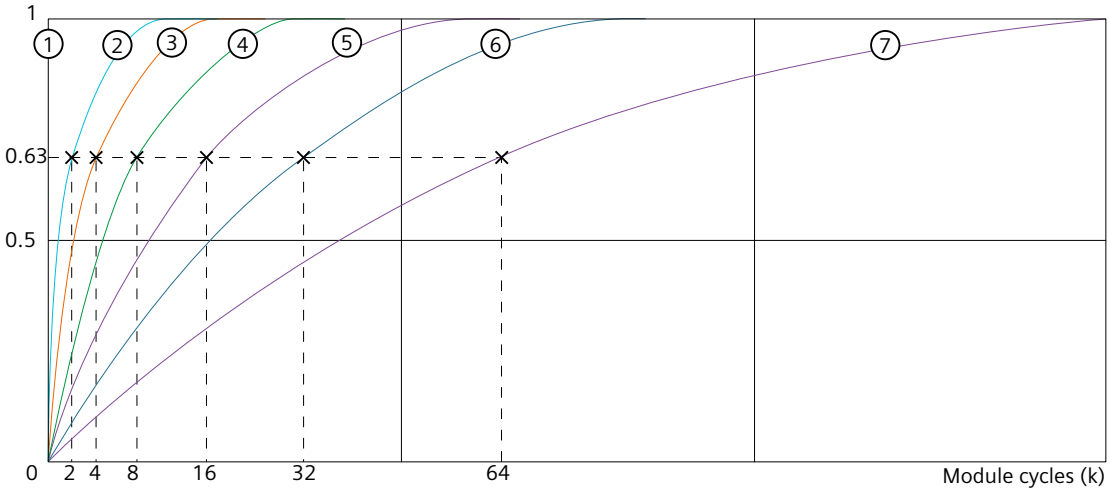

① No smoothing
② 2x smoothing
③ 4x smoothing
④ 8x smoothing
⑤ 16x smoothing
⑥ 32x smoothing
⑦ 64x smoothing

Figure 2-539 Smoothing with AI 2×U/I 2-/4-wire HS

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2, and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take over the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

You finish the station configuration with a server module.

See also

You can find additional information in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

5.4 Oversampling

Function

Oversampling is the acquisition of data in constant bus cycle segments (sub-cycles). The configured number n of sub-cycles corresponds to one PROFINET bus cycle.

Oversampling is useful whenever you require acquisition of data with high time resolution but without using an extremely short PROFINET bus cycle and thus fast CPU cycles.

With oversampling, a PROFINET bus cycle is divided into constant bus sub-cycles:

- One measured value is acquired in each sub-cycle.
- The minimum PROFINET bus cycle is 250 µs. Only a subset of functions is available for shorter sub-cycles.
- The shortest possible sub-cycle is 50 µs.
- You can configure oversampling:
  - For channel 0 (1-channel operation)
  - For channel 0/1 (2-channel operation)
- The number of sub-cycles can be set as follows:
  - From 2 to 16 for one channel
  - From 2 to 8 for two channels

Requirement

Oversampling is only possible when isochronous mode is set.

Configuration

You configure oversampling with the following parameter:

- Sampling rate

NOTE

Do not use a reduction ratio for blocks in the case of configuration with oversampling in the runtime groups of your user program. This will ensure that the data processing in the user program of the CPU is synchronized with the acquisition on the module.

Overview of the operating modes

Function	Normal operation	Oversampling in normal operation		Oversampling in high-speed	
		1-channel operation	2-channel operation	1-channel operation	2-channel operation
Isochronous mode	Yes, optional	Yes, required		Yes, required	
• Shortest send clock	125 µs	500 µs		250 µs	
Oversampling	No	Yes		Yes	
• Number of oversampling levels (sampling rate)	-	2 to 16	2 to 8	2 to 16	2 to 8
• Shortest sub-cycle (= shortest sampling time)	-	250 µs		50 µs	
Hardware interrupt	x	-		-	
Smoothing	x	x		-	
±10 V	x	x		x	
0 to 10 V	x	x		-	
±5 V	x	x		-	
1 to 5 V	x	x		-	
±20 mA	x	x		x	
0 to 20 mA	x	x		-	
4 to 20 mA	x	x		-	
Overflow/underflow	x	x		x[1)]	
Wire break 4 to 20 mA	x	x		-	
Short-circuit (1 to 5 V)	x	x		-	
Short-circuit encoder supply with current measuring ranges	x	x		x	
Load voltage diagnostics	x	x		x	
Value status (QI)	x	-		-	
Address space	4 bytes	32 bytes		32 bytes	

1 As of firmware version 1.x, for release number 1, the result must be present for at least one fieldbus cycle + 250 µs for a reliable detection of the diagnostics (overflow/underflow).

Sampling interval

The duration of a subcycle is the sampling interval. The cycle time T (send clock) for isochronous mode is specified in the configuration software. This time, divided by the configured sampling rate n_{Sample}, yields the sampling interval t_{Sample} of the module.

Example calculation:

$$t_{Sample} = \frac{T}{n_{Sample}} = \frac{1\ ms}{16} = 62{,}5\ \mu s$$

Figure 2-540 Example of calculating the sampling interval

Chronological sequence

The figure shows the chronological sequence for oversampling. The acquired measured vales of a data cycle with oversampling are only copied to the interface module in the subsequent bus cycle and are then available to the processing CPU one bus cycle later.

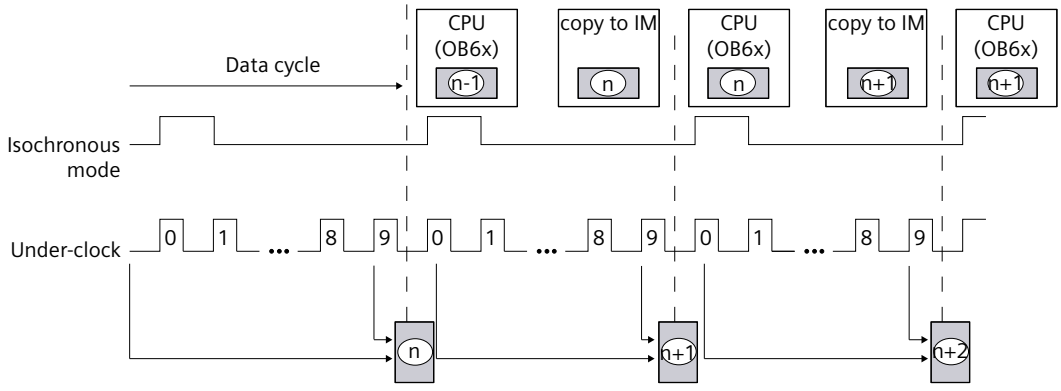

① n = measured values from bus cycle n

Figure 2-541 Oversampling

5.5 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is occupied in the input address space if you enable the value status for the analog module. Bits 0 to 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit =1: No fault is present on the channel.

Bit =0: The wiring, the value created on the channel, or similar is incorrect.

Address space

The following figure shows the assignment of the address space for the AI 2xU/I 2-/4-wire HS with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

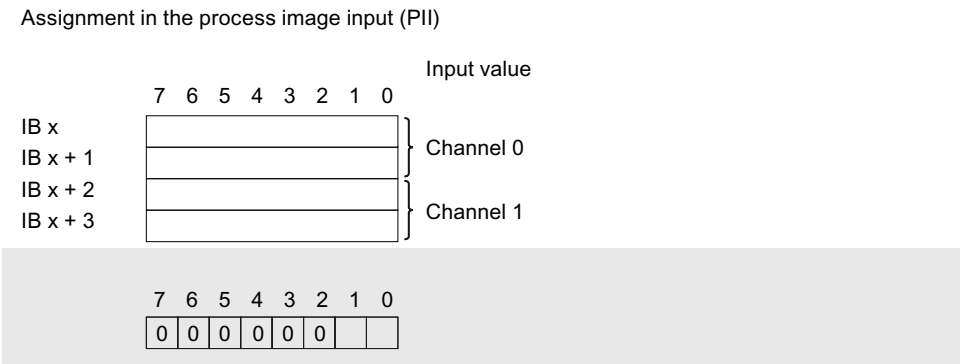

Figure 2-542 Address space of the AI 2xU/I 2-/4-wire HS with value status

Address space of the AI 2×U/I 2-/4-wire HS for oversampling with one channel

The following figure shows the assignment of the address space for oversampling with one channel. Writing always starts from IB x. If fewer than 16 sub-cycles are set, the addresses that are then unused are filled with $7FFF_H$.

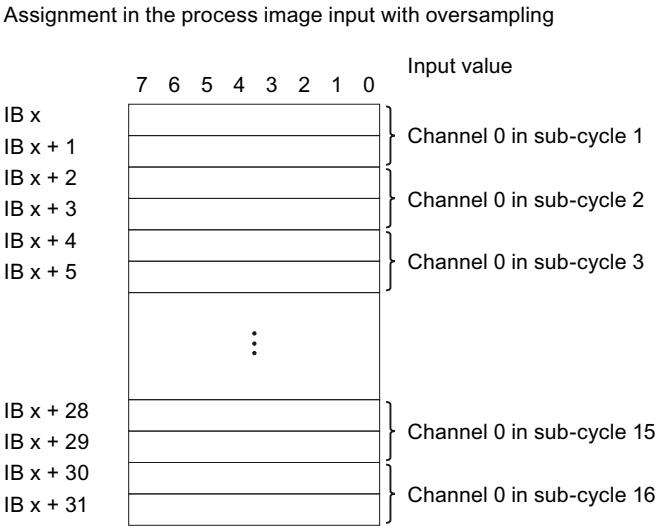

Figure 2-543 Address space of AI 2xU/I 2-/4-wire HS for oversampling with one channel

Address space of the AI 2×U/I 2-/4-wire HS for oversampling with two channels

The following figure shows the assignment of the address space for oversampling with two channels. Writing always starts from IB x. Only a maximum of 8 sub-cycles are possible. If fewer than 8 sub-cycles are set, the addresses that are then unused are filled with $7FFF_H$.

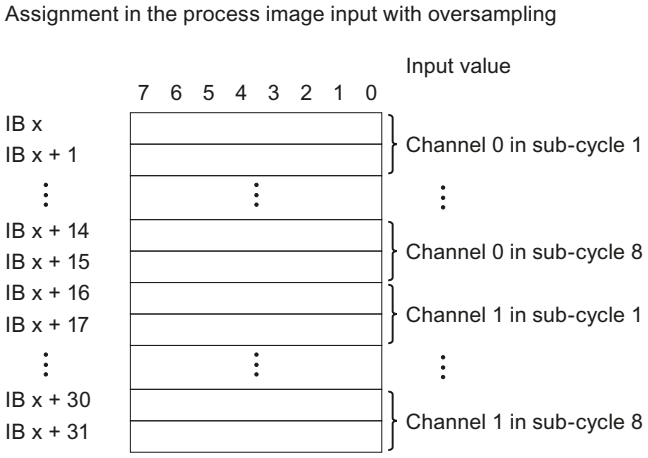

Figure 2-544 Address space of AI 2xU/I 2-/4-wire HS for oversampling with two channels

Interrupts/diagnostics interrupts

6

6.1 Status and error displays

LED displays

The figure below shows the LED displays of the AI 2×U/I 2-/4-wire HS.

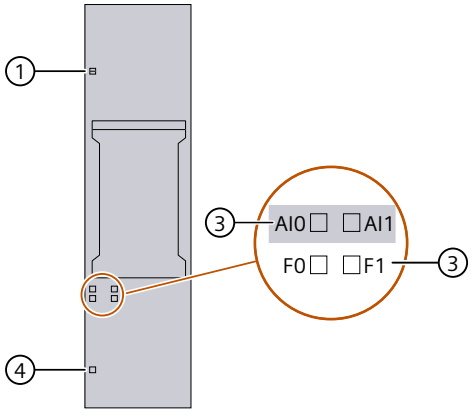

① DIAG (green/red)

② Channel status (green)

③ Channel fault (red)

④ PWR (green)

Figure 2-545 LED displays

Meaning of the LEDs

The meaning of the status and error messages is described in the following tables. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 33).

DIAG LED

Table 2-543 Error display of the DIAG LED

DIAG	Meaning
Off	Backplane bus supply of the system is interrupted or switched off.
Flashes	Module parameters not assigned
On	Module parameters assigned and no module/channel diagnostics data available
Flashes	Module parameters assigned and module/channel diagnostics available

Channel status/channel fault LED

Table 2-544 Status/error display of the channel status/channel fault LED

Channel status	Channel fault	Meaning
Off	Off	Channel deactivated or no load voltage L+
On	Off	Channel activated and no channel diagnostics
Off	On	Channel activated and channel diagnostics
On	On	Not permitted (error)

PWR LED

Table 2-545 Status display of the PWR LED

PWR	Meaning
Off	No supply voltage L+
On	Supply voltage L+ present

6.2 Interrupts

The analog input module AI 2×U/I 2-/4-wire HS supports hardware and diagnostic interrupts.

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- Low limit 1 violated
- High limit 1 violated
- Low limit 2 violated
- High limit 2 violated

If an interrupt occurs, a corresponding interrupt OB is called in the CPU of the IO controller.

S7-1500

Detailed information on the event is available in the STEP 7 online help.

The block interface is shown here with optimized block access, which is set in the TIA Portal by default.

Name	Data type	Comment
LADDR	HW_IO	Hardware identifier of the module triggering the interrupt
USI	WORD	USI (High/Low)
IChannel	USInt	Channel that triggered the hardware interrupt
EventType	Byte	Error event

S7-300/400 or a different CPU

You can obtain detailed information on the event in the hardware interrupt organization block with the instruction "RALARM" (read additional interrupt info) and in the STEP 7 online help.

The channel of the module that triggered the hardware interrupt is entered in the start information of OB4x in the OB4x_POINT_ADDR tag. The following figure shows the assignment to the bits of double word 8 in local data.

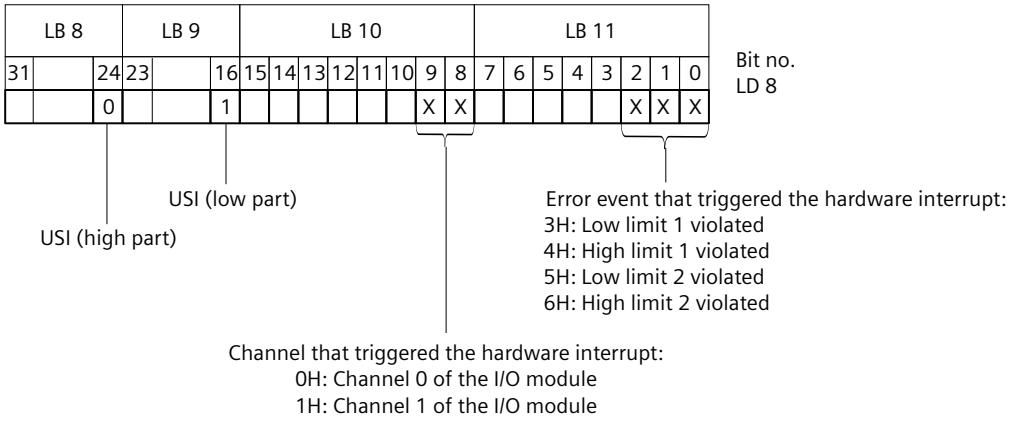

Figure 2-546 OB4x_POINT_ADDR tag

Structure of the additional interrupt information

Table 2-546 Structure of USI = W#16#0001

Data block name		Content	Comment	Bytes
USI		W#16#0001	User Structure Identifier: Additional interrupt info for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#01	Channel 0 and 1 of the I/O module	1
The error event that triggered the hardware interrupt follows.				
	Error event	B#16#03	Low limit 1 violated	1
		B#16#04	High limit 1 violated	
		B#16#05	Low limit 2 violated	
		B#16#06	High limit 2 violated	

Diagnostics interrupt

The module generates a diagnostics interrupt at the following events:

- Short-circuit (current and voltage 1 to 5 V)
- Wire break (current)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- No load voltage
- Channel/component temporarily not available

6.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG LED flashes red on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-547 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit (current)	1_H	Encoder supply to ground	Correct interplay between module and encoder
		Input after encoder supply	
Short-circuit (1 to 5 V)	1_H	Short circuit of input signal	Correct interplay between module and encoder
		Open input	Connect input
Wire break (current)	6_H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate diagnostics • Connect the encoder contacts
High limit violated	7_H	Value is above overrange.	Correct the output value
Low limit violated	8_H	Value is below underrange.	Correct the output value
Error	9_H	Internal module error has occurred (diagnostics alarm on channel 0 applies for the entire module).	Replace the module

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• Module cannot evaluate parameters for the channel • Incorrect parameter assignment	Correct the parameter assignment (wire break diagnostics set only with the permitted measuring ranges).
No load voltage	11_H	No or insufficient supply voltage L+	• Check the supply voltage L+ at the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module does not read any process values in this state.	• Wait for firmware update • Restart the firmware update

Diagnostics alarms in the measured value of analog input modules

Each analog input module supplies the measured value $7FFF_H$ or 8000_H depending on the parameter assignment when an error is detected.

Technical specifications 7

7.1 Technical specifications

Technical specifications of AI 2xU/I 2-/4-wire HS

The following table lists the technical specifications on the issue date. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7134-6HB00-0DA1/td?dl=en).

Article number	6ES7134-6HB00-0DA1
General information	
Product type designation	AI 2xU/I 2-/4-wire HS
HW functional status	from FS21
Firmware version	V2.0.3
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes
• Measuring range scalable	No
• Scalable measured values	No
• Adjustment of measuring range	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V13 SP1
• STEP 7 configurable/integrated from version	V5.5 SP3 / -
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.3
Operating mode	
• Oversampling	Yes; 2 channels per module
• MSI	No
CiR - Configuration in RUN	
Reparameterization possible in RUN	No
Calibration possible in RUN	No

Article number	6ES7134-6HB00-0DA1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	39 mA; without sensor supply
Encoder supply	
24 V encoder supply	
• 24 V	Yes; For current measurement
• Short-circuit protection	Yes
• Output current, max.	20 mA; max. 50 mA per channel for a duration < 10 s
Power loss	
Power loss, typ.	0.95 W; without sensor supply
Address area	
Address space per module	
• Address space per module, max.	4 byte; + 1 byte for QI information (32 bytes in the oversampling operating mode)
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type A0, A1
• 4-wire connection	BU type A0, A1
Analog inputs	
Number of analog inputs	2; Differential inputs
• For current measurement	2
• For voltage measurement	2
permissible input voltage for voltage input (destruction limit), max.	30 V
permissible input current for current input (destruction limit), max.	50 mA
Cycle time (all channels), min.	125 µs
Analog input with oversampling	Yes
• Values per cycle, max.	16
• Resolution, min.	50 µs
Input ranges (rated values), voltages	
• 0 to +10 V	Yes; 15 bit
– Input resistance (0 to 10 V)	75 kΩ

Article number	6ES7134-6HB00-0DA1
• 1 V to 5 V	Yes; 13 bit
– Input resistance (1 V to 5 V)	75 kΩ
• -10 V to +10 V	Yes; 16 bit incl. sign
– Input resistance (-10 V to +10 V)	75 kΩ
• -5 V to +5 V	Yes; 15 bit incl. sign
– Input resistance (-5 V to +5 V)	75 kΩ
Input ranges (rated values), currents	
• 0 to 20 mA	Yes; 15 bit
– Input resistance (0 to 20 mA)	130 Ω
• -20 mA to +20 mA	Yes; 16 bit incl. sign
– Input resistance (-20 mA to +20 mA)	130 Ω
• 4 mA to 20 mA	Yes; 14 bit
– Input resistance (4 mA to 20 mA)	130 Ω
Cable length	
• shielded, max.	1 000 m; 200 m for voltage measurement
Analog value generation for the inputs	
Measurement principle	Actual value encryption (successive approximation)
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Interference voltage suppression for interference frequency f1 in Hz	No
• Conversion time (per channel)	10 µs
Smoothing of measured values	
• Number of smoothing levels	7; none; 2-/4-/8-/16-/32-/64-fold
• parameterizable	Yes
Encoder	
Connection of signal encoders	
• for voltage measurement	Yes
• for current measurement as 2-wire transducer	Yes
– Burden of 2-wire transmitter, max.	650 Ω
• for current measurement as 4-wire transducer	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.03 %
Temperature error (relative to input range), (+/-)	0.01 %/K
Crosstalk between the inputs, min.	-50 dB

Article number	6ES7134-6HB00-0DA1
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.1 %
Operational error limit in overall temperature range	
• Voltage, relative to input range, (+/-)	0.3 %
• Current, relative to input range, (+/-)	0.3 %
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to input range, (+/-)	0.2 %
• Current, relative to input range, (+/-)	0.2 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Common mode voltage, max.	35 V
• Common mode interference, min.	90 dB
Isochronous mode	
Filtering and processing time (TCI), min.	80 µs
Bus cycle time (TDP), min.	125 µs; Starting from firmware Version V2.0.1
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes; two upper and two lower limit values in each case
Diagnoses	
• Wire-break	Yes; channel-by-channel, at 4 to 20 mA only
• Short-circuit	Yes; channel-by-channel, at 1 to 5 V or for current measuring ranges short-circuit in encoder supply
• Group error	Yes
• Overflow/underflow	Yes; channel by channel
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	Yes
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Isolation	
Isolation tested with	707 V DC (type test)

Article number	6ES7134-6HB00-0DA1
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; < 0 °C as of FS07
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; < 0 °C as of FS07
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	32 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Measurement type	Measuring range	Diagnostics					Hardware interrupts
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow	Wire break	
Deactivated		*	*	*	*	*	*
Voltage	1 to 5 V	x	x	x	x	-	x
	±5 V	x	-	x	x	-	x
	±10 V	x	-	x	x	-	x
	0 to 10 V	x	-	x	x	-	x
Current (4-wire transducer)	0 to 20 mA	x	x	x	x	-	x
	±20 mA	x	x	x	x	-	x
	4 to 20 mA	x	x	x	x	x	x
Current (2-wire transducer)	0 to 20 mA	x	x	x	-	-	x
	4 to 20 mA	x	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Diagnostics				Hardware interrupts
		No supply voltage L+	Short-circuit to ground	Overflow/underflow	Wire break	
Deactivated		*	*	*	*	*
Voltage	1 to 5 V	x	x	x	-	-
	+/- 5 V	x	-	x	-	-
	+/- 10 V	x	-	x	-	-
	0 to 10 V	x	-	x	-	-

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Measurement type	Measuring range	Diagnostics				Hardware interrupts
		No supply voltage L+	Short-circuit to ground	Overflow/underflow	Wire break	
Current (4-wire transducer)	0 to 20 mA	x	x	x	-	-
	+/- 20 mA	x	x	x	-	-
	4 to 20 mA	x	x	x	x	-
Current (2-wire transducer)	0 to 20 mA	x	x	x	-	-
	4 to 20 mA	x	x	x	x	-

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reassign the module parameters in your user program, regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can reassign the parameters of the module in RUN. For example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels.

NOTE

Following a firmware update, you need to re-configure the I/O module before you can use the new functions.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

NOTE

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment results in a brief exit from clocked measuring mode and renewed synchronization with the fieldbus cycle. The slowest channel provides the "internal" measuring cycle.

STATUS output parameter

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128 for entire module

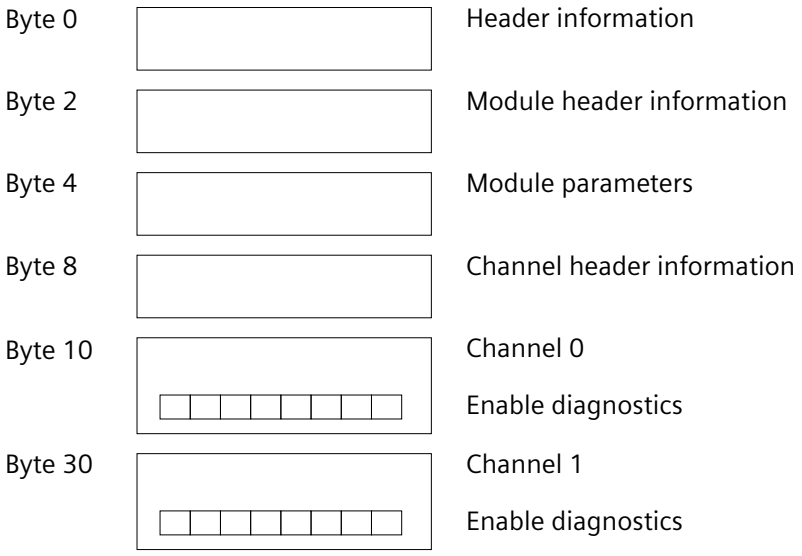

Figure 2-547 Structure of data record 128 for entire module

Header information

The figure below shows the structure of the header information.

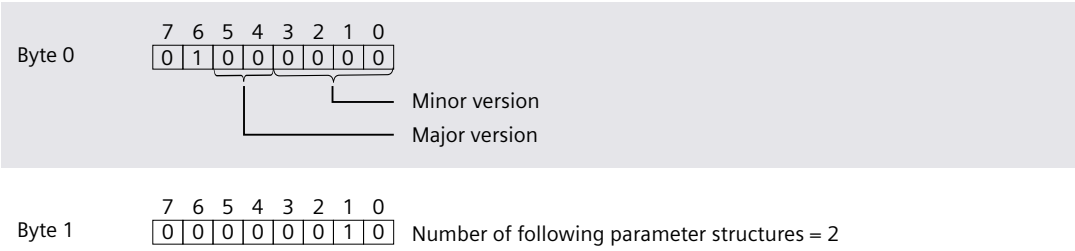

Figure 2-548 Header information

Module header information

The figure below shows the structure of the module header information.

	7	6	5	4	3	2	1	0	
Byte 2	0	0	0	0	0	0	0	1	Number of the following module parameter blocks = 1
Byte 3	0	0	0	0	0	1	0	0	Length of the following module parameter block = 4

Figure 2-549 Module header information

Module parameter block

The figure below shows the structure of the module parameter block.

Enable a parameter by setting the corresponding bit to "1".

	7	6	5	4	3	2	1	0	
Byte 4	0	0	0	0	0	0	0		Operating mode: 0: Normal 1: High speed
Byte 5	0	0	0	0					Sampling rate 0 ... 15 (sub-cycle 1 ... 16)
Byte 6	0	0	0	0	0	0	0	0	Reserved
Byte 7	0	0	0	0	0	0	0	0	

Figure 2-550 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

	7	6	5	4	3	2	1	0	
Byte 8	0	0	0	0	0	0	1	0	Number of following channel parameter blocks = 2
Byte 9	0	0	0	1	0	1	0	0	Length of the following channel parameter block = 20

Figure 2-551 Channel header information

Channel parameter block

The figure below shows the structure of the channel parameter block.

Enable a parameter by setting the corresponding bit to "1".

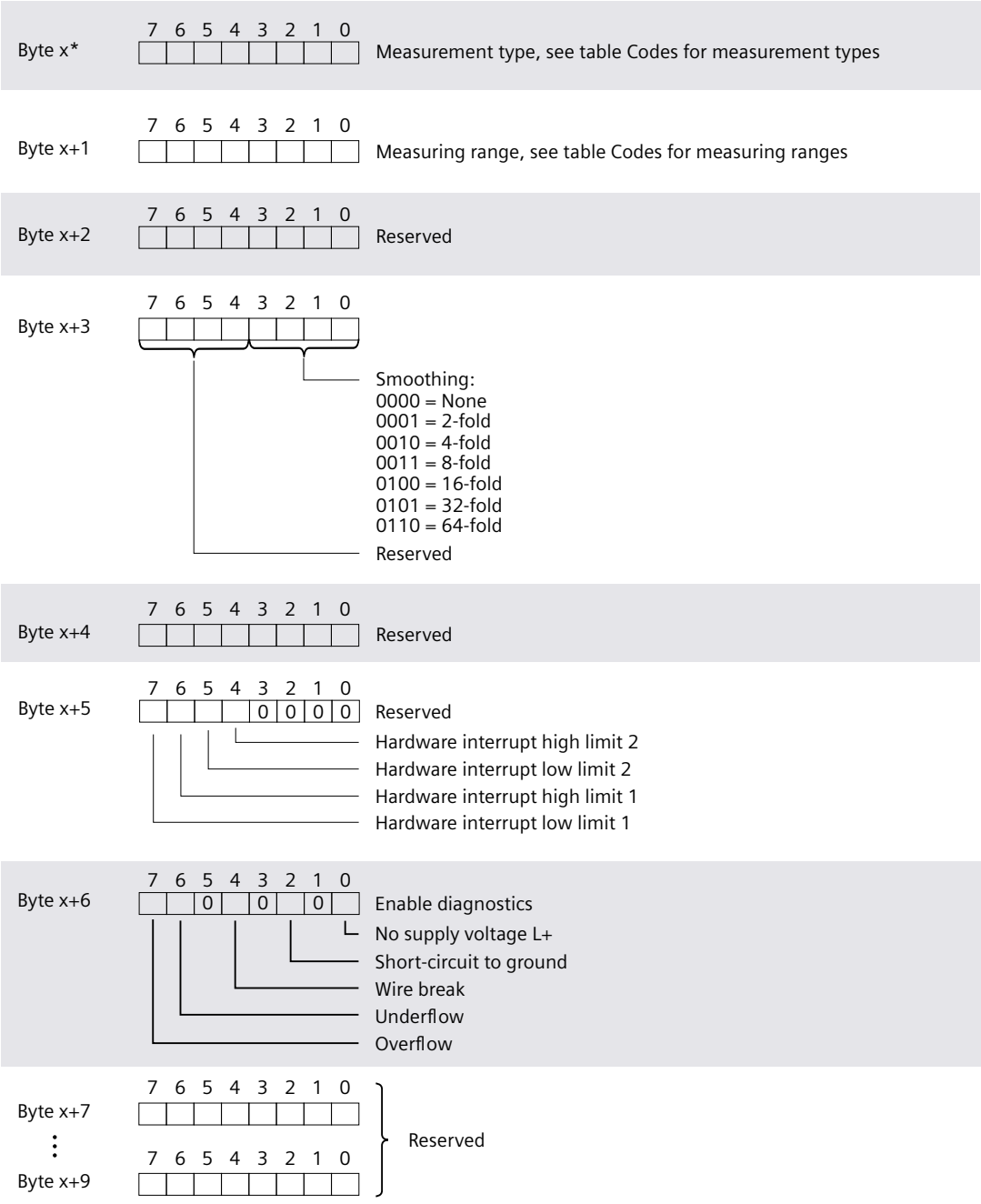

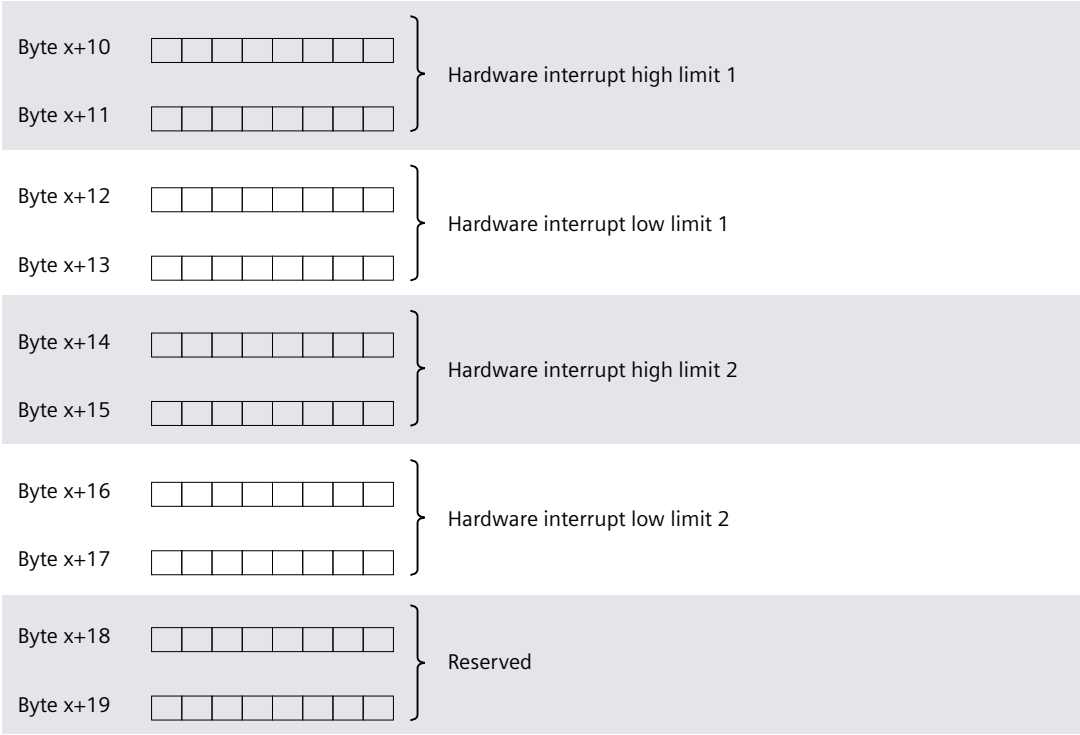

* x = 10 + (channel number × 20); channel number = 0 to 1

Figure 2-552 Structure of byte x to x+19 for channels 0 and 1

Codes for measurement types

The following table contains the codes for the measurement types of the analog input module. You must enter these codes in byte x (see channel parameter block figure).

Table 2-548 Codes for measurement types

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001
Current, 4-wire transducer	0000 0010
Current, 2-wire transducer	0000 0011

Codes for measuring ranges

The following table contains the codes for the measuring ranges of the analog input module. You must enter these codes in byte x+1 (see channel parameter block figure).

Table 2-549 Codes for measuring ranges

Measuring range	Code
Voltage	
±5 V	0000 1000
±10 V	0000 1001
1 to 5 V	0000 1010
0 to 10 V	0000 1011
Current	
±20 mA	0000 0100
0 to 20 mA	0000 0010
4 to 20 mA	0000 0011

Representation of analog values

B

This appendix shows the analog values for all measuring ranges that you can use with the analog module.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its parameter assignment.

The table below shows the representation of binary analog values and of the associated decimal and hexadecimal units of the analog values.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table 2-550 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	**Hexadecimal**	**High byte**	**Low byte**
13	8	8_H	Sign 0 0 0 0 0 0 0	0 0 0 0 1 x x x
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table 2-551 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 2-552 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table 2-553 Voltage measuring range ±10 V and ±5 V

Values		Voltage measuring range		Range
Dec.	**Hex.**	**±10 V**	**±5 V**	
32767	7FFF	> 11.759 V	> 5.879 V	Overflow
32511	7EFF	11.759 V	5.879 V	Overrange
27649	6C01			
27648	6C00	10 V	5 V	Nominal range
20736	5100	7.5 V	3.75 V	
1	1	361.7 µV	180.8 µV	
0	0	0 V	0 V	
-1	FFFF			
-20736	AF00	-7.5 V	-3.75 V	
-27648	9400	-10 V	-5 V	
-27649	93FF			Underrange
-32512	8100	-11.759 V	-5.879 V	
-32768	8000	< -11.759 V	< -5.879 V	Underflow

Table 2-554 Voltage measuring range 1 V to 5 V and 0 V to 10 V

Values		Voltage measuring range		Range
Dec.	**Hex.**	**1 to 5 V**	**0 to 10 V**	
32767	7FFF	> 5.704 V	> 11.759 V	Overflow
32511	7EFF	5.704 V	11.759 V	Overrange

Values		Voltage measuring range		Range
27649	6C01			Overrange
27648	6C00	5 V	10 V	Nominal range
20736	5100	4 V	7.5 V	
1	1	1 V + 144.7 µV	361.7 µV	
0	0	1 V	0 V	
-1	FFFF			Underrange
-4864	ED00	0.296 V	-1.759 V	
-32768	8000	< 0.296 V	< -1.759 V	Underflow

B.3 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table 2-555 Current measuring range ±20 mA

Values		Current measuring range	Range
Dec.	**Hex.**	**±20 mA**	
32767	7FFF	> 23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	< -23.52 mA	Underflow

Table 2-556 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		Range
Dec.	**Hex.**	**0 to 20 mA***	**4 to 20 mA**	
32767	7FFF	> 23.52 mA**	> 22.81 mA**	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange

* For measurement type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

** For measurement type "2-wire transducer", the behavior described here is supported for overflow up to max. 35 mA.

Values		Current measuring range		Range
27649	6C01			Overrange
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	< -3.52 mA	< 1.185 mA	Underflow

* For measurement type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

** For measurement type "2-wire transducer", the behavior described here is supported for overflow up to max. 35 mA.

B.4 Measured values for wire break

The following table contains the measured values at a wire break depending on enabled diagnostics.

Table 2-557 Measured values at a wire break depending on enabled diagnostics

Programmable diagnostics		Measured value		Explanation
Wire break	Underflow			
Enable	Enable	32767	$7FFF_H$	The "wire break" diagnostics is reported, because this has a higher priority.
Disable	Enable	-32768	8000_H	The "Lower limit violated" diagnostics is reported.
Disable	Disable	-32768	8000_H	No diagnostics reported.

SIEMENS

SIMATIC

ET 200SP
Analog input module AI 2xU/I 2-/4-wire HF (6ES7134-6HB00-0CA1)

Equipment Manual

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Preface

1

1.1 Open Source Software

Open-source software is used in the firmware of the I/O modules. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information relating to this on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109739516).

See also

GNU_V5.3.1_201805 (https://support.industry.siemens.com/cs/ww/en/view/109757558)

1.2 Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

ET 200SP Documentation Guide

2

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

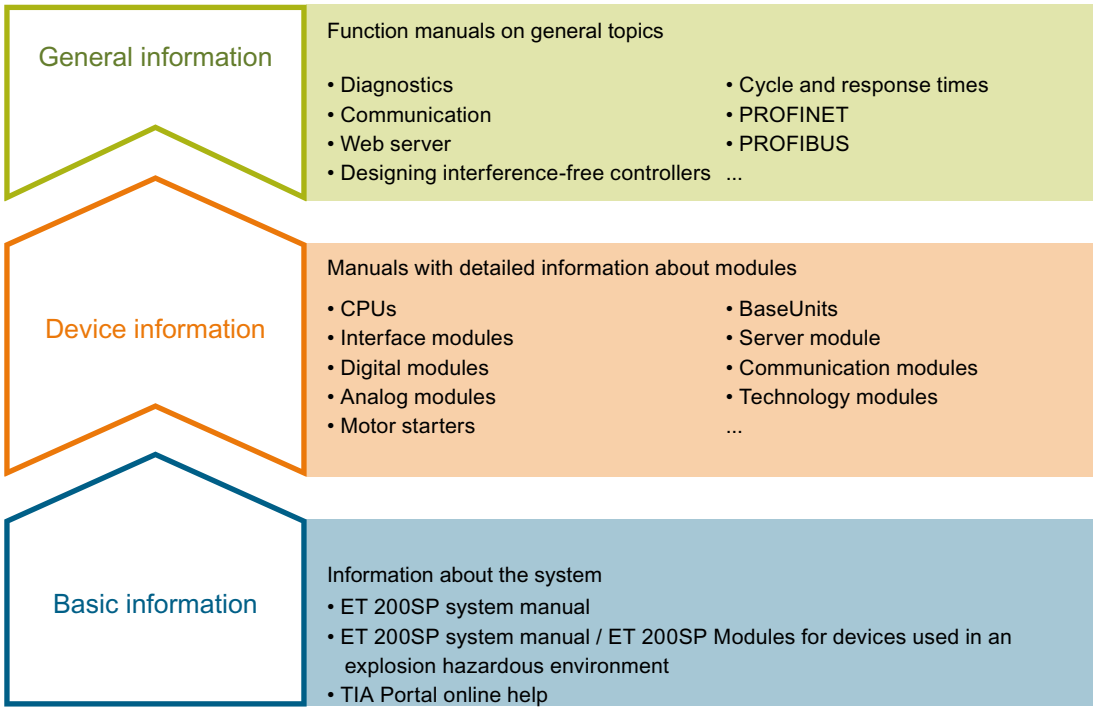

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

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You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/ae).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109767888).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant, incl. fail-safe inputs and outputs.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

3

3.1 Properties

Article number

6ES7134-6HB00-0CA1

View of the module

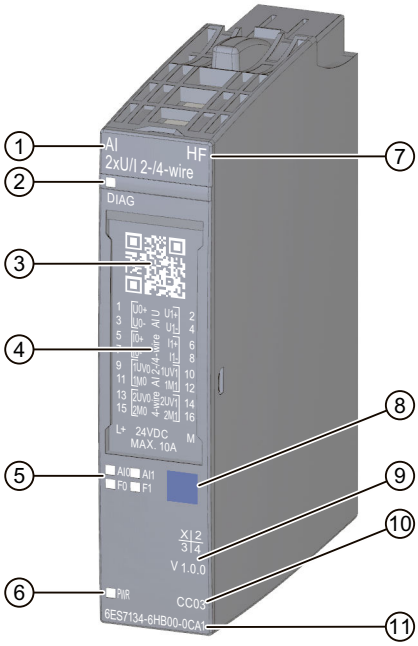

① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Color coding module type
⑨ Function and firmware version
⑩ Color code for selecting the color identification labels
⑪ Article number

Figure 2-553 View of the module AI 2×U/I 2-/4-wire HF

Properties

The module has the following technical properties:

- Analog input module with 2 inputs
- Resolution: Up to 16 bits including sign
- Single channel electrical isolation
- Voltage measurement type can be set per channel
- Current measuring type can be set per channel (for 2-wire or 4-wire transducer)
- Configurable diagnostics for each channel

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy
- Calibration in runtime
- Isochronous mode (PROFINET IO only)
- Value status (PROFINET IO only)

Table 2-558 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Measuring range adjustment	1	V2.0.0
Scaling of measured values	1	V2.0.0
Module-internal shared input (MSI)	1	V2.0.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

More information about version dependency of the GSD file is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/57138621).

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Wiring

4

4.1 Wiring and block diagram

This section includes the block diagram of the AI 2xU/I 2-/4-wire HF module with the various terminal assignments for a 2- und 4-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

NOTE

You can use and combine the different wiring options for all channels.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Wiring: Voltage measurement 2-wire and 4-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the analog input module AI 2xU/I 2-/4-wire HF on the BaseUnit BU type A0/A1.

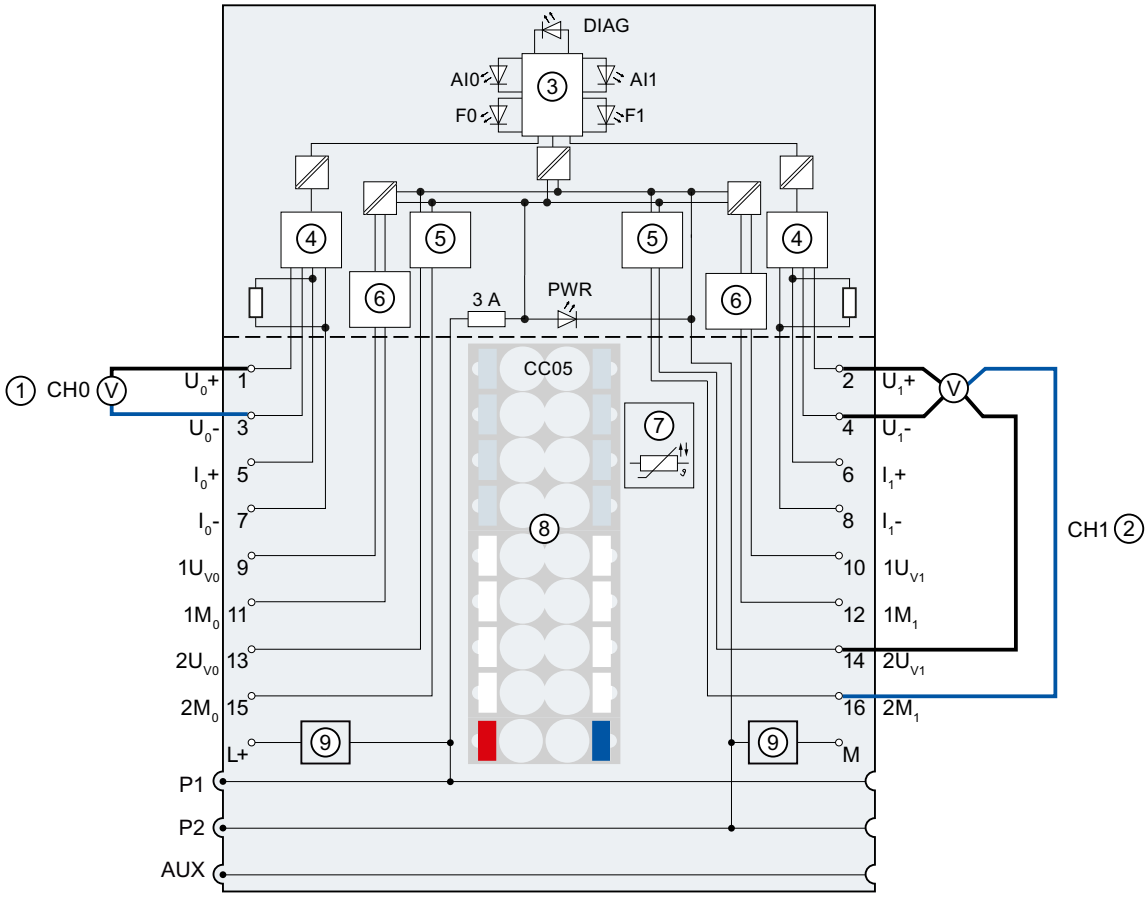

①	2-wire connection for voltage measurement	I_n+	Current input positive, channel n
②	4-wire connection for voltage measurement	I_n-	Current input negative, channel n
③	Backplane bus interface	U_{Vn}	Supply voltage, channel n
④	Analog-to-digital converter (ADC)	M_n	Reference ground to U_{Vn}, channel n
⑤	Current limitation (4-wire)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑥	Current limitation (2-wire)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑧	Color-coded label with color code CC05 (optional)	AI0, AI1	Channel status LED (green)
⑨	Filter connection supply voltage (only when light-colored BaseUnit is present)	F0, F1	Channel fault LED (red)
U_n+	Voltage input positive, channel n	PWR	Power LED (green)
U_n-	Voltage input negative, channel n		

Figure 2-554 Wiring and block diagram for voltage measurement 2-wire and 4-wire connection

NOTE

A connection between the current inputs I_n and the reference ground M_n is not allowed and leads to malfunctions of the module.

Wiring: Voltage and current measurement 3-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the analog input module AI 2xU/I 2-/4-wire HF on the BaseUnit BU type A0/A1.

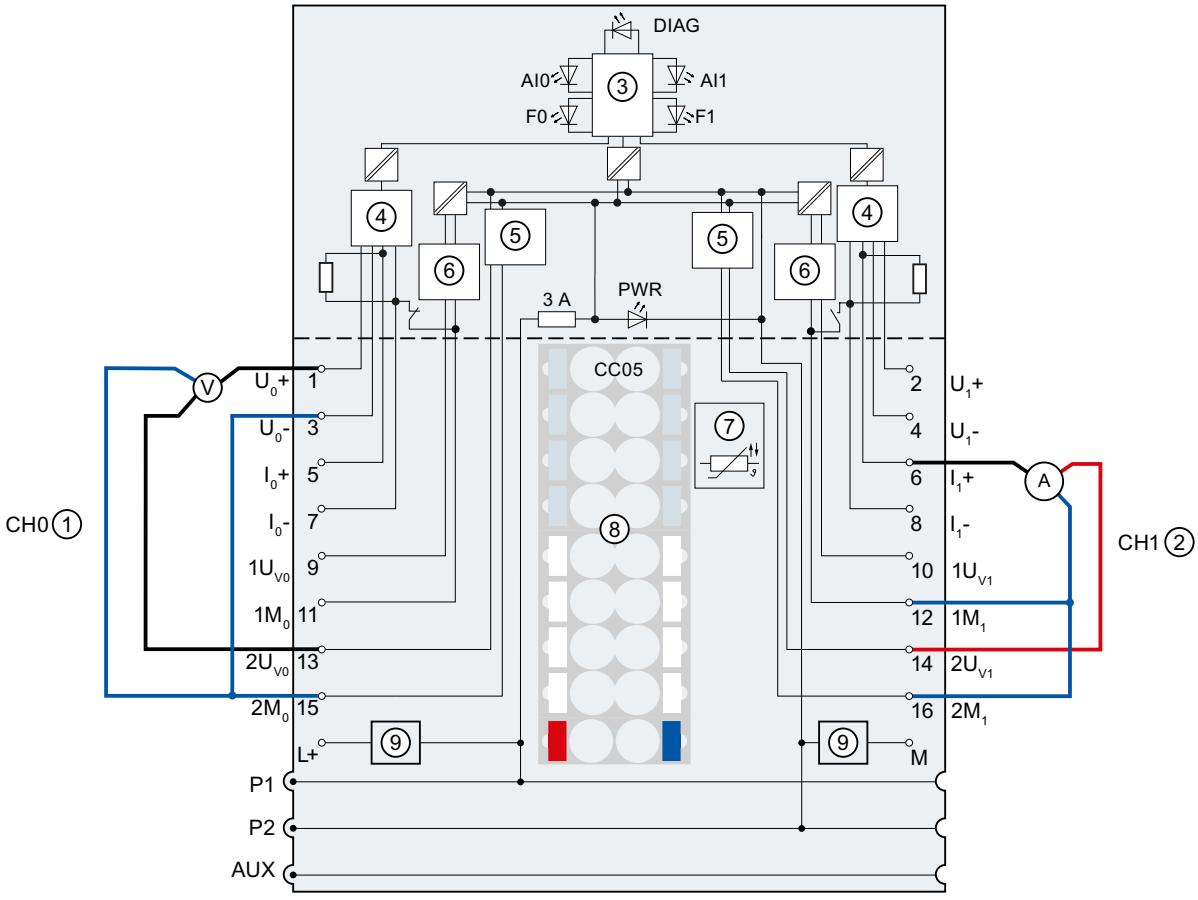

①	3-wire connection for voltage measurement	I_n+	Current input positive, channel n
②	3-wire connection for current measurement	I_n-	Current input negative, channel n
③	Backplane bus interface	U_{Vn}	Supply voltage, channel n
④	Analog-to-digital converter (ADC)	M_n	Reference ground to U_{Vn}, channel n
⑤	Current limitation (4-wire or 3-wire)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑥	Current limitation (2-wire)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)

⑧	Color-coded label with color code CC05 (optional)	AI0, AI1	Channel status LED (green)
⑨	Filter connection supply voltage (only when light-colored BaseUnit is present)	F0, F1	Channel fault LED (red)
U_n+	Voltage input positive, channel n	PWR	Power LED (green)
U_n-	Voltage input negative, channel n		

Figure 2-555 Wiring and block diagram for voltage measurement 3-wire connection

Wiring: Current measurement 2-wire and 4-wire connection (2-wire and 4-wire transducer)

The following figure shows the block diagram and an example of the terminal assignment of the analog input module AI 2xU/I 2-/4-wire HF on the BaseUnit BU type A0/A1.

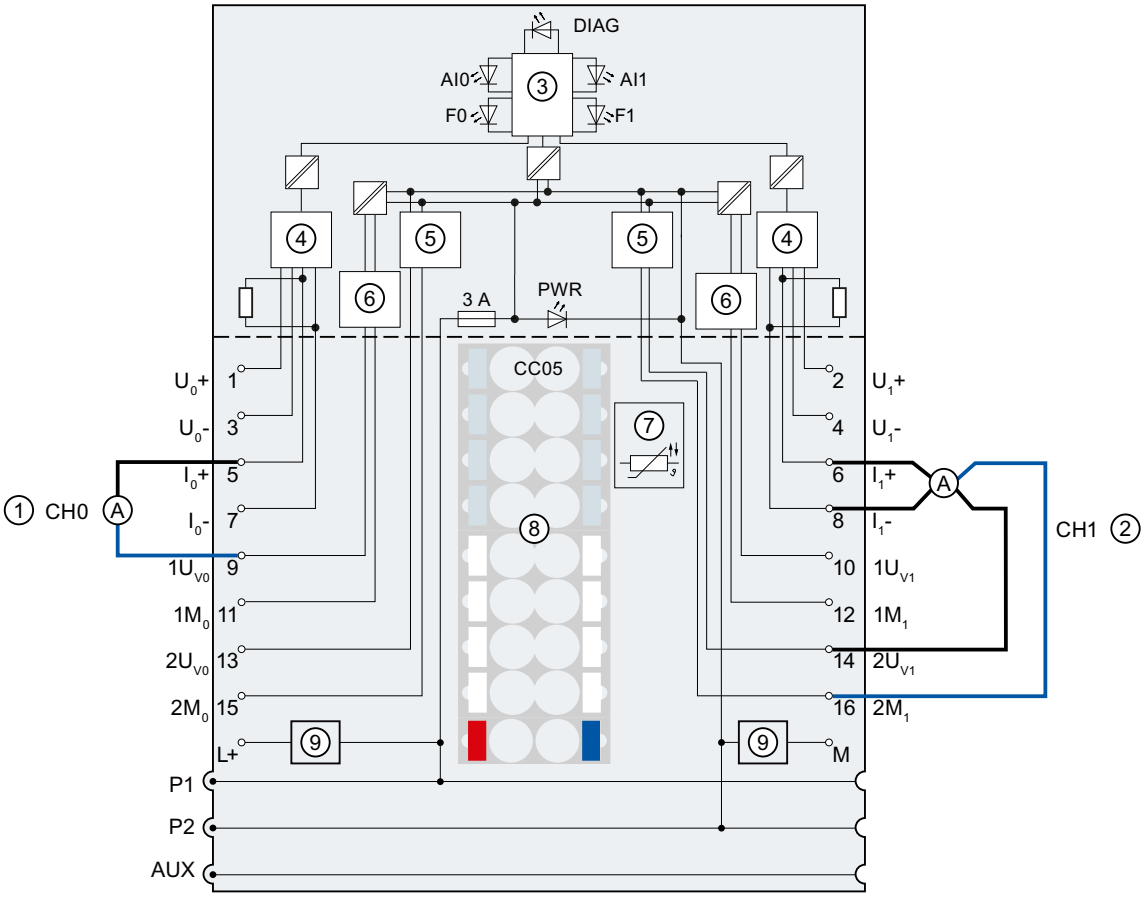

①	2-wire connection for current measurement (2-wire transducer)	U_n+	Voltage input positive, channel n
②	4-wire connection for current measurement (4-wire transducer)	U_n-	Voltage input negative, channel n
③	Backplane bus interface	U_{Vn}	Supply voltage, channel n
④	Analog-to-digital converter (ADC)	M_n	Reference ground to U_{Vn}, channel n
⑤	Current limitation (4-wire)	L+	24 V DC (infeed only with light-colored BaseUnit)

⑥	Current limitation (2-wire)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
⑧	Color-coded label with color code CC05 (optional)	AI0, AI1	Channel status LED (green)
⑨	Filter connection supply voltage (only when light-colored BaseUnit is present)	F0, F1	Channel fault LED (red)
I_n+	Current input positive, channel n	PWR	Power LED (green)
I_n-	Current input negative, channel n		

Figure 2-556 Wiring and block diagram for current measurement 2-wire and 4-wire connection (2-wire and 4-wire transducer)

Parameters/address space 5

5.1 Measurement types and measuring ranges

The following table shows the measurement types and the respective measuring range.

Table 2-559 Measurement types and measuring ranges

Measurement type	Measuring range	Resolution
Voltage	± 5 V ± 10 V 1 to 5 V 0 to 10 V	16 bits incl. sign 16 bits incl. sign 15 bits 15 bits
Current	0 to 20 mA (2-wire and 4-wire transducer) 4 to 20 mA (2-wire and 4-wire transducer) ± 20 mA (only with 4-wire transducer)	15 bits 15 bits 16 bit including sign

You can find the tables of measuring ranges and overflow, overrange, etc. in the appendix Representation of analog values (Page 55) and the "Analog value processing" function manual.

Measuring range adjustment

See Measuring range adjustment (Page 23).

Scaling of measured values

See Scaling of measured values (Page 27).

5.2 Parameters

Parameters of the AI 2xU/I 2-/4-wire HF

The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; refer to the section Parameter assignment and structure of parameter data record (Page 45).

The following parameter settings are possible:

Table 2-560 Configurable parameters and their defaults (GSD file)

Parameter	Range of values	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel
Measurement type/measuring range	• Deactivated • Voltage – ±5 V – ±10 V – 1 V to 5 V – 0 V to 10 V • Current (4-wire transducer) – 0 to 20 mA – 4 to 20 mA – ±20 mA • Current (2-wire transducer) – 0 to 20 mA – 4 to 20 mA	Current (4-wire transducer) 4..20 mA	Yes	Channel	Channel
Smoothing	• None • 2 times • 4 times • 8 times • 16 times • 32 times	None	Yes	Channel	Channel

1 Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 7 bytes.

2 In normal operation, different interference frequency suppression settings can be configured for both channels. These cause different integration times for the analog-to-digital conversion. The module-internal time for updating the user data is now based on the longer integration time for both channels.
In isochronous mode, both channels must be configured with the same interference frequency suppression of 4.8 kHz.

3 Only for configuration SCALE.

Parameter	Range of values	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Interference frequency suppression [2]	• 16.6 Hz (67.5 ms) • 50 Hz (22.5 ms) • 60 Hz (18.75 ms) • 300 Hz (10 ms) • 600 Hz (5 ms) • 1.2 kHz (2.5 ms) • 2.4 kHz (1.25 ms) • 4.8 kHz (0.625 ms)	50 Hz (22.5 ms)	Yes	Channel	Channel
Adjust measuring range [1]	• Disable • Enable	Disable	Yes	Channel	-
Measuring range adjustment high limit [1]	Value within the nominal range of the measuring range in mV or µA	0	Yes	Channel	-
Measuring range adjustment low limit [1]	Value within the nominal range of the measuring range in mV or µA	0	Yes	Channel	-
Scaled high nominal range limit [3]	REAL	20.0	Yes	Channel	-
Scaled low nominal range limit [3]	REAL	4.0	Yes	Channel	-
Hardware interrupt high limit 1 [1]	• Disable • Enable	Disable	Yes	Channel	-
High limit 1 [1]	• Value (INT) • Value (REAL) [3]	• 276480 • 0.0 [3]	Yes	Channel	-
Hardware interrupt low limit 1 [1]	• Disable • Enable	Disable	Yes	Channel	-
Low limit 1 [1]	• Value (INT) • Value (REAL) [3]	• 0 • 0.0 [3]	Yes	Channel	-
Hardware interrupt high limit 2 [1]	• Disable • Enable	Disable	Yes	Channel	-
High limit 2 [1]	• Value (INT) • Value (REAL) [3]	• 27648 • 0.0 [3]	Yes	Channel	-

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 7 bytes.

[2] In normal operation, different interference frequency suppression settings can be configured for both channels. These cause different integration times for the analog-to-digital conversion. The module-internal time for updating the user data is now based on the longer integration time for both channels.
In isochronous mode, both channels must be configured with the same interference frequency suppression of 4.8 kHz.

[3] Only for configuration SCALE.

Parameter	Range of values	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Hardware interrupt low limit 2 [1]	• Disable • Enable	Disable	Yes	Channel	-
Low limit 2 [1]	• Value (INT) • Value (REAL) [3]	• 0 • 0.0 [3]	Yes	Channel	-
Potential group	• Use potential group of the left module (dark-colored BaseUnit) • Enable new potential group (light-colored BaseUnit)	Use potential group of the left module (dark-colored BaseUnit)	No	Module	Module

1 Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 7 bytes.

2 In normal operation, different interference frequency suppression settings can be configured for both channels. These cause different integration times for the analog-to-digital conversion. The module-internal time for updating the user data is now based on the longer integration time for both channels.
In isochronous mode, both channels must be configured with the same interference frequency suppression of 4.8 kHz.

3 Only for configuration SCALE.

NOTE

For the 3-wire connection configure the parameter "Type/range of measurement" with "Current (4-wire transducer) 0..20 mA" or "Current (4-wire transducer) 4..20 mA".

NOTE

Unused channels

Deactivate the unused inputs in the parameter assignment.

A deactivated channel always returns the value $7FFF_H$ (with configuration SCALE: $7F800000_H$).

NOTE

Note that the settings in the "Interference frequency suppression" parameter have a direct effect on the cycle time of the module. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

Property of the module in isochronous mode

The permitted interference frequency suppression of both channels for isochronous mode of the modules is 4.8 kHz (0.625 ms).

Note that no instantaneous value for the time Ti is returned in isochronous mode. The analog module AI 2xU/I 2-/4-wire HF returns a mean value for the range of 0.625 ms starting at Ti.

5.3 Explanation of parameters

Diagnostics No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics if a short-circuit of the actuator supply to ground occurs. A short-circuit is also detected in the range of 1 to 5 V if the input signal is short-circuited or the input is not connected.

The short-circuit and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the short-circuit diagnostics is output.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics: Wire break

Enable the diagnostics if the module has no current flow or has too little current for the measurement in the range of 4 to 20 mA.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the wire break diagnostics is output.

Type/range of measurement

See section Measurement types and measuring ranges (Page 16)

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 5 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This applies to every signal change at the analog input.

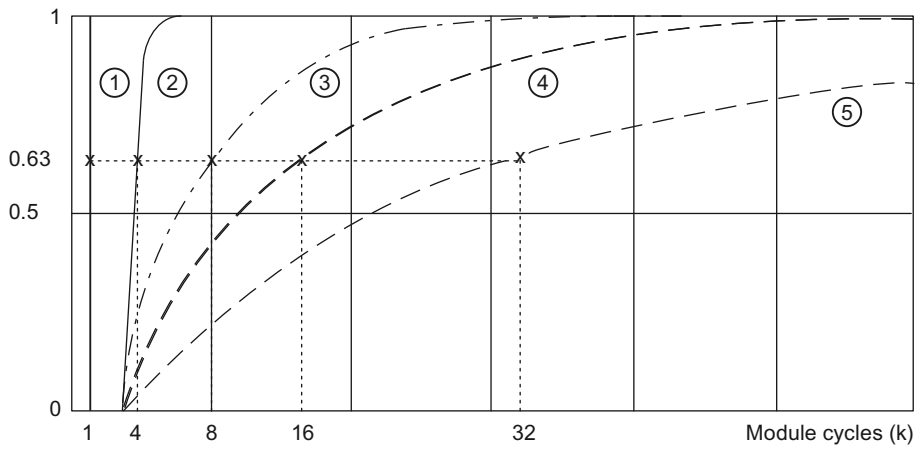

① No smoothing (k = 1)

② Weak (k = 4)

③ Medium (k = 8)

④ Strong (k = 16)

⑤ Very strong (k = 32)

Figure 2-557 Smoothing AI 2×U/I 2-/4-wire HF

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network can negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Adjust measuring range

See section Measuring range adjustment (Page 23).

Measuring range adjustment high limit

See section Measuring range adjustment (Page 23).

Measuring range adjustment low limit

See section Measuring range adjustment (Page 23).

Scaled high nominal range limit

See section Scaling of measured values (Page 27).

Scaled low nominal range limit

See section Scaling of measured values (Page 27).

Hardware interrupt high limit 1/2

Enabling of a hardware interrupt if the high limit 1/2 is violated.

Hardware interrupt low limit 1/2

Enabling of a hardware interrupt if the low limit 1/2 is violated.

High limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

Low limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

Potential group

Specifies whether a light-colored BaseUnit with incoming supply voltage or a dark-colored BaseUnit is located in this slot (see ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual).

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with a dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

See also

You can find additional information in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

5.4 Measuring range adjustment

Function

The measuring range adjustment is a limited section of a measuring range supported by the module.

It allows you to increase the resolution for a configurable part of the measuring range in S7 format. The section of the measuring range is defined by the high and low limits of the measuring range adjustment.

- The function is enabled with the "Adjust measuring range" parameter
- The "Measuring range adjustment high limit" parameter sets the high limit of the measuring range in mV or µA.
- The "Measuring range adjustment low limit" parameter sets the low limit of the measuring range in mV or µA.

NOTE

The "Measuring range adjustment" function can be used in combination with the "Measured value scaling" function. See also Scaling of measured values (Page 27).

The measuring range adjustment is available for current and voltage measuring ranges.

The measuring range adjustment (base measuring range) is valid for the following ranges:

- Nominal range
- Underrange (of the measuring range adjustment)
- Overrange (of the measuring range adjustment)

NOTE

Live zero measuring ranges are not supported.

NOTE

When the "Measuring range adjustment high limit" and "Measuring range adjustment low limit" parameters are too close together, resolution may be lost, which means it may no longer be possible to show every value.

Rules

- The limits of the measuring range adjustment must be selected within the nominal range of the base measuring range. They are specified in integers.
- The measuring range adjustment is resolved depending on the base measuring range from 0_H to $6C00_H$ or 9400_H to $6C00_H$.
- Underranges/overranges apply in accordance with the S7 format and the base measuring range.
  Special consideration: Negative values are not possible for "Current (2-wire transducer) 0..20 mA". With a measuring range adjustment, an underrange is offered when possible and cut off at 0 mA. If the underrange limit ($ED00_H$) is > 0 mA, QI = 0 and the analog value 8000_H are output when it is violated.

Example

The following values result, for example:

Table 2-561 Example of measuring range adjustment

Measuring range adjustment	**Measuring range resolution**	
	Bipolar	**Unipolar**
Base measuring range	±10 V	0 V to 10 V
Adjusted measuring range	+2 V to +5 V	+2 V to +5 V
Measuring range adjustment high limit	5000 mV (S7: +27648)	5000 mV (S7: +27648)
Measuring range adjustment low limit	2000 mV (S7: -27648)	2000 mV (S7: 0)

The following example illustrates the effect of a measuring range adjustment:

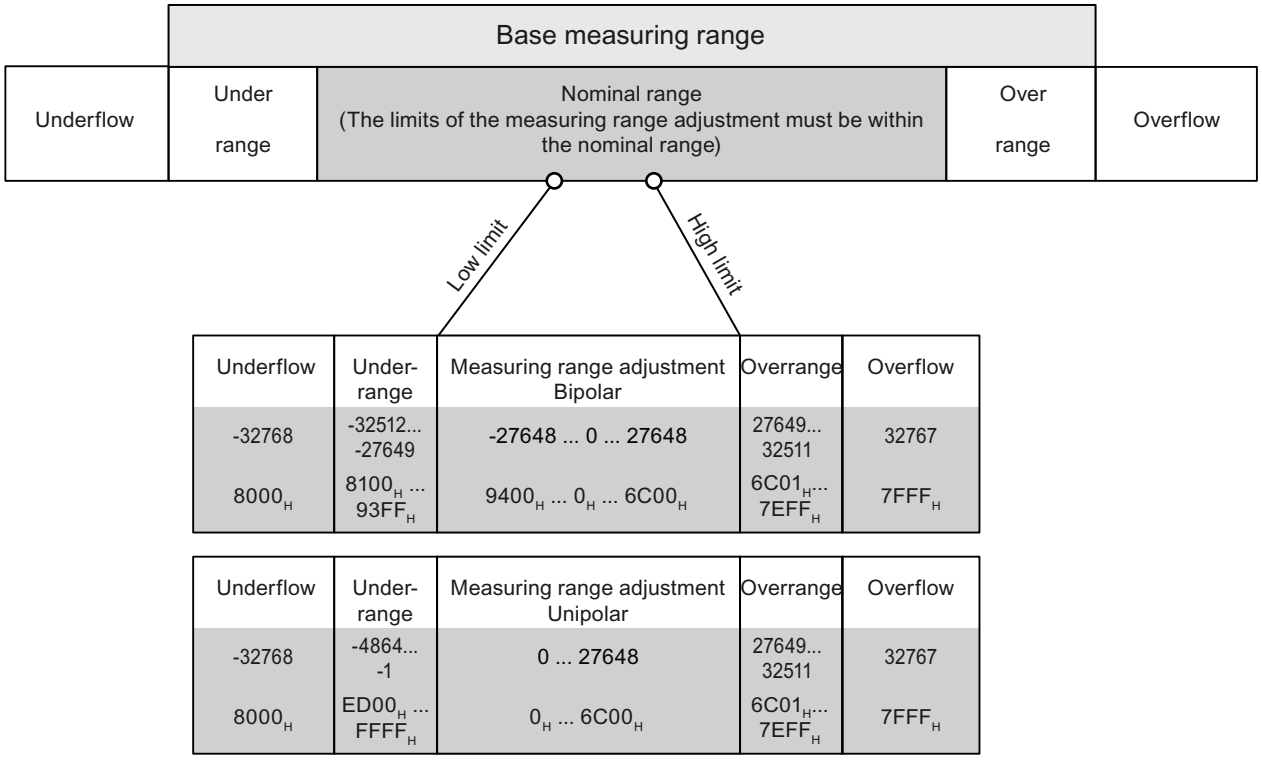

Figure 2-558 Example of a measuring range adjustment

Configuration

The following figure shows an example of a configuration:

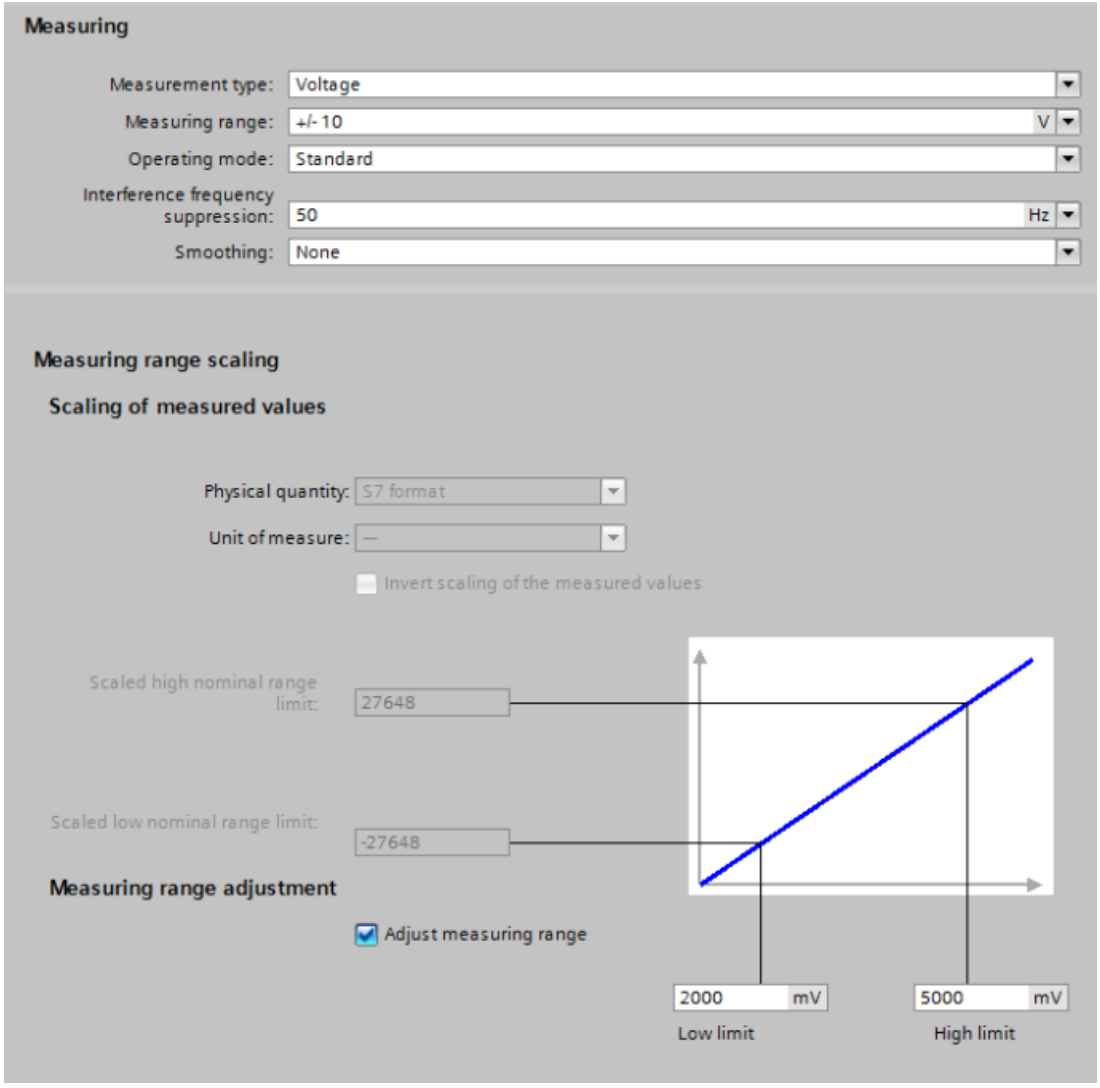

Figure 2-559 Example of a configuration

In the configuration example, a measuring range adjustment of 2000 mV to 5000 mV is displayed.

5.5 Scaling of measured values

Function

With measured value scaling, the user data of the module is displayed as REAL (32-bit floating point) instead of in S7 format.

The representation of the measuring range is defined by the following parameters:

- The "Scaled high nominal range limit" parameter sets the desired display value (in REAL) for the high nominal range limit of the measuring range.
- The "Scaled low nominal range limit" parameter sets the desired display value (in REAL) for the low nominal range limit of the measuring range.

NOTE

With measured value scaling, the substitute value is minus infinity for underflow ($FF800000_H$) and plus infinity for overflow ($7F800000_H$).

NOTE

Effects of inversion

It is possible to set the "Scaled high nominal range limit" parameter lower than the "Scaled low nominal range limit" parameter, whereby the representation of the measuring range will be inverted compared to the terminal value (V, mA).

Overflow/underflow and hardware interrupts are always based on representation in REAL. A terminal value of > 11.76 V triggered an underflow for an inverted measured value scaling. Hardware interrupts react similarly.

NOTE

When the Parameter "Scaled high nominal range limit" and "Scaled low nominal range limit" parameters are too close together, resolution may be lost, which means it may no longer be possible to show every value.

The measured value scaling can be combined with the measuring range adjustment. In this case, the measuring range is adjusted first and then the representation of the measuring range is scaled.

Example

The following values result, for example:

Table 2-562 Example of measured value scaling

	Low nominal range limit	High nominal range limit
Base measuring range	-10 V	+10 V
S7 format	-27648	+27648
Scaling of measured values	1.00	7.00

As shown in the table, -10 V corresponds to 1.00 and +10 V corresponds to 7.00.

Combination with measuring range adjustment

If the measuring range adjustment is enabled in addition to measured value scaling, first the measuring range is scaled and then the representation of the measuring range. The table below shows an example of the combination of measured value scaling and measuring range adjustment.

Table 2-563 Example for a combination of measured value scaling and measuring range adjustment

	Low nominal range limit	High nominal range limit
Measuring range adjustment	-4000 mV	8000 mV
S7 format	-27648	+27648
Scaling of measured values	1.00	7.00

As shown in the table, -4 V corresponds to 1.00 and +8 V corresponds to 7.00.

Configuration

The following figures show examples of a configuration in STEP 7:

Configuration of measured value scaling

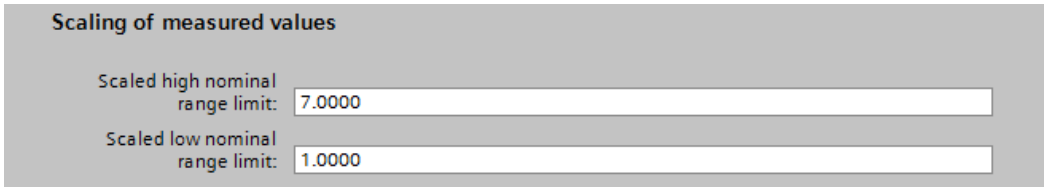

Figure 2-560 Configuration of measured value scaling

Configuration with measuring range adjustment and measured value scaling

In the configuration example, a measuring range adjustment of -4000 mV to 8000 mV is displayed and additionally converted to a scaled high and low nominal range limit of 1.00 to 7.00.

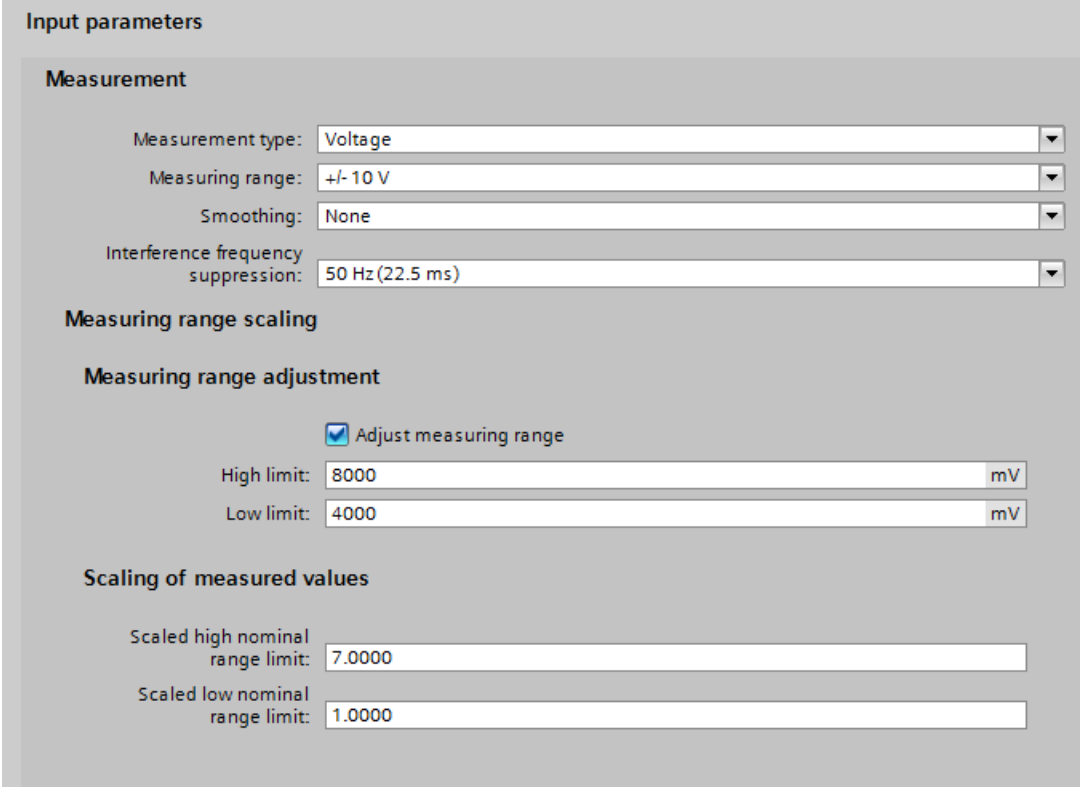

Figure 2-561 Configuration with measuring range adjustment and measured value scaling

5.6 Address space

The module can be configured differently; see following table. Depending on the configuration, additional/different addresses are assigned in the process image of the inputs.

Configuration options of AI 2xU/I 2-/4-wire HF

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-564 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Availability in hardware catalog STEP 7 (TIA Portal)	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 2-channel without value status	AI 2xU/I 2-, 4-wire HF V1.0	Integrated as of STEP7 V13	X	X
1 x 2-channel with value status	AI 2xU/I 2-, 4-wire HF V1.0, QI	Integrated as of STEP7 V13	X	---
1 x 2-channel without value status	AI 2xU/I 2-, 4-wire HF V2.0	• HSP161 STEP7 V13 SP1 • Integrated as of STEP7 V14	X	X
1 x 2-channel with value status	AI 2xU/I 2-, 4-wire HF V2.0, QI	• HSP161 STEP7 V13 SP1 • Integrated as of STEP7 V14	X	---
1 x 2-channel with value status for module-internal Shared Input with up to 4 submodules	AI 2xU/I 2-, 4-wire HF V2.0, MSI	• HSP161 STEP7 V13 SP1 • Integrated as of STEP7 V14	X	---
1 x 2-channel with value status and measured value scaling	AI 2xU/I 2-, 4-wire HF V2.0, SCALE	• HSP161 STEP7 V13 SP1 • Integrated as of STEP7 V14	X	---

Value status (Quality Information, QI)

The value status is always activated for the following module names:

- AI 2xU/I 2-, 4-wire HF, QI,
- AI 2xU/I 2-, 4-wire HF, MSI
- AI 2xU/I 2-, 4-wire HF, SCALE

An additional bit is assigned to each channel for the value status. The value status bit indicates whether the read in analog value is valid. (0 = value is incorrect).

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 and 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: No fault is present on the channel.

Bit = 0: The channel is disabled or the wiring or the value created on the channel, etc. is incorrect.

Address space for configuration as 1 x 2-channel AI 2×U/I 2-/4-wire HF

The figure below shows the assignment of the address space for AI 2xU/I 2-/4-wire HF.

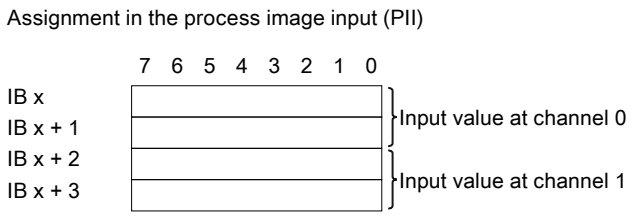

Figure 2-562 Address space of the analog input module AI 2xU/I 2-/4-wire HF

Address space for configuration as 1 x 2-channel AI 2×U/I 2-/4-wire HF, QI

The figure below shows the assignment of the address space for AI 2xU/I 2-/4-wire HF.

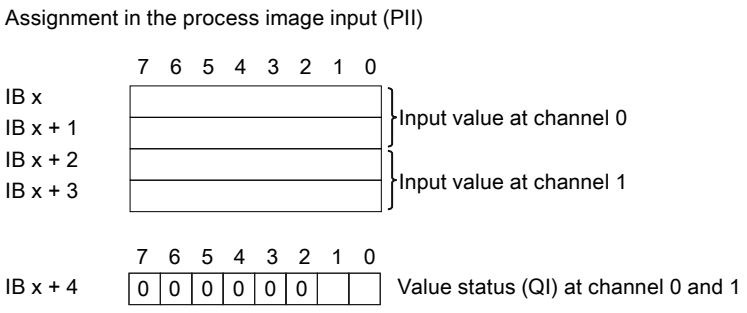

Figure 2-563 Address space of the analog input module AI 2xU/I 2-/4-wire HF, QI

Address space for configuration as 1 x 2-channel AI 2×U/I 2-/4-wire HF MSI

For the configuration as a 1 x 2-channel module (module-internal shared input, MSI), channels 0 and 1 of module are copied to up to four submodules. Channels 0 and 1 are then available with identical input values in various submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of usable submodules is dependent on the interface module used. Please observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect.

For the 2nd to 4th submodule (=MSI submodule), the value status 0 indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

The following figure shows the assignment of the address space with submodules 1 and 2.

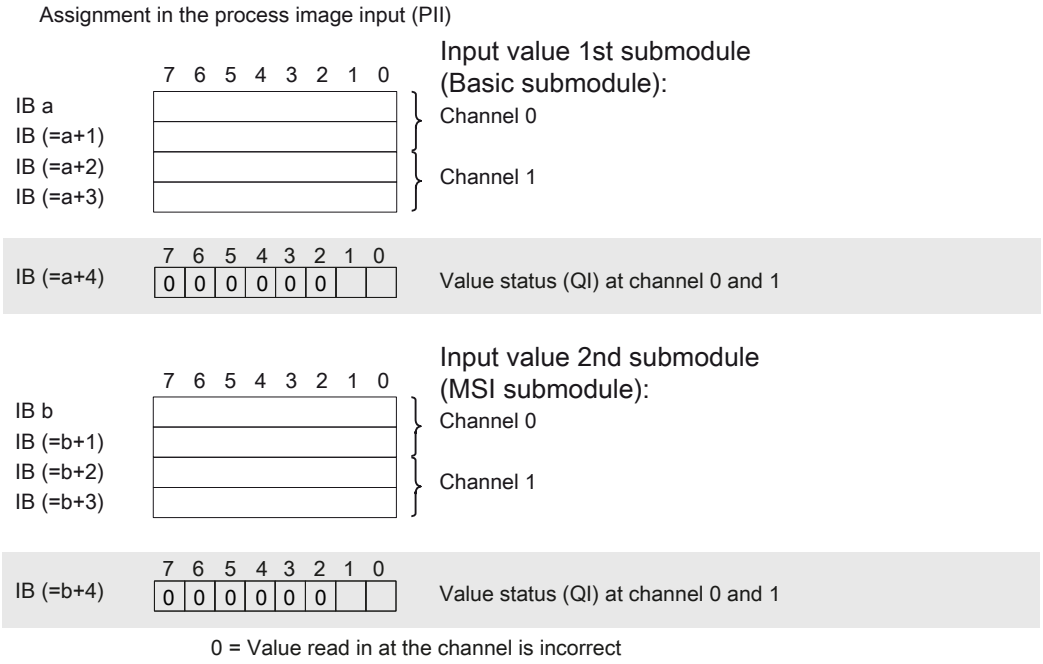

Figure 2-564 Address space for configuration as 1x 2-channel AI 2×U/I 2-/4-wire HF MSI

The figure below shows the assignment of the address space with submodules 3 and 4.

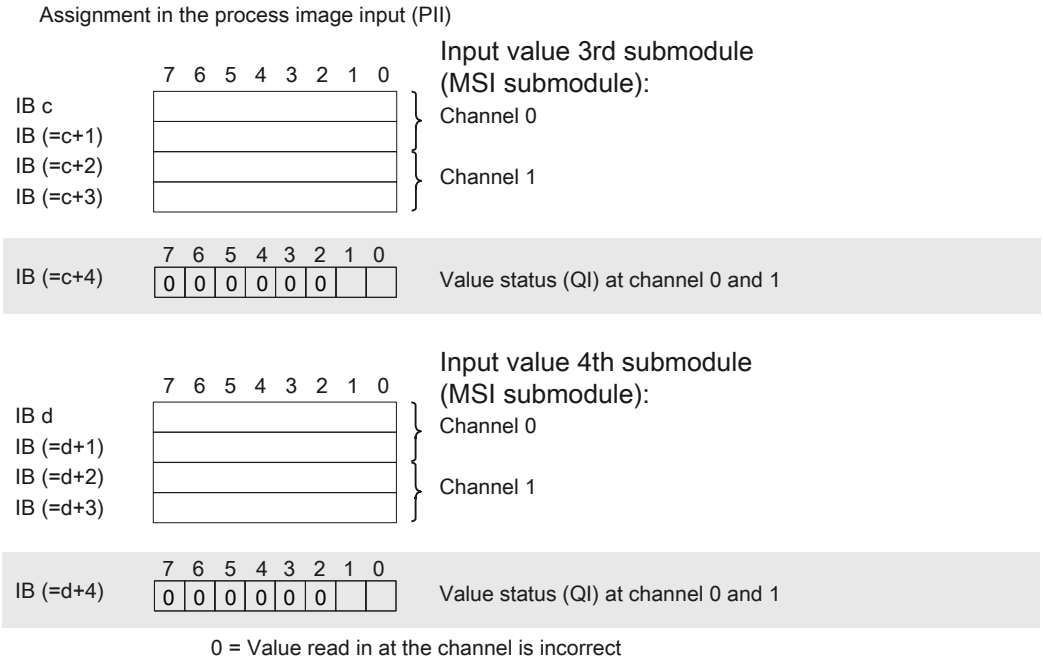

Figure 2-565 Address space for configuration as 1x 2-channel AI 2×U/I 2-/4-wire HF MSI

Address space for configuration as 1 x 2-channel AI 2×U/I 2-/4-wire HF SCALE

The figure below shows the assignment of the address space for AI 2xU/I 2-/4-wire HF, SCALE.

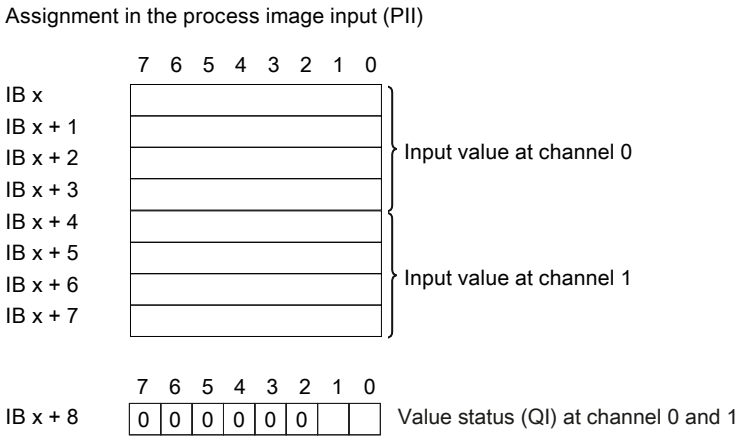

Figure 2-566 Address space for configuration as 1 x 2-channel AI 2×U/I 2-/4-wire HF, SCALE

Interrupts/diagnostics alarms

6

6.1 Status and error displays

LED displays

The following figure shows you the LED display of the AI 2xU/I 2-/4-wire HF.

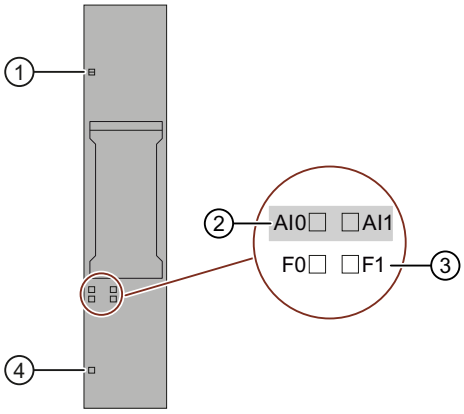

① DIAG (green/red)

② Channel status (green)

③ Channel error (red)

④ PWR (green)

Figure 2-567 LED display

Meaning of the LED displays

The following tables contain the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostics alarms (Page 37).

Table 2-565 Error display DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the system is interrupted or switched off.
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Table 2-566 Status and error display LED channel status / channel error

LEDs		Meaning
Channel status	Channel error	
□ Off	□ Off	Channel deactivated or no load voltage L+
■ On	□ Off	Channel activated and no channel diagnostics
□ Off	■ On	Channel activated and channel diagnostics
■ On	■ On	Not permitted (error)

Table 2-567 PWR LED status display

PWR LED	Meaning
□ Off	Missing supply voltage L+
■ On	Supply voltage L+ present

6.2 Interrupts

The I/O module supports diagnostic and hardware interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit (current: sensor supply; voltage: 1 to 5 V, encoder supply)
- Wire break (current: 4 to 20 mA)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- Hardware interrupt lost
- Supply voltage missing
- Channel temporarily unavailable

Hardware interrupts

The module generates a hardware interrupt at the following events:

- Violation of low limit 1
- Violation of high limit 1
- Violation of low limit 2
- Violation of high limit 2

S7-1500

Detailed information on the event is available in the STEP 7 online help.

The block interface is represented here with optimized block access, which is set in the TIA Portal by default.

Name	Data type	Comment
LADDR	HW_IO	Hardware identifier of the module triggering the interrupt
USI	WORD	USI (High/Low)
IChannel	USInt	Channel that triggered the hardware interrupt
EventType	Byte	Error event

S7-300/400 or a different CPU

You can obtain detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

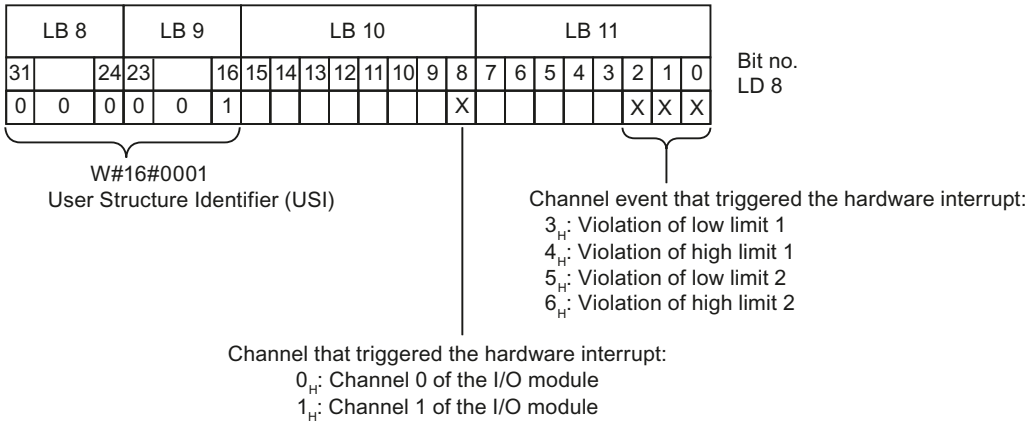

Figure 2-568 OB start information

Structure of the additional interrupt information

Table 2-568 Structure of the additional interrupt information

Data block name		Content	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	Additional interrupt information for hardware interrupts of the I/O module	2
Channel that triggered the hardware interrupt.				
	Channel	B#16#00 to B#16#01	Channel 0 and 1 of the I/O module	1
Event that triggered the hardware interrupt.				
	Error event	B#16#03	Violation of low limit 1	1
		B#16#04	Violation of high limit 1	
		B#16#05	Violation of low limit 2	
		B#16#06	Violation of high limit 2	

6.3 Diagnostics alarms

A diagnostic message is generated and the DIAG-LED flashes red on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-569 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit (encoder supply)	1_H	Short-circuit encoder supply to ground	Correct interplay between module and encoder
Short-circuit (1 to 5 V)	1_H	Short-circuit of input signal	Correct interplay between module and encoder
		Open input	Connect input
Wire break (current 4 to 20 mA)	6_H	Impedance of encoder circuit too high	Use a different encoder type or modify the wiring, e.g. use cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect the encoder contacts
High limit violated	7_H	Value is above the overrange	Correct interplay between module and encoder
Low limit violated	8_H	Value is below the underrange	Correct interplay between module and encoder
Error	9_H	Internal module fault has occurred (diagnostic message applies to the entire module)	Replace module
Parameter assignment error	10_H	The module cannot evaluate parameters for the channel Incorrect parameter assignment	• Correct the parameter assignment

Diagnostics alarm	Error code	Meaning	Solution
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check the supply voltage L+ on the BaseUnit • Check BaseUnit type
Hardware interrupt lost	16_H	Error is reported when a hardware interrupt (high/low limit) could not be reported.	• Limits might be assigned twice • If necessary, reduce the bus cycle • If necessary, use higher SFU
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not read in process values in this state.	• Wait for firmware update • Restart the firmware update
		The channel is currently being calibrated.	Complete calibration

Diagnostic messages in the measured value of analog input modules

Each analog input module supplies the measured value $7FFF_H$ or 8000_H depending on the parameter assignment when an error is detected (with configuration SCALE: $7F800000_H$ or $FF800000_H$).

Technical specifications 7

Technical specifications of the AI 2×U/I 2-/4-wire HF

The following table shows the technical specifications as of 03/2021. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7134-6HB00-0CA1/td?dl=en).

Article number	6ES7134-6HB00-0CA1
General information	
Product type designation	AI 2xU/I 2-/4-wire HF
HW functional status	From FS06
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC03
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes
• Measuring range scalable	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V13
• STEP 7 configurable/integrated from version	V5.5 / -
• PCS 7 configurable/integrated from version	V8.1 SP1
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.3
Operating mode	
• Oversampling	No
• MSI	Yes
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes

Article number	6ES7134-6HB00-0CA1
Input current	
Current consumption (rated value)	39 mA; without sensor supply
24 V encoder supply	
• 24 V	Yes
• Short-circuit protection	Yes
• Output current, max.	20 mA; max. 50 mA per channel for a duration < 10 s (two-wire)
Additional 24 V encoder supply	
• Short-circuit protection	Yes; channel by channel
• Output current, max.	100 mA; max. 150 mA for a duration of < 10 s (four-wire)
Power loss	
Power loss, typ.	0.95 W; without sensor supply
Address area	
Address space per module	
• Address space per module, max.	4 byte; + 4 byte for scaling of measured values, + 1 byte for QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type A0, A1
• 4-wire connection	BU type A0, A1
Analog inputs	
Number of analog inputs	2; Differential inputs
• For current measurement	2
• For voltage measurement	2
permissible input voltage for voltage input (destruction limit), max.	30 V
permissible input current for current input (destruction limit), max.	50 mA
Analog input with oversampling	No
Standardization of measured values	Yes
Input ranges (rated values), voltages	
• 0 to +10 V	Yes; 15 bit
– Input resistance (0 to 10 V)	75 kΩ
• 1 V to 5 V	Yes; 15 bit
– Input resistance (1 V to 5 V)	75 kΩ
• -10 V to +10 V	Yes; 16 bit incl. sign
– Input resistance (-10 V to +10 V)	75 kΩ

Article number	6ES7134-6HB00-0CA1
• -5 V to +5 V	Yes; 16 bit incl. sign
– Input resistance (-5 V to +5 V)	75 kΩ
Input ranges (rated values), currents	
• 0 to 20 mA	Yes; 15 bit
– Input resistance (0 to 20 mA)	130 Ω
• -20 mA to +20 mA	Yes; 16 bit incl. sign
– Input resistance (-20 mA to +20 mA)	130 Ω
• 4 mA to 20 mA	Yes; 15 bit
– Input resistance (4 mA to 20 mA)	130 Ω
Cable length	
• shielded, max.	1 000 m; 200 m for voltage measurement
Analog value generation for the inputs	
Measurement principle	Sigma Delta
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Integration time (ms)	67.5 / 22.5 / 18.75 / 10 / 5 / 2.5 / 1.25 / 0.625 ms
• Basic conversion time, including integration time (ms)	68.03 / 22.83 / 19.03 / 10.28 / 5.23 / 2.68 / 1.43 / 0.730 ms
• Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 / 300 / 600 / 1 200 / 2 400 / 4 800
• Conversion time (per channel)	68.2 / 23 / 19.2 / 10.45 / 5.40 / 2.85 / 1.6 / 0.9 ms
• Basic execution time of the module (all channels released)	1 ms
Smoothing of measured values	
• Number of smoothing levels	6; none; 2-/4-/8-/16-/32-fold
• parameterizable	Yes
Encoder	
Connection of signal encoders	
• for voltage measurement	Yes
• for current measurement as 2-wire transducer	Yes
– Burden of 2-wire transmitter, max.	650 Ω
• for current measurement as 4-wire transducer	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %
Temperature error (relative to input range), (+/-)	0.003 %/K
Crosstalk between the inputs, min.	-50 dB

Article number	6ES7134-6HB00-0CA1
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.01 %
Operational error limit in overall temperature range	
• Voltage, relative to input range, (+/-)	0.1 %
• Current, relative to input range, (+/-)	0.1 %
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to input range, (+/-)	0.05 %; 0.1 % at SFU 4.8 kHz
• Current, relative to input range, (+/-)	0.05 %; 0.1 % at SFU 4.8 kHz
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Common mode voltage, max.	35 V
• Common mode interference, min.	90 dB
Isochronous mode	
Filtering and processing time (TCI), min.	800 µs
Bus cycle time (TDP), min.	1 ms
Jitter, max.	5 µs
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes; two upper and two lower limit values in each case
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; Measuring range 4 to 20 mA only
• Short-circuit	Yes; channel-by-channel, at 1 to 5 V or for short-circuit in encoder supply
• Group error	Yes
• Overflow/underflow	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	Yes
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes

Article number	6ES7134-6HB00-0CA1
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; < 0 °C as of FS06
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; < 0 °C as of FS06
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	32 g

Dimension drawing

See manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

NOTE

For configuration with STEP 7 V13 or higher (TIA Portal), real values between $-7x10^{28}$ and $+7x10^{28}$ can be input. This is true for configuration via HSP and via GSD file (PROFINET).

For configuration with STEP 7 V5.5 SP4 as of HF7, configuration by means of GSD file (PROFINET) with REAL values of $-1.175x10^{38}$ to $+3.402x10^{38}$ is possible.

With STEP 7 SP4 to HF6, parameter assignment of REAL values is not possible. Functions that require REAL values are not available in this case.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Measurement type	**Measuring range**	**Diagnostics**					**Hardware interrupts**
		Underflow	**Overflow**	**Wire break**	**Short-circuit to ground**	**Missing supply voltage L+**	
Deactivated	*	*	*	*	*	*	*
Voltage	±5 V	x	x	–	x [1]	x	x
	±10 V	x	x	–	x [1]	x	x
	1 V to 5 V	x	x	–	x	x	x
	0 V to 10 V	x	x	–	x [1]	x	x
Current (4-wire transducer)	0 mA to 20 mA	x	x	–	x	x	x
	4 mA to 20 mA	x	x	x	x	x	x
	±20 mA	x	x	-	x	x	x
Current (2-wire transducer)	0 mA to 20 mA	x [1] [2]	x	–	x	x	x
	4 mA to 20 mA	x	x	x	x	x	x

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 only possible as of firmware V2.0

2 The diagnostics Underflow can always be enabled for "Current (2-wire transducer) 0..20 mA", but it is only reported when a complete underflow range is created by the measuring range adjustment.

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Table 2-570 Dependencies of the measurement type and measuring range PB

Measurement type	Measuring range	Diagnostics						Hardware interrupts
		Underflow	Overflow	Wire break	Load voltage L+	Short-circuit to ground	Smoothing / interference frequency suppression	
Deactivated	*	*	*	*	*	*	*	*
Voltage	±5 V	x	x	–	x	x [1]	x	–
	±10 V	x	x	–	x	x [1]	x	–
	1 V to 5 V	x	x	–	x	x	x	–
	0 V to 10 V	x	x	–	x	x [1]	x	–
Current (4-wire transducer)	0 mA to 20 mA	x	x	–	x	x	x	–
	4 mA to 20 mA	x	x	x	x	x	x	–
	±20 mA	x	x	-	x	x	x	–
Current (2-wire transducer)	0 mA to 20 mA	–	x	–	x	x	x	–
	4 mA to 20 mA	x	x	x	x	x	x	–

x = property is allowed, – = property is **not allowed**, * = property is not relevant

[1] only possible as of firmware V2.0

A.2 Parameter assignment and structure of parameter data record

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

You can reassign the module parameters in RUN. For example, the measuring range of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set via the configuration do not change in the CPU, which means the parameters set in the CPU are still valid after a restart.

NOTE

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment results in a brief exit from clocked measuring mode and renewed synchronization with the fieldbus cycle. The slowest channel provides the "internal" measuring cycle.

NOTE

Changing parameter settings in runtime can cause the process values to freeze for the duration of the parameter assignment for the module.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. However, the STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

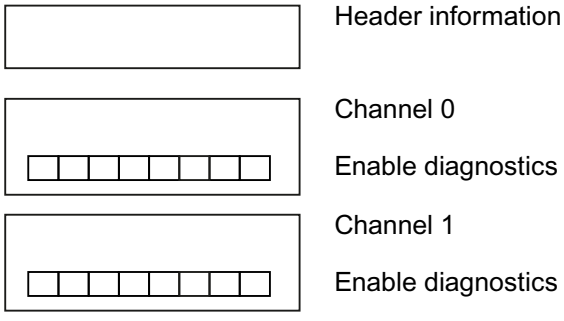

Figure 2-569 Structure of data record 128

Header information (V1.0)

The figure below shows the structure of the header information (V1.0).

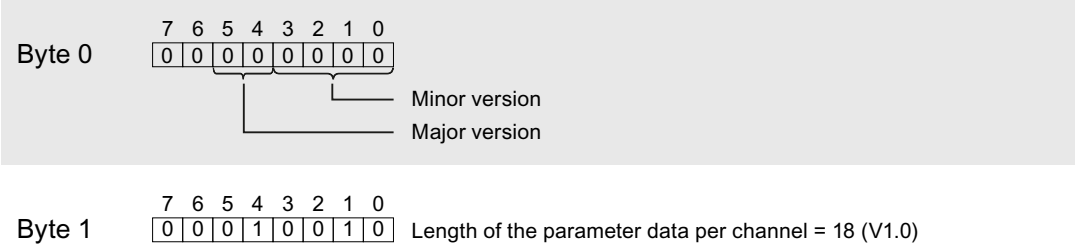

Figure 2-570 Header information (V1.0)

Header information (V2.0)

The figure below shows the structure of the header information (V2.0).

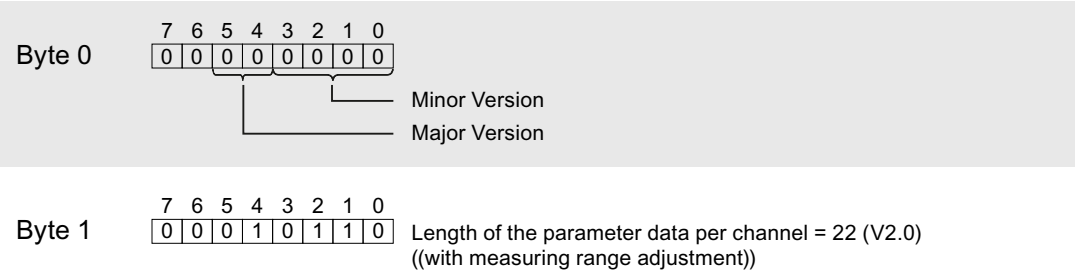

Figure 2-571 Header information (V2.0)

Header information (V2.0 SCALE)

The figure below shows the structure of the header information.

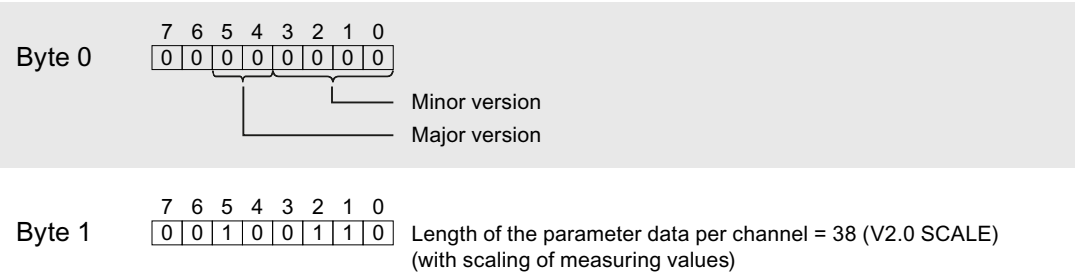

Figure 2-572 Header information (V2.0 SCALE)

Parameter (V1.0)

The following figure shows the structure of the parameters for channels 0 and 1.

You enable a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number x 18); channel number is 0 or 1

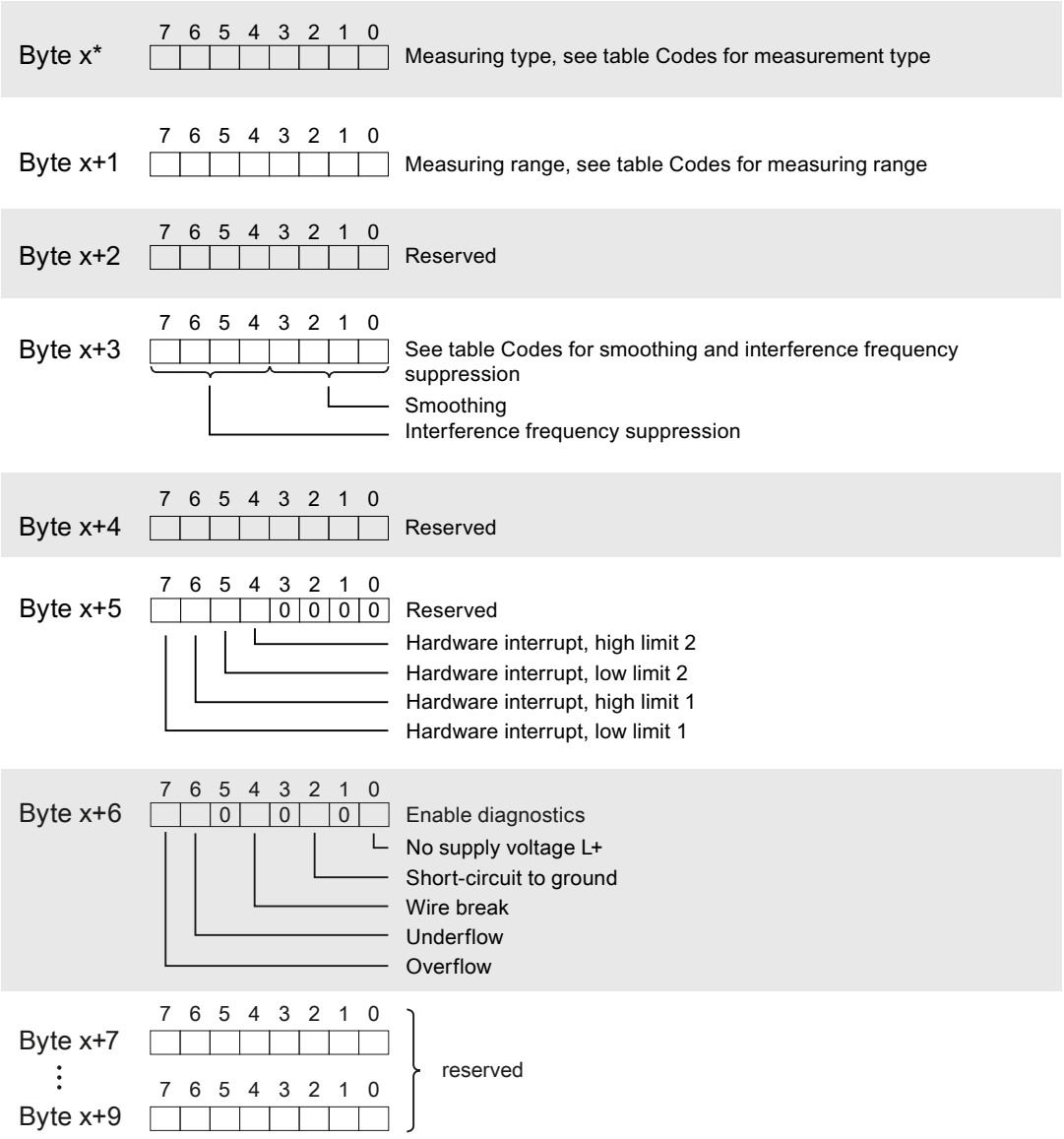

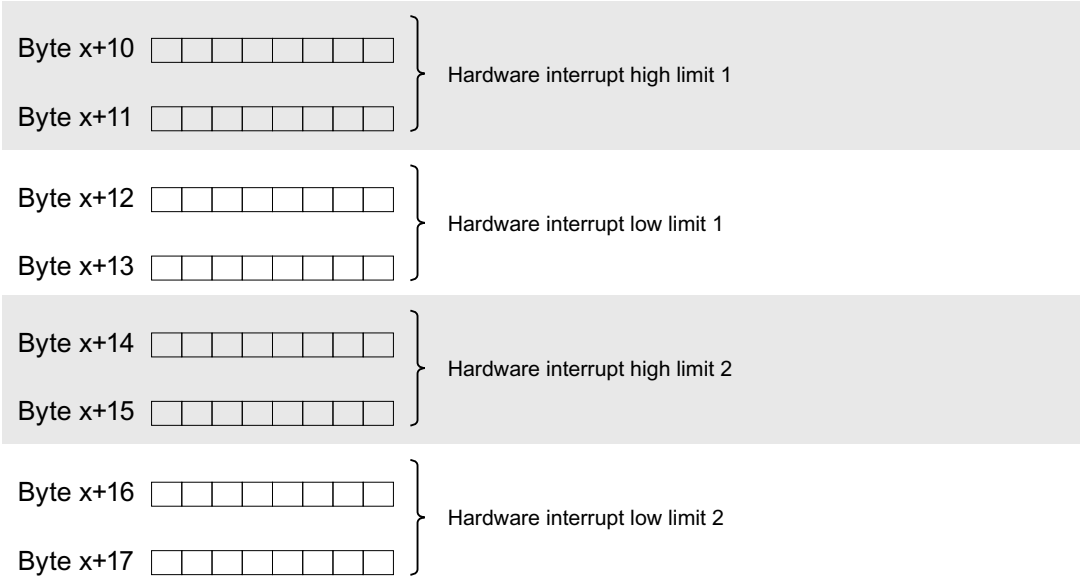

Figure 2-573 Structure of byte x to x+17 for channel 0 and 1

Parameter (V2.0)

The following figure shows the structure of the parameters for channels 0 and 1.

You enable a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number x 22); channel number is 0 or 1

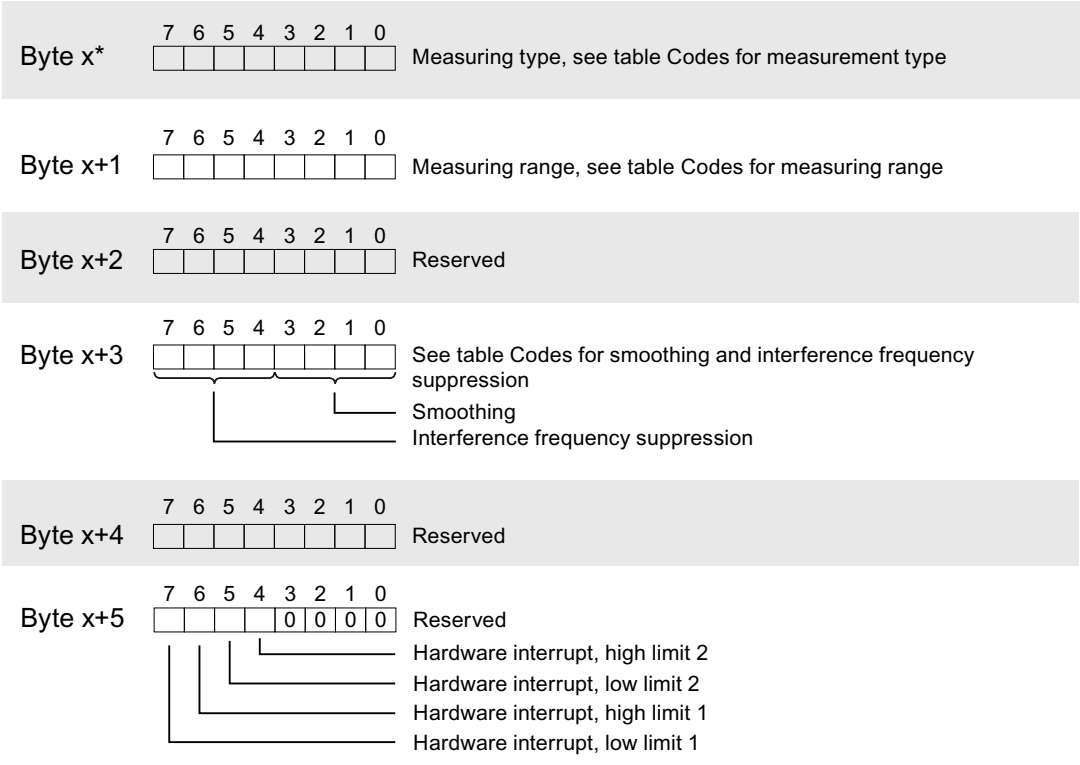

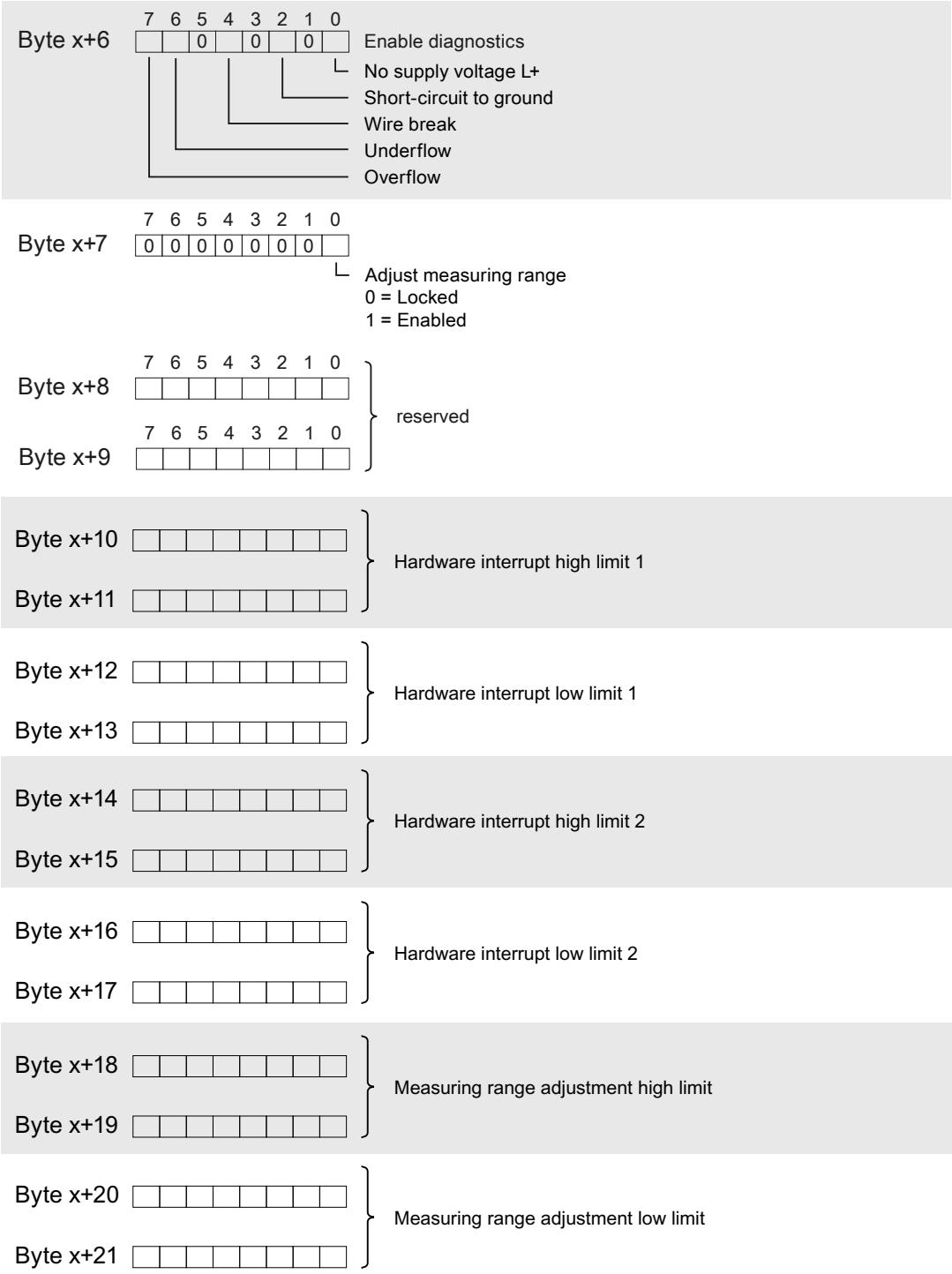

Figure 2-574 Structure of bytes x to x+21 for channels 0 and 1

Parameter (V2.0 SCALE)

The following figure shows the structure of the parameters for channels 0 and 1.

You enable a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number x 38); channel number is 0 or 1

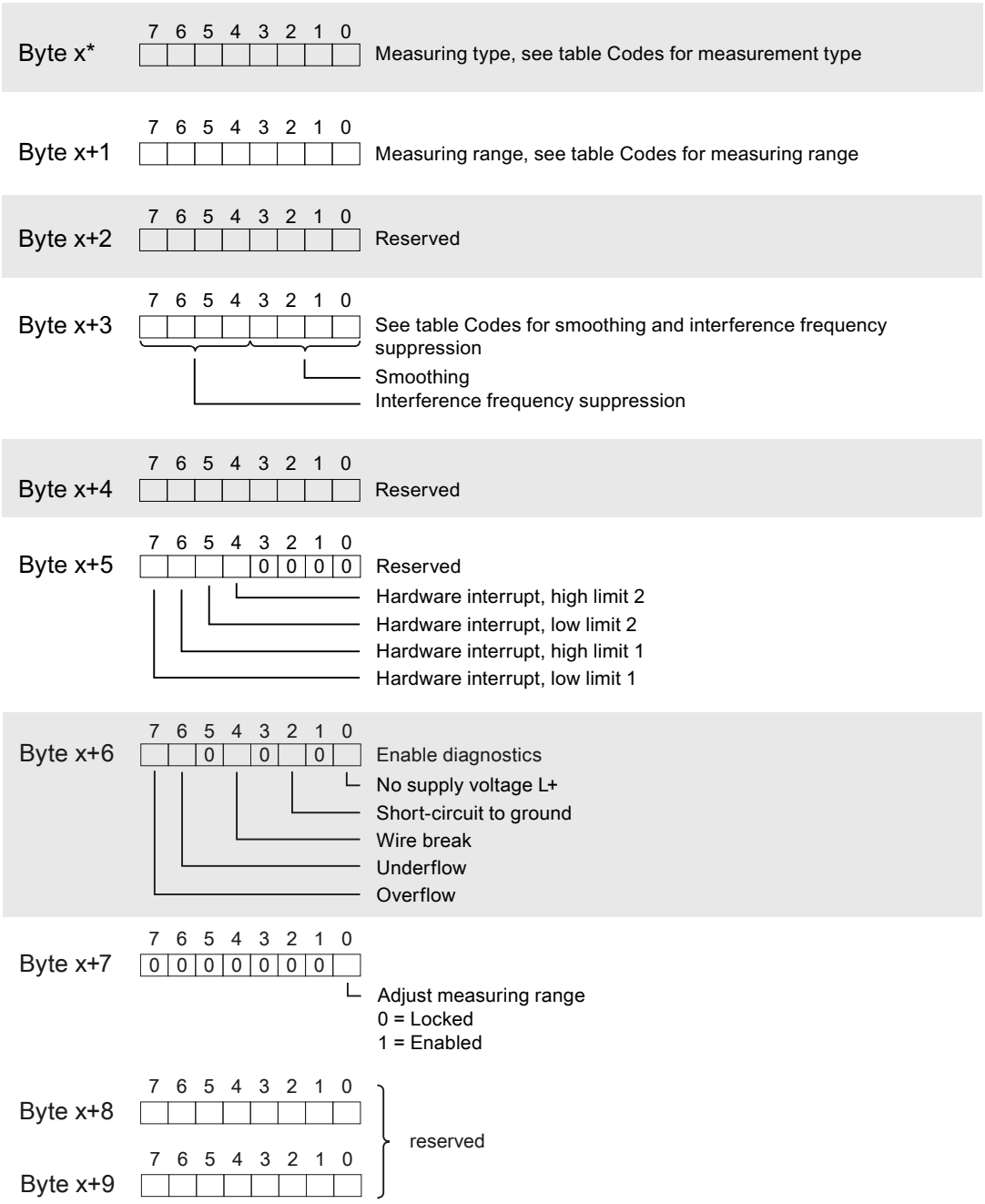

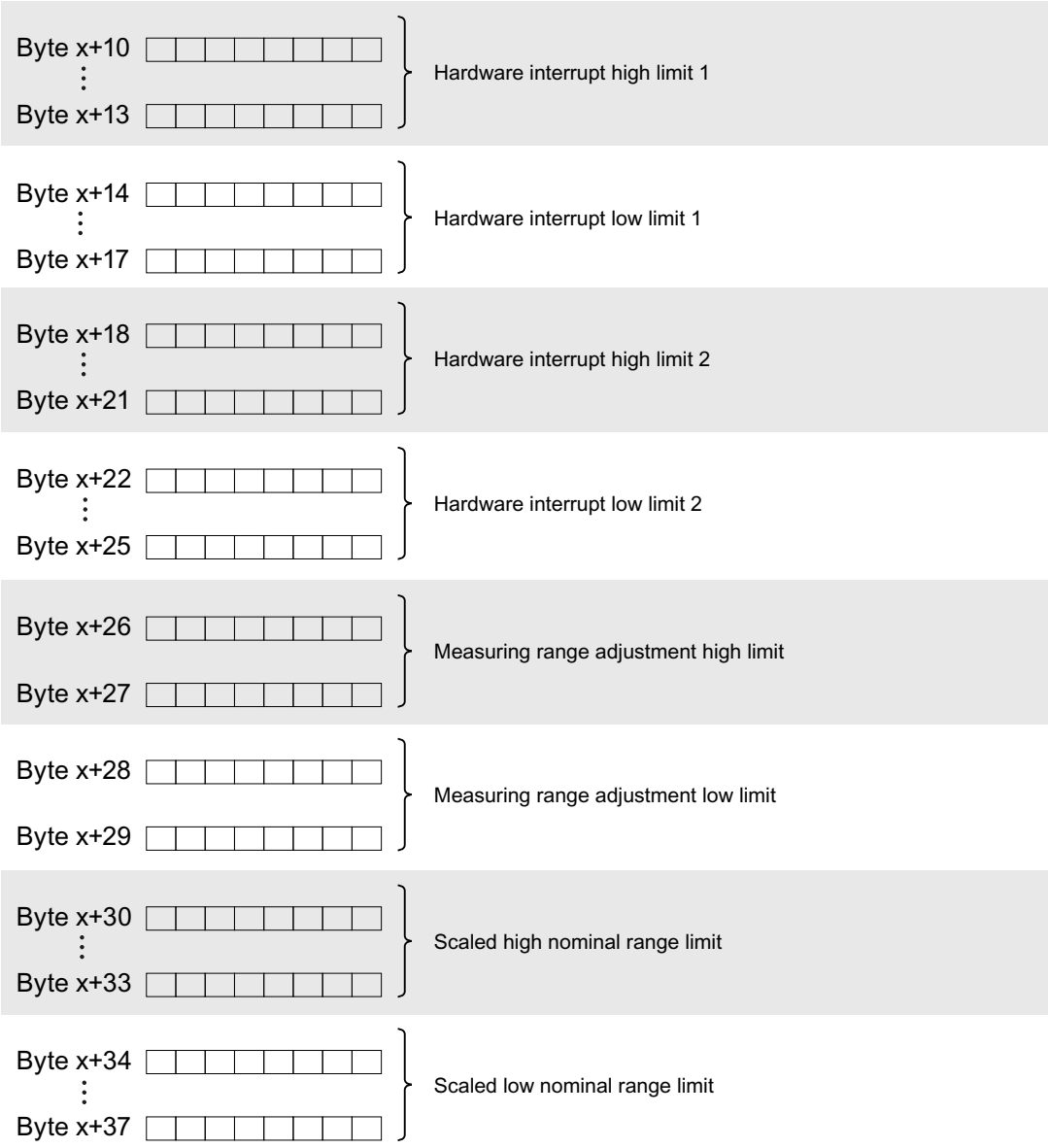

Figure 2-575 Structure of bytes x to x+37 for channels 0 and 1

Codes for measurement types

The following table contains all the measurement types of the analog input module with its codes. You must enter these codes at byte x (see previous figure).

Table 2-571 Codes for measurement types

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001
Current, 4-wire transducer	0000 0010
Current, 2-wire transducer	0000 0011

Codes for measuring ranges

The following table contains all codes for the measuring ranges of the analog input module. You must enter these codes at byte x+1 (see previous figure).

Table 2-572 Codes for measuring ranges

Measuring range	Code
Voltage	
±5 V	0000 1000
±10 V	0000 1001
1 to 5 V	0000 1010
0 to 10 V	0000 1011
Current	
0 mA to 20 mA	0000 0010
4 mA to 20 mA	0000 0011
±20 mA	0000 0100

Codes for smoothing and interference frequency suppression

The following table contains all coding for smoothing and interference frequency suppression. You must enter these codes at byte x (see previous figure).

Table 2-573 Codes for smoothing

Smoothing	Code
None	0000
2 times	0100
4 times	0001
8 times	0101
16 times	0010
32 times	0011

Table 2-574 Codes for interference frequency suppression

Interference frequency suppression	Code
16.6 Hz (67.5 ms)	0100
50 Hz (22.5 ms)	0010
60 Hz (18.75 ms)	0001
300 Hz (10 ms)	0101
600 Hz (5 ms)	0110
1.2 kHz (2.5 ms)	0111
2.4 kHz (1.25 ms)	1000
4.8 kHz (0.625 ms)	1001

Error transmitting the data record

The module always checks all values of the transmitted data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error codes if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station whether the module is plugged in correctly. • Check assigned values for the parameters of the WREC instruction.
DF	80	I0	xx	Incorrect version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	I1	xx	Parameter error	Check the parameters of the module.

Representation of analog values

B

This section shows the analog values for all measuring ranges supported by the analog input module AI 2xU/I 2-/4wire HF.

Measured value resolution

The digitized analog value is the same for input and output values at the same nominal range. The analog values are represented as a fixed point number in the two's complement.

The resolutions 15 and 16 bits including sign are displayed. Each analog value is entered in the ACCU left-justified. The bits marked with "x" are set to "0".

Table 2-575 Resolution of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

The tables below set out the digitized representation of the input ranges by bipolar and unipolar input ranges. The resolution is 16 bits.

Table 2-576 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	> 117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	< -117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 2-577 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	> 117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	< -17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table 2-578 Voltage measuring range ±10 V and ±5 V

Values		Voltage measuring range		Range
Dec.	**Hex.**	**±10 V**	**±5 V**	
32767	7FFF	> 11.759 V	> 5.879 V	Overflow
32511	7EFF	11.759 V	5.879 V	Overrange
27649	6C01			
27648	6C00	10 V	5 V	Nominal range
20736	5100	7.5 V	3.75 V	
1	1	361.7 µV	180.8 µV	
0	0	0 V	0 V	
-1	FFFF			
-20736	AF00	-7.5 V	-3.75 V	
-27648	9400	-10 V	-5 V	
-27649	93FF			Underrange
-32512	8100	-11.759 V	-5.879 V	
-32768	8000	< -11.759 V	< -5.879 V	Underflow

Table 2-579 Voltage measuring range 1 V to 5 V and 0 V to 10 V

Values		Voltage measuring range		Range
Dec.	**Hex.**	**1 to 5 V**	**0 to 10 V**	
32767	7FFF	> 5.704 V	> 11.759 V	Overflow
32511	7EFF	5.704 V	11.759 V	Overrange

Values		Voltage measuring range		Range
27649	6C01			Overrange
27648	6C00	5 V	10 V	Nominal range
20736	5100	4 V	7.5 V	
1	1	1 V + 144.7 µV	361.7 µV	
0	0	1 V	0 V	
-1	FFFF			Underrange
-4864	ED00	0.296 V	-1.759 V	
-32768	8000	< 0.296 V	< -1.759 V	Underflow

B.3 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table 2-580 Current measuring range ±20 mA

Values		Current measuring range	Range
Dec.	**Hex.**	**±20 mA**	
32767	7FFF	> 23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	< -23.52 mA	Underflow

Table 2-581 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		Range
Dec.	**Hex.**	**0 to 20 mA***	**4 to 20 mA**	
32767	7FFF	> 23.52 mA	> 22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range

* For measurement type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

Values		Current measuring range		Range
20736	5100	15 mA	16 mA	Nominal range
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	< -3.52 mA	< 1.185 mA	Underflow

* For measurement type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

B.4 Measured values for wire break

The following table contains the measured values at a wire break depending on enabled diagnostics.

Table 2-582 Measured values at a wire break depending on enabled diagnostics

Programmable diagnostics		Measured value		Explanation
Wire break	Underflow			
Enable	Enable	32767	$7FFF_H$	The "wire break" diagnostics is reported, because this has a higher priority.
Disable	Enable	-32768	8000_H	The "Lower limit violated" diagnostics is reported.
Disable	Disable	-32768	8000_H	No diagnostics reported.

SIEMENS

SIMATIC

ET 200SP
SIMATIC ET 200SP analog input module AI 2xSG 4-/6-wire HS

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Introduction 1

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: The term "CPU" as used in this manual refers to both the central modules of the S7-1500 automation system and to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: We use "STEP 7" as synonym for all versions of "STEP 7 (TIA Portal)" to refer to the configuration and programming software in this documentation.

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

⚠ CAUTION

To prevent injury and damage, read the manual before using the device.

Document history

The overview below summarizes the most important changes in the documentation compared with previous editions.

The table below summarizes the most important changes in the documentation compared with previous editions.

Manual edition	Comments
01/2026	Safety instructions for UL have been revised
10/2022	Section Certificates and approvals (Page 48) revised
05/2020	Min./max. peak value memory (Page 33) added

See also

Mounting (Page 17)

Product compatibility

The following table describes compatibility between manual edition, device revision, engineering system and the engineering system.

Manual edition	Comments	Device revision	Engineering system
10/2022	-	FW: 1.0.1 or higher	STEP 7 TIA Portal V14 SP1 or higher STEP 7 V5.6 or higher
05/2020	-	FW: 1.0.0 or higher	STEP 7 TIA Portal V14 SP1 or higher STEP 7 V5.6 or higher

Safety instructions 2

2.1 Basic safety notes

2.1.1 Safety notices for installation

Safety instructions

When mounting the device, observe the safety instructions listed below.

⚠ WARNING

If a device is operated in an ambient temperature of more than 50 °C, the temperature of the device housing may be higher than 70 °C. The device must therefore be installed so that it is only accessible to service personnel or users that are aware of the reason for restricted access and the required safety measures at an ambient temperature higher than 50 °C.

⚠ WARNING

Impermissible repair of the device

- Repair must be carried out by Siemens authorized personnel only.

2.2 Use in hazardous areas

2.2.1 Use in hazardous area

⚠ WARNING

Use in hazardous area

Risk of explosion.

- Only use equipment that is approved for use in the intended hazardous area and labeled accordingly.
- Do not use devices that have been operated outside the conditions specified for hazardous areas. If you have used the device outside the conditions for hazardous areas, make all Ex markings unrecognizable on the nameplate.

2.2.2 Incorrect mounting

NOTICE

Incorrect mounting

The device can be damaged, destroyed, or its functionality impaired through improper mounting.

- Before installing ensure there is no visible damage to the device.
- Make sure that process connectors are clean, and suitable gaskets and glands are used.
- Mount the device using suitable tools. Refer to the information in Technical specifications (Page 41).

2.2.3 Connecting the device in hazardous areas

WARNING

Establishing or disconnecting devices in the energized state

Risk of explosion in hazardous areas.

- In hazardous area, device connections may only be established or disconnected in a de-energized state.
- Install a suitable shutdown device.

Exceptions:

- Devices with intrinsic safety protection type "Ex i" may also be connected while energized in hazardous areas.

WARNING

If the device is installed in a cabinet, the inner temperature of the cabinet corresponds to the ambient temperature of the device.

WARNING

EXPLOSION HAZARD

The device is designed for operation in closed housing or control cabinet. The inner service temperature of the enclosure/control cabinet corresponds to the ambient temperature of the module. Use cables with a maximum permitted operating temperature of at least 20 °C higher than the maximum ambient temperature.

WARNING

Opening the device
DO NOT OPEN WHEN ENERGIZED.

2.2.4 UL/FM Special conditions for use

This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D, Class I, Zone 2, Group IIC or non-hazardous locations only.

WARNING

Risk of explosion
Do not disconnect while circuit is live unless area is known to be non-hazardous.

WARNING

Risk of explosion
Substitution of any components may impair suitability for Class I, Division 2 or Zone 2.

Safety notices when using the device according to Hazardous Locations (HazLoc)
If you use the device under HazLoc conditions you must also keep to the following safety notices in addition to the general safety notices for protection against explosion:

WARNING

Do not remove or replace while circuit is live when a flammable or combustible atmosphere is present.

WARNING

Wall mounting outside of the control cabinet or housing does not fulfill the requirements of the FM approval.

WARNING

Wall mounting is only permitted if the requirements for the housing, the installation regulations, the clearance and separating regulations for the control cabinets or housings are adhered to. The control cabinet cover or housing must be secured so that it can only be opened with a tool. An appropriate strain-relief assembly for the cable must be used.

NOTE

You must not install the device on a wall in hazardous areas.

2.2.5 ATEX/IECx special conditions for use

⚠ WARNING

Incorrect installation

Risk of explosion in the hazardous area. When used in hazardous areas, observe the following conditions:

- Install the device in a control cabinet or enclosure.
- The control cabinet or enclosure meets at least the requirements of IP54 according to IEC/EN 60079-7 and pollution degree 2 or better according to IEC/EN 60664-1.

NOTE

You must not install the device on a wall in hazardous areas.

⚠ WARNING

Transient overvoltages

Take measures to ensure that temporary transient overvoltages of more than 119 V do not occur.

2.3 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are

available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/global/en/products/services/cert.html.

Documentation Guide

3

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

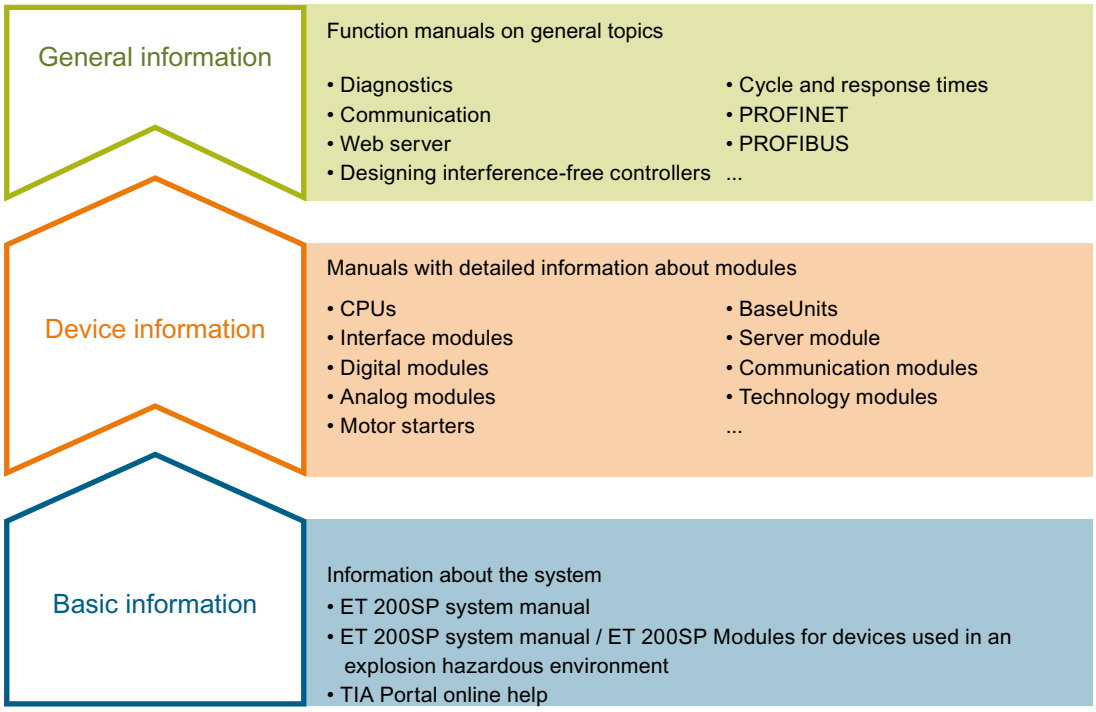

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet.

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant, incl. fail-safe inputs and outputs.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet.

See also

My Documentation Manager (http://support.industry.siemens.com/My/ww/en/documentation)

Product overview

4

View of the module

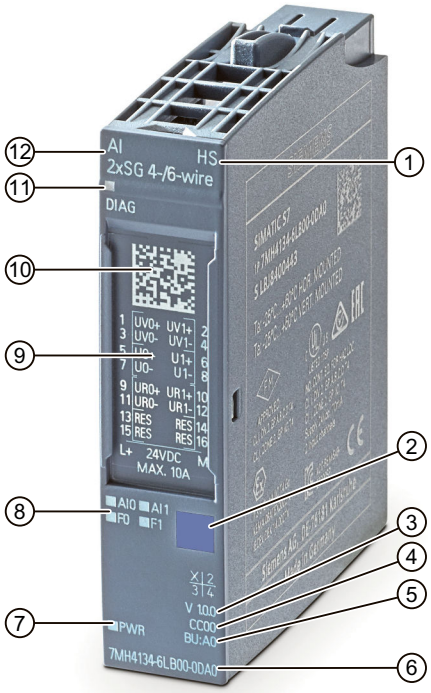

①	Function class	⑦	LED for supply voltage
②	Color labeling module type	⑧	LEDs for channel status
③	Function and firmware version	⑨	Connection diagram
④	Color code for selecting the color-coded labels	⑩	2D matrix code
⑤	BaseUnit type	⑪	LED for diagnostics
⑥	Article number	⑫	Module type and designation

Figure 2-576 View of the AI 2xSG 4-/6-wire HS module

Properties

The module has the following technical properties:

- Analog input module with 2 inputs
- Measurement type voltage of 4-wire and 6-wire strain gauges (full bridges)
  4.85 VDC supply voltage of full bridge
- Input ranges
  - ± 0.5 ... 320 mV/V, resolution 28 bits including sign
  - 16-bit oversampling including sign
- Electrically isolated from supply voltage L+
- Configurable diagnostics (per channel)
- Hardware interrupt on limit violation can be set per channel (two high and two low limits per channel)
- Min./max. peak value memory

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- PROFIenergy
- Isochronous mode
- Oversampling

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system system manual.

Mounting

5

5.1 Mounting on the SIMATIC ET 200SP

The electronic weighing system described here is a module of the SIMATIC ET 200SP series and can be directly connected to the automation system's bus system. The 15 mm wide module has very low installation and cabling requirements.

The module is snapped onto the ET 200SP base unit (BU). You must use base units of type A0 (→ Accessories (Page 50)).

The load cells, power supply and serial interfaces are connected via the terminal box.

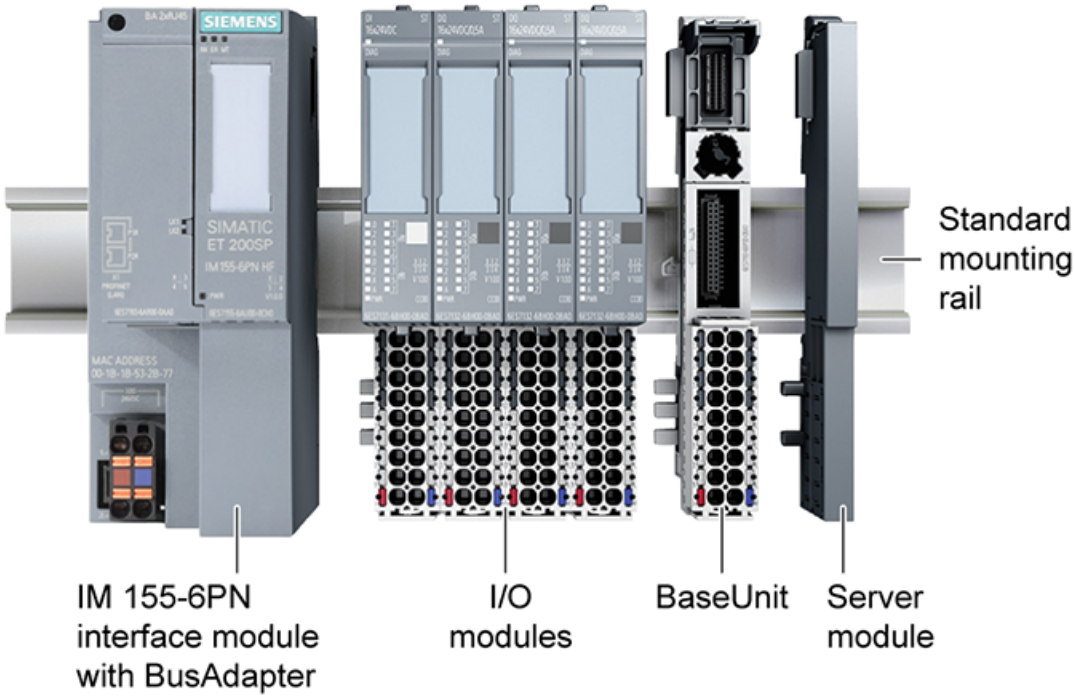

Figure 2-577 Installation of the I/O or SIWAREX modules

Connecting 6

6.1 Basic safety notes

6.1.1 ATEX/IECx special conditions for use

6.1.1.1 Connecting device in energized state in hazardous areas

⚠ WARNING

Connecting or disconnecting device in energized state

Risk of explosion in hazardous areas.

- Connect or disconnect devices in hazardous areas only in a de-energized state.
- Install a suitable switch-off device.

Exceptions:

- Devices having the type of protection "Intrinsic safety Ex i" may also be connected in energized state in hazardous areas.

⚠ WARNING

WARNING – EXPLOSION HAZARD:

DO NOT CONNECT OR DISCONNECT EQUIPMENT WHEN A FLAMMABLE OR COMBUSTIBLE ATMOSPHERE IS PRESENT.

⚠ WARNING

Transient overvoltages

Take measures to ensure that temporary transient overvoltages of more than 119 V do not occur.

6.2 Wiring and block diagram

This section includes the block diagrams of the AI 2xSG 4-/6-wire HS module with pin assignment for a 4-wire connection and for a 6-wire connection.

For more information on wiring the BaseUnit, refer to the System Manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

You may use and combine the different wiring options for all channels.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Connecting the full bridge

The figure below shows the block diagram and the 4-wire/6-wire connection of the analog input module on the BaseUnit BU type A0.

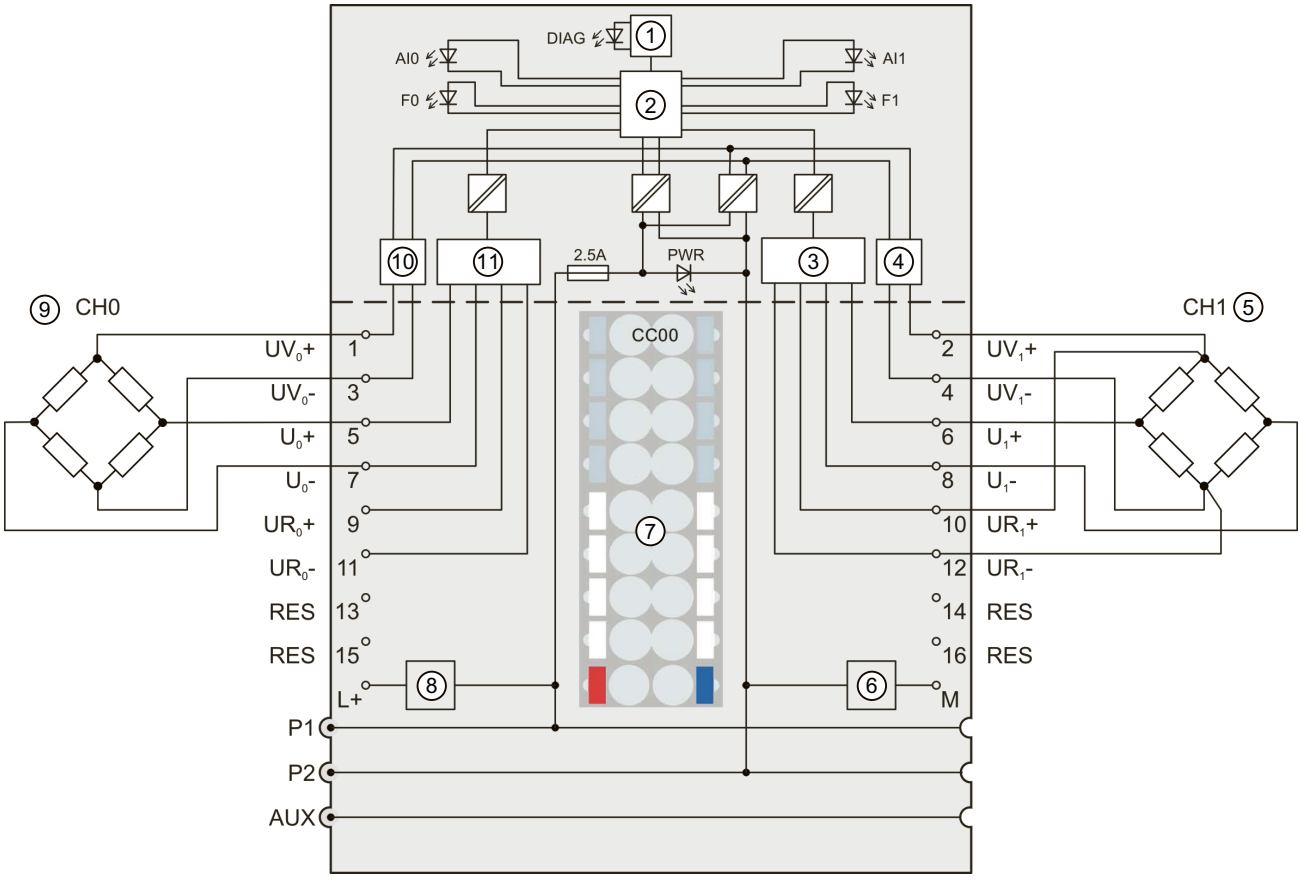

①	Backplane bus interface	⑦	Color identification label CCxx (optional)
②	MCU (microcontroller)	⑧	Filter connection supply voltage (only when light-colored BaseUnit is present)

③	Filter and Analog-to-Digital Converter (ADC)	⑨	4-wire connection DMS bridge
④	DMS bridge supply voltage	⑩	DMS bridge supply voltage
⑤	6-wire connection DMS bridge	⑪	Filter and Analog-to-Digital Converter (ADC)
⑥	Filter connection supply voltage (only when light-colored BaseUnit is present)		
U_n+	Voltage input positive, channel n	RES	Reserve must remain disconnected for future function enhancements
U_n-	Voltage input negative, channel n	M_n	Reference ground to U_{Vn}, channel n
U_{Vn}+	Positive supply voltage, channel n	L+	24 V DC (supply only with light-colored BaseUnit)
U_{Vn}-	Supply voltage ground reference, channel n	P1, P2, AUX	Internal self-establishing voltage buses Connection to the left (dark-colored BaseUnit) Connection interrupted to the left (light-colored BaseUnit)
U_{Rn}+	SENSE voltage positive, channel n	DIAG	Diagnostics LED (green, red)
U_{Rn}-	SENSE voltage ground reference, channel n	AI0, AI1	Channel status LED (green)
PWR	Power LED (green)	F0, F1	Channel fault LED (red)

Figure 2-578 Wiring and block diagrams for 4-wire connection

NOTE

Always specify the connection type used in the hardware configuration (4-wire or 6-wire) to ensure correct operation of the module.

Parameters/address space 7

7.1 Measurement types and measuring ranges

The analog input module has the following measuring ranges:

Table 2-583 Measuring ranges

Measurement type	Measuring range	Resolution
Voltage	± 0.5 ... 320 mV/V	16 bits including sign (oversampling) 28 bits including sign (normal/isochronous operation without oversampling)

The tables of the measuring ranges as well as overflow, overrange, etc., can be found in the section Representation of analog values (Page 63).

7.2 Parameters

Parameters of the AI 2xSG 4-/6-wire HS

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation on an ET 200SP CPU or on an ET 200SP Open Controller
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

In addition to assigning parameters with the configuration software, you can also set the parameters in RUN mode (dynamically) using the user program. With configuration in the user program, the parameters are transferred to the modules via data records with the "WRREC" instruction; see section Parameter assignment (Page 51).

The following parameter settings are possible:

Table 2-584 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Line frequency	50/60 Hz	50 Hz	No	Module	Module
Measurement type	deactivated / 4-wire strain gauge full bridge / 6-wire strain gauge full bridge	4-wire strain gauge full bridge	Yes	Channel	Channel

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 13 bytes.

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Line frequency filter	Enabled/disabled	Activated	Yes	Channel	Channel
Measuring range	0.5 ... 320 mV/V	2 mV/V	Yes	Channel	Channel
Sampling rate	0.1 ... 6.5535 ms	1 ms	Yes	Channel	Channel
Moving average value filter	0 ... 655.35 ms	0 ms	Yes	Channel	[1]
Prefilter "Input lock B"	0 ... 655.35 ms	0 ms	Yes	Channel	[1]
IIR low-pass filter limit frequency	0 ... 6553.5 Hz	0 Hz (=off)	Yes	Channel	[1]
IIR low-pass filter ordinal number	1 ... 4	4	Yes	Channel	[1]
Notch filter frequency	0 ... 1000.0 Hz	0 Hz (=off)	Yes	Channel	[1]
Notch filter quality Q	5.0 ... 250.0	100	Yes	Channel	[1]
Diagnostics: No supply voltage L+	• Locking • Enabling	Locking	Yes	Channel	Channel
Diagnostics Short circuit / wire break at sensor	• Locking • Enabling	Locking	Yes	Channel	Channel
Diagnostics: Underflow	• Locking • Enabling	Locking	Yes	Channel	Channel
Diagnostics: Overflow	• Locking • Enabling	Locking	Yes	Channel	Channel
Hardware interrupt high limit 1	• Locking • Enabling	Locking	Yes	Channel	[1]
Hardware interrupt low limit 1	• Locking • Enabling	Locking	Yes	Channel	[1]
Hardware interrupt high limit 2	• Locking • Enabling	Locking	Yes	Channel	[1]
Hardware interrupt low limit 2	• Locking • Enabling	Locking	Yes	Channel	[1]
High limit 1 (exceeded)	± 2147483648	100.000.000	Yes	Channel	[1]
Low limit 1 (undershot)	± 2147483648	-100,000,000	Yes	Channel	[1]
High limit 2 (exceeded)	± 2147483648	100.000.000	Yes	Channel	[1]
Low limit 2 (undershot)	± 2147483648	-100,000,000	Yes	Channel	[1]
High limit 1 (exceeded) - hysteresis	0 ... 4294967295	100.000.000	Yes	Channel	[1]
Low limit 1 (undershot) - hysteresis	0 ... 4294967295	100.000.000	Yes	Channel	[1]

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 13 bytes.

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
High limit 2 (exceeded) - hysteresis	0 ... 4294967295	100.000.000	Yes	Channel	[1]
Low limit 2 (undershot) - hysteresis	0 ... 4294967295	100.000.000	Yes	Channel	[1]
Potential group	• Use potential group of the left module (dark-colored BaseUnit) • Enable new potential group (light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 13 bytes.

NOTE
Unused channels
"Deactivate" the unused channels in the parameter assignment.
A deactivated channel always returns the value $7FFF_H$.

7.3 Description of parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics alarm for missing or insufficient supply voltage L+.

Diagnostics Short circuit / wire break at sensor

Enabling of the diagnostics in the event of a short-circuit of the encoder supply. In addition, a wire break is also detected at $+/-U_{Rn}$ with configured 6-wire technology. Threshold see section Technical specifications (Page 41).

Diagnostics Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics Underflow

Enabling of the diagnostics when the measured value falls below the underrange.

NOTE

If the diagnostics "Short circuit / wire break at sensor" and "Underflow" are activated at the same time and a wire break occurs, both diagnostics messages are reported by the module.

Potential group

You can use the "Potential group" parameter to specify whether the module is inserted in a light-colored or dark-colored BaseUnit.

A potential group always starts with an I/O module that is inserted on a light-colored BaseUnit. All modules inserted to the right of this on dark-colored BaseUnits belong to the same potential group, because the dark-colored BaseUnits are supplied via the light-colored BaseUnits.

The potential group ends with a new light-colored BaseUnit or the end of the station.

Line frequency

Defines the line frequency of the power supply grid.

Adjustment range: 50 or 60 Hz

Measurement type

Deactivated / 4-wire strain gauge full bridge / 6-wire strain gauge full bridge

Line frequency filter

Enables or disables a line frequency filter which suppresses the power supply grid frequency (50/60 Hz) set under "Line frequency". Because the filter also filters for a multiple of 50/60 Hz, it may be better to disable the filter.

Measuring range

Defines the characteristic value of the connected DMS sensor. Any setting values is scaled to +/- 100,000,000 digits in the module.

Sampling rate

Defines the sampling rate of the analog input module.

Moving average value filter

Defines the period of the moving average value filter.

Prefilter "Input lock B"

Defines the period of the prefilter for the "Input lock B" operating mode. This is a moving average value filter which prefilters the signal when it exits "Input lock B" mode.

IIR low-pass filter limit frequency

Defines the line frequency of the low-pass filter.

IIR low-pass filter ordinal number

Defines the ordinal number of the low-pass filter and therefore has a direct effect on the edge steepness of the filter.

Notch filter frequency

Defines the frequency of the notch filter. The filter is used to filter the specified frequency from the input signal.

Notch filter quality Q

Defines the quality of the notch filter.

7.4 Oversampling

Function

Oversampling is the acquisition of data in constant bus cycle segments (sub-cycles). The configured number n of sub-cycles corresponds to one PROFINET bus cycle.

Oversampling is useful whenever you require acquisition of data with high time resolution but without using an extremely short PROFINET bus cycle and thus fast CPU cycles.

With oversampling, a PROFINET bus cycle is divided into constant bus sub-cycles:

- One measured value is acquired in each sub-cycle.
- The minimum PROFINET bus cycle is 125 µs. Only a subset of functions is available for shorter sub-cycles.
- The shortest possible sub-cycle is 100 µs.

- You can configure oversampling:
  - For channel 0 (1-channel operation)
  - For channel 0/1 (2-channel operation)
- The number of sub-cycles can be set as follows:
  - From 2 to 14 for one channel
  - From 2 to 6 for two channels

Requirement

Oversampling is only possible when isochronous mode is set.

Configuration

You configure oversampling with the following parameter:

- Sampling rate

NOTE

Do not use a reduction ratio for blocks in the case of configuration with oversampling in the runtime groups of your user program. This will ensure that the data processing in the user program of the CPU is synchronized with the acquisition on the module.

Overview of the operating modes

Function	Normal operation	Oversampling	
		1-channel operation	2-channel operation
Isochronous mode	Yes, optional	Yes, required	
• Shortest send clock	• 125 µs isochronous • 100 µs non-isochronous	125 µs	
Oversampling	No	Yes	
• Number of oversampling levels (sampling rate)	-	2 ...14	2 ... 6
• Shortest sub-cycle (= shortest sampling time)	-	100 µs	
Hardware interrupt	x	-	
Filter functions	x	x	
± 320 mV/V	x	x	
Overflow/underflow	x	x	
Short circuit/wire break at U_{Rn}	x	x	

Function	Normal operation	Oversampling	
		1-channel operation	2-channel operation
Load voltage diagnostics	x	x	
Value status (QI)	x	x	
Address space	16 bytes	32 bytes	

Sampling interval

The duration of a subcycle is the sampling interval. The cycle time T (send clock) for isochronous mode is specified in the configuration software. This time, divided by the configured sampling rate n_{Sample}, yields the sampling interval t_{Sample} of the module.

Example calculation:

$$t_{Sample} = \frac{T}{n_{Sample}} = \frac{1\ ms}{10} = 100\ \mu s$$

Figure 2-579 Example of calculating the sampling interval

Chronological sequence

The figure shows the chronological sequence for oversampling. The acquired measured vales of a data cycle with oversampling are only copied to the interface module in the subsequent bus cycle and are then available to the processing CPU one bus cycle later.

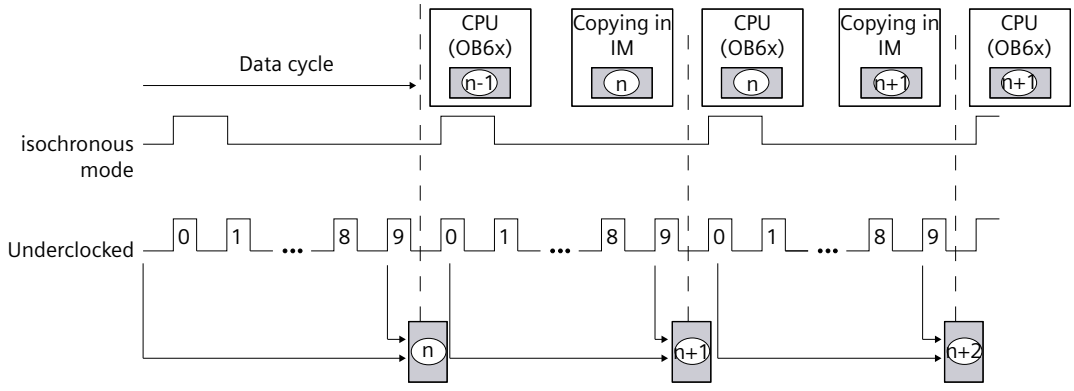

① n = measured values from bus cycle n

Figure 2-580 Oversampling

7.5 Address space

NOTE

Take into account the set mode of the module when programming because the address space can differ.

Address space for normal and isochronous operation

Table 2-585 Assignment in the process image of the inputs

IByte	Bit	Name and meaning
x	0 ... 7	Measured value channel 0 (DINT)
x + 1	0 ... 7	
x + 2	0 ... 7	
x + 3	0 ... 7	
x + 4	0 ... 7	Refresh counter channel 0 (UINT)
x + 5	0 ... 7	
x + 6	0	Channel 0 Measuring range exceeded
	1	Channel 0 Measuring range undershot
	2	Channel 0 Short-circuit / wire break at the sensor
	3	Channel 0 No load voltage L+
	4	Channel 0 ADC faulty
	5	Channel 0 Internal memory error
	6	Channel 0 Watchdog error
	7	Channel 0 Internal error - module defective
x + 7	0	QI bit 0: Bad 1: Good
	1	Input lock 0: Inactive 1: active
	2	Reserved
	3	Measuring range exceeded (common mode)
	4	Limit 1, low limit undershot
	5	Limit 1, high limit exceeded
	6	Limit 2, low limit undershot
	7	Limit 2, high limit exceeded

NOTE

The allocation of channel 1 is identical. To determine the respective parameter addresses, add an offset of 8 bytes to the parameter addresses of channel 0.

Address space for oversampling with one channel

Table 2-586 Assignment in the process image of the inputs

IByte	Bit	Name and meaning
x	0 ... 7	Channel 0 at sub-cycle 1 (INT)
x + 1	0 ... 7	
x + 2	0 ... 7	Channel 0 at sub-cycle 2 (INT)
x + 3	0 ... 7	
x + 4	0 ... 7	Channel 0 at sub-cycle 3 (INT)
x + 5	0 ... 7	
x + 6 to x + 25	0 ... 7	Channel 0 at sub-cycle 4 to 13 (INT)
x + 26	0 ... 7	Channel 0 at sub-cycle 14 (INT)
x + 27	0 ... 7	
x + 28	0 ... 7	Channel 0 at refresh counter (UINT)
x + 29	0 ... 7	
x + 30	0	Channel 0 status Measuring range exceeded
	1	Channel 0 status Measuring range undershot
	2	Channel 0 status short-circuit / wire break at sensor
	3	Channel 0 status No load voltage L+
	4	Channel 0 status ADC faulty
	5	Channel 0 status Internal memory error
	6	Channel 0 status Watchdog error
	7	Channel 0 status Internal error - module defective
x + 31	0	Channel 0 status QI bit 0: Bad 1: Good
	1	Channel 0 status Input lock 0: Inactive 1: active
	2	Reserved
	3	Reserved
	4 ... 7	Reserved

Address space for oversampling with two channels

The following figure shows the assignment of the address space for oversampling with two channels. It is always addressed by IByte x. A maximum of 6 sub-cycles are possible. If less than 6 sub-cycles are set, the addresses not in use are filled with $7FFF_H$.

Table 2-587 Assignment in the process image of the inputs

IByte	Bit	Name and meaning
x	0 ... 7	Channel 0 at sub-cycle 1 (INT)
x + 1	0 ... 7	
x + 2	0 ... 7	Channel 0 at sub-cycle 2 (INT)
x + 3	0 ... 7	
x + 4	0 ... 7	Channel 0 at sub-cycle 3 (INT)
x + 5	0 ... 7	
x + 6 to x + 9	0 ... 7	Channel 0 at sub-cycle 4 to 5 (INT)
x + 10	0 ... 7	Channel 0 at sub-cycle 6 (INT)
x + 11	0 ... 7	
x + 12	0 ... 7	Channel 0 at refresh counter (UINT)
x + 13	0 ... 7	
x + 14	0	Channel 0 status Measuring range exceeded
	1	Channel 0 status Measuring range undershot
	2	Channel 0 status short-circuit / wire break at sensor
	3	Channel 0 status No load voltage L+
	4	Channel 0 status ADC faulty
	5	Channel 0 status Internal memory error
	6	Channel 0 status Watchdog error
	7	Channel 0 status Internal error - module defective
x + 15	0	Channel 0 status QI bit 0: Bad 1: Good
	1	Channel 0 status Input lock 0: Inactive 1: active
	2	Reserved
	3	Reserved
	4 ... 7	Reserved
x + 16	0 ... 7	Channel 1 at sub-cycle 1 (INT)
x + 17	0 ... 7	
x + 18	0 ... 7	Channel 1 at sub-cycle 2 (INT)
x + 19	0 ... 7	
x + 20	0 ... 7	Channel 1 at sub-cycle 3 (INT)
x + 21	0 ... 7	

IByte	Bit	Name and meaning
x + 22 to x + 25	0 ... 7	Channel 1 at sub-cycle 4 to 5 (INT)
x + 26	0 ... 7	Channel 1 at sub-cycle 6 (INT)
x + 27	0 ... 7	
x + 28	0 ... 7	Channel 1 at refresh counter (UINT)
x + 29	0 ... 7	
x + 30	0	Channel 1 status Measuring range exceeded
	1	Channel 1 status Measuring range undershot
	2	Channel 1 status short-circuit / wire break at sensor
	3	Channel 1 status No load voltage L+
	4	Channel 1 status ADC faulty
	5	Channel 1 status Internal memory error
	6	Channel 1 status Watchdog error
	7	Channel 1 status Internal error - module defective
x + 31	0	Channel status 1 QI bit 0: Bad 1: Good
	1	Channel 1 status Input lock 0: Inactive 1: active
	2	Reserved
	3	Reserved
	4 ... 7	Reserved

Process image output

Table 2-588 Process image of the outputs

QByte	Bit	Name and meaning
x	0 ... 7	Input lock channel 0
x+1	0	Activate max. peak value memory channel 0
	1	Activate min. peak value memory channel 0
	2 ... 7	Reserved
x+2	0 ... 7	Reserved
x+3	0 ... 7	Reserved
x+4	0 ... 7	Input lock channel 1
x+5	0	Activate max. peak value memory channel 1
	1	Activate min. peak value memory channel 1

QByte	Bit	Name and meaning
x+5	2 ... 7	Reserved
x+6	0 ... 7	Reserved
x+7	0 ... 7	Reserved

7.6 Input lock

"Input lock" freezes the measuring value. "Input Lock" can be helpful, for example, in case of known interferences to prevent feeding these interferences into the filters of the analog input module.

There are various "Input lock" options.

QByte	Bit	Stop Input lock	Start Input lock A	Start Input lock B
x	0	0	1	0
	1	0	0	1
	2	0	0	0
	3	0	0	0
	4	0	0	0
	5	0	0	0
	6	0	0	0

Input lock A

Once input lock A is activated, no new measured values are fed into the filters of the analog input module. The measured value in the process image input is frozen. Only by stopping input lock A is the measured value refreshed again or the module-internal filters supplied with new values.

Input lock B

Once input lock B is activated, the measured value in the process image input is frozen. After stopping input lock B, the measured value is prefiltered and refreshed again. This prefiltering is done with a configurable average value filter (see prefilter Input lock B).

NOTE

Switching between Input lock A and Input lock B

It is not possible to switch directly between Input lock A and Input lock B.

- To change to a different input lock you must stop the currently active input lock.

7.7 Min./max. peak value memory

The module has an internal min. and max. peak value memory for each channel. The peak value memories can be activated or deactivated separately via control bits (see Process image of the outputs).

The peak value memory has the advantage that peak values can be recorded internally in the module, independent of the CPU cycle, using the configured sampling (up to 10 kHz). The peak values determined can be read out at any time from the user program via acyclic data transfers (READ_REC system function). In addition to the actual peak values, the corresponding value of the refresh counter and channel status are also stored. Time references to the peak value can be calculated in this way. The channel status provides information about the status of the module at the time of the recorded peak value. The peak value memories for channel A are located in data record 10, those for channel 1 in data record 11.

To start peak value acquisition, the respective control bit must undergo an edge transition from 0 to 1. If the control bits are set to 0 again, the last peak values determined remain frozen in the memory. The stored peak values can be read into the user program by reading the respective data record. At a new edge transition to 1, the current measured value is set as the new current peak value.

The structure of the peak value data records is as follows:

Table 2-589 Data record 10 (peak value memory channel 0)

Byte	Bit	Name and meaning
x + 0	0 ... 7	Max. peak value channel 0 (DINT)
x + 1	0 ... 7	
x + 2	0 ... 7	
x + 3	0 ... 7	
x + 4	0 ... 7	Max. peak value refresh counter channel 0 (UINT)
x + 5	0 ... 7	
x + 6	0 ... 7	Max. peak value status channel 0 (UINT)
x + 7	0 ... 7	
x + 8	0 ... 7	Min. peak value channel 0 (DINT)
x + 9	0 ... 7	
x + 10	0 ... 7	
x + 11	0 ... 7	
x + 12	0 ... 7	Min. peak value refresh counter channel 0 (UINT)
x + 13	0 ... 7	
x + 14	0 ... 7	Min. peak value status channel 0 (UINT)
x + 15	0 ... 7	

Data record length = 16 bytes

Table 2-590 Data record 11 (peak value memory channel 1)

Byte	Bit	Name and meaning
x + 0	0 ... 7	Max. peak value channel 1 (DINT)

Data record length = 16 bytes

x + 1	0 ... 7	Max. peak value channel 1 (DINT)
x + 2	0 ... 7	
x + 3	0 ... 7	
x + 4	0 ... 7	Max. peak value refresh counter channel 0 (UINT)
x + 5	0 ... 7	
x + 6	0 ... 7	Max. peak value status channel 1 (UINT)
x + 7	0 ... 7	
x + 8	0 ... 7	Min. peak value channel 1 (DINT)
x + 9	0 ... 7	
x + 10	0 ... 7	
x + 11	0 ... 7	
x + 12	0 ... 7	Min. peak value refresh counter channel 1 (UINT)
x + 13	0 ... 7	
x + 14	0 ... 7	Min. peak value status channel 1 (UINT)
x + 15	0 ... 7	

Data record length = 16 bytes

General procedure for using the peak value memory

1. Start the desired peak value memory via the corresponding control bit in the PIQ.
2. Stop the recording of the peak value via the respective control bit.
3. Read the data record with the desired peak value from the application program using SFB READ_REC.

NOTE

The peak value memory function is only available in non-isochronous mode of the module.

See also

Address space (Page 28)

Interrupts/diagnostics interrupts

8

8.1 Status and error displays

LED displays

The figure below shows the LED display of the AI 2xSG 4-/6-wire HS.

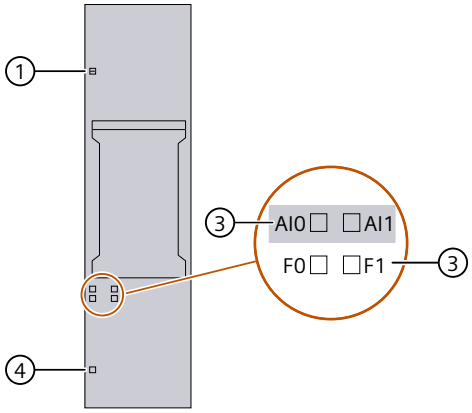

① DIAG (green/red)

② Channel status (green)

③ Channel fault (red)

④ PWR (green)

Figure 2-581 LED displays

Meaning of the LEDs

The following tables contain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 39).

DIAG LED

Table 2-591 Error display of the DIAG LED

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status/channel fault LED

Table 2-592 Status/error display of the channel status/channel fault LED

Channel status	Channel fault	Meaning
Off	Off	Channel deactivated or no load voltage L+
On	Off	Channel activated and no channel diagnostics
Off	On	Channel activated and channel diagnostics
On	On	Not permitted (error)

PWR LED

Table 2-593 Status display of the PWR LED

PWR	Meaning
Off	No supply voltage L+
On	Supply voltage L+ present

8.2 Interrupts

The analog input module AI 2xSG 4-/6-wire HS supports hardware and diagnostic interrupts.

Hardware interrupts cannot be used in Oversampling mode.

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- Low limit 1 violated
- High limit 1 violated
- Low limit 2 violated
- High limit 2 violated

If an interrupt occurs, a corresponding interrupt OB is called in the CPU of the IO controller.

S7-1500

Detailed information on the event is available in the STEP 7 online help.

The block interface is shown here with optimized block access, which is set in the TIA Portal by default.

Name	Data type	Comment
LADDR	HW_IO	Hardware identifier of the module triggering the interrupt
USI	WORD	USI (High/Low)
IChannel	USInt	Channel that triggered the hardware interrupt
EventType	Byte	Error event

S7-300/400 or a different CPU

You can obtain detailed information on the event in the hardware interrupt organization block with the instruction "RALARM" (read additional interrupt info) and in the STEP 7 online help.

The channel of the module that triggered the hardware interrupt is entered in the start information of OB4x in the OB4x_POINT_ADDR tag. The following figure shows the assignment to the bits of double word 8 in local data.

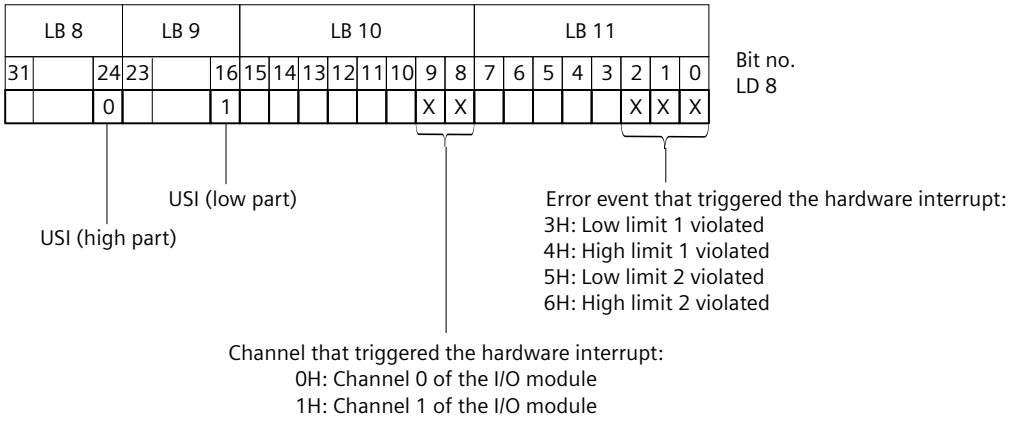

Figure 2-582 OB4x_POINT_ADDR tag

Structure of the additional interrupt information

Table 2-594 Structure of USI = W#16#0001

Data block name		Content	Comment	Bytes
USI		W#16#0001	User Structure Identifier: Additional interrupt info for hardware interrupts of the I/O module	2
The channel that triggered the hardware interrupt follows.				
	Channel	B#16#00 to B#16#01	Channel 0 and 1 of the I/O module	1
The error event that triggered the hardware interrupt follows.				
	Error event	B#16#03	Low limit 1 violated	1
		B#16#04	High limit 1 violated	
		B#16#05	Low limit 2 violated	
		B#16#06	High limit 2 violated	

Diagnostics interrupt

The module generates a diagnostics interrupt at the following events:

- Short circuit / wire break
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- No load voltage
- Channel temporarily unavailable

8.3 Diagnostics alarms

A diagnostic alarm is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostic alarms can, for example, be read from the diagnostic buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-595 Diagnostics alarms, their meanings and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Overflow	7_H	The value is above the overrange.	Correct the output value
Underflow	8_H	Value is below the underrange.	Correct the output value
Error	9_H	Internal module error has occurred (diagnostic alarm on channel 0 applies to the entire module).	Replace the module
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Update of the firmware is being performed or has been canceled. The module does not read any process values in this state.	• Wait for firmware update • Restart the firmware update
Hardware interrupt lost	16^H	Hardware interrupt queue is full	-
Short circuit / wire break at sensor	124_H	Short circuit at the sensor supply (UVn +/-) or wire break at the reference voltage input (URn +/-). Wire break can only be detected with 6-wire sensors.	Check wiring and correct, if necessary
Error in input circuit	313_H	A/D converter is faulty	• Check EMC-compliant wiring in case of recurring message • Replacement of the module
Invalid/inconsistent firmware	$11B_H$	Module-internal checksum error	Replace the module in case of recurring message
Channel/component temporarily unavailable	103_H	Restart due to watchdog reset	Replace the module in case of recurring message

Service and maintenance

9

9.1 Basic safety instructions

NOTE

The device is maintenance-free.

WARNING

Impermissible repair of the device

- Repair must be carried out by Siemens authorized personnel only.

Technical specifications 10

10.1 New technical specifications 7MH41346LB000DA0

Core statement

The technical specifications for 7MH4134-6LB00-0DA0 are:

Article number	7MH4134-6LB00-0DA0
General information	
Product type designation	AI 2xSG 4-/6-wire HS
HW functional status	01
Firmware version	V1.0.1
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Measuring range scalable	Yes
• Scalable measured values	No
• Adjustment of measuring range	Yes; ±0.5 ... 320 mV/V
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V14 SP1
• STEP 7 configurable/integrated from version	V5.6
• PROFIBUS from GSD version/GSD revision	V03.01.105
• PROFINET from GSD version/GSD revision	GSDML V2.33
Operating mode	
• Oversampling	Yes; 2 channels per module
• MSI	No
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	No

Article number	7MH4134-6LB00-0DA0
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Encoder supply	
Output voltage (DC)	4.85 V
Short-circuit protection	Yes
Output current	
• Rated value	60 mA; Per channel
Power	
Power available from the backplane bus	65 mW
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
• Address space per module, max.	32 byte
• Inputs	32 byte
• Outputs	8 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Analog inputs	
Cycle time (all channels), min.	100 µs
Analog input with oversampling	Yes
• Values per cycle, max.	14
• Resolution, min.	100 µs
Input ranges	
• Strain gauges (full bridges)	Yes
Cable length	
• shielded, max.	500 m
Analog value generation for the inputs	
Measurement principle	Sigma Delta
Integration and conversion time/resolution per channel	
• Integration time, parameterizable	Yes
• Interference voltage suppression for interference frequency f1 in Hz	60 / 50 Hz / no
• Conversion time (per channel)	100 µs
Smoothing of measured values	
• IIR low-pass filter frequency	0.01 ... 600 Hz

Article number	7MH4134-6LB00-0DA0
• IIR low-pass filter ordinal number	1 ... 4
• Notch filter frequency	0.1 ... 1 000 Hz
• Notch filter quality	5.00 ... 250.00
• Average value filter	0.1 ... 655.3 ms
Encoder	
Connection of signal encoders	
• For strain gauges (full bridges) with 4-conductor connection	Yes
• For strain gauges (full bridges) with 6-conductor connection	Yes
• Resistance of full bridge, min.	80 Ω
• Resistance of full bridge, max.	5 000 Ω
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.025 %
Temperature error (relative to input range), (+/-)	0.0005 %/°C; Strain gauge full bridge, 6-conductor connection
Temperature coefficient, zero point	≤ ±0.25 µV/K
Temperature coefficient, span, 4-wire connection (in relation to end value)	≤ ±5 ppm/K
Temperature coefficient, span, 6-wire connection (in relation to end value)	≤ ±10 ppm/K
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to input range, (+/-)	0.05 %; See manual for details
Isochronous mode	
Filtering and processing time (TCI), min.	87 µs
Bus cycle time (TDP), min.	125 µs
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Limit value alarm	Yes; two upper and two lower limit values in each case
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• Group error	Yes
• Overflow/underflow	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED

Article number	7MH4134-6LB00-0DA0
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-25 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-25 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Ambient air temperature-barometric pressure-altitude	Tmin ... Tmax at 1 140 hPa ... 795 hPa (-1 000 m ... +2 000 m) // Tmin ... (Tmax - 1 K/100 m) at 795 hPa ... 701 hPa (+2 000 m ... +3 000 m)
Dimensions	
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	45 g

10.2 Mechanical requirements and data

Construction	
Insulation	Tested with 707 V DC (type test)
Dimension	15 mm wide, see manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)
Weight	Approx. 45 g

Operating conditions in accordance with IEC 60721	
Operation	IEC60721-3-3 Class 3M3, stationary use, weather-proofed
Storage/transport	IEC 60721-3-2 Class 2M2 without precipitation

Mechanical requirements and data		
Testing	**Standards**	**Limits**
Vibrational load during operation	IEC 61131-2:2007 IEC 60068-2-6:2007 Test Fc	5 to 8.4 Hz: 3.5 mm out. 8.4 to 150 Hz: 9.8 m/s^2 (=1 g)
Shock load during operation	IEC 61131-2:2007 IEC 0068-2-27:2008 Test Ea	150 m/s^2 (approx. 15 g), half sine Duration: 11 ms
Vibration load during transport	IEC 60068-2-6:2007 Test Fc	5 to 8.4 Hz: 3.5 mm out. 8.4 to 500 Hz: 9.8 m/s^2
Shock load during transport	IEC 60068-2-27:2008 Test Ea	250 m/s^2 (approx. 25 g), half sine Duration: 6 ms
Free fall	IEC 61131-2:2007 IEC 60068-2-31:2008 Test Ec, procedure 1	In product packaging: 300 mm drop height In shipping packaging: 1.0 m drop height

10.3 Electrical, EMC and climatic requirements

Table 2-596 **Product safety**

Requirement	Standards	Comments/measures	
Safety regulations	IEC 61010-1:2010 +C1:2011 + C2:2013 IEC 61010-2-201:2014 UL 61010-1:2005 UL 61010-201:2014 IEC 61131-2:2007 CSA C22.2 No.142-M1987 (R2014) IEC 60664:2007	Overvoltage category II Pollution degree 2	
Protection class	IEC 61140:2016 IEC 61131-2:2007	To maintain the safety characteristics of extra-low voltage circuits, external connections to the analog circuits and the 24 V DC nominal power supplies must be powered by approved sources that fulfill the requirements according to the various standards for SELV, PELV, NEC Class 2, voltage limited or power limited. The ground connection for the DIN rail serves as a functional ground for dissipating interference currents.	
IP degree of protection	DIN IEC 60529:2010 +A1:2000 + A2:2013	IP 20: Protection against contact with standard probe Protection against solid bodies with diameters in excess of 12.5 mm No special protection against water	
Electrical isolation stability	IEC 61131-2:2007 CSA C22.2 No.142-M1987 (R2014)	Between the channels	No

Requirement	Standards	Comments/measures	
Electrical isolation stability	IEC 61131-2:2007 CSA C22.2 No.142-M1987 (R2014)	Between the channels and the backplane bus	707 V DC (type test)
		Between the channels and the power supply	707 V DC (type test)
Electromagnetic compatibility	IEC 61000-6-2 :2004 IEC 61000-6-4 :2007+ A1:2011	All shielded cables must be grounded at both ends to comply with the requirements for electromagnetic compatibility. If the shielded cable is routed out of the hazardous area for explosion-proof equipment, both ends of the cable shield must be connected to the potential equalization.	

Table 2-597 Requirements: Interference emission in industrial area in accordance with EN 61000-6-4

Comments	Standard	Limits
Emission of radio interference (interference field strength)	Class A industrial environment: IEC/CISPR 16-2-3 :2006 EN55016-2-3 :2006	30 – 230 MHz, 40 dB(mV/m) Q 230 – 1000 MHz, 47 dB(mV/m) Q -- 1 GHz to 3 GHz / 76 dB(mV/m) peak, 56 dB(mV/m) average 3 GHz to 6 GHz / 80 dB(mV/m)
Emission on power supply cables	Class A: Industrial environment: IEC/CISPR 16-2-1 :2009 EN 55016-2-1 :2004	Class A: Industrial environment 0.15 ... 0.5 MHz, 79 dB (µV) Q 0.15 ... 0.5 MHz, 66 dB (µV) M 0.5 ... 30 MHz, 73 dB (µV) Q 0.5 ... 30 MHz, 60 dB (µV) M
Emission conducted Ethernet	EN 61000-6-4: 2007+A1:2011 IEC/CISPR 22 :2008 EN55022 :2010	0.15 ... 0.5 MHz: 53 dB (µA) to 43 dB (µA) Q 40 dB (µA) – 30 dB (µA) M 0.5 ... 30 MHz: 43 dB (µA) to 30 dB (µA) M

NOTE

Radio interference is possible

This is a device of class A. The device may cause radio interference in residential areas. Implement appropriate measures (e.g.: use in 8MC cabinets) to prevent radio interference.

Table 2-598 Requirements: Interference immunity in industrial area in accordance with EN 61000-6-2

Comments	Standard	Severity level
Burst pulses on power supply cables	DIN EN 61000-4-2 :2009	±2.0 kV 5/50 ns/5 kHz

1) Not applicable for shielded cables and symmetric ports

2) An external fuse must be provided to comply with the requirement (e.g. Lightning conductor BVTAD24, Dehn & Söhne company)

Comments	Standard	Severity level
	DIN EN 61000-4-3 :2011 DIN EN 61000-4-4 :2013 DIN EN 61000-4-5 :2015 DIN EN 61000-4-6 :2014 IEC 61000-4-2 :2008 IEC 61000-4-3 :2006 +A1:2007 +A2:2010 IEC 61000-4-4 :2012 IEC 61000-4-5 :2014 IEC 61000-4-6 :2014 NAMUR NE21:2011 DIN EN 61131-2 :2008 IEC 61131-2 :2007	±2.0 kV 5/50 ns/100 kHz
Burst pulses on data and signal cables		±2.0 kV 5/50 ns/5 kHz ±2.0 kV 5/50 ns/100 kHz
Electrostatic discharge (ESD)		2, 4, 6 kV direct/indirect
Electrostatic air discharge (ESD)		2, 4, 6, 8 kV
Surge on power supply cables[2)]		±1.0 kV line to line ±2.0 kV line to earth
Electromagnetic RF fields		80 MHz to 3 GHz: 20 V/m
Induced conducted interference		10 kHz to 80 MHz: 10 V_{eff}

1) Not applicable for shielded cables and symmetric ports

2) An external fuse must be provided to comply with the requirement (e.g. Lightning conductor BVTAD24, Dehn & Söhne company)

Ambient conditions

The module can be used under the following conditions:

(Also observe the operating conditions of the ET 200SP system)

Table 2-599 Operating conditions in accordance with IEC 60721

Operation	IEC60721-3-3: Class 3K3, stationary use, weather-proofed
Storage/transport	IEC 60721-3-2 class 2K4 without precipitation

Table 2-600 Climatic requirements

Comments		Ambient conditions	Areas of application
Operating temperature	Vertical installation	-25 to +50 °C	
	Horizontal installation	-25 to +60 °C	
Storage and transport temperature		-40 to +70 °C	
Relative humidity		5 ... 95%	No condensation; corresponds to relative humidity (RH) stress level 2 to DIN IEC 61131-2
Contaminant concentration		SO_2: < 0.5 ppm H_2S: < 0.1 ppm	RH < 60%, no condensation
Air pressure	During operation [1)]	IEC 60068-2-13	1080 to 700 hPa (-1000 to +3000 m above sea level)
	Transport and storage	IEC 60068-2-13	1080 to 660 hPa (-1000 to +3500 m above sea level)

1) As of 2000 m above sea level, a derating of the upper ambient temperature of -1°C / 100 m has to be taken into consideration.

Table 2-601 Reliability

Mean time between failures MTBF	Typical 120 years @Ta= 40 °C

See also

Product information (https://support.industry.siemens.com/cs/ww/en/view/19692172)

10.4 Certificates and approvals

- All certificates are available online at Certificates (https://support.industry.siemens.com/cs/ww/en/ps/7MH4134-6LB00-0DA0/cert).
- The current approvals for your device can be found on the nameplate.
- When using the weighing electronics, observe the requirements specified in the safety instructions for hazardous areas.

CE	EU Declaration of Conformity (with CE marking)
c UL us UL	• Explosion protection in accordance with c-UL-us (USA/Canada) Report No.: E542221 • Electrical Safety (open type, Industrial, Programmable controllers) and Explosion protection: Nonincendive Electrical Equipment for Use in Class I, Division 2, Groups A, B, C, and D; and Class I, Zone 2, Group IIC; for Hazardous (Classified) Locations) • UL File Number OrdLoc: E503417
FM APPROVED	• FM approval zone 2 FM17US0318X • Nonincendive equipment for use in Class I, Division 2, Groups A, B, C and D, T4; and for use in Class I, Zone 2, Group IIC T4; hazardous (classified) locations; indoor environments.
Ex	Explosion protection in accordance with ATEX DEKRA 19ATEX0094 X EN IEC 60079-0 EN 60079-7
UK CA	UK Declaration of Conformity (with UKCA marking) including explosion protection according to UKEX
IECEx	Explosion protection in accordance with IECEx DEK 19.0054X IEC 60079-0 IEC 60079-7
EAC	→ EAC certificate, available soon

	→ Tick mark for Australia and New Zealand
	→ KCC approval
	The modules are RoHS compliant according to EU Directive 2016/65/EU

10.5 Design of the nameplate

Design of the nameplate

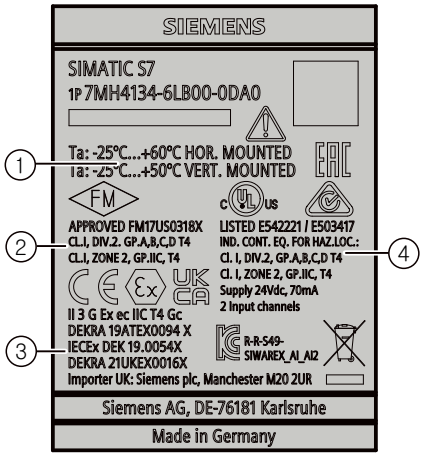

① Permissible ambient temperature for the hazardous area of the corresponding temperature class

② FM APPROVED mark for hazardous areas

③ ATEX/UKEX/IECEx mark for hazardous areas

④ UL mark for all areas

Figure 2-583 Typical nameplate design

Accessories

11

11.1 BaseUnit type A0 (essential)

You can order accessories online: Industry Mall (https://mallstage.industry.siemens.com/mall/en/b0/Catalog/Products/10038765?tree=CatalogTree)

The following accessories are not included in the scope of delivery:

- **Mandatory**: BaseUnit of type A0
  - For opening a new potential group

    BU15P-16+A0+2D[1] or

    BU15P-16+A10+2D[1]
  - For continuing the potential group

    BU15P-16+A0+2B[1]

    BU15P-16+A10+2B[1]

    [1] FM-certified

An overview of the BaseUnits that you can use with the electronic weighing system can be found in the Product Information for the documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

Information regarding selection of the suitable BaseUnit can be found in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864) system manual and in the ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual.

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuration with PROFINET GSD file and with PROFIBUS GSD file

The properties and their dependencies on measuring type and measuring range for PROFINET and PROFIBUS are listed in the table.

Measurement type	Measuring range	Diagnostics				Hardware interrupts	
		No supply voltage L+	Short-circuit to ground	Overflow / underflow	Wire break	PROFINET	PROFIBUS
Deactivated		*	*	*	*	*	*
Voltage	±320 mV	x	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment

Parameter assignment in the user program

You can re-configure the module in RUN. You can, for example, change voltage or current values in single channels in RUN without this change having an effect on the other channels.

NOTE

Following a firmware update, you need to re-configure the I/O module before you can use the new functions.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

In addition, the data records 0 and 1 are available which contain the channel-specific parameters for channel 0 (data record 0) and channel 1 (data record 1). These data records allow for the fastest, channel-specific parameter assignment in RUN.

NOTE
Changing parameters in RUN
A parameter data record that has content different from the startup parameter assignment results in a brief exit from clocked measuring mode and renewed synchronization with the fieldbus cycle. The slowest channel provides the "internal" measuring cycle.

STATUS output parameter

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

See also

Description of parameters (Page 23)

A.3 Parameter data record 128

Structure of parameter data record 128 for the entire module

Byte	Name and meaning
0 ... 1	Header information
2 ... 3	Module header information
4 ... 9	Module parameters
10 ... 11	Channel header information
12 ... 69	Channel parameter block 0
70 ... 127	Channel parameter block 1

Header information

The following tables show the structure of the header information.

Byte	Bit	Allocation	Name and meaning
0	0	0	Minor version
	1	0	
	2	0	
	3	0	
	4	1	Major version
	5	0	
	6	0	Reserved
	7	0	

Byte	Bit	Number of the next parameter structures = 2
1	0	0
	1	1
	2	0
	3	0
	4	0
	5	0
	6	0

Module header information

The following tables show the structure of the header information module.

Byte	Bit	Length of the next module parameter blocks = 1
2	0	1
	1	0
	2	0
	3	0
	4	0
	5	0
	6	0
	7	0

Byte	Bit	Length of the next module parameter block = 6
3	0	0
	1	0
	2	1

Byte	Bit	Length of the next module parameter block = 6
3	3	0
	4	0
	5	0
	6	0
	7	0

Module parameter block

The following table shows the structure of the module parameter block. Enable a parameter by setting the corresponding bit to "1".

Byte	Bit	Name and meaning
4	0	Isochronous mode 0: OFF 1: ON
	1	1/2 channel mode (only with oversampling) 0: 1-channel mode 1: 2 channel mode
	2	Line frequency 0: 50 Hz 1: 60 Hz
	3 ... 7	Reserved
5	0 ... 3	Sampling rate 0 ... 13 (sub-cycle 1 ... 14); only with oversampling operating mode
	4 ... 7	Reserved
6 ... 9	0 ... 7	Reserved

Channel header information

The following tables show the structure of the header information channel.

Byte	Bit	Number of the next channel parameter blocks = 2
10	0	0
	1	1
	2	0
	3	0
	4	0
	5	0
	6	0
	7	0

Byte	Bit	Length of the next channel parameter block = 58
11	0	0
	1	1
	2	0
	3	1
	4	1
	5	1
	6	0
	7	0

Channel parameter block

The following tables show the structure of the channel parameter block. Enable a parameter by setting the corresponding bit to "1".

x = 12 + (channel number x 58); channel number 0 to 1

More information on the parameters is available in the section Description of parameters (Page 23).

Byte	Bit	Name and meaning
x	0 ... 7	Reserved
x + 1	0	Channel function 0: Channel deactivated 1: Channel activated
	1	4/6-wire technology 0: 4-wire technology 1: 6-wire technology
	2	Line frequency suppression 0: OFF 1: ON
	3 ... 7	Reserved
x + 2	0 ... 7	Measuring range (data format DINT)
x + 3	0 ... 7	
x + 4	0 ... 7	
x + 5	0 ... 7	
x + 6	0 ... 7	Sampling rate (data format UInt; 0.1 ms increments)
x + 7	0 ... 7	
x + 8	0 ... 7	Average value filter (data format UInt; 0.1 ms increments)
x + 9	0 ... 7	
x + 10	0 ... 7	Prefilter time Input lock mode B (data format UInt; 0.1 ms increments)
x + 11	0 ... 7	
x + 12	0 ... 7	Limit frequency Low-pass filter (data format UInt; 0.1 Hz increments)
x + 13	0 ... 7	

Byte	Bit	Name and meaning
x + 14	0 ... 7	Ordinal number low-pass filter (data format Uint; 1 ... 4)
x + 15	0 ... 7	
x + 16	0 ... 7	Notch filter frequency (data format UInt; 0.1 Hz increments)
x + 17	0 ... 7	
x + 18	0 ... 7	Notch filter quality (data format UInt; 0.01 Hz increments)
x + 19	0 ... 7	
x + 20	0 ... 3	Reserved
	4	Hardware interrupt high limit 2 exceeded
	5	Hardware interrupt low limit 2 undershot
	6	Hardware interrupt high limit 1 exceeded
	7	Hardware interrupt low limit 1 undershot
x + 21	0	No supply voltage L+
	1	Reserved
	2	Short circuit / wire break at sensor
	3	Reserved
	4	Measuring range undershot
	5	Reserved
	6	Measuring range exceeded
	7	Reserved
x + 22	0 ... 7	Hardware interrupt, low limit 1 (data format DInt)
x + 23	0 ... 7	
x + 24	0 ... 7	
x + 25	0 ... 7	
x + 26	0 ... 7	Hardware interrupt, hysteresis low limit 1 (data format DInt)
x + 27	0 ... 7	
x + 28	0 ... 7	
x + 29	0 ... 7	
x + 30	0 ... 7	Hardware interrupt, high limit 1 (data format DInt)
x + 31	0 ... 7	
x + 32	0 ... 7	
x + 33	0 ... 7	
x + 34	0 ... 7	Hardware interrupt, hysteresis high limit 1 (data format DInt)
x + 35	0 ... 7	
x + 36	0 ... 7	
x + 37	0 ... 7	
x + 38	0 ... 7	Hardware interrupt, low limit 2 (data format DInt)
x + 39	0 ... 7	
x + 40	0 ... 7	
x + 41	0 ... 7	

Byte	Bit	Name and meaning
x + 42	0 ... 7	Hardware interrupt, hysteresis low limit 2 (data format DInt)
x + 43	0 ... 7	
x + 44	0 ... 7	
x + 45	0 ... 7	
x + 46	0 ... 7	Hardware interrupt, high limit 2 (data format DInt)
x + 47	0 ... 7	
x + 48	0 ... 7	
x + 49	0 ... 7	
x + 50	0 ... 7	Hardware interrupt, hysteresis high limit 2 (data format DInt)
x + 51	0 ... 7	
x + 52	0 ... 7	
x + 53	0 ... 7	
x + 54	0 ... 7	Reserved
x + 55	0 ... 7	
x + 56	0 ... 7	
x + 57	0 ... 7	

A.4 Parameter data records 0 and 1

Structure of parameter data records 0 and 1 for channels 0 and 1

Byte	Name and meaning
0 ... 1	Header information
2 ... 3	Channel header information
4 ... 61	Channel parameter block channel x

Header information

The following tables show the structure of the header information.

Byte	Bit	Allocation	Name and meaning
0	0	0	Minor version
	1	0	
	2	0	
	3	0	
	4	1	Major version

Byte	Bit	Allocation	Name and meaning
0	5	0	
	6	0	Reserved
	7	0	

Byte	Bit	Number of the next parameter structures = 2
1	0	0
	1	1
	2	0
	3	0
	4	0
	5	0
	6	0

Channel header information

The following tables show the structure of the header information channel.

Byte	Bit	Number of the next channel parameter blocks = 2
2	0	0
	1	1
	2	0
	3	0
	4	0
	5	0
	6	0
	7	0

Byte	Bit	Length of the next channel parameter block = 58
3	0	0
	1	1
	2	0
	3	1
	4	1
	5	1
	6	0
	7	0

Channel parameter block

The following tables show the structure of the channel parameter block. Enable a parameter by setting the corresponding bit to "1".

More information on the parameters is available in the section Description of parameters (Page 23).

Byte	Bit	Name and meaning
4	0 ... 7	Reserved
5	0	Channel function 0: Channel deactivated 1: Channel activated
	1	4/6-wire technology 0: 4-wire technology 1: 6-wire technology
	2	Line frequency suppression 0: OFF 1: ON
	3 ... 7	Reserved
6	0 ... 7	Measuring range (data format Real)
7	0 ... 7	
8	0 ... 7	
9	0 ... 7	
10	0 ... 7	Sampling rate (data format UInt; 0.1 ms increments)
11	0 ... 7	
12	0 ... 7	Average value filter (data format UInt; 0.1 ms increments)
13	0 ... 7	
14	0 ... 7	Prefilter time Input lock mode B (data format UInt; 0.1 ms increments)
15	0 ... 7	
16	0 ... 7	Limit frequency Low-pass filter (data format UInt; 0.1 Hz increments)
17	0 ... 7	
18	0 ... 7	Ordinal number low-pass filter (data format Uint; 1 ... 4)
19	0 ... 7	
20	0 ... 7	Notch filter frequency (data format UInt; 0.1 Hz increments)
21	0 ... 7	
22	0 ... 7	Notch filter quality (data format UInt; 0.01 Hz increments)
23	0 ... 7	
24	0 ... 3	Reserved
	4	Hardware interrupt high limit 2 exceeded
	5	Hardware interrupt low limit 2 undershot
	6	Hardware interrupt high limit 1 exceeded
	7	Hardware interrupt low limit 1 undershot
25	0	No supply voltage L+
	1	Reserved

Byte	Bit	Name and meaning
25	2	Short circuit / wire break at sensor
	3	Reserved
	4	Measuring range undershot
	5	Reserved
	6	Measuring range exceeded
	7	Reserved
26	0 ... 7	Hardware interrupt, low limit 1 (data format DInt)
27	0 ... 7	
28	0 ... 7	
29	0 ... 7	
30	0 ... 7	Hardware interrupt, hysteresis low limit 1 (data format DInt)
31	0 ... 7	
32	0 ... 7	
33	0 ... 7	
34	0 ... 7	Hardware interrupt, high limit 1 (data format DInt)
35	0 ... 7	
36	0 ... 7	
37	0 ... 7	
38	0 ... 7	Hardware interrupt, hysteresis high limit 1 (data format DInt)
39	0 ... 7	
40	0 ... 7	
41	0 ... 7	
42	0 ... 7	Hardware interrupt, low limit 2 (data format DInt)
43	0 ... 7	
44	0 ... 7	
45	0 ... 7	
46	0 ... 7	Hardware interrupt, hysteresis low limit 2 (data format DInt)
47	0 ... 7	
48	0 ... 7	
49	0 ... 7	
50	0 ... 7	Hardware interrupt, high limit 2 (data format DInt)
51	0 ... 7	
52	0 ... 7	
53	0 ... 7	
54	0 ... 7	Hardware interrupt, hysteresis high limit 2 (data format DInt)
55	0 ... 7	
56	0 ... 7	
57	0 ... 7	
58	0 ... 7	Reserved

Byte	Bit	Name and meaning
59	0 ... 7	Reserved
60	0 ... 7	
61	0 ... 7	

A.5 Parameters specifications

1. Enter the desired values for the parameters according to the specifications in the following table.
2. The corresponding parameter addresses are listed in sections Parameter data record 128 (Page 52) and Parameter data records 0 and 1 (Page 57).

The table refers to the structure of the parameter data record 128. The parameter addresses of the parameter data records 0 and 1 are different.

Parameter	Adjustment range	Meaning	Operating instruction
Measuring range (data type UDInt)	5000 to 3200000	5000 corresponds to 0.5 mV/V 3200000 corresponds to 320 mV/V	• Enter the required value in the data double word (DWord) x + 2.
Sampling rate (data type UInt)	1 .. 65535	1 corresponds to 0.1 ms 65535 corresponds to 6553.5 ms	• Enter the required value in the data double word (DWord) x + 6.
Average value filter (data type UInt)	10 ... 65535	10 corresponds to 0.1 ms 65535 corresponds to 655.35 ms 0 disables the filter	• Enter the required value in the data double word (DWord) x + 8.
Prefilter Input lock mode B (data type UInt)	0 ... 65535	1 corresponds to 0.01 ms 65535 corresponds to 655.35 ms 0 disables the filter	• Enter the required value in the data double word (DWord) x + 10.
Low-pass filter limit frequency (data type UInt)	0 ... 65535	1 corresponds to 0.1 Hz 65535 corresponds to 6553.5 Hz 0 disables the filter	• Enter the required value in the data double word (DWord) x + 12.
Ordinal number IIR low-pass filter (data type UInt)	1 ... 4		• Enter the required value in the data double word (DWord) x + 14.
Notch filter frequency (data type UInt)	1 ... 10000	1 corresponds to 0.1 Hz 10000 corresponds to 1000.0 Hz 0 disables the filter	• Enter the required value in the data double word (DWord) x + 16.

Parameter	Adjustment range	Meaning	Operating instruction
Notch filter quality (data type UInt)	500 ... 25000	500 corresponds to 5.0 25000 corresponds to 250.0	• Enter the required value in the data double word (DWord) x + 18.
High/low limits 1 and 2 (data type DInt)	-2147483648 ... 2147483648	The unit of the limits is digits – identical to the unit of the measured value.	• Enter the required value in the data double word (DWord) x + 22, x + 30, x + 38 or x + 46.
Hysteresis high/low limits 1 and 2 (data type DInt)	0 ... 4294967295	The unit of the hysteresis is digits – identical to the unit of the measured value.	• Enter the required value in the data double word (DWord) x + 26, x + 34, x + 42 or x + 50.

Representation of analog values

B

B.1 Representation of analog values for analog inputs

This appendix describes the analog values for all measuring that you can use with the analog input module.

Measured value resolution

The table below shows the representation of binary analog values and of the associated decimal and hexadecimal units of the analog values.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table 2-602 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	decimal	hexadecimal	High byte	Low byte
13	8	8_H	SIGN 0 0 0 0 0 0 0	0 0 0 0 1 x x x
14	4	4_H	SIGN 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
28	2	2_H	SIGN 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	SIGN 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.2 Representation of the input range

The tables below show the digital representation of the input range.

Table 2-603 Input range for normal and isochronous mode

Dec. value	Measured value in %	Range
≥ 120,000,001	≥ 120%	Overflow
120,000,000	120%	Overshoot range
100,000,001	>100%	
100,000,000	100%	Nominal range
0		
-100,000,000	-100%	
-100,000,001	< -100%	Underrange
-120,000,000	-120%	
≤ -120,000,001	≤ -120%	Underflow

Table 2-604 Input range for oversampling mode

Dec. value	Measured value in %	Range
≥ 30,001	≥ 120%	Overflow
30,000	120%	Overshoot range
25,001	>100%	
25,000	100%	Nominal range
0		
-25,000	-100%	
-25,001	< -100%	Underrange
-30.000	-120%	
≤ -30,001	≤ -120%	Underflow

NOTE

The module still supplies measured values even when the overflow or underflow range is exceeded or undershot. No substitute value is output in this case.

B.3 Analog value representation

The table below contains the decimal and hexadecimal values (codings) of the voltage measuring range. As an example, we are looking at the characteristic values 1.0 mV/V and 2.0 mV/V. The internal module power supply is 4.85 VDC.

Table 2-605 Voltage measuring range 1.0 mV/V and 2 mV/V

Values		Voltage measuring range		Range
Dec.	Hex.	1 mV/V	2 mV/V	
≥ 120,000,001	≥ 7270E01	> 5.82 mV	> 11.64 mV	Overflow
120,000,000	7270E00	5.82 mV	11.64 mV	Overshoot range
100,000,001	5F5E101	> 4.85 mV	> 9.7 mV	
100,000,000	5F5E100	4.85 mV	9.7 mV	Nominal range
0			0	
-100,000,000	FA0A1F00	-4.85 mV	-9.7 mV	
-100,000,001	FA0A1EFF	< -4.85 mV	< -9.7 mV	Underrange
-120,000,000	F8D8F200	-5.82 mV	-11.64 mV	
≤ -120,000,001	≤ F8D8F1FF	< -5.82 mV	< -11.64 mV	Underflow

SIEMENS

SIMATIC

ET 200SP
Analog Input Module AI 4xI 2-/4-wire ST (6ES7134-6GD01-0BA1)

Equipment Manual

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06/2020
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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

Wiring and block diagram has been modified.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

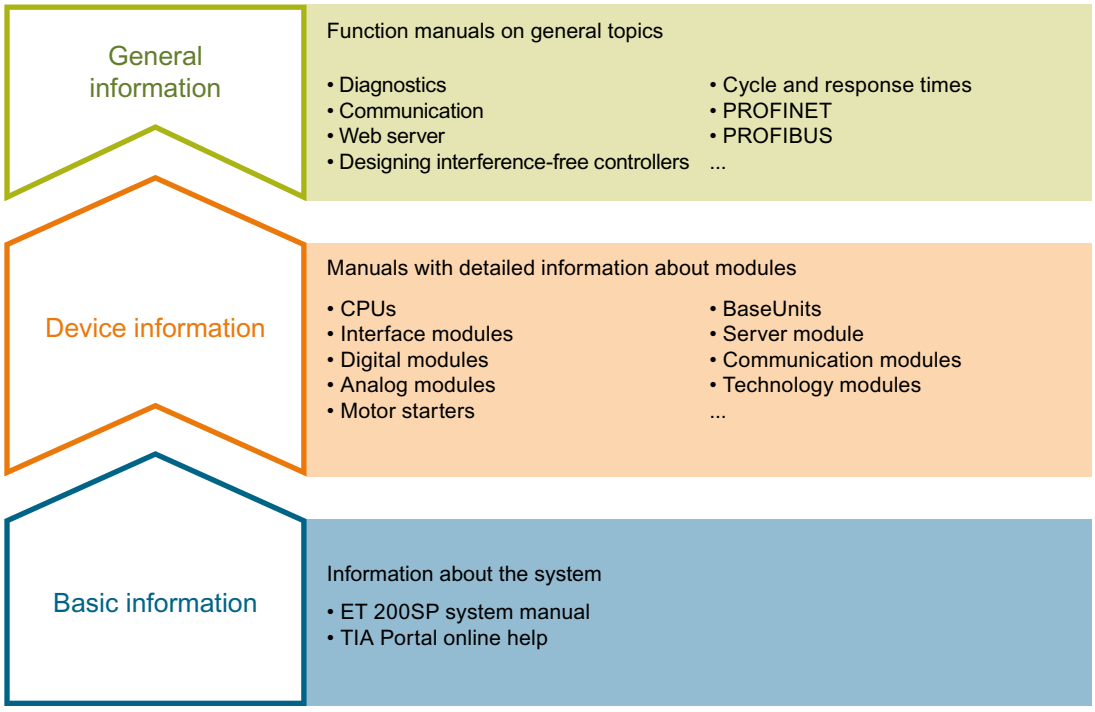

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

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"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://new.siemens.com/global/en/productservices/automation/topics/tia/tia-selection-tool.html).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7134-6GD01-0BA1 (number in pack: 1 unit)

6ES7134-6GD01-2BA1 (number in pack: 10 units)

View of the module

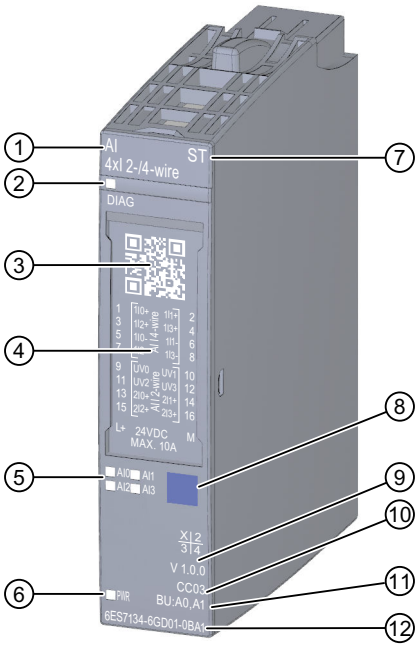

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-584 View of the module AI 4×I 2-/4-wire ST

Properties

The module has the following technical properties:

- Analog input module with 4 inputs
- Current measuring type for 2- and 4-wire transducers adjustable per channel
- Input ranges
  - 4 to 20 mA, resolution 15 bits
  - 0 to 20 mA, resolution 15 bits
  - ±20 mA, resolution 16 bits including sign
- Electrically isolated from the supply voltage L+ (only for input type 4-wire transducer)
- Permitted common mode voltage: 10 V_{SS}
- Configurable diagnostics per module

The module supports the following functions:

Table 2-606 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V2.0.0	V14 or higher with HSP 0239	V5.5 SP3 or higher with HSP 0227 V7.0 or higher	X	X
Identification data I&M0 to I&M3	FS01	V2.0.0	V14 or higher with HSP 0239	V5.5 SP3 or higher with HSP 0227 V7.0 or higher	X	X
Reconfiguration in RUN	FS01	V2.0.0	V14 or higher with HSP 0239	V5.5 SP3 or higher with HSP 0227 V7.0 or higher	X	X
PROFIenergy	FS01	V2.0.0	V14 or higher with HSP 0239	V5.5 SP3 or higher with HSP 0227 V7.0 or higher	X	X
Value status	FS01	V2.0.0	V14 or higher with HSP 0239	V5.5 SP3 or higher with HSP 0227 V7.0 or higher	X	X

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You will find additional information on the accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Wiring up

3

3.1 Wiring and block diagram

This section includes the block diagram of the AI 4xI 2-/4-wire ST module with the various terminal assignments for a 2-wire and 4-wire connection.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

NOTE

You can use and combine the different wiring options for all channels.

NOTE

The load group of the module must begin with a light BaseUnit. Keep this in mind also during the configuration.

Wiring: Current measurement 2-wire and 4-wire connection (2-wire and 4-wire transducer)

The following figure shows the block diagram and an example of the terminal assignment of the analog input module AI 4xI 2-/4-wire ST on the BaseUnit BU type A0/A1.

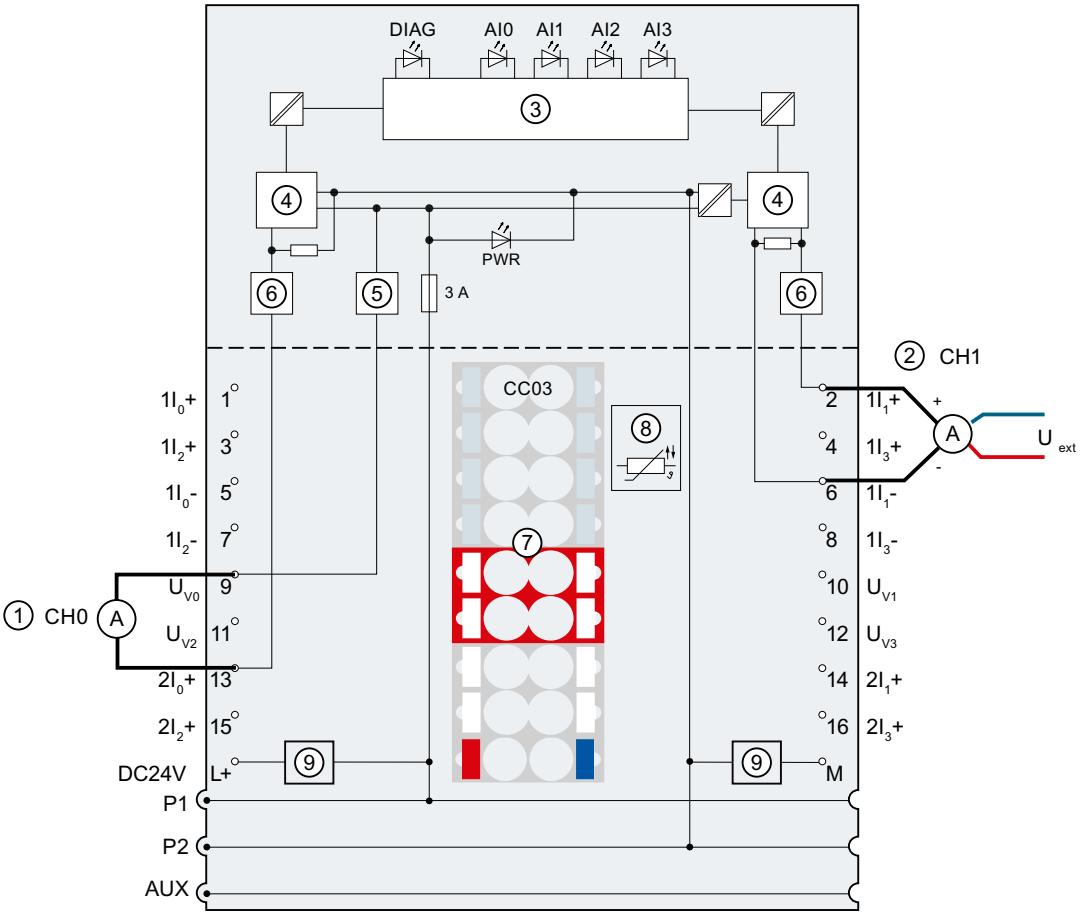

①	2-wire connection for current measurement (2-wire transducer)	$1I_n$+	Current input positive, channel n
②	4-wire connection for current measurement (4-wire transducer)	$1I_n$-	Current input negative, channel n
③	Backplane bus interface	U_{Vn}	Supply voltage, channel n
④	Analog-to-digital converter (ADC)	$2I_n$+	Current input positive, channel n
⑤	Short-circuit protection	L+	24 V DC (infeed only with light BaseUnit)
⑥	Current limitation	M	Ground
⑦	Color-coded label with color code CC03 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark BaseUnit) Connection to left interrupted (light BaseUnit)
⑧	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)
U_{ext}	Encoder supply external	AI0, AI1, AI2, AI3	Channel status LED (green)
		PWR	Power LED (green)

Figure 2-585 Wiring and block diagram for current measurement 2-wire and 4-wire connection (2- and 4-wire transducer)

Parameters/address space

4

4.1 Measuring types and ranges

The analog input module AI 4xI 2-/4-wire ST has the following measuring ranges:

Table 2-607 Measuring ranges

Measuring type	Measuring range	Resolution
Current (2-wire transducer)	0 to 20 mA 4 to 20 mA	15 bits 15 bits
Current (4-wire transducer)	0 to 20 mA 4 to 20 mA ± 20 mA	15 bits 15 bits 16 bits including sign

You will find the tables of the measuring ranges as well as overflow, overrange, etc., in the section Representation of analog values (Page 34).

4.2 Parameters

Parameters of the AI 4xI 2-/4-wire ST

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 29).

The following parameter settings are possible:

Table 2-608 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Configuration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics Short-circuit to ground	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics Overflow	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics Underflow	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics Wire break	• Disable • Enable	Disable	Yes	Module	Module
Measuring type/range	• deactivated • Current (4-wire transducer) 0..20 mA • Current (4-wire transducer) 4..20 mA • Current (4-wire transducer) +/-20 mA • Current (2-wire transducer) 0..20 mA • Current (2-wire transducer) 4..20 mA	Current (4-wire transducer) 4..20 mA	Yes	Channel	Channel
Smoothing	• None • weak • medium • strong	None	Yes	Channel	Channel
Interference frequency suppression [2]	• 60 Hz • 50 Hz[1] • 16.6 Hz	50 Hz	Yes	Channel	Module [3]
Potential group	• Use potential group of the left module (module plugged into a dark BaseUnit) • Enable new potential group (module plugged into light BaseUnit)	Use potential group of the left module	No	Module	Module

1 Interference frequency suppression: Interfering signals at 400 Hz are automatically included in the filtering at 50 Hz.

2 The settings in the "Interference frequency suppression" parameter have a direct effect on the conversion time of the channel. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

3 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. The parameter length of the I/O module is 5 bytes with PROFIBUS GSD configuration. If necessary, you can set this parameter by using the data record 128, see the appendix "Parameter data set".

NOTE

Unused channels

"Disable" unused channels in the parameter assignment to improve the cycle time of the module.

A disabled channel always returns the value $7FFF_H$.

4.3 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics Short-circuit to ground

Enabling of the diagnostics in the event of a short-circuit of the encoder supply to ground or of an input to the encoder supply.

Diagnostics overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics Wire break

Enabling of the diagnostics if the module has no current flow or the current is too weak to be measured at the relevant input.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the wire break diagnostics info is output.

Type/range of measurement

See the section Measuring types and measuring ranges (Page 14).

Smoothing

The individual measured values are smoothed by filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This applies to every signal change at the analog input.

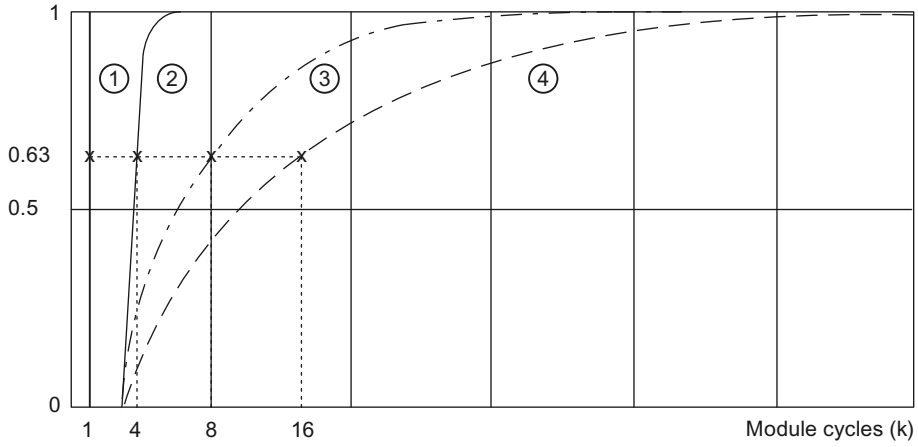

① No smoothing (k = 1)

② Weak (k = 4)

③ Medium (k = 8)

④ Strong (k = 16)

Figure 2-586 Smoothing with AI 4xI 2-/4-wire ST

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network can negatively affect the measured value, in particular when measuring in the low voltage range and with thermocouples. With this parameter, the user specifies the supply frequency that is predominant in the plant.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

4.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 to 3 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: There are no faults/errors on the module.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AI 4×I 2-/4-wire ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

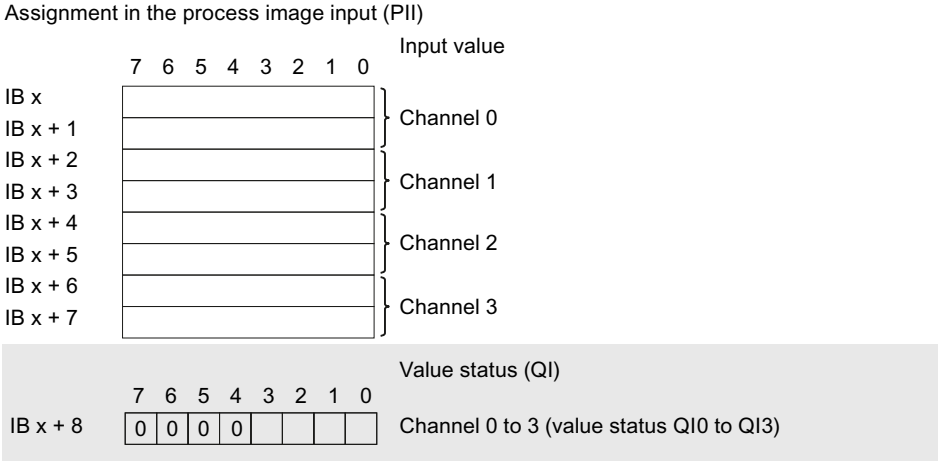

Figure 2-587 Address space of the AI 4×I 2-/4-wire ST with value status

Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays (status and error displays) of the AI 4xI 2-/4-wire ST.

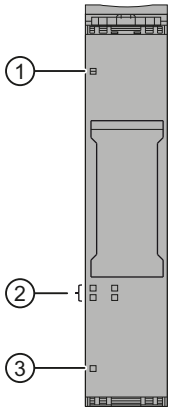

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-588 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 21).

DIAG LED

Table 2-609 DIAG LED fault/error display

DIAG LED	Meaning
☐ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-610 Status display of the channel status LED

Channel status LED	Meaning
☐ Off	Channel disabled
■ On	Channel activated

PWR LED

Table 2-611 Status display of the PWR LED

PWR LED	Meaning
☐ Off	No supply voltage L+
■ On	Supply voltage L+ present

5.2 Interrupts

The analog input module AI 4xI 2-/4-wire ST supports diagnostics interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Channel temporarily unavailable
- Short-circuit (current, 2-wire transducer)
- Wire break (current 4 to 20 mA)
- Low limit violated
- High limit violated
- Error
- Parameter assignment error
- Supply voltage missing

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-612 Diagnostics alarms, their meaning and how to deal with them

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit (2-wire transducer, current)*	1_H	Sensor supply to ground	Correct the module/encoder tuning
		Input to sensor supply	
Wire break (current) **	6_H	Impedance of encoder circuit too high.	Use a different encoder type or modify the wiring, for example, using cables with a larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Disable diagnostics • Connect the sensor contacts
High limit violated	7_H	Value is above the overrange.	Correct the module/encoder tuning
Low limit violated	8_H	Value is below the underrange.	Correct the module/encoder tuning
Error	9_H	Internal module error occurred.	Replace module

* Short-circuit of the encoder supply to ground and/or of the input signal to the encoder supply of a channel can have a temporary effect on other channels (duration < 0.5 s). This means the short-circuit diagnostics can also be reported for unaffected channels and/or the measured value can be affected temporarily.

** In case of activated smoothing the module calculates the measured values across several module cycles. The module only generates the wire break diagnosis if the smoothed measured value is stable. After the wire break has been eliminated, the module supplies stable measured values again depending on the set smoothing level.

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module does not read any process values in this state.	• Wait for firmware update. • Restart the firmware update.

* Short-circuit of the encoder supply to ground and/or of the input signal to the encoder supply of a channel can have a temporary effect on other channels (duration < 0.5 s). This means the short-circuit diagnostics can also be reported for unaffected channels and/or the measured value can be affected temporarily.

** In case of activated smoothing the module calculates the measured values across several module cycles. The module only generates the wire break diagnosis if the smoothed measured value is stable. After the wire break has been eliminated, the module supplies stable measured values again depending on the set smoothing level.

Technical specifications

6

6.1 Technical specifications

Technical specifications of the AI 4×I 2-/4-wire ST

The following table shows the technical specifications as of 06/2020. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7134-6GD01-0BA1/td?dl=en).

Article number	6ES7134-6GD01-0BA1
General information	
Product type designation	AI 4xI 2-/4-wire ST
HW functional status	From FS02
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC03
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Measuring range scalable	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V14 / -
• STEP 7 configurable/integrated as of version	V5.6 and higher
• PCS 7 configurable/integrated as of version	V8.1 SP1
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• Oversampling	No
• MSI	No
CiR – Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	No

Article number	6ES7134-6GD01-0BA1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	37 mA; without sensor supply
24 V encoder supply	
• 24 V	Yes
• Short-circuit protection	Yes
• Output current, max.	20 mA; max. 50 mA per channel for a duration < 10 s
Power loss	
Power loss, typ.	0.85 W; Without encoder supply voltage
Address area	
Address space per module	
• Address space per module, max.	8 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type A0, A1
• 4-wire connection	BU type A0, A1
Analog inputs	
Number of analog inputs	4; Differential inputs
permissible input current for current input (destruction limit), max.	50 mA
Cycle time (all channels), min.	Sum of the basic conversion times and additional processing times (depending on the parameterization of the active channels)
Input ranges (rated values), currents	
• 0 to 20 mA	Yes; 16 bit incl. sign
– Input resistance (0 to 20 mA)	100 Ω; + approx. 0.7 V diode forward voltage in 2-wire operation
• -20 mA to +20 mA	Yes
– Input resistance (-20 mA to +20 mA)	100 Ω
• 4 mA to 20 mA	Yes; 15 bit
– Input resistance (4 mA to 20 mA)	100 Ω; + approx. 0.7 V diode forward voltage in 2-wire operation
Cable length	
• shielded, max.	1 000 m

Article number	6ES7134-6GD01-0BA1
Analog value generation for the inputs	
Measurement principle	integrating (Sigma-Delta)
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz
• Conversion time (per channel)	180 / 60 / 50 ms
Smoothing of measured values	
• Number of smoothing levels	4; None; 4/8/16 times
• parameterizable	Yes
Encoder	
Connection of signal encoders	
• for voltage measurement	No
• for current measurement as 2-wire transducer	Yes
– Burden of 2-wire transmitter, max.	650 Ω
• for current measurement as 4-wire transducer	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %
Temperature error (relative to input range), (+/-)	0.005 %/K
Crosstalk between the inputs, min.	50 dB; Applies to up to ±5 V overvoltage in other channels
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Current, relative to input range, (+/-)	0.5 %
Basic error limit (operational limit at 25 °C)	
• Current, relative to input range, (+/-)	0.3 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	70 dB
• Common mode voltage, max.	10 V
• Common mode interference, min.	90 dB
Interrupts/diagnostics/status information	
Diagnostics function	Yes

Article number	6ES7134-6GD01-0BA1
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	No
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; at 4 to 20 mA
• Short-circuit	Yes; 2-wire mode: Short-circuit of the encoder supply to ground or of an input to the encoder supply
• Group error	Yes
• Overflow/underflow	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green LED
• Channel status display	Yes; green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red LED
Potential separation	
Potential separation channels	
• between the channels	Yes; channel group-specific between 2-wire current input group and 4-wire voltage input group
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes; only for 4-wire transducer
Permissible potential difference	
between the inputs (UCM)	10 V DC
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual

Article number	6ES7134-6GD01-0BA1
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measuring type and measuring range for PROFINET.

Measuring type	Measuring range	Diagnostics				
		No supply voltage L+	Short-circuit to M	Overflow	Underflow	Wire break
deactivated		*	*	*	*	*
Current (4-wire connection)	0..20 mA	x	-	x	x	-
	4..20 mA	x	-	x	x	x
	±20 mA	x	-	x	x	-
Current (2-wire connection)	0..20 mA	x	x	x	x	-
	4..20 mA	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measuring type and measuring range for PROFIBUS.

Measuring type	Measuring range	Diagnostics			
		No supply voltage L+	Short-circuit to M	Overflow/ Underflow	Wire break
deactivated		*	*	*	*
Current (4-wire connection)	0..20 mA	x	-	x	-
	4..20 mA	x	-	x	x
	±20 mA	x	-	x	-
Current (2-wire connection)	0..20 mA	x	x	x	-
	4..20 mA	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can change the parameters of the module in RUN. For example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 contains the diagnostics for the entire module.

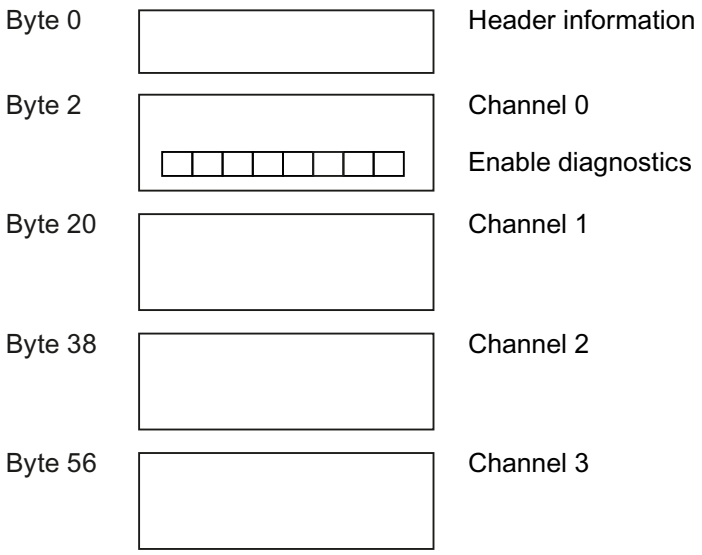

Figure 2-589 Structure of data record 128

Header information

The figure below shows the structure of the header information.

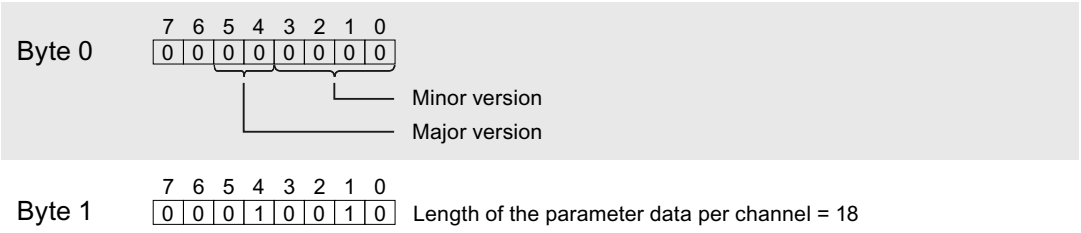

Figure 2-590 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You enable a parameter by setting the corresponding bit to "1".

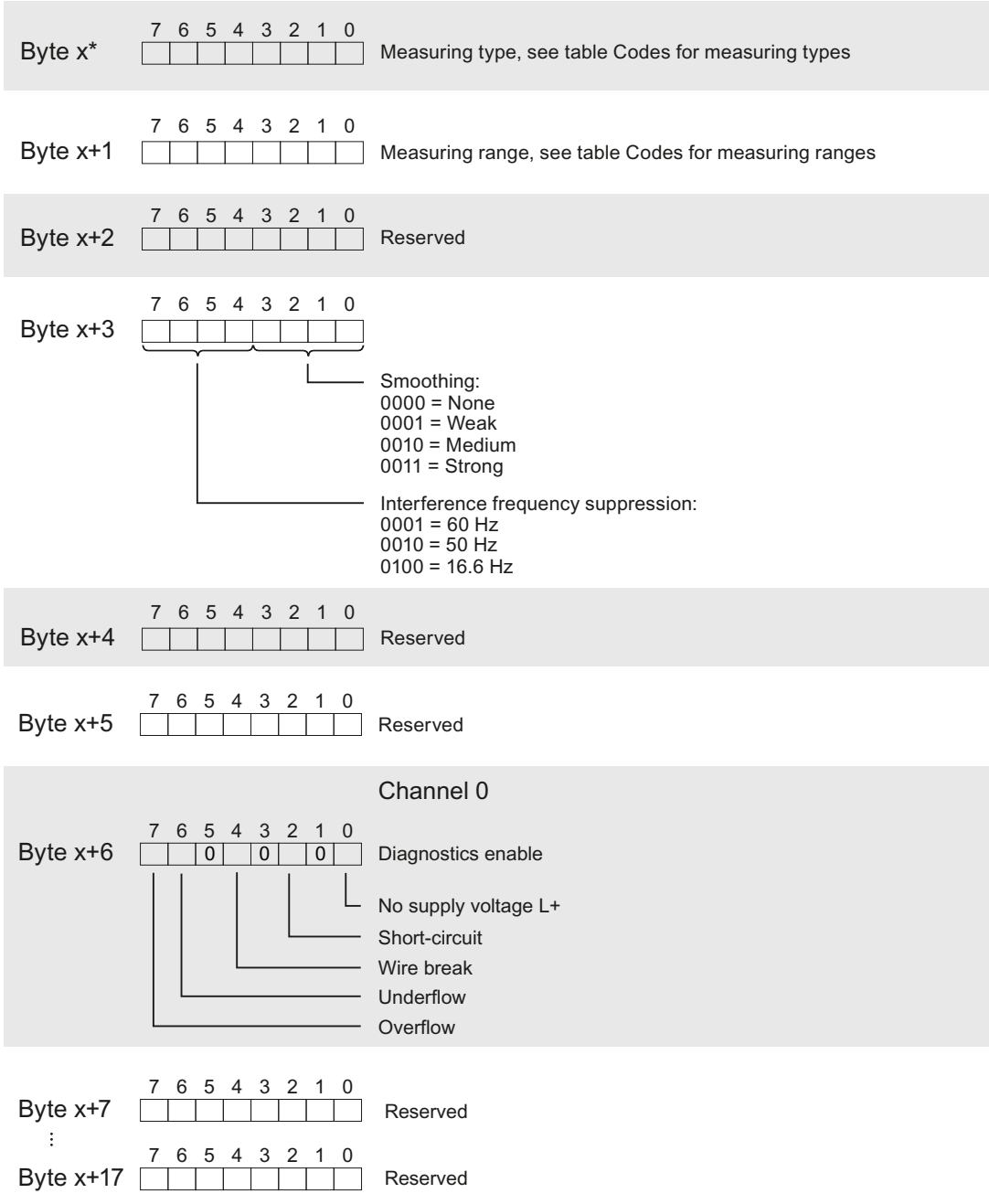

* x = 2 + (channel number × 18); channel number= 0 to 3

Figure 2-591 Structure of byte x to x+17 for channels 0 to 3

Codes for the measuring type

The following table contains the codes for the measuring types of the analog input module. You must enter these codes at byte x (see previous figure).

Table 2-613 Codes for the measuring type

Measuring type	Coding
Deactivated	0000 0000
Current, 4-wire transducer	0000 0010
Current, 2-wire transducer	0000 0011

Codes for the measuring range

The following table contains the codes for the measuring ranges of the analog input module. You enter these codes at byte x+1 (see previous figure).

Table 2-614 Codes for the measuring range

Measuring range	Coding
0 to 20 mA 4 to 20 mA ±20 mA	0000 0010 0000 0011 0000 0100

A.3 Error in transferring the data record analog input

Error transferring the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station to determine whether the module is plugged or pulled. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	E1	01	Reserved bit set	Check the parameters of the module.
DF	80	E1	02	Invalid diagnostics enable bit set for operating mode.	Check the parameters of the module.
DF	80	E1	05	Invalid coding set for measuring range / measurement type.	Check the parameters of the module.
DF	80	E1	08	Invalid coding set for interference frequency suppression / integration time.	Check the parameters of the module.
DF	80	E1	09	Invalid coding for smoothing.	Check the parameters of the module.

Representation of analog values

B

This appendix shows the analog values for all measuring ranges that you can use with the analog module.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its assigned parameters.

The table below shows the representation of binary analog values and of the associated decimal and hexadecimal units of the analog values.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

Table 2-615 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	**Hexadecimal**	**High byte**	**Low byte**
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table 2-616 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 2-617 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table 2-618 Current measuring range ±20 mA

Values		Current measuring range	Range
Dec.	**Hex.**	**±20 mA**	
32767	7FFF	>23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	<-23.52 mA	Underflow

Table 2-619 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		Range
Dec.	**Hex.**	**0 to 20 mA ***	**4 to 20 mA**	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<-3.52 mA	<1.185 mA	Underflow

* For measuring type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

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ET 200SP
Analog Input Module AI 4xI 2-wire 4...20mA HART

Equipment Manual

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Configuring/address space 6

Interrupts/diagnostics alarms 7

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Appendix A

12/2021
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Preface

Validity of the documentation

This manual describes the analog input module AI 4xI 2-wire 4...20mA HART, article number 6ES7134-6TD00-0CA1.

It supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers diverse topics relating to your automation system.

The complete documentation for the ET 200SP system consists of the system manual, function manuals, and manuals for the individual devices.

The STEP 7 information system (online help) also supports you in configuring and programming your automation system.

Overview of documentation for analog input module AI 4xI 2-wire 4...20mA HART

The following table lists further documentation that you will need when using analog input module AI 4xI 2-wire 4...20mA HART.

Table 2-620 Documentation

Topic	Documentation	Most important contents
System description	System Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Commissioning
Analog value processing	Function Manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094)	• Basics of analog technology (wiring, processing, assembly system) • Description/explanation of meaning, e.g., conversion and cycle times, basic error limits, operational limits
System diagnostics	Function manual Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Hardware/software diagnostic evaluation
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)	Technical specifications

SIMATIC manuals

The latest manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

2

2.1 Properties

Article number

6ES7134-6TD00-0CA1

View of the module

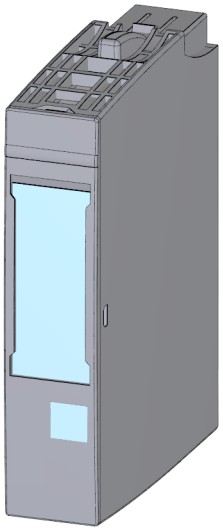

Figure 2-592 View of the AI 4xI 2-wire 4...20mA HART module

Properties

The module has the following technical properties:

- Analog input module with 4 inputs
- Measurement type current for 2-wire HART transducer
- Input range 4 mA to 20 mA
- Resolution 16 bits including sign
- Configurable diagnostics per channel

The module supports the following functions:

- HART communication (Rev. 5 to Rev. 7)
- Firmware update
- I&M identification data
- Configuration in RUN
- Value status (PROFINET IO only)
- Up to four HART variables directly in the input address space

You can configure the module with STEP 7 in the TIA Portal as well as with HW Config and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You will find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring up

3

3.1 Connection and block diagram

The AI 4xI 2-wire 4...20mA HART analog module can be used with all A0 or A1-type BaseUnits.

You connect the transducers to the BaseUnit of the analog module. The infeed of the supply voltage at the light BaseUnit of the associated potential group supplies the module and the transducers connected to the encoder supply voltages.

A new potential group always begins with a light BaseUnit.

BaseUnit

The BaseUnit is not included in the product package of the module and must be ordered separately.

An overview of the BaseUnits that you can use with the analog module can be found in Product information for documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864)

Information regarding selection of the suitable BaseUnit can be found in system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) and in the manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521).

Information regarding wiring of the BaseUnit, creating the cable shield, etc., can be found in system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) in the section "Connecting".

NOTE

The first BaseUnit of a station must be a light BaseUnit. Also keep this in mind during the configuration.

General terminal assignment

	①	Connection of a 2-wire transducer, at channel 0 in this case
	②	Optional connection of an external hand-held (secondary master) to the HART test connection terminal (at channel 0 in this case)
	③	Backplane bus connection
	④	Analog-digital converter (ADC)

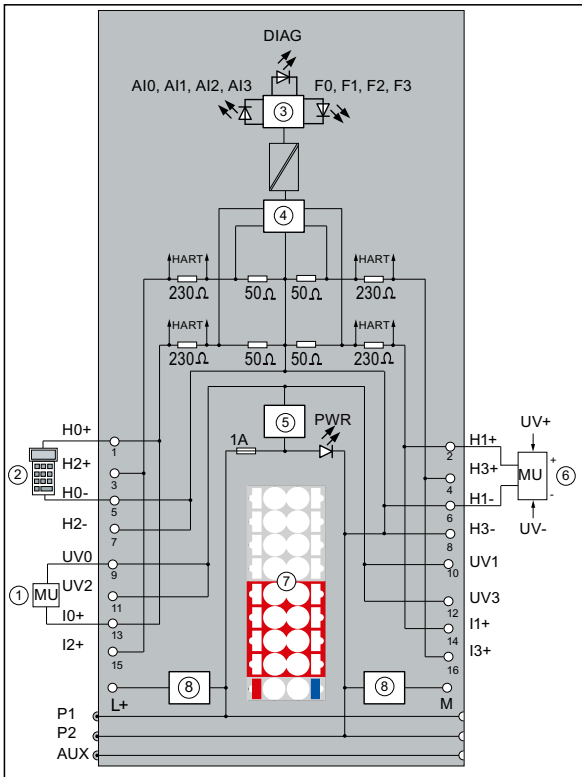

Block diagram AI 4xI 2-wire 4...20mA HART

⑤	Current limitation
⑥	Non-isolated 4-wire connection to the HART test connection terminal (at channel 1 in this case)
⑦	Color-coded label CC03 (optional)
⑧	Filter circuit supply voltage (only available on light-colored BaseUnit)
Hn+	HART signal "+", channel n
Hn-	HART signal "-", channel n
UVn	Supply voltage channel n
In+	Input signal "+" channel n
L+	24 V DC (infeed only with light-colored BaseUnit)
M	Ground
P1,P2, AUX	Internal self-assembling voltage buses Connection to the left (dark-colored BaseUnit) Connection to the right interrupted (light-colored BaseUnit)
DIAG	Diagnostics LED (green, red)
AI0 to AI3	Channel status LED (green)
F0 to F3	Channel fault LED (red)
PWR	Power LED (green)

Supply voltage L+/M

Connect supply voltage (24V DC) to terminals L+ and M. An internal protective circuit protects the analog module from reverse polarity. The analog module monitors the connection of the supply voltage.

HART function

4

Definition

"HART" stands for "Highway Addressable Remote Transducer".

The HART functionality also enables you to use the AI 4xI 2-wire 4...20mA HART analog module to exchange data with the connected field devices. The HART protocol is generally accepted as a standard protocol for communication with intelligent field devices: HART is a registered trademark of the HART Communication Foundation (HCF), which owns all the rights to the HART protocol. You can find detailed information about HART in the HART specification.

Advantages of HART

Using the AI 4xI 2-wire 4...20mA HART analog module offers the following advantages:

- Connection compatibility with standard analog modules: Current loop 4 - 20 mA
- Additional digital communication using the HART protocol
- Numerous field devices with HART functions are in use
- The option to use HART is integrated in the S7 system by means of the AI 4xI 2-wire 4...20mA HART analog module.

Use in the system

The AI 4xI 2-wire 4...20mA HART analog module is used in the distributed I/O connected to PROFIBUS DP or PROFINET IO.

You can connect a field device to any channel: The AI 4xI 2-wire 4...20mA HART analog module operates as a HART master, monodrop; the field devices operate as HART devices.

Typical applications

The following applications are typical:

- Commissioning of field devices (centralized parameter assignment)
- Online modification of field device parameters
- Information, maintenance and diagnostic displays for the field devices
- Integration of configuration tools for field devices via the HART interface

4.1 How HART works

Introduction

The HART protocol describes the physical form of the transfer: transfer procedures, message structure, data formats and commands.

HART signal

The figure below shows the analog signal with the modulated HART signal (FSK method), which consists of sine waves of 1200 Hz and 2200 Hz and has a mean value of 0. It can be filtered out using an input filter so that the original analog signal is available again.

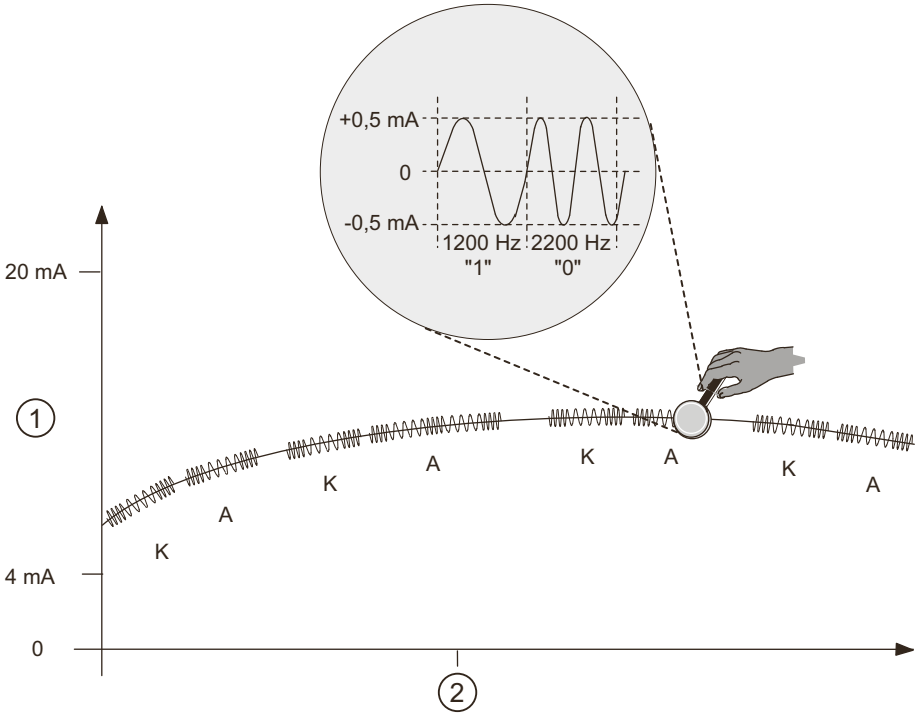

Figure 2-593 The HART signal

1	Analog signal
2	Time (seconds)
K	Command
A	Response

HART communication

The AI 4xI 2-wire 4...20mA HART analog module processes the HART communication in multiplex mode, i.e., consecutively channel-by-channel. As a result, HART commands of the individual channels influence the speed of the HART processing of the other channels.

When HART mode is enabled, the analog module autonomously sends HART commands to the connected field devices. This takes place alternatingly on a channel-specific basis with any pending external HART commands that arrive via the command interface of the module, see section 4.3 "HART command interface".

Commissioning a HART field device

Only HART field devices that are set to the short frame address 0 can be operated. If a HART field device with a different short frame address is connected or a connected field device is reconfigured to a short frame address other than 0 during operation, the module starts a scan of all possible short frame addresses at the next re-establishment of HART communication (command 0 with short frame addresses 1...63). As soon as the connected field device responds, it is converted to the short frame address 0 (HART command 6) by the module. During the scan, the module reports a HART communication error.

HART commands

The assignable properties of the HART field devices (HART parameters) can be set with HART commands and read by means of HART replies. The HART commands and their parameters are divided into three groups with the following properties:

- Universal
- Common practice
- Device-specific

Universal commands must be supported by all manufacturers of HART field devices and common practice commands should be supported. There are also device-specific commands that apply only to the particular field device.

Examples of HART commands

The following two tables show examples of HART commands:

Table 2-621 Examples of universal commands

Command	Function
0	Read manufacturer and device type - only with this command 0 can field devices be addressed by means of a short frame address
11	Read manufacturer and device type
1	Read primary variable and unit

2	Read current output and percent of range, digitally as floating-point number (IEEE 754)
3	Read up to four pre-defined dynamic variables (primary variables, secondary variables, etc.)
13, 18	Read or write tag, descriptor and date (data included in transmission)

Table 2-622 Examples of common practice commands

Command	Function
36	Set upper range value
37	Set lower range value
41	Perform self-test
43	Set the primary variable to zero
109	Switch burst mode on or off

Structure of the HART protocol

Each HART frame sent from the analog module to the connected field device (request frame) and each HART frame from the field device (response frame) has the following basic structure.

PREAMBLE	STRT	ADDR	COM	BCNT	STATUS	DATA	CHK

PREAMBLE: Bytes (0xFF) for synchronizing.
5 to 20 bytes depending on parameter assignment

STRT: Start character (start delimiter)

ADDR: Address of the field device (1 byte; short address or 5 bytes; long address)

COM: HART command number

BCNT: Byte count, number of bytes to follow without checksum

STATUS: HART device status (1st and 2nd status byte). Only present for a response frame. For structure of HART device status, see below.

DATA: Transferred user data / parameters, quantity depending on command (0...230 bytes)

CHK: Checksum

With the exception of the preamble bytes, this structure is contained in the communication data of the HART command interface. See section HART request and response data records (Page 54).

HART replies always contain data. Status information (HART device status; 1st and 2nd status bytes) is always sent together with a HART response. You should evaluate these to make sure the response is correct.

Structure of HART device status (1st and 2nd status bytes).

Table 2-623 1st status byte

When Bit 7 = 1: "Communication error"	
Bit 6 = 1 Bit 5 = 1 Bit 4 = 1 Bit 3 = 1 Bit 2 = 0 Bit 1 = 1 Bit 0 = 0	Parity error Overflow Framing error Checksum error Reserved Overflow in the receive buffer Reserved
When bit 7 = 0: "Specific in line with response frame"	

Table 2-624 2nd status byte

Bit 7 = 1 Bit 6 = 1 Bit 5 = 1 Bit 4 = 1 Bit 3 = 1 Bit 2 = 1 Bit 1 = 1 Bit 0 = 1	Device fault Configuration changed Startup (cold start) Additional status information available Fixed analog output current setting Analog output current saturated Secondary variable outside the limits Primary variable outside the range

HART-Fast-Mode

The AI 4xI 2-wire 4...20mA HART analog module supports the processing of HART commands as a SHC sequence ("Successive HART Command").
That is, if the analog module detects a HART command with SHC bit set for a channel, the complete HART command processing on the HART analog module is reserved for this channel for approximately 2 s. For all other channels of the analog module, no HART frame processing occurs during this time, see section HART communication interface (Page 18)

NOTE

- During the time a HART channel of the AI 4xI 2-wire 4...20mA HART analog module is processing an SHC sequence, and thus the complete HART processing of the module is reserved for this channel, the HART variables of all HART channels are no longer updated. They remain unchanged in terms of value and quality code.
- HART commands for other channels are not processed and are acknowledged correspondingly.

Burst mode

The AI 4xI 2-wire 4...20mA HART analog module does not support burst mode. HART commands with set burst bit are ignored and are not forwarded to the connected field device.

4.2 Use of HART

System environment for the use of HART

To use an intelligent field device with HART functionality, you require the following system environment:

- Current loop 4 - 20 mA

  Connection of the transducers to the AI 4xI 2-wire 4...20mA HART analog module

- HART configuration tool "Client":
  You can assign the HART parameters using an external hand-held operating device (HART Handheld) or a HART configuration tool (PDM). Both assume the function of a "client":

  The configuration tool goes through the AI 4xI 2-wire 4...20mA HART analog module whereas the HART Handheld is connected directly in parallel with the field device. See terminal assignment "HART test connections (terminals 1 to 8)" in the section 3.1 "Terminal assignment".

  PDM (Process Device Manager) is available as a stand-alone unit or integrated in *STEP 7 HW Config*.

- HART system connection:
  The AI 4xI 2-wire 4...20mA HART analog module assumes the function of a "master" by forwarding the commands received from the HART configuration tool or as programmed commands from an S7 user program, for example, to the intelligent field device and sending back the replies. Data records that are transferred via the ET 200SP I/O bus serve as the interface of the AI 4xI 2-wire 4...20mA HART analog module. The data records must be created and interpreted by the client. .

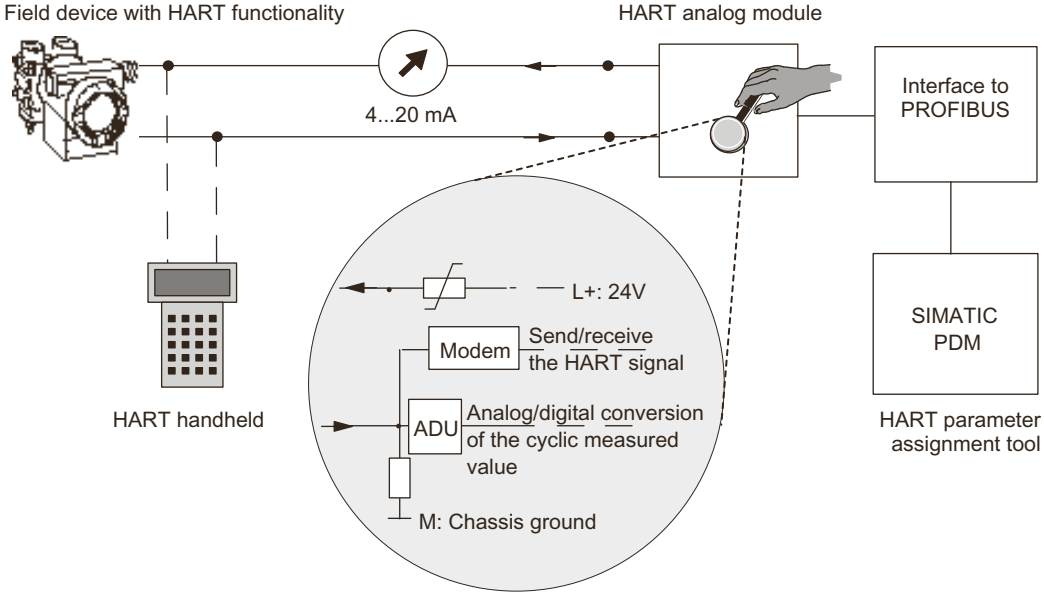

Figure 2-594 System environment for the use of HART

Error management

The two HART status bytes (HART device status) that are transferred with each response of the field device contain error information about the HART communication, HART command, and device status.
This is evaluated by the AI 4xI 2-wire 4...20mA HART analog module and made available in the system via S7 diagnostic messages.

Configuration/commissioning

You configure the AI 4xI 2-wire 4...20mA HART analog module in the SIMATIC system with STEP 7 or the TIA Portal. You assign parameters for the individual channels with respect to the actual analog value acquisition and the use of HART variables in the input address space of the module.
You can configure one field device per channel. By means of this configured field device, the configuration / parameter assignment of the connected field device is then carried out using PDM or the EDD for the ET 200SP.

It is also possible to configure the AI 4xI 2-wire 4...20mA HART analog module using a GSD file for PROFIBUS DP and PROFINET IO. However, in this case, direct configuration / parameter assignment of the connected field devices is not possible.

Parameter reassignment of the field devices

The HART analog module generally accepts parameter reassignments for field devices. Access rights can only be allocated in the configuration tool.

For parameter reassignment of the field devices connected to the HART analog module, proceed as follows:

1. You start the parameter reassignment of a field device using a HART command that you enter using the SIMATIC PDM configuration tool or as a programmed command in the STEP 7 user program.
2. After you have reassigned the parameters of a HART field device, the corresponding bit is set in the device status of the connected field device (in the 2nd status byte).
3. Because of the parameter reassignment of the field device, the HART analog module triggers a diagnostic interrupt "Configuration changed", provided this diagnostic interrupts is enabled. See section 7.3 "Diagnostic alarms". This diagnostic interrupt is to be regarded as information and not as an error and is automatically deleted again by the analog module after approximately 1 minute.

A diagnostic interrupt can also be triggered, if enabled, when parameter reassignment is carried out with the hand-held device.

See also

Connection and block diagram (Page 9)
Diagnostics alarms (Page 34)

4.3 HART communication interface

Data records

The HART commands are sent as so-called external HART requests from the client (e.g., PDM or the STEP 7 user program) to the connected field device via data records. The response of the field device is made available again in the system via data records.

HART communication may only be handled by one client (e.g., PDM) per channel. If a channel is handled by several clients, the response made available by the module cannot be allocated to one client with certainty. The AI 4xI 2-wire 4...20mA HART analog module does not support client management.

Each client/channel is allocated fixed data records:

Table 2-625 Structure of the data records

Channel	Data record number	
	Request to the field device	Response from the field device
0	80	81
1	82	83
2	84	85
3	86	87

The corresponding data records are transferred to the module with the "WRREC" instruction and read by the module with the "RDREC" instruction.

Errors during the transfer are indicated at output parameter STATUS.

Errors during interpretation of the request data record are signaled in the corresponding response data record. The faulty request can be read back again using the request data record.

Rules

- After having written a request data record, a client must read the response data record before it may write another request data record.
- The client can evaluate the "processing status" in the response data record: If the "processing status" indicates "successful" or "error," the response data record contains current response data or error displays.
- The response data record must always be read completely because the analog module may modify the data record after the initial reading with "successful" or "error" status. If the processing status in the response data record indicates "successful" or "error", the data record contains current response data or error displays.

- The client may only write a request data record to the module again when it has read the response to the previously written request data record via the corresponding response data record. Otherwise, the response from the module is overwritten.
- The STATUS component in the response frame (HART device status in the response data) provides information on whether errors have occurred and, if so, which errors.

Each request is stored on a channel-specific basis, and the corresponding request data record is disabled. Another writing of the same request data record is thus not possible and is acknowledged with BUSY.
The disable of the request data record is reset after the termination or completion of the requested HART command.

SHC sequence

If a HART command is sent to the module with a set SHC bit, then this channel is reserved for HART commands for 2 seconds. This means that no more internal HART commands are sent to the field device with this channel.

Each time a HART command with a set SHC bit is sent, the module reserves this channel again for another 2 seconds for HART commands. If a HART command without a set SHC bit is detected for this channel, or if no further command occurs for this channel within 2 seconds after the previous HART command, then command 3 or 9 for reading the HART variables is cyclically sent to the field device for this channel.

4.4 HART variables

Introduction

Numerous HART field devices make available additional measured quantities (e.g. sensor temperature).

A maximum of four HART variables supported by the connected field device can be cyclically read per channel with activated HART functionality. The HART variables are read automatically with HART command 3 (for field devices with HART rev. 5 and 6) or with command 9 (for field devices with HART rev. 7 or later).

These four HART variables per channel are always stored in HART variable data record 121 and can be read at any time. See section HART variable data record (Page 52).

In addition, a maximum of 4 HART variables can be configured directly in the input address space of the AI 4xI 2-wire 4...20mA HART analog module. The HART variables are assigned to a channel in the properties dialog of the module. The parameter assignment uses parameter data record 140, see section AUTOHOTSPOT. This makes it easy for you to process measured values directly from the field device as input data in the automation device.

Address assignment

Provided you map HART variables in the input address space of the module by means of the configuration tool or selection of the appropriate configuration, 20 bytes are always additionally allocated for the HART variables.

Configuration of HART variables

You can configure up to 4 HART variables for each channel

- PV (Primary Variable)
- SV (Secondary Variable)
- TV (Tertiary Variable)
- QV (Quaternary)

When HART mode is enabled, the AI 4xI 2-wire 4...20mA HART analog module autonomously and cyclically reads the variables supplied by the connected field devices and makes them available in the input address space according to the configuration.

Each HART variable consists of a 4-byte value and a quality code byte.

Quality code

The quality code describes the process status of the corresponding HART variable.

Basic structure of the quality code

Bit	7....6	5....2	1...0
	Quality 0 0: Bad 0 1: Uncertain 1 0: Good 1 1: Good	Sub-status Coded according to "PROFIBUS PA Profile for Process Control Devices"	Limits 0 0: OK 0 1: Low limit 1 0: High limit 1 1: Constant

The quality codes generated by the AI 4xI 2-wire 4...20mA HART analog module are based on the HART Revision of the utilized field device.

Field devices with HART Revision 5 and 6

The quality code is formed exclusively from the 1st and 2nd Status byte (HART device status) of the response frames (HART command 3).

Quality code	Meaning (process status)	
80_H	Value is okay	Applies even when the following bits are set in the 2nd status byte of the HART response frame: • Configuration changed • Startup (cold start) • Fixed analog output current setting

Quality code	Meaning (process status)	
78_H	Value is uncertain	Applies even when the following bits are set in the 2nd status byte of the HART response frame: • Additional status information available • Analog output current saturated • Secondary variable outside the limits • Primary variable outside the range
84_H	Response code RC8: Update error	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	After module startup
00_H	Initialization value from S7 system	

Field devices with HART Revision 7 or higher

The quality code is formed from the 1st status byte (HART device status) and the "Device variable status" (DVS) of the response frames (HART command 9).

Quality code	Meaning (process status)	
80_H	Value is okay	
89_H	"Good" with "Low limit"	Process status, formed from the "Device variable status" (DVS) of the response frames with corresponding limits (see above).
$8A_H$	"Good" with "High limit"	
$28_{H...}2B_H$	"Bad"	
$68_{H...}6B_H$	"Poor accuracy"	
$78_{H...}7B_H$	"Manual" or "Fixed" (manually controlled or fixed value)	
$88_{H...}8B_H$	"More device variable state available" (additional status information available)	
84_H	Response code RC8: Update error	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	After module startup
40_H	Read alternatively via command 3	
00_H	Initialization value from S7 system	

Parameters 5

5.1 Parameters of the AI 4xI 2-wire 4...20mA HART

You specify how the AI 4xI 2-wire 4...20mA HART analog module operates using parameters.

The parameters are subdivided into:

- Channel or technology parameters (data record 128)

  With PROFIBUS DP GSD configuration, there is a reduced configuration via the startup configuration (Prm frame).
- Parameters that define the display of HART variables in the address space of the module; HART mapping parameters (data record 140)

With configuration in the user program, the parameters are transferred to the modules via data records with the "WRREC" instruction; see section Parameter assignment and structure of the channel/technology parameters (Page 47).

5.1.1 Channel/technology parameters

Parameters of the AI 4xI 2-/4-wire ST

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

Table 2-626 Configurable channel/technology parameters and their default settings

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics encoder supply	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics overflow	• Disable • Enable	Disable	Yes	Channel	Module [2]

1 Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

2 Because the PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes per ET 200SP station, the options for parameter assignment are limited. In this case, the parameter assignment uses data record 245. If required, you can assign this parameter using data record 128 as described in the "GSD File PROFINET IO" column (see table above).

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics underflow	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics wire break	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics HART	• Disable • Enable	Disable	Yes	Channel	Module [2]
Measuring type/range	• Disabled • Current (2-wire transducer) 4..20 mA • Current (2-wire transducer) 4..20 mA HART	Current (2-wire transducer) 4..20 mA HART	Yes	Channel	Channel
Smoothing	• none • 4-fold (weak) • 16-fold (medium) • 32-fold (strong)	none	Yes	Channel	Channel
Interference frequency suppression	• 60 Hz (integration time 16.6 ms) • 50 Hz [1] (integration time 20 ms) • 10 Hz (integration time 100 ms)	50 Hz	Yes	Channel	Module [2]
Current limit for wire break diagnostics	• 1.185 mA • 3.6 mA	1.185 mA	Yes	Channel	Cannot be changed[2]
Number of HART preamble bytes	5...20	5	Yes	Channel	Cannot be changed[2]
Number of HART repetitions	0...255	5	Yes	Channel	Cannot be changed[2]
Potential group	• Use potential group of the left module • Allow new potential group	Use potential group of the left module	No	Module	Module

1 Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

2 Because the PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes per ET 200SP station, the options for parameter assignment are limited. In this case, the parameter assignment uses data record 245. If required, you can assign this parameter using data record 128 as described in the "GSD File PROFINET IO" column (see table above).

NOTE

Unused channels

"Disable" unused channels in the parameter assignment to improve the cycle time of the module.

A disabled channel always supplies the analog value $7FFF_H$.

See also

Parameter assignment and structure of the channel/technology parameters (Page 47)

5.1.2 Explanation of the channel/technology parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics encoder supply

Enabling of the diagnostics in the event of a short-circuit of the encoder supply to ground or of an input to the encoder supply.

The short-circuit and underflow diagnostics can be enabled simultaneously. If both diagnostic events occur simultaneously, the short-circuit diagnostics information is output.

Diagnostics overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics underflow

Enabling of the diagnostics when the measured value falls below the underrange.

Diagnostics wire break

Enabling of the diagnostics when the module has no current flow at the input or the current flow at the input is below the configured wire break limit.

The wire break and underflow diagnostics can be activated simultaneously. If both diagnostics events occur simultaneously, the wire break diagnostics information is output.

Diagnostics HART

Enabling of the diagnostics of the HART frame-specific monitoring and the status information supplied by the connected field device in the HART frame (HART device status).

Current limit for wire break diagnostics

You use this to specify the current limit for detecting wire breaks. If the current falls below the configured wire break limit, the measured value is declared invalid and, if wire break diagnostics is enabled, corresponding diagnostics information is generated. When value status is configured, the analog value is marked as invalid.

With a wire break limit of 3.6 mA, the measured value becomes invalid when the current falls below 3.6 mA and is marked as valid again when it rises above 3.8 mA.

There is no hysteresis for a wire break limit of 1.185 mA.

Measuring type/range

The AI 4xI 2-wire 4...20mA HART analog input module has the following measuring ranges:

Table 2-627 Measuring ranges

Measuring type	Measuring range	Resolution
Disabled	-	-
Current (2-wire transducer)	4 to 20 mA	15 bits + sign
Current (2-wire transducer)	4 to 20 mA HART	15 bits + sign

An overview of the measuring range as well as overflow, overrange, etc., can be found in the section Analog value representation (Page 60) and in Analog Value Processing function manual.

Smoothing

The individual measured values are smoothed by filtering. Smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This applies to every signal change at the analog input.

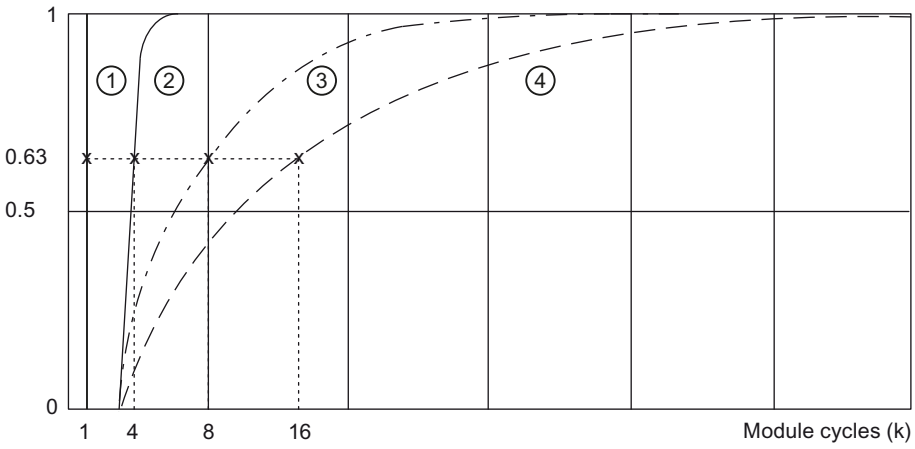

① No smoothing (k = 1)

② Weak (k = 4)

③ Medium (k = 8)

④ Strong (k = 16)

Figure 2-595 Smoothing of the analog value

Interference frequency suppression

Suppresses the interference affecting analog input modules that is caused by the frequency of the AC voltage network used.

The frequency of the AC supply system may interfere with the measured value, in particular in low voltage ranges. .

Number of HART preamble bytes

Specifies the number of preamble bytes that the module prefixes to each HART frame to be sent (FF_H). These bytes are used for synchronizing the frames.

Number of HART repetitions

Specifies the number of HART frame repetitions. If the analog module receives no response or receives a response with error to a HART frame sent to the field device, the frame is accordingly repeated, i.e., resent to the field device.

Because HART communication of the individual channels uses multiplex operation, faulty HART frames affect the other channels when the number of HART repetitions is high. In other words, the other channels are processed less frequently.

Potential group

Specifies that a BaseUnit with supply voltage infeed is located in this slot (see system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)).

See also

Parameters of the AI 4xI 2-wire 4...20mA HART (Page 22)

5.1.3 HART mapping parameters

The HART mapping parameters allow a maximum of 4 HART variables to be configured (mapped) in the address space of the module.

Each HART variable occupies 5 bytes of input data. As soon as you configure (map) at least one HART variable in the input address space, the addresses for all four variables are occupied (20 bytes).

With PROFIBUS DP GSD configuration with HART variables, the HART variables cannot be directly configured. The four secondary variables are supplied in ascending channel order in the address space of the module.
When required, this can be changed using data record 140; see section AUTOHOTSPOT.

Parameters

Table 2-628 Configurable HART mapping parameters

Parameter		Value range	Default	Configuration in RUN	With GSD file PROFIBUS DP
Variable 0	Channel	0...3	0	Yes	0
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quartenary	Non / Cir	Yes	Secondary
Variable 1	Channel	0...3	0	Yes	1
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quartenary	Non / Cir	Yes	Secondary

Parameter		Value range	Default	Configuration in RUN	With GSD file PROFIBUS DP
Variable 2	Channel	0...3	0	Yes	2
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quartenary	Non / Cir	Yes	Secondary
Variable 3	Channel	0...3	0	Yes	3
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quartenary	Non / Cir	Yes	Secondary

Configuring/address space

6

6.1 Configuring

You configure the analog module AI 4xI 2-wire 4...20mA HART

- In the TIA Portal V13.0.1 or higher
- With STEP 7 V5.5 + SP4 or higher (HSP0263)
- Using GSD/GSDML

The GSD files for the ET 200SP Distributed I/O System can be downloaded from the Internet:

- GSDML (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD (http://support.automation.siemens.com/WW/view/en/ 73016883)

Configuration options

The following configurations are possible:

- Without value status and without HART variables ("AI 4xI 2-wire 4...20 mA HART")
- Without value status, with HART variables ("AI 4xI 2-wire 4...20 mA HART, 4 variables")
- With value status and without HART variables ("AI 4xI 2-wire 4...20 mA HART, QI")
- With value status, with HART variables ("AI 4xI 2-wire 4...20 mA HART, 4 variables, QI")

With GSD/GSDML configuration, you must select one of the possible configurations directly.

The configuration for STEP 7 (TIA Portal or HW Config) is made indirectly via the parameters.

Restrictions

- Value status is not available for a PROFIBUS DP station.
- Downstream of a Standard IM (V1.1), the module can be operated only in the "Without value status and without HART variables" configuration.
- TIA Portal:
  - The module behind a standard IM (V1.1) is not available.
  - TIA Portal as of V14.0.1
    The module can be centrally configured on the following CPU:
    - CPU 1510SP-1 (as of V2.1)
    - CPU 1512SP-1 PN (as of V2.1)
  - TIA Portal as of V15.0.0
    The module can be configured as an open controller.
  - The module cannot be used behind fail-safe controllers.

6.2 Address space

The following figure shows the allocation of the address space of the AI 4xI 2-wire 4...20mA HART module for a configuration with value status (Quality Information, QI) and with HART variables.

The addresses for the value status are only available if the value status has been enabled or the corresponding configuration has been configured from the GSDML.

The addresses for the HART variables are only available if configuration/parameter assignment of the HART variables has been carried out or the corresponding configuration has been configured from the GSD/GSDML.

If the HART variables are configured and there is no value status configuration or parameter assignment, the HART variables begin directly after the analog values, thus starting from IB x + 8.

Table 2-629 Address space of analog input module AI 4xI 2-wire 4...20mA HART

Assignment in the process image input (PII)

	7	6	5	4	3	2	1	0	Input value
IB x									Channel 0
IB x + 1									
IB x + 2									Channel 1
IB x + 3									
IB x + 4									Channel 2
IB x + 5									
IB x + 6									Channel 3
IB x + 7									

	7	6	5	4	3	2	1	0	Value status (QI)
IB x + 8	0	0	0	0					Channel 0 to 3 (value status QI0 to QI3)

IB x+9 .... IB x+12	Value	Configured HART variable 0
IB x+13	Quality code	
IB x+14 .... IB x+17	Value	Configured HART variable 1
IB x+18	Quality code	
IB x+19 .... IB x+22	Value	Configured HART variable 2
IB x+23	Quality code	
IB x+24 .... IB x+27	Value	Configured HART variable 3
IB x+28	Quality code	

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 to 3 in this byte are assigned to the corresponding channel. The provide information about the validity of the analog value, namely irrespective of the diagnostics enables.

Bit = 1: There is no error in the analog value or the analog value acquisition of the channel.

Bit = 0: The analog value of the channel cannot be correctly acquired.
The channel is disabled; there is a fault in the wiring or module.

Evaluating HART variables

If you have configured (mapped) HART variables for the analog module, four HART variables with 5 bytes each are stored in the input address space.

Each HART variable consists of a 4-byte real value and a quality code byte. The quality code describes the validity of the value; see section HART variables (Page 19) .

Interrupts/diagnostics alarms

7

7.1 Status and error displays

LED displays

The figure below shows the status and error displays of the AI 4xI 2-wire 4...20mA HART analog input module.

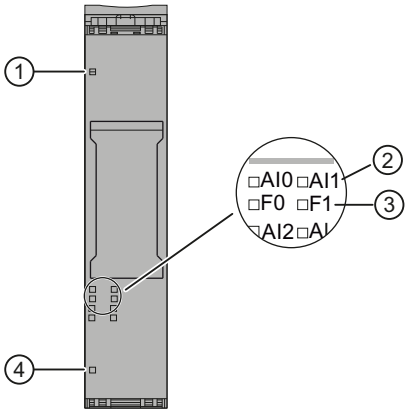

① DIAG (green/red)

② Channel status (green)

③ Channel fault (red)

④ PWR (green)

Figure 2-596 LED displays

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostic alarms can be found in the section Diagnostics alarms (Page 34).

Table 2-630 Status display of the channel status/channel fault LEDs

LEDs		Meaning
Channel status	**Channel fault**	
□ Off	□ Off	Channel disabled or module switched off
■ On	□ Off	Channel enabled and no channel diagnostics present
□ Off	■ On	Channel enabled and channel diagnostics present
■ On	■ On	Channel enabled and **only** HART channel diagnostics present

Table 2-631 DIAG LED error display

DIAG LED	Meaning
□ Off	Backplane bus supply of the ET 200SP is not OK or switched off
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics, at least one error is currently present

Table 2-632 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

7.2 Interrupts

The AI 4xI 2-wire 4...20mA HART analog input module supports diagnostic interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt for the following events:

- Channel/component temporarily unavailable
- Short-circuit / Overload of encoder voltage
- Wire break
- Low limit violated
- High limit violated
- Error
- No supply voltage L+
- HART communication error or HART field device error

7.3 Diagnostics alarms

A diagnostic alarm is generated for each detected diagnostic event. The DIAG LED flashes on the module.

There is additionally a channel-specific display of the diagnostics through the corresponding channel fault/channel status LEDs.

The diagnostic alarms can, for example, be read from the diagnostic buffer of the CPU or be displayed in STEP 7 using the Online and Diagnostics view. You can evaluate the error codes with the user program.

Table 2-633 Diagnostic alarms, their meaning and how to deal with them

Diagnostic alarm	Error code	Meaning	Remedy
Channel/component temporarily unavailable	$1F_H$	• Update of the firmware is being performed or has been canceled. The module does not perform any measurements during this time.	
Short-circuit/overload at external encoder supply *	$10E_H$	• Short-circuit of the encoder supply to M • Short-circuit of the input to the encoder supply • Overload of the encoder supply	• Correct the module/encoder tuning
Wire break	6_H	• Impedance of encoder circuit too high. • Wire break between the module and sensor • Channel not connected (open)	• Use a different encoder type or modify the wiring, for example, using cables with a larger cross-section • Connect the cable • Disable diagnostics • Connect the sensor contacts

* Short-circuit of the encoder supply to ground and/or of the input signal to the encoder supply of a channel can have a temporary effect on other channels (duration < 0.5 s). This means the short-circuit diagnostic information can also be signaled on unaffected channels and/or the measured value can be affected temporarily.

Diagnostic alarm	Error code	Meaning	Remedy
High limit violated	7_H	• The analog value is above the over-range.	• Correct the module/encoder tuning
Low limit violated	8_H	• The analog value is below the under-range.	• Correct the module/encoder tuning
Error	9_H	• Internal module error occurred.	• Replace module
No supply voltage	11_H	• No or insufficient supply voltage L+	• Check wiring of the supply voltage L+ on the BaseUnit • Check BaseUnit type
HART communication error	141_H	• HART field device is not responding • Timing error • HART field device has not understood the sent command (1st status byte)	• Check the process wiring • Correct the parameter assignment • Set output current of ≥4 mA • Increase the number of assigned repetitions
HART primary variable outside range	142_H	• Incorrect parameters in the HART field device • HART field device is at "Primary variable outside the limits" in simulation mode • Incorrect measuring point • Primary variable assigned outside the limits	• Check the parameter assignment of the HART device • Correct the simulation • Check whether the correct transducer is connected
HART output current of the field device saturated	143_H	The output current of the HART field device is saturated: • Incorrect parameters in the HART field device • HART field device is set to a measured value that is too high in simulation mode • Incorrect measuring point	
HART output current of the field device specified	144_H	The output current of the HART field device is set to a fixed value: • Incorrect parameters in the HART field device • HART field device is set to a measured value that is too high in simulation mode • Incorrect measuring point	
HART secondary variable outside the limits	149_H	• Incorrect parameters in the HART field device • HART field device is at "Non-primary variable outside the limits" in simulation mode • Incorrect measuring point • Non-primary variable assigned outside the limits	

* Short-circuit of the encoder supply to ground and/or of the input signal to the encoder supply of a channel can have a temporary effect on other channels (duration < 0.5 s). This means the short-circuit diagnostic information can also be signaled on unaffected channels and/or the measured value can be affected temporarily.

Diagnostic alarm	Error code	Meaning	Remedy
HART - more status available	145_H	• The identifier for "Additional status information available" of the HART field device was set in the HART device status (in the 2nd status byte).	• Read status using HART command 48 and eliminate error/cause, if necessary
HART configuration changed (reset again automatically by the module after approximately 1 minute)	146_H	• The identifier for "Parameter reassignment" of the HART field device was set in the HART device status (in the 2nd status byte).	• If you do not want a diagnostic interrupt to be triggered for parameter reassignment, the diagnostic interrupt must not be enabled.
HART malfunction in field device	147_H	• The field device signals a malfunction in the HART device status (in the 2nd status byte)	• Read status using HART command 48 and eliminate error/cause, if necessary • Replace the field device

* Short-circuit of the encoder supply to ground and/or of the input signal to the encoder supply of a channel can have a temporary effect on other channels (duration < 0.5 s). This means the short-circuit diagnostic information can also be signaled on unaffected channels and/or the measured value can be affected temporarily.

Technical specifications 8

8.1 Standards and Approvals

8.1.1 Currently valid markings and approvals

Introduction

This section contains the technical specifications of the system:

- The standards and test values that the module complies with and fulfills.
- The test criteria according to which the module was tested.

Safety information

WARNING

Explosion hazard

If the electric circuit is live, the following must be observed:

- Do not disconnect the device in a flammable or combustible atmosphere.
- Do not open the enclosure in a flammable or combustible atmosphere.

WARNING

Area of application

This device is intended for use only in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC environments or non-hazardous locations.

WARNING

Environmental conditions

The device may only be used in areas with a pollution degree of not more than 2 according to IEC 60664-1.

WARNING

Enclosure and cables

The device is intended for installation in an enclosure / control cabinet. The internal operating temperature of the enclosure / control cabinet corresponds to the maximum permissible ambient temperature of the module.

Cables must be used whose maximum permissible operating temperature is at least 30 °C above the maximum permissible ambient temperature.

WARNING

Ambient temperature of the device

The temperature of the device housing may be higher than 70 °C if the device is operated at an ambient temperature of more than 50 °C. The device must therefore be installed so that it is only accessible to service technicians or users who are aware of the reason for the restricted access and the necessary safety measures at an ambient temperature of over 50 °C.

WARNING

Safety extra-low voltage

The device is designed for operation with safety extra-low voltage (SELV) from a limited power source (LPS).

Power supplies connected to the power supply terminals must comply with the following:

- SELV/LPS (current source with limited power), according to standards IEC 60950-1 / UL 60950-1 / EN 60950-1 / VDE 0805-1

  or

- Power supply for the NEC Class 2 device as described in the National Electrical Code (r) (ANSI / NFPA 70).

If the device is connected to a redundant power supply (two separate power sources), both must meet these requirements.

NOTICE

Removal and replacement

If you replace components, compliance with Class I, DIV 2 can become invalid.

Replacing components may affect the usability of the device.

NOTICE
Risk of danger Read the manual before use to avoid injury.

Validity of the information on the components

NOTICE
Markings and approvals In the documentation, you can find the markings and approvals which are generally possible or planned in the system. The identification or approval that is printed on the module continues to be exclusively valid. The currently valid markings and approvals are printed on the component.

8.1.2 CCC approval

Certificate: 020322310003113

Ex nA IIC T4 Gc

According to the following standards:

- GB 3836.1-2010 (Explosive atmospheres - Part 1: Equipment - General requirements)
- GB 3836.8-2014 (Explosive atmospheres-Part 8: Equipment protection by type of protection "n")

8.1.3 UKCA approval

DEKRA 21UKEX0020 X

Importer UK:

Siemens plc

Manchester M20 2UR

8.1.4 cULus approval

Underwriters Laboratories Inc. in accordance with

- UL 61010-2-201 (Industrial Control Equipment)
- CSA/ CAN 61010-2-201 (Process Control Equipment)

8.1.5 cULus HAZ. LOC. approval

HAZ. LOC.

Underwriters Laboratories Inc. in accordance with

- UL 61010-2-201 (Industrial Control Equipment)
- CSA / CAN 61010-2-201 (Process Control Equipment)
- ANSI/ISA 12.12.01
- CSA C22.2 No. 213 (Hazardous Location)

APPROVED for use in
Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

8.1.6 ATEX Approval

Table 2-634 ATEX Certification

Type Examination Certificate Number	DEKRA 14ATEX0109 X
Standards	EN 60079-0
	EN 60079-7

ATEX II 3 G Ex ec IIC T4 Gc

NOTE
Special conditions

1. The module may only be used in areas with a pollution degree of not more than 2 according to EN 60664-1.
2. The module must be installed in a suitable enclosure which meets the following requirements:
   The enclosure shall provide a degree of protection of at least IP54 in accordance with EN 60079-7, taking into account the ambient conditions of use.
3. Measures must be taken to protect against exceeding the rated operating voltage by transient interference voltages of more than 119 V.

8.1.7 IECEx Approval

Table 2-635 IECEx certification

Certificate number	IECEx DEK 14.0063X
Standards	IEC 60079-0
	IEC 60079-7

IECEx Ex ec IIC T4 Gc

NOTE
Special conditions

1. The module may only be used in areas with a pollution degree of not more than 2 according to IEC 60664-1.
2. The module must be installed in a suitable enclosure which meets the following requirements:
   The enclosure shall provide a degree of protection of at least IP54 in accordance with IEC 60079-7, taking into account the ambient conditions of use.
3. Measures must be taken to protect against exceeding the rated operating voltage by transient interference voltages of more than 119 V.

8.1.8 FM Approval

Table 2-636 Factory Mutual Research (FM) Certification

Classification	NI, Class I, Div 2, Groups A, B, C and D
	NI, Class I, Zone 2, Groups IIC
Standards	Class No. 3600
	Class No. 3611

Standards	Class No. 3810
	ANSI/ISA-61010-1
	C22.2 No. 0-10
	C22.2 No. 213-17
	C22.2 No. 1010.1
	CAN/CSA C22.2 No. 0.15-15

8.2 Technical specifications of the AI 4xI 2-wire 4...20mA HART

Technical specifications of the AI 4xI 2-wire 4...20mA HART

Article number	**6ES7134-6TD00-0CA1**
General information	
Product type designation	AI 4xI 2-wire HART
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC03
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Measuring range scalable	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V13 SP1
• STEP 7 configurable/integrated as of version	V5.5 SP4 and higher
• PCS 7 configurable/integrated as of version	V8.1 SP1
• PROFIBUS as of GSD version/GSD revision	GSD Revision 5
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• Oversampling	No
• MSI	No
CiR – Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	No

Article number	6ES7134-6TD00-0CA1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	25 mA; without sensor supply
24 V encoder supply	
• 24 V	Yes
• Short-circuit protection	Yes
• Output current, max.	20 mA; max. 50 mA per channel for a duration < 10 s
Power loss	
Power loss, typ.	0.65 W; without sensor supply
Address area	
Address space per module	
• Address space per module, max.	8 byte; + 1 byte for QI information
• Address space per module with HART, max.	28 byte; + 1 byte for QI information
Analog inputs	
Number of analog inputs	4; Differential inputs
• For current measurement	4
permissible input current for current input (destruction limit), max.	50 mA
Input ranges (rated values), currents	
• 0 to 20 mA	No
• -20 mA to +20 mA	No
• 4 mA to 20 mA	Yes; 15 bit + sign
– Input resistance (4 mA to 20 mA)	280 Ω; + approx. 0.35 V diode forward voltage
Cable length	
• shielded, max.	800 m
Analog value generation for the inputs	
Measurement principle	integrating (Sigma-Delta)
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes; channel by channel
• Interference voltage suppression for interference frequency f1 in Hz	10 / 50 / 60 Hz
Smoothing of measured values	
• Number of smoothing levels	4; None; 4/8/16 times

Article number	6ES7134-6TD00-0CA1
• parameterizable	Yes
Encoder	
Connection of signal encoders	
• for voltage measurement	No
• for current measurement as 2-wire transducer	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %
Temperature error (relative to input range), (+/-)	0.005 %/K
Crosstalk between the inputs, min.	60 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Current, relative to input range, (+/-)	0.5 %
Basic error limit (operational limit at 25 °C)	
• Current, relative to input range, (+/-)	0.3 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	60 dB
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; channel by channel
• Short-circuit	Yes; Channel-by-channel, short-circuit of the encoder supply to ground or of an input to the encoder supply
• Group error	Yes
• Overflow/underflow	Yes; channel by channel
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED

Article number	6ES7134-6TD00-0CA1
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Appendix A

A.1 Parameter data records

Parameter assignment in the user program

You have the option of reassigning parameters for individual channels of the module and for the mapping of HART variables in RUN without affecting the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module.

- Channel/technology parameters using data record 128
- The HART mapping using data record 140.

The parameters assigned with STEP 7 are not changed permanently in the CPU, which means the parameters assigned with STEP 7 are valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Parameters

Only the values specified in each case in the following are permitted. Values that are not listed are rejected by the analog module.

Each parameter data record is checked by the analog module. If an incorrect parameter is detected, the complete data record is discarded and the parameters of the analog module remain unchanged.

A.1.1 Parameter assignment and structure of the channel/technology parameters

Structure of data record 128

Data record 128 has a length of 42 bytes and contains the channel/technology parameters of all four channels (10 bytes per channel).

The parameters are divided into parameters that influence the actual analog value acquisition, diagnostic enables, and basic parameters of HART communication.

You can use data records 131 to 134 to assign and change additional parameters and HART-specific settings. See section HART-specific settings (Page 53).

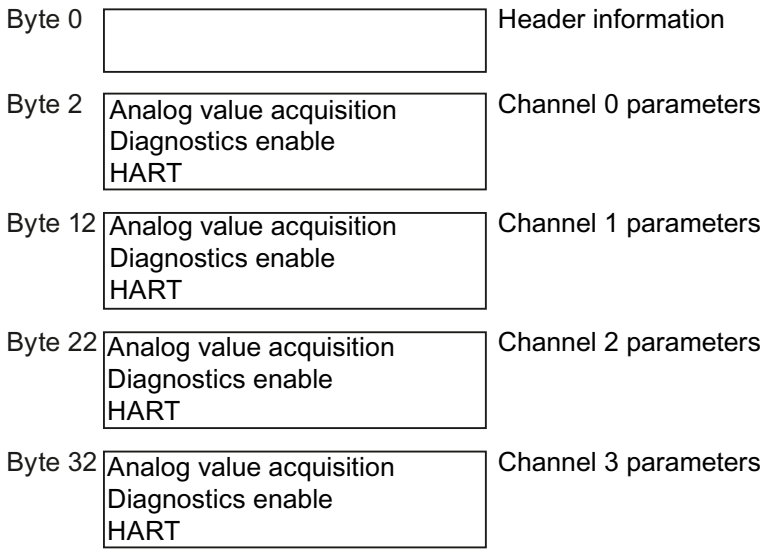

Figure 2-597 Structure of data record 128

Header information

The figure below shows the structure of the header information.

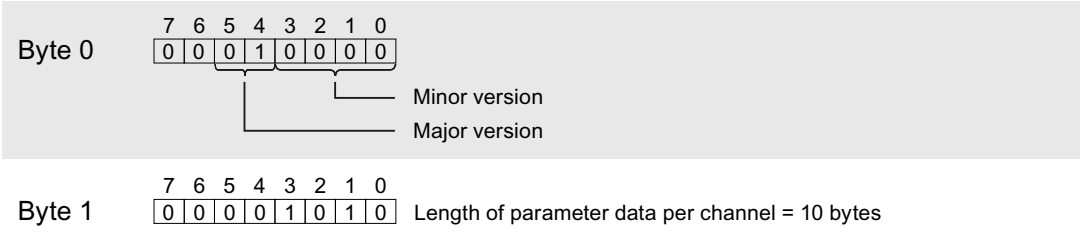

Figure 2-598 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

All unused bits and the bits or bytes marked with "reserved" must be set to zero.
You enable a parameter by setting the corresponding bit to "1" or the appropriate value.

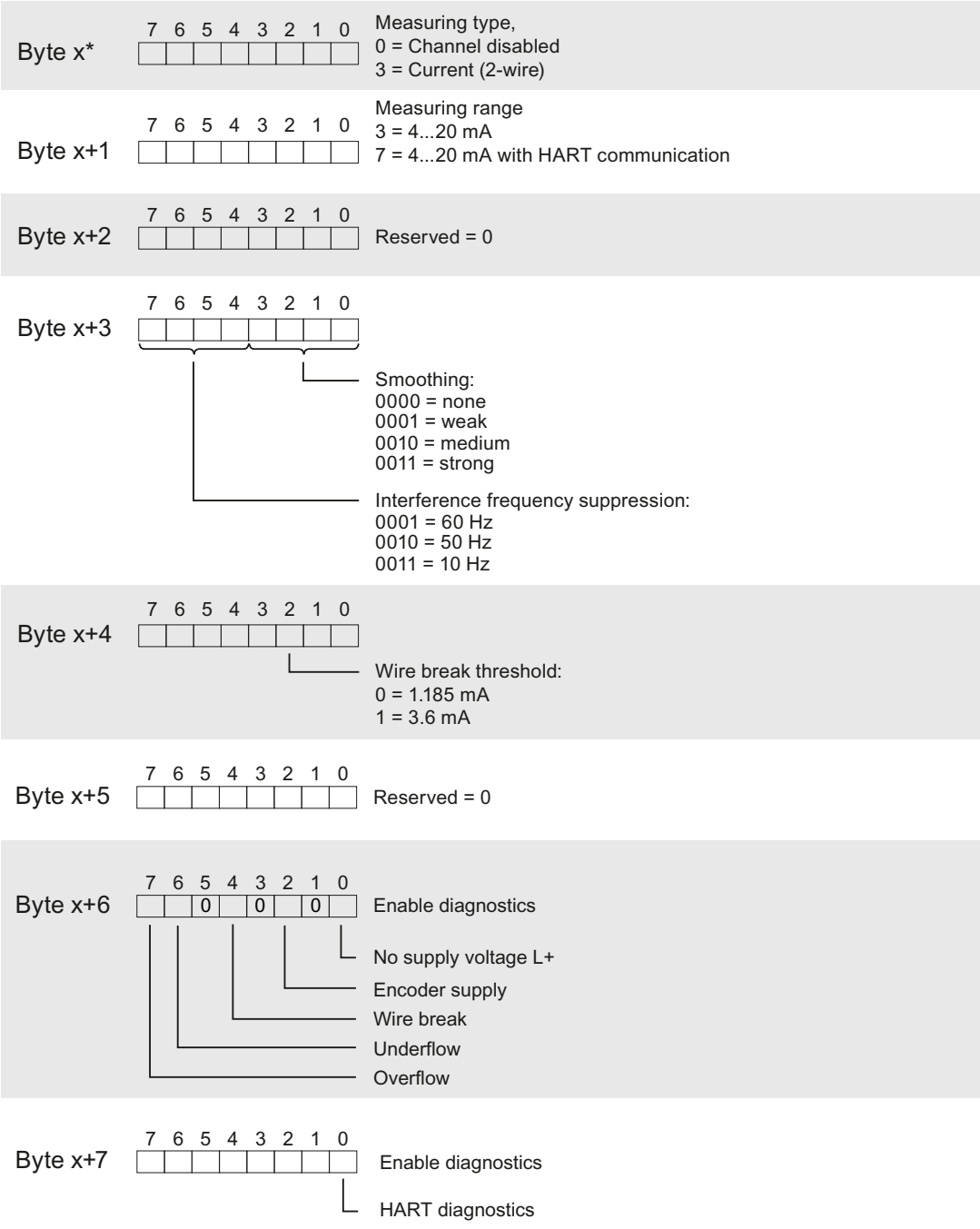

Byte x+8	7 6 5 4 3 2 1 0	Number of HART preamble bytes: 5...20 (default = 5)
Byte x+9	7 6 5 4 3 2 1 0	Number of HART retries: 0...255, internally limited to maximum 10 (default = 5)

* x = 2 + (channel number * 10); with channel number 0 3

Figure 2-599 Structure of bytes x to x+39 for channels 0 to 3

A.1.2 Parameter assignment and structure of the HART mapping parameters

Structure of data record 140

Data block 140 has a total length of 12 bytes.

Using the parameters of data record 140, you can configure/map up to four HART variables of the individual channels in the input address space of the module if the corresponding configuration is selected, see "Configuring (Page 29)".

Header information

The figure below shows the structure of the header information.

Byte 0	7 6 5 4 3 2 1 0	Version = 0
Byte 1	7 6 5 4 3 2 1 0	Block length = 11 bytes
Byte 2	7 6 5 4 3 2 1 0	Block type = 75
Byte 3	7 6 5 4 3 2 1 0	Reserved = 0

Figure 2-600 Header information

Parameters

The following figure shows the parameter assignment of the four HART variables 0...3.

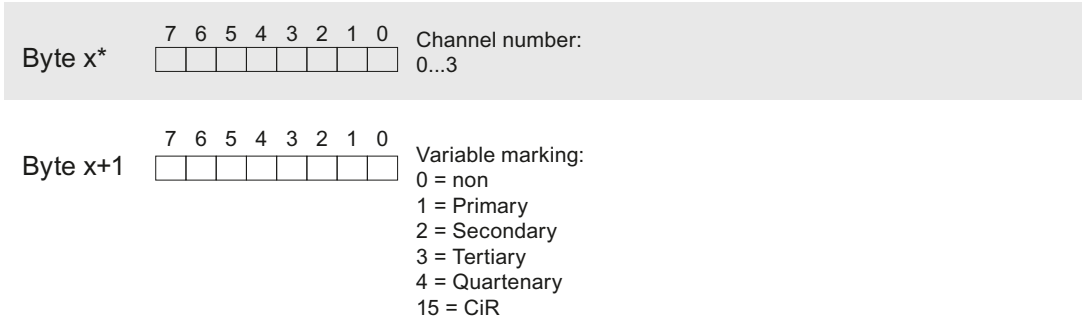

* x = 4 + (HART variable * 2); with HART variable 0....3

Figure 2-601 Parameters

NOTE

Memory area

Allocation of the memory area based on the configuration of the HART variables:

- All four HART variables are set to 0 = "none":
  No memory area is reserved/allocated for HART variables in the input address range.
- As least one HART variable is set to not equal to 0 = "none":
  The entire memory area always allocated to the four HART variables in the input address space. All remaining HART variables are preset to 15 = "CiR" and 0 = "none" is no longer allowed.

A.2 HART operating data records

Reading/writing data in RUN

HART operating data records are transferred to the module with the "WRREC" instruction and read from the module with the "RDREC" instruction.

Errors during the transfer are indicated at output parameter STATUS of the "WRREC" or "RDREC".

The following HART operating data records are available:

Data record number	Description	Length (bytes)	Writable	Readable
80	HART request Channel 0	240	Yes	Yes
81	HART response Channel 0	240	No	Yes
82	HART request Channel 1	240	Yes	Yes
83	HART response Channel 1	240	No	Yes

Data record number	Description	Length (bytes)	Writable	Readable
84	HART request Channel 2	240	Yes	Yes
85	HART response Channel 2	240	No	Yes
86	HART request Channel 3	240	Yes	Yes
87	HART response Channel 3	240	No	Yes
121	HART variables	80	No	Yes
131	HART parameters Channel 0	8	Yes	Yes
132	HART parameters Channel 1	8	Yes	Yes
133	HART parameters Channel 2	8	Yes	Yes
134	HART parameters Channel 3	8	Yes	Yes
148	HART directory	17	No	Yes
149	HART feature data	3	No	Yes

A.2.1 HART directory

Structure of the HART directory

Byte	Meaning	Comment
0	Profile Revision Number	= 2, 0 (Revision 2.0)
1		
2	Index of Client Management	= 255 (not relevant)
3	Number of Clients	= 1
4	Number of Channels	= 4
5	Write Read Index Offset	= 1 (The response to a request data record is made with the data record number of the request data record + 1)
6	Index of HMD Feature Parameter	= 149
7	Index of HMD Module Parameter	= 255 (not relevant)
8	Start Index of Burst Buffer Area	= 255 (not relevant)
9+n	Index of HMD Channel Parameter (Channel n)	= 131+n
9+n+4	Index of HART Client Channel Message Data	= 80+(2*n) The HART request data records cannot be configured. Data records starting from data record number 80 (80, 82, 84, 86) are used.

A.2.2 HART feature data

Structure of the HART feature data

Byte	Meaning	Comment
0	Byte 0	= 0x62 Bit1 = 1: "Parameter check result is given with a read response" Bit5 = 1: "Compact format is supported"
1	Byte 1	= 0
2	Max Length Data Unit	= 240 (maximum length of the HART request data records)

A.2.3 HART variable data record

The AI 4xI 2-wire 4...20mA HART analog module supports a maximum of 4 HART variables per channel that are read cyclically, provided this is supported by the connected field device. These 16 HART variables are are made available in a readable manner in HART variable data record 121.

Each HART variable consists of a 4-byte real value and a quality code byte. See section 4.4.1 "Quality code".

Structure of the HART variable data record

Byte	**Meaning**	
Channel 0		
0...3	Value	Primary Variable (PV)
4	Quality code	
5...8	Value	Secondary Variable (SV)
9	Quality code	
10...13	Value	Tertiary (TV)
14	Quality code	
15...18	Value	Quartenary (QV)
19	Quality code	
Channel 1		
20...39	HART variables same as for Channel 0	
Channel 2		
40...59	HART variables same as for Channel 0	
Channel 3		
60...79	HART variables same as for Channel 0	

If HART is not enabled or the respective HART variable is not supplied from the connected field device, the corresponding variable = 0 and the QC = 0x37 (initialization value from the analog module).

A.2.4 HART-specific settings

The HART communication is available using standard parameter assignment (see section 9.1 "Parameter assignment and structure of the channel/technology parameters").

Additional HART-specific settings can be specified on a channel-specific basis using data records 131 to 134.

The parameters assigned with STEP 7 are not changed permanently in the CPU, which means the parameters assigned with STEP 7 are valid again after a restart.

Each parameter reassignment of the analog module resets the HART-specific settings back to the initial values from parameter data record 128.

Where there is no supply voltage L+, the module does not assume the HART-specific settings.

Channel	Data record number
0	131
1	132
2	133
3	134

Structure of the HART-specific settings

Byte 0	7 6 5 4 3 2 1 0 Must be 128	Bit 7 is reset after evaluation of data record by module
Byte 1	7 6 5 4 3 2 1 0 Must be 5	Offset for manufacturer-specific parameters according to HART specification
Byte 2	7 6 5 4 3 2 1 0	Number of HART retries (0....255, internally limited to 10) Initial value from parameter data record 128
Byte 3	7 6 5 4 3 2 1 0	Number of HART preamble bytes (0, 5...20, 255) * Initial value from parameter data record 128
Byte 4	7 6 5 4 3 2 1 0 Must be 0	Field device mode according to HART specification
Byte 5	7 6 5 4 3 2 1 0	Client timeout in s (1 ... 255 s) Initial value = 60 s
Byte 6	7 6 5 4 3 2 1 0 0 0 0 0 0 0	1 = Enable HART 0 = Disable HART 1 = Primary master 0 = Secondary master Initial value according to HART activation from parameter data record 128 Always as primary master
Byte 7	7 6 5 4 3 2 1 0 Must be 0	Reserved

Figure 2-602 Settings

* When the number of HART preamble bytes = 0, the number of preamble bytes required by the connected field device are used, but no fewer than 5.
When the number of HART preamble bytes = 255, then 20 preamble bytes are used.

A.2.5 HART request and response data records

HART commands are processed on a channel-specific basis via a separate command interface with one request data record and one response data record in each case.

Channel	Data record number	
	Request to the field device	Response from the field device
0	80	81
1	82	83
2	84	85
3	86	87

Structure of request data records 80, 82, 84, 86

Byte	Meaning	Comment
0	Request control	
1	Number of preamble bytes	5....20, 255
2...239	Communication data according to HART specification	

Coding "Request control":

Bit 0...1: Reserved = 0

Bit 2: 0 = Parameters are not checked

Bit 3...4: Reserved = 0

Bit 5: 0 = Transparent format *
1 = Compact format

Bit 6: 1 = Enable SHC mode **

Bit 7: 0 = HART Request

* HART commands are processed by the analog module in transparent message format and in compact message format. However, the response data from the module is always made available in transparent message format.

** Processing of a sequence of HART commands as an SHC sequence affects all other channels with HART enabled. See section 4.3 "HART command interface", SHC sequence.

NOTE

When "Number of Preamble Bytes" = 255, the number of preambles set with the parameters is used. The default setting is five. You can re-configure the number of preamble bytes using the parameters and HART-specific settings (see section HART-specific settings (Page 53)).

Structure of response data records 81, 83, 85, 87

In case of response error

Byte	Meaning	Comment
0	Response control	
1	HART group error display	
2	Protocol error	
3...239	Response data according to HART specification	Only present when "Response result" = 6 = "Error, with data"

In case of response error

Byte	Meaning	Comment
0	Response control	
1	HART group error display	
2...239	Response data according to HART specification	Only present when "Response result" = 4 = "Successful, with data"

Coding "Response control":

Bits 0-2:	Response result (processing status) 0 = Inactive 1 = Inactive (reserved) 2 = Waiting 3 = Waiting, executing 4 = Successful, with data 5 = Successful, without data 6 = Error, with data 7 = Error, without data
Bit 3:	0 = Burst mode not active;
Bit 4:	0 = Response data come directly from the HART device
Bit 5:	0 = Response data in transparent message format
Bit 6:	0 = SHC mode not active 1 = SHC mode active
Bit 7:	0 = HART response

Coding "HART group error display"

Bit number	Meaning	Explanation
0	Additional status information available	(2nd HART status byte) You obtain additional status information, if required, with HART command 48.
1	HART communication error	The field device has detected a communication error when receiving the command. The error information can be found in the 1st HART status byte.

Bit number	Meaning	Explanation
2	Parameter check	0: HMD parameters unchanged 1: Check HMD parameters
3	Reserved	Always 0
4...7	HART protocol error during response	0: Unspecified error 1: HMD error 2: Channel fault 3: Command error 4: Query error 5: Response error 6: Query rejected 7: Profile query rejected 8: Manufacturer-specific query rejected 9 - 15: Not used

Coding "HART protocol error during response"

HART protocol error during response	Meaning	Explanation
0	Unspecified error	Always 0
1	HMD error	0: Not specified 1: Internal communication error 2: Parameter assignment error 3: HW fault 4: Wait time expired 5: HART timer expired 6...127: Reserved 128...255: Manufacturer-specific
2	Channel fault	0: Not specified 1: Line fault 2: Short-circuit 3: Open line 4: Low current output 5: Parameter assignment error 6...127: Reserved 128...255: Manufacturer-specific
3	Command error	0-127: HART protocol, Bit 7 = Always 0
4	Query error	Bit 0 = 0: Reserved Bit 1 = 1: Receive buffer overflow Bit 2 = 0: Reserved Bit 3 = 1: Checksum error Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved

HART protocol error during response	Meaning	Explanation
5	Response error	Bit 0 = 1: GAP timeout Bit 1 = 1: Receive buffer overflow Bit 2 = 1: Timeout Bit 3 = 1: Checksum error Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved
6	Query rejected	0: Unspecified 1: Compact format not supported 2: SHC not supported 3: Impermissible command 4: No resources 5...127: Reserved 128...255: Manufacturer-specific
7	Profile query rejected	0: Not specified (not supported)
8	Manufacturer-specific query rejected	0: Not specified (not supported)

Example of HART programming (HART command interface)

For HART channel 0, the command 01 is to be sent in transparent message format to the HART field device with address "98 CF 38 84 F0".
A positive edge at input 4.0 of a digital input module leads to the writing of the HART command.

The following assumptions are made:

- The module address of the AI 4xI 2-wire 4...20mA HART analog module is 512 (200_H).
- The data record is stored in DB80: starting from address 0.0, length of 11 bytes.
- In this example, DB80 (request data record for channel 0) consists of 11 bytes.

```
STL                                 Explanation
    A I 4.0
    FP M 101.0
    = M 104.0
m2: CALL SFC 58
    REQ :=M104.0                    Write request
    IOID :=B#16#54                  Address range ID
    LADDR :=W#16#200                Module address
    RECNUM :=B#16#50                Data record number 80
    RECORD :=P#DB80.DBX0.0 BYTE     Data record with length of 11 bytes (must corres-
11                                  pond to the exact length that is to be transferred)
    RET_VAL :=MW93                  RET_VAL of SFC 58 (OK/error/...)
    BUSY :=M51.0                    Write operation not yet completed
    A M 51.0
    SPB m2
    BE
```

Table 2-637 DB80: Transparent message format

Byte	Initial value (hex)	Comment (Hex)
0	00	Req_Control (00 = Transparent message format. 40 = Transparent message format with SHC sequence)
1	05	Number of preamble bytes (05-14)
2	82	Start character (02 = Short Frame with command 0) (82 = Long Frame with other commands)
3	98	Address (with command 0, the address is exactly 1 byte long and has the value 0.)
4	CF	
5	38	
6	84	
7	F0	
8	01	Command (CMD)
9	00	Length in bytes
10	98	Checksum (CHK) (calculated starting from byte 2 "Start character" up to the next to last byte)

A HART command can also be sent in compact message format. In this case, the data that is transferred via DB 80 is reduced to 4 bytes.

Table 2-638 DB80: Compact message format

Byte	Initial value (hex)	Comment (Hex)
0	20	Req_Control (20 = Compact message format. 60 = Compact message format with SHC sequence)
1	05	Number of preamble bytes (05-14)
2	01	Command (CMD)
3	00	Length in bytes

You can learn when the response from the field device was received by cyclically reading data record DS81 for HART channel 0. The response is always supplied in transparent message format.

Table 2-639 FC81: Reading of the response to DB81 with SFC 59

```
STL                              Explanation
m3: CALL SFC 59
    REQ :=1                      Read request
    IOID :=B#16#54               Address range ID
    LADDR :=W#16#200             Module address of the HART-AI
```

```
    RECNUM :=B#16#51              Data record number 81
    RECORD :=P#DB81.DBX0.0 BYTE   Data record
75
    RET_VAL :=MW100               RET_VAL of SFC 59 (OK/error/...)
    BUSY :=M49.1                  Read operation not yet completed
    A M 49.1
    SPB m3
    BE
```

The program part A M 49.1 to SPB m3 is only required if reading is to occur synchronously.

As long as "0x03" is in byte 0 of DB81, the response has not been received from the field device. Positive response data that you can evaluate is available from the field device as soon as bit 2 = 1 in byte 0.
If there are errors in the response data, see the "HART group fault display" tables in byte 1 or "HART protocol error during response" in byte 2 of the field device response.

A.3 Analog value representation

Table 2-640 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	**Hexadecimal**	**High byte**	**Low byte**
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

Representation / Value range

The table below contains the decimal and hexadecimal values (codings) of the possible current measuring ranges.

Table 2-641 Current measuring range 4 to 20 mA / 4...20 mA HART

Values		Current measuring range	Range
Dec.	**Hex.**	**4 to 20 mA**	
32767	7FFF	> 22.81 mA	Overflow
32511	7EFF	22.81 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	16 mA	
1	1	4 mA + 578.7 nA	
0	0	4 mA	
-1	FFFF		Underrange
-4864	ED00	1.185 mA	
-32768	8000	< 1.185 mA	Underflow

A.3.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table 2-642 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 2-643 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

A.3.2 Representation of analog values in the current measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table 2-644 Current measuring range ±20 mA

Values		Current measuring range	Range
Dec.	**Hex.**	**±20 mA**	
32767	7FFF	>23.52 mA	Overflow
32511	7EFF	23.52 mA	Overrange
27649	6C01		
27648	6C00	20 mA	Nominal range
20736	5100	15 mA	
1	1	723.4 nA	
0	0	0 mA	
-1	FFFF		
-20736	AF00	-15 mA	
-27648	9400	-20 mA	
-27649	93FF		Underrange
-32512	8100	-23.52 mA	
-32768	8000	<-23.52 mA	Underflow

Table 2-645 Current measuring ranges 0 to 20 mA and 4 to 20 mA

Values		Current measuring range		Range
Dec.	**Hex.**	**0 to 20 mA ***	**4 to 20 mA**	
32767	7FFF	>23.52 mA	>22.81 mA	Overflow
32511	7EFF	23.52 mA	22.81 mA	Overrange
27649	6C01			
27648	6C00	20 mA	20 mA	Nominal range
20736	5100	15 mA	16 mA	
1	1	723.4 nA	4 mA + 578.7 nA	
0	0	0 mA	4 mA	
-1	FFFF			Underrange
-4864	ED00	-3.52 mA	1.185 mA	
-32768	8000	<-3.52 mA	<1.185 mA	Underflow

* For measuring type "2-wire transducer", negative values are not possible for the range "0 to 20 mA". Therefore, no underrange or underflow exists here.

A.4 Contact

Range	Contact
Repair Service Facility	Siemens AG Digital Industries Factory Automation Operative Q functions DI FA MF EWA QM 31 Mr. Alexander Luber Werner-von-Siemens-Str. 5092224 Amberg, Germany Tel.: +49 9621 80-3447
Manufacturer	Siemens AG Digital Industries Factory Automation Operative Q functions DI FA MF EWA Mr. Alexander Luber Werner-von-Siemens-Str. 5092224 Amberg, Germany Tel.: +49 9621 80-3447

SIEMENS

SIMATIC

ET 200SP
Analog input module AI 4xRTD/TC 2-/3-/4-wire HF (6ES7134-6JD00-0CA1)

Equipment Manual

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Preface 1

1.1 Open Source Software

Open-source software is used in the firmware of the I/O modules. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information relating to this on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109739516).

See also

GNU_V5.3.1_201805 (https://support.industry.siemens.com/cs/ww/en/view/109757558)

1.2 Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

ET 200SP Documentation Guide

2

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

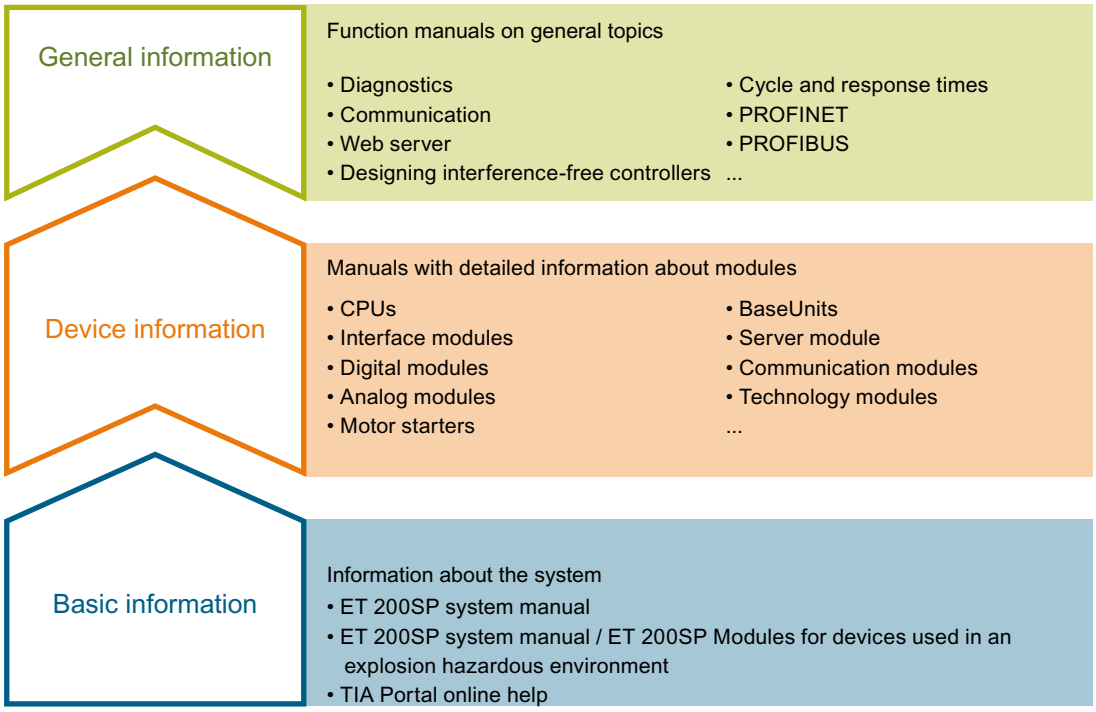

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

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You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/ae).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109767888).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant, incl. fail-safe inputs and outputs.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

3

3.1 Properties

Article number

6ES7134-6JD00-0CA1

View of the module

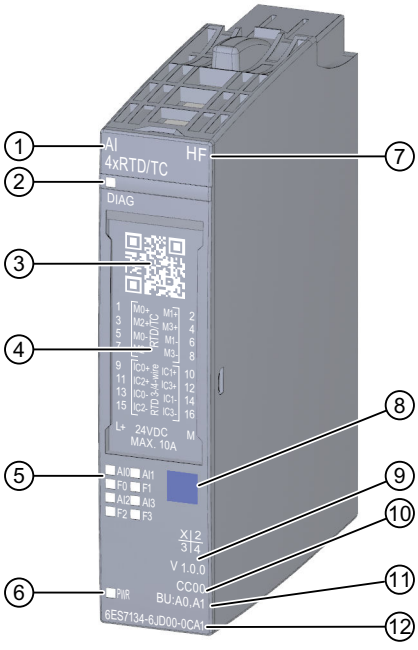

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status and channel fault	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-603 View of the module AI 4×RTD/TC 2-/3-/4-wire HF

Properties

The module has the following technical properties:

- Analog input module with 4 inputs
- 4 measurement types, can be set per channel
  - Thermal resistor (RTD)
  - Thermocouple (TC)
  - Resistor
  - Voltage
- Resolution: Up to 16 bits including sign
  - Can be extended to max. 3 decimal places via the scalable measuring range for the measuring types RTD and TC.
- Configurable diagnostics for each channel
- Hardware interrupt on limit violation can be set per channel (two high and two low limits per channel)
- Adjustable compensation
  - RTD: compensation of the line resistance for a 2-wire and 3-wire connection
  - TC: external or internal temperature compensation
- interference frequency suppression, adjustable

The module supports the following functions:

Table 2-646 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V1.0.0 or higher	V11, SP2 or higher with HSP 0024	V5.5 SP3 or higher with HSP 0227 V1.0 or higher	X	X
Identification data I&M0 to I&M3	FS01	V1.0.0 or higher	V11, SP2 or higher with HSP 0024	V5.5 SP3 or higher with HSP 0227 V1.0 or higher	X	X
Reconfiguration in RUN	FS01	V1.0.0 or higher	V11, SP2 or higher with HSP 0024	V5.5 SP3 or higher with HSP 0227 V1.0 or higher	X	X
Value status (PROFINET IO only)	FS01	V1.1.0 or higher	V12, SP1 or higher with HSP 0057	V5.5 SP3 or higher with HSP 0227 V2.0 or higher	X	-
Calibration in runtime	FS01	V2.0.0 or higher	V13 or higher	V5.5 SP3 or higher with HSP 0227 V3.0 or higher	X	X

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter can only be parameterized later via data record 128.

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Scalable measuring range	FS01	V2.0.0 or higher	V13 or higher	V5.5 SP3 or higher with HSP 0227 V2.0 or higher	X	X [1]
Selectable conductor resistance for 2-wire connection	FS01	V2.0.0 or higher	V13 or higher	V5.5 SP3 or higher with HSP 0227 V3.0 or higher	X	X [1]
Switchable wire break check	FS01	V2.0.0 or higher	V13 or higher	V5.5 SP3 or higher with HSP 0227 V3.0 or higher	X	X
Extended interference frequency suppression • 60 Hz (18.75 ms) • 50 Hz (22.5 ms) • 16.6 Hz (67.5 ms)	FS01	V2.1.0 or higher	V16 or higher with HSP 0357	As of V5.5 SP3 with HSP0227 as of V12.0	X	X [1]

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter can only be parameterized later via data record 128.

You can configure the module with STEP 7 and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connection

See also

You can find more information on accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Wiring

4

4.1 Wiring and block diagram

This section includes the block diagram of the AI 4×RTD/TC 2-/3-/4-wire HF module with the terminal assignments.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

NOTE

- The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.
- When using floating sensors, bridge the m- connections and connect to ground / FE. This increases the immunity of the module.

  Bridging and connecting are not necessary for disabled and disconnected inputs.

NOTE

Compensation of the conductor resistance for RTD or resistance measurement

Configurable conductor resistance for 2-wire connection For compensation of the conductor resistance, a fixed value for the parasitic conductor resistance of the entire measuring loop can be entered via the corresponding parameter.

Automatic compensation for 3-wire connection: The conductor resistance is inherently automatically compensated. The same cable routing and cable cross sections should be used for all 3 measurement cables.

Wiring: 2-wire connection for thermocouples and 4-, 3-, 2-wire connection of resistance-type sensors or thermal resistors (RTD)

The following figure shows the block diagram and an example of the terminal assignment of the analog input module AI 4xRTD/TC 2-/3-/4-wire HF on the BaseUnit BU type A0/A1.

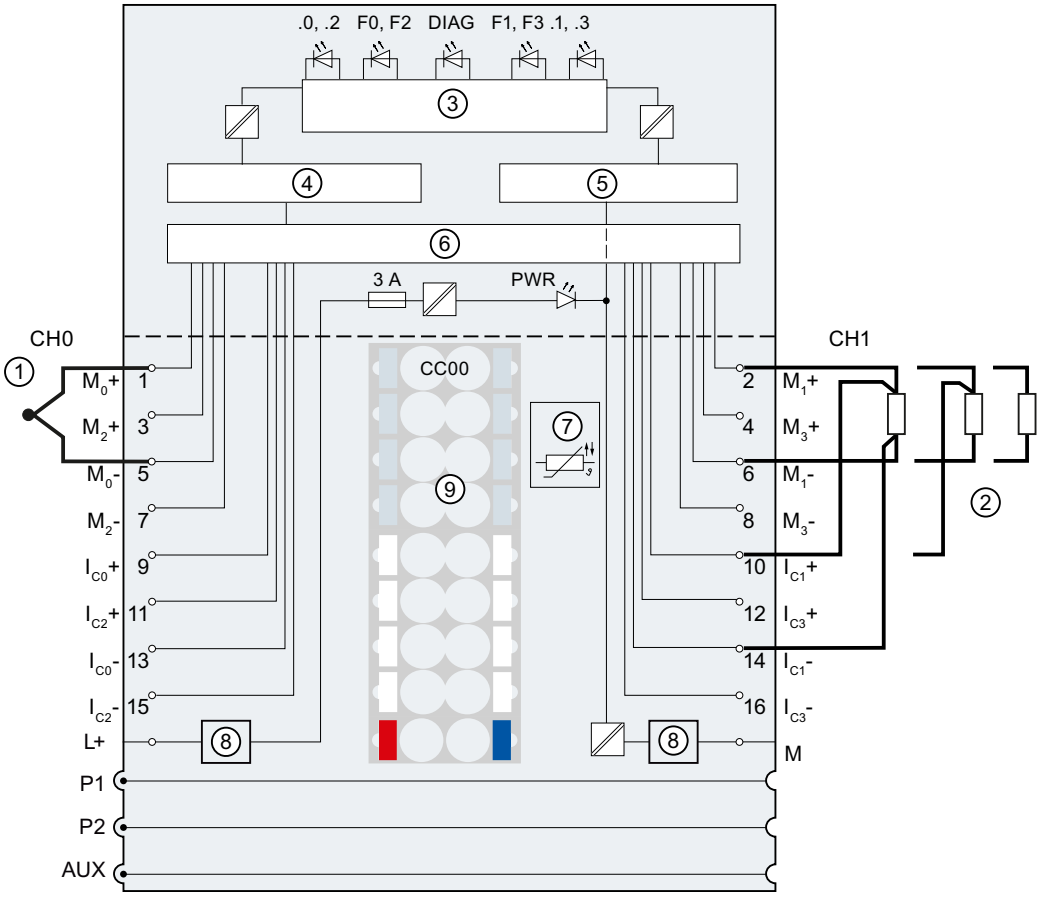

①	2-wire connection of thermocouples / voltage connection	M_n+ M_n-	Measuring line positive, channel n Measuring line negative, channel n
②	4-, 3-, 2-wire connection of resistance-type sensors or thermal resistors (RTD)	I_{Cn}+ I_{Cn}-	Constant current line positive, channel n Constant current line negative, channel n
③	Backplane bus interface	L+	24 V DC (infeed only with light-colored BaseUnit)
④	Analog-to-digital converter (ADC)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Constant current power supply	DIAG	Diagnostics LED (green, red)
⑥	Multiplexer	.0 to .3	Channel status LED (green)

⑦	Temperature recording for BU type A1 only	PWR	Power LED (green)
⑧	Filter connection supply voltage (available with light-colored BaseUnit only)	F0 to F3	Channel fault LED (red)
⑨	Color-coded label with color code CC00 (optional)		

Figure 2-604 Connection and block diagram for connection of thermocouples and resistance-type sensors or thermal resistors (RTD)

Parameters/address space

5

5.1 Measurement types and measuring ranges

The following table describes the measuring range and the temperature coefficients you can configure for each measurement type:

Table 2-647 Measurement types and measuring ranges

Measurement type	Measuring range	Temperature coefficient
Deactivated	–	–
Voltage	±50 mV / ±80 mV / ±250 mV / ±1 V	
Resistor (2-wire connection)	PTC	–
Resistor (2-, 3-, 4-wire connection)	150 Ω / 300 Ω / 600 Ω / 3 kΩ / 6 kΩ	–
Thermal resistor RTD (3-wire connection)	Climatic / Standard Cu 10	Cu 0.00427[1]
Thermal resistor RTD (2, 3, 4-wire connection)	Climatic / Standard Pt 100 Pt 200 Pt 500 Pt 1000	Pt 0.00385 / Pt 0.003916 / Pt 0.003902 / Pt 0.00392 / Pt 0.00385055
	Climatic / Standard Ni 100 Ni 120 Ni 200 Ni 500 Ni 1000	Ni 0.00618 / Ni 0.00672
	Climatic[2] / Standard[2] Ni 1000	Ni 0.005
Thermocouple (TC)	Type E, N, J, K, L, S, R, B, T, C, U, TXK (acc. to GOST)	-

1 The preset temperature coefficients are valid for Europe.

2 For sensors LG-Ni 1000 from Siemens Building Ltd (Landis & Stäfa).

Special features when using Cu10 sensors

- Choose "Thermal resistor (3-wire connection)" and "Cu10" in the parameter assignment.
- Wire the Cu10 sensor into the 3-wire connection technology.
- During operation, automatic, internal compensation of the line resistance of the missing measuring line takes place.

NOTE

To ensure optimum line compensation with Cu10, please observe the following:

– An accurate measured value is only attained if the cable resistance of the positive constant current line to the Cu10 sensor and the cable resistance of the negative measuring line are identical in value.
– Recommendation: Keep the measuring line as short as possible.
– Different resistance values may also occur due to the connection method used.

Special features when using PTC resistors

PTCs are suitable for monitoring temperature and/or as thermal protection devices of complex drives or transformer windings.

- Choose "Thermal resistor (2-wire)" and "PTC" in the parameter assignment.
- Connect the PTC to the 2-wire connection technology.
- Use the PTC resistors, type A (PTC thermistor) in accordance with DIN/VDE 0660, part 302.
- If "Underflow" diagnostic is enabled, a "Low limit violated" diagnostic is generated for resistance values < 18 Ω, indicating a short-circuit.
- Sensor data for the PTC resistor:

Table 2-648 Using PTC resistors

Property	Technical specifications	Comment
Switching points	**Behavior with rising temperature**	
	< 550 Ω	**Normal range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "0" (in the PII)
	550 Ω to 1650 Ω	**Prewarning range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "1" (in the PII)
	> 1650 Ω	**Response range:** • SIMATIC S7: Bit 0 = "1", Bit 2 = "0" (in the PII)
	Behavior with falling temperature	
	> 750 Ω	**Response range:** • SIMATIC S7: Bit 0 = "1", Bit 2 = "0" (in the PII)
	750 Ω to 540 Ω	**Prewarning range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "1" (in the PII)

[1] Below 23 kΩ

Property	Technical specifications	Comment
Switching points	< 540 Ω	**Normal range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "0" (in the PII)
	Reaction to short-circuit	
	< 18 Ω	• SIMATIC S7: Bit 7 (IB x+1) = "1", Bit 0 = "0" and Bit 2 = "0"
(RRT-5) °C (RRT+5) °C (RRT+15) °C Measuring voltage/ voltage at the PTC	Max. 550 Ω min. 1330 Ω min. 4000 Ω Max. 7.5 V[1]	TNF = Rated response temperature of the sensor (according to DIN/VDE 0660)

[1] Below 23 kΩ

Assignment in the process image input (PII) with SIMATIC S7

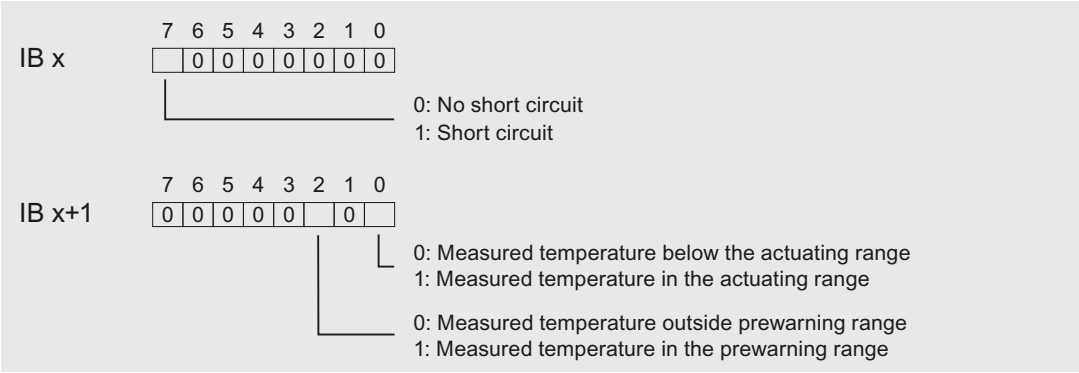

Figure 2-605 Assignment in the process image input (PII)

Notes on programming

- Bits 0+2 are relevant for evaluation in the process image input. You can monitor, for example, the temperature of a motor using bits 0+2.
- Bits 0+2 in the process image input cannot be saved. During parameter assignment, take into consideration that a motor, for example, starts up in a controlled manner (via an acknowledgment).
- Bits 0+2 can never be set at the same time; they are set one after the other.

NOTICE

No measurement is possible in the following cases:

- When I/O modules are pulled out
- When supply voltage to the I/O module fails
- When there is a wire break or short-circuit in the measuring lines

Therefore, always evaluate the diagnostics entries of the AI 4×RTD/TC 2-/3-/4-wire HF for safety reasons.

Example

The diagram shows the temperature curve and the associated switching points.

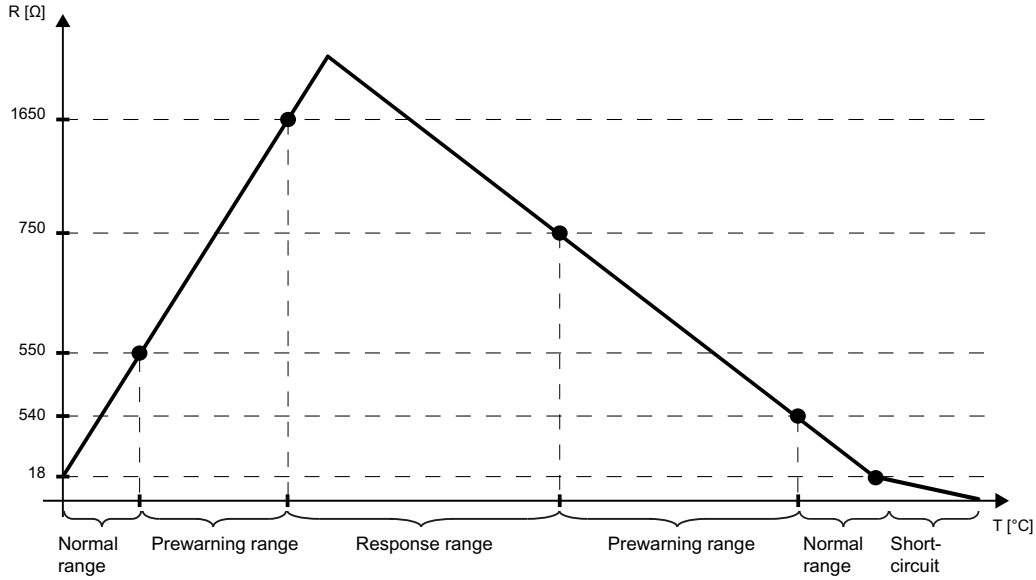

Figure 2-606 Temperature curve with prewarning range

See also

Technical specifications (Page 42)

5.2 Parameters

Parameters of the AI 4xRTD/TC 2-/3-/4-wire HF

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records, see section Parameter assignment and structure of parameter data record (Page 54). The following parameter settings are possible:

Table 2-649 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: Missing supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel [1]
Diagnostics: Reference junction	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Channel	
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel
Type/range of measurement	• Deactivated	Thermal resistor (4-wire connection) Pt 100 standard range	Yes	Channel	Channel
	• Voltage ±50 mV • Voltage ±80 mV • Voltage ±250 mV • Voltage ±1 V				
	Resistor (2-, 3-, 4-wire connection) • 150 Ω • 300 Ω • 600 Ω • 3 kΩ • 6 kΩ				

1 Diagnostics: Missing supply voltage L+: Detection per module or alarm per channel

2 Interference frequency suppression: Interfering signals at 400 Hz are automatically included in the filtering at 50 Hz.

3 The settings in the "Interference frequency suppression" parameter have a direct effect on the conversion time of the channel. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

4 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 13 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter data record".

5 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", "No reference channel mode" is used for RTD and "Fixed reference temperature" is used for TC.

6 For 2-wire connection only

7 Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.

8 By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical specifications).

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Type/range of measurement	Resistor (2-wire connection) PTC	Thermal resistor (4-wire connection) Pt 100 standard range	Yes	Channel	Channel
Type/range of measurement	Thermal resistor (2, 3, 4-wire connection) • Pt 100 climatic range • Pt 200 climatic range • Pt 500 climatic range • Pt 1000 climatic range	Thermal resistor (4-wire connection) Pt 100 standard range	Yes	Channel	Channel
	Thermal resistor (2, 3, 4-wire connection) • Pt 100 standard range • Pt 200 standard range • Pt 500 standard range • Pt 1000 standard range				
Type/range of measurement	Thermal resistor (2, 3, 4-wire connection) • Ni 100 climatic range • Ni 120 climatic range • Ni 200 climatic range • Ni 500 climatic range • Ni 1000 climatic range	Thermal resistor (4-wire connection) Pt 100 standard range	Yes	Channel	Channel
	Thermal resistor (2, 3, 4-wire connection) • Ni 100 standard range • Ni 120 standard range • Ni 200 standard range • Ni 500 standard range • Ni 1000 standard range				

1 Diagnostics: Missing supply voltage L+: Detection per module or alarm per channel

2 Interference frequency suppression: Interfering signals at 400 Hz are automatically included in the filtering at 50 Hz.

3 The settings in the "Interference frequency suppression" parameter have a direct effect on the conversion time of the channel. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

4 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 13 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter data record".

5 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", "No reference channel mode" is used for RTD and "Fixed reference temperature" is used for TC.

6 For 2-wire connection only

7 Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.

8 By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical specifications).

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Type/range of measurement	Thermal resistor (2, 3, 4-wire connection) • LG Ni 1000 climatic range	Thermal resistor (4-wire connection) Pt 100 standard range	Yes	Channel	Channel
	Thermal resistor (2, 3, 4-wire connection) • LG Ni 1000 standard range				
	Thermal resistor (3-wire connection) • Cu 10 climatic range • Cu 10 standard range				
Type/range of measurement	Thermocouple • Type B (PtRh-PtRh) • Type N (NiCrSi-NiSi) • Type E (NiCr-CuNi) • Type R (PtRh-Pt) • Type S (PtRh-Pt) • Type J (Fe-CuNi) • Type L (Fe-CuNi) • Type T (Cu-CuNi) • Type K (NiCr-NiAl) • Type U (Cu-CuNi) • Type C (WRe-WRe) • Type TXK	Thermal resistor (4-wire connection) Pt 100 standard range	Yes	Channel	Channel

1 Diagnostics: Missing supply voltage L+: Detection per module or alarm per channel

2 Interference frequency suppression: Interfering signals at 400 Hz are automatically included in the filtering at 50 Hz.

3 The settings in the "Interference frequency suppression" parameter have a direct effect on the conversion time of the channel. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

4 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 13 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter data record".

5 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", "No reference channel mode" is used for RTD and "Fixed reference temperature" is used for TC.

6 For 2-wire connection only

7 Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.

8 By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical specifications).

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Temperature coefficient	• Pt 0.00385055 • Pt 0.003916 • Pt 0.003902 • Pt 0.00392 • Pt 0.00385 • Ni 0.00618 • Ni 0.00672 • LG-Ni 0.005 • Cu 0.00427	Pt 0.00385055	Yes	Channel	Channel
Temperature unit	• Degrees Celsius • Degrees Fahrenheit • Kelvin	Degrees Celsius	Yes	Channel	Module
Reference junction [5]	• No reference channel mode • Reference channel of the module • Internal reference junction [7] • Reference channel of group 0 to 3 • Fixed reference temperature	No reference channel mode	Yes	Channel	Channel
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel
Interference frequency suppression [3) 4)]	• 60 Hz (50 ms) • 50 Hz (60 ms) [2] • 16.6 Hz (180 ms) • 60 Hz (18.75 ms) [8] • 50 Hz (22.5 ms) [2 8] • 16.6 Hz (67.5 ms) [8]	50 Hz (60 ms)	Yes	Channel	Module

1 Diagnostics: Missing supply voltage L+: Detection per module or alarm per channel

2 Interference frequency suppression: Interfering signals at 400 Hz are automatically included in the filtering at 50 Hz.

3 The settings in the "Interference frequency suppression" parameter have a direct effect on the conversion time of the channel. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

4 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 13 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter data record".

5 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", "No reference channel mode" is used for RTD and "Fixed reference temperature" is used for TC.

6 For 2-wire connection only

7 Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.

8 By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical specifications).

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g., STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Scalable measuring range	• Disable • Enable	Disable	Yes	Channel	-
Measuring range resolution	• 2 decimal places • 3 decimal places	2 decimal places	Yes	Channel	-
Measuring range center	• Value within the nominal range of the measuring range	0	Yes	Channel	-
Conductor resistance [6]	• 0 to 50000 mΩ	0	Yes	Channel	-
Hardware interrupt high limit 1 [4]	• Disable • Enable	Disable	Yes	Channel	-
High limit [4]	• Value	8500	Yes	Channel	-
Hardware interrupt low limit 1 [4]	• Disable • Enable	Disable	Yes	Channel	-
Low limit 1 [4]	• Value	-2000	Yes	Channel	-
Hardware interrupt high limit 2 [4]	• Disable • Enable	Disable	Yes	Channel	-
High limit 2 [4]	• Value	8500	Yes	Channel	-
Hardware interrupt low limit 2 [4]	• Disable • Enable	Disable	Yes	Channel	-
Low limit 2 [4]	• Value	-2000	Yes	Channel	-
Potential group	• Use potential group of the left module (dark-colored BaseUnit) • Enable new potential group (light-colored BaseUnit)	Use potential group of the left module (dark-colored BaseUnit)	No	Module	Module

1 Diagnostics: Missing supply voltage L+: Detection per module or alarm per channel

2 Interference frequency suppression: Interfering signals at 400 Hz are automatically included in the filtering at 50 Hz.

3 The settings in the "Interference frequency suppression" parameter have a direct effect on the conversion time of the channel. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

4 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 13 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter data record".

5 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", "No reference channel mode" is used for RTD and "Fixed reference temperature" is used for TC.

6 For 2-wire connection only

7 Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.

8 By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical specifications).

NOTE

Unused channels

"Deactivate" unused channels in the parameter assignment to improve the cycle time of the module.

A deactivated channel always returns the value $7FFF_H$.

NOTE

For user calibration with a calibration device, deactivate the "Wire-break check" parameter or function.

5.3 Explanation of parameters

Diagnostics: Missing supply voltage L+

Enabling of the diagnostics for missing or insufficient supply voltage L+.

Diagnostics: Reference junction

Enabling of the reference junction diagnostics if the reference temperature of the reference junction needs to be determined for the TC channel being operated.

Reference junction using the PROFINET GSD file

A BaseUnit with an internal temperature sensor (BU..T), the reference channel of group 0, 1, 2, 3, or channel 0 of the I/O module, if it has been configured as "Thermal resistor Pt100 climatic range Degrees Celsius", can be used as reference junction for the TC measurement.

A possible parameter assignment is represented below:

Table 2-650 RTD channel

Setting	Description
No reference channel mode	The temperature value at channel 0 can be used as a reference value for the entire module.
Reference channel of group 0, 1, 2, 3	The channel acts as a **transmitter** for the reference junction temperature of a group. The distribution is performed via the interface module. The RTD channel must be parameterized as follows: • Measurement type/measuring range "Thermal resistance Pt100 climate range" • Temperature unit "Degrees Celsius"

Table 2-651 TC channel

Setting	Description
Reference channel of the module	The corresponding TC channel uses channel 0 of the same module as the reference junction temperature. This channel must be parameterized as follows, otherwise the reference junction diagnostics is triggered: • Measurement type/measuring range "Thermal resistance Pt100 climate range" • Temperature unit "Degrees Celsius" • Reference junction "No reference channel mode"
Internal reference junction	The reference junction temperature is read by an internal temperature sensor on the BaseUnit. Diagnostics: Reference junction is triggered if there is an incorrect BaseUnit type.
Reference channel of group 0, 1, 2, 3	The channel acts as a **receiver** for the reference junction temperature of a group. The RTD channel must be parameterized as **sender** as follows: • Measurement type/measuring range "Thermal resistance Pt100 climate range" • Temperature unit "Degrees Celsius" • Reference junction: Must be the same reference channel of the group
Fixed reference temperature	The reference temperature of the thermocouple is set to 0 °C. As a result, no temperature compensation is performed.

NOTE

Shared Device and "Reference channel of group 0, 1, 2, 3"

If the transmitter and receiver for the reference junction temperature of a group are assigned to different IO controllers, then both IO controllers must be performing data exchange with the IO device to ensure error-free operation of the temperature compensation.

Reference junction using the PROFIBUS GSD file

A BaseUnit with an internal temperature sensor (BU..T), the reference channel of group 0, 1, 2, 3, or channel 0 of the I/O module, if it has been configured as "Thermal resistor Pt100 climatic range Degrees Celsius", can be used as reference junction for the TC measurement.

The set temperature unit (e.g. Degrees Celsius) is valid for the entire module with temperature compensation "Reference channel of the module" and "Reference channel of group 0, 1, 2, 3".

Table 2-652 **RTD channel**

Setting	Description
No reference channel mode	The temperature value at channel 0 can be used as a reference value for the entire module.
Reference channel of group 0, 1, 2, 3	The channel acts as a **transmitter** for the reference junction temperature of a group. The distribution is performed via the interface module. The RTD channel must be parameterized as follows: • Measurement type/measuring range "Thermal resistance Pt100 climate range" • Temperature unit "Degrees Celsius"

Setting	Description
Channel x Reference junction activated	• Disable: Channel x is configured with the setting "No reference channel mode". • Enable: Channel x is configured with the setting selected for the "Reference junction" parameter.

Table 2-653 **TC channel**

Setting	Description
Reference channel of the module	The corresponding TC channel uses channel 0 of the same module as the reference junction temperature. This channel must be parameterized as follows, otherwise the reference junction diagnostics is triggered: • Measurement type/measuring range "Thermal resistance Pt100 climate range" • Temperature unit "Degrees Celsius" • Reference junction "No reference channel mode"
Internal reference junction	The reference junction temperature is read by an internal temperature sensor on the BaseUnit. Diagnostics: Reference junction is triggered if there is an incorrect BaseUnit type.
Reference channel of group 0, 1, 2, 3	The channel acts as a **receiver** for the reference junction temperature of a group. The RTD channel must be parameterized as **sender** as follows: • Measurement type/measuring range "Thermal resistance Pt100 climate range" • Temperature unit "Degrees Celsius" • Reference junction: Must be the same reference channel of the group
Fixed reference temperature	The reference temperature of the thermocouple is set to 0 °C. As a result, no temperature compensation is performed.

Setting	Description
Channel x Reference junction activated	• Disable: Channel x is configured with the setting "Fixed reference temperature". • Enable: Channel x is configured with the setting selected for the "Reference junction" parameter.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics if the measured value falls below the underrange.

Diagnostics: Wire break

Enabling of the diagnostics if the module has no current flow or the current is insufficient for measurement at the correspondingly assigned input.

Type/range of measurement

See the section Measurement types and measuring ranges (Page 15).

Temperature coefficient

The temperature coefficient depends on the chemical composition of the material. In Europe, only one value is used per sensor type (default value).

The temperature coefficient (α value) indicates by how much the resistance of a specific material changes relatively if the temperature increases by 1 °C.

The other values facilitate a sensor-specific setting of the temperature coefficient and enhance accuracy.

Temperature unit

Selection between Degrees Celsius, Fahrenheit and Kelvin as the temperature unit for the selected measuring range.

Smoothing

The individual measured values are smoothed using filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This specification is valid for all signal changes at the analog input.

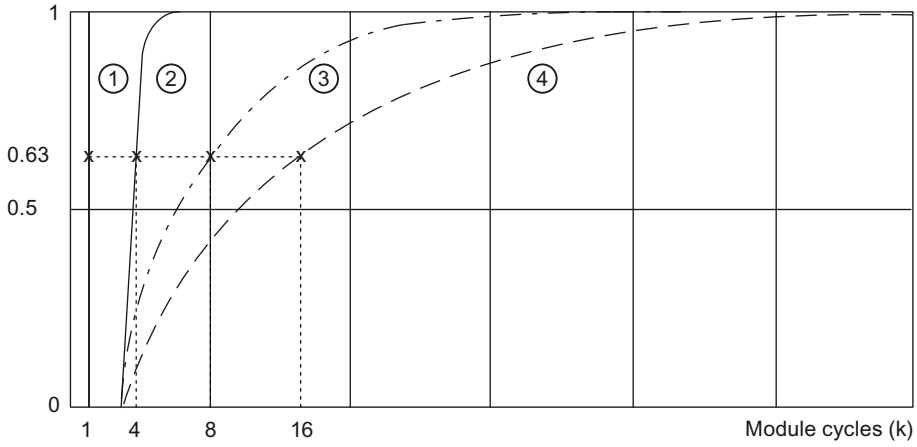

① No smoothing (k = 1)

② Weak (k = 4)

③ Medium (k = 8)

④ Strong (k = 16)

Figure 2-607 Smoothing for AI 4×RTD/TC 2-/3-/4-wire HF

Interference frequency suppression

Suppresses the interferences affecting analog input modules that are caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network is likely to have a negative effect on measured values particularly with measurement in the low voltage range and on thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Scalable measuring range

See the Scalable measuring range (Page 30) section.

Measuring range resolution

See the Scalable measuring range (Page 30) section.

Measuring range center

See the Scalable measuring range (Page 30) section.

Conductor resistance

Parameters for the measurement types resistor and thermal resistor (2-wire connection).

Used to compensate for the conductor resistance without having to interfere with the sensor wiring.

If the "Conductor resistor" parameter is configured higher than a value 0 mΩ, the module then automatically uses the factory calibration data.

Hardware interrupt enable

Enabling of a hardware interrupt if the high limit 1/2 or the low limit 1/2 is violated.

Low limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

High limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

Potential group

Specify whether a light-colored BaseUnit with incoming supply voltage or a dark-colored BaseUnit is located in this slot (see ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual).

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with a dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

5.4 Scalable measuring range

Function

The scalable measuring range is a limited section of a measuring range supported by the module.

It allows you to increase the resolution for a configurable section.

- The function is enabled with the "Scalable measuring range" parameter.
- The "Measuring range resolution" parameter determines the resolution to 2 or 3 decimal places for a configurable section of the measuring range.
- The "Measuring range center" parameter determines the temperature over which the scalable measuring range is symmetrically spanned.

NOTE

The scalable measuring range is available for the temperature measuring ranges of thermal resistors (RTD) standard and thermocouples. The measuring ranges for voltage, resistor and thermal resistor climatic are not supported.

The scalable measuring range is valid for the following ranges:

- Nominal range
- Underrange
- Overrange

Value ranges

Table 2-654 Value ranges

Scalable measuring range	Measuring range resolution		Values hex.
	2 decimal places	3 decimal places	
Overflow	> 325.11	> 32.511	$7FFF_H$
High limit	325.11	32.511	$7EFF_H$
Measuring range center	0	0	0_H
Low limit	-325.12	-32.512	8100_H
Underflow	<-325.12	<-32.512	8000_H

To obtain an absolute temperature, the measuring range center in the application program (as offset) must be calculated with the value of the user data of the scalable measuring range.

The measuring range center is always output in the user data as the value "0". The user data are correspondingly mapped to the bipolar input ranges in S7 format. Underflow / overflow is also formed in accordance with the limits of S7.

Rules

- The measuring range center must be within the nominal range of the underlying measuring range. It is specified in integers.
- The scalable measuring range is spanned symmetrically over the measuring range center. Depending on the resolution, various value ranges result (①, ②).
- The scalable measuring range is limited by underflow and overflow of the underlying measuring range:
  - It is clipped at the underflow when it falls below the limit.
  - It is clipped at the overflow when it exceeds the limit (③).

Example

The following example illustrates the effect of scalable measuring ranges:

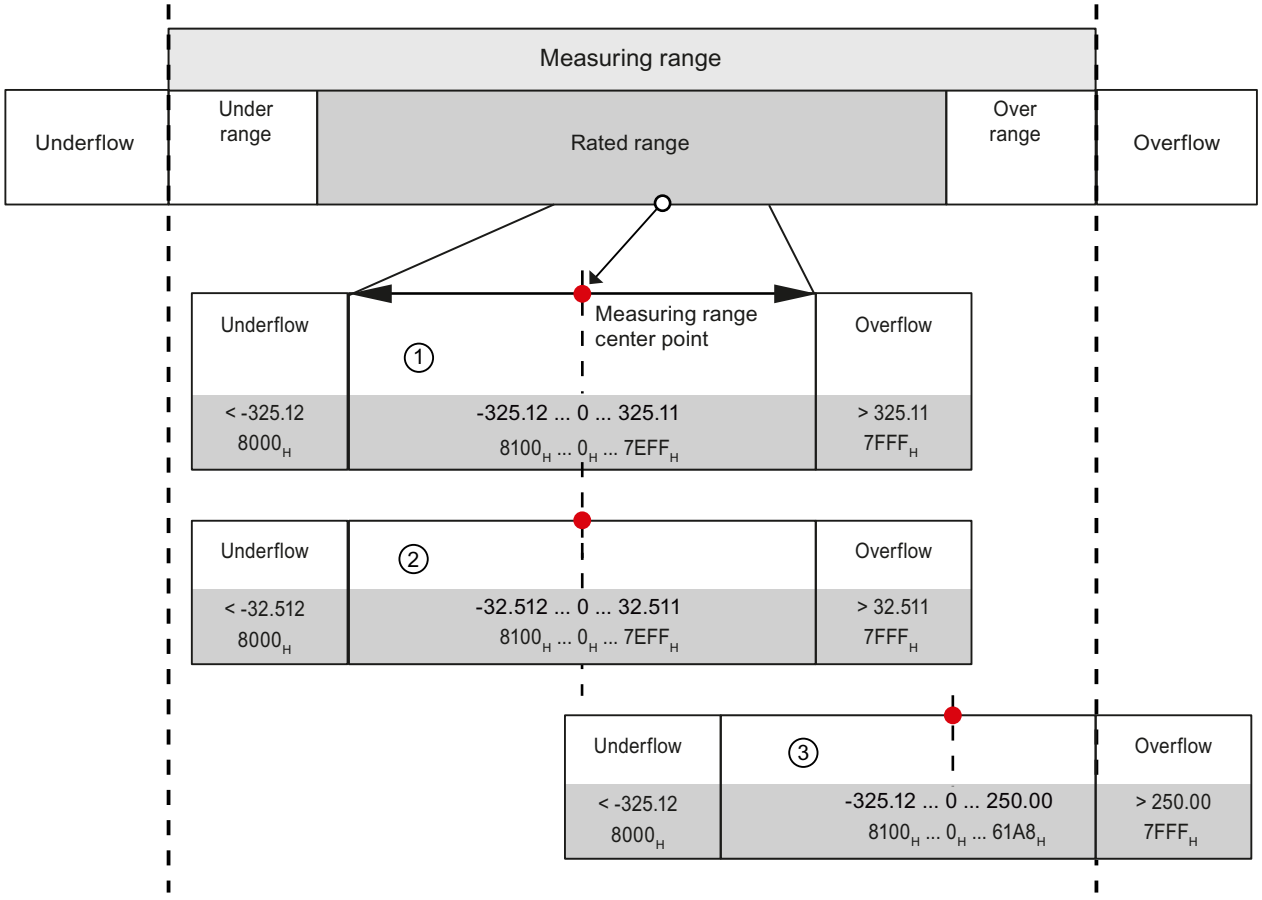

① Scalable measuring range with 2 decimal places in hexadecimal S7 format

② Scalable measuring range with 3 decimal places in hexadecimal S7 format

③ Scalable measuring range which is cut off at the overflow of the underlying measuring range (clipping)

Figure 2-608 Examples of scalable measuring ranges

5.4.1 Configuration

Requirement

You must select a valid temperature measuring range for configuration.

Configuration

The function is activated using the "Scalable measuring range" parameter.
The following figure shows an example of a configuration in STEP 7:

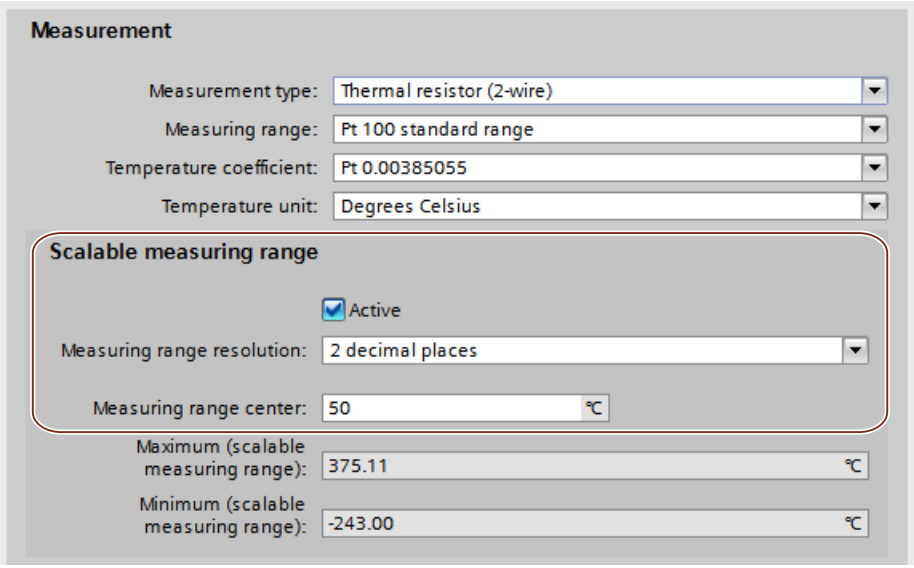

Figure 2-609 Configuration for the scalable measuring range

Reference

You will find more information on the configuration in the STEP 7 online help.

5.4.2 Evaluating data record 235

Evaluation in the user program

In the user program, you can evaluate the status and the limits of the scalable measuring range with data record 235, which may result by reaching underflow/overflow.

Structure of data record 235

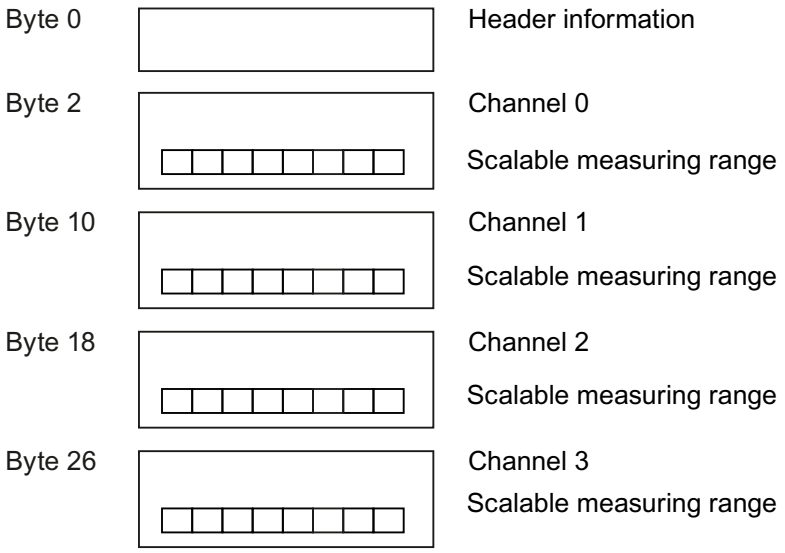

Figure 2-610 Structure of data record 235

Header information

The figure below shows the structure of the header information.

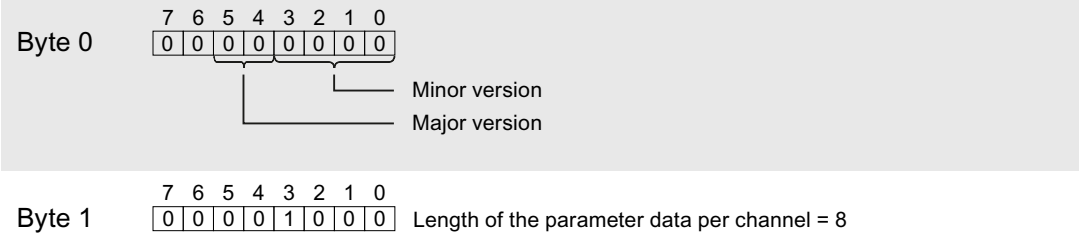

Figure 2-611 Header information of data record 235

Parameters

The figure below shows the structure of the parameter.

If the corresponding bit is set to "1", the parameter is activated.

* x = 2 + (channel number x 8)

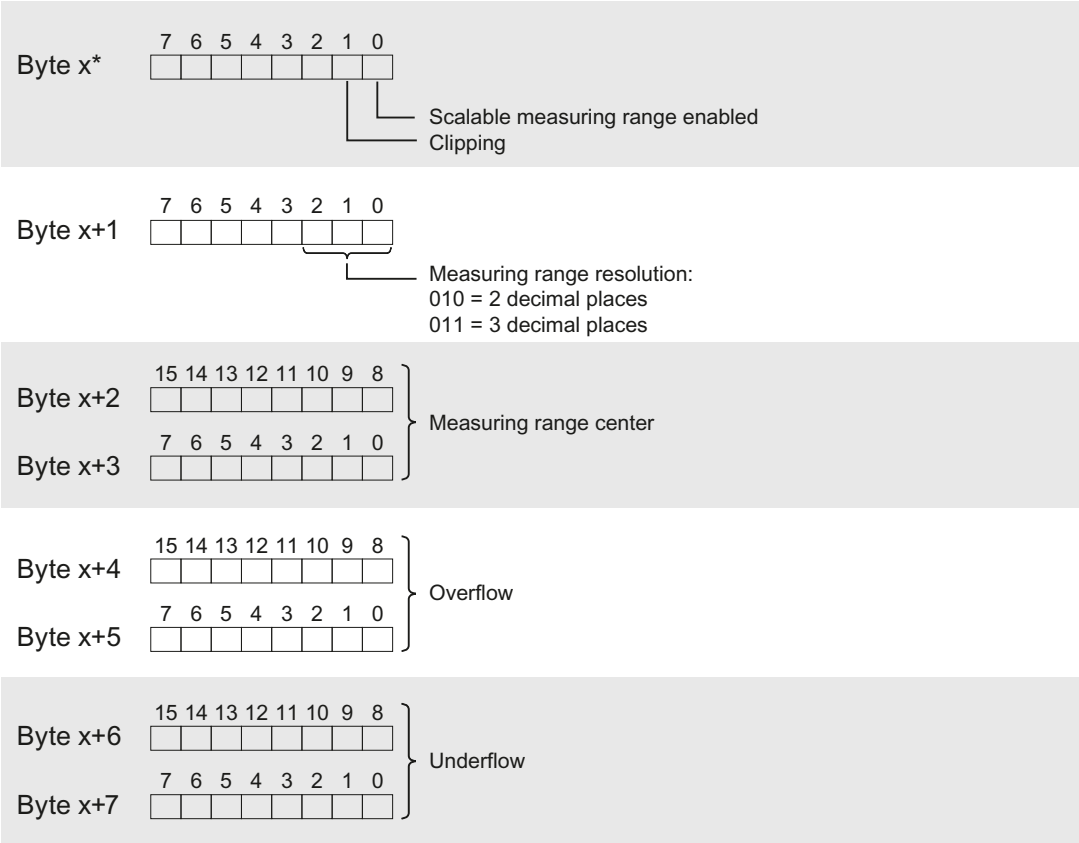

Figure 2-612 Structure of data record 235 - channel parameter byte x to x+7

Description of the parameters

Table 2-655 Description **of the parameters from data record 235**

Parameter	Description
Scalable measuring range enabled	1 = Function is active for this channel.
Clipping	1 = Scalable measuring range cut off at the overflow / underflow of the underlying measuring range (see Figure).
Resolution	2 or 3 decimal places
Measuring range center	Temperature in whole °C / °F / K ("working point" for the scaling)
Overflow/underflow	Limits of the scalable measuring range

Example

The following example shows the values for a thermal resistor Pt 100 Standard, °C:

Table 2-656 Example of a thermal resistor Pt 100 Standard

Hex. value	Dec. value	Evaluation of data record 235
00_H	0	V0.0
08_H	8	8 bytes
03_H	3	Scalable measuring range active and clipped (clipping)
02_H	2	Resolution: 2 decimal places
$02EE_H$	750	Measuring range center: 750 °C
$61A8_H$	25000	Overflow (Maximum): 250**.00** + 750 = 1000.00 °C Scalable measuring range is clipped at the overflow.
8100_H	-32512	Underflow (Minimum): -325**.12** + 750 = 424.88 °C

5.5 Address space

Address space of the analog input module AI 4×RTD/TC 2-/3-/4-wire HF

The figure below shows the assignment of the address space for AI 4×RTD/TC 2-/3-/4-wire HF.

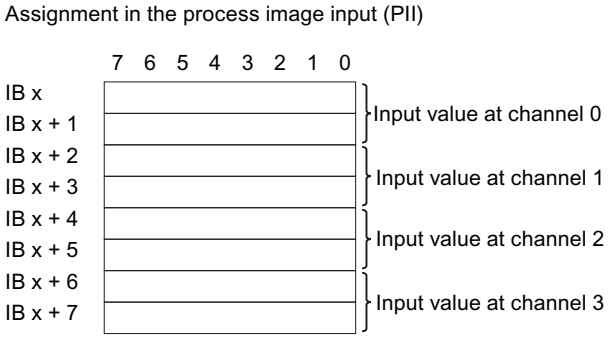

Figure 2-613 Address space AI 4xRTDTC 2-3-4-wire HF without value status

Address space of the analog input module AI 4×RTD/TC 2-/3-/4-wire HF, QI

The figure below shows the assignment of the address space for the AI 4×RTD/TC 2-/3-/4-wire HF, QI. The addresses for the value status are only available if the value status is enabled.

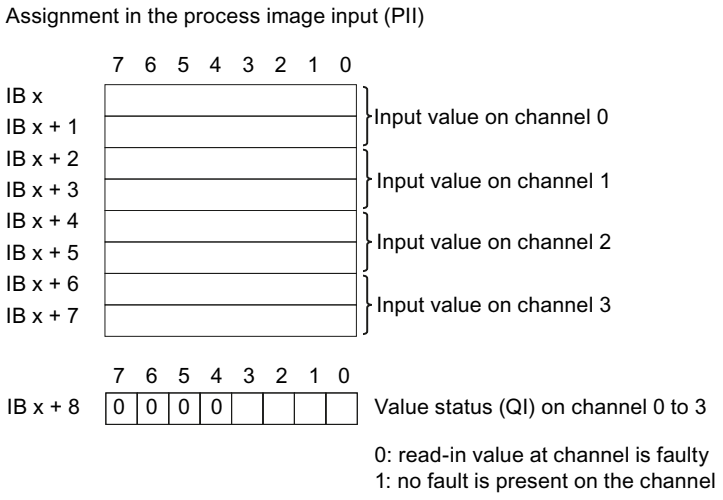

Figure 2-614 Address space AI 4×RTD/TC 2-/3-/4-wire HF with value status

Configuration options of the AI 4xRTD/TC 2-/3-/4-wire HF

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status (as of firmware version V1.1.0)

An additional byte is occupied in the input address space if you enable the value status for the analog module. Bits 0 to 3 in this byte are assigned to a channel and provide information on the validity of the analog value.

Bit = 1: No error is present on the channel.

Bit = 0: The channel is disabled or the wiring or the value created on the channel, etc. is incorrect.

Interrupts/diagnostics alarms

6

6.1 Status and error display

LED display

The figure below shows the LED displays of the AI 4xRTD/TC 2-/3-/4-wire HF:

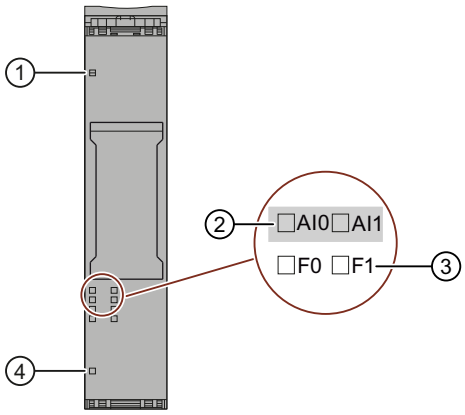

① DIAG (green/red)

② Channel status (green)

③ Channel error (red)

④ PWR (green)

Figure 2-615 LED display

Meaning of the LED displays

The following tables contain the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostics alarms (Page 40).

LED DIAG

Table 2-657 LED DIAG fault display

LED DIAG	Meaning
□ Off	Backplane bus supply of the system is interrupted or switched off
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status/channel error LED

Table 2-658 Status and error display of the LED channel status / channel error

LEDs		Meaning
Channel status	Channel error	
□ Off	□ Off	Channel deactivated or no load voltage L+
■ On	□ Off	Channel activated and no channel diagnostics
□ Off	■ On	Channel activated and channel diagnostics
■ On	■ On	Not permitted (error)

PWR LED

Table 2-659 Status display of the PWR LED

PWR LED	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ present

6.2 Interrupts

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- Violation of low limit 1
- Violation of high limit 1
- Violation of low limit 2
- Violation of high limit 2

You can obtain detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

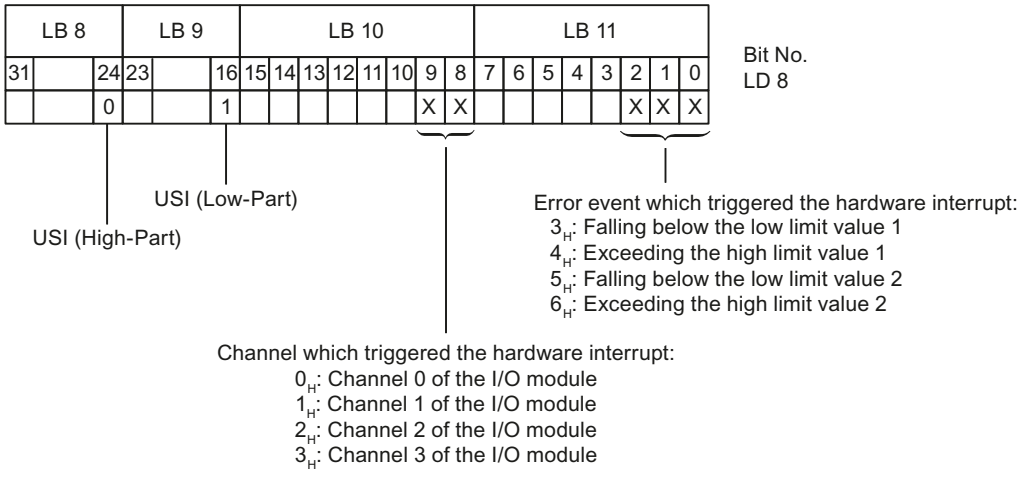

Figure 2-616 OB start information

Structure of the additional interrupt information

Table 2-660 Structure of the additional interrupt information

Data block name		Content	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	additional interrupt information for hardware interrupts of the I/O module	2
Channel that triggered the hardware interrupt.				
	Channel	B#16#00 to B#16#03	Channel 0 to 3 of the I/O module	1
Event that triggered the hardware interrupt.				
	Event	B#16#03	Violation of low limit 1	1
		B#16#04	Violation of high limit 1	
		B#16#05	Violation of low limit 2	
		B#16#06	Violation of high limit 2	

Diagnostic error interrupt

The module generates a diagnostic error interrupt at the following events:

- Channel temporarily unavailable
- Hardware interrupt lost
- Reference channel error
- Error
- Violation of low limit
- Violation of high limit
- Wire break
- Supply voltage missing
- Parameter assignment error

6.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-661 Diagnostics alarms, their meaning and remedies

Diagnostics alarms	Error code	Meaning	Remedy
Wire break	6_H	Resistance of sensor circuit too high	Use a different sensor type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate diagnostics • Connect or deactivate the channel
Violation of high limit[1]	7_H	Value lies above the overrange.	Correct module/sensor interplay
		Wire break[2]	See Wire break
Violation of low limit[1]	8_H	Value lies below the underrange.	Correct module/sensor interplay
Error	9_H	Internal module error has occurred (diagnostics alarm on channel 0 applies to the entire module).	Replace module
Parameter assignment error	10_H	The module cannot evaluate parameters for the channel. Incorrect parameter assignment.	• Correct the parameter assignment (diagnostics wire break set only with the permitted measuring ranges).
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check the supply voltage L+ at the BaseUnit • Check BaseUnit type

1 The alarm refers to the diagnostics and depends on the configured measuring range.

2 For resistor and thermal resistor measuring ranges with deactivated diagnostics for "wire break", this is reported by the "Violation of high limit" diagnostic.

3 Shared Device and diagnostics "Reference temperature": If the sender and receiver of the reference junction temperature of a group are assigned to different IO controllers, you may need to download both configurations again in the case of diagnostics. First download the configuration containing the receiver.

Diagnostics alarms	Error code	Meaning	Remedy
Reference channel error (reference junction)	15_H	Reference temperature of the reference junction for the TC channel being operated with compensation is invalid.	• Check BaseUnit type • Select correct reference junction through parameter assignment[3] • Check whether the reference junction (reference channel of the group 0, 1, 2, 3) is only assigned once as the sender in the entire setup.
Hardware interrupt lost	16_H	At least one hardware interrupt could not be reported because there were too many pending hardware interrupts.	Correct the program or the process
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module does not read any process values in this state.	• Wait for firmware update. • Restart the firmware update.
		The channel is currently being calibrated.	• Complete calibration.

1 The alarm refers to the diagnostics and depends on the configured measuring range.

2 For resistor and thermal resistor measuring ranges with deactivated diagnostics for "wire break", this is reported by the "Violation of high limit" diagnostic.

3 Shared Device and diagnostics "Reference temperature": If the sender and receiver of the reference junction temperature of a group are assigned to different IO controllers, you may need to download both configurations again in the case of diagnostics. First download the configuration containing the receiver.

NOTE

Diagnostic messages in the measured value of analog input modules

Each analog input module supplies the measured value $7FFF_H$ or 8000_H depending on the parameter assignment when an error is detected.

Technical specifications 7

7.1 Technical specifications

Technical specifications of AI 4×RTD/TC 2-/3-/4-wire HF

The following table shows the technical specifications as of 09/2019. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7134-6JD00-0CA1/td?dl=en).

Article number	6ES7134-6JD00-0CA1
General information	
Product type designation	AI 4xRTD/TC 2-/3-/4-wire HF
Firmware version	V2.1
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Adjustment of measuring range	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V12 SP1 / V13
• STEP 7 configurable/integrated from version	V5.5 SP3 / V5.5 SP4
• PCS 7 configurable/integrated from version	V8.1 SP1
• PROFIBUS from GSD version/GSD revision	GSD Revision 5
• PROFINET from GSD version/GSD revision	GSDML V2.3
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Power loss	
Power loss, typ.	0.75 W

Article number	6ES7134-6JD00-0CA1
Address area	
Address space per module	
• Address space per module, max.	8 byte; + 1 byte for QI information
Analog inputs	
Number of analog inputs	4
permissible input voltage for voltage input (destruction limit), max.	30 V
Constant measurement current for resistance-type transmitter, typ.	2 mA
Cycle time (all channels), min.	Sum of the basic conversion times and additional processing times (depending on the parameterization of the active channels); for line compensation in case of a three-wire connection, an additional cycle is necessary
Technical unit for temperature measurement adjustable	Yes; °C/°F/K
Input ranges (rated values), voltages	
• -1 V to +1 V	Yes; 16 bit incl. sign
– Input resistance (-1 V to +1 V)	1 MΩ
• -250 mV to +250 mV	Yes; 16 bit incl. sign
– Input resistance (-250 mV to +250 mV)	1 MΩ
• -50 mV to +50 mV	Yes; 16 bit incl. sign
– Input resistance (-50 mV to +50 mV)	1 MΩ
• -80 mV to +80 mV	Yes; 16 bit incl. sign
– Input resistance (-80 mV to +80 mV)	1 MΩ
Input ranges (rated values), thermocouples	
• Type B	Yes; 16 bit incl. sign
– Input resistance (Type B)	1 MΩ
• Type C	Yes; 16 bit incl. sign
– Input resistance (Type C)	1 MΩ
• Type E	Yes; 16 bit incl. sign
– Input resistance (Type E)	1 MΩ
• Type J	Yes; 16 bit incl. sign
– Input resistance (type J)	1 MΩ
• Type K	Yes; 16 bit incl. sign
– Input resistance (Type K)	1 MΩ
• Type L	Yes; 16 bit incl. sign
– Input resistance (Type L)	1 MΩ
• Type N	Yes; 16 bit incl. sign
– Input resistance (Type N)	1 MΩ

Article number	6ES7134-6JD00-0CA1
• Type R	Yes; 16 bit incl. sign
– Input resistance (Type R)	1 MΩ
• Type S	Yes; 16 bit incl. sign
– Input resistance (Type S)	1 MΩ
• Type T	Yes; 16 bit incl. sign
– Input resistance (Type T)	1 MΩ
• Type U	Yes; 16 bit incl. sign
– Input resistance (Type U)	1 MΩ
• Type TXK/TXK(L) to GOST	Yes; 16 bit incl. sign
– Input resistance (Type TXK/TXK(L) to GOST)	1 MΩ
Input ranges (rated values), resistance thermometer	
• Cu 10	Yes; 16 bit incl. sign
– Input resistance (Cu 10)	1 MΩ
• Ni 100	Yes; 16 bit incl. sign
– Input resistance (Ni 100)	1 MΩ
• Ni 1000	Yes; 16 bit incl. sign
– Input resistance (Ni 1000)	1 MΩ
• LG-Ni 1000	Yes; 16 bit incl. sign
– Input resistance (LG-Ni 1000)	1 MΩ
• Ni 120	Yes; 16 bit incl. sign
– Input resistance (Ni 120)	1 MΩ
• Ni 200	Yes; 16 bit incl. sign
– Input resistance (Ni 200)	1 MΩ
• Ni 500	Yes; 16 bit incl. sign
– Input resistance (Ni 500)	1 MΩ
• Pt 100	Yes; 16 bit incl. sign
– Input resistance (Pt 100)	1 MΩ
• Pt 1000	Yes; 16 bit incl. sign
– Input resistance (Pt 1000)	1 MΩ
• Pt 200	Yes; 16 bit incl. sign
– Input resistance (Pt 200)	1 MΩ
• Pt 500	Yes; 16 bit incl. sign
– Input resistance (Pt 500)	1 MΩ
Input ranges (rated values), resistors	
• 0 to 150 ohms	Yes; 15 bit
– Input resistance (0 to 150 ohms)	1 MΩ

Article number	6ES7134-6JD00-0CA1
• 0 to 300 ohms	Yes; 15 bit
– Input resistance (0 to 300 ohms)	1 MΩ
• 0 to 600 ohms	Yes; 15 bit
– Input resistance (0 to 600 ohms)	1 MΩ
• 0 to 3000 ohms	Yes; 15 bit
– Input resistance (0 to 3000 ohms)	1 MΩ
• 0 to 6000 ohms	Yes; 15 bit
– Input resistance (0 to 6000 ohms)	1 MΩ
• PTC	Yes; 15 bit
– Input resistance (PTC)	1 MΩ
Thermocouple (TC)	
Temperature compensation	
– parameterizable	Yes
– Reference channel of the module	Yes
– internal comparison point	Yes; with BaseUnit type A1
– Number of reference channel groups	4; Group 0 to 3
Cable length	
• shielded, max.	200 m; 50 m with thermocouples
Analog value generation for the inputs	
Measurement principle	integrating (Sigma-Delta)
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Basic conversion time, including integration time (ms)	
– additional processing time for wire-break check	2 ms; In the ranges resistance thermometers, resistors and thermocouples
– additional power line wire-break check	2 ms; for 3/4 wire transducer (resistance thermometer and resistor)
• Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz
• Conversion time (per channel)	180 / 60 / 50 / (67.5 / 22.5 / 18.75) ms
Smoothing of measured values	
• Number of smoothing levels	4; None; 4/8/16 times
• parameterizable	Yes

Article number	6ES7134-6JD00-0CA1
Encoder	
Connection of signal encoders	
• for voltage measurement	Yes
• for resistance measurement with two-wire connection	Yes
• for resistance measurement with three-wire connection	Yes
• for resistance measurement with four-wire connection	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %; ±0.1 % for resistance thermometers and resistance
Temperature error (relative to input range), (+/-)	0.0009 %/K; ±0.005 % / K at thermocouple
Crosstalk between the inputs, min.	-50 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Voltage, relative to input range, (+/-)	0.1 %
• Resistance, relative to input range, (+/-)	0.1 %
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to input range, (+/-)	0.05 %
• Resistance, relative to input range, (+/-)	0.05 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	70 dB; With conversion time 67.5 / 22.5 / 18.75 ms: 40 dB
• Common mode voltage, max.	10 V
• Common mode interference, min.	90 dB
Interrupts/diagnostics/status information	
Alarms	
• Limit value alarm	Yes; two upper and two lower limit values in each case
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; channel by channel
• Group error	Yes
• Overflow/underflow	Yes; channel by channel
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED

Article number	6ES7134-6JD00-0CA1
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; < 0 °C as of FS08
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; < 0 °C as of FS08
• vertical installation, max.	50 °C

Operational and basic error limits for resistance thermometers

Error limits for resistance thermometers	
Operational limit (in the entire temperature range, in relation to input range)	
• Pt 100, Pt 200, Pt 500, Pt 1000 standard	±1.0 K
• Pt 100, Pt 200, Pt 500, Pt 1000 climatic	± 0.25 K
• Ni 100, Ni 120, Ni 200, Ni 500, Ni 1000 standard and climatic	± 0.4 K
• Cu 10	±1.5 K
Basic error limit (operational limit at 25 °C, in relation to input range)	
• Pt 100, Pt 200, Pt 500, Pt 1000 standard	± 0.6 K
• Pt 100, Pt 200, Pt 500, Pt 1000 climatic	± 0.13 K
• Ni 100, Ni 120, Ni 200, Ni 500, Ni 1000 standard and climatic	± 0.2 K
• Cu 10	±1.0 K

Operational and basic error limits for thermocouples [1]

Error limits for thermocouples	
Operational limit for thermocouples (in the entire temperature range)	±1.5 K
Basic error limit for thermocouples (operational limit at 25 °C)	±1 K
Overall error limits when using internal compensation	
• Operational limit (in the entire temperature range at static thermal state, ambient temperature change < 0.3 K/min)	± 2.5 K
• Basic error limit (operational limit at 25 °C at static thermal state, ambient temperature change < 0.3 K/min)	±1.5 K

[1] The indicated error limits apply as of the following temperatures:
Thermocouple type T: -200 °C
Thermocouple type K: -100 °C
Thermocouple type B: +700 °C
Thermocouple type N: -150 °C
Thermocouple type E: -150 °C
Thermocouple type R: +200 °C
Thermocouple type S: +100 °C

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Table 2-662 Dependencies of the measurement type / measuring range

Measurement type	Measuring range	Temperature coefficient	Reference junction	Temperature unit	Conductor resistance
Deactivated	*	*	*	*	*
Voltage	±50 mV, ±80 mV, ±250 mV, ±1 V	*	*	*	*
Resistor (2, 3, 4-wire connection)	150 Ω, 300 Ω, 600 Ω, 3 kΩ, 6 kΩ	*	*	*	x (with 2-wire connection)
Resistor (2-wire connection)	PTC	*	*	*	*
Thermal resistor (2, 3, 4-wire connection)	Pt100 climatic	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	Reference channel of group 0, 1, 2, 3	Degrees Celsius	x (with 2-wire connection)
			No reference channel mode	Degrees Celsius Degrees Fahrenheit	
	Pt200 Pt500 Pt1000 climatic		No reference channel mode	Degrees Celsius Degrees Fahrenheit	

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of "Reference channel of the module":
- Channel 0 must be set as "Pt100 climatic" with temperature unit: "Degrees Celsius".
-For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Reference channel of the module".

2 Use of "Reference channel of group 0, 1, 2, 3":
- An RTD channel must be set as "Pt100 climatic" with temperature unit: "Degrees Celsius".
- "Reference channel of group 0, 1, 2, 3" must be set as the "Reference junction" of this channel.
- There must only be one RTD channel with "Reference junction" = "Reference channel of group 0, 1, 2, 3" per group 0, 1, 2, 3 and IO device!
- For each TC channel in the IO device that is intended to use this reference, "Reference junction" must be set to "Reference channel of group 0, 1, 2, 3".
- If the reference channel is on channel 0, it can also be used as "Reference channel of the module" at the same time.

Measurement type	Measuring range	Temperature coefficient	Reference junction	Temperature unit	Conductor resistance
Thermal resistor (2, 3, 4-wire connection)	Ni100 Ni120 Ni200 Ni500 Ni1000 climatic	Ni 0.00618 Ni 0.00672	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x (with 2-wire connection)
	LG-Ni 1000 climatic	LG-Ni 0.005			
(3-wire connection)	Cu 10 climatic	Cu 0.00427			*
Thermal resistor (2, 3, 4-wire connection)	Pt100 Pt200 Pt500 Pt1000 standard	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x (with 2-wire connection)
	Ni100 Ni120 Ni200 Ni500 Ni1000 standard	Ni 0.00618 Ni 0.00672			
	LG-Ni 1000 standard	LG-Ni 0.005			
Thermal resistor (3-wire connection)	Cu 10 standard	Cu 0.00427			*
Thermocouple	Type B, N, E, R, S, J, L, T, K, U, C, TXK	*	Reference channel of the module[1] Internal reference junction Reference channel of group 0, 1, 2, 3[2]	Degrees Celsius Degrees Fahrenheit Kelvin	*
			Fixed reference temperature		

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of "Reference channel of the module":
- Channel 0 must be set as "Pt100 climatic" with temperature unit: "Degrees Celsius".
-For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Reference channel of the module".

2 Use of "Reference channel of group 0, 1, 2, 3":
- An RTD channel must be set as "Pt100 climatic" with temperature unit: "Degrees Celsius".
- "Reference channel of group 0, 1, 2, 3" must be set as the "Reference junction" of this channel.
- There must only be one RTD channel with "Reference junction" = "Reference channel of group 0, 1, 2, 3" per group 0, 1, 2, 3 and IO device!
- For each TC channel in the IO device that is intended to use this reference, "Reference junction" must be set to "Reference channel of group 0, 1, 2, 3".
- If the reference channel is on channel 0, it can also be used as "Reference channel of the module" at the same time.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type for PROFINET.

Table 2-663 Dependencies on the measurement type

Measurement type	Scalable measuring range	Measuring range resolution	Diagnostics				
			Underflow	Overflow	Wire break	Missing supply voltage L+	Reference junction
Deactivated	*	*	*	*	*	*	*
Voltage	–	*	x	x	–	x	–
Resistor (2, 3, 4-wire connection)	–	*	x	x	x	x	–
Resistor PTC (2-wire connection)	–	*	x	–	–	x	–
Thermal resistor (2, 3, 4-wire connection)	x	2 and 3 decimal places	x	x	x	x	–
Thermocouple	x	2 and 3 decimal places	x	x	x	x	x[1)]

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Property is not relevant if "Fixed reference temperature" is used

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Temperature coefficient	Slot reference junction	Temperature unit	Diagnostics			
					Underflow / overflow	Wire break	Missing supply voltage L+	Reference junction
Deactivated	*	*	*	*	*	*	*	*
Voltage	±50 mV, ±80 mV, ±250 mV, ±1 V	*	*	*	x	–	x	–

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of the "Reference channel of the module":
- Channel 0 must be set to "Pt100 climatic" with the temperature unit "Degrees Celsius".
- For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Enable".

2 Use of "Reference channel of group 0":
- An RTD channel must be set as "Pt100 climatic" with temperature unit "Degrees Celsius".
- "Reference channel of group 0, 1, 2, 3" must be set as the "Reference junction" of this channel.
- There may be only one RTD channel with "Reference junction active" = "Enable" per group and row.
- For each TC channel of this row that is intended to use this reference, "Reference junction active" must be set to "Enable".

3 Underflow = 8000_H; wire break and overflow lead to 01_H (triggered) → (no diagnostics), wire break and overflow are therefore not relevant.

Measurement type	Measuring range	Temperature coefficient	Slot reference junction	Temperature unit	Diagnostics			
					Underflow / overflow	Wire break	Missing supply voltage L+	Reference junction
Resistor (2, 3, 4-wire connection)	150 Ω, 300 Ω, 600 Ω, 3 kΩ, 6 kΩ	*	*	*	x	x	x	–
Resistor (2-wire connection)	PTC[3]	*	*	*	x	–	x	–
Thermal resistor (2, 3, 4-wire connection)	Pt100 climatic	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	Reference channel of group 0, 1, 2, 3	Degrees Celsius	x	x	x	–
			No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
	Pt200 Pt500 Pt1000 climatic	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
Thermal resistor (2, 3, 4-wire connection)	Pt100 Pt200 Pt500 Pt1000 standard	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–
	Ni100 Ni120 Ni200 Ni500 Ni1000 climatic	Ni 0.00618 Ni 0.00672	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
	Ni100 Ni120 Ni200 Ni500 Ni1000 standard	Ni 0.00618 Ni 0.00672	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of the "Reference channel of the module":
- Channel 0 must be set to "Pt100 climatic" with the temperature unit "Degrees Celsius".
- For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Enable".

2 Use of "Reference channel of group 0":
- An RTD channel must be set as "Pt100 climatic" with temperature unit "Degrees Celsius".
- "Reference channel of group 0, 1, 2, 3" must be set as the "Reference junction" of this channel.
- There may be only one RTD channel with "Reference junction active" = "Enable" per group and row.
- For each TC channel of this row that is intended to use this reference, "Reference junction active" must be set to "Enable".

3 Underflow = 8000_H; wire break and overflow lead to 01_H (triggered) → (no diagnostics), wire break and overflow are therefore not relevant.

Measurement type	Measuring range	Temperature coefficient	Slot reference junction	Temperature unit	Diagnostics			
					Underflow / overflow	Wire break	Missing supply voltage L+	Reference junction
Thermal resistor (2, 3, 4-wire connection)	LG-Ni 1000 climatic	LG-Ni 0.005	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
	LG-Ni 1000 standard	LG-Ni 0.005	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–
Thermal resistor (3-wire connection)	Cu 10 climatic	Cu 0.00427	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
	Cu 10 standard	Cu 0.00427	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–
Thermocouple	Type B, N, E, R, S, J, L, T, K, U, C, TXK	*	Reference channel of the module[1] Internal reference junction Reference channel of group 0, 1, 2, 3[2]	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	x
			Fixed reference temperature	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	*

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of the "Reference channel of the module":
- Channel 0 must be set to "Pt100 climatic" with the temperature unit "Degrees Celsius".
- For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Enable".

2 Use of "Reference channel of group 0":
- An RTD channel must be set as "Pt100 climatic" with temperature unit "Degrees Celsius".
- "Reference channel of group 0, 1, 2, 3" must be set as the "Reference junction" of this channel.
- There may be only one RTD channel with "Reference junction active" = "Enable" per group and row.
- For each TC channel of this row that is intended to use this reference, "Reference junction active" must be set to "Enable".

3 Underflow = 8000_H; wire break and overflow lead to 01_H (triggered) → (no diagnostics), wire break and overflow are therefore not relevant.

A.2 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can reassign the parameters of the module in RUN. For example, the measuring range of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 will not be changed on the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128 (as of V2.1)

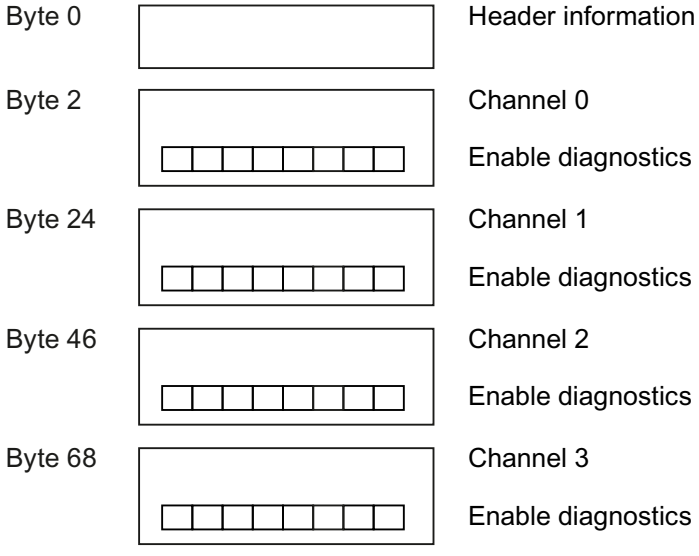

Figure 2-617 Structure of data record 128

Header information

The figure below shows the structure of the header information.

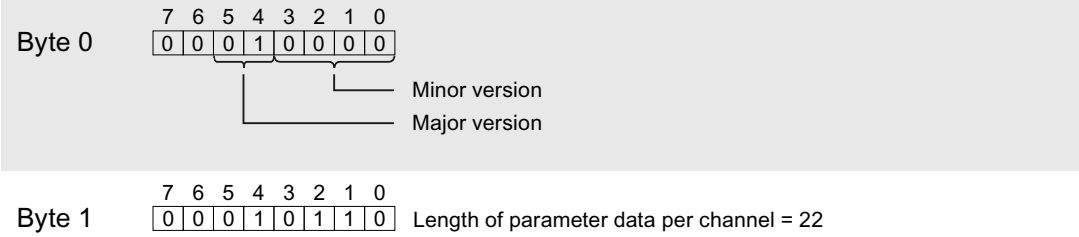

Figure 2-618 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You can activate a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number * 22); channel number = 0 to 3

	7	6	5	4	3	2	1	0	
Byte x*									Measurement type, see table Codes for measurement type
Byte x+1									Measuring range, see table Codes for measuring ranges
Byte x+2									Temperature coefficient, see Coding for Temperature Coefficient table
Byte x+3									
Byte x+4					0	0			
Byte x+5					0	0	0	0	

Byte x+3:

Smoothing:
0000 = None
0001 = Weak
0010 = Medium
0011 = Strong

Interference frequency suppression:
0001 = 60 Hz (50 ms)
0010 = 50 Hz (60 ms)
0100 = 16.6 Hz (180 ms)
1010 = 60 Hz (18.75 ms)
1011 = 50 Hz (22.5 ms)
1100 = 16.6 Hz (67.5 ms)
V2.1 or higher

Byte x+4:

Temperature unit:
00 = Degrees Celsius
01 = Degrees Fahrenheit
10 = Kelvin (not for climatic measuring range)

Reference junction:
(for RTD as reference channel transmitter, for TC as reference channel receiver)
0000 = No reference channel operation
0010 = Reference channel of the module
0011 = Internal reference junction
1000 = Reference channel of group 0
1001 = Reference channel of group 1
1010 = Reference channel of group 2
1011 = Reference channel of group 3
1111 = Fixed reference temperature

Byte x+5:

Enable hardware interrupt, high limit value 2
Enable hardware interrupt, low limit value 2
Enable hardware interrupt, high limit value 1
Enable hardware interrupt, low limit value 1

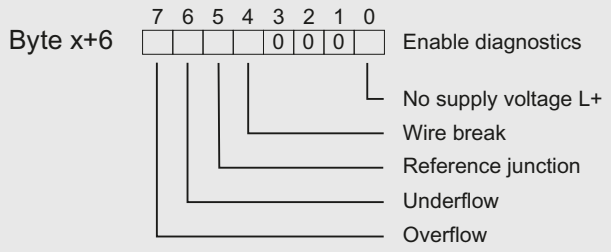
Byte x+6
7 6 5 4 3 2 1 0
0 0 0
Enable diagnostics
No supply voltage L+
Wire break
Reference junction
Underflow
Overflow

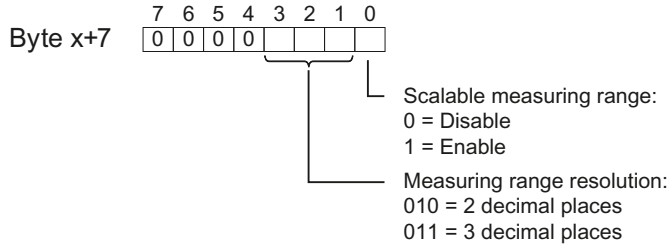
Byte x+7
7 6 5 4 3 2 1 0
0 0 0 0
Scalable measuring range:
0 = Disable
1 = Enable
Measuring range resolution:
010 = 2 decimal places
011 = 3 decimal places

Byte x+8
7 6 5 4 3 2 1 0
0 0 0 0 0 0 0 0
Byte x+9
7 6 5 4 3 2 1 0
0 0 0 0 0 0 0 0

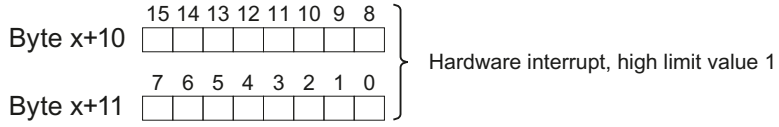
Byte x+10
15 14 13 12 11 10 9 8
Byte x+11
7 6 5 4 3 2 1 0
Hardware interrupt, high limit value 1

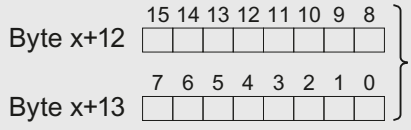
Byte x+12
15 14 13 12 11 10 9 8
Byte x+13
7 6 5 4 3 2 1 0
Hardware interrupt, low limit value 1

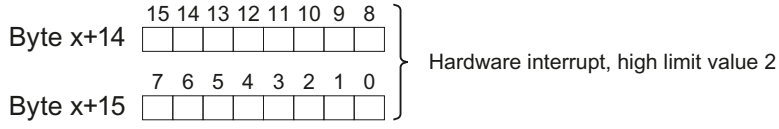
Byte x+14
15 14 13 12 11 10 9 8
Byte x+15
7 6 5 4 3 2 1 0
Hardware interrupt, high limit value 2

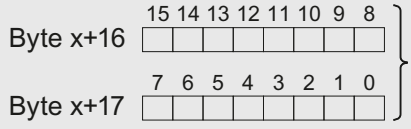
Byte x+16
15 14 13 12 11 10 9 8
Byte x+17
7 6 5 4 3 2 1 0
Hardware interrupt, low limit value 2

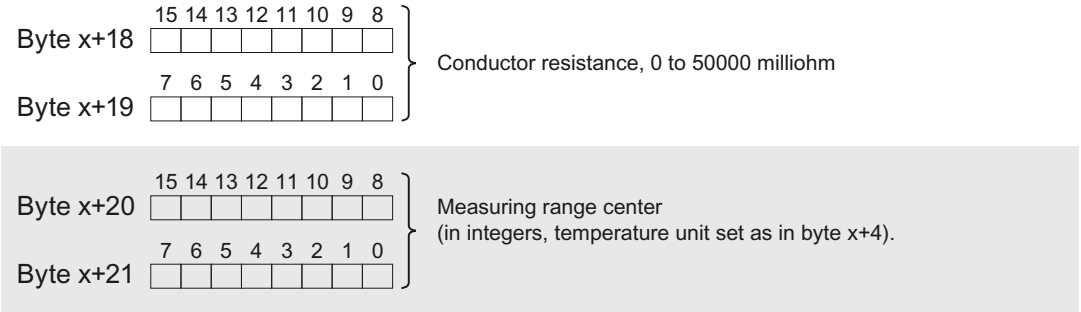

Figure 2-619 Structure of byte x to x+21 for channel 0 to 3

Codes for measurement type

The following table contains the codes for the measurement types of the analog input module. You must enter these codes at byte x (see previous figure).

Table 2-664 Codes for measurement type

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001
Resistor, 4-wire connection	0000 0100
Resistor, 3-wire connection	0000 0101
Resistor, 2-wire connection	0000 0110
Thermal resistor, 4-wire connection	0000 0111
Thermal resistor, 3-wire connection	0000 1000
Thermal resistor, 2-wire connection	0000 1001
Thermocouple	0000 1010

Codes for measuring range

The following table contains the codes for the measuring ranges of the analog input module. You must enter these codes at byte x+1 (see previous figure).

Table 2-665 Codes for measuring range

Measuring range	Code
Voltage	
50 mV	0000 0001
80 mV	0000 0010
250 mV	0000 0011
1 V	0000 0101
Resistor	
150 Ω	0000 0001
300 Ω	0000 0010
600 Ω	0000 0011
3 kΩ	0000 0100
6 kΩ	0000 0101
PTC	0000 1111
Thermal resistor climatic	
Pt 100	0000 0000
Pt 200	0000 0111
Pt 500	0000 1000
Pt 1000	0000 1001
Thermal resistor standard	
Pt 100	0000 0010
Pt 200	0000 1011
Pt 500	0000 0100
Pt 1000	0000 0101
Thermal resistor climatic	
Ni 100	0000 0001
Ni 120	0000 1101
Ni 200	0001 0001
Ni 500	0001 0011
Ni 1000	0000 1010
LG-Ni 1000	0001 1101
Thermal resistor standard	
Ni 100	0000 0011
Ni 120	0000 1100
Ni 200	0001 0000
Ni 500	0001 0010
Ni 1000	0000 0110
LG-Ni 1000	0001 1100
Thermal resistor	
Cu 10 climatic	0000 1110
Cu 10 standard	0000 1111
Thermocouple	
Type B	0000 0000
Type N	0000 0001
Type E	0000 0010
Type R	0000 0011
Type S	0000 0100
Type J	0000 0101
Type L	0000 0110

Measuring range	Code
Type T Type K Type U Type C Type TXK	0000 0111 0000 1000 0000 1001 0000 1010 0000 1011

Codes for temperature coefficient for temperature measurement

The following table contains the codes for the temperature coefficients of the analog input module. You must enter these codes at byte x+2 (see previous figure).

Table 2-666 Codes for temperature coefficient for temperature measurement

Temperature coefficient	Code
Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	0000 0000 0000 0001 0000 0010 0000 0011 0000 0100
Ni 0.00618 Ni 0.00672	0000 1000 0000 1001
LG-Ni 0.005	0000 1010
Cu 0.00427	0000 1100

Limits for hardware interrupts

The following tables contain the permitted limits for hardware interrupts (in each case, the usable value is given). The limits depend on the selected measurement type and the selected measuring range. The value for the overflow must be larger than the value for the underflow. The limits are specified as decimal values. The conversion to the respective temperature unit is (1 digit = 0.1) for the standard range and (1 digit = 0.01) for the climate range, see section Representation of analog values (Page 64).

Table 2-667 Limits for resistor and voltage

Resistor (all possible measuring range settings)	Voltage	
32510	32510	Overflow
1	-32511	Underflow

Table 2-668 Limits for thermocouple types B, C, and E

Thermocouple									
Type B			Type C			Type E			
°C	°F	K	°C	°F	K	°C	°F	K	
20699	32765	23431	24999	32765	27731	11999	21919	14731	Overflow
-1199	-1839	1533	-1199	-1839	1533	-2699	-4539	33	Underflow

Table 2-669 Limits for thermocouple types R, S, J, and L

Thermocouple									
Types R, S			Type J			Type L			
°C	°F	K	°C	°F	K	°C	°F	K	
20189	32765	22921	14499	26419	17231	11499	21019	14231	Overflow
-1699	-2739	1033	-2099	-3459	633	-1999	-3279	733	Underflow

Table 2-670 Limits for thermocouple types T, K, and U

Thermocouple									
Type T			Type K			Type U			
°C	°F	K	°C	°F	K	°C	°F	K	
5399	10039	8131	16219	29515	18951	8499	15619	11231	Overflow
-2699	-4539	33	-2699	-4539	33	-1999	-3279	733	Underflow

Table 2-671 Limits for thermocouple types N and TXK

Thermocouple						
Type N			Type TXK			
°C	°F	K	°C	°F	K	
15499	28219	18231	10499	19219	13231	Overflow
-2699	-4539	33	-1999	-3279	733	Underflow

Table 2-672 Limits for thermal resistor

Thermal resistor						
	Standard			Climatic		
	°C	°F	K	°C	°F	
Cu	3119	5935	5851	17999	32765	Overflow
	-2399	-3999	333	-5999	-7599	Underflow
Pt	9999	18319	12731	15499	31099	Overflow
	-2429	-4053	303	-14499	-22899	Underflow
Ni, Ni-LG	2949	5629	5681	29499	32765	Overflow
	-1049	-1569	1683	-10499	-15699	Underflow

A.3 Errors when transferring the data record

Error transferring the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station to determine whether the module is plugged or pulled. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module.

A.4 Switchable wire break check

Function

The "Switchable wire break check" is available for thermocouples. It switches off the wire break check for the module.

This is required, for example, to calibrate thermocouples, since the test current necessary for a wire break check leads to measurement errors during calibration.

The function has no effect on channels that are not assigned in the thermocouple mode.

NOTE
Startup and parameter reassignment
The wire break check is switched on again at each startup and during any parameter reassignment of the module.

Switch-off via the user program

You can deactivate the wire break check using data record 237.

Table 2-673 Structure of data record 237, switchable wire break check

Byte	Function	Format	Value	Description
0	Command	UBYTE	80_H	Wire break check
1	Identifier	UBYTE	00_H	Not relevant
2	Channel number	UBYTE	FF_H	All channels
3	Calibration step	UBYTE	FF_H	First triggering
4	Measurement type	UBYTE	00_H	Not relevant
5	Measuring range	UBYTE	00_H	Not relevant

Byte	Function	Format	Value	Description
6	Action	UBYTE	01_H	Deactivate wire break check
			02_H	Activate wire break check
7...17	Reserved	UBYTE	00_H	Not relevant

Representation of analog values

B

This appendix shows the analog values for all measuring ranges supported by the analog input module AI 4xRTD/TC 2-/3-/4-wire HF.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its parameter assignment.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

NOTE

Temperature values

The digitized temperature values are the result of a conversion in the analog module. The following resolution therefore does not apply to temperature values.

Table 2-674 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Measured values for wire break and reference channel mode

Measured values for wire break

Table 2-675 Measured values for a wire break as a function of enabled diagnostic information in RTD and TC operating modes

Programmable diagnostics		Measured value		Explanation
Wire break	Underflow			
Enable	*	32767	$7FFF_H$	The "wire break" diagnostics is reported.
Disable	*	32767	$7FFF_H$	No diagnostics reported. A wire-break check is carried out (i.e. test current flows).
Disable[1]	*	Undefined		No "wire break" diagnostics is reported. No wire-break check is carried out (i.e. no test current flows). This is required to calibrate thermocouples, since the measuring current necessary for a wire-break check leads to measurement errors during calibration.

* Parameter assignment not relevant

[1] The wire-break check can only be disabled via data set 237.

Table 2-676 Measured values in case of a line break in a TC measurement with enabled reference junction (reference channel) depending on enabled diagnostic information

Case	Programmable diagnostics				Measured value			
	Reference channel		TC channel		Reference channel		TC channel	
	Wire break	Underflow	Wire break	Underflow				
1	Enable[3]	*[3]	*	*[2]	32767[3]	$7FFF_H$[3]	32767[4]	$7FFF_H$[4]
2	Disable[3]	*[3]	*	*[2]	32767[3]	$7FFF_H$[3]	32767[4]	$7FFF_H$[4]
3	*	*	Enable[3]	*[3]	Valid	Valid	32767[3]	$7FFF_H$[3]
4	*	*	Disable[3]	*[3]	Valid	Valid	32767[3]	$7FFF_H$[3]
5	*	*	Disable[1,3]	*[3]	Valid	Valid	Undefined	

* Parameter assignment not relevant

1 The wire-break check can only be disabled via data set 237.

2 Diagnostics is suppressed in the event of a reference channel error.

3 Channel with line break

4 Measured value taken from the reference channel

Explanations of the cases:

Case	Reference channel	TC channel
1	The "wire break" diagnostics is reported. This has a higher priority than the "Underflow" diagnostics.*	The "Reference channel error" diagnostics is reported if this is enabled. Where own pending diagnostic information ("overflow" or "underflow") is reported as outgoing. Wire break diagnostics is detected independently of the measured value and has the same priority as the "Reference channel error" diagnostics. Both items of diagnostic information can be pending simultaneously. The measured value of the reference channel (RTD channel) is adopted for the TC channel. The validity of the measured value of the TC channel is irrelevant.
2	No diagnostics reported. A wire-break check is carried out (i.e. test current flows).*	*Behavior corresponds to case 1.*
3	*Measured values are in the valid measuring range*	The "wire break" diagnostics is reported.*
4	*Measured values are in the valid measuring range*	No diagnostics reported. A wire-break check is carried out (i.e. test current flows).*
5	*Measured values are in the valid measuring range*	No "wire break" diagnostics is reported. No wire-break check is carried out (i.e. no test current flows). This is required to calibrate thermocouples, since the measuring current necessary for a wire-break check leads to measurement errors during calibration.*

* Channel with wire break

B.2 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table 2-677 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 2-678 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.3 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table 2-679 Voltage measuring range ±1 V

Values		Voltage measuring range	Range
Dec.	**Hex.**	**±1 V**	
32767	7FFF	> 1.176 V	Overflow

Values		Voltage measuring range	Range
32511	7EFF	1.176 V	Overrange
27649	6C01		
27648	6C00	1 V	Nominal range
20736	5100	0.75 V	
1	1	36.17 µV	
0	0	0 V	
-1	FFFF		
-20736	AF00	-0.75 V	
-27648	9400	-1 V	
-27649	93FF		Underrange
-32512	8100	-1.176 V	
-32768	8000	<-1.176 V	Underflow

Table 2-680 Voltage measuring range ±500 mV to ±50 mV

Values		Voltage measuring range			Range
Dec.	**Hex.**	**±250 mV**	**±80 mV**	**±50 mV**	
32767	7FFF	> 294.0 mV	> 94.1 mV	> 58.8 mV	Overflow
32511	7EFF	294.0 mV	94.1 mV	58.8 mV	Overrange
27649	6C01				
27648	6C00	250 mV	80 mV	50 mV	Nominal range
20736	5100	187.5 mV	60 mV	37.5 mA	
1	1	9.04 µV	2.89 µV	1.81 µV	
0	0	0 mV	0 mV	0 mV	
-1	FFFF				
-20736	AF00	-187.5 mV	-60 mV	-37.5 mV	
-27648	9400	-250 mV	-80 mV	-50 mV	
-27649	93FF				Underrange
-32512	8100	-294.0 mV	-94.1 mV	-58.8 mV	
-32768	8000	<-294.0 mV	<-94.1 mV	<-58.8 mV	Underflow

B.4 Representation of analog values for resistance-type sensors

The following tables list the decimal and hexadecimal values (codes) of the possible resistance-type sensor ranges.

Table 2-681 Resistance-type sensors from 150 Ω to 6000 Ω

Values		Resistance-type sensor range					Range
Dec.	**Hex.**	**150 Ω**	**300 Ω**	**600 Ω**	**3000 Ω**	**6000 Ω**	
32767	7FFF	> 176.38 Ω	> 352.77 Ω	> 705.53 Ω	> 3527.7 Ω	> 7055.3 Ω	Overflow

[1] If the resistors are not connected correctly or the conductor resistance is too high

Values		Resistance-type sensor range					Range
32511	7EFF	176.38 Ω	352.77 Ω	705.53 Ω	3527.7 Ω	7055.3 Ω	Overrange
27649	6C01						
27648	6C00	150 Ω	300 Ω	600 Ω	3000 Ω	6000 Ω	Nominal range
20736	5100	112.5 Ω	225 Ω	450 Ω	2250 Ω	4500 Ω	
1	1	5.43 mΩ	10.85 mΩ	21.70 mΩ	108.5 mΩ	217 mΩ	
0	0	0 Ω	0 Ω	0 Ω	0 Ω	0 Ω	
-32768	8000	(negative values are physically impossible)					Underflow[1]

[1] If the resistors are not connected correctly or the conductor resistance is too high

B.5 Representation of analog values for thermal resistors

NOTE

A higher resolution can be configured for the measuring range for the standard resistance thermometers, see section Scalable measuring range (Page 30).

The tables below list the decimal and hexadecimal values (codes) of the thermal resistors.

Table 2-682 Thermal resistor Pt 100, 200, 500, 1000 standard

Pt x00 Standard in °C (1 digit = 0.1°C)	Values		Pt x00 Standard in °F (1 digit = 0.1 °F)	Values		Pt x00 standard in K (1 digit = 0.1 K)	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1000.0	32767	7FFF	> 1832.0	32767	7FFF	> 1273.2	32767	7FFF	Overflow
1000.0 : 850.1	10000 : 8501	2710 : 2135	1832.0 : 1562.1	18320 : 15621	4790 : 3D05	1273.2 : 1123.3	12732 : 11233	31BC : 2BE1	Overrange
850.0 : -200.0	8500 : -2000	2134 : F830	1562.0 : -328.0	15620 : -3280	3D04 : F330	1123.2 : 73.2	11232 : 732	2BE0 : 2DC	Nominal range
-200.1 : -243.0	-2001 : -2430	F82F : F682	-328.1 : -405.4	-3281 : -4054	F32F : F02A	73.1 : 30.2	731 : 302	2DB : 12E	Underrange
< -243.0	-32768	8000	< -405.4	-32768	8000	< 30.2	32768	8000	Underflow

Table 2-683 Thermal resistor Pt 100, 200, 500, 1000 climatic

Pt x00 climatic in °C (1 digit = 0.01 °C)	Values		Pt x00 climatic in °F (1 digit = 0.01 °F)	Values		Range
	Dec.	Hex.		Dec.	Hex.	
> 155.00	32767	7FFF	> 311.00	32767	7FFF	Overflow
155.00 : 130.01	15500 : 13001	3C8C : 32C9	311.00 : 266.01	31100 : 26601	797C : 67E9	Overrange

Pt x00 climatic in °C (1 digit = 0.01 °C)	Values		Pt x00 climatic in °F (1 digit = 0.01 °F)	Values		Range
	Dec.	Hex.		Dec.	Hex.	
130.00 : -120.00	13000 : -12000	32C8 : D120	266.00 : -184.00	26600 : -18400	67E8 : B820	Nominal range
-120.01 : -145.00	-12001 : -14500	D11F : C75C	-184.01 : -229.00	-18401 : -22900	B81F : A68C	Underrange
< -145.00	-32768	8000	< -229.00	-32768	8000	Underflow

Table 2-684 Thermal resistor Ni 100, 120, 200, 500, 1000, LG-Ni 1000 standard

Ni x00 standard in °C (1 digit = 0.1 °C)	Values		Ni x00 standard in °F (1 digit = 0.1 °F)	Values		Ni x00 standard in K (1 digit = 0.1 K)	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 295.0	32767	7FFF	> 563.0	32767	7FFF	> 568.2	32767	7FFF	Overflow
295.0 : 250.1	2950 : 2501	B86 : 9C5	563.0 : 482.1	5630 : 4821	15FE : 12D5	568.2 : 523.3	5682 : 5233	1632 : 1471	Overrange
250.0 : -60.0	2500 : -600	9C4 : FDA8	482.0 : -76.0	4820 : -760	12D4 : FD08	523.2 : 213.2	5232 : 2132	1470 : 854	Nominal range
-60.1 : -105.0	-601 : -1050	FDA7 : FBE6	-76.1 : -157.0	-761 : -1570	FD07 : F9DE	213.1 : 168.2	2131 : 1682	853 : 692	Underrange
< -105.0	-32768	8000	< -157.0	-32768	8000	< 168.2	32768	8000	Underflow

Table 2-685 Thermal resistor Ni 100, 120, 200, 500, 1000, LG-Ni 1000 climatic

Ni x00 climatic in °C (1 digit = 0.01 °C)	Values		Ni x00 climatic in °F (1 digit = 0.01 °F)	Values		Range
	Dec.	Hex.		Dec.	Hex.	
> 295.00	32767	7FFF	> 327.66	32767	7FFF	Overflow
295.00 : 250.01	29500 : 25001	733C : 61A9	327.66 : 280.01	32766 : 28001	7FFE : 6D61	Overrange
250.00 : -60.00	25000 : -6000	61A8 : E890	280.00 : -76.00	28000 : -7600	6D60 : E250	Nominal range
-60.01 : -105.00	-6001 : -10500	E88F : D6FC	-76.01 : -157.00	-7601 : -15700	E24F : C2AC	Underrange
< - 105.00	-32768	8000	< - 157.00	-32768	8000	Underflow

Table 2-686 Thermal resistor Cu 10 standard

Cu 10 standard in °C (1 digit = 0.01 °C)	Values		Cu 10 standard in °F (1 digit = 0.01 °F)	Values		Cu 10 standard in K (1 digit = 0.01 K)	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 312.0	32767	7FFF	> 593.6	32767	7FFF	> 585.2	32767	7FFF	Overflow
312.0 : 260.1	3120 : 2601	C30 : A29	593.6 : 500.1	5936 : 5001	1730 : 12D5	585.2 : 533.3	5852 : 5333	16DC : 14D5	Overrange
260.0 : -200.0	2600 : -2000	A28 : F830	500.0 : -328.0	5000 : -3280	1389 : F330	533.2 : 73.2	5332 : 732	14D4 : $2DC_H$	Nominal range
-200.1 : -240.0	-2001 : -2400	F82F : F6A0	-328.1 : -400.0	-3281 : -4000	F32F : F060	73.1 : 33.2	731 : 332	2DB : $14C_H$	Underrange
< -240.0	-32768	8000	< -400.0	-32768	8000	< 33.2	32768	8000	Underflow

Table 2-687 Thermal resistor Cu 10 climatic

Cu 10 climatic in °C (1 digit = 0.01 °C)	Values		Cu 10 climatic in °F (1 digit = 0.01 °F)	Values		Range
	Dec.	Hex.		Dec.	Hex.	
> 180.00	32767	7FFF	> 325.11	32767	7FFF	Overflow
180.00 : 150.01	18000 : 15001	4650 : 3A99	327.66 : 280.01	32766 : 28001	7FFE : 6D61A	Overrange
150.00 : -50.00	15000 : -5000	3A98 : EC78	280.00 : - 58.00	28000 : -5800	6D60 : $E958_H$	Nominal range
-50.01 : -60.00	-5001 : -6000	EC77 : E890	-58.01 : -76.00	-5801 : -7600	E957 : E250	Underrange
< - 60.00	-32768	8000	< - 76.00	-32768	8000	Underflow

B.6 Representation of analog values for thermocouples

NOTE

A higher resolution can be configured for thermocouples, see section Scalable measuring range (Page 30).

The tables below list the decimal and hexadecimal values (codes) of the thermocouples.

Table 2-688 Thermocouple type B

Type B in °C	Values		Type B in °F	Values		Type B in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2070.0	32767	7FFF	> 3276.6	32767	7FFF	> 2343.2	32767	7FFF	Overflow
2070.0 : 1820.1	20700 : 18201	50DC : 4719	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2343.2 : 2093.3	23432 : 20933	5B88 : 51C5	Overrange
1820.0 : 0.0	18200 : 0	4718 : 0000	2786.5 : 32.0	27865 : 320	6CD9 : 0140	2093.2 : 273.2	20932 : 2732	51C4 : 0AAC	Nominal range
-0.1 : -120.0	-1 : -1200	FFFF : FB50	31.9 : -184.0	319 : -1840	013F : F8D0	273.1 : 153.2	2731 : 1532	0AAB : 05FC	Underrange
< -120.0	-32768	8000	< -184.0	-32768	8000	< 153.2	-32768	8000	Underflow

Table 2-689 Thermocouple type C

Type C in °C	Values		Type C in °F	Values		Type C in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2500.0	32767	7FFF	> 3276.6	32767	7FFF	> 2773.2	32767	7FFF	Overflow
2500.0 : 2315.1	25000 : 23151	61A8 : 5A6F	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2773.2 : 2588.3	27732 : 25883	6C54 : 651B	Overrange
2315.0 : 0.0	23150 : 0	5A6E : 0000	2786.5 : 32.0	27865 : 320	6CD9 : 0140	2588.2 : 273.2	25882 : 2732	651A : 0AAC	Nominal range
-0.1 : -120.0	-1 : -1200	FFFF : FB50	31.9 : -184.0	319 : -1840	013F : F8D0	273.1 : 153.2	2731 : 1532	0AAB : 05FC	Underrange
< -120.0	-32768	8000	< -184.0	-32768	8000	< 153.2	-32768	8000	Underflow

Table 2-690 Thermocouple type E

Type E in °C	Values		Type E in °F	Values		Type E in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1200.0	32767	7FFF	> 2192.0	32767	7FFF	> 1473.2	32767	7FFF	Overflow
1200.0 : 1000.1	12000 : 10001	2EE0 : 2711	2192.0 : 1832.1	21920 : 18321	55A0 : 4791	1473.2 : 1273.3	14732 : 12733	398C : 31BD	Overrange
1000.0 : -270.0	10000 : -2700	2710 : F574	1832.0 : -454.0	18320 : -4540	4790 : EE44	1273.2 : 3.2	12732 : 32	31BC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-691 Thermocouple type J

Type J in °C	Values		Type J in °F	Values		Type J in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1450.0	32767	7FFF	> 2642.0	32767	7FFF	> 1723.2	32767	7FFF	Overflow
1450.0 : 1200.1	14500 : 12001	38A4 : 2EE1	2642.0 : 2192.1	26420 : 21921	6734 : 55A1	1723.2 : 1473.3	17232 : 14733	4350 : 398D	Overrange
1200.0 : -210.0	12000 : -2100	2EE0 : F7CC	2192.0 : -346.0	21920 : -3460	55A0 : F27C	1473.2 : 63.2	14732 : 632	398C : 0278	Nominal range
< -210.0	-32768	8000	< -346.0	-32768	8000	< 63.2	-32768	8000	Underflow

Table 2-692 Thermocouple type K

Type K in °C	Values		Type K in °F	Values		Type K in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1622.0	32767	7FFF	> 2951.6	32767	7FFF	> 1895.2	32767	7FFF	Overflow
1622.0 : 1372.1	16220 : 13721	3F5C : 3599	2951.6 : 2501.7	29516 : 25017	734C : 61B9	1895.2 : 1645.3	18952 : 16453	4A08 : 4045	Overrange
1372.0 : -270.0	13720 : -2700	3598 : F574	2501.6 : -454.0	25016 : -4540	61B8 : EE44	1645.2 : 3.2	16452 : 32	4044 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-693 Thermocouple type L

Type L in °C	Values		Type L in °F	Values		Type L in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1150.0	32767	7FFF	> 2102.0	32767	7FFF	> 1423.2	32767	7FFF	Overflow
1150.0 : 900.1	11500 : 9001	2CEC : 2329	2102.0 : 1652.1	21020 : 16521	521C : 4089	1423.2 : 1173.3	14232 : 11733	3798 : 2DD5	Overrange
900.0 : -200.0	9000 : -2000	2328 : F830	1652.0 : -328.0	16520 : -3280	4088 : F330	1173.2 : 73.2	11732 : 732	2DD4 : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow

Table 2-694 Thermocouple type N

Type N in °C	Values		Type N in °F	Values		Type N in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1550.0	32767	7FFF	> 2822.0	32767	7FFF	> 1823.2	32767	7FFF	Overflow
1550.0 : 1300.1	15500 : 13001	3C8C : 32C9	2822.0 : 2372.1	28220 : 23721	6E3C : 5CA9	1823.2 : 1573.3	18232 : 15733	4738 : 3D75	Overrange
1300.0 : -270.0	13000 : -2700	32C8 : F574	2372.0 : -454.0	23720 : -4540	5CA8 : EE44	1573.2 : 3.2	15732 : 32	3D74 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-695 Thermocouples R and S

Types R, S in °C	Values		Types R, S in °F	Values		Types R, S in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2019.0	32767	7FFF	> 3276.6	32767	7FFF	> 2292.2	32767	7FFF	Overflow
2019.0 : 1769.1	20190 : 17691	4EDE : 451B	3276.6 : 3216.3	32766 : 32163	7FFE : 7DA3	2292.2 : 2042.3	22922 : 20423	598A : 4FC7	Overrange
1769.0 : -50.0	17690 : -500	451A : FE0C	3216.2 : -58.0	32162 : -580	7DA2 : FDBC	2042.2 : 223.2	20422 : 2232	4FC6 : 08B8	Nominal range
-50.1 : -170.0	-501 : -1700	FE0B : F95C	-58.1 : -274.0	-581 : -2740	FDBB : F54C	223.1 : 103.2	2231 : 1032	08B7 : 0408	Underrange
< -170.0	-32768	8000	< -274.0	-32768	8000	< 103.2	< 1032	8000	Underflow

Table 2-696 Thermocouple type T

Type T in °C	Values		Type T in °F	Values		Type T in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 540.0	32767	7FFF	> 1004.0	32767	7FFF	> 813.2	32767	7FFF	Overflow
540.0 : 400.1	5400 : 4001	1518 : 0FA1	1004.0 : 752.1	10040 : 7521	2738 : 1D61	813.2 : 673.3	8132 : 6733	1FC4 : 1AAD	Overrange
400.0 : -270.0	4000 : -2700	0FA0 : F574	752.0 : -454.0	7520 : -4540	1D60 : EE44	673.2 : 3.2	6732 : 32	1AAC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-697 Thermocouple type U

Type U in °C	Values		Type U in °F	Values		Type U in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 850.0	32767	7FFF	> 1562.0	32767	7FFF	> 1123.2	32767	7FFF	Overflow
850.0 : 600.1	8500 : 6001	2134 : 1771	1562.0 : 1112.1	15620 : 11121	2738.0 : 2B71	1123.2 : 873.3	11232 : 8733	2BE0 : 221D	Overrange
600.0 : -200.0	6000 : -2000	1770 : F830	1112.0 : -328.0	11120 : -3280	2B70 : F330	873.2 : 73.2	8732 : 732	221C : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow

Table 2-698 Thermocouple type TXK (GOST)

Type TXK in °C	Values		Type TXK in °F	Values		Type TXK in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1050.0	32767	7FFF	> 1922.0	32767	7FFF	>1323.2	32767	7FFF	Overflow
1050.0 : 800.1	10500 : 8001	2904 : 1F41	1922.0 : 1472.1	19220 : 14721	4B14 : 3981	1323.2 : 1073.3	13232 : 10733	33B0 : 29ED	Overrange
800.0 : 0.0 : -200.0	8000 : 0 : -2000	1F40 : 0000 : F830	1472.0 : 32.0 : -328.0	14720 : 320 : -3280	3980 : 0140 : F330	1073.2 : 273 : 73.2	10732 : 2730 : 732	29EC : 0AAA : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	<73.2	-32768	8000	Underflow

SIEMENS

SIMATIC

ET 200SP
Analog input module AI 4xTC HS (6ES7134-6JD00-0DA1)

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Preface

Purpose of the documentation

This equipment manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this equipment manual and in the system/function manuals supports you in commissioning the system.

Changes compared to the previous version

Compared to the previous version, this equipment manual contains the following change:

- Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.
- Technical specifications: Ambient temperature in horizontal and vertical mounting position, extended to min. -30 °C.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

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B.3 Representation of analog values for thermocouples 63

Guide to documentation

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

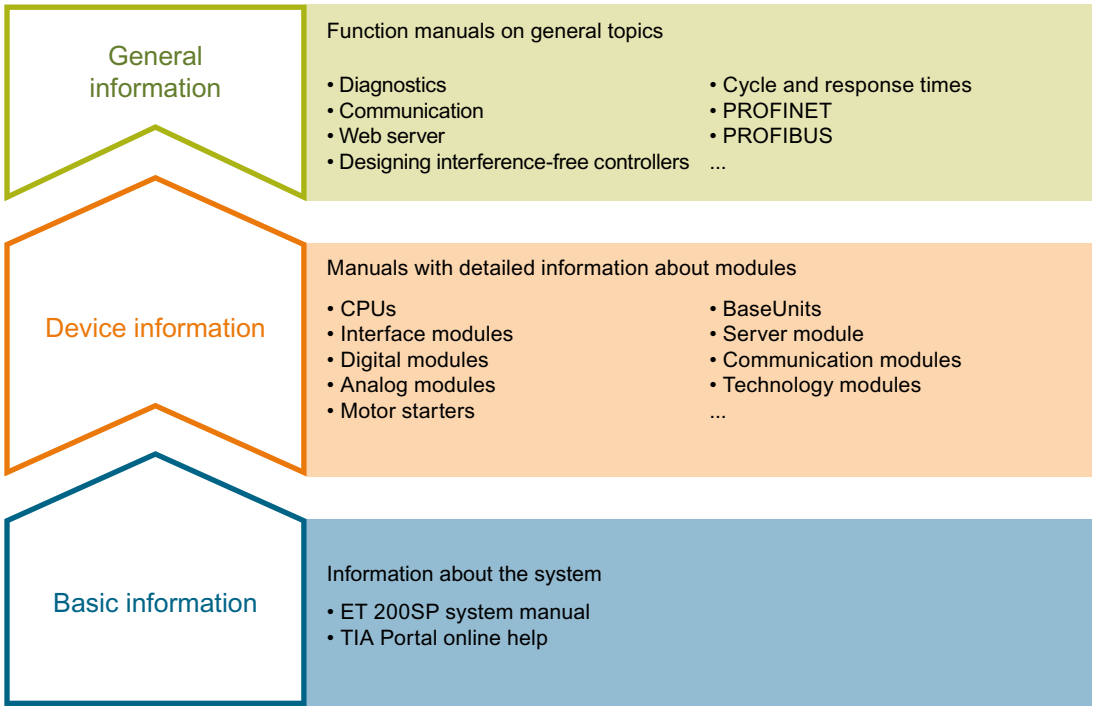

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

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"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7134-6JD00-0DA1

View of the module

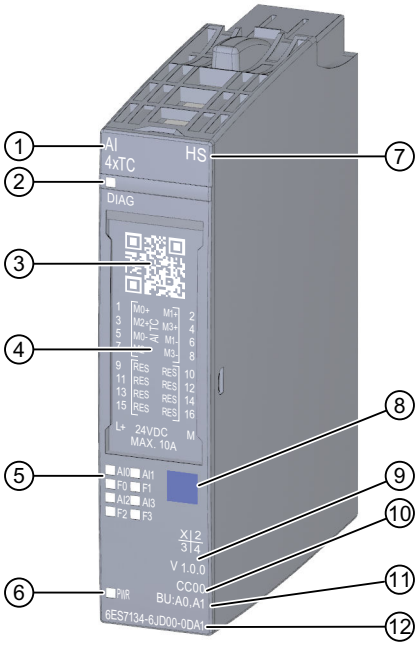

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-620 View of the module AI 4×TC HS

Properties

The module has the following technical properties:

- Analog input module with 4 inputs
- Resolution: Up to 16 bits including sign
- Limited exchange compatibility with analog input module AI 4xRTD/TC 2-/3-/4-wire HF (6ES7134-6JD00-0CA1), see section Spare part compatibility (Page 11)
- Voltage measurement type can be set per channel
- Thermocouple (TC) measurement type can be set per channel
- Configurable diagnostics for each channel
- Configurable wire break check per channel
- Hardware interrupt on limit violation can be set per channel (two high and two low limits per channel)

The module supports the following functions:

Table 2-699 Version dependencies of the functions

Function	STEP 7	GSD file	
	TIA Portal	PROFINET IO	PROFIBUS DP
Outlier suppression	as of V15 with HSP 0265	X	X[1]
Firmware update	as of V15 with HSP 0265	X	X
Identification data I&M0 to I&M3	as of V15 with HSP 0265	X	X
Calibration in runtime	as of V15 with HSP 0265	X	X
Module-internal shared input (MSI)	as of V15 with HSP 0265	X	-
REAL representation	as of V15 with HSP 0265	X	-
Scalable measuring range	as of V15 with HSP 0265	X	-
Configuration in RUN	as of V15 with HSP 0265	X	X
Value status (PROFINET IO only)	as of V15 with HSP 0265	X	-

[1] Outlier suppression is always enabled for configuration with the PROFIBUS GSD file. You can set this parameter via data record 128.

You can configure the module with STEP 7 and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connection

See also

You can find more information on accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2 Spare part compatibility

Replacement of an AI 4xRTD/TC 2-/3-/4-wire HF (6ES7134-6JD00-0CA1)

With an AI 4xTC HS (6ES7134-6JD00-0DA1), you can replace an AI 4xRTD/TC 2-/3-/4-wire HF (6ES7134-6JD00-0CA1), that is configured for the "Thermocouple" or "Voltage" measuring ranges.
You do not have to perform new configuration or new wiring. The "Outlier suppression" function is enabled. You can find additional information on outlier suppression in the section Explanation of parameters (Page 18), "Outlier suppression" section.

NOTE

Restricted measuring range functionality

The AI 4xTC HS module (6ES7134-6JD00-0DA1) does not support RTD and resistance measuring ranges. If you have configured these measuring ranges, the parameter assignment is rejected with the diagnostic message "Parameter assignment error".

Wiring 3

3.1 Wiring and block diagram

This section includes the block diagram of the AI 4×TC HS module with the terminal assignments.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Wiring: 2-wire connection for thermocouples

The following figure shows the block diagram and an example of the terminal assignment of the analog input module AI 4×TC HS on the BaseUnit BU type A0/A1.

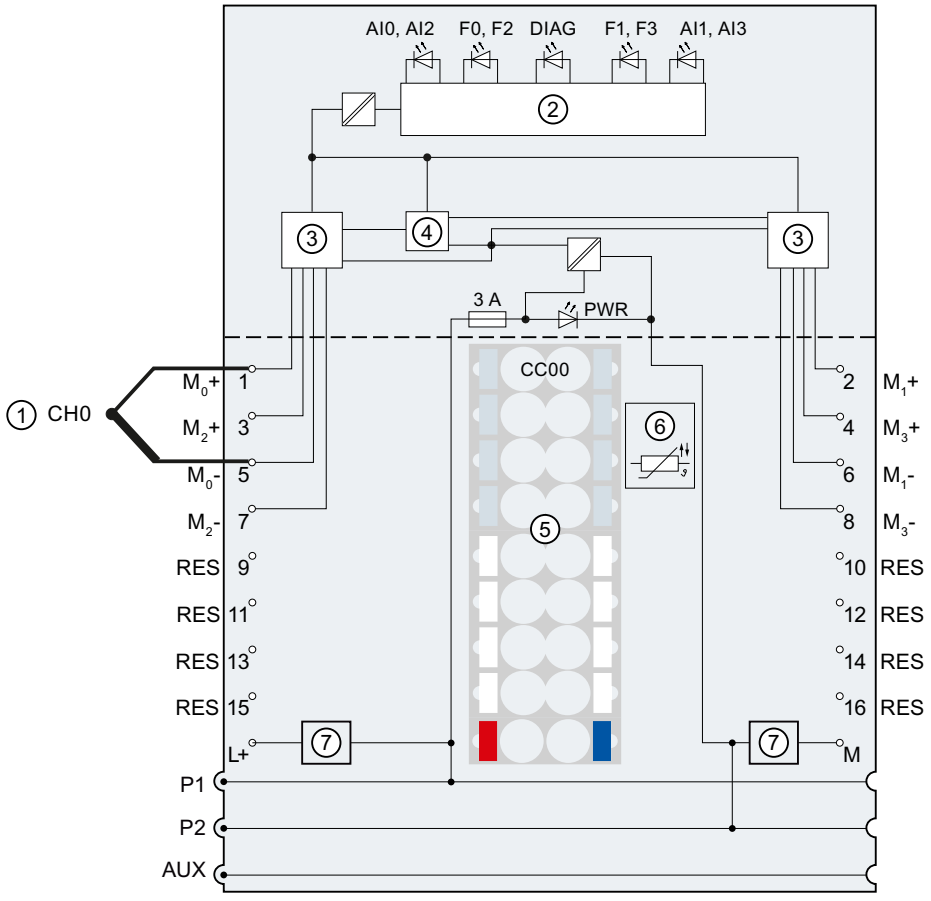

①	2-wire connection of thermocouples	M_n+ M_n-	Measuring line positive, channel n Measuring line negative, channel n
②	Backplane bus interface	L+	24 V DC (feed for light-colored BaseUnit only)
③	Multiplexer	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
④	Analog-to-digital converter (ADC)	DIAG	Diagnostics LED (green, red)
⑤	Color-coded label with color code CC00 (optional)	AI0 to AI3	Channel status LED (green)
⑥	Temperature recording for BU type A1 only	F0 to F3	Channel fault LED (red)
⑦	Filter connection supply voltage (only when light-colored BaseUnit is present)	PWR	Power LED (green)

Figure 2-621 Wiring and block diagram for connection of thermocouples

Parameters/address space

4

4.1 Measurement types and measuring ranges

The following table lists the measuring range you can set for each measuring type:

Table 2-700 Measurement types and measuring ranges

Measurement type	Measuring range
Deactivated	–
Thermocouple (TC)	Type E, N, J, K, L, S, R, B, T, C, U, TXK (acc. to GOST)
Voltage	±50 mV / ±80 mV / ±250 mV / ±1 V

See also

Technical specifications (Page 40)

4.2 Parameters

Parameters of the AI 4xTC HS

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records, see section Parameter assignment and structure of parameter data record (Page 47). The following parameter settings are possible:

Table 2-701 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: Missing supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Reference junction	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Channel	
Wire break check	• Disable • Enable	Enable	Yes	Channel	Module
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel
Type/range of measurement	• Deactivated • Voltage – ±50 mV – ±80 mV – ±250 mV – ± 1 V • Thermocouple – Type B (PtRh-PtRh) – Type N (NiCrSi-NiSi) – Type E (NiCr-CuNi) – Type R (PtRh-Pt) – Type S (PtRh-Pt) – Type J (Fe-CuNi) – Type L (Fe-CuNi) – Type T (Cu-CuNi) – Type K (NiCr-NiAl) – Type U (Cu-CuNi)	Type K (NiCr-NiAl)	Yes	Channel	Channel

1 Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can still assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 13 bytes.

2 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", no "fixed reference temperature" is used for TC.

3 Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

4 Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.

5 Only for REAL representation.

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Outlier suppression [1]	• Disable • Enable	Enable	Yes	Channel	Cannot be changed
Temperature unit	• Degrees Celsius • Degrees Fahrenheit • Kelvin	Degrees Celsius	Yes	Channel	Module
Reference junction [2]	• Internal reference junction [4] • Reference channel of group 0 • Reference channel of group 1 • Reference channel of group 2 • Reference channel of group 3 • Fixed reference temperature	Fixed reference temperature	Yes	Channel	Channel
Fixed reference temperature	Temperature	0 °C	Yes	Channel	-
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel
Interference frequency suppression [1]	• 60 Hz • 50 Hz [3] • 16.6 Hz • None	50 Hz	Yes	Channel	Module
Scalable measuring range [1]	• Disable • Enable	Disable	Yes	Channel	-
Measuring range resolution [1]	• 2 decimal places • 3 decimal places	2 decimal places	Yes	Channel	-
Measuring range center [1]	• Value within the nominal range of the measuring range	0	Yes	Channel	-
Hardware interrupt high limit 1 [1]	• Disable • Enable	Disable	Yes	Channel	-
High limit 1 [1]	• Value (INT) • Value (REAL) [5]	• 13720 • 1372.0 [4]	Yes	Channel	-

[1] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can still assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 13 bytes.

[2] Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", no "fixed reference temperature" is used for TC.

[3] Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

[4] Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.

[5] Only for REAL representation.

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Hardware interrupt low limit 1 [1]	• Disable • Enable	Disable	Yes	Channel	-
Low limit 1 [1]	• Value (INT) • Value (REAL) [5]	• -2699 • -269.9 [4]	Yes	Channel	-
Hardware interrupt high limit 2 [1]	• Disable • Enable	Disable	Yes	Channel	-
High limit 2 [1]	• Value (INT) • Value (REAL) [5]	• 13720 • 1372.0 [4]	Yes	Channel	-
Hardware interrupt low limit 2 [1]	• Disable • Enable	Disable	Yes	Channel	-
Low limit 2 [1]	• Value (INT) • Value (REAL) [5]	• -2699 • -269.9 [4]	Yes	Channel	-
Potential group	• Use potential group of the left module • Enable new potential group	Use potential group of the left module	No	Module	Module

1 Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can still assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 13 bytes.

2 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", no "fixed reference temperature" is used for TC.

3 Interference frequency suppression: Noise at 400 Hz is automatically included in the filtering at 50 Hz.

4 Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.

5 Only for REAL representation.

NOTE

Unused channels

"Deactivate" unused channels in the parameter assignment to improve the cycle time of the module.

A disabled channel always returns the value $7FFF_H$ (REAL representation: $7F800000_H$).

4.3 Explanation of parameters

Diagnostics: Missing supply voltage L+

Enabling of the diagnostics for missing or insufficient supply voltage L+.

Diagnostics: Reference junction

Enabling of the reference junction diagnostics if the reference temperature of the reference junction needs to be determined for the TC channel being operated.

Reference junction using the PROFINET GSD file

As reference junction for the TC measurement, a BaseUnit with internal temperature sensor (BU..T) or the reference channel of the group 0, 1, 2, 3 can be used.

A possible parameter assignment is represented below:

Table 2-702 TC channel

Setting	Description
Internal reference junction	The reference junction temperature is read by an internal temperature sensor on the BaseUnit. Diagnostics: Reference junction is triggered if there is an incorrect BaseUnit type.
Reference channel of group 0, 1, 2, 3	The channel acts as a **receiver** for the reference junction temperature of a group.
Fixed reference temperature	The reference temperature of the thermocouple is set to 0 °C. As a result, no temperature compensation is performed.

NOTE

Shared Device and "Reference channel of group 0, 1, 2, 3"

If the transmitter and receiver for the reference junction temperature of a group are assigned to different IO controllers, then both IO controllers must be performing data exchange with the IO device to ensure error-free operation of the temperature compensation.

Reference junction using the PROFIBUS GSD file

As reference junction for the TC measurement, a BaseUnit with internal temperature sensor (BU..T) or the reference channel of the group 0, 1, 2, 3 can be used.

Table 2-703 **TC channel**

Setting	Description
Internal reference junction	The reference junction temperature is read by an internal temperature sensor on the BaseUnit. Diagnostics: Reference junction is triggered if there is an incorrect BaseUnit type.
Reference channel of group 0, 1, 2, 3	The channel acts as a **receiver** for the reference junction temperature of a group.
Fixed reference temperature	The reference temperature of the thermocouple is set to 0 °C. As a result, no temperature compensation is performed.

Setting	Description
Channel x Reference junction activated	• Disable: Channel x is configured with the setting "Fixed reference temperature". • Enable: Channel x is configured with the setting selected above.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics if the measured value falls below the underrange.

Wire break check

Enable for wire break check. The module only detects an interruption at the input when the wire break check is activated.

Diagnostics: Wire break

Enabling of the diagnostics, if the module detects interruption at the corresponding configured input.

Type/range of measurement

See section Measurement types and measuring ranges (Page 14).

Outlier suppression

Suppresses interference pulses in analog input modules that can be caused, for example, by switching processes in the system.
The last measured values are statistically analyzed (box plot).
Limits within which a new measured value is expected are derived from the distribution (scatter) of the measured values. These limits are dynamically adjusted when the distribution of the measured values changes. New measured values that lie outside the determined limits are suppressed, i.e. the last value is kept.
Faults are suppressed up to a length of three module cycles. On the other hand, actual jumps in the input signal are delayed by the same time.

Temperature unit

Selection between Degrees Celsius, Fahrenheit and Kelvin as the temperature unit for the selected measuring range.

Smoothing

The individual measured values are smoothed using filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This specification is valid for all signal changes at the analog input.

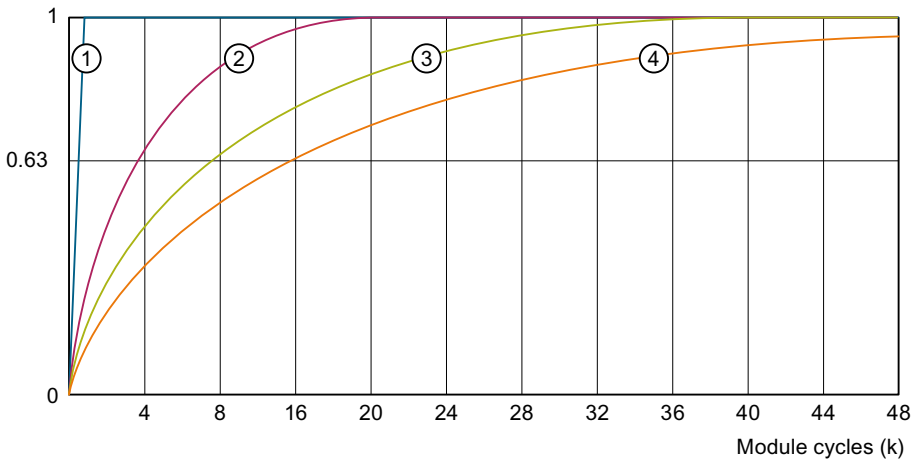

① No smoothing (k = 1)
② Weak (k = 4)
③ Medium (k = 8)
④ Strong (k = 16)

Figure 2-622 Smoothing with AI 4×TC HS

Interference frequency suppression

Suppresses the interferences affecting analog input modules that are caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network is likely to have a negative effect on measured values particularly with measurement in the low voltage range and on thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Measuring range resolution

Parameters for the thermocouple measurement type.

Allows you to increase the resolution to 2 or 3 decimal places for a configurable section of the measuring range. See section Scalable measuring range (Page 22).

Measuring range center

Determines the temperature over which the scalable measuring range is symmetrically spanned. The value must be within the nominal range of the underlying measuring range. It is specified in integers.

Maximum / Minimum

Corresponds to overflow / underflow for the scalable measuring range.

Hardware interrupt enable

Enabling of a hardware interrupt if the high limit 1/2 or the low limit 1/2 is violated.

Low limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

High limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

Potential group

Specifies that a BaseUnit with incoming voltage supply is located on this slot (see system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

4.4 Scalable measuring range

Introduction

The scalable measuring range is available for the temperature measuring ranges of thermocouples. The measuring ranges for voltage are not supported.

The scalable measuring range is valid for the following ranges:

- Nominal range
- Underrange
- Overrange

Function

The scalable measuring range is a limited section of a measuring range supported by the module.

It allows you to increase the resolution for a configurable section.

- The "Measuring range resolution" parameter determines the resolution to 2 or 3 decimal places.
- The "Measuring range center" parameter determines the temperature over which the scalable measuring range is symmetrically spanned.

Value ranges

Table 2-704 Value ranges

Scalable measuring range	Measuring range resolution		Values hex.
	2 decimal places	3 decimal places	
Overflow	> 325.11	> 32.511	$7FFF_H$
High limit	325.11	32.511	$7EFF_H$
Measuring range center	0	0	0_H
Low limit	-325.12	-32.512	8100_H
Underflow	<-325.12	<-32.512	8000_H

To obtain an absolute temperature, the measuring range center in the application program (as offset) must be calculated with the value of the user data of the scalable measuring range.

The measuring range center is always output in the user data as the value "0". The user data are correspondingly mapped to the bipolar input ranges in S7 format. Underflow / overflow is also formed in accordance with the limits of S7.

Rules

- The measuring range center must be within the nominal range of the underlying measuring range. It is specified in integers.
- The scalable measuring range is spanned symmetrically over the measuring range center. Depending on the resolution, various value ranges result (①, ②).
- The scalable measuring range is limited by underflow and overflow of the underlying measuring range:
  - It is clipped at the underflow when it falls below the limit.
  - It is clipped at the overflow when it exceeds the limit (③).

Example

The following example illustrates the effect of scalable measuring ranges:

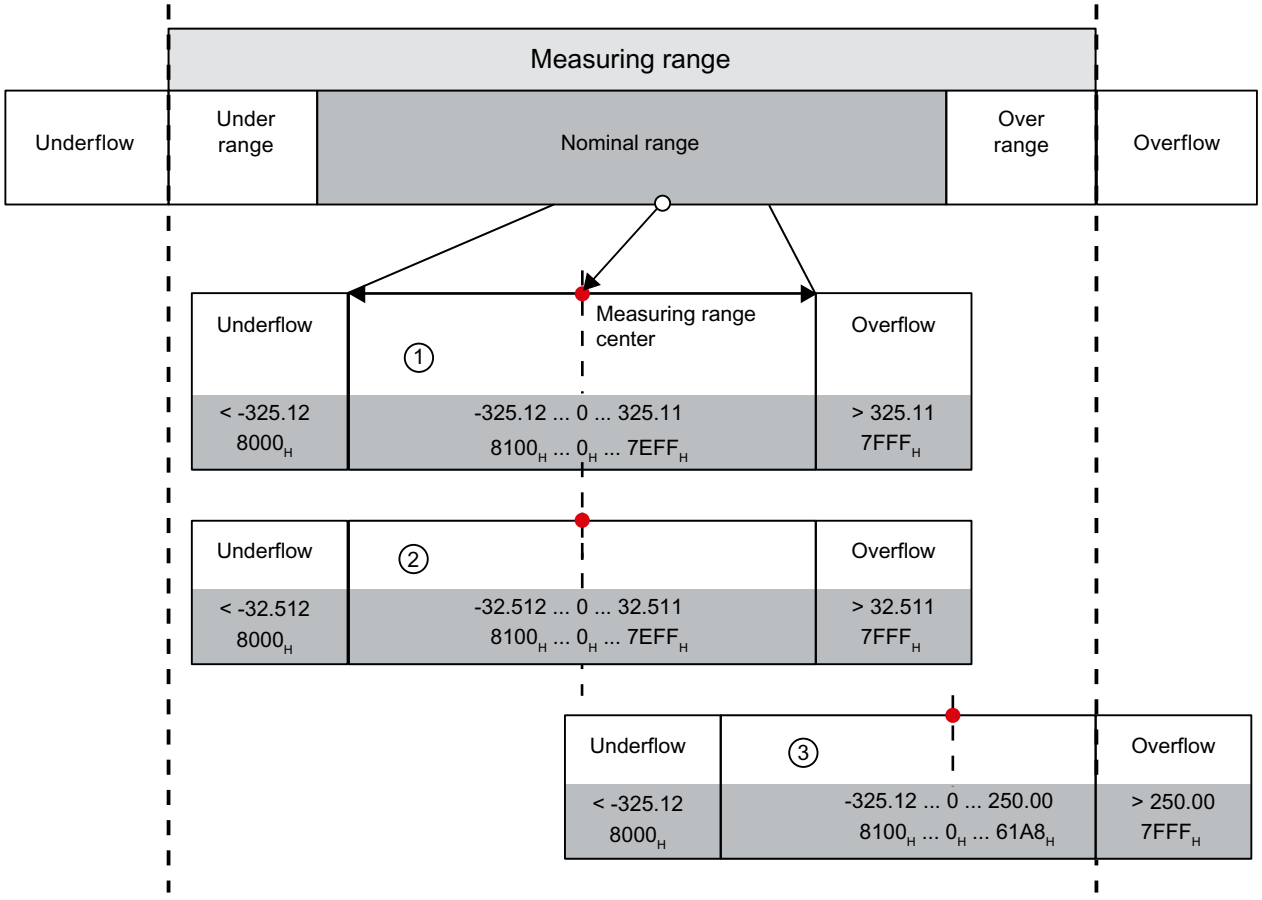

① Scalable measuring range with 2 decimal places in hexadecimal S7 format

② Scalable measuring range with 3 decimal places in hexadecimal S7 format

③ Scalable measuring range which is cut off at the overflow of the underlying measuring range (clipping)

Figure 2-623 Examples of scalable measuring ranges

4.4.1 Configuration

Requirement

You must select a valid temperature measuring range for configuration.

Configuration

The function is activated using the "Scalable measuring range" parameter.

The following figure shows an example of a configuration in STEP 7:

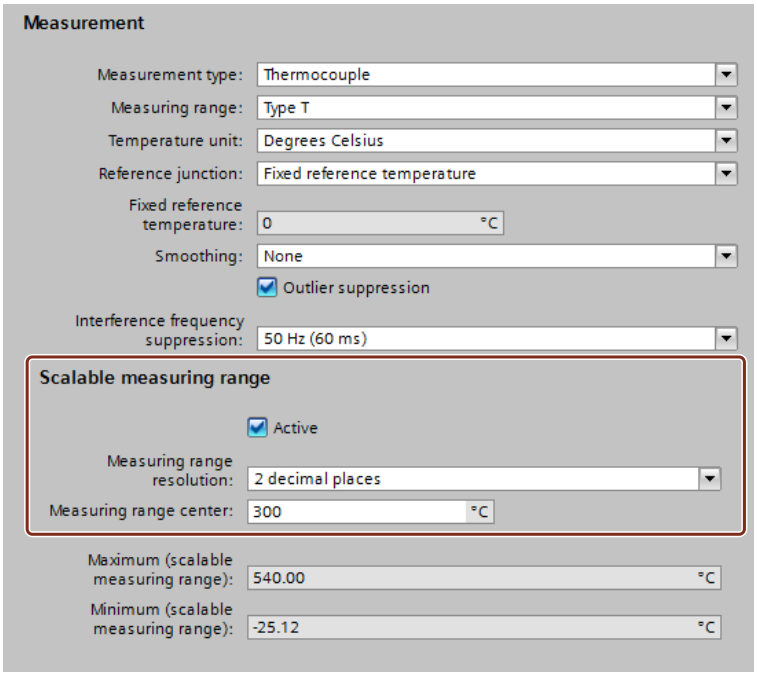

Figure 2-624 Configuration for the scalable measuring range

Reference

You will find more information on the configuration in the STEP 7 online help.

4.4.2 Evaluate status and limits of scalable measuring range

Evaluation in the user program

In the user program, you can evaluate the status and the limits of the scalable measuring range with data record 235, which may result by reaching underflow/overflow.

Structure of data record 235

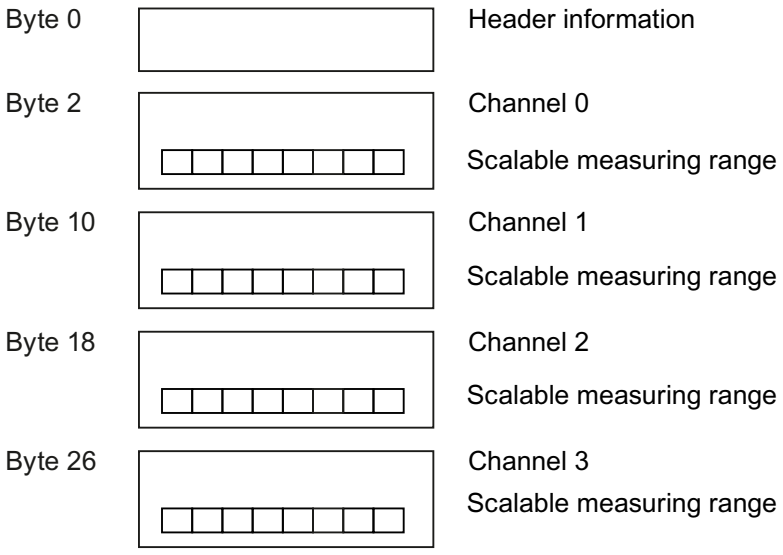

Figure 2-625 Structure of data record 235

Header information

The figure below shows the structure of the header information.

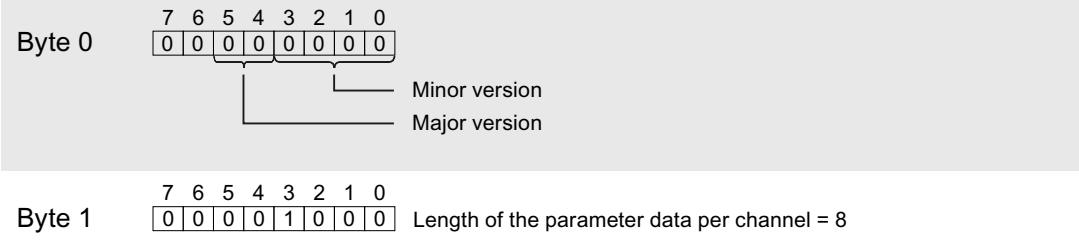

Figure 2-626 Header information of data record 235

Parameters

The figure below shows the structure of the parameter.

If the corresponding bit is set to "1", the parameter is activated.

* x = 2 + (channel number x 8)

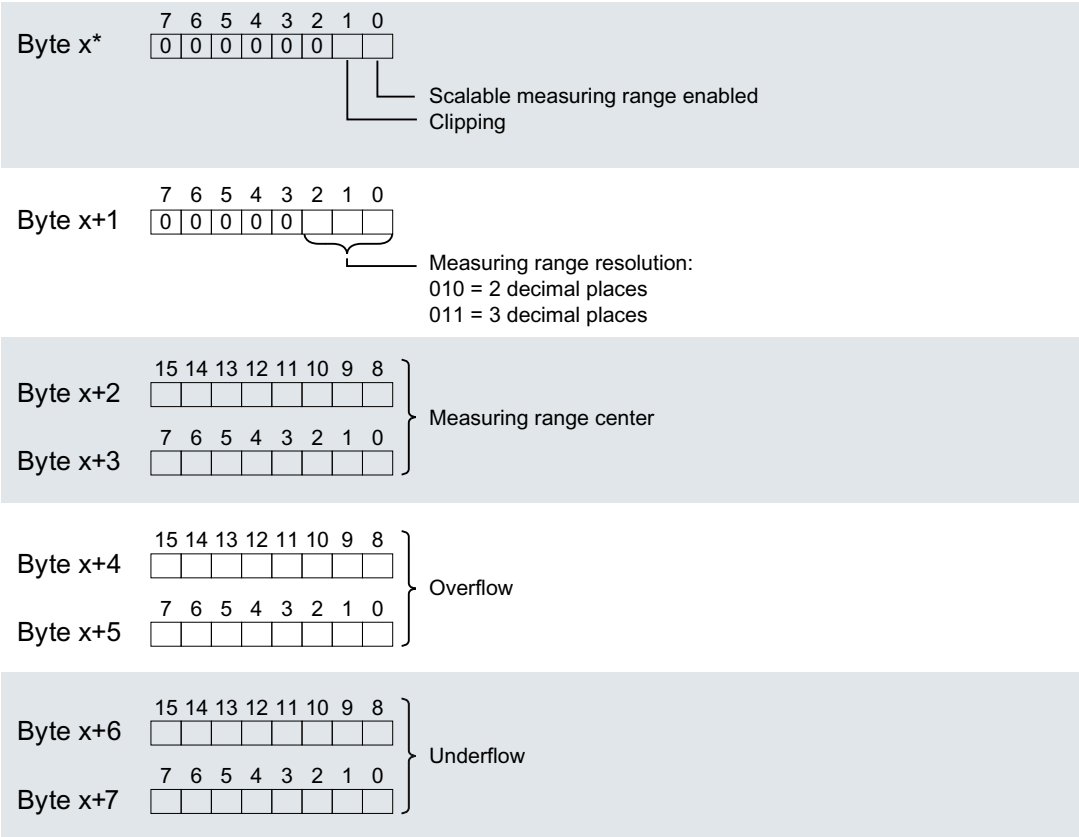

Figure 2-627 Structure of data record 235 - channel parameter byte x to x+7

Description of the parameters

Table 2-705 Description **of the parameters from data record 235**

Parameter	Description
Scalable measuring range enabled	1 = Function is active for this channel.
Clipping	1 = Scalable measuring range cut off at the overflow / underflow of the underlying measuring range (see Figure).
Resolution	2 or 3 decimal places
Measuring range center	Temperature in whole °C / °F / K ("working point" for the scaling)
Overflow/underflow	Limits of the scalable measuring range

Example

The following example shows the values for a thermocouple type T:

Table 2-706 Example of thermocouple type T

Hex. value	Dec. value	Evaluation of data record 235
00_H	0	V0.0
08_H	8	8 bytes
03_H	3	Scalable measuring range active and clipped (clipping)
02_H	2	Resolution: 2 decimal places
$012C_H$	300	Measuring range center: 300 °C
$5DC0_H$	24000	Overflow (Maximum): 240**.00** + 300 = 540.00 °C Scalable measuring range is clipped at the overflow.
8100_H	-32512	Underflow (Minimum): -325**.12** + 300 = -25.12 °C

4.5 REAL representation

Special features of REAL representation

If you have configured the module with REAL representation, the user data and hardware interrupt limits are displayed in REAL data format (32-bit floating point number) instead of S7 format.

The representation of the measured values in the REAL representation is always related to a physical unit, unlike in S7 representation.
This physical unit results from the measuring range you have set. For temperature ranges, the physical unit is determined by the "Temperature unit" parameter.

REAL representation has no influence on the overranges or underranges, the overflow or underflow diagnostics, or the QI characteristics.

NOTE

Substitute value for REAL representation

With REAL representation, the overflow of the substitute value $7F800000_H$ is output, for underflow it is substitute value $FF800000_H$.

Examples

The following examples show value ranges of different measuring ranges in REAL representation:

Table 2-707 Value range in REAL representation

Measuring range	Value range	Unit
Voltage ±1 V	- 1.0 V to + 1.0 V	V
Voltage ± 50 mV	- 50.0 mV to + 50.0 mV	mV
Thermocouple type K	- 270.00 °C to +1372.00 °C	Configured temperature unit (°C, °F, K)

4.6 Address space

The module can be configured differently in STEP 7; see following table. Depending on the configuration, additional/different addresses are assigned in the process image input.

Configuration options of AI 4xTC HS

You can configure the module with STEP 7 (TIA Portal) or with a GSD file. If you configure the module by means of a GSD file, the configurations are available under various short designations/module names; see the table below. The following configurations are possible:

Table 2-708 Configuration options with GSD file

Configuration	Short designation/module name in the GSD file	Configuration software, e.g. with STEP 7 (TIA Portal)		
		Integrated in the hardware catalog STEP 7, as of V15 with HSP0265	GSD file PROFINET IO	GSD file PROFIBUS DP
1 x 4-channel without value status	AI 4xTC HS V1.0	X	X	X
1 x 4-channel with value status	AI 4xTC HS V1.0, QI	X	X	---
1 x 4-channel with value status for module-internal Shared Input with up to 4 submodules	AI 4xTC HS V1.0, MSI [1]	X	X	---
1 x 4-channel with REAL representation	AI 4xTC HS V1.0, REAL	X	X	---
1 x 4-channel with REAL representation and value status	AI 4xTC HS V1.0, REAL, QI	X	X	---
1 x 4-channel with REAL representation, value status for module-internal Shared Input up to 4 submodules	AI 4xTC HS V1.0, REAL, MSI [1]	X	X	---

[1] When using the module in a shared device, ensure that you only configure associated MSI submodules for a basic submodule.

Value status (Quality Information, QI)

The value status is always activated for the following module versions:

- AI 4xTC HS V1.0, QI
- AI 4xTC HS V1.0, MSI
- AI 4xTC HS V1.0, REAL, QI
- AI 4xTC HS V1.0, REAL, MSI

Evaluating the value status

An additional byte is occupied in the input address space if you enable the value status for the analog module. Bits 0 to 3 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit =1: No fault is present on the channel.

Bit = 0: The channel is disabled or the wiring, the value created on the channel, etc. is incorrect.

Address space for configuration as 1 x 4-channel AI 4xTC HS V1.0, QI

The following figure shows the assignment of the address space with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

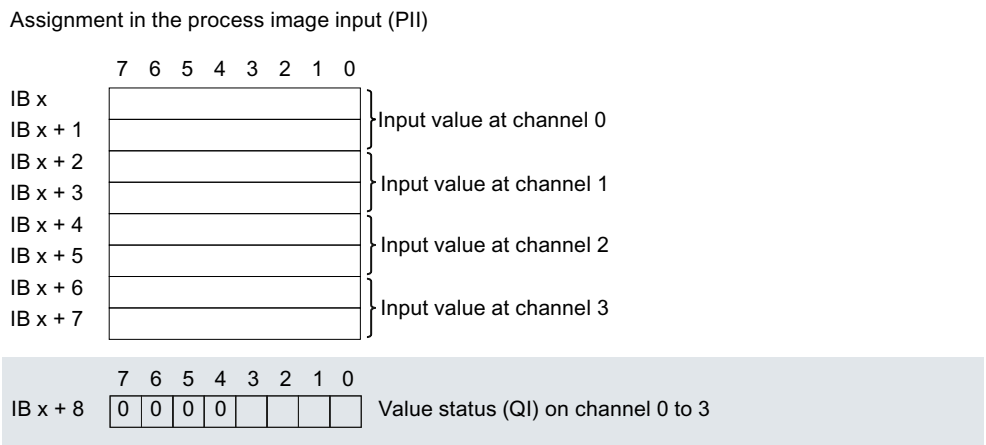

Figure 2-628 Address space for configuration as 1 x 4-channel AI 4xTC HS V1.0, QI with value status

Address space for configuration as 1 x 4-channel AI 4xTC HS V1.0, MSI

The channels 0 to 3 of the module are copied in up to 4 submodules with configuration 1 x 4-channel module (Module-internal shared input, MSI). Channels 0 to 3 are then available with identical input values in different submodules. These submodules can be assigned to up to four IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The number of available submodules depends on the used interface module. Please observe the information in the manual for the particular interface module.

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule on which it occurs.

For the first submodule (=basic submodule), the value status 0 indicates that the value is incorrect.

For the 2nd to 4th submodule (=MSI submodule), the value status 0 indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

The figure below shows the assignment of the address space with submodules 1 and 2.

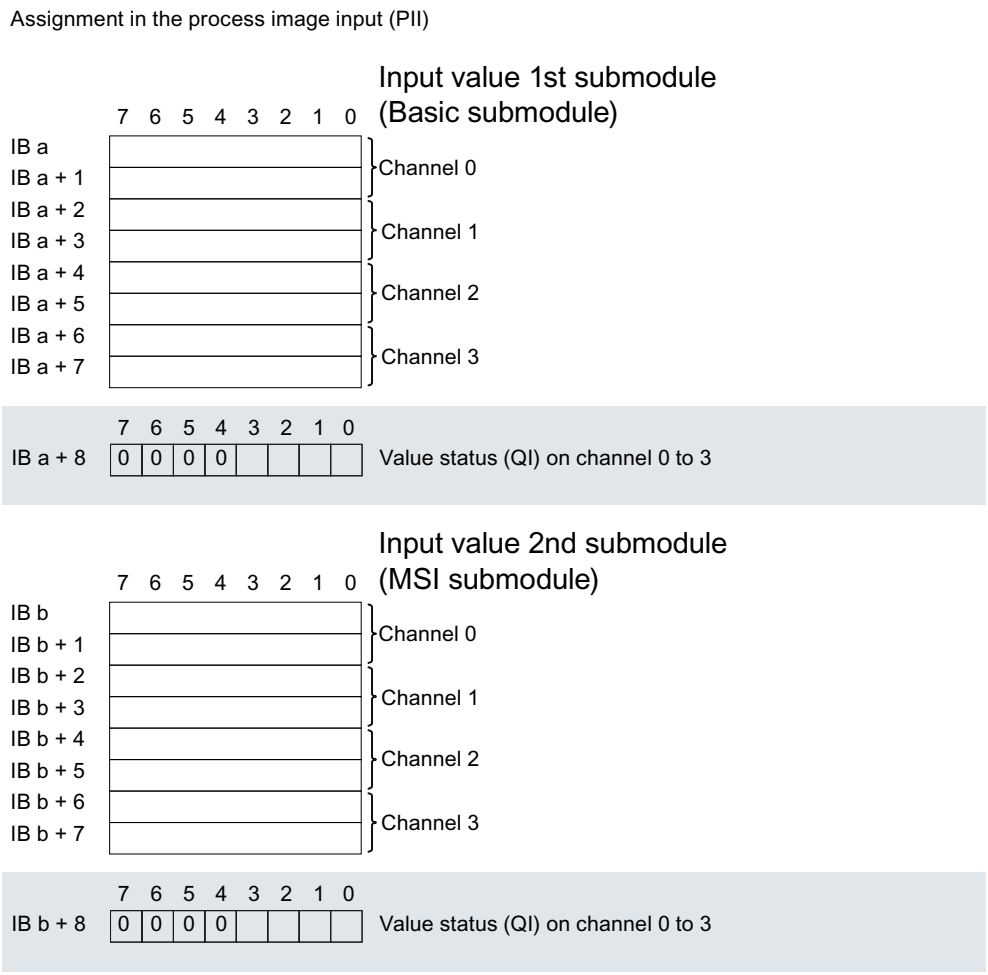

Figure 2-629 Address space for configuration as 1 x 4-channel AI 4xTC HS V1.0, MSI with value status, submodule 1 and 2

The figure below shows the assignment of the address space with submodules 3 and 4.

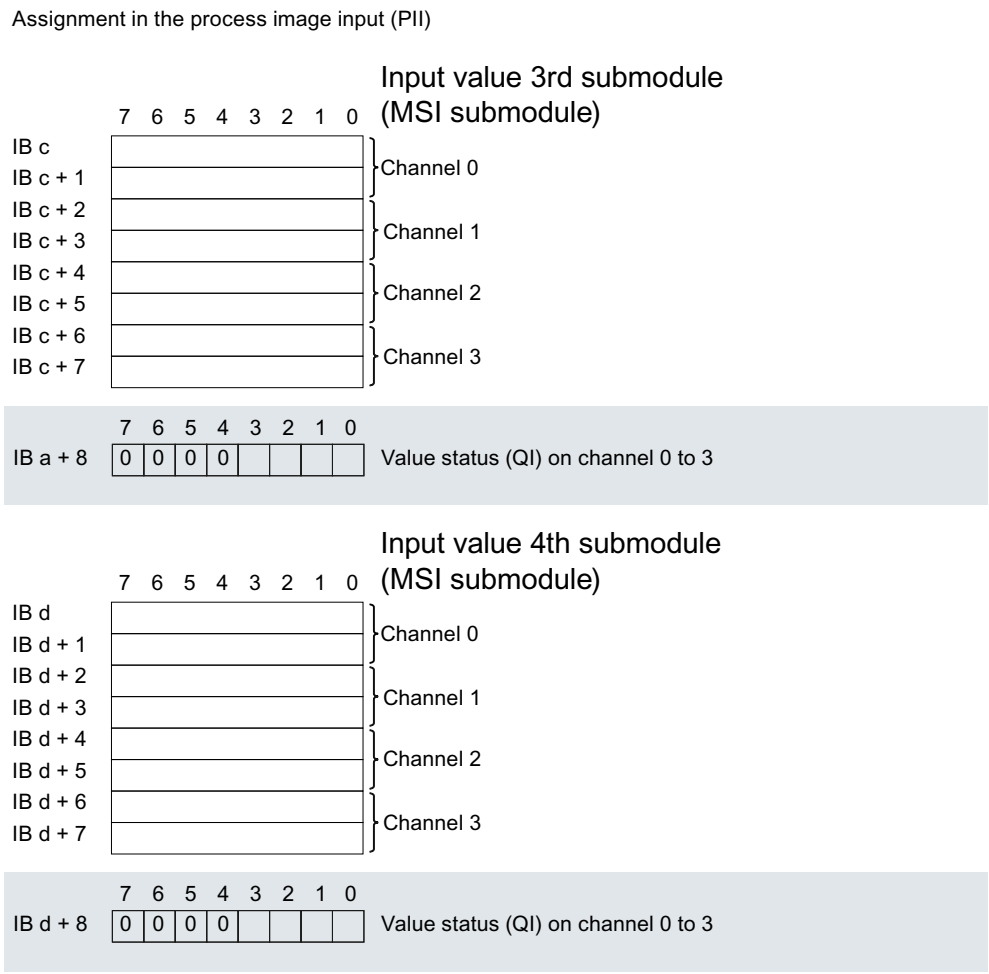

Figure 2-630 Address space for configuration as 1 x 4-channel AI 4xTC HS V1.0, MSI with value status, submodule 3 and 4

Address space for configuration as 1 x 4-channel AI 4xTC HS V1.0, REAL, QI

The following figure shows the assignment of the address space in REAL representation with value status (Quality Information (QI)). In REAL representation, each channel occupies 4 bytes in the process image of the inputs.
The addresses for the value status are only available if the value status is enabled.

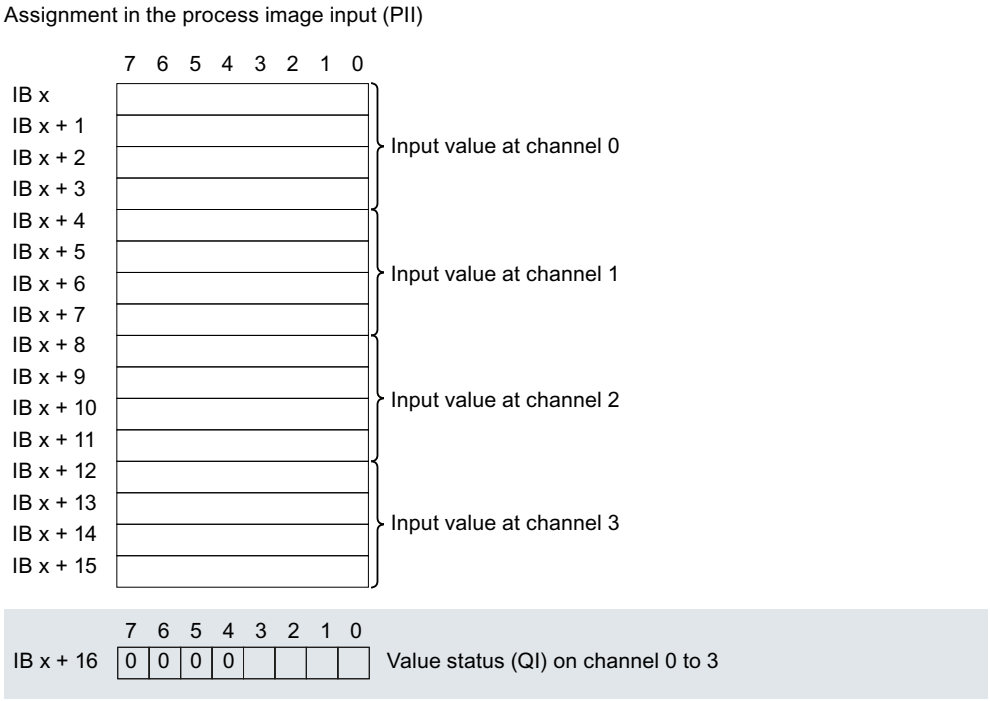

Figure 2-631 Address space for configuration as 1 x 4-channel AI 4xTC HS V1.0, REAL, QI with value status

Address space for configuration as 1 x 4-channel AI 4xTC HS V1.0, REAL, MSI

For the configuration as a 1 x 4-channel module REAL MSI, the channels react as in the 1 x 4-channel AI 4xTC HS V1.0, MSI configuration.
In REAL representation, each channel occupies 4 bytes in the process image of the inputs.

Assignment in the process image input (PII)

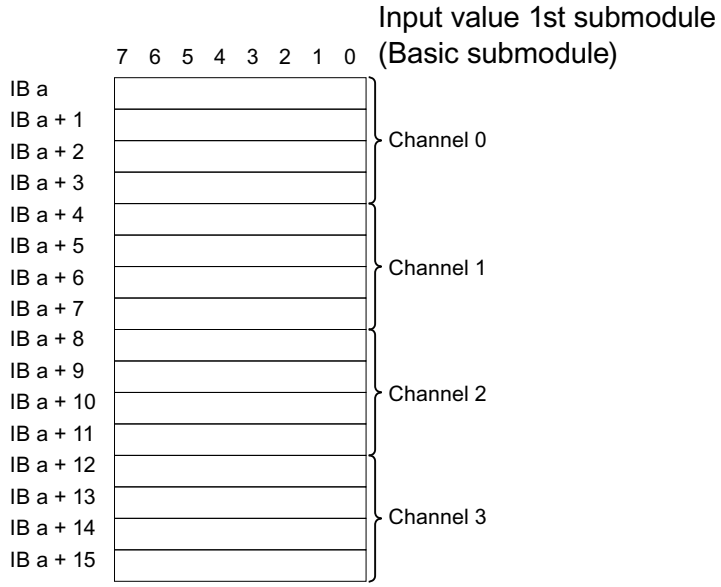

	7	6	5	4	3	2	1	0	
IB a + 16	0	0	0	0					Value status (QI) on channel 0 to 3

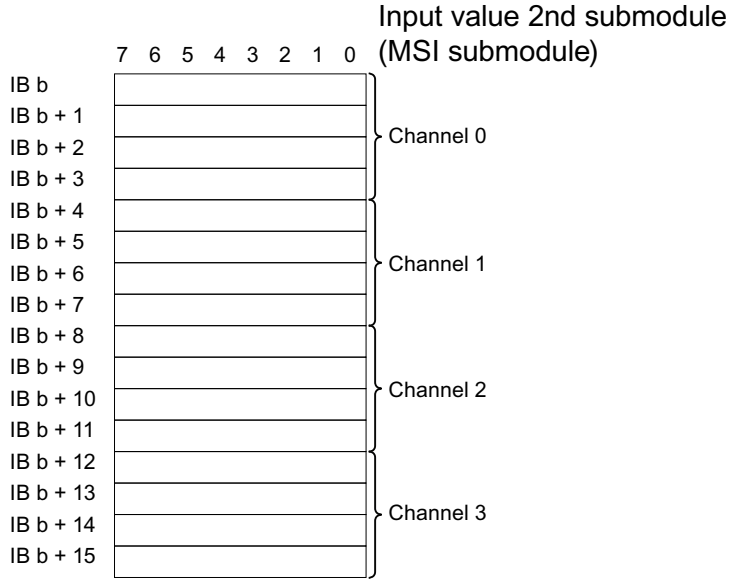

	7	6	5	4	3	2	1	0	
IB b + 16	0	0	0	0					Value status (QI) on channel 0 to 3

Figure 2-632 Address space for configuration as 1 x 4-channel AI 4xTC HS V1.0, REAL, MSI with value status, submodule 1 and 2

The figure below shows the assignment of the address space with submodules 3 and 4.

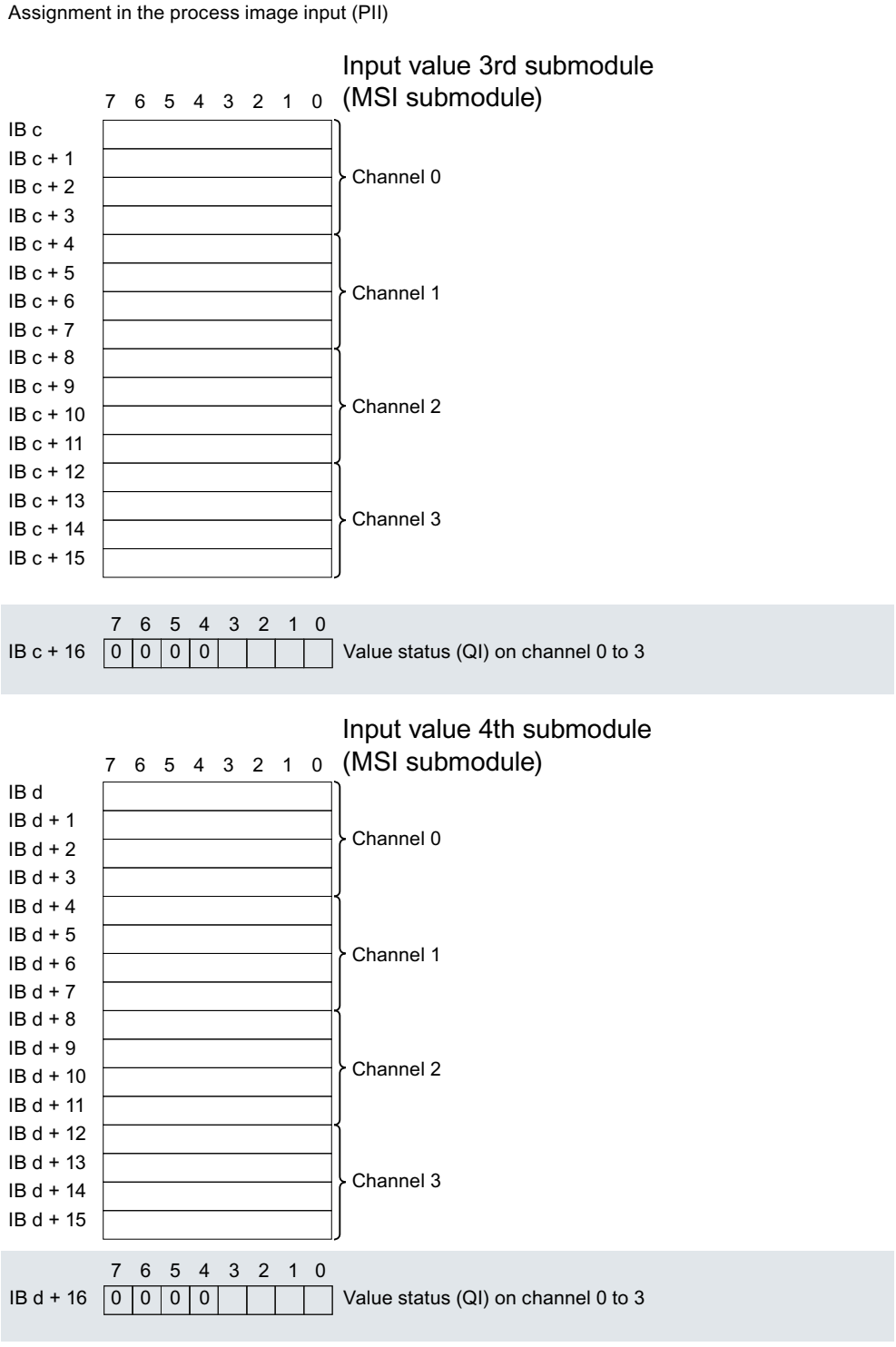

Figure 2-633 Address space for configuration as 1 x 4-channel AI 4xTC HS V1.0, REAL, MSI with value status, submodule 3 and 4

Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The following figure shows you the LED display of the AI 4xTC HS:

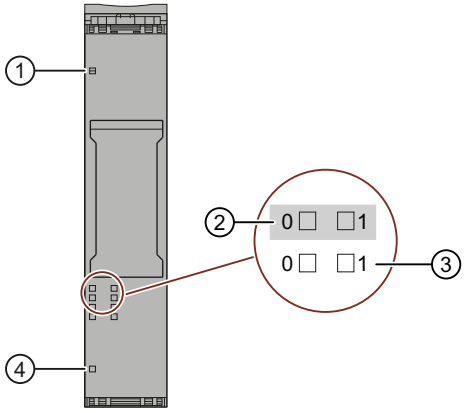

① DIAG (green/red)

② Channel status (green)

③ Channel error (red)

④ PWR (green)

Figure 2-634 LED display

Meaning of the LED displays

The following tables contain the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostics alarms (Page 38).

LED DIAG

Table 2-709 LED DIAG fault display

LED DIAG	Meaning
□ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status/channel error LED

Table 2-710 Status and error display of the LED channel status / channel error

LEDs		Meaning
Channel status	Channel error	
□ Off	□ Off	Channel deactivated
■ On	□ Off	Channel activated and no channel diagnostics
□ Off	■ On	Channel activated and channel diagnostics
■ On	■ On	Not permitted (error)

PWR LED

Table 2-711 Status display of the PWR LED

PWR LED	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ present

5.2 Interrupts

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- Violation of low limit 1
- Violation of high limit 1
- Violation of low limit 2
- Violation of high limit 2

You can obtain detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

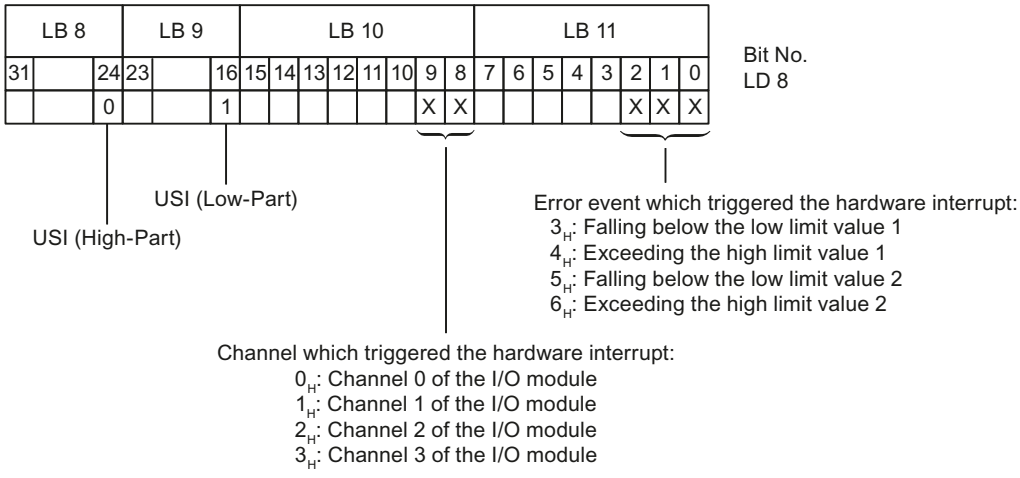

Figure 2-635 OB start information

Structure of the additional interrupt information

Table 2-712 Structure of the additional interrupt information

Data block name		Content	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	additional interrupt information for hardware interrupts of the I/O module	2
Channel that triggered the hardware interrupt.				
	Channel	B#16#00 to B#16#03	Channel 0 to 3 of the I/O module	1
Event that triggered the hardware interrupt.				
	Event	B#16#03	Violation of low limit 1	1
		B#16#04	Violation of high limit 1	
		B#16#05	Violation of low limit 2	
		B#16#06	Violation of high limit 2	

Diagnostic error interrupt

The module generates a diagnostic error interrupt at the following events:

- Channel temporarily unavailable
- Hardware interrupt lost
- Reference channel error
- Error
- Violation of low limit
- Violation of high limit
- Wire break
- Supply voltage missing
- Parameter assignment error

5.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-713 Diagnostics alarms, their meaning and remedies

Diagnostics alarms	Error code	Meaning	Solution
Wire break	6_H	Resistance of sensor circuit too high	Use a different sensor type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate diagnostics • Connect or deactivate the channel
Violation of high limit[1]	7_H	Value lies above the overrange.	Correct module/sensor interplay
Violation of low limit[1]	8_H	Value lies below the underrange.	Correct module/sensor interplay
Error	9_H	Internal module error has occurred (diagnostics alarm on channel 0 applies to the entire module).	Replace module
Parameter assignment error	10_H	The module cannot evaluate parameters for the channel. Incorrect parameter assignment.	Correct the parameter assignment (wire break diagnostics only allowed with the permitted measuring ranges).
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

1 The alarm refers to the diagnostics and depends on the configured measuring range.

2 Shared device and "Reference temperature" diagnostics: If the sender and receiver of the reference junction temperature of a group are assigned to different IO controllers, you may need to download both configurations again in the case of diagnostics. First download the configuration containing the receiver.

Diagnostics alarms	Error code	Meaning	Solution
Reference channel error (reference junction)	15_H	Reference temperature of the reference junction for the TC channel being operated with compensation is invalid.	• Check BaseUnit type • Select correct reference junction through parameter assignment[2] • Check whether the reference junction (reference channel of the group 0, 1, 2, 3) is only assigned once as the sender in the entire setup.
Hardware interrupt lost	16_H	At least one hardware interrupt could not be signaled because too many hardware interrupts are pending.	Correct the program or the process
Channel temporarily unavailable	$1F_H$	• Firmware update is currently in progress or has been canceled. The module does not read in process values in this state. • The channel is currently being calibrated.	• Wait for firmware update. • Restart the firmware update. • Complete calibration.

1 The alarm refers to the diagnostics and depends on the configured measuring range.

2 Shared device and "Reference temperature" diagnostics: If the sender and receiver of the reference junction temperature of a group are assigned to different IO controllers, you may need to download both configurations again in the case of diagnostics. First download the configuration containing the receiver.

Technical specifications 6

Technical specifications of the AI 4xTC HS

The following table shows the technical specifications as of 03/2019. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7134-6JD00-0DA1/td?dl=en).

Article number	6ES7134-6JD00-0DA1
General information	
Product type designation	AI 4xTC HS
HW functional status	From FS02
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Measuring range scalable	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V15 with HSP 265/integrated as of V15.1
• STEP 7 configurable/integrated as of version	V5.5 SP3 or higher
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
• Oversampling	No
• MSI	Yes
CiR – Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	37 mA
Current consumption, max.	50 mA

Article number	6ES7134-6JD00-0DA1
Power loss	
Power loss, typ.	0.9 W
Address area	
Address space per module	
• Address space per module, max.	16 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type A0, A1
Analog inputs	
Number of analog inputs	4
permissible input voltage for voltage input (destruction limit), max.	30 V
Cycle time (all channels), min.	5 ms; Sum of the basic conversion times and additional processing times (depending on the parameterization of the active channels)
Technical unit for temperature measurement adjustable	Yes; °C/°F/K
Input ranges (rated values), voltages	
• -1 V to +1 V	Yes; 16 bit incl. sign
• Input resistance (-1 V to +1 V)	1 MΩ
• -250 mV to +250 mV	Yes; 16 bit incl. sign
• Input resistance (-250 mV to +250 mV)	1 MΩ
• -50 mV to +50 mV	Yes; 16 bit incl. sign
• Input resistance (-50 mV to +50 mV)	1 MΩ
• -80 mV to +80 mV	Yes; 16 bit incl. sign
• Input resistance (-80 mV to +80 mV)	1 MΩ
Input ranges (rated values), thermocouples	
• Type B	Yes; 16 bit incl. sign
• Input resistance (Type B)	1 MΩ
• Type C	Yes; 16 bit incl. sign
• Input resistance (Type C)	1 MΩ
• Type E	Yes; 16 bit incl. sign
• Input resistance (Type E)	1 MΩ
• Type J	Yes; 16 bit incl. sign
• Input resistance (type J)	1 MΩ
• Type K	Yes; 16 bit incl. sign
• Input resistance (Type K)	1 MΩ
• Type L	Yes; 16 bit incl. sign

Article number	6ES7134-6JD00-0DA1
• Input resistance (Type L)	1 MΩ
• Type N	Yes; 16 bit incl. sign
• Input resistance (Type N)	1 MΩ
• Type R	Yes; 16 bit incl. sign
• Input resistance (Type R)	1 MΩ
• Type S	Yes; 16 bit incl. sign
• Input resistance (Type S)	1 MΩ
• Type T	Yes; 16 bit incl. sign
• Input resistance (Type T)	1 MΩ
• Type U	Yes; 16 bit incl. sign
• Input resistance (Type U)	1 MΩ
• Type TXK/TXK(L) to GOST	Yes; 16 bit incl. sign
• Input resistance (Type TXK/TXK(L) to GOST)	1 MΩ
Thermocouple (TC)	
Temperature compensation	
– parameterizable	Yes
– Reference channel of the module	No
– internal comparison point	Yes; with BaseUnit type A1
– Reference channel of the group	Yes
– Number of reference channel groups	4; Group 0 to 3
– fixed reference temperature	Yes
Cable length	
• shielded, max.	200 m; 100 m for thermocouples
Analog value generation for the inputs	
Measurement principle	integrating (Sigma-Delta)
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Basic conversion time, including integration time (ms)	
– additional processing time for wire-break check	1 ms
• Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz / off
• Conversion time (per channel)	180/60/50/1.25 ms
Smoothing of measured values	
• Number of smoothing levels	4; None; 4/8/16 times

Article number	6ES7134-6JD00-0DA1
• parameterizable	Yes
• Step: None	Yes
• Step: low	Yes
• Step: Medium	Yes
• Step: High	Yes
Encoder	
Connection of signal encoders	
• for voltage measurement	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %
Temperature error (relative to input range), (+/-)	0.005 %/K
Crosstalk between the inputs, min.	-70 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.03 %
Operational error limit in overall temperature range	
• Voltage, relative to input range, (+/-)	0.1 %; 0.3 % when SFU OFF
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to input range, (+/-)	0.05 %; 0.2 % when SFU OFF
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	70 dB
• Common mode voltage, max.	60 V; DC
• Common mode interference, min.	90 dB
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes; two upper and two lower limit values in each case
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; channel by channel
• Group error	Yes
• Overflow/underflow	Yes; channel by channel

Article number	6ES7134-6JD00-0DA1
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	Yes; Red LED
• for module diagnostics	Yes; Green/red LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Permissible potential difference	
between the inputs (UCM)	60 V DC
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for applications according to AMS 2750	Yes; Declaration of Conformity, see online support entry 109757262
Suitable for applications according to CQI-9	Yes; Based on AMS 2750 E
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	33 g

Operational and basic error limits for thermocouples

Error limits for thermocouples[1] (Interference frequency suppression: 16.6 Hz / 50 Hz / 60 Hz)	
Operational limit for thermocouples (in the entire temperature range)	±1.5 K
Basic error limit for thermocouples (operational limit at 25 °C)	±1 K
Overall error limits when using internal compensation	
• Operational limit (in the entire temperature range at static thermal state, ambient temperature change < 0.3 K/min)	± 2.5 K
• Basic error limit (operational limit at 25 °C at static thermal state, ambient temperature change < 0.3 K/min)	±1.5 K

1 The indicated error limits apply as of the following temperatures:
Thermocouple type T: -200 °C
Thermocouple type K: -100 °C
Thermocouple type B: +700 °C
Thermocouple type N: -150 °C
Thermocouple type E: -150 °C
Thermocouple type R: +200 °C
Thermocouple type S: +100 °C

Error limits for thermocouples[1] (Interference frequency suppression: None)	
Operational limit for thermocouples (in the entire temperature range)	±3.75 K
Operational limit for thermocouples type B, C, E, R, S (in the entire temperature range)[1]	±7.5 K
Basic error limit for thermocouples (operational limit at 25 °C)	± 2.5 K
Basic error limit for thermocouples type B, C, E, R, S (operational limit at 25 °C)	±5 K
Overall error limits when using internal compensation	
• Operational limit (in the entire temperature range at static thermal state, ambient temperature change < 0.3 K/min)[2]	±5.25 K
• Basic error limit (operational limit at 25 °C at static thermal state, ambient temperature change < 0.3 K/min)[3]	±3 K

1 The indicated error limits apply as of the following temperatures:
Thermocouple type T: -200 °C
Thermocouple type K: -100 °C
Thermocouple type B: +700 °C
Thermocouple type N: -150 °C
Thermocouple type E: -150 °C
Thermocouple type R: +200 °C
Thermocouple type S: +100 °C

2 For thermocouple type B, C, E, R, S: ±9 K

3 For thermocouple type B, C, E, R, S: ±5.5 K

Dimension drawing

See equipment manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data records

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Table 2-714 Dependencies of the measurement type / measuring range

Measurement type	Measuring range	Reference junction	Temperature unit
Deactivated	*	*	*
Voltage	±50 mV, ±80 mV, ±250 mV, ±1 V	*	*
Thermocouple	Type B, N, E, R, S, J, L, T, K, U, C, TXK	Internal reference junction Reference channel of group 0, 1, 2, 3[1]	Degrees Celsius Degrees Fahrenheit Kelvin
		Fixed reference temperature	

x = property is allowed, – = property is **not allowed**, * = property is not relevant.

1 Use of "Reference channel of group 0, 1, 2, 3":
For each TC channel in the IO device that is intended to use this reference, "Reference junction" must be set to "Reference channel of group 0, 1, 2, 3".

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type for PROFINET.

Table 2-715 Dependencies on the measurement type

Measurement type	Scalable measuring range	Measuring range resolution	Wire break check	Diagnostics				
				Underflow	Overflow	Wire break	Missing supply voltage L+	Reference junction
Deactivated	*	*	*	*	*	*	*	*
Voltage	–	*	-	x	x	–	x	–
Thermocouple	x	2 and 3 decimal places	x	x	x	x[1]	x	x[2]

x = property is allowed, – = property is **not allowed**, * = property is not relevant.

1 Property is only permitted if the "Wire break check" parameter is enabled.

2 Property is not relevant when "Fixed reference temperature" is used.

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Table 2-716 Dependencies of the measurement type / measuring range

Measurement type	Measuring range	Slot reference junction	Temperature unit	Wire break check	Diagnostics			
					Underflow / overflow	Wire break	Missing supply voltage L+	Reference junction
Deactivated	*	*	*	*	*	*	*	*
Voltage	±50 mV, ±80 mV, ±250 mV, ±1 V	*	*	-	x	–	x	–
Thermocouple	Type B, N, E, R, S, J, L, T, K, U, C, TXK	Internal reference junction Reference channel of group 0, 1, 2, 3[1]	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x[2]	x	x
		Fixed reference temperature	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x[2]	x	*

x = property is allowed, – = property is **not allowed**, * = property is not relevant.

1 Use of "Reference channel of group 0, 1, 2, 3":
For each TC channel in the IO device that is intended to use this reference, "Reference junction" must be set to "Reference channel of group 0, 1, 2, 3".

2 Property is only allowed if the "Wire break check" is enabled.

A.2 Parameter assignment and structure of the parameter data record (S7 representation)

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can reassign the parameters of the module in RUN. For example, the measuring range of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 will not be changed on the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

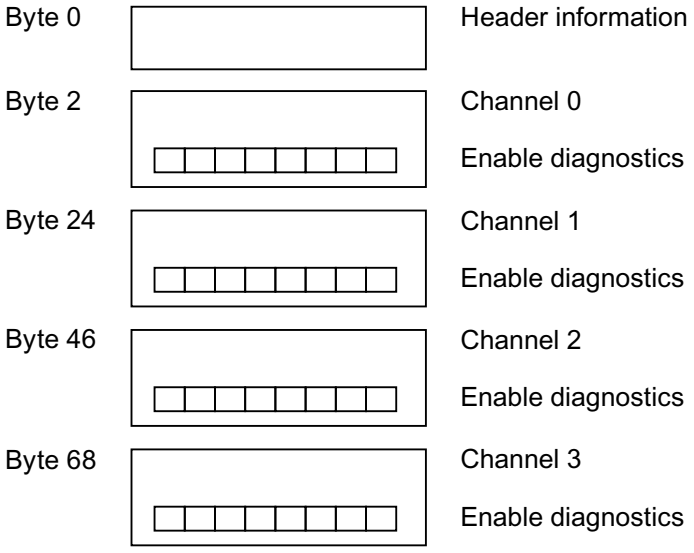

Figure 2-636 Structure of data record 128

Header information

The figure below shows the structure of the header information in S7 representation.

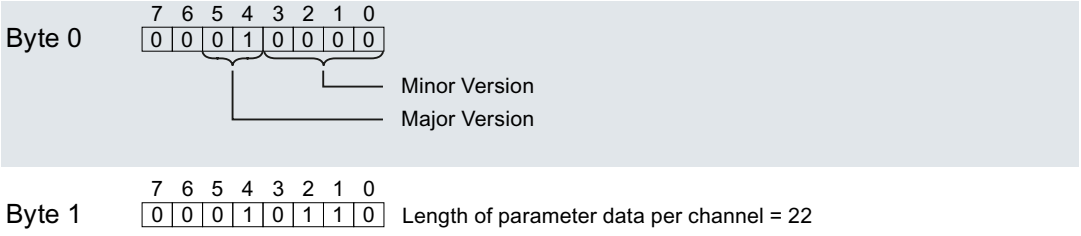

Figure 2-637 Header information - S7 representation

Channel parameter block

The figure below shows the structure of the parameters for channels 0 to 3.

You can activate a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number * 22); channel number = 0 to 3

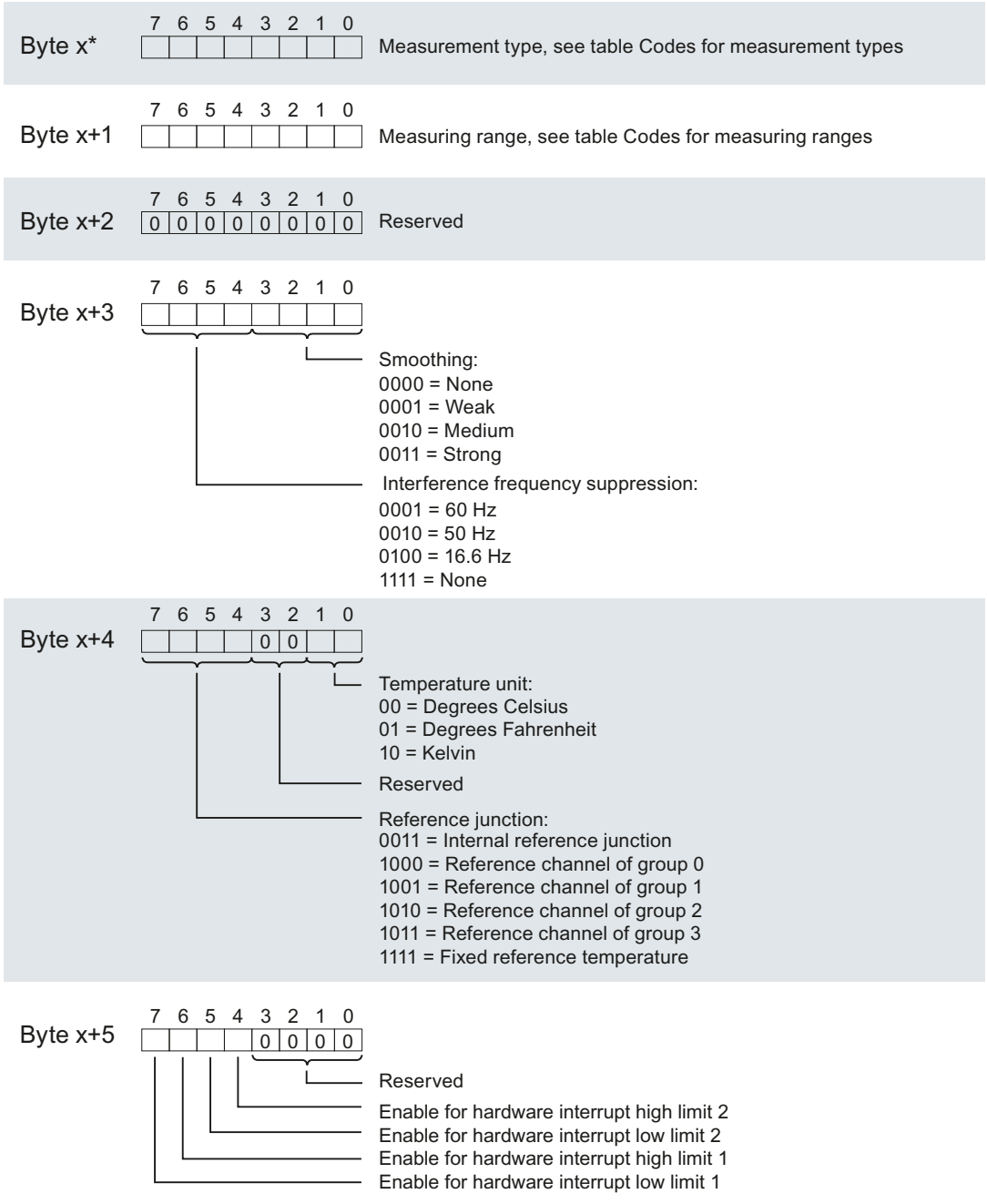

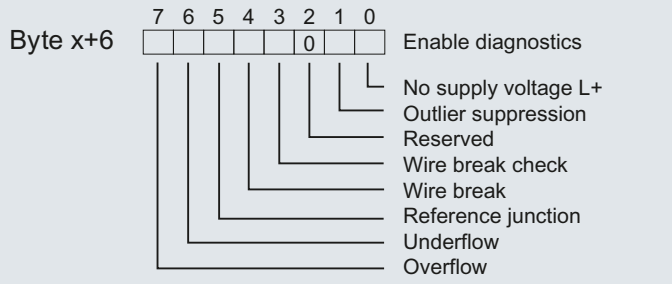
Byte x+6
7 6 5 4 3 2 1 0
0
Enable diagnostics
No supply voltage L+
Outlier suppression
Reserved
Wire break check
Wire break
Reference junction
Underflow
Overflow

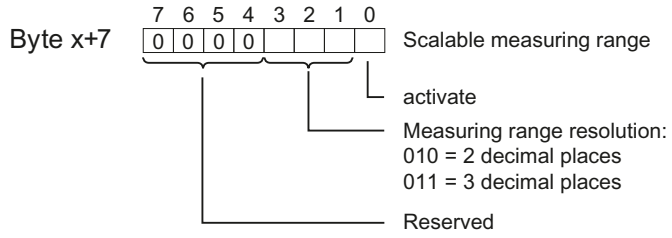
Byte x+7
7 6 5 4 3 2 1 0
0 0 0 0
Scalable measuring range
activate
Measuring range resolution:
010 = 2 decimal places
011 = 3 decimal places
Reserved

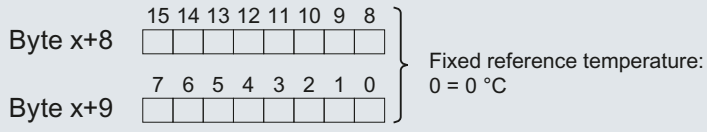
Byte x+8
15 14 13 12 11 10 9 8
Byte x+9
7 6 5 4 3 2 1 0
Fixed reference temperature:
0 = 0 °C

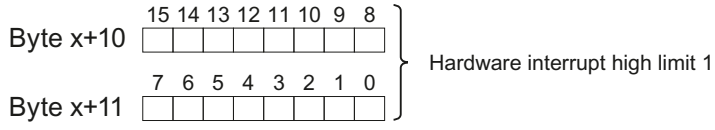
Byte x+10
15 14 13 12 11 10 9 8
Byte x+11
7 6 5 4 3 2 1 0
Hardware interrupt high limit 1

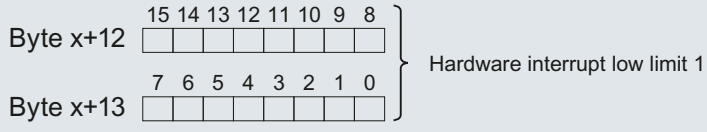
Byte x+12
15 14 13 12 11 10 9 8
Byte x+13
7 6 5 4 3 2 1 0
Hardware interrupt low limit 1

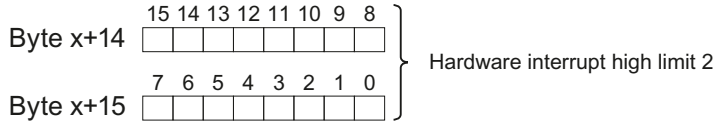
Byte x+14
15 14 13 12 11 10 9 8
Byte x+15
7 6 5 4 3 2 1 0
Hardware interrupt high limit 2

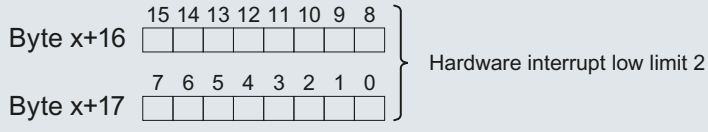
Byte x+16
15 14 13 12 11 10 9 8
Byte x+17
7 6 5 4 3 2 1 0
Hardware interrupt low limit 2

Figure 2-638 Structure of byte x to x+21 for channel 0 to 3 - S7 representation

Codes for measurement type

The following table contains the codes for the measurement types of the analog input module. You need to enter these codes in the relevant byte x.

Table 2-717 Codes for measurement type

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001
Thermocouple	0000 1010

Codes for measuring range

The following table contains the codes for the measuring ranges of the analog input module. You need to enter these codes in the relevant x+1.

Table 2-718 Codes for measuring range

Measuring range	Code
Voltage	
50 mV	0000 0001
80 mV	0000 0010
250 mV	0000 0011
1 V	0000 0101
Thermocouple	
Type B	0000 0000
Type N	0000 0001
Type E	0000 0010
Type R	0000 0011
Type S	0000 0100
Type J	0000 0101
Type L	0000 0110
Type T	0000 0111
Type K	0000 1000
Type U	0000 1001
Type C	0000 1010
Type TXK	0000 1011

Limits for hardware interrupts

The following tables contain the permitted limits for hardware interrupts (in each case, the usable value is given). The limits depend on the selected measurement type and the selected measuring range. The value for the high limit must be greater than the value for the low limit.

Table 2-719 Voltage limits

Voltage	
32510	High limit
-32511	Low limit

Table 2-720 Limits for thermocouple types B, C, and E

Thermocouple									
Type B			Type C			Type E			
°C	°F	K	°C	°F	K	°C	°F	K	
20699	32765	23431	24999	32765	27731	11999	21919	14731	High limit
-1199	-1839	1533	-1199	-1839	1533	-2699	-4539	33	Low limit

Table 2-721 Limits for thermocouple types R, S, J, and L

Thermocouple									
Types R, S			Type J			Type L			
°C	°F	K	°C	°F	K	°C	°F	K	
20189	32765	22921	14499	26419	17231	11499	21019	14231	High limit
-1699	-2739	1033	-2099	-3459	633	-1999	-3279	733	Low limit

Table 2-722 Limits for thermocouple types T, K, and U

Thermocouple									
Type T			Type K			Type U			
°C	°F	K	°C	°F	K	°C	°F	K	
5399	10039	8131	16219	29515	18951	8499	15619	11231	High limit
-2699	-4539	33	-2699	-4539	33	-1999	-3279	733	Low limit

Table 2-723 Limits for thermocouple types N and TXK

Thermocouple						
Type N			Type TXK			
°C	°F	K	°C	°F	K	
15499	28219	18231	10499	19219	13231	High limit
-2699	-4539	33	-1999	-3279	733	Low limit

Error transmitting the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Table 2-724 Error messages, their meaning and corrective measures

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$B0_H$	00_H	Number of the data record unknown	Enter a valid number for the data record.
DF_H	80_H	$B1_H$	01_H	Length of the data record incorrect	Enter a valid value for the data record length.
DF_H	80_H	$B2_H$	00_H	Module not accessible	• Check station. • Module not correctly plugged in. • Check parameters of the WRREC block.
DF_H	80_H	$E0_H$	01_H	Incorrect version in header	Correct version number of the parameter block, see Header information - S7 representation.
DF_H	80_H	$E0_H$	02_H	Error in the header, length or number of parameter blocks	Correct the length and number of the parameter blocks, see Header information - S7 representation.
DF_H	80_H	$E1_H$	01_H	Reserved bit set	Write 0 to all reserved bits.
DF_H	80_H	$E1_H$	02_H	Invalid diagnostics enable bit set	Correct diagnostics enables. (Dependence on measurement type, measuring range, wire break check)
DF_H	80_H	$E1_H$	04_H	Value for hardware interrupt limit invalid	Use valid hardware interrupt limits, see Parameter assignment and structure of the parameter data record (S7 representation) (Page 47), "Limits for hardware interrupts" section.
DF_H	80_H	$E1_H$	08_H	Code for interference frequency suppression invalid	Use valid code for interference frequency suppression, see Structure of byte x to x+21 for channel 0 to 3 - S7 representation, byte x+3.
DF_H	80_H	$E1_H$	09_H	Code for smoothing invalid	Use valid code for smoothing.
DF_H	80_H	$E1_H$	$0F_H$	Code for reference junction invalid or not permissible	Use valid code for reference junction.
DF_H	80_H	$E1_H$	10_H	Code for the measurement type invalid	Use valid code for measurement type, see Codes for measurement type.
DF_H	80_H	$E1_H$	11_H	Code for the measuring range invalid	Use valid code for measuring range, see Codes for measuring range.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$E1_H$	12_H	Value for fixed reference temperature invalid	Use valid reference temperature, see Structure of byte x to x+21 for channel 0 to 3 - S7 representation, byte x+8.
DF_H	80_H	$E1_H$	21_H	Code for temperature unit invalid	Use valid code for temperature unit Structure of byte x to x+21 for channel 0 to 3 - S7 representation, byte x+4.
DF_H	80_H	$E1_H$	22_H	Code for measuring range resolution invalid or scalable measuring range not permissible	• Use valid code for measuring range resolution. • Disable scalable measuring range.

A.3 Parameter assignment and structure of channel parameter (REAL representation)

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can reassign the parameters of the module in RUN. For example, the measuring range of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 will not be changed on the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

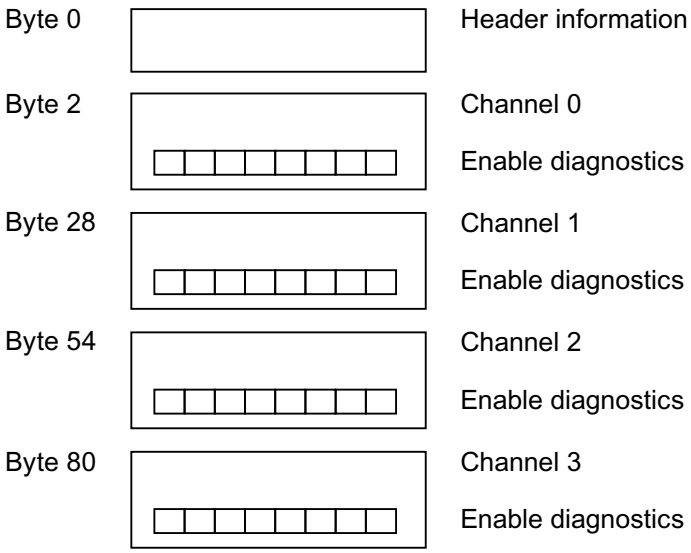

Figure 2-639 Structure of data record 128

Header information

The figure below shows the structure of the header information in REAL representation.

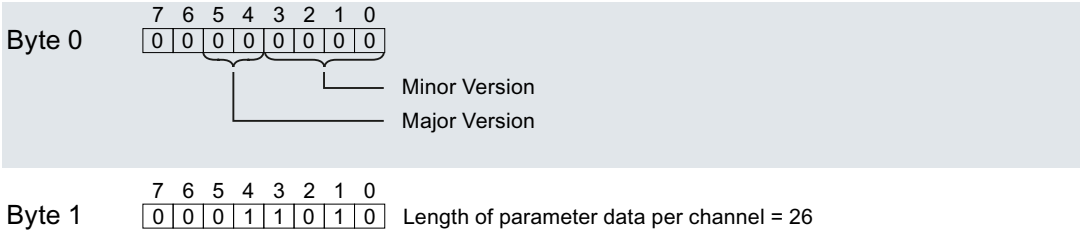

Figure 2-640 Header information - REAL representation

Channel parameter block

The figure below shows the structure of the parameters for channels 0 to 3.

You can activate a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number * 26); channel number = 0 to 3

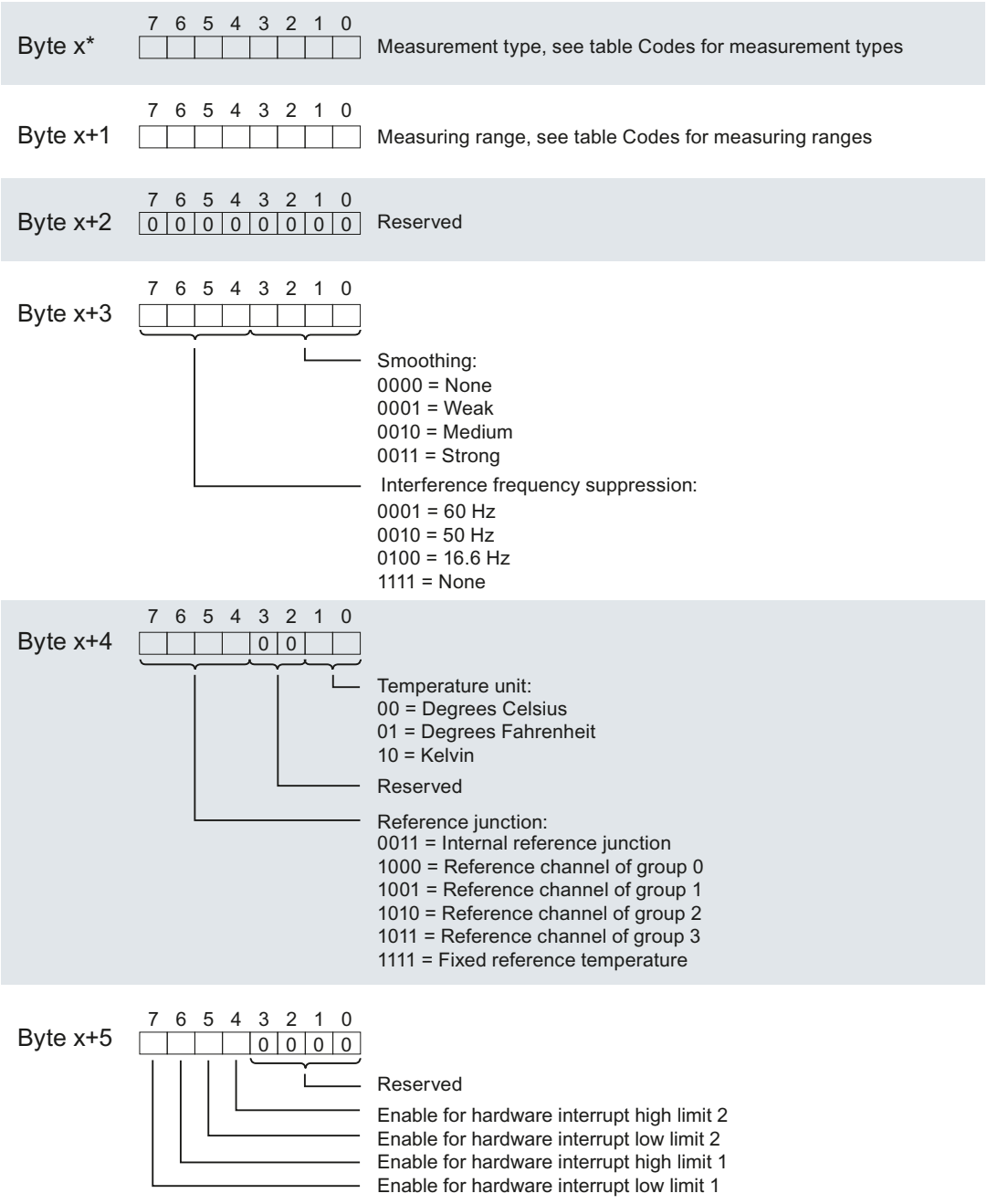

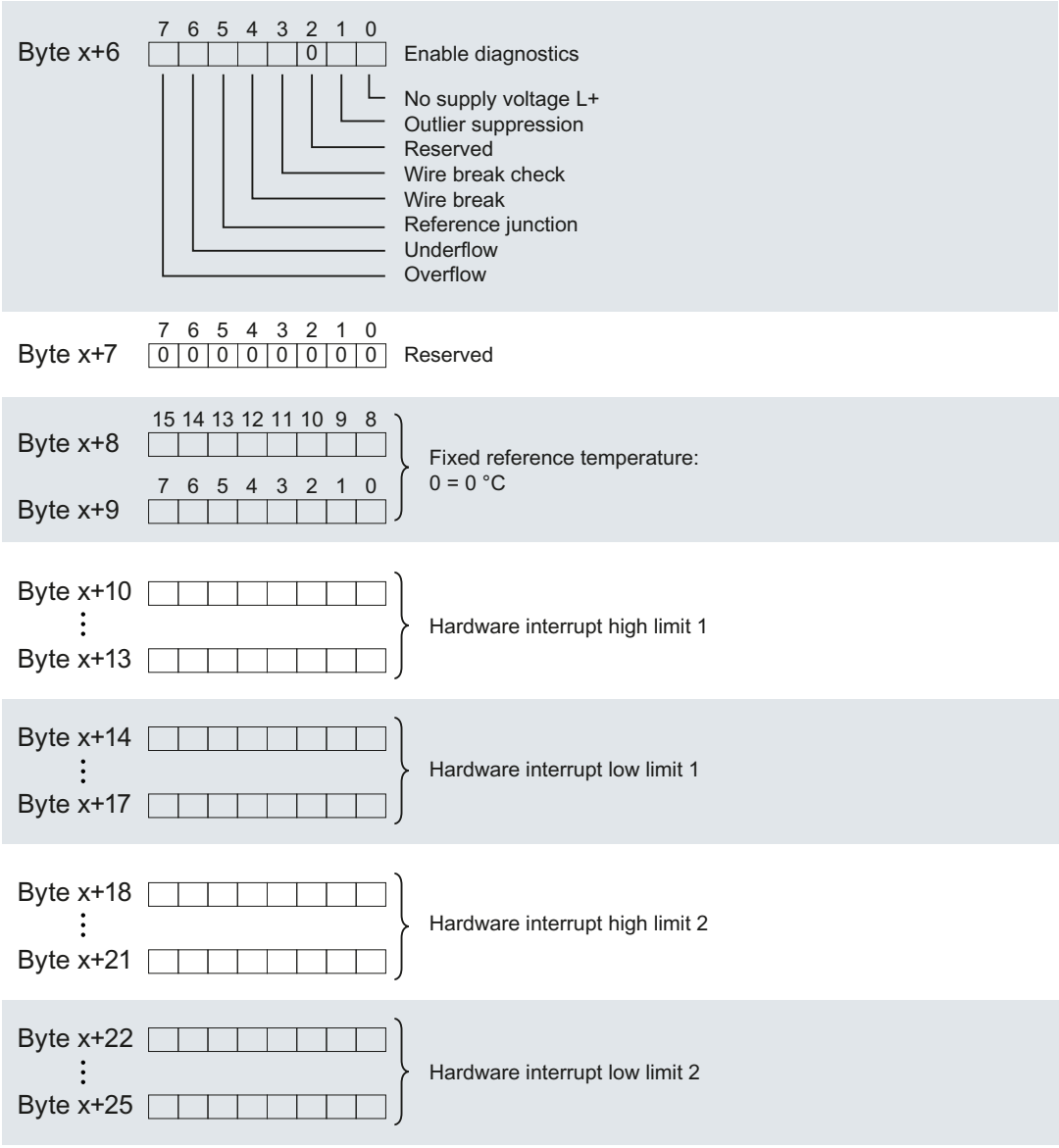

Figure 2-641 Structure of byte x to x+25 for channel 0 to 3 - REAL representation

Codes for measurement type

The following table contains the codes for the measurement types of the analog input module. You need to enter these codes in the relevant byte x.

Table 2-725 Codes for measurement type

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001
Thermocouple	0000 1010

Codes for measuring range

The following table contains the codes for the measuring ranges of the analog input module. You need to enter these codes in the relevant x+1.

Table 2-726 Codes for measuring range

Measuring range	Code
Voltage	
50 mV	0000 0001
80 mV	0000 0010
250 mV	0000 0011
1 V	0000 0101
Thermocouple	
Type B	0000 0000
Type N	0000 0001
Type E	0000 0010
Type R	0000 0011
Type S	0000 0100
Type J	0000 0101
Type L	0000 0110
Type T	0000 0111
Type K	0000 1000
Type U	0000 1001
Type C	0000 1010
Type TXK	0000 1011

Limits for hardware interrupts

The following tables contain the permitted limits for hardware interrupts (in each case, the usable value is given). The limits depend on the selected measurement type and the selected measuring range. The value for the high limit must be greater than the value for the low limit.

Table 2-727 Voltage limits

Voltage				
±50 mV	±80 mV	±250 mV	± 1 V	
58.7927 mV	94.0683 mV	293.963 mV	1.17585 V	High limit
-58.7945 mV	-94.0712 mV	-293.972 mV	-1.17589 V	Low limit

Table 2-728 Limits for thermocouple types B, C, and E

Thermocouple									
Type B			Type C			Type E			
°C	°F	K	°C	°F	K	°C	°F	K	
2069.9	3276.5	2343.1	2499.9	3276.5	2773.1	1199.9	2191.9	1473.1	High limit
-119.9	-183.9	153.3	-119.9	-183.9	153.3	-269.9	-453.9	3.3	Low limit

Table 2-729 Limits for thermocouple types R, S, J, and L

Thermocouple									
Types R, S			Type J			Type L			
°C	°F	K	°C	°F	K	°C	°F	K	
2018.9	3276.5	2292.1	1449.9	2641.9	1723.1	1149.9	2101.9	1423.1	High limit
-169.9	-273.9	103.3	-209.9	-345.9	63.3	-199.9	-327.9	73.3	Low limit

Table 2-730 Limits for thermocouple types T, K, and U

Thermocouple									
Type T			Type K			Type U			
°C	°F	K	°C	°F	K	°C	°F	K	
539.9	1003.9	813.1	1621.9	2951.5	1895.1	849.9	1561.9	1123.1	High limit
-269.9	-453.9	3.3	-269.9	-453.9	3.3	-199.9	-327.9	73.3	Low limit

Table 2-731 Limits for thermocouple types N and TXK

Thermocouple						
Type N			Type TXK			
°C	°F	K	°C	°F	K	
1549.9	2821.9	1823.1	1049.9	1921.9	1323.1	High limit
-269.9	-453.9	3.3	-199.9	-327.9	73.3	Low limit

Error transmitting the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns the appropriate error code if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Table 2-732 Error messages, their meaning and corrective measures

Error code in the STATUS parameter (hexadecimal)				**Meaning**	**Solution**
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF_H	80_H	$B0_H$	00_H	Number of the data record unknown	Enter a valid number for the data record.
DF_H	80_H	$B1_H$	01_H	Length of the data record incorrect	Enter a valid value for the data record length.
DF_H	80_H	$B2_H$	00_H	Module not accessible	• Check station. • Module not correctly plugged in. • Check parameters of the WRREC block.
DF_H	80_H	$E0_H$	01_H	Incorrect version in header	Correct version number of the parameter block, see Header information - REAL representation.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF_H	80_H	$E0_H$	02_H	Error in the header, length or number of parameter blocks	Correct the length and number of the parameter blocks, see Header information - REAL representation.
DF_H	80_H	$E1_H$	01_H	Reserved bit set	Write 0 to all reserved bits.
DF_H	80_H	$E1_H$	02_H	Invalid diagnostics enable bit set	Correct diagnostics enables. (Dependence on measurement type, measuring range, wire break check)
DF_H	80_H	$E1_H$	04_H	Value for hardware interrupt limit invalid	Use valid hardware interrupt limits, see Parameter assignment and structure of channel parameter (REAL representation) (Page 54), "Limits for hardware interrupts" section.
DF_H	80_H	$E1_H$	08_H	Code for interference frequency suppression invalid	Use valid code for interference frequency suppression, see Structure of byte x to x+25 for channel 0 to 3 - REAL representation, byte x+3.
DF_H	80_H	$E1_H$	09_H	Code for smoothing invalid	Use valid code for smoothingStructure of byte x to x+25 for channel 0 to 3 - REAL representation.
DF_H	80_H	$E1_H$	$0F_H$	Code for reference junction invalid or not permissible	Use valid code for reference junctionStructure of byte x to x+25 for channel 0 to 3 - REAL representation.
DF_H	80_H	$E1_H$	10_H	Code for the measurement type invalid	Use valid code for measurement type, see Codes for measurement type.
DF_H	80_H	$E1_H$	11_H	Code for the measuring range invalid	Use valid code for measuring range, see Codes for measuring range.
DF_H	80_H	$E1_H$	12_H	Value for fixed reference temperature invalid	Use valid reference temperature, see Structure of byte x to x+25 for channel 0 to 3 - REAL representation, byte x+8.
DF_H	80_H	$E1_H$	21_H	Code for temperature unit invalid	Use valid code for temperature unit Structure of byte x to x+25 for channel 0 to 3 - REAL representation, byte x+4.

Representation of analog values

B

This appendix shows the analog values for all measuring ranges that you can use with the analog module AI 4xTC HS.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its parameter assignment.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

NOTE

Temperature values

The digitized temperature values are the result of a conversion in the analog module. The following resolution therefore does not apply to temperature values.

Table 2-733 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	**Hexadecimal**	**High byte**	**Low byte**
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table 2-734 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	

Dec. value	Measured value in %	Data word																Range
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.2 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table 2-735 Voltage measuring range ±1 V

Values		Voltage measuring range	Range
Dec.	**Hex.**	**±1 V**	
32767	7FFF	> 1.176 V	Overflow
32511	7EFF	1.176 V	Overrange
27649	6C01		
27648	6C00	1 V	Nominal range
20736	5100	0.75 V	
1	1	36.17 µV	
0	0	0 V	
-1	FFFF		
-20736	AF00	-0.75 V	
-27648	9400	-1 V	
-27649	93FF		Underrange
-32512	8100	-1.176 V	
-32768	8000	<-1.176 V	Underflow

Table 2-736 Voltage measuring range ±500 mV to ±50 mV

Values		Voltage measuring range			Range
Dec.	**Hex.**	**±250 mV**	**±80 mV**	**±50 mV**	
32767	7FFF	> 294.0 mV	> 94.1 mV	> 58.8 mV	Overflow
32511	7EFF	294.0 mV	94.1 mV	58.8 mV	Overrange
27649	6C01				
27648	6C00	250 mV	80 mV	50 mV	Nominal range
20736	5100	187.5 mV	60 mV	37.5 mA	
1	1	9.04 µV	2.89 µV	1.81 µV	
0	0	0 mV	0 mV	0 mV	
-1	FFFF				
-20736	AF00	-187.5 mV	-60 mV	-37.5 mV	
-27648	9400	-250 mV	-80 mV	-50 mV	

Values		Voltage measuring range			Range
-27649	93FF				Underrange
-32512	8100	-294.0 mV	-94.1 mV	-58.8 mV	
-32768	8000	<-294.0 mV	<-94.1 mV	<-58.8 mV	Underflow

B.3 Representation of analog values for thermocouples

NOTE

A higher resolution can be configured for thermocouples, see section Scalable measuring range (Page 22).

The tables below list the decimal and hexadecimal values (codes) of the thermocouples.

Table 2-737 Thermocouple type B

Type B in °C	Values		Type B in °F	Values		Type B in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2070.0	32767	7FFF	> 3276.6	32767	7FFF	> 2343.2	32767	7FFF	Overflow
2070.0 : 1820.1	20700 : 18201	50DC : 4719	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2343.2 : 2093.3	23432 : 20933	5B88 : 51C5	Overrange
1820.0 : 0.0	18200 : 0	4718 : 0000	2786.5 : 32.0	27865 : 320	6CD9 : 0140	2093.2 : 273.2	20932 : 2732	51C4 : 0AAC	Nominal range
-0.1 : -120.0	-1 : -1200	FFFF : FB50	31.9 : -184.0	319 : -1840	013F : F8D0	273.1 : 153.2	2731 : 1532	0AAB : 05FC	Underrange
< -120.0	-32768	8000	< -184.0	-32768	8000	< 153.2	-32768	8000	Underflow

Table 2-738 Thermocouple type C

Type C in °C	Values		Type C in °F	Values		Type C in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2500.0	32767	7FFF	> 3276.6	32767	7FFF	> 2773.2	32767	7FFF	Overflow
2500.0 : 2315.1	25000 : 23151	61A8 : 5A6F	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2773.2 : 2588.3	27732 : 25883	6C54 : 651B	Overrange
2315.0 : 0.0	23150 : 0	5A6E : 0000	2786.5 : 32.0	27865 : 320	6CD9 : 0140	2588.2 : 273.2	25882 : 2732	651A : 0AAC	Nominal range
-0.1 : -120.0	-1 : -1200	FFFF : FB50	31.9 : -184.0	319 : -1840	013F : F8D0	273.1 : 153.2	2731 : 1532	0AAB : 05FC	Underrange
< -120.0	-32768	8000	< -184.0	-32768	8000	< 153.2	-32768	8000	Underflow

Table 2-739 Thermocouple type E

Type E in °C	Values		Type E in °F	Values		Type E in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1200.0	32767	7FFF	> 2192.0	32767	7FFF	> 1473.2	32767	7FFF	Overflow
1200.0 : 1000.1	12000 : 10001	2EE0 : 2711	2192.0 : 1832.1	21920 : 18321	55A0 : 4791	1473.2 : 1273.3	14732 : 12733	398C : 31BD	Overrange
1000.0 : -270.0	10000 : -2700	2710 : F574	1832.0 : -454.0	18320 : -4540	4790 : EE44	1273.2 : 3.2	12732 : 32	31BC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-740 Thermocouple type J

Type J in °C	Values		Type J in °F	Values		Type J in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1450.0	32767	7FFF	> 2642.0	32767	7FFF	> 1723.2	32767	7FFF	Overflow
1450.0 : 1200.1	14500 : 12001	38A4 : 2EE1	2642.0 : 2192.1	26420 : 21921	6734 : 55A1	1723.2 : 1473.3	17232 : 14733	4350 : 398D	Overrange
1200.0 : -210.0	12000 : -2100	2EE0 : F7CC	2192.0 : -346.0	21920 : -3460	55A0 : F27C	1473.2 : 63.2	14732 : 632	398C : 0278	Nominal range
< -210.0	-32768	8000	< -346.0	-32768	8000	< 63.2	-32768	8000	Underflow

Table 2-741 Thermocouple type K

Type K in °C	Values		Type K in °F	Values		Type K in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1622.0	32767	7FFF	> 2951.6	32767	7FFF	> 1895.2	32767	7FFF	Overflow
1622.0 : 1372.1	16220 : 13721	3F5C : 3599	2951.6 : 2501.7	29516 : 25017	734C : 61B9	1895.2 : 1645.3	18952 : 16453	4A08 : 4045	Overrange
1372.0 : -270.0	13720 : -2700	3598 : F574	2501.6 : -454.0	25016 : -4540	61B8 : EE44	1645.2 : 3.2	16452 : 32	4044 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-742 Thermocouple type L

Type L in °C	Values		Type L in °F	Values		Type L in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1150.0	32767	7FFF	> 2102.0	32767	7FFF	> 1423.2	32767	7FFF	Overflow
1150.0 : 900.1	11500 : 9001	2CEC : 2329	2102.0 : 1652.1	21020 : 16521	521C : 4089	1423.2 : 1173.3	14232 : 11733	3798 : 2DD5	Overrange
900.0 : -200.0	9000 : -2000	2328 : F830	1652.0 : -328.0	16520 : -3280	4088 : F330	1173.2 : 73.2	11732 : 732	2DD4 : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow

Table 2-743 Thermocouple type N

Type N in °C	Values		Type N in °F	Values		Type N in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1550.0	32767	7FFF	> 2822.0	32767	7FFF	> 1823.2	32767	7FFF	Overflow
1550.0 : 1300.1	15500 : 13001	3C8C : 32C9	2822.0 : 2372.1	28220 : 23721	6E3C : 5CA9	1823.2 : 1573.3	18232 : 15733	4738 : 3D75	Overrange
1300.0 : -270.0	13000 : -2700	32C8 : F574	2372.0 : -454.0	23720 : -4540	5CA8 : EE44	1573.2 : 3.2	15732 : 32	3D74 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-744 Thermocouples R and S

Types R, S in °C	Values		Types R, S in °F	Values		Types R, S in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2019.0	32767	7FFF	> 3276.6	32767	7FFF	> 2292.2	32767	7FFF	Overflow
2019.0 : 1769.1	20190 : 17691	4EDE : 451B	3276.6 : 3216.3	32766 : 32163	7FFE : 7DA3	2292.2 : 2042.3	22922 : 20423	598A : 4FC7	Overrange
1769.0 : -50.0	17690 : -500	451A : FE0C	3216.2 : -58.0	32162 : -580	7DA2 : FDBC	2042.2 : 223.2	20422 : 2232	4FC6 : 08B8	Nominal range
-50.1 : -170.0	-501 : -1700	FE0B : F95C	-58.1 : -274.0	-581 : -2740	FDBB : F54C	223.1 : 103.2	2231 : 1032	08B7 : 0408	Underrange
< -170.0	-32768	8000	< -274.0	-32768	8000	< 103.2	< 1032	8000	Underflow

Table 2-745 Thermocouple type T

Type T in °C	Values		Type T in °F	Values		Type T in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 540.0	32767	7FFF	> 1004.0	32767	7FFF	> 813.2	32767	7FFF	Overflow
540.0 : 400.1	5400 : 4001	1518 : 0FA1	1004.0 : 752.1	10040 : 7521	2738 : 1D61	813.2 : 673.3	8132 : 6733	1FC4 : 1AAD	Overrange
400.0 : -270.0	4000 : -2700	0FA0 : F574	752.0 : -454.0	7520 : -4540	1D60 : EE44	673.2 : 3.2	6732 : 32	1AAC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-746 Thermocouple type U

Type U in °C	Values		Type U in °F	Values		Type U in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 850.0	32767	7FFF	> 1562.0	32767	7FFF	> 1123.2	32767	7FFF	Overflow
850.0 : 600.1	8500 : 6001	2134 : 1771	1562.0 : 1112.1	15620 : 11121	2738.0 : 2B71	1123.2 : 873.3	11232 : 8733	2BE0 : 221D	Overrange
600.0 : -200.0	6000 : -2000	1770 : F830	1112.0 : -328.0	11120 : -3280	2B70 : F330	873.2 : 73.2	8732 : 732	221C : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow

Table 2-747 Thermocouple type TXK (GOST)

Type TXK in °C	Values		Type TXK in °F	Values		Type TXK in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1050.0	32767	7FFF	> 1922.0	32767	7FFF	>1323.2	32767	7FFF	Overflow
1050.0 : 800.1	10500 : 8001	2904 : 1F41	1922.0 : 1472.1	19220 : 14721	4B14 : 3981	1323.2 : 1073.3	13232 : 10733	33B0 : 29ED	Overrange
800.0 : 0.0 : -200.0	8000 : 0 : -2000	1F40 : 0000 : F830	1472.0 : 32.0 : -328.0	14720 : 320 : -3280	3980 : 0140 : F330	1073.2 : 273 : 73.2	10732 : 2730 : 732	29EC : 0AAA : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	<73.2	-32768	8000	Underflow

SIEMENS

SIMATIC

ET 200SP
Analog input module AI 8xRTD/TC 2-wire HF (6ES7134-6JF00-0CA1)

Equipment Manual

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Preface 1

1.1 Open Source Software

Open-source software is used in the firmware of the I/O modules. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information relating to this on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109739516).

See also

GNU_V5.3.1_201805 (https://support.industry.siemens.com/cs/ww/en/view/109757558)

1.2 Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

ET 200SP Documentation Guide

2

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

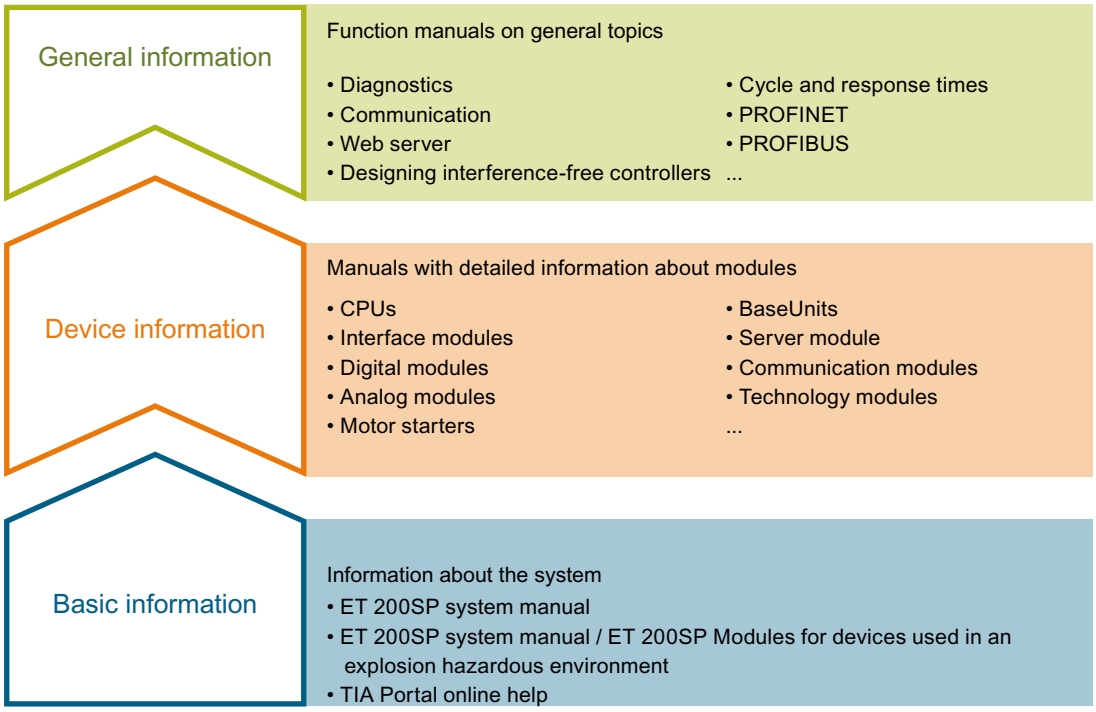

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

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You must register once to use the full functionality of "mySupport".

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"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/ae).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109767888).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant, incl. fail-safe inputs and outputs.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

3

3.1 Properties

Article number

6ES7134-6JF00-0CA1

View of the module

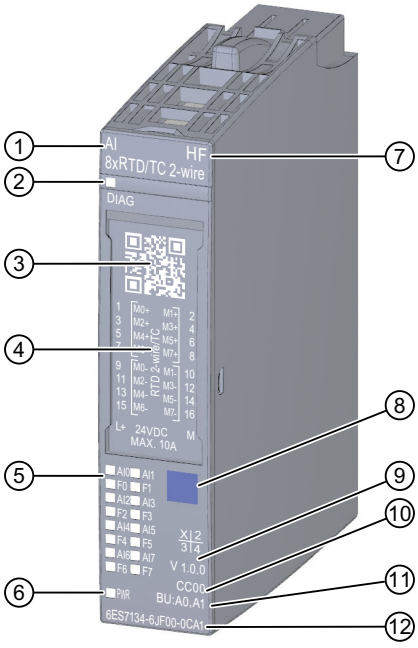

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status and channel fault	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-642 View of the module AI 8×RTD/TC 2-wire HF

Properties

The module has the following technical properties:

- Analog input module with 8 inputs
- 4 measurement types, can be set per channel
  - Thermal resistor (RTD)
  - Thermocouple (TC)
  - Resistor
  - Voltage
- Resolution: Up to 16 bits including sign
  - Can be extended to max. 3 decimal places via the scalable measuring range for the measuring types RTD and TC.
- Configurable diagnostics for each channel
- Hardware interrupt on limit violation can be set per channel (two high and two low limits per channel)
- Adjustable compensation
  - RTD: Compensation of the line resistance for a 2-wire connection
  - TC: external or internal temperature compensation
- interference frequency suppression, adjustable

The module supports the following functions:

Table 2-748 Version dependencies of the functions

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V2.0.0 or higher	V13 or higher	V5.5 SP3 or higher with HSP 0227 V3.0 or higher	X	X
Identification data I&M0 to I&M3	FS01	V2.0.0 or higher	V13 or higher	V5.5 SP3 or higher with HSP 0227 V3.0 or higher	X	X
Reconfiguration in RUN	FS01	V2.0.0 or higher	V13 or higher	V5.5 SP3 or higher with HSP 0227 V3.0 or higher	X	X
Value status (PROFINET IO only)	FS01	V2.0.0 or higher	V13 or higher	V5.5 SP3 or higher with HSP 0227 V3.0 or higher	X	-
Calibration in runtime	FS01	V2.0.0 or higher	V13 or higher	V5.5 SP3 or higher with HSP 0227 V3.0 or higher	X	X
Scalable measuring range	FS01	V2.0.0 or higher	V13 or higher	V5.5 SP3 or higher with HSP 0227 V2.0 or higher	X	X [1]

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter can only be parameterized later via data record 128.

Function	HW version	FW version	STEP 7		GSD file	
			TIA Portal	V5.x	PROFINET IO	PROFIBUS DP
Configurable conductor resistance	FS01	V2.0.0 or higher	V13 or higher	V5.5 SP3 or higher with HSP 0227 V3.0 or higher	X	X [1]
Switchable wire-break check	FS01	V2.0.0 or higher	V13 or higher	V5.5 SP3 or higher with HSP 0227 V3.0 or higher	X	X
Extended interference frequency suppression • 60 Hz (18.75 ms) • 50 Hz (22.5 ms) • 16.6 Hz (67.5 ms)	FS01	V2.1.0 or higher	V16 or higher with HSP 0357	As of V5.5 SP3 with HSP0227 as of V12.0	X	X [1]

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter can only be parameterized later via data record 128.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connection

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

4

4.1 Wiring and block diagram

This section includes the block diagram of the AI 8xRTD/TC 2-wire HF module with the terminal assignments.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

NOTE

- The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.
- When using floating sensors, bridge the m- connections and connect to ground / FE. This increases the immunity of the module.

  Bridging and connecting are not necessary for disabled and disconnected inputs.

NOTE

Compensation of the conductor resistance for RTD or resistance measurement

For compensation of the conductor resistance, a fixed value for the parasitic conductor resistance of the entire measuring loop can be entered via the corresponding parameter.

Wiring: 2-wire connection for thermocouples, resistance-type sensors or thermal resistors (RTD)

The following figure shows the block diagram and an example of the terminal assignment of the analog input module AI 8×RTD/TC 2-wire HF on the BaseUnit BU type A0/A1.

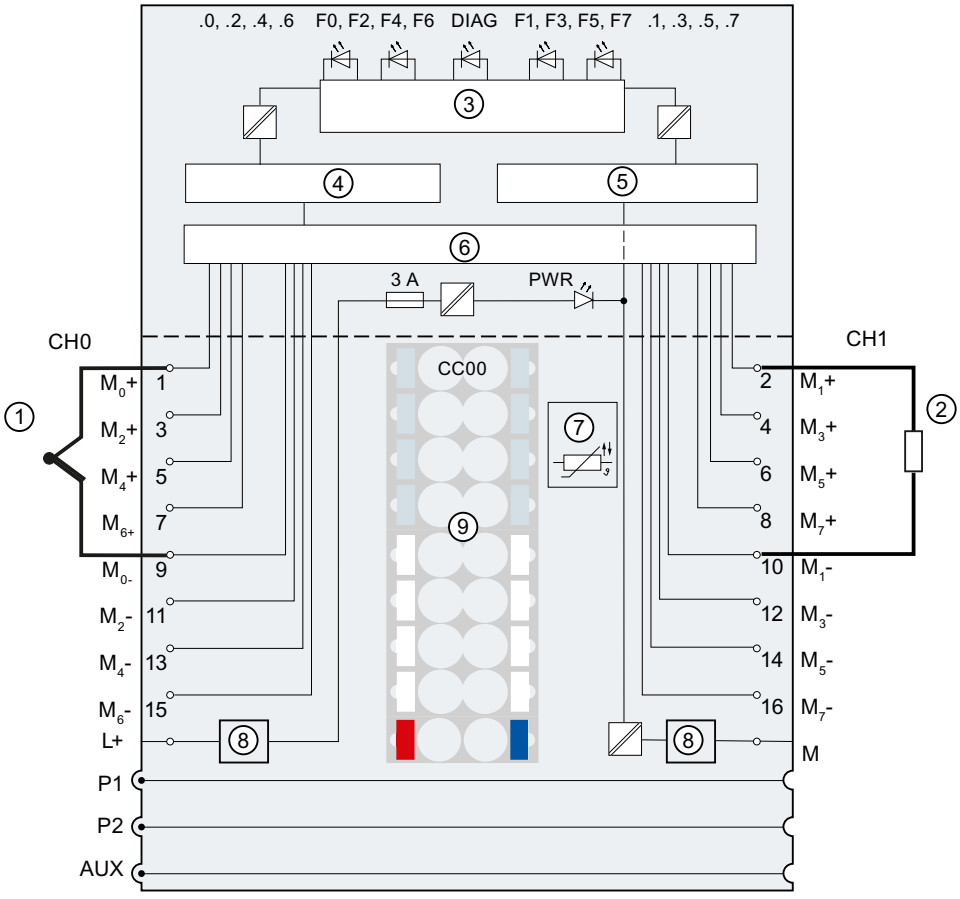

①	2-wire connection of thermocouples	M_n+ M_n-	Measuring line positive, channel n Measuring line negative, channel n
②	2-wire connection of resistance-type sensors or thermal resistors (RTD)	L+	24 V DC (infeed only with light-colored BaseUnit)
③	Backplane bus interface	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
④	Analog-to-digital converter (ADC)	DIAG	Diagnostics LED (green, red)
⑤	Constant current power supply	.0 to .7	Channel status LED (green)
⑥	Multiplexer	PWR	Power LED (green)
⑦	Temperature recording for BU type A1 only	F0 to F7	Channel fault LED (red)
⑧	Filter connection supply voltage (available with light-colored BaseUnit only)		
⑨	Color-coded label with color code CC00 (optional)		

Figure 2-643 Connection- and block diagram for connection of thermocouples, resistance-type sensors or thermal resistors (RTD)

Parameters/address space

5

5.1 Measurement types and measuring ranges

The following table describes the measuring range and the temperature coefficients you can configure for each measurement type:

Table 2-749 Measurement types and measuring ranges

Measurement type	Measuring range	Temperature coefficient
Deactivated	–	–
Voltage	±50 mV / ±80 mV / ±250 mV / ±1 V	
Resistor (2-wire connection)	150 Ω / 300 Ω / 600 Ω / 3 kΩ / 6 kΩ	–
	PTC	-
Thermal resistor RTD (2-wire connection)	Climatic / Standard Pt 100 Pt 200 Pt 500 Pt 1000	Pt 0.00385 / Pt 0.003916 / Pt 0.003902 / Pt 0.00392 / Pt 0.00385055
	Climatic / Standard Ni 100 Ni 120 Ni 200 Ni 500 Ni 1000	Ni 0.00618 / Ni 0.00672
	Climatic[1] / Standard[1] Ni 1000	Ni 0.005
Thermocouple (TC)	Type E, N, J, K, L, S, R, B, T, C, U, TXK (acc. to GOST)	-

[1] For sensors LG-Ni 1000 from Siemens Building Ltd (Landis & Stäfa).

Special features when using PTC resistors

PTCs are suitable for monitoring temperature and as thermal protection devices for complex drives or transformer windings.

- Choose "Resistor (2-wire)" and "PTC" in the parameter assignment.
- Connect the PTC to the 2-wire connection technology.
- Use the PTC resistors, type A (PTC thermistor) in accordance with DIN/VDE 0660, part 302.
- If "Underflow" diagnostics is enabled, a "Violation of low limit" diagnostics is generated for resistance values < 18 Ω, indicating a short-circuit.
- Sensor data for the PTC resistor:

Table 2-750 Using PTC resistors

Property	Technical specifications	Comment
Switching points	**Behavior with rising temperature**	
	< 550 Ω	**Normal range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "0" (in the PII)
	550 Ω to 1650 Ω	**Prewarning range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "1" (in the PII)
	> 1650 Ω	**Response range:** • SIMATIC S7: Bit 0 = "1", Bit 2 = "0" (in the PII)
	Behavior with falling temperature	
	> 750 Ω	**Response range:** • SIMATIC S7: Bit 0 = "1", Bit 2 = "0" (in the PII)
	750 Ω to 540 Ω	**Prewarning range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "1" (in the PII)
	< 540 Ω	**Normal range:** • SIMATIC S7: Bit 0 = "0", Bit 2 = "0" (in the PII)
	Reaction to short-circuit	
	< 18 Ω	• SIMATIC S7: Bit 7 (IB x+1) = "1", Bit 0 = "0" and Bit 2 = "0"
(RRT-5) °C (RRT+5) °C (RRT+15) °C Measuring voltage/ voltage at the PTC	Max. 550 Ω min. 1330 Ω min. 4000 Ω Max. 7.5 V[1]	TNF = Rated response temperature of the sensor (according to DIN/VDE 0660)

[1] Below 23 kΩ

Assignment in the process image input (PII) with SIMATIC S7

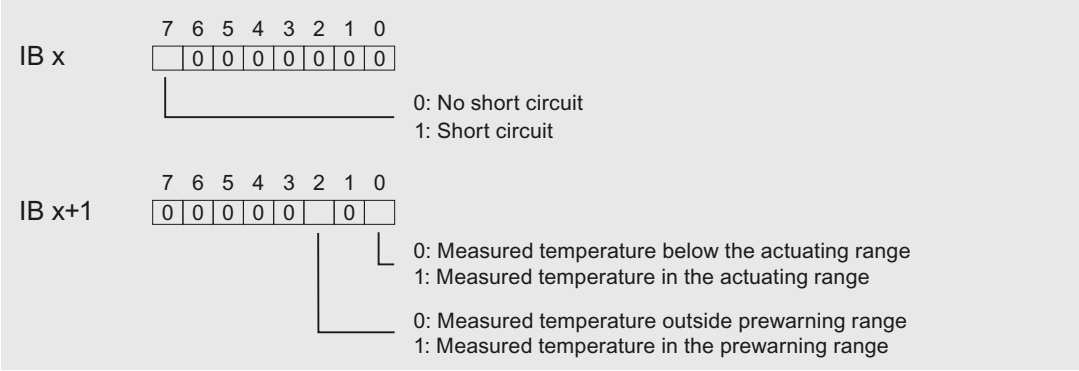

Figure 2-644 Assignment in the process image input (PII)

Notes on programming

- Bits 0+2 are relevant for evaluation in the process image input. You can monitor, for example, the temperature of a motor using bits 0+2.
- Bits 0+2 in the process image input cannot be saved. During parameter assignment, take into consideration that a motor, for example, starts up in a controlled manner (via an acknowledgment).
- Bits 0+2 can never be set at the same time; they are set one after the other.

NOTICE
No measurement is possible in the following cases: • When I/O modules are pulled out • When supply voltage to the I/O module fails • When there is a wire break or short-circuit in the measuring lines You should therefore always evaluate the diagnostic entries of AI 8×RTD/TC 2-wire HF for safety reasons.

Example

The diagram shows the temperature curve and the associated switching points.

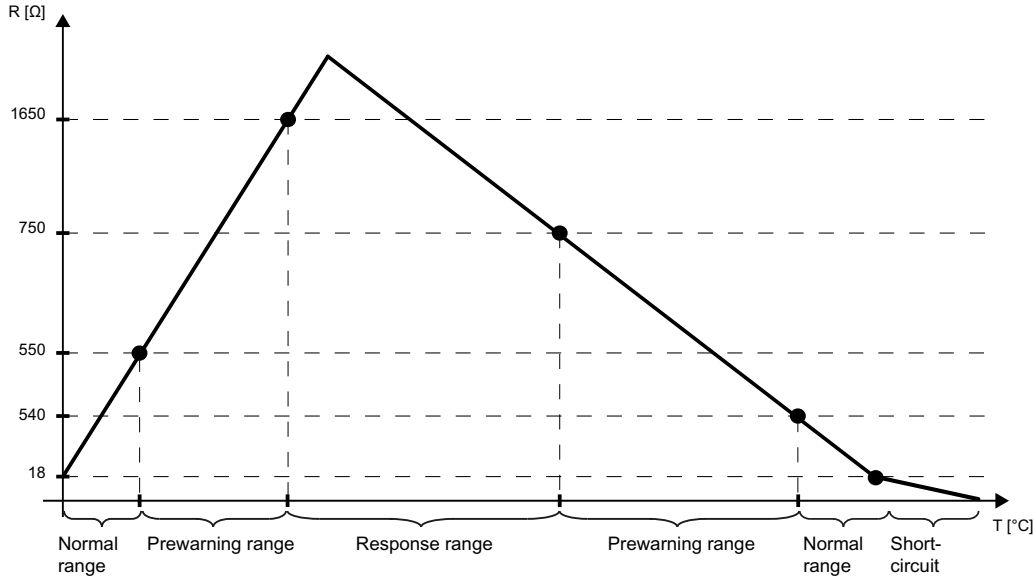

Figure 2-645 Temperature curve with prewarning range

See also

Technical specifications (Page 43)

5.2 Parameters

Parameters of the AI 8xRTD/TC 2-wire HF

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; see section Parameter assignment and structure of parameter data record (Page 54). The following parameter settings are possible:

Table 2-751 Configurable parameters and their defaults (GSD file)

Parameters	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: Missing supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel [1]
Diagnostics: Reference junction	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Channel	Module
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Channel	
Diagnostics: Wire break	• Disable • Enable	Disable	Yes	Channel	Channel
Type/range of measurement	• Deactivated	Thermal resistor (2-wire connection) Pt 100 standard range	Yes	Channel	Channel
	• Voltage ±50 mV • Voltage ±80 mV • Voltage ±250 mV • Voltage ±1 V				
	Resistor (2-wire connection) • 150 Ω • 300 Ω • 600 Ω • 3 kΩ • 6 kΩ				

1 Diagnostics: Missing supply voltage L+: Detection per module or alarm per channel

2 Interference frequency suppression: Interfering signals at 400 Hz are automatically included in the filtering at 50 Hz.

3 The settings in the "Interference frequency suppression" parameter have a direct effect on the conversion time of the channel. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

4 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 24 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter Data Record".

5 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", "No reference channel mode" is used for RTD and "Fixed reference temperature" is used for TC.

6 Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.

7 By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical Specifications).

Parameters	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Type/range of measurement	Resistor (2-wire connection) PTC	Thermal resistor (2-wire connection) Pt 100 standard range	Yes	Channel	Channel
Type/range of measurement	Thermal resistor (2-wire connection) • Pt 100 climatic range • Pt 200 climatic range • Pt 500 climatic range • Pt 1000 climatic range	Thermal resistor (2-wire connection) Pt 100 standard range	Yes	Channel	Channel
	Thermal resistor (2-wire connection) • Pt 100 standard range • Pt 200 standard range • Pt 500 standard range • Pt 1000 standard range				
Type/range of measurement	Thermal resistor (2-wire connection) • Ni 100 climatic range • Ni 120 climatic range • Ni 200 climatic range • Ni 500 climatic range • Ni 1000 climatic range	Thermal resistor (2-wire connection) Pt 100 standard range	Yes	Channel	Channel
	Thermal resistor (2-wire connection) • Ni 100 standard range • Ni 120 standard range • Ni 200 standard range • Ni 500 standard range • Ni 1000 standard range				
Type/range of measurement	Thermocouple • Type B (PtRh-PtRh) • Type N (NiCrSi-NiSi) • Type E (NiCr-CuNi) • Type R (PtRh-Pt)	Thermal resistor (2-wire connection) Pt 100 standard range	Yes	Channel	Channel

1 Diagnostics: Missing supply voltage L+: Detection per module or alarm per channel

2 Interference frequency suppression: Interfering signals at 400 Hz are automatically included in the filtering at 50 Hz.

3 The settings in the "Interference frequency suppression" parameter have a direct effect on the conversion time of the channel. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

4 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 24 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter Data Record".

5 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", "No reference channel mode" is used for RTD and "Fixed reference temperature" is used for TC.

6 Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.

7 By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical Specifications).

Parameters	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
	• Type S (PtRh-Pt) • Type J (Fe-CuNi) • Type L (Fe-CuNi) • Type T (Cu-CuNi) • Type K (NiCr-NiAl) • Type U (Cu-CuNi) • Type C (WRe-WRe) • Type TXK				
Temperature coefficient	• Pt 0.00385055 • Pt 0.003916 • Pt 0.003902 • Pt 0.00392 • Pt 0.00385 • Ni 0.00618 • Ni 0.00672 • LG-Ni 0.005	Pt 0.00385055	Yes	Channel	Channel
Temperature unit	• Degrees Celsius • Degrees Fahrenheit • Kelvin	Degrees Celsius	Yes	Channel	Module
Reference junction [5]	• No reference channel mode • Reference channel of the module • Internal reference junction [6] • Reference channel of group 0 to 3 • Fixed reference temperature	No reference channel mode	Yes	Channel	Channel
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel

1 Diagnostics: Missing supply voltage L+: Detection per module or alarm per channel

2 Interference frequency suppression: Interfering signals at 400 Hz are automatically included in the filtering at 50 Hz.

3 The settings in the "Interference frequency suppression" parameter have a direct effect on the conversion time of the channel. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

4 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 24 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter Data Record".

5 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", "No reference channel mode" is used for RTD and "Fixed reference temperature" is used for TC.

6 Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.

7 By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical Specifications).

Parameters	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Interference frequency suppression [3]	• 60 Hz (50 ms) • 50 Hz (60 ms) [2] • 16.6 Hz (180 ms) • 60 Hz (18.75 ms) [7] • 50 Hz (22.5 ms) [2 7] • 16.6 Hz (67.5 ms) [7]	50 Hz (60 ms)	Yes	Channel	Module
Scalable measuring range	• Disable • Enable	Disable	Yes	Channel	-
Measuring range resolution	• 2 decimal places • 3 decimal places	2 decimal places	Yes	Channel	-
Measuring range center	• Value within the nominal range of the measuring range	0	Yes	Channel	-
Conductor resistance	• 0 to 50000 mΩ	0	Yes	Channel	-
Hardware interrupt high limit 1 [4]	• Disable • Enable	Disable	Yes	Channel	-
High limit 1 [4]	• Value	8500	Yes	Channel	-
Hardware interrupt low limit 1 [4]	• Disable • Enable	Disable	Yes	Channel	-
Low limit 1 [4]	• Value	-2000	Yes	Channel	-
Hardware interrupt high limit 2 [4]	• Disable • Enable	Disable	Yes	Channel	-
High limit 2 [4]	• Value	8500	Yes	Channel	-

1 Diagnostics: Missing supply voltage L+: Detection per module or alarm per channel

2 Interference frequency suppression: Interfering signals at 400 Hz are automatically included in the filtering at 50 Hz.

3 The settings in the "Interference frequency suppression" parameter have a direct effect on the conversion time of the channel. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

4 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 24 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter Data Record".

5 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", "No reference channel mode" is used for RTD and "Fixed reference temperature" is used for TC.

6 Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.

7 By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical Specifications).

Parameters	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Hardware interrupt low limit 2 [4]	• Disable • Enable	Disable	Yes	Channel	-
Low limit 2 [4]	• Value	-2000	Yes	Channel	-
Potential group	• Use potential group of the left module (dark-colored BaseUnit) • Enable new potential group (light-colored BaseUnit)	Use potential group of the left module (dark-colored BaseUnit)	No	Module	Module

1 Diagnostics: Missing supply voltage L+: Detection per module or alarm per channel

2 Interference frequency suppression: Interfering signals at 400 Hz are automatically included in the filtering at 50 Hz.

3 The settings in the "Interference frequency suppression" parameter have a direct effect on the conversion time of the channel. The analog value is therefore also affected by additionally set filtering via the "Smoothing" parameter.

4 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. The parameter length of the I/O module is 24 bytes with PROFIBUS GSD configuration. If necessary, however, you can set these parameters via data record 128, see appendix "Parameter Data Record".

5 Only for configuration with PROFIBUS GSD file: The set reference junction is used with the additional parameter "Kx Reference junction activated" in the case of "Enable". In the case of "Disable", "No reference channel mode" is used for RTD and "Fixed reference temperature" is used for TC.

6 Thermocouple types B and C are not suitable for reference junction temperatures below 0 °C on account of their defined characteristic curve as of 0 °C.

7 By selecting this interference frequency suppression with shorter integration time, the attenuation of the interference frequency that can be achieved is reduced (see Technical Specifications).

NOTE

Unused channels

"Deactivate" unused inputs in the parameter assignment to shorten the cycle time of the module.

A deactivated input always returns the value $7FFF_H$.

NOTE

For user calibration with a calibration device, deactivate the "Wire-break check" parameter or function.

5.3 Explanation of parameters

Diagnostics: Missing supply voltage L+

Enabling of the diagnostics for missing or insufficient supply voltage L+.

Diagnostics: Reference junction

Enabling of the reference junction diagnostics if the reference temperature of the reference junction needs to be determined for the TC channel being operated.

Reference junction using the PROFINET GSD file

A BaseUnit with an internal temperature sensor (BU..T), the reference channel of group 0, 1, 2, 3, or channel 0 of the I/O module, if it has been configured as "Thermal resistor Pt100 climatic range Degrees Celsius", can be used as reference junction for the TC measurement.

A possible parameter assignment is represented below:

Table 2-752 RTD channel

Setting	Description
No reference channel mode	The temperature value at channel 0 can be used as a reference value for the entire module.
Reference channel of group 0, 1, 2, 3	The channel acts as a **transmitter** for the reference junction temperature of a group. The distribution is performed via the interface module. The RTD channel must be parameterized as follows: • Measurement type/measuring range "Thermal resistance Pt100 climate range" • Temperature unit "Degrees Celsius"

Table 2-753 TC channel

Setting	Description
Reference channel of the module	The corresponding TC channel uses channel 0 of the same module as the reference junction temperature. This channel must be parameterized as follows, otherwise the reference junction diagnostics is triggered: • Measurement type/measuring range "Thermal resistance Pt100 climate range" • Temperature unit "Degrees Celsius" • Reference junction "No reference channel mode"
Internal reference junction	The reference junction temperature is read by an internal temperature sensor on the BaseUnit. Diagnostics: Reference junction is triggered if there is an incorrect BaseUnit type.

Setting	Description
Reference channel of group 0, 1, 2, 3	The channel acts as a **receiver** for the reference junction temperature of a group. The RTD channel must be parameterized as **sender** as follows: • Measurement type/measuring range "Thermal resistance Pt100 climate range" • Temperature unit "Degrees Celsius" • Reference junction: Must be the same reference channel of the group
Fixed reference temperature	The reference temperature of the thermocouple is set to 0 °C. As a result, no temperature compensation is performed.

NOTE

Shared Device and "Reference channel of group 0, 1, 2, 3"

If the transmitter and receiver for the reference junction temperature of a group are assigned to different IO controllers, then both IO controllers must be performing data exchange with the IO device to ensure error-free operation of the temperature compensation.

Reference junction using the PROFIBUS GSD file

A BaseUnit with an internal temperature sensor (BU..T), the reference channel of group 0, 1, 2, 3, or channel 0 of the I/O module, if it has been configured as "Thermal resistor Pt100 climatic range Degrees Celsius", can be used as reference junction for the TC measurement.

The set temperature unit (e.g. Degrees Celsius) is valid for the entire module with temperature compensation "Reference channel of the module" and "Reference channel of group 0, 1, 2, 3".

Table 2-754 **RTD channel**

Setting	Description
No reference channel mode	The temperature value at channel 0 can be used as a reference value for the entire module.
Reference channel of group 0, 1, 2, 3	The channel acts as a **transmitter** for the reference junction temperature of a group. The distribution is performed via the interface module. The RTD channel must be parameterized as follows: • Measurement type/measuring range "Thermal resistance Pt100 climate range" • Temperature unit "Degrees Celsius"

Setting	Description
Channel x Reference junction activated	• Disable: Channel x is configured with the setting "No reference channel mode". • Enable: Channel x is configured with the setting selected for the "Reference junction" parameter.

Table 2-755 **TC channel**

Setting	Description
Reference channel of the module	The corresponding TC channel uses channel 0 of the same module as the reference junction temperature. This channel must be parameterized as follows, otherwise the reference junction diagnostics is triggered: • Measurement type/measuring range "Thermal resistance Pt100 climate range" • Temperature unit "Degrees Celsius" • Reference junction "No reference channel mode"
Internal reference junction	The reference junction temperature is read by an internal temperature sensor on the BaseUnit. Diagnostics: Reference junction is triggered if there is an incorrect BaseUnit type.
Reference channel of group 0, 1, 2, 3	The channel acts as a **receiver** for the reference junction temperature of the group. The RTD channel must be parameterized as **sender** as follows: • Measurement type/measuring range "Thermal resistance Pt100 climate range" • Temperature unit "Degrees Celsius" • Reference junction: Must be the same reference channel of the group
Fixed reference temperature	The reference temperature of the thermocouple is set to 0 °C. As a result, no temperature compensation is performed.

Setting	Description
Channel x Reference junction activated	• Disable: Channel x is configured with the setting "Fixed reference temperature". • Enable: Channel x is configured with the setting selected for the "Reference junction" parameter.

Diagnostics: Overflow

Enabling of the diagnostics when the measured value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics if the measured value falls below the underrange.

Diagnostics: Wire break

Enabling of the diagnostics if the module has no current flow or the current is insufficient for measurement at the correspondingly assigned input.

Type/range of measurement

See the section Measurement types and measuring ranges (Page 15).

Temperature coefficient

The temperature coefficient depends on the chemical composition of the material. In Europe, only one value is used per sensor type (default value).

The temperature coefficient (α value) indicates by how much the resistance of a specific material changes relatively if the temperature increases by 1 °C.

The other values facilitate a sensor-specific setting of the temperature coefficient and enhance accuracy.

Temperature unit

Selection between Degrees Celsius, Fahrenheit and Kelvin as the temperature unit for the selected measuring range.

Smoothing

The individual measured values are smoothed using filtering. The smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This specification is valid for all signal changes at the analog input.

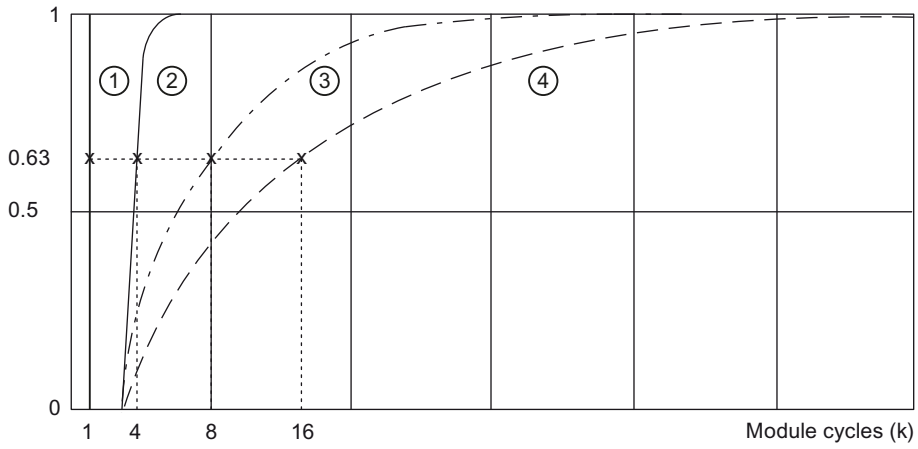

① No smoothing (k = 1)

② Weak (k = 4)

③ Medium (k = 8)

④ Strong (k = 16)

Figure 2-646 Smoothing for AI 8×RTD/TC 2-wire HF

Interference frequency suppression

Suppresses the interferences affecting analog input modules that are caused by the frequency of the AC voltage network used.

The frequency of the AC voltage network is likely to have a negative effect on measured values particularly with measurement in the low voltage range and on thermocouples. With this parameter, the user specifies the line frequency that is predominant in the plant.

Scalable measuring range

See the Scalable measuring range (Page 29) section.

Measuring range resolution

See the Scalable measuring range (Page 29) section.

Measuring range center

See the Scalable measuring range (Page 29) section.

Conductor resistance

Parameters for the measurement types resistor and thermal resistor.

Used to compensate for the conductor resistance without having to interfere with the sensor wiring.

If the "Conductor resistor" parameter is configured higher than a value 0 mΩ, the module then automatically uses the factory calibration data.

Hardware interrupt enable

Enabling of a hardware interrupt if the high limit 1/2 or the low limit 1/2 is violated.

Low limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

High limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

Potential group

Specify whether a light-colored BaseUnit with incoming supply voltage or a dark-colored BaseUnit is located in this slot (see ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual).

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2 and AUX to the left neighbor.

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with a dark-colored BaseUnit, which is followed by a light-colored BaseUnit or server module in the station configuration.

5.4 Scalable measuring range

Function

The scalable measuring range is a limited section of a measuring range supported by the module.

It allows you to increase the resolution for a configurable section.

- The function is enabled with the "Scalable measuring range" parameter.
- The "Measuring range resolution" parameter determines the resolution to 2 or 3 decimal places for a configurable section of the measuring range.
- The "Measuring range center" parameter determines the temperature over which the scalable measuring range is symmetrically spanned.

NOTE

The scalable measuring range is available for the temperature measuring ranges of thermal resistors (RTD) standard and thermocouples. The measuring ranges for voltage, resistor and thermal resistor climatic are not supported.

The scalable measuring range is valid for the following ranges:

- Nominal range
- Underrange
- Overrange

Value ranges

Table 2-756 Value ranges

Scalable measuring range	Measuring range resolution		Values hex.
	2 decimal places	3 decimal places	
Overflow	> 325.11	> 32.511	$7FFF_H$
High limit	325.11	32.511	$7EFF_H$
Measuring range center	0	0	0_H
Low limit	-325.12	-32.512	8100_H
Underflow	<-325.12	<-32.512	8000_H

To obtain an absolute temperature, the measuring range center in the application program (as offset) must be calculated with the value of the user data of the scalable measuring range.

The measuring range center is always output in the user data as the value "0". The user data are correspondingly mapped to the bipolar input ranges in S7 format. Underflow / overflow is also formed in accordance with the limits of S7.

Rules

- The measuring range center must be within the nominal range of the underlying measuring range. It is specified in integers.
- The scalable measuring range is spanned symmetrically over the measuring range center. Depending on the resolution, various value ranges result (①, ②).
- The scalable measuring range is limited by underflow and overflow of the underlying measuring range:
  - It is clipped at the underflow when it falls below the limit.
  - It is clipped at the overflow when it exceeds the limit (③).

Example

The following example illustrates the effect of scalable measuring ranges:

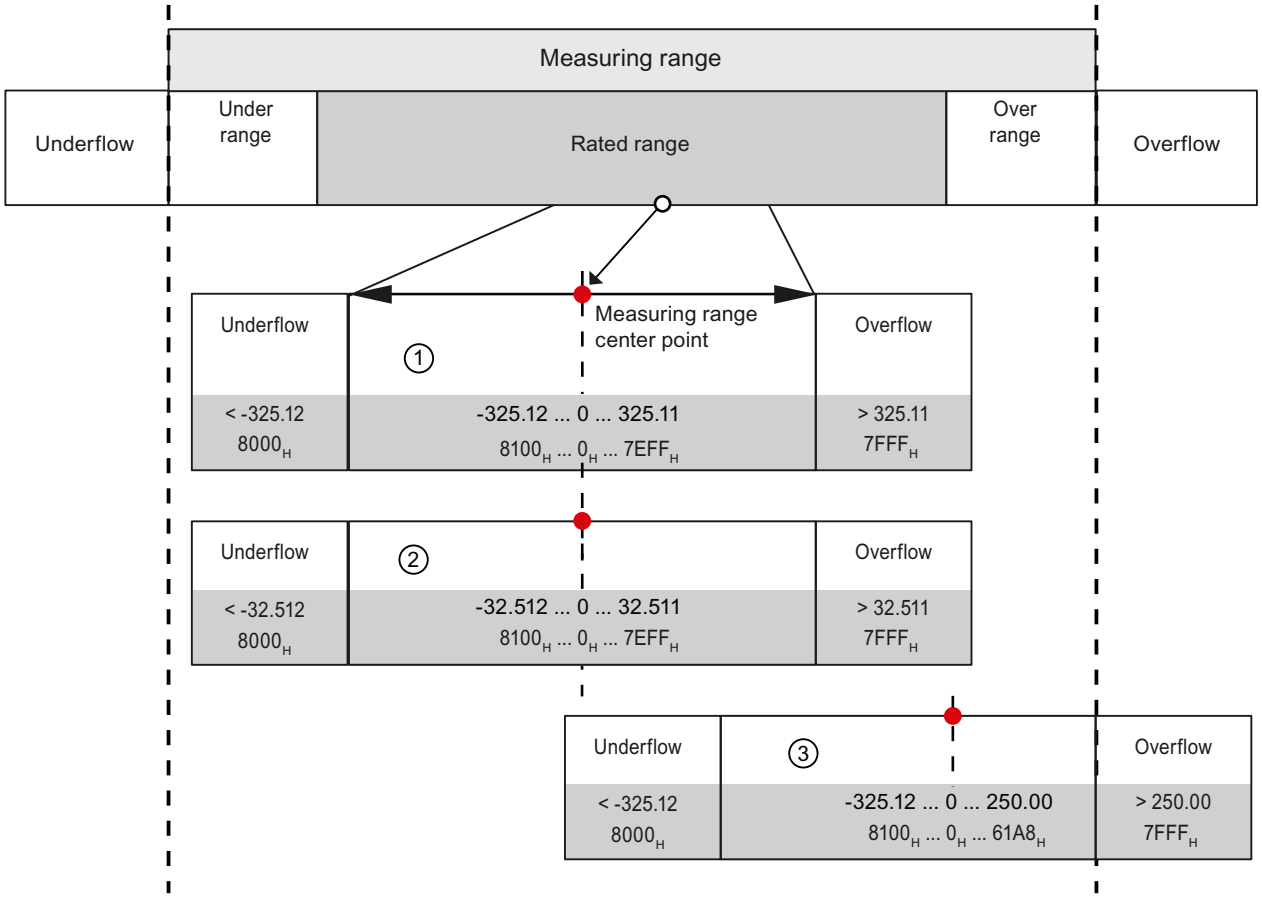

① Scalable measuring range with 2 decimal places in hexadecimal S7 format

② Scalable measuring range with 3 decimal places in hexadecimal S7 format

③ Scalable measuring range which is cut off at the overflow of the underlying measuring range (clipping)

Figure 2-647 Examples of scalable measuring ranges

5.4.1 Configuration

Requirement

You must select a valid temperature measuring range for configuration.

Configuration

The function is activated using the "Scalable measuring range" parameter.
The following figure shows an example of a configuration in STEP 7:

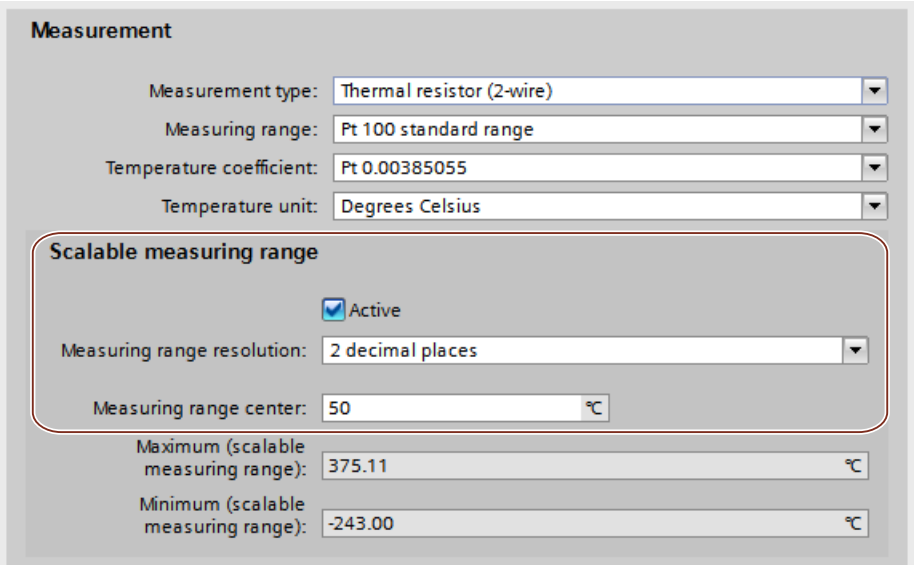

Figure 2-648 Configuration for the scalable measuring range

Reference

You will find more information on the configuration in the STEP 7 online help.

5.4.2 Evaluating data record 235

Evaluation in the user program

In the user program, you can evaluate the status and the limits of the scalable measuring range with data record 235, which may result by reaching underflow/overflow.

Structure of data record 235

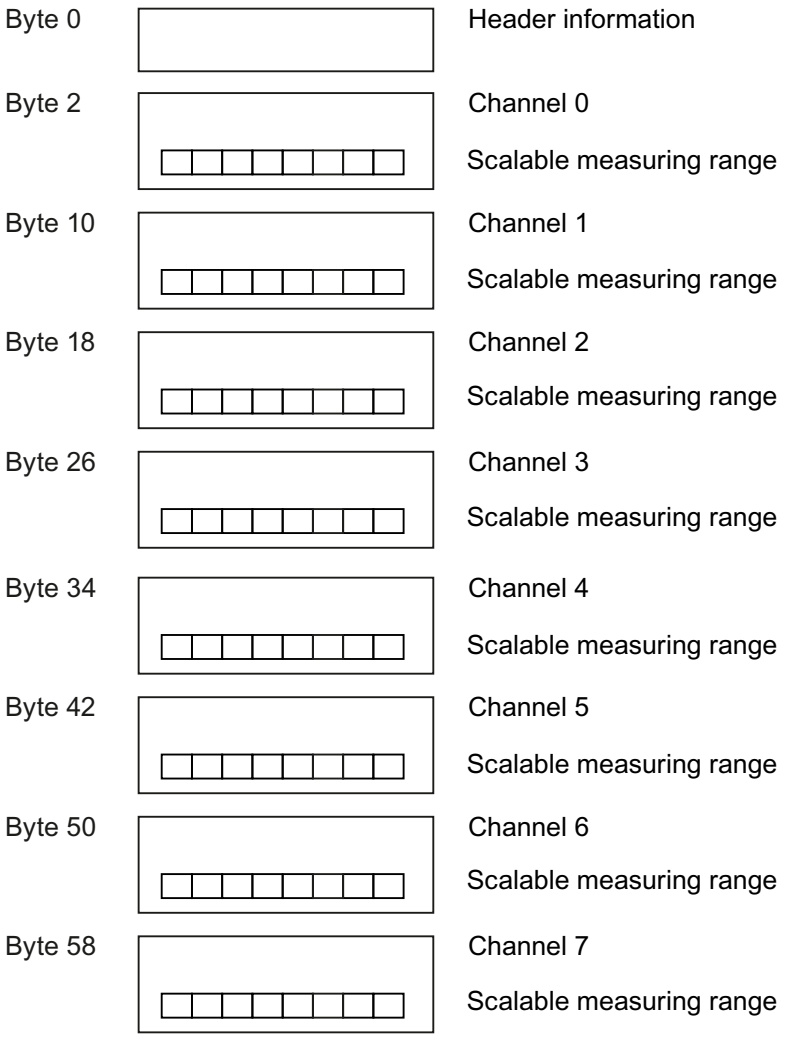

Figure 2-649 Structure of data record 235

Header information

The figure below shows the structure of the header information.

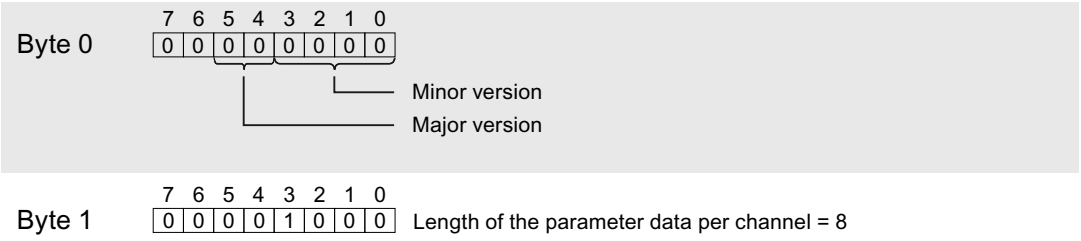

Figure 2-650 Header information of data record 235

Parameters

The figure below shows the structure of the parameter.

If the corresponding bit is set to "1", the parameter is activated.

* x = 2 + (channel number x 8)

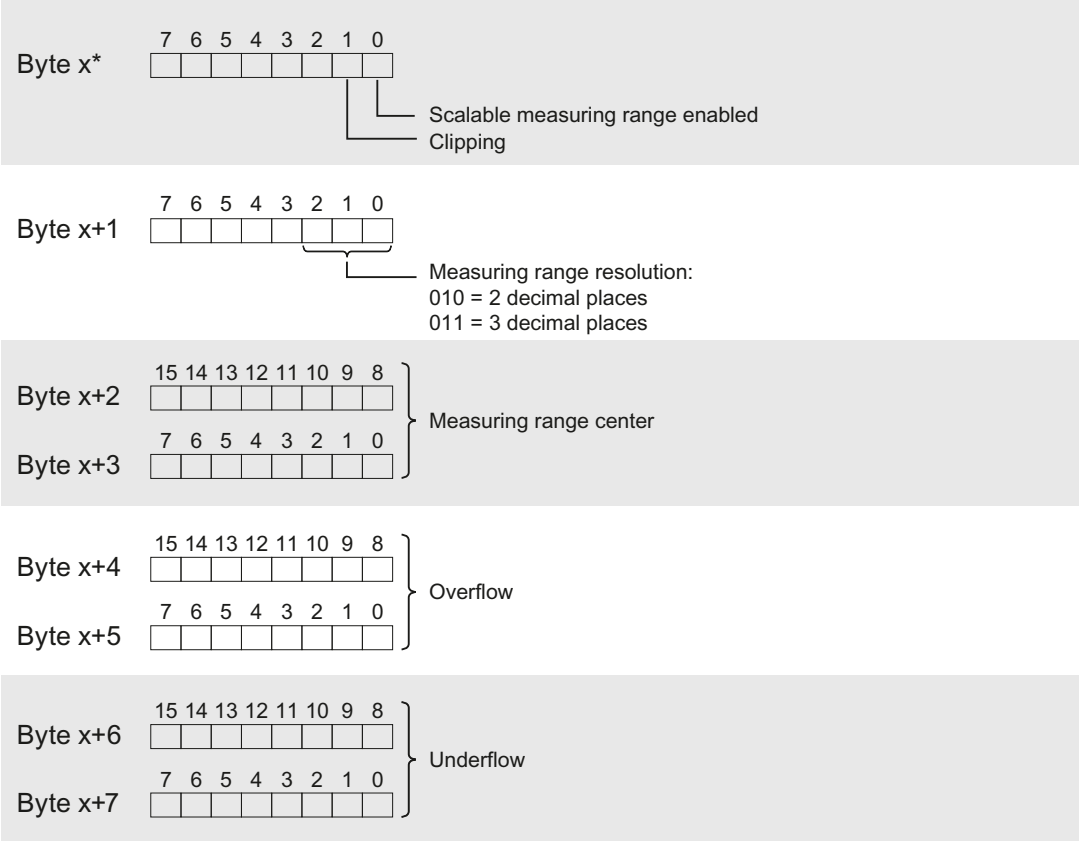

Figure 2-651 Structure of data record 235 - channel parameter byte x to x+7

Description of the parameters

Table 2-757 Description **of the parameters from data record 235**

Parameter	Description
Scalable measuring range enabled	1 = Function is active for this channel.
Clipping	1 = Scalable measuring range cut off at the overflow / underflow of the underlying measuring range (see Figure).
Resolution	2 or 3 decimal places
Measuring range center	Temperature in whole °C / °F / K ("working point" for the scaling)
Overflow/underflow	Limits of the scalable measuring range

Example

The following example shows the values for a thermal resistor Pt 100 Standard, °C:

Table 2-758 Example of a thermal resistor Pt 100 Standard

Hex. value	Dec. value	Evaluation of data record 235
00_H	0	V0.0
08_H	8	8 bytes
03_H	3	Scalable measuring range active and clipped (clipping)
02_H	2	Resolution: 2 decimal places
$02EE_H$	750	Measuring range center: 750 °C
$61A8_H$	25000	Overflow (Maximum): 250**.00** + 750 = 1000.00 °C Scalable measuring range is clipped at the overflow.
8100_H	-32512	Underflow (Minimum): -325**.12** + 750 = 424.88 °C

See also

Scalable measuring range (Page 29)

5.5 Address space

Address space of the analog input module AI 8×RTD/TC 2-wire HF

The figure below shows the assignment of the address space for AI 8×RTD/TC 2-/3-/4-wire HF.

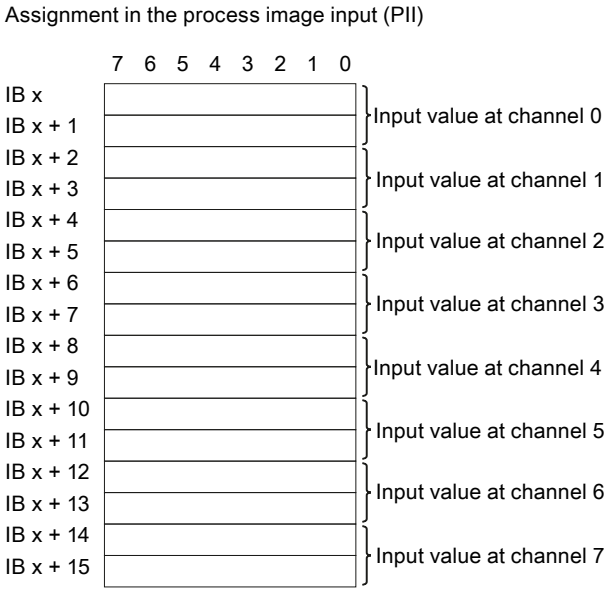

Figure 2-652 Address space AI 8×RTD/TC 2-wire HF without value status

Address space of the analog input module AI 8×RTD/TC 2-wire HF, QI

The figure below shows the assignment of the address space for AI 8×RTD/TC 2-/3-/4-wire HF, QI. The addresses for the value status are only available if the value status is enabled.

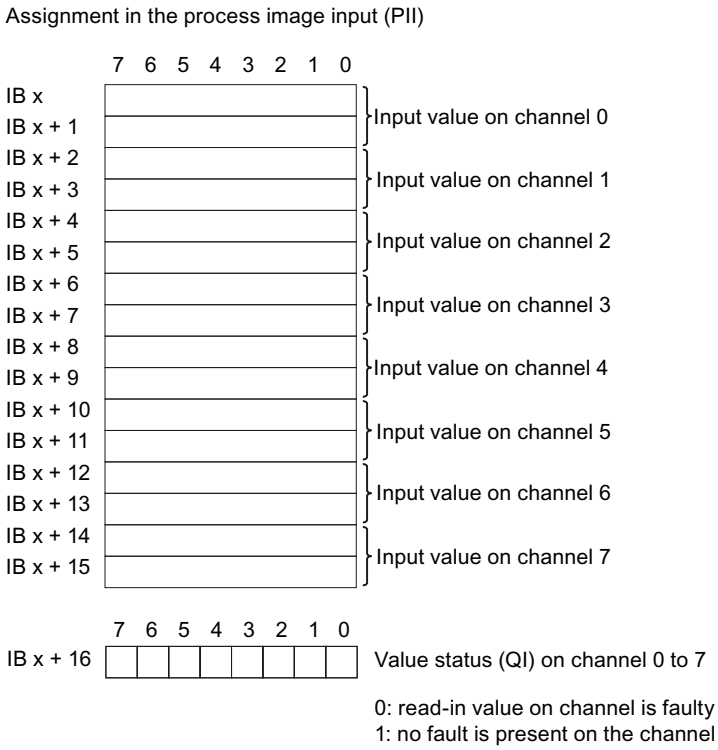

Figure 2-653 Address space of the AI 8×RTD/TC 2-wire HF with value status

Configuration options of the AI 8xRTD/TC 2-wire HF

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status (as of firmware version V1.1.0)

An additional byte is occupied in the input address space if you enable the value status for the analog module. Bits 0 to 7 in this byte are assigned to a channel and provide information on the validity of the analog value.

Bit = 1: No fault is present on the channel.

Bit = 0: The channel is disabled or the wiring or the value created on the channel, etc. is incorrect.

Interrupts/diagnostics alarms

6

6.1 Status and error displays

LED displays

The figure below shows the LED displays of the AI 8xRTD/TC 2-wire HF:

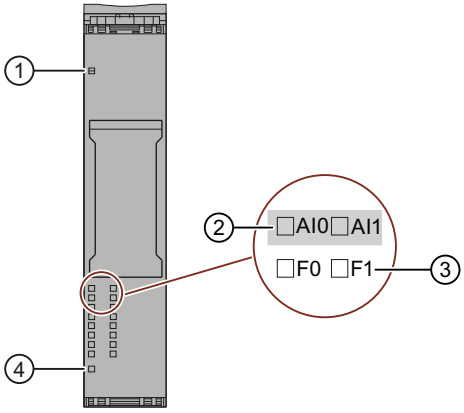

① DIAG (green/red)

② Channel status (green)

③ Channel error (red)

④ PWR (green)

Figure 2-654 LED display

Meaning of the LED displays

The following tables contain the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostics alarms (Page 41).

LED DIAG

Table 2-759 LED DIAG fault display

LED DIAG	Meaning
□ Off	Backplane bus supply of the system is interrupted or switched off
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status/channel error LED

Table 2-760 Status and error display of the LED channel status / channel error

LEDs		Meaning
Channel status	Channel error	
□ Off	□ Off	Channel deactivated or no load voltage L+
■ On	□ Off	Channel activated and no channel diagnostics
□ Off	■ On	Channel activated and channel diagnostics
■ On	■ On	Not permitted (error)

PWR LED

Table 2-761 Status display of the PWR LED

PWR LED	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ present

6.2 Interrupts

Evaluating hardware interrupts with IO controller

The module generates a hardware interrupt at the following events:

- Violation of low limit 1
- Violation of high limit 1
- Violation of low limit 2
- Violation of high limit 2

You can obtain detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

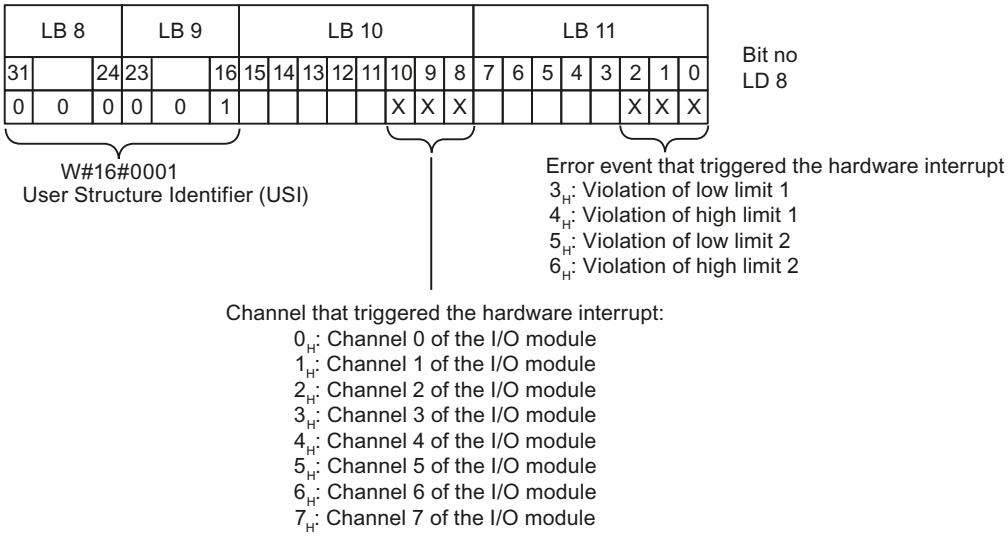

Figure 2-655 OB start information

Structure of the additional interrupt information

Table 2-762 Structure of the additional interrupt information

Data block name		Content	Comment	Bytes
USI (User Structure Identifier)		W#16#0001	additional interrupt information for hardware interrupts of the I/O module	2
Channel that triggered the hardware interrupt.				
	Channel	B#16#00 to B#16#07	Channel 0 to 7 of the I/O module	1
Event that triggered the hardware interrupt.				
	Event	B#16#03	Violation of low limit 1	1

Data block name		Content	Comment	Bytes
	Event	B#16#04	Violation of high limit 1	1
		B#16#05	Violation of low limit 2	
		B#16#06	Violation of high limit 2	

Diagnostic error interrupt

The module generates a diagnostic error interrupt at the following events:

- Channel temporarily unavailable
- Hardware interrupt lost
- Reference channel error
- Error
- Violation of low limit
- Violation of high limit
- Wire break
- Supply voltage missing
- Parameter assignment error

6.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-763 Diagnostics alarms, their meaning and remedies

Diagnostics alarms	Error code	Meaning	Remedy
Wire break	6_H	Resistance of sensor circuit too high	Use a different sensor type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and sensor	Connect the cable
		Channel not connected (open)	• Deactivate diagnostics • Connect or deactivate the channel
Violation of high limit[1]	7_H	Value lies above the overrange.	Correct module/sensor interplay
		Wire break[2]	See Wire break
Violation of low limit[1]	8_H	Value lies below the underrange.	Correct module/sensor interplay

1 The alarm refers to the diagnostics and depends on the configured measuring range.

2 For resistor and thermal resistor measuring ranges with deactivated diagnostics for "wire break", this is reported by the "Violation of high limit" diagnostic.

3 Shared Device and diagnostics "Reference temperature": If the sender and receiver of the reference junction temperature of a group are assigned to different IO controllers, you may need to download both configurations again in the case of diagnostics. First download the configuration containing the receiver.

Diagnostics alarms	Error code	Meaning	Remedy
Error	9_H	Internal module error has occurred (diagnostics alarm on channel 0 applies to the entire module).	Replace module
Parameter assignment error	10_H	The module cannot evaluate parameters for the channel. Incorrect parameter assignment.	• Correct the parameter assignment (diagnostics wire break set only with the permitted measuring ranges).
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check the supply voltage L+ at the BaseUnit • Check BaseUnit type
Reference channel error (reference junction)	15_H	Reference temperature of the reference junction for the TC channel being operated with compensation is invalid.	• Check BaseUnit type • Select correct reference junction through parameter assignment[3] • Check whether the reference junction (reference channel of the group 0, 1, 2, 3) is only assigned once as the sender in the entire setup.
Hardware interrupt lost	16_H	At least one hardware interrupt could not be reported because there were too many pending hardware interrupts.	Correct the program or the process
Channel temporarily unavailable	$1F_H$	Firmware update in progress or update has been canceled. The module does not read any process values in this state.	• Wait for firmware update. • Restart the firmware update.
		The channel is currently being calibrated.	• Complete calibration.

1 The alarm refers to the diagnostics and depends on the configured measuring range.

2 For resistor and thermal resistor measuring ranges with deactivated diagnostics for "wire break", this is reported by the "Violation of high limit" diagnostic.

3 Shared Device and diagnostics "Reference temperature": If the sender and receiver of the reference junction temperature of a group are assigned to different IO controllers, you may need to download both configurations again in the case of diagnostics. First download the configuration containing the receiver.

NOTE

Diagnostic messages in the measured value of analog input modules

Each analog input module supplies the measured value $7FFF_H$ or 8000_H depending on the parameter assignment when an error is detected.

Technical specifications 7

Technical specifications of the AI 8xRTD/TC 2-wire HF

The following table shows the technical specifications as of 09/2019. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7134-6JF00-0CA1/td?dl=en).

Article number	6ES7134-6JF00-0CA1
General information	
Product type designation	AI 8xRTD/TC 2-wire HF
HW functional status	From FS05
Firmware version	V2.1
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Measuring range scalable	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V16, V17 / V18
• STEP 7 configurable/integrated from version	V5.5 SP3 / V5.5 SP4
• PCS 7 configurable/integrated from version	V8.1 SP1
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.35
Operating mode	
• Oversampling	No
• MSI	No
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	Yes
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes

Article number	6ES7134-6JF00-0CA1
Input current	
Current consumption, max.	35 mA
Address area	
Address space per module	
• Address space per module, max.	16 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type A0, A1
Analog inputs	
Number of analog inputs	8
permissible input voltage for voltage input (destruction limit), max.	30 V
Constant measurement current for resistance-type transmitter, typ.	2 mA
Cycle time (all channels), min.	Sum of the basic conversion times and additional processing times (depending on the parameterization of the active channels)
Technical unit for temperature measurement adjustable	Yes; °C/°F/K
Input ranges (rated values), voltages	
• -1 V to +1 V	Yes; 16 bit incl. sign
– Input resistance (-1 V to +1 V)	1 MΩ
• -250 mV to +250 mV	Yes; 16 bit incl. sign
– Input resistance (-250 mV to +250 mV)	1 MΩ
• -50 mV to +50 mV	Yes; 16 bit incl. sign
– Input resistance (-50 mV to +50 mV)	1 MΩ
• -80 mV to +80 mV	Yes; 16 bit incl. sign
– Input resistance (-80 mV to +80 mV)	1 MΩ
Input ranges (rated values), thermocouples	
• Type B	Yes; 16 bit incl. sign
– Input resistance (Type B)	1 MΩ
• Type C	Yes; 16 bit incl. sign
– Input resistance (Type C)	1 MΩ
• Type E	Yes; 16 bit incl. sign
– Input resistance (Type E)	1 MΩ
• Type J	Yes; 16 bit incl. sign
– Input resistance (type J)	1 MΩ
• Type K	Yes; 16 bit incl. sign
– Input resistance (Type K)	1 MΩ

Article number	6ES7134-6JF00-0CA1
• Type L	Yes; 16 bit incl. sign
– Input resistance (Type L)	1 MΩ
• Type N	Yes; 16 bit incl. sign
– Input resistance (Type N)	1 MΩ
• Type R	Yes; 16 bit incl. sign
– Input resistance (Type R)	1 MΩ
• Type S	Yes; 16 bit incl. sign
– Input resistance (Type S)	1 MΩ
• Type T	Yes; 16 bit incl. sign
– Input resistance (Type T)	1 MΩ
• Type U	Yes; 16 bit incl. sign
– Input resistance (Type U)	1 MΩ
• Type TXK/TXK(L) to GOST	Yes; 16 bit incl. sign
– Input resistance (Type TXK/TXK(L) to GOST)	1 MΩ
Input ranges (rated values), resistance thermometer	
• Ni 100	Yes; 16 bit incl. sign
– Input resistance (Ni 100)	1 MΩ
• Ni 1000	Yes; 16 bit incl. sign
– Input resistance (Ni 1000)	1 MΩ
• LG-Ni 1000	Yes; 16 bit incl. sign
– Input resistance (LG-Ni 1000)	1 MΩ
• Ni 120	Yes; 16 bit incl. sign
– Input resistance (Ni 120)	1 MΩ
• Ni 200	Yes; 16 bit incl. sign
– Input resistance (Ni 200)	1 MΩ
• Ni 500	Yes; 16 bit incl. sign
– Input resistance (Ni 500)	1 MΩ
• Pt 100	Yes; 16 bit incl. sign
– Input resistance (Pt 100)	1 MΩ
• Pt 1000	Yes; 16 bit incl. sign
– Input resistance (Pt 1000)	1 MΩ
• Pt 200	Yes; 16 bit incl. sign
– Input resistance (Pt 200)	1 MΩ
• Pt 500	Yes; 16 bit incl. sign
– Input resistance (Pt 500)	1 MΩ

Article number	6ES7134-6JF00-0CA1
Input ranges (rated values), resistors	
• 0 to 150 ohms	Yes; 15 bit
– Input resistance (0 to 150 ohms)	1 MΩ
• 0 to 300 ohms	Yes; 15 bit
– Input resistance (0 to 300 ohms)	1 MΩ
• 0 to 600 ohms	Yes; 15 bit
– Input resistance (0 to 600 ohms)	1 MΩ
• 0 to 3000 ohms	Yes; 15 bit
– Input resistance (0 to 3000 ohms)	1 MΩ
• 0 to 6000 ohms	Yes; 15 bit
– Input resistance (0 to 6000 ohms)	1 MΩ
• PTC	Yes; 15 bit
– Input resistance (PTC)	1 MΩ
Thermocouple (TC)	
Temperature compensation	
– parameterizable	Yes
– Reference channel of the module	Yes
– internal comparison point	Yes; with BaseUnit type A1
– Reference channel of the group	Yes
– Number of reference channel groups	4; Group 0 to 3
– fixed reference temperature	Yes
Cable length	
• shielded, max.	200 m; 50 m with thermocouples
Analog value generation for the inputs	
Measurement principle	integrating (Sigma-Delta)
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Basic conversion time, including integration time (ms)	
– additional processing time for wire-break check	2 ms; In the ranges resistance thermometers, resistors and thermocouples
• Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz
• Conversion time (per channel)	180 / 60 / 50 / (67.5 / 22.5 / 18.75) ms
Smoothing of measured values	
• Number of smoothing levels	4; None; 4/8/16 times
• parameterizable	Yes

Article number	6ES7134-6JF00-0CA1
Encoder	
Connection of signal encoders	
• for voltage measurement	Yes
• for resistance measurement with two-wire connection	Yes
• for resistance measurement with three-wire connection	No
• for resistance measurement with four-wire connection	No
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %; ±0.1 % for resistance thermometers and resistance
Temperature error (relative to input range), (+/-)	0.0009 %/K; ±0.005 % / K at thermocouple
Crosstalk between the inputs, min.	-50 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Voltage, relative to input range, (+/-)	0.1 %
• Resistance, relative to input range, (+/-)	0.1 %
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to input range, (+/-)	0.05 %
• Resistance, relative to input range, (+/-)	0.05 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	70 dB; With conversion time 67.5 / 22.5 / 18.75 ms: 40 dB
• Common mode voltage, max.	10 V
• Common mode interference, min.	90 dB
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes; two upper and two lower limit values in each case
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; channel by channel
• Group error	Yes
• Overflow/underflow	Yes; channel by channel
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED

Article number	6ES7134-6JF00-0CA1
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Permissible potential difference	
between the inputs (UCM)	10 V DC
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm

Operational and basic error limits for thermal resistors

Error limits for thermal resistors	
Operational limit (in the entire temperature range, in relation to input range)	
• Pt 100, Pt 200, Pt 500, Pt 1000 standard	±1.0 K
• Pt 100, Pt 200, Pt 500, Pt 1000 climatic	± 0.25 K
• Ni 100, Ni 120, Ni 200, Ni 500, Ni 1000 standard and climatic	± 0.4 K
Basic error limit (operational limit at 25 °C, in relation to input range)	
• Pt 100, Pt 200, Pt 500, Pt 1000 standard	± 0.6 K
• Pt 100, Pt 200, Pt 500, Pt 1000 climatic	± 0.13 K
• Ni 100, Ni 120, Ni 200, Ni 1000 standard and climatic	± 0.2 K

Operational and basic error limits for thermocouples [1]

Error limits for thermocouples	
Operational limit for thermocouples (in the entire temperature range)	±1.5 K
Basic error limit for thermocouples (operational limit at 25 °C)	±1 K
Overall error limits when using internal compensation	
• Operational limit (in the entire temperature range at static thermal state, ambient temperature change < 0.3 K/min)	± 2.5 K
• Basic error limit (operational limit at 25 °C at static thermal state, ambient temperature change < 0.3 K/min)	±1.5 K

[1] The indicated error limits apply as of the following temperatures:
Thermocouple type T: -200 °C
Thermocouple type K: -100 °C
Thermocouple type B: +700 °C
Thermocouple type N: -150 °C
Thermocouple type E: -150 °C
Thermocouple type R: +200 °C
Thermocouple type S: +100 °C

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Table 2-764 Dependencies of the measurement type / measuring range

Measurement type	Measuring range	Temperature coefficient	Reference junction	Temperature unit	Conductor resistance
Deactivated	*	*	*	*	*
Voltage	±50 mV, ±80 mV, ±250 mV, ±1 V	*	*	*	*
Resistor	150 Ω, 300 Ω, 600 Ω, 3 kΩ, 6 kΩ	*	*	*	x
Resistor	PTC	*	*	*	*
Thermal resistor	Pt100 climatic	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	Reference channel of group 0, 1, 2, 3	Degrees Celsius	x
			No reference channel mode	Degrees Celsius Degrees Fahrenheit	
	Pt200 Pt500 Pt1000 climatic		No reference channel mode	Degrees Celsius Degrees Fahrenheit	
	Ni100 Ni120 Ni200 Ni500 Ni1000 climatic	Ni 0.00618 Ni 0.00672			

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of "Reference channel of the module":
- Channel 0 must be set as "Pt100 climatic" with temperature unit: "Degrees Celsius".
- For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Reference channel of the module".

2 Use of "Reference channel of group 0, 1, 2, 3":
- An RTD channel must be set as "Pt100 climatic" with temperature unit: "Degree Celsius".
- The "Reference junction" of this channel must be configured with "Reference channel of group 0, 1, 2, 3".
- There must only be one RTD channel with "Reference junction" = "Reference channel of group 0, 1, 2, 3" per group 0, 1, 2, 3 and I/O device!
- Each TC channel in the I/O device which is to use this reference must be configured with "Reference channel of group 0, 1, 2, 3" at "Reference junction".
- If the reference channel is on channel 0, it can be used simultaneously as "Reference channel of the module".

Measurement type	Measuring range	Temperature coefficient	Reference junction	Temperature unit	Conductor resistance
Thermal resistor	LG-Ni 1000 climatic	LG-Ni 0.005	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x
Thermal resistor	Pt100 Pt200 Pt500 Pt1000 standard	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x
	Ni100 Ni120 Ni200 Ni500 Ni1000 standard	Ni 0.00618 Ni 0.00672			
	LG-Ni 1000 standard	LG-Ni 0.005			
Thermocouple	Type B, N, E, R, S, J, L, T, K, U, C, TXK	*	Reference channel of the module[1] Internal reference junction Reference channel of group 0, 1, 2, 3[2]	Degrees Celsius Degrees Fahrenheit Kelvin	*
			Fixed reference temperature		

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of "Reference channel of the module":
- Channel 0 must be set as "Pt100 climatic" with temperature unit: "Degrees Celsius".
- For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Reference channel of the module".

2 Use of "Reference channel of group 0, 1, 2, 3":
- An RTD channel must be set as "Pt100 climatic" with temperature unit: "Degree Celsius".
- The "Reference junction" of this channel must be configured with "Reference channel of group 0, 1, 2, 3".
- There must only be one RTD channel with "Reference junction" = "Reference channel of group 0, 1, 2, 3" per group 0, 1, 2, 3 and I/O device!
- Each TC channel in the I/O device which is to use this reference must be configured with "Reference channel of group 0, 1, 2, 3" at "Reference junction".
- If the reference channel is on channel 0, it can be used simultaneously as "Reference channel of the module".

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type for PROFINET.

Table 2-765 Dependencies on the measurement type

Measurement type	Scalable measuring range	Measuring range resolution	Diagnostics				
			Underflow	Overflow	Wire break	Missing supply voltage L+	Reference junction
Deactivated	*	*	*	*	*	*	*
Voltage	–	*	x	x	–	x	–

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Property is not relevant if "Fixed reference temperature" is used

Measurement type	Scalable measuring range	Measuring range resolution	Diagnostics				
			Underflow	Overflow	Wire break	Missing supply voltage L+	Reference junction
Resistor	–	*	x	x	x	x	–
Resistor	–	*	x	–	–	x	–
Thermal resistor	x	2 and 3 decimal places	x	x	x	x	–
Thermocouple	x	2 and 3 decimal places	x	x	x	x	x[1)]

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Property is not relevant if "Fixed reference temperature" is used

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Temperature coefficient	Slot reference junction	Temperature unit	Diagnostics			
					Underflow / overflow	Wire break	Missing supply voltage L+	Reference junction
Deactivated	*	*	*	*	*	*	*	*
Voltage	±50 mV ±80 mV ±250 mV ±1 V	*	*	*	x	–	x	–
Resistor	150 Ω 300 Ω 600 Ω 3 kΩ 6 kΩ	*	*	*	x	x	x	–
Resistor	PTC[3]	*	*	*	x	–	x	–

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of the "Reference channel of the module":
- Channel 0 must be set to "Pt100 climatic" with the temperature unit "Degrees Celsius".
- For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Enable".

2 Use of "Reference channel of group 0":
- An RTD channel must be configured as "Pt100 climatic" with temperature unit "Degree Celsius".
- "Reference channel of group 0, 1, 2, 3" must be configured as the "Reference junction" of this channel.
- There must only be one RTD channel with "Reference junction activated" = "Enabled" per group and line!
- Each TC channel of this line which is to use this reference must be configured with "Enabled" for "Reference junction activated".

3 Underflow = 8000_H; wire break and overflow lead to 01_H (triggered) → (no diagnostics), wire break and overflow are therefore not relevant.

Measurement type	Measuring range	Temperature coefficient	Slot reference junction	Temperature unit	Diagnostics			
					Underflow / overflow	Wire break	Missing supply voltage L+	Reference junction
Thermal resistor	Pt100 climatic	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	Reference channel of group 0, 1, 2, 3	Degrees Celsius	x	x	x	–
			No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
	Pt200 Pt500 Pt1000 climatic	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
Thermal resistor	Pt100 Pt200 Pt500 Pt1000 standard	Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–
	Ni100 Ni120 Ni200 Ni500 Ni1000 climatic	Ni 0.00618 Ni 0.00672	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–
	Ni100 Ni120 Ni200 Ni500 Ni1000 standard	Ni 0.00618 Ni 0.00672	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–
Thermal resistor	LG-Ni 1000 climatic	LG-Ni 0.005	No reference channel mode	Degrees Celsius Degrees Fahrenheit	x	x	x	–

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of the "Reference channel of the module":
- Channel 0 must be set to "Pt100 climatic" with the temperature unit "Degrees Celsius".
- For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Enable".

2 Use of "Reference channel of group 0":
- An RTD channel must be configured as "Pt100 climatic" with temperature unit "Degree Celsius".
- "Reference channel of group 0, 1, 2, 3" must be configured as the "Reference junction" of this channel.
- There must only be one RTD channel with "Reference junction activated" = "Enabled" per group and line!
- Each TC channel of this line which is to use this reference must be configured with "Enabled" for "Reference junction activated".

3 Underflow = 8000_H; wire break and overflow lead to 01_H (triggered) → (no diagnostics), wire break and overflow are therefore not relevant.

Measurement type	Measuring range	Temperature coefficient	Slot reference junction	Temperature unit	Diagnostics			
					Underflow / overflow	Wire break	Missing supply voltage L+	Reference junction
Thermal resistor	LG-Ni 1000 standard	LG-Ni 0.005	No reference channel mode	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	–
Thermocouple	Type B, N, E, R, S, J, L, T, K, U, C, TXK	*	Reference channel of the module[1] Internal reference junction Reference channel of group 0, 1, 2, 3[2]	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	x
			Fixed reference temperature	Degrees Celsius Degrees Fahrenheit Kelvin	x	x	x	*

x = property is allowed, – = property is **not allowed**, * = property is not relevant

1 Use of the "Reference channel of the module":
- Channel 0 must be set to "Pt100 climatic" with the temperature unit "Degrees Celsius".
- For each TC channel of this module that is intended to use channel 0 as reference, "Reference junction" must be set to "Enable".

2 Use of "Reference channel of group 0":
- An RTD channel must be configured as "Pt100 climatic" with temperature unit "Degree Celsius".
- "Reference channel of group 0, 1, 2, 3" must be configured as the "Reference junction" of this channel.
- There must only be one RTD channel with "Reference junction activated" = "Enabled" per group and line!
- Each TC channel of this line which is to use this reference must be configured with "Enabled" for "Reference junction activated".

3 Underflow = 8000_H; wire break and overflow lead to 01_H (triggered) → (no diagnostics), wire break and overflow are therefore not relevant.

A.2 Parameter assignment and structure of parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can reassign the module parameters in RUN. For example, the measuring range of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 will not be changed on the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

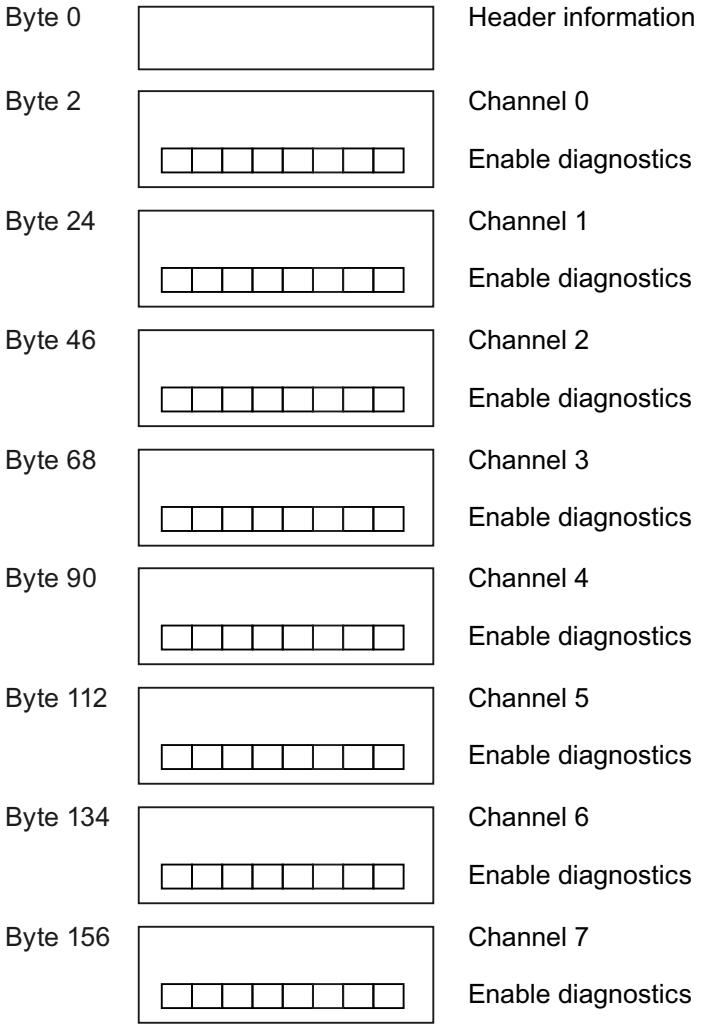

Figure 2-656 Structure of data record 128

Header information

The figure below shows the structure of the header information.

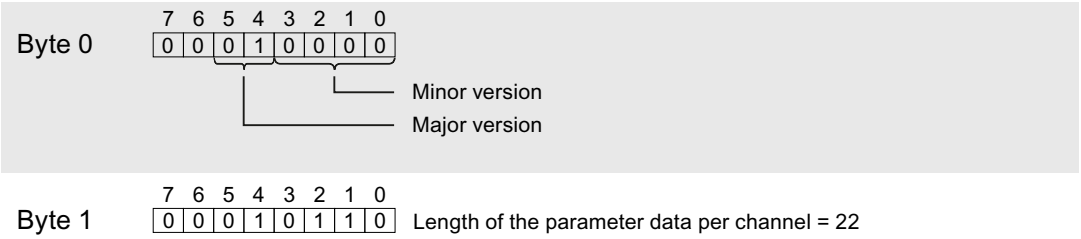

Figure 2-657 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 7.

You can activate a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number x 22); channel number = 0 to 7

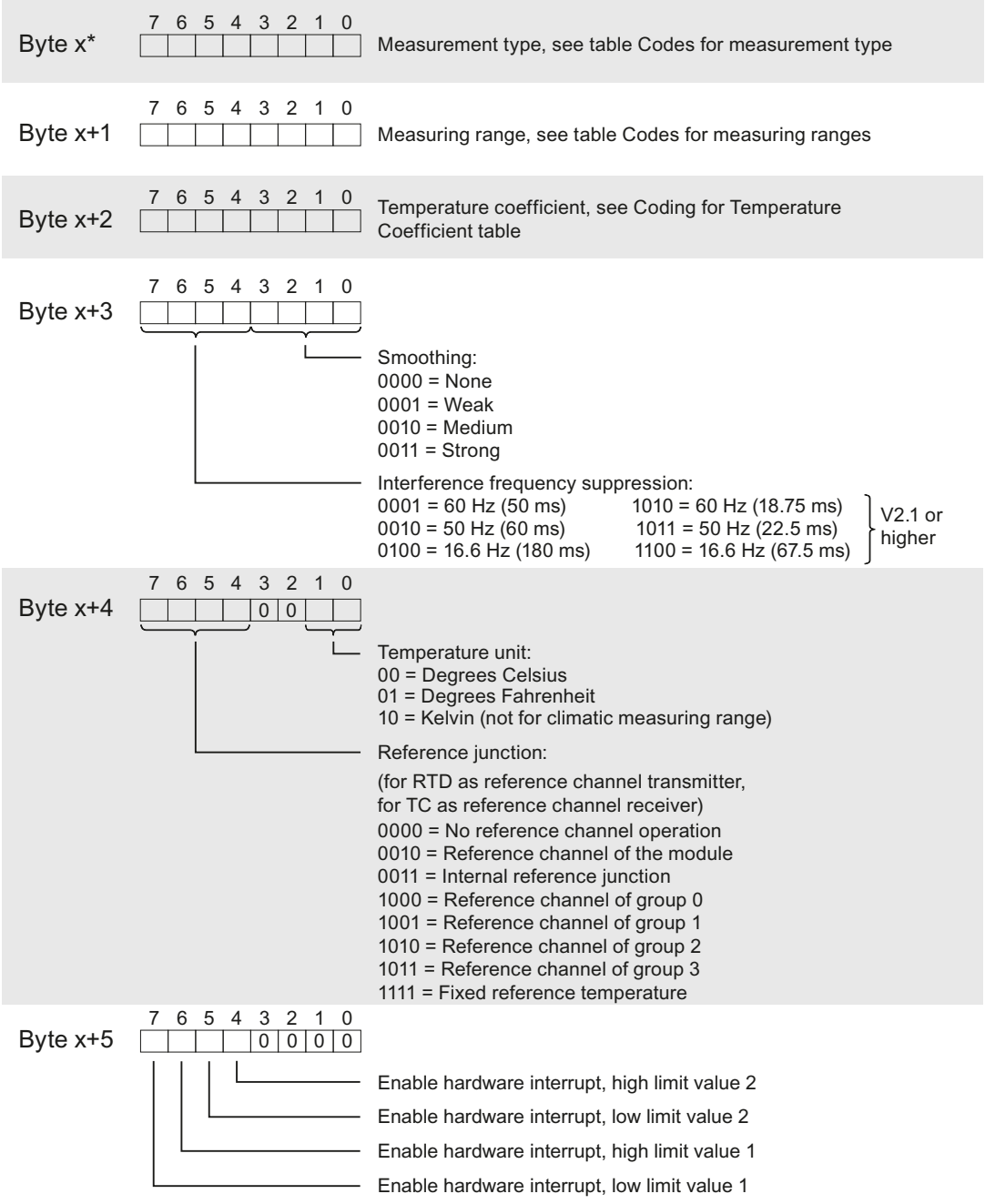

Figure 2-658 Structure DS128 AI 4RTD TC 234wire x+5

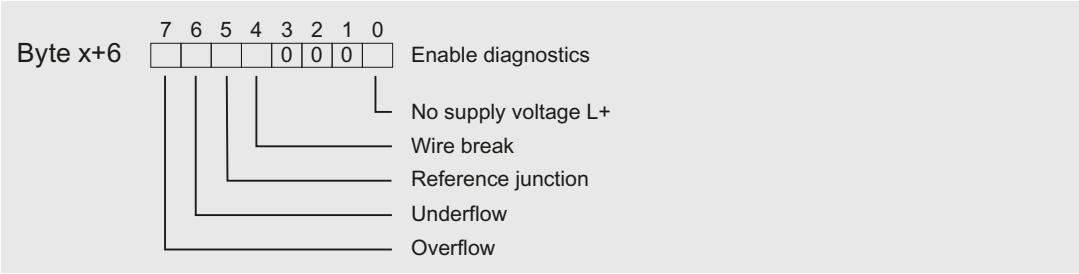

Figure 2-659 Structure_of_the_data_record_AI 4RTD TC 234wire_Part2

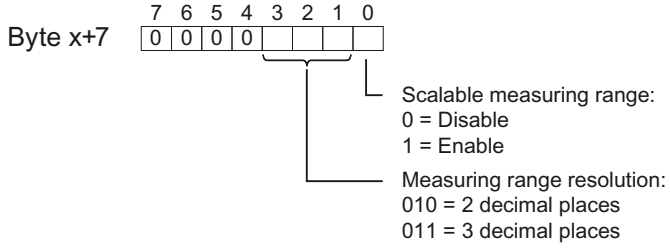

Figure 2-660 Structure DS128 AI8 Byte x+7

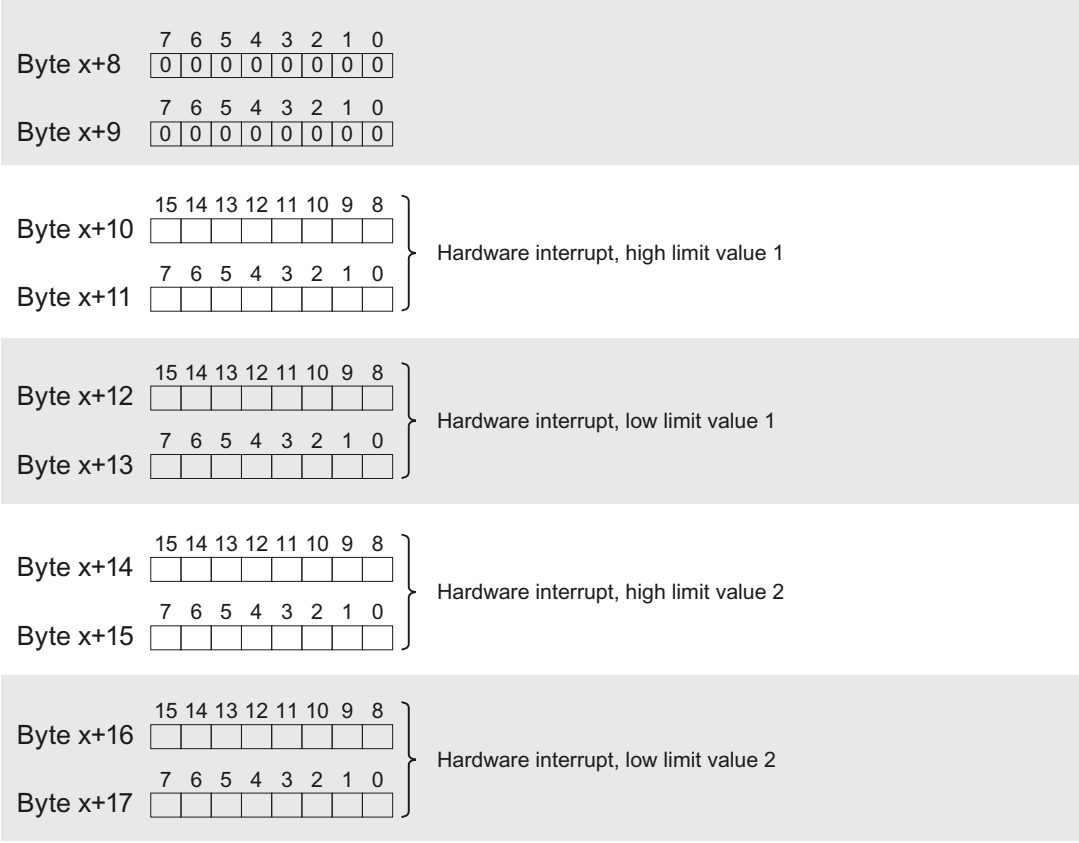

Figure 2-661 Structure DS128 AI 4RTD TC 234wire x+17

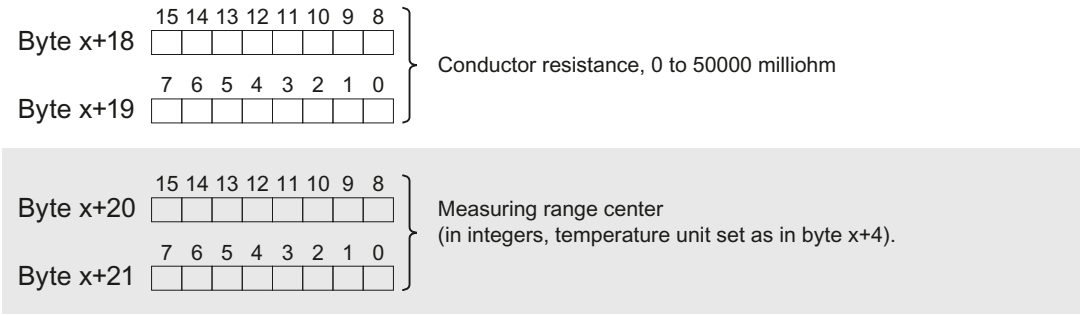

Figure 2-662 Structure of byte x to x+21 for channel 0 to 7

Codes for measurement type

The following table contains the codes for the measurement types of the analog input module. You must enter these codes at byte x (see previous figure).

Table 2-766 Codes for measurement type

Measurement type	Code
Deactivated	0000 0000
Voltage	0000 0001
Resistor, 2-wire connection	0000 0110
Thermal resistor, 2-wire connection	0000 1001
Thermocouple	0000 1010

Codes for measuring range

The following table contains the codes for the measuring ranges of the analog input module. You must enter these codes at byte x+1 (see previous figure).

Table 2-767 Codes for measuring range

Measuring range	Code
Voltage	
50 mV	0000 0001
80 mV	0000 0010
250 mV	0000 0011
1 V	0000 0101
Resistor	
150 Ω	0000 0001
300 Ω	0000 0010
600 Ω	0000 0011
3 kΩ	0000 0100
6 kΩ	0000 0101
PTC	0000 1111

Measuring range	Code
Thermal resistor climatic	
Pt 100	0000 0000
Pt 200	0000 0111
Pt 500	0000 1000
Pt 1000	0000 1001
Thermal resistor standard	
Pt 100	0000 0010
Pt 200	0000 1011
Pt 500	0000 0100
Pt 1000	0000 0101
Thermal resistor climatic	
Ni 100	0000 0001
Ni 120	0000 1101
Ni 200	0001 0001
Ni 500	0001 0011
Ni 1000	0000 1010
Thermal resistor standard	
Ni 100	0000 0011
Ni 120	0000 1100
Ni 200	0001 0000
Ni 500	0001 0010
Ni 1000	0000 0110
Thermal resistor	
LG Ni 1000 climatic	0001 1101
LG Ni 1000 standard	0001 1100
Thermocouple	
Type B	0000 0000
Type N	0000 0001
Type E	0000 0010
Type R	0000 0011
Type S	0000 0100
Type J	0000 0101
Type L	0000 0110
Type T	0000 0111
Type K	0000 1000
Type U	0000 1001
Type C	0000 1010
Type TXK	0000 1011

Codes for temperature coefficient

The following table contains the codes for the temperature coefficients of the analog input module. You must enter these codes at byte x+2 (see previous figure).

Table 2-768 Codes for temperature coefficient for temperature measurement

Temperature coefficient	Code
Pt 0.00385055 Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	0000 0000 0000 0001 0000 0010 0000 0011 0000 0100
Ni 0.00618 Ni 0.00672	0000 1000 0000 1001
LG-Ni 0.005	0000 1010

Limits for hardware interrupts

The following tables contain the permitted limits for hardware interrupts (in each case, the usable value is given). The limits depend on the selected measurement type and the selected measuring range. The value for the overflow must be larger than the value for the underflow. The limits are specified as decimal values. The conversion to the respective temperature unit is (1 digit = 0.1) for the standard range and (1 digit = 0.01) for the climate range, see section Representation of analog values (Page 64).

Table 2-769 Limits for resistor and voltage

Resistor (all possible measuring range settings)	Voltage	
32510	32510	Overflow
1	-32511	Underflow

Table 2-770 Limits for thermocouple types B, C, and E

Thermocouple									
Type B			Type C			Type E			
°C	°F	K	°C	°F	K	°C	°F	K	
20699	32765	23431	24999	32765	27731	11999	21919	14731	Overflow
-1199	-1839	1533	-1199	-1839	1533	-2699	-4539	33	Underflow

Table 2-771 Limits for thermocouple types R, S, J, and L

Thermocouple									
Types R, S			Type J			Type L			
°C	°F	K	°C	°F	K	°C	°F	K	
20189	32765	22921	14499	26419	17231	11499	21019	14231	Overflow
-1699	-2739	1033	-2099	-3459	633	-1999	-3279	733	Underflow

Table 2-772 Limits for thermocouple types T, K, and U

Thermocouple									
Type T			Type K			Type U			
°C	°F	K	°C	°F	K	°C	°F	K	
5399	10039	8131	16219	29515	18951	8499	15619	11231	Overflow
-2699	-4539	33	-2699	-4539	33	-1999	-3279	733	Underflow

Table 2-773 Limits for thermocouple types N and TXK

Thermocouple						
Type N			Type TXK			
°C	°F	K	°C	°F	K	
15499	28219	18231	10499	19219	13231	Overflow
-2699	-4539	33	-1999	-3279	733	Underflow

Table 2-774 Limits for thermal resistor

Thermal resistor						
	Standard			Climatic		
	°C	°F	K	°C	°F	
Pt	9999	18319	12731	15499	31099	Overflow
	-2429	-4053	303	-14499	-22899	Underflow
Ni, Ni-LG	2949	5629	5681	29499	32765	Overflow
	-1049	-1569	1683	-10499	-15699	Underflow

A.3 Errors when transferring the data record

Error transferring the data record

The module always checks all values of the data record to be sent. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter, see also the description of the "STATUS" parameter in the STEP 7 online help).

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown.	Enter a valid number for the data record.
DF	80	B1	xx	Length of the data record incorrect.	Enter a valid value for the data record length.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B2	xx	Slot invalid or cannot be accessed.	• Check the station to determine whether the module is plugged or pulled. • Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	xx	Wrong version or error in the header information.	Correct the version, length and number of parameter blocks.
DF	80	E1	xx	Parameter error	Check the parameters of the module.

A.4 Switchable wire break check

Function

The "Switchable wire break check" is available for thermocouples. It switches off the wire break check for the module.

This is required, for example, to calibrate thermocouples, since the test current necessary for a wire break check leads to measurement errors during calibration.

The function has no effect on channels that are not assigned in the thermocouple mode.

NOTE

Startup and parameter reassignment

The wire break check is switched on again at each startup and during any parameter reassignment of the module.

Switch-off via the user program

You can deactivate the wire break check using data record 237.

Table 2-775 Structure of data record 237, switchable wire break check

Byte	Function	Format	Value	Description
0	Command	UBYTE	80_H	Wire break check
1	Identifier	UBYTE	00_H	Not relevant
2	Channel number	UBYTE	FF_H	All channels
3	Calibration step	UBYTE	FF_H	First triggering
4	Measurement type	UBYTE	00_H	Not relevant
5	Measuring range	UBYTE	00_H	Not relevant
6	Action	UBYTE	01_H	Deactivate wire break check
			02_H	Activate wire break check
7...17	Reserved	UBYTE	00_H	Not relevant

Representation of analog values

B

This appendix shows the analog values for all measuring ranges supported by the analog input module AI 8xRTD/TC 2-wire HF.

Measured value resolution

The resolution of the analog values differs depending on the analog module and its parameter assignment.

Each analog value is written left aligned to the tags. The bits marked with "x" are set to "0".

NOTE

Temperature values

The digitized temperature values are the result of a conversion in the analog module. The following resolution therefore does not apply to temperature values.

Table 2-776 Resolution of the analog values

Resolution in bits including sign	Values		Analog value	
	Decimal	**Hexadecimal**	**High byte**	**Low byte**
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Measured values for wire break and reference channel mode

Measured values for wire break

Table 2-777 Measured values for a wire break as a function of enabled diagnostic information in RTD and TC operating modes

Programmable diagnostics		Measured value		Explanation
Wire break	Underflow			
Enable	*	32767	$7FFF_H$	The "wire break" diagnostics is reported.
Disable	*	32767	$7FFF_H$	No diagnostics reported. A wire-break check is carried out (i.e. test current flows).
Disable[1]	*	Undefined		No "wire break" diagnostics is reported. No wire-break check is carried out (i.e. no test current flows). This is required to calibrate thermocouples, since the measuring current necessary for a wire-break check leads to measurement errors during calibration.

* Parameter assignment not relevant

1 The wire-break check can only be disabled via data set 237.

Table 2-778 Measured values in case of a line break in a TC measurement with enabled reference junction (reference channel) depending on enabled diagnostic information

Case	Programmable diagnostics				Measured value			
	Reference channel		TC channel		Reference channel		TC channel	
	Wire break	Underflow	Wire break	Underflow				
1	Enable[3]	*[3]	*	*[2]	32767[3]	$7FFF_H$[3]	32767[4]	$7FFF_H$[4]
2	Disable[3]	*[3]	*	*[2]	32767[3]	$7FFF_H$[3]	32767[4]	$7FFF_H$[4]
3	*	*	Enable[3]	*[3]	Valid	Valid	32767[3]	$7FFF_H$[3]
4	*	*	Disable[3]	*[3]	Valid	Valid	32767[3]	$7FFF_H$[3]
5	*	*	Disable[1,3]	*[3]	Valid	Valid	Undefined	

* Parameter assignment not relevant

1 The wire-break check can only be disabled via data set 237.

2 Diagnostics is suppressed in the event of a reference channel error.

3 Channel with line break

4 Measured value taken from the reference channel

Explanations of the cases:

Case	Reference channel	TC channel
1	The "wire break" diagnostics is reported. This has a higher priority than the "Underflow" diagnostics.*	The "Reference channel error" diagnostics is reported if this is enabled. Where own pending diagnostic information ("overflow" or "underflow") is reported as outgoing. Wire break diagnostics is detected independently of the measured value and has the same priority as the

Case	Reference channel	TC channel
		"Reference channel error" diagnostics. Both items of diagnostic information can be pending simultaneously. The measured value of the reference channel (RTD channel) is adopted for the TC channel. The validity of the measured value of the TC channel is irrelevant.
2	No diagnostics reported. A wire-break check is carried out (i.e. test current flows).*	*Behavior corresponds to case 1.*
3	*Measured values are in the valid measuring range*	The "wire break" diagnostics is reported.*
4	*Measured values are in the valid measuring range*	No diagnostics reported. A wire-break check is carried out (i.e. test current flows).*
5	*Measured values are in the valid measuring range*	No "wire break" diagnostics is reported. No wire-break check is carried out (i.e. no test current flows). This is required to calibrate thermocouples, since the measuring current necessary for a wire-break check leads to measurement errors during calibration.*

* Channel with wire break

B.2 Representation of input ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar input ranges. The resolution is 16 bits.

Table 2-779 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 2-780 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Underrange
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

B.3 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

Table 2-781 Voltage measuring range ±1 V

Values		Voltage measuring range	Range
Dec.	**Hex.**	**±1 V**	
32767	7FFF	> 1.176 V	Overflow
32511	7EFF	1.176 V	Overrange
27649	6C01		
27648	6C00	1 V	Nominal range
20736	5100	0.75 V	
1	1	36.17 µV	
0	0	0 V	
-1	FFFF		
-20736	AF00	-0.75 V	
-27648	9400	-1 V	
-27649	93FF		Underrange
-32512	8100	-1.176 V	
-32768	8000	<-1.176 V	Underflow

Table 2-782 Voltage measuring range ±500 mV to ±50 mV

Values		Voltage measuring range			Range
Dec.	**Hex.**	**±250 mV**	**±80 mV**	**±50 mV**	
32767	7FFF	> 294.0 mV	> 94.1 mV	> 58.8 mV	Overflow
32511	7EFF	294.0 mV	94.1 mV	58.8 mV	Overrange

Values		Voltage measuring range			Range
27649	6C01				Overrange
27648	6C00	250 mV	80 mV	50 mV	Nominal range
20736	5100	187.5 mV	60 mV	37.5 mA	
1	1	9.04 µV	2.89 µV	1.81 µV	
0	0	0 mV	0 mV	0 mV	
-1	FFFF				
-20736	AF00	-187.5 mV	-60 mV	-37.5 mV	
-27648	9400	-250 mV	-80 mV	-50 mV	
-27649	93FF				Underrange
-32512	8100	-294.0 mV	-94.1 mV	-58.8 mV	
-32768	8000	<-294.0 mV	<-94.1 mV	<-58.8 mV	Underflow

B.4 Representation of analog values for resistance-type sensors

The following tables list the decimal and hexadecimal values (codes) of the possible resistance-type sensors.

Table 2-783 Resistance-type sensors from 150 Ω to 6000 Ω

Values		Resistance-type sensor range					Range
Dec.	**Hex.**	**150 Ω**	**300 Ω**	**600 Ω**	**3000 Ω**	**6000 Ω**	
32767	7FFF	> 176.38 Ω	> 352.77 Ω	> 705.53 Ω	> 3527.7 Ω	> 7055.3 Ω	Overflow
32511	7EFF	176.38 Ω	352.77 Ω	705.53 Ω	3527.7 Ω	7055.3 Ω	Overrange
27649	6C01						
27648	6C00	150 Ω	300 Ω	600 Ω	3000 Ω	6000 Ω	Nominal range
20736	5100	112.5 Ω	225 Ω	450 Ω	2250 Ω	4500 Ω	
1	1	5.43 mΩ	10.85 mΩ	21.70 mΩ	108.5 mΩ	217 mΩ	
0	0	0 Ω	0 Ω	0 Ω	0 Ω	0 Ω	
-32768	8000	(negative values are physically impossible)					Underflow[1]

[1] If the resistors are not connected correctly or the conductor resistance is too high

B.5 Representation of analog values for thermal resistors

NOTE

A higher resolution can be configured for the measuring range for the standard thermal resistors, see section Scalable measuring range (Page 29).

The tables below list the decimal and hexadecimal values (codes) of the thermal resistors.

Table 2-784 Thermal resistor Pt 100, 200, 500, 1000 standard

Pt x00 standard in °C (1 digit = 0.1 °C)	Values		Pt x00 standard in °F (1 digit = 0.1 °F)	Values		Pt x00 standard in K (1 digit = 0.1 K)	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1000.0	32767	7FFF	> 1832.0	32767	7FFF	> 1273.2	32767	7FFF	Overflow
1000.0 : 850.1	10000 : 8501	2710 : 2135	1832.0 : 1562.1	18320 : 15621	4790 : 3D05	1273.2 : 1123.3	12732 : 11233	31BC : 2BE1	Overrange
850.0 : -200.0	8500 : -2000	2134 : F830	1562.0 : -328.0	15620 : -3280	3D04 : F330	1123.2 : 73.2	11232 : 732	2BE0 : 2DC	Nominal range
-200.1 : -243.0	-2001 : -2430	F82F : F682	-328.1 : -405.4	-3281 : -4054	F32F : F02A	73.1 : 30.2	731 : 302	2DB : 12E	Underrange
< -243.0	-32768	8000	< -405.4	-32768	8000	< 30.2	32768	8000	Underflow

Table 2-785 Thermal resistor Pt 100, 200, 500, 1000 climatic

Pt x00 climatic in °C (1 digit = 0.01 °C)	Values		Pt x00 climatic in °F (1 digit = 0.01 °F)	Values		Range
	Dec.	Hex.		Dec.	Hex.	
> 155.00	32767	7FFF	> 311.00	32767	7FFF	Overflow
155.00 : 130.01	15500 : 13001	3C8C : 32C9	311.00 : 266.01	31100 : 26601	797C : 67E9	Overrange
130.00 : -120.00	13000 : -12000	32C8 : D120	266.00 : -184.00	26600 : -18400	67E8 : B820	Nominal range
-120.01 : -145.00	-12001 : -14500	D11F : C75C	-184.01 : -229.00	-18401 : -22900	B81F : A68C	Underrange
< -145.00	-32768	8000	< -229.00	-32768	8000	Underflow

Table 2-786 Thermal resistor Ni 100, 120, 200, 500, 1000, LG-Ni 1000 standard

Ni x00 standard in °C (1 digit = 0.1 °C)	Values		Ni x00 standard in °F (1 digit = 0.1 °F)	Values		Ni x00 standard in K (1 digit = 0.1 K)	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 295.0	32767	7FFF	> 563.0	32767	7FFF	> 568.2	32767	7FFF	Overflow
295.0 : 250.1	2950 : 2501	B86 : 9C5	563.0 : 482.1	5630 : 4821	15FE : 12D5	568.2 : 523.3	5682 : 5233	1632 : 1471	Overrange
250.0 : -60.0	2500 : -600	9C4 : FDA8	482.0 : -76.0	4820 : -760	12D4 : FD08	523.2 : 213.2	5232 : 2132	1470 : 854	Nominal range
-60.1 : -105.0	-601 : -1050	FDA7 : FBE6	-76.1 : -157.0	-761 : -1570	FD07 : F9DE	213.1 : 168.2	2131 : 1682	853 : 692	Underrange
< -105.0	-32768	8000	< -157.0	-32768	8000	< 168.2	32768	8000	Underflow

Table 2-787 Thermal resistor Ni 100, 120, 200, 500, 1000, LG-Ni 1000 climatic

Ni x00 climatic in °C (1 digit = 0.01 °C)	Values		Ni x00 climatic in °F (1 digit = 0.01 °F)	Values		Range
	Dec.	Hex.		Dec.	Hex.	
> 295.00	32767	7FFF	> 327.66	32767	7FFF	Overflow
295.00 : 250.01	29500 : 25001	733C : 61A9	327.66 : 280.01	32766 : 28001	7FFE : 6D61	Overrange
250.00 : -60.00	25000 : -6000	61A8 : E890	280.00 : -76.00	28000 : -7600	6D60 : E250	Nominal range
-60.01 : -105.00	-6001 : -10500	E88F : D6FC	-76.01 : -157.00	-7601 : -15700	E24F : C2AC	Underrange
< - 105.00	-32768	8000	< - 157.00	-32768	8000	Underflow

B.6 Representation of analog values for thermocouples

NOTE

A higher resolution can be configured for thermocouples, see section Scalable measuring range (Page 29).

The tables below list the decimal and hexadecimal values (codes) of the thermocouples.

Table 2-788 Thermocouple type B

Type B in °C	Values		Type B in °F	Values		Type B in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2070.0	32767	7FFF	> 3276.6	32767	7FFF	> 2343.2	32767	7FFF	Overflow
2070.0 : 1820.1	20700 : 18201	50DC : 4719	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2343.2 : 2093.3	23432 : 20933	5B88 : 51C5	Overrange
1820.0 : 0.0	18200 : 0	4718 : 0000	2786.5 : 32.0	27865 : 320	6CD9 : 0140	2093.2 : 273.2	20932 : 2732	51C4 : 0AAC	Nominal range
-0.1 : -120.0	-1 : -1200	FFFF : FB50	31.9 : -184.0	319 : -1840	013F : F8D0	273.1 : 153.2	2731 : 1532	0AAB : 05FC	Underrange
< -120.0	-32768	8000	< -184.0	-32768	8000	< 153.2	-32768	8000	Underflow

Table 2-789 Thermocouple type C

Type C in °C	Values		Type C in °F	Values		Type C in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2500.0	32767	7FFF	> 3276.6	32767	7FFF	> 2773.2	32767	7FFF	Overflow
2500.0 : 2315.1	25000 : 23151	61A8 : 5A6F	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2773.2 : 2588.3	27732 : 25883	6C54 : 651B	Overrange
2315.0 : 0.0	23150 : 0	5A6E : 0000	2786.5 : 32.0	27865 : 320	6CD9 : 0140	2588.2 : 273.2	25882 : 2732	651A : 0AAC	Nominal range
-0.1 : -120.0	-1 : -1200	FFFF : FB50	31.9 : -184.0	319 : -1840	013F : F8D0	273.1 : 153.2	2731 : 1532	0AAB : 05FC	Underrange
< -120.0	-32768	8000	< -184.0	-32768	8000	< 153.2	-32768	8000	Underflow

Table 2-790 Thermocouple type E

Type E in °C	Values		Type E in °F	Values		Type E in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1200.0	32767	7FFF	> 2192.0	32767	7FFF	> 1473.2	32767	7FFF	Overflow
1200.0 : 1000.1	12000 : 10001	2EE0 : 2711	2192.0 : 1832.1	21920 : 18321	55A0 : 4791	1473.2 : 1273.3	14732 : 12733	398C : 31BD	Overrange
1000.0 : -270.0	10000 : -2700	2710 : F574	1832.0 : -454.0	18320 : -4540	4790 : EE44	1273.2 : 3.2	12732 : 32	31BC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-791 Thermocouple type J

Type J in °C	Values		Type J in °F	Values		Type J in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1450.0	32767	7FFF	> 2642.0	32767	7FFF	> 1723.2	32767	7FFF	Overflow
1450.0 : 1200.1	14500 : 12001	38A4 : 2EE1	2642.0 : 2192.1	26420 : 21921	6734 : 55A1	1723.2 : 1473.3	17232 : 14733	4350 : 398D	Overrange
1200.0 : -210.0	12000 : -2100	2EE0 : F7CC	2192.0 : -346.0	21920 : -3460	55A0 : F27C	1473.2 : 63.2	14732 : 632	398C : 0278	Nominal range
< -210.0	-32768	8000	< -346.0	-32768	8000	< 63.2	-32768	8000	Underflow

Table 2-792 Thermocouple type K

Type K in °C	Values		Type K in °F	Values		Type K in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1622.0	32767	7FFF	> 2951.6	32767	7FFF	> 1895.2	32767	7FFF	Overflow
1622.0 : 1372.1	16220 : 13721	3F5C : 3599	2951.6 : 2501.7	29516 : 25017	734C : 61B9	1895.2 : 1645.3	18952 : 16453	4A08 : 4045	Overrange
1372.0 : -270.0	13720 : -2700	3598 : F574	2501.6 : -454.0	25016 : -4540	61B8 : EE44	1645.2 : 3.2	16452 : 32	4044 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-793 Thermocouple type L

Type L in °C	Values		Type L in °F	Values		Type L in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1150.0	32767	7FFF	> 2102.0	32767	7FFF	> 1423.2	32767	7FFF	Overflow
1150.0 : 900.1	11500 : 9001	2CEC : 2329	2102.0 : 1652.1	21020 : 16521	521C : 4089	1423.2 : 1173.3	14232 : 11733	3798 : 2DD5	Overrange
900.0 : -200.0	9000 : -2000	2328 : F830	1652.0 : -328.0	16520 : -3280	4088 : F330	1173.2 : 73.2	11732 : 732	2DD4 : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow

Table 2-794 Thermocouple type N

Type N in °C	Values		Type N in °F	Values		Type N in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1550.0	32767	7FFF	> 2822.0	32767	7FFF	> 1823.2	32767	7FFF	Overflow
1550.0 : 1300.1	15500 : 13001	3C8C : 32C9	2822.0 : 2372.1	28220 : 23721	6E3C : 5CA9	1823.2 : 1573.3	18232 : 15733	4738 : 3D75	Overrange
1300.0 : -270.0	13000 : -2700	32C8 : F574	2372.0 : -454.0	23720 : -4540	5CA8 : EE44	1573.2 : 3.2	15732 : 32	3D74 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-795 Thermocouples R and S

Types R, S in °C	Values		Types R, S in °F	Values		Types R, S in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2019.0	32767	7FFF	> 3276.6	32767	7FFF	> 2292.2	32767	7FFF	Overflow
2019.0 : 1769.1	20190 : 17691	4EDE : 451B	3276.6 : 3216.3	32766 : 32163	7FFE : 7DA3	2292.2 : 2042.3	22922 : 20423	598A : 4FC7	Overrange
1769.0 : -50.0	17690 : -500	451A : FE0C	3216.2 : -58.0	32162 : -580	7DA2 : FDBC	2042.2 : 223.2	20422 : 2232	4FC6 : 08B8	Nominal range
-50.1 : -170.0	-501 : -1700	FE0B : F95C	-58.1 : -274.0	-581 : -2740	FDBB : F54C	223.1 : 103.2	2231 : 1032	08B7 : 0408	Underrange
< -170.0	-32768	8000	< -274.0	-32768	8000	< 103.2	< 1032	8000	Underflow

Table 2-796 Thermocouple type T

Type T in °C	Values		Type T in °F	Values		Type T in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 540.0	32767	7FFF	> 1004.0	32767	7FFF	> 813.2	32767	7FFF	Overflow
540.0 : 400.1	5400 : 4001	1518 : 0FA1	1004.0 : 752.1	10040 : 7521	2738 : 1D61	813.2 : 673.3	8132 : 6733	1FC4 : 1AAD	Overrange
400.0 : -270.0	4000 : -2700	0FA0 : F574	752.0 : -454.0	7520 : -4540	1D60 : EE44	673.2 : 3.2	6732 : 32	1AAC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-797 Thermocouple type U

Type U in °C	Values		Type U in °F	Values		Type U in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 850.0	32767	7FFF	> 1562.0	32767	7FFF	> 1123.2	32767	7FFF	Overflow
850.0 : 600.1	8500 : 6001	2134 : 1771	1562.0 : 1112.1	15620 : 11121	2738.0 : 2B71	1123.2 : 873.3	11232 : 8733	2BE0 : 221D	Overrange
600.0 : -200.0	6000 : -2000	1770 : F830	1112.0 : -328.0	11120 : -3280	2B70 : F330	873.2 : 73.2	8732 : 732	221C : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow

Table 2-798 Thermocouple type TXK (GOST)

Type TXK in °C	Values		Type TXK in °F	Values		Type TXK in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1050.0	32767	7FFF	> 1922.0	32767	7FFF	>1323.2	32767	7FFF	Overflow
1050.0 : 800.1	10500 : 8001	2904 : 1F41	1922.0 : 1472.1	19220 : 14721	4B14 : 3981	1323.2 : 1073.3	13232 : 10733	33B0 : 29ED	Overrange
800.0 : 0.0 : -200.0	8000 : 0 : -2000	1F40 : 0000 : F830	1472.0 : 32.0 : -328.0	14720 : 320 : -3280	3980 : 0140 : F330	1073.2 : 273 : 73.2	10732 : 2730 : 732	29EC : 0AAA : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	<73.2	-32768	8000	Underflow

SIEMENS

SIMATIC

ET 200SP
Analog input module AI Energy Meter CT HF (6ES7134-6PA01-0CU0)

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Preface

Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP (https://support.industry.siemens.com/cs/de/en/view/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

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ET 200SP Documentation Guide

1

1.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/84133942)

1.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in SIOS:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in SIOS and how to use SIOS on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

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You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.3 Tool support

1.3.1 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , it assembles the configuration editors for automation technology already familiar into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- The "Network analysis" offers a quick overview of the PROFINET topology. It is possible to make simple parameter changes (for example, to the names and IP addresses of the devices). In addition, a quick and convenient comparison of the real configuration with a reference system is also possible.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet:
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

Product overview

2

2.1 Properties of the AI Energy Meter CT HF

Article number

6ES7134-6PA01-0CU0

View of the module

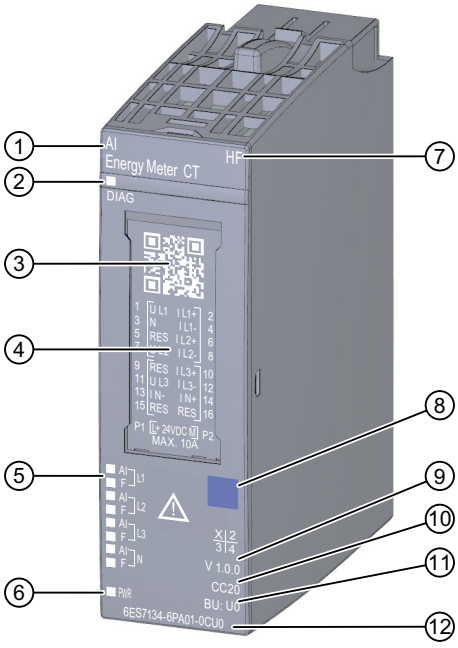

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-663 View of the module AI Energy Meter CT HF

Properties

The module has the following technical properties:

- Measurement of electrical variables from single-phase, two-phase and three-phase supply networks
- Current measurement using 1 A or 5 A current transformer
- Power quality data for voltages and currents
- Measured value recorder (10 ms)
- Max. voltage between two line conductors 519 V AC (with direct connection)
- Retentive storage of the counter values
- Use on frequency converters
- Recording of:
  - Voltages
  - Currents
  - Phase angles
  - Power
  - Energy / electrical work
  - Frequencies
  - Minimum and maximum values with time stamp
  - Power factors
  - Operating hours
  - Limits

The module supports the following functions:

Table 2-799 Version dependencies of the functions

Function	HW version	FW version	STEP 7	GSD file	
			TIA Portal	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	---
Calibration in runtime	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	---	---
Identification data I&M0 to I&M3	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	X
Reconfiguration in RUN	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	X
Diagnostic interrupts	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	X
Hardware interrupts	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	---

NOTE

The AI Energy Meter CT HF is released as of TIA Portal V16.0.0.4.

Accessories

The following accessories must be ordered separately:

- BaseUnit type U0
- Labeling strips
- Reference identification label

You can find additional information on the accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

2.2 Area of application

Introduction

Energy efficiency is playing an increasingly important role in industry. Rising energy prices, increasing pressure to improve profitability and the growing awareness of climate protection are important factors for reducing energy costs and for introducing an energy data management system.

Where can you use the AI Energy Meter CT HF?

The AI Energy Meter CT HF is designed for machine-level deployment in an ET 200SP distributed I/O system. The AI Energy Meter CT HF records over 500 different electrical measurement and energy values. It lets you create transparency about the energy requirements of individual components of a production plant even down to the machine level.

You can use the following measurement values supplied by the AI Energy Meter CT HF for the following applications:

- Energy consumption
- Power consumption
- Power quality
- Forecasts of consumption
- Efficiency

Power consumption measurements are relevant for load management and maintenance. In addition, you can use the measurements for emission reporting and for determining the CO_2 footprint.

NOTE

Measuring dangerous electrical quantities

The AI Energy Meter CT HF is not tested according to DIN EN 61010-2-030 and may therefore not be used to verify, measure or monitor protective measures according to DIN EN 61557.

Qualified personnel must ensure through additional measures that no danger ensues for humans and the environment in case of an incorrect display.

TB, TT and IT system

The AI Energy Meter CT HF can be used in TN, TT and IT systems.

Measuring with the AI Energy Meter CT HF

A typical supply network of a production plant is usually divided into three voltage ranges:

- The infeed of the entire plant
- The subdistribution, for example, to individual lines within the plant
- The end consumers such as the machines in the lines.

The following figure shows the measurement in an electricity supply network:

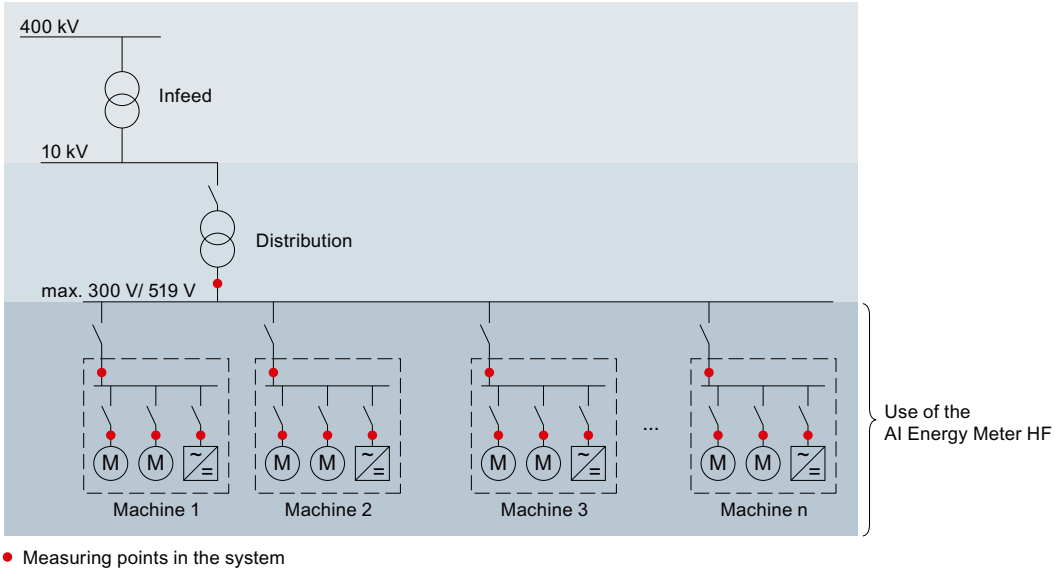

Figure 2-664 Properties of the AI Energy Meter CT HF

Properties of the AI Energy Meter CT HF

The AI Energy Meter CT HF offers the following benefits:

- Space-saving especially for use in control cabinet
- PROFINET IO or PROFIBUS DP (https://www.profibus.com/) (depending on the interface module in use)
- Multiple modules can be used with one interface module
- Extension of existing stations by components for energy recording

2.3 Special considerations for use on the PROFIBUS DP and PROFINET IO

You can read data records from the module or write them to the module with both PROFIBUS DP and PROFINET IO.

Operation of the module on PROFIBUS DP

Please note that with PROFIBUS DP you can write data records up to a maximum length of 240 bytes to the module or read them from the module.

PROFIBUS DPV 1

If the DP Master supports the DPV1, you can reconfigure in your user program with the parameter data records DS 128, DS 129, DS 130, DS 131 or DS 135. Note that the maximum data record length is 240 bytes for DS 135.

The following applies for the measured value data records:

- DS 142: When you read the data record, the module returns the measured value data record DS 142 in version 2.
- DS 147, DS 148, DS 149: When you read the data record, the module returns the measured value data record in version 0.
- DS 154, DS 155, DS 161, DS 163, DS 164: When you read the data record, the module returns the first 240 bytes of the structure of the measured value data record.
- DS 151: You define the user-defined measured value data record DS 151 in the parameter data record DS 135. If the structure in the measured value data record DS 151 is greater than 240 bytes, the module returns the first 240 bytes of the structure.

  Information on the data record length of data records DS 135 and DS151 can be found in the appendix Structure of the parameter data record 135 for data record mapping (Page 172).

PROFIBUS DPV 0

If the DP Master does **not** support DPV1, you cannot reassign parameters which results in the following restrictions:

- There are no phase-specific parameters. All parameters apply for all three phases and the neutral conductor.
- The connection types and usvariants are limited.
- The voltage transformers are not configurable (default: 1:1).
- The current transformer value range primary current is restricted.
- The low limit for measuring current cannot be adjusted (default: 50 mA).
- Energy metering is performed continuously (the gate is not enabled).
- Min/Max calculation of values is enabled (the gate is not enabled).
- 3P4W can be set in the parameters for the connection type 3P3W.
- 3P4W can be set in the parameters for the connection type 3P3W1.
- Counting of operating hours is enabled (the gate is not enabled).
- The residual current measurement is enabled.
- Limit value monitoring cannot be used.
- Energy meter default cannot be used.
- The user-defined payload interface cannot be used.
- The user-defined data record cannot be used.
- The power quality analysis cannot be used.
- The separate settings for measuring the neutral current cannot be used.
- The measured value data records cannot be used.

Operation of the module on PROFINET IO

When reading data records partially from the module, please note the following:

- Measured value data record DS 142:
  - When you read the data record with a length of 240 bytes or less, the module returns the measured value data record DS 142 in version 2.
  - When you read the data record with a length of more than 240 bytes, the module returns the measured value data record DS 142 in version 3.
- Measured value data records DS 147, DS 148, DS 149:
  - When you read the data record with a length of 240 bytes or less, the module returns the measured value data record in version 0.
  - When you read the data record with a length of more than 240 bytes, the module returns the measured value data record in version 1.

Wiring

3

3.1 Terminal and block diagram

General safety instructions

⚠ WARNING

Danger to life due to electric shock

Touching live parts can lead to death or severe injuries.

Before beginning any work deenergize the system and the AI Energy Meter CT HF and short-circuit the installed current transformers.

⚠ WARNING

Danger to life, dangerous system conditions and material damage possible

Removing and inserting the AI Energy Meter CT HF under live voltage is prohibited.

If you remove and insert the AI Energy Meter CT HF under live voltage during operation, the transformers used can produce dangerous induction voltages and electric arcs and dangerous system conditions can arise.

The AI Energy Meter CT HF may only be removed and inserted during operation if the measuring voltages supplied to the BaseUnit at terminals U_{L1} , U_{L2}, U_{L3} are disconnected at all poles **and** special current transformer terminals are used that short-circuit the current transformer on the secondary side on removal.

Supplying the module

The AI Energy Meter CT HF receives its supply voltage via the terminals 17 (24 V DC) and 18 (M).

NOTE

Safe extra low voltage SELV/PELV

Ensure that all devices are connected to the SELV/PELV power supply (or equivalent).

Note the following to ensure the electrical safety of the Energy Meter and the ET 200SP station:

The voltage difference between the inputs for measuring the line voltage at the Energy Meter and the SELV/PELV supply voltages of the Energy Meter and the ET 200SP station must not exceed 300 V AC. This is guaranteed, for example, if the SELV/PELV supply is fed from the same grounded network as the voltage to be measured directly. If voltage transformers are used, they must be grounded on the secondary side.

Current transformer connection requirements

DIN VDE 0100-557 and IEC 60364-5-55 require the following for the connection of current transformers:

NOTE

Wiring current transformers

The secondary circuits of current transformers must not be grounded.

Guards must not be used in the secondary circuits of current transformers.

Protecting the connection cables

To protect the connection cables at U_{L1}, U_{L2} and U_{L3}, make sure there is adequate cable protection, especially after cross-section transitions.

If the cables are routed with short-circuit protection according to IEC 61439-1:2009, for example, in a pipe or in separate cable ducts, there is no need for separate cable protection for the AI Energy Meter CT HF.

Terminal and block diagram

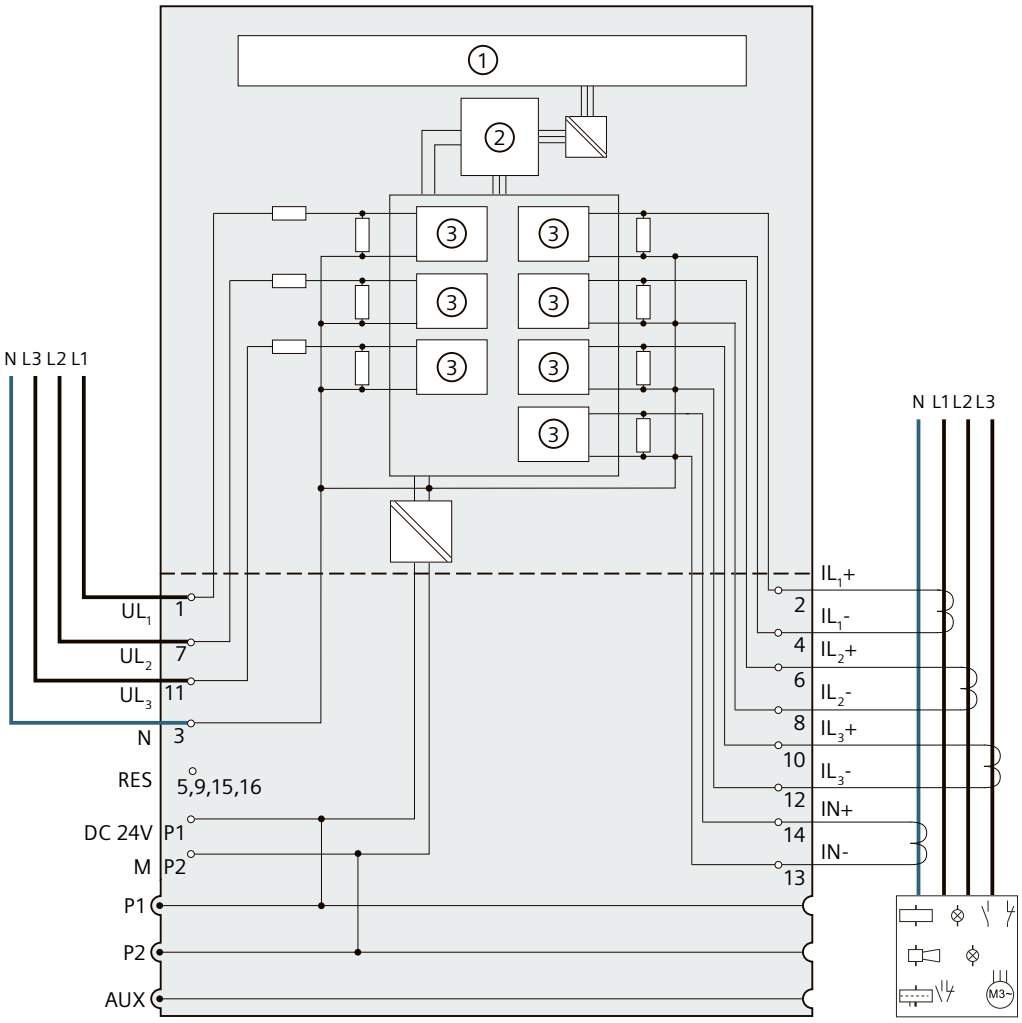

①	Backplane bus interface	UL_n	Connection voltage
②	Microcontroller	IL_n+ / IL_n-	Connection of current transformers
③	Analog-to-digital converter (ADC)	N, IN+ / IN-	Neutral
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark BaseUnit) Connection to left interrupted (light BaseUnit)	RES	Reserve, must remain unused for future function extensions

Figure 2-665 Block diagram of the AI Energy Meter CT HF

Useable BaseUnits

You can use the following BaseUnits:

- Type BU type U0 dark-colored
- Type BU type U0 light-colored

A potential group opened with a light-colored BU type U0 must contain no dark-colored BaseUnit of BU type A0 or A1.

Connection types

The AI Energy Meter CT HF supports the following connection types:

- 3P4W1, 3 phases, 4 conductors, balanced load
- 3P4W, 3 phases, 4 conductors
- 2P3W, 2 phases, 3 conductors
- 1P2W, 1 phase, 2 conductors
- 3 x 1P2W, 3 x 1 phase, 2 conductors
- 3P3W, 3 phases, 3 conductors
- 3P3W1, 3 phases, 3 conductors, balanced load
- 3P4WI, 3 phases, 4 conductors (only for current measurement)

The input circuit of the module must correspond to one of the listed connection types. Select the appropriate connection type for the intended use.

You will find examples of connections in the section Connection examples (Page 26).

Information on the selection of a current transformer is available in the section Data for selection of a current transformer (Page 30).

NOTE

Measurement of other currents

You can also use the connection for neutral current measurement to measure other currents.

3.2 Connection examples

The following figures show the connection of the AI Energy Meter CT HF for three-phase, two-phase and single-phase measurements. Note that the AI Energy Meter CT HF must always be connected via a current transformer. The use of voltage transformers is optional.

Connection type	Wiring diagram	Comment
3P4W Three-phase measurement, 4 wires	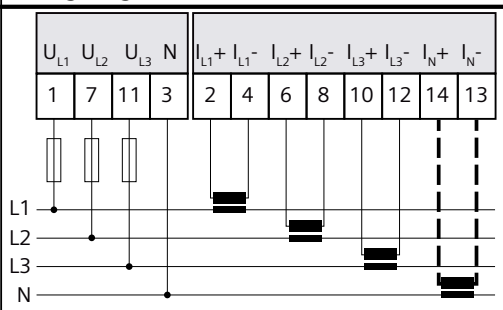	Any load Connection with three current transformers
3P4W Three-phase measurement, 4 wires	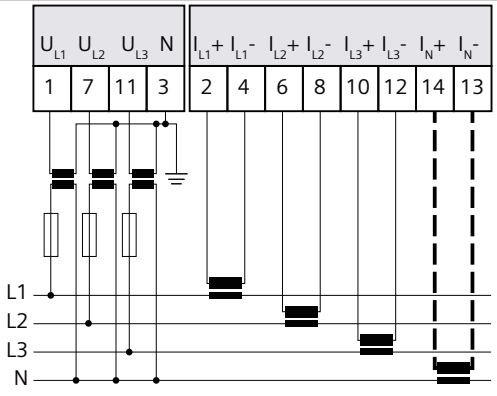	Any load Connection with three current transformers and three voltage transformers.
3P4W1 Three-phase measurement, 4 wires	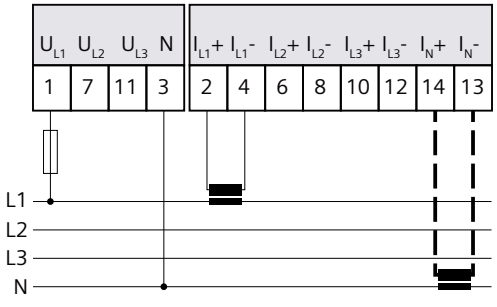	Balanced load Connection with one current transformer
3P4W1 Three-phase measurement, 4 wires	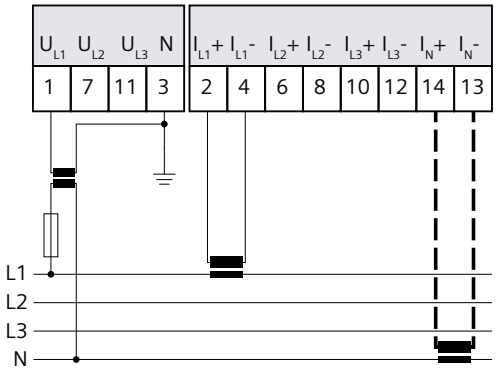	Balanced load Connection with one current transformer and one voltage transformer.

Connection type	Wiring diagram	Comment
2P3W Two-phase measurement, 3 conductors	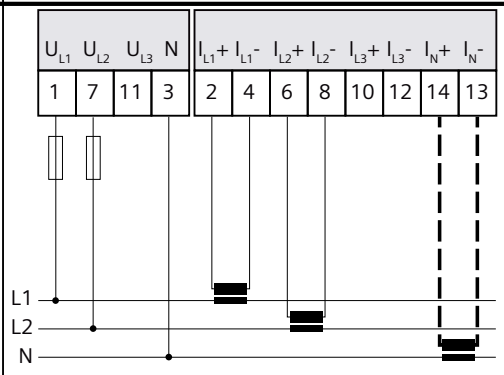	Any load Connection with two current transformers The phase position L1-L2 is arbitrary. AI Energy Meter CT HF supplies the value "0" for all measured values of Phase 3 as well as for some cross-phase measured values.
2P3W Two-phase measurement, 3 conductors	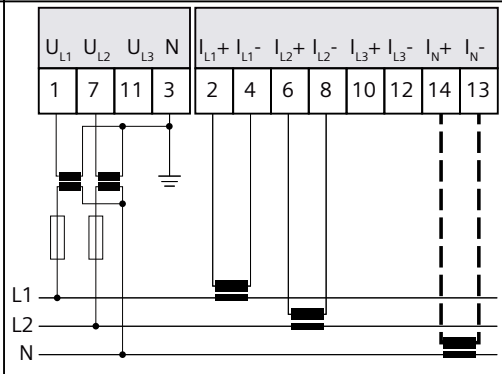	Any load Connection with two current transformers and two voltage transformers. AI Energy Meter CT HF supplies the value "0" for all measured values of Phase 3 as well as for some cross-phase measured values.
1P2W Single-phase measurement, 2 conductors	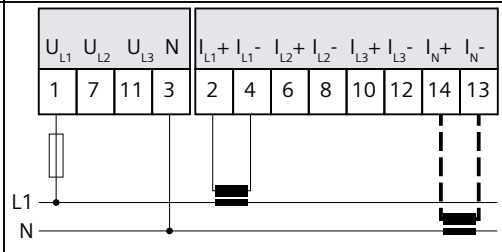	Measurement in an AC network with a current transformer. AI Energy Meter CT HF supplies the value "0" for all measured values of Phase 2 and 3 as well as for some cross-phase measured values.
1P2W Single-phase measurement, 2 conductors	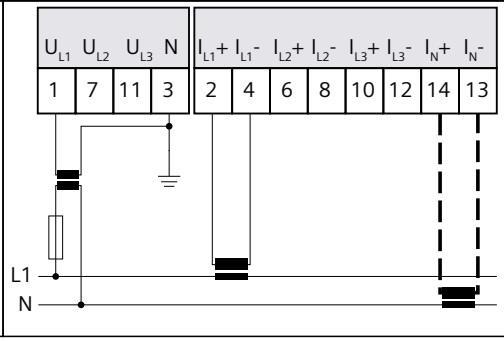	Measuring the load in an AC network with one current transformer and one voltage transformer. AI Energy Meter CT HF supplies the value "0" for all measured values of Phase 2 and 3 as well as for some cross-phase measured values.

Connection type	Wiring diagram	Comment
3 x 1P2W 3 x single-phase measurement	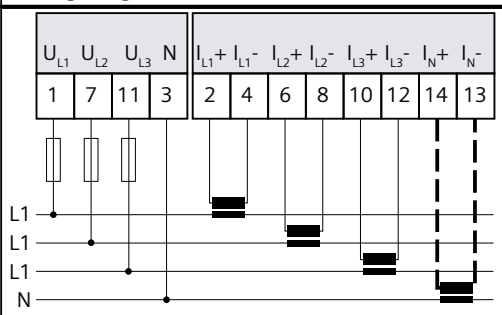	Measurement with three current transformers for any three loads that are each connected to one of the three phases. To reduce the number of fuses used, the voltage phases can also be bridged behind a fuse.
3 x 1P2W 3 x single-phase measurement	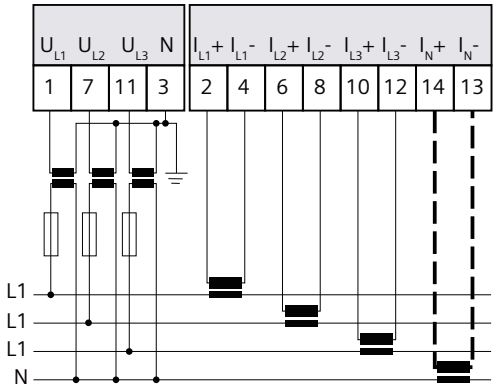	Measurement with three current transformers and three voltage transformers for any three loads that are each connected to one of the three phases. To reduce the number of fuses used, the voltage phases can also be bridged behind a fuse.
3P3W Three-phase measurement	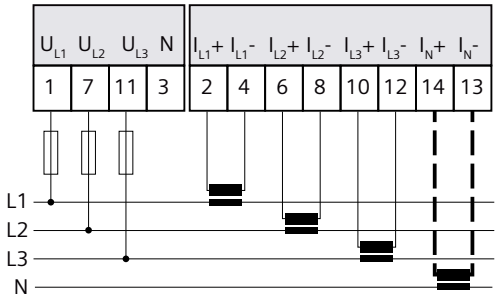	Any load Connection with three current transformers
3P3W Three-phase measurement	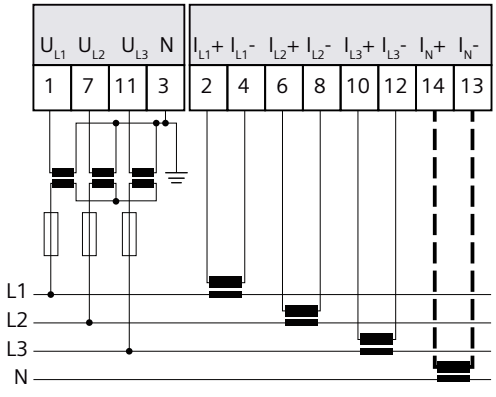	Any load Connection with three current transformers and three voltage transformers.

Connection type	Wiring diagram	Comment
3P3W1 Three-phase measurement	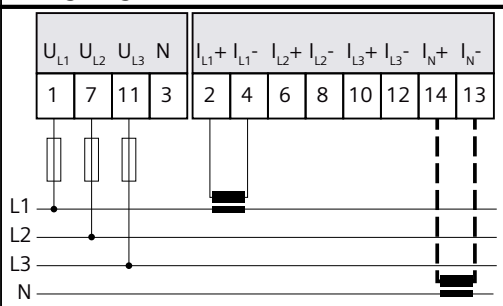	Balanced load Connection with one current transformer
3P3W1 Three-phase measurement	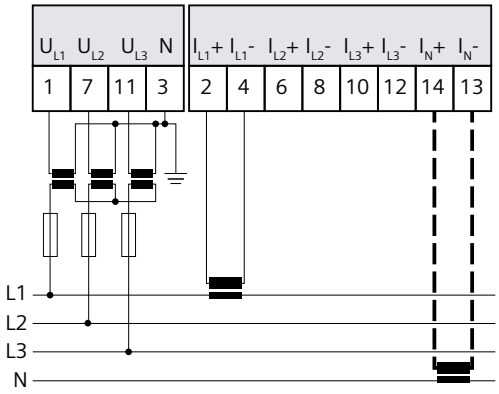	Balanced load Connection with one current transformer and one voltage transformer.
3P4WI Three-phase measurement (only for current measurement)	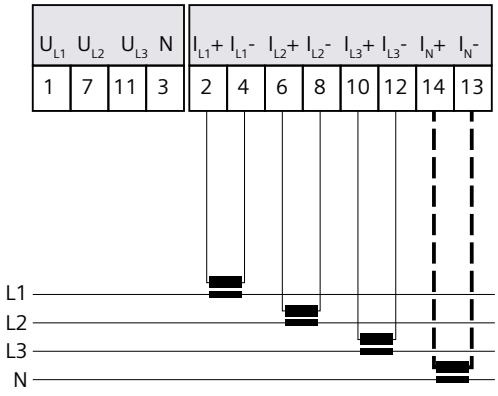	Connection with three current transformers

Current transformer connection requirements

DIN VDE 0100-557 and IEC 60364-5-55 require the following for the connection of current transformers:

- However, if it mandatory to ground the secondary circuits of the current transformers; voltage transformers must be used to separate neutral conductor / neutral point and the protective conductor. Alternatively, the voltage measurement must be omitted.
- The insulation of the secondary cables of transformers must be designed for the highest voltage of all active components, or the secondary cables must be installed in such a way that their insulation cannot touch any active components, such as busbars.
- Connection points must be provided for temporary measurements.

3.3 Current transformer selection data

Introduction

Connection via a current transformer is always required for the current measurement. Use toroids with an accuracy class of 0.5, 1 or 3.

Dimensioning of the current transformer

The correct dimensioning of the current transformer is important for the following reasons:

- You achieve correct results from the measurements and
- You do not overload or damage the current transformers.

Selecting a current transformer

Use current transformers with a burden capacity 1.5 to 2 times greater than the power dissipation in the terminal circuit (consisting of resistance of the connection cables and burden of the AI Energy Meter CT HF). 1.5 times the power loss is required in order to prevent the transformer from overloading. 2 times the power dissipation is important to ensure the current limiting in case of a short-circuit. The burden capacity of the terminal circuit, in turn, must be at least 25% of the rated burden of the transformer in the working point. This is the only way for you to operate the transformer with the specified accuracy.

Maximum length of the connection cable

To avoid overloading or damaging the current transformer, the burden Z_n specified on the data sheet of the current transformer (in VA) must not be exceeded. To prevent this being exceeded, the entire burden resistance (consisting of the resistance of the connection cable and the internal resistance of the AI Energy Meters CT HF (see figure below) must be below a certain resistance value (depending on Z_n and I_{max}).

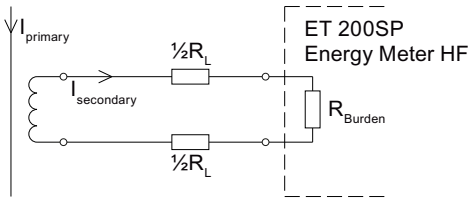

Figure 2-666 Maximum length of the connection cable

The maximum value of the resistance of the connection cable is obtained with the following formula:

$$R_{L,\,max} = \frac{Z_n}{I_{max}^{\ 2}} - R_{burden}$$

R_L	Cable resistance in ohms	I_{max}	Secondary current of the current transformer
Z_n	Rated burden current transformer in VA	R_{burden}	Resistance of the AI Energy Meter CT HF (25 mΩ)

Figure 2-667 Maximum value for the resistance of the connection cable

Based on the maximum cable resistance in ohms, you then calculate the maximum length of the connection cable. To do this, check the data sheet of the connection cable you are using.

NOTE

The length of the connection cable (outwards and return) must not exceed the value of 200 meters.

Example: Usage of a current transformer 500/5 A

You use a current transformer with a transmission ration of 500/5 A that has a rated burden Z_n of 5 VA according to the data sheet.

The maximum primary current in the application amounts to 400 A. This means that the maximum secondary current $I_{max.}$ amounts to 4 A. The burden of the AI Energy Meter CT HF including connection resistance amounts to R_{Burden} = 25 mΩ.

The maximum value of the resistance of the connection cable (outgoing and incoming line) is obtained using the following formula:

$$R_{L,\,max} = \frac{Z_n}{I_{max}^{\ 2}} - R_{Burden} = \frac{5\ AV}{16\ A^2} - 25\ m\Omega = 312.5\ m\Omega - 25\ m\Omega = 287.5\ m\Omega$$

The maximum cable resistance between the transformer and the terminals of the AI Energy Meter CT HF may not exceed 287.5 mΩ in this case. The corresponding cable length (outgoing and incoming line) depends on the cross-section used of the copper line and can be determined by using the following table.

The following table shows the resistance values of copper cables for typical cross-sections with $\rho = 0.017857\ \Omega \times mm^2/m$

Estimating the length for a connection cable

The value in the table must be less than the calculated terminal resistance $R_{L\ max}$ of the cable. For the resistance R_{Lmax} of 287.5 mΩ used in the above example it is possible to use a connection cable (outgoing and incoming line) with a length of 10 m from a cross-section of 0.75 mm² upward.

Cross-section	AWG	Cable overview for copper				
		0.5 m	1 m	5 m	10 m	50 m
0.25 mm²	24	35.7 mΩ	71.4 mΩ	357.1 mΩ	714.3 mΩ	3571.4 mΩ
0.34 mm²	22	26.3 mΩ	52.5 mΩ	262.6 mΩ	525.2 mΩ	2626.0 mΩ
0.5 mm²	21	17.9 mΩ	35.7 mΩ	178.6 mΩ	357.1 mΩ	1785.7 mΩ
0.75 mm²	19/20	11.9 mΩ	23.8 mΩ	119.0 mΩ	238.1 mΩ	1190.5 mΩ
1.0 mm²	18	8.9 mΩ	17.9 mΩ	89.3 mΩ	178.6 mΩ	892.9 mΩ
1.5 mm²	16	6.0 mΩ	11.9 mΩ	59.5 mΩ	119.0 mΩ	595.2 mΩ
2.5 mm²	14	3.6 mΩ	7.1 mΩ	35.7 mΩ	71.4 mΩ	357.1 mΩ

Checking the ratio of burden load and power loss

The rated burden of the transformer must be 1.5 to 2 times greater than the power loss in the connection circuit to ensure that the transformer is not overloaded and that the current limitation is ensured during a short-circuit.

At a maximum secondary current of 4 A the power loss in the connection circuit is calculated in accordance with the following formula for a connection cable (outgoing and incoming line) with a length of 10 m and a cross-section of 1.0 mm² and a burden resistance of the AI Energy Meter CT HF of 25 mΩ:

$$P_{Connection\ circuit} = (R_{Connection\ cable} + R_{Burden}) \times I^2_{Max.\ secondary}$$

$$P_{Connection\ circuit} = (178.6\ m\Omega + 25\ m\Omega) \times 4^2\ A^2\ 3.26\ W$$

The ratio of the rated burden and the power loss in the connection circuit thus amounts to:

$$\frac{Z_{N\ rated\ burden}}{P_{Connection\ circuit}} = \frac{5\ VA}{3.26\ W} = 1.54$$

The required ratio of rated burden and power loss in the connection circuit lies within the required range. The transformer is dimensioned sufficiently large.

See also

Technical specifications (Page 142)

Configuration / address space

4

4.1 Configuring

Introduction

To configure the AI Energy Meter CT HF after connecting it, use configuration software such as STEP 7 (TIA Portal). In addition, you can also change numerous parameters of the AI Energy Meter CT HF in RUN via the user program.

Configuring

You configure the AI Energy Meter CT HF with:

- STEP 7 (TIA Portal) V16 or higher and HSP0335
- GSD file for PROFIBUS or PROFINET

NOTE

Consistency check of the parameter assignment only with STEP 7

If you configure the AI Energy Meter CT HF using STEP 7 (TIA Portal), STEP 7 (TIA Portal) already checks the various parameters for consistency while they are being entered.

If you configure the AI Energy Meter CT HF using a GSD file, a consistency check is not performed. The module does not recognize incorrect entries until after the parameter data record has been transferred. If the module recognizes an invalid parameter, the module rejects the complete data record.

Preferably use STEP 7 (TIA Portal) to configure the AI Energy Meter CT HF.

The following instructions show the theoretical procedure for configuring the AI Energy Meter CT HF with STEP 7 (TIA Portal) V16 or higher with HSP0335.

1. Select the ET 200SP distributed I/O system you are using in the hardware catalog.
2. Insert the module into your station.
3. Open the device view of the ET 200SP and insert the AI Energy Meter CT HF.
4. Configure the AI Energy Meter CT HF to suit your requirements.

   Once the configuration has been compiled without errors, you can download the configuration to the CPU and commission the ET 200SP station while the AI Energy Meter CT HF is running.

4.2 Selecting the module versions

Introduction

The AI Energy Meter CT HF has different module versions.

During the configuration you use the selection of the module version to specify which measured values can be read.

Each module version supplies quality information via the input payload.

With the exception of the module version "2 I / 2 Q" you can read the measured values as payload cyclically from the process image. At each module version you have the option to read measured value records from the AI Energy Meter CT HF by using the RDREC instruction asynchronously.

Influence of the module version on the address space

NOTE

Influence of the AI Energy Meter CT HF on the maximum configuration of the ET 200SP

The available address space of the ET 200SP is influenced by the following factors:

- CPU or interface module
- Plugged I/O modules

The address space made **additionally** available by the AI Energy Meter CT HF is essentially influenced by the length of the payload supplied. The module version determines the length of the payload, which can be supplied by the AI Energy Meter CT HF at maximum.

4.2.1 Module versions at configuration with STEP 7

Module versions with fixed payload assignment

Module version	Payload	Address space	Comment
2 I / 2 Q	No cyclic payload. Access to measured values through "Read data record".	2-byte inputs 2-byte outputs	Information about the structure of the 2 I / 2 Q module version is available in the appendix "2 I / 2 Q" module version (Page 204).
EE@Industry E0	Payload in accordance with EE@Industry measurement data profiles	12-byte inputs / 20-byte outputs	Information about the structure of the EE@Industry measured data profiles is available in the appendix Module version "EE@Industry measured data profile E0 / E1 / E2 / E3" (Page 216).
EE@Industry E1		4-byte inputs / 20-byte outputs	
EE@Industry E2		12-byte inputs / 20-byte outputs	
EE@Industry E3		104-byte inputs / 20-byte outputs	

Module versions with selectable payload variants

Module version	Payload	Address space	Comment
32 I / 20 Q	Payload selectable through defined payload variants	32-byte inputs / 20-byte outputs	You can change over the payload variant during operation. Information about the structure of the 32 I / 20 Q module version is available in the appendix "32 I / 20 Q" module version (Page 206). Information about the payload variants at 32 I / 20 Q is available in appendix Payload variants with 32 bytes input / 20 bytes output data.
User-specific	Payload selectable through payload mapping or through defined payload variant.	variable* / 20-byte outputs	You have to activate the check box "Payload-mapping" (payload-mapping) in STEP 7 to use the module version user-specifically. You can change over the payload variant during operation. Information about the structure of the user-specific module version is available in the appendix "User-specific" module version (Page 214).

* 16 ... 256 bytes in steps of 16 bytes, depending on the mapped measured values

4.2.2 Module versions at configuration with GSD file

Module versions with fixed payload assignment

Module version	Payload	Address space	Comment
2 I / 2 Q	No cyclic payload. Access to measured values through "Read data record".	2-byte inputs 2-byte outputs	Information about the structure of the 2 I / 2 Q module version is available in the appendix "2 I / 2 Q" module version (Page 204).
E0	Payload in accordance with EE@Industry measurement data profiles	12-byte inputs / 20-byte outputs	Information about the structure of the EE@Industry measured data profiles is available in the appendix Module version "EE@Industry measured data profile E0 / E1 / E2 / E3" (Page 216).
E1		4-byte inputs / 20-byte outputs	
E2		12-byte inputs / 20-byte outputs	
E3		104-byte inputs / 20-byte outputs	

Module versions with selectable payload variants

Module version	Payload	Address space	Comment
32 I / 20 Q	Payload selectable through payload variants or	32-byte inputs / 20-byte outputs	You can change over the payload variant during operation.

*Ensure that the payload does not exceed the size of the address space of the module version. If necessary, use a module version with a larger address space

Module version	Payload	Address space	Comment
64 I / 20 Q	through user-specific payload*	64-byte inputs / 20-byte outputs	If you use user-specific payload, you write your measured value profile into the AI Energy Meter CT HF with the data record 130. To do this use the WRREC instruction. Information about the structure of data record 130 is available in appendix Structure of the parameter data records 130 / 131 for payload mapping (Page 164).
128 I / 20 Q		128-byte inputs / 20-byte outputs	
256 I / 20 Q		256-byte inputs / 20-byte outputs	

*Ensure that the payload does not exceed the size of the address space of the module version. If necessary, use a module version with a larger address space

4.2.3 Changing over the user data variant during operation

Introduction

You change the payload variant in the output data of each payload variant in byte 0.

The following figure shows to which payload you can change over at various module versions during operation.

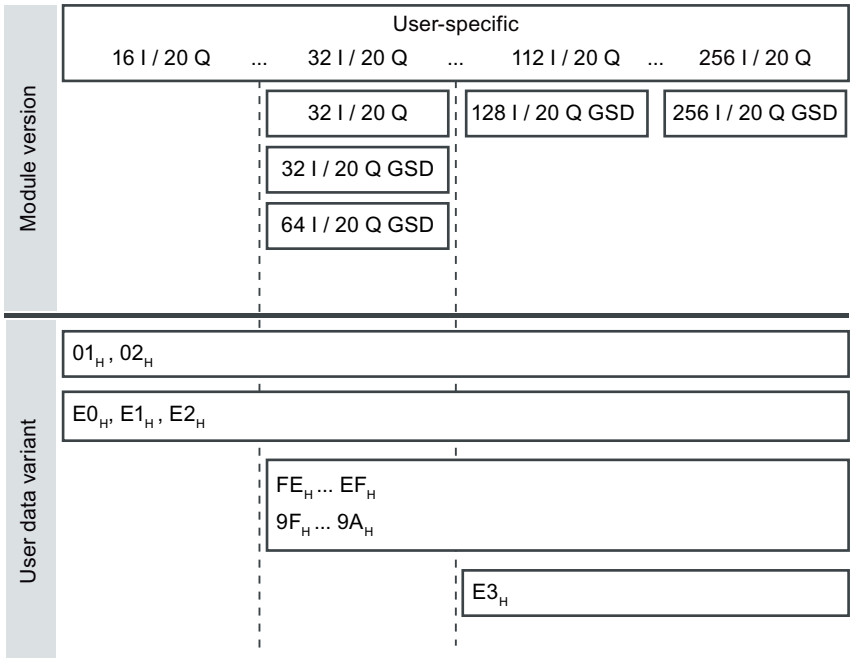

Figure 2-668 Possible payload variants

Requirement

- User program has been created.
- AI Energy Meter CT HF is configured as one of the module versions mentioned in the figure above.
- The start address of the module is known in the process image output.

Procedure

1. Create one constant with the data type BYTE per payload variant.
2. Enter the payload ID as a value in each case.
3. Write the constant to the start address of the module in the process image output.

Result

The payload variant is switched with the next cycle.

NOTE
Information about payload changeover
The parameterized payload variant is set in the following cases:

- A "0" is written in byte 0 in the output data of a payload variant.
- Byte 0 in the output data of a payload variant contains an invalid value:
  - Coding of the payload variant not available
    or
  - Available address space is not sufficient for the selected payload variant.

4.2.4 Recommendations for selecting the module version

The following table shows which module version is suitable for a given purpose.

Module version	Application	Note
2 I / 2 Q	• Use of many AI Energy Meter CT HF in an ET 200SP or when little address space is available	• Read the measured values solely via the RDREC instruction from a measured value data record. • Quality information about the measured values is always available.
EE@Industry measurement data profile E0 / E1 / E2 / E3	• Cyclic measurement per phase • Supplied measured values in accordance with the EE@Industry measured data profile	• Available measured values depend on the configured measurement data profile. • The payload are fixed and cannot be changed dynamically. Alternatively, read the measured values acyclically from a measured value data record via the RDREC instruction. • No quality information

Module version	Application	Note
32 I / 20 Q	• Cyclic measurement per phase • Flexibility by switching pre-defined payload variants	• Quality information about the measured values is always available. • Depending on the payload variant, you must convert the measured values in the CPU to physical values using the supplied scaling factor. • One cycle elapses for each payload changeover. Measured values from the next payload variant are thus supplied with a slight time offset. Alternatively, read the measured values acyclically from a measured value data record via the RDREC instruction. Consistent measured values of a measuring cycle are supplied.
User-specific	• Cyclic measurement of up to 64 measured values configurable • Flexibility by switching pre-defined payload variants	
With GSD configuration • 32 I / 20 Q • 64 I / 20 Q • 128 I / 20 Q • 256 I / 20 Q		

4.3 Applicable modules

Configuring with STEP 7

The following table shows with which controllers the different module versions can be configured with STEP 7.

Table 2-800 Module versions configured with STEP 7

Controller	Module version						
	2 I / 2Q	32 I / 20 Q	User-specific	EE@Industry measurement data profile			
				E0	E1	E2	E3
IM 155-6 PN ST	V3.3 or higher						
IM 155-6 PN HF *	V3.1 or higher						
IM 155-6 PN BA	V3.2 or higher		---	V3.2 or higher			---
IM 155-6 PN HS	V4.0 or higher		---	V4.0 or higher			
IM 155-6 DP HF	V3.0 or higher		---	V3.0 or higher			---
CPU 1510SP-1 PN**	V1.6 or higher		V1.6 or higher*** V2.0 or higher	V1.6 or higher			V2.0 or higher
CPU 1510SP F-1 PN**	V1.7 or higher		V1.7 or higher*** V2.0 or higher	V1.7 or higher			V2.0 or higher
CPU 1512SP-1 PN**	V1.6 or higher		V1.6 or higher*** V2.0 or higher	V1.6 or higher			V2.0 or higher
CPU 1512SP F-1 PN**	V1.7 or higher		V1.7 or higher*** V2.0 or higher	V1.7 or higher			V2.0 or higher
CPU 1515SP PC**	V1.7 or higher		V1.7 or higher*** V2.0 or higher	V1.7 or higher			V2.0 or higher

** Function setting the time as of V4.2

** Function setting the time is not possible

*** Up to a max. of 32 bytes input

Configuring with GSD file

The following table shows with which controllers the different module versions can be configured using a GSD file.

Table 2-801 Module versions configuring with GSD file

Controller	Module version						
	2 I / 2Q	32 I / 20 Q	64 I / 20 Q 128 I / 20 Q 256 I / 20 Q	EE@Industry measurement data profile			
				E0	E1	E2	E3
IM 155-6 PN ST	V3.3 or higher						---
IM 155-6 PN HF	V3.1 or higher						---
IM 155-6 PN BA	V3.2 or higher		---	V3.2 or higher			---
IM 155-6 PN HS	V4.0 or higher		---	V4.0 or higher			---
IM 155-6 DP HF	v4.2 or higher		---	v4.2 or higher			---

Compatibility 5

5.1 Compatibility of modules

Compatibility

The module versions "AI Energy Meter CT ST" and "AI Energy Meter CT HF" are compatible. All module versions can run on the respective other configuration, whereby the CT and RC functionality cannot be swapped.

If you exchange or replace an AI Energy Meter, the following table shows the compatibilities.

	Energy Meter configured		
Energy Meter inserted	**AI Energy Meter CT ST**	**AI Energy Meter CT HF**	**AI Energy Meter 480 VAC CT HF**
AI Energy Meter CT ST	Yes	Yes*	Yes*
AI Energy Meter CT HF	Yes*	Yes	Yes**
AI Energy Meter 480 VAC CT HF	No	No	Yes

*In this case, the module only supports ST functions.

** In this case, the function measured value recorder cannot be configured. The measured values of the following IDs cannot be selected by configuration in the limit value monitoring or in the user-definable data records/payload: 61136, 61137, 61159, 62132, 62135, 62193, 62232, 62235, 62293, 62332, 62335, 62393.

NOTE

The smallest component from configuration and module type determines the resulting scope of functions. This means the ST functionality is supported when either an ST configuration is available, or the ST module is used. An HF functionality, therefore, is only available in case of an HF configuration and HF module.

NOTE

When you install an ST module and use an HF configuration, you must disable the following functions:

- Power quality analysis functions
- Residual current analysis
- Diagnostics power quality
- Overcurrent, detect voltage swell and dip
- Detect peak values of current and voltage
- Harmonics analysis

AI Energy Meter CT HF (6ES7134-6PA01-0CU0) with firmware version V8.0.0

If you want to exchange the hardware and the configuration of the AI Energy Meter 480VAC CT HF V6.0 modules against the corresponding AI Energy Meter CT HF V8.0 modules, then exchange

1. the configuration of V6.0 according to V8.0 and
2. the hardware

If the module does not start correctly after exchanging the AI Energy Meter 480 VAC HF V6.0 configuration to HF V8.0, then

- change one or more module or phase parameters (DS128) and send them to the module again or
- switch off the load voltage of the module at P1 and P2 for a short time and then switch it on again.

Quick start

6

Introduction

This section shows you how to read and view your first measured values on the AI Energy Meter CT HF in a particularly quick and easy way.

Requirement

You have already connected the AI Energy Meter CT HF to your network with one of the connection types shown in the section Connecting (Page 22). The AI Energy Meter CT HF has already been integrated into your configuration tool (such as STEP 7), or the AI Energy Meter CT HF has been integrated in the hardware catalog of your configuration tool with the GSD file.

Procedure

1. Configure an ET 200SP station

   Configure an ET 200SP station with a CPU 151xSP or an IM 155-6.

2. Plug module in ET 200S station

   Plug the AI Energy Meter CT HF into the ET 200SP station and use the module version with 32-byte inputs and 20-byte outputs.

3. Set the module parameters

   Set the following parameters for the AI Energy Meter CT HF:

   – Connection type that you have used for the AI Energy Meter CT HF (e.g. 3P4W)
   – Voltage measuring range
   – Frequency of your network (for example 50 Hz)
   – Nominal value current and nominal value voltage for the phases
   – Primary and secondary current of the current transformer used (e.g. 100 A and 1 A)
   – Primary and secondary voltages of the voltage transformer used (e.g. 230 V and 230 V)

   Leave all other parameters at their default settings and do not change them.

4. Load configuration

   Switch on the ET 200SP station and download the configuration to the CPU.

Result

After being switched on, the AI Energy Meter CT HF supplies the measured values for the "Total power L1L2L3" payload variant with the ID 254 or FE_H.

Read and check the measured values provided by the AI Energy Meter CT HF in the input data.

The table below shows the structure of the payload variant, the measured variables and the data type of the measured values in STEP 7 (TIA Portal) that are stored in the 32 bytes of output data of the module. Each measured variable is referenced via the measured value ID. An overview of all the measured variables with their measured value IDs is provided in the section Measured variables for connection type.

Table 2-802 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
10 ... 11	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038
12 ... 13	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
14 ... 17	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647 to +2147483647	225
18 ... 21	Total reactive energy L1L2L3 (Int32)	DINT	1 varh	-2147483647 to +2147483647	226
22	Reserved	BYTE	-	0	-
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Additional information

If you require further information about the evaluation and interpretation of the measured values, please refer to the section Reading out and processing measured values (Page 44).

Reading and processing measured values 7

7.1 Basics for reading measured values

Introduction

The AI Energy Meter CT HF provides the measured values and variables through the following methods:

- Cyclic: Payload
- Acyclic: Measured value data records

Payload

Payload provide pre-defined or user-defined measured values depending on the configured payload variant. The supplied measured values are cyclically written to the process image of the CPU. With some payload variants, the measured values are supplied as raw data, which you have to convert to the corresponding physical values using a supplied scaling factor.

Measured value data records

Each measured value data record supplies physical values that you can further process immediately. You read the values of a measured value data record acyclically with the RDREC instruction in a PLC tag. You need a corresponding PLC tag for each measured value data record to be read. It is also possible to create the corresponding structure in the static variables of an FB or store this structure in a DB.

You can display the read measured values in a watch table in STEP 7.

NOTE

If you are using CPUs other than S7-1200 or S7-1500, convert 64-bit measured values to 32-bit measured values. Note the conversion can cause loss of accuracy.

For more information, read FAQ: Processing 64-bit floating-point numbers in S7-300/400 (https://support.industry.siemens.com/cs/ww/en/view/56600676).

Validity of the measured values

After turning on the 24 V DC supply voltage, the first measured values are available at terminal 17 after approximately 2 seconds. In the input payload, the content of byte 0 is set to the selected payload variant. You can use this change in byte 0 as a trigger event.

As soon as the module has valid measured values, the value of this byte changes to a value within the value range.

Initial module startup

After the first startup or restart of the module, the parameters are transferred to the module. You can preset a payload variant in the parameters of the hardware configuration. This remains in effect until a different payload variant is selected in the output data (byte 0). This allows input payload to be modified dynamically according to the requirements of the process.

The payload variant defined in parameter data record 128 or configuration tool is used under the following conditions:

- A "0" is written in byte 0 in the output data of a payload variant.
- Byte 0 in the output data of a payload variant contains an invalid value:
  - Coding of the payload variant not available, or
  - Available address space is not sufficient for the selected payload variant.

    See "Selecting the module version (Page 34)".

Current measured values become "0"

The current and all other measured values based on it are suppressed (or set to "0") in the data records and in the payload in the following cases:

- The fed-in current of the current transformer is less than the configured "Low limit for measuring current in relation to nominal value current [0.1%]" parameter.
- Fed-in secondary current at the channel is higher than 12 A.

Among others, the following measured values and derived measured variables of the phase involved become "0":

- Effective current value
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A floating mean value is formed from the power values. These only become "0" after a corresponding time. The operating hours counter and the energy counter for active, reactive and apparent energy of the reset phase stops counting.

General reset

With module versions with 20 bytes of output data you can reset some measured values and counter levels.

An edge change of 0 -> 1 at the bit for the general reset has the following effect:

- Counters for energy, operating hours and limits start at "0" again.
- Results of the power quality analysis and the power failure analysis are deleted.
- Minimum and maximum value calculation starts again with initial values.
- Measured values of the measured value recorder are deleted.

For the general reset, set bit 7 in byte 16 of the output payload. (Page 206)

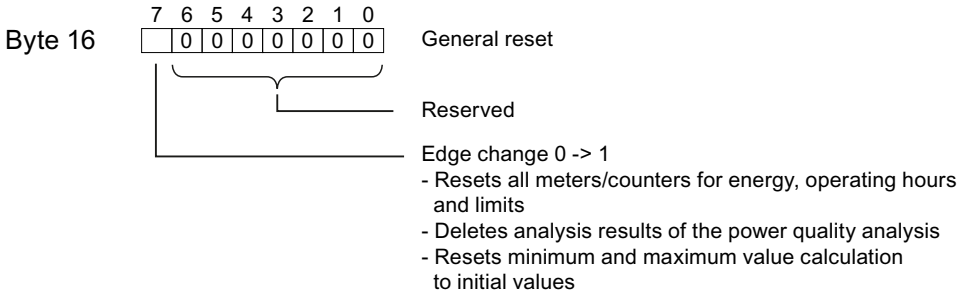

Figure 2-669 Control byte 16 in the output payload for general reset

Substitute value behavior

The substitute values for input values of the AI Energy Meter CT HF are "0".

See also

Reading measured values from user data cyclically (Page 53)

7.2 Quality information

Use the quality information to evaluate the status for currents, voltage, operating quadrants and the rotating field.

The AI Energy Meter CT HF provides quality information:

- In byte 1 of the payload
- In measured value IDs 65500 to 65503
- In the power quality analysis Qualifier ID 65496 (Page 101)

See also

Module version "32 I / 20 Q" (Page 206)

7.2.1 Quality information in byte 1 of the user data

For all user data variants, the module provides brief quality information in an 8-bit field in byte 1 for:

- Currents (I_{L1}, I_{L2}, I_{L3})
- Voltages (U_{L1}, U_{L2}, U_{L3})
- Operating quadrant for a phase

Please note that quality information assignment with user data variants for phase-specific measurement (ID 154 to ID 159) is different from user data variant assignment for 3-phase measurement (ID 244 to ID 254).

Quality information in byte 1 of the user data for 3-phase measurement

The quality information for 3-phase measurement is provided by the module in user data variants ID 244 to ID 254.

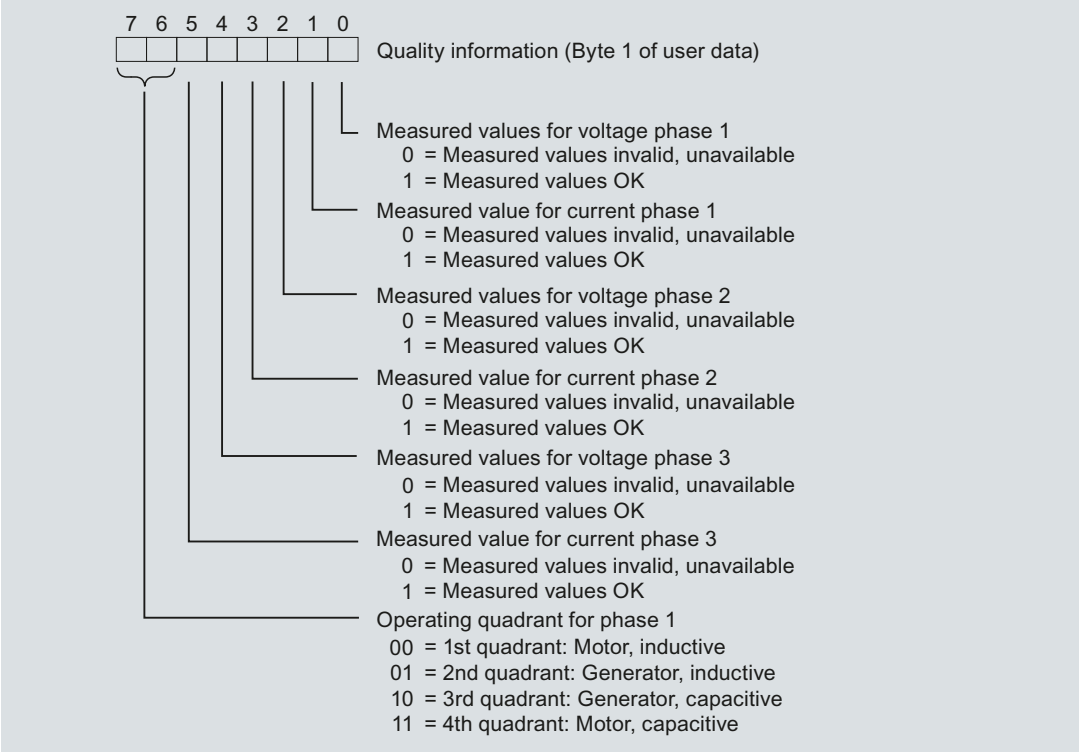

Figure 2-670 Assignment of byte 1 for user data variants ID 224 to ID 254

Quality information in byte 1 for phase-specific measurement

The quality information for phase-specific measurement is provided by the module in user data variants ID 154 to ID 159.

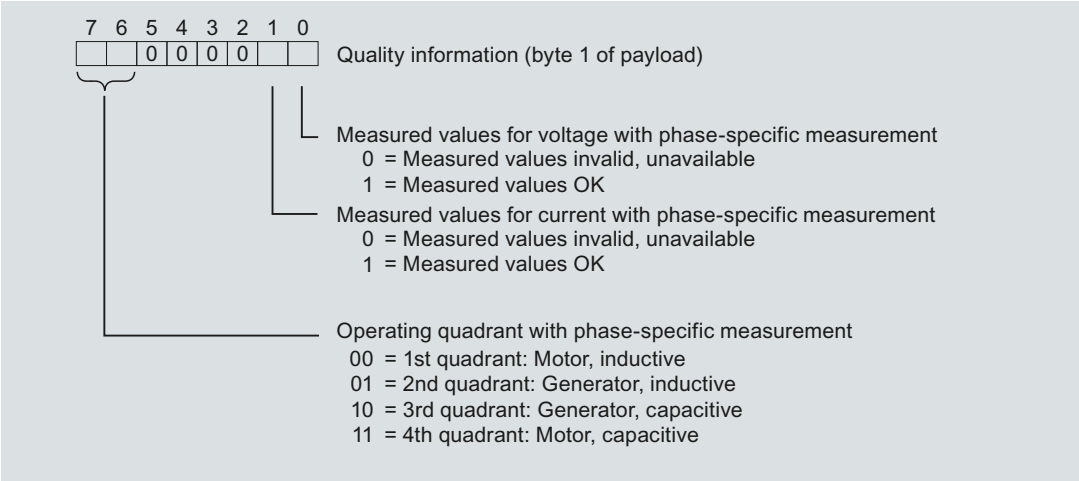

Figure 2-671 Byte 1 assignment for user data variants ID 154 to ID 159

7.2.2 Quality information with measured value IDs

Complete quality information is provided by the module in a 16-bit field with measured value IDs 65500 to 65503.

- Measured value ID 65503 for 3-phase measurement
- Measured value ID 65500, 65501 or 65502 for phase-specific measurement in phase 1, phase 2 or phase 3

Quality information with measured value ID 65503 for 3-phase measurement

The quality information for 3-phase measurement is provided by the module with:

- User data variant "Basic variables quality values three-phase measurement (ID 240 or $F0_H$)
- User data (measured value ID 66503)
- Measured value data record 150

The measured value ID 65503 provides information on:

- Currents (I_{L1}, I_{L2}, I_{L3})
- Voltages (U_{L1}, U_{L2}, U_{L3})
- Operating quadrants for all 3 phases
- Rotating field for the 3-phase system

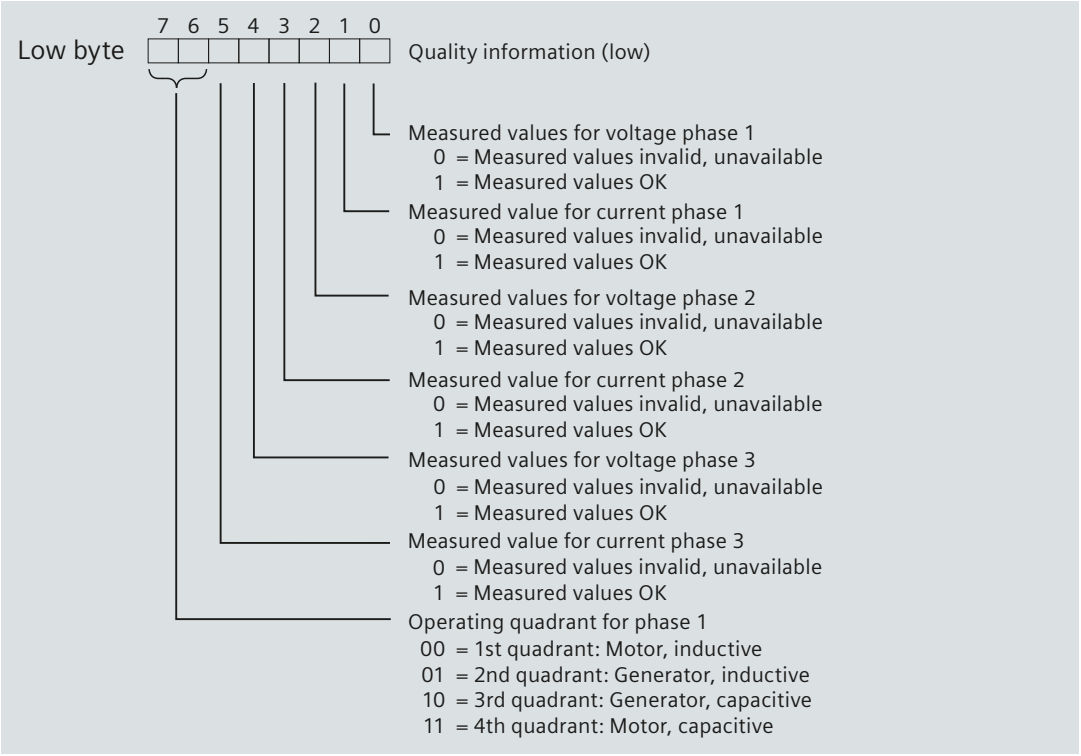

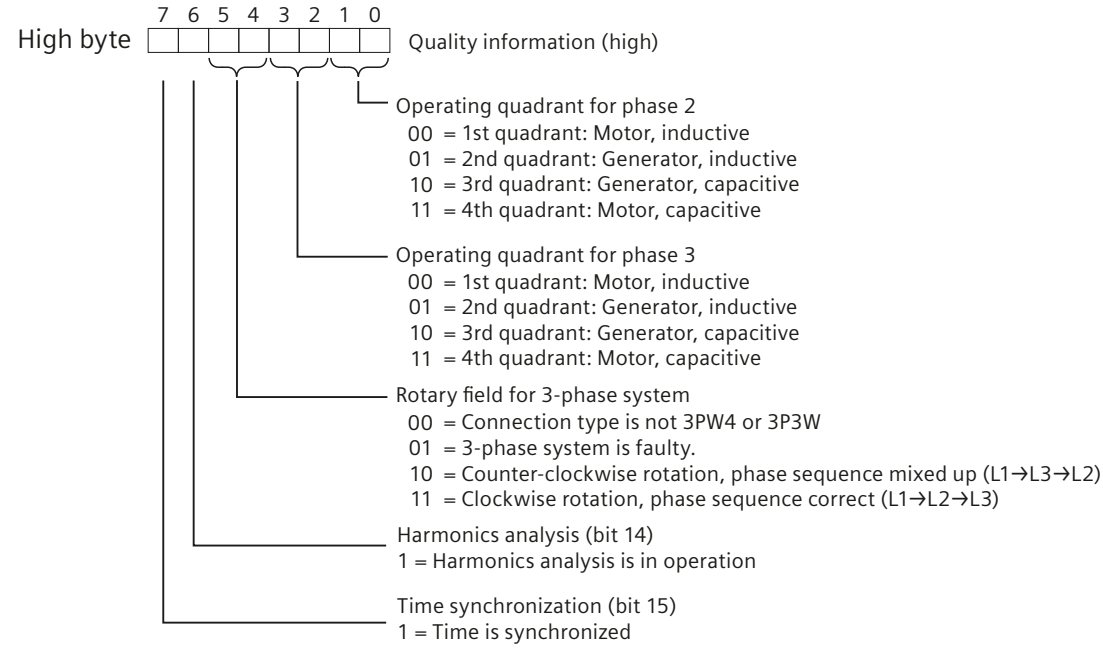

Figure 2-672 Quality information for low and high byte of the measured value ID 65503

Quality information with measured value ID 65500, 65501 or 65502 for phase-specific measurement

The module provides quality information for phase-specific measurement in phase 1, phase 2 or phase 3 with:

- User data (with measured value ID 65500, 65501 or 65502)
- Measured value data record DS 147, 148 or 149

Measured value IDs 65500, 65501 and 65502 provide information on:

- Current of the phase in question
- Voltage of the phase in question
- Operating quadrant of the phase in question

In contrast to the assignment for measured value ID 65503 (figure above), measured value IDs 65500, 65501 and 65502 only contain the phase-specific information for current, voltage and operating quadrant. The information about the other phases and the rotating field have the value 0.

7.2.3 Operating quadrant

The figure below shows the quality information of the operating quadrants.

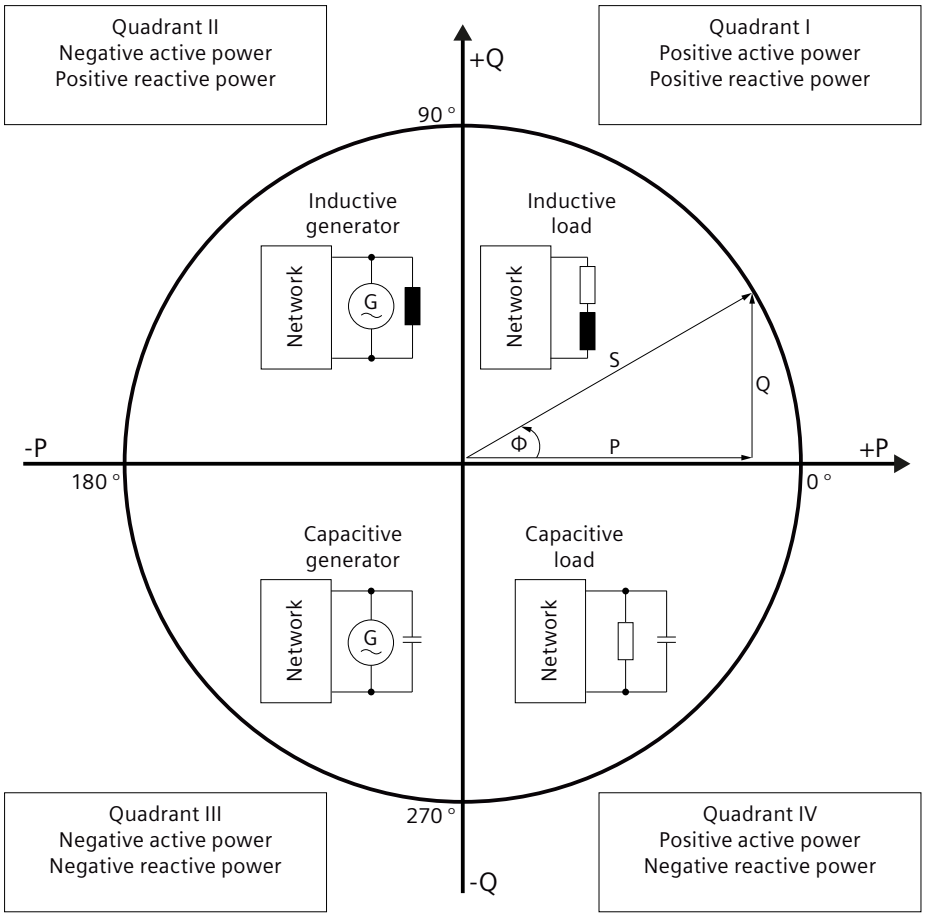

Figure 2-673 Quadrant in the quality bits

7.2.4 Notes for the detection of wiring errors and incorrect rotating field

A variety of quality information is available to evaluate the correct wiring of the Energy Meter and the applied rotary field.

Requirement

Detecting the rotating field requires 3-phase operation with 3P4W or 3P3W connection types.

In byte 1 of the payload, section 7.2.1 or measured value IDs 65500-65503, section 7.2.2

Information on the validity of the measured currents and voltages is encoded in bits 0 to 5.

Information on the operating quadrants is encoded in the bits 6 to 7, see section 7.2.3 (Page 51)

Phase angle between voltages and currents, measured value phase angle Ln

Based on the phase angle, you can recognize whether the flow direction of the current is correct and whether the voltage or current connections have been swapped. You cannot recognize, however, which phases are swapped and how. If the wiring is correct, the phase angle for the consumer must be in the range from 270° to 359° or -0° to -90°. For generators, the phase angle with correct wiring is in the range from 90° to 270° or -180° to -90°.

Angle between the voltages, measured value phase angle ULx-ULy

Based on the phase angle between the voltages, you can check the correct phase sequence and detect an unwanted same-phase connection.

In a symmetrical three-phase network, the angle between the phase voltages is +120°(-240°) or -120°(+240°).

Angle between currents, measured value phase angle ILx-ILy

Based on the phase angle between the currents, you can check the correct phase sequence and flow direction as well as detect an unwanted same-phase connection.

For a symmetrical load, the phase angles between the currents are identical to those between the voltages.

Line-to-line voltage, measured value ULx-ULy

You can detect an unwanted same-phase connection using the line-to-line voltage whose calculation takes into account the angles between the voltage phases.

7.3 Reading measured values from user data cyclically

Requirement

- STEP 7 is open.
- The AI Energy Meter CT HF is configured.

Scaling of measured values in the payload

Since the value range of 16-bit values is often smaller than the value range of the physical value, a scaling factor is supplied together with the basic value in the payload for the respective measured or calculated values. You determine the actual value of the measured variable with the following formula:

Actual value of measured quantity = measured value in the payload x $10^{\text{scaling factor}}$

Procedure

To read measured values from the payload cyclically, proceed as follows:

1. Read the relevant measured value from the input data.
2. Observe the scaling factor at scaled measured values and convert the read measured value using the scaling factor.

Example

The payload variant 254 (FE_H) "Total power L1L2L3" is configured on the AI Energy Meter CT HF. The measured value for "Current L1" should be read.

Table 2-803 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
10 ... 11	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038
12 ... 13	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
14 ... 17	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647 to +2147483647	225
18 ... 21	Total reactive energy L1L2L3 (Int32)	DINT	1 varh	-2147483647 to +2147483647	226

Byte	Allocation	Data type	Unit	Value range	Measured value ID
22	Reserved	BYTE	-	0	-
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

In the payload variant FE_H (254) the measured value for the current L1 is stored in Byte 2 + 3. The current is supplied by the module as a 16-bit-fixed-point number in the value range from 0 to 65535 in the unit 1 mA. In addition the scaling factor for the current L1 has to be considered additionally. The module supplies the related scaling factor in Byte 24.

The actual value for current L1 is calculated as follows:

Actual value for current L1 = Current L1 x $10^{\text{Scaling current L1}}$

See also

Basics for reading measured values (Page 44)

7.4 Read out measured values acyclically using data records

With all module versions you can read out the measured values using data records.

An overview of all measured value data records and exact information about the structure is available in the appendix Overview of all measured value data records.

Requirement

In the STEP 7 project you have created a PLC data type that has an identical structure to the data record you want to evaluate.

Example of the structure of a data record

The following overview shows the structure of the data record DS 142.

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version = 2	UINT8	-	3	-
1	Reserved	UINT8	-	0	-
2...5	Voltage UL1-N	REAL	V	0.0 ... 1000000.0	1
6...9	Voltage UL2-N	REAL	V	0.0 ... 1000000.0	2

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
10...13	Voltage UL3-N	REAL	V	0.0 ... 1000000.0	3
14...17	Voltage UL1-L2	REAL	V	0.0 ... 1000000.0	4
18...21	Voltage UL2-L3	REAL	V	0.0 ... 1000000.0	5
22...25	Voltage UL3-L1	REAL	V	0.0 ... 1000000.0	6
26...29	Current L1	REAL	A	0.0 ... 100000.0	7
30...33	Current L2	REAL	A	0.0 ... 100000.0	8
34...37	Current L3	REAL	A	0.0 ... 100000.0	9
:		:	:	:	:
210...2-13	Neutral current	REAL	A	0.0 ... 100000.0	61149

Procedure

1. Read the desired data record with the RDREC instruction.

   The measured values are in the target range of the data block which you specified with the RDREC instruction.

2. Evaluate the measured values for the desired measured variables.

NOTE

If you want to read or write several data records at the same time in the user program, note that the number of active jobs that you started with the RDREC or WRREC instruction is limited by the resources of the CPU used.

See also

Measured value data record for base measurements (DS 142) (Page 235)

7.5 Time-of-day synchronization and time stamp

The AI Energy Meter CT HF supports time-of-day synchronization and time stamp.

Time-of-day synchronization is only supported by IM 155-6 PN HF as of firmware version V4.2.

Time stamps are used to date the exact occurrence of information. You can find time information in the measured value data records "Measured value data record for maximum values with time stamp (DS 154)" and "Measured value data record for minimum values with time stamp (DS 155)", for example, or the power quality analysis data records DS160, DS161 and DS163. In addition, time information is required for the evaluation of the "Power failure analysis" function (see section Power failure analysis (Page 97)).

For the time on the AI Energy Meter CT HF to correspond to the current system time, the clock must be synchronized externally. Information on this and additional requirements can be found in the application example

(https://support.industry.siemens.com/cs/ww/en/view/109754890). In the absence of time-of-day synchronization, the internal time stamp of the AI Energy Meter CT HF starts at 01.01.1970, 0:00.

Structure of the time stamp

The table below shows the structure of the time stamp:

Byte	PNIO Time	Format	Length
0	Status 0: Synchronization from system time master available 1: Local synchronization available 2: No synchronization available	UINT16	2 bytes
2	Seconds high	UINT16	2 bytes
4	Seconds low	UINT32	4 bytes
8	Nanoseconds	UINT32	4 bytes

The start value (initial value) is 01.01.1970, 0:00.

NOTE

If you use the implementation from the FAQ, the status is always 2.

Energy counters

8

Introduction

The AI Energy Meter CT HF provides several energy and overflow counters that detect both line-based and phase-based energy values, e.g.:

- Active energy (total, outflow, inflow)
- Reactive energy (total, outflow, inflow)
- Apparent energy (total)
- "Output" describes the regenerative operation of the connected system.
- "Reference" describes the motor operation of the connected system.

Retentivity

The AI Energy Meter CT HF stores all counter values retentively. After an interruption (e.g. Power System Off), the energy counting resumes with the retentively stored values.

Functions

The energy meters provide the following basic functions:

- Measured values for infinite and periodical counting can be read out

  End values for periodic counting: 10^3, 10^6, 10^9, 10^{12} and 10^{15} can be selected with overflow counters
- Measuring ranges can be changed in RUN
- Starting and stopping counters via gate is possible
- Preset and apply start values in RUN
- Measured variables can be evaluated via data records and payload.

8.1 Evaluate measured values for energy

There are two ways of evaluating the measured values:

- Reading measured values using the instruction "RDREC".
- Reading measured values from the payload variants (not for module versions with 2 bytes of input data).

Data records for energy meters

You can read out measured values for energy and overflow counters in the following data records.

The evaluation of measured data using data records is described in section Reading out measured values ayclically using data records (Page 54).

Name of the data record	Number of the data record	Comment
Data record for basic measured values (Page 235)	Data record 142	Measured values of the total energy L1L2L3
Data record for energy meter (Page 241)	DS 143	Measured values of energy and overflow counters for phases L1, L2 and L3
Data record for phase-specific measured values L1 (Page 249)	DS 147	Measured values of the phase-specific energy meters L1
Data record for phase-specific measured values L2 (Page 253)	DS 148	Measured values of the phase-specific energy meters L2
Measured value data record for phase-specific measured values L3 (Page 256)	DS 149	Measured values of the phase-specific energy meters L3

Payload variants for energy meters

You can read out measured values for energy and overflow meters in the following payload variants.

The evaluation of measured data using payload variants is described in section Reading measured values cyclically from payloads (Page 53).

Name of the payload variant	Number of the payload variant	Comment
Total energy L1 L2 L3	ID 249 or $F9_H$	Measured values of the total energy L1L2L3
Energy L1	ID 248 or $F8_H$	Measured values of the phase-specific energy meters L1
Energy L2	ID 247 or $F7_H$	Measured values of the phase-specific energy meters L2
Energy L3	ID 246 or $F6_H$	Measured values of the phase-specific energy meters L3
Basic variable quality measurement three-phase measurement	ID 240 or $F0_H$	Status on the overflow of the energy meters for phases L1, L2 and L3
Basic variables energy meter measurement (periodic) L1L2L3	ID 239 or EF_H	Number of counter overflows for energy of phases L1, L2 and L3
EE@Industry measurement data profile E3	ID 227 or $E3_H$	Measured values for total active energy and total reactive energy L1L2L3
EE@Industry measurement data profile E2	ID 226 or $E2_H$	Measured values for total active energy L1L2L3

Name of the payload variant	Number of the payload variant	Comment
Basic variables for phase-specific measurement L1	ID 159 or $9F_H$	Measured values for phase-specific active, reactive and apparent energy for phase L1
Basic variables for phase-specific measurement L1a	ID 158 or $9E_H$	Measured values for phase-specific active, reactive and apparent energy for phase L1
Basic variables for phase-specific measurement L2	ID 157 or $9D_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L2
Basic variables for phase-specific measurement L2a	ID 156 or $9C_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L2
Basic variables for phase-specific measurement L3	ID 155 or $9B_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L3
Basic variables for phase-specific measurement L3a	ID 154 or $9A_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L3
User-defined payload variant	ID 1 or 01_H and ID 2 or 02_H	Measured variables for energy can be selected in a user-defined manner

8.2 Preset and apply start values for energy and overflow counters

At the beginning of a new work order, it may be useful to start the energy and overflow counter with new start values.

Define the new start values for the energy and overflow counter in data record DS 143.

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

For **all** module versions there are two ways of applying the start values:

- Transfer start values from data record DS 143 and apply them **immediately**
- Transfer start values from data record DS 143 and only apply them after setting a special bit (DQ bit for counter reset)

Both options are described in the following sections.

General reset

With module versions with 20 bytes of output data you can reset the energy and overflow counters. With a general reset, you cannot preset any start values; the start values for energy and overflow counters are always zero with a general reset.

You can find additional information on the general reset in the section Basics for reading measured values (Page 44).

8.2.1 Preset start values for the energy meters

Define the start values for the energy and overflow meters in data record DS 143.

Introduction

You have created a PLC data type that has an identical structure to data record DS 143.

Structure of data record DS 143

The following overview shows the structure of the data record DS 143 in simplified form.

More detailed information about the structure of data record DS 143 is available in section Structure of energy meters (DS 143) (Page 241).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Control byte 1 - L1	BYTE	Bit string	-	-
3	Control byte 2 - L1	BYTE	Bit string		
4	Control byte 1 - L2	BYTE	Bit string		
5	Control byte 2 - L2	BYTE	Bit string		
6	Control byte 1 - L3	BYTE	Bit string		
7	Control byte 2 - L3	BYTE	Bit string		
8...15	Start value for active energy inflow L1	LREAL	Wh	You will find the exact assignment in the section Structure of energy meters (DS 143) (Page 241).	61180
16...23	Initial value active energy outflow L1	LREAL	Wh		61181
:	:	:	:		:
128...1-29	Start value for overflow counters active energy inflow L1	UNIT	-		61190
130...1-31	Start value for overflow counter active energy outflow L1	UNIT	-		61191
:	:	:	:		

Assignment of data record DS 143

Byte 0 and Byte 1: Version of the data record

Header information for the version of the data record.

Byte 2 ... Byte 7: Control bytes for energy and overflow counter

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy meters, overflow counters and operating hours counters. The length of the control information amounts to 2 bytes for each phase.

Byte 8 ... Byte 127: Start values for the individual energy meters

The start values for energy meters in data record 143 are 64-bit floating point numbers. The format corresponds to the data type LREAL in S7-1200 and in S7-1500.

Byte 128 ... Byte 157: Initial values for overflow counters

The initial values for overflow counters in data record 143 are 16-bit integers. The format corresponds to the data type UINT in S7-1200 and in S7-1500.

8.2.2 Apply start values from data record DS 143 immediately

It is possible to apply the start values for energy counters and overflow counters for each **individual** phase separately by active, reactive and apparent energy.

Requirement

In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and you have entered the start values.

Procedure for all module versions

1. In control byte 2 of the DS 143 (bytes 3, 5 and 7), for each phase set the category of the energy meters (active, reactive, apparent energy) for which you want to set the start values.

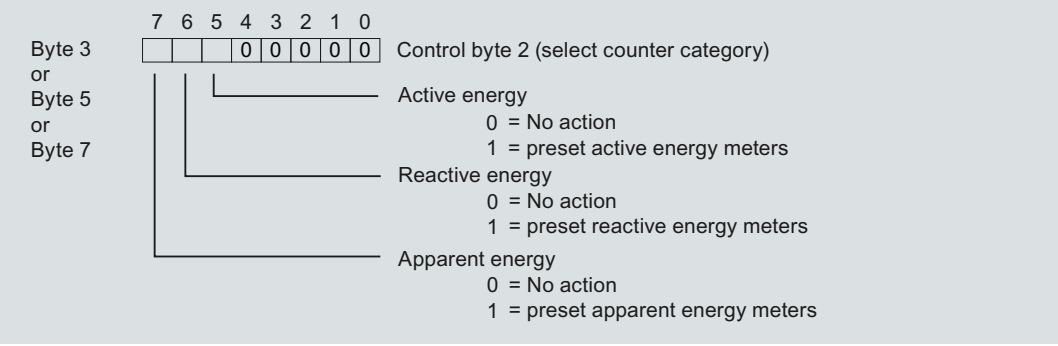

Figure 2-674 Assignment of control byte 2 in DS 143

2. In control byte 1 of DS 143 (bytes 2, 4 and 6), for each phase define whether you want to apply the start values for energy or overflow counters.

   Applying depends on the category selection from control byte 2.

   – Set Bit 0 if you want to apply the start values for the overflow counters.
   – Set Bit 2 if you want to apply the start values for the energy meters.

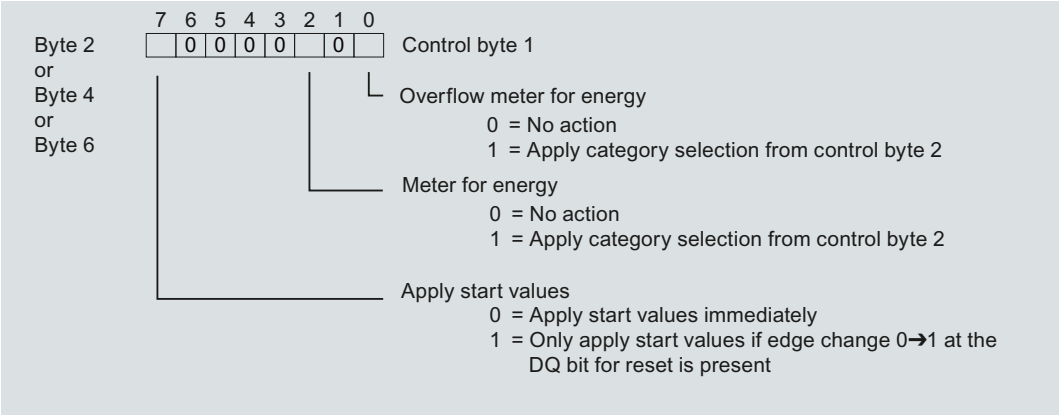

Figure 2-675 Assignment of control byte 1 in DS 143

3. In control byte 1 of DS 143 define that you want to immediately apply the start values.
   – Set Bit 7 to 0 so that the start values are immediately applied after writing the data record.
4. Transfer the data record with the WRREC instruction to the CPU.

8.2.3 Apply start values from data record DS 143 with DQ bit

Due to the differing lengths of the output data, setting of the start values for the energy counters and overflow counters depends on the configured module version.

Module versions with 20 bytes of output data

If you use module versions with 20 bytes of output data, you can:

- Apply start values for energy counters and overflow counters for **all** phases separately by active, reactive and apparent energy.
- Apply start values for energy counters and overflow counters for each **individual** phase separately by active, reactive and apparent energy.

Module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, then you always apply the start values for **all** the energy counters and overflow counters simultaneously.

Requirement

- In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and have entered the start values.

  Applying depends on the category selection from control byte 2.

  – Set Bit 0 if you want to apply the start values for the overflow counters.

  – Set Bit 2 if you want to apply the start values for the energy meters.
- In control byte 1 of the DS 143 you have set Bit 7 to "1" (apply start values via DQ bit)
- You have transferred the data record DS 143 with new start values to the CPU. The assignment of the data record can be found in Structure of energy meters (DS143) (Page 241).

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

Procedure for module version with 20 bytes of output data

Apply start values for energy counters and overflow counters for all three phases

1. In Byte 2 of the output data, select the categories for which you want to apply start values.

   – Set bit 5 for active energy counters.

   – Set bit 6 for reactive energy counters.

   – Set bit 7 for apparent energy counters.

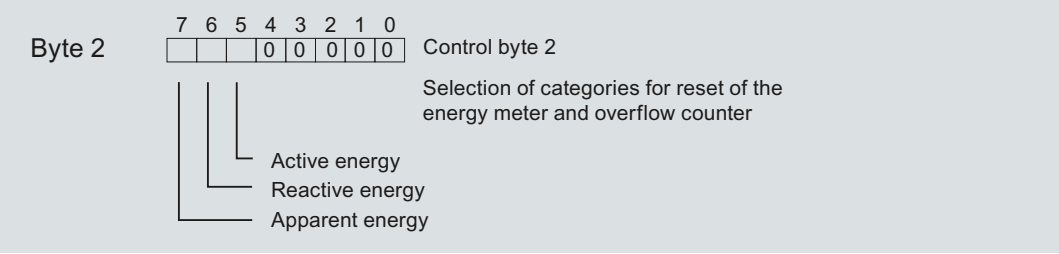

Figure 2-676 Selection of categories for reset

2. Set the reset bit (Bit 7) in byte 1 of the output data.

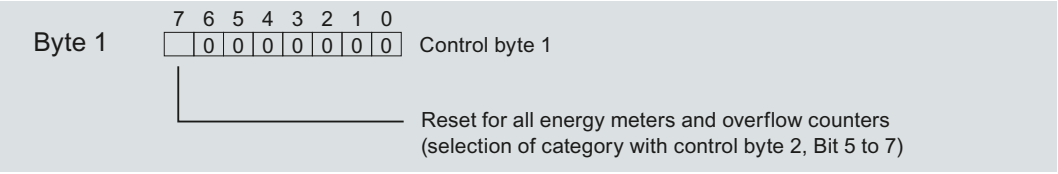

Figure 2-677 Reset bit for energy and overflow counter

If there is an edge change of the reset bit from 0 -> 1, the module resets the energy and overflow counters that you previously selected in byte 2 to their start values.

Apply start values for energy counters and overflow counters for phase-specific counting

You can also reset the energy and overflow counters on a phase-specific basis using the output data.

Follow the procedure as described in "Applying start values for energy counters and overflow counters for all three phases", as applicable.

1. In bytes 7, 9 and 11 of the output data, select the categories for which you want to apply the phase-specific start values.
   - Set Bit 5 for active energy counters.
   - Set Bit 6 for reactive energy counters.
   - Set Bit 7 for apparent energy counters.

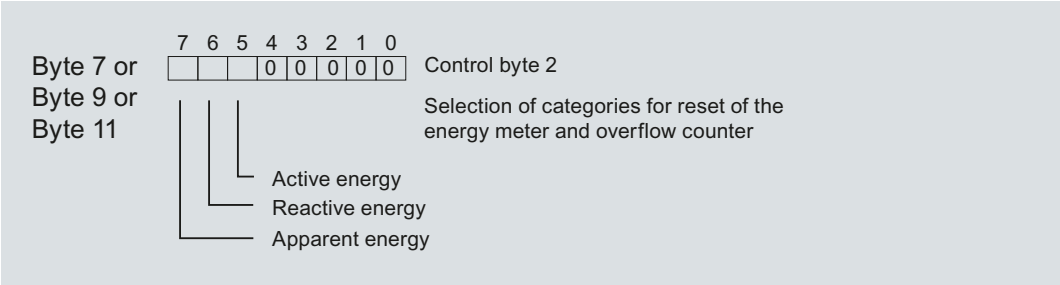

Figure 2-678 Selection of category

2. In bytes 6, 8 and 10 of the output data, set the reset bits (Bit 7) for the phase-specific start values.

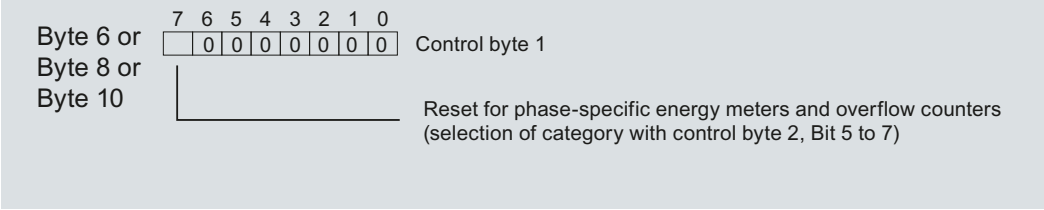

Figure 2-679 Reset bit for phase-specific energy and overflow counters

If there is an edge change of the phase-specific reset bit from 0 -> 1, the module resets the energy and overflow counters that you previously selected in bytes 7, 9 and 11 to their start values.

Procedure for module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, always apply the start values **for all** the energy counters and overflow counters.

- Set the reset bit (Bit 7) in byte 1 of the output data.

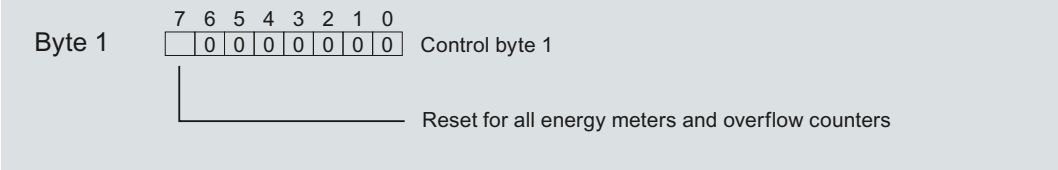

Figure 2-680 Reset bit for all energy and overflow counters

If there is an edge change of the reset bit from 0 -> 1, the module resets **all** energy and overflow counters to their start values.

8.3 Starting and and stopping energy meters

There are two ways of starting or stopping measurement with the energy meter AI Energy Meter CT HF:

- Counting with gate

  The module starts counting when you set the DQ bit for the counter gate in the output data using an edge change from 0 -> 1. If you reset the DQ bit using an edge change from 1 -> 0, the counter stops.

- Counting without gate

  The module starts counting immediately as soon as the module is switched on. Counting cannot be stopped.

Both options are described in the following sections.

Counting with gate

Requirements:

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

If you wish to start counting using the gate, proceed as follows:

1. Activate the parameter "Enable energy meter gate" in the parameter assignment of the module.
2. Set the DQ bit for the counter gate (Bit 6) in control byte 1 in the output data.

The module starts counting as soon as there is an edge change from 0 -> 1 at the DQ bit for the counter gate.

If you wish to stop the counting again, then reset Bit 6 in control byte 1 in the output data. Counting stops at an edge change from 1 -> 0.

The "Enable gate control for the energy counter" parameter and the DQ bit for the "counter date" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

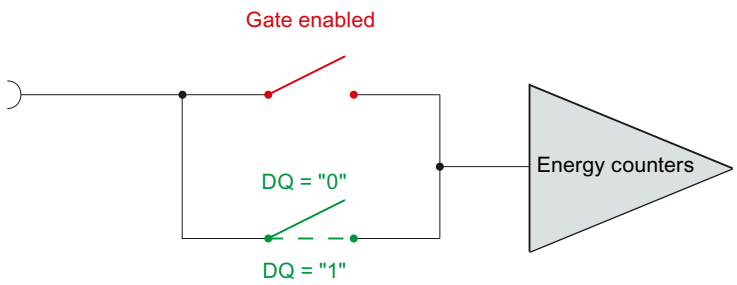

Figure 2-681 Gate enabled

NOTE

Module-global/phase-granular PLC

If you are using the gate control for all three phases simultaneously, use the control byte 1 at output address 1. For a phase-specific resolution of the gate control, use the addresses 6 (Phase1), 8 (Phase2) or 10 (Phase3) as control byte 1. The resolution of a module-global PLC overrules a phase-granular resolution.

Counting without gate

Requirement

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

Deactivate the parameter "Enable energy meter gate" in the parameter assignment of the module.

The module starts counting as soon as the module is started. The counter continues to count.

Gate disabled: Gate is always "open" (signal path closed)

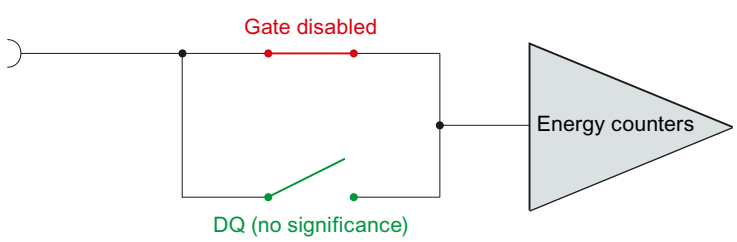

Figure 2-682 Gate disabled

8.4 Example of measuring and resetting an energy meter

The following figure shows resetting and starting/stopping with activated gating using the energy meter as an example:

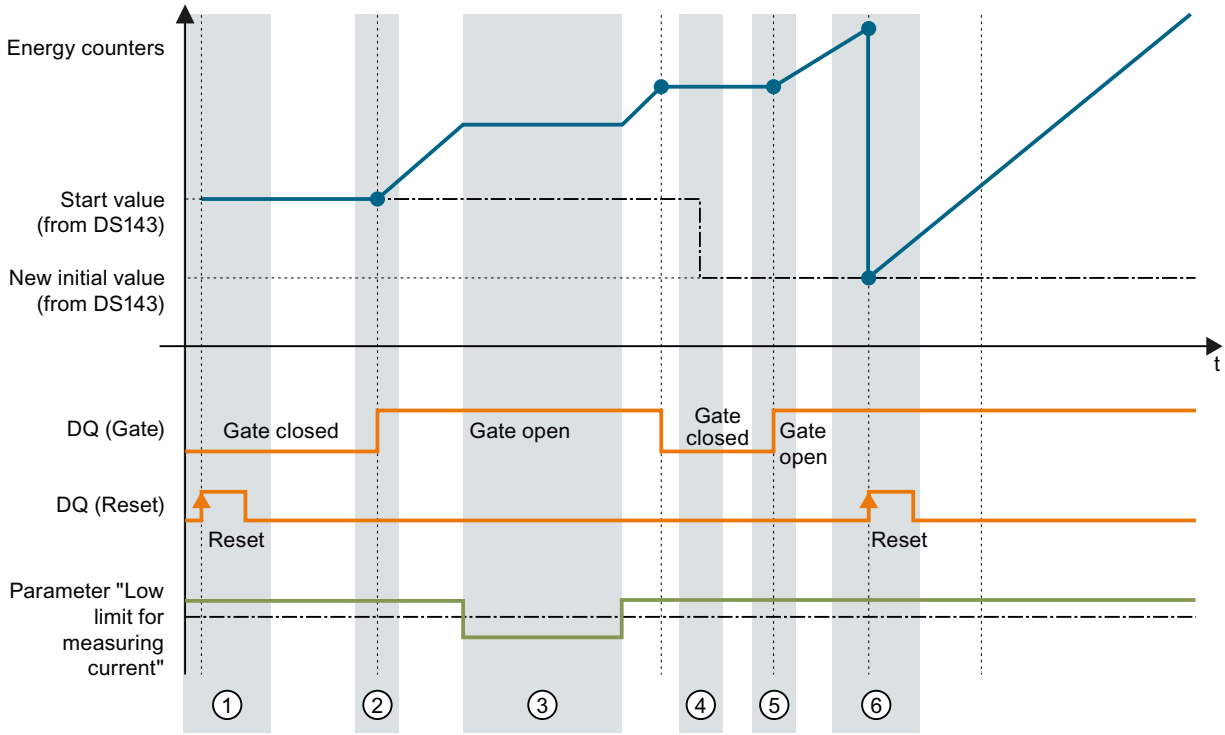

① The counter is reset to the value specified in the configuration. The gate is closed. The counter does not count.

② The gate is opened via the control byte 1 in the output data of the user data variant. The counter counts.

③ The configured current low limit has been violated. The counter does not count.

④ The gate is closed. The counter does not count. A new start value is written to the measured value data record 143 (Page 241) with the WRREC instruction.

⑤ The gate is opened again via the control byte 1 in the output data of the user data variant. The counter counts with the new start value.

⑥ The counter is reset via the control byte 1 in the output data of the user data variant. The counter counts from the new start value that was transferred via the measured value data record 143.

Figure 2-683 Example of an energy meter

8.5 What is the structure of the control and feedback interface for DS 143?

Introduction

Bytes 2 to 7 of data record 143 (Page 241) form the phase-based control and feedback interface for the data record DS 143.

- Bytes 2 and 3: Control and feedback interface for phase 1
- Bytes 4 and 5: Control and feedback interface for phase 2
- Bytes 6 and 7: Control and feedback interface for phase 3

Status information

When data record 143 is read with the RDREC instruction, Bytes 2 to 7 supply phase-specific status information for energy counters, overflow counters and operating hours counters.

The status information enables you can see which counters are returning their values in the data record 143. If energy counters return their values in the status byte 1, you can determine the type of energy counter with status byte 2.

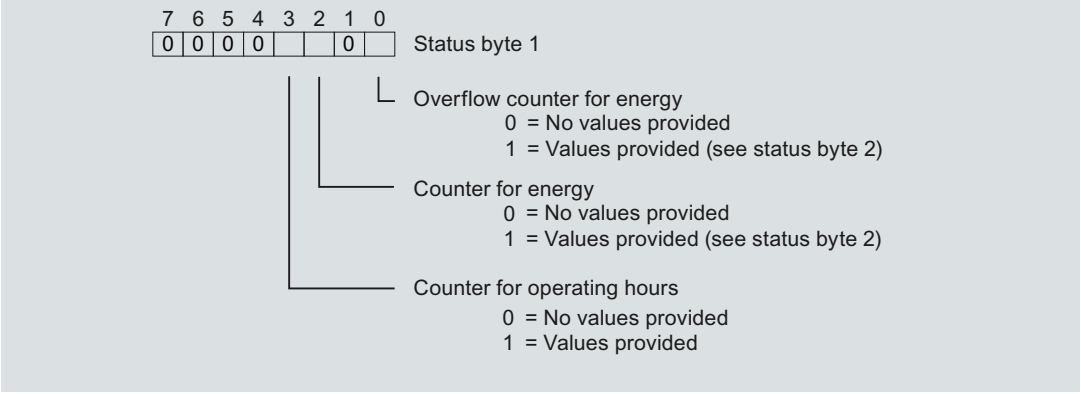

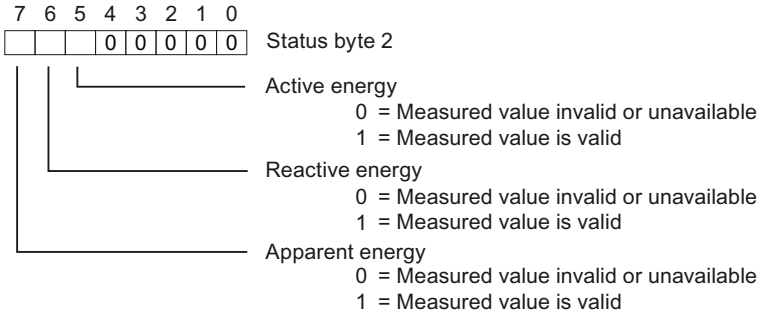

Figure 2-684 Status information DS 143 (read access)

Control information

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy meters, overflow counters and operating hours counters. The length of the control information amounts to 2 bytes for each phase:

- In control byte 1 you determine which counter you want to preset and the time at which counters are to be preset.

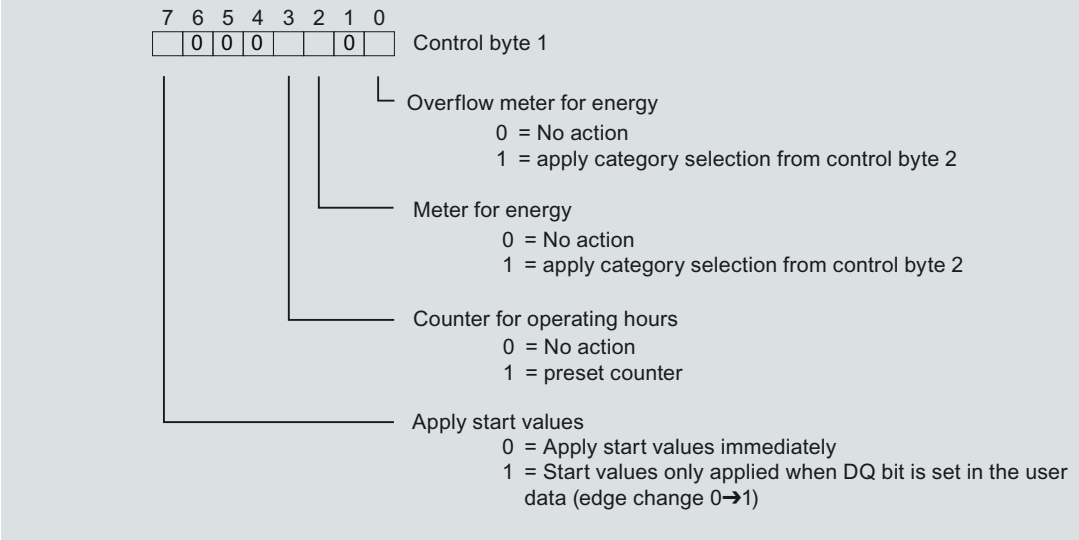

Figure 2-685 Control information DS 143, control byte 1 (write access)

- In control byte 2 you determine which energy meter categories you want to preset.

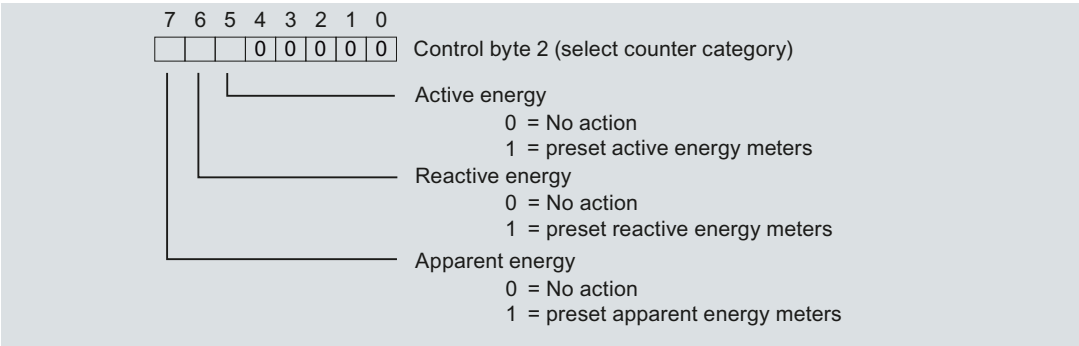

Figure 2-686 Control information DS 143, control byte 2 (write access)

Operating hours counter

9

Introduction

The AI Energy Meter CT HF provides four operating hours counters which count the operating hours of the connected consumers:

- Three phase-specific operating hours counters
- 1 operating hours counter which displays the value of the largest phase-specific operating hours counter.

Retentivity

The AI Energy Meter CT HF stores all counter values retentively. After an interruption (e.g. Power System Off), counting resumes with the retentively stored values.

Functions

The operating hours counters provide the following basic functions:

- Measuring ranges from 0 to 3.4×10^{38} hours.
- Starting and stopping operating hours counters via gate
- Preset and apply start values in RUN
- Evaluating counter states using data records and payload

9.1 Evaluating operating hours counters

There are two ways of evaluating the operating hours counters:

- Reading counter states using data records with the instruction RDREC.
- Reading counter states from the user-defined payload variants.

Data records for operating hours counter

You can read out measured values for operating hours in the following data records.

The evaluation of measured data using data records is described in section Reading out and processing measured values (Page 44).

Name of the data record	Number of the data record	Comment
Data record for energy meter (Page 241)	DS 143	Phase-specific operating hours counter for phase L1, phase L2, phase L3 and largest phase-specific operating hours counter L1L2L3
Measured value data record for advanced measurement and status values	DS 150	
Measured value data record of user-defined data record (Page 262)	DS 151	Operating hours counters can be selected in a user-defined manner

Payload variants for operating hours counters

You can read out measured values for operating hours in the following payload variants.

The evaluation of measured data using payload variants is described in section Payload variants (Page 218).

Name of the payload variant	Number of the payload variant	Comment
User-defined payload variant	ID 1 or 01_H and ID 2 or 02_H	Operating hours counters can be selected in a user-defined manner

9.2 Preset and apply start values for operating hours counters

Introduction

At the beginning of a new work order, it may be useful to start counting of the operating hours counters with new start values.

Define the new start values for the operating hours counters in data record DS 143.

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

For **all** module versions there are two ways of applying the start values:

- Transfer start values from data record DS 143 and apply them **immediately**
- Transfer start values from data record DS 143 and only apply them after setting a special bit (DQ bit for operating hours counter reset)

Both options are described in the following sections.

General reset

With module versions with 20 bytes of payload you can reset the operating hours counters. With a general reset, you cannot preset any start values; the start values for operating hours counters are always zero with a general reset.

You can find additional information on the general reset in the section Basics for reading measured values (Page 44).

9.2.1 Preset start values for operating hours counters

Define the start values for operating hours counters using data record DS 143.

Introduction

You have created a PLC data type that has an identical structure to data record DS 143.

Structure of data record DS 143

The following overview shows the structure of the data record DS 143 in simplified form.

More detailed information about the structure of the data record 143 is available in section Structure of energy meters (DS 143) (Page 241).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Control byte 1 - L1	BYTE	Bit string	-	-
3	Control byte 2 - L1	BYTE	Bit string		
4	Control byte 1 - L2	BYTE	Bit string		
5	Control byte 2 - L2	BYTE	Bit string		
6	Control byte 1 - L3	BYTE	Bit string		
7	Control byte 2 - L3	BYTE	Bit string		
8...15	Start value for active energy inflow L1	LREAL	Wh	You will find the exact assignment	61180
16...23	Initial value active energy outflow L1	LREAL	Wh		61181
:	:	:	:		:

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
158...161	Start value operating hours L1	REAL	h	in the section Structure of energy meters (DS 143) (Page 241).	65505
162...165	Start value operating hours L2	REAL	h		65506
166...169	Start value operating hours L3	REAL	h		65507

Assignment of data record DS 143

Byte 0 and Byte 1: Version of the data record

Header information for the version of the data record.

Byte 2 ... Byte 7: Control bytes for energy and overflow counter

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy meters, overflow counters and operating hours counters. The length of the control information amounts to 2 bytes for each phase.

Byte 8 ... byte 157: Start values for the individual energy meters and overflow counters

The start values for energy counters in data record 143 are 64-bit floating point numbers. The format corresponds to the data type LREAL in S7-1200 and in S7-1500.

The initial values for overflow counters in data record 143 are 16-bit integers. The format corresponds to the data type UINT in S7-1200 and in S7-1500.

Byte 158 ... byte 169: Start values for operating hours counter

The start values for operating hours counters in data record 143 are 32-bit floating-point number. The format corresponds to the data type REAL in S7-1200 and in S7-1500.

9.2.2 Apply start values from data record DS 143 immediately

Applying the start values for each separate operating hours counter is possible.

Requirement

In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and you have entered the start values.

Procedure for all module versions

1. In Control byte 1 of DS 143 (bytes 2, 4 and 6), for each phase, define that you want to immediately apply the start values for operating hours counters.
   - Set the Bit 3 to 1 so that the start values for the operating hours counters are preset.
   - Set the Bit 7 to 0 so that the module **immediately** applies the start values after writing the data record.

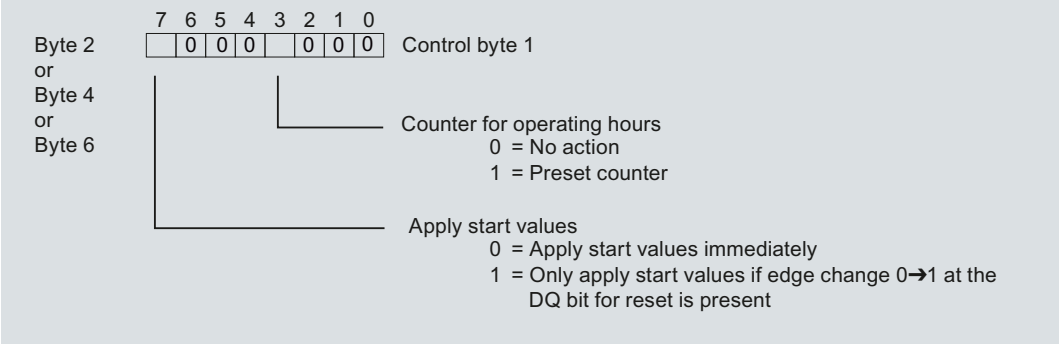

Figure 2-687 Allocation of the control bytes in DS 143 for operating hours

2. Transfer the data record with the WRREC instruction to the CPU.

9.2.3 Apply start values from data record DS 143 with DQ bit

Due to the differing lengths of the output data, setting of the start values for the operating hours counters depends on the configured module version.

Module versions with 20 bytes of output data

If you use module versions with 20 bytes of output data, you can:

- Apply start values for **all** operating hours counters.
- Apply start values for **individual** operating hours counters separately.

Module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, apply the start values for **all** operating hours counters simultaneously.

Requirement

- In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and have entered the start values.
- Set the Bit 3 to 1 so that the start values for the operating hours counters are preset.
- In control byte 1 of DS 143 you have set Bit 7 to "1" (apply start values via DQ bit). (see previous figure)
- You have transferred the data record DS 143 with new start values to the CPU. The assignment of the data record can be found in Structure of energy meters (DS143) (Page 241).

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

Procedure for applying the start values of all operating hours counters

Applying the start values for all operating hours counters with the module versions with 2 bytes and 20 bytes of output data is identical.

1. Set the reset bit for operating hours counters (Bit 5) in Byte 1 in the output data.

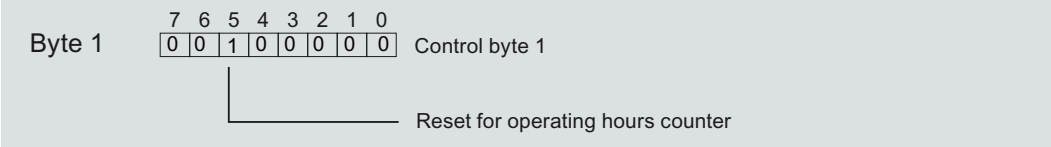

Figure 2-688 Control byte 1 Reset for all operating hours counters

If there is an edge change of the reset bit from 0 to 1, the module applies the start values for all operating hours counters.

Procedure for applying the start values of individual operating hours counters

NOTE

Applying the start values for phase-specific operating hours counters

Applying the start values for phase-specific operating hours counters does not differ from the procedure described above. In the output data, select the reset bits for the phase-specific operating hours counters in bytes 6, 8 and 10.

9.3 Starting and stopping operating hours counters

There are two ways of starting or stopping counting with the operating hours counter AI Energy Meter CT HF:

- Counting with gate

  The module starts counting when you set the DQ bit for the counter gate in the output data using an edge change from 0 -> 1. If you reset the DQ bit for the counter gate using an edge change from 1 -> 0, the counter stops.

- Counting without gate

  The module starts counting immediately as soon as the module is switched on. Counting cannot be stopped.

Both options are described in the following sections.

Counting with gate

Requirements:

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

If you wish to start counting using the gate, proceed as follows:

1. Activate the parameter "Enable operating hours counter gate" in the parameter assignment of the module.
2. Set the DQ bit for the counter gate (Bit 4) in control byte 1 in the output data.

The module starts counting as soon as there is an edge change from 0 -> 1 at the DQ bit for the counter gate.

If you wish to stop the counting again, then reset Bit 4 in control byte 1 in the output data. Counting stops at an edge change from 1 -> 0.

The "Enable operating hours counter gate" parameter and the DQ bit for the "counter date" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

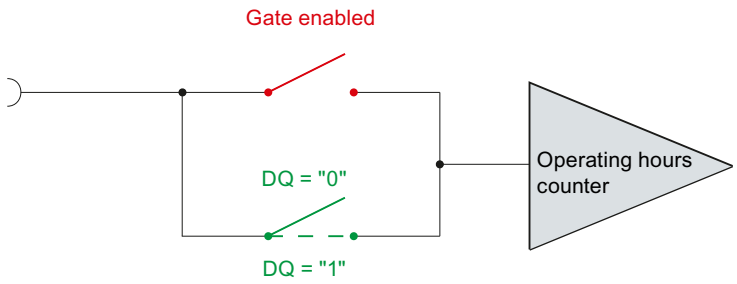

Figure 2-689 Gate enabled

Counting without gate

Requirement

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

Deactivate the parameter "Enable operating hours counter gate" in the parameter assignment of the module.

The module starts counting as soon as the data record has been applied by the CPU.

The counter continues to count.

Gate disabled: Gate is always "open" (signal path closed)

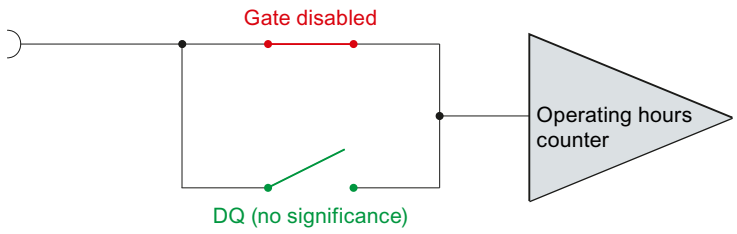

Figure 2-690 Gate disabled

Limit monitoring 10

10.1 How limit monitoring works

Introduction

The AI Energy Meter CT HF supports monitoring of parameterizable low **or** high limits for up to 16 analog measured or calculated variables.

You can also specify multiple limits for each measured or calculated variable, in order to define a high or low value range.

The measured value data record 150 returns the current status of limit violations and one counter per limit that displays the number of limit violations. In addition, a hardware interrupt may be generated for each limit violation.

The status of the limit violations can also be evaluated in the payload variant 240 ($F0_H$) or via the user-defined payload variant or the user-defined data record via the measured value ID 65509.

Benefits

With activated limit monitoring you can already detect any irregularities in the measured value acquisition already in field level.

Retentivity

All the counter states are stored retentively in the AI Energy Meter CT HF. After an interruption (e.g. Power System Off), the counting resumes with the retentively stored values.

Configuring

You configure the following limit monitoring settings in STEP 7:

- Measured variable that is to be monitored.
- Activate / Deactivate limit monitoring.
- Activate / deactivate gate limit monitoring.
- High or low limit values.
- Delay time and hysteresis for each limit.
- Activate / Deactivate hardware interrupts at limit violation.
- Measured value that is subject to limit monitoring.

Hardware interrupt at a limit violation

The hardware interrupt provides the following information:

- Measured value ID of the monitored measured or calculated variable
- Number of the limit (0 = Limit 1. 15 = Limit 16)
- Information on whether limit was exceeded or fallen below

For more detailed information, refer to section Hardware interrupts (Page 120).

Controlling functions in RUN

The following table shows the supported control information:

Control information	Default value	Available in
Enable/disable monitoring per limit[1]	Disabled	Module version with 20 bytes of output data
Reset number of total limit violations	0	Module version starting at 2 bytes of output data

[1] Effective only with enabled gate

10.2 Influence of hysteresis and delay time on limit monitoring

Delay time and hysteresis

In order to prevent the triggering of limit violations with small fluctuations, you have the following configuration options in STEP 7:

- Delay time in seconds (0 to 10 s)

  With the delay time, you filter faults and thereby prevent limit value monitoring from triggering too frequently. The limit violation is counted only when the limit violation is present for longer than the configured delay time. The delay time is also taken into consideration with an outgoing limit violation, directly after a high or low limit has been violated in the permitted range. If the measured variable lies between limit violation and hysteresis after the limit violation has been corrected again, the delay time expires also without leaving the hysteresis.

- Hysteresis as a percentage (0 to 20%)

  With the hysteresis, you suppress fluctuations around the limit. The hysteresis is a tolerance range that you define as a percentage deviation of the configured limit. The limit violation is considered to be corrected only when the monitored value leaves the tolerance range.

NOTE

You can get information about underflow and overflow from the calculation of minimum and maximum values of selected measured variables.

The following figure shows the value-over-time for two measured values using the example of a high and low limit as well as the influence of hysteresis and delay time on the counting of the limit violations.

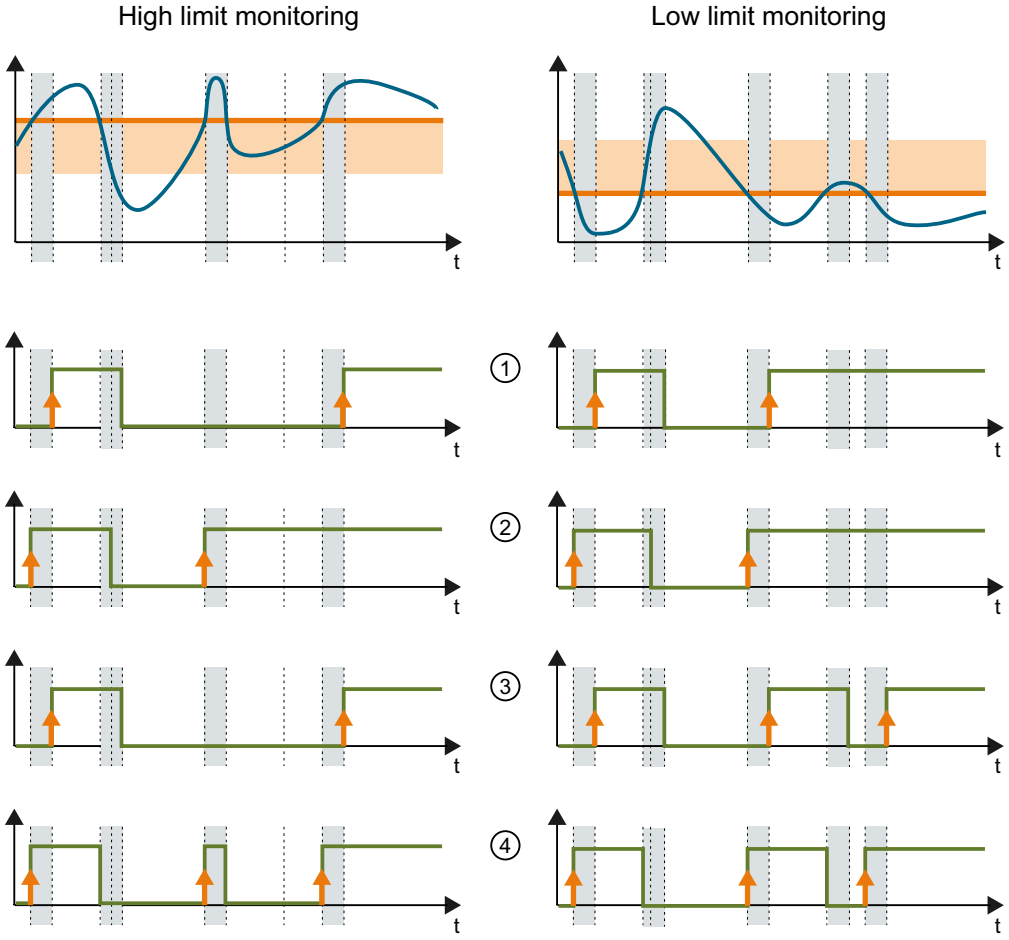

—	Configured limit.	—	Signal wave
▭	Configured delay time. Is taken into consideration during coming and going.	①	Limit monitoring with hysteresis and delay time
▭	Hysteresis range. Only considered for outgoing.	②	Limit monitoring with hysteresis, but without delay time
—	Value-over-time for which the limit is monitored.	③	Limit monitoring without hysteresis, but with delay time
→	Edge change. Counter for limit violations is incremented by 1. If parameterized, a hardware interrupt is triggered.	④	Limit monitoring without hysteresis and delay time

Figure 2-691 Influence of hysteresis and delay time on the limit

See also

How limit monitoring works (Page 78)

10.3 Reset, activate and deactivate counters for limit violation

Introduction

At the beginning of a new work order, it can be useful to reset or also enable/disable the counters for limit violations of the AI Energy Meter CT HF.

Resetting here means that the counters for limit violations are reset to 0.

Due to the differing lengths of the output data resetting of the counters for limit violations depends on the configured module version.

Resetting at module version with 20 bytes of output data

1. Select the counters for limit violations that you want to reset in control bytes 3 and 4; see "Enabling/disabling the counters for limit violations".
2. In control byte 1, set the rest bit (bit 3) with an edge change from 0 to 1; see "Resetting the counters for limit violations".

Resetting for module version with 2 bytes of output data

Set the reset bit (Bit 3) in Control byte 1 from 0 to 1 through an edge change. Resetting acts globally on all the configured counters for limit violation.

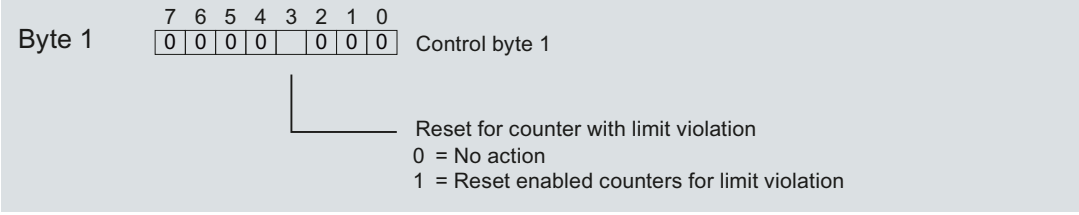

Figure 2-692 Resetting of the counters for limit violations

Activating / Deactivating counters for limit violations

Activating/deactivating of the counters for limit violations is only possible for module versions with 20 bytes of output data.

Requirements: "Gate for limit value monitoring" was parameterized during configuration of the module using STEP 7 or by writing the data record DS 128.

Select the counters for limit violations that you want to activate / deactivate in Control bytes 3 and 4.

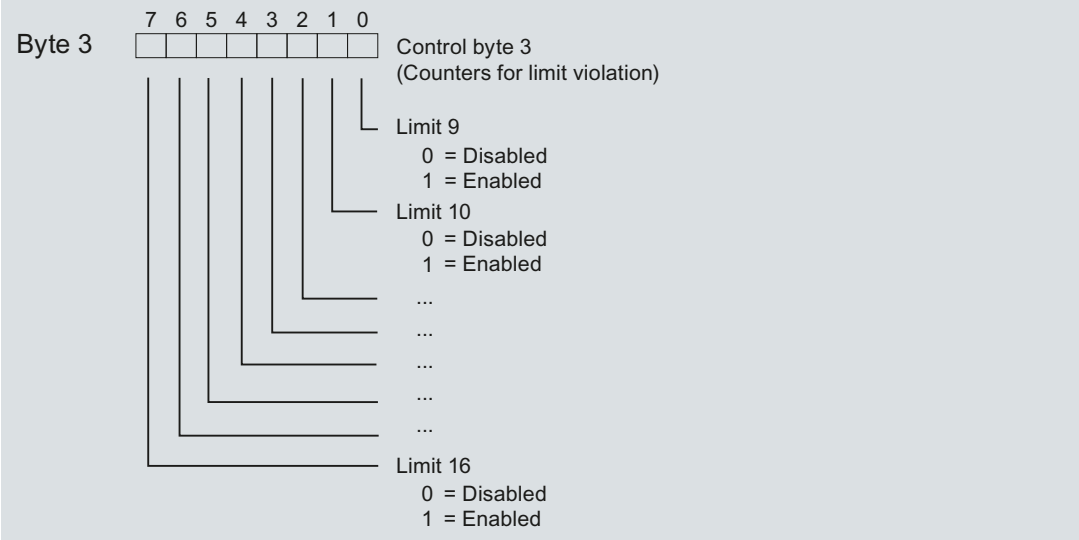

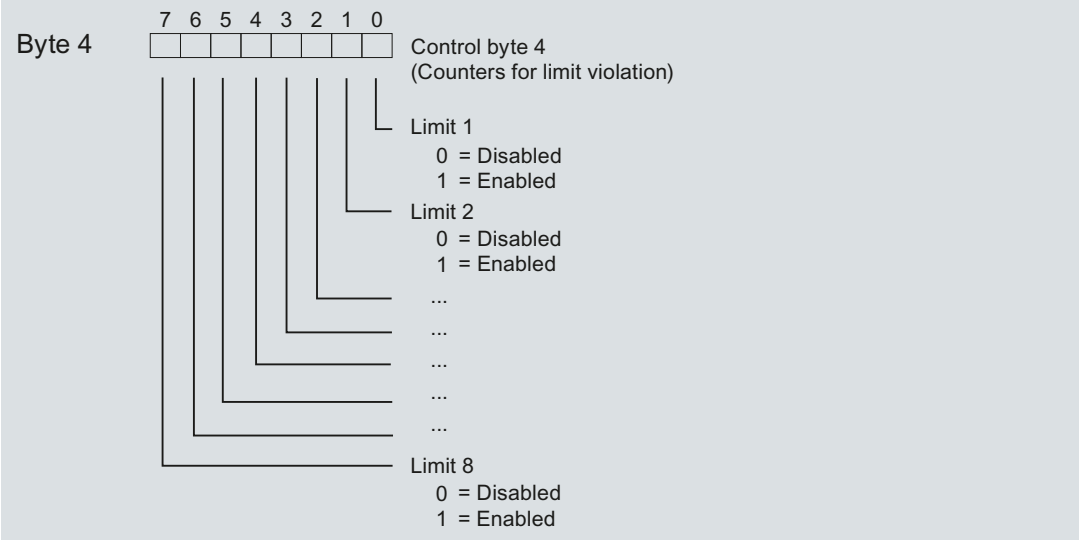

Figure 2-693 Activating / deactivating of the counters for limit violations

10.4 Measured variables for limit monitoring

You can use measured variables from the section Measured variables (Page 175) for limit value monitoring.

The value range of the parameter "Limit x" is -3.0E+09 ... +3.0E+09.

The table below shows you which measured variables are **not** available for limit monitoring.

Measured value ID	Measured variables
220	Active energy inflow L1L2L3 (Int32)
221	Active energy outflow L1L2L3 (Int32)

Measured value ID	Measured variables
222	Reactive energy inflow L1L2L3 (Int32)
223	Reactive energy outflow L1L2L3 (Int32)
224	Apparent energy L1L2L3 (Int32)
225	Total active energy L1L2L3 (Int32)
226	Total reactive energy L1L2L3 (Int32)
61136	Neutral current maximum value
61137	Neutral current minimum value
62110	Active energy inflow L1 (Int32)
62111	Active energy outflow L1 (Int32)
62112	Reactive energy inflow L1 (Int32)
62113	Reactive energy outflow L1 (Int32)
62114	Apparent energy L1 (Int32)
62115	Total active energy L1 (Int32)
62116	Total reactive energy L1 (Int32)
62132	Voltage L1 instantaneous value
62135	Current L1 instantaneous value
62136	Fundamental cos φ active factor L1 (SINT8)
62210	Active energy inflow L2 (Int32)
62211	Active energy outflow L2 (Int32)
62212	Reactive energy inflow L2 (Int32)
62213	Reactive energy outflow L2 (Int32)
62214	Apparent energy L2 (Int32)
62215	Total active energy L2 (Int32)
62216	Total reactive energy L2 (Int32)
62232	Voltage L2 instantaneous value
62235	Current L2 instantaneous value
62236	Fundamental cos φ active factor L2 (SINT8)
62310	Active energy inflow L3 (Int32)
62311	Active energy outflow L3 (Int32)
62312	Reactive energy inflow L3 (Int32)
62313	Reactive energy outflow L3 (Int32)
62314	Apparent energy L3 (Int32)
62315	Total active energy L3 (Int32)
62316	Total reactive energy L3 (Int32)
62332	Voltage L3 instantaneous value
62335	Current L3 instantaneous value
62336	Fundamental cos φ active factor L3 (SINT8)
65496	Power quality analysis qualifier
65497	Current module time

Measured value ID	Measured variables
65500	Qualifier L1
65501	Qualifier L2
65502	Qualifier L3
65503	Qualifier L1L2L3
65508	Status of energy counter overflows
65509	Status of limit violations 1...16
66001	Voltage L1-N
66002	Voltage L2-N
66003	Voltage L3-N
66004	Voltage L1-L2
66005	Voltage L2-L3
66006	Voltage L3-L1
66007	Current L1
66008	Current L2
66009	Current L3
66010	Apparent power L1
66011	Apparent power L2
66012	Apparent power L3
66013	Active power L1
66014	Active power L2
66015	Active power L3
66016	Reactive power Qn L1
66017	Reactive power Qn L2
66018	Reactive power Qn L3
66019	Power factor λ L1
66020	Power factor λ L2
66021	Power factor λ L3
66030	Frequency (Uint8)
66031	Frequency (Uint16)
66034	Active power L1L2L3
66035	Reactive power Qn L1L2L3
66036	Apparent power L1L2L3
66037	Power factor λ L1L2L3
66038	Reactive power Qtot L1L2L3

Minimum and maximum values 11

11.1 Minimum and maximum values

Introduction

The AI Energy Meter CT HF determines the respective highest and lowest measured or calculated value for a series of measured and calculated values. The values are stored retentively in the module and can be read using measured value data records DS 144 (Page 245), DS 145 (Page 247), DS 154 (Page 263) and DS 155 (Page 266).

Benefits

Using the stored minimum and maximum values, for example, you can detect further irregularities in addition to limit monitoring.

Calculation of minimum and maximum values

Minimum and maximum values are only calculated for the phases in accordance with the configured connection type. Existing minimum and maximum values that have not been calculated are assigned initial values. If faults such as under or overcurrent occur during operation, new minimum and maximum values are calculated.

The measured and calculated values are initialized as follows during commissioning of the AI Energy Meter CT HF so that the first calculation of minimum and maximum values supplies a plausible result:

- Maximum values for measured and calculated values: Minimum values
- Minimum values for measured and calculated values: Maximum values

Minimum and maximum values are determined as "slave pointer procedures" from the start of calculation. Start is effective as of activation of the function or after a reset. The module uses the current actual value as the start value.

Output of the measurement values

For technical reasons, after plugging in or switching on the load voltage, the module returns the minimum and maximum values delayed by approx. 2 s.

Configuring

You configure the following settings in STEP 7:

- Enable calculation of minimum and maximum values
- Enable minimum and maximum value calculation gate

Controlling functions in RUN

The following table shows the supported control information:

Control information	Default value	Available in
Reset saved maximum values	0	Module version starting at 2 bytes of output data
Reset saved minimum values	0	Module version starting at 2 bytes of output data

NOTE
Automatic reset
If you change the parameters for current or voltage transformers, the minimum and maximum values are reset automatically to their initial values.

11.2 Resetting minimum and maximum values

Description

At the beginning of a new work order, it may be useful to reset the minimum and maximum values of the AI Energy Meter CT HF. Resetting means that the minimum and maximum values are reset to their initial values. Initial values are described, see section Measured value data record for maximum values (DS 144) (Page 245), Measured value data record for minimum values (DS 145) (Page 247), Measured value data record for maximum values with time stamp (DS 154) (Page 263) and Measured value data record for minimum values with time stamp (DS 155) (Page 266).

Minimum and maximum values are only reset using a Reset via output data (DQ bit).

Due to the differing lengths of the output data resetting of the minimum and maximum values depends on the configured module version. If you use module versions with 20 bytes of output data, you can:

- Reset the minimum and maximum values for **all** phases.
- Reset minimum and maximum values for each **individual** phase.

If you use the module version with 2 bytes of output data, you always reset **all** the minimum and maximum values simultaneously.

Time stamps are set to initial values (01.01.1970, 0:00) on reset.

Procedure for module version with 20 bytes of output data

Resetting the minimum and maximum values for all 3 phases.

1. Select the categories of minimum and maximum value that you want to reset in byte 2.
   - Set bit 0 for voltage and frequency.
   - Set bit 1 for current and power factor.
   - Set bit 2 for active power.
   - Set bit 3 for reactive power.
   - Set bit 4 for apparent power.
   - Set bit 5 for active energy.
   - Set bit 6 for reactive energy.
   - Set bit 7 for apparent energy.

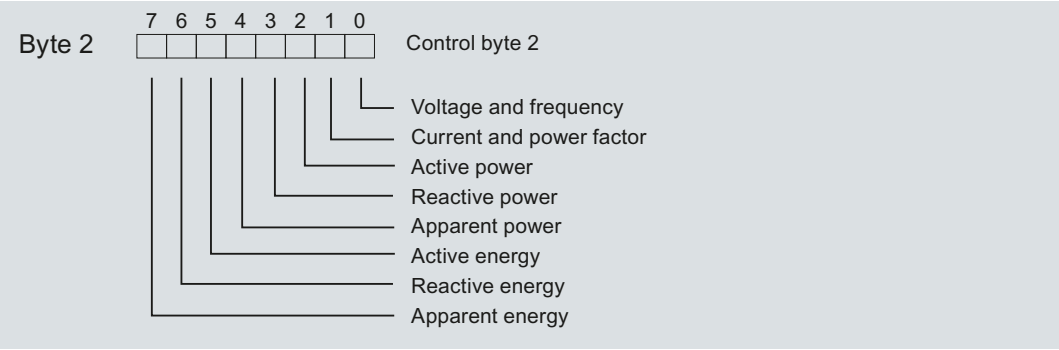

Figure 2-694 Selection of minimum and maximum value category

2. In Byte 1, set reset bit 0 for minimum values or reset bit 1 for maximum values.
   If there is an edge change of the reset bits from 0 to 1, the module resets the selected minimum or maximum values for all 3 phases that you previously selected in Byte 2.

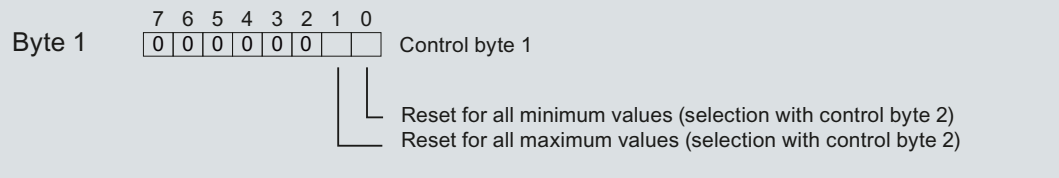

Figure 2-695 Reset bit for minimum and maximum values

Resetting minimum and maximum values for phase-specific measurement

You can also reset the minimum and maximum values on a phase-specific basis using the output data.

Follow the procedure for "Resetting minimum and maximum values for all 3 phases" as applicable.

1. Select the categories of minimum and maximum value that you want to reset on a phase-specific basis.
   - In byte 7, set the bits for the category of minimum and maximum values in phase 1.
   - In byte 9, set the bits for the category of minimum and maximum values in phase 2.
   - In byte 11, set the bits for the category of minimum and maximum values in phase 3.
2. Set the reset bit (bit 0 and bit 1) for minimum or maximum values.
   - in byte 6 for phase 1
   - in byte 8 for phase 2
   - in byte 10 for phase 3

If there is an edge change of the phase-specific reset bits from 0 to 1, the module resets the minimum or maximum values for the given phase.

Procedure for module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, you always reset **all** the minimum and maximum values simultaneously.

Set the reset bit (Bit 0 or Bit 1) in Control byte 1 from 0 to 1 through an edge change.

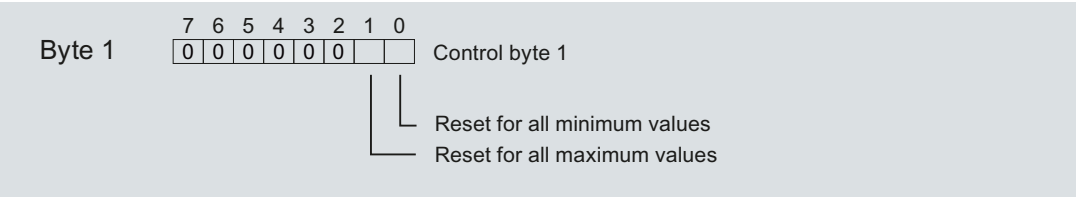

Figure 2-696 Resetting the minimum and maximum values at module version with 2 bytes of output data

11.3 Gate

NOTE
Module version with 2 bytes of output data
The gate is not available for the module version with 2 bytes of output data.

There are two ways of starting or stopping the calculation of the minimum and maximum values:

- Calculation of the minimum and maximum values with gate

  The module starts the calculation when you set the DQ bit for the gate in the output data (output data byte 1, bit 2 = "1") using an edge change from 0 -> 1. If you reset the DQ bit using an edge change from 1 -> 0, the calculation stops.

- Calculation of the minimum and maximum values without gate

  The module starts the calculation as soon as the module is started. The calculation cannot be stopped.

Both options are described in the following sections.

Calculation of the minimum and maximum values with gate

Procedure
If you wish to start calculating using the gate, proceed as follows:

1. Activate the parameter "Enable minimum and maximum value calculation" in the parameter assignment of the module.
2. Set the DQ bit of the gate for minimum and maximum value calculation (Bit 2) in control byte 1 in the output data.

The module starts calculating as soon as there is an edge change from 0 -> 1 at the DQ bit for the gate.

If you wish to stop the calculating again, then reset Bit 2 in control byte 1 in the output data. Calculating stops at an edge change from 1 -> 0.

The "Enable minimum and maximum value calculation" parameter and the DQ bit for the "gate" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

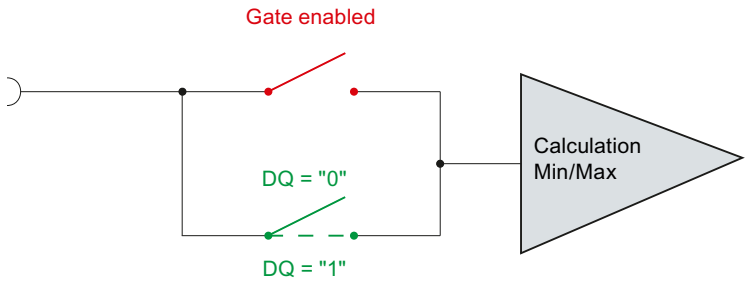

Figure 2-697 Gate enabled

NOTE

Module-global/phase-granular PLC

If you are using the gate control for all three phases simultaneously, use the control byte 1 at output address 1. For a phase-specific resolution of the gate control, use the addresses 6 (Phase1), 8 (Phase2) or 10 (Phase3) as control byte 1. The resolution of a module-global PLC overrules a phase-granular resolution.

Calculation of the minimum and maximum values without gate

Procedure

Deactivate the parameter "Enable minimum and maximum value calculation gate" in the parameter assignment of the module.

The module starts calculating as soon as the module is started. The calculating cannot be stopped.

Gate disabled: Gate is always "open" (signal path closed)

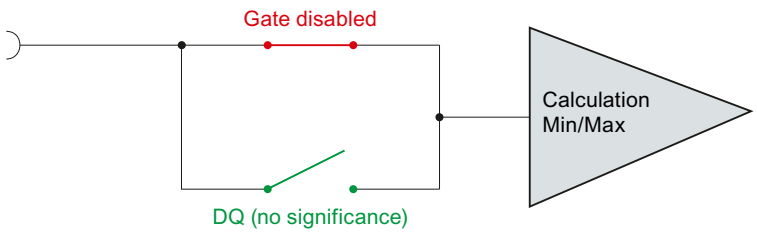

Figure 2-698 Gate disabled

Measured value recorder 12

12.1 How the measured value recorder works

Introduction

The measured value recorder can record up to 200 measured values at two data sources or 400 measured values at one data source. You can freely select the measured value you wish to record for each data source and easily start and stop the recording.

Two recording modes are available: once or in a continuous circular buffer.

You select the measured value you wish to record using its measured value ID. You control the recording using configurable start and stop triggers.

You can retrieve measured values at any time. For two data sources, there is one data record per data source. The measured values of the first data source are available in the DS 173; those of the second data source in the DS 174. If you are using only one data source, both data records DS 173 and DS 174 are written. With one-time recording, these data records are used one after the other as alternating buffers in circular buffer mode.

NOTE

Note that only the use of the alternating buffer can ensure that no data is lost in ring buffer mode.

Benefits

With the measured value recorder, you can record measured values at equidistant intervals of 10 ms to 10 min independently of any other processing and data transport times in the module or the PLC.

Configuration

You configure the following measured value recorder settings in STEP 7:

- Number of activated measured value recordings (1 or 2)
- ID of the measured value for the measured value recording 1 or 2
- Recording interval for the measured value recording 1 or 2
- Mode (once/circular buffer) for the measured value recording 1 or 2
- ID of the start trigger for the measured value recording 1 or 2
- ID of the stop trigger for the measured value recording 1 or 2

A more detailed parameter description of the DS 134 is available in section "Parameters". You can find detailed information on the start and stop triggers in the Appendix, Section A5.

Evaluation of the measurements

Within these measured value data records, the representation of the measured values is specified in REAL format only.

The reading of recordings is possible with data record reading once or cyclically. You can read out the recorded measured values from the following data records.

Name of the data record	Number of the data record
Data record for measured recorder data source 1	DS 173
Data record for measured recorder data source 2*	DS 174

*Or as second data record for data source 1 if you want to record 400 measured values

The data records are described in the section Measured value data record DS 173 (Page 280) (Appendix E18) or Measured value data record DS 174 (Page 281)(Appendix E19).

12.2 Start, hold, continue, reset, restart and evaluate measurement

Parameter assignment of the measurement

To use the measured value recorder function, send parameter data record 134 to the module either with the instruction WRREC (Write data record) or via the parameter assignment of STEP 7. If you want to use the recording of 400 measured values at a data source, the parameter assignment of MV recorder block 1 and MV recorder block 2 must be identical in all parameters. The number of activated measured value recordings must be set to "2".

You can find more information on the parameter data record 134 in the section Parameters and in Appendix A.5 (Page 167).

Starting the measurement

A "1" level at the activated start trigger starts the recording. With disabled start trigger, the recording starts immediately at the time of parameter assignment.

Hold measurement

A "0" level at the activated start trigger or a "1" level at the activated stop trigger stops the recording. If the stop trigger is disabled, the recording ends in the "once" mode after filling the buffer. 200 values are available in this case. Recording continues in "Circular buffer" mode and can only be ended by resetting the measurement.

Continue the measurement

A restart with "1" level at the start trigger and with a "0" level at the stop trigger continues the measurement.

Resetting the measurement for module version with 20 bytes of output data

You delete the recording with reset, general reset or re-parameterization. You can reset the measurements individually. You do this with two specified DQ bits at which you trigger a 0->1 edge.

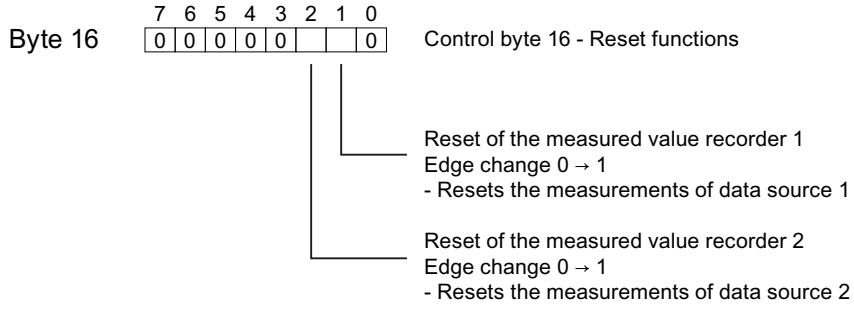

Figure 2-699 Resetting the measurement

Reset via byte 16 is only possible for the module version 20 bytes of output.

Resetting the measurement for module version with 2 bytes of output data

You delete the recording with re-parameterization.

Restarting the measurement

You can restart the measurement after completing a measurement and evaluating the results. We recommend to first disable the start event with level state 0, then reset the respective measurement and retrigger the start event with "1" level again.

Evaluating the measurement

The reading of recordings is possible with data record reading from DS173 and DS174 once or cyclically at any time. Within these measured value data records, the representation of the measured values is specified in REAL format only.

Depending on the application, it may be useful to evaluate the status of the recorders before reading all measured values:

- **Option 1**

  Using data record reading: Byte 1 contains the compressed status in form of 2 bits:

  – Byte 1 = 0x80: Recording ended
  – Byte 1 = 0x40: Recording in progress
  – Byte 1 = 0: No data can be retrieved

- **Option 2**

  Using data record reading: Byte 7 contains the complete recorder status:

  – 0: Initial status
  – 3: Recorder parameterized
  – 4: Recording in progress
  – 5: Recording ended
  – 6: Recording stopped

  NOTE

  To evaluate the status, you can read an abbreviated data record without the measured values. This reduces the runtime for faster cyclical evaluation of the recorder status. Only when the status is "Recording ended" must you read the complete data record.

- **Option 3**

  If the hardware interrupt is enabled in the parameters, a PRAL, whose information can be evaluated in OB4x, is triggered at the time of "Recording ended" (see 17.2.1).

  After evaluation of the PRAL information, the corresponding data record (DS173 or DS174) can be read.

Evaluating measured values for two data sources

If two data sources are used, a fixed assignment of the data records is specified for each data source:

- Recorder 1: DS173
- Recorder 2: DS174

Evaluating measured values for one data source

If the parameter assignment of recorder 1 and recorder 2 is the same, only one data source should be used. Both data records are used for this data source in this case:

- Recorder 1: DS173 (recording starts here) + DS174 (when DS173 is full, recording continues here)

In "once" mode, DS173 is filled first. When its status shows "Recording ended", it can be read. Recording is automatically switched to DS174. When its status also shows "Recording ended",

the recording stops and the DS174 can be read as well. This means you have access to 400 measured values in two buffers.

NOTE

Intermediate reading is also available but not all measured values have been saved yet in this case.

In "Circular buffer" mode, DS173 is also used first. If the status shows "Recording ended", the buffer must be read. In the meantime, DS174 is filled automatically; when its status also shows "Recording ended", DS173 is deleted and recording in it starts anew. This process continues back and forth until recording is stopped.

NOTE

Intermediate reading is also available but not very useful because not all measured values have been saved yet resulting in gaps.

NOTE

At the smallest acquisition interval of 10 ms, one buffer is full every 200 *0.010 s = 2 s. You have two seconds to retrieve the buffer and save the measured values to a different storage, such as a data block.

12.3 Example of measured value recording

Example (for module version with 20 bytes of output data)

Starting with the default parameter assignment in STEP 7, activate the recording as follows:

1. Set the parameter "Number of activated measured value recordings" to 2.
2. Set both recording intervals to 100.
3. Set the start trigger 1 to 230 and the start trigger 2 to 231.
4. Load the changed parameters to the module.

Recording 1 starts after "1" is output to bit 5 from byte 17 of the output data; it records the voltage at phase 1 once every second with 200 measured values.

Recording 2 starts after "1" is output to bit 6 from byte 17 of the output data; it records the current at phase 1 once every second with 200 measured values.

If bit 5 or 6 is reset to "0" during recording, the respective recording comes to a stop. A renewed output of "1" continues the recording.

	Parameter	Value	Meaning
	Number of activated measured value recordings	2	2 recordings
Measured recorder data source 1	ID for measured value recording	1	UL1
	Recording interval for measured value recording	100	1 s

	Parameter	Value	Meaning
Measured recorder data source 1	Mode for measured value recording	0	Once
	ID for start trigger	0	Disabled
	ID for stop trigger	0	Disabled
Measured recorder data source 2	ID for measured value recording	7	IL1
	Recording interval for measured value recording	100	1 s
	Mode for measured value recording	0	Once
	ID for start trigger	0	Disabled
	ID for stop trigger	0	Disabled

Power failure analysis 13

Introduction

When the supply voltage of the system is interrupted, metering of energy and other processes are stopped. An analysis of the breakdown times thus represents an important function in a plant.

NOTE

Requirements

A useful evaluation of the saved breakdown and restart times is only possible when you set the time of the Energy Meter. If the time synchronization is not available, you can only evaluate the relative time between start and failure because the internal clock starts with the initial value of 01.01.1970, 0:00 and runs until the failure.

13.1 Mode of operation of the power failure analysis

Determination of the power failure time

To this end, the current system time is cyclically transferred to the retentive memory while the energy meter calculation is being processed. This means the time from the last calculation cycle is retained in case of a supply voltage failure.

Determination of the power return time

Once the supply voltage returns, the current time is also entered in the retentive memory during run-up of the module. This process waits for the synchronization of the clock.

NOTE

Formation of the restart time

The wait time for a time synchronization after a restart is 30 seconds. If it does not take place by then, the start time (1.1.1970, 0:00:00) is entered as the starting point. The entered time is decreased by the time that has expired in the module in the meantime (max. 30 seconds). Tip: Do not read the data immediately after the restart but wait for at least 60 seconds.

See also section Tips and tricks (Page 282), Time synchronization and time stamp.

Evaluation of the results of the power failure analysis in data record 169

Reading of DS169 returns the saved analysis data. The "Switch-off time/Switch-on time" pair of the stored times thus results in the failure time of the network. Up to nine pairs of switch-off/switch-on times are stored internally in a circular buffer. This means you will see up to nine failure times when reading DS169.

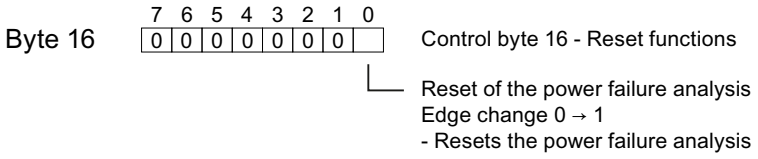

Figure 2-700 Resetting the power failure analysis measurement

For more detailed information, refer to section Measured value data record for power failure analysis (Page 278).

NOTE

Resetting the power failure analysis

Resetting of the power failure analysis is only possible with 32I / 20 O or by using the general reset.

Power quality analysis functions 14

Introduction

Power quality analysis functions are used as an aid to evaluate the quality of the supply network. In a three-phase system, many of these functions only make sense or can be executed if a functioning symmetrical three-phase supply system is available, the detection sensors of the three phases are identical in design and the nominal values current or voltage of the phases have the same values.

The AI Energy Meter CT HF provides you with the following power quality analysis functions in accordance with IEC 61000-4-30 for monitoring the power quality in your power network:

- Measure the neutral current
- Perform residual current analysis
- Determine active and power factor
- Carry out reactive power compensation
- Analyze fundamental values three-phase (voltage, current, power)
- Analyze the harmonics up to the 40th harmonic
- Determine the total harmonic distortion THD+N current/voltage for all three phases
- Detect voltage dip and voltage swell
- Detect overcurrent
- Detect peak value for current and voltage

The power quality analysis only returns useful results if some basic requirements are met. These include:

- Accuracy of the line frequency (50 Hz or 60 Hz) is maintained according to IEC 61557-12.
- Wiring was done correctly and the correct rotating filed is generated (see Notes for the detection of wiring errors and incorrect rotating field (Page 52)).

Delete the results of the power quality analysis

Delete the results of the power quality analysis by setting the corresponding bits in Byte 12 of the output range (Page 206) for at least 100 ms to "1".

Deletion has the following effects:

- Deletion of the result values and status bits for
  - Peak values of the instantaneous values for voltage and current
  - Overcurrent of the current half value
  - Voltage dip and voltage swell of the voltage half-wave value
- Any pending diagnostics "External fault" is deleted.

Harmonic

Harmonics are superimposed vibrations deviating from the fundamental frequency of the supply network (50 Hz or 60 Hz) with an integer multiple of the fundamental frequency. Harmonics are generated by equipment with a non-linear current–voltage characteristic such as transformers, gas discharge lamps and power electronics devices.

Harmonic component THD (Total Harmonic Distortion)

The THD defines the ratio of the power of the harmonics to the power of the fundamental and provides information about the power quality. The value is dimensionless and is stated as a percentage [%].

The AI Energy Meter CT HF returns THD+N (Noise) and considers the entire current signal (DS 163) or voltage signal (DS 161). Interference in the network is not filtered out.

Output of the measurement values

For technical reasons, after plugging in or switching on the load voltage, the module returns the following measured values delayed by approx. 2 s.

- Frequency
- Harmonic distortion THD+N current
- Harmonic distortion THD+N voltage

14.1 Power quality analysis status

Information about the power quality status can be found in the measured value "Power quality analysis qualifier" with the measured value ID 65496.

The bits 0 to 4 in byte 1 to 3 show in status "1" that information has been available since the last reset, which can be retrieved. The bits 5 to 7 in byte 1 to 3 in status "1" show that the event is currently active. If the event is not active, "0" is displayed.

The measured value "Network analysis qualifier" has the following structure:

Address	Content	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0	Power quality analysis qualifier module	Reserved	Reserved	Status of harmonics analysis: 0_D: No data, no start 1_D ... 62_D: running 63_D: Completed, data is available					
Byte 1	Power quality analysis qualifier phase L1	**Overcurrent** Event currently active	**Voltage swell** Event currently active	**Voltage dip** Event currently active	**Overcurrent** Event occurred, data available	**Peak value current** Event occurred, data available	**Voltage peak** Event occurred, data available	**Voltage swell** Event occurred, data available	**Voltage dip** Event occurred, data available
Byte 2	Power quality analysis qualifier phase L2								
Byte 3	Power quality analysis qualifier phase L3								

14.2 Harmonics analysis

The AI Energy Meter CT HF can determine the effective values for current and voltage for each phase up to the 40th harmonic of the fundamental.

The harmonics of the voltage are stored in the data record DS 161 (Page 271).

The harmonics of the current are stored in the data record DS 163 (Page 275).

In addition, you can incorporate the results on IDs with the parameter data records DS 130/DS 131 (Page 164) in the user-defined payload and DS 135 (Page 172) in the user-defined data record DS 151 (Page 262).

The calculation of the harmonics takes several cycles. To determine whether calculation is completed, evaluate the Bits 0 to 5 in the power quality analysis data record DS 160 (Page 269) in Byte 218. If the value 63 is in the Bits 0 to 5, the calculation is completed and the measured values are available.

NOTE

While the calculation is in progress, you cannot read the data records DS 161 and DS 163.

NOTE

While the calculation is in progress, quick measured value acquisition (e.g. for controlling reactive-power compensation) is not possible.

Requirement

- The parameter "Power quality analysis function" is activated.
- The parameter "Analyse harmonics" for the corresponding phase must be released.

Voltage and current are always analyzed simultaneously for the enabled phases.

Control via data outputs

The harmonics analysis starts by setting the DQ bit 6 "Power quality analysis Start/Stop L1L2L3" in Byte 12 of the output data. The results of a previous analysis of harmonics are deleted in the process. Results of non-selected channels are "0". If channels which have not yet been analyzed are added, the data are not plausible at the start of the analysis.

If the DQ bit is reset during an ongoing analysis, the analysis stops.

14.3 Reactive power compensation

Use the power factor of the fundamental for the reactive power compensation.

The power factor of the fundamental is available, among other things, in the measured value data record DS 142 (Page 235), in the measured value data record DS 160 (Page 269) or in the payload (Page 218).

14.4 Detection of residual current

For the residual current analysis (function "Tamper Detect" = Detection of unauthorized interventions), the total current must be determined:

Isum L1L2L3 (t) = IL1 (t) + IL2 (t) + IL3 (t)

The instantaneous residual current If is obtained by subtracting the results of the current neutral current In from the total current:

If = Isum L1L2L3 – In

Analysis starts immediately after parameter assignment. The measured value "Total current IL1+IL2+IL3-IN" (ID = 61153) returns the residual current. It is contained in DS 160, for example. You can monitor a threshold relevant for your application for a limit value (see function Limit value monitoring (Page 78)).

Requirements

- "3P4W" or "3P4WI" is parameterized as the connection type.
- The same current transformers are connected to all three phases.
- The parameter "Reverse current direction" is parameterized identically for all three phases.
- The neutral current is parameterized with "Measuring".
- The residual current analysis is activated in the parameter assignment.

14.5 Active factor and power factor

The AI Energy Meter CT HF returns the active and power factor individually for each phase and as an aggregate.

Active factor

The active factor is defined as follows:

cos φ (active factor, signed, fundamental oscillation): cos φ = P1 / S1

φ = phase shift angle of fundamental oscillation

P1 = active power of fundamental oscillation

S1 = apparent power of fundamental oscillation

Power factor

The power factor λ = cos Φ is the ratio of active power (P) to the total apparent power (S) over the fundamental oscillation and all harmonics (total):

λ (power factor, unsigned, total): λ = cos Φ = |P| / S

14.6 Neutral current In

The module can measure or calculate the neutral current.

For measuring, you have to connect a current transformer to neutral. The behavior "measuring or calculating" can be set for each parameter. The main application of the measured value "Neutral current IN" (ID: 61149) are three-phase networks with existing 4th conductor, neutral: The neutral current usually shows incorrectly flowing currents. In an ideal three-phase network, the neutral current = 0.

An additional possible application is measuring any 4th current on this channel. Please note that in this case the measured value "Neutral current" displays this 4th current and not the actual neutral current.

Additional values in conjunction with the neutral current is set to 0.

The calculation of the neutral current and the comparison of calculated and measured neutral current (used for residual current analysis) is only possible in the operating modes "3P4W" and "3P4WI".

The determination of the neutral current is not subject to current suppression.

Parameter assignment options

If there a neutral in a connection type, the following parameters are available:

- Neutral current measurement deactivated
- Calculate the neutral current measurement
- Measure the neutral current measurement

If there is no neutral in a connection type, the following parameters are available:

- Do not use current channel
- Measure current channel

Display via channel LED

Neutral exists for connection type	calculate	measuring	Error	Channel LED
Yes	Yes	Yes	No	Green
Channel disabled	---	---	---	Off
No	No	Yes	No	Green

14.7 Monitoring the instantaneous or half-wave values

You can enable the following functions:

- Voltage swell (Page 125)
- Voltage dip (Page 128)
- Voltage peaks (Page 130)
- Current peak value (Page 137)
- Overcurrent value (Page 139)

The results are mapped in the phase-specific data records DS 147 (Page 249), DS 148 (Page 253) and DS 149 (Page 256) and in the power quality analysis data record DS 160 (Page 269).

In addition, you can incorporate the results using IDs in the measured value data record of the user-defined data record DS 151 (Page 262) and in the user data variants 1/2.

You can monitor the results for limits (Page 78) and generate hardware interrupts.

Phase-based measured values 15

Introduction

The AI Energy Meter CT HF makes the measured values of individual phases available.

- Through the payload variants
  - Phase-specific measurement phase L1 with payload variants 158 ($9E_H$) and 159 ($9F_H$)
  - Phase-specific measurement Phase L2 with payload variants 156 ($9C_H$) and 157 ($9D_H$)
  - Phase-specific measurement phase L3 with payload variants 154 ($9A_H$) and 155 ($9B_H$)
- Via measured value data records
  - Phase-specific measurement for the phases L1, L2 and L3 with data record 142
  - Phase-specific measurement for phase L1 with data record 147
  - Phase-specific measurement for phase L2 with data record 148
  - Phase-specific measurement for phase L3 with data record 149

Payload variants

Through the payload variants 154 ($9A_H$) to 159 ($9F_H$) you can evaluate the following measured values for each phase of an AC / three-phase network:

- Quality information
- Current and voltage
- Active, reactive and apparent power
- Active, reactive and apparent energy
- Power factor

You can find the structure of the payload variants in appendix Payload variants with 32 bytes of input data / 20 bytes of output data.

Measured value data records

Through the measured value data records DS 142, DS 147, DS 148 and DS 149 you can evaluate the following measured values for each phase of an AC / three-phase network:

- Quality information
- Current and voltage
- Minimum current and minimum voltage
- Maximum current and maximum voltage
- Active, reactive and apparent power
- Minimum active, reactive and apparent power

- Maximum active, reactive and apparent power
- Active, reactive and apparent energy
- Power factor
- Minimum power factor
- Maximum power factor
- Harmonic distortion for voltage and current including minimum/maximum values
- Voltage dip
- Voltage swell
- Peak value for voltage and current
- Overcurrent value

The structure of the measured value data record is available in the appendix E Measured value data record for phase-based measured values L1 (DS 147) version 1 (Page 250).

See also

Measured value data record for phase-based measured values L2 (DS 148) version 1 (Page 254)

Measured value data record for phase-based measured values L3 (DS 149) version 1 (Page 258)

Parameters 16

16.1 Parameters

Parameters of the AI Energy Meters CT HF

You will usually configure the AI Energy Meter CT HF with STEP 7 (TIA Portal, if necessary, with HSP). In this case, STEP 7 (TIA Portal) checks the configured properties for plausibility during configuration.

You can also assign parameters to the module using a GSD file and STEP 7 or the configuration software of any provider. In this case, the module checks the validity of the configured properties only after the configuration has been downloaded. Note that some parameters depend on the selected connection type of the AI Energy Meter CT HF. For example in the connection type 1P2W for measurements in single-phase AC network it does not make sense to enter parameters for Phases 2 and 3. This is not checked by the system if the GSD file is used.

The effective range of the parameters that can be set using a GSD file depends on the type of bus system used:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition you can change the parameterized properties via the user program in RUN mode. When you assign parameters in the user program, the WRREC instruction transfers the parameters to the module using data records (see appendix Parameter assignment using parameter data records (Page 148)).

The following table summarizes all the configurable parameters with STEP 7 (GSD file).

Table 2-804 Parameters AI Energy Meter CT HF (GSD file)

Parameters	Value range	Default setting
Hardware interrupts *	• Disable • Enable	Disable
Inputs		
Diagnostics: No supply voltage L+	• Disable • Enable	Disable
Connection type	• Disabled • 1P2W - 1 phase, 2 conductors • 3P4WI - 3 phase current measurement, 4 conductors • 3P4W1, 3 phases, 4 conductors, balanced load • 3P4W - 3 phases, 4 conductors • 3x1P2W - 3 x 1 phase, 2 conductors each • 2P3W - 2 phases, 3 conductors • 3P3W, 3 phases, 3 conductors • 3P3W1, 3 phases, 3 conductors, balanced load	3P4W - 3 phases, 4 conductors

* Reconfiguration in RUN is not possible.

Parameters	Value range	Default setting
Voltage measuring range	• 100 V • 110 V • 115 V • 120 V • 127 V • 190 V • 200 V • 208 V • 220 V • 230 V • 240 V • 277 V • 300 V	230 V
Line frequency	• 50 Hz • 60 Hz	50 Hz
Activate gate switch for energy meter	• Disable • Enable	Disable
End value energy counter	• No end value (count indefinitely) • Count periodically to 10^3 • Count periodically to 10^6 • Count periodically to 10^9 • Count periodically to 10^{12} • Count periodically to 10^{15}	No end value (count indefinitely)
Payload variant	See the table Overview of the payload variants	Total power L1L2L3 (W#16#FE)
Minimum and maximum value calculation	• Disable • Enable	Disable
Minimum and maximum value calculation gate	• Disable • Enable	Disable
Power quality analysis functions	• Disable • Enable	Disable
Residual current analysis	• Disable • Enable	Disable
Neutral conductor: Current transformer primary current [A]	• 0 = Disabled • 1 ... 99999 = measuring • 4294967295 = Calculating	0
Neutral conductor: Current transformer secondary current [A]	• 1 • 5	1
Voltage dip limit value in relation to nominal value voltage [0.1%]	• 10 ... 1000	100
Voltage swell limit value in relation to nominal value voltage [0.1%]	• 10 ... 10000	100
Overcurrent threshold value in relation to nominal value current [0.1%]	• 10 ... 60000	100
Number of cycles for voltage swell and dip analysis	• 4 ... 32767	10

* Reconfiguration in RUN is not possible.

Parameters	Value range	Default setting
Diagnostics power quality	• Disable • Enable	Disable
Diagnostics overflow current	• Disable • Enable	Disable
Diagnostics overflow voltage	• Disable • Enable	Disable
Diagnostics underflow voltage	• Disable • Enable	Disable
Diagnostics Totalized values overflow	• Disable • Enable	Disable
Detect voltage swell and dip	• Disable • Enable	Disable
Detect peak value current	• Disable • Enable	Disable
Detect peak value voltage	• Disable • Enable	Disable
Detect overcurrent	• Disable • Enable	Disable
Analyse harmonics	• Disable • Enable	Disable
Nominal value current [A]	• 0 ... 99999	1
Tolerance factor overcurrent in relation to nominal value current [0.1%]	• 10 ... 60000	100
Tolerance time overcurrent [ms]	• 0 ... 60000	40000
Low limit current measurement in relation to nominal value current [0.1%]	• 0 ... 200	10
Enable operating hours counter	• Disable • Enable	Disable
Activate operating hours counter gate	• Disable • Enable	Disable
Current transformer primary current [A]	• 1 ... 99999 A	1 A
Current transformer secondary current	• 1 A • 5 A	1 A
Reverse current direction	• Disabled • Reverse current direction	Disabled
Nominal value voltage [V]	• 1 ... 999999	230 V
Tolerance factor overvoltage/undervoltage [0.1%]	• 10 ... 500	100
Voltage transformer primary voltage [V]	• 1 ... 999999 V	230 V

* Reconfiguration in RUN is not possible.

Parameters	Value range	Default setting
Voltage transformer secondary voltage [V]	• 1 ... 500 V	230 V
Limits		
Number of limit values	• 0 ... 16	0
Limit monitoring	• Disable • Enable	Disable
Measured variable	• Measured value ID, see Measured value data records	None
Activate gate switch for limit monitoring	• Disable • Enable	Disable
Hardware interrupt	• Disable • Enable	Disable
Limit	• depending on the selected measured variable	0.0000
Type	• High limit • Low limit	High limit
Hysteresis for limit monitoring [0.1%]	• 0 ... 200 [0.1%]	10
Delay time for limit monitoring [s]	• None • 1 ... 10 s	None
Payload mapping I/II		
Number of measured values	• 0 ... 64	0
Measured variable	• Measured value ID, see Measured variables	None
Data record mapping		
Number of measured values	• 0 ... 150	0
Measured variable	• Measured value ID, see Measured variables	None
Measured value recorder		
Number of activated measured value recordings	• 0: No recording • 1: Recording 1 • 2: Recording 1 and 2	0
Measured variable	• Measured value ID, see Measured variables	ID1 = 1, ID2 = 7
Recording interval for measured value recording 1 or 2	• 1...60000 in the unit 10 ms	10 = 100 ms
Mode for measured value recording 1 or 2	• Once • Circular buffer	0 (once)
ID for start or stop trigger 1 and 2	See Structure of the parameter data record 134 for measured value recording (Page 167)	None
Hardware interrupt enable for DS173 (measured value recording 1) or DS174 (measured value recording 2) full	0x80: Trigger hardware interrupt 0x00: Trigger no hardware interrupt	0 (trigger no hardware interrupt)

* Reconfiguration in RUN is not possible.

16.2 Explanation of parameters

Basic parameters

Hardware interrupts

Enable the hardware interrupt for the entire module here.

Diagnostics: No supply voltage L+

Activate the diagnostics Missing load voltage L+. If there is no voltage or too little voltage at terminal 17, the message "Supply voltage missing" is output and a diagnostics interrupt is triggered.

Connection type

Specify the connection type you used for the AI Energy Meter CT HF.

For more detailed information, refer to "Connection examples (Page 26)".

Voltage measuring range

Here you set the voltage measuring range in which the system connected to the AI Energy Meter CT HF works. This parameter is only required when calibrating the module.

Line frequency

Here you set the line frequency in which the system connected to the AI Energy Meter CT HF works.

Enable gate energy counter

Enable the gate for the energy counter When the gate is activated, the energy counter only counts when the corresponding output data bit (DQ bit) is set to "1".

End value energy counter

Select the end value for the periodic counting of the energy counter. You can also specify that the energy counter is to count without a full-scale value (infinite counting). The calculated energy counter values are stored retentively in the module.

Payload variant

Select payload variant with which the module is to operate once it is started up.

Minimum and maximum value calculation

Activate calculation of the minimum and maximum values. The minimum and maximum value are calculated from the start of the measurement. The values determined are stored retentively in the AI Energy Meter CT HF together with the time stamp.

Minimum and maximum value calculation gate

Activate the gate for minimum and maximum value calculation. When the gate is activated, the energy counter only counts when the corresponding output data bit (DQ bit) is set to "1".

Power quality analysis function

Enable the power quality analysis function for the entire module.

Residual current analysis

Enable the residual current analysis for the entire module. The residual current analysis is only available in the connection types 3P4W or 3P4WI and the concurrently activated parameter "Neutral conductor current measurement".

This parameter does not apply to parameter assignment with GSD file.

Neutral conductor: Current transformer primary current [A]

To determine the current transformer ratio, enter the primary current. The transformer ratio is calculated from the primary and secondary current.

The following applies to parameter assignment with GSD file:

- 0 = Neutral function deactivated
- 1 ... 99999 = measure neutral current
- 4294967295 = calculate neutral current (0xFFFF FFFF)

Neutral conductor: Current transformer secondary current [A]

To determine the current transformer ratio, enter the secondary current. The transformer ratio is calculated from the primary and secondary current.

Limit value voltage dip in relation to nominal value voltage [0.1 %]

Further information can be found under Voltage dip of the voltage half-wave value (Page 128).

Limit value voltage swell in relation to nominal value voltage [0.1 %]

Further information can be found under Voltage swell of the voltage half-wave value (Page 125).

Threshold overcurrent in relation to nominal value current [0.1%]

Further information can be found under Overcurrent of the current half value (Page 139).

Number of cycles for voltage swell and dip analysis

Further information can be found under Voltage swell of the voltage half-wave value (Page 125) and Voltage dip of the voltage half-wave value (Page 128).

Diagnostics power quality

Depending on the enable of the individual functions, the diagnostics are triggered when a voltage swell, voltage dip or overcurrent event has occurred.

Diagnostics overflow current

The measured current is monitored after expiry of the "Tolerance time" for "Overcurrent [0.1 A] tolerance value". Exceeding the value generates the diagnostics "Overflow current".

Diagnostics overflow voltage

The nominal values voltage are monitored for tolerance. An overflow triggers a diagnostics interrupt.

Diagnostics underflow voltage

The nominal values voltage are monitored for tolerance. An underflow triggers a diagnostics interrupt.

Diagnostics overflow cumulative values

A cumulative overflow in the calculated variables is displayed. The values stop at the high or low limit. A violation triggers a diagnostics interrupt.

Detect voltage swell and dip

Activates the detection of voltage swell and dip. Further information can be found under Diagnostics: Overflow/underflow (Page 123).

Detect peak value current

Activates the detection of current peak values. Further information can be found under Peak values of the instantaneous values for current (Page 137).

Detect peak value voltage

Activates the detection of voltage peak values. Further information can be found under Peak values of the instantaneous values for voltage (Page 130).

Detect overcurrent

Activates the detection of overcurrent. Further information can be found under Overcurrent of the current half value (Page 139).

Analyse harmonics

Activates harmonics analysis

Nominal value current [A]

Enter the nominal value for the current. This is the "operating point" in your application.

Tolerance factor overcurrent in relation to nominal value current [0.1%]

Further information can be found under Diagnostics: Overload (Page 133).

Tolerance time overcurrent [ms]

Further information can be found under Diagnostics: Overload (Page 133).

Low limit current measurement in relation to nominal value current [0.1%]

The configurable low limit for measuring current refers to the nominal value and is used to avoid incorrect calculations in the case of very low currents. Incorrect measurements of very low currents in particular are a cause of inaccuracies in the current transformer used. Set the low limit for the current measurement to the required value depending on your process.

NOTE

Tip: If you want to find the low limit for the current measurement experimentally, set it to a lower value. Then, feed in a very precise low current and determine the measurement error that can no longer be tolerated. Afterwards, set the low limit for the current measurement to the limit value you have determined.

If current falls below the low limit for the current measurement, the following measured values and derived variables of the affected phase are reset.

- Effective current value
- Neutral current
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A moving mean value is generated from the power values and they only become "0" after a corresponding time. The energy counters for active, reactive and apparent energy as well as the operating hours counters do not count any longer.

Further information can be found under Low limit for measuring current undershot (Page 135).

Enable operating hours counter

Enable the operating hours counter. The counting starts from the configurable low limit of the current measurement. The counter can be reset or pre-assigned using data record or output bit.

Activate operating hours counter gate

Enable the gate for the operating hours counter. When the gate is activated, the operating hours counter only counts when the corresponding output data bit (DQ bit) is set to "1".

Current transformer primary current

Enter the nominal value for the primary current of the current transformer used. The transformer ratio is calculated from the primary and secondary current.

Current transformer secondary current

Enter the nominal value for the secondary current (1 A or 5 A) of the current transformer used. The transformer ratio is calculated from the primary and secondary current.

Reverse current direction

Setting to determine whether or not to reverse the direction of current.

In the event of inadvertent incorrect connection, this parameter can be used to correct the measured values, thus saving the hassle of rewiring. The direction of the current is only evident from the power measurement values. The current measurement value is an rms value.

Nominal value voltage [V]

Enter the nominal value for the voltage. This is the "operating point" in your application.

Tolerance factor overvoltage/undervoltage [0.1%]

Enter the tolerance factor overvoltage/undervoltage here in increments of 0.1%. You can find additional information under Diagnostics: Overflow/underflow (Page 123).

Voltage transformer primary voltage [V]

Enter the nominal value for the primary voltage of the voltage transformer used. The transformer ratio is calculated from the primary and secondary voltage.

Voltage transformer secondary voltage [V]

Enter the nominal value for the secondary voltage of the voltage transformer used. The transformer ratio is calculated from the primary and secondary voltage.

Limits

Number of limit values

Enter the number of measured values that you want to monitor for limits.

Limit monitoring

Activate the monitoring of the limit for a freely definable measured value here. Limit violations are counted and the count values stored retentively.

Measured variable

Enter the measured value ID (Page 175) that you want to use for limit monitoring.

Activate gate switch for limit monitoring

Activate the gate switch for limit monitoring. When the gate is activated, the limit monitoring is only started when the corresponding bit of the associated output payload is set to "1".

Hardware interrupt

Activate the hardware interrupt. The hardware interrupt is triggered if a high or low limit is violated. Without activation of a hardware interrupt, a limit violation is only displayed in the payload and in DS 150.

Limit

Enter the limit that is to trigger a limit violation when exceeded or fallen below. Limit violations are displayed in the payload and in DS 150.

Type

Select whether it is a high or low limit. Depending on this selection, the limit violation or hardware interrupt is triggered when a value exceeds (high limit) or falls below (low limit) the limit.

Hysteresis for limit monitoring [0.1%]

Enter the hysteresis for limit in percent.

The hysteresis band is below the high limit or above the low limit. The parameter in % refers to the configured limit. If a measured value fluctuates around the limit but does not leave the hysteresis band, a new limit violation is not triggered.

Delay time for limit monitoring [s]

Select the delay time for limit violation. The delay refers to the time that must elapse before an occurrence of a limit violation is reported. Faults can be filtered out by selection of the delay time. The delay time is also taken into consideration during outgoing of the limit violation.

Payload mapping I/II

Number of measured values

Specify the number of measured values/variables that you want to use for the user-specific payload mapping.

Measured variable

Select the measured variable (with the measured value ID (Page 175)) that you want to use for the user-specific payload mapping.

Data record mapping

Number of measured values

Specify the number of measured values/variables that you want to use for the user-specific data record mapping.

Measured variable

Select the measured variable (with the measured value ID (Page 175)) that you want to use for the user-specific data record mapping.

Measured value recorder

Number of activated measured value recordings:

- 0 (function disabled), 1 (MV recorder2 block is ignored) or 2 (MV recorder1 and MV recorder2 enabled).
- Factory setting: 0

NOTE

For a recording of 400 measured values at only one data source, set the "Number of activated measured value recordings" to 2 and all subsequent parameters for measured value recording 1 or with identical values.

ID for measured value recording 1 or 2:

All IDs that can be used with user-definable payload (DS130, DS131) and user-definable data records (DS135) are possible. Factory setting: ID1 = 1 (UL1) and ID2 = 7 (IL1).

Exception:

- PNIO_Time_type cannot be used (measured value ID 65497 is thus blocked)
- While use is possible for bit fields, their measured values cannot be displayed in a meaningful way because the format of the measured values is always REAL. This affects the IDs: 65496, 65500, 65501, 65502, 65503, 65508, 65509, 62193, 62293, 62393, 65495

NOTE

The use of measured values that are only generated upon request (e.g. from the analysis of the harmonic component started by command, IDs: 63000 ... 63879) does not make much sense.

NOTE

Note that, depending on the connection type used, the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

Recording interval for measured value recording 1 or 2:

- Value range 1...60000 in the unit 10 ms
- Factory setting: 10 = 100 ms

NOTE

The shortest recording cycle is 10 ms (half-wave at 50 Hz line frequency). This short interval only makes sense for measured values that are generated that quickly. These are all half-wave and instantaneous values. Frequency measured values and THD values are measured every second; all other values (the majority of the measured values) are measured in a 50 ms cycle.

Mode for measured value recording 1 or 2:

- 0 (Factory setting): Once, which means the buffer is filled from the top. The recording stops when the buffer is full or when the recording is stopped.
- 1: Circular buffer. For circular buffer mode, the oldest element is always listed first, which means the buffer is filled from the bottom.

Hardware interrupt for measured value recording 1 or 2:

- 0 (Factory setting): Trigger no hardware interrupt
- 0x80: Trigger hardware interrupt when data record is full

ID for start or stop trigger 1 and 2:

- "0": Start or stop trigger is not activated. "0" in the start trigger starts the measurement immediately after parameter assignment; "0" in the stop trigger ignores this function
- Factory setting: 0 = Not activated
- You can find additional information in the appendix A, Structure of the parameter data record D134 (Page 167).

Interrupts/diagnostic alarms 17

17.1 Status and error display

LED display

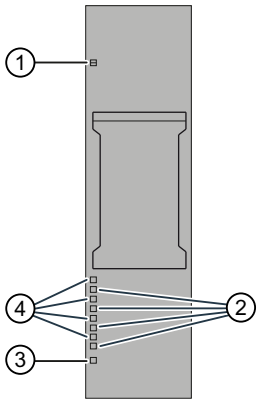

① DIAG (green/red)

② Error (red)

③ PWR (green)

④ Status (green)

Figure 2-701 LED display

Meaning of the LED displays

The following table explains the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 121).

DIAG LED

Table 2-805 Meaning of the DIAG LED

DIAG	Meaning
☐ Off	Supply voltage of the ET 200SP not OK
☼ Flashes	Module not ready for operation (no parameters assigned)
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Status LED

Table 2-806 Meaning of the Status LED

Status	Meaning
☐ Off	Channel deactivated or error
■ On	Channel activated and no error

see also Neutral current In (Page 103)

Error LED

Table 2-807 Meaning of the Error LED

Status	Meaning
☐ Off	Channel is OK
■ On	Channel is faulty

PWR LED

Table 2-808 Meaning of the PWR LED

PWR	Meaning
☐ Off	Line voltage missing
■ On	Line voltage available

17.2 Interrupts

The analog input module AI Energy Meter CT HF supports hardware and diagnostics interrupts.

17.2.1 Hardware interrupts

Hardware interrupts

The module generates a hardware interrupt at the following events:

- Violation of low limit 1 to 16
- Violation of high limit 1 to 16
- Measuring value recording of 200 measured values completed (DS173/ DS174 full)

You can find detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment of the local data double word 8 by the start information of the hardware interrupt organization block.

NOTE

When configuring with a GSD file, you operate the AI Energy Meter CT HF downstream of an S7-1500 CPU. For the correct OB start information to become visible for evaluation by the hardware interrupt, disable the optimized block access at the alarm OB.

LB 8								LB 9								LB 10								LB 11								Bit No.LD 8
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X						X	X	X	

ID of the measured value for limit monitoring or measured value recording

0000 0000 0000 0001 : 1
0000 0000 0000 0010 : 2
:
:
1111 1111 1111 1111 : 65535

Number of the limit or data record number of the measured value recording

0000: 1
0001: 2
:
:
1111: 16
10101101: DS173
10101110: DS174

Event that hastriggered the hardware interrupt

011: Low limit undershot
100: High limit exceeded
001: DS173 full
010: DS174 full

Figure 2-702 Start information of the organization block

17.2.2 Diagnostics interrupt

Diagnostic interrupt

The module generates a diagnostic error interrupt at the following events:

- Power quality
- Channel is temporarily unavailable
- Hardware interrupt lost
- Error
- Supply voltage missing
- Parameter assignment error
- Underflow voltage (tolerance for supply voltage) violated
- Overflow voltage (tolerance for supply voltage) exceeded
- Overload (current measurement > 12 A or tolerance overcurrent exceeded after expiry of the tolerance time)
- Overflow of the calculated values (measured or calculated values screen exceed the representable range of values)

17.3 Diagnostic alarms

NOTE

Assignment channel in diagnostic message ⇔ Phase

In the diagnostic messages the channels are counted from Channel "0" on, in the AI Energy Meter CT HF from phase "1" on.

Note the following assignment:

- Channel "0" ⇔ Phase "1"
- Channel "1" ⇔ Phase "2"
- Channel "2" ⇔ Phase "3"

Table 2-809 Error types

Diagnostic message	Error code	Meaning	Solution
Undervoltage	2_H	Line voltage (measuring range) is monitored for tolerance. Violation leads to voltage overflow/underflow	Observe the line voltage range
Overvoltage	3_H		
Overload	4_H	• The measured current is monitored after the "Tolerance time" for "Tolerance value overcurrent [0.1A]" has expired. Exceeding this results in overflow current. • The maximum value of the secondary current (12 A) has been exceeded.	Observe the current range
Error	9_H	Internal module error (diagnostic alarm on channel 0 applies to the entire module).	Replace the module

Diagnostic message	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Load voltage missing	11_H	Missing or insufficient line voltage at terminal 17	Check supply
External fault	$1A_H$	Voltage swell/dip and overcurrent	see: • Voltage swell of the voltage half-wave value (Page 125) • Voltage dip of the voltage half-wave value (Page 128) • Overcurrent of the current half value (Page 139)
Channel is temporarily unavailable	$1F_H$	Firmware upgrade is being performed. Channel 0 applies to the entire module. The module is currently not performing any measurements.	--
		A user calibration is being executed at the channel.	Complete the user calibration

17.4 Diagnostics response

Diagnostics response

This section describes the response of the AI Energy Meters CT HF when diagnostics information is reported.

Measured values in the case of diagnostics

Even in the case of diagnostics, measured values continue to be displayed as long as they can still be acquired. If measured values cannot be measured or calculated, "0" is displayed.

Low limit for current measurement undershot (zero suppression)

If the supplied current is less than the configured "Low limit for current measurement" parameter, the current measurement and all dependent variables are suppressed and set to "0".

If current falls below the low limit for the current measurement, the following measured values and derived variables of the affected phase are reset.

- Effective current value
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A moving mean value is formed from the power values and they only become "0" after a corresponding time. The energy meters for active, reactive and apparent energy as well as the operating hours counters do not count any longer.

If the secondary current fed in at the channel is higher than 12 A, the module changes to limitation and the current measurement value of the current and all dependent variables are set to "0".

Input data to "0"

If the AI Energy Meter CT HF is no longer recognized by the interface module (for example, because it is defective or not plugged in), all input data are set to "0".

17.4.1 Voltage diagnostics

17.4.1.1 Diagnostics: Overflow/underflow

Introduction

You use the parameter "Tolerance factor overvoltage/undervoltage" to define a tolerance range around the set nominal value voltage at the operating point. If the effective value of the primary voltage exceeds this tolerance range, the module reports the diagnostics "overflow" or "underflow".

Calculation of tolerance value measuring voltage

The tolerance value measuring voltage is calculated with the following formula:

Tolerance value measuring voltage = "Nominal value voltage" ± ("Tolerance factor overvoltage/undervoltage [%]" × "Nominal value voltage")

The "Nominal value voltage" is the primary voltage at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-810 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Diagnostics overflow	Enable
Diagnostics underflow	Enable
Nominal value voltage	1 ... 999999 V
Voltage transformer primary voltage	1 ... 999999 V
Voltage transformer secondary voltage	1 ... 500 V
Tolerance factor overflow/underflow	10 ... 50%

Example

The following figure is a schematic diagram of the principle of operation:

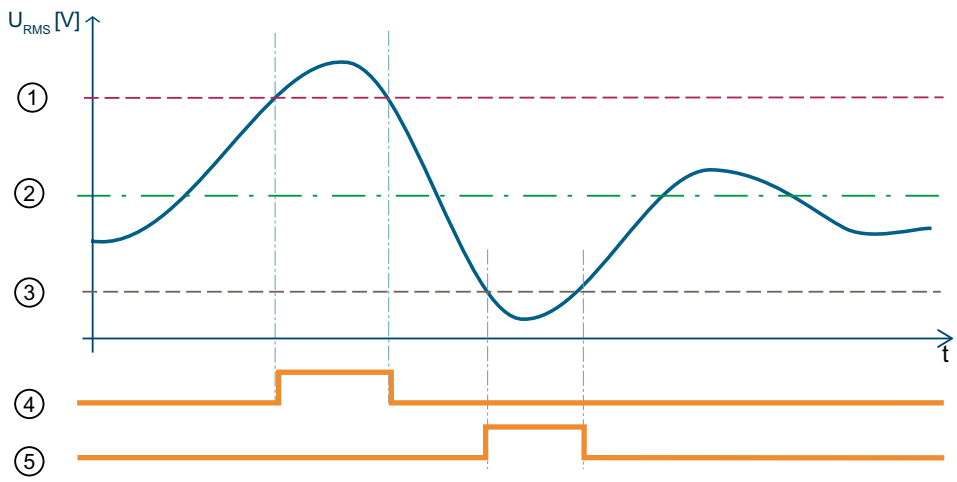

① Upper tolerance value measuring voltage
② Nominal voltage
③ Lower tolerance value measuring voltage
④ Diagnostics "overflow"
⑤ Diagnostics "underflow"

Figure 2-703 "Overflow/Underflow" diagnostics of the effective voltage value

The following table shows the parameter assignment for the example:

Table 2-811 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Diagnostics overflow	Enable
Diagnostics underflow	Enable

Parameter	
Nominal value voltage	230 V
Voltage transformer primary voltage	1000 V
Voltage transformer secondary voltage	500 V
Tolerance factor overflow/underflow	20%

In this example a voltage transformer is used with a ratio of 1000V/500V. The operating point of the application is set to 230 V via the Nominal Value Voltage parameter. The tolerance range in this example is ±20%, which corresponds to an effective value of primary voltage of ±46V.

In the figure the effective value of the primary voltage first exceeds the tolerance range. As long as the effective value of the primary voltage exceeds the tolerance range the module reports the diagnostics "overflow".

The effective value of the primary voltage then exceeds the tolerance range. As long as the effective value of the primary voltage exceeds the tolerance range the module reports the diagnostics "underflow".

17.4.1.2 Voltage swell of the voltage half-wave value

Introduction

Voltage swells are short-term increases in the line voltage which can occur, for example, when switching off large consumers.

With the parameter "Number of cycles for analysis" you define how many measuring cycles the voltage swell must apply at until the module reports the voltage swell. The module reports the diagnostics "Power quality". The module also sets the qualifier bit 6 for the respective phase in data record DS 160 (Page 269). If the voltage lies below the limit for voltage swell again, the module sets the diagnostics "Power quality" again and resets the qualifier bit 6 again.

The AI Energy Meter CT HF returns the maximum value and the duration of the voltage swell, e.g. in data record 160. The duration is determined exactly to ± 2 cycles.

In the event of voltage swell again, only the diagnostics "Power quality" is reported again and the duration, and if applicable, the maximum voltage swell value is updated.

For technical reasons, if the process value for the voltage goes to "0", then the module shows a slightly longer time for a voltage swell.

Calculation of voltage swell limit value

The Voltage swell limit value is the value from which level of voltage the AI Energy Meter CT HF recognizes a voltage swell.

The "Voltage swell limit value" is calculated by the following formula:

Voltage swell limit = "Nominal value voltage" + ("Voltage swell limit [%]" × "Nominal value voltage")

The "Nominal value voltage" is the primary voltage at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-812 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Number of cycles for analysis	4 ... 32767
Diagnostics power quality	Enable
Determination of voltage swell and dip	Enable
Nominal value voltage	1 ... 999999 V
Voltage swell limit	1 ... 1000%

Example

The following figure is a schematic diagram of the principle of operation:

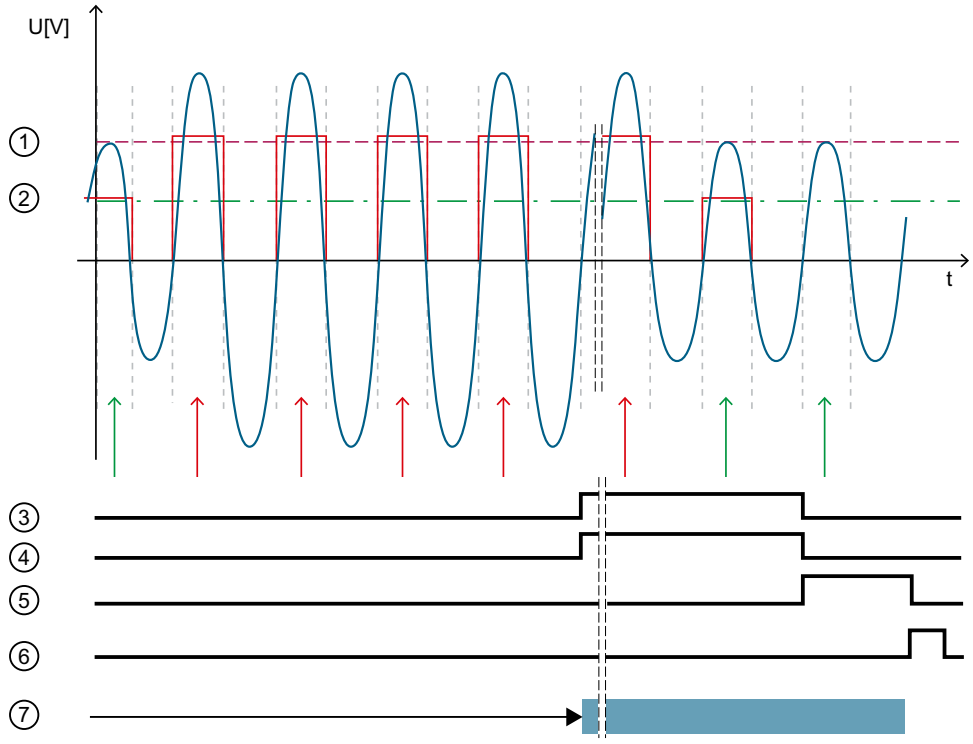

① Voltage swell limit
② Nominal voltage
③ Diagnostics "power quality"
④ Qualifier Bit 6
⑤ Status "Power quality voltage swell"
⑥ Bit "Reset status "power quality""
⑦ Min. voltage swell (half-wave) and duration can be read

Figure 2-704 Example of principle of operation

The following table shows the parameter assignment for the example:

Table 2-813 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Number of cycles for analysis	4
Diagnostics power quality	Enable
Determination of voltage swell and dip	Enable
Nominal value voltage	230 V
Voltage swell limit	20%

If the module detects that the "Voltage swell limit value" has been exceeded:

- The module reports the diagnostics "Power quality" from "Number of cycles for analysis" as long as there is a voltage swell.
- The module sets the qualifier bit 6 from "Number of cycles for analysis" as long as there is a voltage swell.
- After the module has reset the diagnostics "Power quality" and reset the qualifier bit again, Bit 1 is set.

As long as Bit 1 is set, the module returns the maximum value and the duration of the voltage swell, e.g. in data record 160.

You reset Bit 1 with the bit "reset status "power quality"".

17.4.1.3 Voltage dip of the voltage half-wave value

Introduction

Voltage dips are short-term decreases in the line voltage which can occur, for example, when switching on large consumers.

With the parameter "Number of cycles for analysis" you define how many measuring cycles the voltage dip must be present until the module reports the voltage dip. If the voltage lies above the "Voltage dip limit" again, the module sets the diagnostics "Power quality" and resets the qualifier bit 5 again.

The AI Energy Meter CT HF returns the maximum value and the duration of the voltage dip, e.g. in data record DS 160 (Page 269). The duration is determined exactly to ± 2 cycles.

In the event of voltage dip, the module reports a "Power quality" diagnostic. The module also sets the qualifier bit 5 for the respective phase in data record DS 160. In the event of voltage dip again, only the "Power quality" diagnostics is reported again and the duration, and if applicable, the minimum voltage dip value is updated.

For technical reasons, if the process value for the voltage goes to "0", then the module shows a slightly longer time for a voltage dip.

Calculation of voltage dip limit

The voltage dip limit is the value from which level of voltage the AI Energy Meter CT HF detects a voltage dip.

The voltage dip limit is calculated by the following formula:

Voltage dip limit = "Nominal value voltage" - ("Voltage dip limit [%]" × "Nominal value voltage")

The "Nominal value voltage" is the primary voltage at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-814 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Number of cycles for analysis	4 ... 32767
Diagnostics power quality	Enable
Determination of voltage swell and dip	Enable
Nominal value voltage	1 ... 999999 V
Voltage dip limit	1 ... 100%

Example

The following figure is a schematic diagram of the principle of operation:

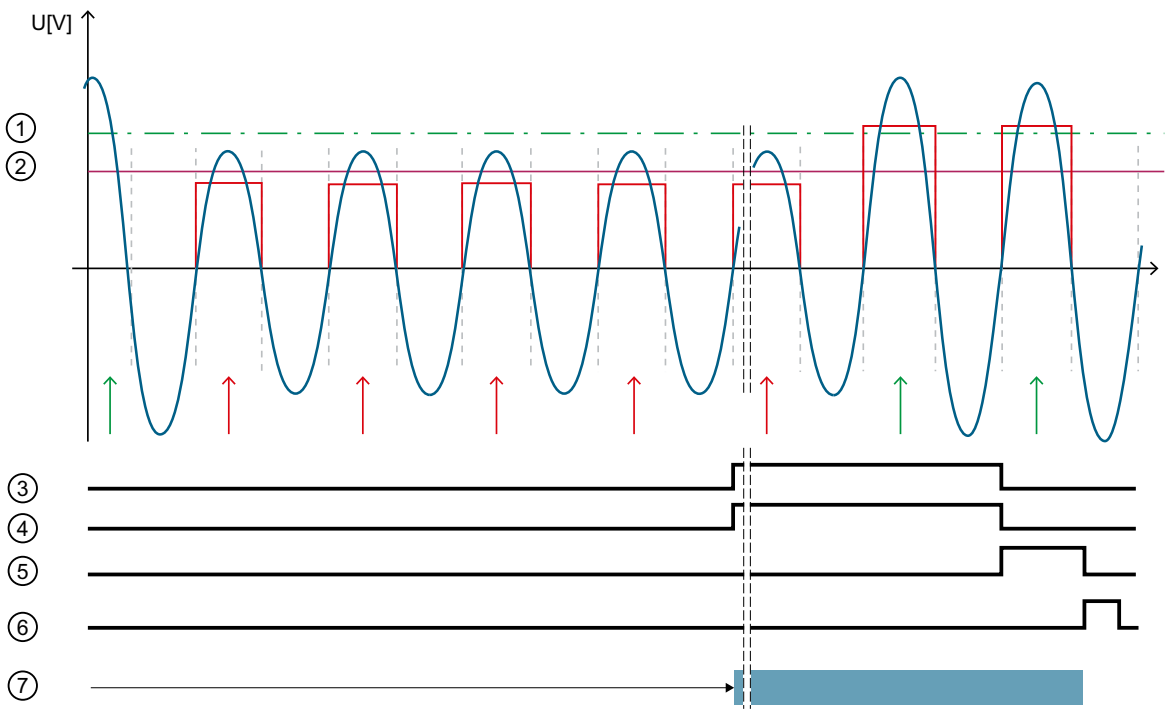

① Nominal voltage
② Voltage dip limit
③ Diagnostics "power quality"
④ Qualifier Bit 0
⑤ Status "Power quality voltage dip"
⑥ Bit "Reset status "power quality""
⑦ Min. voltage dip (half-wave) and duration can be read

Figure 2-705 Example of principle of operation

The following table shows the parameter assignment for the example:

Table 2-815 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Number of cycles for analysis	4
Diagnostics power quality	Enable
Determination of voltage swell and dip	Enable
Nominal voltage	230 V
Voltage dip limit	50%

If the module detects that the "Voltage dip limit" has been undershot:

- The module reports the diagnostics "Power quality" from "Number of cycles for analysis" as long as there is a voltage dip.
- The module sets the qualifier bit 5 from "Number of cycles for analysis" as long as there is a voltage dip.
- After the module has reset the diagnostics "Power quality" and reset the qualifier bit again, bit 0 is set.

As long as bit 0 is set, the module returns the minimum value and the duration of the voltage dip, e.g. in data record 160.

You reset Bit 0 with the bit "Reset status "power quality"".

17.4.1.4 Peak values of the instantaneous values for voltage

Introduction

The AI Energy Meter CT HF determines the maximum instantaneous value for the voltage for up to three phases.

The function "Detect peak value voltage" returns the largest voltage value and the associated phase. The module sets the qualifier bit 2 ("Power quality voltage peak") for the phase in question. You can read the maximum voltage value, for example, in the data record DS 160 (Page 269).

Voltage peak detection is based on the function for recording swells of the supply voltage in accordance with IEC 61000-4-30. This function is used to record the maximum voltage value in the supply network. In three-phase systems this function is only useful if the system is symmetrical and when all phases show the same voltage transformers.

Accordingly, measurement always records only the peak value over all phases. In addition to the requirements of IEC 61000-4-30, the phase on which the peak value voltage occurred is detected.

For metrological reasons, only the phase concerned that shows this maximum value can be returned. This might mean that the maximum voltage values of the other phases remain "0". With a "reset power quality analysis" the analysis starts afresh and the current results are discarded.

Peak value detection of voltage

For technical reasons, both the "Detect peak value current" and "Detect peak value voltage" functions are activated at the same time internally to ensure the correct evaluation of the peak value detection of the voltage of a phase.

The AI Energy Meter CT HF always shows the phase that exhibits the highest instantaneous value for voltage respectively.

If peak values are displayed for several phases, you can correlate the available phase values to determine the maximum value of the module.

Peak value detection of the instantaneous values of voltage only works when the module is correctly connected to the corresponding phases selected for the connection type.

- For connection type 1P2W only phase 1 should be connected.
- For connection type 2P3W only the phases 1 and 2 should be connected.

Parameter assignment

The following table shows the necessary parameters:

Table 2-816 Parameter assignment

Parameter	
Power quality analysis function (module)	Enable
Determine peak value voltage (channel)	Enable

Example

The following figure is a schematic diagram of the principle of operation:

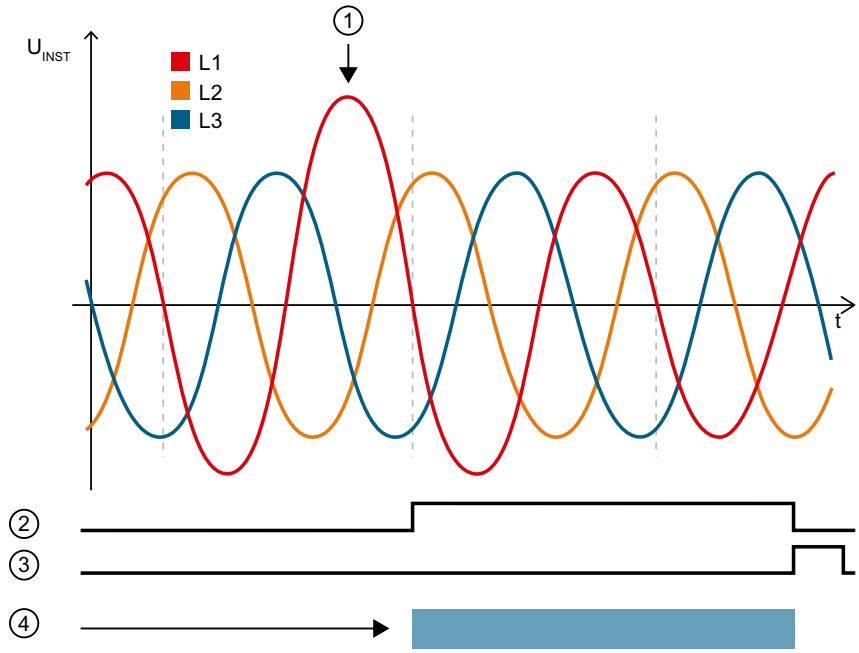

① Voltage peak in L1
② Status "Power quality voltage peak"
③ Bit "Reset status "power quality""
④ Max. voltage peaks instantaneous value can be read out

Figure 2-706 Example of principle of operation

The following table shows the parameter assignment for the example:

Table 2-817 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Determination of voltage peak value L1	Enable
Determination of voltage peak value L2	Enable
Determination of voltage peak value L3	Enable

The module detects the voltage peak in phase 1 and sets the qualifier bit 2 for phase 1. You can find the maximum voltage value, for example, in the data record DS 160 in bytes 174 to 177 ("Voltage peak value L1").

17.4.2 Current diagnostics

17.4.2.1 Diagnostics: Overload

Introduction

As long as one of the following conditions is met, the module reports the diagnostics "Overload" for each phase:

- If the tolerance value measured current parameterized for each phase is exceeded for the tolerance time overcurrent parameterized for each phase.
- If the maximum measured current of the AI Energy Meters CT HF is exceeded:
  - Secondary measured current: 12 A

Calculation of tolerance value measured current

The tolerance value measured current is calculated with the following formula:

Tolerance value measured current = "Nominal value current" + ("Tolerance factor overcurrent [%]" × "Nominal value current")

The "Nominal value current" is the primary current at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-818 Parameter assignment

Parameter	
Diagnostics overload	Enable
Nominal value current	0 ... 99999 A
Current transformer primary current	1 ... 99999 A
Current transformer secondary current	5 A
Tolerance factor overcurrent	1 ... 6000%
Tolerance time overcurrent	0 ... 60000 ms

Example

The following figure is a schematic diagram of the principle of operation:

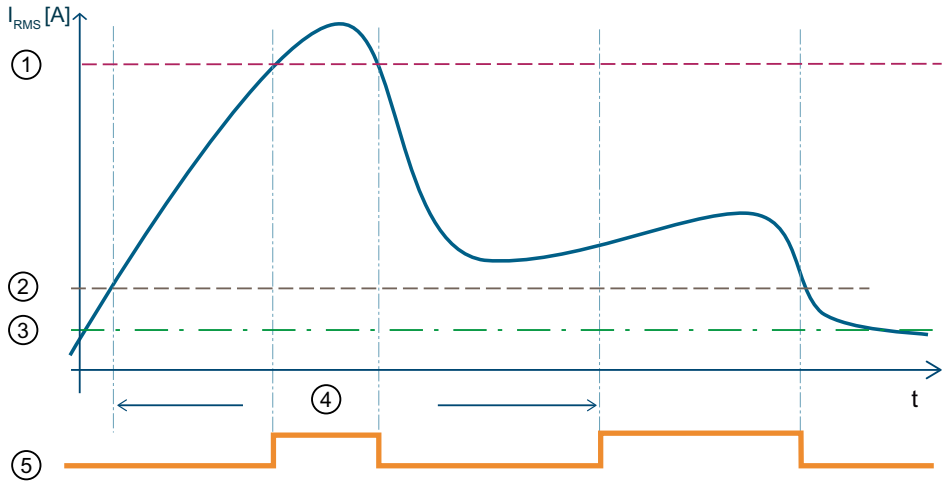

① Maximum measured current 12 A secondary current (CT) or 424 mV secondary voltage (RC)

② Tolerance value measured current

③ Nominal value current

④ Tolerance time

⑤ Diagnostics "overload"

Figure 2-707 Diagnostics "overload" of the effective current value

The following table shows the parameter assignment for the example:

Table 2-819 Parameter assignment

Parameter	
Diagnostics overload	Enable
Nominal value current	2000 A
Current transformer primary current	5000 A
Current transformer secondary current	5 A
Tolerance factor overcurrent	20%
Tolerance time overcurrent	40000 ms

If the maximum measured current for the module (12000 A primary current) is exceeded, the module reports the diagnostics "Overload" as long as the maximum measured current is exceeded.

After the "Tolerance time overcurrent" of 40000 ms has expired, the module reports the diagnostics "Overload" as long as the configured "Tolerance value measured current" is exceeded.

17.4.2.2 Low limit for measuring current undershot

Introduction

With the function "Low limit for measuring current undershot" the AI Energy Meter CT HF monitors the low limit of the effective value of the current per phase.

If the low limit for measuring current is undershot, the module sets the current value to 0 (zero point suppression). Information as to which current measured values are set to 0 can be found under Basics for reading measured values (Page 44).

You activate the function by setting the parameter "Low limit for measuring current" > 0%.

Calculation of low limit for measuring current

The low limit for measuring current is calculated with the following formula:

Low limit measured current = "Nominal value current" × "Low limit for measuring current [%]"

The "Nominal value current" is the primary current at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-820 Parameter assignment

Parameter	
Nominal value current	0 ... 99999 A
Current transformer primary current	1 ... 99999 A
Current transformer secondary current	1 ... 16000 A
Low limit for current measurement	0 ... 20% *

* 0% means deactivation of the function

Example

The following figure is a schematic diagram of the principle of operation:

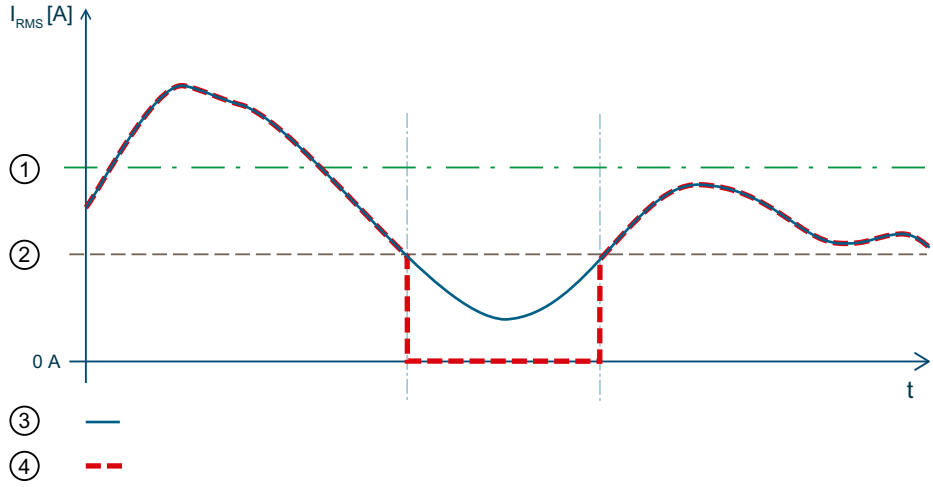

① Nominal current
② Low limit measured current
③ Measured value
④ Returned value

Figure 2-708 Behavior in the event of value falling below "Low limit for measuring current undershot"

The following table shows the parameter assignment for the example:

Table 2-821 Parameter assignment

Parameter	
Nominal value current	2000 A
Current transformer primary current	5000 A
Current transformer secondary current	5 A
Low limit for current measurement	10%

In this example you define the "Low limit for measuring current" with 10%. This corresponds to an effective value of the primary voltage of 200 A.

If the value falls below the calculated low limit for current measurement, the module sets all current-dependent measured values (effective value current, active power, reactive power, apparent power, phase angle and power factor) to 0 A until the low limit for measuring current is exceeded again (zero point suppression). The energy meters and operating hours counters are stopped during this time.

17.4.2.3 Peak values of the instantaneous values for current

Introduction

The AI Energy Meter CT HF determines the maximum instantaneous value for the current for up to three phases.

The function "Detect peak value current" returns the largest current value and the associated phase. The module sets the qualifier bit 3 ("Power quality current peak") for the phase in question. You can read the maximum current value, for example, in the data record DS 160 (Page 269).

Current peak detection is based on the function for recording swells of the supply voltage in accordance with IEC 61000-4-30. This function is used to record the maximum current value in the supply network. In three-phase systems this function is only useful if current recording is symmetrical and if all phases show the same current transformers.

Accordingly, measurement always records only the peak value over all phases. In addition to the requirements of IEC 61000-4-30, the phase on which the peak value current occurred is detected.

For metrological reasons, only the phase concerned that shows this maximum value can be returned. This might mean that the maximum current values of the other phases remain "0". With a "reset power quality analysis" the analysis starts afresh and the current results are discarded.

Peak value detection of current

For technical reasons, both the "Detect peak value current" and "Detect peak value voltage" functions are activated at the same time internally to ensure the correct evaluation of the peak value detection of the current of a phase.

The AI Energy Meter CT HF always shows the phase that exhibits the highest instantaneous value for current respectively.

If peak values are displayed for several phases, you can correlate the available phase values to determine the maximum value of the module.

Peak value detection of the instantaneous values of current only works when the module is correctly connected to the corresponding phases selected for the connection type.

- For connection type 1P2W only phase 1 should be connected.
- For connection type 2P3W only the phases 1 and 2 should be connected.

Parameter assignment

The following table shows the necessary parameters:

Table 2-822 Parameter assignment

Parameter	
Power quality analysis function (module)	Enable
Determine peak value current (Channel)	Enable

Example

The following figure is a schematic diagram of the principle of operation:

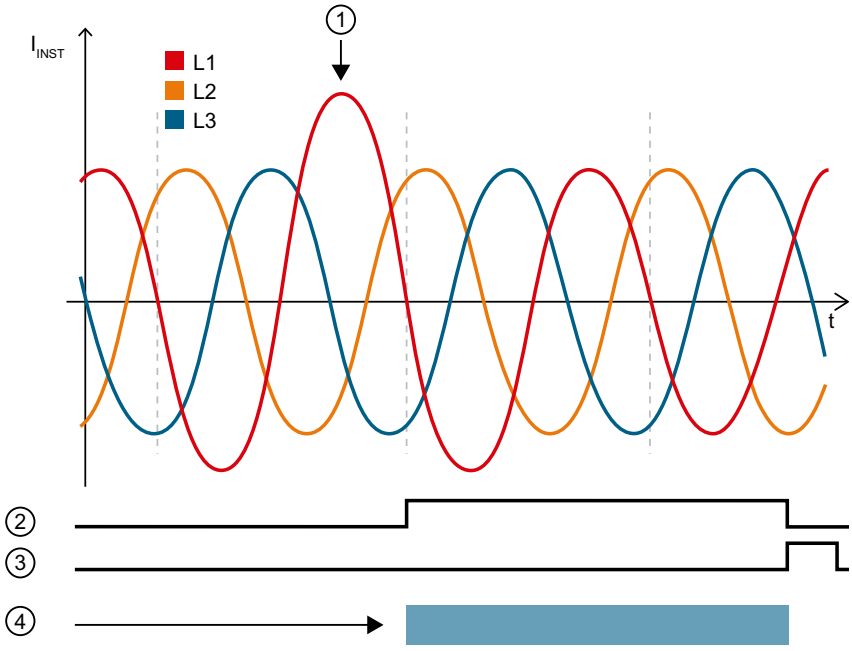

① Current peak in L1
② Status "Power quality current peak"
③ Bit "Reset status "power quality""
④ Max. current peaks instantaneous value can be read out

Figure 2-709 Example of principle of operation

The following table shows the parameter assignment for the example:

Table 2-823 Parameter assignment

Parameter	
Power quality analysis function	Enable
Determine peak value current (L1)	Enable
Determine peak value current (L2)	Enable
Determine peak value current (L3)	Enable

The module detects the peak value current in phase 1 and sets the qualifier bit 3 for phase 1. You can find the maximum current value, for example, in the data record DS 160 in bytes 186 to 189 ("Current peak value L1").

17.4.2.4 Overcurrent of the current half value

Introduction

The AI Energy Meter CT HF returns the maximum overcurrent value of the current half-wave value. If the value to be monitored is exceeded, the module reports the diagnostics "Power quality" and the qualifier bit 7 is set. The module also sets Bit 4 for the respective phase in data record DS 160 (Page 269). In the event that the current half-value is exceeded again, only the diagnostics "Power quality" is reported again and, if applicable, the maximum current swell value is updated.

Calculation of overcurrent limit

The overcurrent limit is calculated based on the following formula:

Overcurrent limit = "Nominal value current" + ("Threshold overcurrent [%]" × "Nominal value current")

The "Nominal value current" is the primary current at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-824 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Diagnostics power quality	Enable
Determining the overcurrent	Enable
Nominal value current	0 ... 99999 A
Threshold overcurrent	1 ... 6000%

Example

The following figure is a schematic diagram of the principle of operation:

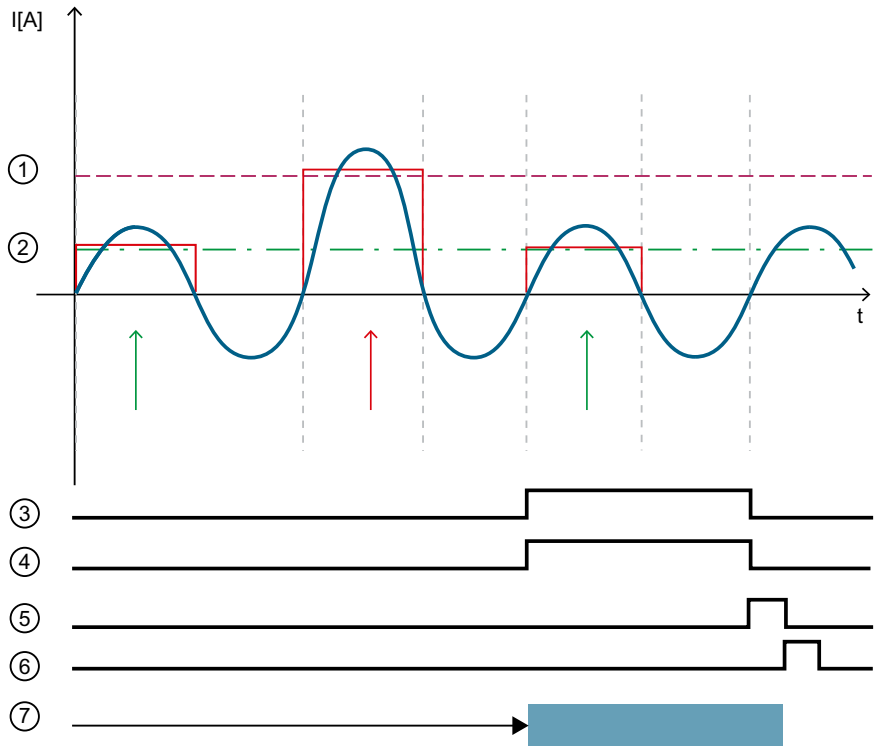

① Threshold overcurrent
② Nominal current
③ Qualifier Bit 7
④ Diagnostics power quality
⑤ Status "power quality overcurrent"
⑥ Bit "Reset status "power quality""
⑦ Max. overcurrent (half-wave) value can be read

Figure 2-710 Example of principle of operation

The following table shows the parameter assignment for the example:

Table 2-825 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Diagnostics power quality	Enable
Determining the overcurrent	Enable
Nominal value current	2000 A
Threshold overcurrent	100%

In this example you define the Threshold overcurrent of 100%. This corresponds to a primary current of 4000 A.

If the "Threshold overcurrent" is exceeded, the module sets Bit 4 "Overcurrent" for the phase in the data record DS 160.

As long as the "Threshold overcurrent" is exceeded, the module reports the diagnostics "Power quality" and the qualifier bit 7 is set.

Technical specifications 18

18.1 Technical specifications

Technical specifications of the AI Energy Meter CT HF

The following table shows the technical specifications as of 03/2021. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7134-6PA01-0CU0/td?dl=en).

Article number	6ES7134-6PA01-0CU0
General information	
Product type designation	AI Energy Meter CT HF
Firmware version	V8.0
• FW update possible	Yes
usable BaseUnits	BU type U0
Supported power supply systems	TT, TN, IT
Product function	
• Voltage measurement	Yes
– without voltage transformer	Yes
– with voltage transformer	Yes
• Current measurement	Yes; Max. 4
– without current transformer	No
– with current transformer	Yes; 1 A or 5 A current transformer
– With Rogowski coil	No
– With current-voltage-converter	No
• Energy measurement	Yes
• Frequency measurement	Yes
• Power measurement	Yes
• Active power measurement	Yes
• Reactive power measurement	Yes
• Power factor measurement	Yes
• Active factor measurement	Yes
• Reactive power compensation	Yes
• Line analysis	Yes
– Monitoring of instantaneous and half-wave values	Yes

Article number	6ES7134-6PA01-0CU0
– THD measurement for current and voltage	Yes
– Harmonics for current and voltage	Yes
– Voltage dip (DIP)	Yes
– Voltage swell	Yes
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V16 or higher with HSP
• STEP 7 configurable/integrated from version	V5.5 SP3 or higher
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	V2.3
Operating mode	
• Switching between operating modes in RUN	Yes; For module version 32 I/20 Q, it is possible to dynamically switch between 25 user data variants, 23 of which are pre-defined and 2 of which can be defined by the specific user
• Cyclic measured value access	Yes
• Acyclic measured value access	Yes
• Fixed measured value sets	Yes
• Freely definable measured value sets	Yes; For cyclic and acyclic measured value access
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	Yes
Installation type/mounting	
Mounting position	any
Supply voltage	
Design of the power supply	DC
Type of supply voltage	24 V DC
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Input current	
Current consumption (rated value)	12.5 mA
Current consumption, max.	17 mA
Power loss	
Power loss, typ.	1.4 W; 4x 6 A input current, 3x 230 V AC
Address area	
Address space per module	
• Inputs	256 byte
• Outputs	20 byte

Article number	6ES7134-6PA01-0CU0
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type U0
Time of day	
Operating hours counter	
• present	Yes
Analog inputs	
Cycle time (all channels), typ.	50 ms; Time for consistent update of all measured and calculated values (cyclic und acyclic data)
Cable length	
• shielded, max.	200 m
• unshielded, max.	200 m
Analog value generation for the inputs	
Sampling frequency, max.	2 048 kHz
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes
• Hardware interrupt	Yes; Monitoring of up to 16 freely selectable process values (exceeding or undershooting of value)
Diagnoses	
• Line quality	Yes
• Supply voltage	Yes
• Hardware interrupt lost	Yes
• Parameter assignment error	Yes
• Module fault	Yes
• Channel not available	Yes
• Overflow/underflow	Yes
• Overload current	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red Fn LED
• for module diagnostics	Yes; green/red DIAG LED

Article number	6ES7134-6PA01-0CU0
Integrated Functions	
Measuring functions	
• Measuring procedure for voltage measurement	TRMS
• Measuring procedure for current measurement	TRMS
• Type of measured value acquisition	seamless
• Curve shape of voltage	Sinusoidal or distorted
• Buffering of measured variables	Yes
• Parameter length	128 byte
• Bandwidth of measured value acquisition	3.2 kHz; Harmonics: 63 / 50 Hz, 52 / 60 Hz
Measuring range	
– Frequency measurement, min.	40 Hz
– Frequency measurement, max.	70 Hz
Measuring inputs for voltage	
– Measurable line voltage between phase and neutral conductor	277 V
– Measurable line voltage between the line conductors	480 V
– Measurable line voltage between phase and neutral conductor, min.	3 V
– Measurable line voltage between phase and neutral conductor, max.	300 V
– Measurable line voltage between the line conductors, min.	6 V
– Measurable line voltage between the line conductors, max.	519 V
– Internal resistance line conductor and neutral conductor	1.5 MΩ
– Power consumption per phase	60 mW; 300 V AC
– Impulse voltage resistance 1,2/50µs	2.5 kV
Measuring inputs for current	
– measurable relative current (AC), min.	1 %; Relative to measuring range; 1 A, 5 A
– measurable relative current (AC), max.	120 %; Relative to the secondary rated current 5 A
– Continuous current with AC, maximum permissible	5 A; 6 A permanent thermal overload
– Apparent power consumption per phase for measuring range 5 A	0.6 V·A
– Rated value short-time withstand current restricted to 1 s	100 A
– Input resistance measuring range 0 to 5 A	25 mΩ; At the terminal
– Surge strength	10 A; for 1 minute

Article number	6ES7134-6PA01-0CU0
– Zero point suppression	0 ... 20%, referred to the nominal current
Accuracy class according to IEC 61557-12	
– Measured variable apparent power	0.5
– Measured variable active power	0.5
– Measured variable power factor	0.5
– Measured variable active energy	0.5
– Measured variable phase angle	±0.5 °; not covered by IEC 61557-12
– Measured variable frequency	0.05; only valid for the permissible voltage measuring range
Accuracy class line analysis acc. to IEC 61000-4-30	
– Measured variable voltage	Class S
– Measured variable current	Class S
– Measured variable frequency	Class S
– Measured variable voltage interruption	Class S
– Measured variable voltage dip and swell	Class S
– Measured variable harmonic voltage	Class S
– Measured variable harmonic current	Class S
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• Between the channels and load voltage L+	Yes; Including FE
Isolation	
Isolation tested with	Between channels and backplane bus, 24 V supply: Routine test, 1 920 V AC, 2 s; between backplane bus and 24 V supply: Type test, 707 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm

Article number	6ES7134-6PA01-0CU0
Weights	
Weight, approx.	45 g
Other	
Data for selecting a voltage transformer	
• Secondary side, max.	300 V
Data for selecting a current transformer	
• Burden power current transformer x/1A, min.	As a function of cable length and cross section, see device manual
• Burden power current transformer x/5A, min.	As a function of cable length and cross section, see device manual

Dimension drawing

See ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) manual

Parameter data records

A

A.1 Configuration via parameter data records

The parameter data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Overview of the parameter data records

- Parameter data record DS 128 for the complete module
- Parameter data record DS 129 for limit monitoring
- Parameter data records DS 130/131 for payload mapping
- Parameter data record DS 134 for measured value recording
- Parameter data record DS 135 for data record mapping

Parameter assignment in the user program

You can reassign the module parameters in RUN mode, for example change the diagnostics behavior, define new limits or configure a modified payload mapping.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module via the respective data record. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

If you reconfigure a module (so that the payload size changes) and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing". The diagnostics "Supply voltage missing" is signaled as outgoing.

A reconfiguration in run is not bumpless. It can take up to 1 second for all measured values to become stable.

STATUS output parameter

If errors occur during the transfer of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

A.2 Structure of the parameter data record 128 for the entire module

Structure of data record 128

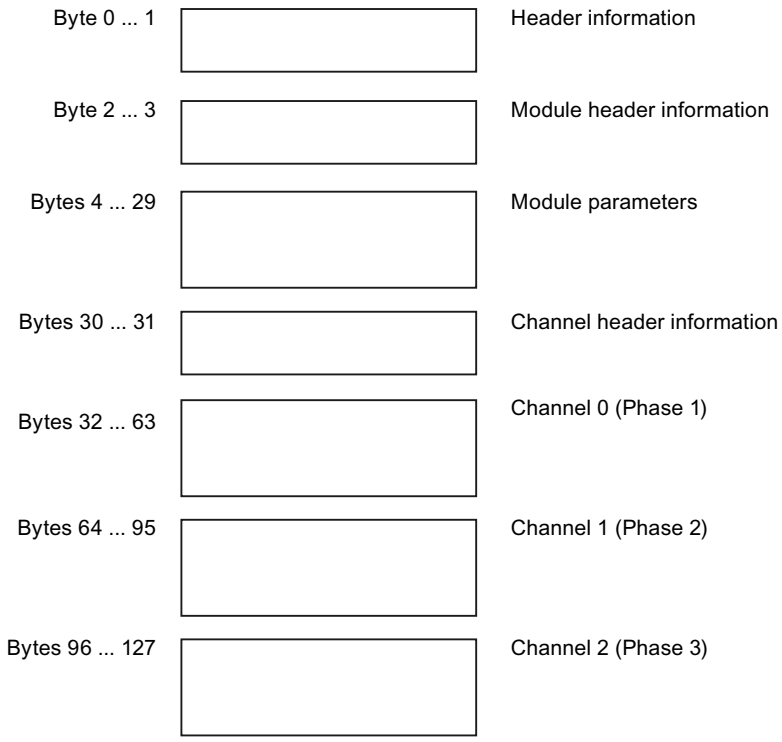

Figure 2-711 Parameter data record 128

Header information

The figure below shows the structure of the header information.

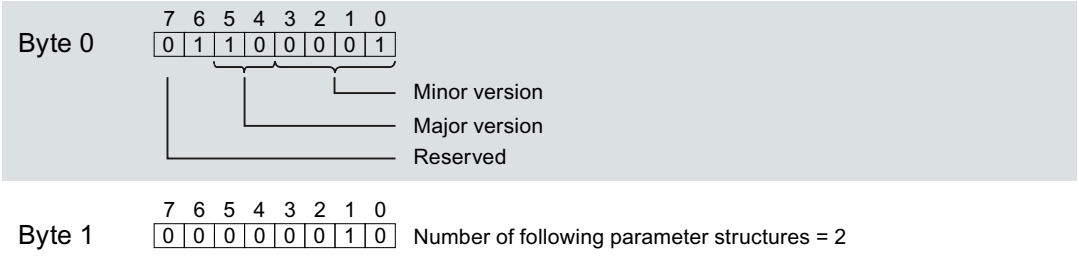

Figure 2-712 Header information

Module header information

The figure below shows the structure of the header information for a module.

	7	6	5	4	3	2	1	0	
Byte 2	0	0	0	0	0	0	0	1	Number of the following module parameter blocks = 1
Byte 3	0	0	0	1	1	0	1	0	Length of the following module parameter block = 26

Figure 2-713 Module header information

Module parameter block

The figure below shows the structure of the module parameter block.

Byte 4 (7 6 5 4 3 2 1 0)

Connection type of the phases

- 00_H = disabled
- $0B_H$ = 1P2W: 1-phase alternating current, 2 conductors
- $0C_H$ = 3P4W: 3-phase, 4 conductors
- $0D_H$ = 3P4WI: 3-phase current measurement, 4 conductors
- $0E_H$ = 3P4W1: 3-phase, 4 conductors, balanced load
- $0F_H$ = 3x1P2W: 3x1-phase alternating current, 2 conductors
- 10_H = 2P3W: 2-phase, 3 conductors
- 11_H = 3P3W: 3-phase, 3 conductors
- 12_H = 3P3W1: 3-phase, 3 conductors, balanced load

Byte 5 (7 6 5 4 3 2 1 0)

Voltage measuring range of the power supply system
(Supply voltage, nominal value of phase voltage)

- 01_H = 100 V
- 02_H = 110 V
- 03_H = 115 V
- 04_H = 120 V
- 05_H = 127 V
- 06_H = 190 V
- 07_H = 200 V
- 08_H = 208 V
- 09_H = 220 V
- $0A_H$ = 230 V
- $0B_H$ = 240 V
- $0C_H$ = 277 V
- $0D_H$ = 300 V

Byte 6 (7 6 5 4 3 2 1 0)

Line frequency of the power supply system

- 0001 = 60 Hz
- 0010 = 50 Hz

Full-scale value for energy counter

- 000 = No end value - infinite counting
- 001 = Count periodically to 10^3
- 010 = Count periodically to 10^6
- 011 = Count periodically to 10^9
- 100 = Count periodically to 10^{12}
- 101 = Count periodically to 10^{15}

Energy counter gate

- 0 = Energy counter always counting
- 1 = Energy counter gate

Byte 7 (7 6 5 4 3 2 1 0): 0 0 0 0 0 0 0 0 — reserved

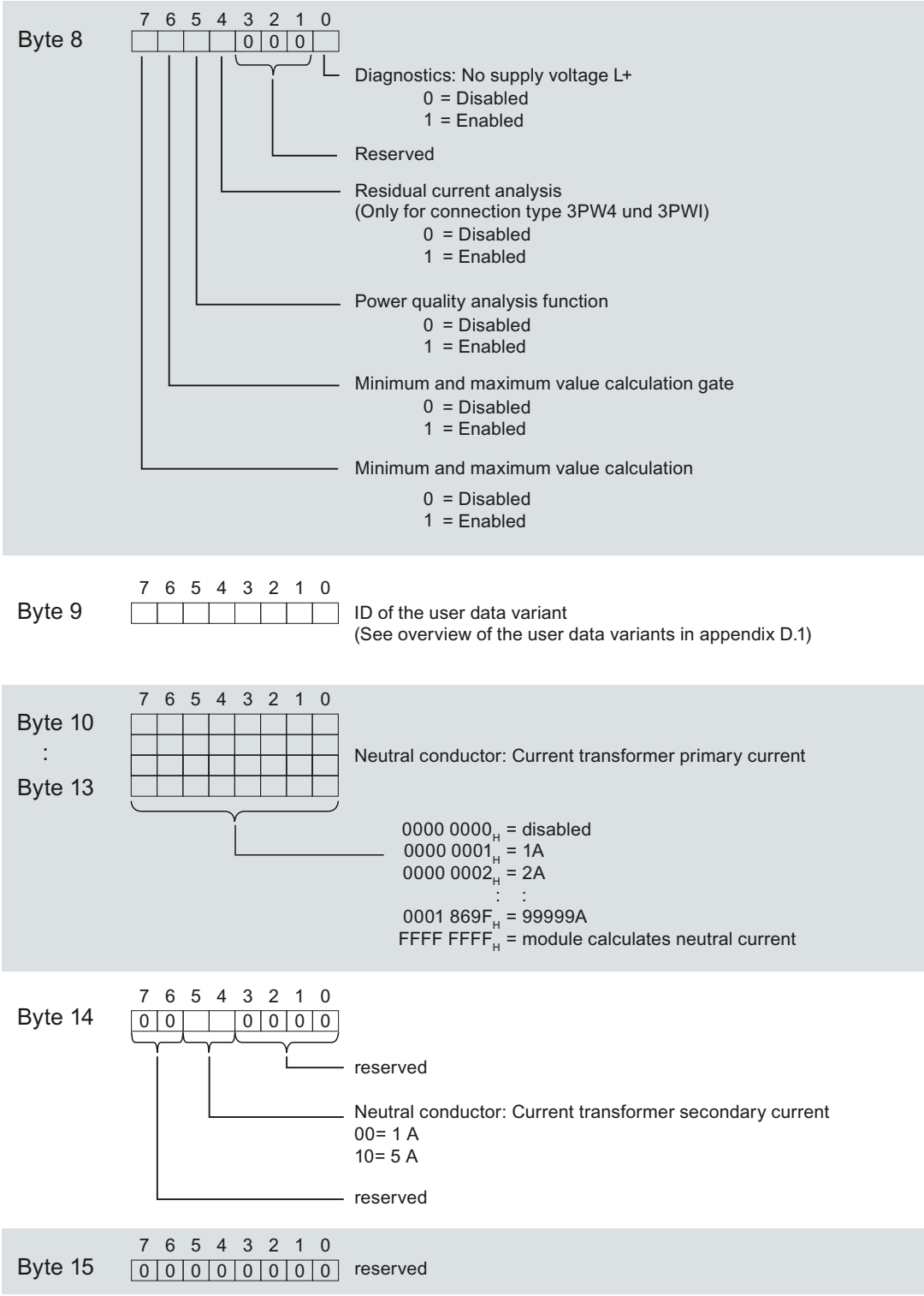

Figure 2-714 Module parameter block

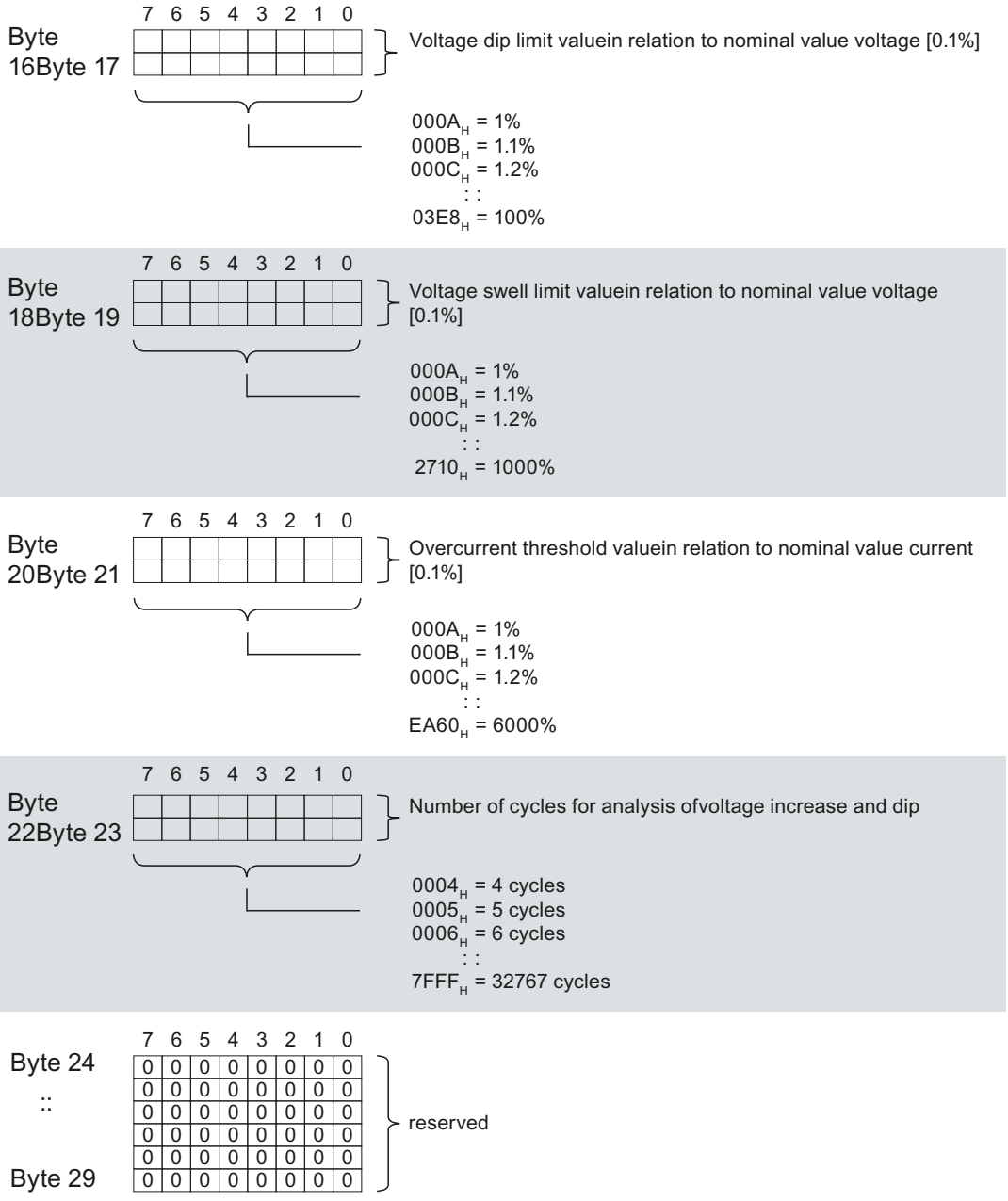

Figure 2-715 Module parameter block

You can find the payload variant in the section Overview of the payload variants (Page 218).

Channel header information

The following figure shows the structure of the header information for a channel.

	7	6	5	4	3	2	1	0	
Byte 30	0	0	0	0	0	0	1	1	Number of following channel parameter blocks = 3
Byte 31	0	0	1	0	0	0	0	0	Length of the following channel parameter block = 32

Figure 2-716 Channel header information

Channel parameter block for channel 0 (Phase 1)

The following figure shows an example of the structure of the channel parameter block for channel 0 (phase 1, bytes 32 to 63).

For channel 1 (phase 2; bytes 64 to 95) and channel 2 (phase: 3; bytes 96 to 127), the structure is identical.

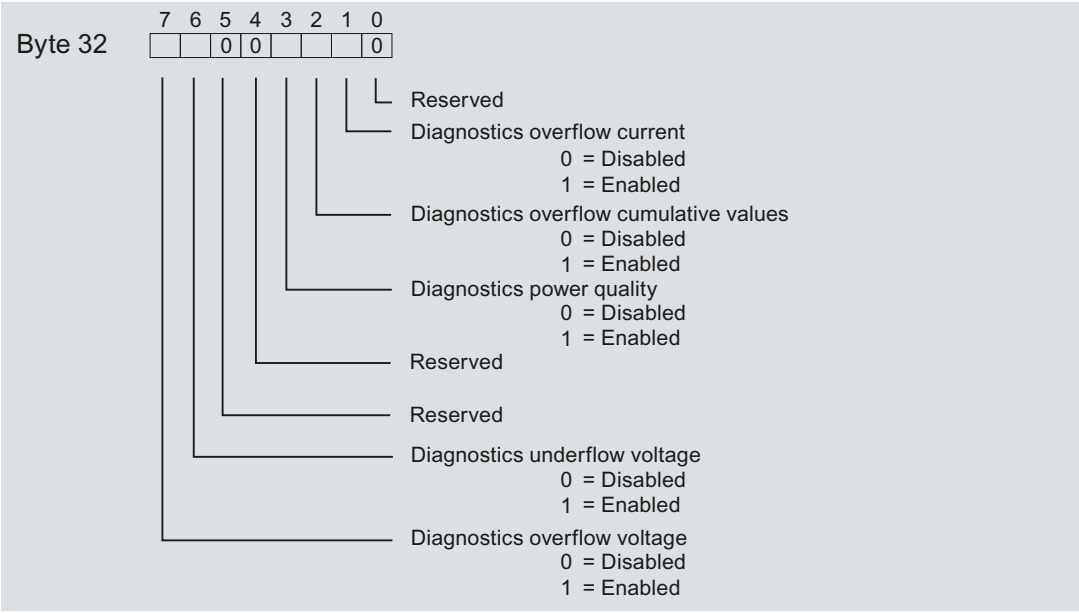

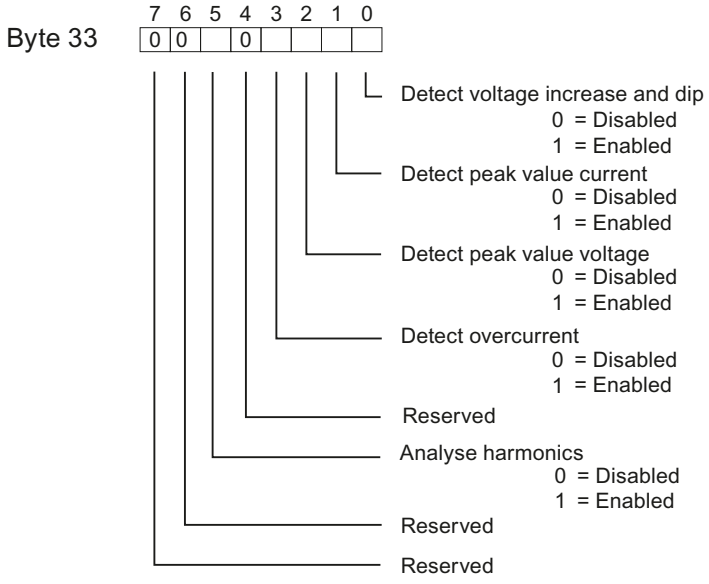

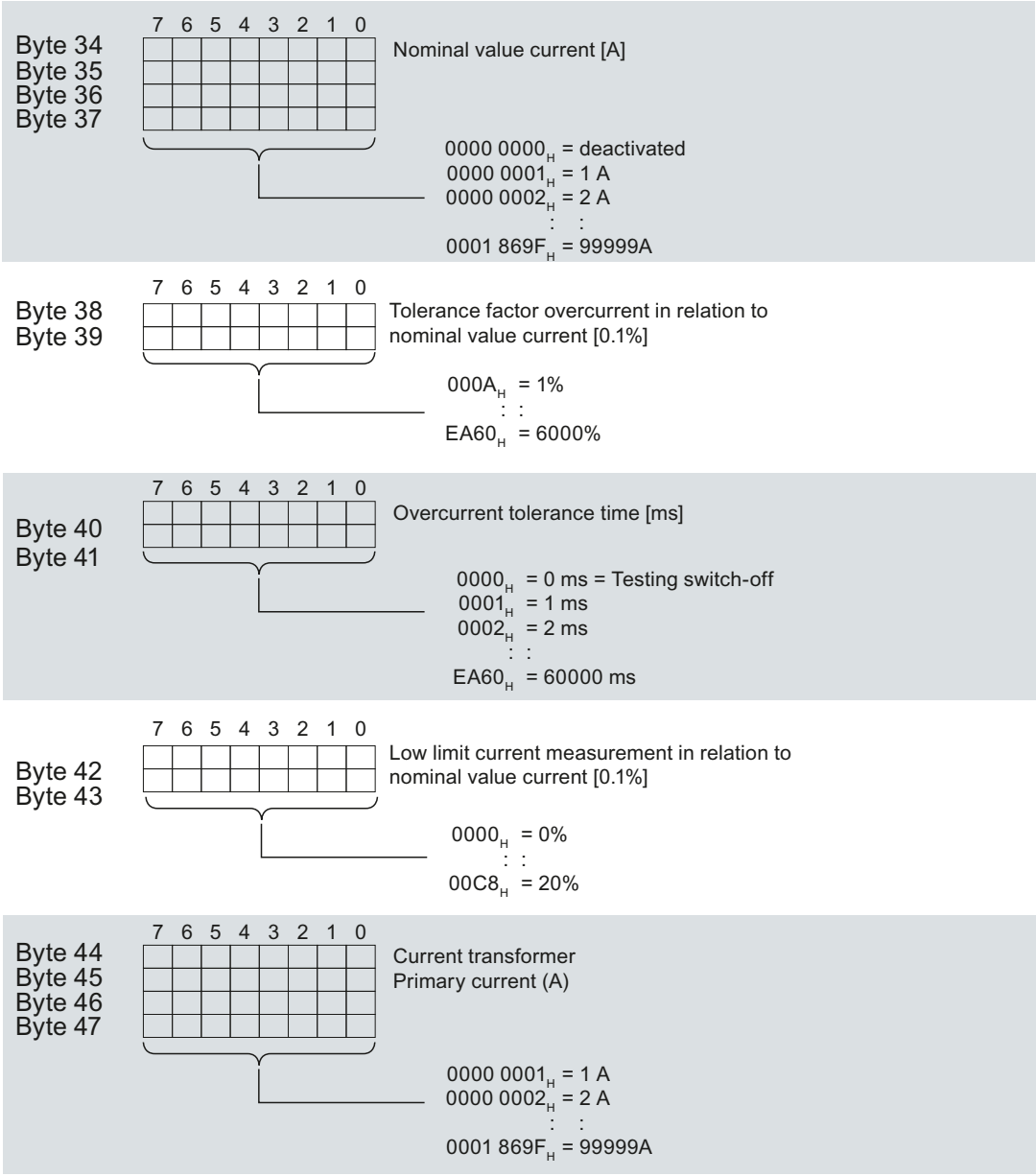

Figure 2-717 Channel parameter block

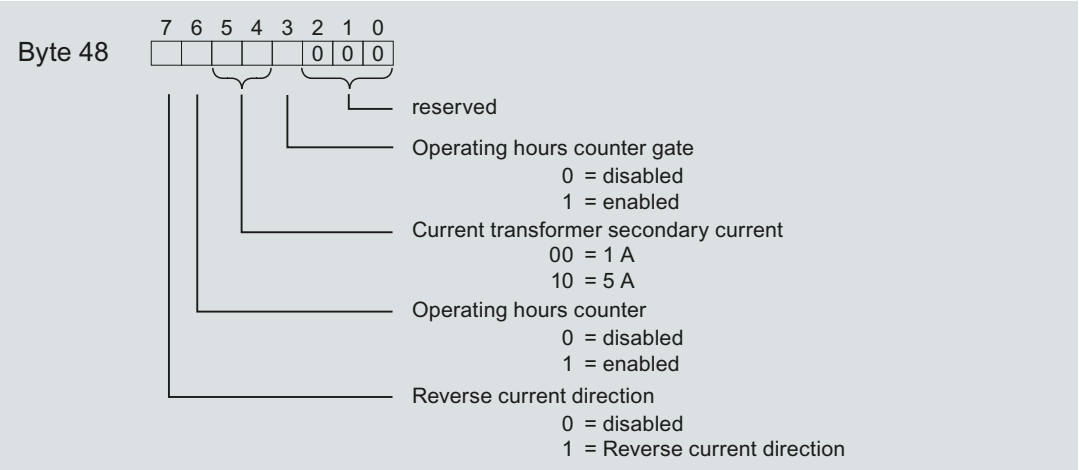
Byte 48
7 6 5 4 3 2 1 0
0 0 0
reserved
Operating hours counter gate
0 = disabled
1 = enabled
Current transformer secondary current
00 = 1 A
10 = 5 A
Operating hours counter
0 = disabled
1 = enabled
Reverse current direction
0 = disabled
1 = Reverse current direction

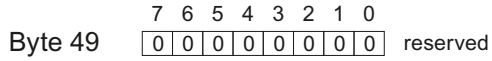
Byte 49
7 6 5 4 3 2 1 0
0 0 0 0 0 0 0 0
reserved

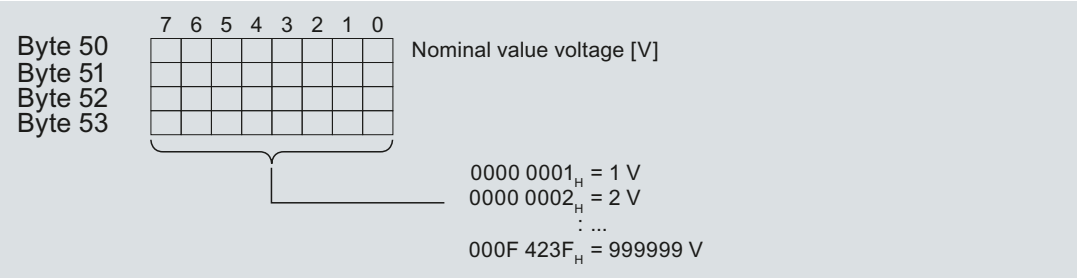
Byte 50
Byte 51
Byte 52
Byte 53
7 6 5 4 3 2 1 0
Nominal value voltage [V]
0000 0001H = 1 V
0000 0002H = 2 V
: ...
000F 423FH = 999999 V

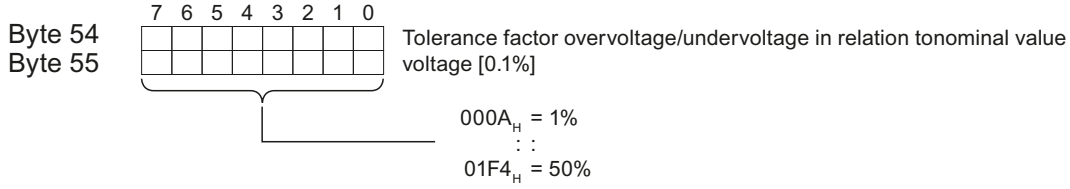
Byte 54
Byte 55
7 6 5 4 3 2 1 0
Tolerance factor overvoltage/undervoltage in relation tonominal value voltage [0.1%]
000AH = 1%
: :
01F4H = 50%

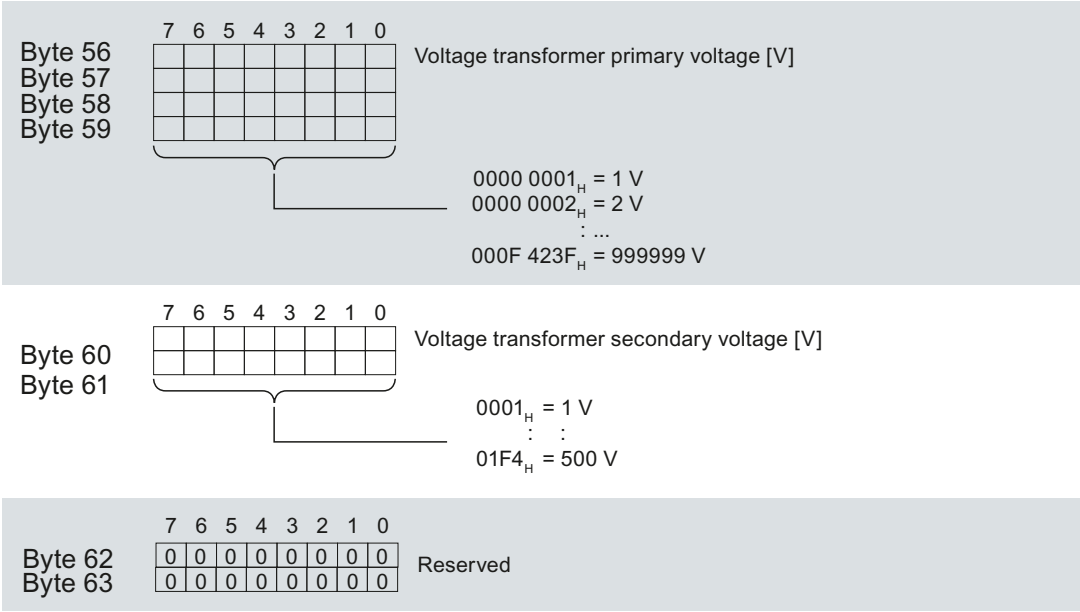

Figure 2-718 Channel parameter block

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check bytes 1 ... 3, 30, 31. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check bytes 7, 8, 14, 15, 24...29, 32, 33, 48, 49, 62...65, 80, 81, 94...97, 112, 113, 126, 127 and reset the reserved bits to 0.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	05	"Voltage measuring range" invalid	Check Byte 5. Permitted values: 01_H to $0D_H$
DF	80	E1	20	"Connection type" invalid	Check Byte 4. Permitted values: 00_H, $0B_H$...12_H
DF	80	E1	21	"Payload variant" not possible or input data configuration not large enough	Check Byte 9. Select a different payload variant or change the configuration.
DF	80	E1	22	"Payload variant" invalid	Check Byte 9. Select a valid code for the payload variant.
DF	80	E1	23	"Line frequency" invalid	Check Byte 6. Enter valid values.
DF	80	E1	29	"Tolerance factor overcurrent in relation to nominal value current [0.1%]" invalid	Check bytes 38...39, 70...71, 102...103. Enter valid values.
DF	80	E1	2A	"Tolerance time overcurrent" invalid	Check bytes 40...41, 72...73, 104...105. Enter valid values.
DF	80	E1	2B	"Low limit current measurement" in relation to nominal value current [0.1%] invalid	Check bytes 42...43, 74...75, 106...107. Enter valid values.
DF	80	E1	2C	"Current transformer primary current [A]" invalid.	Check bytes 10...13, 44...47, 76...79, 108...111. Enter valid values.
DF	80	E1	2D	"Voltage transformer primary voltage [V]" invalid	Check bytes 56...59, 88...91, 120...123. Enter valid values.
DF	80	E1	2E	"Voltage transformer secondary voltage [V]" invalid	Check bytes 60, 61 and 92, 93 and 124, 125. Enter valid values.
DF	80	E1	2F	"End value energy meter" invalid	Check Bit 4...6 in Byte 6. Enter valid values.
DF	80	E1	30	Invalid data record number.	Check the data record number. Enter a valid data record number.
DF	80	E1	3E	Only for connection type 3P4W1 and 3P3W1. Current or voltage transformer parameters for the different phases are not identical.	Check bytes 44...47 and 76...79 and 108...111 or bits 4, 5 and 7 in bytes 48, 80 and 112 or 56...59 and 88...91 and 120...123 or 60, 61 and 92, 93 and 124, 125 for identical values. For all 3 phases, enter identical values for current transformer (secondary current, primary current, direction of current) and voltage transformer (secondary voltage, primary voltage).
DF	80	E1	3F	"End value for energy meter" or transmission ratio (primary value, secondary value) of current and voltage too low.	Increase the end value of the energy meter or the ratio of primary to secondary current for current transformer and/or primary to secondary voltage for voltage transformer.
DF	80	E1	43	"Current transformer secondary current" for neutral conductor or all 3 phases invalid	Check bits 4, 5 in byte 14, 48, 80 and 112. Enter valid values.
DF	80	E1	44	"Voltage dip limit value in relation to nominal value voltage [0.1%]" invalid	Check bytes 16...17. Enter valid values (voltage dip limit value must be smaller than the respective nominal voltage)
DF	80	E1	45	"Voltage swell limit value in relation to nominal value voltage [0.1%]" invalid	Check bytes 20...23. Enter valid values (voltage swell limit value must be greater than the respective nominal voltage)

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	46	"Threshold overcurrent in relation to nominal value current [0.1%]" invalid	Check bytes 24...27. Enter valid values (threshold overcurrent must be greater than primary current)
DF	80	E1	47	"Number of cycles for analysis of voltage swell/dip" invalid	Check bytes 28...29. Enter valid values.
DF	80	E1	49	Current transformer parameter for "residual current analysis" invalid	Only with connection type 3P4W and 3P4WI and if neutral current is measured. Current transformer primary current and secondary current and direction of current of the three phases must have identical parameters.
DF	80	E1	4 A	Voltage converter for voltage swell/dip invalid	Check the parameters secondary voltage, primary voltage, nominal value voltage. Enabled channels must have identical parameters.
DF	80	E1	4B	Current transformer parameter for "Detect overcurrent" invalid	Check the parameters secondary current, primary current, nominal value current and direction of current. Enabled channels must have identical parameters.
DF	80	E1	4C	Parameters for determining the neutral current invalid	Neutral current can only be determined with connection type 3P4W and 3P4WI Current transmission parameters primary current, secondary current, nominal value current and direction of current of the three phases must be identical.
DF	80	E1	4D	"Nominal value current [A]" invalid	The nominal current value must be measurable with the current transformer and thus be smaller than the primary measured variable of the transformer (current transformer primary current). Check bytes 34...37, 66...69, 98...101. Enter valid values.
DF	80	E1	4E	"Nominal value voltage [V]" invalid	The nominal value voltage must be measurable with the voltage transformer and thus be smaller than the primary measured variable of the transformer (voltage transformer primary voltage). Check bytes 50...53, 82...85, 114...117. Enter valid values.
DF	80	E1	4F	"Low limit current measurement in relation to nominal value current [0.1%]" invalid	Check bytes 42...43, 74...75, 106...107. Enter valid values.
DF	80	E1	50	The combination of "Nominal value voltage [V]" and "Voltage dip limit value in relation to nominal value voltage [0.1%]" is invalid.	Select the permissible value in % so that the secondary measuring voltage does not fall below 0 V.
DF	80	E1	51	The combination of "Nominal value voltage [V]" and "Voltage swell limit value in relation to nominal value voltage [0.1%]" invalid.	Select the permissible value in % so that the secondary measuring voltage of 300 V is not exceeded.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	52	The combination of "Nominal value current [A]" and "Threshold overcurrent in relation to nominal value current [0.1%]" invalid	Select the permissible value in % so that the secondary measuring current of 6 A is not exceeded.
DF	80	E1	53	The combination of "Nominal value current [A]" and "Tolerance factor overcurrent in relation to nominal value current [0.1%]" invalid	Select the permissible value in % so that the secondary measuring current of 6 A is not exceeded.
DF	80	E1	54	The combination of "Nominal value voltage [V]" and "Tolerance factor overvoltage/undervoltage in relation to nominal value voltage [0.1%]" lies outside the permissible range.	Select the permissible value in % so that the secondary measuring voltage of 300 V is not exceeded.
DF	80	E1	55	"Nominal value current [A]" is too high. "Nominal value current" x transmission factor current generates a secondary current measured variable which exceeds its value range.	Select the permissible value in A so that the secondary measuring current of 6 A is not exceeded. The transmission factor current is calculated from "Current transformer primary current [A]" / "Current transformer secondary current [A]"
DF	80	E1	56	"Nominal value voltage [V]" is too high. "Nominal value voltage" x transmission factor voltage generates a secondary voltage measured variable which exceeds its value range.	Select the permissible value in V so that the secondary measuring voltage of 300 V is not exceeded. The transmission factor voltage is calculated from "Voltage transformer primary voltage [V]" / "Voltage transformer secondary voltage [V]"

A.3 Structure of the parameter data record 129 for limit monitoring

Structure of data record 129

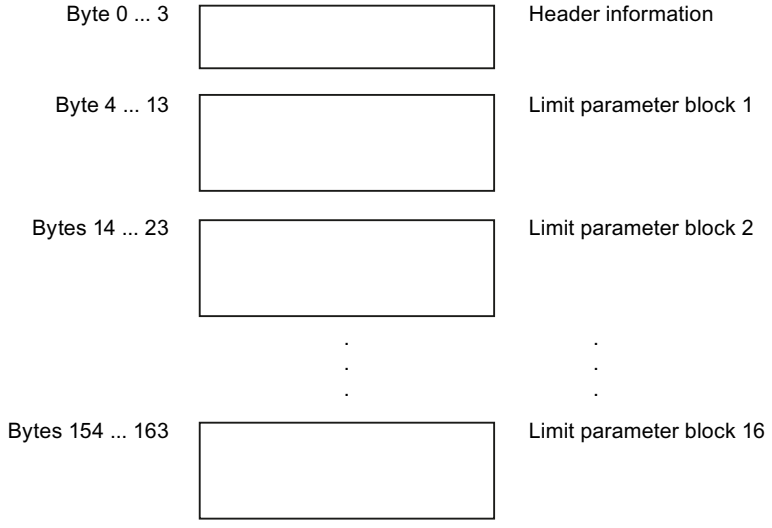

Figure 2-719 Structure of data record 129

Header information

The figure below shows the structure of the header information.

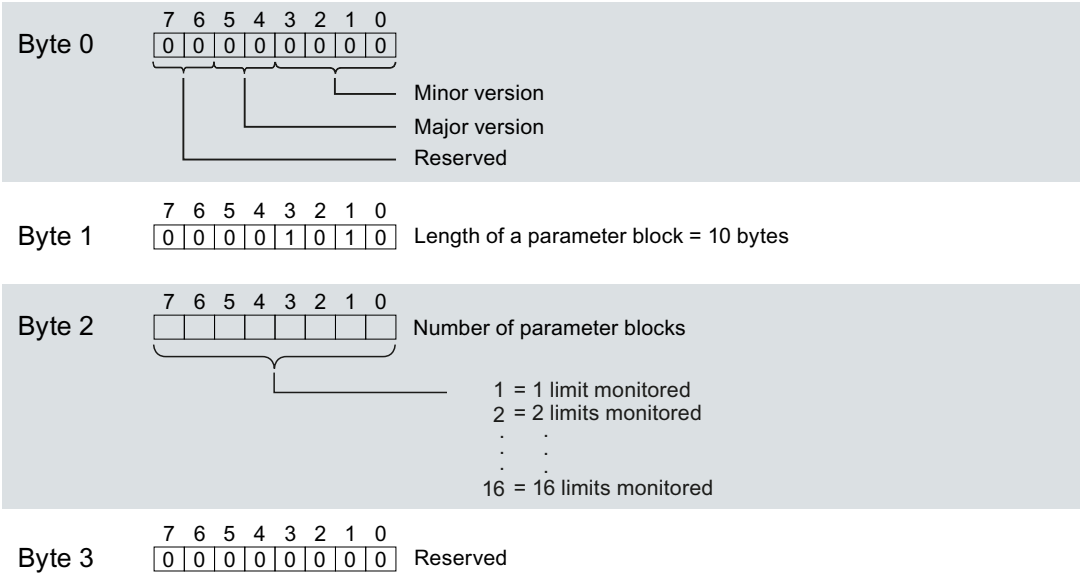

Figure 2-720 Header information DS 129

Limit parameter block

The following diagram shows the structure of the parameter blocks for limit monitoring.

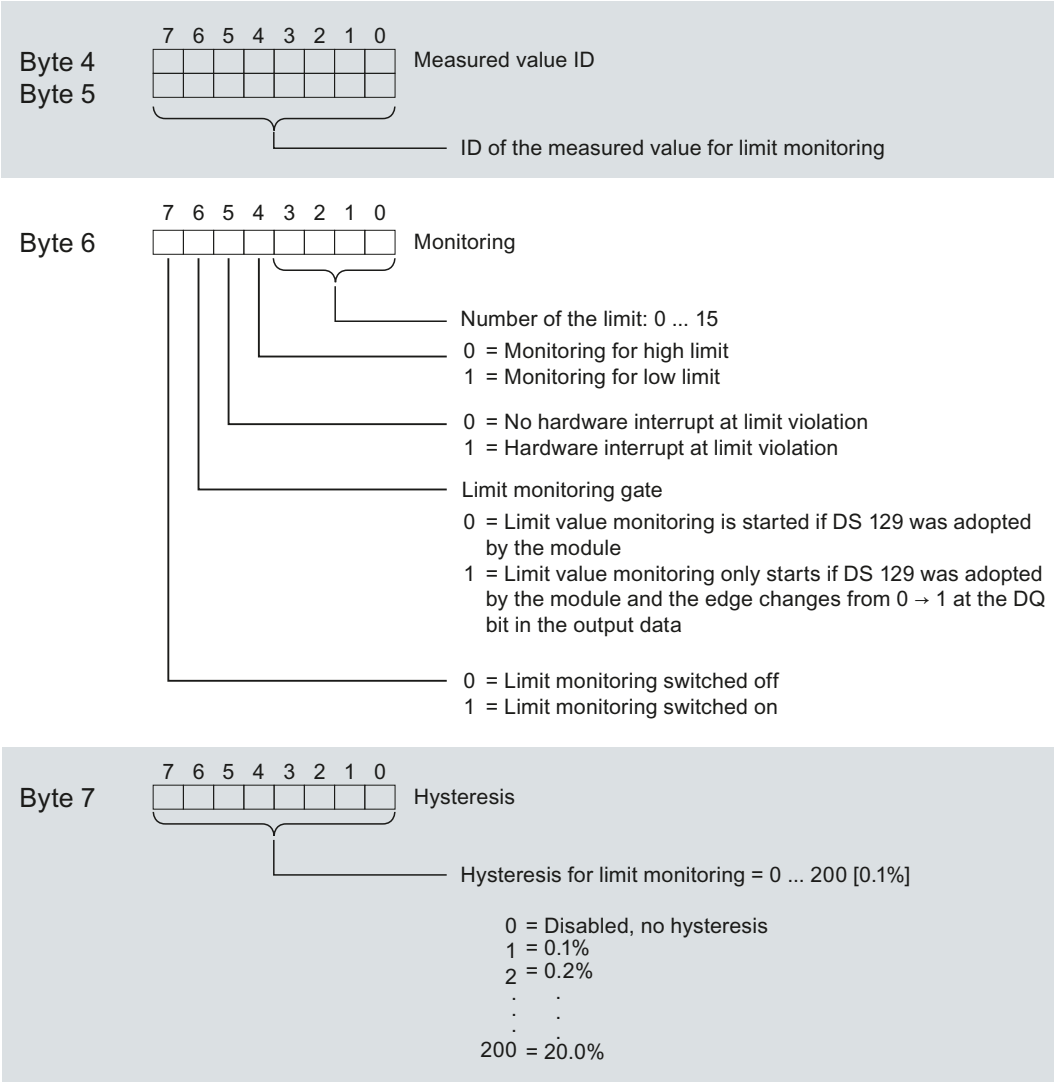

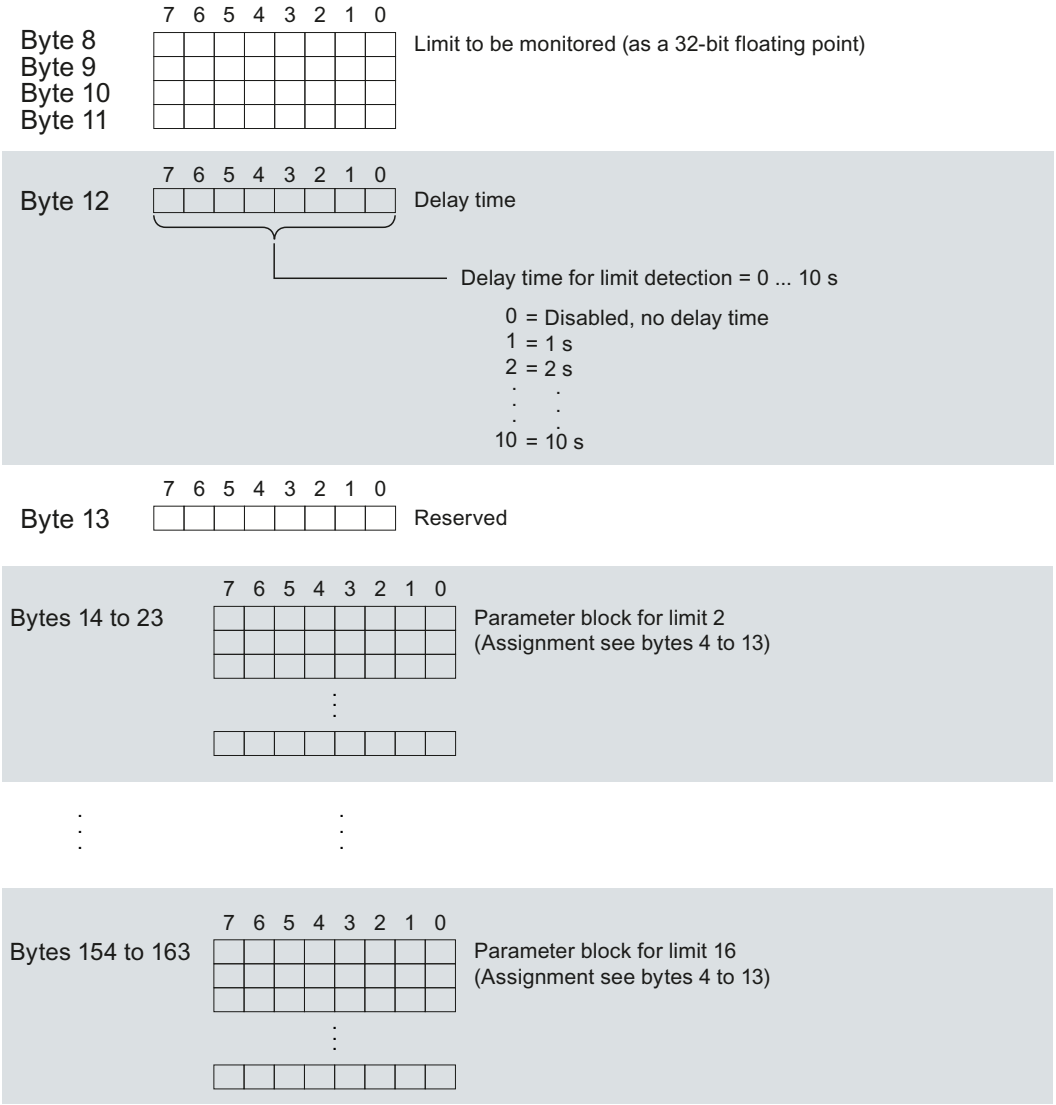

Figure 2-721 Limit parameter data block

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 129.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check bytes 3, 13, 23, 33...163 and set the reserved bits back to 0.
DF	80	E1	31	"Length of the parameter block" invalid.	Length of the sent record incorrect. Note byte 2 ("number of parameter blocks").
DF	80	E1	32	"Number of parameter blocks" invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	"ID of the measured value for limit monitoring" invalid.	Check Bytes 4 and 5. Enter valid values.
DF	80	E1	34	Parameters for monitoring the limits invalid	Check bits 0...3 in Byte 6. Enter valid values.
DF	80	E1	35	"Number of limit" in 'Monitoring assigned multiple times' parameter	Check bits 0...3 in Byte 6. Do not use limit number several times.
DF	80	E1	36	"Hysteresis for limit monitoring" invalid	Check Byte 7. Enter valid values.
DF	80	E1	37	"Limit" invalid.	Check Byte 8...11. Enter valid values.
DF	80	E1	38	"Delay time for limit monitoring" invalid.	Check Byte 12. Enter valid values.

A.4 Structure of the parameter data records 130/131 for user-data mapping

Structure of data record 130/131

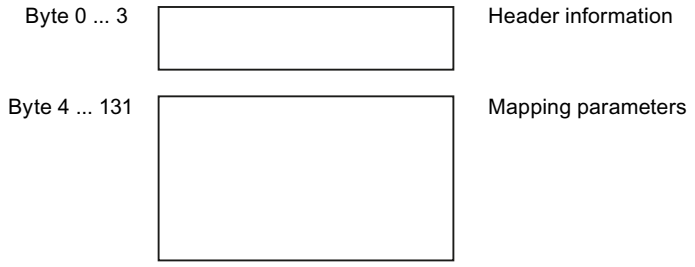

Figure 2-722 Structure of data record 130/131

Header information

The figure below shows the structure of the header information.

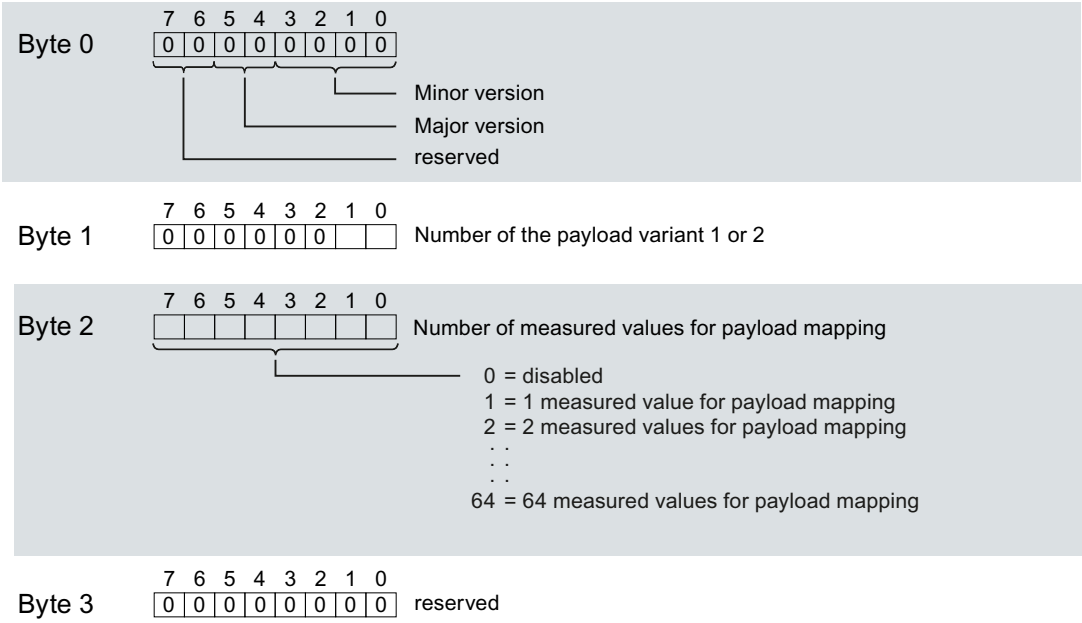

Figure 2-723 Header information DS 130/131

Parameter block for payload mapping

The following diagram shows the structure of the parameter blocks for payload mapping.

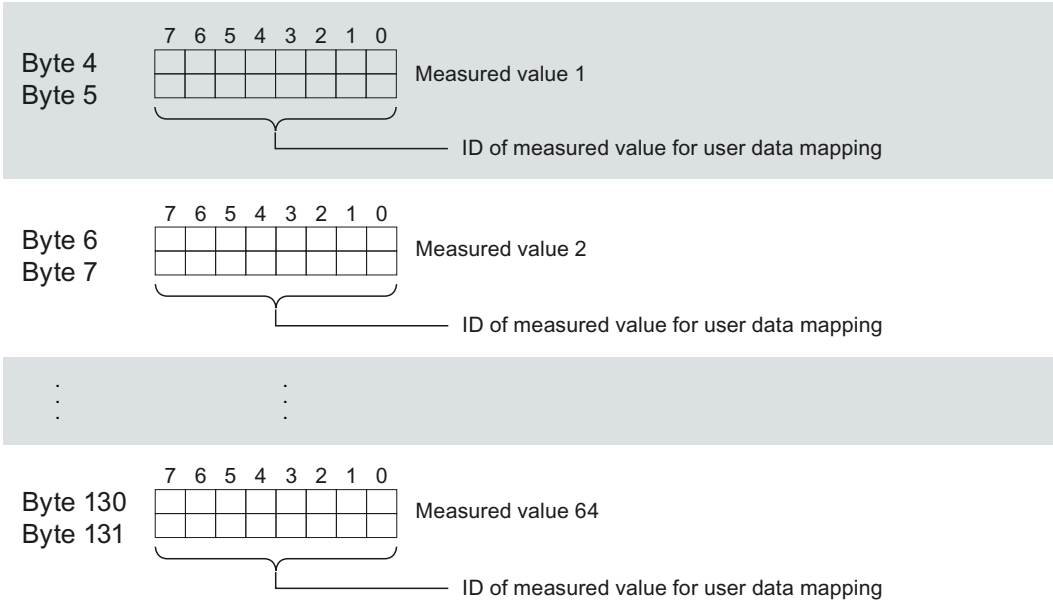

Figure 2-724 Parameter block for payload mapping

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 130/131.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check Byte 3 and set reserved bits back to 0.
DF	80	E1	21	"Payload variant" not possible or input data configuration not large enough	Select a different payload variant or change the configuration.
DF	80	E1	30	Data record number invalid	Check the data record number. Enter a valid data record number.
DF	80	E1	31	"Length of the parameter block" invalid.	Length of the sent record incorrect. Note byte 2 ("number of measured values").
DF	80	E1	32	"Number of parameter blocks" invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	"ID of measured value for payload mapping" invalid.	Check Bytes 4 and 5. Enter valid values.
DF	80	E1	3B	"ID of the type of payload mapping" not permitted.	Check Byte 1. Number for user-specific payload variant has to be 01_H or 02_H.

Measured variables for payload mapping

You can find the measured variables under "Measured variables for connection type". The following measured variables are not available to you for payload mapping:

- 220 to 226
- 62110 to 62116
- 62210 to 62216
- 62310 to 62316

A.5 Structure of the parameter data record for measured value recording (DS 134)

Structure of data record 134

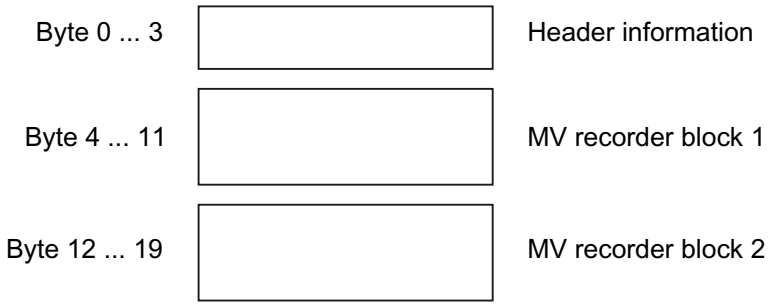

Figure 2-725 Structure of data record 134

Header information

The figure below shows the structure of the header information.

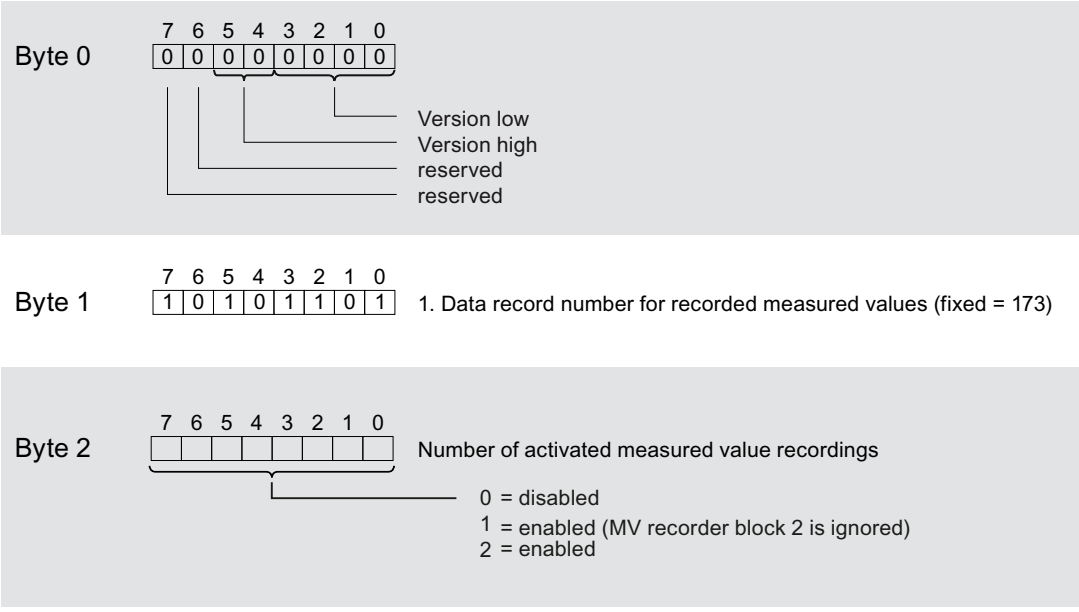

Figure 2-726 Header information DS 134

Parameter block

The following figures show the structure of the parameter blocks for measured value recording.

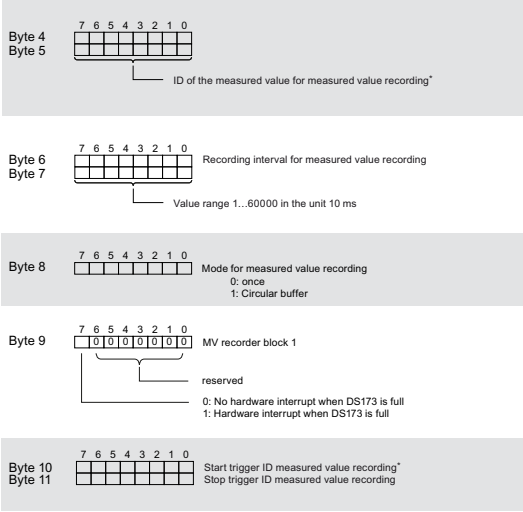

Figure 2-727 MV record block 1

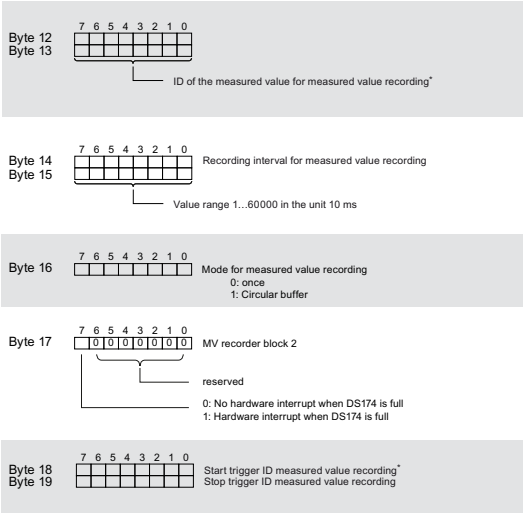

* You can find additional information in Appendix B.

Figure 2-728 MV record block 2

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 134.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Data record unknown	Enter the valid number for the data record.
DF	80	B1	01	Incorrect length during writing	Enter the permissible value for the data record length.
DF	80	B2	00	Slot/Subslot unknown	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	01	Version faulty	Enter the valid values.
DF	80	E0	02	Error in the header information	Check byte 1 and byte 2. Correct the number of parameter blocks.
DF	80	E1	01	Reserved bits are not 0	Set byte 4 or byte 6 in the measured value block to 0.
DF	80	E1	59	Measurement interval too long	Set bytes 7/8 or 13/14: Measuring interval 〈 60000.
DF	80	E1	58	Incorrect measuring mode	Byte 9 or 15: Only mode 0 or 1 is possible.
DF	80	E1	31	"Length of the parameter block" invalid	Length does not match the set number of records.
DF	80	E1	32	"Number of parameter blocks" invalid	Check byte 3. Number must be ≤ 2.
DF	80	E1	33	"ID of the measured value for measured value recording" invalid	Byte 5/6 or 11/12 has faulty measured value ID. Enter valid values.
DF	80	E1	30	Data record 134 is not supported on this module type	Do not send the data record.
DF	80	E1	5a	The function is not supported on this module type	Do not send the data record.
DF	80	E1	60	Start or stop trigger ID is invalid	Check the trigger IDs and eliminate the error.

Start/Stop trigger IDs

Power quality analysis qualifier

	Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
Phase	L3							
	Overcurrent L3 (event active)	Voltage swell L3 (event active)	Voltage dip L3 (event active)	Overcurrent L3 (event occurred)	Current peak L3 (event occurred)	Voltage peak L3 (event occurred)	Voltage swell L3 (event occurred)	Voltage dip L3 (event occurred)
Trigger ID	32	31	30	29	28	27	26	25

	Bit 23	**Bit 22**	**Bit 21**	**Bit 20**	**Bit 19**	**Bit 18**	**Bit 17**	**Bit 16**
Phase	L2							
	Overcurrent L2 (event active)	Voltage swell L2 (event active)	Voltage dip L2 (event active)	Overcurrent L2 (event occurred)	Current peak L2 (event occurred)	Voltage peak L2 (event occurred)	Voltage swell L2 (event occurred)	Voltage dip L2 (event occurred)
Trigger ID	24	23	22	21	20	19	18	17
	Bit 15	**Bit 14**	**Bit 13**	**Bit 12**	**Bit 11**	**Bit 10**	**Bit 9**	**Bit 8**
Phase	L1							
	Overcurrent L1 (event active)	Voltage swell L1 (event active)	Voltage dip L1 (event active)	Overcurrent L1 (event occurred)	Current peak L1 (event occurred)	Voltage peak L1 (event occurred)	Voltage swell L1 (event occurred)	Voltage dip L1 (event occurred)
Trigger ID	16	15	14	13	12	11	10	9
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Phase	L1L2L3							
	reserved	reserved	Status of harmonics analysis Bit 5	Status of harmonics analysis Bit 4	Status of harmonics analysis Bit 3	Status of harmonics analysis Bit 2	Status of harmonics analysis Bit 1	Status of harmonics analysis Bit 0
Trigger ID	8	7	6	5	4	3	2	1

Qualifier Lx

	Bit 7	**Bit 6**	**Bit 1**	**Bit 0**
	Operating quadrant Lx (high)	Operating quadrant Lx (low)	ILx (ok)	ULx (ok)
L1	48	47	34	33
L2	64	63	50	49
L3	80	79	66	65

Qualifier L1L2L3

	Bit 15	**Bit 14**	**Bit 13**	**Bit 12**	**Bit 11**	**Bit 10**	**Bit 9**	**Bit 8**
Phase	L1L2L3				L3		L2	
	Time synchronization (ok)	Analysis of harmonic component	Rotating field status (high)	Rotating field status (low)	Operating quadrant L3 (high)	Operating quadrant L3 (low)	Operating quadrant L2 (high)	Operating quadrant L2 (low)
Trigger ID	96	95	94	93	92	91	90	89
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Phase	L1		L3		L2		L1	
	Operating quadrant L1 (high)	Operating quadrant L1 (low)	Measured values IL3 (ok)	Measured values UL3 (ok)	Measured values IL2 (ok)	Measured values UL2 (ok)	Measured values IL1 (ok)	Measured values UL1 (ok)
Trigger ID	88	87	86	85	84	83	82	81

Status of energy counter overflows

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
Phase	reserved	L3					L2	
	---	Overflow apparent energy L3	Overflow reactive energy out-flow L3	Overflow reactive energy inflow L3	Overflow active energy outflow L3	Overflow active energy inflow L3	Overflow apparent energy L2	Overflow reactive energy out-flow L2
Trigger ID	112	111	110	109	108	107	106	105

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Phase	L2			L1				
	Overflow reactive energy inflow L2	Overflow active energy outflow L2	Overflow active energy inflow L2	Overflow apparent energy L1	Overflow reactive energy out-flow L1	Reactive energy inflow L1	Overflow active energy outflow L1	Overflow active energy inflow L1
Trigger ID	104	103	102	101	100	99	98	97

Status of limits

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
	Limit viola-tion LV16	Limit viola-tion LV15	Limit viola-tion LV14	Limit viola-tion LV13	Limit viola-tion LV12	Limit viola-tion LV11	Limit viola-tion LV10	Limit viola-tion LV9
Trigger ID	128	127	126	125	124	123	122	121
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	Limit viola-tion LV8	Limit viola-tion LV7	Limit viola-tion LV6	Limit viola-tion LV5	Limit viola-tion LV4	Limit viola-tion LV3	Limit viola-tion LV2	Limit viola-tion LV1
Trigger ID	120	119	118	117	116	115	114	113

32-bit diagnostic bit track ET200SP diagnostics

	Bit 31	Bit 26	Bit 22	Bit 17	Bit 16	Bit 7	Bit 4	Bit 3	Bit 2
	Channel temporarily not avail-able	Power qual-ity	Hardware interrupt lost	Supply voltage missing	Parameter error	Overflow of the calcula-tion values	Overload	Overflow voltage	Underflow voltage
Trigger ID L1	160	155	151	146	145	136	133	132	131
Trigger ID L2	192	187	183	178	177	168	165	164	163
Trigger ID L3	224	219	215	210	209	200	197	196	195

DQ control measured value acquisition

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	DQ address 17 (control byte 8)							
Trigger ID	232	231	230	229	228	27	226	225

A.6 Structure of the parameter data record 135 for data record mapping

Structure of data record 135

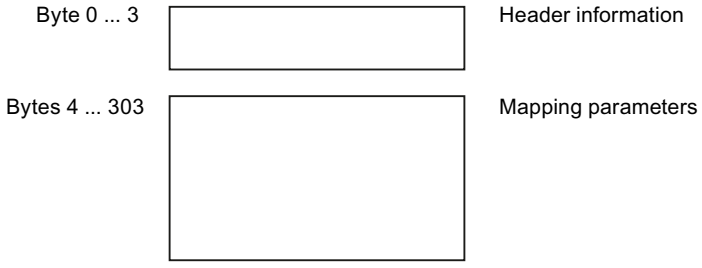

Figure 2-729 Structure of data record 135

Header information

The figure below shows the structure of the header information.

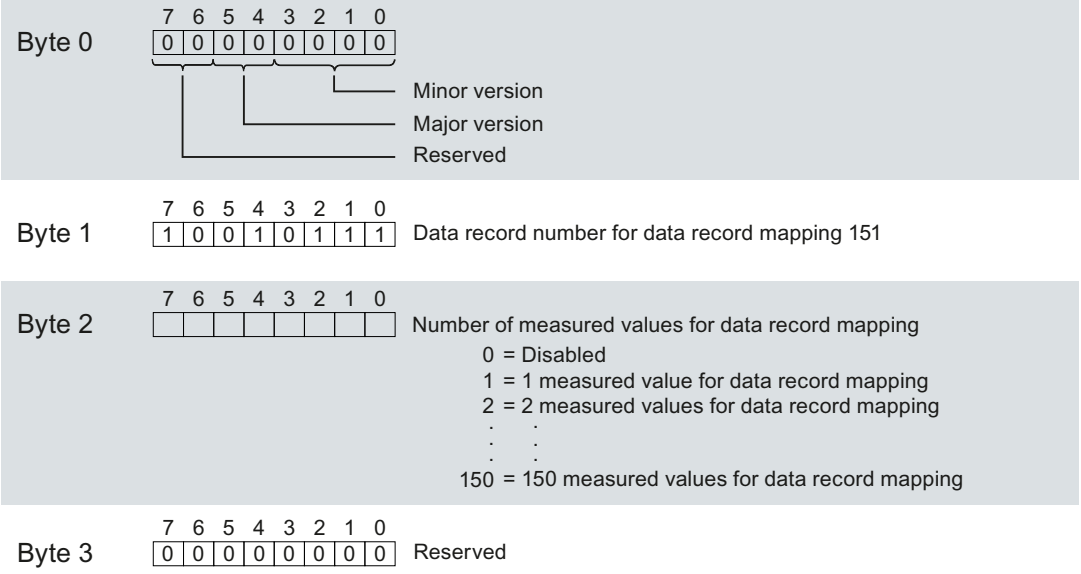

Figure 2-730 Header information DS 135

Parameter block for data record mapping

The following diagram shows the structure of the parameter blocks for data record mapping.

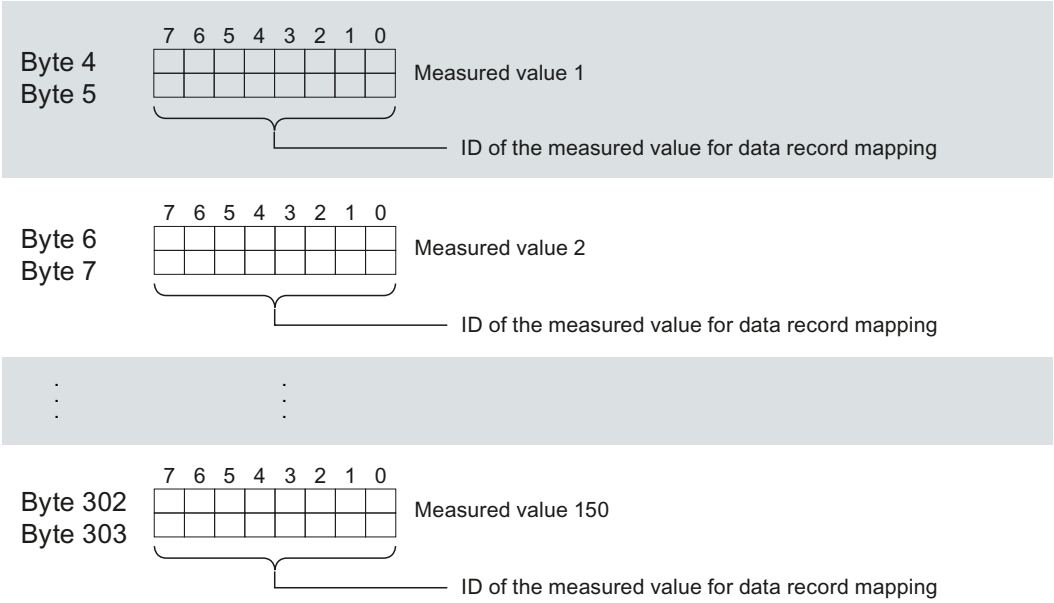

Figure 2-731 Parameter block for data record mapping

Data record length DS 135 and DS151

The table below shows the data record lengths of the parameter data record DS 135 and the user-defined data record DS 151 (Page 262).

The length of the data records depends on the number and the format of the measured values.

Number Measured values	Data record length in bytes		
	REAL measured values		LREAL measured values
	DS 135	DS 151	DS 151
29	62	118	234
30	64	122	242 *
40	84	162	322 *
50	104	202	402 *
59	122	238	474 *
100	204	402 *	802 *
118	240	474 *	946 *
150	304*	602 *	1202 *

* not with PROFIBUS DP

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 130/131/135.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check Byte 3 and set reserved bits back to 0.
DF	80	E1	21	"Payload variant" not possible or input data configuration not large enough	Select a different payload variant or change the configuration.
DF	80	E1	30	Data record number invalid	Check the data record number. Enter a valid data record number.
DF	80	E1	31	"Length of the parameter block" invalid.	Length of the sent record incorrect. Note byte 2 ("number of measured values").
DF	80	E1	32	"Number of parameter blocks" invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	"ID of the measured value for limit monitoring" invalid.	Check Bytes 4 and 5. Enter valid values.

Measured variables for data record mapping

You can find the measured variables under "Measured variables for connection type". The following measured variables are not available to you for data record mapping:

- 220 to 226
- 62110 to 62116
- 62210 to 62216
- 62310 to 62316

Measured variables

B

B.1 Measured variables for connection type

Measured variables for data records and payload

The following table provides an overview of all measured variables that are used in the data records and payload.

On the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755917) you can find an overview of the assignment of the measured values to the payload variants and data records.

Table 2-826 Measured variables for data records and payload

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
1	Voltage L1-N [1]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
2	Voltage L2-N [1]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
3	Voltage L3-N [1]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
4	Voltage L1-L2 [2]	REAL	V	0.0 ... 1000000.0		✓		✓	✓	✓	✓	
5	Voltage L2-L3 [2]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
6	Voltage L3-L1 [2]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
7	Current L1 [1]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
8	Current L2 [1]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
9	Current L3 [1]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
10	Apparent power L1 [3]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
11	Apparent power L2 [3]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
12	Apparent power L3 [3]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
13	Active power L1 [3]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
14	Active power L2 [3]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
15	Active power L3 [3]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
16	Reactive power Qn L1[3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
17	Reactive power Qn L2[3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
18	Reactive power Qn L3[3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
19	Power factor λ L1 [3]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
20	Power factor λ L2 [3]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓	✓	✓	
21	Power factor λ L3 [3]	REAL	-	0.0 ... 1.0			✓	✓	✓	✓	✓	
22	Reactive power Qtot L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
23	Reactive power Qtot L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
24	Reactive power Qtot L3 [3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
30	Frequency L1L2L3 [4]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓	✓
31	Average Voltage L-N (U_{sum}) [12]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
32	Average Voltage L-L [12]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
33	Average Current L1L2L3 (I_{sum}) [12]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
34	Active power L1L2L3 [5]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
35	Reactive power Q_n L1L2L3 [5]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
36	Apparent power L1L2L3 [5]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
37	Power factor λ L1L2L3 [6]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
38	Reactive power Qtot L1L2L3[3] [5]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
40	Max. voltage L1-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
41	Max. voltage L2-N [14]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
42	Max. voltage L3-N [14]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
43	Max. voltage L1-L2 [14]	REAL	V	0.0 ... 1000000.0		✓		✓	✓	✓	✓	
44	Max. voltage L2-L3 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
45	Max. voltage L3-L1 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
46	Max. current L1 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
47	Max. current L2 [14]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
48	Max. current L3 [14]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
49	Max. apparent power L1 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
50	Max. apparent power L2 [14]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
51	Max. apparent power L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
52	Max. active power L1 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
53	Max. active power L2 [14]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
54	Max. active power L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
55	Max. reactive power Q_n L1 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
56	Max. reactive power Q_n L2 [14]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
57	Max. reactive power Q_n L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
58	Max. power factor λ L1 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
59	Max. power factor λ L2 [14]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓	✓	✓	
60	Max. power factor λ L3 [14]	REAL	-	0.0 ... 1.0			✓	✓	✓	✓	✓	
61	Max. frequency [14]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓	✓
62	Max. mean voltage L-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓			
63	Max. mean voltage L-L [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
64	Max. mean current L1L2L3 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
65	Max. active power L1L2L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
66	Max. reactive power Qn L1L2L3[14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
67	Max. apparent power L1L2L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
68	Max. power factor λ L1L2L3 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
70	Min. voltage L1-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
71	Min. voltage L2-N [14]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
72	Min. voltage L3-N [14]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
73	Min. voltage L1-L2 [14]	REAL	V	0.0 ... 1000000.0		✓		✓	✓	✓	✓	
74	Min. voltage L2-L3 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
75	Min. voltage L3-L1 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
76	Min. current L1 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
77	Min. current L2 [14]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
78	Min. current L3 [14]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
79	Min. apparent power L1 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
80	Min. apparent power L2 [14]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
81	Min. apparent power L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
82	Min. active power L1 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
83	Min. active power L2 [14]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
84	Min. active power L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
85	Max. reactive power Q_n L1 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
86	Max. reactive power Q_n L2 [14]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
87	Max. reactive power Q_n L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
88	Min. power factor λ L1 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
89	Min. power factor λ L2 [14]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓	✓	✓	
90	Min. power factor λ L3 [14]	REAL	-	0.0 ... 1.0			✓	✓	✓	✓	✓	
91	Min. frequency [14]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓	✓
92	Min. mean voltage L-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓			
93	Min. mean voltage L-L [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
94	Min. mean current L1L2L3[14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
95	Min. active power L1L2L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
96	Min. reactive power Q_n L1L2L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
97	Min. apparent power L1L2L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
98	Min. power factor λ L1L2L3 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
166	Mean power factor λ L1L2L3[12]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
200	Active energy inflow L1L2L3 (Float) [6]	REAL	Wh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
201	Active energy outflow L1L2L3 (Float) [6]	REAL	Wh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
202	Reactive energy inflow L1L2L3 (Float) [6]	REAL	varh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
203	Reactive energy outflow L1L2L3 (Float) [6]	REAL	varh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
204	Apparent energy L1L2L3 (Float) [6]	REAL	VAh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
205	Total active energy L1L2L3 (Float) [6]	REAL	Wh	-3.4028e+38 ... +3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
206	Total reactive energy L1L2L3 (Float) [6]	REAL	varh	-3.4028e+38 ... +3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
210	Active energy inflow L1L2L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
211	Active energy outflow L1L2L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
212	Reactive energy inflow L1L2L3 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
213	Reactive energy outflow L1L2L3 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
214	Apparent energy L1L2L3 [6]	LREAL	VAh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
215	Total active energy L1L2L3 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
216	Total reactive energy L1L2L3 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
220	Active energy inflow L1L2L3 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
221	Active energy outflow L1L2L3 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
222	Reactive energy inflow L1L2L3 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
223	Reactive energy outflow L1L2L3 (Int32) [6]	UDINT	VAh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
224	Apparent energy L1L2L3 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
225	Total active energy L1L2L3 (Int32) [6]	DINT	Wh	-2147483647 ... +2147483647	✓	✓	✓	✓	✓	✓	✓	
226	Total reactive energy L1L2L3 (Int32) [6]	DINT	varh	-2147483647 ... +2147483647	✓	✓	✓	✓	✓	✓	✓	
61130	Phase angle UL1-UL2 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	
61131	Phase angle UL2-UL3 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	
61132	Phase angle UL3-UL1 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	
61133	Phase angle IL1-IL2 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	✓
61134	Phase angle IL2-IL3 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	✓
61135	Phase angle IL3-IL1 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	✓
61136	Max. neutral current [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
61137	Min. neutral current [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
61138	Max. reactive power Qtot L1L2L3[3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
61139	Min. reactive power Qtot L1L2L3[3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
61140	Overflow counter active energy inflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61141	Overflow counter active energy outflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61142	Overflow counter reactive energy inflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
61143	Overflow counter reactive energy outflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61144	Overflow counter apparent energy L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61146	Fundamental cos φ active factor L1L2L3[17]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
61147	Max. fundamental cos φ active factor L1L2L3[17]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
61148	Min. fundamental cos φ active factor L1L2L3[17]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
61149	Neutral current IN [1]	REAL	A	0.0 ... 100000.0	Z	Z	Z	✓	✓	Z	Z	✓
61150	Neutral current 10-12 cycles [1, 19]	REAL	A	0.0 ... 100000.0	Z	Z	Z	✓	✓	Z	Z	✓
61151	Neutral current half cycle [1, 16, 19]	REAL	A	0.0 ... 100000.0	Z	Z	Z	✓	✓	Z	Z	✓
61153	Total current IL1+IL2+IL3-IN [1]	REAL	A	-100000.0 ... 100000.0				✓				✓
61154	Reactive power (fundamental) L1L2L3[5]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
61155	Max. reactive power (fundamental) L1L2L3[14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
61156	Min. reactive power (fundamental) L1L2L3[14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
61157	Amplitude unbalance voltage U2 [2]	REAL	%	0 ... 100				✓	✓	✓	✓	
61158	Amplitude unbalance current Iunsym [2]	REAL	%	0 ... 100				✓	✓	✓	✓	✓
61159	Instantaneous value line frequency [17]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓	✓
61178	Phase angle L1 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	
61180	Active energy inflow L1 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
61181	Active energy outflow L1 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
61182	Reactive energy inflow L1 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
61183	Reactive energy outflow L1 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
61184	Apparent energy L1 [6]	LREAL	VAh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
61185	Total active energy L1 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
61186	Total reactive energy L1 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
61190	Overflow counter active energy inflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61191	Overflow counter active energy outflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61192	Overflow counter reactive energy inflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61193	Overflow counter reactive energy outflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61194	Overflow counter apparent energy L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61195	Overflow counter total active energy L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61196	Overflow counter total reactive energy L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61198	Phase angle L2 [3]	REAL	°	0.0 ... 360.0		✓	✓	✓	✓	✓	✓	
61200	Active energy inflow L2 [6]	LREAL	Wh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓	
61201	Active energy outflow L2 [6]	LREAL	Wh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓	
61202	Reactive energy inflow L2 [6]	LREAL	varh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓	
61203	Reactive energy outflow L2 [6]	LREAL	varh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓	
61204	Apparent energy L2 [6]	LREAL	VAh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓	
61205	Total active energy L2 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308		✓	✓	✓	✓	✓	✓	
61206	Total reactive energy L2 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308		✓	✓	✓	✓	✓	✓	
61210	Overflow counter active energy inflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓	
61211	Overflow counter active energy outflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓	
61212	Overflow counter reactive energy inflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓	
61213	Overflow counter reactive energy outflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓	
61214	Overflow counter apparent energy L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓	
61215	Overflow counter total active energy L2 [6]	UINT	-	0 ...65535		✓	✓	✓	✓	✓	✓	
61216	Overflow counter total reactive energy L2 [6]	UINT	-	0 ...65535		✓	✓	✓	✓	✓	✓	
61218	Phase angle L3 [3]	REAL	°	0.0 ... 360.0			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
61220	Active energy inflow L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓	
61221	Active energy outflow L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓	
61222	Reactive energy inflow L3 [6]	LREAL	varh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓	
61223	Reactive energy outflow L3 [6]	LREAL	varh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓	
61224	Apparent energy L3 [6]	LREAL	VAh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓	
61225	Total active energy L3 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308			✓	✓	✓	✓	✓	
61226	Total reactive energy L3 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308			✓	✓	✓	✓	✓	
61230	Overflow counter active energy inflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓	
61231	Overflow counter active energy outflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓	
61232	Overflow counter reactive energy inflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓	
61233	Overflow counter reactive energy outflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓	
61234	Overflow counter apparent energy L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓	
61235	Overflow counter total active energy L3 [6]	UINT	-	0 ...65535			✓	✓	✓	✓	✓	
61236	Overflow counter total reactive energy L3 [6]	UINT	-	0 ...65535			✓	✓	✓	✓	✓	
62110	Active energy inflow L1 (Int32) [6]	DINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
62111	Active energy outflow L1 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
62112	Reactive energy inflow L1 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
62113	Reactive energy outflow L1 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
62114	Apparent energy L1 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
62115	Total active energy L1 (Int32) [6]	DINT	Wh	-2147483647 ... + 2147483647	✓	✓	✓	✓	✓	✓	✓	
62116	Total reactive energy L1 (Int32) [6]	DINT	varh	-2147483647 ... + 2147483647	✓	✓	✓	✓	✓	✓	✓	
62120	Total harmonic distortion (THD+N) voltage L1 [13]	REAL	1%	0 % bis 100 %	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62121	Total harmonic distortion (THD+N) current L1 [13]	REAL	1%	0 % bis 100 %	✓	✓	✓	✓	✓	✓	✓	✓
62122	Fundamental voltage L1 [1]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62123	Fundamental current L1 [1]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62124	Fundamental reactive power L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62125	Fundamental apparent power L1 [3]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62126	Fundamental active power L1 [3]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62127	Fundamental cos φ active factor L1 [17]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
62130	Voltage L1 10-12 cycles [1, 19]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62131	Voltage L1 half cycle [1, 16, 19]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62132	Voltage L1 - instantaneous value [17]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62133	Current L1 10-12 cycles [1, 19]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62134	Current L1 half cycle [1, 16, 19]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62135	Current L1 - instantaneous value [17]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62136	Fundamental cos φ active factor L1 (SINT8) [17]	SINT	0.01	-100...100	✓	✓	✓	✓	✓	✓	✓	
62150	Max. total harmonic distortion (THD+N) voltage L1 [14]	REAL	1%	0 % bis 100 %	✓	✓	✓	✓	✓	✓	✓	
62151	Max. total harmonic distortion (THD+N) current L1 [14]	REAL	1%	0 % bis 100 %	✓	✓	✓	✓	✓	✓	✓	✓
62152	Max. fundamental voltage L1 [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62153	Max. fundamental current L1 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62154	Max. fundamental reactive power L1 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62155	Max. fundamental apparent power L1 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62156	Max. fundamental active power L1 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62157	Max. fundamental cos φ active factor L1 [14]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
62160	Max. reactive power Qtot L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62170	Min. total harmonic distortion (THD+N) voltage L1 [14]	REAL	1%	0 % bis 100 %	✓	✓	✓	✓	✓	✓	✓	
62171	Min. total harmonic distortion (THD+N) current L1 [14]	REAL	1%	0 % bis 100 %	✓	✓	✓	✓	✓	✓	✓	✓
62172	Min. fundamental voltage L1 [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62173	Min. fundamental current L1 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62174	Min. fundamental reactive power L1 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62175	Min. fundamental apparent power L1[14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62176	Min. fundamental active power L1 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62177	Min. fundamental cos φ active factor L1[14]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
62180	Min. reactive power Qtot L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62193	Diagnostics L1 [20]	DWORD	Bit track	0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
62194	Voltage dip - value L1 [16]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62195	Voltage swell - value L1 [16]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62196	Voltage peak value L1 [17]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62197	Current peak value L1 [17]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62198	Overcurrent- value L1 [16]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62199	Voltage dip - duration L1 [16]	REAL	ms	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	
62200	Voltage swell - duration L1 [16]	REAL	ms	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	
62210	Active energy inflow L2 (Int32) [6]	DINT	Wh	0... 2147483647		✓	✓	✓	✓	✓	✓	
62211	Active energy outflow L2 (Int32) [6]	DINT	Wh	0... 2147483647		✓	✓	✓	✓	✓	✓	
62212	Reactive energy inflow L2 (Int32) [6]	DINT	varh	0... 2147483647		✓	✓	✓	✓	✓	✓	
62213	Reactive energy outflow L2 (Int32) [6]	DINT	varh	0... 2147483647		✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62214	Apparent energy L2 (Int32) [6]	DINT	VAh	0... 2147483647		✓	✓	✓	✓	✓	✓	
62215	Total active energy L2 (Int32) [6]	DINT	Wh	-2147483647... +2147483647		✓	✓	✓	✓	✓	✓	
62216	Total reactive energy L2 (Int32) [6]	DINT	varh	-2147483647... +2147483647		✓	✓	✓	✓	✓	✓	
62220	Total harmonic distortion (THD+N) voltage L2 [13]	REAL	1%	0 % bis 100 %		✓	✓	✓	✓	✓	✓	
62221	Total harmonic distortion (THD+N) current L2 [13]	REAL	1%	0 % bis 100 %		✓	✓	✓	✓	✓	✓	✓
62222	Fundamental voltage L2[2]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62223	Fundamental current L2 [1]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62224	Fundamental reactive power L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62225	Fundamental apparent power L2 [3]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62226	Fundamental active power L2 [3]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62227	Fundamental cos φ active factor L2 [17]	REAL	-	-1.0 ... 1.0		✓	✓	✓	✓	✓	✓	
62230	Voltage L2 10-12 cycles [1, 19]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62231	Voltage L2 half cycle [1, 16, 19]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62232	Voltage L2 - instantaneous value [17]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62233	Current L2 10-12 cycles [1, 19]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62234	Current L2 half cycle [1, 16, 19]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62235	Current L2 - instantaneous value [17]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62236	Fundamental cos φ active factor L2 (SINT8) [17]	SINT	0.01	-100...100		✓	✓	✓	✓	✓	✓	
62250	Max. total harmonic distortion (THD+N) voltage L2 [14]	REAL	1%	0 % bis 100 %		✓	✓	✓	✓	✓	✓	
62251	Max. total harmonic distortion (THD+N) current L2 [14]	REAL	1%	0 % bis 100 %		✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62252	Max. fundamental voltage L2 [14]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62253	Max. fundamental current L2 [14]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62254	Max. fundamental reactive power L2 [14]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62255	Max. fundamental apparent power L2 [14]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62256	Max. fundamental active power L2 [14]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62257	Max. fundamental cos φ active factor L2 [14]	REAL	-	-1.0 ... 1.0		✓	✓	✓	✓	✓	✓	
62260	Max. reactive power Qtot L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62270	Min. total harmonic distortion (THD+N) voltage L2 [14]	REAL	1%	0 % bis 100 %		✓	✓	✓	✓	✓	✓	
62271	Min. total harmonic distortion (THD+N) current L2 [14]	REAL	1%	0 % bis 100 %		✓	✓	✓	✓	✓	✓	✓
62272	Min. fundamental voltage L2 [14]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62273	Min. fundamental current L2 [14]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62274	Min. fundamental reactive power L2 [14]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62275	Min. fundamental apparent power L2[14]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62276	Min. fundamental active power L2 [14]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62277	Min. fundamental cos φ active factor L2[14]	REAL	-	-1.0 ... 1.0		✓	✓	✓	✓	✓	✓	
62280	Min. reactive power Qtot L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62293	Diagnostics L2 [20]	DWORD	Bit track	0 ... 4294967295		✓	✓	✓	✓	✓	✓	✓
62294	Voltage dip - value L2 [16]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62295	Voltage swell - value L2 [16]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62296	Voltage peak value L2 [17]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62297	Current peak value L2 [17]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62298	Overcurrent- value L2 [16]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62299	Voltage dip - duration L2 [16]	REAL	ms	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62300	Voltage swell - duration L2 [16]	REAL	ms	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	
62310	Active energy inflow L3 (Int32) [6]	DINT	Wh	0... 2147483647			✓	✓	✓	✓	✓	
62311	Active energy outflow L3 (Int32) [6]	DINT	Wh	0... 2147483647			✓	✓	✓	✓	✓	
62312	Reactive energy inflow L3 (Int32) [6]	DINT	varh	0... 2147483647			✓	✓	✓	✓	✓	
62313	Reactive energy outflow L3 (Int32) [6]	DINT	varh	0... 2147483647			✓	✓	✓	✓	✓	
62314	Apparent energy L3 (Int32) [6]	DINT	VAh	0... 2147483647			✓	✓	✓	✓	✓	
62315	Total active energy L3 (Int32) [6]	DINT	Wh	-2147483647... +2147483647			✓	✓	✓	✓	✓	
62316	Total reactive energy L3 (Int32) [6]	DINT	varh	-2147483647... +2147483647			✓	✓	✓	✓	✓	
62320	Total harmonic distortion (THD+N) voltage L3 [13]	REAL	1%	0 % bis 100 %			✓	✓	✓	✓	✓	
62321	Total harmonic distortion (THD+N) current L3 [13]	REAL	1%	0 % bis 100 %			✓	✓	✓	✓	✓	✓
62322	Fundamental voltage L3 [2]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62323	Fundamental current L3 [1]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62324	Fundamental reactive power L3 [3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62325	Fundamental apparent power L3 [3]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62326	Fundamental active power L3[3]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62327	Fundamental cos φ active factor L3 [17]	REAL	-	-1.0 ... 1.0			✓	✓	✓	✓	✓	
62330	Voltage L3 10-12 cycles [1, 19]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62331	Voltage L3 half cycle [1, 16, 19]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62332	Voltage L3 - instantaneous value [17]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62333	Current L3 10-12 cycles [1, 19]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62334	Current L3 half cycle [1, 16, 19]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62335	Current L3 - instantaneous value [17]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62336	Fundamental cos φ active factor L3 (SINT8) [17]	SINT	0.01	-100...100			✓	✓	✓	✓	✓	
62350	Max. total harmonic distortion (THD+N) current L3 [14]	REAL	1%	0 % bis 100 %			✓	✓	✓	✓	✓	
62351	Max. total harmonic distortion (THD+N) voltage L3 [14]	REAL	1%	0 % bis 100 %			✓	✓	✓	✓	✓	✓
62352	Max. fundamental voltage L3[14]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62353	Max. fundamental current L3[14]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62354	Max. fundamental reactive power L3[14]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62355	Max. fundamental apparent power L3[14]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62356	Max. fundamental active power L3[14]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62357	Max. fundamental cos φ active factor L3[14]	REAL	-	-1.0 ... 1.0			✓	✓	✓	✓	✓	
62360	Max. reactive power Qtot L3[3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62370	Min. total harmonic distortion (THD+N) voltage L3 [14]	REAL	1%	0 % bis 100 %			✓	✓	✓	✓	✓	
62371	Min. total harmonic distortion (THD+N) current L3 [14]	REAL	1%	0 % bis 100 %			✓	✓	✓	✓	✓	✓
62372	Min. fundamental voltage L3[14]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62373	Min. fundamental current L3 [14]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62374	Min. fundamental reactive power L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62375	Min. fundamental apparent power L3[14]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62376	Min. fundamental active power L3[14]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62377	Min. fundamental cos φ active factor L3[14]	REAL	-	-1.0 ... 1.0			✓	✓	✓	✓	✓	
62380	Min. reactive power Qtot L3[3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62393	Diagnostics L3 [20]	DWORD	Bit track	0 ... 4294967295			✓	✓	✓	✓	✓	✓
62394	Voltage dip - value L3[16]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62395	Voltage swell - value L3[16]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62396	Voltage peak value L3[17]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62397	Current peak value L3 [17]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62398	Overcurrent- value L3[16]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62399	Voltage dip - duration L3[16]	REAL	ms	0.0 ... 100000.0			✓	✓	✓	✓	✓	
62400	Voltage swell - duration L3[16]	REAL	ms	0.0 ... 100000.0			✓	✓	✓	✓	✓	
Harmonics												
63000	Harmonics 1: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63001	Harmonics 1: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63002	Harmonics 2: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63003	Harmonics 2: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63004	Harmonics 3: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63005	Harmonics 3: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63006	Harmonics 4: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63007	Harmonics 4: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63008	Harmonics 5: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63009	Harmonics 5: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63010	Harmonics 6: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63011	Harmonics 6: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63012	Harmonics 7: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63013	Harmonics 7: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63014	Harmonics 8: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63015	Harmonics 8: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63016	Harmonics 9: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63017	Harmonics 9: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63018	Harmonics 10: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63019	Harmonics 10: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63020	Harmonics 11: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63021	Harmonics 11: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63022	Harmonics 12: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63023	Harmonics 12: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63024	Harmonics 13: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63025	Harmonics 13: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63026	Harmonics 14: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63027	Harmonics 14: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63028	Harmonics 15: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63029	Harmonics 15: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63030	Harmonics 16: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63031	Harmonics 16: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63032	Harmonics 17: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63033	Harmonics 17: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63034	Harmonics 18: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63035	Harmonics 18: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63036	Harmonics 19: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63037	Harmonics 19: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63038	Harmonics 20: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63039	Harmonics 20: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63040	Harmonics 21: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63041	Harmonics 21: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63042	Harmonics 22: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63043	Harmonics 22: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63044	Harmonics 23: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63045	Harmonics 23: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63046	Harmonics 24: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63047	Harmonics 24: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63048	Harmonics 25: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63049	Harmonics 25: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63050	Harmonics 26: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63051	Harmonics 26: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63052	Harmonics 27: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63053	Harmonics 27: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63054	Harmonics 28: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63055	Harmonics 28: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63056	Harmonics 29: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63057	Harmonics 29: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63058	Harmonics 30: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63059	Harmonics 30: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63060	Harmonics 31: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63061	Harmonics 31: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63062	Harmonics 32: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63063	Harmonics 32: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63064	Harmonics 33: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63065	Harmonics 33: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63066	Harmonics 34: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63067	Harmonics 34: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63068	Harmonics 35: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63069	Harmonics 35: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63070	Harmonics 36: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63071	Harmonics 36: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63072	Harmonics 37: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63073	Harmonics 37: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63074	Harmonics 38: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63075	Harmonics 38: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63076	Harmonics 39: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63077	Harmonics 39: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63078	Harmonics 40: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63079	Harmonics 40: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63400	Harmonics 1: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63401	Harmonics 1: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63402	Harmonics 2: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63403	Harmonics 2: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63404	Harmonics 3: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63405	Harmonics 3: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63406	Harmonics 4: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63407	Harmonics 4: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63408	Harmonics 5: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63409	Harmonics 5: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63410	Harmonics 6: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63411	Harmonics 6: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63412	Harmonics 7: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63413	Harmonics 7: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63414	Harmonics 8: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63415	Harmonics 8: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63416	Harmonics 9: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63417	Harmonics 9: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63418	Harmonics 10: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63419	Harmonics 10: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63420	Harmonics 11: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63421	Harmonics 11: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63422	Harmonics 12: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63423	Harmonics 12: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63424	Harmonics 13: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63425	Harmonics 13: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63426	Harmonics 14: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63427	Harmonics 14: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63428	Harmonics 15: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63429	Harmonics 15: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63430	Harmonics 16: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63431	Harmonics 16: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63432	Harmonics 17: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63433	Harmonics 17: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63434	Harmonics 18: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63435	Harmonics 18: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63436	Harmonics 19: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63437	Harmonics 19: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63438	Harmonics 20: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63439	Harmonics 20: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63440	Harmonics 21: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63441	Harmonics 21: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63442	Harmonics 22: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63443	Harmonics 22: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63444	Harmonics 23: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63445	Harmonics 23: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63446	Harmonics 24: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63447	Harmonics 24: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63448	Harmonics 25: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63449	Harmonics 25: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63450	Harmonics 26: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63451	Harmonics 26: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63452	Harmonics 27: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63453	Harmonics 27: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63454	Harmonics 28: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63455	Harmonics 28: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63456	Harmonics 29: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63457	Harmonics 29: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63458	Harmonics 30: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63459	Harmonics 30: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63460	Harmonics 31: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63461	Harmonics 31: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63462	Harmonics 32: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63463	Harmonics 32: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63464	Harmonics 33: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63465	Harmonics 33: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63466	Harmonics 34: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63467	Harmonics 34: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63468	Harmonics 35: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63469	Harmonics 35: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63470	Harmonics 36: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63471	Harmonics 36: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63472	Harmonics 37: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63473	Harmonics 37: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63474	Harmonics 38: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63475	Harmonics 38: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63476	Harmonics 39: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63477	Harmonics 39: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63478	Harmonics 40: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63479	Harmonics 40: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63800	Harmonics 1: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63801	Harmonics 1: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63802	Harmonics 2: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63803	Harmonics 2: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63804	Harmonics 3: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63805	Harmonics 3: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63806	Harmonics 4: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63807	Harmonics 4: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63808	Harmonics 5: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63809	Harmonics 5: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63810	Harmonics 6: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63811	Harmonics 6: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63812	Harmonics 7: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63813	Harmonics 7: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63814	Harmonics 8: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63815	Harmonics 8: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63816	Harmonics 9: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63817	Harmonics 9: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63818	Harmonics 10: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63819	Harmonics 10: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63820	Harmonics 11: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63821	Harmonics 11: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63822	Harmonics 12: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63823	Harmonics 12: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63824	Harmonics 13: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63825	Harmonics 13: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63826	Harmonics 14: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63827	Harmonics 14: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63828	Harmonics 15: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63829	Harmonics 15: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63830	Harmonics 16: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63831	Harmonics 16: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63832	Harmonics 17: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63833	Harmonics 17: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63834	Harmonics 18: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63835	Harmonics 18: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63836	Harmonics 19: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63837	Harmonics 19: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63838	Harmonics 20: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63839	Harmonics 20: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63840	Harmonics 21: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63841	Harmonics 21: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63842	Harmonics 22: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63843	Harmonics 22: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63844	Harmonics 23: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63845	Harmonics 23: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63846	Harmonics 24: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63847	Harmonics 24: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63848	Harmonics 25: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63849	Harmonics 25: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63850	Harmonics 26: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63851	Harmonics 26: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63852	Harmonics 27: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63853	Harmonics 27: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63854	Harmonics 28: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63855	Harmonics 28: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63856	Harmonics 29: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63857	Harmonics 29: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63858	Harmonics 30: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63859	Harmonics 30: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63860	Harmonics 31: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63861	Harmonics 31: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63862	Harmonics 32: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63863	Harmonics 32: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63864	Harmonics 33: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63865	Harmonics 33: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63866	Harmonics 34: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63867	Harmonics 34: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63868	Harmonics 35: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63869	Harmonics 35: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63870	Harmonics 36: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63871	Harmonics 36: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63872	Harmonics 37: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63873	Harmonics 37: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63874	Harmonics 38: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63875	Harmonics 38: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63876	Harmonics 39: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63877	Harmonics 39: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63878	Harmonics 40: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63879	Harmonics 40: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
65495[2-1]	DQ control measured value acquisition [17]	BYTE	Bit track	0 ... 255	✓	✓	✓	✓	✓	✓	✓	✓
65496	Power quality analysis - Qualifier	UDINT	Bit track	0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65497	Current module time	PNIO	sec		✓	✓	✓	✓	✓	✓	✓	✓
65500	Qualifier L1	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	✓
65501	Qualifier L2	UINT	Bit track	0 ... 65535		✓	✓	✓	✓	✓	✓	✓
65502	Qualifier L3	UINT	Bit track	0 ... 65535			✓	✓	✓	✓	✓	✓
65503	Qualifier L1L2L3 [22]	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	✓
65504	Operating hours counter L1L2L3 [5]	REAL	h	0.0 ... 3.4e+38	✓	✓	✓	✓	✓	✓	✓	✓
65505	Operating hours counter L1 [5]	REAL	h	0.0 ... 3.4e+38	✓	✓	✓	✓	✓	✓	✓	✓
65506	Operating hours counter L2 [5]	REAL	h	0.0 ... 3.4e+38		✓	✓	✓	✓	✓	✓	✓
65507	Operating hours counter L3 [5]	REAL	h	0.0 ... 3.4e+38			✓	✓	✓	✓	✓	✓
65508	Status of energy counter overflows	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	✓
65509	Status of limit violations 1...16	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	✓
65510	Counter for limit violations GW1 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65511	Counter for limit violations GW2 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65512	Counter for limit violations GW3 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65513	Counter for limit violations GW4 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
65514	Counter for limit violations GW5 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65515	Counter for limit violations GW6 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65516	Counter for limit violations GW7 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65517	Counter for limit violations GW8 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65518	Counter for limit violations GW9 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65519	Counter for limit violations GW10 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65520	Counter for limit violations GW11 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65521	Counter for limit violations GW12 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65522	Counter for limit violations GW13 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65523	Counter for limit violations GW14 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65524	Counter for limit violations GW15 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65525	Counter for limit violations GW16 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓

The table below is relevant for the description of the payload variants:

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P-2W	3P 4W	3P 4-W1	3P 3W	3P 3-W1	3P 4-WI
66001	Voltage L1-N [1]	UINT	0.01 V	0 ... 65535	✓	✓	✓	✓	✓			
66002	Voltage L2-N [1]	UINT	0.01 V	0 ... 65535		✓	✓	✓	✓			
66003	Voltage L3-N [1]	UINT	0.01 V	0 ... 65535			✓	✓	✓			
66004	Voltage L1-L2 [2]	UINT	0.01 V	0 ... 65535		✓		✓	✓	✓	✓	
66005	Voltage L2-L3 [2]	UINT	0.01 V	0 ... 65535				✓	✓	✓	✓	
66006	Voltage L3-L1 [2]	UINT	0.01 V	0 ... 65535				✓	✓	✓	✓	
66007	Current L1 [1]	UINT	1 mA	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	✓
66008	Current L2 [1]	UINT	1 mA	0 ... 65535		✓	✓	✓	✓	✓	✓	✓
66009	Current L3 [1]	UINT	1 mA	0 ... 65535			✓	✓	✓	✓	✓	✓
66010	Apparent power L1 [3]	INT	1 VA	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66011	Apparent power L2 [3]	INT	1 VA	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66012	Apparent power L3 [3]	INT	1 VA	-32768 ... 32767			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P-2W	3P 4W	3P 4-W1	3P 3W	3P 3-W1	3P 4-WI
66013	Active power L1 [3]	INT	1 W	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66014	Active power L2 [3]	INT	1 W	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66015	Active power L3 [3]	INT	1 W	-32768 ... 32767			✓	✓	✓	✓	✓	
66016	Reactive power Qn L1[3]	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66017	Reactive power Qn L2[3]	INT	1 var	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66018	Reactive power Qn L3[3]	INT	1 var	-32768 ... 32767			✓	✓	✓	✓	✓	
66019	Power factor λ L1 [3]	USINT	0.01	0 ... 100	✓	✓	✓	✓	✓	✓	✓	
66020	Power factor λ L2 [3]	USINT	0.01	0 ... 100		✓	✓	✓	✓	✓	✓	
66021	Power factor λ L3 [3]	USINT	0.01	0 ... 100			✓	✓	✓	✓	✓	
66022	Reactive power Qtot L1 [3]	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66023	Reactive power Qtot L2 [3]	INT	1 var	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66024	Reactive power Qtot L3 [3]	INT	1 var	-32768 ... 32767			✓	✓	✓	✓	✓	
66030	Frequency (Uint8) [4]	USINT	1 Hz	40 ... 70	✓	✓	✓	✓	✓	✓	✓	✓
66031	Frequency (Uint16) [4]	UINT	0.01 Hz	4000 ... 7000	✓	✓	✓	✓	✓	✓	✓	✓
66034	Active power L1L2L3 [5]	INT	1 W	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66035	Reactive power Qn L1L2L3[5]	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66036	Apparent power L1L2L3 [5]	INT	1 VA	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66037	Power factor λ L1L2L3 [6]	USINT	0.01	0 ... 100	✓	✓	✓	✓	✓	✓	✓	
66038	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	✓

Z = additionally possible measured values in the current path (e.g. instead of neutral current)

1 Effective value

2 IEC 61557-12

3 floating arithmetic average value above 200 ms

4 floating arithmetic mean value above 10 s, available for UL-N>3 V. Frequencies outside the measuring range of lower than 40 Hz or higher than 70 Hz cannot be displayed. In these cases, the configured frequency (50 Hz or 60 Hz) is displayed and is used in further calculations.

5 Simple summation

6 Calculation from the start/restart (inflow and outflow values are positive numbers)

7 floating arithmetic average value above 3 s

8 floating arithmetic average value above 600 s

9 floating arithmetic average value above 900 s

10 Block measurement over 900 s

11 direct measurement of the signal wave at 8 ksps

12 Total of the parts / number of parts

13 THD (Total Harmonic Distortion) is calculated once per second by the RMS of the fundamental oscillation and the total effective value (IEEE standard 1459–2010)

14 Min./Max: Slave pointer function of the respective basic value from start/reset

15 Calculation according to DIN EN 61000-3-316 half-wave value

16 Half-wave value

[17] Instantaneous value

[18] FFT (Fast Fourier Transformation)

[19] While pure RMS measured values only contain AC voltage components of the signal, 10/12 and half-wave measured values also show DC voltage components of the signal

[20] ET 200SP Diagnostics:

Bit2: Voltage less than tolerance range (for diagnostics enable Voltage underflow)

Bit3: Voltage greater than tolerance range (for diagnostics enable Voltage overflow)

Bit4: Current value > Current maximum value longer than tolerance time (for diagnostics enable Current overflow)

Bit7: Calculated value > value range (for diagnostics enable Calculated value overflow)

Bit16: Parameter error

Bit17: Load voltage error (for diagnostics enable No supply voltage)

Bit22: PRAL lost

Bit26: Power quality error (for diagnostics enable Power quality)

Bit31: Calibration or firmware update

[21] ID 65495 is only available for triggers of the measured value acquisition (not for limit monitoring and user-defined payload or data records)

[22] Only available for connection types 3PxW/only available for 3-phase system

Format

Table 2-827 Format and its length in bytes

Format in STEP 7 (TIA Portal)	Format to IEEE	Length in bytes	Comment
BYTE	BYTE	1 byte	Bit field with 8 bit
WORD	WORD	2 bytes	Bit field with 16 bit
DWORD	DWORD	4 bytes	Bit field with 32 bits
SINT	INT8 (signed)	1 byte	Fixed-point number 8 bits with sign
USINT	INT8 (unsigned)	1 byte	Fixed-point number 8 bits without sign
INT	INT (signed)	2 bytes	Fixed-point number 16 bits with sign
UINT	INT (unsigned)	2 bytes	Fixed-point number 16 bits without sign
UDINT	INT32 (unsigned)	4 bytes	Fixed-point number 32 bits without sign
DINT	INT32 (signed)	4 bytes	Fixed-point number, 32 bits with sign
REAL	Float32	4 bytes	Floating-point number 32 bits with sign
LREAL	Float64	8 bytes	Floating-point number 64 bits with sign

Module versions

C

C.1 Module version "2 I / 2 Q"

User data of the module

The module has 2 bytes of input user data and 2 bytes of output user data for status and control information. At this module version measured variables can be read solely via measured value data records (no measured variables can be evaluated via user data).

Structure of input user data

The structure of the input user data is fixed.

Table 2-828 Structure of input user data (2 bytes)

Byte	Validity	Designation	Comment
0	Module	User data variant	Constant = 0x80
1	Module	Quality information	Quality bits to describe the quality of the basic measured values

Allocation of the input user data

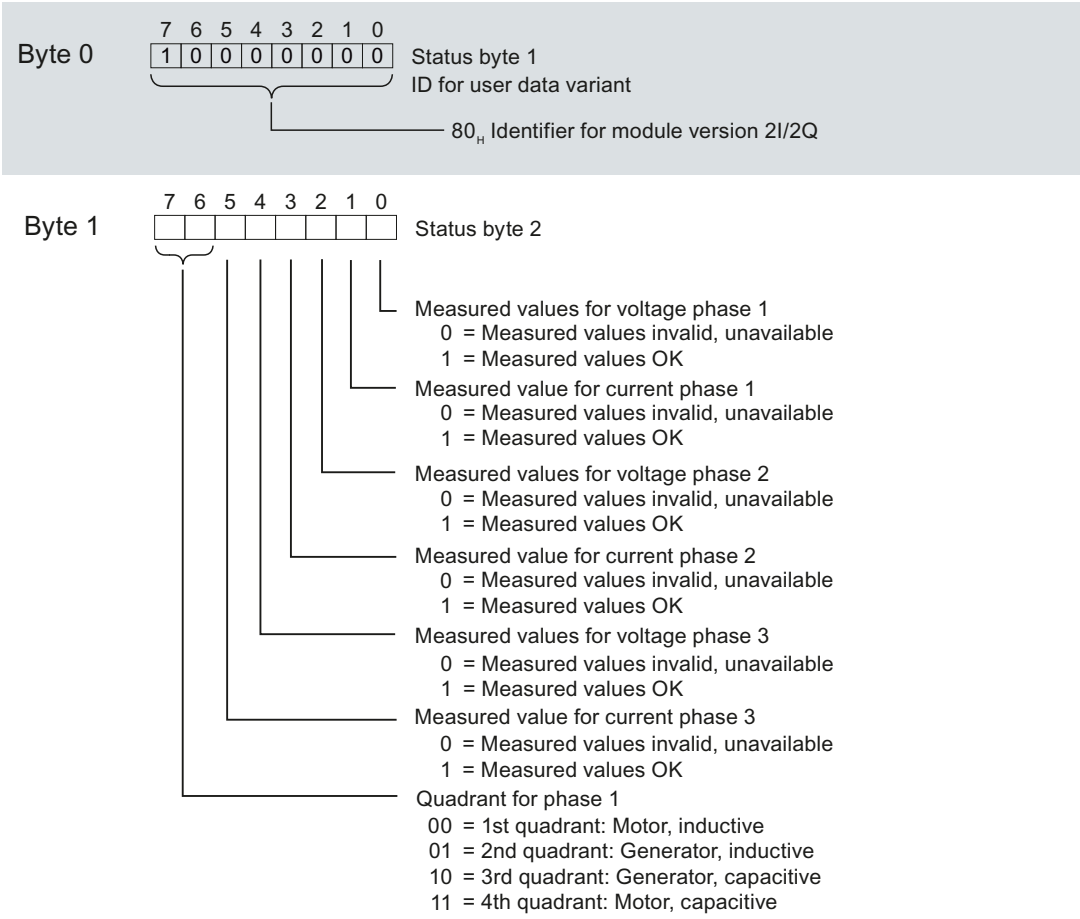

Figure 2-732 Allocation of the status bytes in the input user data (2 bytes)

Structure of output user data

The structure of the output user data is fixed.

Table 2-829 Structure of output user data (2 bytes)

Byte	Validity	Designation	Comment
0	Module	Reserved	Reserved
1	Module	Control outputs	Reset of values and counters, gate

Assignment of the output user data

Via the output user data you control for all phases

- Resetting for all minimum values, maximum values, limits, operating hours counter and energy meters.
- The counter gates for operating hours counter and energy counters.

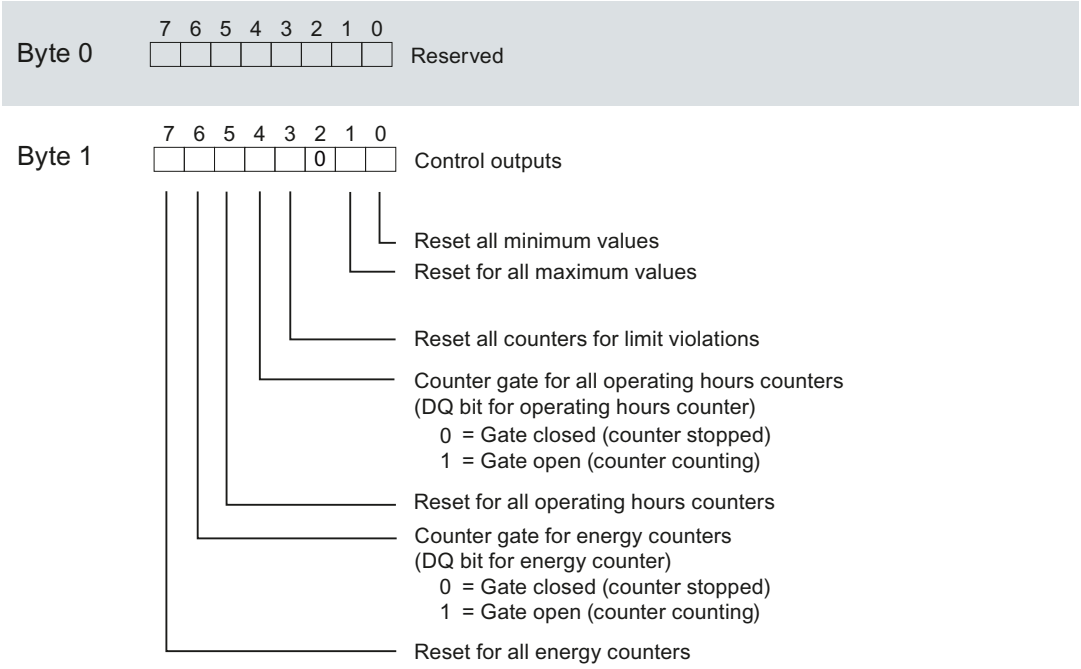

Figure 2-733 Allocation of the control byte in the output user data (1 byte)

NOTE

For module version 2 I / 2 Q, a reset of the selected variables always acts on **all** measured values/counter levels of the three phases.

- Reset energy counter: Acts on all active, reactive and apparent energies of all phases
- Reset operating hours counter: Acts on the counters of Phases 1 to 3
- Reset minimum / maximum values: Acts on the minimum and maximum value calculations of Phases 1-3
- Reset all counters for limit violations: Acts on all 16 limit values.

C.2 Module version "32 I / 20 Q"

Payload of the module

The module occupies 32 bytes of input payload and 20 bytes of output payload. Of these the module uses 2 bytes input data for status information and 20 bytes output data for control information. Measured variables can be read cyclically via payload (Bytes 2 to 31) or acyclically via measured value data records

Structure of input payload

You can set the contents of the input payload dynamically. You can choose between different payload variants.

Table 2-830 Structure of input payload (32 bytes)

Byte	Validity	Designation	Comment
0	Module	Payload variant	-
1	Module	Quality information	Quality bits to describe the quality of the basic measured values
2 ... 31	Module or phase	Data	2 or 4 byte measured values or cumulative values according to payload variant

Allocation of the input payload

You can change the measured variables during operation. You can choose between different payload variants.

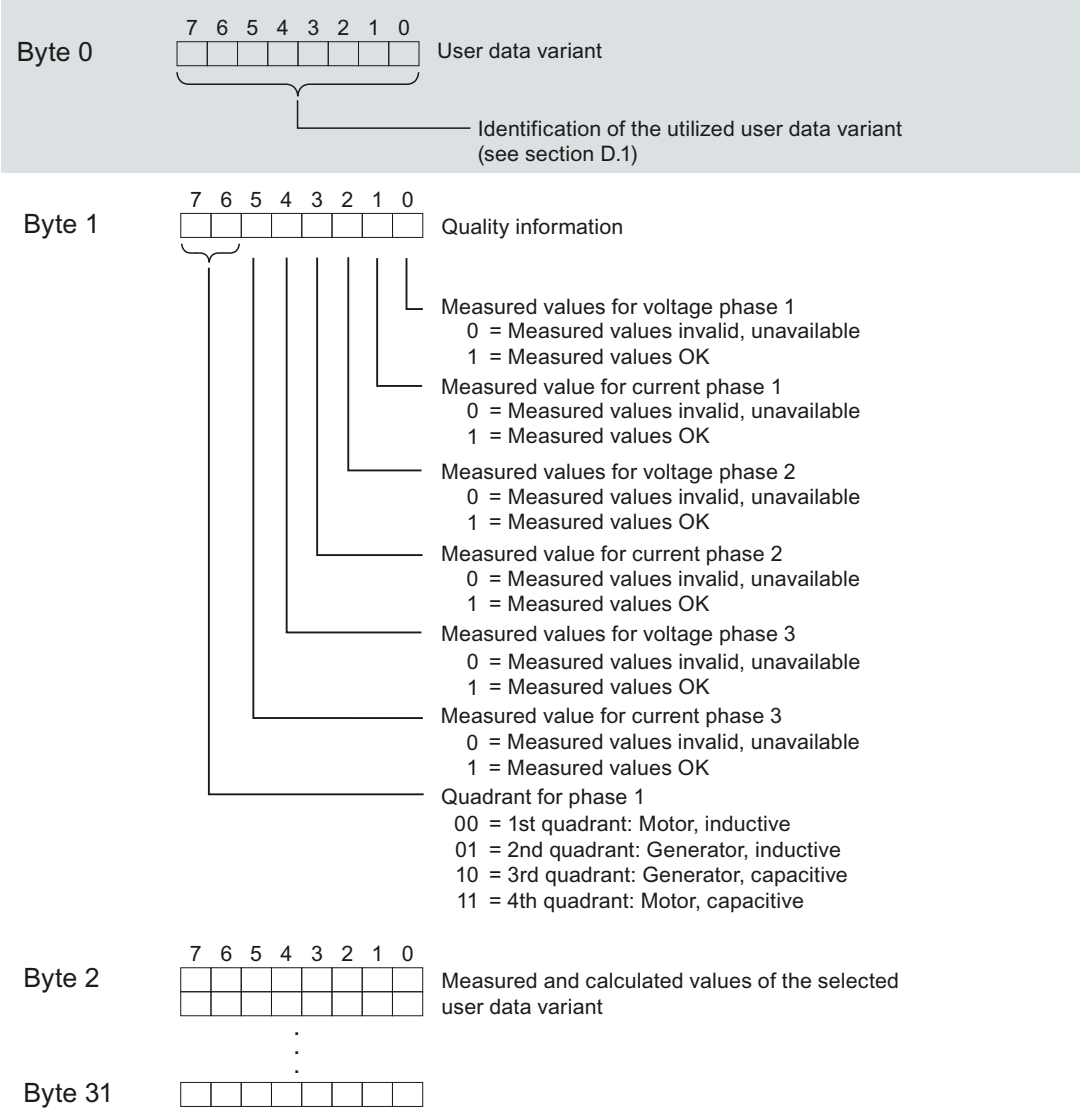

Figure 2-734 Assignment of the input payload (32 bytes)

Structure of output payload

The structure of the output payload is fixed and is the same at all the selectable payload variants.

Via the output payload you control globally or phase-specifically

- Resetting for minimum values, maximum values, limits, operating hours counter and energy meters.
- The counter gates for operating hours counter and energy counters.
- Gate for limits, minimum values and maximum values.

Table 2-831 Structure of output payload (20 bytes)

Byte	Validity	Designation	Comment
0	Module	Payload variant	Control byte for switching the payload variant
1	Module	Control byte 1	Global resetting of values and counters, gate Selection of the energy counter to be reset
2	Module	Control byte 2	
3	Module	Control byte 3	Control of the limit monitoring of limit values 9 to 16
4	Module	Control byte 4	Control of the limit monitoring of limit values 1 to 8
5	Module	Reserved	-
6	Phase L1	Control byte 6	Phase-specific resetting of values and counters, gate for Phase L1
7	Phase L1	Control byte 7	
8	Phase L2	Control byte 8	Phase-specific resetting of values and counters, gate for Phase L2
9	Phase L2	Control byte 9	
10	Phase L3	Control byte 10	Phase-specific resetting of values and counters, gate for Phase L3
11	Phase L3	Control byte 11	
12	Module and phases L1, L2, L3	Control byte 12	Deletion of power quality analysis results or starting/stopping the analysis of harmonics
13	Reserved		
14	Reserved		
15	Reserved		
16	Module and phases L1, L2, L3	Control byte 16	General reset Reset of measured value recorders 1 and 2, reset of the power failure analysis
17	Module	Control byte 17	Bit 0 = 0->1: Measured value recorder start/stop trigger ID 225 Bit 1 = 0->1: Measured value recorder start/stop trigger ID 226 Bit 2 = 0->1: Measured value recorder start/stop trigger ID 227 Bit 3 = 0->1: Measured value recorder start/stop trigger ID 228 Bit 4 = 0->1: Measured value recorder start/stop trigger ID 229 Bit 5 = 0->1: Measured value recorder start/stop trigger ID 230 Bit 6 = 0->1: Measured value recorder start/stop trigger ID 231 Bit 7 = 0->1: Measured value recorder start/stop trigger ID 232
18	Reserved		
19	Reserved		

Control bytes for payload variant

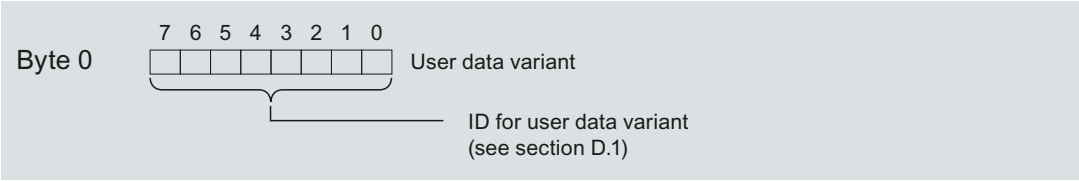

Figure 2-735 Allocation of the control bytes for payload variant (Byte 0)

Control bytes for all three phases

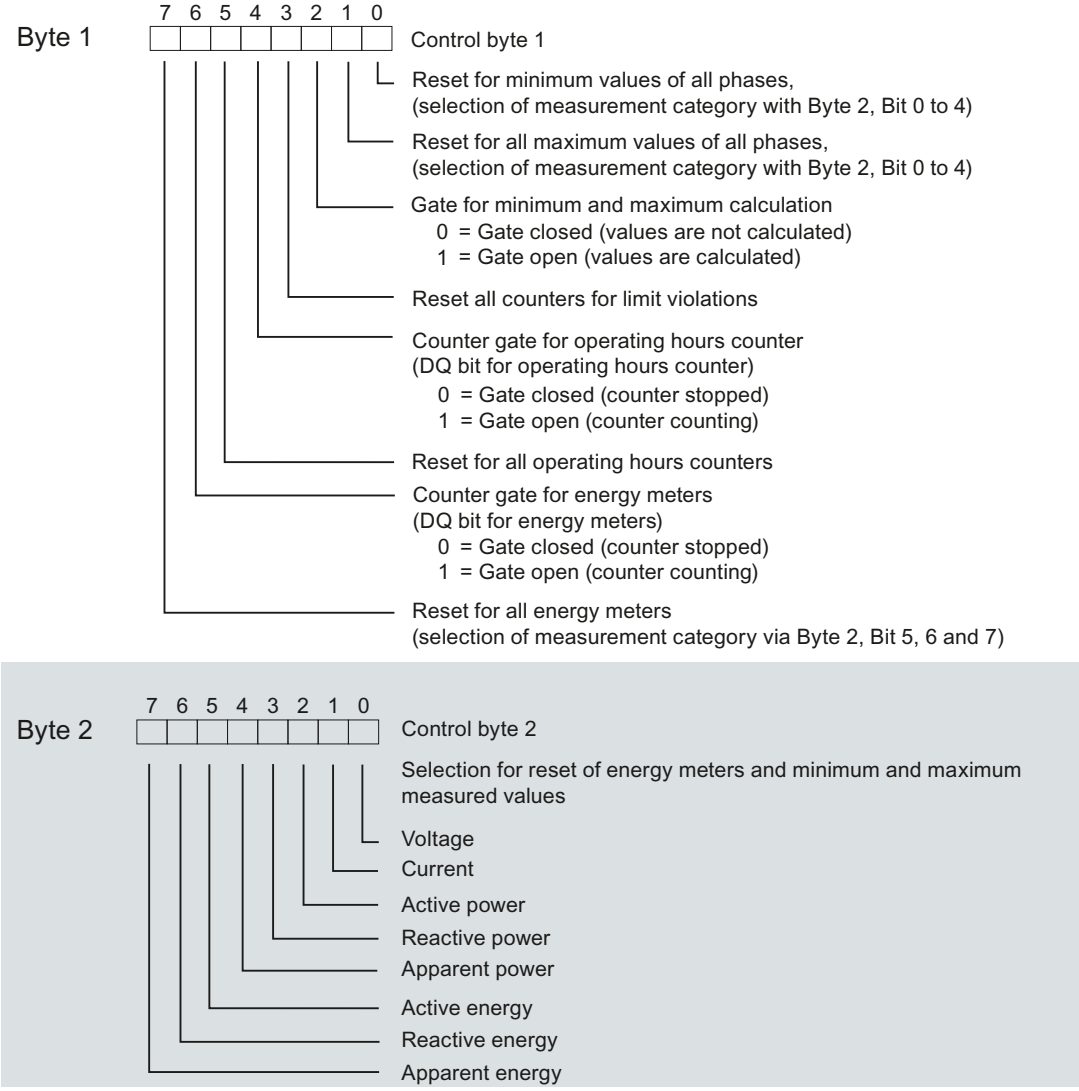

Figure 2-736 Allocation of the control bytes for all three phases (bytes 1 and 2)

Control bytes for limit monitoring

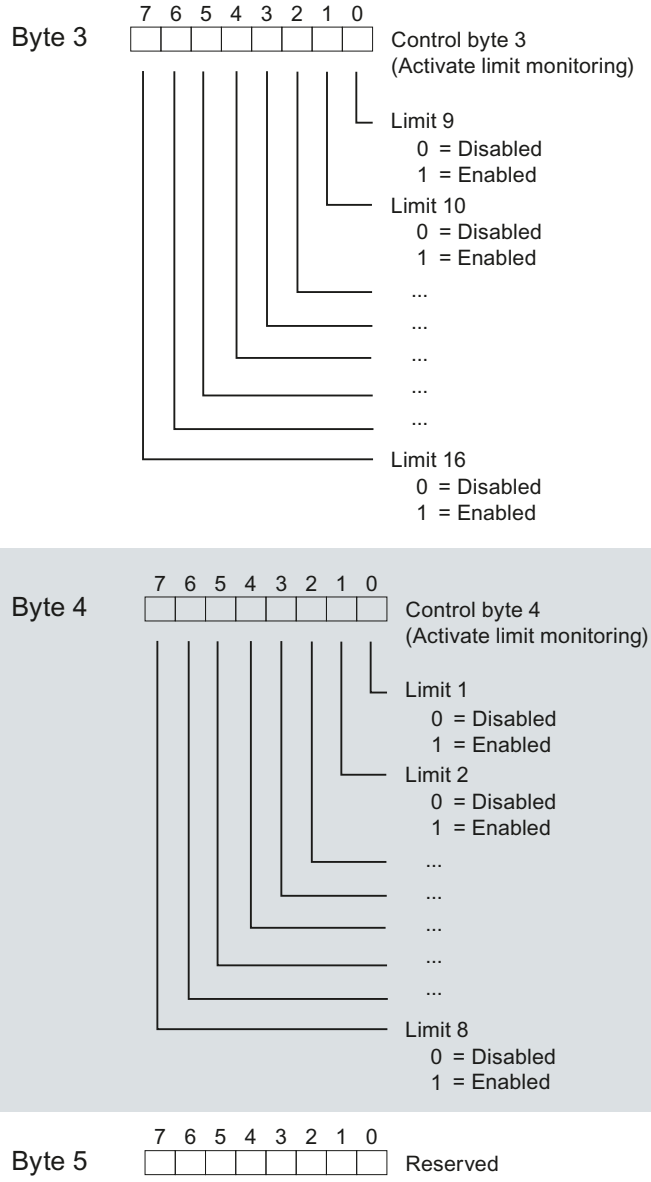

Figure 2-737 Allocation of the control bytes for limit monitoring (bytes 3 to 5)

Control bytes for each individual phase

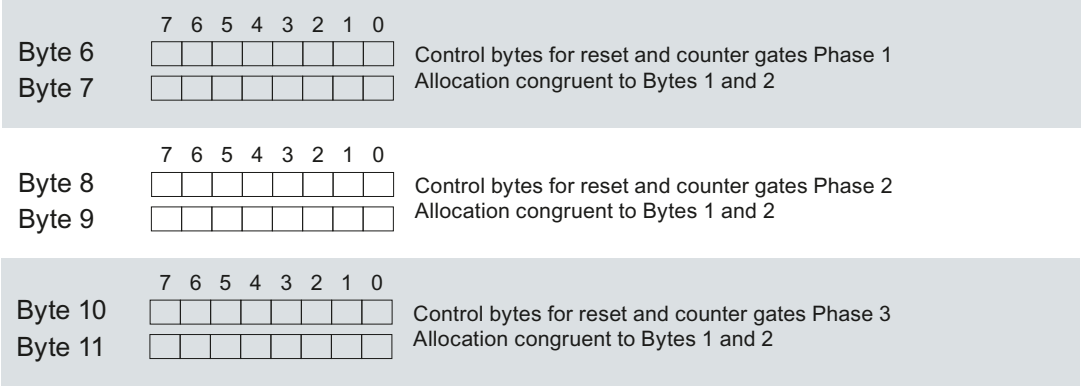

Figure 2-738 Allocation of the control bytes for each individual phase (bytes 6 to 11)

Control byte 12 Power quality analysis

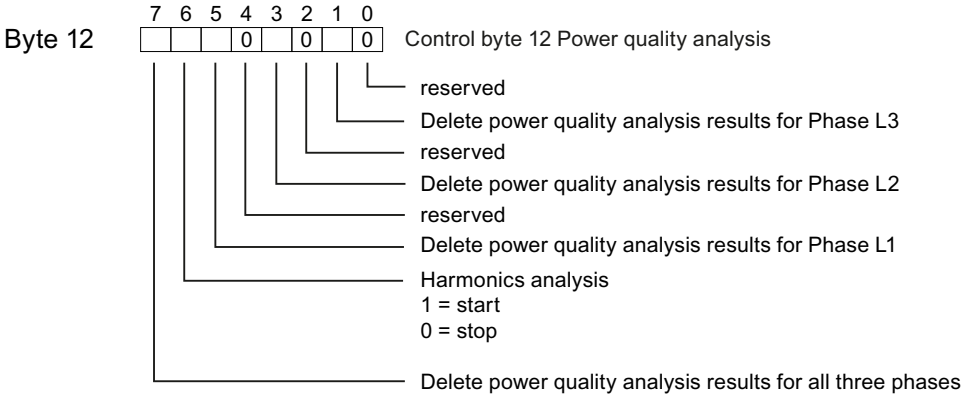

Figure 2-739 Control byte 12 Power quality analysis

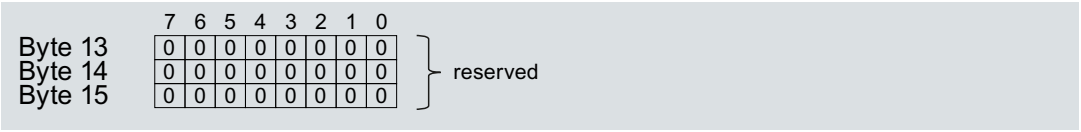

Figure 2-740 Allocation of the control bytes for each individual phase (bytes 13 to 15)

Control byte reset functions

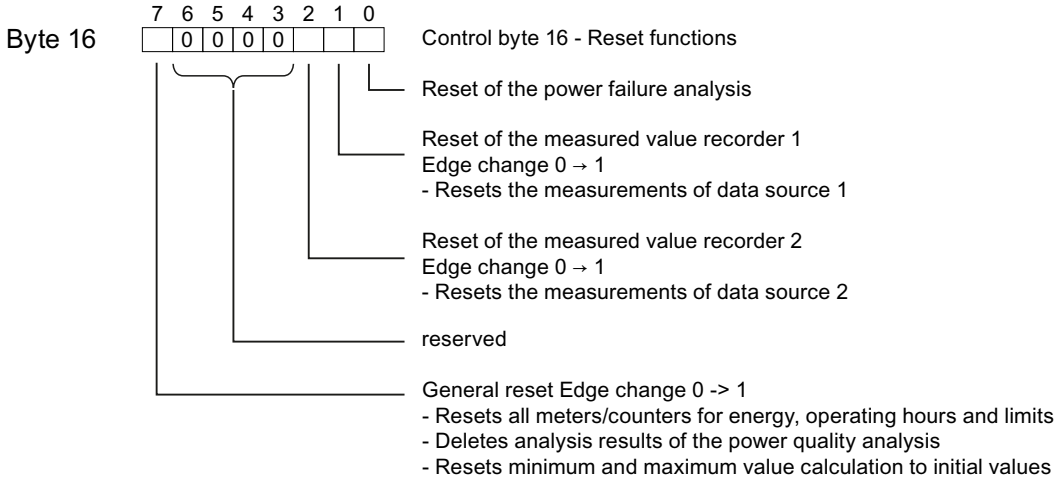

Figure 2-741 Allocation of the control bytes for reset functions (byte 16)

Control byte measured value recorder trigger

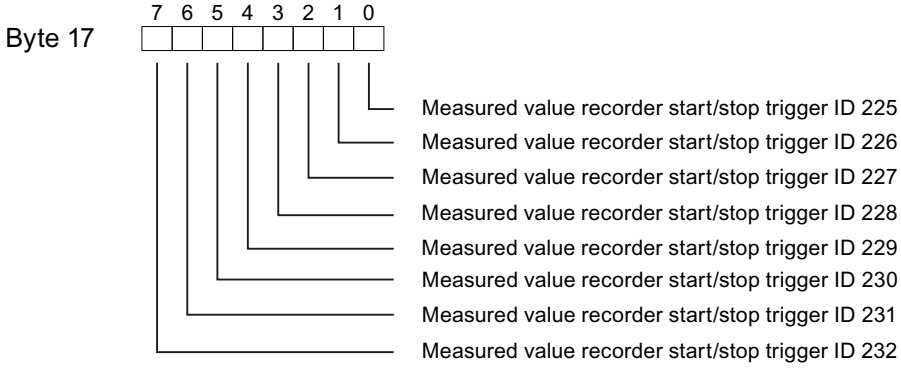

Figure 2-742 Allocation of the control bytes for measured value recorder trigger (byte 17)

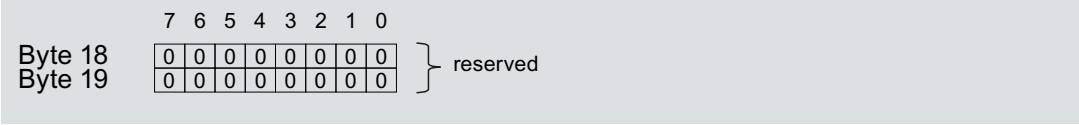

Figure 2-743 Allocation of the control bytes for each individual phase (bytes 18 to 19)

C.3 "User-specific" module version

Payload of the module

The module occupies between 16 and 256 bytes of input payload and 20 bytes of output payload. Of these the module uses 2 bytes input data for status information and 20 bytes output data for control information. Measured variables can be read cyclically via payload (as of Byte 2) or acyclically via measured value data records

Structure of input payload

You configure the structure of the input payload starting at Byte 2 at this module version itself. An input payload length of 32 bytes also allows you to set the input payload dynamically. You can choose between different payload variants.

Table 2-832 Structure of input payload (16 to 256 bytes)

Byte	Validity	Designation	Comment
0	Module	Payload variant	-
1	Module	Quality information	Quality bits to describe the quality of the basic measured values
2 ... 255	Module or phase	Data	Measured values or calculated values in accordance with their configuration: • At configuration in STEP 7 the size of the input payload is calculated automatically. • With configuration via the GSD file the size of the input payload amounts to 32, 64, 128 or 256 bytes. The memory area has to be sufficiently large for the measured variables defined in parameter data record 130 or 131.

Allocation of the input payload

You can change the measured variables during operation. You can choose between different payload variants.

The allocation of the status information in bytes 0 and 1 corresponds to the module version 32 I / 20 Q, see appendix Module version "32 I / 20 Q" (Page 206).

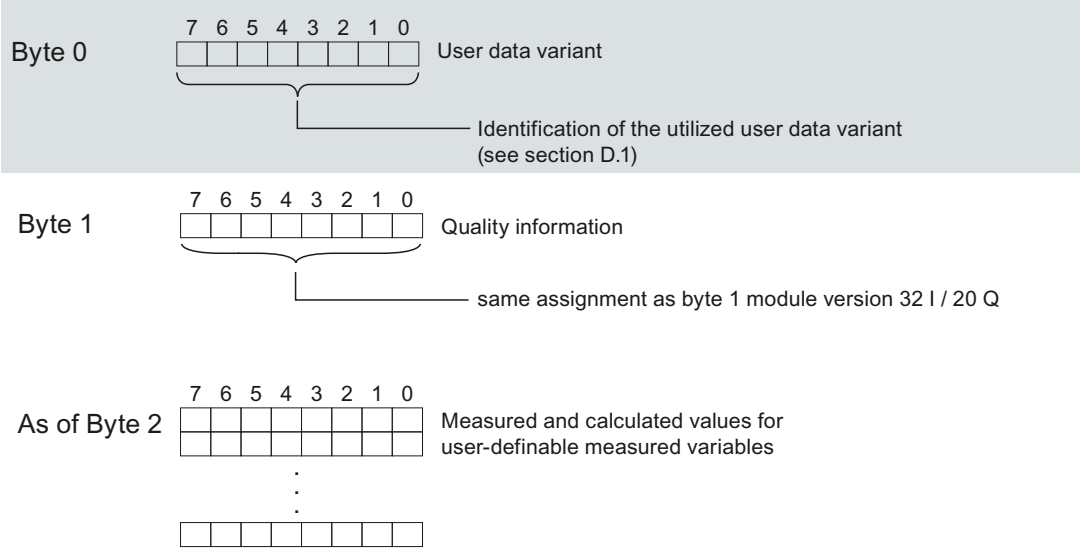

Figure 2-744 Allocation of the input payload ("User-specific" module version"

NOTE

Behavior at switchover in case of the input payload being too small

If the configured size of the variable input payload is smaller than the sized of the fixed payload variant, the response depends on the type of switchover:

- Re-assigning parameters via parameter data records DS 128 / DS 130 / DS 131: Output of a parameter assignment error (33). No switchover.
- Switchover using output byte 0 of a payload variant: No switchover and no error message.

Structure of output payload

The structure of the 20-byte output payload is fixed and is identical to the output payload (control bytes) of the Module version "32 I / 20 Q" (Page 206).

C.4 Module version "EE@Industry measurement data profile E0 / E1 / E2 / E3"

Payload of the module

The four versions according to EE@Industry use between 4 and 104 bytes of input payload and 20 bytes of output payload. A dynamic switchover of the input payload is not possible.

Structure of input payload

The structure of the input payload for the module versions according to the EE@Industry standard is fixed and depends on the selected measurement data profile.

Table 2-833 Measurement data profile E0

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Current L1	REAL	1 A	0.0 ... 100000.0	7
4...7	Current L2	REAL	1 A	0.0 ... 100000.0	8
8...11	Current L3	REAL	1 A	0.0 ... 100000.0	9

Table 2-834 Measurement data profile E1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Active power L1L2L3	REAL	1 W	-3.0e+9 ... +3.0e+9	34

Table 2-835 Measurement data profile E2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Active power L1L2L3	REAL	1 W	-3.0e+9 ... +3.0e+9	34
4...7	Active energy inflow L1L2L3 (Float)	REAL	1 Wh	0.0 ... 3.4028e+38	200
8...11	Active energy outflow L1L2L3 (Float)	REAL	1 Wh	0.0 ... 3.4028e+38	201

Table 2-836 Measurement data profile E3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Active power L1	REAL	1 W	-3.0e+9 ... +3.0e+9	13
4...7	Active power L2	REAL	1 W	-3.0e+9 ... +3.0e+9	14
8...11	Active power L3	REAL	1 W	-3.0e+9 ... +3.0e+9	15
12...15	Reactive power Qtot L1	REAL	1 var	-3.0e+9 ... +3.0e+9	22
16...19	Reactive power Qtot L2	REAL	1 var	-3.0e+9 ... +3.0e+9	23
20...23	Reactive power Qtot L3	REAL	1 var	-3.0e+9 ... +3.0e+9	24
24...31	Active energy inflow L1L2L3	LREAL	1 Wh	0.0 ... 1.7976e+308	210
32...39	Active energy outflow L1L2L3	LREAL	1 Wh	0.0 ... 1.7976e+308	211
40...47	Reactive energy inflow L1L2L3	LREAL	1 varh	0.0 ... 1.7976e+308	212

Byte	Allocation	Data type	Unit	Value range	Measured value ID
48...55	Reactive energy outflow L1L2L3	LREAL	1 varh	0.0 ... 1.7976e+308	213
56...59	Voltage L1-N	REAL	1 V	0.0 ... 1000000.0	1
60...63	Voltage L2-N	REAL	1 V	0.0 ... 1000000.0	2
64...67	Voltage L3-N	REAL	1 V	0.0 ... 1000000.0	3
68...71	Voltage L1-L2	REAL	1 V	0.0 ... 1000000.0	4
72...75	Voltage L2-L3	REAL	1 V	0.0 ... 1000000.0	5
76...79	Voltage L3-L1	REAL	1 V	0.0 ... 1000000.0	6
80...83	Current L1	REAL	1 A	0.0 ... 100000.0	7
84...87	Current L2	REAL	1 A	0.0 ... 100000.0	8
88...91	Current L3	REAL	1 A	0.0 ... 100000.0	9
92...95	Power factor λ L1	REAL	-	0.0 ... 1.0	19
96...99	Power factor λ L2	REAL	-	0.0 ... 1.0	20
100...1-03	Power factor λ L3	REAL	-	0.0 ... 1.0	21

Structure of output payload

The structure of the 20-byte output payload is fixed and is identical to the output payload (control bytes) of the Module version "32 I / 20 Q" (Page 206).

User data variants

D

D.1 User data variants with 32 bytes input data / 20 bytes output data

Payload

The following table shows the existing payload variants.

Table 2-837 Overview of the payload variants

Payload	Payload variant
Total power L1L2L3	254 (FE_H) - default setting
Active power L1L2L3	253 (FD_H)
Reactive power L1L2L3	252 (FC_H)
Apparent power L1L2L3	251 (FB_H)
Basic measured values L1L2L3	250 (FA_H)
Total energy L1L2L3	249 ($F9_H$)
Energy L1	248 ($F8_H$)
Energy L2	247 ($F7_H$)
Energy L3	246 ($F6_H$)
Basic variables three-phase measurement L1L2L3	245 ($F5_H$)
Reactive power compensation	244 ($F4_H$)
Quality values three-phase measurement	240 ($F0_H$)
Energy measurement (periodic) overflow counter	239 (EF_H)
EE@Industry measurement data profile E3	227 ($E3_H$)
EE@Industry measurement data profile E2	226 ($E2_H$)
EE@Industry measurement data profile E1	225 ($E1_H$)
EE@Industry measurement data profile E0	224 ($E0_H$)
Basic variables phase-specific measurement L1	159 ($9F_H$)
Single-phase measurement L1 with voltage scaling value	158 ($9E_H$)
Basic variables phase-specific measurement L2	157 ($9D_H$)
Single-phase measurement L2 with voltage scaling value	156 ($9C_H$)
Basic variables phase-specific measurement L3	155 ($9B_H$)
Single-phase measurement L3 with voltage scaling value	154 ($9A_H$)
User-defined payload structure I	1 (01_H)
User-defined payload structure II	2 (02_H)

Information on using and dynamic switching of the payload variants can be found under "Selection of the module version (Page 34)".

Total power L1L2L3 (ID 254 or FE_H)

Table 2-838 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
10 ... 11	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038
12 ... 13	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
14 ... 17	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	225
18 ... 21	Total reactive energy L1L2L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	226
22	Reserved	BYTE	-	0	-
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Active power L1L2L3 (ID 253 or FD_H)

Table 2-839 Active power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	253 (FD_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1	INT	1 W	-32768 ... 32767	66013
10 ... 11	Active power L2	INT	1 W	-32768 ... 32767	66014
12 ... 13	Active power L3	INT	1 W	-32768 ... 32767	66015
14 ... 15	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
16 ... 19	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	225
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1	USINT	-	0 ... 255	-
28	Scaling active power L2	USINT	-	0 ... 255	-
29	Scaling active power L3	USINT	-	0 ... 255	-
30	Scaling active power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-

Reactive power L1L2L3 (ID 252 or FC_H)

Table 2-840 Reactive power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	252 (FC_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	66022
10 ... 11	Reactive power Qtot L2	INT	1 var	-32768 ... 32767	66023
12 ... 13	Reactive power Qtot L3	INT	1 var	-32768 ... 32767	66024
14 ... 15	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038

Byte	Allocation	Data type	Unit	Value range	Measured value ID
16 ... 19	Reactive energy inflow L1L2L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	222
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling reactive power L1	USINT	-	0 ... 255	-
28	Scaling reactive power L2	USINT	-	0 ... 255	-
29	Scaling reactive power L3	USINT	-	0 ... 255	-
30	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Apparent power L1L2L3 (ID 251 or FB_H)

Table 2-841 Apparent power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	251 (FB_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Apparent power L1	INT	1 VA	-32768 ... 32767	66010
10 ... 11	Apparent power L2	INT	1 VA	-32768 ... 32767	66011
12 ... 13	Apparent power L3	INT	1 VA	-32768 ... 32767	66012
14 ... 15	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
16 ... 19	Apparent energy L1L2L3 (Int32)	DINT	1 VAh	0 to 2147483647	224
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Scaling apparent power L2	USINT	-	0 ... 255	-
29	Scaling apparent power L3	USINT	-	0 ... 255	-
30	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total apparent energy L1L2L3	USINT	-	0 ... 255	-

Basic measured values L1L2L3 (ID 250 or FA_H)

Table 2-842 Basic measured values L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	250 (FA_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
10 ... 11	Voltage L2-N	UINT	0.01 V	0 ... 65535	66002
12 ... 13	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003
14 ... 15	Voltage L1-L2	UINT	0.01 V	0 ... 65535	66004
16 ... 17	Voltage L2-L3	UINT	0.01 V	0 ... 65535	66005
18 ... 19	Voltage L3-L1	UINT	0.01 V	0 ... 65535	66006
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling voltage UL1-N (UL1-UL2)	USINT	-	0 ... 255	-
28	Scaling voltage UL2-N (UL2-UL3)	USINT	-	0 ... 255	-
29	Scaling voltage UL3-N (UL3-UL1)	USINT	-	0 ... 255	-
30 ... 31	Frequency (Uint16)	UINT	0.01 Hz	4000 ... 7000	66031

Total energy L1L2L3 (ID 249 or $F9_H$)

Table 2-843 Total energy L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	249 ($F9_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2	Reserved	BYTE	-	0	-
3	Reserved	BYTE	-	0	-
4 ... 7	Active energy inflow L1L2L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	220
8 ... 11	Active energy outflow L1L2L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	221
11 ... 15	Reactive energy inflow L1L2L3 (Int32)	UDINT	1 varh	0 ... 2147483647	222
16 ... 19	Reactive energy outflow L1L2L3 (Int32)	UDINT	1 varh	0 ... 2147483647	223
20 ... 23	Apparent energy L1L2L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	224
24	Reserved	BYTE	-	0	-
25	Scaling active energy, inflow	USINT	-	0 ... 255	-
26	Scaling active energy, outflow	USINT	-	0 ... 255	-
27	Scaling reactive energy, inflow	USINT	-	0 ... 255	-
28	Scaling reactive energy, outflow	USINT	-	0 ... 255	-
29	Scaling apparent energy	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037

Energy L1 (ID 248 or $F8_H$)

Table 2-844 Energy L1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	248 ($F8_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 7	Active energy inflow L1 (Int32)	UDINT	1 Wh	0 ... 2147483647	62110
8 ... 11	Active energy outflow L1 (Int32)	UDINT	1 Wh	0 ... 2147483647	62111
11 ... 15	Reactive energy inflow L1 (Int32)	UDINT	1 varh	0 ... 2147483647	62112
16 ... 19	Reactive energy outflow L1 (Int32)	UDINT	1 varh	0 ... 2147483647	62113
20 ... 23	Apparent energy L1 (Int32)	UDINT	1 VAh	0 ... 2147483647	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active energy inflow L1	USINT	-	0 ... 255	-
26	Scaling active energy outflow L1	USINT	-	0 ... 255	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
27	Scaling reactive energy inflow L1	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L1	USINT	-	0 ... 255	-
29	Scaling apparent energy L1	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L1	USINT	0.01	0 ... 100	66019

Energy L2 (ID 247 or $F7_H$)

Table 2-845 Energy L2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	247 ($F7_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L2	UINT	1 mA	0 ... 65535	66008
4 ... 7	Active energy inflow L2 (Int32)	UDINT	1 Wh	0 ... 2147483647	62210
8 ... 11	Active energy outflow L2 (Int32)	UDINT	1 Wh	0 ... 2147483647	62211
11 ... 15	Reactive energy inflow L2 (Int32)	UDINT	1 varh	0 ... 2147483647	62212
16 ... 19	Reactive energy outflow L2 (Int32)	UDINT	1 varh	0 ... 2147483647	62213
20 ... 23	Apparent energy L2 (Int32)	UDINT	1 VAh	0 ... 2147483647	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active energy inflow L2	USINT	-	0 ... 255	-
26	Scaling active energy outflow L2	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L2	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L2	USINT	-	0 ... 255	-
29	Scaling apparent energy L2	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L2	USINT	0.01	0 ... 100	66020

Energy L3 (ID 246 or $F6_H$)

Table 2-846 Energy L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	246 ($F6_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L3	UINT	1 mA	0 ... 65535	66009
4 ... 7	Active energy inflow L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	62310
8 ... 11	Active energy outflow L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	62311
11 ... 15	Reactive energy inflow L3 (Int32)	UDINT	1 varh	0 ... 2147483647	62312
16 ... 19	Reactive energy outflow L3 (Int32)	UDINT	1 varh	0 ... 2147483647	62313
20 ... 23	Apparent energy L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active energy inflow L3	USINT	-	0 ... 255	-
26	Scaling active energy outflow L3	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L3	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L3	USINT	-	0 ... 255	-
29	Scaling apparent energy L3	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L3	USINT	0.01	0 ... 100	66021

Basic variables three-phase measurements (ID 245 or $F5_H$)

Table 2-847 Basic variables three-phase measurements

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	245 ($F5_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1L2L3	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	34
6 ... 9	Active energy outflow L1L2L3	REAL	1 Wh	0.0 ... 3.4×10^{38}	201
10 ... 13	Active energy inflow L1L2L3	REAL	1 Wh	0.0 ... 3.4×10^{38}	200
14 ... 17	Current L1	REAL	1 A	0.0 ... 100000.0	7
18 ... 21	Current L2	REAL	1 A	0.0 ... 100000.0	8
22 ... 25	Current L3	REAL	1 A	0.0 ... 100000.0	9
26 ... 27	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
28 ... 29	Voltage L2-N	UINT	0.01 V	0 ... 65535	66002
30 ... 31	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003

Reactive power compensation (ID 244 or $F4_H$)

Table 2-848 Reactive power compensation

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	244 ($F4_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2	Fundamental cos φ active factor L1 (SINT8)	BYTE	0.01	-100 ... 100	62136
3	Fundamental cos φ active factor L2 (SINT8)	BYTE	0.01	-100 ... 100	62236
4	Fundamental cos φ active factor L3 (SINT8)	BYTE	0.01	-100 ... 100	62336
5	Reserved	BYTE	-	0	-
6 ... 9	Fundamental reactive power L1	REAL	var	-3×10^9 ... $+3 \times 10^9$	62124
10 ... 13	Fundamental reactive power L2	REAL	var	-3×10^9 ... $+3 \times 10^9$	62224
14 ... 17	Fundamental reactive power L3	REAL	var	-3×10^9 ... $+3 \times 10^9$	62324

Basic variables quality values three-phase measurement (ID 240 or $F0_H$)

Table 2-849 Basic variables quality values three-phase measurement

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	240 (F0H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Status of the limit violations GW 1 ... 16 (*)	WORD	Bit string	xxxx xxxx xxxx xxxx	65509
4 ... 5	Status of the energy counter overflows (**)	WORD	Bit string	xxxx xxxx xxxx xxxx	65508
6 ... 7	Qualifier L1L2L3	WORD	Bit string	xxxx xxxx xxxx xxxx	65503
8 ... 11	Power quality analysis - Qualifier	UDINT	Bit string	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx	65496
12 ... 13	Reserved	WORD	-	0	-
14 ... 15	Reserved	WORD	-	0	-
16 ... 17	Reserved	WORD	-	0	-
18 ... 19	Reserved	WORD	-	0	-
20 ... 21	Reserved	WORD	-	0	-
22 ... 23	Reserved	WORD	-	0	-
24 ... 25	Reserved	WORD	-	0	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
26 ... 27	Reserved	WORD	-	0	-
28 ... 29	Reserved	WORD	-	0	-
30 ... 31	Reserved	WORD	-	0	-

(*) Limit violation in:
Bit 0 = limit 1 to bit 15 = limit 16

(**) Energy counter count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1
Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

Basic variables energy counter measurement (periodic) overflow counter (ID 239 or EF_H)

Table 2-850 Basic variables energy counter measurement (periodic) overflow counter

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	239 (EFH)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Overflow counter active energy inflow L1	UINT	-	0 ... 65535	61190
4 ... 5	Overflow counter active energy outflow L1	UINT	-	0 ... 65535	61191
6 ... 7	Overflow counter reactive energy inflow L1	UINT	-	0 ... 65535	61192
8 ... 9	Overflow counter reactive energy outflow L1	UINT	-	0 ... 65535	61193
10 ... 11	Overflow counter apparent energy L1	UINT	-	0 ... 65535	61194
12 ... 13	Overflow counter active energy inflow L2	UINT	-	0 ... 65535	61210
14 ... 15	Overflow counter active energy outflow L2	UINT	-	0 ... 65535	61211
16 ... 17	Overflow counter reactive energy inflow L2	UINT	-	0 ... 65535	61212
18 ... 19	Overflow counter reactive energy outflow L2	UINT	-	0 ... 65535	61213
20 ... 21	Overflow counter apparent energy L2	UINT	-	0 ... 65535	61214
22 ... 23	Overflow counter active energy inflow L3	UINT	-	0 ... 65535	61230

Byte	Allocation	Data type	Unit	Value range	Measured value ID
24 ... 25	Overflow counter active energy outflow L3	UINT	-	0 ... 65535	61231
26 ... 27	Overflow counter reactive energy inflow L3	UINT	-	0 ... 65535	61232
28 ... 29	Overflow counter reactive energy outflow L3	UINT	-	0 ... 65535	61233
30 ... 31	Overflow counter apparent energy L3	UINT	-	0 ... 65535	61234

Basic variables measurement data profile (ID 227 or $E3_H$)

Table 2-851 Basic variables measurement data profile Energy E3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	227 ($E3_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	13
6 ... 9	Active power L2	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	14
10 ... 13	Active power L3	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	15
14 ... 17	Reactive power Qtot L1	REAL	1 var	-3×10^9 ... $+3 \times 10^9$	22
18 ... 21	Reactive power Qtot L2	REAL	1 var	-3×10^9 ... $+3 \times 10^9$	23
22 ... 25	Reactive power Qtot L3	REAL	1 var	-3×10^9 ... $+3 \times 10^9$	24
26 ... 33	Active energy inflow L1L2L3	LREAL	1 Wh	0.0 ... 1.8×10^{308}	210
34 ... 41	Active energy outflow L1L2L3	LREAL	1 Wh	0.0 ... 1.8×10^{308}	211
42 ... 49	Reactive energy inflow L1L2L3	LREAL	1 varh	0.0 ... 1.8×10^{308}	212
50 ... 57	Reactive energy outflow L1L2L3	LREAL	1 varh	0.0 ... 1.8×10^{308}	213
58 ... 61	Voltage L1-N	REAL	1 V	0.0 ... 1000000.0	1
62 ... 65	Voltage L2-N	REAL	1 V	0.0 ... 1000000.0	2
66 ... 69	Voltage L3-N	REAL	1 V	0.0 ... 1000000.0	3
70 ... 73	Voltage L1-L2	REAL	1 V	0.0 ... 1000000.0	4
74 ... 77	Voltage L2-L3	REAL	1 V	0.0 ... 1000000.0	5
78 ... 81	Voltage L3-L1	REAL	1 V	0.0 ... 1000000.0	6
82 ... 85	Current L1	REAL	1 A	0.0 ... 100000.0	7
86 ... 89	Current L2	REAL	1 A	0.0 ... 100000.0	8
90 ... 93	Current L3	REAL	1 A	0.0 ... 100000.0	9
94 ... 97	Power factor λ L1	REAL	-	0.0 ... 1.0	19
98 ... 101	Power factor λ L2	REAL	-	0.0 ... 1.0	20
102 ... 105	Power factor λ L3	REAL	-	0.0 ... 1.0	21

Basic variables measurement data profile (ID 226 or $E2_H$)

Table 2-852 Basic variables measurement data profile Energy E2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	226 ($E2_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	34
6 ... 9	Active energy inflow L1L2L3 (Float)	REAL	1 W	3.0×10^9	200
10 ...13	Active energy outflow L1L2L3 (Float)	REAL	1 W	3.0×10^9	201

Basic variables measurement data profile (ID 225 or $E1_H$)

Table 2-853 Basic variables measurement data profile Energy E1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	225 ($E1_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	34

Basic variables measurement data profile (ID 224 or $E0_H$)

Table 2-854 Basic variables measurement data profile Energy E0

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	224 ($E0_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Current L1	REAL	1 A	0.0 ... 100000.0	7
6 ... 9	Current L2	REAL	1 A	0.0 ... 100000.0	8
10 ...13	Current L3	REAL	1 A	0.0 ... 100000.0	9

Basic variables phase-specific measurement (ID 159 or $9F_H$)

Table 2-855 Basic variables phase-specific measurement L1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	159 (9FH)	-
1	Quality information = Q Q_1 0 0 0 0 I_1 U_1	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
6 ... 7	Active power L1	INT	1 W	-32768 ... 32767	66013
8 ... 9	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	66022
10 ... 11	Apparent power L1	INT	1 VA	-32768 ... 32767	66010
12 ... 15	Total active energy L1 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62115
16 ... 19	Total reactive energy L1 (Int32)	DINT	1 varh	-2147483647... +2147483647	62116
20 ... 23	Apparent energy L1 (Int32)	UDINT	1 VAh	0 ... 2147483647	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active power L1	USINT	-	0 ... 255	-
26	Scaling reactive power L1	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Total scaling active energy L1	USINT	-	0 ... 255	-
29	Total scaling reactive energy L1	USINT	-	0 ... 255	-
30	Scaling apparent energy L1	USINT	-	0 ... 255	-
31	Power factor λ L1	USINT	0.01	0 ... 100	66019

Basic variables phase-specific measurement (ID 158 or $9E_H$)

Table 2-856 Single-phase measurement L1 with voltage scaling value

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	158 (9EH)	-
1	Quality information = Q Q_1 0 0 0 0 I_1 U_1	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
6 ... 7	Active power L1	INT	1 W	-32768 ... 32767	66013
8 ... 9	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	66022
10 ... 11	Apparent power L1	INT	1 VA	-32768 ... 32767	66010
12 ... 15	Total active energy L1	UDINT	1 Wh	0 ... 4294967295	62115

Byte	Allocation	Data type	Unit	Value range	Measured value ID
16 ... 19	Total reactive energy L1	UDINT	1 varh	0 ... 4294967295	62116
20 ... 23	Apparent energy L1 (Int32)	UDINT	1 VAh	0 ... 4294967295	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active power L1	USINT	-	0 ... 255	-
26	Scaling reactive power L1	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Total scaling active energy L1	USINT	-	0 ... 255	-
29	Total scaling reactive energy L1	USINT	-	0 ... 255	-
30	Scaling apparent energy L1	USINT	-	0 ... 255	-
31	Scaling voltage L1-N	USINT	-	0 ... 255	-

Basic variables phase-specific measurement (ID 157 or $9D_H$)

Table 2-857 Basic variables phase-specific measurement L2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	157 ($9D_H$)	-
1	Quality information = Q Q_1 0 0 0 0 I_2 U_2	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L2	UINT	1 mA	0 ... 65535	66008
4 ... 5	Voltage L2-N	UINT	0.01 V	0 ... 65535	66002
6 ... 7	Active power L2	INT	1 W	-32768 ... 32767	66014
8 ... 9	Reactive power Qtot L2	INT	1 var	-32768 ... 32767	66023
10 ... 11	Apparent power L2	INT	1 VA	-32768 ... 32767	66011
12 ... 15	Total active energy L2 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62215
16 ... 19	Total reactive energy L2 (Int32)	DINT	1 varh	-2147483647... +2147483647	62216
20 ... 23	Apparent energy L2 (Int32)	UDINT	1 VAh	0 ... 2147483647	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active power L2	USINT	-	0 ... 255	-
26	Scaling reactive power L2	USINT	-	0 ... 255	-
27	Scaling apparent power L2	USINT	-	0 ... 255	-
28	Total scaling active energy L1	USINT	-	0 ... 255	-
29	Total scaling reactive energy L1	USINT	-	0 ... 255	-
30	Scaling apparent energy L2	USINT	-	0 ... 255	-
31	Power factor λ L2	USINT	0.01	0 ... 100	66020

Basic variables phase-specific measurement (ID 156 or $9C_H$)

Table 2-858 Single-phase measurement L2 with voltage scaling value

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	156 (9CH)	-
1	Quality information = Q Q_1 0 0 0 0 I_2 U_2	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L2	UINT	1 mA	0 ... 65535	66008
4 ... 5	Voltage UL2-N	UINT	0.01 V	0 ... 65535	66002
6 ... 7	Active power L2	INT	1 W	-32768 ... 32767	66014
8 ... 9	Reactive power Qtot L2	INT	1 var	-32768 ... 32767	66023
10 ... 11	Apparent power L2	INT	1 VA	-32768 ... 32767	66011
12 ... 15	Total active energy L2 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62215
16 ... 19	Total reactive energy L2 (Int32)	DINT	1 varh	-2147483647... +2147483647	62216
20 ... 23	Apparent energy L2 (Int32)	UDINT	1 VAh	0 ... 2147483647	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active power L2	USINT	-	0 ... 255	-
26	Scaling reactive power L2	USINT	-	0 ... 255	-
27	Scaling apparent power L2	USINT	-	0 ... 255	-
28	Total scaling active energy L2	USINT	-	0 ... 255	-
29	Total scaling reactive energy L2	USINT	-	0 ... 255	-
30	Scaling apparent energy L2	USINT	-	0 ... 255	-
31	Scaling voltage L2-N	USINT	-	0 ... 255	-

Basic variables phase-specific measurement (ID 155 or $9B_H$)

Table 2-859 Basic variables phase-specific measurement L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	155 ($9B_H$)	-
1	Quality information = Q Q_1 0 0 0 0 I_3 U_3	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L3	UINT	1 mA	0 ... 65535	66009
4 ... 5	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003
6 ... 7	Active power L3	INT	1 W	-32768 ... 32767	66015
8 ... 9	Reactive power Qtot L3	INT	1 var	-32768 ... 32767	66024
10 ... 11	Apparent power L3	INT	1 VA	-32768 ... 32767	66012
12 ... 15	Total active energy L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62315

Byte	Allocation	Data type	Unit	Value range	Measured value ID
16 ... 19	Total reactive energy L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	62316
20 ... 23	Apparent energy L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active power L3	USINT	-	0 ... 255	-
26	Scaling reactive power L3	USINT	-	0 ... 255	-
27	Scaling apparent power L3	USINT	-	0 ... 255	-
28	Total scaling active energy L3	USINT	-	0 ... 255	-
29	Total scaling reactive energy L3	USINT	-	0 ... 255	-
30	Scaling apparent energy L3	USINT	-	0 ... 255	-
31	Power factor L3	USINT	0.01	0 ... 100	66021

Basic variables phase-specific measurement (ID 154 or $9A_H$)

Table 2-860 Single-phase measurement L3 with voltage scaling value

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	154 ($9A_H$)	-
1	Quality information = Q Q_1 0 0 0 0 I_3 U_3	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L3	UINT	1 mA	0 ... 65535	66009
4 ... 5	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003
6 ... 7	Active power L3	INT	1 W	-32768 ... 32767	66015
8 ... 9	Reactive power Qtot L3	INT	1 var	-32768 ... 32767	66024
10 ... 11	Apparent power L3	INT	1 VA	-32768 ... 32767	66012
12 ... 15	Total active energy L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62315
16 ... 19	Total reactive energy L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	62316
20 ... 23	Apparent energy L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active power L3	USINT	-	0 ... 255	-
26	Scaling reactive power L3	USINT	-	0 ... 255	-
27	Scaling apparent power L3	USINT	-	0 ... 255	-
28	Total scaling active energy L3	USINT	-	0 ... 255	-
29	Total scaling reactive energy L3	USINT	-	0 ... 255	-
30	Scaling apparent energy L3	USINT	-	0 ... 255	-
31	Scaling voltage L3-N	USINT	-	0 ... 255	-

Measured value data records

E

E.1 Overview of all measured value data records

The AI Energy Meter CT HF writes the measured values in several data records that you can read acyclically using the RDREC instruction in the user program.

The following tables show the structure of the individual data records:

- Data record DS 142 for basic measured values version 2 (read only).
- Data record DS 142 for basic measured values version 3 (read only).
- Data record DS 143 for energy counters (read and write).
- Data record DS 144 for maximum values (read only).
- Data record DS 154 for maximum values with time stamp (read only).
- Data record DS 145 for minimum values (read only).
- Data record DS 155 for minimum values with time stamp (read only).
- Data record DS 147 for phase-specific measured values L1 version 0 (read only).
- Data record DS 147 for phase-specific measured values L1 version 1 (read only).
- Data record DS 148 for phase-specific measured values L2 DS version 0 (read only).
- Data record DS 148 for phase-specific measured values L2 DS version 1 (read only).
- Data record DS 149 for phase-specific measured values L3 DS version 0 (read only).
- Data record DS 149 for phase-specific measured values L3 DS version 1 (read only).
- Data record DS 150 for advanced measurement and status values (read only).
- Data record DS 151 for user-defined data record (read only).
- Data record DS 160 for power quality analysis (read only).
- Data record DS 161 for harmonics voltage (DS 161) (read only).
- Data record DS 163 for harmonics current (DS 163) (read only).
- Data record DS 169 for power failure analysis (read only).
- Data record DS 170 information data record on available measured values (read only).
- Data record DS 173 for measured value recording recorder channel 1 (read only).
- Data record DS 174 for measured value recording recorder channel 2 (read only).

E.2 Measured value data record for base measurements (DS 142)

E.2.1 Measured value data record for basic measured values (DS 142) version 2

Measured variables of the module

The following table provides an overview of all the measured variables that data record 142 supplies. Please note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix (Measured variables for connection type).

Table 2-861 Data record 142

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version = 2	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...5	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
6...9	Voltage L2-N	REAL	V	0.0 ... 1000000.0	2
10...13	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
14...17	Voltage L1-L2	REAL	V	0.0 ... 1000000.0	4
18...21	Voltage L2-L3	REAL	V	0.0 ... 1000000.0	5
22...25	Voltage L3-L1	REAL	V	0.0 ... 1000000.0	6
26...29	Current L1	REAL	A	0.0 ... 100000.0	7
30...33	Current L2	REAL	A	0.0 ... 100000.0	8
34...37	Current L3	REAL	A	0.0 ... 100000.0	9
38...41	Power factor λ L1	REAL	-	0.0 ... 1.0	19
42...45	Power factor λ L2	REAL	-	0.0 ... 1.0	20
46...49	Power factor λ L3	REAL	-	0.0 ... 1.0	21
50...53	Power factor λ L1L2L3	REAL	-	0.0 ... 1.0	37
54...57	Frequency L1L2L3	REAL	1 Hz	40.0 ... 70.0	30
58...61	Amplitude unbalance voltage U_2	REAL	%	0 ... 100	61157
62...65	Amplitude unbalance current I_{asym}	REAL	%	0 to 100	61158
66...69	Apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	10
70...73	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
74...77	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
78...81	Apparent power L1L2L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	36
82...85	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
86...89	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
90...93	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
94...97	Reactive power Qtot L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	38
98...101	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
102...105	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
106...109	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
110...113	Active power L1L2L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	34
114...117	Phase angle L1	REAL	°	0.0 ... 360.0	61178
118...121	Phase angle L2	REAL	°	0.0 ... 360.0	61198
122...125	Phase angle L3	REAL	°	0.0 ... 360.0	61218
126...129	Apparent energy L1L2L3 (Float)	REAL	VAh	0.0 ... 3.4×10^{38}	204
130...133	Total reactive energy L1L2L3 (Float)	REAL	varh	-3.4×10^{38} to $+3.4 \times 10^{38}$	206
134...137	Total active energy L1L2L3 (Float)	REAL	Wh	-3.4×10^{38} to $+3.4 \times 10^{38}$	205
138...141	Reactive energy inflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	202
142...145	Reactive energy outflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	203
146...149	Active energy inflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	200
150...153	Active energy outflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	201
154...161	Apparent energy L1L2L3	LREAL	VAh	0.0 ... 1.8×10^{308}	214
162...169	Total reactive energy L1L2L3	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	216
170...177	Total active energy L1L2L3	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	215
178...185	Reactive energy inflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	212
186...193	Reactive energy outflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	213
194...201	Active energy inflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	210
202...209	Active energy outflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	211
210...213	Neutral current IN	REAL	A	0.0 ... 100000.0	61149

Neutral current

If you operate the AI Energy Meter CT HF with connection type 3P4W, 3P4W1 or 3P3W, the neutral current is also calculated under the following conditions:

- Transmission factors of all phase currents (primary and secondary currents) are identical.
- Measured phase currents are greater than the value of the "Low limit for measuring current parameter.
- The parameter "Reverse current direction" must be the same on all phases.

If one of the conditions is not met, 0 is entered as the value for the neutral current. You can read the neutral current calculated using measured value data record 142.

Procedure

Data record 142 is located on the AI Energy Meter CT HF. Use the RDREC instruction to read out the data record from the module. This system function block is stored in the STEP 7 library.

E.2.2 Measured value data record for basic measured values (DS 142) version 3

Measured variables of the module

The following table provides an overview of all the measured variables that data record 142 supplies. Note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix (Measured variables for connection type (Page 175)).

Table 2-862 Data record 142

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version = 3	BYTE	-	3	-
1	Reserved	BYTE	-	0	-
2...5	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
6...9	Voltage L2-N	REAL	V	0.0 ... 1000000.0	2
10...13	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
14...17	Voltage L1-L2	REAL	V	0.0 ... 1000000.0	4
18...21	Voltage L2-L3	REAL	V	0.0 ... 1000000.0	5
22...25	Voltage L3-L1	REAL	V	0.0 ... 1000000.0	6
26...29	Current L1	REAL	A	0.0 ... 100000.0	7
30...33	Current L2	REAL	A	0.0 ... 100000.0	8
34...37	Current L3	REAL	A	0.0 ... 100000.0	9
38...41	Power factor λ L1	REAL	-	0.0 ... 1.0	19
42...45	Power factor λ L2	REAL	-	0.0 ... 1.0	20

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
46...49	Power factor λ L3	REAL	-	0.0 ... 1.0	21
50...53	Power factor λ L1L2L3	REAL	-	0.0 ... 1.0	37
54...57	Frequency L1L2L3	REAL	1 Hz	40.0 ... 70.0	30
58...61	Amplitude unbalance voltage U_2	REAL	%	0 ... 100	61157
62...65	Amplitude unbalance current I_{asym}	REAL	%	0 ... 100	61158
66...69	Apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	10
70...73	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
74...77	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
78...81	Apparent power L1L2L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	36
82...85	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22
86...89	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
90...93	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
94...97	Reactive power Qtot L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	38
98...101	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
102...105	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
106...109	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
110...113	Active power L1L2L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	34
114...117	Phase angle L1	REAL	°	0.0 ... 360.0	61178
118...121	Phase angle L2	REAL	°	0.0 ... 360.0	61198
122...125	Phase angle L3	REAL	°	0.0 ... 360.0	61218
126...129	Apparent energy L1L2L3 (Float)	REAL	VAh	0.0 ... 3.4×10^{38}	204
130...133	Total reactive energy L1L2L3 (Float)	REAL	varh	-3.4×10^{38} to $+3.4 \times 10^{38}$	206
134...137	Total active energy L1L2L3 (Float)	REAL	Wh	-3.4×10^{38} to $+3.4 \times 10^{38}$	205
138...141	Reactive energy inflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	202
142...145	Reactive energy outflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	203
146...149	Active energy inflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	200
150...153	Active energy outflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	201
154...161	Apparent energy L1L2L3	LREAL	VAh	0.0 ... 1.8×10^{308}	214

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
162...169	Total reactive energy L1L2L3	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	216
170...177	Total active energy L1L2L3	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	215
178...185	Reactive energy inflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	212
186...193	Reactive energy outflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	213
194...201	Active energy inflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	210
202...209	Active energy outflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	211
210...213	Neutral current IN	REAL	A	0.0 ... 100000.0	61149
214...217	Neutral current 10-12 cycles	REAL	A	0.0 ... 100000.0	61150
218...221	Reactive power Qn L1	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	16
222...225	Reactive power Qn L2	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	17
226...229	Reactive power Qn L3	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	18
230...233	Reactive power Qn L1L2L3	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	35
234...237	Average voltage load LN (Utot)	REAL	V	0.0 ... 300.0	31
238...241	Average voltage L-L	REAL	V	0.0 ... 600.0	32
242...245	Average current L1L2L3 (Itot)	REAL	A	0.0 ... 100000.0	33
246...249	Mean power factor λ L1L2L3	REAL	-	0.0 ... 1.0	166
250...253	Fundamental voltage L1	REAL	V	0.0 ... 440.0	62122
254...257	Fundamental voltage L2	REAL	V	0.0 ... 440.0	62222
258...261	Fundamental voltage L3	REAL	V	0.0 ... 440.0	62322
262...265	Fundamental current L1	REAL	A	0.0 ... 100000.0	62123
266...269	Fundamental current L2	REAL	A	0.0 ... 100000.0	62223
270...273	Fundamental current L3	REAL	A	0.0 ... 100000.0	62323
274...277	Fundamental apparent power L1	REAL	VA	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62125
278...281	Fundamental apparent power L2	REAL	VA	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62225
282...285	Fundamental apparent power L3	REAL	VA	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62325
286...289	Fundamental reactive power L1	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62124
290...293	Fundamental reactive power L2	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62224
294...297	Fundamental reactive power L3	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62324
298...301	Fundamental active power L1	REAL	W	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62126

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
302...305	Fundamental active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62226
306...309	Fundamental active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62326
310...313	Fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62127
314...317	Fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62227
318...321	Fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62327
322...325	Total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62120
326...329	Total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62220
330...333	Total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62320
334...337	Total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62121
338...341	Total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62221
342...345	Total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62321
346...357	Current module time	PNIOTime	sec	-	65497

Neutral current

If you operate the AI Energy Meter CT HF with connection type 3P4W, 3P4W1 or 3P3W, the neutral current is also calculated under the following conditions:

- Transmission factors of all phase currents (primary and secondary currents) are identical.
- Measured phase currents are greater than the value of the "Low limit for measuring current" parameter.
- The parameter "Reverse current direction" must be the same on all phases.

If one of the conditions is not met, 0 is entered as the value for the neutral current. You can read the neutral current calculated using measured value data record 142.

Procedure

Data record 142 is located on the AI Energy Meter CT HF. Use the RDREC instruction to read out the data record from the module. This system function block is stored in the STEP 7 library.

E.3 Structure for energy counters (DS 143)

Energy meter data record 143 for different actions

The energy meter data record 143 includes all energy meters available on the module phase-by-phase. The data record can be used for different actions:

- Reset the energy meters to user-specific value (e.g. "0")
- Reading the current values of the energy counters
- Reading the overflow counters
- Reading the operating hours

NOTE

- The cumulative value of the energy counters in 3-phase operation is obtained from the sums of the respective individual values of the phases.
- Inflow and outflow energy meters are always positive values.
- The operating hours counter for the entire module is calculated from the maximum of the operating hours of the individual phases.

Energy meter data record 143

Table 2-863 Energy meter data record 143

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Status / control byte 1 - L1	BYTE	Bit string	-	-
3	Status / control byte 2 - L1	BYTE	Bit string		
4	Status / control byte 1 - L2	BYTE	Bit string		
5	Status / control byte 2 - L2	BYTE	Bit string		
6	Status / control byte 1 - L3	BYTE	Bit string		
7	Status / control byte 2 - L3	BYTE	Bit string		
8...15	Active energy inflow (initial value) L1	LREAL	Wh	During reading: 0.0...1.8 x 10^{308} During writing For continuous counting: 0.0...3.4 x 10^{12} During writing For periodic counting:	61180
16...23	Active energy outflow (initial value) L1	LREAL	Wh		61181
24...31	Reactive energy inflow (initial value) L1	LREAL	varh		61182
32...39	Reactive energy outflow (initial value) L1	LREAL	varh		61183
40...47	Apparent energy (initial value) L1	LREAL	VAh		61184
48...55	Active energy inflow (initial value) L2	LREAL	Wh		61200
56...63	Active energy outflow (initial value) L2	LREAL	Wh		61201
64...61	Reactive energy inflow (initial value) L2	LREAL	varh		61202
72...79	Reactive energy outflow (initial value) L2	LREAL	varh		61203
80...87	Apparent energy (initial value) L2	LREAL	VAh		61204

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
88...95	Active energy inflow (initial value) L3	LREAL	Wh	0...configured full-scale value (10^3 ...10^{15})	61220
96...10-3	Active energy outflow (initial value) L3	LREAL	Wh		61221
104...1-11	Reactive energy inflow (initial value) L3	LREAL	varh		61222
112...1-19	Reactive energy outflow (initial value) L3	LREAL	varh		61223
120...1-27	Apparent energy (initial value) L3	LREAL	VAh		61224
128...1-29	Overflow counter active energy inflow L1	UINT	-	During reading: 0...65535 During writing for continuous counting: 0 During writing for periodic counting: 0...65500	61190
130..1-31	Overflow counter active energy outflow L1	UINT	-		61191
132...1-33	Overflow counter reactive energy inflow L1	UINT	-		61192
134...1-35	Overflow counter reactive energy outflow L1	UINT	-		61193
136...1-37	Overflow counter apparent energy L1	UINT	-		61194
138...1-39	Overflow counter active energy inflow L2	UINT	-		61210
140...1-41	Overflow counter active energy outflow L2	UINT	-		61211
142...1-43	Overflow counter reactive energy inflow L2	UINT	-		61212
144...1-45	Overflow counter reactive energy outflow L2	UINT	-		61213
146...1-47	Overflow counter apparent energy L2	UINT	-		61214
148...1-49	Overflow counter active energy inflow L3	UINT	-		61230
150...1-51	Overflow counter active energy outflow L3	UINT	-		61231
152...1-53	Overflow counter reactive energy inflow L3	UINT	-		61232
154...1-55	Overflow counter reactive energy outflow L3	UINT	-		61233
156...1-57	Overflow counter apparent energy L3	UINT	-		61234
158...1-61	Operating hours counter L1 (initial value)	REAL	h	During reading: 0...3.4x10^{38} During writing: 0...10^9	65505
162...1-65	Operating hours counter L2 (initial value)	REAL	h		65506
166...1-69	Operating hours counter L3 (initial value)	REAL	h		65507

Status information

When data record 143 is read with the RDREC instruction, Bytes 2 to 7 supply phase-specific status information for energy counters, overflow counters and operating hours counters.

The status information enables you can see which counters are returning their values in the data record 143. If energy counters return their values in the status byte 1, you can determine the type of energy counter with status byte 2.

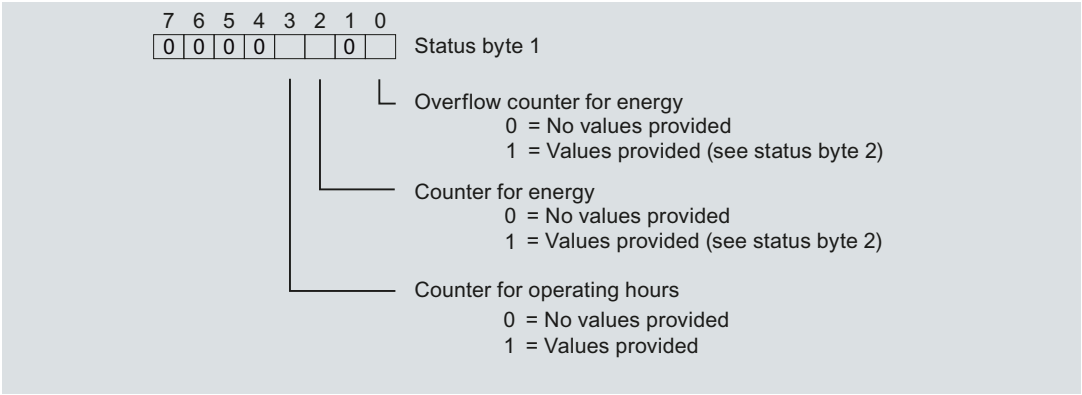

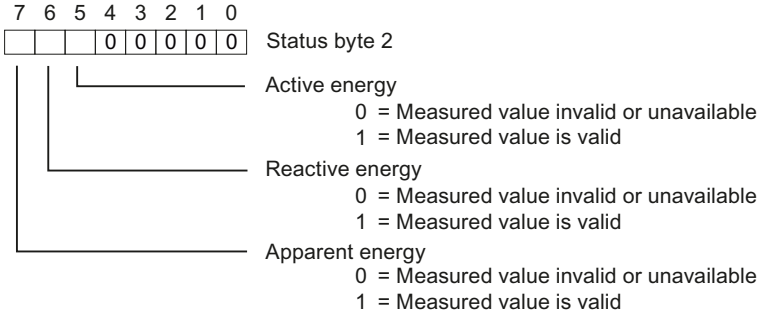

Figure 2-745 Status information DS 143 (read access)

Control information

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy counters, overflow counters and operating hours counter. The length of the control information amounts to 2 bytes for each phase:

- In control byte 1 you determine which counter you want to reset and the time at which counters are reset.
- In Control byte 2 you determine which energy counters and which overflow counters you want to reset.

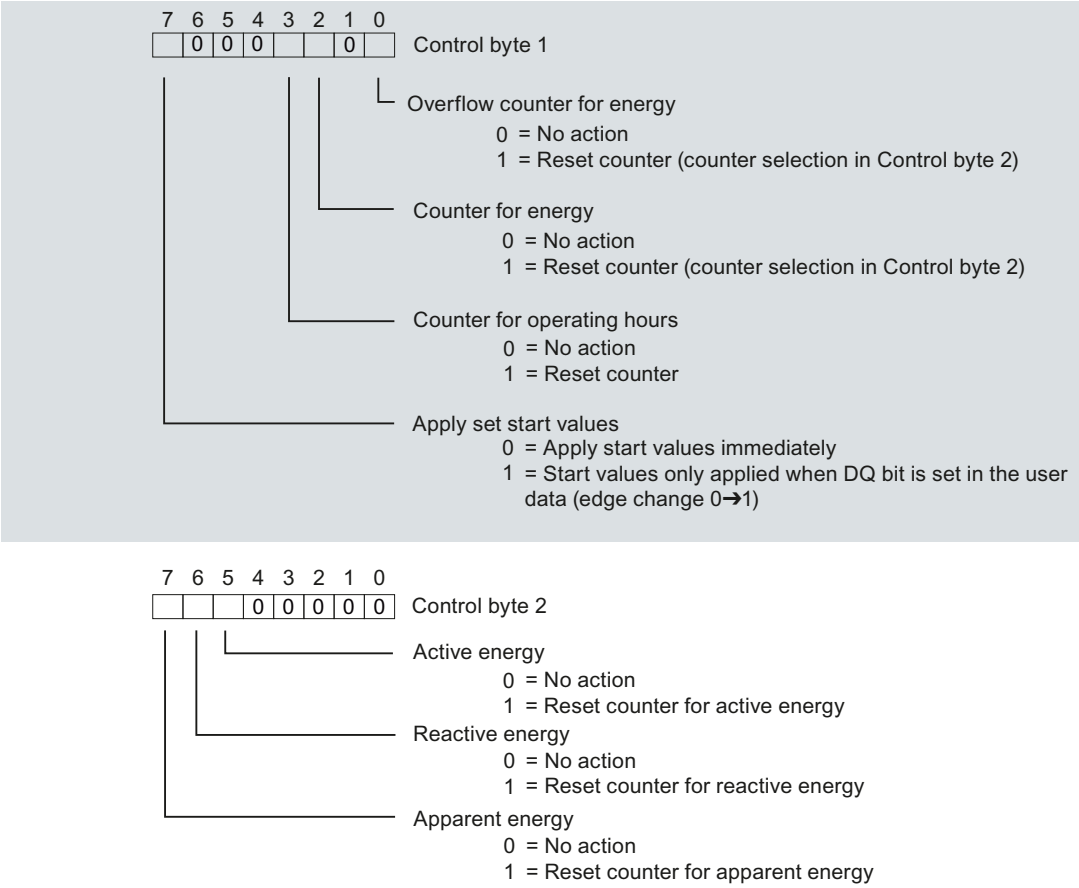

Figure 2-746 Control information DS 143 (write access)

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the measured value data record 143:

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	00	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	01	Reserved bits are not 0.	Check Byte 2...7 and set the reserved bits back to 0.
DF	80	E1	39	Incorrect version entered.	Check Byte 0. Enter a valid version.
DF	80	E1	3A	Incorrect data record length entered.	Check the parameters of the WRREC instruction. Enter a valid length.
DF	80	E1	3C	At least one start value is invalid.	Check Bytes 8...103 and Bytes 158...169. The start values may not be negative.
DF	80	E1	3D	At least one start value is too large	Check Bytes 8...103 and Bytes 158...169. Observe the ranges of values for start values.

E.4 Measured value data record for maximum values (DS 144)

Measured variables of the module

The largest values ever measured or calculated from the time the AI Energy Meter HF was started are stored in this data record.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 175)).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...5	Max. voltage L1-N	REAL	V	0	40
6...9	Max. voltage L2-N	REAL	V	0	41
10...13	Max. voltage L3-N	REAL	V	0	42
14...17	Max. voltage L1-L2	REAL	V	0	43
18...21	Max. voltage L2-L3	REAL	V	0	44
22...25	Max. voltage L3-L1	REAL	V	0	45
26...29	Max. current L1 [1]	REAL	A	0	46
30...33	Max. current L2 [1]	REAL	A	0	47
34...37	Max. current L3 [1]	REAL	A	0	48
38...41	Max. apparent power L1	REAL	VA	0	49
42...45	Max. apparent power L2	REAL	VA	0	50
46...49	Max. apparent power L3	REAL	VA	0	51
50...53	Max. active power L1	REAL	W	-3.0×10^9	52
54...57	Max. active power L2	REAL	W	-3.0×10^9	53

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
58...61	Max. active power L3	REAL	W	-3.0×10^9	54
62...65	Max. reactive power Qtot L1	REAL	var	-3.0×10^9	62160
66...69	Max. reactive power Qtot L2	REAL	var	-3.0×10^9	62260
70...73	Max. reactive power Qtot L3	REAL	var	-3.0×10^9	62360
74...77	Max. power factor λ L1	REAL	-	0	58
78...81	Max. power factor λ L2	REAL	-	0	59
82...85	Max. power factor λ L3	REAL	-	0	60
86...89	Max. frequency	REAL	Hz	40	61
90...93	Max. apparent power L1L2L3	REAL	VA	0	67
94...97	Max. active power L1L2L3	REAL	W	-3.0×10^9	65
98...101	Max. reactive power Qtot L1L2L3	REAL	var	-3.0×10^9	61138
102...105	Max. power factor λ L1L2L3	REAL	-	0	68
106...109	Max. reactive power Qn L1	REAL	var	-3.0×10^9	55
110...113	Max. reactive power Qn L2	REAL	var	-3.0×10^9	56
114...117	Max. reactive power Qn L3	REAL	var	-3.0×10^9	57
118...121	Max. mean voltage L-N	REAL	V	0	62
122...125	Max. mean voltage L-L	REAL	V	0	63
126...129	Max. mean current L1L2L3	REAL	A	0	64
130...133	Max. fundamental voltage L1	REAL	V	0	62152
134...137	Max. fundamental voltage L2	REAL	V	0	62252
138...141	Max. fundamental voltage L3	REAL	V	0	62352
142...145	Max. fundamental current L1	REAL	A	0	62153
146...149	Max. fundamental current L2	REAL	A	0	62253
150...153	Max. fundamental current L3	REAL	A	0	62353
154...157	Max. fundamental apparent power L1	REAL	VA	-3.0×10^9	62155
158...161	Max. fundamental apparent power L2	REAL	VA	-3.0×10^9	62255
162...165	Max. fundamental apparent power L3	REAL	VA	-3.0×10^9	62355
166...169	Max. fundamental reactive power L1	REAL	var	-3.0×10^9	62154
170...173	Max. fundamental reactive power L2	REAL	var	-3.0×10^9	62254
174...177	Max. fundamental reactive power L3	REAL	var	-3.0×10^9	62354
178...181	Max. fundamental active power L1	REAL	W	-3.0×10^9	62156
182...185	Max. fundamental active power L2	REAL	W	-3.0×10^9	62256
186...189	Max. fundamental active power L3	REAL	W	-3.0×10^9	62356
190...193	Max. fundamental cos φ active factor L1	REAL	-	-1	62157
194...197	Max. fundamental cos φ active factor L2	REAL	-	-1	62257
198...201	Max. fundamental cos φ active factor L3	REAL	-	-1	62357
202...205	Max. total harmonic distortion (THD+N) voltage L1	REAL	1%	0	62150

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
206...209	Max. total harmonic distortion (THD+N) voltage L2	REAL	1%	0	62250
210...213	Max. total harmonic distortion (THD+N) voltage L3	REAL	1%	0	62350
214...217	Max. total harmonic distortion (THD+N) current L1	REAL	1%	0	62151
218...221	Max. total harmonic distortion (THD+N) current L2	REAL	1%	0	62251
222...225	Max. total harmonic distortion (THD+N) current L3	REAL	1%	0	62351
226...229	Max. neutral current	REAL	A	0	61136

[1] The values reference the amount of the current measured value

E.5 Measured value data record for minimum values (DS 145)

Measured variables of the module

The smallest values ever measured or calculated from the time the AI Energy Meter HF was started are stored in this data record.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 175)).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...5	Min. voltage L1-N	REAL	V	1000000	70
6...9	Min. voltage L2-N	REAL	V	1000000	71
10...13	Min. voltage L3-N	REAL	V	1000000	72
14...17	Min. voltage L1-L2	REAL	V	1800000	73
18...21	Min. voltage L2-L3	REAL	V	1800000	74
22...25	Min. voltage L3-L1	REAL	V	1800000	75
26...29	Min. current L1 [1]	REAL	A	100000	76
30...33	Min. current L2 [1]	REAL	A	100000	77
34...37	Min. current L3 [1]	REAL	A	100000	78
38...41	Min. apparent power L1	REAL	VA	$+3.0 \times 10^9$	79
42...45	Min. apparent power L2	REAL	VA	$+3.0 \times 10^9$	80
46...49	Min. apparent power L3	REAL	VA	$+3.0 \times 10^9$	81
50...53	Min. active power L1	REAL	W	$+3.0 \times 10^9$	82

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
54...57	Min. active power L2	REAL	W	$+3.0 \times 10^9$	83
58...61	Min. active power L3	REAL	W	$+3.0 \times 10^9$	84
62...65	Min. reactive power Qtot L1	REAL	var	$+3.0 \times 10^9$	62180
66...69	Min. reactive power Qtot L2	REAL	var	$+3.0 \times 10^9$	62280
70...73	Min. reactive power Qtot L3	REAL	var	$+3.0 \times 10^9$	62380
74...77	Min. power factor λ L1	REAL	-	1	88
78...81	Min. power factor λ L2	REAL	-	1	89
82...85	Min. power factor λ L3	REAL	-	1	90
86...89	Min. frequency	REAL	Hz	70	91
90...93	Min. apparent power L1L2L3	REAL	VA	$+3.0 \times 10^9$	97
94...97	Min. active power L1L2L3	REAL	W	$+3.0 \times 10^9$	95
98...101	Min. reactive power Qn L1L2L3	REAL	var	$+3.0 \times 10^9$	61139
102...105	Min. power factor λ L1L2L3	REAL	-	1	98
106...109	Min. reactive power Qn L1	REAL	var	$+3.0 \times 10^9$	85
110...113	Min. reactive power Qn L2	REAL	var	$+3.0 \times 10^9$	86
114...117	Min. reactive power Qn L3	REAL	var	$+3.0 \times 10^9$	87
118...121	Min. mean voltage L-N	REAL	V	1000000	92
122...125	Min. mean voltage L-L	REAL	V	1800000	93
126...129	Min. mean current L1L2L3	REAL	A	100000	94
130...133	Min. fundamental voltage L1	REAL	V	0	62172
134...137	Min. fundamental voltage L2	REAL	V	0	62272
138...141	Min. fundamental voltage L3	REAL	V	0	62372
142...145	Min. fundamental current L1	REAL	A	1000000	62173
146...149	Min. fundamental current L2	REAL	A	1000000	62273
150...153	Min. fundamental current L3	REAL	A	1000000	62373
154...157	Min. fundamental apparent power L1	REAL	VA	$+3.0 \times 10^9$	62175
158...161	Min. fundamental apparent power L2	REAL	VA	$+3.0 \times 10^9$	62275
162...165	Min. fundamental apparent power L3	REAL	VA	$+3.0 \times 10^9$	62375
166...169	Min. fundamental reactive power L1	REAL	var	$+3.0 \times 10^9$	62174
170...173	Min. fundamental reactive power L2	REAL	var	$+3.0 \times 10^9$	62274
174...177	Min. fundamental reactive power L3	REAL	var	$+3.0 \times 10^9$	62374
178...181	Min. fundamental active power L1	REAL	W	$+3.0 \times 10^9$	62176
182...185	Min. fundamental active power L2	REAL	W	$+3.0 \times 10^9$	62276
186...189	Min. fundamental active power L3	REAL	W	$+3.0 \times 10^9$	62376
190...193	Min. fundamental cos φ active factor L1	REAL	-	1	62177
194...197	Min. fundamental cos φ active factor L2	REAL	-	1	62277
198...201	Min. fundamental cos φ active factor L3	REAL	-	1	62377

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
202...205	Min. total harmonic distortion (THD+N) voltage L1	REAL	1%	100	62170
206...209	Min. total harmonic distortion (THD+N) voltage L2	REAL	1%	100	62270
210...213	Min. total harmonic distortion (THD+N) voltage L3	REAL	1%	100	62370
214...217	Min. total harmonic distortion (THD+N) current L1	REAL	1%	100	62171
218...221	Min. total harmonic distortion (THD+N) current L2	REAL	1%	100	62271
222...225	Min. total harmonic distortion (THD+N) current L3	REAL	1%	100	62371
226...229	Min. neutral current	REAL	A	100000.0	61137

[1] The values reference the amount of the current measured value

E.6 Measured value data record for phase-based measured values L1 (DS 147)

E.6.1 Measured value data record for phase-based measured values L1 (DS 147) version 0

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...3	Qualifier L1	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65500
4...7	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
8...11	Current L1	REAL	A	0.0 ... 100000.0	7
12...15	Apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	10
16...19	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
20...23	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22
24...27	Power factor λ L1	REAL	-	0.0 ... 1.0	19
28...31	Phase angle L1	REAL	°	0.0 ... 360.0	61178

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
32...39	Apparent energy L1	LREAL	VAh	0.0 ... 1.8 x 10^{308}	61184
40...47	Total active energy L1	LREAL	Wh	-1.8 x 10^{308} ... +1.8 x 10^{308}	61185
48...55	Total reactive energy L1	LREAL	varh	-1.8 x 10^{308} ... +1.8 x 10^{308}	61186
56...59	Max. voltage L1-N	REAL	V	0.0 ... 1000000.0	40
60...63	Max. current L1	REAL	A	0.0 ... 100000.0	46
64...67	Max. apparent power L1	REAL	VA	-3.0 x 10^9 ... +3.0 x 10^9	49
68...71	Max. active power L1	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	52
72...75	Max. reactive power Qtot L1	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	62160
76...79	Max. power factor λ L1	REAL	-	0.0 ... 1.0	58
80...83	Min. voltage L1-N	REAL	V	0.0 ... 1000000.0	70
84...87	Min. current L1	REAL	A	0.0 ... 100000.0	76
88...91	Min. apparent power L1	REAL	VA	-3.0 x 10^9 ... +3.0 x 10^9	79
92...95	Min. active power L1	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	82
96...99	Min. reactive power Qtot L1	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	62180
100...103	Min. power factor λ L1	REAL	-	0.0 ... 1.0	88

E.6.2 Measured value data record for phase-based measured values L1 (DS 147) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	-	1	-
1	Reserved	UINT8	-	0	-
2...3	Qualifier L1	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65500
4...7	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
8...11	Current L1	REAL	A	0.0 ... 100000.0	7
12...15	Apparent power L1	REAL	VA	-3.0 x 10^9 ... +3.0 x 10^9	10

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
16...19	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
20...23	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22
24...27	Power factor λ L1	REAL	-	0.0 ... 1.0	19
28...31	Phase angle L1	REAL	°	0.0 ... 360.0	61178
32...39	Apparent energy L1	LREAL	VAh	0.0 ... 1.8×10^{308}	61184
40...47	Total active energy L1	LREAL	Wh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61185
48...55	Total reactive energy L1	LREAL	varh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61186
56...59	Max. voltage L1-N	REAL	V	0.0 ... 1000000.0	40
60...63	Max. current L1	REAL	A	0.0 ... 100000.0	46
64...67	Max. apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	49
68...71	Max. active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	52
72...75	Max. reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62160
76...79	Max. power factor λ L1	REAL	-	0.0 ... 1.0	58
80...83	Min. voltage L1-N	REAL	V	0.0 ... 1000000.0	70
84...87	Min. current L1	REAL	A	0.0 ... 100000.0	76
88...91	Min. apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	79
92...95	Min. active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	82
96...99	Min. reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62180
100...103	Min. power factor λ L1	REAL	-	0.0 ... 1.0	88
104...107	Reactive power Qn L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	16
108...111	Current L1 10-12 cycles	REAL	V	0.0 ... 760.0	62130
112...115	Current L1 10-12 cycles	REAL	A	0.0 ... 100000.0	62133
116...119	Max. reactive power Qn L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	55
120...123	Min. reactive power Qn L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	85
124...127	Fundamental voltage L1	REAL	V	0.0 ... 440.0	62122
128...131	Fundamental current L1	REAL	A	0.0 ... 100000.0	62123
132...135	Fundamental apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62125
136...139	Fundamental reactive power L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62124

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
140...143	Fundamental active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62126
144...147	Fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62127
148...151	Max. fundamental voltage L1	REAL	V	0.0 ... 760.0	62152
152...155	Max. fundamental current L1	REAL	A	0.0 ... 100000.0	62153
156...159	Max. fundamental apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62155
160...163	Max. fundamental reactive power L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62154
164...167	Max. fundamental active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62156
168...171	Max. fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62157
172...175	Min. fundamental voltage L1	REAL	V	0.0 ... 440.0	62172
176...179	Min. fundamental current L1	REAL	A	0.0 ... 100000.0	62173
180...183	Min. fundamental apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62175
184...187	Min. fundamental reactive power L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62174
188...191	Min. fundamental active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62176
192...195	Min. fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62177
196...199	Total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62120
200...203	Total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62121
204...207	Max. total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62150
208...211	Max. total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62151
212...215	Min. total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62170
216...219	Min. total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62171
220...223	Voltage dip - value L1	REAL	V	0.0 ... 440.0	62194
224...227	Voltage dip - duration L1	REAL	ms	0.0 ... 100000.0	62199
228...231	Voltage swell - value L1	REAL	V	0.0 ... 440.0	62195
232...235	Voltage swell - duration L1	REAL	ms	0.0 ... 100000.0	62200
236...239	Voltage peak value L1	REAL	V	0.0 ... 440.0	62196
240...243	Current peak value L1	REAL	A	0.0 ... 100000.0	62197
244...247	Overcurrent value L1	REAL	A	0.0 ... 100000.0	62198

E.7 Measured value data record for phase-based measured values L2 (DS 148)

E.7.1 Measured value data record for phase-based measured values L2 (DS 148) version 0

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...3	Qualifier L2	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65501
4...7	Voltage L1-N	REAL	V	0.0 ... 1000000.0	2
8...11	Current L2	REAL	A	0.0 ... 100000.0	8
12...15	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
16...19	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
20...23	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
24...27	Power factor λ L2	REAL	-	0.0 ... 1.0	20
28...31	Phase angle L2	REAL	°	0.0 ... 360.0	61198
32...39	Apparent energy L2	LREAL	VAh	0.0 ... 1.8×10^{308}	61204
40...47	Total active energy L2	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61205
48...55	Total reactive energy L2	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61206
56...59	Max. voltage L2-N	REAL	V	0.0 ... 1000000.0	41
60...63	Max. current L2	REAL	A	0.0 ... 100000.0	47
64...67	Max. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	50
68...71	Max. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	53
72...75	Max. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62260
76...79	Max. power factor λ L2	REAL	-	0.0 ... 1.0	59
80...83	Min. voltage L2-N	REAL	V	0.0 ... 1000000.0	71
84...87	Min. current L2	REAL	A	0.0 ... 100000.0	77
88...91	Min. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	80

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
92...95	Min. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	83
96...99	Min. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62280
100...103	Min. power factor λ L2	REAL	-	0.0 ... 1.0	89

E.7.2 Measured value data record for phase-based measured values L2 (DS 148) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	-	1	-
1	Reserved	UINT8	-	0	-
2...3	Qualifier L2	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65501
4...7	Voltage L2-N	REAL	V	0.0 ... 1000000.0	2
8...11	Current L2	REAL	A	0.0 ... 100000.0	8
12...15	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
16...19	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
20...23	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
24...27	Power factor λ L2	REAL	-	0.0 ... 1.0	20
28...31	Phase angle L2	REAL	°	0.0 ... 360.0	61198
32...39	Apparent energy L2	LREAL	VAh	0.0 ... 1.8×10^{308}	61204
40...47	Total active energy L2	LREAL	Wh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61205
48...55	Total reactive energy L2	LREAL	varh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61206
56...59	Max. voltage L2-N	REAL	V	0.0 ... 1000000.0	41
60...63	Max. current L2	REAL	A	0.0 ... 100000.0	47
64...67	Max. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	50
68...71	Max. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	53
72...75	Max. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62260

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
76...79	Max. power factor λ L2	REAL	-	0.0 ... 1.0	59
80...83	Min. voltage L2-N	REAL	V	0.0 ... 1000000.0	71
84...87	Min. current L2	REAL	A	0.0 ... 100000.0	77
88...91	Min. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	80
92...95	Min. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	83
96...99	Min. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62280
100...103	Min. power factor λ L2	REAL	-	0.0 ... 1.0	89
104...107	Reactive power Qn L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	17
108...111	Current L2 10-12 cycles	REAL	V	0.0 ... 760.0	62230
112...115	Current L2 10-12 cycles	REAL	A	0.0 ... 100000.0	62233
116...119	Max. reactive power Qn L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	56
120...123	Min. reactive power Qn L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	86
124...127	Fundamental voltage L2	REAL	V	0.0 ... 440.0	62222
128...131	Fundamental current L2	REAL	A	0.0 ... 100000.0	62223
132...135	Fundamental apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62225
136...139	Fundamental reactive power L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62224
140...143	Fundamental active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62226
144...147	Fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62227
148...151	Max. fundamental voltage L2	REAL	V	0.0 ... 760.0	62252
152...155	Max. fundamental current L2	REAL	A	0.0 ... 100000.0	62253
156...159	Max. fundamental apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62255
160...163	Max. fundamental reactive power L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62254
164...167	Max. fundamental active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62256
168...171	Max. fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62257
172...175	Min. fundamental voltage L2	REAL	V	0.0 ... 440.0	62272
176...179	Min. fundamental current L2	REAL	A	0.0 ... 100000.0	62273
180...183	Min. fundamental apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62275
184...187	Min. fundamental reactive power L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62274

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
188...191	Min. fundamental active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62276
192...195	Min. fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62277
196...199	Total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62220
200...203	Total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62221
204...207	Max. total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62250
208...211	Max. total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62251
212...215	Min. total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62270
216...219	Min. total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62271
220...223	Voltage dip - value L2	REAL	V	0.0 ... 440.0	62294
224...227	Voltage dip - duration L2	REAL	ms	0.0 ... 100000.0	62299
228...231	Voltage swell - value L2	REAL	V	0.0 ... 440.0	62295
232...235	Voltage swell - duration L2	REAL	ms	0.0 ... 100000.0	62300
236...239	Voltage peak value L2	REAL	V	0.0 ... 440.0	62296
240...243	Current peak value L2	REAL	A	0.0 ... 100000.0	62297
244...247	Overcurrent value L2	REAL	A	0.0 ... 100000.0	62298

E.8 Measured value data record for phase-based measured values L3 (DS 149)

E.8.1 Measured value data record for phase-based measured values L3 (DS 149) version 0

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...3	Qualifier L3	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65502
4...7	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
8...11	Current L3	REAL	A	0.0 ... 100000.0	9

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
12...15	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
16...19	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
20...23	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
24...27	Power factor λ L3	REAL	-	0.0 ... 1.0	21
28...31	Phase angle L3	REAL	°	0.0 ... 360.0	61218
32...39	Apparent energy L3	LREAL	VAh	0.0 ... 1.8×10^{308}	61224
40...47	Total active energy L3	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61225
48...55	Total reactive energy L3	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61226
56...59	Max. voltage L3-N	REAL	V	0.0 ... 1000000.0	42
60...63	Max. current L3	REAL	A	0.0 ... 100000.0	48
64...67	Max. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	51
68...71	Max. active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	54
72...75	Max. reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62360
76...79	Max. power factor λ L3	REAL	-	0.0 ... 1.0	60
80...83	Min. voltage L3-N	REAL	V	0.0 ... 1000000.0	72
84...87	Min. current L3	REAL	A	0.0 ... 100000.0	78
88...91	Min. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	81
92...95	Min. active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	84
96...99	Min. reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62380
100...103	Min. power factor λ L3	REAL	-	0.0 ... 1.0	90

E.8.2 Measured value data record for phase-based measured values L3 (DS 149) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	-	1	-
1	Reserved	UINT8	-	0	-
2...3	Qualifier L3	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65502
4...7	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
8...11	Current L3	REAL	A	0.0 ... 100000.0	9
12...15	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
16...19	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
20...23	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
24...27	Power factor λ L3	REAL	-	0.0 ... 1.0	21
28...31	Phase angle L3	REAL	°	0.0 ... 360.0	61218
32...39	Apparent energy L3	LREAL	VAh	0.0 ... 1.8×10^{308}	61224
40...47	Total active energy L3	LREAL	Wh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61225
48...55	Total reactive energy L3	LREAL	varh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61226
56...59	Max. voltage L3-N	REAL	V	0.0 ... 1000000.0	42
60...63	Max. current L3	REAL	A	0.0 ... 100000.0	48
64...67	Max. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	51
68...71	Max. active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	54
72...75	Max. reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62360
76...79	Max. power factor λ L3	REAL	-	0.0 ... 1.0	60
80...83	Min. voltage L3-N	REAL	V	0.0 ... 1000000.0	72
84...87	Min. current L3	REAL	A	0.0 ... 100000.0	78
88...91	Min. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	81
92...95	Min. active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	84

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
96...99	Min. reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62380
100...103	Min. power factor λ L3	REAL	-	0.0 ... 1.0	90
104...107	Reactive power Qn L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	18
108...111	Current L3 10-12 cycles	REAL	V	0.0 ... 760.0	62330
112...115	Current L3 10-12 cycles	REAL	A	0.0 ... 100000.0	62333
116...119	Max. reactive power Qn L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	57
120...123	Min. reactive power Qn L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	87
124...127	Fundamental voltage L3	REAL	V	0.0 ... 440.0	62322
128...131	Fundamental current L3	REAL	A	0.0 ... 100000.0	62323
132...135	Fundamental apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62325
136...139	Fundamental reactive power L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62324
140...143	Fundamental active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62326
144...147	Fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62327
148...151	Max. fundamental voltage L3	REAL	V	0.0 ... 760.0	62352
152...155	Max. fundamental current L3	REAL	A	0.0 ... 100000.0	62353
156...159	Max. fundamental apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62355
160...163	Max. fundamental reactive power L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62354
164...167	Max. fundamental active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62356
168...171	Max. fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62357
172...175	Min. fundamental voltage L3	REAL	V	0.0 ... 440.0	62372
176...179	Min. fundamental current L3	REAL	A	0.0 ... 100000.0	62373
180...183	Min. fundamental apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62375
184...187	Min. fundamental reactive power L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62374
188...191	Min. fundamental active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62376
192...195	Min. fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62377
196...199	Total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62320
200...203	Total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62321

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
204...207	Max. total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62350
208...211	Max. total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62351
212...215	Min. total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62370
216...219	Min. total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62371
220...223	Voltage dip - value L3	REAL	V	0.0 ... 440.0	62394
224...227	Voltage dip - duration L3	REAL	ms	0.0 ... 100000.0	62399
228...231	Voltage swell - value L3	REAL	V	0.0 ... 440.0	62395
232...235	Voltage swell - duration L3	REAL	ms	0.0 ... 100000.0	62400
236...239	Voltage peak value L3	REAL	V	0.0 ... 440.0	62396
240...243	Current peak value L3	REAL	A	0.0 ... 100000.0	62397
244...247	Overcurrent value L3	REAL	A	0.0 ... 100000.0	62398

E.9 Measured value data record for advanced measurement and status values (DS 150) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-

[1] Energy counters count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1
Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
2...5	Operating hours counter L1L2L3	REAL	h	0.0 ... 3.4 x 10^{38}	65504
6...9	Operating hours counter L1	REAL	h	0.0 ... 3.4 x 10^{38}	65505
10...13	Operating hours counter L2	REAL	h	0.0 ... 3.4 x 10^{38}	65506
14...17	Operating hours counter L3	REAL	h	0.0 ... 3.4 x 10^{38}	65507
18...19	Status limit violation GW 1...16	WORD	Bit string	xxxx xxxx xxxx xxxx	65509
20...21	Status of energy counter overflows [1]	WORD	Bit string	xxxx xxxx xxxx xxxx	65508
22...25	Counter limit violation GW 1	UDINT	-	0 ... 4294967296	65510
26...29	Counter limit violation GW 2	UDINT	-	0 ... 4294967296	65511
30...33	Counter limit violation GW 3	UDINT	-	0 ... 4294967296	65512
34...37	Counter limit violation GW 4	UDINT	-	0 ... 4294967296	65513
38...41	Counter limit violation GW 5	UDINT	-	0 ... 4294967296	65514
42...45	Counter limit violation GW 6	UDINT	-	0 ... 4294967296	65515
46...49	Counter limit violation GW 7	UDINT	-	0 ... 4294967296	65516
50...53	Counter limit violation GW 8	UDINT	-	0 ... 4294967296	65517
54...57	Counter limit violation GW 9	UDINT	-	0 ... 4294967296	65518
58...61	Counter limit violation GW 10	UDINT	-	0 ... 4294967296	65519
62...65	Counter limit violation GW 11	UDINT	-	0 ... 4294967296	65520
66...69	Counter limit violation GW 12	UDINT	-	0 ... 4294967296	65521
70...73	Counter limit violation GW 13	UDINT	-	0 ... 4294967296	65522
74...77	Counter limit violation GW 14	UDINT	-	0 ... 4294967296	65523
78...81	Counter limit violation GW 15	UDINT	-	0 ... 4294967296	65524
82...85	Counter limit violation GW 16	UDINT	-	0 ... 4294967296	65525

[1] Energy counters count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1
Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
86...87	Qualifier L1L2L3	WORD	Bit string	xxxx xxxx xxxx xxxx	65503
88...91	Power quality analysis - Qualifier	UDINT	Bit string	-	65496
92...103	Current module time	PNIOTime	sec	-	65497

[1] Energy counters count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1
Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

E.10 Measured value data record of user-defined data record (DS 151)

The length and structure of the data record DS 151 depends on the parameter assignment of the data record DS 135 (Page 172).

Byte	Measured variable	Data type	Unit	Value range
0	Version	UINT8	-	0
1	Number of measured values	UINT8	-	0 ... 150
2	Measured value 1 corresponding to measured value ID 1 in DS135	Depending on the corresponding measured value ID		
3	Measured value 2 corresponding to measured value ID 2 in DS135	Depending on the corresponding measured value ID		
...	...	Depending on the corresponding measured value ID		
... m	Measured value n corresponding to measured value ID n in DS135	Depending on the corresponding measured value ID		

E.11 Measured value data record for maximum values with time stamp (DS 154)

Measured variables of the module

The largest values ever measured or calculated from the time the AI Energy Meter HF was started are stored in this data record.

The measured values (REAL 4 bytes) are each followed by a time stamp (PNIO Time 12 bytes).

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

More detailed information about the structure of time stamps is available in section Time synchronization and time stamp (Page 55).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...17	Max. voltage L1-N	REAL + PNIO Time	V	0	40
18...33	Max. voltage L2-N	REAL + PNIO Time	V	0	41
34...49	Max. voltage L3-N	REAL + PNIO Time	V	0	42
50...65	Max. voltage L1-L2	REAL + PNIO Time	V	0	43
66...81	Max. voltage L2-L3	REAL + PNIO Time	V	0	44
82...97	Max. voltage L3-L1	REAL + PNIO Time	V	0	45
98...113	Max. current L1[1]	REAL + PNIO Time	A	0	46
114...129	Max. current L2[1]	REAL + PNIO Time	A	0	47
130...145	Max. current L3[1]	REAL + PNIO Time	A	0	48
146...161	Max. apparent power L1	REAL + PNIO Time	VA	0	49
162...177	Max. apparent power L2	REAL + PNIO Time	VA	0	50
178...193	Max. apparent power L3	REAL + PNIO Time	VA	0	51
194...209	Max. active power L1	REAL + PNIO Time	W	-3.0×10^9	52
210...225	Max. active power L2	REAL + PNIO Time	W	-3.0×10^9	53

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
226...241	Max. active power L3	REAL + PNIO Time	W	-3.0×10^9	54
242...257	Max. reactive power Qtot L1	REAL + PNIO Time	var	-3.0×10^9	62160
258...273	Max. reactive power Qtot L2	REAL + PNIO Time	var	-3.0×10^9	62260
274...289	Max. reactive power Qtot L3	REAL + PNIO Time	var	-3.0×10^9	62360
290...305	Max. power factor λ L1	REAL + PNIO Time	-	0	58
306...321	Max. power factor λ L2	REAL + PNIO Time	-	0	59
322...337	Max. power factor λ L3	REAL + PNIO Time	-	0	60
338...353	Max. frequency	REAL + PNIO Time	Hz	40	61
354...369	Max. apparent power L1L2L3	REAL + PNIO Time	VA	0	67
370...385	Max. active power L1L2L3	REAL + PNIO Time	W	-3.0×10^9	65
386...401	Max. reactive power Qtot L1L2L3	REAL + PNIO Time	var	-3.0×10^9	61138
402...417	Max. power factor λ L1L2L3	REAL + PNIO Time	-	0	68
418...433	Max. reactive power Qn L1	REAL + PNIO Time	var	-3.0×10^9	55
434...449	Max. reactive power Qn L2	REAL + PNIO Time	var	-3.0×10^9	56
450...465	Max. reactive power Qn L3	REAL + PNIO Time	var	-3.0×10^9	57
466...481	Max. mean voltage L-N	REAL + PNIO Time	V	0	62
482...497	Max. mean voltage L-L	REAL + PNIO Time	V	0	63
498...513	Max. sum mean value current L1L2L3	REAL + PNIO Time	A	0	64
514...529	Max. fundamental voltage L1	REAL + PNIO Time	V	0	62152
530...545	Max. fundamental voltage L2	REAL + PNIO Time	V	0	62252
546...561	Max. fundamental voltage L3	REAL + PNIO Time	V	0	62352
562...577	Max. fundamental current L1	REAL + PNIO Time	A	0	62153

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
578...593	Max. fundamental current L2	REAL + PNIO Time	A	0	62253
594...609	Max. fundamental current L3	REAL + PNIO Time	A	0	62353
610...625	Max. fundamental apparent power L1	REAL + PNIO Time	VA	-3.0×10^9	62155
626...641	Max. fundamental apparent power L2	REAL + PNIO Time	VA	-3.0×10^9	62255
642...657	Max. fundamental apparent power L3	REAL + PNIO Time	VA	-3.0×10^9	62355
658...673	Max. fundamental reactive power L1	REAL + PNIO Time	var	-3.0×10^9	62154
674...689	Max. fundamental reactive power L2	REAL + PNIO Time	var	-3.0×10^9	62254
690...705	Max. fundamental reactive power L3	REAL + PNIO Time	var	-3.0×10^9	62354
706...721	Max. fundamental active power L1	REAL + PNIO Time	W	-3.0×10^9	62156
722...737	Max. fundamental active power L2	REAL + PNIO Time	W	-3.0×10^9	62256
738...753	Max. fundamental active power L3	REAL + PNIO Time	W	-3.0×10^9	62356
754...769	Max. fundamental cos φ active factor L1	REAL + PNIO Time	-	-1	62157
770...785	Max. fundamental cos φ active factor L2	REAL + PNIO Time	-	-1	62257
786...801	Max. fundamental cos φ active factor L3	REAL + PNIO Time	-	-1	62357
802...817	Max. total harmonic distortion (THD+N) voltage L1	REAL + PNIO Time	1%	0	62150
818...833	Max. total harmonic distortion (THD+N) voltage L2	REAL + PNIO Time	1%	0	62250
834...849	Max. total harmonic distortion (THD+N) voltage L3	REAL + PNIO Time	1%	0	62350
850...865	Max. total harmonic distortion (THD+N) current L1	REAL + PNIO Time	1%	0	62151
866...881	Max. total harmonic distortion (THD+N) current L2	REAL + PNIO Time	1%	0	62251
882...897	Max. total harmonic distortion (THD+N) current L3	REAL + PNIO Time	1%	0	62351
898...913	Max. neutral current	REAL + PNIO Time	A	0	61136

[1] The values reference the amount of the current measured value

E.12 Measured value data record for minimum values with time stamp (DS 155)

Measured variables of the module

The smallest values ever measured or calculated from the time the AI Energy Meter HF was started are stored in this data record.

The measured values (REAL 4 bytes) are each followed by a time stamp (PNIO Time 12 bytes).

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

More detailed information about the structure of time stamps is available in section Time synchronization and time stamp (Page 55).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...17	Min. voltage L1-N	REAL + PNIO Time	V	1000000	70
18...33	Min. voltage L2-N	REAL + PNIO Time	V	1000000	71
34...49	Min. voltage L3-N	REAL + PNIO Time	V	1000000	72
50...65	Min. voltage L1-L2	REAL + PNIO Time	V	1800000	73
66...81	Min. voltage L2-L3	REAL + PNIO Time	V	1800000	74
82...97	Min. voltage L3-L1	REAL + PNIO Time	V	1800000	75
98...113	Min. current L1[1]	REAL + PNIO Time	A	100000	76
114...129	Min. current L2[1]	REAL + PNIO Time	A	100000	77
130...145	Min. current L3[1]	REAL + PNIO Time	A	100000	78
146...161	Min. apparent power L1	REAL + PNIO Time	VA	$+3.0 \times 10^9$	79
162...177	Min. apparent power L2	REAL + PNIO Time	VA	$+3.0 \times 10^9$	80
178...193	Min. apparent power L3	REAL + PNIO Time	VA	$+3.0 \times 10^9$	81
194...209	Min. active power L1	REAL + PNIO Time	W	$+3.0 \times 10^9$	82
210...225	Min. active power L2	REAL + PNIO Time	W	$+3.0 \times 10^9$	83

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
226...241	Min. active power L3	REAL + PNIO Time	W	$+3.0 \times 10^9$	84
242...257	Min. reactive power Qtot L1	REAL + PNIO Time	var	$+3.0 \times 10^9$	62180
258...273	Min. reactive power Qtot L2	REAL + PNIO Time	var	$+3.0 \times 10^9$	62280
274...289	Min. reactive power Qtot L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	62380
290...305	Min. power factor λ L1	REAL + PNIO Time	-	1	88
306...321	Min. power factor λ L2	REAL + PNIO Time	-	1	89
322...337	Min. power factor λ L3	REAL + PNIO Time	-	1	90
338...353	Min. frequency	REAL + PNIO Time	Hz	70	91
354...369	Min. apparent power L1L2L3	REAL + PNIO Time	VA	$+3.0 \times 10^9$	97
370...385	Min. active power L1L2L3	REAL + PNIO Time	W	$+3.0 \times 10^9$	95
386...401	Min. reactive power Qn L1L2L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	61139
402...417	Min. power factor λ L1L2L3	REAL + PNIO Time	-	1	98
418...433	Min. reactive power Qn L1	REAL + PNIO Time	var	$+3.0 \times 10^9$	85
434...449	Min. reactive power Qn L2	REAL + PNIO Time	var	$+3.0 \times 10^9$	86
450...465	Min. reactive power Qn L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	87
466...481	Min. mean voltage L-N	REAL + PNIO Time	V	1000000	92
482...497	Min. mean voltage L-L	REAL + PNIO Time	V	1800000	93
498...513	Min. mean current L1L2L3	REAL + PNIO Time	A	100000	94
514...529	Min. fundamental voltage L1	REAL + PNIO Time	V	0	62172
530...545	Min. fundamental voltage L2	REAL + PNIO Time	V	0	62272
546...561	Min. fundamental voltage L3	REAL + PNIO Time	V	0	62372
562...577	Min. fundamental current L1	REAL + PNIO Time	A	1000000	62173

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
578...593	Min. fundamental current L2	REAL + PNIO Time	A	1000000	62273
594...609	Min. fundamental current L3	REAL + PNIO Time	A	1000000	62373
610...625	Min. fundamental apparent power L1	REAL + PNIO Time	VA	$+3.0 \times 10^9$	62175
626...641	Min. fundamental apparent power L2	REAL + PNIO Time	VA	$+3.0 \times 10^9$	62275
642...657	Min. fundamental apparent power L3	REAL + PNIO Time	VA	$+3.0 \times 10^9$	62375
658...673	Min. fundamental reactive power L1	REAL + PNIO Time	var	$+3.0 \times 10^9$	62174
674...689	Min. fundamental reactive power L2	REAL + PNIO Time	var	$+3.0 \times 10^9$	62274
690...705	Min. fundamental reactive power L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	62374
706...721	Min. fundamental active power L1	REAL + PNIO Time	W	$+3.0 \times 10^9$	62176
722...737	Min. fundamental active power L2	REAL + PNIO Time	W	$+3.0 \times 10^9$	62276
738...753	Min. fundamental active power L3	REAL + PNIO Time	W	$+3.0 \times 10^9$	62376
754...769	Min. fundamental cos φ active factor L1	REAL + PNIO Time	-	1	62177
770...785	Min. fundamental cos φ active factor L2	REAL + PNIO Time	-	1	62277
786...801	Min. fundamental cos φ active factor L3	REAL + PNIO Time	-	1	62377
802...817	Min. total harmonic distortion (THD+N) voltage L1	REAL + PNIO Time	1%	100	62170
818...833	Min. total harmonic distortion (THD+N) voltage L2	REAL + PNIO Time	1%	100	62270
834...849	Min. total harmonic distortion (THD+N) voltage L3	REAL + PNIO Time	1%	100	62370
850...865	Min. total harmonic distortion (THD+N) current L1	REAL + PNIO Time	1%	100	62171
866...881	Min. total harmonic distortion (THD+N) current L2	REAL + PNIO Time	1%	100	62271
882...897	Min. total harmonic distortion (THD+N) current L3	REAL + PNIO Time	1%	100	62371
898...913	Min. neutral current	REAL + PNIO Time	A	100000.0	61137

[1] The values reference the amount of the current measured value

E.13 Measured value data record for power quality analysis (DS 160)

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...5	Neutral current IN	REAL	A	0.0 ... 100000.0	61149
6...9	Neutral current 10-12 cycles	REAL	A	0.0 ... 100000.0	61150
10...13	Total current IL1+IL2+IL3-IN	REAL	A	-100000.0 ... 100000.0	61153
14...17	(Fundamental) reactive power L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	61154
18...21	Max. (fundamental) reactive power L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	61155
22...25	Min. (fundamental) reactive power L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	61156
26...29	Power factor λ L1L2L3	REAL	-	0.0 ... 1.0	37
30...33	Fundamental reactive power L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62124
34...37	Fundamental reactive power L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62224
38...41	Fundamental reactive power L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62324
42...45	Fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62127
46...49	Fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62227
50...53	Fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62327
54...57	Total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62120
58...61	Total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62220
62...65	Total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62320
66...69	Total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62121
70...73	Total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62221
74...77	Total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62321
78...81	Max. total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62150

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
82...85	Max. total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62250
86...89	Max. total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62350
90...93	Max. total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62151
94...97	Max. total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62251
98...101	Max. total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62351
102...105	Min. total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62170
106...109	Min. total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62270
110...113	Min. total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62370
114...117	Min. total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62171
118...121	Min. total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62271
122...125	Min. total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62371
126...129	Voltage dip - value L1	REAL	V	0 ... 440.0	62194
130...133	Voltage dip - duration L1	REAL	ms	0.0 ... 100000.0	62199
134...137	Voltage dip - value L2	REAL	V	0 ... 440.0	62294
138...141	Voltage dip - duration L2	REAL	ms	0.0 ... 100000.0	62299
142...145	Voltage dip - value L3	REAL	V	0 ... 440.0	62394
146...149	Voltage dip - duration L3	REAL	ms	0.0 ... 100000.0	62399
150...153	Voltage increase - value L1	REAL	V	0 ... 440.0	62195
154...157	Voltage increase - duration L1	REAL	ms	0.0 ... 100000.0	62200
158...161	Voltage increase - value L2	REAL	V	0 ... 440.0	62295
162...165	Voltage increase - duration L2	REAL	ms	0.0 ... 100000.0	62300
166...169	Voltage increase - value L3	REAL	V	0 ... 440.0	62395
170...173	Voltage increase - duration L3	REAL	ms	0.0 ... 100000.0	62400
174...177	Voltage peak value L1	REAL	V	0 ... 440.0	62196
178...181	Voltage peak value L2	REAL	V	0 ... 440.0	62296
182...185	Voltage peak value L3	REAL	V	0 ... 440.0	62396
186...189	Current peak value L1	REAL	A	0.0 ... 100000.0	62197
190...193	Current peak value L2	REAL	A	0.0 ... 100000.0	62297
194...197	Current peak value L3	REAL	A	0.0 ... 100000.0	62397
198...201	Overcurrent value L1	REAL	A	0.0 ... 100000.0	62198
202...205	Overcurrent value L2	REAL	A	0.0 ... 100000.0	62298

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
206...209	Overcurrent value L3	REAL	A	0.0 ... 100000.0	62398
210...213	Amplitude unbalance voltage U_2	REAL	%	0 ... 100	61157
214...217	Amplitude unbalance current I_{asym}	REAL	%	0 ... 100	61158
218...221	Power quality analysis - Qualifier	UDINT	Bit string	-	65496
222...233	Current module time	PNIO Time	sec	-	65497

E.14 Measured value data record for harmonics voltage (DS 161)

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...5	Total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62120
6...9	Voltage L1-N	REAL	V	0.0 ... 440.0	1
10...13	Harmonics 1: Voltage L1	REAL	V	0.0 ... 760.0	63000
14...17	Harmonics 2: Voltage L1	REAL	V	0.0 ... 760.0	63002
18...21	Harmonics 3: Voltage L1	REAL	V	0.0 ... 760.0	63004
22...25	Harmonics 4: Voltage L1	REAL	V	0.0 ... 760.0	63006
26...29	Harmonics 5: Voltage L1	REAL	V	0.0 ... 760.0	63008
30...33	Harmonics 6: Voltage L1	REAL	V	0.0 ... 760.0	63010
34...37	Harmonics 7: Voltage L1	REAL	V	0.0 ... 760.0	63012
38...41	Harmonics 8: Voltage L1	REAL	V	0.0 ... 760.0	63014
42...45	Harmonics 9: Voltage L1	REAL	V	0.0 ... 760.0	63016
46...49	Harmonics 10: Voltage L1	REAL	V	0.0 ... 760.0	63018
50...53	Harmonics 11: Voltage L1	REAL	V	0.0 ... 760.0	63020
54...57	Harmonics 12: Voltage L1	REAL	V	0.0 ... 760.0	63022
58...61	Harmonics 13: Voltage L1	REAL	V	0.0 ... 760.0	63024
62...65	Harmonics 14: Voltage L1	REAL	V	0.0 ... 760.0	63026
66...69	Harmonics 15: Voltage L1	REAL	V	0.0 ... 760.0	63028
70...73	Harmonics 16: Voltage L1	REAL	V	0.0 ... 760.0	63030
74...77	Harmonics 17: Voltage L1	REAL	V	0.0 ... 760.0	63032
78...81	Harmonics 18: Voltage L1	REAL	V	0.0 ... 760.0	63034
82...85	Harmonics 19: Voltage L1	REAL	V	0.0 ... 760.0	63036

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
86...89	Harmonics 20: Voltage L1	REAL	V	0.0 ... 760.0	63038
90...93	Harmonics 21: Voltage L1	REAL	V	0.0 ... 760.0	63040
94...97	Harmonics 22: Voltage L1	REAL	V	0.0 ... 760.0	63042
98...101	Harmonics 23: Voltage L1	REAL	V	0.0 ... 760.0	63044
102...105	Harmonics 24: Voltage L1	REAL	V	0.0 ... 760.0	63046
106...109	Harmonics 25: Voltage L1	REAL	V	0.0 ... 760.0	63048
110...113	Harmonics 26: Voltage L1	REAL	V	0.0 ... 760.0	63050
114...117	Harmonics 27: Voltage L1	REAL	V	0.0 ... 760.0	63052
118...121	Harmonics 28: Voltage L1	REAL	V	0.0 ... 760.0	63054
122...125	Harmonics 29: Voltage L1	REAL	V	0.0 ... 760.0	63056
126...129	Harmonics 30: Voltage L1	REAL	V	0.0 ... 760.0	63058
130...133	Harmonics 31: Voltage L1	REAL	V	0.0 ... 760.0	63060
134...137	Harmonics 32: Voltage L1	REAL	V	0.0 ... 760.0	63062
138...141	Harmonics 33: Voltage L1	REAL	V	0.0 ... 760.0	63064
142...145	Harmonics 34: Voltage L1	REAL	V	0.0 ... 760.0	63066
146...149	Harmonics 35: Voltage L1	REAL	V	0.0 ... 760.0	63068
150...153	Harmonics 36: Voltage L1	REAL	V	0.0 ... 760.0	63070
154...157	Harmonics 37: Voltage L1	REAL	V	0.0 ... 760.0	63072
158...161	Harmonics 38: Voltage L1	REAL	V	0.0 ... 760.0	63074
162...165	Harmonics 39: Voltage L1	REAL	V	0.0 ... 760.0	63076
166...169	Harmonics 40: Voltage L1	REAL	V	0.0 ... 760.0	63078
170...173	Total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62220
174...177	Voltage L2-N	REAL	V	0.0 ... 440.0	2
178...181	Harmonics 1: Voltage L2	REAL	V	0.0 ... 760.0	63400
182...185	Harmonics 2: Voltage L2	REAL	V	0.0 ... 760.0	63402
186...189	Harmonics 3: Voltage L2	REAL	V	0.0 ... 760.0	63404
190...193	Harmonics 4: Voltage L2	REAL	V	0.0 ... 760.0	63406
194...197	Harmonics 5: Voltage L2	REAL	V	0.0 ... 760.0	63408
198...201	Harmonics 6: Voltage L2	REAL	V	0.0 ... 760.0	63410
202...205	Harmonics 7: Voltage L2	REAL	V	0.0 ... 760.0	63412
206...209	Harmonics 8: Voltage L2	REAL	V	0.0 ... 760.0	63414
210...213	Harmonics 9: Voltage L2	REAL	V	0.0 ... 760.0	63416
214...217	Harmonics 10: Voltage L2	REAL	V	0.0 ... 760.0	63418
218...221	Harmonics 11: Voltage L2	REAL	V	0.0 ... 760.0	63420
222...225	Harmonics 12: Voltage L2	REAL	V	0.0 ... 760.0	63422
226...229	Harmonics 13: Voltage L2	REAL	V	0.0 ... 760.0	63424
230...233	Harmonics 14: Voltage L2	REAL	V	0.0 ... 760.0	63426
234...237	Harmonics 15: Voltage L2	REAL	V	0.0 ... 760.0	63428

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
238...241	Harmonics 16: Voltage L2	REAL	V	0.0 ... 760.0	63430
242...245	Harmonics 17: Voltage L2	REAL	V	0.0 ... 760.0	63432
246...249	Harmonics 18: Voltage L2	REAL	V	0.0 ... 760.0	63434
250...253	Harmonics 19: Voltage L2	REAL	V	0.0 ... 760.0	63436
254...257	Harmonics 20: Voltage L2	REAL	V	0.0 ... 760.0	63438
258...261	Harmonics 21: Voltage L2	REAL	V	0.0 ... 760.0	63440
262...265	Harmonics 22: Voltage L2	REAL	V	0.0 ... 760.0	63442
266...269	Harmonics 23: Voltage L2	REAL	V	0.0 ... 760.0	63444
270...273	Harmonics 24: Voltage L2	REAL	V	0.0 ... 760.0	63446
274...277	Harmonics 25: Voltage L2	REAL	V	0.0 ... 760.0	63448
278...281	Harmonics 26: Voltage L2	REAL	V	0.0 ... 760.0	63450
281...285	Harmonics 27: Voltage L2	REAL	V	0.0 ... 760.0	63452
286...289	Harmonics 28: Voltage L2	REAL	V	0.0 ... 760.0	63454
290...293	Harmonics 29: Voltage L2	REAL	V	0.0 ... 760.0	63456
294...297	Harmonics 30: Voltage L2	REAL	V	0.0 ... 760.0	63458
298...301	Harmonics 31: Voltage L2	REAL	V	0.0 ... 760.0	63460
302...305	Harmonics 32: Voltage L2	REAL	V	0.0 ... 760.0	63462
306...309	Harmonics 33: Voltage L2	REAL	V	0.0 ... 760.0	63464
310...313	Harmonics 34: Voltage L2	REAL	V	0.0 ... 760.0	63466
314...317	Harmonics 35: Voltage L2	REAL	V	0.0 ... 760.0	63468
318...321	Harmonics 36: Voltage L2	REAL	V	0.0 ... 760.0	63470
322...325	Harmonics 37: Voltage L2	REAL	V	0.0 ... 760.0	63472
326...329	Harmonics 38: Voltage L2	REAL	V	0.0 ... 760.0	63474
330...333	Harmonics 39: Voltage L2	REAL	V	0.0 ... 760.0	63476
334...337	Harmonics 40: Voltage L2	REAL	V	0.0 ... 760.0	63478
338...341	Total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62320
342...345	Voltage L3-N	REAL	V	0.0 ... 440.0	3
346...349	Harmonics 1: Voltage L3	REAL	V	0.0 ... 760.0	63800
350...353	Harmonics 2: Voltage L3	REAL	V	0.0 ... 760.0	63802
354...357	Harmonics 3: Voltage L3	REAL	V	0.0 ... 760.0	63804
358...361	Harmonics 4: Voltage L3	REAL	V	0.0 ... 760.0	63806
362...365	Harmonics 5: Voltage L3	REAL	V	0.0 ... 760.0	63808
366...369	Harmonics 6: Voltage L3	REAL	V	0.0 ... 760.0	63810
370...373	Harmonics 7: Voltage L3	REAL	V	0.0 ... 760.0	63812
374...377	Harmonics 8: Voltage L3	REAL	V	0.0 ... 760.0	63814
378...381	Harmonics 9: Voltage L3	REAL	V	0.0 ... 760.0	63816
382...385	Harmonics 10: Voltage L3	REAL	V	0.0 ... 760.0	63818
386...389	Harmonics 11: Voltage L3	REAL	V	0.0 ... 760.0	63820

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
390...393	Harmonics 12: Voltage L3	REAL	V	0.0 ... 760.0	63822
394...397	Harmonics 13: Voltage L3	REAL	V	0.0 ... 760.0	63824
398...401	Harmonics 14: Voltage L3	REAL	V	0.0 ... 760.0	63826
402...405	Harmonics 15: Voltage L3	REAL	V	0.0 ... 760.0	63828
406...409	Harmonics 16: Voltage L3	REAL	V	0.0 ... 760.0	63830
410...413	Harmonics 17: Voltage L3	REAL	V	0.0 ... 760.0	63832
414...417	Harmonics 18: Voltage L3	REAL	V	0.0 ... 760.0	63834
418...421	Harmonics 19: Voltage L3	REAL	V	0.0 ... 760.0	63836
422...425	Harmonics 20: Voltage L3	REAL	V	0.0 ... 760.0	63838
426...429	Harmonics 21: Voltage L3	REAL	V	0.0 ... 760.0	63840
430...433	Harmonics 22: Voltage L3	REAL	V	0.0 ... 760.0	63842
434...437	Harmonics 23: Voltage L3	REAL	V	0.0 ... 760.0	63844
438...441	Harmonics 24: Voltage L3	REAL	V	0.0 ... 760.0	63846
442...445	Harmonics 25: Voltage L3	REAL	V	0.0 ... 760.0	63848
446...449	Harmonics 26: Voltage L3	REAL	V	0.0 ... 760.0	63850
450...453	Harmonics 27: Voltage L3	REAL	V	0.0 ... 760.0	63852
454...457	Harmonics 28: Voltage L3	REAL	V	0.0 ... 760.0	63854
458...461	Harmonics 29: Voltage L3	REAL	V	0.0 ... 760.0	63856
462...465	Harmonics 30: Voltage L3	REAL	V	0.0 ... 760.0	63858
466...469	Harmonics 31: Voltage L3	REAL	V	0.0 ... 760.0	63860
470...473	Harmonics 32: Voltage L3	REAL	V	0.0 ... 760.0	63862
474...477	Harmonics 33: Voltage L3	REAL	V	0.0 ... 760.0	63864
478...481	Harmonics 34: Voltage L3	REAL	V	0.0 ... 760.0	63866
482...485	Harmonics 35: Voltage L3	REAL	V	0.0 ... 760.0	63868
486...489	Harmonics 36: Voltage L3	REAL	V	0.0 ... 760.0	63870
490...493	Harmonics 37: Voltage L3	REAL	V	0.0 ... 760.0	63872
494...497	Harmonics 38: Voltage L3	REAL	V	0.0 ... 760.0	63874
498...501	Harmonics 39: Voltage L3	REAL	V	0.0 ... 760.0	63876
502...505	Harmonics 40: Voltage L3	REAL	V	0.0 ... 760.0	63878
506...517	Current module time	PNIOTime	sec	-	65497

E.15 Measured value data record for harmonics current (DS 163)

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...5	Total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62121
6...9	Current L1	REAL	A	0.0 ... 100000.0	7
10...13	Harmonics 1: Current L1	REAL	A	0.0 ... 100000.0	63001
14...17	Harmonics 2: Current L1	REAL	A	0.0 ... 100000.0	63003
18...21	Harmonics 3: Current L1	REAL	A	0.0 ... 100000.0	63005
22...25	Harmonics 4: Current L1	REAL	A	0.0 ... 100000.0	63007
26...29	Harmonics 5: Current L1	REAL	A	0.0 ... 100000.0	63009
30...33	Harmonics 6: Current L1	REAL	A	0.0 ... 100000.0	63011
34...37	Harmonics 7: Current L1	REAL	A	0.0 ... 100000.0	63013
38...41	Harmonics 8: Current L1	REAL	A	0.0 ... 100000.0	63015
42...45	Harmonics 9: Current L1	REAL	A	0.0 ... 100000.0	63017
46...49	Harmonics 10: Current L1	REAL	A	0.0 ... 100000.0	63019
50...53	Harmonics 11: Current L1	REAL	A	0.0 ... 100000.0	63021
54...57	Harmonics 12: Current L1	REAL	A	0.0 ... 100000.0	63023
58...61	Harmonics 13: Current L1	REAL	A	0.0 ... 100000.0	63025
62...65	Harmonics 14: Current L1	REAL	A	0.0 ... 100000.0	63027
66...69	Harmonics 15: Current L1	REAL	A	0.0 ... 100000.0	63029
70...73	Harmonics 16: Current L1	REAL	A	0.0 ... 100000.0	63031
74...77	Harmonics 17: Current L1	REAL	A	0.0 ... 100000.0	63033
78...81	Harmonics 18: Current L1	REAL	A	0.0 ... 100000.0	63035
82...85	Harmonics 19: Current L1	REAL	A	0.0 ... 100000.0	63037
86...89	Harmonics 20: Current L1	REAL	A	0.0 ... 100000.0	63039
90...93	Harmonics 21: Current L1	REAL	A	0.0 ... 100000.0	63041
94...97	Harmonics 22: Current L1	REAL	A	0.0 ... 100000.0	63043
98...101	Harmonics 23: Current L1	REAL	A	0.0 ... 100000.0	63045
102...105	Harmonics 24: Current L1	REAL	A	0.0 ... 100000.0	63047
106...109	Harmonics 25: Current L1	REAL	A	0.0 ... 100000.0	63049
110...113	Harmonics 26: Current L1	REAL	A	0.0 ... 100000.0	63051
114...117	Harmonics 27: Current L1	REAL	A	0.0 ... 100000.0	63053
118...121	Harmonics 28: Current L1	REAL	A	0.0 ... 100000.0	63055

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
122...125	Harmonics 29: Current L1	REAL	A	0.0 ... 100000.0	63057
126...129	Harmonics 30: Current L1	REAL	A	0.0 ... 100000.0	63059
130...133	Harmonics 31: Current L1	REAL	A	0.0 ... 100000.0	63061
134...137	Harmonics 32: Current L1	REAL	A	0.0 ... 100000.0	63063
138...141	Harmonics 33: Current L1	REAL	A	0.0 ... 100000.0	63065
142...145	Harmonics 34: Current L1	REAL	A	0.0 ... 100000.0	63067
146...149	Harmonics 35: Current L1	REAL	A	0.0 ... 100000.0	63069
150...153	Harmonics 36: Current L1	REAL	A	0.0 ... 100000.0	63071
154...157	Harmonics 37: Current L1	REAL	A	0.0 ... 100000.0	63073
158...161	Harmonics 38: Current L1	REAL	A	0.0 ... 100000.0	63075
162...165	Harmonics 39: Current L1	REAL	A	0.0 ... 100000.0	63077
166...169	Harmonics 40: Current L1	REAL	A	0.0 ... 100000.0	63079
170...173	Total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62221
174...177	Current L2	REAL	A	0.0 ... 100000.0	8
178...181	Harmonics 1: Current L2	REAL	A	0.0 ... 100000.0	63401
182...185	Harmonics 2: Current L2	REAL	A	0.0 ... 100000.0	63403
186...189	Harmonics 3: Current L2	REAL	A	0.0 ... 100000.0	63405
190...193	Harmonics 4: Current L2	REAL	A	0.0 ... 100000.0	63407
194...197	Harmonics 5: Current L2	REAL	A	0.0 ... 100000.0	63409
198...201	Harmonics 6: Current L2	REAL	A	0.0 ... 100000.0	63411
202...205	Harmonics 7: Current L2	REAL	A	0.0 ... 100000.0	63413
206...209	Harmonics 8: Current L2	REAL	A	0.0 ... 100000.0	63415
210...213	Harmonics 9: Current L2	REAL	A	0.0 ... 100000.0	63417
214...217	Harmonics 10: Current L2	REAL	A	0.0 ... 100000.0	63419
218...221	Harmonics 11: Current L2	REAL	A	0.0 ... 100000.0	63421
222...225	Harmonics 12: Current L2	REAL	A	0.0 ... 100000.0	63423
226...229	Harmonics 13: Current L2	REAL	A	0.0 ... 100000.0	63425
230...233	Harmonics 14: Current L2	REAL	A	0.0 ... 100000.0	63427
234...237	Harmonics 15: Current L2	REAL	A	0.0 ... 100000.0	63429
238...241	Harmonics 16: Current L2	REAL	A	0.0 ... 100000.0	63431
242...245	Harmonics 17: Current L2	REAL	A	0.0 ... 100000.0	63433
246...249	Harmonics 18: Current L2	REAL	A	0.0 ... 100000.0	63435
250...253	Harmonics 19: Current L2	REAL	A	0.0 ... 100000.0	63437
254...257	Harmonics 20: Current L2	REAL	A	0.0 ... 100000.0	63439
258...261	Harmonics 21: Current L2	REAL	A	0.0 ... 100000.0	63441
262...265	Harmonics 22: Current L2	REAL	A	0.0 ... 100000.0	63443
266...269	Harmonics 23: Current L2	REAL	A	0.0 ... 100000.0	63445
270...273	Harmonics 24: Current L2	REAL	A	0.0 ... 100000.0	63447

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
274...277	Harmonics 25: Current L2	REAL	A	0.0 ... 100000.0	63449
278...281	Harmonics 26: Current L2	REAL	A	0.0 ... 100000.0	63451
281...285	Harmonics 27: Current L2	REAL	A	0.0 ... 100000.0	63453
286...289	Harmonics 28: Current L2	REAL	A	0.0 ... 100000.0	63455
290...293	Harmonics 29: Current L2	REAL	A	0.0 ... 100000.0	63457
294...297	Harmonics 30: Current L2	REAL	A	0.0 ... 100000.0	63459
298...301	Harmonics 31: Current L2	REAL	A	0.0 ... 100000.0	63461
302...305	Harmonics 32: Current L2	REAL	A	0.0 ... 100000.0	63463
306...309	Harmonics 33: Current L2	REAL	A	0.0 ... 100000.0	63465
310...313	Harmonics 34: Current L2	REAL	A	0.0 ... 100000.0	63467
314...317	Harmonics 35: Current L2	REAL	A	0.0 ... 100000.0	63469
318...321	Harmonics 36: Current L2	REAL	A	0.0 ... 100000.0	63471
322...325	Harmonics 37: Current L2	REAL	A	0.0 ... 100000.0	63473
326...329	Harmonics 38: Current L2	REAL	A	0.0 ... 100000.0	63475
330...333	Harmonics 39: Current L2	REAL	A	0.0 ... 100000.0	63477
334...337	Harmonics 40: Current L2	REAL	A	0.0 ... 100000.0	63479
338...341	Total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62321
342...345	Current L3	REAL	A	0.0 ... 100000.0	9
346...349	Harmonics 1: Current L3	REAL	A	0.0 ... 100000.0	63801
350...353	Harmonics 2: Current L3	REAL	A	0.0 ... 100000.0	63803
354...357	Harmonics 3: Current L3	REAL	A	0.0 ... 100000.0	63805
358...361	Harmonics 4: Current L3	REAL	A	0.0 ... 100000.0	63807
362...365	Harmonics 5: Current L3	REAL	A	0.0 ... 100000.0	63809
366...369	Harmonics 6: Current L3	REAL	A	0.0 ... 100000.0	63811
370...373	Harmonics 7: Current L3	REAL	A	0.0 ... 100000.0	63813
374...377	Harmonics 8: Current L3	REAL	A	0.0 ... 100000.0	63815
378...381	Harmonics 9: Current L3	REAL	A	0.0 ... 100000.0	63817
382...385	Harmonics 10: Current L3	REAL	A	0.0 ... 100000.0	63819
386...389	Harmonics 11: Current L3	REAL	A	0.0 ... 100000.0	63821
390...393	Harmonics 12: Current L3	REAL	A	0.0 ... 100000.0	63823
394...397	Harmonics 13: Current L3	REAL	A	0.0 ... 100000.0	63825
398...401	Harmonics 14: Current L3	REAL	A	0.0 ... 100000.0	63827
402...405	Harmonics 15: Current L3	REAL	A	0.0 ... 100000.0	63829
406...409	Harmonics 16: Current L3	REAL	A	0.0 ... 100000.0	63831
410...413	Harmonics 17: Current L3	REAL	A	0.0 ... 100000.0	63833
414...417	Harmonics 18: Current L3	REAL	A	0.0 ... 100000.0	63835
418...421	Harmonics 19: Current L3	REAL	A	0.0 ... 100000.0	63837
422...425	Harmonics 20: Current L3	REAL	A	0.0 ... 100000.0	63839

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
426...429	Harmonics 21: Current L3	REAL	A	0.0 ... 100000.0	63841
430...433	Harmonics 22: Current L3	REAL	A	0.0 ... 100000.0	63843
434...437	Harmonics 23: Current L3	REAL	A	0.0 ... 100000.0	63845
438...441	Harmonics 24: Current L3	REAL	A	0.0 ... 100000.0	63847
442...445	Harmonics 25: Current L3	REAL	A	0.0 ... 100000.0	63849
446...449	Harmonics 26: Current L3	REAL	A	0.0 ... 100000.0	63851
450...453	Harmonics 27: Current L3	REAL	A	0.0 ... 100000.0	63853
454...457	Harmonics 28: Current L3	REAL	A	0.0 ... 100000.0	63855
458...461	Harmonics 29: Current L3	REAL	A	0.0 ... 100000.0	63857
462...465	Harmonics 30: Current L3	REAL	A	0.0 ... 100000.0	63859
466...469	Harmonics 31: Current L3	REAL	A	0.0 ... 100000.0	63861
470...473	Harmonics 32: Current L3	REAL	A	0.0 ... 100000.0	63863
474...477	Harmonics 33: Current L3	REAL	A	0.0 ... 100000.0	63865
478...481	Harmonics 34: Current L3	REAL	A	0.0 ... 100000.0	63867
482...485	Harmonics 35: Current L3	REAL	A	0.0 ... 100000.0	63869
486...489	Harmonics 36: Current L3	REAL	A	0.0 ... 100000.0	63871
490...493	Harmonics 37: Current L3	REAL	A	0.0 ... 100000.0	63873
494...497	Harmonics 38: Current L3	REAL	A	0.0 ... 100000.0	63875
498...501	Harmonics 39: Current L3	REAL	A	0.0 ... 100000.0	63877
502...505	Harmonics 40: Current L3	REAL	A	0.0 ... 100000.0	63879
506...517	Current module time	PNIOTime	sec	-	65497

E.16 Measured value data record for power failure analysis (DS 169)

Evaluation of the results of the power failure analysis in data record 169

The "Switch-off time/Switch-on time" pair of the stored times is the result of the module failure time. The "Overflow" cell shows the number of overflows of this list. This will inform you about how much information is no longer stored in the module. The "Next index" cell is a pointer to the new list index for the next entry and thus does not contain any information or the oldest information form the last potential overflow. Note that "Next index" as list index has the value range from 0 to 8 and thus shows, for example, "Next index = 1" to the pair "2: Switch-off time/ 2: Switch-on time". The cell "Current time" provides the module time as of the time when the DS169 was read.

You can find the description of the function "Power failure analysis" in the section Power failure analysis (Page 97).

Data record 169

Byte	Measured variable	Data type	Unit	Value range
0	Version	BYTE	-	0
1	Reserved	BYTE	-	0
2	Next index	BYTE	-	0 ... 8
3	Overflow	BYTE	-	0 ... 255
4 ... 15	1: Switch-off time	PNIOTime	sec	-
16 ... 27	1: Switch-on time	PNIOTime	sec	-
28 ... 39	2: Switch-off time	PNIOTime	sec	-
40 ... 51	2: Switch-on time	PNIOTime	sec	-
52 ... 63	3: Switch-off time	PNIOTime	sec	-
64 ... 75	3: Switch-on time	PNIOTime	sec	-
76 ... 87	4: Switch-off time	PNIOTime	sec	-
88 ... 99	4: Switch-on time	PNIOTime	sec	-
100 ... 111	5: Switch-off time	PNIOTime	sec	-
112... 123	5: Switch-on time	PNIOTime	sec	-
124 ... 135	6: Switch-off time	PNIOTime	sec	-
136 ... 147	6: Switch-on time	PNIOTime	sec	-
148 ... 159	7: Switch-off time	PNIOTime	sec	-
160 ... 171	7: Switch-on time	PNIOTime	sec	-
172 ... 183	8: Switch-off time	PNIOTime	sec	-
184 ... 195	8: Switch-on time	PNIOTime	sec	-
196 ... 207	9: Switch-off time	PNIOTime	sec	-
208 ... 219	9: Switch-on time	PNIOTime	sec	-
220 ... 231	Current module time	PNIOTime	sec	-

E.17 Information data record on available measured values (DS 170)

Measured variables of the module

Byte	Name	Data type	Unit	Value range
0	Version	BYTE	-	0
1	Reserved	BYTE	-	0
2...3	Number of IDs	UINT16	-	599
4...5	ID measured value 1	UINT16	-	-
5...6	ID measured value 2	UINT16	-	-
...	...	...	-	-
1200 ... 1201	ID measured value 599	UINT16	-	-

E.18 Measured value data record for measured value recording 1 (DS 173)

Measured variables of the module

The following table provides an overview of all the measured variables from the measured value recorder, record 1 (see section Measuring value recorder). Note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

Table 2-864 Data record 173

Byte	Measured variable	Data type	Unit	Value range
0	Version	BYTE	-	0
1	Status bits	BYTE	-	80h: Recording ended 40h: Recording in progress 00h: Evaluating data not useful
2 ... 3	Number of measured values	UINT16	-	0 ... 200
4 ... 5	Stop index	UINT16		0 ... 199
6	Overflow	BYTE	-	0 ... 255
7	Recorder status	BYTE	-	0: Initial status 3: Recorder parameterized 4: Recording in progress 5: Recording ended 6: Recording stopped
8 ... 19	Current module time	PNIO Time	sec	-
20 ... 23	Measured value 1	REAL	Depending on measured value	Depending on measured value
24 ... 27	Measured value 2	REAL	Depending on measured value	Depending on measured value
...	...	...	...	...
816 ... 819	Measured value 200	REAL	Depending on measured value	Depending on measured value

In "Circular buffer" mode, the "Stop index" always shows the last recorded element during the ongoing recording. Note that the "Stop index" serves as an index in the measured value list and can therefore take on the values from 0 to 199. If the circular buffer is filled once, the current element is always the last one in the buffer ("Stop index" = 199). The "Overflow" measured variable displays the number of circular buffer overflows. If the function is stopped, the "Stop index" points to the measured value at the stop trigger event. In "once" mode, the "Stop index" will initially stop during a restart until the next stop. This makes the last recording interruption visible in the data. The time information "Current module time" corresponds to the time of the last measured value recording.

E.19 Measured value data record for measured value recording 2 (DS 174)

Measured variables of the module

The following table provides an overview of all the measured variables from the measured value recorder, record 2 (see section Measuring value recorder). Note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

Table 2-865 Data record 174

Byte	Measured variable	Data type	Unit	Value range
0	Version	BYTE	-	0
1	Status bits	BYTE	-	80h: Recording ended 40h: Recording in progress 00h: Evaluating data not useful
2 ... 3	Number of measured values	UINT16	-	0 ... 200
4 ... 5	Stop index	UINT16		0 ... 199
6	Overflow	BYTE	-	0 ... 255
7	Recorder status	BYTE	-	0: Initial status 3: Recorder parameterized 4: Recording in progress 5: Recording ended 6: Recording stopped
8 ... 19	Current module time	PNIO Time	sec	-
20 ... 23	Measured value 1	REAL	Depending on measured value	Depending on measured value
24 ... 27	Measured value 2	REAL	Depending on measured value	Depending on measured value
...	...	...	...	...
816 ... 819	Measured value 200	REAL	Depending on measured value	Depending on measured value

In "Circular buffer" mode, the "Stop index" always shows the last recorded element during the ongoing recording. Note that the "Stop index" serves as an index in the measured value list and can therefore take on the values from 0 to 199. If the circular buffer is filled once, the current element is always the last one in the buffer ("Stop index" = 199). The "Overflow" measured variable displays the number of circular buffer overflows. If the function is stopped, the "Stop index" points to the measured value at the stop trigger event. In "once" mode, the "Stop index" will initially stop during a restart until the next stop. This makes the last recording interruption visible in the data. The time information "Current module time" corresponds to the time of the last measured value recording.

Tips and tricks

F

F.1 Tips and tricks

Processing and visualizing energy data

On the basis of an application example we show you how the measured values of the AI Energy Meter CT HF can be processed further and visualized.

You can find this application example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86299299).

Overview of the measurement data with update time

We provide you with an overview of the assignment of the measured values to the payload variants and data records in an Excel file.

You will find the Excel file on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755917).

Time-of-day synchronization and time stamp

In an application example, we show you how to synchronize the time with the AI Energy Meter CT HF and work with measured values with time stamps.

You can find this application example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109754890).

Rotating field

To recognize wiring errors and evaluate the generated rotating field, you use the combined measurement functions from the section Notes for the recognition of wiring errors and incorrect rotating field (Page 52).

Measured values in STEP 7 as of V5.5

Measured values are represented as negative values in STEP 7 as of V5.5 if the value range of the integer format (32767 dec) is exceeded. This is not an error in the measured value. Solution: Select hexadecimal representation.

Conversion of 64-bit floating-point numbers

If you cannot process 64-bit floating-point numbers in your automation system, we recommend conversion to 32-bit floating-point numbers. Note the conversion can cause loss of accuracy. For a description of the conversion of the 64-bit floating-point numbers (data type LREAL) into 32-bit floating-point numbers (data type REAL) please refer to the Internet (https://support.industry.siemens.com/cs/ww/en/view/56600676).

SIEMENS

SIMATIC

ET 200SP
Analog input module AI Energy Meter RC HF
(6ES7134-6PA21-0CU0)

Equipment Manual

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ET 200SP
Analog input module AI Energy Meter RC HF (6ES7134-6PA21-0CU0)

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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Current measuring transformer: When the term "current measuring transformer" is used in this manual, it applies both to current/voltage transformers and Rogowski coils.

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary

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Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

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ET 200SP Documentation Guide

1

1.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/84133942)

1.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in SIOS:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in SIOS and how to use SIOS on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

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You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.3 Tool support

1.3.1 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , it assembles the configuration editors for automation technology already familiar into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- The "Network analysis" offers a quick overview of the PROFINET topology. It is possible to make simple parameter changes (for example, to the names and IP addresses of the devices). In addition, a quick and convenient comparison of the real configuration with a reference system is also possible.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet:
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

Product overview

2

2.1 Properties of the AI Energy Meters RC HF

Article number

6ES7134-6PA21-0CU0

View of the module

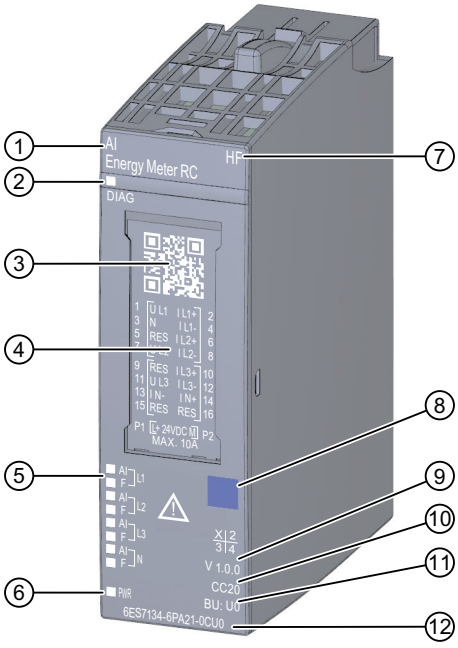

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-747 View of the module AI Energy Meter RC HF

Properties

The module has the following technical properties:

- Measurement of electrical variables from single-phase, two-phase and three-phase supply networks
- Current measurement using Rogowski coil or current-voltage converter (333 mV)
- Power quality data for voltages and currents
- Measured value recorder (10 ms)
- Max. voltage between two line conductors 519 V AC (with direct connection)
- Retentive storage of the counter values
- Use on frequency converters
- Recording of:
  - Voltages
  - Currents
  - Phase angles
  - Power
  - Energy / electrical work
  - Frequencies
  - Minimum and maximum values with time stamp
  - Power factors
  - Operating hours
  - Limits

The module supports the following functions:

Table 2-866 Version dependencies of the functions

Function	HW version	FW version	STEP 7	GSD file	
			TIA Portal	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	---
Calibration in runtime	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	---	---
Identification data I&M0 to I&M3	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	X
Reconfiguration in RUN	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	X
Diagnostic interrupts	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	X
Hardware interrupts	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	---

NOTE

The AI Energy Meter RC HF is released as of TIA Portal V16.0.0.4.

Accessories

The following accessories must be ordered separately:

- BaseUnit type U0
- Labeling strips
- Reference identification label

You can find additional information on the accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

2.2 Area of application

Introduction

Energy efficiency is playing an increasingly important role in industry. Rising energy prices, increasing pressure to improve profitability and the growing awareness of climate protection are important factors for reducing energy costs and for introducing an energy data management system.

Where can you use the AI Energy Meter RC HF?

The AI Energy Meter RC HF is designed for machine-level deployment in an ET 200SP distributed I/O system. The AI Energy Meter RC HF records over 500 different electrical measurement and energy values. It lets you create transparency about the energy requirements of individual components of a production plant even down to the machine level.

You can use the following measurement values supplied by the AI Energy Meter RC HF for the following applications:

- Energy consumption
- Power consumption
- Power quality
- Forecasts of consumption
- Efficiency

Power consumption measurements are relevant for load management and maintenance. In addition, you can use the measurements for emission reporting and for determining the CO_2 footprint.

NOTE

Measuring dangerous electrical quantities

The AI Energy Meter RC HF is not tested according to DIN EN 61010-2-030 and may therefore not be used to verify, measure or monitor protective measures according to DIN EN 61557.

Qualified personnel must ensure through additional measures that no danger ensues for humans and the environment in case of an incorrect display.

TB, TT and IT system

The AI Energy Meters RC HF can be used in TN, TT and IT systems.

Measuring with the AI Energy Meter RC HF

A typical supply network of a production plant is usually divided into three voltage ranges:

- The infeed of the entire plant
- The subdistribution, for example, to individual lines within the plant
- The end consumers such as the machines in the lines.

The following figure shows the measurement in an electricity supply network:

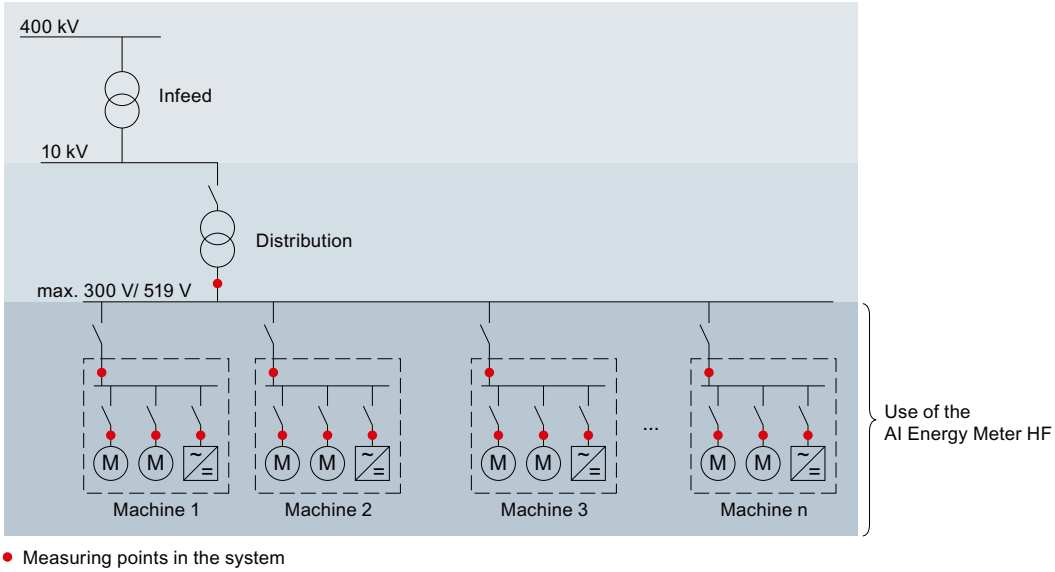

Figure 2-748 Use of the AI Energy Meter HF

Advantages of the AI Energy Meters RC HF

The AI Energy Meter RC HF offers the following benefits:

- Space-saving especially for use in control cabinet
- PROFINET IO or PROFIBUS DP (https://www.profibus.com/) (depending on the interface module in use)
- Multiple modules can be used with one interface module
- Extension of existing stations by components for energy recording

2.3 Special considerations for use on the PROFIBUS DP and PROFINET IO

You can read data records from the module or write them to the module with both PROFIBUS DP and PROFINET IO.

Operation of the module on PROFIBUS DP

Please note that with PROFIBUS DP you can write data records up to a maximum length of 240 bytes to the module or read them from the module.

PROFIBUS DPV 1

If the DP Master supports the DPV1, you can reconfigure in your user program with the parameter data records DS 128, DS 129, DS 130, DS 131 or DS 135. Note that the maximum data record length is 240 bytes for DS 135.

The following applies for the measured value data records:

- DS 142: When you read the data record, the module returns the measured value data record DS 142 in version 2.
- DS 147, DS 148, DS 149: When you read the data record, the module returns the measured value data record in version 0.
- DS 154, DS 155, DS 161, DS 163, DS 164: When you read the data record, the module returns the first 240 bytes of the structure of the measured value data record.
- DS 151: You define the user-defined measured value data record DS 151 in the parameter data record DS 135. If the structure in the measured value data record DS 151 is greater than 240 bytes, the module returns the first 240 bytes of the structure.

  Information on the data record length of data records DS 135 and DS151 can be found in the appendix Structure of the parameter data record for data record mapping (DS 135) (Page 171).

PROFIBUS DPV 0

If the DP Master does **not** support DPV1, you cannot reassign parameters which results in the following restrictions:

- There are no phase-specific parameters. All parameters apply for all three phases and the neutral conductor.
- The connection types and payload variants are limited.
- The voltage transformers are not configurable (default: 1:1).
- The current transformer value range primary current is restricted.
- The low limit for measuring current cannot be adjusted (default: 50 mA).
- Energy metering is performed continuously (the gate is not enabled).
- Min/Max calculation of values is enabled (the gate is not enabled).
- 3P4W can be set in the parameters for the connection type 3P3W.
- 3P4W can be set in the parameters for the connection type 3P3W1.
- Counting of operating hours is enabled (the gate is not enabled).
- The residual current measurement is enabled.
- Limit value monitoring cannot be used.
- Energy meter default cannot be used.
- The user-defined payload interface cannot be used.
- The user-defined data record cannot be used.
- The power quality analysis cannot be used.
- The separate settings for measuring the neutral current cannot be used.
- The measured value data records cannot be used.

Operation of the module on PROFINET IO

When reading data records partially from the module, please note the following:

- Measured value data record DS 142:
  - When you read the data record with a length of 240 bytes or less, the module returns the measured value data record DS 142 in version 2.
  - When you read the data record with a length of more than 240 bytes, the module returns the measured value data record DS 142 in version 3.
- Measured value data records DS 147, DS 148, DS 149:
  - When you read the data record with a length of 240 bytes or less, the module returns the measured value data record in version 0.
  - When you read the data record with a length of more than 240 bytes, the module returns the measured value data record in version 1.

Wiring

3

3.1 Terminal and block diagram

General safety instructions

⚠ WARNING

Danger to life due to electric shock

Touching live parts can lead to death or severe injuries.

Before beginning any work, deenergize the system and the AI Energy Meter RC HF.

⚠ WARNING

Danger to life, dangerous system conditions and material damage possible

Removing and inserting the Al Energy Meter RC HF under live voltage is prohibited.

When you remove and insert the AI Energy Meter RC HF under live voltage during operation, the transformers used can produce dangerous induction voltages and electric arcs and dangerous system conditions can arise.

The AI Energy Meter RC HF may only be removed and inserted during operation if the measuring voltages supplied to the BaseUnit at terminals U_{L1} , U_{L2}, U_{L3} are disconnected at all poles.

Supplying the module

The AI Energy Meter RC HF receives its supply voltage via the terminals 17 (24 V DC) and 18 (M).

NOTE

Safe extra low voltage SELV/PELV

Ensure that all devices are connected to the SELV/PELV power supply (or equivalent).

Note the following to ensure the electrical safety of the Energy Meter and the ET 200SP station:

The voltage difference between the inputs for measuring the line voltage at the Energy Meter and the SELV/PELV supply voltages of the Energy Meter and the ET 200SP station must not exceed 300 V AC. This is guaranteed, for example, if the SELV/PELV supply is fed from the same grounded network as the voltage to be measured directly. If voltage transformers are used, they must be grounded on the secondary side.

Protecting the connection cables

To protect the connection cables at U_{L1}, U_{L2} and U_{L3}, make sure there is adequate cable protection, especially after cross-section transitions.

If the cables are routed with short-circuit protection according to IEC 61439-1:2009, for example, in a pipe or in separate cable ducts, there is no need for separate cable protection for the AI Energy Meter RC HF.

Terminal and block diagram

The figure below shows the pin assignments for connecting voltage transformers, current-voltage transformers and Rogowski coils.

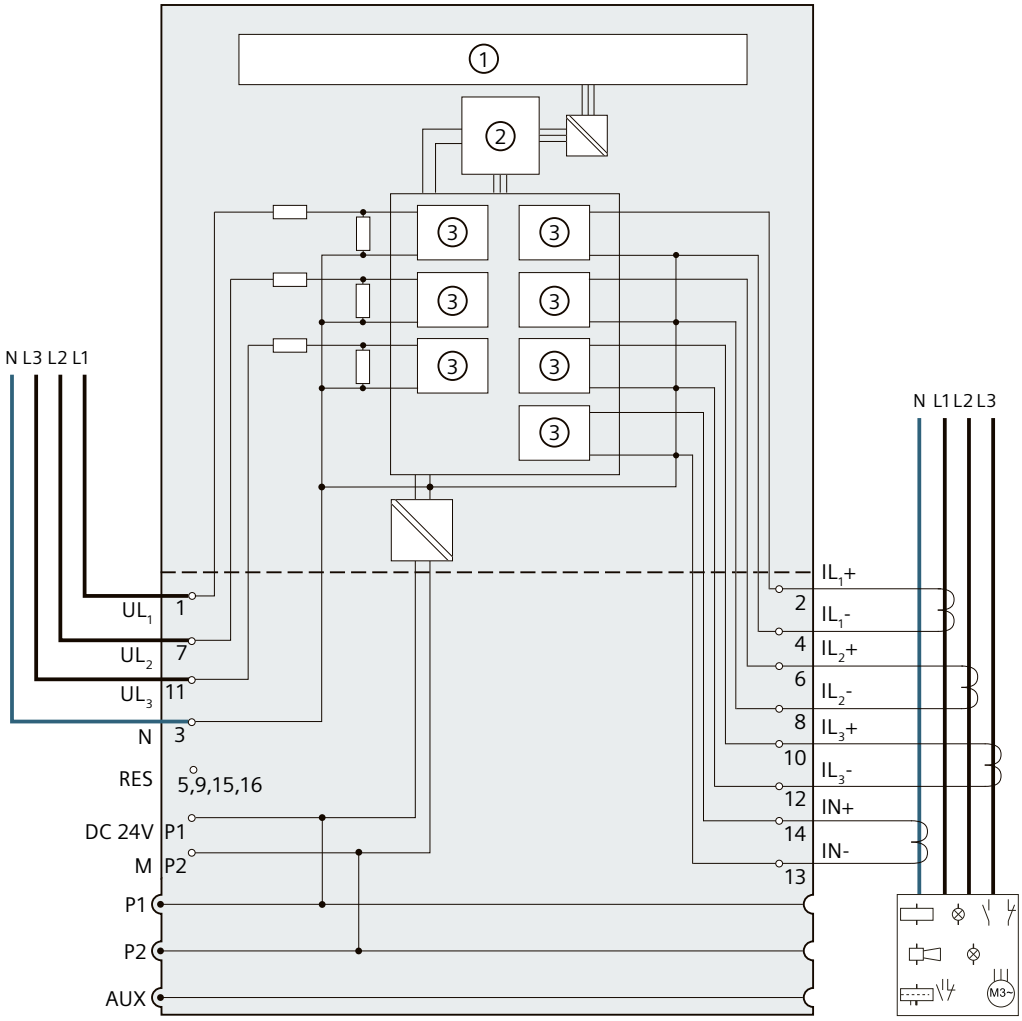

①	Microcontroller	UL_n	Connection voltage
②	Backplane bus interface	IL_n+ / IL_n-	Connection of current/voltage transformers and Rogowski coils
③	Analog-to-digital converter (ADC)	N, IN+ / IN-	Neutral
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	RES	Reserve, must remain unused for future function extensions

Figure 2-749 Block diagram of the AI Energy Meter RC HF

Useable BaseUnits

You can use the following BaseUnits:

- Type BU type U0 dark-colored
- Type BU type U0 light-colored

A potential group opened with a light-colored BU type U0 must contain no dark-colored BaseUnit of BU type A0 or A1.

Connection types

The AI Energy Meter RC HF supports the following connection types:

- 3P4W1, 3 phases, 4 conductors, balanced load
- 3P4W, 3 phases, 4 conductors
- 2P3W, 2 phases, 3 conductors
- 1P2W, 1 phase, 2 conductors
- 3 x 1P2W, 3 x 1 phase, 2 conductors
- 3P3W, 3 phases, 3 conductors
- 3P3W1, 3 phases, 3 conductors, balanced load
- 3P4WI, 3 phases, 4 conductors (only for current measurement)

The input circuit of the module must correspond to one of the listed connection types. Select the appropriate connection type for the intended use.

You will find examples of connections in the section Connection examples (Page 25).

Selection of a current/voltage transformer can be found in the section Selection of a current measuring transformer (Page 29).

NOTE

Measurement of other currents

You can also use the connection for measurement of the neutral current for measuring other currents.

3.2 Connection examples

The following figures show the connection of the AI Energy Meter RC HF for three-phase, two-phase and single-phase measurements. Note that the AI Energy Meter RC HF must always be connected via a current measuring transformer. The use of voltage transformers is optional.

Connection type	Wiring diagram	Comment
3P4W Three-phase measurement, 4 wires	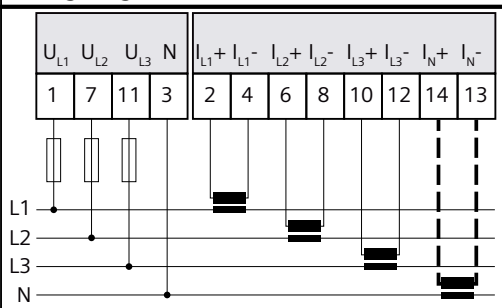	Any load Connection with three current transformers
3P4W Three-phase measurement, 4 wires	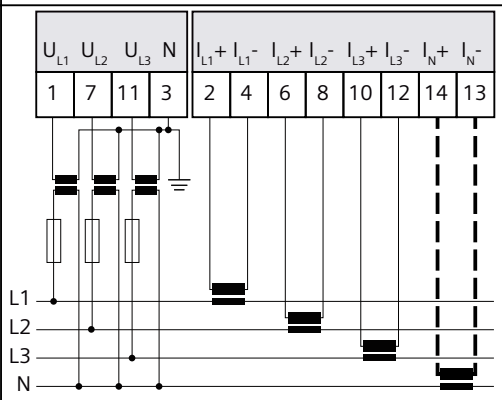	Any load Connection with three current measuring transformers and three voltage transformers.
3P4W1 Three-phase measurement, 4 wires	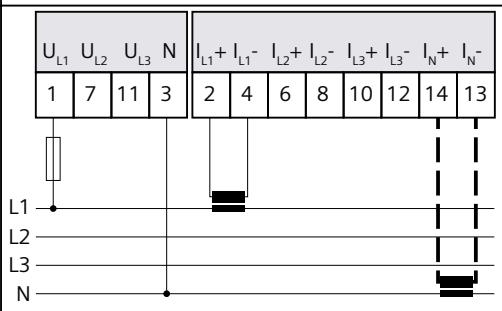	Balanced load Connection with one current measuring transformer
3P4W1 Three-phase measurement, 4 wires	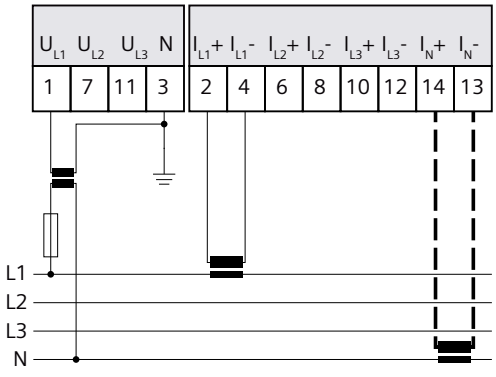	Balanced load Connection with one current measuring transformer and one voltage transformer.

Connection type	Wiring diagram	Comment
2P3W Two-phase measurement, 3 conductors	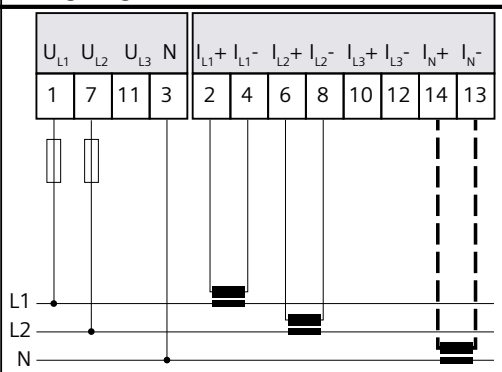	Any load Connection with two current measuring transformers The phase position L1-L2 is arbitrary. AI Energy Meter RC HF supplies the value "0" for all measured values of Phase 3 as well as for some cross-phase measured values.
2P3W Two-phase measurement, 3 conductors	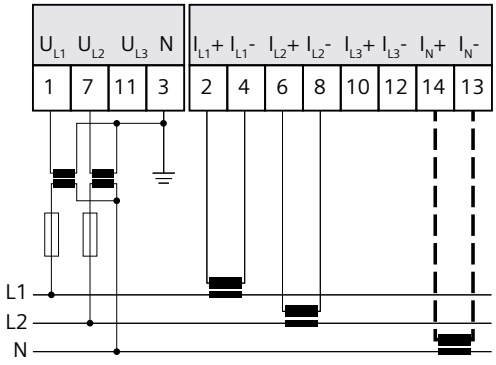	Any load Connection with two current measuring transformers and two voltage transformers. AI Energy Meter RC HF supplies the value "0" for all measured values of Phase 3 as well as for some cross-phase measured values.
1P2W Single-phase measurement, 2 conductors	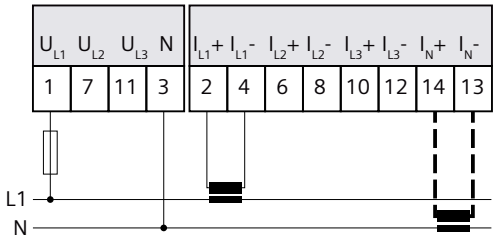	Measurement in an AC network with a current measuring transformer AI Energy Meter RC HF supplies the value "0" for all measured values of Phase 2 and 3 as well as for some cross-phase measured values.
1P2W Single-phase measurement, 2 conductors	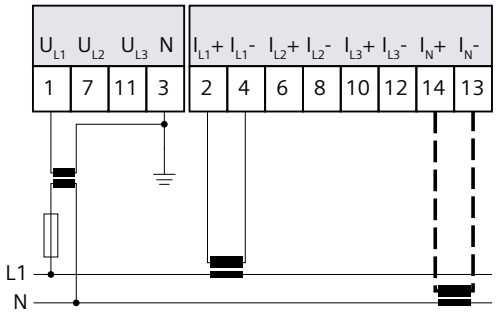	Measuring the load in an AC network with a current measuring transformer and a voltage transformer. AI Energy Meter RC HF supplies the value "0" for all measured values of Phase 2 and 3 as well as for some cross-phase measured values.

Connection type	Wiring diagram	Comment
3 x 1P2W 3 x single-phase measurement	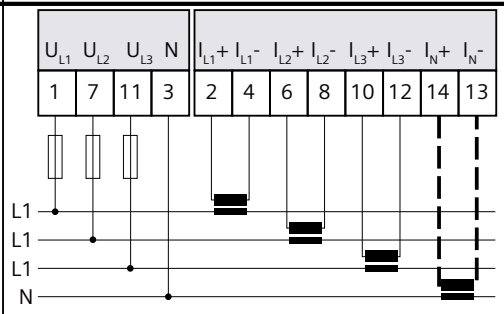	Measurement with three current measuring transformers for any three loads that are each connected to one of the three phases. To reduce the number of fuses used, the voltage phases can also be bridged behind a fuse.
3 x 1P2W 3 x single-phase measurement	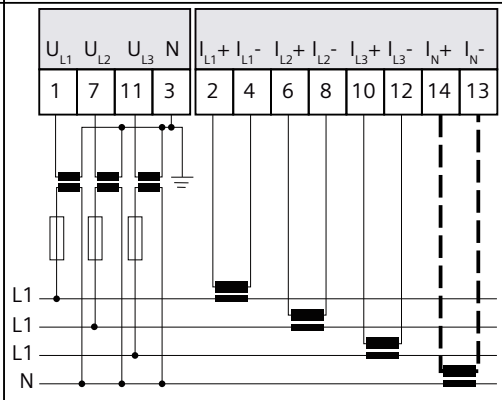	Measurement with three current measuring transformers and three voltage transformers for any three loads that are each connected to one of the three phases. To reduce the number of fuses used, the voltage phases can also be bridged behind a fuse.
3P3W Three-phase measurement	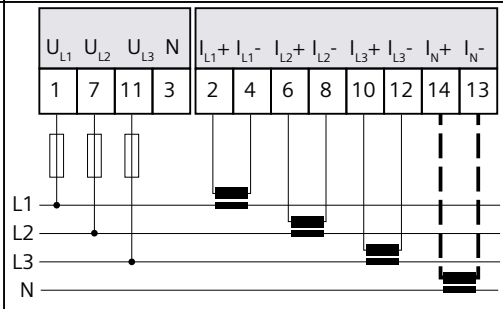	Any load Connection with three current transformers
3P3W Three-phase measurement	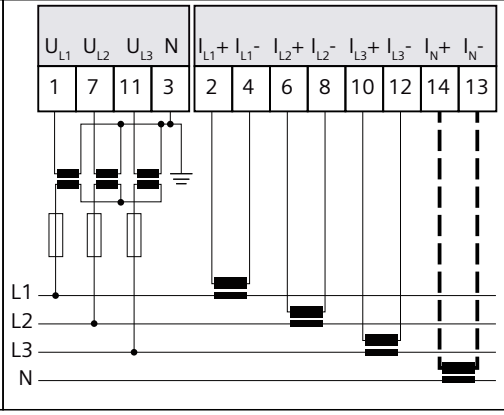	Any load Connection with three current measuring transformers and three voltage trans-formers.

Connection type	Wiring diagram	Comment
3P3W1 Three-phase measurement	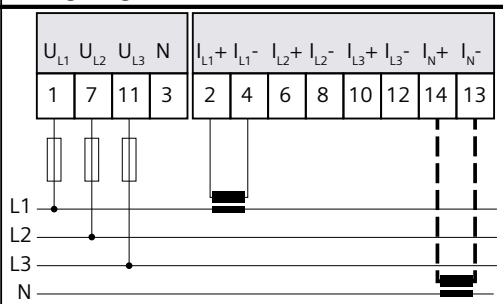	Balanced load Connection with one current measuring transformer.
3P3W1 Three-phase measurement	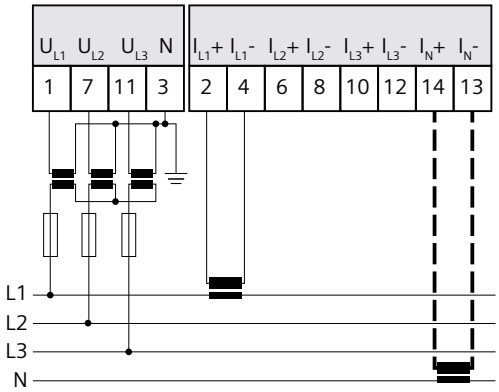	Balanced load Connection with one current measuring transformer and one voltage transformer.
3P4WI Three-phase measurement (only for current measurement)	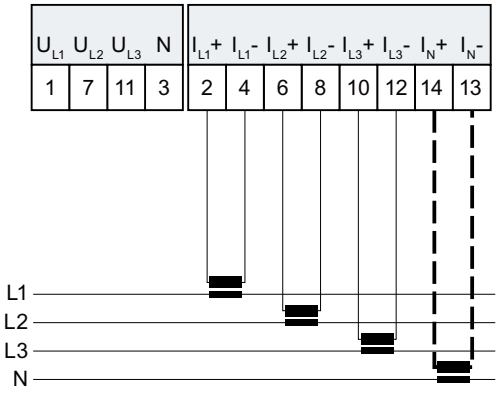	Connection with three current transformers

3.3 Selection of a current measuring transformer

Introduction

The AI Energy Meter RC HF is designed for the connection of current/voltage transformers with 333 mV interface and Rogowski coils.

NOTE

Overall accuracy

For the total accuracy of the system consisting of the AI Energy Meter RC HF and current/voltage transformer or Rogowski coil, ensure that the secondary voltage generated by the current to be measured is within the range for which the measurement accuracy of the AI Energy Meter RC HF applies.

Current/voltage transformer

The Energy Meter RC HF is designed for the connection of current/voltage transformers with 333 mV interface.

Unlike classic current transformers, these small-signal current transformers do not have to pay attention to load power. The length and cross-section of the connecting cables to the Energy Meter RC HF do not affect the measurement accuracy or the measuring range.

Just make sure that the minimum secondary resistance required for the transformer matches the input resistance of the Energy Meter RC HF. The Energy Meter RC HF has a typical differential input resistance at the channel terminals of 120 kΩ.

Rogowski coils

Rogowski coils are current/voltage transformers based on air coils. They do not work on a transformer principle like current transformers, but instead convert the rate of change of the current to a proportional voltage. This principle generates a phase shift of the secondary voltage vis-a-vis the primary current of 90°. An integrator in the AI Energy Meter RC HF, connected by the selection of the current transformer type in the configuration, compensates the phase shift again.

Interposing current transformers or integrators for connecting Rogowski coils are not required.

The accuracy of Rogowski coils is independent of the cable length. Just make sure that the minimum secondary resistance required for the transformer matches the input resistance of the Energy Meter RC HF. The AI Energy Meter RC HF has a typical input resistance of 120 kΩ.

The secondary voltage is very low in case of an open converter input or when the primary currents are too low. If the secondary voltage is less than 4 mV, it is difficult to measure the current. This noise should be measured when the Rogowski coil is not under load, and the "Low limit for current measurement" should be adjusted accordingly with some room to move at the top.

See also

Technical specifications (Page 140)

Configuration / address space

4

4.1 Configuring

Introduction

To configure the AI Energy Meter RC HF after connecting it, use configuration software such as STEP 7 (TIA Portal). In addition, you can also change numerous parameters of the AI Energy Meters RC HF in RUN via the user program.

Configuring

You configure the AI Energy Meter RC HF with:

- STEP 7 (TIA Portal) V16 or higher and HSP0335
- GSD file for PROFIBUS or PROFINET

NOTE

Consistency check of the parameter assignment only with STEP 7

If you configure the AI Energy Meter RC HF using STEP 7 (TIA Portal), STEP 7 (TIA Portal) already checks the various parameters for consistency while they are being entered.

If you configure the AI Energy Meter RC HF using a GSD file, a consistency check is not performed. The module does not recognize incorrect entries until after the parameter data record has been transferred. If the module recognizes an invalid parameter, the module rejects the complete data record.

Preferably use STEP 7 (TIA Portal) to configure the AI Energy Meters RC HF.

The following instructions show the theoretical procedure for configuring the AI Energy Meters RC HF with STEP 7 (TIA Portal) V16 or higher with HSP0335.

1. Select the ET 200SP distributed I/O system you are using in the hardware catalog.
2. Insert the module into your station.
3. Open the device view of the ET 200SP and insert the AI Energy Meter RC HF.
4. Configure the AI Energy Meter RC HF to suit your requirements.

   Once the configuration has been compiled without errors, you can download the configuration to the CPU and commission the ET 200SP station while the AI Energy Meter RC HF is running.

4.2 Selecting the module versions

4.2.1 Selecting the module version

Introduction

The AI Energy Meter RC HF has different module versions.

During the configuration, you use the selection of the module version to specify which measured values can be read.

Each module version supplies quality information via the input payload.

With the exception of the module version "2 I / 2 Q", you can read the measured values as payload cyclically from the process image. At each module version you have the option to read measured value records from the AI Energy Meter RC HF by using the RDREC instruction asynchronously.

Influence of the module version on the address space

NOTE

Influence of the AI Energy Meters RC HF on the maximum configuration of the ET 200SP

The available address space of the ET 200SP is influenced by the following factors:

- CPU or interface module
- Plugged I/O modules

The address space made **additionally** available by the AI Energy Meter RC HF is essentially influenced by the length of the payload supplied. The module variant determines the length of the payload, which can be supplied by the AI Energy Meter RC HF at maximum.

4.2.2 Module versions at configuration with STEP 7

Module versions with fixed payload assignment

Module version	Payload	Address space	Comment
2 I / 2 Q	No cyclic payload. Access to measured values through "Read data record".	2-byte inputs 2-byte outputs	Information about the structure of the 2 I / 2 Q module version is available in the appendix "2 I / 2 Q" module version (Page 203).
EE@Industry E0	Payload in accordance with EE@Industry measurement data profiles	12-byte inputs / 20-byte outputs	Information about the structure of the EE@Industry measured data profiles is available in the appendix Module version "EE@Industry measured data profile E0 / E1 / E2 / E3" (Page 215).
EE@Industry E1		4-byte inputs / 20-byte outputs	
EE@Industry E2		12-byte inputs / 20-byte outputs	
EE@Industry E3		104-byte inputs / 20-byte outputs	

Module versions with selectable payload variants

Module version	Payload	Address space	Comment
32 I / 20 Q	Payload selectable through defined payload variants	32-byte inputs / 20-byte outputs	You can change over the payload variant during operation. Information about the structure of the 32 I / 20 Q module version is available in the appendix "32 I / 20 Q" module version (Page 205). Information about the payload variants at 32 I / 20 Q is available in appendix Payload variants with 32 bytes input / 20 bytes output data (Page 217).
User-specific	Payload selectable through payload mapping or through defined payload variant	variable* / 20-byte outputs	You have to activate the check box "Payload-mapping" in STEP 7 to use the module version user-specifically. You can change over the payload variant during operation. Information about the structure of the user-specific module version is available in the appendix "User-specific" module version (Page 213).

* 16 ... 256 bytes in steps of 16 bytes, depending on the mapped measured values

4.2.3 Module versions at configuration with GSD file

Module versions with fixed payload assignment

Module version	Payload	Address space	Comment
2 I / 2 Q	No cyclic payload. Access to measured values through "Read data record".	2-byte inputs 2-byte outputs	Information about the structure of the 2 I / 2 Q module version is available in the appendix "2 I / 2 Q" module version (Page 203).
E0	Payload in accordance with EE@Industry measurement data profiles	12-byte inputs / 20-byte outputs	Information about the structure of the EE@Industry measured data profiles is available in the appendix Module version "EE@Industry measured data profile E0 / E1 / E2 / E3" (Page 215).
E1		4-byte inputs / 20-byte outputs	
E2		12-byte inputs / 20-byte outputs	
E3		104-byte inputs / 20-byte outputs	

Module versions with selectable payload variants

Module version	Payload	Address space	Comment
32 I / 20 Q	Payload selectable through payload variants or	32-byte inputs / 20-byte outputs	You can change over the payload variant during operation.

*Ensure that the payload do not exceed the size of the address space of the module version. If necessary, use a module version with a larger address space

Module version	Payload	Address space	Comment
64 I / 20 Q	through user-specific payload*	64-byte inputs / 20-byte outputs	If you use user-specific payload, you write your measured value profile into the AI Energy Meter RC HF with the data record 130. To do this use the WRREC instruction. Information about the structure of data record 130 is available in appendix Structure of the parameter data records for payload mapping DS 130/DS 131 (Page 163).
128 I / 20 Q		128-byte inputs / 20-byte outputs	
256 I / 20 Q		256-byte inputs / 20-byte outputs	

*Ensure that the payload do not exceed the size of the address space of the module version. If necessary, use a module version with a larger address space

4.2.4 Changing over the user data variant during operation

Introduction

You change the payload variant in the output data of each payload variant in Byte 0.

The following figure shows to which payload you can change over at various module versions during operation.

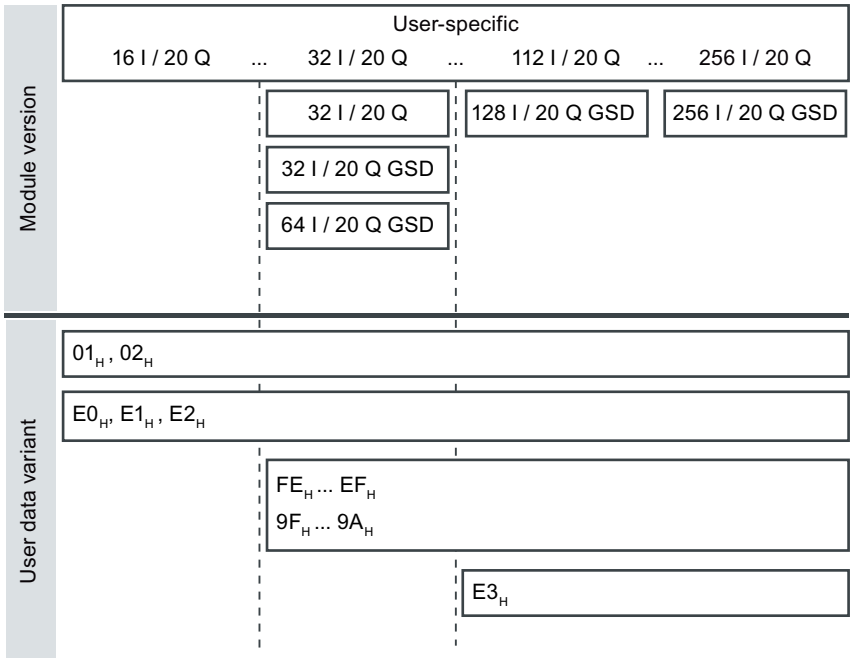

Figure 2-750 Possible payload variants

Requirement

- User program has been created.
- AI Energy Meter RC HF is configured as one of the module versions mentioned in the figure above.
- The start address of the module is known in the process image output.

Procedure

1. Create one constant with the data type BYTE per payload variant.
2. Enter the payload ID as a value in each case.
3. Write the constant to the start address of the module in the process image output.

Result

The payload variant is switched with the next cycle.

NOTE
Information about payload changeover
The parameterized payload variant is set in the following cases:

- A "0" is written in byte 0 in the output data of a payload variant.
- Byte 0 in the output data of a payload variant contains an invalid value:
  - Coding of the payload variant not available
    or
  - Available address space is not sufficient for the selected payload variant.

4.2.5 Recommendations for selecting the module version

The following table shows which module version is suitable for a given purpose.

Module version	Application	Note
2 I / 2 Q	• Use of many AI Energy Meter RC HF in an ET 200SP or when little address space is available	• Read the measured values solely via the RDREC instruction from a measured value data record. • Quality information about the measured values is always available.
EE@Industry measurement data profile E0 / E1 / E2 / E3	• Cyclic measurement per phase • Supplied measured values in accordance with the EE@Industry measured data profile	• Available measured values depend on the configured measurement data profile. • The payload are fixed and cannot be changed dynamically. Alternatively, read the measured values acyclically from a measured value data record via the RDREC instruction. • No quality information

Module version	Application	Note
32 I / 20 Q	• Cyclic measurement per phase • Flexibility by switching pre-defined payload variants	• Quality information about the measured values is always available. • Depending on the payload variant, you must convert the measured values in the CPU to physical values using the supplied scaling factor. • One cycle elapses for each payload changeover. Measured values from the next payload variant are thus supplied with a slight time offset. Alternatively, read the measured values acyclically from a measured value data record via the RDREC instruction. Consistent measured values of a measuring cycle are supplied.
User-specific	• Cyclic measurement of up to 64 measured values configurable • Flexibility by switching pre-defined payload variants	
With GSD configuration • 32 I / 20 Q • 64 I / 20 Q • 128 I / 20 Q • 256 I / 20 Q		

4.3 Applicable modules

Configuring with STEP 7

The following table shows with which controllers the different module versions can be configured with STEP 7.

Table 2-867 Module versions configured with STEP 7

Controller	Module version						
	2 I / 2Q	32 I / 20 Q	User-specific	EE@Industry measurement data profile			
				E0	E1	E2	E3
IM 155-6 PN ST	V3.3 or higher						
IM 155-6 PN HF *	V3.1 or higher						
IM 155-6 PN BA	V3.2 or higher		---	V3.2 or higher			---
IM 155-6 PN HS	V4.0 or higher		---	V4.0 or higher			
IM 155-6 DP HF	V3.0 or higher		---	V3.0 or higher			---
CPU 1510SP-1 PN**	V1.6 or higher		V1.6 or higher*** V2.0 or higher	V1.6 or higher			V2.0 or higher
CPU 1510SP F-1 PN**	V1.7 or higher		V1.7 or higher*** V2.0 or higher	V1.7 or higher			V2.0 or higher
CPU 1512SP-1 PN**	V1.6 or higher		V1.6 or higher*** V2.0 or higher	V1.6 or higher			V2.0 or higher
CPU 1512SP F-1 PN**	V1.7 or higher		V1.7 or higher*** V2.0 or higher	V1.7 or higher			V2.0 or higher
CPU 1515SP PC**	V1.7 or higher		V1.7 or higher*** V2.0 or higher	V1.7 or higher			V2.0 or higher

** Function setting the time as of V4.2

** Function setting the time is not possible

*** Up to a max. of 32 bytes input

Configuring with GSD file

The following table shows with which controllers the different module versions can be configured using a GSD file.

Table 2-868 Module versions configuring with GSD file

Controller	Module version						
	2 I / 2Q	32 I / 20 Q	64 I / 20 Q 128 I / 20 Q 256 I / 20 Q	EE@Industry measurement data profile			
				E0	E1	E2	E3
IM 155-6 PN ST	V3.3 or higher						---
IM 155-6 PN HF	V3.1 or higher						---
IM 155-6 PN BA	V3.2 or higher		---	V3.2 or higher			---
IM 155-6 PN HS	V4.0 or higher		---	V4.0 or higher			---
IM 155-6 DP HF	V4.2 or higher		---	V4.2 or higher			---

Compatibility 5

5.1 Compatibility of modules

Compatibility

The module versions "AI Energy Meter RC ST" and "AI Energy Meter RC HF" are compatible. All module versions can run on the respective other configuration, whereby the CT and RC functionality cannot be swapped.

If you exchange or replace an AI Energy Meter, the following table shows the compatibilities.

	Energy Meter configured		
Energy Meter inserted	**AI Energy Meter RC ST**	**AI Energy Meter RC HF**	**AI Energy Meter 480 VAC RC HF**
AI Energy Meter RC ST	Yes	Yes*	Yes*
AI Energy Meter RC HF	Yes*	Yes	Yes**
AI Energy Meter 480 VAC RC HF	No	No	Yes

*In this case, the module only supports ST functions.

** In this case, the function measured value recorder cannot be configured. The measured values of the following IDs cannot be selected by configuration in the limit value monitoring or in the user-definable data records/payload: 61136, 61137, 61159, 62132, 62135, 62193, 62232, 62235, 62293, 62332, 62335, 62393.

NOTE

The smallest component from configuration and module type determines the resulting scope of functions. This means the ST functionality is supported when either an ST configuration is available, or the ST module is used. An HF functionality, therefore, is only available in case of an HF configuration and HF module.

NOTE

When you install an ST module and use an HF configuration, you must disable the following functions:

- Power quality analysis functions
- Residual current analysis
- Diagnostics power quality
- Overcurrent, detect voltage swell and dip
- Detect peak values of current and voltage
- Harmonics analysis

AI Energy Meter RC HF (6ES7134-6PA21-0CU0) with firmware version V8.0.0

If you want to exchange the hardware and the configuration of the AI Energy Meter 480VAC RC HF V6.0 modules against the corresponding AI Energy Meter RC HF V8.0 modules, then exchange

1. the configuration of V6.0 according to V8.0 and
2. the hardware

If the module does not start correctly after exchanging the AI Energy Meter 480 VAC HF V6.0 configuration to HF V8.0, then

- change one or more module or phase parameters (DS128) and send them to the module again or
- switch off the load voltage of the module at P1 and P2 for a short time and then switch it on again.

Quick start

6

Introduction

This section shows you how to read and view your first measured values on the AI Energy Meter RC HF in a particularly quick and easy way.

NOTE

Current measuring transformer:

When the term "current measuring transformer" is used in this manual, it applies both to current/voltage transformers and Rogowski coils.

Requirement

You have already connected the AI Energy Meter RC HF to your network with one of the connection types shown in the section Connecting (Page 22). The AI Energy Meter RC HF has already been integrated into your configuration tool (such as STEP 7), or the AI Energy Meter RC HF has been integrated in the hardware catalog of your configuration tool with the GSD file.

Procedure

1. Configure an ET 200SP station

   Configure an ET 200SP station with a CPU 151xSP or an IM 155-6.

2. Plug module in ET 200S station

   Plug the AI Energy Meter RC HF into the ET 200SP station and use the module version with 32-byte inputs and 20-byte outputs.

3. Set the module parameters

   Set the following parameters for the AI Energy Meter RC HF:

   – Connection type that you have used for the AI Energy Meter RC HF (e.g. 3P4W)
   – Voltage measuring range (e.g. 230 V)
   – Frequency of your network (for example 50 Hz)
   – Current transformer type for line conductors L1, L2, L3 and neutral conductor (e.g. Rogowski coil)
   – Current transformer primary rated current and secondary voltage (e.g. 1000 A and 333 mV)
   – Voltage transformer primary and secondary voltages (e.g. 230 V and 230 V)

   Leave all other parameters at their default settings and do not change them.

4. Load configuration

   Switch on the ET 200SP station and download the configuration to the CPU.

Result

After being switched on, the AI Energy Meter RC HF supplies the measured values for the "Total power L1L2L3" payload variant with the ID 254 or FE_H.

Read and check the measured values provided by the AI Energy Meter RC HF in the input data.

The table below shows the structure of the payload variant, the measured variables and the data type of the measured values in STEP 7 (TIA Portal) that are stored in the 32 bytes of output data of the module. Each measured variable is referenced via the measured value ID. An overview of all the measured variables with their measured value IDs is provided in the section Reading out and processing measured values (Page 43).

Table 2-869 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
10 ... 11	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038
12 ... 13	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
14 ... 17	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647 to +2147483647	225
18 ... 21	Total reactive energy L1L2L3 (Int32)	DINT	1 varh	-2147483647 to +2147483647	226
22	Reserved	BYTE	-	0	-
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Additional information

If you require further information about the evaluation and interpretation of the measured values, please refer to the section Reading out and processing measured values (Page 43).

Reading and processing measured values 7

7.1 Basics for reading measured values

Introduction

The AI Energy Meter RC HF provides the measured values and variables through the following methods:

- Cyclic: Payload
- Acyclic: Measured value data records

Payload

Payload provide pre-defined or user-defined measured values depending on the configured payload variant. The supplied measured values are cyclically written to the process image of the CPU. With some payload variants, the measured values are supplied as raw data, which you have to convert to the corresponding physical values using a supplied scaling factor.

Measured value data records

Each measured value data record supplies physical values that you can further process immediately. You read the values of a measured value data record acyclically with the RDREC instruction in a PLC tag. You need a corresponding PLC tag for each measured value data record to be read. It is also possible to create the corresponding structure in the static variables of an FB or store this structure in a DB.

You can display the read measured values in a watch table in STEP 7.

NOTE

If you are using CPUs other than S7-1200 or S7-1500, convert 64-bit measured values to 32-bit measured values. Note the conversion can cause loss of accuracy.

For more information, read FAQ: Processing 64-bit floating-point numbers in S7-300/400 (https://support.industry.siemens.com/cs/ww/en/view/56600676).

Validity of the measured values

After turning on the 24 V DC supply voltage, the first measured values are available at terminal 17 after approximately 2 seconds. In the input payload, the content of byte 0 is set to the selected payload variant. You can use this change in byte 0 as a trigger event.

As soon as the module has valid measured values, the value of this byte changes to a value within the value range.

Initial module startup

After the first startup or restart of the module, the parameters are transferred to the module. You can preset a payload variant in the parameters of the hardware configuration. This remains in effect until a different payload variant is selected in the output data (byte 0). This allows input payload to be modified dynamically according to the requirements of the process.

The payload variant defined in parameter data record 128 or configuration tool is used under the following conditions:

- A "0" is written in byte 0 in the output data of a payload variant.
- Byte 0 in the output data of a payload variant contains an invalid value:
  - Coding of the payload variant not available, or
  - Available address space is not sufficient for the selected payload variant.

    See "Selecting the module version".

Current measured values become "0"

The current and all other measured values based on it are suppressed (or set to "0") in the data records and in the payload in the following cases:

- The incoming current of the current measuring transformer is lower than the configured "Low limit for measuring current in relation to nominal value current [0.1%]" parameter
- Fed-in secondary voltage at the current measuring channel is higher than 2 V.

Among others, the following measured values and derived measured variables of the phase involved become "0":

- Effective current value
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A floating mean value is formed from the power values. These only become "0" after a corresponding time. The operating hours counter and the energy counter for active, reactive and apparent energy of the reset phase stops counting.

General reset

With module versions with 20 bytes of output data you can reset some measured values and counter levels.

An edge change of 0 -> 1 at the bit for the general reset has the following effect:

- Counters for energy, operating hours and limits start at "0" again.
- Results of the power quality analysis and the power failure analysis are deleted.
- Minimum and maximum value calculation starts again with initial values.
- Measured values of the measured value recorder are deleted.

For the general reset, set bit 7 in byte 16 of the output payload. (Page 205)

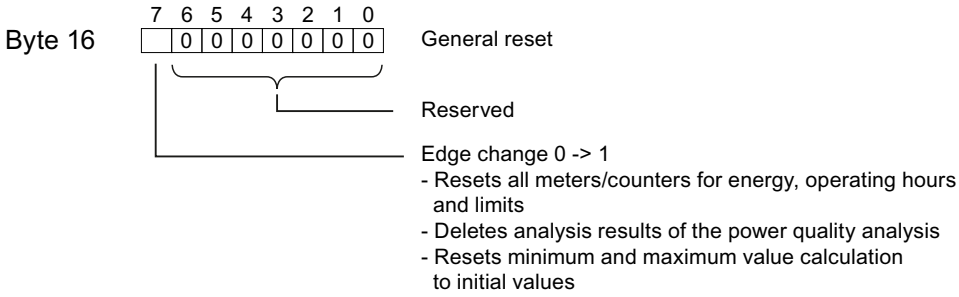

Figure 2-751 Control byte 16 in the output payload for general reset

Substitute value behavior

The substitute values for input values of the AI Energy Meters RC HF amount to "0".

See also

Reading measured values from user data cyclically (Page 52)

7.2 Quality information

Use the quality information to evaluate the status for currents, voltage, operating quadrants and the rotating field.

The AI Energy Meter RC HF provides quality information:

- In byte 1 of the payload
- In measured value IDs 65500 to 65503
- In the power quality analysis Qualifier ID 65496 (Page 99)

See also

Module version "32 I / 20 Q" (Page 205)

7.2.1 Quality information in byte 1 of the user data

For all user data variants, the module provides brief quality information in an 8-bit field in byte 1 for:

- Currents (I_{L1}, I_{L2}, I_{L3})
- Voltages (U_{L1}, U_{L2}, U_{L3})
- Operating quadrant for a phase

Please note that quality information assignment with user data variants for phase-specific measurement (ID 154 to ID 159) is different from user data variant assignment for 3-phase measurement (ID 244 to ID 254).

Quality information in byte 1 of the user data for 3-phase measurement

The quality information for 3-phase measurement is provided by the module in user data variants ID 244 to ID 254.

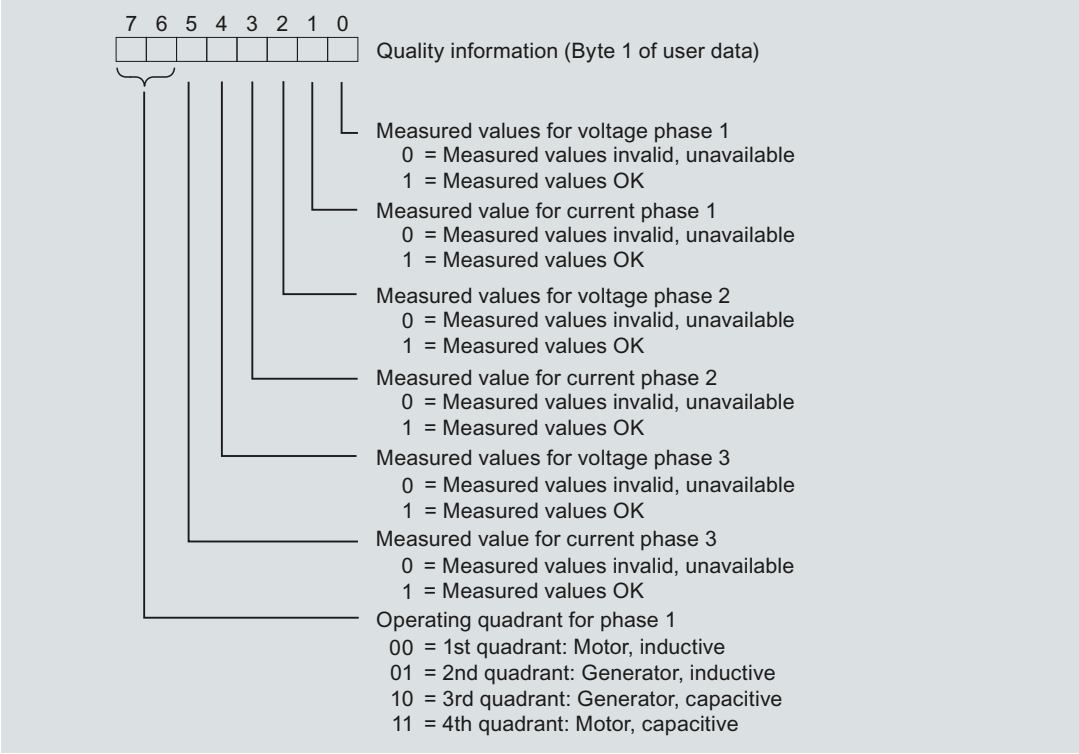

Figure 2-752 Assignment of byte 1 for user data variants ID 224 to ID 254

Quality information in byte 1 for phase-specific measurement

The quality information for phase-specific measurement is provided by the module in user data variants ID 154 to ID 159.

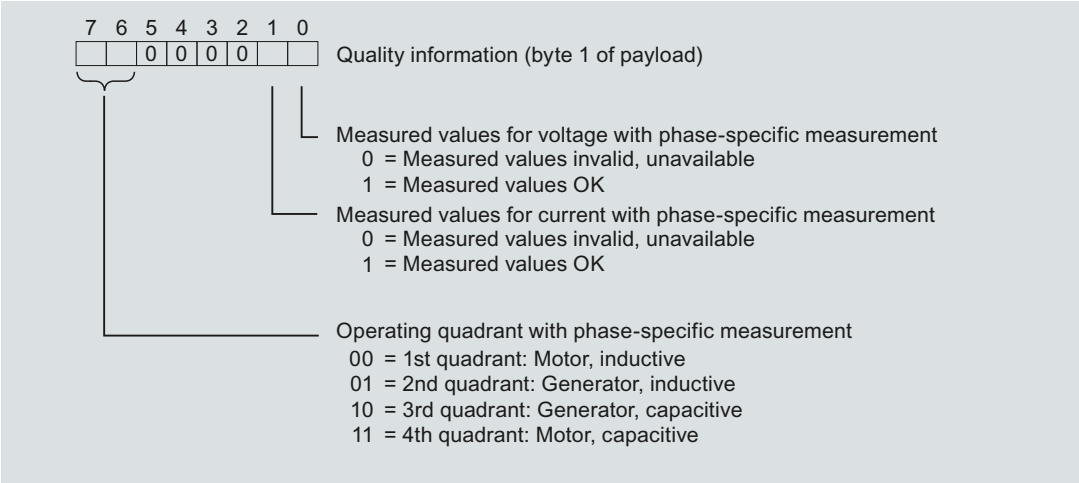

Figure 2-753 Byte 1 assignment for user data variants ID 154 to ID 159

7.2.2 Quality information with measured value IDs

Complete quality information is provided by the module in a 16-bit field with measured value IDs 65500 to 65503.

- Measured value ID 65503 for 3-phase measurement
- Measured value ID 65500, 65501 or 65502 for phase-specific measurement in phase 1, phase 2 or phase 3

Quality information with measured value ID 65503 for 3-phase measurement

The quality information for 3-phase measurement is provided by the module with:

- User data variant "Basic variables quality values three-phase measurement (ID 240 or $F0_H$)"
- User data (measured value ID 66503)
- Measured value data record 150

The measured value ID 65503 provides information on:

- Currents (I_{L1}, I_{L2}, I_{L3})
- Voltages (U_{L1}, U_{L2}, U_{L3})
- Operating quadrants for all 3 phases
- Rotating field for the 3-phase system

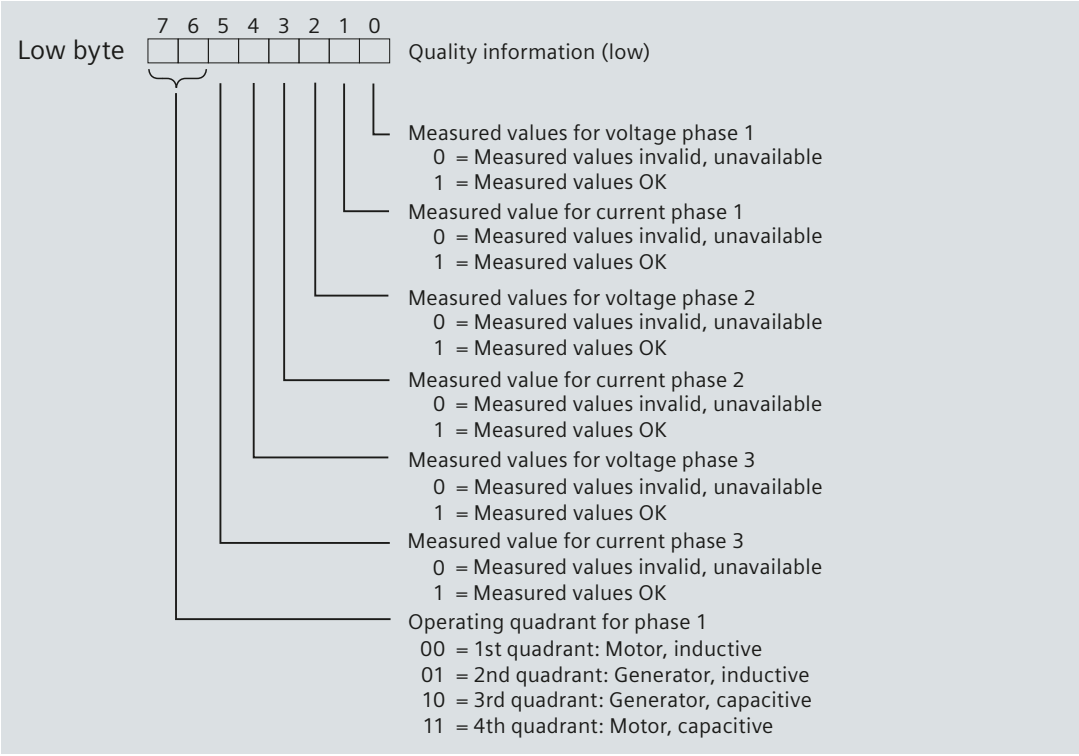

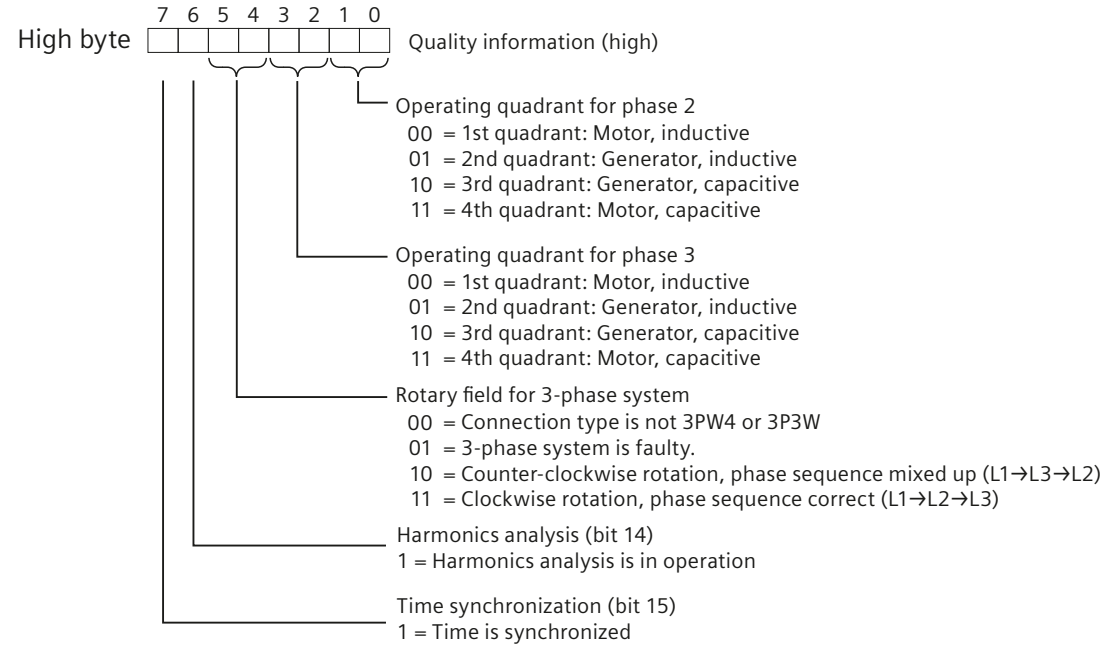

Figure 2-754 Quality information for low and high byte of the measured value ID 65503

Quality information with measured value ID 65500, 65501 or 65502 for phase-specific measurement

The module provides quality information for phase-specific measurement in phase 1, phase 2 or phase 3 with:

- User data (with measured value ID 65500, 65501 or 65502)
- Measured value data record DS 147, 148 or 149

Measured value IDs 65500, 65501 and 65502 provide information on:

- Current of the phase in question
- Voltage of the phase in question
- Operating quadrant of the phase in question

In contrast to the assignment for measured value ID 65503 (figure above), measured value IDs 65500, 65501 and 65502 only contain the phase-specific information for current, voltage and operating quadrant. The information about the other phases and the rotating field have the value 0.

7.2.3 Operating quadrant

The figure below shows the quality information of the operating quadrants.

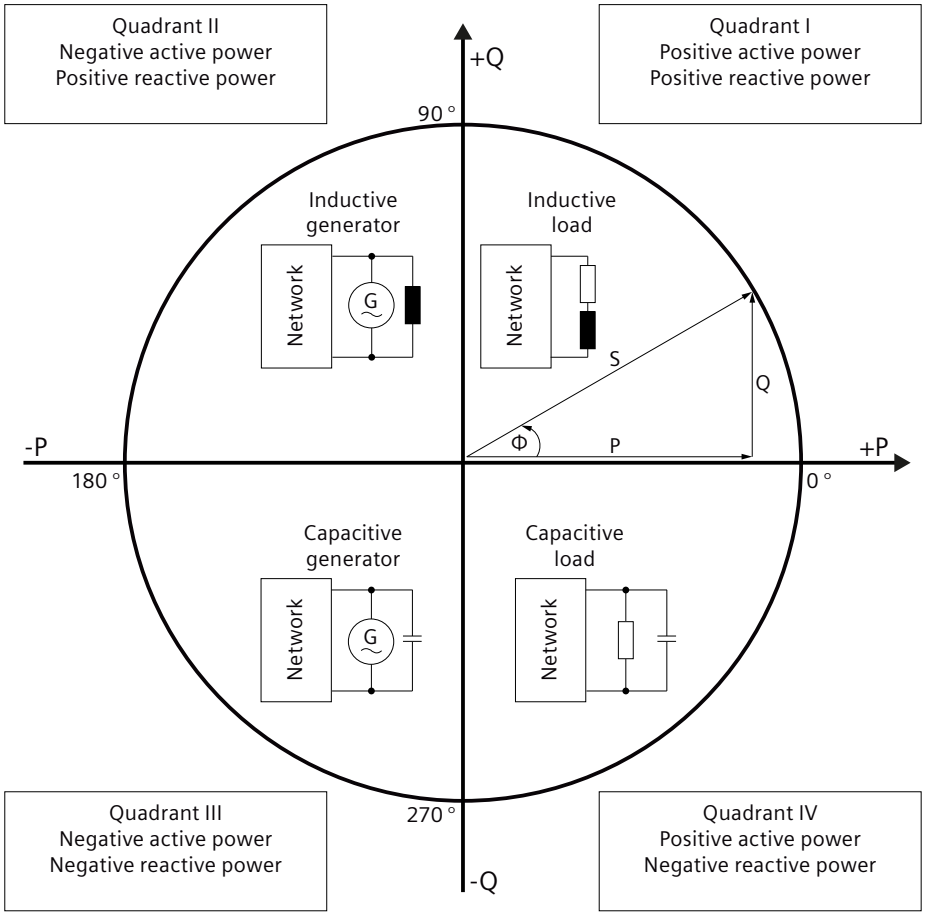

Figure 2-755 Quadrant in the quality bits

7.2.4 Notes for the detection of wiring errors and incorrect rotating field

A variety of quality information is available to evaluate the correct wiring of the Energy Meter and the applied rotary field.

Requirement

Detecting the rotating field requires 3-phase operation with 3P4W or 3P3W connection types.

In byte 1 of the payload, section 7.2.1 or measured value IDs 65500-65503, section 7.2.2

Information on the validity of the measured currents and voltages is encoded in bits 0 to 5.

Information on the operating quadrants is encoded in the bits 6 to 7, see section 7.2.3 (Page 50)

Phase angle between voltages and currents, measured value phase angle Ln

Based on the phase angle, you can recognize whether the flow direction of the current is correct and whether the voltage or current connections have been swapped. You cannot recognize, however, which phases are swapped and how. If the wiring is correct, the phase angle for the consumer must be in the range from 270° to 359° or -0° to -90°. For generators, the phase angle with correct wiring is in the range from 90° to 270° or -180° to -90°.

Angle between the voltages, measured value phase angle ULx-ULy

Based on the phase angle between the voltages, you can check the correct phase sequence and detect an unwanted same-phase connection.

In a symmetrical three-phase network, the angle between the phase voltages is +120°(-240°) or -120°(+240°).

Angle between currents, measured value phase angle ILx-ILy

Based on the phase angle between the currents, you can check the correct phase sequence and flow direction as well as detect an unwanted same-phase connection.

For a symmetrical load, the phase angles between the currents are identical to those between the voltages.

Line-to-line voltage, measured value ULx-ULy

You can detect an unwanted same-phase connection using the line-to-line voltage whose calculation takes into account the angles between the voltage phases.

See also

FAQ (https://support.industry.siemens.com/cs/ww/en/view/109755917)

7.3 Reading measured values from user data cyclically

Requirement

- STEP 7 is open.
- The AI Energy Meter RC HF is configured.

Scaling of measured values in the payload

Since the value range of 16-bit values is often smaller than the value range of the physical value, a scaling factor is supplied together with the basic value in the payload for the respective measured or calculated values. You determine the actual value of the measured variable with the following formula:

Actual value of measured quantity = measured value in the payload x $10^{\text{scaling factor}}$

Procedure

To read measured values from the payload cyclically, proceed as follows:

1. Read the relevant measured value from the input data.
2. Observe the scaling factor at scaled measured values and convert the read measured value using the scaling factor.

Example

The payload variant 254 (FE_H) "Total power L1L2L3" is configured on the AI Energy Meter RC HF. The measured value for "Current L1" should be read.

Table 2-870 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
10 ... 11	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038
12 ... 13	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036

Byte	Allocation	Data type	Unit	Value range	Measured value ID
14 ... 17	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647 to +2147483647	225
18 ... 21	Total reactive energy L1L2L3 (Int32)	DINT	1 varh	-2147483647 to +2147483647	226
22	Reserved	BYTE	-	0	-
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

In the payload variant FE_H (254) the measured value for the current L1 is stored in Byte 2 + 3. The current is supplied by the module as a 16-bit-fixed-point number in the value range from 0 to 65535 in the unit 1 mA. In addition the scaling factor for the current L1 has to be considered additionally. The module supplies the related scaling factor in Byte 24.

The actual value for current L1 is calculated as follows:

Actual value for current L1 = Current L1 x $10^{\text{Scaling current L1}}$

See also

Basics for reading measured values (Page 43)

7.4 Read out measured values acyclically using data records

With all module versions you can read out the measured values using data records.

An overview of all measured value data records and exact information about the structure is available in the appendix Overview of all measured value data records (Page 233).

Requirement

In the STEP 7 project you have created a PLC data type that has an identical structure to the data record you want to evaluate.

Example of the structure of a data record

The following overview shows the structure of the data record DS 142.

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	3	-	-
1	Reserved	UINT8	0	-	-
2...5	Voltage UL1-N	REAL	V	0.0 ... 1000000.0	1
6...9	Voltage UL2-N	REAL	V	0.0 ... 1000000.0	2
10...13	Voltage UL3-N	REAL	V	0.0 ... 1000000.0	3
14...17	Voltage UL1-L2	REAL	V	0.0 ... 1000000.0	4
18...21	Voltage UL2-L3	REAL	V	0.0 ... 1000000.0	5
22...25	Voltage UL3-L1	REAL	V	0.0 ... 1000000.0	6
26...29	Current L1	REAL	A	0.0 ... 100000.0	7
30...33	Current L2	REAL	A	0.0 ... 100000.0	8
34...37	Current L3	REAL	A	0.0 ... 100000.0	9
:		:	:	:	:
210...2-13	Neutral current	REAL	A	0.0 ... 100000.0	61149

Procedure

1. Read the desired data record with the RDREC instruction.

   The measured values are in the target range of the data block which you specified with the RDREC instruction.

2. Evaluate the measured values for the desired measured variables.

NOTE

If you want to read or write several data records at the same time in the user program, note that the number of active jobs that you started with the RDREC or WRREC instruction is limited by the resources of the CPU used.

7.5 Time-of-day synchronization and time stamp

The AI Energy Meter RC HF supports time-of-day synchronization and time stamp.

Time-of-day synchronization is only supported by IM 155-6 PN HF as of firmware version V4.2.

Time stamps are used to date the exact occurrence of information. You can find time information in the measured value data records "Measured value data record for maximum values with time stamp (DS 154)" and "Measured value data record for minimum values with time stamp (DS 155)", for example, or the power quality analysis data records DS160, DS161 and DS163. In addition, time information is required for the evaluation of the "Power failure analysis" function (see section Power failure analysis (Page 95)).

For the time on the AI Energy Meter RC HF to correspond to the current system time, the clock must be synchronized externally. Information on this and additional requirements can be found in the application example (https://support.industry.siemens.com/cs/ww/en/view/109754890). In the absence of time-of-day synchronization, the internal time stamp of the AI Energy Meters RC HF starts at 01.01.1970, 0:00.

Structure of the time stamp

The table below shows the structure of the time stamp:

Byte	PNIO Time	Format	Length
0	Status 0: Synchronization from system time master available 1: Local synchronization available 2: No synchronization available	UINT16	2 bytes
2	Seconds high	UINT16	2 bytes
4	Seconds low	UINT32	4 bytes
8	Nanoseconds	UINT32	4 bytes

The start value (initial value) is 01.01.1970, 0:00.

NOTE

If you use the implementation from the FAQ, the status is always 2.

Energy counters

8

Introduction

The AI Energy Meter RC HF provides several energy and overflow counters that detect both line-based and phase-based energy values, e.g.:

- Active energy (total, outflow, inflow)
- Reactive energy (total, outflow, inflow)
- Apparent energy (total)
- "Output" describes the regenerative operation of the connected system.
- "Reference" describes the motor operation of the connected system.

Retentivity

The AI Energy Meter RC HF stores all counter values retentively. After an interruption (e.g. Power System Off), the energy counting resumes with the retentively stored values.

Functions

The energy meters provide the following basic functions:

- Measured values for infinite and periodical counting can be read out

  End values for periodic counting: 10^3, 10^6, 10^9, 10^{12} and 10^{15} can be selected with overflow counters
- Measuring ranges can be changed in RUN
- Starting and stopping counters via gate is possible
- Preset and apply start values in RUN
- Measured variables can be evaluated via data records and payload.

8.1 Evaluate measured values for energy

There are two ways of evaluating the measured values:

- Reading measured values using the instruction "RDREC".
- Reading measured values from the payload variants (not for module versions with 2 bytes of input data).

Data records for energy meters

You can read out measured values for energy and overflow counters in the following data records.

The evaluation of measured data using data records is described in section Reading out measured values ayclically using data records (Page 53).

Name of the data record	Number of the data record	Comment
Data record for basic measured values (Page 234)	Data record 142	Measured values of the total energy L1L2L3
Data record for energy meter (Page 240)	DS 143	Measured values of energy and overflow counters for phases L1, L2 and L3
Data record for phase-specific measured values L1 (Page 248)	DS 147	Measured values of the phase-specific energy meters L1
Data record for phase-specific measured values L2 (Page 252)	DS 148	Measured values of the phase-specific energy meters L2
Measured value data record for phase-specific measured values L3 (Page 255)	DS 149	Measured values of the phase-specific energy meters L3

Payload variants for energy meters

You can read out measured values for energy and overflow meters in the following payload variants.

The evaluation of measured data using payload variants is described in section Reading measured values cyclically from payload (Page 52).

Name of the payload variant	Number of the payload variant	Comment
Total energy L1 L2 L3	ID 249 or $F9_H$	Measured values of the total energy L1L2L3
Energy L1	ID 248 or $F8_H$	Measured values of the phase-specific energy meters L1
Energy L2	ID 247 or $F7_H$	Measured values of the phase-specific energy meters L2
Energy L3	ID 246 or $F6_H$	Measured values of the phase-specific energy meters L3
Basic variable quality measurement three-phase measurement	ID 240 or $F0_H$	Status on the overflow of the energy meters for phases L1, L2 and L3
Basic variables energy meter measurement (periodic) L1L2L3	ID 239 or EF_H	Number of counter overflows for energy of phases L1, L2 and L3
EE@Industry measurement data profile E3	ID 227 or $E3_H$	Measured values for total active energy and total reactive energy L1L2L3
EE@Industry measurement data profile E2	ID 226 or $E2_H$	Measured values for total active energy L1L2L3

Name of the payload variant	Number of the payload variant	Comment
Basic variables for phase-specific measurement L1 (Page 217)	ID 159 or $9F_H$	Measured values for phase-specific active, reactive and apparent energy for phase L1
Basic variables for phase-specific measurement L1a	ID 158 or $9E_H$	Measured values for phase-specific active, reactive and apparent energy for phase L1
Basic variables for phase-specific measurement L2	ID 157 or $9D_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L2
Basic variables for phase-specific measurement L2a	ID 156 or $9C_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L2
Basic variables for phase-specific measurement L3	ID 155 or $9B_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L3
Basic variables for phase-specific measurement L3a	ID 154 or $9A_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L3
User-defined payload variant	ID 1 or 01_H and ID 2 or 02_H	Measured variables for energy can be selected in a user-defined manner

8.2 Preset and apply start values for energy and overflow counters

At the beginning of a new work order, it may be useful to start the energy and overflow counter with new start values.

Define the new start values for the energy and overflow counter in data record DS 143.

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

For **all** module versions there are two ways of applying the start values:

- Transfer start values from data record DS 143 and apply them **immediately**
- Transfer start values from data record DS 143 and only apply them after setting a special bit (DQ bit for counter reset)

Both options are described in the following sections.

General reset

With module versions with 20 bytes of output data you can reset the energy and overflow counters. With a general reset, you cannot preset any start values; the start values for energy and overflow counters are always zero with a general reset.

You can find additional information on the general reset in the section Basics for reading measured values (Page 43).

8.2.1 Preset start values for the energy meters

Define the start values for the energy and overflow meters in data record DS 143.

Introduction

You have created a PLC data type that has an identical structure to data record DS 143.

Structure of data record DS 143

The following overview shows the structure of the data record DS 143 in simplified form.

More detailed information about the structure of data record DS 143 is available in section Structure of energy meters (DS 143) (Page 240).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Control byte 1 - L1	BYTE	Bit string	-	-
3	Control byte 2 - L1	BYTE	Bit string		
4	Control byte 1 - L2	BYTE	Bit string		
5	Control byte 2 - L2	BYTE	Bit string		
6	Control byte 1 - L3	BYTE	Bit string		
7	Control byte 2 - L3	BYTE	Bit string		
8...15	Start value for active energy inflow L1	LREAL	Wh	You will find the exact assignment in the section Structure of energy meters (DS 143) (Page 240).	61180
16...23	Initial value active energy outflow L1	LREAL	Wh		61181
:	:	:	:		:
128...1-29	Start value for overflow counters active energy inflow L1	UNIT	-		61190
130...1-31	Start value for overflow counter active energy outflow L1	UNIT	-		61191
:	:	:	:		

Assignment of data record DS 143

Byte 0 and Byte 1: Version of the data record

Header information for the version of the data record.

Byte 2 ... Byte 7: Control bytes for energy and overflow counter

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy meters, overflow counters and operating hours counters. The length of the control information amounts to 2 bytes for each phase.

Byte 8 ... Byte 127: Start values for the individual energy meters

The start values for energy meters in data record 143 are 64-bit floating point numbers. The format corresponds to the data type LREAL in S7-1200 and in S7-1500.

Byte 128 ... Byte 157: Initial values for overflow counters

The initial values for overflow counters in data record 143 are 16-bit integers. The format corresponds to the data type UINT in S7-1200 and in S7-1500.

8.2.2 Apply start values from data record DS 143 immediately

It is possible to apply the start values for energy counters and overflow counters for each **individual** phase separately by active, reactive and apparent energy.

Requirement

In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and you have entered the start values.

Procedure for all module versions

1. In control byte 2 of the DS 143 (bytes 3, 5 and 7), for each phase set the category of the energy meters (active, reactive, apparent energy) for which you want to set the start values.

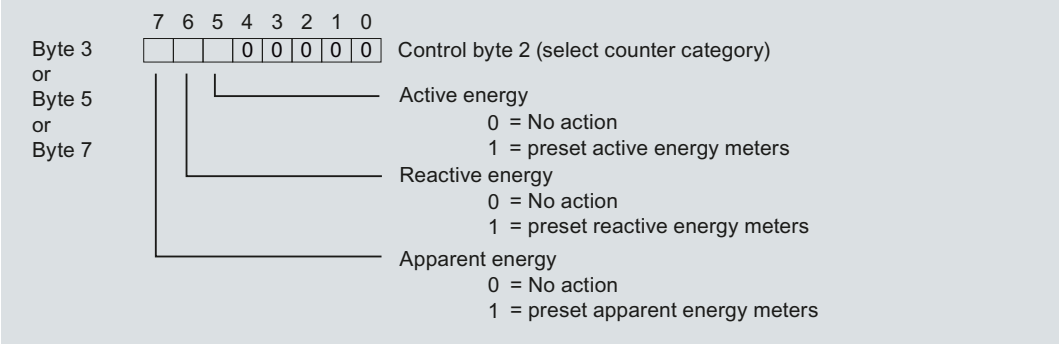

Figure 2-756 Assignment of control byte 2 in DS 143

2. In control byte 1 of DS 143 (bytes 2, 4 and 6), for each phase define whether you want to apply the start values for energy or overflow counters.

   Applying depends on the category selection from control byte 2.

   – Set Bit 0 if you want to apply the start values for the overflow counters.
   – Set Bit 2 if you want to apply the start values for the energy meters.

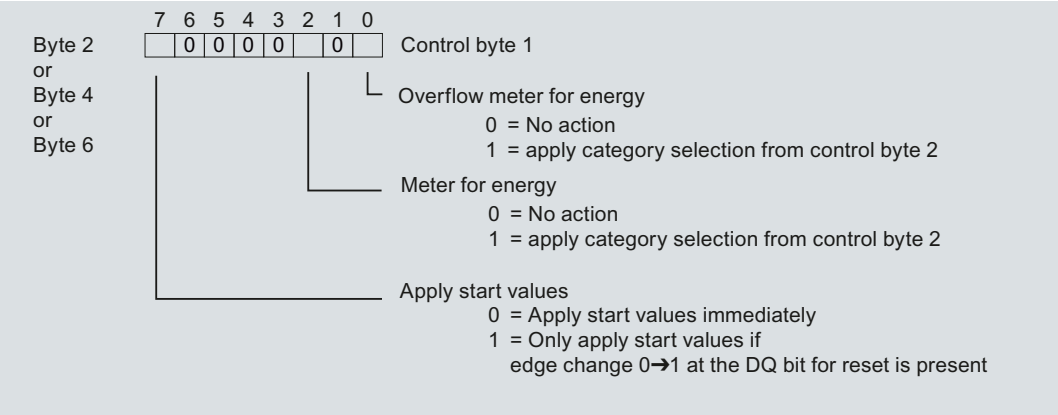

Figure 2-757 Assignment of control byte 1 in DS 143

3. In control byte 1 of DS 143 define that you want to immediately apply the start values.
   – Set Bit 7 to 0 so that the start values are immediately applied after writing the data record.
4. Transfer the data record with the WRREC instruction to the CPU.

8.2.3 Apply start values from data record DS 143 with DQ bit

Due to the differing lengths of the output data, setting of the start values for the energy counters and overflow counters depends on the configured module version.

Module versions with 20 bytes of output data

If you use module versions with 20 bytes of output data, you can:

- Apply start values for energy counters and overflow counters for **all** phases separately by active, reactive and apparent energy.
- Apply start values for energy counters and overflow counters for each **individual** phase separately by active, reactive and apparent energy.

Module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, then you always apply the start values for **all** the energy counters and overflow counters simultaneously.

Requirement

- In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and have entered the start values.

  Applying depends on the category selection from control byte 2.

  – Set Bit 0 if you want to apply the start values for the overflow counters.

  – Set Bit 2 if you want to apply the start values for the energy meters.
- In control byte 1 of the DS 143 you have set Bit 7 to "1" (apply start values via DQ bit)
- You have transferred the data record DS 143 with new start values to the CPU. The assignment of the data record can be found in Structure of energy meters (DS143) (Page 240).

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

Procedure for module version with 20 bytes of output data

Apply start values for energy counters and overflow counters for all three phases

1. In Byte 2 of the output data, select the categories for which you want to apply start values.

   – Set bit 5 for active energy counters.

   – Set bit 6 for reactive energy counters.

   – Set bit 7 for apparent energy counters.

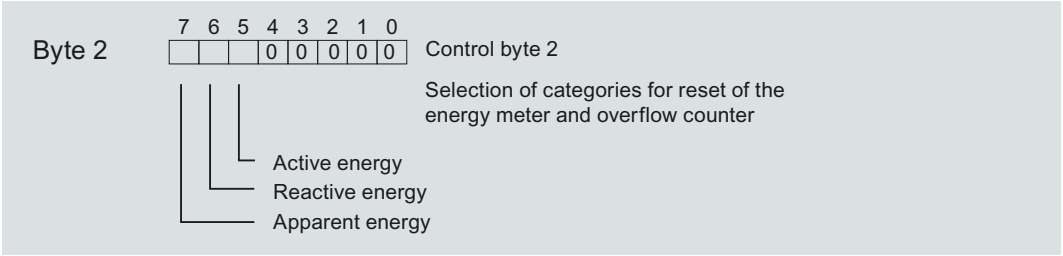

Figure 2-758 Selection of categories for reset

2. Set the reset bit (Bit 7) in byte 1 of the output data.

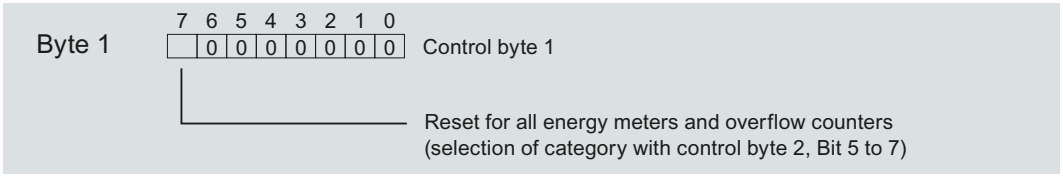

Figure 2-759 Reset bit for energy and overflow counter

If there is an edge change of the reset bit from 0 -> 1, the module resets the energy and overflow counters that you previously selected in byte 2 to their start values.

Apply start values for energy counters and overflow counters for phase-specific counting

You can also reset the energy and overflow counters on a phase-specific basis using the output data.

Follow the procedure as described in "Applying start values for energy counters and overflow counters for all three phases", as applicable.

1. In bytes 7, 9 and 11 of the output data, select the categories for which you want to apply the phase-specific start values.
   - Set Bit 5 for active energy counters.
   - Set Bit 6 for reactive energy counters.
   - Set Bit 7 for apparent energy counters.

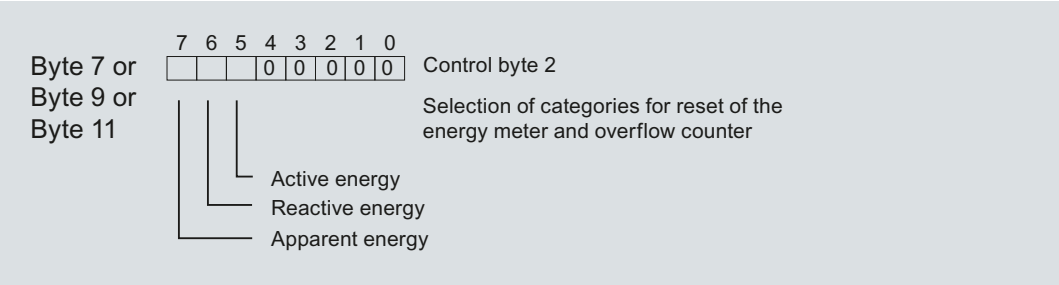

Figure 2-760 Selection of category

2. In bytes 6, 8 and 10 of the output data, set the reset bits (Bit 7) for the phase-specific start values.

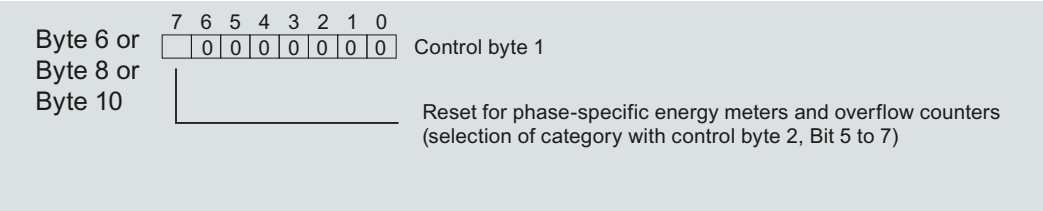

Figure 2-761 Reset bit for phase-specific energy and overflow counters

If there is an edge change of the phase-specific reset bit from 0 -> 1, the module resets the energy and overflow counters that you previously selected in bytes 7, 9 and 11 to their start values.

Procedure for module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, always apply the start values **for all** the energy counters and overflow counters.

- Set the reset bit (Bit 7) in byte 1 of the output data.

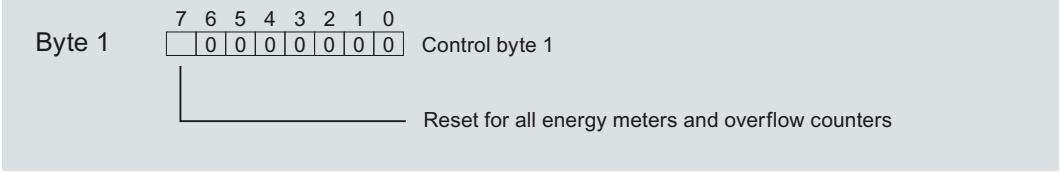

Figure 2-762 Reset bit for all energy and overflow counters

If there is an edge change of the reset bit from 0 -> 1, the module resets **all** energy and overflow counters to their start values.

8.3 Starting and and stopping energy meters

There are two ways of starting or stopping measurement with the energy meter AI Energy Meter RC HF:

- Counting with gate

  The module starts counting when you set the DQ bit for the counter gate in the output data using an edge change from 0 -> 1. If you reset the DQ bit using an edge change from 1 -> 0, the counter stops.

- Counting without gate

  The module starts counting immediately as soon as the module is switched on. Counting cannot be stopped.

Both options are described in the following sections.

Counting with gate

Requirements:

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

If you wish to start counting using the gate, proceed as follows:

1. Activate the parameter "Enable energy meter gate" in the parameter assignment of the module.
2. Set the DQ bit for the counter gate (Bit 6) in control byte 1 in the output data.

The module starts counting as soon as there is an edge change from 0 -> 1 at the DQ bit for the counter gate.

If you wish to stop the counting again, then reset Bit 6 in control byte 1 in the output data. Counting stops at an edge change from 1 -> 0.

The "Enable gate control for the energy counter" parameter and the DQ bit for the "counter date" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

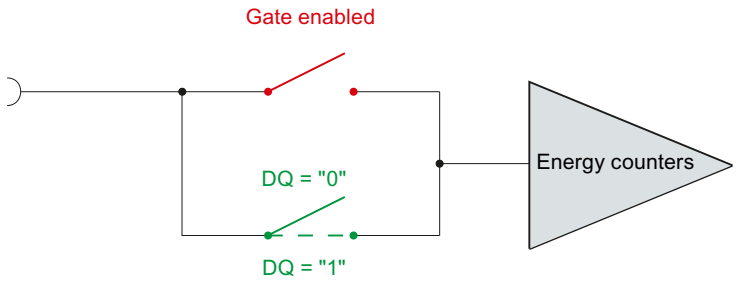

Figure 2-763 Gate enabled

NOTE

Module-global/phase-granular PLC

If you are using the gate control for all three phases simultaneously, use the control byte 1 at output address 1. For a phase-specific resolution of the gate control, use the addresses 6 (Phase1), 8 (Phase2) or 10 (Phase3) as control byte 1. The resolution of a module-global PLC overrules a phase-granular resolution.

Counting without gate

Requirement

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

Deactivate the parameter "Enable energy meter gate" in the parameter assignment of the module.

The module starts counting as soon as the module is started. The counter continues to count.

Gate disabled: Gate is always "open" (signal path closed)

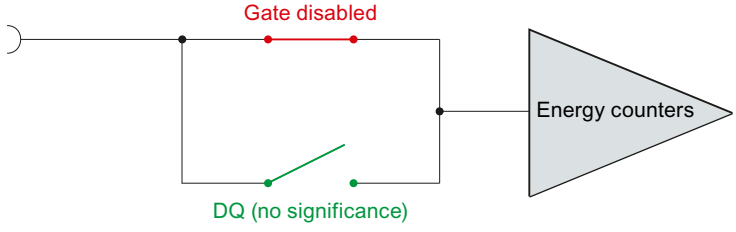

Figure 2-764 Gate disabled

8.4 Example of measuring and resetting an energy meter

The following figure shows resetting and starting/stopping with activated gating using the energy meter as an example:

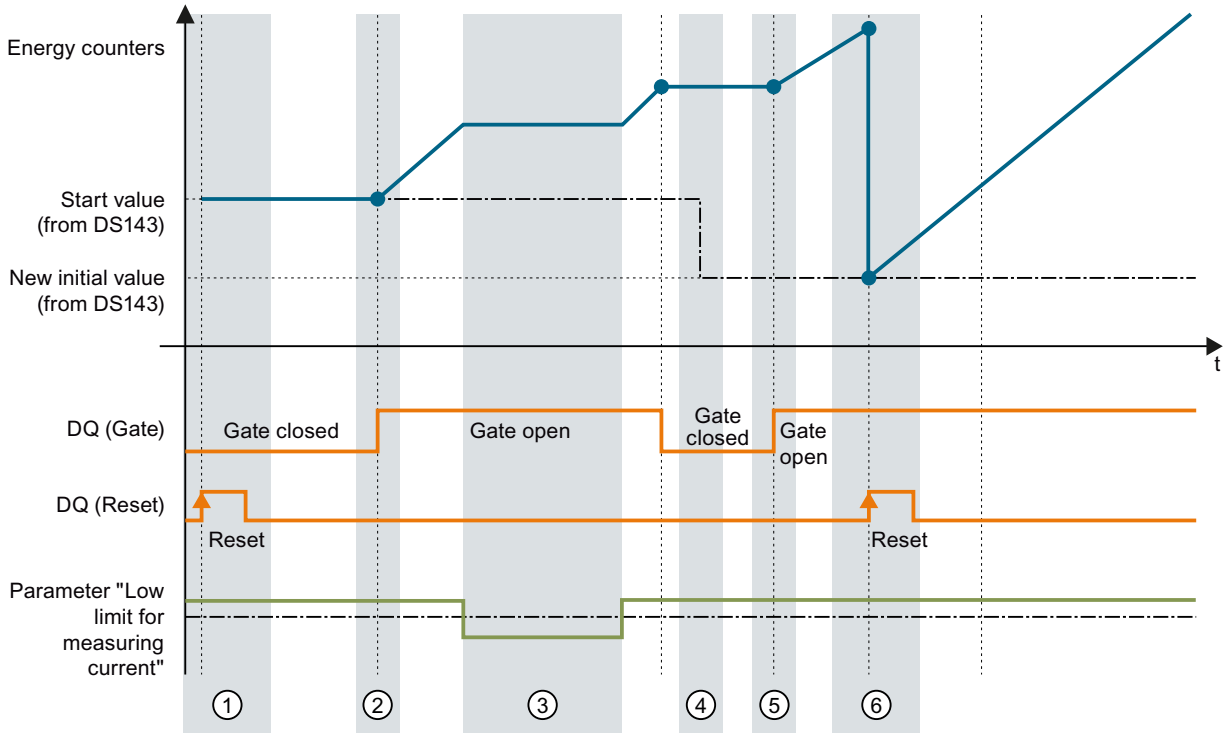

① The counter is reset to the value specified in the configuration. The gate is closed. The counter does not count.

② The gate is opened via the control byte 1 in the output data of the user data variant. The counter counts.

③ The configured current low limit has been violated. The counter does not count.

④ The gate is closed. The counter does not count. A new start value is written to the measured value data record 143 (Page 240) with the WRREC instruction.

⑤ The gate is opened again via the control byte 1 in the output data of the user data variant. The counter counts with the new start value.

⑥ The counter is reset via the control byte 1 in the output data of the user data variant. The counter counts from the new start value that was transferred via the measured value data record 143.

Figure 2-765 Example of an energy meter

8.5 What is the structure of the control and feedback interface for DS 143?

Introduction

Bytes 2 to 7 of data record 143 (Page 240) form the phase-based control and feedback interface for the data record DS 143.

- Bytes 2 and 3: Control and feedback interface for phase 1
- Bytes 4 and 5: Control and feedback interface for phase 2
- Bytes 6 and 7: Control and feedback interface for phase 3

Status information

When data record 143 is read with the RDREC instruction, Bytes 2 to 7 supply phase-specific status information for energy counters, overflow counters and operating hours counters.

The status information enables you can see which counters are returning their values in the data record 143. If energy counters return their values in the status byte 1, you can determine the type of energy counter with status byte 2.

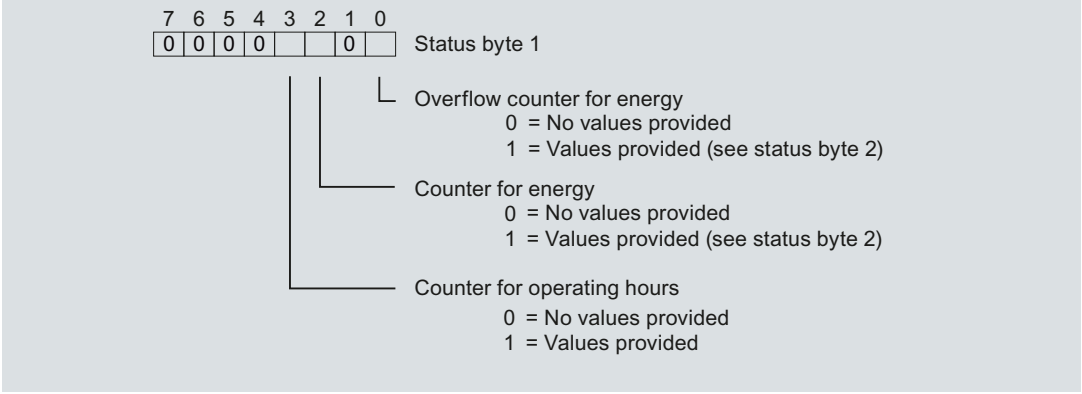

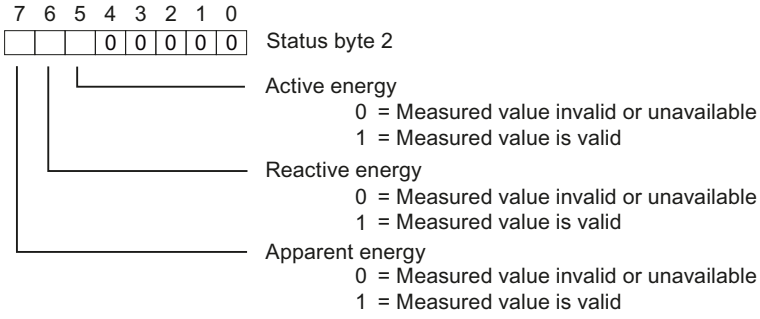

Figure 2-766 Status information DS 143 (read access)

Control information

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy meters, overflow counters and operating hours counters. The length of the control information amounts to 2 bytes for each phase:

- In control byte 1 you determine which counter you want to preset and the time at which counters are to be preset.

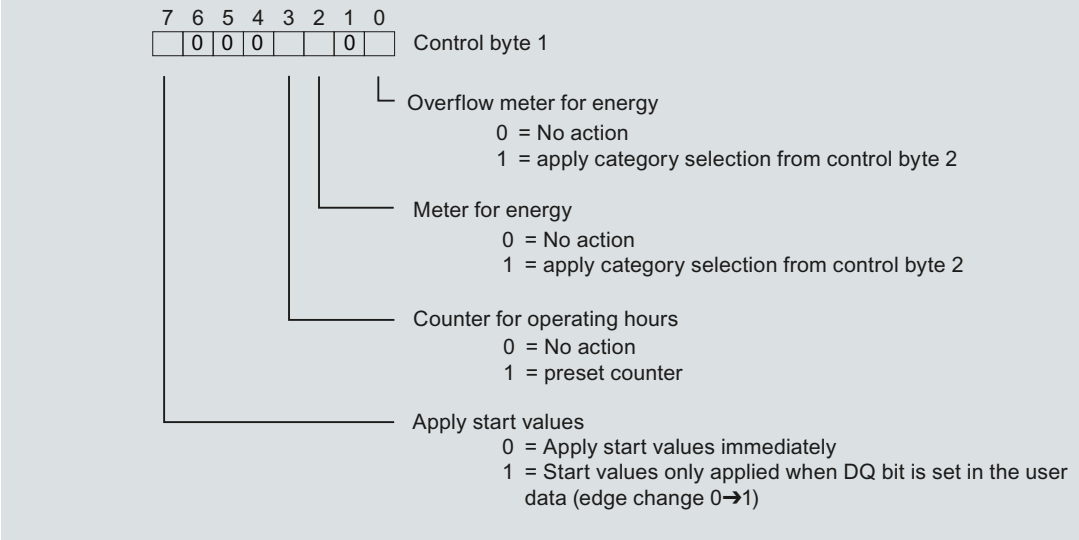

Figure 2-767 Control information DS 143, control byte 1 (write access)

- In control byte 2 you determine which energy meter categories you want to preset.

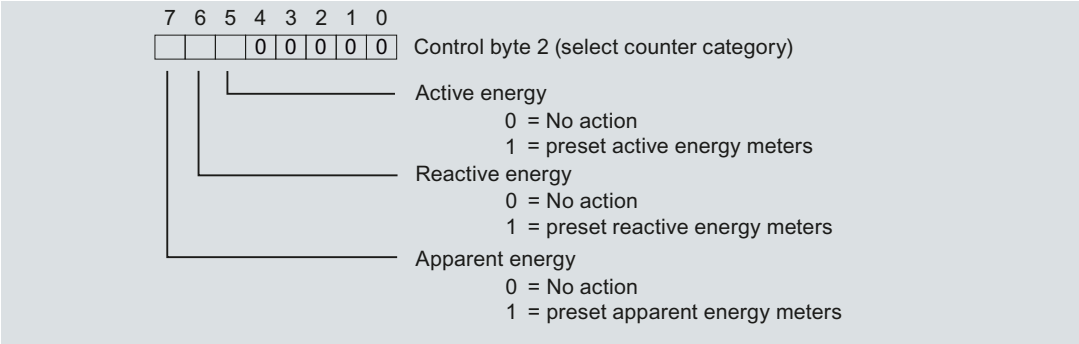

Figure 2-768 Control information DS 143, control byte 2 (write access)

Operating hours counter

9

Introduction

The AI Energy Meter RC HF provides four operating hours counters which count the operating hours of the connected consumers:

- Three phase-specific operating hours counters
- 1 operating hours counter which displays the value of the largest phase-specific operating hours counter.

Retentivity

The AI Energy Meter RC HF stores all counter values retentively. After an interruption (e.g. Power System Off), counting resumes with the retentively stored values.

Functions

The operating hours counters provide the following basic functions:

- Measuring ranges from 0 to 3.4 x 10^{38} hours.
- Starting and stopping operating hours counters via gate
- Preset and apply start values in RUN
- Evaluating counter states using data records and payload

9.1 Evaluating operating hours counters

There are two ways of evaluating the operating hours counters:

- Reading counter states using data records with the instruction RDREC.
- Reading counter states from the user-defined payload variants.

Data records for operating hours counter

You can read out measured values for operating hours in the following data records.

The evaluation of measured data using data records is described in section Reading out and processing measured values (Page 43).

Name of the data record	Number of the data record	Comment
Data record for energy meter (Page 240)	DS 143	Phase-specific operating hours counter for phase L1, phase L2, phase L3 and largest phase-specific operating hours counter L1L2L3
Measured value data record for advanced measurement and status values	DS 150	
Measured value data record of user-defined data record (Page 261)	DS 151	Operating hours counters can be selected in a user-defined manner

Payload variants for operating hours counters

You can read out measured values for operating hours in the following payload variants.

The evaluation of measured data using payload variants is described in section Payload variants with 32 bytes input data / 20 bytes output data (Page 217).

Name of the payload variant	Number of the payload variant	Comment
User-defined payload variant	ID 1 or 01_H and ID 2 or 02_H	Operating hours counters can be selected in a user-defined manner

9.2 Preset and apply start values for operating hours counters

Introduction

At the beginning of a new work order, it may be useful to start counting of the operating hours counters with new start values.

Define the new start values for the operating hours counters in data record DS 143.

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

For **all** module versions there are two ways of applying the start values:

- Transfer start values from data record DS 143 and apply them **immediately**
- Transfer start values from data record DS 143 and only apply them after setting a special bit (DQ bit for operating hours counter reset)

Both options are described in the following sections.

General reset

With module versions with 20 bytes of user data you can reset the operating hours counters. With a general reset, you cannot preset any start values; the start values for operating hours counters are always zero with a general reset.

You can find additional information on the general reset in the section Basics for reading measured values (Page 43).

9.2.1 Preset start values for operating hours counters

Define the start values for operating hours counters using data record DS 143.

Introduction

You have created a PLC data type that has an identical structure to data record DS 143.

Structure of data record DS 143

The following overview shows the structure of the data record DS 143 in simplified form.

More detailed information about the structure of the data record 143 is available in section Structure of energy meters (DS 143) (Page 240).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Control byte 1 - L1	BYTE	Bit string	-	-
3	Control byte 2 - L1	BYTE	Bit string		
4	Control byte 1 - L2	BYTE	Bit string		
5	Control byte 2 - L2	BYTE	Bit string		
6	Control byte 1 - L3	BYTE	Bit string		
7	Control byte 2 - L3	BYTE	Bit string		
8...15	Start value for active energy inflow L1	LREAL	Wh	You will find the exact assignment	61180
16...23	Initial value active energy outflow L1	LREAL	Wh		61181
:	:	:	:		:

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
158...161	Start value operating hours L1	REAL	h	in the section Structure of energy meters (DS 143) (Page 240).	65505
162...165	Start value operating hours L2	REAL	h		65506
166...169	Start value operating hours L3	REAL	h		65507

Assignment of data record DS 143

Byte 0 and Byte 1: Version of the data record

Header information for the version of the data record.

Byte 2 ... Byte 7: Control bytes for energy and overflow counter

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy meters, overflow counters and operating hours counters. The length of the control information amounts to 2 bytes for each phase.

Byte 8 ... byte 157: Start values for the individual energy meters and overflow counters

The start values for energy counters in data record 143 are 64-bit floating point numbers. The format corresponds to the data type LREAL in S7-1200 and in S7-1500.

The initial values for overflow counters in data record 143 are 16-bit integers. The format corresponds to the data type UINT in S7-1200 and in S7-1500.

Byte 158 ... byte 169: Start values for operating hours counter

The start values for operating hours counters in data record 143 are 32-bit floating-point number. The format corresponds to the data type REAL in S7-1200 and in S7-1500.

9.2.2 Apply start values from data record DS 143 immediately

Applying the start values for each separate operating hours counter is possible.

Requirement

In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and you have entered the start values.

Procedure for all module versions

1. In Control byte 1 of DS 143 (bytes 2, 4 and 6), for each phase, define that you want to immediately apply the start values for operating hours counters.
   - Set the Bit 3 to 1 so that the start values for the operating hours counters are preset.
   - Set the Bit 7 to 0 so that the module **immediately** applies the start values after writing the data record.

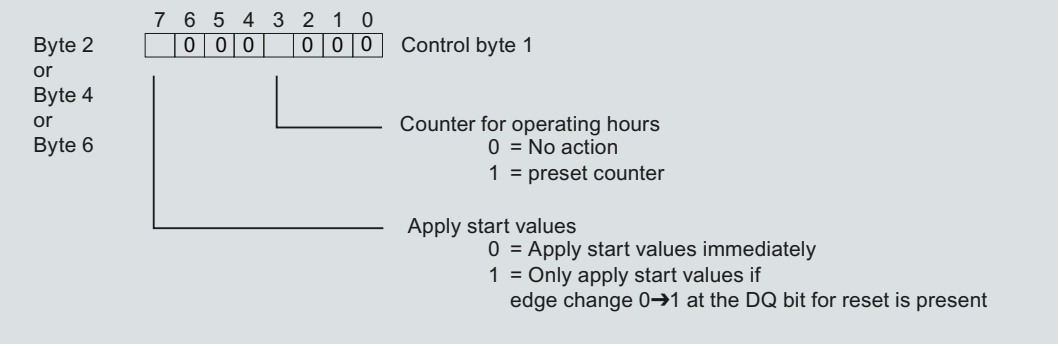

Figure 2-769 Allocation of the control bytes in DS 143 for operating hours

2. Transfer the data record with the WRREC instruction to the CPU.

9.2.3 Apply start values from data record DS 143 with DQ bit

Due to the differing lengths of the output data, setting of the start values for the operating hours counters depends on the configured module version.

Module versions with 20 bytes of output data

If you use module versions with 20 bytes of output data, you can:

- Apply start values for **all** operating hours counters.
- Apply start values for **individual** operating hours counters separately.

Module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, apply the start values for **all** operating hours counters simultaneously.

Requirement

- In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and have entered the start values.
- Set the Bit 3 to 1 so that the start values for the operating hours counters are preset.
- In control byte 1 of DS 143 you have set Bit 7 to "1" (apply start values via DQ bit). (see previous figure)
- You have transferred the data record DS 143 with new start values to the CPU. The assignment of the data record can be found in Structure of energy meters (DS143) (Page 240).

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

Procedure for applying the start values of all operating hours counters

Applying the start values for all operating hours counters with the module versions with 2 bytes and 20 bytes of output data is identical.

1. Set the reset bit for operating hours counters (Bit 5) in Byte 1 in the output data.

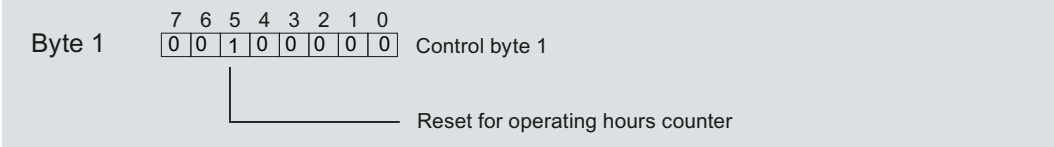

Figure 2-770 Control byte 1 Reset for all operating hours counters

If there is an edge change of the reset bit from 0 to 1, the module applies the start values for all operating hours counters.

Procedure for applying the start values of individual operating hours counters

NOTE

Applying the start values for phase-specific operating hours counters

Applying the start values for phase-specific operating hours counters does not differ from the procedure described above. In the output data, select the reset bits for the phase-specific operating hours counters in bytes 6, 8 and 10.

9.3 Starting and stopping operating hours counters

There are two ways of starting or stopping counting with the operating hours counter AI Energy Meter RC HF:

- Counting with gate

  The module starts counting when you set the DQ bit for the counter gate in the output data using an edge change from 0 -> 1. If you reset the DQ bit for the counter gate using an edge change from 1 -> 0, the counter stops.

- Counting without gate

  The module starts counting immediately as soon as the module is switched on. Counting cannot be stopped.

Both options are described in the following sections.

Counting with gate

Requirements:

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

If you wish to start counting using the gate, proceed as follows:

1. Activate the parameter "Enable operating hours counter gate" in the parameter assignment of the module.
2. Set the DQ bit for the counter gate (Bit 4) in control byte 1 in the output data.

The module starts counting as soon as there is an edge change from 0 -> 1 at the DQ bit for the counter gate.

If you wish to stop the counting again, then reset Bit 4 in control byte 1 in the output data. Counting stops at an edge change from 1 -> 0.

The "Enable operating hours counter gate" parameter and the DQ bit for the "counter date" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

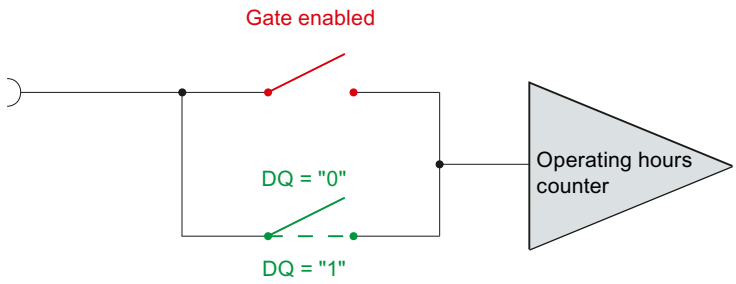

Figure 2-771 Gate enabled

Counting without gate

Requirement

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

Deactivate the parameter "Enable operating hours counter gate" in the parameter assignment of the module.

The module starts counting as soon as the data record has been applied by the CPU.

The counter continues to count.

Gate disabled: Gate is always "open" (signal path closed)

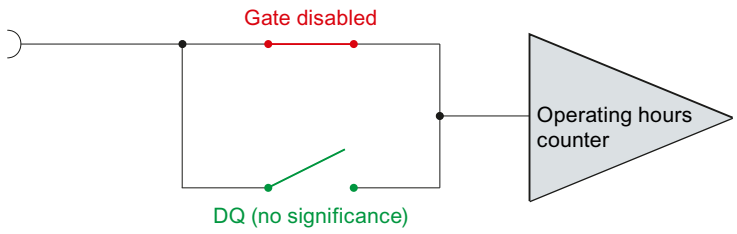

Figure 2-772 Gate disabled

Limit monitoring 10

10.1 How limit monitoring works

Introduction

The AI Energy Meter RC HF supports monitoring of parameterizable low **or** high limits for up to 16 analog measured or calculated variables.

You can also specify multiple limits for each measured or calculated variable, in order to define a high or low value range.

The measured value data record 150 returns the current status of limit violations and one counter per limit that displays the number of limit violations. In addition, a hardware interrupt may be generated for each limit violation.

The status of the limit violations can also be evaluated in the payload variant 240 ($F0_H$) or via the user-defined payload variant or the user-defined data record via the measured value ID 65509.

Benefits

With activated limit monitoring you can already detect any irregularities in the measured value acquisition already in field level.

Retentivity

All counter states are stored retentively in the AI Energy Meter RC HF. After an interruption (e.g. Power System Off), the counting resumes with the retentively stored values.

Configuring

You configure the following limit monitoring settings in STEP 7:

- Measured variable that is to be monitored.
- Activate / Deactivate limit monitoring.
- Activate / deactivate gate limit monitoring.
- High or low limit values.
- Delay time and hysteresis for each limit.
- Activate / Deactivate hardware interrupts at limit violation.
- Measured value that is subject to limit monitoring.

Hardware interrupt at a limit violation

The hardware interrupt provides the following information:

- Measured value ID of the monitored measured or calculated variable
- Number of the limit (0 = Limit 1. 15 = Limit 16)
- Information on whether limit was exceeded or fallen below

For more detailed information, refer to section Hardware interrupts (Page 118).

Controlling functions in RUN

The following table shows the supported control information:

Control information	Default value	Available in
Enable/disable monitoring per limit[1]	Disabled	Module version with 20 bytes of output data
Reset number of total limit violations	0	Module version starting at 2 bytes of output data

[1] Effective only with enabled gate

10.2 Influence of hysteresis and delay time on limit monitoring

Delay time and hysteresis

In order to prevent the triggering of limit violations with small fluctuations, you have the following configuration options in STEP 7:

- Delay time in seconds (0 to 10 s)

  With the delay time, you filter faults and thereby prevent limit value monitoring from triggering too frequently. The limit violation is counted only when the limit violation is present for longer than the configured delay time. The delay time is also taken into consideration with an outgoing limit violation, directly after a high or low limit has been violated in the permitted range. If the measured variable lies between limit violation and hysteresis after the limit violation has been corrected again, the delay time expires also without leaving the hysteresis.

- Hysteresis as a percentage (0 to 20%)

  With the hysteresis, you suppress fluctuations around the limit. The hysteresis is a tolerance range that you define as a percentage deviation of the configured limit. The limit violation is considered to be corrected only when the monitored value leaves the tolerance range.

NOTE

You can get information about underflow and overflow from the calculation of minimum and maximum values of selected measured variables.

The following figure shows the value-over-time for two measured values using the example of a high and low limit as well as the influence of hysteresis and delay time on the counting of the limit violations.

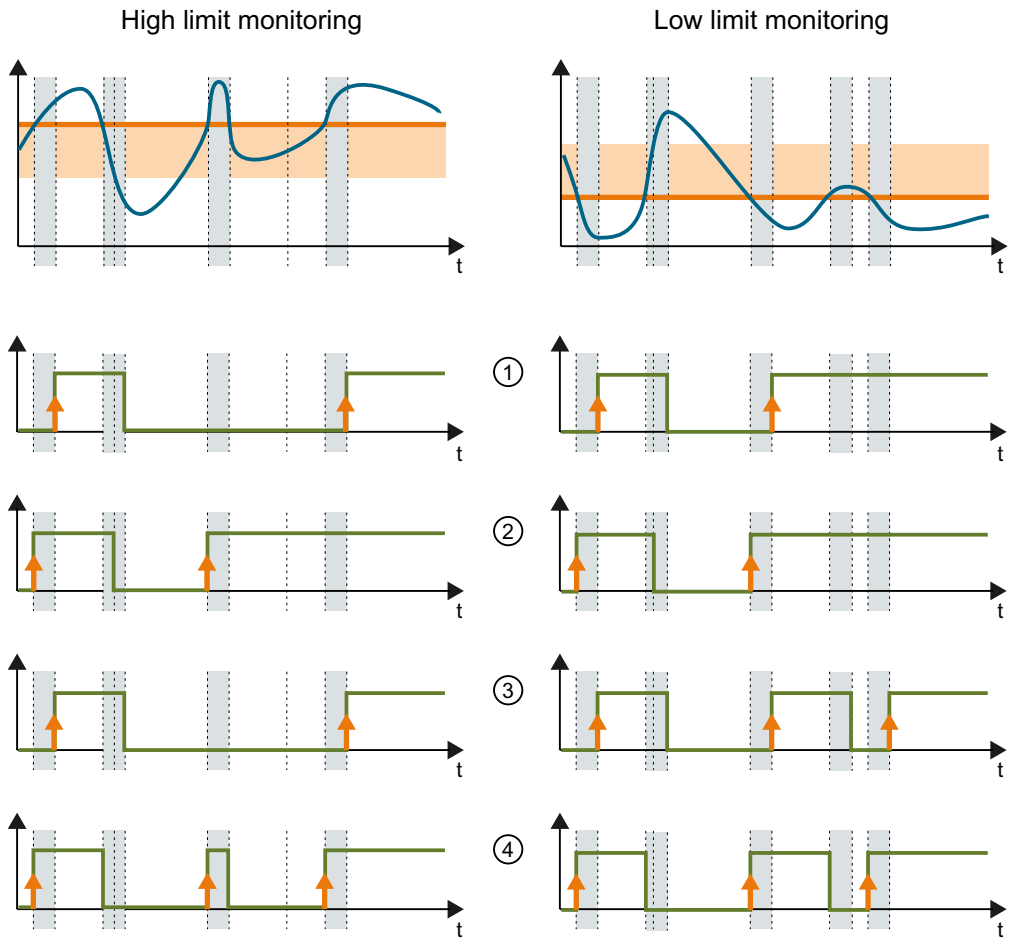

	Configured limit.		Signal wave
	Configured delay time. Is taken into consideration during coming and going.	①	Limit monitoring with hysteresis and delay time
	Hysteresis range. Only considered for outgoing.	②	Limit monitoring with hysteresis, but without delay time
	Value-over-time for which the limit is monitored.	③	Limit monitoring without hysteresis, but with delay time
	Edge change. Counter for limit violations is incremented by 1. If parameterized, a hardware interrupt is triggered.	④	Limit monitoring without hysteresis and delay time

Figure 2-773 Influence of hysteresis and delay time on the limit

See also

How limit monitoring works (Page 77)
Minimum and maximum values (Page 84)

10.3 Reset, activate and deactivate counters for limit violation

Introduction

At the beginning of a new work order, it can be useful to reset or also enable/disable the counters for limit violations of the AI Energy Meter HF.

Resetting here means that the counters for limit violations are reset to 0.

Due to the differing lengths of the output data resetting of the counters for limit violations depends on the configured module version.

Resetting at module version with 20 bytes of output data

1. Select the counters for limit violations that you want to reset in control bytes 3 and 4; see "Enabling/disabling the counters for limit violations".
2. In control byte 1, set the rest bit (bit 3) with an edge change from 0 to 1; see "Resetting the counters for limit violations".

Resetting for module version with 2 bytes of output data

Set the reset bit (Bit 3) in Control byte 1 from 0 to 1 through an edge change. Resetting acts globally on all the configured counters for limit violation.

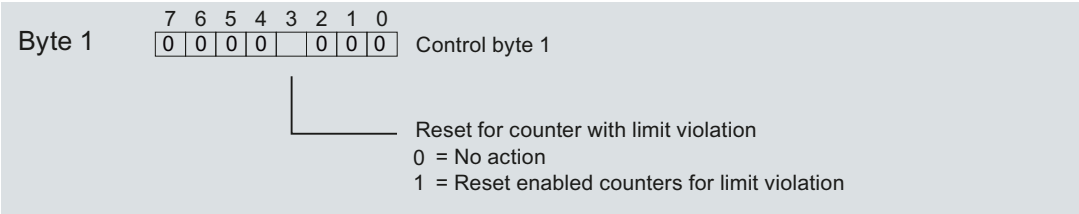

Figure 2-774 Resetting of the counters for limit violations

Activating / Deactivating counters for limit violations

Activating/deactivating of the counters for limit violations is only possible for module versions with 20 bytes of output data.

Requirements: "Gate for limit value monitoring" was parameterized during configuration of the module using STEP 7 or by writing the data record DS 128.

Select the counters for limit violations that you want to activate / deactivate in Control bytes 3 and 4.

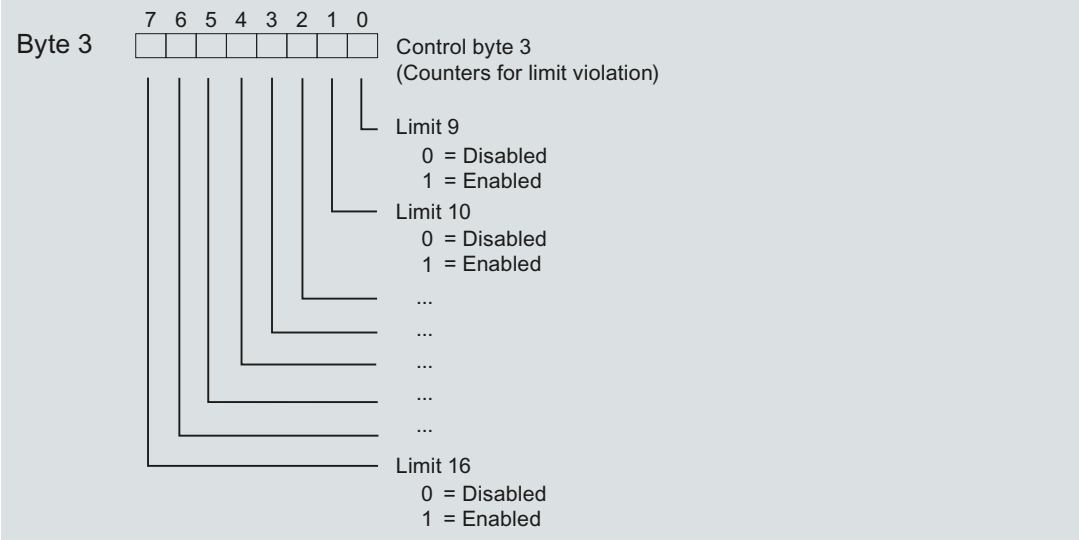

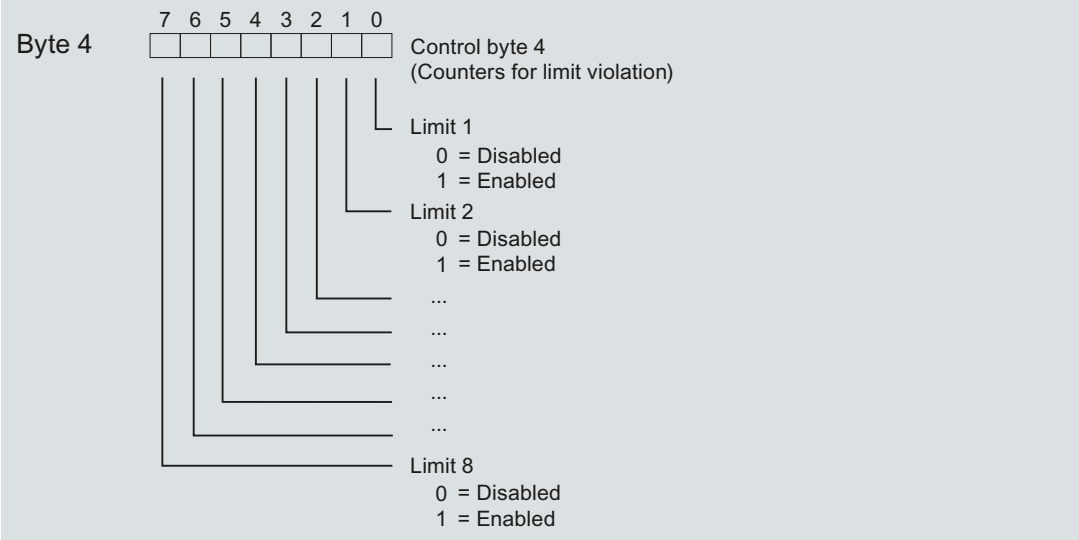

Figure 2-775 Activating / deactivating of the counters for limit violations

10.4 Measured variables for limit monitoring

You can use measured variables from the section Measured variables (Page 174) for limit value monitoring.

The value range of the parameter "Limit x" is -3.0E+09 ... +3.0E+09.

The table below shows you which measured variables are **not** available for limit monitoring.

Measured value ID	Measured variables
220	Active energy inflow L1L2L3 (Int32)
221	Active energy outflow L1L2L3 (Int32)

Measured value ID	Measured variables
222	Reactive energy inflow L1L2L3 (Int32)
223	Reactive energy outflow L1L2L3 (Int32)
224	Apparent energy L1L2L3 (Int32)
225	Total active energy L1L2L3 (Int32)
226	Total reactive energy L1L2L3 (Int32)
61136	Neutral current maximum value
61137	Neutral current minimum value
62110	Active energy inflow L1 (Int32)
62111	Active energy outflow L1 (Int32)
62112	Reactive energy inflow L1 (Int32)
62113	Reactive energy outflow L1 (Int32)
62114	Apparent energy L1 (Int32)
62115	Total active energy L1 (Int32)
62116	Total reactive energy L1 (Int32)
62132	Voltage L1 instantaneous value
62135	Current L1 instantaneous value
62136	Fundamental cos φ active factor L1 (SINT8)
62210	Active energy inflow L2 (Int32)
62211	Active energy outflow L2 (Int32)
62212	Reactive energy inflow L2 (Int32)
62213	Reactive energy outflow L2 (Int32)
62214	Apparent energy L2 (Int32)
62215	Total active energy L2 (Int32)
62216	Total reactive energy L2 (Int32)
62232	Voltage L2 instantaneous value
62235	Current L2 instantaneous value
62236	Fundamental cos φ active factor L2 (SINT8)
62310	Active energy inflow L3 (Int32)
62311	Active energy outflow L3 (Int32)
62312	Reactive energy inflow L3 (Int32)
62313	Reactive energy outflow L3 (Int32)
62314	Apparent energy L3 (Int32)
62315	Total active energy L3 (Int32)
62316	Total reactive energy L3 (Int32)
62332	Voltage L3 instantaneous value
62335	Current L3 instantaneous value
62336	Fundamental cos φ active factor L3 (SINT8)
65496	Power quality analysis qualifier
65497	Current module time

Measured value ID	Measured variables
65500	Qualifier L1
65501	Qualifier L2
65502	Qualifier L3
65503	Qualifier L1L2L3
65508	Status of energy counter overflows
65509	Status of limit violations 1...16
66001	Voltage L1-N
66002	Voltage L2-N
66003	Voltage L3-N
66004	Voltage L1-L2
66005	Voltage L2-L3
66006	Voltage L3-L1
66007	Current L1
66008	Current L2
66009	Current L3
66010	Apparent power L1
66011	Apparent power L2
66012	Apparent power L3
66013	Active power L1
66014	Active power L2
66015	Active power L3
66016	Reactive power Qn L1
66017	Reactive power Qn L2
66018	Reactive power Qn L3
66019	Power factor λ L1
66020	Power factor λ L2
66021	Power factor λ L3
66030	Frequency (Uint8)
66031	Frequency (Uint16)
66034	Active power L1L2L3
66035	Reactive power Qn L1L2L3
66036	Apparent power L1L2L3
66037	Power factor λ L1L2L3
66038	Reactive power Qtot L1L2L3

Minimum and maximum values 11

11.1 Minimum and maximum values

Introduction

The AI Energy Meter RC HF determines the respective highest and lowest measured or calculated value for a series of measured and calculated values. The values are stored retentively in the module and can be read using measured value data records DS 144 (Page 244), DS 145 (Page 246), DS 154 and DS 155 (Page 264).

Benefits

Using the stored minimum and maximum values, for example, you can detect further irregularities in addition to limit monitoring.

Calculation of minimum and maximum values

Minimum and maximum values are only calculated for the phases in accordance with the configured connection type. Existing minimum and maximum values that have not been calculated are assigned initial values. If faults such as under or overcurrent occur during operation, new minimum and maximum values are calculated.

The measured and calculated values are initialized as follows during commissioning of the AI Energy Meter HF so that the first calculation of minimum and maximum values supplies a plausible result:

- Maximum values for measured and calculated values: Minimum values
- Minimum values for measured and calculated values: Maximum values

Minimum and maximum values are determined as "slave pointer procedures" from the start of calculation. Start is effective as of activation of the function or after a reset. The module uses the current actual value as the start value.

Output of the measurement values

For technical reasons, after plugging in or switching on the load voltage, the module returns the minimum and maximum values delayed by approx. 2 s.

Configuring

You configure the following settings in STEP 7:

- Enable calculation of minimum and maximum values
- Enable minimum and maximum value calculation gate

Controlling functions in RUN

The following table shows the supported control information:

Control information	Default value	Available in
Reset saved maximum values	0	Module version starting at 2 bytes of output data
Reset saved minimum values	0	Module version starting at 2 bytes of output data

NOTE
Automatic reset
If you change the parameters for current or voltage transformers, the minimum and maximum values are reset automatically to their initial values.

11.2 Resetting minimum and maximum values

Description

At the beginning of a new work order, it may be useful to reset the minimum and maximum values of the AI Energy Meter RC HF. Resetting means that the minimum and maximum values are reset to their initial values. Initial values are described, see section Measured value data record for maximum values (DS 144) (Page 244), Measured value data record for minimum values (DS 145) (Page 246), Measured value data record for maximum values with time stamp (DS 154) and Measured value data record for minimum values with time stamp (DS 155) (Page 264).

Minimum and maximum values are only reset using a Reset via output data (DQ bit).

Due to the differing lengths of the output data resetting of the minimum and maximum values depends on the configured module version. If you use module versions with 20 bytes of output data, you can:

- Reset the minimum and maximum values for **all** phases.
- Reset the minimum and maximum values for each **individual** phase.

If you use the module version with 2 bytes of output data, you always reset **all** minimum and maximum values simultaneously.

Time stamps are set to initial values (01.01.1970, 0:00) on reset.

Procedure for module version with 20 bytes of output data

Resetting the minimum and maximum values for all three phases

1. In byte 2, select the categories of the minimum and maximum values that you want to reset.
   - Set bit 0 for voltage and frequency.
   - Set bit 1 for current and power factor.
   - Set bit 2 for active power.
   - Set bit 3 for reactive power.
   - Set bit 4 for apparent power.
   - Set bit 5 for active energy.
   - Set bit 6 for reactive energy.
   - Set bit 7 for apparent energy.

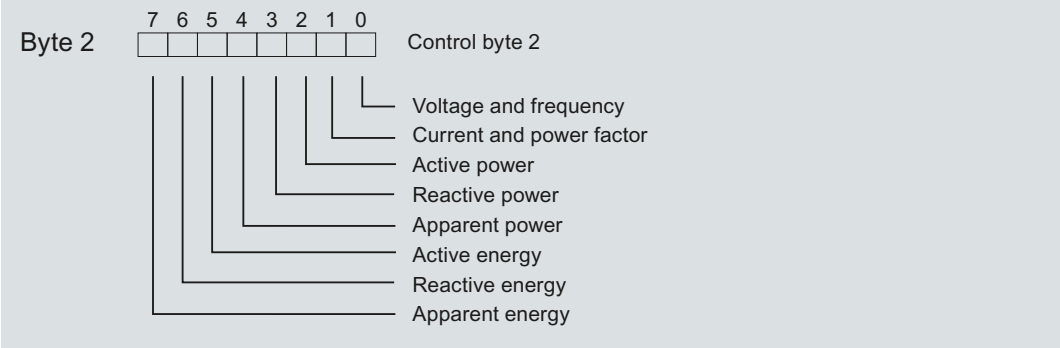

Figure 2-776 Selection of minimum and maximum value category

2. In byte 1, set reset bit 0 for minimum values or reset bit 1 for maximum values.
   If there is an edge change of the reset bits from 0 to 1, the module resets the selected minimum or maximum values for all three phases that you previously selected in Byte 2.

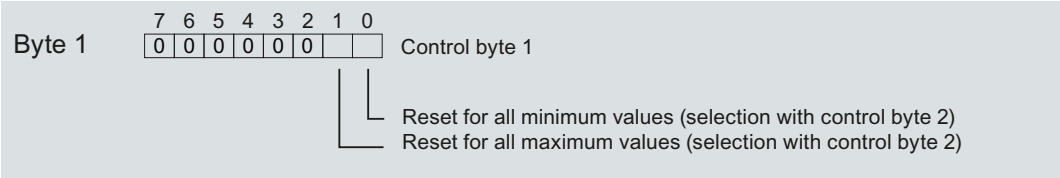

Figure 2-777 Reset bit for minimum and maximum values

Resetting minimum and maximum values for phase-specific measurement

You can also reset the minimum and maximum values on a phase-specific basis using the output data.

Follow the procedure for "Resetting minimum and maximum values for all three phases" as applicable.

1. Select the categories of minimum and maximum values that you want to reset on a phase-specific basis.
   - In byte 7, set the bits for the category of minimum and maximum values in phase 1.
   - In byte 9, set the bits for the category of minimum and maximum values in phase 2.
   - In byte 11, set the bits for the category of minimum and maximum values in phase 3.
2. Set the reset bit (bit 0 and bit 1) for minimum or maximum values.
   - in byte 6 for phase 1
   - in byte 8 for phase 2
   - in byte 10 for phase 3

If there is an edge change of the phase-specific reset bits from 0 to 1, the module resets the minimum or maximum values for the given phase.

11.3 Gate

NOTE
Module version with 2 bytes of output data
The gate is not available for the module version with 2 bytes of output data.

There are two ways of starting or stopping the calculation of the minimum and maximum values:

- Calculation of the minimum and maximum values with gate

  The module starts the calculation when you set the DQ bit for the gate in the output data (output data byte 1, bit 2 = "1") using an edge change from 0 -> 1. If you reset the DQ bit using an edge change from 1 -> 0, the calculation stops.
- Calculation of the minimum and maximum values without gate

  The module starts the calculation as soon as the module is started. The calculation cannot be stopped.

Both options are described in the following sections.

Calculation of the minimum and maximum values with gate

Procedure
If you wish to start calculating using the gate, proceed as follows:

1. Activate the parameter "Enable minimum and maximum value calculation" in the parameter assignment of the module.
2. Set the DQ bit of the gate for minimum and maximum value calculation (Bit 2) in control byte 1 in the output data.

The module starts calculating as soon as there is an edge change from 0 -> 1 at the DQ bit for the gate.

If you wish to stop the calculating again, then reset Bit 2 in control byte 1 in the output data. Calculating stops at an edge change from 1 -> 0.

The "Enable minimum and maximum value calculation" parameter and the DQ bit for the "gate" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

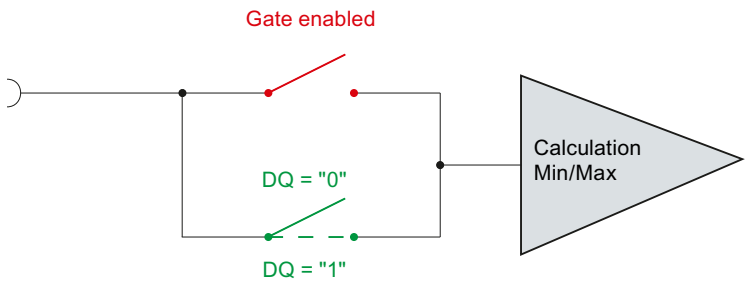

Figure 2-778 Gate enabled

NOTE

Module-global/phase-granular PLC

If you are using the gate control for all three phases simultaneously, use the control byte 1 at output address 1. For a phase-specific resolution of the gate control, use the addresses 6 (Phase1), 8 (Phase2) or 10 (Phase3) as control byte 1. The resolution of a module-global PLC overrules a phase-granular resolution.

Calculation of the minimum and maximum values without gate

Procedure

Deactivate the parameter "Enable minimum and maximum value calculation gate" in the parameter assignment of the module.

The module starts calculating as soon as the module is started. The calculating cannot be stopped.

Gate disabled: Gate is always "open" (signal path closed)

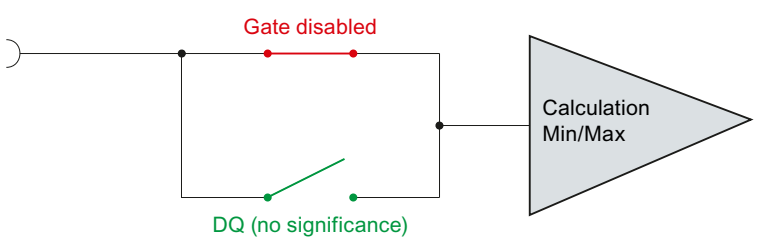

Figure 2-779 Gate disabled

Measured value recorder 12

12.1 How the measured value recorder works

Introduction

The measured value recorder can record up to 200 measured values at two data sources or 400 measured values at one data source. You can freely select the measured value you wish to record for each data source and easily start and stop the recording.

Two recording modes are available: once or in a continuous circular buffer.

You select the measured value you wish to record using its measured value ID. You control the recording using configurable start and stop triggers.

You can retrieve measured values at any time. For two data sources, there is one data record per data source. The measured values of the first data source are available in the DS 173; those of the second data source in the DS 174. If you are using only one data source, both data records DS 173 and DS 174 are written. With one-time recording, these data records are used one after the other as alternating buffers in circular buffer mode.

NOTE

Note that only the use of the alternating buffer can ensure that no data is lost in ring buffer mode.

Benefits

With the measured value recorder, you can record measured values at equidistant intervals of 10 ms to 10 min independently of any other processing and data transport times in the module or the PLC.

Configuration

You configure the following measured value recorder settings in STEP 7:

- Number of activated measured value recordings (1 or 2)
- ID of the measured value for the measured value recording 1 or 2
- Recording interval for the measured value recording 1 or 2
- Mode (once/circular buffer) for the measured value recording 1 or 2
- ID of the start trigger for the measured value recording 1 or 2
- ID of the stop trigger for the measured value recording 1 or 2

A more detailed parameter description of the DS 134 is available in section "Parameters". You can find detailed information on the start and stop triggers in the Appendix, Section A5.

Evaluation of the measurements

Within these measured value data records, the representation of the measured values is specified in REAL format only.

The reading of recordings is possible with data record reading once or cyclically. You can read out the recorded measured values from the following data records.

Name of the data record	Number of the data record
Data record for measured recorder data source 1	DS 173
Data record for measured recorder data source 2*	DS 174

*Or as second data record for data source 1 if you want to record 400 measured values

The data records are described in the section Measured value data record DS 173 (Appendix E18) or Measured value data record DS 174 (Appendix E19).

12.2 Start, hold, continue, reset, restart and evaluate measurement

Parameter assignment of the measurement

To use the measured value recorder function, send parameter data record 134 to the module either with the instruction WRREC (Write data record) or via the parameter assignment of STEP 7. If you want to use the recording of 400 measured values at a data source, the parameter assignment of MV recorder block 1 and MV recorder block 2 must be identical in all parameters. The number of activated measured value recordings must be set to "2".

You can find more information on the parameter data record 134 in the section Parameters and in Appendix A.5 (Page 166).

Starting the measurement

A "1" level at the activated start trigger starts the recording. With disabled start trigger, the recording starts immediately at the time of parameter assignment.

Hold measurement

A "0" level at the activated start trigger or a "1" level at the activated stop trigger stops the recording. If the stop trigger is disabled, the recording ends in the "once" mode after filling the buffer. 200 values are available in this case. Recording continues in "Circular buffer" mode and can only be ended by resetting the measurement.

Continue the measurement

A restart with "1" level at the start trigger and with a "0" level at the stop trigger continues the measurement.

Resetting the measurement for module version with 20 bytes of output data

You delete the recording with reset, general reset or re-parameterization. You can reset the measurements individually. You do this with two specified DQ bits at which you trigger a 0->1 edge.

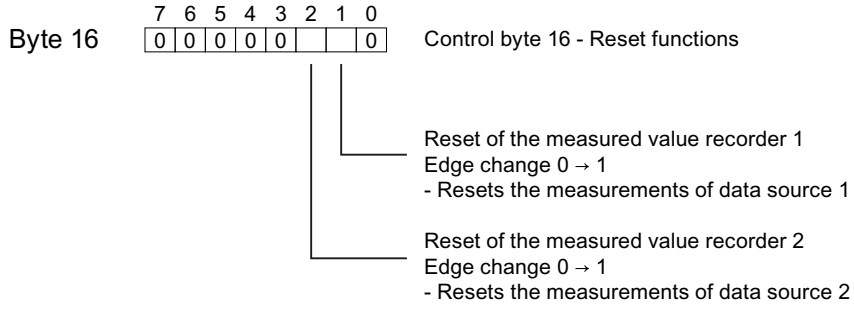

Figure 2-780 Resetting the measurement

Reset via byte 16 is only possible for the module version 20 bytes of output.

Resetting the measurement for module version with 2 bytes of output data

You delete the recording with re-parameterization.

Restarting the measurement

You can restart the measurement after completing a measurement and evaluating the results. We recommend to first disable the start event with level state 0, then reset the respective measurement and retrigger the start event with "1" level again.

Evaluating the measurement

The reading of recordings is possible with data record reading from DS173 and DS174 once or cyclically at any time. Within these measured value data records, the representation of the measured values is specified in REAL format only.

Depending on the application, it may be useful to evaluate the status of the recorders before reading all measured values:

- **Option 1**

  Using data record reading: Byte 1 contains the compressed status in form of 2 bits:

  – Byte 1 = 0x80: Recording ended
  – Byte 1 = 0x40: Recording in progress
  – Byte 1 = 0: No data can be retrieved

- **Option 2**

  Using data record reading: Byte 7 contains the complete recorder status:

  – 0: Initial status
  – 3: Recorder parameterized
  – 4: Recording in progress
  – 5: Recording ended
  – 6: Recording stopped

  NOTE

  To evaluate the status, you can read an abbreviated data record without the measured values. This reduces the runtime for faster cyclical evaluation of the recorder status. Only when the status is "Recording ended" must you read the complete data record.

- **Option 3**

  If the hardware interrupt is enabled in the parameters, a PRAL, whose information can be evaluated in OB4x, is triggered at the time of "Recording ended" (see 17.2.1).

  After evaluation of the PRAL information, the corresponding data record (DS173 or DS174) can be read.

Evaluating measured values for two data sources

If two data sources are used, a fixed assignment of the data records is specified for each data source:

- Recorder 1: DS173
- Recorder 2: DS174

Evaluating measured values for one data source

If the parameter assignment of recorder 1 and recorder 2 is the same, only one data source should be used. Both data records are used for this data source in this case:

- Recorder 1: DS173 (recording starts here) + DS174 (when DS173 is full, recording continues here)

In "once" mode, DS173 is filled first. When its status shows "Recording ended", it can be read. Recording is automatically switched to DS174. When its status also shows "Recording ended",

the recording stops and the DS174 can be read as well. This means you have access to 400 measured values in two buffers.

NOTE

Intermediate reading is also available but not all measured values have been saved yet in this case.

In "Circular buffer" mode, DS173 is also used first. If the status shows "Recording ended", the buffer must be read. In the meantime, DS174 is filled automatically; when its status also shows "Recording ended", DS173 is deleted and recording in it starts anew. This process continues back and forth until recording is stopped.

NOTE

Intermediate reading is also available but not very useful because not all measured values have been saved yet resulting in gaps.

NOTE

At the smallest acquisition interval of 10 ms, one buffer is full every 200 *0.010s = 2 s. You have two seconds to retrieve the buffer and save the measured values to a different storage, such as a data block.

12.3 Example of measured value recording

Example (for module version with 20 bytes of output data)

Starting with the default parameter assignment in STEP 7, activate the recording as follows:

1. Set the parameter "Number of activated measured value recordings" to 2.
2. Set both recording intervals to 100.
3. Set the start trigger 1 to 230 and the start trigger 2 to 231.
4. Load the changed parameters to the module.

Recording 1 starts after "1" is output to bit 5 from byte 17 of the output data; it records the voltage at phase 1 once every second with 200 measured values.

Recording 2 starts after "1" is output to bit 6 from byte 17 of the output data; it records the current at phase 1 once every second with 200 measured values.

If bit 5 or 6 is reset to "0" during recording, the respective recording comes to a stop. A renewed output of "1" continues the recording.

	Parameter	Value	Meaning
	Number of activated measured value recordings	2	2 recordings
Measured recorder data source 1	ID for measured value recording	1	UL1
	Recording interval for measured value recording	100	1 s

	Parameter	Value	Meaning
Measured recorder data source 1	Mode for measured value recording	0	Once
	ID for start trigger	0	Disabled
	ID for stop trigger	0	Disabled
Measured recorder data source 2	ID for measured value recording	7	IL1
	Recording interval for measured value recording	100	1 s
	Mode for measured value recording	0	Once
	ID for start trigger	0	Disabled
	ID for stop trigger	0	Disabled

Power failure analysis 13

Introduction

When the supply voltage of the system is interrupted, metering of energy and other processes are stopped. An analysis of the breakdown times thus represents an important function in a plant.

NOTE

Requirements

A useful evaluation of the saved breakdown and restart times is only possible when you set the time of the Energy Meter. If the time synchronization is not available, you can only evaluate the relative time between start and failure because the internal clock starts with the initial value of 01.01.1970, 0:00 and runs until the failure.

13.1 Mode of operation of the power failure analysis

Determination of the power failure time

To this end, the current system time is cyclically transferred to the retentive memory while the energy meter calculation is being processed. This means the time from the last calculation cycle is retained in case of a supply voltage failure.

Determination of the power return time

Once the supply voltage returns, the current time is also entered in the retentive memory during run-up of the module. This process waits for the synchronization of the clock.

NOTE

Formation of the restart time

The wait time for a time synchronization after a restart is 30 seconds. If it does not take place by then, the start time (1.1.1970, 0:00:00) is entered as the starting point. The entered time is decreased by the time that has expired in the module in the meantime (max. 30 seconds). Tip: Do not read the data immediately after the restart but wait for at least 60 seconds.

See also section Tips and tricks (Page 283), Time synchronization and time stamp.

Evaluation of the results of the power failure analysis in data record 169

Reading of DS169 returns the saved analysis data. The "Switch-off time/Switch-on time" pair of the stored times thus results in the failure time of the network. Up to nine pairs of switch-off/switch-on times are stored internally in a circular buffer. This means you will see up to nine failure times when reading DS169.

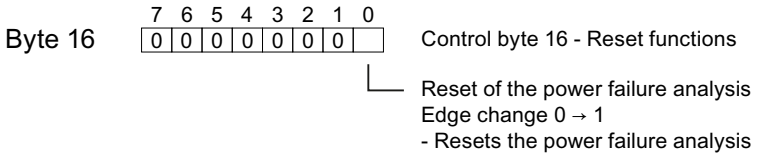

Figure 2-781 Resetting the power failure analysis measurement

For more detailed information, refer to section Measured value data record for power failure analysis (Page 278).

NOTE

Resetting the power failure analysis

Resetting of the power failure analysis is only possible with 32I / 20 O or by using the general reset.

Power quality analysis functions 14

Introduction

Power quality analysis functions are used as an aid to evaluate the quality of the supply network. In a three-phase system, many of these functions only make sense or can be executed if a functioning symmetrical three-phase supply system is available, the detection sensors of the three phases are identical in design and the nominal values current or voltage of the phases have the same values.

The AI Energy Meter RC HF provides you with the following power quality analysis functions in accordance with IEC 61000-4-30 for monitoring the power quality in your power network:

- Measure the neutral current
- Perform residual current analysis
- Determine active and power factor
- Carry out reactive power compensation
- Analyze fundamental values three-phase (voltage, current, power)
- Analyze the harmonics up to the 40th harmonic
- Determine the total harmonic distortion THD+N current/voltage for all three phases
- Detect voltage dip and voltage swell
- Detect overcurrent
- Detect peak value for current and voltage

The power quality analysis only returns useful results if some basic requirements are met. These include:

- Accuracy of the line frequency (50 Hz or 60 Hz) is maintained according to IEC 61557-12.
- Wiring was done correctly and the correct rotating filed is generated (see Notes for the detection of wiring errors and incorrect rotating field (Page 51)).

Delete the results of the power quality analysis

Delete the results of the power quality analysis by setting the corresponding bits in Byte 12 of the output range (Page 205) for at least 100 ms to "1".

Deletion has the following effects:

- Deletion of the result values and status bits for
  - Peak values of the instantaneous values for voltage and current
  - Overcurrent of the current half value
  - Voltage dip and voltage swell of the voltage half-wave value
- Any pending diagnostics "External fault" is deleted.

Harmonic

Harmonics are superimposed vibrations deviating from the fundamental frequency of the supply network (50 Hz or 60 Hz) with an integer multiple of the fundamental frequency. Harmonics are generated by equipment with a non-linear current–voltage characteristic such as transformers, gas discharge lamps and power electronics devices.

Harmonic component THD (Total Harmonic Distortion)

The THD defines the ratio of the power of the harmonics to the power of the fundamental and provides information about the power quality. The value is dimensionless and is stated as a percentage [%].

The AI Energy Meter RC HF returns THD+N (Noise) and considers the entire current signal (DS 163) or voltage signal (DS 161). Interference in the network is not filtered out.

Output of the measurement values

For technical reasons, after plugging in or switching on the load voltage, the module returns the following measured values delayed by approx. 2 s.

- Frequency
- Harmonic distortion THD+N current
- Harmonic distortion THD+N voltage

14.1 Power quality analysis status

Information about the power quality status can be found in the measured value "Power quality analysis qualifier" with the measured value ID 65496.

The bits 0 to 4 in byte 1 to 3 show in status "1" that information has been available since the last reset, which can be retrieved. The bits 5 to 7 in byte 1 to 3 in status "1" show that the event is currently active. If the event is not active, "0" is displayed.

The measured value "Network analysis qualifier" has the following structure:

Address	Content	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0	Power quality analysis qualifier module	Reserved	Reserved	Status of harmonics analysis: 0_D: No data, no start 1_D ... 62_D: running 63_D: Completed, data is available					
Byte 1	Power quality analysis qualifier phase L1	**Overcurrent** Event currently active	**Voltage swell** Event currently active	**Voltage dip** Event currently active	**Overcurrent** Event occurred, data available	**Peak value current** Event occurred, data available	**Voltage peak** Event occurred, data available	**Voltage swell** Event occurred, data available	**Voltage dip** Event occurred, data available
Byte 2	Power quality analysis qualifier phase L2								
Byte 3	Power quality analysis qualifier phase L3								

14.2 Harmonics analysis

The AI Energy Meter RC HF can determine the effective values for current and voltage for each phase up to the 40th harmonic of the fundamental.

The harmonics of the voltage are stored in the data record DS 161.

The harmonics of the current are stored in the data record DS 163 (Page 273).

In addition, you can incorporate the results on IDs with the parameter data records DS 130/DS 131 (Page 163) in the user-defined payload and DS 135 (Page 171) in the user-defined data record DS 151 (Page 261).

The calculation of the harmonics takes several cycles. To determine whether calculation is completed, evaluate the Bits 0 to 5 in the power quality analysis data record DS 160 (Page 267) in Byte 218. If the value 63 is in the Bits 0 to 5, the calculation is completed and the measured values are available.

NOTE

While the calculation is in progress, you cannot read the data records DS 161 and DS 163.

NOTE

While the calculation is in progress, quick measured value acquisition (e.g. for controlling reactive-power compensation) is not possible.

Requirement

- The parameter "Power quality analysis function" is activated.
- The parameter "Analyse harmonics" for the corresponding phase must be released.

Voltage and current are always analyzed simultaneously for the enabled phases.

Control via data outputs

The harmonics analysis starts by setting the DQ bit 6 "Power quality analysis Start/Stop L1L2L3" in Byte 12 of the output data. The results of a previous analysis of harmonics are deleted in the process. Results of non-selected channels are "0". If channels which have not yet been analyzed are added, the data are not plausible at the start of the analysis.

If the DQ bit is reset during an ongoing analysis, the analysis stops.

14.3 Reactive power compensation

Use the power factor of the fundamental for the reactive power compensation.

The power factor of the fundamental is available, among other things, in the measured value data record DS 142 (Page 234), in the measured value data record DS 160 (Page 267) or in the payload (Page 217).

14.4 Detection of residual current

For the residual current analysis (function "Tamper Detect" = Detection of unauthorized interventions), the total current must be determined:

Isum L1L2L3 (t) = IL1 (t) + IL2 (t) + IL3 (t)

The instantaneous residual current If is obtained by subtracting the results of the current neutral current In from the total current:

If = Isum L1L2L3 – In

Analysis starts immediately after parameter assignment. The measured value "Total current IL1+IL2+IL3-IN" (ID = 61153) returns the residual current. It is contained in DS 160, for example. You can monitor a threshold relevant for your application for a limit value (see function Limit value monitoring (Page 77)).

Requirements

- "3P4W" or "3P4WI" is parameterized as the connection type.
- The same current/voltage transformers or Rogowski coils are connected to all three phases.
- The parameter "Reverse current direction" is parameterized identically for all three phases.
- The neutral current is parameterized with "Measuring".
- The residual current analysis is activated in the parameter assignment.

14.5 Active factor and power factor

The AI Energy Meter RC HF returns the active and power factor individually for each phase and as an aggregate.

Active factor

The active factor is defined as follows:

cos φ (active factor, signed, fundamental oscillation): cos φ = P1 / S1

φ = phase shift angle of fundamental oscillation

P1 = active power of fundamental oscillation

S1 = apparent power of fundamental oscillation

Power factor

The power factor λ = cos Φ is the ratio of active power (P) to the total apparent power (S) over the fundamental oscillation and all harmonics (total):

λ (power factor, unsigned, total): λ = cos Φ = |P| / S

14.6 Neutral current In

The module can measure or calculate the neutral current.

For measuring, you have to connect a current/voltage transformer or Rogowski coil to neutral. The behavior "measuring or calculating" can be set for each parameter. The main application of the measured value "Neutral current IN" (ID: 61149) are three-phase networks with existing 4th conductor, neutral: The neutral current usually shows incorrectly flowing currents. In an ideal three-phase network, the neutral current = 0.

An additional possible application is measuring any 4th current on this channel. Please note that in this case the measured value "Neutral current" displays this 4th current and not the actual neutral current.

Additional values in conjunction with the neutral current is set to 0.

The calculation of the neutral current and the comparison of calculated and measured neutral current (used for residual current analysis) is only possible in the operating modes "3P4W" and "3P4WI".

The determination of the neutral current is not subject to current suppression.

Parameter assignment options

If there a neutral in a connection type, the following parameters are available:

- Neutral current measurement deactivated
- Calculate the neutral current measurement
- Measure the neutral current measurement

If there is no neutral in a connection type, the following parameters are available:

- Do not use current channel
- Measure current channel

Display via channel LED

Neutral exists for connection type	calculate	measuring	Error	Channel LED
Yes	Yes	Yes	No	Green
Channel disabled	---	---	---	Off
No	No	Yes	No	Green

14.7 Monitoring the instantaneous or half-wave values

You can enable the following functions:

- Voltage swell (Page 123)
- Voltage dip (Page 126)
- Voltage peaks (Page 128)
- Current peak value (Page 135)
- Overcurrent value (Page 137)

The results are mapped in the phase-specific data records DS 147 (Page 248), DS 148 (Page 252) and DS 149 (Page 255) and in the power quality analysis data record DS 160 (Page 267).

In addition, you can incorporate the results using IDs in the measured value data record of the user-defined data record DS 151 (Page 261) and in the user data variants 1/2.

You can monitor the results for limits (Page 77) and generate hardware interrupts.

Phase-based measured values 15

Introduction

The AI Energy Meter RC HF makes the measured values of individual phases available.

- Through the payload variants
  - Phase-specific measurement phase L1 with payload variants 158 ($9E_H$) and 159 ($9F_H$)
  - Phase-specific measurement Phase L2 with payload variants 156 ($9C_H$) and 157 ($9D_H$)
  - Phase-specific measurement phase L3 with payload variants 154 ($9A_H$) and 155 ($9B_H$)
- Via measured value data records
  - Phase-specific measurement for the phases L1, L2 and L3 with data record 142
  - Phase-specific measurement for phase L1 with data record 147
  - Phase-specific measurement for phase L2 with data record 148
  - Phase-specific measurement for phase L3 with data record 149

Payload variants

Through the payload variants 154 ($9A_H$) to 159 ($9F_H$) you can evaluate the following measured values for each phase of an AC / three-phase network:

- Quality information
- Current and voltage
- Active, reactive and apparent power
- Active, reactive and apparent energy
- Power factor

You can find the structure of the payload variants in appendix Payload variants with 32 bytes of input data / 20 bytes of output data (Page 217).

Measured value data records

Through the measured value data records DS 142, DS 147, DS 148 and DS 149 you can evaluate the following measured values for each phase of an AC / three-phase network:

- Quality information
- Current and voltage
- Minimum current and minimum voltage
- Maximum current and maximum voltage
- Active, reactive and apparent power
- Minimum active, reactive and apparent power

- Maximum active, reactive and apparent power
- Active, reactive and apparent energy
- Power factor
- Minimum power factor
- Maximum power factor
- Harmonic distortion for voltage and current including minimum/maximum values
- Voltage dip
- Voltage swell
- Peak value for voltage and current
- Overcurrent value

The structure of the measured value data record is available in the appendix E Measured value data record for phase-based measured values L1 (DS 147) version 1 (Page 249).

See also

Measured value data record for phase-based measured values L2 (DS 148) version 1 (Page 253)

Measured value data record for phase-based measured values L3 (DS 149) version 1 (Page 257)

Parameters 16

16.1 Parameters

Parameters of AI Energy Meters RC HF

You will usually configure the AI Energy Meter RC HF with STEP 7 (TIA Portal, if necessary, with HSP). In this case, STEP 7 (TIA Portal) checks the configured properties for plausibility during configuration.

You can also assign parameters to the module using a GSD file and STEP 7 or the configuration software of any provider. In this case, the module checks the validity of the configured properties only after the configuration has been downloaded. Note that some parameters depend on the selected connection type of the AI Energy Meter RC HF. For example in the connection type 1P2W for measurements in single-phase AC network it does not make sense to enter parameters for Phases 2 and 3. This is not checked by the system if the GSD file is used.

The effective range of the parameters that can be set using a GSD file depends on the type of bus system used:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition, you can control parameterized functions via the user program in RUN mode. When you assign parameters in the user program, the WRREC instruction transfers the parameters to the module using data records (see appendix Parameter assignment using parameter data records (Page 146)).

The following table summarizes all the configurable parameters with STEP 7 (GSD file).

Table 2-871 Parameters AI Energy Meter RC HF (GSD file)

Parameters	Value range	Default setting
Hardware interrupts *	• Disable • Enable	Disable
Inputs		
Diagnostics: No supply voltage L+	• Disable • Enable	Disable
Connection type	• Disabled • 1P2W - 1 phase, 2 conductors • 3P4WI - 3 phase current measurement, 4 conductors • 3P4W1, 3 phases, 4 conductors, balanced load • 3P4W - 3 phases, 4 conductors • 3x1P2W - 3 x 1 phase, 2 conductors each • 2P3W - 2 phases, 3 conductors • 3P3W, 3 phases, 3 conductors • 3P3W1, 3 phases, 3 conductors, balanced load	3P4W - 3 phases, 4 conductors

* Reconfiguration in RUN is not possible.

Parameters	Value range	Default setting
Voltage measuring range	• 100 V • 110 V • 115 V • 120 V • 127 V • 190 V • 200 V • 208 V • 220 V • 230 V • 240 V • 277 V • 300 V	230 V
Line frequency	• 50 Hz • 60 Hz	50 Hz
Activate gate switch for energy meter	• Disable • Enable	Disable
End value energy meter	• No end value (infinite counting) • Count periodically to 10^3 • Count periodically to 10^6 • Count periodically to 10^9 • Count periodically to 10^{12} • Count periodically to 10^{15}	No end value (infinite counting)
Payload variant	See the table Overview of the payload variants (Page 217)	Total power L1L2L3 (W#16#FE)
Minimum and maximum value calculation	• Disable • Enable	Disable
Minimum and maximum value calculation gate	• Disable • Enable	Disable
Power quality analysis functions	• Disable • Enable	Disable
Residual current analysis	• Disable • Enable	Disable
Neutral: Current transformer secondary voltage [0.1 mV]	• 0 = Disabled • 100 ... 6000 = measuring • 65535 = calculation	250
Neutral: Current transformer primary rated current [A]	• 1 ... 16000	1000
Current transformer type for line conductors L1, L2, L3 and neutral conductor	• 0 = Rogowski coil • 1 = current/voltage transformer	Rogowski coil
Voltage dip limit value in relation to nominal value voltage [0.1%]	• 10 ... 1000	100
Voltage swell limit value in relation to nominal value voltage [0.1%]	• 10 ... 10000	100
Threshold overcurrent in relation to nominal value current [0.1%]	• 10 ... 60000	100

* Reconfiguration in RUN is not possible.

Parameters	Value range	Default setting
Number of cycles for voltage swell and dip analysis	• 4 ... 32767	10
Diagnostics power quality	• Disable • Enable	Disable
Diagnostics overflow current	• Disable • Enable	Disable
Diagnostics overflow voltage	• Disable • Enable	Disable
Diagnostics underflow voltage	• Disable • Enable	Disable
Diagnostics overflow cumulative values	• Disable • Enable	Disable
Detect voltage swell and dip	• Disable • Enable	Disable
Detect peak value current	• Disable • Enable	Disable
Detect peak value voltage	• Disable • Enable	Disable
Detect overcurrent	• Disable • Enable	Disable
Analyse harmonics	• Disable • Enable	Disable
Nominal value current [A]	• 0 ... 99999	1
Tolerance factor overcurrent in relation to nominal value current [0.1%]	• 10 ... 60000	100
Tolerance time overcurrent [ms]	• 0 ... 60000	40000
Low limit current measurement in relation to nominal value current [0.1%]	• 0 ... 200	10
Enable operating hours counter	• Disable • Enable	Disable
Enable gate of operating hours counter	• Disable • Enable	Disable
Current transformer secondary voltage [0.1 mV]	• 100 ... 6000	250
Current transformer primary rated current [A]	• 1 ... 16000	1000
Reverse current direction	• Disabled • Reverse current direction	Disabled
Nominal value voltage [V]	• 1 ... 999999	230 V
Tolerance factor overvoltage/undervoltage [0.1%]	• 10 ... 500	100

* Reconfiguration in RUN is not possible.

Parameters	Value range	Default setting
Voltage transformer primary voltage [V]	• 1 ... 999999 V	230 V
Voltage transformer secondary voltage [V]	• 1 ... 500 V	230 V
Limits		
Number of limit values	• 0 ... 16	0
Limit monitoring	• Disable • Enable	Disable
Measured variable	• Measured value ID, see Measured value data records	None
Enable limit monitoring gate	• Disable • Enable	Disable
Hardware interrupt	• Disable • Enable	Disable
Limit	• depending on the selected measured variable	0.0000
Type	• High limit • Low limit	High limit
Hysteresis for limit monitoring [0.1%]	• 0 ... 200 [0.1%]	10
Delay time for limit monitoring [s]	• None • 1 ... 10 s	None
Payload mapping I/II		
Number of measured values	• 0 ... 64	0
Measured variable	• Measured value ID, see Measured variables	None
Data record mapping		
Number of measured values	• 0 ... 150	0
Measured variable	• Measured value ID, see Measured variables	None
Measured value recorder		
Number of activated measured value recordings	• 0: No recording • 1: Recording 1 • 2: Recording 1 and 2	0
Measured variable	• Measured value ID, see Measured variables	ID1 = 1, ID2 = 7
Recording interval for measured value recording 1 or 2	• 1...60000 in the unit 10 ms	10 = 100 ms
Mode for measured value recording 1 or 2	• Once • Circular buffer	Once
ID for start or stop trigger 1 and 2	See Structure of the parameter data record 134 for measured value recording	None
Hardware interrupt enable for DS173 (measured value recording 1) or DS174 (measured value recording 2) full	0x80: Trigger hardware interrupt 0x00: Trigger no hardware interrupt	0 (trigger no hardware interrupt)

* Reconfiguration in RUN is not possible.

16.2 Description of parameters

Basic parameters

Hardware interrupts

Enable the hardware interrupt for the entire module here.

Diagnostics: No supply voltage L+

Activate the diagnostics No supply voltage L+. If there is no voltage or too little voltage at terminal 17, the message "No supply voltage" is output and a diagnostic interrupt is triggered.

Connection type

Specify the connection type you used for the AI Energy Meter RC HF.

For more detailed information, refer to "Connection examples (Page 25)".

Voltage measuring range

Here you set the voltage measuring range in which the system connected to the AI Energy Meter RC HF works. This parameter is only required when calibrating the module.

Line frequency

Here you set the line frequency in which the system connected to the AI Energy Meter RC HF works.

Enable gate energy counter

Enable the gate for the energy counter When the gate is enabled, the energy counter only counts when the corresponding output data bit (DQ bit) is set to "1".

End value energy counter

Select the end value for the periodic counting of the energy counter. You can also specify that the energy counter is to count without a full-scale value (infinite counting). The calculated energy counter values are stored retentively in the module.

Payload variant

Select payload variant with which the module is to operate once it is started up.

Minimum and maximum value calculation

Enable calculation of the minimum and maximum values. The minimum and maximum value are calculated from the start of the measurement. The values determined are stored retentively in the AI Energy Meter RC HF together with the time stamp.

Minimum and maximum value calculation gate

Enable the gate for minimum and maximum value calculation. When the gate is enabled, the energy counter only counts when the corresponding output data bit (DQ bit) is set to "1".

Power quality analysis function

Enable the power quality analysis function for the entire module.

Residual current analysis

Enable the residual current analysis for the entire module. The residual current analysis is only available in the connection types 3P4W or 3P4WI and the concurrently activated parameter "Neutral current measurement".

Neutral conductor current measurement

Defines whether the neutral current is measured or calculated.

This parameter does not apply to parameter assignment with GSD file.

Neutral conductor: Current transformer secondary voltage [0.1 mV]

Enter the secondary voltage to determine the current/voltage transformer ratio. The conversion ratio is determined from the primary rated current and the secondary voltage.

The following applies to parameter assignment with GSD file:

- 0 = Neutral conductor function deactivated
- 100 ... 6000 = measure neutral current
- 65535 = calculate neutral current (0xFFFF)

Neutral conductor: Current transformer primary rated current [A]

To determine the current/voltage transformer ratio, enter the primary rated current. The conversion ratio is determined from the primary rated current and the secondary voltage.

Current transformer type for line conductors L1, L2, L3 and neutral conductor

Select the connected current measuring transformer type.

Voltage dip limit value in relation to nominal value voltage [0.1%]

Further information can be found under Voltage dip of the voltage half-wave value (Page 126).

Voltage swell limit value in relation to nominal value voltage [0.1%]

Further information can be found under Voltage swell of the voltage half-wave value (Page 123).

Threshold overcurrent in relation to nominal value current [0.1%]

Further information can be found under Overcurrent of the current half value (Page 137).

Number of cycles for voltage swell and dip analysis

Further information can be found under Voltage swell of the voltage half-wave value (Page 123) and Voltage dip of the voltage half-wave value (Page 126).

Diagnostics power quality

Depending on the enable of the individual functions the diagnostics are triggered when a voltage swell, voltage dip or overcurrent event has occurred.

Diagnostics overflow current

The measured current is monitored after expiry of the "Tolerance time" for "Overcurrent [0.1 A] tolerance value". Exceeding the value generates the diagnostics "overflow current".

Diagnostics overflow voltage

The nominal values voltage are monitored for tolerance. An overflow triggers a diagnostic interrupt.

Diagnostics underflow voltage

The nominal values voltage are monitored for tolerance. An underflow triggers a diagnostic interrupt.

Diagnostics overflow cumulative values

A cumulative overflow in the calculated variables is displayed. The values stop at the high or low limit. A violation triggers a diagnostic interrupt.

Detect voltage swell and dip

Activates the detection of voltage swell and dip. Further information can be found under Diagnostics: Overflow/underflow (Page 121).

Detect peak value current

Activates the detection of current peak values. Further information can be found under Peak values of the instantaneous values for current (Page 135).

Detect peak value voltage

Activates the detection of voltage peak values. Further information can be found under Peak values of the instantaneous values for voltage (Page 128).

Detect overcurrent

Activates the detection of overcurrent. Further information can be found under Overcurrent of the current half value (Page 137).

Analyse harmonics

Activates harmonics analysis

Nominal value current [A]

Enter the nominal value for the current. This is the "operating point" in your application.

Tolerance factor overcurrent in relation to nominal value current [0.1%]

Further information can be found under Diagnostics: Overload (Page 131).

Tolerance time overcurrent [ms]

Further information can be found under Diagnostics: Overload (Page 131).

Low limit current measurement in relation to nominal value current [0.1%]

The configurable low limit for measuring current refers to the nominal value and is used to avoid incorrect calculations in the case of very low currents. Incorrect measurements of very low currents in particular are a cause of inaccuracies in the current transformer used. Set the low limit for the current measurement to the required value depending on your process.

NOTE

Tip: If you want to find the low limit for the current measurement experimentally, set it to a lower value. Then, feed in a very precise low current and determine the measurement error that can no longer be tolerated. Afterwards, set the low limit for the current measurement to the limit value you have determined.

If current falls below the low limit for the current measurement, the following measured values and derived variables of the affected phase are reset.

- Effective current value
- Neutral current
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A moving mean value is formed from the power values and they only become "0" after a corresponding time. The energy counters for active, reactive and apparent energy as well as the operating hours counters do not count any longer.

Further information can be found under Low limit for measuring current undershot (Page 133).

Enable operating hours counter

Enable the operating hours counter. The counting starts from the configurable low limit of the current measurement. The counter can be reset or pre-assigned using data record or output bit.

Enable gate of operating hours counter

Enable the gate for the operating hours counter. When the gate is activated, the operating hours counter only counts when the corresponding output data bit (DQ bit) is set to "1".

Current transformer secondary voltage [0.1 mV]

Enter the nominal value for the secondary voltage (10.0 mV to 600.0 mV) of the current-voltage-converter or Rogowski coil used. The conversion ratio is determined from the primary rated current and the secondary voltage.

Current transformer primary rated current [A]

Enter the nominal value for the primary rated current (1 A or 16000 A) of the current/voltage transformer used or Rogowski coil. The conversion ratio is determined from the primary rated current and the secondary voltage.

Reverse current direction

Setting to determine whether or not to reverse the direction of current.

In the event of inadvertent incorrect connection, this parameter can be used to correct the measured values, thus saving the hassle of rewiring. The direction of the current is only evident from the power measurement values. The current measurement value is an rms value.

Nominal value voltage [V]

Enter the nominal value for the voltage. This is the "operating point" in your application.

Tolerance factor overvoltage/undervoltage [0.1%]

Enter the tolerance factor overvoltage/undervoltage here in increments of 0.1%. You can find additional information under Diagnostics: Overflow/underflow (Page 121).

Voltage transformer primary voltage [V]

Enter the nominal value for the primary voltage of the voltage transformer used. The transformer ratio is calculated from the primary and secondary voltage.

Voltage transformer secondary voltage [V]

Enter the nominal value for the secondary voltage of the voltage transformer used. The transformer ratio is calculated from the primary and secondary voltage.

Limits

Number of limit values

Enter the number of measured values that you want to monitor for limits.

Limit monitoring

Enable the monitoring of the limit for a freely definable measured value here. Limit violations are counted and the count values stored retentively.

Measured variable

Enter the measured value ID (Page 174) that you want to use for limit monitoring.

Enable limit monitoring gate

Enable the limit monitoring gate. When the gate is enabled, the limit monitoring is only started when the corresponding bit of the associated output payload is set to "1".

Hardware interrupt

Enable the hardware interrupt. The hardware interrupt is triggered if a high or low limit is violated. Without activation of a hardware interrupt, a limit violation is only displayed in the payload and in DS 150.

Limit

Enter the limit that is to trigger a limit violation when exceeded or fallen below. Limit violations are displayed in the payload and in DS 150.

Type

Select whether it is a high or low limit. Depending on this selection, the limit violation or hardware interrupt is triggered when a value exceeds (high limit) or falls below (low limit) the limit.

Hysteresis for limit monitoring [0.1%]

Enter the hysteresis for limit in percent.

The hysteresis band is below the high limit or above the low limit. The parameter in % refers to the configured limit. If a measured value fluctuates around the limit but does not leave the hysteresis band, a new limit violation is not triggered.

Delay time for limit monitoring [s]

Select the delay time for limit violation. The delay refers to the time that must elapse before an occurrence of a limit violation is reported. Faults can be filtered out by selection of the delay time. The deceleration time is also taken into consideration during outgoing of the limit violation.

Payload mapping I/II

Number of measured values

Specify the number of measured values/variables that you want to use for the user-specific payload mapping.

Measured variable

Select the measured variable (with the measured value ID (Page 174)) that you want to use for the user-specific payload mapping.

Data record mapping

Number of measured values

Specify the number of measured values/variables that you want to use for the user-specific data record mapping.

Measured variable

Select the measured variable (with the measured value ID (Page 174)) that you want to use for the user-specific data record mapping.

Measured value recorder

Number of activated measured value recordings:

- 0 (function disabled), 1 (MV recorder2 block is ignored) or 2 (MV recorder1 and MV recorder2 enabled).
- Factory setting: 0

NOTE

For a recording of 400 measured values at only one data source, set the "Number of activated measured value recordings" to 2 and all subsequent parameters for measured value recording 1 or with identical values.

ID for measured value recording 1 or 2:

All IDs that can be used with user-definable payload (DS130, DS131) and user-definable data records (DS135) are possible. Factory setting: ID1 = 1 (UL1) and ID2 = 7 (IL1).

Exception:

- PNIO_Time_type cannot be used (measured value ID 65497 is thus blocked)
- While use is possible for bit fields, their measured values cannot be displayed in a meaningful way because the format of the measured values is always REAL. This affects the IDs: 65496, 65500, 65501, 65502, 65503, 65508, 65509, 62193, 62293, 62393, 65495

NOTE

The use of measured values that are only generated upon request (e.g. from the analysis of the harmonic component started by command, IDs: 63000 ... 63879) does not make much sense.

NOTE

Note that, depending on the connection type used, the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

Recording interval for measured value recording 1 or 2:

- Value range 1...60000 in the unit 10 ms
- Factory setting: 10 = 100 ms

NOTE

The shortest recording cycle is 10 ms (half-wave at 50 Hz line frequency). This short interval only makes sense for measured values that are generated that quickly. These are all half-wave and instantaneous values. Frequency measured values and THD values are measured every second; all other values (the majority of the measured values) are measured in a 50 ms cycle.

Mode for measured value recording 1 or 2:

- 0 (Factory setting): Once, which means the buffer is filled from the top. The recording stops when the buffer is full or when the recording is stopped.
- 1: Circular buffer. For circular buffer mode, the oldest element is always listed first, which means the buffer is filled from the bottom.

Hardware interrupt for measured value recording 1 or 2:

- 0 (Factory setting): Trigger no hardware interrupt
- 0x80: Trigger hardware interrupt when data record is full

ID for start or stop trigger 1 and 2:

- "0": Start or stop trigger is not activated. "0" in the start trigger starts the measurement immediately after parameter assignment; "0" in the stop trigger ignores this function
- Factory setting: 0 = Not activated
- You can find additional information in the appendix A, Structure of the parameter data record D134 (Page 166).

Interrupts/diagnostic alarms 17

17.1 Status and error display

LED display

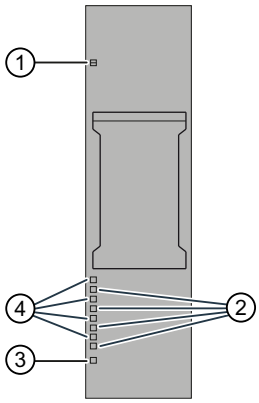

① DIAG (green/red)

② Error (red)

③ PWR (green)

④ Status (green)

Figure 2-782 LED display

Meaning of the LED displays

The following table explains the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 119).

DIAG LED

Table 2-872 Meaning of the DIAG LED

DIAG	Meaning
□ Off	Supply voltage of the ET 200SP not OK
☼ Flashes	Module not ready for operation (no parameters assigned)
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Status LED

Table 2-873 Meaning of the Status LED

Status	Meaning
□ Off	Channel deactivated or error
■ On	Channel activated and no error

see also Neutral current In (Page 101)

Error LED

Table 2-874 Meaning of the Error LED

Status	Meaning
□ Off	Channel is OK
■ On	Channel is faulty

PWR LED

Table 2-875 Meaning of the PWR LED

PWR	Meaning
□ Off	Line voltage missing
■ On	Line voltage available

17.2 Interrupts

The analog input module AI Energy Meter RC HF supports hardware and diagnostic interrupts.

17.2.1 Hardware interrupts

Hardware interrupts

The module generates a hardware interrupt at the following events:

- Violation of low limit 1 to 16
- Violation of high limit 1 to 16
- Measuring value recording of 200 measured values completed (DS173/ DS174 full)

You can find detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment of the local data double word 8 by the start information of the hardware interrupt organization block.

NOTE

When configuring with a GSD file, you operate the AI Energy Meter RC HF downstream of an S7-1500 CPU. For the correct OB start information to become visible for evaluation by the hardware interrupt, disable the optimized block access at the alarm OB.

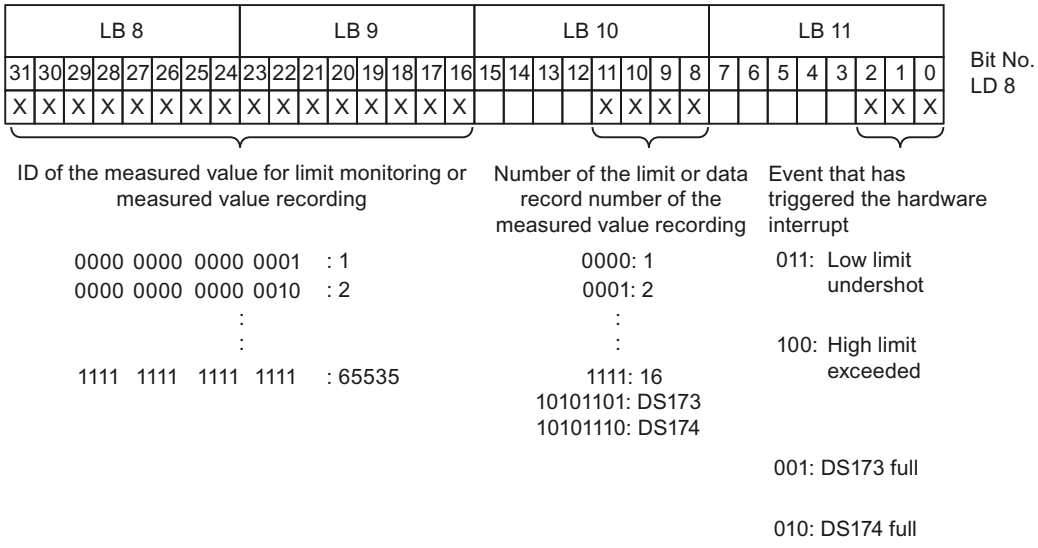

Figure 2-783 Start information of the organization block

17.2.2 Diagnostics interrupt

Diagnostic interrupt

The module generates a diagnostic error interrupt at the following events:

- Power quality
- Channel is temporarily unavailable
- Hardware interrupt lost
- Error
- Supply voltage missing
- Parameter assignment error
- Underflow voltage (tolerance for supply voltage) violated
- Overflow voltage (tolerance for supply voltage) exceeded
- Overload (voltage measured value > 2 V or tolerance value overcurrent exceeded after the tolerance time has expired)
- Overflow of the calculated values (measured or calculated values screen exceed the representable range of values)

17.3 Diagnostic alarms

NOTE

Assignment channel in diagnostic message ⇔ Phase

In the diagnostic messages the channels are counted from Channel "0" on, in the AI Energy Meter RC HF from phase "1" on.

Note the following assignment:

- Channel "0" ⇔ Phase "1"
- Channel "1" ⇔ Phase "2"
- Channel "2" ⇔ Phase "3"

Table 2-876 Error types

Diagnostic message	Error code	Meaning	Solution
Undervoltage	2_H	Line voltage (measuring range) is monitored for tolerance. Violation leads to voltage overflow/underflow	Observe the line voltage range
Overvoltage	3_H		
Overload	4_H	• The measured current is monitored after the "Tolerance time" for "Tolerance value overcurrent [0.1A]" has expired. Exceeding this results in overflow current. • The maximum value of the secondary voltage (2 V) is exceeded.	Observe the current range
Error	9_H	Internal module error (diagnostic alarm on channel 0 applies to the entire module).	Replace the module

Diagnostic message	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Load voltage missing	11_H	Missing or insufficient line voltage at terminal 17	Check supply
External fault	$1A_H$	Voltage swell/dip and overcurrent	see: • Voltage swell of the voltage half-wave value (Page 123) • Voltage dip of the voltage half-wave value (Page 126) • Overcurrent of the current half value (Page 137)
Channel is temporarily unavailable	$1F_H$	Firmware upgrade is being performed. Channel 0 applies to the entire module. The module is currently not performing any measurements.	--
		A user calibration is being executed at the channel.	Complete the user calibration

17.4 Diagnostics response

Diagnostics response

This section describes the response of the AI Energy Meters RC HF when diagnostics information is reported.

Measured values in the case of diagnostics

Even in the case of diagnostics, measured values continue to be displayed as long as they can still be acquired. If measured values cannot be measured or calculated, "0" is displayed.

Low limit for current measurement undershot (zero suppression)

If the supplied current is less than the configured "Low limit for current measurement" parameter, the current measurement and all dependent variables are suppressed and set to "0".

If current falls below the low limit for the current measurement, the following measured values and derived variables of the affected phase are reset.

- Effective current value
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A moving mean value is formed from the power values and they only become "0" after a corresponding time. The energy meters for active, reactive and apparent energy as well as the operating hours counters do not count any longer.

Input data to "0"

If the AI Energy Meter RC HF is no longer recognized by the interface module (for example, because it is defective or not plugged in), all input data are set to "0".

17.4.1 Voltage diagnostics

17.4.1.1 Diagnostics: Overflow/underflow

Introduction

You use the parameter "Tolerance factor overvoltage/undervoltage" to define a tolerance range around the set nominal value voltage at the operating point. If the effective value of the primary voltage exceeds this tolerance range, the module reports the diagnostics "overflow" or "underflow".

Calculation of tolerance value measuring voltage

The tolerance value measuring voltage is calculated with the following formula:

Tolerance value measuring voltage = "Nominal value voltage" ± ("Tolerance factor overvoltage/undervoltage [%]" × "Nominal value voltage")

The "Nominal value voltage" is the primary voltage at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-877 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Diagnostics overflow	Enable
Diagnostics underflow	Enable
Nominal value voltage	1 ... 999999 V
Voltage transformer primary voltage	1 ... 999999 V
Voltage transformer secondary voltage	1 ... 500 V
Tolerance factor overflow/underflow	10 ... 50%

Example

The following figure is a schematic diagram of the principle of operation:

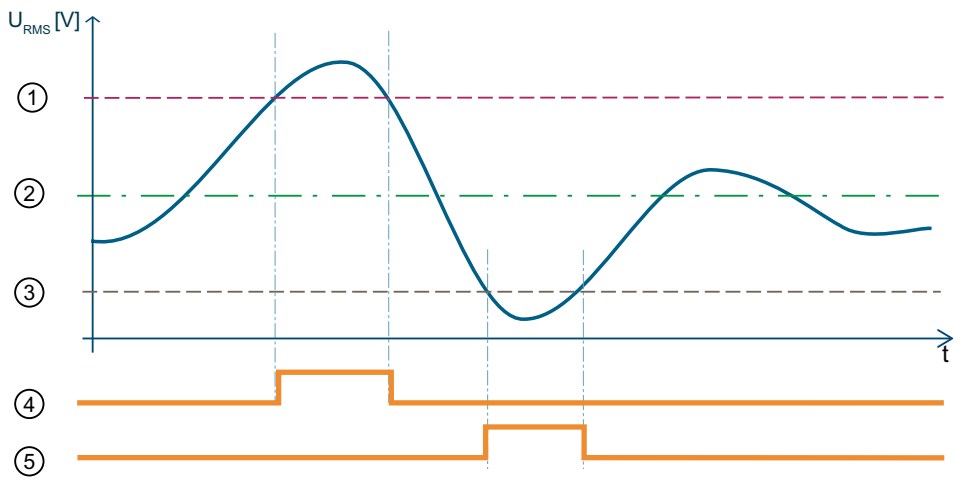

① Upper tolerance value measuring voltage
② Nominal voltage
③ Lower tolerance value measuring voltage
④ Diagnostics "overflow"
⑤ Diagnostics "underflow"

Figure 2-784 "Overflow/Underflow" diagnostics of the effective voltage value

The following table shows the parameter assignment for the example:

Table 2-878 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Diagnostics overflow	Enable
Diagnostics underflow	Enable

Parameter	
Nominal value voltage	230 V
Voltage transformer primary voltage	1000 V
Voltage transformer secondary voltage	500 V
Tolerance factor overflow/underflow	20%

In this example a voltage transformer is used with a ratio of 1000V/500V. The operating point of the application is set to 230 V via the Nominal Value Voltage parameter. The tolerance range in this example is ±20%, which corresponds to an effective value of primary voltage of ±46V.

In the figure the effective value of the primary voltage first exceeds the tolerance range. As long as the effective value of the primary voltage exceeds the tolerance range the module reports the diagnostics "overflow".

The effective value of the primary voltage then exceeds the tolerance range. As long as the effective value of the primary voltage exceeds the tolerance range the module reports the diagnostics "underflow".

17.4.1.2 Voltage swell of the voltage half-wave value

Introduction

Voltage swells are short-term increases in the line voltage which can occur, for example, when switching off large consumers.

With the parameter "Number of cycles for analysis" you define how many measuring cycles the voltage swell must apply at until the module reports the voltage swell. The module reports the diagnostics "Power quality". The module also sets the qualifier bit 6 for the respective phase in data record DS 160 (Page 267). If the voltage lies below the limit for voltage swell again, the module sets the diagnostics "Power quality" again and resets the qualifier bit 6 again.

The AI Energy Meter RC HF returns the maximum value and the duration of the voltage swell, e.g. in data record 160. The duration is determined exactly to ± 2 cycles.

In the event of voltage swell again, only the diagnostics "Power quality" is reported again and the duration, and if applicable, the maximum voltage swell value is updated.

For technical reasons, if the process value for the voltage goes to "0", then the module shows a slightly longer time for a voltage swell.

Calculation of voltage swell limit value

The Voltage swell limit value is the value from which level of voltage the AI Energy Meter RC HF recognizes a voltage swell.

The "Voltage swell limit value" is calculated by the following formula:

Voltage swell limit = "Nominal value voltage" + ("Voltage swell limit [%]" × "Nominal value voltage")

The "Nominal value voltage" is the primary voltage at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-879 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Number of cycles for analysis	4 ... 32767
Diagnostics power quality	Enable
Determination of voltage swell and dip	Enable
Nominal value voltage	1 ... 999999 V
Voltage swell limit	1 ... 1000%

Example

The following figure is a schematic diagram of the principle of operation:

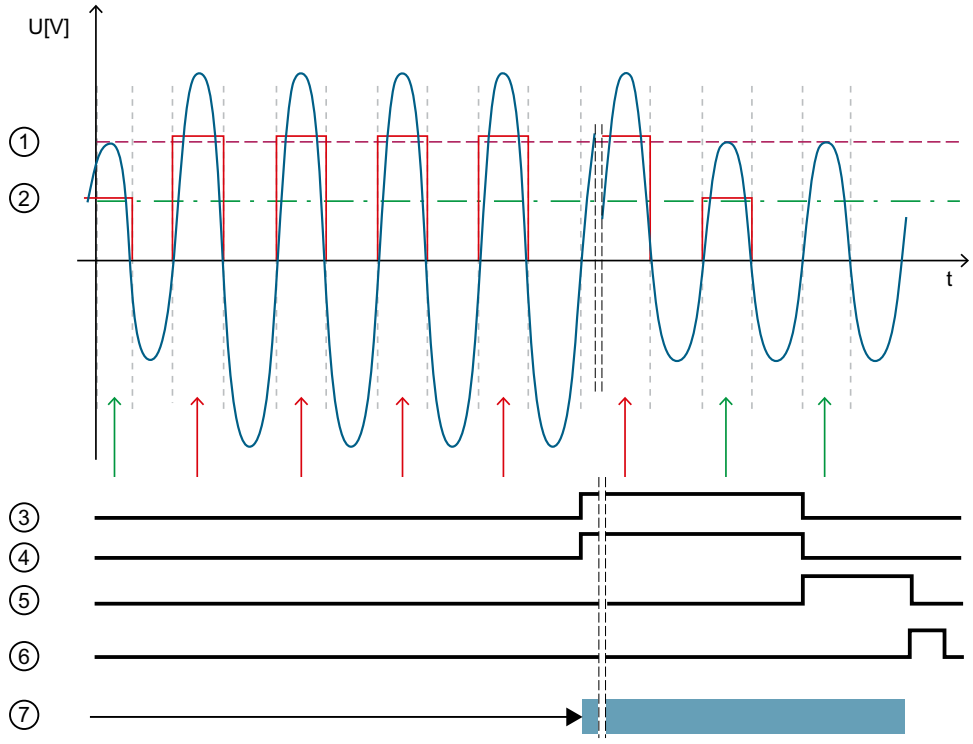

① Voltage swell limit
② Nominal voltage
③ Diagnostics "power quality"
④ Qualifier Bit 6
⑤ Status "Power quality voltage swell"
⑥ Bit "Reset status "power quality""
⑦ Min. voltage swell (half-wave) and duration can be read

Figure 2-785 Example of principle of operation

The following table shows the parameter assignment for the example:

Table 2-880 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Number of cycles for analysis	4
Diagnostics power quality	Enable
Determination of voltage swell and dip	Enable
Nominal value voltage	230 V
Voltage swell limit	20%

If the module detects that the "Voltage swell limit value" has been exceeded:

- The module reports the diagnostics "Power quality" from "Number of cycles for analysis" as long as there is a voltage swell.
- The module sets the qualifier bit 6 from "Number of cycles for analysis" as long as there is a voltage swell.
- After the module has reset the diagnostics "Power quality" and reset the qualifier bit again, Bit 1 is set.

As long as Bit 1 is set, the module returns the maximum value and the duration of the voltage swell, e.g. in data record 160.

You reset Bit 1 with the bit "reset status "power quality"".

17.4.1.3 Voltage dip of the voltage half-wave value

Introduction

Voltage dips are short-term decreases in the line voltage which can occur, for example, when switching on large consumers.

With the parameter "Number of cycles for analysis" you define how many measuring cycles the voltage dip must be present until the module reports the voltage dip. If the voltage lies above the "Voltage dip limit" again, the module sets the diagnostics "Power quality" and resets the qualifier bit 5 again.

The AI Energy Meter RC HF returns the maximum value and the duration of the voltage dip, e.g. in data record DS 160 (Page 267). The duration is determined exactly to ± 2 cycles.

In the event of voltage dip, the module reports a "Power quality" diagnostic. The module also sets the qualifier bit 5 for the respective phase in data record DS 160. In the event of voltage dip again, only the "Power quality" diagnostics is reported again and the duration, and if applicable, the minimum voltage dip value is updated.

For technical reasons, if the process value for the voltage goes to "0", then the module shows a slightly longer time for a voltage dip.

Calculation of voltage dip limit

The voltage dip limit is the value from which level of voltage the AI Energy Meter RC HF detects a voltage dip.

The voltage dip limit is calculated by the following formula:

Voltage dip limit = "Nominal value voltage" - ("Voltage dip limit [%]" × "Nominal value voltage")

The "Nominal value voltage" is the primary voltage at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-881 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Number of cycles for analysis	4 ... 32767
Diagnostics power quality	Enable
Determination of voltage swell and dip	Enable
Nominal value voltage	1 ... 999999 V
Voltage dip limit	1 ... 100%

Example

The following figure is a schematic diagram of the principle of operation:

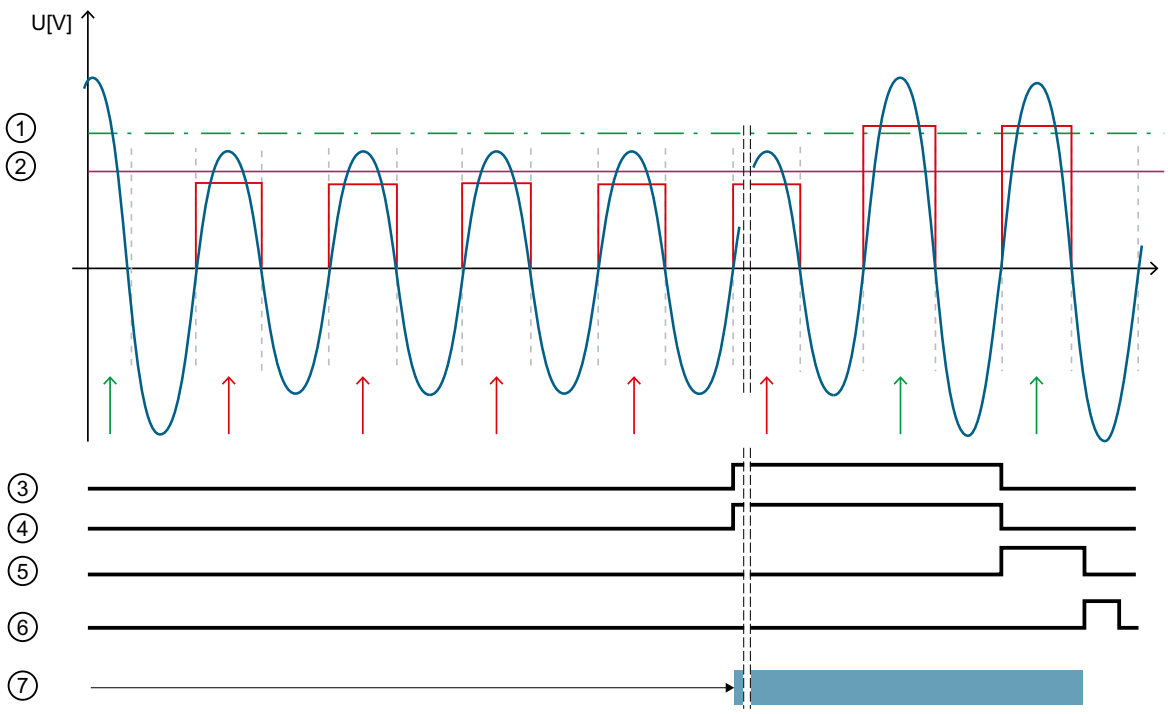

① Nominal voltage
② Voltage dip limit
③ Diagnostics "power quality"
④ Qualifier Bit 0
⑤ Status "Power quality voltage dip"
⑥ Bit "Reset status "power quality""
⑦ Min. voltage dip (half-wave) and duration can be read

Figure 2-786 Example of principle of operation

The following table shows the parameter assignment for the example:

Table 2-882 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Number of cycles for analysis	4
Diagnostics power quality	Enable
Determination of voltage swell and dip	Enable
Nominal voltage	230 V
Voltage dip limit	50%

If the module detects that the "Voltage dip limit" has been undershot:

- The module reports the diagnostics "Power quality" from "Number of cycles for analysis" as long as there is a voltage dip.
- The module sets the qualifier bit 5 from "Number of cycles for analysis" as long as there is a voltage dip.
- After the module has reset the diagnostics "Power quality" and reset the qualifier bit again, bit 0 is set.

As long as bit 0 is set, the module returns the minimum value and the duration of the voltage dip, e.g. in data record 160.

You reset Bit 0 with the bit "Reset status "power quality"".

17.4.1.4 Peak values of the instantaneous values for voltage

Introduction

The AI Energy Meter RC HF determines the maximum instantaneous value for the voltage for up to three phases.

The function "Detect peak value voltage" returns the largest voltage value and the associated phase. The module sets the qualifier bit 2 ("Power quality voltage peak") for the phase in question. You can read the maximum voltage value, for example, in the data record DS 160 (Page 267).

Voltage peak detection is based on the function for recording swells of the supply voltage in accordance with IEC 61000-4-30. This function is used to record the maximum voltage value in the supply network. In three-phase systems this function is only useful if the system is symmetrical and when all phases show the same voltage transformers.

Accordingly, measurement always records only the peak value over all phases. In addition to the requirements of IEC 61000-4-30, the phase on which the peak value voltage occurred is detected.

For metrological reasons, only the phase concerned that shows this maximum value can be returned. This might mean that the maximum voltage values of the other phases remain "0". With a "reset power quality analysis" the analysis starts afresh and the current results are discarded.

Peak value detection of voltage

For technical reasons, both the "Detect peak value current" and "Detect peak value voltage" functions are activated at the same time internally to ensure the correct evaluation of the peak value detection of the voltage of a phase.

The AI Energy Meter RC HF always shows the phase that exhibits the highest instantaneous value for voltage respectively.

If peak values are displayed for several phases, you can correlate the available phase values to determine the maximum value of the module.

Peak value detection of the instantaneous values of voltage only works when the module is correctly connected to the corresponding phases selected for the connection type.

- For connection type 1P2W only phase 1 should be connected.
- For connection type 2P3W only the phases 1 and 2 should be connected.

Parameter assignment

The following table shows the necessary parameters:

Table 2-883 Parameter assignment

Parameter	
Power quality analysis function (module)	Enable
Determine peak value voltage (channel)	Enable

Example

The following figure is a schematic diagram of the principle of operation:

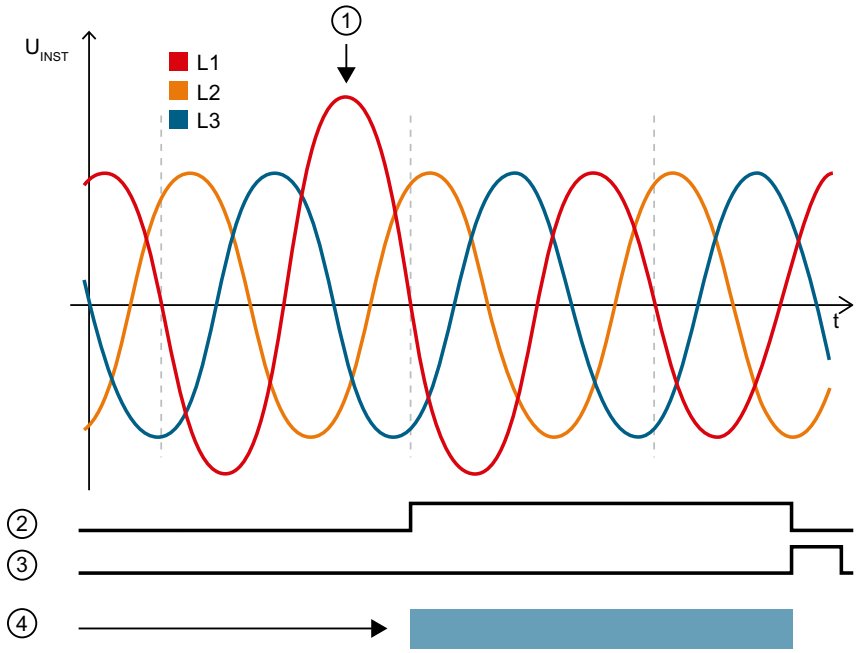

① Voltage peak in L1
② Status "Power quality voltage peak"
③ Bit "Reset status "power quality""
④ Max. voltage peaks instantaneous value can be read out

Figure 2-787 Example of principle of operation

The following table shows the parameter assignment for the example:

Table 2-884 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Determination of voltage peak value L1	Enable
Determination of voltage peak value L2	Enable
Determination of voltage peak value L3	Enable

The module detects the voltage peak in phase 1 and sets the qualifier bit 2 for phase 1. You can find the maximum voltage value, for example, in the data record DS 160 in bytes 174 to 177 ("Voltage peak value L1").

17.4.2 Current diagnostics

17.4.2.1 Diagnostics: Overload

Introduction

As long as one of the following conditions is met, the module reports the diagnostics "Overload" for each phase:

- Parameterized maximum relative measured current longer than the parameterized "Tolerance time overcurrent" is exceeded.
- Maximum permissible secondary voltage of 2 V at a current measuring channel of the AI Energy Meters HF is exceeded.

Calculation of the parameterizable maximum measured current

The tolerance value for the maximum relative measured current is calculated with the following formula:

Tolerance factor for maximum relative measured current = "Nominal value current" + ("Tolerance factor overcurrent [%]" × "Nominal value current")

The "Nominal value current" is the primary current at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-885 Parameter assignment

Parameter	
Diagnostics overload	Enable
Nominal value current	0 ... 99999 A
Current transformer primary rated current	1 ... 16000 A
Current transformer secondary voltage	10 ... 600 mV
Tolerance factor overcurrent	1 ... 6000%
Tolerance time overcurrent	0 ... 60000 ms

Example

The following figure is a schematic diagram of the signal wave for the diagnostics "Overload":

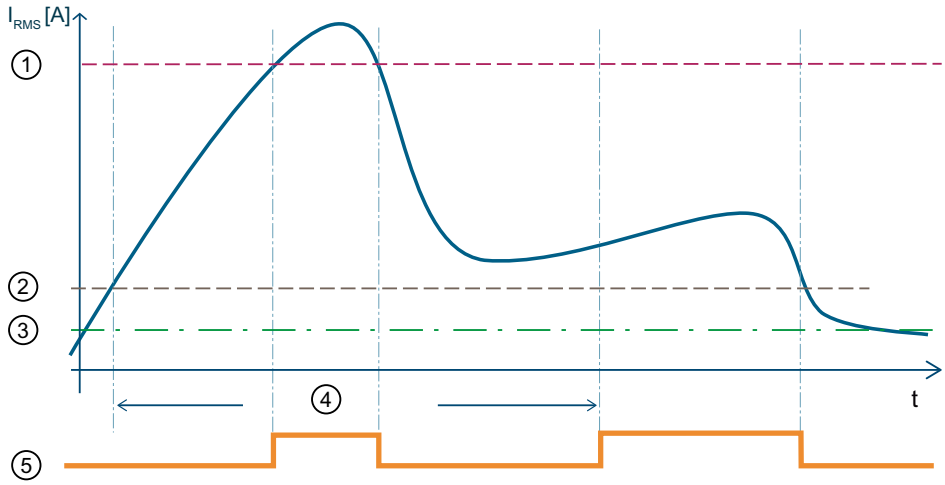

① Maximum relative measured current at permissible secondary voltage of 2 V
The module reports the diagnostics overload when the maximum permissible secondary voltage amounting to 2 V is exceeded (primary current = 2 V x 10000 A / 333 mV = 60060 A).

② Tolerance value measured current
After the "Tolerance time overcurrent" of 40000 ms has expired, the module reports the diagnostics "Overload" as long as the configured tolerance value for the maximum measured current of 2400 A
(= 2000 A + 20% x 2000 A) is exceeded.

③ Nominal value current

④ Tolerance time

⑤ Diagnostics "overload"

Figure 2-788 Diagnostics "overload" of the effective current value

The following table shows the parameter assignment for the example:

Table 2-886 Parameter assignment

Parameter	
Diagnostics overload	Enable
Nominal value current	2000 A
Current transformer primary rated current	10000 A
Current transformer secondary voltage	333 mV
Tolerance factor overcurrent	20%
Tolerance time overcurrent	40000 ms

17.4.2.2 Low limit for measuring current undershot

Introduction

With the function "Low limit for measuring current undershot" the AI Energy Meter RC HF monitors the low limit of the effective value of the current per phase.

If the low limit for measuring current is undershot, the module sets the current value to 0. Information as to which current measured values are set to 0 can be found under Basics for reading measured values (Page 43).

You activate the function by setting the parameter "Low limit for measuring current" > 0%.

Calculation of low limit for measuring current

The low limit for measuring current is calculated using the following formula:

Low limit measured current = "Nominal value current" × "Low limit for measuring current [%]"

The "Nominal value current" is the primary current at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-887 Parameter assignment

Parameter	
Nominal value current	0 ... 99999 A
Current transformer primary rated current	1 ... 16000 A
Current transformer secondary voltage	10 ... 600 mV
Low limit for current measurement	0 ... 20% *

* 0% means deactivation of the function

Example

The following figure is a schematic diagram of the principle of operation:

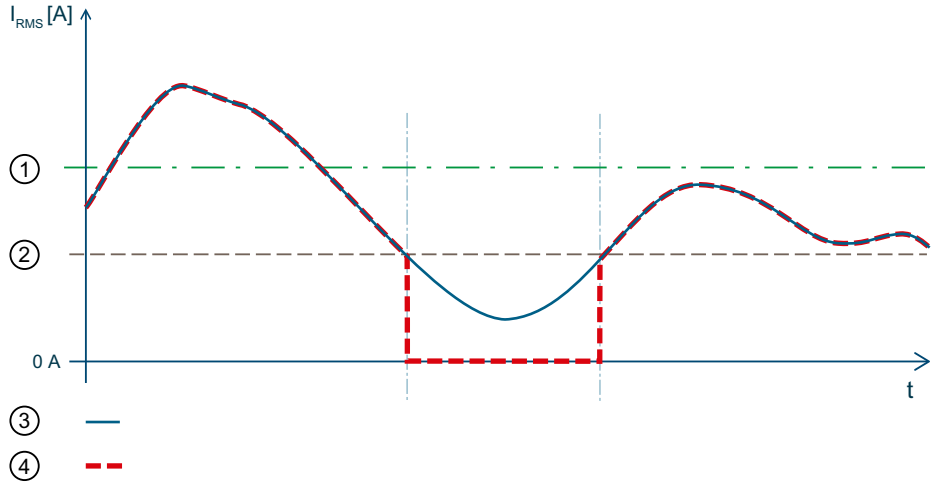

① Nominal current
② Low limit measured current
③ Measured value
④ Returned value

Figure 2-789 Behavior in the event of value falling below "Low limit for measuring current undershot"

The following table shows the parameter assignment for the example:

Table 2-888 Parameter assignment

Parameter	
Nominal value current	2000 A
Current transformer primary rated current	5000 A
Current transformer secondary voltage	333 mV
Low limit for current measurement	10%

In this example you define the "Low limit for measuring current" with 10%. This corresponds to an effective value of the primary voltage of 200 A.

If the value falls below the calculated low limit current measurement ②, the module sets all the current-dependent measured values (effective value current, active power, reactive power, apparent power, phase angle and power factor) to 0 A until the low limit measuring current is exceeded again. The energy meters and operating hours counters are stopped during this time.

17.4.2.3 Peak values of the instantaneous values for current

Introduction

The AI Energy Meter RC HF determines the maximum instantaneous value for the current for up to three phases.

The function "Detect peak value current" returns the largest current value and the associated phase. The module sets the qualifier bit 3 ("Power quality current peak") for the phase in question. You can read the maximum current value, for example, in the data record DS 160 (Page 267).

Current peak detection is based on the function for recording swells of the supply voltage in accordance with IEC 61000-4-30. This function is used to record the maximum current value in the supply network. In three-phase systems this function is only useful if current recording is symmetrical and if all phases show the same current measuring transformers.

Accordingly, measurement always records only the peak value over all phases. In addition to the requirements of IEC 61000-4-30, the phase on which the peak value current occurred is detected.

For metrological reasons, only the phase concerned that shows this maximum value can be returned. This might mean that the maximum current values of the other phases remain "0". With a "reset power quality analysis" the analysis starts afresh and the current results are discarded.

Peak value detection of current

For technical reasons, both the "Detect peak value current" and "Detect peak value voltage" functions are activated at the same time internally to ensure the correct evaluation of the peak value detection of the current of a phase.

The AI Energy Meter RC HF always shows the phase that exhibits the highest instantaneous value for current respectively.

If peak values are displayed for several phases, you can correlate the available phase values to determine the maximum value of the module.

Peak value detection of the instantaneous values of current only works when the module is correctly connected to the corresponding phases selected for the connection type.

- For connection type 1P2W only phase 1 should be connected.
- For connection type 2P3W only the phases 1 and 2 should be connected.

Parameter assignment

The following table shows the necessary parameters:

Table 2-889 Parameter assignment

Parameter	
Power quality analysis function (module)	Enable
Determine peak value current (Channel)	Enable

Example

The following figure is a schematic diagram of the principle of operation:

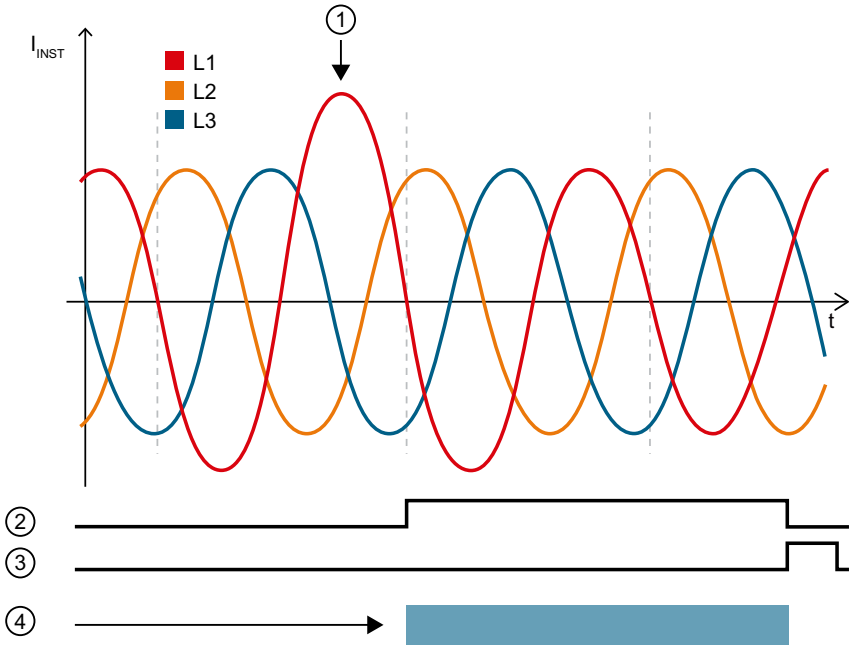

① Current peak in L1
② Status "Power quality current peak"
③ Bit "Reset status "power quality""
④ Max. current peaks instantaneous value can be read out

Figure 2-790 Example of principle of operation

The following table shows the parameter assignment for the example:

Table 2-890 Parameter assignment

Parameter	
Power quality analysis function	Enable
Determine peak value current (L1)	Enable
Determine peak value current (L2)	Enable
Determine peak value current (L3)	Enable

The module detects the peak value current in phase 1 and sets the qualifier bit 3 for phase 1. You can find the maximum current value, for example, in the data record DS 160 in bytes 186 to 189 ("Current peak value L1").

17.4.2.4 Overcurrent of the current half value

Introduction

The AI Energy Meter RC HF returns the maximum overcurrent value of the current half-wave value. If the value to be monitored is exceeded, the module reports the diagnostics "Power quality" and the qualifier bit 7 is set. The module also sets Bit 4 for the respective phase in data record DS 160 (Page 267). In the event that the current half-value is exceeded again, only the diagnostics "Power quality" is reported again and, if applicable, the maximum current swell value is updated.

Calculation of overcurrent limit

The overcurrent limit is calculated based on the following formula:

Overcurrent limit = "Nominal value current" + ("Threshold overcurrent [%]" × "Nominal value current")

The "Nominal value current" is the primary current at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-891 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Diagnostics power quality	Enable
Determining the overcurrent	Enable
Nominal value current	0 ... 99999 A
Threshold overcurrent	1 ... 6000%

Example

The following figure is a schematic diagram of the principle of operation:

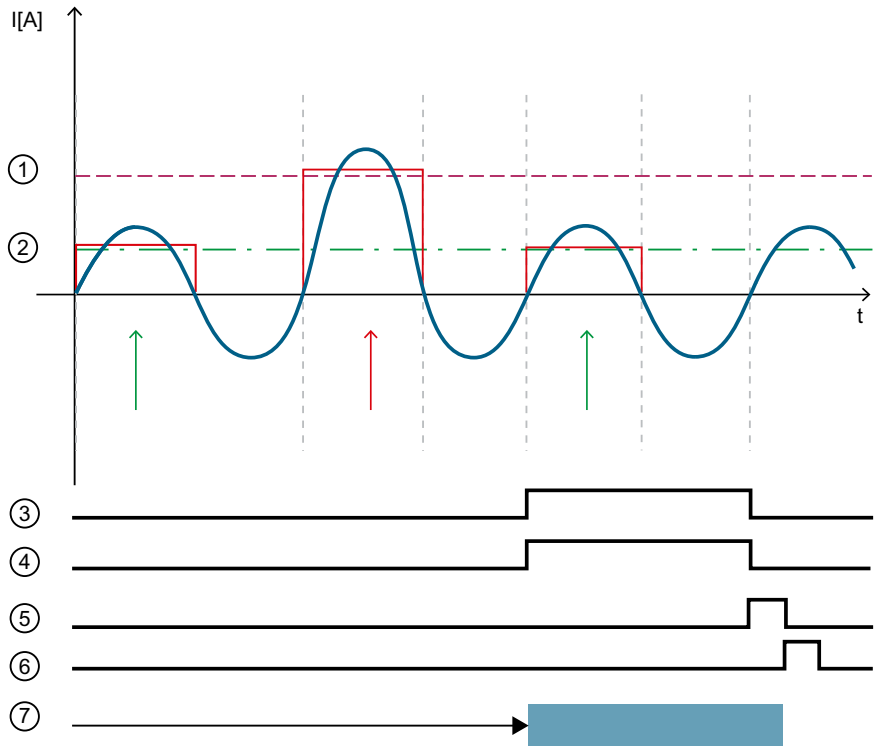

① Threshold overcurrent
② Nominal current
③ Qualifier Bit 7
④ Diagnostics power quality
⑤ Status "power quality overcurrent"
⑥ Bit "Reset status "power quality""
⑦ Max. overcurrent (half-wave) value can be read

Figure 2-791 Example of principle of operation

The following table shows the parameter assignment for the example:

Table 2-892 Parameter assignment

Parameter	
Power quality analysis functions	Enable
Diagnostics power quality	Enable
Determining the overcurrent	Enable
Nominal value current	2000 A
Threshold overcurrent	100%

In this example you define the Threshold overcurrent of 100%. This corresponds to a primary current of 4000 A.

If the "Threshold overcurrent" is exceeded, the module sets Bit 4 "Overcurrent" for the phase in the data record DS 160.

As long as the "Threshold overcurrent" is exceeded, the module reports the diagnostics "Power quality" and the qualifier bit 7 is set.

Technical specifications 18

18.1 Technical specifications

Technical specifications of the AI Energy Meters RC HF

The following table shows the technical specifications as of 03/2021. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7134-6PA21-0CU0/td?dl=en).

Article number	6ES7134-6PA21-0CU0
General information	
Product type designation	AI Energy Meter RC HF
Firmware version	V8.0
• FW update possible	Yes
usable BaseUnits	BU type U0
Supported power supply systems	TT, TN, IT
Product function	
• Voltage measurement	Yes
– without voltage transformer	Yes
– with voltage transformer	Yes
• Current measurement	Yes; Max. 4
– without current transformer	No
– with current transformer	No
– With Rogowski coil	Yes
– With current-voltage-converter	Yes; 333 mV interface
• Energy measurement	Yes
• Frequency measurement	Yes
• Power measurement	Yes
• Active power measurement	Yes
• Reactive power measurement	Yes
• Power factor measurement	Yes
• Active factor measurement	Yes
• Reactive power compensation	Yes
• Line analysis	Yes
– Monitoring of instantaneous and half-wave values	Yes

Article number	6ES7134-6PA21-0CU0
– THD measurement for current and voltage	Yes
– Harmonics for current and voltage	Yes
– Voltage dip (DIP)	Yes
– Voltage swell	Yes
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V16 or higher with HSP
• STEP 7 configurable/integrated from version	V5.5 SP3 or higher
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	V2.3
Operating mode	
• Switching between operating modes in RUN	Yes; For module version 32 I/20 Q, it is possible to dynamically switch between 25 user data variants, 23 of which are pre-defined and 2 of which can be defined by the specific user
• Cyclic measured value access	Yes
• Acyclic measured value access	Yes
• Fixed measured value sets	Yes
• Freely definable measured value sets	Yes; For cyclic and acyclic measured value access
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	Yes
Installation type/mounting	
Mounting position	any
Supply voltage	
Design of the power supply	DC
Type of supply voltage	24 V DC
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Input current	
Current consumption (rated value)	12.5 mA
Current consumption, max.	17 mA
Power loss	
Power loss, typ.	400 mW; 3x 230 V AC
Address area	
Address space per module	
• Inputs	256 byte
• Outputs	20 byte

Article number	6ES7134-6PA21-0CU0
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type U0
Time of day	
Operating hours counter	
• present	Yes
Analog inputs	
Cycle time (all channels), typ.	50 ms; Time for consistent update of all measured and calculated values (cyclic und acyclic data)
Cable length	
• shielded, max.	200 m
• unshielded, max.	200 m
Analog value generation for the inputs	
Sampling frequency, max.	2 048 kHz
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes
• Hardware interrupt	Yes; Monitoring of up to 16 freely selectable process values (exceeding or undershooting of value)
Diagnoses	
• Line quality	Yes
• Supply voltage	Yes
• Hardware interrupt lost	Yes
• Parameter assignment error	Yes
• Module fault	Yes
• Channel not available	Yes
• Overflow/underflow	Yes
• Overload current	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red Fn LED
• for module diagnostics	Yes; green/red DIAG LED

Article number	6ES7134-6PA21-0CU0
Integrated Functions	
Measuring functions	
• Measuring procedure for voltage measurement	TRMS
• Measuring procedure for current measurement	TRMS
• Type of measured value acquisition	seamless
• Curve shape of voltage	Sinusoidal or distorted
• Buffering of measured variables	Yes
• Parameter length	128 byte
• Bandwidth of measured value acquisition	3.2 kHz; Harmonics: 63 / 50 Hz, 52 / 60 Hz
Measuring range	
– Frequency measurement, min.	40 Hz
– Frequency measurement, max.	70 Hz
Measuring inputs for voltage	
– Measurable line voltage between phase and neutral conductor	277 V
– Measurable line voltage between the line conductors	480 V
– Measurable line voltage between phase and neutral conductor, min.	3 V
– Measurable line voltage between phase and neutral conductor, max.	300 V
– Measurable line voltage between the line conductors, min.	6 V
– Measurable line voltage between the line conductors, max.	519 V
– Internal resistance line conductor and neutral conductor	1.5 MΩ
– Power consumption per phase	60 mW; 300 V AC
– Impulse voltage resistance 1,2/50µs	2.5 kV
– Overvoltage category	CAT II according to IEC 61010 Part 1
Measuring inputs for current (Rog. or I/U converter)	
– Measurable current at AC, max.	424 mV
– Continuous voltage, maximum permissible	2 V
– Rated value, short-time withstand voltage restricted to 1 s	30 V
– Input resistance	120 kΩ
– Zero point suppression	Yes; 0 ... 20%, referred to the nominal current
Accuracy class according to IEC 61557-12	
– Measured variable apparent power	0.5

Article number	6ES7134-6PA21-0CU0
– Measured variable active power	0.5
– Measured variable power factor	0.5
– Measured variable active energy	0.5
– Measured variable phase angle	±0.5 °; not covered by IEC 61557-12
– Measured variable frequency	0.05; only valid for the permissible voltage measuring range
Accuracy class line analysis acc. to IEC 61000-4-30	
– Measured variable voltage	Class S
– Measured variable current	Class S
– Measured variable frequency	Class S
– Measured variable voltage interruption	Class S
– Measured variable voltage dip and swell	Class S
– Measured variable harmonic voltage	Class S
– Measured variable harmonic current	Class S
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• Between the channels and load voltage L+	Yes; Including FE
Isolation	
Isolation tested with	Between channels and backplane bus, 24 V supply: Routine test, 1 920 V AC, 2 s; between backplane bus and 24 V supply: Type test, 707 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	45 g

Article number	6ES7134-6PA21-0CU0
Other	
Data for selecting a voltage transformer	
• Secondary side, max.	300 V

Dimension drawing

See ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) manual

Parameter data records

A

A.1 Configuration via parameter data records

The parameter data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Overview of the parameter data records

- Parameter data record DS 128 for the complete module
- Parameter data record DS 129 for limit monitoring
- Parameter data records DS 130/131 for payload mapping
- Parameter data record DS 134 for measured value recording
- Parameter data record DS 135 for data record mapping

Parameter assignment in the user program

You can reassign the module parameters in RUN mode, for example change the diagnostics behavior, define new limits or configure a modified payload mapping.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module via the respective data record. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

If you reconfigure a module (so that the payload size changes) and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing". The diagnostics "Supply voltage missing" is signaled as outgoing.

A reconfiguration in run is not bumpless. It can take up to 1 second for all measured values to become stable.

STATUS output parameter

If errors occur during the transfer of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

A.2 Structure of the parameter data record for the entire module (DS 128)

Structure of data record 128

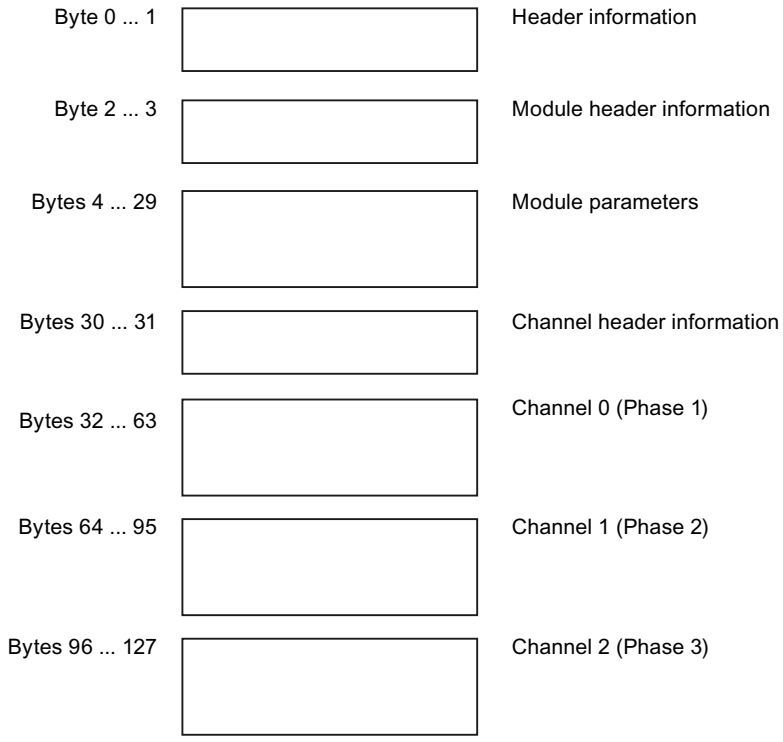

Figure 2-792 Parameter data record 128

Header information

The figure below shows the structure of the header information.

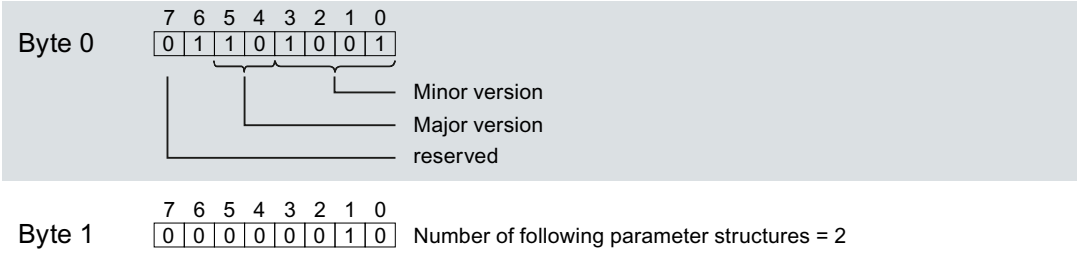

Figure 2-793 Header information

Module header information

The figure below shows the structure of the header information for a module.

	7	6	5	4	3	2	1	0	
Byte 2	0	0	0	0	0	0	0	1	Number of the following module parameter blocks = 1
Byte 3	0	0	0	1	1	0	1	0	Length of the following module parameter block = 26

Figure 2-794 Module header information

Module parameter block

The figure below shows the structure of the module parameter block.

Byte 4 (7 6 5 4 3 2 1 0)

Connection type of the phases

- 00_H = disabled
- $0B_H$ = 1P2W: 1-phase alternating current, 2 conductors
- $0C_H$ = 3P4W: 3-phase, 4 conductors
- $0D_H$ = 3P4WI: 3-phase current measurement, 4 conductors
- $0E_H$ = 3P4W1: 3-phase, 4 conductors, balanced load
- $0F_H$ = 3x1P2W: 3x1-phase alternating current, 2 conductors
- 10_H = 2P3W: 2-phase, 3 conductors
- 11_H = 3P3W: 3-phase, 3-conductors
- 12_H = 3P3W1: 3-phase, 3 conductors, balanced load

Byte 5 (7 6 5 4 3 2 1 0)

Voltage measuring range of the power supply system
(Supply voltage, nominal value of phase voltage)

- 01_H = 100 V
- 02_H = 110 V
- 03_H = 115 V
- 04_H = 120 V
- 05_H = 127 V
- 06_H = 190 V
- 07_H = 200 V
- 08_H = 208 V
- 09_H = 220 V
- $0A_H$ = 230 V
- $0B_H$ = 240 V
- $0C_H$ = 277 V
- $0D_H$ = 300 V

Byte 6 (7 6 5 4 3 2 1 0)

Line frequency of the power supply system

- 0001 = 60 Hz
- 0010 = 50 Hz

Full-scale value for energy counter

- 000 = No end value - infinite counting
- 001 = Count periodically to 10^3
- 010 = Count periodically to 10^6
- 011 = Count periodically to 10^9
- 100 = Count periodically to 10^{12}
- 101 = Count periodically to 10^{15}

Energy counter gate

- 0 = Energy counter always counting
- 1 = Energy counter gate

Byte 7 (7 6 5 4 3 2 1 0): 0 0 0 0 0 0 0 0 — reserved

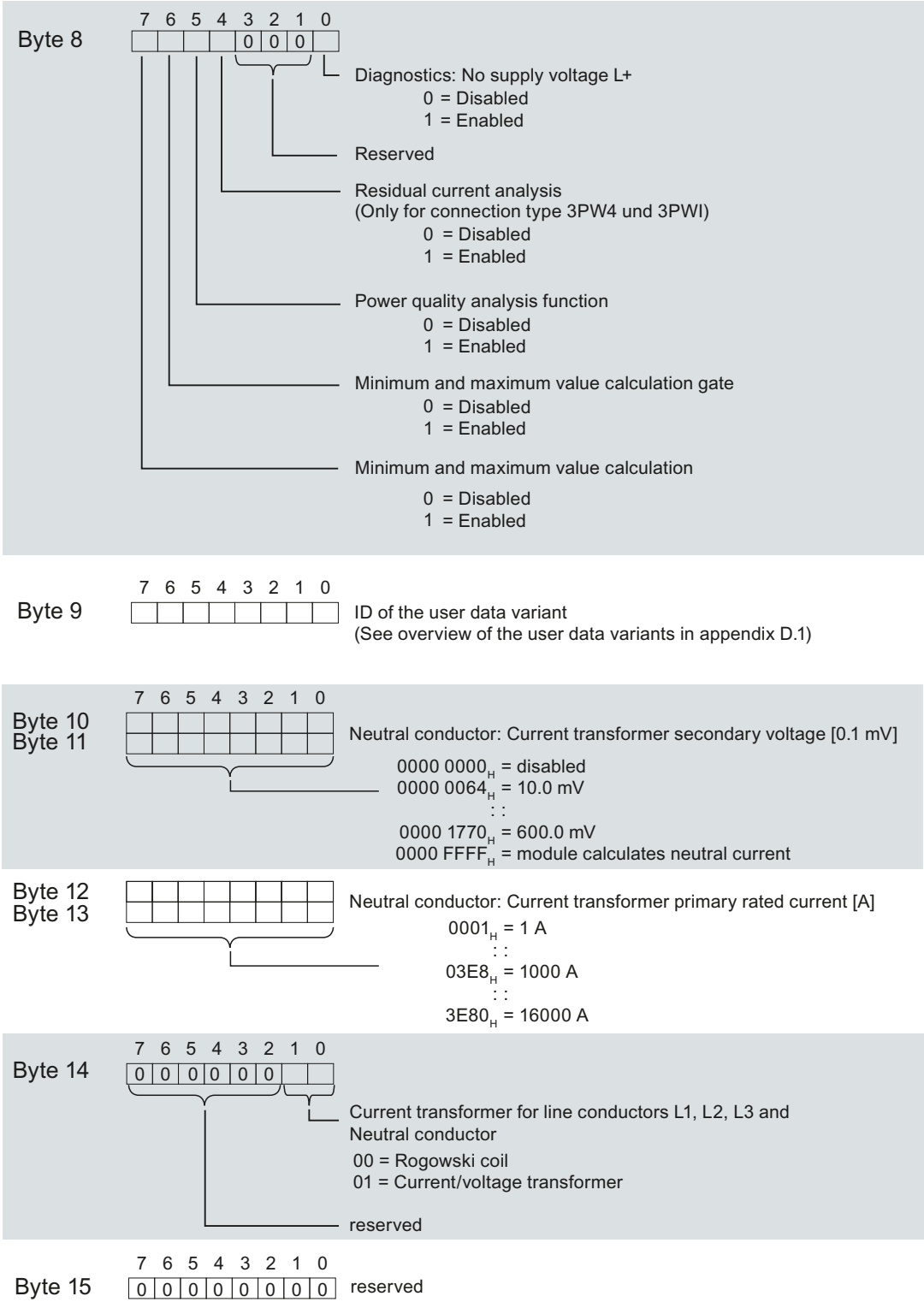

Figure 2-795 Module parameter block

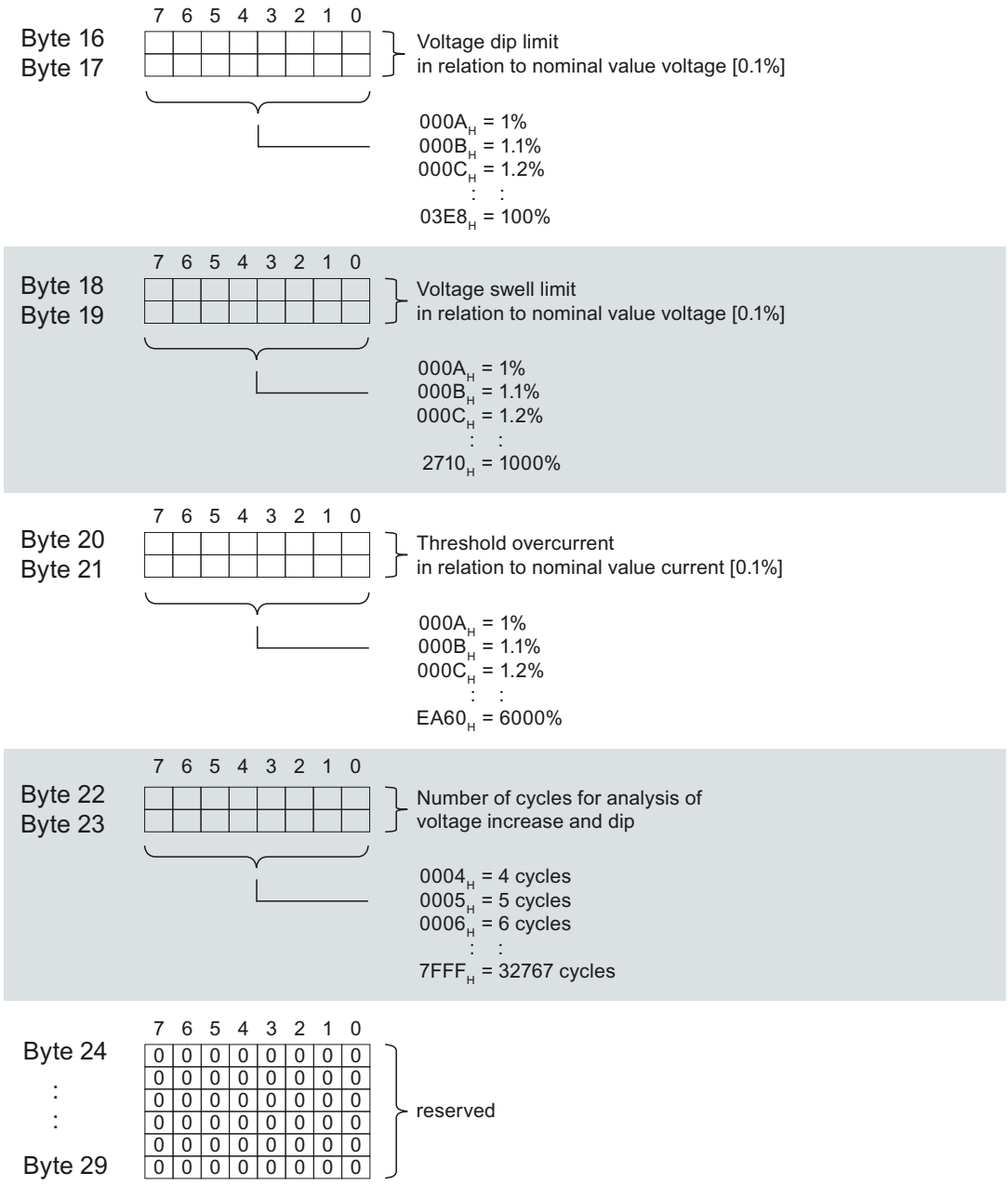

Figure 2-796 Module parameter block

You can find the payload variant in the section Overview of the payload variants (Page 217).

Channel header information

The following figure shows the structure of the header information for a channel.

	7	6	5	4	3	2	1	0	
Byte 30	0	0	0	0	0	0	1	1	Number of following channel parameter blocks = 3
Byte 31	0	0	1	0	0	0	0	0	Length of the following channel parameter block = 32

Figure 2-797 Channel header information

Channel parameter block for channel 0 (Phase 1)

The following figure shows an example of the structure of the channel parameter block for channel 0 (phase 1, bytes 32 to 63).

For channel 1 (phase 2; bytes 64 to 95) and channel 2 (phase: 3; bytes 96 to 127), the structure is identical.

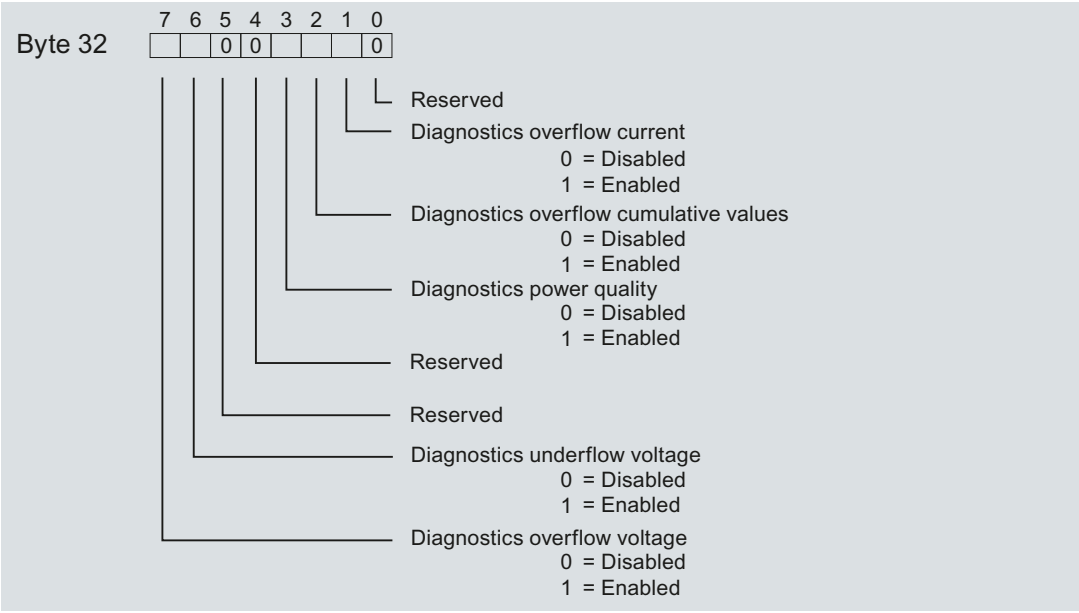

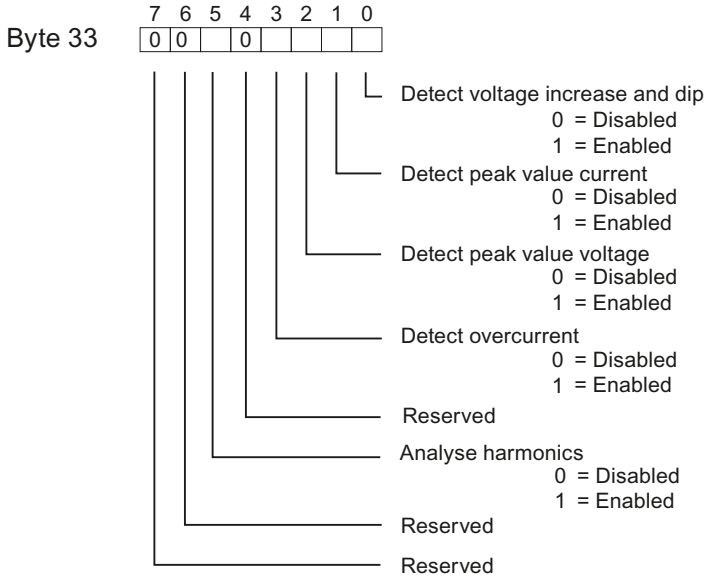

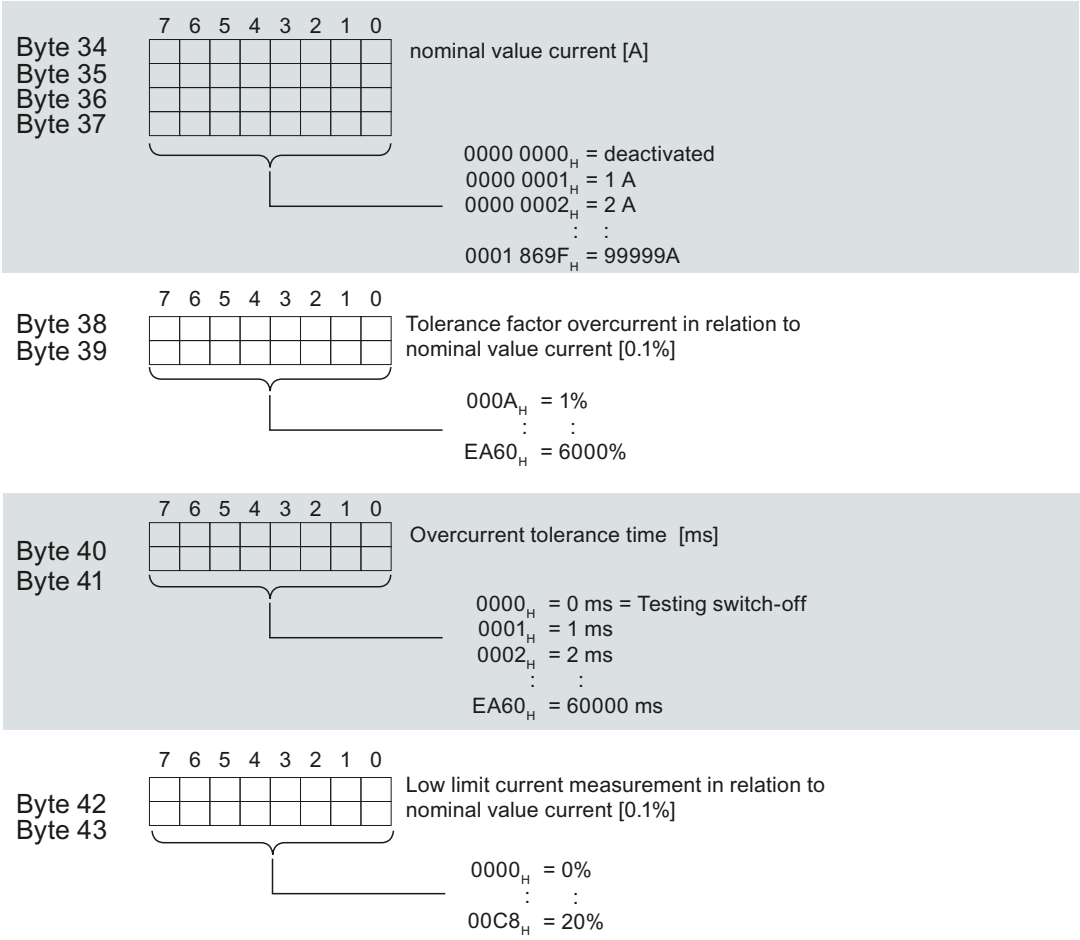

Figure 2-798 Channel parameter block

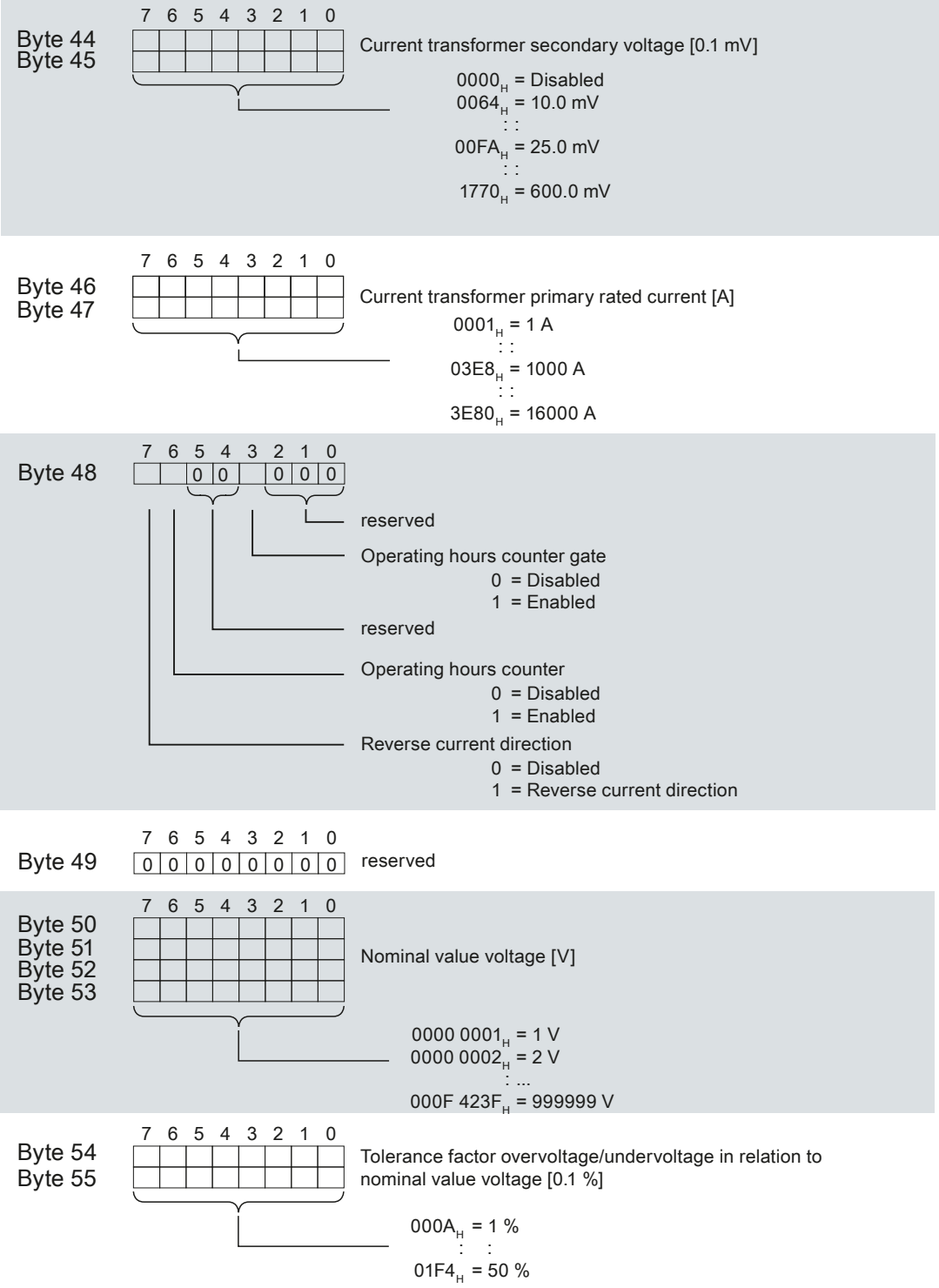
7 6 5 4 3 2 1 0
Byte 44
Byte 45
Current transformer secondary voltage [0.1 mV]
0000H = Disabled
0064H = 10.0 mV
00FAH = 25.0 mV
1770H = 600.0 mV
Byte 46
Byte 47
Current transformer primary rated current [A]
0001H = 1 A
03E8H = 1000 A
3E80H = 16000 A
Byte 48
0 0 0 0 0
reserved
Operating hours counter gate
0 = Disabled
1 = Enabled
reserved
Operating hours counter
0 = Disabled
1 = Enabled
Reverse current direction
0 = Disabled
1 = Reverse current direction
Byte 49
0 0 0 0 0 0 0 0
reserved
Byte 50
Byte 51
Byte 52
Byte 53
Nominal value voltage [V]
0000 0001H = 1 V
0000 0002H = 2 V
000F 423FH = 999999 V
Byte 54
Byte 55
Tolerance factor overvoltage/undervoltage in relation to nominal value voltage [0.1 %]
000AH = 1 %
01F4H = 50 %

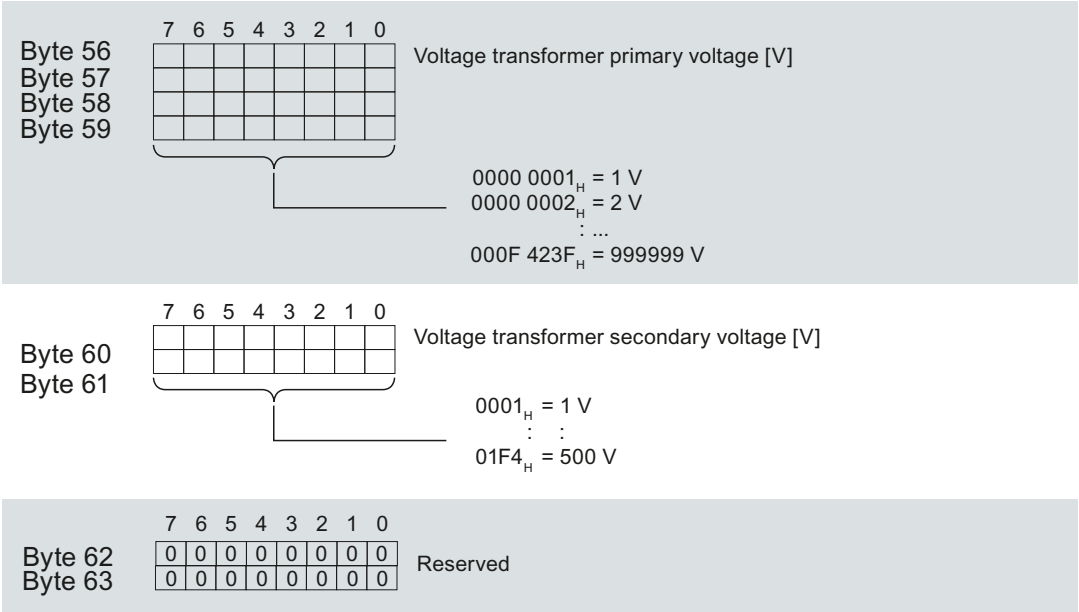

Figure 2-799 Channel parameter block

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check bytes 1 ... 3, 30, 31. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check bytes 7, 8, 14, 15, 24...29, 32, 33, 48, 49, 62...65, 80, 81, 94...97, 112, 113, 126, 127 and reset the reserved bits to 0.
DF	80	E1	05	"Voltage measuring range" invalid	Check Byte 5. Permitted values: 01_H to $0D_H$

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	20	"Connection type" invalid	Check Byte 4. Permitted values: 00_H, $0B_H$...12_H
DF	80	E1	21	"Payload variant" not possible or input data configuration not large enough	Check Byte 9. Select a different payload variant or change the configuration.
DF	80	E1	22	"Payload variant" invalid	Check Byte 9. Select a valid code for the payload variant.
DF	80	E1	23	"Line frequency" invalid	Check Byte 6. Enter valid values.
DF	80	E1	29	"Tolerance factor overcurrent in relation to nominal value current [0.1%]" invalid	Check bytes 38...39, 70...71, 102...103. Enter valid values.
DF	80	E1	2A	"Tolerance time overcurrent" invalid	Check bytes 40...41, 72...73, 104...105. Enter valid values.
DF	80	E1	2B	"Low limit current measurement" in relation to nominal value current [0.1%] invalid	Check bytes 42...43, 74...75, 106...107. Enter valid values.
DF	80	E1	2C	"Current transformer primary rated current [A]" invalid.	Check 46...47, 78...79, 110...111. Enter valid values.
DF	80	E1	2D	"Voltage transformer primary voltage [V]" invalid	Check bytes 56...59, 88...91, 120...123. Enter valid values.
DF	80	E1	2E	"Voltage transformer secondary voltage [V]" invalid	Check bytes 60, 61 and 92, 93 and 124, 125. Enter valid values.
DF	80	E1	2F	"End value energy meter" invalid	Check Bit 4...6 in Byte 6. Enter valid values.
DF	80	E1	30	Invalid data record number.	Check the data record number. Enter a valid data record number.
DF	80	E1	3E	Only for connection type 3P4W1 and 3P3W1. Current or voltage transformer parameters for the different phases are not identical.	Check bytes 44...47 and 76...79 and 108...111 or bits 4, 5 and 7 in bytes 48, 80 and 112 or 56...59 and 88...91 and 120...123 or 60, 61 and 92, 93 and 124, 125 for identical values. Enter identical values for current measuring transformer (secondary current, primary current, direction of current) and voltage transformer (secondary voltage, primary voltage) at all three phases.
DF	80	E1	3F	"End value for energy meter" or transmission ratio (primary value, secondary value) of current and voltage too low.	Increase the end value of the energy meter or the ratio of primary to secondary current for current measuring transformer and/or primary rated current to secondary voltage for voltage transformer.
DF	80	E1	42	"Current transformer type for line conductors L1, L2, L3 and neutral conductor" invalid	Check Bit 0... in Byte 14. Enter valid values.
DF	80	E1	44	"Voltage dip limit value in relation to nominal value voltage [0.1%]" invalid	Check bytes 16...17. Enter valid values (voltage dip limit value must be smaller than the respective nominal voltage)
DF	80	E1	45	"Voltage swell limit value in relation to nominal value voltage [0.1%]" invalid	Check bytes 20...23. Enter valid values (voltage swell limit value must be greater than the respective nominal voltage)

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	46	"Threshold overcurrent in relation to nominal value current [0.1%]" invalid	Check bytes 24...27. Enter valid values (threshold overcurrent must be greater than primary current)
DF	80	E1	47	"Number of cycles for analysis of voltage swell/dip" invalid	Check bytes 28...29. Enter valid values.
DF	80	E1	48	"Current transformer secondary voltage " invalid	Check bytes 10...11, 44...45, 76...77, 108...109. Enter valid values.
DF	80	E1	49	Current transformer parameter for "residual current analysis" invalid	Only with connection type 3P4W and 3P4WI and if neutral current is measured. Current measuring transformer primary rated current and secondary voltage and direction of current of the three phases must have identical parameters.
DF	80	E1	4 A	Voltage transformer parameters for voltage swell/dip invalid	Check the parameters secondary voltage, primary voltage, nominal value voltage. Enabled channels must have identical parameters.
DF	80	E1	4B	Current transformer parameter for "Detect overcurrent" invalid	Check the parameters secondary voltage, primary rated current, nominal value current and direction of current. Enabled channels must have identical parameters.
DF	80	E1	4C	Parameters for determining the neutral current invalid	Neutral current can only be determined with connection type 3P4W and 3P4WI Current transmission parameters primary current, secondary voltage, nominal value current and direction of current of the three phases must be identical.
DF	80	E1	4D	"Nominal value current [A]" invalid	The nominal current value must be measurable with the current transformer and thus be smaller than the primary measured variable of the transformer (current transformer primary rated current). Check bytes 34...37, 66...69, 98...101. Enter valid values.
DF	80	E1	4E	"Nominal value voltage [V]" invalid	The nominal voltage value must be measurable with the voltage transformer and thus be smaller than the primary measured variable of the transformer (voltage transformer primary voltage). Check bytes 50...53, 82...85, 114...117. Enter valid values.
DF	80	E1	4F	"Low limit current measurement in relation to nominal value current [0.1%]" invalid	Check bytes 42...43, 74...75, 106...107. Enter valid values.
DF	80	E1	50	The combination of "Nominal value voltage [V]" and "Voltage dip limit value in relation to nominal value voltage [0.1%]" invalid.	Select the permissible value in % so that the secondary measuring voltage of 0 V is not undershot.
DF	80	E1	51	The combination of "Nominal value voltage [V]" and "Voltage swell limit value in relation to nominal value voltage [0.1%]" invalid.	Select the permissible value in % so that the secondary measuring voltage of 300 V is not exceeded.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	52	The combination of "Nominal value current [A]" and "Threshold overcurrent in relation to nominal value current [0.1%]" invalid	Select the permissible value in % so that the secondary measuring voltage of 424 mA is not exceeded.
DF	80	E1	53	The combination of "Nominal value current [A]" and "Tolerance factor overcurrent in relation to nominal value current [0.1%]" invalid	Select the permissible value in % so that the secondary measuring voltage of 424 mA is not exceeded.
DF	80	E1	54	The combination of "Nominal value voltage [V]" and "Tolerance factor overvoltage/undervoltage in relation to nominal value voltage [0.1%]" lies outside the permissible range.	Select the permissible value in % so that the secondary measuring voltage of 300 V is not exceeded.
DF	80	E1	55	"Nominal value current [A]" is too high. "Nominal value current" x transmission factor current generates a secondary current measured variable which exceeds its value range.	Select the permissible value in A so that the secondary measuring voltage of 424 mA is not exceeded. The transmission factor current is calculated from "Current transformer primary rated current [A]" / "Current transformer secondary voltage [0.1 mV]"
DF	80	E1	56	"Nominal value voltage [V]" is too high. "Nominal value voltage" x transmission factor voltage generates a secondary voltage measured variable which exceeds its value range.	Select the permissible value in V so that the secondary measuring voltage of 300 V is not exceeded. The transmission factor voltage is calculated from "Voltage transformer primary voltage [V]" / "Voltage transformer secondary voltage [V]"

A.3 Structure of the parameter data record for limit monitoring (DS 129)

Structure of data record 129

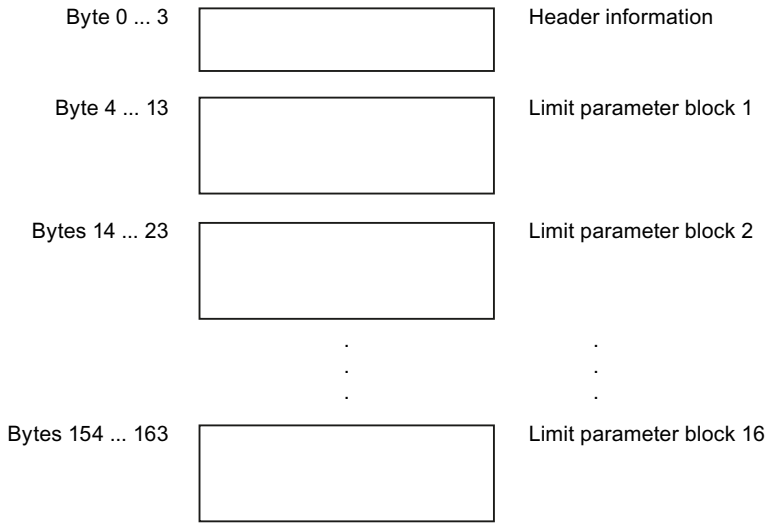

Figure 2-800 Structure of data record 129

Header information

The figure below shows the structure of the header information.

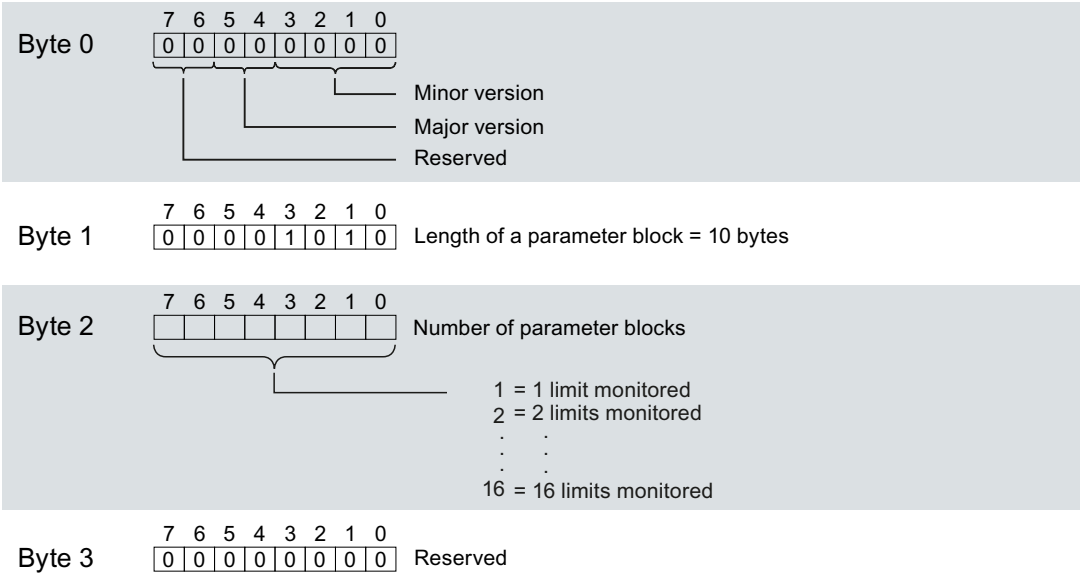

Figure 2-801 Header information DS 129

Limit parameter block

The following diagram shows the structure of the parameter blocks for limit monitoring.

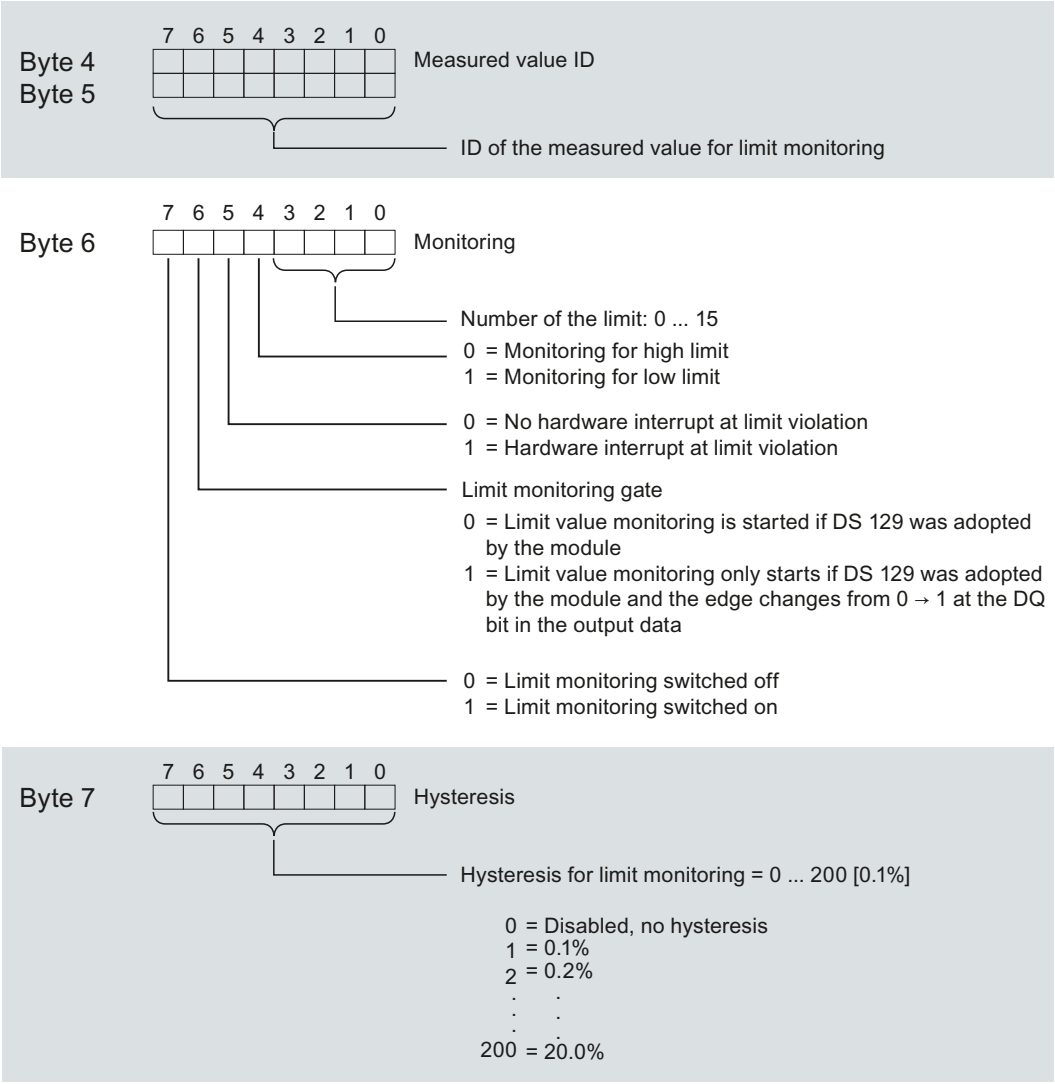

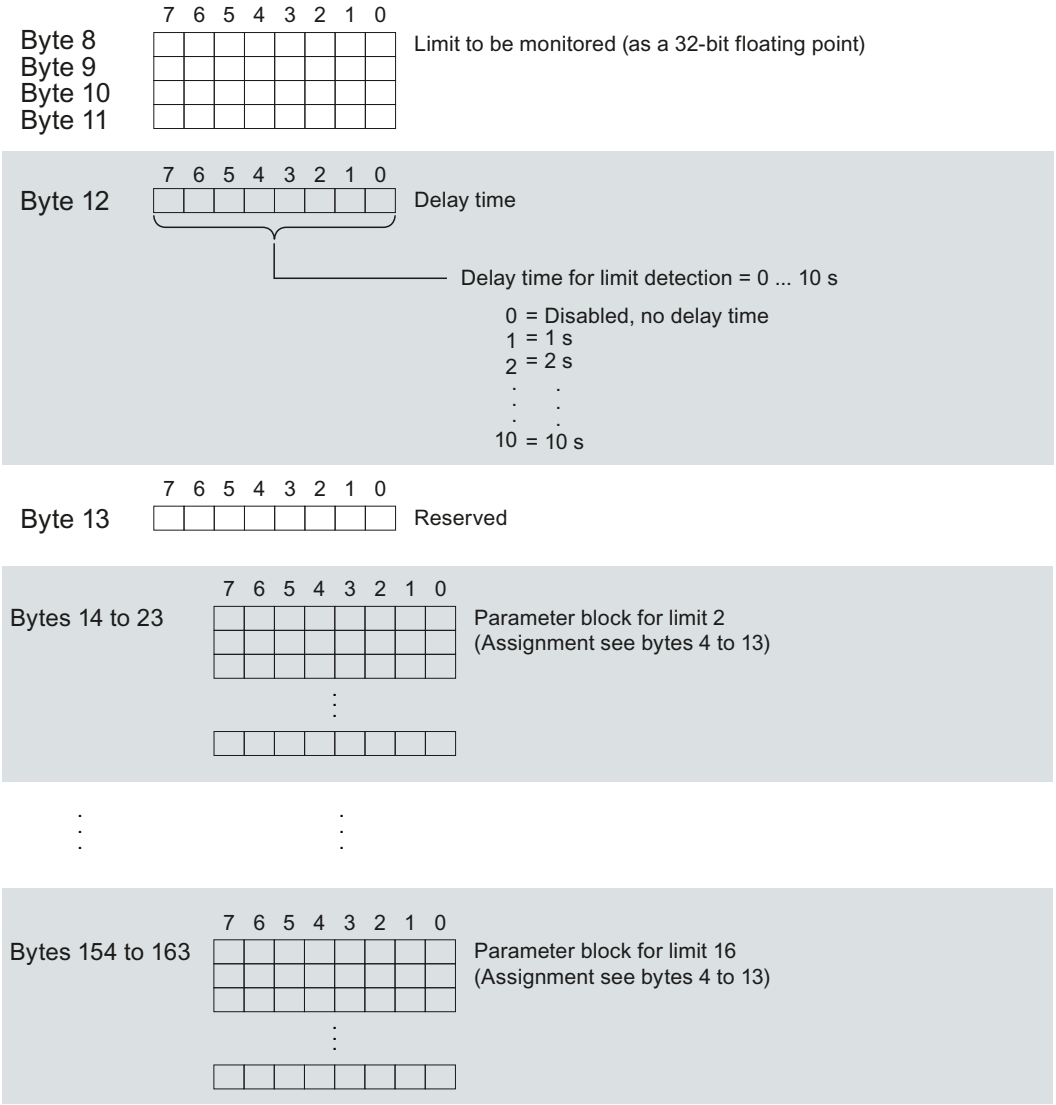

Figure 2-802 Limit parameter data block

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 129.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check bytes 3, 13, 23, 33...163 and set the reserved bits back to 0.
DF	80	E1	31	"Length of the parameter block" invalid.	Length of the sent record incorrect. Note byte 2 ("number of parameter blocks").
DF	80	E1	32	"Number of parameter blocks" invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	"ID of the measured value for limit monitoring" invalid.	Check Bytes 4 and 5. Enter valid values.
DF	80	E1	34	Parameters for monitoring the limits invalid	Check bits 0...3 in Byte 6. Enter valid values.
DF	80	E1	35	"Number of limit" in 'Monitoring assigned multiple times' parameter	Check bits 0...3 in Byte 6. Do not use limit number several times.
DF	80	E1	36	"Hysteresis for limit monitoring" invalid	Check Byte 7. Enter valid values.
DF	80	E1	37	"Limit" invalid.	Check Byte 8...11. Enter valid values.
DF	80	E1	38	"Delay time for limit monitoring" invalid.	Check Byte 12. Enter valid values.

A.4 Structure of the parameter data records for payload mapping DS 130/DS 131

Structure of data record 130/131

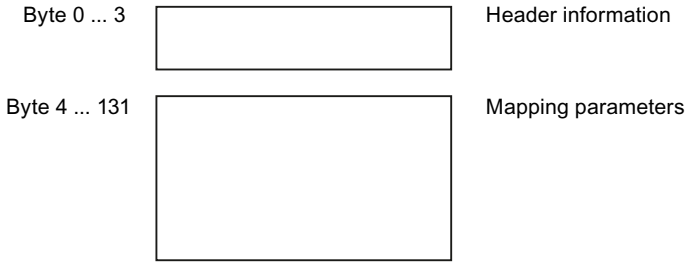

Figure 2-803 Structure of data record 130/131

Header information

The figure below shows the structure of the header information.

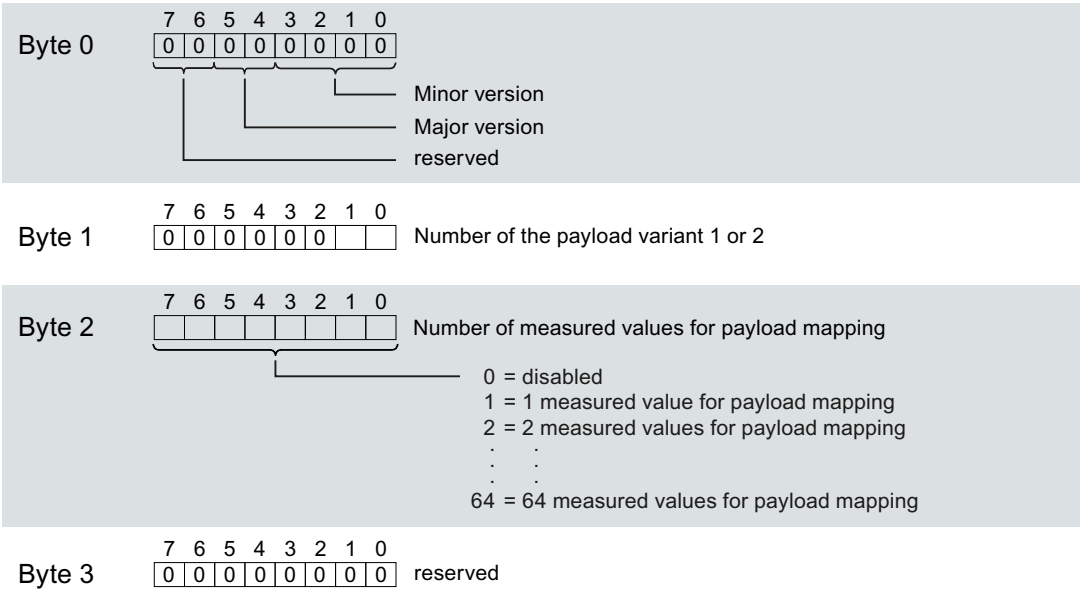

Figure 2-804 Header information DS 130/131

Parameter block for payload mapping

The following diagram shows the structure of the parameter blocks for payload mapping.

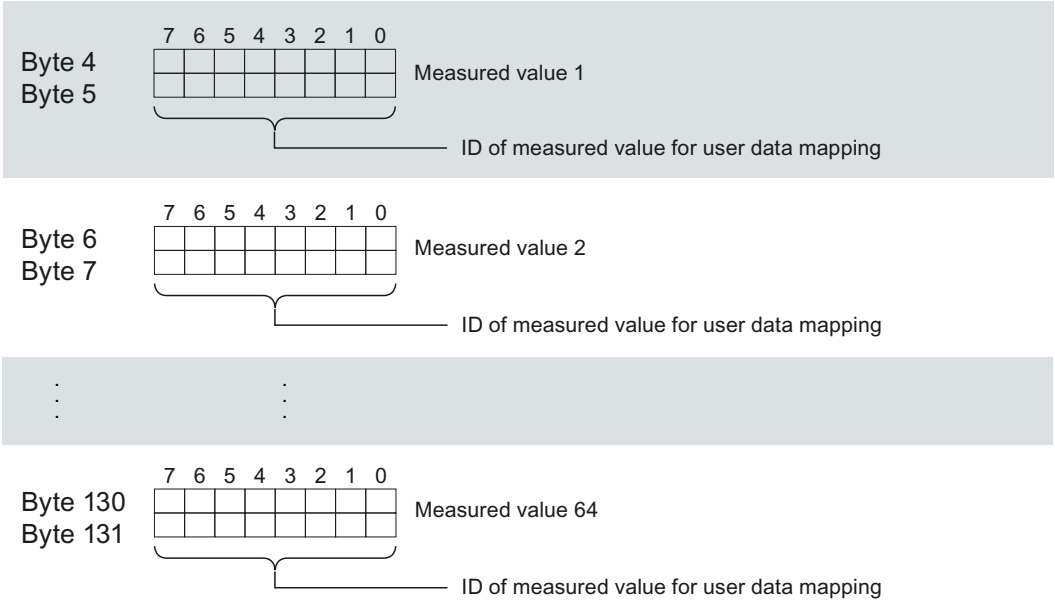

Figure 2-805 Parameter block for payload mapping

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 130/131.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check Byte 3 and set reserved bits back to 0.
DF	80	E1	21	"Payload variant" not possible or input data configuration not large enough	Select a different payload variant or change the configuration.
DF	80	E1	30	Data record number invalid	Check the data record number. Enter a valid data record number.
DF	80	E1	31	"Length of the parameter block" invalid.	Length of the sent record incorrect. Note byte 2 ("number of measured values").
DF	80	E1	32	"Number of parameter blocks" invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	"ID of measured value for payload mapping" invalid.	Check Bytes 4 and 5. Enter valid values.
DF	80	E1	3B	"ID of the type of payload mapping" not permitted.	Check Byte 1. Number for user-specific payload variant has to be 01_H or 02_H.

Measured variables for payload mapping

You can find the measured variables under "Measured variables for connection type 1H (Page 174)". The following measured variables are not available to you for payload mapping:

- 220 to 226
- 62110 to 62116
- 62210 to 62216
- 62310 to 62316

A.5 Structure of the parameter data record for measured value recording (DS 134)

Structure of data record 134

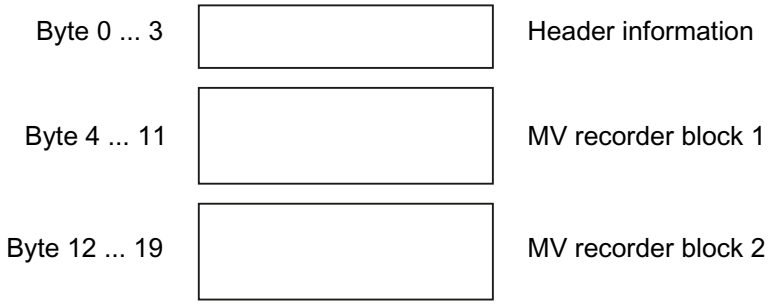

Figure 2-806 Structure of data record 134

Header information

The figure below shows the structure of the header information.

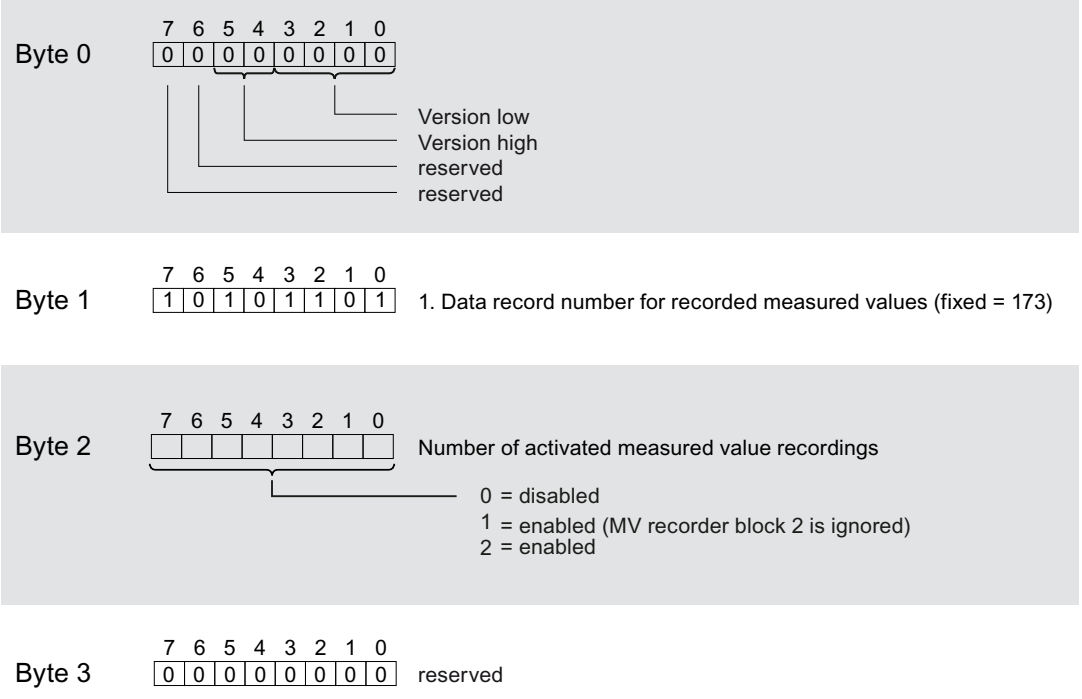

Figure 2-807 Header information DS 134

Parameter block

The following figures show the structure of the parameter blocks for measured value recording.

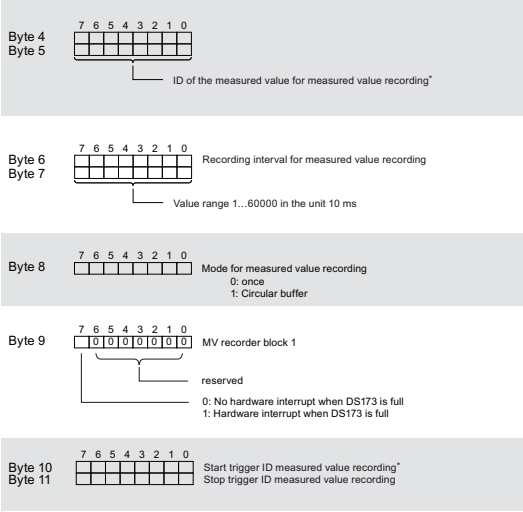

Figure 2-808 MV record block 1

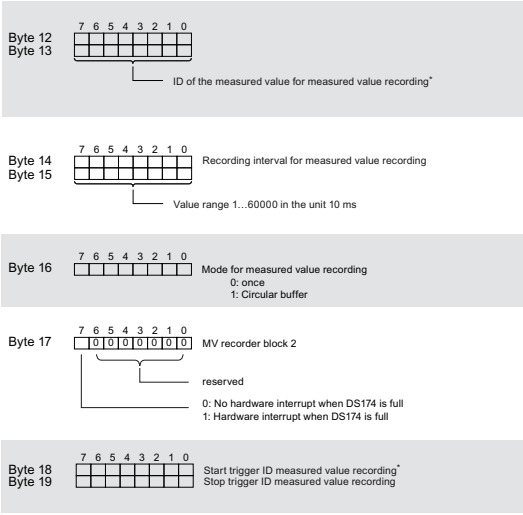

* You can find additional information in Appendix B (Page 174).

Figure 2-809 MV record block 2

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 134.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	00	Data record unknown	Enter the valid number for the data record.
DF	80	B1	01	Incorrect length during writing	Enter the permissible value for the data record length.
DF	80	B2	00	Slot/Subslot unknown	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction.
DF	80	E0	01	Version faulty	Enter the valid values.
DF	80	E0	02	Error in the header information	Check byte 1 and byte 2. Correct the number of parameter blocks.
DF	80	E1	01	Reserved bits are not 0	Set byte 4 or byte 6 in the measured value block to 0.
DF	80	E1	59	Measurement interval too long	Set bytes 7/8 or 13/14: Measuring interval 〈 60000.
DF	80	E1	58	Incorrect measuring mode	Byte 9 or 15: Only mode 0 or 1 is possible.
DF	80	E1	31	"Length of the parameter block" invalid	Length does not match the set number of records.
DF	80	E1	32	"Number of parameter blocks" invalid	Check byte 3. Number must be ≤ 2.
DF	80	E1	33	"ID of the measured value for measured value recording" invalid	Byte 5/6 or 11/12 has faulty measured value ID. Enter valid values.
DF	80	E1	30	Data record 134 is not supported on this module type	Do not send the data record.
DF	80	E1	5a	The function is not supported on this module type	Do not send the data record.
DF	80	E1	60	Start or stop trigger ID is invalid	Check the trigger IDs and eliminate the error.

Start/Stop trigger IDs

Power quality analysis qualifier

	Bit 31	**Bit 30**	**Bit 29**	**Bit 28**	**Bit 27**	**Bit 26**	**Bit 25**	**Bit 24**
Phase	L3							
	Overcurrent L3 (event active)	Voltage swell L3 (event active)	Voltage dip L3 (event active)	Overcurrent L3 (event occurred)	Current peak L3 (event occurred)	Voltage peak L3 (event occurred)	Voltage swell L3 (event occurred)	Voltage dip L3 (event occurred)
Trigger ID	32	31	30	29	28	27	26	25

	Bit 23	**Bit 22**	**Bit 21**	**Bit 20**	**Bit 19**	**Bit 18**	**Bit 17**	**Bit 16**
Phase	L2							
	Overcurrent L2 (event active)	Voltage swell L2 (event active)	Voltage dip L2 (event active)	Overcurrent L2 (event occurred)	Current peak L2 (event occurred)	Voltage peak L2 (event occurred)	Voltage swell L2 (event occurred)	Voltage dip L2 (event occurred)
Trigger ID	24	23	22	21	20	19	18	17
	Bit 15	**Bit 14**	**Bit 13**	**Bit 12**	**Bit 11**	**Bit 10**	**Bit 9**	**Bit 8**
Phase	L1							
	Overcurrent L1 (event active)	Voltage swell L1 (event active)	Voltage dip L1 (event active)	Overcurrent L1 (event occurred)	Current peak L1 (event occurred)	Voltage peak L1 (event occurred)	Voltage swell L1 (event occurred)	Voltage dip L1 (event occurred)
Trigger ID	16	15	14	13	12	11	10	9
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Phase	L1L2L3							
	reserved	reserved	Status of harmonics analysis Bit 5	Status of harmonics analysis Bit 4	Status of harmonics analysis Bit 3	Status of harmonics analysis Bit 2	Status of harmonics analysis Bit 1	Status of harmonics analysis Bit 0
Trigger ID	8	7	6	5	4	3	2	1

Qualifier Lx

	Bit 7	**Bit 6**	**Bit 1**	**Bit 0**
	Operating quadrant Lx (high)	Operating quadrant Lx (low)	ILx (ok)	ULx (ok)
L1	48	47	34	33
L2	64	63	50	49
L3	80	79	66	65

Qualifier L1L2L3

	Bit 15	**Bit 14**	**Bit 13**	**Bit 12**	**Bit 11**	**Bit 10**	**Bit 9**	**Bit 8**
Phase	L1L2L3				L3		L2	
	Time synchronization (ok)	Analysis of harmonic component	Rotating field status (high)	Rotating field status (low)	Operating quadrant L3 (high)	Operating quadrant L3 (low)	Operating quadrant L2 (high)	Operating quadrant L2 (low)
Trigger ID	96	95	94	93	92	91	90	89
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
Phase	L1		L3		L2		L1	
	Operating quadrant L1 (high)	Operating quadrant L1 (low)	Measured values IL3 (ok)	Measured values UL3 (ok)	Measured values IL2 (ok)	Measured values UL2 (ok)	Measured values IL1 (ok)	Measured values UL1 (ok)
Trigger ID	88	87	86	85	84	83	82	81

Status of energy counter overflows

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
Phase	reserved	L3					L2	
	---	Overflow apparent energy L3	Overflow reactive energy out-flow L3	Overflow reactive energy inflow L3	Overflow active energy outflow L3	Overflow active energy inflow L3	Overflow apparent energy L2	Overflow reactive energy out-flow L2
Trigger ID	112	111	110	109	108	107	106	105

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Phase	L2			L1				
	Overflow reactive energy inflow L2	Overflow active energy outflow L2	Overflow active energy inflow L2	Overflow apparent energy L1	Overflow reactive energy out-flow L1	Reactive energy inflow L1	Overflow active energy outflow L1	Overflow active energy inflow L1
Trigger ID	104	103	102	101	100	99	98	97

Status of limits

	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
	Limit viola-tion LV16	Limit viola-tion LV15	Limit viola-tion LV14	Limit viola-tion LV13	Limit viola-tion LV12	Limit viola-tion LV11	Limit viola-tion LV10	Limit viola-tion LV9
Trigger ID	128	127	126	125	124	123	122	121
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
	Limit viola-tion LV8	Limit viola-tion LV7	Limit viola-tion LV6	Limit viola-tion LV5	Limit viola-tion LV4	Limit viola-tion LV3	Limit viola-tion LV2	Limit viola-tion LV1
Trigger ID	120	119	118	117	116	115	114	113

32-bit diagnostic bit track ET200SP diagnostics

	Bit 31	Bit 26	Bit 22	Bit 17	Bit 16	Bit 7	Bit 4	Bit 3	Bit 2
	Channel temporarily not avail-able	Power qual-ity	Hardware interrupt lost	Supply voltage missing	Parameter error	Overflow of the calcula-tion values	Overload	Overflow voltage	Underflow voltage
Trigger ID L1	160	155	151	146	145	136	133	132	131
Trigger ID L2	192	187	183	178	177	168	165	164	163
Trigger ID L3	224	219	215	210	209	200	197	196	195

DQ control measured value acquisition

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	DQ address 17 (control byte 8)							
Trigger ID	232	231	230	229	228	27	226	225

A.6 Structure of the parameter data record for data mapping (DS 135)

Structure of data record 135

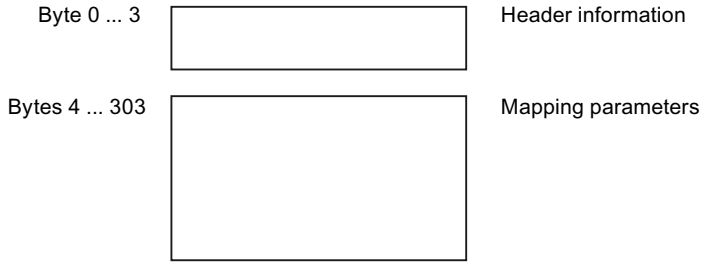

Figure 2-810 Structure of data record 135

Header information

The figure below shows the structure of the header information.

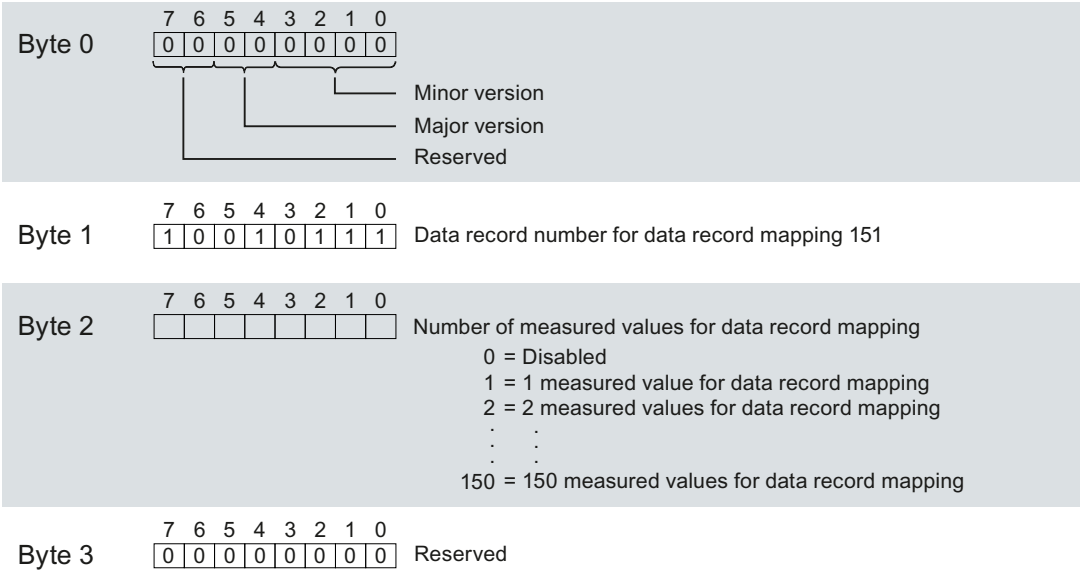

Figure 2-811 Header information DS 135

Parameter block for data record mapping

The following diagram shows the structure of the parameter blocks for data record mapping.

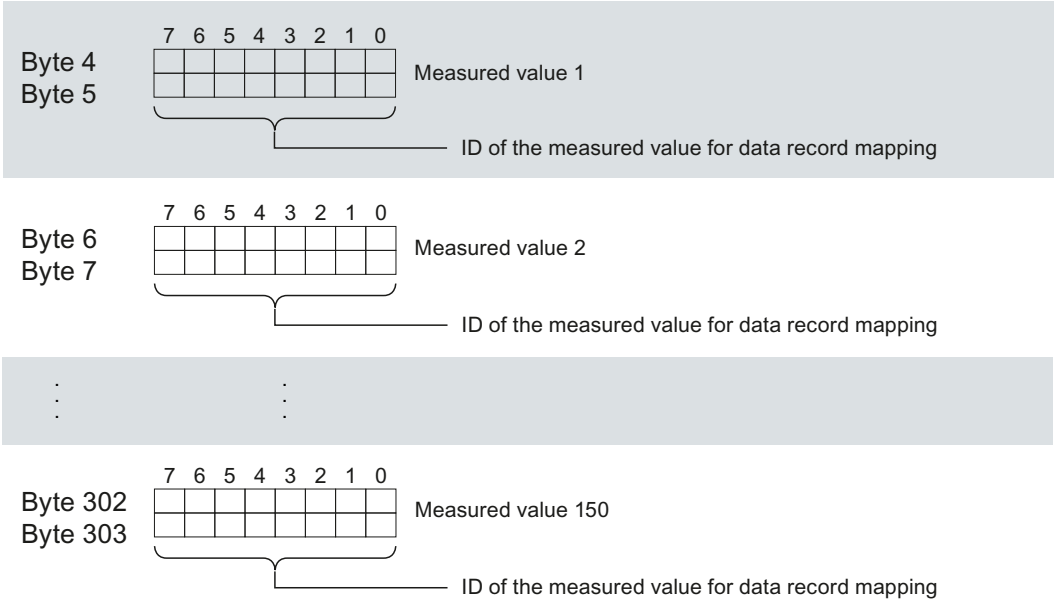

Figure 2-812 Parameter block for data record mapping

Data record length DS 135 and DS151

The table below shows the data record lengths of the parameter data record DS 135 and the user-defined data record DS 151 (Page 261).

The length of the data records depends on the number and the format of the measured values.

Number Measured values	Data record length in bytes		
	REAL measured values		LREAL measured values
	DS 135	DS 151	DS 151
29	62	118	234
30	64	122	242 *
40	84	162	322 *
50	104	202	402 *
59	122	238	474 *
100	204	402 *	802 *
118	240	474 *	946 *
150	304*	602 *	1202 *

* not with PROFIBUS DP

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 130/131/135.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check Byte 3 and set reserved bits back to 0.
DF	80	E1	21	"Payload variant" not possible or input data configuration not large enough	Select a different payload variant or change the configuration.
DF	80	E1	30	Data record number invalid	Check the data record number. Enter a valid data record number.
DF	80	E1	31	"Length of the parameter block" invalid.	Length of the sent record incorrect. Note byte 2 ("number of measured values").
DF	80	E1	32	"Number of parameter blocks" invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	"ID of the measured value for limit monitoring" invalid.	Check Bytes 4 and 5. Enter valid values.

Measured variables for data record mapping

You can find the measured variables under "Measured variables for connection type 1H (Page 174)". The following measured variables are not available to you for data record mapping:

- 220 to 226
- 62110 to 62116
- 62210 to 62216
- 62310 to 62316

Measured variables

B

B.1 Measured variables for connection type

Measured variables for data records and payload

The following table provides an overview of all measured variables that are used in the data records and payload.

On the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755917) you can find an overview of the assignment of the measured values to the payload variants and data records.

Table 2-893 Measured variables for data records and payload

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
1	Voltage L1-N [1]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
2	Voltage L2-N [1]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
3	Voltage L3-N [1]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
4	Voltage L1-L2 [2]	REAL	V	0.0 ... 1000000.0		✓		✓	✓	✓	✓	
5	Voltage L2-L3 [2]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
6	Voltage L3-L1 [2]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
7	Current L1 [1]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
8	Current L2 [1]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
9	Current L3 [1]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
10	Apparent power L1 [3]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
11	Apparent power L2 [3]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
12	Apparent power L3 [3]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
13	Active power L1 [3]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
14	Active power L2 [3]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
15	Active power L3 [3]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
16	Reactive power Qn L1[3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
17	Reactive power Qn L2[3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
18	Reactive power Qn L3[3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
19	Power factor λ L1 [3]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
20	Power factor λ L2 [3]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓	✓	✓	
21	Power factor λ L3 [3]	REAL	-	0.0 ... 1.0			✓	✓	✓	✓	✓	
22	Reactive power Qtot L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
23	Reactive power Qtot L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
24	Reactive power Qtot L3 [3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
30	Frequency L1L2L3 [4]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓	✓
31	Average Voltage L-N (U_{sum}) [12]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
32	Average Voltage L-L [12]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
33	Average Current L1L2L3 (I_{sum}) [12]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
34	Active power L1L2L3 [5]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
35	Reactive power Q_n L1L2L3 [5]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
36	Apparent power L1L2L3 [5]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
37	Power factor λ L1L2L3 [6]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
38	Reactive power Qtot L1L2L3[3] [5]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
40	Max. voltage L1-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
41	Max. voltage L2-N [14]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
42	Max. voltage L3-N [14]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
43	Max. voltage L1-L2 [14]	REAL	V	0.0 ... 1000000.0		✓		✓	✓	✓	✓	
44	Max. voltage L2-L3 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
45	Max. voltage L3-L1 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
46	Max. current L1 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
47	Max. current L2 [14]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
48	Max. current L3 [14]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
49	Max. apparent power L1 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
50	Max. apparent power L2 [14]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
51	Max. apparent power L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
52	Max. active power L1 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
53	Max. active power L2 [14]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
54	Max. active power L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
55	Max. reactive power Q_n L1 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
56	Max. reactive power Q_n L2 [14]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
57	Max. reactive power Q_n L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
58	Max. power factor λ L1 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
59	Max. power factor λ L2 [14]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓	✓	✓	
60	Max. power factor λ L3 [14]	REAL	-	0.0 ... 1.0			✓	✓	✓	✓	✓	
61	Max. frequency [14]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓	✓
62	Max. mean voltage L-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓			
63	Max. mean voltage L-L [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
64	Max. mean current L1L2L3 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
65	Max. active power L1L2L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
66	Max. reactive power Qn L1L2L3[14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
67	Max. apparent power L1L2L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
68	Max. power factor λ L1L2L3 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
70	Min. voltage L1-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
71	Min. voltage L2-N [14]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
72	Min. voltage L3-N [14]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
73	Min. voltage L1-L2 [14]	REAL	V	0.0 ... 1000000.0		✓		✓	✓	✓	✓	
74	Min. voltage L2-L3 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
75	Min. voltage L3-L1 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
76	Min. current L1 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
77	Min. current L2 [14]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
78	Min. current L3 [14]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
79	Min. apparent power L1 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
80	Min. apparent power L2 [14]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
81	Min. apparent power L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
82	Min. active power L1 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
83	Min. active power L2 [14]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
84	Min. active power L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
85	Max. reactive power Q_n L1 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
86	Max. reactive power Q_n L2 [14]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
87	Max. reactive power Q_n L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
88	Min. power factor λ L1 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
89	Min. power factor λ L2 [14]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓	✓	✓	
90	Min. power factor λ L3 [14]	REAL	-	0.0 ... 1.0			✓	✓	✓	✓	✓	
91	Min. frequency [14]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓	✓
92	Min. mean voltage L-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓			
93	Min. mean voltage L-L [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓	
94	Min. mean current L1L2L3[14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
95	Min. active power L1L2L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
96	Min. reactive power Q_n L1L2L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
97	Min. apparent power L1L2L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
98	Min. power factor λ L1L2L3 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
166	Mean power factor λ L1L2L3[12]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
200	Active energy inflow L1L2L3 (Float) [6]	REAL	Wh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
201	Active energy outflow L1L2L3 (Float) [6]	REAL	Wh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
202	Reactive energy inflow L1L2L3 (Float) [6]	REAL	varh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
203	Reactive energy outflow L1L2L3 (Float) [6]	REAL	varh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
204	Apparent energy L1L2L3 (Float) [6]	REAL	VAh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
205	Total active energy L1L2L3 (Float) [6]	REAL	Wh	-3.4028e+38 ... +3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
206	Total reactive energy L1L2L3 (Float) [6]	REAL	varh	-3.4028e+38 ... +3.4028e+38	✓	✓	✓	✓	✓	✓	✓	
210	Active energy inflow L1L2L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
211	Active energy outflow L1L2L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
212	Reactive energy inflow L1L2L3 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
213	Reactive energy outflow L1L2L3 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
214	Apparent energy L1L2L3 [6]	LREAL	VAh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
215	Total active energy L1L2L3 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
216	Total reactive energy L1L2L3 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
220	Active energy inflow L1L2L3 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
221	Active energy outflow L1L2L3 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
222	Reactive energy inflow L1L2L3 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
223	Reactive energy outflow L1L2L3 (Int32) [6]	UDINT	VAh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
224	Apparent energy L1L2L3 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
225	Total active energy L1L2L3 (Int32) [6]	DINT	Wh	-2147483647 ... +2147483647	✓	✓	✓	✓	✓	✓	✓	
226	Total reactive energy L1L2L3 (Int32)rl. [6]	DINT	varh	-2147483647 ... +2147483647	✓	✓	✓	✓	✓	✓	✓	
61130	Phase angle UL1-UL2 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	
61131	Phase angle UL2-UL3 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	
61132	Phase angle UL3-UL1 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	
61133	Phase angle IL1-IL2 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	✓
61134	Phase angle IL2-IL3 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	✓
61135	Phase angle IL3-IL1 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	✓
61136	Max. neutral current [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
61137	Min. neutral current [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
61138	Max. reactive power Qtot L1L2L3[3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
61139	Min. reactive power Qtot L1L2L3[3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
61140	Overflow counter active energy inflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61141	Overflow counter active energy outflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61142	Overflow counter reactive energy inflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
61143	Overflow counter reactive energy outflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61144	Overflow counter apparent energy L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61146	Fundamental cos φ active factor L1L2L3[17]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
61147	Max. fundamental cos φ active factor L1L2L3[17]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
61148	Min. fundamental cos φ active factor L1L2L3[17]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
61149	Neutral current IN [1]	REAL	A	0.0 ... 100000.0	Z	Z	Z	✓	✓	Z	Z	✓
61150	Neutral current 10-12 cycles [1, 19]	REAL	A	0.0 ... 100000.0	Z	Z	Z	✓	✓	Z	Z	✓
61151	Neutral current half cycle [1, 16, 19]	REAL	A	0.0 ... 100000.0	Z	Z	Z	✓	✓	Z	Z	✓
61153	Total current IL1+IL2+IL3-IN [1]	REAL	A	-100000.0 ... 100000.0				✓				✓
61154	Reactive power (fundamental) L1L2L3[5]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
61155	Max. reactive power (fundamental) L1L2L3[14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
61156	Min. reactive power (fundamental) L1L2L3[14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
61157	Amplitude unbalance voltage U2 [2]	REAL	%	0 ... 100				✓	✓	✓	✓	
61158	Amplitude unbalance current Iunsym [2]	REAL	%	0 ... 100				✓	✓	✓	✓	✓
61159	Instantaneous value line frequency [17]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓	✓
61178	Phase angle L1 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓	
61180	Active energy inflow L1 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
61181	Active energy outflow L1 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
61182	Reactive energy inflow L1 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
61183	Reactive energy outflow L1 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
61184	Apparent energy L1 [6]	LREAL	VAh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
61185	Total active energy L1 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓	
61186	Total reactive energy L1 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
61190	Overflow counter active energy inflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61191	Overflow counter active energy outflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61192	Overflow counter reactive energy inflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61193	Overflow counter reactive energy outflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61194	Overflow counter apparent energy L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61195	Overflow counter total active energy L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61196	Overflow counter total reactive energy L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	
61198	Phase angle L2 [3]	REAL	°	0.0 ... 360.0		✓	✓	✓	✓	✓	✓	
61200	Active energy inflow L2 [6]	LREAL	Wh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓	
61201	Active energy outflow L2 [6]	LREAL	Wh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓	
61202	Reactive energy inflow L2 [6]	LREAL	varh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓	
61203	Reactive energy outflow L2 [6]	LREAL	varh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓	
61204	Apparent energy L2 [6]	LREAL	VAh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓	
61205	Total active energy L2 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308		✓	✓	✓	✓	✓	✓	
61206	Total reactive energy L2 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308		✓	✓	✓	✓	✓	✓	
61210	Overflow counter active energy inflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓	
61211	Overflow counter active energy outflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓	
61212	Overflow counter reactive energy inflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓	
61213	Overflow counter reactive energy outflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓	
61214	Overflow counter apparent energy L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓	
61215	Overflow counter total active energy L2 [6]	UINT	-	0 ...65535		✓	✓	✓	✓	✓	✓	
61216	Overflow counter total reactive energy L2 [6]	UINT	-	0 ...65535		✓	✓	✓	✓	✓	✓	
61218	Phase angle L3 [3]	REAL	°	0.0 ... 360.0			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
61220	Active energy inflow L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓	
61221	Active energy outflow L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓	
61222	Reactive energy inflow L3 [6]	LREAL	varh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓	
61223	Reactive energy outflow L3 [6]	LREAL	varh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓	
61224	Apparent energy L3 [6]	LREAL	VAh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓	
61225	Total active energy L3 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308			✓	✓	✓	✓	✓	
61226	Total reactive energy L3 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308			✓	✓	✓	✓	✓	
61230	Overflow counter active energy inflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓	
61231	Overflow counter active energy outflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓	
61232	Overflow counter reactive energy inflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓	
61233	Overflow counter reactive energy outflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓	
61234	Overflow counter apparent energy L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓	
61235	Overflow counter total active energy L3 [6]	UINT	-	0 ...65535			✓	✓	✓	✓	✓	
61236	Overflow counter total reactive energy L3 [6]	UINT	-	0 ...65535			✓	✓	✓	✓	✓	
62110	Active energy inflow L1 (Int32) [6]	DINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
62111	Active energy outflow L1 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
62112	Reactive energy inflow L1 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
62113	Reactive energy outflow L1 (Int32)l. [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
62114	Apparent energy L1 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓	
62115	Total active energy L1 (Int32). [6]	DINT	Wh	-2147483647 ... + 2147483647	✓	✓	✓	✓	✓	✓	✓	
62116	Total reactive energy L1 (Int32) [6]	DINT	varh	-2147483647 ... + 2147483647	✓	✓	✓	✓	✓	✓	✓	
62120	Total harmonic distortion (THD+N) voltage L1 [13]	REAL	1%	0 % bis 100 %	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62121	Total harmonic distortion (THD+N) current L1 [13]	REAL	1%	0 % bis 100 %	✓	✓	✓	✓	✓	✓	✓	✓
62122	Fundamental voltage L1 [1]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62123	Fundamental current L1 [1]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62124	Fundamental reactive power L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62125	Fundamental apparent power L1 [3]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62126	Fundamental active power L1 [3]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62127	Fundamental cos φ active factor L1 [17]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
62130	Voltage L1 10-12 cycles [1, 19]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62131	Voltage L1 half cycle [1, 16, 19]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62132	Voltage L1 - instantaneous value [17]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62133	Current L1 10-12 cycles [1, 19]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62134	Current L1 half cycle [1, 16, 19]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62135	Current L1 - instantaneous value [17]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62136	Fundamental cos φ active factor L1 (SINT8) [17]	SINT	0.01	-100...100	✓	✓	✓	✓	✓	✓	✓	
62150	Max. total harmonic distortion (THD+N) voltage L1 [14]	REAL	1%	0 % bis 100 %	✓	✓	✓	✓	✓	✓	✓	
62151	Max. total harmonic distortion (THD+N) current L1 [14]	REAL	1%	0 % bis 100 %	✓	✓	✓	✓	✓	✓	✓	✓
62152	Max. fundamental voltage L1 [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62153	Max. fundamental current L1 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62154	Max. fundamental reactive power L1 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62155	Max. fundamental apparent power L1 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62156	Max. fundamental active power L1 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62157	Max. fundamental cos φ active factor L1 [14]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
62160	Max. reactive power Qtot L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62170	Min. total harmonic distortion (THD+N) voltage L1 [14]	REAL	1%	0 % bis 100 %	✓	✓	✓	✓	✓	✓	✓	
62171	Min. total harmonic distortion (THD+N) current L1 [14]	REAL	1%	0 % bis 100 %	✓	✓	✓	✓	✓	✓	✓	✓
62172	Min. fundamental voltage L1 [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62173	Min. fundamental current L1 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62174	Min. fundamental reactive power L1 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62175	Min. fundamental apparent power L1[14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62176	Min. fundamental active power L1 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62177	Min. fundamental cos φ active factor L1[14]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓	
62180	Min. reactive power Qtot L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓	
62193	Diagnostics L1 [20]	DWORD	Bit track	0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
62194	Voltage dip - value L1 [16]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62195	Voltage swell - value L1 [16]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62196	Voltage peak value L1 [17]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
62197	Current peak value L1 [17]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62198	Overcurrent- value L1 [16]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
62199	Voltage dip - duration L1 [16]	REAL	ms	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	
62200	Voltage swell - duration L1 [16]	REAL	ms	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	
62210	Active energy inflow L2 (Int32) [6]	DINT	Wh	0... 2147483647		✓	✓	✓	✓	✓	✓	
62211	Active energy outflow L2 (Int32) [6]	DINT	Wh	0... 2147483647		✓	✓	✓	✓	✓	✓	
62212	Reactive energy inflow L2 (Int32) [6]	DINT	varh	0... 2147483647		✓	✓	✓	✓	✓	✓	
62213	Reactive energy outflow L2 (Int32) [6]	DINT	varh	0... 2147483647		✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62214	Apparent energy L2 Active energy inflow L2 (Int32) [6]	DINT	VAh	0... 2147483647		✓	✓	✓	✓	✓	✓	
62215	Total active energy L2 (Int32) [6]	DINT	Wh	-2147483647... +2147483647		✓	✓	✓	✓	✓	✓	
62216	Total reactive energy L2 (Int32) [6]	DINT	varh	-2147483647... +2147483647		✓	✓	✓	✓	✓	✓	
62220	Total harmonic distortion (THD+N) voltage L2 [13]	REAL	1%	0 % bis 100 %		✓	✓	✓	✓	✓	✓	
62221	Total harmonic distortion (THD+N) current L2 [13]	REAL	1%	0 % bis 100 %		✓	✓	✓	✓	✓	✓	✓
62222	Fundamental voltage L2[2]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62223	Fundamental current L2 [1]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62224	Fundamental reactive power L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62225	Fundamental apparent power L2 [3]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62226	Fundamental active power L2 [3]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62227	Fundamental cos φ active factor L2 [17]	REAL	-	-1.0 ... 1.0		✓	✓	✓	✓	✓	✓	
62230	Voltage L2 10-12 cycles [1, 19]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62231	Voltage L2 half cycle [1, 16, 19]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62232	Voltage L2 - instantaneous value [17]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62233	Current L2 10-12 cycles [1, 19]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62234	Current L2 half cycle [1, 16, 19]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62235	Current L2 - instantaneous value [17]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62236	Fundamental cos φ active factor L2 (SINT8) [17]	SINT	0.01	-100...100		✓	✓	✓	✓	✓	✓	
62250	Max. total harmonic distortion (THD+N) voltage L2 [14]	REAL	1%	0 % bis 100 %		✓	✓	✓	✓	✓	✓	
62251	Max. total harmonic distortion (THD+N) current L2 [14]	REAL	1%	0 % bis 100 %		✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62252	Max. fundamental voltage L2 [14]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62253	Max. fundamental current L2 [14]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62254	Max. fundamental reactive power L2 [14]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62255	Max. fundamental apparent power L2 [14]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62256	Max. fundamental active power L2 [14]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62257	Max. fundamental cos φ active factor L2 [14]	REAL	-	-1.0 ... 1.0		✓	✓	✓	✓	✓	✓	
62260	Max. reactive power Qtot L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62270	Min. total harmonic distortion (THD+N) voltage L2 [14]	REAL	1%	0 % bis 100 %		✓	✓	✓	✓	✓	✓	
62271	Min. total harmonic distortion (THD+N) current L2 [14]	REAL	1%	0 % bis 100 %		✓	✓	✓	✓	✓	✓	✓
62272	Min. fundamental voltage L2 [14]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62273	Min. fundamental current L2 [14]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62274	Min. fundamental reactive power L2 [14]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62275	Min. fundamental apparent power L2[14]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62276	Min. fundamental active power L2 [14]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62277	Min. fundamental cos φ active factor L2[14]	REAL	-	-1.0 ... 1.0		✓	✓	✓	✓	✓	✓	
62280	Min. reactive power Qtot L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓	
62293	Diagnostics L2 [20]	DWORD	Bit track	0 ... 4294967295		✓	✓	✓	✓	✓	✓	✓
62294	Voltage dip - value L2 [16]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62295	Voltage swell - value L2 [16]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62296	Voltage peak value L2 [17]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
62297	Current peak value L2 [17]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62298	Overcurrent- value L2 [16]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
62299	Voltage dip - duration L2 [16]	REAL	ms	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62300	Voltage swell - duration L2 [16]	REAL	ms	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	
62310	Active energy inflow L3 (Int32) [6]	DINT	Wh	0... 2147483647			✓	✓	✓	✓	✓	
62311	Active energy outflow L3 (Int32) [6]	DINT	Wh	0... 2147483647			✓	✓	✓	✓	✓	
62312	Reactive energy inflow L3 (Int32) [6]	DINT	varh	0... 2147483647			✓	✓	✓	✓	✓	
62313	Reactive energy outflow L3 (Int32) [6]	DINT	varh	0... 2147483647			✓	✓	✓	✓	✓	
62314	Apparent energy L3 (Int32) [6]	DINT	VAh	0... 2147483647			✓	✓	✓	✓	✓	
62315	Total active energy L3 (Int32) [6]	DINT	Wh	-2147483647... +2147483647			✓	✓	✓	✓	✓	
62316	Total reactive energy L3 (Int32) [6]	DINT	varh	-2147483647... +2147483647			✓	✓	✓	✓	✓	
62320	Total harmonic distortion (THD+N) voltage L3 [13]	REAL	1%	0 % bis 100 %			✓	✓	✓	✓	✓	
62321	Total harmonic distortion (THD+N) current L3 [13]	REAL	1%	0 % bis 100 %			✓	✓	✓	✓	✓	✓
62322	Fundamental voltage L3 [2]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62323	Fundamental current L3 [1]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62324	Fundamental reactive power L3 [3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62325	Fundamental apparent power L3 [3]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62326	Fundamental active power L3[3]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62327	Fundamental cos φ active factor L3 [17]	REAL	-	-1.0 ... 1.0			✓	✓	✓	✓	✓	
62330	Voltage L3 10-12 cycles [1, 19]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62331	Voltage L3 half cycle [1, 16, 19]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62332	Voltage L3 - instantaneous value [17]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62333	Current L3 10-12 cycles [1, 19]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62334	Current L3 half cycle [1, 16, 19]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62335	Current L3 - instantaneous value [17]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62336	Fundamental cos φ active factor L3 (SINT8) [17]	SINT	0.01	-100...100			✓	✓	✓	✓	✓	
62350	Max. total harmonic distortion (THD+N) voltage L3 [14]	REAL	1%	0 % bis 100 %			✓	✓	✓	✓	✓	
62351	Max. total harmonic distortion (THD+N) current L3 [14]	REAL	1%	0 % bis 100 %			✓	✓	✓	✓	✓	✓
62352	Max. fundamental voltage L3[14]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62353	Max. fundamental current L3[14]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62354	Max. fundamental reactive power L3[14]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62355	Max. fundamental apparent power L3[14]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62356	Max. fundamental active power L3[14]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62357	Max. fundamental cos φ active factor L3[14]	REAL	-	-1.0 ... 1.0			✓	✓	✓	✓	✓	
62360	Max. reactive power Qtot L3[3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62370	Min. total harmonic distortion (THD+N) voltage L3 [14]	REAL	1%	0 % bis 100 %			✓	✓	✓	✓	✓	
62371	Min. total harmonic distortion (THD+N) current L3 [14]	REAL	1%	0 % bis 100 %			✓	✓	✓	✓	✓	✓
62372	Min. fundamental voltage L3[14]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62373	Min. fundamental current L3 [14]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62374	Min. fundamental reactive power L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62375	Min. fundamental apparent power L3[14]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62376	Min. fundamental active power L3[14]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	
62377	Min. fundamental cos φ active factor L3[14]	REAL	-	-1.0 ... 1.0			✓	✓	✓	✓	✓	
62380	Min. reactive power Qtot L3[3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
62393	Diagnostics L3 [20]	DWORD	Bit track	0 ... 4294967295			✓	✓	✓	✓	✓	✓
62394	Voltage dip - value L3[16]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62395	Voltage swell - value L3[16]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62396	Voltage peak value L3[17]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
62397	Current peak value L3 [17]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62398	Overcurrent- value L3[16]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
62399	Voltage dip - duration L3[16]	REAL	ms	0.0 ... 100000.0			✓	✓	✓	✓	✓	
62400	Voltage swell - duration L3[16]	REAL	ms	0.0 ... 100000.0			✓	✓	✓	✓	✓	
Harmonics												
63000	Harmonics 1: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63001	Harmonics 1: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63002	Harmonics 2: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63003	Harmonics 2: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63004	Harmonics 3: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63005	Harmonics 3: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63006	Harmonics 4: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63007	Harmonics 4: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63008	Harmonics 5: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63009	Harmonics 5: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63010	Harmonics 6: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63011	Harmonics 6: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63012	Harmonics 7: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63013	Harmonics 7: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63014	Harmonics 8: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63015	Harmonics 8: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63016	Harmonics 9: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63017	Harmonics 9: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63018	Harmonics 10: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63019	Harmonics 10: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63020	Harmonics 11: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63021	Harmonics 11: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63022	Harmonics 12: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63023	Harmonics 12: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63024	Harmonics 13: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63025	Harmonics 13: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63026	Harmonics 14: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63027	Harmonics 14: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63028	Harmonics 15: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63029	Harmonics 15: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63030	Harmonics 16: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63031	Harmonics 16: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63032	Harmonics 17: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63033	Harmonics 17: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63034	Harmonics 18: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63035	Harmonics 18: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63036	Harmonics 19: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63037	Harmonics 19: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63038	Harmonics 20: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63039	Harmonics 20: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63040	Harmonics 21: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63041	Harmonics 21: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63042	Harmonics 22: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63043	Harmonics 22: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63044	Harmonics 23: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63045	Harmonics 23: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63046	Harmonics 24: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63047	Harmonics 24: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63048	Harmonics 25: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63049	Harmonics 25: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63050	Harmonics 26: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63051	Harmonics 26: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63052	Harmonics 27: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63053	Harmonics 27: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63054	Harmonics 28: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63055	Harmonics 28: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63056	Harmonics 29: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63057	Harmonics 29: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63058	Harmonics 30: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63059	Harmonics 30: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63060	Harmonics 31: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63061	Harmonics 31: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63062	Harmonics 32: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63063	Harmonics 32: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63064	Harmonics 33: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63065	Harmonics 33: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63066	Harmonics 34: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63067	Harmonics 34: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63068	Harmonics 35: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63069	Harmonics 35: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63070	Harmonics 36: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63071	Harmonics 36: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63072	Harmonics 37: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63073	Harmonics 37: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63074	Harmonics 38: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63075	Harmonics 38: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63076	Harmonics 39: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63077	Harmonics 39: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63078	Harmonics 40: Voltage L1 [18]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓	
63079	Harmonics 40: Current L1 [18]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓	✓
63400	Harmonics 1: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63401	Harmonics 1: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63402	Harmonics 2: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63403	Harmonics 2: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63404	Harmonics 3: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63405	Harmonics 3: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63406	Harmonics 4: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63407	Harmonics 4: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63408	Harmonics 5: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63409	Harmonics 5: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63410	Harmonics 6: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63411	Harmonics 6: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63412	Harmonics 7: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63413	Harmonics 7: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63414	Harmonics 8: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63415	Harmonics 8: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63416	Harmonics 9: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63417	Harmonics 9: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63418	Harmonics 10: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63419	Harmonics 10: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63420	Harmonics 11: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63421	Harmonics 11: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63422	Harmonics 12: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63423	Harmonics 12: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63424	Harmonics 13: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63425	Harmonics 13: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63426	Harmonics 14: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63427	Harmonics 14: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63428	Harmonics 15: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63429	Harmonics 15: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63430	Harmonics 16: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63431	Harmonics 16: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63432	Harmonics 17: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63433	Harmonics 17: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63434	Harmonics 18: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63435	Harmonics 18: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63436	Harmonics 19: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63437	Harmonics 19: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63438	Harmonics 20: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63439	Harmonics 20: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63440	Harmonics 21: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63441	Harmonics 21: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63442	Harmonics 22: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63443	Harmonics 22: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63444	Harmonics 23: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63445	Harmonics 23: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63446	Harmonics 24: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63447	Harmonics 24: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63448	Harmonics 25: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63449	Harmonics 25: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63450	Harmonics 26: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63451	Harmonics 26: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63452	Harmonics 27: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63453	Harmonics 27: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63454	Harmonics 28: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63455	Harmonics 28: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63456	Harmonics 29: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63457	Harmonics 29: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63458	Harmonics 30: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63459	Harmonics 30: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63460	Harmonics 31: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63461	Harmonics 31: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63462	Harmonics 32: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63463	Harmonics 32: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63464	Harmonics 33: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63465	Harmonics 33: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63466	Harmonics 34: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63467	Harmonics 34: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63468	Harmonics 35: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63469	Harmonics 35: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63470	Harmonics 36: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63471	Harmonics 36: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63472	Harmonics 37: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63473	Harmonics 37: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63474	Harmonics 38: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63475	Harmonics 38: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63476	Harmonics 39: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63477	Harmonics 39: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63478	Harmonics 40: Voltage L2 [18]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓	
63479	Harmonics 40: Current L2 [18]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓	✓
63800	Harmonics 1: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63801	Harmonics 1: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63802	Harmonics 2: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63803	Harmonics 2: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63804	Harmonics 3: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63805	Harmonics 3: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63806	Harmonics 4: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63807	Harmonics 4: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63808	Harmonics 5: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63809	Harmonics 5: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63810	Harmonics 6: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63811	Harmonics 6: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63812	Harmonics 7: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63813	Harmonics 7: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63814	Harmonics 8: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63815	Harmonics 8: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63816	Harmonics 9: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63817	Harmonics 9: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63818	Harmonics 10: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63819	Harmonics 10: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63820	Harmonics 11: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63821	Harmonics 11: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63822	Harmonics 12: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63823	Harmonics 12: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63824	Harmonics 13: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63825	Harmonics 13: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63826	Harmonics 14: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63827	Harmonics 14: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63828	Harmonics 15: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63829	Harmonics 15: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63830	Harmonics 16: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63831	Harmonics 16: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63832	Harmonics 17: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63833	Harmonics 17: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63834	Harmonics 18: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63835	Harmonics 18: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63836	Harmonics 19: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63837	Harmonics 19: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63838	Harmonics 20: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63839	Harmonics 20: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63840	Harmonics 21: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63841	Harmonics 21: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63842	Harmonics 22: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63843	Harmonics 22: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63844	Harmonics 23: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63845	Harmonics 23: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63846	Harmonics 24: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63847	Harmonics 24: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63848	Harmonics 25: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63849	Harmonics 25: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63850	Harmonics 26: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63851	Harmonics 26: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63852	Harmonics 27: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63853	Harmonics 27: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63854	Harmonics 28: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63855	Harmonics 28: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63856	Harmonics 29: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63857	Harmonics 29: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63858	Harmonics 30: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63859	Harmonics 30: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63860	Harmonics 31: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63861	Harmonics 31: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63862	Harmonics 32: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63863	Harmonics 32: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63864	Harmonics 33: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63865	Harmonics 33: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63866	Harmonics 34: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63867	Harmonics 34: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63868	Harmonics 35: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63869	Harmonics 35: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63870	Harmonics 36: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63871	Harmonics 36: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63872	Harmonics 37: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63873	Harmonics 37: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63874	Harmonics 38: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
63875	Harmonics 38: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63876	Harmonics 39: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63877	Harmonics 39: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
63878	Harmonics 40: Voltage L3 [18]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓	
63879	Harmonics 40: Current L3 [18]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓	✓
65495[2-1]	DQ control measured value acquisition [17]	BYTE	Bit track	0 ... 255	✓	✓	✓	✓	✓	✓	✓	✓
65496	Power quality analysis - Qualifier	UDINT	Bit track	0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65497	Current module time	PNIO	sec		✓	✓	✓	✓	✓	✓	✓	✓
65500	Qualifier L1	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	✓
65501	Qualifier L2	UINT	Bit track	0 ... 65535		✓	✓	✓	✓	✓	✓	✓
65502	Qualifier L3	UINT	Bit track	0 ... 65535			✓	✓	✓	✓	✓	✓
65503	Qualifier L1L2L3 [22]	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	✓
65504	Operating hours counter L1L2L3 [5]	REAL	h	0.0 ... 3.4e+38	✓	✓	✓	✓	✓	✓	✓	✓
65505	Operating hours counter L1 [5]	REAL	h	0.0 ... 3.4e+38	✓	✓	✓	✓	✓	✓	✓	✓
65506	Operating hours counter L2 [5]	REAL	h	0.0 ... 3.4e+38		✓	✓	✓	✓	✓	✓	✓
65507	Operating hours counter L3 [5]	REAL	h	0.0 ... 3.4e+38			✓	✓	✓	✓	✓	✓
65508	Status of energy counter overflows	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	✓
65509	Status of limit violations 1...16	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	✓
65510	Counter for limit violations GW1 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65511	Counter for limit violations GW2 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65512	Counter for limit violations GW3 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65513	Counter for limit violations GW4 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1	3P 4WI
65514	Counter for limit violations GW5 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65515	Counter for limit violations GW6 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65516	Counter for limit violations GW7 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65517	Counter for limit violations GW8 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65518	Counter for limit violations GW9 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65519	Counter for limit violations GW10 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65520	Counter for limit violations GW11 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65521	Counter for limit violations GW12 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65522	Counter for limit violations GW13 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65523	Counter for limit violations GW14 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65524	Counter for limit violations GW15 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓
65525	Counter for limit violations GW16 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓	✓

The table below is relevant for the description of the payload variants:

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P-2W	3P 4W	3P 4-W1	3P 3W	3P 3-W1	3P 4-WI
66001	Voltage L1-N [1]	UINT	0.01 V	0 ... 65535	✓	✓	✓	✓	✓			
66002	Voltage L2-N [1]	UINT	0.01 V	0 ... 65535		✓	✓	✓	✓			
66003	Voltage L3-N [1]	UINT	0.01 V	0 ... 65535			✓	✓	✓			
66004	Voltage L1-L2 [2]	UINT	0.01 V	0 ... 65535		✓		✓	✓	✓	✓	
66005	Voltage L2-L3 [2]	UINT	0.01 V	0 ... 65535				✓	✓	✓	✓	
66006	Voltage L3-L1 [2]	UINT	0.01 V	0 ... 65535				✓	✓	✓	✓	
66007	Current L1 [1]	UINT	1 mA	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	✓
66008	Current L2 [1]	UINT	1 mA	0 ... 65535		✓	✓	✓	✓	✓	✓	✓
66009	Current L3 [1]	UINT	1 mA	0 ... 65535			✓	✓	✓	✓	✓	✓
66010	Apparent power L1 [3]	INT	1 VA	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66011	Apparent power L2 [3]	INT	1 VA	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66012	Apparent power L3 [3]	INT	1 VA	-32768 ... 32767			✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P-2W	3P 4W	3P 4-W1	3P 3W	3P 3-W1	3P 4-WI
66013	Active power L1 [3]	INT	1 W	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66014	Active power L2 [3]	INT	1 W	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66015	Active power L3 [3]	INT	1 W	-32768 ... 32767			✓	✓	✓	✓	✓	
66016	Reactive power Qn L1[3]	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66017	Reactive power Qn L2[3]	INT	1 var	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66018	Reactive power Qn L3[3]	INT	1 var	-32768 ... 32767			✓	✓	✓	✓	✓	
66019	Power factor λ L1 [3]	USINT	0.01	0 ... 100	✓	✓	✓	✓	✓	✓	✓	
66020	Power factor λ L2 [3]	USINT	0.01	0 ... 100		✓	✓	✓	✓	✓	✓	
66021	Power factor λ L3 [3]	USINT	0.01	0 ... 100			✓	✓	✓	✓	✓	
66022	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66023	Reactive power Qtot L2	INT	1 var	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66024	Reactive power Qtot L3	INT	1 var	-32768 ... 32767			✓	✓	✓	✓	✓	
66030	Frequency (Uint8) [4]	USINT	1 Hz	40 ... 70	✓	✓	✓	✓	✓	✓	✓	✓
66031	Frequency (Uint16) [4]	UINT	0.01 Hz	4000 ... 7000	✓	✓	✓	✓	✓	✓	✓	✓
66034	Active power L1L2L3 [5]	INT	1 W	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66035	Reactive power Qn L1L2L3[5]	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66036	Apparent power L1L2L3 [5]	INT	1 VA	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66037	Power factor λ L1L2L3 [6]	USINT	0.01	0 ... 100	✓	✓	✓	✓	✓	✓	✓	
66038	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	✓

Z = additionally possible measured values in the current path (e.g. instead of neutral current)

1 Effective value

2 IEC 61557-12

3 floating arithmetic average value above 200 ms

4 floating arithmetic mean value above 10 s, available for UL-N>3 V. Frequencies outside the measuring range of lower than 40 Hz or higher than 70 Hz cannot be displayed. In these cases, the configured frequency (50 Hz or 60 Hz) is displayed and is used in further calculations.

5 Simple summation

6 Calculation from the start/restart (inflow and outflow values are positive numbers)

7 floating arithmetic average value above 3 s

8 floating arithmetic average value above 600 s

9 floating arithmetic average value above 900 s

10 Block measurement over 900 s

11 direct measurement of the signal wave at 8 ksps

12 Total of the parts / number of parts

13 THD (Total Harmonic Distortion) is calculated once per second by the RMS of the fundamental oscillation and the total effective value (IEEE standard 1459–2010)

14 Min./Max: Slave pointer function of the respective basic value from start/reset

15 Calculation according to DIN EN 61000-3-316 half-wave value

16 Half-wave value

17 Instantaneous value

18 FFT (Fast Fourier Transformation)

19 While pure RMS measured values only contain AC voltage components of the signal, 10/12 and half-wave measured values also show DC voltage components of the signal

20 ET 200SP Diagnostics:

Bit2: Voltage less than tolerance range (for diagnostics enable Voltage underflow)

Bit3: Voltage greater than tolerance range (for diagnostics enable Voltage overflow)

Bit4: Current value > Current maximum value longer than tolerance time (for diagnostics enable Current overflow)

Bit7: Calculated value > value range (for diagnostics enable Calculated value overflow)

Bit16: Parameter error

Bit17: Load voltage error (for diagnostics enable No supply voltage)

Bit22: PRAL lost

Bit26: Power quality error (for diagnostics enable Power quality)

Bit31: Calibration or firmware update

21 ID 65495 is only available for triggers of the measured value acquisition (not for limit monitoring and user-defined payload or data records)

22 Only available for connection types 3PxW/only available for 3-phase system

Format

Table 2-894 Format and its length in bytes

Format in STEP 7 (TIA Portal)	Format to IEEE	Length in bytes	Comment
BYTE	BYTE	1 byte	Bit field with 8 bit
WORD	WORD	2 bytes	Bit field with 16 bit
DWORD	DWORD	4 bytes	Bit field with 32 bits
SINT	INT8 (signed)	1 byte	Fixed-point number 8 bits with sign
USINT	INT8 (unsigned)	1 byte	Fixed-point number 8 bits without sign
INT	INT (signed)	2 bytes	Fixed-point number 16 bits with sign
UINT	INT (unsigned)	2 bytes	Fixed-point number 16 bits without sign
UDINT	INT32 (unsigned)	4 bytes	Fixed-point number 32 bits without sign
DINT	INT32 (signed)	4 bytes	Fixed-point number, 32 bits with sign
REAL	Float32	4 bytes	Floating-point number 32 bits with sign
LREAL	Float64	8 bytes	Floating-point number 64 bits with sign

Module versions

C

C.1 Module version "2 I / 2 Q"

User data of the module

The module has 2 bytes of input user data and 2 bytes of output user data for status and control information. At this module version measured variables can be read solely via measured value data records (no measured variables can be evaluated via user data).

Structure of input user data

The structure of the input user data is fixed.

Table 2-895 Structure of input user data (2 bytes)

Byte	Validity	Designation	Comment
0	Module	User data variant	Constant = 0x80
1	Module	Quality information	Quality bits to describe the quality of the basic measured values

Allocation of the input user data

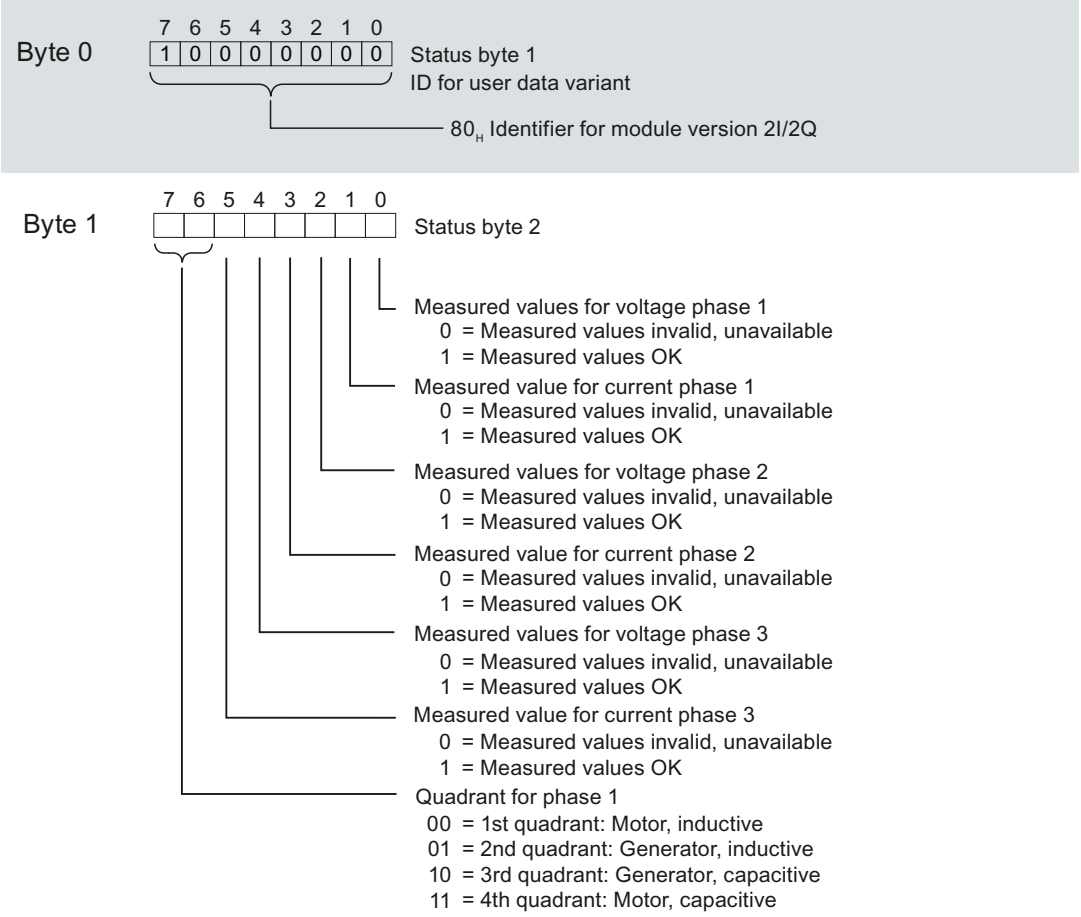

Figure 2-813 Allocation of the status bytes in the input user data (2 bytes)

Structure of output user data

The structure of the output user data is fixed.

Table 2-896 Structure of output user data (2 bytes)

Byte	Validity	Designation	Comment
0	Module	Reserved	Reserved
1	Module	Control outputs	Reset of values and counters, gate

Assignment of the output user data

Via the output user data you control for all phases

- Resetting for all minimum values, maximum values, limits, operating hours counter and energy meters.
- The counter gates for operating hours counter and energy counters.

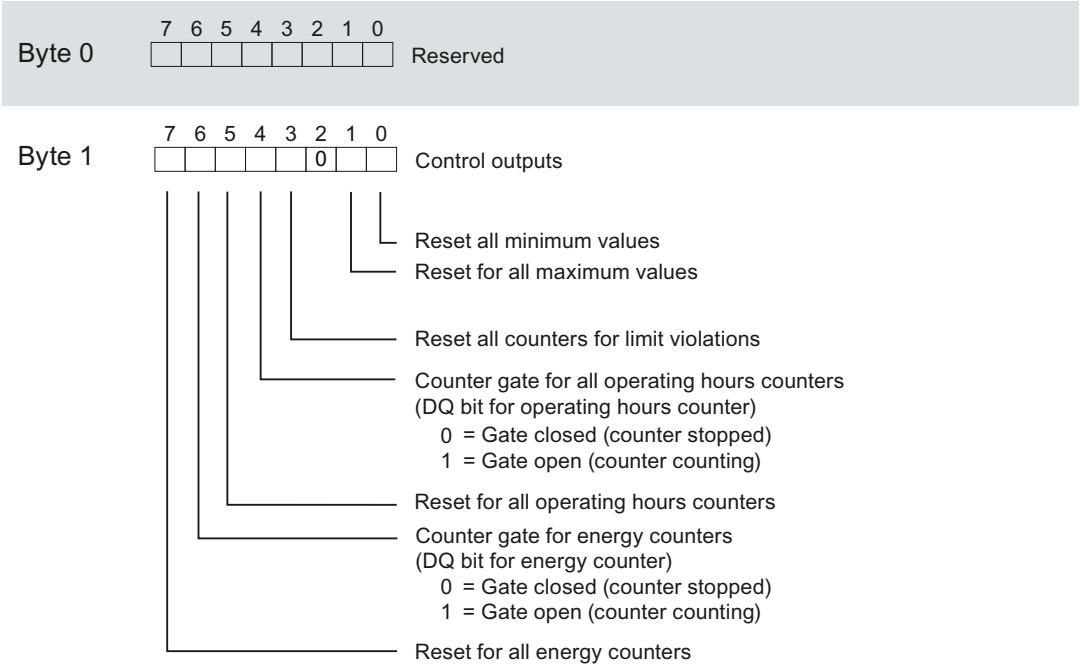

Figure 2-814 Allocation of the control byte in the output user data (1 byte)

NOTE

For module version 2 I / 2 Q, a reset of the selected variables always acts on **all** measured values/counter levels of the three phases.

- Reset energy counter: Acts on all active, reactive and apparent energies of all phases
- Reset operating hours counter: Acts on the counters of Phases 1 to 3
- Reset minimum / maximum values: Acts on the minimum and maximum value calculations of Phases 1-3
- Reset all counters for limit violations: Acts on all 16 limit values.

C.2 Module version "32 I / 20 Q"

Payload of the module

The module occupies 32 bytes of input payload and 20 bytes of output payload. Of these the module uses 2 bytes input data for status information and 20 bytes output data for control information. Measured variables can be read cyclically via payload (Bytes 2 to 31) or acyclically via measured value data records

Structure of input payload

You can set the contents of the input payload dynamically. You can choose between different payload variants.

Table 2-897 Structure of input payload (32 bytes)

Byte	Validity	Designation	Comment
0	Module	Payload variant	-
1	Module	Quality information	Quality bits to describe the quality of the basic measured values
2 ... 31	Module or phase	Data	2 or 4 byte measured values or cumulative values according to payload variant

Allocation of the input payload

You can change the measured variables during operation. You can choose between different payload variants.

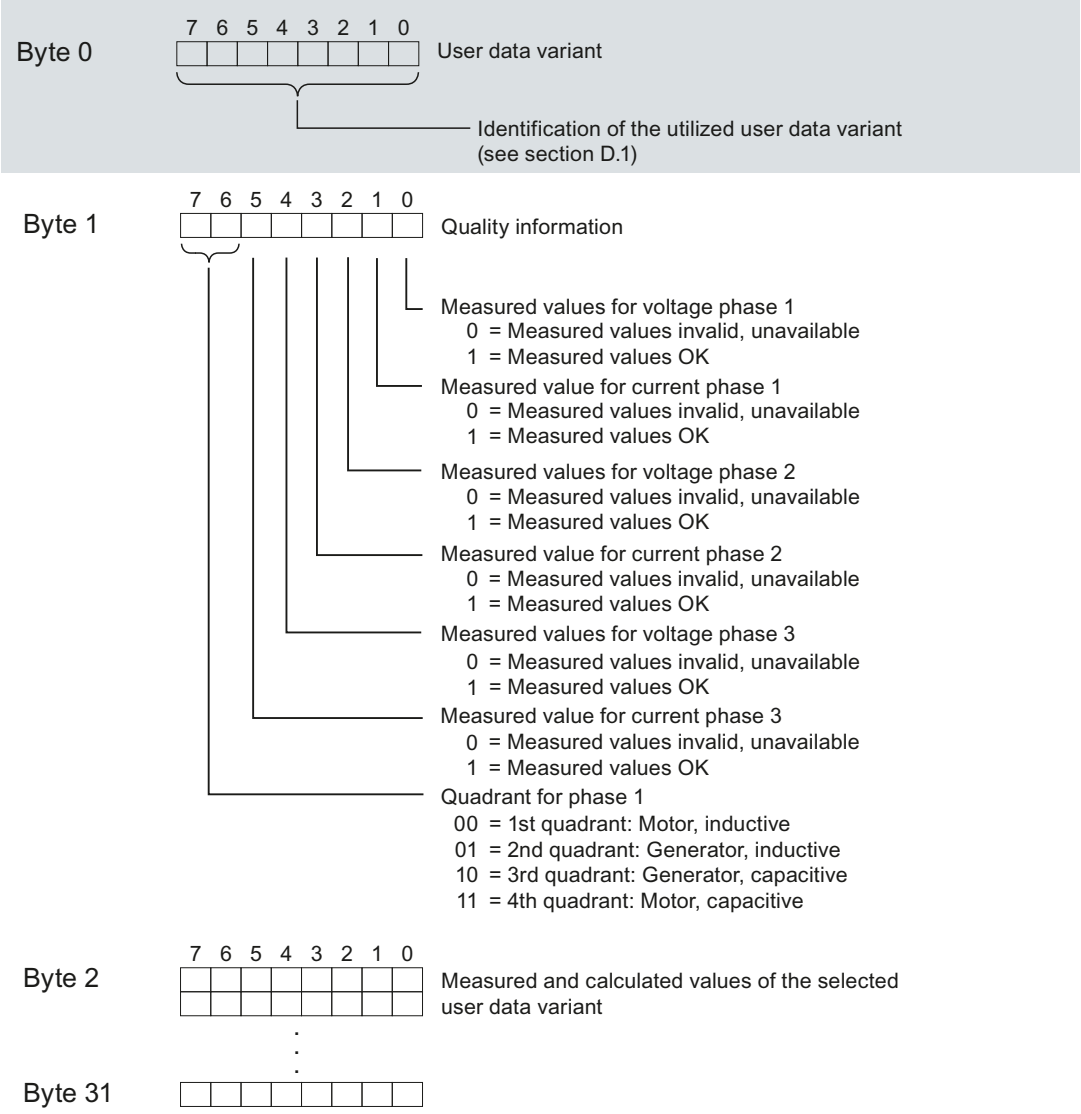

Figure 2-815 Assignment of the input payload (32 bytes)

Structure of output payload

The structure of the output payload is fixed and is the same at all the selectable payload variants.

Via the output payload you control globally or phase-specifically

- Resetting for minimum values, maximum values, limits, operating hours counter and energy meters.
- The counter gates for operating hours counter and energy counters.
- Gate for limits, minimum values and maximum values.

Table 2-898 Structure of output payload (20 bytes)

Byte	Validity	Designation	Comment
0	Module	Payload variant	Control byte for switching the payload variant
1	Module	Control byte 1	Global resetting of values and counters, gate Selection of the energy counter to be reset
2	Module	Control byte 2	
3	Module	Control byte 3	Control of the limit monitoring of limit values 9 to 16
4	Module	Control byte 4	Control of the limit monitoring of limit values 1 to 8
5	Module	Reserved	-
6	Phase L1	Control byte 6	Phase-specific resetting of values and counters, gate for Phase L1
7	Phase L1	Control byte 7	
8	Phase L2	Control byte 8	Phase-specific resetting of values and counters, gate for Phase L2
9	Phase L2	Control byte 9	
10	Phase L3	Control byte 10	Phase-specific resetting of values and counters, gate for Phase L3
11	Phase L3	Control byte 11	
12	Module and phases L1, L2, L3	Control byte 12	Phase-specific deletion of power quality analysis results
13	Reserved		
14	Reserved		
15	Reserved		
16	Module and phases L1, L2, L3	Control byte 16	General reset Reset of measured value recorders 1 and 2, reset of the power failure analysis
17	Module	Control byte 17	Bit 0 = 0->1: Measured value recorder start/stop ID 225 Bit 1 = 0->1: Measured value recorder start/stop ID 226 Bit 2 = 0->1: Measured value recorder start/stop ID 227 Bit 3 = 0->1: Measured value recorder start/stop ID 228 Bit 4 = 0->1: Measured value recorder start/stop ID 229 Bit 5 = 0->1: Measured value recorder start/stop ID 230 Bit 6 = 0->1: Measured value recorder start/stop ID 231 Bit 7 = 0->1: Measured value recorder start/stop ID 232
18	Reserved		
19	Reserved		

Control bytes for payload variant

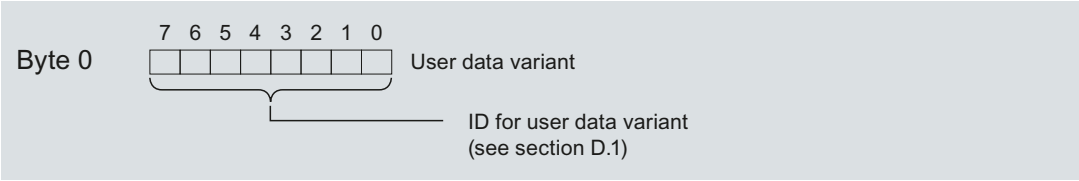

Figure 2-816 Allocation of the control bytes for payload variant (Byte 0)

Control bytes for all three phases

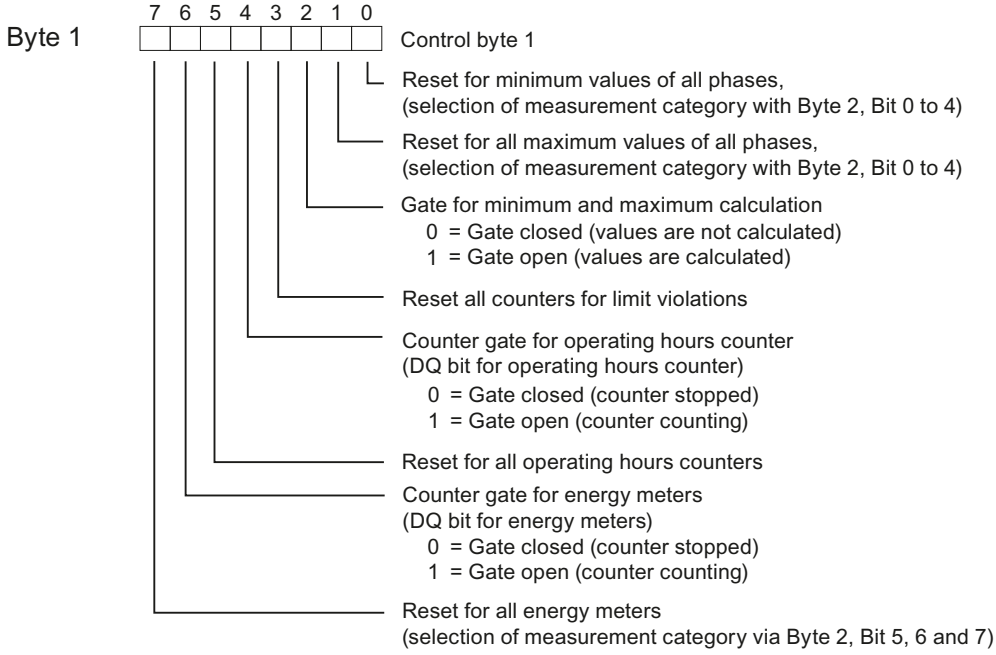

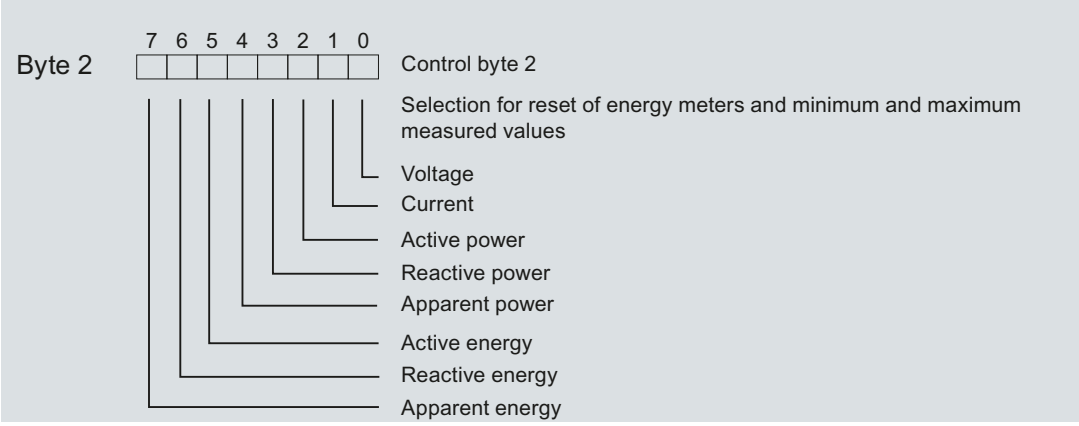

Figure 2-817 Allocation of the control bytes for all three phases (bytes 1 and 2)

Control bytes for limit monitoring

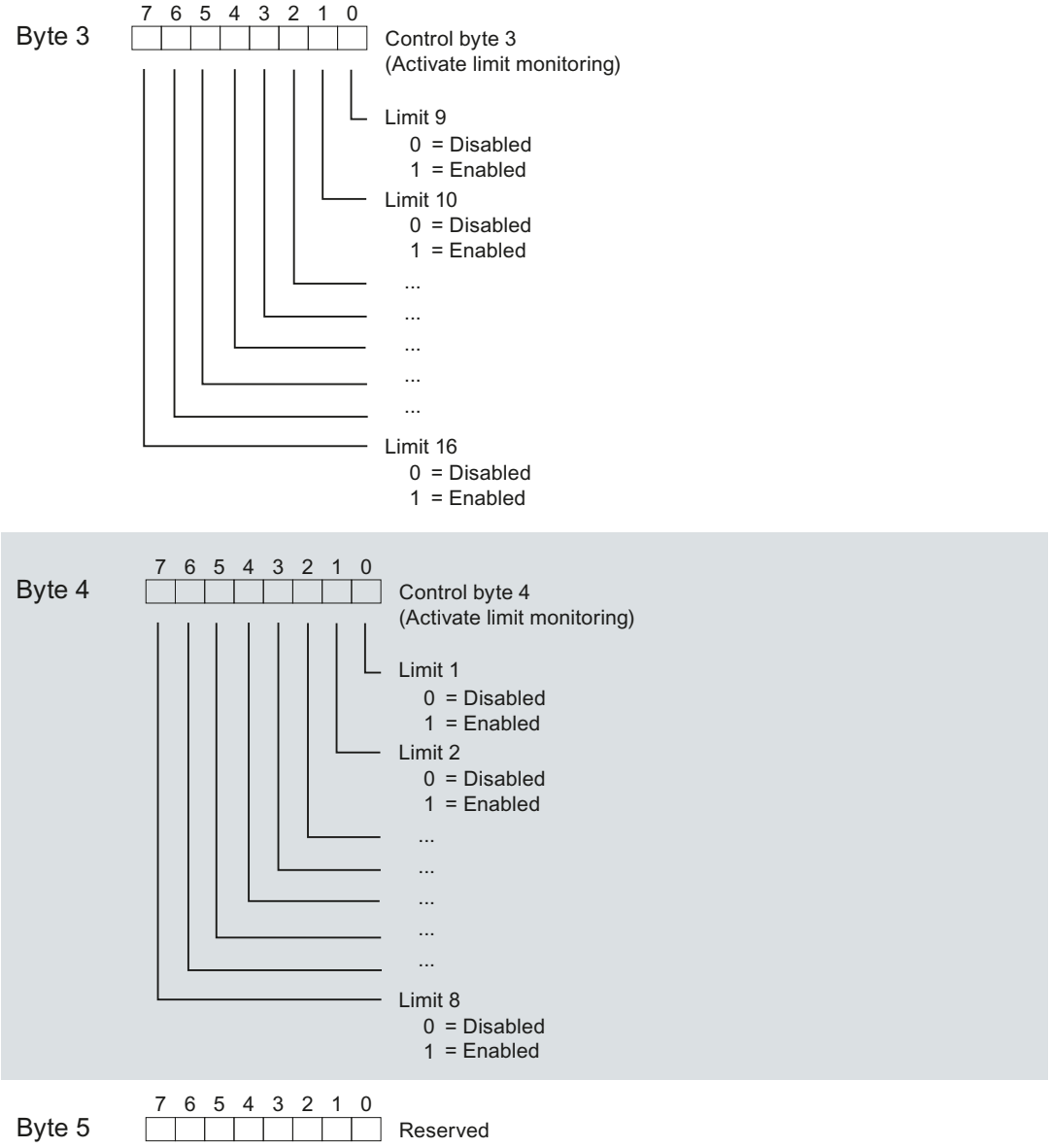

Figure 2-818 Allocation of the control bytes for limit monitoring (bytes 3 to 5)

Control bytes for each individual phase

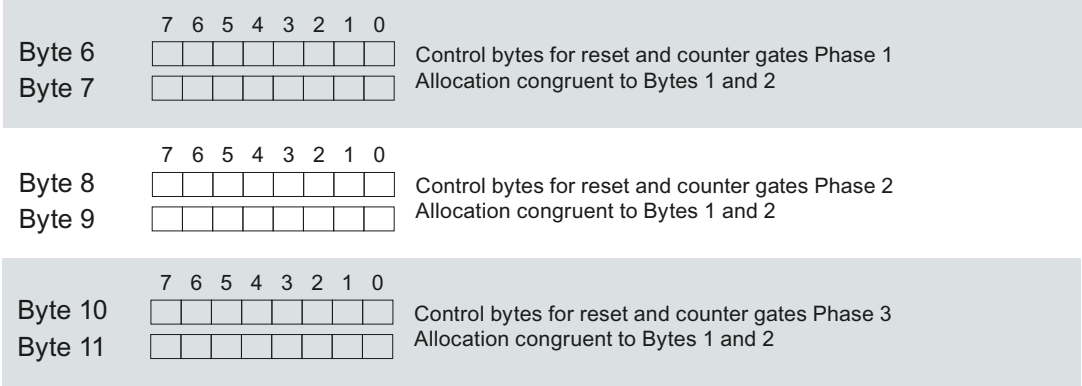

Figure 2-819 Allocation of the control bytes for each individual phase (bytes 6 to 11)

Control byte 12 Power quality analysis

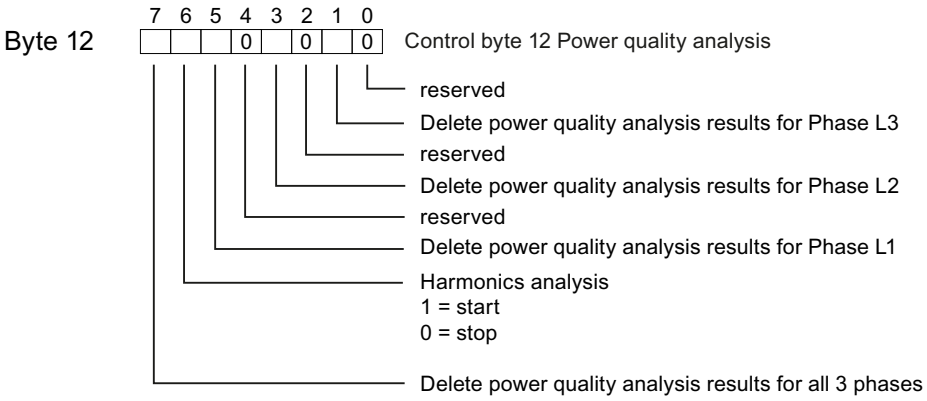

Figure 2-820 Control byte 12 Power quality analysis

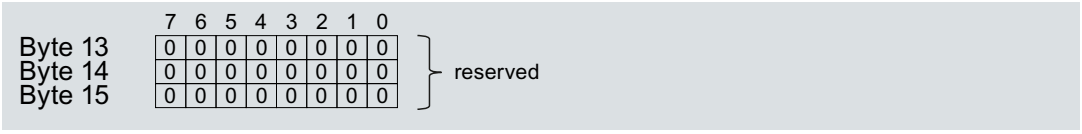

Figure 2-821 Allocation of the control bytes for each individual phase (bytes 13 to 15)

Control byte reset functions

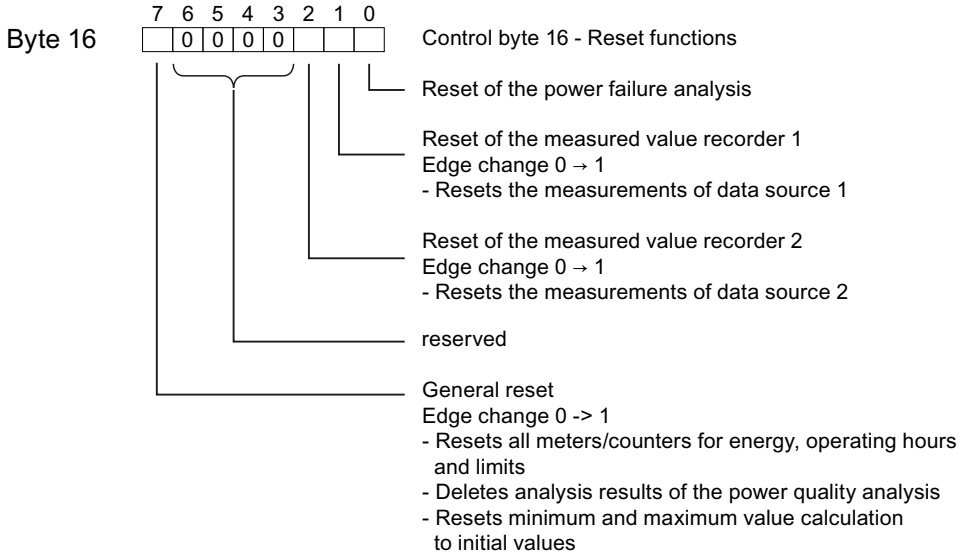

Figure 2-822 Allocation of the control bytes for reset functions (byte 16)

Control byte measured value recorder trigger

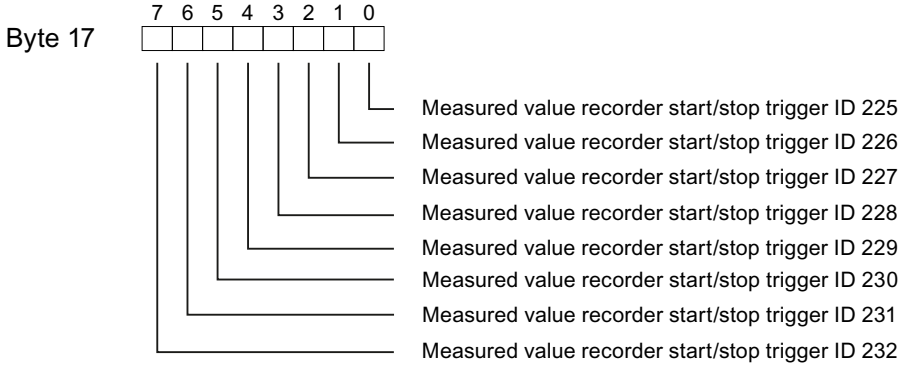

Figure 2-823 Allocation of the control bytes for measured value recorder trigger (byte 17)

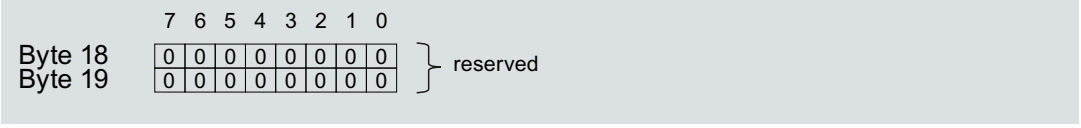

Figure 2-824 Allocation of the control bytes for each individual phase (bytes 18 to 19)

C.3 "User-specific" module version

Payload of the module

The module occupies between 16 and 256 bytes of input payload and 20 bytes of output payload. Of these the module uses 2 bytes input data for status information and 20 bytes output data for control information. Measured variables can be read cyclically via payload (as of Byte 2) or acyclically via measured value data records

Structure of input payload

You configure the structure of the input payload starting at Byte 2 at this module version itself. An input payload length of 32 bytes also allows you to set the input payload dynamically. You can choose between different payload variants.

Table 2-899 Structure of input payload (16 to 256 bytes)

Byte	Validity	Designation	Comment
0	Module	Payload variant	-
1	Module	Quality information	Quality bits to describe the quality of the basic measured values
2 ... 255	Module or phase	Data	Measured values or calculated values in accordance with their configuration: • At configuration in STEP 7 the size of the input payload is calculated automatically. • With configuration via the GSD file the size of the input payload amounts to 32, 64, 128 or 256 bytes. The memory area has to be sufficiently large for the measured variables defined in parameter data record 130 or 131.

Allocation of the input payload

You can change the measured variables during operation. You can choose between different payload variants.

The allocation of the status information in bytes 0 and 1 corresponds to the module version 32 I / 20 Q, see appendix Module version "32 I / 20 Q" (Page 205).

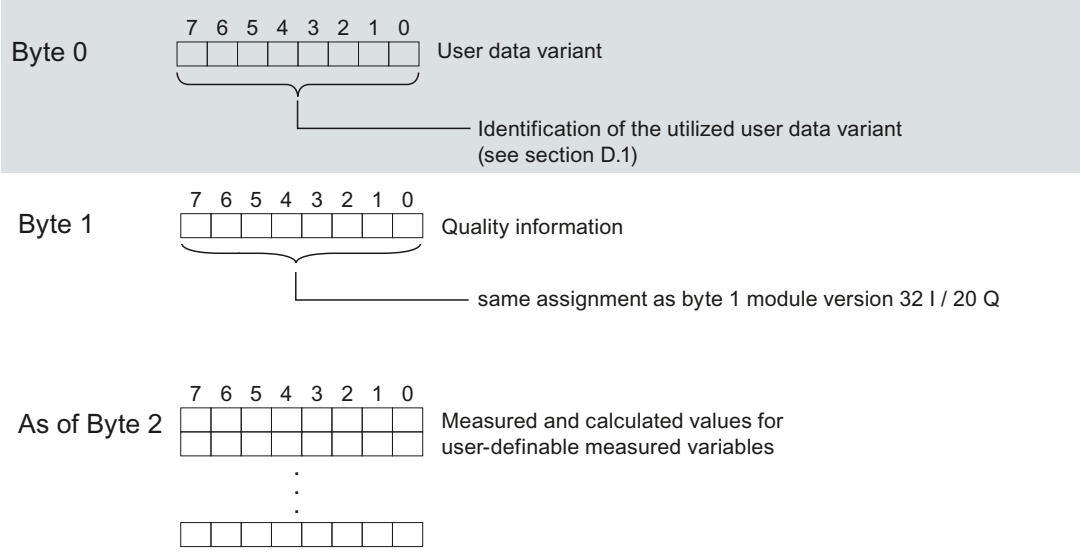

Figure 2-825 Allocation of the input payload ("User-specific" module version"

NOTE

Behavior at switchover in case of the input payload being too small

If the configured size of the variable input payload is smaller than the sized of the fixed payload variant, the response depends on the type of switchover:

- Re-assigning parameters via parameter data records DS 128 / DS 130 / DS 131: Output of a parameter assignment error (33). No switchover.
- Switchover using output byte 0 of a payload variant: No switchover and no error message.

Structure of output payload

The structure of the 20-byte output payload is fixed and is identical to the output payload (control bytes) of the Module version "32 I / 20 Q" (Page 205).

C.4 Module version "EE@Industry measurement data profile E0 / E1 / E2 / E3"

Payload of the module

The four versions according to EE@Industry use between 4 and 104 bytes of input payload and 20 bytes of output payload. A dynamic switchover of the input payload is not possible.

Structure of input payload

The structure of the input payload for the module versions according to the EE@Industry standard is fixed and depends on the selected measurement data profile.

Table 2-900 Measurement data profile E0

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Current L1	REAL	1 A	0.0 ... 100000.0	7
4...7	Current L2	REAL	1 A	0.0 ... 100000.0	8
8...11	Current L3	REAL	1 A	0.0 ... 100000.0	9

Table 2-901 Measurement data profile E1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Active power L1L2L3	REAL	1 W	-3.0e+9 ... +3.0e+9	34

Table 2-902 Measurement data profile E2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Active power L1L2L3	REAL	1 W	-3.0e+9 ... +3.0e+9	34
4...7	Active energy inflow L1L2L3 (Float)	REAL	1 Wh	0.0 ... 3.4028e+38	200
8...11	Active energy outflow L1L2L3 (Float)	REAL	1 Wh	0.0 ... 3.4028e+38	201

Table 2-903 Measurement data profile E3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Active power L1	REAL	1 W	-3.0e+9 ... +3.0e+9	13
4...7	Active power L2	REAL	1 W	-3.0e+9 ... +3.0e+9	14
8...11	Active power L3	REAL	1 W	-3.0e+9 ... +3.0e+9	15
12...15	Reactive power Qtot L1	REAL	1 var	-3.0e+9 ... +3.0e+9	22
16...19	Reactive power Qtot L2	REAL	1 var	-3.0e+9 ... +3.0e+9	23
20...23	Reactive power Qtot L3	REAL	1 var	-3.0e+9 ... +3.0e+9	24
24...31	Active energy inflow L1L2L3	LREAL	1 Wh	0.0 ... 1.7976e+308	210
32...39	Active energy outflow L1L2L3	LREAL	1 Wh	0.0 ... 1.7976e+308	211
40...47	Reactive energy inflow L1L2L3	LREAL	1 varh	0.0 ... 1.7976e+308	212

Byte	Allocation	Data type	Unit	Value range	Measured value ID
48...55	Reactive energy outflow L1L2L3	LREAL	1 varh	0.0 ... 1.7976e+308	213
56...59	Voltage L1-N	REAL	1 V	0.0 ... 1000000.0	1
60...63	Voltage L2-N	REAL	1 V	0.0 ... 1000000.0	2
64...67	Voltage L3-N	REAL	1 V	0.0 ... 1000000.0	3
68...71	Voltage L1-L2	REAL	1 V	0.0 ... 1000000.0	4
72...75	Voltage L2-L3	REAL	1 V	0.0 ... 1000000.0	5
76...79	Voltage L3-L1	REAL	1 V	0.0 ... 1000000.0	6
80...83	Current L1	REAL	1 A	0.0 ... 100000.0	7
84...87	Current L2	REAL	1 A	0.0 ... 100000.0	8
88...91	Current L3	REAL	1 A	0.0 ... 100000.0	9
92...95	Power factor λ L1	REAL	-	0.0 ... 1.0	19
96...99	Power factor λ L2	REAL	-	0.0 ... 1.0	20
100...1-03	Power factor λ L3	REAL	-	0.0 ... 1.0	21

Structure of output payload

The structure of the 20-byte output payload is fixed and is identical to the output payload (control bytes) of the Module version "32 I / 20 Q" (Page 205).

User data variants

D

D.1 User data variants with 32 bytes input data / 20 bytes output data

Payload

The following table shows the existing payload variants.

Table 2-904 Overview of the payload variants

Payload	Payload variant
Total power L1L2L3	254 (FE_H) - default setting
Active power L1L2L3	253 (FD_H)
Reactive power L1L2L3	252 (FC_H)
Apparent power L1L2L3	251 (FB_H)
Basic measured values L1L2L3	250 (FA_H)
Total energy L1L2L3	249 ($F9_H$)
Energy L1	248 ($F8_H$)
Energy L2	247 ($F7_H$)
Energy L3	246 ($F6_H$)
Basic variables three-phase measurement L1L2L3	245 ($F5_H$)
Reactive power compensation	244 ($F4_H$)
Quality values three-phase measurement	240 ($F0_H$)
Energy measurement (periodic) overflow counter	239 (EF_H)
EE@Industry measurement data profile E3	227 ($E3_H$)
EE@Industry measurement data profile E2	226 ($E2_H$)
EE@Industry measurement data profile E1	225 ($E1_H$)
EE@Industry measurement data profile E0	224 ($E0_H$)
Basic variables phase-specific measurement L1	159 ($9F_H$)
Single-phase measurement L1 with voltage scaling value	158 ($9E_H$)
Basic variables phase-specific measurement L2	157 ($9D_H$)
Single-phase measurement L2 with voltage scaling value	156 ($9C_H$)
Basic variables phase-specific measurement L3	155 ($9B_H$)
Single-phase measurement L3 with voltage scaling value	154 ($9A_H$)
User-defined payload structure I	1 (01_H)
User-defined payload structure II	2 (02_H)

Information on using and dynamic switching of the payload variants can be found under "Selection of the module version".

Total power L1L2L3 (ID 254 or FE_H)

Table 2-905 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
10 ... 11	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038
12 ... 13	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
14 ... 17	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	225
18 ... 21	Total reactive energy L1L2L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	226
22	Reserved	BYTE	-	0	-
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Active power L1L2L3 (ID 253 or FD_H)

Table 2-906 Active power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	253 (FD_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1	INT	1 W	-32768 ... 32767	66013
10 ... 11	Active power L2	INT	1 W	-32768 ... 32767	66014
12 ... 13	Active power L3	INT	1 W	-32768 ... 32767	66015
14 ... 15	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
16 ... 19	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	225
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1	USINT	-	0 ... 255	-
28	Scaling active power L2	USINT	-	0 ... 255	-
29	Scaling active power L3	USINT	-	0 ... 255	-
30	Scaling active power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-

Reactive power L1L2L3 (ID 252 or FC_H)

Table 2-907 Reactive power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	252 (FC_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	66022
10 ... 11	Reactive power Qtot L2	INT	1 var	-32768 ... 32767	66023
12 ... 13	Reactive power Qtot L3	INT	1 var	-32768 ... 32767	66024
14 ... 15	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038

Byte	Allocation	Data type	Unit	Value range	Measured value ID
16 ... 19	Reactive energy inflow L1L2L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	222
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling reactive power L1	USINT	-	0 ... 255	-
28	Scaling reactive power L2	USINT	-	0 ... 255	-
29	Scaling reactive power L3	USINT	-	0 ... 255	-
30	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Apparent power L1L2L3 (ID 251 or FB_H)

Table 2-908 Apparent power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	251 (FB_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Apparent power L1	INT	1 VA	-32768 ... 32767	66010
10 ... 11	Apparent power L2	INT	1 VA	-32768 ... 32767	66011
12 ... 13	Apparent power L3	INT	1 VA	-32768 ... 32767	66012
14 ... 15	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
16 ... 19	Apparent energy L1L2L3 (Int32)	DINT	1 VAh	0 to 2147483647	224
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Scaling apparent power L2	USINT	-	0 ... 255	-
29	Scaling apparent power L3	USINT	-	0 ... 255	-
30	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total apparent energy L1L2L3	USINT	-	0 ... 255	-

Basic measured values L1L2L3 (ID 250 or FA_H)

Table 2-909 Basic measured values L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	250 (FA_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
10 ... 11	Voltage L2-N	UINT	0.01 V	0 ... 65535	66002
12 ... 13	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003
14 ... 15	Voltage L1-L2	UINT	0.01 V	0 ... 65535	66004
16 ... 17	Voltage L2-L3	UINT	0.01 V	0 ... 65535	66005
18 ... 19	Voltage L3-L1	UINT	0.01 V	0 ... 65535	66006
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling voltage UL1-N (UL1-UL2)	USINT	-	0 ... 255	-
28	Scaling voltage UL2-N (UL2-UL3)	USINT	-	0 ... 255	-
29	Scaling voltage UL3-N (UL3-UL1)	USINT	-	0 ... 255	-
30 ... 31	Frequency (Uint16)	UINT	0.01 Hz	4000 ... 7000	66031

Total energy L1L2L3 (ID 249 or $F9_H$)

Table 2-910 Total energy L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	249 ($F9_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2	Reserved	BYTE	-	0	-
3	Reserved	BYTE	-	0	-
4 ... 7	Active energy inflow L1L2L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	220
8 ... 11	Active energy outflow L1L2L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	221
11 ... 15	Reactive energy inflow L1L2L3 (Int32)	UDINT	1 varh	0 ... 2147483647	222
16 ... 19	Reactive energy outflow L1L2L3 (Int32)	UDINT	1 varh	0 ... 2147483647	223
20 ... 23	Apparent energy L1L2L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	224
24	Reserved	BYTE	-	0	-
25	Scaling active energy, inflow	USINT	-	0 ... 255	-
26	Scaling active energy, outflow	USINT	-	0 ... 255	-
27	Scaling reactive energy, inflow	USINT	-	0 ... 255	-
28	Scaling reactive energy, outflow	USINT	-	0 ... 255	-
29	Scaling apparent energy	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037

Energy L1 (ID 248 or $F8_H$)

Table 2-911 Energy L1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	248 ($F8_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 7	Active energy inflow L1 (Int32)	UDINT	1 Wh	0 ... 2147483647	62110
8 ... 11	Active energy outflow L1 (Int32)	UDINT	1 Wh	0 ... 2147483647	62111
11 ... 15	Reactive energy inflow L1 (Int32)	UDINT	1 varh	0 ... 2147483647	62112
16 ... 19	Reactive energy outflow L1 (Int32)	UDINT	1 varh	0 ... 2147483647	62113
20 ... 23	Apparent energy L1 (Int32)	UDINT	1 VAh	0 ... 2147483647	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active energy inflow L1	USINT	-	0 ... 255	-
26	Scaling active energy outflow L1	USINT	-	0 ... 255	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
27	Scaling reactive energy inflow L1	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L1	USINT	-	0 ... 255	-
29	Scaling apparent energy L1	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L1	USINT	0.01	0 ... 100	66019

Energy L2 (ID 247 or $F7_H$)

Table 2-912 Energy L2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	247 ($F7_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L2	UINT	1 mA	0 ... 65535	66008
4 ... 7	Active energy inflow L2 (Int32)	UDINT	1 Wh	0 ... 2147483647	62210
8 ... 11	Active energy outflow L2 (Int32)	UDINT	1 Wh	0 ... 2147483647	62211
11 ... 15	Reactive energy inflow L2 (Int32)	UDINT	1 varh	0 ... 2147483647	62212
16 ... 19	Reactive energy outflow L2 (Int32)	UDINT	1 varh	0 ... 2147483647	62213
20 ... 23	Apparent energy L2 (Int32)	UDINT	1 VAh	0 ... 2147483647	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active energy inflow L2	USINT	-	0 ... 255	-
26	Scaling active energy outflow L2	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L2	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L2	USINT	-	0 ... 255	-
29	Scaling apparent energy L2	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L2	USINT	0.01	0 ... 100	66020

Energy L3 (ID 246 or $F6_H$)

Table 2-913 Energy L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	246 ($F6_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L3	UINT	1 mA	0 ... 65535	66009
4 ... 7	Active energy inflow L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	62310
8 ... 11	Active energy outflow L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	62311
11 ... 15	Reactive energy inflow L3 (Int32)	UDINT	1 varh	0 ... 2147483647	62312
16 ... 19	Reactive energy outflow L3 (Int32)	UDINT	1 varh	0 ... 2147483647	62313
20 ... 23	Apparent energy L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active energy inflow L3	USINT	-	0 ... 255	-
26	Scaling active energy outflow L3	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L3	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L3	USINT	-	0 ... 255	-
29	Scaling apparent energy L3	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L3	USINT	0.01	0 ... 100	66021

Basic variables three-phase measurements (ID 245 or $F5_H$)

Table 2-914 Basic variables three-phase measurements

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	245 ($F5_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1L2L3	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	34
6 ... 9	Active energy outflow L1L2L3	REAL	1 Wh	0.0 ... 3.4×10^{38}	201
10 ... 13	Active energy inflow L1L2L3	REAL	1 Wh	0.0 ... 3.4×10^{38}	200
14 ... 17	Current L1	REAL	1 A	0.0 ... 100000.0	7
18 ... 21	Current L2	REAL	1 A	0.0 ... 100000.0	8
22 ... 25	Current L3	REAL	1 A	0.0 ... 100000.0	9
26 ... 27	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
28 ... 29	Voltage L2-N	UINT	0.01 V	0 ... 65535	66002
30 ... 31	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003

Reactive power compensation (ID 244 or $F4_H$)

Table 2-915 Reactive power compensation

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	244 ($F4_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2	Fundamental cos φ active factor L1 (SINT8)	BYTE	0.01	-100 ... 100	62136
3	Fundamental cos φ active factor L2 (SINT8)	BYTE	0.01	-100 ... 100	62236
4	Fundamental cos φ active factor L3 (SINT8)	BYTE	0.01	-100 ... 100	62336
5	Reserved	BYTE	-	0	-
6 ... 9	Fundamental reactive power L1	REAL	var	-3×10^9 ... $+3 \times 10^9$	62124
10 ... 13	Fundamental reactive power L2	REAL	var	-3×10^9 ... $+3 \times 10^9$	62224
14 ... 17	Fundamental reactive power L3	REAL	var	-3×10^9 ... $+3 \times 10^9$	62324

Basic variables quality values three-phase measurement (ID 240 or $F0_H$)

Table 2-916 Basic variables quality values three-phase measurement

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	240 (F0H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Status of the limit violations GW 1 ... 16 (*)	WORD	Bit string	xxxx xxxx xxxx xxxx	65509
4 ... 5	Status of the energy counter overflows (**)	WORD	Bit string	xxxx xxxx xxxx xxxx	65508
6 ... 7	Qualifier L1L2L3	WORD	Bit string	xxxx xxxx xxxx xxxx	65503
8 ... 11	Power quality analysis - Qualifier	UDINT	Bit string	xxxx xxxx xxxx xxxx xxxx xxxx xxxx xxxx	65496
12 ... 13	Reserved	WORD	-	0	-
14 ... 15	Reserved	WORD	-	0	-
16 ... 17	Reserved	WORD	-	0	-
18 ... 19	Reserved	WORD	-	0	-
20 ... 21	Reserved	WORD	-	0	-
22 ... 23	Reserved	WORD	-	0	-
24 ... 25	Reserved	WORD	-	0	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
26 ... 27	Reserved	WORD	-	0	-
28 ... 29	Reserved	WORD	-	0	-
30 ... 31	Reserved	WORD	-	0	-

(*) Limit violation in:
Bit 0 = limit 1 to bit 15 = limit 16

(**) Energy counter count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1
Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

Basic variables energy counter measurement (periodic) overflow counter (ID 239 or EF_H)

Table 2-917 Basic variables energy counter measurement (periodic) overflow counter

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	239 (EFH)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Overflow counter active energy inflow L1	UINT	-	0 ... 65535	61190
4 ... 5	Overflow counter active energy outflow L1	UINT	-	0 ... 65535	61191
6 ... 7	Overflow counter reactive energy inflow L1	UINT	-	0 ... 65535	61192
8 ... 9	Overflow counter reactive energy outflow L1	UINT	-	0 ... 65535	61193
10 ... 11	Overflow counter apparent energy L1	UINT	-	0 ... 65535	61194
12 ... 13	Overflow counter active energy inflow L2	UINT	-	0 ... 65535	61210
14 ... 15	Overflow counter active energy outflow L2	UINT	-	0 ... 65535	61211
16 ... 17	Overflow counter reactive energy inflow L2	UINT	-	0 ... 65535	61212
18 ... 19	Overflow counter reactive energy outflow L2	UINT	-	0 ... 65535	61213
20 ... 21	Overflow counter apparent energy L2	UINT	-	0 ... 65535	61214
22 ... 23	Overflow counter active energy inflow L3	UINT	-	0 ... 65535	61230

Byte	Allocation	Data type	Unit	Value range	Measured value ID
24 ... 25	Overflow counter active energy outflow L3	UINT	-	0 ... 65535	61231
26 ... 27	Overflow counter reactive energy inflow L3	UINT	-	0 ... 65535	61232
28 ... 29	Overflow counter reactive energy outflow L3	UINT	-	0 ... 65535	61233
30 ... 31	Overflow counter apparent energy L3	UINT	-	0 ... 65535	61234

Basic variables measurement data profile (ID 227 or $E3_H$)

Table 2-918 Basic variables measurement data profile Energy E3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	227 ($E3_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	13
6 ... 9	Active power L2	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	14
10 ... 13	Active power L3	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	15
14 ... 17	Reactive power Qtot L1	REAL	1 var	-3×10^9 ... $+3 \times 10^9$	22
18 ... 21	Reactive power Qtot L2	REAL	1 var	-3×10^9 ... $+3 \times 10^9$	23
22 ... 25	Reactive power Qtot L3	REAL	1 var	-3×10^9 ... $+3 \times 10^9$	24
26 ... 33	Active energy inflow L1L2L3	LREAL	1 Wh	0.0 ... 1.8×10^{308}	210
34 ... 41	Active energy outflow L1L2L3	LREAL	1 Wh	0.0 ... 1.8×10^{308}	211
42 ... 49	Reactive energy inflow L1L2L3	LREAL	1 varh	0.0 ... 1.8×10^{308}	212
50 ... 57	Reactive energy outflow L1L2L3	LREAL	1 varh	0.0 ... 1.8×10^{308}	213
58 ... 61	Voltage L1-N	REAL	1 V	0.0 ... 1000000.0	1
62 ... 65	Voltage L2-N	REAL	1 V	0.0 ... 1000000.0	2
66 ... 69	Voltage L3-N	REAL	1 V	0.0 ... 1000000.0	3
70 ... 73	Voltage L1-L2	REAL	1 V	0.0 ... 1000000.0	4
74 ... 77	Voltage L2-L3	REAL	1 V	0.0 ... 1000000.0	5
78 ... 81	Voltage L3-L1	REAL	1 V	0.0 ... 1000000.0	6
82 ... 85	Current L1	REAL	1 A	0.0 ... 100000.0	7
86 ... 89	Current L2	REAL	1 A	0.0 ... 100000.0	8
90 ... 93	Current L3	REAL	1 A	0.0 ... 100000.0	9
94 ... 97	Power factor λ L1	REAL	-	0.0 ... 1.0	19
98 ... 101	Power factor λ L2	REAL	-	0.0 ... 1.0	20
102 ... 105	Power factor λ L3	REAL	-	0.0 ... 1.0	21

Basic variables measurement data profile (ID 226 or $E2_H$)

Table 2-919 Basic variables measurement data profile Energy E2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	226 ($E2_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	34
6 ... 9	Active energy inflow L1L2L3 (Float)	REAL	1 W	3.0×10^9	200
10 ...13	Active energy outflow L1L2L3 (Float)	REAL	1 W	3.0×10^9	201

Basic variables measurement data profile (ID 225 or $E1_H$)

Table 2-920 Basic variables measurement data profile Energy E1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	225 ($E1_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	34

Basic variables measurement data profile (ID 224 or $E0_H$)

Table 2-921 Basic variables measurement data profile Energy E0

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	224 ($E0_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Current L1	REAL	1 A	0.0 ... 100000.0	7
6 ... 9	Current L2	REAL	1 A	0.0 ... 100000.0	8
10 ...13	Current L3	REAL	1 A	0.0 ... 100000.0	9

Basic variables phase-specific measurement (ID 159 or $9F_H$)

Table 2-922 Basic variables phase-specific measurement L1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	159 (9FH)	-
1	Quality information = Q Q_1 0 0 0 0 I_1 U_1	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
6 ... 7	Active power L1	INT	1 W	-32768 ... 32767	66013
8 ... 9	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	66022
10 ... 11	Apparent power L1	INT	1 VA	-32768 ... 32767	66010
12 ... 15	Total active energy L1 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62115
16 ... 19	Total reactive energy L1 (Int32)	DINT	1 varh	-2147483647... +2147483647	62116
20 ... 23	Apparent energy L1 (Int32)	UDINT	1 VAh	0 ... 2147483647	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active power L1	USINT	-	0 ... 255	-
26	Scaling reactive power L1	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Total scaling active energy L1	USINT	-	0 ... 255	-
29	Total scaling reactive energy L1	USINT	-	0 ... 255	-
30	Scaling apparent energy L1	USINT	-	0 ... 255	-
31	Power factor λ L1	USINT	0.01	0 ... 100	66019

Basic variables phase-specific measurement (ID 158 or $9E_H$)

Table 2-923 Single-phase measurement L1 with voltage scaling value

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	158 (9EH)	-
1	Quality information = Q Q_1 0 0 0 0 I_1 U_1	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
6 ... 7	Active power L1	INT	1 W	-32768 ... 32767	66013
8 ... 9	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	66022
10 ... 11	Apparent power L1	INT	1 VA	-32768 ... 32767	66010
12 ... 15	Total active energy L1	UDINT	1 Wh	0 ... 4294967295	62115

Byte	Allocation	Data type	Unit	Value range	Measured value ID
16 ... 19	Total reactive energy L1	UDINT	1 varh	0 ... 4294967295	62116
20 ... 23	Apparent energy L1 (Int32)	UDINT	1 VAh	0 ... 4294967295	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active power L1	USINT	-	0 ... 255	-
26	Scaling reactive power L1	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Total scaling active energy L1	USINT	-	0 ... 255	-
29	Total scaling reactive energy L1	USINT	-	0 ... 255	-
30	Scaling apparent energy L1	USINT	-	0 ... 255	-
31	Scaling voltage L1-N	USINT	-	0 ... 255	-

Basic variables phase-specific measurement (ID 157 or $9D_H$)

Table 2-924 Basic variables phase-specific measurement L2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	157 ($9D_H$)	-
1	Quality information = Q Q_1 0 0 0 0 I_2 U_2	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L2	UINT	1 mA	0 ... 65535	66008
4 ... 5	Voltage L2-N	UINT	0.01 V	0 ... 65535	66002
6 ... 7	Active power L2	INT	1 W	-32768 ... 32767	66014
8 ... 9	Reactive power Qtot L2	INT	1 var	-32768 ... 32767	66023
10 ... 11	Apparent power L2	INT	1 VA	-32768 ... 32767	66011
12 ... 15	Total active energy L2 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62215
16 ... 19	Total reactive energy L2 (Int32)	DINT	1 varh	-2147483647... +2147483647	62216
20 ... 23	Apparent energy L2 (Int32)	UDINT	1 VAh	0 ... 2147483647	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active power L2	USINT	-	0 ... 255	-
26	Scaling reactive power L2	USINT	-	0 ... 255	-
27	Scaling apparent power L2	USINT	-	0 ... 255	-
28	Total scaling active energy L1	USINT	-	0 ... 255	-
29	Total scaling reactive energy L1	USINT	-	0 ... 255	-
30	Scaling apparent energy L2	USINT	-	0 ... 255	-
31	Power factor λ L2	USINT	0.01	0 ... 100	66020

Basic variables phase-specific measurement (ID 156 or $9C_H$)

Table 2-925 Single-phase measurement L2 with voltage scaling value

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	156 (9CH)	-
1	Quality information = Q Q_1 0 0 0 0 I_2 U_2	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L2	UINT	1 mA	0 ... 65535	66008
4 ... 5	Voltage UL2-N	UINT	0.01 V	0 ... 65535	66002
6 ... 7	Active power L2	INT	1 W	-32768 ... 32767	66014
8 ... 9	Reactive power Qtot L2	INT	1 var	-32768 ... 32767	66023
10 ... 11	Apparent power L2	INT	1 VA	-32768 ... 32767	66011
12 ... 15	Total active energy L2 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62215
16 ... 19	Total reactive energy L2 (Int32)	DINT	1 varh	-2147483647... +2147483647	62216
20 ... 23	Apparent energy L2 (Int32)	UDINT	1 VAh	0 ... 2147483647	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active power L2	USINT	-	0 ... 255	-
26	Scaling reactive power L2	USINT	-	0 ... 255	-
27	Scaling apparent power L2	USINT	-	0 ... 255	-
28	Total scaling active energy L2	USINT	-	0 ... 255	-
29	Total scaling reactive energy L2	USINT	-	0 ... 255	-
30	Scaling apparent energy L2	USINT	-	0 ... 255	-
31	Scaling voltage L2-N	USINT	-	0 ... 255	-

Basic variables phase-specific measurement (ID 155 or $9B_H$)

Table 2-926 Basic variables phase-specific measurement L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	155 ($9B_H$)	-
1	Quality information = Q Q_1 0 0 0 0 I_3 U_3	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L3	UINT	1 mA	0 ... 65535	66009
4 ... 5	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003
6 ... 7	Active power L3	INT	1 W	-32768 ... 32767	66015
8 ... 9	Reactive power Qtot L3	INT	1 var	-32768 ... 32767	66024
10 ... 11	Apparent power L3	INT	1 VA	-32768 ... 32767	66012
12 ... 15	Total active energy L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62315

Byte	Allocation	Data type	Unit	Value range	Measured value ID
16 ... 19	Total reactive energy L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	62316
20 ... 23	Apparent energy L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active power L3	USINT	-	0 ... 255	-
26	Scaling reactive power L3	USINT	-	0 ... 255	-
27	Scaling apparent power L3	USINT	-	0 ... 255	-
28	Total scaling active energy L3	USINT	-	0 ... 255	-
29	Total scaling reactive energy L3	USINT	-	0 ... 255	-
30	Scaling apparent energy L3	USINT	-	0 ... 255	-
31	Power factor L3	USINT	0.01	0 ... 100	66021

Basic variables phase-specific measurement (ID 154 or $9A_H$)

Table 2-927 Single-phase measurement L3 with voltage scaling value

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	154 ($9A_H$)	-
1	Quality information = Q Q_1 0 0 0 0 I_3 U_3	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L3	UINT	1 mA	0 ... 65535	66009
4 ... 5	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003
6 ... 7	Active power L3	INT	1 W	-32768 ... 32767	66015
8 ... 9	Reactive power Qtot L3	INT	1 var	-32768 ... 32767	66024
10 ... 11	Apparent power L3	INT	1 VA	-32768 ... 32767	66012
12 ... 15	Total active energy L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62315
16 ... 19	Total reactive energy L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	62316
20 ... 23	Apparent energy L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active power L3	USINT	-	0 ... 255	-
26	Scaling reactive power L3	USINT	-	0 ... 255	-
27	Scaling apparent power L3	USINT	-	0 ... 255	-
28	Total scaling active energy L3	USINT	-	0 ... 255	-
29	Total scaling reactive energy L3	USINT	-	0 ... 255	-
30	Scaling apparent energy L3	USINT	-	0 ... 255	-
31	Scaling voltage L3-N	USINT	-	0 ... 255	-

Measured value data records

E

E.1 Overview of all measured value data records

The AI Energy Meter RC HF writes the measured values in several data records that you can read acyclically using the RDREC instruction in the user program.

The following tables show the structure of the individual data records:

- Data record DS 142 for basic measured values version 2 (read only).
- Data record DS 142 for basic measured values version 3 (read only).
- Data record DS 143 for energy counters (read and write).
- Data record DS 144 for maximum values (read only).
- Data record DS 154 for maximum values with time stamp (read only).
- Data record DS 145 for minimum values (read only).
- Data record DS 155 for minimum values with time stamp (read only).
- Data record DS 147 for phase-specific measured values L1 version 0 (read only).
- Data record DS 147 for phase-specific measured values L1 version 1 (read only).
- Data record DS 148 for phase-specific measured values L2 DS version 0 (read only).
- Data record DS 148 for phase-specific measured values L2 DS version 1 (read only).
- Data record DS 149 for phase-specific measured values L3 DS version 0 (read only).
- Data record DS 149 for phase-specific measured values L3 DS version 1 (read only).
- Data record DS 150 for advanced measurement and status values (read only).
- Data record DS 151 for user-defined data record (read only).
- Data record DS 160 for power quality analysis (read only).
- Data record DS 161 for harmonics voltage (DS 161) (read only).
- Data record DS 163 for harmonics current (DS 163) (read only).
- Data record DS 169 for power failure analysis (read only).
- Data record DS 170 information data record on available measured values (read only).
- Data record DS 173 for measured value recording recorder channel 1 (read only).
- Data record DS 174 for measured value recording recorder channel 2 (read only).

E.2 Measured value data record for base measurements (DS 142)

E.2.1 Measured value data record for basic measured values (DS 142) version 2

Measured variables of the module

The following table provides an overview of all the measured variables that data record 142 supplies. Please note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in the Appendix.

Table 2-928 Data record 142

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version = 2	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...5	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
6...9	Voltage L2-N	REAL	V	0.0 ... 1000000.0	2
10...13	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
14...17	Voltage L1-L2	REAL	V	0.0 ... 1000000.0	4
18...21	Voltage L2-L3	REAL	V	0.0 ... 1000000.0	5
22...25	Voltage L3-L1	REAL	V	0.0 ... 1000000.0	6
26...29	Current L1	REAL	A	0.0 ... 100000.0	7
30...33	Current L2	REAL	A	0.0 ... 100000.0	8
34...37	Current L3	REAL	A	0.0 ... 100000.0	9
38...41	Power factor λ L1	REAL	-	0.0 ... 1.0	19
42...45	Power factor λ L2	REAL	-	0.0 ... 1.0	20
46...49	Power factor λ L3	REAL	-	0.0 ... 1.0	21
50...53	Power factor λ L1L2L3	REAL	-	0.0 ... 1.0	37
54...57	Frequency L1L2L3	REAL	1 Hz	40.0 ... 70.0	30
58...61	Amplitude unbalance voltage U_2	REAL	%	0 ... 100	61157
62...65	Amplitude unbalance current I_{asym}	REAL	%	0 to 100	61158
66...69	Apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	10
70...73	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
74...77	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
78...81	Apparent power L1L2L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	36
82...85	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
86...89	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
90...93	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
94...97	Reactive power Qtot L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	38
98...101	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
102...105	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
106...109	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
110...113	Active power L1L2L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	34
114...117	Phase angle L1	REAL	°	0.0 ... 360.0	61178
118...121	Phase angle L2	REAL	°	0.0 ... 360.0	61198
122...125	Phase angle L3	REAL	°	0.0 ... 360.0	61218
126...129	Apparent energy L1L2L3 (Float)	REAL	VAh	0.0 ... 3.4×10^{38}	204
130...133	Total reactive energy L1L2L3 (Float)	REAL	varh	-3.4×10^{38} to $+3.4 \times 10^{38}$	206
134...137	Total active energy L1L2L3 (Float)	REAL	Wh	-3.4×10^{38} to $+3.4 \times 10^{38}$	205
138...141	Reactive energy inflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	202
142...145	Reactive energy outflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	203
146...149	Active energy inflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	200
150...153	Active energy outflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	201
154...161	Apparent energy L1L2L3	LREAL	VAh	0.0 ... 1.8×10^{308}	214
162...169	Total reactive energy L1L2L3	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	216
170...177	Total active energy L1L2L3	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	215
178...185	Reactive energy inflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	212
186...193	Reactive energy outflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	213
194...201	Active energy inflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	210
202...209	Active energy outflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	211
210...213	Neutral current IN	REAL	A	0.0 ... 100000.0	61149

Neutral current

If you operate the AI Energy Meter RC HF with connection type 3P4W, 3P4W1 or 3P3W, the neutral current is also calculated under the following conditions:

- Transmission factors of all phase currents (primary rated current and secondary voltage) are identical.
- Measured phase currents are greater than the value of the "Low limit for measuring current parameter.
- The parameter "Reverse current direction" must be the same on all phases.

If one of the conditions is not met, 0 is entered as the value for the neutral current. You can read the neutral current calculated using measured value data record 142.

Procedure

Data record 142 is located on the AI Energy Meter RC HF. Use the RDREC instruction to read out the data record from the module. This system function block is stored in the STEP 7 library.

E.2.2 Measured value data record for basic measured values (DS 142) version 3

Measured variables of the module

The following table provides an overview of all the measured variables that data record 142 supplies. Note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in the Appendix.

Table 2-929 Data record 142

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version = 3	BYTE	-	3	-
1	Reserved	BYTE	-	0	-
2...5	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
6...9	Voltage L2-N	REAL	V	0.0 ... 1000000.0	2
10...13	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
14...17	Voltage L1-L2	REAL	V	0.0 ... 1000000.0	4
18...21	Voltage L2-L3	REAL	V	0.0 ... 1000000.0	5
22...25	Voltage L3-L1	REAL	V	0.0 ... 1000000.0	6
26...29	Current L1	REAL	A	0.0 ... 100000.0	7
30...33	Current L2	REAL	A	0.0 ... 100000.0	8
34...37	Current L3	REAL	A	0.0 ... 100000.0	9
38...41	Power factor λ L1	REAL	-	0.0 ... 1.0	19
42...45	Power factor λ L2	REAL	-	0.0 ... 1.0	20

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
46...49	Power factor λ L3	REAL	-	0.0 ... 1.0	21
50...53	Power factor λ L1L2L3	REAL	-	0.0 ... 1.0	37
54...57	Frequency L1L2L3	REAL	1 Hz	40.0 ... 70.0	30
58...61	Amplitude unbalance voltage U_2	REAL	%	0 ... 100	61157
62...65	Amplitude unbalance current I_{asym}	REAL	%	0 ... 100	61158
66...69	Apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	10
70...73	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
74...77	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
78...81	Apparent power L1L2L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	36
82...85	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22
86...89	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
90...93	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
94...97	Reactive power Qtot L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	38
98...101	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
102...105	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
106...109	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
110...113	Active power L1L2L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	34
114...117	Phase angle L1	REAL	°	0.0 ... 360.0	61178
118...121	Phase angle L2	REAL	°	0.0 ... 360.0	61198
122...125	Phase angle L3	REAL	°	0.0 ... 360.0	61218
126...129	Apparent energy L1L2L3 (Float)	REAL	VAh	0.0 ... 3.4×10^{38}	204
130...133	Total reactive energy L1L2L3 (Float)	REAL	varh	-3.4×10^{38} to $+3.4 \times 10^{38}$	206
134...137	Total active energy L1L2L3 (Float)	REAL	Wh	-3.4×10^{38} to $+3.4 \times 10^{38}$	205
138...141	Reactive energy inflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	202
142...145	Reactive energy outflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	203
146...149	Active energy inflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	200
150...153	Active energy outflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	201
154...161	Apparent energy L1L2L3	LREAL	VAh	0.0 ... 1.8×10^{308}	214

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
162...169	Total reactive energy L1L2L3	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	216
170...177	Total active energy L1L2L3	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	215
178...185	Reactive energy inflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	212
186...193	Reactive energy outflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	213
194...201	Active energy inflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	210
202...209	Active energy outflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	211
210...213	Neutral current IN	REAL	A	0.0 ... 100000.0	61149
214...217	Neutral current 10-12 cycles	REAL	A	0.0 ... 100000.0	61150
218...221	Reactive power Qn L1	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	16
222...225	Reactive power Qn L2	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	17
226...229	Reactive power Qn L3	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	18
230...233	Reactive power Qn L1L2L3	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	35
234...237	Average voltage load LN (Utot)	REAL	V	0.0 ... 300.0	31
238...241	Average voltage L-L	REAL	V	0.0 ... 600.0	32
242...245	Average current L1L2L3 (Itot)	REAL	A	0.0 ... 100000.0	33
246...249	Mean power factor λ L1L2L3	REAL	-	0.0 ... 1.0	166
250...253	Fundamental voltage L1	REAL	V	0.0 ... 440.0	62122
254...257	Fundamental voltage L2	REAL	V	0.0 ... 440.0	62222
258...261	Fundamental voltage L3	REAL	V	0.0 ... 440.0	62322
262...265	Fundamental current L1	REAL	A	0.0 ... 100000.0	62123
266...269	Fundamental current L2	REAL	A	0.0 ... 100000.0	62223
270...273	Fundamental current L3	REAL	A	0.0 ... 100000.0	62323
274...277	Fundamental apparent power L1	REAL	VA	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62125
278...281	Fundamental apparent power L2	REAL	VA	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62225
282...285	Fundamental apparent power L3	REAL	VA	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62325
286...289	Fundamental reactive power L1	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62124
290...293	Fundamental reactive power L2	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62224
294...297	Fundamental reactive power L3	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62324
298...301	Fundamental active power L1	REAL	W	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62126

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
302...305	Fundamental active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62226
306...309	Fundamental active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62326
310...313	Fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62127
314...317	Fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62227
318...321	Fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62327
322...325	Total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62120
326...329	Total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62220
330...333	Total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62320
334...337	Total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62121
338...341	Total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62221
342...345	Total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62321
346...357	Current module time	PNIOTime	sec	-	65497

Neutral current

If you operate the AI Energy Meter RC HF with connection type 3P4W, 3P4W1 or 3P3W, the neutral current is also calculated under the following conditions:

- Transmission factors of all phase currents (primary rated current and secondary voltage) are identical.
- Measured phase currents are greater than the value of the "Low limit for measuring current" parameter.
- The parameter "Reverse current direction" must be the same on all phases.

If one of the conditions is not met, 0 is entered as the value for the neutral current. You can read the neutral current calculated using measured value data record 142.

Procedure

Data record 142 is located on the AI Energy Meter RC HF. Use the RDREC instruction to read out the data record from the module. This system function block is stored in the STEP 7 library.

E.3 Structure for energy counters (DS 143)

Energy meter data record 143 for different actions

The energy meter data record 143 includes all energy meters available on the module phase-by-phase. The data record can be used for different actions:

- Reset the energy meters to user-specific value (e.g. "0")
- Reading the current values of the energy counters
- Reading the overflow counters
- Reading the operating hours

NOTE

- The cumulative value of the energy counters in 3-phase operation is obtained from the sums of the respective individual values of the phases.
- Inflow and outflow energy meters are always positive values.
- The operating hours counter for the entire module is calculated from the maximum of the operating hours of the individual phases.

Energy meter data record 143

Table 2-930 Energy meter data record 143

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Status / control byte 1 - L1	BYTE	Bit string	-	-
3	Status / control byte 2 - L1	BYTE	Bit string		
4	Status / control byte 1 - L2	BYTE	Bit string		
5	Status / control byte 2 - L2	BYTE	Bit string		
6	Status / control byte 1 - L3	BYTE	Bit string		
7	Status / control byte 2 - L3	BYTE	Bit string		
8...15	Active energy inflow (initial value) L1	LREAL	Wh	During reading: 0.0...1.8 x 10^{308} During writing For continuous counting: 0.0...3.4 x 10^{12} During writing For periodic counting:	61180
16...23	Active energy outflow (initial value) L1	LREAL	Wh		61181
24...31	Reactive energy inflow (initial value) L1	LREAL	varh		61182
32...39	Reactive energy outflow (initial value) L1	LREAL	varh		61183
40...47	Apparent energy (initial value) L1	LREAL	VAh		61184
48...55	Active energy inflow (initial value) L2	LREAL	Wh		61200
56...63	Active energy outflow (initial value) L2	LREAL	Wh		61201
64...61	Reactive energy inflow (initial value) L2	LREAL	varh		61202
72...79	Reactive energy outflow (initial value) L2	LREAL	varh		61203
80...87	Apparent energy (initial value) L2	LREAL	VAh		61204

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
88...95	Active energy inflow (initial value) L3	LREAL	Wh	0...configured full-scale value (10^3 ...10^{15})	61220
96...10-3	Active energy outflow (initial value) L3	LREAL	Wh		61221
104...1-11	Reactive energy inflow (initial value) L3	LREAL	varh		61222
112...1-19	Reactive energy outflow (initial value) L3	LREAL	varh		61223
120...1-27	Apparent energy (initial value) L3	LREAL	VAh		61224
128...1-29	Overflow counter active energy inflow L1	UINT	-	During reading: 0...65535 During writing for continuous counting: 0 During writing for periodic counting: 0...65500	61190
130..1-31	Overflow counter active energy outflow L1	UINT	-		61191
132...1-33	Overflow counter reactive energy inflow L1	UINT	-		61192
134...1-35	Overflow counter reactive energy outflow L1	UINT	-		61193
136...1-37	Overflow counter apparent energy L1	UINT	-		61194
138...1-39	Overflow counter active energy inflow L2	UINT	-		61210
140...1-41	Overflow counter active energy outflow L2	UINT	-		61211
142...1-43	Overflow counter reactive energy inflow L2	UINT	-		61212
144...1-45	Overflow counter reactive energy outflow L2	UINT	-		61213
146...1-47	Overflow counter apparent energy L2	UINT	-		61214
148...1-49	Overflow counter active energy inflow L3	UINT	-		61230
150...1-51	Overflow counter active energy outflow L3	UINT	-		61231
152...1-53	Overflow counter reactive energy inflow L3	UINT	-		61232
154...1-55	Overflow counter reactive energy outflow L3	UINT	-		61233
156...1-57	Overflow counter apparent energy L3	UINT	-		61234
158...1-61	Operating hours counter L1 (initial value)	REAL	h	During reading: 0...3.4x10^{38} During writing: 0...10^9	65505
162...1-65	Operating hours counter L2 (initial value)	REAL	h		65506
166...1-69	Operating hours counter L3 (initial value)	REAL	h		65507

Status information

When data record 143 is read with the RDREC instruction, Bytes 2 to 7 supply phase-specific status information for energy counters, overflow counters and operating hours counters.

The status information enables you can see which counters are returning their values in the data record 143. If energy counters return their values in the status byte 1, you can determine the type of energy counter with status byte 2.

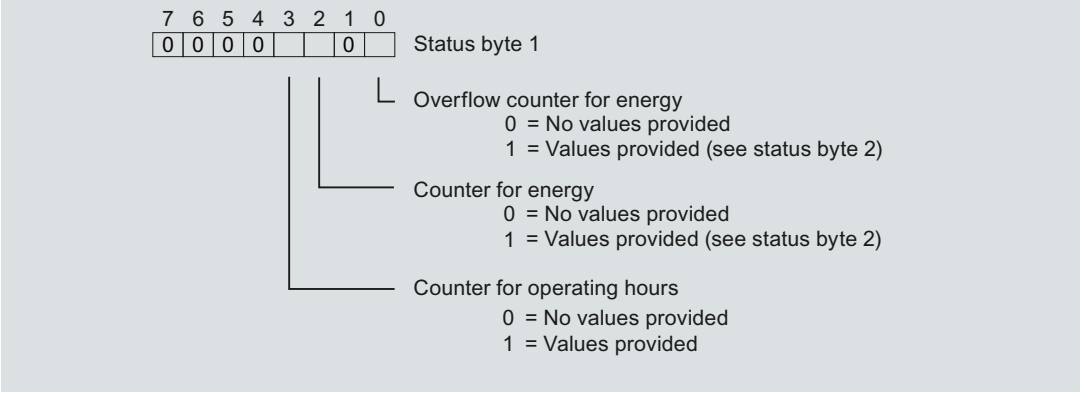

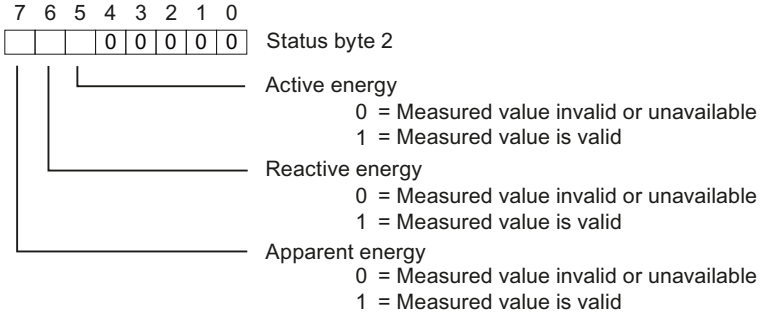

Figure 2-826 Status information DS 143 (read access)

Control information

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy counters, overflow counters and operating hours counter. The length of the control information amounts to 2 bytes for each phase:

- In control byte 1 you determine which counter you want to reset and the time at which counters are reset.
- In Control byte 2 you determine which energy counters and which overflow counters you want to reset.

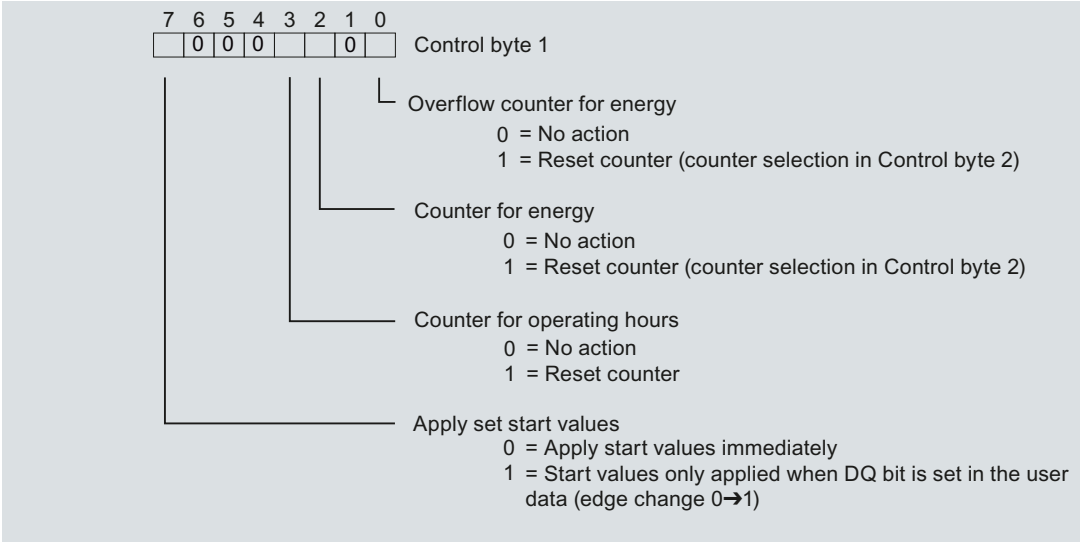

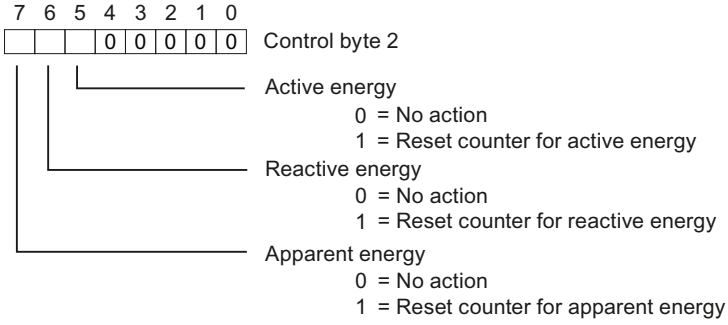

Figure 2-827 Control information DS 143 (write access)

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the measured value data record 143:

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	00	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	01	Reserved bits are not 0.	Check Byte 2...7 and set the reserved bits back to 0.
DF	80	E1	39	Incorrect version entered.	Check Byte 0. Enter a valid version.
DF	80	E1	3A	Incorrect data record length entered.	Check the parameters of the WRREC instruction. Enter a valid length.
DF	80	E1	3C	At least one start value is invalid.	Check Bytes 8...103 and Bytes 158...169. The start values may not be negative.
DF	80	E1	3D	At least one start value is too large	Check Bytes 8...103 and Bytes 158...169. Observe the ranges of values for start values.

E.4 Measured value data record for maximum values (DS 144)

Measured variables of the module

The largest values ever measured or calculated from the time the AI Energy Meter HF was started are stored in this data record.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...5	Max. voltage L1-N	REAL	V	0	40
6...9	Max. voltage L2-N	REAL	V	0	41
10...13	Max. voltage L3-N	REAL	V	0	42
14...17	Max. voltage L1-L2	REAL	V	0	43
18...21	Max. voltage L2-L3	REAL	V	0	44
22...25	Max. voltage L3-L1	REAL	V	0	45
26...29	Max. current L1 [1]	REAL	A	0	46
30...33	Max. current L2 [1]	REAL	A	0	47
34...37	Max. current L3 [1]	REAL	A	0	48
38...41	Max. apparent power L1	REAL	VA	0	49
42...45	Max. apparent power L2	REAL	VA	0	50
46...49	Max. apparent power L3	REAL	VA	0	51
50...53	Max. active power L1	REAL	W	-3.0×10^9	52
54...57	Max. active power L2	REAL	W	-3.0×10^9	53

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
58...61	Max. active power L3	REAL	W	-3.0×10^9	54
62...65	Max. reactive power Qtot L1	REAL	var	-3.0×10^9	62160
66...69	Max. reactive power Qtot L2	REAL	var	-3.0×10^9	62260
70...73	Max. reactive power Qtot L3	REAL	var	-3.0×10^9	62360
74...77	Max. power factor λ L1	REAL	-	0	58
78...81	Max. power factor λ L2	REAL	-	0	59
82...85	Max. power factor λ L3	REAL	-	0	60
86...89	Max. frequency	REAL	Hz	40	61
90...93	Max. apparent power L1L2L3	REAL	VA	0	67
94...97	Max. active power L1L2L3	REAL	W	-3.0×10^9	65
98...101	Max. reactive power Qtot L1L2L3	REAL	var	-3.0×10^9	61138
102...105	Max. power factor λ L1L2L3	REAL	-	0	68
106...109	Max. reactive power Qn L1	REAL	var	-3.0×10^9	55
110...113	Max. reactive power Qn L2	REAL	var	-3.0×10^9	56
114...117	Max. reactive power Qn L3	REAL	var	-3.0×10^9	57
118...121	Max. mean voltage L-N	REAL	V	0	62
122...125	Max. mean voltage L-L	REAL	V	0	63
126...129	Max. mean current L1L2L3	REAL	A	0	64
130...133	Max. fundamental voltage L1	REAL	V	0	62152
134...137	Max. fundamental voltage L2	REAL	V	0	62252
138...141	Max. fundamental voltage L3	REAL	V	0	62352
142...145	Max. fundamental current L1	REAL	A	0	62153
146...149	Max. fundamental current L2	REAL	A	0	62253
150...153	Max. fundamental current L3	REAL	A	0	62353
154...157	Max. fundamental apparent power L1	REAL	VA	-3.0×10^9	62155
158...161	Max. fundamental apparent power L2	REAL	VA	-3.0×10^9	62255
162...165	Max. fundamental apparent power L3	REAL	VA	-3.0×10^9	62355
166...169	Max. fundamental reactive power L1	REAL	var	-3.0×10^9	62154
170...173	Max. fundamental reactive power L2	REAL	var	-3.0×10^9	62254
174...177	Max. fundamental reactive power L3	REAL	var	-3.0×10^9	62354
178...181	Max. fundamental active power L1	REAL	W	-3.0×10^9	62156
182...185	Max. fundamental active power L2	REAL	W	-3.0×10^9	62256
186...189	Max. fundamental active power L3	REAL	W	-3.0×10^9	62356
190...193	Max. fundamental cos φ active factor L1	REAL	-	-1	62157
194...197	Max. fundamental cos φ active factor L2	REAL	-	-1	62257
198...201	Max. fundamental cos φ active factor L3	REAL	-	-1	62357
202...205	Max. total harmonic distortion (THD+N) voltage L1	REAL	1%	0	62150

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
206...209	Max. total harmonic distortion (THD+N) voltage L2	REAL	1%	0	62250
210...213	Max. total harmonic distortion (THD+N) voltage L3	REAL	1%	0	62350
214...217	Max. total harmonic distortion (THD+N) current L1	REAL	1%	0	62151
218...221	Max. total harmonic distortion (THD+N) current L2	REAL	1%	0	62251
222...225	Max. total harmonic distortion (THD+N) current L3	REAL	1%	0	62351
226...229	Max. neutral current	REAL	A	0	61136

[1] The values reference the amount of the current measured value

E.5 Measured value data record for minimum values (DS 145)

Measured variables of the module

The smallest values ever measured or calculated from the time the AI Energy Meter HF was started are stored in this data record.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...5	Min. voltage L1-N	REAL	V	1000000	70
6...9	Min. voltage L2-N	REAL	V	1000000	71
10...13	Min. voltage L3-N	REAL	V	1000000	72
14...17	Min. voltage L1-L2	REAL	V	1800000	73
18...21	Min. voltage L2-L3	REAL	V	1800000	74
22...25	Min. voltage L3-L1	REAL	V	1800000	75
26...29	Min. current L1 [1]	REAL	A	100000	76
30...33	Min. current L2 [1]	REAL	A	100000	77
34...37	Min. current L3 [1]	REAL	A	100000	78
38...41	Min. apparent power L1	REAL	VA	$+3.0 \times 10^9$	79
42...45	Min. apparent power L2	REAL	VA	$+3.0 \times 10^9$	80
46...49	Min. apparent power L3	REAL	VA	$+3.0 \times 10^9$	81
50...53	Min. active power L1	REAL	W	$+3.0 \times 10^9$	82

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
54...57	Min. active power L2	REAL	W	$+3.0 \times 10^9$	83
58...61	Min. active power L3	REAL	W	$+3.0 \times 10^9$	84
62...65	Min. reactive power Qtot L1	REAL	var	$+3.0 \times 10^9$	62180
66...69	Min. reactive power Qtot L2	REAL	var	$+3.0 \times 10^9$	62280
70...73	Min. reactive power Qtot L3	REAL	var	$+3.0 \times 10^9$	62380
74...77	Min. power factor λ L1	REAL	-	1	88
78...81	Min. power factor λ L2	REAL	-	1	89
82...85	Min. power factor λ L3	REAL	-	1	90
86...89	Min. frequency	REAL	Hz	70	91
90...93	Min. apparent power L1L2L3	REAL	VA	$+3.0 \times 10^9$	97
94...97	Min. active power L1L2L3	REAL	W	$+3.0 \times 10^9$	95
98...101	Min. reactive power Qn L1L2L3	REAL	var	$+3.0 \times 10^9$	61139
102...105	Min. power factor λ L1L2L3	REAL	-	1	98
106...109	Min. reactive power Qn L1	REAL	var	$+3.0 \times 10^9$	85
110...113	Min. reactive power Qn L2	REAL	var	$+3.0 \times 10^9$	86
114...117	Min. reactive power Qn L3	REAL	var	$+3.0 \times 10^9$	87
118...121	Min. mean voltage L-N	REAL	V	1000000	92
122...125	Min. mean voltage L-L	REAL	V	1800000	93
126...129	Min. mean current L1L2L3	REAL	A	100000	94
130...133	Min. fundamental voltage L1	REAL	V	0	62172
134...137	Min. fundamental voltage L2	REAL	V	0	62272
138...141	Min. fundamental voltage L3	REAL	V	0	62372
142...145	Min. fundamental current L1	REAL	A	1000000	62173
146...149	Min. fundamental current L2	REAL	A	1000000	62273
150...153	Min. fundamental current L3	REAL	A	1000000	62373
154...157	Min. fundamental apparent power L1	REAL	VA	$+3.0 \times 10^9$	62175
158...161	Min. fundamental apparent power L2	REAL	VA	$+3.0 \times 10^9$	62275
162...165	Min. fundamental apparent power L3	REAL	VA	$+3.0 \times 10^9$	62375
166...169	Min. fundamental reactive power L1	REAL	var	$+3.0 \times 10^9$	62174
170...173	Min. fundamental reactive power L2	REAL	var	$+3.0 \times 10^9$	62274
174...177	Min. fundamental reactive power L3	REAL	var	$+3.0 \times 10^9$	62374
178...181	Min. fundamental active power L1	REAL	W	$+3.0 \times 10^9$	62176
182...185	Min. fundamental active power L2	REAL	W	$+3.0 \times 10^9$	62276
186...189	Min. fundamental active power L3	REAL	W	$+3.0 \times 10^9$	62376
190...193	Min. fundamental cos φ active factor L1	REAL	-	1	62177
194...197	Min. fundamental cos φ active factor L2	REAL	-	1	62277
198...201	Min. fundamental cos φ active factor L3	REAL	-	1	62377

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
202...205	Min. total harmonic distortion (THD+N) voltage L1	REAL	1%	100	62170
206...209	Min. total harmonic distortion (THD+N) voltage L2	REAL	1%	100	62270
210...213	Min. total harmonic distortion (THD+N) voltage L3	REAL	1%	100	62370
214...217	Min. total harmonic distortion (THD+N) current L1	REAL	1%	100	62171
218...221	Min. total harmonic distortion (THD+N) current L2	REAL	1%	100	62271
222...225	Min. total harmonic distortion (THD+N) current L3	REAL	1%	100	62371
226...229	Min. neutral current	REAL	A	100000.0	61137

[1] The values reference the amount of the current measured value

E.6 Measured value data record for phase-based measured values L1 (DS 147)

E.6.1 Measured value data record for phase-based measured values L1 (DS 147) version 0

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Page 174).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...3	Qualifier L1	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65500
4...7	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
8...11	Current L1	REAL	A	0.0 ... 100000.0	7
12...15	Apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	10
16...19	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
20...23	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22
24...27	Power factor λ L1	REAL	-	0.0 ... 1.0	19
28...31	Phase angle L1	REAL	°	0.0 ... 360.0	61178
32...39	Apparent energy L1	LREAL	VAh	0.0 ... 1.8×10^{308}	61184

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
40...47	Total active energy L1	LREAL	Wh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61185
48...55	Total reactive energy L1	LREAL	varh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61186
56...59	Max. voltage L1-N	REAL	V	0.0 ... 1000000.0	40
60...63	Max. current L1	REAL	A	0.0 ... 100000.0	46
64...67	Max. apparent power L1	REAL	VA	-3.0×10^{9} ... $+3.0 \times 10^{9}$	49
68...71	Max. active power L1	REAL	W	-3.0×10^{9} ... $+3.0 \times 10^{9}$	52
72...75	Max. reactive power Qtot L1	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62160
76...79	Max. power factor λ L1	REAL	-	0.0 ... 1.0	58
80...83	Min. voltage L1-N	REAL	V	0.0 ... 1000000.0	70
84...87	Min. current L1	REAL	A	0.0 ... 100000.0	76
88...91	Min. apparent power L1	REAL	VA	-3.0×10^{9} ... $+3.0 \times 10^{9}$	79
92...95	Min. active power L1	REAL	W	-3.0×10^{9} ... $+3.0 \times 10^{9}$	82
96...99	Min. reactive power Qtot L1	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62180
100...103	Min. power factor λ L1	REAL	-	0.0 ... 1.0	88

E.6.2 Measured value data record for phase-based measured values L1 (DS 147) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Page 174).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	-	1	-
1	Reserved	UINT8	-	0	-
2...3	Qualifier L1	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65500
4...7	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
8...11	Current L1	REAL	A	0.0 ... 100000.0	7
12...15	Apparent power L1	REAL	VA	-3.0×10^{9} ... $+3.0 \times 10^{9}$	10
16...19	Active power L1	REAL	W	-3.0×10^{9} ... $+3.0 \times 10^{9}$	13

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
20...23	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22
24...27	Power factor λ L1	REAL	-	0.0 ... 1.0	19
28...31	Phase angle L1	REAL	°	0.0 ... 360.0	61178
32...39	Apparent energy L1	LREAL	VAh	0.0 ... 1.8×10^{308}	61184
40...47	Total active energy L1	LREAL	Wh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61185
48...55	Total reactive energy L1	LREAL	varh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61186
56...59	Max. voltage L1-N	REAL	V	0.0 ... 1000000.0	40
60...63	Max. current L1	REAL	A	0.0 ... 100000.0	46
64...67	Max. apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	49
68...71	Max. active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	52
72...75	Max. reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62160
76...79	Max. power factor λ L1	REAL	-	0.0 ... 1.0	58
80...83	Min. voltage L1-N	REAL	V	0.0 ... 1000000.0	70
84...87	Min. current L1	REAL	A	0.0 ... 100000.0	76
88...91	Min. apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	79
92...95	Min. active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	82
96...99	Min. reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62180
100...103	Min. power factor λ L1	REAL	-	0.0 ... 1.0	88
104...107	Reactive power Qn L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	16
108...111	Current L1 10-12 cycles	REAL	V	0.0 ... 760.0	62130
112...115	Current L1 10-12 cycles	REAL	A	0.0 ... 100000.0	62133
116...119	Max. reactive power Qn L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	55
120...123	Min. reactive power Qn L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	85
124...127	Fundamental voltage L1	REAL	V	0.0 ... 440.0	62122
128...131	Fundamental current L1	REAL	A	0.0 ... 100000.0	62123
132...135	Fundamental apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62125
136...139	Fundamental reactive power L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62124
140...143	Fundamental active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62126

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
144...147	Fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62127
148...151	Max. fundamental voltage L1	REAL	V	0.0 ... 760.0	62152
152...155	Max. fundamental current L1	REAL	A	0.0 ... 100000.0	62153
156...159	Max. fundamental apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62155
160...163	Max. fundamental reactive power L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62154
164...167	Max. fundamental active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62156
168...171	Max. fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62157
172...175	Min. fundamental voltage L1	REAL	V	0.0 ... 440.0	62172
176...179	Min. fundamental current L1	REAL	A	0.0 ... 100000.0	62173
180...183	Min. fundamental apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62175
184...187	Min. fundamental reactive power L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62174
188...191	Min. fundamental active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62176
192...195	Min. fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62177
196...199	Total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62120
200...203	Total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62121
204...207	Max. total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62150
208...211	Max. total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62151
212...215	Min. total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62170
216...219	Min. total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62171
220...223	Voltage dip - value L1	REAL	V	0.0 ... 440.0	62194
224...227	Voltage dip - duration L1	REAL	ms	0.0 ... 100000.0	62199
228...231	Voltage swell - value L1	REAL	V	0.0 ... 440.0	62195
232...235	Voltage swell - duration L1	REAL	ms	0.0 ... 100000.0	62200
236...239	Voltage peak value L1	REAL	V	0.0 ... 440.0	62196
240...243	Current peak value L1	REAL	A	0.0 ... 100000.0	62197
244...247	Overcurrent value L1	REAL	A	0.0 ... 100000.0	62198

E.7 Measured value data record for phase-based measured values L2 (DS 148)

E.7.1 Measured value data record for phase-based measured values L2 (DS 148) version 0

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 174)).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...3	Qualifier L2	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65501
4...7	Voltage L1-N	REAL	V	0.0 ... 1000000.0	2
8...11	Current L2	REAL	A	0.0 ... 100000.0	8
12...15	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
16...19	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
20...23	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
24...27	Power factor λ L2	REAL	-	0.0 ... 1.0	20
28...31	Phase angle L2	REAL	°	0.0 ... 360.0	61198
32...39	Apparent energy L2	LREAL	VAh	0.0 ... 1.8×10^{308}	61204
40...47	Total active energy L2	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61205
48...55	Total reactive energy L2	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61206
56...59	Max. voltage L2-N	REAL	V	0.0 ... 1000000.0	41
60...63	Max. current L2	REAL	A	0.0 ... 100000.0	47
64...67	Max. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	50
68...71	Max. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	53
72...75	Max. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62260
76...79	Max. power factor λ L2	REAL	-	0.0 ... 1.0	59
80...83	Min. voltage L2-N	REAL	V	0.0 ... 1000000.0	71
84...87	Min. current L2	REAL	A	0.0 ... 100000.0	77
88...91	Min. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	80

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
92...95	Min. active power L2	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	83
96...99	Min. reactive power Qtot L2	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	62280
100...103	Min. power factor λ L2	REAL	-	0.0 ... 1.0	89

E.7.2 Measured value data record for phase-based measured values L2 (DS 148) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 174)).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	-	1	-
1	Reserved	UINT8	-	0	-
2...3	Qualifier L2	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65501
4...7	Voltage L2-N	REAL	V	0.0 ... 1000000.0	2
8...11	Current L2	REAL	A	0.0 ... 100000.0	8
12...15	Apparent power L2	REAL	VA	-3.0 x 10^9 ... +3.0 x 10^9	11
16...19	Active power L2	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	14
20...23	Reactive power Qtot L2	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	23
24...27	Power factor λ L2	REAL	-	0.0 ... 1.0	20
28...31	Phase angle L2	REAL	°	0.0 ... 360.0	61198
32...39	Apparent energy L2	LREAL	VAh	0.0 ... 1.8 x 10^{308}	61204
40...47	Total active energy L2	LREAL	Wh	-1.8 x10^{308} ... +1.8 x 10^{308}	61205
48...55	Total reactive energy L2	LREAL	varh	-1.8 x10^{308} ... +1.8 x 10^{308}	61206
56...59	Max. voltage L2-N	REAL	V	0.0 ... 1000000.0	41
60...63	Max. current L2	REAL	A	0.0 ... 100000.0	47
64...67	Max. apparent power L2	REAL	VA	-3.0 x 10^9 ... +3.0 x 10^9	50
68...71	Max. active power L2	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	53
72...75	Max. reactive power Qtot L2	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	62260

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
76...79	Max. power factor λ L2	REAL	-	0.0 ... 1.0	59
80...83	Min. voltage L2-N	REAL	V	0.0 ... 1000000.0	71
84...87	Min. current L2	REAL	A	0.0 ... 100000.0	77
88...91	Min. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	80
92...95	Min. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	83
96...99	Min. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62280
100...103	Min. power factor λ L2	REAL	-	0.0 ... 1.0	89
104...107	Reactive power Qn L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	17
108...111	Current L2 10-12 cycles	REAL	V	0.0 ... 760.0	62230
112...115	Current L2 10-12 cycles	REAL	A	0.0 ... 100000.0	62233
116...119	Max. reactive power Qn L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	56
120...123	Min. reactive power Qn L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	86
124...127	Fundamental voltage L2	REAL	V	0.0 ... 440.0	62222
128...131	Fundamental current L2	REAL	A	0.0 ... 100000.0	62223
132...135	Fundamental apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62225
136...139	Fundamental reactive power L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62224
140...143	Fundamental active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62226
144...147	Fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62227
148...151	Max. fundamental voltage L2	REAL	V	0.0 ... 760.0	62252
152...155	Max. fundamental current L2	REAL	A	0.0 ... 100000.0	62253
156...159	Max. fundamental apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62255
160...163	Max. fundamental reactive power L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62254
164...167	Max. fundamental active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62256
168...171	Max. fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62257
172...175	Min. fundamental voltage L2	REAL	V	0.0 ... 440.0	62272
176...179	Min. fundamental current L2	REAL	A	0.0 ... 100000.0	62273
180...183	Min. fundamental apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62275
184...187	Min. fundamental reactive power L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62274

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
188...191	Min. fundamental active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62276
192...195	Min. fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62277
196...199	Total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62220
200...203	Total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62221
204...207	Max. total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62250
208...211	Max. total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62251
212...215	Min. total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62270
216...219	Min. total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62271
220...223	Voltage dip - value L2	REAL	V	0.0 ... 440.0	62294
224...227	Voltage dip - duration L2	REAL	ms	0.0 ... 100000.0	62299
228...231	Voltage swell - value L2	REAL	V	0.0 ... 440.0	62295
232...235	Voltage swell - duration L2	REAL	ms	0.0 ... 100000.0	62300
236...239	Voltage peak value L2	REAL	V	0.0 ... 440.0	62296
240...243	Current peak value L2	REAL	A	0.0 ... 100000.0	62297
244...247	Overcurrent value L2	REAL	A	0.0 ... 100000.0	62298

E.8 Measured value data record for phase-based measured values L3 (DS 149)

E.8.1 Measured value data record for phase-based measured values L3 (DS 149) version 0

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 174)).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...3	Qualifier L3	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65502
4...7	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
8...11	Current L3	REAL	A	0.0 ... 100000.0	9

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
12...15	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
16...19	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
20...23	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
24...27	Power factor λ L3	REAL	-	0.0 ... 1.0	21
28...31	Phase angle L3	REAL	°	0.0 ... 360.0	61218
32...39	Apparent energy L3	LREAL	VAh	0.0 ... 1.8×10^{308}	61224
40...47	Total active energy L3	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61225
48...55	Total reactive energy L3	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61226
56...59	Max. voltage L3-N	REAL	V	0.0 ... 1000000.0	42
60...63	Max. current L3	REAL	A	0.0 ... 100000.0	48
64...67	Max. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	51
68...71	Max. active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	54
72...75	Max. reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62360
76...79	Max. power factor λ L3	REAL	-	0.0 ... 1.0	60
80...83	Min. voltage L3-N	REAL	V	0.0 ... 1000000.0	72
84...87	Min. current L3	REAL	A	0.0 ... 100000.0	78
88...91	Min. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	81
92...95	Min. active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	84
96...99	Min. reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62380
100...103	Min. power factor λ L3	REAL	-	0.0 ... 1.0	90

E.8.2 Measured value data record for phase-based measured values L3 (DS 149) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 174)).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	-	1	-
1	Reserved	UINT8	-	0	-
2...3	Qualifier L3	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65502
4...7	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
8...11	Current L3	REAL	A	0.0 ... 100000.0	9
12...15	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
16...19	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
20...23	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
24...27	Power factor λ L3	REAL	-	0.0 ... 1.0	21
28...31	Phase angle L3	REAL	°	0.0 ... 360.0	61218
32...39	Apparent energy L3	LREAL	VAh	0.0 ... 1.8×10^{308}	61224
40...47	Total active energy L3	LREAL	Wh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61225
48...55	Total reactive energy L3	LREAL	varh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61226
56...59	Max. voltage L3-N	REAL	V	0.0 ... 1000000.0	42
60...63	Max. current L3	REAL	A	0.0 ... 100000.0	48
64...67	Max. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	51
68...71	Max. active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	54
72...75	Max. reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62360
76...79	Max. power factor λ L3	REAL	-	0.0 ... 1.0	60
80...83	Min. voltage L3-N	REAL	V	0.0 ... 1000000.0	72
84...87	Min. current L3	REAL	A	0.0 ... 100000.0	78
88...91	Min. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	81
92...95	Min. active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	84

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
96...99	Min. reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62380
100...103	Min. power factor λ L3	REAL	-	0.0 ... 1.0	90
104...107	Reactive power Qn L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	18
108...111	Current L3 10-12 cycles	REAL	V	0.0 ... 760.0	62330
112...115	Current L3 10-12 cycles	REAL	A	0.0 ... 100000.0	62333
116...119	Max. reactive power Qn L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	57
120...123	Min. reactive power Qn L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	87
124...127	Fundamental voltage L3	REAL	V	0.0 ... 440.0	62322
128...131	Fundamental current L3	REAL	A	0.0 ... 100000.0	62323
132...135	Fundamental apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62325
136...139	Fundamental reactive power L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62324
140...143	Fundamental active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62326
144...147	Fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62327
148...151	Max. fundamental voltage L3	REAL	V	0.0 ... 760.0	62352
152...155	Max. fundamental current L3	REAL	A	0.0 ... 100000.0	62353
156...159	Max. fundamental apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62355
160...163	Max. fundamental reactive power L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62354
164...167	Max. fundamental active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62356
168...171	Max. fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62357
172...175	Min. fundamental voltage L3	REAL	V	0.0 ... 440.0	62372
176...179	Min. fundamental current L3	REAL	A	0.0 ... 100000.0	62373
180...183	Min. fundamental apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	62375
184...187	Min. fundamental reactive power L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62374
188...191	Min. fundamental active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	62376
192...195	Min. fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62377
196...199	Total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62320
200...203	Total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62321

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
204...207	Max. total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62350
208...211	Max. total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62351
212...215	Min. total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62370
216...219	Min. total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62371
220...223	Voltage dip - value L3	REAL	V	0.0 ... 440.0	62394
224...227	Voltage dip - duration L3	REAL	ms	0.0 ... 100000.0	62399
228...231	Voltage swell - value L3	REAL	V	0.0 ... 440.0	62395
232...235	Voltage swell - duration L3	REAL	ms	0.0 ... 100000.0	62400
236...239	Voltage peak value L3	REAL	V	0.0 ... 440.0	62396
240...243	Current peak value L3	REAL	A	0.0 ... 100000.0	62397
244...247	Overcurrent value L3	REAL	A	0.0 ... 100000.0	62398

E.9 Measured value data record for advanced measurement and status values (DS 150)

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the **measured variables for connection type 1H** (Page 174)).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2...5	Operating hours counter L1L2L3	REAL	h	0.0 ... 3.4 x 10^{38}	65504

[1] Energy counters count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1
Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
6...9	Operating hours counter L1	REAL	h	0.0 ... 3.4 x 10^{38}	65505
10...13	Operating hours counter L2	REAL	h	0.0 ... 3.4 x 10^{38}	65506
14...17	Operating hours counter L3	REAL	h	0.0 ... 3.4 x 10^{38}	65507
18...19	Status limit violation GW 1...16	WORD	Bit string	xxxx xxxx xxxx xxxx	65509
20...21	Status of energy counter overflows [1]	WORD	Bit string	xxxx xxxx xxxx xxxx	65508
22...25	Counter limit violation GW 1	UDINT	-	0 ... 4294967296	65510
26...29	Counter limit violation GW 2	UDINT	-	0 ... 4294967296	65511
30...33	Counter limit violation GW 3	UDINT	-	0 ... 4294967296	65512
34...37	Counter limit violation GW 4	UDINT	-	0 ... 4294967296	65513
38...41	Counter limit violation GW 5	UDINT	-	0 ... 4294967296	65514
42...45	Counter limit violation GW 6	UDINT	-	0 ... 4294967296	65515
46...49	Counter limit violation GW 7	UDINT	-	0 ... 4294967296	65516
50...53	Counter limit violation GW 8	UDINT	-	0 ... 4294967296	65517
54...57	Counter limit violation GW 9	UDINT	-	0 ... 4294967296	65518
58...61	Counter limit violation GW 10	UDINT	-	0 ... 4294967296	65519
62...65	Counter limit violation GW 11	UDINT	-	0 ... 4294967296	65520
66...69	Counter limit violation GW 12	UDINT	-	0 ... 4294967296	65521
70...73	Counter limit violation GW 13	UDINT	-	0 ... 4294967296	65522
74...77	Counter limit violation GW 14	UDINT	-	0 ... 4294967296	65523
78...81	Counter limit violation GW 15	UDINT	-	0 ... 4294967296	65524
82...85	Counter limit violation GW 16	UDINT	-	0 ... 4294967296	65525
86...87	Qualifier L1L2L3	WORD	Bit string	xxxx xxxx xxxx xxxx	65503
88...91	Power quality analysis - Qualifier	UDINT	Bit string	-	65496
92...103	Current module time	PNIOTime	sec	-	65497

[1] Energy counters count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1
Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

E.10 Measured value data record of user-defined data record (DS 151)

The length and structure of the data record DS 151 depends on the parameter assignment of the data record DS 135 (Page 171).

Byte	Measured variable	Data type	Unit	Value range
0	Version	UINT8	-	0
1	Number of measured values	UINT8	-	0 ... 150
2	Measured value 1 corresponding to measured value ID 1 in DS135	Depending on the corresponding measured value ID		
3	Measured value 2 corresponding to measured value ID 2 in DS135	Depending on the corresponding measured value ID		
...	...	Depending on the corresponding measured value ID		
... m	Measured value n corresponding to measured value ID n in DS135	Depending on the corresponding measured value ID		

E.11 Measured value data record for maximum values with time stamp (DS 154)

Measured variables of the module

The largest values ever measured or calculated from the time AI Energy Meters HF was started are stored in this data record.

The measured values (REAL 4 bytes) are each followed by a time stamp (PNIO Time 12 bytes).

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 174)).

More detailed information about the structure of time stamps is available in section Time synchronization and time stamp (Page 54).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...17	Max. voltage L1-N	REAL + PNIO Time	V	0	40
18...33	Max. voltage L2-N	REAL + PNIO Time	V	0	41
34...49	Max. voltage L3-N	REAL + PNIO Time	V	0	42
50...65	Max. voltage L1-L2	REAL + PNIO Time	V	0	43
66...81	Max. voltage L2-L3	REAL + PNIO Time	V	0	44

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
82...97	Max. voltage L3-L1	REAL + PNIO Time	V	0	45
98...113	Max. current L1[1]	REAL + PNIO Time	A	0	46
114...129	Max. current L2[1]	REAL + PNIO Time	A	0	47
130...145	Max. current L3[1]	REAL + PNIO Time	A	0	48
146...161	Max. apparent power L1	REAL + PNIO Time	VA	0	49
162...177	Max. apparent power L2	REAL + PNIO Time	VA	0	50
178...193	Max. apparent power L3	REAL + PNIO Time	VA	0	51
194...209	Max. active power L1	REAL + PNIO Time	W	-3.0×10^9	52
210...225	Max. active power L2	REAL + PNIO Time	W	-3.0×10^9	53
226...241	Max. active power L3	REAL + PNIO Time	W	-3.0×10^9	54
242...257	Max. reactive power Qtot L1	REAL + PNIO Time	var	-3.0×10^9	62160
258...273	Max. reactive power Qtot L2	REAL + PNIO Time	var	-3.0×10^9	62260
274...289	Max. reactive power Qtot L3	REAL + PNIO Time	var	-3.0×10^9	62360
290...305	Max. power factor λ L1	REAL + PNIO Time	-	0	58
306...321	Max. power factor λ L2	REAL + PNIO Time	-	0	59
322...337	Max. power factor λ L3	REAL + PNIO Time	-	0	60
338...353	Max. frequency	REAL + PNIO Time	Hz	40	61
354...369	Max. apparent power L1L2L3	REAL + PNIO Time	VA	0	67
370...385	Max. active power L1L2L3	REAL + PNIO Time	W	-3.0×10^9	65
386...401	Max. reactive power Qtot L1L2L3	REAL + PNIO Time	var	-3.0×10^9	61138
402...417	Max. power factor λ L1L2L3	REAL + PNIO Time	-	0	68
418...433	Max. reactive power Qn L1	REAL + PNIO Time	var	-3.0×10^9	55

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
434...449	Max. reactive power Qn L2	REAL + PNIO Time	var	-3.0×10^9	56
450...465	Max. reactive power Qn L3	REAL + PNIO Time	var	-3.0×10^9	57
466...481	Max. mean voltage L-N	REAL + PNIO Time	V	0	62
482...497	Max. mean voltage L-L	REAL + PNIO Time	V	0	63
498...513	Max. sum mean value current L1L2L3	REAL + PNIO Time	A	0	64
514...529	Max. fundamental voltage L1	REAL + PNIO Time	V	0	62152
530...545	Max. fundamental voltage L2	REAL + PNIO Time	V	0	62252
546...561	Max. fundamental voltage L3	REAL + PNIO Time	V	0	62352
562...577	Max. fundamental current L1	REAL + PNIO Time	A	0	62153
578...593	Max. fundamental current L2	REAL + PNIO Time	A	0	62253
594...609	Max. fundamental current L3	REAL + PNIO Time	A	0	62353
610...625	Max. fundamental apparent power L1	REAL + PNIO Time	VA	-3.0×10^9	62155
626...641	Max. fundamental apparent power L2	REAL + PNIO Time	VA	-3.0×10^9	62255
642...657	Max. fundamental apparent power L3	REAL + PNIO Time	VA	-3.0×10^9	62355
658...673	Max. fundamental reactive power L1	REAL + PNIO Time	var	-3.0×10^9	62154
674...689	Max. fundamental reactive power L2	REAL + PNIO Time	var	-3.0×10^9	62254
690...705	Max. fundamental reactive power L3	REAL + PNIO Time	var	-3.0×10^9	62354
706...721	Max. fundamental active power L1	REAL + PNIO Time	W	-3.0×10^9	62156
722...737	Max. fundamental active power L2	REAL + PNIO Time	W	-3.0×10^9	62256
738...753	Max. fundamental active power L3	REAL + PNIO Time	W	-3.0×10^9	62356
754...769	Max. fundamental cos φ active factor L1	REAL + PNIO Time	-	-1	62157
770...785	Max. fundamental cos φ active factor L2	REAL + PNIO Time	-	-1	62257

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
786...801	Max. fundamental cos φ active factor L3	REAL + PNIO Time	-	-1	62357
802...817	Max. total harmonic distortion (THD+N) voltage L1	REAL + PNIO Time	1%	0	62150
818...833	Max. total harmonic distortion (THD+N) voltage L2	REAL + PNIO Time	1%	0	62250
834...849	Max. total harmonic distortion (THD+N) voltage L3	REAL + PNIO Time	1%	0	62350
850...865	Max. total harmonic distortion (THD+N) current L1	REAL + PNIO Time	1%	0	62151
866...881	Max. total harmonic distortion (THD+N) current L2	REAL + PNIO Time	1%	0	62251
882...897	Max. total harmonic distortion (THD+N) current L3	REAL + PNIO Time	1%	0	62351
898...913	Max. neutral current	REAL + PNIO Time	A	0	61136

[1] The values reference the amount of the current measured value

E.12 Measured value data record for minimum values with time stamp (DS 155)

Measured variables of the module

The smallest values ever measured or calculated from the time the AI Energy Meter HF was started are stored in this data record.

The measured values (REAL 4 bytes) are each followed by a time stamp (PNIO Time 12 bytes).

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

More detailed information about the structure of time stamps is available in section Time synchronization and time stamp.

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...17	Min. voltage L1-N	REAL + PNIO Time	V	1000000	70
18...33	Min. voltage L2-N	REAL + PNIO Time	V	1000000	71
34...49	Min. voltage L3-N	REAL + PNIO Time	V	1000000	72

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
50...65	Min. voltage L1-L2	REAL + PNIO Time	V	1800000	73
66...81	Min. voltage L2-L3	REAL + PNIO Time	V	1800000	74
82...97	Min. voltage L3-L1	REAL + PNIO Time	V	1800000	75
98...113	Min. current L1[1]	REAL + PNIO Time	A	100000	76
114...129	Min. current L2[1]	REAL + PNIO Time	A	100000	77
130...145	Min. current L3[1]	REAL + PNIO Time	A	100000	78
146...161	Min. apparent power L1	REAL + PNIO Time	VA	$+3.0 \times 10^9$	79
162...177	Min. apparent power L2	REAL + PNIO Time	VA	$+3.0 \times 10^9$	80
178...193	Min. apparent power L3	REAL + PNIO Time	VA	$+3.0 \times 10^9$	81
194...209	Min. active power L1	REAL + PNIO Time	W	$+3.0 \times 10^9$	82
210...225	Min. active power L2	REAL + PNIO Time	W	$+3.0 \times 10^9$	83
226...241	Min. active power L3	REAL + PNIO Time	W	$+3.0 \times 10^9$	84
242...257	Min. reactive power Qtot L1	REAL + PNIO Time	var	$+3.0 \times 10^9$	62180
258...273	Min. reactive power Qtot L2	REAL + PNIO Time	var	$+3.0 \times 10^9$	62280
274...289	Min. reactive power Qtot L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	62380
290...305	Min. power factor λ L1	REAL + PNIO Time	-	1	88
306...321	Min. power factor λ L2	REAL + PNIO Time	-	1	89
322...337	Min. power factor λ L3	REAL + PNIO Time	-	1	90
338...353	Min. frequency	REAL + PNIO Time	Hz	70	91
354...369	Min. apparent power L1L2L3	REAL + PNIO Time	VA	$+3.0 \times 10^9$	97
370...385	Min. active power L1L2L3	REAL + PNIO Time	W	$+3.0 \times 10^9$	95
386...401	Min. reactive power Qn L1L2L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	61139

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
402...417	Min. power factor λ L1L2L3	REAL + PNIO Time	-	1	98
418...433	Min. reactive power Qn L1	REAL + PNIO Time	var	$+3.0 \times 10^9$	85
434...449	Min. reactive power Qn L2	REAL + PNIO Time	var	$+3.0 \times 10^9$	86
450...465	Min. reactive power Qn L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	87
466...481	Min. mean voltage L-N	REAL + PNIO Time	V	1000000	92
482...497	Min. mean voltage L-L	REAL + PNIO Time	V	1800000	93
498...513	Min. mean current L1L2L3	REAL + PNIO Time	A	100000	94
514...529	Min. fundamental voltage L1	REAL + PNIO Time	V	0	62172
530...545	Min. fundamental voltage L2	REAL + PNIO Time	V	0	62272
546...561	Min. fundamental voltage L3	REAL + PNIO Time	V	0	62372
562...577	Min. fundamental current L1	REAL + PNIO Time	A	1000000	62173
578...593	Min. fundamental current L2	REAL + PNIO Time	A	1000000	62273
594...609	Min. fundamental current L3	REAL + PNIO Time	A	1000000	62373
610...625	Min. fundamental apparent power L1	REAL + PNIO Time	VA	$+3.0 \times 10^9$	62175
626...641	Min. fundamental apparent power L2	REAL + PNIO Time	VA	$+3.0 \times 10^9$	62275
642...657	Min. fundamental apparent power L3	REAL + PNIO Time	VA	$+3.0 \times 10^9$	62375
658...673	Min. fundamental reactive power L1	REAL + PNIO Time	var	$+3.0 \times 10^9$	62174
674...689	Min. fundamental reactive power L2	REAL + PNIO Time	var	$+3.0 \times 10^9$	62274
690...705	Min. fundamental reactive power L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	62374
706...721	Min. fundamental active power L1	REAL + PNIO Time	W	$+3.0 \times 10^9$	62176
722...737	Min. fundamental active power L2	REAL + PNIO Time	W	$+3.0 \times 10^9$	62276
738...753	Min. fundamental active power L3	REAL + PNIO Time	W	$+3.0 \times 10^9$	62376

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
754...769	Min. fundamental cos φ active factor L1	REAL + PNIO Time	-	1	62177
770...785	Min. fundamental cos φ active factor L2	REAL + PNIO Time	-	1	62277
786...801	Min. fundamental cos φ active factor L3	REAL + PNIO Time	-	1	62377
802...817	Min. total harmonic distortion (THD+N) voltage L1	REAL + PNIO Time	1%	100	62170
818...833	Min. total harmonic distortion (THD+N) voltage L2	REAL + PNIO Time	1%	100	62270
834...849	Min. total harmonic distortion (THD+N) voltage L3	REAL + PNIO Time	1%	100	62370
850...865	Min. total harmonic distortion (THD+N) current L1	REAL + PNIO Time	1%	100	62171
866...881	Min. total harmonic distortion (THD+N) current L2	REAL + PNIO Time	1%	100	62271
882...897	Min. total harmonic distortion (THD+N) current L3	REAL + PNIO Time	1%	100	62371
898...913	Min. neutral current	REAL + PNIO Time	A	100000.0	61137

[1] The values reference the amount of the current measured value

E.13 Measured value data record for power quality analysis (DS 160)

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 174)).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...5	Neutral current IN	REAL	A	0.0 ... 100000.0	61149
6...9	Neutral current 10-12 cycles	REAL	A	0.0 ... 100000.0	61150
10...13	Total current IL1+IL2+IL3-IN	REAL	A	-100000.0 ... 100000.0	61153
14...17	(Fundamental) reactive power L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	61154
18...21	Max. (fundamental) reactive power L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	61155
22...25	Min. (fundamental) reactive power L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	61156

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
26...29	Power factor λ L1L2L3	REAL	-	0.0 ... 1.0	37
30...33	Fundamental reactive power L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62124
34...37	Fundamental reactive power L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62224
38...41	Fundamental reactive power L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62324
42...45	Fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62127
46...49	Fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62227
50...53	Fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62327
54...57	Total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62120
58...61	Total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62220
62...65	Total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62320
66...69	Total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62121
70...73	Total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62221
74...77	Total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62321
78...81	Max. total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62150
82...85	Max. total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62250
86...89	Max. total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62350
90...93	Max. total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62151
94...97	Max. total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62251
98...101	Max. total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62351
102...105	Min. total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62170
106...109	Min. total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62270
110...113	Min. total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62370
114...117	Min. total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62171
118...121	Min. total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62271

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
122...125	Min. total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62371
126...129	Voltage dip - value L1	REAL	V	0 ... 440.0	62194
130...133	Voltage dip - duration L1	REAL	ms	0.0 ... 100000.0	62199
134...137	Voltage dip - value L2	REAL	V	0 ... 440.0	62294
138...141	Voltage dip - duration L2	REAL	ms	0.0 ... 100000.0	62299
142...145	Voltage dip - value L3	REAL	V	0 ... 440.0	62394
146...149	Voltage dip - duration L3	REAL	ms	0.0 ... 100000.0	62399
150...153	Voltage increase - value L1	REAL	V	0 ... 440.0	62195
154...157	Voltage increase - duration L1	REAL	ms	0.0 ... 100000.0	62200
158...161	Voltage increase - value L2	REAL	V	0 ... 440.0	62295
162...165	Voltage increase - duration L2	REAL	ms	0.0 ... 100000.0	62300
166...169	Voltage increase - value L3	REAL	V	0 ... 440.0	62395
170...173	Voltage increase - duration L3	REAL	ms	0.0 ... 100000.0	62400
174...177	Voltage peak value L1	REAL	V	0 ... 440.0	62196
178...181	Voltage peak value L2	REAL	V	0 ... 440.0	62296
182...185	Voltage peak value L3	REAL	V	0 ... 440.0	62396
186...189	Current peak value L1	REAL	A	0.0 ... 100000.0	62197
190...193	Current peak value L2	REAL	A	0.0 ... 100000.0	62297
194...197	Current peak value L3	REAL	A	0.0 ... 100000.0	62397
198...201	Overcurrent value L1	REAL	A	0.0 ... 100000.0	62198
202...205	Overcurrent value L2	REAL	A	0.0 ... 100000.0	62298
206...209	Overcurrent value L3	REAL	A	0.0 ... 100000.0	62398
210...213	Amplitude unbalance voltage U_2	REAL	%	0 ... 100	61157
214...217	Amplitude unbalance current I_{asym}	REAL	%	0 ... 100	61158
218...221	Power quality analysis - Qualifier	UDINT	Bit string	-	65496
222...233	Current module time	PNIO Time	sec	-	65497

E.14 Measured value data record for harmonics voltage (DS 161)

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 174)).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
2...5	Total harmonic distortion (THD+N) voltage L1	REAL	1%	0% to 100%	62120
6...9	Voltage L1-N	REAL	V	0.0 ... 440.0	1
10...13	Harmonics 1: Voltage L1	REAL	V	0.0 ... 760.0	63000
14...17	Harmonics 2: Voltage L1	REAL	V	0.0 ... 760.0	63002
18...21	Harmonics 3: Voltage L1	REAL	V	0.0 ... 760.0	63004
22...25	Harmonics 4: Voltage L1	REAL	V	0.0 ... 760.0	63006
26...29	Harmonics 5: Voltage L1	REAL	V	0.0 ... 760.0	63008
30...33	Harmonics 6: Voltage L1	REAL	V	0.0 ... 760.0	63010
34...37	Harmonics 7: Voltage L1	REAL	V	0.0 ... 760.0	63012
38...41	Harmonics 8: Voltage L1	REAL	V	0.0 ... 760.0	63014
42...45	Harmonics 9: Voltage L1	REAL	V	0.0 ... 760.0	63016
46...49	Harmonics 10: Voltage L1	REAL	V	0.0 ... 760.0	63018
50...53	Harmonics 11: Voltage L1	REAL	V	0.0 ... 760.0	63020
54...57	Harmonics 12: Voltage L1	REAL	V	0.0 ... 760.0	63022
58...61	Harmonics 13: Voltage L1	REAL	V	0.0 ... 760.0	63024
62...65	Harmonics 14: Voltage L1	REAL	V	0.0 ... 760.0	63026
66...69	Harmonics 15: Voltage L1	REAL	V	0.0 ... 760.0	63028
70...73	Harmonics 16: Voltage L1	REAL	V	0.0 ... 760.0	63030
74...77	Harmonics 17: Voltage L1	REAL	V	0.0 ... 760.0	63032
78...81	Harmonics 18: Voltage L1	REAL	V	0.0 ... 760.0	63034
82...85	Harmonics 19: Voltage L1	REAL	V	0.0 ... 760.0	63036
86...89	Harmonics 20: Voltage L1	REAL	V	0.0 ... 760.0	63038
90...93	Harmonics 21: Voltage L1	REAL	V	0.0 ... 760.0	63040
94...97	Harmonics 22: Voltage L1	REAL	V	0.0 ... 760.0	63042
98...101	Harmonics 23: Voltage L1	REAL	V	0.0 ... 760.0	63044
102...105	Harmonics 24: Voltage L1	REAL	V	0.0 ... 760.0	63046
106...109	Harmonics 25: Voltage L1	REAL	V	0.0 ... 760.0	63048
110...113	Harmonics 26: Voltage L1	REAL	V	0.0 ... 760.0	63050
114...117	Harmonics 27: Voltage L1	REAL	V	0.0 ... 760.0	63052
118...121	Harmonics 28: Voltage L1	REAL	V	0.0 ... 760.0	63054
122...125	Harmonics 29: Voltage L1	REAL	V	0.0 ... 760.0	63056
126...129	Harmonics 30: Voltage L1	REAL	V	0.0 ... 760.0	63058
130...133	Harmonics 31: Voltage L1	REAL	V	0.0 ... 760.0	63060
134...137	Harmonics 32: Voltage L1	REAL	V	0.0 ... 760.0	63062
138...141	Harmonics 33: Voltage L1	REAL	V	0.0 ... 760.0	63064
142...145	Harmonics 34: Voltage L1	REAL	V	0.0 ... 760.0	63066
146...149	Harmonics 35: Voltage L1	REAL	V	0.0 ... 760.0	63068
150...153	Harmonics 36: Voltage L1	REAL	V	0.0 ... 760.0	63070

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
154...157	Harmonics 37: Voltage L1	REAL	V	0.0 ... 760.0	63072
158...161	Harmonics 38: Voltage L1	REAL	V	0.0 ... 760.0	63074
162...165	Harmonics 39: Voltage L1	REAL	V	0.0 ... 760.0	63076
166...169	Harmonics 40: Voltage L1	REAL	V	0.0 ... 760.0	63078
170...173	Total harmonic distortion (THD+N) voltage L2	REAL	1%	0% to 100%	62220
174...177	Voltage L2-N	REAL	V	0.0 ... 440.0	2
178...181	Harmonics 1: Voltage L2	REAL	V	0.0 ... 760.0	63400
182...185	Harmonics 2: Voltage L2	REAL	V	0.0 ... 760.0	63402
186...189	Harmonics 3: Voltage L2	REAL	V	0.0 ... 760.0	63404
190...193	Harmonics 4: Voltage L2	REAL	V	0.0 ... 760.0	63406
194...197	Harmonics 5: Voltage L2	REAL	V	0.0 ... 760.0	63408
198...201	Harmonics 6: Voltage L2	REAL	V	0.0 ... 760.0	63410
202...205	Harmonics 7: Voltage L2	REAL	V	0.0 ... 760.0	63412
206...209	Harmonics 8: Voltage L2	REAL	V	0.0 ... 760.0	63414
210...213	Harmonics 9: Voltage L2	REAL	V	0.0 ... 760.0	63416
214...217	Harmonics 10: Voltage L2	REAL	V	0.0 ... 760.0	63418
218...221	Harmonics 11: Voltage L2	REAL	V	0.0 ... 760.0	63420
222...225	Harmonics 12: Voltage L2	REAL	V	0.0 ... 760.0	63422
226...229	Harmonics 13: Voltage L2	REAL	V	0.0 ... 760.0	63424
230...233	Harmonics 14: Voltage L2	REAL	V	0.0 ... 760.0	63426
234...237	Harmonics 15: Voltage L2	REAL	V	0.0 ... 760.0	63428
238...241	Harmonics 16: Voltage L2	REAL	V	0.0 ... 760.0	63430
242...245	Harmonics 17: Voltage L2	REAL	V	0.0 ... 760.0	63432
246...249	Harmonics 18: Voltage L2	REAL	V	0.0 ... 760.0	63434
250...253	Harmonics 19: Voltage L2	REAL	V	0.0 ... 760.0	63436
254...257	Harmonics 20: Voltage L2	REAL	V	0.0 ... 760.0	63438
258...261	Harmonics 21: Voltage L2	REAL	V	0.0 ... 760.0	63440
262...265	Harmonics 22: Voltage L2	REAL	V	0.0 ... 760.0	63442
266...269	Harmonics 23: Voltage L2	REAL	V	0.0 ... 760.0	63444
270...273	Harmonics 24: Voltage L2	REAL	V	0.0 ... 760.0	63446
274...277	Harmonics 25: Voltage L2	REAL	V	0.0 ... 760.0	63448
278...281	Harmonics 26: Voltage L2	REAL	V	0.0 ... 760.0	63450
281...285	Harmonics 27: Voltage L2	REAL	V	0.0 ... 760.0	63452
286...289	Harmonics 28: Voltage L2	REAL	V	0.0 ... 760.0	63454
290...293	Harmonics 29: Voltage L2	REAL	V	0.0 ... 760.0	63456
294...297	Harmonics 30: Voltage L2	REAL	V	0.0 ... 760.0	63458
298...301	Harmonics 31: Voltage L2	REAL	V	0.0 ... 760.0	63460
302...305	Harmonics 32: Voltage L2	REAL	V	0.0 ... 760.0	63462

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
306...309	Harmonics 33: Voltage L2	REAL	V	0.0 ... 760.0	63464
310...313	Harmonics 34: Voltage L2	REAL	V	0.0 ... 760.0	63466
314...317	Harmonics 35: Voltage L2	REAL	V	0.0 ... 760.0	63468
318...321	Harmonics 36: Voltage L2	REAL	V	0.0 ... 760.0	63470
322...325	Harmonics 37: Voltage L2	REAL	V	0.0 ... 760.0	63472
326...329	Harmonics 38: Voltage L2	REAL	V	0.0 ... 760.0	63474
330...333	Harmonics 39: Voltage L2	REAL	V	0.0 ... 760.0	63476
334...337	Harmonics 40: Voltage L2	REAL	V	0.0 ... 760.0	63478
338...341	Total harmonic distortion (THD+N) voltage L3	REAL	1%	0% to 100%	62320
342...345	Voltage L3-N	REAL	V	0.0 ... 440.0	3
346...349	Harmonics 1: Voltage L3	REAL	V	0.0 ... 760.0	63800
350...353	Harmonics 2: Voltage L3	REAL	V	0.0 ... 760.0	63802
354...357	Harmonics 3: Voltage L3	REAL	V	0.0 ... 760.0	63804
358...361	Harmonics 4: Voltage L3	REAL	V	0.0 ... 760.0	63806
362...365	Harmonics 5: Voltage L3	REAL	V	0.0 ... 760.0	63808
366...369	Harmonics 6: Voltage L3	REAL	V	0.0 ... 760.0	63810
370...373	Harmonics 7: Voltage L3	REAL	V	0.0 ... 760.0	63812
374...377	Harmonics 8: Voltage L3	REAL	V	0.0 ... 760.0	63814
378...381	Harmonics 9: Voltage L3	REAL	V	0.0 ... 760.0	63816
382...385	Harmonics 10: Voltage L3	REAL	V	0.0 ... 760.0	63818
386...389	Harmonics 11: Voltage L3	REAL	V	0.0 ... 760.0	63820
390...393	Harmonics 12: Voltage L3	REAL	V	0.0 ... 760.0	63822
394...397	Harmonics 13: Voltage L3	REAL	V	0.0 ... 760.0	63824
398...401	Harmonics 14: Voltage L3	REAL	V	0.0 ... 760.0	63826
402...405	Harmonics 15: Voltage L3	REAL	V	0.0 ... 760.0	63828
406...409	Harmonics 16: Voltage L3	REAL	V	0.0 ... 760.0	63830
410...413	Harmonics 17: Voltage L3	REAL	V	0.0 ... 760.0	63832
414...417	Harmonics 18: Voltage L3	REAL	V	0.0 ... 760.0	63834
418...421	Harmonics 19: Voltage L3	REAL	V	0.0 ... 760.0	63836
422...425	Harmonics 20: Voltage L3	REAL	V	0.0 ... 760.0	63838
426...429	Harmonics 21: Voltage L3	REAL	V	0.0 ... 760.0	63840
430...433	Harmonics 22: Voltage L3	REAL	V	0.0 ... 760.0	63842
434...437	Harmonics 23: Voltage L3	REAL	V	0.0 ... 760.0	63844
438...441	Harmonics 24: Voltage L3	REAL	V	0.0 ... 760.0	63846
442...445	Harmonics 25: Voltage L3	REAL	V	0.0 ... 760.0	63848
446...449	Harmonics 26: Voltage L3	REAL	V	0.0 ... 760.0	63850
450...453	Harmonics 27: Voltage L3	REAL	V	0.0 ... 760.0	63852
454...457	Harmonics 28: Voltage L3	REAL	V	0.0 ... 760.0	63854

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
458...461	Harmonics 29: Voltage L3	REAL	V	0.0 ... 760.0	63856
462...465	Harmonics 30: Voltage L3	REAL	V	0.0 ... 760.0	63858
466...469	Harmonics 31: Voltage L3	REAL	V	0.0 ... 760.0	63860
470...473	Harmonics 32: Voltage L3	REAL	V	0.0 ... 760.0	63862
474...477	Harmonics 33: Voltage L3	REAL	V	0.0 ... 760.0	63864
478...481	Harmonics 34: Voltage L3	REAL	V	0.0 ... 760.0	63866
482...485	Harmonics 35: Voltage L3	REAL	V	0.0 ... 760.0	63868
486...489	Harmonics 36: Voltage L3	REAL	V	0.0 ... 760.0	63870
490...493	Harmonics 37: Voltage L3	REAL	V	0.0 ... 760.0	63872
494...497	Harmonics 38: Voltage L3	REAL	V	0.0 ... 760.0	63874
498...501	Harmonics 39: Voltage L3	REAL	V	0.0 ... 760.0	63876
502...505	Harmonics 40: Voltage L3	REAL	V	0.0 ... 760.0	63878
506...517	Current module time	PNIOTime	sec	-	65497

E.15 Measured value data record for harmonics current (DS 163)

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 174)).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...5	Total harmonic distortion (THD+N) current L1	REAL	1%	0% to 100%	62121
6...9	Current L1	REAL	A	0.0 ... 100000.0	7
10...13	Harmonics 1: Current L1	REAL	A	0.0 ... 100000.0	63001
14...17	Harmonics 2: Current L1	REAL	A	0.0 ... 100000.0	63003
18...21	Harmonics 3: Current L1	REAL	A	0.0 ... 100000.0	63005
22...25	Harmonics 4: Current L1	REAL	A	0.0 ... 100000.0	63007
26...29	Harmonics 5: Current L1	REAL	A	0.0 ... 100000.0	63009
30...33	Harmonics 6: Current L1	REAL	A	0.0 ... 100000.0	63011
34...37	Harmonics 7: Current L1	REAL	A	0.0 ... 100000.0	63013
38...41	Harmonics 8: Current L1	REAL	A	0.0 ... 100000.0	63015
42...45	Harmonics 9: Current L1	REAL	A	0.0 ... 100000.0	63017
46...49	Harmonics 10: Current L1	REAL	A	0.0 ... 100000.0	63019
50...53	Harmonics 11: Current L1	REAL	A	0.0 ... 100000.0	63021
54...57	Harmonics 12: Current L1	REAL	A	0.0 ... 100000.0	63023

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
58...61	Harmonics 13: Current L1	REAL	A	0.0 ... 100000.0	63025
62...65	Harmonics 14: Current L1	REAL	A	0.0 ... 100000.0	63027
66...69	Harmonics 15: Current L1	REAL	A	0.0 ... 100000.0	63029
70...73	Harmonics 16: Current L1	REAL	A	0.0 ... 100000.0	63031
74...77	Harmonics 17: Current L1	REAL	A	0.0 ... 100000.0	63033
78...81	Harmonics 18: Current L1	REAL	A	0.0 ... 100000.0	63035
82...85	Harmonics 19: Current L1	REAL	A	0.0 ... 100000.0	63037
86...89	Harmonics 20: Current L1	REAL	A	0.0 ... 100000.0	63039
90...93	Harmonics 21: Current L1	REAL	A	0.0 ... 100000.0	63041
94...97	Harmonics 22: Current L1	REAL	A	0.0 ... 100000.0	63043
98...10-1	Harmonics 23: Current L1	REAL	A	0.0 ... 100000.0	63045
102...1-05	Harmonics 24: Current L1	REAL	A	0.0 ... 100000.0	63047
106...1-09	Harmonics 25: Current L1	REAL	A	0.0 ... 100000.0	63049
110...1-13	Harmonics 26: Current L1	REAL	A	0.0 ... 100000.0	63051
114...1-17	Harmonics 27: Current L1	REAL	A	0.0 ... 100000.0	63053
118...1-21	Harmonics 28: Current L1	REAL	A	0.0 ... 100000.0	63055
122...1-25	Harmonics 29: Current L1	REAL	A	0.0 ... 100000.0	63057
126...1-29	Harmonics 30: Current L1	REAL	A	0.0 ... 100000.0	63059
130...1-33	Harmonics 31: Current L1	REAL	A	0.0 ... 100000.0	63061
134...1-37	Harmonics 32: Current L1	REAL	A	0.0 ... 100000.0	63063
138...1-41	Harmonics 33: Current L1	REAL	A	0.0 ... 100000.0	63065
142...1-45	Harmonics 34: Current L1	REAL	A	0.0 ... 100000.0	63067
146...1-49	Harmonics 35: Current L1	REAL	A	0.0 ... 100000.0	63069
150...1-53	Harmonics 36: Current L1	REAL	A	0.0 ... 100000.0	63071
154...1-57	Harmonics 37: Current L1	REAL	A	0.0 ... 100000.0	63073
158...1-61	Harmonics 38: Current L1	REAL	A	0.0 ... 100000.0	63075
162...1-65	Harmonics 39: Current L1	REAL	A	0.0 ... 100000.0	63077

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
166...169	Harmonics 40: Current L1	REAL	A	0.0 ... 100000.0	63079
170...173	Total harmonic distortion (THD+N) current L2	REAL	1%	0% to 100%	62221
174...177	Current L2	REAL	A	0.0 ... 100000.0	8
178...181	Harmonics 1: Current L2	REAL	A	0.0 ... 100000.0	63401
182...185	Harmonics 2: Current L2	REAL	A	0.0 ... 100000.0	63403
186...189	Harmonics 3: Current L2	REAL	A	0.0 ... 100000.0	63405
190...193	Harmonics 4: Current L2	REAL	A	0.0 ... 100000.0	63407
194...197	Harmonics 5: Current L2	REAL	A	0.0 ... 100000.0	63409
198...201	Harmonics 6: Current L2	REAL	A	0.0 ... 100000.0	63411
202...205	Harmonics 7: Current L2	REAL	A	0.0 ... 100000.0	63413
206...209	Harmonics 8: Current L2	REAL	A	0.0 ... 100000.0	63415
210...213	Harmonics 9: Current L2	REAL	A	0.0 ... 100000.0	63417
214...217	Harmonics 10: Current L2	REAL	A	0.0 ... 100000.0	63419
218...221	Harmonics 11: Current L2	REAL	A	0.0 ... 100000.0	63421
222...225	Harmonics 12: Current L2	REAL	A	0.0 ... 100000.0	63423
226...229	Harmonics 13: Current L2	REAL	A	0.0 ... 100000.0	63425
230...233	Harmonics 14: Current L2	REAL	A	0.0 ... 100000.0	63427
234...237	Harmonics 15: Current L2	REAL	A	0.0 ... 100000.0	63429
238...241	Harmonics 16: Current L2	REAL	A	0.0 ... 100000.0	63431
242...245	Harmonics 17: Current L2	REAL	A	0.0 ... 100000.0	63433
246...249	Harmonics 18: Current L2	REAL	A	0.0 ... 100000.0	63435
250...253	Harmonics 19: Current L2	REAL	A	0.0 ... 100000.0	63437
254...257	Harmonics 20: Current L2	REAL	A	0.0 ... 100000.0	63439

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
258...2-61	Harmonics 21: Current L2	REAL	A	0.0 ... 100000.0	63441
262...2-65	Harmonics 22: Current L2	REAL	A	0.0 ... 100000.0	63443
266...2-69	Harmonics 23: Current L2	REAL	A	0.0 ... 100000.0	63445
270...2-73	Harmonics 24: Current L2	REAL	A	0.0 ... 100000.0	63447
274...2-77	Harmonics 25: Current L2	REAL	A	0.0 ... 100000.0	63449
278...2-81	Harmonics 26: Current L2	REAL	A	0.0 ... 100000.0	63451
281...2-85	Harmonics 27: Current L2	REAL	A	0.0 ... 100000.0	63453
286...2-89	Harmonics 28: Current L2	REAL	A	0.0 ... 100000.0	63455
290...2-93	Harmonics 29: Current L2	REAL	A	0.0 ... 100000.0	63457
294...2-97	Harmonics 30: Current L2	REAL	A	0.0 ... 100000.0	63459
298...3-01	Harmonics 31: Current L2	REAL	A	0.0 ... 100000.0	63461
302...3-05	Harmonics 32: Current L2	REAL	A	0.0 ... 100000.0	63463
306...3-09	Harmonics 33: Current L2	REAL	A	0.0 ... 100000.0	63465
310...3-13	Harmonics 34: Current L2	REAL	A	0.0 ... 100000.0	63467
314...3-17	Harmonics 35: Current L2	REAL	A	0.0 ... 100000.0	63469
318...3-21	Harmonics 36: Current L2	REAL	A	0.0 ... 100000.0	63471
322...3-25	Harmonics 37: Current L2	REAL	A	0.0 ... 100000.0	63473
326...3-29	Harmonics 38: Current L2	REAL	A	0.0 ... 100000.0	63475
330...3-33	Harmonics 39: Current L2	REAL	A	0.0 ... 100000.0	63477
334...3-37	Harmonics 40: Current L2	REAL	A	0.0 ... 100000.0	63479
338...3-41	Total harmonic distortion (THD+N) current L3	REAL	1%	0% to 100%	62321
342...3-45	Current L3	REAL	A	0.0 ... 100000.0	9
346...3-49	Harmonics 1: Current L3	REAL	A	0.0 ... 100000.0	63801

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
350...353	Harmonics 2: Current L3	REAL	A	0.0 ... 100000.0	63803
354...357	Harmonics 3: Current L3	REAL	A	0.0 ... 100000.0	63805
358...361	Harmonics 4: Current L3	REAL	A	0.0 ... 100000.0	63807
362...365	Harmonics 5: Current L3	REAL	A	0.0 ... 100000.0	63809
366...369	Harmonics 6: Current L3	REAL	A	0.0 ... 100000.0	63811
370...373	Harmonics 7: Current L3	REAL	A	0.0 ... 100000.0	63813
374...377	Harmonics 8: Current L3	REAL	A	0.0 ... 100000.0	63815
378...381	Harmonics 9: Current L3	REAL	A	0.0 ... 100000.0	63817
382...385	Harmonics 10: Current L3	REAL	A	0.0 ... 100000.0	63819
386...389	Harmonics 11: Current L3	REAL	A	0.0 ... 100000.0	63821
390...393	Harmonics 12: Current L3	REAL	A	0.0 ... 100000.0	63823
394...397	Harmonics 13: Current L3	REAL	A	0.0 ... 100000.0	63825
398...401	Harmonics 14: Current L3	REAL	A	0.0 ... 100000.0	63827
402...405	Harmonics 15: Current L3	REAL	A	0.0 ... 100000.0	63829
406...409	Harmonics 16: Current L3	REAL	A	0.0 ... 100000.0	63831
410...413	Harmonics 17: Current L3	REAL	A	0.0 ... 100000.0	63833
414...417	Harmonics 18: Current L3	REAL	A	0.0 ... 100000.0	63835
418...421	Harmonics 19: Current L3	REAL	A	0.0 ... 100000.0	63837
422...425	Harmonics 20: Current L3	REAL	A	0.0 ... 100000.0	63839
426...429	Harmonics 21: Current L3	REAL	A	0.0 ... 100000.0	63841
430...433	Harmonics 22: Current L3	REAL	A	0.0 ... 100000.0	63843
434...437	Harmonics 23: Current L3	REAL	A	0.0 ... 100000.0	63845
438...441	Harmonics 24: Current L3	REAL	A	0.0 ... 100000.0	63847

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
442...4-45	Harmonics 25: Current L3	REAL	A	0.0 ... 100000.0	63849
446...4-49	Harmonics 26: Current L3	REAL	A	0.0 ... 100000.0	63851
450...4-53	Harmonics 27: Current L3	REAL	A	0.0 ... 100000.0	63853
454...4-57	Harmonics 28: Current L3	REAL	A	0.0 ... 100000.0	63855
458...4-61	Harmonics 29: Current L3	REAL	A	0.0 ... 100000.0	63857
462...4-65	Harmonics 30: Current L3	REAL	A	0.0 ... 100000.0	63859
466...4-69	Harmonics 31: Current L3	REAL	A	0.0 ... 100000.0	63861
470...4-73	Harmonics 32: Current L3	REAL	A	0.0 ... 100000.0	63863
474...4-77	Harmonics 33: Current L3	REAL	A	0.0 ... 100000.0	63865
478...4-81	Harmonics 34: Current L3	REAL	A	0.0 ... 100000.0	63867
482...4-85	Harmonics 35: Current L3	REAL	A	0.0 ... 100000.0	63869
486...4-89	Harmonics 36: Current L3	REAL	A	0.0 ... 100000.0	63871
490...4-93	Harmonics 37: Current L3	REAL	A	0.0 ... 100000.0	63873
494...4-97	Harmonics 38: Current L3	REAL	A	0.0 ... 100000.0	63875
498...5-01	Harmonics 39: Current L3	REAL	A	0.0 ... 100000.0	63877
502...5-05	Harmonics 40: Current L3	REAL	A	0.0 ... 100000.0	63879
506...5-17	Current module time	PNIOTime	sec	-	65497

E.16 Measured value data record for power failure analysis (DS 169)

Evaluation of the results of the power failure analysis in data record 169

The "Switch-off time/Switch-on time" pair of the stored times is the result of the module failure time. The "Overflow" cell shows the number of overflows of this list. This will inform you about how much information is no longer stored in the module. The "Next index" cell is a pointer to the new list index for the next entry and thus does not contain any information or the oldest information form the last potential overflow. Note that "Next index" as list index

has the value range from 0 to 8 and thus shows, for example, "Next index = 1" to the pair "2: Switch-off time/ 2: Switch-on time". The cell "Current time" provides the module time as of the time when the DS169 was read.

You can find the description of the function "Power failure analysis" in the section Power failure analysis (Page 95).

Data record 169

Byte	Measured variable	Data type	Unit	Value range
0	Version	BYTE	-	0
1	Reserved	BYTE	-	0
2	Next index	BYTE	-	0 ... 8
3	Overflow	BYTE	-	0 ... 255
4 ... 15	1: Switch-off time	PNIOTime	sec	-
16 ... 27	1: Switch-on time	PNIOTime	sec	-
28 ... 39	2: Switch-off time	PNIOTime	sec	-
40 ... 51	2: Switch-on time	PNIOTime	sec	-
52 ... 63	3: Switch-off time	PNIOTime	sec	-
64 ... 75	3: Switch-on time	PNIOTime	sec	-
76 ... 87	4: Switch-off time	PNIOTime	sec	-
88 ... 99	4: Switch-on time	PNIOTime	sec	-
100 ... 111	5: Switch-off time	PNIOTime	sec	-
112... 123	5: Switch-on time	PNIOTime	sec	-
124 ... 135	6: Switch-off time	PNIOTime	sec	-
136 ... 147	6: Switch-on time	PNIOTime	sec	-
148 ... 159	7: Switch-off time	PNIOTime	sec	-
160 ... 171	7: Switch-on time	PNIOTime	sec	-
172 ... 183	8: Switch-off time	PNIOTime	sec	-
184 ... 195	8: Switch-on time	PNIOTime	sec	-
196 ... 207	9: Switch-off time	PNIOTime	sec	-
208 ... 219	9: Switch-on time	PNIOTime	sec	-
220 ... 231	Current module time	PNIOTime	sec	-

E.17 Information data record on available measured values (DS 170)

Measured variables of the module

Byte	Name	Data type	Unit	Value range
0	Version	BYTE	-	0
1	Reserved	BYTE	-	0
2...3	Number of IDs	UINT16	-	599
4...5	ID measured value 1	UINT16	-	-
5...6	ID measured value 2	UINT16	-	-
...	...	...	-	-
1200 ... 1201	ID measured value 599	UINT16	-	-

E.18 Measured value data record for measured value recording 1 (DS 173)

Measured variables of the module

The following table provides an overview of all the measured variables from the measured value recorder, record 1 (see section Measuring value recorder (Page 89)). Note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

Table 2-931 Data record 173

Byte	Measured variable	Data type	Unit	Value range
0	Version	BYTE	-	0
1	Status bits	BYTE	-	80h: Recording ended 40h: Recording in progress 00h: Evaluating data not useful
2 ... 3	Number of measured values	UINT16	-	0 ... 200
4 ... 5	Stop index	UINT16		0 ... 199
6	Overflow	BYTE	-	0 ... 255
7	Recorder status	BYTE	-	0: Initial status 3: Recorder parameterized 4: Recording in progress 5: Recording ended 6: Recording stopped
8 ... 19	Current module time	PNIO Time	sec	-
20 ... 23	Measured value 1	REAL	Depending on measured value	Depending on measured value

Byte	Measured variable	Data type	Unit	Value range
24 ... 27	Measured value 2	REAL	Depending on measured value	Depending on measured value
...	...	...	...	...
816 ... 819	Measured value 200	REAL	Depending on measured value	Depending on measured value

In "Circular buffer" mode, the "Stop index" always shows the last recorded element during the ongoing recording. Note that the "Stop index" serves as an index in the measured value list and can therefore take on the values from 0 to 199. If the circular buffer is filled once, the current element is always the last one in the buffer ("Stop index" = 199). The "Overflow" measured variable displays the number of circular buffer overflows. If the function is stopped, the "Stop index" points to the measured value at the stop trigger event. In "once" mode, the "Stop index" will initially stop during a restart until the next stop. This makes the last recording interruption visible in the data. The time information "Current module time" corresponds to the time of the last measured value recording.

E.19 Measured value data record for measured value recording 2 (DS 174)

Measured variables of the module

The following table provides an overview of all the measured variables from the measured value recorder, record 2 (see section Measuring value recorder (Page 89)). Note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

Table 2-932 Data record 174

Byte	Measured variable	Data type	Unit	Value range
0	Version	BYTE	-	0
1	Status bits	BYTE	-	80h: Recording ended 40h: Recording in progress 00h: Evaluating data not useful
2 ... 3	Number of measured values	UINT16	-	0 ... 200
4 ... 5	Stop index	UINT16		0 ... 199
6	Overflow	BYTE	-	0 ... 255
7	Recorder status	BYTE	-	0: Initial status 3: Recorder parameterized 4: Recording in progress 5: Recording ended 6: Recording stopped
8 ... 19	Current module time	PNIO Time	sec	-
20 ... 23	Measured value 1	REAL	Depending on measured value	Depending on measured value

Byte	Measured variable	Data type	Unit	Value range
24 ... 27	Measured value 2	REAL	Depending on measured value	Depending on measured value
...	...	...	...	...
816 ... 819	Measured value 200	REAL	Depending on measured value	Depending on measured value

In "Circular buffer" mode, the "Stop index" always shows the last recorded element during the ongoing recording. Note that the "Stop index" serves as an index in the measured value list and can therefore take on the values from 0 to 199. If the circular buffer is filled once, the current element is always the last one in the buffer ("Stop index" = 199). The "Overflow" measured variable displays the number of circular buffer overflows. If the function is stopped, the "Stop index" points to the measured value at the stop trigger event. In "once" mode, the "Stop index" will initially stop during a restart until the next stop. This makes the last recording interruption visible in the data. The time information "Current module time" corresponds to the time of the last measured value recording.

Tips and tricks

F

F.1 Tips and tricks

Processing and visualizing energy data

On the basis of an application example, we show you how the measured values of the AI Energy Meter RC HF can be processed further and visualized.

You can find this application example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86299299).

Overview of the measurement data with update time

We provide you with an overview of the assignment of the measured values to the payload variants and data records in an Excel file.

You will find the Excel file on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755917).

Time-of-day synchronization and time stamp

In an application example, we show you how to synchronize the time with the AI Energy Meter RC HF and work with measured values with time stamps.

You can find this application example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109754890).

Rotating field

To recognize wiring errors and evaluate the generated rotating field, you use the combined measurement functions from the section Notes for the recognition of wiring errors and incorrect rotating field (Page 51).

Measured values in STEP 7 as of V5.5

Measured values are represented as negative values in STEP 7 as of V5.5 if the value range of the integer format (32767 dec) is exceeded. This is not an error in the measured value. Solution: Select hexadecimal representation.

Conversion of 64-bit floating-point numbers

If you cannot process 64-bit floating-point numbers in your automation system, we recommend conversion to 32-bit floating-point numbers. Note the conversion can cause loss of accuracy. For a description of the conversion of the 64-bit floating-point numbers (data type LREAL) into 32-bit floating-point numbers (data type REAL) please refer to the Internet (https://support.industry.siemens.com/cs/ww/en/view/56600676).

SIEMENS

SIMATIC

ET 200SP
Analog input module AI Energy Meter CT ST
(6ES7134-6PA01-0BU0)

Equipment Manual

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ET 200SP
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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

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ET 200SP Documentation Guide

1

1.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/84133942)

1.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in SIOS:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in SIOS and how to use SIOS on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

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CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.3 Tool support

1.3.1 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , it assembles the configuration editors for automation technology already familiar into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- The "Network analysis" offers a quick overview of the PROFINET topology. It is possible to make simple parameter changes (for example, to the names and IP addresses of the devices). In addition, a quick and convenient comparison of the real configuration with a reference system is also possible.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet:
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

Product overview

2

2.1 Properties of the AI Energy Meter CT ST

Article number

6ES7134-6PA01-0BU0

View of the module

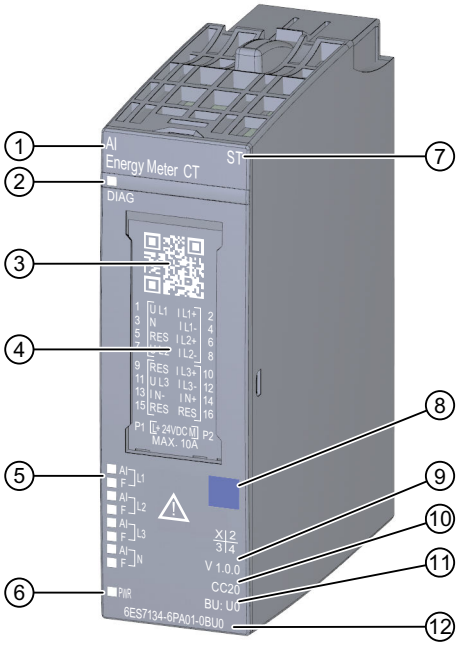

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-828 View of the module AI Energy Meter CT ST

Properties

The module has the following technical properties:

- Measurement of electrical variables from single-phase, two-phase and three-phase supply networks
- Current measurement using 1 A or 5 A current transformer
- Max. voltage between two line conductors 519 V AC (with direct connection)
- Retentive storage of the counter values
- Use on frequency converters
- Recording of:
  - Voltages
  - Currents
  - Phase angles
  - Power
  - Energy / electrical work
  - Frequencies
  - Minimum and maximum values with time stamp
  - Power factors
  - Operating hours
  - Limits

The module supports the following functions:

Table 2-933 Version dependencies of the functions

Function	HW version	FW version	STEP 7	GSD file	
			TIA Portal	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	---
Calibration in runtime	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	---	---
Identification data I&M0 to I&M3	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	X
Reconfiguration in RUN	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	X
Diagnostic interrupts	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	X
Hardware interrupts	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	---

NOTE

The AI Energy Meter CT ST is released as of TIA Portal V16.0.0.4.

Accessories

The following accessories must be ordered separately:

- BaseUnit type U0
- Labeling strips
- Reference identification label

You can find additional information on the accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

2.2 Area of application

Introduction

Energy efficiency is playing an increasingly important role in industry. Rising energy prices, increasing pressure to improve profitability and the growing awareness of climate protection are important factors for reducing energy costs and for introducing an energy data management system.

Where can you use the AI Energy Meter CT ST?

The AI Energy Meter CT ST is designed for machine-level deployment in an ET 200SP distributed I/O system. The AI Energy Meter CT ST records over 300 different electrical measurement and energy values. It lets you create transparency about the energy requirements of individual components of a production plant even down to the machine level.

You can use the following measurement values supplied by the AI Energy Meter CT ST for the following applications:

- Energy consumption
- Power consumption
- Forecasts of consumption
- Efficiency

Power consumption measurements are relevant for load management and maintenance. In addition, you can use the measurements for emission reporting and for determining the CO_2 footprint.

NOTE

Measuring dangerous electrical quantities

The AI Energy Meter CT ST is not tested according to DIN EN 61010-2-030 and may therefore not be used to verify, measure or monitor protective measures according to DIN EN 61557.

Qualified personnel must ensure through additional measures that no danger ensues for humans and the environment in case of an incorrect display.

TB, TT and IT system

The AI Energy Meter CT ST can be used in TN, TT and IT systems.

Measuring with the AI Energy Meter CT ST

A typical supply network of a production plant is usually divided into three voltage ranges:

- The infeed of the entire plant
- The subdistribution, for example, to individual lines within the plant
- The end consumers such as the machines in the lines.

The following figure shows the measurement in an electricity supply network:

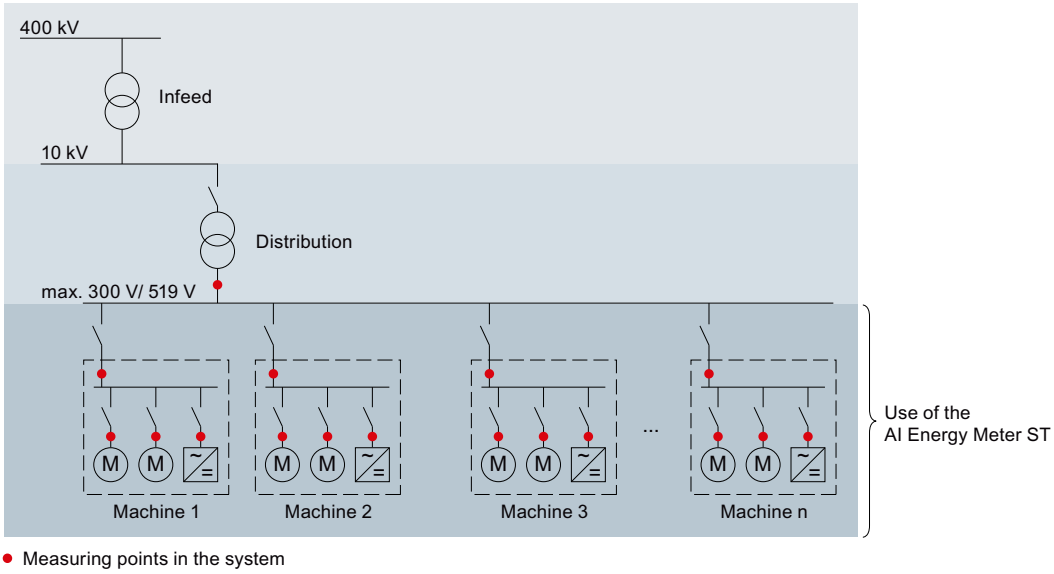

Figure 2-829 Properties of the AI Energy Meter CT ST

Properties of the AI Energy Meter CT ST

The AI Energy Meter CT ST offers the following benefits:

- Space-saving especially for use in control cabinet
- PROFINET IO or PROFIBUS DP (https://www.profibus.com/) (depending on the interface module in use)
- Multiple modules can be used with one interface module
- Extension of existing stations by components for energy recording

2.3 Special considerations for use on the PROFIBUS DP and PROFINET IO

You can read data records from the module or write them to the module with both PROFIBUS DP and PROFINET IO.

Operation of the module on PROFIBUS DP

Please note that with PROFIBUS DP you can write data records up to a maximum length of 240 bytes to the module or read them from the module.

PROFIBUS DPV 1

If the DP Master supports the DPV1, you can reconfigure in your user program with the parameter data records DS 128, DS 129, DS 130 or DS 135. Note that the maximum data record length is 240 bytes for DS 135.

The following applies for the measured value data records:

- DS 142: When you read the data record, the module returns the measured value data record DS 142 in version 2.
- DS 147, DS 148, DS 149: When you read the data record, the module returns the measured value data record in version 0.
- DS 154, DS 155: When you read the data record, the module returns the first 240 bytes of the structure of the measured value data record.
- DS 151: You define the user-defined measured value data record DS 151 in the parameter data record DS 135. If the structure in the measured value data record DS 151 is greater than 240 bytes, the module returns the first 240 bytes of the structure.

  Information on the data record length of data records DS 135 and DS151 can be found in the appendix Structure of the parameter data record 135 for data record mapping (Page 133).

PROFIBUS DPV 0

If the DP Master does **not** support DPV1, you cannot reassign parameters which results in the following restrictions:

- There are no phase-specific parameters. All parameters apply for all three phases and the neutral conductor.
- The connection types and payload variants are limited.
- The voltage transformers are not configurable (default: 1:1).
- The current transformer value range primary current is restricted.
- The low limit for measuring current cannot be adjusted (default: 50 mA).
- Energy metering is performed continuously (the gate is not enabled).
- Min/Max calculation of values is enabled (the gate is not enabled).
- 3P4W can be set in the parameters for the connection type 3P3W.
- 3P4W can be set in the parameters for the connection type 3P3W1.
- Counting of operating hours is enabled (the gate is not enabled).
- Limit value monitoring cannot be used.
- Energy meter default cannot be used.

- The user-defined payload interface cannot be used.
- The user-defined data record cannot be used.
- The separate settings for measuring the neutral current cannot be used.
- The measured value data records cannot be used.

Operation of the module on PROFINET IO

When reading data records partially from the module, please note the following:

- Measured value data record DS 142:
  - When you read the data record with a length of 240 bytes or less, the module returns the measured value data record DS 142 in version 2.
  - When you read the data record with a length of more than 240 bytes, the module returns the measured value data record DS 142 in version 3.
- Measured value data records DS 147, DS 148, DS 149:
  - When you read the data record with a length of 240 bytes or less, the module returns the measured value data record in version 0.
  - When you read the data record with a length of more than 240 bytes, the module returns the measured value data record in version 1.

Wiring

3

3.1 Terminal and block diagram

General safety instructions

⚠ WARNING

Danger to life due to electric shock

Touching live parts can lead to death or severe injuries.

Before beginning any work deenergize the system and the AI Energy Meter CT ST and short-circuit the installed current transformers.

⚠ WARNING

Danger to life, dangerous system conditions and material damage possible

Removing and inserting the AI Energy Meter CT ST under live voltage is prohibited.

If you remove and insert the AI Energy Meter CT ST under live voltage during operation, the transformers used can produce dangerous induction voltages and electric arcs and dangerous system conditions can arise.

The AI Energy Meter CT ST may only be removed and inserted during operation if the measuring voltages supplied to the BaseUnit at terminals U_{L1} , U_{L2}, U_{L3} are disconnected at all poles **and** special current transformer terminals are used that short-circuit the current transformer on the secondary side on removal.

Supplying the module

The AI Energy Meter CT ST receives its supply voltage via the terminals 17 (24 V DC) and 18 (M).

NOTE

Safe extra low voltage SELV/PELV

Ensure that all devices are connected to the SELV/PELV power supply (or equivalent).

Note the following to ensure the electrical safety of the Energy Meter and the ET 200SP station:

The voltage difference between the inputs for measuring the line voltage at the Energy Meter and the SELV/PELV supply voltages of the Energy Meter and the ET 200SP station must not exceed 300 V AC. This is guaranteed, for example, if the SELV/PELV supply is fed from the same grounded network as the voltage to be measured directly. If voltage transformers are used, they must be grounded on the secondary side.

Current transformer connection requirements

DIN VDE 0100-557 and IEC 60364-5-55 require the following for the connection of current transformers:

NOTE

Wiring current transformers

The secondary circuits of current transformers must not be grounded.

Guards must not be used in the secondary circuits of current transformers.

Protecting the connection cables

To protect the connection cables at U_{L1}, U_{L2} and U_{L3}, make sure there is adequate cable protection, especially after cross-section transitions.

If the cables are routed with short-circuit protection according to IEC 61439-1:2009, for example, in a pipe or in separate cable ducts, there is no need for separate cable protection for the AI Energy Meter CT ST.

Terminal and block diagram

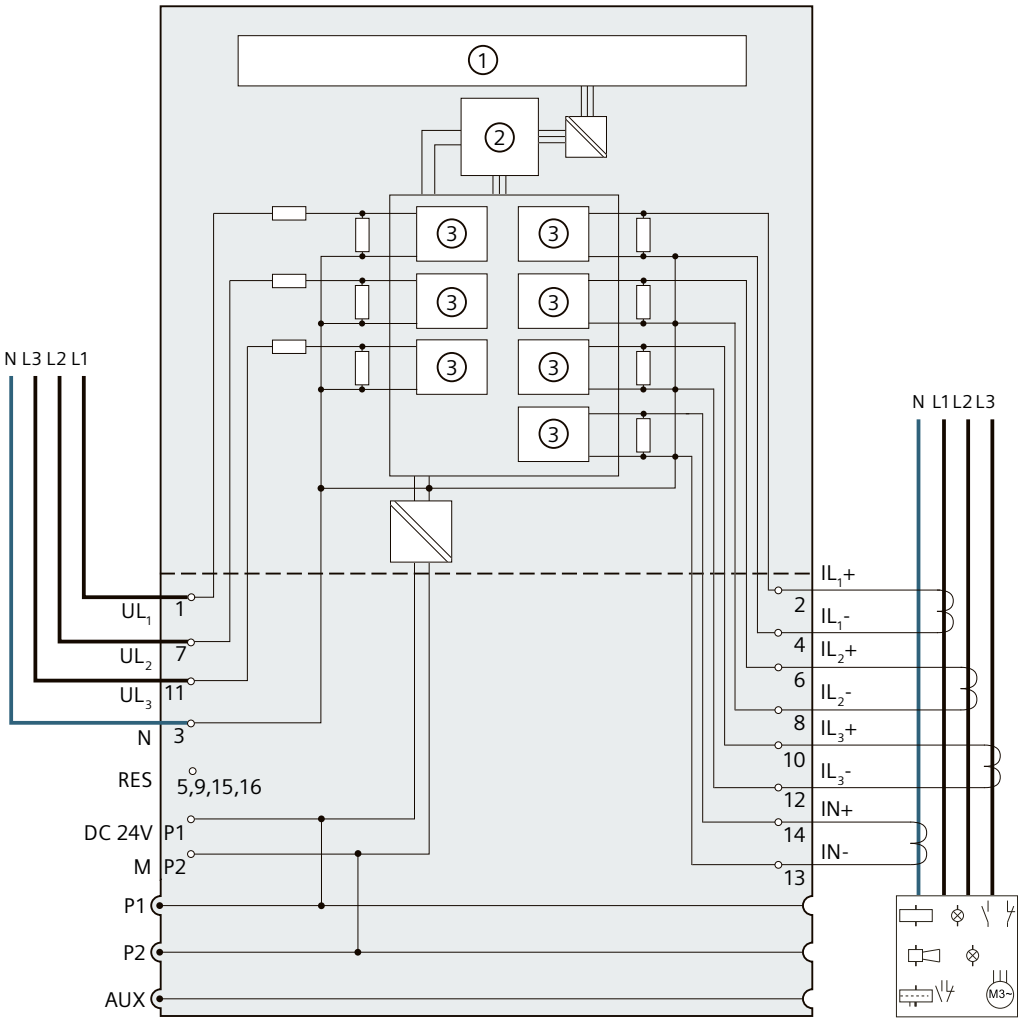

①	Backplane bus interface	UL_n	Connection voltage
②	Microcontroller	IL_n+ / IL_n-	Connection of current transformers
③	Analog-to-digital converter (ADC)	N, IN+ / IN-	Neutral
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark BaseUnit) Connection to left interrupted (light BaseUnit)	RES	Reserve, must remain unused for future function extensions

Figure 2-830 Block diagram of the AI Energy Meter CT ST

Useable BaseUnits

You can use the following BaseUnits:

- Type BU type U0 dark-colored
- Type BU type U0 light-colored

A potential group opened with a light-colored BU type U0 must contain no dark-colored BaseUnit of BU type A0 or A1.

Connection types

The AI Energy Meter CT ST supports the following connection types:

- 3P4W1, 3 phases, 4 conductors, balanced load
- 3P4W, 3 phases, 4 conductors
- 2P3W, 2 phases, 3 conductors
- 1P2W, 1 phase, 2 conductors
- 3 x 1P2W, 3 x 1 phase, 2 conductors
- 3P3W, 3 phases, 3 conductors
- 3P3W1, 3 phases, 3 conductors, balanced load

The input circuit of the module must correspond to one of the listed connection types. Select the appropriate connection type for the intended use.

You will find examples of connections in the section Connection examples (Page 23).

Information on the selection of a current transformer is available in the section Data for selection of a current transformer (Page 27).

3.2 Connection examples

The following figures show the connection of the AI Energy Meter CT ST for three-phase, two-phase and single-phase measurements. Note that the AI Energy Meter CT ST must always be connected via a current transformer. The use of voltage transformers is optional.

Connection type	Wiring diagram	Comment
3P4W Three-phase measurement, 4 wires	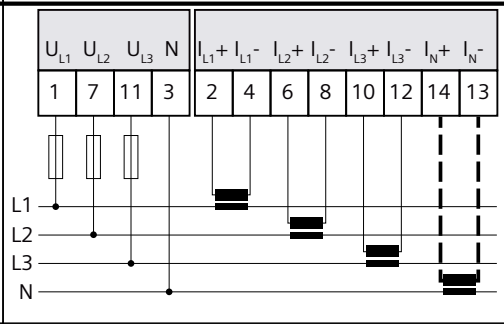	Any load Connection with three current transformers

Connection type	Wiring diagram	Comment
3P4W Three-phase measurement, 4 wires	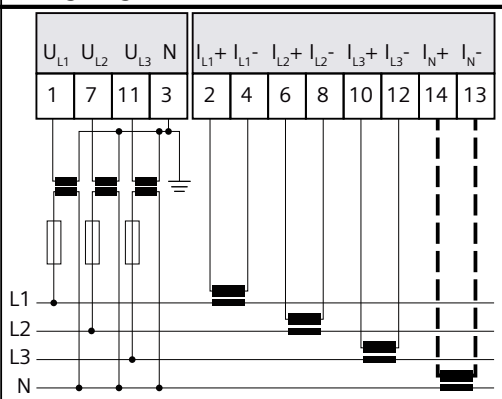	Any load Connection with three current transformers and three voltage transformers.
3P4W1 Three-phase measurement, 4 wires	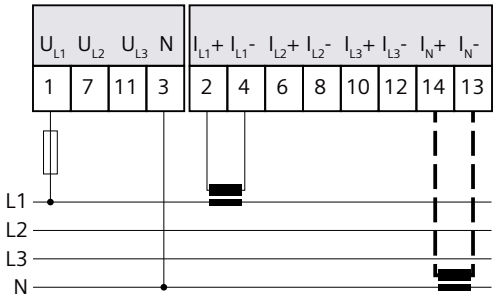	Balanced load Connection with one current transformer
3P4W1 Three-phase measurement, 4 wires	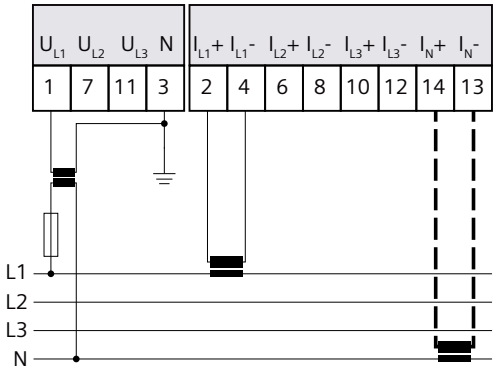	Balanced load Connection with one current transformer and one voltage transformer.
2P3W Two-phase measurement, 3 conductors	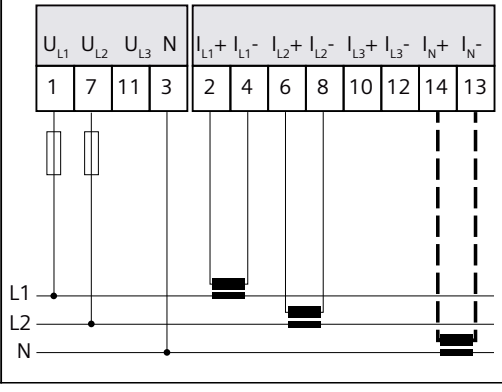	Any load Connection with two current transformers The phase position L1-L2 is arbitrary. AI Energy Meter CT ST supplies the value "0" for all measured values of Phase 3 as well as for some cross-phase measured values.

Connection type	Wiring diagram	Comment
2P3W Two-phase measurement, 3 conductors	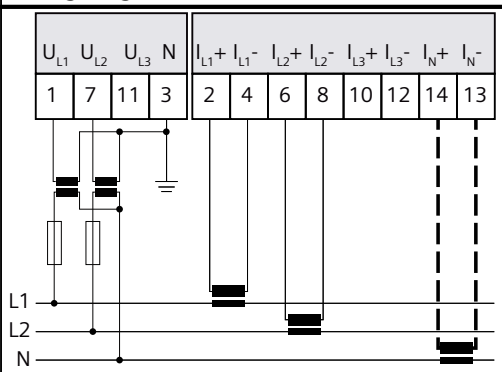	Any load Connection with two current transformers and two voltage transformers. AI Energy Meter CT ST supplies the value "0" for all measured values of Phase 3 as well as for some cross-phase measured values.
1P2W Single-phase measurement, 2 conductors	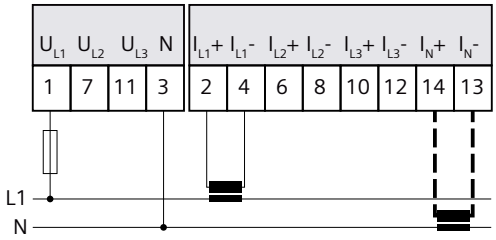	Measurement in an AC network with a current transformer. AI Energy Meter CT ST supplies the value "0" for all measured values of Phase 2 and 3 as well as for some cross-phase measured values.
1P2W Single-phase measurement, 2 conductors	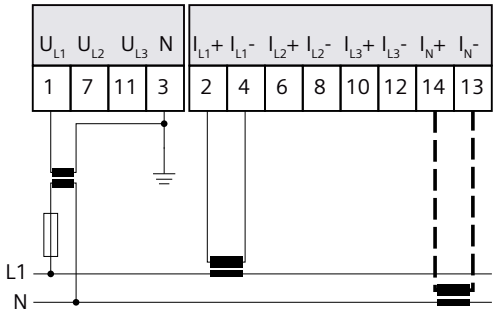	Measuring the load in an AC network with one current transformer and one voltage transformer. AI Energy Meter CT ST supplies the value "0" for all measured values of Phase 2 and 3 as well as for some cross-phase measured values.
3 x 1P2W 3 x single-phase measurement	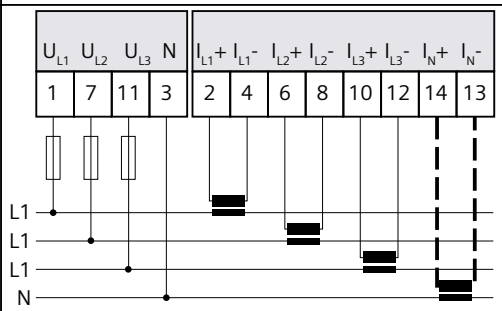	Measurement with three current transformers for any three loads that are each connected to one of the three phases. To reduce the number of fuses used, the voltage phases can also be bridged behind a fuse.
3 x 1P2W 3 x single-phase measurement		Measurement with three current transformers and three voltage transformers for any three loads that are each connected to one of the three phases. To reduce the number of fuses used, the voltage phases can also be bridged behind a fuse.

Connection type	Wiring diagram	Comment
3P3W Three-phase measurement	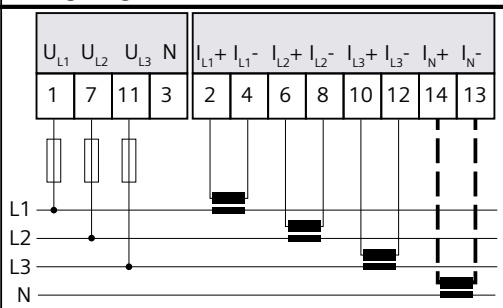	Any load Connection with three current transformers
3P3W Three-phase measurement	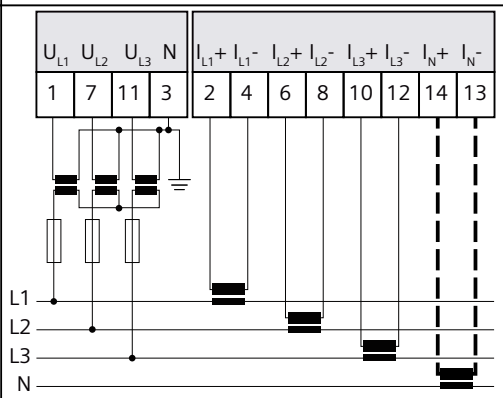	Any load Connection with three current transformers and three voltage transformers.
3P3W1 Three-phase measurement	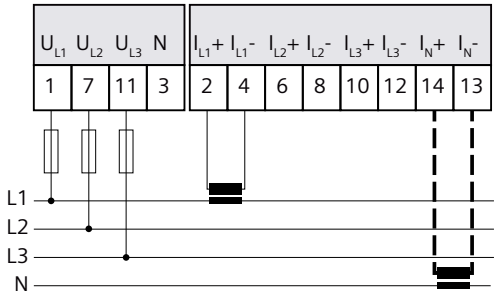	Balanced load Connection with one current transformer
3P3W1 Three-phase measurement	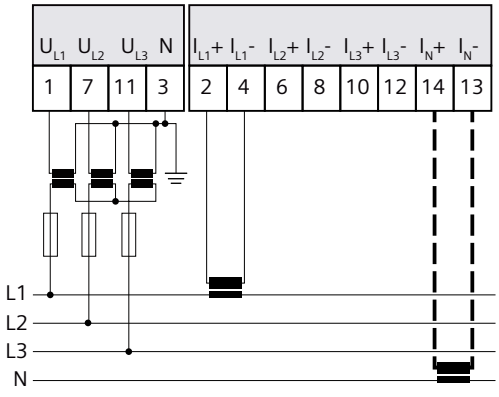	Balanced load Connection with one current transformer and one voltage transformer.

Current transformer connection requirements

DIN VDE 0100-557 and IEC 60364-5-55 require the following for the connection of current transformers:

- However, if it mandatory to ground the secondary circuits of the current transformers; voltage transformers must be used to separate neutral conductor / neutral point and the protective conductor. Alternatively, the voltage measurement must be omitted.
- The insulation of the secondary cables of transformers must be designed for the highest voltage of all active components, or the secondary cables must be installed in such a way that their insulation cannot touch any active components, such as busbars.
- Connection points must be provided for temporary measurements.

3.3 Current transformer selection data

Introduction

Connection via a current transformer is always required for the current measurement. Use toroids with an accuracy class of 0.5, 1 or 3.

Dimensioning of the current transformer

The correct dimensioning of the current transformer is important for the following reasons:

- You achieve correct results from the measurements and
- You do not overload or damage the current transformers.

Selecting a current transformer

Use current transformers with a burden capacity 1.5 to 2 times greater than the power dissipation in the terminal circuit (consisting of resistance of the connection cables and burden of the AI Energy Meter CT ST). 1.5 times the power loss is required in order to prevent the transformer from overloading. 2 times the power dissipation is important to ensure the current limiting in case of a short-circuit. The burden capacity of the terminal circuit, in turn, must be at least 25% of the rated burden of the transformer in the working point. This is the only way for you to operate the transformer with the specified accuracy.

Maximum length of the connection cable

To avoid overloading or damaging the current transformer, the burden Z_n specified on the data sheet of the current transformer (in VA) must not be exceeded. To prevent this being exceeded, the entire burden resistance (consisting of the resistance of the connection cable and the internal resistance of the AI Energy Meters CT ST (see figure below) must be below a certain resistance value (depending on Z_n and I_{max}).

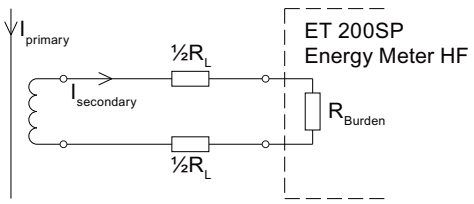

Figure 2-831 Maximum length of the connection cable

The maximum value of the resistance of the connection cable is obtained with the following formula:

$$R_{L,\,max} = \frac{Z_n}{I_{max}^{\ 2}} - R_{burden}$$

R_L	Cable resistance in ohms	I_{max}	Secondary current of the current transformer
Z_n	Rated burden current transformer in VA	R_{burden}	Resistance of the AI Energy Meter CT ST (25 mΩ)

Figure 2-832 Maximum value for the resistance of the connection cable

Based on the maximum cable resistance in ohms, you then calculate the maximum length of the connection cable. To do this, check the data sheet of the connection cable you are using.

NOTE

The length of the connection cable (outwards and return) must not exceed the value of 200 meters.

Example: Usage of a current transformer 500/5 A

You use a current transformer with a transmission ration of 500/5 A that has a rated burden Z_n of 5 VA according to the data sheet.

The maximum primary current in the application amounts to 400 A. This means that the maximum secondary current $I_{max.}$ amounts to 4 A. The burden of the AI Energy Meter CT ST including connection resistance amounts to R_{Burden} = 25 mΩ.

The maximum value of the resistance of the connection cable (outgoing and incoming line) is obtained using the following formula:

$$R_{L,\,max} = \frac{Z_n}{I_{max}^{\ 2}} - R_{Burden} = \frac{5\ AV}{16\ A^2} - 25\ m\Omega = 312.5\ m\Omega - 25\ m\Omega = 287.5\ m\Omega$$

The maximum cable resistance between the transformer and the terminals of the AI Energy Meter CT HF may not exceed 287.5 mΩ in this case. The corresponding cable length (outgoing and incoming line) depends on the cross-section used of the copper line and can be determined by using the following table.

The following table shows the resistance values of copper cables for typical cross-sections with ρ = 0.017857 Ω x mm²/m

Estimating the length for a connection cable

The value in the table must be less than the calculated terminal resistance $R_{L\ max}$ of the cable. For the resistance R_{Lmax} of 287.5 mΩ used in the above example it is possible to use a connection cable (outgoing and incoming line) with a length of 10 m from a cross-section of 0.75 mm² upward.

Cross-section	AWG	Cable overview for copper				
		0.5 m	1 m	5 m	10 m	50 m
0.25 mm²	24	35.7 mΩ	71.4 mΩ	357.1 mΩ	714.3 mΩ	3571.4 mΩ
0.34 mm²	22	26.3 mΩ	52.5 mΩ	262.6 mΩ	525.2 mΩ	2626.0 mΩ
0.5 mm²	21	17.9 mΩ	35.7 mΩ	178.6 mΩ	357.1 mΩ	1785.7 mΩ
0.75 mm²	19/20	11.9 mΩ	23.8 mΩ	119.0 mΩ	238.1 mΩ	1190.5 mΩ
1.0 mm²	18	8.9 mΩ	17.9 mΩ	89.3 mΩ	178.6 mΩ	892.9 mΩ
1.5 mm²	16	6.0 mΩ	11.9 mΩ	59.5 mΩ	119.0 mΩ	595.2 mΩ
2.5 mm²	14	3.6 mΩ	7.1 mΩ	35.7 mΩ	71.4 mΩ	357.1 mΩ

Checking the ratio of burden load and power loss

The rated burden of the transformer must be 1.5 to 2 times greater than the power loss in the connection circuit to ensure that the transformer is not overloaded and that the current limitation is ensured during a short-circuit.

At a maximum secondary current of 4 A the power loss in the connection circuit is calculated in accordance with the following formula for a connection cable (outgoing and incoming line) with a length of 10 m and a cross-section of 1.0 mm² and a burden resistance of the AI Energy Meter CT ST of 25 mΩ:

$$P_{Connection\ circuit} = (R_{Connection\ cable} + R_{Burden}) \times I^2_{Max.\ secondary}$$

$$P_{Connection\ circuit} = (178.6\ m\Omega + 25\ m\Omega) \times 4^2\ A^2\ 3.26\ W$$

The ratio of the rated burden and the power loss in the connection circuit thus amounts to:

$$\frac{Z_{N\ rated\ burden}}{P_{Connection\ circuit}} = \frac{5\ VA}{3.26\ W} = 1.54$$

The required ratio of rated burden and power loss in the connection circuit lies within the required range. The transformer is dimensioned sufficiently large.

See also

Technical specifications (Page 110)

Configuration / address space

4

4.1 Configuring

Introduction

To configure the AI Energy Meter CT ST after connecting it, use configuration software such as STEP 7 (TIA Portal). In addition, you can also change numerous parameters of the AI Energy Meter CT ST in RUN via the user program.

Configuring

You configure the AI Energy Meter CT ST with:

- STEP 7 (TIA Portal) V16 or higher and HSP0335
- GSD file for PROFIBUS or PROFINET

NOTE

Consistency check of the parameter assignment only with STEP 7

If you configure the AI Energy Meter CT ST using STEP 7 (TIA Portal), STEP 7 (TIA Portal) already checks the various parameters for consistency while they are being entered.

If you configure the AI Energy Meter CT ST using a GSD file, a consistency check is not performed. The module does not recognize incorrect entries until after the parameter data record has been transferred. If the module recognizes an invalid parameter, the module rejects the complete data record.

Preferably use STEP 7 (TIA Portal) to configure the AI Energy Meter CT ST.

The following instructions show the theoretical procedure for configuring the AI Energy Meter CT ST with STEP 7 (TIA Portal) V16 or higher with HSP0335.

1. Select the ET 200SP distributed I/O system you are using in the hardware catalog.
2. Insert the module into your station.
3. Open the device view of the ET 200SP and insert the AI Energy Meter CT ST.
4. Configure the AI Energy Meter CT ST to suit your requirements.

   Once the configuration has been compiled without errors, you can download the configuration to the CPU and commission the ET 200SP station while the AI Energy Meter CT ST is running.

4.2 Selecting the module versions

Introduction

The AI Energy Meter CT ST has different module versions.

During the configuration, you use the selection of the module version to specify which measured values can be read.

Each module version supplies quality information via the input payload.

With the exception of the module version "2 I / 2 Q", you can read the measured values as payload cyclically from the process image. At each module variant you have the option to read measured value records from the AI Energy Meter CT ST by using the RDREC instruction asynchronously.

Influence of the module version on the address space

NOTE

Influence of the AI Energy Meter CT ST on the maximum configuration of the ET 200SP

The available address space of the ET 200SP is influenced by the following factors:

- CPU or interface module
- Plugged I/O modules

The address space made **additionally** available by the AI Energy Meter CT ST is essentially influenced by the length of the payload supplied. The module variant determines the length of the payload, which can be supplied by the AI Energy Meter CT ST at maximum.

4.2.1 Module versions at configuration with STEP 7

Module versions with fixed payload assignment

Module version	Payload	Address space	Comment
2 I / 2 Q	No cyclic payload. Access to measured values through "Read data record".	2-byte inputs 2-byte outputs	Information about the structure of the 2 I / 2 Q module version is available in the appendix "2 I / 2 Q" module version (Page 148).
EE@Industry E0	Payload in accordance with EE@Industry measurement data profiles	12-byte inputs / 20-byte outputs	Information about the structure of the EE@Industry measured data profiles is available in the appendix Module version "EE@Industry measured data profile E0 / E1 / E2 / E3" (Page 159).
EE@Industry E1		4-byte inputs / 20-byte outputs	
EE@Industry E2		12-byte inputs / 20-byte outputs	
EE@Industry E3		104-byte inputs / 20-byte outputs	

Module versions with selectable payload variants

Module version	Payload	Address space	Comment
32 I / 20 Q	Payload selectable through defined payload variants	32-byte inputs / 20-byte outputs	You can change over the payload variant during operation. Information about the structure of the 32 I / 20 Q module version is available in the appendix "32 I / 20 Q" module version (Page 150). Information about the payload variants at 32 I / 20 Q is available in appendix Payload variants with 32 bytes input / 20 bytes output data (Page 161).
User-specific	Payload selectable through payload mapping or through defined payload variant.	variable* / 20-byte outputs	You have to activate the check box "Payload-mapping" (payload-mapping) in STEP 7 to use the module version user-specifically. You can change over the payload variant during operation. Information about the structure of the user-specific module version is available in the appendix "User-specific" module version (Page 157).

* 16 ... 256 bytes in steps of 16 bytes, depending on the mapped measured values

4.2.2 Module versions at configuration with GSD file

Module versions with fixed payload assignment

Module version	Payload	Address space	Comment
2 I / 2 Q	No cyclic payload. Access to measured values through "Read data record".	2-byte inputs 2-byte outputs	Information about the structure of the 2 I / 2 Q module version is available in the appendix "2 I / 2 Q" module version (Page 148).
E0	Payload in accordance with EE@Industry measurement data profiles	12-byte inputs / 20-byte outputs	Information about the structure of the EE@Industry measured data profiles is available in the appendix Module version "EE@Industry measured data profile E0 / E1 / E2 / E3" (Page 159).
E1		4-byte inputs / 20-byte outputs	
E2		12-byte inputs / 20-byte outputs	
E3		104-byte inputs / 20-byte outputs	

Module versions with selectable payload variants

Module version	Payload	Address space	Comment
32 I / 20 Q	Payload selectable through payload variants or	32-byte inputs / 20-byte outputs	You can change over the payload variant during operation.

*Ensure that the payload does not exceed the size of the address space of the module version. If necessary, use a module version with a larger address space

Module version	Payload	Address space	Comment
64 I / 20 Q	through user-specific payload*	64-byte inputs / 20-byte outputs	If you use user-specific payload, you write your measured value profile into the AI Energy Meter CT ST with the data record 130. To do this use the WRREC instruction. Information about the structure of data record 130 is available in appendix Structure of the parameter data records 130 for payload mapping (Page 130).
128 I / 20 Q		128-byte inputs / 20-byte outputs	
256 I / 20 Q		256-byte inputs / 20-byte outputs	

*Ensure that the payload does not exceed the size of the address space of the module version. If necessary, use a module version with a larger address space

4.2.3 Changing over the user data variant during operation

Introduction

You change the payload variant in the output data of each payload variant in byte 0.

The following figure shows to which payload you can change over at various module versions during operation.

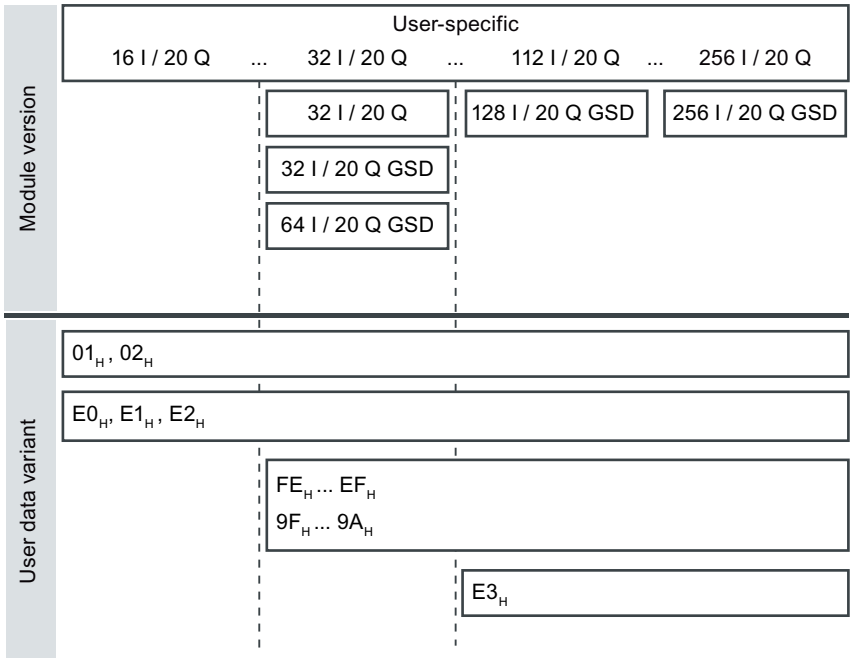

Figure 2-833 Possible payload variants

Requirement

- User program has been created.
- AI Energy Meter CT ST is configured as one of the module versions mentioned in the figure above.
- The start address of the module is known in the process image output.

Procedure

1. Create one constant with the data type BYTE per payload variant.
2. Enter the payload ID as a value in each case.
3. Write the constant to the start address of the module in the process image output.

Result

The payload variant is switched with the next cycle.

NOTE
Information about payload changeover
The parameterized payload variant is set in the following cases:

- A "0" is written in byte 0 in the output data of a payload variant.
- Byte 0 in the output data of a payload variant contains an invalid value:
  - Coding of the payload variant not available
    or
  - Available address space is not sufficient for the selected payload variant.

4.2.4 Recommendations for selecting the module version

The following table shows which module version is suitable for a given purpose.

Module version	Application	Note
2 I / 2 Q	• Use of many AI Energy Meter CT ST in an ET 200SP or when little address space is available	• Read the measured values solely via the RDREC instruction from a measured value data record. • Quality information about the measured values is always available.
EE@Industry measurement data profile E0 / E1 / E2 / E3	• Cyclic measurement per phase • Supplied measured values in accordance with the EE@Industry measured data profile	• Available measured values depend on the configured measurement data profile. • The payload are fixed and cannot be changed dynamically. Alternatively, read the measured values acyclically from a measured value data record via the RDREC instruction. • No quality information

Module version	Application	Note
32 I / 20 Q	• Cyclic measurement per phase • Flexibility by switching pre-defined payload variants	• Quality information about the measured values is always available. • Depending on the payload variant, you must convert the measured values in the CPU to physical values using the supplied scaling factor. • One cycle elapses for each payload changeover. Measured values from the next payload variant are thus supplied with a slight time offset. Alternatively, read the measured values acyclically from a measured value data record via the RDREC instruction. Consistent measured values of a measuring cycle are supplied.
User-specific	• Cyclic measurement of up to 64 measured values configurable • Flexibility by switching pre-defined payload variants	
With GSD configuration • 32 I / 20 Q • 64 I / 20 Q • 128 I / 20 Q • 256 I / 20 Q		

4.3 Applicable modules

Configuring with STEP 7

The following table shows with which controllers the different module versions can be configured with STEP 7.

Table 2-934 Module versions configured with STEP 7

Controller	Module version						
	2 I / 2Q	32 I / 20 Q	User-specific	EE@Industry measurement data profile			
				E0	E1	E2	E3
IM 155-6 PN ST	V3.3 or higher						
IM 155-6 PN HF *	V3.1 or higher						
IM 155-6 PN BA	V3.2 or higher		---	V3.2 or higher			---
IM 155-6 PN HS	V4.0 or higher		---	V4.0 or higher			
IM 155-6 DP HF	V3.0 or higher		---	V3.0 or higher			---
CPU 1510SP-1 PN**	V1.6 or higher		V1.6 or higher*** V2.0 or higher	V1.6 or higher			V2.0 or higher
CPU 1510SP F-1 PN**	V1.7 or higher		V1.7 or higher*** V2.0 or higher	V1.7 or higher			V2.0 or higher
CPU 1512SP-1 PN**	V1.6 or higher		V1.6 or higher*** V2.0 or higher	V1.6 or higher			V2.0 or higher
CPU 1512SP F-1 PN**	V1.7 or higher		V1.7 or higher*** V2.0 or higher	V1.7 or higher			V2.0 or higher
CPU 1515SP PC**	V1.7 or higher		V1.7 or higher*** V2.0 or higher	V1.7 or higher			V2.0 or higher

** Function setting the time as of V4.2

** Function setting the time is not possible

*** Up to a max. of 32 bytes input

Configuring with GSD file

The following table shows with which controllers the different module versions can be configured using a GSD file.

Table 2-935 Module versions configuring with GSD file

Controller	Module version						
	2 I / 2Q	32 I / 20 Q	64 I / 20 Q 128 I / 20 Q 256 I / 20 Q	EE@Industry measurement data profile			
				E0	E1	E2	E3
IM 155-6 PN ST	V3.3 or higher						---
IM 155-6 PN HF	V3.1 or higher						---
IM 155-6 PN BA	V3.2 or higher		---	V3.2 or higher			---
IM 155-6 PN HS	V4.0 or higher		---	V4.0 or higher			---
IM 155-6 DP HF	v4.2 or higher		---	v4.2 or higher			---

Compatibility 5

5.1 Compatibility of modules

Compatibility

The module versions "AI Energy Meter CT ST" and "AI Energy Meter CT HF" are compatible. All module versions can run on the respective other configuration, whereby the CT and RC functionality cannot be swapped.

If you exchange or replace an AI Energy Meter, the following table shows the compatibilities.

	Energy Meter configured		
Energy Meter inserted	**AI Energy Meter CT ST**	**AI Energy Meter CT HF**	**AI Energy Meter 480 VAC CT HF**
AI Energy Meter CT ST	Yes	Yes*	Yes*
AI Energy Meter CT HF	Yes*	Yes	Yes**
AI Energy Meter 480 VAC CT HF	No	No	Yes

*In this case, the module only supports ST functions.

** In this case, the function measured value recorder cannot be configured. The measured values of the following IDs cannot be selected by configuration in the limit value monitoring or in the user-definable data records/payload: 61130, 61131, 61132, 61133, 61134, 61135, 61136, 61137, 61159, 62132, 62135, 62193, 62232, 62235, 62293, 62332, 62335, 62393.

NOTE

The smallest component from configuration and module type determines the resulting scope of functions. This means the ST functionality is supported when either an ST configuration is available, or the ST module is used. An HF functionality, therefore, is only available in case of an HF configuration and HF module.

NOTE

When you install an ST module and use an HF configuration, you must disable the following functions:

- Power quality analysis functions
- Residual current analysis
- Diagnostics power quality
- Overcurrent, detect voltage swell and dip
- Detect peak values of current and voltage
- Harmonics analysis

Quick start

6

Introduction

This section shows you how to read and view your first measured values on the AI Energy Meter CT ST in a particularly quick and easy way.

Requirement

You have already connected the AI Energy Meter CT ST to your network with one of the connection types shown in the section Connecting (Page 20). The AI Energy Meter CT ST has already been integrated into your configuration tool (such as STEP 7), or the AI Energy Meter CT ST has been integrated in the hardware catalog of your configuration tool with the GSD file.

Procedure

1. Configure an ET 200SP station

   Configure an ET 200SP station with a CPU 151xSP or an IM 155-6.

2. Plug module in ET 200S station

   Plug the AI Energy Meter CT ST into the ET 200SP station and use the module variant with 32-byte inputs and 20-byte outputs.

3. Set the module parameters

   Set the following parameters for the AI Energy Meter CT ST:

   – Connection type that you have used for the AI Energy Meter CT ST (e.g. 3P4W)
   – Voltage measuring range
   – Frequency of your network (for example 50 Hz)
   – Nominal value current and nominal value voltage for the phases
   – Primary and secondary current of the used current transformer (e.g. 100 A and 1 A)
   – Primary and secondary voltages of the used voltage transformer (e.g. 230 V and 230 V)

   Leave all other parameters at their default settings and do not change them.

4. Load configuration

   Switch on the ET 200SP station and download the configuration to the CPU.

Result

After being switched on, the AI Energy Meter CT ST supplies the measured values for the "Total power L1L2L3" payload variant with the ID 254 or FE_H.

Read and check the measured values provided by the AI Energy Meter CT ST in the input data.

The table below shows the structure of the user data variant, the measured variables and the data type of the measured values in STEP 7 (TIA Portal) that are stored in the 32 bytes of output data of the module. Each measured variable is referenced via the measured value ID. An overview of all the measured variables with their measured value IDs is provided in the section Measured variables for connection type.

Table 2-936 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
10 ... 11	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038
12 ... 13	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
14 ... 17	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647 to +2147483647	225
18 ... 21	Total reactive energy L1L2L3 (Int32)	DINT	1 varh	-2147483647 to +2147483647	226
22	Reserved	BYTE	-	0	-
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Additional information

If you require further information about the evaluation and interpretation of the measured values, please refer to the section Reading out and processing measured values (Page 41).

Reading and processing measured values 7

7.1 Basics for reading measured values

Introduction

The AI Energy Meter CT ST provides the measured values and variables through the following methods:

- Cyclic: Payload
- Acyclic: Measured value data records

Payload

Payload provide pre-defined or user-defined measured values depending on the configured payload variant. The supplied measured values are cyclically written to the process image of the CPU. With some payload variants, the measured values are supplied as raw data, which you have to convert to the corresponding physical values using a supplied scaling factor.

Measured value data records

Each measured value data record supplies physical values that you can further process immediately. You read the values of a measured value data record acyclically with the RDREC instruction in a PLC tag. You need a corresponding PLC tag for each measured value data record to be read. It is also possible to create the corresponding structure in the static variables of an FB or store this structure in a DB.

You can display the read measured values in a watch table in STEP 7.

NOTE

If you are using CPUs other than S7-1200 or S7-1500, convert 64-bit measured values to 32-bit measured values. Note the conversion can cause loss of accuracy.

For more information, read FAQ: Processing 64-bit floating-point numbers in S7-300/400 (https://support.industry.siemens.com/cs/ww/en/view/56600676).

Validity of the measured values

After turning on the 24 V DC supply voltage, the first measured values are available at terminal 17 after approximately 2 seconds. In the input payload, the content of byte 0 is set to the selected payload variant. You can use this change in byte 0 as a trigger event.

As soon as the module has valid measured values, the value of this byte changes to a value within the value range.

Initial module startup

After the first startup or restart of the module, the parameters are transferred to the module. You can preset a payload variant in the parameters of the hardware configuration. This remains in effect until a different payload variant is selected in the output data (byte 0). This allows input payload to be modified dynamically according to the requirements of the process.

The payload variant defined in parameter data record 128 or configuration tool is used under the following conditions:

- A "0" is written in byte 0 in the output data of a payload variant.
- Byte 0 in the output data of a payload variant contains an invalid value:
  - Coding of the payload variant not available, or
  - Available address space is not sufficient for the selected payload variant.

    See "Selecting the module version (Page 31)".

Current measured values become "0"

The current and all other measured values based on it are suppressed (or set to "0") in the data records and in the payload in the following cases:

- The fed-in current of the current transformer is less than the configured "Low limit for measuring current in relation to nominal value current [0.1%]" parameter.
- Fed-in secondary current at the channel is higher than 12 A.

Among others, the following measured values and derived measured variables of the phase involved become "0":

- Effective current value
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A floating mean value is formed from the power values. These only become "0" after a corresponding time. The operating hours counter and the energy meter for active, reactive and apparent energy of the reset phase stops counting.

General reset

With module versions with 20 bytes of output data you can reset some measured values and counter levels.

An edge change of 0 -> 1 at the bit for the general reset has the following effect:

- Counters for energy, operating hours and limits start at "0" again.
- Minimum and maximum value calculation starts again with initial values.
- Measured values of the measured value recorder are deleted.

For the general reset, set bit 7 in byte 16 of the output payload. (Page 150)

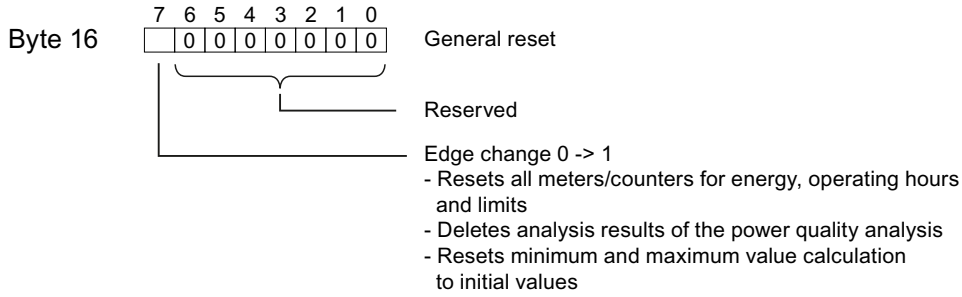

Figure 2-834 Control byte 16 in the output payload for general reset

Substitute value behavior

The substitute values for input values of the AI Energy Meter CT ST are "0".

See also

Reading measured values from user data cyclically (Page 49)

7.2 Quality information

Use the quality information to evaluate the status for currents, voltage, operating quadrants and the rotating field.

The AI Energy Meter CT ST provides quality information:

- In byte 1 of the payload
- In measured value IDs 65500 to 65503

See also

Module version "32 I / 20 Q" (Page 150)

7.2.1 Quality information in byte 1 of the user data

For all user data variants, the module provides brief quality information in an 8-bit field in byte 1 for:

- Currents (I_{L1}, I_{L2}, I_{L3})
- Voltages (U_{L1}, U_{L2}, U_{L3})
- Operating quadrant for a phase

Please note that quality information assignment with user data variants for phase-specific measurement (ID 154 to ID 159) is different from user data variant assignment for 3-phase measurement (ID 244 to ID 254).

Quality information in byte 1 of the user data for 3-phase measurement

The quality information for 3-phase measurement is provided by the module in user data variants ID 244 to ID 254.

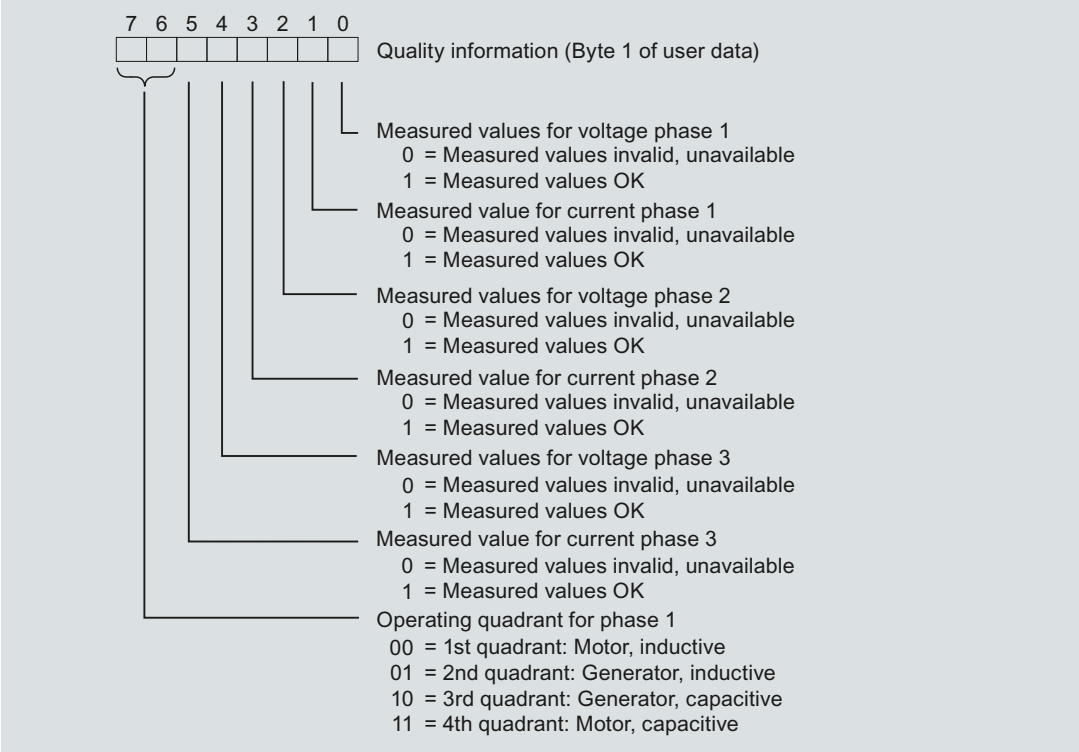

Figure 2-835 Assignment of byte 1 for user data variants ID 224 to ID 254

Quality information in byte 1 for phase-specific measurement

The quality information for phase-specific measurement is provided by the module in user data variants ID 154 to ID 159.

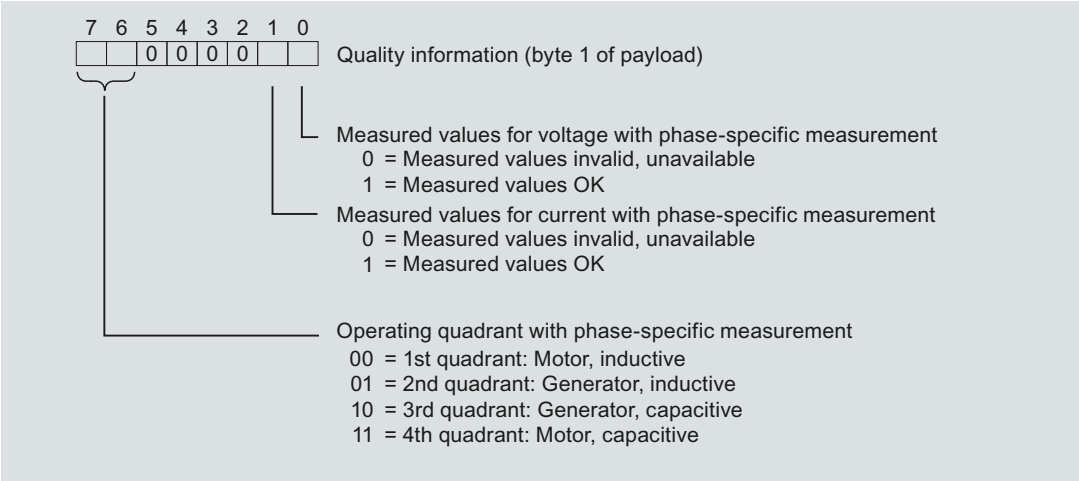

Figure 2-836 Byte 1 assignment for user data variants ID 154 to ID 159

7.2.2 Quality information with measured value IDs

Complete quality information is provided by the module in a 16-bit field with measured value IDs 65500 to 65503.

- Measured value ID 65503 for 3-phase measurement
- Measured value ID 65500, 65501 or 65502 for phase-specific measurement in phase 1, phase 2 or phase 3

Quality information with measured value ID 65503 for 3-phase measurement

The quality information for 3-phase measurement is provided by the module with:

- User data variant "Basic variables quality values three-phase measurement (ID 240 or $F0_H$)"
- User data (measured value ID 66503)
- Measured value data record 150

The measured value ID 65503 provides information on:

- Currents (I_{L1}, I_{L2}, I_{L3})
- Voltages (U_{L1}, U_{L2}, U_{L3})
- Operating quadrants for all 3 phases
- Rotating field for the 3-phase system

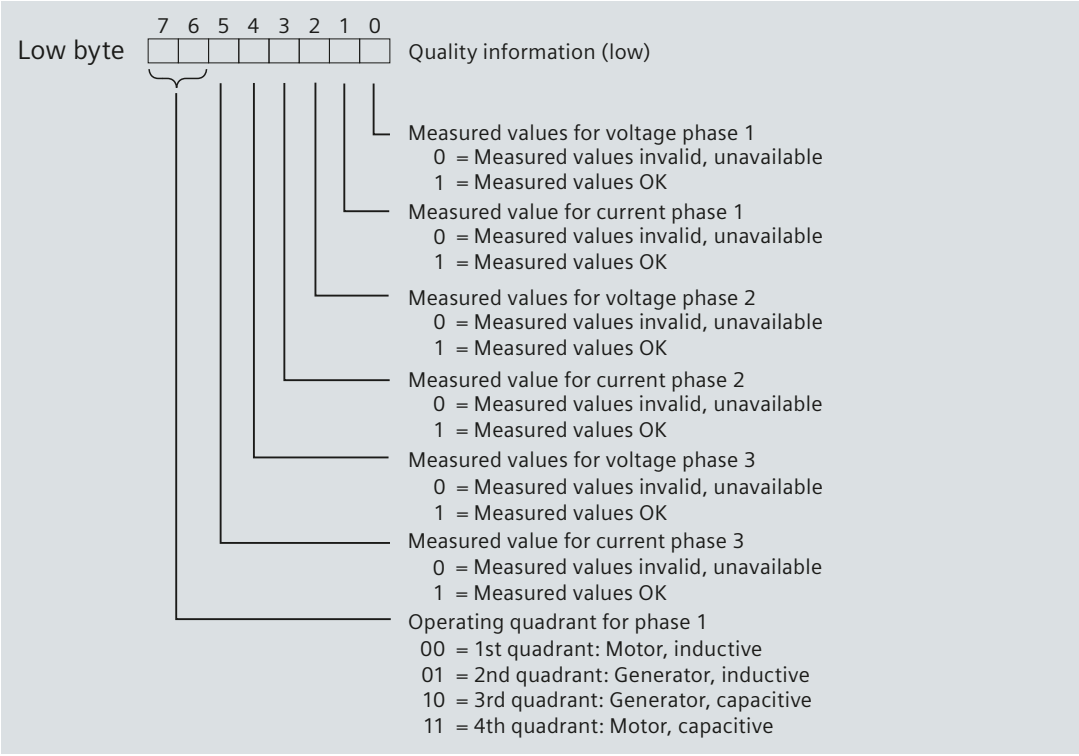

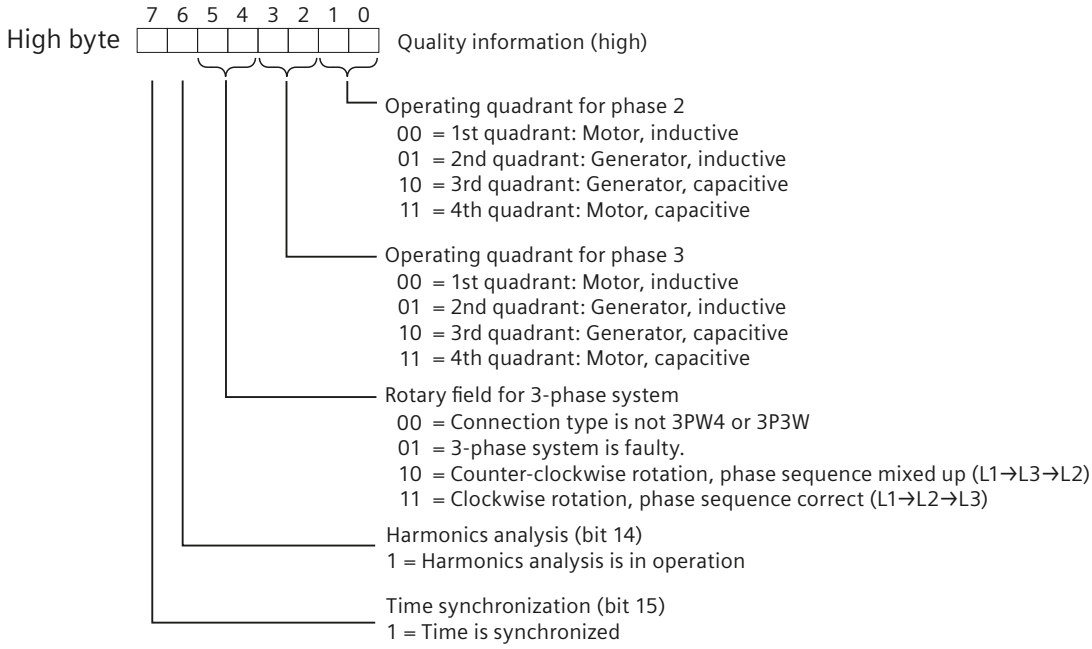

Figure 2-837 Quality information for low and high byte of the measured value ID 65503

Quality information with measured value ID 65500, 65501 or 65502 for phase-specific measurement

The module provides quality information for phase-specific measurement in phase 1, phase 2 or phase 3 with:

- User data (with measured value ID 65500, 65501 or 65502)
- Measured value data record DS 147, 148 or 149

Measured value IDs 65500, 65501 and 65502 provide information on:

- Current of the phase in question
- Voltage of the phase in question
- Operating quadrant of the phase in question

In contrast to the assignment for measured value ID 65503 (figure above), measured value IDs 65500, 65501 and 65502 only contain the phase-specific information for current, voltage and operating quadrant. The information about the other phases and the rotating field have the value 0.

7.2.3 Operating quadrant

The figure below shows the quality information of the operating quadrants.

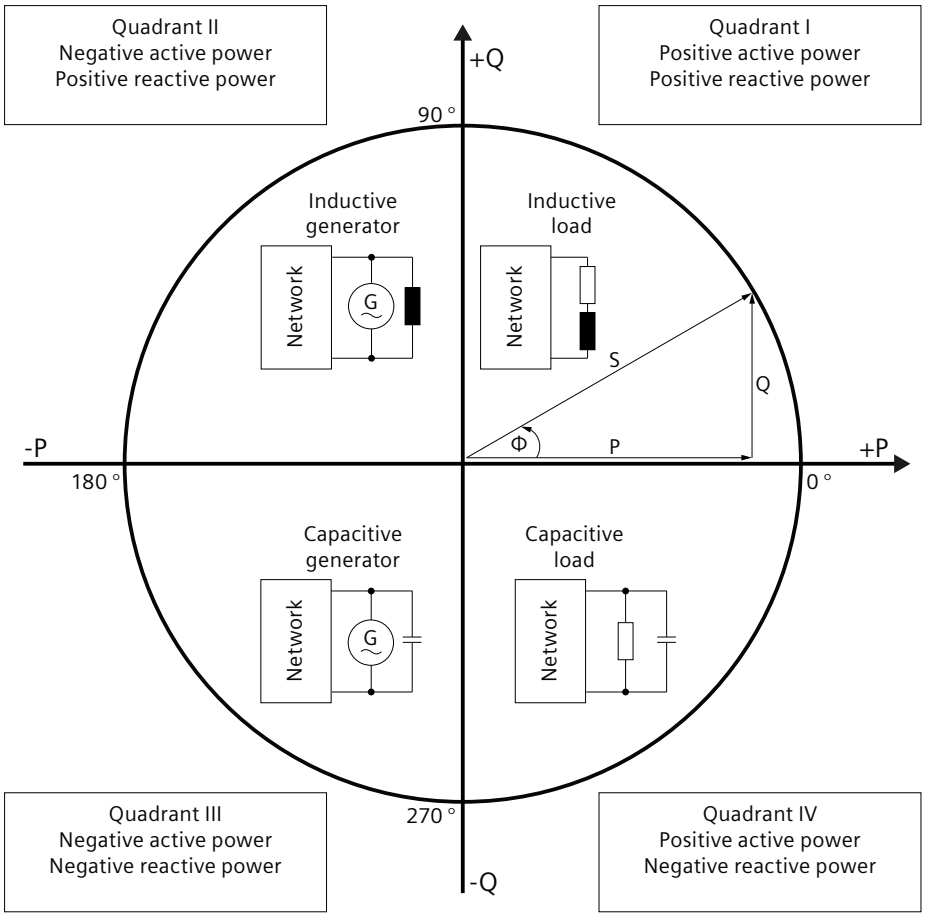

Figure 2-838 Quadrant in the quality bits

7.2.4 Notes for the detection of wiring errors and incorrect rotating field

A variety of quality information is available to evaluate the correct wiring of the Energy Meter and the applied rotary field.

Requirement

Detecting the rotating field requires 3-phase operation with 3P4W or 3P3W connection types.

In byte 1 of the payload, section 7.2.1 or measured value IDs 65500-65503, section 7.2.2

Information on the validity of the measured currents and voltages is encoded in bits 0 to 5.

Information on the operating quadrants is encoded in the bits 6 to 7, see section 7.2.3 (Page 47)

Phase angle between voltages and currents, measured value phase angle Ln

Based on the phase angle, you can recognize whether the flow direction of the current is correct and whether the voltage or current connections have been swapped. You cannot recognize, however, which phases are swapped and how. If the wiring is correct, the phase angle for the consumer must be in the range from 270° to 359° or -0° to -90°. For generators, the phase angle with correct wiring is in the range from 90° to 270° or -180° to -90°.

Angle between the voltages, measured value phase angle ULx-ULy

Based on the phase angle between the voltages, you can check the correct phase sequence and detect an unwanted same-phase connection.

In a symmetrical three-phase network, the angle between the phase voltages is +120°(-240°) or -120°(+240°).

Angle between currents, measured value phase angle ILx-ILy

Based on the phase angle between the currents, you can check the correct phase sequence and flow direction as well as detect an unwanted same-phase connection.

For a symmetrical load, the phase angles between the currents are identical to those between the voltages.

Line-to-line voltage, measured value ULx-ULy

You can detect an unwanted same-phase connection using the line-to-line voltage whose calculation takes into account the angles between the voltage phases.

7.3 Reading measured values from user data cyclically

Requirement

- STEP 7 is open.
- The AI Energy Meter CT ST is configured.

Scaling of measured values in the user data

Since the value range of 16-bit values is often smaller than the value range of the physical value, a scaling factor is supplied together with the basic value in the user data for the respective measured or calculated values. You determine the actual value of the measured variable with the following formula:

Actual value of measured quantity = measured value in the user data x $10^{\text{scaling factor}}$

Procedure

To read measured values from the user data cyclically, proceed as follows:

1. Read the relevant measured value from the input data.
2. Observe the scaling factor at scaled measured values and convert the read measured value using the scaling factor.

Example

The payload variant 254 (FE_H) "Total power L1L2L3" is configured on the AI Energy Meter CT ST. The measured value for "Current L1" should be read.

Table 2-937 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
10 ... 11	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038
12 ... 13	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
14 ... 17	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647 to +2147483647	225
18 ... 21	Total reactive energy L1L2L3 (Int32)	DINT	1 varh	-2147483647 to +2147483647	226

Byte	Allocation	Data type	Unit	Value range	Measured value ID
22	Reserved	BYTE	-	0	-
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

In the user data variant FE_H (254) the measured value for the current L1 is stored in Byte 2 + 3. The current is supplied by the module as a 16-bit-fixed-point number in the value range from 0 to 65535 in the unit 1 mA. In addition the scaling factor for the current L1 has to be considered additionally. The module supplies the related scaling factor in Byte 24.

The actual value for current L1 is calculated as follows:

Actual value for current L1 = Current L1 x $10^{\text{Scaling current L1}}$

See also

Basics for reading measured values (Page 41)

7.4 Read out measured values acyclically using data records

With all module versions you can read out the measured values using data records.

An overview of all measured value data records and exact information about the structure is available in the appendix Overview of all measured value data records.

Requirement

In the STEP 7 project you have created a PLC data type that has an identical structure to the data record you want to evaluate.

Example of the structure of a data record

The following overview shows the structure of the data record DS 142.

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version = 2	UINT8	-	3	-
1	Reserved	UINT8	-	0	-
2...5	Voltage UL1-N	REAL	V	0.0 ... 1000000.0	1
6...9	Voltage UL2-N	REAL	V	0.0 ... 1000000.0	2

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
10...13	Voltage UL3-N	REAL	V	0.0 ... 1000000.0	3
14...17	Voltage UL1-L2	REAL	V	0.0 ... 1000000.0	4
18...21	Voltage UL2-L3	REAL	V	0.0 ... 1000000.0	5
22...25	Voltage UL3-L1	REAL	V	0.0 ... 1000000.0	6
26...29	Current L1	REAL	A	0.0 ... 100000.0	7
30...33	Current L2	REAL	A	0.0 ... 100000.0	8
34...37	Current L3	REAL	A	0.0 ... 100000.0	9
:		:	:	:	:
210...2-13	Neutral current	REAL	A	0.0 ... 100000.0	61149

Procedure

1. Read the desired data record with the RDREC instruction.

   The measured values are in the target range of the data block which you specified with the RDREC instruction.
2. Evaluate the measured values for the desired measured variables.

NOTE

If you want to read or write several data records at the same time in the user program, note that the number of active jobs that you started with the RDREC or WRREC instruction is limited by the resources of the CPU used.

NOTE

When reading data records that do not exist on the ST module with RDREC, the error 0x80B0 is displayed.

See also

Measured value data record for base measurements (DS 142) (Page 179)

7.5 Time-of-day synchronization and time stamp

The AI Energy Meter CT ST supports time-of-day synchronization and time stamp.

Time-of-day synchronization is only supported by IM 155-6 PN ST as of firmware version V4.2.

Time stamps are used to date the exact occurrence of information. You can find time information in the measured value data records "Measured value data record for maximum values with time stamp (DS 154)" and "Measured value data record for minimum values with time stamp (DS 155)", for example.

For the time on the AI Energy Meter CT ST to correspond to the current system time, the clock must be synchronized externally. Information on this and additional requirements can be found in the application example (https://support.industry.siemens.com/cs/ww/en/view/109754890). In the absence of time-of-day synchronization, the internal time stamp of the AI Energy Meter CT ST starts at 01.01.1970, 0:00.

Structure of the time stamp

The table below shows the structure of the time stamp:

Byte	PNIO Time	Format	Length
0	Status 0: Synchronization from system time master available 1: Local synchronization available 2: No synchronization available	UINT16	2 bytes
2	Seconds high	UINT16	2 bytes
4	Seconds low	UINT32	4 bytes
8	Nanoseconds	UINT32	4 bytes

The start value (initial value) is 01.01.1970, 0:00.

NOTE

If you use the implementation from the FAQ, the status is always 2.

Energy counters

8

Introduction

The AI Energy Meter CT ST provides several energy and overflow counters that detect both line-based and phase-based energy values, e.g.:

- Active energy (total, outflow, inflow)
- Reactive energy (total, outflow, inflow)
- Apparent energy (total)
- "Output" describes the regenerative operation of the connected system.
- "Reference" describes the motor operation of the connected system.

Retentivity

The AI Energy Meter CT ST stores all counter values retentively. After an interruption (e.g. Power System Off), the energy counting resumes with the retentively stored values.

Functions

The energy meters provide the following basic functions:

- Measured values for infinite and periodical counting can be read out

  End values for periodic counting: 10^3, 10^6, 10^9, 10^{12} and 10^{15} can be selected with overflow counters
- Measuring ranges can be changed in RUN
- Starting and stopping counters via gate is possible
- Preset and apply start values in RUN
- Measured variables can be evaluated via data records and payload.

8.1 Evaluate measured values for energy

There are two ways of evaluating the measured values:

- Reading measured values using the instruction "RDREC".
- Reading measured values from the payload variants (not for module versions with 2 bytes of input data).

Data records for energy meters

You can read out measured values for energy and overflow counters in the following data records.

The evaluation of measured data using data records is described in section Reading out measured values ayclically using data records (Page 50).

Name of the data record	Number of the data record	Comment
Data record for basic measured values (Page 179)	Data record 142	Measured values of the total energy L1L2L3
Data record for energy meter (Page 185)	DS 143	Measured values of energy and overflow counters for phases L1, L2 and L3
Data record for phase-specific measured values L1 (Page 193)	DS 147	Measured values of the phase-specific energy meters L1
Data record for phase-specific measured values L2 (Page 196)	DS 148	Measured values of the phase-specific energy meters L2
Measured value data record for phase-specific measured values L3 (Page 200)	DS 149	Measured values of the phase-specific energy meters L3

Payload variants for energy meters

You can read out measured values for energy and overflow meters in the following payload variants.

The evaluation of measured data using payload variants is described in section Reading measured values cyclically from payloads (Page 49).

Name of the payload variant	Number of the payload variant	Comment
Total energy L1 L2 L3 (Page 161)	ID 249 or $F9_H$	Measured values of the total energy L1L2L3
Energy L1 (Page 161)	ID 248 or $F8_H$	Measured values of the phase-specific energy meters L1
Energy L2 (Page 161)	ID 247 or $F7_H$	Measured values of the phase-specific energy meters L2
Energy L3 (Page 161)	ID 246 or $F6_H$	Measured values of the phase-specific energy meters L3
Basic variable quality measurement three-phase measurement (Page 161)	ID 240 or $F0_H$	Status on the overflow of the energy meters for phases L1, L2 and L3
Basic variables energy meter measurement (periodic) L1L2L3 (Page 161)	ID 239 or EF_H	Number of counter overflows for energy of phases L1, L2 and L3
EE@Industry measurement data profile E3 (Page 161)	ID 227 or $E3_H$	Measured values for total active energy and total reactive energy L1L2L3

Name of the payload variant	Number of the payload variant	Comment
EE@Industry measurement data profile E2 (Page 161)	ID 226 or $E2_H$	Measured values for total active energy L1L2L3
Basic variables for phase-specific measurement L1 (Page 161)	ID 159 or $9F_H$	Measured values for phase-specific active, reactive and apparent energy for phase L1
Basic variables for phase-specific measurement L1a (Page 161)	ID 158 or $9E_H$	Measured values for phase-specific active, reactive and apparent energy for phase L1
Basic variables for phase-specific measurement L2 (Page 161)	ID 157 or $9D_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L2
Basic variables for phase-specific measurement L2a (Page 161)	ID 156 or $9C_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L2
Basic variables for phase-specific measurement L3 (Page 161)	ID 155 or $9B_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L3
Basic variables for phase-specific measurement L3a (Page 161)	ID 154 or $9A_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L3
User-defined payload variant	ID 1 or 01_H and ID 2 or 02_H	Measured variables for energy can be selected in a user-defined manner

8.2 Preset and apply start values for energy and overflow counters

At the beginning of a new work order, it may be useful to start the energy and overflow counter with new start values.

Define the new start values for the energy and overflow counter in data record DS 143.

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

For **all** module versions there are two ways of applying the start values:

- Transfer start values from data record DS 143 and apply them **immediately**
- Transfer start values from data record DS 143 and only apply them after setting a special bit (DQ bit for counter reset)

Both options are described in the following sections.

General reset

With module versions with 20 bytes of output data you can reset the energy and overflow counters. With a general reset, you cannot preset any start values; the start values for energy and overflow counters are always zero with a general reset.

You can find additional information on the general reset in the section Basics for reading measured values (Page 41).

8.2.1 Preset start values for the energy meters

Define the start values for the energy and overflow meters in data record DS 143.

Introduction

You have created a PLC data type that has an identical structure to data record DS 143.

Structure of data record DS 143

The following overview shows the structure of the data record DS 143 in simplified form.

More detailed information about the structure of data record DS 143 is available in section Structure of energy meters (DS 143) (Page 185).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Control byte 1 - L1	BYTE	Bit string	-	-
3	Control byte 2 - L1	BYTE	Bit string		
4	Control byte 1 - L2	BYTE	Bit string		
5	Control byte 2 - L2	BYTE	Bit string		
6	Control byte 1 - L3	BYTE	Bit string		
7	Control byte 2 - L3	BYTE	Bit string		
8...15	Start value for active energy inflow L1	LREAL	Wh	You will find the exact assignment in the section Structure of energy meters (DS 143) (Page 185).	61180
16...23	Initial value active energy outflow L1	LREAL	Wh		61181
:	:	:	:		:
128...1-29	Start value for overflow counters active energy inflow L1	UNIT	-		61190
130...1-31	Start value for overflow counter active energy outflow L1	UNIT	-		61191
:	:	:	:		

Assignment of data record DS 143

Byte 0 and Byte 1: Version of the data record

Header information for the version of the data record.

Byte 2 ... Byte 7: Control bytes for energy and overflow counter

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy meters, overflow counters and operating hours counters. The length of the control information amounts to 2 bytes for each phase.

Byte 8 ... Byte 127: Start values for the individual energy meters

The start values for energy meters in data record 143 are 64-bit floating point numbers. The format corresponds to the data type LREAL in S7-1200 and in S7-1500.

Byte 128 ... Byte 157: Initial values for overflow counters

The initial values for overflow counters in data record 143 are 16-bit integers. The format corresponds to the data type UINT in S7-1200 and in S7-1500.

8.2.2 Apply start values from data record DS 143 immediately

It is possible to apply the start values for energy counters and overflow counters for each **individual** phase separately by active, reactive and apparent energy.

Requirement

In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and you have entered the start values.

Procedure for all module versions

1. In control byte 2 of the DS 143 (bytes 3, 5 and 7), for each phase set the category of the energy meters (active, reactive, apparent energy) for which you want to set the start values.

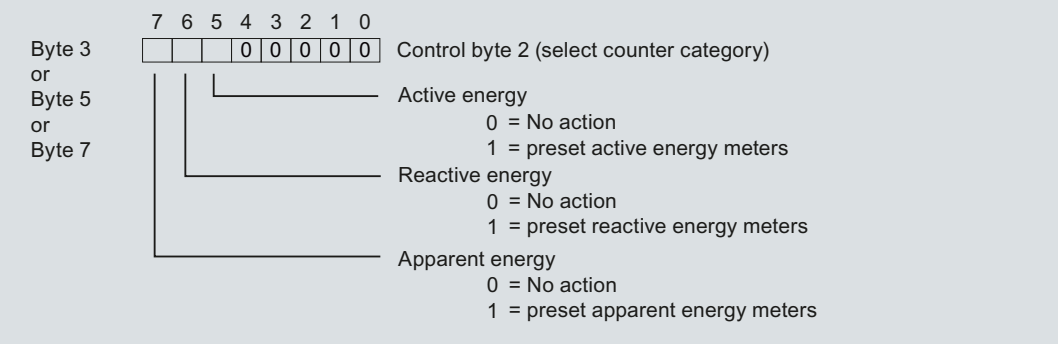

Figure 2-839 Assignment of control byte 2 in DS 143

2. In control byte 1 of DS 143 (bytes 2, 4 and 6), for each phase define whether you want to apply the start values for energy or overflow counters.

   Applying depends on the category selection from control byte 2.

   – Set Bit 0 if you want to apply the start values for the overflow counters.
   – Set Bit 2 if you want to apply the start values for the energy meters.

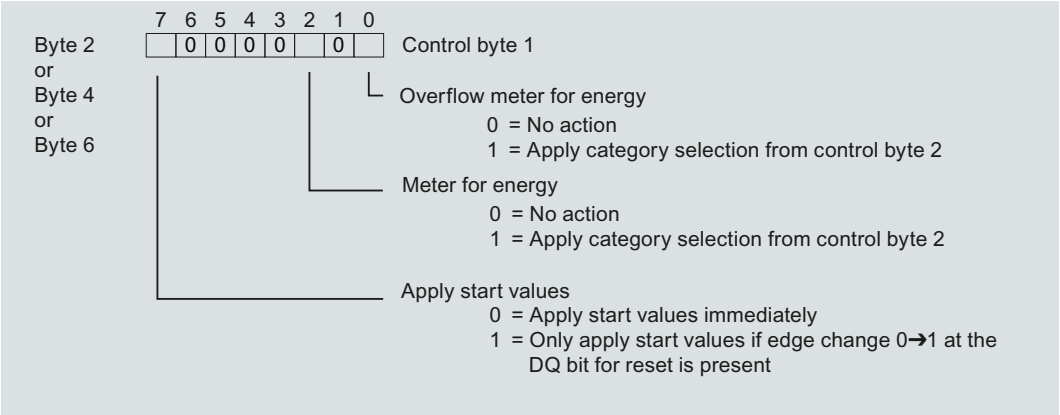

Figure 2-840 Assignment of control byte 1 in DS 143

3. In control byte 1 of DS 143 define that you want to immediately apply the start values.
   – Set Bit 7 to 0 so that the start values are immediately applied after writing the data record.
4. Transfer the data record with the WRREC instruction to the CPU.

8.2.3 Apply start values from data record DS 143 with DQ bit

Due to the differing lengths of the output data, setting of the start values for the energy counters and overflow counters depends on the configured module version.

Module versions with 20 bytes of output data

If you use module versions with 20 bytes of output data, you can:

- Apply start values for energy counters and overflow counters for **all** phases separately by active, reactive and apparent energy.
- Apply start values for energy counters and overflow counters for each **individual** phase separately by active, reactive and apparent energy.

Module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, then you always apply the start values for **all** the energy counters and overflow counters simultaneously.

Requirement

- In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and have entered the start values.

  Applying depends on the category selection from control byte 2.

  – Set Bit 0 if you want to apply the start values for the overflow counters.

  – Set Bit 2 if you want to apply the start values for the energy meters.
- In control byte 1 of the DS 143 you have set Bit 7 to "1" (apply start values via DQ bit)
- You have transferred the data record DS 143 with new start values to the CPU. The assignment of the data record can be found in Structure of energy meters (DS143) (Page 185).

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

Procedure for module version with 20 bytes of output data

Apply start values for energy counters and overflow counters for all three phases

1. In Byte 2 of the output data, select the categories for which you want to apply start values.

   – Set bit 5 for active energy counters.

   – Set bit 6 for reactive energy counters.

   – Set bit 7 for apparent energy counters.

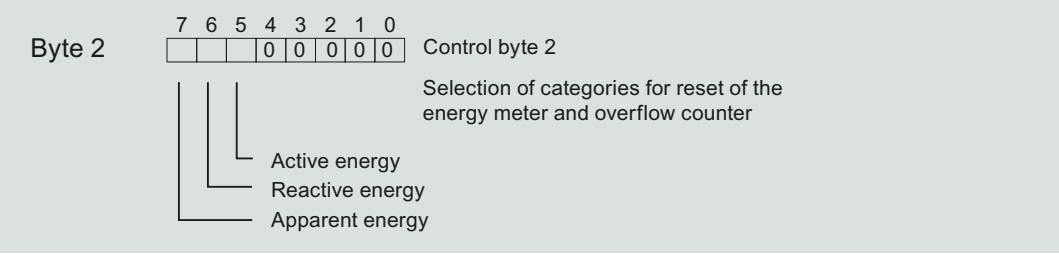

Figure 2-841 Selection of categories for reset

2. Set the reset bit (Bit 7) in byte 1 of the output data.

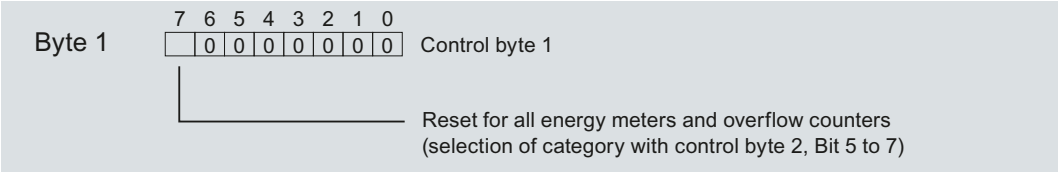

Figure 2-842 Reset bit for energy and overflow counter

If there is an edge change of the reset bit from 0 -> 1, the module resets the energy and overflow counters that you previously selected in byte 2 to their start values.

Apply start values for energy counters and overflow counters for phase-specific counting

You can also reset the energy and overflow counters on a phase-specific basis using the output data.

Follow the procedure as described in "Applying start values for energy counters and overflow counters for all three phases", as applicable.

1. In bytes 7, 9 and 11 of the output data, select the categories for which you want to apply the phase-specific start values.
   - Set Bit 5 for active energy counters.
   - Set Bit 6 for reactive energy counters.
   - Set Bit 7 for apparent energy counters.

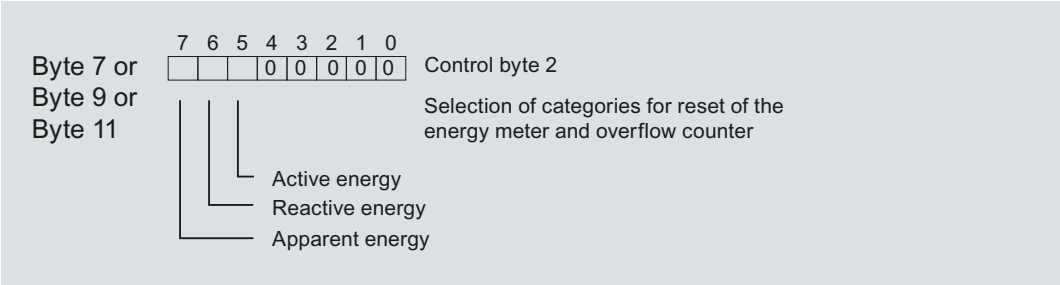

Figure 2-843 Selection of category

2. In bytes 6, 8 and 10 of the output data, set the reset bits (Bit 7) for the phase-specific start values.

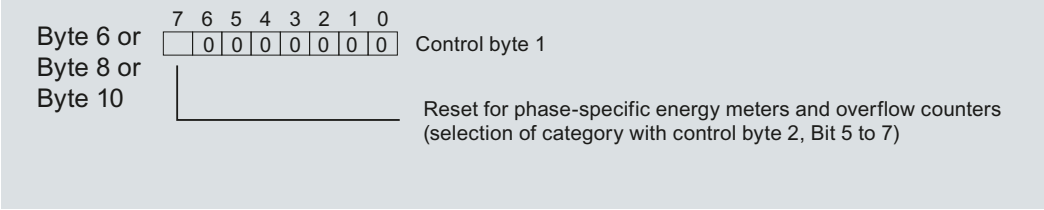

Figure 2-844 Reset bit for phase-specific energy and overflow counters

If there is an edge change of the phase-specific reset bit from 0 -> 1, the module resets the energy and overflow counters that you previously selected in bytes 7, 9 and 11 to their start values.

Procedure for module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, always apply the start values **for all** the energy counters and overflow counters.

- Set the reset bit (Bit 7) in byte 1 of the output data.

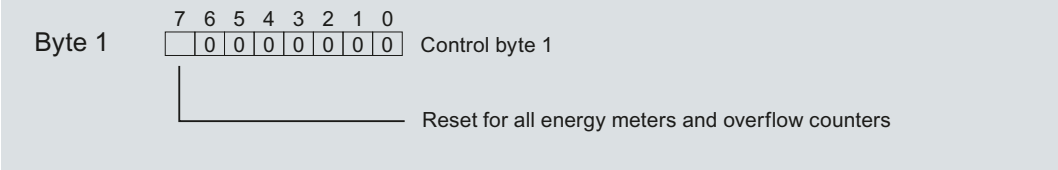

Figure 2-845 Reset bit for all energy and overflow counters

If there is an edge change of the reset bit from 0 -> 1, the module resets **all** energy and overflow counters to their start values.

8.3 Starting and and stopping energy meters

There are two ways of starting or stopping measurement with the energy meter AI Energy Meter CT ST:

- Counting with gate

  The module starts counting when you set the DQ bit for the counter gate in the output data using an edge change from 0 -> 1. If you reset the DQ bit using an edge change from 1 -> 0, the counter stops.

- Counting without gate

  The module starts counting immediately as soon as the module is switched on. Counting cannot be stopped.

Both options are described in the following sections.

Counting with gate

Requirements:

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

If you wish to start counting using the gate, proceed as follows:

1. Activate the parameter "Activate gate switch for energy meter" in the parameter assignment of the module.
2. Set the DQ bit for the counter gate (Bit 6) in control byte 1 in the output data.

The module starts counting as soon as there is an edge change from 0 -> 1 at the DQ bit for the counter gate.

If you wish to stop the counting again, then reset Bit 6 in control byte 1 in the output data. Counting stops at an edge change from 1 -> 0.

The "Activate gate switch for energy meter" parameter and the DQ bit for the "counter gate" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

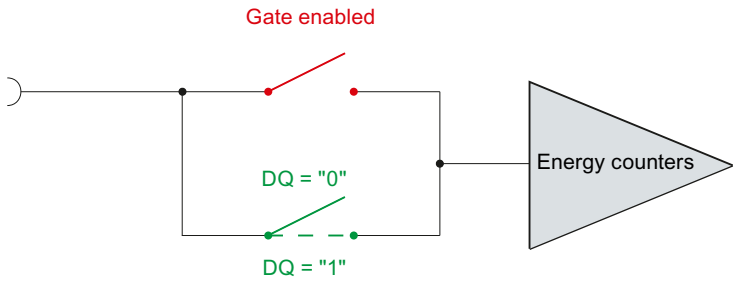

Figure 2-846 Gate enabled

NOTE

Module-global/phase-granular PLC

If you are using the gate control for all three phases simultaneously, use the control byte 1 at output address 1. For a phase-specific resolution of the gate control, use the addresses 6 (Phase1), 8 (Phase2) or 10 (Phase3) as control byte 1. The resolution of a module-global PLC overrules a phase-granular resolution.

Counting without gate

Requirement

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

Deactivate the parameter "Activate gate switch for energy meter" in the parameter assignment of the module.

The module starts counting as soon as the module is started. The counter continues to count.

Gate disabled: Gate is always "open" (signal path closed)

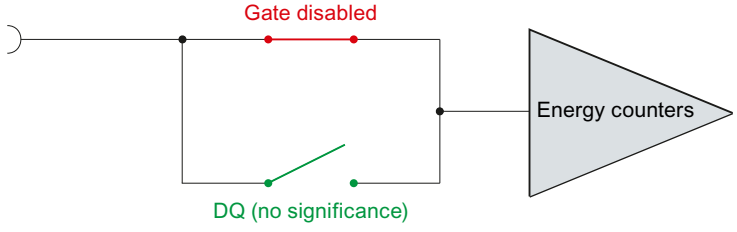

Figure 2-847 Gate disabled

8.4 Example of measuring and resetting an energy meter

The following figure shows resetting and starting/stopping with activated gating using the energy meter as an example:

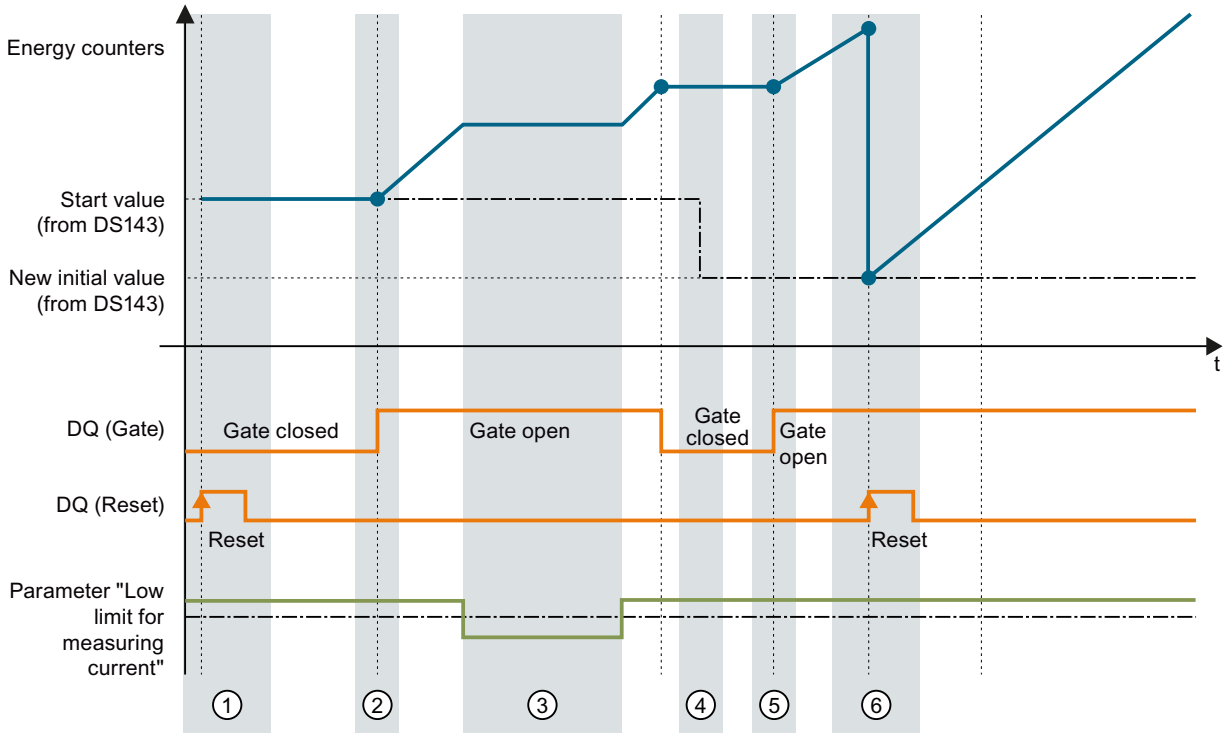

① The counter is reset to the value specified in the configuration. The gate is closed. The counter does not count.

② The gate is opened via the control byte 1 in the output data of the user data variant. The counter counts.

③ The configured current low limit has been violated. The counter does not count.

④ The gate is closed. The counter does not count. A new start value is written to the measured value data record 143 (Page 185) with the WRREC instruction.

⑤ The gate is opened again via the control byte 1 in the output data of the user data variant. The counter counts with the new start value.

⑥ The counter is reset via the control byte 1 in the output data of the user data variant. The counter counts from the new start value that was transferred via the measured value data record 143.

Figure 2-848 Example of an energy meter

8.5 What is the structure of the control and feedback interface for DS 143?

Introduction

Bytes 2 to 7 of data record 143 (Page 185) form the phase-based control and feedback interface for the data record DS 143.

- Bytes 2 and 3: Control and feedback interface for phase 1
- Bytes 4 and 5: Control and feedback interface for phase 2
- Bytes 6 and 7: Control and feedback interface for phase 3

Status information

When data record 143 is read with the RDREC instruction, Bytes 2 to 7 supply phase-specific status information for energy counters, overflow counters and operating hours counters.

The status information enables you can see which counters are returning their values in the data record 143. If energy counters return their values in the status byte 1, you can determine the type of energy counter with status byte 2.

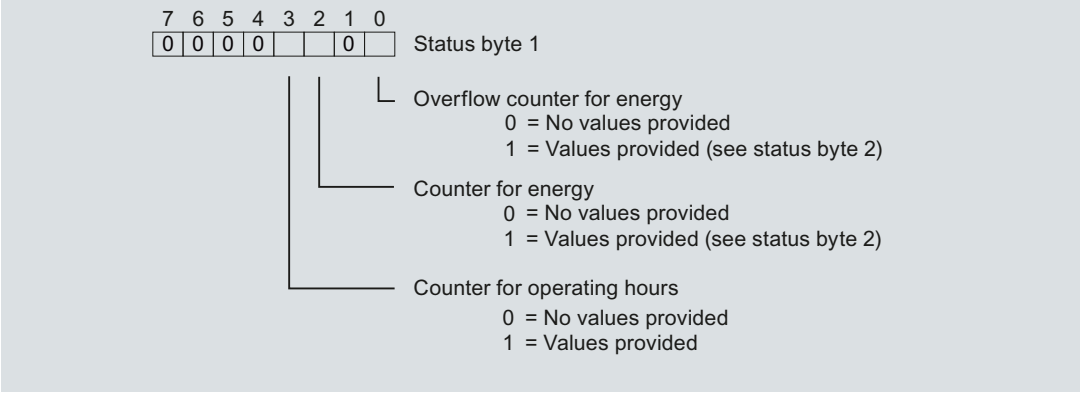

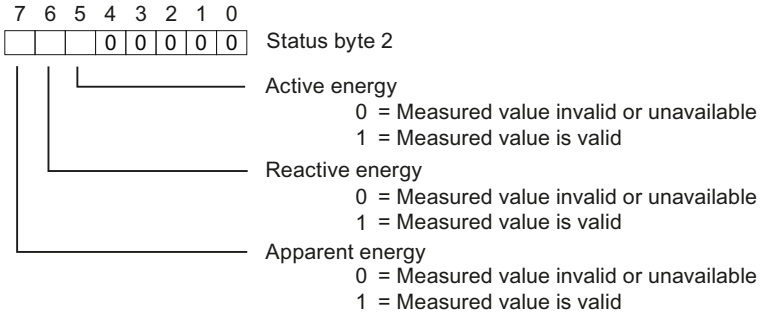

Figure 2-849 Status information DS 143 (read access)

Control information

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy meters, overflow counters and operating hours counters. The length of the control information amounts to 2 bytes for each phase:

- In control byte 1 you determine which counter you want to preset and the time at which counters are to be preset.

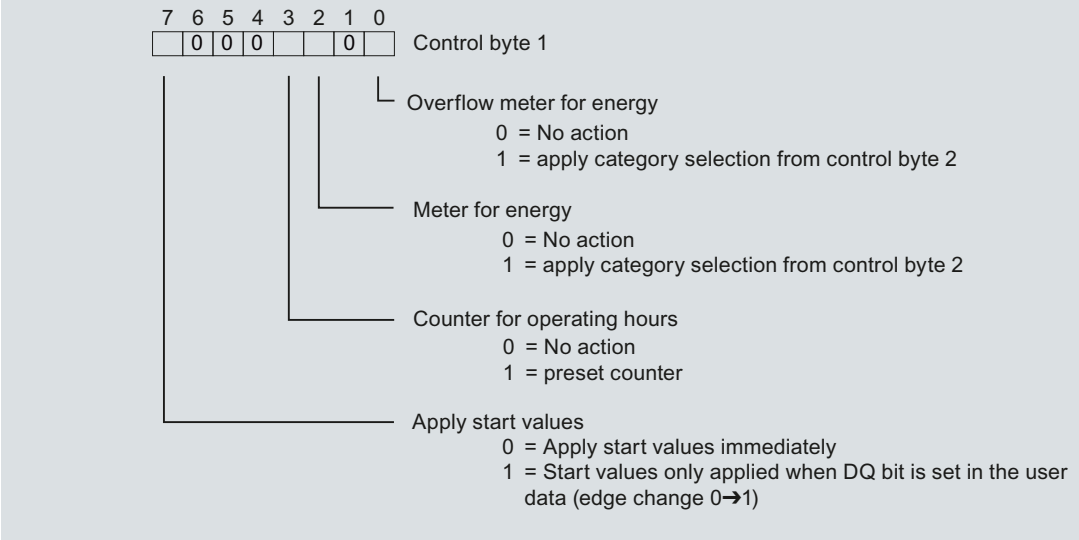

Figure 2-850 Control information DS 143, control byte 1 (write access)

- In control byte 2 you determine which energy meter categories you want to preset.

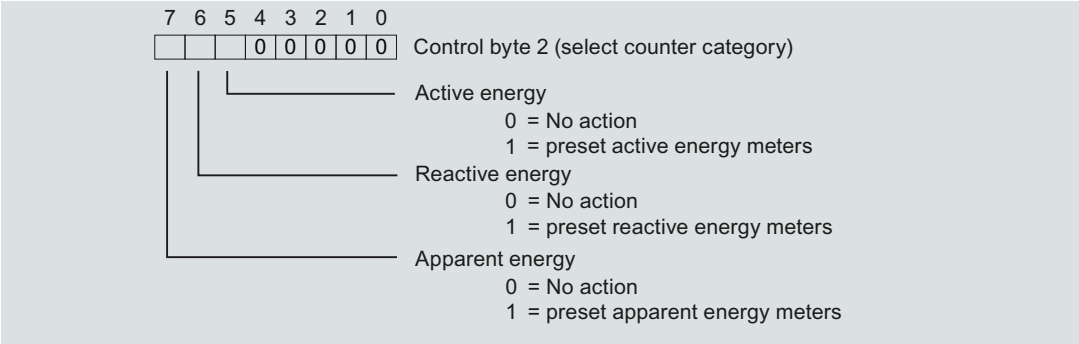

Figure 2-851 Control information DS 143, control byte 2 (write access)

Operating hours counter

9

Introduction

The AI Energy Meter CT ST provides four operating hours counters which count the operating hours of the connected consumers:

- Three phase-specific operating hours counters
- 1 operating hours counter which displays the value of the largest phase-specific operating hours counter.

Retentivity

The AI Energy Meter CT ST stores all counter values retentively. After an interruption (e.g. Power System Off), counting resumes with the retentively stored values.

Functions

The operating hours counters provide the following basic functions:

- Measuring ranges from 0 to 3.4×10^{38} hours.
- Starting and stopping operating hours counters via gate
- Preset and apply start values in RUN
- Evaluating counter states using data records and payload

9.1 Evaluating operating hours counters

There are two ways of evaluating the operating hours counters:

- Reading counter states using data records with the instruction RDREC.
- Reading counter states from the user-defined payload variants.

Data records for operating hours counter

You can read out measured values for operating hours in the following data records.

The evaluation of measured data using data records is described in section Reading out and processing measured values (Page 41).

Name of the data record	Number of the data record	Comment
Data record for energy meter (Page 185)	DS 143	Phase-specific operating hours counter for phase L1, phase L2, phase L3 and largest phase-specific operating hours counter L1L2L3
Measured value data record for advanced measurement and status values	DS 150	
Measured value data record of user-defined data record (Page 205)	DS 151	Operating hours counters can be selected in a user-defined manner

Payload variants for operating hours counters

You can read out measured values for operating hours in the following payload variants.

The evaluation of measured data using payload variants is described in section Payload variants (Page 161).

Name of the payload variant	Number of the payload variant	Comment
User-defined payload variant	ID 1 or 01_H and ID 2 or 02_H	Operating hours counters can be selected in a user-defined manner

9.2 Preset and apply start values for operating hours counters

Introduction

At the beginning of a new work order, it may be useful to start counting of the operating hours counters with new start values.

Define the new start values for the operating hours counters in data record DS 143.

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

For **all** module versions there are two ways of applying the start values:

- Transfer start values from data record DS 143 and apply them **immediately**
- Transfer start values from data record DS 143 and only apply them after setting a special bit (DQ bit for operating hours counter reset)

Both options are described in the following sections.

General reset

With module versions with 20 bytes of payload you can reset the operating hours counters. With a general reset, you cannot preset any start values; the start values for operating hours counters are always zero with a general reset.

You can find additional information on the general reset in the section Basics for reading measured values (Page 41).

9.2.1 Preset start values for operating hours counters

Define the start values for operating hours counters using data record DS 143.

Introduction

You have created a PLC data type that has an identical structure to data record DS 143.

Structure of data record DS 143

The following overview shows the structure of the data record DS 143 in simplified form.

More detailed information about the structure of the data record 143 is available in section Structure of energy meters (DS 143) (Page 185).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Control byte 1 - L1	BYTE	Bit string	-	-
3	Control byte 2 - L1	BYTE	Bit string		
4	Control byte 1 - L2	BYTE	Bit string		
5	Control byte 2 - L2	BYTE	Bit string		
6	Control byte 1 - L3	BYTE	Bit string		
7	Control byte 2 - L3	BYTE	Bit string		
8...15	Start value for active energy inflow L1	LREAL	Wh	You will find the exact assignment	61180
16...23	Initial value active energy outflow L1	LREAL	Wh		61181
:	:	:	:		:

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
158...161	Start value operating hours L1	REAL	h	in the section Structure of energy meters (DS 143) (Page 185).	65505
162...165	Start value operating hours L2	REAL	h		65506
166...169	Start value operating hours L3	REAL	h		65507

Assignment of data record DS 143

Byte 0 and Byte 1: Version of the data record

Header information for the version of the data record.

Byte 2 ... Byte 7: Control bytes for energy and overflow counter

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy meters, overflow counters and operating hours counters. The length of the control information amounts to 2 bytes for each phase.

Byte 8 ... byte 157: Start values for the individual energy meters and overflow counters

The start values for energy counters in data record 143 are 64-bit floating point numbers. The format corresponds to the data type LREAL in S7-1200 and in S7-1500.

The initial values for overflow counters in data record 143 are 16-bit integers. The format corresponds to the data type UINT in S7-1200 and in S7-1500.

Byte 158 ... byte 169: Start values for operating hours counter

The start values for operating hours counters in data record 143 are 32-bit floating-point number. The format corresponds to the data type REAL in S7-1200 and in S7-1500.

9.2.2 Apply start values from data record DS 143 immediately

Applying the start values for each separate operating hours counter is possible.

Requirement

In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and you have entered the start values.

Procedure for all module versions

1. In Control byte 1 of DS 143 (bytes 2, 4 and 6), for each phase, define that you want to immediately apply the start values for operating hours counters.
   - Set the Bit 3 to 1 so that the start values for the operating hours counters are preset.
   - Set the Bit 7 to 0 so that the module **immediately** applies the start values after writing the data record.

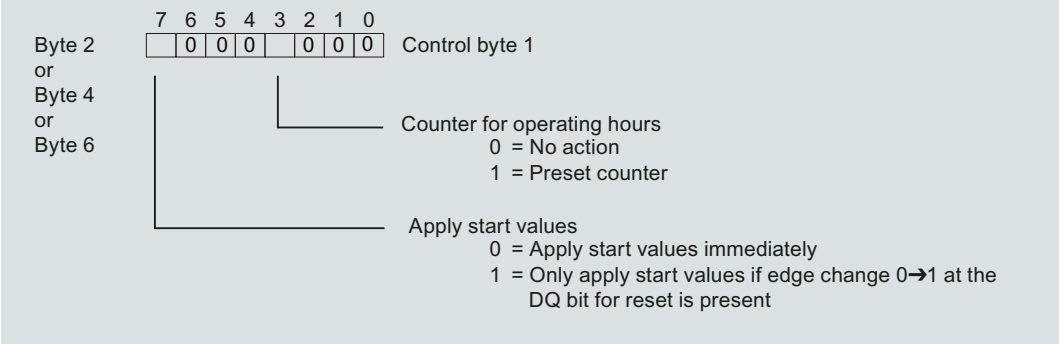

Figure 2-852 Allocation of the control bytes in DS 143 for operating hours

2. Transfer the data record with the WRREC instruction to the CPU.

9.2.3 Apply start values from data record DS 143 with DQ bit

Due to the differing lengths of the output data, setting of the start values for the operating hours counters depends on the configured module version.

Module versions with 20 bytes of output data

If you use module versions with 20 bytes of output data, you can:

- Apply start values for **all** operating hours counters.
- Apply start values for **individual** operating hours counters separately.

Module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, apply the start values for **all** operating hours counters simultaneously.

Requirement

- In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and have entered the start values.
- Set the Bit 3 to 1 so that the start values for the operating hours counters are preset.
- In control byte 1 of DS 143 you have set Bit 7 to "1" (apply start values via DQ bit). (see previous figure)
- You have transferred the data record DS 143 with new start values to the CPU. The assignment of the data record can be found in Structure of energy meters (DS143) (Page 185).

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

Procedure for applying the start values of all operating hours counters

Applying the start values for all operating hours counters with the module versions with 2 bytes and 20 bytes of output data is identical.

1. Set the reset bit for operating hours counters (Bit 5) in Byte 1 in the output data.

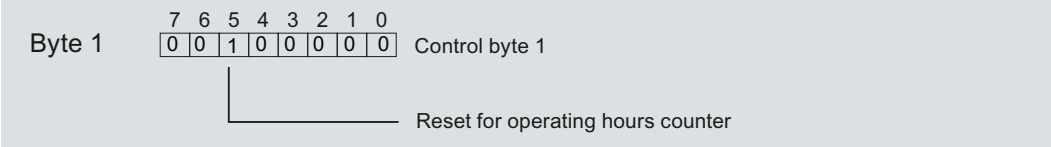

Figure 2-853 Control byte 1 Reset for all operating hours counters

If there is an edge change of the reset bit from 0 to 1, the module applies the start values for all operating hours counters.

Procedure for applying the start values of individual operating hours counters

NOTE

Applying the start values for phase-specific operating hours counters

Applying the start values for phase-specific operating hours counters does not differ from the procedure described above. In the output data, select the reset bits for the phase-specific operating hours counters in bytes 6, 8 and 10.

9.3 Starting and stopping operating hours counters

There are two ways of starting or stopping counting with the operating hours counter AI Energy Meter CT ST:

- Counting with gate

  The module starts counting when you set the DQ bit for the counter gate in the output data using an edge change from 0 -> 1. If you reset the DQ bit for the counter gate using an edge change from 1 -> 0, the counter stops.

- Counting without gate

  The module starts counting immediately as soon as the module is switched on. Counting cannot be stopped.

Both options are described in the following sections.

Counting with gate

Requirements:

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

If you wish to start counting using the gate, proceed as follows:

1. Activate the parameter "Enable operating hours counter gate" in the parameter assignment of the module.
2. Set the DQ bit for the counter gate (Bit 4) in control byte 1 in the output data.

The module starts counting as soon as there is an edge change from 0 -> 1 at the DQ bit for the counter gate.

If you wish to stop the counting again, then reset Bit 4 in control byte 1 in the output data. Counting stops at an edge change from 1 -> 0.

The "Enable operating hours counter gate" parameter and the DQ bit for the "counter date" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

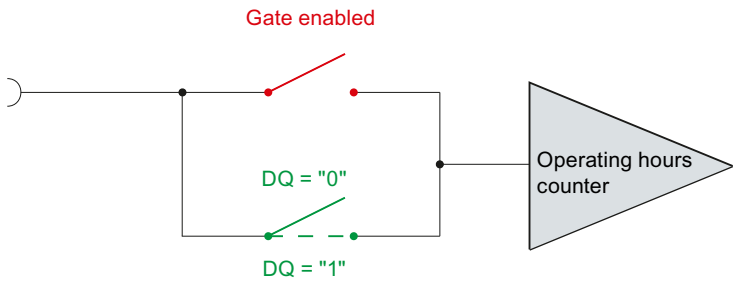

Figure 2-854 Gate enabled

Counting without gate

Requirement

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

Deactivate the parameter "Enable operating hours counter gate" in the parameter assignment of the module.

The module starts counting as soon as the data record has been applied by the CPU.

The counter continues to count.

Gate disabled: Gate is always "open" (signal path closed)

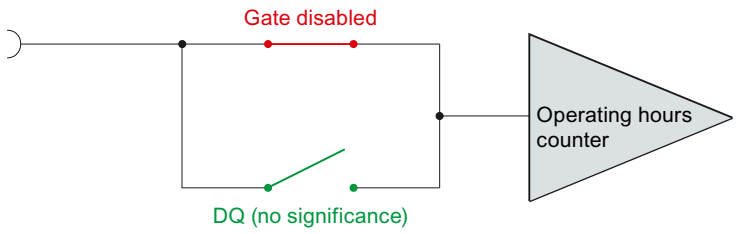

Figure 2-855 Gate disabled

Limit monitoring 10

10.1 How limit monitoring works

Introduction

The AI Energy Meter CT ST supports monitoring of parameterizable low **or** high limits for up to 16 analog measured or calculated variables.

You can also specify multiple limits for each measured or calculated variable, in order to define a high or low value range.

The measured value data record 150 returns the current status of limit violations and one counter per limit that displays the number of limit violations. In addition, a hardware interrupt may be generated for each limit violation.

The status of the limit violations can also be evaluated in the payload variant 240 ($F0_H$) or via the user-defined payload variant or the user-defined data record via the measured value ID 65509.

Benefits

With activated limit monitoring you can already detect any irregularities in the measured value acquisition already in field level.

Retentivity

All the counter states are stored retentively in the AI Energy Meter CT ST. After an interruption (e.g. Power System Off), the counting resumes with the retentively stored values.

Configuring

You configure the following limit monitoring settings in STEP 7:

- Measured variable that is to be monitored.
- Activate / Deactivate limit monitoring.
- Activate / deactivate gate limit monitoring.
- High or low limit values.
- Delay time and hysteresis for each limit.
- Activate / Deactivate hardware interrupts at limit violation.
- Measured value that is subject to limit monitoring.

Hardware interrupt at a limit violation

The hardware interrupt provides the following information:

- Measured value ID of the monitored measured or calculated variable
- Number of the limit (0 = Limit 1. 15 = Limit 16)
- Information on whether limit was exceeded or fallen below

For more detailed information, refer to section Hardware interrupts (Page 101).

Controlling functions in RUN

The following table shows the supported control information:

Control information	Default value	Available in
Enable/disable monitoring per limit[1]	Disabled	Module version with 20 bytes of output data
Reset number of total limit violations	0	Module version starting at 2 bytes of output data

[1] Effective only with enabled gate

10.2 Influence of hysteresis and delay time on limit monitoring

Delay time and hysteresis

In order to prevent the triggering of limit violations with small fluctuations, you have the following configuration options in STEP 7:

- Delay time in seconds (0 to 10 s)

  With the delay time, you filter faults and thereby prevent limit value monitoring from triggering too frequently. The limit violation is counted only when the limit violation is present for longer than the configured delay time. The delay time is also taken into consideration with an outgoing limit violation, directly after a high or low limit has been violated in the permitted range. If the measured variable lies between limit violation and hysteresis after the limit violation has been corrected again, the delay time expires also without leaving the hysteresis.

- Hysteresis as a percentage (0 to 20%)

  With the hysteresis, you suppress fluctuations around the limit. The hysteresis is a tolerance range that you define as a percentage deviation of the configured limit. The limit violation is considered to be corrected only when the monitored value leaves the tolerance range.

NOTE

You can get information about underflow and overflow from the calculation of minimum and maximum values of selected measured variables.

The following figure shows the value-over-time for two measured values using the example of a high and low limit as well as the influence of hysteresis and delay time on the counting of the limit violations.

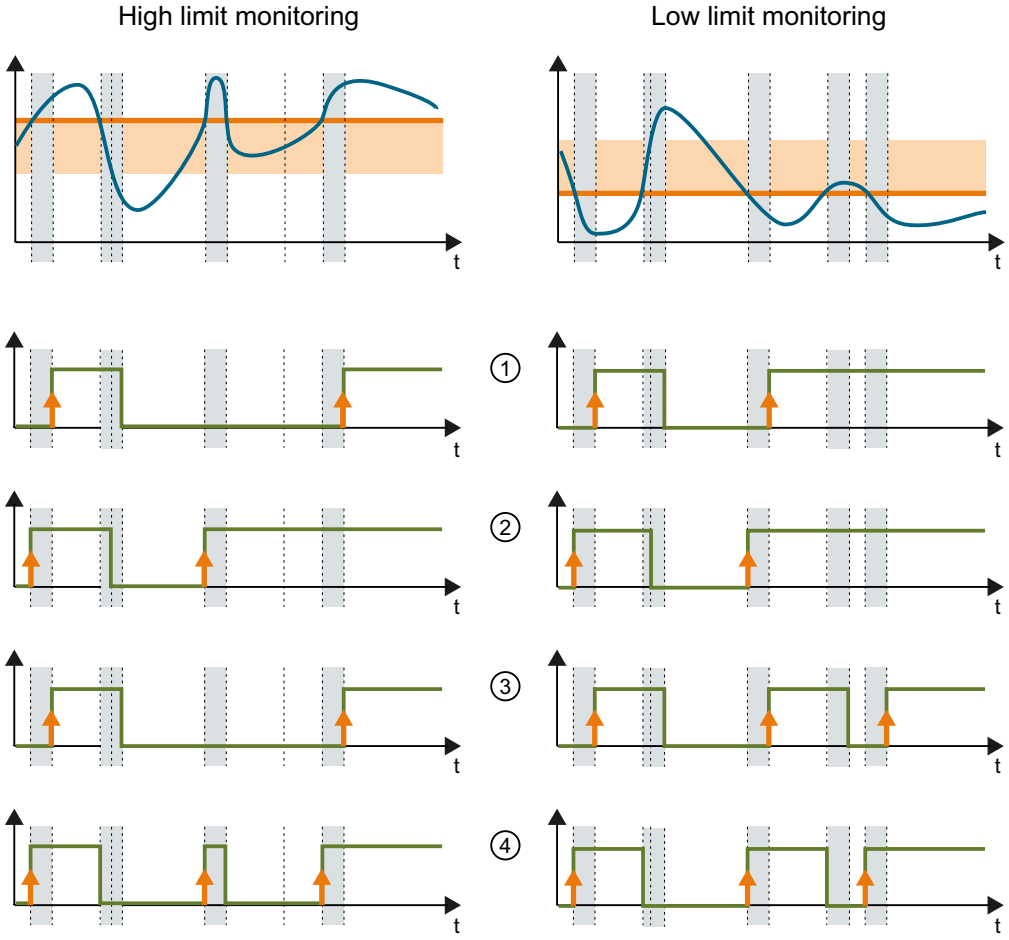

—	Configured limit.	—	Signal wave
▭	Configured delay time. Is taken into consideration during coming and going.	①	Limit monitoring with hysteresis and delay time
▭	Hysteresis range. Only considered for outgoing.	②	Limit monitoring with hysteresis, but without delay time
—	Value-over-time for which the limit is monitored.	③	Limit monitoring without hysteresis, but with delay time
→	Edge change. Counter for limit violations is incremented by 1. If parameterized, a hardware interrupt is triggered.	④	Limit monitoring without hysteresis and delay time

Figure 2-856 Influence of hysteresis and delay time on the limit

See also

How limit monitoring works (Page 74)

10.3 Reset, activate and deactivate counters for limit violation

Introduction

At the beginning of a new work order, it can be useful to reset or also enable/disable the counters for limit violations of the AI Energy Meter CT ST.

Resetting here means that the counters for limit violations are reset to 0.

Due to the differing lengths of the output data resetting of the counters for limit violations depends on the configured module version.

Resetting at module version with 20 bytes of output data

1. Select the counters for limit violations that you want to reset in control bytes 3 and 4; see "Enabling/disabling the counters for limit violations".
2. In control byte 1, set the rest bit (bit 3) with an edge change from 0 to 1; see "Resetting the counters for limit violations".

Resetting for module version with 2 bytes of output data

Set the reset bit (Bit 3) in Control byte 1 from 0 to 1 through an edge change. Resetting acts globally on all the configured counters for limit violation.

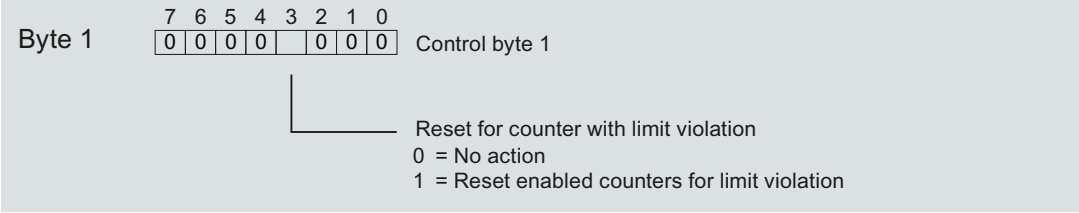

Figure 2-857 Resetting of the counters for limit violations

Activating / Deactivating counters for limit violations

Activating/deactivating of the counters for limit violations is only possible for module versions with 20 bytes of output data.

Requirements: "Gate for limit value monitoring" was parameterized during configuration of the module using STEP 7 or by writing the data record DS 128.

Select the counters for limit violations that you want to activate / deactivate in Control bytes 3 and 4.

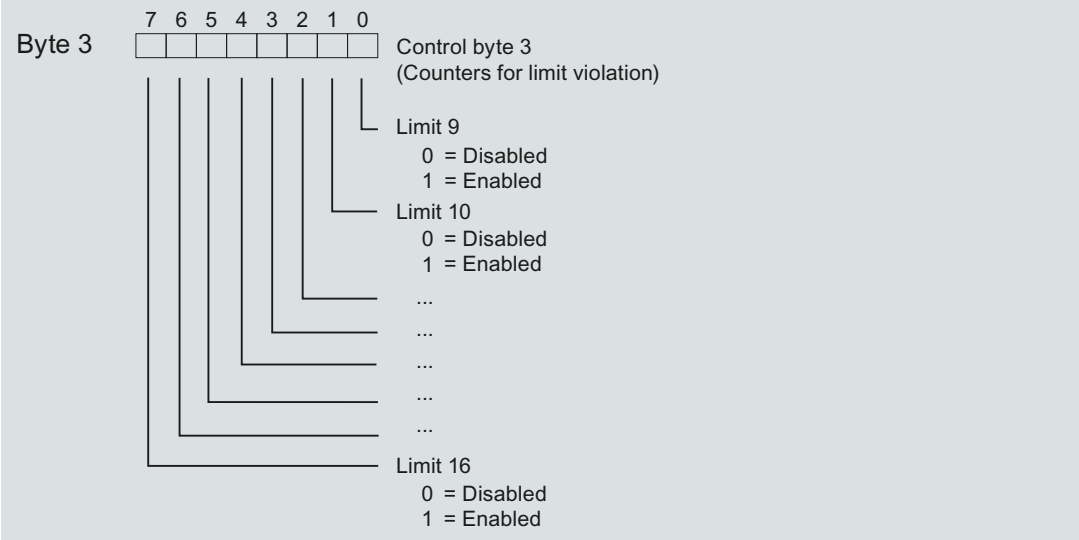

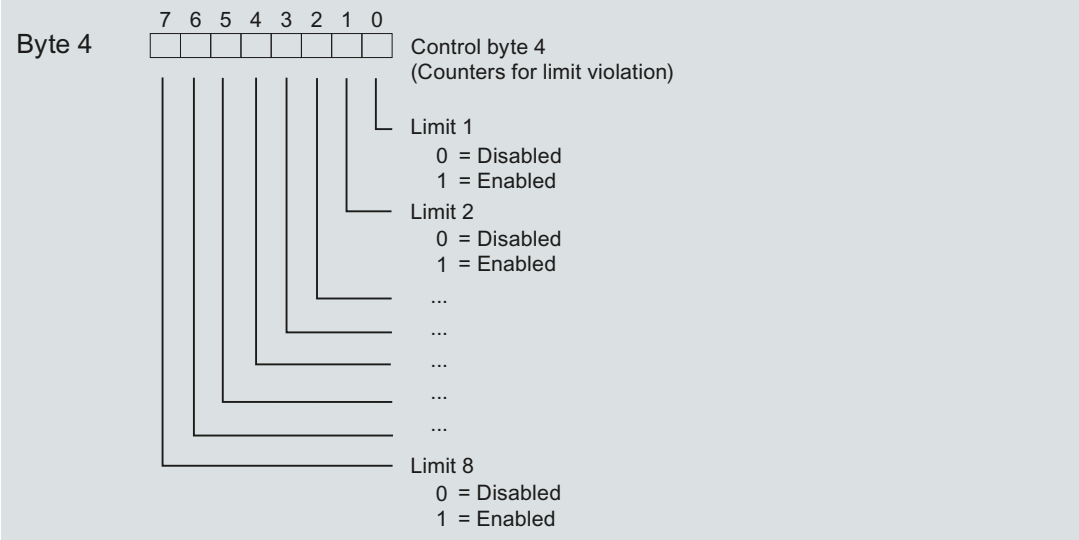

Figure 2-858 Activating / deactivating of the counters for limit violations

10.4 Measured variables for limit monitoring

You can use measured variables from the section Measured variables (Page 136) for limit monitoring.

The value range of the parameter "Limit x" is -3.0E+09 ... +3.0E+09.

The table below shows you which measured variables are **not** available for limit monitoring.

Measured value ID	Measured variables
220	Active energy inflow L1L2L3 (Int32)
221	Active energy outflow L1L2L3 (Int32)

Measured value ID	Measured variables
222	Reactive energy inflow L1L2L3 (Int32)
223	Reactive energy outflow L1L2L3 (Int32)
224	Apparent energy L1L2L3 (Int32)
225	Total active energy L1L2L3 (Int32)
226	Total reactive energy L1L2L3 (Int32)
61136	Neutral current maximum value
61137	Neutral current minimum value
62110	Active energy inflow L1 (Int32)
62111	Active energy outflow L1 (Int32)
62112	Reactive energy inflow L1 (Int32)
62113	Reactive energy outflow L1 (Int32)
62114	Apparent energy L1 (Int32)
62115	Total active energy L1 (Int32)
62116	Total reactive energy L1 (Int32)
62136	Fundamental cos φ active factor L1 (SINT8)
62210	Active energy inflow L2 (Int32)
62211	Active energy outflow L2 (Int32)
62212	Reactive energy inflow L2 (Int32)
62213	Reactive energy outflow L2 (Int32)
62214	Apparent energy L2 (Int32)
62215	Total active energy L2 (Int32)
62216	Total reactive energy L2 (Int32)
62236	Fundamental cos φ active factor L2 (SINT8)
62310	Active energy inflow L3 (Int32)
62311	Active energy outflow L3 (Int32)
62312	Reactive energy inflow L3 (Int32)
62313	Reactive energy outflow L3 (Int32)
62314	Apparent energy L3 (Int32)
62315	Total active energy L3 (Int32)
62316	Total reactive energy L3 (Int32)
62336	Fundamental cos φ active factor L3 (SINT8)
65497	Current module time
65500	Qualifier L1
65501	Qualifier L2
65502	Qualifier L3
65503	Qualifier L1L2L3
65508	Status of energy counter overflows
65509	Status of limit violations 1...16
66001	Voltage L1-N

Measured value ID	Measured variables
66002	Voltage L2-N
66003	Voltage L3-N
66004	Voltage L1-L2
66005	Voltage L2-L3
66006	Voltage L3-L1
66007	Current L1
66008	Current L2
66009	Current L3
66010	Apparent power L1
66011	Apparent power L2
66012	Apparent power L3
66013	Active power L1
66014	Active power L2
66015	Active power L3
66016	Reactive power Qn L1
66017	Reactive power Qn L2
66018	Reactive power Qn L3
66019	Power factor λ L1
66020	Power factor λ L2
66021	Power factor λ L3
66030	Frequency (Uint8)
66031	Frequency (Uint16)
66034	Active power L1L2L3
66035	Reactive power Qn L1L2L3
66036	Apparent power L1L2L3
66037	Power factor λ L1L2L3
66038	Reactive power Qtot L1L2L3

Minimum and maximum values 11

11.1 Minimum and maximum values

Introduction

The AI Energy Meter CT ST determines the respective highest and lowest measured or calculated value for a series of measured and calculated values. The values are stored retentively in the module and can be read using measured value data records DS 144 (Page 189), DS 145 (Page 191), DS 154 (Page 205) and DS 155 (Page 208).

Benefits

Using the stored minimum and maximum values, for example, you can detect further irregularities in addition to limit monitoring.

Calculation of minimum and maximum values

Minimum and maximum values are only calculated for the phases in accordance with the configured connection type. Existing minimum and maximum values that have not been calculated are assigned initial values. If faults such as under or overcurrent occur during operation, new minimum and maximum values are calculated.

The measured and calculated values are initialized as follows during commissioning of the AI Energy Meter CT ST so that the first calculation of minimum and maximum values supplies a plausible result:

- Maximum values for measured and calculated values: Minimum values
- Minimum values for measured and calculated values: Maximum values

Minimum and maximum values are determined as "slave pointer procedures" from the start of calculation. Start is effective as of activation of the function or after a reset. The module uses the current actual value as the start value.

Output of the measurement values

For technical reasons, after plugging in or switching on the load voltage, the module returns the minimum and maximum values delayed by approx. 2 s.

Configuring

You configure the following settings in STEP 7:

- Enable calculation of minimum and maximum values
- Enable minimum and maximum value calculation gate

Controlling functions in RUN

The following table shows the supported control information:

Control information	Default value	Available in
Reset saved maximum values	0	Module version starting at 2 bytes of output data
Reset saved minimum values	0	Module version starting at 2 bytes of output data

NOTE
Automatic reset
If you change the parameters for current or voltage transformers, the minimum and maximum values are reset automatically to their initial values.

11.2 Resetting minimum and maximum values

Description

At the beginning of a new work order, it may be useful to reset the minimum and maximum values of the AI Energy Meter CT ST. Resetting means that the minimum and maximum values are reset to their initial values. Initial values are described, see section Measured value data record for maximum values (DS 144) (Page 189), Measured value data record for minimum values (DS 145) (Page 191), Measured value data record for maximum values with time stamp (DS 154) (Page 205) and Measured value data record for minimum values with time stamp (DS 155) (Page 208).

Minimum and maximum values are only reset using a Reset via output data (DQ bit).

Due to the differing lengths of the output data resetting of the minimum and maximum values depends on the configured module version. If you use module versions with 20 bytes of output data, you can:

- Reset the minimum and maximum values for **all** phases.
- Reset the minimum and maximum values for each **individual** phase.

If you use the module version with 2 bytes of output data, you always reset **all** the minimum and maximum values simultaneously.

Time stamps are set to initial values (01.01.1970, 0:00) on reset.

Procedure for module version with 20 bytes of output data

Resetting the minimum and maximum values for all three phases

1. In byte 2, select the categories of the minimum and maximum values that you want to reset.
   - Set bit 0 for voltage and frequency.
   - Set bit 1 for current and power factor.
   - Set bit 2 for active power.
   - Set bit 3 for reactive power.
   - Set bit 4 for apparent power.
   - Set bit 5 for active energy.
   - Set bit 6 for reactive energy.
   - Set bit 7 for apparent energy.

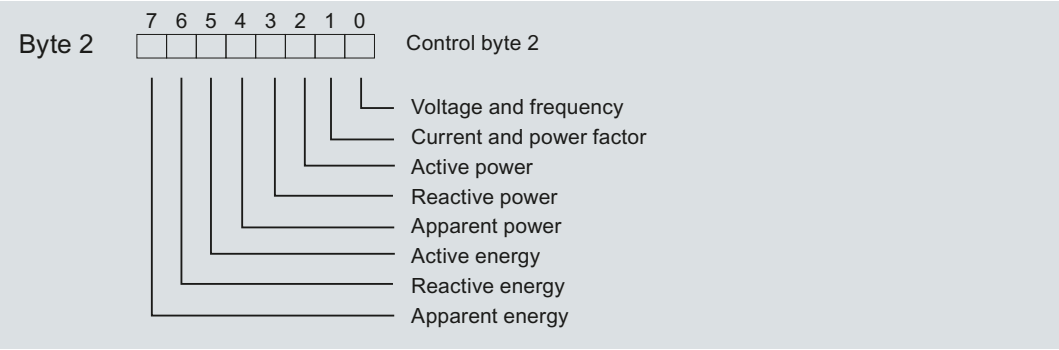

Figure 2-859 Selection of minimum and maximum value category

2. In byte 1, set reset bit 0 for minimum values or reset bit 1 for maximum values.
   If there is an edge change of the reset bits from 0 to 1, the module resets the selected minimum or maximum values for all three phases that you previously selected in byte 2.

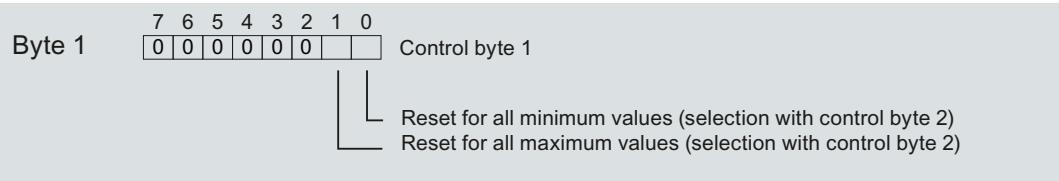

Figure 2-860 Reset bit for minimum and maximum values

Resetting minimum and maximum values for phase-specific measurement

You can also reset the minimum and maximum values on a phase-specific basis using the output data.

Follow the procedure for "Resetting minimum and maximum values for all three phases" as applicable.

1. Select the categories of minimum and maximum value that you want to reset on a phase-specific basis.
   - In byte 7, set the bits for the category of minimum and maximum values in phase 1.
   - In byte 9, set the bits for the category of minimum and maximum values in phase 2.
   - In byte 11, set the bits for the category of minimum and maximum values in phase 3.
2. Set the reset bit (bit 0 and bit 1) for minimum or maximum values.
   - in byte 6 for phase 1
   - in byte 8 for phase 2
   - in byte 10 for phase 3

If there is an edge change of the phase-specific reset bits from 0 to 1, the module resets the minimum or maximum values for the given phase.

Procedure for module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, you always reset **all** the minimum and maximum values simultaneously.

Set the reset bit (Bit 0 or Bit 1) in Control byte 1 from 0 to 1 through an edge change.

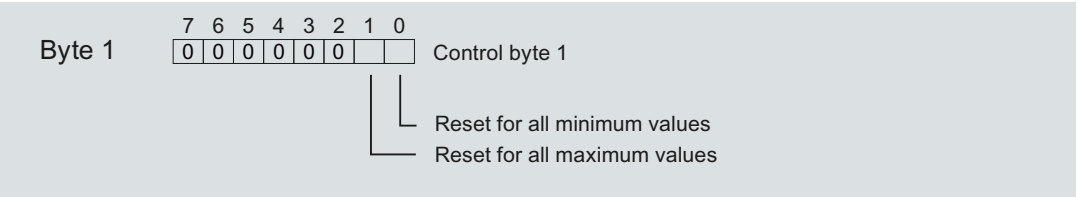

Figure 2-861 Resetting the minimum and maximum values at module version with 2 bytes of output data

11.3 Gate

NOTE
Module version with 2 bytes of output data
The gate is not available for the module version with 2 bytes of output data.

There are two ways of starting or stopping the calculation of the minimum and maximum values:

- Calculation of the minimum and maximum values with gate

  The module starts the calculation when you set the DQ bit for the gate in the output data (output data byte 1, bit 2 = "1") using an edge change from 0 -> 1. If you reset the DQ bit using an edge change from 1 -> 0, the calculation stops.

- Calculation of the minimum and maximum values without gate

  The module starts the calculation as soon as the module is started. The calculation cannot be stopped.

Both options are described in the following sections.

Calculation of the minimum and maximum values with gate

Procedure
If you wish to start calculating using the gate, proceed as follows:

1. Activate the parameter "Enable minimum and maximum value calculation" in the parameter assignment of the module.
2. Set the DQ bit of the gate for minimum and maximum value calculation (Bit 2) in control byte 1 in the output data.

The module starts calculating as soon as there is an edge change from 0 -> 1 at the DQ bit for the gate.

If you wish to stop the calculating again, then reset Bit 2 in control byte 1 in the output data. Calculating stops at an edge change from 1 -> 0.

The "Enable minimum and maximum value calculation" parameter and the DQ bit for the "gate" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

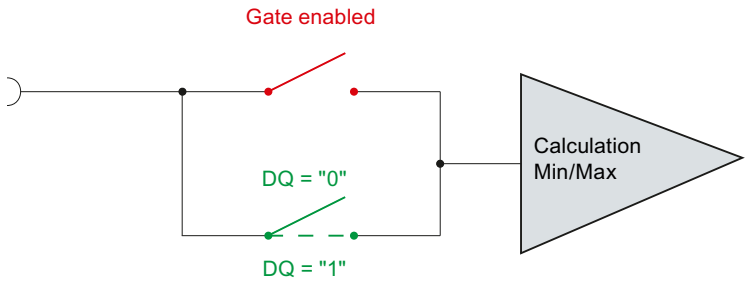

Figure 2-862 Gate enabled

NOTE

Module-global/phase-granular PLC

If you are using the gate control for all three phases simultaneously, use the control byte 1 at output address 1. For a phase-specific resolution of the gate control, use the addresses 6 (Phase1), 8 (Phase2) or 10 (Phase3) as control byte 1. The resolution of a module-global PLC overrules a phase-granular resolution.

Calculation of the minimum and maximum values without gate

Procedure

Deactivate the parameter "Enable minimum and maximum value calculation gate" in the parameter assignment of the module.

The module starts calculating as soon as the module is started. The calculating cannot be stopped.

Gate disabled: Gate is always "open" (signal path closed)

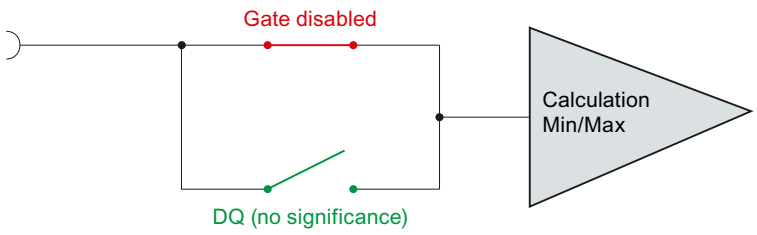

Figure 2-863 Gate disabled

Quality analysis functions 12

12.1 Reactive power compensation

Use the power factor of the fundamental for the reactive power compensation.

The power factor of the fundamental is available, among other things, in the measured value data record DS 142 (Page 179) or in the payload (Page 161).

12.2 Active factor and power factor

The AI Energy Meter CT ST returns the active and power factor individually for each phase and as an aggregate.

Active factor

The active factor is defined as follows:

cos φ (active factor, signed, fundamental oscillation): $\cos \varphi = P1 / S1$

φ = phase shift angle of fundamental oscillation

P1 = active power of fundamental oscillation

S1 = apparent power of fundamental oscillation

Power factor

The power factor $\lambda = \cos \Phi$ is the ratio of active power (P) to the total apparent power (S) over the fundamental oscillation and all harmonics (total):

λ (power factor, unsigned, total): $\lambda = \cos \Phi = |P| / S$

12.3 Neutral current In

The module can measure or calculate the neutral current.

For measuring, you have to connect a current transformer to neutral. The behavior "measuring or calculating" can be set for each parameter. The main application of the measured value "Neutral current IN" (ID: 61149) are three-phase networks with existing 4th conductor, neutral: The neutral current usually shows incorrectly flowing currents. In an ideal three-phase network, the neutral current = 0.

The determination of the neutral current is not subject to current suppression.

Parameter assignment options

If there a neutral conductor in a connection type, the following parameters are available:

- Neutral current measurement deactivated
- Calculate the neutral current measurement
- Measure the neutral current measurement

If there is no neutral conductor in a connection type, the following parameters are available:

- Do not use current channel
- Measure current channel

Display via channel LED

Neutral conductor exists for connection type	calculate	measuring	Error	Channel LED
Yes	Yes	Yes	No	Green
Channel disabled	---	---	---	Off
No	No	Yes	No	Green

Phase-based measured values 13

Introduction

The AI Energy Meter CT ST makes the measured values of individual phases available.

- Through the payload variants
  - Phase-specific measurement Phase L1 with payload variants 158 ($9E_H$) and 159 ($9F_H$)
  - Phase-specific measurement phase L2 with payload variants 156 ($9C_H$) and 157 ($9D_H$)
  - Phase-specific measurement phase L3 with payload variants 154 ($9A_H$) and 155 ($9B_H$)
- Via measured value data records
  - Phase-specific measurement for the phases L1, L2 and L3 with data record 142
  - Phase-specific measurement for phase L1 with data record 147
  - Phase-specific measurement for phase L2 with data record 148
  - Phase-specific measurement for phase L3 with data record 149

Payload variants

Through the payload variants 154 ($9A_H$) to 159 ($9F_H$) you can evaluate the following measured values for each phase of an AC / three-phase network:

- Quality information
- Current and voltage
- Active, reactive and apparent power
- Active, reactive and apparent energy
- Power factor

You can find the structure of the payload variants in appendix Payload variants with 32 bytes of input data / 20 bytes of output data (Page 161).

Measured value data records

Through the measured value data records DS 142, DS 147, DS 148 and DS 149 you can evaluate the following measured values for each phase of an AC / three-phase network:

- Quality information
- Current and voltage
- Minimum current and minimum voltage
- Maximum current and maximum voltage
- Active, reactive and apparent power
- Minimum active, reactive and apparent power

- Maximum active, reactive and apparent power
- Active, reactive and apparent energy
- Power factor
- Minimum power factor
- Maximum power factor

The structure of the measured value data record is available in the appendix E Measured value data record for phase-based measured values L1 (DS 147) version 1 (Page 194).

See also

Measured value data record for phase-based measured values L2 (DS 148) version 1 (Page 197)

Measured value data record for phase-based measured values L3 (DS 149) version 1 (Page 201)

Parameter 14

14.1 Parameter

Parameters of the AI Energy Meters CT ST

You will usually configure the AI Energy Meter CT ST with STEP 7 (TIA Portal, if necessary, with HSP). In this case, STEP 7 (TIA Portal) checks the configured properties for plausibility during configuration.

You can also assign parameters to the module using a GSD file and STEP 7 or the configuration software of any provider. In this case, the module checks the validity of the configured properties only after the configuration has been downloaded. Note that some parameters depend on the selected connection type of the AI Energy Meter CT ST. For example in the connection type 1P2W for measurements in single-phase AC network it does not make sense to enter parameters for Phases 2 and 3. This is not checked by the system if the GSD file is used.

The effective range of the parameters that can be set using a GSD file depends on the type of bus system used:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition you can change the parameterized properties via the user program in RUN mode. When you assign parameters in the user program, the WRREC instruction transfers the parameters to the module using data records (see appendix Parameter assignment using parameter data records (Page 115)).

The following table summarizes all the configurable parameters with STEP 7 (GSD file).

Table 2-938 Parameters AI Energy Meter CT ST (GSD file)

Parameter	Value range	Default setting
Hardware interrupts *	• Disable • Enable	Disable
Inputs		
Diagnostics: No supply voltage L+	• Disable • Enable	Disable
Connection type	• Disabled • 1P2W - 1 phase, 2 conductors • 3P4W1, 3 phases, 4 conductors, balanced load • 3P4W - 3 phases, 4 conductors • 3x1P2W - 3 x 1 phase, 2 conductors each • 2P3W - 2 phases, 3 conductors • 3P3W, 3 phases, 3 conductors • 3P3W1, 3 phases, 3 conductors, balanced load	3P4W - 3 phases, 4 conductors

* Reconfiguration in RUN is not possible.

Parameter	Value range	Default setting
Voltage measuring range	• 100 V • 110 V • 115 V • 120 V • 127 V • 190 V • 200 V • 208 V • 220 V • 230 V • 240 V • 277 V • 300 V	230 V
Line frequency	• 50 Hz • 60 Hz	50 Hz
Activate gate switch for energy meter	• Disable • Enable	Disable
End value energy meter	• No end value (infinite counting) • Count periodically to 10^3 • Count periodically to 10^6 • Count periodically to 10^9 • Count periodically to 10^{12} • Count periodically to 10^{15}	No end value (infinite counting)
Payload variant	See the table Overview of the payload variants (Page 161)	Total power L1L2L3 (W#16#FE)
Minimum and maximum value calculation	• Disable • Enable	Disable
Minimum and maximum value calculation gate	• Disable • Enable	Disable
Neutral conductor: Current transformer primary current [A]	• 0 = Disabled • 1 ... 99999 = measuring • 4294967295 = Calculating	0
Neutral conductor: Current transformer secondary current [A]	• 1 • 5	1
Diagnostics overflow current	• Disable • Enable	Disable
Diagnostics overflow voltage	• Disable • Enable	Disable
Diagnostics underflow voltage	• Disable • Enable	Disable
Diagnostics Overflow cumulative values	• Disable • Enable	Disable
Nominal value current [A]	• 0 ... 99999	1
Tolerance factor overcurrent in relation to nominal value current [0.1%]	• 10 ... 60000	100
Tolerance time overcurrent [ms]	• 0 ... 60000	40000

* Reconfiguration in RUN is not possible.

Parameter	Value range	Default setting
Low limit current measurement in relation to nominal value current [0.1%]	• 0 ... 200	10
Enable operating hours counter	• Disable • Enable	Disable
Activate gate switch for energy meter	• Disable • Enable	Disable
Current transformer primary current [A]	• 1 ... 99999 A	1 A
Current transformer secondary current	• 1 A • 5 A	1 A
Reverse current direction	• Disabled • Reverse current direction	Disabled
Nominal value voltage [V]	• 1 ... 999999	230 V
Tolerance factor overvoltage/under-voltage [0.1%]	• 10 ... 500	100
Voltage transformer primary voltage [V]	• 1 ... 999999 V	230 V
Voltage transformer secondary voltage [V]	• 1 ... 500 V	230 V
Limits		
Number of limit values	• 0 ... 16	0
Limit monitoring	• Disable • Enable	Disable
Measured variable	• Measured value ID, see Measured value data records	None
Activate gate switch for energy meter	• Disable • Enable	Disable
Hardware interrupt	• Disable • Enable	Disable
Limit	• depending on the selected measured variable	0.0000
Type	• High limit • Low limit	High limit
Hysteresis for limit monitoring [0.1%]	• 0 ... 200 [0.1%]	10
Delay time for limit monitoring [s]	• None • 1 ... 10 s	None
Payload mapping		
Number of measured values	• 0 ... 64	0
Measured variable	• Measured value ID, see Measured variables	None
Data record mapping		
Number of measured values	• 0 ... 150	0
Measured variable	• Measured value ID, see Measured variables	None

* Reconfiguration in RUN is not possible.

14.2 Explanation of parameters

Basic parameters

Hardware interrupts

Enable the hardware interrupt for the entire module here.

Diagnostics: No supply voltage L+

Activate the diagnostics Missing load voltage L+. If there is no voltage or too little voltage at terminal 17, the message "Missing load voltage" is output and a diagnostics interrupt is triggered.

Connection type

Specify the connection type you used for the AI Energy Meter CT ST.

For more detailed information, refer to "Connection examples (Page 23)".

Voltage measuring range

Here you set the voltage measuring range in which the system connected to the AI Energy Meter CT ST works. This parameter is only required when calibrating the module.

Line frequency

Here you set the line frequency in which the system connected to the AI Energy Meter ST works.

Energy meters gate switch

Activate gate switch for energy meter When the gate is activated, the energy meter only counts when the corresponding output data bit (DQ bit) is set to "1".

End value energy meter

Select the end value for the periodic counting of the energy meter. You can also specify that the energy meter is to count without a end value (infinite counting). The calculated energy meter values are stored retentively in the module.

Payload variant

Select payload variant with which the module is to operate once it is started up.

Minimum and maximum value calculation

Activate calculation of the minimum and maximum values. The minimum and maximum value are calculated from the start of the measurement. The values determined are stored retentively in the AI Energy Meter CT ST together with the time stamp.

Minimum and maximum value calculation gate

Activate the gate for minimum and maximum value calculation. When the gate is activated, the energy meter only counts when the corresponding output data bit (DQ bit) is set to "1".

Neutral conductor: Current transformer primary current [A]

To determine the current transformer ratio, enter the primary current. The transformer ratio is calculated from the primary and secondary current.

The following applies to parameter assignment with GSD file:

- 0 = Neutral function deactivated
- 1 ... 99999 = measure neutral current
- 4294967295 = calculate neutral current (0xFFFF FFFF)

Neutral conductor: Current transformer secondary current [A]

To determine the current transformer ratio, enter the secondary current. The transformer ratio is calculated from the primary and secondary current.

Diagnostics overflow current

The measured current is monitored after expiry of the "Tolerance time" for "Overcurrent [0.1 A] tolerance value". Exceeding the value generates the diagnostics "Overflow current".

Diagnostics overflow voltage

The nominal values voltage are monitored for tolerance. An overflow triggers a diagnostics interrupt.

Diagnostics underflow voltage

The nominal values voltage are monitored for tolerance. An underflow triggers a diagnostics interrupt.

Diagnostics overflow cumulative values

A cumulative overflow in the calculated variables is displayed. The values stop at the high or low limit. A violation triggers a diagnostics interrupt.

Nominal value current [A]

Enter the nominal value for the current. This is the "operating point" in your application.

Tolerance factor overcurrent in relation to nominal value current [0.1%]

Further information can be found under Diagnostics: Overload (Page 106).

Tolerance time overcurrent [ms]

Further information can be found under Diagnostics: Overload (Page 106).

Low limit current measurement in relation to nominal value current [0.1%]

The configurable low limit for measuring current refers to the nominal value and is used to avoid incorrect calculations in the case of very low currents. Incorrect measurements of very low currents in particular are a cause of inaccuracies in the current transformer used. Set the low limit for the current measurement to the required value depending on your process.

NOTE

Tip: If you want to find the low limit for the current measurement experimentally, set it to a lower value. Then, feed in a very precise low current and determine the measurement error that can no longer be tolerated. Afterwards, set the low limit for the current measurement to the limit value you have determined.

If current falls below the low limit for the current measurement, the following measured values and derived variables of the affected phase are reset.

- Effective current value
- Neutral current
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A moving mean value is formed from the power values and they only become "0" after a corresponding time. The energy meters for active, reactive and apparent energy as well as the operating hours counters do not count any longer.

Further information can be found under Low limit for measuring current undershot (Page 108).

Enable operating hours counter

Enable the operating hours counter. The counting starts from the configurable low limit of the current measurement. The counter can be reset or pre-assigned using data record or output bit.

Activate gate switch for energy meter

Enable the gate for the operating hours counter. When the gate is activated, the operating hours counter only counts when the corresponding output data bit (DQ bit) is set to "1".

Current transformer primary current

Enter the nominal value for the primary current of the current transformer used. The transformer ratio is calculated from the primary and secondary current.

Current transformer secondary current

Enter the nominal value for the secondary current (1 A or 5 A) of the current transformer used. The transformer ratio is calculated from the primary and secondary current.

Reverse current direction

Setting to determine whether or not to reverse the direction of current.

In the event of inadvertent incorrect connection, this parameter can be used to correct the measured values, thus saving the hassle of rewiring. The direction of the current is only evident from the power measurement values. The current measurement value is an rms value.

Nominal value voltage [V]

Enter the nominal value for the voltage. This is the "operating point" in your application.

Tolerance factor overvoltage/undervoltage [0.1%]

Enter the tolerance factor overvoltage/undervoltage here in increments of 0.1%. You can find additional information under Diagnostics: Overflow/underflow (Page 104).

Voltage transformer primary voltage [V]

Enter the nominal value for the primary voltage of the voltage transformer used. The transformer ratio is calculated from the primary and secondary voltage.

Voltage transformer secondary voltage [V]

Enter the nominal value for the secondary voltage of the voltage transformer used. The transformer ratio is calculated from the primary and secondary voltage.

Limits

Number of limit values

Enter the number of measured values that you want to monitor for limits.

Limit monitoring

Activate the monitoring of the limit for a freely definable measured value here. Limit violations are counted and the count values stored retentively.

Measured variable

Enter the measured value ID (Page 136) that you want to use for limit monitoring.

Activate gate switch for energy meter

Activate the gate switch for limit monitoring. When the gate is activated, the limit monitoring is only started when the corresponding bit of the associated output payload is set to "1".

Hardware interrupt

Activate the hardware interrupt. The hardware interrupt is triggered if a high or low limit is violated. Without activation of a hardware interrupt, a limit violation is only displayed in the payload and in DS 150.

Limit

Enter the limit that is to trigger a limit violation when exceeded or fallen below. Limit violations are displayed in the payload and in DS 150.

Type

Select whether it is a high or low limit. Depending on this selection, the limit violation or hardware interrupt is triggered when a value exceeds (high limit) or falls below (low limit) the limit.

Hysteresis for limit monitoring [0.1%]

Enter the hysteresis for limit in percent.

The hysteresis band is below the high limit or above the low limit. The parameter in % refers to the configured limit. If a measured value fluctuates around the limit but does not leave the hysteresis band, a new limit violation is not triggered.

Delay time for limit monitoring [s]

Select the delay time for limit violation. The delay refers to the time that must elapse before an occurrence of a limit violation is reported. Faults can be filtered out by selection of the delay time. The time lag is also taken into consideration during outgoing of the limit violation.

Payload mapping

Number of measured values

Specify the number of measured values/variables that you want to use for the user-specific payload mapping.

Measured variable

Select the measured variable (with the measured value ID (Page 136)) that you want to use for the user-specific payload mapping.

Data record mapping

Number of measured values

Specify the number of measured values/variables that you want to use for the user-specific data record mapping.

Measured variable

Select the measured variable (with the measured value ID (Page 136)) that you want to use for the user-specific data record mapping.

Interrupts/diagnostic alarms 15

15.1 Status and error display

LED display

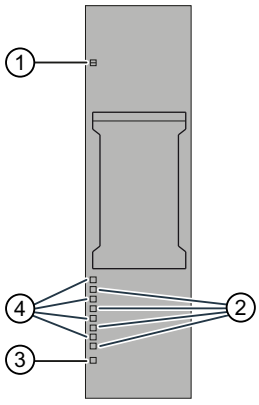

① DIAG (green/red)

② Error (red)

③ PWR (green)

④ Status (green)

Figure 2-864 LED display

Meaning of the LED displays

The following table explains the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 102).

DIAG LED

Table 2-939 Meaning of the DIAG LED

DIAG	Meaning
☐ Off	Supply voltage of the ET 200SP not OK
☼ Flashes	Module not ready for operation (no parameters assigned)
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Status LED

Table 2-940 Meaning of the Status LED

Status	Meaning
☐ Off	Channel deactivated or error
■ On	Channel activated and no error

see also Neutral current In

Error LED

Table 2-941 Meaning of the Error LED

Status	Meaning
☐ Off	Channel is OK
■ On	Channel is faulty

PWR LED

Table 2-942 Meaning of the PWR LED

PWR	Meaning
☐ Off	Line voltage missing
■ On	Line voltage available

15.2 Interrupts

The analog input module AI Energy Meter CT ST supports hardware and diagnostics interrupts.

15.2.1 Hardware interrupts

Hardware interrupts

The module generates a hardware interrupt at the following events:

- Violation of low limit 1 to 16
- Violation of high limit 1 to 16

You can find detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment of the local data double word 8 by the start information of the hardware interrupt organization block.

NOTE

When configuring with a GSD file, you operate the AI Energy Meter CT ST downstream of an S7-1500 CPU. For the correct OB start information to become visible for evaluation by the hardware interrupt, disable the optimized block access at the alarm OB.

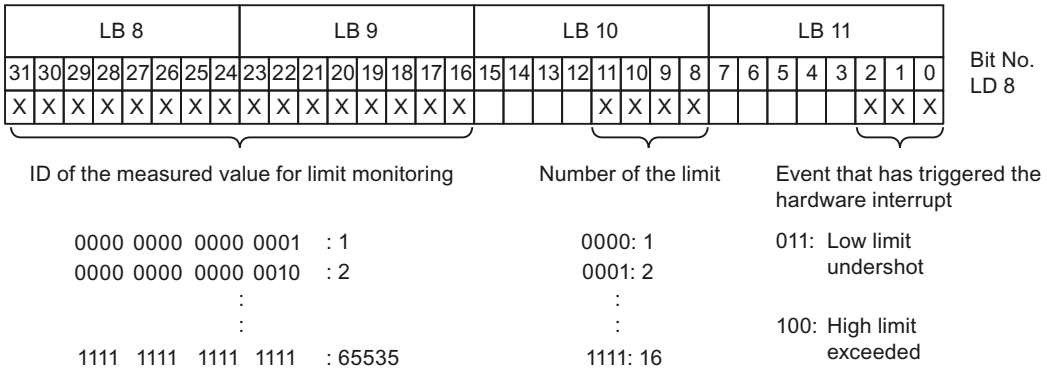

Figure 2-865 Start information of the organization block

15.2.2 Diagnostics interrupt

Diagnostic interrupt

The module generates a diagnostic error interrupt at the following events:

- Channel is temporarily unavailable
- Hardware interrupt lost
- Error
- Supply voltage missing
- Parameter assignment error
- Underflow voltage (tolerance for supply voltage) violated
- Overflow voltage (tolerance for supply voltage) exceeded
- Overload (current measurement > 12 A or tolerance overcurrent exceeded after expiry of the tolerance time)
- Overflow of the calculated values (measured or calculated values screen exceed the representable range of values)

15.3 Diagnostic alarms

NOTE

Assignment channel in diagnostic message ⇔ Phase

In the diagnostic messages the channels are counted from Channel "0" on, in the AI Energy Meter CT ST from phase "1" on.

Note the following assignment:

- Channel "0" ⇔ Phase "1"
- Channel "1" ⇔ Phase "2"
- Channel "2" ⇔ Phase "3"

Table 2-943 Error types

Diagnostic message	Error code	Meaning	Solution
Undervoltage	2_H	Line voltage (measuring range) is monitored for tolerance. Violation leads to voltage overflow/underflow	Observe the line voltage range
Overvoltage	3_H		
Overload	4_H	• The measured current is monitored after the "Tolerance time" for "Tolerance value overcurrent [0.1A]" has expired. Exceeding this results in overflow current. • The maximum value of the secondary current (12 A) has been exceeded.	Observe the current range
Error	9_H	Internal module error (diagnostic alarm on channel 0 applies to the entire module).	Replace the module

Diagnostic message	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Load voltage missing	11_H	Missing or insufficient line voltage at terminal 17	Check supply
Channel is temporarily unavailable	$1F_H$	Firmware upgrade is being performed. Channel 0 applies to the entire module. The module is currently not performing any measurements.	--
		A user calibration is being executed at the channel.	Complete the user calibration

15.4 Diagnostics response

Diagnostics response

This section describes the response of the AI Energy Meters CT ST when diagnostics information is reported.

Measured values in the case of diagnostics

Even in the case of diagnostics, measured values continue to be displayed as long as they can still be acquired. If measured values cannot be measured or calculated, "0" is displayed.

Low limit for current measurement undershot (zero suppression)

If the supplied current is less than the configured "Low limit for current measurement" parameter, the current measurement and all dependent variables are suppressed and set to "0".

If current falls below the low limit for the current measurement, the following measured values and derived variables of the affected phase are reset.

- Effective current value
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A moving mean value is formed from the power values and they only become "0" after a corresponding time. The energy meters for active, reactive and apparent energy as well as the operating hours counters do not count any longer.

If the secondary current fed in at the channel is higher than 12 A, the module changes to limitation and the current measurement value of the current and all dependent variables are set to "0".

Input data to "0"

If the AI Energy Meter CT ST is no longer recognized by the interface module (for example, because it is defective or not plugged in), all input data are set to "0".

15.4.1 Voltage diagnostics

15.4.1.1 Diagnostics: Overflow/underflow

Introduction

You use the parameter "Tolerance factor overvoltage/undervoltage" to define a tolerance range around the set nominal value voltage at the operating point. If the effective value of the primary voltage exceeds this tolerance range, the module reports the diagnostics "overflow" or "underflow".

Calculation of tolerance value measuring voltage

The tolerance value measuring voltage is calculated with the following formula:

Tolerance value measuring voltage = "Nominal value voltage" ± ("Tolerance factor overvoltage/undervoltage [%]" × "Nominal value voltage")

The "Nominal value voltage" is the primary voltage at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-944 Parameter assignment

Parameter	
Diagnostics overflow	Enable
Diagnostics underflow	Enable
Nominal value voltage	1 ... 999999 V
Voltage transformer primary voltage	1 ... 999999 V
Voltage transformer secondary voltage	1 ... 500 V
Tolerance factor overflow/underflow	10 ... 50%

Example

The following figure is a schematic diagram of the principle of operation:

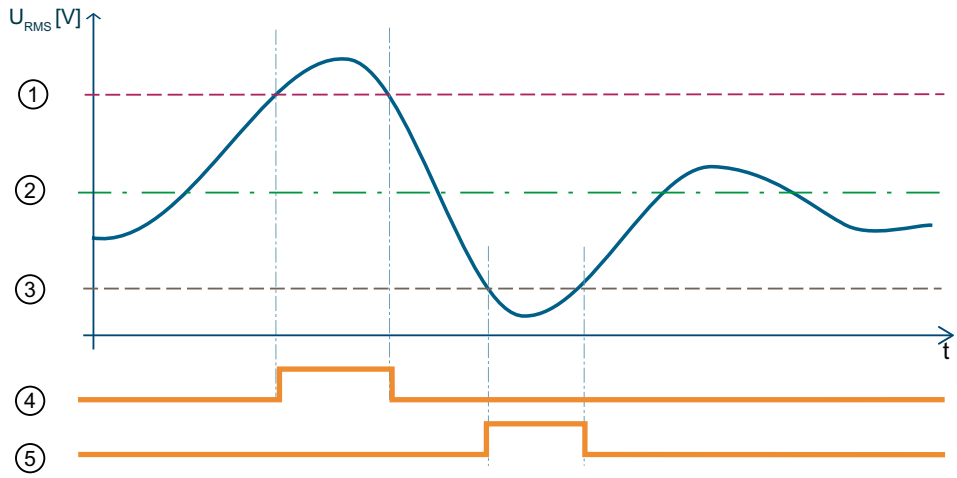

① Upper tolerance value measuring voltage
② Nominal voltage
③ Lower tolerance value measuring voltage
④ Diagnostics "overflow"
⑤ Diagnostics "underflow"

Figure 2-866 "Overflow/Underflow" diagnostics of the effective voltage value

The following table shows the parameter assignment for the example:

Table 2-945 Parameter assignment

Parameter	
Diagnostics overflow	Enable
Diagnostics underflow	Enable
Nominal value voltage	230 V
Voltage transformer primary voltage	1000 V
Voltage transformer secondary voltage	500 V
Tolerance factor overflow/underflow	20%

In this example a voltage transformer is used with a ratio of 1000V/500V. The operating point of the application is set to 230 V via the Nominal Value Voltage parameter. The tolerance range in this example is ±20%, which corresponds to an effective value of primary voltage of ±46V.

In the figure the effective value of the primary voltage first exceeds the tolerance range. As long as the effective value of the primary voltage exceeds the tolerance range the module reports the diagnostics "overflow".

The effective value of the primary voltage then exceeds the tolerance range. As long as the effective value of the primary voltage exceeds the tolerance range the module reports the diagnostics "underflow".

15.4.2 Current diagnostics

15.4.2.1 Diagnostics: Overload

Introduction

As long as one of the following conditions is met, the module reports the diagnostics "Overload" for each phase:

- If the tolerance value measured current parameterized for each phase is exceeded for the tolerance time overcurrent parameterized for each phase.
- If the maximum measured current of the AI Energy Meters CT ST is exceeded:
  - Secondary measured current: 12 A

Calculation of tolerance value measured current

The tolerance value measured current is calculated with the following formula:

Tolerance value measured current = "Nominal value current" + ("Tolerance factor overcurrent [%]" × "Nominal value current")

The "Nominal value current" is the primary current at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-946 Parameter assignment

Parameter	
Diagnostics overload	Enable
Nominal value current	0 ... 99999 A
Current transformer primary current	1 ... 99999 A
Current transformer secondary current	5 A
Tolerance factor overcurrent	1 ... 6000%
Tolerance time overcurrent	0 ... 60000 ms

Example

The following figure is a schematic diagram of the principle of operation:

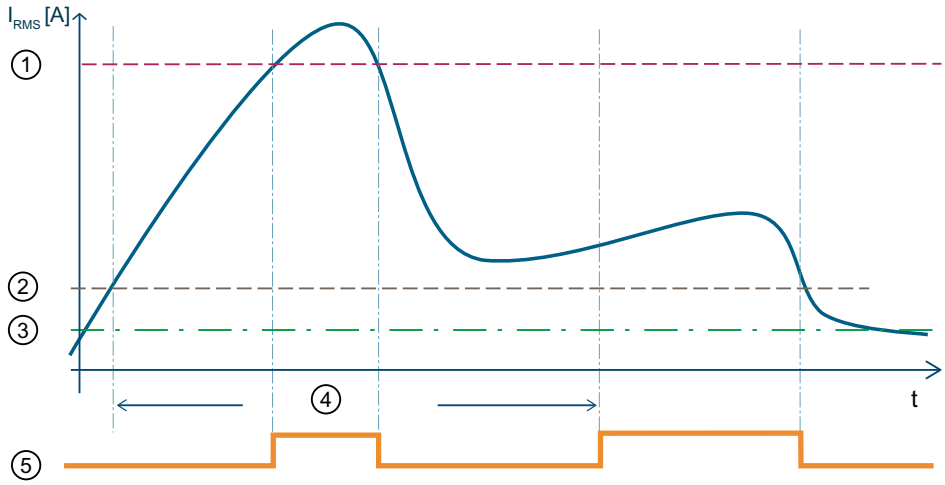

① Maximum measured current 12 A secondary current (CT) or 424 mV secondary voltage (RC)

② Tolerance value measured current

③ Nominal value current

④ Tolerance time

⑤ Diagnostics "overload"

Figure 2-867 Diagnostics "overload" of the effective current value

The following table shows the parameter assignment for the example:

Table 2-947 Parameter assignment

Parameter	
Diagnostics overload	Enable
Nominal value current	2000 A
Current transformer primary current	5000 A
Current transformer secondary current	5 A
Tolerance factor overcurrent	20%
Tolerance time overcurrent	40000 ms

If the maximum measured current for the module (12000 A primary current) is exceeded, the module reports the diagnostics "Overload" as long as the maximum measured current is exceeded.

After the "Tolerance time overcurrent" of 40000 ms has expired, the module reports the diagnostics "Overload" as long as the configured "Tolerance value measured current" is exceeded.

15.4.2.2 Low limit for measuring current undershot

Introduction

With the function "Low limit for measuring current undershot" the AI Energy Meter CT ST monitors the low limit of the effective value of the current per phase.

If the low limit for measuring current is undershot, the module sets the current value to 0 (zero point suppression). Information as to which current measured values are set to 0 can be found under Basics for reading measured values (Page 41).

You activate the function by setting the parameter "Low limit for measuring current" > 0%.

Calculation of low limit for measuring current

The low limit for measuring current is calculated using the following formula:

Low limit measured current = "Nominal value current" × "Low limit for measuring current [%]"

The "Nominal value current" is the primary current at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-948 Parameter assignment

Parameter	
Nominal value current	0 ... 99999 A
Current transformer primary current	1 ... 99999 A
Current transformer secondary current	1 ... 16000 A
Low limit for current measurement	0 ... 20% *

* 0% means deactivation of the function

Example

The following figure is a schematic diagram of the principle of operation:

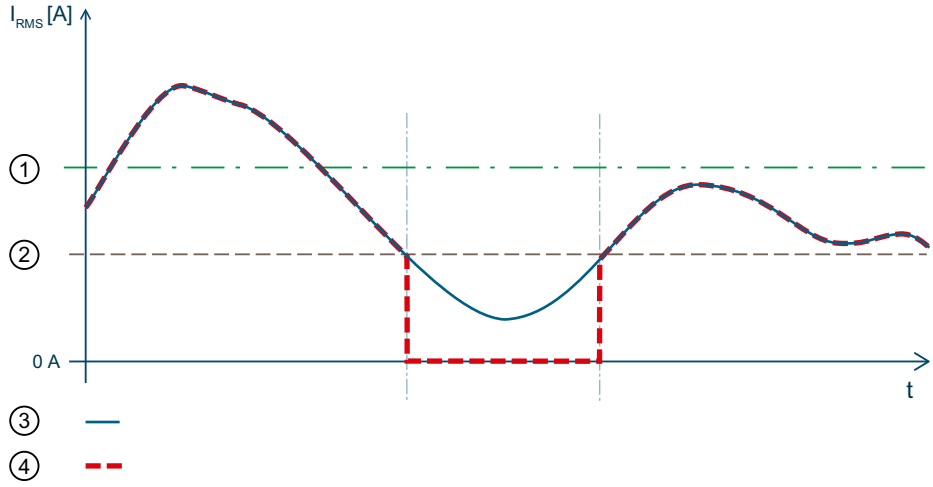

① Nominal current
② Low limit measured current
③ Measured value
④ Returned value

Figure 2-868 Behavior in the event of value falling below "Low limit for measuring current undershot"

The following table shows the parameter assignment for the example:

Table 2-949 Parameter assignment

Parameter	
Nominal value current	2000 A
Current transformer primary current	5000 A
Current transformer secondary current	5 A
Low limit for current measurement	10%

In this example you define the "Low limit for measuring current" with 10%. This corresponds to an effective value of the primary voltage of 200 A.

If the value falls below the calculated low limit for current measurement, the module sets all current-dependent measured values (effective value current, active power, reactive power, apparent power, phase angle and power factor) to 0 A until the low limit for measuring current is exceeded again (zero point suppression). The energy meters and operating hours counters are stopped during this time.

Technical specifications 16

16.1 Technical specifications

Technical specifications of the AI Energy Meter CT ST

The following table shows the technical specifications as of 03/2021. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7134-6PA01-0BU0/td?dl=en).

Article number	6ES7134-6PA01-0BU0
General information	
Product type designation	AI Energy Meter CT ST
Firmware version	V8.0
• FW update possible	Yes
usable BaseUnits	BU type U0
Supported power supply systems	TT, TN, IT
Product function	
• Voltage measurement	Yes
– without voltage transformer	Yes
– with voltage transformer	Yes
• Current measurement	Yes; max. 3 + neutral conductor
– without current transformer	No
– with current transformer	Yes; 1 A or 5 A current transformer
– With Rogowski coil	No
– With current-voltage-converter	No
• Energy measurement	Yes
• Frequency measurement	Yes
• Power measurement	Yes
• Active power measurement	Yes
• Reactive power measurement	Yes
• Power factor measurement	Yes
• Active factor measurement	Yes
• Reactive power compensation	Yes
• Line analysis	No
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No

Article number	6ES7134-6PA01-0BU0
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V16 or higher with HSP
• STEP 7 configurable/integrated from version	Configurable via GSD file
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	V2.3
Operating mode	
• Switching between operating modes in RUN	Yes; For module version 32 I/20 Q, it is possible to dynamically switch between 25 user data variants, 23 of which are pre-defined and 2 of which can be defined by the specific user
• Cyclic measured value access	Yes
• Acyclic measured value access	Yes
• Fixed measured value sets	Yes
• Freely definable measured value sets	Yes; For cyclic and acyclic measured value access
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	Yes
Installation type/mounting	
Mounting position	any
Supply voltage	
Design of the power supply	DC
Type of supply voltage	24 V DC
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Input current	
Current consumption (rated value)	12.5 mA
Current consumption, max.	17 mA
Power loss	
Power loss, typ.	1 W; 3x 5 A input current, 3x 230 V AC
Address area	
Address space per module	
• Inputs	256 byte
• Outputs	20 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type U0

Article number	6ES7134-6PA01-0BU0
Time of day	
Operating hours counter	
• present	Yes
Analog inputs	
Cycle time (all channels), typ.	50 ms; Time for consistent update of all measured and calculated values (cyclic und acyclic data)
Cable length	
• shielded, max.	200 m
• unshielded, max.	200 m
Analog value generation for the inputs	
Sampling frequency, max.	2 048 kHz
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes
• Hardware interrupt	Yes; Monitoring of up to 16 freely selectable process values (exceeding or undershooting of value)
Diagnoses	
• Supply voltage	Yes
• Hardware interrupt lost	Yes
• Parameter assignment error	Yes
• Module fault	Yes
• Channel not available	Yes
• Overflow/underflow	Yes
• Overload current	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red Fn LED
• for module diagnostics	Yes; green/red DIAG LED
Integrated Functions	
Measuring functions	
• Measuring procedure for voltage measurement	TRMS
• Measuring procedure for current measurement	TRMS
• Type of measured value acquisition	seamless
• Curve shape of voltage	Sinusoidal or distorted
• Buffering of measured variables	Yes

Article number	6ES7134-6PA01-0BU0
• Parameter length	128 byte
• Bandwidth of measured value acquisition	3.2 kHz; Harmonics: 63 / 50 Hz, 52 / 60 Hz
Measuring range	
– Frequency measurement, min.	40 Hz
– Frequency measurement, max.	70 Hz
Measuring inputs for voltage	
– Measurable line voltage between phase and neutral conductor	277 V
– Measurable line voltage between the line conductors	480 V
– Measurable line voltage between phase and neutral conductor, min.	3 V
– Measurable line voltage between phase and neutral conductor, max.	300 V
– Measurable line voltage between the line conductors, min.	6 V
– Measurable line voltage between the line conductors, max.	519 V
– Internal resistance line conductor and neutral conductor	1.5 MΩ
– Power consumption per phase	60 mW; 300 V AC
– Impulse voltage resistance 1,2/50µs	2.5 kV
Measuring inputs for current	
– measurable relative current (AC), min.	1 %; Relative to measuring range; 1 A, 5 A
– measurable relative current (AC), max.	100 %; Relative to the secondary rated current 5 A
– Continuous current with AC, maximum permissible	5 A
– Apparent power consumption per phase for measuring range 5 A	0.6 V·A
– Rated value short-time withstand current restricted to 1 s	100 A
– Input resistance measuring range 0 to 5 A	25 mΩ; At the terminal
– Surge strength	10 A; for 1 minute
– Zero point suppression	0 ... 20%, referred to the nominal current
Accuracy class according to IEC 61557-12	
– Measured variable apparent power	0.5
– Measured variable active power	0.5
– Measured variable power factor	0.5
– Measured variable active energy	0.5
– Measured variable phase angle	±0.5 °; not covered by IEC 61557-12

Article number	6ES7134-6PA01-0BU0
– Measured variable frequency	0.05; only valid for the permissible voltage measuring range
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• Between the channels and load voltage L+	Yes; Including FE
Isolation	
Isolation tested with	Between channels and backplane bus, 24 V supply: Routine test, 1 920 V AC, 2 s; between backplane bus and 24 V supply: Type test, 707 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	45 g
Other	
Data for selecting a voltage transformer	
• Secondary side, max.	300 V
Data for selecting a current transformer	
• Burden power current transformer x/1A, min.	As a function of cable length and cross section, see device manual
• Burden power current transformer x/5A, min.	As a function of cable length and cross section, see device manual

Dimension drawing

See ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) manual

Parameter data records

A

A.1 Configuration via parameter data records

The parameter data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Overview of the parameter data records

- Parameter data record DS 128 for the complete module
- Parameter data record DS 129 for limit monitoring
- Parameter data record DS 130 for user data mapping
- Parameter data record DS 135 for data record mapping

Parameter assignment in the user program

You can reassign the module parameters in RUN mode, for example change the diagnostics behavior, define new limits or configure a modified user data mapping.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module via the respective data record. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

If you reconfigure a module (so that the user data size changes) and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing". The diagnostics "Supply voltage missing" is signaled as outgoing.

A reconfiguration in run is not bumpless. It can take up to 1 second for all measured values to become stable.

STATUS output parameter

If errors occur during the transfer of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

A.2 Structure of the parameter data record 128 for the entire module

Structure of data record 128

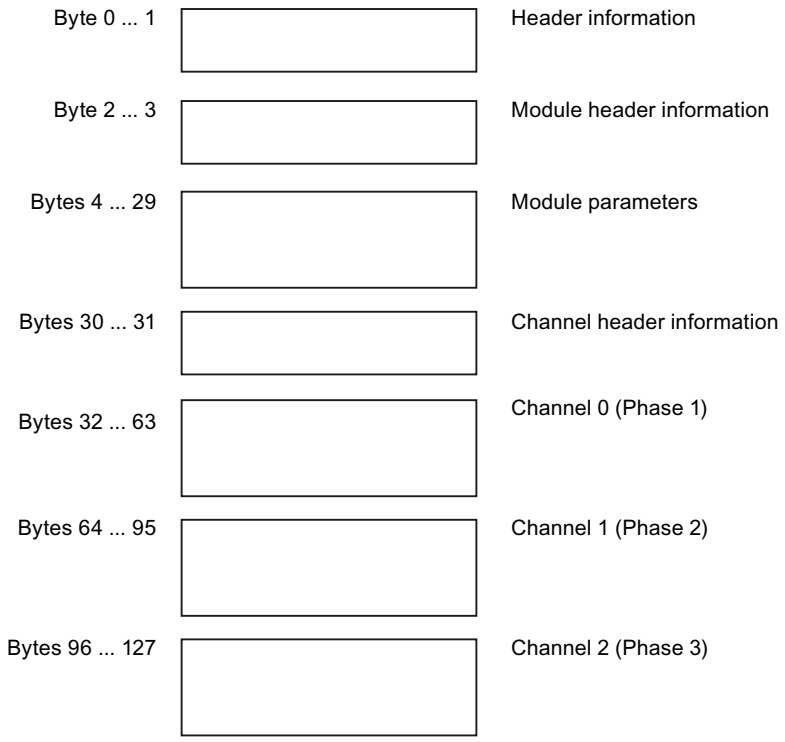

Figure 2-869 Parameter data record 128

Header information

The figure below shows the structure of the header information.

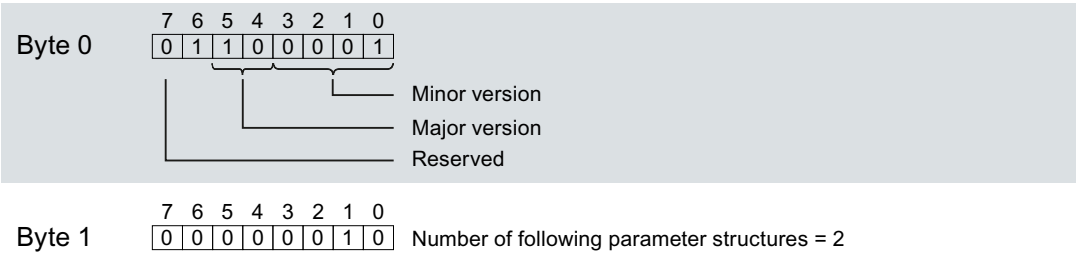

Figure 2-870 Header information

Module header information

The figure below shows the structure of the header information for a module.

	7	6	5	4	3	2	1	0	
Byte 2	0	0	0	0	0	0	0	1	Number of the following module parameter blocks = 1
Byte 3	0	0	0	1	1	0	1	0	Length of the following module parameter block = 26

Figure 2-871 Module header information

Module parameter block

The figure below shows the structure of the module parameter block.

Byte 4 (7 6 5 4 3 2 1 0)

Connection type of the phases

- 00_H = disabled
- $0B_H$ = 1P2W: 1-phase alternating current, 2 conductors
- $0C_H$ = 3P4W: 3-phase, 4 conductors
- $0E_H$ = 3P4W1: 3-phase, 4 conductors, balanced load
- $0F_H$ = 3x1P2W: 3x1-phase alternating current, 2 conductors
- 10_H = 2P3W: 2-phase, 3 conductors
- 11_H = 3P3W: 3-phase, 3-conductors
- 12_H = 3P3W1: 3-phase, 3 conductors, balanced load

Byte 5 (7 6 5 4 3 2 1 0)

Voltage measuring range of the power supply system
(Supply voltage, nominal value of phase voltage)

- 01_H = 100 V
- 02_H = 110 V
- 03_H = 115 V
- 04_H = 120 V
- 05_H = 127 V
- 06_H = 190 V
- 07_H = 200 V
- 08_H = 208 V
- 09_H = 220 V
- $0A_H$ = 230 V
- $0B_H$ = 240 V
- $0C_H$ = 277 V
- $0D_H$ = 300 V

Byte 6 (7 6 5 4 3 2 1 0)

Line frequency of the power supply system

- 0001 = 60 Hz
- 0010 = 50 Hz

End value for energy meter

- 000 = No end value - infinite counting
- 001 = Count periodically to 10^3
- 010 = Count periodically to 10^6
- 011 = Count periodically to 10^9
- 100 = Count periodically to 10^{12}
- 101 = Count periodically to 10^{15}

Energy meters gate switch

- 0 = Energy meter always counting
- 1 = Energy meters gate switch

Byte 7 (7 6 5 4 3 2 1 0): 0 0 0 0 0 0 0 0 reserved

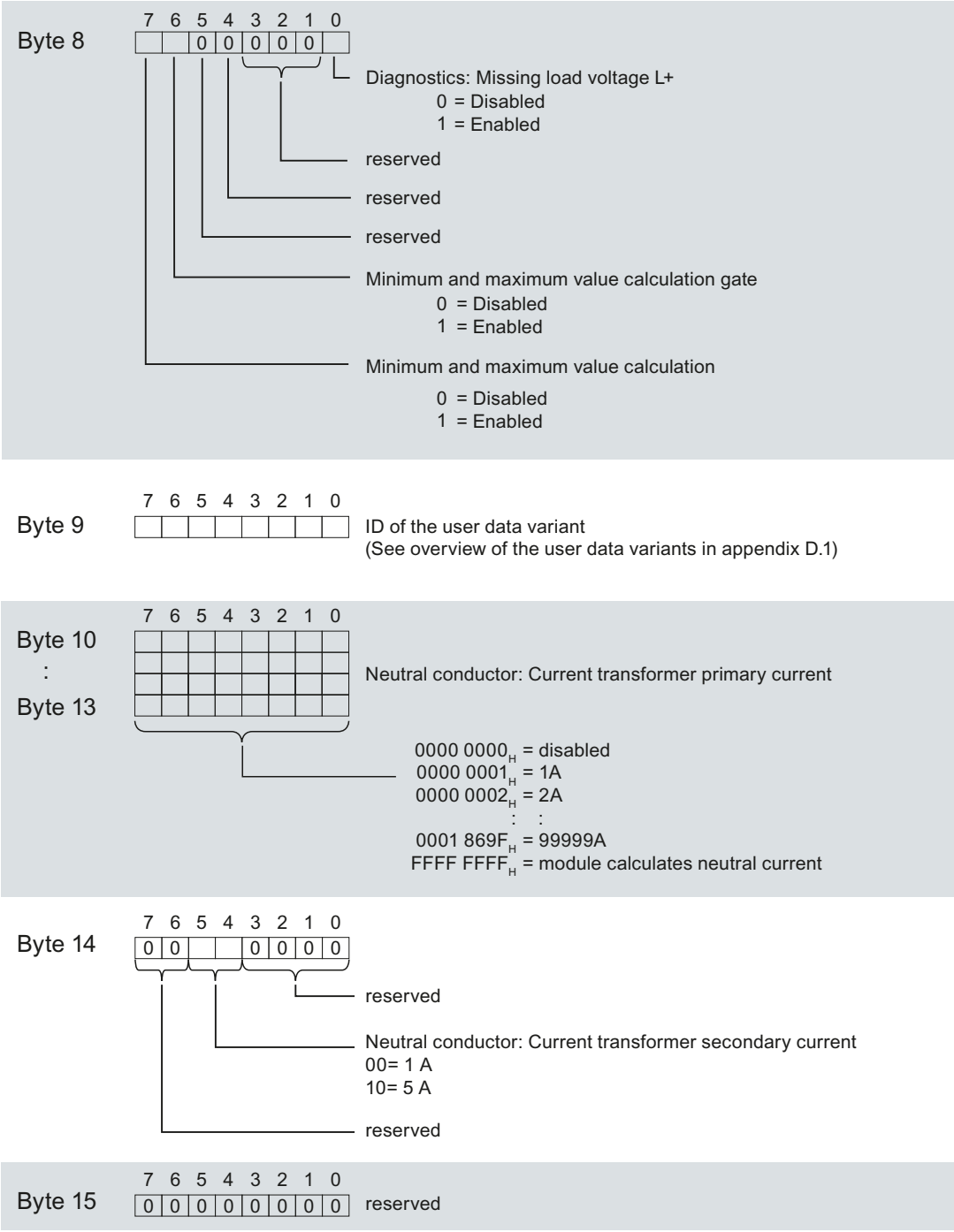

Figure 2-872 Module parameter block

	7	6	5	4	3	2	1	0	
Byte 16	0	0	0	0	0	0	0	0	reserved
Byte 17	0	0	0	0	0	0	0	0	
Byte 18	0	0	0	0	0	0	0	0	reserved
Byte 19	0	0	0	0	0	0	0	0	
Byte 20	0	0	0	0	0	0	0	0	reserved
Byte 21	0	0	0	0	0	0	0	0	
Byte 22	0	0	0	0	0	0	0	0	reserved
Byte 23	0	0	0	0	0	0	0	0	
Byte 24	0	0	0	0	0	0	0	0	reserved
:	0	0	0	0	0	0	0	0	
:	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	
Byte 29	0	0	0	0	0	0	0	0	

Figure 2-873 Module parameter block

You can find the user data variant in the section Overview of the user data variants (Page 161).

Channel header information

The following figure shows the structure of the header information for a channel.

	7	6	5	4	3	2	1	0	
Byte 30	0	0	0	0	0	0	1	1	Number of following channel parameter blocks = 3
Byte 31	0	0	1	0	0	0	0	0	Length of the following channel parameter block = 32

Figure 2-874 Channel header information

Channel parameter block for channel 0 (Phase 1)

The following figure shows an example of the structure of the channel parameter block for channel 0 (phase 1, bytes 32 to 63).

For channel 1 (phase 2; bytes 64 to 95) and channel 2 (phase: 3; bytes 96 to 127), the structure is identical.

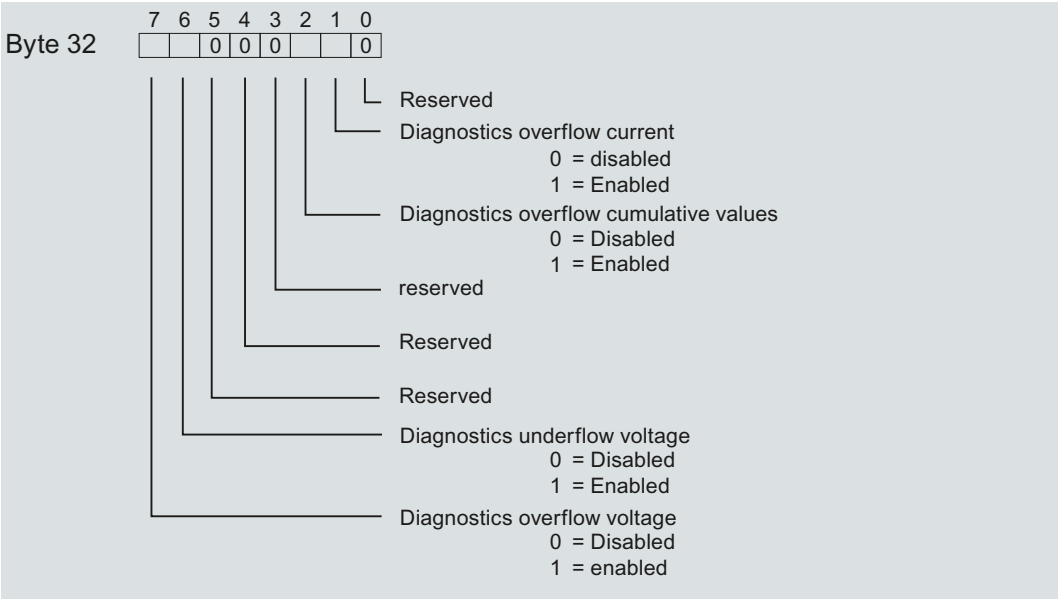

Byte 33

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	reserved

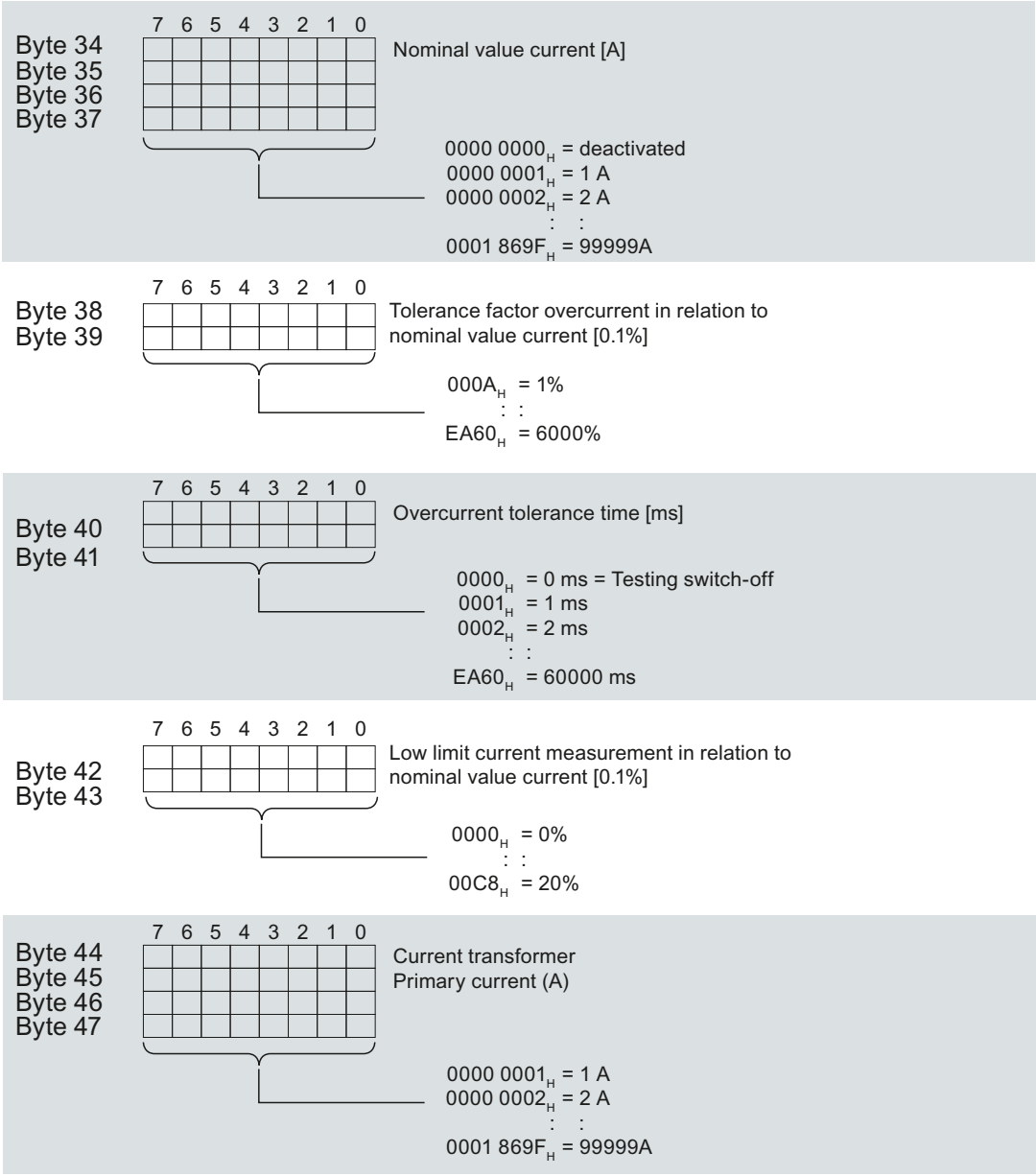

Figure 2-875 Channel parameter block

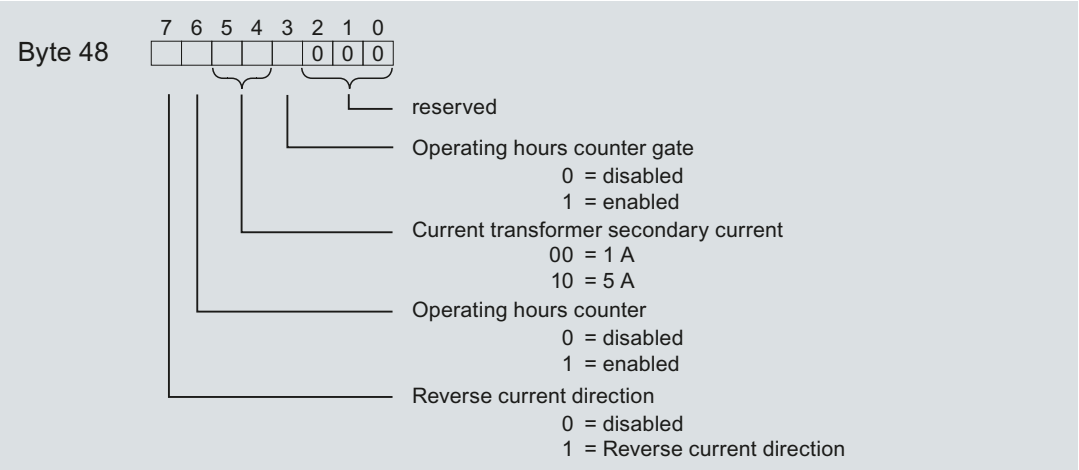
Byte 48
7 6 5 4 3 2 1 0
0 0 0
reserved
Operating hours counter gate
0 = disabled
1 = enabled
Current transformer secondary current
00 = 1 A
10 = 5 A
Operating hours counter
0 = disabled
1 = enabled
Reverse current direction
0 = disabled
1 = Reverse current direction

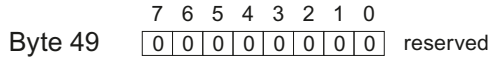
Byte 49
7 6 5 4 3 2 1 0
0 0 0 0 0 0 0 0
reserved

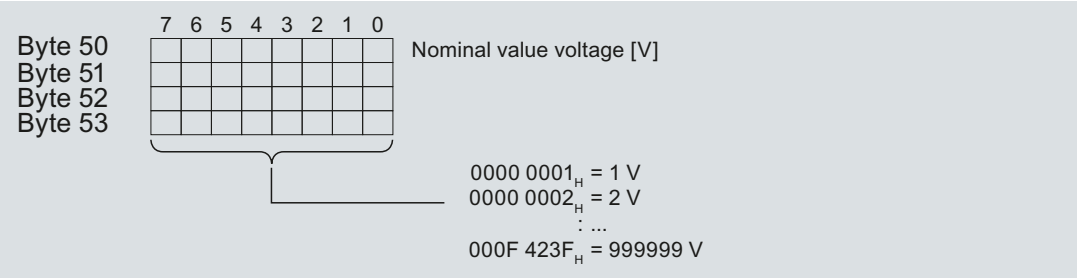
Byte 50
Byte 51
Byte 52
Byte 53
7 6 5 4 3 2 1 0
Nominal value voltage [V]
0000 0001H = 1 V
0000 0002H = 2 V
: ...
000F 423FH = 999999 V

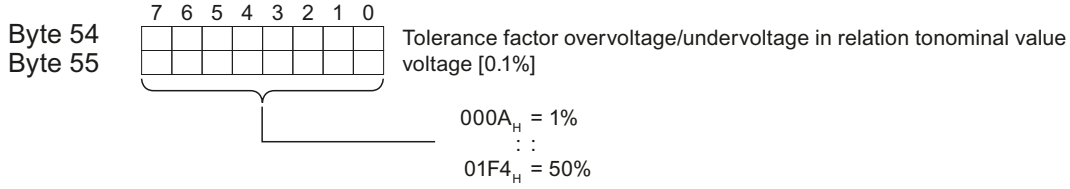
Byte 54
Byte 55
7 6 5 4 3 2 1 0
Tolerance factor overvoltage/undervoltage in relation tonominal value voltage [0.1%]
000AH = 1%
: :
01F4H = 50%

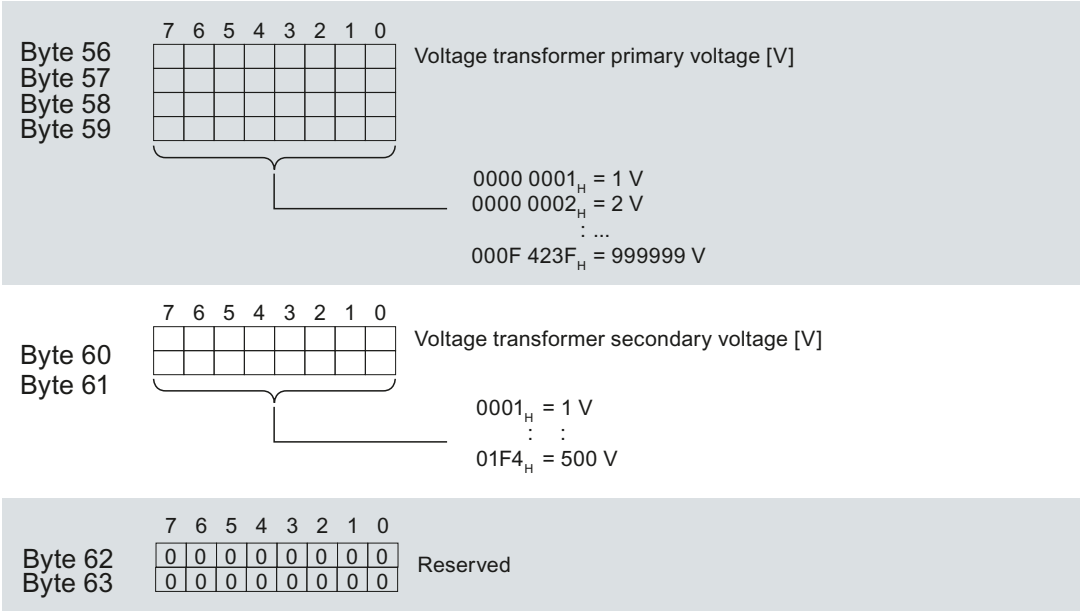

Figure 2-876 Channel parameter block

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check bytes 1 ... 3, 30, 31. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check bytes 7, 8, 14, 15, 24...29, 32, 33, 48, 49, 62...65, 80, 81, 94...97, 112, 113, 126, 127 and set the reserved bits back to 0.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	05	"Voltage measuring range" invalid	Check Byte 5. Permitted values: 01_H to $0D_H$
DF	80	E1	20	"Connection type" invalid	Check Byte 4. Permitted values: 00_H, $0B_H$, $0C_H$, $0E_H$...12_H
DF	80	E1	21	"Payload variant" not possible or input data configuration not large enough	Check Byte 9. Select a different payload variant or change the configuration.
DF	80	E1	22	"User data variant" invalid	Check Byte 9. Select a valid code for the user data variant.
DF	80	E1	23	"Line frequency" invalid	Check Byte 6. Enter valid values.
DF	80	E1	29	"Tolerance factor overcurrent in relation to nominal value current [0.1%]" invalid	Check bytes 38...39, 70...71, 102...103. Enter valid values.
DF	80	E1	2A	"Tolerance time overcurrent" invalid	Check bytes 40...41, 72...73, 104...105 prüfen. Enter valid values.
DF	80	E1	2B	"Low limit current measurement" in relation to nominal value current [0.1%] invalid	Check bytes 42...43, 74...75, 106...107. Enter valid values.
DF	80	E1	2C	"Current transformer primary current [A]" invalid.	Check bytes 10...13, 44...47, 76...79, 108...111. Enter valid values.
DF	80	E1	2D	"Voltage transformer primary voltage [V]" invalid	Check bytes 56...59, 88...91, 120...123. Enter valid values.
DF	80	E1	2E	"Voltage transformer secondary voltage [V]" invalid	Check bytes 60, 61 and 92, 93 and 124, 125. Enter valid values.
DF	80	E1	2F	"End value energy meter" invalid	Check Bit 4...6 in Byte 6. Enter valid values.
DF	80	E1	30	Invalid data record number.	Check the data record number. Enter a valid data record number.
DF	80	E1	3E	Only for connection type 3P4W1 and 3P3W1. Current or voltage transformer parameters for the different phases are not identical.	Check bytes 44...47 and 76...79 and 108...111 or bits 4, 5 and 7 in bytes 48, 80 and 112 or 56...59 and 88...91 and 120...123 or 60, 61 and 92, 93 and 124, 125 for identical values. Enter identical values for current transformer (secondary current, primary current, direction of current) and voltage transformer (secondary voltage, primary voltage) at all three phases.
DF	80	E1	3F	"End value for energy meter" or transmission ratio (primary value, secondary value) of current and voltage too low.	Increase the end value of the energy meter or the ratio of primary to secondary current for current transformer and/or primary to secondary voltage for voltage transformer.
DF	80	E1	43	"Current transformer secondary current" for neutral conductor or all three phases invalid	Check bits 4, 5 in byte 14, 48, 80 and 112. Enter valid values.
DF	80	E1	4 A	Voltage transformer parameters for voltage swell/dip invalid	Check the parameters secondary voltage, primary voltage, nominal value voltage. Enabled channels must have identical parameters.
DF	80	E1	4B	Current transformer parameter for "Detect overcurrent" invalid	Check the parameters secondary current, primary current, nominal value current and direction of current. Enabled channels must have identical parameters.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	4C	Parameters for determining the neutral current invalid	Neutral current can only be determined with connection type 3P4W. Current transmission parameters primary current, secondary current, nominal value current and direction of current of the three phases must be identical.
DF	80	E1	4D	"Nominal value current [A]" invalid	The nominal value current must be measurable with the current transformer and thus be smaller than the primary measured variable of the transformer (current transformer primary current). Check bytes 34...37, 66...69, 98...101. Enter valid values.
DF	80	E1	4E	"Nominal value voltage [V]" invalid	The nominal value voltage must be measurable with the voltage transformer and thus be smaller than the primary measured variable of the transformer (voltage transformer primary voltage). Check bytes 50...53, 82...85, 114...117. Enter valid values.
DF	80	E1	4F	"Low limit current measurement in relation to nominal value current [0.1%]" invalid	Check bytes 42...43, 74...75, 106...107. Enter valid values.
DF	80	E1	50	The combination of "Nominal value voltage [V]" and "Voltage dip limit value in relation to nominal value voltage [0.1%]" invalid.	Select the permissible value in % so that the secondary measuring voltage of 0 V is not undershot.
DF	80	E1	51	The combination of "Nominal value voltage [V]" and "Voltage swell limit value in relation to nominal value voltage [0.1%]" invalid.	Select the permissible value in % so that the secondary measuring voltage of 300 V is not exceeded.
DF	80	E1	52	The combination of "Nominal value current [A]" and "Threshold overcurrent in relation to nominal value current [0.1%]" invalid	Select the permissible value in % so that the secondary measuring current of 6 A is not exceeded.
DF	80	E1	53	The combination of "Nominal value current [A]" and "Tolerance factor overcurrent in relation to nominal value current [0.1%]" invalid	Select the permissible value in % so that the secondary measuring current of 6 A is not exceeded.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	54	The combination of "Nominal value voltage [V]" and "Tolerance factor overvoltage/undervoltage in relation to nominal value voltage [0.1%]" lies outside the permissible range.	Select the permissible value in % so that the secondary measuring voltage of 300 V is not exceeded.
DF	80	E1	55	"Nominal value current [A]" is too high. "Nominal value current" x transmission factor current generates a secondary current measured variable which exceeds its value range.	Select the permissible value in A so that the secondary measuring current of 6 A is not exceeded. The transmission factor current is calculated from "Current transformer primary current [A]" / "Current transformer secondary current [A]"
DF	80	E1	56	"Nominal value voltage [V]" is too high. "Nominal value voltage" x transmission factor voltage generates a secondary voltage measured variable which exceeds its value range.	Select the permissible value in V so that the secondary measuring voltage of 300 V is not exceeded. The transmission factor voltage is calculated from "Voltage transformer primary voltage [V]" / "Voltage transformer secondary voltage [V]"

A.3 Structure of the parameter data record 129 for limit monitoring

Structure of data record 129

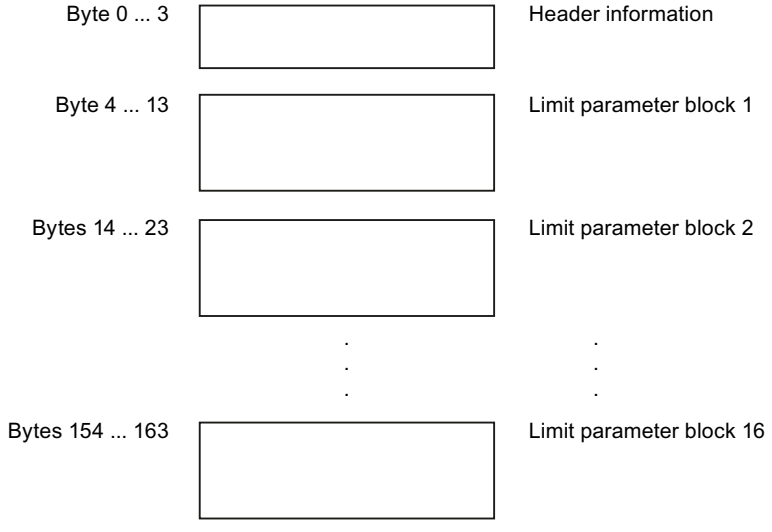

Figure 2-877 Structure of data record 129

Header information

The figure below shows the structure of the header information.

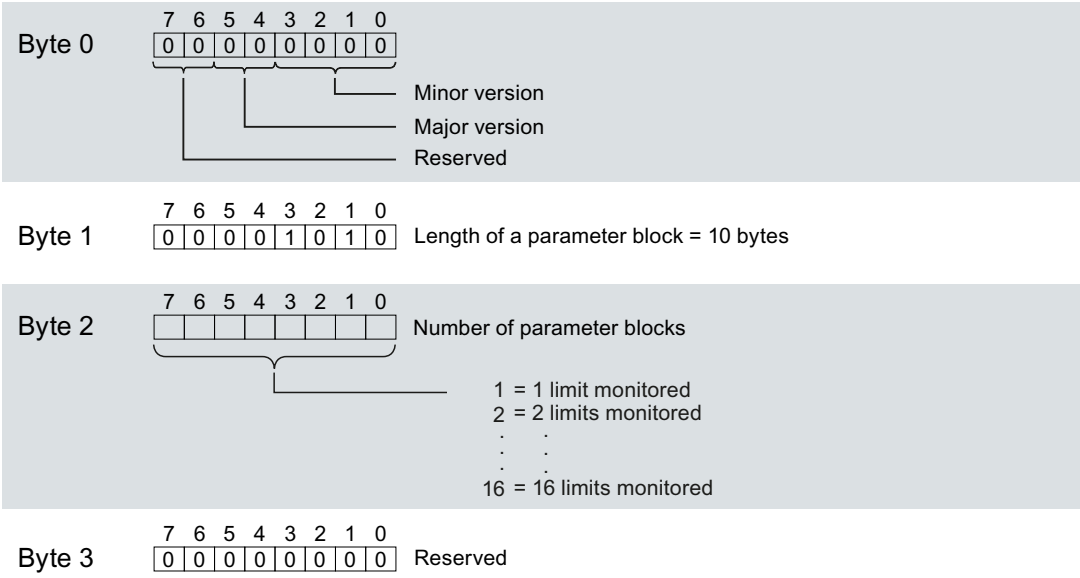

Figure 2-878 Header information DS 129

Limit parameter block

The following diagram shows the structure of the parameter blocks for limit monitoring.

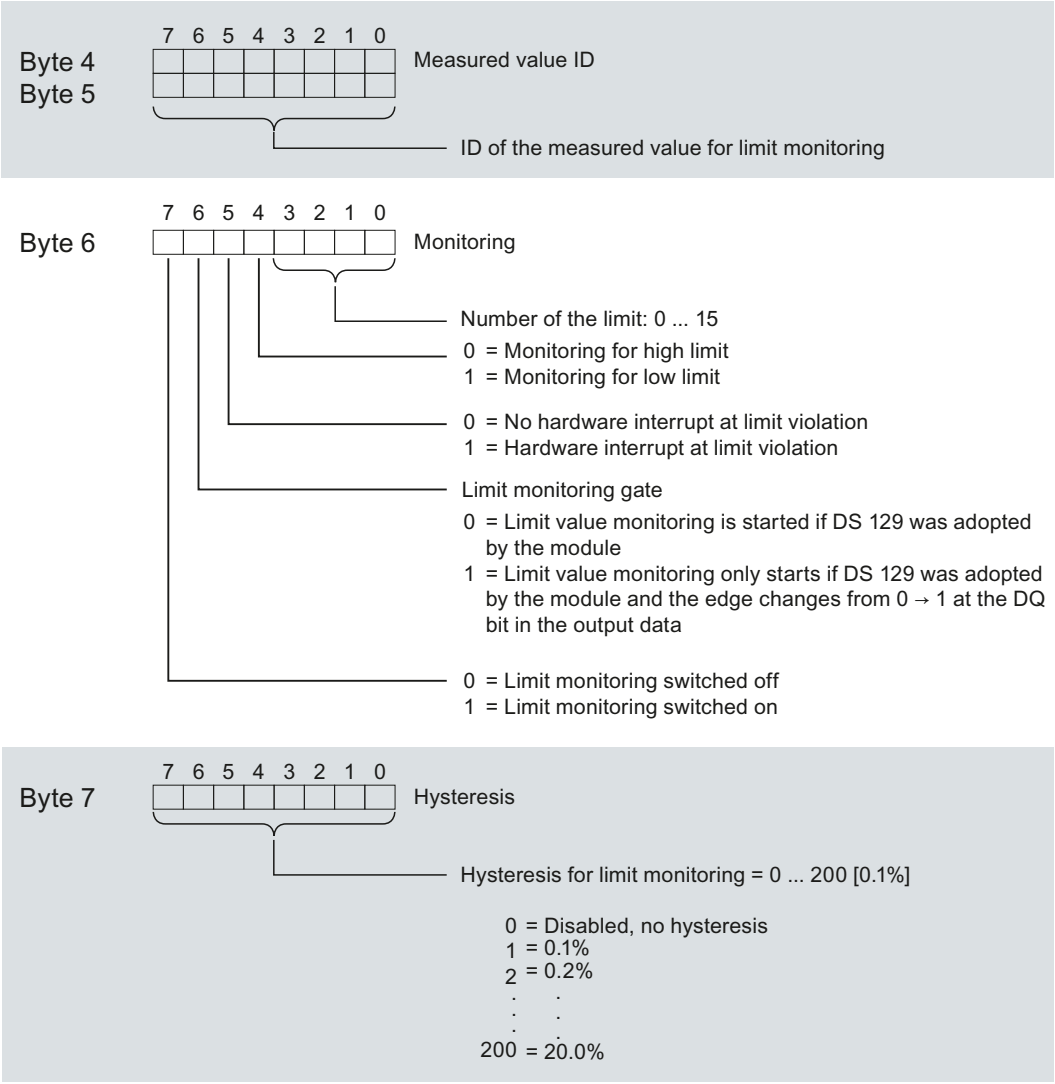

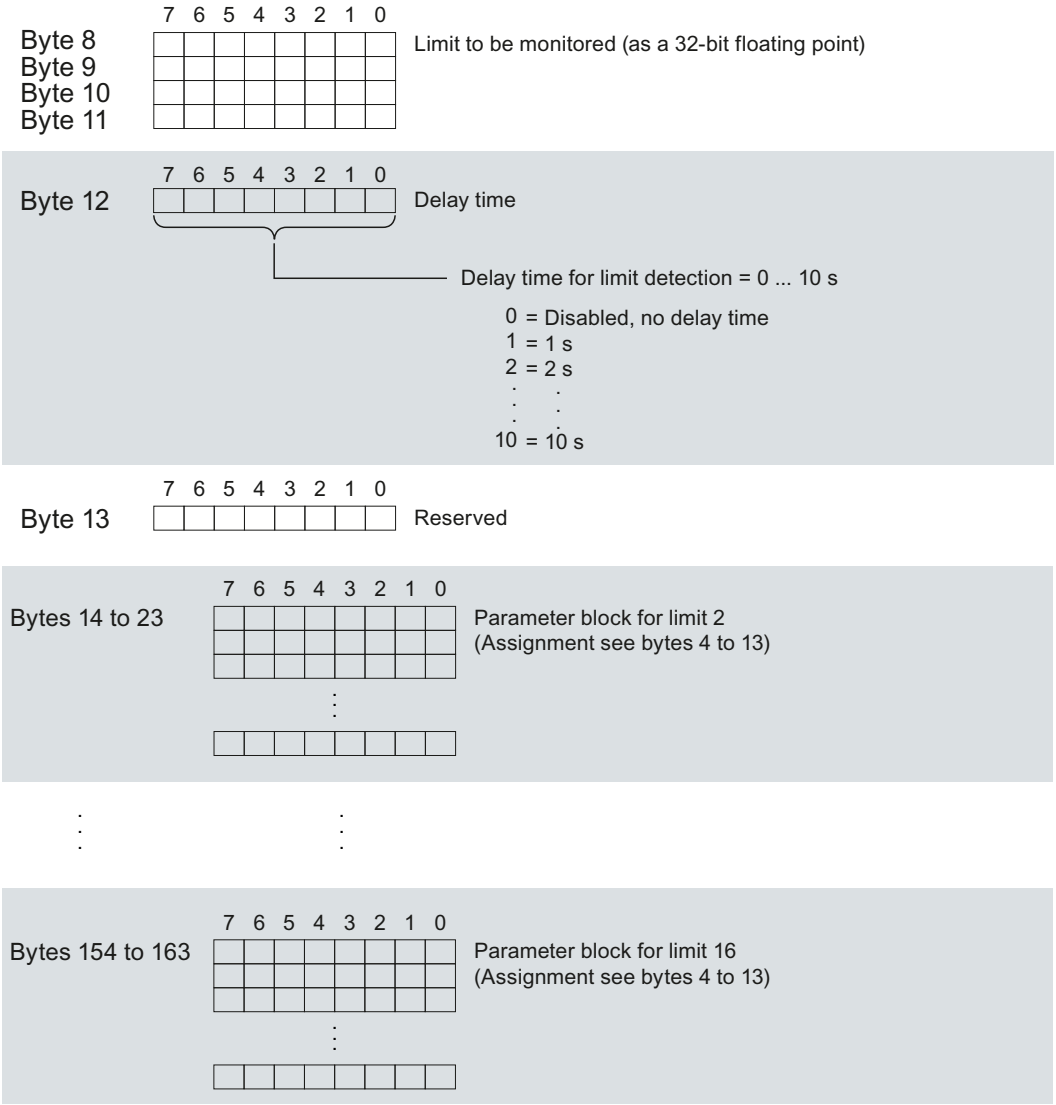

Figure 2-879 Limit parameter data block

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 129.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check bytes 3, 13, 23, 33...163 and set the reserved bits back to 0.
DF	80	E1	31	"Length of the parameter block" invalid.	Length of the sent record incorrect. Note byte 2 ("number of parameter blocks").
DF	80	E1	32	"Number of parameter blocks" invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	"ID of the measured value for limit monitoring" invalid.	Check Bytes 4 and 5. Enter valid values.
DF	80	E1	34	Parameters for monitoring the limits invalid	Check bits 0...3 in Byte 6. Enter valid values.
DF	80	E1	35	"Number of limit" in 'Monitoring assigned multiple times' parameter	Check bits 0...3 in Byte 6. Do not use limit number several times.
DF	80	E1	36	"Hysteresis for limit monitoring" invalid	Check Byte 7. Enter valid values.
DF	80	E1	37	"Limit" invalid.	Check Byte 8...11. Enter valid values.
DF	80	E1	38	"Delay time for limit monitoring" invalid.	Check Byte 12. Enter valid values.

A.4 Structure of the parameter data record 130 for user-data mapping

Structure of data record 130

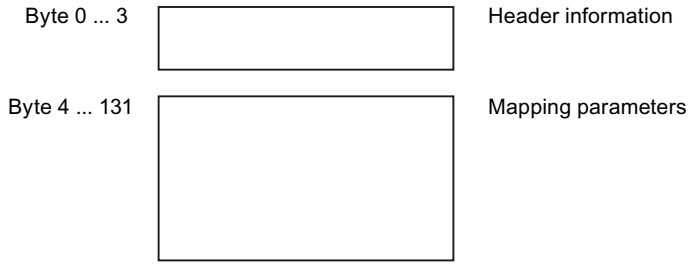

Figure 2-880 Structure of data record 130

Header information

The figure below shows the structure of the header information.

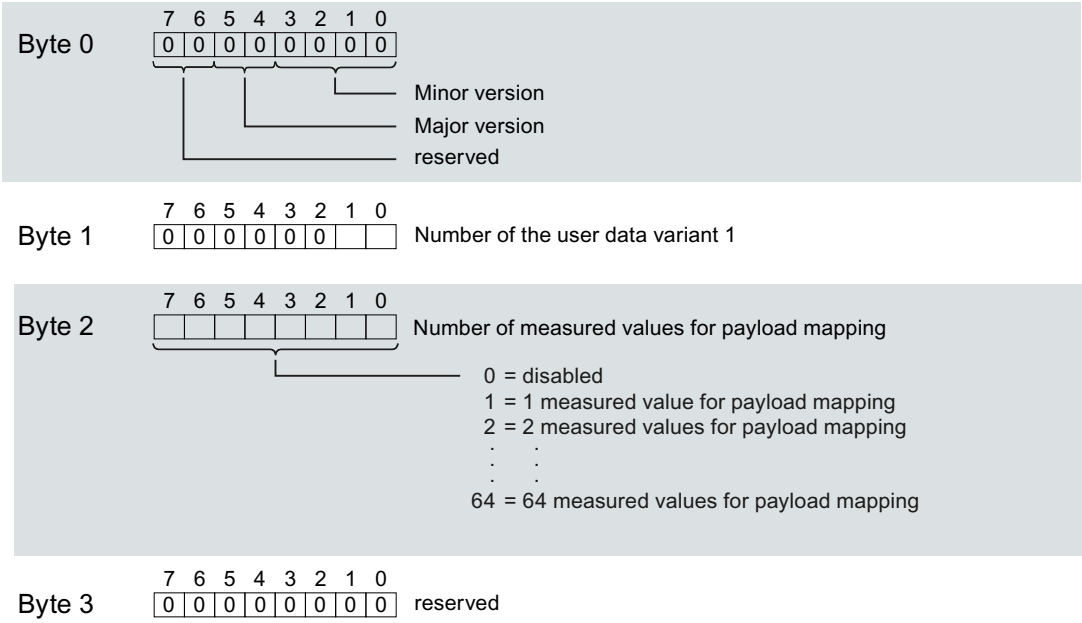

Figure 2-881 Header information DS 130

Parameter block for payload mapping

The following diagram shows the structure of the parameter blocks for payload mapping.

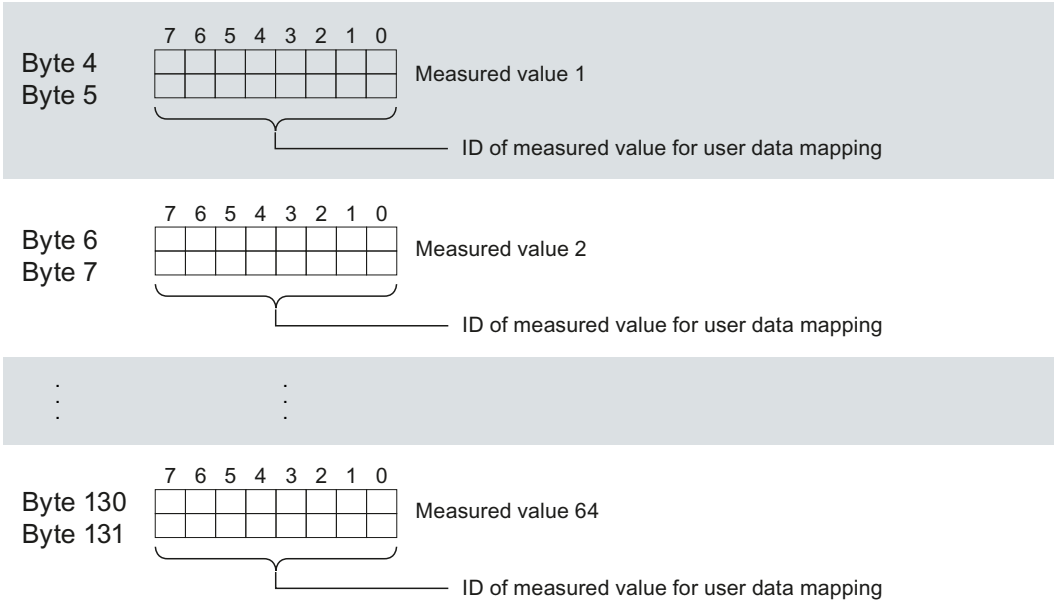

Figure 2-882 Parameter block for payload mapping

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 130.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check Byte 3 and set reserved bits back to 0.
DF	80	E1	21	"Payload variant" not possible or input data configuration not large enough	Select a different payload variant or change the configuration.
DF	80	E1	30	Data record number invalid	Check the data record number. Enter a valid data record number.
DF	80	E1	31	"Length of the parameter block" invalid.	Length of the sent record incorrect. Note byte 2 ("number of measured values").
DF	80	E1	32	"Number of parameter blocks" invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	"ID of measured value for payload mapping" invalid.	Check Bytes 4 and 5. Enter valid values.
DF	80	E1	3B	"ID of the type of payload mapping" not permitted.	Check Byte 1. Number for user-specific payload variant has to be 01_H.

Measured variables for payload mapping

You can find the measured variables under "Measured variables for connection type". The following measured variables are not available to you for payload mapping:

- 220 to 226
- 62110 to 62116
- 62210 to 62216
- 62310 to 62316

A.5 Structure of the parameter data record 135 for data record mapping

Structure of data record 135

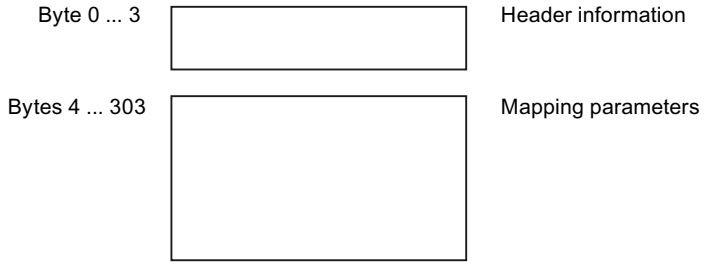

Figure 2-883 Structure of data record 135

Header information

The figure below shows the structure of the header information.

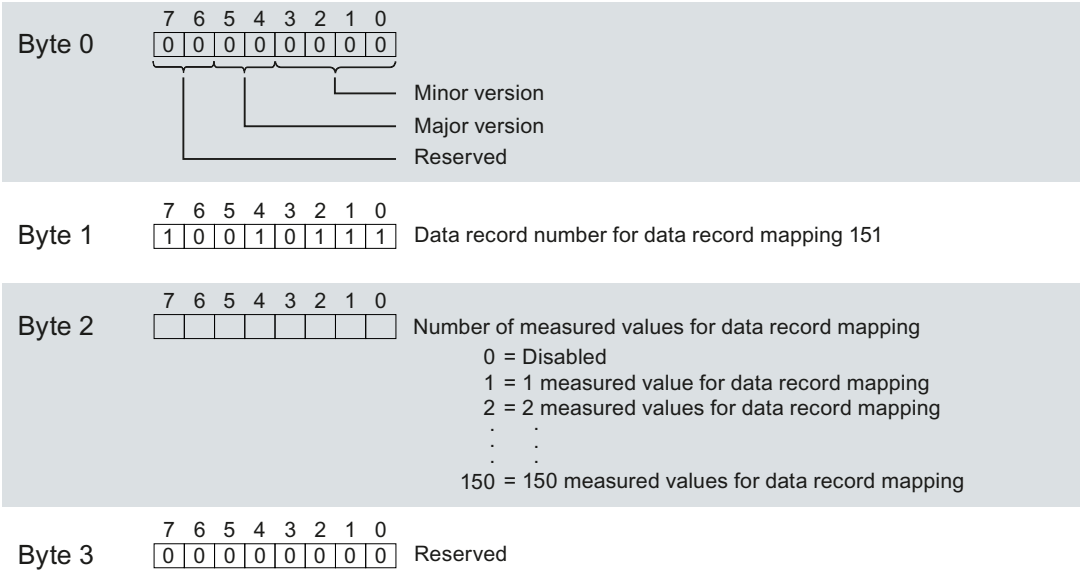

Figure 2-884 Header information DS 135

Parameter block for data record mapping

The following diagram shows the structure of the parameter blocks for data record mapping.

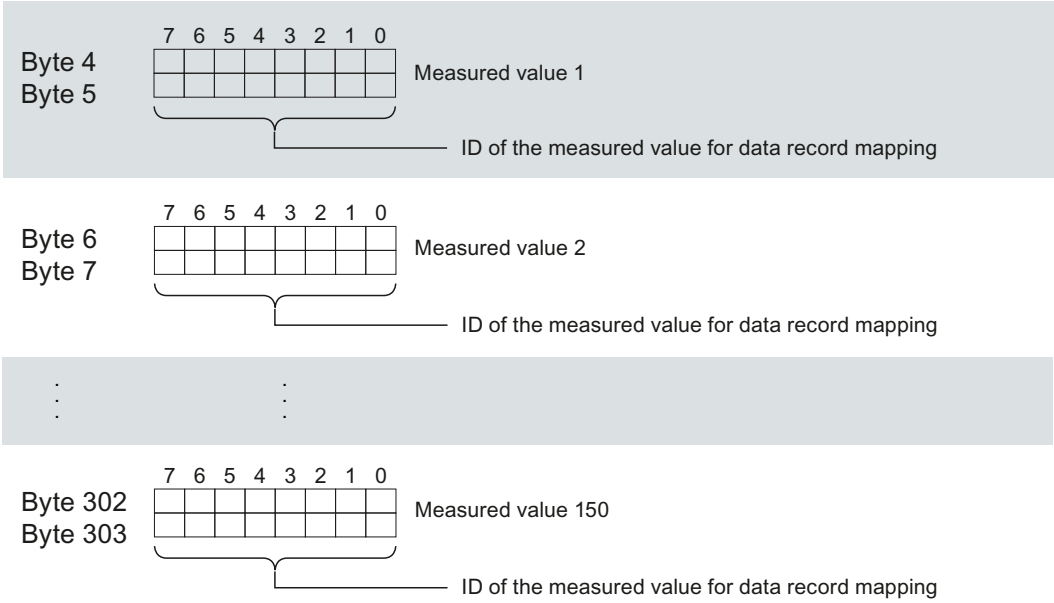

Figure 2-885 Parameter block for data record mapping

Data record length DS 135 and DS151

The table below shows the data record lengths of the parameter data record DS 135 and the user-defined data record DS 151 (Page 205).

The length of the data records depends on the number and the format of the measured values.

Number Measured values	Data record length in bytes		
	REAL measured values		LREAL measured values
	DS 135	DS 151	DS 151
29	62	118	234
30	64	122	242 *
40	84	162	322 *
50	104	202	402 *
59	122	238	474 *
100	204	402 *	802 *
118	240	474 *	946 *
150	304*	602 *	1202 *

* not with PROFIBUS DP

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 130/135.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check Byte 3 and set reserved bits back to 0.
DF	80	E1	21	"Payload variant" not possible or input data configuration not large enough	Select a different payload variant or change the configuration.
DF	80	E1	30	Data record number invalid	Check the data record number. Enter a valid data record number.
DF	80	E1	31	"Length of the parameter block" invalid.	Length of the sent record incorrect. Note byte 2 ("number of measured values").
DF	80	E1	32	"Number of parameter blocks" invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	"ID of the measured value for limit monitoring" invalid.	Check Bytes 4 and 5. Enter valid values.

Measured variables for data record mapping

You can find the measured variables under "Measured variables for connection type". The following measured variables are not available to you for payload mapping:

- 220 to 226
- 62110 to 62116
- 62210 to 62216
- 62310 to 62316

Measured variables

B

B.1 Measured variables for connection type

Measured variables for data records and payload

The following table provides an overview of all measured variables that are used in the data records and payload.

On the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755917) you can find an overview of the assignment of the measured values to the payload variants and data records.

Table 2-950 Measured variables for data records and payload

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
1	Voltage L1-N [1]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓
2	Voltage L2-N [1]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓
3	Voltage L3-N [1]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓
4	Voltage L1-L2 [2]	REAL	V	0.0 ... 1000000.0		✓		✓	✓	✓	✓
5	Voltage L2-L3 [2]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
6	Voltage L3-L1 [2]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
7	Current L1 [1]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
8	Current L2 [1]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓
9	Current L3 [1]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓
10	Apparent power L1 [3]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
11	Apparent power L2 [3]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
12	Apparent power L3 [3]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
13	Active power L1 [3]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
14	Active power L2 [3]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
15	Active power L3 [3]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
16	Reactive power Qn L1[3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
17	Reactive power Qn L2[3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
18	Reactive power Qn L3[3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
19	Power factor λ L1 [3]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
20	Power factor λ L2 [3]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓	✓	✓
21	Power factor λ L3 [3]	REAL	-	0.0 ... 1.0			✓	✓	✓	✓	✓
22	Reactive power Qtot L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
23	Reactive power Qtot L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
24	Reactive power Qtot L3 [3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
30	Frequency L1L2L3 [4]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓
31	Average Voltage L-N (U_{sum}) [12]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓
32	Average Voltage L-L [12]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
33	Average Current L1L2L3 (I_{sum}) [12]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
34	Active power L1L2L3 [5]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
35	Reactive power Q_n L1L2L3 [5]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
36	Apparent power L1L2L3 [5]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
37	Power factor λ L1L2L3 [6]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
38	Reactive power Qtot L1L2L3[3 5]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
40	Max. voltage L1-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓
41	Max. voltage L2-N [14]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓
42	Max. voltage L3-N [14]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓
43	Max. voltage L1-L2 [14]	REAL	V	0.0 ... 1000000.0		✓		✓	✓	✓	✓
44	Max. voltage L2-L3 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
45	Max. voltage L3-L1 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
46	Max. current L1 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
47	Max. current L2 [14]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓
48	Max. current L3 [14]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓
49	Max. apparent power L1 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
50	Max. apparent power L2 [14]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
51	Max. apparent power L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
52	Max. active power L1 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
53	Max. active power L2 [14]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
54	Max. active power L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
55	Max. reactive power Q_n L1 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
56	Max. reactive power Q_n L2 [14]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
57	Max. reactive power Q_n L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
58	Max. power factor λ L1 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
59	Max. power factor λ L2 [14]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓	✓	✓
60	Max. power factor λ L3 [14]	REAL	-	0.0 ... 1.0			✓	✓	✓	✓	✓
61	Max. frequency [14]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓
62	Max. mean voltage L-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓		
63	Max. mean voltage L-L [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
64	Max. mean current L1L2L3 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
65	Max. active power L1L2L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
66	Max. reactive power Qn L1L2L3[14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
67	Max. apparent power L1L2L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
68	Max. power factor λ L1L2L3 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
70	Min. voltage L1-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓
71	Min. voltage L2-N [14]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓
72	Min. voltage L3-N [14]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓
73	Min. voltage L1-L2 [14]	REAL	V	0.0 ... 1000000.0		✓		✓	✓	✓	✓
74	Min. voltage L2-L3 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
75	Min. voltage L3-L1 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
76	Min. current L1 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
77	Min. current L2 [14]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓
78	Min. current L3 [14]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓
79	Min. apparent power L1 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
80	Min. apparent power L2 [14]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
81	Min. apparent power L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
82	Min. active power L1 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
83	Min. active power L2 [14]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
84	Min. active power L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
85	Max. reactive power Q_n L1 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
86	Max. reactive power Q_n L2 [14]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
87	Max. reactive power Q_n L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
88	Min. power factor λ L1 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
89	Min. power factor λ L2 [14]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓	✓	✓
90	Min. power factor λ L3 [14]	REAL	-	0.0 ... 1.0			✓	✓	✓	✓	✓
91	Min. frequency [14]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓
92	Min. mean voltage L-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓		
93	Min. mean voltage L-L [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
94	Min. mean current L1L2L3[14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
95	Min. active power L1L2L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
96	Min. reactive power Q_n L1L2L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
97	Min. apparent power L1L2L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
98	Min. power factor λ L1L2L3 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
166	Mean power factor λ L1L2L3[12]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
200	Active energy inflow L1L2L3 (Float) [6]	REAL	Wh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓
201	Active energy outflow L1L2L3 (Float) [6]	REAL	Wh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓
202	Reactive energy inflow L1L2L3 (Float) [6]	REAL	varh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓
203	Reactive energy outflow L1L2L3 (Float) [6]	REAL	varh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓
204	Apparent energy L1L2L3 (Float) [6]	REAL	VAh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓
205	Total active energy L1L2L3 (Float) [6]	REAL	Wh	-3.4028e+38 ... +3.4028e+38	✓	✓	✓	✓	✓	✓	✓
206	Total reactive energy L1L2L3 (Float) [6]	REAL	varh	-3.4028e+38 ... +3.4028e+38	✓	✓	✓	✓	✓	✓	✓
210	Active energy inflow L1L2L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
211	Active energy outflow L1L2L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
212	Reactive energy inflow L1L2L3 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
213	Reactive energy outflow L1L2L3 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
214	Apparent energy L1L2L3 [6]	LREAL	VAh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
215	Total active energy L1L2L3 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓
216	Total reactive energy L1L2L3 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓
220	Active energy inflow L1L2L3 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
221	Active energy outflow L1L2L3 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
222	Reactive energy inflow L1L2L3 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
223	Reactive energy outflow L1L2L3 (Int32) [6]	UDINT	VAh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
224	Apparent energy L1L2L3 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
225	Total active energy L1L2L3 (Int32) [6]	DINT	Wh	-2147483647 ... +2147483647	✓	✓	✓	✓	✓	✓	✓
226	Total reactive energy L1L2L3 (Int32) [6]	DINT	varh	-2147483647 ... +2147483647	✓	✓	✓	✓	✓	✓	✓
61130	Phase angle UL1-UL2 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓
61131	Phase angle UL2-UL3 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓
61132	Phase angle UL3-UL1 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
61133	Phase angle IL1-IL2 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓
61134	Phase angle IL2-IL3 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓
61135	Phase angle IL3-IL1 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓
61136	Max. neutral current [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
61137	Min. neutral current [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
61138	Max. reactive power Qtot L1L2L3[3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
61139	Min. reactive power Qtot L1L2L3[3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
61140	Overflow counter active energy inflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61141	Overflow counter active energy outflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61142	Overflow counter reactive energy inflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61143	Overflow counter reactive energy outflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61144	Overflow counter apparent energy L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61146	Fundamental cos φ active factor L1L2L3[17]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
61149	Neutral current IN [1]	REAL	A	0.0 ... 100000.0	Z	Z	Z	✓	✓	Z	Z
61154	Reactive power (fundamental) L1L2L3[5]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
61157	Amplitude unbalance voltage U2 [2]	REAL	%	0 ... 100				✓	✓	✓	✓
61158	Amplitude unbalance current Iunsym [2]	REAL	%	0 ... 100				✓	✓	✓	✓
61178	Phase angle L1 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓
61180	Active energy inflow L1 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61181	Active energy outflow L1 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61182	Reactive energy inflow L1 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61183	Reactive energy outflow L1 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61184	Apparent energy L1 [6]	LREAL	VAh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61185	Total active energy L1 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61186	Total reactive energy L1 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61190	Overflow counter active energy inflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61191	Overflow counter active energy outflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
61192	Overflow counter reactive energy inflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61193	Overflow counter reactive energy outflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61194	Overflow counter apparent energy L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61195	Overflow counter total active energy L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61196	Overflow counter total reactive energy L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61198	Phase angle L2 [3]	REAL	°	0.0 ... 360.0		✓	✓	✓	✓	✓	✓
61200	Active energy inflow L2 [6]	LREAL	Wh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓
61201	Active energy outflow L2 [6]	LREAL	Wh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓
61202	Reactive energy inflow L2 [6]	LREAL	varh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓
61203	Reactive energy outflow L2 [6]	LREAL	varh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓
61204	Apparent energy L2 [6]	LREAL	VAh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓
61205	Total active energy L2 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308		✓	✓	✓	✓	✓	✓
61206	Total reactive energy L2 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308		✓	✓	✓	✓	✓	✓
61210	Overflow counter active energy inflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓
61211	Overflow counter active energy outflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓
61212	Overflow counter reactive energy inflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓
61213	Overflow counter reactive energy outflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓
61214	Overflow counter apparent energy L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓
61215	Overflow counter total active energy L2 [6]	UINT	-	0 ...65535		✓	✓	✓	✓	✓	✓
61216	Overflow counter total reactive energy L2 [6]	UINT	-	0 ...65535		✓	✓	✓	✓	✓	✓
61218	Phase angle L3 [3]	REAL	°	0.0 ... 360.0			✓	✓	✓	✓	✓
61220	Active energy inflow L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓
61221	Active energy outflow L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓
61222	Reactive energy inflow L3 [6]	LREAL	varh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓
61223	Reactive energy outflow L3 [6]	LREAL	varh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓
61224	Apparent energy L3 [6]	LREAL	VAh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓
61225	Total active energy L3 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308			✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
61226	Total reactive energy L3 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308			✓	✓	✓	✓	✓
61230	Overflow counter active energy inflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓
61231	Overflow counter active energy outflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓
61232	Overflow counter reactive energy inflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓
61233	Overflow counter reactive energy outflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓
61234	Overflow counter apparent energy L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓
61235	Overflow counter total active energy L3 [6]	UINT	-	0 ...65535			✓	✓	✓	✓	✓
61236	Overflow counter total reactive energy L3 [6]	UINT	-	0 ...65535			✓	✓	✓	✓	✓
62110	Active energy inflow L1 (Int32) [6]	DINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
62111	Active energy outflow L1 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
62112	Reactive energy inflow L1 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
62113	Reactive energy outflow L1 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
62114	Apparent energy L1 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
62115	Total active energy L1 (Int32) [6]	DINT	Wh	-2147483647 ... + 2147483647	✓	✓	✓	✓	✓	✓	✓
62116	Total reactive energy L1 (Int32) [6]	DINT	varh	-2147483647 ... + 2147483647	✓	✓	✓	✓	✓	✓	✓
62124	Fundamental reactive power L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
62127	Fundamental cos φ active factor L1 [17]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
62136	Fundamental cos φ active factor L1 (SINT8) [17]	SINT	0.01	-100...100	✓	✓	✓	✓	✓	✓	✓
62160	Max. reactive power Qtot L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
62180	Min. reactive power Qtot L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
62193	Diagnostics L1 [20]	DWORD	Bit track	0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
62210	Active energy inflow L2 (Int32) [6]	DINT	Wh	0... 2147483647		✓	✓	✓	✓	✓	✓
62211	Active energy outflow L2 (Int32) [6]	DINT	Wh	0... 2147483647		✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
62212	Reactive energy inflow L2 (Int32) [6]	DINT	varh	0... 2147483647		✓	✓	✓	✓	✓	✓
62213	Reactive energy outflow L2 (Int32) [6]	DINT	varh	0... 2147483647		✓	✓	✓	✓	✓	✓
62214	Apparent energy L2 (Int32) [6]	DINT	VAh	0... 2147483647		✓	✓	✓	✓	✓	✓
62215	Total active energy L2 (Int32) [6]	DINT	Wh	-2147483647... +2147483647		✓	✓	✓	✓	✓	✓
62216	Total reactive energy L2 (Int32) [6]	DINT	varh	-2147483647... +2147483647		✓	✓	✓	✓	✓	✓
62224	Fundamental reactive power L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
62227	Fundamental cos φ active factor L2 [17]	REAL	-	-1.0 ... 1.0		✓	✓	✓	✓	✓	✓
62236	Fundamental cos φ active factor L2 (SINT8) [17]	SINT	0.01	-100...100		✓	✓	✓	✓	✓	✓
62260	Max. reactive power Qtot L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
62280	Min. reactive power Qtot L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
62293	Diagnostics L2 [20]	DWORD	Bit track	0 ... 4294967295		✓	✓	✓	✓	✓	✓
62310	Active energy inflow L3 (Int32) [6]	DINT	Wh	0... 2147483647			✓	✓	✓	✓	✓
62311	Active energy outflow L3 (Int32) [6]	DINT	Wh	0... 2147483647			✓	✓	✓	✓	✓
62312	Reactive energy inflow L3 (Int32) [6]	DINT	varh	0... 2147483647			✓	✓	✓	✓	✓
62313	Reactive energy outflow L3 (Int32) [6]	DINT	varh	0... 2147483647			✓	✓	✓	✓	✓
62314	Apparent energy L3 (Int32) [6]	DINT	VAh	0... 2147483647			✓	✓	✓	✓	✓
62315	Total active energy L3 (Int32) [6]	DINT	Wh	-2147483647... +2147483647			✓	✓	✓	✓	✓
62316	Total reactive energy L3 (Int32) [6]	DINT	varh	-2147483647... +2147483647			✓	✓	✓	✓	✓
62324	Fundamental reactive power L3 [3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
62327	Fundamental cos φ active factor L3 [17]	REAL	-	-1.0 ... 1.0			✓	✓	✓	✓	✓
62336	Fundamental cos φ active factor L3 (SINT8) [17]	SINT	0.01	-100...100			✓	✓	✓	✓	✓
62360	Max. reactive power Qtot L3[3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
62380	Min. reactive power Qtot L3[3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
62393	Diagnostics L3 [20]	DWORD	Bit track	0 ... 4294967295			✓	✓	✓	✓	✓
65497	Current module time	PNIO	sec		✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
65500	Qualifier L1	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
65501	Qualifier L2	UINT	Bit track	0 ... 65535		✓	✓	✓	✓	✓	✓
65502	Qualifier L3	UINT	Bit track	0 ... 65535			✓	✓	✓	✓	✓
65503	Qualifier L1L2L3 [21]	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
65504	Operating hours counter L1L2L3 [5]	REAL	h	0.0 ... 3.4e+38	✓	✓	✓	✓	✓	✓	✓
65505	Operating hours counter L1 [5]	REAL	h	0.0 ... 3.4e+38	✓	✓	✓	✓	✓	✓	✓
65506	Operating hours counter L2 [5]	REAL	h	0.0 ... 3.4e+38		✓	✓	✓	✓	✓	✓
65507	Operating hours counter L3 [5]	REAL	h	0.0 ... 3.4e+38			✓	✓	✓	✓	✓
65508	Status of energy counter overflows	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
65509	Status of limit violations 1...16	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
65510	Counter for limit violations GW1 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65511	Counter for limit violations GW2 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65512	Counter for limit violations GW3 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65513	Counter for limit violations GW4 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65514	Counter for limit violations GW5 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65515	Counter for limit violations GW6 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65516	Counter for limit violations GW7 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65517	Counter for limit violations GW8 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65518	Counter for limit violations GW9 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65519	Counter for limit violations GW10 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65520	Counter for limit violations GW11 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65521	Counter for limit violations GW12 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65522	Counter for limit violations GW13 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
65523	Counter for limit violations GW14 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65524	Counter for limit violations GW15 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65525	Counter for limit violations GW16 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓

The table below is relevant for the description of the payload variants:

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P-2W	3P 4W	3P 4-W1	3P 3W	3P 3-W1	3P 4-WI
66001	Voltage L1-N [1]	UINT	0.01 V	0 ... 65535	✓	✓	✓	✓	✓			
66002	Voltage L2-N [1]	UINT	0.01 V	0 ... 65535		✓	✓	✓	✓			
66003	Voltage L3-N [1]	UINT	0.01 V	0 ... 65535			✓	✓	✓			
66004	Voltage L1-L2 [2]	UINT	0.01 V	0 ... 65535		✓		✓	✓	✓	✓	
66005	Voltage L2-L3 [2]	UINT	0.01 V	0 ... 65535				✓	✓	✓	✓	
66006	Voltage L3-L1 [2]	UINT	0.01 V	0 ... 65535				✓	✓	✓	✓	
66007	Current L1 [1]	UINT	1 mA	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	✓
66008	Current L2 [1]	UINT	1 mA	0 ... 65535		✓	✓	✓	✓	✓	✓	✓
66009	Current L3 [1]	UINT	1 mA	0 ... 65535			✓	✓	✓	✓	✓	✓
66010	Apparent power L1 [3]	INT	1 VA	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66011	Apparent power L2 [3]	INT	1 VA	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66012	Apparent power L3 [3]	INT	1 VA	-32768 ... 32767			✓	✓	✓	✓	✓	
66013	Active power L1 [3]	INT	1 W	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66014	Active power L2 [3]	INT	1 W	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66015	Active power L3 [3]	INT	1 W	-32768 ... 32767			✓	✓	✓	✓	✓	
66016	Reactive power Qn L1[3]	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66017	Reactive power Qn L2[3]	INT	1 var	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66018	Reactive power Qn L3[3]	INT	1 var	-32768 ... 32767			✓	✓	✓	✓	✓	
66019	Power factor λ L1 [3]	USINT	0.01	0 ... 100	✓	✓	✓	✓	✓	✓	✓	
66020	Power factor λ L2 [3]	USINT	0.01	0 ... 100		✓	✓	✓	✓	✓	✓	
66021	Power factor λ L3 [3]	USINT	0.01	0 ... 100			✓	✓	✓	✓	✓	
66022	Reactive power Qtot L1 [3]	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66023	Reactive power Qtot L2 [3]	INT	1 var	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66024	Reactive power Qtot L3 [3]	INT	1 var	-32768 ... 32767			✓	✓	✓	✓	✓	
66030	Frequency (Uint8) [4]	USINT	1 Hz	40 ... 70	✓	✓	✓	✓	✓	✓	✓	✓
66031	Frequency (Uint16) [4]	UINT	0.01 Hz	4000 ... 7000	✓	✓	✓	✓	✓	✓	✓	✓
66034	Active power L1L2L3 [5]	INT	1 W	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P-2W	3P 4W	3P 4-W1	3P 3W	3P 3-W1	3P 4-WI
66035	Reactive power Qn L1L2L3[5]	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66036	Apparent power L1L2L3 [5]	INT	1 VA	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66037	Power factor λ L1L2L3 [6]	USINT	0.01	0 ... 100	✓	✓	✓	✓	✓	✓	✓	
66038	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	✓

Z = additionally possible measured values in the current path (e.g. instead of neutral current)

1 Effective value

2 IEC 61557-12

3 floating arithmetic average value above 200 ms

4 floating arithmetic mean value above 10 s, available for UL-N>3 V. Frequencies outside the measuring range of lower than 40 Hz or higher than 70 Hz cannot be displayed. In these cases, the configured frequency (50 Hz or 60 Hz) is displayed and is used in further calculations.

5 Simple summation

6 Calculation from the start/restart (inflow and outflow values are positive numbers)

7 floating arithmetic average value above 3 s

8 floating arithmetic average value above 600 s

9 floating arithmetic average value above 900 s

10 Block measurement over 900 s

11 direct measurement of the signal wave at 8 ksps

12 Total of the parts / number of parts

14 Min./Max: Slave pointer function of the respective basic value from start/reset

17 Instantaneous value

20 ET 200SP Diagnostics:

Bit2: Voltage less than tolerance range (for diagnostics enable Voltage underflow)

Bit3: Voltage greater than tolerance range (enable overflow voltage for diagnostics)

Bit4: Current value > Current maximum value longer than tolerance time (for diagnostics enable Current overflow)

Bit7: Calculated value > value range (for diagnostics enable Calculated value overflow)

Bit16: Parameter error

Bit17: Load voltage error (missing load voltage for diagnostics enable)

Bit22: PRAL lost

Bit31: Calibration or firmware update

21 Only available for connection types 3PxW/only available for 3-phase system

Format

Table 2-951 Format and its length in bytes

Format in STEP 7 (TIA Portal)	Format to IEEE	Length in bytes	Comment
BYTE	BYTE	1 byte	Bit field with 8 bit
WORD	WORD	2 bytes	Bit field with 16 bit
DWORD	DWORD	4 bytes	Bit field with 32 bits

Format in STEP 7 (TIA Portal)	Format to IEEE	Length in bytes	Comment
SINT	INT8 (signed)	1 byte	Fixed-point number 8 bits with sign
USINT	INT8 (unsigned)	1 byte	Fixed-point number 8 bits without sign
INT	INT (signed)	2 bytes	Fixed-point number 16 bits with sign
UINT	INT (unsigned)	2 bytes	Fixed-point number 16 bits without sign
UDINT	INT32 (unsigned)	4 bytes	Fixed-point number 32 bits without sign
DINT	INT32 (signed)	4 bytes	Fixed-point number, 32 bits with sign
REAL	Float32	4 bytes	Floating-point number 32 bits with sign
LREAL	Float64	8 bytes	Floating-point number 64 bits with sign

Module versions

C

C.1 Module version "2 I / 2 Q"

User data of the module

The module has 2 bytes of input user data and 2 bytes of output user data for status and control information. At this module version measured variables can be read solely via measured value data records (no measured variables can be evaluated via user data).

Structure of input user data

The structure of the input user data is fixed.

Table 2-952 Structure of input user data (2 bytes)

Byte	Validity	Designation	Comment
0	Module	User data variant	Constant = 0x80
1	Module	Quality informa-tion	Quality bits to describe the quality of the basic measured values

Allocation of the input user data

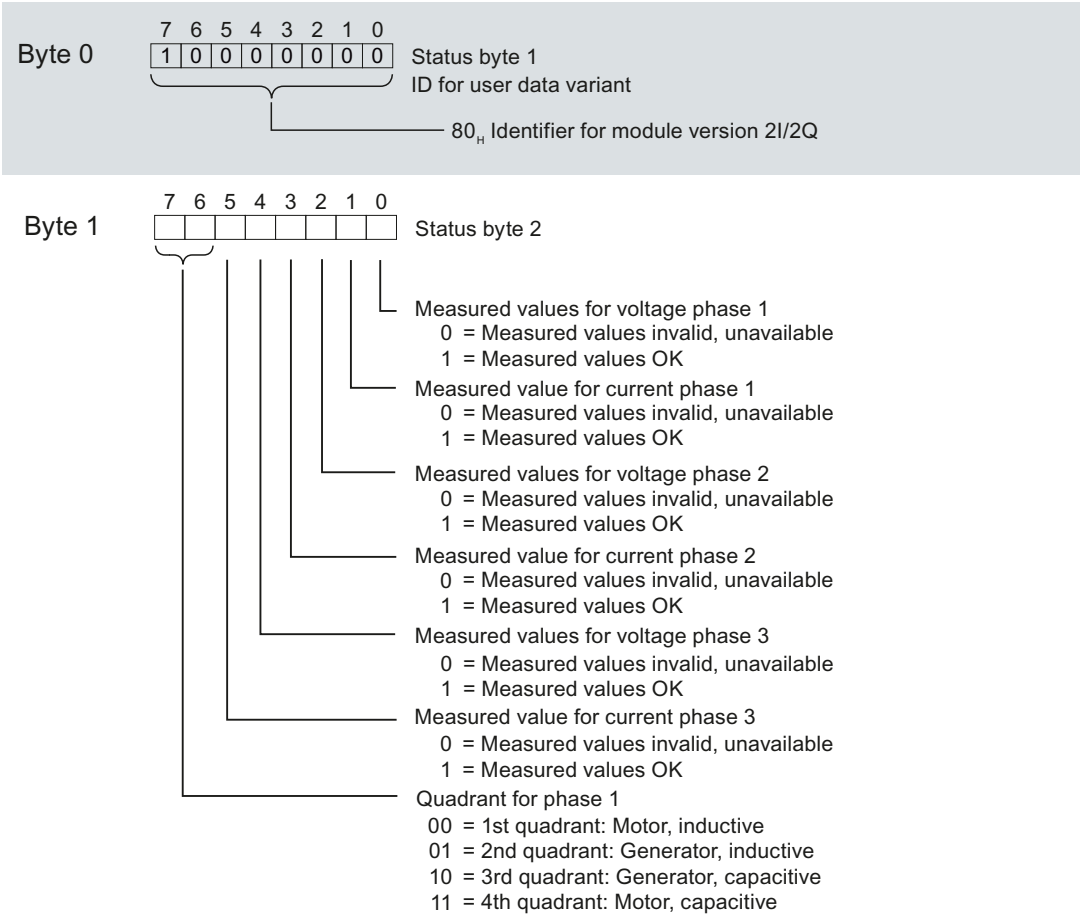

Figure 2-886 Allocation of the status bytes in the input user data (2 bytes)

Structure of output user data

The structure of the output user data is fixed.

Table 2-953 Structure of output user data (2 bytes)

Byte	Validity	Designation	Comment
0	Module	Reserved	Reserved
1	Module	Control outputs	Reset of values and counters, gate

Assignment of the output user data

Via the output user data you control for all phases

- Resetting for all minimum values, maximum values, limits, operating hours counter and energy meters.
- The counter gates for operating hours counter and energy counters.

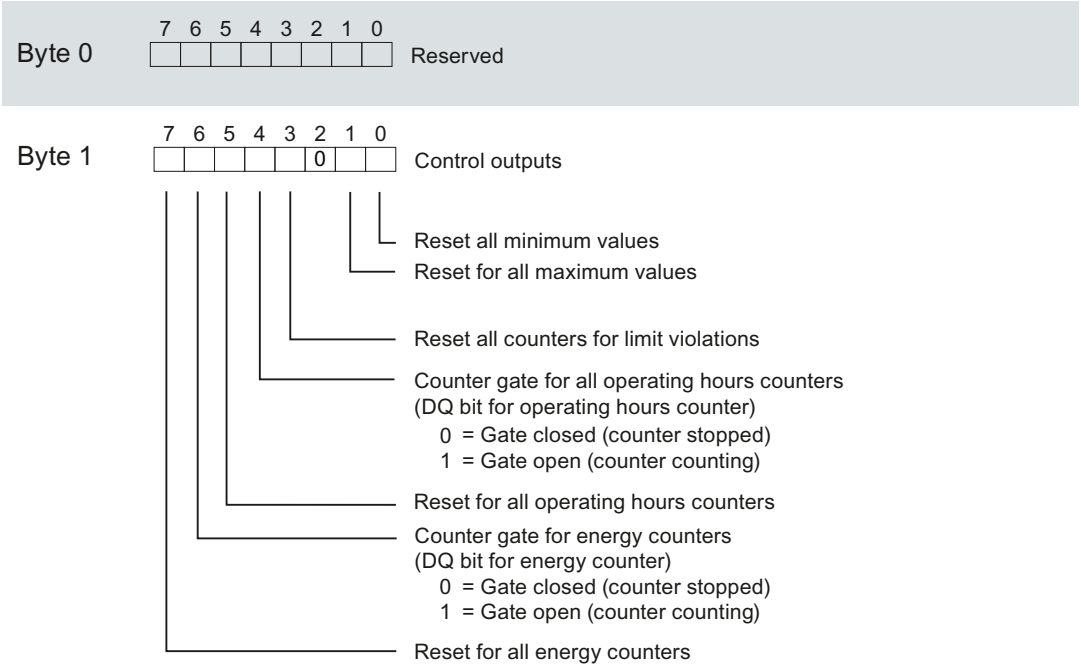

Figure 2-887 Allocation of the control byte in the output user data (1 byte)

NOTE

For module version 2 I / 2 Q, a reset of the selected variables always acts on **all** measured values/counter levels of the three phases.

- Reset energy counter: Acts on all active, reactive and apparent energies of all phases
- Reset operating hours counter: Acts on the counters of Phases 1 to 3
- Reset minimum / maximum values: Acts on the minimum and maximum value calculations of Phases 1-3
- Reset all counters for limit violations: Acts on all 16 limit values.

C.2 Module version "32 I / 20 Q"

Payload of the module

The module occupies 32 bytes of input payload and 20 bytes of output payload. Of these the module uses 2 bytes input data for status information and 20 bytes output data for control information. Measured variables can be read cyclically via payload (Bytes 2 to 31) or acyclically via measured value data records

Structure of input payload

You can set the contents of the input payload dynamically. You can choose between different payload variants.

Table 2-954 Structure of input payload (32 bytes)

Byte	Validity	Designation	Comment
0	Module	Payload variant	-
1	Module	Quality information	Quality bits to describe the quality of the basic measured values
2 ... 31	Module or phase	Data	2 or 4 byte measured values or cumulative values according to payload variant

Allocation of the input payload

You can change the measured variables during operation. You can choose between different payload variants.

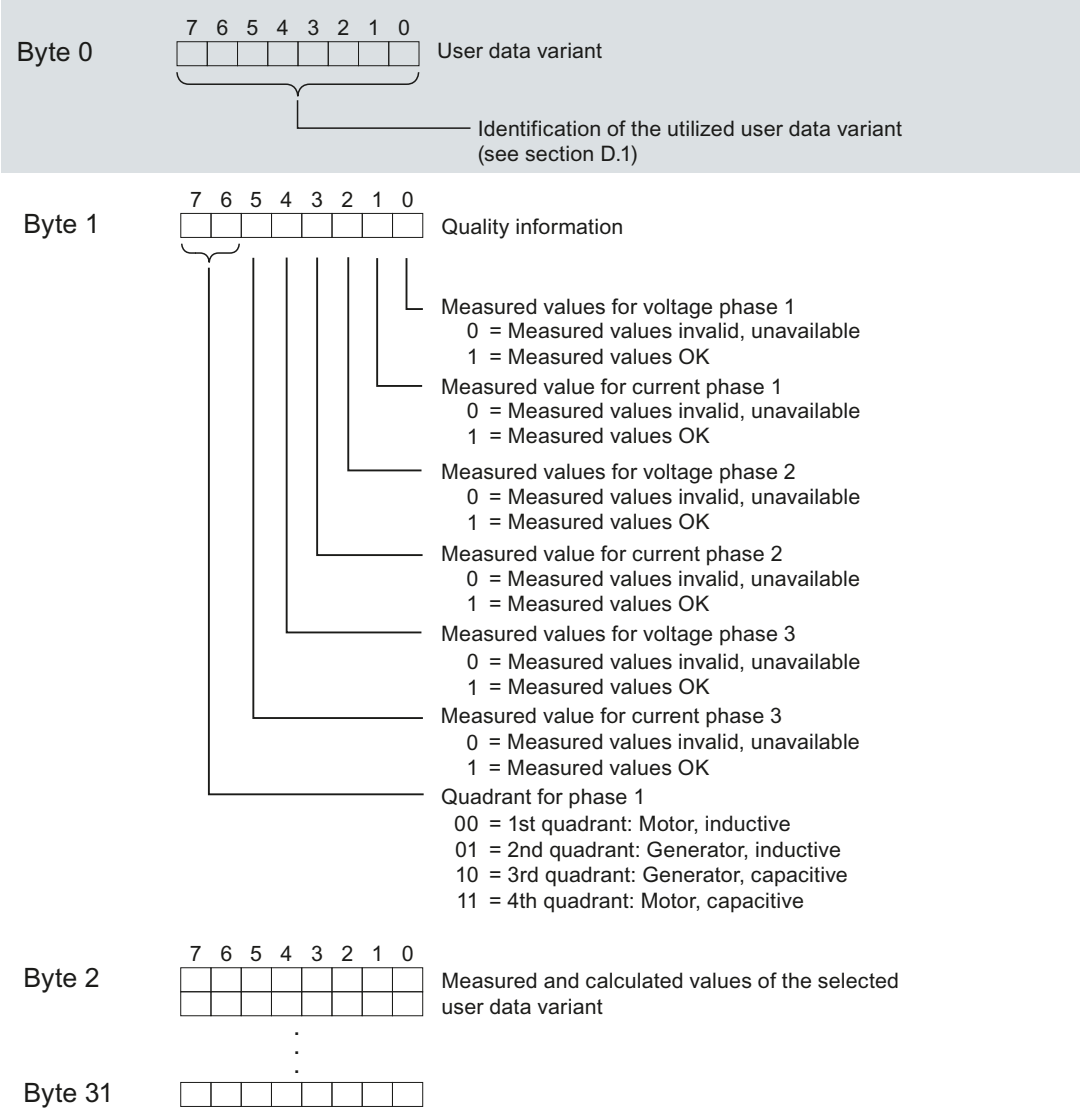

Figure 2-888 Assignment of the input payload (32 bytes)

Structure of output payload

The structure of the output payload is fixed and is the same at all the selectable payload variants.

Via the output payload you control globally or phase-specifically

- Resetting for minimum values, maximum values, limits, operating hours counter and energy meters.
- The counter gates for operating hours counter and energy meter.
- Gate for limits, minimum values and maximum values.

Table 2-955 Structure of output payload (20 bytes)

Byte	Validity	Designation	Comment
0	Module	Payload variant	Control byte for switching the payload variant
1	Module	Control byte 1	Global resetting of values and counters, gate Selection of the energy meter to be reset
2	Module	Control byte 2	
3	Module	Control byte 3	Control of the limit monitoring of limit values 9 to 16
4	Module	Control byte 4	Control of the limit monitoring of limit values 1 to 8
5	Module	Reserved	-
6	Phase L1	Control byte 6	Phase-specific resetting of values and counters, gate for Phase L1
7	Phase L1	Control byte 7	
8	Phase L2	Control byte 8	Phase-specific resetting of values and counters, gate for Phase L2
9	Phase L2	Control byte 9	
10	Phase L3	Control byte 10	Phase-specific resetting of values and counters, gate for Phase L3
11	Phase L3	Control byte 11	
12	reserved		
13	Reserved		
14	Reserved		
15	Reserved		
16	Module	Control byte 16	General reset
17	Reserved		
18	Reserved		
19	Reserved		

Control bytes for payload variant

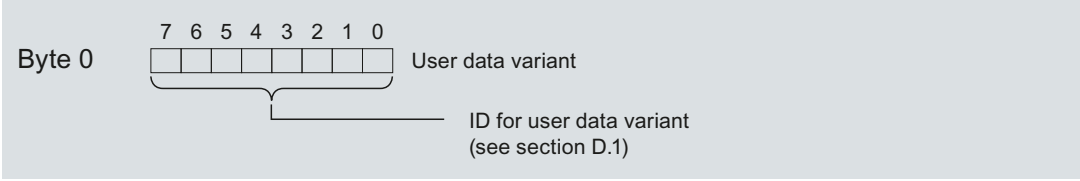

Figure 2-889 Allocation of the control bytes for payload variant (Byte 0)

Control bytes for all three phases

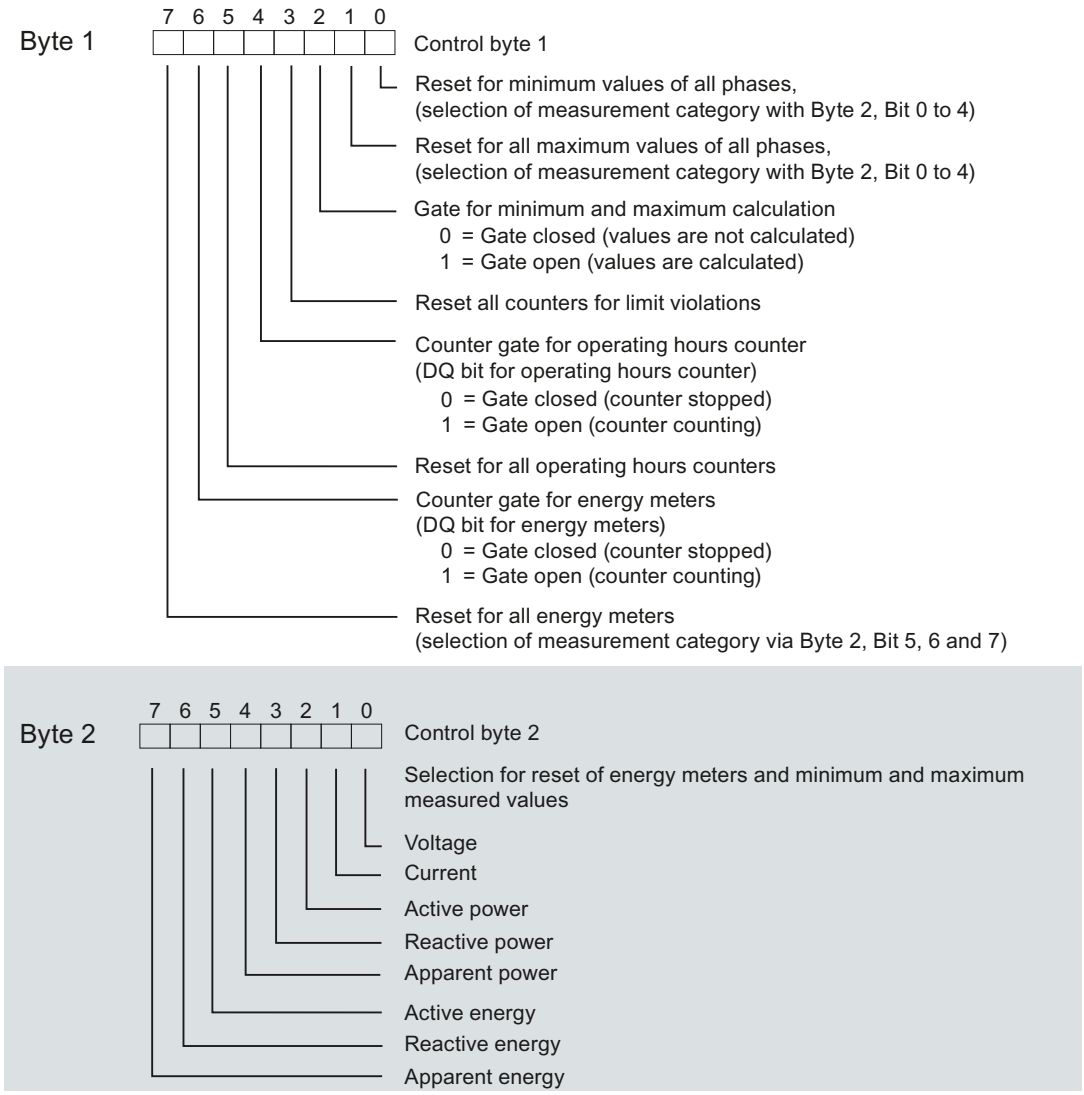

Figure 2-890 Allocation of the control bytes for all three phases (bytes 1 and 2)

Control bytes for limit monitoring

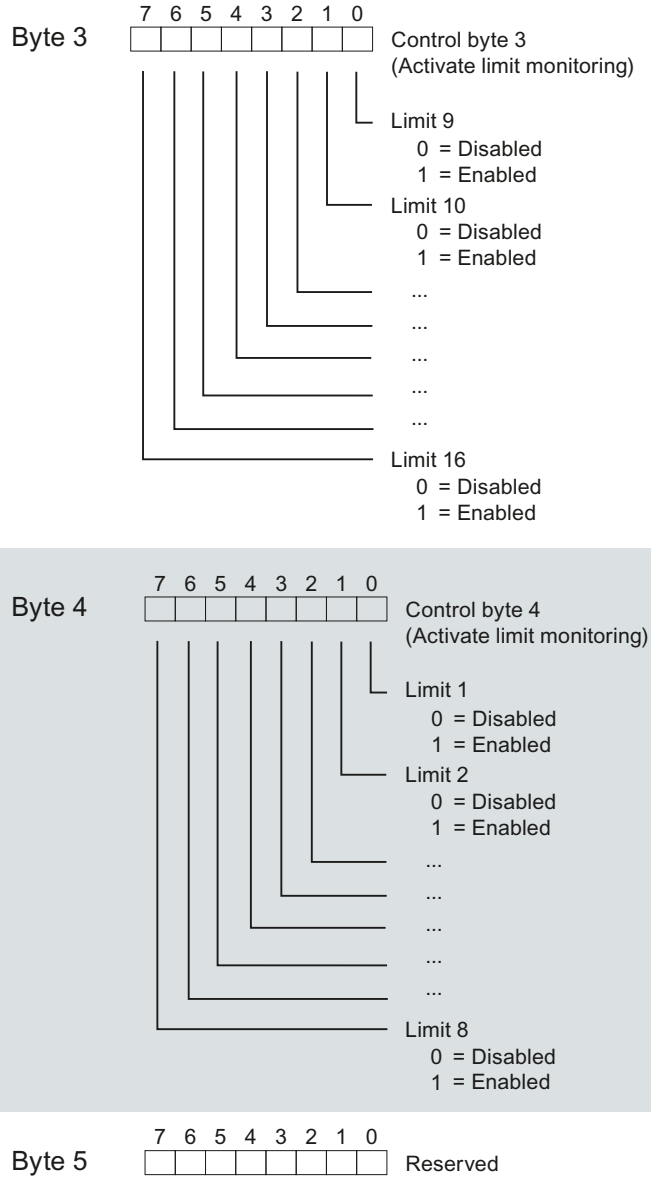

Figure 2-891 Allocation of the control bytes for limit monitoring (bytes 3 to 5)

Control bytes for each individual phase

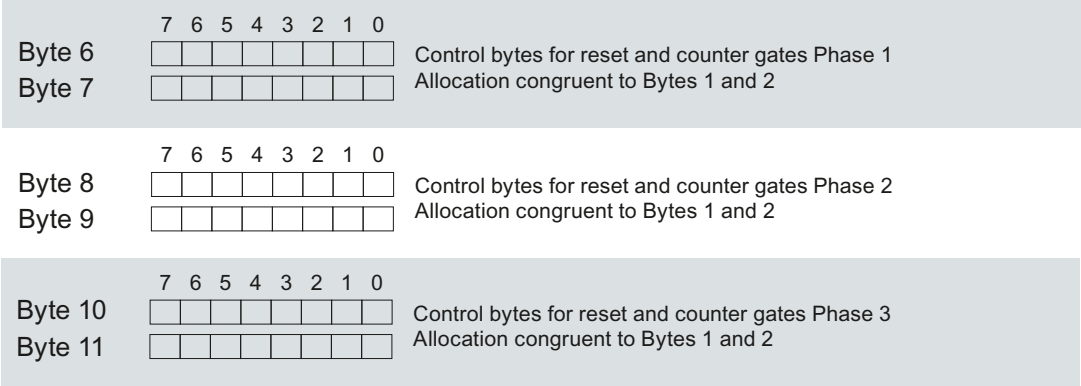

Figure 2-892 Allocation of the control bytes for each individual phase (bytes 6 to 11)

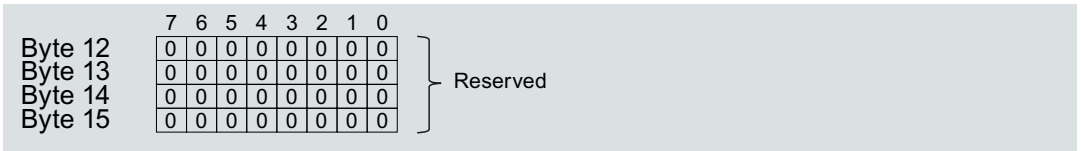

Figure 2-893 Allocation of the control bytes for each individual phase (bytes 12 to 15)

Control byte reset functions

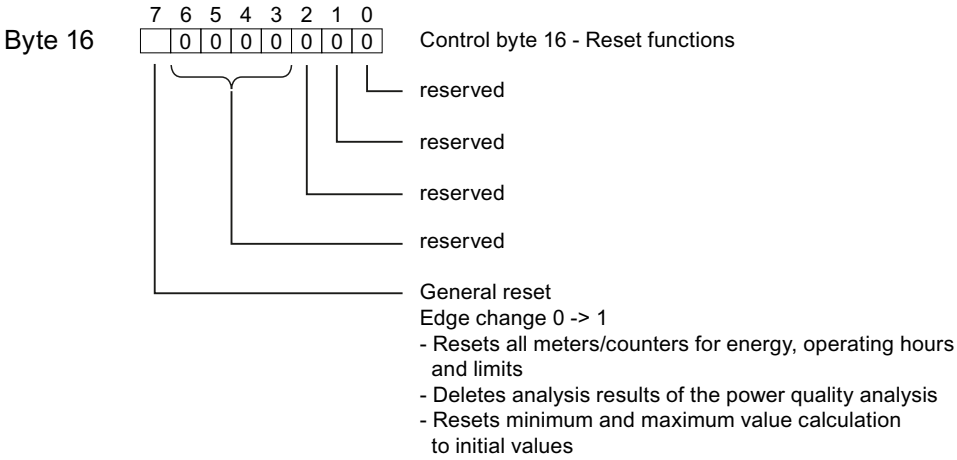

Figure 2-894 Allocation of the control bytes for reset functions (byte 16)

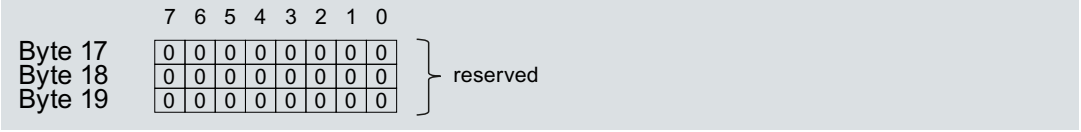

Figure 2-895 Allocation of the control bytes for each individual phase (bytes 17 to 19)

C.3 "User-specific" module version

Payload of the module

The module occupies between 16 and 256 bytes of input payload and 20 bytes of output payload. Of these the module uses 2 bytes input data for status information and 20 bytes output data for control information. Measured variables can be read cyclically via payload (as of Byte 2) or acyclically via measured value data records

Structure of input payload

You configure the structure of the input payload starting at Byte 2 at this module version itself. An input payload length of 32 bytes also allows you to set the input payload dynamically. You can choose between different payload variants.

Table 2-956 Structure of input payload (16 to 256 bytes)

Byte	Validity	Designation	Comment
0	Module	Payload variant	-
1	Module	Quality information	Quality bits to describe the quality of the basic measured values
2 ... 255	Module or phase	Data	Measured values or calculated values in accordance with their configuration: • At configuration in STEP 7 the size of the input payload is calculated automatically. • With configuration via the GSD file the size of the input payload amounts to 32, 64, 128 or 256 bytes. The memory area has to be sufficiently large for the measured variables defined in parameter data record 130.

Allocation of the input payload

You can change the measured variables during operation. You can choose between different payload variants.

The allocation of the status information in bytes 0 and 1 corresponds to the module version 32 I / 20 Q, see appendix Module version "32 I / 20 Q" (Page 150).

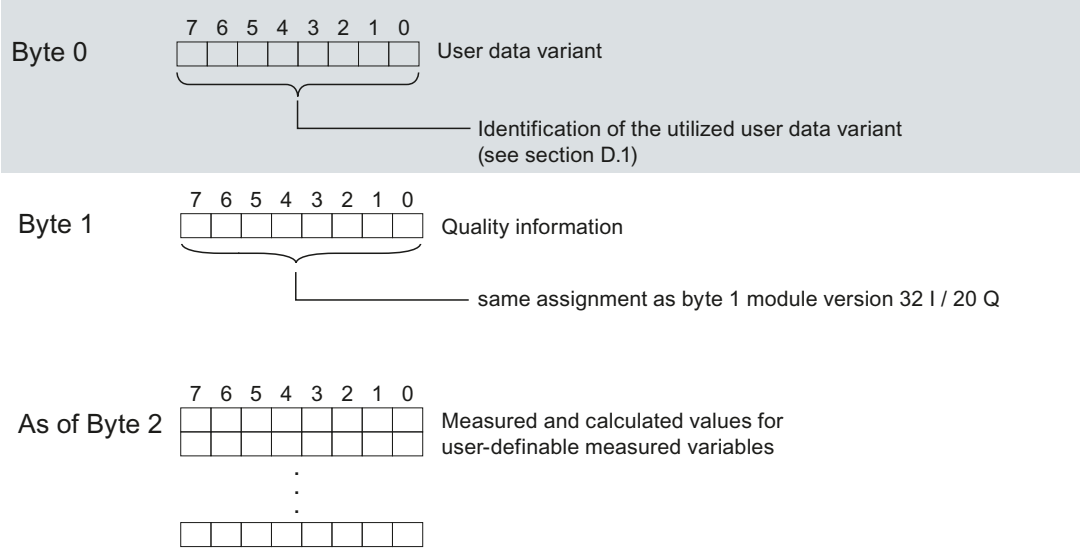

Figure 2-896 Allocation of the input payload ("User-specific" module version"

NOTE

Behavior at switchover in case of the input payload being too small

If the configured size of the variable input payload is smaller than the sized of the fixed payload variant, the response depends on the type of switchover:

- Re-assigning parameters via parameter data records DS 128 / DS 130: Output of a parameter assignment error (33). No switchover.
- Switchover using output byte 0 of a payload variant: No switchover and no error message.

Structure of output payload

The structure of the 20-byte output payload is fixed and is identical to the output payload (control bytes) of the Module version "32 I / 20 Q" (Page 150).

C.4 Module version "EE@Industry measurement data profile E0 / E1 / E2 / E3"

Payload of the module

The four versions according to EE@Industry use between 4 and 104 bytes of input payload and 20 bytes of output payload. A dynamic switchover of the input payload is not possible.

Structure of input payload

The structure of the input payload for the module versions according to the EE@Industry standard is fixed and depends on the selected measurement data profile.

Table 2-957 Measurement data profile E0

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Current L1	REAL	1 A	0.0 ... 100000.0	7
4...7	Current L2	REAL	1 A	0.0 ... 100000.0	8
8...11	Current L3	REAL	1 A	0.0 ... 100000.0	9

Table 2-958 Measurement data profile E1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Active power L1L2L3	REAL	1 W	-3.0e+9 ... +3.0e+9	34

Table 2-959 Measurement data profile E2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Active power L1L2L3	REAL	1 W	-3.0e+9 ... +3.0e+9	34
4...7	Active energy inflow L1L2L3 (Float)	REAL	1 Wh	0.0 ... 3.4028e+38	200
8...11	Active energy outflow L1L2L3 (Float)	REAL	1 Wh	0.0 ... 3.4028e+38	201

Table 2-960 Measurement data profile E3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Active power L1	REAL	1 W	-3.0e+9 ... +3.0e+9	13
4...7	Active power L2	REAL	1 W	-3.0e+9 ... +3.0e+9	14
8...11	Active power L3	REAL	1 W	-3.0e+9 ... +3.0e+9	15
12...15	Reactive power Qtot L1	REAL	1 var	-3.0e+9 ... +3.0e+9	22
16...19	Reactive power Qtot L2	REAL	1 var	-3.0e+9 ... +3.0e+9	23
20...23	Reactive power Qtot L3	REAL	1 var	-3.0e+9 ... +3.0e+9	24
24...31	Active energy inflow L1L2L3	LREAL	1 Wh	0.0 ... 1.7976e+308	210
32...39	Active energy outflow L1L2L3	LREAL	1 Wh	0.0 ... 1.7976e+308	211
40...47	Reactive energy inflow L1L2L3	LREAL	1 varh	0.0 ... 1.7976e+308	212

Byte	Allocation	Data type	Unit	Value range	Measured value ID
48...55	Reactive energy outflow L1L2L3	LREAL	1 varh	0.0 ... 1.7976e+308	213
56...59	Voltage L1-N	REAL	1 V	0.0 ... 1000000.0	1
60...63	Voltage L2-N	REAL	1 V	0.0 ... 1000000.0	2
64...67	Voltage L3-N	REAL	1 V	0.0 ... 1000000.0	3
68...71	Voltage L1-L2	REAL	1 V	0.0 ... 1000000.0	4
72...75	Voltage L2-L3	REAL	1 V	0.0 ... 1000000.0	5
76...79	Voltage L3-L1	REAL	1 V	0.0 ... 1000000.0	6
80...83	Current L1	REAL	1 A	0.0 ... 100000.0	7
84...87	Current L2	REAL	1 A	0.0 ... 100000.0	8
88...91	Current L3	REAL	1 A	0.0 ... 100000.0	9
92...95	Power factor λ L1	REAL	-	0.0 ... 1.0	19
96...99	Power factor λ L2	REAL	-	0.0 ... 1.0	20
100...1-03	Power factor λ L3	REAL	-	0.0 ... 1.0	21

Structure of output payload

The structure of the 20-byte output payload is fixed and is identical to the output payload (control bytes) of the Module version "32 I / 20 Q" (Page 150).

User data variants

D

D.1 User data variants with 32 bytes input data / 20 bytes output data

Payload

The following table shows the existing user data variants.

Table 2-961 Overview of the user data variants

Payload	User data variant
Total power L1L2L3	254 (FE_H) - default setting
Active power L1L2L3	253 (FD_H)
Reactive power L1L2L3	252 (FC_H)
Apparent power L1L2L3	251 (FB_H)
Basic measured values L1L2L3	250 (FA_H)
Total energy L1L2L3	249 ($F9_H$)
Energy L1	248 ($F8_H$)
Energy L2	247 ($F7_H$)
Energy L3	246 ($F6_H$)
Basic variables three-phase measurement L1L2L3	245 ($F5_H$)
Reactive power compensation	244 ($F4_H$)
Quality values three-phase measurement	240 ($F0_H$)
Energy measurement (periodic) overflow counter	239 (EF_H)
EE@Industry measurement data profile E3	227 ($E3_H$)
EE@Industry measurement data profile E2	226 ($E2_H$)
EE@Industry measurement data profile E1	225 ($E1_H$)
EE@Industry measurement data profile E0	224 ($E0_H$)
Basic variables phase-specific measurement L1	159 ($9F_H$)
Single-phase measurement L1 with voltage scaling value	158 ($9E_H$)
Basic variables phase-specific measurement L2	157 ($9D_H$)
Single-phase measurement L2 with voltage scaling value	156 ($9C_H$)
Basic variables phase-specific measurement L3	155 ($9B_H$)
Single-phase measurement L3 with voltage scaling value	154 ($9A_H$)
User-defined user data structure I	1 (01_H)

Information on using and dynamic switching of the payload variants can be found under "Selection of the module variant".

Total power L1L2L3 (ID 254 or FE_H)

Table 2-962 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
10 ... 11	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038
12 ... 13	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
14 ... 17	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	225
18 ... 21	Total reactive energy L1L2L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	226
22	Reserved	BYTE	-	0	-
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Active power L1L2L3 (ID 253 or FD_H)

Table 2-963 Active power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	253 (FD_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1	INT	1 W	-32768 ... 32767	66013
10 ... 11	Active power L2	INT	1 W	-32768 ... 32767	66014
12 ... 13	Active power L3	INT	1 W	-32768 ... 32767	66015
14 ... 15	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
16 ... 19	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	225
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1	USINT	-	0 ... 255	-
28	Scaling active power L2	USINT	-	0 ... 255	-
29	Scaling active power L3	USINT	-	0 ... 255	-
30	Scaling active power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-

Reactive power L1L2L3 (ID 252 or FC_H)

Table 2-964 Reactive power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	252 (FC_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	66022
10 ... 11	Reactive power Qtot L2	INT	1 var	-32768 ... 32767	66023
12 ... 13	Reactive power Qtot L3	INT	1 var	-32768 ... 32767	66024
14 ... 15	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038

Byte	Allocation	Data type	Unit	Value range	Measured value ID
16 ... 19	Reactive energy inflow L1L2L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	222
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling reactive power L1	USINT	-	0 ... 255	-
28	Scaling reactive power L2	USINT	-	0 ... 255	-
29	Scaling reactive power L3	USINT	-	0 ... 255	-
30	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Apparent power L1L2L3 (ID 251 or FB_H)

Table 2-965 Apparent power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	251 (FB_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Apparent power L1	INT	1 VA	-32768 ... 32767	66010
10 ... 11	Apparent power L2	INT	1 VA	-32768 ... 32767	66011
12 ... 13	Apparent power L3	INT	1 VA	-32768 ... 32767	66012
14 ... 15	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
16 ... 19	Apparent energy L1L2L3 (Int32)	DINT	1 VAh	0 to 2147483647	224
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Scaling apparent power L2	USINT	-	0 ... 255	-
29	Scaling apparent power L3	USINT	-	0 ... 255	-
30	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total apparent energy L1L2L3	USINT	-	0 ... 255	-

Basic measured values L1L2L3 (ID 250 or FA_H)

Table 2-966 Basic measured values L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	250 (FA_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
10 ... 11	Voltage L2-N	UINT	0.01 V	0 ... 65535	66002
12 ... 13	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003
14 ... 15	Voltage L1-L2	UINT	0.01 V	0 ... 65535	66004
16 ... 17	Voltage L2-L3	UINT	0.01 V	0 ... 65535	66005
18 ... 19	Voltage L3-L1	UINT	0.01 V	0 ... 65535	66006
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling voltage UL1-N (UL1-UL2)	USINT	-	0 ... 255	-
28	Scaling voltage UL2-N (UL2-UL3)	USINT	-	0 ... 255	-
29	Scaling voltage UL3-N (UL3-UL1)	USINT	-	0 ... 255	-
30 ... 31	Frequency (Uint16)	UINT	0.01 Hz	4000 ... 7000	66031

Total energy L1L2L3 (ID 249 or $F9_H$)

Table 2-967 Total energy L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	249 ($F9_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2	Reserved	BYTE	-	0	-
3	Reserved	BYTE	-	0	-
4 ... 7	Active energy inflow L1L2L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	220
8 ... 11	Active energy outflow L1L2L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	221
11 ... 15	Reactive energy inflow L1L2L3 (Int32)	UDINT	1 varh	0 ... 2147483647	222
16 ... 19	Reactive energy outflow L1L2L3 (Int32)	UDINT	1 varh	0 ... 2147483647	223
20 ... 23	Apparent energy L1L2L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	224
24	Reserved	BYTE	-	0	-
25	Scaling active energy, inflow	USINT	-	0 ... 255	-
26	Scaling active energy, outflow	USINT	-	0 ... 255	-
27	Scaling reactive energy, inflow	USINT	-	0 ... 255	-
28	Scaling reactive energy, outflow	USINT	-	0 ... 255	-
29	Scaling apparent energy	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037

Energy L1 (ID 248 or $F8_H$)

Table 2-968 Energy L1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	248 ($F8_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 7	Active energy inflow L1 (Int32)	UDINT	1 Wh	0 ... 2147483647	62110
8 ... 11	Active energy outflow L1 (Int32)	UDINT	1 Wh	0 ... 2147483647	62111
11 ... 15	Reactive energy inflow L1 (Int32)	UDINT	1 varh	0 ... 2147483647	62112
16 ... 19	Reactive energy outflow L1 (Int32)	UDINT	1 varh	0 ... 2147483647	62113
20 ... 23	Apparent energy L1 (Int32)	UDINT	1 VAh	0 ... 2147483647	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active energy inflow L1	USINT	-	0 ... 255	-
26	Scaling active energy outflow L1	USINT	-	0 ... 255	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
27	Scaling reactive energy inflow L1	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L1	USINT	-	0 ... 255	-
29	Scaling apparent energy L1	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L1	USINT	0.01	0 ... 100	66019

Energy L2 (ID 247 or $F7_H$)

Table 2-969 Energy L2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	247 ($F7_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L2	UINT	1 mA	0 ... 65535	66008
4 ... 7	Active energy inflow L2 (Int32)	UDINT	1 Wh	0 ... 2147483647	62210
8 ... 11	Active energy outflow L2 (Int32)	UDINT	1 Wh	0 ... 2147483647	62211
11 ... 15	Reactive energy inflow L2 (Int32)	UDINT	1 varh	0 ... 2147483647	62212
16 ... 19	Reactive energy outflow L2 (Int32)	UDINT	1 varh	0 ... 2147483647	62213
20 ... 23	Apparent energy L2 (Int32)	UDINT	1 VAh	0 ... 2147483647	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active energy inflow L2	USINT	-	0 ... 255	-
26	Scaling active energy outflow L2	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L2	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L2	USINT	-	0 ... 255	-
29	Scaling apparent energy L2	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L2	USINT	0.01	0 ... 100	66020

Energy L3 (ID 246 or $F6_H$)

Table 2-970 Energy L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	246 ($F6_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L3	UINT	1 mA	0 ... 65535	66009
4 ... 7	Active energy inflow L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	62310
8 ... 11	Active energy outflow L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	62311
11 ... 15	Reactive energy inflow L3 (Int32)	UDINT	1 varh	0 ... 2147483647	62312
16 ... 19	Reactive energy outflow L3 (Int32)	UDINT	1 varh	0 ... 2147483647	62313
20 ... 23	Apparent energy L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active energy inflow L3	USINT	-	0 ... 255	-
26	Scaling active energy outflow L3	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L3	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L3	USINT	-	0 ... 255	-
29	Scaling apparent energy L3	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L3	USINT	0.01	0 ... 100	66021

Basic variables three-phase measurements (ID 245 or $F5_H$)

Table 2-971 Basic variables three-phase measurements

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	245 ($F5_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1L2L3	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	34
6 ... 9	Active energy outflow L1L2L3	REAL	1 Wh	0.0 ... 3.4×10^{38}	201
10 ... 13	Active energy inflow L1L2L3	REAL	1 Wh	0.0 ... 3.4×10^{38}	200
14 ... 17	Current L1	REAL	1 A	0.0 ... 100000.0	7
18 ... 21	Current L2	REAL	1 A	0.0 ... 100000.0	8
22 ... 25	Current L3	REAL	1 A	0.0 ... 100000.0	9
26 ... 27	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
28 ... 29	Voltage L2-N	UINT	0.01 V	0 ... 65535	66002
30 ... 31	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003

Reactive power compensation (ID 244 or $F4_H$)

Table 2-972 Reactive power compensation

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	244 ($F4_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2	Fundamental cos φ active factor L1 (SINT8)	BYTE	0.01	-100 ... 100	62136
3	Fundamental cos φ active factor L2 (SINT8)	BYTE	0.01	-100 ... 100	62236
4	Fundamental cos φ active factor L3 (SINT8)	BYTE	0.01	-100 ... 100	62336
5	Reserved	BYTE	-	0	-
6 ... 9	Fundamental reactive power L1	REAL	var	-3×10^9 ... $+3 \times 10^9$	62124
10 ... 13	Fundamental reactive power L2	REAL	var	-3×10^9 ... $+3 \times 10^9$	62224
14 ... 17	Fundamental reactive power L3	REAL	var	-3×10^9 ... $+3 \times 10^9$	62324

Basic variables quality values three-phase measurement (ID 240 or $F0_H$)

Table 2-973 Basic variables quality values three-phase measurement

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	240 (F0H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Status limit violation GW 1 ... 16 (*)	WORD	Bit string	xxxx xxxx xxxx xxxx	65509
4 ... 5	Status of the energy counter overflows (**)	WORD	Bit string	xxxx xxxx xxxx xxxx	65508
6 ... 7	Qualifier L1L2L3	WORD	Bit string	xxxx xxxx xxxx xxxx	65503
8 ... 11	Reserved	UDINT	-	0	-
12 ... 13	Reserved	WORD	-	0	-
14 ... 15	Reserved	WORD	-	0	-
16 ... 17	Reserved	WORD	-	0	-
18 ... 19	Reserved	WORD	-	0	-
20 ... 21	Reserved	WORD	-	0	-
22 ... 23	Reserved	WORD	-	0	-
24 ... 25	Reserved	WORD	-	0	-

(*) Limit violation in:
Bit 0 = limit 1 to bit 15 = limit 16

(**) Energy meter count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
26 ... 27	Reserved	WORD	-	0	-
28 ... 29	Reserved	WORD	-	0	-
30 ... 31	Reserved	WORD	-	0	-

(*) Limit violation in:
Bit 0 = limit 1 to bit 15 = limit 16

Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

Basic variables energy meter measurement (periodic) overflow counter (ID 239 or EF_H)

Table 2-974 Basic variables energy meter measurement (periodic) overflow counter

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	239 (EFH)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Overflow counter active energy inflow L1	UINT	-	0 ... 65535	61190
4 ... 5	Overflow counter active energy outflow L1	UINT	-	0 ... 65535	61191
6 ... 7	Overflow counter reactive energy inflow L1	UINT	-	0 ... 65535	61192
8 ... 9	Overflow counter reactive energy outflow L1	UINT	-	0 ... 65535	61193
10 ... 11	Overflow counter apparent energy L1	UINT	-	0 ... 65535	61194
12 ... 13	Overflow counter active energy inflow L2	UINT	-	0 ... 65535	61210
14 ... 15	Overflow counter active energy outflow L2	UINT	-	0 ... 65535	61211
16 ... 17	Overflow counter reactive energy inflow L2	UINT	-	0 ... 65535	61212
18 ... 19	Overflow counter reactive energy outflow L2	UINT	-	0 ... 65535	61213
20 ... 21	Overflow counter apparent energy L2	UINT	-	0 ... 65535	61214
22 ... 23	Overflow counter active energy inflow L3	UINT	-	0 ... 65535	61230

Byte	Allocation	Data type	Unit	Value range	Measured value ID
24 ... 25	Overflow counter active energy outflow L3	UINT	-	0 ... 65535	61231
26 ... 27	Overflow counter reactive energy inflow L3	UINT	-	0 ... 65535	61232
28 ... 29	Overflow counter reactive energy outflow L3	UINT	-	0 ... 65535	61233
30 ... 31	Overflow counter apparent energy L3	UINT	-	0 ... 65535	61234

Basic variables measurement data profile (ID 227 or $E3_H$)

Table 2-975 Basic variables measurement data profile Energy E3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	227 ($E3_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	13
6 ... 9	Active power L2	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	14
10 ... 13	Active power L3	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	15
14 ... 17	Reactive power Qtot L1	REAL	1 var	-3×10^9 ... $+3 \times 10^9$	22
18 ... 21	Reactive power Qtot L2	REAL	1 var	-3×10^9 ... $+3 \times 10^9$	23
22 ... 25	Reactive power Qtot L3	REAL	1 var	-3×10^9 ... $+3 \times 10^9$	24
26 ... 33	Active energy inflow L1L2L3	LREAL	1 Wh	0.0 ... 1.8×10^{308}	210
34 ... 41	Active energy outflow L1L2L3	LREAL	1 Wh	0.0 ... 1.8×10^{308}	211
42 ... 49	Reactive energy inflow L1L2L3	LREAL	1 varh	0.0 ... 1.8×10^{308}	212
50 ... 57	Reactive energy outflow L1L2L3	LREAL	1 varh	0.0 ... 1.8×10^{308}	213
58 ... 61	Voltage L1-N	REAL	1 V	0.0 ... 1000000.0	1
62 ... 65	Voltage L2-N	REAL	1 V	0.0 ... 1000000.0	2
66 ... 69	Voltage L3-N	REAL	1 V	0.0 ... 1000000.0	3
70 ... 73	Voltage L1-L2	REAL	1 V	0.0 ... 1000000.0	4
74 ... 77	Voltage L2-L3	REAL	1 V	0.0 ... 1000000.0	5
78 ... 81	Voltage L3-L1	REAL	1 V	0.0 ... 1000000.0	6
82 ... 85	Current L1	REAL	1 A	0.0 ... 100000.0	7
86 ... 89	Current L2	REAL	1 A	0.0 ... 100000.0	8
90 ... 93	Current L3	REAL	1 A	0.0 ... 100000.0	9
94 ... 97	Power factor λ L1	REAL	-	0.0 ... 1.0	19
98 ... 101	Power factor λ L2	REAL	-	0.0 ... 1.0	20
102 ... 105	Power factor λ L3	REAL	-	0.0 ... 1.0	21

Basic variables measurement data profile (ID 226 or $E2_H$)

Table 2-976 Basic variables measurement data profile Energy E2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	226 ($E2_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	34
6 ... 9	Active energy inflow L1L2L3 (Float)	REAL	1 W	3.0×10^9	200
10 ...13	Active energy outflow L1L2L3 (Float)	REAL	1 W	3.0×10^9	201

Basic variables measurement data profile (ID 225 or $E1_H$)

Table 2-977 Basic variables measurement data profile Energy E1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	225 ($E1_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	34

Basic variables measurement data profile (ID 224 or $E0_H$)

Table 2-978 Basic variables measurement data profile Energy E0

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	224 ($E0_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Current L1	REAL	1 A	0.0 ... 100000.0	7
6 ... 9	Current L2	REAL	1 A	0.0 ... 100000.0	8
10 ...13	Current L3	REAL	1 A	0.0 ... 100000.0	9

Basic variables phase-specific measurement (ID 159 or $9F_H$)

Table 2-979 Basic variables phase-specific measurement L1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	159 (9FH)	-
1	Quality information = Q Q_1 0 0 0 0 I_1 U_1	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
6 ... 7	Active power L1	INT	1 W	-32768 ... 32767	66013
8 ... 9	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	66022
10 ... 11	Apparent power L1	INT	1 VA	-32768 ... 32767	66010
12 ... 15	Total active energy L1 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62115
16 ... 19	Total reactive energy L1 (Int32)	DINT	1 varh	-2147483647... +2147483647	62116
20 ... 23	Apparent energy L1 (Int32)	UDINT	1 VAh	0 ... 2147483647	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active power L1	USINT	-	0 ... 255	-
26	Scaling reactive power L1	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Total scaling active energy L1	USINT	-	0 ... 255	-
29	Total scaling reactive energy L1	USINT	-	0 ... 255	-
30	Scaling apparent energy L1	USINT	-	0 ... 255	-
31	Power factor λ L1	USINT	0.01	0 ... 100	66019

Basic variables phase-specific measurement (ID 158 or $9E_H$)

Table 2-980 Single-phase measurement L1 with voltage scaling value

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	158 (9EH)	-
1	Quality information = Q Q_1 0 0 0 0 I_1 U_1	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
6 ... 7	Active power L1	INT	1 W	-32768 ... 32767	66013
8 ... 9	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	66022
10 ... 11	Apparent power L1	INT	1 VA	-32768 ... 32767	66010
12 ... 15	Total active energy L1	UDINT	1 Wh	0 ... 4294967295	62115

Byte	Allocation	Data type	Unit	Value range	Measured value ID
16 ... 19	Total reactive energy L1	UDINT	1 varh	0 ... 4294967295	62116
20 ... 23	Apparent energy L1 (Int32)	UDINT	1 VAh	0 ... 4294967295	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active power L1	USINT	-	0 ... 255	-
26	Scaling reactive power L1	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Total scaling active energy L1	USINT	-	0 ... 255	-
29	Total scaling reactive energy L1	USINT	-	0 ... 255	-
30	Scaling apparent energy L1	USINT	-	0 ... 255	-
31	Scaling voltage L1-N	USINT	-	0 ... 255	-

Basic variables phase-specific measurement (ID 157 or $9D_H$)

Table 2-981 Basic variables phase-specific measurement L2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	157 ($9D_H$)	-
1	Quality information = Q Q_1 0 0 0 0 I_2 U_2	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L2	UINT	1 mA	0 ... 65535	66008
4 ... 5	Voltage L2-N	UINT	0.01 V	0 ... 65535	66002
6 ... 7	Active power L2	INT	1 W	-32768 ... 32767	66014
8 ... 9	Reactive power Qtot L2	INT	1 var	-32768 ... 32767	66023
10 ... 11	Apparent power L2	INT	1 VA	-32768 ... 32767	66011
12 ... 15	Total active energy L2 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62215
16 ... 19	Total reactive energy L2 (Int32)	DINT	1 varh	-2147483647... +2147483647	62216
20 ... 23	Apparent energy L2 (Int32)	UDINT	1 VAh	0 ... 2147483647	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active power L2	USINT	-	0 ... 255	-
26	Scaling reactive power L2	USINT	-	0 ... 255	-
27	Scaling apparent power L2	USINT	-	0 ... 255	-
28	Total scaling active energy L1	USINT	-	0 ... 255	-
29	Total scaling reactive energy L1	USINT	-	0 ... 255	-
30	Scaling apparent energy L2	USINT	-	0 ... 255	-
31	Power factor λ L2	USINT	0.01	0 ... 100	66020

Basic variables phase-specific measurement (ID 156 or $9C_H$)

Table 2-982 Single-phase measurement L2 with voltage scaling value

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	156 (9CH)	-
1	Quality information = Q Q_1 0 0 0 0 I_2 U_2	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L2	UINT	1 mA	0 ... 65535	66008
4 ... 5	Voltage UL2-N	UINT	0.01 V	0 ... 65535	66002
6 ... 7	Active power L2	INT	1 W	-32768 ... 32767	66014
8 ... 9	Reactive power Qtot L2	INT	1 var	-32768 ... 32767	66023
10 ... 11	Apparent power L2	INT	1 VA	-32768 ... 32767	66011
12 ... 15	Total active energy L2 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62215
16 ... 19	Total reactive energy L2 (Int32)	DINT	1 varh	-2147483647... +2147483647	62216
20 ... 23	Apparent energy L2 (Int32)	UDINT	1 VAh	0 ... 2147483647	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active power L2	USINT	-	0 ... 255	-
26	Scaling reactive power L2	USINT	-	0 ... 255	-
27	Scaling apparent power L2	USINT	-	0 ... 255	-
28	Total scaling active energy L2	USINT	-	0 ... 255	-
29	Total scaling reactive energy L2	USINT	-	0 ... 255	-
30	Scaling apparent energy L2	USINT	-	0 ... 255	-
31	Scaling voltage L2-N	USINT	-	0 ... 255	-

Basic variables phase-specific measurement (ID 155 or $9B_H$)

Table 2-983 Basic variables phase-specific measurement L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	155 ($9B_H$)	-
1	Quality information = Q Q_1 0 0 0 0 I_3 U_3	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L3	UINT	1 mA	0 ... 65535	66009
4 ... 5	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003
6 ... 7	Active power L3	INT	1 W	-32768 ... 32767	66015
8 ... 9	Reactive power Qtot L3	INT	1 var	-32768 ... 32767	66024
10 ... 11	Apparent power L3	INT	1 VA	-32768 ... 32767	66012
12 ... 15	Total active energy L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62315

Byte	Allocation	Data type	Unit	Value range	Measured value ID
16 ... 19	Total reactive energy L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	62316
20 ... 23	Apparent energy L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active power L3	USINT	-	0 ... 255	-
26	Scaling reactive power L3	USINT	-	0 ... 255	-
27	Scaling apparent power L3	USINT	-	0 ... 255	-
28	Total scaling active energy L3	USINT	-	0 ... 255	-
29	Total scaling reactive energy L3	USINT	-	0 ... 255	-
30	Scaling apparent energy L3	USINT	-	0 ... 255	-
31	Power factor L3	USINT	0.01	0 ... 100	66021

Basic variables phase-specific measurement (ID 154 or $9A_H$)

Table 2-984 Single-phase measurement L3 with voltage scaling value

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	154 ($9A_H$)	-
1	Quality information = Q Q_1 0 0 0 0 I_3 U_3	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L3	UINT	1 mA	0 ... 65535	66009
4 ... 5	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003
6 ... 7	Active power L3	INT	1 W	-32768 ... 32767	66015
8 ... 9	Reactive power Qtot L3	INT	1 var	-32768 ... 32767	66024
10 ... 11	Apparent power L3	INT	1 VA	-32768 ... 32767	66012
12 ... 15	Total active energy L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62315
16 ... 19	Total reactive energy L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	62316
20 ... 23	Apparent energy L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active power L3	USINT	-	0 ... 255	-
26	Scaling reactive power L3	USINT	-	0 ... 255	-
27	Scaling apparent power L3	USINT	-	0 ... 255	-
28	Total scaling active energy L3	USINT	-	0 ... 255	-
29	Total scaling reactive energy L3	USINT	-	0 ... 255	-
30	Scaling apparent energy L3	USINT	-	0 ... 255	-
31	Scaling voltage L3-N	USINT	-	0 ... 255	-

See also

Module versions at configuration with STEP 7 (Page %getreference)

Measured value data records

E

E.1 Overview of all measured value data records

The AI Energy Meter CT ST writes the measured values in several data records that you can read acyclically using the RDREC instruction in the user program.

The following tables show the structure of the individual data records:

- Data record DS 142 for basic measured values version 2 (read only).
- Data record DS 142 for basic measured values version 3 (read only).
- Data record DS 143 for energy meters (read and write).
- Data record DS 144 for maximum values (read only).
- Data record DS 154 for maximum values with time stamp (read only).
- Data record DS 145 for minimum values (read only).
- Data record DS 155 for minimum values with time stamp (read only).
- Data record DS 147 for phase-specific measured values L1 version 0 (read only).
- Data record DS 147 for phase-specific measured values L1 version 1 (read only).
- Data record DS 148 for phase-specific measured values L2 DS version 0 (read only).
- Data record DS 148 for phase-specific measured values L2 DS version 1 (read only).
- Data record DS 149 for phase-specific measured values L3 DS version 0 (read only).
- Data record DS 149 for phase-specific measured values L3 DS version 1 (read only).
- Data record DS 150 for advanced measurement and status values (read only).
- Data record DS 151 for user-defined data record (read only).

NOTE

When reading data records that do not exist on the ST module with RDREC, the error 0x80B0 is displayed.

E.2 Measured value data record for base measurements (DS 142)

E.2.1 Measured value data record for basic measured values (DS 142) version 2

Measured variables of the module

The following table provides an overview of all the measured variables that data record 142 supplies. Note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix (Measured variables for connection type).

Table 2-985 Data record 142

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version = 2	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...5	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
6...9	Voltage L2-N	REAL	V	0.0 ... 1000000.0	2
10...13	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
14...17	Voltage L1-L2	REAL	V	0.0 ... 1000000.0	4
18...21	Voltage L2-L3	REAL	V	0.0 ... 1000000.0	5
22...25	Voltage L3-L1	REAL	V	0.0 ... 1000000.0	6
26...29	Current L1	REAL	A	0.0 ... 100000.0	7
30...33	Current L2	REAL	A	0.0 ... 100000.0	8
34...37	Current L3	REAL	A	0.0 ... 100000.0	9
38...41	Power factor λ L1	REAL	-	0.0 ... 1.0	19
42...45	Power factor λ L2	REAL	-	0.0 ... 1.0	20
46...49	Power factor λ L3	REAL	-	0.0 ... 1.0	21
50...53	Power factor λ L1L2L3	REAL	-	0.0 ... 1.0	37
54...57	Frequency L1L2L3	REAL	1 Hz	40.0 ... 70.0	30
58...61	Amplitude unbalance voltage U_2	REAL	%	0 ... 100	61157
62...65	Amplitude unbalance current I_{asym}	REAL	%	0 ... 100	61158
66...69	Apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	10
70...73	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
74...77	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
78...81	Apparent power L1L2L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	36
82...85	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
86...89	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
90...93	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
94...97	Reactive power Qtot L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	38
98...101	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
102...105	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
106...109	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
110...113	Active power L1L2L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	34
114...117	Phase angle L1	REAL	°	0.0 ... 360.0	61178
118...121	Phase angle L2	REAL	°	0.0 ... 360.0	61198
122...125	Phase angle L3	REAL	°	0.0 ... 360.0	61218
126...129	Apparent energy L1L2L3 (Float)	REAL	VAh	0.0 ... 3.4×10^{38}	204
130...133	Total reactive energy L1L2L3 (Float)	REAL	varh	-3.4×10^{38} to $+3.4 \times 10^{38}$	206
134...137	Total active energy L1L2L3 (Float)	REAL	Wh	-3.4×10^{38} to $+3.4 \times 10^{38}$	205
138...141	Reactive energy inflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	202
142...145	Reactive energy outflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	203
146...149	Active energy inflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	200
150...153	Active energy outflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	201
154...161	Apparent energy L1L2L3	LREAL	VAh	0.0 ... 1.8×10^{308}	214
162...169	Total reactive energy L1L2L3	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	216
170...177	Total active energy L1L2L3	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	215
178...185	Reactive energy inflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	212
186...193	Reactive energy outflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	213
194...201	Active energy inflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	210
202...209	Active energy outflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	211
210...213	Neutral current IN	REAL	A	0.0 ... 100000.0	61149

Neutral current

If you operate the AI Energy Meter CT ST with connection type 3P4W, 3P4W1 or 3P3W, the neutral current is also calculated under the following conditions:

- Transmission factors of all phase currents (primary and secondary currents) are identical.
- Measured phase currents are greater than the value of the "Low limit for measuring current" parameter.
- The parameter "Reverse current direction" must be the same on all phases.

If one of the conditions is not met, 0 is entered as the value for the neutral current. You can read the neutral current calculated using measured value data record 142.

Procedure

Data record 142 is located on the AI Energy Meter CT ST. Use the RDREC instruction to read out the data record from the module. This system function block is stored in the STEP 7 library.

E.2.2 Measured value data record for basic measured values (DS 142) version 3

Measured variables of the module

The following table provides an overview of all the measured variables that data record 142 supplies. Note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix (Measured variables for connection type (Page 136)).

Table 2-986 Data record 142

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version = 3	BYTE	-	3	-
1	Reserved	BYTE	-	0	-
2...5	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
6...9	Voltage L2-N	REAL	V	0.0 ... 1000000.0	2
10...13	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
14...17	Voltage L1-L2	REAL	V	0.0 ... 1000000.0	4
18...21	Voltage L2-L3	REAL	V	0.0 ... 1000000.0	5
22...25	Voltage L3-L1	REAL	V	0.0 ... 1000000.0	6
26...29	Current L1	REAL	A	0.0 ... 100000.0	7
30...33	Current L2	REAL	A	0.0 ... 100000.0	8
34...37	Current L3	REAL	A	0.0 ... 100000.0	9
38...41	Power factor λ L1	REAL	-	0.0 ... 1.0	19
42...45	Power factor λ L2	REAL	-	0.0 ... 1.0	20

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
46...49	Power factor λ L3	REAL	-	0.0 ... 1.0	21
50...53	Power factor λ L1L2L3	REAL	-	0.0 ... 1.0	37
54...57	Frequency L1L2L3	REAL	1 Hz	40.0 ... 70.0	30
58...61	Amplitude unbalance voltage U_2	REAL	%	0 ... 100	61157
62...65	Amplitude unbalance current I_{asym}	REAL	%	0 ... 100	61158
66...69	Apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	10
70...73	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
74...77	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
78...81	Apparent power L1L2L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	36
82...85	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22
86...89	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
90...93	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
94...97	Reactive power Qtot L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	38
98...101	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
102...105	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
106...109	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
110...113	Active power L1L2L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	34
114...117	Phase angle L1	REAL	°	0.0 ... 360.0	61178
118...121	Phase angle L2	REAL	°	0.0 ... 360.0	61198
122...125	Phase angle L3	REAL	°	0.0 ... 360.0	61218
126...129	Apparent energy L1L2L3 (Float)	REAL	VAh	0.0 ... 3.4×10^{38}	204
130...133	Total reactive energy L1L2L3 (Float)	REAL	varh	-3.4×10^{38} to $+3.4 \times 10^{38}$	206
134...137	Total active energy L1L2L3 (Float)	REAL	Wh	-3.4×10^{38} to $+3.4 \times 10^{38}$	205
138...141	Reactive energy inflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	202
142...145	Reactive energy outflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	203
146...149	Active energy inflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	200
150...153	Active energy outflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	201
154...161	Apparent energy L1L2L3	LREAL	VAh	0.0 ... 1.8×10^{308}	214

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
162...169	Total reactive energy L1L2L3	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	216
170...177	Total active energy L1L2L3	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	215
178...185	Reactive energy inflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	212
186...193	Reactive energy outflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	213
194...201	Active energy inflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	210
202...209	Active energy outflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	211
210...213	Neutral current IN	REAL	A	0.0 ... 100000.0	61149
214...217	Reserved	DWORD	-	-	-
218...221	Reactive power Qn L1	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	16
222...225	Reactive power Qn L2	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	17
226...229	Reactive power Qn L3	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	18
230...233	Reactive power Qn L1L2L3	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	35
234...237	Average voltage load LN (Utot)	REAL	V	0.0 ... 300.0	31
238...241	Average voltage L-L	REAL	V	0.0 ... 600.0	32
242...245	Average current L1L2L3 (Itot)	REAL	A	0.0 ... 100000.0	33
246...249	Mean power factor λ L1L2L3	REAL	-	0.0 ... 1.0	166
250...253	Reserved	DWORD	-	-	-
254...257	Reserved	DWORD	-	-	-
258...261	Reserved	DWORD	-	-	-
262...265	Reserved	DWORD	-	-	-
266...269	Reserved	DWORD	-	-	-
270...273	Reserved	DWORD	-	-	-
274...277	Reserved	DWORD	-	-	-
278...281	Reserved	DWORD	-	-	-
282...285	Reserved	DWORD	-	-	-
286...289	Fundamental reactive power L1	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62124
290...293	Fundamental reactive power L2	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62224
294...297	Fundamental reactive power L3	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62324
298...301	Reserved	DWORD	-	-	-
302...305	Reserved	DWORD	-	-	-
306...309	Reserved	DWORD	-	-	-
310...313	Fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62127

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
314...317	Fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62227
318...321	Fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62327
322...325	Reserved	DWORD	-	-	-
326...329	Reserved	DWORD	-	-	-
330...333	Reserved	DWORD	-	-	-
334...337	Reserved	DWORD	-	-	-
338...341	Reserved	DWORD	-	-	-
342...345	Reserved	DWORD	-	-	-
346...357	Current module time	PNIOTime	sec	-	65497

Neutral current

If you operate the AI Energy Meter CT ST with connection type 3P4W, 3P4W1 or 3P3W, the neutral current is also calculated under the following conditions:

- Transmission factors of all phase currents (primary and secondary currents) are identical.
- Measured phase currents are greater than the value of the "Low limit for measuring current" parameter.
- The parameter "Reverse current direction" must be the same on all phases.

If one of the conditions is not met, 0 is entered as the value for the neutral current. You can read the neutral current calculated using measured value data record 142.

Procedure

Data record 142 is located on the AI Energy Meter CT ST. Use the RDREC instruction to read out the data record from the module. This system function block is stored in the STEP 7 library.

E.3 Structure for energy counters (DS 143)

Energy meter data record 143 for different actions

The energy meter data record 143 includes all energy meters available on the module phase-by-phase. The data record can be used for different actions:

- Reset the energy meters to user-specific value (e.g. "0")
- Reading the current values of the energy counters
- Reading the overflow counters
- Reading the operating hours

NOTE

- The cumulative value of the energy counters in 3-phase operation is obtained from the sums of the respective individual values of the phases.
- Inflow and outflow energy meters are always positive values.
- The operating hours counter for the entire module is calculated from the maximum of the operating hours of the individual phases.

Energy meter data record 143

Table 2-987 Energy meter data record 143

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Status / control byte 1 - L1	BYTE	Bit string	-	-
3	Status / control byte 2 - L1	BYTE	Bit string		
4	Status / control byte 1 - L2	BYTE	Bit string		
5	Status / control byte 2 - L2	BYTE	Bit string		
6	Status / control byte 1 - L3	BYTE	Bit string		
7	Status / control byte 2 - L3	BYTE	Bit string		
8...15	Active energy inflow (initial value) L1	LREAL	Wh	During reading: 0.0...1.8 x 10^{308} During writing For continuous counting: 0.0...3.4 x 10^{12} During writing For periodic counting:	61180
16...23	Active energy outflow (initial value) L1	LREAL	Wh		61181
24...31	Reactive energy inflow (initial value) L1	LREAL	varh		61182
32...39	Reactive energy outflow (initial value) L1	LREAL	varh		61183
40...47	Apparent energy (initial value) L1	LREAL	VAh		61184
48...55	Active energy inflow (initial value) L2	LREAL	Wh		61200
56...63	Active energy outflow (initial value) L2	LREAL	Wh		61201
64...61	Reactive energy inflow (initial value) L2	LREAL	varh		61202
72...79	Reactive energy outflow (initial value) L2	LREAL	varh		61203
80...87	Apparent energy (initial value) L2	LREAL	VAh		61204

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
88...95	Active energy inflow (initial value) L3	LREAL	Wh	0...configured full-scale value (10^3 ...10^{15})	61220
96...103	Active energy outflow (initial value) L3	LREAL	Wh		61221
104...111	Reactive energy inflow (initial value) L3	LREAL	varh		61222
112...119	Reactive energy outflow (initial value) L3	LREAL	varh		61223
120...127	Apparent energy (initial value) L3	LREAL	VAh		61224
128...129	Overflow counter active energy inflow L1	UINT	-	During reading: 0...65535 During writing for continuous counting: 0 During writing for periodic counting: 0...65500	61190
130..131	Overflow counter active energy outflow L1	UINT	-		61191
132...133	Overflow counter reactive energy inflow L1	UINT	-		61192
134...135	Overflow counter reactive energy outflow L1	UINT	-		61193
136...137	Overflow counter apparent energy L1	UINT	-		61194
138...139	Overflow counter active energy inflow L2	UINT	-		61210
140...141	Overflow counter active energy outflow L2	UINT	-		61211
142...143	Overflow counter reactive energy inflow L2	UINT	-		61212
144...145	Overflow counter reactive energy outflow L2	UINT	-		61213
146...147	Overflow counter apparent energy L2	UINT	-		61214
148...149	Overflow counter active energy inflow L3	UINT	-		61230
150...151	Overflow counter active energy outflow L3	UINT	-		61231
152...153	Overflow counter reactive energy inflow L3	UINT	-		61232
154...155	Overflow counter reactive energy outflow L3	UINT	-		61233
156...157	Overflow counter apparent energy L3	UINT	-		61234
158...161	Operating hours counter L1 (initial value)	REAL	h	During reading: 0...3.4x10^{38} During writing: 0...10^9	65505
162...165	Operating hours counter L2 (initial value)	REAL	h		65506
166...169	Operating hours counter L3 (initial value)	REAL	h		65507

Status information

When data record 143 is read with the RDREC instruction, Bytes 2 to 7 supply phase-specific status information for energy counters, overflow counters and operating hours counters.

The status information enables you can see which counters are returning their values in the data record 143. If energy counters return their values in the status byte 1, you can determine the type of energy counter with status byte 2.

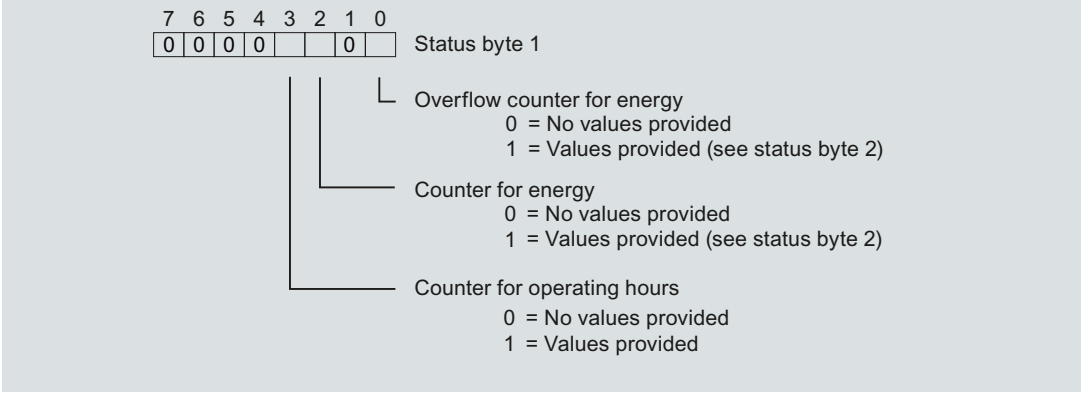

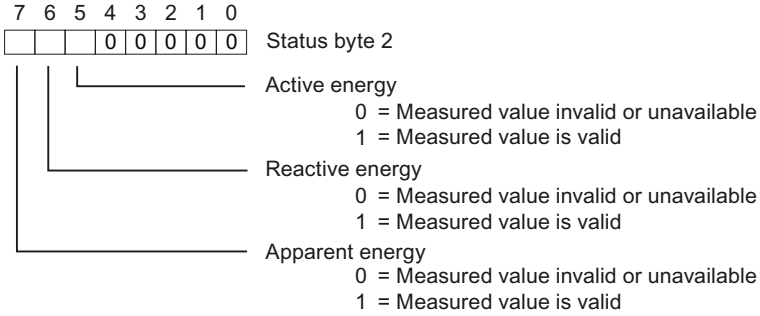

Figure 2-897 Status information DS 143 (read access)

Control information

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy counters, overflow counters and operating hours counter. The length of the control information amounts to 2 bytes for each phase:

- In control byte 1 you determine which counter you want to reset and the time at which counters are reset.
- In Control byte 2 you determine which energy counters and which overflow counters you want to reset.

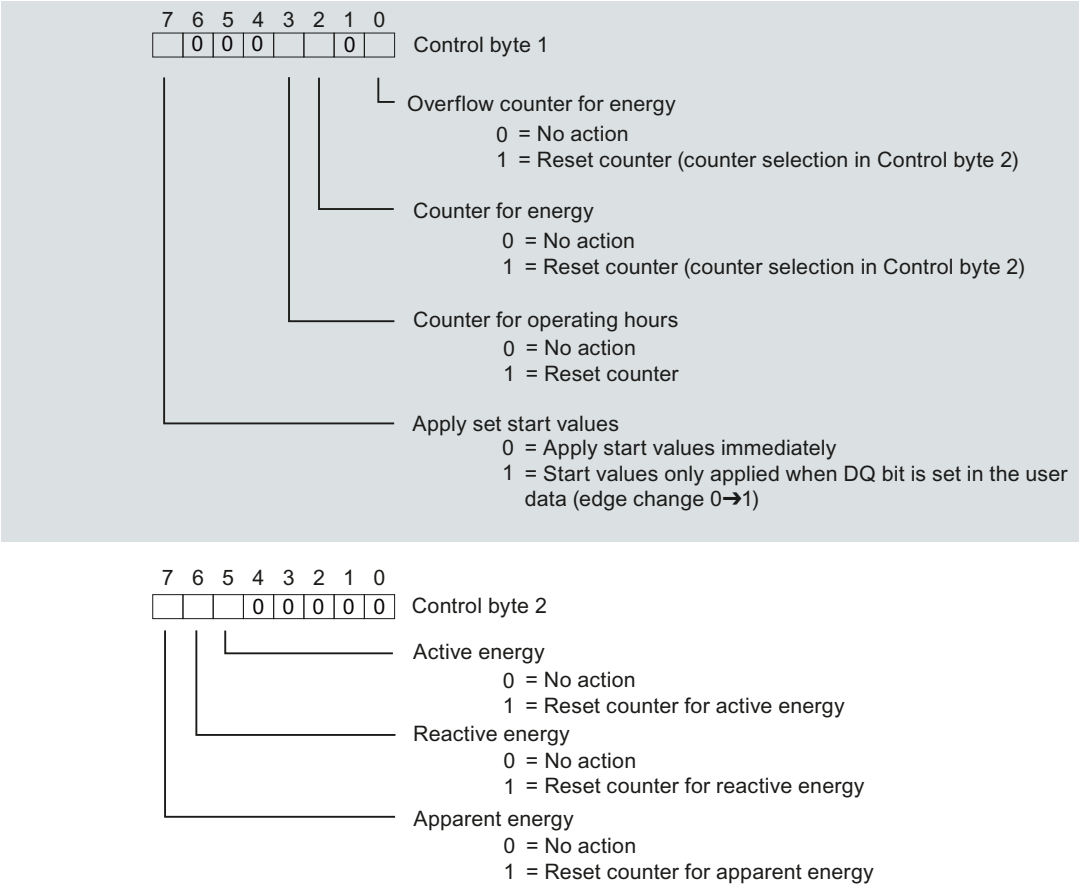

Figure 2-898 Control information DS 143 (write access)

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the measured value data record 143:

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	00	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	01	Reserved bits are not 0.	Check Byte 2...7 and set the reserved bits back to 0.
DF	80	E1	39	Incorrect version entered.	Check Byte 0. Enter a valid version.
DF	80	E1	3A	Incorrect data record length entered.	Check the parameters of the WRREC instruction. Enter a valid length.
DF	80	E1	3C	At least one start value is invalid.	Check Bytes 8...103 and Bytes 158...169. The start values may not be negative.
DF	80	E1	3D	At least one start value is too large	Check Bytes 8...103 and Bytes 158...169. Observe the ranges of values for start values.

E.4 Measured value data record for maximum values (DS 144)

Measured variables of the module

The largest values ever measured or calculated from the time the AI Energy Meter CT was started are stored in this data record.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 136)).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...5	Max. voltage L1-N	REAL	V	0	40
6...9	Max. voltage L2-N	REAL	V	0	41
10...13	Max. voltage L3-N	REAL	V	0	42
14...17	Max. voltage L1-L2	REAL	V	0	43
18...21	Max. voltage L2-L3	REAL	V	0	44
22...25	Max. voltage L3-L1	REAL	V	0	45
26...29	Max. current L1 [1]	REAL	A	0	46
30...33	Max. current L2 [1]	REAL	A	0	47
34...37	Max. current L3 [1]	REAL	A	0	48
38...41	Max. apparent power L1	REAL	VA	0	49
42...45	Max. apparent power L2	REAL	VA	0	50
46...49	Max. apparent power L3	REAL	VA	0	51
50...53	Max. active power L1	REAL	W	-3.0×10^9	52
54...57	Max. active power L2	REAL	W	-3.0×10^9	53

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
58...61	Max. active power L3	REAL	W	-3.0×10^9	54
62...65	Max. reactive power Qtot L1	REAL	var	-3.0×10^9	62160
66...69	Max. reactive power Qtot L2	REAL	var	-3.0×10^9	62260
70...73	Max. reactive power Qtot L3	REAL	var	-3.0×10^9	62360
74...77	Max. power factor λ L1	REAL	-	0	58
78...81	Max. power factor λ L2	REAL	-	0	59
82...85	Max. power factor λ L3	REAL	-	0	60
86...89	Max. frequency	REAL	Hz	40	61
90...93	Max. apparent power L1L2L3	REAL	VA	0	67
94...97	Max. active power L1L2L3	REAL	W	-3.0×10^9	65
98...101	Max. reactive power Qtot L1L2L3	REAL	var	-3.0×10^9	61138
102...105	Max. power factor λ L1L2L3	REAL	-	0	68
106...109	Max. reactive power Qn L1	REAL	var	-3.0×10^9	55
110...113	Max. reactive power Qn L2	REAL	var	-3.0×10^9	56
114...117	Max. reactive power Qn L3	REAL	var	-3.0×10^9	57
118...121	Reserved	DWORD	-	-	-
122...125	Reserved	DWORD	-	-	-
126...129	Reserved	DWORD	-	-	-
130...133	Reserved	DWORD	-	-	-
134...137	Reserved	DWORD	-	-	-
138...141	Reserved	DWORD	-	-	-
142...145	Reserved	DWORD	-	-	-
146...149	Reserved	DWORD	-	-	-
150...153	Reserved	DWORD	-	-	-
154...157	Reserved	DWORD	-	-	-
158...161	Reserved	DWORD	-	-	-
162...165	Reserved	DWORD	-	-	-
166...169	Reserved	DWORD	-	-	-
170...173	Reserved	DWORD	-	-	-
174...177	Reserved	DWORD	-	-	-
178...181	Reserved	DWORD	-	-	-
182...185	Reserved	DWORD	-	-	-
186...189	Reserved	DWORD	-	-	-
190...193	Reserved	DWORD	-	-	-
194...197	Reserved	DWORD	-	-	-
198...201	Reserved	DWORD	-	-	-
202...205	Reserved	DWORD	-	-	-

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
206...209	Reserved	DWORD	-	-	-
210...213	Reserved	DWORD	-	-	-
214...217	Reserved	DWORD	-	-	-
218...221	Reserved	DWORD	-	-	-
222...225	Reserved	DWORD	-	-	-
226...229	Max. neutral current	REAL	A	0	61136

[1] The values reference the amount of the current measured value

E.5 Measured value data record for minimum values (DS 145)

Measured variables of the module

The smallest values ever measured or calculated from the time the AI Energy Meter CT was started are stored in this data record.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 136)).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...5	Min. voltage L1-N	REAL	V	1000000	70
6...9	Min. voltage L2-N	REAL	V	1000000	71
10...13	Min. voltage L3-N	REAL	V	1000000	72
14...17	Min. voltage L1-L2	REAL	V	1800000	73
18...21	Min. voltage L2-L3	REAL	V	1800000	74
22...25	Min. voltage L3-L1	REAL	V	1800000	75
26...29	Min. current L1[1]	REAL	A	100000	76
30...33	Min. current L2 [1]	REAL	A	100000	77
34...37	Min. current L3[1]	REAL	A	100000	78
38...41	Min. apparent power L1	REAL	VA	$+3.0 \times 10^9$	79
42...45	Min. apparent power L2	REAL	VA	$+3.0 \times 10^9$	80
46...49	Min. apparent power L3	REAL	VA	$+3.0 \times 10^9$	81
50...53	Min. active power L1	REAL	W	$+3.0 \times 10^9$	82
54...57	Min. active power L2	REAL	W	$+3.0 \times 10^9$	83
58...61	Min. active power L3	REAL	W	$+3.0 \times 10^9$	84
62...65	Min. reactive power Qtot L1	REAL	var	$+3.0 \times 10^9$	62180
66...69	Min. reactive power Qtot L2	REAL	var	$+3.0 \times 10^9$	62280

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
70...73	Min. reactive power Qtot L3	REAL	var	$+3.0 \times 10^9$	62380
74...77	Min. power factor λ L1	REAL	-	1	88
78...81	Min. power factor λ L2	REAL	-	1	89
82...85	Min. power factor λ L3	REAL	-	1	90
86...89	Min. frequency	REAL	Hz	70	91
90...93	Min. apparent power L1L2L3	REAL	VA	$+3.0 \times 10^9$	97
94...97	Min. active power L1L2L3	REAL	W	$+3.0 \times 10^9$	95
98...101	Min. reactive power Qn L1L2L3	REAL	var	$+3.0 \times 10^9$	61139
102...105	Min. power factor λ L1L2L3	REAL	-	1	98
106...109	Min. reactive power Qn L1	REAL	var	$+3.0 \times 10^9$	85
110...113	Min. reactive power Qn L2	REAL	var	$+3.0 \times 10^9$	86
114...117	Min. reactive power Qn L3	REAL	var	$+3.0 \times 10^9$	87
118...121	Reserved	DWORD	-	-	-
122...125	Reserved	DWORD	-	-	-
126...129	Reserved	DWORD	-	-	-
130...133	Reserved	DWORD	-	-	-
134...137	Reserved	DWORD	-	-	-
138...141	Reserved	DWORD	-	-	-
142...145	Reserved	DWORD	-	-	-
146...149	Reserved	DWORD	-	-	-
150...153	Reserved	DWORD	-	-	-
154...157	Reserved	DWORD	-	-	-
158...161	Reserved	DWORD	-	-	-
162...165	Reserved	DWORD	-	-	-
166...169	Reserved	DWORD	-	-	-
170...173	Reserved	DWORD	-	-	-
174...177	Reserved	DWORD	-	-	-
178...181	Reserved	DWORD	-	-	-
182...185	Reserved	DWORD	-	-	-
186...189	Reserved	DWORD	-	-	-
190...193	Reserved	DWORD	-	-	-
194...197	Reserved	DWORD	-	-	-
198...201	Reserved	DWORD	-	-	-
202...205	Reserved	DWORD	-	-	-
206...209	Reserved	DWORD	-	-	-
210...213	Reserved	DWORD	-	-	-
214...217	Reserved	DWORD	-	-	-

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
218...221	Reserved	DWORD	-	-	-
222...225	Reserved	DWORD	-	-	-
226...229	Min. neutral current	REAL	A	100000.0	61137

[1] The values reference the amount of the current measured value

E.6 Measured value data record for phase-based measured values L1 (DS 147)

E.6.1 Measured value data record for phase-based measured values L1 (DS 147) version 0

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...3	Qualifier L1	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65500
4...7	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
8...11	Current L1	REAL	A	0.0 ... 100000.0	7
12...15	Apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	10
16...19	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
20...23	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22
24...27	Power factor λ L1	REAL	-	0.0 ... 1.0	19
28...31	Phase angle L1	REAL	°	0.0 ... 360.0	61178
32...39	Apparent energy L1	LREAL	VAh	0.0 ... 1.8×10^{308}	61184
40...47	Total active energy L1	LREAL	Wh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61185
48...55	Total reactive energy L1	LREAL	varh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61186
56...59	Max. voltage L1-N	REAL	V	0.0 ... 1000000.0	40
60...63	Max. current L1	REAL	A	0.0 ... 100000.0	46
64...67	Max. apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	49

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
68...71	Max. active power L1	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	52
72...75	Max. reactive power Qtot L1	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	62160
76...79	Max. power factor λ L1	REAL	-	0.0 ... 1.0	58
80...83	Min. voltage L1-N	REAL	V	0.0 ... 1000000.0	70
84...87	Min. current L1	REAL	A	0.0 ... 100000.0	76
88...91	Min. apparent power L1	REAL	VA	-3.0 x 10^9 ... +3.0 x 10^9	79
92...95	Min. active power L1	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	82
96...99	Min. reactive power Qtot L1	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	62180
100...103	Min. power factor λ L1	REAL	-	0.0 ... 1.0	88

E.6.2 Measured value data record for phase-based measured values L1 (DS 147) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	-	1	-
1	Reserved	UINT8	-	0	-
2...3	Qualifier L1	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65500
4...7	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
8...11	Current L1	REAL	A	0.0 ... 100000.0	7
12...15	Apparent power L1	REAL	VA	-3.0 x 10^9 ... +3.0 x 10^9	10
16...19	Active power L1	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	13
20...23	Reactive power Qtot L1	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	22
24...27	Power factor λ L1	REAL	-	0.0 ... 1.0	19
28...31	Phase angle L1	REAL	°	0.0 ... 360.0	61178
32...39	Apparent energy L1	LREAL	VAh	0.0 ... 1.8 x 10^{308}	61184
40...47	Total active energy L1	LREAL	Wh	-1.8 x 10^{308} ... +1.8 x 10^{308}	61185

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
48...55	Total reactive energy L1	LREAL	varh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61186
56...59	Max. voltage L1-N	REAL	V	0.0 ... 1000000.0	40
60...63	Max. current L1	REAL	A	0.0 ... 100000.0	46
64...67	Max. apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	49
68...71	Max. active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	52
72...75	Max. reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62160
76...79	Max. power factor λ L1	REAL	-	0.0 ... 1.0	58
80...83	Min. voltage L1-N	REAL	V	0.0 ... 1000000.0	70
84...87	Min. current L1	REAL	A	0.0 ... 100000.0	76
88...91	Min. apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	79
92...95	Min. active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	82
96...99	Min. reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62180
100...103	Min. power factor λ L1	REAL	-	0.0 ... 1.0	88
104...107	Reactive power Qn L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	16
108...111	Reserved	DWORD	-	-	-
112...115	Reserved	DWORD	-	-	-
116...119	Reserved	DWORD	-	-	-
120...123	Reserved	DWORD	-	-	-
124...127	Reserved	DWORD	-	-	-
128...131	Reserved	DWORD	-	-	-
132...135	Reserved	DWORD	-	-	-
136...139	Fundamental reactive power L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62124
140...143	Reserved	DWORD	-	-	-
144...147	Fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62127
148...151	Reserved	DWORD	-	-	-
152...155	Reserved	DWORD	-	-	-
156...159	Reserved	DWORD	-	-	-
160...163	Reserved	DWORD	-	-	-
164...167	Reserved	DWORD	-	-	-
168...171	Reserved	DWORD	-	-	-
172...175	Reserved	DWORD	-	-	-
176...179	Reserved	DWORD	-	-	-

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
180...183	Reserved	DWORD	-	-	-
184...187	Reserved	DWORD	-	-	-
188...191	Reserved	DWORD	-	-	-
192...195	Reserved	DWORD	-	-	-
196...199	Reserved	DWORD	-	-	-
200...203	Reserved	DWORD	-	-	-
204...207	Reserved	DWORD	-	-	-
208...211	Reserved	DWORD	-	-	-
212...215	Reserved	DWORD	-	-	-
216...219	Reserved	DWORD	-	-	-
220...223	Reserved	DWORD	-	-	-
224...227	Reserved	DWORD	-	-	-
228...231	Reserved	DWORD	-	-	-
232...235	Reserved	DWORD	-	-	-
236...239	Reserved	DWORD	-	-	-
240...243	Reserved	DWORD	-	-	-
244...247	Reserved	DWORD	-	-	-

E.7 Measured value data record for phase-based measured values L2 (DS 148)

E.7.1 Measured value data record for phase-based measured values L2 (DS 148) version 0

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...3	Qualifier L2	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65501
4...7	Voltage L1-N	REAL	V	0.0 ... 1000000.0	2
8...11	Current L2	REAL	A	0.0 ... 100000.0	8
12...15	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
16...19	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
20...23	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
24...27	Power factor λ L2	REAL	-	0.0 ... 1.0	20
28...31	Phase angle L2	REAL	°	0.0 ... 360.0	61198
32...39	Apparent energy L2	LREAL	VAh	0.0 ... 1.8×10^{308}	61204
40...47	Total active energy L2	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61205
48...55	Total reactive energy L2	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61206
56...59	Max. voltage L2-N	REAL	V	0.0 ... 1000000.0	41
60...63	Max. current L2	REAL	A	0.0 ... 100000.0	47
64...67	Max. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	50
68...71	Max. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	53
72...75	Max. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62260
76...79	Max. power factor λ L2	REAL	-	0.0 ... 1.0	59
80...83	Min. voltage L2-N	REAL	V	0.0 ... 1000000.0	71
84...87	Min. current L2	REAL	A	0.0 ... 100000.0	77
88...91	Min. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	80
92...95	Min. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	83
96...99	Min. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62280
100...103	Min. power factor λ L2	REAL	-	0.0 ... 1.0	89

E.7.2 Measured value data record for phase-based measured values L2 (DS 148) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	-	1	-
1	Reserved	UINT8	-	0	-

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
2...3	Qualifier L2	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65501
4...7	Voltage L2-N	REAL	V	0.0 ... 1000000.0	2
8...11	Current L2	REAL	A	0.0 ... 100000.0	8
12...15	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
16...19	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
20...23	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
24...27	Power factor λ L2	REAL	-	0.0 ... 1.0	20
28...31	Phase angle L2	REAL	°	0.0 ... 360.0	61198
32...39	Apparent energy L2	LREAL	VAh	0.0 ... 1.8×10^{308}	61204
40...47	Total active energy L2	LREAL	Wh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61205
48...55	Total reactive energy L2	LREAL	varh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61206
56...59	Max. voltage L2-N	REAL	V	0.0 ... 1000000.0	41
60...63	Max. current L2	REAL	A	0.0 ... 100000.0	47
64...67	Max. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	50
68...71	Max. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	53
72...75	Max. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62260
76...79	Max. power factor λ L2	REAL	-	0.0 ... 1.0	59
80...83	Min. voltage L2-N	REAL	V	0.0 ... 1000000.0	71
84...87	Min. current L2	REAL	A	0.0 ... 100000.0	77
88...91	Min. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	80
92...95	Min. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	83
96...99	Min. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62280
100...103	Min. power factor λ L2	REAL	-	0.0 ... 1.0	89
104...107	Reactive power Qn L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	17
108...111	Reserved	DWORD	-	-	-
112...115	Reserved	DWORD	-	-	-
116...119	Reserved	DWORD	-	-	-
120...123	Reserved	DWORD	-	-	-
124...127	Reserved	DWORD	-	-	-

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
128...131	Reserved	DWORD	-	-	-
132...135	Reserved	DWORD	-	-	-
136...139	Fundamental reactive power L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62224
140...143	Reserved	DWORD	-	-	-
144...147	Fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62227
148...151	Reserved	DWORD	-	-	-
152...155	Reserved	DWORD	-	-	-
156...159	Reserved	DWORD	-	-	-
160...163	Reserved	DWORD	-	-	-
164...167	Reserved	DWORD	-	-	-
168...171	Reserved	DWORD	-	-	-
172...175	Reserved	DWORD	-	-	-
176...179	Reserved	DWORD	-	-	-
180...183	Reserved	DWORD	-	-	-
184...187	Reserved	DWORD	-	-	-
188...191	Reserved	DWORD	-	-	-
192...195	Reserved	DWORD	-	-	-
196...199	Reserved	DWORD	-	-	-
200...203	Reserved	DWORD	-	-	-
204...207	Reserved	DWORD	-	-	-
208...211	Reserved	DWORD	-	-	-
212...215	Reserved	DWORD	-	-	-
216...219	Reserved	DWORD	-	-	-
220...223	Reserved	DWORD	-	-	-
224...227	Reserved	DWORD	-	-	-
228...231	Reserved	DWORD	-	-	-
232...235	Reserved	DWORD	-	-	-
236...239	Reserved	DWORD	-	-	-
240...243	Reserved	DWORD	-	-	-
244...247	Reserved	DWORD	-	-	-

E.8 Measured value data record for phase-based measured values L3 (DS 149)

E.8.1 Measured value data record for phase-based measured values L3 (DS 149) version 0

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...3	Qualifier L3	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65502
4...7	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
8...11	Current L3	REAL	A	0.0 ... 100000.0	9
12...15	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
16...19	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
20...23	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
24...27	Power factor λ L3	REAL	-	0.0 ... 1.0	21
28...31	Phase angle L3	REAL	°	0.0 ... 360.0	61218
32...39	Apparent energy L3	LREAL	VAh	0.0 ... 1.8×10^{308}	61224
40...47	Total active energy L3	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61225
48...55	Total reactive energy L3	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61226
56...59	Max. voltage L3-N	REAL	V	0.0 ... 1000000.0	42
60...63	Max. current L3	REAL	A	0.0 ... 100000.0	48
64...67	Max. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	51
68...71	Max. active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	54
72...75	Max. reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62360
76...79	Max. power factor λ L3	REAL	-	0.0 ... 1.0	60
80...83	Min. voltage L3-N	REAL	V	0.0 ... 1000000.0	72
84...87	Min. current L3	REAL	A	0.0 ... 100000.0	78
88...91	Min. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	81

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
92...95	Min. active power L3	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	84
96...99	Min. reactive power Qtot L3	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	62380
100...103	Min. power factor λ L3	REAL	-	0.0 ... 1.0	90

E.8.2 Measured value data record for phase-based measured values L3 (DS 149) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	-	1	-
1	Reserved	UINT8	-	0	-
2...3	Qualifier L3	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65502
4...7	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
8...11	Current L3	REAL	A	0.0 ... 100000.0	9
12...15	Apparent power L3	REAL	VA	-3.0 x 10^9 ... +3.0 x 10^9	12
16...19	Active power L3	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	15
20...23	Reactive power Qtot L3	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	24
24...27	Power factor λ L3	REAL	-	0.0 ... 1.0	21
28...31	Phase angle L3	REAL	°	0.0 ... 360.0	61218
32...39	Apparent energy L3	LREAL	VAh	0.0 ... 1.8 x 10^{308}	61224
40...47	Total active energy L3	LREAL	Wh	-1.8 x 10^{308} ... +1.8 x 10^{308}	61225
48...55	Total reactive energy L3	LREAL	varh	-1.8 x 10^{308} ... +1.8 x 10^{308}	61226
56...59	Max. voltage L3-N	REAL	V	0.0 ... 1000000.0	42
60...63	Max. current L3	REAL	A	0.0 ... 100000.0	48
64...67	Max. apparent power L3	REAL	VA	-3.0 x 10^9 ... +3.0 x 10^9	51
68...71	Max. active power L3	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	54
72...75	Max. reactive power Qtot L3	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	62360

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
76...79	Max. power factor λ L3	REAL	-	0.0 ... 1.0	60
80...83	Min. voltage L3-N	REAL	V	0.0 ... 1000000.0	72
84...87	Min. current L3	REAL	A	0.0 ... 100000.0	78
88...91	Min. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	81
92...95	Min. active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	84
96...99	Min. reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62380
100...103	Min. power factor λ L3	REAL	-	0.0 ... 1.0	90
104...107	Reactive power Qn L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	18
108...111	Reserved	DWORD	-	-	-
112...115	Reserved	DWORD	-	-	-
116...119	Reserved	DWORD	-	-	-
120...123	Reserved	DWORD	-	-	-
124...127	Reserved	DWORD	-	-	-
128...131	Reserved	DWORD	-	-	-
132...135	Reserved	DWORD	-	-	-
136...139	Fundamental reactive power L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62324
140...143	Reserved	DWORD	-	-	-
144...147	Fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62327
148...151	Reserved	DWORD	-	-	-
152...155	Reserved	DWORD	-	-	-
156...159	Reserved	DWORD	-	-	-
160...163	Reserved	DWORD	-	-	-
164...167	Reserved	DWORD	-	-	-
168...171	Reserved	DWORD	-	-	-
172...175	Reserved	DWORD	-	-	-
176...179	Reserved	DWORD	-	-	-
180...183	Reserved	DWORD	-	-	-
184...187	Reserved	DWORD	-	-	-
188...191	Reserved	DWORD	-	-	-
192...195	Reserved	DWORD	-	-	-
196...199	Reserved	DWORD	-	-	-
200...203	Reserved	DWORD	-	-	-
204...207	Reserved	DWORD	-	-	-
208...211	Reserved	DWORD	-	-	-
212...215	Reserved	DWORD	-	-	-

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
216...219	Reserved	DWORD	-	-	-
220...223	Reserved	DWORD	-	-	-
224...227	Reserved	DWORD	-	-	-
228...231	Reserved	DWORD	-	-	-
232...235	Reserved	DWORD	-	-	-
236...239	Reserved	DWORD	-	-	-
240...243	Reserved	DWORD	-	-	-
244...247	Reserved	DWORD	-	-	-

E.9 Measured value data record for advanced measurement and status values (DS 150) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2...5	Operating hours counter L1L2L3	REAL	h	0.0 ... 3.4 x 10^{38}	65504
6...9	Operating hours counter L1	REAL	h	0.0 ... 3.4 x 10^{38}	65505
10...13	Operating hours counter L2	REAL	h	0.0 ... 3.4 x 10^{38}	65506
14...17	Operating hours counter L3	REAL	h	0.0 ... 3.4 x 10^{38}	65507
18...19	Status limit violation GW 1...16	WORD	Bit string	xxxx xxxx xxxx xxxx	65509

[1] Energy meters count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1
Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
20...21	Status of energy counter overflows [1]	WORD	Bit string	xxxx xxxx xxxx xxxx	65508
22...25	Counter limit violation GW 1	UDINT	-	0 ... 4294967296	65510
26...29	Counter limit violation GW 2	UDINT	-	0 ... 4294967296	65511
30...33	Counter limit violation GW 3	UDINT	-	0 ... 4294967296	65512
34...37	Counter limit violation GW 4	UDINT	-	0 ... 4294967296	65513
38...41	Counter limit violation GW 5	UDINT	-	0 ... 4294967296	65514
42...45	Counter limit violation GW 6	UDINT	-	0 ... 4294967296	65515
46...49	Counter limit violation GW 7	UDINT	-	0 ... 4294967296	65516
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70...73	Counter limit violation GW 13	UDINT	-	0 ... 4294967296	65522
74...77	Counter limit violation GW 14	UDINT	-	0 ... 4294967296	65523
78...81	Counter limit violation GW 15	UDINT	-	0 ... 4294967296	65524
82...85	Counter limit violation GW 16	UDINT	-	0 ... 4294967296	65525
86...87	Qualifier L1L2L3	WORD	Bit string	xxxx xxxx xxxx xxxx	65503
88...91	Reserved	UDINT	-	-	-
92...103	Current module time	PNIOTime	sec	-	65497

[1] Energy meters count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1
Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

E.10 Measured value data record of user-defined data record (DS 151)

The length and structure of the data record DS 151 depends on the parameter assignment of the data record DS 135 (Page 133).

Byte	Measured variable	Data type	Unit	Value range
0	Version	UINT8	-	0
1	Number of measured values	UINT8	-	0 ... 150
2	Measured value 1 corresponding to measured value ID 1 in DS135	Depending on the corresponding measured value ID		
3	Measured value 2 corresponding to measured value ID 2 in DS135	Depending on the corresponding measured value ID		
...	...	Depending on the corresponding measured value ID		
... m	Measured value n corresponding to measured value ID n in DS135	Depending on the corresponding measured value ID		

E.11 Measured value data record for maximum values with time stamp (DS 154)

Measured variables of the module

The largest values ever measured or calculated from the time the AI Energy Meter HF was started are stored in this data record.

The measured values (REAL 4 bytes) are each followed by a time stamp (PNIO Time 12 bytes).

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

More detailed information about the structure of time stamps is available in section Time synchronization and time stamp (Page 51).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...17	Max. voltage L1-N	REAL + PNIO Time	V	0	40
18...33	Max. voltage L2-N	REAL + PNIO Time	V	0	41
34...49	Max. voltage L3-N	REAL + PNIO Time	V	0	42
50...65	Max. voltage L1-L2	REAL + PNIO Time	V	0	43
66...81	Max. voltage L2-L3	REAL + PNIO Time	V	0	44

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
82...97	Max. voltage L3-L1	REAL + PNIO Time	V	0	45
98...113	Max. current L1 [1]	REAL + PNIO Time	A	0	46
114...129	Max. current L2 [1]	REAL + PNIO Time	A	0	47
130...145	Max. current L3 [1]	REAL + PNIO Time	A	0	48
146...161	Max. apparent power L1	REAL + PNIO Time	VA	0	49
162...177	Max. apparent power L2	REAL + PNIO Time	VA	0	50
178...193	Max. apparent power L3	REAL + PNIO Time	VA	0	51
194...209	Max. active power L1	REAL + PNIO Time	W	-3.0×10^9	52
210...225	Max. active power L2	REAL + PNIO Time	W	-3.0×10^9	53
226...241	Max. active power L3	REAL + PNIO Time	W	-3.0×10^9	54
242...257	Max. reactive power Qtot L1	REAL + PNIO Time	var	-3.0×10^9	62160
258...273	Max. reactive power Qtot L2	REAL + PNIO Time	var	-3.0×10^9	62260
274...289	Max. reactive power Qtot L3	REAL + PNIO Time	var	-3.0×10^9	62360
290...305	Max. power factor λ L1	REAL + PNIO Time	-	0	58
306...321	Max. power factor λ L2	REAL + PNIO Time	-	0	59
322...337	Max. power factor λ L3	REAL + PNIO Time	-	0	60
338...353	Max. frequency	REAL + PNIO Time	Hz	40	61
354...369	Max. apparent power L1L2L3	REAL + PNIO Time	VA	0	67
370...385	Max. active power L1L2L3	REAL + PNIO Time	W	-3.0×10^9	65
386...401	Max. reactive power Qtot L1L2L3	REAL + PNIO Time	var	-3.0×10^9	61138
402...417	Max. power factor λ L1L2L3	REAL + PNIO Time	-	0	68
418...433	Max. reactive power Qn L1	REAL + PNIO Time	var	-3.0×10^9	55

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
434...449	Max. reactive power Qn L2	REAL + PNIO Time	var	-3.0×10^9	56
450...465	Max. reactive power Qn L3	REAL + PNIO Time	var	-3.0×10^9	57
466...481	Reserved	Byte array[16]	-	-	-
482...497	Reserved	Byte array[16]	-	-	-
498...513	Reserved	Byte array[16]	-	-	-
514...529	Reserved	Byte array[16]	-	-	-
530...545	Reserved	Byte array[16]	-	-	-
546...561	Reserved	Byte array[16]	-	-	-
562...577	Reserved	Byte array[16]	-	-	-
578...593	Reserved	Byte array[16]	-	-	-
594...609	Reserved	Byte array[16]	-	-	-
610...625	Reserved	Byte array[16]	-	-	-
626...641	Reserved	Byte array[16]	-	-	-
642...657	Reserved	Byte array[16]	-	-	-
658...673	Reserved	Byte array[16]	-	-	-
674...689	Reserved	Byte array[16]	-	-	-
690...705	Reserved	Byte array[16]	-	-	-
706...721	Reserved	Byte array[16]	-	-	-
722...737	Reserved	Byte array[16]	-	-	-
738...753	Reserved	Byte array[16]	-	-	-
754...769	Reserved	Byte array[16]	-	-	-
770...785	Reserved	Byte array[16]	-	-	-
786...801	Reserved	Byte array[16]	-	-	-
802...817	Reserved	Byte array[16]	-	-	-
818...833	Reserved	Byte array[16]	-	-	-
834...849	Reserved	Byte array[16]	-	-	-
850...865	Reserved	Byte array[16]	-	-	-
866...881	Reserved	Byte array[16]	-	-	-
882...897	Reserved	Byte array[16]	-	-	-
898...913	Max. neutral current	REAL + PNIO Time	A	0	61136

[1] The values reference the amount of the current measured value

E.12 Measured value data record for minimum values with time stamp (DS 155)

Measured variables of the module

The smallest values ever measured or calculated from the time the AI Energy Meter HF was started are stored in this data record.

The measured values (REAL 4 bytes) are each followed by a time stamp (PNIO Time 12 bytes).

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

More detailed information about the structure of time stamps is available in section Time synchronization and time stamp (Page 51).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...17	Min. voltage L1-N	REAL + PNIO Time	V	1000000	70
18...33	Min. voltage L2-N	REAL + PNIO Time	V	1000000	71
34...49	Min. voltage L3-N	REAL + PNIO Time	V	1000000	72
50...65	Min. voltage L1-L2	REAL + PNIO Time	V	1800000	73
66...81	Min. voltage L2-L3	REAL + PNIO Time	V	1800000	74
82...97	Min. voltage L3-L1	REAL + PNIO Time	V	1800000	75
98...113	Min. current L1[1]	REAL + PNIO Time	A	100000	76
114...129	Min. current L2 [1]	REAL + PNIO Time	A	100000	77
130...145	Min. current L3[1]	REAL + PNIO Time	A	100000	78
146...161	Min. apparent power L1	REAL + PNIO Time	VA	$+3.0 \times 10^9$	79
162...177	Min. apparent power L2	REAL + PNIO Time	VA	$+3.0 \times 10^9$	80
178...193	Min. apparent power L3	REAL + PNIO Time	VA	$+3.0 \times 10^9$	81
194...209	Min. active power L1	REAL + PNIO Time	W	$+3.0 \times 10^9$	82
210...225	Min. active power L2	REAL + PNIO Time	W	$+3.0 \times 10^9$	83

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
226...241	Min. active power L3	REAL + PNIO Time	W	$+3.0 \times 10^9$	84
242...257	Min. reactive power Qtot L1	REAL + PNIO Time	var	$+3.0 \times 10^9$	62180
258...273	Min. reactive power Qtot L2	REAL + PNIO Time	var	$+3.0 \times 10^9$	62280
274...289	Min. reactive power Qtot L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	62380
290...305	Min. power factor λ L1	REAL + PNIO Time	-	1	88
306...321	Min. power factor λ L2	REAL + PNIO Time	-	1	89
322...337	Min. power factor λ L3	REAL + PNIO Time	-	1	90
338...353	Min. frequency	REAL + PNIO Time	Hz	70	91
354...369	Min. apparent power L1L2L3	REAL + PNIO Time	VA	$+3.0 \times 10^9$	97
370...385	Min. active power L1L2L3	REAL + PNIO Time	W	$+3.0 \times 10^9$	95
386...401	Min. reactive power Qn L1L2L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	61139
402...417	Min. power factor λ L1L2L3	REAL + PNIO Time	-	1	98
418...433	Min. reactive power Qn L1	REAL + PNIO Time	var	$+3.0 \times 10^9$	85
434...449	Min. reactive power Qn L2	REAL + PNIO Time	var	$+3.0 \times 10^9$	86
450...465	Min. reactive power Qn L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	87
466...481	Reserved	Byte array[16]	-	-	-
482...497	Reserved	Byte array[16]	-	-	-
498...513	Reserved	Byte array[16]	-	-	-
514...529	Reserved	Byte array[16]	-	-	-
530...545	Reserved	Byte array[16]	-	-	-
546...561	Reserved	Byte array[16]	-	-	-
562...577	Reserved	Byte array[16]	-	-	-
578...593	Reserved	Byte array[16]	-	-	-
594...609	Reserved	Byte array[16]	-	-	-
610...625	Reserved	Byte array[16]	-	-	-
626...641	Reserved	Byte array[16]	-	-	-
642...657	Reserved	Byte array[16]	-	-	-

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
658...673	Reserved	Byte array[16]	-	-	-
674...689	Reserved	Byte array[16]	-	-	-
690...705	Reserved	Byte array[16]	-	-	-
706...721	Reserved	Byte array[16]	-	-	-
722...737	Reserved	Byte array[16]	-	-	-
738...753	Reserved	Byte array[16]	-	-	-
754...769	Reserved	Byte array[16]	-	-	-
770...785	Reserved	Byte array[16]	-	-	-
786...801	Reserved	Byte array[16]	-	-	-
802...817	Reserved	Byte array[16]	-	-	-
818...833	Reserved	Byte array[16]	-	-	-
834...849	Reserved	Byte array[16]	-	-	-
850...865	Reserved	Byte array[16]	--	-	-
866...881	Reserved	Byte array[16]	-	-	-
882...897	Reserved	Byte array[16]	-	-	-
898...913	Min. neutral current	REAL + PNIO Time	A	100000.0	61137

[1] The values reference the amount of the current measured value

Tips and tricks

F

F.1 Tips and tricks

Processing and visualizing energy data

On the basis of an application example we show you how the measured values of the AI Energy Meter CT ST can be processed further and visualized.

You can find this application example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86299299).

Overview of the measurement data with update time

We provide you with an overview of the assignment of the measured values to the payload variants and data records in an Excel file.

You will find the Excel file on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755917).

Time-of-day synchronization and time stamp

In an application example, we show you how to synchronize the time with the AI Energy Meter CT ST and work with measured values with time stamps.

You can find this application example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109754890).

Rotating field

To recognize wiring errors and evaluate the generated rotating field, you use the combined measurement functions from the section Notes for the recognition of wiring errors and incorrect rotating field (Page 48).

Measured values in STEP 7 as of V5.5

Measured values are represented as negative values in STEP 7 as of V5.5 if the value range of the integer format (32767 dec) is exceeded. This is not an error in the measured value. Solution: Select hexadecimal representation.

Conversion of 64-bit floating-point numbers

If you cannot process 64-bit floating-point numbers in your automation system, we recommend conversion to 32-bit floating-point numbers. Note the conversion can cause loss of accuracy. For a description of the conversion of the 64-bit floating-point numbers (data type LREAL) into 32-bit floating-point numbers (data type REAL) please refer to the Internet (https://support.industry.siemens.com/cs/ww/en/view/56600676).

SIEMENS

SIMATIC

ET 200SP
Analog input module AI Energy Meter RC ST
(6ES7134-6PA21-0BU0)

Equipment Manual

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ET 200SP
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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Current measuring transformer: When the term "current measuring transformer" is used in this manual, it applies both to current/voltage transformers and Rogowski coils.

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

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ET 200SP Documentation Guide

1

1.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/84133942)

1.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in SIOS:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in SIOS and how to use SIOS on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

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You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.3 Tool support

1.3.1 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , it assembles the configuration editors for automation technology already familiar into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- The "Network analysis" offers a quick overview of the PROFINET topology. It is possible to make simple parameter changes (for example, to the names and IP addresses of the devices). In addition, a quick and convenient comparison of the real configuration with a reference system is also possible.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet:
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

Product overview

2

2.1 Properties of the AI Energy Meters RC ST

Article number

6ES7134-6PA21-0BU0

View of the module

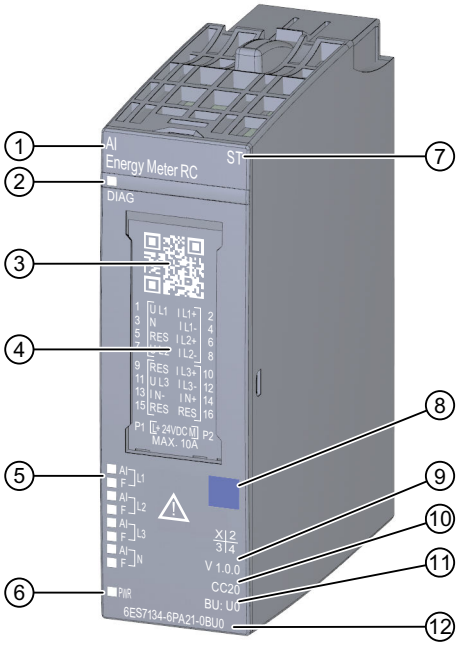

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-899 View of the module AI Energy Meter RC ST

Properties

The module has the following technical properties:

- Measurement of electrical variables from single-phase, two-phase and three-phase supply networks
- Current measurement using Rogowski coil or current-voltage converter (333 mV)
- Max. voltage between two line conductors 519 V AC (with direct connection)
- Retentive storage of the counter values
- Use on frequency converters
- Recording of:
  - Voltages
  - Currents
  - Phase angles
  - Power
  - Energy / electrical work
  - Frequencies
  - Minimum and maximum values with time stamp
  - Power factors
  - Operating hours
  - Limits

The module supports the following functions:

Table 2-988 Version dependencies of the functions

Function	HW version	FW version	STEP 7	GSD file	
			TIA Portal	PROFINET IO	PROFIBUS DP
Firmware update	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	---
Calibration in runtime	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	---	---
Identification data I&M0 to I&M3	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	X
Reconfiguration in RUN	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	X
Diagnostic interrupts	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	X
Hardware interrupts	FS01	V8.0.0 or higher	V16 or higher with HSP0335 V17 or higher	X	---

NOTE

The AI Energy Meter RC ST is released as of TIA Portal V16.0.0.4.

Accessories

The following accessories must be ordered separately:

- BaseUnit type U0
- Labeling strips
- Reference identification label

You can find additional information on the accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

2.2 Area of application

Introduction

Energy efficiency is playing an increasingly important role in industry. Rising energy prices, increasing pressure to improve profitability and the growing awareness of climate protection are important factors for reducing energy costs and for introducing an energy data management system.

Where can you use the AI Energy Meter RC ST?

The AI Energy Meter RC ST is designed for machine-level deployment in an ET 200SP distributed I/O system. The AI Energy Meter RC ST records over 300 different electrical measurement and energy values. It lets you create transparency about the energy requirements of individual components of a production plant even down to the machine level.

You can use the following measurement values supplied by the AI Energy Meter RC ST for the following applications:

- Energy consumption
- Power consumption
- Forecasts of consumption
- Efficiency

Power consumption measurements are relevant for load management and maintenance. In addition, you can use the measurements for emission reporting and for determining the CO_2 footprint.

NOTE

Measuring dangerous electrical quantities

The AI Energy Meter RC ST is not tested according to DIN EN 61010-2-030 and may therefore not be used to verify, measure or monitor protective measures according to DIN EN 61557.

Qualified personnel must ensure through additional measures that no danger ensues for humans and the environment in case of an incorrect display.

TB, TT and IT system

The AI Energy Meters RC ST can be used in TN, TT and IT systems.

Measuring with the AI Energy Meter RC ST

A typical supply network of a production plant is usually divided into three voltage ranges:

- The infeed of the entire plant
- The subdistribution, for example, to individual lines within the plant
- The end consumers such as the machines in the lines.

The following figure shows the measurement in an electricity supply network:

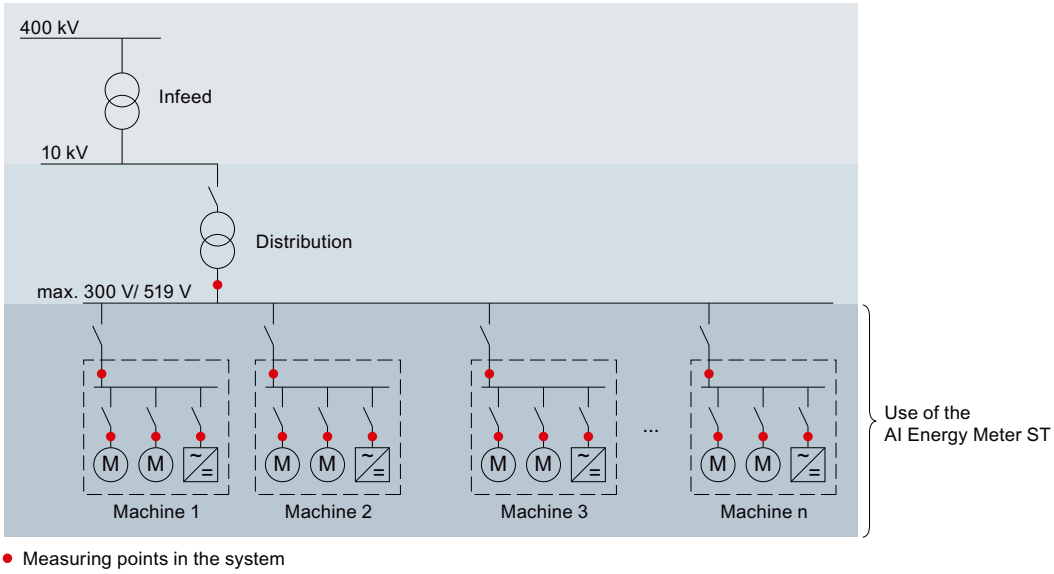

Figure 2-900 Use of the AI Energy Meter RC ST

Advantages of the AI Energy Meters RC ST

The AI Energy Meter RC ST offers the following benefits:

- Space-saving especially for use in control cabinet
- PROFINET IO or PROFIBUS DP (https://www.profibus.com/) (depending on the interface module in use)
- Multiple modules can be used with one interface module
- Extension of existing stations by components for energy recording

2.3 Special considerations for use on the PROFIBUS DP and PROFINET IO

You can read data records from the module or write them to the module with both PROFIBUS DP and PROFINET IO.

Operation of the module on PROFIBUS DP

Please note that with PROFIBUS DP you can write data records up to a maximum length of 240 bytes to the module or read them from the module.

PROFIBUS DPV 1

If the DP Master supports the DPV1, you can reconfigure in your user program with the parameter data records DS 128, DS 129, DS 130 or DS 135. Note that the maximum data record length is 240 bytes for DS 135.

The following applies for the measured value data records:

- DS 142: When you read the data record, the module returns the measured value data record DS 142 in version 2.
- DS 147, DS 148, DS 149: When you read the data record, the module returns the measured value data record in version 0.
- DS 154, DS 155: When you read the data record, the module returns the first 240 bytes of the structure of the measured value data record.
- DS 151: You define the user-defined measured value data record DS 151 in the parameter data record DS 135. If the structure in the measured value data record DS 151 is greater than 240 bytes, the module returns the first 240 bytes of the structure.

  Information on the data record length of data records DS 135 and DS151 can be found in the appendix Structure of the parameter data record for data record mapping (DS 135) (Page 132).

PROFIBUS DPV 0

If the DP Master does **not** support DPV1, you cannot reassign parameters which results in the following restrictions:

- There are no phase-specific parameters. All parameters apply for all three phases and the neutral conductor.
- The connection types and payload variants are limited.
- The voltage transformers are not configurable (default: 1:1).
- The current transformer value range primary current is restricted.
- The low limit for measuring current cannot be adjusted (default: 50 mA).
- Energy metering is performed continuously (the gate is not enabled).
- Min/Max calculation of values is enabled (the gate is not enabled).
- 3P4W can be set in the parameters for the connection type 3P3W.
- 3P4W can be set in the parameters for the connection type 3P3W1.
- Counting of operating hours is enabled (the gate is not enabled).
- Limit value monitoring cannot be used.
- Energy meter default cannot be used.

- The user-defined payload interface cannot be used.
- The user-defined data record cannot be used.
- The separate settings for measuring the neutral current cannot be used.
- The measured value data records cannot be used.

Operation of the module on PROFINET IO

When reading data records partially from the module, please note the following:

- Measured value data record DS 142:
  - When you read the data record with a length of 240 bytes or less, the module returns the measured value data record DS 142 in version 2.
  - When you read the data record with a length of more than 240 bytes, the module returns the measured value data record DS 142 in version 3.
- Measured value data records DS 147, DS 148, DS 149:
  - When you read the data record with a length of 240 bytes or less, the module returns the measured value data record in version 0.
  - When you read the data record with a length of more than 240 bytes, the module returns the measured value data record in version 1.

Wiring

3

3.1 Terminal and block diagram

General safety instructions

⚠ WARNING

Danger to life due to electric shock

Touching live parts can lead to death or severe injuries.

Before beginning any work, deenergize the system and the AI Energy Meter RC ST.

⚠ WARNING

Danger to life, dangerous system conditions and material damage possible

Removing and inserting the AI Energy Meter RC ST under live voltage is prohibited.

When you remove and insert the AI Energy Meter RC ST under live voltage during operation, the transformers used can produce dangerous induction voltages and electric arcs and dangerous system conditions can arise.

The AI Energy Meter RC ST may only be removed and inserted during operation if the measuring voltages supplied to the BaseUnit at terminals U_{L1} , U_{L2}, U_{L3} are disconnected at all poles.

Supplying the module

The AI Energy Meter RC ST receives its supply voltage via the terminals 17 (24 V DC) and 18 (M).

NOTE

Safe extra low voltage SELV/PELV

Ensure that all devices are connected to the SELV/PELV power supply (or equivalent).

Note the following to ensure the electrical safety of the Energy Meter and the ET 200SP station:

The voltage difference between the inputs for measuring the line voltage at the Energy Meter and the SELV/PELV supply voltages of the Energy Meter and the ET 200SP station must not exceed 300 V AC. This is guaranteed, for example, if the SELV/PELV supply is fed from the same grounded network as the voltage to be measured directly. If voltage transformers are used, they must be grounded on the secondary side.

Protecting the connection cables

To protect the connection cables at U_{L1}, U_{L2} and U_{L3}, make sure there is adequate cable protection, especially after cross-section transitions.

If the cables are routed with short-circuit protection according to IEC 61439-1:2009, for example, in a pipe or in separate cable ducts, there is no need for separate cable protection for the AI Energy Meter RC ST.

Terminal and block diagram

The figure below shows the pin assignments for connecting voltage transformers, current-voltage transformers and Rogowski coils.

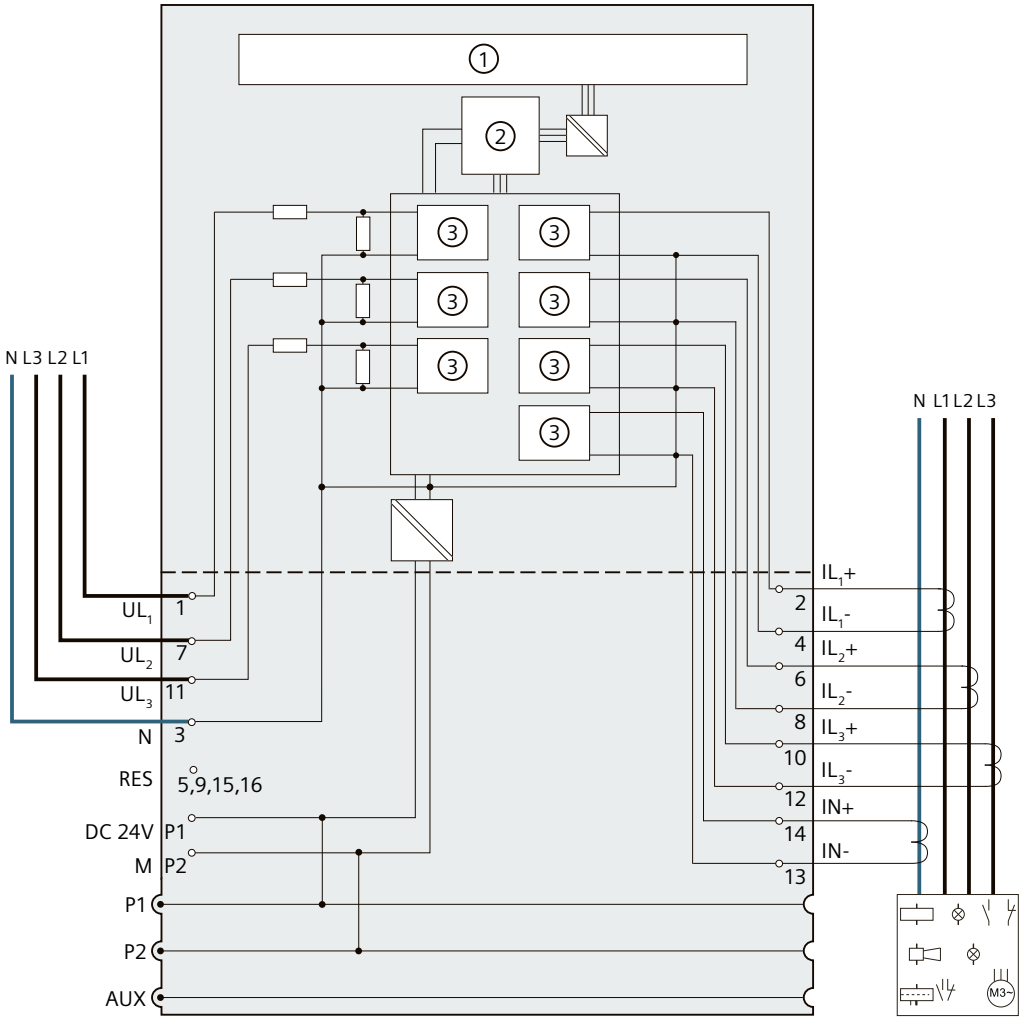

①	Microcontroller	UL_n	Connection voltage
②	Backplane bus interface	IL_n+ / IL_n-	Connection of current/voltage transformers and Rogowski coils
③	Analog-to-digital converter (ADC)	N, IN+ / IN-	Neutral
P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)	RES	Reserve, must remain unused for future function extensions

Figure 2-901 Block diagram of the AI Energy Meter RC ST

Useable BaseUnits

You can use the following BaseUnits:

- Type BU type U0 dark-colored
- Type BU type U0 light-colored

A potential group opened with a light-colored BU type U0 must contain no dark-colored BaseUnit of BU type A0 or A1.

Connection types

The AI Energy Meter RC ST supports the following connection types:

- 3P4W1, 3 phases, 4 conductors, balanced load
- 3P4W, 3 phases, 4 conductors
- 2P3W, 2 phases, 3 conductors
- 1P2W, 1 phase, 2 conductors
- 3 x 1P2W, 3 x 1 phase, 2 conductors
- 3P3W, 3 phases, 3 conductors
- 3P3W1, 3 phases, 3 conductors, balanced load

The input circuit of the module must correspond to one of the listed connection types. Select the appropriate connection type for the intended use.

You will find examples of connections in the section Connection examples (Page 23).

Selection of a current/voltage transformer can be found in the section Selection of a current measuring transformer (Page 26).

3.2 Connection examples

The following figures show the connection of the AI Energy Meter RC ST for three-phase, two-phase and single-phase measurements. Note that the AI Energy Meter RC ST must always be connected via a current measuring transformer. The use of voltage transformers is optional.

Connection type	Wiring diagram	Comment
3P4W Three-phase measurement, 4 wires	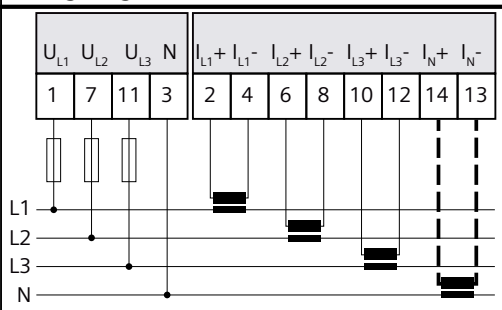	Any load Connection with three current transformers
3P4W Three-phase measurement, 4 wires	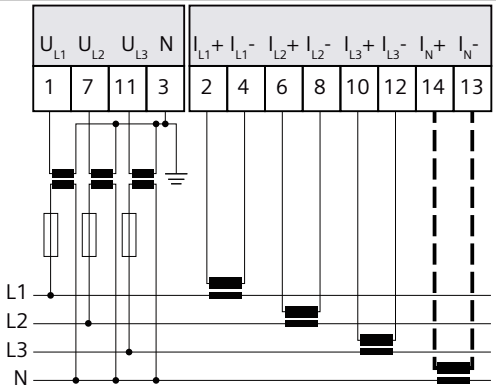	Any load Connection with three current measuring transformers and three voltage transformers.
3P4W1 Three-phase measurement, 4 wires	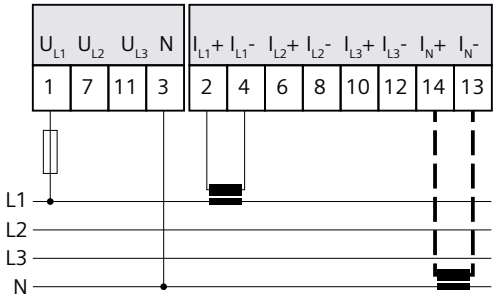	Balanced load Connection with one current measuring transformer
3P4W1 Three-phase measurement, 4 wires	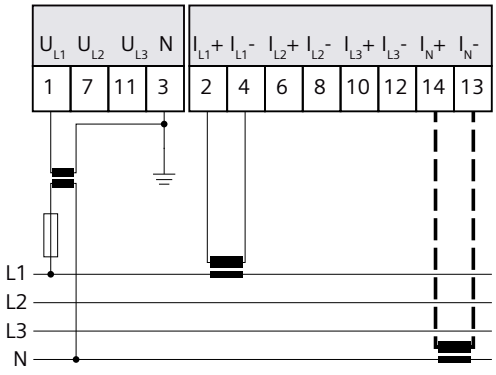	Balanced load Connection with one current measuring transformer and one voltage transformer.

Connection type	Wiring diagram	Comment
2P3W Two-phase measurement, 3 conductors	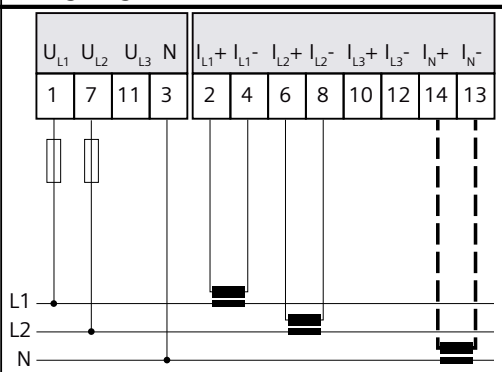	Any load Connection with two current measuring transformers The phase position L1-L2 is arbitrary. AI Energy Meter RC ST supplies the value "0" for all measured values of Phase 3 as well as for some cross-phase measured values.
2P3W Two-phase measurement, 3 conductors	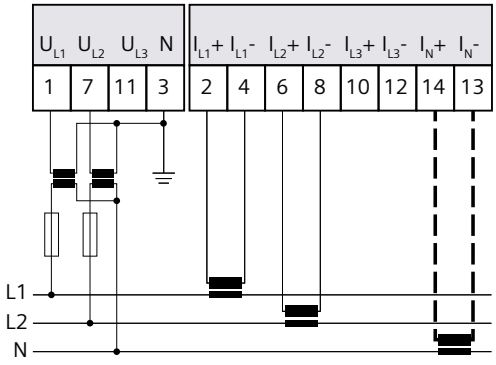	Any load Connection with two current measuring transformers and two voltage transformers. AI Energy Meter RC ST supplies the value "0" for all measured values of Phase 3 as well as for some cross-phase measured values.
1P2W Single-phase measurement, 2 conductors	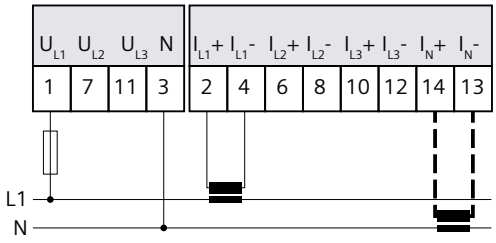	Measurement in an AC network with a current measuring transformer AI Energy Meter RC ST supplies the value "0" for all measured values of Phase 2 and 3 as well as for some cross-phase measured values.
1P2W Single-phase measurement, 2 conductors	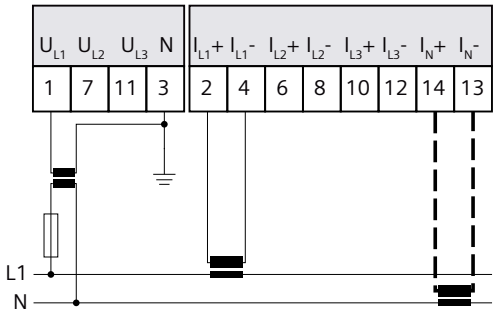	Measuring the load in an AC network with a current measuring transformer and a voltage transformer. AI Energy Meter RC ST supplies the value "0" for all measured values of Phase 2 and 3 as well as for some cross-phase measured values.

Connection type	Wiring diagram	Comment
3 x 1P2W 3 x single-phase measurement	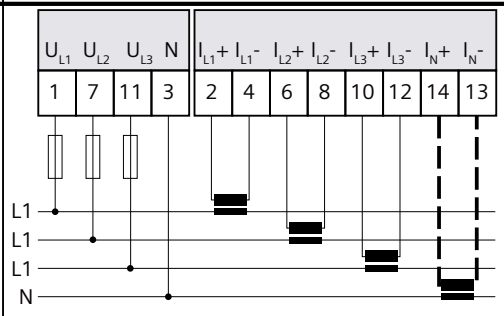	Measurement with three current measuring transformers for any three loads that are each connected to one of the three phases. To reduce the number of fuses used, the voltage phases can also be bridged behind a fuse.
3 x 1P2W 3 x single-phase measurement	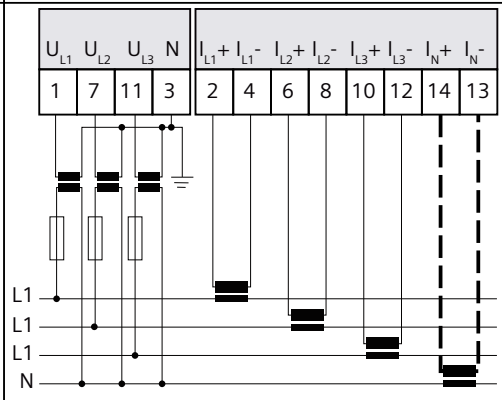	Measurement with three current measuring transformers and three voltage transformers for any three loads that are each connected to one of the three phases. To reduce the number of fuses used, the voltage phases can also be bridged behind a fuse.
3P3W Three-phase measurement	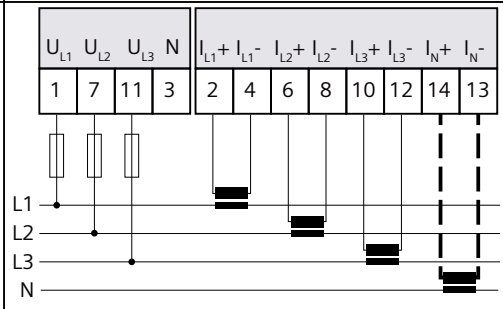	Any load Connection with three current transformers
3P3W Three-phase measurement	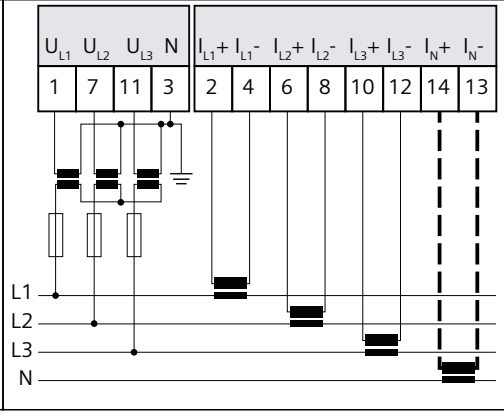	Any load Connection with three current measuring transformers and three voltage trans-formers.

Connection type	Wiring diagram	Comment
3P3W1 Three-phase measurement	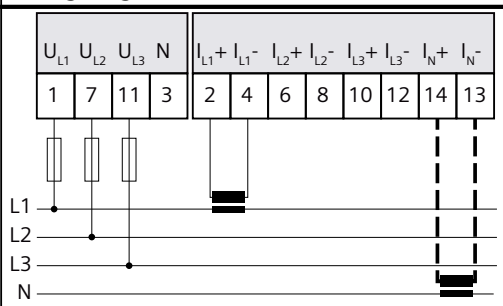	Balanced load Connection with one current measuring transformer.
3P3W1 Three-phase measurement	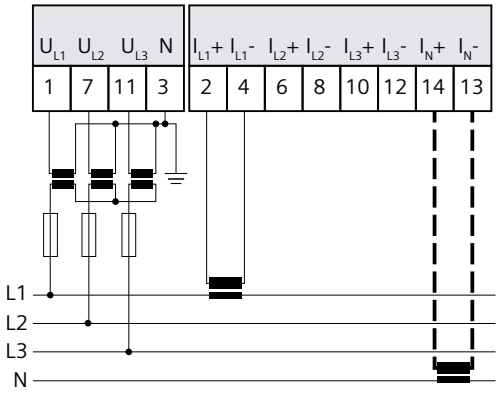	Balanced load Connection with one current measuring transformer and one voltage transformer.

3.3 Selection of a current measuring transformer

Introduction

The AI Energy Meter RC ST is designed for the connection of current/voltage transformers with 333 mV interface and Rogowski coils.

NOTE

Overall accuracy

For the total accuracy of the system consisting of the AI Energy Meter RC ST and current/voltage transformer or Rogowski-coil, ensure that the secondary voltage of the current/voltage transformer or Rogowski coil lies in the specified accuracy range of the AI Energy Meter ST.

Current/voltage transformer

The accuracy specified by the transformer manufacturer, in contrast to pure current transformers, depends on the cable length and the resulting load resistance. Observe the specified minimum resistance of the evaluation electronics. The AI Energy Meter RC ST has a typical differential input resistance at the channel terminals of 120 kΩ.

Rogowski coils

Rogowski coils are current/voltage transformers based on air coils. They do not work on a transformer principle like current transformers, but instead convert the rate of change of the current to a proportional voltage. This principle generates a phase shift of the secondary voltage vis-a-vis the primary current of 90°. An integrator in the AI Energy Meter RC ST, connected by the selection of the current transformer type in the configuration, compensates the phase shift again.

Interposing current transformers or integrators for connecting Rogowski coils are not required.

The accuracy of Rogowski coils is independent of the cable length. Ensure that the required minimum input resistance of the evaluation electronics is observed. The AI Energy Meter RC ST has a typical input resistance of 120 kΩ.

The secondary voltage is very low in case of an open converter input or when the primary currents are too low. If the secondary voltage is less than 4 mV, it is difficult to measure the current. This noise should be measured when the Rogowski coil is not under load, and the "Low limit for current measurement" should be adjusted accordingly with some room to move at the top.

See also

Technical specifications (Page 108)

Configuration / address space

4

4.1 Configuring

Introduction

To configure the AI Energy Meter RC ST after connecting it, use configuration software such as STEP 7 (TIA Portal). In addition, you can also change numerous parameters of the AI Energy Meters RC ST in RUN via the user program.

Configuring

You configure the AI Energy Meter RC ST with:

- STEP 7 (TIA Portal) V16 or higher and HSP0335
- GSD file for PROFIBUS or PROFINET

NOTE

Consistency check of the parameter assignment only with STEP 7

If you configure the AI Energy Meter RC ST using STEP 7 (TIA Portal), STEP 7 (TIA Portal) already checks the various parameters for consistency while they are being entered.

If you configure the AI Energy Meter RC ST using a GSD file, a consistency check is not performed. The module does not recognize incorrect entries until after the parameter data record has been transferred. If the module recognizes an invalid parameter, the module rejects the complete data record.

Preferably use STEP 7 (TIA Portal) to configure the AI Energy Meters RC ST.

The following instructions show the theoretical procedure for configuring the AI Energy Meters RC ST with STEP 7 (TIA Portal) V16 or higher with HSP0335.

1. Select the ET 200SP distributed I/O system you are using in the hardware catalog.
2. Insert the module into your station.
3. Open the device view of the ET 200SP and insert the AI Energy Meter RC ST.
4. Configure the AI Energy Meter RC ST to suit your requirements.

   Once the configuration has been compiled without errors, you can download the configuration to the CPU and commission the ET 200SP station while the AI Energy Meter RC ST is running.

4.2 Selecting the module versions

4.2.1 Selecting the module version

Introduction

The AI Energy Meter RC ST has different module versions.

During the configuration, you use the selection of the module version to specify which measured values can be read.

Each module version supplies quality information via the input payload.

With the exception of the module version "2 I / 2 Q", you can read the measured values as payload cyclically from the process image. At each module variant you have the option to read measured value records from the AI Energy Meter CT ST by using the RDREC instruction asynchronously.

Influence of the module version on the address space

NOTE

Influence of the AI Energy Meters RC ST on the maximum configuration of the ET 200SP

The available address space of the ET 200SP is influenced by the following factors:

- CPU or interface module
- Plugged I/O modules

The address space made **additionally** available by the AI Energy Meter RC ST is essentially influenced by the length of the payload supplied. The module variant determines the length of the payload, which can be supplied by the AI Energy Meter RC ST at maximum.

4.2.2 Module versions at configuration with STEP 7

Module versions with fixed payload assignment

Module version	Payload	Address space	Comment
2 I / 2 Q	No cyclic payload. Access to measured values through "Read data record".	2-byte inputs 2-byte outputs	Information about the structure of the 2 I / 2 Q module version is available in the appendix "2 I / 2 Q" module version (Page 147).
EE@Industry E0	Payload in accordance with EE@Industry measurement data profiles	12-byte inputs / 20-byte outputs	Information about the structure of the EE@Industry measured data profiles is available in the appendix Module version "EE@Industry measured data profile E0 / E1 / E2 / E3" (Page 158).
EE@Industry E1		4-byte inputs / 20-byte outputs	
EE@Industry E2		12-byte inputs / 20-byte outputs	
EE@Industry E3		104-byte inputs / 20-byte outputs	

Module versions with selectable payload variants

Module version	Payload	Address space	Comment
32 I / 20 Q	Payload selectable through defined payload variants	32-byte inputs / 20-byte outputs	You can change over the payload variant during operation. Information about the structure of the 32 I / 20 Q module version is available in the appendix "32 I / 20 Q" module version (Page 149). Information about the payload variants at 32 I / 20 Q is available in appendix Payload variants with 32 bytes input / 20 bytes output data (Page 160).
User-specific	Payload selectable through payload mapping or through defined payload variant	variable* / 20-byte outputs	You have to activate the check box "Payload-mapping" in STEP 7 to use the module version user-specifically. You can change over the payload variant during operation. Information about the structure of the user-specific module version is available in the appendix "User-specific" module version (Page 156).

* 16 ... 256 bytes in steps of 16 bytes, depending on the mapped measured values

4.2.3 Module versions at configuration with GSD file

Module versions with fixed payload assignment

Module version	Payload	Address space	Comment
2 I / 2 Q	No cyclic payload. Access to measured values through "Read data record".	2-byte inputs 2-byte outputs	Information about the structure of the 2 I / 2 Q module version is available in the appendix "2 I / 2 Q" module version (Page 147).
E0	Payload in accordance with EE@Industry measurement data profiles	12-byte inputs / 20-byte outputs	Information about the structure of the EE@Industry measured data profiles is available in the appendix Module version "EE@Industry measured data profile E0 / E1 / E2 / E3" (Page 158).
E1		4-byte inputs / 20-byte outputs	
E2		12-byte inputs / 20-byte outputs	
E3		104-byte inputs / 20-byte outputs	

Module versions with selectable payload variants

Module version	Payload	Address space	Comment
32 I / 20 Q	Payload selectable through payload variants or	32-byte inputs / 20-byte outputs	You can change over the payload variant during operation.

*Ensure that the payload does not exceed the size of the address space of the module version. If necessary, use a module version with a larger address space

Module version	Payload	Address space	Comment
64 I / 20 Q	through user-specific payload*	64-byte inputs / 20-byte outputs	If you use user-specific payload, you write your measured value profile into the AI Energy Meter RC ST with the data record 130. To do this use the WRREC instruction. Information about the structure of data record 130 is available in appendix Structure of the parameter data record for data mapping (DS 130) (Page 129).
128 I / 20 Q		128-byte inputs / 20-byte outputs	
256 I / 20 Q		256-byte inputs / 20-byte outputs	

*Ensure that the payload does not exceed the size of the address space of the module version. If necessary, use a module version with a larger address space

4.2.4 Changing over the user data variant during operation

Introduction

You change the payload variant in the output data of each payload variant in Byte 0.

The following figure shows to which payload you can change over at various module versions during operation.

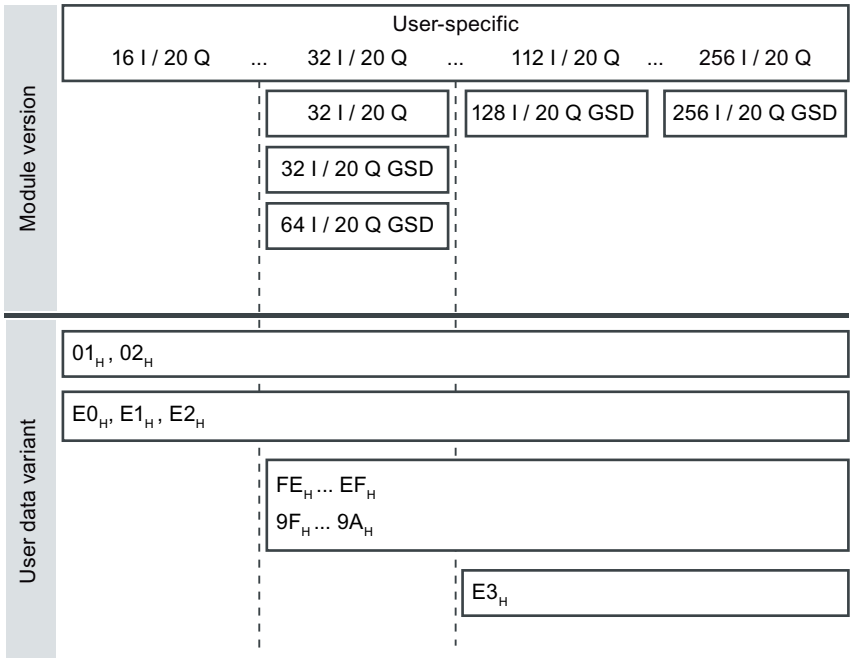

Figure 2-902 Possible payload variants

Requirement

- User program has been created.
- AI Energy Meter RC ST is configured as one of the module versions mentioned in the figure above.
- The start address of the module is known in the process image output.

Procedure

1. Create one constant with the data type BYTE per payload variant.
2. Enter the payload ID as a value in each case.
3. Write the constant to the start address of the module in the process image output.

Result

The payload variant is switched with the next cycle.

NOTE
Information about payload changeover
The parameterized payload variant is set in the following cases:

- A "0" is written in byte 0 in the output data of a payload variant.
- Byte 0 in the output data of a payload variant contains an invalid value:
  - Coding of the payload variant not available
    or
  - Available address space is not sufficient for the selected payload variant.

4.2.5 Recommendations for selecting the module version

The following table shows which module version is suitable for a given purpose.

Module version	Application	Note
2 I / 2 Q	• Use of many AI Energy Meter RC ST in an ET 200SP or when little address space is available	• Read the measured values solely via the RDREC instruction from a measured value data record. • Quality information about the measured values is always available.
EE@Industry measurement data profile E0 / E1 / E2 / E3	• Cyclic measurement per phase • Supplied measured values in accordance with the EE@Industry measured data profile	• Available measured values depend on the configured measurement data profile. • The payload are fixed and cannot be changed dynamically. Alternatively, read the measured values acyclically from a measured value data record via the RDREC instruction. • No quality information

Module version	Application	Note
32 I / 20 Q	• Cyclic measurement per phase • Flexibility by switching pre-defined payload variants	• Quality information about the measured values is always available. • Depending on the payload variant, you must convert the measured values in the CPU to physical values using the supplied scaling factor. • One cycle elapses for each payload changeover. Measured values from the next payload variant are thus supplied with a slight time offset. Alternatively, read the measured values acyclically from a measured value data record via the RDREC instruction. Consistent measured values of a measuring cycle are supplied.
User-specific	• Cyclic measurement of up to 64 measured values configurable • Flexibility by switching pre-defined payload variants	
With GSD configuration • 32 I / 20 Q • 64 I / 20 Q • 128 I / 20 Q • 256 I / 20 Q		

4.3 Applicable modules

Configuring with STEP 7

The following table shows with which controllers the different module versions can be configured with STEP 7.

Table 2-989 Module versions configured with STEP 7

Controller	Module version						
	2 I / 2Q	32 I / 20 Q	User-specific	EE@Industry measurement data profile			
				E0	E1	E2	E3
IM 155-6 PN ST	V3.3 or higher						
IM 155-6 PN HF *	V3.1 or higher						
IM 155-6 PN BA	V3.2 or higher		---	V3.2 or higher			---
IM 155-6 PN HS	V4.0 or higher		---	V4.0 or higher			
IM 155-6 DP HF	V3.0 or higher		---	V3.0 or higher			---
CPU 1510SP-1 PN**	V1.6 or higher		V1.6 or higher*** V2.0 or higher	V1.6 or higher			V2.0 or higher
CPU 1510SP F-1 PN**	V1.7 or higher		V1.7 or higher*** V2.0 or higher	V1.7 or higher			V2.0 or higher
CPU 1512SP-1 PN**	V1.6 or higher		V1.6 or higher*** V2.0 or higher	V1.6 or higher			V2.0 or higher
CPU 1512SP F-1 PN**	V1.7 or higher		V1.7 or higher*** V2.0 or higher	V1.7 or higher			V2.0 or higher
CPU 1515SP PC**	V1.7 or higher		V1.7 or higher*** V2.0 or higher	V1.7 or higher			V2.0 or higher

** Function setting the time as of V4.2

** Function setting the time is not possible

*** Up to a max. of 32 bytes input

Configuring with GSD file

The following table shows with which controllers the different module versions can be configured using a GSD file.

Table 2-990 Module versions configuring with GSD file

Controller	Module version						
	2 I / 2Q	32 I / 20 Q	64 I / 20 Q 128 I / 20 Q 256 I / 20 Q	EE@Industry measurement data profile			
				E0	E1	E2	E3
IM 155-6 PN ST	V3.3 or higher						---
IM 155-6 PN HF	V3.1 or higher						---
IM 155-6 PN BA	V3.2 or higher		---	V3.2 or higher			---
IM 155-6 PN HS	V4.0 or higher		---	V4.0 or higher			---
IM 155-6 DP HF	V4.2 or higher		---	V4.2 or higher			---

Compatibility 5

5.1 Compatibility of modules

Compatibility

The module versions "AI Energy Meter RC ST" and "AI Energy Meter RC HF" are compatible. All module versions can run on the respective other configuration, whereby the CT and RC functionality cannot be swapped.

If you exchange or replace an AI Energy Meter, the following table shows the compatibilities.

	Energy Meter configured		
Energy Meter inserted	**AI Energy Meter RC ST**	**AI Energy Meter RC HF**	**AI Energy Meter 480 VAC RC HF**
AI Energy Meter RC ST	Yes	Yes*	Yes*
AI Energy Meter RC HF	Yes*	Yes	Yes**
AI Energy Meter 480 VAC RC HF	No	No	Yes

*In this case, the module only supports ST functions.

** In this case, the function measured value recorder cannot be configured. The measured values of the following IDs cannot be selected by configuration in the limit value monitoring or in the user-definable data records/payload: 61130, 61131, 61132, 61133, 61134, 61135, 61136, 61137, 61159, 62132, 62135, 62193, 62232, 62235, 62293, 62332, 62335, 62393.

NOTE

The smallest component from configuration and module type determines the resulting scope of functions. This means the ST functionality is supported when either an ST configuration is available, or the ST module is used. An HF functionality, therefore, is only available in case of an HF configuration and HF module.

NOTE

When you install an ST module and use an HF configuration, you must disable the following functions:

- Power quality analysis functions
- Residual current analysis
- Diagnostics power quality
- Overcurrent, detect voltage swell and dip
- Detect peak values of current and voltage
- Harmonics analysis

Quick start

6

Introduction

This section shows you how to read and view your first measured values on the AI Energy Meter RC ST in a particularly quick and easy way.

NOTE

Current measuring transformer:

When the term "current measuring transformer" is used in this manual, it applies both to current/voltage transformers and Rogowski coils.

Requirement

You have already connected the AI Energy Meter RC ST to your network with one of the connection types shown in the section Connecting (Page 20). The AI Energy Meter RC ST has already been integrated into your configuration tool (such as STEP 7), or the AI Energy Meter RC ST has been integrated in the hardware catalog of your configuration tool with the GSD file.

Procedure

1. Configure an ET 200SP station

   Configure an ET 200SP station with a CPU 151xSP or an IM 155-6.

2. Plug module in ET 200S station

   Plug the AI Energy Meter RC ST into the ET 200SP station and use the module variant with 32-byte inputs and 20-byte outputs.

3. Set the module parameters

   Set the following parameters for the AI Energy Meter RC ST:

   – Connection type that you have used for the AI Energy Meter RC ST (e.g. 3P4W)
   – Voltage measuring range (e.g. 230 V)
   – Frequency of your network (for example 50 Hz)
   – Current transformer type for line conductors L1, L2, L3 and neutral conductor (e.g. Rogowski coil)
   – Current transformer primary rated current and secondary voltage (e.g. 1000 A and 333 mV)
   – Voltage transformer primary and secondary voltages (e.g. 230 V and 230 V)

   Leave all other parameters at their default settings and do not change them.

4. Load configuration

   Switch on the ET 200SP station and download the configuration to the CPU.

Result

After being switched on, the AI Energy Meter RC ST supplies the measured values for the "Total power L1L2L3" payload variant with the ID 254 or FE_H.

Read and check the measured values provided by the AI Energy Meter RC ST in the input data.

The table below shows the structure of the user data variant, the measured variables and the data type of the measured values in STEP 7 (TIA Portal) that are stored in the 32 bytes of output data of the module. Each measured variable is referenced via the measured value ID. An overview of all the measured variables with their measured value IDs is provided in the section Reading out and processing measured values (Page 40).

Table 2-991 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
10 ... 11	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038
12 ... 13	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
14 ... 17	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647 to +2147483647	225
18 ... 21	Total reactive energy L1L2L3 (Int32)	DINT	1 varh	-2147483647 to +2147483647	226
22	Reserved	BYTE	-	0	-
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Additional information

If you require further information about the evaluation and interpretation of the measured values, please refer to the section Reading out and processing measured values (Page 40).

Reading and processing measured values 7

7.1 Basics for reading measured values

Introduction

The AI Energy Meter RC ST provides the measured values and variables through the following methods:

- Cyclic: Payload
- Acyclic: Measured value data records

Payload

Payload provide pre-defined or user-defined measured values depending on the configured payload variant. The supplied measured values are cyclically written to the process image of the CPU. With some payload variants, the measured values are supplied as raw data, which you have to convert to the corresponding physical values using a supplied scaling factor.

Measured value data records

Each measured value data record supplies physical values that you can further process immediately. You read the values of a measured value data record acyclically with the RDREC instruction in a PLC tag. You need a corresponding PLC tag for each measured value data record to be read. It is also possible to create the corresponding structure in the static variables of an FB or store this structure in a DB.

You can display the read measured values in a watch table in STEP 7.

NOTE

If you are using CPUs other than S7-1200 or S7-1500, convert 64-bit measured values to 32-bit measured values. Note the conversion can cause loss of accuracy.

For more information, read FAQ: Processing 64-bit floating-point numbers in S7-300/400 (https://support.industry.siemens.com/cs/ww/en/view/56600676).

Validity of the measured values

After turning on the 24 V DC supply voltage, the first measured values are available at terminal 17 after approximately 2 seconds. In the input payload, the content of byte 0 is set to the selected payload variant. You can use this change in byte 0 as a trigger event.

As soon as the module has valid measured values, the value of this byte changes to a value within the value range.

Initial module startup

After the first startup or restart of the module, the parameters are transferred to the module. You can preset a payload variant in the parameters of the hardware configuration. This remains in effect until a different payload variant is selected in the output data (byte 0). This allows input payload to be modified dynamically according to the requirements of the process.

The payload variant defined in parameter data record 128 or configuration tool is used under the following conditions:

- A "0" is written in byte 0 in the output data of a payload variant.
- Byte 0 in the output data of a payload variant contains an invalid value:
  - Coding of the payload variant not available, or
  - Available address space is not sufficient for the selected payload variant.

    See "Selecting the module version".

Current measured values become "0"

The current and all other measured values based on it are suppressed (or set to "0") in the data records and in the payload in the following cases:

- The incoming current of the current measuring transformer is lower than the configured "Low limit for measuring current in relation to nominal value current [0.1%]" parameter
- Fed-in secondary voltage at the current measuring channel is higher than 2 V.

Among others, the following measured values and derived measured variables of the phase involved become "0":

- Effective current value
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A floating mean value is formed from the power values. These only become "0" after a corresponding time. The operating hours counter and the energy meter for active, reactive and apparent energy of the reset phase stops counting.

General reset

With module versions with 20 bytes of output data you can reset some measured values and counter levels.

An edge change of 0 -> 1 at the bit for the general reset has the following effect:

- Counters for energy, operating hours and limits start at "0" again.
- Minimum and maximum value calculation starts again with initial values.
- Measured values of the measured value recorder are deleted.

For the general reset, set bit 7 in byte 16 of the output payload. (Page 149)

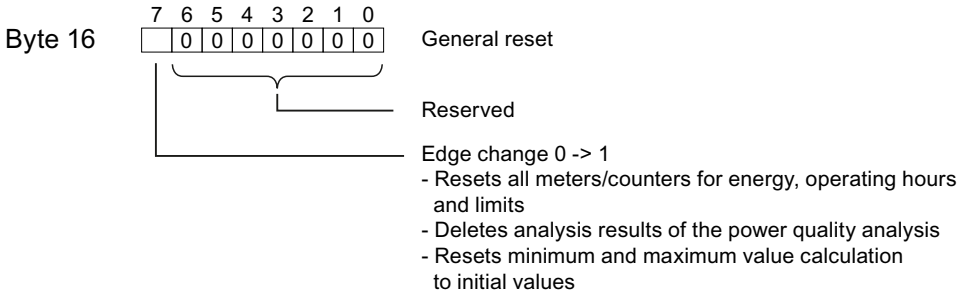

Figure 2-903 Control byte 16 in the output payload for general reset

Substitute value behavior

The substitute values for input values of the AI Energy Meters RC ST amount to "0".

See also

Reading measured values from user data cyclically (Page 48)

7.2 Quality information

Use the quality information to evaluate the status for currents, voltage, operating quadrants and the rotating field.

The AI Energy Meter RC ST provides quality information:

- In byte 1 of the payload
- In measured value IDs 65500 to 65503

7.2.1 Quality information in byte 1 of the user data

For all user data variants, the module provides brief quality information in an 8-bit field in byte 1 for:

- Currents (I_{L1}, I_{L2}, I_{L3})
- Voltages (U_{L1}, U_{L2}, U_{L3})
- Operating quadrant for a phase

Please note that quality information assignment with user data variants for phase-specific measurement (ID 154 to ID 159) is different from user data variant assignment for 3-phase measurement (ID 244 to ID 254).

Quality information in byte 1 of the user data for 3-phase measurement

The quality information for 3-phase measurement is provided by the module in user data variants ID 244 to ID 254.

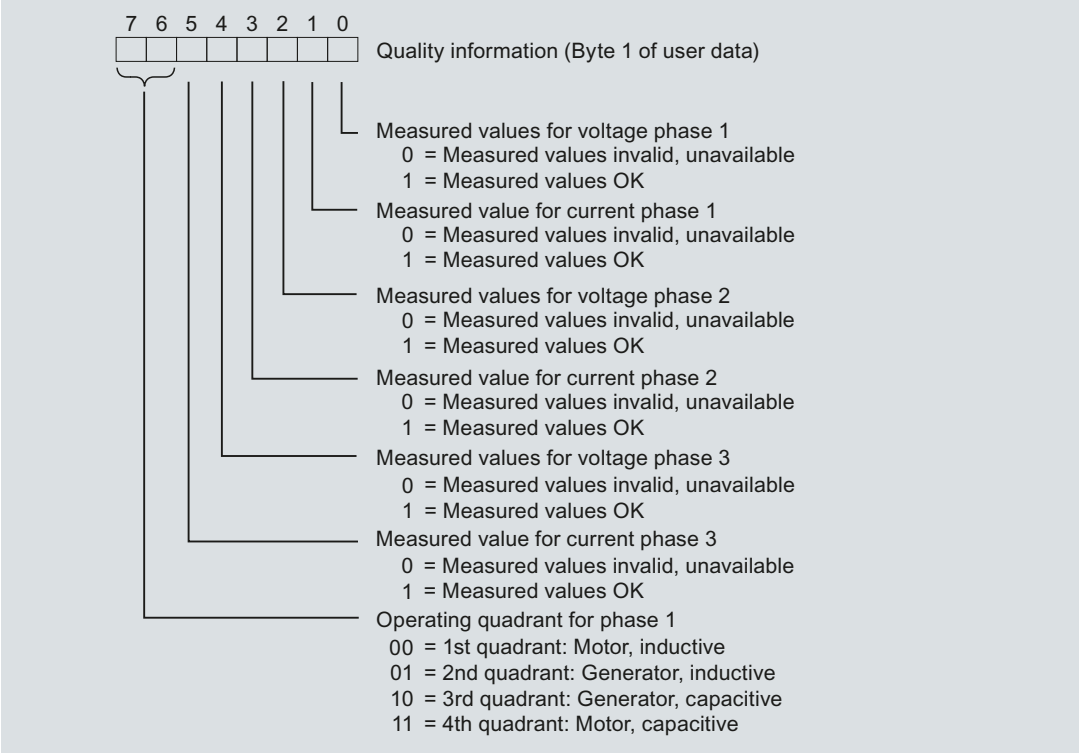

Figure 2-904 Assignment of byte 1 for user data variants ID 224 to ID 254

Quality information in byte 1 for phase-specific measurement

The quality information for phase-specific measurement is provided by the module in user data variants ID 154 to ID 159.

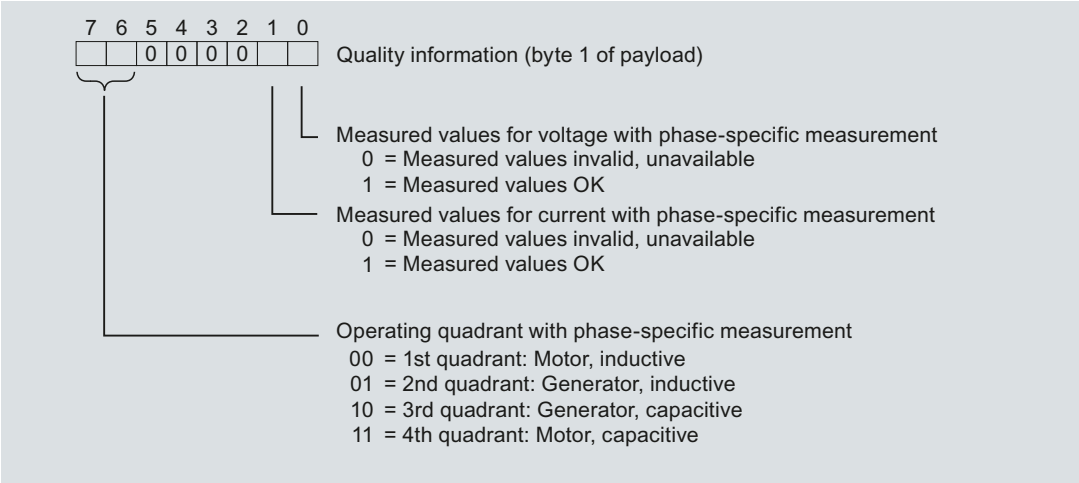

Figure 2-905 Byte 1 assignment for user data variants ID 154 to ID 159

7.2.2 Quality information with measured value IDs

Complete quality information is provided by the module in a 16-bit field with measured value IDs 65500 to 65503.

- Measured value ID 65503 for 3-phase measurement
- Measured value ID 65500, 65501 or 65502 for phase-specific measurement in phase 1, phase 2 or phase 3

Quality information with measured value ID 65503 for 3-phase measurement

The quality information for 3-phase measurement is provided by the module with:

- User data variant "Basic variables quality values three-phase measurement (ID 240 or $F0_H$)"
- User data (measured value ID 66503)
- Measured value data record 150

The measured value ID 65503 provides information on:

- Currents (I_{L1}, I_{L2}, I_{L3})
- Voltages (U_{L1}, U_{L2}, U_{L3})
- Operating quadrants for all 3 phases
- Rotating field for the 3-phase system

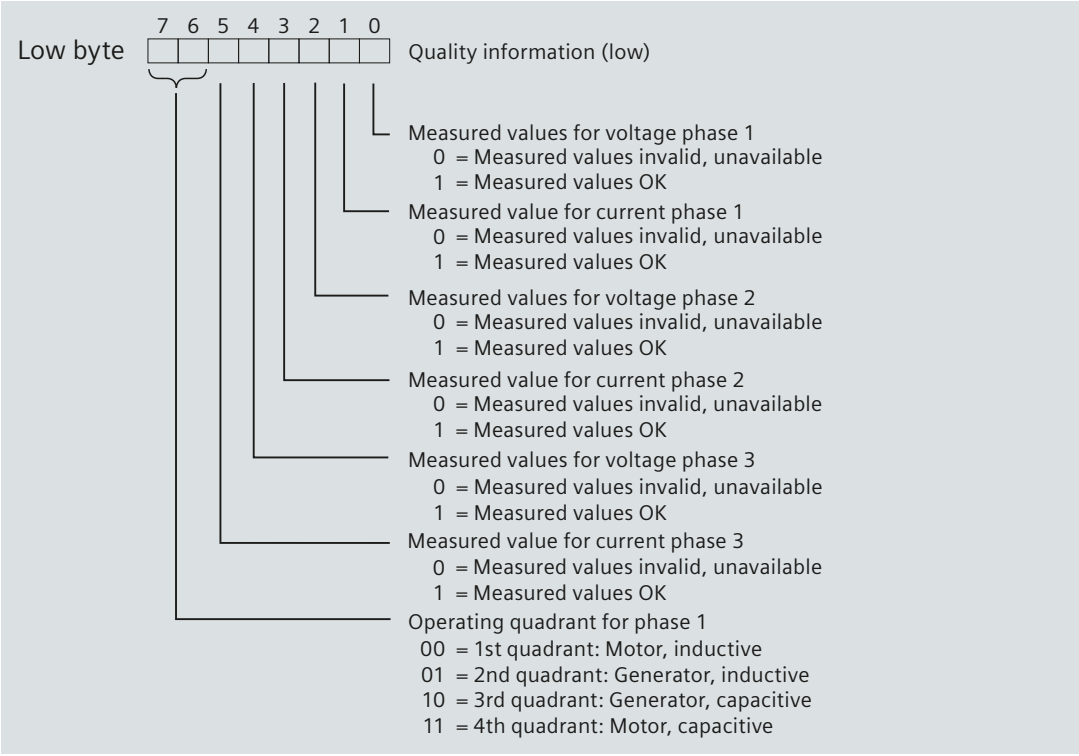

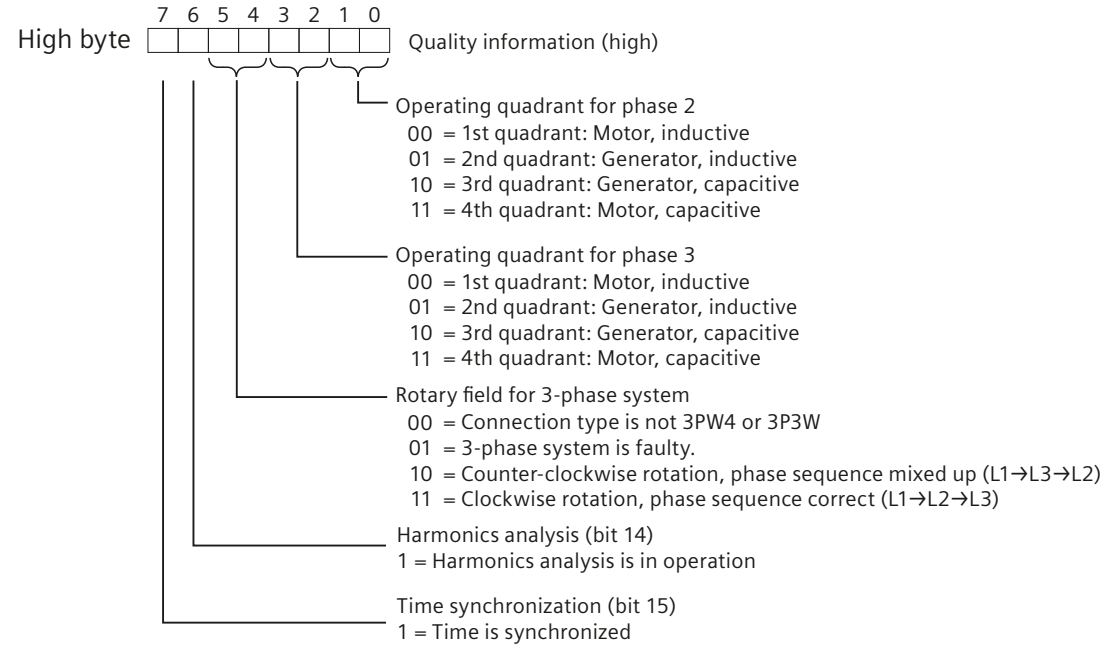

Figure 2-906 Quality information for low and high byte of the measured value ID 65503

Quality information with measured value ID 65500, 65501 or 65502 for phase-specific measurement

The module provides quality information for phase-specific measurement in phase 1, phase 2 or phase 3 with:

- User data (with measured value ID 65500, 65501 or 65502)
- Measured value data record DS 147, 148 or 149

Measured value IDs 65500, 65501 and 65502 provide information on:

- Current of the phase in question
- Voltage of the phase in question
- Operating quadrant of the phase in question

In contrast to the assignment for measured value ID 65503 (figure above), measured value IDs 65500, 65501 and 65502 only contain the phase-specific information for current, voltage and operating quadrant. The information about the other phases and the rotating field have the value 0.

7.2.3 Operating quadrant

The figure below shows the quality information of the operating quadrants.

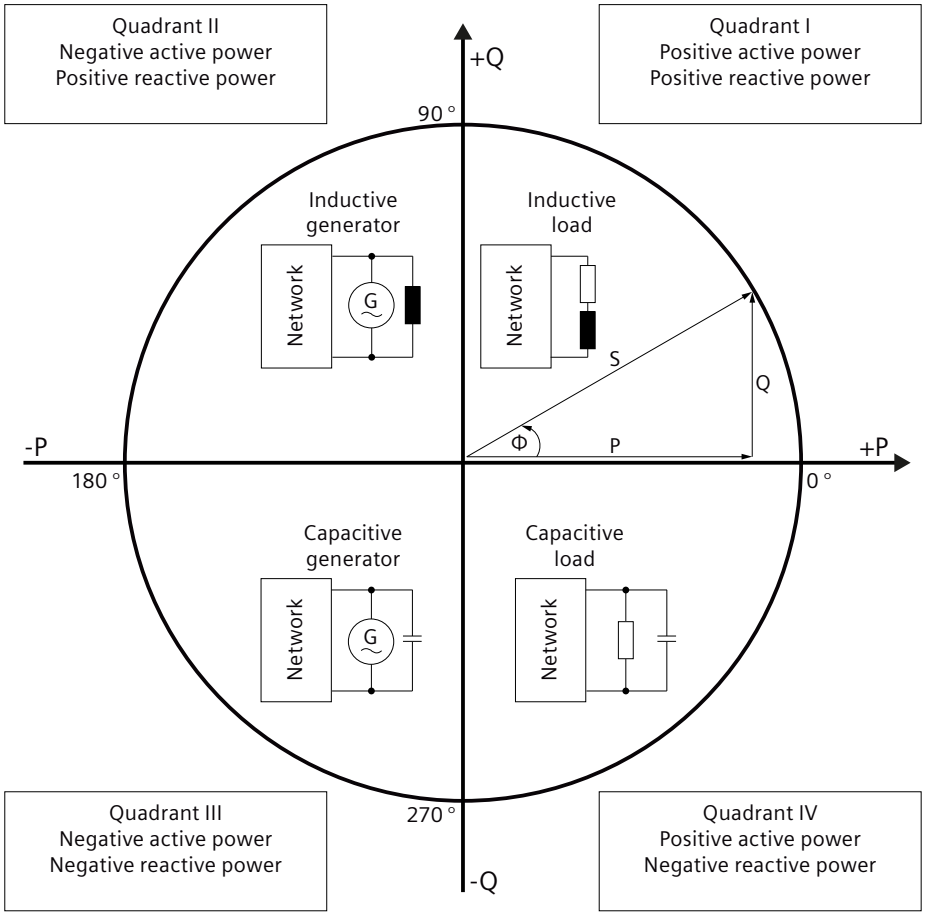

Figure 2-907 Quadrant in the quality bits

7.2.4 Notes for the detection of wiring errors and incorrect rotating field

A variety of quality information is available to evaluate the correct wiring of the Energy Meter and the applied rotary field.

Requirement

Detecting the rotating field requires 3-phase operation with 3P4W or 3P3W connection types.

In byte 1 of the payload, section 7.2.1 or measured value IDs 65500-65503, section 7.2.2

Information on the validity of the measured currents and voltages is encoded in bits 0 to 5.

Information on the operating quadrants is encoded in the bits 6 to 7, see section 7.2.3 (Page 46)

Phase angle between voltages and currents, measured value phase angle Ln

Based on the phase angle, you can recognize whether the flow direction of the current is correct and whether the voltage or current connections have been swapped. You cannot recognize, however, which phases are swapped and how. If the wiring is correct, the phase angle for the consumer must be in the range from 270° to 359° or -0° to -90°. For generators, the phase angle with correct wiring is in the range from 90° to 270° or -180° to -90°.

Angle between the voltages, measured value phase angle ULx-ULy

Based on the phase angle between the voltages, you can check the correct phase sequence and detect an unwanted same-phase connection.

In a symmetrical three-phase network, the angle between the phase voltages is +120°(-240°) or -120°(+240°).

Angle between currents, measured value phase angle ILx-ILy

Based on the phase angle between the currents, you can check the correct phase sequence and flow direction as well as detect an unwanted same-phase connection.

For a symmetrical load, the phase angles between the currents are identical to those between the voltages.

Line-to-line voltage, measured value ULx-ULy

You can detect an unwanted same-phase connection using the line-to-line voltage whose calculation takes into account the angles between the voltage phases.

7.3 Reading measured values from user data cyclically

Requirement

- STEP 7 is open.
- The AI Energy Meter RC ST is configured.

Scaling of measured values in the user data

Since the value range of 16-bit values is often smaller than the value range of the physical value, a scaling factor is supplied together with the basic value in the user data for the respective measured or calculated values. You determine the actual value of the measured variable with the following formula:

Actual value of measured quantity = measured value in the user data x $10^{\text{scaling factor}}$

Procedure

To read measured values from the user data cyclically, proceed as follows:

1. Read the relevant measured value from the input data.
2. Observe the scaling factor at scaled measured values and convert the read measured value using the scaling factor.

Example

The payload variant 254 (FE_H) "Total power L1L2L3" is configured on the AI Energy Meter RC ST. The measured value for "Current L1" should be read.

Table 2-992 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
10 ... 11	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038
12 ... 13	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
14 ... 17	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647 to +2147483647	225
18 ... 21	Total reactive energy L1L2L3 (Int32)	DINT	1 varh	-2147483647 to +2147483647	226

Byte	Allocation	Data type	Unit	Value range	Measured value ID
22	Reserved	BYTE	-	0	-
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

In the user data variant FE_H (254) the measured value for the current L1 is stored in Byte 2 + 3. The current is supplied by the module as a 16-bit-fixed-point number in the value range from 0 to 65535 in the unit 1 mA. In addition the scaling factor for the current L1 has to be considered additionally. The module supplies the related scaling factor in Byte 24.

The actual value for current L1 is calculated as follows:

Actual value for current L1 = Current L1 x $10^{\text{Scaling current L1}}$

See also

Basics for reading measured values (Page 40)

7.4 Read out measured values acyclically using data records

With all module versions you can read out the measured values using data records.

An overview of all measured value data records and exact information about the structure is available in the appendix Overview of all measured value data records (Page 176).

Requirement

In the STEP 7 project you have created a PLC data type that has an identical structure to the data record you want to evaluate.

Example of the structure of a data record

The following overview shows the structure of the data record DS 142.

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	3	-	-
1	Reserved	UINT8	0	-	-
2...5	Voltage UL1-N	REAL	V	0.0 ... 1000000.0	1
6...9	Voltage UL2-N	REAL	V	0.0 ... 1000000.0	2

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
10...13	Voltage UL3-N	REAL	V	0.0 ... 1000000.0	3
14...17	Voltage UL1-L2	REAL	V	0.0 ... 1000000.0	4
18...21	Voltage UL2-L3	REAL	V	0.0 ... 1000000.0	5
22...25	Voltage UL3-L1	REAL	V	0.0 ... 1000000.0	6
26...29	Current L1	REAL	A	0.0 ... 100000.0	7
30...33	Current L2	REAL	A	0.0 ... 100000.0	8
34...37	Current L3	REAL	A	0.0 ... 100000.0	9
:		:	:	:	:
210...2-13	Neutral current	REAL	A	0.0 ... 100000.0	61149

Procedure

1. Read the desired data record with the RDREC instruction.

   The measured values are in the target range of the data block which you specified with the RDREC instruction.

2. Evaluate the measured values for the desired measured variables.

NOTE

If you want to read or write several data records at the same time in the user program, note that the number of active jobs that you started with the RDREC or WRREC instruction is limited by the resources of the CPU used.

NOTE

When reading data records that do not exist on the ST module with RDREC, the error 0x80B0 is displayed.

7.5 Time-of-day synchronization and time stamp

The AI Energy Meter RC ST supports time-of-day synchronization and time stamp.

Time-of-day synchronization is only supported by IM 155-6 PN HF as of firmware version V4.2.

Time stamps are used to date the exact occurrence of information. You can find time information in the measured value data records "Measured value data record for maximum values with time stamp (DS 154)" and "Measured value data record for minimum values with time stamp (DS 155)", for example.

For the time on the AI Energy Meter RC ST to correspond to the current system time, the clock must be synchronized externally. Information on this and additional requirements can be found in the application example (https://support.industry.siemens.com/cs/ww/en/view/109754890). In the absence of time-of-

day synchronization, the internal time stamp of the AI Energy Meters RC ST starts at 01.01.1970, 0:00.

Structure of the time stamp

The table below shows the structure of the time stamp:

Byte	PNIO Time	Format	Length
0	Status 0: Synchronization from system time master available 1: Local synchronization available 2: No synchronization available	UINT16	2 bytes
2	Seconds high	UINT16	2 bytes
4	Seconds low	UINT32	4 bytes
8	Nanoseconds	UINT32	4 bytes

The start value (initial value) is 01.01.1970, 0:00.

NOTE

If you use the implementation from the FAQ, the status is always 2.

Energy counters

8

Introduction

The AI Energy Meter RC ST provides several energy and overflow counters that detect both line-based and phase-based energy values, e.g.:

- Active energy (total, outflow, inflow)
- Reactive energy (total, outflow, inflow)
- Apparent energy (total)
- "Output" describes the regenerative operation of the connected system.
- "Reference" describes the motor operation of the connected system.

Retentivity

The AI Energy Meter RC ST stores all counter values retentively. After an interruption (e.g. Power System Off), the energy counting resumes with the retentively stored values.

Functions

The energy meters provide the following basic functions:

- Measured values for infinite and periodical counting can be read out

  End values for periodic counting: 10^3, 10^6, 10^9, 10^{12} and 10^{15} can be selected with overflow counters
- Measuring ranges can be changed in RUN
- Starting and stopping counters via gate is possible
- Preset and apply start values in RUN
- Measured variables can be evaluated via data records and payload.

8.1 Evaluate measured values for energy

There are two ways of evaluating the measured values:

- Reading measured values using the instruction "RDREC".
- Reading measured values from the payload variants (not for module versions with 2 bytes of input data).

Data records for energy meters

You can read out measured values for energy and overflow counters in the following data records.

The evaluation of measured data using data records is described in section Reading out measured values ayclically using data records (Page 49).

Name of the data record	Number of the data record	Comment
Data record for basic measured values (Page 177)	Data record 142	Measured values of the total energy L1L2L3
Data record for energy meter (Page 183)	DS 143	Measured values of energy and overflow counters for phases L1, L2 and L3
Data record for phase-specific measured values L1 (Page 191)	DS 147	Measured values of the phase-specific energy meters L1
Data record for phase-specific measured values L2 (Page 194)	DS 148	Measured values of the phase-specific energy meters L2
Measured value data record for phase-specific measured values L3 (Page 198)	DS 149	Measured values of the phase-specific energy meters L3

Payload variants for energy meters

You can read out measured values for energy and overflow meters in the following payload variants.

The evaluation of measured data using payload variants is described in section Reading measured values cyclically from payload (Page 48).

Name of the payload variant	Number of the payload variant	Comment
Total energy L1 L2 L3	ID 249 or $F9_H$	Measured values of the total energy L1L2L3
Energy L1	ID 248 or $F8_H$	Measured values of the phase-specific energy meters L1
Energy L2	ID 247 or $F7_H$	Measured values of the phase-specific energy meters L2
Energy L3	ID 246 or $F6_H$	Measured values of the phase-specific energy meters L3
Basic variable quality measurement three-phase measurement	ID 240 or $F0_H$	Status on the overflow of the energy meters for phases L1, L2 and L3
Basic variables energy meter measurement (periodic) L1L2L3	ID 239 or EF_H	Number of counter overflows for energy of phases L1, L2 and L3
EE@Industry measurement data profile E3	ID 227 or $E3_H$	Measured values for total active energy and total reactive energy L1L2L3
EE@Industry measurement data profile E2	ID 226 or $E2_H$	Measured values for total active energy L1L2L3

Name of the payload variant	Number of the payload variant	Comment
Basic variables for phase-specific measurement L1 (Page 160)	ID 159 or $9F_H$	Measured values for phase-specific active, reactive and apparent energy for phase L1
Basic variables for phase-specific measurement L1a	ID 158 or $9E_H$	Measured values for phase-specific active, reactive and apparent energy for phase L1
Basic variables for phase-specific measurement L2	ID 157 or $9D_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L2
Basic variables for phase-specific measurement L2a	ID 156 or $9C_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L2
Basic variables for phase-specific measurement L3	ID 155 or $9B_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L3
Basic variables for phase-specific measurement L3a	ID 154 or $9A_H$	Measured values for phase-specific active, reactive and apparent energy for Phase L3
User-defined payload variant	ID 1 or 01_H and ID 2 or 02_H	Measured variables for energy can be selected in a user-defined manner

8.2 Preset and apply start values for energy and overflow counters

At the beginning of a new work order, it may be useful to start the energy and overflow counter with new start values.

Define the new start values for the energy and overflow counter in data record DS 143.

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

For **all** module versions there are two ways of applying the start values:

- Transfer start values from data record DS 143 and apply them **immediately**
- Transfer start values from data record DS 143 and only apply them after setting a special bit (DQ bit for counter reset)

Both options are described in the following sections.

General reset

With module versions with 20 bytes of output data you can reset the energy and overflow counters. With a general reset, you cannot preset any start values; the start values for energy and overflow counters are always zero with a general reset.

You can find additional information on the general reset in the section Basics for reading measured values (Page 40).

8.2.1 Preset start values for the energy meters

Define the start values for the energy and overflow meters in data record DS 143.

Introduction

You have created a PLC data type that has an identical structure to data record DS 143.

Structure of data record DS 143

The following overview shows the structure of the data record DS 143 in simplified form.

More detailed information about the structure of data record DS 143 is available in section Structure of energy meters (DS 143) (Page 183).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Control byte 1 - L1	BYTE	Bit string	-	-
3	Control byte 2 - L1	BYTE	Bit string		
4	Control byte 1 - L2	BYTE	Bit string		
5	Control byte 2 - L2	BYTE	Bit string		
6	Control byte 1 - L3	BYTE	Bit string		
7	Control byte 2 - L3	BYTE	Bit string		
8...15	Start value for active energy inflow L1	LREAL	Wh	You will find the exact assignment in the section Structure of energy meters (DS 143) (Page 183).	61180
16...23	Initial value active energy outflow L1	LREAL	Wh		61181
:	:	:	:		:
128...1-29	Start value for overflow counters active energy inflow L1	UNIT	-		61190
130...1-31	Start value for overflow counter active energy outflow L1	UNIT	-		61191
:	:	:	:		

Assignment of data record DS 143

Byte 0 and Byte 1: Version of the data record

Header information for the version of the data record.

Byte 2 ... Byte 7: Control bytes for energy and overflow counter

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy meters, overflow counters and operating hours counters. The length of the control information amounts to 2 bytes for each phase.

Byte 8 ... Byte 127: Start values for the individual energy meters

The start values for energy meters in data record 143 are 64-bit floating point numbers. The format corresponds to the data type LREAL in S7-1200 and in S7-1500.

Byte 128 ... Byte 157: Initial values for overflow counters

The initial values for overflow counters in data record 143 are 16-bit integers. The format corresponds to the data type UINT in S7-1200 and in S7-1500.

8.2.2 Apply start values from data record DS 143 immediately

It is possible to apply the start values for energy counters and overflow counters for each **individual** phase separately by active, reactive and apparent energy.

Requirement

In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and you have entered the start values.

Procedure for all module versions

1. In control byte 2 of the DS 143 (bytes 3, 5 and 7), for each phase set the category of the energy meters (active, reactive, apparent energy) for which you want to set the start values.

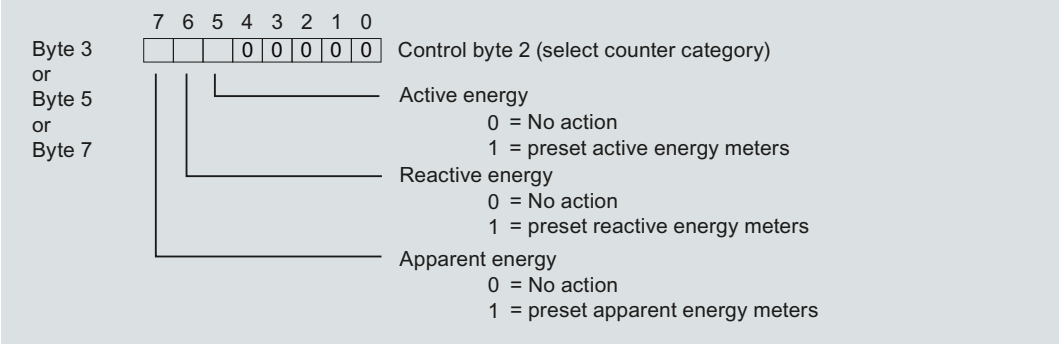

Figure 2-908 Assignment of control byte 2 in DS 143

2. In control byte 1 of DS 143 (bytes 2, 4 and 6), for each phase define whether you want to apply the start values for energy or overflow counters.

   Applying depends on the category selection from control byte 2.

   – Set Bit 0 if you want to apply the start values for the overflow counters.
   – Set Bit 2 if you want to apply the start values for the energy meters.

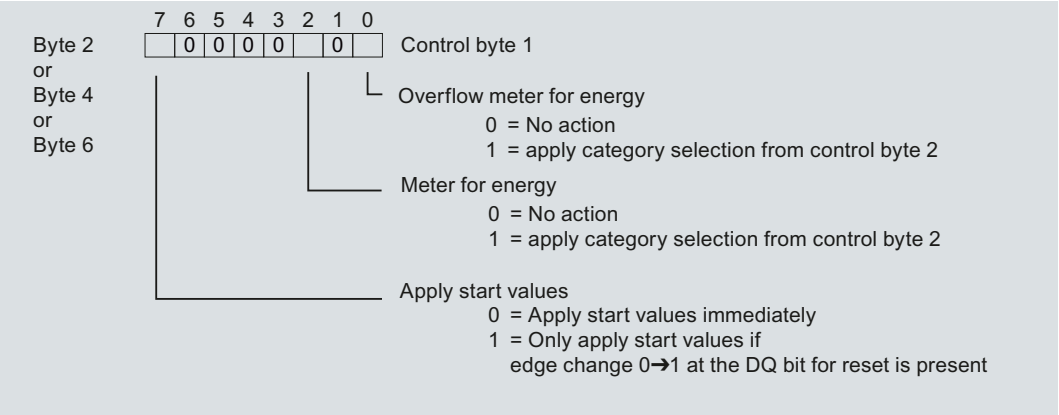

Figure 2-909 Assignment of control byte 1 in DS 143

3. In control byte 1 of DS 143 define that you want to immediately apply the start values.
   – Set Bit 7 to 0 so that the start values are immediately applied after writing the data record.
4. Transfer the data record with the WRREC instruction to the CPU.

8.2.3 Apply start values from data record DS 143 with DQ bit

Due to the differing lengths of the output data, setting of the start values for the energy counters and overflow counters depends on the configured module version.

Module versions with 20 bytes of output data

If you use module versions with 20 bytes of output data, you can:

- Apply start values for energy counters and overflow counters for **all** phases separately by active, reactive and apparent energy.
- Apply start values for energy counters and overflow counters for each **individual** phase separately by active, reactive and apparent energy.

Module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, then you always apply the start values for **all** the energy counters and overflow counters simultaneously.

Requirement

- In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and have entered the start values.

  Applying depends on the category selection from control byte 2.

  – Set Bit 0 if you want to apply the start values for the overflow counters.

  – Set Bit 2 if you want to apply the start values for the energy meters.
- In control byte 1 of the DS 143 you have set Bit 7 to "1" (apply start values via DQ bit)
- You have transferred the data record DS 143 with new start values to the CPU. The assignment of the data record can be found in Structure of energy meters (DS143) (Page 183).

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

Procedure for module version with 20 bytes of output data

Apply start values for energy counters and overflow counters for all three phases

1. In Byte 2 of the output data, select the categories for which you want to apply start values.

   – Set bit 5 for active energy counters.

   – Set bit 6 for reactive energy counters.

   – Set bit 7 for apparent energy counters.

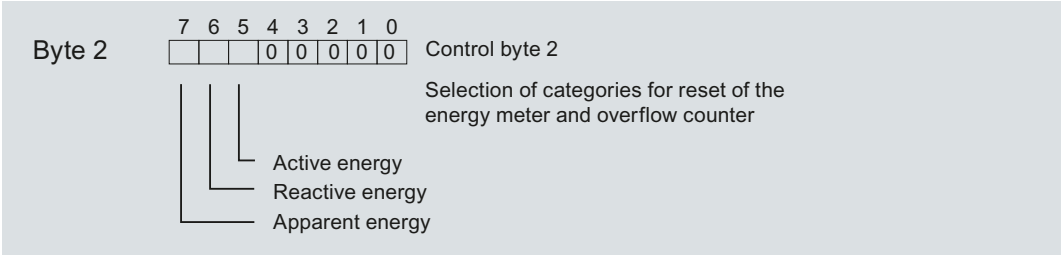

Figure 2-910 Selection of categories for reset

2. Set the reset bit (Bit 7) in byte 1 of the output data.

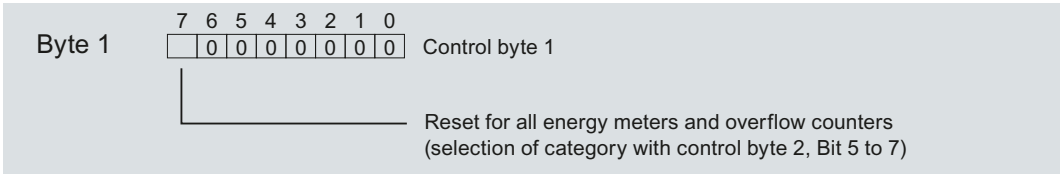

Figure 2-911 Reset bit for energy and overflow counter

If there is an edge change of the reset bit from 0 -> 1, the module resets the energy and overflow counters that you previously selected in byte 2 to their start values.

Apply start values for energy counters and overflow counters for phase-specific counting

You can also reset the energy and overflow counters on a phase-specific basis using the output data.

Follow the procedure as described in "Applying start values for energy counters and overflow counters for all three phases", as applicable.

1. In bytes 7, 9 and 11 of the output data, select the categories for which you want to apply the phase-specific start values.
   - Set Bit 5 for active energy counters.
   - Set Bit 6 for reactive energy counters.
   - Set Bit 7 for apparent energy counters.

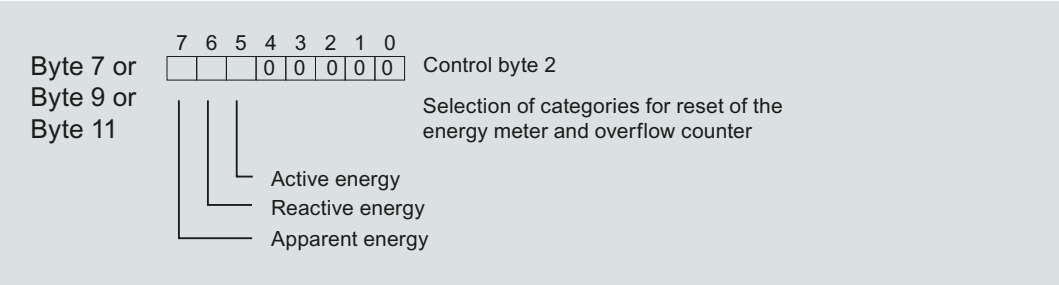

Figure 2-912 Selection of category

2. In bytes 6, 8 and 10 of the output data, set the reset bits (Bit 7) for the phase-specific start values.

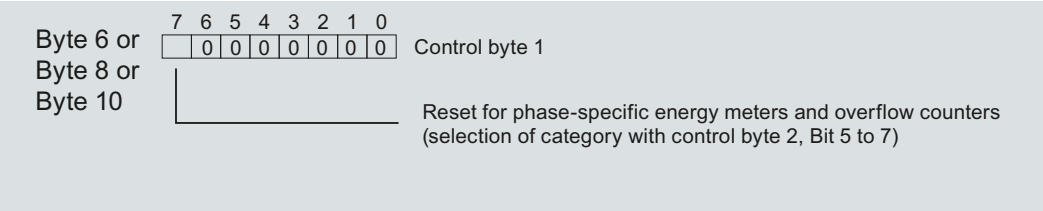

Figure 2-913 Reset bit for phase-specific energy and overflow counters

If there is an edge change of the phase-specific reset bit from 0 -> 1, the module resets the energy and overflow counters that you previously selected in bytes 7, 9 and 11 to their start values.

Procedure for module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, always apply the start values **for all** the energy counters and overflow counters.

- Set the reset bit (Bit 7) in byte 1 of the output data.

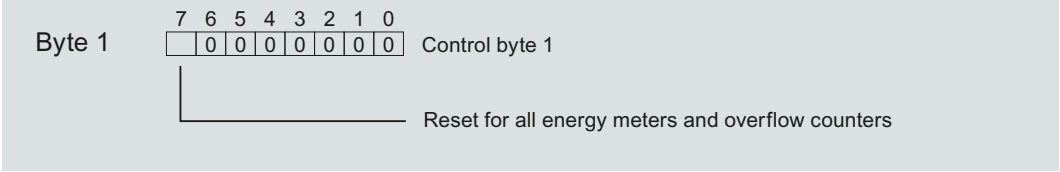

Figure 2-914 Reset bit for all energy and overflow counters

If there is an edge change of the reset bit from 0 -> 1, the module resets **all** energy and overflow counters to their start values.

8.3 Starting and and stopping energy meters

There are two ways of starting or stopping measurement with the energy meter AI Energy Meter RC ST:

- Counting with gate

  The module starts counting when you set the DQ bit for the counter gate in the output data using an edge change from 0 -> 1. If you reset the DQ bit using an edge change from 1 -> 0, the counter stops.

- Counting without gate

  The module starts counting immediately as soon as the module is switched on. Counting cannot be stopped.

Both options are described in the following sections.

Counting with gate

Requirements:

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

If you wish to start counting using the gate, proceed as follows:

1. Activate the parameter "Activate gate switch for energy meter" in the parameter assignment of the module.
2. Set the DQ bit for the counter gate (Bit 6) in control byte 1 in the output data.

The module starts counting as soon as there is an edge change from 0 -> 1 at the DQ bit for the counter gate.

If you wish to stop the counting again, then reset Bit 6 in control byte 1 in the output data. Counting stops at an edge change from 1 -> 0.

The "Activate gate switch for energy meter" parameter and the DQ bit for the "counter date" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

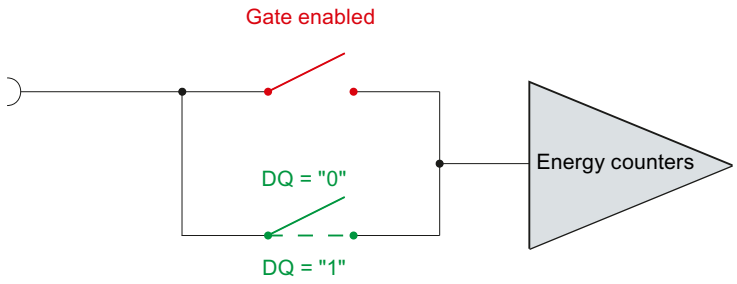

Figure 2-915 Gate enabled

NOTE

Module-global/phase-granular PLC

If you are using the gate control for all three phases simultaneously, use the control byte 1 at output address 1. For a phase-specific resolution of the gate control, use the addresses 6 (Phase1), 8 (Phase2) or 10 (Phase3) as control byte 1. The resolution of a module-global PLC overrules a phase-granular resolution.

Counting without gate

Requirement

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

Deactivate the parameter "Activate gate switch for energy meter" in the parameter assignment of the module.

The module starts counting as soon as the module is started. The counter continues to count.

Gate disabled: Gate is always "open" (signal path closed)

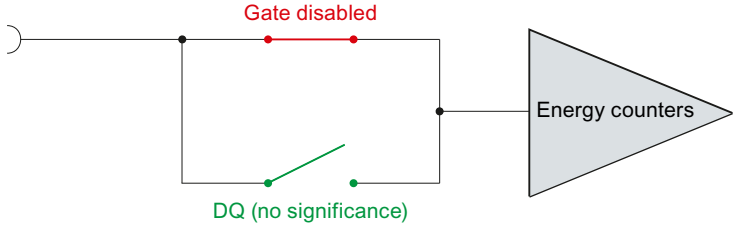

Figure 2-916 Gate disabled

8.4 Example of measuring and resetting an energy meter

The following figure shows resetting and starting/stopping with activated gating using the energy meter as an example:

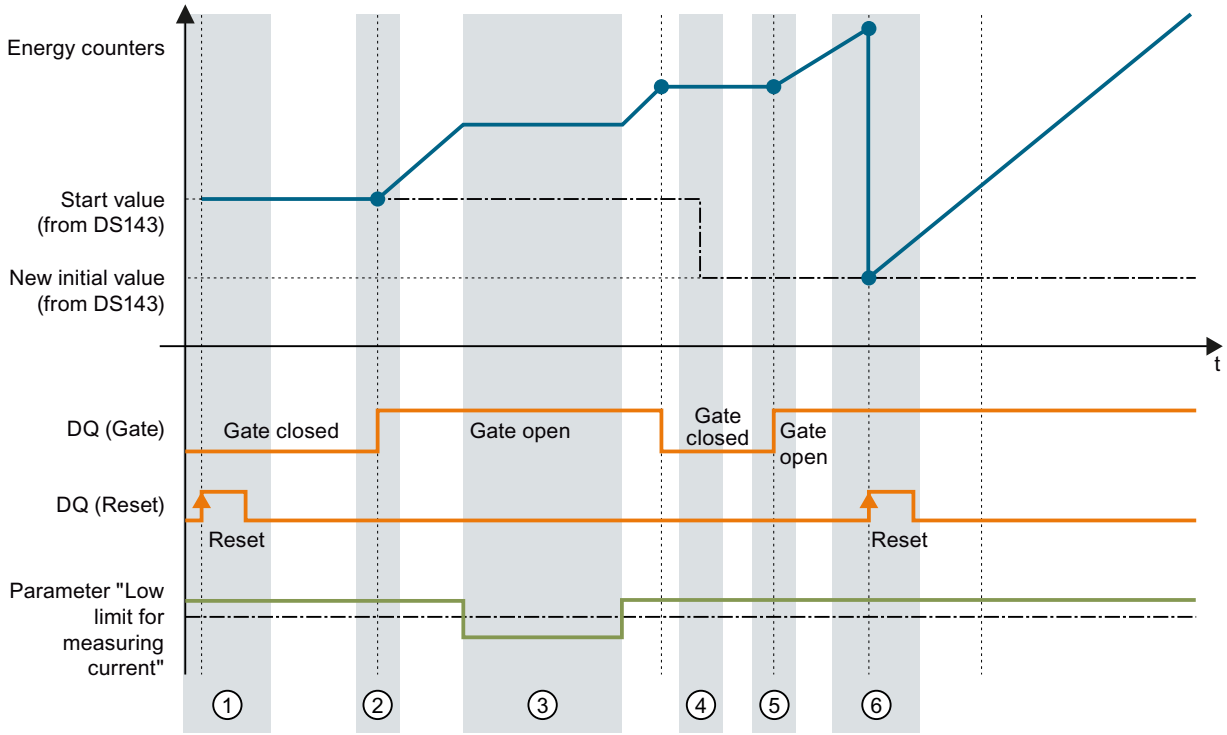

① The counter is reset to the value specified in the configuration. The gate is closed. The counter does not count.

② The gate is opened via the control byte 1 in the output data of the user data variant. The counter counts.

③ The configured current low limit has been violated. The counter does not count.

④ The gate is closed. The counter does not count. A new start value is written to the measured value data record 143 (Page 183) with the WRREC instruction.

⑤ The gate is opened again via the control byte 1 in the output data of the user data variant. The counter counts with the new start value.

⑥ The counter is reset via the control byte 1 in the output data of the user data variant. The counter counts from the new start value that was transferred via the measured value data record 143.

Figure 2-917 Example of an energy meter

8.5 What is the structure of the control and feedback interface for DS 143?

Introduction

Bytes 2 to 7 of data record 143 (Page 183) form the phase-based control and feedback interface for the data record DS 143.

- Bytes 2 and 3: Control and feedback interface for phase 1
- Bytes 4 and 5: Control and feedback interface for phase 2
- Bytes 6 and 7: Control and feedback interface for phase 3

Status information

When data record 143 is read with the RDREC instruction, Bytes 2 to 7 supply phase-specific status information for energy counters, overflow counters and operating hours counters.

The status information enables you can see which counters are returning their values in the data record 143. If energy counters return their values in the status byte 1, you can determine the type of energy counter with status byte 2.

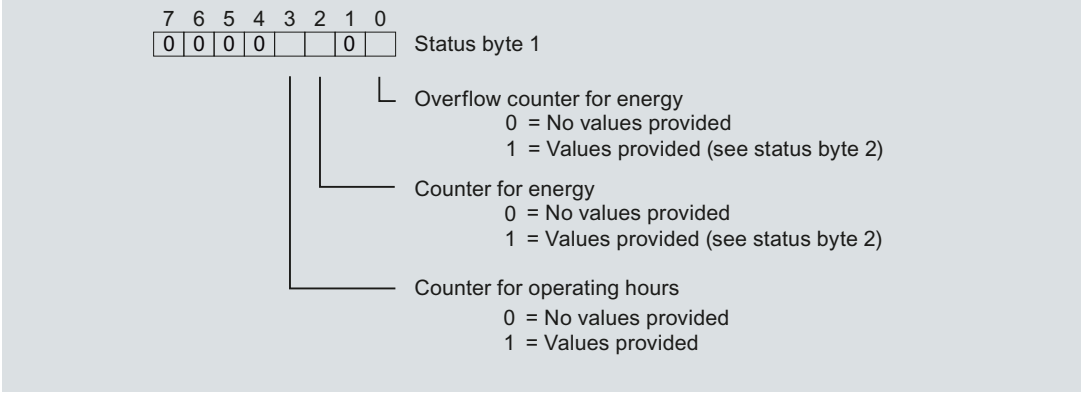

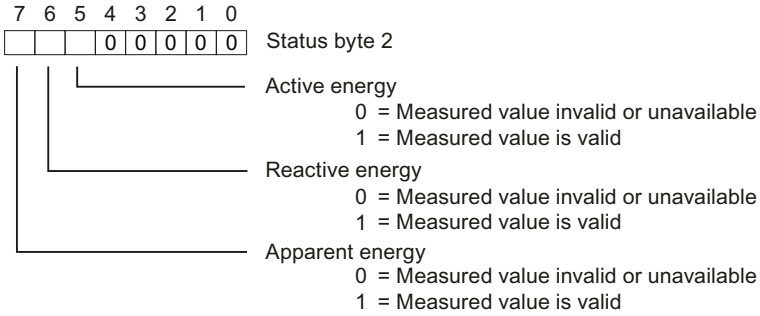

Figure 2-918 Status information DS 143 (read access)

Control information

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy meters, overflow counters and operating hours counters. The length of the control information amounts to 2 bytes for each phase:

- In control byte 1 you determine which counter you want to preset and the time at which counters are to be preset.

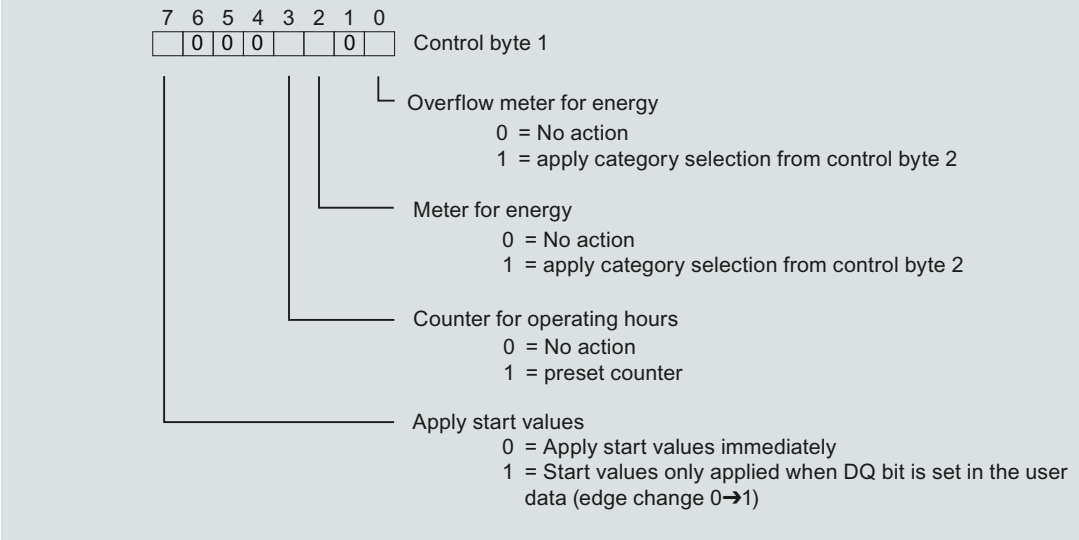

Figure 2-919 Control information DS 143, control byte 1 (write access)

- In control byte 2 you determine which energy meter categories you want to preset.

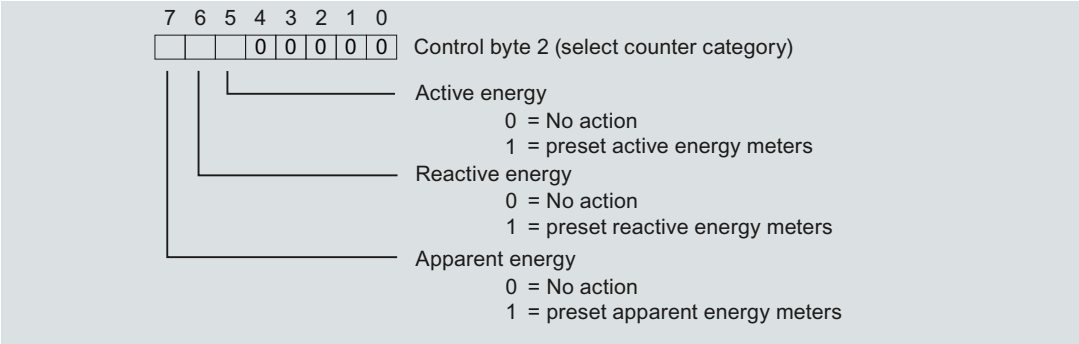

Figure 2-920 Control information DS 143, control byte 2 (write access)

Operating hours counter

9

Introduction

The AI Energy Meter RC ST provides four operating hours counters which count the operating hours of the connected consumers:

- Three phase-specific operating hours counters
- 1 operating hours counter which displays the value of the largest phase-specific operating hours counter.

Retentivity

The AI Energy Meter RC ST stores all counter values retentively. After an interruption (e.g. Power System Off), counting resumes with the retentively stored values.

Functions

The operating hours counters provide the following basic functions:

- Measuring ranges from 0 to 3.4 x 10^{38} hours.
- Starting and stopping operating hours counters via gate
- Preset and apply start values in RUN
- Evaluating counter states using data records and payload

9.1 Evaluating operating hours counters

There are two ways of evaluating the operating hours counters:

- Reading counter states using data records with the instruction RDREC.
- Reading counter states from the user-defined payload variants.

Data records for operating hours counter

You can read out measured values for operating hours in the following data records.

The evaluation of measured data using data records is described in section Reading out and processing measured values (Page 40).

Name of the data record	Number of the data record	Comment
Data record for energy meter (Page 183)	DS 143	Phase-specific operating hours counter for phase L1, phase L2, phase L3 and largest phase-specific operating hours counter L1L2L3
Measured value data record for advanced measurement and status values	DS 150	
Measured value data record of user-defined data record (Page 203)	DS 151	Operating hours counters can be selected in a user-defined manner

Payload variants for operating hours counters

You can read out measured values for operating hours in the following payload variants.

The evaluation of measured data using payload variants is described in section Payload variants with 32 bytes input data / 20 bytes output data (Page 160).

Name of the payload variant	Number of the payload variant	Comment
User-defined payload variant	ID 1 or 01_H and ID 2 or 02_H	Operating hours counters can be selected in a user-defined manner

9.2 Preset and apply start values for operating hours counters

Introduction

At the beginning of a new work order, it may be useful to start counting of the operating hours counters with new start values.

Define the new start values for the operating hours counters in data record DS 143.

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

For **all** module versions there are two ways of applying the start values:

- Transfer start values from data record DS 143 and apply them **immediately**
- Transfer start values from data record DS 143 and only apply them after setting a special bit (DQ bit for operating hours counter reset)

Both options are described in the following sections.

General reset

With module versions with 20 bytes of user data you can reset the operating hours counters. With a general reset, you cannot preset any start values; the start values for operating hours counters are always zero with a general reset.

You can find additional information on the general reset in the section Basics for reading measured values (Page 40).

9.2.1 Preset start values for operating hours counters

Define the start values for operating hours counters using data record DS 143.

Introduction

You have created a PLC data type that has an identical structure to data record DS 143.

Structure of data record DS 143

The following overview shows the structure of the data record DS 143 in simplified form.

More detailed information about the structure of the data record 143 is available in section Structure of energy meters (DS 143) (Page 183).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Control byte 1 - L1	BYTE	Bit string	-	-
3	Control byte 2 - L1	BYTE	Bit string		
4	Control byte 1 - L2	BYTE	Bit string		
5	Control byte 2 - L2	BYTE	Bit string		
6	Control byte 1 - L3	BYTE	Bit string		
7	Control byte 2 - L3	BYTE	Bit string		
8...15	Start value for active energy inflow L1	LREAL	Wh	You will find the exact assignment	61180
16...23	Initial value active energy outflow L1	LREAL	Wh		61181
:	:	:	:		:

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
158...161	Start value operating hours L1	REAL	h	in the section Structure of energy meters (DS 143) (Page 183).	65505
162...165	Start value operating hours L2	REAL	h		65506
166...169	Start value operating hours L3	REAL	h		65507

Assignment of data record DS 143

Byte 0 and Byte 1: Version of the data record

Header information for the version of the data record.

Byte 2 ... Byte 7: Control bytes for energy and overflow counter

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy meters, overflow counters and operating hours counters. The length of the control information amounts to 2 bytes for each phase.

Byte 8 ... byte 157: Start values for the individual energy meters and overflow counters

The start values for energy counters in data record 143 are 64-bit floating point numbers. The format corresponds to the data type LREAL in S7-1200 and in S7-1500.

The initial values for overflow counters in data record 143 are 16-bit integers. The format corresponds to the data type UINT in S7-1200 and in S7-1500.

Byte 158 ... byte 169: Start values for operating hours counter

The start values for operating hours counters in data record 143 are 32-bit floating-point number. The format corresponds to the data type REAL in S7-1200 and in S7-1500.

9.2.2 Apply start values from data record DS 143 immediately

Applying the start values for each separate operating hours counter is possible.

Requirement

In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and you have entered the start values.

Procedure for all module versions

1. In Control byte 1 of DS 143 (bytes 2, 4 and 6), for each phase, define that you want to immediately apply the start values for operating hours counters.
   - Set the Bit 3 to 1 so that the start values for the operating hours counters are preset.
   - Set the Bit 7 to 0 so that the module **immediately** applies the start values after writing the data record.

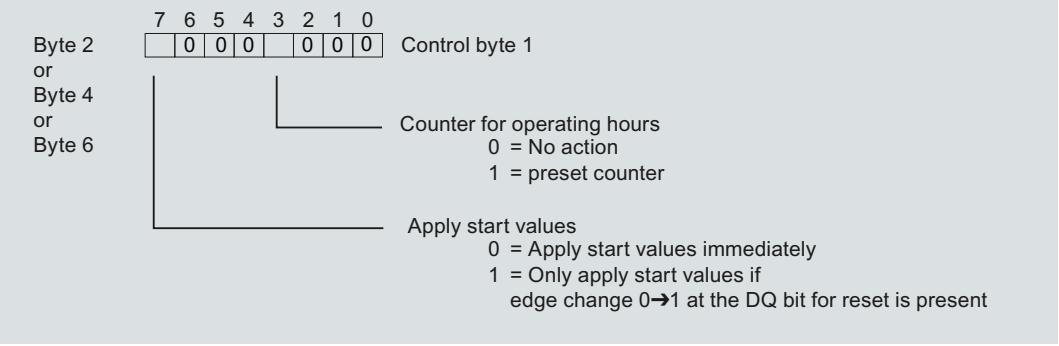

Figure 2-921 Allocation of the control bytes in DS 143 for operating hours

2. Transfer the data record with the WRREC instruction to the CPU.

9.2.3 Apply start values from data record DS 143 with DQ bit

Due to the differing lengths of the output data, setting of the start values for the operating hours counters depends on the configured module version.

Module versions with 20 bytes of output data

If you use module versions with 20 bytes of output data, you can:

- Apply start values for **all** operating hours counters.
- Apply start values for **individual** operating hours counters separately.

Module version with 2 bytes of output data

If you use the module version with 2 bytes of output data, apply the start values for **all** operating hours counters simultaneously.

Requirement

- In your STEP 7 project you have created a PLC data type that has an identical structure to data record DS 143 and have entered the start values.
- Set the Bit 3 to 1 so that the start values for the operating hours counters are preset.
- In control byte 1 of DS 143 you have set Bit 7 to "1" (apply start values via DQ bit). (see previous figure)
- You have transferred the data record DS 143 with new start values to the CPU. The assignment of the data record can be found in Structure of energy meters (DS143) (Page 183).

NOTE

Pre-set start values for counters

If you have not yet transferred any start values to the CPU using the data record DS 143, then start the counters with the value 0.

Procedure for applying the start values of all operating hours counters

Applying the start values for all operating hours counters with the module versions with 2 bytes and 20 bytes of output data is identical.

1. Set the reset bit for operating hours counters (Bit 5) in Byte 1 in the output data.

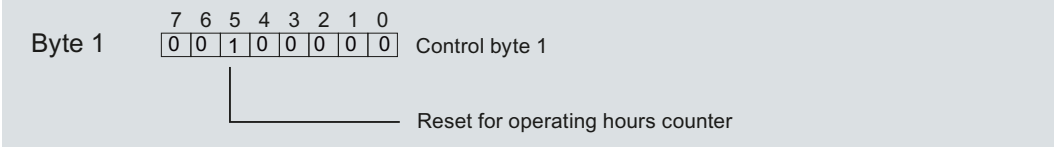

Figure 2-922 Control byte 1 Reset for all operating hours counters

If there is an edge change of the reset bit from 0 to 1, the module applies the start values for all operating hours counters.

Procedure for applying the start values of individual operating hours counters

NOTE

Applying the start values for phase-specific operating hours counters

Applying the start values for phase-specific operating hours counters does not differ from the procedure described above. In the output data, select the reset bits for the phase-specific operating hours counters in bytes 6, 8 and 10.

9.3 Starting and stopping operating hours counters

There are two ways of starting or stopping counting with the operating hours counter AI Energy Meter RC ST:

- Counting with gate

  The module starts counting when you set the DQ bit for the counter gate in the output data using an edge change from 0 -> 1. If you reset the DQ bit for the counter gate using an edge change from 1 -> 0, the counter stops.

- Counting without gate

  The module starts counting immediately as soon as the module is switched on. Counting cannot be stopped.

Both options are described in the following sections.

Counting with gate

Requirements:

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

If you wish to start counting using the gate, proceed as follows:

1. Activate the parameter "Enable operating hours counter gate" in the parameter assignment of the module.
2. Set the DQ bit for the counter gate (Bit 4) in control byte 1 in the output data.

The module starts counting as soon as there is an edge change from 0 -> 1 at the DQ bit for the counter gate.

If you wish to stop the counting again, then reset Bit 4 in control byte 1 in the output data. Counting stops at an edge change from 1 -> 0.

The "Enable operating hours counter gate" parameter and the DQ bit for the "counter date" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

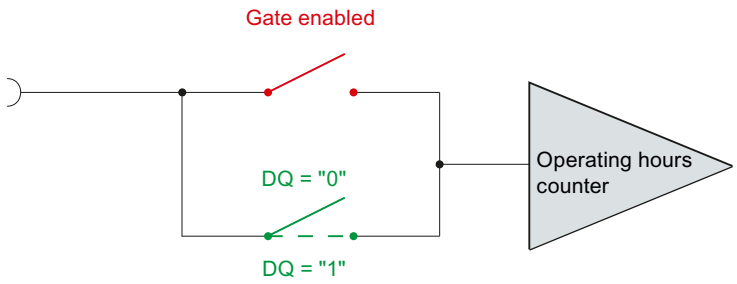

Figure 2-923 Gate enabled

Counting without gate

Requirement

The current value is higher than the configured "Low limit for measuring current in relation to nominal value current [0.1%]".

Procedure

Deactivate the parameter "Enable operating hours counter gate" in the parameter assignment of the module.

The module starts counting as soon as the data record has been applied by the CPU.

The counter continues to count.

Gate disabled: Gate is always "open" (signal path closed)

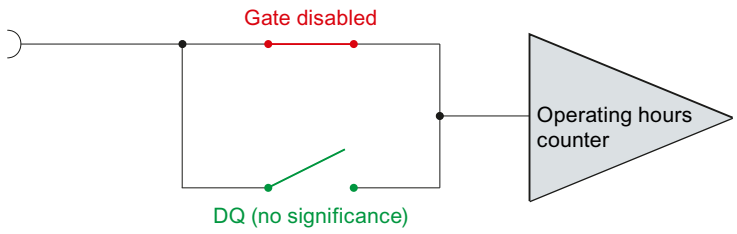

Figure 2-924 Gate disabled

Limit monitoring 10

10.1 How limit monitoring works

Introduction

The AI Energy Meter RC ST supports monitoring of parameterizable low **or** high limits for up to 16 analog measured or calculated variables.

You can also specify multiple limits for each measured or calculated variable, in order to define a high or low value range.

The measured value data record 150 returns the current status of limit violations and one counter per limit that displays the number of limit violations. In addition, a hardware interrupt may be generated for each limit violation.

The status of the limit violations can also be evaluated in the payload variant 240 ($F0_H$) or via the user-defined payload variant or the user-defined data record via the measured value ID 65509.

Benefits

With activated limit monitoring you can already detect any irregularities in the measured value acquisition already in field level.

Retentivity

All counter states are stored retentively in the AI Energy Meter RC ST. After an interruption (e.g. Power System Off), the counting resumes with the retentively stored values.

Configuring

You configure the following limit monitoring settings in STEP 7:

- Measured variable that is to be monitored.
- Activate / Deactivate limit monitoring.
- Activate / deactivate gate limit monitoring.
- High or low limit values.
- Delay time and hysteresis for each limit.
- Activate / Deactivate hardware interrupts at limit violation.
- Measured value that is subject to limit monitoring.

Hardware interrupt at a limit violation

The hardware interrupt provides the following information:

- Measured value ID of the monitored measured or calculated variable
- Number of the limit (0 = Limit 1. 15 = Limit 16)
- Information on whether limit was exceeded or fallen below

For more detailed information, refer to section Hardware interrupts (Page 99).

Controlling functions in RUN

The following table shows the supported control information:

Control information	Default value	Available in
Enable/disable monitoring per limit[1]	Disabled	Module version with 20 bytes of output data
Reset number of total limit violations	0	Module version starting at 2 bytes of output data

[1] Effective only with enabled gate

10.2 Influence of hysteresis and delay time on limit monitoring

Delay time and hysteresis

In order to prevent the triggering of limit violations with small fluctuations, you have the following configuration options in STEP 7:

- Delay time in seconds (0 to 10 s)

  With the delay time, you filter faults and thereby prevent limit value monitoring from triggering too frequently. The limit violation is counted only when the limit violation is present for longer than the configured delay time. The delay time is also taken into consideration with an outgoing limit violation, directly after a high or low limit has been violated in the permitted range. If the measured variable lies between limit violation and hysteresis after the limit violation has been corrected again, the delay time expires also without leaving the hysteresis.

- Hysteresis as a percentage (0 to 20%)

  With the hysteresis, you suppress fluctuations around the limit. The hysteresis is a tolerance range that you define as a percentage deviation of the configured limit. The limit violation is considered to be corrected only when the monitored value leaves the tolerance range.

NOTE

You can get information about underflow and overflow from the calculation of minimum and maximum values of selected measured variables.

The following figure shows the value-over-time for two measured values using the example of a high and low limit as well as the influence of hysteresis and delay time on the counting of the limit violations.

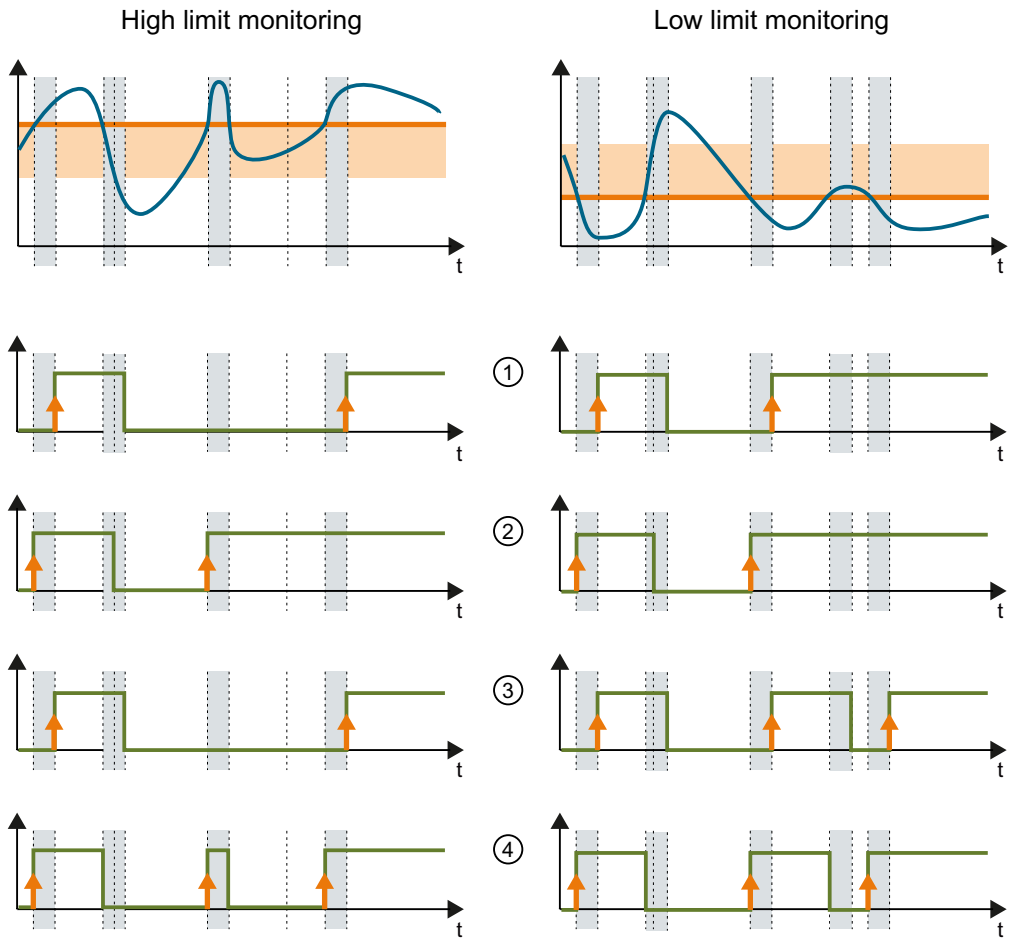

	Configured limit.		Signal wave
	Configured delay time. Is taken into consideration during coming and going.	①	Limit monitoring with hysteresis and delay time
	Hysteresis range. Only considered for outgoing.	②	Limit monitoring with hysteresis, but without delay time
	Value-over-time for which the limit is monitored.	③	Limit monitoring without hysteresis, but with delay time
	Edge change. Counter for limit violations is incremented by 1. If parameterized, a hardware interrupt is triggered.	④	Limit monitoring without hysteresis and delay time

Figure 2-925 Influence of hysteresis and delay time on the limit

See also

How limit monitoring works (Page 73)
Minimum and maximum values (Page 80)

10.3 Reset, activate and deactivate counters for limit violation

Introduction

At the beginning of a new work order, it can be useful to reset or also enable/disable the counters for limit violations of the AI Energy Meter RC ST.

Resetting here means that the counters for limit violations are reset to 0.

Due to the differing lengths of the output data resetting of the counters for limit violations depends on the configured module version.

Resetting at module version with 20 bytes of output data

1. Select the counters for limit violations that you want to reset in control bytes 3 and 4; see "Enabling/disabling the counters for limit violations".
2. In control byte 1, set the rest bit (bit 3) with an edge change from 0 to 1; see "Resetting the counters for limit violations".

Resetting for module version with 2 bytes of output data

Set the reset bit (Bit 3) in Control byte 1 from 0 to 1 through an edge change. Resetting acts globally on all the configured counters for limit violation.

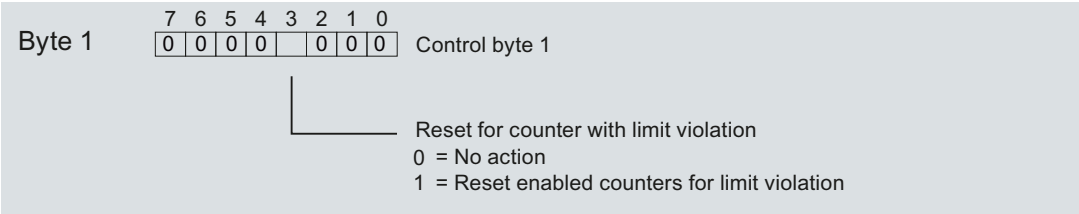

Figure 2-926 Resetting of the counters for limit violations

Activating / Deactivating counters for limit violations

Activating/deactivating of the counters for limit violations is only possible for module versions with 20 bytes of output data.

Requirements: "Gate for limit value monitoring" was parameterized during configuration of the module using STEP 7 or by writing the data record DS 128.

Select the counters for limit violations that you want to activate / deactivate in Control bytes 3 and 4.

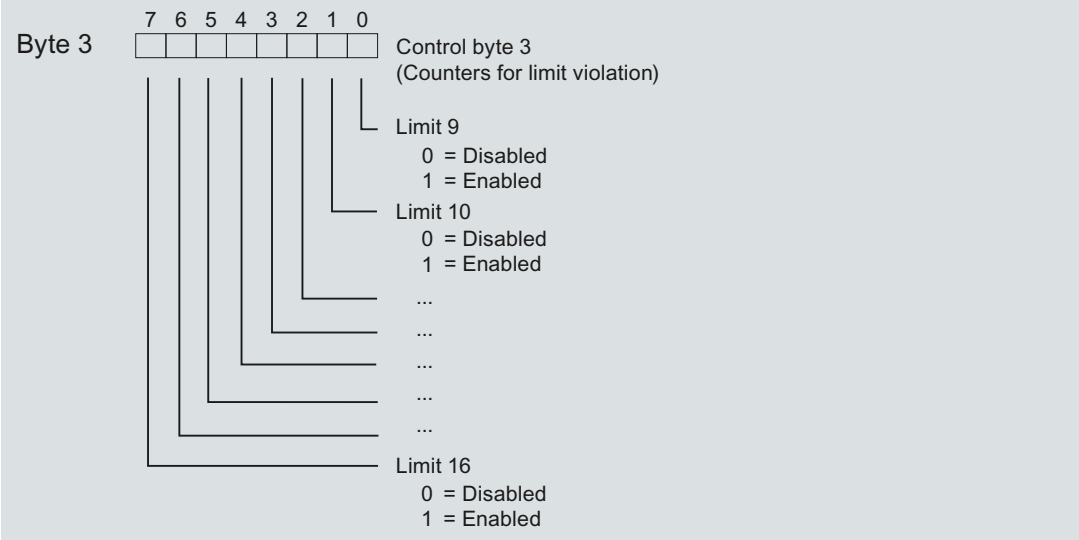

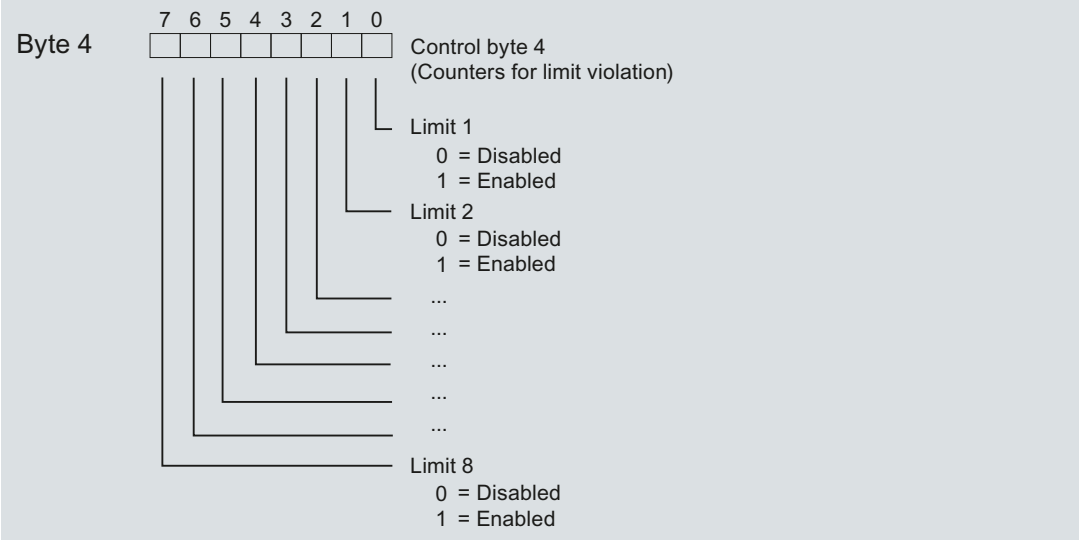

Figure 2-927 Activating / deactivating of the counters for limit violations

10.4 Measured variables for limit monitoring

You can use measured variables from the section Measured variables (Page 135) for limit monitoring.

The value range of the parameter "Limit x" is -3.0E+09 ... +3.0E+09.

The table below shows you which measured variables are **not** available for limit monitoring.

Measured value ID	Measured variables
220	Active energy inflow L1L2L3 (Int32)
221	Active energy outflow L1L2L3 (Int32)

Measured value ID	Measured variables
222	Reactive energy inflow L1L2L3 (Int32)
223	Reactive energy outflow L1L2L3 (Int32)
224	Apparent energy L1L2L3 (Int32)
225	Total active energy L1L2L3 (Int32)
226	Total reactive energy L1L2L3 (Int32)
61136	Neutral current maximum value
61137	Neutral current minimum value
62110	Active energy inflow L1 (Int32)
62111	Active energy outflow L1 (Int32)
62112	Reactive energy inflow L1 (Int32)
62113	Reactive energy outflow L1 (Int32)
62114	Apparent energy L1 (Int32)
62115	Total active energy L1 (Int32)
62116	Total reactive energy L1 (Int32)
62136	Fundamental cos φ active factor L1 (SINT8)
62210	Active energy inflow L2 (Int32)
62211	Active energy outflow L2 (Int32)
62212	Reactive energy inflow L2 (Int32)
62213	Reactive energy outflow L2 (Int32)
62214	Apparent energy L2 (Int32)
62215	Total active energy L2 (Int32)
62216	Total reactive energy L2 (Int32)
62236	Fundamental cos φ active factor L2 (SINT8)
62310	Active energy inflow L3 (Int32)
62311	Active energy outflow L3 (Int32)
62312	Reactive energy inflow L3 (Int32)
62313	Reactive energy outflow L3 (Int32)
62314	Apparent energy L3 (Int32)
62315	Total active energy L3 (Int32)
62316	Total reactive energy L3 (Int32)
62336	Fundamental cos φ active factor L3 (SINT8)
65497	Current module time
65500	Qualifier L1
65501	Qualifier L2
65502	Qualifier L3
65503	Qualifier L1L2L3
65508	Status of energy counter overflows
65509	Status of limit violations 1...16
66001	Voltage L1-N

Measured value ID	Measured variables
66002	Voltage L2-N
66003	Voltage L3-N
66004	Voltage L1-L2
66005	Voltage L2-L3
66006	Voltage L3-L1
66007	Current L1
66008	Current L2
66009	Current L3
66010	Apparent power L1
66011	Apparent power L2
66012	Apparent power L3
66013	Active power L1
66014	Active power L2
66015	Active power L3
66016	Reactive power Qn L1
66017	Reactive power Qn L2
66018	Reactive power Qn L3
66019	Power factor λ L1
66020	Power factor λ L2
66021	Power factor λ L3
66030	Frequency (Uint8)
66031	Frequency (Uint16)
66034	Active power L1L2L3
66035	Reactive power Qn L1L2L3
66036	Apparent power L1L2L3
66037	Power factor λ L1L2L3
66038	Reactive power Qtot L1L2L3

Minimum and maximum values 11

11.1 Minimum and maximum values

Introduction

The AI Energy Meter RC ST determines the respective highest and lowest measured or calculated value for a series of measured and calculated values. The values are stored retentively in the module and can be read using measured value data records DS 144 (Page 187), DS 145 (Page 189), DS 154 and DS 155 (Page 206).

Benefits

Using the stored minimum and maximum values, for example, you can detect further irregularities in addition to limit monitoring.

Calculation of minimum and maximum values

Minimum and maximum values are only calculated for the phases in accordance with the configured connection type. Existing minimum and maximum values that have not been calculated are assigned initial values. If faults such as under or overcurrent occur during operation, new minimum and maximum values are calculated.

The measured and calculated values are initialized as follows during commissioning of the AI Energy Meter RC ST so that the first calculation of minimum and maximum values supplies a plausible result:

- Maximum values for measured and calculated values: Minimum values
- Minimum values for measured and calculated values: Maximum values

Minimum and maximum values are determined as "slave pointer procedures" from the start of calculation. Start is effective as of activation of the function or after a reset. The module uses the current actual value as the start value.

Output of the measurement values

For technical reasons, after plugging in or switching on the load voltage, the module returns the minimum and maximum values delayed by approx. 2 s.

Configuring

You configure the following settings in STEP 7:

- Enable calculation of minimum and maximum values
- Enable minimum and maximum value calculation gate

Controlling functions in RUN

The following table shows the supported control information:

Control information	Default value	Available in
Reset saved maximum values	0	Module version starting at 2 bytes of output data
Reset saved minimum values	0	Module version starting at 2 bytes of output data

NOTE
Automatic reset
If you change the parameters for current or voltage transformers, the minimum and maximum values are reset automatically to their initial values.

11.2 Resetting minimum and maximum values

Description

At the beginning of a new work order, it may be useful to reset the minimum and maximum values of the AI Energy Meter RC ST. Resetting means that the minimum and maximum values are reset to their initial values. Initial values are described, see section Measured value data record for maximum values (DS 144) (Page 187), Measured value data record for minimum values (DS 145) (Page 189), Measured value data record for maximum values with time stamp (DS 154) and Measured value data record for minimum values with time stamp (DS 155) (Page 206).

Minimum and maximum values are only reset using a Reset via output data (DQ bit).

Due to the differing lengths of the output data resetting of the minimum and maximum values depends on the configured module version. If you use module versions with 20 bytes of output data, you can:

- Reset the minimum and maximum values for **all** phases.
- Reset the minimum and maximum values for each **individual** phase.

If you use the module version with 2 bytes of output data, you always reset **all** the minimum and maximum values simultaneously.

Time stamps are set to initial values (01.01.1970, 0:00) on reset.

Procedure for module version with 20 bytes of output data

Resetting the minimum and maximum values for all three phases

1. In byte 2, select the categories of the minimum and maximum values that you want to reset.
   - Set bit 0 for voltage and frequency.
   - Set bit 1 for current and power factor.
   - Set bit 2 for active power.
   - Set bit 3 for reactive power.
   - Set bit 4 for apparent power.
   - Set bit 5 for active energy.
   - Set bit 6 for reactive energy.
   - Set bit 7 for apparent energy.

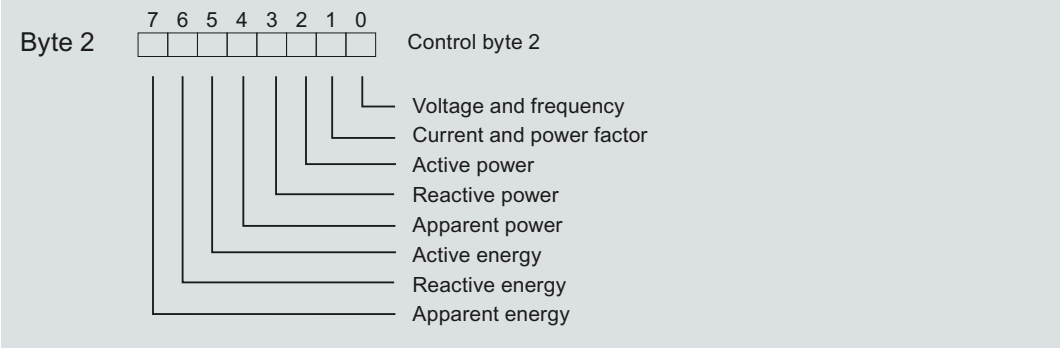

Figure 2-928 Selection of minimum and maximum value category

2. In byte 1, set reset bit 0 for minimum values or reset bit 1 for maximum values.
   If there is an edge change of the reset bits from 0 to 1, the module resets the selected minimum or maximum values for all three phases that you previously selected in byte 2.

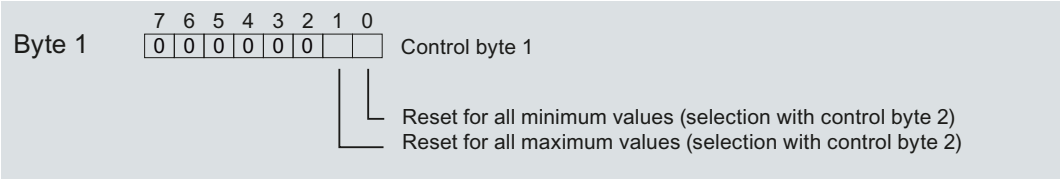

Figure 2-929 Reset bit for minimum and maximum values

Resetting minimum and maximum values for phase-specific measurement

You can also reset the minimum and maximum values on a phase-specific basis using the output data.

Follow the procedure for "Resetting minimum and maximum values for all three phases" as applicable.

1. Select the categories of minimum and maximum value that you want to reset on a phase-specific basis.
   - In byte 7, set the bits for the category of minimum and maximum values in phase 1.
   - In byte 9, set the bits for the category of minimum and maximum values in phase 2.
   - In byte 11, set the bits for the category of minimum and maximum values in phase 3.
2. Set the reset bit (bit 0 and bit 1) for minimum or maximum values.
   - in byte 6 for phase 1
   - in byte 8 for phase 2
   - in byte 10 for phase 3

If there is an edge change of the phase-specific reset bits from 0 to 1, the module resets the minimum or maximum values for the given phase.

11.3 Gate

NOTE
Module version with 2 bytes of output data
The gate is not available for the module version with 2 bytes of output data.

There are two ways of starting or stopping the calculation of the minimum and maximum values:

- Calculation of the minimum and maximum values with gate

  The module starts the calculation when you set the DQ bit for the gate in the output data (output data byte 1, bit 2 = "1") using an edge change from 0 -> 1. If you reset the DQ bit using an edge change from 1 -> 0, the calculation stops.
- Calculation of the minimum and maximum values without gate

  The module starts the calculation as soon as the module is started. The calculation cannot be stopped.

Both options are described in the following sections.

Calculation of the minimum and maximum values with gate

Procedure
If you wish to start calculating using the gate, proceed as follows:

1. Activate the parameter "Enable minimum and maximum value calculation" in the parameter assignment of the module.
2. Set the DQ bit of the gate for minimum and maximum value calculation (Bit 2) in control byte 1 in the output data.

The module starts calculating as soon as there is an edge change from 0 -> 1 at the DQ bit for the gate.

If you wish to stop the calculating again, then reset Bit 2 in control byte 1 in the output data. Calculating stops at an edge change from 1 -> 0.

The "Enable minimum and maximum value calculation" parameter and the DQ bit for the "gate" behave like the parallel connection of contacts.

Gate enabled: Gate "open" if DQ = "1"

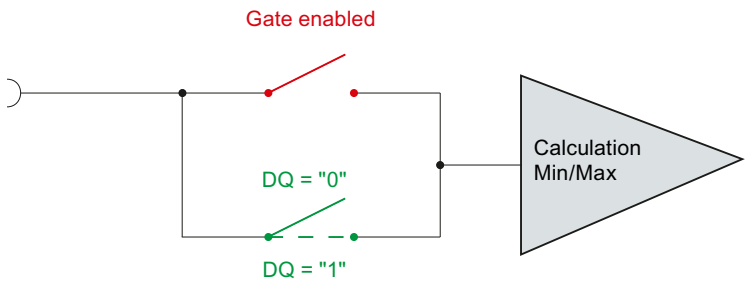

Figure 2-930 Gate enabled

NOTE

Module-global/phase-granular PLC

If you are using the gate control for all three phases simultaneously, use the control byte 1 at output address 1. For a phase-specific resolution of the gate control, use the addresses 6 (Phase1), 8 (Phase2) or 10 (Phase3) as control byte 1. The resolution of a module-global PLC overrules a phase-granular resolution.

Calculation of the minimum and maximum values without gate

Procedure

Deactivate the parameter "Enable minimum and maximum value calculation gate" in the parameter assignment of the module.

The module starts calculating as soon as the module is started. The calculating cannot be stopped.

Gate disabled: Gate is always "open" (signal path closed)

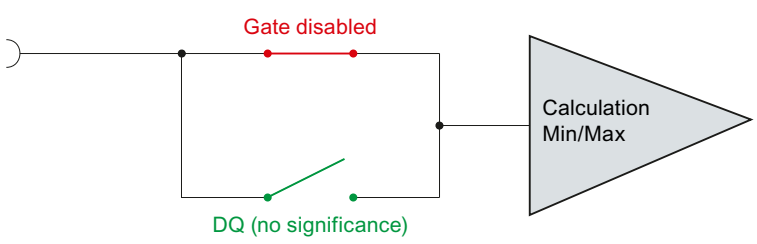

Figure 2-931 Gate disabled

Quality analysis functions 12

12.1 Reactive power compensation

Use the power factor of the fundamental for the reactive power compensation.

The power factor of the fundamental is available, among other things, in the measured value data record DS 142 (Page 177) or in the payload.

12.2 Active factor and power factor

The AI Energy Meter RC ST returns the active and power factor individually for each phase and as an aggregate.

Active factor

The active factor is defined as follows:

cos φ (active factor, signed, fundamental oscillation): $\cos \varphi = P1 / S1$

φ = phase shift angle of fundamental oscillation

P1 = active power of fundamental oscillation

S1 = apparent power of fundamental oscillation

Power factor

The power factor $\lambda = \cos \Phi$ is the ratio of active power (P) to the total apparent power (S) over the fundamental oscillation and all harmonics (total):

λ (power factor, unsigned, total): $\lambda = \cos \Phi = |P| / S$

12.3 Neutral current In

The module can measure or calculate the neutral current.

For measuring, you have to connect a current/voltage transformer or Rogowski-coil to the neutral conductor. The behavior "measuring or calculating" can be set for each parameter. The main application of the measured value "Neutral current IN" (ID: 61149) are three-phase networks with existing 4th conductor, neutral: The neutral current usually shows incorrectly flowing currents. In an ideal three-phase network, the neutral current = 0.

The determination of the neutral current is not subject to current suppression.

Parameter assignment options

If there a neutral conductor in a connection type, the following parameters are available:

- Neutral current measurement deactivated
- Calculate the neutral current measurement
- Measure the neutral current measurement

If there is no neutral conductor in a connection type, the following parameters are available:

- Do not use current channel
- Measure current channel

Display via channel LED

Neutral conductor exists for connection type	calculate	measuring	Error	Channel LED
Yes	Yes	Yes	No	Green
Channel disabled	---	---	---	Off
No	No	Yes	No	Green

Phase-based measured values 13

Introduction

The AI Energy Meter RC ST makes the measured values of individual phases available.

- Through the payload variants
  - Phase-specific measurement Phase L1 with payload variants 158 ($9E_H$) and 159 ($9F_H$)
  - Phase-specific measurement phase L2 with payload variants 156 ($9C_H$) and 157 ($9D_H$)
  - Phase-specific measurement phase L3 with payload variants 154 ($9A_H$) and 155 ($9B_H$)
- Via measured value data records
  - Phase-specific measurement for the phases L1, L2 and L3 with data record 142
  - Phase-specific measurement for phase L1 with data record 147
  - Phase-specific measurement for phase L2 with data record 148
  - Phase-specific measurement for phase L3 with data record 149

Payload variants

Through the payload variants 154 ($9A_H$) to 159 ($9F_H$) you can evaluate the following measured values for each phase of an AC / three-phase network:

- Quality information
- Current and voltage
- Active, reactive and apparent power
- Active, reactive and apparent energy
- Power factor

You can find the structure of the payload variants in appendix Payload variants with 32 bytes of input data / 20 bytes of output data (Page 160).

Measured value data records

Through the measured value data records DS 142, DS 147, DS 148 and DS 149 you can evaluate the following measured values for each phase of an AC / three-phase network:

- Quality information
- Current and voltage
- Minimum current and minimum voltage
- Maximum current and maximum voltage
- Active, reactive and apparent power
- Minimum active, reactive and apparent power

- Maximum active, reactive and apparent power
- Active, reactive and apparent energy
- Power factor
- Minimum power factor
- Maximum power factor

The structure of the measured value data record is available in the appendix E Measured value data record for phase-based measured values L1 (DS 147) version 1 (Page 192).

See also

Measured value data record for phase-based measured values L2 (DS 148) version 1 (Page 195)

Measured value data record for phase-based measured values L3 (DS 149) version 1 (Page 199)

Parameters 14

14.1 Parameters

Parameters of AI Energy Meters RC ST

You will usually configure the AI Energy Meter RC ST with STEP 7 (TIA Portal, if necessary, with HSP). In this case, STEP 7 (TIA Portal) checks the configured properties for plausibility during configuration.

You can also assign parameters to the module using a GSD file and STEP 7 or the configuration software of any provider. In this case, the module checks the validity of the configured properties only after the configuration has been downloaded. Note that some parameters depend on the selected connection type of the AI Energy Meter RC ST. For example in the connection type 1P2W for measurements in single-phase AC network it does not make sense to enter parameters for Phases 2 and 3. This is not checked by the system if the GSD file is used.

The effective range of the parameters that can be set using a GSD file depends on the type of bus system used:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation with PROFIBUS DP in an ET 200SP system

In addition, you can control parameterized functions via the user program in RUN mode. When you assign parameters in the user program, the WRREC instruction transfers the parameters to the module using data records (see appendix Parameter assignment using parameter data records (Page 113)).

The following table summarizes all the configurable parameters with STEP 7 (GSD file).

Table 2-993 Parameters AI Energy Meter RC ST (GSD file)

Parameters	Value range	Default setting
Hardware interrupts *	• Disable • Enable	Disable
Inputs		
Diagnostics: No supply voltage L+	• Disable • Enable	Disable
Connection type	• Disabled • 1P2W - 1 phase, 2 conductors • 3P4W1, 3 phases, 4 conductors, balanced load • 3P4W - 3 phases, 4 conductors • 3x1P2W - 3 x 1 phase, 2 conductors each • 2P3W - 2 phases, 3 conductors • 3P3W, 3 phases, 3 conductors • 3P3W1, 3 phases, 3 conductors, balanced load	3P4W - 3 phases, 4 conductors

* Reconfiguration in RUN is not possible.

Parameters	Value range	Default setting
Voltage measuring range	• 100 V • 110 V • 115 V • 120 V • 127 V • 190 V • 200 V • 208 V • 220 V • 230 V • 240 V • 277 V • 300 V	230 V
Line frequency	• 50 Hz • 60 Hz	50 Hz
Activate gate switch for energy meter	• Disable • Enable	Disable
End value energy meter	• No end value (infinite counting) • Count periodically to 10^3 • Count periodically to 10^6 • Count periodically to 10^9 • Count periodically to 10^{12} • Count periodically to 10^{15}	No end value (infinite counting)
Payload variant	See the table Overview of the payload variants (Page 160)	Total power L1L2L3 (W#16#FE)
Minimum and maximum value calculation	• Disable • Enable	Disable
Minimum and maximum value calculation gate	• Disable • Enable	Disable
Neutral conductor: Current transformer secondary voltage [0.1 mV]	• 0 = Disabled • 100 ... 6000 = measuring • 65535 = calculation	250
Neutral conductor: Current transformer primary rated current [A]	• 1 ... 16000	1000
Current transformer type for line conductors L1, L2, L3 and neutral conductor	• 0 = Rogowski-coil • 1 = current/voltage transformer	0
Diagnostics overflow current	• Disable • Enable	Disable
Diagnostics overflow voltage	• Disable • Enable	Disable
Diagnostics underflow voltage	• Disable • Enable	Disable
Diagnostics overflow cumulative values	• Disable • Enable	Disable
Nominal value current [A]	• 0 ... 99999	1

* Reconfiguration in RUN is not possible.

Parameters	Value range	Default setting
Tolerance factor overcurrent in relation to nominal value current [0.1%]	• 10 ... 60000	100
Tolerance time overcurrent [ms]	• 0 ... 60000	40000
Low limit current measurement in relation to nominal value current [0.1%]	• 0 ... 200	10
Enable operating hours counter	• Disable • Enable	Disable
Activate gate switch for energy meter	• Disable • Enable	Disable
Current transformer secondary voltage [0.1 mV]	• 100 ... 6000	250
Current transformer primary rated current [A]	• 1 ... 16000	1000
Reverse current direction	• Disabled • Reverse current direction	Disabled
Nominal value voltage [V]	• 1 ... 999999	230 V
Tolerance factor overvoltage/undervoltage [0.1%]	• 10 ... 500	100
Voltage transformer primary voltage [V]	• 1 ... 999999 V	230 V
Voltage transformer secondary voltage [V]	• 1 ... 500 V	230 V
Limits		
Number of limit values	• 0 ... 16	0
Limit monitoring	• Disable • Enable	Disable
Measured variable	• Measured value ID, see Measured value data records	None
Activate gate switch for energy meter	• Disable • Enable	Disable
Hardware interrupt	• Disable • Enable	Disable
Limit	• depending on the selected measured variable	0.0000
Type	• High limit • Low limit	High limit
Hysteresis for limit monitoring [0.1%]	• 0 ... 200 [0.1%]	10
Delay time for limit monitoring [s]	• None • 1 ... 10 s	None
Payload mapping		
Number of measured values	• 0 ... 64	0
Measured variable	• Measured value ID, see Measured variables	None

* Reconfiguration in RUN is not possible.

Parameters	Value range	Default setting
Data record mapping		
Number of measured values	• 0 ... 150	0
Measured variable	• Measured value ID, see Measured variables	None

* Reconfiguration in RUN is not possible.

See also

Measured variables for connection type (Page 135)

14.2 Description of parameters

Basic parameters

Hardware interrupts

Enable the hardware interrupt for the entire module here.

Diagnostics: No supply voltage L+

Activate the diagnostics Missing load voltage L+. If there is no voltage or too little voltage at terminal 17, the message "Missing load voltage" is output and a diagnostics interrupt is triggered.

Connection type

Specify the connection type you used for the AI Energy Meter RC ST.

For more detailed information, refer to "Connection examples (Page 23)".

Voltage measuring range

Here you set the voltage measuring range in which the system connected to the AI Energy Meter RC ST works. This parameter is only required when calibrating the module.

Line frequency

Here you set the line frequency in which the system connected to the AI Energy Meter RC ST works.

Energy meters gate switch

Activate gate switch for energy meter When the gate is activated, the energy meter only counts when the corresponding output data bit (DQ bit) is set to "1".

End value energy meter

Select the end value for the periodic counting of the energy meter. You can also specify that the energy meter is to count without a end value (infinite counting). The calculated energy meter values are stored retentively in the module.

Payload variant

Select payload variant with which the module is to operate once it is started up.

Minimum and maximum value calculation

Activate calculation of the minimum and maximum values. The minimum and maximum value are calculated from the start of the measurement. The values determined are stored retentively in the AI Energy Meter RC ST together with the time stamp.

Minimum and maximum value calculation gate

Activate the gate for minimum and maximum value calculation. When the gate is activated, the energy meter only counts when the corresponding output data bit (DQ bit) is set to "1".

Neutral conductor current measurement

Defines whether the neutral current is measured or calculated.

This parameter does not apply to parameter assignment with GSD file.

Neutral conductor: Current transformer secondary voltage [0.1 mV]

Enter the secondary voltage to determine the current/voltage transformer ratio. The conversion ratio is determined from the primary rated current and the secondary voltage.

The following applies to parameter assignment with GSD file:

- 0 = Neutral conductor function deactivated
- 100 ... 6000 = measure neutral current
- 65535 = calculate neutral current (0xFFFF)

Neutral conductor: Current transformer primary rated current [A]

To determine the current/voltage transformer ratio, enter the primary rated current. The conversion ratio is determined from the primary rated current and the secondary voltage.

Current transformer type for line conductors L1, L2, L3 and neutral conductor

Select the connected current measuring transformer type.

Diagnostics overflow current

The measured current is monitored after expiry of the "Tolerance time" for "Overcurrent [0.1 A] tolerance value". Exceeding the value generates the diagnostics "overflow current".

Diagnostics overflow voltage

The nominal values voltage are monitored for tolerance. An overflow triggers a diagnostics interrupt.

Diagnostics underflow voltage

The nominal values voltage are monitored for tolerance. An underflow triggers a diagnostics interrupt.

Diagnostics overflow cumulative values

A cumulative overflow in the calculated variables is displayed. The values stop at the high or low limit. A violation triggers a diagnostics interrupt.

Nominal value current [A]

Enter the nominal value for the current. This is the "operating point" in your application.

Tolerance factor overcurrent in relation to nominal value current [0.1%]

Further information can be found under Diagnostics: Overload (Page 104).

Tolerance time overcurrent [ms]

Further information can be found under Diagnostics: Overload (Page 104).

Low limit current measurement in relation to nominal value current [0.1%]

The configurable low limit for measuring current refers to the nominal value and is used to avoid incorrect calculations in the case of very low currents. Incorrect measurements of very low currents in particular are a cause of inaccuracies in the current transformer used. Set the low limit for the current measurement to the required value depending on your process.

NOTE

Tip: If you want to find the low limit for the current measurement experimentally, set it to a lower value. Then, feed in a very precise low current and determine the measurement error that can no longer be tolerated. Afterwards, set the low limit for the current measurement to the limit value you have determined.

If current falls below the low limit for the current measurement, the following measured values and derived variables of the affected phase are reset.

- Effective current value
- Neutral current
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A moving mean value is formed from the power values and they only become "0" after a corresponding time. The energy meters for active, reactive and apparent energy as well as the operating hours counters do not count any longer.

Further information can be found under Low limit for measuring current undershot (Page 106).

Enable operating hours counter

Enable the operating hours counter. The counting starts from the configurable low limit of the current measurement. The counter can be reset or pre-assigned using data record or output bit.

Activate gate switch for energy meter

Enable the gate for the operating hours counter. When the gate is activated, the operating hours counter only counts when the corresponding output data bit (DQ bit) is set to "1".

Current transformer secondary voltage [0.1 mV]

Enter the nominal value for the secondary voltage (10.0 mV to 600.0 mV) of the current-voltage-converter or Rogowski coil used. The conversion ratio is determined from the primary rated current and the secondary voltage.

Current transformer primary rated current [A]

Enter the nominal value for the primary rated current (1 A or 16000 A) of the current/voltage transformer used or Rogowski coil. The conversion ratio is determined from the primary rated current and the secondary voltage.

Reverse current direction

Setting to determine whether or not to reverse the direction of current.

In the event of inadvertent incorrect connection, this parameter can be used to correct the measured values, thus saving the hassle of rewiring. The direction of the current is only

evident from the power measurement values. The current measurement value is an rms value.

Nominal value voltage [V]

Enter the nominal value for the voltage. This is the "operating point" in your application.

Tolerance factor overvoltage/undervoltage [0.1%]

Enter the tolerance factor overvoltage/undervoltage here in increments of 0.1%. You can find additional information under Diagnostics: Overflow/underflow (Page 102).

Voltage transformer primary voltage [V]

Enter the nominal value for the primary voltage of the voltage transformer used. The transformer ratio is calculated from the primary and secondary voltage.

Voltage transformer secondary voltage [V]

Enter the nominal value for the secondary voltage of the voltage transformer used. The transformer ratio is calculated from the primary and secondary voltage.

Limits

Number of limit values

Enter the number of measured values that you want to monitor for limits.

Limit monitoring

Activate the monitoring of the limit for a freely definable measured value here. Limit violations are counted and the count values stored retentively.

Measured variable

Enter the measured value ID (Page 135) that you want to use for limit monitoring.

Activate gate switch for energy meter

Activate the gate switch for limit monitoring. When the gate is activated, the limit monitoring is only started when the corresponding bit of the associated output payload is set to "1".

Hardware interrupt

Activate the hardware interrupt. The hardware interrupt is triggered if a high or low limit is violated. Without activation of a hardware interrupt, a limit violation is only displayed in the payload and in DS 150.

Limit

Enter the limit that is to trigger a limit violation when exceeded or fallen below. Limit violations are displayed in the payload and in DS 150.

Type

Select whether it is a high or low limit. Depending on this selection, the limit violation or hardware interrupt is triggered when a value exceeds (high limit) or falls below (low limit) the limit.

Hysteresis for limit monitoring [0.1%]

Enter the hysteresis for limit in percent.

The hysteresis band is below the high limit or above the low limit. The parameter in % refers to the configured limit. If a measured value fluctuates around the limit but does not leave the hysteresis band, a new limit violation is not triggered.

Delay time for limit monitoring [s]

Select the delay time for limit violation. The delay refers to the time that must elapse before an occurrence of a limit violation is reported. Faults can be filtered out by selection of the delay time. The time lag is also taken into consideration during outgoing of the limit violation.

Payload mapping

Number of measured values

Specify the number of measured values/variables that you want to use for the user-specific payload mapping.

Measured variable

Select the measured variable (with the measured value ID (Page 135)) that you want to use for the user-specific payload mapping.

Data record mapping

Number of measured values

Specify the number of measured values/variables that you want to use for the user-specific data record mapping.

Measured variable

Select the measured variable (with the measured value ID (Page 135)) that you want to use for the user-specific data record mapping.

Interrupts/diagnostic alarms 15

15.1 Status and error display

LED display

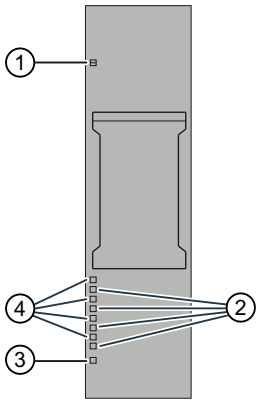

① DIAG (green/red)

② Error (red)

③ PWR (green)

④ Status (green)

Figure 2-932 LED display

Meaning of the LED displays

The following table explains the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostics alarms (Page 100).

DIAG LED

Table 2-994 Meaning of the DIAG LED

DIAG	Meaning
□ Off	Supply voltage of the ET 200SP not OK
☼ Flashes	Module not ready for operation (no parameters assigned)
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Status LED

Table 2-995 Meaning of the Status LED

Status	Meaning
□ Off	Channel deactivated or error
■ On	Channel activated and no error

see also Neutral current In (Page 85)

Error LED

Table 2-996 Meaning of the Error LED

Status	Meaning
□ Off	Channel is OK
■ On	Channel is faulty

PWR LED

Table 2-997 Meaning of the PWR LED

PWR	Meaning
□ Off	Line voltage missing
■ On	Line voltage available

15.2 Interrupts

The analog input module AI Energy Meter RC ST supports hardware and diagnostics interrupts.

15.2.1 Hardware interrupts

Hardware interrupts

The module generates a hardware interrupt at the following events:

- Violation of low limit 1 to 16
- Violation of high limit 1 to 16

You can find detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

The module channel that triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment of the local data double word 8 by the start information of the hardware interrupt organization block.

NOTE

When configuring with a GSD file, you operate the AI Energy Meter RC ST downstream of an S7-1500 CPU. For the correct OB start information to become visible for evaluation by the hardware interrupt, disable the optimized block access at the alarm OB.

LB 8								LB 9								LB 10								LB 11								Bit No. LD 8
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					X	X	X	X						X	X	X	

ID of the measured value for limit monitoring

0000 0000 0000 0001 : 1
0000 0000 0000 0010 : 2
:
:
1111 1111 1111 1111 : 65535

Number of the limit

0000: 1
0001: 2
:
:
1111: 16

Event that has triggered the hardware interrupt

011: Low limit undershot

100: High limit exceeded

Figure 2-933 Start information of the organization block

15.2.2 Diagnostics interrupt

Diagnostic interrupt

The module generates a diagnostic error interrupt at the following events:

- Channel is temporarily unavailable
- Hardware interrupt lost
- Error
- Supply voltage missing
- Parameter assignment error
- Underflow voltage (tolerance for supply voltage) violated
- Overflow voltage (tolerance for supply voltage) exceeded
- Overload (voltage measured value > 2 V or tolerance value overcurrent exceeded after the tolerance time has expired)
- Overflow of the calculated values (measured or calculated values screen exceed the representable range of values)

15.3 Diagnostic alarms

NOTE

Assignment channel in diagnostic message ⇔ Phase

In the diagnostic messages the channels are counted from Channel "0" on, in the AI Energy Meter RC ST from phase "1" on.

Note the following assignment:

- Channel "0" ⇔ Phase "1"
- Channel "1" ⇔ Phase "2"
- Channel "2" ⇔ Phase "3"

Table 2-998 Error types

Diagnostic message	Error code	Meaning	Solution
Undervoltage	2_H	Line voltage (measuring range) is monitored for tolerance. Violation leads to voltage overflow/underflow	Observe the line voltage range
Overvoltage	3_H		
Overload	4_H	• The measured current is monitored after the "Tolerance time" for "Tolerance value overcurrent [0.1A]" has expired. Exceeding this results in overflow current. • The maximum value of the secondary voltage (2 V) is exceeded.	Observe the current range
Error	9_H	Internal module error (diagnostic alarm on channel 0 applies to the entire module).	Replace the module

Diagnostic message	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Load voltage missing	11_H	Missing or insufficient line voltage at terminal 17	Check supply
Channel is temporarily unavailable	$1F_H$	Firmware upgrade is being performed. Channel 0 applies to the entire module. The module is currently not performing any measurements.	--
		A user calibration is being executed at the channel.	Complete the user calibration

15.4 Diagnostics response

Diagnostics response

This section describes the response of the AI Energy Meters RC ST when diagnostics information is reported.

Measured values in the case of diagnostics

Even in the case of diagnostics, measured values continue to be displayed as long as they can still be acquired. If measured values cannot be measured or calculated, "0" is displayed.

Low limit for current measurement undershot (zero suppression)

If the supplied current is less than the configured "Low limit for current measurement" parameter, the current measurement and all dependent variables are suppressed and set to "0".

If current falls below the low limit for the current measurement, the following measured values and derived variables of the affected phase are reset.

- Effective current value
- Active power
- Reactive power
- Apparent power
- Phase angle
- Power factor

A moving mean value is formed from the power values and they only become "0" after a corresponding time. The energy meters for active, reactive and apparent energy as well as the operating hours counters do not count any longer.

Input data to "0"

If the AI Energy Meter RC ST is no longer recognized by the interface module (for example, because it is defective or not plugged in), all input data are set to "0".

15.4.1 Voltage diagnostics

15.4.1.1 Diagnostics: Overflow/underflow

Introduction

You use the parameter "Tolerance factor overvoltage/undervoltage" to define a tolerance range around the set nominal value voltage at the operating point. If the effective value of the primary voltage exceeds this tolerance range, the module reports the diagnostics "overflow" or "underflow".

Calculation of tolerance value measuring voltage

The tolerance value measuring voltage is calculated with the following formula:

Tolerance value measuring voltage = "Nominal value voltage" ± ("Tolerance factor overvoltage/undervoltage [%]" × "Nominal value voltage")

The "Nominal value voltage" is the primary voltage at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-999 Parameter assignment

Parameter	
Diagnostics overflow	Enable
Diagnostics underflow	Enable
Nominal value voltage	1 ... 999999 V
Voltage transformer primary voltage	1 ... 999999 V
Voltage transformer secondary voltage	1 ... 500 V
Tolerance factor overflow/underflow	10 ... 50%

Example

The following figure is a schematic diagram of the principle of operation:

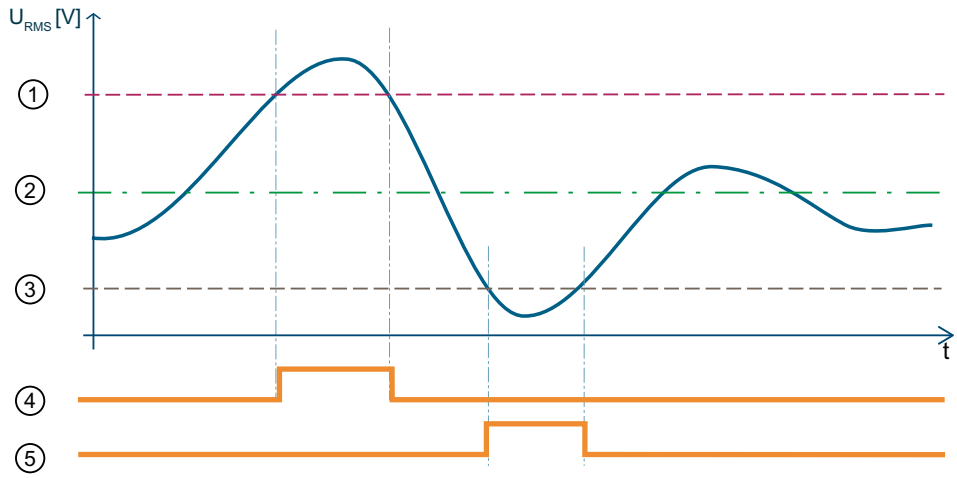

① Upper tolerance value measuring voltage
② Nominal voltage
③ Lower tolerance value measuring voltage
④ Diagnostics "overflow"
⑤ Diagnostics "underflow"

Figure 2-934 "Overflow/Underflow" diagnostics of the effective voltage value

The following table shows the parameter assignment for the example:

Table 2-1000 Parameter assignment

Parameter	
Diagnostics overflow	Enable
Diagnostics underflow	Enable
Nominal value voltage	230 V
Voltage transformer primary voltage	1000 V
Voltage transformer secondary voltage	500 V
Tolerance factor overflow/underflow	20%

In this example a voltage transformer is used with a ratio of 1000V/500V. The operating point of the application is set to 230 V via the Nominal Value Voltage parameter. The tolerance range in this example is ±20%, which corresponds to an effective value of primary voltage of ±46V.

In the figure the effective value of the primary voltage first exceeds the tolerance range. As long as the effective value of the primary voltage exceeds the tolerance range the module reports the diagnostics "overflow".

The effective value of the primary voltage then exceeds the tolerance range. As long as the effective value of the primary voltage exceeds the tolerance range the module reports the diagnostics "underflow".

15.4.2 Current diagnostics

15.4.2.1 Diagnostics: Overload

Introduction

As long as one of the following conditions is met, the module reports the diagnostics "Overload" for each phase:

- Parameterized maximum relative measured current longer than the parameterized "Tolerance time overcurrent" is exceeded.
- Maximum permissible secondary voltage of 2 V at a current measuring channel of the AI Energy Meters RC ST is exceeded.

Calculation of the parameterizable maximum measured current

The tolerance value for the maximum relative measured current is calculated with the following formula:

Tolerance factor for maximum relative measured current = "Nominal value current" + ("Tolerance factor overcurrent [%]" × "Nominal value current")

The "Nominal value current" is the primary current at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-1001 Parameter assignment

Parameter	
Diagnostics overload	Enable
Nominal value current	0 ... 99999 A
Current transformer primary rated current	1 ... 16000 A
Current transformer secondary voltage	10 ... 600 mV
Tolerance factor overcurrent	1 ... 6000%
Tolerance time overcurrent	0 ... 60000 ms

Example

The following figure is a schematic diagram of the signal wave for the diagnostics "Overload":

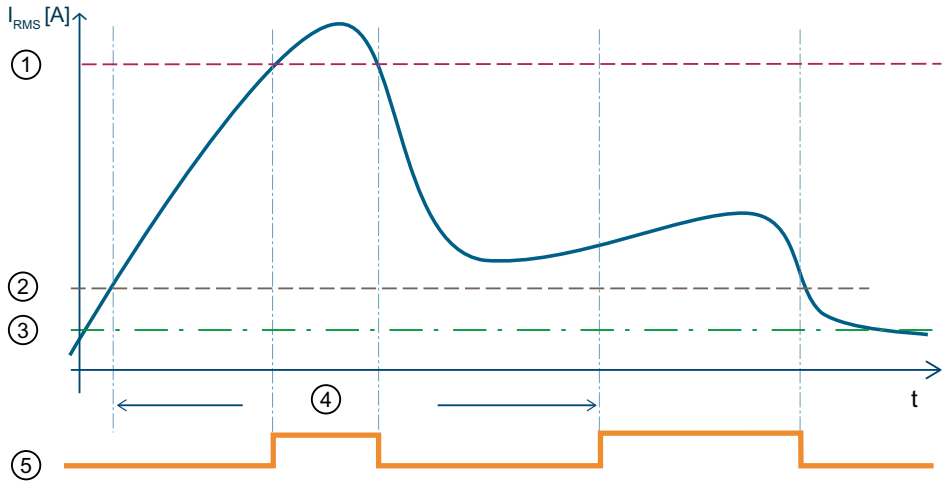

① Maximum relative measured current at permissible secondary voltage of 2 V
The module reports the diagnostics overload when the maximum permissible secondary voltage amounting to 2 V is exceeded (primary current = 2 V x 10000 A / 333 mV = 60060 A).

② Tolerance value measured current
After the "Tolerance time overcurrent" of 40000 ms has expired, the module reports the diagnostics "Overload" as long as the configured tolerance value for the maximum measured current of 2400 A
(= 2000 A + 20% x 2000 A) is exceeded.

③ Nominal value current

④ Tolerance time

⑤ Diagnostics "overload"

Figure 2-935 Diagnostics "overload" of the effective current value

The following table shows the parameter assignment for the example:

Table 2-1002 Parameter assignment

Parameter	
Diagnostics overload	Enable
Nominal value current	2000 A
Current transformer primary rated current	10000 A
Current transformer secondary voltage	333 mV
Tolerance factor overcurrent	20%
Tolerance time overcurrent	40000 ms

15.4.2.2 Low limit for measuring current undershot

Introduction

With the function "Low limit for measuring current undershot" the AI Energy Meter RC ST monitors the low limit of the effective value of the current per phase.

If the low limit for measuring current is undershot, the module sets the current value to 0. Information as to which current measured values are set to 0 can be found under Basics for reading measured values (Page 40).

You activate the function by setting the parameter "Low limit for measuring current" > 0%.

Calculation of low limit for measuring current

The low limit for measuring current is calculated using the following formula:

Low limit measured current = "Nominal value current" × "Low limit for measuring current [%]"

The "Nominal value current" is the primary current at the operating point.

Parameter assignment

The following table shows the necessary parameters:

Table 2-1003 Parameter assignment

Parameter	
Nominal value current	0 ... 99999 A
Current transformer primary rated current	1 ... 16000 A
Current transformer secondary voltage	10 ... 600 mV
Low limit for current measurement	0 ... 20% *

* 0% means deactivation of the function

Example

The following figure is a schematic diagram of the principle of operation:

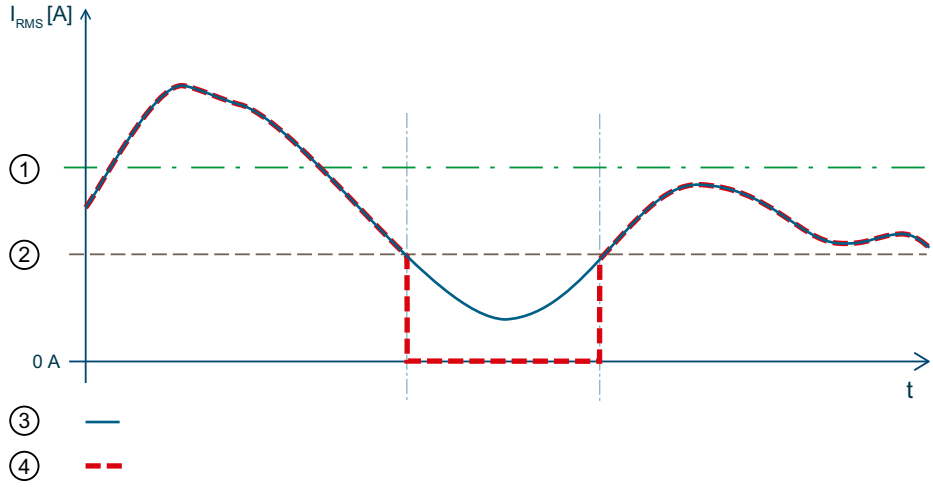

① Nominal current
② Low limit measured current
③ Measured value
④ Returned value

Figure 2-936 Behavior in the event of value falling below "Low limit for measuring current undershot"

The following table shows the parameter assignment for the example:

Table 2-1004 Parameter assignment

Parameter	
Nominal value current	2000 A
Current transformer primary rated current	5000 A
Current transformer secondary voltage	333 mV
Low limit for current measurement	10%

In this example you define the "Low limit for measuring current" with 10%. This corresponds to an effective value of the primary voltage of 200 A.

If the value falls below the calculated low limit current measurement ②, the module sets all the current-dependent measured values (effective value current, active power, reactive power, apparent power, phase angle and power factor) to 0 A until the low limit measuring current is exceeded again. The energy meters and operating hours counters are stopped during this time.

Technical specifications 16

16.1 Technical specifications

Technical specifications of the AI Energy Meter RC ST

The following table shows the technical specifications as of 03/2021. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7134-6PA21-0BU0/td?dl=en).

Article number	6ES7134-6PA21-0BU0
General information	
Product type designation	AI Energy Meter RC ST
Firmware version	V8.0
• FW update possible	Yes
usable BaseUnits	BU type U0
Supported power supply systems	TT, TN, IT
Product function	
• Voltage measurement	Yes
– without voltage transformer	Yes
– with voltage transformer	Yes
• Current measurement	Yes; max. 3 + neutral conductor
– without current transformer	No
– with current transformer	No
– With Rogowski coil	Yes
– With current-voltage-converter	Yes; 333 mV interface
• Energy measurement	Yes
• Frequency measurement	Yes
• Power measurement	Yes
• Active power measurement	Yes
• Reactive power measurement	Yes
• Power factor measurement	Yes
• Active factor measurement	Yes
• Reactive power compensation	Yes
• Line analysis	No
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No

Article number	6ES7134-6PA21-0BU0
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V16 or higher with HSP
• STEP 7 configurable/integrated from version	Configurable via GSD file
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	V2.3
Operating mode	
• Switching between operating modes in RUN	Yes; For module version 32 I/20 Q, it is possible to dynamically switch between 25 user data variants, 23 of which are pre-defined and 2 of which can be defined by the specific user
• Cyclic measured value access	Yes
• Acyclic measured value access	Yes
• Fixed measured value sets	Yes
• Freely definable measured value sets	Yes; For cyclic and acyclic measured value access
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	Yes
Installation type/mounting	
Mounting position	any
Supply voltage	
Design of the power supply	DC
Type of supply voltage	24 V DC
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Input current	
Current consumption (rated value)	12.5 mA
Current consumption, max.	17 mA
Power loss	
Power loss, typ.	400 mW; 3x 230 V AC
Address area	
Address space per module	
• Inputs	256 byte
• Outputs	20 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type U0

Article number	6ES7134-6PA21-0BU0
Time of day	
Operating hours counter	
• present	Yes
Analog inputs	
Cycle time (all channels), typ.	50 ms; Time for consistent update of all measured and calculated values (cyclic und acyclic data)
Cable length	
• shielded, max.	200 m
• unshielded, max.	200 m
Analog value generation for the inputs	
Sampling frequency, max.	2 048 kHz
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes
• Hardware interrupt	Yes; Monitoring of up to 16 freely selectable process values (exceeding or undershooting of value)
Diagnoses	
• Supply voltage	Yes
• Hardware interrupt lost	Yes
• Parameter assignment error	Yes
• Module fault	Yes
• Channel not available	Yes
• Overflow/underflow	Yes
• Overload current	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red Fn LED
• for module diagnostics	Yes; green/red DIAG LED
Integrated Functions	
Measuring functions	
• Measuring procedure for voltage measurement	TRMS
• Measuring procedure for current measurement	TRMS
• Type of measured value acquisition	seamless
• Curve shape of voltage	Sinusoidal or distorted
• Buffering of measured variables	Yes

Article number	6ES7134-6PA21-0BU0
• Parameter length	128 byte
• Bandwidth of measured value acquisition	3.2 kHz; Harmonics: 63 / 50 Hz, 52 / 60 Hz
Measuring range	
– Frequency measurement, min.	40 Hz
– Frequency measurement, max.	70 Hz
Measuring inputs for voltage	
– Measurable line voltage between phase and neutral conductor	277 V
– Measurable line voltage between the line conductors	480 V
– Measurable line voltage between phase and neutral conductor, min.	3 V
– Measurable line voltage between phase and neutral conductor, max.	300 V
– Measurable line voltage between the line conductors, min.	6 V
– Measurable line voltage between the line conductors, max.	519 V
– Internal resistance line conductor and neutral conductor	1.5 MΩ
– Power consumption per phase	60 mW; 300 V AC
– Impulse voltage resistance 1,2/50µs	2.5 kV
– Overvoltage category	CAT II according to IEC 61010 Part 1
Measuring inputs for current (Rog. or I/U converter)	
– Measurable current at AC, max.	424 mV
– Continuous voltage, maximum permissible	2 V
– Rated value, short-time withstand voltage restricted to 1 s	30 V
– Input resistance	120 kΩ
– Zero point suppression	Yes; 0 ... 20%, referred to the nominal current
Accuracy class according to IEC 61557-12	
– Measured variable apparent power	0.5
– Measured variable active power	0.5
– Measured variable power factor	0.5
– Measured variable active energy	0.5
– Measured variable phase angle	±0.5 °; not covered by IEC 61557-12
– Measured variable frequency	0.05; only valid for the permissible voltage measuring range

Article number	6ES7134-6PA21-0BU0
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• Between the channels and load voltage L+	Yes; Including FE
Isolation	
Isolation tested with	Between channels and backplane bus, 24 V supply: Routine test, 1 920 V AC, 2 s; between backplane bus and 24 V supply: Type test, 707 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	45 g
Other	
Data for selecting a voltage transformer	
• Secondary side, max.	300 V

Dimension drawing

See ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) manual

Parameter data records

A

A.1 Configuration via parameter data records

The parameter data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Overview of the parameter data records

- Parameter data record DS 128 for the complete module
- Parameter data record DS 129 for limit monitoring
- Parameter data record DS 130 for user data mapping
- Parameter data record DS 135 for data record mapping

Parameter assignment in the user program

You can reassign the module parameters in RUN mode, for example change the diagnostics behavior, define new limits or configure a modified user data mapping.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module via the respective data record. The parameters set in STEP 7 do not change in the CPU, which means the parameters set in STEP 7 are still valid after a restart.

If you reconfigure a module (so that the user data size changes) and diagnostics are pending prior to the reconfiguration, these diagnostics are not signaled as "outgoing". The diagnostics "Supply voltage missing" is signaled as outgoing.

A reconfiguration in run is not bumpless. It can take up to 1 second for all measured values to become stable.

STATUS output parameter

If errors occur during the transfer of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. However, a corresponding error code is written to the STATUS output parameter.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help.

A.2 Structure of the parameter data record for the entire module (DS 128)

Structure of data record 128

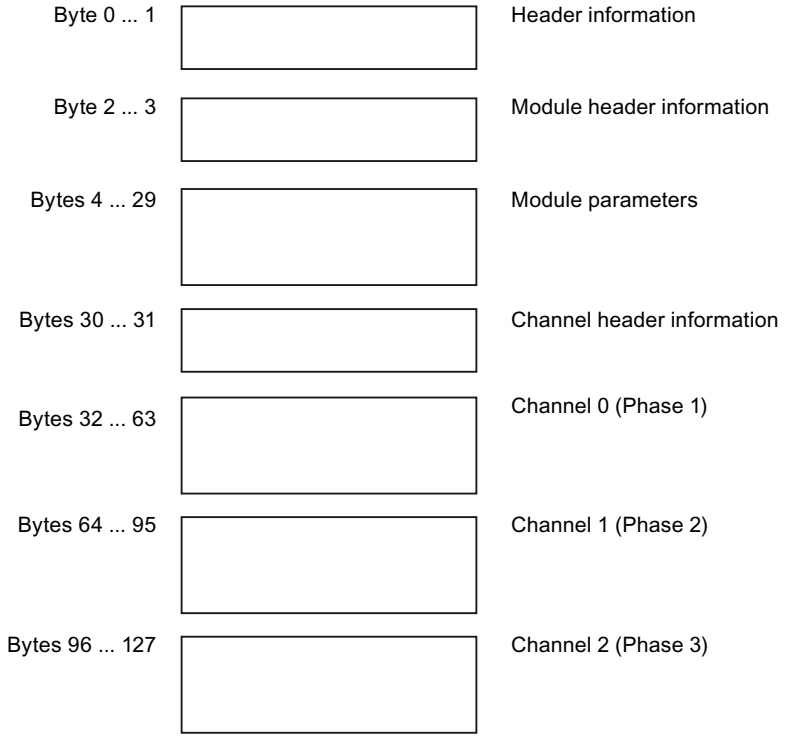

Figure 2-937 Parameter data record 128

Header information

The figure below shows the structure of the header information.

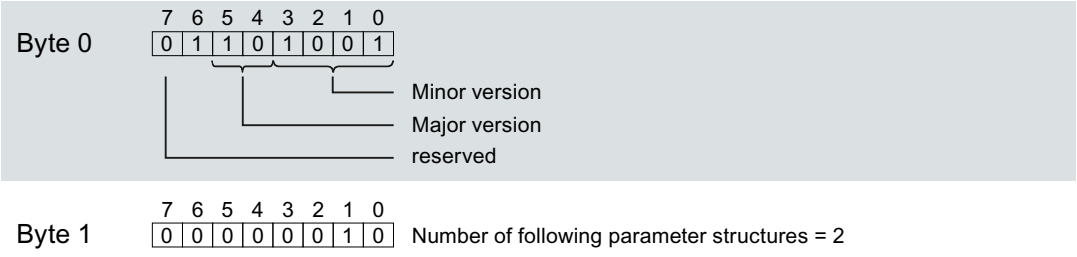

Figure 2-938 Header information

Module header information

The figure below shows the structure of the header information for a module.

	7	6	5	4	3	2	1	0	
Byte 2	0	0	0	0	0	0	0	1	Number of the following module parameter blocks = 1
Byte 3	0	0	0	1	1	0	1	0	Length of the following module parameter block = 26

Figure 2-939 Module header information

Module parameter block

The figure below shows the structure of the module parameter block.

Byte 4 (7 6 5 4 3 2 1 0)

Connection type of the phases

- 00_H = disabled
- $0B_H$ = 1P2W: 1-phase alternating current, 2 conductors
- $0C_H$ = 3P4W: 3-phase, 4 conductors
- $0E_H$ = 3P4W1: 3-phase, 4 conductors, balanced load
- $0F_H$ = 3x1P2W: 3x1-phase alternating current, 2 conductors
- 10_H = 2P3W: 2-phase, 3 conductors
- 11_H = 3P3W: 3-phase, 3-conductors
- 12_H = 3P3W1: 3-phase, 3 conductors, balanced load

Byte 5 (7 6 5 4 3 2 1 0)

Voltage measuring range of the power supply system
(Supply voltage, nominal value of phase voltage)

- 01_H = 100 V
- 02_H = 110 V
- 03_H = 115 V
- 04_H = 120 V
- 05_H = 127 V
- 06_H = 190 V
- 07_H = 200 V
- 08_H = 208 V
- 09_H = 220 V
- $0A_H$ = 230 V
- $0B_H$ = 240 V
- $0C_H$ = 277 V
- $0D_H$ = 300 V

Byte 6 (7 6 5 4 3 2 1 0)

Line frequency of the power supply system

- 0001 = 60 Hz
- 0010 = 50 Hz

End value for energy meter

- 000 = No end value - infinite counting
- 001 = Count periodically to 10^3
- 010 = Count periodically to 10^6
- 011 = Count periodically to 10^9
- 100 = Count periodically to 10^{12}
- 101 = Count periodically to 10^{15}

Energy meters gate switch

- 0 = Energy meter always counting
- 1 = Energy meters gate switch

Byte 7 (7 6 5 4 3 2 1 0): 0 0 0 0 0 0 0 0 reserved

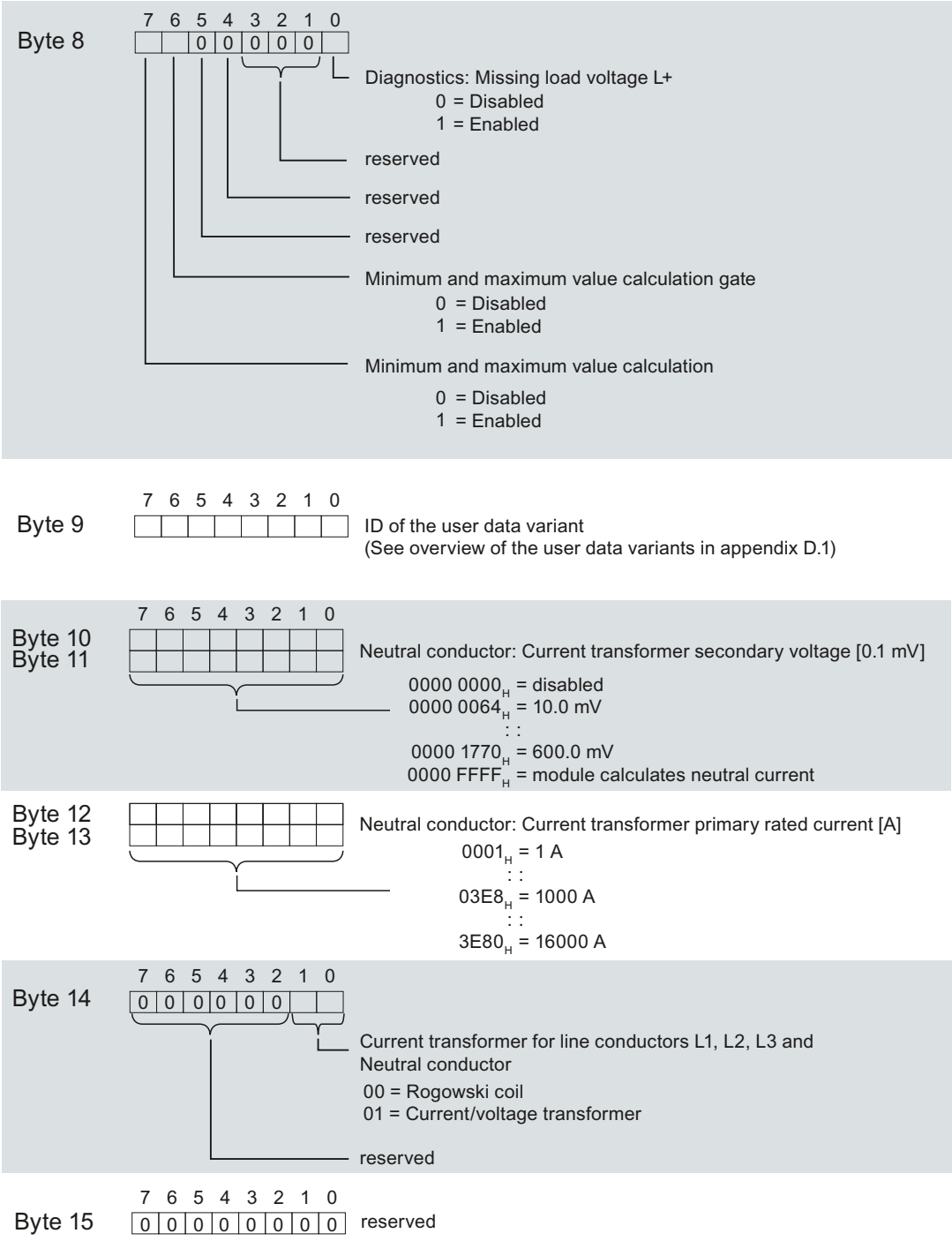

Figure 2-940 Module parameter block

	7	6	5	4	3	2	1	0	
Byte 16	0	0	0	0	0	0	0	0	reserved
Byte 17	0	0	0	0	0	0	0	0	
Byte 18	0	0	0	0	0	0	0	0	reserved
Byte 19	0	0	0	0	0	0	0	0	
Byte 20	0	0	0	0	0	0	0	0	reserved
Byte 21	0	0	0	0	0	0	0	0	
Byte 22	0	0	0	0	0	0	0	0	reserved
Byte 23	0	0	0	0	0	0	0	0	
Byte 24	0	0	0	0	0	0	0	0	reserved
:	0	0	0	0	0	0	0	0	
:	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	
	0	0	0	0	0	0	0	0	
Byte 29	0	0	0	0	0	0	0	0	

Figure 2-941 Module parameter block

You can find the user data variant in the section Overview of the user data variants (Page 160).

Channel header information

The following figure shows the structure of the header information for a channel.

	7	6	5	4	3	2	1	0	
Byte 30	0	0	0	0	0	0	1	1	Number of following channel parameter blocks = 3
Byte 31	0	0	1	0	0	0	0	0	Length of the following channel parameter block = 32

Figure 2-942 Channel header information

Channel parameter block for channel 0 (Phase 1)

The following figure shows an example of the structure of the channel parameter block for channel 0 (phase 1, bytes 32 to 63).

For channel 1 (phase 2; bytes 64 to 95) and channel 2 (phase: 3; bytes 96 to 127), the structure is identical.

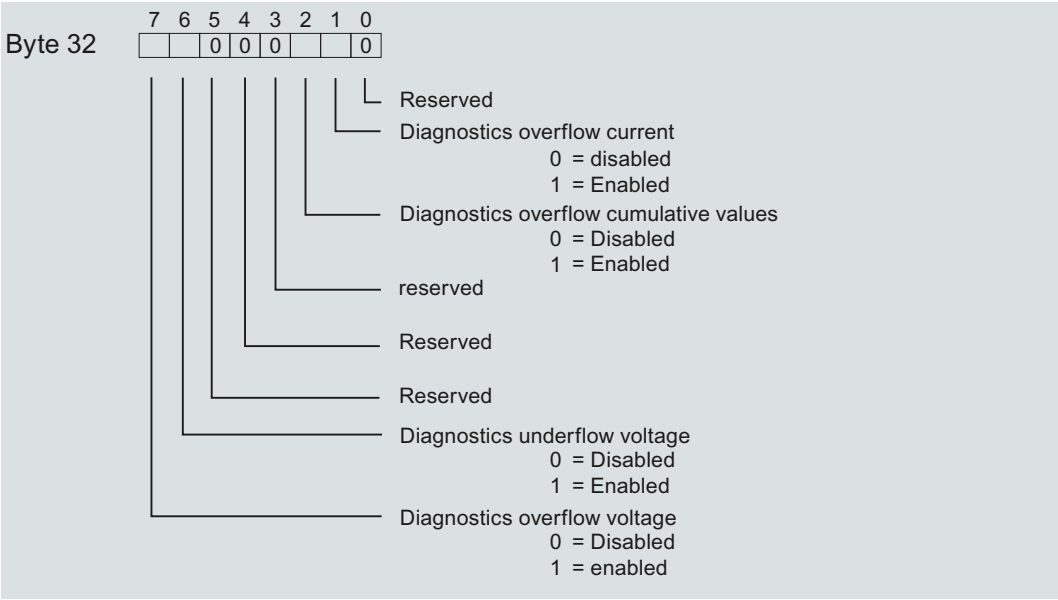

Byte 33

7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	reserved

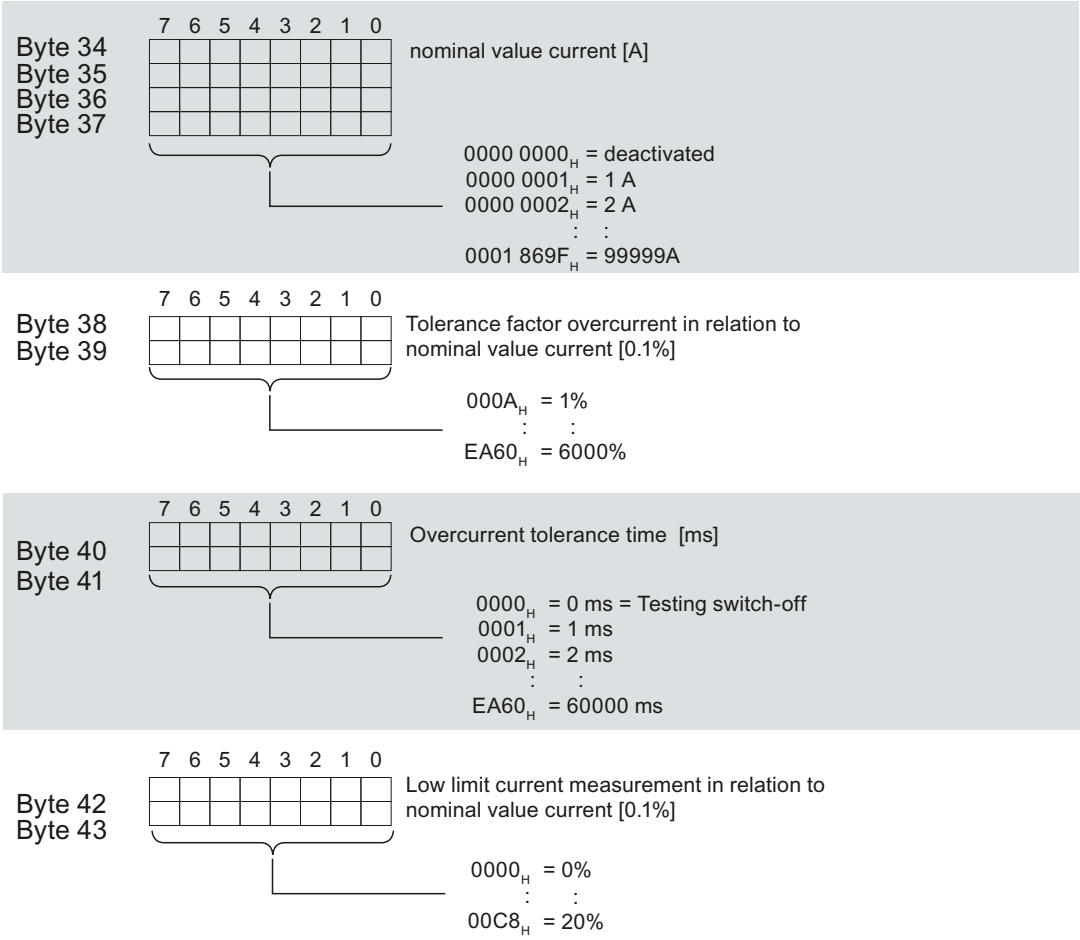

Figure 2-943 Channel parameter block

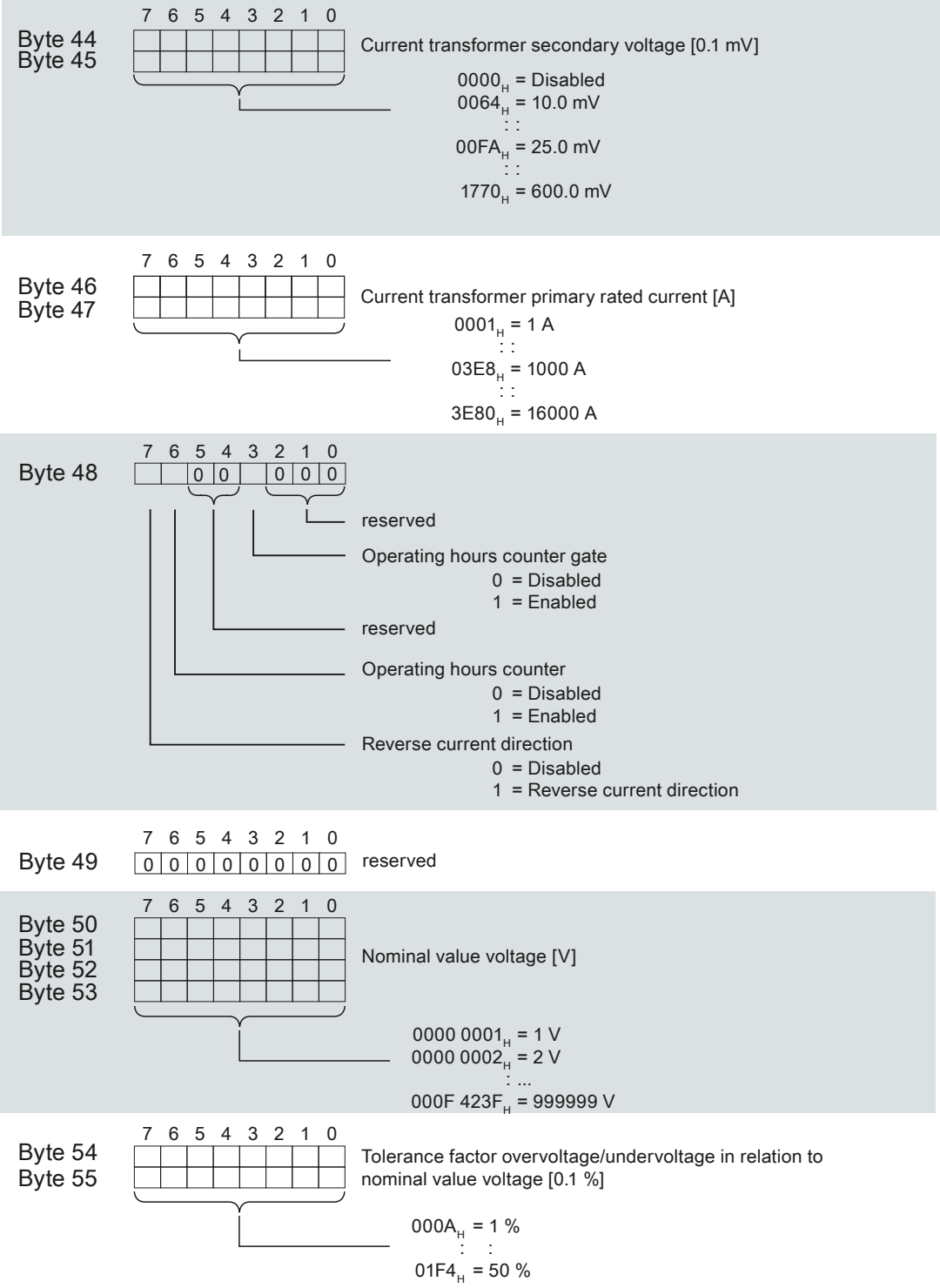
Byte 44
Byte 45
7 6 5 4 3 2 1 0
Current transformer secondary voltage [0.1 mV]
0000H = Disabled
0064H = 10.0 mV
00FAH = 25.0 mV
1770H = 600.0 mV
Byte 46
Byte 47
Current transformer primary rated current [A]
0001H = 1 A
03E8H = 1000 A
3E80H = 16000 A
Byte 48
reserved
Operating hours counter gate
0 = Disabled
1 = Enabled
reserved
Operating hours counter
0 = Disabled
1 = Enabled
Reverse current direction
0 = Disabled
1 = Reverse current direction
Byte 49
reserved
Byte 50
Byte 51
Byte 52
Byte 53
Nominal value voltage [V]
0000 0001H = 1 V
0000 0002H = 2 V
000F 423FH = 999999 V
Byte 54
Byte 55
Tolerance factor overvoltage/undervoltage in relation to nominal value voltage [0.1 %]
000AH = 1 %
01F4H = 50 %

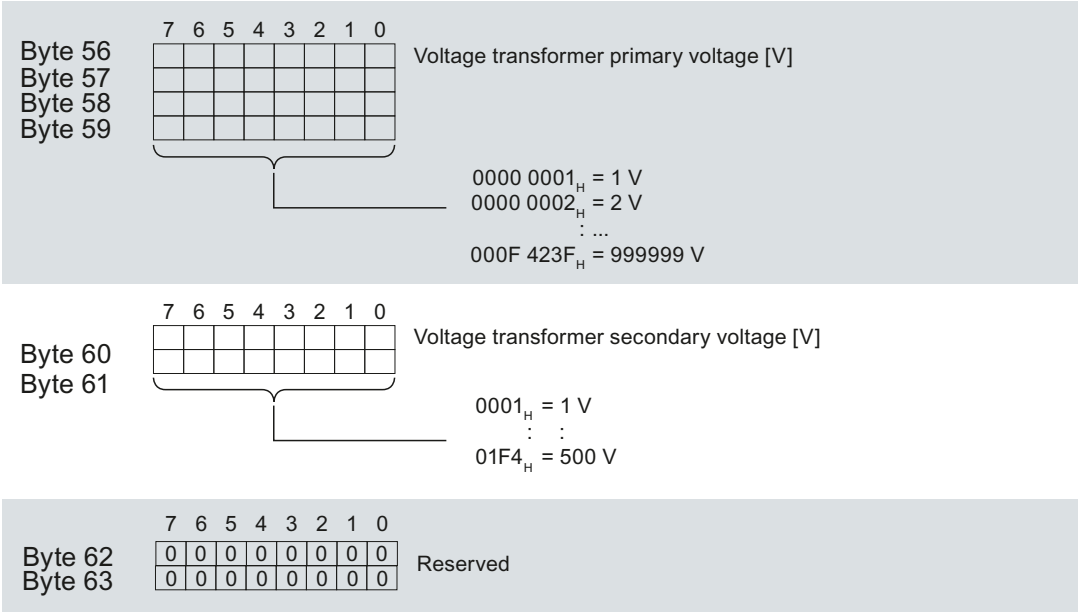

Figure 2-944 Channel parameter block

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 128.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check bytes 1 ... 3, 30, 31. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check bytes 7, 8, 14, 15, 24...29, 32, 33, 48, 49, 62...65, 80, 81, 94...97, 112, 113, 126, 127 and set the reserved bits back to 0.
DF	80	E1	05	"Voltage measuring range" invalid	Check Byte 5. Permitted values: 01_H to $0D_H$

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	20	"Connection type" invalid	Check Byte 4. Permitted values: 00_H, $0B_H$, $0C_H$, $0E_H$...12_H
DF	80	E1	21	"Payload variant" not possible or input data configuration not large enough	Check Byte 9. Select a different payload variant or change the configuration.
DF	80	E1	22	"User data variant" invalid	Check Byte 9. Select a valid code for the user data variant.
DF	80	E1	23	"Line frequency" invalid	Check Byte 6. Enter valid values.
DF	80	E1	29	"Tolerance factor overcurrent in relation to nominal value current [0.1%]" invalid	Check bytes 38...39, 70...71, 102...103. Enter valid values.
DF	80	E1	2A	"Tolerance time overcurrent" invalid	Check bytes 40...41, 72...73, 104...105 prüfen. Enter valid values.
DF	80	E1	2B	"Low limit current measurement" in relation to nominal value current [0.1%] invalid	Check bytes 42...43, 74...75, 106...107. Enter valid values.
DF	80	E1	2C	"Current transformer primary rated current [A]" invalid.	Check 46...47, 78...79, 110...111. Enter valid values.
DF	80	E1	2D	"Voltage transformer primary voltage [V]" invalid	Check bytes 56...59, 88...91, 120...123. Enter valid values.
DF	80	E1	2E	"Voltage transformer secondary voltage [V]" invalid	Check bytes 60, 61 and 92, 93 and 124, 125. Enter valid values.
DF	80	E1	2F	"End value energy meter" invalid	Check Bit 4...6 in Byte 6. Enter valid values.
DF	80	E1	30	Invalid data record number.	Check the data record number. Enter a valid data record number.
DF	80	E1	3E	Only for connection type 3P4W1 and 3P3W1. Current or voltage transformer parameters for the different phases are not identical.	Check bytes 44...47 and 76...79 and 108...111 or bits 4, 5 and 7 in bytes 48, 80 and 112 or 56...59 and 88...91 and 120...123 or 60, 61 and 92, 93 and 124, 125 for identical values. Enter identical values for current measuring transformer (secondary current, primary current, direction of current) and voltage transformer (secondary voltage, primary voltage) at all three phases.
DF	80	E1	3F	"End value for energy meter" or transmission ratio (primary value, secondary value) of current and voltage too low.	Increase the end value of the energy meter or the ratio of primary to secondary current for current measuring transformer and/or primary rated current to secondary voltage for voltage transformer.
DF	80	E1	43	"Current transformer secondary current" for neutral conductor or all three phases invalid	Check bits 4...5 in bytes 14, 42, 62, 82. Enter valid values.
DF	80	E1	48	Parameter "Current transformer secondary voltage " invalid	Check bytes 10...11, 44...45, 76...77, 108...109. Enter valid values.
DF	80	E1	4 A	Voltage transformer parameters for voltage swell/dip invalid	Check the parameters secondary voltage, primary voltage, nominal value voltage. Enabled channels must have identical parameters.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	4B	Current transformer parameter for "Detect overcurrent" invalid	Check the parameters secondary voltage, primary rated current, nominal value current and direction of current. Enabled channels must have identical parameters.
DF	80	E1	4C	Parameters for determining the neutral current invalid	Neutral current can only be determined with connection type 3P4W. Current transmission parameters primary current, secondary voltage, nominal value current and direction of current of the three phases must be identical.
DF	80	E1	4D	"Nominal value current [A]" invalid	The nominal value current must be measurable with the current transformer and thus be smaller than the primary measured variable of the transformer (current transformer primary rated current). Check bytes 34...37, 66...69, 98...101. Enter valid values.
DF	80	E1	4E	"Nominal value voltage [V]" invalid	The nominal value voltage must be measurable with the voltage transformer and thus be smaller than the primary measured variable of the transformer (voltage transformer primary voltage). Check bytes 50...53, 82...85, 114...117. Enter valid values.
DF	80	E1	4F	"Low limit current measurement in relation to nominal value current [0.1%]" invalid	Check bytes 42...43, 74...75, 106...107. Enter valid values.
DF	80	E1	50	The combination of "Nominal value voltage [V]" and "Voltage dip limit value in relation to nominal value voltage [0.1%]" invalid.	Select the permissible value in % so that the secondary measuring voltage of 0 V is not undershot.
DF	80	E1	51	The combination of "Nominal value voltage [V]" and "Voltage swell limit value in relation to nominal value voltage [0.1%]" invalid.	Select the permissible value in % so that the secondary measuring voltage of 300 V is not exceeded.
DF	80	E1	52	The combination of "Nominal value current [A]" and "Threshold overcurrent in relation to nominal value current [0.1%]" invalid	Select the permissible value in % so that the secondary measuring voltage of 424 mA is not exceeded.
DF	80	E1	53	The combination of "Nominal value current [A]" and "Tolerance factor overcurrent in relation to nominal value current [0.1%]" invalid	Select the permissible value in % so that the secondary measuring voltage of 424 mA is not exceeded.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	54	The combination of "Nominal value voltage [V]" and "Tolerance factor overvoltage/undervoltage in relation to nominal value voltage [0.1%]" lies outside the permissible range.	Select the permissible value in % so that the secondary measuring voltage of 300 V is not exceeded.
DF	80	E1	55	"Nominal value current [A]" is too high. "Nominal value current" x transmission factor current generates a secondary current measured variable which exceeds its value range.	Select the permissible value in A so that the secondary measuring voltage of 424 mA is not exceeded. The transmission factor current is calculated from "Current transformer primary rated current [A]" / "Current transformer secondary voltage [0.1 mV]"
DF	80	E1	56	"Nominal value voltage [V]" is too high. "Nominal value voltage" x transmission factor voltage generates a secondary voltage measured variable which exceeds its value range.	Select the permissible value in V so that the secondary measuring voltage of 300 V is not exceeded. The transmission factor voltage is calculated from "Voltage transformer primary voltage [V]" / "Voltage transformer secondary voltage [V]"

A.3 Structure of the parameter data record for limit monitoring (DS 129)

Structure of data record 129

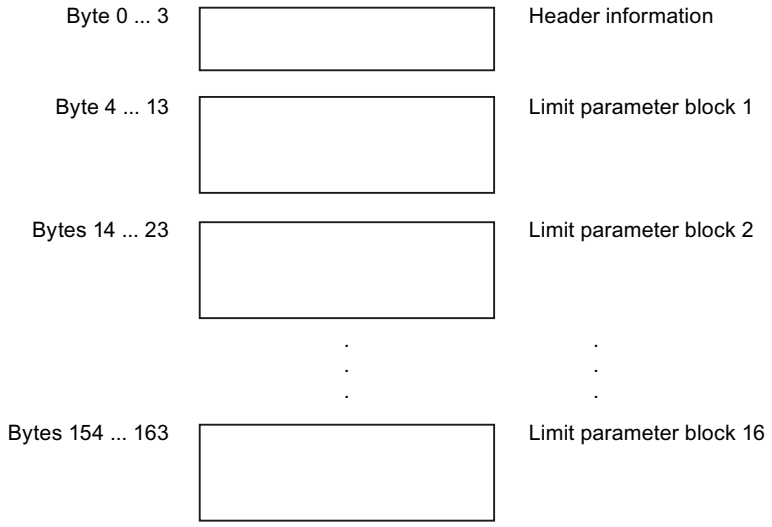

Figure 2-945 Structure of data record 129

Header information

The figure below shows the structure of the header information.

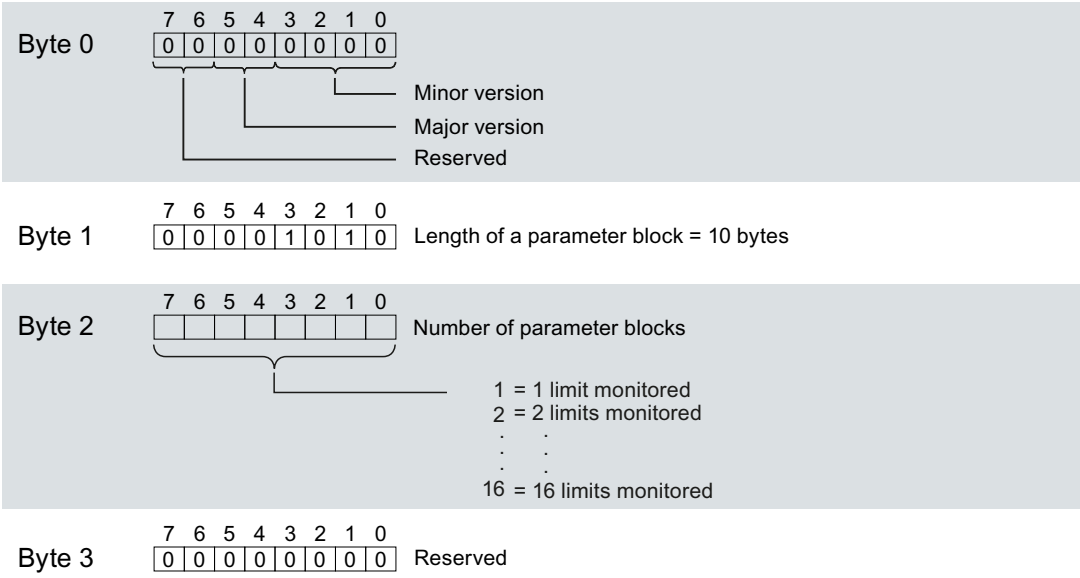

Figure 2-946 Header information DS 129

Limit parameter block

The following diagram shows the structure of the parameter blocks for limit monitoring.

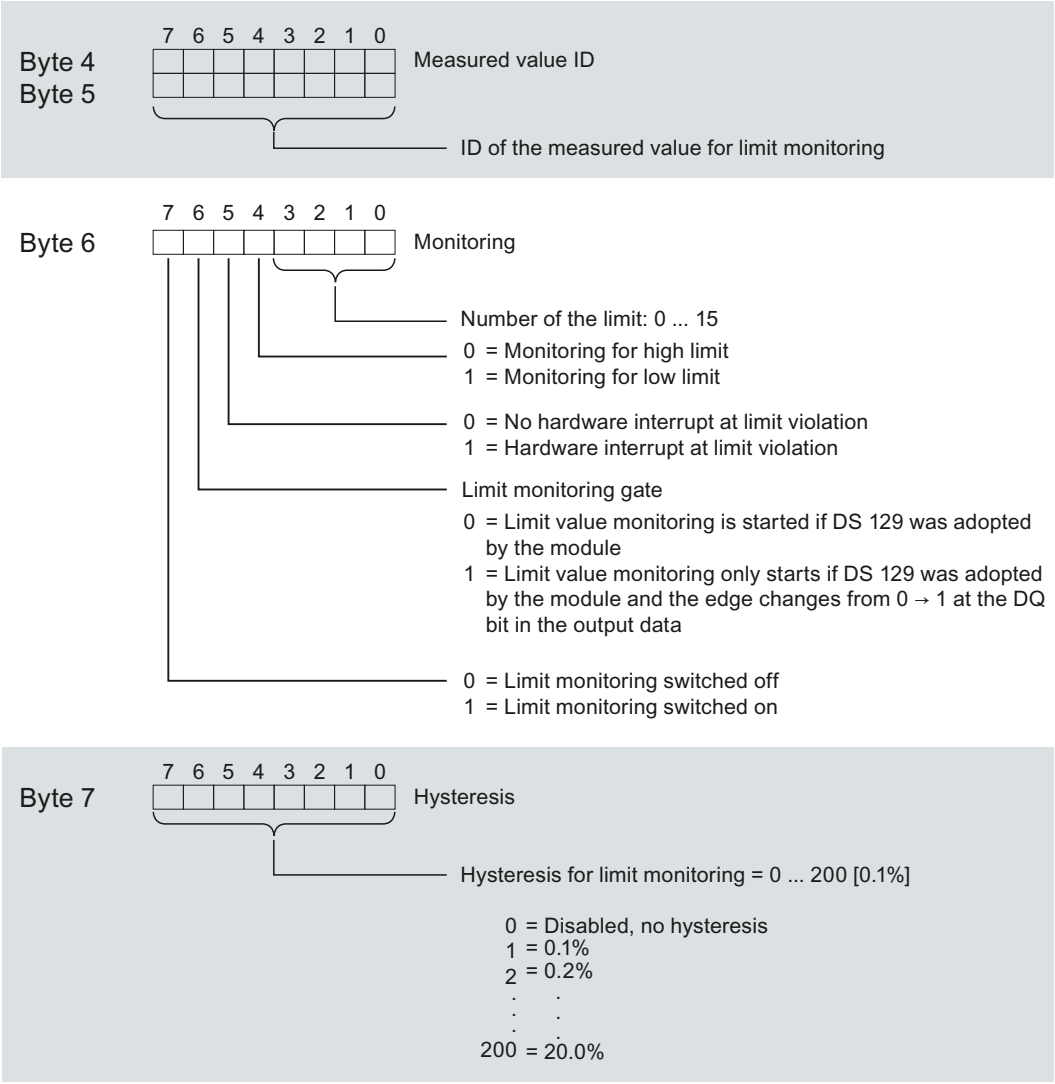

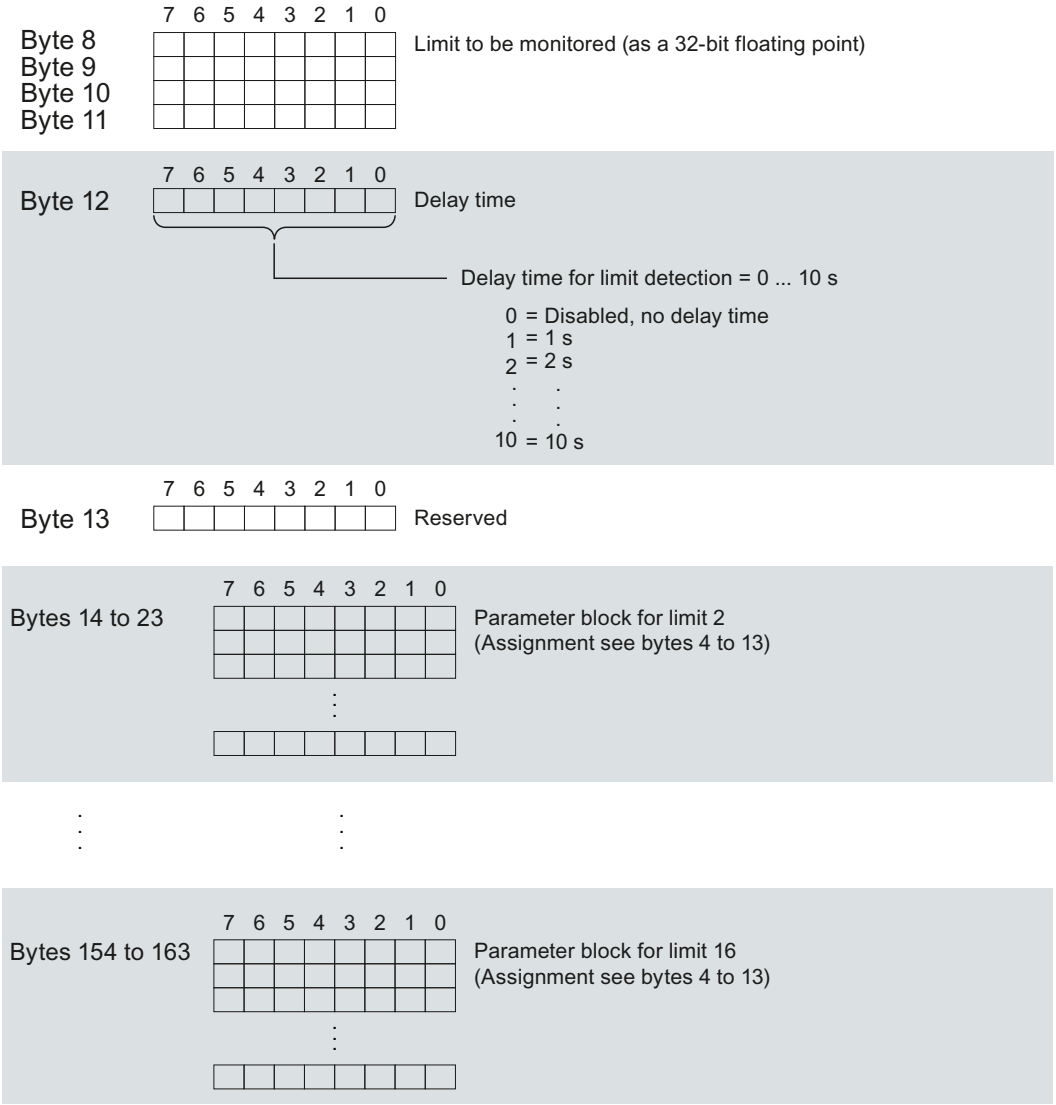

Figure 2-947 Limit parameter data block

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 129.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check bytes 3, 13, 23, 33...163 and set the reserved bits back to 0.
DF	80	E1	31	"Length of the parameter block" invalid.	Length of the sent record incorrect. Note byte 2 ("number of parameter blocks").
DF	80	E1	32	"Number of parameter blocks" invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	"ID of the measured value for limit monitoring" invalid.	Check Bytes 4 and 5. Enter valid values.
DF	80	E1	34	Parameters for monitoring the limits invalid	Check bits 0...3 in Byte 6. Enter valid values.
DF	80	E1	35	"Number of limit" in 'Monitoring assigned multiple times' parameter	Check bits 0...3 in Byte 6. Do not use limit number several times.
DF	80	E1	36	"Hysteresis for limit monitoring" invalid	Check Byte 7. Enter valid values.
DF	80	E1	37	"Limit" invalid.	Check Byte 8...11. Enter valid values.
DF	80	E1	38	"Delay time for limit monitoring" invalid.	Check Byte 12. Enter valid values.

A.4 Structure of the parameter data record for data mapping (DS 130)

Structure of data record 130

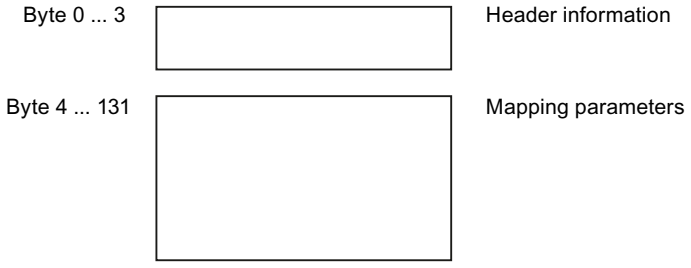

Figure 2-948 Structure of data record 130

Header information

The figure below shows the structure of the header information.

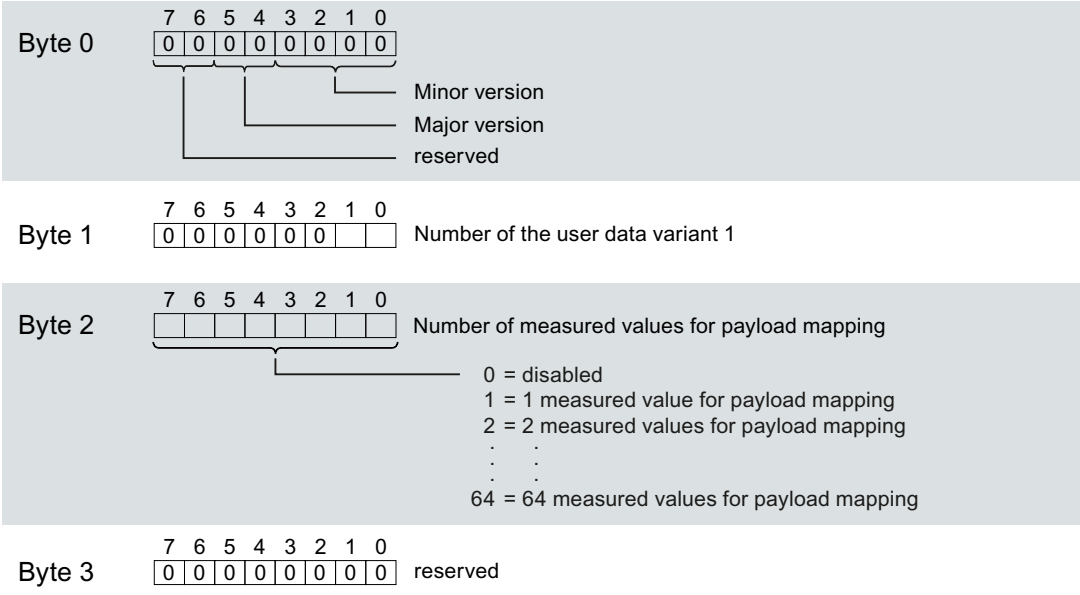

Figure 2-949 Header information DS 130

Parameter block for payload mapping

The following diagram shows the structure of the parameter blocks for payload mapping.

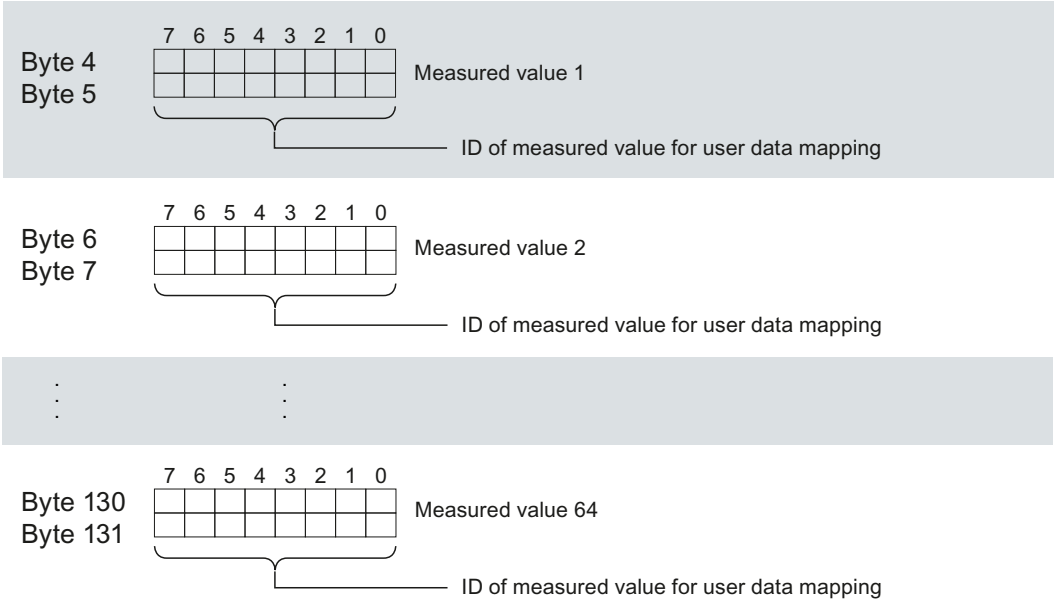

Figure 2-950 Parameter block for payload mapping

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 130.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check Byte 3 and set reserved bits back to 0.
DF	80	E1	21	"Payload variant" not possible or input data configuration not large enough	Select a different payload variant or change the configuration.
DF	80	E1	30	Data record number invalid	Check the data record number. Enter a valid data record number.
DF	80	E1	31	"Length of the parameter block" invalid.	Length of the sent record incorrect. Note byte 2 ("number of measured values").
DF	80	E1	32	"Number of parameter blocks" invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	"ID of measured value for payload mapping" invalid.	Check Bytes 4 and 5. Enter valid values.
DF	80	E1	3B	"ID of the type of payload mapping" not permitted.	Check Byte 1. Number for user-specific payload variant has to be 01_H.

Measured variables for payload mapping

You can find the measured variables under "Measured variables for connection type 1H (Page 135)". The following measured variables are not available to you for payload mapping:

- 220 to 226
- 62110 to 62116
- 62210 to 62216
- 62310 to 62316

A.5 Structure of the parameter data record for data mapping (DS 135)

Structure of data record 135

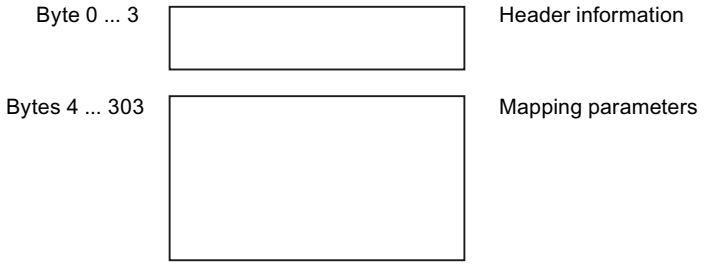

Figure 2-951 Structure of data record 135

Header information

The figure below shows the structure of the header information.

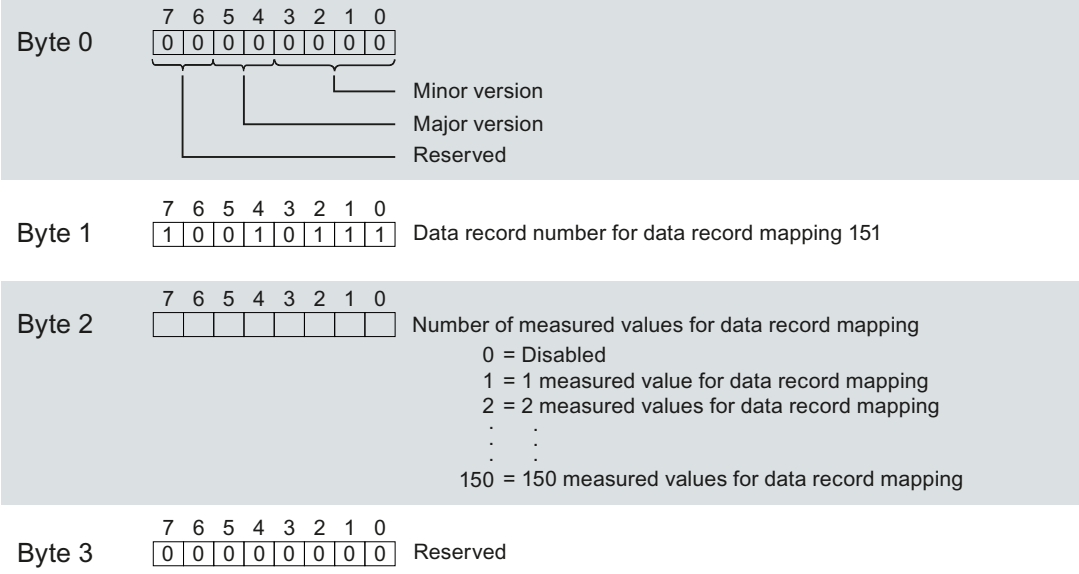

Figure 2-952 Header information DS 135

Parameter block for data record mapping

The following diagram shows the structure of the parameter blocks for data record mapping.

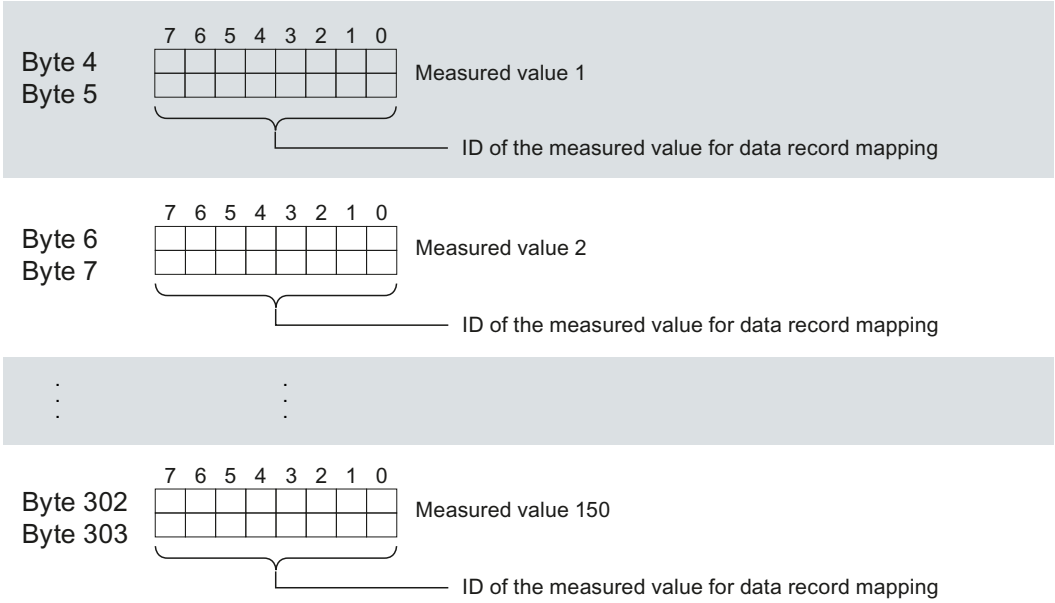

Figure 2-953 Parameter block for data record mapping

Data record length DS 135 and DS151

The table below shows the data record lengths of the parameter data record DS 135 and the user-defined data record DS 151 (Page 203).

The length of the data records depends on the number and the format of the measured values.

Number Measured values	Data record length in bytes		
	REAL measured values		LREAL measured values
	DS 135	DS 151	DS 151
29	62	118	234
30	64	122	242 *
40	84	162	322 *
50	104	202	402 *
59	122	238	474 *
100	204	402 *	802 *
118	240	474 *	946 *
150	304*	602 *	1202 *

* not with PROFIBUS DP

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the parameter data record 130/135.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	01	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction
DF	80	E0	01	Incorrect version	Check Byte 0. Enter valid values.
DF	80	E0	02	Error in the header information	Check Bytes 1 and 2. Correct the length and number of the parameter blocks.
DF	80	E1	01	Reserved bits are not 0.	Check Byte 3 and set reserved bits back to 0.
DF	80	E1	21	"Payload variant" not possible or input data configuration not large enough	Select a different payload variant or change the configuration.
DF	80	E1	30	Data record number invalid	Check the data record number. Enter a valid data record number.
DF	80	E1	31	"Length of the parameter block" invalid.	Length of the sent record incorrect. Note byte 2 ("number of measured values").
DF	80	E1	32	"Number of parameter blocks" invalid.	Check Byte 2. Enter valid values.
DF	80	E1	33	"ID of the measured value for limit monitoring" invalid.	Check Bytes 4 and 5. Enter valid values.

Measured variables for data record mapping

You can find the measured variables under "Measured variables for connection type 1H (Page 135)". The following measured variables are not available to you for payload mapping:

- 220 to 226
- 62110 to 62116
- 62210 to 62216
- 62310 to 62316

Measured variables

B

B.1 Measured variables for connection type

Measured variables for data records and payload

The following table provides an overview of all measured variables that are used in the data records and payload.

On the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755917) you can find an overview of the assignment of the measured values to the payload variants and data records.

Table 2-1005 Measured variables for data records and payload

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
1	Voltage L1-N [1]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓
2	Voltage L2-N [1]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓
3	Voltage L3-N [1]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓
4	Voltage L1-L2 [2]	REAL	V	0.0 ... 1000000.0		✓		✓	✓	✓	✓
5	Voltage L2-L3 [2]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
6	Voltage L3-L1 [2]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
7	Current L1 [1]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
8	Current L2 [1]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓
9	Current L3 [1]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓
10	Apparent power L1 [3]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
11	Apparent power L2 [3]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
12	Apparent power L3 [3]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
13	Active power L1 [3]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
14	Active power L2 [3]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
15	Active power L3 [3]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
16	Reactive power Qn L1[3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
17	Reactive power Qn L2[3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
18	Reactive power Qn L3[3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
19	Power factor λ L1 [3]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
20	Power factor λ L2 [3]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓	✓	✓
21	Power factor λ L3 [3]	REAL	-	0.0 ... 1.0			✓	✓	✓	✓	✓
22	Reactive power Qtot L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
23	Reactive power Qtot L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
24	Reactive power Qtot L3 [3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
30	Frequency L1L2L3 [4]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓
31	Average Voltage L-N (U_{sum}) [12]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓
32	Average Voltage L-L [12]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
33	Average Current L1L2L3 (I_{sum}) [12]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
34	Active power L1L2L3 [5]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
35	Reactive power Q_n L1L2L3 [5]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
36	Apparent power L1L2L3 [5]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
37	Power factor λ L1L2L3 [6]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
38	Reactive power Qtot L1L2L3[3 5]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
40	Max. voltage L1-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓
41	Max. voltage L2-N [14]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓
42	Max. voltage L3-N [14]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓
43	Max. voltage L1-L2 [14]	REAL	V	0.0 ... 1000000.0		✓		✓	✓	✓	✓
44	Max. voltage L2-L3 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
45	Max. voltage L3-L1 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
46	Max. current L1 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
47	Max. current L2 [14]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓
48	Max. current L3 [14]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓
49	Max. apparent power L1 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
50	Max. apparent power L2 [14]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
51	Max. apparent power L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
52	Max. active power L1 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
53	Max. active power L2 [14]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
54	Max. active power L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
55	Max. reactive power Q_n L1 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
56	Max. reactive power Q_n L2 [14]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
57	Max. reactive power Q_n L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
58	Max. power factor λ L1 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
59	Max. power factor λ L2 [14]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓	✓	✓
60	Max. power factor λ L3 [14]	REAL	-	0.0 ... 1.0			✓	✓	✓	✓	✓
61	Max. frequency [14]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓
62	Max. mean voltage L-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓		
63	Max. mean voltage L-L [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
64	Max. mean current L1L2L3 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
65	Max. active power L1L2L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
66	Max. reactive power Qn L1L2L3[14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
67	Max. apparent power L1L2L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
68	Max. power factor λ L1L2L3 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
70	Min. voltage L1-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓	✓	✓
71	Min. voltage L2-N [14]	REAL	V	0.0 ... 1000000.0		✓	✓	✓	✓	✓	✓
72	Min. voltage L3-N [14]	REAL	V	0.0 ... 1000000.0			✓	✓	✓	✓	✓
73	Min. voltage L1-L2 [14]	REAL	V	0.0 ... 1000000.0		✓		✓	✓	✓	✓
74	Min. voltage L2-L3 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
75	Min. voltage L3-L1 [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
76	Min. current L1 [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
77	Min. current L2 [14]	REAL	A	0.0 ... 100000.0		✓	✓	✓	✓	✓	✓
78	Min. current L3 [14]	REAL	A	0.0 ... 100000.0			✓	✓	✓	✓	✓
79	Min. apparent power L1 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
80	Min. apparent power L2 [14]	REAL	VA	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
81	Min. apparent power L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
82	Min. active power L1 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
83	Min. active power L2 [14]	REAL	W	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
84	Min. active power L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
85	Max. reactive power Q_n L1 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
86	Max. reactive power Q_n L2 [14]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
87	Max. reactive power Q_n L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
88	Min. power factor λ L1 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
89	Min. power factor λ L2 [14]	REAL	-	0.0 ... 1.0		✓	✓	✓	✓	✓	✓
90	Min. power factor λ L3 [14]	REAL	-	0.0 ... 1.0			✓	✓	✓	✓	✓
91	Min. frequency [14]	REAL	Hz	40.0 ... 70.0	✓	✓	✓	✓	✓	✓	✓
92	Min. mean voltage L-N [14]	REAL	V	0.0 ... 1000000.0	✓	✓	✓	✓	✓		
93	Min. mean voltage L-L [14]	REAL	V	0.0 ... 1000000.0				✓	✓	✓	✓
94	Min. mean current L1L2L3[14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
95	Min. active power L1L2L3 [14]	REAL	W	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
96	Min. reactive power Q_n L1L2L3 [14]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
97	Min. apparent power L1L2L3 [14]	REAL	VA	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
98	Min. power factor λ L1L2L3 [14]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
166	Mean power factor λ L1L2L3[12]	REAL	-	0.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
200	Active energy inflow L1L2L3 (Float) [6]	REAL	Wh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓
201	Active energy outflow L1L2L3 (Float) [6]	REAL	Wh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓
202	Reactive energy inflow L1L2L3 (Float) [6]	REAL	varh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓
203	Reactive energy outflow L1L2L3 (Float) [6]	REAL	varh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓
204	Apparent energy L1L2L3 (Float) [6]	REAL	VAh	0.0 ... 3.4028e+38	✓	✓	✓	✓	✓	✓	✓
205	Total active energy L1L2L3 (Float) [6]	REAL	Wh	-3.4028e+38 ... +3.4028e+38	✓	✓	✓	✓	✓	✓	✓
206	Total reactive energy L1L2L3 (Float) [6]	REAL	varh	-3.4028e+38 ... +3.4028e+38	✓	✓	✓	✓	✓	✓	✓
210	Active energy inflow L1L2L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
211	Active energy outflow L1L2L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
212	Reactive energy inflow L1L2L3 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
213	Reactive energy outflow L1L2L3 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
214	Apparent energy L1L2L3 [6]	LREAL	VAh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
215	Total active energy L1L2L3 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓
216	Total reactive energy L1L2L3 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓
220	Active energy inflow L1L2L3 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
221	Active energy outflow L1L2L3 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
222	Reactive energy inflow L1L2L3 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
223	Reactive energy outflow L1L2L3 (Int32) [6]	UDINT	VAh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
224	Apparent energy L1L2L3 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
225	Total active energy L1L2L3 (Int32) [6]	DINT	Wh	-2147483647 ... +2147483647	✓	✓	✓	✓	✓	✓	✓
226	Total reactive energy L1L2L3 (Int32)rl. [6]	DINT	varh	-2147483647 ... +2147483647	✓	✓	✓	✓	✓	✓	✓
61130	Phase angle UL1-UL2 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓
61131	Phase angle UL2-UL3 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓
61132	Phase angle UL3-UL1 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
61133	Phase angle IL1-IL2 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓
61134	Phase angle IL2-IL3 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓
61135	Phase angle IL3-IL1 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓
61136	Max. neutral current [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
61137	Min. neutral current [14]	REAL	A	0.0 ... 100000.0	✓	✓	✓	✓	✓	✓	✓
61138	Max. reactive power Qtot L1L2L3[3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
61139	Min. reactive power Qtot L1L2L3[3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
61140	Overflow counter active energy inflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61141	Overflow counter active energy outflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61142	Overflow counter reactive energy inflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61143	Overflow counter reactive energy outflow L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61144	Overflow counter apparent energy L1L2L3 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61146	Fundamental cos φ active factor L1L2L3[17]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
61149	Neutral current IN [1]	REAL	A	0.0 ... 100000.0	Z	Z	Z	✓	✓	Z	Z
61154	Reactive power (fundamental) L1L2L3[5]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
61157	Amplitude unbalance voltage U2 [2]	REAL	%	0 ... 100				✓	✓	✓	✓
61158	Amplitude unbalance current Iunsym [2]	REAL	%	0 ... 100				✓	✓	✓	✓
61178	Phase angle L1 [3]	REAL	°	0.0 ... 360.0	✓	✓	✓	✓	✓	✓	✓
61180	Active energy inflow L1 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61181	Active energy outflow L1 [6]	LREAL	Wh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61182	Reactive energy inflow L1 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61183	Reactive energy outflow L1 [6]	LREAL	varh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61184	Apparent energy L1 [6]	LREAL	VAh	0.0 ... 1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61185	Total active energy L1 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61186	Total reactive energy L1 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308	✓	✓	✓	✓	✓	✓	✓
61190	Overflow counter active energy inflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61191	Overflow counter active energy outflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
61192	Overflow counter reactive energy inflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61193	Overflow counter reactive energy outflow L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61194	Overflow counter apparent energy L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61195	Overflow counter total active energy L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61196	Overflow counter total reactive energy L1 [6]	UINT	-	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
61198	Phase angle L2 [3]	REAL	°	0.0 ... 360.0		✓	✓	✓	✓	✓	✓
61200	Active energy inflow L2 [6]	LREAL	Wh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓
61201	Active energy outflow L2 [6]	LREAL	Wh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓
61202	Reactive energy inflow L2 [6]	LREAL	varh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓
61203	Reactive energy outflow L2 [6]	LREAL	varh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓
61204	Apparent energy L2 [6]	LREAL	VAh	0.0 ... 1.7976e+308		✓	✓	✓	✓	✓	✓
61205	Total active energy L2 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308		✓	✓	✓	✓	✓	✓
61206	Total reactive energy L2 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308		✓	✓	✓	✓	✓	✓
61210	Overflow counter active energy inflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓
61211	Overflow counter active energy outflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓
61212	Overflow counter reactive energy inflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓
61213	Overflow counter reactive energy outflow L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓
61214	Overflow counter apparent energy L2 [6]	UINT	-	0 ... 65535		✓	✓	✓	✓	✓	✓
61215	Overflow counter total active energy L2 [6]	UINT	-	0 ...65535		✓	✓	✓	✓	✓	✓
61216	Overflow counter total reactive energy L2 [6]	UINT	-	0 ...65535		✓	✓	✓	✓	✓	✓
61218	Phase angle L3 [3]	REAL	°	0.0 ... 360.0			✓	✓	✓	✓	✓
61220	Active energy inflow L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓
61221	Active energy outflow L3 [6]	LREAL	Wh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓
61222	Reactive energy inflow L3 [6]	LREAL	varh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓
61223	Reactive energy outflow L3 [6]	LREAL	varh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓
61224	Apparent energy L3 [6]	LREAL	VAh	0.0 ... 1.7976e+308			✓	✓	✓	✓	✓
61225	Total active energy L3 [6]	LREAL	Wh	-1.7976e+308 ... +1.7976e+308			✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
61226	Total reactive energy L3 [6]	LREAL	varh	-1.7976e+308 ... +1.7976e+308			✓	✓	✓	✓	✓
61230	Overflow counter active energy inflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓
61231	Overflow counter active energy outflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓
61232	Overflow counter reactive energy inflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓
61233	Overflow counter reactive energy outflow L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓
61234	Overflow counter apparent energy L3 [6]	UINT	-	0 ... 65535			✓	✓	✓	✓	✓
61235	Overflow counter total active energy L3 [6]	UINT	-	0 ...65535			✓	✓	✓	✓	✓
61236	Overflow counter total reactive energy L3 [6]	UINT	-	0 ...65535			✓	✓	✓	✓	✓
62110	Active energy inflow L1 (Int32) [6]	DINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
62111	Active energy outflow L1 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
62112	Reactive energy inflow L1 (Int32) [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
62113	Reactive energy outflow L1 (Int32)l. [6]	UDINT	varh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
62114	Apparent energy L1 (Int32) [6]	UDINT	Wh	0 ... 2147483647	✓	✓	✓	✓	✓	✓	✓
62115	Total active energy L1 (Int32). [6]	DINT	Wh	-2147483647 ... + 2147483647	✓	✓	✓	✓	✓	✓	✓
62116	Total reactive energy L1 (Int32) [6]	DINT	varh	-2147483647 ... + 2147483647	✓	✓	✓	✓	✓	✓	✓
62124	Fundamental reactive power L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
62127	Fundamental cos φ active factor L1 [17]	REAL	-	-1.0 ... 1.0	✓	✓	✓	✓	✓	✓	✓
62136	Fundamental cos φ active factor L1 (SINT8) [17]	SINT	0.01	-100...100	✓	✓	✓	✓	✓	✓	✓
62160	Max. reactive power Qtot L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
62180	Min. reactive power Qtot L1 [3]	REAL	var	-3.0e+9 ... +3.0e+9	✓	✓	✓	✓	✓	✓	✓
62193	Diagnostics L1 [20]	DWORD	Bit track	0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
62210	Active energy inflow L2 (Int32) [6]	DINT	Wh	0... 2147483647		✓	✓	✓	✓	✓	✓
62211	Active energy outflow L2 (Int32) [6]	DINT	Wh	0... 2147483647		✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
62212	Reactive energy inflow L2 (Int32) [6]	DINT	varh	0... 2147483647		✓	✓	✓	✓	✓	✓
62213	Reactive energy outflow L2 (Int32) [6]	DINT	varh	0... 2147483647		✓	✓	✓	✓	✓	✓
62214	Apparent energy L2 Active energy inflow L2 (Int32) [6]	DINT	VAh	0... 2147483647		✓	✓	✓	✓	✓	✓
62215	Total active energy L2 (Int32) [6]	DINT	Wh	-2147483647... +2147483647		✓	✓	✓	✓	✓	✓
62216	Total reactive energy L2 (Int32) [6]	DINT	varh	-2147483647... +2147483647		✓	✓	✓	✓	✓	✓
62224	Fundamental reactive power L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
62227	Fundamental cos φ active factor L2 [17]	REAL	-	-1.0 ... 1.0		✓	✓	✓	✓	✓	✓
62236	Fundamental cos φ active factor L2 (SINT8) [17]	SINT	0.01	-100...100		✓	✓	✓	✓	✓	✓
62260	Max. reactive power Qtot L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
62280	Min. reactive power Qtot L2 [3]	REAL	var	-3.0e+9 ... +3.0e+9		✓	✓	✓	✓	✓	✓
62293	Diagnostics L2 [20]	DWORD	Bit track	0 ... 4294967295		✓	✓	✓	✓	✓	✓
62310	Active energy inflow L3 (Int32) [6]	DINT	Wh	0... 2147483647			✓	✓	✓	✓	✓
62311	Active energy outflow L3 (Int32) [6]	DINT	Wh	0... 2147483647			✓	✓	✓	✓	✓
62312	Reactive energy inflow L3 (Int32) [6]	DINT	varh	0... 2147483647			✓	✓	✓	✓	✓
62313	Reactive energy outflow L3 (Int32) [6]	DINT	varh	0... 2147483647			✓	✓	✓	✓	✓
62314	Apparent energy L3 (Int32) [6]	DINT	VAh	0... 2147483647			✓	✓	✓	✓	✓
62315	Total active energy L3 (Int32) [6]	DINT	Wh	-2147483647... +2147483647			✓	✓	✓	✓	✓
62316	Total reactive energy L3 (Int32) [6]	DINT	varh	-2147483647... +2147483647			✓	✓	✓	✓	✓
62324	Fundamental reactive power L3 [3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
62327	Fundamental cos φ active factor L3 [17]	REAL	-	-1.0 ... 1.0			✓	✓	✓	✓	✓
62336	Fundamental cos φ active factor L3 (SINT8) [17]	SINT	0.01	-100...100			✓	✓	✓	✓	✓
62360	Max. reactive power Qtot L3[3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
62380	Min. reactive power Qtot L3[3]	REAL	var	-3.0e+9 ... +3.0e+9			✓	✓	✓	✓	✓
62393	Diagnostics L3 [20]	DWORD	Bit track	0 ... 4294967295			✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
65497	Current module time	PNIO	sec		✓	✓	✓	✓	✓	✓	✓
65500	Qualifier L1	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
65501	Qualifier L2	UINT	Bit track	0 ... 65535		✓	✓	✓	✓	✓	✓
65502	Qualifier L3	UINT	Bit track	0 ... 65535			✓	✓	✓	✓	✓
65503	Qualifier L1L2L3 [22]	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
65504	Operating hours counter L1L2L3 [5]	REAL	h	0.0 ... 3.4e+38	✓	✓	✓	✓	✓	✓	✓
65505	Operating hours counter L1 [5]	REAL	h	0.0 ... 3.4e+38	✓	✓	✓	✓	✓	✓	✓
65506	Operating hours counter L2 [5]	REAL	h	0.0 ... 3.4e+38		✓	✓	✓	✓	✓	✓
65507	Operating hours counter L3 [5]	REAL	h	0.0 ... 3.4e+38			✓	✓	✓	✓	✓
65508	Status of energy counter overflows	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
65509	Status of limit violations 1...16	UINT	Bit track	0 ... 65535	✓	✓	✓	✓	✓	✓	✓
65510	Counter for limit violations GW1 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65511	Counter for limit violations GW2 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65512	Counter for limit violations GW3 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65513	Counter for limit violations GW4 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65514	Counter for limit violations GW5 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65515	Counter for limit violations GW6 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65516	Counter for limit violations GW7 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65517	Counter for limit violations GW8 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65518	Counter for limit violations GW9 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65519	Counter for limit violations GW10 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65520	Counter for limit violations GW11 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65521	Counter for limit violations GW12 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type						
					1P 2W	2P 3W	3x 1P2W	3P 4W	3P 4W1	3P 3W	3P 3W1
65522	Counter for limit violations GW13 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65523	Counter for limit violations GW14 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65524	Counter for limit violations GW15 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓
65525	Counter for limit violations GW16 [5]	UDINT		0 ... 4294967295	✓	✓	✓	✓	✓	✓	✓

The table below is relevant for the description of the payload variants:

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P-2W	3P 4W	3P 4-W1	3P 3W	3P 3-W1	3P 4-WI
66001	Voltage L1-N [1]	UINT	0.01 V	0 ... 65535	✓	✓	✓	✓	✓			
66002	Voltage L2-N [1]	UINT	0.01 V	0 ... 65535		✓	✓	✓	✓			
66003	Voltage L3-N [1]	UINT	0.01 V	0 ... 65535			✓	✓	✓			
66004	Voltage L1-L2 [2]	UINT	0.01 V	0 ... 65535		✓		✓	✓	✓	✓	
66005	Voltage L2-L3 [2]	UINT	0.01 V	0 ... 65535				✓	✓	✓	✓	
66006	Voltage L3-L1 [2]	UINT	0.01 V	0 ... 65535				✓	✓	✓	✓	
66007	Current L1 [1]	UINT	1 mA	0 ... 65535	✓	✓	✓	✓	✓	✓	✓	✓
66008	Current L2 [1]	UINT	1 mA	0 ... 65535		✓	✓	✓	✓	✓	✓	✓
66009	Current L3 [1]	UINT	1 mA	0 ... 65535			✓	✓	✓	✓	✓	✓
66010	Apparent power L1 [3]	INT	1 VA	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66011	Apparent power L2 [3]	INT	1 VA	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66012	Apparent power L3 [3]	INT	1 VA	-32768 ... 32767			✓	✓	✓	✓	✓	
66013	Active power L1 [3]	INT	1 W	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66014	Active power L2 [3]	INT	1 W	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66015	Active power L3 [3]	INT	1 W	-32768 ... 32767			✓	✓	✓	✓	✓	
66016	Reactive power Qn L1[3]	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66017	Reactive power Qn L2[3]	INT	1 var	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66018	Reactive power Qn L3[3]	INT	1 var	-32768 ... 32767			✓	✓	✓	✓	✓	
66019	Power factor λ L1 [3]	USINT	0.01	0 ... 100	✓	✓	✓	✓	✓	✓	✓	
66020	Power factor λ L2 [3]	USINT	0.01	0 ... 100		✓	✓	✓	✓	✓	✓	
66021	Power factor λ L3 [3]	USINT	0.01	0 ... 100			✓	✓	✓	✓	✓	
66022	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66023	Reactive power Qtot L2	INT	1 var	-32768 ... 32767		✓	✓	✓	✓	✓	✓	
66024	Reactive power Qtot L3	INT	1 var	-32768 ... 32767			✓	✓	✓	✓	✓	
66030	Frequency (Uint8) [4]	USINT	1 Hz	40 ... 70	✓	✓	✓	✓	✓	✓	✓	✓
66031	Frequency (Uint16) [4]	UINT	0.01 Hz	4000 ... 7000	✓	✓	✓	✓	✓	✓	✓	✓

Measured value ID	Measured variables	Data type	Unit	Value range	Connection type							
					1P 2W	2P 3W	3x 1P-2W	3P 4W	3P 4-W1	3P 3W	3P 3-W1	3P 4-WI
66034	Active power L1L2L3 [5]	INT	1 W	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66035	Reactive power Qn L1L2L3[5]	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66036	Apparent power L1L2L3 [5]	INT	1 VA	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	
66037	Power factor λ L1L2L3 [6]	USINT	0.01	0 ... 100	✓	✓	✓	✓	✓	✓	✓	
66038	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	✓	✓	✓	✓	✓	✓	✓	✓

Z = additionally possible measured values in the current path (e.g. instead of neutral current)

[1] Effective value

[2] IEC 61557-12

[3] floating arithmetic average value above 200 ms

[4] floating arithmetic mean value above 10 s, available for UL-N>3 V. Frequencies outside the measuring range of lower than 40 Hz or higher than 70 Hz cannot be displayed. In these cases, the configured frequency (50 Hz or 60 Hz) is displayed and is used in further calculations.

[5] Simple summation

[6] Calculation from the start/restart (inflow and outflow values are positive numbers)

[7] floating arithmetic average value above 3 s

[8] floating arithmetic average value above 600 s

[9] floating arithmetic average value above 900 s

[10] Block measurement over 900 s

[11] direct measurement of the signal wave at 8 ksps

[12] Total of the parts / number of parts

[13] THD (Total Harmonic Distortion) is calculated once per second by the RMS of the fundamental oscillation and the total effective value (IEEE standard 1459–2010)

[14] Min./Max: Slave pointer function of the respective basic value from start/reset

[15] Calculation according to DIN EN 61000-3-316 half-wave value

[16] Half-wave value

[17] Instantaneous value

[18] FFT (Fast Fourier Transformation)

[19] While pure RMS measured values only contain AC voltage components of the signal, 10/12 and half-wave measured values also show DC voltage components of the signal

[20] ET 200SP Diagnostics:

Bit2: Voltage less than tolerance range (for diagnostics enable Voltage underflow)

Bit3: Voltage greater than tolerance range (enable overflow voltage for diagnostics)

Bit4: Current value > Current maximum value longer than tolerance time (for diagnostics enable Current overflow)

Bit7: Calculated value > value range (for diagnostics enable Calculated value overflow)

Bit16: Parameter error

Bit17: Load voltage error (missing load voltage for diagnostics enable)

Bit22: PRAL lost

Bit31: Calibration or firmware update

[21] ID 65495 is only available for triggers of the measured value acquisition (not for limit monitoring and user-defined payload or data records)

22 Only available for connection types 3PxW/only available for 3-phase system

Format

Table 2-1006 Format and its length in bytes

Format in STEP 7 (TIA Portal)	Format to IEEE	Length in bytes	Comment
BYTE	BYTE	1 byte	Bit field with 8 bit
WORD	WORD	2 bytes	Bit field with 16 bit
DWORD	DWORD	4 bytes	Bit field with 32 bits
SINT	INT8 (signed)	1 byte	Fixed-point number 8 bits with sign
USINT	INT8 (unsigned)	1 byte	Fixed-point number 8 bits without sign
INT	INT (signed)	2 bytes	Fixed-point number 16 bits with sign
UINT	INT (unsigned)	2 bytes	Fixed-point number 16 bits without sign
UDINT	INT32 (unsigned)	4 bytes	Fixed-point number 32 bits without sign
DINT	INT32 (signed)	4 bytes	Fixed-point number, 32 bits with sign
REAL	Float32	4 bytes	Floating-point number 32 bits with sign
LREAL	Float64	8 bytes	Floating-point number 64 bits with sign

Module versions

C

C.1 Module version "2 I / 2 Q"

User data of the module

The module has 2 bytes of input user data and 2 bytes of output user data for status and control information. At this module version measured variables can be read solely via measured value data records (no measured variables can be evaluated via user data).

Structure of input user data

The structure of the input user data is fixed.

Table 2-1007 Structure of input user data (2 bytes)

Byte	Validity	Designation	Comment
0	Module	User data variant	Constant = 0x80
1	Module	Quality information	Quality bits to describe the quality of the basic measured values

Allocation of the input user data

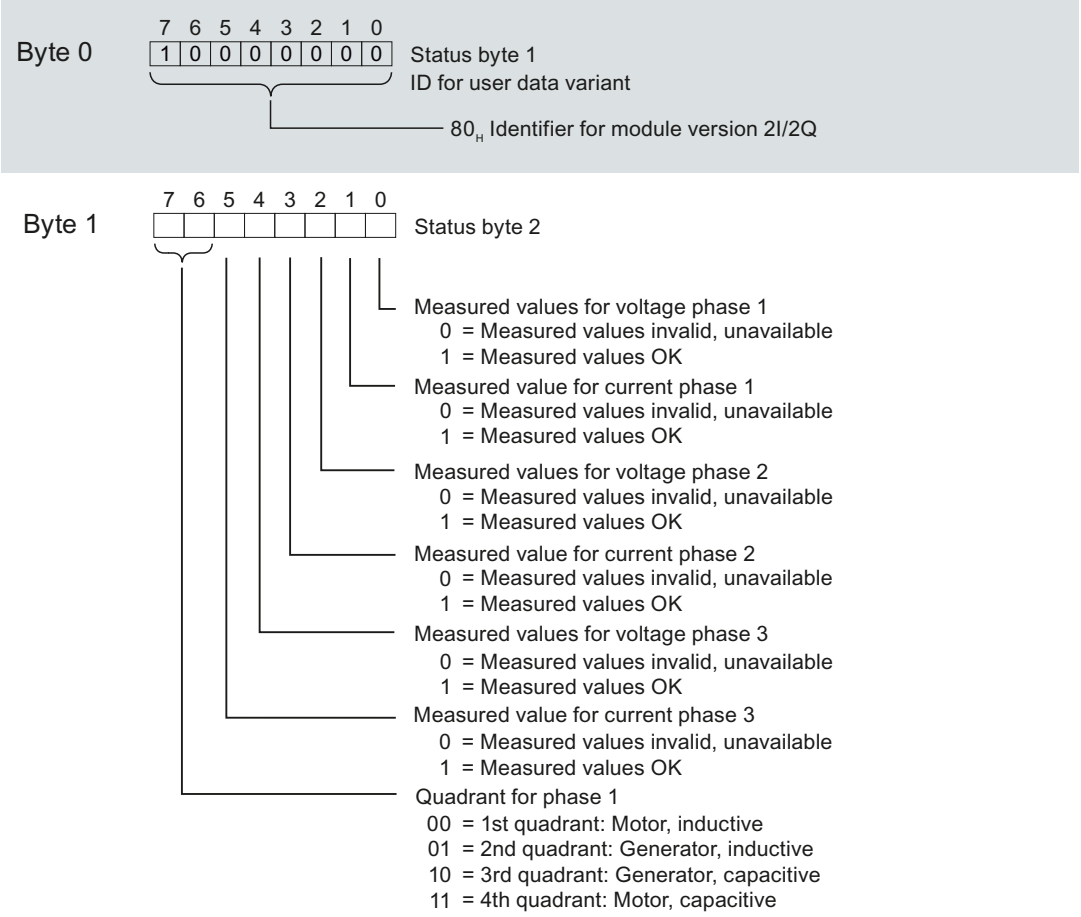

Figure 2-954 Allocation of the status bytes in the input user data (2 bytes)

Structure of output user data

The structure of the output user data is fixed.

Table 2-1008 Structure of output user data (2 bytes)

Byte	Validity	Designation	Comment
0	Module	Reserved	Reserved
1	Module	Control outputs	Reset of values and counters, gate

Assignment of the output user data

Via the output user data you control for all phases

- Resetting for all minimum values, maximum values, limits, operating hours counter and energy meters.
- The counter gates for operating hours counter and energy counters.

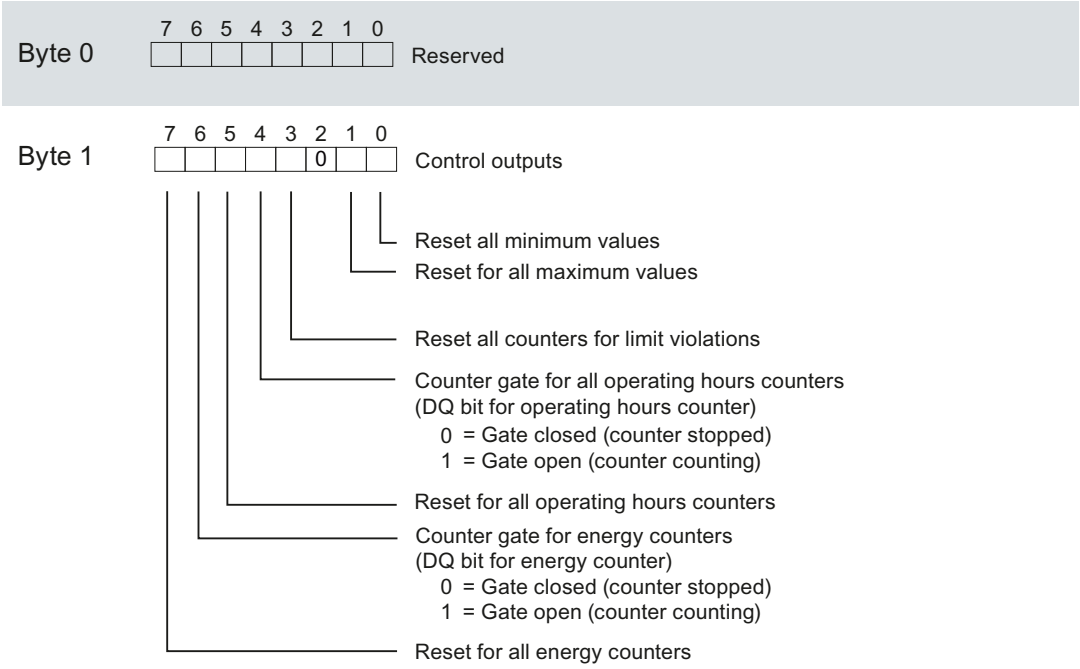

Figure 2-955 Allocation of the control byte in the output user data (1 byte)

NOTE

For module version 2 I / 2 Q, a reset of the selected variables always acts on **all** measured values/counter levels of the three phases.

- Reset energy counter: Acts on all active, reactive and apparent energies of all phases
- Reset operating hours counter: Acts on the counters of Phases 1 to 3
- Reset minimum / maximum values: Acts on the minimum and maximum value calculations of Phases 1-3
- Reset all counters for limit violations: Acts on all 16 limit values.

C.2 Module version "32 I / 20 Q"

Payload of the module

The module occupies 32 bytes of input payload and 20 bytes of output payload. Of these the module uses 2 bytes input data for status information and 20 bytes output data for control information. Measured variables can be read cyclically via payload (Bytes 2 to 31) or acyclically via measured value data records

Structure of input payload

You can set the contents of the input payload dynamically. You can choose between different payload variants.

Table 2-1009 Structure of input payload (32 bytes)

Byte	Validity	Designation	Comment
0	Module	Payload variant	-
1	Module	Quality information	Quality bits to describe the quality of the basic measured values
2 ... 31	Module or phase	Data	2 or 4 byte measured values or cumulative values according to payload variant

Allocation of the input payload

You can change the measured variables during operation. You can choose between different payload variants.

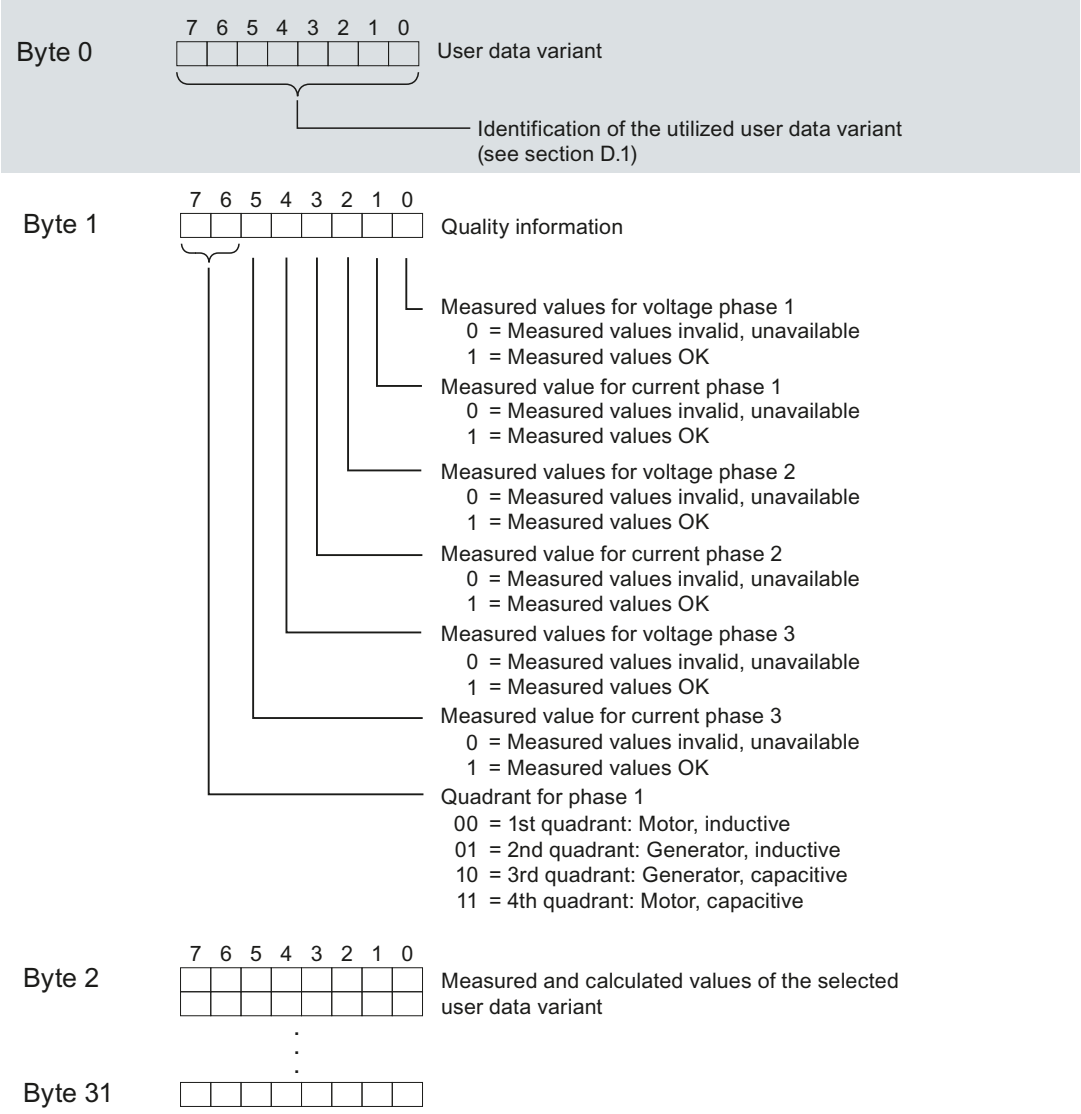

Figure 2-956 Assignment of the input payload (32 bytes)

Structure of output payload

The structure of the output payload is fixed and is the same at all the selectable payload variants.

Via the output payload you control globally or phase-specifically

- Resetting for minimum values, maximum values, limits, operating hours counter and energy meters.
- The counter gates for operating hours counter and energy meter.
- Gate for limits, minimum values and maximum values.

Table 2-1010 Structure of output payload (20 bytes)

Byte	Validity	Designation	Comment
0	Module	Payload variant	Control byte for switching the payload variant
1	Module	Control byte 1	Global resetting of values and counters, gate Selection of the energy meter to be reset
2	Module	Control byte 2	
3	Module	Control byte 3	Control of the limit monitoring of limit values 9 to 16
4	Module	Control byte 4	Control of the limit monitoring of limit values 1 to 8
5	Module	Reserved	-
6	Phase L1	Control byte 6	Phase-specific resetting of values and counters, gate for Phase L1
7	Phase L1	Control byte 7	
8	Phase L2	Control byte 8	Phase-specific resetting of values and counters, gate for Phase L2
9	Phase L2	Control byte 9	
10	Phase L3	Control byte 10	Phase-specific resetting of values and counters, gate for Phase L3
11	Phase L3	Control byte 11	
12	reserved		
13	Reserved		
14	Reserved		
15	Reserved		
16	Module	Control byte 16	General reset
17	Reserved		
18	Reserved		
19	Reserved		

Control bytes for payload variant

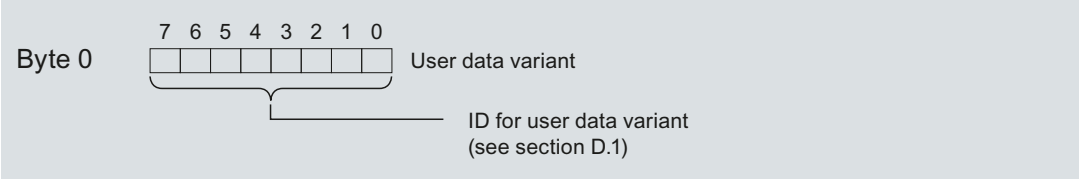

Figure 2-957 Allocation of the control bytes for payload variant (Byte 0)

Control bytes for all three phases

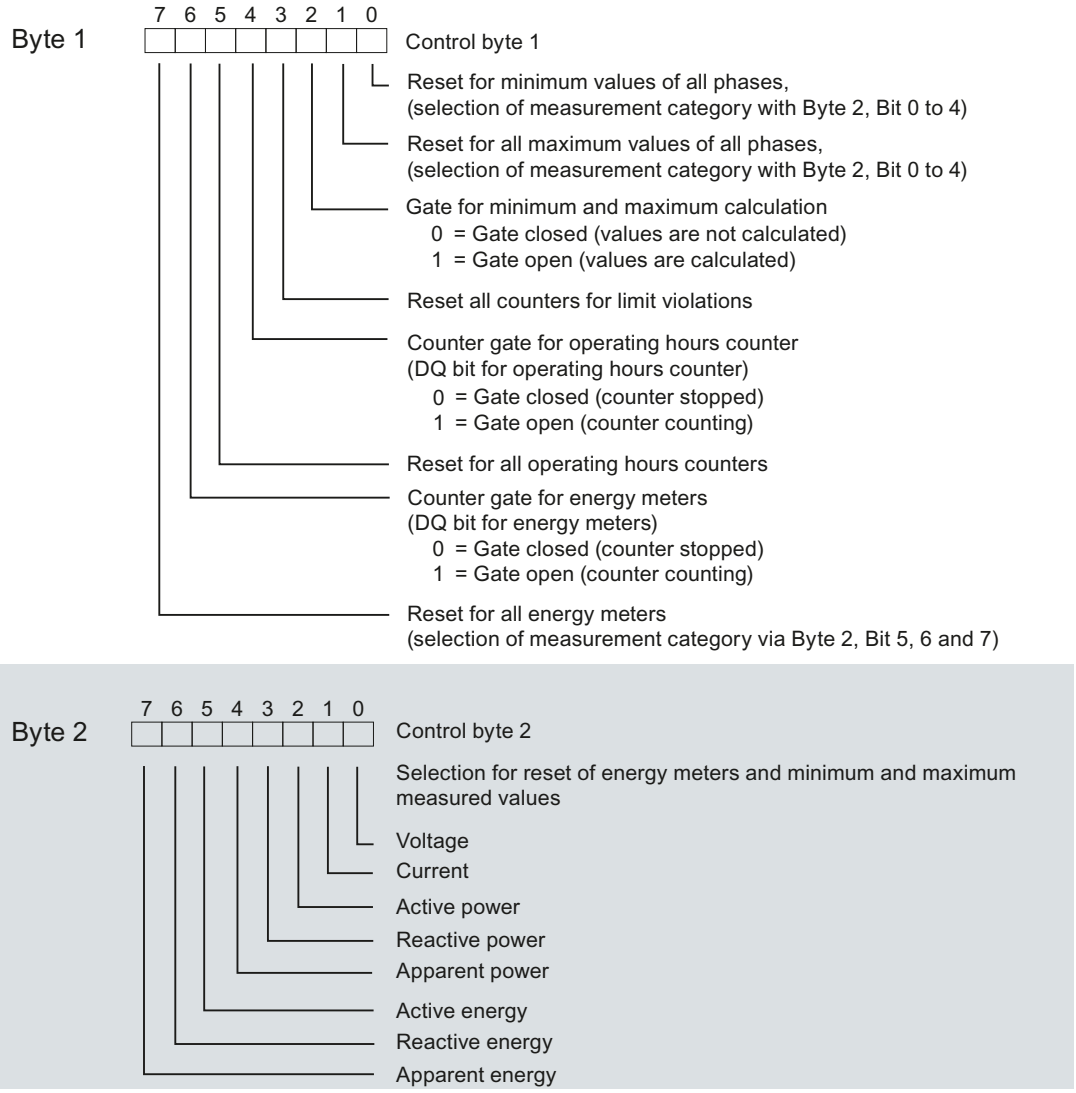

Figure 2-958 Allocation of the control bytes for all three phases (bytes 1 and 2)

Control bytes for limit monitoring

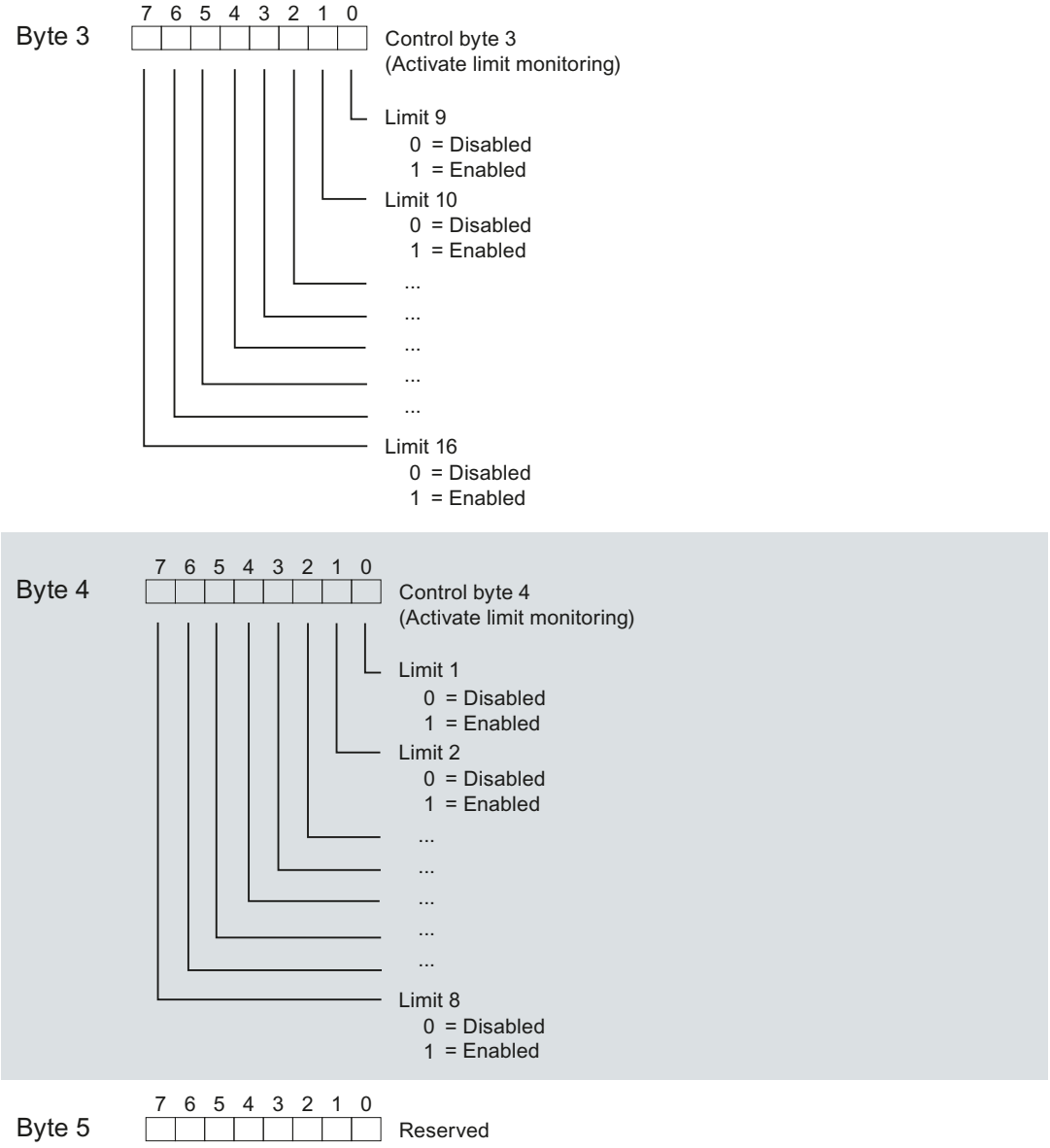

Figure 2-959 Allocation of the control bytes for limit monitoring (bytes 3 to 5)

Control bytes for each individual phase

	7	6	5	4	3	2	1	0	
Byte 6									Control bytes for reset and counter gates Phase 1
Byte 7									Allocation congruent to Bytes 1 and 2

	7	6	5	4	3	2	1	0	
Byte 8									Control bytes for reset and counter gates Phase 2
Byte 9									Allocation congruent to Bytes 1 and 2

	7	6	5	4	3	2	1	0	
Byte 10									Control bytes for reset and counter gates Phase 3
Byte 11									Allocation congruent to Bytes 1 and 2

Figure 2-960 Allocation of the control bytes for each individual phase (bytes 6 to 11)

	7	6	5	4	3	2	1	0	
Byte 12	0	0	0	0	0	0	0	0	Reserved
Byte 13	0	0	0	0	0	0	0	0	
Byte 14	0	0	0	0	0	0	0	0	
Byte 15	0	0	0	0	0	0	0	0	

Figure 2-961 Allocation of the control bytes for each individual phase (bytes 12 to 15)

Control byte reset functions

	7	6	5	4	3	2	1	0	
Byte 16		0	0	0	0	0	0	0	Control byte 16 - Reset functions

- 0 → reserved
- 0 → reserved
- 0 → reserved
- 0 → reserved
- 0 → General reset
  Edge change 0 -> 1
  - Resets all meters/counters for energy, operating hours and limits
  - Deletes analysis results of the power quality analysis
  - Resets minimum and maximum value calculation to initial values

Figure 2-962 Allocation of the control bytes for reset functions (byte 16)

	7	6	5	4	3	2	1	0	
Byte 17	0	0	0	0	0	0	0	0	reserved
Byte 18	0	0	0	0	0	0	0	0	
Byte 19	0	0	0	0	0	0	0	0	

Figure 2-963 Allocation of the control bytes for each individual phase (bytes 17 to 19)

C.3 "User-specific" module version

Payload of the module

The module occupies between 16 and 256 bytes of input payload and 20 bytes of output payload. Of these the module uses 2 bytes input data for status information and 20 bytes output data for control information. Measured variables can be read cyclically via payload (as of Byte 2) or acyclically via measured value data records

Structure of input payload

You configure the structure of the input payload starting at Byte 2 at this module version itself. An input payload length of 32 bytes also allows you to set the input payload dynamically. You can choose between different payload variants.

Table 2-1011 Structure of input payload (16 to 256 bytes)

Byte	Validity	Designation	Comment
0	Module	Payload variant	-
1	Module	Quality information	Quality bits to describe the quality of the basic measured values
2 ... 255	Module or phase	Data	Measured values or calculated values in accordance with their configuration: • At configuration in STEP 7 the size of the input payload is calculated automatically. • With configuration via the GSD file the size of the input payload amounts to 32, 64, 128 or 256 bytes. The memory area has to be sufficiently large for the measured variables defined in parameter data record 130.

Allocation of the input payload

You can change the measured variables during operation. You can choose between different payload variants.

The allocation of the status information in bytes 0 and 1 corresponds to the module version 32 I / 20 Q, see appendix Module version "32 I / 20 Q" (Page 149).

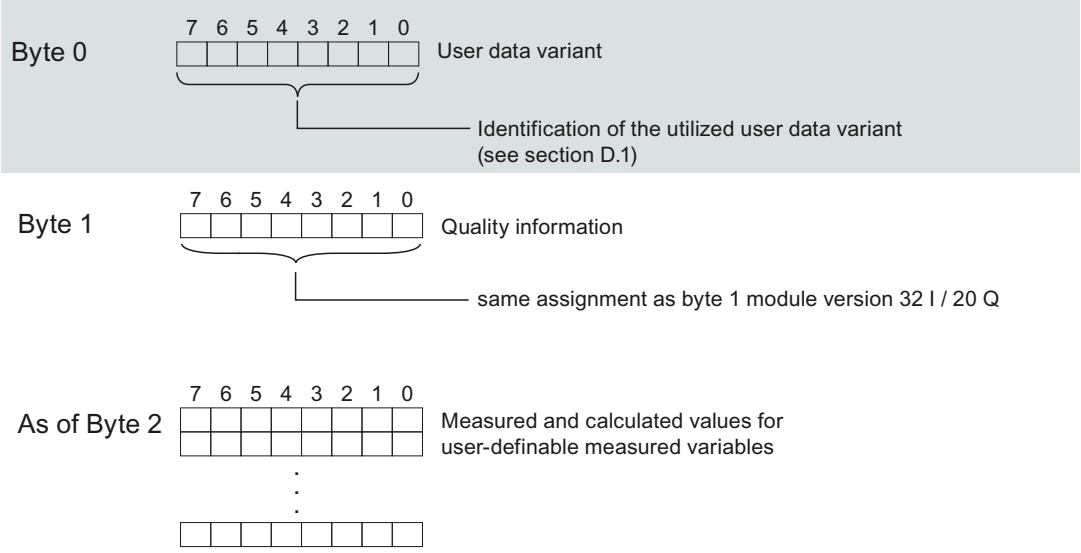

Figure 2-964 Allocation of the input payload ("User-specific" module version"

NOTE

Behavior at switchover in case of the input payload being too small

If the configured size of the variable input payload is smaller than the sized of the fixed payload variant, the response depends on the type of switchover:

- Re-assigning parameters via parameter data records DS 128 / DS 130: Output of a parameter assignment error (33). No switchover.
- Switchover using output byte 0 of a payload variant: No switchover and no error message.

Structure of output payload

The structure of the 20-byte output payload is fixed and is identical to the output payload (control bytes) of the Module version "32 I / 20 Q" (Page 149).

C.4 Module version "EE@Industry measurement data profile E0 / E1 / E2 / E3"

Payload of the module

The four versions according to EE@Industry use between 4 and 104 bytes of input payload and 20 bytes of output payload. A dynamic switchover of the input payload is not possible.

Structure of input payload

The structure of the input payload for the module versions according to the EE@Industry standard is fixed and depends on the selected measurement data profile.

Table 2-1012 Measurement data profile E0

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Current L1	REAL	1 A	0.0 ... 100000.0	7
4...7	Current L2	REAL	1 A	0.0 ... 100000.0	8
8...11	Current L3	REAL	1 A	0.0 ... 100000.0	9

Table 2-1013 Measurement data profile E1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Active power L1L2L3	REAL	1 W	-3.0e+9 ... +3.0e+9	34

Table 2-1014 Measurement data profile E2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Active power L1L2L3	REAL	1 W	-3.0e+9 ... +3.0e+9	34
4...7	Active energy inflow L1L2L3 (Float)	REAL	1 Wh	0.0 ... 3.4028e+38	200
8...11	Active energy outflow L1L2L3 (Float)	REAL	1 Wh	0.0 ... 3.4028e+38	201

Table 2-1015 Measurement data profile E3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0...3	Active power L1	REAL	1 W	-3.0e+9 ... +3.0e+9	13
4...7	Active power L2	REAL	1 W	-3.0e+9 ... +3.0e+9	14
8...11	Active power L3	REAL	1 W	-3.0e+9 ... +3.0e+9	15
12...15	Reactive power Qtot L1	REAL	1 var	-3.0e+9 ... +3.0e+9	22
16...19	Reactive power Qtot L2	REAL	1 var	-3.0e+9 ... +3.0e+9	23
20...23	Reactive power Qtot L3	REAL	1 var	-3.0e+9 ... +3.0e+9	24
24...31	Active energy inflow L1L2L3	LREAL	1 Wh	0.0 ... 1.7976e+308	210
32...39	Active energy outflow L1L2L3	LREAL	1 Wh	0.0 ... 1.7976e+308	211
40...47	Reactive energy inflow L1L2L3	LREAL	1 varh	0.0 ... 1.7976e+308	212

Byte	Allocation	Data type	Unit	Value range	Measured value ID
48...55	Reactive energy outflow L1L2L3	LREAL	1 varh	0.0 ... 1.7976e+308	213
56...59	Voltage L1-N	REAL	1 V	0.0 ... 1000000.0	1
60...63	Voltage L2-N	REAL	1 V	0.0 ... 1000000.0	2
64...67	Voltage L3-N	REAL	1 V	0.0 ... 1000000.0	3
68...71	Voltage L1-L2	REAL	1 V	0.0 ... 1000000.0	4
72...75	Voltage L2-L3	REAL	1 V	0.0 ... 1000000.0	5
76...79	Voltage L3-L1	REAL	1 V	0.0 ... 1000000.0	6
80...83	Current L1	REAL	1 A	0.0 ... 100000.0	7
84...87	Current L2	REAL	1 A	0.0 ... 100000.0	8
88...91	Current L3	REAL	1 A	0.0 ... 100000.0	9
92...95	Power factor λ L1	REAL	-	0.0 ... 1.0	19
96...99	Power factor λ L2	REAL	-	0.0 ... 1.0	20
100...1-03	Power factor λ L3	REAL	-	0.0 ... 1.0	21

Structure of output payload

The structure of the 20-byte output payload is fixed and is identical to the output payload (control bytes) of the Module version "32 I / 20 Q" (Page 149).

User data variants

D

D.1 User data variants with 32 bytes input data / 20 bytes output data

Payload

The following table shows the existing user data variants.

Table 2-1016 Overview of the user data variants

Payload	Payload variant
Total power L1L2L3	254 (FE_H) - default setting
Active power L1L2L3	253 (FD_H)
Reactive power L1L2L3	252 (FC_H)
Apparent power L1L2L3	251 (FB_H)
Basic measured values L1L2L3	250 (FA_H)
Total energy L1L2L3	249 ($F9_H$)
Energy L1	248 ($F8_H$)
Energy L2	247 ($F7_H$)
Energy L3	246 ($F6_H$)
Basic variables three-phase measurement L1L2L3	245 ($F5_H$)
Reactive power compensation	244 ($F4_H$)
Quality values three-phase measurement	240 ($F0_H$)
Energy measurement (periodic) overflow counter	239 (EF_H)
EE@Industry measurement data profile E3	227 ($E3_H$)
EE@Industry measurement data profile E2	226 ($E2_H$)
EE@Industry measurement data profile E1	225 ($E1_H$)
EE@Industry measurement data profile E0	224 ($E0_H$)
Basic variables phase-specific measurement L1	159 ($9F_H$)
Single-phase measurement L1 with voltage scaling value	158 ($9E_H$)
Basic variables phase-specific measurement L2	157 ($9D_H$)
Single-phase measurement L2 with voltage scaling value	156 ($9C_H$)
Basic variables phase-specific measurement L3	155 ($9B_H$)
Single-phase measurement L3 with voltage scaling value	154 ($9A_H$)
User-defined user data structure I	1 (01_H)

Information on using and dynamic switching of the payload variants can be found under "Selection of the module variant".

Total power L1L2L3 (ID 254 or FE_H)

Table 2-1017 Total power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	254 (FE_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
10 ... 11	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038
12 ... 13	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
14 ... 17	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	225
18 ... 21	Total reactive energy L1L2L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	226
22	Reserved	BYTE	-	0	-
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1L2L3	USINT	-	0 ... 255	-
28	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
29	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
30	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Active power L1L2L3 (ID 253 or FD_H)

Table 2-1018 Active power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	253 (FD_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Active power L1	INT	1 W	-32768 ... 32767	66013
10 ... 11	Active power L2	INT	1 W	-32768 ... 32767	66014
12 ... 13	Active power L3	INT	1 W	-32768 ... 32767	66015
14 ... 15	Active power L1L2L3	INT	1 W	-32768 ... 32767	66034
16 ... 19	Total active energy L1L2L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	225
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling active power L1	USINT	-	0 ... 255	-
28	Scaling active power L2	USINT	-	0 ... 255	-
29	Scaling active power L3	USINT	-	0 ... 255	-
30	Scaling active power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total active energy L1L2L3	USINT	-	0 ... 255	-

Reactive power L1L2L3 (ID 252 or FC_H)

Table 2-1019 Reactive power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	252 (FC_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	66022
10 ... 11	Reactive power Qtot L2	INT	1 var	-32768 ... 32767	66023
12 ... 13	Reactive power Qtot L3	INT	1 var	-32768 ... 32767	66024
14 ... 15	Reactive power Qtot L1L2L3	INT	1 var	-32768 ... 32767	66038

Byte	Allocation	Data type	Unit	Value range	Measured value ID
16 ... 19	Reactive energy inflow L1L2L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	222
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling reactive power L1	USINT	-	0 ... 255	-
28	Scaling reactive power L2	USINT	-	0 ... 255	-
29	Scaling reactive power L3	USINT	-	0 ... 255	-
30	Scaling reactive power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total reactive energy L1L2L3	USINT	-	0 ... 255	-

Apparent power L1L2L3 (ID 251 or FB_H)

Table 2-1020 Apparent power L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	251 (FB_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Apparent power L1	INT	1 VA	-32768 ... 32767	66010
10 ... 11	Apparent power L2	INT	1 VA	-32768 ... 32767	66011
12 ... 13	Apparent power L3	INT	1 VA	-32768 ... 32767	66012
14 ... 15	Apparent power L1L2L3	INT	1 VA	-32768 ... 32767	66036
16 ... 19	Apparent energy L1L2L3 (Int32)	DINT	1 VAh	0 to 2147483647	224
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Scaling apparent power L2	USINT	-	0 ... 255	-
29	Scaling apparent power L3	USINT	-	0 ... 255	-
30	Scaling apparent power L1L2L3	USINT	-	0 ... 255	-
31	Scaling total apparent energy L1L2L3	USINT	-	0 ... 255	-

Basic measured values L1L2L3 (ID 250 or FA_H)

Table 2-1021 Basic measured values L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	250 (FA_H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Current L2	UINT	1 mA	0 ... 65535	66008
6 ... 7	Current L3	UINT	1 mA	0 ... 65535	66009
8 ... 9	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
10 ... 11	Voltage L2-N	UINT	0.01 V	0 ... 65535	66002
12 ... 13	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003
14 ... 15	Voltage L1-L2	UINT	0.01 V	0 ... 65535	66004
16 ... 17	Voltage L2-L3	UINT	0.01 V	0 ... 65535	66005
18 ... 19	Voltage L3-L1	UINT	0.01 V	0 ... 65535	66006
20	Power factor λ L1	USINT	0.01	0 ... 100	66019
21	Power factor λ L2	USINT	0.01	0 ... 100	66020
22	Power factor λ L3	USINT	0.01	0 ... 100	66021
23	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling current L2	USINT	-	0 ... 255	-
26	Scaling current L3	USINT	-	0 ... 255	-
27	Scaling voltage UL1-N (UL1-UL2)	USINT	-	0 ... 255	-
28	Scaling voltage UL2-N (UL2-UL3)	USINT	-	0 ... 255	-
29	Scaling voltage UL3-N (UL3-UL1)	USINT	-	0 ... 255	-
30 ... 31	Frequency (Uint16)	UINT	0.01 Hz	4000 ... 7000	66031

Total energy L1L2L3 (ID 249 or $F9_H$)

Table 2-1022 Total energy L1L2L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	249 ($F9_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2	Reserved	BYTE	-	0	-
3	Reserved	BYTE	-	0	-
4 ... 7	Active energy inflow L1L2L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	220
8 ... 11	Active energy outflow L1L2L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	221
11 ... 15	Reactive energy inflow L1L2L3 (Int32)	UDINT	1 varh	0 ... 2147483647	222
16 ... 19	Reactive energy outflow L1L2L3 (Int32)	UDINT	1 varh	0 ... 2147483647	223
20 ... 23	Apparent energy L1L2L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	224
24	Reserved	BYTE	-	0	-
25	Scaling active energy, inflow	USINT	-	0 ... 255	-
26	Scaling active energy, outflow	USINT	-	0 ... 255	-
27	Scaling reactive energy, inflow	USINT	-	0 ... 255	-
28	Scaling reactive energy, outflow	USINT	-	0 ... 255	-
29	Scaling apparent energy	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L1L2L3	USINT	0.01	0 ... 100	66037

Energy L1 (ID 248 or $F8_H$)

Table 2-1023 Energy L1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	248 ($F8_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 7	Active energy inflow L1 (Int32)	UDINT	1 Wh	0 ... 2147483647	62110
8 ... 11	Active energy outflow L1 (Int32)	UDINT	1 Wh	0 ... 2147483647	62111
11 ... 15	Reactive energy inflow L1 (Int32)	UDINT	1 varh	0 ... 2147483647	62112
16 ... 19	Reactive energy outflow L1 (Int32)	UDINT	1 varh	0 ... 2147483647	62113
20 ... 23	Apparent energy L1 (Int32)	UDINT	1 VAh	0 ... 2147483647	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active energy inflow L1	USINT	-	0 ... 255	-
26	Scaling active energy outflow L1	USINT	-	0 ... 255	-

Byte	Allocation	Data type	Unit	Value range	Measured value ID
27	Scaling reactive energy inflow L1	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L1	USINT	-	0 ... 255	-
29	Scaling apparent energy L1	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L1	USINT	0.01	0 ... 100	66019

Energy L2 (ID 247 or $F7_H$)

Table 2-1024 Energy L2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	247 ($F7_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L2	UINT	1 mA	0 ... 65535	66008
4 ... 7	Active energy inflow L2 (Int32)	UDINT	1 Wh	0 ... 2147483647	62210
8 ... 11	Active energy outflow L2 (Int32)	UDINT	1 Wh	0 ... 2147483647	62211
11 ... 15	Reactive energy inflow L2 (Int32)	UDINT	1 varh	0 ... 2147483647	62212
16 ... 19	Reactive energy outflow L2 (Int32)	UDINT	1 varh	0 ... 2147483647	62213
20 ... 23	Apparent energy L2 (Int32)	UDINT	1 VAh	0 ... 2147483647	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active energy inflow L2	USINT	-	0 ... 255	-
26	Scaling active energy outflow L2	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L2	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L2	USINT	-	0 ... 255	-
29	Scaling apparent energy L2	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L2	USINT	0.01	0 ... 100	66020

Energy L3 (ID 246 or $F6_H$)

Table 2-1025 Energy L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	246 ($F6_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Current L3	UINT	1 mA	0 ... 65535	66009
4 ... 7	Active energy inflow L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	62310
8 ... 11	Active energy outflow L3 (Int32)	UDINT	1 Wh	0 ... 2147483647	62311
11 ... 15	Reactive energy inflow L3 (Int32)	UDINT	1 varh	0 ... 2147483647	62312
16 ... 19	Reactive energy outflow L3 (Int32)	UDINT	1 varh	0 ... 2147483647	62313
20 ... 23	Apparent energy L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active energy inflow L3	USINT	-	0 ... 255	-
26	Scaling active energy outflow L3	USINT	-	0 ... 255	-
27	Scaling reactive energy inflow L3	USINT	-	0 ... 255	-
28	Scaling reactive energy outflow L3	USINT	-	0 ... 255	-
29	Scaling apparent energy L3	USINT	-	0 ... 255	-
30	Reserved	BYTE	-	0	-
31	Power factor λ L3	USINT	0.01	0 ... 100	66021

Basic variables three-phase measurements (ID 245 or $F5_H$)

Table 2-1026 Basic variables three-phase measurements

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	245 ($F5_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1L2L3	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	34
6 ... 9	Active energy outflow L1L2L3	REAL	1 Wh	0.0 ... 3.4×10^{38}	201
10 ... 13	Active energy inflow L1L2L3	REAL	1 Wh	0.0 ... 3.4×10^{38}	200
14 ... 17	Current L1	REAL	1 A	0.0 ... 100000.0	7
18 ... 21	Current L2	REAL	1 A	0.0 ... 100000.0	8
22 ... 25	Current L3	REAL	1 A	0.0 ... 100000.0	9
26 ... 27	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
28 ... 29	Voltage L2-N	UINT	0.01 V	0 ... 65535	66002
30 ... 31	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003

Reactive power compensation (ID 244 or $F4_H$)

Table 2-1027 Reactive power compensation

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	244 ($F4_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2	Fundamental cos φ active factor L1 (SINT8)	BYTE	0.01	-100 ... 100	62136
3	Fundamental cos φ active factor L2 (SINT8)	BYTE	0.01	-100 ... 100	62236
4	Fundamental cos φ active factor L3 (SINT8)	BYTE	0.01	-100 ... 100	62336
5	Reserved	BYTE	-	0	-
6 ... 9	Fundamental reactive power L1	REAL	var	-3×10^9 ... $+3 \times 10^9$	62124
10 ... 13	Fundamental reactive power L2	REAL	var	-3×10^9 ... $+3 \times 10^9$	62224
14 ... 17	Fundamental reactive power L3	REAL	var	-3×10^9 ... $+3 \times 10^9$	62324

Basic variables quality values three-phase measurement (ID 240 or $F0_H$)

Table 2-1028 Basic variables quality values three-phase measurement

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	240 (F0H)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Status limit violation GW 1 ... 16 (*)	WORD	Bit string	xxxx xxxx xxxx xxxx	65509
4 ... 5	Status of the energy counter overflows (**)	WORD	Bit string	xxxx xxxx xxxx xxxx	65508
6 ... 7	Qualifier L1L2L3	WORD	Bit string	xxxx xxxx xxxx xxxx	65503
8 ... 11	Reserved	UDINT	-	0	-
12 ... 13	Reserved	WORD	-	0	-
14 ... 15	Reserved	WORD	-	0	-
16 ... 17	Reserved	WORD	-	0	-
18 ... 19	Reserved	WORD	-	0	-
20 ... 21	Reserved	WORD	-	0	-
22 ... 23	Reserved	WORD	-	0	-
24 ... 25	Reserved	WORD	-	0	-

(*) Limit violation in:
Bit 0 = limit 1 to bit 15 = limit 16

(**) Energy meter count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
26 ... 27	Reserved	WORD	-	0	-
28 ... 29	Reserved	WORD	-	0	-
30 ... 31	Reserved	WORD	-	0	-

(*) Limit violation in:
Bit 0 = limit 1 to bit 15 = limit 16

Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

Basic variables energy meter measurement (periodic) overflow counter (ID 239 or EF_H)

Table 2-1029 Basic variables energy meter measurement (periodic) overflow counter

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	239 (EFH)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 3	Overflow counter active energy inflow L1	UINT	-	0 ... 65535	61190
4 ... 5	Overflow counter active energy outflow L1	UINT	-	0 ... 65535	61191
6 ... 7	Overflow counter reactive energy inflow L1	UINT	-	0 ... 65535	61192
8 ... 9	Overflow counter reactive energy outflow L1	UINT	-	0 ... 65535	61193
10 ... 11	Overflow counter apparent energy L1	UINT	-	0 ... 65535	61194
12 ... 13	Overflow counter active energy inflow L2	UINT	-	0 ... 65535	61210
14 ... 15	Overflow counter active energy outflow L2	UINT	-	0 ... 65535	61211
16 ... 17	Overflow counter reactive energy inflow L2	UINT	-	0 ... 65535	61212
18 ... 19	Overflow counter reactive energy outflow L2	UINT	-	0 ... 65535	61213
20 ... 21	Overflow counter apparent energy L2	UINT	-	0 ... 65535	61214
22 ... 23	Overflow counter active energy inflow L3	UINT	-	0 ... 65535	61230

Byte	Allocation	Data type	Unit	Value range	Measured value ID
24 ... 25	Overflow counter active energy outflow L3	UINT	-	0 ... 65535	61231
26 ... 27	Overflow counter reactive energy inflow L3	UINT	-	0 ... 65535	61232
28 ... 29	Overflow counter reactive energy outflow L3	UINT	-	0 ... 65535	61233
30 ... 31	Overflow counter apparent energy L3	UINT	-	0 ... 65535	61234

Basic variables measurement data profile (ID 227 or $E3_H$)

Table 2-1030 Basic variables measurement data profile Energy E3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	227 ($E3_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	13
6 ... 9	Active power L2	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	14
10 ... 13	Active power L3	REAL	1 W	-3×10^9 ... $+3 \times 10^9$	15
14 ... 17	Reactive power Qtot L1	REAL	1 var	-3×10^9 ... $+3 \times 10^9$	22
18 ... 21	Reactive power Qtot L2	REAL	1 var	-3×10^9 ... $+3 \times 10^9$	23
22 ... 25	Reactive power Qtot L3	REAL	1 var	-3×10^9 ... $+3 \times 10^9$	24
26 ... 33	Active energy inflow L1L2L3	LREAL	1 Wh	0.0 ... 1.8×10^{308}	210
34 ... 41	Active energy outflow L1L2L3	LREAL	1 Wh	0.0 ... 1.8×10^{308}	211
42 ... 49	Reactive energy inflow L1L2L3	LREAL	1 varh	0.0 ... 1.8×10^{308}	212
50 ... 57	Reactive energy outflow L1L2L3	LREAL	1 varh	0.0 ... 1.8×10^{308}	213
58 ... 61	Voltage L1-N	REAL	1 V	0.0 ... 1000000.0	1
62 ... 65	Voltage L2-N	REAL	1 V	0.0 ... 1000000.0	2
66 ... 69	Voltage L3-N	REAL	1 V	0.0 ... 1000000.0	3
70 ... 73	Voltage L1-L2	REAL	1 V	0.0 ... 1000000.0	4
74 ... 77	Voltage L2-L3	REAL	1 V	0.0 ... 1000000.0	5
78 ... 81	Voltage L3-L1	REAL	1 V	0.0 ... 1000000.0	6
82 ... 85	Current L1	REAL	1 A	0.0 ... 100000.0	7
86 ... 89	Current L2	REAL	1 A	0.0 ... 100000.0	8
90 ... 93	Current L3	REAL	1 A	0.0 ... 100000.0	9
94 ... 97	Power factor λ L1	REAL	-	0.0 ... 1.0	19
98 ... 101	Power factor λ L2	REAL	-	0.0 ... 1.0	20
102 ... 105	Power factor λ L3	REAL	-	0.0 ... 1.0	21

Basic variables measurement data profile (ID 226 or $E2_H$)

Table 2-1031 Basic variables measurement data profile Energy E2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	226 ($E2_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	34
6 ... 9	Active energy inflow L1L2L3 (Float)	REAL	1 W	3.0×10^9	200
10 ...13	Active energy outflow L1L2L3 (Float)	REAL	1 W	3.0×10^9	201

Basic variables measurement data profile (ID 225 or $E1_H$)

Table 2-1032 Basic variables measurement data profile Energy E1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	225 ($E1_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Active power L1L2L3	REAL	1 W	-3.0×10^9 ... $+ 3.0 \times 10^9$	34

Basic variables measurement data profile (ID 224 or $E0_H$)

Table 2-1033 Basic variables measurement data profile Energy E0

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	224 ($E0_H$)	-
1	Quality information = QQ_1 I_3 U_3 I_2 U_2 I_1 U_1	BYTE	Bit string	qq xx xx xx	-
2 ... 5	Current L1	REAL	1 A	0.0 ... 100000.0	7
6 ... 9	Current L2	REAL	1 A	0.0 ... 100000.0	8
10 ...13	Current L3	REAL	1 A	0.0 ... 100000.0	9

Basic variables phase-specific measurement (ID 159 or $9F_H$)

Table 2-1034 Basic variables phase-specific measurement L1

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	159 (9FH)	-
1	Quality information = Q Q_1 0 0 0 0 I_1 U_1	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
6 ... 7	Active power L1	INT	1 W	-32768 ... 32767	66013
8 ... 9	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	66022
10 ... 11	Apparent power L1	INT	1 VA	-32768 ... 32767	66010
12 ... 15	Total active energy L1 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62115
16 ... 19	Total reactive energy L1 (Int32)	DINT	1 varh	-2147483647... +2147483647	62116
20 ... 23	Apparent energy L1 (Int32)	UDINT	1 VAh	0 ... 2147483647	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active power L1	USINT	-	0 ... 255	-
26	Scaling reactive power L1	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Total scaling active energy L1	USINT	-	0 ... 255	-
29	Total scaling reactive energy L1	USINT	-	0 ... 255	-
30	Scaling apparent energy L1	USINT	-	0 ... 255	-
31	Power factor λ L1	USINT	0.01	0 ... 100	66019

Basic variables phase-specific measurement (ID 158 or $9E_H$)

Table 2-1035 Single-phase measurement L1 with voltage scaling value

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	158 (9EH)	-
1	Quality information = Q Q_1 0 0 0 0 I_1 U_1	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L1	UINT	1 mA	0 ... 65535	66007
4 ... 5	Voltage L1-N	UINT	0.01 V	0 ... 65535	66001
6 ... 7	Active power L1	INT	1 W	-32768 ... 32767	66013
8 ... 9	Reactive power Qtot L1	INT	1 var	-32768 ... 32767	66022
10 ... 11	Apparent power L1	INT	1 VA	-32768 ... 32767	66010
12 ... 15	Total active energy L1	UDINT	1 Wh	0 ... 4294967295	62115

Byte	Allocation	Data type	Unit	Value range	Measured value ID
16 ... 19	Total reactive energy L1	UDINT	1 varh	0 ... 4294967295	62116
20 ... 23	Apparent energy L1 (Int32)	UDINT	1 VAh	0 ... 4294967295	62114
24	Scaling current L1	USINT	-	0 ... 255	-
25	Scaling active power L1	USINT	-	0 ... 255	-
26	Scaling reactive power L1	USINT	-	0 ... 255	-
27	Scaling apparent power L1	USINT	-	0 ... 255	-
28	Total scaling active energy L1	USINT	-	0 ... 255	-
29	Total scaling reactive energy L1	USINT	-	0 ... 255	-
30	Scaling apparent energy L1	USINT	-	0 ... 255	-
31	Scaling voltage L1-N	USINT	-	0 ... 255	-

Basic variables phase-specific measurement (ID 157 or $9D_H$)

Table 2-1036 Basic variables phase-specific measurement L2

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	157 ($9D_H$)	-
1	Quality information = Q Q_1 0 0 0 0 I_2 U_2	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L2	UINT	1 mA	0 ... 65535	66008
4 ... 5	Voltage L2-N	UINT	0.01 V	0 ... 65535	66002
6 ... 7	Active power L2	INT	1 W	-32768 ... 32767	66014
8 ... 9	Reactive power Qtot L2	INT	1 var	-32768 ... 32767	66023
10 ... 11	Apparent power L2	INT	1 VA	-32768 ... 32767	66011
12 ... 15	Total active energy L2 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62215
16 ... 19	Total reactive energy L2 (Int32)	DINT	1 varh	-2147483647... +2147483647	62216
20 ... 23	Apparent energy L2 (Int32)	UDINT	1 VAh	0 ... 2147483647	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active power L2	USINT	-	0 ... 255	-
26	Scaling reactive power L2	USINT	-	0 ... 255	-
27	Scaling apparent power L2	USINT	-	0 ... 255	-
28	Total scaling active energy L1	USINT	-	0 ... 255	-
29	Total scaling reactive energy L1	USINT	-	0 ... 255	-
30	Scaling apparent energy L2	USINT	-	0 ... 255	-
31	Power factor λ L2	USINT	0.01	0 ... 100	66020

Basic variables phase-specific measurement (ID 156 or $9C_H$)

Table 2-1037 Single-phase measurement L2 with voltage scaling value

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	156 (9CH)	-
1	Quality information = Q Q_1 0 0 0 0 I_2 U_2	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L2	UINT	1 mA	0 ... 65535	66008
4 ... 5	Voltage UL2-N	UINT	0.01 V	0 ... 65535	66002
6 ... 7	Active power L2	INT	1 W	-32768 ... 32767	66014
8 ... 9	Reactive power Qtot L2	INT	1 var	-32768 ... 32767	66023
10 ... 11	Apparent power L2	INT	1 VA	-32768 ... 32767	66011
12 ... 15	Total active energy L2 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62215
16 ... 19	Total reactive energy L2 (Int32)	DINT	1 varh	-2147483647... +2147483647	62216
20 ... 23	Apparent energy L2 (Int32)	UDINT	1 VAh	0 ... 2147483647	62214
24	Scaling current L2	USINT	-	0 ... 255	-
25	Scaling active power L2	USINT	-	0 ... 255	-
26	Scaling reactive power L2	USINT	-	0 ... 255	-
27	Scaling apparent power L2	USINT	-	0 ... 255	-
28	Total scaling active energy L2	USINT	-	0 ... 255	-
29	Total scaling reactive energy L2	USINT	-	0 ... 255	-
30	Scaling apparent energy L2	USINT	-	0 ... 255	-
31	Scaling voltage L2-N	USINT	-	0 ... 255	-

Basic variables phase-specific measurement (ID 155 or $9B_H$)

Table 2-1038 Basic variables phase-specific measurement L3

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	User data variant	BYTE	-	155 ($9B_H$)	-
1	Quality information = Q Q_1 0 0 0 0 I_3 U_3	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L3	UINT	1 mA	0 ... 65535	66009
4 ... 5	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003
6 ... 7	Active power L3	INT	1 W	-32768 ... 32767	66015
8 ... 9	Reactive power Qtot L3	INT	1 var	-32768 ... 32767	66024
10 ... 11	Apparent power L3	INT	1 VA	-32768 ... 32767	66012
12 ... 15	Total active energy L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62315

Byte	Allocation	Data type	Unit	Value range	Measured value ID
16 ... 19	Total reactive energy L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	62316
20 ... 23	Apparent energy L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active power L3	USINT	-	0 ... 255	-
26	Scaling reactive power L3	USINT	-	0 ... 255	-
27	Scaling apparent power L3	USINT	-	0 ... 255	-
28	Total scaling active energy L3	USINT	-	0 ... 255	-
29	Total scaling reactive energy L3	USINT	-	0 ... 255	-
30	Scaling apparent energy L3	USINT	-	0 ... 255	-
31	Power factor L3	USINT	0.01	0 ... 100	66021

Basic variables phase-specific measurement (ID 154 or $9A_H$)

Table 2-1039 Single-phase measurement L3 with voltage scaling value

Byte	Allocation	Data type	Unit	Value range	Measured value ID
0	Payload variant	BYTE	-	154 ($9A_H$)	-
1	Quality information = Q Q_1 0 0 0 0 I_3 U_3	BYTE	Bit string	qq 00 00 xx	-
2 ... 3	Current L3	UINT	1 mA	0 ... 65535	66009
4 ... 5	Voltage L3-N	UINT	0.01 V	0 ... 65535	66003
6 ... 7	Active power L3	INT	1 W	-32768 ... 32767	66015
8 ... 9	Reactive power Qtot L3	INT	1 var	-32768 ... 32767	66024
10 ... 11	Apparent power L3	INT	1 VA	-32768 ... 32767	66012
12 ... 15	Total active energy L3 (Int32)	DINT	1 Wh	-2147483647... +2147483647	62315
16 ... 19	Total reactive energy L3 (Int32)	DINT	1 varh	-2147483647... +2147483647	62316
20 ... 23	Apparent energy L3 (Int32)	UDINT	1 VAh	0 ... 2147483647	62314
24	Scaling current L3	USINT	-	0 ... 255	-
25	Scaling active power L3	USINT	-	0 ... 255	-
26	Scaling reactive power L3	USINT	-	0 ... 255	-
27	Scaling apparent power L3	USINT	-	0 ... 255	-
28	Total scaling active energy L3	USINT	-	0 ... 255	-
29	Total scaling reactive energy L3	USINT	-	0 ... 255	-
30	Scaling apparent energy L3	USINT	-	0 ... 255	-
31	Scaling voltage L3-N	USINT	-	0 ... 255	-

Measured value data records

E

E.1 Overview of all measured value data records

The AI Energy Meter RC ST writes the measured values in several data records that you can read acyclically using the RDREC instruction in the user program.

The following tables show the structure of the individual data records:

- Data record DS 142 for basic measured values version 2 (read only).
- Data record DS 142 for basic measured values version 3 (read only).
- Data record DS 143 for energy meters (read and write).
- Data record DS 144 for maximum values (read only).
- Data record DS 154 for maximum values with time stamp (read only).
- Data record DS 145 for minimum values (read only).
- Data record DS 155 for minimum values with time stamp (read only).
- Data record DS 147 for phase-specific measured values L1 version 0 (read only).
- Data record DS 147 for phase-specific measured values L1 version 1 (read only).
- Data record DS 148 for phase-specific measured values L2 DS version 0 (read only).
- Data record DS 148 for phase-specific measured values L2 DS version 1 (read only).
- Data record DS 149 for phase-specific measured values L3 DS version 0 (read only).
- Data record DS 149 for phase-specific measured values L3 DS version 1 (read only).
- Data record DS 150 for advanced measurement and status values (read only).
- Data record DS 151 for user-defined data record (read only).

NOTE

When reading data records that do not exist on the ST module with RDREC, the error 0x80B0 is displayed.

E.2 Measured value data record for base measurements (DS 142)

E.2.1 Measured value data record for basic measured values (DS 142) version 2

Measured variables of the module

The following table provides an overview of all the measured variables that data record 142 supplies. Note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in the Appendix.

Table 2-1040 Data record 142

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version = 2	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...5	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
6...9	Voltage L2-N	REAL	V	0.0 ... 1000000.0	2
10...13	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
14...17	Voltage L1-L2	REAL	V	0.0 ... 1000000.0	4
18...21	Voltage L2-L3	REAL	V	0.0 ... 1000000.0	5
22...25	Voltage L3-L1	REAL	V	0.0 ... 1000000.0	6
26...29	Current L1	REAL	A	0.0 ... 100000.0	7
30...33	Current L2	REAL	A	0.0 ... 100000.0	8
34...37	Current L3	REAL	A	0.0 ... 100000.0	9
38...41	Power factor λ L1	REAL	-	0.0 ... 1.0	19
42...45	Power factor λ L2	REAL	-	0.0 ... 1.0	20
46...49	Power factor λ L3	REAL	-	0.0 ... 1.0	21
50...53	Power factor λ L1L2L3	REAL	-	0.0 ... 1.0	37
54...57	Frequency L1L2L3	REAL	1 Hz	40.0 ... 70.0	30
58...61	Amplitude unbalance voltage U_2	REAL	%	0 ... 100	61157
62...65	Amplitude unbalance current I_{asym}	REAL	%	0 ... 100	61158
66...69	Apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	10
70...73	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
74...77	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
78...81	Apparent power L1L2L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	36
82...85	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
86...89	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
90...93	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
94...97	Reactive power Qtot L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	38
98...101	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
102...105	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
106...109	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
110...113	Active power L1L2L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	34
114...117	Phase angle L1	REAL	°	0.0 ... 360.0	61178
118...121	Phase angle L2	REAL	°	0.0 ... 360.0	61198
122...125	Phase angle L3	REAL	°	0.0 ... 360.0	61218
126...129	Apparent energy L1L2L3 (Float)	REAL	VAh	0.0 ... 3.4×10^{38}	204
130...133	Total reactive energy L1L2L3 (Float)	REAL	varh	-3.4×10^{38} to $+3.4 \times 10^{38}$	206
134...137	Total active energy L1L2L3 (Float)	REAL	Wh	-3.4×10^{38} to $+3.4 \times 10^{38}$	205
138...141	Reactive energy inflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	202
142...145	Reactive energy outflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	203
146...149	Active energy inflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	200
150...153	Active energy outflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	201
154...161	Apparent energy L1L2L3	LREAL	VAh	0.0 ... 1.8×10^{308}	214
162...169	Total reactive energy L1L2L3	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	216
170...177	Total active energy L1L2L3	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	215
178...185	Reactive energy inflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	212
186...193	Reactive energy outflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	213
194...201	Active energy inflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	210
202...209	Active energy outflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	211
210...213	Neutral current IN	REAL	A	0.0 ... 100000.0	61149

Neutral current

If you operate the AI Energy Meter RC ST with connection type 3P4W, 3P4W1 or 3P3W, the neutral current is also calculated under the following conditions:

- Transmission factors of all phase currents (primary rated current and secondary voltage) are identical.
- Measured phase currents are greater than the value of the "Low limit for measuring current" parameter.
- The parameter "Reverse current direction" must be the same on all phases.

If one of the conditions is not met, 0 is entered as the value for the neutral current. You can read the neutral current calculated using measured value data record 142.

Procedure

Data record 142 is located on the AI Energy Meter RC ST. Use the RDREC instruction to read out the data record from the module. This system function block is stored in the STEP 7 library.

E.2.2 Measured value data record for basic measured values (DS 142) version 3

Measured variables of the module

The following table provides an overview of all the measured variables that data record 142 supplies. Note that, depending on the connection type used the display of some measured variables does not make sense and that the module deletes measured values that are not relevant.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in the Appendix.

Table 2-1041 Data record 142

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version = 3	BYTE	-	3	-
1	Reserved	BYTE	-	0	-
2...5	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
6...9	Voltage L2-N	REAL	V	0.0 ... 1000000.0	2
10...13	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
14...17	Voltage L1-L2	REAL	V	0.0 ... 1000000.0	4
18...21	Voltage L2-L3	REAL	V	0.0 ... 1000000.0	5
22...25	Voltage L3-L1	REAL	V	0.0 ... 1000000.0	6
26...29	Current L1	REAL	A	0.0 ... 100000.0	7
30...33	Current L2	REAL	A	0.0 ... 100000.0	8
34...37	Current L3	REAL	A	0.0 ... 100000.0	9
38...41	Power factor λ L1	REAL	-	0.0 ... 1.0	19
42...45	Power factor λ L2	REAL	-	0.0 ... 1.0	20

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
46...49	Power factor λ L3	REAL	-	0.0 ... 1.0	21
50...53	Power factor λ L1L2L3	REAL	-	0.0 ... 1.0	37
54...57	Frequency L1L2L3	REAL	1 Hz	40.0 ... 70.0	30
58...61	Amplitude unbalance voltage U_2	REAL	%	0 ... 100	61157
62...65	Amplitude unbalance current I_{asym}	REAL	%	0 ... 100	61158
66...69	Apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	10
70...73	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
74...77	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
78...81	Apparent power L1L2L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	36
82...85	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22
86...89	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
90...93	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
94...97	Reactive power Qtot L1L2L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	38
98...101	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
102...105	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
106...109	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
110...113	Active power L1L2L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	34
114...117	Phase angle L1	REAL	°	0.0 ... 360.0	61178
118...121	Phase angle L2	REAL	°	0.0 ... 360.0	61198
122...125	Phase angle L3	REAL	°	0.0 ... 360.0	61218
126...129	Apparent energy L1L2L3 (Float)	REAL	VAh	0.0 ... 3.4×10^{38}	204
130...133	Total reactive energy L1L2L3 (Float)	REAL	varh	-3.4×10^{38} to $+3.4 \times 10^{38}$	206
134...137	Total active energy L1L2L3 (Float)	REAL	Wh	-3.4×10^{38} to $+3.4 \times 10^{38}$	205
138...141	Reactive energy inflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	202
142...145	Reactive energy outflow L1L2L3 (Float)	REAL	varh	0.0 ... 3.4×10^{38}	203
146...149	Active energy inflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	200
150...153	Active energy outflow L1L2L3 (Float)	REAL	Wh	0.0 ... 3.4×10^{38}	201
154...161	Apparent energy L1L2L3	LREAL	VAh	0.0 ... 1.8×10^{308}	214

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
162...169	Total reactive energy L1L2L3	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	216
170...177	Total active energy L1L2L3	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	215
178...185	Reactive energy inflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	212
186...193	Reactive energy outflow L1L2L3	LREAL	varh	0.0 ... 1.8×10^{308}	213
194...201	Active energy inflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	210
202...209	Active energy outflow L1L2L3	LREAL	Wh	0.0 ... 1.8×10^{308}	211
210...213	Neutral current IN	REAL	A	0.0 ... 100000.0	61149
214...217	Reserved	DWORD	-	-	-
218...221	Reactive power Qn L1	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	16
222...225	Reactive power Qn L2	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	17
226...229	Reactive power Qn L3	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	18
230...233	Reactive power Qn L1L2L3	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	35
234...237	Average voltage load LN (Utot)	REAL	V	0.0 ... 300.0	31
238...241	Average voltage L-L	REAL	V	0.0 ... 600.0	32
242...245	Average current L1L2L3 (Itot)	REAL	A	0.0 ... 100000.0	33
246...249	Mean power factor λ L1L2L3	REAL	-	0.0 ... 1.0	166
250...253	Reserved	DWORD	-	-	-
254...257	Reserved	DWORD	-	-	-
258...261	Reserved	DWORD	-	-	-
262...265	Reserved	DWORD	-	-	-
266...269	Reserved	DWORD	-	-	-
270...273	Reserved	DWORD	-	-	-
274...277	Reserved	DWORD	-	-	-
278...281	Reserved	DWORD	-	-	-
282...285	Reserved	DWORD	-	-	-
286...289	Fundamental reactive power L1	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62124
290...293	Fundamental reactive power L2	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62224
294...297	Fundamental reactive power L3	REAL	var	-3.0×10^{9} ... $+3.0 \times 10^{9}$	62324
298...301	Reserved	DWORD	-	-	-
302...305	Reserved	DWORD	-	-	-
306...309	Reserved	DWORD	-	-	-
310...313	Fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62127

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
314...317	Fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62227
318...321	Fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62327
322...325	Reserved	DWORD	-	-	-
326...329	Reserved	DWORD	-	-	-
330...333	Reserved	DWORD	-	-	-
334...337	Reserved	DWORD	-	-	-
338...341	Reserved	DWORD	-	-	-
342...345	Reserved	DWORD	-	-	-
346...357	Current module time	PNIOTime	sec	-	65497

Neutral current

If you operate the AI Energy Meter RC ST with connection type 3P4W, 3P4W1 or 3P3W, the neutral current is also calculated under the following conditions:

- Transmission factors of all phase currents (primary rated current and secondary voltage) are identical.
- Measured phase currents are greater than the value of the "Low limit for measuring current" parameter.
- The parameter "Reverse current direction" must be the same on all phases.

If one of the conditions is not met, 0 is entered as the value for the neutral current. You can read the neutral current calculated using measured value data record 142.

Procedure

Data record 142 is located on the AI Energy Meter RC ST. Use the RDREC instruction to read out the data record from the module. This system function block is stored in the STEP 7 library.

E.3 Structure for energy counters (DS 143)

Energy meter data record 143 for different actions

The energy meter data record 143 includes all energy meters available on the module phase-by-phase. The data record can be used for different actions:

- Reset the energy meters to user-specific value (e.g. "0")
- Reading the current values of the energy counters
- Reading the overflow counters
- Reading the operating hours

NOTE

- The cumulative value of the energy counters in 3-phase operation is obtained from the sums of the respective individual values of the phases.
- Inflow and outflow energy meters are always positive values.
- The operating hours counter for the entire module is calculated from the maximum of the operating hours of the individual phases.

Energy meter data record 143

Table 2-1042 Energy meter data record 143

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2	Status / control byte 1 - L1	BYTE	Bit string	-	-
3	Status / control byte 2 - L1	BYTE	Bit string		
4	Status / control byte 1 - L2	BYTE	Bit string		
5	Status / control byte 2 - L2	BYTE	Bit string		
6	Status / control byte 1 - L3	BYTE	Bit string		
7	Status / control byte 2 - L3	BYTE	Bit string		
8...15	Active energy inflow (initial value) L1	LREAL	Wh	During reading: $0.0...1.8 \times 10^{308}$ During writing For continuous counting: $0.0...3.4 \times 10^{12}$ During writing For periodic counting:	61180
16...23	Active energy outflow (initial value) L1	LREAL	Wh		61181
24...31	Reactive energy inflow (initial value) L1	LREAL	varh		61182
32...39	Reactive energy outflow (initial value) L1	LREAL	varh		61183
40...47	Apparent energy (initial value) L1	LREAL	VAh		61184
48...55	Active energy inflow (initial value) L2	LREAL	Wh		61200
56...63	Active energy outflow (initial value) L2	LREAL	Wh		61201
64...61	Reactive energy inflow (initial value) L2	LREAL	varh		61202
72...79	Reactive energy outflow (initial value) L2	LREAL	varh		61203
80...87	Apparent energy (initial value) L2	LREAL	VAh		61204

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
88...95	Active energy inflow (initial value) L3	LREAL	Wh	0...configured full-scale value (10^3 ...10^{15})	61220
96...103	Active energy outflow (initial value) L3	LREAL	Wh		61221
104...111	Reactive energy inflow (initial value) L3	LREAL	varh		61222
112...119	Reactive energy outflow (initial value) L3	LREAL	varh		61223
120...127	Apparent energy (initial value) L3	LREAL	VAh		61224
128...129	Overflow counter active energy inflow L1	UINT	-	During reading: 0...65535 During writing for continuous counting: 0 During writing for periodic counting: 0...65500	61190
130..131	Overflow counter active energy outflow L1	UINT	-		61191
132...133	Overflow counter reactive energy inflow L1	UINT	-		61192
134...135	Overflow counter reactive energy outflow L1	UINT	-		61193
136...137	Overflow counter apparent energy L1	UINT	-		61194
138...139	Overflow counter active energy inflow L2	UINT	-		61210
140...141	Overflow counter active energy outflow L2	UINT	-		61211
142...143	Overflow counter reactive energy inflow L2	UINT	-		61212
144...145	Overflow counter reactive energy outflow L2	UINT	-		61213
146...147	Overflow counter apparent energy L2	UINT	-		61214
148...149	Overflow counter active energy inflow L3	UINT	-		61230
150...151	Overflow counter active energy outflow L3	UINT	-		61231
152...153	Overflow counter reactive energy inflow L3	UINT	-		61232
154...155	Overflow counter reactive energy outflow L3	UINT	-		61233
156...157	Overflow counter apparent energy L3	UINT	-		61234
158...161	Operating hours counter L1 (initial value)	REAL	h	During reading: 0...3.4x10^{38} During writing: 0...10^9	65505
162...165	Operating hours counter L2 (initial value)	REAL	h		65506
166...169	Operating hours counter L3 (initial value)	REAL	h		65507

Status information

When data record 143 is read with the RDREC instruction, Bytes 2 to 7 supply phase-specific status information for energy counters, overflow counters and operating hours counters.

The status information enables you can see which counters are returning their values in the data record 143. If energy counters return their values in the status byte 1, you can determine the type of energy counter with status byte 2.

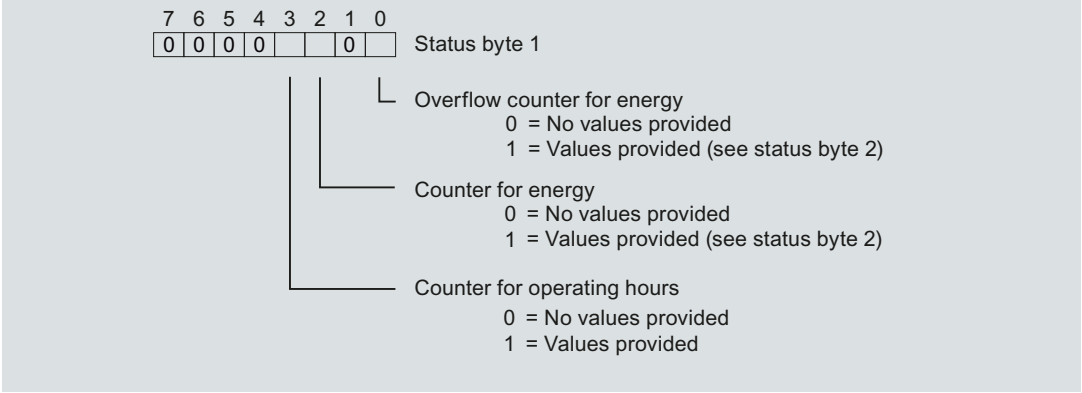

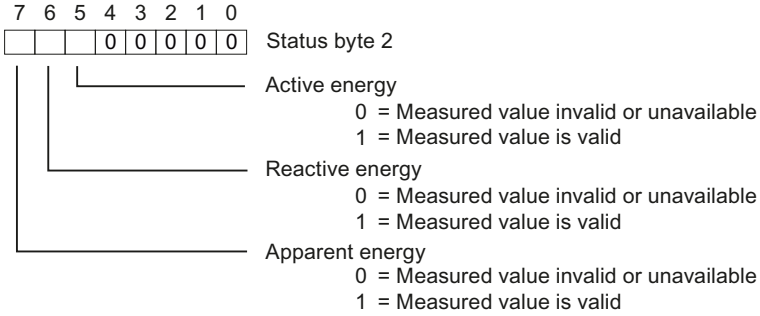

Figure 2-965 Status information DS 143 (read access)

Control information

When data record 143 is written with the WRREC instruction, Bytes 2 to 7 are used as phase-specific control information for energy counters, overflow counters and operating hours counter. The length of the control information amounts to 2 bytes for each phase:

- In control byte 1 you determine which counter you want to reset and the time at which counters are reset.
- In Control byte 2 you determine which energy counters and which overflow counters you want to reset.

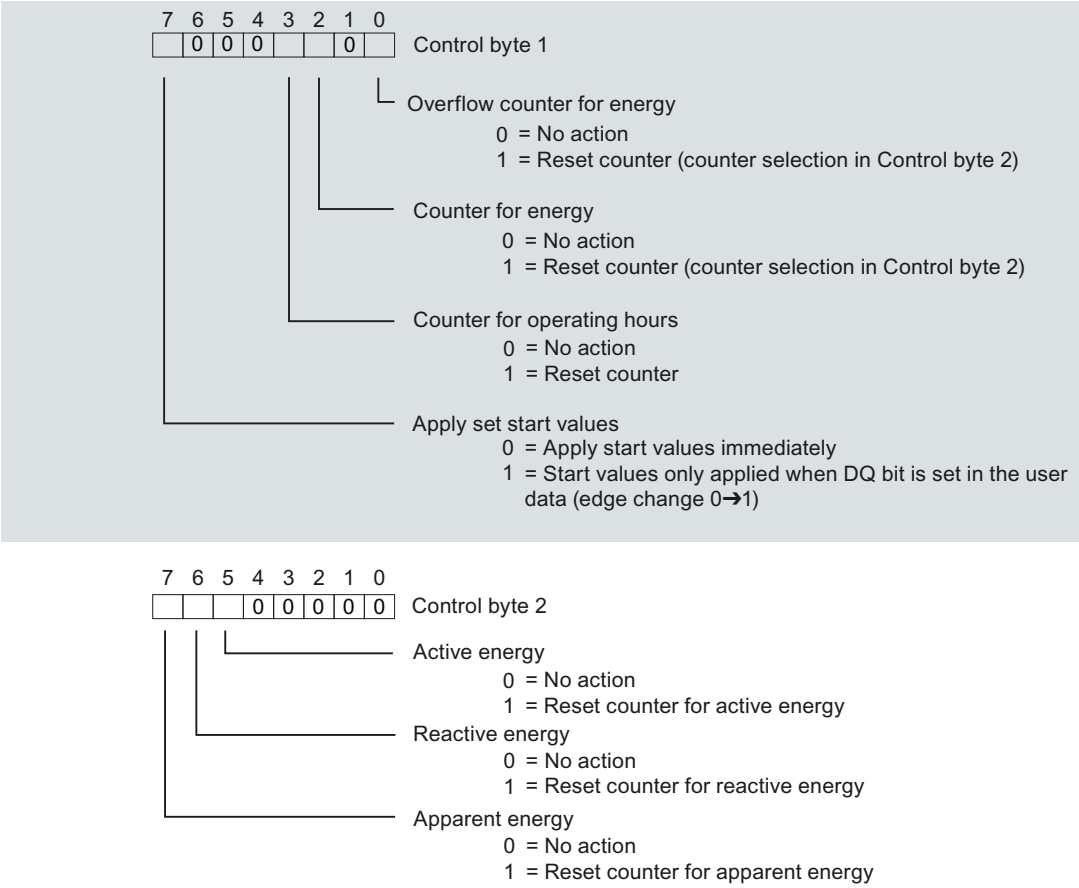

Figure 2-966 Control information DS 143 (write access)

Error while transferring the data record

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The WRREC instruction for writing data records returns corresponding error codes when errors occur in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for the measured value data record 143:

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Number of the data record unknown	Enter a valid number for the data record.
DF	80	B1	00	Length of the data record incorrect	Enter a valid value for the data record length.
DF	80	B2	00	Slot invalid or cannot be accessed.	Check the station whether the module is plugged or drawn. Check the assigned values for the parameters of the WRREC instruction

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	01	Reserved bits are not 0.	Check Byte 2...7 and set the reserved bits back to 0.
DF	80	E1	39	Incorrect version entered.	Check Byte 0. Enter a valid version.
DF	80	E1	3A	Incorrect data record length entered.	Check the parameters of the WRREC instruction. Enter a valid length.
DF	80	E1	3C	At least one start value is invalid.	Check Bytes 8...103 and Bytes 158...169. The start values may not be negative.
DF	80	E1	3D	At least one start value is too large	Check Bytes 8...103 and Bytes 158...169. Observe the ranges of values for start values.

E.4 Measured value data record for maximum values (DS 144)

Measured variables of the module

The largest values ever measured or calculated from the time the AI Energy Meter RC ST was started are stored in this data record.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...5	Max. voltage L1-N	REAL	V	0	40
6...9	Max. voltage L2-N	REAL	V	0	41
10...13	Max. voltage L3-N	REAL	V	0	42
14...17	Max. voltage L1-L2	REAL	V	0	43
18...21	Max. voltage L2-L3	REAL	V	0	44
22...25	Max. voltage L3-L1	REAL	V	0	45
26...29	Max. current L1 [1]	REAL	A	0	46
30...33	Max. current L2 [1]	REAL	A	0	47
34...37	Max. current L3 [1]	REAL	A	0	48
38...41	Max. apparent power L1	REAL	VA	0	49
42...45	Max. apparent power L2	REAL	VA	0	50
46...49	Max. apparent power L3	REAL	VA	0	51
50...53	Max. active power L1	REAL	W	-3.0×10^9	52
54...57	Max. active power L2	REAL	W	-3.0×10^9	53

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
58...61	Max. active power L3	REAL	W	-3.0×10^9	54
62...65	Max. reactive power Qtot L1	REAL	var	-3.0×10^9	62160
66...69	Max. reactive power Qtot L2	REAL	var	-3.0×10^9	62260
70...73	Max. reactive power Qtot L3	REAL	var	-3.0×10^9	62360
74...77	Max. power factor λ L1	REAL	-	0	58
78...81	Max. power factor λ L2	REAL	-	0	59
82...85	Max. power factor λ L3	REAL	-	0	60
86...89	Max. frequency	REAL	Hz	40	61
90...93	Max. apparent power L1L2L3	REAL	VA	0	67
94...97	Max. active power L1L2L3	REAL	W	-3.0×10^9	65
98...101	Max. reactive power Qtot L1L2L3	REAL	var	-3.0×10^9	61138
102...105	Max. power factor λ L1L2L3	REAL	-	0	68
106...109	Max. reactive power Qn L1	REAL	var	-3.0×10^9	55
110...113	Max. reactive power Qn L2	REAL	var	-3.0×10^9	56
114...117	Max. reactive power Qn L3	REAL	var	-3.0×10^9	57
118...121	Reserved	DWORD	-	-	-
122...125	Reserved	DWORD	-	-	-
126...129	Reserved	DWORD	-	-	-
130...133	Reserved	DWORD	-	-	-
134...137	Reserved	DWORD	-	-	-
138...141	Reserved	DWORD	-	-	-
142...145	Reserved	DWORD	-	-	-
146...149	Reserved	DWORD	-	-	-
150...153	Reserved	DWORD	-	-	-
154...157	Reserved	DWORD	-	-	-
158...161	Reserved	DWORD	-	-	-
162...165	Reserved	DWORD	-	-	-
166...169	Reserved	DWORD	-	-	-
170...173	Reserved	DWORD	-	-	-
174...177	Reserved	DWORD	-	-	-
178...181	Reserved	DWORD	-	-	-
182...185	Reserved	DWORD	-	-	-
186...189	Reserved	DWORD	-	-	-
190...193	Reserved	DWORD	-	-	-
194...197	Reserved	DWORD	-	-	-
198...201	Reserved	DWORD	-	-	-
202...205	Reserved	DWORD	-	-	-

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
206...209	Reserved	DWORD	-	-	-
210...213	Reserved	DWORD	-	-	-
214...217	Reserved	DWORD	-	-	-
218...221	Reserved	DWORD	-	-	-
222...225	Reserved	DWORD	-	-	-
226...229	Max. neutral current	REAL	A	0	61136

[1] The values reference the amount of the current measured value

E.5 Measured value data record for minimum values (DS 145)

Measured variables of the module

The smallest values ever measured or calculated from the time the AI Energy Meter RC ST was started are stored in this data record.

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...5	Min. voltage L1-N	REAL	V	1000000	70
6...9	Min. voltage L2-N	REAL	V	1000000	71
10...13	Min. voltage L3-N	REAL	V	1000000	72
14...17	Min. voltage L1-L2	REAL	V	1800000	73
18...21	Min. voltage L2-L3	REAL	V	1800000	74
22...25	Min. voltage L3-L1	REAL	V	1800000	75
26...29	Min. current L1[1]	REAL	A	100000	76
30...33	Min. current L2 [1]	REAL	A	100000	77
34...37	Min. current L3[1]	REAL	A	100000	78
38...41	Min. apparent power L1	REAL	VA	$+3.0 \times 10^9$	79
42...45	Min. apparent power L2	REAL	VA	$+3.0 \times 10^9$	80
46...49	Min. apparent power L3	REAL	VA	$+3.0 \times 10^9$	81
50...53	Min. active power L1	REAL	W	$+3.0 \times 10^9$	82
54...57	Min. active power L2	REAL	W	$+3.0 \times 10^9$	83
58...61	Min. active power L3	REAL	W	$+3.0 \times 10^9$	84
62...65	Min. reactive power Qtot L1	REAL	var	$+3.0 \times 10^9$	62180
66...69	Min. reactive power Qtot L2	REAL	var	$+3.0 \times 10^9$	62280

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
70...73	Min. reactive power Qtot L3	REAL	var	$+3.0 \times 10^9$	62380
74...77	Min. power factor λ L1	REAL	-	1	88
78...81	Min. power factor λ L2	REAL	-	1	89
82...85	Min. power factor λ L3	REAL	-	1	90
86...89	Min. frequency	REAL	Hz	70	91
90...93	Min. apparent power L1L2L3	REAL	VA	$+3.0 \times 10^9$	97
94...97	Min. active power L1L2L3	REAL	W	$+3.0 \times 10^9$	95
98...101	Min. reactive power Qn L1L2L3	REAL	var	$+3.0 \times 10^9$	61139
102...105	Min. power factor λ L1L2L3	REAL	-	1	98
106...109	Min. reactive power Qn L1	REAL	var	$+3.0 \times 10^9$	85
110...113	Min. reactive power Qn L2	REAL	var	$+3.0 \times 10^9$	86
114...117	Min. reactive power Qn L3	REAL	var	$+3.0 \times 10^9$	87
118...121	Reserved	DWORD	-	-	-
122...125	Reserved	DWORD	-	-	-
126...129	Reserved	DWORD	-	-	-
130...133	Reserved	DWORD	-	-	-
134...137	Reserved	DWORD	-	-	-
138...141	Reserved	DWORD	-	-	-
142...145	Reserved	DWORD	-	-	-
146...149	Reserved	DWORD	-	-	-
150...153	Reserved	DWORD	-	-	-
154...157	Reserved	DWORD	-	-	-
158...161	Reserved	DWORD	-	-	-
162...165	Reserved	DWORD	-	-	-
166...169	Reserved	DWORD	-	-	-
170...173	Reserved	DWORD	-	-	-
174...177	Reserved	DWORD	-	-	-
178...181	Reserved	DWORD	-	-	-
182...185	Reserved	DWORD	-	-	-
186...189	Reserved	DWORD	-	-	-
190...193	Reserved	DWORD	-	-	-
194...197	Reserved	DWORD	-	-	-
198...201	Reserved	DWORD	-	-	-
202...205	Reserved	DWORD	-	-	-
206...209	Reserved	DWORD	-	-	-
210...213	Reserved	DWORD	-	-	-
214...217	Reserved	DWORD	-	-	-

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
218...221	Reserved	DWORD	-	-	-
222...225	Reserved	DWORD	-	-	-
226...229	Min. neutral current	REAL	A	100000.0	61137

[1] The values reference the amount of the current measured value

E.6 Measured value data record for phase-based measured values L1 (DS 147)

E.6.1 Measured value data record for phase-based measured values L1 (DS 147) version 0

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Page 135).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...3	Qualifier L1	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65500
4...7	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
8...11	Current L1	REAL	A	0.0 ... 100000.0	7
12...15	Apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	10
16...19	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
20...23	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22
24...27	Power factor λ L1	REAL	-	0.0 ... 1.0	19
28...31	Phase angle L1	REAL	°	0.0 ... 360.0	61178
32...39	Apparent energy L1	LREAL	VAh	0.0 ... 1.8×10^{308}	61184
40...47	Total active energy L1	LREAL	Wh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61185
48...55	Total reactive energy L1	LREAL	varh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61186
56...59	Max. voltage L1-N	REAL	V	0.0 ... 1000000.0	40
60...63	Max. current L1	REAL	A	0.0 ... 100000.0	46
64...67	Max. apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	49

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
68...71	Max. active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	52
72...75	Max. reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62160
76...79	Max. power factor λ L1	REAL	-	0.0 ... 1.0	58
80...83	Min. voltage L1-N	REAL	V	0.0 ... 1000000.0	70
84...87	Min. current L1	REAL	A	0.0 ... 100000.0	76
88...91	Min. apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	79
92...95	Min. active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	82
96...99	Min. reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62180
100...103	Min. power factor λ L1	REAL	-	0.0 ... 1.0	88

E.6.2 Measured value data record for phase-based measured values L1 (DS 147) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Page 135).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	-	1	-
1	Reserved	UINT8	-	0	-
2...3	Qualifier L1	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65500
4...7	Voltage L1-N	REAL	V	0.0 ... 1000000.0	1
8...11	Current L1	REAL	A	0.0 ... 100000.0	7
12...15	Apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	10
16...19	Active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	13
20...23	Reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	22
24...27	Power factor λ L1	REAL	-	0.0 ... 1.0	19
28...31	Phase angle L1	REAL	°	0.0 ... 360.0	61178
32...39	Apparent energy L1	LREAL	VAh	0.0 ... 1.8×10^{308}	61184
40...47	Total active energy L1	LREAL	Wh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61185
48...55	Total reactive energy L1	LREAL	varh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61186

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
56...59	Max. voltage L1-N	REAL	V	0.0 ... 1000000.0	40
60...63	Max. current L1	REAL	A	0.0 ... 100000.0	46
64...67	Max. apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	49
68...71	Max. active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	52
72...75	Max. reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62160
76...79	Max. power factor λ L1	REAL	-	0.0 ... 1.0	58
80...83	Min. voltage L1-N	REAL	V	0.0 ... 1000000.0	70
84...87	Min. current L1	REAL	A	0.0 ... 100000.0	76
88...91	Min. apparent power L1	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	79
92...95	Min. active power L1	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	82
96...99	Min. reactive power Qtot L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62180
100...103	Min. power factor λ L1	REAL	-	0.0 ... 1.0	88
104...107	Reactive power Qn L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	16
108...111	Reserved	DWORD	-	-	-
112...115	Reserved	DWORD	-	-	-
116...119	Reserved	DWORD	-	-	-
120...123	Reserved	DWORD	-	-	-
124...127	Reserved	DWORD	-	-	-
128...131	Reserved	DWORD	-	-	-
132...135	Reserved	DWORD	-	-	-
136...139	Fundamental reactive power L1	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62124
140...143	Reserved	DWORD	-	-	-
144...147	Fundamental cos φ active factor L1	REAL	-	-1.0 ... 1.0	62127
148...151	Reserved	DWORD	-	-	-
152...155	Reserved	DWORD	-	-	-
156...159	Reserved	DWORD	-	-	-
160...163	Reserved	DWORD	-	-	-
164...167	Reserved	DWORD	-	-	-
168...171	Reserved	DWORD	-	-	-
172...175	Reserved	DWORD	-	-	-
176...179	Reserved	DWORD	-	-	-
180...183	Reserved	DWORD	-	-	-
184...187	Reserved	DWORD	-	-	-

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
188...191	Reserved	DWORD	-	-	-
192...195	Reserved	DWORD	-	-	-
196...199	Reserved	DWORD	-	-	-
200...203	Reserved	DWORD	-	-	-
204...207	Reserved	DWORD	-	-	-
208...211	Reserved	DWORD	-	-	-
212...215	Reserved	DWORD	-	-	-
216...219	Reserved	DWORD	-	-	-
220...223	Reserved	DWORD	-	-	-
224...227	Reserved	DWORD	-	-	-
228...231	Reserved	DWORD	-	-	-
232...235	Reserved	DWORD	-	-	-
236...239	Reserved	DWORD	-	-	-
240...243	Reserved	DWORD	-	-	-
244...247	Reserved	DWORD	-	-	-

E.7 Measured value data record for phase-based measured values L2 (DS 148)

E.7.1 Measured value data record for phase-based measured values L2 (DS 148) version 0

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 135)).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...3	Qualifier L2	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65501
4...7	Voltage L1-N	REAL	V	0.0 ... 1000000.0	2
8...11	Current L2	REAL	A	0.0 ... 100000.0	8
12...15	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
16...19	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
20...23	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
24...27	Power factor λ L2	REAL	-	0.0 ... 1.0	20
28...31	Phase angle L2	REAL	°	0.0 ... 360.0	61198
32...39	Apparent energy L2	LREAL	VAh	0.0 ... 1.8×10^{308}	61204
40...47	Total active energy L2	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61205
48...55	Total reactive energy L2	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61206
56...59	Max. voltage L2-N	REAL	V	0.0 ... 1000000.0	41
60...63	Max. current L2	REAL	A	0.0 ... 100000.0	47
64...67	Max. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	50
68...71	Max. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	53
72...75	Max. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62260
76...79	Max. power factor λ L2	REAL	-	0.0 ... 1.0	59
80...83	Min. voltage L2-N	REAL	V	0.0 ... 1000000.0	71
84...87	Min. current L2	REAL	A	0.0 ... 100000.0	77
88...91	Min. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	80
92...95	Min. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	83
96...99	Min. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62280
100...103	Min. power factor λ L2	REAL	-	0.0 ... 1.0	89

E.7.2 Measured value data record for phase-based measured values L2 (DS 148) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 135)).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	-	1	-
1	Reserved	UINT8	-	0	-
2...3	Qualifier L2	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65501
4...7	Voltage L2-N	REAL	V	0.0 ... 1000000.0	2

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
8...11	Current L2	REAL	A	0.0 ... 100000.0	8
12...15	Apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	11
16...19	Active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	14
20...23	Reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	23
24...27	Power factor λ L2	REAL	-	0.0 ... 1.0	20
28...31	Phase angle L2	REAL	°	0.0 ... 360.0	61198
32...39	Apparent energy L2	LREAL	VAh	0.0 ... 1.8×10^{308}	61204
40...47	Total active energy L2	LREAL	Wh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61205
48...55	Total reactive energy L2	LREAL	varh	-1.8×10^{308} ... $+1.8 \times 10^{308}$	61206
56...59	Max. voltage L2-N	REAL	V	0.0 ... 1000000.0	41
60...63	Max. current L2	REAL	A	0.0 ... 100000.0	47
64...67	Max. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	50
68...71	Max. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	53
72...75	Max. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62260
76...79	Max. power factor λ L2	REAL	-	0.0 ... 1.0	59
80...83	Min. voltage L2-N	REAL	V	0.0 ... 1000000.0	71
84...87	Min. current L2	REAL	A	0.0 ... 100000.0	77
88...91	Min. apparent power L2	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	80
92...95	Min. active power L2	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	83
96...99	Min. reactive power Qtot L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62280
100...103	Min. power factor λ L2	REAL	-	0.0 ... 1.0	89
104...107	Reactive power Qn L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	17
108...111	Reserved	DWORD	-	-	-
112...115	Reserved	DWORD	-	-	-
116...119	Reserved	DWORD	-	-	-
120...123	Reserved	DWORD	-	-	-
124...127	Reserved	DWORD	-	-	-
128...131	Reserved	DWORD	-	-	-
132...135	Reserved	DWORD	-	-	-

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
136...139	Fundamental reactive power L2	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62224
140...143	Reserved	DWORD	-	-	-
144...147	Fundamental cos φ active factor L2	REAL	-	-1.0 ... 1.0	62227
148...151	Reserved	DWORD	-	-	-
152...155	Reserved	DWORD	-	-	-
156...159	Reserved	DWORD	-	-	-
160...163	Reserved	DWORD	-	-	-
164...167	Reserved	DWORD	-	-	-
168...171	Reserved	DWORD	-	-	-
172...175	Reserved	DWORD	-	-	-
176...179	Reserved	DWORD	-	-	-
180...183	Reserved	DWORD	-	-	-
184...187	Reserved	DWORD	-	-	-
188...191	Reserved	DWORD	-	-	-
192...195	Reserved	DWORD	-	-	-
196...199	Reserved	DWORD	-	-	-
200...203	Reserved	DWORD	-	-	-
204...207	Reserved	DWORD	-	-	-
208...211	Reserved	DWORD	-	-	-
212...215	Reserved	DWORD	-	-	-
216...219	Reserved	DWORD	-	-	-
220...223	Reserved	DWORD	-	-	-
224...227	Reserved	DWORD	-	-	-
228...231	Reserved	DWORD	-	-	-
232...235	Reserved	DWORD	-	-	-
236...239	Reserved	DWORD	-	-	-
240...243	Reserved	DWORD	-	-	-
244...247	Reserved	DWORD	-	-	-

E.8 Measured value data record for phase-based measured values L3 (DS 149)

E.8.1 Measured value data record for phase-based measured values L3 (DS 149) version 0

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 135)).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	0	-
1	Reserved	BYTE	-	0	-
2...3	Qualifier L3	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65502
4...7	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
8...11	Current L3	REAL	A	0.0 ... 100000.0	9
12...15	Apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	12
16...19	Active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	15
20...23	Reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	24
24...27	Power factor λ L3	REAL	-	0.0 ... 1.0	21
28...31	Phase angle L3	REAL	°	0.0 ... 360.0	61218
32...39	Apparent energy L3	LREAL	VAh	0.0 ... 1.8×10^{308}	61224
40...47	Total active energy L3	LREAL	Wh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61225
48...55	Total reactive energy L3	LREAL	varh	-1.8×10^{308} to $+1.8 \times 10^{308}$	61226
56...59	Max. voltage L3-N	REAL	V	0.0 ... 1000000.0	42
60...63	Max. current L3	REAL	A	0.0 ... 100000.0	48
64...67	Max. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	51
68...71	Max. active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	54
72...75	Max. reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62360
76...79	Max. power factor λ L3	REAL	-	0.0 ... 1.0	60
80...83	Min. voltage L3-N	REAL	V	0.0 ... 1000000.0	72
84...87	Min. current L3	REAL	A	0.0 ... 100000.0	78
88...91	Min. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	81

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
92...95	Min. active power L3	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	84
96...99	Min. reactive power Qtot L3	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	62380
100...103	Min. power factor λ L3	REAL	-	0.0 ... 1.0	90

E.8.2 Measured value data record for phase-based measured values L3 (DS 149) version 1

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 135)).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	UINT8	-	1	-
1	Reserved	UINT8	-	0	-
2...3	Qualifier L3	WORD	Bit field	0b 00 00 00 00 0b qq 00 00 xx	65502
4...7	Voltage L3-N	REAL	V	0.0 ... 1000000.0	3
8...11	Current L3	REAL	A	0.0 ... 100000.0	9
12...15	Apparent power L3	REAL	VA	-3.0 x 10^9 ... +3.0 x 10^9	12
16...19	Active power L3	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	15
20...23	Reactive power Qtot L3	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	24
24...27	Power factor λ L3	REAL	-	0.0 ... 1.0	21
28...31	Phase angle L3	REAL	°	0.0 ... 360.0	61218
32...39	Apparent energy L3	LREAL	VAh	0.0 ... 1.8 x 10^{308}	61224
40...47	Total active energy L3	LREAL	Wh	-1.8 x 10^{308} ... +1.8 x 10^{308}	61225
48...55	Total reactive energy L3	LREAL	varh	-1.8 x 10^{308} ... +1.8 x 10^{308}	61226
56...59	Max. voltage L3-N	REAL	V	0.0 ... 1000000.0	42
60...63	Max. current L3	REAL	A	0.0 ... 100000.0	48
64...67	Max. apparent power L3	REAL	VA	-3.0 x 10^9 ... +3.0 x 10^9	51
68...71	Max. active power L3	REAL	W	-3.0 x 10^9 ... +3.0 x 10^9	54
72...75	Max. reactive power Qtot L3	REAL	var	-3.0 x 10^9 ... +3.0 x 10^9	62360

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
76...79	Max. power factor λ L3	REAL	-	0.0 ... 1.0	60
80...83	Min. voltage L3-N	REAL	V	0.0 ... 1000000.0	72
84...87	Min. current L3	REAL	A	0.0 ... 100000.0	78
88...91	Min. apparent power L3	REAL	VA	-3.0×10^9 ... $+3.0 \times 10^9$	81
92...95	Min. active power L3	REAL	W	-3.0×10^9 ... $+3.0 \times 10^9$	84
96...99	Min. reactive power Qtot L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62380
100...103	Min. power factor λ L3	REAL	-	0.0 ... 1.0	90
104...107	Reactive power Qn L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	18
108...111	Reserved	DWORD	-	-	-
112...115	Reserved	DWORD	-	-	-
116...119	Reserved	DWORD	-	-	-
120...123	Reserved	DWORD	-	-	-
124...127	Reserved	DWORD	-	-	-
128...131	Reserved	DWORD	-	-	-
132...135	Reserved	DWORD	-	-	-
136...139	Fundamental reactive power L3	REAL	var	-3.0×10^9 ... $+3.0 \times 10^9$	62324
140...143	Reserved	DWORD	-	-	-
144...147	Fundamental cos φ active factor L3	REAL	-	-1.0 ... 1.0	62327
148...151	Reserved	DWORD	-	-	-
152...155	Reserved	DWORD	-	-	-
156...159	Reserved	DWORD	-	-	-
160...163	Reserved	DWORD	-	-	-
164...167	Reserved	DWORD	-	-	-
168...171	Reserved	DWORD	-	-	-
172...175	Reserved	DWORD	-	-	-
176...179	Reserved	DWORD	-	-	-
180...183	Reserved	DWORD	-	-	-
184...187	Reserved	DWORD	-	-	-
188...191	Reserved	DWORD	-	-	-
192...195	Reserved	DWORD	-	-	-
196...199	Reserved	DWORD	-	-	-
200...203	Reserved	DWORD	-	-	-
204...207	Reserved	DWORD	-	-	-
208...211	Reserved	DWORD	-	-	-
212...215	Reserved	DWORD	-	-	-

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
216...219	Reserved	DWORD	-	-	-
220...223	Reserved	DWORD	-	-	-
224...227	Reserved	DWORD	-	-	-
228...231	Reserved	DWORD	-	-	-
232...235	Reserved	DWORD	-	-	-
236...239	Reserved	DWORD	-	-	-
240...243	Reserved	DWORD	-	-	-
244...247	Reserved	DWORD	-	-	-

E.9 Measured value data record for advanced measurement and status values (DS 150)

Measured variables of the module

The measured value identification (measured value ID) is an index which references the overview table of the **measured variables for connection type 1H** (Page 135).

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
0	Version	BYTE	-	1	-
1	Reserved	BYTE	-	0	-
2...5	Operating hours counter L1L2L3	REAL	h	0.0 ... 3.4 x 10^{38}	65504
6...9	Operating hours counter L1	REAL	h	0.0 ... 3.4 x 10^{38}	65505
10...13	Operating hours counter L2	REAL	h	0.0 ... 3.4 x 10^{38}	65506
14...17	Operating hours counter L3	REAL	h	0.0 ... 3.4 x 10^{38}	65507
18...19	Status limit violation GW 1...16	WORD	Bit string	xxxx xxxx xxxx xxxx	65509

[1] Energy meters count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1
Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

Byte	Measured variable	Data type	Unit	Value range	Measured value ID
20...21	Status of energy counter overflows [1]	WORD	Bit string	xxxx xxxx xxxx xxxx	65508
22...25	Counter limit violation GW 1	UDINT	-	0 ... 4294967296	65510
26...29	Counter limit violation GW 2	UDINT	-	0 ... 4294967296	65511
30...33	Counter limit violation GW 3	UDINT	-	0 ... 4294967296	65512
34...37	Counter limit violation GW 4	UDINT	-	0 ... 4294967296	65513
38...41	Counter limit violation GW 5	UDINT	-	0 ... 4294967296	65514
42...45	Counter limit violation GW 6	UDINT	-	0 ... 4294967296	65515
46...49	Counter limit violation GW 7	UDINT	-	0 ... 4294967296	65516
50...53	Counter limit violation GW 8	UDINT	-	0 ... 4294967296	65517
54...57	Counter limit violation GW 9	UDINT	-	0 ... 4294967296	65518
58...61	Counter limit violation GW 10	UDINT	-	0 ... 4294967296	65519
62...65	Counter limit violation GW 11	UDINT	-	0 ... 4294967296	65520
66...69	Counter limit violation GW 12	UDINT	-	0 ... 4294967296	65521
70...73	Counter limit violation GW 13	UDINT	-	0 ... 4294967296	65522
74...77	Counter limit violation GW 14	UDINT	-	0 ... 4294967296	65523
78...81	Counter limit violation GW 15	UDINT	-	0 ... 4294967296	65524
82...85	Counter limit violation GW 16	UDINT	-	0 ... 4294967296	65525
86...87	Qualifier L1L2L3	WORD	Bit string	xxxx xxxx xxxx xxxx	65503
88...91	Reserved	DWORD	-	-	-
92...103	Current module time	PNIOTime	sec	-	65497

[1] Energy meters count periodically - counter overflow at:
Bit 0 = 1: Active energy inflow L1
Bit 1 = 1: Active energy outflow L1
Bit 2 = 1: Reactive energy inflow L1
Bit 3 = 1: Reactive energy outflow L1
Bit 4 = 1: Apparent energy L1
Bit 5 = 1: Active energy inflow L2
Bit 6 = 1: Active energy outflow L2
Bit 7 = 1: Reactive energy inflow L2
Bit 8 = 1: Reactive energy outflow L2
Bit 9 = 1: Apparent energy L2
Bit 10 = 1: Active energy inflow L3
Bit 11 = 1: Active energy outflow L3
Bit 12 = 1: Reactive energy inflow L3
Bit 13 = 1: Reactive energy outflow L3
Bit 14 = 1: Apparent energy L3
Bit 15: Reserved

E.10 Measured value data record of user-defined data record (DS 151)

The length and structure of the data record DS 151 depends on the parameter assignment of the data record DS 135 (Page 132).

Byte	Measured variable	Data type	Unit	Value range
0	Version	UINT8	-	0
1	Number of measured values	UINT8	-	0 ... 150
2	Measured value 1 corresponding to measured value ID 1 in DS135	Depending on the corresponding measured value ID		
3	Measured value 2 corresponding to measured value ID 2 in DS135	Depending on the corresponding measured value ID		
...	...	Depending on the corresponding measured value ID		
... m	Measured value n corresponding to measured value ID n in DS135	Depending on the corresponding measured value ID		

E.11 Measured value data record for maximum values with time stamp (DS 154)

Measured variables of the module

The largest values ever measured or calculated from the time AI Energy Meters RC ST was started are stored in this data record.

The measured values (REAL 4 bytes) are each followed by a time stamp (PNIO Time 12 bytes).

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type (Page 135)).

More detailed information about the structure of time stamps is available in section Time synchronization and time stamp (Page 50).

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...17	Max. voltage L1-N	REAL + PNIO Time	V	0	40
18...33	Max. voltage L2-N	REAL + PNIO Time	V	0	41
34...49	Max. voltage L3-N	REAL + PNIO Time	V	0	42
50...65	Max. voltage L1-L2	REAL + PNIO Time	V	0	43
66...81	Max. voltage L2-L3	REAL + PNIO Time	V	0	44

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
82...97	Max. voltage L3-L1	REAL + PNIO Time	V	0	45
98...113	Max. current L1 [1]	REAL + PNIO Time	A	0	46
114...129	Max. current L2 [1]	REAL + PNIO Time	A	0	47
130...145	Max. current L3 [1]	REAL + PNIO Time	A	0	48
146...161	Max. apparent power L1	REAL + PNIO Time	VA	0	49
162...177	Max. apparent power L2	REAL + PNIO Time	VA	0	50
178...193	Max. apparent power L3	REAL + PNIO Time	VA	0	51
194...209	Max. active power L1	REAL + PNIO Time	W	-3.0×10^9	52
210...225	Max. active power L2	REAL + PNIO Time	W	-3.0×10^9	53
226...241	Max. active power L3	REAL + PNIO Time	W	-3.0×10^9	54
242...257	Max. reactive power Qtot L1	REAL + PNIO Time	var	-3.0×10^9	62160
258...273	Max. reactive power Qtot L2	REAL + PNIO Time	var	-3.0×10^9	62260
274...289	Max. reactive power Qtot L3	REAL + PNIO Time	var	-3.0×10^9	62360
290...305	Max. power factor λ L1	REAL + PNIO Time	-	0	58
306...321	Max. power factor λ L2	REAL + PNIO Time	-	0	59
322...337	Max. power factor λ L3	REAL + PNIO Time	-	0	60
338...353	Max. frequency	REAL + PNIO Time	Hz	40	61
354...369	Max. apparent power L1L2L3	REAL + PNIO Time	VA	0	67
370...385	Max. active power L1L2L3	REAL + PNIO Time	W	-3.0×10^9	65
386...401	Max. reactive power Qtot L1L2L3	REAL + PNIO Time	var	-3.0×10^9	61138
402...417	Max. power factor λ L1L2L3	REAL + PNIO Time	-	0	68
418...433	Max. reactive power Qn L1	REAL + PNIO Time	var	-3.0×10^9	55

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
434...449	Max. reactive power Qn L2	REAL + PNIO Time	var	-3.0×10^9	56
450...465	Max. reactive power Qn L3	REAL + PNIO Time	var	-3.0×10^9	57
466...481	Reserved	Byte array[16]	-	-	-
482...497	Reserved	Byte array[16]	-	-	-
498...513	Reserved	Byte array[16]	-	-	-
514...529	Reserved	Byte array[16]	-	-	-
530...545	Reserved	Byte array[16]	-	-	-
546...561	Reserved	Byte array[16]	-	-	-
562...577	Reserved	Byte array[16]	-	-	-
578...593	Reserved	Byte array[16]	-	-	-
594...609	Reserved	Byte array[16]	-	-	-
610...625	Reserved	Byte array[16]	-	-	-
626...641	Reserved	Byte array[16]	-	-	-
642...657	Reserved	Byte array[16]	-	-	-
658...673	Reserved	Byte array[16]	-	-	-
674...689	Reserved	Byte array[16]	-	-	-
690...705	Reserved	Byte array[16]	-	-	-
706...721	Reserved	Byte array[16]	-	-	-
722...737	Reserved	Byte array[16]	-	-	-
738...753	Reserved	Byte array[16]	-	-	-
754...769	Reserved	Byte array[16]	-	-	-
770...785	Reserved	Byte array[16]	-	-	-
786...801	Reserved	Byte array[16]	-	-	-
802...817	Reserved	Byte array[16]	-	-	-
818...833	Reserved	Byte array[16]	-	-	-
834...849	Reserved	Byte array[16]	-	-	-
850...865	Reserved	Byte array[16]	-	-	-
866...881	Reserved	Byte array[16]	-	-	-
882...897	Reserved	Byte array[16]	-	-	-
898...913	Max. neutral current	REAL + PNIO Time	A	0	61136

[1] The values reference the amount of the current measured value

E.12 Measured value data record for minimum values with time stamp (DS 155)

Measured variables of the module

The smallest values ever measured or calculated from the time the AI Energy Meter RC ST was started are stored in this data record.

The measured values (REAL 4 bytes) are each followed by a time stamp (PNIO Time 12 bytes).

The measured value identification (measured value ID) is an index which references the overview table of the measured variables in Appendix B (Measured variables for connection type).

More detailed information about the structure of time stamps is available in section Time synchronization and time stamp.

Byte	Measured variable	Data type	Unit	Default	Measured value ID
0	Version	UINT8	-	2	-
1	Reserved	UINT8	-	0	-
2...17	Min. voltage L1-N	REAL + PNIO Time	V	1000000	70
18...33	Min. voltage L2-N	REAL + PNIO Time	V	1000000	71
34...49	Min. voltage L3-N	REAL + PNIO Time	V	1000000	72
50...65	Min. voltage L1-L2	REAL + PNIO Time	V	1800000	73
66...81	Min. voltage L2-L3	REAL + PNIO Time	V	1800000	74
82...97	Min. voltage L3-L1	REAL + PNIO Time	V	1800000	75
98...113	Min. current L1[1]	REAL + PNIO Time	A	100000	76
114...129	Min. current L2 [1]	REAL + PNIO Time	A	100000	77
130...145	Min. current L3[1]	REAL + PNIO Time	A	100000	78
146...161	Min. apparent power L1	REAL + PNIO Time	VA	$+3.0 \times 10^9$	79
162...177	Min. apparent power L2	REAL + PNIO Time	VA	$+3.0 \times 10^9$	80
178...193	Min. apparent power L3	REAL + PNIO Time	VA	$+3.0 \times 10^9$	81
194...209	Min. active power L1	REAL + PNIO Time	W	$+3.0 \times 10^9$	82
210...225	Min. active power L2	REAL + PNIO Time	W	$+3.0 \times 10^9$	83

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
226...241	Min. active power L3	REAL + PNIO Time	W	$+3.0 \times 10^9$	84
242...257	Min. reactive power Qtot L1	REAL + PNIO Time	var	$+3.0 \times 10^9$	62180
258...273	Min. reactive power Qtot L2	REAL + PNIO Time	var	$+3.0 \times 10^9$	62280
274...289	Min. reactive power Qtot L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	62380
290...305	Min. power factor λ L1	REAL + PNIO Time	-	1	88
306...321	Min. power factor λ L2	REAL + PNIO Time	-	1	89
322...337	Min. power factor λ L3	REAL + PNIO Time	-	1	90
338...353	Min. frequency	REAL + PNIO Time	Hz	70	91
354...369	Min. apparent power L1L2L3	REAL + PNIO Time	VA	$+3.0 \times 10^9$	97
370...385	Min. active power L1L2L3	REAL + PNIO Time	W	$+3.0 \times 10^9$	95
386...401	Min. reactive power Qn L1L2L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	61139
402...417	Min. power factor λ L1L2L3	REAL + PNIO Time	-	1	98
418...433	Min. reactive power Qn L1	REAL + PNIO Time	var	$+3.0 \times 10^9$	85
434...449	Min. reactive power Qn L2	REAL + PNIO Time	var	$+3.0 \times 10^9$	86
450...465	Min. reactive power Qn L3	REAL + PNIO Time	var	$+3.0 \times 10^9$	87
466...481	Reserved	Byte array[16]	-	-	-
482...497	Reserved	Byte array[16]	-	-	-
498...513	Reserved	Byte array[16]	-	-	-
514...529	Reserved	Byte array[16]	-	-	-
530...545	Reserved	Byte array[16]	-	-	-
546...561	Reserved	Byte array[16]	-	-	-
562...577	Reserved	Byte array[16]	-	-	-
578...593	Reserved	Byte array[16]	-	-	-
594...609	Reserved	Byte array[16]	-	-	-
610...625	Reserved	Byte array[16]	-	-	-
626...641	Reserved	Byte array[16]	-	-	-
642...657	Reserved	Byte array[16]	-	-	-

[1] The values reference the amount of the current measured value

Byte	Measured variable	Data type	Unit	Default	Measured value ID
658...673	Reserved	Byte array[16]	-	-	-
674...689	Reserved	Byte array[16]	-	-	-
690...705	Reserved	Byte array[16]	-	-	-
706...721	Reserved	Byte array[16]	-	-	-
722...737	Reserved	Byte array[16]	-	-	-
738...753	Reserved	Byte array[16]	-	-	-
754...769	Reserved	Byte array[16]	-	-	-
770...785	Reserved	Byte array[16]	-	-	-
786...801	Reserved	Byte array[16]	-	-	-
802...817	Reserved	Byte array[16]	-	-	-
818...833	Reserved	Byte array[16]	-	-	-
834...849	Reserved	Byte array[16]	-	-	-
850...865	Reserved	Byte array[16]	-	-	-
866...881	Reserved	Byte array[16]	-	-	-
882...897	Reserved	Byte array[16]	-	-	-
898...913	Min. neutral current	REAL + PNIO Time	A	100000.0	61137

[1] The values reference the amount of the current measured value

Tips and tricks

F

F.1 Tips and tricks

Processing and visualizing energy data

On the basis of an application example, we show you how the measured values of the AI Energy Meter RC ST can be processed further and visualized.

You can find this application example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86299299).

Overview of the measurement data with update time

We provide you with an overview of the assignment of the measured values to the payload variants and data records in an Excel file.

You will find the Excel file on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755917).

Time-of-day synchronization and time stamp

In an application example, we show you how to synchronize the time with the AI Energy Meter RC ST and work with measured values with time stamps.

You can find this application example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109754890).

Rotating field

To recognize wiring errors and evaluate the generated rotating field, you use the combined measurement functions from the section Notes for the recognition of wiring errors and incorrect rotating field (Page 47).

Measured values in STEP 7 as of V5.5

Measured values are represented as negative values in STEP 7 as of V5.5 if the value range of the integer format (32767 dec) is exceeded. This is not an error in the measured value. Solution: Select hexadecimal representation.

Conversion of 64-bit floating-point numbers

If you cannot process 64-bit floating-point numbers in your automation system, we recommend conversion to 32-bit floating-point numbers. Note the conversion can cause loss of accuracy. For a description of the conversion of the 64-bit floating-point numbers (data type LREAL) into 32-bit floating-point numbers (data type REAL) please refer to the Internet (https://support.industry.siemens.com/cs/ww/en/view/56600676).

SIEMENS

SIMATIC

ET 200SP
Analog output module AQ 2xI ST (6ES7135-6GB00-0BA1)

Equipment Manual

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Introduction 1

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

- Wiring and block diagrams have been revised.
- The technical specifications have been updated.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

3

3.1 Properties

Article number

6ES7135-GB00-0BA1

View of the module

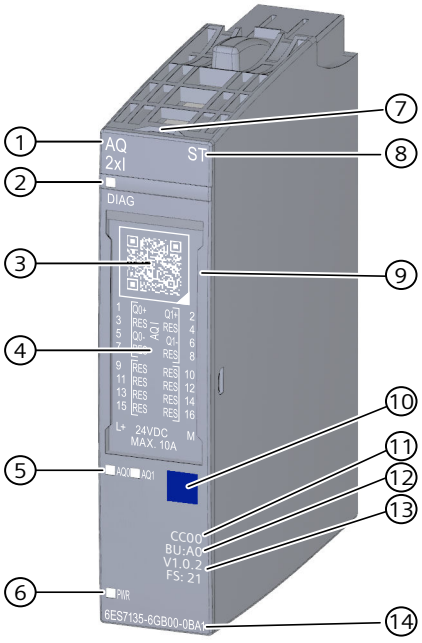

① Module type and name
② LED for diagnostics
③ QR code for identification link
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Slot for optional equipment labeling plate
⑧ Function class
⑨ Insertion option for optional labeling strip
⑩ Color coding module type
⑪ Color code for selecting the color identification labels
⑫ BU type
⑬ Firmware and function version
⑭ Article number

Figure 2-967 View of the module AQ 2xI ST

Properties

The module has the following technical properties:

- Analog output module with 2 outputs
  - for current output
- Output range for current output:
  - ±20 mA, resolution 16 bits including sign
  - 0 mA to 20 mA, resolution 15 bits
  - 4 to 20 mA, resolution 14 bits
- Electrically isolated from supply voltage L+
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy
- Value status

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

4

4.1 Wiring diagram

This section shows the wiring diagram of the AQ 2xI ST module with the pin assignments.

You can find information on wiring the BaseUnit in the System Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Pin assignment

The following table shows an example of the pin assignment of the analog output module AQ 2xI ST on the BaseUnit BU type A0/A1:

Description	Signal	Terminal	BaseUnit BU type A0/A1	Terminal	Signal	Description
Analog output current positive, channel 0	Q_0+	1	1 CC00 2	2	Q_1+	Analog output current positive, channel 1
-	RES[1)]	3	3 4	4	RES[1)]	-
Analog output current negative, channel 0	Q_0-	5	5 6	6	Q_1-	Analog output current negative, channel 1
-	RES[1)]	7	7 8	8	RES[1)]	-
-	RES[1)]	9	9 10	10	RES[1)]	-
-	RES[1)]	11	11 12	12	RES[1)]	-
-	RES[1)]	13	13 14	14	RES[1)]	-
-	RES[1)]	15	15 16	16	RES[1)]	-
24 V DC supply voltage[2)]	L+	L+	L+ M	M	M	Ground

1) Reserve, must remain unused for future function extensions

2) Infeed only with light-colored BaseUnit

Connection types

2-wire connection for current output

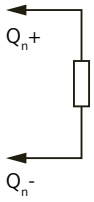

4.2 Schematic circuit diagram

This section contains the schematic circuit diagram of the AQ 2×I ST analog output module.

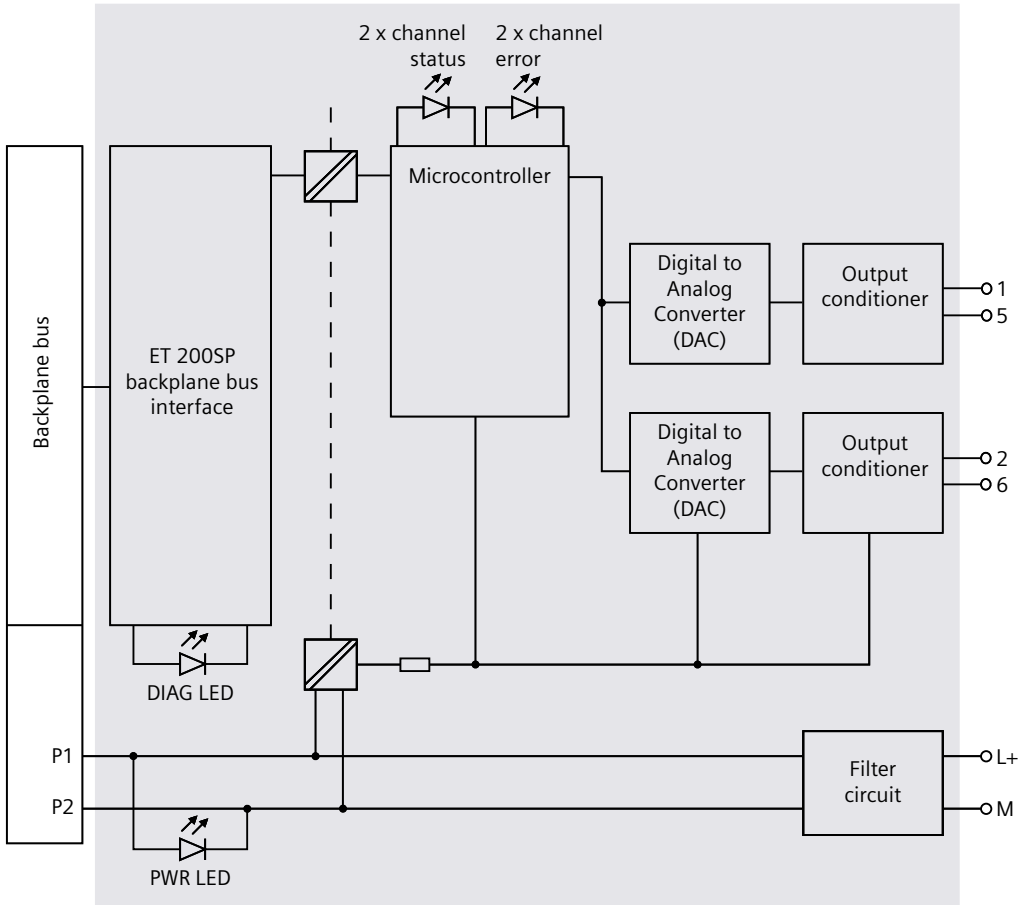

Figure 2-968 Schematic circuit diagram AQ 2xI ST analog output module

Parameters/address space

5

5.1 Output ranges

The analog output module AQ 2×I ST has the following output ranges:

Table 2-1043 Output ranges

Output type	Output ranges	Resolution
Current	± 20 mA 0 mA to 20 mA 4 mA to 20 mA	16 bits incl. sign 15 bits 14 bits

The tables of the output ranges, overflow, overrange, etc. can be found in section Representation of analog values (Page 33).

5.2 Parameters

Parameters of the AQ 2xI ST

Specify the module properties with the various parameters during parameter assignment of the module with STEP 7. The following table lists the configurable parameters. The efficiency range of the configurable parameters depends on the type of configuration.
The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of the parameter data record (Page 29).

The following parameter settings are possible:

Table 2-1044 Configurable parameters and their defaults (GSD file)

Parameters	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Overflow [1]	• Disable • Enable	Disable	Yes	Module	Module [1]
Diagnostics: Underflow [1]	• Disable • Enable	Disable	Yes	Module	
Diagnostics: Wire break [2]	• Disable • Enable	Disable	Yes	Module	Module
Output type/range	• Deactivated • Current +/- 20 mA • Current 0 - 20 mA • Current 4 - 20 mA	Current 4 - 20 mA	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value	Turn off	Yes	Channel	Module
Substitute value	For permissible substitute values for the various output ranges, see appendix Parameter assignment and structure of the parameter data record (Page 29), Substitute values → Codes for substitute values table	0	Yes	Channel	Channel
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 7 bytes.

[2] No diagnostics detection between -3 and +3 mA (no wire break detection)

NOTE

Unused channels

A disabled channel always returns the value "no current or voltage".

5.3 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Overflow

Enabling of the diagnostics when the output value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the output value exceeds the overrange, falls below the minimum output value or reaches underflow.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Output type / output range

See section Output ranges (Page 17).

Reaction to CPU STOP

Determines the behavior of the module at CPU STOP.

Substitute value

The substitute value is the value that the module outputs in case of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2, and AUX to the left neighbor.

Specify the slot in which a light-colored BaseUnit with supply voltage infeed or a dark-colored BaseUnit is to be located (see ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) System Manual).

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

5.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 and 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: There are no errors on the module.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AQ 2×I ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

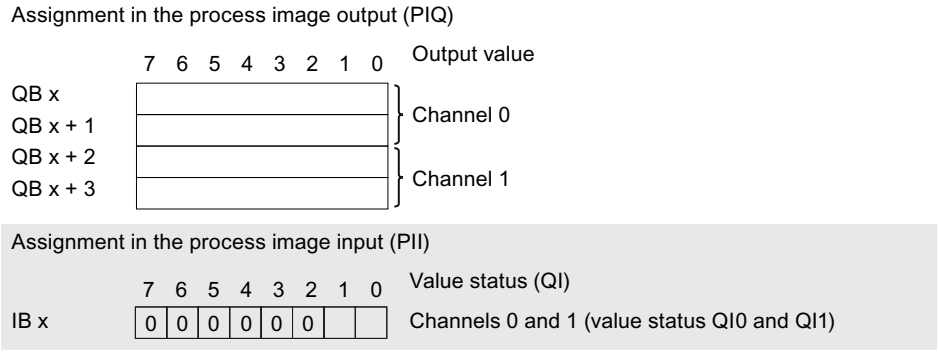

Figure 2-969 Address space of the AQ 2×I ST with value status

Interrupts/diagnostics alarms

6

6.1 Status and error display

LED display

The following figure shows you the LED display of the AQ 2xI ST.

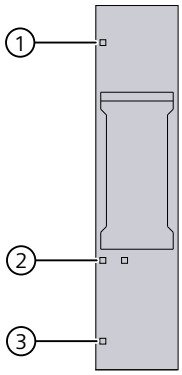

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-970 LED display

Meaning of the LEDs

The following tables show the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 23).

DIAG LED

Table 2-1045 Error display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the system is disrupted or switched off.
Flashes	Module parameters not assigned
On	Module parameters assigned and no module diagnostics
Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-1046 Status display of the channel status LED

Channel status LED	Meaning
□ Off	Channel disabled
■ On	Channel activated

PWR LED

Table 2-1047 Status display of the PWR LED

PWR LED	Meaning
□ Off	Missing supply voltage L+
■ On	Supply voltage L+ present

6.2 Interrupts

The AQ 2×I ST analog output module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Line break (current)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

6.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-1048 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Wire break	6_H	Actuator circuit impedance too high	Use a different actuator type or modify the wiring, e.g. use cables with larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable the channel ("output type" parameter) • Connect the channel
High limit violated	7_H	The output value specified by the user program exceeds the overrange.	Correct the output value
Low limit violated	8_H	The output value specified by the user program is below the underrange.	Correct the output value
Error	9_H	Internal module error occurred.	Replace module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check the supply voltage L+ at the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

Technical specifications 7

7.1 Technical specifications

Technical specifications of the AQ 2×I ST

The following table lists the technical specifications on the issue date. A data sheet including daily updated technical specifications is available on the Internet (https://support.industry.siemens.com/cs/ww/de/pv/6ES7135-6GB00-0BA1/td?dl=en).

Article number	6ES7135-6GB00-0BA1
General information	
Product type designation	AQ 2xI ST
HW functional status	from FS21
Firmware version	V1.0.2
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Output range scalable	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V13 SP1 / -
• STEP 7 configurable/integrated from version	V5.5 SP3 / -
• PROFIBUS from GSD version/GSD revision	GSD Revision 5
• PROFINET from GSD version/GSD revision	GSDML V2.3
Operating mode	
• Oversampling	No
• MSO	No
CiR - Configuration in RUN	
Reparameterization possible in RUN	No
Calibration possible in RUN	No

Article number	6ES7135-6GB00-0BA1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	110 mA
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
• Address space per module, max.	4 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Analog outputs	
Number of analog outputs	2
Cycle time (all channels), min.	1 ms
Analog output with oversampling	No
Output ranges, current	
• 0 to 20 mA	Yes; 15 bit
• -20 mA to +20 mA	Yes; 16 bit incl. sign
• 4 mA to 20 mA	Yes; 14 bit
Connection of actuators	
• for current output two-wire connection	Yes
Load impedance (in rated range of output)	
• with current outputs, max.	500 Ω
• with current outputs, inductive load, max.	1 mH
Destruction limits against externally applied voltages and currents	
• Voltages at the outputs	30 V
Cable length	
• shielded, max.	1 000 m
Analog value generation for the outputs	
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit

Article number	6ES7135-6GB00-0BA1
Settling time	
• for resistive load	0.1 ms; Typical value
• for inductive load	0.5 ms
Errors/accuracies	
Linearity error (relative to output range), (+/-)	0.03 %
Temperature error (relative to output range), (+/-)	0.005 %/K
Crosstalk between the outputs, min.	-50 dB
Repeat accuracy in steady state at 25 °C (relative to output range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Voltage, relative to output range, (+/-)	0.5 %
• Current, relative to output range, (+/-)	0.5 %
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to output range, (+/-)	0.3 %
• Current, relative to output range, (+/-)	0.3 %
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Group error	Yes
• Overflow/underflow	Yes; Module-wise
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Isolation	
Isolation tested with	707 V DC (type test)

Article number	6ES7135-6GB00-0BA1
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; < 0 °C as of FS03
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; < 0 °C as of FS03
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP System Manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the output type and output range for PROFINET.

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Overflow	Underflow	Wire break		
Deactivated		*	*	*	*	*	*
Current	±20 mA	x	x	x	x	x	x
	0 mA to 20 mA	x	x	x	x	x	x
	4 mA to 20 mA	x	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the output type and output range for PROFIBUS.

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Overflow	Underflow	Wire break		
Deactivated		*	*	*	*	*	*
Current	±20 mA	x	x	x	x	x	x
	0 mA to 20 mA	x	x	x	x	x	x
	4 mA to 20 mA	x	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reassign the module parameters in your user program, regardless of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can change the parameters of the module in RUN. For example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

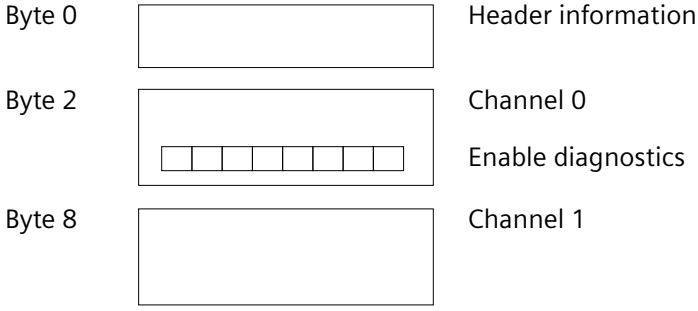

Figure 2-971 Structure of data record 128

Header information

The figure below shows the structure of the header information.

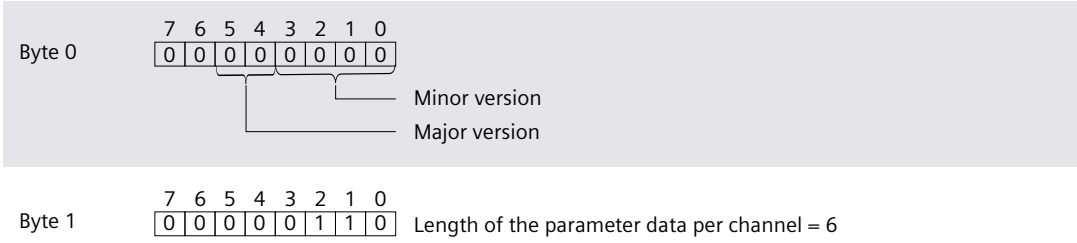

Figure 2-972 Header information

Parameters

The following figure shows the structure of the parameters for channels 0 and 1.
You enable a parameter by setting the corresponding bit to "1".

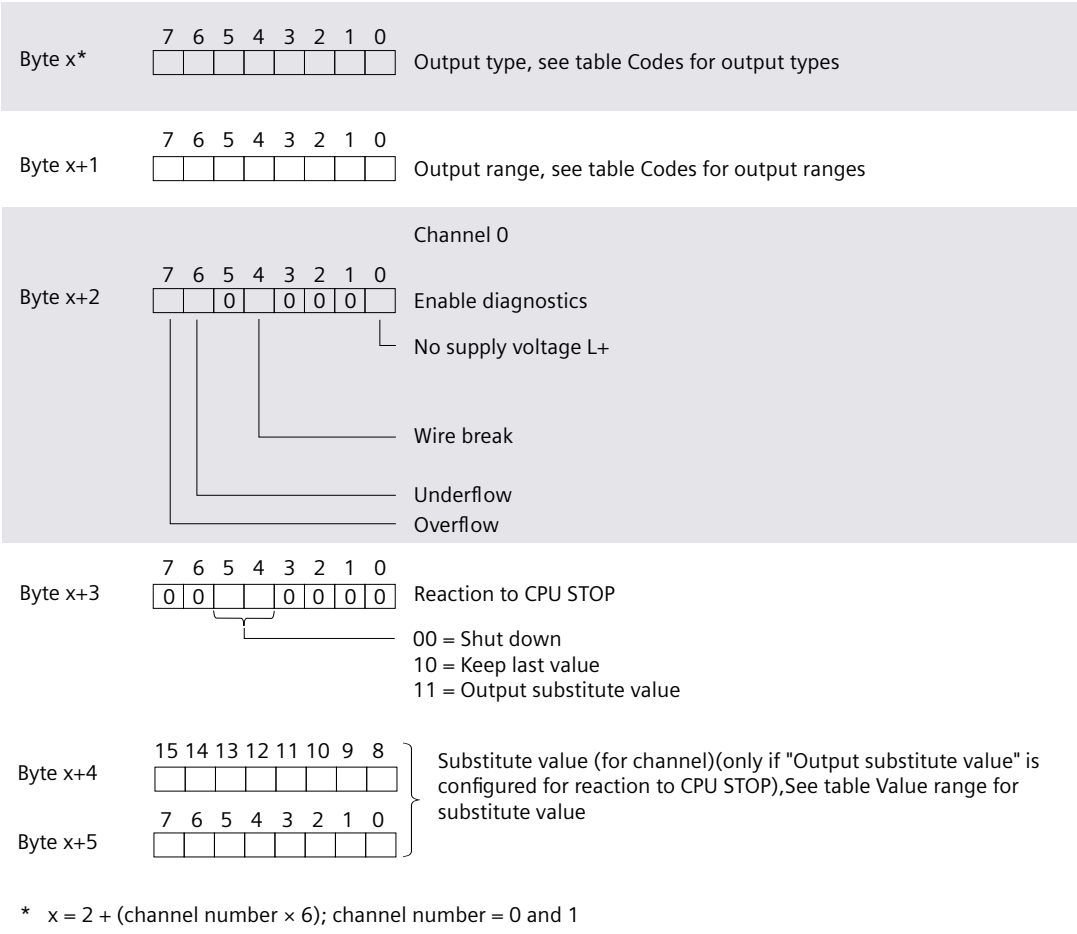

* x = 2 + (channel number × 6); channel number = 0 and 1

Figure 2-973 Structure of bytes x to x+5 for channels 0 and 1

Codes for output types

The following table contains the codes for the output types of the analog output module. You enter this coding in byte x (see previous figure).

Table 2-1049 Codes for output types

Output type	Code
Deactivated	0000 0000
Current	0000 0011

Codes for output ranges

The following table contains the codes for the output ranges of the analog output module. You enter these codes in byte x+1 of data record 128 (see previous figure).

Table 2-1050 Codes for output ranges

Output range	Code
Current	
±20 mA	0000 0000
0 mA to 20 mA	0000 0001
4 mA to 20 mA	0000 0010

Value range for substitute value

The following table contains the value ranges for the substitute values. You must enter the corresponding codes in bytes x+4 and x+5 (see previous figure).

Output range	Permissible value range
Current	
±20 mA	-29031 to 29030
0 mA to 20 mA	0 to 29030
4 to 20 mA	-692 to 29376

Error transmitting the data record

The module always checks all the values of the transferred data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error codes if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine if the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	I0	xx	Incorrect version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	I1	xx	Parameter error	Check the parameters of the module.

Representation of analog values

B

B.1 Representation of analog values

This appendix describes the analog values for all output ranges supported by the AQ 2xI ST analog module.

Measured value resolution

The digitized analog value is the same for all output values at the same nominal range. Analog values are output as fixed point numbers in two's complement.

In the following table, you will find the representation of the binary analog values and the associated decimal or hexadecimal units of the analog values.

The resolutions 15 and 16 bits including sign are shown. Each analog value is entered left aligned into the ACCU. The bits marked with "x" are set to "0".

Table 2-1051 Possible resolutions of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.2 Representation of output ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar range output ranges. The resolution is 16 bits.

Table 2-1052 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
≥32512	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	

Dec. value	Output value in %	Data word																Range
-27649	100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
≤ -32513	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value

Table 2-1053 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥32512	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
≤ 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value

B.3 Representation of analog values in the current output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible current output ranges.

Table 2-1054 Current output range ±20 mA

Values			Current output range	Range
	Dec.	Hex.	±20 mA	
118.5149%	32767	7FFF	21 mA	Overflow*
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	-723.4 nA	
-75%	-20736	AF00	-15 mA	
-100%	-27648	9400	-20 mA	
	-27649	93FF	-20 mA + 723.4 nA	Underrange

* Outputs positive maximum value or negative minimum value

Values			Current output range	Range
-105%	-29031	8E99	-21 mA	Underrange
	-29032	8E98	-21 mA	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

Table 2-1055 Current output range 0 to 20 mA

Values			Current output range	Range
	Dec.	**Hex.**	**0 to 20 mA**	
118.5149%	32767	7FFF	21 mA	Overflow*
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	0 mA	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

Table 2-1056 Current output ranges 4 to 20 mA

Values			Current output range	Range
	Dec.	**Hex.**	**4 to 20 mA**	
118.5149%	32767	7FFF	21 mA	Overflow*
	29377	72C1		
106.25%	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100%	27648	6C00	20 mA	Nominal range
75%	19008	4A40	16 mA	
0.003617%	1	1	4 mA + 578.7 nA	
0%	0	0	4 mA	
	-1	FFFF	3.9995 mA	Underrange
-2.5%	-692	FD4C	3.6 mA	
	-693	FD4B	3.6 mA	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

SIEMENS

SIMATIC

ET 200SP
Analog output module AQ 2xU ST (6ES7135-6FB00-0BA1)

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Introduction 1

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

- Wiring and block diagrams have been revised.
- The technical specifications have been updated.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

3

3.1 Properties

Article number

6ES7135-6FB00-0BA1

View of the module

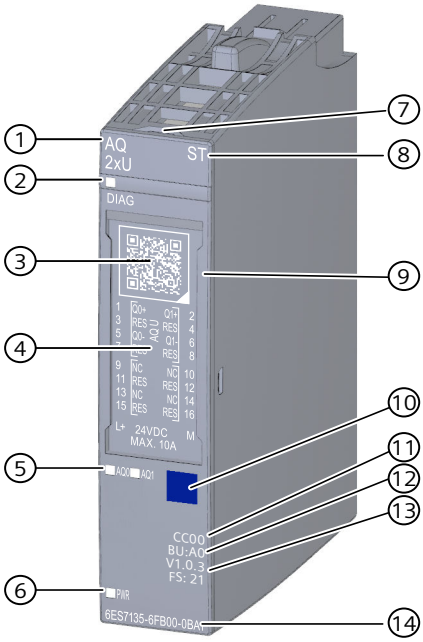

① Module type and name
② LED for diagnostics
③ QR code for identification link
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Slot for optional equipment labeling plate
⑧ Function class
⑨ Insertion option for optional labeling strip
⑩ Color coding module type
⑪ Color code for selecting the color identification labels
⑫ BU type
⑬ Firmware and function version
⑭ Article number

Figure 2-974 View of the module AQ 2×U ST

Properties

The module has the following technical properties:

- Analog output module with 2 outputs
  - for voltage output
- Output range for voltage output:
  - ±10 V, resolution 16 bits including sign
  - ±5 V, resolution 15 bits including sign
  - 0 to 10 V, resolution 15 bits
  - 1 to 5 V, resolution 13 bits
- Electrically isolated from supply voltage L+
- Configurable diagnostics (per module)
- Configurable substitute values (per channel)

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy
- Value status

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring

4

4.1 Connection diagram

This section includes the connection diagram of the AQ 2xU ST module with the terminal assignments for a 2-wire connection.

You can find information on wiring the BaseUnit in the System Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Pin assignment

The following table shows an example of the pin assignment of the analog output module AQ 2xU ST on the BaseUnit BU type A0/A1:

Description	Signal	Terminal	BaseUnit BU type A0/A1	Terminal	Signal	Description
Analog output voltage positive, channel 0	Q_0+	1	1 CC00 2	2	Q_1+	Analog output voltage positive, channel 1
-	RES[1)]	3	3 4	4	RES[1)]	-
Analog output voltage negative, channel 0	Q_0-	5	5 6	6	Q_1-	Analog output voltage negative, channel 1
-	RES[1)]	7	7 8	8	RES[1)]	-
-	NC[2)]	9	9 10	10	NC[2)]	-
-	RES[1)]	11	11 12	12	RES[1)]	-
-	NC[2)]	13	13 14	14	NC[2)]	-
-	RES[1)]	15	15 16	16	RES[1)]	-
24 V DC supply voltage[2)]	L+	L+	L+ M	M	M	Ground

1) Reserve, must remain unused for future function extensions

2) Not connected

3) Infeed only with light-colored BaseUnit

Connection types

2-wire connection for voltage output

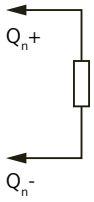

4.2 Schematic circuit diagram

This section contains the schematic circuit diagram of the AQ 2×U ST analog output module.

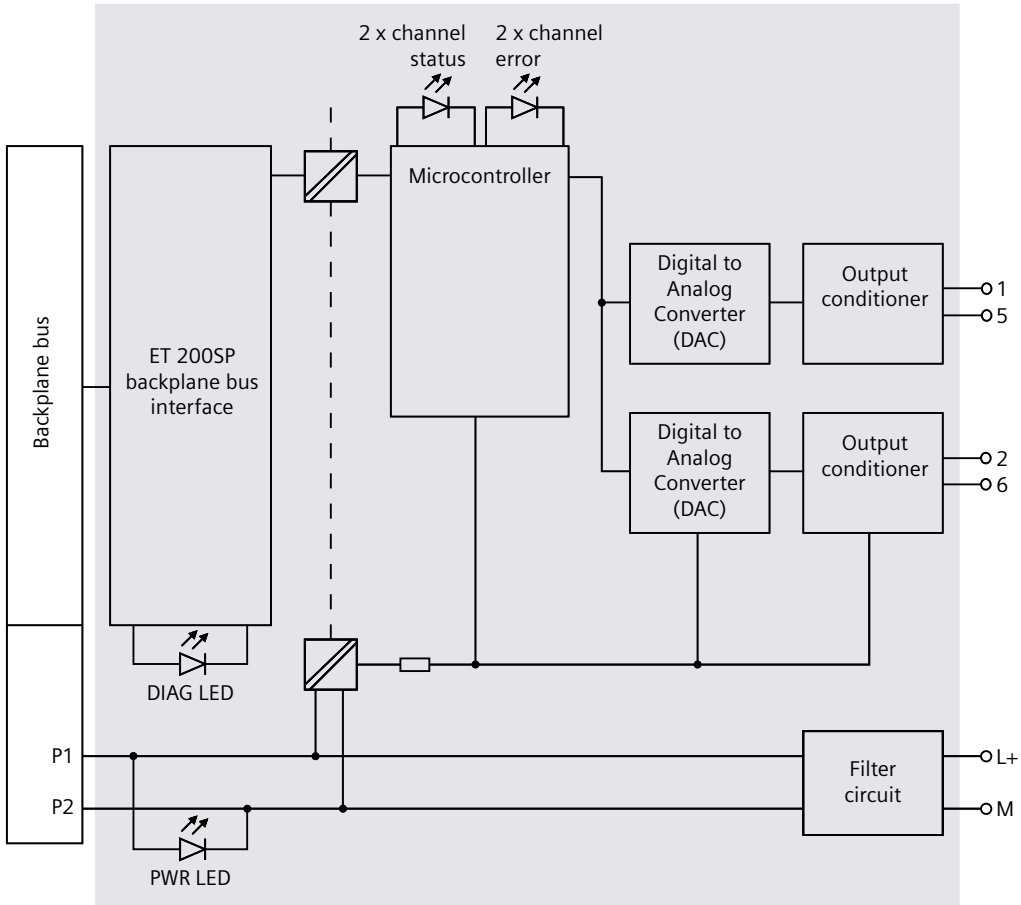

Figure 2-975 Schematic circuit diagram analog output module AQ 2xU ST

Parameters/address space

5

5.1 Output ranges

The analog output module AQ 2×U ST has the following output ranges:

Table 2-1057 Output ranges

Output type	Output ranges	Resolution
Voltage	± 10 V ± 5 V 0 to 10 V 1 to 5 V	16 bits incl. sign 15 bits including sign 15 bits 13 bits

The tables of the output ranges, overflow, overrange, etc. can be found in section Representation of analog values (Page 33).

5.2 Parameters

Parameters of the AQ 2xU ST

Specify the module properties with the various parameters in the course of your STEP 7 configuration. The following table lists the configurable parameters. The efficiency range of the configurable parameters depends on the type of configuration.
The following configurations are possible:

- Central operation with an ET 200SP CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to section Parameter assignment and structure of the parameter data record (Page 29).

The following parameter settings are possible:

Table 2-1058 Configurable parameters and their defaults (GSD file)

Parameters	Range of values	Default	Parameter reassignment in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics Short-circuit to ground[1]	• Disable • Enable	Disable	Yes	Module	Module
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Module	Module [2]
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Module	
Output type/range	• Deactivated • Voltage +/- 10 V • Voltage +/- 5 V • Voltage 0..10 V • Voltage 1..5 V	Voltage +/- 10 V	Yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value	Turn off	Yes	Channel	Module
Substitute value	For permissible substitute values for the various output ranges, see appendix Parameter assignment and structure of the parameter data record (Page 29), Substitute values → Codes for substitute values table	0	Yes	Channel	Channel
Potential group	• Use the potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

1 No diagnostics detection between -0.5 V and +0.5 V (no short-circuit detection)

2 Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 7 bytes.

NOTE

Unused channels

A deactivated channel always returns the value "no voltage".

5.3 Explanation of the parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Diagnostics: Overflow

Enabling of the diagnostics when the output value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the output value exceeds the overrange, falls below the minimum output value or reaches underflow.

Output type / output range

See section Output ranges (Page 17)

Reaction to CPU STOP

Determines the behavior of the module at CPU STOP.

Substitute value

The substitute value is the value that the module outputs in case of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2, and AUX to the left neighbor.

Specify the slot in which a light-colored BaseUnit with supply voltage infeed or a dark-colored BaseUnit is to be located (see ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) System Manual).

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

5.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 and 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: There are no errors on the module.

Bit = 0: Channel is deactivated or there is a fault on the module.

If a fault occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AQ 2×U ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

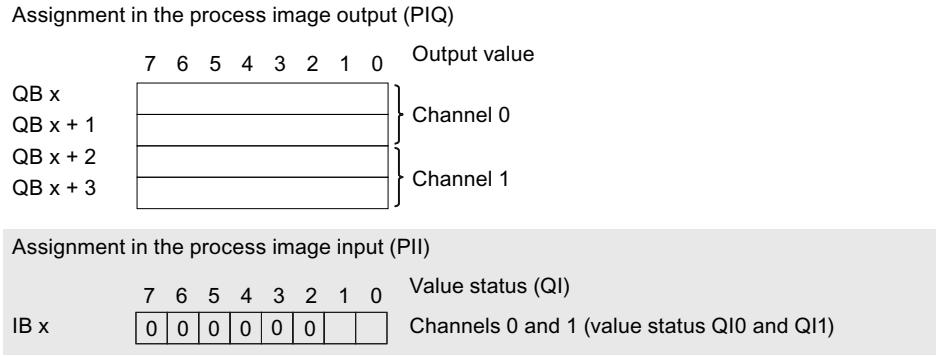

Figure 2-976 Address space of the AQ 2×U ST with value status

Interrupts/diagnostics alarms

6

6.1 Status and error display

LED display

The following figure shows you the LED display of the AQ 2xU ST.

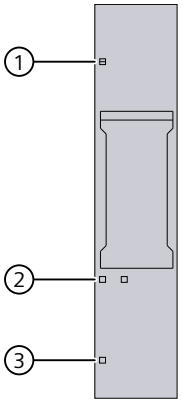

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-977 LED display

Meaning of the LEDs

The following tables show the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 23).

DIAG LED

Table 2-1059 Error display of the DIAG LED

DIAG LED	Meaning
☐ Off	Backplane bus supply of the system is disrupted or switched off.
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-1060 Status display of the channel status LED

Channel status LED	Meaning
☐ Off	Channel disabled
■ On	Channel activated

PWR LED

Table 2-1061 Status display of the PWR LED

PWR LED	Meaning
☐ Off	Missing supply voltage L+
■ On	Supply voltage L+ present

6.2 Interrupts

The AQ 2×U ST analog output module supports diagnostics interrupts.

Diagnostics interrupts

The module generates a diagnostic interrupt at the following events:

- Short-circuit (voltage)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- Supply voltage missing
- Channel temporarily unavailable

6.3 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-1062 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit	1_H	Short-circuit of the actuator supply	Correct the process wiring
High limit violated	7_H	The output value specified by the user program exceeds the overrange.	Correct the output value
Low limit violated	8_H	The output value specified by the user program is below the underrange.	Correct the output value
Error	9_H	Internal module error occurred.	Replace module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check the supply voltage L+ at the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update • Restart the firmware update

Technical specifications 7

7.1 Technical specifications

Technical specifications of the AQ 2×U ST

The following table lists the technical specifications on the issue date. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/de/pv/6ES7135-6FB00-0BA1/td?dl=en).

Article number	6ES7135-6FB00-0BA1
General information	
Product type designation	AQ 2xU ST
HW functional status	from FS21
Firmware version	V1.0.3
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Output range scalable	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V13 SP1 / -
• STEP 7 configurable/integrated from version	V5.5 SP3 / -
• PROFIBUS from GSD version/GSD revision	GSD Revision 5
• PROFINET from GSD version/GSD revision	GSDML V2.3
Operating mode	
• Oversampling	No
• MSO	No
CiR - Configuration in RUN	
Reparameterization possible in RUN	No
Calibration possible in RUN	No

Article number	6ES7135-6FB00-0BA1
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	80 mA
Power loss	
Power loss, typ.	1 W
Address area	
Address space per module	
• Address space per module, max.	4 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Analog outputs	
Number of analog outputs	2
Voltage output, short-circuit current, max.	45 mA
Cycle time (all channels), min.	1 ms
Analog output with oversampling	No
Output ranges, voltage	
• 0 to 10 V	Yes; 15 bit
• 1 V to 5 V	Yes; 13 bit
• -5 V to +5 V	Yes; 15 bit incl. sign
• -10 V to +10 V	Yes; 16 bit incl. sign
Connection of actuators	
• for voltage output two-wire connection	Yes
• for voltage output four-wire connection	No
Load impedance (in rated range of output)	
• with voltage outputs, min.	2 kΩ
• with voltage outputs, capacitive load, max.	1 µF
Destruction limits against externally applied voltages and currents	
• Voltages at the outputs	30 V
Cable length	
• shielded, max.	200 m

Article number	6ES7135-6FB00-0BA1
Analog value generation for the outputs	
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
Settling time	
• for resistive load	0.1 ms
• for capacitive load	1 ms
Errors/accuracies	
Linearity error (relative to output range), (+/-)	0.03 %
Temperature error (relative to output range), (+/-)	0.005 %/K
Crosstalk between the outputs, min.	-50 dB
Repeat accuracy in steady state at 25 °C (relative to output range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Voltage, relative to output range, (+/-)	0.5 %
• Current, relative to output range, (+/-)	0.5 %
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to output range, (+/-)	0.3 %
• Current, relative to output range, (+/-)	0.3 %
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnoses	
• Monitoring the supply voltage	Yes
• Short-circuit	Yes; Module-wise
• Group error	Yes
• Overflow/underflow	Yes; Module-wise
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	No
• for module diagnostics	Yes; green/red DIAG LED

Article number	6ES7135-6FB00-0BA1
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; < 0 °C as of FS03
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; < 0 °C as of FS03
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the output type and output range for PROFINET.

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow		
Deactivated		*	*	*	*	*	*
Voltage	±10 V	x	x	x	x	x	x
	±5 V	x	x	x	x	x	x
	0 V to 10 V	x	x	x	x	x	x
	1 V to 5 V	x	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the output type and output range for PROFIBUS.

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow		
Deactivated		*	*	*	*	*	*
Voltage	±10 V	x	x	x	x	x	x
	±5 V	x	x	x	x	x	x
	0 V to 10 V	x	x	x	x	x	x
	1 V to 5 V	x	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reassign the module parameters in your user program, independently of your programming. This means that you can use all the functions of the module even if you configured it via PROFIBUS-GSD.

Parameter assignment in the user program

You can reassign the module parameters in RUN. For example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 includes the diagnostics enable for the entire module.

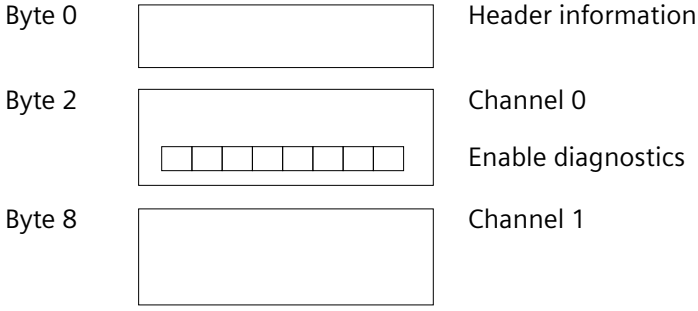

Figure 2-978 Structure of data record 128

Header information

The figure below shows the structure of the header information.

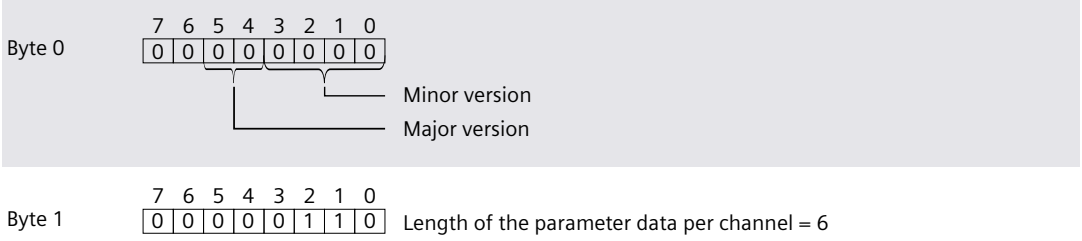

Figure 2-979 Header information

Parameters

The following figure shows the structure of the parameters for channels 0 and 1.
You enable a parameter by setting the corresponding bit to "1".

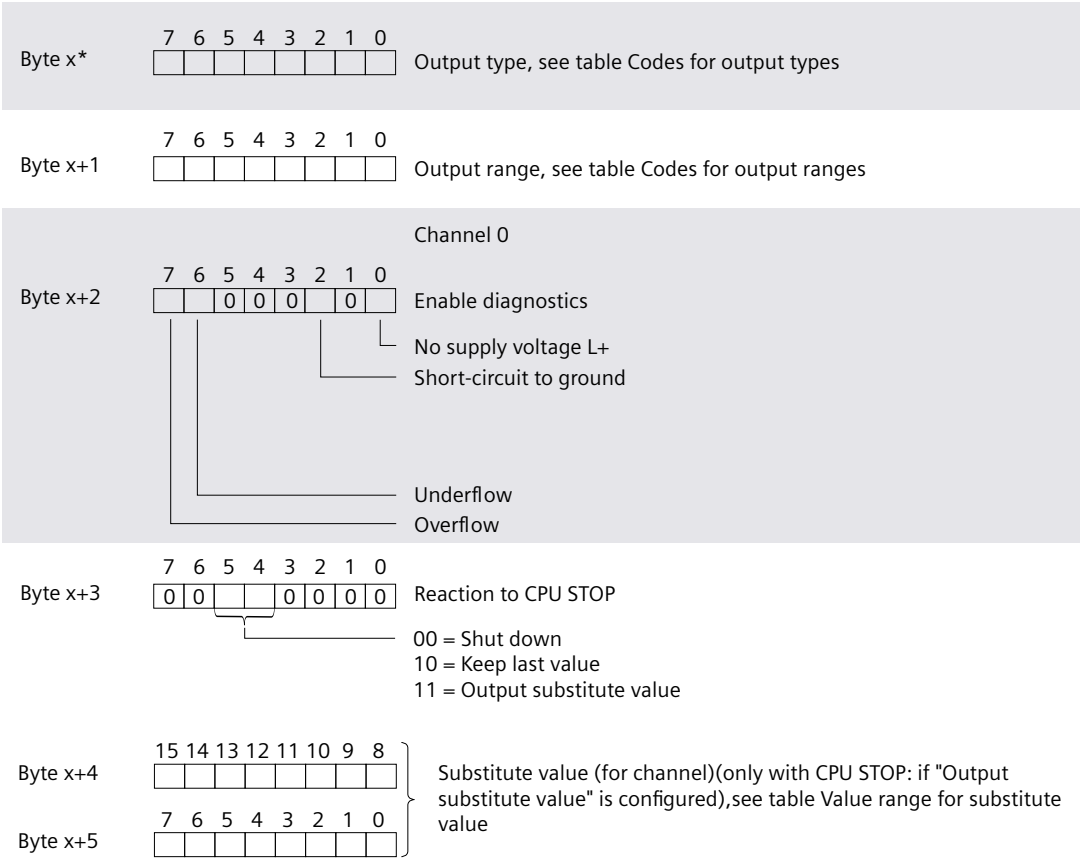

* x = 2 + (channel number × 6); channel number = 0 and 1

Figure 2-980 Structure of bytes x to x+5 for channels 0 and 1

Codes for output types

The following table contains the codes for the output types of the analog output module. You enter this coding in byte x (see previous figure).

Table 2-1063 Codes for output types

Output type	Code
Deactivated	0000 0000
Voltage	0000 0001

Codes for output ranges

The following table contains the codes for the output ranges of the analog output module. You enter these codes in byte x+1 of data record 128 (see previous figure).

Table 2-1064 Codes for output ranges

Output range	Code
Voltage	
±10 V	0000 0000
±5 V	0000 0001
0 to 10 V	0000 0010
1 to 5 V	0000 0011

Value range for substitute value

The following table contains the value ranges for the substitute values. You must enter the corresponding codes in bytes x+4 and x+5 (see previous figure).

Output range	Permissible value range
Voltage	
±10 V	-32512 to 32511
±5 V	-32512 to 32511
0 to 10 V	0 to 32511
1 to 5 V	-6912 to 32511

Error transmitting the data record

The module always checks all the values of the transferred data record. The module applies the values from the data record only when all values have been transmitted without errors.

The WRREC instruction for writing data records returns the appropriate error codes if there are errors in the STATUS parameter.

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Error code in the STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	B0	xx	Number of the data record unknown	Enter valid number for data record.
DF	80	B1	xx	Length of the data record incorrect	Enter valid value for data record length.
DF	80	B2	xx	Slot invalid or unavailable	• Check the station to determine if the module is plugged in or pulled. • Check assigned values for the parameters of the WREC instruction.
DF	80	I0	xx	Incorrect version or error in the header information	Correct the version, length and number of parameter blocks.
DF	80	I1	xx	Parameter error	Check the parameters of the module.

Representation of analog values

B

B.1 Representation of analog values

This appendix describes the analog values for all output ranges supported by the AQ 2xU ST analog module.

Measured value resolution

The digitized analog value is the same for all output values at the same nominal range. Analog values are output as fixed point numbers in two's complement.

In the following table, you will find the representation of the binary analog values and the associated decimal or hexadecimal units of the analog values.

The resolutions 13, 14, 15 and 16 bits including sign are shown. Each analog value is entered left aligned into the ACCU. The bits marked with "x" are set to "0".

Table 2-1065 Possible resolutions of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
13	8	8_H	Sign 0 0 0 0 0 0 0	0 0 0 0 1 x x x
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.2 Representation of output ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar range output ranges. The resolution is 16 bits.

Table 2-1066 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
≥32512	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	

Dec. value	Output value in %	Data word																Range
-27649	100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
≤ -32513	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value

Table 2-1067 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥32512	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
≤ 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value

B.3 Representation of analog values in the voltage output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible voltage output ranges.

Table 2-1068 Voltage output ranges ±10 V and ±5 V

Values			Voltage output range		Range
	Dec.	Hex.	±10 V	±5 V	
118.5149%	32767	7FFF	11.76 V	5.88 V	Overflow*
	32512	7F00			
117.589%	32511	7EFF	11.76 V	5.88 V	Overrange
	27649	6C01			
100%	27648	6C00	10 V	5 V	Nominal range
75%	20736	5100	7.5 V	3.75 V	
0.003617%	1	1	361.7 µV	180.8 µV	
0%	0	0	0 V	0 V	
	-1	FFFF	-361.7 µV	-180.8 µV	
-75%	-20736	AF00	-7.5 V	-3.75 V	
-100%	-27648	9400	-10 V	-5 V	
	-27649	93FF			Underrange

* Outputs positive maximum value or negative minimum value

Values			Voltage output range		Range
-117.593%	-32512	8100	-11.76 V	-5.88 V	Underrange
	-32513	80FF	-11.76	-5.88 V	Underflow*
-118.519%	-32768	8000			

* Outputs positive maximum value or negative minimum value

Table 2-1069 Voltage output range 0 V to 10 V

Values			Voltage output range	Range
	Dec.	**Hex.**	**0 to 10 V**	
118.519%	32767	7FFF	11.76 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	11.76 V	Overrange
	27649	6C01		
100%	27648	6C00	10 V	Nominal range
75%	20736	5100	7.5 V	
0.003617%	1	1	361.7 µV	
0%	0	0	0 V	
	-1	FFFF	0 V	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

Table 2-1070 Voltage output range 1 V to 5 V

Values			Voltage output range	Range
	Dec.	**Hex.**	**1 to 5 V**	
118.519%	32767	7FFF	5.70 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	5.70 V	Overrange
	27649	6C01		
100%	27648	6C00	5 V	Nominal range
75%	20736	5100	4 V	
0.003617%	1	1	1 V + 144.7 µV	
0%	0	0	1 V	
	-1	FFFF	1 V - 144.7 µV	Underrange
-25%	-6912	E500	0 V	
	-6913	E4FF	0 V	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

SIEMENS

SIMATIC

ET 200SP
Analog output module AQ 2xU/I HS (6ES7135-6HB00-0DA1)

Equipment Manual

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Parameters/address space 4

Interrupts/diagnostics alarms 5

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Representation of analog values B

09/2016
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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit (http://www.siemens.com/industrialsecurity).

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To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

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Documentation Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

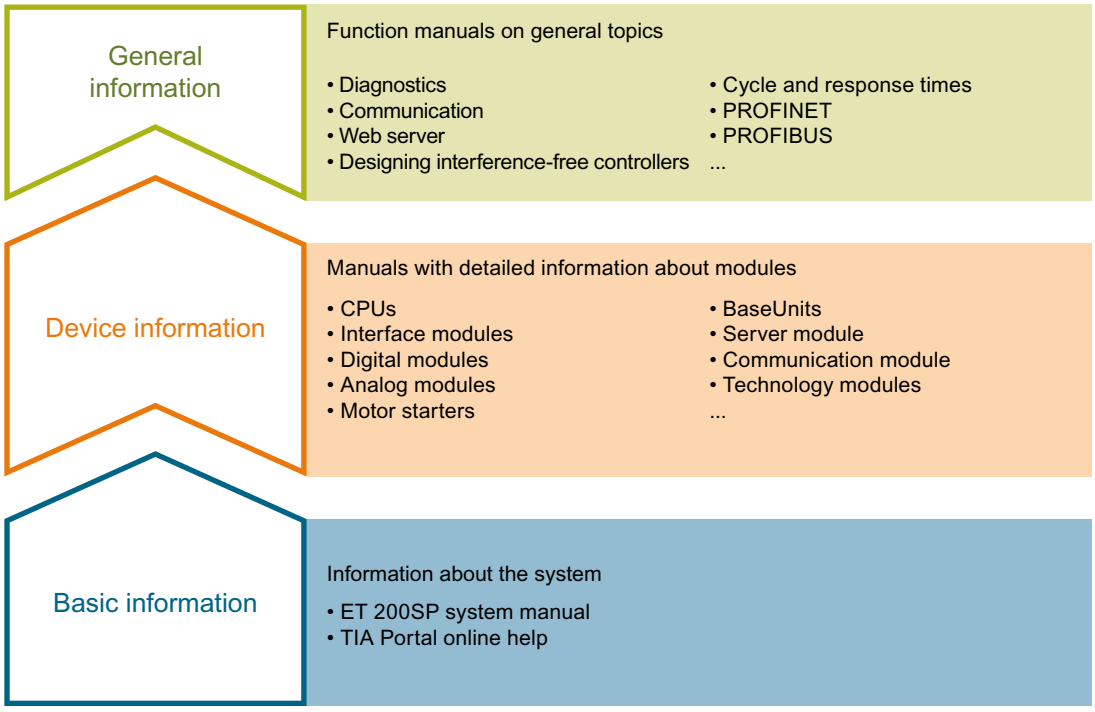

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

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In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Product overview

2

2.1 Properties

Article number

6ES7135-6HB00-0DA1

View of the module

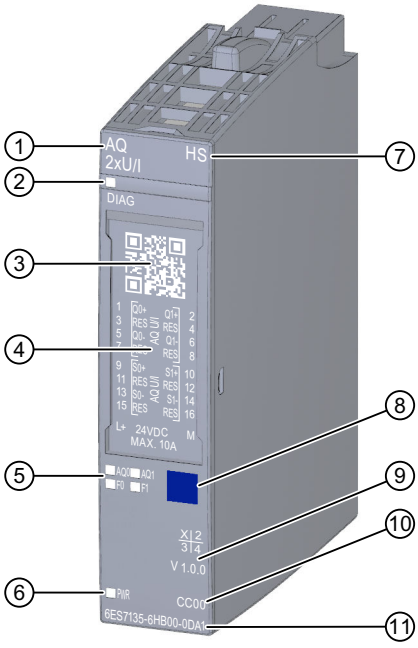

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	Article number
⑥	LED for supply voltage		

Figure 2-981 View of the AQ 2×U/I HS module

Properties

The module has the following technical properties:

- Analog output module with 2 outputs
  - For current output and
  - Voltage output
- Output ranges for current output:
  - ±20 mA, resolution 16 bit including sign
  - 0 to 20 mA, resolution 15 bit
  - 4 to 20 mA, resolution 14 bit
- Output ranges for voltage output:
  - ±10 V, resolution 16 bit including sign
  - ±5 V, resolution 15 bit incl. sign
  - 0 to 10 V, resolution 15 bit
  - 1 to 5 V, resolution 13 bit
- Electrically isolated from supply voltage L+
- Configurable diagnostics (per channel)

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- PROFIenergy

Table 2-1071 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Basic version	1	V1.0.0
Isochronous mode with send clock up to 250 µs	2	V1.1.0
Value status	2	V1.1.0
Oversampling channel 0	2	V1.1.0
Oversampling channel 0 and 1	2	V2.0.0
Isochronous mode with send clock up to 125 µs	2	V2.0.1

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Reference identification label
- Shield connector

See also

You can find more information on accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Connecting 3

3.1 Wiring and block diagram

This section includes the block diagram of the module with the AQ 2xU/I HS pin assignments for a 2-wire, 3-wire and 4-wire connection for voltage output.

The 3-wire and 4-wire connection are used for the compensation of the voltage drop on the connection cables.

You can find information on wiring the BaseUnit in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

NOTE

You may use and combine the different wiring options for all channels.

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Connection: Current output 2-wire connection

The figure below shows the block diagram and an example of the terminal assignment of the analog output module AQ 2xU/I HS on the BaseUnit BU type A0/A1.

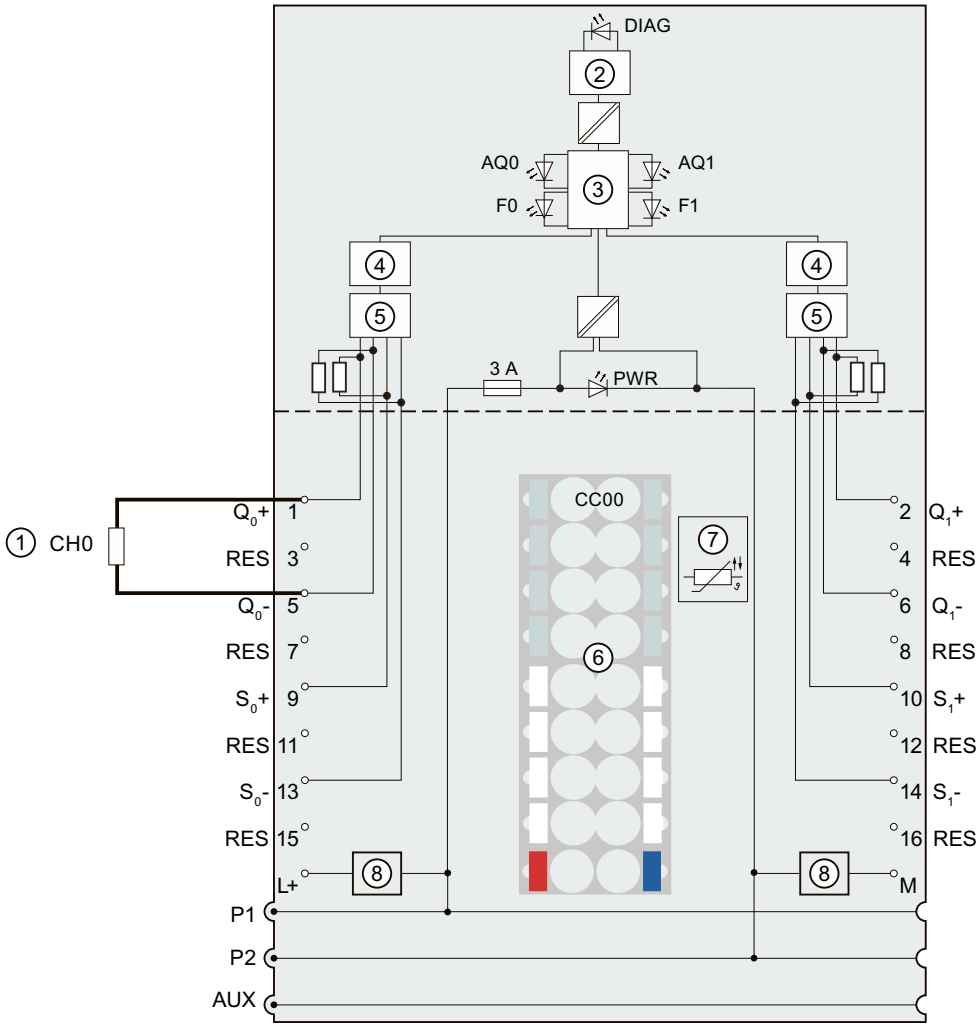

①	2-wire connection for current output	S_n+	Sensor cable positive, channel n
②	Backplane bus interface	S_n-	Sensor cable negative, channel n
③	Microcontroller	RES	Reserve, must remain unused for future function extensions
④	Digital-to-analog converter (DAC)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Output conditioner	M	Ground
⑥	Color identification label CCxx (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Temperature recording for BU type A1 only (function cannot be used for this module)	DIAG	Diagnostics LED (green, red)

⑧	Filter connection supply voltage (only when light-colored BaseUnit is present)	AQ0, AQ1	Channel status LED (green)
Q_n+	Analog output voltage/current positive, channel n	F0, F1	Channel fault LED (red)
Q_n-	Analog output voltage/current negative, channel n	PWR	Power LED (green)

Figure 2-982 Wiring and block diagram for current output 2-wire connection

Connection: Voltage output 2-wire and 3-wire connection

The following figure shows the block diagram and an example of the terminal assignment of the analog output module AQ 2xU/I HSon the BaseUnit BU type A0/A1.

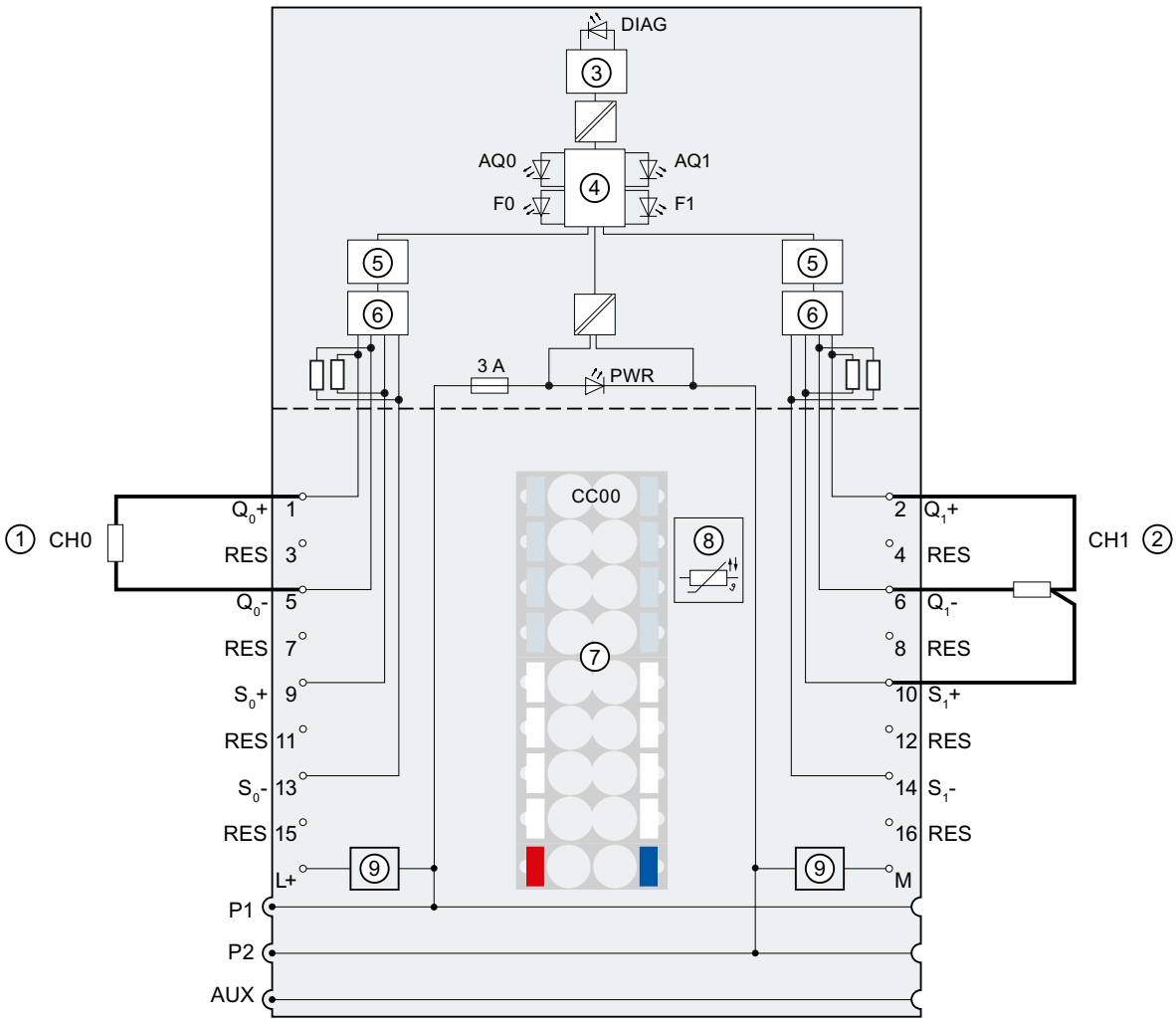

①	2-wire connection for voltage output	S_n+	Sensor cable positive, channel n
②	3-wire connection for voltage output	S_n-	Sensor cable negative, channel n
③	Output conditioner	RES	Reserve, must remain unused for future function extensions

④	Digital-to-analog converter (DAC)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Microcontroller	M	Ground
⑥	Backplane bus interface	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Color identification label CCxx (optional)	DIAG	Diagnostics LED (green, red)
⑧	Temperature recording for BU type A1 only (function cannot be used for this module)	AQ0, AQ1	Channel status LED (green)
⑨	Filter connection supply voltage (only when light-colored BaseUnit is present)	F0, F1	Channel fault LED (red)
Q_n+	Analog output voltage/current positive, channel n	PWR	Power LED (green)
Q_n-	Analog output voltage/current negative, channel n		

Figure 2-983 Wiring and block diagram for voltage output 2-wire and 3-wire connection

Connection: Voltage output 2-wire and 4-wire connection

The figure below shows the block diagram and an example of the terminal assignment of the analog output module AQ 2xU/I HS on the BaseUnit BU type A0/A1.

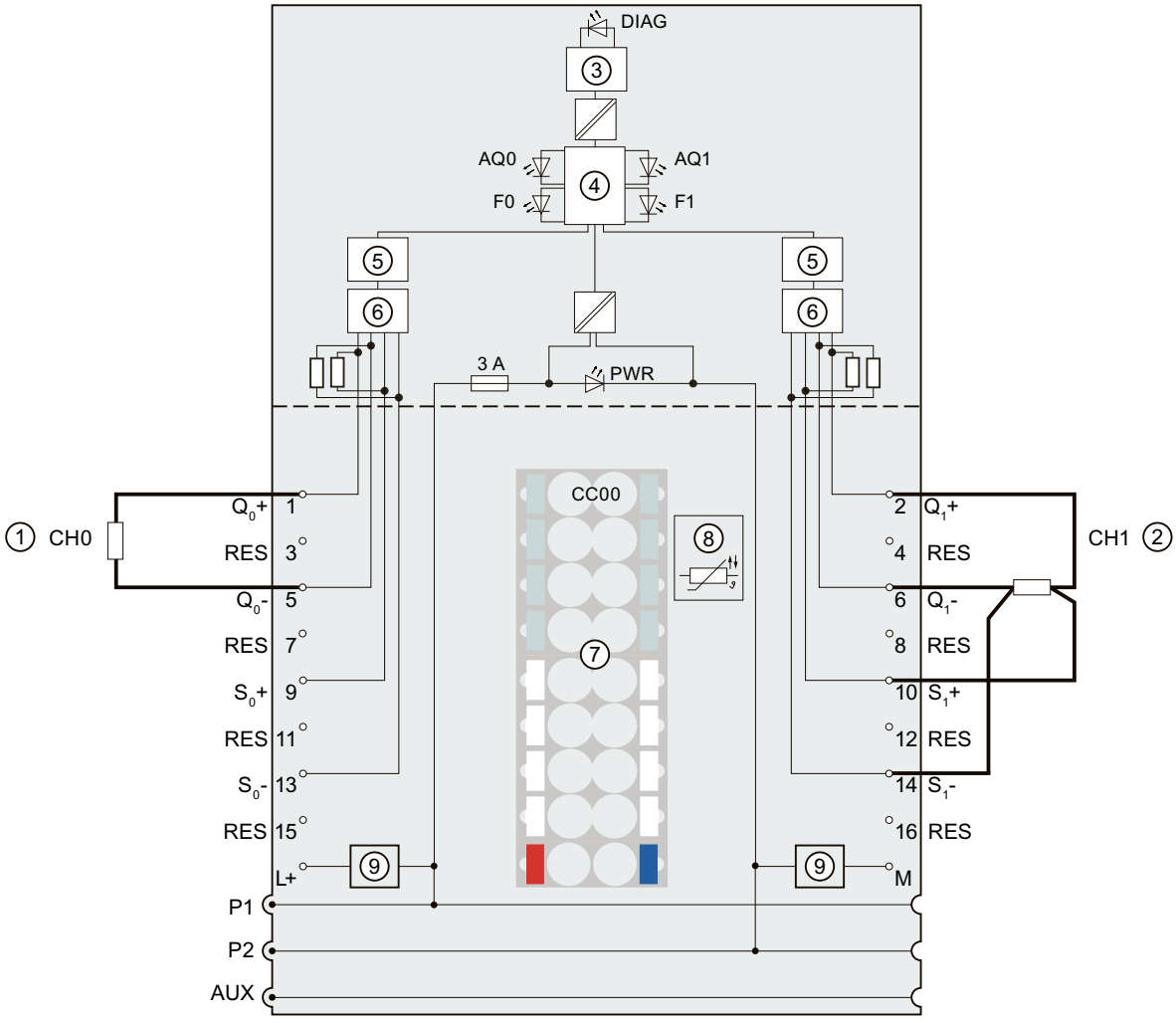

①	2-wire connection for voltage output	S_n+	Sensor cable positive, channel n
②	4-wire connection for voltage output	S_n-	Sensor cable negative, channel n
③	Output conditioner	RES	Reserve, must remain unused for future function extensions
④	Digital-to-analog converter (DAC)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Microcontroller	M	Ground
⑥	Backplane bus interface	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑦	Color identification label CCxx (optional)	DIAG	Diagnostics LED (green, red)
⑧	Temperature recording for BU type A1 only (function cannot be used for this module)	AQ0, AQ1	Channel status LED (green)

⑨	Filter connection supply voltage (only when light-colored BaseUnit is present)	F0, F1	Channel fault LED (red)
Q_n+	Analog output voltage/current positive, channel n	PWR	Power LED (green)
Q_n-	Analog output voltage/current negative, channel n		

Figure 2-984 Wiring and block diagram for voltage output 2-wire and 4-wire connection

Parameters/address space

4

4.1 Output types and output ranges

The analog output module AQ 2×U/I HS has the following output ranges:

Table 2-1072 Output ranges

Output type	Output range	Resolution
Current	±20 mA 0 to 20 mA 4 to 20 mA	16 bit incl. sign 15 bit 14 bit
Voltage	± 10 V ± 5 V 0 to 10 V 1 to 5 V	16 bit incl. sign 15 bit incl. sign 15 bit 13 bit

You will find the tables of output ranges and overflow, overrange, etc. in the section Representation of analog values (Page 40) and the "Analog value processing" function manual.

4.2 Parameters

Parameters of the AQ 2×U/I HS

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation on an ET 200SP oder an einem ET 200SP Open Controller CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

In addition to assigning parameters with the configuration software, you can also set the parameters in RUN mode (dynamically) using the user program. When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module by means of data records; see section Parameter assignment and structure of parameter data record (Page 35).

The following parameter settings are possible:

Table 2-1073 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Sampling rate	1 value/cycle	1 value/cycle	No	Module	Module
Diagnostics: No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground [1]	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Overflow	• Disable • Enable	Disable	Yes	Channel	Channel [3]
Diagnostics: Underflow	• Disable • Enable	Disable	Yes	Channel	
Diagnostics: Wire break[2]	• Disable • Enable	Disable	Yes	Channel	Channel
Output type/range	• Deactivated • Voltage +/- 10 V • Voltage +/- 5 V • Voltage 0 to 10 V • Voltage 1 to 5 V • Current +/- 20 mA • Current 0 to 20 mA • Current 4 to 20 mA	Current 4 to 20 mA	Yes	Channel	Channel
Reaction to CPU STOP	• Shut down • Keep last value • Output substitute value	Shut down	Yes	Channel	Module [3]
Substitute value	For permissible substitute values for the various output ranges, see Parameter assignment and structure of the parameter data record (Page 35) appendix, Substitute values → Codes for substitute values table	0	Yes	Channel	Channel
Potential group	• Use potential group of the left module (dark-colored BaseUnit) • Enable new potential group (light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] No diagnostics detection between -0.5 V and +0.5 V (no short-circuit detection)

[2] No diagnostics detection between -3 mA and +3 mA (no wire break detection)

[3] Due to the limited number of parameters of a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the parameter assignment options are restricted. If required, you can still assign these parameters using the data record 128 as described in the column "GSD file PROFINET IO" (see table above). The parameter length of the I/O module is 7 bytes.

NOTE
Unused channels
A deactivated channel always returns the value "no current or voltage".

4.3 Description of parameters

Diagnostics: No supply voltage L+

Enabling of the diagnostics alarm for missing or insufficient supply voltage L+.

Diagnostics: Short-circuit to ground

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Diagnostics: Overflow

Enabling of the diagnostics when the output value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the output value falls below the underrange or reaches the minimum output value or underflow.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Output type/output range

See the section Output types and output ranges (Page 17).

Reaction to CPU STOP

Determines the behavior of the module at CPU STOP.

Substitute value

The substitute values are values issued by the outputs (the output) in the event of a CPU STOP.

Potential group

You can use the "Potential group" parameter to specify whether the module is inserted in a light-colored or dark-colored BaseUnit.

A potential group always starts with an I/O module that is inserted on a light-colored BaseUnit. All modules inserted to the right of this on dark-colored BaseUnits belong to the same potential group, because the dark-colored BaseUnits are supplied via the light-colored BaseUnits.

The potential group ends with a new light-colored BaseUnit or the end of the station.

See also

ET 200SP Distributed I/O System
(http://support.automation.siemens.com/WW/view/en/58649293)

4.4 Oversampling

Function

Oversampling is the output of data in constant bus cycle segments (sub-cycles), whereby n sub-cycles correspond to one PROFINET bus cycle. A data packet is transmitted from the controller to the module, which outputs the packet in n constant bus sub-cycles.

Oversampling is useful whenever you require output of data with high time resolution but without using an extremely short PROFINET bus cycle and thus fast CPU cycles.

With oversampling, a PROFINET bus cycle is divided into constant bus sub-cycles:

- Each sub-cycle returns an output value.
- The minimum PROFINET bus cycle for oversampling is 250 µs.
- You can configure oversampling for:
  - Channel 0 (1-channel operation)
  - Channel 0/1 (2-channel operation)
- The number of sub-cycles can be set as follows:
  - From 2 to 16 for one channel
  - From 2 to 8 for two channels

Requirement

Oversampling is only possible when isochronous mode is set.

Configuration

You configure oversampling with the following parameter:

- Sampling rate

NOTE

Do not use a reduction ratio for blocks in the case of configuration with oversampling in the runtime groups of your user program. This will ensure that the data processing in the user program of the CPU is synchronized with the acquisition on the module.

Overview of the operating modes

Function	Normal operation	Oversampling in normal operation	
		1-channel operation	2-channel operation
Isochronous mode	Yes, optional	Yes, required	
• Shortest send clock	125 µs	250 µs	
Oversampling	No	Yes	Yes
• Number of over-sampling levels (output rate)	-	2 to 16	2 to 8
• Shortest sub-cycle (= shortest sampling time)	-	35 µs	45 µs
±10 V	x	x	
0 to 10 V	x	x	
±5 V	x	x	
1 to 5 V	x	x	
±20 mA	x	x	
0 to 20 mA	x	x	
4 to 20 mA	x	x	
Overflow	x	x	
Underflow	x	x	
Wire break for current	x	x	
Short-circuit for voltage	x	x	
Load voltage diagnostics	x	x	
Value status (QI)	x	-	
Reaction to CPU STOP	x	x	
Data length	4 bytes	32 bytes	

Chronological sequence

The figure shows the chronological sequence for oversampling. The output data present in the CPU is output in the data cycle after the next one, distributed across the sub-cycles which are generated on the actual module.

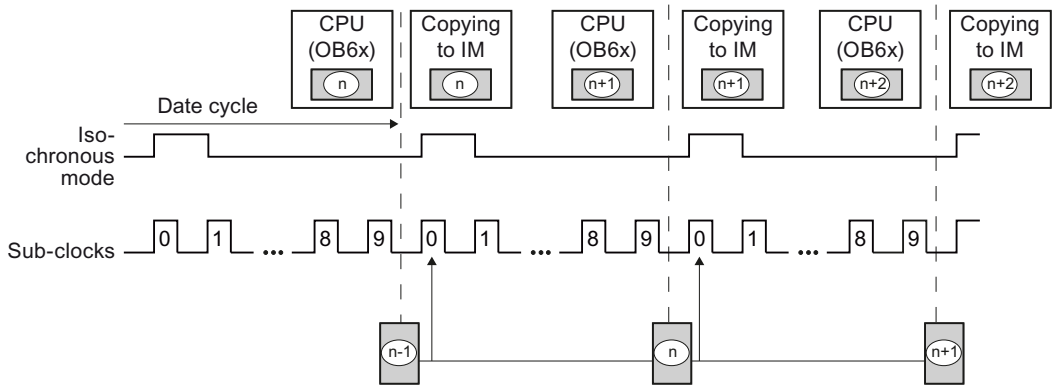

① n = output values from bus cycle n

Figure 2-985 Oversampling

4.5 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is occupied in the input address space if you enable the value status for the analog module. Bit 0 and 1 in this byte are assigned to the module. They provide information about the validity of the analog value.

Bit =1: No fault is present on the channel.

Bit =0: The wiring, the value created on the channel, or similar is incorrect.

Address space

The following figure shows the assignment of the address space for the AQ 2xU/I HS with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

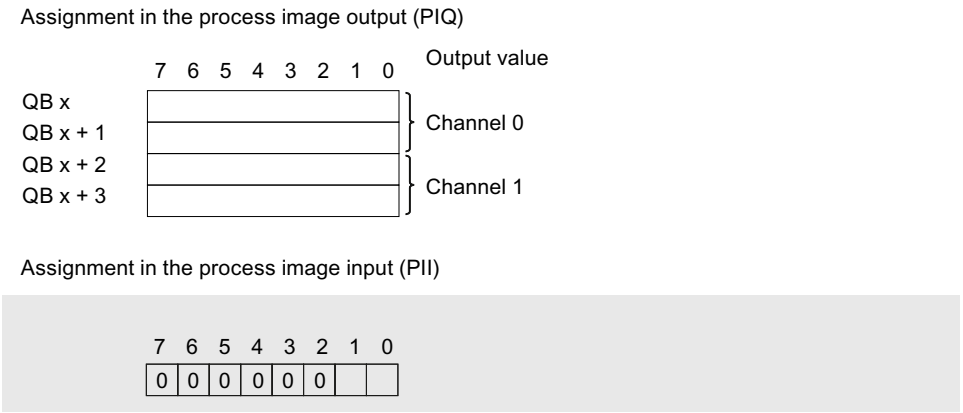

Figure 2-986 Address space of the AQ 2xU/I HS with value status

Address space of the AQ 2xU/I HS for oversampling with one channel

The following figure shows the assignment of the address space for oversampling with one channel. Writing always starts from QB x. Only a maximum of 16 sub-cycles are possible.

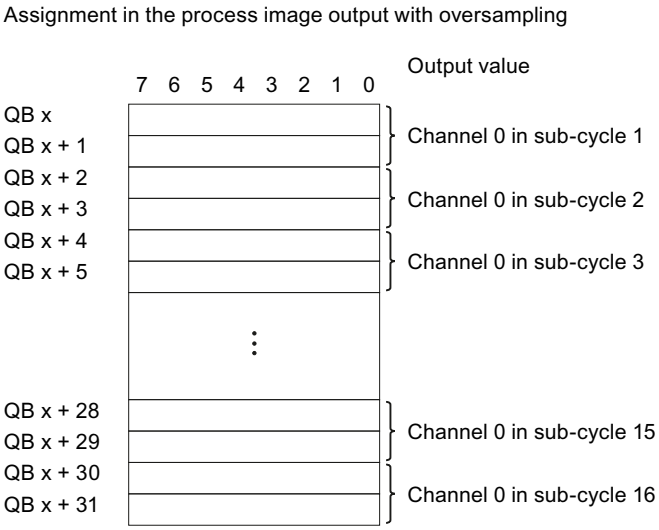

Figure 2-987 Address space of the AQ 2xU/I HS for oversampling with one channel

Address space of the AQ 2xU/I HS for oversampling with two channels

The following figure shows the assignment of the address space for oversampling with two channels. Writing always starts from QB x. Only a maximum of 8 sub-cycles are possible.

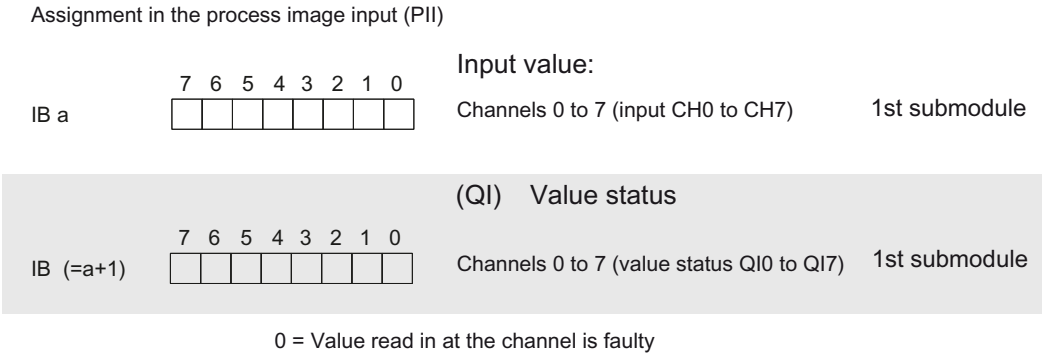

Figure 2-988 Address space of the AQ 2xU/I HS for oversampling with two channels

Interrupts/diagnostics alarms

5

5.1 Status and error displays

LED display

The figure below shows the LED displays of the AQ 2×U/I HS.

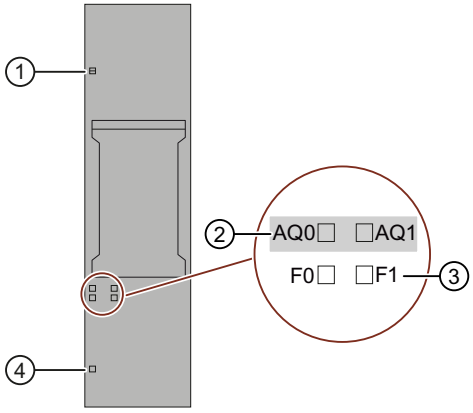

① DIAG (green/red)

② Channel status (green)

③ Channel fault (red)

④ PWR (green)

Figure 2-989 LED displays

Meaning of the LEDs

The following table contains the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in section Diagnostics alarms (Page 27).

DIAG LED

Table 2-1074 Error display of the DIAG LED

DIAG	Meaning
☐ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status/channel fault LED

Table 2-1075 Status/error display of the channel status/channel fault LED

Channel status	Channel fault	Meaning
☐ Off	☐ Off	Channel deactivated or no load voltage L+
■ On	☐ Off	Channel activated and no channel diagnostics
☐ Off	■ On	Channel activated and channel diagnostics
■ On	■ On	Not permitted (error)

PWR LED

Table 2-1076 Status display of the PWR LED

PWR	Meaning
☐ Off	No supply voltage L+
■ On	Supply voltage L+ present

5.2 Interrupts

The analog output module AQ 2×U/I HS supports diagnostics interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt at the following events:

- Short-circuit
- Overtemperature
- Wire break
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- No load voltage
- Channel temporarily unavailable

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED flashes on the module. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program

Table 2-1077 Error types

Diagnostics alarm	Error code	Meaning	Solution
Short-circuit (current)	1_H	Short-circuit of the actuator supply	Correct the process wiring
Overtemperature	4_H	Thermal overload of the I/O module	Reduce the ambient temperature, pay attention to derating
Wire break (current)	6_H	Impedance of actuator circuit too high	Use a different actuator type or modify the wiring, for example, using cables with larger cross-section
		Wire break between the module and actuat-or	Connect the cable
		Channel not connected (open)	• Deactivate the channel ("Output type" parameter) • Deactivate diagnostics • Connect the channel
High limit violated	7_H	The output value defined by the user pro-gram is above the overrange.	Correct the output value
Low limit violated	8_H	The output value defined by the user pro-gram is below the underrange.	Correct the output value
Error	9_H	Internal module error occurred	Replace the module

Diagnostics alarm	Error code	Meaning	Solution
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type
Channel temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update • Restart the firmware update

Technical specifications 6

6.1 Technical specifications

Technical specifications of the AQ 2×U/I HS

	6ES7135-6HB00-0DA1
Product type designation	ET 200SP, AQ 2xU/I High Speed
General information	
Firmware version	V2.0.1
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC00
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 SP1
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	GSDML V2.3
Operating mode	
Oversampling	Yes; 2 channels per module
CiR Configuration in RUN	
Reconfiguration in RUN possible	Yes
Calibration in RUN possible	Yes
Supply voltage	
Rated value (DC)	24 V
Valid range, low limit (DC)	19.2 V
Valid range, high limit (DC)	28.8 V
Input current	
Current consumption (rated value)	45 mA; no load
Power loss	
Power loss, typ.	0.9 W
Address area	
Address space per module	
Address space per module, max.	4 byte; + 1 byte for QI information (32 bytes in oversampling mode)
Analog outputs	
Number of analog outputs	2

	6ES7135-6HB00-0DA1
Voltage output, short-circuit protection	Yes
Voltage output, short-circuit current, max.	45 mA
Cycle time (all channels), min.	125 µs
Analog output with oversampling	Yes
Values per cycle, max.	16
Resolution, min.	45 µs; (2 channels), 35 µs (1 channel)
Output ranges, voltage	
0 to 10 V	Yes; 15 bit
1 V to 5 V	Yes; 13 bit
-5 V to +5 V	Yes; 15 bit incl. sign
-10 V to +10 V	Yes; 16 bit incl. sign
Output ranges, current	
0 to 20 mA	Yes; 15 bit
-20 mA to +20 mA	Yes; 16 bit incl. sign
4 mA to 20 mA	Yes; 14 bit
Wiring the actuators	
for voltage output two-wire connection	Yes
for voltage output four-wire connection	Yes
for current output two-wire connection	Yes
Load resistance (in rated range of the output)	
For voltage outputs, min.	2 kΩ
For voltage outputs, capacitive load, max.	1 µF
For current outputs, max.	500 Ω
For current outputs, inductive load, max.	1 mH
Destruction limit for externally applied voltages and currents	
Voltages at the outputs	30 V
Cable length	
Shielded, max.	1000 m; 200 m for voltage output
Formation of analog values for the outputs	
Settling time	
For resistive load	0.05 ms
For capacitive load	0.05 ms; max. 47 nF and 20 m cable length
For inductive load	0.05 ms
Errors/accuracies	
Output ripple (in relation to output range, bandwidth 0 kHz to 50 kHz), (+/-)	0.02%
Linearity error (in relation to output range), (+/-)	0.03%
Temperature error (in relation to output range), (+/-)	0.003%/K
Crosstalk between outputs, max.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to output range), (+/-)	0.03%

	6ES7135-6HB00-0DA1
Operational limit in the entire temperature range	
Voltage in relation to output range, (+/-)	0.2%
Current in relation to output range, (+/-)	0.2%
Basic error limit (operational limit at 25 °C)	
Voltage in relation to output range, (+/-)	0.1%
Current in relation to output range, (+/-)	0.1%
Isochronous mode	
Isochronous mode (application synchronized up to terminal)	Yes
Execution and activation time (TCO), min.	70 µs
Bus cycle time (TDP), min.	125 µs
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes; channel-based, only for output type current
Short-circuit	Yes; channel-based, only for output type voltage
Overflow/underflow	Yes
Diagnostics display LED	
Monitoring of supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Insulation	
Insulation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Dimensions	

	6ES7135-6HB00-0DA1
Width	15 mm
Weights	
Weight, approx.	31 g

Derating trends with horizontal installation:

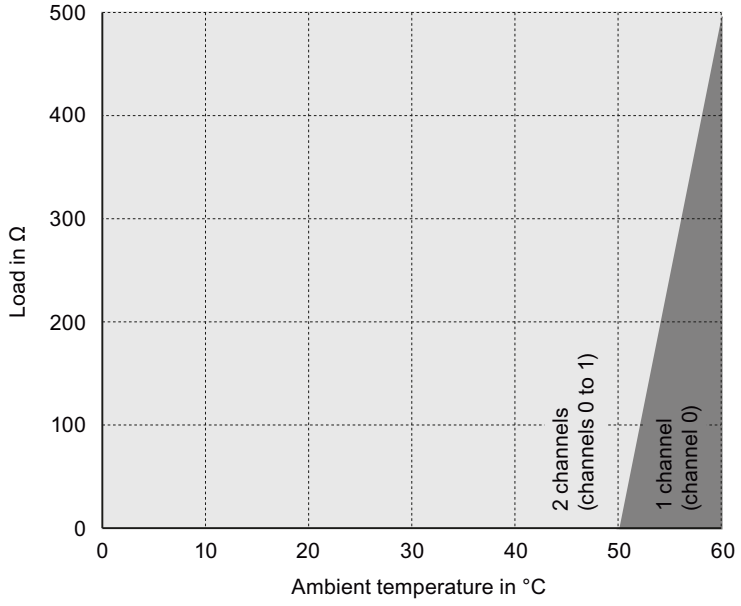

Figure 2-990 Derating trend current output (horizontal)

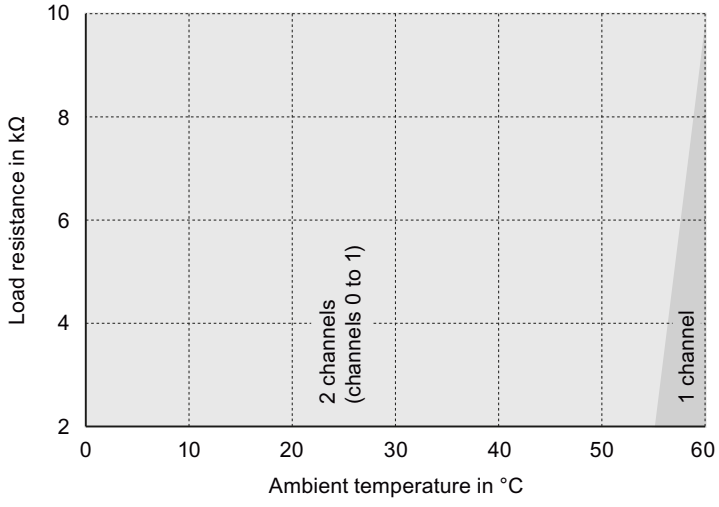

Figure 2-991 Derating trend voltage output (horizontal)

Derating trends with vertical installation:

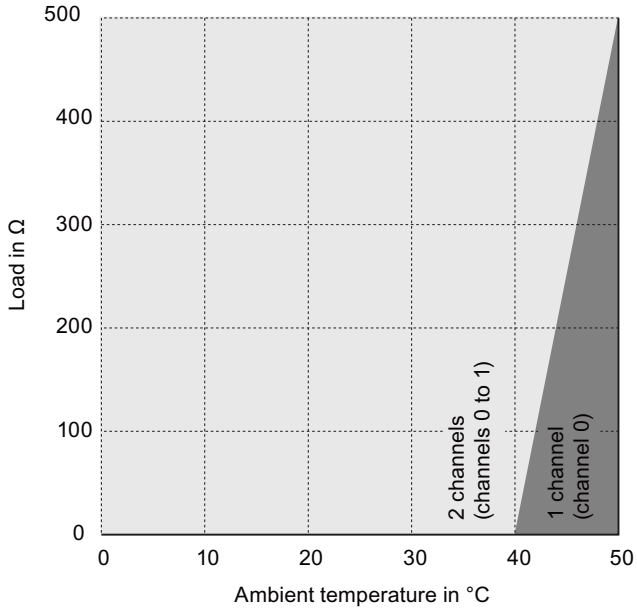

Figure 2-992 Derating trend current output (vertical)

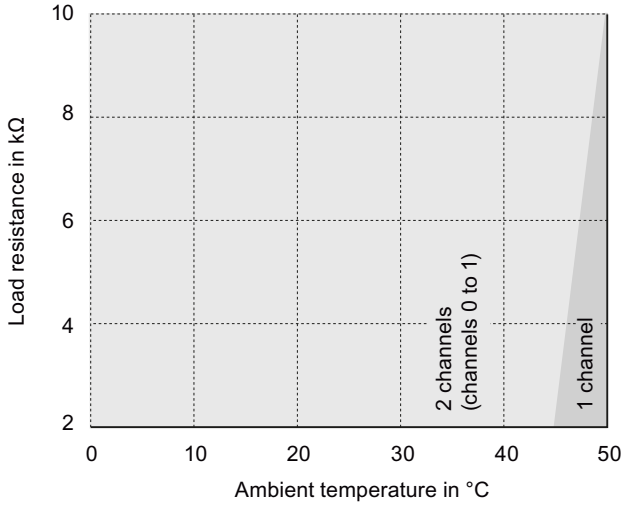

Figure 2-993 Derating trend voltage trend (vertical)

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Output type	Output range	Diagnostics					Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to ground	Overflow	Underflow	Wire break		
Deactivated		*	*	*	*	*	*	*
Voltage	±5 V	x	x	x	x	-	x	x
	±10 V	x	x	x	x	-	x	x
	1 to 5 V	x	x	x	x	-	x	x
	0 to 10 V	x	x	x	x	-	x	x
Current	±20 mA	x	-	x	x	x	x	x
	0 to 20 mA	x	-	x	x	x	x	x
	4 to 20 mA	x	-	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to ground	Overflow/ Underflow	Wire break		
Deactivated		*	*	*	*	*	*
Voltage	±5 V	x	x	x	-	x	x
	±10 V	x	x	x	-	x	x
	1 to 5 V	x	x	x	-	x	x
	0 to 10 V	x	x	x	-	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to ground	Overflow/ Underflow	Wire break		
Current	±20 mA	x	-	x	x	x	x
	0 to 20 mA	x	-	x	x	x	x
	4 to 20 mA	x	-	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

The module can be re-configured in RUN (for example, the voltage or current ranges of selected channels can be changed in RUN without having an effect on the other channels).

NOTE

Following a firmware update, you need to re-configure the I/O module before you can use the new functions.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means the parameters set in STEP 7 are valid again after a restart.

NOTE

Changing parameters in RUN

A parameter data record that has content different from the startup parameter assignment results in a brief exit from clocked measuring mode and renewed synchronization with the fieldbus cycle. The slowest channel provides the "internal" measuring cycle.

STATUS output parameter

The module ignores errors that occur during the transfer of parameters with the "WRREC" instruction and continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The description of the "WRREC" instruction and the error codes is available in the STEP 7 online help.

Structure of data record 128 for entire module

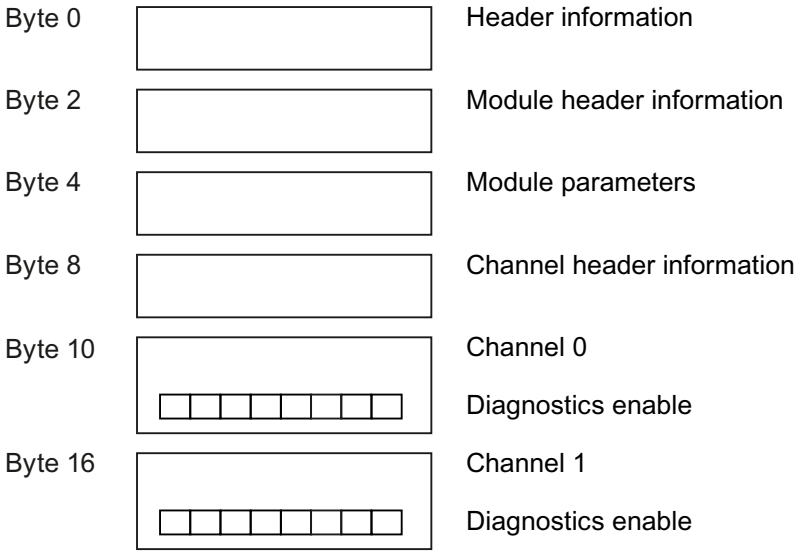

Figure 2-994 Structure of data record 128 for entire module

Header information

The figure below shows the structure of the header information.

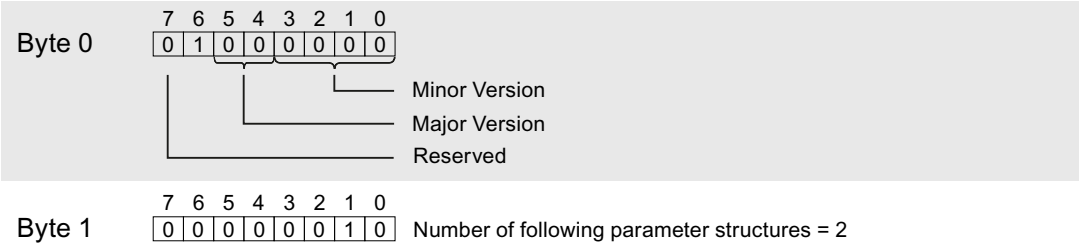

Figure 2-995 Header information

Module header information

The figure below shows the structure of the module header information.

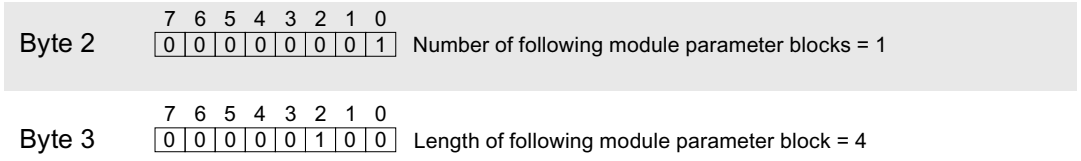

Figure 2-996 Module header information

Module parameter block

The figure below shows the structure of the module parameter block for channels 0 and 1.

Enable a parameter by setting the corresponding bit to "1".

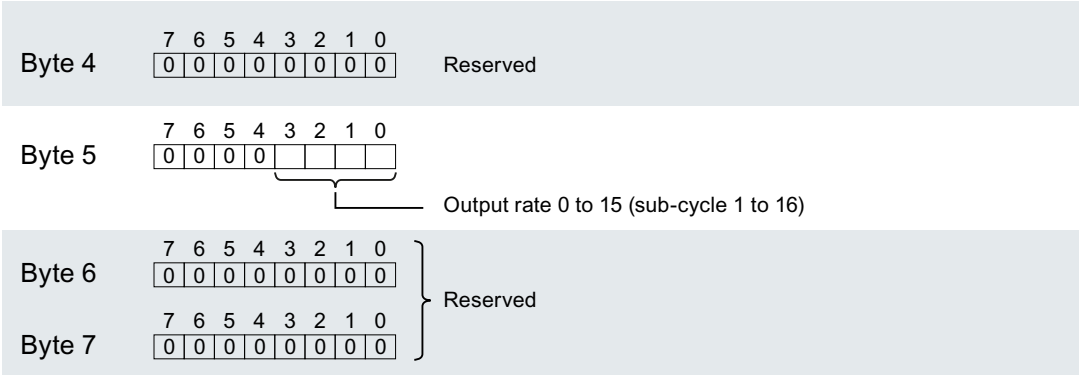

Figure 2-997 Module parameter block

Channel header information

The figure below shows the structure of the channel header information.

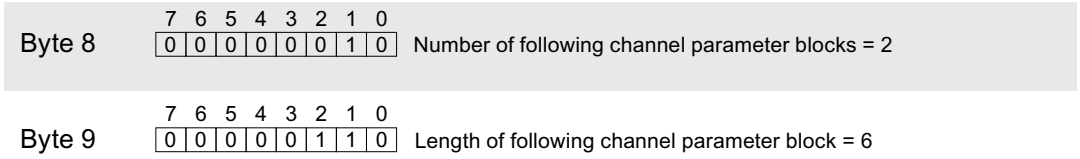

Figure 2-998 Channel header information

Channel parameter block

The figure below shows the structure of the channel parameter block.

Enable a parameter by setting the corresponding bit to "1".

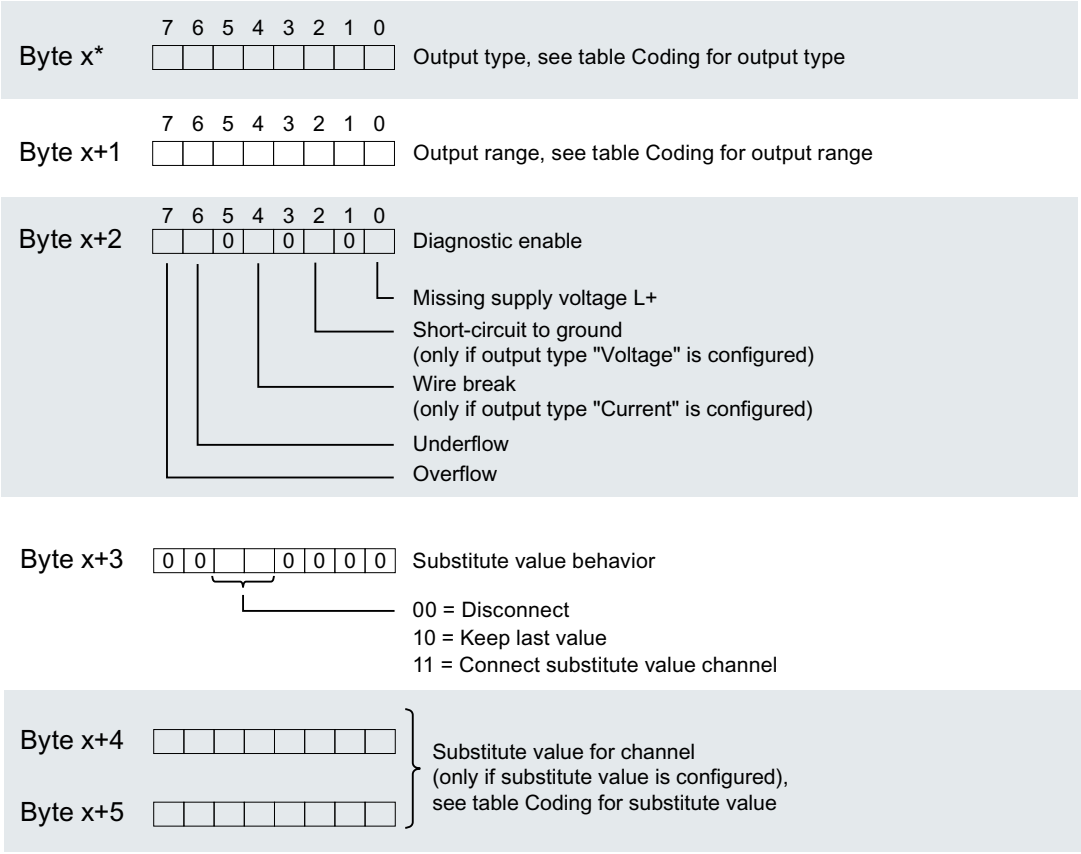

* x = 10 + (channel number × 6); channel number = 0 to 1

Figure 2-999 Structure of byte x to x+5 for channels 0 and 1

Codes for output types

The table below contains the codes for the output types of the analog output module. You must enter these codes in bytes x of the channel parameter block of data record 128 (see previous figure).

Table 2-1078 Codes for output types

Output type	Code
Deactivated	0000 0000
Voltage	0000 0001
Current	0000 0011

Codes for output ranges

The table below contains the codes for the output ranges of the analog output module. You must enter these codes in bytes x+1 of the channel parameter block of data record 128 (see previous figure).

Table 2-1079 Codes for output ranges

Output range	Code
Voltage	
±10 V	0000 0000
±5 V	0000 0001
0 to 10 V	0000 0010
1 to 5 V	0000 0011
Current	
±20 mA	0000 0000
0 to 20 mA	0000 0001
4 to 20 mA	0000 0010

Codes for substitute values

The table below contains the codes for the substitute values. You must enter these codes in bytes x+4 and x+5 (see previous figure).

Table 2-1080 Codes for substitute values

Output range for	Permitted substitute value
Voltage	
±10 V	-32512 ... +32511
±5 V	-32512 ... +32511
0 to 10 V	0 ... +32511
1 to 5 V	-6912 ... +32511
Current	
±20 mA	-29031 ... +29030
0 to 20 mA	0 ... +29030
4 to 20 mA	-692 ... +29030

Representation of analog values

B

This appendix describes the analog values for all output ranges supported by the AQ 2xU/I HS analog output module.

Measured value resolution

The digitized analog value is the same for input and output values at the same nominal range. The analog values are represented as a fixed point number in the two's complement.

The following table shows the representation of the binary analog values and the associated decimal and hexadecimal units of the analog values.

The resolutions 13, 14, 15, and 16 bit including sign are displayed. Each analog value is entered in the ACCU left-justified. The bits marked with "x" are set to "0".

Table 2-1081 Possible resolutions of the analog values

Resolution in bit	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
13	8	8_H	Sign 0 0 0 0 0 0 0	0 0 0 0 1 x x x
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of output ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar range output ranges. The resolution is 16 bits.

Table 2-1082 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
≥32512	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	

Dec. value	Output value in %	Data word																Range
-27649	100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
≤ -32513	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value

Table 2-1083 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥32512	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
≤ 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value

B.2 Representation of analog values in the voltage output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible voltage output ranges.

Table 2-1084 Voltage output ranges ±10 V and ±5 V

Values			Voltage output range		Range
	Dec.	Hex.	±10 V	±5 V	
118.515%	32767	7FFF	11.76 V	5.88 V	Overflow*
	32512	7F00			
117.589%	32511	7EFF	11.76 V	5.88 V	Overrange
	27649	6C01			
100%	27648	6C00	10 V	5 V	Nominal range
75%	20736	5100	7.5 V	3.75 V	
0.003617%	1	1	361.7 µV	180.8 µV	
0%	0	0	0 V	0 V	
	-1	FFFF	-361.7 µV	-180.8 µV	
-75%	-20736	AF00	-7.5 V	-3.75 V	
-100%	-27648	9400	-10 V	-5 V	
	-27649	93FF			Underrange

* Outputs positive maximum value or negative minimum value

Values			Voltage output range		Range
-117.593%	-32512	8100	-11.76 V	-5.88 V	Underrange
	-32513	80FF	-11.76	-5.88 V	Underflow*
-118.519%	-32768	8000			

* Outputs positive maximum value or negative minimum value

Table 2-1085 Voltage output range 0 V to 10 V

Values			Voltage output range	Range
	Dec.	**Hex.**	**0 to 10 V**	
118.515%	32767	7FFF	11.76 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	11.76 V	Overrange
	27649	6C01		
100%	27648	6C00	10 V	Nominal range
75%	20736	5100	7.5 V	
0.003617%	1	1	361.7 µV	
0%	0	0	0 V	
	-1	FFFF	0 V	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

Table 2-1086 Voltage output range 1 V to 5 V

Values			Voltage output range	Range
	Dec.	**Hex.**	**1 to 5 V**	
118.515%	32767	7FFF	5.70 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	5.70 V	Overrange
	27649	6C01		
100%	27648	6C00	5 V	Nominal range
75%	20736	5100	4 V	
0.003617%	1	1	1 V + 144.7 µV	
0%	0	0	1 V	
	-1	FFFF	1 V - 144.7 µV	Underrange
-25%	-6912	E500	0 V	
	-6913	E4FF	0 V	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

B.3 Representation of analog values in the current output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible current output ranges.

Table 2-1087 Current output range ±20 mA

Values			Current output range	Range
	Dec.	Hex.	±20 mA	
118.515%	32767	7FFF	21 mA	Overflow*
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	-723.4 nA	
-75%	-20736	AF00	-15 mA	
-100%	-27648	9400	-20 mA	
	-27649	93FF	-20 mA - 723.4nA	Underrange
-105%	-29031	8E99	-21 mA	
	-29032	8E98	-21 mA	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

Table 2-1088 Current output range 0 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	0 to 20 mA	
118.515%	32767	7FFF	21 mA	Overflow*
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	0 mA	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

Table 2-1089 Current output ranges 4 to 20 mA

Values			Current output range	Range
	Dec.	**Hex.**	**4 to 20 mA**	
118.515%	32767	7FFF	21 mA	Overflow*
	29377	72C1		
106.25%	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100%	27648	6C00	20 mA	Nominal range
75%	19008	4A40	16 mA	
0.003617%	1	1	4 mA + 578.7 nA	
0%	0	0	4 mA	
	-1	FFFF	3.9995 mA	Underrange
-2.5%	-692	FD4C	3.6 mA	
	-693	FD4B	3.6 mA	Underflow*
-118.519%	-32768	8000		

* Outputs positive maximum value or negative minimum value

SIEMENS

SIMATIC

ET 200SP
Analog output module AQ 2xU/I HF (6ES7135-6HB00-0CA1)

Equipment Manual

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Industrial cybersecurity 2

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Introduction

1

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (https://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Compared to the previous version, this manual contains the following change:

- Wiring and block diagrams have been revised.
- The technical specifications have been updated.

Conventions

CPU: When the term "CPU" is used in the following, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
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Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

3

3.1 Properties

Article number

6ES7135-6HB00-0CA1

View of the module

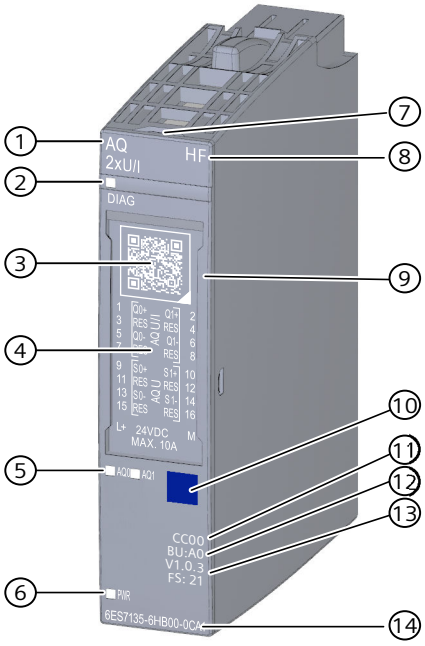

① Module type and designation
② LED for diagnostics
③ QR code for identification link
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Slot for optional equipment labeling plate
⑧ Function class
⑨ Insertion option for optional labeling strip
⑩ Color coding module type
⑪ Color code for selecting the color-coded labels
⑫ BU type
⑬ Firmware and function version
⑭ Article number

Figure 2-1000 View of the module AQ 2×U/I HF

Properties

The module has the following technical properties:

- Analog output module with 2 outputs
- Resolution: Up to 16 bits including sign
- Voltage output can be set for each channel
- Current output can be set for each channel
- Configurable diagnostics for each channel

The module supports the following functions:

- Firmware update
- I&M identification data
- Reconfiguration in RUN
- PROFIenergy
- Calibration in runtime
- Isochronous mode (PROFINET IO only)
- Value status (PROFINET IO only)

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connection

See also

For more information on accessories, refer to the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Wiring

4

4.1 Wiring diagram

This section shows the wiring diagram of the AQ 2xU/I HF module with the terminal assignments.

You can find information on wiring the BaseUnit in the System Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

NOTE

The load group of the module must begin with a light-colored BaseUnit. Keep this in mind also during the configuration.

Pin assignment

The following table shows an example of the pin assignment of the analog output module AQ 2xU/I HF on the BaseUnit BU type A0/A1:

Description	Signal	Terminal	BaseUnit BU type A0/A1	Terminal	Signal	Description
Analog output voltage/current positive, channel 0	Q_0+	1	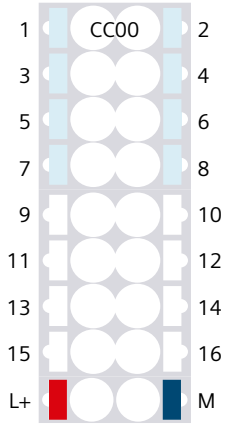	2	Q_1+	Analog output voltage/current positive, channel 1
-	RES[1)]	3		4	RES[1)]	-
Analog output voltage/current negative, channel 0	Q_0-	5		6	Q_1-	Analog output voltage/current negative, channel 1
-	RES[1)]	7		8	RES[1)]	-
Analog output sensor cable positive, channel 0	S_0+	9		10	S_1+	Analog output sensor cable positive, channel
-	RES[1)]	11		12	RES[1)]	-
Analog output sensor cable negative, channel 0	S_0-	13		14	S_1-	Analog output sensor cable negative, channel 1
-	RES[1)]	15		16	RES[1)]	-
24 V DC supply voltage[2)]	L+	L+		M	M	Ground

1) Reserve, must remain unused for future function extensions

2) Infeed only with light-colored BaseUnit

Connection types

2-wire connection for voltage output/current output	3-wire connection for voltage output	4-wire connection for voltage output
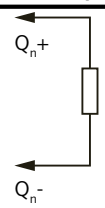	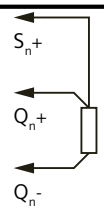	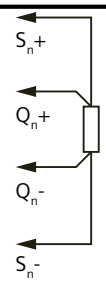

The 3-wire connection and 4-wire connection make compensation for line impedance possible. The compensation is not possible for 2-wire connections due to the missing sensor cable. Select the 4-wire connection for optimum compensation.

4.2 Block diagram

This section contains the block diagram of the AQ 2×U/I HF analog output module.

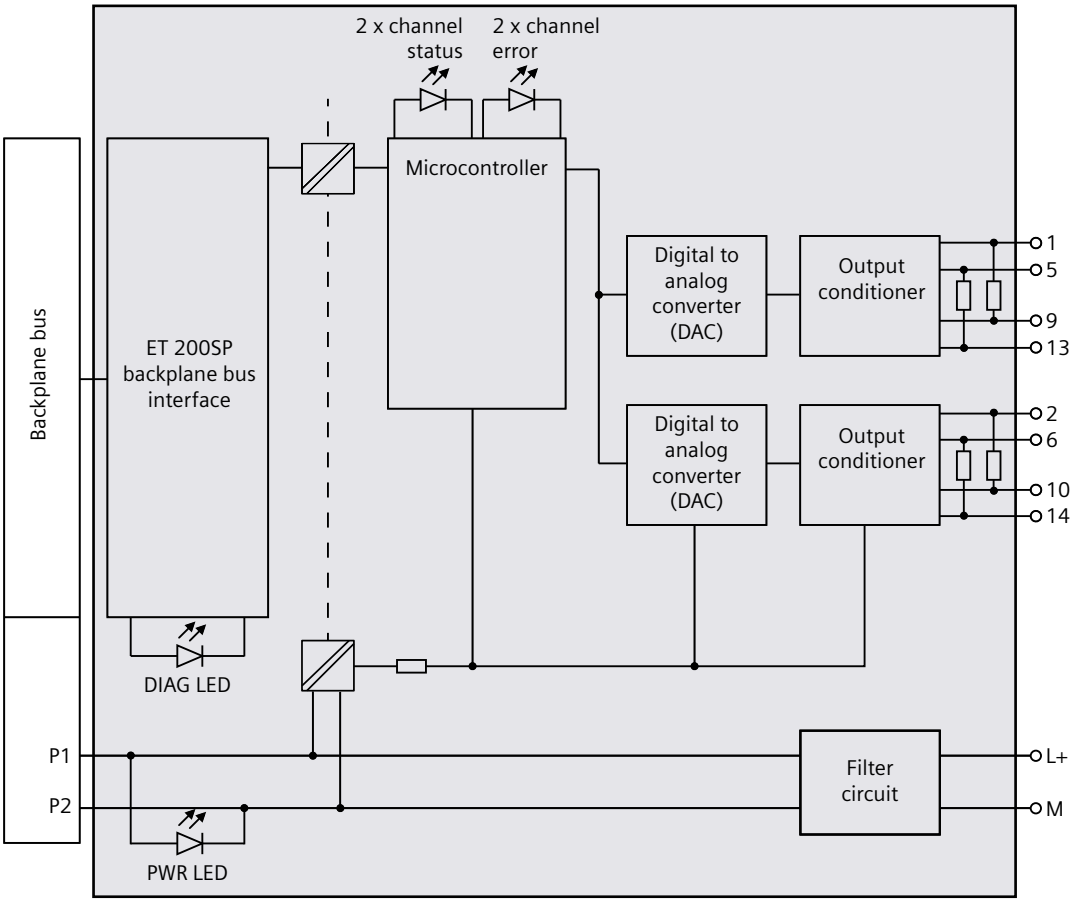

Figure 2-1001 Block diagram analog output module AQ 2×U/I HF

Parameters/address space

5

5.1 Output type and output ranges

The following table shows the output type and the respective output ranges.

Table 2-1090 Output ranges

Output type	Output ranges	Resolution
Current	± 20 mA 0 to 20 mA 4 to 20 mA	16 bit including sign 15 bit 14 bit
Voltage	± 10 V ± 5 V 0 to 10 V 1 to 5 V	16 bit including sign 15 bit including sign 15 bit 13 bit

You can find the tables of output ranges and overflow, overload, etc. in the section Representation of analog values (Page 33) and in the function manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094).

5.2 Parameters

Parameters of the AQ 2xU/I HF

The following table lists the configurable parameters. The effective range of the configurable parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the WRREC instruction to transfer the parameters to the module by means of data records; refer to the section Parameter assignment and structure of parameter data record (Page 29).

The following parameter settings are possible:

Table 2-1091 Configurable parameters and their defaults (GSD file)

Parameter	Value range	Default	Reconfiguration in RUN	Scope with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP [3]
Diagnostics: Missing supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Short-circuit to ground [1]	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Overflow [3]	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Underflow [3]	• Disable • Enable	Disable	Yes	Channel	Channel
Diagnostics: Wire break [2]	• Disable • Enable	Disable	Yes	Channel	Channel
Output type/range	• Deactivated • Voltage ±10 V • Voltage ±5 V • Voltage 0..10 V • Voltage 1..5 V • Current ±20 mA • Current 0 - 20 mA • Current 4 - 20 mA	Current 4 - 20 mA	Yes	Channel	Channel
Reaction to CPU STOP [3]	• Turn off • Keep last value • Output substitute value	Turn off	Yes	Channel	Module
Substitute value	For permissible substitute values for the various measuring ranges, see device manual AQ 2xU/I HF, Substitute values → Codes for substitute value table	0	Yes	Channel	Channel
Potential group	• Use potential group of the left module (module plugged into a dark-colored BaseUnit) • Enable new potential group (module plugged into light-colored BaseUnit)	Use potential group of the left module	No	Module	Module

[1] No diagnostics detection between -0.5 and +0.5 V (no short-circuit detection)

[2] No diagnostics detection between -3 and +3 mA (no wire break detection)

[3] Due to the limited number of parameters at a maximum of 244 bytes per ET 200SP station with a PROFIBUS GSD configuration, the configuration options are restricted. If required, you can still assign these parameters using data record 128 as described in the "GSD file PROFINET IO" column (see table above). The parameter length of the I/O module is 8 bytes.

NOTE
Unused channels
"Deactivate" the unused outputs in the parameter assignment.
A deactivated output always returns the value "no current or voltage".

5.3 Explanation of parameters

Diagnostics: Missing supply voltage L+

Enabling of the diagnostics for missing or insufficient supply voltage L+.

Diagnostics: Short-circuit

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Diagnostics: Overflow

Enabling of the diagnostics when the output value exceeds the overrange.

Diagnostics: Underflow

Enabling of the diagnostics when the output value falls below the underrange or reaches the minimum output value or underflow.

Diagnostics: Wire break

Enabling of the diagnostics if the line to the actuator is broken.

Substitute value

The substitute value is the value that the module outputs in case of a CPU STOP.

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station, which are supplied via a common supply voltage.

A potential group begins with a light-colored BaseUnit through which the required voltage is supplied for all modules of the potential group. The light-colored BaseUnit interrupts the three self-assembling voltage buses P1, P2, and AUX to the left neighbor.

Specify the slot in which a light-colored BaseUnit with supply voltage infeed or a dark-colored BaseUnit is to be located (see ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual).

All additional I/O modules of this potential group are plugged into dark-colored BaseUnits. You take the potential of the self-assembling voltage buses P1, P2 and AUX from the left neighbor.

A potential group ends with the dark-colored BaseUnit, which follows a light-colored BaseUnit or server module in the station configuration.

5.4 Address space

Address space of the analog output module AQ 2×U/I HF

The following figure shows the assignment of the address space for the AQ 2xU/I HF with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

Assignment in the process image output (PIQ)

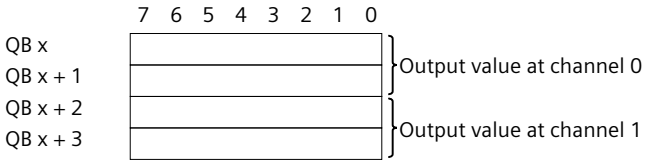

Assignment in the process image input (PII)

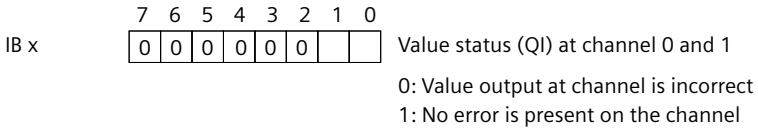

Figure 2-1002 Address space of the analog output module AQ 2×U/I HF

Configuration options of the AQ 2xU/I HF

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

An additional byte is occupied in the input address space if you enable the value status for the analog module. Bits 0 to 1 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: No fault is present on the channel.

Bit = 0: The wiring, the value created on the channel, or similar is incorrect.

Interrupts/diagnostics alarms

6

6.1 Status and error displays

LED displays

The figure below shows the LED displays of the AQ 2xU/I HF.

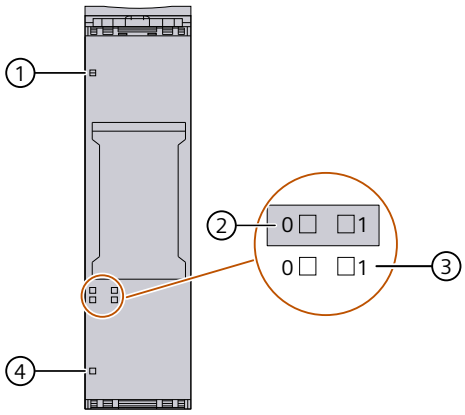

① DIAG (green/red)

② Channel status (green)

③ Channel error (red)

④ PWR (green)

Figure 2-1003 LED display

Meaning of the LED displays

The following tables contain the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostics alarms (Page 22).

LED DIAG

Table 2-1092 Error display of the DIAG LED

LED DIAG	Meaning
☐ Off	Backplane bus supply of the system is disrupted or switched off.
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-1093 Status display of the channel status LED

Channel status	Channel error	Meaning
☐ Off	☐ Off	Channel deactivated or load voltage L+ missing
■ On	☐ Off	Channel activated and no channel diagnostics
☐ Off	■ On	Channel activated and channel diagnostics
■ On	■ On	Not permitted (error)

PWR LED

Table 2-1094 Status display of the PWR LED

PWR LED	Meaning
☐ Off	Supply voltage L+ missing
■ On	Supply voltage L+ present

6.2 Interrupts

The analog output module AQ 2×U/I HF supports diagnostic error interrupts.

Diagnostic error interrupt

The module generates a diagnostic error interrupt at the following events:

- Channel temporarily unavailable
- Short-circuit
- Overtemperature
- Wire break
- Violation of high limit
- Violation of low limit
- Error
- Parameter assignment error
- Load voltage missing

You can obtain detailed information on the event in the hardware interrupt organization block with the "RALARM" (read additional interrupt information) instruction and in the STEP 7 online help.

6.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is output and the DIAG LED flashes on the module for each diagnostics event. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-1095 Diagnostics alarms, their meaning and remedies

Diagnostics alarm	Error code	Meaning	Remedy
Channel temporarily unavailable	$1F_H$	Firmware update is being performed. Channel 0 applies to the entire module. The module is currently not performing any measurements.	–
		The channel is currently being calibrated.	
Short-circuit	1_H	Short-circuit of the actuator supply	Correct the process wiring
Overtemperature	4_H	Thermal overload of the I/O module	Correct the process wiring
Wire break	6_H	Actuator circuit resistance too high	Use a different actuator type or change the wiring, for example, use cables with larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Deactivate the channel ("Measurement type" parameter) • Connect the channel

Diagnostics alarm	Error code	Meaning	Remedy
Violation of high limit	7_H	The output value specified by the user program exceeds the overrange.	Correct the output value
Violation of low limit	8_H	The output value specified by the user program falls below the underrange.	Correct the output value
Error	9_H	Internal module error has occurred (diagnostics alarm on channel 0 applies to the entire module).	Replace module
Parameter assignment error	10_H	The module cannot evaluate parameters for the channel: Module plugged in does not match the configuration. Incorrect parameter assignment.	• Correct the configuration (comparison of preset and actual setup). • Correct the parameter assignment (diagnostics wire break set only with the permitted measuring ranges).
Load voltage missing	11_H	Missing or insufficient supply voltage L+	• Check the supply voltage L+ at the BaseUnit • Check BaseUnit type

Technical specifications 7

Technical specifications of AQ 2×U/I HF

The following table lists the technical specifications on the issue date. You will find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/de/pv/6ES7135-6HB00-0CA1/td?dl=en).

Article number	6ES7135-6HB00-0CA1
General information	
Product type designation	AQ 2xU/I HF
HW functional status	from FS21
Firmware version	V1.0.3
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V13 / V13
• STEP 7 configurable/integrated from version	V5.5 SP3 / -
• PCS 7 configurable/integrated from version	V8.1 SP1
• PROFIBUS from GSD version/GSD revision	GSD Revision 5
• PROFINET from GSD version/GSD revision	GSDML V2.3
Operating mode	
• Oversampling	No
• MSO	No
CiR - Configuration in RUN	
Reparameterization possible in RUN	No
Calibration possible in RUN	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes

Article number	6ES7135-6HB00-0CA1
Input current	
Current consumption (rated value)	45 mA; without load
Current consumption, max.	90 mA; 2 channels current output 20 mA
Power loss	
Power loss, typ.	0.9 W
Address area	
Address space per module	
• Address space per module, max.	4 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	Type A
Analog outputs	
Number of analog outputs	2
Voltage output, short-circuit protection	Yes
Voltage output, short-circuit current, max.	45 mA
Cycle time (all channels), min.	750 µs
Output ranges, voltage	
• 0 to 10 V	Yes; 15 bit
• 1 V to 5 V	Yes; 13 bit
• -5 V to +5 V	Yes; 15 bit incl. sign
• -10 V to +10 V	Yes; 16 bit incl. sign
Output ranges, current	
• 0 to 20 mA	Yes; 15 bit
• -20 mA to +20 mA	Yes; 16 bit incl. sign
• 4 mA to 20 mA	Yes; 14 bit
Connection of actuators	
• for voltage output two-wire connection	Yes
• for voltage output four-wire connection	Yes
• for current output two-wire connection	Yes
Load impedance (in rated range of output)	
• with voltage outputs, min.	2 kΩ
• with voltage outputs, capacitive load, max.	1 µF
• with current outputs, max.	500 Ω
• with current outputs, inductive load, max.	1 mH
Destruction limits against externally applied voltages and currents	
• Voltages at the outputs	30 V
Cable length	
• shielded, max.	1 000 m; 200 m for voltage output

Article number	6ES7135-6HB00-0CA1
Analog value generation for the outputs	
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
Settling time	
• for resistive load	0.05 ms
• for capacitive load	0.05 ms; Max. 47 nF and 20 m cable length
• for inductive load	0.05 ms
Errors/accuracies	
Output ripple (relative to output range, bandwidth 0 to 50 kHz), (+/-)	0.02 %
Linearity error (relative to output range), (+/-)	0.03 %
Temperature error (relative to output range), (+/-)	0.003 %/K
Crosstalk between the outputs, max.	-50 dB
Repeat accuracy in steady state at 25 °C (relative to output range), (+/-)	0.03 %
Operational error limit in overall temperature range	
• Voltage, relative to output range, (+/-)	0.2 %
• Current, relative to output range, (+/-)	0.2 %
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to output range, (+/-)	0.1 %
• Current, relative to output range, (+/-)	0.1 %
Isochronous mode	
Execution and activation time (TCO), min.	500 µs
Bus cycle time (TDP), min.	750 µs
Jitter, max.	5 µs
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; channel-by-channel, only for output type "current"
• Short-circuit	Yes; channel-by-channel, only for output type "voltage"
• Group error	Yes
• Overflow/underflow	Yes; channel by channel

Article number	6ES7135-6HB00-0CA1
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; < 0 °C as of FS04
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; < 0 °C as of FS04
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP System Manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFINET.

Measurement type	Measuring range	Diagnostics				
		Underflow	Overflow	Wire break	Short-circuit to ground	Missing supply voltage L+
Deactivated	*	*	*	*	*	*
Voltage	±10 V	x	x	–	x	x
	±5 V	x	x	–	x	x
	0 to 10 V	x	x	–	x	x
	1 to 5 V	x	x	–	x	x
Current	±20 mA	x	x	x	–	x
	0 to 20 mA	x	x	x	–	x
	4 to 20 mA	x	x	x	–	x

x = property is allowed, – = property is **not allowed**, * = property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the measurement type and measuring range for PROFIBUS.

Measurement type	Measuring range	Diagnostics			
		Underflow / overflow	Wire break	Load voltage L+	Short-circuit to ground
Deactivated	*	*	*	*	*
Voltage	±10 V	x	–	x	x
	±5 V	x	–	x	x
	0 to 10 V	x	–	x	x
	1 to 5 V	x	–	x	x

x = property is allowed, – = property is **not allowed**, * = property is not relevant

Measurement type	Measuring range	Diagnostics			
		Underflow / overflow	Wire break	Load voltage L+	Short-circuit to ground
Current	±20 mA	x	x	x	–
Current (2-wire connection)	0 to 20 mA	x	x	x	–
	4 to 20 mA	x	x	x	–

x = property is allowed, – = property is **not allowed**, * = property is not relevant

A.2 Parameter assignment and structure of parameter data record

The data records of the module have an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO.

Parameter assignment in the user program

The module parameter settings can be changed in RUN (for example, the voltage or current values of selected channels can be edited in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set with STEP 7 will not be changed on the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. However, the STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

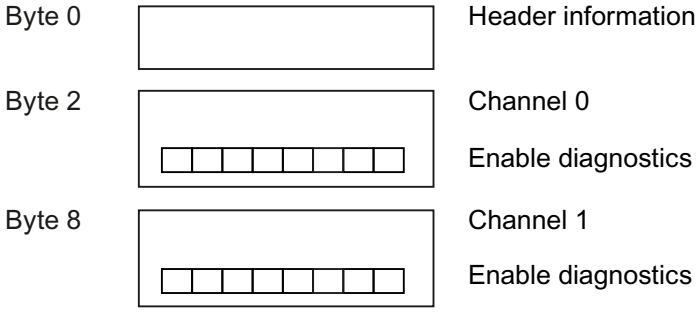

Figure 2-1004 Structure of data record 128

Header information

The figure below shows the structure of the header information.

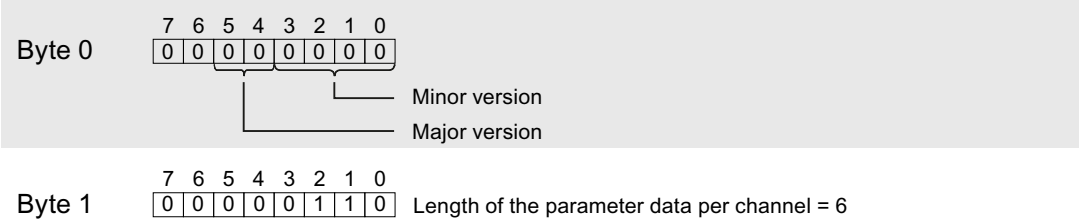

Figure 2-1005 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 1.

You can activate a parameter by setting the corresponding bit to "1".

* x = 2 + (channel number x 6); channel number = 0 to 1

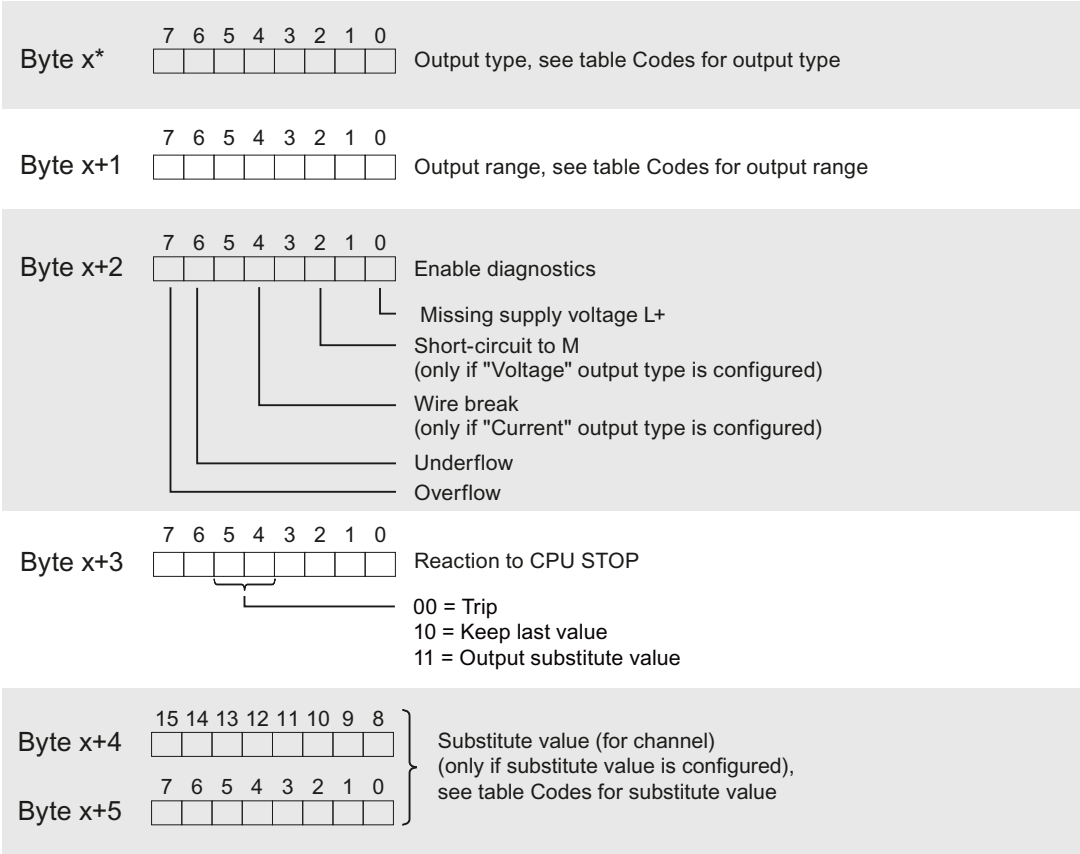

Figure 2-1006 Structure of byte x to x+5 for channel 0 and 1

Codes for output type

The following table contains the codes for the output types of the analog output module. You must enter these codes in byte x (see previous figure).

Table 2-1096 Codes for output type

Output range for voltage	Code
Deactivated	0000 0000
Voltage	0000 0001
Current	0000 0011

Codes for output range

The following table contains the codes for the output ranges of the analog output module. You must enter these codes in byte x+1 (see previous figure).

Table 2-1097 Codes for output range

Output range for voltage	Code
±10 V ±5 V 0 to 10 V 1 to 5 V	0000 0000 0000 0001 0000 0010 0000 0011
Output range for current	**Code**
±20 mA 0 to 20 mA 4 to 20 mA	0000 0000 0000 0001 0000 0010

Codes for substitute value

The following table contains the codes for the substitute values. You must enter these codes in bytes x+4 and x+5 (see previous figure).

Table 2-1098 Codes for substitute value

Output range for voltage and current	Valid substitute value
±10 V ±5 V 0 to 10 V 1 to 5 V	-32512 to 32511 -32512 to 32511 0 to 32511 -6912 to 32511
±20 mA 0 to 20 mA 4 to 20 mA	-29031 to 29030 0 to 29030 -692 to 29376

Representation of analog values

B

This appendix describes the analog values for all output ranges supported by the AQ 2xU/I HF analog module.

Measured value resolution

The digitized analog value is the same for all output values at the same nominal range. The analog values are represented as a fixed point number in the two's complement.

The resolutions 13, 14, 15, and 16 bit including sign are displayed. Each analog value is entered in the ACCU left-justified. The bits marked with "x" are set to "0".

Table 2-1099 Possible resolutions of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
13	8	8_H	Sign 0 0 0 0 0 0 0	0 0 0 0 1 x x x
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of output ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar range output ranges. The resolution is 16 bits.

Table 2-1100 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
≥32512	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
≤ -32513	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value

Table 2-1101 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥32512	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
≤ 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value

B.2 Representation of analog values in the voltage output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible voltage output ranges.

Table 2-1102 Voltage output ranges ±10 V and ±5 V

Values			Voltage output range		Range
	Dec.	**Hex.**	**±10 V**	**±5 V**	
118.515%	32767	7FFF	11.76 V	5.88 V	Overflow*
	32512	7F00			
117.589%	32511	7EFF	11.76 V	5.88 V	Overrange
	27649	6C01			
100%	27648	6C00	10 V	5 V	Nominal range
75%	20736	5100	7.5 V	3.75 V	
0.003617%	1	1	361.7 µV	180.8 µV	
0%	0	0	0 V	0 V	
	-1	FFFF	-361.7 µV	-180.8 µV	
-75%	-20736	AF00	-7.5 V	-3.75 V	
-100%	-27648	9400	-10 V	-5 V	
	-27649	93FF			Underrange
-117.593%	-32512	8100	-11.76 V	-5.88 V	
	-32513	80FF	-11.76	-5.88 V	Underflow*
-118.519%	-32768	8000			

* outputs positive maximum value or negative minimum value

Table 2-1103 Voltage output range 0 V to 10 V

Values			Voltage output range	Range
	Dec.	**Hex.**	**0 to 10 V**	
118.519%	32767	7FFF	11.76 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	11.76 V	Overrange
	27649	6C01		
100%	27648	6C00	10 V	Nominal range
75%	20736	5100	7.5 V	
0.003617%	1	1	361.7 µV	
0%	0	0	0 V	
	-1	FFFF	0 V	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

Table 2-1104 Voltage output range 1 V to 5 V

Values			Voltage output range	Range
	Dec.	**Hex.**	**1 to 5 V**	
118.519%	32767	7FFF	5.70 V	Overflow*
	32512	7F00		
117.589%	32511	7EFF	5.70 V	Overrange
	27649	6C01		
100%	27648	6C00	5 V	Nominal range
75%	20736	5100	4 V	
0.003617%	1	1	1 V + 144.7 µV	
0%	0	0	1 V	
	-1	FFFF	1 V - 144.7 µV	Underrange
-25%	-6912	E500	0 V	
	-6913	E4FF	0 V	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

B.3 Representation of analog values in the current output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible current output ranges.

Table 2-1105 Current output range ±20 mA

Values			Current output range	Range
	Dec.	**Hex.**	**±20 mA**	
118.5149%	32767	7FFF	21 mA	Overflow*
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	-723.4 nA	
-75%	-20736	AF00	-15 mA	
-100%	-27648	9400	-20 mA	
	-27649	93FF	-20 mA + 723.4 nA	Underrange
-105%	-29031	8E99	-21 mA	
	-29032	8E98	-21 mA	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

Table 2-1106 Current output range 0 to 20 mA

Values			Current output range	Range
	Dec.	**Hex.**	**0 to 20 mA**	
118.5149%	32767	7FFF	21 mA	Overflow*
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	0 mA	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

Table 2-1107 Current output ranges 4 to 20 mA

Values			Current output range	Range
	Dec.	**Hex.**	**4 to 20 mA**	
118.5149%	32767	7FFF	21 mA	Overflow*
	29377	72C1		
106.25%	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100%	27648	6C00	20 mA	Nominal range
75%	19008	4A40	16 mA	
0.003617%	1	1	4 mA + 578.7 nA	
0%	0	0	4 mA	
	-1	FFFF	3.9995 mA	Underrange
-2.5%	-692	FD4C	3.6 mA	
	-693	FD4B	3.6 mA	Underflow*
-118.519%	-32768	8000		

* outputs positive maximum value or negative minimum value

SIEMENS

SIMATIC

ET 200SP
Analog Output Module AQ 4xU/I ST (6ES7135-6HD00-0BA1)

Equipment Manual

Documentation guide 1

Product overview 2

Wiring up 3

Parameters/address space 4

Interrupts/diagnostics alarms 5

Technical specifications 6

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Representation of analog values B

03/2016
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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Changes compared to previous version

Changes described in this manual, compared to the edition 07/2014:

- 3-wire connection for voltage output
- Derating trends for current output for modules as of hardware version FS 06.

Conventions

CPU: When the term "CPU" is used in this manual, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the distributed I/O system ET 200SP.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

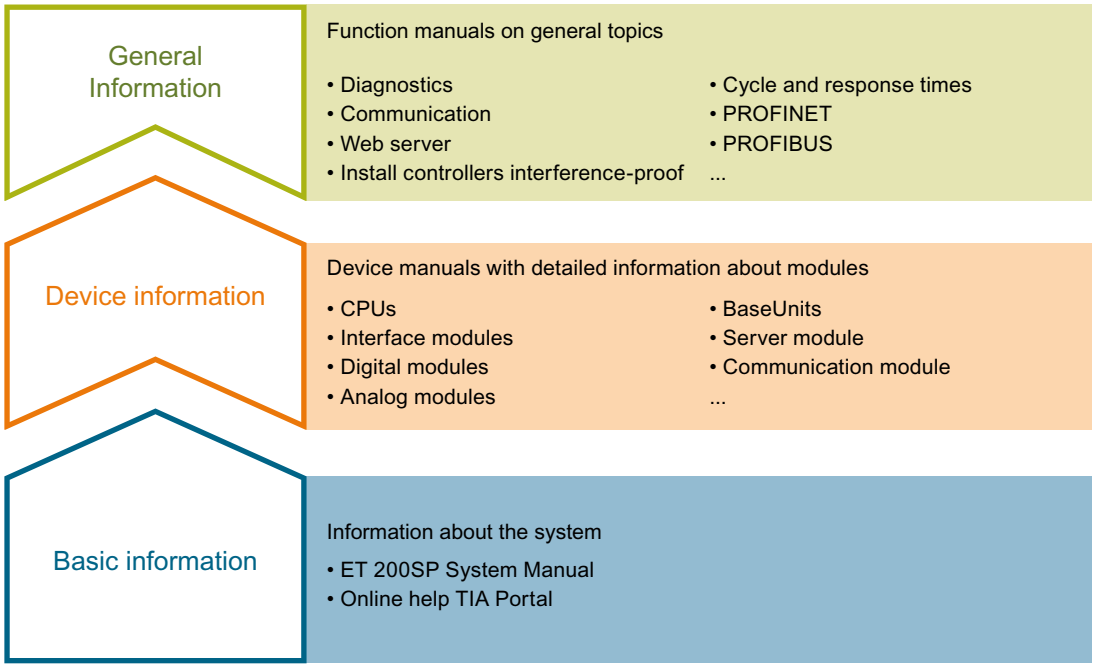

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

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In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

Product overview

2

2.1 Properties

Article number

6ES7135-6HD00-0BA1

View of the module

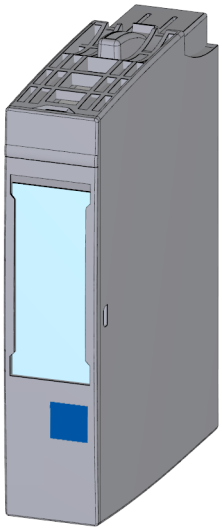

Figure 2-1007 View of the module AQ 4×U/I ST

Properties

The module has the following technical properties:

- Analog output module with 4 outputs
  - For current output and
  - voltage output
- Output range for current output:
  - ±20 mA, resolution 16 bits including sign
  - 0 to 20 mA, resolution 15 bits
  - 4 to 20 mA, resolution 14 bits

- Output range for voltage output:
  - ±10 V, resolution 16 bits including sign
  - ±5 V, resolution 15 bits including sign
  - 0 to 10 V, resolution 15 bits
  - 1 to 5 V, resolution 13 bits
- Electrically isolated from supply voltage L+
- Configurable diagnostics per module

The module supports the following functions:

- Firmware update
- I&M identification data
- Configuration in RUN
- PROFIenergy

Table 2-1108 Version dependencies of other module functions

Function	Product version of the module as of	Firmware version of the module as of
Value status	1	V1.1.0

You can configure the module with STEP 7 (TIA Portal) and with a GSD file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You will find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Wiring up

3

3.1 Terminal assignment

General terminal assignment

Table 2-1109 Terminal assignment

Terminal assignment for AQ 4×U/I ST (6ES7135-6HD00-0BA1)						
Terminal	**Assign-ment**	**Terminal**	**Assignment**	**Explanation**	**BaseUnit**[1]	**Color identification label**
1	Q_0+	**2**	Q_1+	• Q_n+: Analog output voltage/current (positive), channel n • Q_n-: Analog output voltage/current (negative), channel n • S_n+: Sensor line positive, channel n • S_n-: Sensor line negative, channel n	A0 A1	---
3	Q_2+	**4**	Q_3+			
5	Q_0-	**6**	Q_1-			
7	Q_2-	**8**	Q_3-			
9	S_0+	**10**	S_1+			
11	S_2+	**12**	S_3+			
13	S_0-	**14**	S_1-			
15	S_2-	**16**	S_3-			
L+	24 VDC	**M**	M			
Voltage 2-wire connection 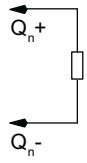		Voltage 3-wire connection 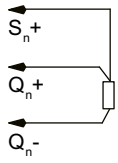		Voltage 4-wire connection 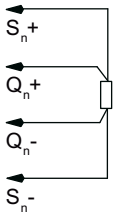		Current 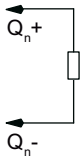

[1] Usable BaseUnit types, can be identified by the last two digits of the article number.

NOTE

The first BaseUnit of a station must be a light-colored BaseUnit. Also keep this in mind during the configuration.

You will find additional information on the BaseUnit types in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.2 Schematic circuit diagram

Schematic circuit diagram

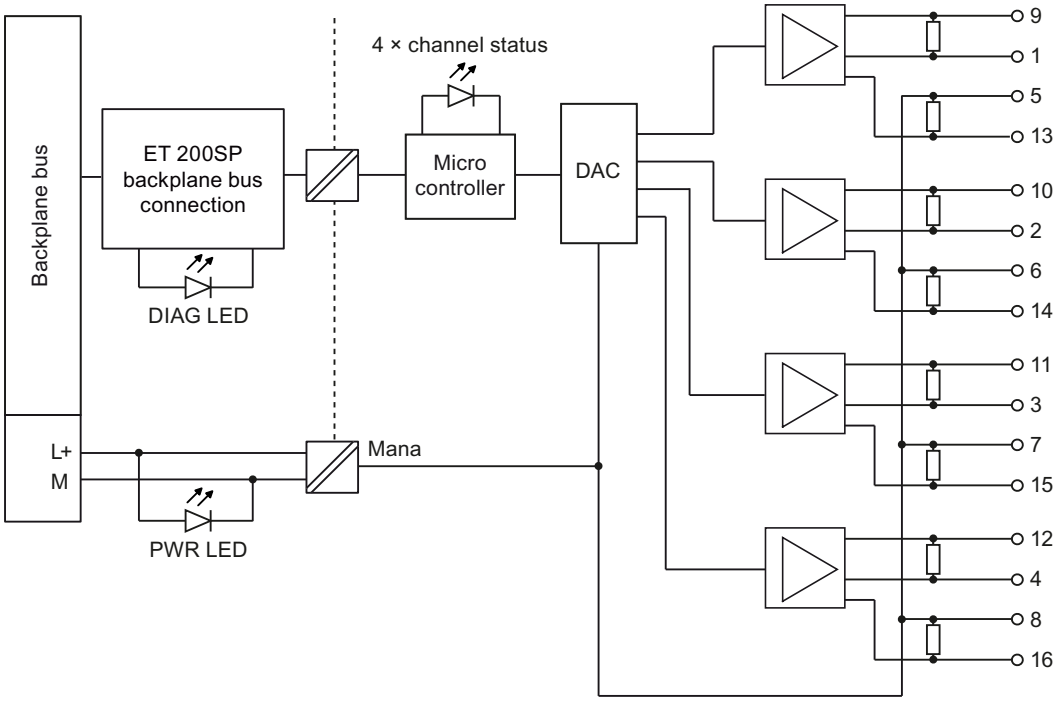

Figure 2-1008 Schematic circuit diagram for AQ 4×U/I ST

Parameters/address space

4

4.1 Output ranges

The analog output module AQ 4×U/I ST has the following measuring ranges:

Table 2-1110 Output ranges

Output type	Output ranges	Resolution
Current	± 20 mA 0 to 20 mA 4 to 20 mA	16 bits including sign 15 bits 14 bits
Voltage	±10 V ±5 V 0 to 10 V 1 to 5 V	16 bits including sign 15 bits including sign 15 bits 13 bits

The tables of the output ranges, overflow, overrange, etc. can be found in section Representation of analog values (Page 30).

4.2 Parameters

Parameters of the AQ 4xU/I ST

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Central operation with an S7-1500 CPU
- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

When assigning parameters in the user program, use the "WRREC" instruction to transfer the parameters to the module using the data records; refer to the section Parameter assignment and structure of the parameter data record (Page 26).

The following parameter settings are possible:

Table 2-1111 Settable parameters and their defaults (GSD file)

Parameters	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file PROFINET IO	GSD file PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	yes	Module	Module
Diagnostics: Short-circuit[1]	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Overflow	• Disable • Enable	Disable	yes	Module	Module
Diagnostics Underflow	• Disable • Enable	Disable	yes	Module	Module
Diagnostics wire break[2]	• Disable • Enable	Disable	yes	Module	Module
Output type/range	• deactivated • Voltage +/- 10 V • Voltage +/- 5 V • Voltage 0..10 V • Voltage 1..5 V • Current +/- 20 mA • Current 0 - 20 mA • Current 4 - 20 mA	Current 4 - 20 mA	yes	Channel	Channel
Reaction to CPU STOP	• Turn off • Keep last value • Output substitute value	Turn off	yes	Channel	Module
Substitute value	For permissible substitute values for the various output ranges, see appendix Parameter data record (Page 25), Substitute values → Codes for substitute value table	0	yes	Channel	Channel
Potential group	• Use potential group of the left module • Allow new potential group	Use potential group of the left module	no	Module	Module

[1] no diagnostics detection between -0.5 V and +0.5 V (no short-circuit detection)

[2] no diagnostics detection between -3 mA and +3 mA (no wire break detection)

NOTE

Unused channels

"Disable" the unused channels in the parameter assignment. This improves the temperature characteristics of the module, see Derating, section Technical specifications (Page 20).

A disabled channel always returns the value "no current or voltage".

4.3 Explanation of the parameters

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics: Short-circuit

Enabling of the diagnostics when a short-circuit of the actuator supply occurs.

Diagnostics overflow

Enabling of the diagnostics when the output value exceeds the overrange.

Diagnostics underflow

Enabling of the diagnostics when the output value exceeds the overrange, falls below the minimum output value or reaches underflow.

Diagnostics wire break

Enabling of the diagnostics if the line to the actuator is broken.

Output type / output range

See section Output ranges (Page 12)

Reaction to CPU STOP

Determines the behavior of the module at CPU STOP.

Substitute value

The substitute value is the value that the module outputs in case of a CPU STOP.

Potential group

Specifies that a BaseUnit with voltage supply feed-in is located in this slot (see system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)).

4.4 Address space

Configuration options

The following configurations are possible:

- Configuration 1: Without value status
- Configuration 2: With value status

Evaluating the value status

If you enable the value status for the analog module, an additional byte is occupied in the input address space. Bits 0 to 3 in this byte are assigned to a channel. They provide information about the validity of the analog value.

Bit = 1: There are no faults/errors on the module.

Bit = 0: Channel is disabled or there is a fault/error on the module.

If a fault/error occurs on a channel with this module, the value status for all channels is 0.

Address space

The following figure shows the assignment of the address space for the AQ 4×U/I ST with value status (Quality Information (QI)). The addresses for the value status are only available if the value status is enabled.

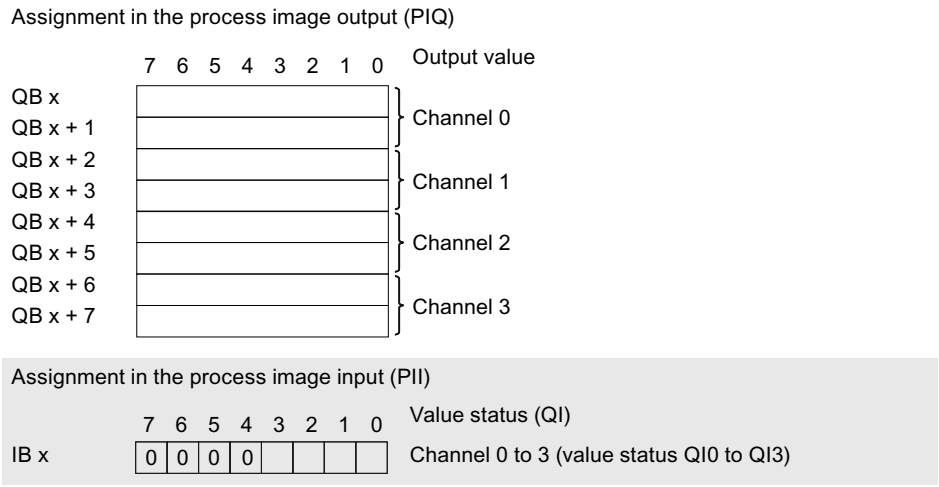

Figure 2-1009 Address space of the AQ 4×U/I ST with value status

Interrupts/diagnostics alarms

5

5.1 Status and error display

LED display

The figure below shows the LED displays of the AQ 4xU/I ST.

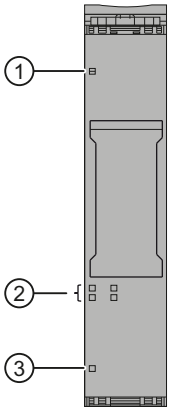

① DIAG (green/red)

② Channel status (green)

③ PWR (green)

Figure 2-1010 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 18).

DIAG LED

Table 2-1112 DIAG LED fault/error display

DIAG LED	Meaning
☐ off	Backplane bus supply of the ET 200SP not OK
☼ Flashes	Module parameters not assigned
■ on	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics

Channel status LED

Table 2-1113 Status display of the channel status LED

Channel status LED	Meaning
☐ off	Channel disabled
■ on	Channel enabled

PWR LED

Table 2-1114 Status display of the PWR LED

PWR LED	Meaning
☐ off	No supply voltage L+
■ on	Supply voltage L+ present

5.2 Interrupts

The analog output module AQ 4×U/I ST supports diagnostic interrupts.

Diagnostics interrupt

The module generates a diagnostics interrupt for the following events:

- Channel temporarily unavailable
- Short-circuit (voltage)
- Overtemperature
- Line break (current)
- High limit violated
- Low limit violated
- Error
- Parameter assignment error
- No load voltage

5.3 Diagnostics alarms

A diagnostics alarm is output for each diagnostics event and the DIAG LED on the module flashes. The diagnostics alarms can, for example, be read from the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-1115 Diagnostics alarms, their meaning and how to deal with them

Diagnostics alarm	Error code	Meaning	Remedy
Channel temporarily unavailable	$1F_H$	Firmware being updated. The module is currently not performing any outputs.	–
		The channel is currently being calibrated.	
Short-circuit	1_H	Short-circuit of the actuator supply	Correct the process wiring
Overtemperature	4_H	Thermal overload of the I/O module	Correct the process wiring
Wire break	6_H	Actuator circuit impedance too high.	Use a different actuator type or wire differently, e.g. use cables with a larger cross-section
		Wire break between the module and actuator	Connect the cable
		Channel not connected (open)	• Disable the channel ("output type" parameter) • Connect the channel
High limit violated	7_H	The output value specified by the user program exceeds the overrange.	Correct the output value
Low limit violated	8_H	The output value specified by the user program is below the underrange.	Correct the output value

Diagnostics alarm	Error code	Meaning	Remedy
Error	9_H	Internal module error occurred.	Replace module
Parameter assignment error	10_H	• The module cannot evaluate parameters for the channel. • Incorrect parameter assignment.	Correct the parameter assignment
No load voltage	11_H	No or insufficient supply voltage L+	• Check supply voltage L+ on the BaseUnit • Check BaseUnit type

Technical specifications 6

6.1 Technical specifications

Technical specifications of AQ 4×U/I ST

	6ES7135-6HD00-0BA1
Product type designation	AQ 4xU/I ST
General information	
Firmware version	V1.1
Usable BaseUnits	BU type A0, A1
Color code for module-specific color identification label	CC00
Product function	
I&M data	Yes
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V11 SP2 / V13
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	GSD revision 5
PROFINET as of GSD version/GSD revision	V2.3 / -
CiR Configuration in RUN	
Configuration in RUN possible	Yes
Installation type/mounting	
Rack mounting possible	Yes
Front installation possible	Yes
Rail mounting possible	Yes
Wall/direct mounting possible	No
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	150 mA
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
Address space per module, max.	8 bytes; + 1 byte for QI information
Analog outputs	

	6ES7135-6HD00-0BA1
Number of analog outputs	4
Voltage output, short-circuit current, max.	45 mA
Cycle time (all channels), min.	5 ms
Output ranges, voltage	
0 to 10 V	Yes; 15 bits
1 to 5 V	Yes; 13 bits
-5 to +5 V	Yes; 15 bits including sign
-10 to +10 V	Yes; 16 bits including sign
Output ranges, current	
0 to 20 mA	Yes; 15 bits
-20 to +20 mA	Yes; 16 bits including sign
4 to 20 mA	Yes; 14 bits
Connection of actuators	
for voltage output two-wire connection	Yes
for voltage output three-wire connection	Yes
for voltage output four-wire connection	Yes
for current output two-wire connection	Yes
Load resistance (in nominal range of the output)	
For voltage outputs, min.	2 kΩ
For voltage outputs, capacitive load, max.	1 µF
For current outputs, max.	500 Ω
For current outputs, inductive load, max.	1 mH
Destruction limit for externally applied voltages and currents	
Voltages at the outputs	30 V
Cable length	
Cable length shielded, max.	1000 m; 200 m for voltage output
Analog value formation	
Oscillation time	
For resistive load	0.1 ms
For capacitive load	1 ms
For inductive load	0.5 ms
Errors/accuracies	
Linearity error (in relation to output range), (+/-)	±0.03 %
Temperature error (in relation to output range), (+/-)	0.005 %/K
Crosstalk between outputs, min.	-50 dB
Repeat accuracy in settled state at 25 °C (in relation to output range), (+/-)	±0.05 %
Operational limit in the entire temperature range	
Voltage in relation to output range, (+/-)	±0.5 %
Current in relation to output range, (+/-)	±0.5 %
Basic error limit (operational limit at 25 °C)	
Voltage in relation to output range, (+/-)	±0.3 %

	6ES7135-6HD00-0BA1
Current in relation to output range, (+/-)	±0.3 %
Interrupts/diagnostics/status information	
Substitute values can be applied	Yes
Interrupts	
Diagnostics interrupt	Yes
Diagnostics alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Wire break	Yes
Short-circuit	Yes
Overflow/underflow	Yes
Diagnostics display LED	
Monitoring of the supply voltage (PWR LED)	Yes; green LED
Channel status display	Yes; green LED
For module diagnostics	Yes; green/red LED
Electrical isolation	
Electrical isolation of channels	
Between the channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	Yes
Permitted potential difference	
Between different circuits	75 VDC / 60 VAC (basic isolation)
Insulation	
Insulation tested with	707 VDC (type test)
Environmental conditions	
Operating temperature	
Horizontal installation, min.	0 ℃
Horizontal installation, max.	60 ℃
Vertical installation, min.	0 ℃
Vertical installation, max.	50 ℃
Dimensions	
Width	15 mm
Weights	
Weight, approx.	31 g

Derating trend for permitted load during power output and horizontal mounting position:

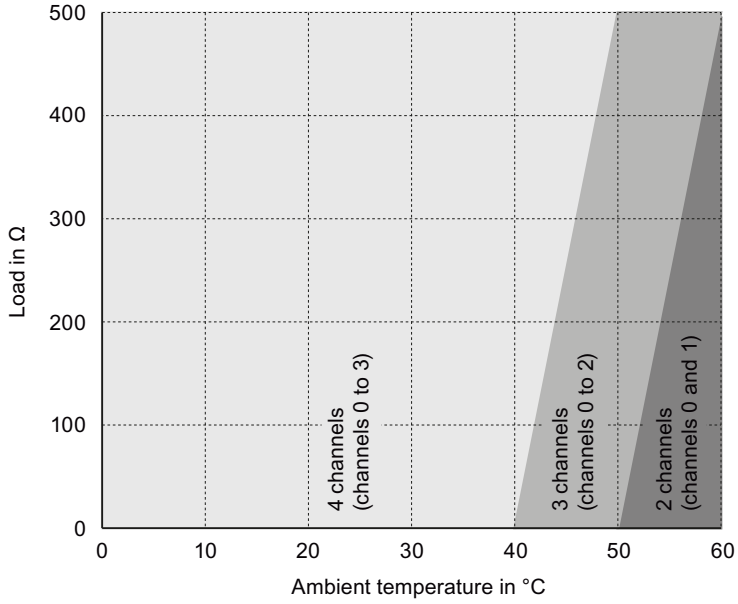

Figure 2-1011 Derating trend current output (horizontal)

Derating trend for permitted load during power output and vertical mounting position:

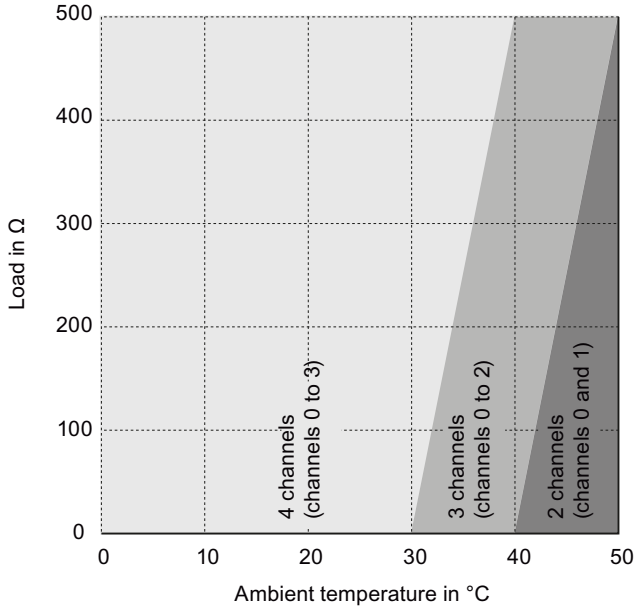

Figure 2-1012 Derating trend current output (vertical)

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

Parameter data record

A

A.1 Dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the settings of some parameters are dependent on each other.

Configuring with a PROFINET GSD file

The table lists the properties and their dependencies on the output type and output range for PROFINET.

Output type	Output range	Diagnostics					Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to M	Overflow	Underflow	Wire break		
deactivated		*	*	*	*	*	*	*
Voltage	±5 V	x	x	x	x	-	x	x
	±10 V	x	x	x	x	-	x	x
	1..5 V	x	x	x	x	-	x	x
	0..10 V	x	x	x	x	-	x	x
Current	±20 mA	x	-	x	x	x	x	x
	0..20 mA	x	-	x	x	x	x	x
	4..20 mA	x	-	x	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Configuring with a PROFIBUS GSD file

The table lists the properties and their dependencies on the output type and output range for PROFIBUS.

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to M	Overflow/ Underflow	Wire break		
deactivated		*	*	*	*	*	*
Voltage	±5 V	x	x	x	-	x	x
	±10 V	x	x	x	-	x	x
	1..5 V	x	x	x	-	x	x
	0..10 V	x	x	x	-	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

Output type	Output range	Diagnostics				Reaction to CPU STOP	Substitute value
		No supply voltage L+	Short-circuit to M	Overflow/ Underflow	Wire break		
Current	±20 mA	x	-	x	x	x	x
	0..20 mA	x	-	x	x	x	x
	4..20 mA	x	-	x	x	x	x

x = Property is allowed, - = Property is **not allowed**, * = Property is not relevant

A.2 Parameter assignment and structure of the parameter data record

Parameter assignment in the user program

The module can be re-configured in RUN (for example, the voltage or current values of selected channels can be changed in RUN without having an effect on the other channels).

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Structure of data record 128

NOTE

Channel 0 contains the diagnostics for the entire module.

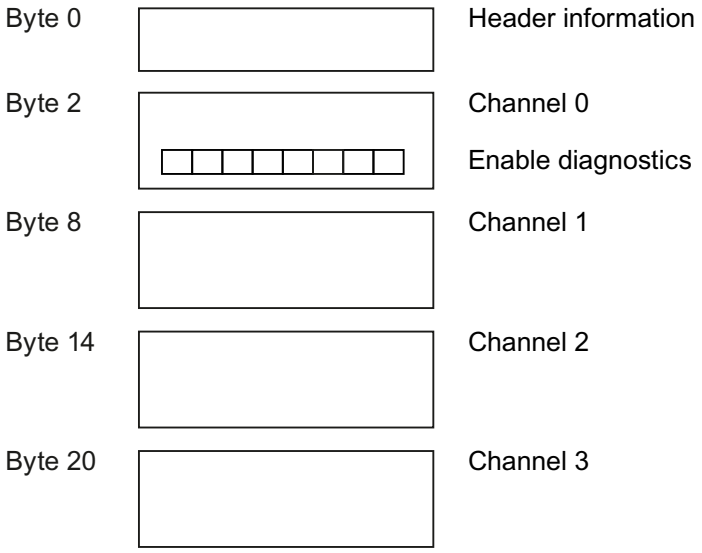

Figure 2-1013 Structure of data record 128

Header information

The figure below shows the structure of the header information.

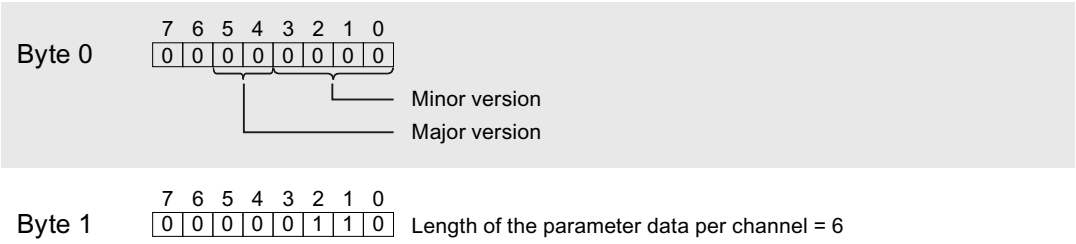

Figure 2-1014 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

You enable a parameter by setting the corresponding bit to "1".

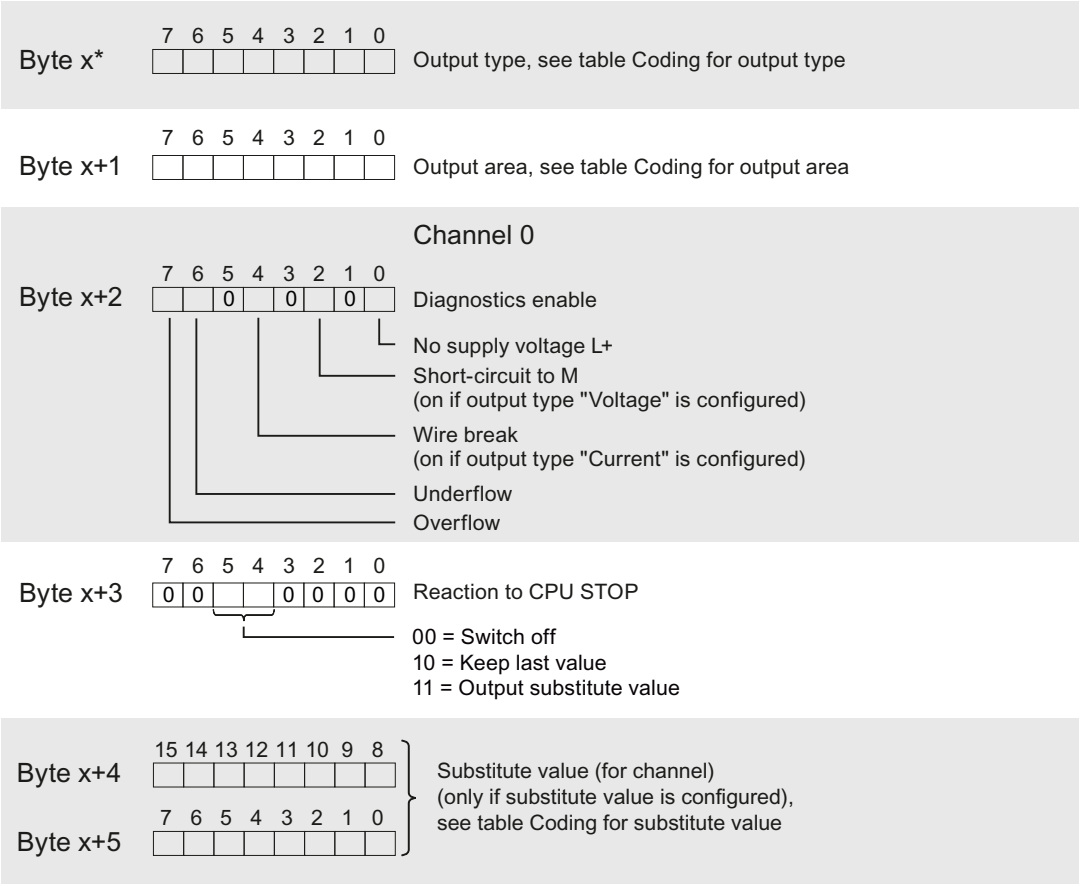

* x = 2 + (channel number × 6); channel number = 0 to 3

Figure 2-1015 Structure byte x up to x+5 for the channel 0 to 3

Codes for output type

The following table contains the codes for the output types of the analog output module. You enter this coding in byte x (see previous figure).

Table 2-1116 Codes for output type

Output type	Coding
Deactivated	0000 0000
Voltage	0000 0001
Current	0000 0011

Codes for output range

The following table contains the codes for the output ranges of the analog output module. You enter these codes in byte x+1 of data record 128 (see previous figure).

Table 2-1117 Codes for output range

Output range	Coding
Voltage	
±10 V	0000 0000
±5 V	0000 0001
0 to 10 V	0000 0010
1 to 5 V	0000 0011
Current	
±20 mA	0000 0000
0 to 20 mA	0000 0001
4 to 20 mA	0000 0010

Codes for substitute value

The following table contains the codes for the substitute values. You enter these codes in bytes x+4 and x+5 (see previous figure).

Output range	Permissible substitute value
Voltage	
±10 V	-32512 to 32511
±5 V	-32512 to 32511
0 to 10 V	0 to 32511
1 to 5 V	-6912 to 32511
Current	
±20 mA	-29031 to 29030
0 to 20 mA	0 to 29030
4 to 20 mA	-692 to 29376

Representation of analog values

B

This appendix describes the analog values for all output ranges that you can use with the analog module AQ 4xU/I ST.

Measured value resolution

The digitized analog value is the same for all output values at the same nominal range. Analog values are output as fixed point numbers in two's complement.

In the following table, you will find the representation of the binary analog values and the associated decimal or hexadecimal units of the analog values.

The resolutions 14, 15 and 16 bits including sign are shown. Each analog value is entered in the ACCU left-justified. The bits marked with "x" are set to "0".

Table 2-1118 Possible resolutions of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
14	4	4_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 1 x x
15	2	2_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 1 x
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of output ranges

In the following tables, you can find the digitized representation of the bipolar and unipolar range output ranges. The resolution is 16 bits.

Table 2-1119 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
≥32512	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	

Dec. value	Output value in %	Data word																Range
-27649	100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Underrange
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
≤ -32513	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value

Table 2-1120 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
≥32512	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Overrange
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Nominal range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
≤ 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value

B.2 Representation of analog values in the voltage output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible voltage output ranges.

Table 2-1121 Voltage output ranges ±10 V and ±5 V

Values			Voltage output range		Range
	Dec.	Hex.	±10 V	±5 V	
118.5149 %	32767	7FFF	11.76 V	5.88 V	Overflow*
	32512	7F00			
117.589 %	32511	7EFF	11.76 V	5.88 V	Overrange
	27649	6C01			
100 %	27648	6C00	10 V	5 V	Nominal range
75 %	20736	5100	7.5 V	3.75 V	
0.003617 %	1	1	361.7 µV	180.8 µV	
0 %	0	0	0 V	0 V	
	-1	FFFF	-361.7 µV	-180.8 µV	
-75 %	-20736	AF00	-7.5 V	-3.75 V	
-100 %	-27648	9400	-10 V	-5 V	
	-27649	93FF			Underrange

* outputs positive maximum value or negative minimum value

Values			Voltage output range		Range
-117.593 %	-32512	8100	-11.76 V	-5.88 V	Underrange
	-32513	80FF	-11.76	-5.88 V	Underflow*
-118.519 %	-32768	8000			

* outputs positive maximum value or negative minimum value

Table 2-1122 Voltage output range 0 V to 10 V

Values			Voltage output range	Range
	Dec.	**Hex.**	**0 to 10 V**	
118.519 %	32767	7FFF	11.76 V	Overflow*
	32512	7F00		
117.589 %	32511	7EFF	11.76 V	Overrange
	27649	6C01		
100 %	27648	6C00	10 V	Nominal range
75 %	20736	5100	7.5 V	
0.003617 %	1	1	361.7 µV	
0 %	0	0	0 V	
	-1	FFFF	0 V	Underflow*
-118.519 %	-32768	8000		

* outputs positive maximum value or negative minimum value

Table 2-1123 Voltage output range 1 V to 5 V

Values			Voltage output range	Range
	Dec.	**Hex.**	**1 to 5 V**	
118.519 %	32767	7FFF	5.70 V	Overflow*
	32512	7F00		
117.589 %	32511	7EFF	5.70 V	Overrange
	27649	6C01		
100 %	27648	6C00	5 V	Nominal range
75 %	20736	5100	4 V	
0.003617 %	1	1	1 V + 144.7 µV	
0 %	0	0	1 V	
	-1	FFFF	1 V - 144.7 µV	Underrange
-25 %	-6912	E500	0 V	
	-6913	E4FF	0 V	Underflow*
-118.519 %	-32768	8000		

* outputs positive maximum value or negative minimum value

B.3 Representation of analog values in the current output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible current output ranges.

Table 2-1124 Current output range ±20 mA

Values			Current output range	Range
	Dec.	**Hex.**	**±20 mA**	
118.5149 %	32767	7FFF	21 mA	Overflow*
	29031	7167		
105 %	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100 %	27648	6C00	20 mA	Nominal range
75 %	20736	5100	15 mA	
0.003617 %	1	1	723.4 nA	
0 %	0	0	0 mA	
	-1	FFFF	-723.4 nA	
-75 %	-20736	AF00	-15 mA	
-100 %	-27648	9400	-20 mA	
	-27649	93FF	-20 mA + 723.4 nA	Underrange
-105 %	-29031	8E99	-21 mA	
	-29032	8E98	-21 mA	Underflow*
-118.519 %	-32768	8000		

* outputs positive maximum value or negative minimum value

Table 2-1125 Current output range 0 to 20 mA

Values			Current output range	Range
	Dec.	**Hex.**	**0 to 20 mA**	
118.5149 %	32767	7FFF	21 mA	Overflow*
	29031	7167		
105 %	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100 %	27648	6C00	20 mA	Nominal range
75 %	20736	5100	15 mA	
0.003617 %	1	1	723.4 nA	
0 %	0	0	0 mA	
	-1	FFFF	0 mA	Underflow*
-118.519 %	-32768	8000		

* outputs positive maximum value or negative minimum value

Table 2-1126 Current output ranges 4 to 20 mA

Values			Current output range	Range
	Dec.	**Hex.**	**4 to 20 mA**	
118.5149 %	32767	7FFF	21 mA	Overflow*
	29377	72C1		
106.25 %	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100 %	27648	6C00	20 mA	Nominal range
75 %	19008	4A40	16 mA	
0.003617 %	1	1	4 mA + 578.7 nA	
0 %	0	0	4 mA	
	-1	FFFF	3.9995 mA	Underrange
-2.5 %	-692	FD4C	3.6 mA	
	-693	FD4B	3.6 mA	Underflow*
-118.519 %	-32768	8000		

* outputs positive maximum value or negative minimum value

SIEMENS

SIMATIC

ET 200SP
Analog Output Module AQ 4xI HART HF

Equipment Manual

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Appendix A

12/2021
A5E35098013-AB

Preface

Validity of the documentation

This documentation describes the analog output module AQ 4xI HART HF, article number 6ES7135-6TD00-0CA1.

It supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). Functions that generally relate to the system are described in this manual.

The information in this documentation and in the system/function manuals enables you to commission the system.

Conventions

The following terms are used synonymously in this documentation:

Term	Synonyms	Notes
AQ 4xI HART HF	AQ 4xI HART; Analog output module AQ 4xI HART	Unless otherwise specified, applies to the product analog output module AQ 4xI HART HF, article number 6ES7135-6TD00-0CA1.
Actuator	Field device	The following applies in this documentation: The field devices connected to the analog output module are actuators. The field devices connected to an input module, on the other hand, are sensors.

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers diverse topics relating to your automation system.

The complete documentation for the ET 200SP system consists of the system manual, function manuals, and manuals for the individual devices.

The STEP 7 information system (online help) also supports you in configuring and programming your automation system.

Overview of documentation for analog output module AQ 4xI HART HF

The following table lists additional documentation that you require for using the analog output module.

Table 2-1127 Documentation

Topic	Documentation	Most important contents
System description	System Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Commissioning
Analog value processing	Function Manual Analog value processing (http://support.automation.siemens.com/WW/view/en/67989094)	• Basics of analog technology (wiring, processing, assembly system) • Description/explanation of meaning, e.g., conversion and cycle times, basic error limits, operational limits
System diagnostics	Function manual Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	• Overview • Hardware/software diagnostic evaluation
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521)	Technical specifications

SIMATIC manuals

The latest manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Product overview

2

2.1 Properties

Article number

6ES7135-6TD00-0CA1

View of the module

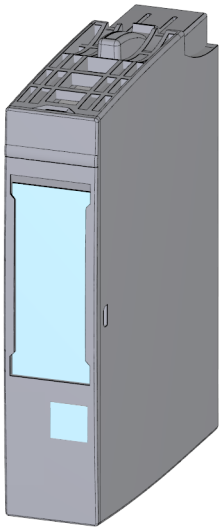

Figure 2-1016 View of the AQ 4xI HART HF module

Properties

The module has the following technical properties:

- Analog output module with 4 outputs
- Current output in output ranges 0 to 20 mA, 4 to 20 mA and 4 to 20 mA HART
- Resolution 16 bits including sign
- Channel-specific configurable diagnostics

The module supports the following functions:

- HART communication (Rev. 5 to Rev. 7)
- Firmware update
- I&M identification data
- Configuration in RUN
- Value status (PROFINET IO only)
- Up to four HART variables directly in the input address space

You can configure the module with STEP 7 in the TIA Portal as well as with HW Config and with a GSD/GSDML file.

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector

See also

You will find additional information on the accessories in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/91696622) system manual.

Wiring up

3

3.1 Connection and block diagram

The AQ 4xI HART HF analog module can be used with all BaseUnits of the type A0 or A1.

You connect the final controlling elements to the BaseUnit of the analog module. The infeed of the supply voltage on the light BaseUnit of the associated potential group supplies the module and the final controlling elements.

A new potential group always begins with a light BaseUnit.

BaseUnit

The BaseUnit is not included in the product package of the module and must be ordered separately.

You can find an overview of the BaseUnits that you can use with the analog module in Product information for documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864)

You can find information regarding selection of the suitable BaseUnit in system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) and in the equipment manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521).

Information regarding wiring of the BaseUnit, creating the cable shield, etc., can be found in system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) in the section "Connecting".

NOTE

The first BaseUnit of a station must be a light BaseUnit. Also keep this in mind during the configuration.

General terminal assignment

	①	Optional connection of an external hand-held unit (secondary master) to the HART test connection terminals (at channel 0 in this case)
	②	Connecting an actuator with 4...20 mA interface, with or without HART
	③	Backplane bus connection
	④	External Controller for in-process data processing

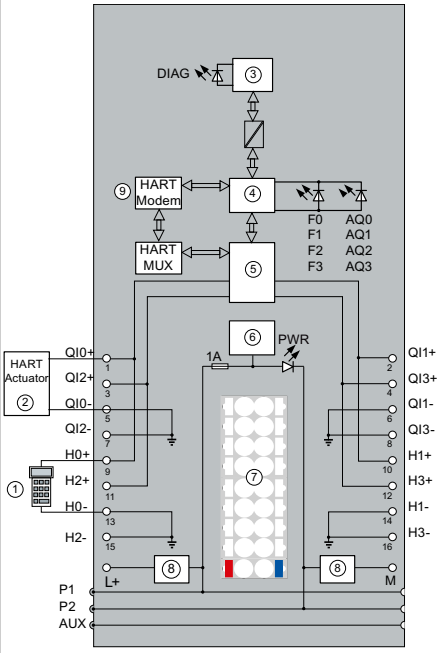

Block diagram AQ 4xI HART HA

⑤	Digital-to-analog converter for generating the output currents and coupling the HART signals
⑥	Power supply for generating the internal supply voltages from the 24 V load voltage supply
⑦	Color-coded label CC00 (optional)
⑧	Filter circuit supply voltage (only available on light-colored BaseUnit)
⑨	HART modem for generating and processing the HART signal
Hn+	HART signal "+"; channel n
Hn-	HART signal "-", channel n
QIn+	Analog output current "+" to the field device; channel n
QIn-	Analog output current "-" to the field device; channel n
L+	24 V DC (infeed only with light-colored BaseUnit)
M	Ground
P1, P2, AUX	Internal self-assembling voltage buses Connection to the left (dark-colored BaseUnit) Connection to the right interrupted (light-colored BaseUnit)
DIAG	Diagnostics LED (green, red)
AQ0 to AQ3	Channel status LED (green)
F0 to F3	Channel fault LED (red)
PWR	Power LED (green)

NOTE

Parallel connection of the outputs to increase the power is not permitted.

Each actuator must be connected separately to the corresponding terminals (QIn+ and QIn-) (no common cable routing).

Supply voltage L+/M

Connect supply voltage (24V DC) to terminals L+ and M. An internal protective circuit protects the analog module from reverse polarity. The analog module monitors the connection of the supply voltage.

HART function

4

Definition

"HART" stands for "Highway Addressable Remote Transducer". The HART protocol is a standardized communication protocol for communication with the suitable field devices over a bus system.

HART is a registered trademark of the HART Communication Foundation (HCF), which owns all the rights to the HART protocol.

You can find detailed information about HART in the HART specification.

Advantages of HART

Using the AQ 4xI HART analog module provides you the following advantages:

- Connection compatibility with standard analog modules: Current loop 4 - 20 mA
- The AQ 4xI HART analog module is an interface between the S7 system and HART devices
- Communication using the HART protocol
- Communication to field devices with HART functions

Use in the system

The AQ 4xI HART analog module is used in the distributed I/O that is connected to PROFIBUS-DP or PROFINET IO.

You can connect a HART field device to any channel:

- The AQ 4xI HART analog module operates as a HART master, monodrop;
- the HART field devices operate as HART devices.

Typical applications

The following applications are typical:

- Commissioning of field devices (centralized parameter assignment)
- Online modification of field device parameters
- Information, maintenance and diagnostic displays for the field devices
- Integration of configuration tools for field devices via the HART interface

4.1 How HART works

Introduction

The HART protocol describes the physical form of the transfer: transfer procedures, message structure, data formats and commands.

HART signal

The figure below shows the analog signal with the modulated HART signal (FSK method), which consists of sine waves of 1200 Hz and 2200 Hz and has a mean value of 0. It can be filtered out using an input filter so that the original analog signal is available again.

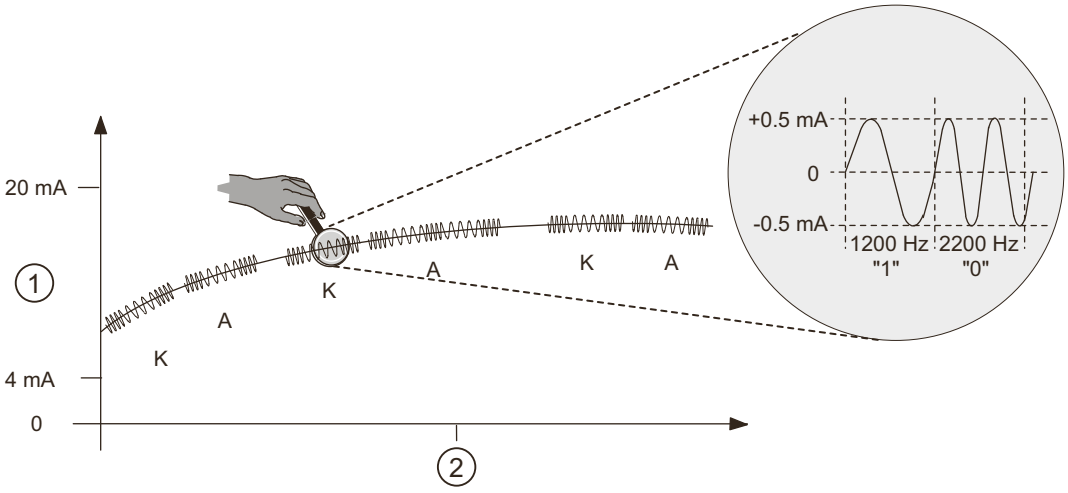

Figure 2-1017 The HART signal

1	Analog signal
2	Time (seconds)
K	Command
A	Response

HART communication

The AQ 4xI HART analog module processes the HART communication in multiplex mode, i.e. one channel after the other. As a result, HART commands of the individual channels influence the speed of the HART processing of the other channels.

When HART mode is enabled, the analog module autonomously sends HART commands to the connected field devices. For each channel, commands are always sent time about with any pending external HART commands that are received over the command interface of the module, see section "HART communication interface (Page 17)".

Commissioning a HART field device

Only HART field devices that are set to the short frame address 0 can be operated.

If a HART field device with a different short frame address is connected or a connected field device is reconfigured to a short frame address other than 0 during operation, the module starts a scan of all possible short frame addresses at the next re-establishment of HART communication (command 0 with short frame addresses 1...63).

As soon as the connected field device responds, it is converted to the short frame address 0 (HART command 6) by the module. During the scan, the module reports a HART communication error.

HART commands

The assignable properties of the HART field devices (HART parameters) can be set with HART commands and read by means of HART replies. The HART commands and their parameters are divided into three groups with the following properties:

- Universal
- Common practice
- Device-specific

Universal commands must be supported by all manufacturers of HART field devices and common practice commands should be supported. There are also device-specific commands that apply only to the particular field device.

Examples of HART commands

The following two tables show examples of HART commands:

Table 2-1128 Examples of universal commands

Command	Function
0	Read manufacturer and device type - only with this command 0 can field devices be addressed by means of a short frame address
11	Read manufacturer and device type
1	Read primary variable and unit
2	Read current output and percent of range, digitally as floating-point number (IEEE 754)
3	Read up to four pre-defined dynamic variables (primary variables, secondary variables, etc.)
9	For field devices starting from HART Rev. 7, read up to four pre-defined dynamic variables (primary variable, secondary variable, etc.)
13, 18	Read or write tag, descriptor and date (data included in transmission)

Table 2-1129 Examples of common practice commands

Command	Function
36	Set upper range value
37	Set lower range value
41	Perform self-test
43	Set the primary variable to zero

Structure of the HART protocol

Each HART frame sent from the analog module to the connected field device (request frame) and each HART frame from the field device (response frame) has the following basic structure.

Table 2-1130 Structure of the HART protocol

PREAMBLE	STRT	ADDR	COM	BCNT	STATUS	DATA	CHK
Key:							
PREAMBLE:	Bytes (0xFF) for synchronizing.					5 to 20 bytes depending on parameter assignment	
STRT:	Start character (start delimiter)					1 byte	
ADDR:	Addresses of the field device					1 byte; short address or 5 bytes; long address	
COM:	HART command number					1 byte	
BCNT:	Byte count, number of bytes to follow without checksum					1 byte	
STATUS:	HART device status. Only present for a response frame. see following tables "Structure of HART device status"					1st and 2nd status bytes	
DATA:	Transferred user data / parameters, quantity depending on command					0 ... 230 bytes	
CHK:	Checksum					1 byte	

With the exception of the preamble bytes, this structure is contained in the communication data of the HART command interface. See section HART request and response data records (Page 54).

HART replies always contain data. Together with a HART response, the HART device status (1st and 2nd status bytes) is sent. Always evaluate the HART device status. If no error is pending, the HART response is correct.

Structure of HART device status (1st and 2nd status bytes).

Table 2-1131 1st status byte

When bit 7 = 1: "Communication error"	
Bit 6 = 1 Bit 5 = 1 Bit 4 = 1 Bit 3 = 1 Bit 2 = 0 Bit 1 = 1 Bit 0 = 0	Parity error Overflow Framing error Checksum error Reserved Overflow in the receive buffer Reserved
When bit 7 = 0: "Specific in line with response frame"	

Table 2-1132 2nd status byte

Bit 7 = 1	Device fault
Bit 6 = 1	Configuration changed
Bit 5 = 1	Startup (cold start)
Bit 4 = 1	Additional status information available
Bit 3 = 1	Fixed analog output current setting
Bit 2 = 1	Analog output current saturated
Bit 1 = 1	Secondary variable outside the limits
Bit 0 = 1	Primary variable outside the range

HART-Fast-Mode

The AQ 4xI HART analog module supports processing HART commands as a SHC sequence ("Successive HART Command").
That is, if the analog module detects a HART command with SHC bit set for a channel, the complete HART command processing on the HART analog module is reserved for this channel for approximately 2 s. For all other channels of the analog module, no HART frame processing occurs during this time, see section HART communication interface (Page 17)

NOTE

- During the time a HART channel of the AQ 4xI HART analog module is processing an SHC sequence, and thus the complete HART processing of the module is reserved for this channel, the HART variables of all HART channels are no longer updated. They remain unchanged in terms of value and quality code.
- HART commands for other channels are not processed and are acknowledged correspondingly.

Burst mode

The AQ 4xI HART analog module does not support burst mode. HART commands with set burst bit are ignored and are not forwarded to the connected field device.

4.2 Use of HART

System environment for the use of HART

To use an intelligent field device with HART functionality, you require the following system environment:

- Current loop 4 to 20 mA
  Connection of the field device to the analog module AQ 4xI HART
- **HART system integration:**
  The analog module takes on the function of a "master" by receiving commands from the HART configuration tool or programmed from an S7 user program, for example, forwarding them to the smart field device and returning the responses. The interface of the analog module represents data records that are transferred via the ET 200SP I/O bus. The data records must be created and interpreted by the client.

- **HART parameter assignment tool "Client":**
  You can assign the HART parameters using an external hand-held operating device (HART Hand-held) or a HART configuration tool (PDM). Both assume the function of a "client".

  The parameter assignment tool affects the entire analog module; the HART handheld is connected in parallel to the field device. See pin assignment "HART test connections (terminals 9 to 16)" in the section "Connection and block diagram (Page 9)".

  PDM (Process Device Manager) is available as a stand-alone unit or integrated in *STEP 7 HW Config*.

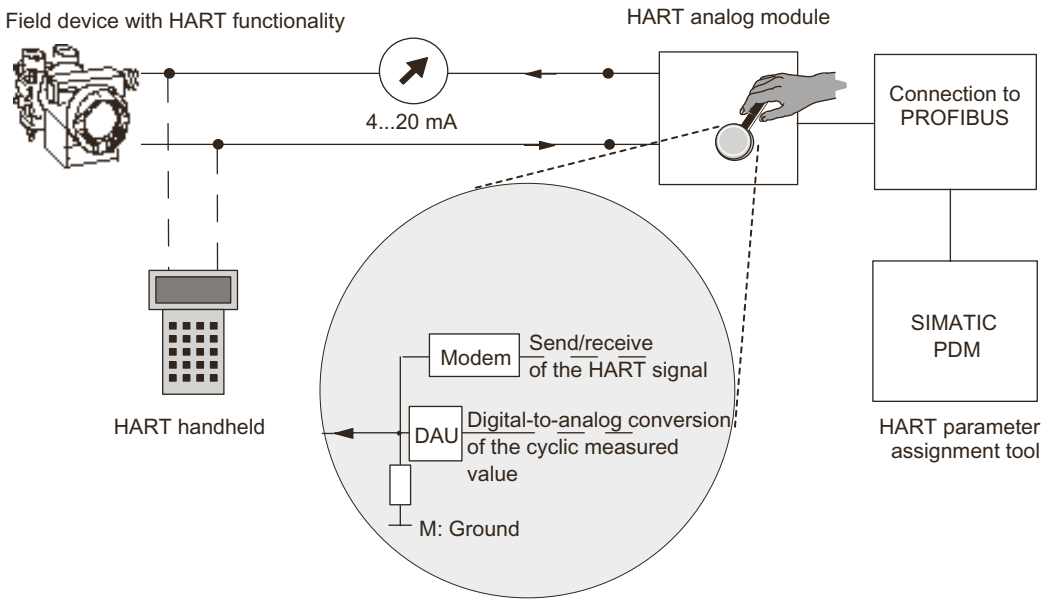

Figure 2-1018 System environment for the use of HART

Error management

The two HART status bytes (HART device status) that are transferred with each field device response contain error statements about HART communication, HART command and device status.
These statements are evaluated by the analog module and provided in the system via S7 diagnostics messages.

Configuration/commissioning

You can configure the analog module in the SIMATIC system with STEP 7 or the TIA Portal.

You assign parameters for the individual channels with respect to the actual analog value output and the use of the HART variables in the input address space of the module.

You can configure one field device per channel. The configuration/parameter assignment of the connected field device is then carried out from this configured field device using PDM or the EDD for the ET 200SP.

The analog module can also be configured via a GSD file, both for PROFIBUS DP and PROFINET IO. However, in this case and with the TIA Portal, direct configuration / parameter assignment of the connected field devices is not possible.

Parameter reassignment of the field devices

The HART analog module generally accepts parameter reassignments for field devices. Access rights can only be allocated in the configuration tool.

For parameter reassignment of the field devices connected to the HART analog module, proceed as follows:

1. You start the parameter reassignment of a field device using a HART command that you enter using the SIMATIC PDM configuration tool or as a programmed command in the STEP 7 user program.
2. After you have reassigned the parameters of a HART field device, the corresponding bit is set in the HART device status of the connected field device (in the 2nd status byte).
3. Because of the parameter reassignment of the field device, the HART analog module triggers a diagnostic interrupt "Configuration changed", provided this diagnostic interrupts is enabled. See section "Diagnostics alarms (Page 35)". This diagnostic interrupt is to be regarded as information and not as an error and is automatically deleted again by the analog module after approximately 1 minute.

A diagnostic interrupt can also be triggered, if enabled, when parameter reassignment is carried out with the hand-held device.

4.3 HART communication interface

Data records

The HART commands are sent over data records to the connected field device as "external HART jobs" from the client (e.g. PDM or the STEP 7 user program). The response of the field device is made available again in the system via data records.

HART communication may only be handled by one client (e.g., PDM) per channel. If a channel is handled by several clients, the response made available by the module cannot be allocated to one client with certainty. The analog module AQ 4xI HART does not support client management.

Each client/channel is allocated fixed data records:

Table 2-1133 Structure of the data records

Channel	Data record number	
	Request to the field device	Response from the field device
0	80	81
1	82	83
2	84	85
3	86	87

The corresponding data records are transferred to the module with the "WRREC" instruction and read by the module with the "RDREC" instruction.

Errors during the transfer are indicated at output parameter STATUS.

Errors during interpretation of the request data record are signaled in the corresponding response data record. The faulty request can be read back again using the request data record.

Rules

- After having written a request data record, a client must read the response data record before it may write another request data record.
- The client can evaluate the "processing status" in the response data record: If the "processing status" indicates "successful" or "error," the response data record contains current response data or error displays.
- The response data record must always be read completely because the analog module may modify the data record after the initial reading with "successful" or "error" status.
  If the processing status in the response data record indicates "successful" or "error", the data record contains current response data or error displays.
- The client may only write a request data record to the module again when it has read the response to the previously written request data record via the corresponding response data record.
  If this condition is not fulfilled, the response from the module is overwritten.
- The STATUS component in the response frame (HART device status in the response data) provides information on whether errors have occurred and, if so, which errors.

Each request is stored on a channel-specific basis, and the corresponding request data record is disabled. Another writing of the same request data record is thus not possible and is acknowledged with BUSY.
The disable of the request data record is reset after the termination or completion of the requested HART command.

SHC sequence

If a HART command with a set SHC bit is sent to the module, this channel is reserved for 2 seconds for HART commands. That is, if the module detects a HART command with SHC bit set for a channel, the complete HART interface of the analog module is reserved for this channel for approximately 2 seconds. There is no processing of internal HART requests, and there is no HART command processing for all other channels of the analog module during this time.

Each time a HART command with a set SHC bit is sent, the analog module reserves this channel again for another 2 seconds for HART commands. If a HART command without SHC bit set is detected for this channel or if no other command for this channel occurs within 2 seconds after the previous HART command, the analog module returns to "normal" HART operation. This means all HART channels are processed again.

4.4 HART variables

Introduction

Numerous HART field devices make available additional measured quantities (e.g. sensor temperature).

A maximum of four HART variables supported by the connected field device can be cyclically read per channel with activated HART functionality. The HART variables are read automatically with HART command 3 (for field devices with HART rev. 5 and 6) or with command 9 (for field devices with HART rev. 7 or later).

These four HART variables per channel are always stored in HART variable data record 121 and can be read at any time. See section HART variable data record (Page 52).

In addition, a maximum of 4 HART variables can be configured directly in the input address space of the AQ 4xI HART analog module. The HART variables are assigned to a channel in the properties dialog of the module. The parameter assignment uses parameter data record 140, see section Parameter assignment and structure of the HART mapping parameters (Page 49). This allows you to easily work with process values directly from the field device as input data in the automation device.

Address assignment

Provided you map HART variables in the input address space of the module by means of the configuration tool or selection of the appropriate configuration, 20 bytes are always additionally allocated for the HART variables.

Configuration of HART variables

You can configure up to 4 HART variables for each channel. When configuring, you select these from the four HART variables provided by each channel:

- PV (Primary Variable)
- SV (Secondary Variable)
- TV (Tertiary Variable)
- QV (Quaternary Variable)

When HART mode is enabled, the analog module cyclically reads the variables provided by the connected field devices independently and makes them available in the configured input address space. You specify during parameter assignment which variables are supplied by a field device.

Each HART variable consists of a 4-byte value and a quality code byte.

Quality code

The quality code describes the process status of the corresponding HART variable.

Basic structure of the quality code

Bit	7...6	5...2	1...0
	Quality 0 0: Bad 0 1: Uncertain 1 0: Good 1 1: Good	Sub-status Coded according to "PROFIBUS PA Profile for Process Control Devices"	Limits 0 0: OK 0 1: Low limit 1 0: High limit 1 1: Constant

The quality codes generated by the analog module are based on the HART revision of the field device in use.

Field devices with HART Revision 5 and 6

The quality code is formed exclusively from the 1st and 2nd Status byte (HART device status) of the response frames (HART command 3).

Quality code	Meaning (process status)	Note
80_H	Value is okay	Applies even when the following bits are set in the 2nd status byte of the HART response frame: • Configuration changed • Startup (cold start) • Fixed analog output current setting
78_H	Value is uncertain	Applies even when the following bits are set in the 2nd status byte of the HART response frame: • Additional status information available • Analog output current saturated • Secondary variable outside the limits • Primary variable outside the range
84_H	Response code RC8: Update error	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	After module startup
00_H	Initialization value from S7 system	

Field devices with HART Revision 7 or higher

The quality code is formed from the 1st status byte (HART device status) and the "Device variable status" (DVS) of the response frames (HART command 9).

Quality code	Meaning (process status)	Note
80_H	Value is okay	
89_H	"Good" with "Low limit"	Process status, formed from the "Device variable status" (DVS) of the response frames with corresponding limits (see above).
$8A_H$	"Good" with "High limit"	
28_H...$2B_H$	"Bad"	

Quality code	Meaning (process status)	Note
$68_{H...}6B_H$	"Poor accuracy"	Process status, formed from the "Device variable status" (DVS) of the response frames with corresponding limits (see above).
$78_{H...}7B_H$	"Manual" or "Fixed"	
$88_{H...}8B_H$	"More device variable state available"	
84_H	Response code RC8: Update error	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	After module startup
40_H	Read alternatively via command 3	
00_H	Initialization value from S7 system	

Parameters 5

5.1 Parameters of AQ 4xI HART

You define the functioning of the Q 4xI HART analog module via parameters.

The parameters are subdivided into:

- Channel/ technology parameters (data record 128)

  With PROFIBUS DP GSD configuration, there is a reduced configuration via the startup configuration (Prm frame).
- Parameters that define the display of HART variables in the address space of the module; HART mapping parameters (data record 140)

With configuration in the user program, the parameters are transferred to the modules via data records with the "WRREC" instruction; see section Parameter assignment and structure of the channel/technology parameters (Page 48).

5.1.1 Channel/technology parameters

Parameters of AQ 4xI HART

The effective range of the parameters depends on the type of configuration. The following configurations are possible:

- Distributed operation on PROFINET IO in an ET 200SP system
- Distributed operation on PROFIBUS DP in an ET 200SP system

Table 2-1134 Configurable channel/technology parameters and their default settings

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file[1] PROFINET IO	GSD file[1] PROFIBUS DP
Diagnostics No supply voltage L+	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics Overflow	• Disable • Enable	Disable	Yes	Channel	Module [2]

1) GSD file/GSDML file

2) Because the PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes per ET 200SP station, the options for parameter assignment are limited. In this case, configuration is performed via data record 245. If necessary, you can set these parameters via data record 128 as described in the "GSD file PROFINET IO" column (see table above).

3) When the number of HART preamble bytes = 0, the number of preamble bytes required by the connected field device are used, but no fewer than 5. When the number of HART preamble bytes = 255, then 20 preamble bytes are used.

Parameter	Value range	Default	Configuration in RUN	Effective range with configuration software, e.g. STEP 7 (TIA Portal)	
				GSD file[1] PROFINET IO	GSD file[1] PROFIBUS DP
Diagnostics Underflow	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics, Wire break	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics, Short-circuit	• Disable • Enable	Disable	Yes	Channel	Module [2]
Diagnostics HART	• Disable • Enable	Disable	Yes	Channel	Module [2]
Output type/range	• Disabled • Current 0..20 mA • Current 4..20 mA • Current 4..20 mA HART	Current 4..20 mA HART	Yes	Channel	Channel
Reaction to CPU STOP	• Switch off • Keep last value • Output substitute value	Switch off	Yes	Channel	Module [2]
Substitute value	The value range depends on the set output range. The substitute value must be in the nominal range or in the overrange/underrange.	0	Yes	Channel	Channel
Number of HART preamble bytes	0 [3]; 5...20; 255	5	Yes	Channel	Cannot be changed [2]
Number of HART repetitions	0...10	5	Yes	Channel	Cannot be changed [2]
Potential group	• Use potential group of the left module • Allow new potential group	Use potential group of the left module	No	Module	Module

1) GSD file/GSDML file

2) Because the PROFIBUS GSD configuration limits the number of parameters to a maximum of 244 bytes per ET 200SP station, the options for parameter assignment are limited. In this case, configuration is performed via data record 245. If necessary, you can set these parameters via data record 128 as described in the "GSD file PROFINET IO" column (see table above).

3) When the number of HART preamble bytes = 0, the number of preamble bytes required by the connected field device are used, but no fewer than 5. When the number of HART preamble bytes = 255, then 20 preamble bytes are used.

NOTE

Unused channels

"Disable" unused channels in the parameter assignment to improve the cycle time of the module.

A disabled channel always returns the output value 0 mA.

See also

Parameter assignment and structure of the channel/technology parameters (Page 48)

5.1.2 Explanation of the channel/technology parameters

Output type/range

The analog module has the following output ranges:

Table 2-1135 Output range

Type of output	Output range	Resolution
Disabled	-	-
Current	0 to 20 mA	16-bit including sign
Current	4 to 20 mA	16-bit including sign
Current	4 to 20 mA HART	16-bit including sign

An overview of the output range, overflow and overrange etc. can be found in the appendix "Analog value display (Page 59)".

Settling time dependent on the activation of HART communication

You can find the settling time without HART communication (x ms) in section "Technical specifications of the AQ 4xI HART (Page 38)".

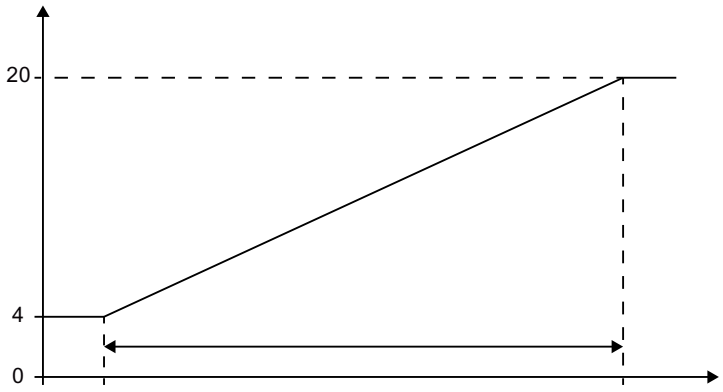

Figure 2-1019 Example diagram of settling time without HART communication

If HART communication is activated for the output range, the settling time of the output values can vary (max: 50 ms).

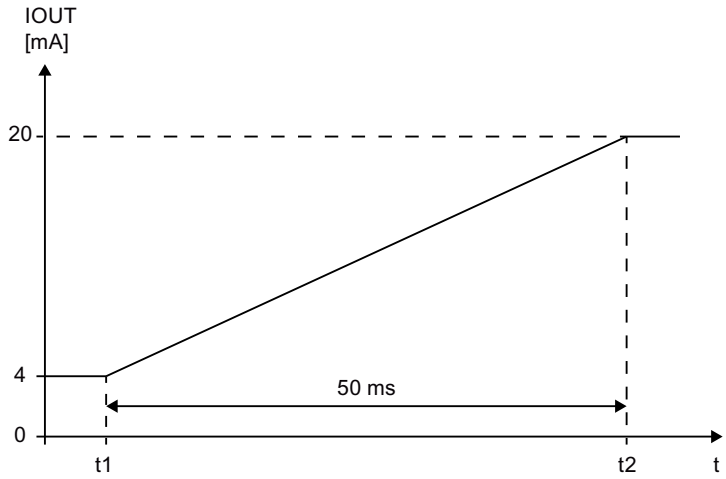

Figure 2-1020 Example diagram of settling time with HART communication

Diagnostics no supply voltage L+

Enabling of the diagnostics for no or insufficient supply voltage L+.

Diagnostics, Wire break

Enabling of the diagnostics if the analog module does not detect any current flow.

Monitoring is effective from an output current of ≥ 240 µA.

If the output current drops below 240 µA when the "Wire break" diagnostics message is pending, the diagnostic message cannot be canceled until the output current is set above 240 µA again and the error has been eliminated.

Diagnostics, Short-circuit

Short-circuit detection is possible for all current output ranges (short-circuit of output QI_n+ to QI_n-).

Monitoring is effective from an output current of at least 1 mA.

The diagnostics short-circuit applies from a connected load of < 20 Ω. From a load of > 30 Ω the short-circuit is reported as outgoing again.

Diagnostics overflow

Enable diagnostics.

- The event is signaled when the output value violates the overrange.
- The current output is limited to the end of the overrange if the overrange is violated.

Diagnostics underflow

Enable diagnostics.

- The event is signaled when the output value violates the underrange.

Diagnostics HART

Enable the following diagnostics:

- HART frame-specific monitoring
- Status information provided by the connected field device in the HART frame (HART device status).

Number of HART repetitions

Specifies the number of HART frame repetitions. If the analog module receives no response or a response with errors to a HART frame sent to the field device, the frame is repeated, i.e. sent to the field device again.

Because HART communication of the individual channels uses multiplex operation, faulty HART frames affect the other channels when the number of HART repetitions is high. This means the other channels are processed less frequently.

Number of HART preamble bytes

Specifies the number of preamble bytes that the module prefixes to each HART frame to be sent (FF_H). These bytes are used to synchronize the frames.

Reaction to CPU STOP

Determines the reaction of the analog module to CPU STOP or to failure of communication between the interface module and CPU.

Substitute value

The substitute value is output by the module at CPU STOP if you set the "Reaction to CPU STOP" parameter to "Substitute value".
The substitute value must not exceed the overrange and must not fall below the underrange.

Number of HART repetitions

Specifies the number of HART frame repetitions. If the analog module receives no response or receives a response with error to a HART frame sent to the field device, the frame is accordingly repeated, i.e., resent to the field device.

Because HART communication of the individual channels uses multiplex mode, faulty HART frames affect the other channels when the number of HART repetitions is high. This means the other channels are processed less frequently.

Potential group

Specifies that a BaseUnit with supply voltage infeed is located in this slot (see system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)).

5.1.3 HART mapping parameters

A maximum of 4 HART variables can be configured (mapped) to the address space of the module with the HART mapping parameters.

Each HART variable occupies 5 bytes of input data. As soon as you configure (map) at least one HART variable in the input address space, the addresses for all four variables are allocated (20 bytes).

With PROFIBUS DP GSD configuration with HART variables, the HART variables cannot be directly configured. The four secondary variables are supplied in ascending channel order in the address space of the module.
When required, this can be changed using data record 140; see section Parameter assignment and structure of the HART mapping parameters (Page 49).

Parameters

Table 2-1136 Configurable HART mapping parameters

Parameter		Value range	Default	Configuration in RUN	With GSD file PROFIBUS DP
Variable 0	Channel	0...3	0	Yes	0
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quaternary	Non / Cir	Yes	Secondary
Variable 1	Channel	0...3	0	Yes	1
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quaternary	Non / Cir	Yes	Secondary

Parameter		Value range	Default	Configuration in RUN	With GSD file PROFIBUS DP
Variable 2	Channel	0...3	0	Yes	2
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quaternary	Non / Cir	Yes	Secondary
Variable 3	Channel	0...3	0	Yes	3
	Type	• Non / Cir • Primary • Secondary • Tertiary • Quaternary	Non / Cir	Yes	Secondary

Configuring/address space

6

6.1 Configuring

You can configure the AQ 4xI HART analog output module

- in TIA Portal as of V15.1 (HSP0283), otherwise as of TIA Portal V16
- With STEP 7 V5.6 + SP4 or higher (HSP0263)
- Using GSD/GSDML

The GSD files for the ET 200SP Distributed I/O System can be downloaded from the Internet:

GSDML (http://support.automation.siemens.com/WW/view/en/57138621)

GSD (http://support.automation.siemens.com/WW/view/en/73016883)

Configuration options

The following configurations are possible:

- Without value status and without HART variables ("AQ 4xI HART")
- Without value status, with HART variables ("AQ 4xI HART, 4 variables")
- With value status, without HART variables ("AQ 4xI HART, QI")
- With value status, with HART variables ("AQ 4xI HART, 4 variables, QI")

With GSD/GSDML configuration, you must select one of the possible configurations directly.

With STEP 7 configuration (TIA Portal or HW Config), the configuration occurs indirectly via the parameters.

Restrictions

- Value status is not available for a PROFIBUS DP station.
- Downstream of a Standard IM (V1.1), the module can be operated only in the "Without value status and without HART variables" configuration.
- TIA Portal:
  - The module behind a standard IM (V1.1) is not available.
  - TIA Portal as of V15.1
    The module can be centrally configured on the following CPU:
    - CPU 1510SP-1 (as of V2.1)
    - CPU 1512SP-1 PN (as of V2.1)
  - TIA Portal as of V15.1
    The module can be configured as an open controller.
  - The module cannot be used behind fail-safe controllers.

6.2 Address space

The following tables shows the mapping of the address space of the AQ 4xI HART analog output module for a configuration **with** value status (Quality Information, QI) and **with** HART variables.

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input area
- "QB" stands for output byte, that is the module start address in the output area
- "AQ" stands for analog output
- "QAQn" stands for value status (QI) of the analog output n
- "QC"stands for Quality Code

Address space

The following tables show the allocation of the address space of the I/O module.

- The addresses for the value status are only available if the value status has been enabled or configured.
- The addresses for the HART variables are only available if the HART variables have been configured or parameterized.

Evaluating the value status

If you enable the value status for the analog output module, an additional byte is occupied in the input address space. This additional byte offsets the HART range by one byte. Bits 0 to 3 in this byte are assigned to the corresponding channel. The provide information about the validity of the analog value, namely irrespective of the diagnostics enables.

There is one bit value status for each analog output in the input address space.

Irrespective of the diagnostics enables, each value status (each QI bit) provides information on the validity of the corresponding process value.

- Value status = 1: Process value okay, "good"
- Value status = 0: Process value not okay, "bad"

Generally, the value status is set to "good" if the analog value can be output without errors. The value status is set to "bad" in the following cases:

- The analog value cannot be output due to an error.
- The analog output is deactivated.
- The substitute value is output at the analog output.

Evaluating HART variables

If you have configured (mapped) HART variables for the analog output module, four HART variables with 5 bytes each are stored in the input address space.

Each HART variable consists of a 4-byte real value and a quality code byte. The quality code describes the validity of the value; see section HART variables (Page 19) .

The assigned HART variables are automatically updated by the I/O module and can be used directly in the user program.

Input area

If the HART variables are configured or parameterized, then HART variables begin directly after the value status, i.e. from IB x + 1.

IB x +	Meaning							
0 *	-	-	-	-	QAQ3	QAQ2	QAQ1	QAQ0
1	HART range							
: :								

* This additional byte offsets the HART range by one byte.

The structure of the HART range is dependent on the configuration:

- With the configuration with 4 variables, the range is 20 bytes long and always contains 4 HART variables, each with 4 bytes value and a byte quality code.

Table 2-1137 HART range: Configuration

IB x +	HART range	
1 : 4	Value	Configured HART variable 0
5	QC	
6 : 9	Value	Configured HART variable 1
10	QC	
: : :		
16 : 19	Value	Configured HART variable 3
20	QC	

Output range

QB x +	Meaning
0...1	Analog value of analog output 0 (AQ0)
2...3	Analog value of analog output 1 (AQ1)
4...5	Analog value of analog output 2 (AQ2)
6...7	Analog value of analog output 3 (AQ3)

Interrupts/diagnostics alarms 7

7.1 Status and error displays

LED displays

The following figure shows the status and error displays of the AQ 4xI HART analog output module.

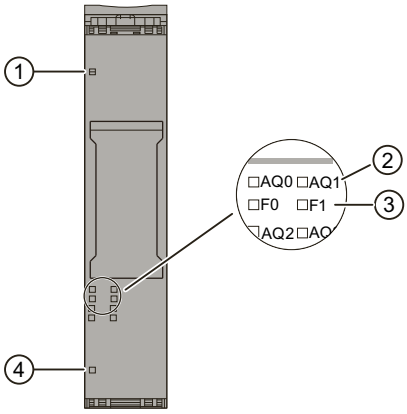

① DIAG (green/red)

② Channel status (green)

③ Channel fault (red)

④ PWR (green)

Figure 2-1021 LED displays

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostic alarms can be found in the section Diagnostics alarms (Page 35).

Table 2-1138 Status display of the channel status/channel fault LEDs

LEDs		Meaning
Channel status	**Channel fault**	
□ Off	□ Off	Channel disabled or module switched off
■ On	□ Off	Channel enabled and no channel diagnostics present
□ Off	■ On	Channel enabled and channel diagnostics present
■ On	■ On	Channel enabled and **only** HART channel diagnostics present

Table 2-1139 DIAG LED error display

DIAG LED	Meaning
□ Off	Backplane bus supply of the ET 200SP is not OK or switched off
☼ Flashes	Module parameters not assigned
■ On	Module parameters assigned and no module diagnostics
☼ Flashes	Module parameters assigned and module diagnostics, at least one error is currently present

Table 2-1140 Status display of the PWR LED

PWR LED	Meaning
□ Off	No supply voltage L+
■ On	Supply voltage L+ present

System response (channel LED, error LED and PWR LED switch off briefly).

If all the grounds of the channels are drawn simultaneously (e.g. common ground wiring), the channel LED, the error LED and the PWR LED switch off briefly.

7.2 Interrupts

The AQ 4xI HART analog output module supports diagnostic interrupts.

Diagnostic interrupt

The module generates a diagnostic interrupt for the following events:

- Channel/component temporarily unavailable
- Short-circuit
- Wire break
- Low limit violated
- High limit violated
- No supply voltage L+
- HART communication error or HART field device error
- Overtemperature
- Parameter assignment error

7.3 Diagnostics alarms

A diagnostic alarm is generated for each detected diagnostic event. The DIAG LED flashes on the module.

There is additionally a channel-specific display of the diagnostics through the corresponding channel fault/channel status LEDs.

The diagnostic alarms can, for example, be read from the diagnostic buffer of the CPU or be displayed in STEP 7 using the Online and Diagnostics view. You can evaluate the error codes with the user program.

Table 2-1141 Diagnostic alarms, their meaning and how to deal with them

Diagnostic alarm	Error code	Meaning	Remedy
Channel/component temporarily unavailable	$1F_H$	• Update of the firmware is being performed or has been canceled. The module does not perform any processing during this time	• Restart firmware update • Wait for firmware update
Short-circuit	1_H	• Short-circuit of cable to the actuator or impedance too low	• Correct process wiring • Check connected final controlling element
Overtemperature	5_H	• Ambient temperature is too high • Total current of the analog outputs too high • Short-circuit of one or more analog outputs	• Check wiring • Check the ambient condition
Wire break	6_H	• Wire break between the module and actuator • Channel not connected (open)	• Connect the cable • Disable diagnostics
High limit violated	7_H	• The analog value is above the overrange.	• Correct the output value

Diagnostic alarm	Error code	Meaning	Remedy
Low limit violated	8_H	• The analog value is below the under-range.	• Correct the output value
Parameter assignment error	10_H	• Incorrect parameter assignment	• Correct the parameter assignment
No supply voltage	11_H	• No or insufficient supply voltage L+	• Check wiring of the supply voltage L+ on the BaseUnit • Check BaseUnit type
HART communication error	141_H	• HART field device is not responding • Timing error • HART field device did not understand the command that was sent (1st status byte)	• Check the process wiring • Correct the parameter assignment • Set current ≥4 mA • Increase the number of assigned repetitions
HART primary variable outside range	142_H	• Incorrect parameters in the HART field device • HART field device is set to "Primary variable outside of limits" in simulation mode • Primary variable assigned outside the limits	• Check the parameter assignment of the HART device • Correct the simulation • Check if the correct field device is connected
HART output current saturated	143_H	• The output current of the HART field device is saturated: • Incorrect parameters in the HART field device • HART field device is set to too high a measured value in simulation mode	
HART fixed analog output current	144_H	• The output current of the HART field device is fixed: • Incorrect parameters in the HART field device • HART field device is set to too high a measured value in simulation mode	
HART secondary variable outside the limits	149_H	• Incorrect parameters in the HART field device • HART field device is set to "Non-primary variable outside the limits" in simulation mode • Non-primary variable assigned outside the limits	

Diagnostic alarm	Error code	Meaning	Remedy
HART - more status available	145_H	• The identifier for "Additional status information available" of the HART field device was set in the HART device status (in the 2nd status byte).	• Read status using HART command 48 and eliminate error/cause, if necessary
HART configuration changed (reset again automatically by the module after approximately 1 minute)	146_H	• The identifier for "Parameter reassignment" of the HART field device was set in the HART device status (in the 2nd status byte).	• If you do not want a diagnostic interrupt to be triggered for parameter reassignment, the diagnostic interrupt must not be enabled.
HART malfunction in field device	147_H	• The field device signals a malfunction in the HART device status (in the 2nd status byte)	• Read status using HART command 48 and eliminate error/cause, if necessary • Replace the field device

Technical specifications 8

8.1 Technical specifications of the AQ 4xI HART

Technical specifications

Article number	6ES7135-6TD00-0CA1
General information	
Product type designation	AQ 4xI HART HF
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V15 SP1
• STEP 7 configurable/integrated as of version	V5.6 and higher
• PCS 7 configurable/integrated as of version	V9.0 SP1
• PROFIBUS as of GSD version/GSD revision	V04.02.14
• PROFINET as of GSD version/GSD revision	GSDML V2.34
CiR – Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	115 mA
Current consumption, max.	125 mA
Power loss	
Power loss, typ.	1.7 W

Article number	6ES7135-6TD00-0CA1
Address area	
Address space per module	
• Address space per module, max.	8 byte; + 1 byte for QI information
• Address space per module with HART, max.	28 byte; + 1 byte for QI information
Analog outputs	
Number of analog outputs	4
Current output, no-load voltage, max.	28 V
Cycle time (all channels), min.	3 ms
Output ranges, current	
• 0 to 20 mA	Yes; 16 bit incl. sign
• -20 mA to +20 mA	No
• 4 mA to 20 mA	Yes; 16 bit incl. sign
Connection of actuators	
• for current output two-wire connection	Yes
Load impedance (in rated range of output)	
• with current outputs, max.	750 Ω
• with current outputs, inductive load, max.	10 mH
Destruction limits against externally applied voltages and currents	
• Voltages at the outputs	30 V
Cable length	
• shielded, max.	800 m
Settling time	
• for resistive load	2 ms; 750 ohm
• for capacitive load	2 ms
• for inductive load	2 ms
Errors/accuracies	
Output ripple (relative to output range, bandwidth 0 to 50 kHz), (+/-)	0.02 %
Linearity error (relative to output range), (+/-)	0.03 %
Temperature error (relative to output range), (+/-)	0.003 %/K
Crosstalk between the outputs, min.	-50 dB
Repeat accuracy in steady state at 25 °C (relative to output range), (+/-)	0.03 %
Operational error limit in overall temperature range	
• Current, relative to output range, (+/-)	0.3 %; 0 ... 60 °C: 0.2 %
Basic error limit (operational limit at 25 °C)	
• Current, relative to output range, (+/-)	0.1 %

Article number	6ES7135-6TD00-0CA1
Protocols	
HART protocol	Yes
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes; Module-wise
• Wire-break	Yes; channel by channel
• Short-circuit	Yes
• Overflow/underflow	Yes; channel by channel
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	Yes; Red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• Between the channels and load voltage L+	Yes
Permissible potential difference	
between different circuits	60 V DC/30 V AC
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	31 g

Dimension drawing

See manual ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/59753521)

8.2 Standards and Approvals

8.2.1 Currently valid markings and approvals

Introduction

This section contains the technical specifications of the system:

- The standards and test values that the module complies with and fulfills.
- The test criteria according to which the module was tested.

Safety information

WARNING

Explosion hazard

If the electric circuit is live, the following must be observed:

- Do not disconnect the device in a flammable or combustible atmosphere.
- Do not open the enclosure in a flammable or combustible atmosphere.

WARNING

Area of application

This device is intended for use only in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC environments or non-hazardous locations.

WARNING

Environmental conditions

The device may only be used in areas with a pollution degree of not more than 2 according to IEC 60664-1.

WARNING

Enclosure and cables

The device is intended for installation in an enclosure / control cabinet. The internal operating temperature of the enclosure / control cabinet corresponds to the maximum permissible ambient temperature of the module.

Cables must be used whose maximum permissible operating temperature is at least 30 °C above the maximum permissible ambient temperature.

WARNING

Ambient temperature of the device

The temperature of the device housing may be higher than 70 °C if the device is operated at an ambient temperature of more than 50 °C. The device must therefore be installed so that it is only accessible to service technicians or users who are aware of the reason for the restricted access and the necessary safety measures at an ambient temperature of over 50 °C.

WARNING

Safety extra-low voltage

The device is designed for operation with safety extra-low voltage (SELV) from a limited power source (LPS).

Power supplies connected to the power supply terminals must comply with the following:

- SELV/LPS (current source with limited power), according to standards IEC 60950-1 / UL 60950-1 / EN 60950-1 / VDE 0805-1

  or

- Power supply for the NEC Class 2 device as described in the National Electrical Code (r) (ANSI / NFPA 70).

If the device is connected to a redundant power supply (two separate power sources), both must meet these requirements.

NOTICE

Removal and replacement

If you replace components, the suitability for Class I, DIV. 2 becomes invalid.

Replacing components may affect the usability of the device.

NOTICE
Risk of danger Read the manual before use to avoid injury.

Validity of the information on the components

NOTICE
Markings and approvals In the documentation, you can find the markings and approvals which are generally possible or planned in the system. The identification or approval that is printed on the module continues to be exclusively valid. The currently valid markings and approvals are printed on the component.

8.2.2 CCC approval

Certificate: 020322310003113

Ex nA IIC T4 Gc

According to the following standards:

- GB 3836.1-2010 (Explosive atmospheres - Part 1: Equipment - General requirements)
- GB 3836.8-2014 (Explosive atmospheres-Part 8: Equipment protection by type of protection "n")

8.2.3 UKCA approval

DEKRA 21UKEX0020 X

Importer UK:

Siemens plc

Manchester M20 2UR

8.2.4 cULus approval

Underwriters Laboratories Inc. in accordance with

- UL 61010-2-201 (Industrial Control Equipment)
- CSA/ CAN 61010-2-201 (Process Control Equipment)

8.2.5 cULus HAZ. LOC. approval

HAZ. LOC.

Underwriters Laboratories Inc. in accordance with

- UL 61010-2-201 (Industrial Control Equipment)
- CSA / CAN 61010-2-201 (Process Control Equipment)
- ANSI/ISA 12.12.01
- CSA C22.2 No. 213 (Hazardous Location)

APPROVED for use in
Class I, Division 2, Group A, B, C, D Tx;
Class I, Zone 2, Group IIC Tx

8.2.6 ATEX Approval

Table 2-1142 ATEX Certification

Type Examination Certificate Number	DEKRA 14ATEX0109 X
Standards	EN 60079-0
	EN 60079-7

ATEX II 3 G Ex ec IIC T4 Gc

NOTE
Special conditions

1. The module may only be used in areas with a pollution degree of not more than 2 according to EN 60664-1.
2. The module must be installed in a suitable enclosure which meets the following requirements:
   The enclosure shall provide a degree of protection of at least IP54 in accordance with EN 60079-7, taking into account the ambient conditions of use.
3. Measures must be taken to protect against exceeding the rated operating voltage by transient interference voltages of more than 119 V.

8.2.7 IECEx Approval

Table 2-1143 IECEx certification

Certificate number	IECEx DEK 14.0063X
Standards	IEC 60079-0
	IEC 60079-7

IECEx Ex ec IIC T4 Gc

NOTE
Special conditions

1. The module may only be used in areas with a pollution degree of not more than 2 according to IEC 60664-1.
2. The module must be installed in a suitable enclosure which meets the following requirements:
   The enclosure shall provide a degree of protection of at least IP54 in accordance with IEC 60079-7, taking into account the ambient conditions of use.
3. Measures must be taken to protect against exceeding the rated operating voltage by transient interference voltages of more than 119 V.

8.2.8 FM Approval

Table 2-1144 Factory Mutual Research (FM) Certification

Classification	NI, Class I, Div 2, Groups A, B, C and D
	NI, Class I, Zone 2, Groups IIC
Standards	Class No. 3600
	Class No. 3611

Standards	Class No. 3810
	ANSI/ISA-61010-1
	C22.2 No. 0-10
	C22.2 No. 213-17
	C22.2 No. 1010.1
	CAN/CSA C22.2 No. 0.15-15

Appendix A

A.1 Parameter data records

Parameter assignment in the user program

You have the option of reassigning parameters for individual channels of the module and for the mapping of HART variables in RUN without affecting the other channels.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module.

- Channel/technology parameters using data record 128
- The HART mapping using data record 140.

The parameters assigned with STEP 7 are not changed permanently in the CPU, which means the parameters assigned with STEP 7 are valid again after a restart.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Parameters

Only the values specified in each case in the following are permitted. Values that are not listed are rejected by the analog module.

Each parameter data record is checked by the analog module. If an incorrect parameter is detected, the complete data record is discarded and the parameters of the analog module remain unchanged.

A.1.1 Parameter assignment and structure of the channel/technology parameters

Structure of data record 128

Data record 128 has a length of 34 bytes and contains the channel or technology parameters of all four channels, each 8 bytes per channel.

The parameters are divided into parameters which influence the actual analog value output, diagnostic enables and basic parameters of the HART communication.

You can use data records 131 to 134 to assign and change additional parameters and HART-specific settings. See section HART-specific settings (Page 53).

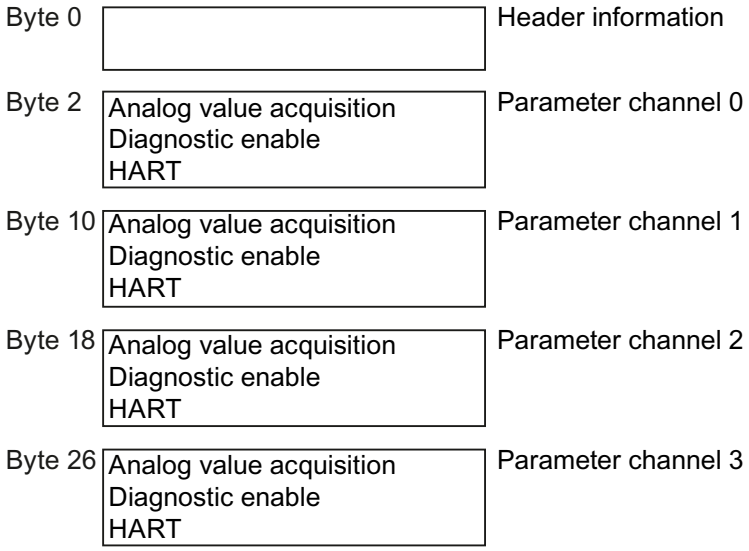

Figure 2-1022 Structure of data record 128

Header information

The figure below shows the structure of the header information.

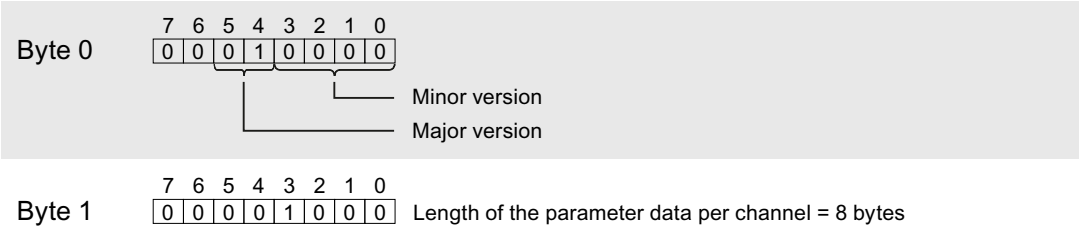

Figure 2-1023 Header information

Parameters

The figure below shows the structure of the parameters for channels 0 to 3.

All unused bits and the bits or bytes marked with "reserved" must be set to zero.
You enable a parameter by setting the corresponding bit to "1" or the appropriate value.

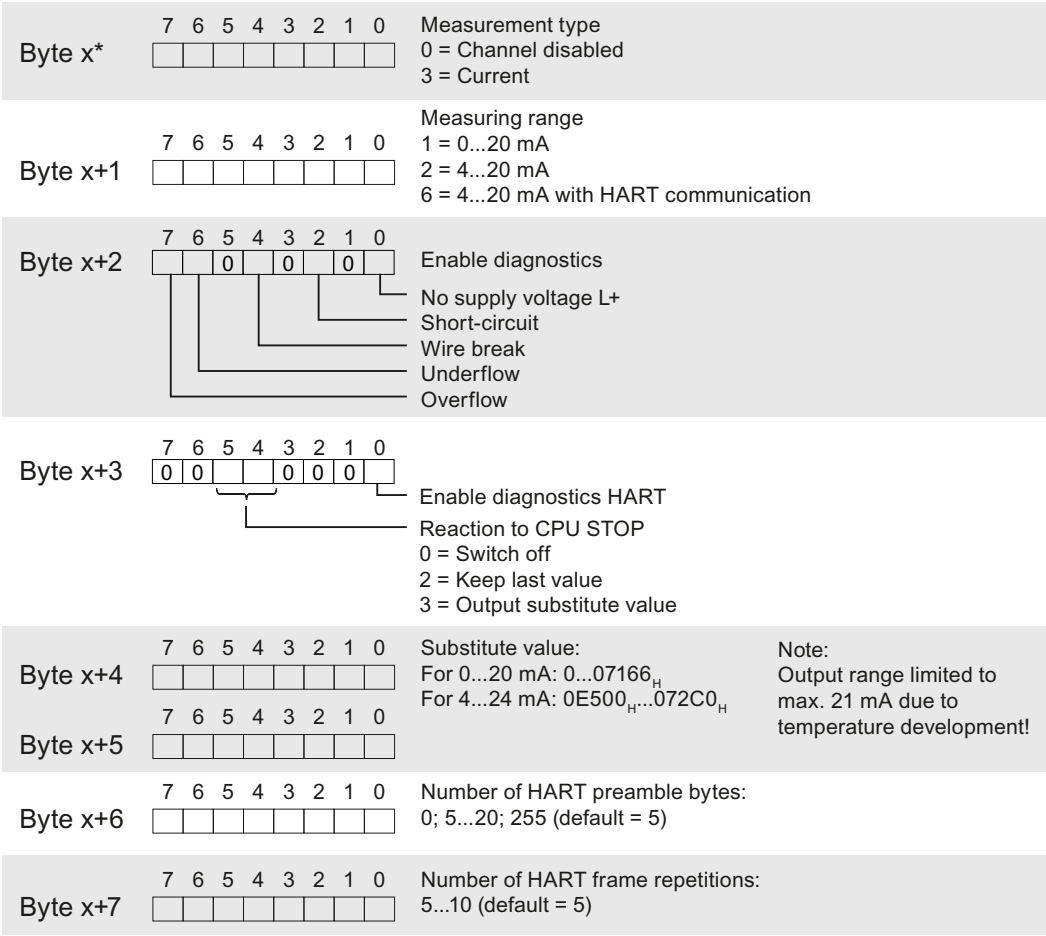

* x = 2 + (channel number * 8); with channel number 0....3

Figure 2-1024 Structure byte x to x+33 for channels 0 to 3

A.1.2 Parameter assignment and structure of the HART mapping parameters

Structure of data record 140

Data record 140 has a total length of 12 bytes.

Using the parameters of data record 140, you can configure/map up to four HART variables of the individual channels in the input address space of the module if the corresponding configuration is selected, see "Configuring (Page 29)".

Header information

The figure below shows the structure of the header information.

	7 6 5 4 3 2 1 0	
Byte 0		Version = 0
Byte 1		Block length = 11 bytes
Byte 2		Block type = 75
Byte 3		Reserved = 0

Figure 2-1025 Header information

Parameters

The following figure shows the parameter assignment of the four HART variables 0...3.

	7 6 5 4 3 2 1 0	
Byte x*		Channel number: 0...3
Byte x+1		Variable marking: 0 = non 1 = Primary 2 = Secondary 3 = Tertiary 4 = Quartenary 15 = CiR

* x = 4 + (HART variable * 2); with HART variable 0....3

Figure 2-1026 Parameters

NOTE

Memory area allocation

- HART variables set to 0 = "non"
  If all four HART variables are set to 0 = "non", no memory area for HART variables is reserved/allocated in the input address area.
- HART variable set as not equal to 0
  If at least one HART variable is not set to 0, then the complete memory area of the four HART variables in the input address space is always allocated.
  All HART variables set to 0 = "non" are automatically preset to 15 = "CiR" (0 = "non" is inadmissible).

A.2 HART operating data records

Reading/writing data in RUN

HART operating data records are transferred to the module with the "WRREC" instruction and read from the module with the "RDREC" instruction.

Errors during the transfer are indicated at output parameter STATUS of the "WRREC" or "RDREC".

The following HART operating data records are available:

Data record number	Description	Length (bytes)	Writable	Readable
80	HART request Channel 0	240	Yes	Yes
81	HART response Channel 0	240	No	Yes
82	HART request Channel 1	240	Yes	Yes
83	HART response Channel 1	240	No	Yes
84	HART request Channel 2	240	Yes	Yes
85	HART response Channel 2	240	No	Yes
86	HART request Channel 3	240	Yes	Yes
87	HART response Channel 3	240	No	Yes
121	HART variables	80	No	Yes
131	HART parameters Channel 0	8	Yes	Yes
132	HART parameters Channel 1	8	Yes	Yes
133	HART parameters Channel 2	8	Yes	Yes
134	HART parameters Channel 3	8	Yes	Yes
148	HART directory	17	No	Yes
149	HART feature data	3	No	Yes

A.2.1 HART directory

Structure of the HART directory

Byte	Meaning	Comment
0	Profile Revision Number	= 2, 0 (Revision 2.0)
1		
2	Index of Client Management	= 255 (not relevant)
3	Number of Clients	= 1
4	Number of Channels	= 4
5	Write Read Index Offset	= 1 (The response to a request data record is made with the data record number of the request data record + 1)
6	Index of HMD Feature Parameter	= 149

Byte	Meaning	Comment
7	Index of HMD Module Parameter	= 255 (not relevant)
8	Start Index of Burst Buffer Area	= 255 (not relevant)
9+n	Index of HMD Channel Parameter (Channel n)	= 131+n
9+n+4	Index of HART Client Channel Message Data	= 80+(2*n) The HART request data records cannot be configured. Data records starting from data record number 80 (80, 82, 84, 86) are used.

A.2.2 HART feature data

Structure of the HART feature data

Byte	Meaning	Comment
0	Byte 0	= 0x62 Bit1 = 1: "Parameter check result is given with a read response" Bit5 = 1: "compact format is supported"
1	Byte 1	= 0
2	Max Length Data Unit	= 230 (maximum length of the HART request data records)

A.2.3 HART variable data record

The AQ 4xI HART analog module supports a maximum of 4 HART variables per channel. Provided they are supported by the connected field device, these variables are ready cyclically.
These 16 HART variables are made available as readable variables in HART variable data record 121.

Each HART variable consists of a 4-byte real value and a quality code byte. See section "HART variables (Page 19); "Quality code".

Structure of the HART variable data record

Byte	Meaning	
Channel 0		
0...3	Value	Primary Variable (PV)
4	Quality code	
5...8	Value	Secondary Variable (SV)
9	Quality code	
10...13	Value	Tertiary (TV)
14	Quality code	
15...18	Value	Quartenary (QV)

Byte	Meaning	
19	Quality code	Quartenary (QV)
Channel 1		
20...39	HART variables same as for Channel 0	
Channel 2		
40...59	HART variables same as for Channel 0	
Channel 3		
60...79	HART variables same as for Channel 0	

If HART is not enabled or the respective HART variable is not supplied from the connected field device, the corresponding variable = 0 and the QC = 0x37 (initialization value from the analog module).

A.2.4 HART-specific settings

The HART communication is available using the standard parameter assignment (see section "Parameter assignment and structure of the channel/technology parameters (Page 48)").

Additional HART-specific settings can be specified on a channel-specific basis using data records 131 to 134.

The parameters assigned with STEP 7 are not changed permanently in the CPU, which means the parameters assigned with STEP 7 are valid again after a restart.

Each parameter reassignment of the analog module resets the HART-specific settings back to the initial values from parameter data record 128.

Where there is no supply voltage L+, the module does not assume the HART-specific settings.

Channel	Data record number
0	131
1	132
2	133
3	134

Structure of the HART-specific settings

Byte 0	7 6 5 4 3 2 1 0 Must be 128	Bit 7 is reset after evaluation of data record by module
Byte 1	7 6 5 4 3 2 1 0 Must be 5	Offset for manufacturer-specific parameters according to HART specification
Byte 2	7 6 5 4 3 2 1 0 	Number of HART repetitions (0 ... 10) Initial value from parameter data record 128
Byte 3	7 6 5 4 3 2 1 0 	Number of HART preamble bytes (0, 5...20, 255) * Initial value from parameter data record 128
Byte 4	7 6 5 4 3 2 1 0 Must be 0	Field device mode according to HART specification
Byte 5	7 6 5 4 3 2 1 0 	Client timeout in s (1 ... 255 s) Initial value = 60 s
Byte 6	7 6 5 4 3 2 1 0 0 0 0 0 0 0 | | 1 = Enable HART 0 = Disable HART 1 = Primary master 0 = Secondary master	Initial value according to HART activation from parameter data record 128 Always as primary master
Byte 7	7 6 5 4 3 2 1 0 Must be 0	Reserved

Figure 2-1027 Settings

* When the number of HART preamble bytes = 0, the number of preamble bytes required by the connected field device are used, but no fewer than 5. When the number of HART preamble bytes = 255, then 20 preamble bytes are used.

A.2.5 HART request and response data records

HART commands are processed on a channel-specific basis via a separate command interface with one request data record and one response data record in each case.

Channel	Data record number	
	Request to the field device	Response from the field device
0	80	81
1	82	83
2	84	85
3	86	87

Structure of request data records 80, 82, 84, 86

Byte	Meaning	Comment	
0	Request control	**Coding "Request control":**	
		Bit 0...1:	Reserved = 0
		Bit 2:	0 = Parameters are not checked
		Bit 3...4:	Reserved = 0
		Bit 5:	• 0 = Transparent format HART commands are processed by the analog module in transparent message format and in compact message format. However, the response data from the module is always made available in transparent message format. • 1 = Compact format
		Bit 6:	1 = Activate SHC mode Execution of a sequence of HART commands as an SHC sequence affects all other channels with HART enabled. See section "HART communication interface (Page 17)"; SHC sequence.
		Bit 7:	0 = HART request
1	Number of preamble bytes	0.5...20, 255 When "Number of Preamble Bytes" = 255, the number of preambles set with the parameters is used. The default setting is five. You can re-configure the number of preamble bytes using the parameters and HART-specific settings (see section HART-specific settings (Page 53)).	
3...239	Communication data according to HART specification		

Structure of response data records 81, 83, 85, 87

In case of response error

Byte	Meaning	Comment
0	Response control	See table below: Coding "Response control":
1	HART group error display	See table below: Coding "HART group error display"
2	Protocol error	
3...239	Response data according to HART specification	Only present when "Response result" = 6 = "Error, with data" see table below: Coding "HART protocol error during response"

In case of response error

Byte	Meaning	Comment
0	Response control	See table below: Coding "Response control":
1	HART group error display	See table below: Coding "HART group error display"
2...239	Response data according to HART specification	Only present when "Response result" = 4 = "Successful, with data" see table below: Coding "HART protocol error during response"

Coding "Response control":

Bits 0-2: Response Result (processing status):

0 = Inactive	4 = Successful, with data
1 = Inactive (reserved)	5 = Successful, without data
2 = Waiting	6 = Incorrect, with data
3 = Waiting, executing	7 = Incorrect, without data

Bit 3: 0 = Burst mode not active;

Bit 4: 0 = Response data come directly from the HART device

Bit 5: 0 = Response data in transparent message format

Bit 6: 0 = SHC mode not active; 1 = SHC mode active

Bit 7: 0 = HART response

Coding "HART group error display"

Bit number	Meaning	Explanation	
0	Additional status information available	(2nd HART status byte) You obtain additional status information, if required, with HART command 48.	
1	HART communication error	The field device has detected a communication error when receiving the command. The error information can be found in the 1st HART status byte.	
2	Parameter check	0: HMD parameters unchanged	1: Check HMD parameters
3	Reserved	Always 0	
4...7	HART protocol error during response	0: Unspecified error 1: HMD error 2: Channel fault 3: Command error 4: Query error	5: Response error 6: Query rejected 7: Profile query rejected 8: Manufacturer-specific query rejected 9 - 15: Not used

Coding "HART protocol error during response"

HART protocol error during response	Meaning	Explanation	
0	Unspecified error	Always 0	
1	HMD error	0: Not specified 1: Internal communication error 2: Parameter assignment error 3: HW fault	4: Wait time expired 5: HART timer expired 6...127: Reserved 128...255: Manufacturer-specific
2	Channel fault	0: Not specified 1: Line fault 2: Short-circuit 3: Open line	4: Low current output 5: Parameter assignment error 6...127: Reserved 128...255: Manufacturer-specific
3	Command error	0-127: HART protocol, Bit 7 = Always 0	

HART protocol error during response	Meaning	Explanation	
4	Query error	Bit 0 = 0: Reserved Bit 1 = 1: Receive buffer overflow Bit 2 = 0: Reserved Bit 3 = 1: Checksum error	Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved
5	Response error	Bit 0 = 1: GAP timeout Bit 1 = 1: Receive buffer overflow Bit 2 = 1: Timeout Bit 3 = 1: Checksum error	Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved
6	Query rejected	0: Unspecified 1: Compact format not supported 2: SHC not supported 3: Impermissible command	4: No resources 5...127: Reserved 128...255: Manufacturer-specific
7	Profile query rejected	0: Not specified (not supported)	
8	Manufacturer-specific query rejected	0: Not specified (not supported)	

A.2.6 Example of HART programming (HART command interface)

Example of HART programming (HART command interface)

For HART channel 0, the command 01 is to be sent in transparent message format to the HART field device with address "98 CF 38 84 F0".
A positive edge at input 4.0 of a digital input module leads to the writing of the HART command.

The following assumptions are made:

- The module address of the AQ 4xI HART analog module is 512 (200_H).
- The data record is stored in DB80: starting from address 0.0, length of 11 bytes.
- In this example, DB80 (request data record for channel 0) consists of 11 bytes.

STL	Explanation
`U E 4.0`	
`FP M 101.0`	
`= M 104.0`	
`m2: CALL SFC 58`	
`REQ :=M104.0`	Write request
`IOID :=B#16#54`	Address range identifier
`LADDR :=W#16#200`	Module address
`RECNUM :=B#16#50`	Data record number 80
`RECORD :=P#DB80.DBX0.0 BYTE 11`	Data record with length 11 bytes (must correspond exactly to the length that is to be transmitted)
`RET _ VAL :=MW93`	RET_VAL from SFC 58 (OK/error/...)
`BUSY :=M51.0`	Write operation is not finished yet
`A M 51.0`	
`SPB m2`	
`BE`	

Table 2-1145 DB80: Transparent message format

Byte	Initial value (hex)	Comment (Hex)
0	00	Req_Control (00 = Transparent message format. 40 = Transparent message format with SHC sequence)
1	05	Number of preamble bytes (0.05 ... 14,FF)
2	82	Start character (02 = Short Frame with command 0) (82 = Long Frame with other commands)
3	98	Address (with command 0, the address is exactly 1 byte long and has the value 0.)
4	CF	
5	38	
6	84	
7	F0	
8	01	Command (CMD)
9	00	Length in bytes
10	98	Checksum (CHK) (calculated starting from byte 2 "Start character" up to the next to last byte)

A HART command can also be sent in compact message format. In this case, the data that is transferred via DB 80 is reduced to 4 bytes.

Table 2-1146 DB80: Compact message format

Byte	Initial value (hex)	Comment (Hex)
0	20	Req_Control (20 = Compact message format. 60 = Compact message format with SHC sequence)
1	05	Number of preamble bytes (0.05 ... 14,FF)
2	01	Command (CMD)
3	00	Length in bytes

You can learn when the response from the field device was received by cyclically reading data record DS81 for HART channel 0. The response is always supplied in transparent message format.

FC81: Reading of the response to DB81 with SFC 59

STL	Explanation
`m3: CALL SFC 59`	
`REQ :=1`	Read request
`IOID :=B#16#54`	Address range identifier
`LADDR :=W#16#200`	Module address for HART AI
`RECNUM :=B#16#51`	Data record number 81
`RECORD :=P#DB81.DBX0.0 BYTE 75`	Data record
`RET _ VAL :=MW100`	RET_VAL from SFC 59 (OK/error/...)
`BUSY :=M49.1`	Read operation is not finished yet
`A M 49.1`	
`m3`	
`BE`	

The program part A M 49.1 to SPB m3 is only required if reading is to occur synchronously.

As long as "0x03" is in byte 0 of DB81, the response has not been received from the field device. Positive response data that you can evaluate is available from the field device as soon as bit 2 = 1 in byte 0.
If there are errors in the response data, see the "HART group fault display" tables in byte 1 or "HART protocol error during response" in byte 2 of the field device response.

A.3 Analog value display

In the following tables, you can find the digitized representation of the unipolar output ranges.

Display of analog value of current output ranges:

- Analog value display in the current output range 0 to 20 mA (Page 59)
- Analog value display in the current output range 4 to 20 mA (Page 60)

A.3.1 Analog value display in the current output range 0 to 20 mA

The following table shows you the decimal and hexadecimal values (codes) in the current output range 0 to 20 mA. The resolution is 16-bit including sign.

Analog value display

Table 2-1147 Current output range 0 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	0 to 20 mA	
118.5149%	32767	7FFF	21 mA	Overflow
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	0 mA	Underflow
-118.519%	-32768	8000		

A.3.2 Analog value display in the current output range 4 to 20 mA

The following table shows you the decimal and hexadecimal values (codes) in the current output range 4 to 20 mA. The resolution is 16-bit including sign.

Analog value display

Table 2-1148 Current output ranges 4 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	4 to 20 mA	
118.5149%	32767	7FFF	21 mA	Overflow
	29377	72C1		
106.25%	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	16 mA	
0.003617%	1	1	4 mA + 578.7 nA	
0%	0	0	4 mA	
	-1	FFFF	4 mA – 578.7 nA	Underrange
-25%	-6912	E500	0 mA	
	-6913	E4FF	0 mA	Underflow
-118.519%	-32768	8000		

A.4 Contact

Range	Contact
Repair Service Facility	Siemens AG Digital Industries Factory Automation Operative Q functions DI FA MF EWA QM 31 Mr. Alexander Luber Werner-von-Siemens-Str. 5092224 Amberg, Germany Tel.: +49 9621 80-3447
Manufacturer	Siemens AG Digital Industries Factory Automation Operative Q functions DI FA MF EWA Mr. Alexander Luber Werner-von-Siemens-Str. 5092224 Amberg, Germany Tel.: +49 9621 80-3447

SIEMENS

Industrial Controls

ET 200SP Motor starter (3RK1308-0**00-0CP0)

Equipment Manual

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Introduction 1

Purpose of the documentation

This Equipment Manual describes the non-fail-safe and the fail-safe ET 200SP motor starters with firmware version V1.0.0 or higher.

This Equipment Manual supplements the ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293). Functions affecting the system in general are described in the System Manual. There, you will also find information on installation, connection and the installation conditions of the ET 200SP motor starter.

The information provided in this Equipment Manual, the System Manual and the function manuals enables you to commission the ET 200SP distributed I/O system.

Basic knowledge required

A general knowledge of the following areas is needed in order to understand this manual:

- Industrial controls
- Digital circuit logic
- Automation technology
- Safety functions
- PROFINET and PROFIBUS bus topology
- TIA Portal

Definition

In the manual, "ET 200SP motor starter" is used as a synonym for all non-fail-safe and fail-safe variants of the ET 200SP motor starter.

1.1 Responsibility for system configuration and functionality

The products described here have been developed to carry out safety-related functions as part of a complete plant or machine. In general, a complete safety system consists of sensors, evaluation units, signaling devices and methods for safe tripping. It is the responsibility of the manufacturer to ensure that the system or machine is functioning properly as a whole.

Siemens AG, its subsidiaries, and associated companies (hereinafter referred to as "Siemens") are not in a position to guarantee every characteristic of a complete plant or machine not designed by Siemens.

Nor can Siemens assume liability for recommendations that appear or are implied in the following description. No new guarantee, warranty, or liability claims beyond the scope of the SIEMENS general terms of supply are to be derived or inferred from the following description.

1.2 Change documentation

Release number	Changes
03/2025	Incorporation of new firmware functions V1.2.2 such as chatter monitoring and "5-life"

1.3 Siemens Industry Online Support

Information and service

At Siemens Industry Online Support you can obtain up-to-date information from our global support database:

- Product support
- Application examples
- Forum
- mySupport

Link: Siemens Industry Online Support (https://support.industry.siemens.com/cs/de/en)

Product support

You can find information and comprehensive know-how covering all aspects of your product here:

- **FAQs**

  Answers to frequently asked questions
- **Manuals/operating instructions**

  Read online or download, available as PDF or individually configurable.
- **Certificates**

  Clearly sorted according to approving authority, type and country.
- **Characteristics**

  For support in planning and configuring your system.
- **Product announcements**

  The latest information and news concerning our products.
- **Downloads**

  Here you will find updates, service packs, HSPs and much more for your product.
- **Application examples**

  Function blocks, background and system descriptions, performance statements, demonstration systems, and application examples, clearly explained and represented.
- **Technical data**

  Technical product data for support in planning and implementing your project

Link: Product support (https://support.industry.siemens.com/cs/ww/en/ps)

mySupport

The following functions are available in your personal work area "mySupport":

- **Support Request**

  Search for request number, product or subject
- **My filters**

  With filters, you limit the content of the online support to different focal points.
- **My favorites**

  With favorites you bookmark articles and products that you need frequently.
- **My notifications**

  Your personal mailbox for exchanging information and managing your contacts. You can compile your own individual newsletter in the "Notifications" section.
- **My products**

  With product lists you can virtually map your control cabinet, your system or your entire automation project.
- **My documentation**

  Configure your individual documentation from different manuals.
- **CAx data**

  Easy access to CAx data, e.g. 3D models, 2D dimension drawings, EPLAN macros, device circuit diagrams
- **My IBase registrations**

  Register your Siemens products, systems and software.

1.4 Siemens Industry Online Support app

Siemens Industry Online Support app

The Siemens Industry Online Support app provides you access to all the device-specific information available on the Siemens Industry Online Support portal for a particular article number, such as operating instructions, manuals, data sheets, FAQs etc.

The Siemens Industry Online Support app is available for Android and iOS:

Android

iOS

1.5 Support Request

After you have registered, you can use the Support Request form in the online support to send your question directly to Technical Support:

Support Request:	Internet (https://support.industry.siemens.com/My/ww/en/requests)

1.6 Recycling and disposal

These devices can be recycled thanks to their low pollutant content.

NOTE

For environmentally friendly recycling and disposal of your old device, contact a company certified for the disposal of electronic waste and dispose of the device in accordance with the regulations in your country.

Cybersecurity information 2

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Information about third-party software 3

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```

Product-specific safety instructions 4

4.1 General safety notes

DANGER

Hazardous voltage.
Will cause death or serious injury.

Turn off and lock out all power supplying this device before working on this device.

NOTICE

Damage caused by electrostatic charge

The motor starter can become damaged by an electrostatic charge if the unoccupied pins of the motor starter are contacted.

When handling and installing the ET 200SP motor starter, ensure protection against electrostatic charging of the components. Changes to the system configuration and wiring are only permissible after disconnection from the power supply.

It is only permitted to connect ET 200SP motor starters after disconnection of the electronic power supply (PELV and SELV) and of the line power supply (500 V AC).

WARNING

Use of radio devices or cell phones

Malfunctions are possible when using radio devices or cell phones in the immediate vicinity of fail-safe I/O. This can cause death, serious physical injury or material damage.

If you scan the 2D matrix code/ID link or use the "SIEMENS Industry Support App" when the fail-safe I/O is switched on, deactivate all wireless connections of the radio/cell phone beforehand. Alternatively, switch off the fail-safe I/O before scanning.

Switch off radio devices in the immediate vicinity of fail-safe I/O.

4.2 Safety information for hazardous areas

WARNING

Explosion hazard in Class I and Class II Hazardous Locations.
Can cause death or serious injury.

The fail-safe motor starter is permitted for the operation of device group II, Cat (2), area G D.

The fail-safe motor starter itself must not be located in the hazardous area.

4.3 Safety instructions for safety-related applications

⚠ WARNING

Hazardous voltage.
Will cause death or serious injury.

To avoid an electric shock, observe the following safety measures when working on the plant and the device:

- Turn off and lock out all power supplying this device before working on this device.
- Make sure that the device cannot be switched back on.
- Verify that the equipment is not live.
- Ground the plant.
- Cover adjacent live parts or erect barriers around them.

⚠ WARNING

Hazardous Voltage

Work on live parts of the ET 200SP motor starter system can result in death or serious injury.

The device is only allowed to be commissioned and operated by qualified personnel. For the purpose of the safety information in this documentation, a "qualified person" is someone who is authorized to energize, ground, and tag equipment, systems, and circuits in accordance with established safety procedures.

NOTICE

Loss of the safety function

For the fail-safe ET 200SP motor starter, the key safety values apply in the case of a function test interval (state change of the outputs) ≤ 1 month.

To check functioning of the switching elements, switch the motor on or off at least once every month. For additional information on checking the switching elements, see chapter"Operating motor starters (Page 34)".

⚠ WARNING

Loss of the safety function with incorrect wiring

If wiring is incorrect, the motor starter cannot shut down in the event of a fault and the motor will continue to run. There is a risk of severe injury or death. Material damage is also possible.

To ensure the safety function, in the case of a single-phase load route the phase and the neutral conductor through the motor starter. You will find additional information next to the connection examples in chapter "Single-phase motor (Page 156)". In the case of a three-phase load, do not connect the neutral conductor to the star point of the load.

NOTICE

Electromagnetic interference

To ensure interference immunity of the motor starter, ground PELV/SELV power supply units in accordance with regulations. (Please also note the documentation for the respective power supply unit in this regard.)

4.4 Intended use

WARNING

Improper use of hardware products.
Serious damage to property, can cause death or serious injury.

This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens.

Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults.

EU note: Commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed complies with the stipulations of the Directive 2006/42/EC.

4.5 Current information about operational safety

Important note for maintaining operational safety of your system

DANGER

Hazardous voltage

Can cause death, serious injury or property damage

Please take note of our latest information!

Systems with safety-related characteristics are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. We therefore also provide information in the newsletters Industrial controls (https://new.siemens.com/global/en/products/automation/industrial-controls/forms/newsletter.html) and Safety Integrated (https://new.siemens.com/global/en/products/automation/topic-areas/safety-integrated/factory-automation/newsletter.html) about new products, further technical developments as well as standards and guidelines.

4.6 Declaration of conformity

The manufacturer declares that the safety components of the fail-safe ET 200SP motor starter series in the designs marketed by us comply with the applicable basic health and safety requirements of the EC Directives stated (including amendments), and that the stated standards were applied in their design and construction.

You can download the entire EC Declaration of Conformity: Declaration of Conformity (http://www.siemens.com/sirius/approvals).

Standards

The table below shows the standards that each of the ET 200SP motor starters comply with:

Standard	Direct-on-line starter	Reversing starter	Fail-safe direct-on-line starter	Fail-safe reversing starter
IEC 60947-4-2:2011-05	x	x	x	x
IEC 60947-4-3:2011-07	x	-	-	-
EN 62061: 2005	-	-	x	x
EN ISO 13849-1:2015	-	-	x	x
IEC 61508-1:2010	-	-	x	x
IEC 61508-2:2010	-	-	x	x
IEC 61508-3:2010	-	-	x	x

ET 200SP Documentation Guide

5

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

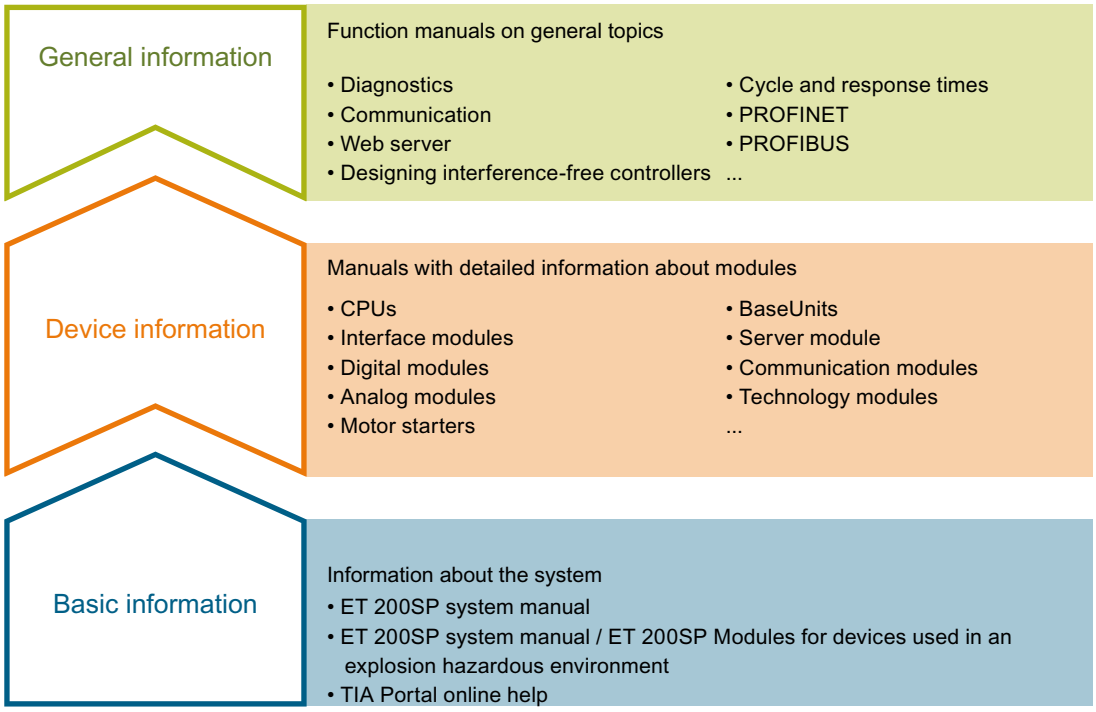

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

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You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/ae).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109767888).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant, incl. fail-safe inputs and outputs.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product features

6

6.1 Article numbers, properties, accessories

Article numbers

Short code	Article number
Direct-on-line starter	
DS 0.1 - 0.4 A HF	3RK1308-0AA00-0CP0
DS 0.3 - 1 A HF	3RK1308-0AB00-0CP0
DS 0.9 - 3 A HF	3RK1308-0AC00-0CP0
DS 2.8 - 9 A HF	3RK1308-0AD00-0CP0
DS 4.0 - 12 A HF including fan (3RW4928-8VB00)	3RK1308-0AE00-0CP0
Reversing starter	
RS 0.1 - 0.4 A HF	3RK1308-0BA00-0CP0
RS 0.3 - 1 A HF	3RK1308-0BB00-0CP0
RS 0.9 - 3 A HF	3RK1308-0BC00-0CP0
RS 2.8 - 9 A HF	3RK1308-0BD00-0CP0
RS 4.0 - 12 A HF including fan (3RW4928-8VB00)	3RK1308-0BE00-0CP0
Fail-safe direct-on-line starters	
F-DS 0.1 - 0.4 A HF	3RK1308-0CA00-0CP0
F-DS 0.3 - 1 A HF	3RK1308-0CB00-0CP0
F-DS 0.9 - 3 A HF	3RK1308-0CC00-0CP0
F-DS 2.8 - 9 A HF	3RK1308-0CD00-0CP0
F-DS 4.0 - 12 A HF including fan (3RW4928-8VB00)	3RK1308-0CE00-0CP0
Fail-safe reversing starters	
F-RS 0.1 - 0.4 A HF	3RK1308-0DA00-0CP0
F-RS 0.3 - 1 A HF	3RK1308-0DB00-0CP0
F-RS 0.9 - 3 A HF	3RK1308-0DC00-0CP0
F-RS 2.8 - 9 A HF	3RK1308-0DD00-0CP0
F-RS 4.0 - 12 A HF including fan (3RW4928-8VB00)	3RK1308-0DE00-0CP0

Views of the ET 200SP motor starter

The ET 200SP motor starter is a 30-mm-wide compact device with hybrid technology. The ET 200SP motor starter has electronic overload protection for switching of three-phase asynchronous motors and single-phase AC motors up to 5.5 kW (at 500 V) during normal operating conditions. Fail-safe variants of the motor starter are also available.

The figure below shows an ET 200SP HF motor starter:

Figure 2-1028 View of the ET 200SP motor starter with mounted 3DI/LC module (optionally available)

The figure below shows a fail-safe ET 200SP motor starter:

Figure 2-1029 View of the fail-safe ET 200SP motor starter with mounted 3DI/LC module (optionally available)

Properties of the ET 200SP motor starter

The ET 200SP motor starter has the following technical properties:

- Switching and protection device for three-phase asynchronous motors and single-phase AC motors
- Integrated short-circuit and overload protection
- Direct-on-line or reversing start function

Fail-safe motor starters additionally support safety-related disconnection (Safe Torque Off). The fail-safe variants of the motor starter are therefore suitable for the following uses:

- Safety-related applications up to SIL 3 to EN 61508, PL e/Cat. 4 to EN ISO 13849-1
- Overload protection of motors in hazardous areas

You can find all the functions supported by the ET 200SP motor starter in Chapter Functions (Page 46)

The following system functions of the ET 200SP family remain supported:

- I&M data
- Firmware update
- Maintenance
- PROFIenergy

You will find the descriptions of these functions and also rules and regulations for commissioning in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/de/view/58649293/en?dl=en).

Accessories of the ET 200SP motor starter

You can order the following accessories separately:

- BaseUnit with width of 30 mm (3RK1908-0AP00-0xx0)
- Labeling strips in various versions:
  - 500 units light-gray on a roll (6ES7193-6LR10-0AA0)
  - 500 units yellow on a roll (6ES7193-6LR10-0AA0)
  - 1000 units light-gray on DIN A4 sheets (6ES7193-6LA10-0AG0)
  - 1000 units yellow on DIN A4 sheets (6ES7193-6LA10-0AG0)
- 160 reference identification labels (6ES7193-6LF30-0AW0)
- 3DI/LC module (3RK1908-1AA00-0BP0)
- Fan (3RW4928-8VB00); is already included with all 4-12 A motor starters

NOTICE
Blowing direction of the fan Observe the blowing direction of the fan when mounting. The air flow must be directed into the inside of the motor starter. The correct blowing direction is indicated by arrows on the bottom of the fan. See ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/de/view/58649293/en?dl=en), "Installing fans" section.

- Mechanical bracket for BaseUnit (3RK1908-1EA00-1BP0)
- Cover for an empty BaseUnit (3RK1908-1CA00-0BP0)
- Touch protection for infeed bus (3RK1908-1DA00-2BP0); is already provided with all BaseUnits with 500 V AC infeed

You can find further information on accessories in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/de/view/58649293/en?dl=en) in the Appendix "Accessories/spare parts".

See also

Introduction (Page 6)

6.2 Electromagnetic compatibility

Definition of EMC

Electromagnetic compatibility (EMC) is the ability of an electrical installation to function satisfactorily in its electromagnetic environment without interfering with that environment.

Designing interference-free motor starters

For interference-free operation of the ET 200SP station in accordance with standard IEC 60947-4-2, use a dummy module before the first motor starter. No dummy module is necessary to the right of the motor starter.

Note the following mounting rules:

Use the following dummy module on the standard mounting rail between the previous module and the ET 200SP motor starter:

BU cover 15 mm: 6ES7133-6CV15-1AM0 with BaseUnit 6ES7193-6BP00-0BA0

For operation of the ET 200SP station with an unused BaseUnit, a cover must be provided for the open BaseUnit plug contacts (power connector, power bus connector, and backplane bus connector).

The cover protects the plug contacts against dirt. The BU cover can be ordered as an accessory.

NOTE

Use of interference suppressors with hybrid switchgear

No EMC protective wiring (e.g. RC element or varistor interference suppression module) is ever necessary with the ET 200SP motor starter. Observe the following section in this context Designing motor starters in conjunction with electromechanical switching devices (Page 28).

Under normal operating conditions, the motor is always switched off in current zero due to the specific properties of the hybrid switching technology. As result, no critical states in terms of EMC ever arise in the surrounding environment.

If EMC interferences nevertheless arise, an RC element can be connected to the motor (see section Designing motor starters in conjunction with electromechanical switching devices (Page 28), figure "Use of RC elements for reducing voltage peaks").

Mounting the dummy module

The figure below provides a schematic representation of how to implement measures for improving interference immunity.

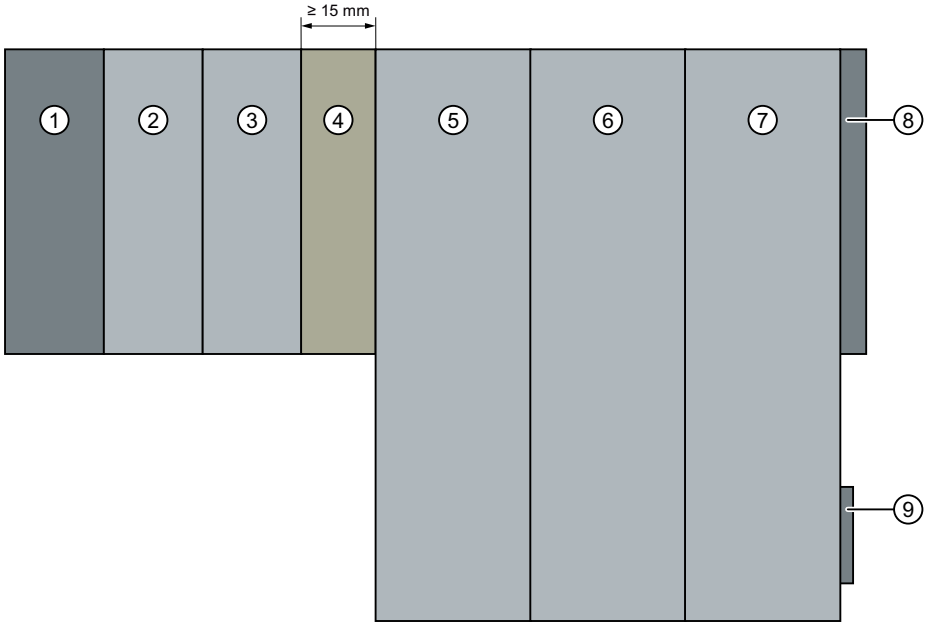

①	Interface module	⑥	Motor starter
②	Digital input module	⑦	Motor starter
③	Digital output module	⑧	Server module
④	Dummy module	⑨	Infeed bus cover
⑤	Motor starter		

NOTICE

Ensuring interference immunity

You must not plug any other module into the BaseUnit of the dummy module, otherwise interference immunity is no longer ensured.

NOTE

Using a dummy module

The dummy module cannot be configured in all versions of TIA Portal.

In this case, leave this slot unoccupied in TIA Portal.

6.3 Designing motor starters in conjunction with electromechanical switching devices

NOTICE
Use of motor starters in series with mechanical switching devices, e.g. line contactors When using motor starters in series with mechanical switching devices, e.g. line contactors, ensure that voltage peaks are prevented by means of the mechanical shutdown of small motors (high inductance). You can achieve this with a corresponding shutdown sequence or through the use of RC elements.

One advantage of the hybrid motor starters is, among other things, the shutdown in the current zero point, which has the advantage that no voltage peaks or arcing occur in the power circuit. Thus, electromagnetic interferences no longer exists due to the shutdown.

Switching an inductive load, in particular of motors with an output of < 1 kW with correspondingly high inductance, e.g. with a contactor, can cause an inductive voltage of several 1000 V with steep voltage edges, depending on the switching time. This can also occur multiple times due to the bouncing of the contactor contacts and the resultant arcs. For a contactor, this leads to increased contact erosion (wear) and to high electromagnetic load on other components due to coupling into other electric lines.

If a line contactor is also connected upstream or downstream of a motor starter, the shutdown of the line contactor when the motor is running generates a counter-acting self-induction voltage, which can reach a voltage of several 1000 V with a very steep voltage rise.

The motor starter is protected against overvoltage by internal varistors. If, however, the voltage peaks are significantly higher and/or they occur more frequently or in rapid succession (due to contactor bouncing), the varistors become overloaded and can no longer limit the voltage peaks. The voltage peaks are then present directly on the electronic switching element of the motor starter and can ultimately lead to damage and a defective device.

Remedial measures

- Delayed shutdown of the line contactor by the motor starter shutting down before the contact (in current zero point). These voltage peaks do not occur at all and the contactor can be shut down (de-energized) approx. 100 ms later. This also results in an increased service life of the contactor, because it always switches without load.
- Use of RC elements on the 3 motor phases. As a consequence, the voltage peaks and also the steep voltage rise are reduced.

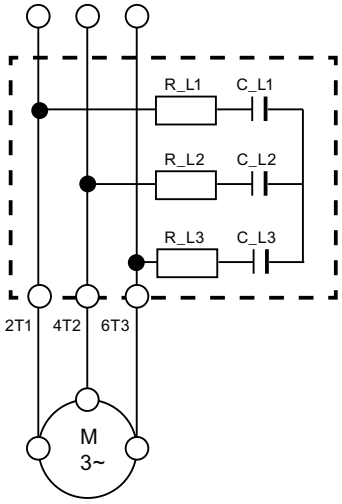

Figure 2-1030 Use of RC elements for reducing voltage peaks

The following RC elements are suitable:

- 3RK1911-6EA00 for the direct mounting on standard mounting rail
- 3RK1911-6EB00 for direct attachment to the motor terminal board
- RC elements for direct attachment on the S00 contactor (3RT2916-1P*). RC elements for load contactors larger than size S00 must be obtained through third-party manufacturers.

NOTICE
Connected motors Observe the dimensioning of the connected motors.

If other regenerative components (FU, motors, transformers, etc.) are connected to the motor starter, the FAQ "EMC interference with fail-safe ET 200SP motor starter with a device fault (https://support.industry.siemens.com/cs/us/en/view/109818881)" must be observed.

6.4 Applications

You can use the ET 200SP motor starters wherever you want to switch and protect drives up to 5.5 kW with an ET 200SP system.

The ET 200SP motor starters are used for the following, for example:

- Conveyor technology
- Logistics systems
- Production machines
- Machine tools
- Gas discharge lamps

Fail-safe motor starters are designed exclusively for the switching and protection of motor loads.

6.5 Permissible ambient temperatures up to 1000 m above sea level.

General supplementary conditions

You can install the motor starter in two mounting positions:

- Horizontal mounting position
- Vertical mounting position

The mounting position depends on the position of the standard mounting rail. The following maximum permissible ambient temperatures apply depending on the mounting position:

- Horizontal mounting position: 60 °C
- Vertical mounting position: 50 °C

Observe the following general conditions when using the motor starters:

- Parameterized rated operational current I_e
- Current of the infeed system (500 V AC)
- Current of the power bus (24 V DC)
- Fan operation; the fan switches itself on and off automatically depending on the temperature in the motor starter.

Stand-alone installation

You can operate motor starters equipped with fans with the max. parameterizable I_e within the specified temperature limits.

Use of fans in group configuration (side by side)

1) Operation with infeed system (500 V AC) up to 27 A

See the table below for the cases in which you must use a fan depending on the ambient temperature during operation with a infeed system (500 V AC) up to 27 A:

Set operational current I_e	Direct-on-line starter		Reversing starter	
	Horizontal mounting position	Vertical mounting position	Horizontal mounting position	Vertical mounting position
	Ambient temperature			
1 A	45°... 60 °C 1)	40°... 50 °C 1)	45°... 60 °C 1)	40°... 50 °C 1)
3 A	45 ... 60 °C 1)	40°... 50 °C 1)	45°... 60 °C 1)	40°... 50 °C 1)
5 A	40°... 60 °C 1)	35 ... 50 °C 1)	37°... 60 °C 1)	32°... 50 °C 1)
7 A	35 ... 60 °C 1)	30°... 50 °C 1)	32 ... 60 °C 1)	27°... 50 °C 1)
9 A	30°... 60 °C 1)	25 ... 50 °C 1)	25°... 55 °C 1)	20°... 50 °C 1)
> 9 A	Up to max. 50 °C 1) 2)	Up to max. 50 °C 1) 2)	Up to max. 50 °C 1) 2)	Up to max. 50 °C 1) 2)
> 10 A	Up to max. 45 °C 1) 2)	Up to max. 45 °C1) 2)	Up to max. 45 °C 1) 2)	Up to max. 45 °C 1) 2)

1) In operation with an infeed system up to 32 A, the maximum usage temperature is reduced by 10 K.

2) Fans are included in the scope of supply

NOTICE
Loadability of the power bus The power bus (24V DC) can only be loaded with up to 7 A when used with the motor starters.

2) Current of the infeed system (500 V AC) in accordance with UL/CSA requirements

NOTICE
A fan is absolutely necessary In this type of operation you always have to use a fan.

See the table below for the maximum ambient temperature at which you can run the motor starter when operating it with a infeed system (500 V AC) in accordance with UL/CSA requirements:

Set operational current I_e	**Direct-on-line starter, reversing starter**	
	Horizontal mounting position	**Vertical mounting position**
	Ambient temperature	
1 A	Up to max. 60 °C	Up to max. 50 °C
3 A	Up to max. 60 °C	Up to max. 50 °C
5 A	Up to max. 60 °C	Up to max. 50 °C
> 5 A	Up to max. 50 °C	Up to max. 50 °C
> 9 A	Up to max. 45 °C [1)]	Up to max. 45 °C [1)]

1) Fans are included in the scope of supply

NOTICE
Loadability of the power bus The power bus (24V DC) can only be loaded with up to 7 A when used with the motor starters.

6.6 Permissible ambient temperatures at more than 1000 m above sea level.

Current derating as a function of the installation altitude is applicable for devices with and without fans.

Possible restrictions through current derating at installation altitudes above 1000 m above sea level can be compensated for by using a fan.

The following table shows the current derating as a function of the altitude of the installation location:

Installation altitude h in m	I_e in %	Max. ambient temperature (vertical/horizontal installation)
1000 m	100 % (see above)	
2000 m	92 %	+ 60 °C ... + 50 °C
3000 m	85 %	+ 54 °C ... + 45 °C
4000 m	78 %	+ 48 °C ... + 40 °C

The I_e values can be interpolated on the basis of the available altitude specifications.

NOTICE

Derating of the nominal/rated data for the insulation coordination beyond specific altitudes above sea level

- Up to an elevation of 2000 m above sea level, operation is possible without derating of the nominal/rated data for the insulation coordination.
- With an installation altitude higher than 2000 m and below 4000 m above sea level, observe the following:
  - Line connection / E-bus: the permitted overvoltage category is reduced from III to II
  - Power bus (24 V power supply): only SELV / PELV supply permitted

NOTICE

Extension of the application range for fail-safe SIMATIC ET 200SP motor starters at installation altitudes of up to 4000 m above sea level

For information on this, please refer to the current product release Extension of the application range for fail-safe SIMATIC ET 200SP motor starters up to an installation altitude of 4000 m (https://support.industry.siemens.com/cs/ww/en/view/109778836).

6.7 Device versions

Current ranges

The table below shows the switchable motor powers depending on the primary voltage, according to DIN EN 60947-4-1: Table G.1. The stated current ranges are valid for the ET 200SP motor starters.

	0.1 ... 0.4 A		0.3 ... 1 A		0.9 ... 3 A		2.8 ... 9 A		4 ... 12 A	
	0.1 A	**0.4 A**	**0.3 A**	**1 A**	**0.9 A**	**3 A**	**2.8 A**	**9 A**	**4 A**	**12 A**
230 V AC	< 0.06 kW	0.09 kW	< 0.06 kW	0.18 kW	0.18 kW	0.55 kW	0.55 kW	2.20 kW	0.75 kW	3.0 kW
400 V AC	< 0.06 kW	0.12 kW	< 0.09 kW	0.25 kW	0.37 kW	1.10 kW	1.50 kW	4.00 kW	1.5 kW	5.5 kW
500 V AC	< 0.06 kW	0.18 kW	< 0.12 kW	0.37 kW	0.55 kW	1.50 kW	1.50 kW	4.00 kW	2.2 kW	5.5 kW

The assignments of the motor currents to the motor powers are recommended values. Due to the introduction of energy-efficient motors (IE3, IE4) to the market, rated currents are falling for any given power. At the same time, the start-up currents rise.

NOTICE

Dimensioning instructions

Take the current characteristics of the connected motor and motor starter into account when dimensioning. The following characteristic values are relevant:

- Ratio of rated current to motor starting current
- The maximum starting current of the motor may deviate from the values specified by the manufacturer by 20% in accordance with EN 60034-1.
- Maximum permissible current range of the motor starter: The permissible current range can be found in the graphic in Chapter "Device protection model (Page 72)".

You will find more information on dimensioning switching devices for IE3/IE4 motors in the Switching devices application manual (http://support.automation.siemens.com/WW/view/en/94770820).

6.8 Operating motor starters

Hardware and software requirements

Fail-safe ET 200SP motor starters are supported by IM155-6PN BA interface modules with firmware V3.2 or higher, IM155-6PN ST with firmware V3.1 or higher, IM155-6PN HF with firmware V3.1 or higher and IM155-6DP HF with firmware V3.0 or higher.

You require SIMATIC STEP 7 V14 or higher for configuring and programming fail-safe ET 200SP motor starters. No additional safety software (e.g. F-Configuration Pack) is required for configuring and programming the fail-safe ET 200SP motor starter.

NOTE

Requirements for manual bus mode

The device firmware V1.2.0 or higher is required for manual bus mode of the ET 200SP motor starter.

NOTE

Configuration of the ET 200SP motor starters with the TIA Portal software SIMATIC STEP 7 V13 or higher is possible with a GSD file (GSDML).

Checking switching elements

The switching elements (semiconductors, relays) are checked automatically when the motor is switched off and on via the motor starter.

The switching elements cannot be checked in the following operating states:

- During operation (Motor ON)
- In the switched-off state (Motor OFF)

Therefore ensure that the switching elements are regularly checked by the following actions:

- Monthly self-test of the motor starter if the motor starter has been switched off for more than a month:
  - Self-test by switching the motor on and off

  or alternatively
  - Commissioning of the entire system
- If the motor is operated continuously, disconnect it from the power supply at least once monthly by way of the motor starter.
- In the case of reversing starters, check the switching elements for both directions of rotation: To do this, start the motor once in the clockwise direction and once in the counter-clockwise direction.

The switching on and off routines must be run through without errors. This means:

- Current must flow.
- The motor starter must not display any errors.
- The supply voltage must be stable.

The switching on or off routine is canceled as soon as an error is detected. The motor starter assumes the safe OFF state. Observe to the diagnostic messages in DS72 logbook - Read device error (Page 133). Depending on the error message, you can reset the error by switching off the 24 V supply voltage and then switching it on again.

If you switch on when the line voltage is interrupted or a load is missing, the following messages are generated:

- Residual current detected
- Residual current disconnection

This message can be acknowledged by the Trip Reset / Reset pushbutton.

If the supply voltage is interrupted during switching on or off, this may lead to a device fault (entry 308 in data set 92 (Page 139)). In addition, the following entries in DS72 logbook - Read device error (Page 133) are possible:

- 20017 "Residual current detection during switching on/off routine or bypass element does not close"
- 20018 "Error in switching element diagnostics in the switching off process"

You can reset these faults and subsequently continue operating the motor starter following a fault-free test cycle as described above. If the faults recur, this indicates that the motor starter is defective in spite of the fact that the supply voltage conditions are stable. Replace the motor starter in this case.

Replacing the fail-safe motor starter

When replacing a fail-safe motor starter, pay attention to the commissioning specifications for fail-safe systems.

Fail-safe input F-DI on the BaseUnit

The fail-safe input on the BaseUnit is designated as follows in the manual with "F-DI".

In the case of safety-related applications, control the F-DI on the BaseUnit from a safe output.

NOTICE
Connection of the F-DI input of the BU-30-MS5 to BU-30-MS10 BaseUnits to surge filters If your equipment makes it necessary to protect the contact against overvoltage, you have to connect the F-DI input of the BU-30-MS5 to BU-30-MS10 BaseUnits to surge filters! Refer to Chapter "Electromagnetic compatibility" in ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/de/view/58649293/en?dl=en).

WARNING

Safety-related shutdown via the F-DI

Depending on peripherals used, the shutdown takes place via one or two output channels (terminals):

- PM switching: The shutdown takes place via two output channels.
- PP switching: The shutdown takes place via one output channel.

Shutdown via one output channel (PP switching) achieves SILCL 3 according to EN 62061, PL e/Cat. 4 according to EN ISO 13849-1 if steps are taken to ensure that the cables are installed in such a way that they are protected against a cross-circuit/line-to-line fault.

For the BU-30-MS7 to BU-30-MS10 F-DI forwarding BaseUnits, only PP switching is possible.

For the single F-DI BaseUnits BU-30-MS5 and BU-30-MS6, PM and PP switching are possible.

Bright and dark tests

With bright and dark tests, safety relays such as ET 200SP F-PM-E (6ES7136-6PA00-0BC0) or SIRIUS 3SK check whether their safe outputs can still be activated and deactivated. The bright and dark tests are run cyclically. The ET 200SP motor starter is intended for operation with an F-PM-E or 3SK connected upstream and is adapted to the bright and dark test times of these devices.

You can find more information on the operating principle and parameter assignment of bright and dark tests in the respective device manual.

To avoid an unintentional response of the fail-safe motor starter during the bright and dark test, these tests must not exceed a certain time. Due to component aging, the permissible read-back time can also decrease throughout the motor starter's service life. The voltage of the power supply unit also has an influence on the permissible read-back time. Increase the power supply unit's output voltage to minimize the risk of incorrect deactivation during dark tests.

By trial and error, set the read-back time as low as possible, but so high that the output channel is not deactivated.

WARNING

Inadvertent starting of the motor if the bright test lasts too long

The motor can start if the bright test lasts more than 10 ms. There is a risk of severe injury or death. Material damage is also possible.

Make sure that the bright test lasts less than 10 ms on devices that are connected upstream of the motor starter.

Power supply

In the case of a 24 V DC power supply, observe the following safety measures:

- Ensure safe electrical separation and separate routing of cables.
- Ensure increased insulation of the extra-low voltage (SELV/PELV) from circuits with hazardous potentials in accordance with IEC 60364-4-41.

- To deactivate safely via the 24 V power bus, use a suitable power supply in compliance with the requirements of the safety classification used.
- In corner-grounded delta networks, ensure increased insulation of the extra-low voltage (SELV/PELV) from circuits with hazardous potentials in accordance with NFPA 79.

Current consumption of the ET 200SP motor starters in the electric torque

NOTICE
Brief current peak possible In the electric torque of the 24 V DC power supply, a brief current peak can occur depending on the number of motor starters. Ensure an appropriate layout of your voltage source, taking this current peak into consideration.

Selection of a SITOP power supply including selective load circuit monitoring for an ET 200SP station with fail-safe I/O modules and motor starters:

See FAQ ET 200SP motor starter + fail-safe I/O + SITOP including selectivity (https://support.industry.siemens.com/cs/ww/en/view/109781189) in Industry Online Support.

Peak current in the start-stop torque

Number of motor starters	Current in A	Time in ms (until 8 A rated current is reached)
1	25	0.145
2	47	0.24
3	64	0.32
4	78	0.36
5	91	0.42
6	101	0.46
7	111	0.51
8	119	0.56
9	127	0.61
10	134	0.67
11	140	0.71
12	145	0.78
13	150	0.85
14	155	0.90
15	159	0.97
16	162	1.05
17	165	1.10
18	168	1.20

Number of motor starters	Current in A	Time in ms (until 8 A rated current is reached)
19	170	1.30
20	172	1.40
21	174	1.50
22	176	1.60
23	178	1.80
24	179	2.10
25	180	2.50
26	181	3.20
27	182	4.00
28	183	5.00
29	184	6.90
30	186	9.00

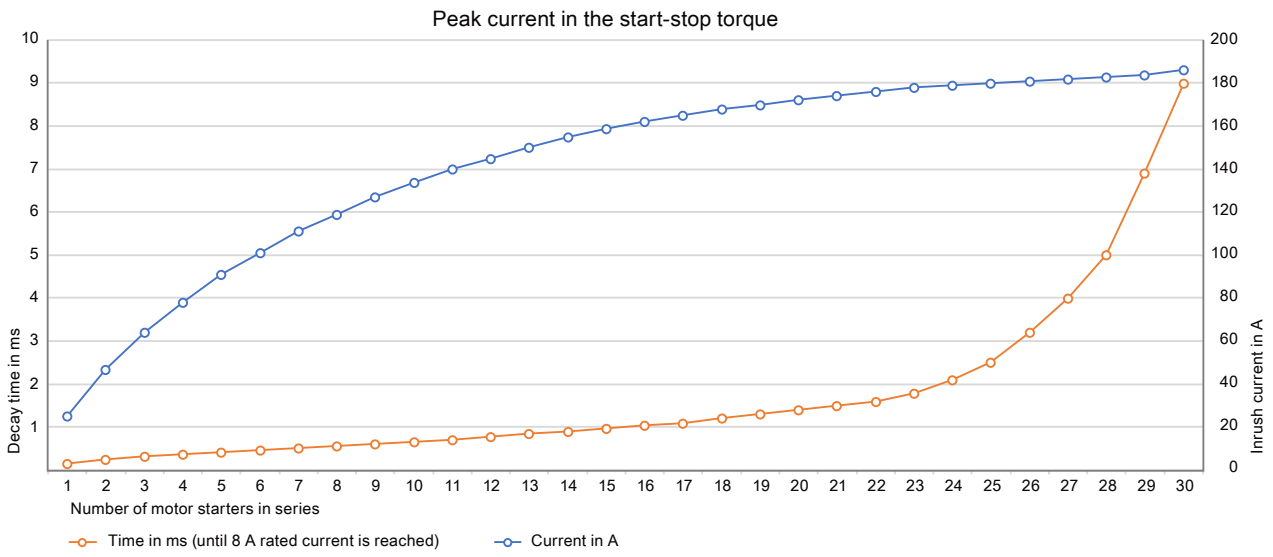

Figure 2-1031 Peak current in the start-stop torque

Connecting and operating motor brakes

ET 200SP motor starters can be operated for the following braking applications:

- Variant 1: High Feature DOL starter or reversing starter and F DOL starter or F reversing starter with 400 V brake
- Variant 2: High Feature DOL starter or reversing starter with 230 V brake
- Variant 3: High Feature DOL starter or reversing starter and F DOL starter or F reversing starter with 230 V brake without connection to the neutral conductor

Variant 1. High Feature DOL starter or reversing starter and F DOL starter or F reversing starter with 400 V brake

The current for the braking device is drawn from two phases.

NOTICE
Current drain for the braking device Note that the current for the braking device may only be taken from terminals T1 and T3. Otherwise, the motor starter may be damaged.

The connection of the motor brake leads to phase asymmetry at the motor connection. This is detected by the motor starter, which responds based on its parameter settings and the magnitude of the asymmetry.

Asymmetry limit:

The asymmetry limit is a percentage value by which the motor current is allowed to deviate in each phase. Asymmetry is detected as soon as one of the three phases deviates by more than 40 % from the mean value of all phases.

Response to asymmetry:

You use this device parameter to determine the behavior of the motor starter in the event of asymmetry:

- Warning (not permissible for fail-safe motor starters in ATEX operation)
- Shutdown

NOTE

Using brake motors

When using brake motors, you have to increase the set rated motor current by the braking current (see example on motor and brake starting current later in this chapter).

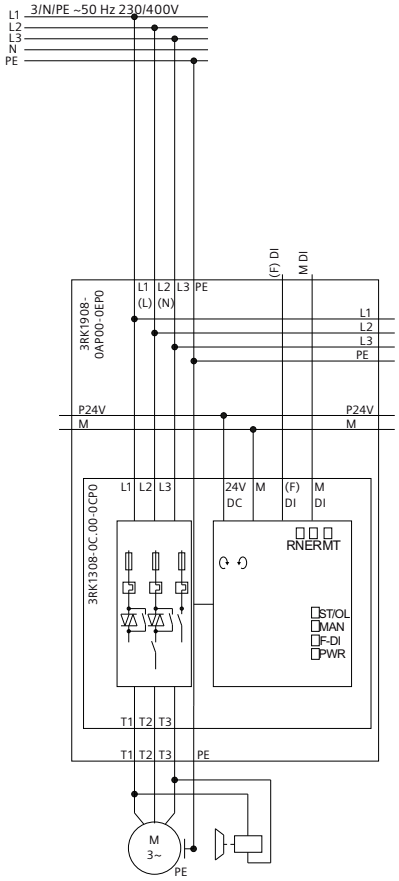

Figure 2-1032 Connection of a 400 V brake to an ET 200SP motor starter

Variant 2. High Feature DOL starter or reversing starter with 230 V brake

The current for the braking device is drawn from only one switched phase. Connection is via T1.

The single-phase connection of the motor brake leads to phase asymmetry at the motor connection. This is detected by the motor starter, which responds based on its parameter settings and the magnitude of the asymmetry.

Asymmetry limit:

The asymmetry limit is a percentage value by which the motor current is allowed to deviate in each phase. Asymmetry is detected as soon as one of the three phases deviates by more than 40 % from the mean value of all phases.

Response to asymmetry:

You use this device parameter to determine the behavior of the motor starter in the event of asymmetry:

- Warning (not permissible for fail-safe motor starters in ATEX operation)
- Shutdown

NOTE

Using brake motors

When using brake motors, you have to increase the set rated motor current by the braking current (see example on motor and brake starting current later in this chapter).

NOTICE

Using this mode

This operating mode is **not** suitable for 3RK1308-0C and fail-safe 3RK1308-0D motor starters as there is a connection to the neutral conductor.

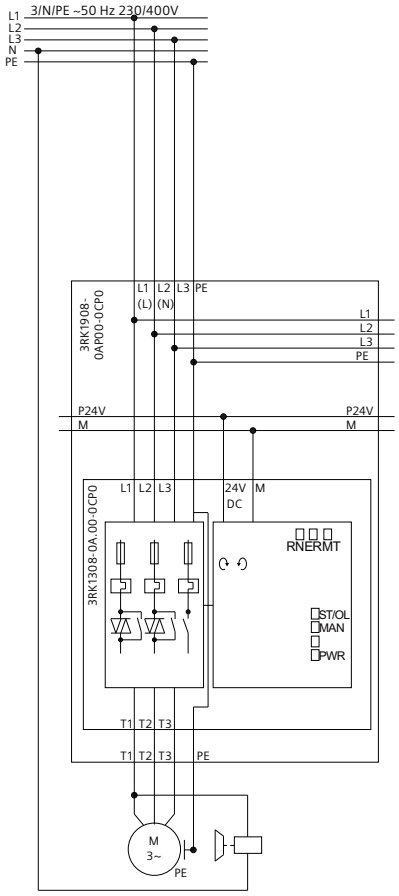

Figure 2-1033 Connection of a 230 V brake with connection to the neutral conductor to an ET 200SP motor starter

Variant 3. High Feature DOL starter or reversing starter and F DOL starter or F reversing starter with 230 V brake without connection to the neutral conductor

The current for the braking device is drawn from only one switched phase. Connection is via T1. The second connection of the braking device is made at the neutral point of the motor windings and there is **no** connection to the neutral conductor.

The single-phase connection of the motor brake leads to phase asymmetry at the motor connection. This is detected by the motor starter, which responds based on its parameter settings and the magnitude of the asymmetry.

Asymmetry limit:

The asymmetry limit is a percentage value by which the motor current is allowed to deviate in each phase. Asymmetry is detected as soon as one of the three phases deviates by more than 40 % from the mean value of all phases.

Response to asymmetry:

You use this device parameter to determine the behavior of the motor starter in the event of asymmetry:

- Warning (not permissible for fail-safe motor starters in ATEX operation)
- Shutdown

NOTE

Using brake motors

When using brake motors, you have to increase the set rated motor current by the braking current (see example on motor and brake starting current later in this chapter).

NOTICE

Using this mode

This operating mode is **also** suitable for fail-safe 3RK1308-0C and 3RK1308-0D motor starters as there is no connection to the neutral conductor.

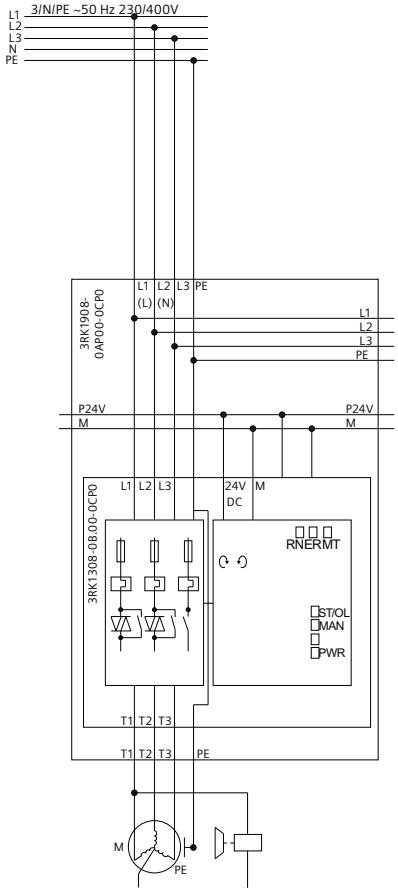

Figure 2-1034 Connection of a 230 V brake in star connection and connection to the neutral point on an ET 200SP motor starter

Overview

The table below shows which motor starters can be operated with which of the three variants (✓ = permissible; - = not permissible):

Version	**1** **400 V brake**	**2** **230 V brake with connection to the neutral conductor**	**3** **230 V brake with connection to the neutral point**
Motor connection	Star or delta connection	Star or delta connection	Star connection only
Brake closing time 1)	Long	Very short	Medium
High Feature DOL starter	✓	✓	✓
High Feature reversing starter	✓	✓	✓
High Feature F DOL starter	✓	-	✓
High Feature F reversing starter	✓	-	✓

NOTICE
Brake properties The brake properties vary depending on the type of connection. Please observe the information provided by the motor manufacturer.

NOTE

1)

The brake closing time is influenced accordingly by the type of connection and the selected braking device.

For detailed information, see the documentation provided by the motor manufacturer. The brake configurations described can result in a time response that deviates from the specifications of the motor manufacturer.

Checking the settings

Always check the safety-related parameters during acceptance of the system. Also always check the parameters if a parameter has been changed or if you are commissioning the system for the first time.

Example of the correct engineering of a motor starter

NOTICE
Maximum current-carrying capacity Note that the sum of the starting current of the motor and the inrush current of the brake must not exceed the maximum current-carrying capacity of the selected motor starter.

- Rated motor current I_{rated}: 2.45 A
- Braking current I_B: 0.50 A
- Setting value on motor starter: $I_e = I_{rated} + I_B = 2.95$ A
- Motor starting current factor: I_{St}/I_{rated} 8-fold
- Brake inrush current factor: 8-fold
- Motor starting current: $I_{St} = I_{rated} * I_{St}/I_{rated} = 2.45$ A * 8 = 19.6 A
- Maximum brake inrush current: I_B * 8 = 0.5 A * 8 = 4 A
- Motor starting current + brake inrush current: 19.6 A + 4 A = 23.6 A

- Maximum current-carrying capacity of 3 A motor starter (3RK1308 - 0AC00-0CP0): 30 A; see also data sheet (https://support.industry.siemens.com/cs/ww/en/ps/21800/faq (https://support.industry.siemens.com/cs/ww/en/ps/21800/faq))
- **Result:** The maximum current-carrying capacity is 23.6 A. It is below 30 A for this application. This means that you can use the ET 200SP motor starter (3RK1308 - 0AC00-0CP0) for this application.

Operation by experienced users only

WARNING

Qualified personnel required

All work involved in connecting, commissioning, operation and maintenance must be carried out by **qualified, responsible** personnel.

Failure to follow proper procedures may result in **personal injury and damage to property**.

ATEX-certified motor overload protection

Fail-safe ET 200SP motor starters are approved under device group II, Category 2) in the "GD" area. This means that the fail-safe motor starters can protect motors that are located in hazardous gas, vapor, mist and air mixtures and also combustible dust.

WARNING

The motor starter is not suitable for installation in hazardous areas.

Due to the increased danger in hazardous areas, observe the following standards:

- EN 60079-14 / VDE 0165-1 Explosive atmospheres - Part 14: Electrical installations
- EN 60079-17 Explosive atmospheres - Part 17: Electrical installations inspection and maintenance
- EN 50495 Safety devices required for the safe functioning of equipment with respect to explosion risks

See also

FAQ ET 200SP motor starter (https://support.industry.siemens.com/cs/ww/en/ps/21800/faq)

Functions

7

7.1 Overview of functions

The table below shows the functions of the various versions of ET 200SP motor starters:

	Direct-on-line starter	Reversing starter	Fail-safe direct-on-line starter	Fail-safe reversing starter
Basic function/basic parameter (Page 49)				
• Rated operational current (Page 49)	x	x	x	x
• Load type (Page 51)	x	--- (Only 3-phase possible)	x ("1-phase" not possible for ATEX applications)	---
Motor control (Page 52)				
• Electronic switching technology (hybrid switching technology) (Page 52)	x	x	x	x
• Control function (Page 54)	---	x	---	x
• Operating modes (Page 55)	x	x	x	x
Overload protection (Page 57)	x	x	x (Restrictions in ATEX operation)	x (Restrictions in ATEX operation)
Substation monitoring (Page 67)				
• Response to residual current detection (Page 67)	x	x	--- (Only "Deactivate" possible)	--- (Only "Deactivate" possible)
• Upper/lower current warning limit (Page 71)	x	x	x	x
• Upper/lower current limit (Page 71)	x	x	x	x
• Substation monitoring (Page 67)	x	x	x	x
• Blocking time and blocking current (Page 72)	x	x	x	x
• Blocking time and blocking current (Page 72)	x	x	x	x
• Asymmetry monitoring (Page 75)	x	x	x (Restrictions in ATEX operation)	x (Restrictions in ATEX operation)
• Short-circuit protection (fuses) (Page 76)	x	x	x	x
Response to CPU/master STOP (Page 78)	x	x	x	x

	Direct-on-line starter	Reversing starter	Fail-safe direct-on-line starter	Fail-safe reversing starter
Group fault diagnostics/group warning diagnostics (Page 78)	x	x	x	x
TEST/RESET button (Page 124)	x	x	x	x
Emergency start (Page 87)	x	x	x (Not with an ATEX application)	x (Not with an ATEX application)
Trip RESET (Page 91)	x	x	x	x
Cold start (Page 91)	x	x	x [1)]	x [1)]
PROFIenergy (Page 94)	x	x	x	x
Logbook (Page 93)	x	x	x	x
Maintenance (Page 127)	x	x	x	x
Parameter start interlock [1)]	x	x	x	x
Manual bus [1)]	x	x	x	x
Diagnosis "Supply voltage too low"	x	x	x	x

1) From FW Version 1.2.0

The following functions are available when using the 3DI/LC module via the inputs:

	Direct-on-line starter	Reversing starter	Fail-safe direct-on-line starter	Fail-safe reversing starter
Inputs (Page 78)	x	x	x	x
Manual local (local control) (Page 84)	x	x	x	x
Trip without restart (Page 84)	x	x	x	x
Trip with restart (Page 84)	x	x	x	x
Trip emergency end position CW (Page 85)	x	x	x	x
Trip emergency end position CCW (Page 86)	x	x	x	x
Group warning (Page 87)	x	x	x	x
Emergency start (Page 87)	x	x	x (Not with an ATEX application)	x (Not with an ATEX application)
Motor CW (Page 88)	x	x	x	x
Motor CCW (Page 88)	---	x	---	x
Quick Stop direction-independent (Page 88)	x	x	x	x
Quick Stop clockwise (Page 90)	x	x	x	x
Quick Stop counter-clockwise (Page 90)	---	x	---	x
Trip RESET (Page 91)	x	x	x	x
Cold start (Page 91)	x	x	x [1)]	x [1)]
Operational trip end position CW (Page 92)	x	x	x	x
Operational trip end position CCW (Page 92)	x	x	x	x

1) From FW Version 1.2.0

The following functions are safety-related:

	Fail-safe direct-on-line starter	Fail-safe reversing starter
Response to safety-related tripping (Page 76) (STO = Safe Torque Off)	x	x
Ex motor application (Page 77)	x	x
Rated operational current (Page 49)	x (ATEX application only)	x (ATEX application only)
Overload protection (Page 57)	x (ATEX application only)	x (ATEX application only)

NOTE

Restrictions in relation to monitoring and input functions

When you activate safety-related functions, parameterization of the monitoring or input functions may be restricted.

7.2 Intrinsic protection

The ET 200SP motor starter protects itself against overload. Intrinsic device protection cannot be parameterized or switched off. You can find more information on the permissible ambient temperatures in chapter Permissible ambient temperatures up to 1000 m above sea level. (Page 30).

If the intrinsic protection becomes active, the follow responses occur:

- The motor trips.
- Emergency starting is not possible in the case of tripping due to intrinsic device protection.
- The diagnostic message "Switching element overload" is output in DS92 Read device diagnostics (Page 139).
- The entry "Number of switching element overload trips" in DS95 Read statistics (Page 144) is incremented by 1.

As of device firmware V1.2.0, the value of the device protection model can be read out via the DS94 Read measured values (Page 143).

If the intrinsic device protection was active, the device's diagnostics function indicates a device fault.

NOTICE

Damage due to operation of capacitive loads possible

When capacitive loads are used, the switching components in the ET 200SP motor starter can be destroyed by high inrush currents.

NOTICE
Material damage due to operation with frequency converters possible Operation in series with a frequency converter is not allowed. The switching components in the motor starter can be destroyed when operating an ET 200SP motor starter in series with a frequency converter.

7.3 Basic function/basic parameter

7.3.1 Basic functions/parameters during first commissioning

The default settings listed in the following two chapters apply to first commissioning and as defaults for the programming devices (exception: rated operational current). When a motor starter is set to the commissioning mode again, it uses the values that were valid when the technology supply voltage was last lost.

7.3.2 Rated operational current

This parameter is used to set the rated operational current that the feeder can carry without interruption. Usually, the rated operational current of the motor is specified on the rating plate of the motor. The adjustment range depends on the performance class of the ET 200SP motor starter.

NOTE

Rated operational current

The rated operational current is one of the key parameters.

You cannot disable motor protection completely. However, you can prevent the shutdown of the motor by selecting the parameter Overload protection (Page 57).

In this case, motor protection must be ensured by other measures (e.g. a thermistor in the motor).

NOTE

Functional switching

Observe the minimum loads for the ET 200SP motor starters.

The minimum loads are specified in the technical specifications of the relevant device. You can find more information on the minimum loads in chapter "Minimum load current (Page 54)".

Current motor current

The latest current in the motor starter is returned via the process image for analysis. In addition, you can read out the latest current with phase precision in data set 94.

The current is measured in two phases. The current for the third phase is calculated. The highest of the three values is determined. The returned 6-bit value specifies the motor current ratio I_{curr} / I_{rated} (I_{rated} = parameterized rated operational current).

The value is represented by one digit before the decimal point (DI 1.5) and five digits after the point (DI 1.0 to DI 1.4). This results in a maximum ratio for I_{curr} / I_{rated} of 1.96875 (approx. 197 %).
The resolution is 1/32 per bit (3.125 %).

DI 1.5	DI 1.4	DI 1.3	DI 1.2	DI 1.1	DI 1.0	
2^0	2^{-1}	2^{-2}	2^{-3}	2^{-4}	2^{-5}	
1	0.5	0.25	0.125	0.0625	0.03125	Sum = 1.96875
0	0	0	0	0	0	I_{curr} = 0
1	0	0	0	0	0	I_{curr} = I_{rated} x 1
1	0	1	1	0	0	I_{curr} = I_{rated} x 1.375
1	1	1	1	1	1	I_{curr} = I_{rated} x 1.96875

I_{curr} = rated operational current I_{rated} x value (DI 1.0 to DI 1.5)

I_{rated} = rated current of the motor

Default setting

- In the ET 200SP motor starter, the rated operational current is preset at the factory to the maximum value. In the event of renewed parameterization, the parameters last set apply.
- Due to the engineering systems, the rated operational current is preset to the minimum value for safety reasons. You must therefore parameterize this value when you configure the system. The ET 200SP motor starter may otherwise trip due to overload on first starting.

Settings

Table 2-1149 Settings for actual motor current

Device parameters	Default settings	Setting range
Rated operational current	• In the motor starter: maximum value or last parameterization • In engineering systems: minimum value	• 0.1 A ... 0.4 A • 0.3 A ... 1 A • 0.9 A ... 3 A • 2.8 A ... 9 A • 4 A ... 12 A Increment: 0.01 A

The setting range depends on the device type.

7.3.3 Load type

This is where you select whether the motor starter should protect a single-phase or a three-phase load.

NOTE

Reversing starter

1-phase loads are not permissible on the reversing starter. 1-phase operation is also not permissible after activation of the "EX motor" parameter in the case of fail-safe direct motor starters.

Settings

Table 2-1150 Settings for load type

Device parameters	Default setting	Setting range
Load type	3-phase	• 3-phase • 1-phase

3-phase operation

In 3-phase operation, you can operate a 3-phase asynchronous motor at the connections of the motor starter.

To ensure motor protection, do not connect more than one motor to one motor starter.

Do not operate several single-phase motors on one motor starter in three-phase operation.

1-phase operation

In 1-phase operation, you can operate a 1-phase asynchronous motor at the connections of the motor starter. 1-phase operation is only possible when using a direct-on-line starter. The relevant three-pole tripping characteristics apply to single-phase operation.

Feed in the line voltage on terminals L1 and L2(N) only and connect the single-phase motor to the terminals T1 and T2 only.

An ATEX application in 1-phase operation is not possible with the motor starter.

7.4 Motor control

7.4.1 Electronic switching technology (hybrid switching technology)

The ET 200SP motor starter combines the advantages of semiconductor technology and relay technology.

The ET 200SP motor starter switches the load in phases L1 and L2 via semiconductors and bypass relays. Phase L3 is always switched via a relay.

DANGER

Hazardous Voltage
Can Cause Death or Serious Injury

If the line voltage is applied at the infeed bus of the motor starter, a hazardous voltage may be active at the output of the motor starter even without a motor ON command. When working on the feeder, you must ensure disconnection from the power, e.g. by the position "Parking position/OFF".

You will find further information on the "Parking position/OFF" in the System Manual.

This combination is known as hybrid switching technology. Hybrid switching technology in the ET 200SP motor starter is characterized by the following properties:

Switching on

The inrush current in the case of motorized loads is conducted briefly via the semiconductors.

Advantage: The relay contacts are protected. Longer service life is achieved thanks to reduced wear and tear.

Current routing

The continuous current is routed via relay contacts.

Advantage: Relay contacts cause lower thermal losses than semiconductors.

Switching off

Switching off is implemented via the semiconductors.

Advantage: The contacts are not stressed with arcs when switching via the semiconductors. This results in increased service life.

Schematic circuit diagram

The following figures show schematic circuit diagrams of the High Feature version and of the fail-safe version of the ET 200SP motor starter (direct-on-line starter version):

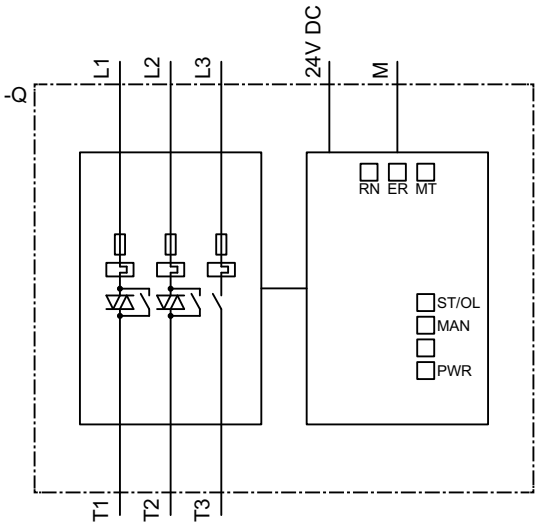

Figure 2-1035 Schematic circuit diagram of HF direct-on-line starter

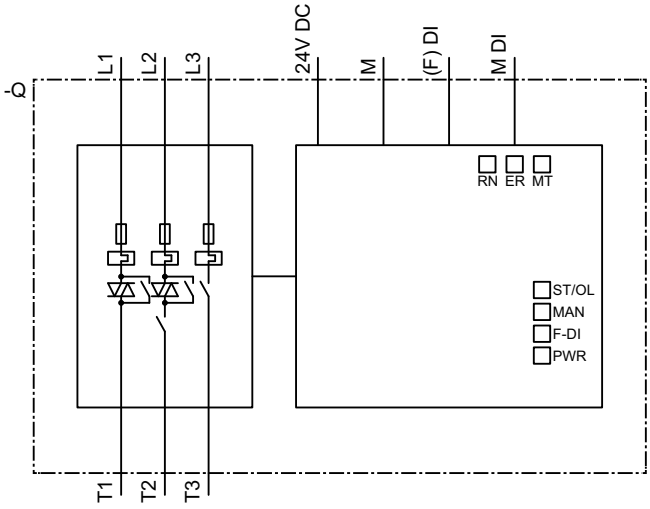

Figure 2-1036 Schematic circuit diagram of fail-safe direct-on-line starter

The ET 200SP motor starters do not possess any galvanic isolation of the switching elements in the main circuits. The isolating function in compliance with EN 60947-1 is only warranted in the parking position.

See also

ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293)

7.4.2 Minimum load current

The minimum load current is 20% of the set motor current, but at least the absolute minimum current specified in the tables below.

The minimum load current differs between the ET 200SP motor starters and the fail-safe ET 200SP motor starters:

Load current	0.1 ... 0.4 A	0.3 ... 1 A	0.9 ... 3 A	2.8 ... 9 A	4 ... 12 A
Motor/ohmic load of motor starter	0.05	0.15	0.18	0.56	0.8
Motor load of fail-safe motor starter	0.05	0.15	0.45	1.4	2

As soon as the minimum current limit is undershot during operation, the fault detection (residual current detection) picks up.

Disconnection or a warning is triggered depending on the setting of the "Response to residual current detection" parameter.

Residual current detection cannot be parameterized to "Warn" in the case of fail-safe motor starters.

See also

DS72 logbook - Read device error (Page 133)

DS92 Read device diagnostics (Page 139)

7.4.3 Control function

The motor starter controls the direction of rotation of motors with the control function. Internal logic prevents you from activating both directions of rotation simultaneously.

The graphic below shows the reaction times of the motor starter to control commands. The reaction times when restarting and changing direction of rotation are identical.

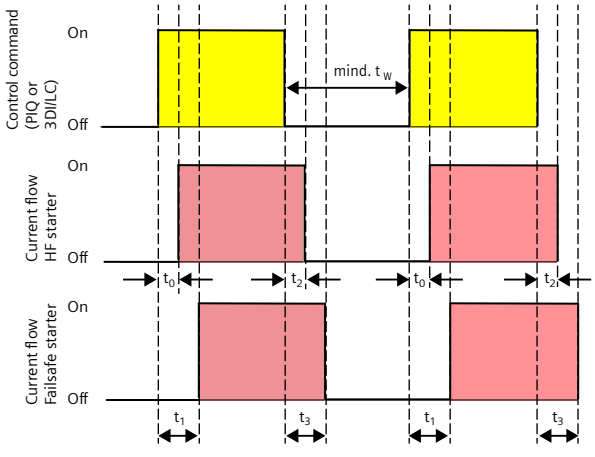

Figure 2-1037 Control command reaction times

Timing:

Times t_0 to t_3 for the PIQ include a time dependency on the clock of the fieldbus and the station topology of +5 ms jitter.

For the 3DI/LC modules, a debounce time of 10 ms is included.

Timing (worst case) PIQ

- t_0: Time until current flow after the switch-on command for the HF starter: 30 ms (up to V1.2.0 25ms)
- t_1: Time until current flow after the switch-on command Safety starter: 40 ms (up to V1.2.0 30ms)
- t_2: OFF delay after switch-off command HF starter: 35 ms
- t_3: OFF delay after switch-off command Failsafe starter: 50 ms
- t_W: Recovery time: Time that must elapse due to an internal interlocking time until a repeat switch-off command is accepted after a switch-off command:
  - HF starter 195 ms
  - Failsafe starter: 215 ms

Timing (worst case) 3DI/LC

- t_0: Time until current flow after the switch-on command for the HF starter: 35 ms (up to V1.2.0 30 ms)
- t_1: Time until current flow after the switch-on command Safety starter: 45 ms (up to V1.2.0 35 ms)
- t_2: OFF delay after switch-off command HF starter: 40 ms
- t_3: OFF delay after switch-off command Failsafe starter: 55 ms
- t_W: Recovery time: Time that must elapse due to an internal interlocking time until a repeat switch-off command is accepted after a switch-off command:
  - HF starter 200 ms
  - Failsafe starter: 220 ms

7.4.4 Operating modes

The following modes are available (in ascending order of priority):

- Operating mode: Automatic (lowest priority)

  The motor starter can only be controlled with the PLC via the fieldbus.

  Automatic mode is activated automatically when communication with the interface module or the higher-level CPU is established.
- Operating mode: Manual bus: Controlling the motor starter by means of software, e.g. TIA Portal V16, via fieldbus is possible [1)]

- Operating mode: Manual local via the 3DI/LC module (highest priority)

  The motor starter can be controlled as follows:

  – Set the "Local Control" (LC on the 3DI/LC module) input to activate manual local mode.
  – Also set a digital input on the 3DI/LC module (1, 2 or 3, depending on the parameterization) to "Motor CW" or "Motor CCW", for example.

Using the LED "MAN", the message bits in the Address space (Page 117) and the DS92 Read device diagnostics (Page 139), you detect which control source currently has control priority:

- Operating mode: Automatic ("MAN" LED off)
- Operating mode: Manual local ("MAN" LED on)

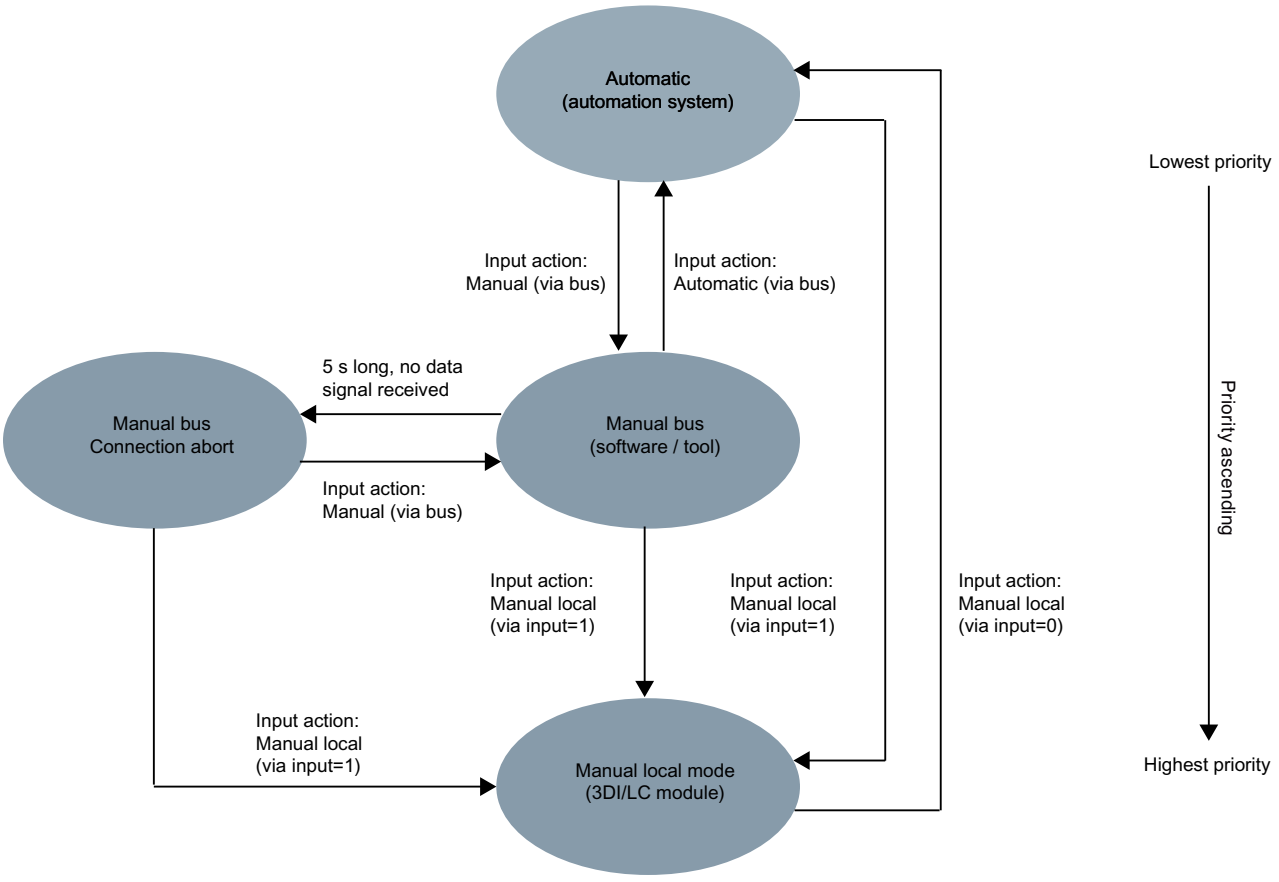

Figure 2-1038 Operating modes

1) possible as of firmware version 1.2.0

7.5 Overload protection

Description

The approximate temperature of the motor is calculated using the measured motor currents and device parameters "Rated operating current" and "Tripping class". This indicates whether the motor is overloaded or is functioning in the normal operating range.

NOTE

Ensuring overload protection

Do not connect multiple motors to one motor starter due to overload protection, mutual interference between the motors, etc.

Response of the thermal motor model on restart

You set the response of the thermal motor model on restart with this parameter:

- Retention of the thermal motor model on restart

  If the motor starter has been disconnected from the 24 V power supply, the thermal motor model is at the same motor temperature rise state when the power supply is restored as it was before disconnection. This behavior protects the motor against overload in the case of brief failures of the 24 V power supply. With this setting, you can therefore specify that the motor starter retains the thermal motor model when the power supply is restored.

- Deletion of the thermal motor model on restart

  If the motor starter has been disconnected from the 24 V power supply for a longer period, for maintenance purposes, for example, the saved values can result in an incorrect interpretation of the motor state. With this setting, you can therefore specify that the motor starter deletes the thermal motor model when the power supply is restored.

In ATEX operation, fail-safe motor starters can only be parameterized to "Retention of the thermal motor model on restart", however.

Principle of operation

The electronics continuously calculate a model of the thermal load on the motor dependent on the operating time and the current load. The motor memory model charges when the motor is switched on. The motor memory model discharges after the motor is switched off.

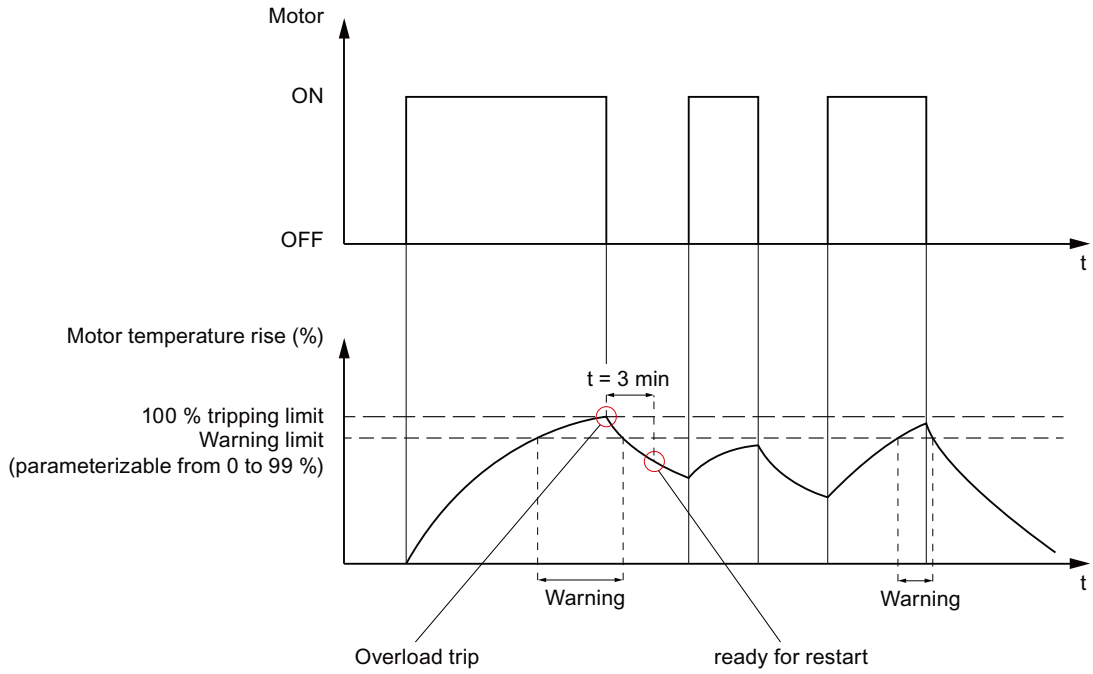

Figure 2-1039 Principle of operation

Following an overload tripping operation, the motor memory model is fully discharged after approximately three minutes. You must wait for this cooling time to elapse before you can acknowledge the fault. If the control supply voltage fails, the motor starter can store the remaining cooling time if the relevant parameters have been set. When the control supply voltage is restored, the remaining cooling time elapses before the load can be switched on again.

If you initiate a restart within a very short time after switching off the motor, it may be that the motor memory model has not yet fully discharged. This can result in an extremely fast overload trip after the restart. In continuous operation (partially charged motor memory model), the tripping times are reduced depending on the pre-charge.

Warning limit motor heating

The motor starter displays a warning if the motor heating limit is overshot. You use this parameter to preset a motor heating value in percent as a warning limit.

This function is deactivated with a warning limit for motor temperature rise of 0%.

If the warning limit for motor heating is exceeded, a group warning and the "Thermal motor model overload" maintenance alarm are output.

Response to overload - thermal motor model

You use this device parameter to specify how the motor starter is to respond to overload:

- Trip without restart
- Trip with restart

> **WARNING**
>
> **Hazardous Voltage.**
> **Can Cause Death, Serious Injury, or Property Damage.**
>
> When the cooling time has expired following an overload trip, and a RESET takes place, or automatic restart has been parameterized, the machine starts up immediately if a control command is active. People in the danger area may be injured.
>
> Make sure that the danger area of the machine is kept clear of people.

- Warning: a general warning is set.

In ATEX operation, you can only parameterize fail-safe motor starters to "Trip without restart".

Trip class

The trip class (CLASS) specifies the maximum time within which a protective device must trip from a cold state at 7.2 x the setting current (motor protection to IEC 60947-2).

The tripping characteristics represent the time to trip as a function of the current multiple. The continuous black line in the following diagrams illustrates the tripping characteristic curve for three-pole symmetrical loads and for single-phase loads. The continuous red line illustrates the tripping characteristic curve for three-pole loads when one phase fails.

The following diagram shows the overload protection for CLASS OFF:

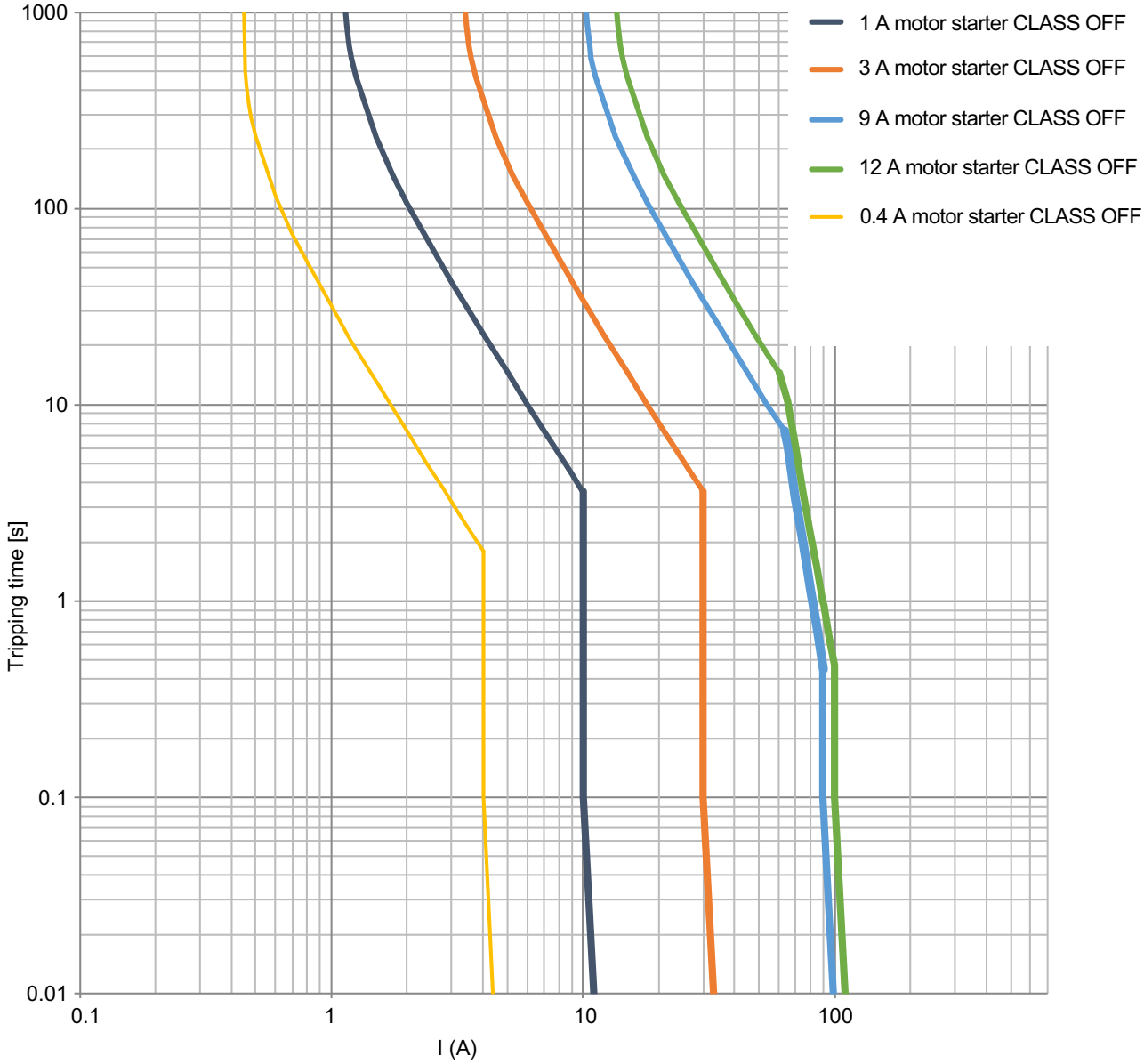

Figure 2-1040 CLASS OFF overload protection

The following diagram shows the overload protection for CLASS 5:

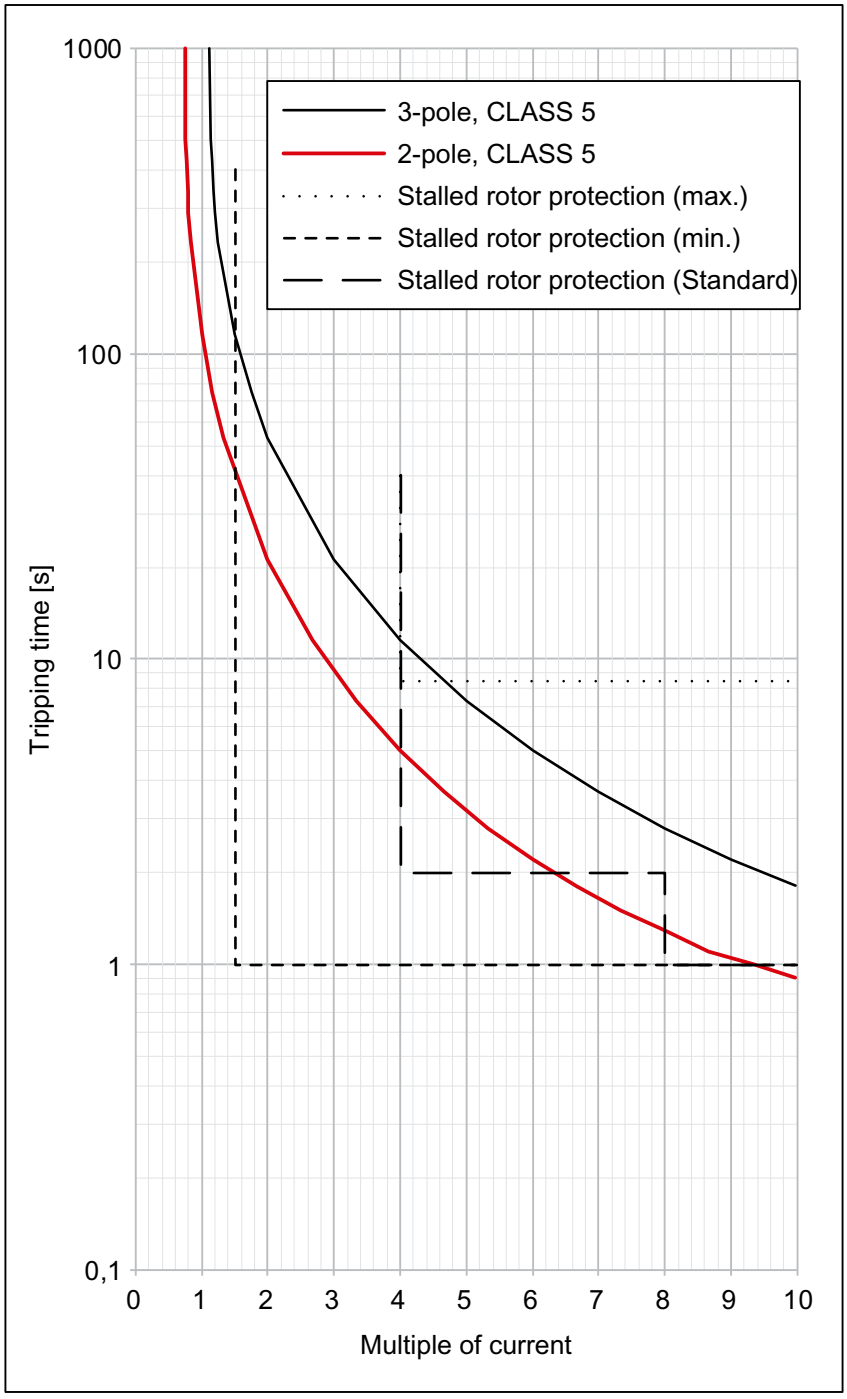

Figure 2-1041 CLASS 5 overload protection

The following diagram shows the overload protection for CLASS 10:

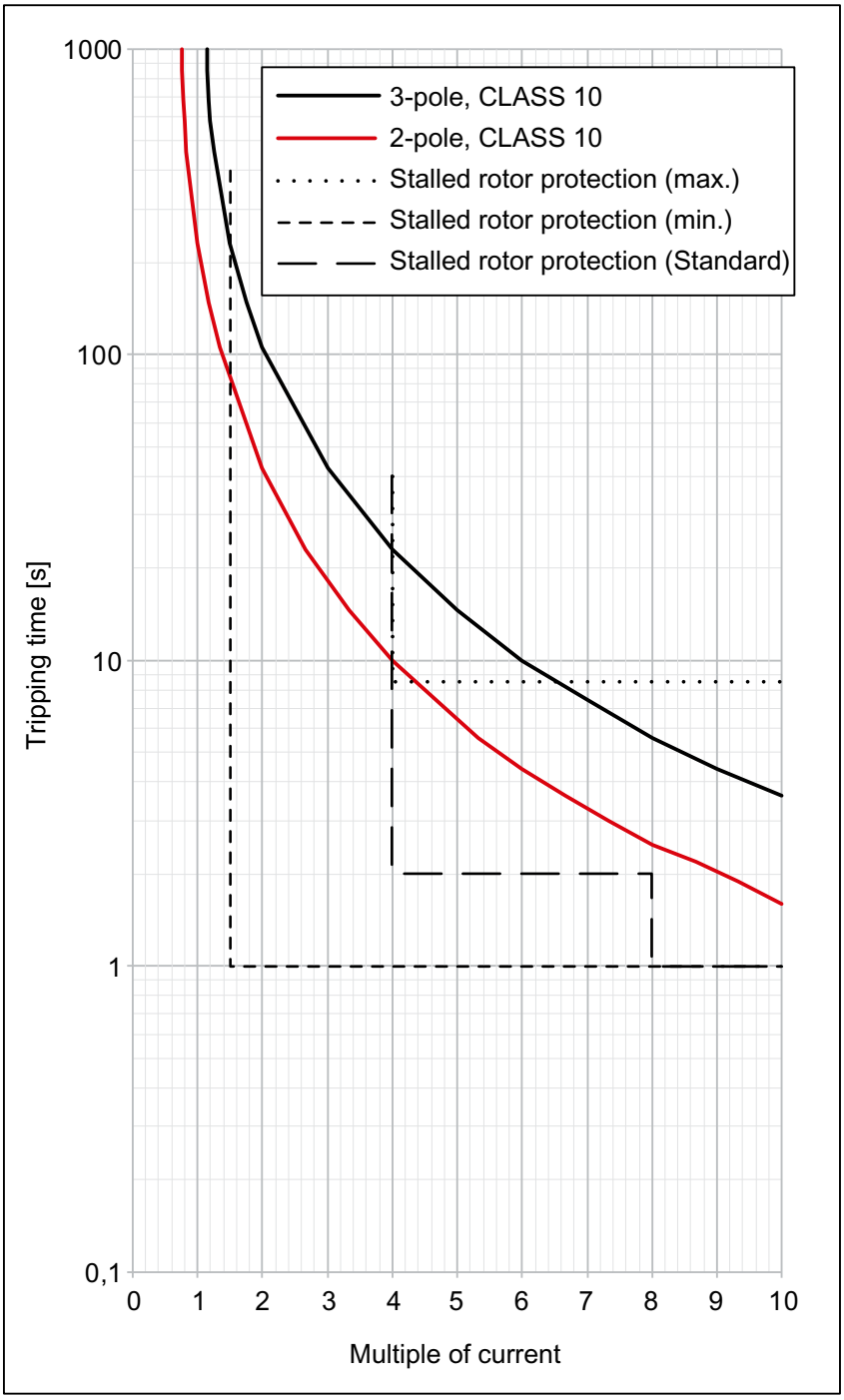

Figure 2-1042 CLASS 10 overload protection

You can find out how to calculate the switching cycles in chapter Calculating switching cycles (Page 63).

The following trip classes can be parameterized according to IEC 60947-4-2:

- CLASS OFF
- CLASS 5 (10 A)
- CLASS 10

To protect the switching elements in the main circuit against impermissible operating states, an integrated intrinsic device protection is provided in the upper load range. At overload currents greater than 65 A, shutdown becomes effective earlier than with the motor protection function (intrinsic device protection model).

The setting range of the overload protection is 1:3.

You can find more information about intrinsic device protection in chapter Device protection model (Page 72).

7.6 Calculating switching cycles

The switching cycles attainable by the ET200 SP motor starter are determined by the root-mean-square of the motor current I_{rms_motor}. The switching cycle considered is admissible if the following criterion is met:

$I_{rms_motor} \leq I_e * 1.05$

I_{rms_motor} is determined on the basis of the root-mean-squares of the motor currents during the startup time and the motor operation time taking the motor OFF time into account. In the following formula, I_e corresponds to the rated current of the connected motor.

x = starting current factor $I_{Startup}/I_e$

Table 2-1151 Switching frequency per hour of the 3RK1308 motor starter for the switch-on duration of 0.5 s:

Current setting [A]		0.4	1	3	9	10	12
x = starting current factor $I_{Startup}/I_e$	Startup time [s]	Number of starting operations per h					
2.5	0.1	4131	4131	4131	4131	4131	4131
2.5	0.3	1377	1377	1377	1377	1377	1377
2.5	0.5	826	826	826	826	826	826
2.5	0.7	590	590	590	590	590	590
2.5	2	207	207	207	207	207	207
4	0.1	1446	1446	1446	1446	1446	1446
4	0.3	482	482	482	482	482	482
4	0.5	289	289	289	289	289	289
4	0.7	207	207	207	207	207	207
4	2	72	72	72	72	72	72
6	0.1	620	620	620	620	620	620
6	0.3	207	207	207	207	207	207
6	0.5	124	124	124	124	124	123
6	0.7	89	89	89	89	89	86
6	2	31	31	31	31	31	25

8	0.1	344	344	344	339	292	75
8	0.3	115	115	115	108	93	20
8	0.5	69	69	69	62	53	8
8	0.7	49	49	49	43	36	0
8	2	17	17	17	9	6	0
10	0.1	219	219	219	51	54	0
10	0.3	73	73	73	12	13	0
10	0.5	44	44	44	0	0	0
10	0.7	31	31	31	0	0	0
10	2	11	11	11	0	0	0

$$I_{rms_motor} = \sqrt{\frac{1}{T}\left[(x * I_e)^2 * t_{Startup} + I_e^2 * t_{Motor}\right]}$$

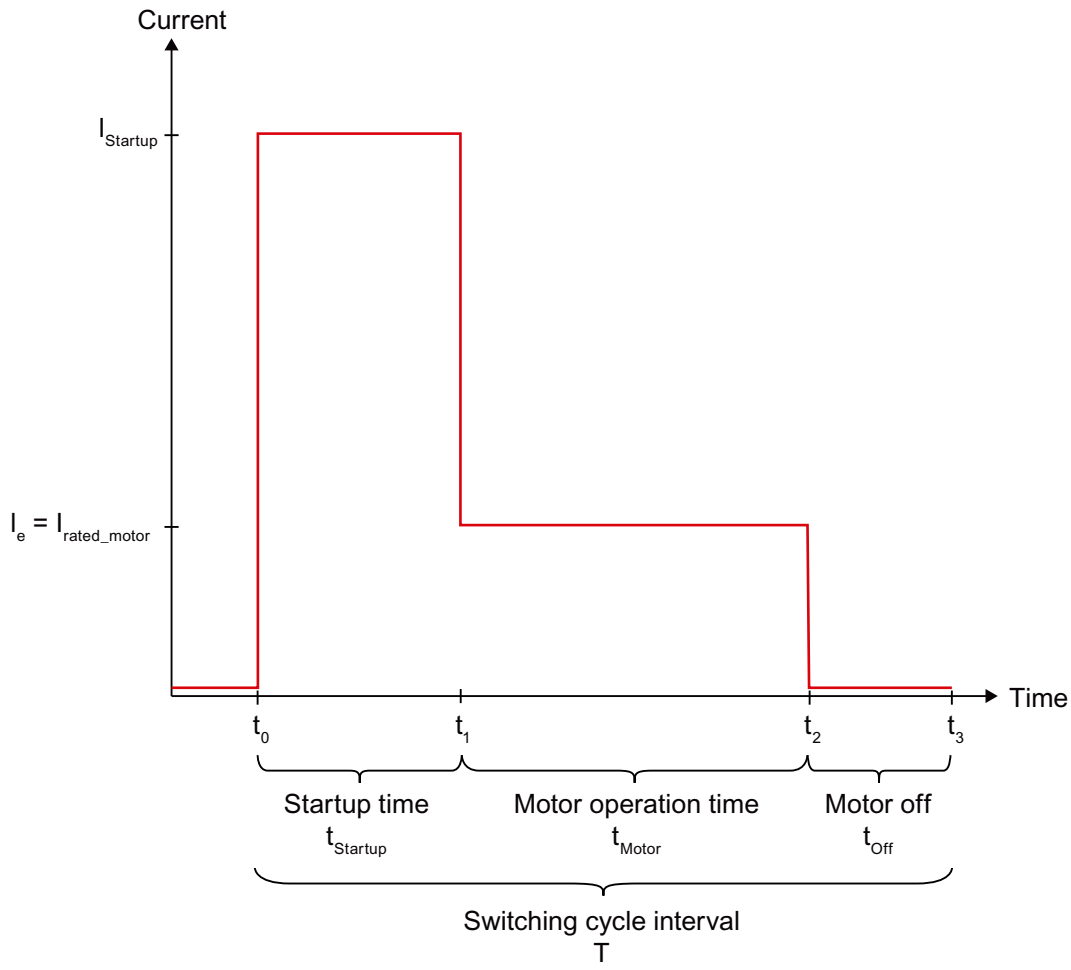

Switching cycle parameters

The following table shows all the parameters that you have to consider for calculation of the permissible switching cycle:

Parameters		Description	Conditions
Starting time	$t_{Startup}$ [s]	Time during which the motor accelerates up to its operating speed from standstill	The maximum is determined by the parameterized tripping class and the intrinsic device protection (see also Overload protection (Page 57)).
Starting current	$I_{Startup}$ [A]	Root-mean-square of the motor current that flows during the starting time. It is considered as a multiple x of the rated value of the motor I_{rated_motor} or of the parameterized rated operational current I_e. $I_{Startup}$ [A] = x * I_e [A]	The maximum is the permissible current of the relevant device class. Consider additional idle times in the case of starting currents in excess of 65 A (see example graphics). (Also see: Overload protection (Page 57) and the example graphics)
Motor operation time	t_{Motor}[s]	Time in which the motor is in operation after startup.	-
Rated operational current	I_e [A]	Root-mean-square of the motor current in the operating phase after the starting time or the parameterized value I_e of the motor starter	The permissible I_e is determined by the adjustment range of the motor starter used and its ambient temperature (see also: Overload protection (Page 57)).
Motor OFF time:	t_{Off} [s]	Idle time of the motor within the switching cycle	Consider additional idle times in the case of starting currents in excess of 65 A (see example graphics).
Switching cycle interval	T [s]	Total of t_{Off}, t_{Motor} and $t_{Startup}$	The maximum time is 300 s.

You use the switching cycle interval time to determine the permissible starting frequency per hour as follows:

$$\text{Switching cycles [1/h]} = \frac{1}{T} * 3600$$

As from a starting current of 65 A in the case of the 9 A and 12 A motor starters, consider the device protection model for calculation of the switching cycles. The following graphics show the minimum idle time depending on the starting current:

Minimum idle time (T_{Off}) 9 A motor starter at $I_{Startup}/I_{rated_motor}$ = 8

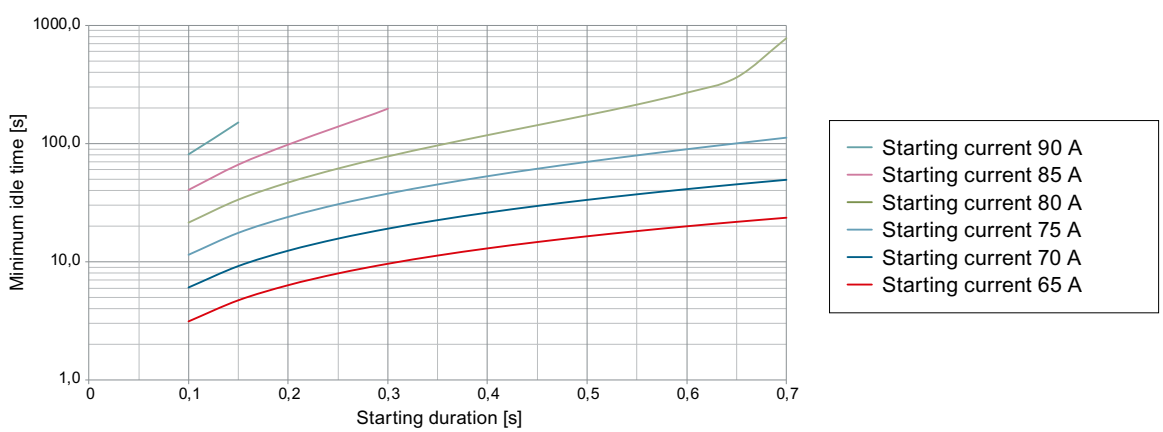

Minimum idle time (T_{Off}) 12 A motor starter at $I_{Startup}/I_{rated_motor}$ = 8

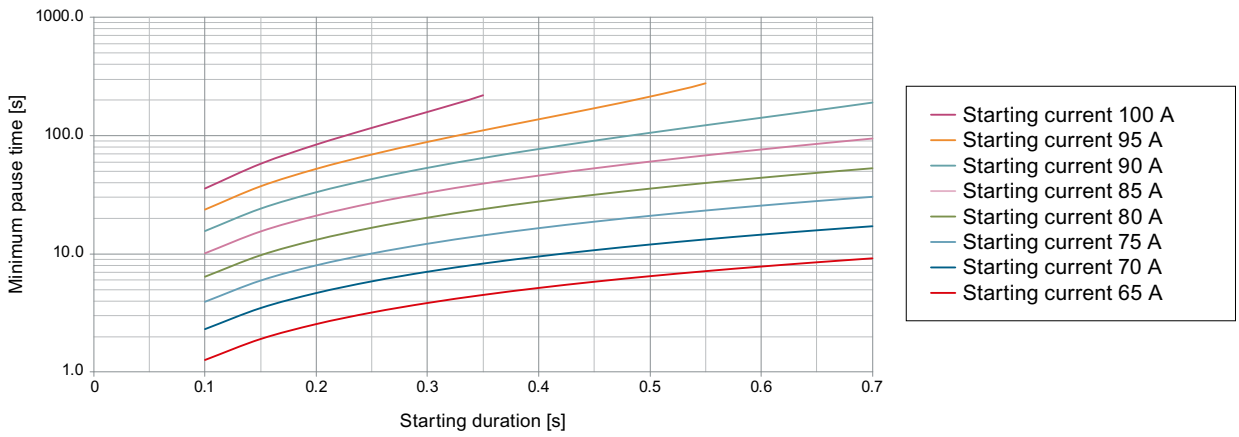

Example for the minimum idle time (T_{Off}) 12 A motor starter at $I_{Startup}/I_{rated}$ = 8

The graphic below shows the minimum idle time of a 12 A motor starter with the following parameters:

I_{rated_motor} = 10.4 A

$I_{startup/Irated_motor}$ = 8.6; thus: $I_{Startup} \approx 89$ A

$T_{Startup}$ = 0.125 s $T_{Off} \geq 19$ s

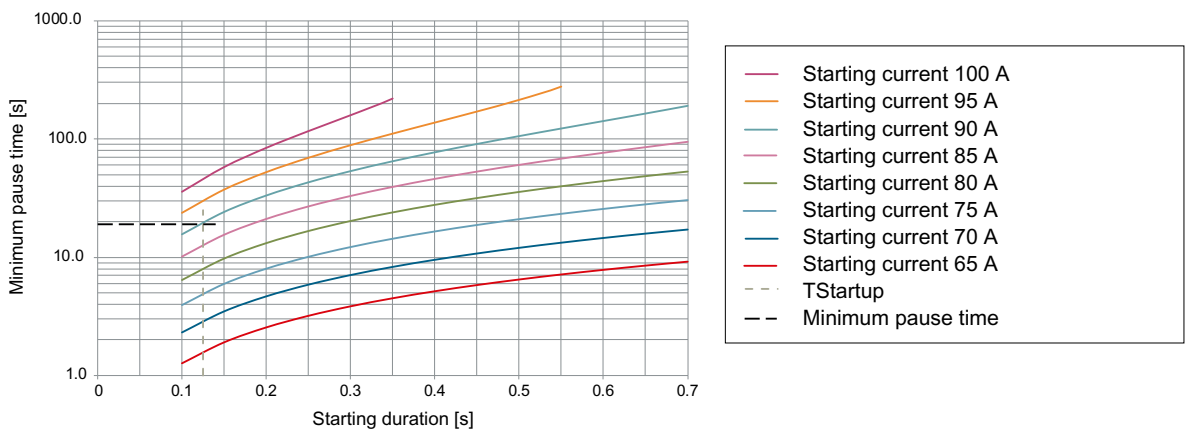

7.7 Substation monitoring

You can determine various system states with the help of the motor current and the current limits.

System state	Current value	Protection by:
Motor operates more sluggishly, e. g. due to bearing damage	Current is higher than normal	Upper current limit Upper current warning limit
Motor operates more smoothly, e. g. because the system has run out of processing material.	Current is lower than normal	Lower current limit Lower current warning limit
Motor is blocked	Very high current flowing	Blocking protection
• Open circuit • Defective fuse • Motor idling • Power failure • No load connected	Very low current flowing Minimum load undershot	Residual current detection

7.7.1 Response to residual current detection

If the motor current drops to under 20% from the set operational current or below the minimum load limit in one of the phases, residual current detection responds. You use this device parameter to specify how the motor starter is to behave in the event of residual current being detected:

- Warning (not in the case of fail-safe motor starters)
- Tripping

NOTE

When the motor is switched on, residual current detection is suppressed for approximately 1 s.

This does not apply to fail-safe motor starters.

Residual current detection for motor starters with 0.1 ... 0.4 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.1 to 0.4 A:

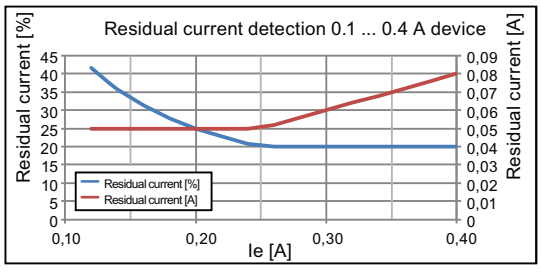

Figure 2-1043 Residual current detection 0.1-0.4 A device

Residual current detection for motor starters with 0.3 ... 1 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.3 to 1 A:

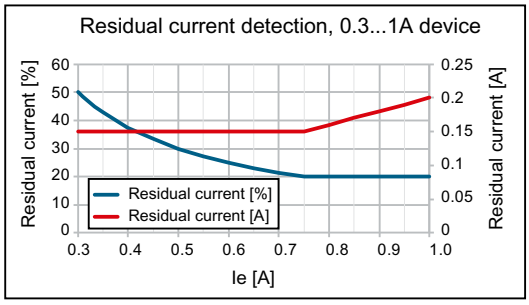

Figure 2-1044 Residual current detection 0.3-1 A device

Residual current detection for motor starters with 0.9 ... 3 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.9 to 3 A:

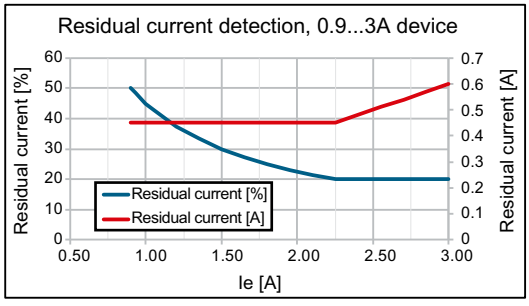

Figure 2-1045 Residual current detection 0.9-3 A device

Residual current detection for motor starters with 2.8 ... 9 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 2.8 to 9 A:

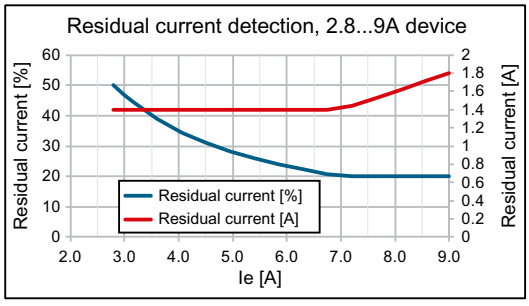

Figure 2-1046 Residual current detection 2.8-9 A device

Residual current detection for motor starters with 4 ... 12 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 4 to 12 A:

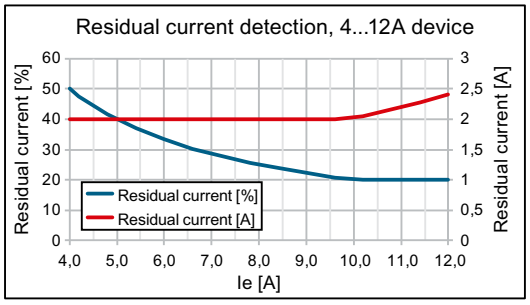

Figure 2-1047 Residual current detection 4-12 A device

Residual current detection for fail-safe motor starters with 0.1 ... 0.4 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.1 to 0.4 A:

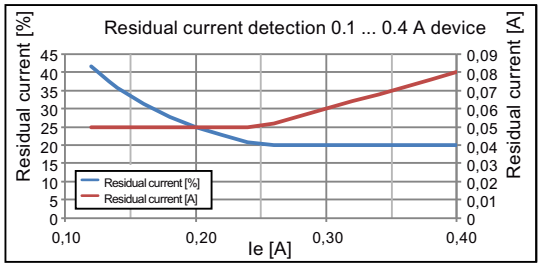

Figure 2-1048 Residual current detection 0.1-0.4 A device

Residual current detection for fail-safe motor starters with 0.3 ... 1 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.3 to 1 A:

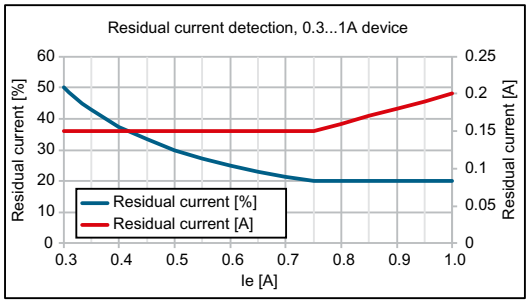

Figure 2-1049 Residual current detection 0.3-1 A device

Residual current detection for fail-safe motor starters with 0.9 ... 3 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 0.9 to 3 A:

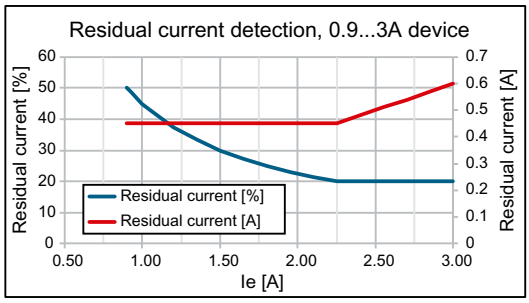

Figure 2-1050 Residual current detection 0.9-3 A device

Residual current detection for fail-safe motor starters with 2.8 ... 9 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 2.8 to 9 A:

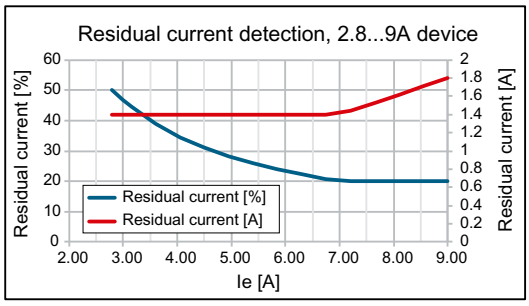

Figure 2-1051 Residual current detection 2.8-9 A device

Residual current detection in the case of fail-safe motor starters with 4 ... 12 A

The following graphic shows the dependence of residual current detection on the set motor current in the case of motor starters with 4 to 12 A:

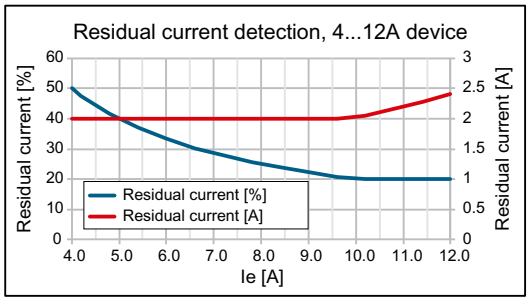

Figure 2-1052 Residual current detection 4-12 A device

7.7.2 Upper/lower current warning limit

You can enter an upper and/or a lower current warning limit value. If the current warning values are exceeded or undershot, the motor starter responds with a warning message without tripping. The warning message is acknowledged as soon as the warning threshold is exceeded or undershot by 5%.

NOTE

The current warning thresholds are activated by default. You can deactivate the current warning thresholds, however. The current warning thresholds are not activated until the CLASS time expires.

Setting ranges

The table below shows the possible setting range for the lower and upper current warning limits:

Device parameters	Default setting	Setting range
Lower current warning limit	21.875%	• 18.75 ... 100% of I_e • 0% (= deactivated) Increment: 3.125%
Upper current warning limit	112.5%	• 50 to 400% of I_e • 0% (= deactivated) Increment: 3.125%

7.7.3 Upper/lower current limit

You can enter an upper and/or a lower current limit. The current limits are deactivated by default. If the current limits are overshot or undershot, the motor starter responds by tripping. The "I_e upper limit value violation" or "I_e lower limit value violation" message is issued. If the current exceeds the maximum rated operational current by a factor of ten, the motor starter shuts down the motor even if the current limit values are deactivated. An entry in the logbook (data set 73 (Page 136)) is generated.

Example

The following example shows an application for the upper and lower current limit:

- The viscosity of the mixed mass is too high, that is, the upper current limit has been overshot.
- No load because drive belt is broken. In other words, the lower current limit has been violated.

NOTE

The parameterized current warning thresholds are not activated until the CLASS time expires.

Setting ranges

The table below shows the possible setting range for the lower and upper current warning limits:

Device parameters	Default setting	Setting range
Lower current limit	Deactivated	• 18.75 ... 100 % of I_e • 0 % (= deactivated) Increment: 3.125 %
Upper current limit	Deactivated	• 50 to 400 % of I_e • 0 % (= deactivated) Increment: 3.125 %

7.7.4 Blocking time and blocking current

The blocking current specifies how much current is consumed by the motor (at rated voltage) when the drive is blocked.

If the motor current exceeds 400 % of the set motor current I_e for a time > 1 s after the motor ramps up, the blocking protection is tripped and a trip command is generated.

After the motor is switched on, the parameterized values for the blocking current and blocking time apply. A switchover to the fixed values (400 %, 1 s) takes place depending on the set motor protection class (CLASS 5/ 10 A → 5 s, CLASS 10, off → 10 s).

- The "Tripping due to motor blocking" and "Group fault" diagnostic messages are generated
- The statistic "Number of motor overload trips" is incremented by 1

If the parameter "Group fault diagnostics" is set to "Enabled", a corresponding diagnostic interrupt is set if blocking protection responds.

Setting ranges

The table below shows the possible setting range for the blocking current and the blocking time:

Device parameters	Default setting	Setting range
Blocking current	800 %	150 ... 1500 % of I_e Increment: 50 %
Blocking time	1 s	1 ... 7.5 s Increment: 0.5 s

7.7.5 Device protection model

To protect the switching elements in the main circuit against impermissible operating states, an integrated intrinsic device protection is provided in the upper load range. The device protection model consists of the relay protection model (dotted line) and the thermal motor model (continuous line) with the highest permissible current setting. The device protection is active 20 ms after the ON command. This means that, in the case of ET 200SP motor starters, an overload trip may occur in the upper current range before the motor protection trips. The device protection is active even when the overload protection is set to "Warn" and the "Response of the thermal motor model on restart" parameter is set to "Delete".

The motor starter operates within a permissible current range. The following graphic shows the permissible current range:

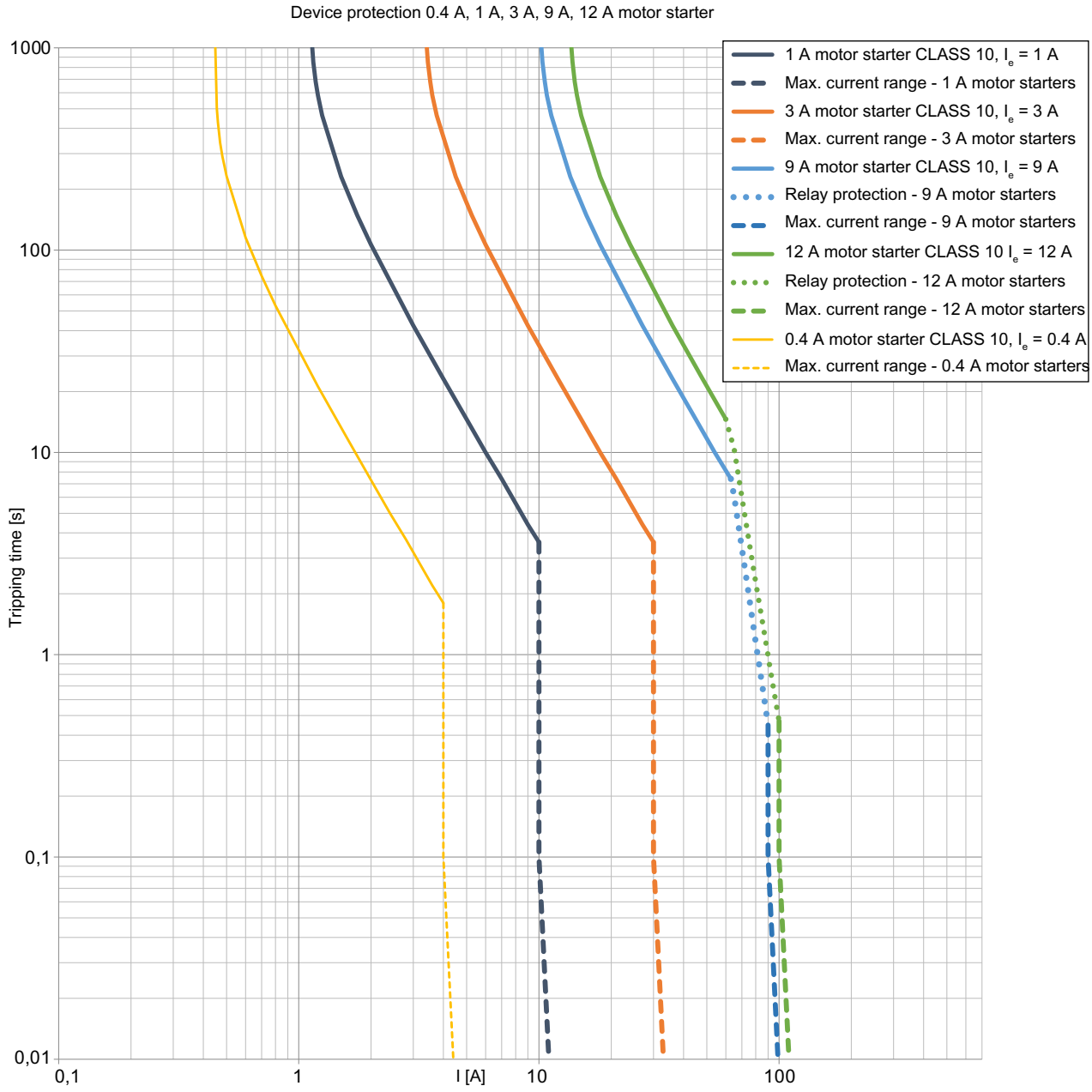

Figure 2-1053 Device protection

How the motor starter's device protection works is described below.

Shutting down the motor starter within the permissible current range

The motor starter switches off in the following cases:

- The motor starter is too hot.
- The CLASS 10 tripping characteristic for the maximum current setting has been exceeded.
- The relay protection characteristic in the case of 9 A and in the case of 12 A motor starters has been exceeded.

Wait at least three minutes after shutting down the motor starter. Then trigger a trip reset. The motor starter is operable again.

Violation of the permissible current range

Switching elements may be damaged if the permissible current range (represented by the vertical line in the graphic) is exceeded. The motor starter switches off. The "Current measuring range overshot" message is issued. 9 A and 12 A motor starters switch off without the support of the semiconductors. This is referred to as "hard switching" and is output as a fault diagnosis.

To prevent response of the device protection, a motor's maximum starting current must not be higher than the motor starter's max. permissible current range.

NOTICE
Violation of the permissible current range **Fail-safe motor starters** are defective after overshoot of the permissible current range and cannot be activated again. Reactivation of **non-fail-safe motor starters** is possible. The service life of a non-fail-safe motor starter is, however, limited.

7.7.6 Temperature monitoring

The motor starter has an internal temperature monitoring function. If the motor starter exceeds its internal temperature warning threshold, the "Switching element hot" alarm is issued in data set 75 (Page 137). The motor starter switches off if the temperature continues to rise. The "Switching element overload" diagnostic message (object number 309) is issued in data set 92 (Page 139) if temperature monitoring responds.

You can trigger trip reset on the motor starter after a cooling time of at least three minutes. You can activate the motor starter again once it has sufficiently cooled down.

Fan control

The fan is controlled temperature-based by the internal temperature monitoring function. The thermal device protection model can also lead to the activation of the fan.

7.7.7 Asymmetry monitoring

Description

Three-phase asynchronous motors respond to slight asymmetries in the supply voltage with a higher asymmetric current consumption. As a result, the temperature in the stator and rotor windings of the drive increases. The ET 200SP motor starter protects the load against overload by issuing a warning or by tripping. You can parameterize whether a warning is output or tripping occurs.

NOTE

When the motor is switched on, asymmetry evaluation is suppressed for approx. 0.5 s.

Asymmetry limit

The asymmetry limit is a percentage value by which the motor current is allowed to deviate in each phase. Asymmetry is detected as soon as one of the three phases deviates by more than 40 % from the mean value of all phases.

Response to asymmetry

You use this device parameter to determine the behavior of the motor starter in the event of asymmetry:

- Warning (not permissible for fail-safe motor starters in ATEX operation)
- Tripping

Settings

Table 2-1152 Settings for asymmetry monitoring

Device parameters	Default setting	Setting range
Response to asymmetry	Tripping	• Warn • Tripping

7.7.8 Short-circuit protection (fuses)

Description

The ET 200SP motor starter is equipped with integrated safety fuses as short-circuit protection. Short-circuit protection is implemented both between a phase and ground (= ground fault), and between two phases.

Switching performance

The ET 200SP motor starter switches off short-circuits in the motor or in the cables. The ET 200SP motor starter complies with the requirements of type of coordination 1 (IEC 60947-4-2).

On tested assemblies, the type of coordination defines the permissible condition of devices following a short-circuit. Type of coordination 1 means that the load feeder is non-operational after a short circuit has been cleared.

Messages and actions

After the fuse responds, the "Residual current detection" message is output in the case of non-fail-safe motor starters. The "Switching element defective" message is issued in the case of fail-safe motor starters. Then replace the starter.

7.8 Safety-related functions

7.8.1 Self-test

ET 200SP fail-safe motor starters run a self-test of the switching elements every time they are switched on and off.

Ensure a stable line power supply. An unstable power supply may lead to a situation in which the motor starter incorrectly signals a fault.

7.8.2 Response to safety-related tripping

The STO (Safe Torque Off) function is the safety function integrated in the fail-safe motor starter. It ensures the safe disconnection of torque-generating energy on the motor. Safety Torque Off prevents unintentional start-up in compliance with EN 60204-1, Section 5.4. The drive is safely free from torque. This state is monitored in the motor starter.

Safety-related tripping is achieved for the fail-safe motor starters thanks to the special arrangement and checking of the switching elements.

Safety-related tripping is performed by a low level ("0" signal) at the F-DI. As an alternative, safety-related tripping can be achieved by removing the 24 V supply voltage from the power bus.

In the case of fail-safe ET 200SP motor starters, the OFF state is defined as the safe state (Safety torque off). ET 200SP Failsafe motor starters are self-monitoring. A diagnostic message can be sent to the controller in the event of tripping via F-DI.

The signal (F-DI) is provided via the corresponding BaseUnit with F-DI-infeed or F-DI forwarding.

Settings

Table 2-1153 Response to safety-related tripping

Device parameters	Default setting	Setting range
Response to safety-related tripping	No warning	• No warning • Warning

7.8.3 Ex motor application

Set the "Ex motor application" parameter if the fail-safe motor starter is to switch and protect an explosion-proof motor.

NOTE

ATEX Ex II (2) G D zones

You can use the fail-safe motor starter for explosion-proof motors that are situated in ATEX Ex II (2) G D zones.

An ATEX approval is not possible with the motor starter when it is used in 1-phase operation. An ATEX approval is possible by means of further measures such as thermoclick.

NOTE

It is not possible to set the motor protection to Class OFF in EX operation.

Settings

Table 2-1154 Settings for Ex motor application

Device parameters	Default setting	Setting range
Ex motor application	No	• No • Yes

The maintenance alarm 0x1036, "New safety-related parameters received", is issued if you have activated the "EX motor" parameter. Before the "EX motor" parameter is accepted, you must confirm it on the device with the blue button.

See also

Setting safety-related parameters (Page 109)

7.9 Response to CPU/master STOP

With this parameter, you set the response of the PIQ following a CPU STOP:

- Retain last value

  The last received and valid value of the process image of the outputs is retained.
- Switch substitute value 0

  The process image of the outputs is assigned the value "0". "Switch substitute value 0" is active even if the header module of the ET 200SP station is deenergized.

NOTE

The response to CPU/master STOP is only relevant in "Automatic" mode.

7.10 Group fault diagnostics/group warning diagnostics

You can use these parameters to determine whether diagnostics are enabled or disabled. If you set the group diagnostics parameter to "Disable", no diagnostic messages are output to the CPU. If you set the group warning diagnostics parameter to "Disable", no maintenance alarms are output.

You will find the requirements for the use of maintenance alarms in an Maintenance FAQ (https://support.industry.siemens.com/cs/ww/en/view/109485777).

Settings

Table 2-1155 Settings for group fault/group warning diagnostics

Device parameter	Default setting	Setting range
Group fault diagnostics	Enable	• Disable • Enable
Group warning diagnostics	Disable	• Disable • Enable

7.11 Inputs

If you use the optional 3DI/LC module (3RK1908-1AA00-0BP0), the motor starter can execute various actions with the "Inputs" device function. The actions are parameterizable. The signals are evaluated on the 3DI/LC module for this purpose. Inputs 1 to 3 (DI 0.4 to 0.6) can be connected directly with contact elements or sensors.

The bit 2.5 in the process image of the inputs indicates whether a 3DI/LC module is inserted.

The signal states are transferred in parallel via the process image. In addition, the signal states in DS92 Read device diagnostics (Page 139) can be read out. The input actions of the individual digital inputs affect the motor starter functions independently of one another.

The input LC (local control) switches over to manual local mode. You cannot change the parameterization of the input. This input is always implemented as an NO contact. You can

detect whether or not manual local is active if bits 0.7 and 1.6 are active in the process image input.

For information on this topic, see Chapter "Connecting the 3DI/LC module for the motor starter" in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/de/view/58649293/en?dl=en).

Inputs for commissioning

To ensure operation of a motor in the unparameterized state of the ET 200SP motor starter with the aid of the 3DI/LC module, the input parameters in data set 201 are permanently assigned the following values by default:

- DI1: Motor CW
- DI2: Motor CCW
- DI3: Cold start (fail-safe motor starters as of V1.2.0)

This pre-parameterization is overwritten when the ET 200SP motor starter is parameterized.

Response to sensor supply overload

The supply voltage for the digital inputs is short-circuit proof. The current is limited to a maximum of 100 mA. If a short-circuit or overload situation occurs in the sensor supply, the switching elements (motor) are shut down and a group fault is output. Acknowledge the fault with Trip Reset.

⚠ WARNING

The digital inputs (1 to 4) are not isolated. The reference potential is M (5), and therefore SELV/PELV. Only supply the inputs with the 24 V DC output (6).
Do not connect any temperature sensors for winding control of motors if they do not have protective separation. Otherwise, in the event of a fault, a dangerous voltage may be transmitted to the sensor cables and thus to the SELV/PELV circuits. If these cables are then touched, it can lead to death, serious injury and enormous material damage.

You will find more information in chapter Connecting 3DI/LC module (Page 162).

Response to removal of the 3DI/LC module:

Bit 2.5 is reset in the process image input if you remove the 3DI/LC module during operation. You can evaluate the bit and thus indicate unintentional removal. The inputs are not open-circuit-proof.

⚠ WARNING

The motor can continue to run with the corresponding parameterization

When you remove the 3DI/LC module, the motor can continue to run with the appropriate parameterization.

Input signal delay

The input signal delay is fixed at 10 ms.

Input n signal

You can use this device parameter to determine whether or not the input level of the inputs is to be saved.

- Retentive, i.e. latching mode (edge evaluation)

  Regardless of the input signal present, the action can only be deactivated again by a further event and remains active even after cancellation until it is overwritten by another action (e.g. process image of the outputs).
- Non-retentive, that is, jog (level evaluation)

  This input action is active as long as the input is active.

Input n level

You use this device parameter to specify the input logic:

- NC contact
- NO contact

NOTE

Parameterization only as NO contact.

For "Input n action": "Emergency start", "Motor CW", "Motor CCW", "Cold start" and "Trip reset", "Input n level" can only be parameterized as an NO contact.

NOTE

Change from NC contact to NO contact

If "Input n level" is changed from a normally closed contact to a normally open contact and the associated "Input n action" is parameterized as "Trip without restart", the "Input tripping" message bit is set and shut down accordingly in the case of an open input due to the input delay!

NOTE

Applied input voltage

If input voltage is applied (input active), the value "1" is transferred to the controller regardless of the "Input n level" parameter.

Input n action

Different actions can be triggered when an input signal is present. You can parameterize the following actions dependent on "Input n level", "Input n signal" and "Mode".

NOTE

If "Input n-signal" = retentive, and "Input n-action" = motor CW/CCW, at least one input must always be parameterized with input action "Tripping ..." or "Quick Stop". If this rule is violated, the motor starter will reject the parameters with the relevant diagnostic message.

Table 2-1156 Input n action

Input n action	Input n level	Input n signal	Operating mode	Description
No action	NO/NC	n. ret./ret.	All	No direct action on the motor starter. Evaluation und further processing possible using the process image.
Trip without restart	NO/NC	n. ret.	All	• Results in tripping of the motor. • Must be acknowledged once the cause of the tripping has been rectified (initial status).
Trip with restart (AUTO RESET)	NO/NC	n. ret.	All	• Results in tripping of the motor. • Acknowledged automatically after the cause of the trip has been rectified (initial status).
Trip end position CW	NO/NC	n. ret.	All	• The motor is switched off regardless of the direction of rotation. • A fault is generated and reported. • The motor can only be switched on with "Motor CCW"
Trip end position CCW	NO/NC	n. ret.	All	• The motor is switched off regardless of the direction of rotation. • A fault is generated and reported. • The motor can only be switched on with "Motor CW"
Group warning	NO/NC	n. ret./ret.	All	• The diagnosis "Group warning" is output. • The motor starter is not switched off.
Emergency start	NO	n. ret.	All	• Starts the load when an ON command is issued despite the fact that an internal trip command is present. • Intrinsic device protection of the motor starter remains active and prevents the device from being destroyed. • Only allowed as an NO contact • Not parameterizable when the "EX motor" parameter is active.

Input n action	Input n level	Input n signal	Operating mode	Description
Motor CW Motor CCW (with reversing starters only)	NO	n. ret./ret.	Manual local mode	• The motor starter must be in "manual local" mode for these actions. • Motor CW: Switching the motor on or off • Motor CCW: Switching the motor on or off • Only allowed as an NO contact • n. ret. The input action is active while the input signal is pending. • ret.: The action becomes active by means of the rising edge of the input and remains active regardless of the level. The action is reset by the input action "Quick Stop" or "group fault".
Quick Stop	NO/NC	n. ret./ret.	All	• Motor is switched off direction-independently without group fault. • "Quick Stop" takes priority over "Motor CW" and "Motor CCW"
Quick Stop clockwise	NO/NC	n. ret./ret.	All	• Motor is switched off with "Motor CW" without group fault. • "Quick Stop" takes priority over "Motor CW"
Quick Stop counter-clockwise	NO/NC	n. ret./ret.	All	• Motor is switched off with "Motor CCW" without group fault. • "Quick Stop" takes priority over "Motor CCW" • The action is only available for reversing starters.
Trip RESET	NO	n. ret.	All	• "Trip RESET" is triggered once. • "Trip RESET" is only possible as NO contact.
Cold start	NO	n. ret.	All	Enables switch-on without main power. If the main power supply is nevertheless present (current flowing), an internal trip command is generated. For fail-safe motor starters as of firmware version V1.2.0
Operational trip end position CW	NO/NC	n. ret.	All	The motor is tripped regardless of the direction of rotation (CW or CCW). • The motor can only be switched on with "Motor CCW". • The parameter can only be implemented as "non-retentive". • A group fault is not generated, but a diagnostic message is set in data set 92.
Operational trip end position CCW	NO/NC	n. ret.	All	The motor is tripped regardless of the direction of rotation (CW or CCW). • The motor can only be switched on with "Motor CW". • The parameter can only be implemented as "non-retentive". • A group fault is not generated, but a diagnostic message is set in data set 92.

Input n action	Input n level	Input n signal	Operating mode	Description
NO: NO contact NC: NC contact ret.: Retentive n. ret.: non-retentive (activation and deactivation of the input action follows the status of the input signal (= jog))				

Settings

Table 2-1157 Settings for inputs

Device parameters	Default setting	Setting range
Input signal delay	• 10 ms	-
Input 1 level	• NO contact	• NC contact • NO contact
Input 2 level		
Input 3 level		
Input 1 action	• Motor CW	• No action • Trip without restart • Trip with restart • Trip end position CW • Trip end position CCW • Group warning • Emergency start • Motor CW • Motor CCW • Quick Stop (direction-independent) • Quick Stop clockwise • Quick Stop counter-clockwise • Trip RESET • Cold start • Operational trip end position CW • Operational trip end position CCW
Input 2 action	• Motor CCW (RS) • No action (DS)	
Input 3 action	• Cold start	
Input 1 signal	• Non-retentive	• Retentive • Non-retentive
Input 2 signal		
Input 3 signal		

7.12 Manual local (local control)

Manual local control with the ET 200SP motor starter is only possible when the 3DI/LC module is inserted. A digital input is permanently assigned the function "Manual local" (LC connection). If the digital input is active, that is, "manual local" is requested, the ET 200SP motor starter changes to manual local mode even in the case of motor ON. To exit manual local mode, the manual local input must be inactive and the motor must be switched off via the DI module. That is, with active input action "Motor CCW" or "Motor CW", the ET 200SP motor starter remains in manual local mode and thus in the "Motor ON" state as long as the input action is not interrupted.

NOTE

Removal during operation

If the 3DI/LC module is removed from the ET 200SP motor starter during manual local mode, this results immediately in shutdown of the running motor and then to exiting of manual local mode.

If a removed 3DI/LC module is plugged onto the ET 200SP motor starter while "manual local" is active, a changeover is made to manual local mode.

The motor starter assumes automatic mode when manual local mode is ended, i.e. the motor starter switches to the control priority of the CPU. The motor can start immediately when CW or CCW command is pending via the process image of the outputs.

7.13 Trip without restart

The action "Trip without restart" results in the following behavior:

- The motor is tripped. Acknowledge disconnection via Trip Reset after remedying the cause of tripping. You can then switch on the motor again.
- The parameter can only be implemented as "non-retentive".
- A group fault is generated and a diagnostics entry created.

7.14 Trip with restart

The action "Trip with restart" results in the following behavior:

- The motor is tripped.
- Acknowledged automatically after the cause of the trip has been rectified (input status).
- The parameter can only be implemented as "non-retentive".
- A group fault is generated and a diagnostics entry created.

7.15 Trip emergency end position CW

If the motor control command is not equal to "Motor OFF", the diagnostic interrupt "Trip end position CW responded" incoming is triggered when a 0 → 1 edge is detected at the digital input. This diagnostic interrupt results in internal tripping of the motor when emergency start is deactivated. The interrupt "Trip end position CW" is reported as outgoing (DS92 entry is deleted) if the motor control command is "Motor OFF". If the motor control command "Motor CW" is issued in the case of trip end position CW DI static "1", an incoming diagnostic message "trip end position CW" is triggered (only if the diagnostic message was already outgoing or has been deleted). This diagnostic message prevents renewed switch-on of the motor in the CW direction of rotation (emergency start deactivated).

The action "Trip end position CW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation (CW or CCW).
- You can switch the motor back on again after deletion of the control command "Motor CW/CCW".
- The motor can only be switched on with "Motor CCW".
- The parameter can only be implemented as "non-retentive".
- A group fault is generated and a diagnostics entry created.
- Emergency trip end position CW can be overridden by emergency starting.

Example

The following example shows the "trip end position CW" with digital input 1 parameterized to "Trip end position CW":

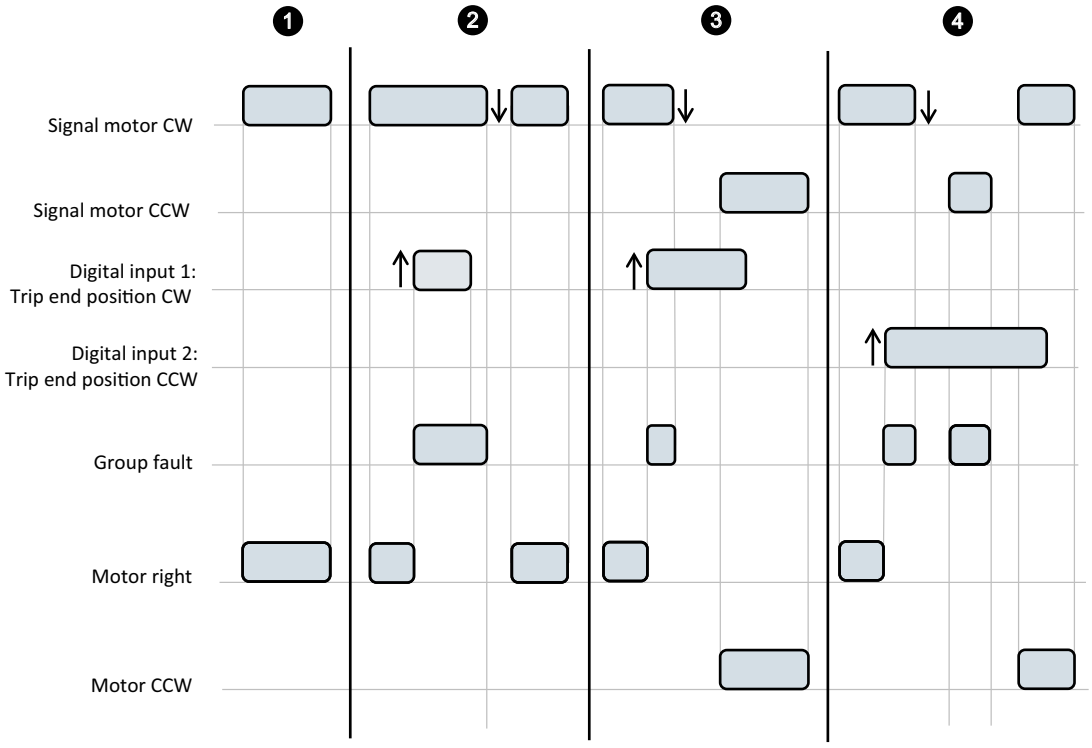

Figure 2-1054 Example of trip end position CW

① You switch the motor on by means of "Motor CW". The motor is running.

② You switch the motor on by means of "Motor CW". The motor is running. The motor is switched off by setting the digital input 1 (parameterized to input action 1 = Trip end position CW). A group fault is generated at the same time by the starter. To switch the motor back on again, digital input 1 and the signal "Motor CW" must be reset again. Thereafter you can start the motor again via the signal "Motor CW". The group fault is deleted when the signal "Motor CW" is canceled.

③ You switch the motor on by means of "Motor CW". The motor is switched off by setting the digital input 1 (parameterized to input action 1 = Trip end position CW). A group fault is generated at the same time by the starter. While digital input 1 is set, you can only run the motor counter-clockwise. The group fault is deleted when the signal "Motor CW" is canceled.

④ You switch the motor on by means of "Motor CW". The motor is also switched off by setting the digital input 2 (parameterized to input action 1 = Trip end position CCW). A group fault is generated at the same time by the starter. While digital input 2 is set, you can only run the motor clockwise. To switch the motor back on again, digital input 2 and the signal "Motor CW" or "Motor CCW" must be reset again. Thereafter you can start the motor again via the signal "Motor CW". The group fault is deleted when the signal "Motor CW" is canceled.

7.16 Trip emergency end position CCW

If the motor control command is not equal to "Motor OFF", the diagnostic interrupt "Trip end position CCW responded" incoming is triggered when a 0 → 1 edge is detected at the digital input. This diagnostic interrupt results in internal tripping of the motor when emergency start is deactivated. The interrupt "Trip end position CCW" is reported as outgoing (entry 92 is deleted) if the motor control command is "Motor OFF". If the motor control command "Motor CCW" is issued in the case of trip limit CCW DI static "1", an incoming diagnostic message "trip end position CCW" is triggered (only if the diagnostic message was already outgoing or has been deleted). This diagnostic message prevents renewed switch-on of the motor in the CCW direction of rotation (emergency start deactivated).

The action "Trip end position CCW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation (CW or CCW).
- You can switch the motor back on again after deletion of the control command "Motor CW/CCW".
- The motor can only be switched on with "Motor CW".
- The parameter can only be implemented as "non-retentive".
- A group fault is generated and a diagnostics entry created.
- Emergency trip end position CCW can be overridden by emergency starting.

7.17 Group warning

The action "Group warning" results in the following behavior:

- A "group warning" is generated.
- An entry with the object number 304 (byte 0, bit 7) is generated in the DS92 Read device diagnostics (Page 139).
- A logbook entry is created in the DS75 logbook - Read events (Page 137).
- The motor is not tripped.
- A maintenance alarm is generated when group warning diagnostics is enabled.

7.18 Emergency start

Description

Emergency start enables restart despite an internal trip command. Emergency start is possible if there is an ON switching command for the motor. The motor is switched on despite a pending trip cause. At a limit trip, the motor starts in the opposite direction.

Emergency starting is not possible in the following situations:

- When you are using a fail-safe motor starter in ATEX operation
- If a device fault is active
- If there is no switched/unswitched 24 V DC supply voltage, or if the supply voltage is outside the specified range.
- The blocking protection has responded
- If a process image error is active

You can activate the function "Emergency start" as follows:

- PIQ 0.4 "Emergency start"
- Via the 3DI/LC module
- Via manual bus mode
- In manual bus mode via DS68

Messages and actions

Table 2-1158 Messages and actions emergency start

Message	Action
Emergency start active	Remains pending while emergency start is active, even if the motor is switched off.

7.19 Motor CW

In automatic mode, the motor is activated or deactivated in the CW direction with the aid of the process image of the outputs. If you would like to control the motor via the 3DI/LC module, activate the LC input on the 3DI/LC module (manual local mode). Bit 0.0 "Motor CW" in the process image of the outputs is ignored in manual local mode.

The parameter can only be implemented as an "NO contact".

If "Input n-signal" = retentive, and "Input n-action" = Motor-CW/CCW, at least one input must always be parameterized with the "Tripping ... " or "Quick Stop" input action.
If this rule is violated, the motor starter will reject the parameters with the relevant diagnostic message.

7.20 Motor CCW

In automatic mode, the motor is activated or deactivated in the CCW direction with the aid of the process image of the outputs. If you would like to control the motor via the 3DI/LC module, activate the LC input on the 3DI/LC module (manual local mode). Bit 0.1 "Motor CCW" in the process image of the outputs is ignored in manual local mode.

The parameter can only be implemented as an "NO contact".

If "Input n-signal" = retentive, and "Input n-action" = Motor-CW/CCW, at least one input must always be parameterized with the "Tripping ... " or "Quick Stop" input action.
If this rule is violated, the motor starter will reject the parameters with the relevant diagnostic message.

7.21 Quick Stop direction-independent

- Motor is tripped without group fault.
- "Quick Stop" takes priority over "Motor CW" and "Motor CCW"
- The input action responds to the active edge of the input signal, which means that deactivation is possible when the static input signal "Quick stop" is present.
- The input trigger is reset through cancelation of the "Motor CW" and "Motor CCW" control commands, or by means of "Disable quick stop" (in the process image). This applies only in the case of control via manual local mode or in the case of a retentive Quick Stop signal.
- The motor is tripped regardless of the direction of rotation.

Example 1: Input 1 signal = retentive/edge-triggered

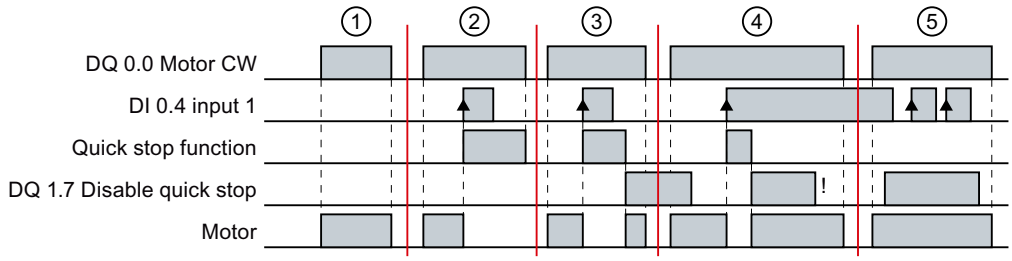

① The motor is switched on by "Motor CW".

② Motor is switched on by "Motor CW", then switched off by the rising edge at digital input 1 (parameterized to input action 1 = Quick Stop). By revoking the "Motor CW" command, the Quick Stop function is reset.

③ Motor is switched on by "Motor CW", then switched off by the rising edge at digital input 1. By setting Disable quick stop, the Quick Stop function is reset and the motor runs "CW" again until the "Motor CW" command is revoked.

④ Motor is switched on by "Motor CW", then switched off by the rising edge at digital input 1. By setting Disable quick stop, the Quick Stop function is reset and the motor runs "CW" again. Although the static digital input signal 1 (DI2) is still present, the motor continues to run and is only reset by revoking the "Motor CW" command.
Reason: The input action is edge-triggered.

⑤ Motor is switched on by "Motor CW" and continues to run uninterrupted since Disable quick stop continuously overwrites the edges of the signal of digital input 1 (DI2).

Example 2: Input 1 signal = non-retentive

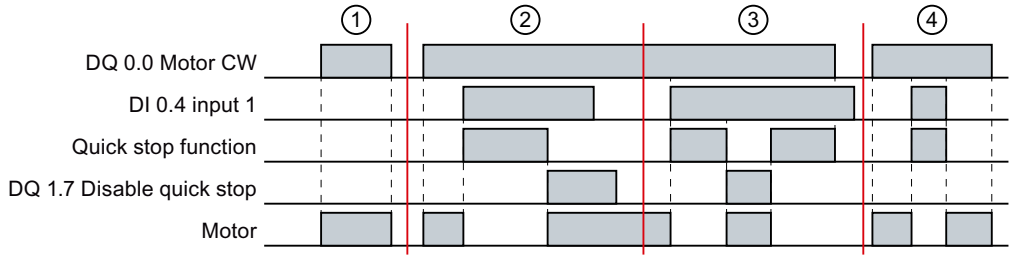

① The motor is switched on and off by "Motor CW".

② The motor is switched on by "Motor CW", then switched off by the level at digital input 1 (parameterized with input action 1 = Quick Stop). The Quick Stop function is reset by Disable quick stop. The motor is switched on again since "Motor CW" is still active.

③ The motor is switched off by the level at digital input 1. The "Quick Stop" function is reset by setting "Disable quick stop". As the level "Motor CW" is still active, the motor runs "CW" again until the "Disable quick stop" command is revoked.

④ Motor is switched on by "Motor CW", then switched off by the level at digital input 1. While the "Quick Stop" function is active, the motor remains switched off and starts up again when "Quick Stop" is revoked until "Motor CW" is switched off.

7.22 Quick Stop clockwise

The action "Quick Stop CW" results in the following behavior:

- The motor is switched off with pending signal "Motor CW" without group fault
- The motor is not switched off with pending signal "Motor CCW"
- "Quick Stop CW" takes priority over "Motor CW"
- The input action responds to the active edge of the input signal, which means deactivation is possible when the static input signal "Quick Stop" is present.
- The input trigger is reset through cancelation of the control commands "Motor CW" or "Disable quick stop" (in the process image). This applies only in the case of control via manual local mode or in the case of a retentive Quick Stop signal.

7.23 Quick Stop counter-clockwise

The action "Quick Stop CCW" results in the following behavior:

- The motor is switched off with pending signal "Motor CCW" without group fault
- The motor is not switched off with pending signal "Motor CW"
- "Quick Stop CCW" takes priority over "Motor CCW"
- The input action responds to the active edge of the input signal, Deactivation is possible when the static input signal "Quick Stop" is present.
- The input trigger is reset through cancelation of the commands "Motor CCW" or "Disable quick stop" (in the process image). This applies only in the case of control via manual local mode or in the case of a retentive Quick Stop signal.

NOTE

No quick stop CW in the case of direct-on-line starters

You cannot use quick stop CCW in combination with direct-on-line starters.

7.24 Trip RESET

"Trip RESET" acknowledges all the errors/faults that are currently active and that can be acknowledged. An error/fault can be acknowledged if its cause has been rectified or if it is no longer present.

Trip RESET is triggered by:

- Loading a valid parameterization
- Remote RESET via PLC (PIQ bit 0.3 Trip RESET)
- Remote RESET via input actions (if parameterized)
- TEST/RESET button on the ET 200SP motor starter
- Power-on reset (switching off and on again of the 24 V supply voltages on the device)

NOTE

TRIP RESET as input n signal

The "Trip Reset" action is only possible as an "input n signal" (non-retentive).

7.25 Cold start

Description

The "cold start" function enables control of a motor without error messages. The motor starter responds here as if the main power supply were connected to the system. Thus, in the commissioning phase, for example, the relevant control commands are accepted from the controller and the relevant messages are sent.

The "cold start" function enables activation of the motor starter without a main power supply. The motor starter responds here as if the main power supply were connected to the system. The error message "Residual current detection/tripping" is suppressed. Thus, in the commissioning phase, for example, the relevant control commands are accepted from the controller and the relevant messages are sent.

NOTE

The "cold start" function is not possible for the command "Motor on" in an ATEX configuration.

NOTE

If the main power supply is nevertheless present (current flowing), an internal trip command is generated.

NOTE

The "cold start" action is only permissible as an "input n level" (NO contact) and only as an "input n signal" (non-retentive).

You can activate the "cold start" function as follows:

- PIQ 0.7 "Cold start"
- Via the 3DI/LC module
- In manual bus mode via DS68

7.26 Operational trip end position CW

If the motor control command is not equal to "Motor OFF", an operational trip of the motor is triggered when a signal change at the operational trip end position CW DI is detected. This motor tripping triggered by the operational trip end position is revoked by the motor control command "Motor OFF". If the motor control command "Motor CW" is issued in the case of operational trip end position CW DI static "1", an operational trip is triggered again. This motor tripping triggered by the operational trip end position prevents renewed switch-on of the motor in the CW direction of rotation.

The action "Operational trip end position CW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation (CW or CCW).
- The motor can only be switched on with "Motor CCW".
- The parameter can only be implemented as "non-retentive".
- A group fault is not generated, but a diagnostic message is set in data set 92.
- Operational trip end position CW cannot be overridden by emergency start.

7.27 Operational trip end position CCW

If the motor control command is not equal to "Motor OFF", an operational trip of the motor is triggered when a signal change at the operational trip end position CCW DI is detected. This motor tripping triggered by the operational trip end position is revoked by the motor control command "Motor OFF". If the motor control command "Motor CCW" is issued in the case of operational trip end position CW DI static "1", an operational trip is triggered again. This motor tripping triggered by the operational trip end position prevents renewed switch-on of the motor in the CCW direction of rotation.

The action "Operational trip end position CCW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation (CW or CCW).
- The motor can only be switched on with "Motor CW".
- The parameter can only be implemented as "non-retentive".
- A group fault is not generated, but a diagnostics message is set in data set 92.
- Operational trip end position CCW cannot be overridden by emergency start.

7.28 Chatter monitoring

- The following two events trigger the chatter monitoring (it does not matter which channel is used for the switch-on command):
  - There is a new switch-on command within 500 ms after the last switch-on command.
  - There is a switch-on command within the interlock time (standard: 55 to 170 ms after switch-off command, safety: 95 ms to 195 ms after switch-off command).
- The number of new switch-on commands within 500 ms is stored in the statistics data (Page 144).
- 0x311 is sent as a diagnostic interrupt (frequency too high).
- The warning 0x311 (frequency too high) is canceled if no further switch-on command has occurred within 1.5 s.

7.29 Logbook

Description

The logbooks contain a chronological list of device faults, trips and events that are assigned a time stamp, thus creating a log. The log is stored internally so that the causes can be evaluated at a later stage.

Logbooks

Three logbooks that can be read as a data set are available:

- DS72: DS72 logbook - Read device error (Page 133)
- DS73: DS73 logbook - Read triggering operations (Page 136)
- DS75: DS75 logbook - Read events (Page 137)

The operating hours (see Chapter DS95 Read statistics (Page 144)) of the device in seconds are used as a time stamp. You can find the object numbers of the relevant messages in the relevant data sets. The last 21 entries are stored in the logbooks. You can read out the entries with the relevant data sets. The logbook is designed as a circular buffer. After 21 entries, the oldest entry is overwritten. The latest entry is at the first location.

In case of a retentive error "Fail-safe motor starter defective" (see DS72 logbook - Read device error (Page 133), "Assignment of object number to device fault message" table), the DS72, DS73 and DS75 logbooks are frozen when the supply voltage (24 V DC) is removed, i.e. no further entries are permitted.

Logbook - Read device errors

The logbook "Read device errors" contains all device errors/faults. The object numbers of the actual fault causes are entered, e.g. object number 476, "Current measurement defective".

Logbook - Read trips

The logbook "Read trips" contains all group faults. The object numbers of the actual fault causes are entered, e.g. "Switching element defective".

Logbook - Read events

The logbook "Read events" contains all warnings as well as certain actions. Incoming events are reported as incoming. In addition, some events are also reported as outgoing. Incoming entries are marked "+". Outgoing events are marked "-".

7.30 PROFIenergy

7.30.1 What is PROFIenergy?

PROFIenergy supports the following two functions:

- Energy saving function

  Supports targeted shutdown of loads during idle times.
- Measured value function

  Energy management is an instrument which is ideally suited to reducing energy consumption and thereby energy costs within a company both systematically and on a long term basis. The aim of energy management is to optimize the use of energy in a company - from the purchasing of energy through to the consumption of energy - economically and ecologically. The measured value function provides the measured values required for optimization.

7.30.2 PROFIenergy in the motor starter

The ET 200SP motor starter supports the "Energy saving function" and "Measured value function" for the motor current. These are identified as commands, since they trigger reactions in the ET 200SP motor starter.

In addition, the ET 200SP motor starter also provides so-called services that provide information on the status of the motor starter as defined in PROFIenergy. These can then be evaluated and further processed in the user program.

Using PROFIenergy with the ET 200SP motor starter

SIEMENS provides two function blocks for using PROFIenergy:

- PE_START_END (FB815) supports the switch to an energy-saving mode.
- PE_CMD (FB816) supports the reading out of measured values and the switch to an energy-saving mode

You will find further information in the document entitled "Common Application Profile PROFIenergy, Technical Specification for PROFINET Version V1.1 Edition 2, Dec. 2013, Order Number 3802" published by PROFIBUS International (PI).

NOTE

PROFIenergy is not possible with PROFIBUS interface modules.

NOTE

The PROFIenergy function is available with firmware version V3.3 of the interface modules.

Commands

The following tables show the supported commands:

Control commands	
Start_Pause	The starter switches to energy-saving mode.
Start_Pause_with_time_response	The starter switches to energy-saving mode and signals its minimum idle times.
End_Pause	The starter switches back to operating mode.

Status commands	
PE_Identify	Provides a list of supported PROFIenergy commands/functions.
PEM_Status	Returns the current mode.
PEM_Status_with_time_response	Returns the extended status of the current mode.
Query_Modes	
List_Energy_Saving_Modes	Provides a list of supported energy-saving modes.
Get_Mode	Provides the parameter values with which the energy-saving function works.
Query_Version	Shows the implemented PROFIenergy profile.
Query_Measurement	
Get_Measurement_List	Provides a list of supported measured values.
Get_Measurement_List_with_object_-number	Provides a list of supported measured values and the associated object number.
Get_Measurement_Values	Provides the requested measured values.
Get_Measurement_Values_with_obje-ct_number	Provides the requested measured values together with the object number.

The ET 200SP motor starter operates with the following PROFIenergy modes (PE modes):

PE_Mode_ID = 255	Ready to operate
PE_Mode_ID = 01	Energy-saving mode

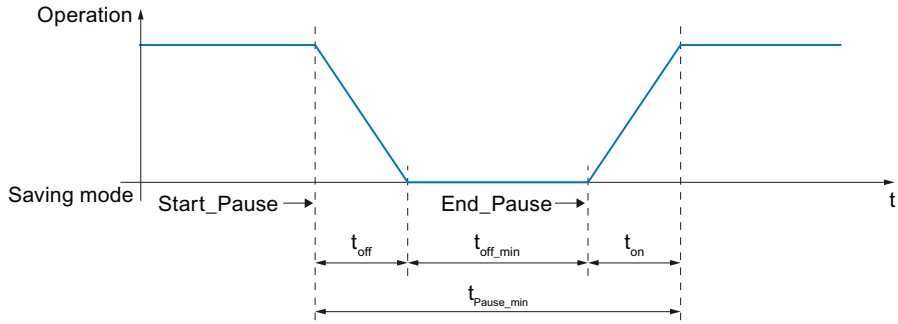

t_{off}	Time_to_Pause	Time the starter requires in order to change to energy saving mode. With the ET 200SP motor starter, this time is always 100 ms.
t_{off_min}	Time_min_length_of_stay	Minimum time that the device spends or should spend in saving mode. For the ET 200SP motor starter: 150 ms
t_{on}	Time_to_operate	Time that will elapse before the starter changes back to the operating state. For the ET 200SP motor starter: 100 ms (due to startup sequence)
t_{Pause_min}	Time_min_Pause	Time that is compared with t_{Pause} (is transferred together with the "Start_Pause" command to the motor starter); if $t_{Pause} \geq t_{Pause_min}$, the device switches to saving mode.

"Measured value function" command

Measured values for energy need to be supplied for efficient energy management. The PROFIenergy specification offers various measured values from which to choose, each of which is assigned a measured value ID. The ET 200SP motor starter supports the instantaneous values of the phase current and the mean value of the phase currents as measured values.

The measured values are uniquely identified by IDs. The following measured value IDs 7, 8, 9, and 33 are supported:

- ID = 7: Current rms value of the phase current a (L1)
- ID = 8: Current rms value of the phase current b (L2)
- ID = 9: Current rms value of the phase current c (L3)
- ID = 33: Mean value of the three phase currents (a+b+c)/3

The current values are transferred with the following tolerances:

- Domain = 0x03 → IEC 61557-12
- Class = 0x0B → 5 %

The result is that the measured values are transferred with an accuracy of 5 % relative to the maximum configurable rated operational current I_e.

Reaction of the starter when energy-saving mode is activated

Shutdown of the motor by suppression of the PIQ bits (Motor CW, Motor CCW). The other PIQ bits (e.g. Trip RESET) remain active.

Interactions with the various operating modes

- PROFIenergy is operative only in Automatic mode
- Manual local mode is not influenced by PROFIenergy; it is still possible to switch to manual mode and thereby to control the motor manually
- Both cyclic and acyclic data transmission (PIQ, PII, data sets, diagnostics, alarms, etc.) to and from the motor starter are still possible

Prerequisites for the starter to switch to energy-saving mode (min. idle time, etc.)

The changeover to "Pause" energy-saving mode only becomes effective when the idle time sent is greater than the device-specific minimum idle time. This means that a switch is only performed when the pause is longer than the motor starter requires to switch the main energy for the load off and on again.

The switch to energy-saving mode is recorded in the "Events" logbook. Entry: "Energy saving mode active"

See also

Application example (https://support.industry.siemens.com/cs/ww/en/view/109478388)
PROFINET system description
(http://support.automation.siemens.com/WW/view/en/19292127)

7.31 Firmware update

Introduction

During operation it may be necessary to update the firmware (e.g. to extend the available functions). You update the firmware of the motor starter with the help of firmware files.

NOTE

Note the preconditions for a firmware update/downgrade

You can find the preconditions for a firmware update/downgrade in the Siemens Industry Online Support under the entry Firmware update for ET 200SP motor starter (https://support.industry.siemens.com/cs/ww/en/view/109486088).

Loading and installing a firmware update

- Click "Product Support" on the Siemens Industry Online Support (https://support.industry.siemens.com/) page.
- In the product tree selection field, select "Automation engineering → Automation systems → SIMATIC industrial automation systems → Controllers → IO systems → ET 200 systems for the control cabinet → ET 200SP".

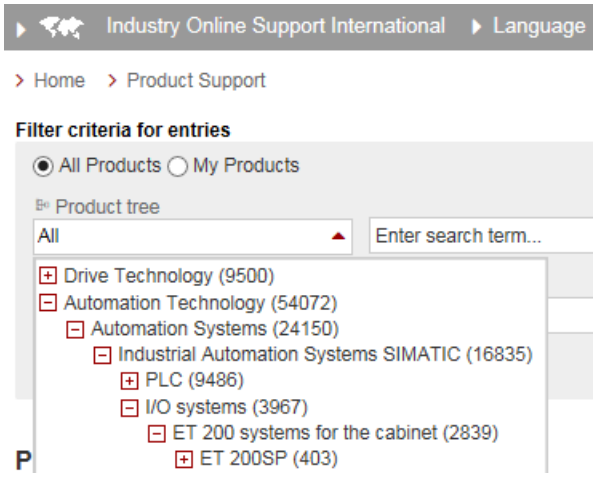

Figure 2-1055 ET 200SP in the product tree

- Navigate to the specific type of module that you want to update.
- Under "Product information → Support", click on the "Software downloads" link.
- Download the required firmware update files.

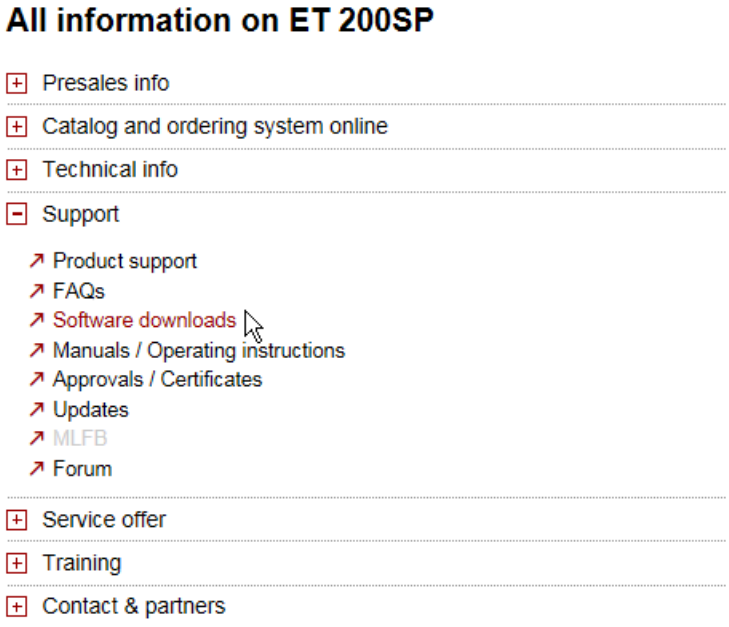

Figure 2-1056 Selecting the software downloads

- Before installing the firmware update, make sure that the modules are not being used.

NOTICE

Firmware update for fail-safe motor starters

In the case of fail-safe motor starters, the firmware update is permissible only if the motor starter is the only module on a rack.

Make sure before a firmware downgrade of fail-safe motor starters with a F-DI BaseUnit (MS5-MS10) that the associated F-DI is on 1-signal (=value of "1").

Also make sure that the motor starter is only connected to the device on which the firmware is being updated (e.g. PG/PC or CPU).

NOTICE

Loss of the safety function after an incorrect firmware update

The safety functions can be lost if you inadvertently install a firmware update on a motor starter for which the update was not intended.

Make sure that the PG/PC or the CPU is exclusively connected to the motor starter on which the firmware is being updated.

NOTE

Securing the supply voltage

On starting, and during the firmware update, the 24 V DC supply voltage must be applied at the header module and the motor starter.

NOTE

Interrupted firmware update

If a firmware update has been interrupted, remove and reconnect the affected module before a renewed firmware update.

WARNING

Risk of impermissible system states

The CPU switches to STOP mode or the interface module to "station failure" as a result of the firmware update being installed. STOP or station failure due to a firmware update can cause an unpredictable motor starter state. After completion of the update, the current PIO and the input actions take effect again.

Unexpected operation of a process or a machine can lead to fatal or severe injuries and/or to property damage.

Before installing the firmware update, ensure that the motor starter, the CPU and the interface module are not executing an active process.

More options for the firmware update

The following options are available for updating firmware:

- Online via PROFINET IO/PROFIBUS DP (with STEP 7), see below
- Via the integrated Web server (possible for CPU as well as centralized and distributed I/O modules), see below
- With the TIA Portal:
  - Non-fail-safe ET 200SP motor starter, SIMATIC STEP 7 V13 SP1 or higher with installed HSP
  - Fail-safe ET 200SP motor starter, SIMATIC STEP 7 V14 or higher with installed HSP
- Via a SIMATIC memory card, see below
- With SIMATIC STEP 7 Version V5.5 SP4 or higher

Procedure using STEP 7

Proceed as follows to perform an online firmware update with STEP 7:

1. Select the module in the device view.
2. Select the "Online & diagnostics" command from the shortcut menu.
3. Select the "Firmware update" group in the "Functions" folder.
4. Click the "Browse" button to select the path to the firmware update files in the "Firmware update" area.
5. Select the suitable firmware file. The table in the firmware update area lists all modules for which an update is possible with the selected firmware file.
6. Click the "Run update" button. If the module can interpret the selected file, the file is downloaded to the module.

NOTE

If a firmware update is interrupted, you need to remove and insert the module before starting the firmware update again.

Procedure using a SIMATIC memory card

Proceed as follows to perform a firmware update via the SIMATIC memory card:

1. Insert a SIMATIC memory card into the SD card reader of your programming device / computer.
2. To save the update file on the SIMATIC memory card, mark the SIMATIC memory card in the project navigator under "Card reader/USB memory".
3. In the "Project" menu, select the command "Card Reader/USB memory → Create firmware update memory card".
4. Use a file selection dialog to navigate to the firmware update file. In a further step you can decide whether you want to delete the content of the SIMATIC memory card or whether you want to add the firmware update files to the SIMATIC memory card.
5. Insert the SIMATIC memory card containing the firmware update files in the CPU.

Procedure using the Web server

The procedure is described in the Function Manual Web server (http://support.automation.siemens.com/WW/view/en/59193560).

Behavior during the firmware update

Note the following behavior during the firmware update of the motor starter:

- The LEDs flash as described in chapter "Status and error displays (Page 120)".
- The motor starter powers up again after completion of the firmware update. Diagnoses are reset. The firmware update does not affect the thermal motor type and the cooling time.
- The sensor supply of the DI module remains active.

Behavior after the firmware update

After the firmware update, check the firmware version of the updated module. A successfully loaded firmware update is activated immediately.

If a fail-safe motor starter is in "Manual local" mode during the firmware update, the motor starter switches to Commissioning mode (Page 103) after the successful firmware update operation. You must first confirm ATEX parameters before you can perform manual local control (see Configuring ATEX operation (Page 110)).

Online help for STEP 7

You can find more information on the procedure in the STEP 7 online help.

Parameters/address space 8

8.1 Parameter assignment

When configuring an ET 200SP motor starter, the full parameterization scope is set and automatically transferred to the motor starter. When parameterizing in the user program, the parameters are transferred to the module via the data sets with the statement "WRREC". If the CPU initiates a new parameter assignment, e.g. if communication breaks down, the parameterization is overwritten by the system parameterization via the user program.

The modules of the ET 200SP distributed I/O system support the full parameterization scope of the ET 200SP motor starters.

NOTE

List of supported ET 200SP header modules

You will find a list of the compatible ET 200SP header modules in the Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/109485777).

NOTE

Reduction to default parameters

In the following cases, the full scope of parameterization is reduced by the configuring software to the standard parameters (DS201) for system reasons:

- Activated DPV0 alarm mode (in the case of PROFIBUS IMs)
- Activated option handling (in the case of PROFIBUS IMs)
- When configuring using a GSD (for parameters, see Read/write DS201 device parameter 1 (Page 145))

NOTE

Trip RESET

When you send valid parameters to the motor starter, a trip RESET is triggered. Acknowledgeable active faults are deleted.

Parameters for ET 200SP motor starter

The effective range of the adjustable parameters depends on the type of configuration. The following configurations are possible:

- Centralized operation with an ET 200SP CPU and the ET 200SP Open Controller
- Distributed operation on the PROFINET IO in an ET 200SP system
- Distributed operation on the PROFIBUS IO in an ET 200SP system

When you assign parameters in the user program, transfer the parameters to the module via the data sets with the "WRREC" statement.

The parameters that can be set can be found in the Appendix in Read/write DS201 device parameter 1 (Page 145) and Read/write DS202 device parameter 2 (Page 148).

You will find an explanation of the parameters in Chapter Declaration of parameters (Page 106).

NOTE

Changing the parameters during operation

If parameters are modified during operation, they will be overwritten by the parameters configured in the hardware configuration during a restart of the control system.

If this is not desired, a command must be issued to disable parameterization.

You set the parameter block in theDS93 Write command (Page 142).

8.2 Commissioning mode

Commissioning mode is available for fail-safe ET 200SP motor starters.

When setting up a system, you can test the wiring without the functioning PROFINET or PROFIBUS connection. Perform the test in commissioning mode.

The motor starter switches to commissioning mode in the following cases:

- After the power supply has been activated, the motor starter does not receive any parameterization via the backplane bus.
- The DI module's "Local Control" switch is activated.

  As soon as Local Control is active, the parameterization saved last is used when the power supply is activated. Control via the DI module is possible after confirmation via the TEST/RESET button.

To switch to commissioning mode in the case of fail-safe motor starters, confirm the change with the blue button. During ATEX operation, additionally confirm the current parameters, as described in chapter "Configuring ATEX operation (Page 110)".

If the motor starter receives valid parameterization via the backplane bus in commissioning mode, the parameterization is placed in intermediate storage. The parameterization becomes active when "Local Control" is terminated (motor OFF). The commissioning mode is exited.

Inputs for commissioning

To ensure operation of a motor in the unparameterized state of the ET 200SP motor starter with the aid of the 3DI/LC module, the input parameters in data record 201 are permanently assigned the following values by default:

- DI1: Motor CW
- DI2: Motor CCW
- DI3: Cold start (fail-safe motor starters as of V1.2.0)

This pre-parameterization is overwritten when the ET 200SP motor starter is parameterized.

8.3 Parameterization using a GSD file

For the ET 200SP-IM155 interface module of the ET 200SP system, there are two different GSD files, one for operation with PROFINET and one for operation with PROFIBUS. The GSD and GSDML files can be used with STEP 7 V5.5 SP4 and higher, and TIA Portal V13 SP1 and higher.

If you configure the ET 200SP motor starter in the PROFIBUS environment with GSD, and the standard values in data set 202 have to be changed, then you create data set 202 via the user program on initial commissioning of the starter. Transfer the data set to the PLC.

Parameterization with the PROFINET GSDML file

The ET 200SP motor starter can be fully configured with all parameters with the GSDML file for PROFINET.

Parameterization with the PROFIBUS GSD file

Two parameter data sets (DS201 and DS202) are used for configuring the ET 200SP motor starter. Only data set DS 201 is ever transferred as the startup data set when using a PROFIBUS GSD.

8.4 Slot rules

You can find further information on the structure of a system with an ET 200SP motor starter in the ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293).

8.5 Data plausibility check

Check of the incoming parameters in the "Automatic" and "Manual bus" modes

The motor starter checks all incoming parameters for validity and plausibility, provided manual local mode is not active. The valid parameters are stored in data set 203 and 204.

In the case of incorrect parameters during startup (after power ON):

- The diagnoses "Group fault" and "Invalid parameter value" are set in the DS92 Read device diagnostics (Page 139).
- The motor remains shut down.
- An "Invalid parameter value" logbook entry (object number 365) is created in DS73 logbook - Read triggering operations (Page 136).
- The currently valid parameter values are retained and can be read via the Read DS203 device parameter 1 (Page 148). Incorrect parameters can be read back and verified in the Read/write DS201 device parameter 1 (Page 145).

In the case of incorrect parameters from the user program and when the motor is switched off:

- The "Group warning" and "Invalid parameter value" diagnoses are set and the number of the invalid parameter is entered in DS92 Read device diagnostics (Page 139).
- A logbook entry is created in the DS75 logbook - Read events (Page 137).
- The currently valid parameter values are retained and can be read via the Read DS203 device parameter 1 (Page 148). Incorrect parameters can be read back and verified in data set 201.

For parameters when the motor is running:

- The parameters are not accepted by the starter.
- The "Parameters cannot be changed in ON state" maintenance alarm is set if the maintenance alarm is enabled in the current parameterization.
- The "Group warning" and "Invalid parameter value" entries are set in DS92 Read device diagnostics (Page 139) and the number of the invalid parameter is entered.
- The motor is not switched off.
- A logbook entry is created in the DS75 logbook - Read events (Page 137).
- The currently valid parameter values are retained and can be read via the Read DS203 device parameter 1 (Page 148). Incorrect parameters can be read back and verified in the Read/write DS201 device parameter 1 (Page 145).

Checking incoming parameters in "Manual local" mode

The incoming parameters are checked as follows in "Manual local" mode:

- When the motor is switched off:

  The motor starter saves the parameter and accepts it only when the motor starter has switched over to "Automatic" mode again. Only after changing to "Automatic" are the parameters checked.
- When the motor is running:
  - The parameters are not accepted by the motor starter, even if the motor starter changes later to "Automatic" mode.
  - The diagnosis "Parameters cannot be changed in ON state" is set in the DS75 logbook - Read events (Page 137).
  - The diagnosis "Group warning" is set.
  - The motor is not switched off.
  - A logbook entry is created
  - The currently valid parameter values are retained.

Checking incoming parameters in "Manual bus" mode

The incoming parameters are not accepted and saved in "Manual bus" mode.

8.6 Declaration of parameters

Trip class

The trip class (CLASS) specifies the maximum time within which a protective device must trip from a cold state at 7.2x the setting current (motor protection to IEC 60947).

For more information, see Chapter Overload protection (Page 57).

Rated operational current I_e

This is where you can enter the rated operational current that the branch (switchgear and motor) can carry without interruption. The setting range depends on the relevant device's rating class.

For more information, see Chapter Rated operational current (Page 49).

Blocking current

If the blocking current is overshot, the motor starter detects stalling.

For more information, see Chapter Blocking time and blocking current (Page 72).

Blocking time

The blocking time is the time a motor block can be permitted without tripping the motor. If the blocking time expires and the system is still stalled, the motor starter switches off.

For more information, see Chapter Blocking time and blocking current (Page 72).

Diagnosis Electronics supply voltage too low

With this device parameter, you define whether a message is to be displayed if the supply voltage is too low (as of firmware V1.2.0).

Input n action

Different actions can be triggered when an input signal is present.

You can find out which actions you can parameterize depending on "Input n level", "Input n signal" and "Mode" in chapter Inputs (Page 78).

Input n level

You use this device parameter to specify the input logic.

For more information, see Chapter Inputs (Page 78).

Input n signal

You use this device parameter to determine whether or not the input level of the digital inputs is to be saved.

For more information, see Chapter Inputs (Page 78).

Load type

Here, you can specify whether the motor starter must protect a 1-phase load (direct-on-line starters only) or a 3-phase load.

For more information, see Chapter Load type (Page 51).

Upper/lower current limit

You can enter a lower and/or an upper current limit value.

NOTE

The current limits are not activated for startup override until the CLASS time expires, e.g. after 10 seconds for CLASS 10.

For more information, see Chapter Upper/lower current limit (Page 71).

Upper/lower current warning limit

You can enter a lower and/or an upper current warning limit value.

NOTE

The current limits are not activated for startup override until the CLASS time expires, e.g. after 10 seconds for CLASS 10.

For more information, see Chapter Upper/lower current warning limit (Page 71).

Group error diagnostics

You use this parameter to determine whether diagnostics via PROFINET or PROFIBUS DP (fault type) are enabled or disabled.

For more information, see Chapter Group fault diagnostics/group warning diagnostics (Page 78).

General warning diagnostics

You use this device parameter to determine whether or not a maintenance alarm is forwarded to the higher-level CPU.

For more information, see Chapter Group fault diagnostics/group warning diagnostics (Page 78).

Thermal motor model (response to overload)

You use this device parameter to determine how the motor starter is to respond to overload.

For more information, see Chapter Overload protection (Page 57).

Response to CPU/master STOP

Determines the module's response to CPU STOP.

For more information, see Chapter Response to CPU/master STOP (Page 78).

Response to residual current detection

You use this device parameter to specify how the motor starter is to respond to residual current detection.

For more information, see Chapter Response to residual current detection (Page 67).

Response to asymmetry

You use this device parameter to determine how the motor starter is to behave in the event of asymmetry.

For more information, see Chapter Asymmetry monitoring (Page 75).

Warning limit motor heating

The motor starter displays a warning if the motor heating limit is overshot. You use this parameter to preset a motor heating value in percent as a warning limit. At a warning limit of 0 %, the function is deactivated.

For more information, see Chapter Overload protection (Page 57).

8.7 Assigning fail-safe motor starter parameters

8.7.1 Explanation of safety-related parameters

Ex motor

The motor starter can switch and protect loads in an EX protection zone (see Ex motor application (Page 77)).

Response to safety-related tripping

The motor starter can send a warning to the CPU if tripping has been triggered through the fail-safe input (see Response to safety-related tripping (Page 76)).

8.7.2 Setting safety-related parameters

Fail-safe motor starters possess the following safety-related parameters:

- Ex motor
- Rated operational current
- Trip class

Response to modified safety-related parameters

If modified safety-related parameters are received during run-up, the parameters are displayed. Confirm the modified parameters by pressing the Reset button twice before continuing work.

If modified safety-related parameters are received after run-up has been completed, the motor starter responds as follows depending on its status:

- Motor OFF in automatic mode

  The motor starter accepts the new parameters. The parameters are indicated by the LEDs' flashing sequence. To activate the parameters, confirm them with the blue button. The motor cannot be switched on before the parameters are activated.

- Motor ON in automatic mode and in manual local mode

  The motor starter rejects the parameters. The "Parameter changes not allowed in motor ON state" message is issued. As communication is not secure, the motor starter does not respond to the modified parameters. Depending on the parameterization, entries in data set "DS92" or diagnostic interrupts are generated. The entries in data set "DS92" are deleted as soon as the modified parameters are active.

- Manual local mode

  The motor starter accepts the new parameters and saves them. As soon as manual local mode is ended, the parameters are activated and indicated by means of the LEDs' flashing sequence. Confirm the parameters with the blue button. The motor cannot be switched on before the parameters are activated.

- Manual bus mode

  The motor starter accepts the new parameters. The parameters are indicated by the LEDs' flashing sequence. To activate the parameters, confirm them with the blue button. The motor cannot be switched on before the parameters are activated.

The motor starter remains in the safe state (STO) until you have confirmed the parameters. Before you have confirmed the parameters, they can already be read out in data set "DS203". Data set "DS201" is accepted. A group warning in the DS92 Read device diagnostics (Page 139) and in the process image input is triggered. Moreover, a maintenance alarm, "New safety-related parameters received" (0x1036), can be generated.

Response to invalid parameterization

If inconsistent or invalid parameterization is detected, the applicable parameters are discarded. Entries in data set "DS92" or diagnostic interrupts are generated. To narrow down the invalid parameterization, compare the parameter values from the data sets "DS201" and "DS203" or "DS202" and "DS204".

Reading back the data sets "DS201" and "DS202" returns the last correctly transferred data set, even if it is rejected later due to inadmissible content.

Data sets with incorrect lengths are rejected and discarded. The starter continues to operate with the last valid parameter.

8.7.3 Configuring ATEX operation

ET 200SP fail-safe motor starters protect motors in an ATEX environment. The following parameters are considered to be safety-related in ATEX operation:

- Rated operational current (I_e)
- Trip class

You set the parameters via the data sets or using the engineering software.

Before the new safety-related parameters are accepted, however, check and confirm the new parameters. The parameter settings are indicated by means of a flashing sequence of the LEDs on the fail-safe motor starter. As soon as you have ensured with the aid of the LEDs that all parameters are correctly set, confirm the new parameters on the device by means of the blue button. The parameters are not accepted until you have confirmed and the motor starter is "Ready for motor ON". Changes to parameters that are not safety-related do not require confirmation.

LED flashing sequence

The following graphic shows the order in which the LEDs flash:

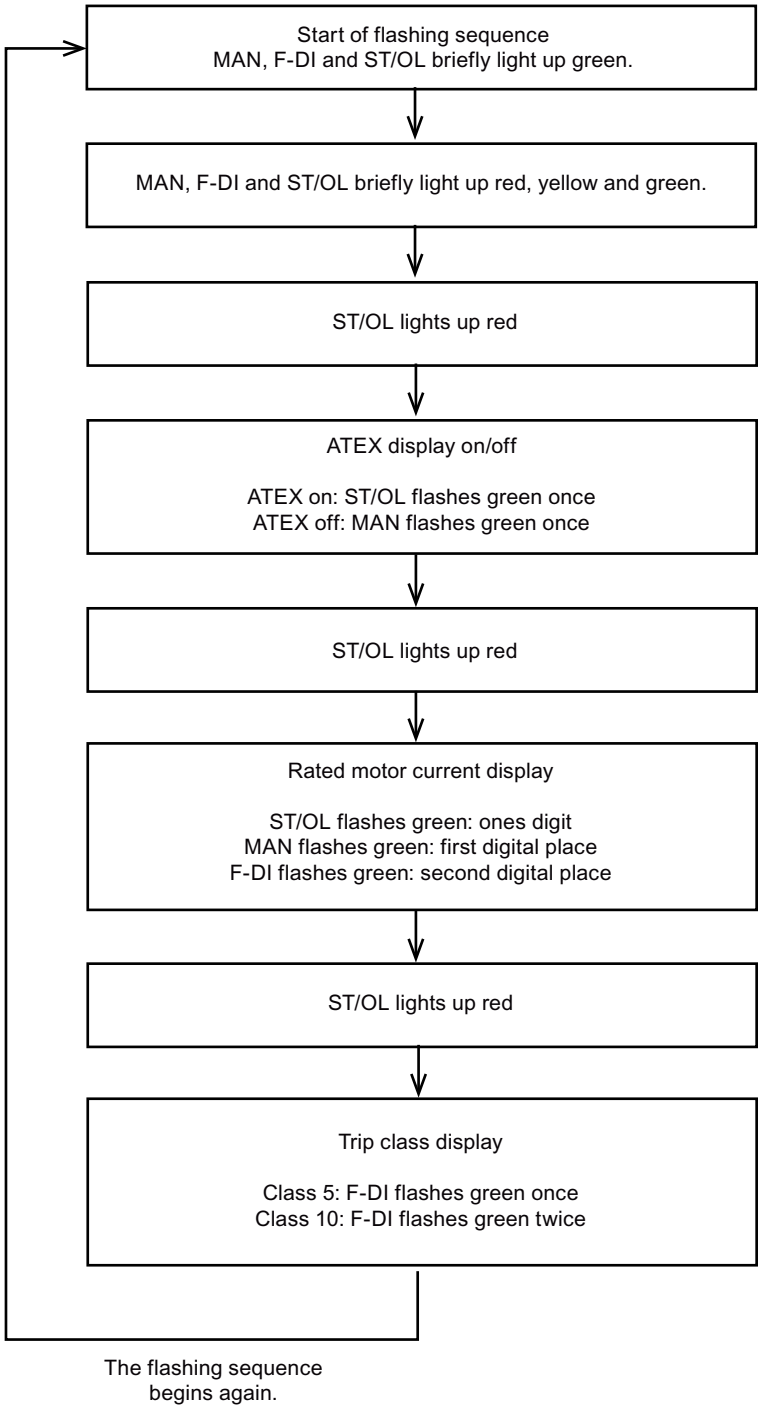

Figure 2-1057 Flashing sequence during ATEX operation

The start of the flashing sequence is indicated by the "MAN", "F-DI" and "ST/OL" LEDs, which light up briefly in green all at the same time. The multi-colored LEDs then light up in red and yellow. Lighting up also serves to verify that all LEDs are functioning correctly.

To signal display of the next parameter, the "ST/OL" LED briefly lights up in red between every flashing signal for a set parameter.

The flashing sequence ends as soon as you press the blue button twice and confirm the set parameters.

NOTE

Receiving several parameter assignments

If safety-related parameters are received during a flashing sequence, conform the first parameters (or reject them) first. Only then are the parameters that have been sent last indicated. The motor cannot be started until the parameters last sent are valid and you have confirmed them.

NOTE

ATEX operation is not possible in connection with an activated parameter block

If the parameter block is activated and an ATEX parameter assignment is received, the device fault 461 and the diagnostic interrupt 0x1095 are output.

Disable the parameter block of the corresponding motor starter before you send ATEX parameters.

Rejecting ATEX parameterization

Proceed as follows if you want to reject the set parameterization:

1. Press the blue button for longer than five seconds.

   A group fault is output and the "Invalid parameter value" diagnostic message in data set 92 is set. A logbook entry is also created in data set 73. The diagnostic interrupt 0x1095 is also triggered if group fault diagnostics is enabled. In this state you cannot trigger any of the other functions.
2. Send the correct parameterization via the data set "DS201".
3. Confirm the correct parameterization.

Displaying ATEX parameters

To display the safety-related parameter settings during normal operation, press the TEST/RESET button for at least five seconds.

8.7.4 Examples of LED flashing sequences

Below you see a few examples of the LED flashing sequence.

Example of I_e = 5 A and CLASS 10

The following figure shows the LED flashing sequence with a fail-safe motor starter that has trip class I_e = 5 A and CLASS 10:

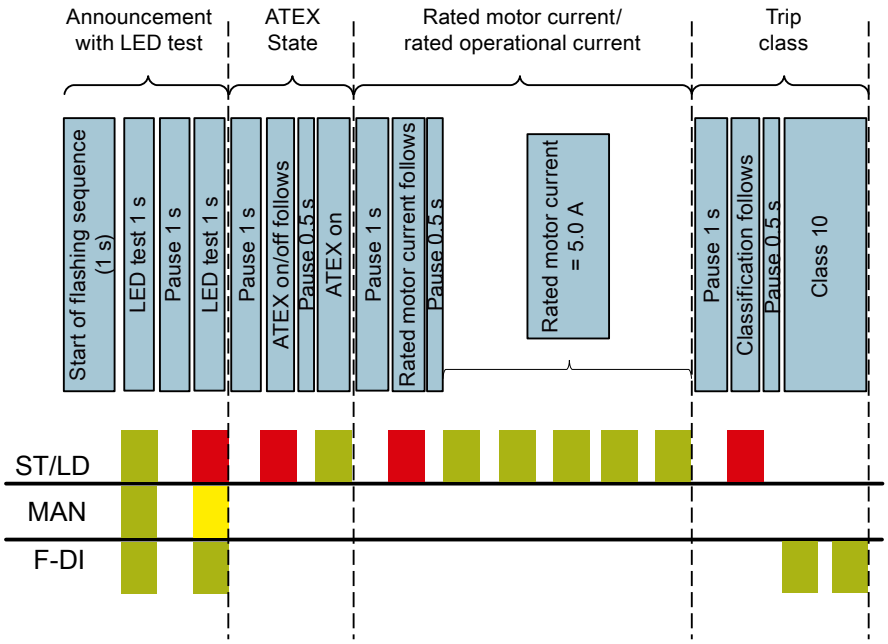

Figure 2-1058 Display example I_e = 5.0 A CLASS 10

Example of I_e = 0.34 A and CLASS 5

The following figure shows the LED flashing sequence with a fail-safe motor starter that has trip class I_e = 0.34 A and CLASS 5:

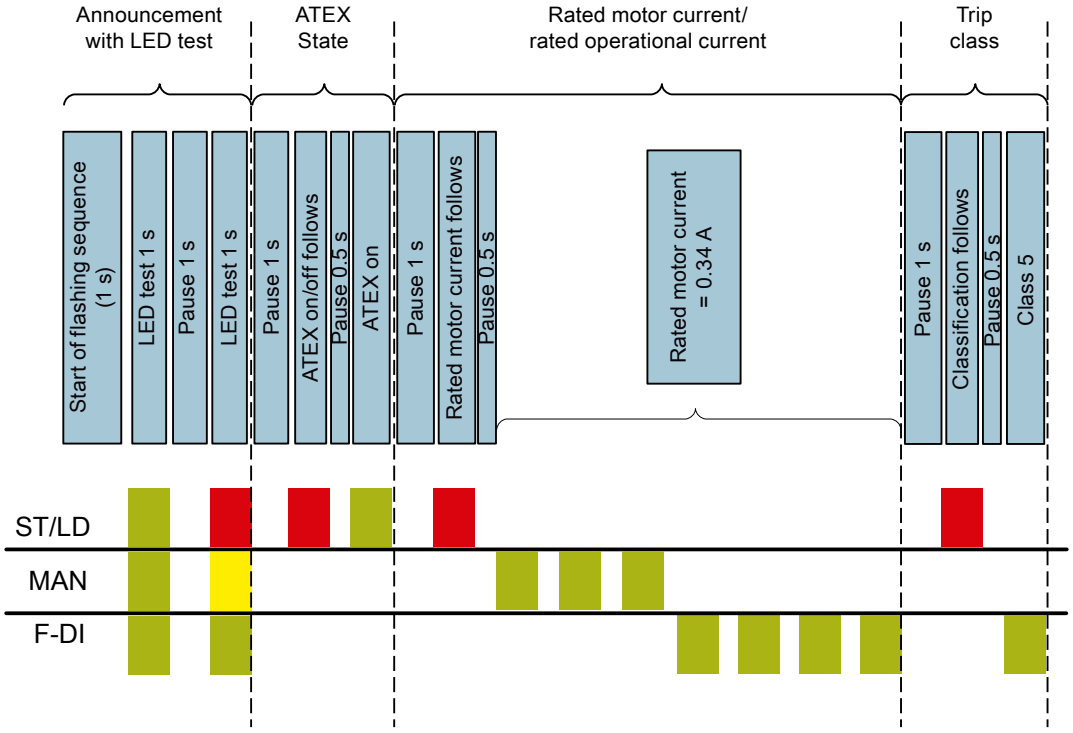

Figure 2-1059 Display example I_e = 0.34 A CLASS 5

Example of I_e = 11.4 A and CLASS 5

The following figure shows the LED flashing sequence with a fail-safe motor starter that has trip class I_e = 11.4 A and CLASS 5:

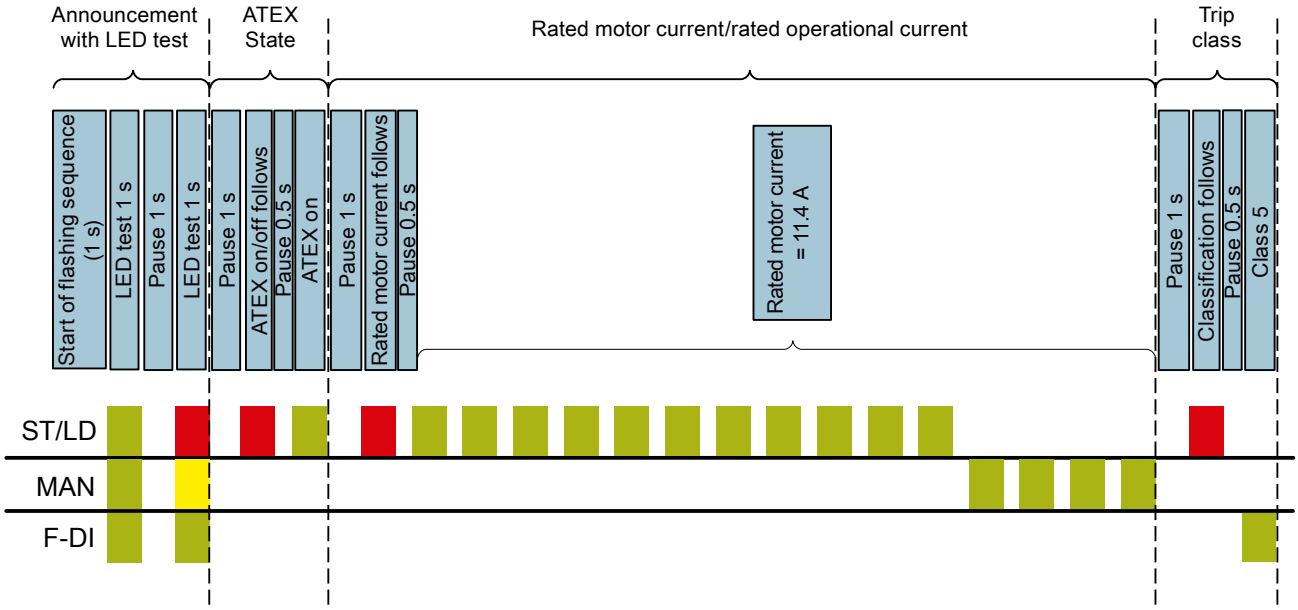

Figure 2-1060 Display example 11.4 A CLASS 5

Example of I_e = 3.75 A and CLASS 5

The following figure shows the LED flashing sequence with a fail-safe motor starter that has trip class I_e = 3.75 A and CLASS 5:

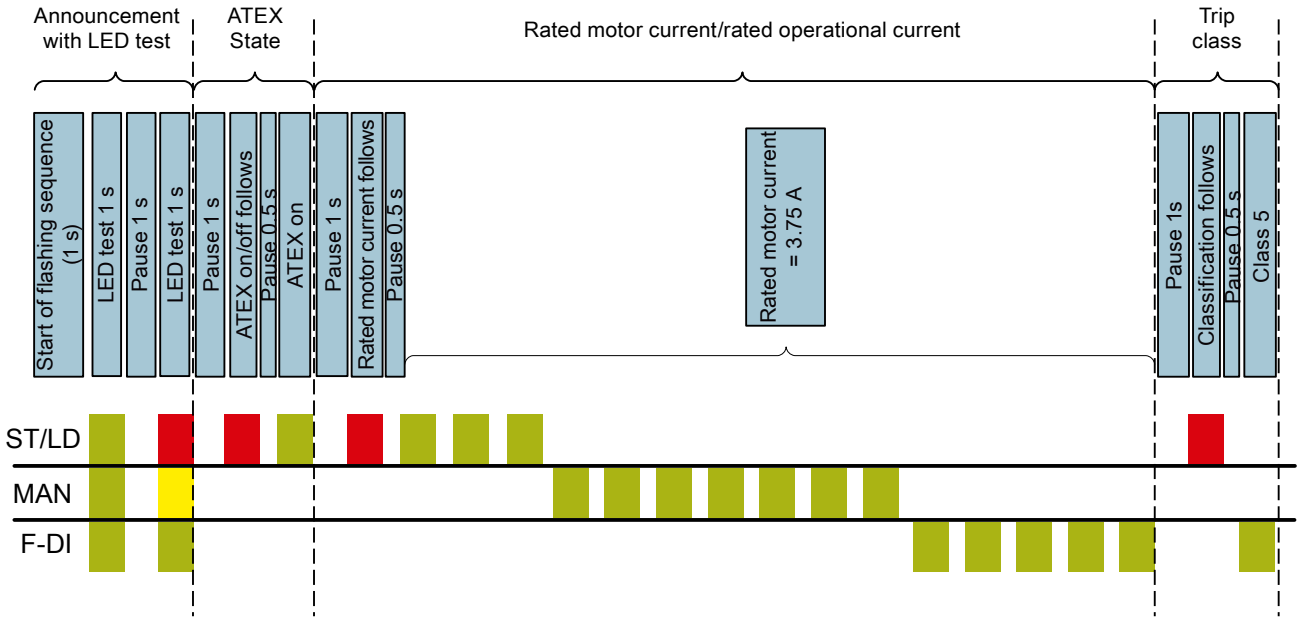

Figure 2-1061 Display example Ie = 3.75 A CLASS 5

ATEX off display

The following figure shows the LED flashing sequence when ATEX operation for a fail-safe motor starter is deactivated:

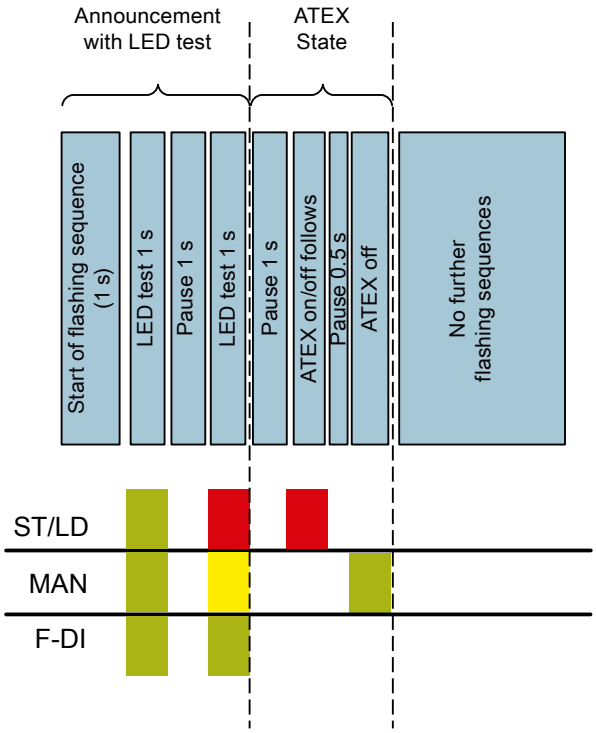

Figure 2-1062 ATEX off display

8.8 Address space

Process image of the outputs

Table 2-1159 Contents of process image of the outputs (in bytes 0 to 1)

Process data	Meaning	Relevant for
DQ 0.0	Motor CW	All
DQ 0.1	Motor CCW	Reversing starters only
DQ 0.2	-	-
DQ 0.3	Trip RESET	All
DQ 0.4	Emergency start	All (except activate "EX motor" parameter)
DQ 0.5	-	-
DQ 0.6	-	-
DQ 0.7	Cold start	All
DQ 1.0	-	-
DQ 1.1	-	-

Process data	Meaning	Relevant for
DQ 1.2	-	-
DQ 1.3	-	-
DQ 1.4	-	-
DQ 1.5	-	-
DQ 1.6	-	-
DQ 1.7	Disable quick stop	All

Process image of the inputs

Table 2-1160 Process image of the inputs (in bytes 0 to 3)

Process data	Meaning	Relevant for
DI 0.0	Ready (automatic)	All
DI 0.1	Motor ON	All
DI 0.2	Group fault	All
DI 0.3	Group warning	All
DI 0.4	Input 1	All (with 3DI/LC module)
DI 0.5	Input 2	All (with 3DI/LC module)
DI 0.6	Input 3	All (with 3DI/LC module)
DI 0.7	Input LC	All (with 3DI/LC module)
DI 1.0	Motor current I_{curr} [%] bit 0	All
DI 1.1	Motor current I_{curr} [%] bit 1	All
DI 1.2	Motor current I_{curr} [%] bit 2	All
DI 1.3	Motor current I_{curr} [%] bit 3	All
DI 1.4	Motor current I_{curr} [%] bit 4	All
DI 1.5	Motor current I_{curr} [%] bit 5	All
DI 1.6	Manual local mode	All (with 3DI/LC module)
DI 1.7	-	-
DI 2.0	Ready to start for motor ON	All
DI 2.1	Motor ON - RIGHT	All
DI 2.2	Motor ON - LEFT	Reversing starters only
DI 2.3	Quick stop active	All
DI 2.4	Energy saving mode active	All
DI 2.5	DI module inserted	All
DI 2.6	Explosion protection of the motor active	Fail-safe starters only
DI 2.7	Parameter block active	All [1)]
DI 3.0	Thermal motor model overload	All
DI 3.1	-	-
DI 3.2	I_e current limit tripping	All
DI 3.3	F-DI status	Fail-safe starters only

Process data	Meaning	Relevant for
DI 3.4	Residual current detected	All
DI 3.5	Asymmetry detected	All
DI 3.6	Overtemperature	All
DI 3.7	-	-

1) From FW Version 1.2.0

Alarms/diagnostic messages

9

9.1 Status and error displays

LED display

The figure below shows the LED display on the ET 200SP motor starter:

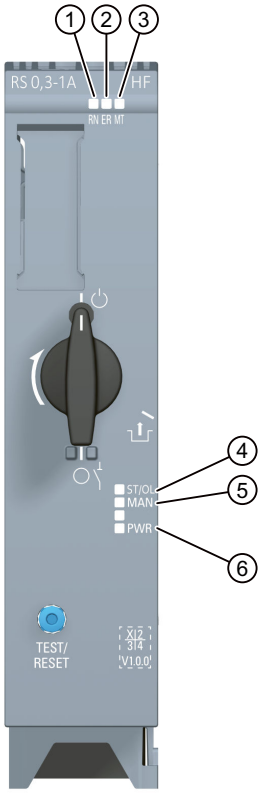

①	RN	(green)	- Run
②	ER	(red)	- Error
③	MT	(yellow)	- Maintenance
④	ST/OL	(red/green)	- State/overload
⑤	MAN	(yellow)	- Manual (manual local mode)
⑥	PWR	(green)	- Power

Figure 2-1063 LED display on the ET 200SP motor starter

The figure below shows the LED display on the fail-safe ET 200SP motor starter:

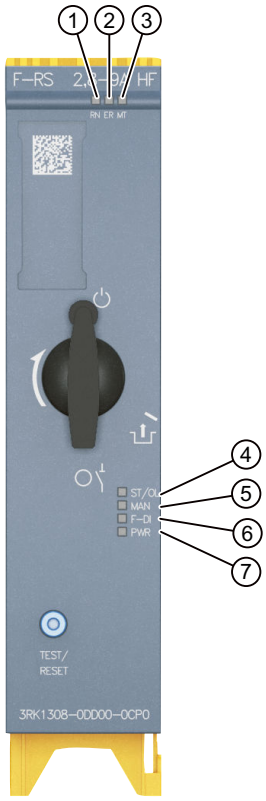

①	RN	(green)	- Run
②	ER	(red)	- Error
③	MT	(yellow)	- Maintenance
④	ST/OL	(red/green)	- State/overload
⑤	MAN	(yellow)	- Manual (manual local mode)
⑥	F-DI	(green)	- Fail-safe digital input
⑦	PWR	(green)	- Power

Figure 2-1064 LED display on the ET 200SP Failsafe motor starter

Meaning of the LEDs

The tables below give the meanings of the status and fault displays:

RN/ER/MT LED

Table 2-1161 RN/ER/MT status and error displays

LEDs			Meaning	Explanation
RN (RUN)	**ER (ERROR)**	**MT (MAINT)**		
■ On	Not relevant	Not relevant	Operating state "RUN", the ET 200SP motor starter is in a "normal" application and executes the control commands. The current operating mode is not relevant.	-
☼ Flashes	Not relevant	Not relevant	Startup (Cfg + Par.) Self-test Module deactivated Parameterization error	System operating state "System startup" A parameterization fault during startup prevents exiting of this state. The SIMATIC ET 200SP motor starter reports a fault.
				Wait until the ET 200SP motor starter is ready.
				Firmware update
				The module has been deconfigured.
Not relevant	Not relevant	■ On	Maintenance demanded (warning)	Group warning At least one Maintenance demanded alarm has been transferred to the controller. Possible causes: • Motor model has exceeded warning limit • Current value has exceeded or undershot warning limit • Start disabled, ET 200SP motor starter too warm (without ON command)
Not relevant	☼ Flashes at ≥ 2 Hz	Not relevant	Error	Group fault At least one Error alarm has been transferred to the controller. Possible causes: • Electronics supply voltage too low or too high • Motor protection disconnection • Thermal overload of the ET 200SP motor starter • Missing load voltage, phase failure/missing load • The mechanical rotary interlock is not in the READY position.
■ On	OFF	☼ Flashes	PROFIenergy active	-
☼ Flashes	OFF	☼ Flashes	Action required	Ex motor (ATEX): New safety-related parameters are available for release.

ST/OL (STATE/OVERLOAD) LED

Table 2-1162 Status display ST/OL

ST/OL LED	Motor operating state	Meaning
■ On	Operation	ON command for motor active
□ Off	STOP	The motor is switched off. It is not known whether the motor is still rotating or not.
☼ Flashes at 0.5 Hz	Overload	The thermal motor model or device protection model has tripped.

MAN (MANUAL) LED

Table 2-1163 Status display MAN

MAN LED	Meaning	Remedy
□ Off	Manual local mode deactivated	-
■ On	Manual local mode activated	-
☼ Flashes at 1 Hz	Connection abort in manual bus mode	-

PWR (POWER) LED

Table 2-1164 Status display PWR

PWR LED	Meaning	Remedy
□ Off	Supply voltage not present or too low	Check the supply voltage.
■ On	Supply voltage present	-

LED F-DI for fail-safe motor starters

Table 2-1165 Status display F-DI

LED F-DI	Meaning	Remedy
□ Off	LOW level at the fail-safe digital input on the BaseUnit in the case of a fail-safe motor starter.	-
■ On	HIGH level at the fail-safe digital input on the BaseUnit in the case of a fail-safe motor starter.	-

LED combinations

Table 2-1166 Status displays ST/OL/MAN/PWR

LEDs			Meaning	Explanation
ST/OL (State/Overload)	MAN (Manual)	PWR (Power)		
Lights up for 4 s	Lights up for 4 s	Lights up for 4 s	LED/fan test	All LEDs are switched on for 4 s (triggered by pressing the blue button).
Flashes	Flashes	Lights up	Firmware update active or canceled	-
OFF	OFF	OFF	No supply voltage	No supply voltage available A detected undervoltage (in the case of still functioning electronics) is not reported as power OFF, but as a fault.
Flashes at 1 Hz	Flashes	Lights up	Device fault	Non-correctable fault detected following self-diagnostics (contactor contacts, switching element, etc.). Remedy: Check the wiring and, if necessary, replace the device.

9.2 TEST/RESET button

The RESET button has the following functions:

Designation	Tripping	Description
LED/fan test	Press of a button for less than two seconds	The LED/fan test is activated. All LEDs (ST/OL, MAN, PWR) light up and the fan is switched on for 4 s. An LED/fan test is not possible in the case of fail-safe motor starters with F-DI deactivated (safety-related shutdown by low level).
RESET function	Press of a button	If a group fault is active, you can acknowledge this fault using the blue button. You can acknowledge device faults in principle only via ON/OFF of the control voltage. Note: If a fault is active, you cannot execute the LED/fan test.

Additional functions in the case of fail-safe motor starters

Confirming ATEX parameters	Press of a button	You confirm display of the parameters via an LED flashing sequence by pressing the RESET button twice.
Discarding ATEX parameterization	Press of a button for longer than five seconds.	By pressing the button for longer than five seconds, you discard newly set ATEX parameters and you return to the original parameterization.
Displaying ATEX parameterization	Press of a button for longer than five seconds.	By pressing the button for longer than five seconds, you can display the currently set ATEX parameters during operation.
Switching to commissioning mode	Press of a button	In "Manual local" mode, confirm the change to commissioning mode by the fail-safe motor starter by pressing the button.

9.3 Interrupts

The ET 200SP motor starter supports diagnostic interrupts and maintenance. You can read out the diagnoses of the motor starter in the following data sets:

- DS72 logbook - Read device error (Page 133)
- DS73 logbook - Read triggering operations (Page 136)
- DS75 logbook - Read events (Page 137)
- DS92 Read device diagnostics (Page 139)

A diagnostic message is output for each diagnostics event and the ER LED flashes on the module when group fault diagnostics are enabled. You can read out the diagnostic messages in the diagnostics buffer of the CPU, for example. You can evaluate the error codes via the user program. The following table shows the individual diagnostic messages:

Error type channel diagnostics	Fault text	Generated at data record object number	Remedial measures
0003_h (3_{dec})	Overvoltage	1407	Cause: The supply voltage is above the tolerance limit. Remedy: Change the power supply.
1000_h (4096_{dec})	Zero current after ON command	338	No current flow is detected in the motor feeder after an ON command. Possible cause: main circuit interrupted (energy supply missing, internal fuse defective, load missing)
1021_h (4129_{dec})	Phase unbalance	340, 341	The limit value for phase unbalance has been exceeded. Phase unbalance can cause an overload. Possible causes: Failure of the phase, fault in the motor windings Remedy: Check the motor feeder and the motor.
1022_h (4130_{dec})	Thermal motor model overload	327, 328	The motor feeder has been overloaded. The motor temperature rise has exceeded a limit. Remedy: Please check the motor and the applications that are being driven by the motor. After a trip, you can switch the motor on again after the cooling time has expired, or after the thermal motor model has been deleted.
1036_n (4150_{dec})	Parameters for EX motor protection received	1537	Parameters for the EX motor protection have been received. Remedy: Remedy: Confirm the correctness of the parameters directly on the device.
1040_h (4160_{dec})	Threshold I exceeded	334, 1541	The current has exceeded a limit. Remedy: Please check the application that is being driven by the motor.
1041_h (4161_{dec})	Threshold I undershot	335, 1542	The current has undershot a limit. Remedy: Please check the application that is being driven by the motor.
1093_h (4243_{dec})	Sensor supply overload	354	The output driver for the sensor supply is overloaded. Remedy: Check the cabling and the sensor.
$104C_h$ (4172_{dec})	Motor blocking	339	The maximum motor current has exceeded a limit for blocking protection. Possible cause: The motor is blocked. Remedy: Please check the application that is being driven by the motor.

Error type channel diagnostics	Fault text	Generated at data record object number	Remedial measures
1080_h (4224_{dec})	Device fault	308, 338, 381,456, 458, 460, 476, 480, 490, 1414, 1417, 1466, 1467, 1482, 20010, 20011, 20012, 20013, 20015, 20018, 20017 (up to V1.2.0)	Non-correctable fault detected following self-diagnostics (contactor contacts, switching element, etc.). Remedy: Check the logbook entries. Check the wiring and, if necessary, replace the device.
1083_h (4227_{dec})	Switching element overload	309, 1580	Switching element (switching contact, power semiconductor) too hot. Check the ambient conditions linked to cooling. You might have to take derating into consideration. Check the number of switching operations. Also check whether the fan is working properly.
1084_h (4228_{dec})	Electronics supply voltage too low	317	The supply voltage is below the permissible value. Remedy: Check the power supply (load measurement, voltage range)
1088_h (4232_{dec})	No switching element supply voltage	333	No supply voltage has been detected or the mechanical rotary interlock is not in the READY position. Remedy: Check the power supply to the switching elements and the cabling or turn the mechanical rotary interlock to the READY position.
1095_h (4245_{dec})	Parameter error	365, 366, 384, 461	The module is not yet parameterized or is incorrectly parameterized or the safety-related parameters have been rejected. Remedy: Correct the parameterization.
1096_h (4246_{dec})	Process image error	355	The process image output (PIQ) contains invalid control bit combinations (e.g. control bits for clockwise and counter-clockwise set simultaneously). Remedy: Check and correct the process image output (PIQ).
$10A5_h$ (4261_{dec})	Residual current	337, 338	No current flow is detected in the motor feeder after an ON command. Possible causes: Phase failure, fault in the motor winding, fuse in the device defective Remedy: Check the motor feeder (main circuit) and the motor. Clear the short-circuit in the system and replace the device.
$100A_h$ (4106_{dec})	Test mode current flow	1406	Current is flowing in the motor feeder although the motor feeder is in test mode or the test position. Possible causes: The main circuit is not interrupted in test operation. The cold start function of the ET 200SP motor starter is activated. Remedy: Check the wiring or deactivate the cold start function
$109D_h$ (4253_{dec})	Input Action	348, 351	A warning or trip signal is active on at least one input. Remedy: Check the application.
$109E_h$ (4254_{dec})	Emergency end position CW	349	The "CW" emergency end position has been passed. Remedy: Check the end position of the drive.
$001F_h$ (31_{dec})	Channel temporarily unavailable		Wait until the firmware update is completed.

Error type channel diagnostics	Fault text	Generated at data record object number	Remedial measures
$109F_h$ (4255_{dec})	Emergency trip end position CCW	350	The "CCW" emergency end position has been passed. Remedy: Check the end position of the drive.
$134B_h$ (4939_{dec})	Trip Reset not possible		Trip reset is currently not possible (e.g. because the cooling phase is in progress). Remedy: Repeat the action later (e.g. after the cooling time has elapsed).
1080_h		20013, 1466, 1417, 20010, 1467 (as of V1.2.2)	When the error occurs for the 1st to 4th time. On the 5th occurrence, error type channel diagnostics 1080_h is reported again.

9.4 Maintenance

A maintenance alarm is output for each group warning and the MT LED lights up on the module when group warning diagnostics are enabled. You can read out the diagnostic messages in the diagnostics buffer of the CPU, for example. You read the maintenance alarms in data set 75 (Page 137) of the motor starter.

Extended maintenance

You will find general information on extended maintenance in "Diagnostics" in the SIMATIC PROFINET Function Manual (https://support.industry.siemens.com/cs/de/de/view/49948856/en).

The PROFINET interfaces of the interface module support the diagnostics concept and maintenance concept in PROFINET according to the standard IEC 61158-6-10. The aim is early detection and correction of potential faults. The motor starter's full functionality (maintenance) is available with firmware version V3.3 of the interface module.

The maintenance information is generated in STEP 7 with the following system messages:

- Maintenance request - symbolized by a yellow screwdriver.
- Faults - symbolized by a red screwdriver

See also

SIMATIC ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293)

Technical data

10

10.1 Technical data in Siemens Industry Online Support

Technical data sheet

You can also find the technical data of the product at Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/).

1. Enter the full article number of the desired device in the "Product" field, and confirm with the Enter key.
2. Click the "Technical data" link.

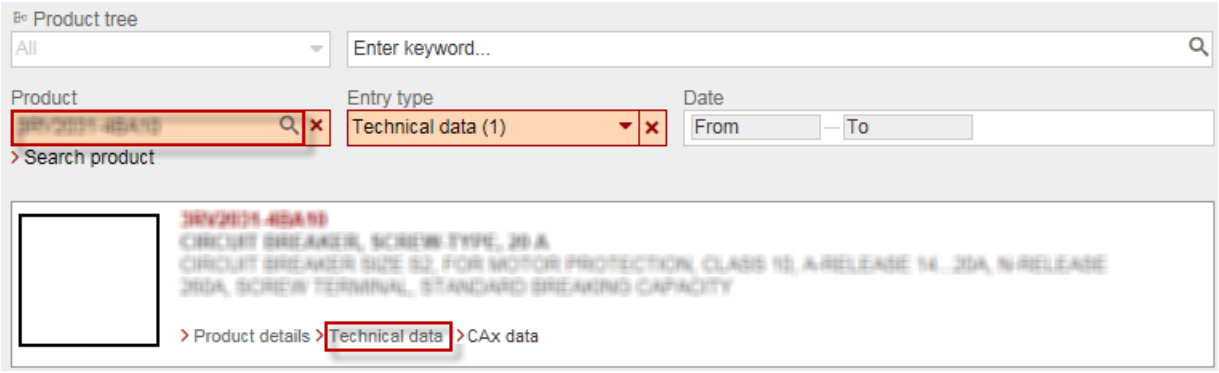

10.2 Final conditions for safety-related parameters

Safety-related parameters

The safety-related parameters in the data sheet have been determined on the basis of the following final conditions:

- Side-by-side mounting at rated current I_n
- 100% ON period of electronics
- 40 °C ambient temperature
- DIN EN 60721-3-7 noxious gas environment: class 3C2

B10d value

NOTICE
Consider the B10d value stated for the motor starter in your application. The maximum number of operating cycles (B10d) may not be exceeded within the mission time T1. If the expected number of operating cycles exceeds the B10d value during the device's service life, you must set correspondingly shorter replacement intervals.

You can calculate the maximum service life of the device as follows: T10D = B10d / nop; nop: Operating cycles/year

Validity of safety engineering data

The safety engineering data specified in the data sheet is valid under the following prerequisites:

The specified PFH/PFD value is valid until the electrical endurance (B10) or the mission time has been reached. Replace the device if either the electrical endurance or the mission time has been exceeded. The application is outside of the specification if the maximum number of starting operations is exceeded.

NOTE

Definition of "number of starting operations"

The "number of starting operations" stands for the frequency of switching of the main conducting path switching elements, i.e. switching on and off of the connected motor and not requesting of STO via the power supply or the fail-safe digital input.

NOTICE
Use of ET 200SP motor starters at installation altitudes higher than 2000 m above sea level Refer to the current product information for use at an altitude higher than 2000 m above sea level (Extension of the application range for fail-safe SIMATIC ET 200SP motor starters up to an installation altitude of 4000 m (https://support.industry.siemens.com/cs/ww/en/view/109778836)).

CAx data

11

11.1 CAx data

You can find the CAx data in the Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/).

1. Enter the full article number of the desired device in the "Product" field, and confirm with the Enter key.
2. Click the "CAx data link.

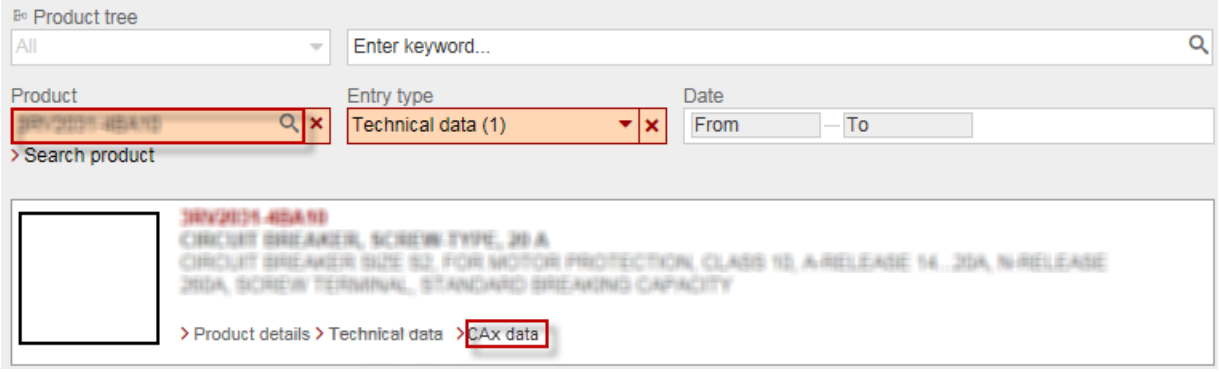

Data sets

A

A.1 Reading and writing of data records

You can access the data sets of the motor starter from STEP 7:

- Writing data sets by calling SFB 53 "WRREC"
- Reading data sets by calling SFB 52 "RDREC"

You will find further information about the SFB in the STEP 7 online help.

A.2 Byte arrangements

When data longer than one byte is stored, the bytes are arranged as follows ("big endian"):

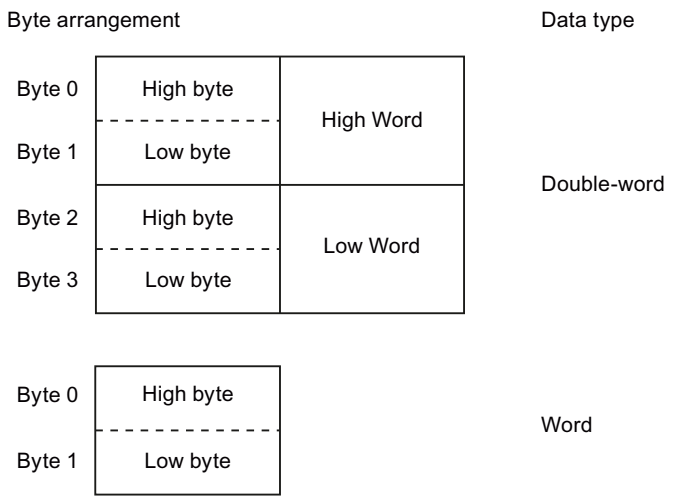

A.3 DS68 Read/write process image output

NOTE

Please note that data set 68 is overwritten by the cyclic process image in automatic mode!

Byte	Content	Value / value range	Meaning
0	Coordination	0x21	Write via acyclic bus channel (PLC)
1	Reserved	0x00	-
2	Reserved	0x00	-
3	Reserved	0x00	-

Byte	Content	Value / value range	Meaning
Process image of the outputs			
4	Process data	DQ 0.0 to DQ 0.7	See table below
5	Process data	DQ 1.0 to DQ 1.7	See table below

Table 2-1167 Content of process image of the outputs (in bytes 4 and 5)

Byte.Bit	Encoding	Process data	Meaning	Relevant for
4.0	Bit (1 = active)	DQ 0.0	Motor CW	All
4.1		DQ 0.1	Motor CCW	Reversing starters only
4.2		DQ 0.2	-	-
4.3		DQ 0.3	Trip reset	All
4.4		DQ 0.4	Emergency start	All [1)]
4.5		DQ 0.5	-	-
4.6		DQ 0.6	-	-
4.7		DQ 0.7	Cold start	All [2)]
5.0	Bit (1 = active)	DQ 1.0	-	-
5.1		DQ 1.1	-	-
5.2		DQ 1.2	-	-
5.3		DQ 1.3	-	-
5.4		DQ 1.4	-	-
5.5		DQ 1.5	-	-
5.6		DQ 1.6	-	-
5.7		DQ 1.7	Disable quick stop	All

1) Not for EX motor

2) F starter as of FW V 1.2.0

A.4 DS69 Read process image input

Byte	Content	Value / value range	Meaning
0	Process data	DI 0.0 to DI 0.7	See table below
1	Process data	DI 1.0 to DI 1.7	See table below
2	Process data	DI 2.0 to DI 2.7	See table below
3	Process data	DI 3.0 to DI 3.7	See table below

Table 2-1168 Process image input (in bytes 0 and 3)

Byte.Bit	Encoding	Process data	Meaning	Relevant for
0.0	Bit (1 = active)	DI 0.0	Ready (automatic)	All
0.1		DI 0.1	Motor ON	All
0.2		DI 0.2	Group fault	All

Byte.Bit	Encoding	Process data	Meaning	Relevant for
0.3	Bit (1 = active)	DI 0.3	Group warning	All
0.4		DI 0.4	Input 1	All
0.5		DI 0.5	Input 2	All
0.6		DI 0.6	Input 3	All
0.7		DI 0.7	Input 4	All
1.0	Bit (1 = active)	DI 1.0	Motor current I_{act}-bit0	All
1.1		DI 1.1	Motor current I_{act}-bit1	All
1.2		DI 1.2	Motor current I_{act}-bit2	All
1.3		DI 1.3	Motor current I_{act}-bit3	All
1.4		DI 1.4	Motor current I_{act}-bit4	All
1.5		DI 1.5	Motor current I_{act}-bit5	All
1.6		DI 1.6	Manual local mode	All
1.7		DI 1.7	-	-
2.0	Bit (1 = active)	DI 2.0	Ready to start for motor ON	All
2.1		DI 2.1	Motor CW	All
2.2		DI 2.2	Motor CCW	Reversing starters only
2.3		DI 2.3	Quick stop active	All
2.4		DI 2.4	Energy saving mode active	All
2.5		DI 2.5	DI module inserted	All
2.6		DI 2.6	Ex motor active	F starters only
2.7		DI 2.7	Parameters disabled CPU/master active	All
3.0	Bit (1 = active)	DI 3.0	Thermal model overload	All
3.1		DI 3.1	-	-
3.2		DI 3.2	I_e current limit tripping	All
3.3		DI 3.3	F-DI status	F starters only
3.4		DI 3.4	Residual current detected	All
3.5		DI 3.5	Asymmetry detected	All
3.6		DI 3.6	Overtemperature	All
3.7		DI 3.7	-	-

A.5 DS72 logbook - Read device error

Byte	Data type	Meaning	Range of values	Increment
Entry 1 (= latest entry)				
0 ... 3	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
4 ... 5	Signed 16	Object number	0 ... ±32767	1
Entry 2 (= second-latest entry)				
6 ... 9	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s

Byte	Data type	Meaning	Range of values	Increment
10 - 11	Signed 16	Object number	0 ... ±32767	1
... ...				
Entry 21 (last, oldest entry)				
120 ... 123	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
124 ... 125	Signed 16	Object number	0 ... ±32767	1

The data set call "Logbook device fault" returns the operating hour of the event that has occurred and an associated object number for each entry. This data set can accommodate 21 entries. When all locations have been overwritten, the oldest entry is overwritten again.

Following a retentive device fault (fail-safe motor starter defective), new entries are no longer entered into the logbook as soon as the 24 V supply voltage has been interrupted (e.g. pulling/plugging in the device).

NOTE

The latest entry is entered at the first location of the data set. The remaining entries are moved one entry down. You cannot delete logbooks yourself.

The supported object numbers and their meanings are shown in the table below: In the case of HF motor starters, you can acknowledge faults by switching off the supply voltage and by switching it on again. Replace the motor starter if the fault occurs again.

NOTE

In the case of fail-safe motor starters, there are some faults that you cannot acknowledge. If the relevant message in the "Fail-safe motor starter defective" column is marked with an "x", you can reset this error a maximum of 5 times. After that, the motor starter must be replaced.

Table 2-1169 Assignment of error types to device faults

Object No.	Device fault messages	Fail-safe motor starter defective	5-life Error	F	Unit	Comment
308	Switching element defective	x	-	x	x	-
417	Stack overflow	-	-	x	x	These messages are used for the exact analysis of the cause of the error, in DS92 all are mapped to object number 381 "Error during self-test". The failure type defined there also applies.
418	Stack underflow	-	-	x	x	
423	Invalid command	-	-	x	x	
434	Error in system software	-	-	x	x	
437	Watchdog overflow	-	-	x	x	
456	EEPROM: memory defective	x	-	x	x	
458	EEPROM: CRC error "Device parameter"	x	-	x	x	
460	EEPROM: Contains invalid data	x	-	x	x	

Object No.	Device fault messages	Fail-safe motor starter defective	5-life Error	F	Unit	Comment
462	EEPROM: Invalid pointer for device parameter buffer	x	-	x	x	These messages are used for the exact analysis of the cause of the error, in DS92 all are mapped to object number 381 "Error during self-test". The failure type defined there also applies.
464	ROM error	x	-	x	x	
465	RAM error	x	-	x	x	
476	Current measuring defective	x	-	x	x	These messages are used for the exact analysis of the cause of the error, in DS92 all are mapped to object number 308 "Switching element defective". The failure type defined there also applies.
478	Bypass element does not close	-	-	x	x	
479	Bypass element does not open	x	-	x	x	
480	Bypass element protection has opened unintentionally during operation	- [2]	-	x	x	
486	Program execution check: Sequential program execution error	-	-	x	x	These messages are used for the exact analysis of the cause of the error, in DS92 all are mapped to object number 381 "Error during self-test". The failure type defined there also applies.
487	Program execution check: Logical programming error	-	-	x	x	
490	Incorrect power section detected	x	-	x	x	-
1414	Switching element short-circuited	x	-	x	x	-
1417	Bypass element defective	- [1] [4]	**x**	x	x	-
1466	Contact 1 failed	- [4]	**x**	x	x	These messages are used for the exact analysis of the cause of the error, in DS92 all are mapped to object number 308 "Switching element defective". The failure type defined there also applies.
1467	Contact 2 failed	- [4]	**x**	x	x	
381	Error during self-test		-	x	x	-
1407	Electronics supply voltage too high	-	-	x	x	Previously in D73
1482	Current measuring range overshot	x [3]	-	x	x	Previously in D73
20010	Direct-on-line or reversing relay defective	- [4]	**x**	x	-	These messages are used for the exact analysis of the cause of the error, in DS92 all are mapped to object number 308 "Switching element defective". The failure type defined there also applies.
20011	12 V supply defective	x	-	x	-	
20012	F-DI defective	x	-	x	-	

Object No.	Device fault messages	Fail-safe motor starter defective	5-life Error	F	Unit	Comment
20013	Hard switching of relays	- [4]	**x**	x	-	These messages are used for the exact analysis of the cause of the error, in DS92 all are mapped to object number 308 "Switching element defective". The failure type defined there also applies.
20015	Relay control defective feedback message	x	-	x	-	
20018	Bypass relay hard switched in the permissible current range (< 1 A at 0.4 A, < 3 A at 1 A MS and 3 A MS, < 8 A at 9 A MS and 12 A MS)	-	-	x	-	

[1] Defective fail-safe ET200 SP motor starters up to V1.0.1 with error code 1417 can be reset once to V1.0.2 by means of a firmware update.

[2] The error is present if the bypass relay could no longer be closed during the on/off routine of the fail-safe motor starter.

[3] In case of error 1482, the last measured current value is stored in data set 95 as object number 608 as of firmware version V1.2.0.

[4] **Defective fail-safe ET200 SP motor starters as of V1.0.1 can be reset to V1.2.2 by means of a firmware update. These errors are now tolerated 4 times.**

A.6 DS73 logbook - Read triggering operations

Byte	Data type	Meaning	Range of values	Increment
Entry 1 (latest entry)				
0 ... 3	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
4 ... 5	Signed 16	Object number	0 ... ±32767	
Entry 2 (second-latest entry)				
6 ... 9	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
10 ... 11	Signed 16	Object number	0 ... ±32767	
... ...				
Entry 21 (last, oldest entry)				
120 ... 123	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
124 ... 125	Signed 16	Object number	0 ... ±32767	

The data set call "Logbook trips" returns the operating hour of the event that has occurred and an associated object number for each entry. This data set can accommodate 21 entries. When all locations have been overwritten, the oldest entry is overwritten again.

NOTE

The latest entry is entered at the first location of the data set. The remaining entries are moved one entry down. You cannot delete the logbook.

Following a retentive device fault (fail-safe motor starter defective), new entries are no longer entered into the logbook as soon as the 24 V supply voltage has been interrupted (e.g. pulling/plugging in the device).

The supported object numbers and their meaning are shown in the table below:

Table 2-1170 Assignment of object number to trips message

Object No.	Trips message	Comment
305	Safety-related tripping	Fail-safe motor starters only
309	Switching element overload	-
317	Electronics supply voltage too low	-
328	Motor overload trip	Tripping of the thermal motor model
333	Mechanical rotary interlock is not in the READY position	-
334	I_e upper limit violation	-
335	I_e lower limit violation	-
338	Residual current tripping	-
339	Tripping due to motor blocking	-
341	Asymmetry tripping	-
348	Input tripping	-
349	Input trip CW	-
350	Input trip CCW	-
354	Sensor supply overload	
355	Process image error	-
365	Invalid parameter value	Group fault only on startup
384	No external startup parameters received	-
1406	Cold start tripping	For all motor starters
20016	Insufficient temperature	-

A.7 DS75 logbook - Read events

Byte	Data type	Meaning	Range of values	Increment
User data (technology data)				
Entry 1 (latest entry)				
0 ... 3	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
4 ... 5	Signed 16	Object number	0 ... ±32767	

Byte	Data type	Meaning	Range of values	Increment
User data (technology data)				
Entry 2 (second-latest entry)				
6 ... 9	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
10 ... 11	Signed 16	Object number	0 ... ±32767	
... ...				
Entry 21 (oldest entry)				
120 ... 123	Unsigned 32	Operating hours - device	0 ... 2^{32}-1	1 s
124 ... 125	Signed 16	Object number	0 ... ±32767	

The data set call "Logbook events" returns the operating hour of the event that has occurred and an associated object number for each entry. This data set can accommodate 21 entries. When all locations have been overwritten, the oldest entry is overwritten again.

NOTE

The latest entry is entered at the first location of the data set. The remaining entries are moved one entry down. You cannot delete the logbook.

Following a retentive device fault (fail-safe motor starter defective), new entries are no longer entered into the logbook as soon as the 24 V supply voltage has been interrupted (e.g. pulling/plugging in the device).

The supported object numbers and their meaning are shown in the table below:

Table 2-1171 Assignment of object number to event message

Object No.	Event messages	Comment
Warnings		
327	Thermal motor model overload	In the case of a group fault, the message "Motor overload trip" is also queued.
337	Residual current detected	-
340	± Asymmetry detected	-
351	Input warning	-
365	Invalid parameter value	Not in the case of startup since it is a group fault
366	Parameters cannot be changed in ON state	-
1541	± I_e warning threshold exceeded	-
1542	± I_e warning threshold undershot	-
Actions		
310	± Emergency start active	-
357	Automatic mode	Enter at the time of changeover
358	Manual bus mode	Enter at the time of changeover
359	Manual local mode	Enter at the time of changeover
360	Manual bus mode	Connection abort

±: Event is entered as "incoming" (+) and "outgoing" (-) event. Other messages are entered only as "incoming" messages

Object No.	Event messages	Comment
368	± Parameters block CPU/master active	-
376	Firmware update successful	-
378	Firmware update has errors	-
454	Internal communication fault	-
1520	± Energy-saving mode active	-
1580	Switching element hot	-

±: Event is entered as "incoming" (+) and "outgoing" (-) event. Other messages are entered only as "incoming" messages

A.8 DS92 Read device diagnostics

Object number	Byte.Bit	Meaning	Relevant for
User data (technology data) Switching/controlling			
301	0.0	Ready (automatic) The device is ready for operation via the controller. There is no connection to the mechanical rotary interlock.	All
306	0.1	Motor CW	All
307	0.2	Motor CCW	Reversing starter
309	0.3	Switching element overload	All
308	0.4	Switching element defective	All
310	0.5	Emergency start active	All
302	0.6	Group fault	All
304	0.7	Group warning	All
-	1.01.7	Reserved	-
Protection function (motor, cable, short-circuit)			
-	2.0-2	Reserved	
327	2.3	Thermal motor model overload	All
328	2.4	Overload tripping	All
-	2.5	Reserved	-
330	2.6	Cooling time active	All
305	2.7	F-DI status	Fail-safe motor starters
-	3.0-1	Reserved	-
333	3.2	Mechanical rotary interlock is not in the READY position	All
-	3.3-6	Reserved	-
352	3.7	Input control	All
340	4.0	Asymmetry detected	All
341	4.1	Asymmetry tripping	All
334	4.2	I_e upper limit violation	All
335	4.3	I_e lower limit violation	All

Object number	Byte.Bit	Meaning	Relevant for
-	4.4	-	-
337	4.5	Residual current detected	All
338	4.6	Residual current tripping	All
339	4.7	Tripping due to motor blocking	All
344	5.0	Input 1	All
345	5.1	Input 2	All
346	5.2	Input 3	All
347	5.3	Input LC	All
348	5.4	Input tripping	All
349	5.5	Input trip CW	All
351	5.6	Input warning	All
350	5.7	Input trip CCW	All
-	6.0-1	Reserved	-
353	6.2	Quick stop active	All
354	6.3	Sensor supply overload	All
-	6.4-6	Reserved	-
317	6.7	Electronics supply voltage too low	All
Communication			
-	7.0	Reserved	-
356	7.1	CPU or master STOP	All
357	7.2	Automatic mode	All
358	7.3	Manual bus mode	All
359	7.4	Manual local mode (local control)	All
	7.5	Reserved	-
360	7.6	Connection abort in manual mode	All
-	7.5-6	Reserved	-
355	7.7	Process image error	Reversing starter
-	8.0	Reserved	-
358		Manual bus mode	All
365	8.1	Invalid parameter value • During operation • During starting • Rejected safety-related parameters	All
366	8.2	Parameters cannot be changed in ON state	All
368	8.3	Parameters disabled CPU/master active	All
384	8.4	No external startup parameters received	All
-	8.5-7	Reserved	-
-	9.0-1	Reserved	-
381	9.2	Error during self-test	Fail-safe motor starters only

Object number	Byte.Bit	Meaning	Relevant for
-	9.3-7	Reserved	-
367	10-11	Incorrect parameter number (as word)	All
	12-13	Reserved	All
Device functions			
1405	14.0	Cold start active	All; F starters as of V1.2.0
1406	14.1	Cold start tripping	All; F starters as of V1.2.0
-	14.2-7	Reserved	-
-	15-18	Reserved	-
Switching/controlling			
1407	19.0	Electronics supply voltage too high	All
1470	19.1	Ready for motor ON	All
1414	19.2	Switching element short-circuited	All
1417	19.3	Bypass element defective	All
-	19.4-7	Reserved	-
1422	20.0	Thermal motor model deactivated	All
-	21.0-1	Reserved	-
Protection function			
1482	21.2	Current measuring range exceeded [1)]	All
-	21.3-7	Reserved	-
Communication (operating modes)			
357	22.0	Automatic mode (redundant to bit 7.2)	All
-	22.1-2	Manual bus mode (redundant to bit 7.3)	All, as of Firmware V1.2.0
359	22.3	Manual local mode (redundant to bit 7.4)	All
-	22.4-7	Reserved	-
-	23	Reserved	-
Prewarnings			
-	24-25	Reserved	-
Maintenance			
-	26-31	Reserved	-
Quick Stop			
1508	32.0	Quick Stop 1 - direction-independent	All
1509	32.1	Quick Stop 1 - clockwise	All
1510	32.2	Quick Stop 1 - counter-clockwise	Reversing starter
-	32.3-7	Reserved	-
-	33	Reserved	-
End position			
1507	34.0	Input operational trip - end position CW	All

Object number	Byte.Bit	Meaning	Relevant for
1506	34.1	Input operational trip - end position CCW	All
-	34.2-7	Reserved	-
-	35	Reserved	-
Energy saving function			
-	36.0-5	Reserved	-
1522	36.6	Start_Pause command is pending	All
1520	36.7	Energy saving mode active	All
-	37	Reserved	-
Operating states			
-	38-49	Reserved	-
Ex motor protection			
1535	50.0	Explosion protection of the motor active	Fail-safe motor starters only
-	50.1	Reserved	-
1537	50.2	New safety-related parameters received	Fail-safe motor starters only
-	50.3-7	Reserved	-
-	51	Reserved	-
Warnings			
1580	52.0	Switching element hot; as of firmware version V1.2.1	-
1573	52.3	Chatter monitoring	All
1541	52.4	I_e warning limit exceeded	All
1542	52.5	I_e warning limit undershot	All
-	52.6-7	Reserved	-
-	53	Reserved	-

1) As of Firmware version V1.2.0. If the starting current exceeds the maximum current measuring range (see technical data sheet), this bit is set and the measured value is stored in data set 95.

A.9 DS93 Write command

Write structure of data set 93 command

Byte	Content	Value / value range	Meaning
0	Coordination	0x21	Write via acyclic bus channel
1	Reserved	0x00	-
2	Reserved	0x00	-
3	Reserved	0x00	-
Command			
4	Number of commands	0 ... 1	Number of subsequent valid commands
5	Command 1	Command number	Optional; for meaning see the following table

Byte	Content	Value / value range	Meaning
6	Reserved	Reserved	Reserved
7	Reserved	Reserved	Reserved
8	Reserved	Reserved	Reserved
9	Reserved	Reserved	Reserved

Assignment of command to command number and their meaning (byte 5 to 9)

Object number	Command number	Command	Meaning
0	0	Reserved	No function
703	1	Trip reset	Resets and acknowledges error messages
709	4	Automatic mode	Transition to automatic mode (control by DP master)
711	5	Manual bus mode	Transition to manual mode. The motor starter switches to manual bus mode depending on the interface via which the command is received.
707	10	Parameters disabled CPU/master ON	Parameterization by parameterizing master not possible, or its parameters are ignored
708	11	Parameters disabled CPU/master OFF	Parameterization by parameterizing master is possible

A.10 DS94 Read measured values

Object number	Byte.Bit	Coding	Meaning	Range of values	Increment
	User data (technology data)				
	Measured values (volatile)				
504	0	Unsigned 8	Phase current I_{L1} (%)	0 ... 796 %	3.125 %
505	1	Unsigned 8	Phase current I_{L2} (%)	0 ... 796 %	3.125 %
506	2	Unsigned 8	Phase current I_{L3} (%)	0 ... 796 %	3.125 %
-	3 ... 6	0x00	Reserved	-	-
503	7	Unsigned 8	Unbalance	0 ... 255 %	1 %
502	8 ... 9	Unsigned 16	Motor heating	0 ... 1,000 %	1 %
518	10, 11		Switching element heating	0 ... 1,000 %	1 %
-	12 ... 27	0x00	Reserved	-	-
513	28 ... 31	Signed 32	Phase current $I_{L1(rms)}$	±0 ... 20,000 A	0.01 A
514	32 ... 35	Signed 32	Phase current $I_{L2(rms)}$	±0 ... 20,000 A	0.01 A
515	36 ... 39	Signed 32	Phase current $I_{L3(rms)}$	±0 ... 20,000 A	0.01 A
516	40 ... 41	Unsigned 16	Electronics supply voltage	0 ... 1,500 V	0.1 V

Object number	Byte.Bit	Coding	Meaning	Range of values	Increment
-	42 ... 43	0x00	Reserved	-	-
531	44 ... 47	Signed 32	I_{max} current motor switch-on cycle	±0 ... 20,000 A	0.01 A (as of V.1.2.1)
-	48 ... 63	0x00	Reserved	-	-

A.11 DS95 Read statistics

Object number	Byte.Bit	Coding	Meaning	Range of values	Increment
	User data (technology data)				
-	0	0	Reserved	-	-
-	1.0-5	0	Reserved	-	-
-	1.6-7	11_B	Bit 6 operating hours resolution 1 second Bit 7 operating hours selection 1 operating hour - device	11 (fixed)	1
-	2 ... 3	0x00	Reserved	-	-
682	4 ... 7	Unsigned 32	Device operating hours in seconds	0 ... (2^{32}-1)	1 s
603	8 ... 11	Unsigned 32	Number of motor CW starts	0 ... (2^{32}-1)	1
604	12 ... 15	Unsigned 32	Number of starts motor CCW	0 ... (2^{32}-1)	1
605	16 ... 17	Unsigned 16	Number of motor overload trips Is incremented on tripping by: • Blocking current monitoring • Overload protection	0 ... (2^{16}-1)	1
20051	18	Unsigned 8	Number of chatter monitoring errors	0 ... (2^8 - 1)	1 [1]
-	18 ... 19	0x00	Reserved	-	-
609 [2]	20 ... 23	Signed 32	Motor current $I_{max\ (rms)}$	±0 ... 20 000	0.01 A
608 [3]	24 ... 27	Signed 32	Last tripping current $I_{A\ (rms)}$	±0 ... 20 000	0.01 A
602	28 ... 31	Unsigned 32	Motor operating hours in seconds	0 ... (2^{32}-1)	1 s
615	32 ... 49	0x00	Reserved	-	-
616	50 ... 51	Unsigned 16	Number of switching element overload trips	0 ... (2^{16}-1)	1
2013 [4]	52 ... 53	Unsigned 16	Number of hard switching operations of the relay	0 ... (2^{16}-1)	1
-	54 ... 89	0x00	Reserved	-	-
20050	54	Unsigned 8	Number of 5 life errors	0 ... 5	1 [1]

[1] As of firmware version V1.2.2

[2] The motor current $I_{max\ (rms)}$ shows the maximum rms value present in a phase over the operating period (min/max pointer function). It is calculated every 10 ms. Excluded are the first 20 ms after start (inrush current).

[3] The last tripping current $I_{A\ (rms)}$ is updated for each trip, irrespective of the magnitude of the current that was present there beforehand (no min/max pointer function).

[4] Previously, the object number could only contain a maximum of "1". Now the motor starter can be reset for values from "1" to "4". The starter should only be replaced at "5"

Up to firmware version V1.2.0 the value is entered if

- the motor is blocked,
- the maximum value of the motor model is exceeded,
- the maximum value of the device or relay model is exceeded.

As of firmware version V1.2.0, an additional entry is made if a measured value is exceeded or if hard switching occurs with the fail-safe motor starter.

NOTE
Operating hours counter
The operating hours counter runs as soon as the motor starter is supplied with 24 V.

A.12 Read/write DS201 device parameter 1

DS201 contains the second part of the device parameters.

If incorrect parameters are sent to the motor starter in DS201, these incorrect parameters will also be reported back when reading DS201. In the case of incorrect parameters, the object number of the first incorrect parameter is output in WORD 10 of DS92.

The defaults for factory settings of the motor starter appear in italics in the Value range column. In the engineering system, a distinction is made between the default values of the input actions and the current range of the defaults of the motor starter.

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
-	0.0	[0]	Reserved	-
3	0.1	*[0]: 3-phase* [1]: 1-phase	Load type (only for direct-on-line starters)	Load type (Page 51)
2209	0.2-0.3	*[0]: No* [1]: Yes	EX motor application (ATEX operation)	Ex motor application (Page 77)
6	0.4 - 0.7	[3]: CLASS 5 (10a) [0]: CLASS 10 [15]: CLASS OFF (not in ATEX mode) [1]	Trip class [1]	Overload protection (Page 57)
5	1.0 - 1.1	*[0]: Trip without restart* [1]: Tripping with restart (not during ATEX operation) [2]: Warning (not during ATEX operation)	Response to overload - TMM	Overload protection (Page 57)

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
4	1.2	*[0]: Retention of the thermal motor model on restart* [1]: Deletion of the thermal motor model on restart (not during ATEX operation)	The charge state of the thermal motor model is deleted at run-up. In this way, unintentional early trips can be prevented if the motor starter has been switched off for an extended period.	Overload protection (Page 57)
20000	1.3	*[0]: No warning in the case of safety-related tripping [0019H]* [1]: Warning in the case of safety-oriented tripping	Response to safety-related tripping with F-DI	Response to safety-related tripping (Page 76)
34	1.4	*[0]: Switch substitute value* [1]: Retain last value	Response to CPU/master STOP	Response to CPU/master STOP (Page 78)
19	1.5	[0]: Warning (not in the case of fail-safe motor starters) *[1]: Tripping*	Response to residual current detection	Response to residual current detection (Page 67)
20	1.6	[0]: Warning (not during ATEX operation) *[1]: Tripping*	Response to asymmetry	Asymmetry monitoring (Page 75)
317	1.7	Diagnosis Supply voltage too low [1)]	[0] released (default) [1] block	Diagnosis supply voltage too low (Data plausibility check (Page 104))
25	2.0	[0]: NC contact *[1]: NO contact*	Input 1 level	Inputs (Page 78)
27	2.1	See input 1 level	Input 2 level	Inputs (Page 78)
29	2.2	See input 1 level	Input 3 level	Inputs (Page 78)
193	2.3	*[0]: Enable* [1]: Disable	Group fault diagnostics	Group fault diagnostics/group warning diagnostics (Page 78)
80	2.4	*[0]: Non-retentive* [1]: Retentive	Input 1 signal	Inputs (Page 78)
81	2.5	See input 1 signal	Input 2 signal	Inputs (Page 78)
82	2.6	See input 1 signal	Input 3 signal	Inputs (Page 78)
191	2.7	[0]: Enable *[1]: Disable*	Group warning diagnostics	Group fault diagnostics/group warning diagnostics (Page 78)
194	3	[0]: No action [1]: Trip without restart [2]: Trip with restart [3]: Trip end position CW [4]: Trip end position CCW [5]: Group warning	Input 1 action	Inputs (Page 78)

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
		[7]: Emergency start (not during ATEX operation) *[8]: Motor CW* [9]: Motor CCW [11]: Quick Stop (direction-independent) [12]: Trip RESET [13]: Cold start (not during ATEX operation) [14]: Quick Stop clockwise [15]: Quick Stop counter-clockwise [37]: Operational trip end position CW [38]: Operational trip end position CCW		
195	4	See input 1 - action *[9]: Motor CCW (default for reversing starters)*	Input 2 action	Inputs (Page 78)
196	5	See input 1 - action *[13]: Cold start (default for HF motor starters)*	Input 3 action	Inputs (Page 78)
2	6 - 7	0.1 ... 12 A/10 mA *The maximum current is preset.*	Rated operational current I_e The rated operational current is MLFB-dependent, and thus also the maximum setting range.	Rated operational current (Page 49)
15	8	18.75 ... 100%/3.125% [6 ... 32] *[0]: Deactivated*	Lower current limit	Upper/lower current limit (Page 71)
16	9	50 ... 400%/3.125% [16 ... 128] *[0]: Deactivated*	Upper current limit	Upper/lower current limit (Page 71)

1) As of Firmware version V1.2.0

A.13 Read/write DS202 device parameter 2

DS202 contains the second part of the device parameters.

If incorrect parameters are sent to the motor starter in DS202, these incorrect parameters will also be reported back when reading DS202. In the case of incorrect parameters, the object number of the first incorrect parameter is output in WORD 10 of DS92.

The defaults appear in italics in the Value range column.

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
18	0.0 - 0.3	*1 ... 7.5 s/0.5 s* [2 ... 15] *Default value is [2]: 1 s.*	Blocking time	Blocking time and blocking current (Page 72)
-	0.4 - 0.7	[0]: Reserved	Reserved	-
2210	1	0 ... 99 %/1 % [0 ... 99] [0]: *Deactivated*	Warning limit - motor heating	Overload protection (Page 57)
-	2 - 3	[0]: Reserved	Reserved	-
-	4 - 5	[0]: Reserved	Reserved	-
17	6	150 ... 1500 %/50 % [3 ... 20] *Default value is [16]: 800 %* As of firmware version V1.2.0	Blocking current	Blocking time and blocking current (Page 72)
-	7	[0]: Reserved	Reserved	-
2213	8	18.75 ... 100 %/3.125 % [6 ... 32] [0]: Deactivated *Default value is [7]: 21.875 %*	Lower current warning limit	Upper/lower current warning limit (Page 71)
2214	9	50 ... 400 %/3.125 % [16 ... 128] [0]: Deactivated *Default value is [36]: 112.5 %*	Upper current warning limit	Upper/lower current warning limit (Page 71)

A.14 Read DS203 device parameter 1

DS203 contains the second part of the incorrect parameter with which the motor starter is working. The defaults appear in italics in the Value range column.

Object number	Byte .Bit	Range of values	Meaning	See Chapter ...
-	0.0	[0]	Reserved	-
3	0.1	*[0]: 3-phase* [1]: 1-phase	Load type (only for direct-on-line starters)	Load type (Page 51)
2209	0.2--0.3	*[0]: No* [1]: Yes	EX motor application (ATEX operation)	Ex motor application (Page 77)
6	0.4 - 0.7	[3]: CLASS 5 (10a) [0]: CLASS 10 [15]: CLASS off (as of firmware version V1.2.0)	Trip class [1)]	Overload protection (Page 57)

Object number	Byte .Bit	Range of values	Meaning	See Chapter ...
5	1.0 - 1.1	*[0]: Trip without restart* [1]: Tripping with restart (not during ATEX operation) [2]: Warning (not during ATEX operation)	Response to overload - TMM	Overload protection (Page 57)
4	1.2	*[0]: Retention of the thermal motor model on restart* [1]: Deletion of the thermal motor model on restart (not during ATEX operation)	The charge state of the thermal motor model is deleted at run-up. In this way, unintentional early trips can be prevented if the motor starter has been switched off for an extended period.	Overload protection (Page 57)
20000	1.3	*[0]: No warning in the case of safety-related tripping [0019H]* [1]: Warning in the case of safety-related tripping [0019H]	Response to safety-related tripping with F-DI	Response to safety-related tripping (Page 76)
34	1.4	*[0]: Switch substitute value* [1]: Retain last value	Response to CPU/master STOP	Group fault diagnostics/group warning diagnostics (Page 78)
19	1.5	[0]: Warning (not in the case of fail-safe motor starters) *[1]: Tripping*	Response to residual current detection	Response to residual current detection (Page 67)
20	1.6	[0]: Warning (not during ATEX operation) *[1]: Tripping*	Response to asymmetry	Asymmetry monitoring (Page 75)
317	1.7	Diagnosis Supply voltage too low (all motor starters as of firmware version V1.2.0)	[0] released (default) [1] block	-
25	2.0	[0]: NC contact *[1]: NO contact*	Input 1 level	Inputs (Page 78)
27	2.1	See input 1 level	Input 2 level	Inputs (Page 78)
29	2.2	See input 1 level	Input 3 level	Inputs (Page 78)
193	2.3	*[0]: Enable* [1]: Disable	Group fault diagnostics	Group fault diagnostics/group warning diagnostics (Page 78)
80	2.4	*[0]: Non-retentive* [1]: Retentive	Input 1 signal	Inputs (Page 78)
81	2.5	See input 1 signal	Input 2 signal	Inputs (Page 78)
82	2.6	See input 1 signal	Input 3 signal	Inputs (Page 78)
191	2.7	[0]: Enable *[1]: Disable*	Group warning diagnostics	Group fault diagnostics/group warning diagnostics (Page 78)
194	3	[0]: No action [1]: Trip without restart [2]: Trip with restart [3]: Trip end position CW [4]: Trip end position CCW [5]: Group warning	Input 1 action	Inputs (Page 78)

Object number	Byte .Bit	Range of values	Meaning	See Chapter ...
		[7]: Emergency start (not during ATEX operation) *[8]: Motor CW* [9]: Motor CCW [11]: Quick Stop (direction-independent) [12]: Trip RESET [13]: Cold start (not during ATEX operation) [14]: Quick Stop clockwise [15]: Quick Stop counter-clockwise [37]: Operational trip end position CW [38]: Operational trip end position CCW		
195	4	See input 1 - action *[9]: Motor CCW (default for reversing starters)*	Input 2 action	Inputs (Page 78)
196	5	See input 1 - action *[13]: Cold start (default for HF motor starters)*	Input 3 action	Inputs (Page 78)
2	6 - 7	0.1 ... 12 A/10 mA *The maximum current is pre-set.*	Rated operational current I_e The rated operational current is MLFB-dependent, and thus also the maximum setting range.	Rated operational current (Page 49)
15	8	18.75 ... 100 %/3.125 % [6 ... 32] *[0]: Deactivated*	Lower current limit	Upper/lower current limit (Page 71)
16	9	50 ... 400 %/3.125 % [16 ... 128] *[0]: Deactivated*	Upper current limit	Upper/lower current limit (Page 71)

A.15 Read DS204 device parameter 2

DS204 contains the second part of the incorrect parameters with which the motor starter is working.

The defaults appear in italics in the Value range column.

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
18	0.0 - 0.3	*1* ... 7.5 s/0.5 s [2 ... 15] *Default value is [2]: 1 s.*	Blocking time	Blocking time and blocking current (Page 72)
-	0.4 - 0.7	[0]: Reserved	Reserved	-
2210	1	0 ... 99 %/1 % [0 ... 99] [0]: *Deactivated*	Warning limit - motor heating	Overload protection (Page 57)

Object number	Byte.Bit	Range of values	Meaning	See Chapter ...
-	2 - 3	[0]: Reserved	Reserved	-
-	4 - 5	[0]: Reserved	Reserved	-
17	6	150 ... 1500 %/50 % [3 ... 20] *Default value is [16]: 800 %* As of firmware version V1.2.0	Blocking current	Blocking time and blocking current (Page 72)
-	7	[0]: Reserved	Reserved	-
2213	8	18.75 ... 100 %/3.125 % [6 ... 32] [0]: Deactivated *Default value is [7]: 21.875 %*	Lower current warning limit	Upper/lower current warning limit (Page 71)
2214	9	50 ... 400 %/3.125 % [16 ... 128] [0]: Deactivated *Default value is [36]: 112.5 %*	Upper current warning limit	Upper/lower current warning limit (Page 71)

A.16 I&M data

A.16.1 I&M data

The following I&M data (Identification & Maintenance function) are supported by all ET 200SP motor starters:

Number	Name	Comment
I&M 0	Device identification	This is stored in the device on initialization
I&M 1	Equipment identifier	These are entered in the engineering system.
I&M 2	Installation	
I&M 3	Description	

NOTE

With PROFINET, the I&M data can be accessed via data sets 0xAFF0 - 0xAFF3 (PNO).

With PROFIBUS, the I&M data can be accessed via data set 255.

A.16.2 I&M 0: Read device identification

The following data are saved:

Byte	Data type	Content	Meaning
I&M header			
0 ... 1	Unsigned16	0x0020	Block type
2 ... 3	Unsigned16	0x0038	Block length = 56
4 ... 5	Unsigned16	0x0100	Block version = 1.0
I&M0 data block 0			
6 ... 7	Unsigned16	MANUFACTURER_ID	42 = Manufacturer ID SIEMENS
8 ... 27	Char[20]	ORDER_ID	Article number (MLFB)
28 ... 43	Char[16]	SERIAL_NUMBER	Serial number
44 ... 45	Unsigned16	HARDWARE REVISION	Hardware revision or product version
46 ... 49	Char	SOFTWARE_REVISION	Firmware version
50 ... 51	Unsigned16	REV_COUNTER	Provides information about the parameterized changes on the module. The "REV_ COUNTER" is incremented after each change.
52 ... 53	Unsigned16	PROFILE_ID	Gives information about the PROFIBUS profile supported by the device and the line of products belonging to the device.
54 ... 55	Unsigned16	PROFILE_SPECIFIC_TYPE	Used to supplement the object "PROFILE_ID" and contains further information on the profile.
56 ... 57	Unsigned16	IM_VERSION	Provides information about the version of the identification data (01 01hex = Version 1.1).
58 ... 59	Unsigned16	IM_SUPPORTED	Provides information about the available identification data (Index 2 to 4).

A.16.3 I&M 1: Read/write equipment identifier

The following data are saved:

Byte	Length	Content	Meaning
I&M header			
0 ... 1	Unsigned16	0x0021	Block type
2 ... 3	Unsigned16	0x0038	Block length = 56
4 ... 5	Unsigned16	0x0100	Block version = 1.0
I&M data block 1			
6 ... 37	Char[32]	TAG FUNCTION	Plant identifier Fill unused positions with blanks (0x20)
38 ... 59	Char[22]	TAG LOCATION	Location designation Fill unused positions with blanks (0x20)

A.16.4 I&M 2: Read/write installation

The following data are saved:

Byte	Data type	Content	Meaning
I&M header			
0 ... 1	Unsigned16	0x0022	Block type
2 ... 3	Unsigned16	0x0012	Block length = 18
4 ... 5	Unsigned16	0x0100	Block version = 1.0
I&M data block 2			
6 ... 21	Char[16]	IM_DATE	Specification of an input date (YYYY-MM-DD HH:MM)

A.16.5 I&M 3: Read/write description

The following data are saved:

Byte	Data type	Content	Meaning
I&M header			
0 ... 1	Unsigned16	0x0023	Block type
2 ... 3	Unsigned16	0x0038	Block length = 56
4 ... 5	Unsigned16	0x0100	Block version = 1.0
I&M data block 3			
6 ... 59	Char[54]	IM_DESCRIPTOR	Comment Fill unused positions with blanks (0x20)

Circuit examples

B

B.1 Connection examples for motor starters

B.1.1 Connecting and operating motor brakes

See Chapter Operating motor starters (Page 34).

B.1.2 Example of the correct engineering of a motor starter

See Chapter Operating motor starters (Page 34).

B.1.3 Induction machine

Direct-on-line starter
Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starter: 3RK1308-0A*00-0CP0

Reversing starter
Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starter: 3RK1308-0B*00-0CP0

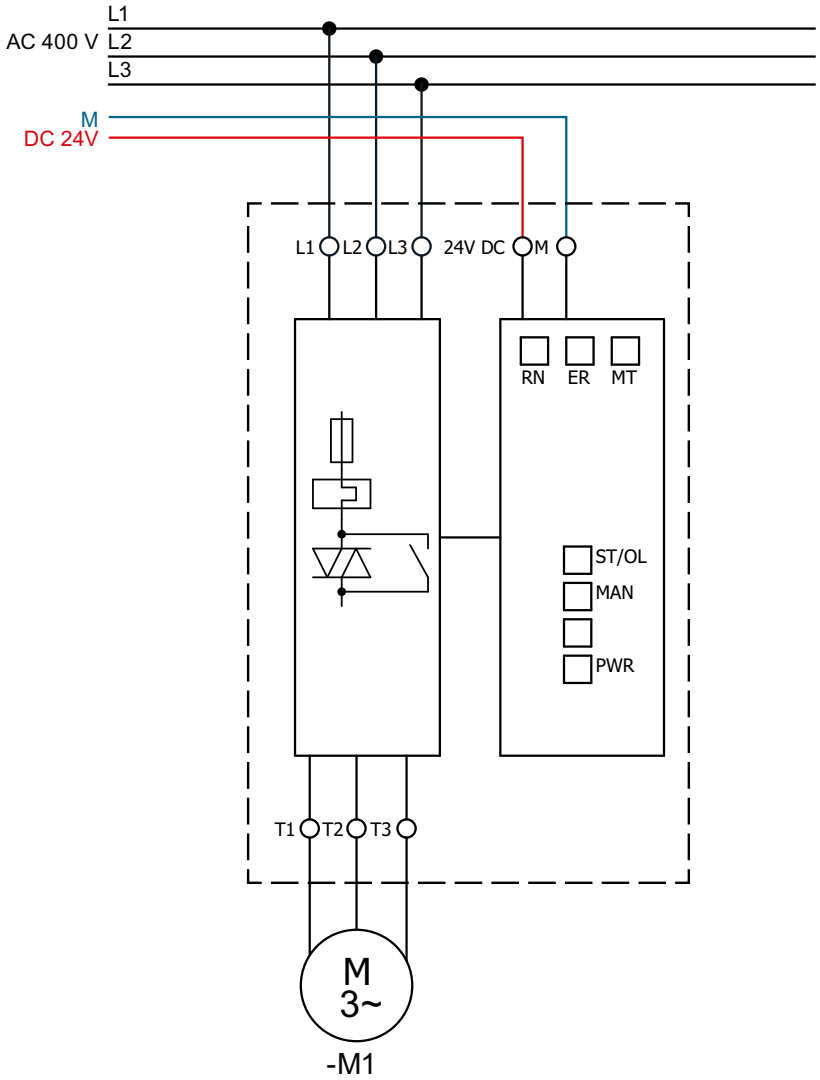

In the multi-pole representation, the N and PE conductors are not shown separately. Do not connect PE or N to the neutral point.

B.1.4 Single-phase motor

Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starters: 3RK1308-0A*00-0CP0.
- Alternatively, this wiring can also be performed using a fail-safe 3RK1308-0C*00-0CP0 direct starter.

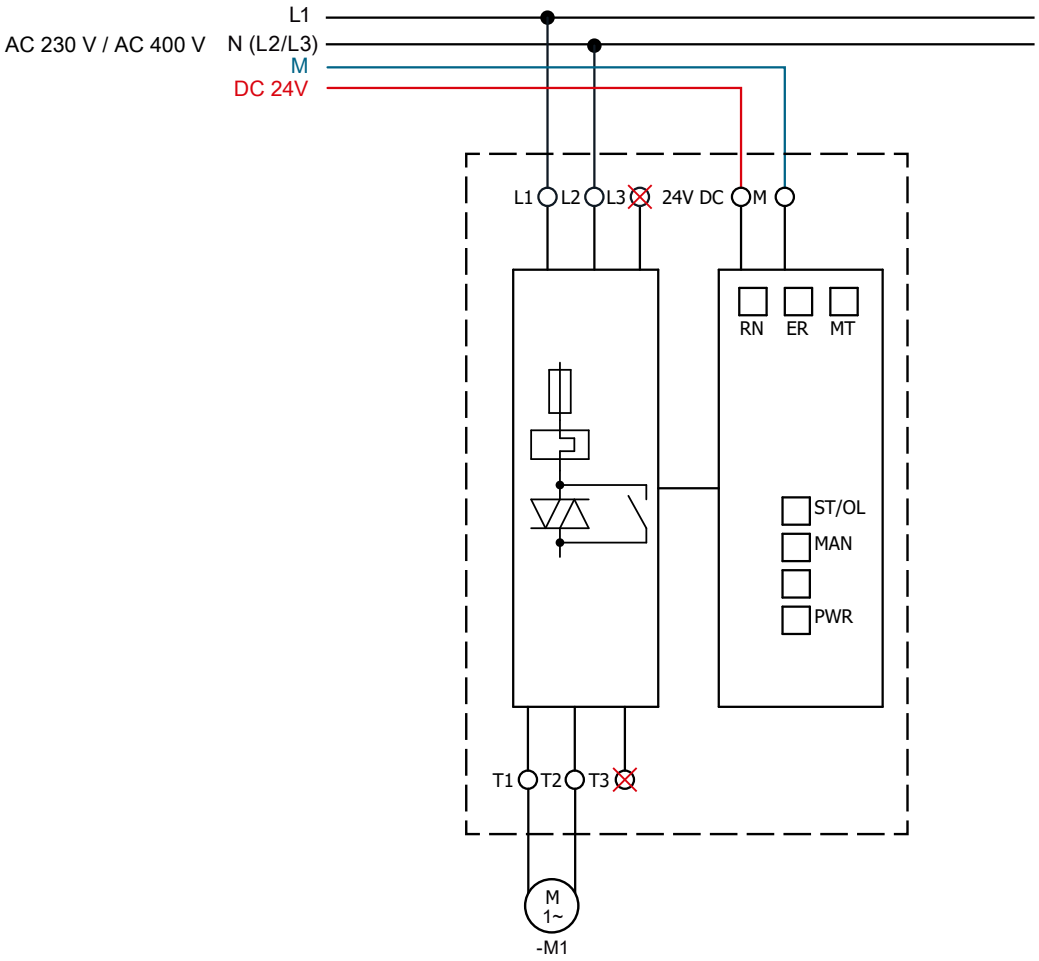

In the multi-pole representation, the PE conductor is not shown separately.

B.1.5 Resistive load

Star connection

Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starters: 3RK1308-0A*00-0CP0

Delta connection:

Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starters: 3RK1308-0A*00-0CP0

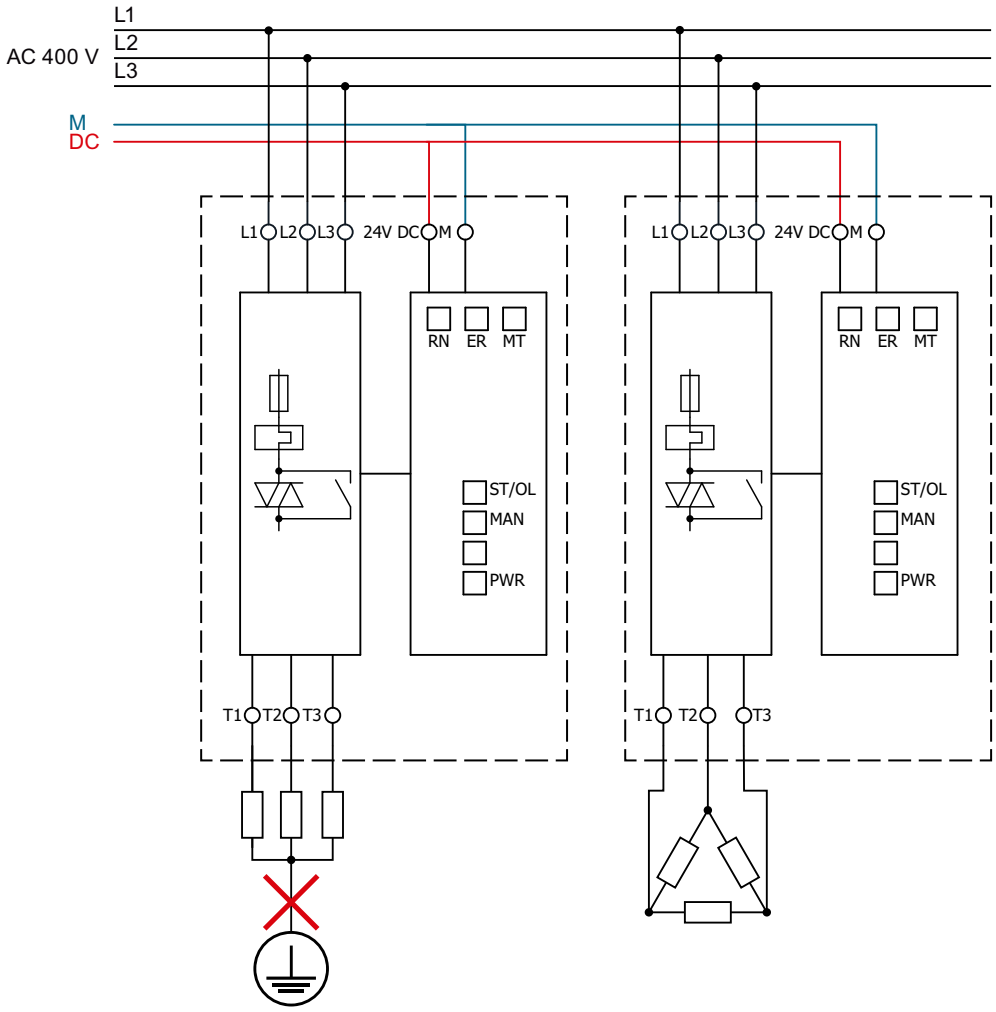

Do not connect PE or N to the neutral point.

In the multi-pole representation, the N and PE conductors are not shown separately.

B.1.6 Gas discharge lamps

Article numbers:

- BaseUnit: 3RK1908-0AP00-0AP0
- Motor starters: 3RK1308-0A*00-0CP0

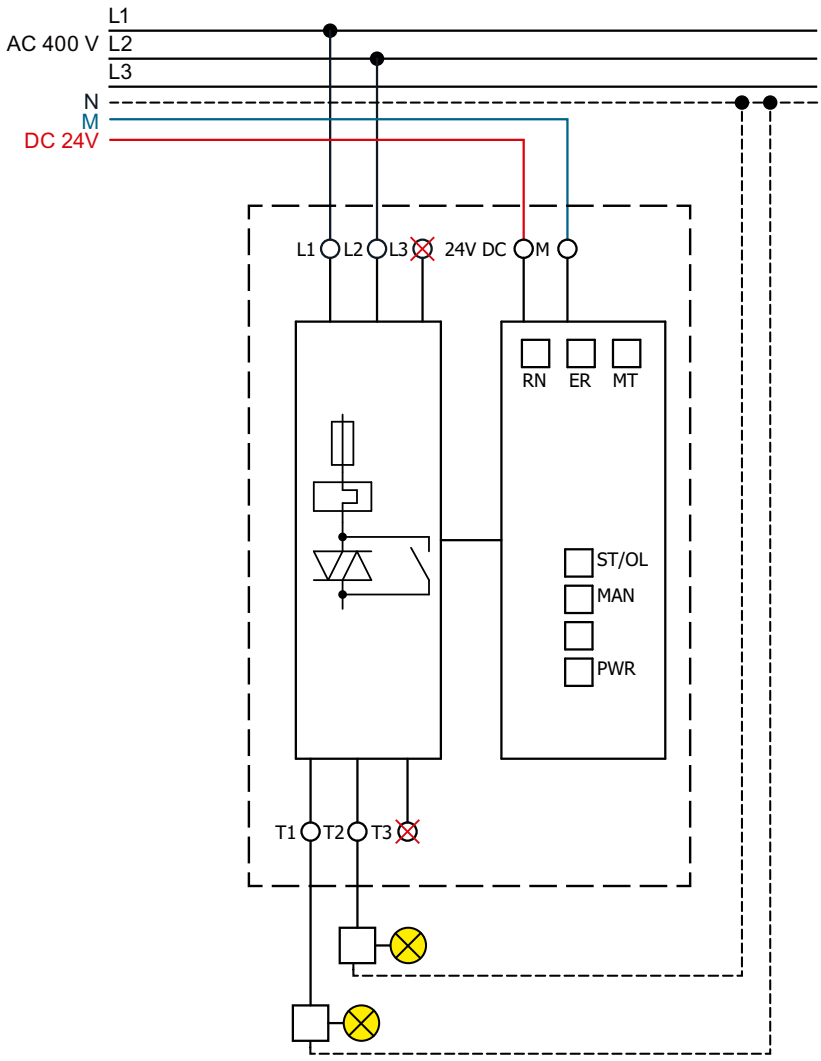

In the multi-pole representation, the PE conductor is not shown separately.

NOTE

Motor model und response to overload of the gas discharge lamp

Observe the set motor model and the overload response of the gas discharge lamp for the parameterization of the motor starter.

B.2 Connection examples for fail-safe motor starters

B.2.1 General information

Shutdown options

The safe tripping of the ET 200SP motor starter can take place in various ways, e.g.

- With a 3SK safety relay
- With a fail-safe ET 200SP F-DQ digital output module
- With a fail-safe ET 200SP F-PM E power module

Documentation and sample projects

You will find an entry Safe shutdown of ET 200SP motor starters (https://support.industry.siemens.com/cs/ww/en/view/109748128) in the Industry Online Support. This entry describes methods of switching off one or more ET 200SP F motor starters in a safety-oriented manner.

The attached documentation "Power module F PM-E" contains a decision-making matrix, which illustrates the various switch-off variants.

Shutdown principle ET 200SP F motor starter		**Application example with SK safety relay**	**Application example with fail-safe digital output F-DQ**	**Application example with fail-safe power module F-PM-E**
Hardware variety	Suitable for group shutdown	Yes	Yes	Yes
	Suitable for single shutdown	Yes	Yes	No
Use in cyclically requested safety functions (e.g. protective door, light curtain)		Yes	Yes	No
Use in acyclically requested safety functions (e.g. emergency stop)		Yes	Yes	Yes
Motor starter can still be addressed by CPU after fail-safe shutdown		Yes	Yes	No
Suitable for immediate recovery		Yes	Yes	No (recovery time ≥ 2.2 s)
External wiring effort		Yes	Yes	No
Standard and safety engineering		Separate	Integrated into a device	Integrated into a device

Further information

See"SIRIUS Safety Integrated" Application Manual (https://support.industry.siemens.com/cs/ww/en/view/83150405).

B.2.2 Safety-related shutdown

Single shutdown

With the BaseUnits BU30-MS5 to BU30-MS6, a single shutdown can be implemented with the aid of the F-DI. Single shutdown in SIL3 Cat. 4 PL e is possible here with fail-safe control modules with pp-switching or pm-switching.

For the single use of the BU30-MS7 and BU30-MS10, a fail-safe control module with pp-switching is basically to be used.

			1)	2)	3)	4)	5)	6)	7)	8)	9)
BU30-MS1	BU with 24 V and 500 V infeed	3RK1908-0AP00-0AP0	x	-	x	x	-	x	-	-	-
BU30-MS2	BU with 500 V infeed	3RK1908-0AP00-0CP0	-	x	x	x	-	x	-	-	-
BU30-MS3	BU with 24 V infeed	3RK1908-0AP00-0BP0	x	-	x	-	x	x	-	-	-
BU30-MS4	BU without infeed	3RK1908-0AP00-0DP0	-	x	x	-	x	x	-	-	-
BU30-MS5	BU F-DI (without forwarding) with 500 V infeed	3RK1908-0AP00-0EP0	-	x	x	x	-	x	x	-	-
BU30-MS6	BU F-DI (without forwarding) without infeed	3RK1908-0AP00-0FP0	-	x	x	-	x	x	x	-	-
BU30-MS7	BU F-DI infeed with 500 V infeed	3RK1908-0AP00-0GP0	-	x	x	x	-	x	x	-	x
BU30-MS8	BU F-DI forwarding with 500 V infeed	3RK1908-0AP00-0HP0	-	x	x	x	-	x	-	x	x
BU30-MS9	BU F-DI forwarding without infeed	3RK1908-0AP00-0JP0	-	x	x	-	x	x	-	x	x
BU30-MS10	BU F-DI infeed without 500 V infeed	3RK1908-0AP00-0KP0	-	x	x	-	x	x	x	-	x

1) 24 V infeed
2) 24 V import from left module
3) 24 V forwarding
4) 500 V infeed
5) 500 V import from left
6) 500 V forwarding
7) F-DI infeed
8) F-DI import from left
9) F-DI forwarding

Group shutdown

With the BaseUnits BU30-MS7 to BU30-MS10, a group shutdown can be implemented with the aid of the F-DI.

The group shutdown in SIL3 Cat 4 PL e is only possible with fail-safe control modules with pp-switching. A group shutdown is also possible by a fail-safe shutdown of the supply voltage with all motor starter BaseUnits.

WARNING

Safety-related shutdown using the F-DI

Depending on the I/O used, the shutdown takes place via one or two output channels (terminals):

- PM-switching: The shutdown takes place via two output channels.
- PP-switching: The shutdown takes place via one output channel.

Shutdown via one output channel (PP switching) achieves SILCL 3 according to EN 62061, PL e/Cat. 4 according to EN ISO 13849-1 if steps are taken to ensure that the cables are installed in such a way that they are protected against a cross-circuit/line-to-line fault.

For the BU-30-MS7 to BU-30-MS10 F-DI forwarding BaseUnits, only PP switching is possible.

For the single F-DI BaseUnits BU-30-MS5 and BU-30-MS6, PM and PP switching are possible.

B.2.3 Connecting the 3DI/LC module for the motor starter

Procedure

The figure below shows the connections of the 3DI/LC module:

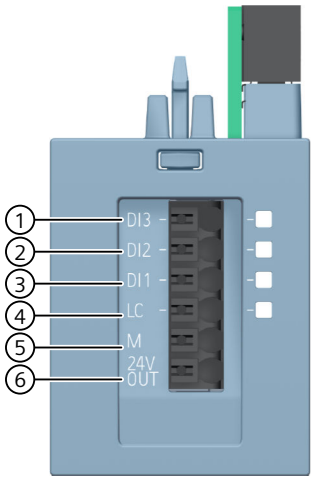

① Digital input 3
② Digital input 2
③ Digital input 1
④ Local control (manual local)
⑤ Ground
⑥ 24 V DC/ 100 mA output

NOTE

The digital inputs (1 to 4) are not isolated. The reference potential is M (5). Control the digital inputs only via a unit supplied from the 24 V DC output (6).

Connect only cables of maximum 30 m to the 3DI/LC module.

The supply (5 and 6) is protected against short circuits.

Terminal sketch of the 3DI/LC module

The following diagram shows a terminal sketch of the 3DI/LC module:

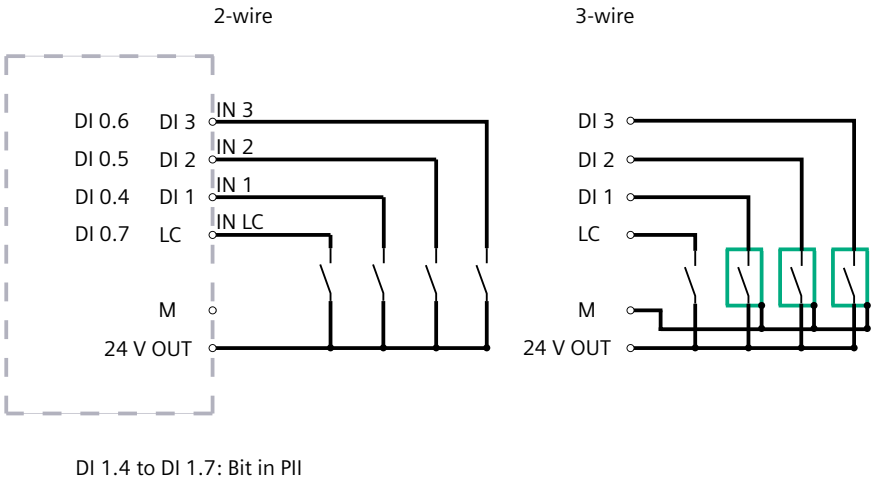

Figure 2-1065 Connection example of inputs

WARNING

The digital inputs (1 to 4) are not isolated. The reference potential is M (5), and therefore SELV/PELV. Only supply the inputs with the 24 V DC output (6).
Do not connect any temperature sensors for winding control of motors if they do not have protective separation. Otherwise, in the event of a fault, a dangerous voltage may be transmitted to the sensor cables and thus to the SELV/PELV circuits. If these cables are then touched, it can lead to death, serious injury and enormous material damage.

SIEMENS

Industrial controls

SIMATIC ET 200SP e-Starter (3RD1000)

Equipment Manual

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11/2025
A5W00712805B/RS-AC/003

Continued

Appendix A

List of abbreviations B

SIMATIC ET 200SP e-Starter (3RD1000)

Equipment Manual

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B.1 List of abbreviations 184

Introduction 1

1.1 Purpose of the documentation

This documentation contains a detailed description of the e-Starter ET 200SP product series, including all associated components, and provides information and instructions on configuration, installation, commissioning, diagnostics, and disposal.

The present Equipment Manual supplements the System Manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) and the Function Manuals. The Equipment Manual contains a compact description of the module-specific information. The system-related functions are described in the System Manual. All cross-system functions are described in the Function Manuals.

This Equipment Manual describes the e-Starter ET 200SP from firmware version V1.1.
The Equipment Manual supplements the System Manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293). Functions that concern the system in general are described in the System Manual.
The information provided in this Equipment Manual, the System Manual and the Function Manuals enables you to commission
the ET 200SP distributed I/O system.

1.2 Change documentation

Release number	Changes
11/2025	• Note on the product versions (Page 16) • Extension of the current range from 2 A to 3 A and from 7 A to 9 A for AC-1 loads • Integration of emergency run into the device functionality • 3-phase power control for AC-1 loads • Option to display the status of the main voltage via the GRID LED
03/2025	• Change of connection examples • Changes in the section "Use and operation"
01/2025	Initial release

1.3 Validity of the documentation

This document is valid for the e-Starter ET 200SP, including all associated components. It contains the information that is valid at the time of publication.

1.4 Required basic knowledge

To understand the document, good specialist knowledge of the following fields of electrical engineering are required:

- Low-voltage controls and distribution
- Digital circuit logic
- Automation technology
- Safety functions
- Bus topology PROFINET, Modbus TCP, and EtherNet/IP
- STEP 7 TIA Portal

1.5 Siemens Industry Online Support

Information and service

At Siemens Industry Online Support you can obtain up-to-date information from our global support database:

- Product support
- Application examples
- Forum
- mySupport

Link: Siemens Industry Online Support (https://support.industry.siemens.com/cs/de/en)

Product support

You can find information and comprehensive know-how covering all aspects of your product here:

- **FAQs**

  Answers to frequently asked questions
- **Manuals/operating instructions**

  Read online or download, available as PDF or individually configurable.
- **Certificates**

  Clearly sorted according to approving authority, type and country.
- **Characteristics**

  For support in planning and configuring your system.

- **Product announcements**

  The latest information and news concerning our products.
- **Downloads**

  Here you will find updates, service packs, HSPs and much more for your product.
- **Application examples**

  Function blocks, background and system descriptions, performance statements, demonstration systems, and application examples, clearly explained and represented.
- **Technical data**

  Technical product data for support in planning and implementing your project

Link: Product support (https://support.industry.siemens.com/cs/ww/en/ps)

mySupport

The following functions are available in your personal work area "mySupport":

- **Support Request**

  Search for request number, product or subject
- **My filters**

  With filters, you limit the content of the online support to different focal points.
- **My favorites**

  With favorites you bookmark articles and products that you need frequently.
- **My notifications**

  Your personal mailbox for exchanging information and managing your contacts. You can compile your own individual newsletter in the "Notifications" section.
- **My products**

  With product lists you can virtually map your control cabinet, your system or your entire automation project.
- **My documentation**

  Configure your individual documentation from different manuals.
- **CAx data**

  Easy access to CAx data, e.g. 3D models, 2D dimension drawings, EPLAN macros, device circuit diagrams
- **My IBase registrations**

  Register your Siemens products, systems and software.

1.6 Siemens Industry Online Support app

Siemens Industry Online Support app

The Siemens Industry Online Support app provides you access to all the device-specific information available on the Siemens Industry Online Support portal for a particular article number, such as operating instructions, manuals, data sheets, FAQs etc.

The Siemens Industry Online Support app is available for Android and iOS:

Android

iOS

1.7 Support request

After you have registered, you can use the Support Request form in the online support to send your question directly to Technical Support:

Support Request:	Internet (https://www.siemens.com/support-request)

1.8 ID link

ID link for the digital nameplate

The ID link is a globally unique identifier according to IEC 61406-1, which you can find as a QR code on your product.

The ID link takes you to the digital nameplate of your product.

Using the ID link saves paper and energy.

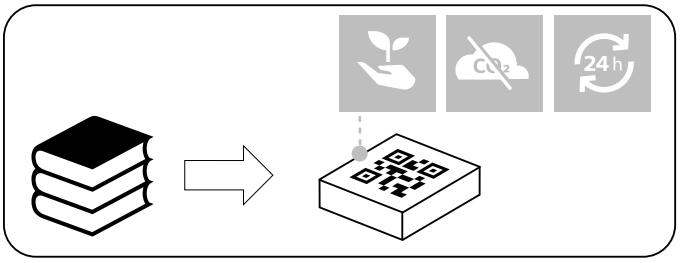

Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call the ID-Link.

In the digital nameplate, you will find product data, manuals, declarations of conformity, certificates, and other helpful information about your product.

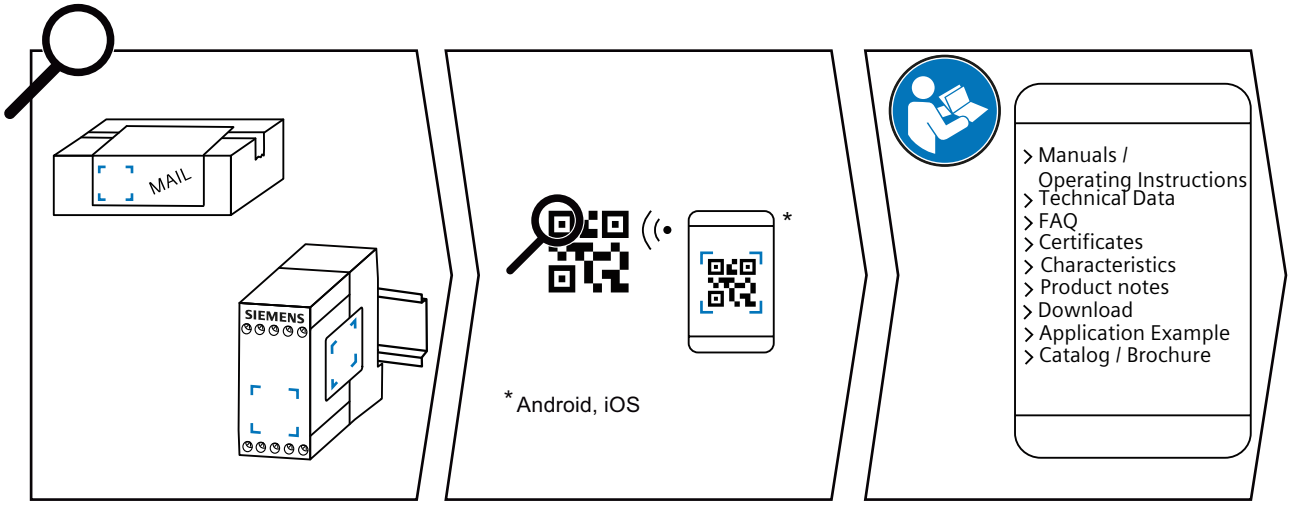

WARNING

Interference caused by radios and mobile phones
Can cause death or serious injury.

Malfunctions may occur if a radio or mobile phone is used near the product.

- Therefore, only use radios and mobile phones in the vicinity of the product when the product is switched off or no ON command is applied.
- Alternatively, turn off all radio connections of the radio/mobile phone when you are near the product.

1.9 Recycling and disposal

For environmentally-friendly recycling and disposal of your old device, contact a company certified for the disposal of used electrical and electronic equipment, and dispose of the device as specified in the regulations for your particular country.

Safety instructions 2

2.1 Industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Find out about general information and measures relating to industrial cybersecurity in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

This chapter provides an overview of safety-relevant information relating to your SIEMENS device.

2.1.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed at (https://www.siemens.com/cert):

2.1.2 Reading out service data

The service data can be read out via the TIA Portal (as of HSP version 19) and handed over to Technical Support.

The e-Starter ET 200SP also has an interface for the 4DI (LC) submodule, which Siemens personnel can use to read out service data locally.

2.2 Safety instructions for planning the system

2.2.1 Functional restrictions as a result of the production version

NOTE

Firmware versions for the SIMATIC ET 200SP e-Starter

With firmware version V1.0, the SIMATIC ET 200SP e-Starter has a limited scope of functions.

The history of the versions with the new features is provided on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109974597).

2.2.2 General safety notes

Hazardous voltage

Disconnect the system and all devices from the power supply before starting work.

2.2.3 Intended use

Improper use of the product

Improper use of the product and its accessories results in a risk of death, risk of serious injury or property damage.

This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens.

Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults.

Before you run any sample programs or programs that you have written yourself, make sure that running the plant cannot cause injury to anyone else or damage to the machine itself.

2.2.4 Declaration of Conformity

You can download the entire EU Declaration of Conformity: Declaration of Conformity (http://www.siemens.com/sirius/approvals)

2.2.5 Electromagnetic compatibility (EMC) according to IEC 60947-4-1

This is a product for use in an industrial environment (environment A). When used in or in the immediate vicinity of residential, commercial, and business areas (environment B), this device may cause unwanted radio frequency interference, in which case the user may be required to take adequate mitigation measures.

2.2.6 Handling devices carefully

Handle devices carefully after unpacking, in particular do not drop them

Electronic devices can be damaged by excessive shock loads without showing any visible signs. Handle the devices carefully after unpacking: In particular avoid dropping them on hard surfaces.

2.2.7 Electromagnetic interferences

Electromagnetic interferences

To ensure immunity of the ET 200SP e-Starter, ground the PELV/SELV power supply units in accordance with regulations. (Also note the documentation for the respective power supply unit in this regard.)

2.2.8 Setting up an interference-proof system

Use of a dummy module for interference-proof operation

For interference-proof operation of the ET 200SP station in accordance with the standard IEC 60947-4-2, use a dummy module upstream of the first e-Starter ET 200SP.
More information can be found in chapter Interference-proof setup of the e-Starter ET 200SP (Page 41).

2.2.9 ESD Guidelines

ESD

All electronic devices are equipped with large-scale integrated ICs or components. Due to their design, these electronic elements are highly sensitive to overvoltage, and thus to any electrostatic discharge.

ESD devices are identified by the following symbol:

NOTICE
Electrostatic discharge ESD devices can be destroyed by voltages well below the threshold of human perception. These static voltages develop when you touch a component or electrical connection of a device without having drained the static charges present on your body. The damage caused to a device by overvoltage is usually not immediately evident and is only noticed after an extended period of operation.

Electrostatic charging

Anyone who is not connected to the electrical potential of their surroundings can be electrostatically charged.

The diagram below shows the maximum electrostatic voltage which may build up on a person coming into contact with the materials specified in the diagram. These values are in conformity with the specifications of IEC 61000-4-2.

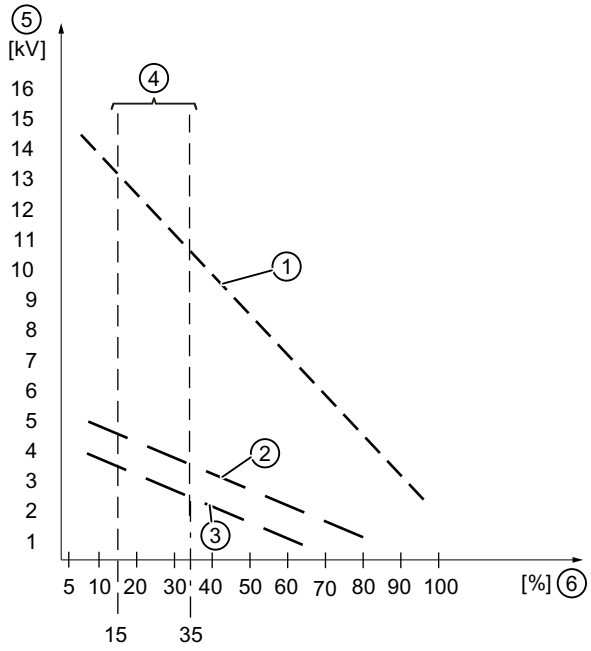

① Synthetic material

② Wool

③ Antistatic material, e.g. wood or concrete

④ E.g. office spaces without humidity control (in winter)

⑤ Voltage

⑥ Relative humidity

NOTICE

Protective measures against damage to equipment due to discharge of static electricity

Electronic devices contain components that can be damaged by electrostatic discharge if they are handled improperly.

- **Grounding/discharge**
  When handling electrostatic sensitive devices, ensure that your body, the workplace, and packaging are grounded. In this way, you can avoid becoming electrostatically charged. Discharge your body electrostatically immediately before touching an electronic component. To do this, touch a conductive, grounded object, e.g., a bare metal part of a switch cabinet or the water pipe.
  Electrostatically sensitive devices should not be brought into contact with electrically insulating materials such as plastic film, plastic parts, insulating table supports, or clothing made of synthetic fibers.
- **Direct contact**
  Only touch electrostatic sensitive devices when this is unavoidable (e.g. during maintenance work). Handle the devices, if possible, only by the plastic enclosure and without touching any chip pins or PCB traces. In this way, the discharged energy cannot reach or damage sensitive devices.
  Discharge your body before taking any necessary measurements on a device. Do so by touching grounded metallic parts. Use only grounded measuring instruments.
  Always place an electrostatic sensitive device on conductive bases.
- **Storage and transport**
  Always store and transport electrostatic sensitive devices or components in ESD-safe conductive packaging, e.g. metallized plastic or metal containers. Leave the device in its packaging until installation.

NOTICE

Storage and transport in non-conductive packaging

If you have to store or transport the electrostatic sensitive device in non-conductive packaging, you must first pack the device in ESD-safe, conductive material, e.g., conductive foam rubber, ESD bag.

The diagrams below illustrate the required ESD protective measures for electrostatic sensitive devices.

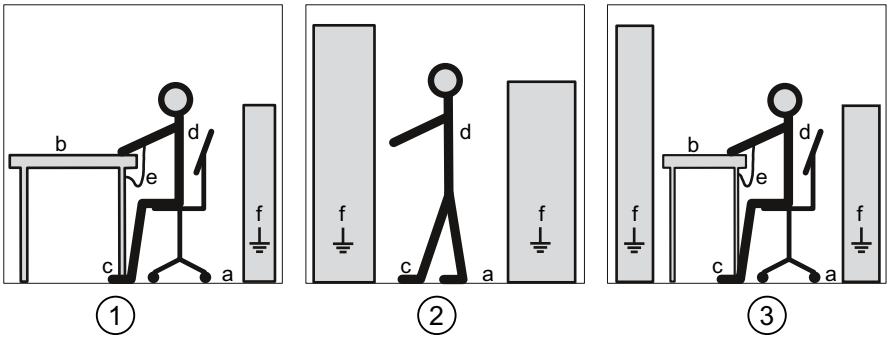

① ESD seat

② ESD standing position

③ ESD seat and ESD standing position

Protective measures

a Conductive floor

b ESD table

c ESD shoes

d ESD smock

e ESD bracelet

f Cabinet ground connection

2.3 Safety instructions for configuration

2.3.1 Non-existent galvanic isolation at the digital inputs of the 4DI (LC) submodule

Non-existent galvanic isolation of the digital inputs

The use of external 24 V infeeds can lead to a defect or failure of the device (e.g. motor temperature switches).

The digital inputs are not isolated. The reference potential is mass. Control the digital inputs only via a unit supplied from the 24 V DC output. Only connect cables with a maximum length of 30 m to the Basic 4DI (LC) submodule. The supply is short-circuit proof.

You will find more information in the section Basic 4DI (LC) submodule (Page 33).

2.4 Safety instructions for installation

2.4.1 Qualified personnel

Qualified personnel required

Failure to follow proper procedures may result in personal injury and damage to property.

All work involved in connecting, commissioning and maintenance must be carried out by qualified, responsible personnel.

2.4.2 Five safety rules for working in or on electrical systems

A set of rules, which are summarized in DIN VDE 0105 as the "five safety rules", are defined for working in or on electrical systems as a preventative measure against electrical accidents:

1. **Isolating**: "Isolating" refers to the disconnection of all poles and all sides of an electrical system from live parts. An isolating distance of varying length, depending on the operating voltage, must be created between live and de-energized parts of the system.
   All-pole disconnection can be achieved by, for example:
   - Switching off the miniature circuit breaker
   - Switching off the electronic protective switching device by setting it to the OFF position
   - Switching off the motor circuit breaker
   - Unscrewing fuses
   - Pulling LV HRC fuses
2. **Securing against re-connection**: To prevent a system that is currently being worked on from being switched back on by accident, it must be reliably prevented from being switched back on and a sign prohibiting it from being switched back on must be provided.
   For legal reasons, a distinction is made in the scope of the protection as to whether the equipment is accessible to lay electricians or is located in a closed area, room or environment that is only accessible to qualified electricians.
   In areas that are freely accessible to laypersons, the restart must always be designed in such a way that the lock can only be removed by using additional tools. Simply switching off the motor or system circuit breaker is not sufficient.
   It must also be secured against being switched on by a lockout device (lock) or the unscrewed fuses must be replaced by lockable locking elements.
   If the switching device is located in a closed area that is only accessible to qualified electricians – this is always the case for systems with high voltage and in electrical equipment rooms – it is sufficient to affix a sign prohibiting reactivation for the duration of the work. This sign should also include information on who is authorized to remove this prohibition sign after the work has been completed. In remote-controlled switchgear, a virtual switching lockout is set in the controller area by means of a configuration, which indicates to the operator in the control center that switching on is prohibited.
3. **Make sure that the unit is de-energized**: The de-energized state of the equipment should be verified using suitable test equipment, e.g. a 2-pole voltmeter. 1-pole test pins are not suitable for this purpose. The absence of power must be established for all poles, phase to phase, and phase to N/PE.

4. **Grounding and short-circuiting**: Grounding and short-circuiting are only mandatory if the system has a rated voltage greater than 1 kV. In this case, the system should always be grounded first and then connected to the live parts to be short-circuited.
5. **Erect barriers around or cover adjacent live parts**: These parts should be covered, or barriers erected around them, to avoid accidental contact during the work with adjacent parts that are still live.

These five safety rules must be applied in the above order prior to starting work on an electrical system. After completing the work, proceed in the reverse order.

It is assumed that every electrically skilled person is familiar with these rules.

2.4.3 Personal protective equipment, installation and connection

Observe the following during installation and connection:

- We recommend touching components, modules and devices only if they are grounded by means of one of the following measures:
  - Wearing an ESD wrist strap.
  - Wearing ESD shoes or ESD grounding straps in ESD areas with conductive flooring.
- Only place electronic components, modules, or devices on conductive surfaces (e.g. table with ESD surface, conductive ESD foam, ESD packaging, ESD transport container).
- Ensure adequate overvoltage protection.

2.4.4 Installing the touch protection for the power bus

It is necessary to use touch protection for the power bus.

Serious injury can occur if the touch protection for the power bus is not used.

To avoid serious injury, place the touch protection on the contacts of the power bus on the last BaseUnit plugged into the ET 200SP system.

2.5 Safety instructions for operation

2.5.1 Current information about operational safety

Important note for maintaining operational safety of your system

Please take note of our latest information. Systems with safety-related characteristics are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. For this reason, we publish special newsletters containing information on product features that are (or could be) relevant to operation of safety-related systems. By subscribing to the appropriate newsletters, you will ensure that you are always up to date and able to make changes to your system when necessary:

- Safety Integrated (https://new.siemens.com/global/en/products/automation/topic-areas/safety-integrated/factory-automation/newsletter.html)
- Industrial controls (https://new.siemens.com/global/en/products/automation/industrial-controls/forms/newsletter.html)

Click "Subscribe to newsletter".

2.5.2 Replacement of modules during operation

Possibility of replacing modules during operation

Hot swapping refers to the replacement of modules while the system is in operation. In the event of a fault, you can replace the e-Starter ET 200SP during operation while the system is live. The station remains functional and the plant remains available. It is not necessary to switch off and restart the system for this purpose.

Only remove the e-Starter ET 200SP from the BaseUnit if no Motor ON command is present.

2.5.3 Interference caused by radios and mobile phones

Interference caused by the use of a radio or mobile phone near the product

Malfunctions may occur when using a radio or mobile phone in close proximity to the product, e.g. to scan the ID link. This can cause death or serious injury.

- Therefore, only use radios and mobile phones in the vicinity of the product when the product is switched off or no ON command is applied.
- Alternatively, turn off all radio connections of the radio/mobile phone when you are near the product.

Product description

3

3.1 SIMATIC ET 200SP product family

Description

SIMATIC ET 200SP is a scalable and highly flexible distributed I/O system for connecting process signals to a higher-level controller via a fieldbus.

Applications

Thanks to its multifunctionality, the SIMATIC ET 200SP distributed I/O system is suitable for a wide range of applications. Its scalable design allows you to tailor your configuration to local requirements. Different CPUs/interface modules are available for connection to PROFINET IO, EtherNet/IP and Modbus TCP. SIMATIC ET 200SP with CPU allows intelligent pre-processing to relieve the higher-level controller. The CPU can also be used as standalone device. A wide range of I/O modules rounds off the product range. SIMATIC ET 200SP is designed with degree of protection IP20 and is intended for installation in a control cabinet.

The e-Starter ET 200SP in the ET 200SP system

Compact design

- Small dimensions and great variability due to scalability
- Maximum transparency in the most restricted space due to the innovative labeling system
- System-integrated load power supply

Easy to use

- Compact modules, permanent wiring with single-conductor or multi-conductor connection
- Time savings through tool-free connection system with push-in terminals
- Configuration adaptation for future expansions through integrated configuration control

e-Starter ET 200SP

- Easy integration of motor starters with overload and short-circuit protection
- Compact design with up to 3 kW power

Communication standards

- PROFINET IO
- EtherNet/IP
- Modbus TCP

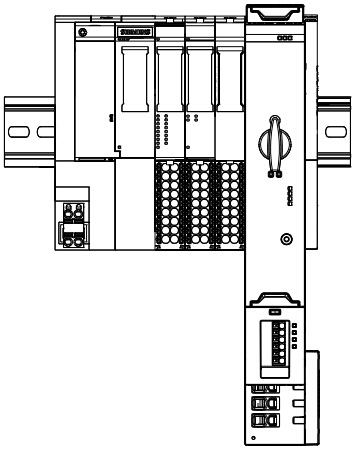

Powerful technology

- Protection and controlling of loads

CPU / IM

- PROFINET interface with up to 3 ports
- IO controller
- I-device

Example setup with e-Starter ET 200SP

The SIMATIC ET 200SP distributed I/O system consists of:
- A CPU/interface module
- Up to 64 I/O modules for plugging into BaseUnits
- A server module that completes the ET 200SP set-up.

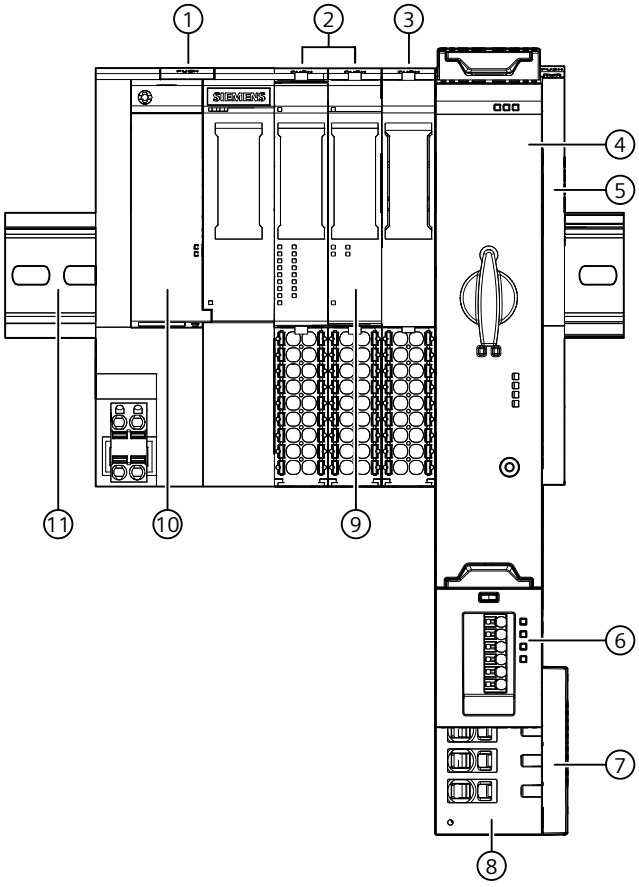

① CPU or interface module

② Light BaseUnit BU..D with infeed of the supply voltage or dark BaseUnit BU..B for continuing the potential group

③ BU cover 15 mm for interference-proof operation and to protect empty spaces

④ e-Starter ET 200SP

⑤ Server module

⑥ 4DI (LC) submodule

⑦ Touch protection for the power bus

⑧ BaseUnit for e-Starter ET 200SP or motor starter ET 200SP (3RK1308)

⑨ I/O module

⑩ Bus adapter

⑪ Mounting rail

3.2 e-Starter ET 200SP

Description

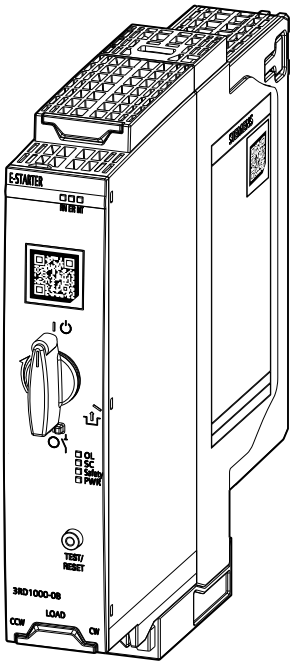

The e-Starter ET 200SP is a compact device that offers measuring, monitoring, protection and control functions. The e-Starter ET 200SP uses new circuit technologies to combine several switching and protection technologies in one device.
The e-Starter ET 200SP also integrates electronic short-circuit protection.

Design

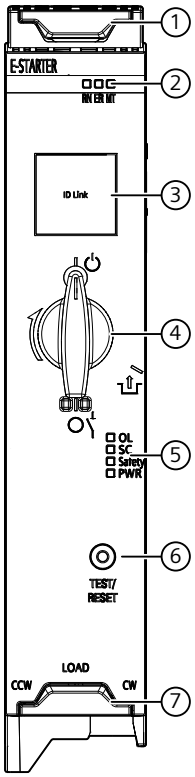

① Device LED "GRID" for the indication of operating states from the application point of view (on the line side)

② System LEDs to indicate the system operating status

③ ID link

④ Lockable rotary interlock

⑤ Device LEDs for indicating the operating states of the device and the load

⑥ TEST/RESET button

⑦ Device LED "LOAD" for the indication of operating states from the application point of view (on the load side)

Positions of the lockable rotary interlock

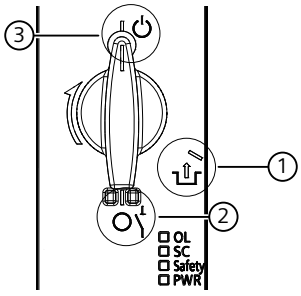

① Assembly/disassembly position: All electrical contacts are open. You can insert the e-Starter ET 200SP into the BaseUnit or remove it from the BaseUnit.

② Parking position/OFF: In this position, you cannot remove the e-Starter ET 200SP from the BaseUnit, but all electrical contacts are still disconnected. In addition, you can open the locking lever on the mechanical rotary interlock in this position, and fix the position with a padlock (shackle diameter 3 mm). This ensures the isolating function in accordance with IEC 60947-1. This position is only permissible for maintenance purposes and not for continuous operation. In this position, neither dust protection nor mechanical fatigue strength are guaranteed. If you are not using the e-Starter ET 200SP for a longer period of time, remove the e-Starter ET 200SP and insert the empty enclosure (3RK1908-1CA00-0BP0).

③ Operating position/READY: The e-Starter ET 200SP is firmly locked in the BaseUnit and the electrical contacts are connected.

NOTE

Removing the e-Starter ET 200SP from the BaseUnit

Only remove the e-Starter ET 200SP from the BaseUnit if no Motor ON command is present.

If you are not using the e-Starter ET 200SP for a longer period of time, remove the e-Starter ET 200SP and insert the empty enclosure (3RK1908-1CA00-0BP0).

Functions

All variants of the e-Starter ET 200SP feature the following functionality:

- e-Starter ET 200SP for switching and protecting any three-phase loads up to 3 kW from 208 to 480 V AC line-to-line voltage
- Fully electronic short-circuit protection up to 100 kA. The shutdown takes less than 5 µs and can be reset.
- Self-assembling 32 A power bus, i.e. the load voltage is only fed in once for a group of e-Starters ET 200SP
- All supply voltages are connected only once, i.e. when modules are added, they are automatically connected to the next module (referred to the BaseUnits)
- Hot swapping: Replacement of e-Starters ET 200SP during ongoing operation of the system
- Digital inputs can be used optionally via a Basic 4DI (LC) submodule.
- Controlling the e-Starter ET 200SP from the controller via the cyclic process image
- Diagnostics-capable for active monitoring of the switching and protection functions

- The signal states in the process image of the e-Starter ET 200SP provide information about protective devices (e.g. overload), the switching status of the e-Starter ET 200SP and system errors (diagnosis state).
- Smart Start function to avoid high current peaks and torque surges during starting compared to direct starting
- Phase-optimized connection to avoid inrush currents
- Upgradeable for future functions

Applications

The e-Starter ET 200SP is suitable for the following applications:

- Switching, protecting and monitoring of
  - 3-phase motors with overload and fully electronic short-circuit protection
  - 1-phase motors with overload and fully electronic short-circuit protection (e.g. 230 V motors for pump applications)
  - Ohmic loads with overload and short-circuit protection (e.g. for heaters)
- Plant monitoring and energy management in conveyor systems:
  Drive belt monitoring and blocking monitoring are possible by means of the phase asymmetry and residual current detection during current measurement, for example.
- Track switching and lifting table control in conveyor systems:
  Track switches can be implemented using the quick stop function and lifting table controls by means of the "immediate end position disconnection" function without any laborious programming.
- Safe isolation of the drive from main power supply:
  The isolating functions according to IEC 60947-1 offer protection against inadvertent activation during plant maintenance.

Benefits

The e-Starters ET 200SP offer a number of advantages:

- Fully integrated into the ET 200SP I/O system (including TIA Selection Tool and TIA Portal)
- Fully electronic short-circuit protection
- Phase-optimized switching on
- Integrated reversing functionality
- Simple integrated transmission of measured values (current, voltage, power, etc.)
- Clear parameterization and diagnostics in STEP7 (TIA Portal)
- Increase of availability through fast replacement of units (easy mounting and plug-in technology)
- Long service life and low wear due to fully electronic switching
- Less space required in the control cabinet (up to 80%) due to high functional density

- Comprehensive diagnostics, information and limit value monitoring for preventive maintenance
- Parameterizable inputs via the Basic 4DI (LC) submodule
- Less wiring and testing required as a result of integrating several functions into a single device
- Reduced stock-keeping and configuration costs due to reduced variance due to high functional density and wide setting range of the rated operational current
- Compatibility mode for direct replacement of the ET 200SP motor starter (3RK1308) (except for the failsafe motor starter variants) without having to stop the CPU
- Smart Start function to prevent torque surges during the starting process of asynchronous motors

3.3 BaseUnits

Description

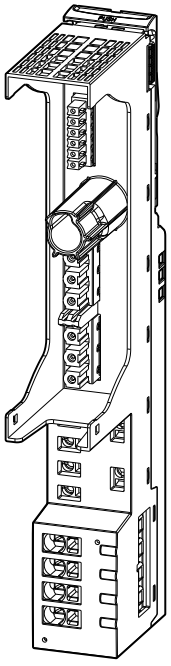

The BaseUnits ensures the electrical and mechanical connection between the e-Starter ET 200SP and the ET 200SP station.

Suitable BaseUnits are available for the different requirements of the system structure. For the 24 V DC potential group and for the 480 V AC infeed system, different groups can be established independently of each other.

Design

The figure below shows the connections of a BaseUnit with 480 V AC infeed:

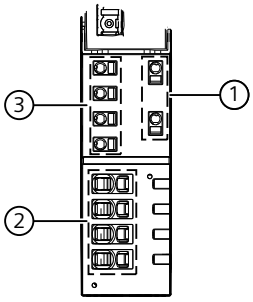

① Terminal strip of the 24 V DC incoming unit
② Terminal strip of the 480 V AC incoming unit
③ Terminal strip motor feeder

Applications

The BaseUnit complements the product portfolio of the SIMATIC ET 200SP distributed I/O system.

3.4 Basic 4DI (LC) submodule

Description

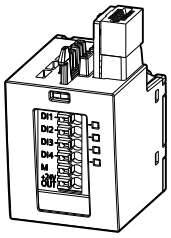

The Basic 4DI (LC) submodule with four inputs can be mounted on the ET 200SP e-Starter. The status of the inputs of the Basic 4DI (LC) submodule can be seen via the process image input (PII) of the ET 200SP e-Starter.

The input actions can be parameterized.

Design

The figure below shows the connections of Basic 4DI (LC) submodule:

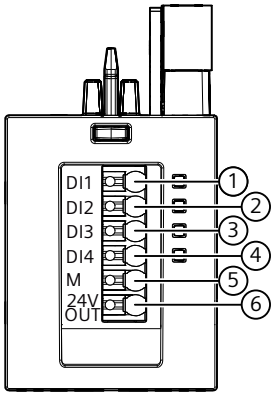

① Digital input DI 1 assigned by default with "Motor-CW"

② Digital input DI 2 assigned by default with "Motor-CCW"

③ Digital input DI 3 assigned by default with "no action"

④ Digital input DI 4 assigned by default with "Local Control (LC)"

⑤ Mass (M)

⑥ Output 24 V DC / 100 mA

NOTE

Non-existent galvanic isolation of the digital inputs

The use of external 24 V infeeds can lead to a defect or failure of the device (e.g. motor temperature switch).

The digital inputs (1 to 4) are not isolated. The reference potential is M (5). Control the digital inputs only via a unit supplied from the 24 V DC output (6). Only connect cables with a maximum length of 30 m to the Basic 4DI (LC) submodule. The supply (5 and 6) is protected against short-circuits.

Benefits

The Basic 4DI (LC) submodule permits the use of additional actions and functions in combination with the e-Starter ET 200SP, such as manual local control. These are defined in the device parameterization of the e-Starter ET 200SP.

3.5 Fan unit

Description

All e-Starter ET 200SP units are supplied with a fan unit already mounted on the device as standard.
A fan unit with 2 fans can also be used as an optional accessory for applications with more difficult ambient or load conditions.

The following figure shows the two variants of the fan units:

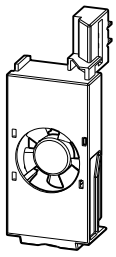

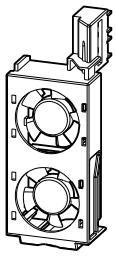

3.6 Touch protection for the power bus

Description

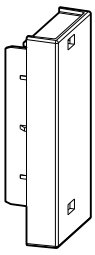

The cover for the power bus serves as touch protection for the main circuit. Use the touch protection on the last BaseUnit of the system structure. The touch protection is included in the scope of supply of a BaseUnit with 480 V AC infeed and can be ordered separately.

3.7 Additional mounting for the BaseUnit

Description

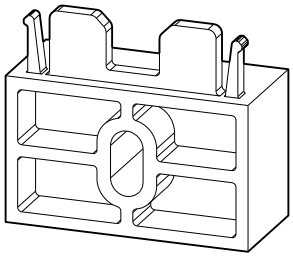

The additional mountings are used to attach the BaseUnits more securely. The additional mountings for the BaseUnit are suitable for 7 mm and 15 mm DIN rails and can be ordered as an option.

3.8 BU cover 30 mm for protection of empty slots

Description

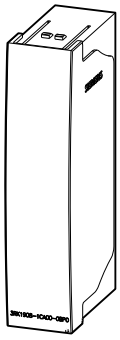

The BU cover 30 mm for protecting empty slots is used on BaseUnits whose slots are not equipped with I/O modules, or whose slots are reserved for future expansion. The BU cover 30 mm for protection of empty slots protects against soiling.

Mounting and disassembly

4

4.1 Minimum clearances

The following graphic shows the minimum distances required for mounting and dismounting the e-Starter ET 200SP:

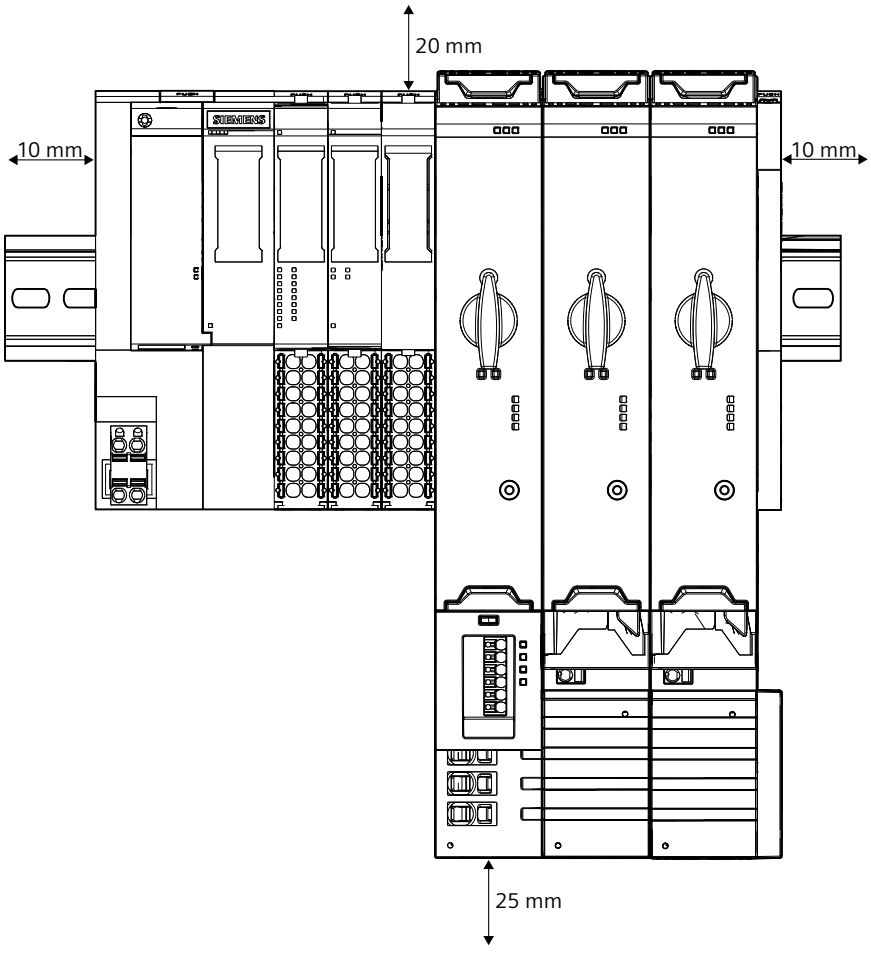

The installation height of the e-Starter ET 200SP varies depending on the DIN rail selected:

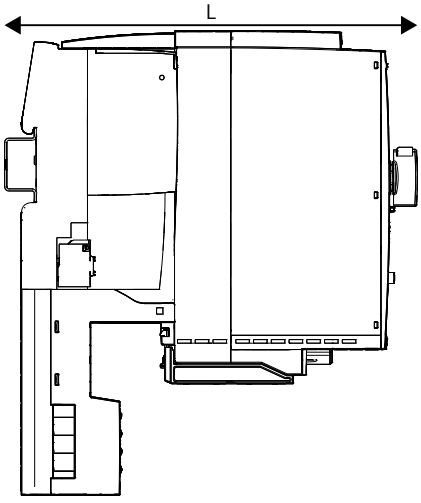

- DIN rail 35 x 15 mm according to DIN EN 60715: L: 195 mm
- DIN rail 35 x 7.5 mm according to DIN EN 60715: L: 188 mm
- SIMATIC S7 mounting rail 6ES5710-8MA11 (35 x 15): L: 195 mm

4.2 Mounting rules for reducing the thermal stress

The following rules reduce the thermal stress on the ET 200SP system in the control cabinet.

- Mix modules with higher power loss and modules with lower power loss, e.g. 2 A and 7 A e-Starter ET 200SP.
- Prefer the horizontal mounting position.
- In the vertical mounting position, insert modules with high power loss at the top and the interface module or CPU at the bottom.

4.3 Mounting conditions

Observe the following installation conditions when using the e-Starter ET 200SP:

Mounting position

You can install the e-Starter ET 200SP vertically or horizontally. The mounting position refers to the alignment of the mounting rail

Current carrying capacity of the ET 200SP components

Take the current carrying capacity of the ET 200SP components into account.

The maximum current load of the e-Starter ET 200SP via the power bus is 7 A and via the infeed bus 32 A with derating.
For each e-Starter ET 200SP, 190 mA are used from the 24 V DC supply. However, the ET 200SP system, consisting of CPU/IM and I/O modules, may only have a maximum length of 1 m.

Permissible ambient temperatures

The e-Starter ET 200SP is approved for operation in a temperature range from -25 °C to +60 °C. Consider the derating of the rated operational current at ambient temperatures >40 °C.

The following table shows the derating curves of the e-Starter ET 200SP in the version 0.1 - 2.0 A and 0.7 - 7.0 A and with one fan and with two fans:

		e-Starter ET 200SP 0.7 - 7 A with 1 fan	**e-Starter ET 200SP 0.7 - 7 A with 2 fans**	**e-Starter ET 200SP 0.2 - 2 A with 1 fan**
Installation altitude	**T_a in °C**	**I_e in A**	**I_e in A**	**I_e in A**
1000 m	40	7	7	2
	45	6.5	6.8	2
	50	6	6.6	2
	55	5.4	6.2	2
	60	4.7	5.6	2
2000 m	40	6.6	7	2
	45	6.2	6.8	2
	50	5.6	6.3	2
	55	5	5.7	2
	60	4.1	5	2
4000 m	40	5.8	6.5	2
	45	5.3	6	2
	50	4.7	5.5	2
	55	4	4.9	2
	60	3	4.1	1.7

Maximum current cold restart capability

The following table shows the measured values of an ET 200SP e-starter 0.7 - 7 A:

Temperature in °C	Class10E (7.2*I/I_e for max. 6 s) in A	Class20E (7.2*I/Ie for max.12 s) in A
40	7	6.3[1)]
45	6.8	6.1[1)]
50	6.6	5.9[1)]
55	6.4	5.8
60	6.2	5.6

1) Derating required

Suitable mounting rails

Use one of the following mounting rails:

- 35x15 mm DIN rail in accordance with DIN EN 60715
- 35x7.5 mm DIN rail in accordance with DIN EN 60715
- SIMATIC S7 mounting rail

Selecting accessories

The figure below shows the criteria the station must meet:

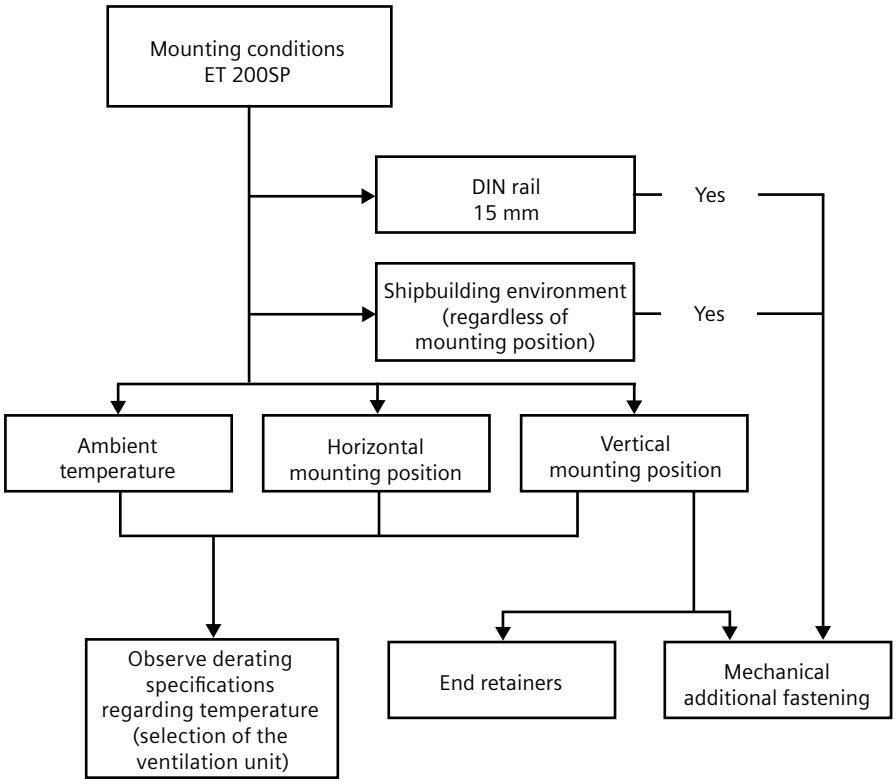

In the case of a vertical mounting position, use end retainers "8WA1808" at both ends of the ET 200SP station:

Use of the fan units

Depending on the operating conditions, the e-Starter ET 200SP should be operated with a fan unit consisting of one fan or two fans.

with a fan unit consisting of one fan or two fans.

4.4 Interference-proof setup of the e-Starter ET 200SP

For interference-proof operation of the ET 200SP station in accordance with the standard IEC 60947-4-2, use a dummy module upstream of the first e-Starter ET 200SP. No dummy module is required to the right of the e-Starter ET 200SP.

Note the following mounting rules:
Use the following dummy module on the mounting rail between the upstream module and the e-Starter ET 200SP: BU cover 15 mm 6ES7133-6CV15-1AM0 with BaseUnit 6ES7193-6BP00-0BA0.

For operation of the ET 200SP station with an unequipped BaseUnit, touch protection must be provided for the open BaseUnit plug contacts (power connector, power bus connector,

and backplane bus connector). The touch protection protects the plug contacts against dirt. The BU cover 30 mm 3RK1908-1CA00-0BP0 can be ordered as an accessory.

4.5 Mounting a BaseUnit

Safety instructions

WARNING

Risk of injury due to accessibility of the contact gaps
Can cause death or serious injury

Serious injury can occur if the touch protection for the power bus is not used.

To avoid serious injury, place the touch protection on the contacts of the power bus on the last BaseUnit plugged into the ET 200SP system.

Requirement

- The DIN rail is mounted.

Instructions

1. Hook the BaseUnit into the DIN rail from above.
2. Swivel the BaseUnit back until the BaseUnit audibly clicks into place.

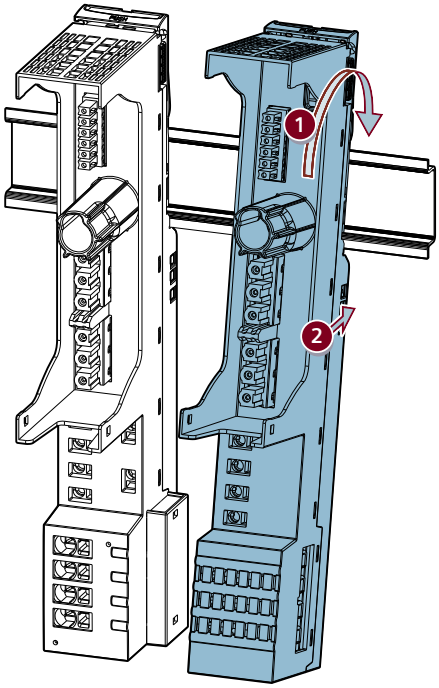

3. Remove the touch protection for the power bus of the adjacent BaseUnit.
4. Slide the BaseUnit left onto the adjacent BaseUnit until it audibly clicks into place.

5. Insert the touch protection for the power bus into the opening of the BaseUnit until it audibly engages.

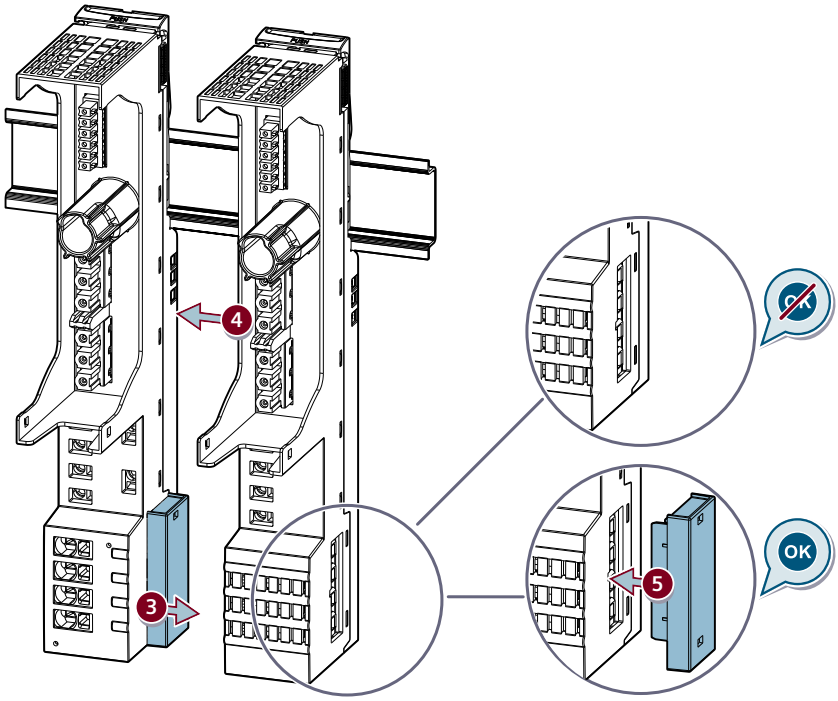

4.6 Removing the BaseUnit

Requirement

- 24 V DC supply voltage and main voltage are switched off.

Instructions

1. Disconnect the wiring of the BaseUnit.
2. Press and hold the pushbutton of the BaseUnit.
3. Slide the BaseUnit that is being removed to the right.
4. Swivel the bottom part of the BaseUnit away from the DIN rail to the front.

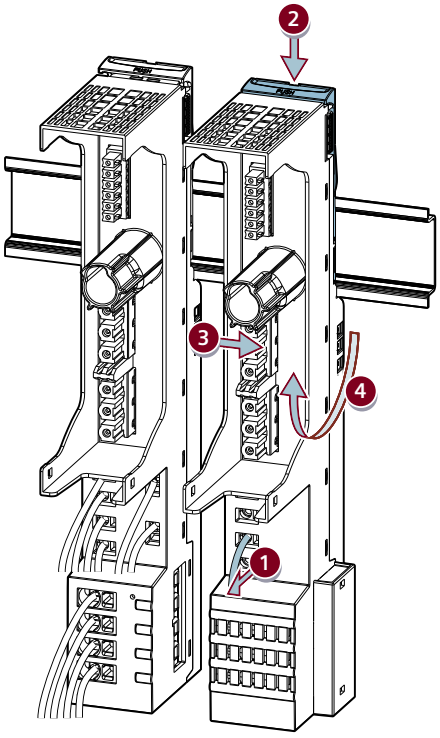

4.7 Mounting the e-Starter ET 200SP

Requirement

- The BaseUnit is mounted on the DIN rail.
- The BaseUnit is wired.

Instructions

1. Turn the lockable rotary interlock of the e-Starter ET 200SP to the assembly/disassembly position.
2. Guide the e-Starter ET 200SP into the BaseUnit.

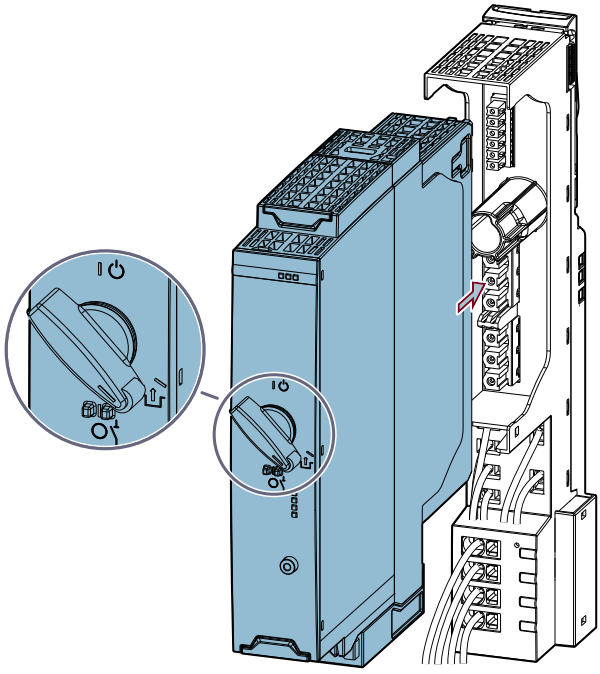

3. Turn the lockable rotary interlock clockwise to the operating position.

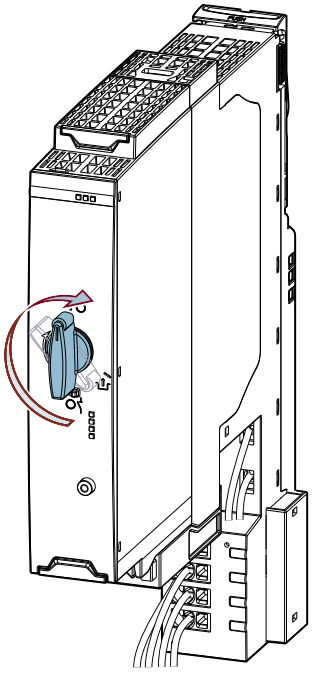

4.8 Removing the e-Starter ET 200SP

Requirement

- Motor ON command is not set.

Instructions

1. Turn the lockable rotary interlock counter-clockwise to the assembly/disassembly position.
2. Remove the e-Starter ET 200SP from the BaseUnit.

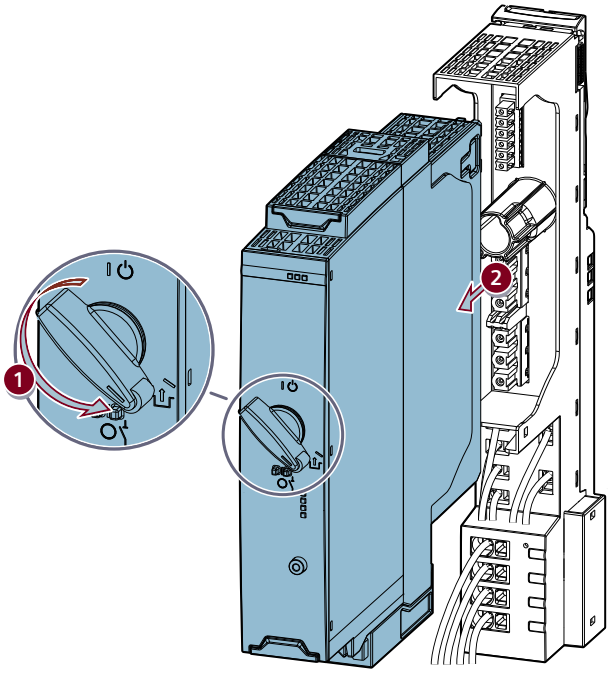

4.9 Mounting the 4DI (LC) submodule

Safety instructions

WARNING

Risk of injury due to automatic restart.
Can cause death or serious injury.

Depending on the parameterization of the Basic 4DI (LC) submodule in the e-Starter ET 200SP dangerous conditions can arise. This can result in property damage or serious injury caused by connected devices that are automatically started up.

Revoke the ON commands at DI1 to DI4 before mounting the Basic 4DI (LC) submodule.

Requirement

- The e-Starter ET 200SP is located in the mounted and wired BaseUnit.

Instructions

1. Insert the 4DI (LC) submodule at the bottom into the e-Starter ET 200SP.

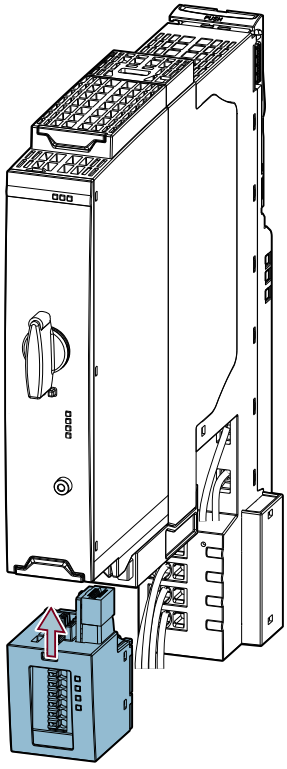

4.10 Removing the 4DI (LC) submodule

Instructions

1. Push the release lever on the rear of the 4DI (LC) submodule.
2. Remove the 4DI (LC) submodule from the e-Starter ET 200SP while holding down the release lever.

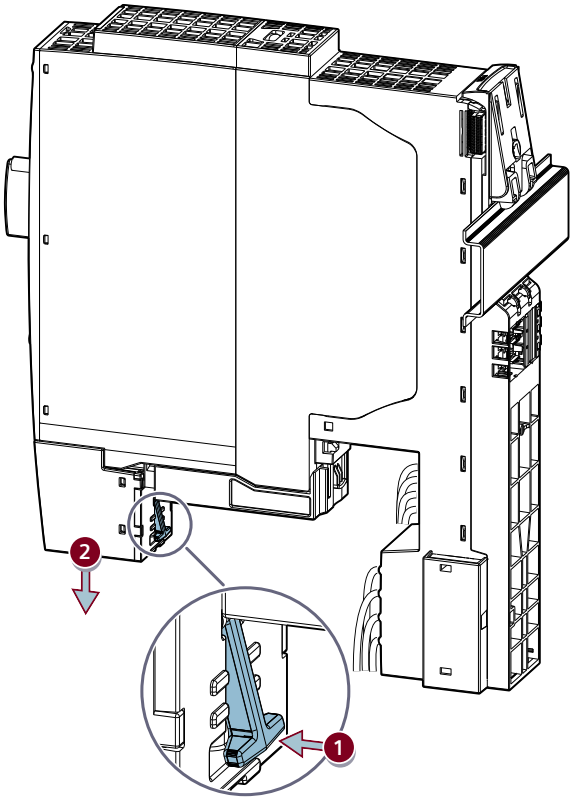

NOTE

Removal during operation

If the Basic 4DI (LC) submodule is disconnected from the e-Starter ET 200SP during manual - local mode, this will directly cause the running motor to switch off and then an exit from manual - local mode.
In addition, an error alarm is generated in the DS 92 if a 4DI (LC) submodule is configured (see byte 22.3 TARGET =/= ACTUAL configuration).

4.11 Removing the fan unit

Requirement

- The e-Starter ET 200SP has been removed.

Instructions

1. Grasp the front and rear ends of the fan unit with two fingers. Apply light pressure to the fan unit with your finger that is pointing toward the back of the device.
2. Pull off the fan unit.

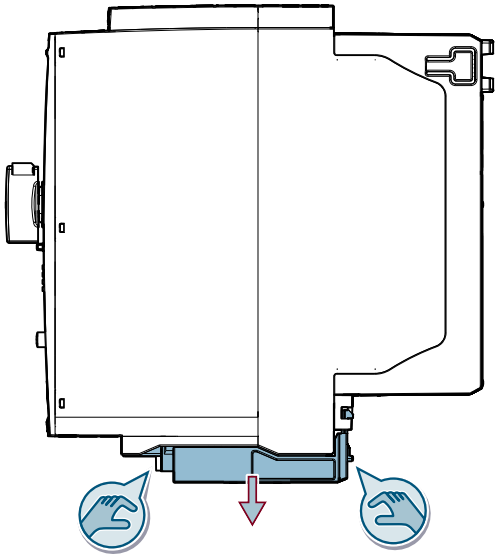

4.12 Mounting the fan unit

Safety instructions

NOTE

Ensuring cooling

If the ventilation grilles and air inlets are blocked, the device may overheat. If this is the case, the warning (maintenance alarm) "Check fan" (DS92, byte 77.5) is first generated and can be recognized by the yellow "MT" LED lighting up. The message "Switching element overload" (DS92, byte 10.3) is then issued.

Make sure that the ventilation grilles and air inlets are kept clear.

Instructions

1. Slide the fan unit into the e-Starter ET 200SP.
2. Press the fan unit into the e-Starter ET 200SP until it audibly clicks into place.

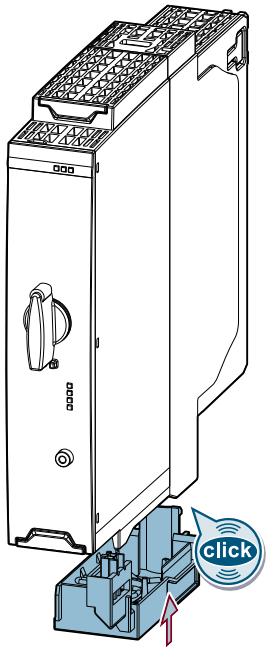

4.13 Installing the additional mounting for the BaseUnit

Necessary tools

- Screwdriver

Necessary tools

- M4 screw

Area of application

- When using a 15 mm DIN rail
- With a vertical mounting position
- For applications according to shipbuilding standards in all mounting positions with 7.5 mm and 15 mm DIN rails

Instructions

1. Insert the additional mounting for the BaseUnit into the opening at the bottom of the BaseUnit. Note the position of the additional mounting for the BaseUnit during installation.

7.5 mm DIN rail	15 mm DIN rail
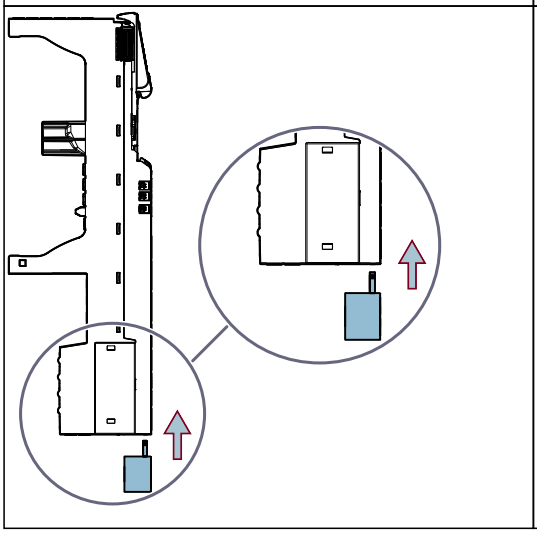	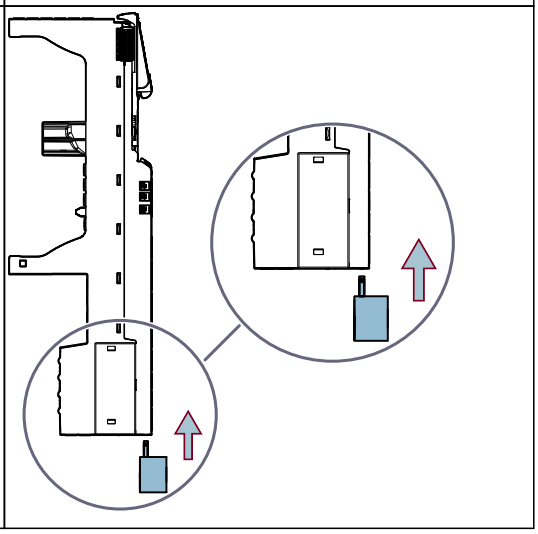

2. Hook the BaseUnit into the DIN rail from above.
3. Swivel the BaseUnit back until the BaseUnit audibly clicks into place.

4. Screw the additional mounting for the BaseUnit to the wall.

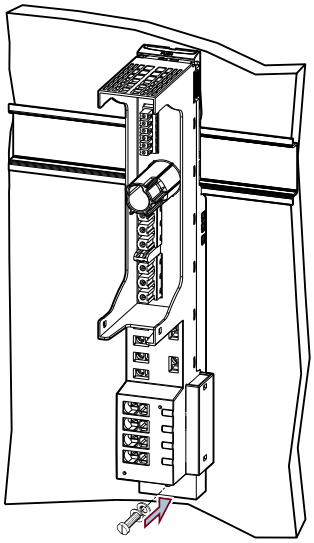

Result

You can achieve improved stability by using the additional mounting for the BaseUnit.

4.14 Removing the additional mounting for the BaseUnit

Instructions

1. Loosen the screw that secures the additional mounting for the BaseUnit to the mounting plate.
2. Remove the BaseUnit from the DIN rail.
3. Remove the additional mounting from the BaseUnit.

Connecting 5

5.1 Connecting the terminals of the 480 V AC power bus of the BaseUnit

Safety instructions

⚠ DANGER
Hazardous voltage. Can cause death or serious injury. Disconnect the system and all devices from the power supply before starting work.

Requirement

- Supply voltage is switched off.
- The BaseUnit is mounted on the DIN rail.

Tools

Cables with permitted cross-section and a stripped length of 15 mm:

- Solid: 1x 1 ... 6 mm^2
- Finely stranded: 1x 1 ... 6 mm^2
- Finely stranded with end sleeve: 1x 1 ... 6 mm^2
- AWG cable, solid or finely stranded 1x 18 ... 10

Necessary tools

- Screwdriver with dimensions 3.0 mm x 0.5 mm x 100 mm (3RA2908-1A), when using finely stranded cables

480 V AC power bus

The BaseUnits BU30-MS1, BU30-MS2 are suitable for 480 V AC infeed.

Note the following properties of the power bus:

- The power bus is set up by connecting the BaseUnits. Wiring is performed automatically.
- The power bus distributes the energy to the e-Starter ET 200SP. within one load group
- The max. current carrying capacity is 32 A (3-phase) If this is exceeded, a new infeed BaseUnit must be used.
- The voltage range for energy supply is 208 ... 480 V AC line-to-line voltage.

Design

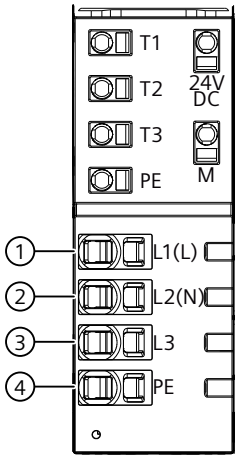

① Terminal L1 (L)
② Terminal L2 (N)
③ Terminal L3
④ Terminal PE

Instructions

1. Insert the cables into the push-in terminals as far as they will go.
2. Pull on the cable to ensure that it is firmly clamped.

5.2 Connect the terminals of the 24 V DC power bus of the BaseUnit

Safety instructions

NOTE
Applied voltage
Disconnect the system and all devices from the power supply before starting work.

Requirement

- Supply voltage is switched off.
- The BaseUnit is mounted on the DIN rail.

Tools

Cables with permitted cross-section and a stripped length of 10 mm:

- Solid: 1x 0.5 ... 2.5 mm^2
- Finely stranded: 1x 0.5 ... 2.5 mm^2
- Finely stranded with end sleeve: 1x 0.5 ... 2.5 mm^2
- AWG cable, solid or finely stranded 1x 20 ... 12

Necessary tools

- Screwdriver with dimensions 3.0 mm x 0.5 mm x 100 mm (3RA2908-1A), when using finely stranded cables

24 V DC power bus

The BaseUnits BU30-MS1, BU30-MS3 are suitable for one infeed.

Note the following properties of the power bus:

- The maximum current carrying capacity is 7 A. Even when the maximum current carrying capacity is observed, the ET 200SP station may only have a maximum length of 1 m.
- The nominal voltage range is 20.4 ... 28.8 V DC.

Design

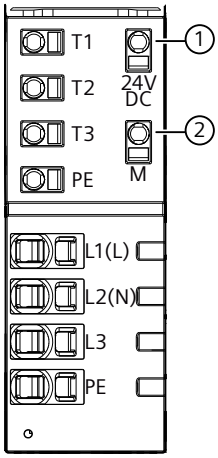

① Terminal 24 V DC

② Terminal M

Instructions

1. Insert the cables into the push-in terminals as far as they will go.
2. Pull on the cable to ensure that it is firmly clamped.

5.3 Connecting the terminals of the motor feeder of the BaseUnit

Safety instructions

⚠ DANGER
Hazardous voltage. Can cause death or serious injury. Disconnect the system and all devices from the power supply before starting work.

Requirement

- Supply voltage is switched off.
- The BaseUnit is mounted on the DIN rail.

Tools

Cables with permitted cross-section and a stripped length of 10 mm:

- Solid: 1x 0.5 ... 2.5 mm^2
- Finely stranded: 1x 0.5 ... 2.5 mm^2
- Finely stranded with end sleeve: 1x 0.5 ... 2.5 mm^2
- AWG cable, solid or finely stranded 1x 20 ... 12

Necessary tools

- Screwdriver with dimensions 3.0 mm x 0.5 mm x 100 mm (3RA2908-1A), when using finely stranded cables

Design

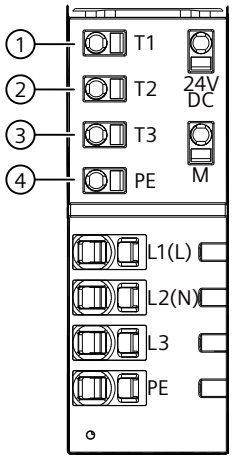

① Terminal T1
② Terminal T2
③ Terminal T3
④ Terminal PE

Instructions

1. Insert the cables into the push-in terminals as far as they will go.
2. Pull on the cable to ensure that it is firmly clamped.

5.4 Connecting the terminals of the 4DI (LC) submodule

Safety instructions

NOTE
Connecting the terminals in the unmounted state.
Only connect the 4DI (LC) submodule when it is not mounted.

Tools

Cables with permitted cross-section and a stripped length of 8 mm:

- Solid: 1x 0.2 ... 1.5 mm^2
- Finely stranded: 1x 0.2 ... 1.5 mm^2
- Finely stranded with end sleeve: 1x 0.25 ... 1.5 mm^2
- AWG cable, solid or finely stranded 1x 24 ... 16

Necessary tools

- Screwdriver with dimensions 3.0 mm x 0.5 mm x 100 mm (3RA2908-1A), when using finely stranded cables

Design

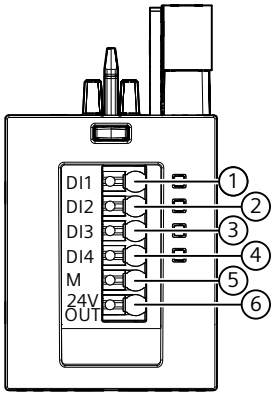

① Digital input DI 1 assigned by default with "Motor-CW"
② Digital input DI 2 assigned by default with "Motor-CCW"
③ Digital input DI 3 assigned by default with "no action"
④ Digital input DI 4 assigned by default with "LC"
⑤ M
⑥ Output 24 V DC / 100 mA

Instructions

1. Insert the cables into the push-in terminals as far as they will go.
2. Pull on the cable to ensure that it is firmly clamped.

Configuration 6

6.1 Coordination of electrical equipment - selectivity

Electrical equipment can influence each other's function in an electrical system. The effects must be considered already when planning electrical systems. It is necessary to coordinate operating equipment with other equipment in a targeted manner so that overload and short-circuit events in particular have as little impact as possible on the operating equipment and, above all, on the entire system.

Selectivity

Selectivity exists if, in the event of an automatic shutdown due to a fault in the electrical system or on equipment, only the protective device immediately upstream of the fault location switches off. Other protective devices that are connected upstream on the supply side or those that supply parallel circuits remain switched on so that only the smallest possible part of the electrical system is disconnected from the line supply.

NOTE

Ensuring high availability of the system when interconnecting the e-Starter ET 200SP in the load feeder

In the load feeder, the e-Starter ET 200SP must always be connected directly upstream of the load. Further distribution of the electrical energy to downstream feeders must be avoided.

Proof of selectivity

Proof of selectivity under short-circuit conditions cannot be provided by the system planner (e.g. by comparing the technical specifications of the individual protective devices). Siemens provides relevant selectivity data for this purpose. On the other hand, selectivity can be verified under overload conditions by comparing the characteristic curves.

In order to achieve selectivity to the higher-level protective device, the protection devices must either be staggered over the rated current (e.g. in a ratio ≥ 2.5:1) or the upstream protective device must be delayed in time.

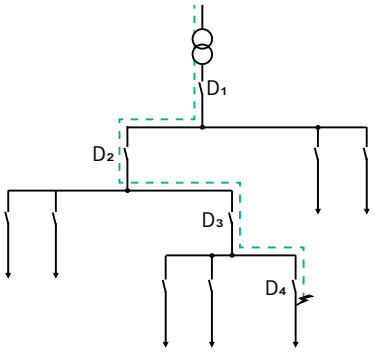

Energy selectivity with e-Starter ET 200SP

The e-Starter ET 200SP supports energy selectivity more simply and effectively than conventional selectivity techniques due to the following properties:

- Minimum load on the system (limitation of î and I^2t)
- Switch-off safety
- Minimal influence on the fault-free part of the system

An appropriate combination of protection devices must be used for this purpose.

The data required for this is provided by Siemens in catalogs or planning tools.

6.2 Switching times

Operating diagram

A = Control command (PIQ or 4DI)

B = Current flow e-Starter ET 200SP

1 = ON

2 = OFF

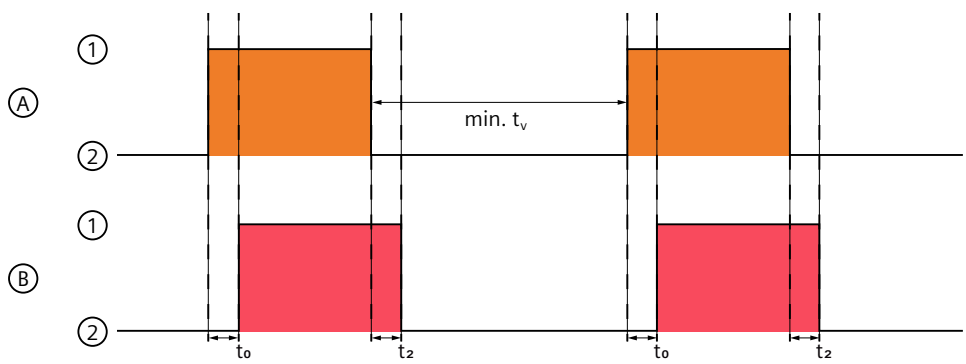

Notes on the maximum time lapse

NOTE

If no new switching command is received after 0.5 h, the electromechanical contacts integrated in the device are opened until the next switching operation in order to save power.

NOTE

To ensure the functionality of the switching elements, they are checked cyclically every 100 operating cycles or every 20 h.

Maximum time laps PIQ

The time lapse (worst case) PIQ can be influenced under the "Reversing time behavior" parameter:

Set value [0] Optimized switching times:

t_0 Time until current flow after the ON command: 35 ms
t_2 OFF delay after OFF command: 15 ms
t_v Interlock time starting command (time that must elapse due to an internal interlocking time until a repeat switch-on command is accepted after a switch-off command): 200 ms

Set value [1] Lifetime optimized switching [Default]:

t_0 Time until current flow after the ON command (with identical direction): 35 ms
t_2 OFF delay after OFF command: 15 ms

t_0 Time until current flow after the ON command (with direction reversal): 60 ms
t_2 OFF delay after OFF command: 15 ms

t_v Interlock time starting command (time that must elapse due to an internal interlocking time until a repeat switch-on command is accepted after a switch-off command): 200 ms

Maximum time lapse 4DI (LC) submodule

The time lapse (worst case) 4DI (LC) submodule can be influenced under the "Reversing time behavior" parameter:

Set value [0] Optimized switching times:

t_0 Time until current flow after the ON command e-Starter ET 200SP: 40 ms

Set value [1] Lifetime optimized switching [Default]:

t_0 Time until current flow after the ON command (with identical direction): 40 ms
t_0 Time until current flow after the ON command (with direction reversal): 65 ms

t_2 OFF delay after the OFF command e-Starter ET 200SP < 20 ms
t_v Interlock time starting command (time that must elapse due to an internal interlocking time until a repeat switch-on command is accepted after a switch-off command): 200 ms

Debounce times of the 4DI (LC) submodule

Electromechanical switches and pushbuttons bounce during a switching operation. To prevent the effect on the switching signals, the inputs of the 4DI (LC) submodule are debounced for 5 ms.

6.3 Hot swapping

Replacement of modules during operation

Hot swapping refers to the replacement of modules while the system is in operation.
In the event of a fault, you can replace the e-Starter ET 200SP during operation while the system is live. The station remains functional and the plant remains available. It is not necessary to switch off and restart the system for this purpose. While you are replacing the e-Starter ET 200SP, the wiring is retained. A distinction is made between multi-hot swap and single hot swap:

- Multi-hot swap: Several modules can be removed and inserted during operation.
- Single hot swap: Only one module can be removed or replaced during operation.

Below is an overview of further products that support hot swapping:
Single hot swap is supported by all head modules.
Multi-hot swap is supported by the following modules:

- IM 155-6 PN HS interface modules
- IM 155-6 PN HF interface modules
- SIMATIC ET 200SP CPU

NOTE

The IM 155-6 PN HS/HF interface modules do not support the hot swapping of server modules, interface modules, or bus adapters during operation.

6.4 Intelligent fan control

Description

The e-Starter ET 200SP has intelligent fan control.

This results in the following advantages:

- The service life of the installed fan unit is increased.
- The maintenance intervals are extended.
- A defect in the fan is detected by the device and a warning is sent via DS92. The device is still ready for operation until the intrinsic device protection (Page 102) is triggered.

6.5 Configuration in the TIA environment and integration of device description files

6.5.1 Configuring using the TIA Portal configuration software

Requirement

- PROFINET GSD file or HSP file
- One of the following combinations:
  - Firmware version V1.0 and TIA Portal from V19
  - Firmware version V1.1/V2.0 and TIA Portal V19

NOTE
Use of an HSP or PROFINET GSD file required for configuration in the TIA Portal
A corresponding HSP or PROFINET GSD file is required for configuration of the device in the TIA Portal.

Description

You configure and parameterize the ET 200SP distributed I/O system with TIA Portal (CPU/interface module, I/O modules, motor starter and server module) or the configuration software of another manufacturer (interface module, I/O modules, motor starter and server module).
"Configuration" refers to the arrangement, setting and networking of devices and modules within the device or network view. TIA Portal represents modules and module racks graphically. Just like "real" module racks, the device view allows the insertion of a defined number of modules. When you insert the modules, TIA Portal automatically assigns the addresses and the unique hardware identifier (HW ID). You can change the addresses later. The hardware identifiers cannot be changed. When the automation system is started, the CPU/interface module compares the configured preset configuration with the system's actual configuration.
"Parameterizing" the components used signifies setting their properties. When parameterizing, the hardware parameters are set and the settings for data exchange are made:

- Properties of parameterizable modules
- Settings for data exchange between components

TIA Portal compiles the hardware configuration (the result of "Configure" and "Parameterize") and loads it into the CPU. The CPU/interface module then connects to the configured components and transfers their configuration and parameters.

6.5.2 Use of GSD/PROFINET GSD and HSP files

Description

The following GSD, PROFINET GSD and HSP/MDD files can be used in connection with the ET 200SP e-Starter.

Device description files in centralized and distributed architecture in connection with TIA Portal

Architecture	PROFIBUS GSD	PROFINET GSD (GSDML)	HSP/MDD
Centralized (CPU)[1]	Not supported	Not supported	Supported
Distributed (IM)	Not supported	Supported	Supported

[1] Restrictions, see Compatibility with head modules (Page 74)

Device description files in centralized and distributed architecture in connection with STEP 7 Classic

Architecture	PROFIBUS GSD	PROFINET GSD (GSDML)
Centralized (CPU)[1]	Not supported	Not supported
Distributed (IM)	Not supported	Supported

[1] Restrictions, see Compatibility with head modules (Page 74)

Device description files in centralized and distributed architecture in connection with the ET 200SP HA system

Architecture	PROFINET GSD (GSDML)
Centralized (CPU)	Not supported
Distributed (IM)[1]	Supported

[1] Only for use of IM155-6 PN HA (6DL1155-6AU00-0PM0 V 1.2 or higher)

Downloading the PROFINET GSD files

The current PROFINET GSD files for the SIMATIC ET 200SP input/output modules -including PROFIsafe - are available for download under the entry PROFINET GSD files: I/O - ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/57138621).

The current versions of the PROFINET GSD file (GSDML) for the SIMATIC ET 200SP HA for integration into control systems are available under the entry PROFINET GSD file (GSDML) - SIMATIC ET 200SP HA (https://support.industry.siemens.com/cs/ww/en/view/109781191).

Downloading the HSP files

The current HSP files are available for download under the entry Hardware support package "e-Starter ET 200SP" (https://support.industry.siemens.com/cs/ww/en/view/109986549)

Legend

- GSD file: Device description for PROFIBUS
- PROFINET GSD file (GSDML): Device description for PROFINET
- HSP/MDD file: Siemens-specific hardware support

6.5.3 Compatibility of the PROFINET GSD file

Compatibility of the PROFINET GSD file with TIA Portal and STEP 7 Classic

The following list provides an overview of the versions under which the PROFINET GSD file of the e-Starter ET 200SP can be installed.

- TIA Portal:
  - From version V17
- STEP 7 Classic:
  - STEP 7 V5.6 SP2 (hotfix from HF2)
  - STEP 7 V5.7 (hotfix from HF4)
  - From STEP 7 V5.7 SP1

6.6 Configuration control

Description

The e-Starter ET 200SP supports configuration control.
In the non-configured state, the e-Starter ET 200SP behaves as follows:

- The PIQ/PII is not evaluated or updated.
- Data set traffic is not possible.
- Diagnostic interrupts are not generated.
- In "Automatic" mode, the motor is stopped regardless of the parameter assignment.
- Manual - local is permitted. The e-Starter ET 200SP works with the last valid parameters.

6.7 Voltage, current and power measuring errors

The measurement of the e-Starter ET 200SP results in the following measuring errors for certain input variables:

Motor current e-Starter ET 200SP 2 A

Measuring error at Ie [%]

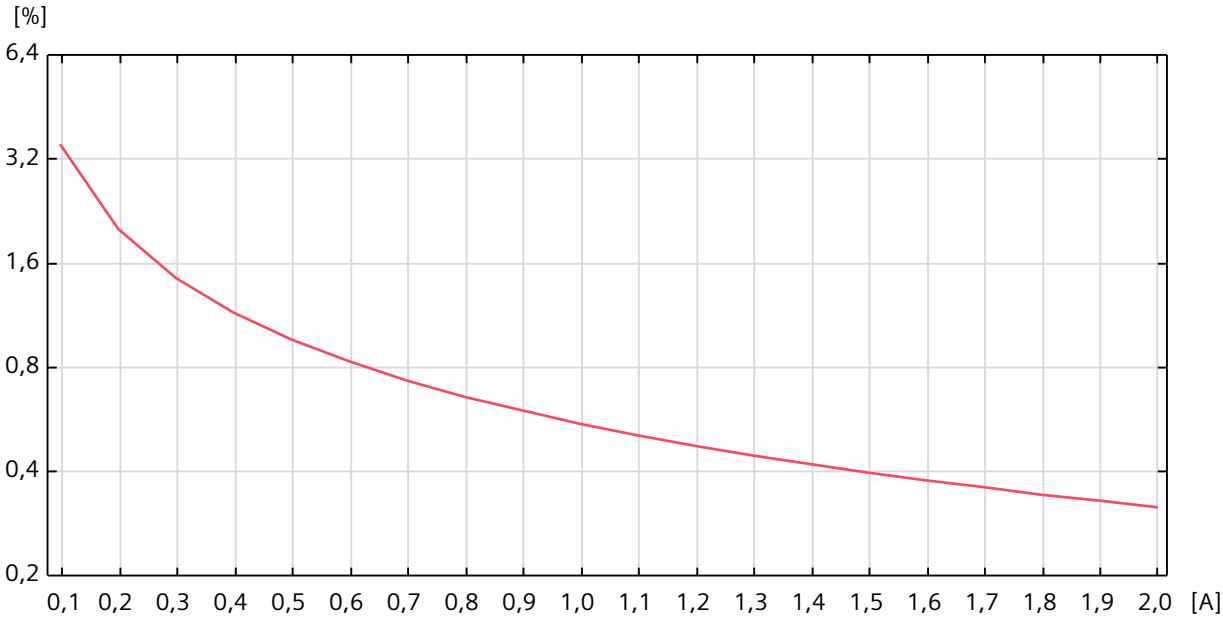

Measuring error at I_e [%]

X axis: I_{rated} [A] rms = Effective polyphase-line current [A]

Motor current e-Starter ET 200SP 7 A

Measuring error at Ie [%]

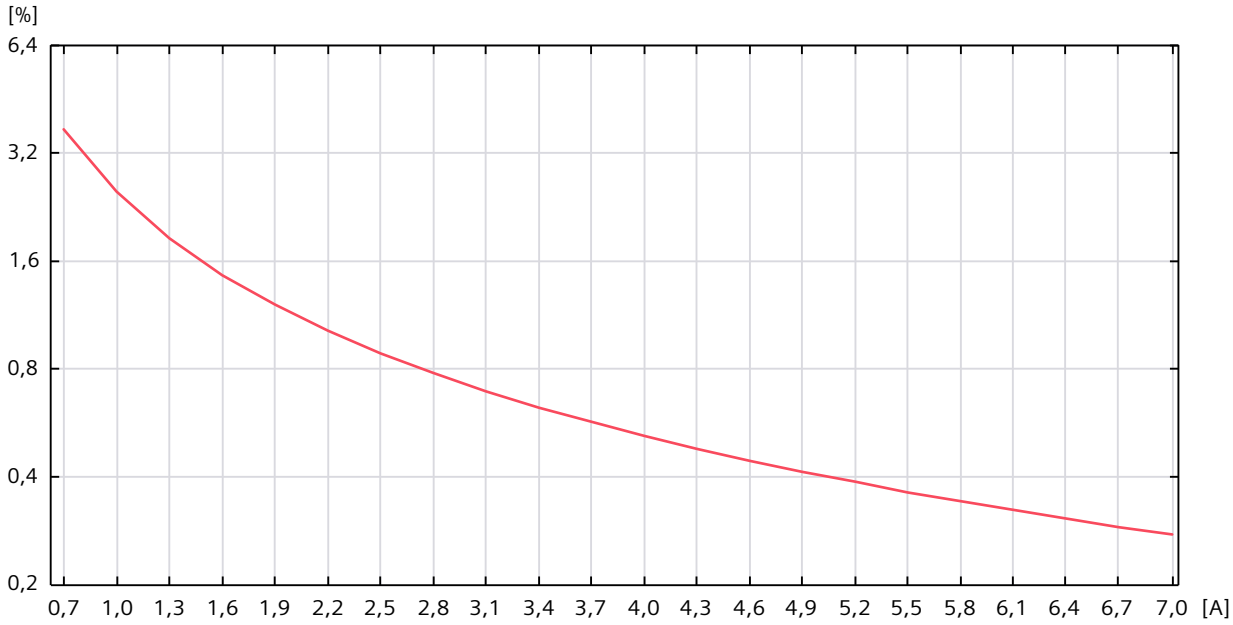

Measuring error at I_e [%]

X axis: I rated [A] rms = Effective polyphase-line current [A]

Line voltage e-Starter ET 200SP 2 A and 7 A

Measuring error voltage measurement between line conductors

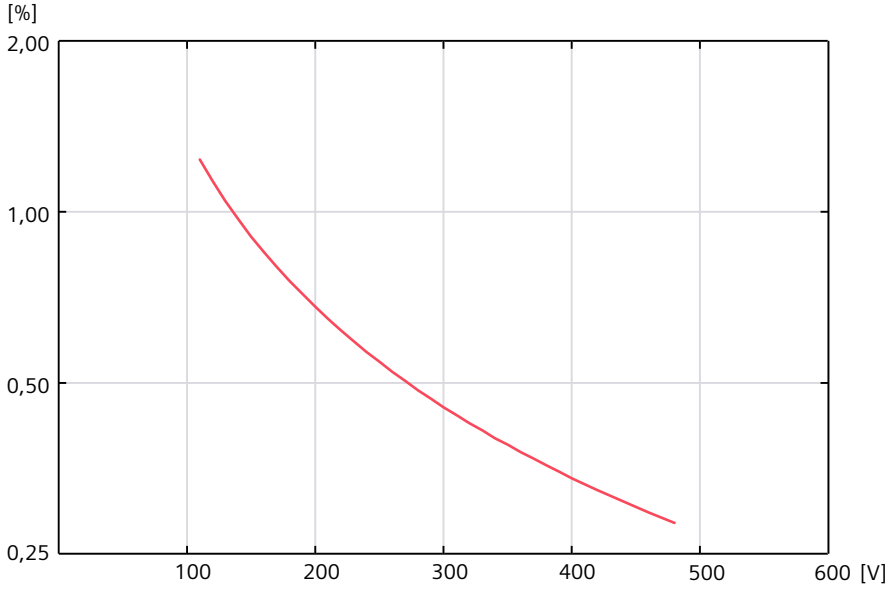

Measuring error voltage measurement between line conductors

X axis: Voltage between line conductors [V]

Power measurement e-Starter ET 200SP 2 A

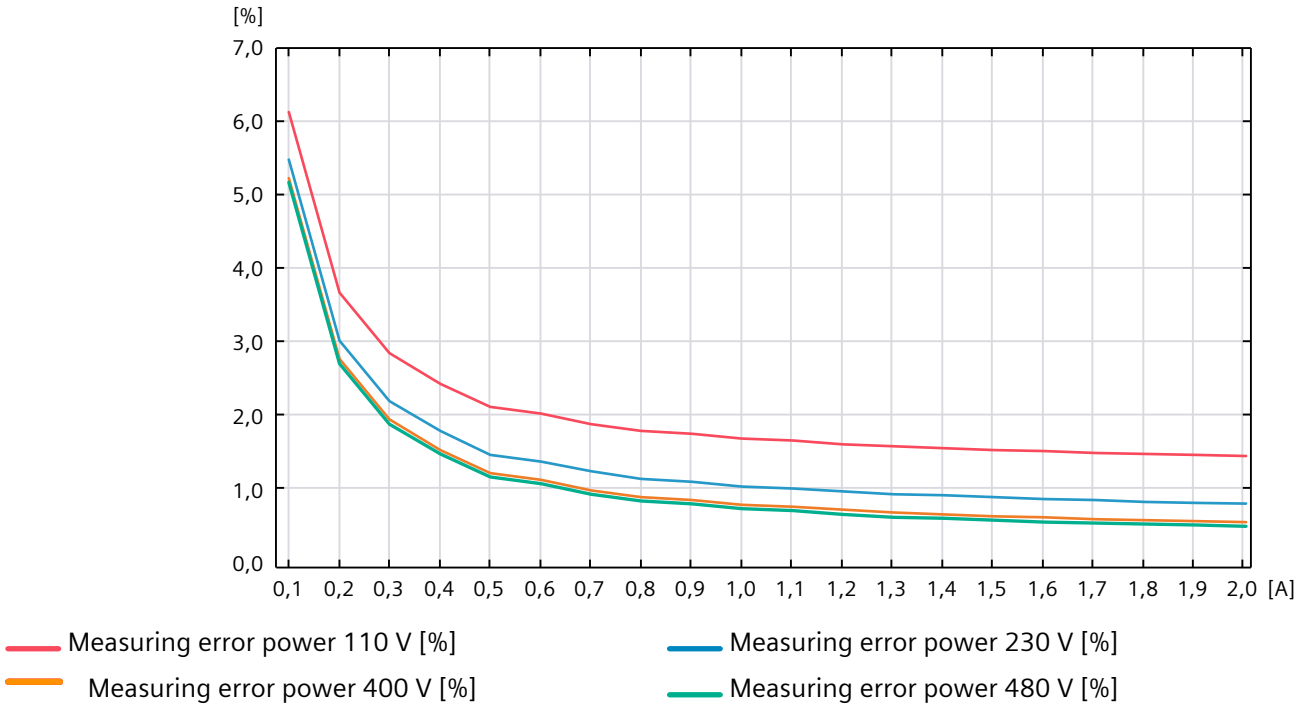

Power measurement e-Starter ET 200SP 7 A

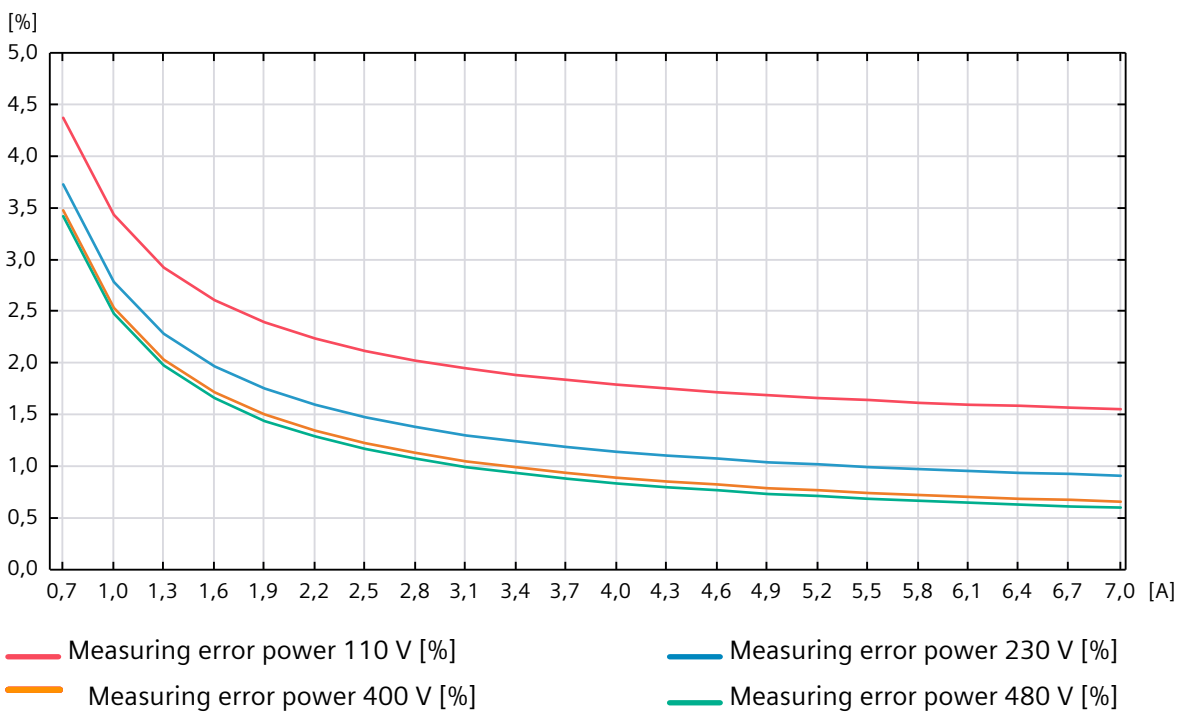

6.8 Submodules

Description

The e-Starter ET 200SP supports the division of I/O modules into up to 2 additional submodules. This allows parts of the e-Starter ET 200SP to be configured and parameterized separately.

Essential accessories

- A compatible interface module (IM) for the e-Starter ET 200SP used

NOTE
Use of compatible accessories when configuring submodules
The configuration of subslots is only partially supported by ET 200SP CPUs. Support for the third subslot is not available.

Submodules for the e-Starter ET 200SP

Up to 3 submodules can be used for the e-Starter ET 200SP:

Example for the e-Starter ET 200SP 2 A:

module	**E-STARTER 0.1 - 2A_1**
Submodule 1	E-STARTER 0.1 - 2A_1
Submodule 2	4DI BA_1
Submodule 3	I_L1, I_L2, I_L3

Submodule 1 refers to the e-Starter ET 200SP.

Submodule 2 refers to the optionally available Basic 4DI (LC) submodule.

Submodule 3 refers to the optional PI Extension submodule.

6.8.1 Configuration of a 4DI (LC) submodule

Optionally, configure a Basic 4DI (LC) submodule in submodule 2.

Chapter Compatibility of 3DI/LC module with the Basic 4DI (LC) submodule (Page 78) describes the possible reactions in the configuration of submodule 2.

6.8.2 PI extension

The PI extension describes an extension of the process image that can be freely assigned. The e-Starter ET 200SP has a virtual PI extension submodule for displaying 3 predefined measured values and for extending the address space from 4 to 16 bytes. These optionally configurable measured values are transmitted cyclically in Float32 format in the PII (process image input). This allows you to display the selected values in real time and as a real number.

Essential accessories

- A compatible interface module (IM) for the e-Starter ET 200SP used

NOTE
Use of compatible accessories in conjunction with the PI extension
The use of PI extensions is not supported by ET 200SP CPUs.

Description

You can select the following measured values as PI extension in the virtual submodule:

$I_L1_{(RMS)}$, $I_L2_{(RMS)}$, $I_L3_{(RMS)}$

$I_Lavg_{(RMS)}$, $U_Lavg_{(RMS)}$, $P_Lavg_{(RMS)}$

$U_L1\text{-}L2_{(RMS)}$, $U_L2\text{-}L3_{(RMS)}$, $U_L3\text{-}L1_{(RMS)}$

Configuring the PI extension in the TIA Portal

In the device view, drag and drop the submodule into the 3rd subslot of the e-Starter ET 200SP.

Reading out the measured values

The 3 configurable measured values can be read out cyclically via the PII or acyclically via data set 69.

DS69

Measured value 1: Byte 16 ... 19

Measured value 2: Byte 20 ... 23

Measured value 3: Byte 24 ... 27

PII

Measured value 1: Byte 4 ... 7
Measured value 2: Byte 8 ... 11
Measured value 3: Byte 12 ... 15

6.9 Compatibility

NOTE
Compatibility with PROFIBUS components
The e-Starter ET 200SP does not support compatibility with ET 200SP PROFIBUS components.

NOTE
Availability of the compatibility mode
Compatibility mode is only supported for data exchange via PROFINET.

6.9.1 Compatibility with head modules

Compatibility of the e-Starter ET 200SP with ET 200SP head modules and firmware versions

The following table provides an overview of which head modules with which firmware version are compatible with the e-Starter ET 200SP.

ET 200SP IM / CPU	At least firmware version
IM 155-6 PN ST (6ES7 155-6AU00-0BN0)	V3.1
IM 155-6 PN ST (6ES7 155-6AU01-0BN0)	
IM 155-6 PN ST (6ES7 155-6AU02-0BN0)	
IM 155-6 PN HF (6ES7 155-6AU00-0CN0)	V4.2 or higher
IM 155-6 PN/2 HF (6ES7 155-6AU01-0CN0)	
IM 155-6 PN/3 HF (6ES7 155-6AU30-0CN0)	
IM 155-6 PN R1 (6ES7 155-6AU00-0HM0)	V6.0 or higher
IM 155-6 PN HS (6ES7 155-6AU00-0DN0)	V4.0
CPU 1510SP-1 PN (6ES7 510-1DJ00-0AB0)	V1.7
CPU 1510SP-1 PN (6ES7 510-1DJ01-0AB0)	V2.8
CPU 1510SP-1 PN (6ES7 510-1DK03-0AB0)	V3.0
CPU 1512SP-1 PN (6ES7 512-1DK00-0AB0)	V1.7
CPU 1512SP-1 PN (6ES7 512-1DK01-0AB0)	V2.8
CPU 1512SP-1 PN (6ES7 512-1DM03-0AB0)	V3.0
CPU 1514SP-2 PN (6ES7 514-2DN03-0AB0)	V3.0
CPU 1510SP-1F PN (6ES7 510-1SJ00-0AB0)	V1.7
CPU 1510SP-1F PN (6ES7 510-1SJ01-0AB0)	V2.8

ET 200SP IM / CPU	At least firmware version
CPU 1510SP-1F PN (6ES7 510-1SK03-0AB00)	V3.0
CPU 1512SP-1F PN (6ES7 512-1SK00-0AB0)	V1.7
CPU 1512SP-1F PN (6ES7 512-1SK01-0AB0)	V2.8
CPU 1512SP-1F PN (6ES7 512-1SM03-0AB0)	V3.0
CPU 1514SP F-2 PN (6ES7 514-2SN03-0AB0)	V3.0
CPU 1514SP T-2 PN (6ES7 514-2VN03-0AB0)	V3.0
CPU 1514SP TF-2 PN (6ES7 514-2WN03-0AB0)	V3.0
CPU 1515SP PC (6ES7 677-2AAxx-0xB0)	V2.0
CPU 1515SP PC (6ES7 677-2DBx2-0xB0)	V20.8
CPU 1515SP PC (6ES7 677-2DBx2-0xB1)	V30.0
CPU 1515SP PC (6ES7 677-2DBx3-0xB0)	V21.9
CPU 1515SP PC (6ES7 677-2DBx3-0xB1)	V30.0
CPU 1515SP PC F (6ES7 677-2FAxx-0xB0)	V2.0
CPU 1515SP PC F (6ES7 677-2SBx2-0xB0)	V20.8
CPU 1515SP PC F (6ES7 677-2SBx2-0xB1)	V30.0
CPU 1515SP PC F (6ES7 677-2SBx3-0xB0)	V21.9
CPU 1515SP PC F (6ES7 677-2SBx3-0xB1)	V30.0
CPU 1515SP PC T (6ES7 677-2VBx2-0xB0)	V20.8
CPU 1515SP PC T (6ES7 677-2VBx2-0xB1)	V30.0
CPU 1515SP PC T (6ES7 677-2VBx3-0xB0)	V20.8
CPU 1515SP PC TF (6ES7 677-2WBx2-0xB0)	V20.8
CPU 1515SP PC TF (6ES7 677-2WBx2-0xB1)	V30.0
CPU 1515SP PC TF (6ES7 677-2WBx3-0xB0)	V20.8

Compatibility with MultiFieldbus IM

Compatibility with the following interface modules is only possible using the PROFINET GSD file:

- 6ES7155-6MU00-0CN0 V5.0 or higher
- 6ES7 155-6MU01-0CN0 V6.2 or higher

No compatibility of the ET 200SP head modules with the e-Starter ET 200SP

The following head modules are not compatible with the e-Starter ET 200SP:

- IN 155-6 PN HA (6DL1 155-6AU00-0PM0)
- IN 155-6 PN HA (6DL1 155-6AU00-0EM0)
- IM 155-6 PN BA (6ES7 155-6AR00-0AN0)
- IM 155-6 PN BA (6ES7 155-6AR01-0AN0)
- IM 155-6 DP HF (6ES7 155-6BU00-0CN0)
- IM 155-6 DP HF (6ES7 155-6BU01-0CN0)

6.9.2 Compatibility of the e-Starter ET 200SP with the ET 200SP motor starters (3RK1308)

Replacing the ET 200SP motor starter (3RK1308) with the e-Starter ET 200SP

The e-Starter ET 200SP is partially compatible with the ET 200SP motor starter (3RK1308). Partial compatibility only applies to ET 200SP standard motor starter variants. ET 200SP safety motor starter variants must not be replaced by an e-Starter ET 200SP.

If the ET 200SP motor starter (3RK1308) is replaced by the e-Starter ET 200SP without reconfiguration, the following support for the ET 200SP motor starter data sets applies:

- DS 68 PIQ (supported)
- DS 69 PII (supported)
- DS 72, 73 75 logbooks (not supported)
- DS 92 (supported)
- DS 93 (not supported)
- DS94 (supported)
- DS 95 (supported)
- DS 201 (supported)
- DS 202 (supported)
- DS 203 (read only supported)
- DS 204 (read only supported)

NOTE

Retaining the scope of functions when replacing an ET 200SP motor starter (3RK1308) with an e-Starter ET 200SP

When replacing the ET 200SP motor starter (3RK1308) with an e-Starter ET 200SP, it is recommended to adapt the configuration using a PROFINET GSD file or HSP file in order to use the full scope of functions of the e-Starter ET 200SP.

NOTE
Availability of the compatibility mode
Compatibility mode is only supported for data exchange via PROFINET.

Compatibility options for e-starter ET 200SP and ET 200SP motor starter (3RK1308)

The compatibility options shown in the following table refer exclusively to the usable current ranges of the devices.

MLFB direct motor starter (3RK1308) Short designation	MLFB reversing motor starter (3RK1308) Short designation	MLFB e-Starter Short designation	Alternative MLFB e-Starter Short designation
3RK1308-0AA00-0CP0 DS 0.1 - 0.4 A HF	3RK1308-0BA00-0CP0 RS 0.1 - 0.4 A HF	3RD1000-0BA00-0EP0 Basic, 0.1 - 2 A[1)]	–
3RK1308-0AB00-0CP0 DS 0.3 - 1 A HF	3RK1308-0BB00-0CP0 RS 0.3 - 1 A HF	3RD1000-0BA00-0EP0 Basic, 0.1 - 2 A[1)]	3RD1000-0BB00-0EP0 Basic, 0.7 - 7 A[2)]
3RK1308-0AC00-0CP0 DS 0.9 - 3 A H	3RK1308-0BC00-0CP0 RS 0.9 - 3 A HF	3RD1000-0BB00-0EP0 Basic, 0.7 - 7 A[1)]	3RD1000-0BA00-0EP0 Basic, 0.1 - 2 A[2)]
3RK1308-0AD00-0CP0 DS 2.8 - 9 A HF	3RK1308-0BD00-0CP0 RS 2.8 - 9 A HF	3RD1000-0BB00-0EP0 Basic, 0.7 - 7 A[2)]	–
3RK1308-0AE00-0CP0 DS 4.0 - 12 A HF	3RK1308-0BE00-0CP0 RS 4.0 - 12 A HF	3RD1000-0BB00-0EP0 Basic, 0.7 - 7 A[2)]	–

1) Fully compatible

2) Fully compatible (set/parameterized current value must be in the valid range of the e-Starter ET 200SP)

6.9.3 Compatibility of 3DI/LC module with the Basic 4DI (LC) submodule

The 3DI/LC module of the ET 200SP motor starter (3RK1308) is partially compatible with the Basic 4DI (LC) submodule.

Various compatibility options are shown in the following examples.

Situation 1

- The e-Starter ET 200SP is configured without Basic 4DI (LC) submodule in TIA Portal
- 3DI/LC module is inserted

Response:

- The parameterized input actions for DI1, DI2 and DI3 are accepted and are available
- No monitoring of the remove/insert functionality

NOTE

Default setting of the 3DI/LC module to "manual local" (LC)

Since the 3DI/LC module does not have a DI4 input, it is irrelevant how the DI4 input is parameterized. The LC input of the 3DI/LC module is always set to the input action "manual local". This is evaluated as a normally open contact and non-latching.

Situation 2

- The e-Starter ET 200SP is configured without Basic 4DI (LC) submodule in TIA Portal
- A Basic 4DI (LC) submodule is inserted

Response:

- The functionality is identical to the configured input actions
- No monitoring of the remove/insert functionality

Situation 3

- The e-Starter ET 200SP is configured with a Basic 4DI (LC) submodule in TIA Portal
- 3DI/LC module is inserted

Response:

- No function
- Error message "Module slot wrong or configuration faulty"

Situation 4

- The e-Starter ET 200SP is configured with a Basic 4DI (LC) submodule in TIA Portal
- A Basic 4DI (LC) submodule is inserted

Response:

- The functionality is identical to the configured input actions
- Error message "Module slot wrong or configuration faulty" when the Basic 4DI (LC) submodule is removed

Situation 5

- Motor starter is configured in compatibility mode
- An e-Starter ET 200SP is inserted

Response:

- The 3DI/LC module and Basic 4DI (LC) submodule behave according to the configuration. The DI4 or LC input is automatically set to the "manual local" input action and is evaluated as a normally open contact and non-latching.
- No monitoring of the remove/insert functionality

6.9.4 Compatibility of the e-Starter ET 200SP with the BaseUnits

Compatibility of the e-Starter ET 200SP with the BaseUnits

The following table provides an overview of which BaseUnits are compatible with the e-Starter ET200SP.

	Basic 0.1 - 2.0 A 3RD1000-0BA00-0EP0	**Basic 0.7 - 7.0 A 3RD1000-0BB00-0EP0**
BU30-MS1 - BaseUnit with 24 V DC and 500 V AC infeed 3RK1908-0AP00-0AP0	x	x
BU30-MS2 - BaseUnit with 500 V AC infeed 3RK1908-0AP00-0CP0	x	x
BU30-MS3 - BaseUnit with 24 V DC infeed 3RK1908-0AP00-0BP0	x	x
BU30-MS4 - BaseUnit without infeed 3RK1908-0AP00-0DP0	x	x
BU30-MS5 - BaseUnit with 500 V AC infeed and individual F-DI 3RK1908-0AP00-0EP0	–	–

	Basic 0.1 - 2.0 A 3RD1000-0BA00-0EP0	Basic 0.7 - 7.0 A 3RD1000-0BB00-0EP0
BU30-MS6 - BaseUnit without infeed and with individual F-DI 3RK1908-0AP00-0FP0	–	–
BU30-MS7 - BaseUnit with infeed F-DI and 500 V AC 3RK1908-0AP00-0GP0	–	–
BU30-MS8 - BaseUnit with infeed 500 V AC and forwarding F-DI 3RK1908-0AP00-0HP0	–	–
BU30-MS9 - BaseUnit with forwarding F-DI 3RK1908-0AP00-0JP0	–	–
BU30-MS10 - BaseUnit with infeed F-DI 3RK1908-0AP00-0KP0	–	–

6.10 Mixed operation of 1-phase and 3-phase loads

Description

The e-Starter ET 200SP supports switching, protecting, measuring, and monitoring 1-phase and 3-phase electrical loads. Certain requirements must be observed when setting up the infeed to ensure reliable and error-free operation.

The joint operation of 1-phase and 3-phase loads within a 500 V BaseUnit infeed group is not permitted. If one or more phases in the infeed fail, this can lead to a delay in measured signals and, as a result, to incorrect measured values, displays, and diagnoses during network detection in the e-Starter ET 200SP.

For correct operation, the 3-phase loads and the 1-phase loads are supplied with a separate BaseUnit.

Parameter setting 7

7.1 Using OB100

NOTE

SIMATIC-specific solution

The OB100 is a SIMATIC-specific solution. It is not possible to use this organization block when using a third-party controller.

Benefits

In some applications, system parts may have to be replaced due to wear, e.g. asynchronous motors. This can lead to early tripping if the rated operational current of the asynchronous motor is not identical. It is possible to make parameter changes to the device using the OB100 in the user program so that the parameterization does not have to be changed in the controller when maintenance is demanded.

NOTE

Resulting behavior when selecting the set value "Keep last value" of the parameter "Response to CPU/Master STOP"

If the set value "Keep last value" is selected for the parameter "Response to CPU/Master Stop", a running motor will not be switched off if communication fails.

It can only be switched off by restarting communication (and setting the corresponding control bits) or by disconnecting the supply voltage for the electronics (PWR) or contactor control (AUX-PWR).

NOTE

Resulting behavior when selecting the set value "Keep last value" of the parameter "Response to CPU/Master STOP"

If the set value "Keep last value" is selected for the parameter "Response to CPU/Master STOP", the motor may briefly stop during the restart of communication when the motor is running. To prevent this, the corresponding control bits must be set in the PLC in OB100.

Application

Immediately after the start-up parameterization, the new desired rated operational current, which was entered via a SIMATIC HMI, for example, is transferred to the device once using the OB100 before the user program (OB1) is started.

7.2 Parameterizing the e-Starter ET 200SP

When configuring an e-Starters ET 200SP, the full parameterization scope is set and automatically transferred to the e-Starter ET 200SP. When parameterizing in the user program, the parameters are transferred to the module via the data sets with the statement "WRREC". If the CPU initiates a new parameter assignment, e.g. if communication breaks down, the parameterization is overwritten by the system parameterization via the user program.

The modules of the ET 200SP distributed I/O system support the full parameterization scope of the e-Starter ET 200SP.

The parameters that can be set can be found in the Appendix in DS131 (Page 173), DS132 (Page 178) and DS134 (Page 179).

You will find an explanation of the load parameters in Chapter Load parameters (Page 83).

NOTE

Changing the parameters during operation

If parameters are modified during operation, they will be overwritten by the parameters configured in the hardware configuration when the control is restarted.

If this is not desired, a command must be issued to disable parameterization.

You set the parameter block in the DS93 (Page 169) Write command.

Parameterization options

- TIA Portal

7.3 Data plausibility check

Checking incoming parameters in "Automatic" mode

The e-Starter ET 200SP checks all incoming parameters for validity and plausibility, provided manual - local mode is not active. The valid parameters are stored in data set 131, 132 and 134.

In the case of incorrect parameters during startup of the station (after power ON)

- The error messages "Group error" (byte 10.6) and "Invalid parameter value" (byte 18.1) are set in the DS92.
- The object number of the invalid parameter is entered under "Faulty parameter number" (from byte 20.0) in the DS92.
- The motor remains shut down.
- An "Invalid parameter value" logbook entry (object number 365) is created in DS76.
- The error messages cannot be reset. As soon as valid parameter values are transmitted, the error messages are automatically reset.

In the case of incorrect parameters from the user program and when the motor is switched off

- The information "Invalid parameter value" (byte 91.3) is set in the DS92.
- The object number of the invalid parameter is entered under "Faulty parameter number" (from byte 20.0) in the DS92.
- The currently valid parameter values are retained.

In case of incorrect parameters and running motor

- Specific parameters are not accepted by the e-Starter ET 200SP. An overview of the parameters that can be changed during operation can be found in the Appendix (Page 159).
- The information messages "Invalid parameter value" (byte 91.3) and "Parameterization not permitted in ON state" (byte 18.2) are set in DS92.
- The object number of the invalid parameter is entered under "Faulty parameter number" (from byte 20.0) in the DS92.
- The motor is not switched off.
- The currently valid parameter values are retained.

Checking incoming parameters in "Manual - local" and "Manual - bus" modes

The incoming parameters are checked as follows in "Manual - local" and "Manual - bus" mode:

In case of parameters from the user program

- Parameters are discarded without a message.

In the case of parameters during startup of the station (after power ON)

- The e-Starter ET 200SP saves the parameters and only accepts them when the e-Starter ET 200SP has switched over to "Automatic" mode again. Only after changing to "Automatic" are the parameters checked.

7.4 Load parameters

Set the load parameters of the e-Starter ET 200SP.

Parameters	Description
Rated operational current Ie	This parameter is used to set the rated operational current that the feeder can carry without interruption. The rated operational current of the load can be found, for example, on the nameplate of a motor. The adjustment range depends on the performance class of the e-Starter ET 200SP.

1) The "resistive load" setting corresponds to heating loads/IR radiators. Using the "resistive load" setting expands the rated operational current range.

Parameters	Description
Load configuration	Use this parameter to set whether the e-Starter ET 200SP should protect a 1-phase or 3-phase load. • **3-phase** • 1-phase
Load type	This parameter is used to set the current load. • **Motor** • Resistive load [1)]
Maintenance timer warning limit	This parameter is used to set the warning limit for the maintenance timer. The maintenance timer is used to set a time interval after which a motor is to be serviced. • Factory setting: 94608000 • Setting range: 0 ... 4294967295 s • In steps of 1 s

1) The "resistive load" setting corresponds to heating loads/IR radiators. Using the "resistive load" setting expands the rated operational current range.

7.5 Parameter dependencies

There are dependencies between some parameters, depending on the set value. If these parameter dependencies are not taken into account, error messages can occur (see Data plausibility check (Page 82)).
The individual dependencies are always checked by the device. For configuration via the HSP/MDD, this is checked when the hardware configuration is loaded. For configuration with a PROFINET GSD file, the check is only made on the device.

Load configuration (DS131, byte 16.0)

Set parameter "Emergency run" (DS132, byte 76.0) to 0 = disable if you have selected the set value 1 = 1-phase for the "Load configuration" parameter.

Load type (DS131, byte 16.4)

Set parameter "Emergency run" (DS132, byte 76.0) to 0 = disable if you have selected the set value 2 = Resistive load for the "Load configuration" parameter. Selecting the set value 2 = Resistive load results in enlargement of the rated operational current range.

Input 1-4 Action (DS131, from byte 76.0)

Depending on the selected set value of parameter "Input 1-4 Action", the following settings should be made.

- 1 = Trip without restart:
  Set the associated parameter "Input 1-4 Signal" (DS 131, from byte 74.0) to the set value 0 = Non-latching.
- 2 = Trip with restart:
  Set the associated parameter "Input 1-4 Signal" (DS 131, from byte 74.0) to the set value 0 = Non-latching.

- 3 = Trip end position CW Rotation:
  Set the associated parameter "Input 1-4 Signal" (DS 131, from byte 74.0) to the set value 0 = Non-latching.
- 4 = Trip end position CCW Rotation:
  Set the associated parameter "Input 1-4 Signal" (DS 131, from byte 74.0) to the set value 0 = Non-latching.
- 6 = Operating mode manual - local:
  Set the associated parameter "Input 1-4 Signal" (DS 131, from byte 74.0) to the set value 0 = Non-latching.
- 7 = Emergency start:
  Set the associated parameter "Input 1-4 Signal" (DS 131, from byte 74.0) to the set value 0 = Non-latching. Also set the associated parameter "Input 1-4 Level" (DS 131, from byte 74.0) to the set value 1 = NO contact.
- 8 = Motor CW:
  Set the associated parameter "Input 1-4 Level" (DS 131, from byte 38.4) to the set value 1 = NO contact.
  Also, if you have set the associated parameter "Input 1-4 Signal" (DS 131, from byte 74.0) to the set value 1 = Latching, ensure that at least one of the other "Input 1-4 Action" parameters has one of the following set values: 1, 2, 3, 4, 11, 14, 37, 38.
- 9 = Motor CCW:
  Set the associated parameter "Input 1-4 Level" (DS 131, from byte 38.4) to the set value 1 = NO contact.
  Also, if you have set the associated parameter "Input 1-4 Signal" (DS 131, from byte 74.0) to the set value 1 = Latching, ensure that at least one of the other "Input 1-4 Action" parameters has one of the following set values: 1, 2, 3, 4, 11, 14, 37, 38.
- 12 = Reset:
  Set the associated parameter "Input 1-4 Signal" (DS 131, from byte 74.0) to the set value 0 = Non-latching. Also set the associated parameter "Input 1-4 - level" (DS 131, from byte 38.4) to the set value 1 = NO contact.
- 13 = Cold running:
  Set the associated parameter "Input 1-4 Signal" (DS 131, from byte 74.0) to the set value 0 = Non-latching. Also set the associated parameter "Input 1-4 - level" (DS 131, from byte 38.4) to the set value 1 = NO contact.
- 37 = Operational trip end position CW:
  Set the associated parameter "Input 1-4 Signal" (DS 131, from byte 74.0) to the set value 0 = Non-latching.
- 38 = Operational trip end position CCW:
  Set the associated parameter "Input 1-4 Signal" (DS 131, from byte 74.0) to the set value 0 = Non-latching.

Current upper limit error (DS132, from byte 172.0)

Set parameter "Current upper limit - maintenance demanded" (DS 132, byte 174.0) to a lower value than parameter "Current upper limit
error" (DS132, byte 172.0).

Current lower limit error (DS132, from byte 178.0)

Set parameter "Current lower limit - maintenance demanded" (DS 132, byte 179.0) to a higher value than parameter "Current lower limit
error" (DS132, byte 178.0).

Use and operation 8

8.1 Machine and control cabinet tests with e-Starters ET 200SP

Due to the combination of electromechanical and electronic switching elements, specifications must be observed for some tests in order to prevent damage to the devices.

In the following table you will find our recommendations for the tests and the corresponding handling of the e-Starter ET 200SP.

Benefits

The tests must be carried out for the following reasons:

- To ensure the proper functioning and the electrical safety of electrical equipment, particularly at the interfaces between components and assemblies.
- Errors and faults during assembly, wiring and inadmissible combinations of components are to be avoided.

Standards

The tests and verifications described are based on the following standards:

- IEC 60204-1 – Electrical Equipment of Machines Part 1 – General Requirements

  Each of the verification procedures described in IEC 60204-1 is a routine test which shall be carried out on each individual machine and its electrical equipment. IEC 60204-1 does not discuss type tests.
- IEC 61439-1 – Low-Voltage Switchgear and Controlgear Assemblies – Part 1 General Rules

Requirements in the standards

Some tests in the standards are mandatory, others are voluntary. In other words, it is left to the discretion of the manufacturer to consider the possible risks and, within the framework of the risk evaluation, to conduct voluntary tests in addition to the mandatory tests for a specific application.

Requirements of IEC 60204-1	Explanation	Obligation	Relevance when using e-Starters ET 200SP	Special measures for e-Starter ET 200SP
Visual inspection	–	Yes	Yes	No special measures are necessary.
Verification of conditions for protection by automatic disconnection of supply	Verification of the continuity of the protective conductor current circuit	Yes	Yes	No special measures are necessary.

Requirements of IEC 60204-1	Explanation	Obligation	Relevance when using e-Starters ET 200SP	Special measures for e-Starter ET 200SP
	Fault loop impedance verification and suitability of the associated overcurrent protective device	Yes	Yes	To avoid damaging the e-Starter ET 200SP, remove it from the circuit before testing. To carry out a measurement, bridge the input and output sides of the BaseUnit. Calculation: The contribution to impedance by the e-Starter ET 200SP can be regarded as negligible.
	Determination of the switch-off time by adjustment (according to standard < 5 s)	Yes	No, as the e-Starter ET 200SP is not in the circuit due to the fault loop impedance check (see line above).	No special measures are necessary.
Insulation resistance test	–	Optional	No	No special measures are necessary.
Voltage test	–	Optional	Conditionally relevant	To avoid damaging the e-Starter ET 200SP, remove it from the circuit before testing. The e-Starter ET 200SP itself is already tested in the factory against high voltages in accordance with the product standard and can therefore be removed from the current circuit prior to installation.
Protection against residual voltages	–	Optional	No	No special measures are necessary.
Function tests	–	Optional	No	No special measures are necessary.
Retesting	–	Optional	No	No special measures are necessary.

Requirements of DIN EN 61439-1	Explanation	Obligation	Relevance when using e-Starters ET 200SP	Special measures for e-Starter ET 200SP
Power-frequency voltage testing for main circuits	–	Yes	Not applicable	To avoid damaging the e-Starter ET 200SP, remove it from the circuit before testing.

8.2 Floating state of the e-Starter ET 200SP when switched off

Description

When switched off and no ON command is present, the motor feeder (terminals T1 - T3) of the e-Starter ET 200SP is in a floating state. This means that there is no electrical connection to the main voltage. The motor output remains deactivated until a valid ON command is received and processed. This function serves to protect connected loads and increases the operational safety of the system. The floating state supports the implementation of electrical engineering safety rules in particular. However, this is not "disconnection" in the sense of the 5 safety rules. To ensure safe disconnection of the load, it is also necessary to place the e-Starter ET 200SP in the park position.

8.3 User test

Benefits

You can use the user test (self-test) to check the proper functioning of the e-Starter ET 200SP: LEDs, fan and electronic motor overload protection.

Requirement

- The e-Starter ET 200SP is in a fault-free condition.
- Carry out the test with the load switched off.

Operating principle

You activate the user test by pressing the TEST/RESET button or by setting bit 12.5 in DS68 (PIQ). Depending on how long the TEST/RESET button is held pressed or the bit is set, the following tests are performed in the specified sequence. If you press the TEST/RESET button for longer than 5 seconds, all tests are carried out. If you press and hold the TEST/RESET button for just 3 seconds, the first two tests are carried out.

Time of pressing the TEST/RESET button	Test step	Explanation
0.15 s ... 2 s	LED/fan test	All device LEDs and the built-in fan are switched on for 2 seconds.
2 s ... 5 s	Hardware test	• Internal check of the hardware. • A device error is output in the event of a hardware error.
> 5 s	Overload tripping	An internal trip command is issued. Message: "Motor overload protection - switch-off" Subsequent acknowledgment is necessary.

If the user test is aborted, the respective step is carried out to the end.

Display sequence of the LEDs

–	0 - 2 s	2 - 5 s	> 5 s
GRID			–
OL		–	
SC		–	–
Safety		–	–
PWR		–	–
Load CW			–
Load CCW			–

The display sequence begins with an LED test of the display of the device LEDs involved.

The user test is then indicated by the "red flickering (8Hz)" of the grid and load LEDs until it is completed.

The required overload release (without cooling time) is then carried out and indicated by the "OL" overload device LED flashing red.

Functions

9

9.1 Function overview e-Starter ET 200SP

The following table shows the functions of the e-Starter ET 200SP:

Function	Function class
	Basic
Measuring	
Motor current I(rms)	x
Line voltage U(rms)	x
Line frequency	x
Operation temperature	x
Active power measurement	x
Short-circuit measured values	x
Monitoring	
Motor current monitoring	x
Blocking current monitoring	x
Current asymmetry monitoring	x
Ground fault monitoring	x
Main energy monitoring[1)]	x
Electronics voltage monitoring	x
Communication connection	x
Load missing monitoring	x
Protecting	
Electronic motor overload protection	x
Electronic short-circuit protection	x
Intrinsic device protection	x
Perform diagnostics	
Process image input DS 69 (Page 162)	x
Diagnosis DS 92 (Page 166)	x
Measured values DS 94 (Page 170)	x
Maximum pointer DS 96 (Page 172)	x
Statistics DS 95 (Page 171)	x
Logbooks DS 70-79 (Page 163)	x
Control	
Priority of control sources	

1) Set value available from firmware version V1.1

Function	Function class
	Basic
Process image output DS 68 (Page 161)	x
Commands DS3 / DS93 (Page 169)	x
Reversing	x
Emergency mode • Emergency start • Emergency run[1)]	x
Starting mode (direct, Smart Start, etc.)	x
DI actions (Page 111)	x
Configuration	
Parameter DS131, 132, ... (Page 173)	x
Identification (Page 181)	x
Device identification I&M 0	x
Reference designation I&M 1	x
Installation date I&M 2	x
Commentary I&M 3	x
Maintenance	
Maintenance function	x
System/general	
Firmware update (Page 128)	x
Device error (Page 144)	x
TEST/RESET button (Page 139)	x
LEDs (Page 135)	x
Factory setting	x
PROFINET GSD file (GSDML)	x
HSP file	x
Compatibility ET 200SP motor starter (3RK1308) (Page 74)	x
Functions for resistive loads (Page 121)[1)]	x

1) Set value available from firmware version V1.1

9.2 Function overview Basic 4DI (LC) submodule

The following functions are available via the inputs when the Basic 4DI (LC) submodule is used:

Function	Basic 4DI (LC) submodule
Inputs (Page 111)	x
Manual - local (local control) (Page 114)	x
Switch off without restart (Page 114)	x
Switch off with restart (Page 115)	x

Function	Basic 4DI (LC) submodule
Switch off emergency end position - motor CW (Page 115)	x
Switch off emergency end position - motor CCW (Page 115)	x
Group warning (Page 116)	x
Emergency start (Page 116)	x
Motor CW (Page 117)	x
Motor CCW (Page 117)	x
Quick Stop direction-independent (Page 118)	x
Quick Stop clockwise (Page 118)	x
Quick Stop counter-clockwise (Page 118)	x
Trip RESET (Page 119)	x
Cold running (Page 119)	x
Operational trip end position CW (Page 119)	x
Operational trip end position CCW (Page 120)	x

9.3 Measuring

Overall, measurement functions allow you to better monitor, diagnose and maintain your load, which can result in improved performance, reliability and efficiency of your systems.

The measured values and maximum pointer values of the measuring functions can be viewed via data sets 94, 95 and 96.

9.4 Monitoring

Monitoring functions enable the user to monitor the operating state of the e-Starter ET 200SP in order to detect potential problems at an early stage. This helps to prevent accidents and failures and to ensure the safety of personnel and plants.

Overall, monitoring functions allow you to proactively and effectively manage your switchgear, resulting in improved operational safety, efficiency and reliability.

9.4.1 Motor current monitoring

Method of operation

The current flow is influenced by the loading status of the motor.

- If the motor current is increased, this indicates bearing damage, for example.
- If a very low motor current is flowing, this can indicate a broken conveyor belt or a motor in no-load operation.
- If a very high motor current is flowing, this can indicate a blocked system and an overloaded motor.

The current monitoring is deactivated automatically during starting and stopping. The rated operational current I_e acts as a reference value for the current limit monitoring function.

Parameters

Parameters	Description
Current upper limit error	If the current exceeds this limit relative to the rated operational current I_e, an error is generated and the e-Starter ET 200SP behaves as set in the parameter "Response to current upper error limit violation". The setting "0" deactivates the monitoring of the limit value. • Factory setting: 0 • Setting range: 50 ... 400 of I_e • In steps of: 1%
Current upper limit - maintenance demanded	If the current exceeds this limit relative to the rated operational current I_e, a warning is generated. The setting "0" deactivates the monitoring of the limit value. The warning is reset if the value falls below the limit value. • Factory setting: 0 • Setting range: 50 ... 400 of I_e • In steps of: 1%
Response to current upper error limit violation	**Do not turn off** (factory setting) The motor is not switched off if the "Current upper limit error" is exceeded.
	Turn off If the "Current upper limit error" is exceeded, the motor is switched off.
Current lower limit error	If the current falls below this limit relative to the rated operational current I_e, an error is generated and the e-Starter ET 200SP behaves as set in the parameter "Response to current lower error limit violation". The setting "0" deactivates the monitoring of the limit value. • Factory setting: 0 • Setting range: 19 ... 100 of I_e • In steps of: 1%
Current lower limit - maintenance demanded	If the current falls below this limit relative to the rated operational current I_e, a warning is generated. The setting "0" deactivates the monitoring of the limit value. If the limit value is exceeded, the warning is reset. • Factory setting: 0 • Setting range: 19 ... 100 of I_e • In steps of: 1%
Response to current lower error limit violation	**Do not turn off** (factory setting) The motor is not switched off if the value falls below "Current lower limit error".
	Turn off The motor is switched off if the value falls below the "Current lower limit error".

9.4.2 Blocking current monitoring

Method of operation

Blocking current monitoring is used for disconnection of the motor when the motor current overshoots an adjustable limit value. The rated operational current I_e acts as a reference value. Based on this reference value, a percentage value can be set with the "Blocking current" parameter, which results in the limit value. You can also set a time delay with the "Blocking time" parameter. The motor is only switched off by the e-Starter ET 200SP after the set time has elapsed if the limit value is still being exceeded.

If the currents are too high, the intrinsic device protection may switch off before blocking protection is activated.

Parameters

Parameters	Description
Blocking current	Use this parameter to parameterize a limit value. If the motor current exceeds the limit value relative to the rated operational current I_e, the monitoring system responds and the e-Starter ET 200SP switches off after the time set in the "Blocking time" parameter has elapsed. • Factory setting: 16 • Setting range: 3 ... 30 of I_e • In steps of: 50%
Blocking time	You use this parameter to set the delay time. If the limit value continues to be exceeded, the e-Starter ET 200SP switches off after the time has elapsed. • Factory setting: 2 • Setting range: 2 ... 10 • In steps of: 0.5 s

9.4.3 Current asymmetry monitoring

Method of operation

In certain phases of the motor, an asymmetrical current consumption can cause a reduction in power or damage to the motor. Possible causes for this are a different line or phase voltage or an already damaged motor winding. The current asymmetry monitoring monitors the 3 phase currents and issues a warning or switches the motor off when parameterizable limits are reached. The current asymmetry can be displayed via the measured value "Phase unbalance (Page 170)"

Parameters

Parameters	Description
Asymmetry limit warning	If the phase unbalance in relation to the rated operational current I_e exceeds this limit, a warning is generated and the motor continues to run. The setting "0%" deactivates the limit value. • Factory setting: 0 • Limit: 10 ... 60 of I_e • In steps of: 5%
Asymmetry limit error	If the phase unbalance in relation to the rated operational current I_e exceeds this limit, an error is generated and the motor is shut off. The setting "0%" deactivates the limit value. • Factory setting: 30 • Limit: 10 ... 60 of I_e • In steps of: 5%
Response to asymmetry-error limit violation	**Turn off** (factory setting) On exceeding "Asymmetry limit error", the motor is turned off.

9.4.4 Ground fault monitoring

Method of operation

The ground fault monitoring function of the e-Starter ET 200SP detects and monitors all 3-phase currents. By evaluating the total current of the 3 current values, the motor feeder can be monitored for a possible fault current or ground fault.
Ground fault monitoring refers to measuring errors in current measurement.

Parameters

Parameters	Description
Ground fault limit warning	If the ground fault current in relation to the rated operational current I_e exceeds this limit, a warning is generated and the motor continues to run. The setting "0%" deactivates the monitoring of the limit value. • Factory setting: 0 • Limit: 10 ... 95 of I_e • In steps of: 5%
Ground fault limit error	If the ground fault current in relation to the rated operational current I_e exceeds this limit, an error is generated and the motor is shut off. The setting "0%" deactivates the monitoring of the limit value. • Factory setting: 20 • Limit: 10 ... 95 of I_e • In steps of: 5%
Response to ground fault-error limit violation	**Turn off** (factory setting) If the "Ground fault limit error" is exceeded, the motor is switched off.

9.4.5 Main energy monitoring

Requirement

- A device of product version E01 with firmware V1.1 or higher

Method of operation

The main energy is monitored to ensure stable operation of the e-Starter ET 200SP. A distinction is made as to whether an error is present during the starting command or occurs during operation. When a start command is set, the e-Starter ET 200SP checks the voltage within the valid limits. The valid range is between 208 V and 480 V.
If a starting command is set and no main energy is present, no internal start command is issued. Similarly, no starting command is issued if the voltage is too high at start-up.
If the voltage is present within the first second after the start command, the load starts. If, on the other hand, there is no voltage 1 second after the starting command, the error "Main circuit power failure" is reported. If a voltage dip below the minimum value occurs during operation for more than 100 ms, the e-Starter ET 200SP stops but does not report an error. If a main voltage is detected within 5 seconds after falling below the minimum value, the load starts again. If this is not the case, the error "Main circuit power failure" is reported.

The main power monitoring display is parameterizable via the "GRID LED behavior" parameter in data set 131, byte 32.0 (obj. no. 2369). This display option makes it possible to read the diagnostic messages and also to check the availability of the main energy directly on site at the e-Starter ET 200SP via the GRID LED (Page 137).
The display takes into account the voltage, frequency, and direction of rotation of the connected supply. However, it is not possible to evaluate the absence of voltage in accordance with the standard using the GRID LED.

Special feature for 1-phase loads

If the neutral conductor (N) is interrupted in a single-phase supply, the GRID LED indicates the "off" state, even though L1 may still be live.

Special feature for 3-phase loads

If voltage is only present on one phase while the other two are de-energized, the device lacks a complete reference point for evaluating the supply. In this case, the GRID LED remains off even though voltage is still present on one phase.

Parameters

Parameters	Description
Behavior of the GRID LED	This device parameter allows you to determine how the e-Starter ET 200SP display should behave when main energy is available: • **Deactivated** (factory setting) • **Activated** The GRID LED can assume 2 additional states. – Green - lit: Main energy available and within all limits and main power rotation is correct – Green - flashing: Main energy available, but not within all limits, or main power rotation faulty (limits: 208 - 480 V)

Diagnostic messages

For a detailed assessment of the grid quality, the e-Starter ET 200SP provides diagnostics bits in the DS92, which can be read out independently of the set value of the "GRID LED behavior" parameter:

Bit	Meaning	3-phase load	1-phase load
75.1	Main energy available	Line voltage (L1 or L2 or L3) > 40 V	Line voltage (L1 against L2 (N))> 40 V
75.2	Main energy available and ok	Line voltage L1, L2 and L3 within range (208 V - 480 V), main power rotation and frequency ok	Line voltage L1 within range (208 V - 480 V)
75.4	Main energy available and not ok	Overvoltage/undervoltage, frequency outside tolerance, main power rotation not ok	Overvoltage/undervoltage, frequency outside tolerance, main power rotation not ok

9.4.6 Electronics voltage monitoring

Description

Electronics voltage monitoring is used to detect irregularities in the electronics supply. The electronics supply voltage supplies the electronics and sensors of the e-Starter ET 200SP with voltage. This voltage ensures an existing connection to the e-Starter ET 200SP through bus or local operation, e.g. in the event of an EMERGENCY STOP. With electronics voltage monitoring, the measured value of the electronics supply voltage is monitored for overvoltage, undervoltage, and voltage failure. If the voltage value is in an impermissible range, the device reports the present group error.
Value range: 20.4 - 28.8 V

9.4.7 Communication connection

Method of operation

The e-Starter ET 200SP continuously monitors the connection to the higher-level controller.

Parameters

Parameters	Description
Response to CPU/Master Stop	This parameter determines how the e-Starter ET 200SP behaves in the event of a bus connection failure or a CPU/master stop when the e-Starter ET 200SP is in "Automatic" mode.
	Switch substitute value (factory setting) The process image output is automatically changed by the e-Starter ET 200SP to the values specified in the "Substitute value" parameter.
	Keep last value If the connection is interrupted, the process image output is not changed and the current control signals are retained.
Substitute value	If the bus connection fails or in case of a CPU/master stop, the e-Starter ET 200SP can be controlled by a substitute process image output (e.g. Motor CW, Motor CCW).

9.4.8 Load missing monitoring

Method of operation

If the e-Starter ET 200SP receives an ON command but no current flow is detected, the e-Starter ET 200SP reports "No load" (DS 92, byte 25.0).
This message indicates that no electrical load was detected despite an active switching command. Monitoring is based on the measured current value, with current-free conditions being interpreted as errors. For the current ranges of the e-Starter ET 200SP 0.1 - 2.0 A, a detection limit of 0.01 A applies, while for the e-Starter ET 200SP 0.7 - 7.0 A, a detection limit of 0.07 A applies.
This enables precise detection of deviations in the current flow in order to indicate possible load interruptions at an early stage.

9.5 Protecting

The protection functions of the e-Starter ET 200SP include electronic overload protection, short-circuit protection and intrinsic device protection.
These functions are designed to protect your application and the device in the best possible way.

9.5.1 Electronic motor overload protection

Method of operation

The electronic motor overload protection calculates the approximate temperature rise state of the motor from the measured motor currents, the set rated motor current, and the device parameter "Trip class". This indicates whether the motor is overloaded or is functioning in the normal operating range. To do this, set the load parameters of your motor.

The current motor temperature rise can be displayed via the measured value "Motor temperature rise (Page 170)".

Parameters

WARNING

Automatic restart following fault acknowledgment/restart.
Can cause death or serious injury.

The e-Starter ET 200SP immediately continues to operate with the values specified by the control following fault acknowledgment/restart. Outputs are activated when the ON condition is met.

Take appropriate measures to prevent unintentional restarting and to ensure a defined start of the system.

Parameters	Description
Trip class	Deactivates the electronic motor overload protection. You will find more information below the table. • **CLASS OFF**
	The tripping times correspond to the trip class. You will find more information below the table. • **CLASS 10A** • **CLASS 10E** (factory setting) • **CLASS 20E**
Remaining time for tripping warning limit	The e-Starter ET 200SP can generate a warning before an imminent motor overload shutdown. The parameter "Remaining time for tripping" defines the time between the warning and imminent motor overload shutdown. The instant of the imminent motor overload shutdown is calculated on the assumption that the current operating conditions will continue. The setting "0" deactivates the function. • Factory setting: 0 • Setting range: 0 ... 500 • In steps of: 1 s The time until motor overload protection is tripped can be displayed via the measured value "Remaining time for motor overload protection (Page 170)".
Motor heating warning limit	You use this parameter to preset a motor temperature rise value in percent as a warning limit. The setting "0" deactivates the function. • Factory setting: 0 • Setting range: 0 ... 99 • In steps of: 1%

Parameters	Description
Response to overload thermal motor model	You use this device parameter to determine how the e-Starter ET 200SP should behave in the event of a motor overload: • **Turn off without restart** (factory setting) On the occurrence of the motor overload, an error is generated and the motor is tripped. When the parameterized recovery time (cooling time) has elapsed, the error and the trip can be acknowledged with the "Reset" function. • **Turn off with restart** On the occurrence of the motor overload, an error is generated and the motor is tripped. When the parameterized recovery time (cooling time) has elapsed, the error and the motor trip are automatically canceled.
Recovery time	Minimum cooling down time for the motor after a motor overload trip. Reset signals present during the recovery time have no effect. • Factory setting: 90 s • Setting range: 60 ... 1 800 s • In steps of: 30 s The remaining recovery time following a motor overload shutdown can be displayed via the measured value "Remaining motor cooling time".
Non-volatile tripping status	If the non-volatile tripping status is activated, the current tripping status of the electronic motor overload protection (thermal memory) is stored in the e-Starter ET 200SP. The current recovery time is only counted down after a motor overload shutdown if a supply voltage (control supply voltage) is applied at the e-Starter ET 200SP. If the supply voltage is switched off in this period, counting down the recovery time is interrupted until the supply voltage is applied again. • **Yes** (factory setting) • No

Trip class

The trip class (CLASS) specifies the maximum time within which a protective device must trip from a cold state at 7.2 times the rated operational current I_e (motor protection to IEC 60947). The trip class defines the starting time at a particular current before the trip occurs. Depending on the startup behavior of the application, different tripping characteristics can be set. The higher the class, the longer the permitted starting time.

The difference between classes 10A and 10E relates to the tripping times for motor protection trips:

- Class 10A: Motor protection tripping must not occur before 2 seconds have elapsed and must also occur after 10 seconds at the latest.
- Class 10E: Motor protection tripping must not occur before 5 seconds have elapsed and must also occur after 10 seconds at the latest. The tolerance band is narrower, which makes tripping operations more precise.
- Class 20E: Motor protection tripping must not occur before 10 seconds have elapsed and must also occur after 20 seconds at the latest.

These differences are important to optimize the protection and efficiency of motors in various applications.

9.5.2 Electronic short-circuit protection

Method of operation

The e-Starter ET 200SP has integrated electronic short-circuit protection that triggers in the event of a short-circuit. After a short-circuit trip, the e-Starter ET 200SP is ready for use again by eliminating the short-circuit and error acknowledgment with trip reset.

The following figure shows the short-circuit trip of a 7 A e-Starter ET 200SP when the short-circuit threshold value of 115 A is exceeded:

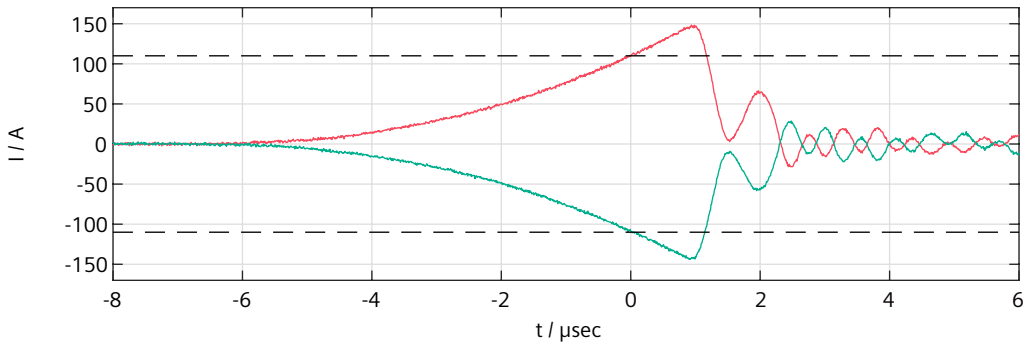

For an e-Starter ET 200SP of the 2 A variant, the short-circuit threshold value is 33.9 A.

The short-circuit threshold is permanently set and cannot be changed. If a short-circuit is detected, all 3 phases are switched off. In addition, short-circuit detection is only available on the load side and with an existing ON command. No short-circuit detection is available when the motor is switched off. The short-circuit cannot be overridden with the emergency mode function.

9.5.3 Intrinsic device protection

Method of operation

The e-Starter ET 200SP has an integrated intrinsic device protection, which protects the device against impermissible overload.

In order to protect the device, the startup and maximum operational currents of the motor are limited and the temperature monitored if current measurement is available.

The current switching element heating can be displayed via the measured value "Switching element heating (Page 170)"

Acknowledgment after cooling time has elapsed

If the e-Starter ET 200SP is switched off via an intrinsic device protection tripping operation, the action cannot be acknowledged using the "Reset" function until the cooling time of the switching element has expired. The remaining cooling time can be displayed via the measured value "Remaining switching element cooling time".
The behavior of the e-Starter ET 200SP depends on the set parameter "Response to overload switching element".

Parameter

Parameter	Description
Response to overload switching element	You use this device parameter to specify how the e-Starter ET 200SP is to respond to overload: • **Turn off without restart** (factory setting) On the occurrence of the overload, an error is generated and the motor is tripped. When the parameterized recovery time (cooling time) has elapsed, the error and the trip can be acknowledged with the "Reset" function. • **Turn off with restart** On the occurrence of the overload, an error is generated and the motor is tripped. When the parameterized recovery time (cooling time) has elapsed, the error and the motor trip are automatically canceled.

9.6 Control

9.6.1 Priority of control sources

Description

During normal operation of the e-Starter ET 200SP with multiple control sources, the following priority sequence applies – from low to high:

1. **Automatic mode (lowest priority) via, for example, an automation system (CPU), PRONETA, etc.**
   Automatic mode takes over the controller unless other control sources actively intervene. In automatic mode, it is possible to allow the input actions "Motor CW" and "Motor CCW" via the Basic 4DI (LC) submodule by setting the "Input controls" bit DQ 3.0 in the process image of the controller. If this bit is set, the control commands "Motor CW" and "Motor CCW" from the PIQ of the controller have no effect.
2. **Master control functions (medium priority) via "Manual bus – PC controls" via TIA Portal**
   The master control functions take precedence over automatic mode and can override it. If the master control function connection is interrupted, the motor is switched off after 5 seconds and the warning "Manual operation connection abort" (DS92, byte 17.6) is displayed. The control source can only be changed by restoring the master control function or switching to manual local mode.
3. **Input control (highest priority) via "manual local" using the Basic 4DI (LC) submodule**
   Control commands via the digital inputs on the Basic 4DI (LC) submodule have the highest priority.
   Manual local mode is activated via the "Local Control" input action of the Basic 4DI (LC) submodule.
   If the Basic 4DI (LC) submodule is removed, the control source reverts to automatic mode after 1 second.

Manual switching to a lower priority operating mode is only possible if the motor is not switched on ("Motor On" PII bit 0.1).

If a start command is present in the lower priority operating mode, it is executed immediately as soon as this control source takes over.

Manual switching to a higher priority operating mode is possible at any time, even when the motor is switched on ("Motor On" PII bit 0.1).

9.6.2 Process images

The basic functions of the e-Starter ET 200SP are controlled and monitored through the process data in the process images.

The following options are available for transferring the process images:

- Cyclically in the bus protocol
- Acyclically using data sets

Process image input (PII) and process image output (PIQ)

The following process images are transferred:

- Process image input with 4 bytes (16 bytes when using the PI extension (Page 73))
- Process image output with 4 bytes

The tables for the process images describe only the supported process data. Inputs and outputs that are not listed are not assigned.

Process image input (PII)

Process data	Process image
DI 0.0	Ready (automatic)
DI 0.1	Motor On
DI 0.2	Group error
DI 0.3	Group warning
DI 0.4	Input 1
DI 0.5	Input 2
DI 0.6	Input 3
DI 0.7	Input 4
DI 1.0	Motor current Iact-bit0
DI 1.1	Motor current Iact-bit1
DI 1.2	Motor current Iact-bit2
DI 1.3	Motor current Iact-bit3
DI 1.4	Motor current Iact-bit4
DI 1.5	Motor current Iact-bit5
DI 1.6	Operating mode manual - local
DI 1.7	Ramp operation
DI 2.0	Motor CW

Process data	Process image
DI 2.1	Motor CCW
DI 2.4	Starting mode active
DI 2.5	Operation active
DI 2.6	Stopping mode active
DI 2.7	Parameter lock active
DI 3.0	Thermal motor model overload
DI 3.2	Switching element overload
DI 3.3	Safety release
DI 3.5	Main energy faulty
DI 3.6	Overtemperature
AI 4 (Float32)	Measured value 1
AI 8 (Float32)	Measured value 2
AI 12 (Float32)	Measured value 3

Process image output (PIQ)

Process data	Process image
DQ 0.0	Motor CW
DQ 0.1	Motor CCW
DQ 0.3	Reset
DQ 0.4	Emergency start
DQ 0.5	Self-test (user-test)
DQ 0.6	Disable Quick-stop
DQ 2.2	Cold running
DQ 3.0	Input controlled

9.6.3 Reversing

Method of operation

The integrated reversing control function makes it possible to start the motor in clockwise or counter-clockwise rotation by reversing the line conductors L1 and L2 in the device.

Physical connection	Permissible direction of rotation of the main energy supply	Operating the motor in forward direction	Operating the motor in reverse direction
L1-L2-L3 (CW configuration/clockwise)	Any	Motor in operation	Motor in operation
	CW (clockwise)	Motor in operation	Motor in operation
	CCW (counter-clockwise)	No operation and error	No operation and error

Physical connection	Permissible direction of rotation of the main energy supply	Operating the motor in forward direction	Operating the motor in reverse direction
L1-L3-L2 (CCW configuration/counter-clockwise)	Any	Motor in operation	Motor in operation
	CW (clockwise)	No operation and error	No operation and error
	CCW (counter-clockwise)	Motor in operation	Motor in operation

Parameters

Parameters	Description
Reversing time behavior (see also Switching times (Page 63))	This parameter is used to select the reversing time behavior of the e-Starter ET 200SP. In addition to its electronic switching elements, the e-Starter ET 200SP has electromechanical contacts in series. To ensure all functionalities, the device must monitor itself and run internal test routines. To adapt the influence of the test routines to the application, the set values can be selected according to requirements: • **Optimized switching times** Select this set value if identical switching times are required with frequent changes in the direction of rotation. • **Lifetime optimized switching** (factory setting) Select this set value if the focus is on lifetime-optimized use and/or the same direction of rotation is predominantly required. This may lead to a fluctuation in the switching times.

NOTE

Time-based switching offset when using the "Lifetime optimized switching" setting

With switching time-optimized behavior, the tests are performed with every switching request; with lifetime-optimized switching, they are performed every 100 switching cycles and/or after 20 hours. With lifetime-optimized switching, the test routine can therefore cause a time-based switching offset.

9.6.4 Emergency operation functions

The main function of the e-Starter ET 200SP is to protect, control, measure, and monitor a load used to operate a plant or part of a plant.
During fault-free operation, the focus is on the controller and measuring the connected load. If a fault occurs, the primary task of the e-Starter ET 200SP shifts to protecting the load and the application. The aim is to prevent damage caused by overload, short-circuit, or other faults.
For special applications where, in the event of a fault, the priority is not to protect the load or the application but to ensure that operation continues, e.g., in special processes or in production with high availability requirements, various emergency operation functions are available for the e-Starter ET 200SP.

The emergency operation functions of the e-Starter ET 200SP include the emergency start function and the emergency run function.

9.6.4.1 Emergency start function

NOTICE
Consequential damage caused by using the emergency start function. **Property damage may occur.** If the emergency start function is activated, both system defects and system protection messages are ignored. This can cause further damage to the plant.

Method of operation

The emergency start function allows a motor to be switched on even when an internal trip command (e.g. due to a group error) is active. This is particularly important in order to be able to complete critical processes in a controlled manner – even if this means deliberately accepting an increased risk to the motor or plant. It is particularly necessary for processes in which a production stoppage would render the manufactured goods unusable.

The emergency start is only activated in the following situations:

- There is a system error that triggers a shutdown command.
- The emergency start has been enabled.

In this mode, the motor is switched on via a standard control command, with the safety logic taking the emergency start into account.

In the case of some errors, the motor can be started via the "Emergency start" function despite a pending group error:

- Motor overload protection - overload (DS 92, byte 12.3)
- Asymmetry limit error exceeded (DS 92, byte 14.0)
- Current limit error exceeded (DS 92, byte 14.2)
- Current limit error undershot (DS 92, byte 14.3)
- Input shutoff (DS 92, byte 15.4)
- Input shutoff end position CW (DS 92, byte 15.5)
- Input shutoff end position CCW (DS 92, byte 15.7)
- Sensor supply overload (DS 92, byte 16.3)
- Invalid parameter value (DS 92, byte 18.1)
- Cold start tripping (DS 92, byte 24.1)
- Maximum starting time exceeded (DS 92, byte 92.4)
- Ground fault limit error exceeded (DS 92, byte 62.7)

To use the emergency start function, the emergency start command must be activated before a shutdown command occurs. A fault that occurs later must not automatically shut down the motor (exception: device protection continues to apply).
Manual activation of the emergency start is not stored. After a power-off/on, the user must consciously re-activate it.
The emergency start can be enabled or disabled via the DS93 command data set or via the corresponding bit in the PIQ. The enabling/disabling of the emergency start is edge-triggered, i.e. an edge change from 0 to 1 of the PIQ bit enables the emergency start, and an edge change from 1 to 0 disables the emergency start.

Parameters

Parameters	Description
Emergency start	Use this parameter to set whether the emergency start function is always disabled or can be enabled or disabled manually using the commands. • **Disable** With this set value, you block the emergency start function. Activation of the emergency start is not possible. • **Manually enable/disable** (factory setting) If this value is set, you can manually disable and enable the emergency start function. In the event of a device error, intrinsic device protection shutdown, process mapping error, or blocking protection, an emergency start is also not possible via the corresponding command in DS93 or the corresponding bit in PIQ.

9.6.4.2 Emergency run function

Requirement

- A device of product version E01 with firmware V1.1 or higher

Method of operation

The "Emergency run" function allows the e-Starter ET 200SP to continue operating with limited functionality if an electromechanical switching element fails. This prevents a complete system shutdown and maintains limited operation of the motor and plant.
However, emergency run is not possible if the semiconductor switching element is defective, as the necessary protective functions can no longer be guaranteed in this case.
The activation and behavior of the emergency run function are configured via the "Emergency run" parameter. This function is deactivated in the factory setting, meaning that emergency run is not possible.
The function can be enabled in any operating state. As long as there is no fault (e.g. semiconductor failure), the emergency run function remains inactive and has no influence on the normal operation of the e-Starter ET 200SP.
The intrinsic device protection and short-circuit protection of the e-Starter ET 200SP remain fully effective even during active emergency run. This ensures that continued operation of the motor and plant does not cause any consequential damage, even when using the "emergency run" function.
Behavior when an electromechanical switching element that no longer opens is detected:

- Direct operation: only clockwise operation possible
- Reversing operation: only counter-clockwise operation possible
- Direct or reversing operation: clockwise or counter-clockwise operation possible

Behavior during manual release after failure of an electromechanical switching element that no longer opens:

If the e-Starter ET 200SP detects an electromechanical switching element that no longer opens, it generates an error with a shutdown command and the message "Switching element L defective". You can use the command / control command "Enable emergency run" to activate the emergency run. Activation of the emergency run results in the error being

acknowledged and the e-Starter ET 200SP switches back into the previously active operating state.

Behavior during manual release before failure of an electromechanical switching element that no longer opens:

When a switching element that no longer opens fails, the e-Starter ET 200SP behaves as if the "Emergency run" parameter were set to "Enabled".
An active emergency run is not stored in the e-Starter ET 200SP in a non-volatile manner. The emergency run remains active until the command/control command is revoked ("Disable emergency run"), the "Emergency run" function (parameter) is deactivated or the supply voltage (control supply voltage) is switched off.

The "Emergency run" function is enabled. If the e-Starter ET 200SP detects an electromechanical switching element that no longer opens, emergency run is automatically activated and the e-Starter ET 200SP generates a warning.
If the motor is starting up during the failure of an electromechanical switching element, the start-up is aborted and the motor is restarted with a 2-phase controller. This can cause motor influences such as speed drop or jerking.
Emergency operation remains active until the function is disabled.

Diagnosis via data set 92 during emergency run

When emergency run is enabled, bit 72.4 in data set 92 is set. If an electromechanical switching element is defective, bit 72.5 is also set, as is bit 73.3 for the maintenance display. This indicates that the emergency run functionality is active with defective relays. The diagnosis via bit 72.6 (emergency run motor CW possible) or bit 72.7 (emergency run motor CCW possible) indicates in which direction the e-Starter ET 200SP can still start.

Parameters

Parameters	Description
Emergency run	Use this parameter to set whether the emergency run function is always disabled or can be enabled or disabled manually via a command or a control command. • **Disable** (factory setting) This set value is used to block the emergency run function. Activation of the emergency run is not possible. If the e-Starter ET 200SP detects a fused power semiconductor or electromechanical switching element, it generates an error with a shutdown command and the message "Switching element defective". • **Manually enable/disable** If this value is set, you can manually disable and enable the emergency run function.

9.6.5 Starting mode

9.6.5.1 Smart Start

Description

Abrupt, direct starting causes torque surges that can damage the mechanical components of the application. Smart Start reduces the rate of rise of the torque and protects the application.

NOTE
Use of an electromechanical brake
If you are using an electromechanical brake, deactivate the Smart Start function to reduce wear.

Parameter	Description
Smart Start time	This parameter is used to set the ramp time. • Factory setting: 120 • Setting range: 60 ... 2000 • In steps of: 1 ms

9.6.5.2 Direct start (phase-optimized switching)

Description

Frequently occurring and very high inrush currents additionally heat up the motor and thus reduce the availability of the motor.
The inrush current is a dynamic compensation process.
It results from the following processes:

- Connection of an inductive load (motor) to an AC system or DC system
- Dynamic current transients in the motor
- Saturation effects in the laminated cores of the motor (these occur during all switch-on (direct start) and changeover processes)

The highest currents usually occur within one or two phases in the first half-wave. The absolute level depends on the switch-on phase position, the motor type, and the specific line voltage.
Furthermore, inrush currents can lead to false tripping of the circuit breaker in classic motor feeders.
By switching on e-Starters ET 200SP in a phase-optimized manner in the direct and/or reversing process, the motor is protected in an appropriate way by limiting the inrush currents and thus increasing the availability of the drive application.

Phase-optimized switching is included as standard in the range of functions of the e-Starters ET 200SP and cannot be parameterized.

The following figure shows the current and speed curve when starting a motor with the different starting modes.

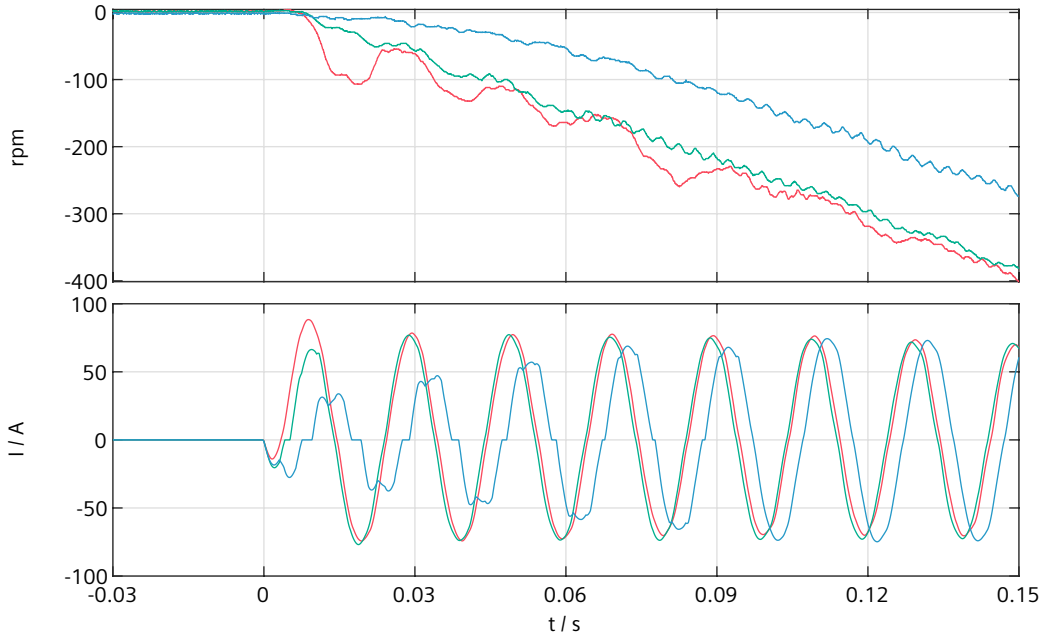

Blue	Smart Start
Green	Phase-optimized switching on
Red	Direct start

The direct start shows the greatest fluctuations in speed increase and has the highest current load. Phase-optimized switching on avoids or dampens the inrush currents and achieves a comparably fast start-up. Smart Start significantly reduces the starting current and leads to a smoother start-up.

9.7 Functions of the Basic 4DI (LC) submodule

If the Basic 4DI (LC) submodule is parameterized in the hardware configuration, monitoring takes place as to whether the Basic 4DI (LC) submodule has been inserted or removed. An error alarm is generated in data set 92 byte 22.3. If the Basic 4DI (LC) submodule is not configured in the hardware configuration, no monitoring takes place, but the parameterized input actions can also be used.

9.7.1 Inputs

Description

By using the optional Basic 4DI (LC) submodule, the e-Starter ET 200SP can perform various actions with the "Inputs" function. The actions are parameterizable. For this purpose, the signals are evaluated on the Basic 4DI (LC) submodule. All 4 inputs can be parameterized and the signal states are visible in the process image input (byte 0, bits 4 - 7).

Method of operation

The signal states are transferred in parallel via the process image. In addition, the signal states in DS92 can be read out. The input actions of the individual digital inputs influence the functions of the e-Starter ET 200SP independently of one another.

Inputs for commissioning

To ensure operation of a motor in the unparameterized state of the e-Starter ET 200SP with the aid of the Basic 4DI (LC) submodule, the input parameters in data set 131 are preassigned the following values by default:

- DI1: Motor CW
- DI2: Motor CCW
- DI3: No action
- DI4: Local control (LC) / manual - local

Response to sensor supply overload

The supply voltage for the digital inputs is short-circuit-proof. The current is limited to a maximum of 100 mA. If a short-circuit or overload situation occurs in the sensor supply, the switching elements (motor) are shut down and a group error is output (byte 31, bit 2) Acknowledge the errors with Trip Reset.
In addition, the 24 V supply of the e-Starter ET 200SP is disconnected from the 24 V output of the Basic 4DI (LC) submodule.

Behavior when removing the Basic 4DI (LC) submodule

The inputs are not open-circuit-proof. If you remove the Basic 4DI (LC) submodule, the e-Starter ET 200SP reacts according to the control command applied.

Debounce time

The inputs are debounced for 5 ms.

Input n signal

You can use this device parameter to determine whether or not the input level of the inputs is to be saved.

- Latching, i.e. self-holding mode (edge evaluation)
  Regardless of the input signal present, the action can only be deactivated again by a further event and remains active even after cancellation until it is overwritten by another action, e.g. process image output.
- Not latching, i.e. jog mode (level evaluation)
  This input action is active as long as the input is active.

Input n level

You use this device parameter to specify the input logic:

- NC contact
- NO contact

NOTE

Change from NC contact to NO contact

If "Input n level" is changed from a normally closed contact to a normally open contact and the associated "Input n action" is parameterized as "Switch off without restart", the "Input shutoff" message bit is set and shut down accordingly in the case of an open input due to the input delay!

NOTE

Applied input voltage

If input voltage is applied (input active), the value "1" is transferred to the controller regardless of the "Input n level" parameter.

Input n-Action

Different actions can be triggered when an input signal is present. You can parameterize the following actions dependent on "Input n level", "Input n signal" and "Mode".

NOTE

Necessary parameterization combination

If "Input n signal" = latching, and "Input n action" = Motor CW/CCW, at least one input must always be parameterized with input action "Tripping ...", "Switch off..." or "Quick Stop...". If this rule is violated, the e-Starter ET 200SP will reject the parameters with the relevant diagnostic message.

Input n-Action	Input n level	Input n signal	Evaluation in operating mode
No action	NO/NC	n. lat./lat.	All
Local control (LC) / manual - local	NO/NC	n. lat.	All
Switch off without restart	NO/NC	n. lat.	All
Switch off with restart	NO/NC	n. lat.	All
Switch off end position - motor CW	NO/NC	n. lat.	All
Switch off end position - motor CCW	NO/NC	n. lat.	All
Group warning	NO/NC	n. lat./lat.	All
Emergency start	NO	n. lat.	All
Motor CW	NO	n. lat./lat.	"Manual - local" or "Automatic operation - Input controlled"
Motor CCW	NO	n. lat./lat.	"Manual - local" or "Automatic operation - Input controlled"

Input n-Action	Input n level	Input n signal	Evaluation in operating mode
Quick Stop direction-independent	NO/NC	n. lat./lat.	All
Quick Stop clockwise	NO/NC	n. lat./lat.	All
Quick Stop clockwise	NO/NC	n. lat./lat.	All
Trip RESET	NO	n. lat.	All
Cold running	NO	n. lat.	All
Operational trip end position CW	NO/NC	n. lat.	All
Operational trip end position CCW	NO/NC	n. lat.	All
F: NO contact NC: NC contact lat.: Latching n. lat.: Not latching (activation and deactivation of the input action follows the status of the input signal (= jog))			

9.7.2 Manual - local (local control)

Method of operation

Manual - local control is only possible with the e-Starter ET 200SP with an inserted Basic 4DI (LC) submodule. By default, the digital input DI4 is assigned "manual - local" (Local Control) by default. If a digital input that is parameterized with LC is active, i.e. "Manual - local" is requested, the e-Starter ET 200SP also switches to manual - local mode when the motor is ON. To exit manual - local operation, the manual - local input must be inactive and the motor must be switched off via the Basic 4DI (LC) submodule.
When the motor is switched on, the e-Starter ET 200SP remains in manual - local mode and thus in the "Motor On" state until the input action is interrupted.
If a Basic 4DI (LC) submodule with "manual - local" activated is plugged into the e-Starter ET 200SP, the system switches to manual - local operation.
When manual - local mode is exited, the e-Starter ET 200SP switches to automatic mode. The e-Starter ET 200SP thus changes to the master control of the CPU. If a CW or CCW command is present via the process image output, the motor can start up directly.
If the Basic 4DI (LC) submodule is removed from the e-Starter ET 200SP, this immediately switches off a running motor and manual - local mode is exited.

9.7.3 Switch off without restart

Method of operation

The action "Switch off without restart" results in the following behavior:

- The motor is tripped. Acknowledge disconnection via Trip Reset after remedying the cause of tripping. You can then switch on the motor again.
- The parameter can only be implemented as "not latching".
- A group error is generated and a diagnostics entry created.

9.7.4 Switch off with restart

Method of operation

The action "Switch off with restart" results in the following behavior:

- The motor is tripped.
- Acknowledged automatically after the cause of the trip has been rectified (input status).
- The parameter can only be implemented as "not latching".
- A group error is generated and a diagnostics entry created.
- The motor restarts automatically.

9.7.5 Switch off emergency end position - motor CW

Method of operation

If the motor control command is not equal to "Motor OFF", the diagnostic interrupt "Switch off end position - motor CW" incoming is triggered when a 0 → 1 edge is detected at the digital input. This diagnostic interrupt results in internal tripping of the motor. The interrupt "Switch off end position - motor CW" is reported as outgoing (DS92 entry is deleted) if the motor control command is "Motor OFF". If the motor control command "Motor CW" is issued in the case of "Switch off end position - motor CW" DI static "1", an incoming diagnostic message "Switch off end position - motor CW" is triggered (only if the diagnostic message was already outgoing or has been deleted). This diagnostic message prevents renewed switch-on of the motor in the CW direction of rotation.

The action "Switch off end position - motor CW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation.
- You can switch the motor back on again after deletion of the control command "Motor CW/CCW".
- The motor can only be switched on with "Motor CCW".
- The parameter can only be implemented as "not latching".
- A group error is generated and a diagnostics entry created.

9.7.6 Switch off emergency end position - motor CCW

Method of operation

If the motor control command is not equal to "Motor OFF", the diagnostic interrupt "Switch off end position - motor CCW" incoming is triggered when a 0 → 1 edge is detected at the digital input. This diagnostic interrupt results in internal tripping of the motor. The interrupt "Switch off end position - motor CCW" is reported as outgoing (entry DS92 is deleted) if the motor control command is "Motor OFF". If the motor control command "Motor CCW" is issued in the case of "Switch off end position - motor CCW" DI static "1", an incoming diagnostic message "Switch off end position - motor CCW" is triggered (only if the diagnostic message was already outgoing or has been deleted). This diagnostic message prevents renewed switch-on of the motor in the CCW direction of rotation.

The action "Emergency end position CCW" results in the following behavior:

- The motor is tripped regardless of the direction of rotation.
- You can switch the motor back on again after deletion of the control command "Motor CW/CCW".
- The motor can only be switched on with "Motor CW".
- The parameter can only be implemented as "not latching".
- A group error is generated and a diagnostics entry created.

9.7.7 Group warning

Method of operation

The action "Group warning" results in the following behavior:

- A "group warning" is generated.
- Entries with the object numbers 304 (group warning) and 351 (input warning) are created in the DS92.
- A logbook entry is created in DS72.
- The motor is not shut off.
- If the group warning diagnosis is enabled, a maintenance alarm is generated.

9.7.8 Emergency start

Safety instructions

NOTE

Consequential damage caused by using the emergency start function

The emergency start function allows you to override system malfunctions and system protection shutdowns, which may result in consequential damage due to continued operation of the motor and the system.

Method of operation

The emergency start enables a hot restart despite an internal trip command. The motor is switched on despite a pending trip cause.

Emergency starting is not possible in the following situations:

- If a device error is active.
- If there is no switched/unswitched 24 V DC supply voltage, or if the supply voltage is outside the specified range.
- The blocking protection has triggered.
- If a process mapping error is active.

You can activate the functions as follows:

- PIQ 0.4 "Emergency start"
- Via the Basic 4DI (LC) submodule
- In manual - bus mode via DS68 (byte 14, bit 4)

9.7.9 Motor CW

Method of operation

In automatic mode, the motor is activated or deactivated in the CW direction with the aid of the process image of the outputs. If you want to control the motor via the Basic 4DI (LC) submodule, activate the manual - local mode via the "Local Control" input action on the Basic 4DI (LC) submodule or set bit 3.0 (input controls) in automatic mode. Bit 0.0 "Motor CW" in the process image output is overridden in manual - local mode, or if bit 3.0 (input controls) is set in automatic mode.

The parameter can only be implemented as an "NO contact".

If "Input n signal" = latching, and "Input n action" = Motor CW/CCW, at least one input must always be parameterized with input action "Tripping ...", "Switch off..." or "Quick Stop...". If this rule is violated, the e-Starter ET 200SP will reject the parameters with a relevant diagnostic message.

9.7.10 Motor CCW

Method of operation

In automatic mode, the motor is activated or deactivated in the CCW direction with the aid of the process image of the outputs. If you want to control the motor via the Basic 4DI (LC) submodule, activate the manual - local mode via the "Local Control" input action on the Basic 4DI (LC) submodule or set bit 3.0 (input controls) in automatic mode. Bit 0.1 "Motor CCW" in the process image output is overridden in manual - local mode, or if bit 3.0 (input controls) is set in automatic mode.

The parameter can only be implemented as an "NO contact".

If "Input n signal" = latching, and "Input n action" = Motor CW/CCW, at least one input must always be parameterized with input action "Tripping ...", "Switch off..." or "Quick Stop...". If this rule is violated, the e-Starter ET 200SP will reject the parameters with a relevant diagnostic message.

9.7.11 Quick-stop

Method of operation

The action "Quick Stop" results in the following behavior:

- Motor is tripped without group error.
- "Quick Stop" takes priority over "Motor CW" and "Motor CCW"
- The input action responds to the active edge of the input signal, which means that deactivation is possible when the static input signal "Quick stop" is present.
- The input trigger is reset by cancellation of the commands "Motor CW" and "Motor CCW" or "Disable Quick Stop" in the process image. This only applies to control via manual - local mode.
- The motor is tripped regardless of the direction of rotation.
- After the "Quick Stop" command is canceled, the motor behaves according to the pending control command.

9.7.12 Quick Stop clockwise

Method of operation

The action "Quick Stop CW" results in the following behavior:

- The motor is switched off with pending signal "Motor CW" without group error
- The motor is not switched off with pending signal "Motor CCW"
- "Quick Stop CW" takes priority over "Motor CW"
- The input action responds to the active edge of the input signal, which means deactivation is possible when the static input signal "Quick Stop" is present.
- The input trigger is reset by cancellation of the control commands "Motor CW" or "Disable Quick Stop" in the process image.

9.7.13 Quick Stop counter-clockwise

Method of operation

The action "Quick Stop CCW" results in the following behavior:

- The motor is switched off with pending signal "Motor CCW" without group error
- The motor is not switched off with pending signal "Motor CW"
- "Quick Stop CCW" takes priority over "Motor CCW"
- The input action responds to the active edge of the input signal, Deactivation is possible when the static input signal "Quick Stop" is present.
- The input trigger is reset by cancellation of the commands "Motor CCW" or "Disable Quick Stop" in the process image.

9.7.14 Trip RESET

Description

Trip RESET acknowledges all errors/faults that are currently present and can be acknowledged in the e-Starter ET 200SP An error/fault can be acknowledged if its cause has been rectified or if it is no longer present.

The "Trip RESET" action is not possible as non-latching action.
The Trip RESET is triggered by:

- Trip RESET via PLC (PIQ bit 0.3 Trip RESET)
- Trip RESET via input action if it corresponds to the parameterization
- TEST/RESET button on the e-Starter ET 200SP
- Power-on RESET (switching off and on again of the 24 V supply voltages on the device)

9.7.15 Cold running

Method of operation

The e-Starter ET 200SP can be switched on and off without connected line voltage to test the controller's user program without generating an error. The corresponding control commands are accepted by the controller and the corresponding messages are generated as if the line voltage were present. This function cannot be used for a wiring test.

The "Cold running" function can be activated as follows:

- "Cold running" input action
- "Cold running on/off" commands
- PIQ (process image output) - "Cold running" control bit

If an internal trip command requiring acknowledgment via Trip Reset is pending when the "Cold running" function is activated due to missing line voltage, residual current or the Ie limit value being undershot, this must first be acknowledged with Trip Reset before the switching element can be switched on.

If an internal trip command is pending, the motor cannot be switched on. When the "Cold start" function is active, an internal trip command is generated and a "Cold start tripping" message is set in DS 92 byte 24.1 as soon as a current flow or an applied line voltage is detected.

9.7.16 Operational trip end position CW

Method of operation

If the motor control command is not equal to "Motor OFF", an operational trip of the motor is triggered when a signal change at the operational trip end position CW DI is detected. This motor switch-off, triggered by the "Operational trip end position" action, is canceled by a "Motor OFF" motor control command. If the motor control command "Motor CW" is issued in the case of operational trip end position CW DI static "1", an operational trip is triggered again. This trip action, triggered by the "Operational trip end position" action, prevents the

motor from being switched back on in the clockwise direction of rotation.
The "Operational trip end position CW" action leads to the following behavior:

- The motor is tripped regardless of the direction of rotation.
- The motor can only be switched on with "Motor CCW".
- The parameter can only be implemented as "not latching".
- A group error is not generated, but a diagnostic message is set in data set 92.

9.7.17 Operational trip end position CCW

Method of operation

If the motor control command is not equal to "Motor OFF", an operational trip of the motor is triggered when a signal change at the operational trip end position CCW DI is detected. This motor switch-off, triggered by the "Operational trip end position" action, is canceled by a "Motor OFF" motor control command. If the motor control command "Motor CCW" is issued in the case of operational trip end position CW DI static "1", an operational trip is triggered again. This trip action, triggered by the "Operational trip end position" action, prevents the motor from being switched back on in the counterclockwise direction of rotation.
The "Operational trip end position CCW" action leads to the following behavior:

- The motor is switched off regardless of the direction of rotation.
- The motor can only be switched on with "Motor CW".
- The parameter can only be implemented as "not latching".
- A group error is not generated, but a diagnostic message is set in data set 92.

9.8 Maintenance

9.8.1 Maintenance timer

Method of operation

A maintenance timer is implemented. The maintenance timer is used to set a time interval after which a motor is to be serviced. The maintenance timer runs when the motor is active. Exceeding the maintenance timer warning limit value is indicated in data set 92 in bit 37.1. A diagnostic message is also generated if the group warning diagnosis is enabled.

Parameter

Parameter	Description
Maintenance timer warning limit	This parameter is used to set the warning limit for the maintenance timer. • Factory setting: 94608000 • Setting range: 0 ... 4294967295 s • In steps of: 1 s

9.9 Functions for resistive loads

9.9.1 Requirements for operation of resistive loads

Description

When operating resistive loads, set the following parameters to the corresponding settings:

- Load type: Resistive load
- Trip class: CLASS Off
- Rated operational current: If the "Load type" parameter is set to "Resistive load", the expanded rated operational current range can be set.

9.9.2 Switching of resistance heating loads and infrared sources

Description

The e-Starter ET 200SP offers a compact, intelligent, and safe solution for switching, protecting, measuring, and monitoring resistive heating loads and infrared sources in industrial applications. Its integrated protective functions, flexible control, and easy integration into the TIA Portal make it ideal for thermal processes with high requirements for reliability, EMC behavior, and service life.

Starting with firmware version V1.1, the e-Starter ET 200SP supports switching, protecting, measuring, and monitoring of resistive loads (AC1) in 1 and 3-phase operation of an expanded current setting.

- 3RD1000-0BA00-0EP0: 0.1-3.0 A
- 3RD1000-0BB00-0EP0: 0.7-9.0 A

The interconnection of the resistive loads (resistance heating loads/IPR radiators) is shown in Connection example for resistance loads (Page 157).

9.9.3 Heating with resistance heating cartridges

Description

Resistance heating cartridges are used in numerous applications in industry and mechanical engineering because they are precise, efficient, and compact heat sources.

Application areas

Industry	Application	Description
Tool and mold making	Injection molding	Heating to achieve and maintain the mold temperature
	Extruders and blow molding	Temperature control in extrusion and blow molding processes

Industry	Application	Description
Tool and mold making	Die casting molding	Preheating and temperature control of metal casting molds
Packaging industry	Heat sealing tools	Sealing of films and bags in packaging machines
	Sealing bars	Hot welding of plastics
	Thermoforming machines	Heating of plastic sheets before molding
Process industry	Chemical and pharmaceutical processes	Heating of reactors, tanks, and pipelines
	Food processing	Heating up liquids (e.g. grease, oil) and process chambers
	Ovens and chambers	Use in laboratory ovens, drying ovens, and heat chambers
Mechanical engineering	Machine tools	Heating of clamping devices or slides for precision manufacturing
	Hydraulic systems	Heating of hydraulic oil for viscosity control
	3D printer	Heating of pressure nozzles or pressure beds (FDM process)
Energy & environmental technology	Renewable energies	Heating of heat storage tanks or solar thermal systems
	Exhaust gas post-treatment	Heating of catalytic converters or diesel particulate filters in vehicles and industrial plants
Medical engineering	Sterilizers	Temperature control in autoclaves and sterilization chambers
	Analyzers	Temperature control in laboratory and diagnostic equipment

Requirement for safe and efficient control of resistance heating cartridges

The control and electrical protection of resistance heating cartridges are crucial for setting and regulating their performance, extending their service life, and preventing potential damage or hazards.

The e-Starter ET 200SP, controlled using the PID control methods available in the TIA Portal, provides an optimal basis for high switching cycles and precise temperature control.

In addition, the e-Starter ET 200SP offers optimum protection for resistive loads due to its design. The most common technical failures in resistance heating cartridges can be divided into electrical and thermal problems. These symptoms often indicate specific causes of failure.

Electrical failure symptoms

- Fused heating element
  - Cause: Overload due to excessively high voltage or overheating.
  - Consequences: Interruption of the electric circuit, no heat development.
- Short-circuit
  - Cause: Insulation failure between heating element and sheath due to moisture or mechanical damage.
  - Consequences: Sudden power failure or unplanned outage.
- Overcurrent or overvoltage
  - Cause: Voltage peaks in the power grid or incorrectly dimensioned control.
  - Consequences: Overload of the heating element and premature failure.

Thermal failure symptoms

- Heater does not reach the desired temperature
  - Cause: Wear or partial burnout of the heating element
  - Consequences: Insufficient thermal output, irregular operation.

9.9.4 Heating with infrared sources

Description

Switching and protecting infrared sources (IR sources) poses several challenges due to their electrical and thermal characteristics. Problems often arise with powerful IR sources, such as those used in industrial applications (e.g. drying, plastics processing).

Requirements for safe and efficient control of infrared sources

The control and electrical protection of IR sources are crucial for setting and regulating their performance, extending their service life, and preventing potential damage or hazards.

The e-Starter ET 200SP provides an optimal basis for high switching cycles, precise temperature control, and safe operation with the help of the PID control methods available in the TIA Portal and the Smart Start functionality that can be configured in the e-Starter ET 200SP.

IR sources (especially halogen emitters) have a very low cold resistance when switched on. This leads to a high starting current for a short time, which can be 10 to 15 times the rated current. The activatable Smart Start of the e-Starter ET 200SP counteracts this effect.

Frequent switching on and off (e.g. when controlled by pulse width modulation) places considerable strain on mechanical switches or relays. Furthermore, IR sources react quickly to changes in current. Switching via generalized phase control can lead to harmonics and EMC interference, which can affect the power supply network and other devices.

These problems can be counteracted by using the full-wave controls of the e-Starter ET 200SP in conjunction with the PID controller. Unlike generalized phase control, full-wave control does not generate abrupt current and voltage changes within a cycle. This prevents the

formation of harmonics and electromagnetic interference, which protects both the IR source and other devices in the network.

Advantages of full-wave control and soft start for IR source

- IR source has a very low cold resistance, which leads to extremely high inrush currents. The soft start ramp reduces this current surge.
- Full-wave control switches at zero point, which minimizes EMC interference and also offers a major advantage over phase control.
- Uniform energy supply extends the service life of the sensitive heating coils.
- Mains load balancing is useful for multiple IR sources to avoid mains overload.

9.9.5 Control-related basics

Description

Control loop

A simple example of a control loop is the regulation of temperature by a heater (resistance heating load). This temperature is measured by a sensor and fed to a controller. The controller compares the current temperature with a setpoint and calculates an output value (control variable) for controlling the heater.

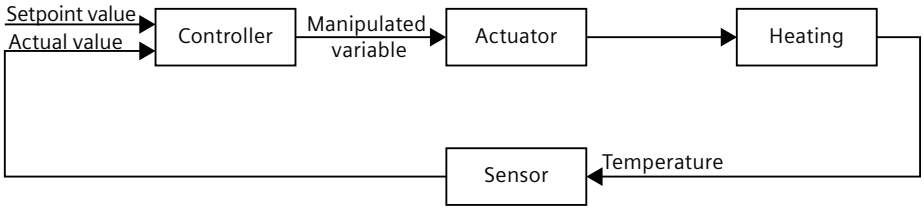

With conventional switching of heating loads, the actual value often changes with a time delay when the output value changes. This behavior is to be compensated for by a controller. A correctly set PID controller reaches the setpoint as quickly as possible and then keeps it constant.

Actuator

The actuator is part of the control loop and is influenced by the controller. This changes the power flow. In the case of temperature control, the e-Starter ET 200SP is the actuator.

9.9.6 Use of PID controllers with the e-Starter ET 200SP

Description

For temperature control, controllers with PID behavior (2) have the advantage that, once the actual value has stabilized, it does not show any deviation from the setpoint. During startup, the actual value fluctuates above the setpoint.

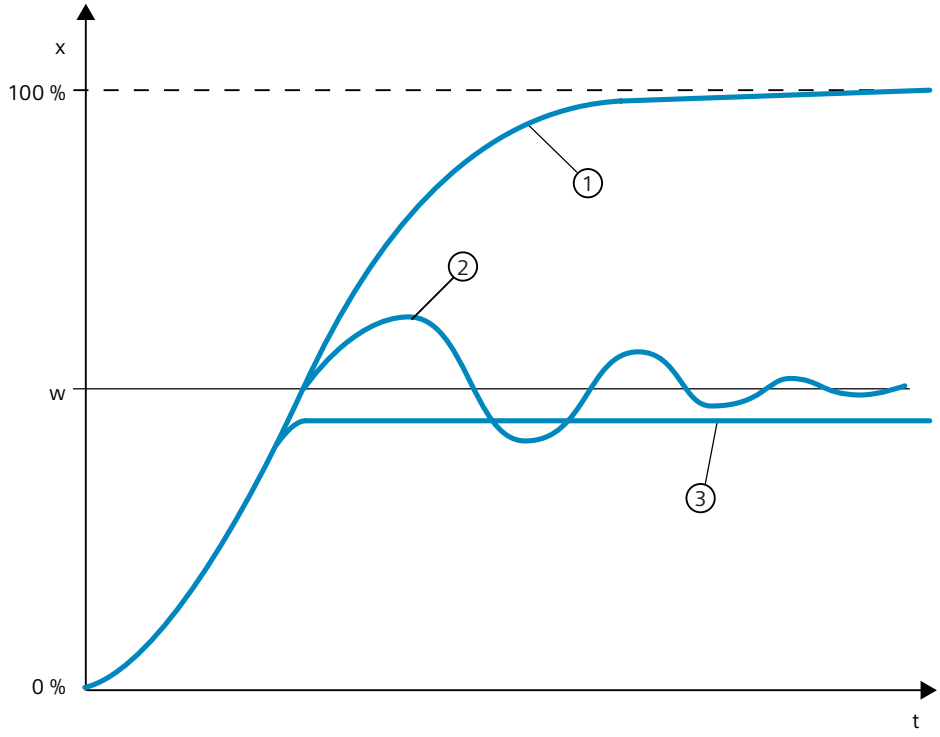

① No controller
② PID controller
③ PD controller
w Setpoint value
x Actual value
t Time

Use of the PID controller is described in Function Manual SIMATIC S7-1200, S7-1500 PID control (https://support.industry.siemens.com/cs/ww/en/view/108210036).

Effect of the PWM duty factor on the current flow

PWM duty factor	3-phase output voltage	Current
0%	Semiconductor does not switch → 0 V	No current flow
50%	Semiconductor conducts 50% of the time → Average voltage is reduced	Current flow corresponds to partial power
100%	Semiconductor fully conductive → Line voltage at the output	Maximum current flow to the load

Typical settings for PID temperature controllers in the TIA Portal

- A PID_Compact is used.
- Control cycle (e.g. 1 s)
- The controller calculates a new control variable between 0 and 100% at specific time intervals.
- This control variable is transmitted to the e-Starter ET 200SP.

9.9.7 Power control with full-wave control for heating loads

Requirement

- A device of product version E01 with firmware V1.1 or higher

Method of operation

A power controller with full-wave control regulates the supplied electrical power by selectively switching entire sine waves of the line voltage on or off. The power frequency (e.g. 50 Hz) is used to control the energy supply in discrete time intervals. The control here is wave-based, i.e. in 20 ms steps at 50 Hz.

Benefits

- Low line perturbations due to fewer harmonics
- High reliability in rugged applications
- Fewer EMC problems compared to phase control

Example of power reduction to 80%

At a power frequency of 50 Hz, the cycle duration is 20 ms. This means that 50 full waves occur in one second.
To achieve an average power of 80%, 40 of the 50 waves are switched through (ON) and 10 waves are blocked (OFF). This is done in blocks.
The characteristic curve shows the current curve of a full-wave control at 80% power (50 Hz, 1 second):

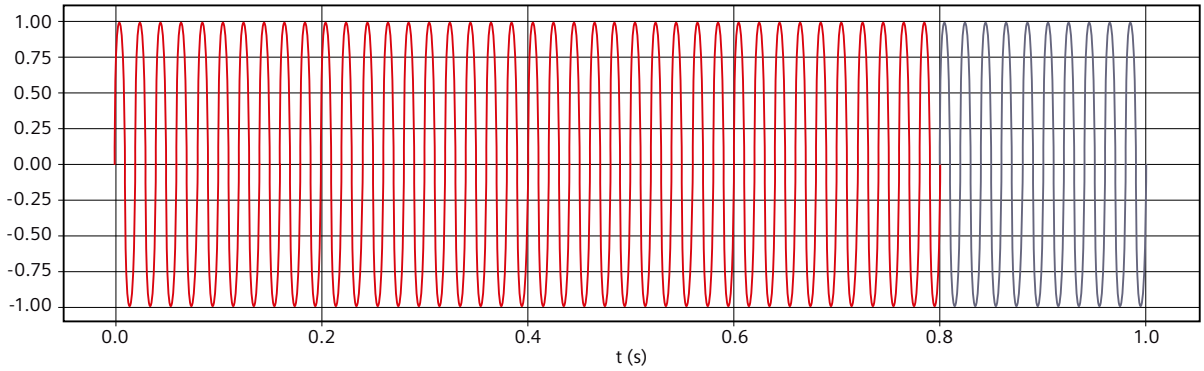

	Switched through (ON)
	Disabled (OFF)
X axis	Time in s
Y axis	Current in A

Control of the power controller via TIA Portal

The percentage value of the power can be set using the "Powercontrol" function block.
Here is an example of the assignment in OB1:

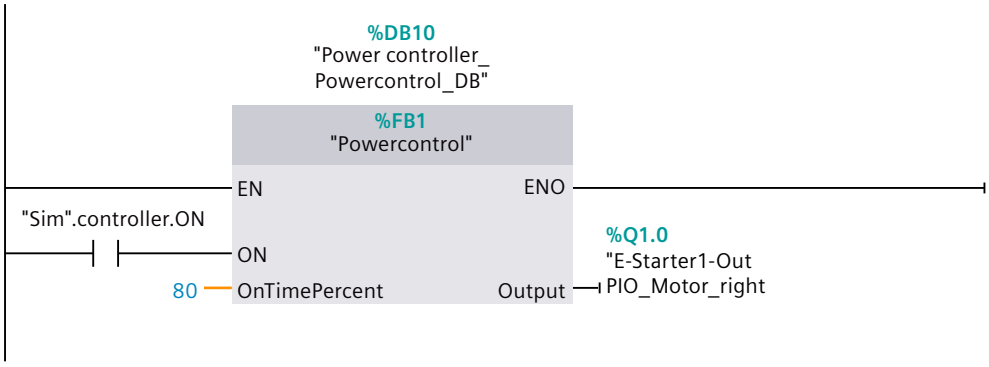

ON	Start of power control
OnTimePercent	Percentage power controller value
Output	Connection to PIQ e-Starter ET 200SP

Maintenance and service 10

10.1 Maintenance

The e-Starter ET 200SP is maintenance-free.

10.2 Repair

Repairs to a e-Starter ET 200SP may only be carried out by the manufacturer.

10.3 Firmware update

Description

During operation, it may be necessary to update the firmware of the e-Starters ET 200SP (e.g. to extend the available functions, for bug fixes, ...). Ensure that the firmware is up to date to be able to use the full range of functions.
You update the firmware with the help of firmware files. The retentive data is retained after the firmware has been updated.

Safety instructions

WARNING

Risk of injury due to unauthorized system states during firmware update
Can cause death or serious injury

The CPU switches to STOP mode or the interface module to "CPU stop" as a result of the firmware update being installed. STOP or CPU stop due to a firmware update can cause an unpredictable state of the e-Starter ET 200SP. Once the update is complete, the current PIQ and the input actions are effective again.
Before installing the firmware update, make sure that the e-Starter ET 200SP, the CPU, and the interface module are not executing an active process.

Requirement

- You can find the preconditions for a firmware update/firmware downgrade in the entry Firmware update and OSS information (https://support.industry.siemens.com/cs/ww/en/view/109974597).
- The modules selected for the firmware update are currently not in active operation and are not being controlled.
- The 24 V DC supply voltage is connected to the head module and the e-Starter ET 200SP.
- There is no pending start command for the load on the e-Starter ET 200SP.
- The connected Basic 4DI (LC) submodule must not removed during a firmware update.

Options for a firmware update

You have the following options for performing a firmware update:

- Online via PROFINET IO (with TIA Portal)
- Via a SIMATIC Memory Card (or a CPU)
- Via the integrated web server
- Via the SIMATIC Automation Tool
- Via the Multi Fieldbus Configuration Tool (MFCT)

Downloading the firmware files

1. The required firmware update files and OSS information can be found in the entry Firmware update and OSS information (https://support.industry.siemens.com/cs/ww/en/view/109974597).
2. Download the latest firmware update file for the module and store it locally.

Procedure using TIA Portal

NOTE

Performing a firmware update during the configuration of the ET 200SP via a PROFINET GSD file

If the ET 200SP has been configured via a PROFINET GSD file, you will find instructions for the firmware update in the entry How do you perform a firmware update for ET 200SP modules in STEP 7 V5.x if the ET 200SP has been configured using a GSDML file? (https://support.industry.siemens.com/cs/ww/en/view/109770994).

1. Select the e-Starter ET 200SP in the device view.
2. Select the "Online & Diagnostics" command from the context menu.
3. Select the "Firmware update" group in the "Functions" folder.
4. Click the "Browse" button to select the path to the firmware update files.

5. Select the downloaded firmware file. The table in the firmware update area lists all modules for which an update is possible with the selected firmware file.
6. Click the "Run update" button. If the module can interpret the selected file, the file is downloaded to the module.

Make sure that the "Activate firmware after update" check box is still selected. When the loading process is complete, the module works with the new firmware.

Procedure using a SIMATIC Memory Card

1. Insert a SIMATIC Memory Card into the SD card reader of your programming device / computer.
2. To save the firmware update file on the SIMATIC Memory Card, mark the SIMATIC Memory Card in the project navigator under "Card reader/USB memory".
3. Select the "Card Reader/USB memory > Create firmware update memory card" command in the "Project" menu.
4. Navigate to the firmware update file via a file selection dialog. In a further step you can decide whether you want to delete the content of the SIMATIC Memory Card or whether you want to add the firmware update files to the SIMATIC Memory Card.
5. Insert the SIMATIC Memory Card with the firmware update files into the CPU.
6. Remove any inserted SIMATIC Memory Card.
7. Insert the SIMATIC Memory Card with the firmware update files into the CPU.
8. The firmware update begins shortly after the SIMATIC Memory Card has been plugged in.
9. Once the firmware update is complete, remove the SIMATIC Memory Card. The RUN LED on the CPU lights up yellow, the MAINT LED flashes yellow.
10. Delete the firmware update files manually if you then want to use the SIMATIC Memory Card as program card.

NOTE

Update of all affected modules in the hardware configuration

If your hardware configuration contains several modules, the CPU updates all affected modules in the slot sequence, which means in ascending order of the module position in the STEP 7 device configuration.

Procedure using the web server

The procedure is described in the Function Manual S7-1500/ET 200, SIMATIC Drive Controller Webserver (https://support.industry.siemens.com/cs/ww/en/view/109977246).

Procedure using the SIMATIC Automation Tool

The necessary settings and how to perform the firmware update are described in the SIMATIC Automation Tool user manual (https://support.industry.siemens.com/cs/ww/en/view/109986787).

Procedure with the Multi Fieldbus Configuration Tool (MFCT)

Alternatively, the e-Starter ET 200SP can also perform a firmware update via the MFCT. The procedure is described in the download article for the MultiFieldbus Configuration Tool (MFCT) (https://support.industry.siemens.com/cs/ww/en/view/109773881).

Behavior during the firmware update

Note the following behavior during the firmware update:

- The LEDs flash as described in chapter "Alarm, fault and system events" (Page 134).
- PIQ and PII are ignored.
- Acyclic data traffic is generally possible, but this slows down the firmware update.

Behavior after the firmware update

- After the firmware update, check the firmware version of the updated module. A successfully loaded firmware update is activated immediately.
- The e-Starter ET 200SP restarts after the firmware update has been completed.
- The diagnostic information is reset. The firmware update does not affect the electronic motor overload protection and the cooling time.

Procedure in the event of a faulty firmware update

If a firmware update attempt fails, the old firmware version is retained.

1. Turn the lockable rotary interlock to the parking position.
2. Then turn the lockable rotary interlock back to the operating position.
3. Start a new attempt to perform the firmware update.

10.4 Replacing the e-Starter ET 200SP

Safety instructions

⚠ WARNING

Risk of injury due to automatic restart.
Can cause death or serious injury

When you replace the e-Starter ET 200SP, the e-Starter ET 200SP can restart again autonomously if an ON command is active. This can result in property damage or serious injury caused by connected devices that are automatically started up.

Cancel the ON commands on the e-Starter ET 200SP before replacing the e-Starter ET 200SP.

Requirement

- ON commands are canceled.
- The supply voltages are turned off.
- De-energized state is established.

Instructions

1. Turn the lockable rotary interlock counter-clockwise to the assembly/disassembly position.
2. Remove the e-Starter ET 200SP from the BaseUnit.
3. Insert the new e-Starter ET 200SP into the BaseUnit.
4. Turn the lockable rotary interlock clockwise from the mounting/disassembly position to the operating position.

10.5 Securing against restarting

Requirement

- The lockable rotary lock of the e-Starter ET 200SP is in the parking position.

Essential accessories

- Padlock (shackle diameter 3 mm)

Instructions

1. Open the locking lever on the lockable rotary lock.

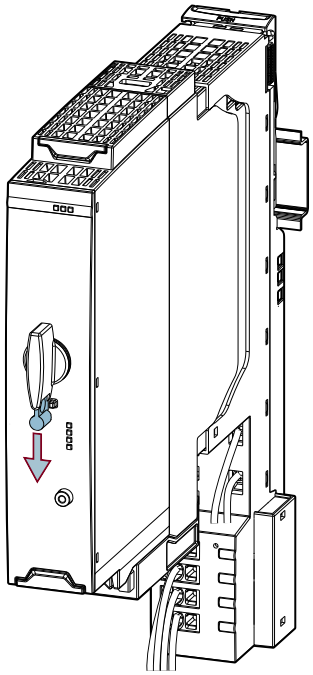

2. Secure this position with the padlock.

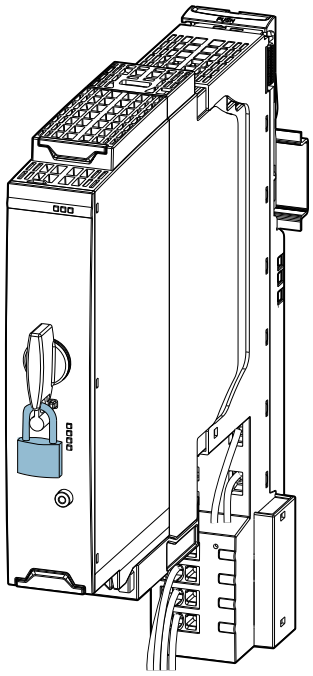

Result

- The isolating function in accordance with IEC 60947-1 is ensured.

Alarm, fault and system events 11

11.1 Diagnostics options

The e-Starter ET 200SP provides you with the following diagnostic options:

- LEDs on the e-Starter ET 200SP
- Diagnostic option via the TIA Portal
- Data sets 92, 94, 95, 96

11.2 LED lights

11.2.1 Overview of the device LEDs of the e-Starter ET 200SP

LED arrangement on the e-Starter ET 200SP

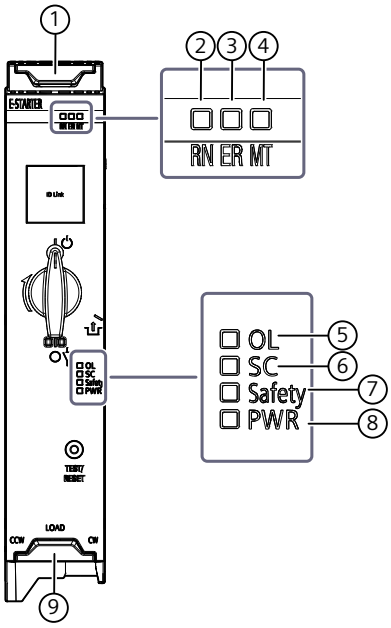

① GRID (red/yellow)
② RN (green) - RUN
③ ER (red) - error
④ MT (yellow) - maintenance
⑤ OL (red) - overload
⑥ SC (red) - short circuit
⑦ Safety (green) - safety
⑧ PWR (green)
⑨ LOAD / CW / CCW (green / red / yellow)

11.2.2 Status and error displays

The e-Starter ET 200SP has LEDs that indicate certain device states.

The tables below give the meanings of the status and fault displays.

11.2.3 LED RUN / ER / MT

LED status			Meaning	Explanation
RN (RUN)	**ER (Error)**	**MT (Maintenance)**		
Green - lit	Not relevant	Not relevant	Normal operation RUN	Device operating state "Normal operation RUN" • The e-Starter ET 200SP has received a valid configuration and parameter data sets. • The e-Starter ET 200SP is in "normal" operation and executes the control commands.
Green - flashing	Not relevant	Not relevant	• Startup (Cfg + Par.) • Parameterization error	**System operating state "System startup"** A parameterization error during startup prevents exiting of this state.
Not relevant	Off	Not relevant	No error	No group error No error alarm was transmitted to the controller.
Not relevant	Red - flashing (2 Hz)	Not relevant	Error	Group error (message can be deactivated) At least one error alarm has been transferred to the controller. Possible causes: • Electronics supply voltage impermissible • Motor protection trip overload • Thermal overload on the device • Missing load voltage, missing load • Start inhibited, device too hot (with ON command) – Firmware update (channel temporarily unavailable). This message cannot be deactivated. For further causes, see section Overview of warnings and errors (Page 142).
Not relevant	Not relevant	Off	No maintenance	No group warning

LED status			Meaning	Explanation
RN (RUN)	ER (Error)	MT (Mainten-ance)		
Not relevant	Not relevant	Yellow - lit	Maintenance demanded (warning)	Group warning (message can be deactiv-ated). At least one maintenance demanded alarm was transmitted to the controller. Possible causes: • Motor model has exceeded warning limit • Current value has exceeded/undershot warning limit For further causes, see section Overview of warnings and errors (Page 142).
Green - flashing	Red - flashing	Yellow - flashing	Defective	Device error detected, e.g. a defective switching element.

11.2.4 GRID

When the display is deactivated by setting the "Behavior of the GRID LED" parameter to "deactivated"

LED status	Meaning	Explanation
Off	• Main voltage present • No pending starting command	–
Red - flashing	Group error on the line side with ON command	• Line voltage missing / low / high • Phase failure • Main power rotation faulty

When the display is deactivated by setting the "Behavior of the GRID LED" parameter to "deactivated"

LED status	Meaning	3-phase load	1-phase load
Green - lit	Main energy available and ok	Line voltage L1, L2 and L3 within range (208 V - 480 V), main power rotation and frequency ok	Line voltage L1 within range (208 V - 480 V), main power rotation and frequency ok
Green - flashing	Main energy available and not ok	Overvoltage/undervoltage, fre-quency outside tolerance, main power rotation not ok	Overvoltage/under-voltage, frequency out-side tolerance
Red - flashing	Group error on the line side with ON command	Supply voltage missing/low/too high, phase failure, main power rotation faulty	Supply voltage miss-ing/low/too high, phase failure, main power rotation faulty

11.2.5 LOAD CW / CCW

LED status	Meaning	Explanation
Red - flashing	Error present on the load side	• Current limit monitoring • Motor blocking • Current unbalance • Missing load / connected incorrectly • Motor overload • Short-circuit • Ground fault • Process mapping error
Yellow - lit	Group warning on the load side	• Ground fault • Motor current • Current unbalance
Green - flashing	SmartStart	–
Green - lit	Start-up completed	Start-up in the selected direction of rotation is completed.
Green/red - flashing alternately	Ongoing emergency start	Signals the operation of the device in emergency start mode.

11.2.6 Overload / Short Circuit / Safety / Power

LED status				Meaning	Explanation
OL (Overload)	**SC** (Short Circuit)	**Safety**	**PWR** (Power)		
Red - flashing	Not applicable	Not applicable	Not applicable	Motor overload	Thermal motor model has tripped.
Not applicable	Red - flashing	Not applicable	Not applicable	Short-circuit	–
Not applicable	Not applicable	Not applicable	Green - lit	Supply voltage present	–

11.2.7 LED combinations

LED status						Meaning
OL (Overload)	**SC** (Short Circuit)	**Safety**	**PWR** (Power)	**GRID**	**LOAD (CD/CCW)**	
Red - lit	Red - lit	Green - lit	Green - lit	Yellow - lit	Yellow - lit	LED/fan test

11.3 TEST/RESET button

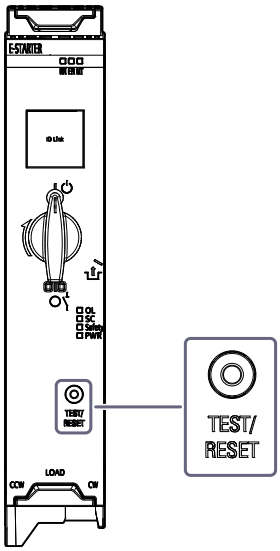

The TEST/RESET button has the following functions:

Designation	Tripping	Description
LED/fan test - press button	Actuation < 2 seconds	The LED/fan test is activated.
RESET function	Press of a button	If a group error is active, you can acknowledge this fault using the blue button if the error cause is no longer present. You can acknowledge device errors in principle only via ON/OFF of the control voltage. Process mapping error, shutdown due to input action "Emergency end position", "Setpoint unequal actual removal error" are acknowledged automatically.

NOTE

If a fault is active, you cannot execute the LED/fan test.

11.4 Diagnostics via the controller

If a specific fault occurs, the e-Starter ET 200SP generates an alarm and sends it to the head module. The head module then interrupts processing of the user program and calls up interrupt OBs automatically. The OB number and start information already provide you with information on the cause and type of fault.

Alarms

The e-Starter ET 200SP supports the following alarms:

- Diagnostic interrupt (error interrupt)
- Diagnostics interrupt (maintenance interrupt)
- Removal and insertion interrupt

11.5 Diagnostic interrupt (error interrupt) is triggered

In the case of a coming or going event, with appropriate parameterization, the e-Starter ET 200SP triggers a diagnostic interrupt. The diagnostic interrupt can either be disabled or enabled via the corresponding parameter in parameter data set 131.

Behavior when a diagnostic interrupt (error) is triggered

- The "ER" LED flashes red.
- The CPU of the controller then interrupts processing of the user program and processes the diagnostics interrupt OB (OB 82).
- The interrupt triggering event is logged in the start information of the diagnostic interrupt OB.
- Depending on the model, the controller switches to the "STOP" operating state if the diagnostics interrupt OB is not available.

11.6 Diagnostic interrupt (maintenance) is triggered

The aim of maintenance interrupts is to enable early detection and correction of potential faults. In the case of a coming or going event, with appropriate parameterization, the e-Starter ET 200SP triggers a diagnostic interrupt (maintenance interrupt). The diagnostic interrupt can either be disabled or enabled via the corresponding parameter in parameter data set 131.

Behavior when a diagnostic interrupt (maintenance) is triggered

- The "MT" LED lights up yellow.
- The CPU of the controller then interrupts processing of the user program and processes the diagnostics interrupt OB (OB 82).
- The interrupt triggering event is logged in the start information of the diagnostic interrupt OB.
- Depending on the model, the controller switches to the "STOP" operating state if the diagnostics interrupt OB is not available.

11.7 Extended maintenance

You will find general information on extended maintenance in the "Diagnostics" chapter of the SIMATIC PROFINET (https://support.industry.siemens.com/cs/ww/en/view/49948856) Function Manual.

The PROFINET interfaces of the interface module support the diagnostics concept and the maintenance concept in PROFINET according to the standard IEC 61158-6-10.

System alarms for maintenance

The maintenance information is generated in STEP 7 with the following system messages:

- Maintenance demanded, symbolized by a yellow screwdriver.
- Faults, symbolized by a red screwdriver.

11.8 Removal and insertion interrupt is triggered

The removal and insertion interrupt is triggered by turning the lockable rotary interlock to the parking position, and then turning it back to the operating position.

Behavior with triggered removal and insertion interrupt

- The CPU of the controller then interrupts processing of the user program and processes the removal and insertion OB (OB 83).
- The interrupt triggering event is logged in the start information of the removal and insertion interrupt OB.

11.9 Reading out the diagnostics in STEP 7 (TIA Portal)

You have the following options for reading out the diagnostics using the TIA portal:

- HW Config: Device diagnostics as plain text on the STEP 7 user interface
- SFB 52 (RDREC): Read data sets from the I/O device
- SFB 54 (RALRM): Receive interrupts from the I/O device

More information

You can find more information in the Online Help for STEP 7 and in the corresponding manuals for PROFINET.

11.10 Overview of warnings and errors

The following table lists the error types supported by the e-Starter ET 200SP. These errors and warnings are also transmitted to the engineering system (TIA Portal) and displayed there in plaintext. In addition, the supported errors and warnings can also be found in data set 92. The error codes are also transmitted to higher-level systems via PROFINET, enabling comprehensive diagnosis and further processing.

Error type	Error type (decimal)	Fault / Warning	Type	Object No.	Byte.Bit
0x0003	3	Overvoltage	Error	1407	29.0
0x0007	7	High limit exceeded	Error	1482	31.2
0x011B	283	Invalid/inconsistent firmware present	Error	378	38.3
0x0317	791	Relay cannot be switched off (contacts welded)	Warning	1657	73.3
0x100B	4107	Main circuit power failure	Error	319	11.1
0x1011	4113	Generator operation	Warning	322	13.6
0x1013	4115	2-phase control active	Warning	1578	73.0
0x1014	4116	Error after self-diagnosis	Error	381	19.2
0x1019	4121	Phase failure L1	Error	1409	25.2
0x101A	4122	Phase failure L2	Error	1410	25.3
0x101B	4123	Phase failure L3	Error	1411	25.4
0x1020	4128	Prewarning overload (I>115%Ie)	Warning	1539	62.3
0x1021	4129	Phase unbalance	Error	340	14.0
0x1021	4129	Phase unbalance	Warning	1543	62.6
0x1022	4130	Thermal motor model overload	Error	327	12.3
0x1027	4135	Ground fault	Error	342	16.0
0x1027	4135	Ground fault	Warning	1544	62.7
0x1040	4160	Above threshold I	Error	334	14.2
0x1040	4160	Above threshold I	Warning	1541	62.4
0x1041	4161	Below threshold I	Error	335	14.3
0x1041	4161	Below threshold I	Warning	1542	62.5

Error type	Error type (decimal)	Fault / Warning	Type	Object No.	Byte.Bit
0x1046	4166	Actuator shutoff	Error	328	12.4
0x1046	4166	Actuator shutoff	Error	341	14.1
0x1046	4166	Actuator shutoff	Error	336	14.4
0x1046	4166	Actuator shutoff	Error	343	16.1
0x1046	4166	Actuator shutoff	Error	20007	–
0x104C	4172	Motor blockage	Error	339	14.7
0x104C	4172	Motor blockage during start-up	Error	1622	82.1
0x104C	4172	Motor blockage during operation	Error	1623	82.2
0x1080	4224	Device error	Error	1523	35.0
0x1080	4224	Device error	Error	452	–
0x1080	4224	Device error	Error	456	–
0x1080	4224	Device error	Error	464	–
0x1080	4224	Device error	Error	465	–
0x1080	4224	Device error	Error	486	–
0x1080	4224	Device error	Error	487	–
0x1082	4226	Power semiconductor device defective	Error	308	10.4
0x1083	4227	Switching element overload	Error	309	10.3
0x1083	4227	Switching element overload	Warning	1416	31.1
0x1083	4227	Switching element overload	Warning	1580	77.0
0x1084	4228	Electronics supply voltage too low	Error	317	16.7
0x1088	4232	Supply voltage to switching element missing	Error	318	11.0
0x1089	4233	Remaining time for tripping underrun	Warning	1538	62.2
0x1093	4243	Sensor supply overload	Error	354	16.3
0x1094	4244	Module slot wrong or configuration faulty	Error	1454	22.3
0x1095	4245	Parameter fault	Error	365	18.1
0x1096	4246	Process mapping error	Error	355	17.7
0x1098	4248	Connection abort in manual-bus mode	Warning	360	17.6
0x109D	4253	Input shutoff	Error	348	15.4
0x109D	4253	Input shutoff end position CW	Error	349	15.5
0x109D	4253	Input warning	Warning	351	15.6
0x109D	4253	Input shutoff end position CCW	Error	350	15.7
0x1601	5633	Main voltage device limit exceeded	Error	1481	25.7
0x1609	5641	Missing load	Error	1408	25.0
0x1619	5657	Switching element in phase L1 defective	Error	1466	29.5
0x161A	5658	Switching element in phase L2 defective	Error	1467	29.6
0x161B	5659	Switching element in phase L3 defective	Error	1468	29.7
0x161D	5661	Short-circuit in phase T1	Error	1799	81.4
0x161E	5662	Short-circuit in phase T2	Error	1800	81.5

Error type	Error type (decimal)	Fault / Warning	Type	Object No.	Byte.Bit
0x161F	5663	Short-circuit in phase T3	Error	1801	81.6
0x1621	5665	Maintenance demanded for the application	Warning	1461	37.1
0x510A	20746	Fan error	Warning	1629	77.5
0x510E	20750	Error rotating field	Error	1563	75.0

11.11 Errors and remedial actions

Error	Cause	Remedy
Switching element overload	Switching element (switching contact, power semiconductor) too hot.	• Check the ambient conditions linked to cooling. You might have to take derating into consideration. • Check the number of switching operations. • Acknowledgment after cooling down. The acknowledgment depends on the "Response to overload switching element" parameter that has been set.
Switching element defective	The power semiconductors in the device are defective.	Replace the device.
Supply voltage to switching element missing	No supply voltage detected.	Check the power supply to the switching elements and the cabling.
Main circuit power failure	A power failure lasted longer than the max. permissible power failure time.	Check the wiring of the main infeed or the switching status of an upstream circuit breaker.
Thermal motor model overload	• The motor feeder has been overloaded. • The motor temperature rise has exceeded a limit.	• Check the motor and the applications driven by the motor. • You can switch on the motor again after the cooling-down period has expired or after deleting the thermal motor model. The acknowledgment depends on the "Response to overload - thermal motor model" parameter that has been set.
Actuator shutoff	The module has disconnected the actuator.	An additional diagnostic message will be displayed to provide you with more detailed information about the cause.
Phase unbalance	The limit value for asymmetry has been exceeded. Asymmetry can cause an overload. Possible causes: • Phase failure • Fault in the motor windings	Check the motor feeder and the motor.
Above threshold I	The current has exceeded a limit.	Check the application driven by the motor.
Below threshold I	The current has undershot a limit value.	Check the application driven by the motor.

Error	Cause	Remedy
Motor blockage	The maximum motor current has exceeded a limit for blocking protection. Possible causes: • The motor is blocked.	Check the application that is driven by the motor.
Input action	An error shutdown or warning was triggered by an input action of the Basic 4DI (LC) submodule.	Check the application.
Ground fault	The ground-fault monitoring has responded. An impermissibly high residual current is flowing.	Check the connecting cable of the motor and the motor for damage.
Sensor supply overload	The output driver for the sensor supply is overloaded.	Check the cabling and the sensor.
Electronics supply voltage too low	The supply voltage is below the permissible value.	Check the power supply (load dimensioning, voltage range).
Process mapping error	The process image output (PIQ) contains invalid control bit combinations (e. g. control bits for clockwise and counter-clockwise rotation set at the same time).	Check and correct the process image outputs (PIQ).
Parameter fault	The module is not or is incorrectly parameterized or changes to parameter settings are rejected in the current operating state.	• Correct the parameter settings and apply the corrected settings. • Change the operating state and repeat the parameterization.
Error after self-diagnosis	Error after self-diagnosis (self-test) detected.	Switch off the supply voltage (control supply voltage) for at least 5 seconds and switch it on again. If the error is still present, proceed as follows: • Contact technical support. • Replace the device.
Module slot wrong or configuration faulty	Real and configured slot of the module are different.	Ensure consistency between the inserted and configured position of the module. There may also be a wiring error on the referenced module.
Missing load	The switching element is closed, main voltage is present, but no current is flowing in at least one of the phases. Possible causes: • Voltage interrupted or current too low to be detected.	Check the wiring from the device to the load. Acknowledgment once the cause has been rectified.
Phase failure L1	The main energy monitoring system has detected a phase failure.	Check the cabling of phase L1. Acknowledgment once the cause has been rectified.
Phase failure L2	The main energy monitoring system has detected a phase failure.	Check the cabling of phase L2. Acknowledgment once the cause has been rectified.
Phase failure L3	The main energy monitoring system has detected a phase failure.	Check the cabling of phase L3. Acknowledgment once the cause has been rectified.
Main voltage device limit exceeded	The main voltage has exceeded the limits of the device.	Check the main voltage.

Error	Cause	Remedy
Overvoltage	The supply voltage is above the tolerance limit.	Change the power supply.
Switching element in phase L1 defective	A defect was detected in the switching element of phase L1 for the load.	Perform a self-test of the device. Replace the device if errors recur.
Switching element in phase L2 defective	A defect was detected in the switching element of phase L2 for the load.	Perform a self-test of the device. Replace the device if errors recur.
Switching element in phase L3 defective	A defect was detected in the switching element of phase L3 for the load.	Perform a self-test of the device. Replace the device if errors recur.
High limit exceeded	• With sensors: The measured value has exceeded the range limits. • With actuators: The output value has exceeded an upper limit.	Check the interaction between the module and the sensor or actuator.
Device error	Irrecoverable error after self-diagnosis (self-test, switching element, etc.).	Replace the device.
Invalid/inconsistent firmware present	The firmware is incomplete, the firmware extensions are incomplete or incompatible, or the firmware update was canceled.	• Execute a complete firmware update. • Check any error messages that occur. • Check to see whether or not the firmware update has been interrupted. • If a firmware update is canceled: Repeat the firmware update or set the rotary lock of the e-Starter ET 200SP to the park position and then turn the rotary lock back to the operating position. The e-Starter ET 200SP will then start up again.
Error rotating field	The direction of rotation field is not correct.	–
Short-circuit in phase T1	A short-circuit was detected in phase T1 and switched off.	Check the connected load.
Short-circuit in phase T2	A short-circuit was detected in phase T2 and switched off.	Check the connected load.
Short-circuit in phase T3	A short-circuit was detected in phase T3 and switched off.	Check the connected load.

Technical data

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12.1 Technical specifications in the Siemens SiePortal

Technical data sheet

You can find the technical specifications for the product in Siemens SiePortal (https://sieportal.siemens.com/su/bldxc).

1. Enter the article number of the desired device in the "Products" field.
2. Click the "Technical specifications" link in the result.

Dimensional drawings

13

13.1 CAx data in the Siemens SiePortal

You can find CAx data for the product in the SiePortal (https://sieportal.siemens.com/su/bldxc).

1. Enter the article number of the desired device in the "Products" field.
2. Click the "CAx data" link in the result.

Circuit diagrams 14

14.1 CAx data in the Siemens SiePortal

You can find CAx data for the product in the SiePortal (https://sieportal.siemens.com/su/bldxc).

1. Enter the article number of the desired device in the "Products" field.
2. Click the "CAx data" link in the result.

Connection examples/applications 15

15.1 Connection and operation of asynchronous motors with integrated holding brake

Safety instructions

NOTE

Increase of the rated current

When using the e-Starter ET 200SP with asynchronous motors with integrated holding brakes, you must increase the set rated current of the motor by the brake current.

NOTE

Adjusting the limits for current asymmetry monitoring

Operating the e-Starter ET 200SP with asynchronous motors with integrated holding brakes results in phase asymmetry at the motor connection, which is detected by the e-Starter ET 200SP and to which it reacts depending on the parameterization and magnitude of the asymmetry. As a result, the asymmetry limit should be adjusted or asymmetry monitoring should be deactivated.

Description

The e-Starter ET 200SP enables direct control of asynchronous motors with integrated holding brakes. No additional switchgear is required.
A holding brake for asynchronous motors is an electromagnetically operated brake that ensures the motor shaft remains stationary when the motor is switched off. It is often used in applications where a load must be held in position, e.g. in elevators, cranes, or conveyor systems.
The holding brake prevents the motor shaft from continuing to rotate unintentionally when at a standstill by acting mechanically on the shaft as soon as the motor is de-energized. It is closed by spring force and opened by applying an electrical voltage.
This function is implemented in such a way that both the asynchronous motor and the holding brake are connected together to the motor feeder of the e-Starter ET 200SP.
When the asynchronous motor is controlled, the brake is automatically released via the connected brake rectifier so that it can start freely. After the asynchronous motor is switched off, the brake voltage drops, causing the brake to apply again and reliably hold the motor in the desired position.
The current for 400 V brake rectifiers can be taken from any phase. For 230 V brake rectifiers, it must be taken from T1.

15.2 Connection example for asynchronous motor

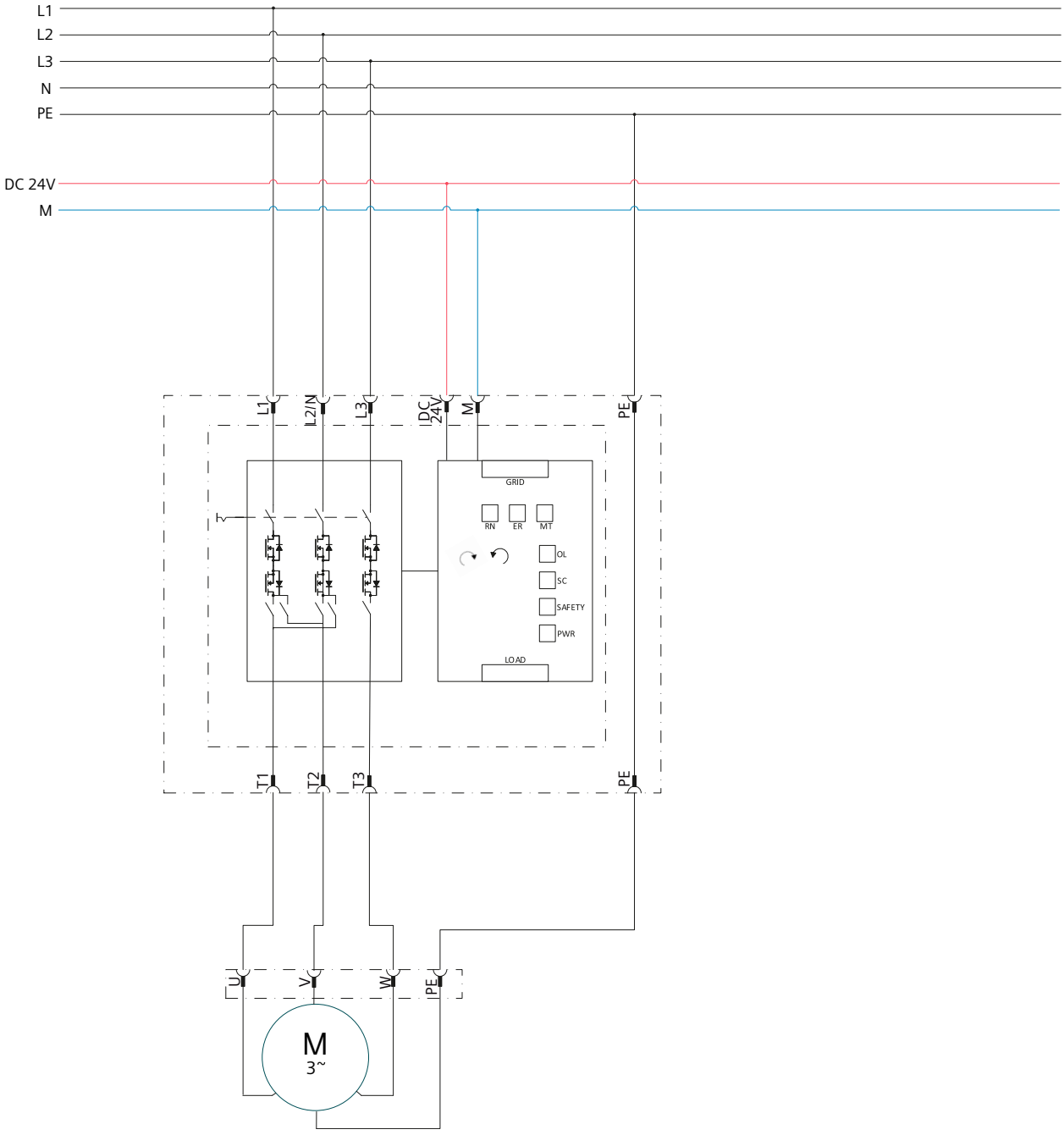

15.3 Connection example for asynchronous motor with electromechanical brake between 2 phases

The following connection example shows the connection of the brake to L1 and L2. The brake can also be connected to L2 and L3, as well as L1 and L3.

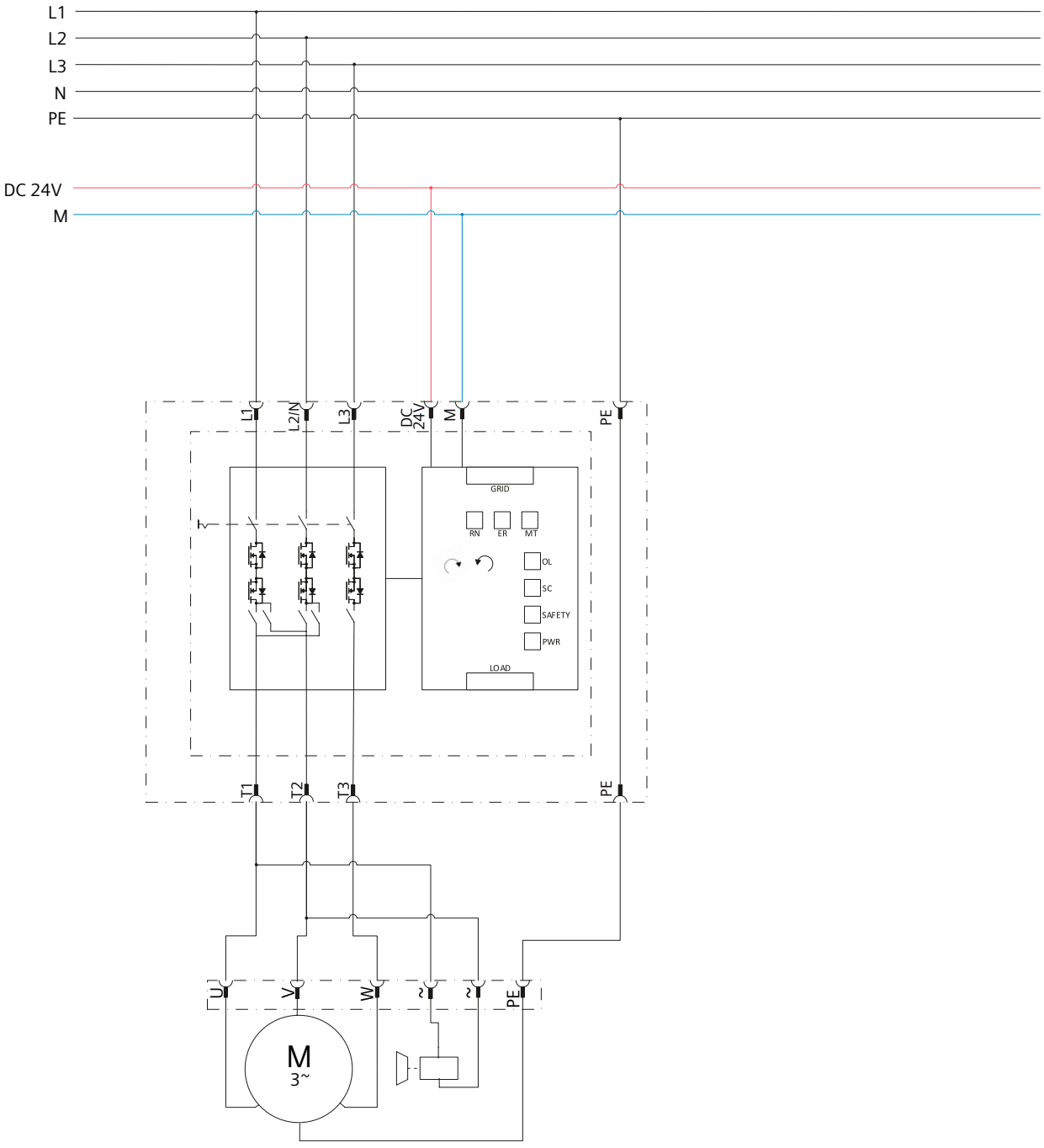

15.4 Connection example for asynchronous motor with electromechanical brake 230 V - neutral point connection

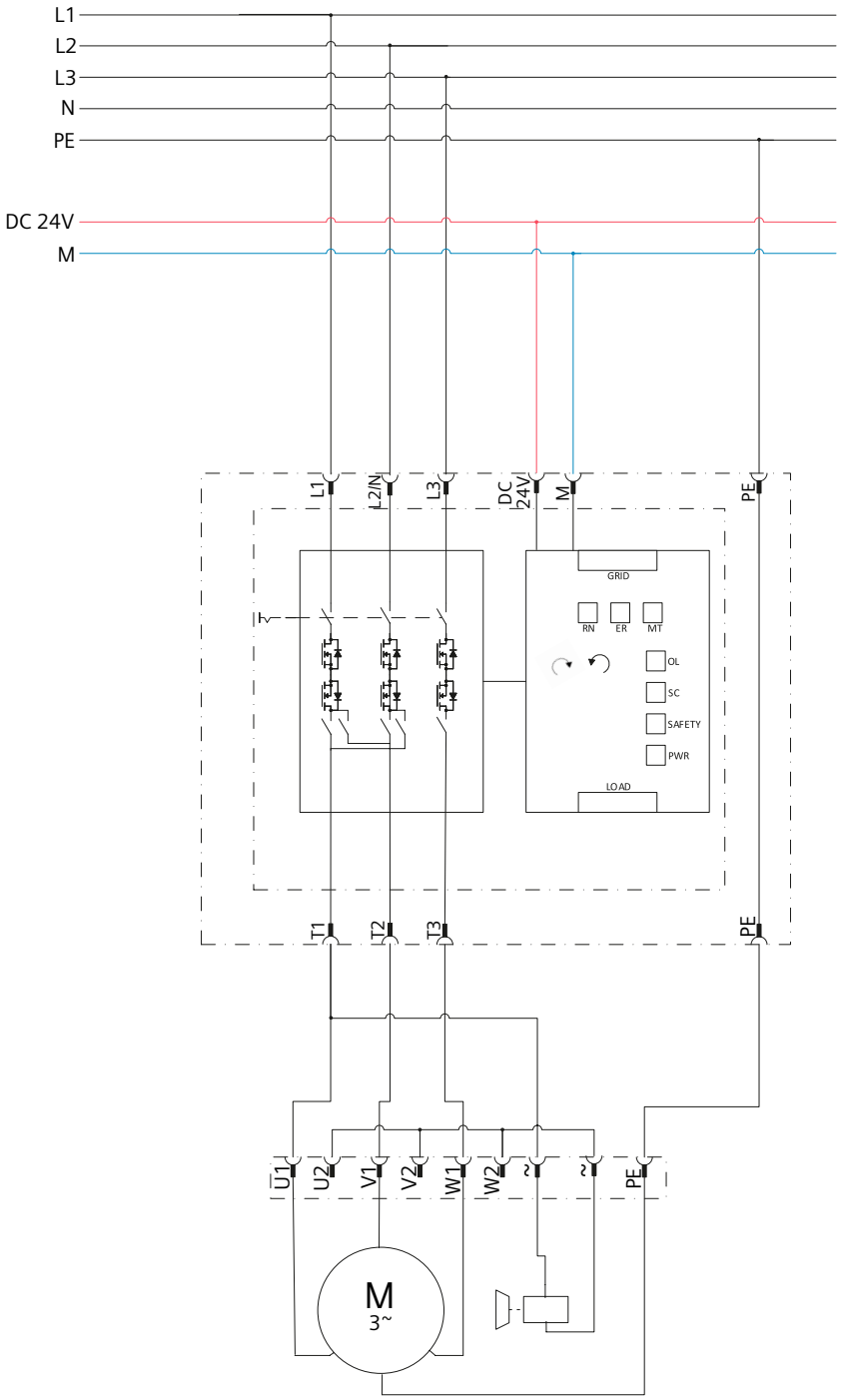

15.5 Connection example for asynchronous motor in Steinmetz circuit (1-phase operation)

The following connection example shows the connection of the motor to L1.

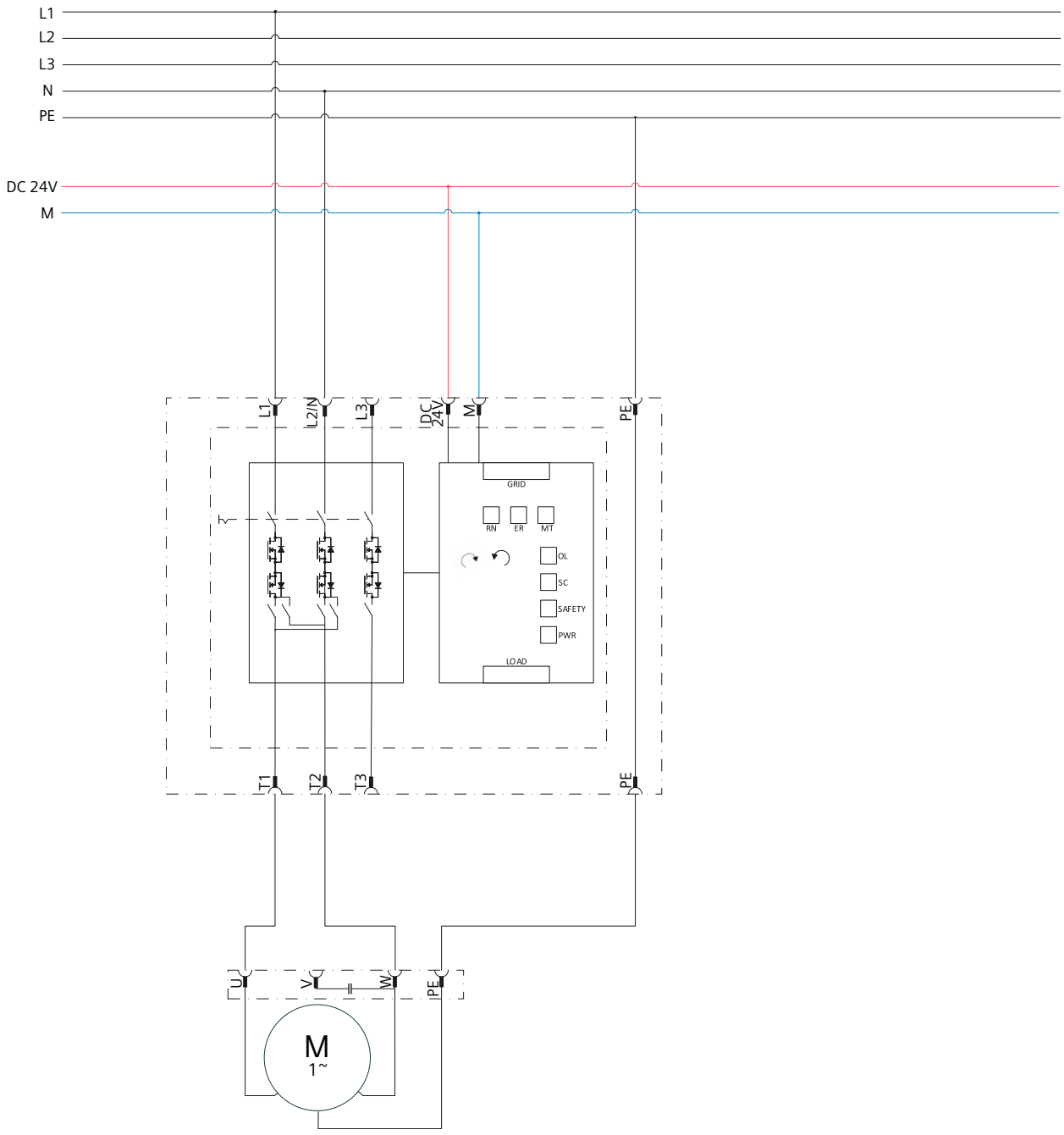

15.6 Connection example for single-phase motor (capacitor motor) - clockwise rotation

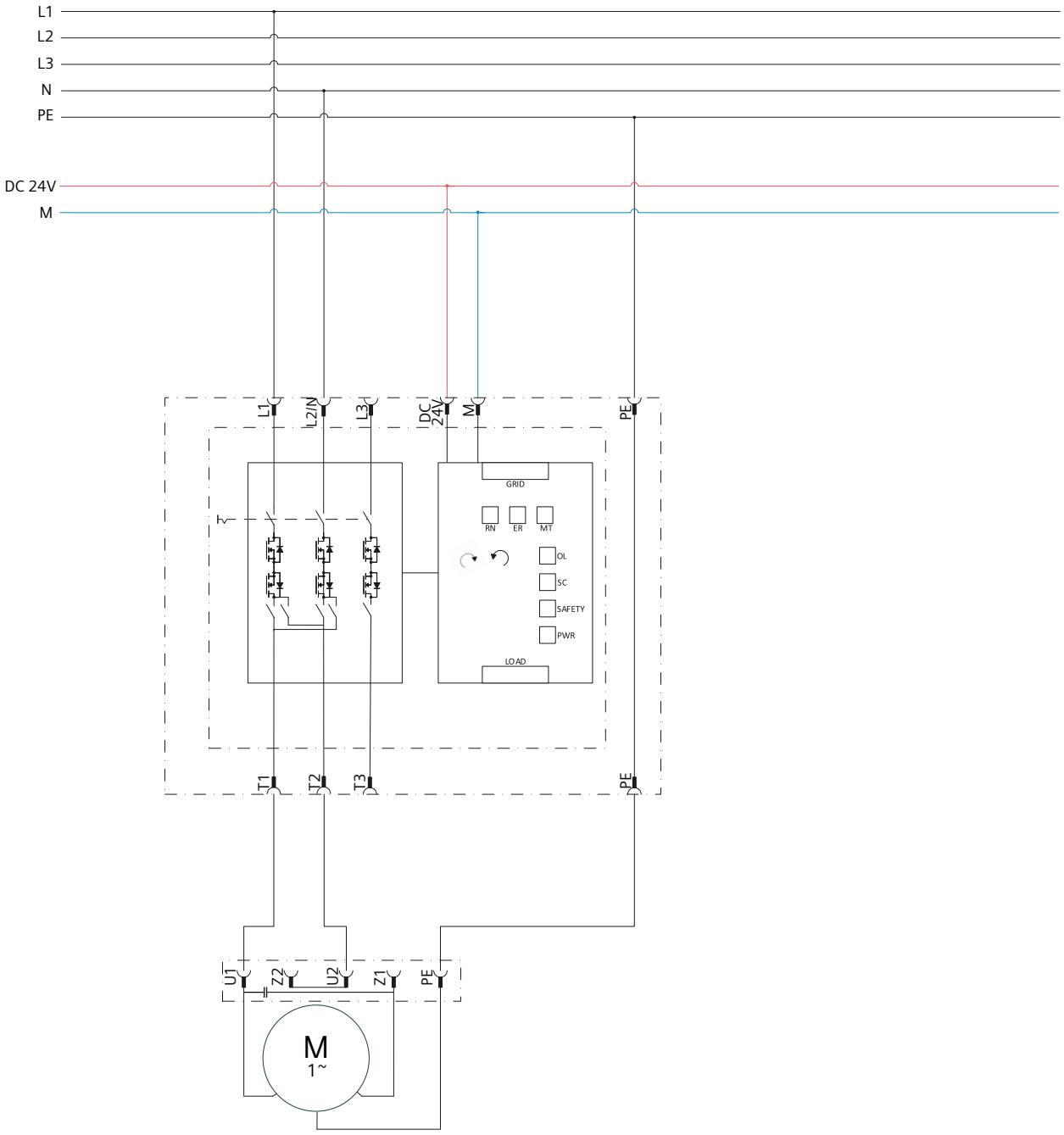

15.7 Connection example for single-phase motor (capacitor motor) - counter-clockwise rotation

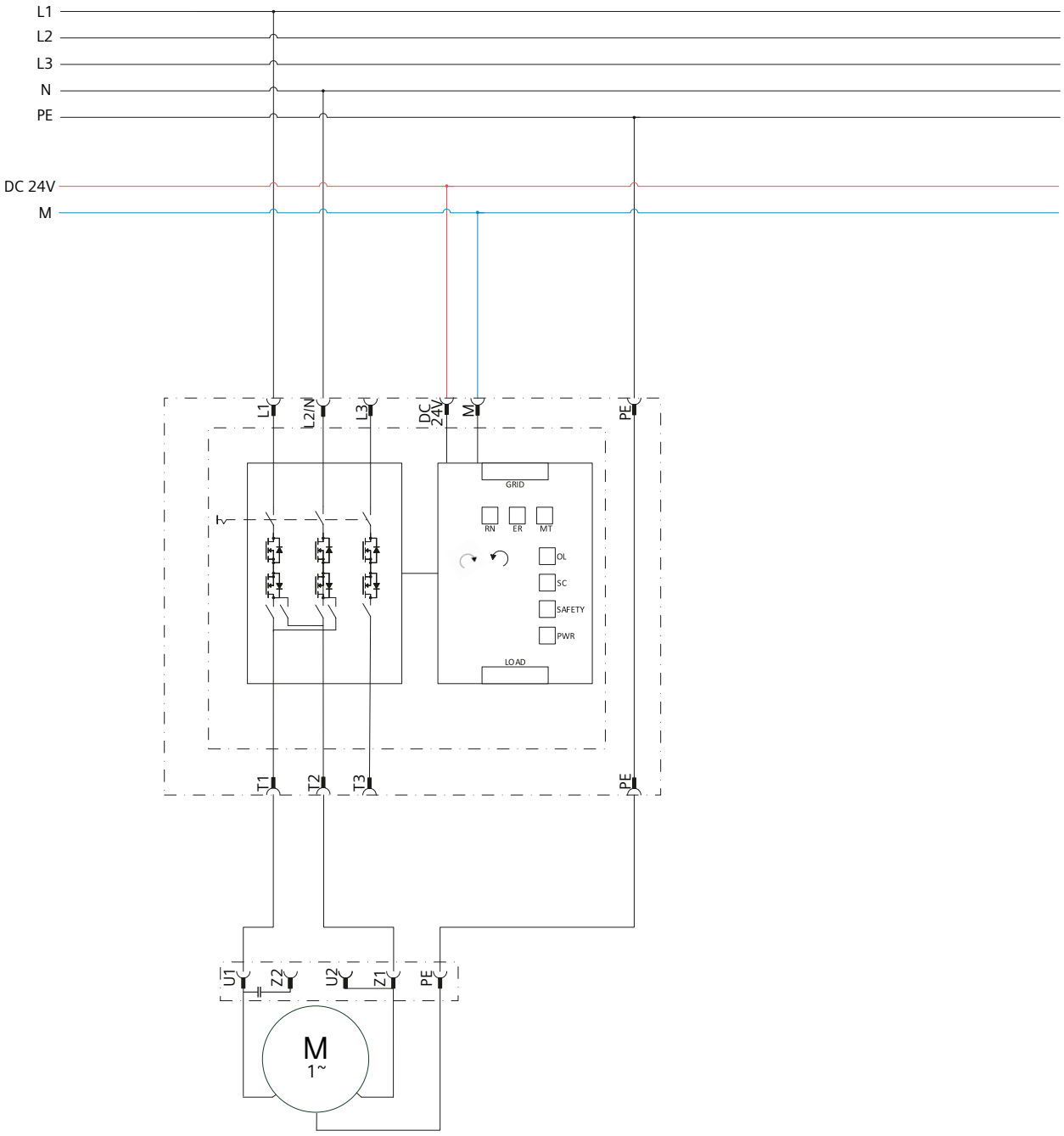

15.8 Connection example for resistance loads

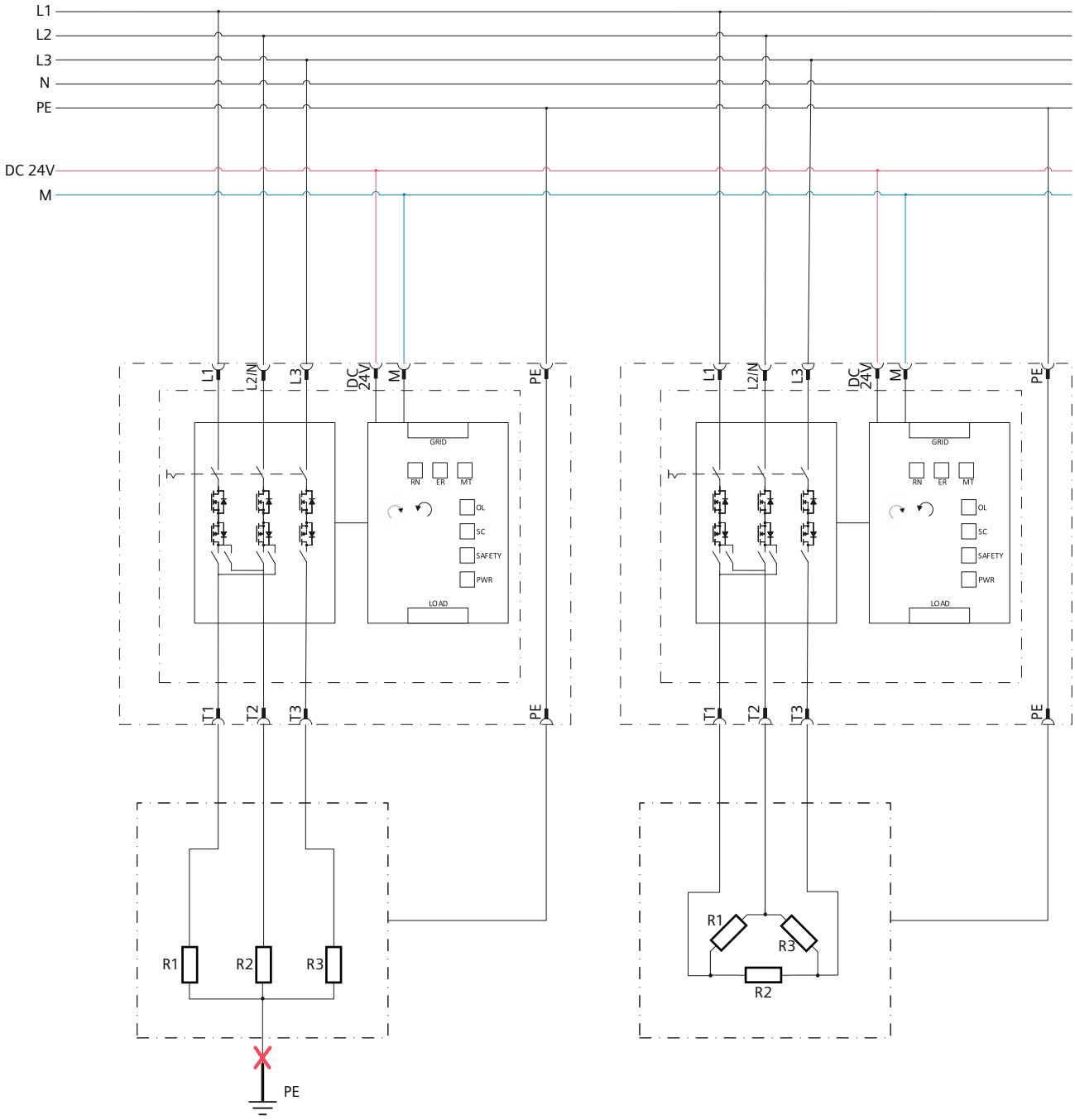

15.9 Basic 4DI (LC) submodule connection diagram

The following graphic shows a connection diagram of the Basic 4DI (LC) submodule:

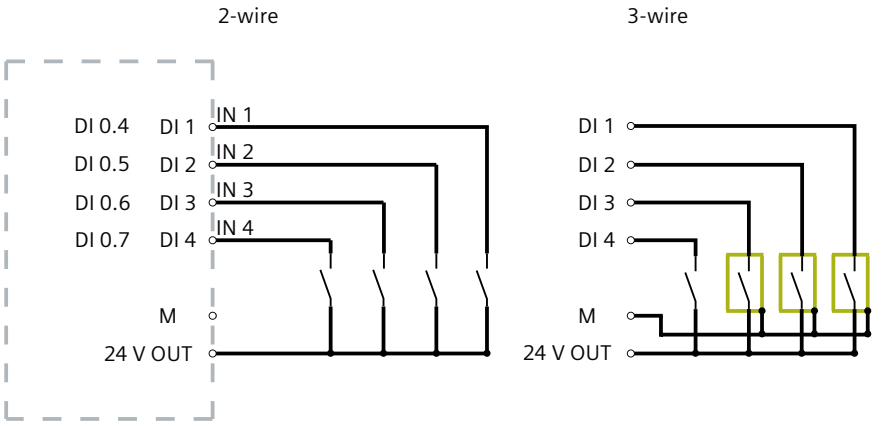

DI 0.4 to DI 0.7: Bit in PII

Appendix A

A.1 Data sets

Data set		Length
Number	**Description**	
3	Commands with additional values (Page 161)	200 bytes
68	Process image output (PIQ) (Page 161)	16 bytes
69	Process image input (PII) (Page 162)	28 bytes
70-79	Logbooks (Page 163)	200 bytes
92	Diagnostics (Page 166)	100 bytes
93	Commands (Page 169)	10 bytes
94	Measured values (Page 170)	120 bytes
95	Statistic data (Page 171)	200 bytes
96	Maximum pointer (Page 172)	200 bytes
131	Parameters (Page 173)	200 bytes
132	Advanced parameters 1 (Page 178)	200 bytes
134	Parameter - maintenance (Page 179)	200 bytes
135	Parameter cyclic process image (Page 180)	24 bytes
222	Access via object no. (Page 180)	12 bytes
I&M data (Page 181)		
0xAFF0	I&M0 data - Device identification	60 bytes
0xAFF1	I&M1 - reference designation	60 bytes
0xAFF2	I&M2 - installation	22 bytes
0xAFF3	I&M3 - description	60 bytes

A.1.1 Byte arrangement

When data longer than one byte are stored, the bytes are arranged as follows ("big endian"):

Byte arrangement			Data type
Byte 0	High byte	High word	Double word
Byte 1	Low byte		
Byte 2	High byte	Low word	
Byte 3	Low byte		
Byte 0	High byte		Word
Byte 1	Low byte		
Byte 0	Byte 0		Byte
Byte 1	Byte 1		

A.1.2 Specifications

The following specifications apply in the data sets:

- Non-relevant (reserved) entries are not listed.

  Fill these entries with "0" when writing.

  When reading the data sets, unsupported bytes are delivered with 0x00.
- In data sets for parameters, the set values are listed.
  "(D)" denotes the default coding.

A.1.3 Object number (Obj. No.)

Object number (Obj. No.)

The object number (Obj. No.) is used for unique identification of all parameters available in the e-Starter ET 200SP. In the case of a parameterization error, the object number of the faulty parameter is displayed in data set 92 under "Faulty parameter number" (20.0).

A.1.4 Data set 3: Commands with additional values

You can use this data set to set the corresponding values using a command.
To do this, enter the object number of the value you want to change in byte 12 of the data set. Also enter the desired value in byte 14. These two values are processed by the device and then automatically deleted from the command memory.

With object number 12003, you can set the operating hours of the motor to a defined value.

With object number 12004, you can change the connection monitoring time in manual operation bus mode to a range from 0 to 255 s (default setting: 5 s). The device enters a safe state if the connection is interrupted within the set time. If the connection is interrupted, the error message "Manual operation connection abort" (DS92 byte 17.6) is also output.

Byte	Data type	Meaning
0	USINT	Coordination [0x21] Write via acyclic bus channel – user program
12	UINT	Object No. of the command • 12003 = Set operating hours - motor • 12004 = Manual operation
Additional values (command-specific)		
14	UDINT	Operating hours (object no. 12003)
14	USINT	Monitoring time [s] (object no. 12004)

A.1.5 Data set 68: Process image of the outputs (PIQ)

Read (r) and write (w) access to the process image output (PIQ) is possible.

NOTE

Note that data set 68 is overwritten by the cyclic process image in "Automatic" mode.

Byte	Bit	Data type	Meaning
0	0	USINT	Coordination [0x21] Write via acyclic bus channel – user program
12	0	BOOL	Motor CW
12	1	BOOL	Motor CCW
12	3	BOOL	Reset
12	4	BOOL	Emergency start
12	5	BOOL	Self-test (user-test)
13	7	BOOL	Disable Quick-stop
14	2	BOOL	Cold running
15	0	BOOL	Input controlled

NOTE

In "Automatic" mode, the PLC specifies the process image of the outputs. In this case, reading of data set 68 returns the process image output as transmitted by the PLC.

A.1.6 Data set 69: Process image input (PII)

Only read (r) access to the process image input (PII) is possible.

Byte	Bit	Data type	Meaning
0	0	USINT	Coordination
12	0	BOOL	Ready (automatic)
12	1	BOOL	Motor On
12	2	BOOL	Group error
12	3	BOOL	Group warning
12	4	BOOL	Input 1
12	5	BOOL	Input 2
12	6	BOOL	Input 3
12	7	BOOL	Input 4
13	0	BOOL	Motor current Iact-bit0[1)]
13	1	BOOL	Motor current Iact-bit1[1)]
13	2	BOOL	Motor current Iact-bit2[1)]
13	3	BOOL	Motor current Iact-bit3[1)]
13	4	BOOL	Motor current Iact-bit4[1)]
13	5	BOOL	Motor current Iact-bit5[1)]
13	6	BOOL	Operating mode manual - local
13	7	BOOL	Ramp operation
14	0	BOOL	Motor CW
14	1	BOOL	Motor CCW
14	4	BOOL	Starting mode active
14	5	BOOL	Operation active
14	7	BOOL	Parameter lock active
15	0	BOOL	Thermal motor model overload
15	2	BOOL	Switching element overload
15	5	BOOL	Main energy faulty
15	6	BOOL	Overtemperature
16	0	REAL	Measured value 1
20	0	REAL	Measured value 2
24	0	REAL	Measured value 3

1) stated in % with factor 3.125

A.1.7 Data set 70 - 79: Logbooks

Method of operation

The logbook lists events, warnings, and errors in chronological order. Each of these entries is given a time stamp (operating hours of the device). With the e-Starter ET 200SP, there are the following logbooks:

Data set	Message source	Message type	Number of entries	Note
70	Application	Fault	112	• Can be deleted • Overwritable (ring buffer) • All messages are entered as incoming messages (in DS 72 and 74 also as out-going messages)
72		Warning	112	
74		Event	112	
76	Device	Fault, operation fault, warning, prewarning, event	112	• Cannot be deleted • Overwritable (ring buffer) • All messages are entered as incoming messages
77	Service	Fault (disturbance, operation fault)	112	• Can only be deleted by Service • Overwritable (ring buffer) • All messages are entered as incoming messages
79		Event	371	

Data structure

DS 7...		
0 ... 3	–	Data set header
Data structure header		
4 ... 5	UINT	Length of data structure
6 ... 7	UINT	StartPosition
8 ... 9	–	Reserved
Logbook structure		
10 ... 19	–	Logbook structure
Logbook entry 1		
20	UDINT	Operating hours
24	Long double	Reserved
32	USINT	Reserved
33	USINT	Reserved
34	UDINT	Device component ID

DS 7...		
38	UINT	No. device address level 1
40	USINT	Message type
41	USINT	Reserved
42	UINT	Object number
Logbook entry 2		
44	UDINT	Operating hours
48	Long double	Reserved
56	USINT	Reserved
57	USINT	Reserved
58	UDINT	Device component ID
62	UINT	No. device address level 1
64	USINT	Message type
65	USINT	Reserved
66	UINT	Object number
Logbook entry 3 .... n		

If the data structure length is longer than the max. 200 bytes, the data structure is automatically transferred in segments. If the data structure is shorter, there is no segmented transfer.

Before the first read-out, i.e. the first data segment, the "StartPosition" object contains the value "0". To read the following entries, the same data set must be read again within 5 seconds. With each subsequent readout, the start position is incremented, as indicated by byte 6.
If the data record is read after 5 seconds have elapsed, the first block (entries 1-7) is read out again. This can be seen in byte 6 of the start position. If the value of the start position is 0, the first block is read or the end of the logbook has been reached.

NOTE

Timeout during readout leads to termination

If the access source does not request the next data segment within a certain time (5 seconds), the device aborts the segmented readout and starts again at StartPos "0".

Reading from the device

1st reading (total length of up to 188 bytes)

Byte	Meaning
0-3	NST2000 header
4-9	Data structure header
10-19	Logbook structure
20-187 (7x 24)	Logbook entry 1 - 7

During the 1st reading, the logbook structure is output in addition to the data set header, the data structure header, and the logbook entries. This means that the output of the 1st logbook entry begins at byte 20.

2nd to nth reading (total length of up to 178 bytes)

Byte	Meaning
0-3	NST2000 header
4-9	Data structure header
10-177 (7x 24)	Logbook entry 8-14 (2nd reading) 15-21 (3rd reading) ...

With each subsequent read operation within 5 seconds, the logbook structure is no longer output. This means that the output of the logbook entries starts at byte 10.

Number of log entries output per read operation

During a read operation, 7 log entries are output, except for the last read operation. During the last read operation, the remaining log entries are output.

If, for example, 22 logbook entries are available, during the 1st, 2nd, and 3rd read operations 7 logbook entries are output. During the 4th read operation, only 1 logbook entry is output.

Example of a read logbook data set

```
00 00 00 00 01 90 00 00 00 00 00 00 00 00 00 00 00 00 00 01 00 00 80 0F
00 00 00 00 00 00 00 00 00 00 01 00 4F 81 00 04 01 00 01 3F 00 00 80 0D
00 00 00 00 00 00 00 00 00 00 01 00 4F 81 00 04 01 00 01 47 00 00 80 09
00 00 00 00 00 00 00 00 00 00 01 00 4F 81 00 04 01 00 06 1B 00 00 80 04
00 00 00 00 00 00 00 00 00 00 01 00 4F 81 00 04 01 00 05 83 00 00 44 DB
00 00 00 00 00 00 00 00 00 00 01 00 4F 81 00 04 01 00 01 62 00 00 44 D4
00 00 00 00 00 00 00 00 00 00 01 00 4F 81 00 04 01 00 07 07 00 00 44 CF
00 00 00 00 00 00 00 00 00 00 01 00 4F 81 00 04 01 00 06 1B

00 00 00 00 01 90 00 B8 00 00 00 00 44 9A 00 00 00 00 00 00 00 00 00 00
01 00 4F 81 00 04 01 00 05 80 00 00 21 C9 00 00 00 00 00 00 00 00 00 00
01 00 4F 81 00 04 01 00 01 3D 00 00 05 8A 00 00 00 00 00 00 00 00 00 00
01 00 4F 81 00 04 01 00 01 3D 00 00 05 88 00 00 00 00 00 00 00 00 00 00
01 00 4F 81 00 04 01 00 01 3D 00 00 05 86 00 00 00 00 00 00 00 00 00 00
01 00 4F 81 00 04 01 00 01 3D 00 00 05 84 00 00 00 00 00 00 00 00 00 00
01 00 4F 81 00 04 01 00 01 3D 00 00 05 81 00 00 00 00 00 00 00 00 00 00
01 00 4F 81 00 04 01 00 01 3D

00 00 00 00 01 90 01 60 00 00 00 00 05 7A 00 00 00 00 00 00 00 00 00 00
01 00 4F 81 00 04 01 00 01 3F 00 00 05 23 00 00 00 00 00 00 00 00 00 00
01 00 4F 81 00 04 01 00 01 47
```

Blue	Length of data structure (formula: 16 + "number of logbook entries in the logbook" * 24)
Red	Start position: The start position counts up with each readout. (formula: 16 + "number of read operations" * 7 * 24)
Green	Logbook structure: The logbook structure is only available for the first readout.
Yellow	1st entry of the corresponding readout process
Gray	Device component ID
Orange	No. device address level 1: Slot number

Message types

Output value	Meaning of message type
1	Error
2	Operating error
3	Warning
4	Pre-warning
5	Event
6	Information

A.1.8 Data set 92: Diagnostics

The diagnosis describes the current state of the e-Starter ET 200SP.

Only read (r) access to the diagnosis is possible.

Byte	Bit	Data type	Obj. No.	Meaning
0	0	USINT	–	Coordination
4	0	UINT	–	Length of data structure
6	0	UINT	–	Start position
10	0	BOOL	301	Ready (automatic)
10	1	BOOL	306	Motor CW
10	2	BOOL	307	Motor CCW
10	3	BOOL	309	Switching element overload
10	4	BOOL	308	Switching element defective
10	5	BOOL	310	Emergency start active[1)]
10	6	BOOL	302	Group error
10	7	BOOL	304	Group warning
11	0	BOOL	318	Supply voltage to switching element missing
11	1	BOOL	319	No supply voltage
11	3	BOOL	312	Starting mode active
12	3	BOOL	327	Thermal motor model overload
12	4	BOOL	328	Motor overload protection - shutoff
12	6	BOOL	330	Cooling time active
13	6	BOOL	322	Generator operation
13	7	BOOL	352	Input control
14	0	BOOL	340	Asymmetry limit error exceeded
14	1	BOOL	341	Asymmetry shutoff
14	2	BOOL	334	Current limit error exceeded
14	3	BOOL	335	Current limit error undershot
14	4	BOOL	336	Current limit error shutoff
14	7	BOOL	339	Motor blocking shutoff

1) Set value available from firmware version V1.1

Byte	Bit	Data type	Obj. No.	Meaning
15	0	BOOL	344	Input 1
15	1	BOOL	345	Input 2
15	2	BOOL	346	Input 3
15	3	BOOL	347	Input 4
15	4	BOOL	348	Input shutoff
15	5	BOOL	349	Input shutoff end position CW
15	6	BOOL	351	Input warning
15	7	BOOL	350	Input shutoff end position CCW
16	0	BOOL	342	Ground fault limit error exceeded
16	1	BOOL	343	Ground fault tripping
16	2	BOOL	353	Quick-stop active
16	3	BOOL	354	Sensor supply overload
16	6	BOOL	363	Maximum pointer reset
16	7	BOOL	317	Electronics supply voltage too low
17	0	BOOL	303	Bus error
17	1	BOOL	356	CPU/Master STOP
17	2	BOOL	357	Automatic mode
17	3	BOOL	358	Operating mode manual - bus
17	4	BOOL	359	Operating mode manual - local
17	6	BOOL	360	Connection abort in manual mode
17	7	BOOL	355	Error process image
18	1	BOOL	365	Invalid parameter value
18	2	BOOL	366	Parameters cannot be changed in ON state
18	3	BOOL	368	Parameters disable CPU/master active
18	5	BOOL	1727	No external start parameters received[1)]
19	0	BOOL	379	Self-test active
19	2	BOOL	381	Self-test error
19	3	BOOL	369	Factory settings restored
20	0	UINT	367	Faulty parameter number
22	3	BOOL	1454	Preset unequal actual configuration
24	0	BOOL	1405	Cold running active
24	1	BOOL	1406	Cold running shutoff
25	0	BOOL	1408	Missing load
25	2	BOOL	1409	Phase failure L1
25	3	BOOL	1410	Phase failure L2
25	4	BOOL	1411	Phase failure L3
25	5	BOOL	1412	Main power rotation CW
25	6	BOOL	1413	Main power rotation CCW

1) Set value available from firmware version V1.1

Byte	Bit	Data type	Obj. No.	Meaning
25	7	BOOL	1481	Supply voltage too high
29	0	BOOL	1407	Electronics supply voltage too high
29	1	BOOL	1470	Ready to start for motor ON
29	5	BOOL	1466	Switching element L1 failed
29	6	BOOL	1467	Switching element L2 failed
29	7	BOOL	1468	Switching element L3 failed
30	0	BOOL	1422	Thermal motor model deactivated
31	0	BOOL	1415	Switching element cooling time active
31	1	BOOL	1416	Switching element too hot for Start
31	2	BOOL	1482	Current measuring range exceeded
32	0	BOOL	357	Automatic mode
32	1	BOOL	358	Operating mode manual - bus
32	2	BOOL	1443	Manual operation bus - PC controlled
32	3	BOOL	359	Operating mode manual - local
32	4	BOOL	1444	Manual operation local - input controlled
33	2	BOOL	1721	Automatic operation - PLC controlled
33	3	BOOL	1722	Automatic operation - Input controlled
35	0	BOOL	1523	Device error
37	1	BOOL	1461	Maintenance timer - limit exceeded
38	0	BOOL	377	FW update rejected
38	1	BOOL	375	FW update active
38	2	BOOL	376	FW update successful
38	3	BOOL	378	FW update faulty
39	7	BOOL	1489	Operation active
42	0	BOOL	1508	Quickstop 1 - direction independent
42	1	BOOL	1509	Quickstop 1 - CW rotation
42	2	BOOL	1510	Quickstop 1 - CCW rotation
44	0	BOOL	1506	Input operational trip end position CCW
44	1	BOOL	1507	Input operational trip end position CW
52	3	BOOL	1527	Factory mode active
52	6	BOOL	1530	Normal operation active
54	0	BOOL	1816	Module dropped out[1)]
62	2	BOOL	1538	Remaining time for tripping warning limit undershot
62	3	BOOL	1539	Motor heating warning limit exceeded
62	4	BOOL	1541	Current limit - maintenance demanded exceeded
62	5	BOOL	1542	Current limit - maintenance demanded undershot
62	6	BOOL	1543	Asymmetry limit warning exceeded
62	7	BOOL	1544	Ground fault limit warning exceeded

1) Set value available from firmware version V1.1

Byte	Bit	Data type	Obj. No.	Meaning
72	2	BOOL	1575	Emergency start enabled
72	4	BOOL	1576	Emergency run enabled[1)]
72	5	BOOL	1577	Emergency run active[1)]
72	6	BOOL	1654	Emergency run motor CW possible[1)]
72	7	BOOL	1655	Emergency run motor CCW possible[1)]
73	3	BOOL	1657	Emergency run active with defective relay[1)]
75	0	BOOL	1563	Main power rotation faulty
75	1	BOOL	–	Indication main energy available[1)]
75	2	BOOL	–	Indication main energy available and ok[1)]
75	4	BOOL	–	Indication main energy available and not ok[1)]
77	0	BOOL	1580	Switching element hot
77	5	BOOL	1629	Check fan
81	4	BOOL	1799	Short circuit T1
81	5	BOOL	1800	Short circuit T2
81	6	BOOL	1801	Short circuit T3
82	1	BOOL	1622	Blocking protection during start-up
82	2	BOOL	1623	Blocking protection during operation
91	3	BOOL	1628	Invalid parameter value
93	0	BOOL	1553	Logbook application - errors deleted
93	2	BOOL	1555	Logbook application - warnings deleted
93	4	BOOL	1557	Logbook application - events deleted

1) Set value available from firmware version V1.1

A.1.9 Data set 93: Commands

Only write (w) access to the command is possible.

1 to 5 commands can be used.

Byte	Data type	Meaning
0	USINT	Coordination [0x21] Write via acyclic bus channel – user program
4	USINT	Number of commands
5	USINT	Command_1
6	USINT	Command_2
7	USINT	Command_3
8	USINT	Command_4
9	USINT	Command_5

The following table describes the coding of the commands that are equally valid for all 5:

Command	Command number
No function	0
Reset	1
Enable Emergency start	2
Disable Emergency start	3
Automatic mode	4
Operating mode manual	5
Factory settings	6
Reset maximum pointer	7
Restart	9
Parameters disable CPU/master ON	10
Parameters disable CPU/master OFF	11
Cold running ON	15
Cold running OFF	16
Reset maintenance timer	17
Delete logbook application - error	20
Delete logbook application - warning	22
Delete logbook application - events	24
Delete number of faulty shutdowns	31
Enable emergency run[1)]	42
Disable emergency run[1)]	43

1) Set value available from firmware version V1.1

A.1.10 Data set 94: Measured values

In this data set, the current measured values of the e-Starter ET 200SP are recorded.

Only read (r) access to the measured values is possible.

Byte	Bit	Data type	Meaning	Factor	Unit
0	0	USINT	Coordination	–	–
12	0	USINT	Phase current I L1 (%)	3.125	%
13	0	USINT	Phase current I L2 (%)	3.125	%
14	0	USINT	Phase current I L3 (%)	3.125	%
16	0	UINT	Remaining motor cooling time	0.1	s
18	0	SINT	Operation temperature	1	°C
19	0	USINT	Phase unbalance	1	%
20	0	UINT	Motor temperature rise	1	%
28	0	USINT	Output frequency	0.5	Hz
32	0	USINT	Line frequency	0.5	Hz
34	0	UINT	Line voltage U L1-L2 (rms)	0.1	V

Byte	Bit	Data type	Meaning	Factor	Unit
36	0	UINT	Line voltage U L2-L3 (rms)	0.1	V
38	0	UINT	Line voltage U L3-L1 (rms)	0.1	V
40	0	DINT	Phase current I L1 (rms)	0.01	A
44	0	DINT	Phase current I L2 (rms)	0.01	A
48	0	DINT	Phase current I L3 (rms)	0.01	A
55	0	USINT	Switching element heating	1	%
56	0	UINT	Remaining switching element cooling time	0.1	s
58	0	UINT	Remaining time for tripping the motor overload protection	0.1	s
60	0	DINT	Active power	0.0001	kW
76	0	USINT	Phase current average (%)	3.125	%
80	0	DINT	Phase current average (rms)	0.01	A

A.1.11 Data set 95: Statistic data

The statistic data group together the operating states from the past that are relevant to the load.

Only read (r) access to the statistical data is possible.

Byte	Bit	Data type	Meaning	Factor	Unit
0	0	USINT	Coordination	–	–
12	0	USINT	Phase current max (%)	3.125	%
13	6	BOOL	Resolution of operating hours	–	–
14	0	UINT	Last tripping current IA (%)	3.125	%
16	0	UDINT	Operating hours - device	1	s
20	0	UDINT	Number of starts motor CW	–	–
24	0	UDINT	Number of starts motor CCW	–	–
28	0	UINT	Number of motor overload trips	–	–
32	0	DINT	Phase current max (rms)	0.01	A
36	0	DINT	Last tripping current IA (rms)	0.01	A
40	0	UDINT	Operating hours - motor	1	s
44	0	UDINT	Operating hours - motor current = 18...49.9% x Iemax	1	s
48	0	UDINT	Operating hours - motor current = 50...89.9% x Iemax	1	s
52	0	UDINT	Operating hours - motor current = 90...119.9% x Iemax	1	s
56	0	UDINT	Operating hours - motor current = 120...1000% x Iemax	1	s
62	0	UINT	Number of switching element overload trips	–	–
66	0	UINT	Number of short-circuit trips	–	–
96	0	UDINT	Maintenance timer warning limit	1	s
128	0	REAL	Active energy import (total)	1	Wh
146	0	UINT	Number of error shutdowns	–	–

A.1.12 Data set 96: Maximum pointer

The maximum pointers are stored extreme values of measured values from the past. The extreme values can be deleted.

Only read (r) access to the maximum pointer is possible.

Byte	Bit	Data type	Meaning	Factor	Unit
0	0	USINT	Coordination	–	–
12	0	USINT	Phase current I L1 min (%)	3.125	%
13	0	USINT	Phase current I L2 min (%)	3.125	%
14	0	USINT	Phase current I L3 min (%)	3.125	%
16	0	USINT	Phase current I L1 max (%)	3.125	%
17	0	USINT	Phase current I L2 max (%)	3.125	%
18	0	USINT	Phase current I L3 max (%)	3.125	%
20	0	UINT	Maximum trigger current (%)	3.125	%
22	0	UINT	Number of motor overload trips	1	–
24	0	DINT	Maximum trigger current (rms)	0.01	A
28	0	DINT	Phase current I L1 min (rms)	0.01	A
32	0	DINT	Phase current I L2 min (rms)	0.01	A
36	0	DINT	Phase current I L3 min (rms)	0.01	A
40	0	DINT	Phase current I L1 max (rms)	0.01	A
44	0	DINT	Phase current I L2 max (rms)	0.01	A
48	0	DINT	Phase current I L3 max (rms)	0.01	A
52	0	UINT	Line voltage U L1-L2 min	0.1	V
54	0	UINT	Line voltage U L2-L3 min	0.1	V
56	0	UINT	Line voltage U L3-L1 min	0.1	V
58	0	UINT	Line voltage U L1-L2 max	0.1	V
60	0	UINT	Line voltage U L2-L3 max	0.1	V
62	0	UINT	Line voltage U L3-L1 max	0.1	V
69	0	USINT	Maximum switching element heating	1	%
70	0	USINT	Minimum line frequency	0.5	Hz
71	0	USINT	Maximum line frequency	0.5	Hz
72	0	UDINT	Operating hours - motor current 18...49.9% x Ie	1	s
76	0	UDINT	Operating hours - motor current 50...89.9% x Ie	1	s
80	0	UDINT	Operating hours - motor current = 90...119.9% x Ie	1	s
84	0	UDINT	Operating hours - motor current = 120...1000% x Ie	1	s
88	0	UDINT	Operating hours - device	1	s
100	0	DINT	Starting current I L1 max (rms)	0.01	A
104	0	DINT	Starting current I L2 max (rms)	0.01	A
108	0	DINT	Starting current I L3 max (rms)	0.01	A
126	0	SINT	Maximum operating temperature	1	°C

A.1.13 Data set 131: Parameter

Read (r) and write (w) access to the parameter is possible.

Obj. No.	Byte	Bit	Data type	Meaning	Setting range/set values (default value)	Calculated setting range (default value)	Fact-or	Unit	Can be chan-ged in oper-ation
–	0	0	USINT	Coordination [0x21] Write via acyclic bus channel – user program	–	–	–	–	No
130	12	0	UDINT	Rated operational current Ie	–	–	–	–	Yes
3	16	0	BOOL	Load configuration	(0 = 3-phase), 1 = 1-phase	–	–	–	No
4	16	1	BOOL	Non-volatile tripping status	0 = no, (1 = yes)	–	–	–	Yes
132	16	4	BOOL	Load type	(0 = Motor), 2 = Resistive load	–	–	–	No
	16	5	BOOL						
	16	6	BOOL						
	16	7	BOOL						
5	18	0	BOOL	Response to overload thermal motor model	(0 = Turn off without restart), 1 = Turn off with restart	–	–	–	Yes
	18	1	BOOL						
232	18	4	BOOL	Response to faulty main power	(1 = Group error only at ON command)	–	–	–	Yes
	18	5	BOOL						
	18	6	BOOL						
	18	7	BOOL						
6	19	0	BOOL	Trip class	(0 = CLASS 10E), 1 = CLASS 20E, 3 = CLASS 10A, 15 = CLASS Off	–	–	–	Yes
	19	1	BOOL						
	19	2	BOOL						
	19	3	BOOL						
234	19	4	BOOL	Reversing time behavior	0 = Optimized switch-ing times, (1 = Lifetime optim-ized switching)	–	–	–	Yes
	19	5	BOOL						
	19	6	BOOL						
	19	7	BOOL						
7	20	0	USINT	Recovery time	2 ... 60 (3)	60 ... 1800 (90)	30	s	Yes
13	26	0	UINT	Smart start time	60 ... 2000 (120)	–	1	ms	Yes
2369	32	0	BOOL	Behavior of the GRID LED[2)]	(0 = deactivated), 1 = activated	–	–	–	Yes
	32	1	BOOL						

1) Deactivation of the parameter by set value "0"

2) Set value available from firmware version V1.1

Obj. No.	Byte	Bit	Data type	Meaning	Setting range/set values (default value)	Calculated setting range (default value)	Fact-or	Unit	Can be chan-ged in oper-ation
2369	32	2	BOOL	Behavior of the GRID LED[2)]	(0 = deactivated), 1 = activated	–	–	–	Yes
	32	3	BOOL						
114	32	4	BOOL	Response to missing supply voltage switching element	(1 = Group error only at ON command)	–	–	–	Yes
	32	5	BOOL						
140	33	2	BOOL	Response to overload switching element	(0 = Turn off without restart), 1 = Turn off with restart	–	–	–	Yes
	33	3	BOOL						
21	34	0	BOOL	Asymmetry limit error	2 ... 12 (6)	10 ... 60 (30)	5	%	Yes
	34	1	BOOL						
	34	2	BOOL						
	34	3	BOOL						
236	34	4	BOOL	Reset mode at faulty main power	(0 = Manual)	–	–	–	Yes
	34	5	BOOL						
20	34	6	BOOL	Response to asymmetry-error limit violation	(1 = Turn off)	–	–	–	Yes
22	34	7	BOOL	Response to ground fault-error limit violation	(1 = Turn off)	–	–	–	Yes
25	38	4	BOOL	Input 1 - Level	0 = NC contact, (1 = NO contact)	–	–	–	No
27	38	5	BOOL	Input 2 - Level	0 = NC contact, (1 = NO contact)	–	–	–	No
29	38	6	BOOL	Input 3 - Level	0 = NC contact, (1 = NO contact)	–	–	–	No
31	38	7	BOOL	Input 4 - Level	0 = NC contact, (1 = NO contact)	–	–	–	No
167	51	0	BOOL	Starting mode	(0 = Direct), 7 = Smart Start	–	–	–	No
	51	1	BOOL						
	51	2	BOOL						
	51	3	BOOL						
35	52	–	–	Substitute value	–	–	–	–	Yes
–	52	0	BOOL	Substitute value: Motor CW	–	–	–	–	Yes
–	52	1	BOOL	Substitute value: Motor CCW	–	–	–	–	Yes
–	52	3	BOOL	Substitute value: Reset	–	–	–	–	Yes
–	52	4	BOOL	Substitute value: Emergency start	–	–	–	–	Yes

1) Deactivation of the parameter by set value "0"

2) Set value available from firmware version V1.1

Obj. No.	Byte	Bit	Data type	Meaning	Setting range/set values (default value)	Calculated setting range (default value)	Fact-or	Unit	Can be chan-ged in oper-ation
–	52	5	BOOL	Substitute value: Self-test (user-test)	–	–	–	–	Yes
–	53	7	BOOL	Substitute value: Disable Quick-stop	–	–	–	–	Yes
–	54	2	BOOL	Substitute value: Cold running	–	–	–	–	Yes
–	55	0	BOOL	Substitute value: Input con-trolled	–	–	–	–	Yes
34	56	7	BOOL	Response to CPU/Master Stop	(0 = Switch substitute value), 1 = Keep last value	–	–	–	Yes
193	57	1	BOOL	Group error diagnosis	(0 = Enable), 1 = Disable	–	–	–	Yes
191	57	2	BOOL	Group warning diagnostics	(0 = Enable), 1 = Disable	–	–	–	Yes
2234	73	0	BOOL	Permissible main power rotation	(0 = Any), 2 = Clockwise, 3 = Counter-clock-wise	–	–	–	No
	73	1	BOOL						
	73	2	BOOL						
	73	3	BOOL						
143	74	0	BOOL	Input 1 - signal	(0 = Not latching), 1 = Latching	–	–	–	No
	74	1	BOOL						
	74	2	BOOL						
	74	3	BOOL						
144	74	4	BOOL	Input 2 - signal	(0 = Not latching), 1 = Latching	–	–	–	No
	74	5	BOOL						
	74	6	BOOL						
	74	7	BOOL						
145	75	0	BOOL	Input 3 - signal	(0 = Not latching), 1 = Latching	–	–	–	No
	75	1	BOOL						
	75	2	BOOL						
	75	3	BOOL						
146	75	4	BOOL	Input 4 - signal	(0 = Not latching), 1 = Latching	–	–	–	No
	75	5	BOOL						
	75	6	BOOL						
	75	7	BOOL						
194	76	0	USINT	Input 1-Action	0 = No action, 1 = Switch off	–	–	–	No

1) Deactivation of the parameter by set value "0"

2) Set value available from firmware version V1.1

Obj. No.	Byte	Bit	Data type	Meaning	Setting range/set values (default value)	Calculated setting range (default value)	Fact-or	Unit	Can be chan-ged in oper-ation
					without restart, 2 = Switch off with restart, 3 = Switch off end position - motor CW, 4 = Switch off end position - motor CCW, 5 = Group warning, 6 = Operating mode manual - local, 7 = Emergency start, (8 = Motor CW), 9 = Motor CCW, 11 = Quick stop, 12 = Reset, 13 = Cold running, 14 = Quick stop - motor CW, 15 = Quick stop - motor CCW, 37 = Operational trip end position CW, 38 = Operational trip end position CCW				
195	77	0	USINT	Input 2-Action	0 = No action, 1 = Switch off without restart, 2 = Switch off with restart, 3 = Switch off end position - motor CW, 4 = Switch off end position - motor CCW, 5 = Group warning, 6 = Operating mode manual - local, 7 = Emergency start, 8 = Motor CW, (9 = Motor CCW), 11 = Quick stop, 12 = Reset, 13 = Cold running, 14 = Quick stop - motor CW, 15 = Quick stop - motor CCW, 37 = Operational trip end position CW,	–	–	–	No

1) Deactivation of the parameter by set value "0"

2) Set value available from firmware version V1.1

Obj. No.	Byte	Bit	Data type	Meaning	Setting range/set values (default value)	Calculated setting range (default value)	Fact-or	Unit	Can be chan-ged in oper-ation
					38 = Operational trip end position CCW				
196	78	0	USINT	Input 3-Action	(0 = No action), 1 = Switch off without restart, 2 = Switch off with restart, 3 = Switch off end position - motor CW, 4 = Switch off end position - motor CCW, 5 = Group warning, 6 = Operating mode manual - local, 7 = Emergency start, 8 = Motor CW, 9 = Motor CCW, 11 = Quick stop, 12 = Reset, 13 = Cold running, 14 = Quick stop - motor CW, 15 = Quick stop - motor CCW, 37 = Operational trip end position CW, 38 = Operational trip end position CCW	–	–	–	No
197	79	0	USINT	Input 4-Action	0 = No action, 1 = Switch off without restart, 2 = Switch off with restart, 3 = Switch off end position - motor CW, 4 = Switch off end position - motor CCW, 5 = Group warning, (6 = Operating mode manual - local), 7 = Emergency start, 8 = Motor CW, 9 = Motor CCW, 11 = Quick stop, 12 = Reset, 13 = Cold running, 14 = Quick stop -	–	–	–	No

1) Deactivation of the parameter by set value "0"

2) Set value available from firmware version V1.1

Obj. No.	Byte	Bit	Data type	Meaning	Setting range/set values (default value)	Calculated setting range (default value)	Fact-or	Unit	Can be chan-ged in oper-ation
					motor CW, 15 = Quick stop - motor CCW, 37 = Operational trip end position CW, 38 = Operational trip end position CCW				
2210	148	0	USINT	Motor heating warning limit	0 ... 99 (0)[1]	–	1	%	Yes
2211	150	0	UINT	Remaining time for tripping warning limit	0 ... 500 (0)	–	1	s	Yes
2218	157	0	BOOL	Asymmetry limit warning	2 ... 12 (0)[1]	10 ... 60 (0)	5	%	Yes
	157	1	BOOL						
	157	2	BOOL						
	157	3	BOOL						
2220	158	0	USINT	Ground fault limit warning	2 ... 19 (0)[1]	10 ... 95 (0)	5	%	Yes
2294	168	0	USINT	Ground fault limit error	2 ... 19 (4)	10 ... 95 (20)	5	%	Yes

1) Deactivation of the parameter by set value "0"

2) Set value available from firmware version V1.1

A.1.14 Data set 132: Advanced parameters 1

Read (r) and write (w) access to the parameter is possible.

Obj. No.	Byte	Bit	Data type	Meaning	Setting range/set values (default value)	Calculated setting range (default value)	Fact-or	Unit	Can be chang-ed in opera-tion
–	0	0	USINT	Coordination [0x21] Write via acyclic bus channel – user pro-gram	–	–	–	–	No
2242	75	0	BOOL	Emergency start	0 = disable, (1 = manually enable/dis-able)	–	–	–	Yes
2243	76	0	BOOL	Emergency run[2]	(0 = Disable), 1 = Manually enable/disable	–	–	–	Yes

1) Deactivation of the parameter by set value "0"

2) Set value available from firmware version V1.1

Obj. No.	Byte	Bit	Data type	Meaning	Setting range/set values (default value)	Calculated setting range (default value)	Fact-or	Unit	Can be chang-ed in opera-tion
2337	172	0	UINT	Current upper limit error	50 ... 400 (0)[1]	–	1	%	Yes
2338	174	0	UINT	Current upper limit - maintenance demanded	50 ... 400 (0)[1]	–	1	%	Yes
2340	178	0	USINT	Current lower limit error	19 ... 100 (0)[1]	–	1	%	Yes
2341	179	0	USINT	Current lower limit - maintenance demanded	19 ... 100 (0)[1]	–	1	%	Yes
14	186	0	BOOL	Response to current upper error limit violation	(0 = Do not turn off), 1 = Turn off	–	–	–	Yes
2296	186	4	BOOL	Response to current lower error limit violation	(0 = Do not turn off), 1 = Turn off	–	–	–	Yes
17	191	0	USINT	Blocking current	3 ... 30 (16)	150 ... 1500 (800)	50	%	Yes
18	192	0	BOOL	Blocking time	2 ... 10 (2)	1 ... 5 (1)	0.5	s	Yes
	192	1	BOOL						
	192	2	BOOL						
	192	3	BOOL						

1) Deactivation of the parameter by set value "0"

2) Set value available from firmware version V1.1

A.1.15 Data set 134: Parameter - maintenance

Read (r) and write (w) access to the parameter is possible.

Obj. No.	Byte	Bit	Data type	Meaning	Setting range/set values (default value)	Factor	Unit	Can be changed in opera-tion
–	0	0	USINT	Coordination [0x21] Write via acyclic bus channel – user program	–	–	–	No
202	16	0	UDINT	Maintenance timer warning limit	0 ... 4294967295 (94608000)	1	s	Yes

A.1.16 Data set 135: Parameter cyclic process image

Access to the measured values is read-only (r).
As soon as the PI extension is used or subslot 3 is occupied, 3 measured values are returned in DS 69 (from byte 16). The numerical values of the measured values are output in the DS 69. The DS 135 uses object numbers to link the output value to a unit. This is helpful, for example, when using an HMI in conjunction with several e-Starters ET 200SP. The associated object numbers of the measured values are identical for all 3 measured values.

Obj. No.	Byte	Bit	Data type	Meaning
–	0	0	USINT	Coordination [0x21] Write via acyclic bus channel – user program
2002	16	0	UINT	Measured value 1
2003	18	0	UINT	Measured value 2
2004	20	0	UINT	Measured value 3

Linking the object numbers to the measured values

Object number	Linked measured value
0	Fixed value = 0
20000	Phase current I L1 (rms)
20001	Phase current I L2 (rms)
20002	Phase current I L3 (rms)
20004	Active energy import (total)
20005	Active power
20007	Line voltage U L1-L2 (rms)
20008	Line voltage U L2-L3 (rms)
20009	Line voltage U L3-L1 (rms)
20010	Average linked voltage (rms)

A.1.17 Data set 222: Access via object number

Read (r) and write (w) access is possible.

The "Rated motor current" parameter with object number 130 can be read and written via the DS222.

To read the data set, it must first be written. To do this, first set the object access to 0 (corresponds to "read"), then write the values from the data type using the WRREC block. These values are ignored. Reading is then possible. The value of the object number and the value of the object are filled.

Obj. No.	Byte	Bit	Data type	Meaning	Setting range/set values (default value)
–	0	0	USINT	Coordination [0x21] Write via acyclic bus channel – user program	–
32301	4	0	BOOL	Object access	–

Obj. No.	Byte	Bit	Data type	Meaning	Setting range/set values (default value)
32303	5	0	USINT	Parameter set number	(0 = no parameter set)
32304	6	0	INT	Object number	–
–	8	0	UDINT	Value of the object	–

A.1.18 I&M data

I&M data overview

The e-Starter ET 200SP supports the following identification & maintenance function (I&M) data:

Number	Name	Comment
I&M0	Device identification	This is stored in the device on initialization.
I&M1	Reference designation	These are entered in the Engineering System.
I&M2	Installation	
I&M3	Description	

NOTE
Access to I&M data
With PROFINET, the I&M data can also be accessed via data sets 0xAFF0 to 0xAFF3 (PNO).

0xAFF0: I&M0 - Device identification

Only read (r) access to the device identification (I&M0) is possible.

Byte	Data type	Content	Meaning
I&M header			
0 ... 1	UINT	0x0020	Block type
2 ... 3	UINT	0x0038	Block length = 56
4 ... 5	UINT	0x0100	Block version = 1.0
I&M0 - data block 0			
6 ... 7	UINT	MANUFACTURER_ID	42 = Manufacturer ID SIEMENS
8 ... 27	Char[20]	ORDER_ID	Article number (MLFB)
28 ... 43	Char[16]	SERIAL_NUMBER	Serial number
44 ... 45	UINT	HARDWARE REVISION	Hardware revision or product version
46 ... 49	Char	SOFTWARE_REVISION	Firmware version
50 ... 51	UINT	REV_COUNTER	Provides information about the parameterized changes on the module. The "REV_ COUNTER" is incremented after each change.

Byte	Data type	Content	Meaning
52 ... 53	UINT	PROFILE_ID	Provides information about the PROFIBUS profile supported by the device and the device family belonging to the device.
54 ... 55	UINT	PROFILE_SPECIFIC_TYPE	Used to supplement the object "PROFILE_ID" and contains further information on the profile.
56 ... 57	UINT	IM_VERSION	Provides information about the version of the identification data (01 01hex = Version 1.1).
58 ... 59	UINT	IM_SUPPORTED	Provides information about the available identification data (index 2 to 4).

0xAFF1: I&M1 - reference designation

Read (r) and write (w) access to the equipment identifier (I&M1) is possible.

Byte	Data type	Content	Meaning
I&M header			
0 ... 1	UINT	0x0021	Block type
2 ... 3	UINT	0x0038	Block length = 56
4 ... 5	UINT	0x0100	Block version = 1.0
I&M - data block 1			
6 ... 37	Char[32]	TAG FUNCTION	Plant designation Fill unused positions with blanks (0x20)
38 ... 59	Char[22]	TAG LOCATION	Location designation Fill unused positions with blanks (0x20)

0xAFF2: I&M2 installation

Read (r) and write (w) access to the installation (I&M2) is possible.

NOTE

Validity of write access

The e-Starter ET 200SP checks the validity of the write access. The accepted display formats are "YYYY-MM-DD" (year-month-day) and "YYYY-MM-DD HH:MM" (year-month-day hour:minute). If the e-Starter ET 200SP does not accept the data for write access, the device responds with a negative acknowledgment.

YYYY (year): 0001 - 9999

MM (month): 01 - 12

DD (day): 01 - 31 (depending on month)

HH (hour): 00 - 23

MM (minute): 00 - 59

Byte	Data type	Content	Meaning
I&M header			
0 ... 1	UINT	0x0022	Block type
2 ... 3	UINT	0x0012	Block length = 18
4 ... 5	UINT	0x0100	Block version = 1.0
I&M - data block 2			
6 ... 21	Char[16]	IM_DATE	Specifies an input date (YYYY-MM-DD HH:MM)

0xAFF3: I&M3 - description

Read (r) and write (w) access to the description (I&M3) is possible.

NOTE

Validity of write access

The e-Starter ET 200SP checks the validity of the write access. The ASCII characters 0x20 - 0x7E are accepted. If the e-Starter ET 200SP does not accept the data for write access, the device responds with a negative acknowledgment.

Byte	Data type	Content	Meaning
I&M header			
0 ... 1	UINT	0x0023	Block type
2 ... 3	UINT	0x0038	Block length = 56
4 ... 5	UINT	0x0100	Block version = 1.0
I&M - data block 3			
6 ... 59	Char[54]	IM_DESCRIPTOR	Comment Fill unused positions with blanks (0x20)

List of abbreviations

B

B.1 List of abbreviations

Abbreviations

Abbreviation	Description
PII	Process image input
PIQ	Process image output
Submodule	Extension module for extending the range of functions
LC	Local control/manual - local

SIEMENS

SIMATIC

ET 200SP TM Count 1x24V (6ES7138-6AA01-0BA0) technology module

Equipment Manual

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Wiring 3

Configuring/address space 4

Interrupts/diagnostic messages 5

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Parameter data record A

07/2019

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Preface

Purpose of the documentation

This manual includes module-specific information on wiring, diagnostics and the technical specifications of the technology module.

General information regarding design and commissioning of the ET 200SP is available in the ET 200SP system manual.

The counting and measuring functions of the TM Count 1x24V technology module are described in more detail in the Counting, Measurement and Position Detection (http://support.automation.siemens.com/WW/view/en/59709820) function manual.

Conventions

Please observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

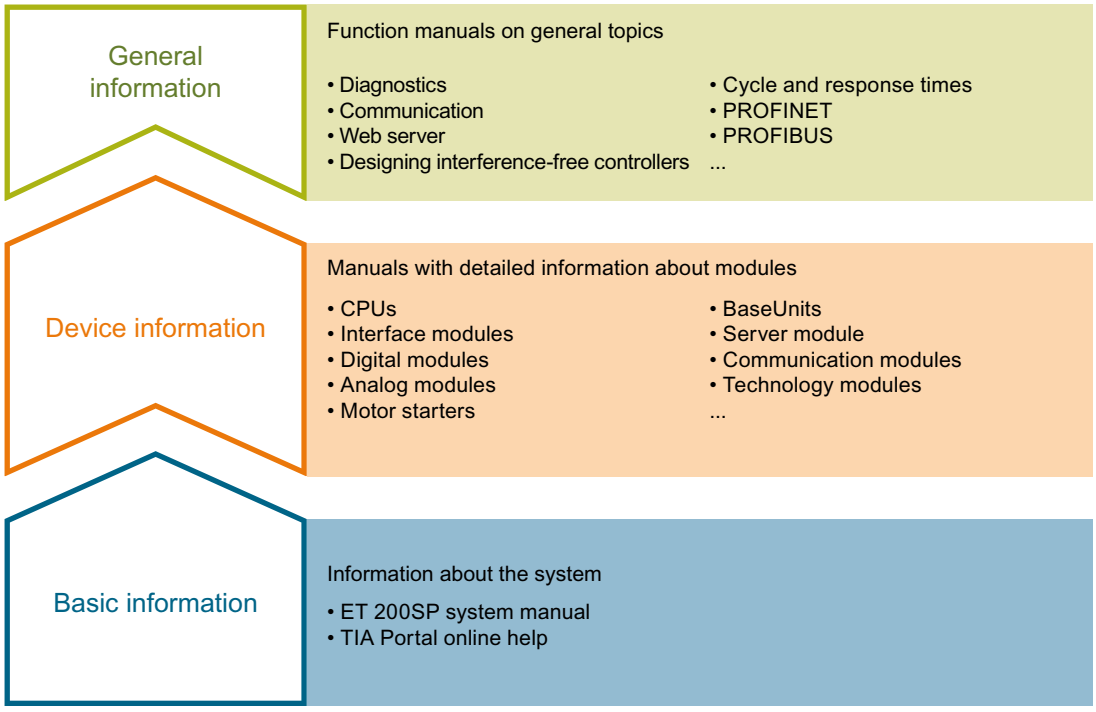

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/84133942).

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You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview 2

2.1 Properties

Article number

6ES7138-6AA01-0BA0 (packing unit: pack of 1)

6ES7138-6AA01-2BA0 (packing unit: pack of 10)

The TM Count 1x24V technology module with article number 6ES7138-6AA01-0BA0 and firmware version V2.0 is a compatible replacement for the TM Count 1x24V with article number 6ES7138-6AA00-0BA0.

Firmware version

This manual describes the properties of firmware version V2.0 of the module.

View of the module

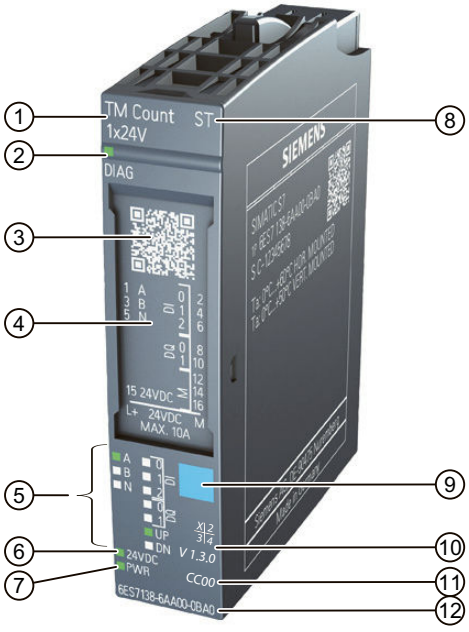

①	Module type and designation	⑦	LED for supply voltage
②	LED for diagnostics	⑧	Function class
③	2D matrix code	⑨	Module type color coding
④	Wiring diagram	⑩	Function and firmware version
⑤	LEDs for channel status	⑪	Color code for selection of the color-coded labels and BaseUnit type
⑥	LED for encoder supply	⑫	Article number

Figure 2-1066 View of the TM Count 1x24V module as an example

Properties

The TM Count 1x24V technology module has the following properties:

- Technical properties
  - One channel
  - Interfaces:

    24 V encoder signals A, B and N from sourcing, sinking or push-pull encoders and sensors

    24 V encoder supply, short-circuit-proof

    DI0, DI1 and DI2 digital input signals

    DQ0 and DQ1 digital output signals

    Supply voltage L+
  - Count range: 32 bits
  - Monitoring of encoder signals for wire break

  - Hardware interrupts configurable
  - Input filters for suppression of interferences at encoder inputs and digital inputs can be configured
- Supported encoder/signal types
  - 24 V incremental encoder with N signal
  - 24 V incremental encoder without N signal
  - 24 V pulse encoder with direction signal
  - 24 V pulse encoder without direction signal
  - 24 V pulse encoder with up/down counting signal
- Supported system functions
  - Isochronous mode
  - Firmware update
  - Identification data I&M

The module supports the following functions:

Table 2-1172 Version dependencies of the functions

Function	Firmware version of module	Configurable as of			
		STEP 7 (TIA Portal)	STEP 7	GSD file	
				PROFINET IO	PROFIBUS DP
Firmware update	V1.0 or higher	V13	V5.5 SP4	X	—
I&M identification data	V1.0 or higher	V13	V5.5 SP4	X	X
Parameter reassignment in RUN	V1.0 or higher	V13	V5.5 SP4	X	X
Isochronous mode	V1.0 or higher	V13	V5.5 SP4	—	—
Counting/measuring	V1.0 or higher	V13	V5.5 SP4 or V5.5 SP3 with HSP0240 V1.0	X	X
Operating with technology object "Counting and measurement"	V1.0 or higher	V13	—	—	—
Position input for "Motion Control" technology object	V1.0 or higher	V13	—	—	—
Central operation on CPU 151xSP	V1.1 or higher	V13 SP1	—	—	—
Fast Mode	V1.2 or higher	V14 SP1 or V14 with HSP0199	V5.6 or V5.5 SP4 with HSP0240 V5.0	X	X

Function	Firmware version of module	Configurable as of			
		STEP 7 (TIA Portal)	STEP 7	GSD file	
				PROFINET IO	PROFIBUS DP
Operating with "Measuring input" technology object	V1.3 or higher	V15 with HSP0256	—	—	—
Position value range of 32 bits	V1.3 or higher	V15 with HSP0256	—	X	X
Display of digital input states in the process image for position input for "Motion Control" technology object	V2.0 or higher	V15.1 with HSP0300	—	—	—

Firmware versions V1.x are available for the article number 6ES7138-6AA00-0BA0. Firmware version V2.0 is available for the article number 6ES7138-6AA01-xBA0.

Accessories

A **BaseUnit** of **type A0** is needed for operation of the technology module. You can find an overview of the BaseUnits that you can use with the technology module in the product information for the documentation of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/73021864).

For detailed information on the installation procedure, refer to the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2 Functions

2.2.1 Detection of counting signals

Counting is the detecting and adding up of events. The counters of the technology module detect encoder signals and pulses and evaluate them accordingly. The count direction can be specified using encoder or pulse signals or through the user program.

You can control the counting processes with the digital inputs. In addition, you can read the signal state of the respective digital input via the feedback interface.

You can specify the counter characteristics using the functions described below.

Counting limits

The counting limits define the counter value range used. The counting limits are configurable and can be modified during runtime with the user program.

You can configure the behavior of the counter at the counting limits.

Start value

You can configure a start value within the counting limits. The start value can be modified during runtime with the user program.

Gate control

You can define the time window in which the count signals are acquired with the hardware gate (HW gate) and software gate (SW gate).

Capture (Latch)

You can configure an external reference signal edge that triggers the saving of the current counter value as Capture value. The following external signals can trigger the Capture function:

- Rising or falling edge of a digital input
- Both edges of a digital input
- Rising edge of the N signal at the encoder input

The "Frequency of Capture function" parameter specifies whether the function is executed at each configured edge or only once after each enable.

Measuring input

If you use Position input for Motion Control (Page 15), you can use the "Measuring input" technology object to execute a measuring input function with a hardware digital input.

Hardware interrupts

The technology module can trigger a hardware interrupt in the CPU, for example, if a comparison event occurs, in the event of overflow or underflow, in the event of a zero crossing of the counter and/or of a change of count direction (direction reversal). You can specify which events during operation are to trigger a hardware interrupt.

2.2.2 Measured value determination

The following high-accuracy measurement functions are available (accuracy up to 100 ppm):

- Frequency measurement with the unit of hertz
- Period measurement with the unit of seconds
- Velocity measurement with a flexibly adaptable unit

Update time

You can configure the interval at which the technology module updates the measured values cyclically as the update time.

Gate control

You can define the time window in which the count signals are acquired with the hardware gate (HW gate) and software gate (SW gate).

2.2.3 Switching the outputs at comparison values

The available digital outputs DQ0 and DQ1 can be directly activated/switched by the specified comparison values or via the user program. The comparison values are configurable and can be modified during runtime with the user program. This enables very fast reaction times to be achieved.

Comparison values in the Counting mode

You define two comparison values in the Counting mode. If the current counter value meets the configured comparison condition, the corresponding digital output can be set to directly initiate control processes in the process.

Comparison values in the Measuring mode

You define two comparison values in the Measuring mode. If the current measured value meets the configured comparison condition, the corresponding digital output can be set to directly initiate control processes in the process.

2.2.4 Position input for Motion Control

You can use the technology module for position detection for the following axis technology objects of S7-1500 Motion Control :

- TO_PositioningAxis
- TO_SynchronousAxis
- TO_ExternalEncoder

In this operating mode, you can use the measuring input technology object (TO_MeasuringInput) to execute a measuring input function with hardware digital input DI1.

Additional information

You can find a detailed description of the use of Motion Control and its configuration in the following:

- Function manual S7-1500 Motion Control available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59381279)
- Function manual S7-1500T Motion Control available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109481326)

2.2.5 Fast Mode

You can use the technology module in Fast Mode for very fast input of the counter value in case of compressed functionality. A reduced feedback interface but no control interface is available in Fast Mode. This allows you to use a shorter send clock for the CPU.

2.2.6 Additional functions

Synchronization

You can configure the edge of an external reference signal that loads the counter with the specified start value. The following external signals can trigger a synchronization:

- Rising or falling edge of a digital input
- Rising edge of signal N at the encoder input
- Rising edge of signal N at the encoder input depending on the level of the assigned digital input

The "Frequency of synchronization" parameter specifies whether the function is executed at each configured edge or only once after each enable.

Hysteresis

You can specify a hysteresis for the comparison values within which a digital output will be prevented from switching again.

Diagnostic interrupt

The technology module can trigger diagnostic interrupts. You enable the diagnostic interrupts in the device configuration.

Input filter

To suppress interference, you can configure an input filter for the 24 V encoder inputs and for the digital inputs.

Isochronous mode

The technology module supports the "Isochronous mode" system function. This system function enables counter values and measured values to be acquired in a defined system cycle.

Wiring 3

3.1 Pin assignment and block diagram

The TM Count 1x24V technology module is used with a BaseUnit of type A0 (article number 6ES7193-6BPx0-0xA0).

You connect the encoder signals, digital input and output signals and the encoder supply to the BaseUnit of the technology module. The supply voltage feed on the light-colored BaseUnit BU...D of the associated potential group supplies the module and the digital outputs, and generates the encoder supply voltage.

BaseUnit

The BaseUnit is not included in the scope of delivery of the module and must be ordered separately.

You can find an overview of the BaseUnits that you can use with the technology module in the product information for the documentation of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/73021864).

You can find information about selecting a suitable BaseUnit in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual.

You can find information on wiring the BaseUnit, connecting cable shields, etc. in the Connecting section of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Supply voltage L+/M

With a light-colored BaseUnit, you connect the supply voltage to the L+ and M terminals. With a dark-colored BaseUnit, the supply voltage of the left module is used. An internal protection circuit protects the technology module from reverse polarity of the supply voltage. The technology module monitors whether the supply voltage is connected.

Encoder supply

For supplying the encoders and sensors connected to the digital inputs, the technology module provides a 24 V DC supply voltage at output 24VDC (terminal 15) with reference to M (terminals 12, 14 and 16). The voltage is monitored for short-circuit and overload.

Digital inputs DI0, DI1 and DI2

The digital inputs are used for gate control, synchronization and the Capture function.

The digital inputs are not isolated from each other.

Input delay for digital inputs

In order to suppress noise you can configure an input delay for the digital inputs.

NOTE

If you select the "None" or "0.05 ms" option, you must use shielded cables for connection of the digital inputs.

Digital outputs DQ0 and DQ1

The digital outputs are not isolated from each other.

The digital outputs are 24 V sourcing outputs in reference to M and can carry a rated load current of 0.5 A. They are protected against overload and short-circuit.

Relays and contactors can be directly connected without an external protective circuit. You can find information on the maximum possible operating frequencies and the inductive loads connected to the digital outputs in section Technical specifications (Page 70).

24 V encoder signals/count signals

The 24 V encoder signals are designated with the letters A, B and N. You can connect the following encoder types:

- Incremental encoder with N signal:

  The A, B and N signals are connected using the correspondingly marked terminals. The A and B signals are the two 90° phase-shifted incremental signals. N is the zero mark signal that supplies one pulse per revolution.

- Incremental encoder without N signal:

  The A and B signals are connected using the correspondingly marked terminals. The A and B signals are the two 90° phase-shifted incremental signals. The N terminal remains unconnected.

- Pulse encoder without direction signal:

  The counting signal is connected to the A terminal. The count direction can be specified via the control interface. The B and N terminals remain unconnected.

- Pulse encoder with direction signal:

  The counting signal is connected to the A terminal. The direction signal is connected to the B terminal. Counting down takes place at a high level of the direction signal. The N terminal remains unconnected.

- Pulse encoder with up/down counting signal:

  The up counting signal is connected to the A terminal. The down counting signal is connected to the B terminal. The N terminal remains unconnected.

The inputs are not isolated from each other. The inputs are isolated from the backplane bus.

You can connect the following encoders or sensors to the A, B and N inputs:

- Sourcing output:
  The A, B and N inputs are switched by the encoder or sensor to 24VDC .
- Sinking output:
  The A, B and N inputs are switched by the encoder or sensor to ground M .
- Push-pull:
  The A, B and N inputs are switched by the encoder or sensor alternately to 24VDC and ground M . Monitoring for wire break is possible with this type of encoder/sensor.

Pin assignment of BaseUnit

The table below shows the pin assignment, using the BaseUnit BU15-P16+A0+2B as an example.

Table 2-1173 Pin assignment of BaseUnit BU15-P16+A0+2B

Designation					Signal name		View	Signal name		Designation
24 V incremental encoder		**24 V pulse encoder**								
with signal N	**without signal N**	**with direction signal**	**without direction signal**	**up/down**						
Encoder signal A		Counting signal A		Up counting signal A	A	1	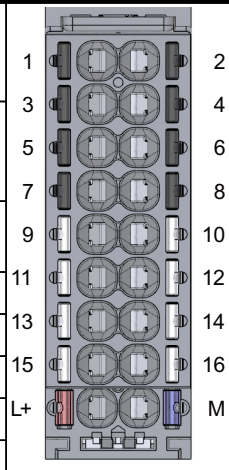	2	DI0	Digital input DI0
Encoder signal B		Direction signal B	—	Down counting signal B	B	3		4	DI1	Digital input DI1
Encoder signal N	—				N	5		6	DI2	Digital input DI2
—					—	7		8	DQ0	Digital output DQ0
—					—	9		10	DQ1	Digital output DQ1
—					—	11		12	M	Ground for encoder supply, digital inputs and digital outputs
—					—	13		14	M	
Encoder supply 24 V DC					24VDC	15		16	M	
Supply voltage DC 24 V					L+				M	Ground for supply voltage

Block diagram

The figure below shows the block diagram of the technology module.

You must ground the shields of the cables between encoder and technology module both through the shield terminal on the BaseUnit (shield bracket and terminal) and also on the encoder.

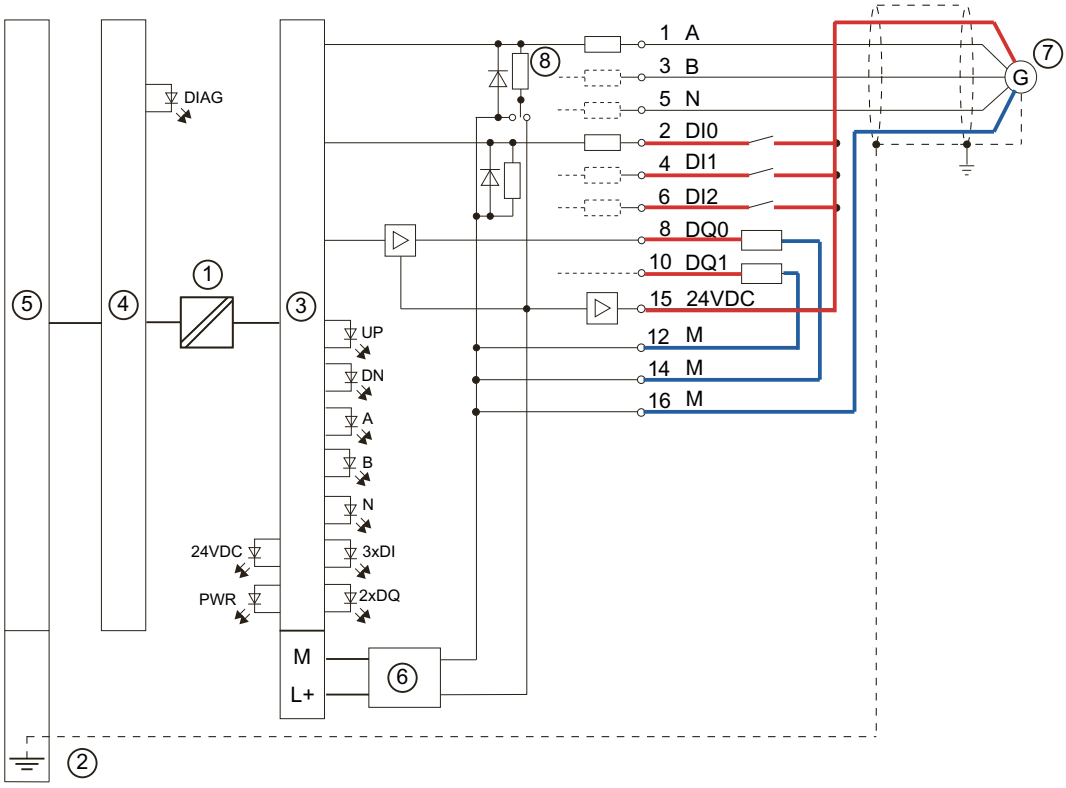

① Electrical isolation

② Shield terminal on the BaseUnit

③ Technology

④ Backplane bus interface module of the technology module

⑤ Backplane bus

⑥ Input filter

⑦ Incremental encoder with signal N

⑧ Resistance is controlled depending on the connected encoder (sourcing output, sinking output or push-pull)

Figure 2-1067 Block diagram with incremental encoder

Configuring/address space

4

4.1 Operating with "Counting and measurement" technology object

4.1.1 Configuring

Introduction

You configure the technology module and assign its parameters with STEP 7 (TIA Portal).

The technology object is used to control and monitor the functions of the technology module.

System environment

The technology module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central operation with a CPU 151xSP	• ET 200SP automation system • TM Count 1x24V	STEP 7 (TIA Portal): • Device configuration with hardware configuration • Parameter setting with High_Speed_Counter technology object	High_Speed_Counter instruction
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM Count 1x24V		

Additional information

You can find a detailed description of the counting and measurement functions and their configuration in the following:

- Function manual Counting, Measurement and Position Detection available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820)
- Information system of STEP 7 (TIA Portal) under "Using technology functions > Counting, measurement and position input > Counting, measurement and position input (S7-1500)"

Hardware Support Packages (HSP)

If firmware version V2.0 of the module is not yet integrated in the TIA Portal version V15.1 you are using, you can integrate a corresponding module with HSP0300.

You can find the Hardware Support Packages (HSP) for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).

You can also access this download from the menu bar of STEP 7 (TIA Portal): "Options > Support packages > Download from the Internet".

4.1.2 Reaction to CPU STOP

You set the response of the technology module to CPU STOP for each channel in the basic parameters of the device configuration.

Table 2-1174 Response of technology module to CPU STOP

Option	Meaning
Continue operation	The technology module remains fully functional. Incoming count pulses are processed. The digital outputs continue to switch according to the parameter assignment.
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the start value and the digital outputs switch according to the parameter assignment.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. If a digital output with the function "At comparison value for a pulse duration" is set at CPU stop, the digital output is reset after the pulse duration elapses. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the start value and the digital outputs switch according to the parameter assignment.

4.1.3 Parameter setting

You specify the properties of the technology module using various parameters. Depending on the settings, not all parameters are available. When parameters are assigned in the user program, the parameters are transferred to the module with the "WRREC" instruction and data record 128 (Page 78).

You set the parameters of the module as follows in this operating mode:

1. Insert the module from the hardware catalog under "Technology modules".
2. Set the operating mode "Operating with technology object "Counting and measurement"" and the further device configuration in the hardware configuration.
3. Insert the High_Speed_Counter technology object from the project tree in folder "Technology objects > Add new object > Counting and measurement".
   You can find information on configuring with a technology object in function manual Counting, measurement and position detection (http://support.automation.siemens.com/WW/view/en/59709820).
4. Open the configuration of the High_Speed_Counter technology object, e.g. using the Configuration button in the instruction for the technology object.
5. Set the parameters of the technology object.
6. Download the project to the CPU.

Parameters of the TM Count 1x24V

The following parameter settings are possible in the hardware configuration. The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1175 Configurable parameters and their default setting

Parameter	Value range	Scope
Potential group	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Reaction to CPU STOP	• **Output substitute value** • Keep last value • Continue operation	Channel
Enable diagnostic interrupt on wire break	• **Deactivated** • Activated	Channel
Enable additional diagnostic interrupts	• **Deactivated** • Activated	Channel
Hardware interrupt: New Capture value available	• **Deactivated** • Activated	Channel
Hardware interrupt: Synchronization of the counter by an external signal	• **Deactivated** • Activated	Channel
Hardware interrupt: Gate start	• **Deactivated** • Activated	Channel
Hardware interrupt: Gate stop	• **Deactivated** • Activated	Channel
Hardware interrupt: Overflow (high counting limit violated)	• **Deactivated** • Activated	Channel
Hardware interrupt:Underflow (low counting limit violated)	• **Deactivated** • Activated	Channel
Hardware interrupt: Direction reversal	• **Deactivated** • Activated	Channel
Hardware interrupt: Zero crossing	• **Deactivated** • Activated	Channel
Hardware interrupt: Comparison event for DQ0 occurred	• **Deactivated** • Activated	Channel
Hardware interrupt: Comparison event for DQ1 occurred	• **Deactivated** • Activated	Channel

The following parameter settings are possible in the technology object:

Table 2-1176 Configurable parameters and their default setting

Parameter	Value range	Scope
Signal type	• Pulse (A) • **Pulse (A) and direction (B)** • Count up (A), count down (B) • Incremental encoder (A, B phase-shifted) • Incremental encoder (A, B, N)	Channel
Signal evaluation for counter inputs	• **Single** • Double • Quadruple	Channel
Invert direction (counter inputs)	• **Deactivated** • Activated	Channel
Filter frequency for counter inputs	• 100 Hz • 200 Hz • 500 Hz • 1 kHz • 2 kHz • 5 kHz • 10 kHz • 20 kHz • 50 kHz • 100 kHz • **200 kHz**	Channel
Sensor type	• **Sourcing output** • Sinking output • Push-pull (sinking and sourcing output)	Channel
Reaction to signal N	• **No reaction to signal N** • Synchronization at signal N • Capture at signal N	Channel
Frequency of synchronization	• **Once** • Periodic	Channel
Frequency of Capture function	• Once • **Periodic**	Channel
High counting limit	-2147483648...**2147483647**	Channel
Start value	-2147483648...**0**...2147483647	Channel
Counting low limit	**-2147483648**...2147483647	Channel
Reaction to violation of a counting limit	• Stop counting • **Continue counting**	Channel
Reset when counting limit is violated	• **To opposite counting limit** • To start value	Channel
Reaction to gate start	• Set to start value • **Continue with current value**	Channel

Parameter	Value range	Scope
Set function of DI	• Gate start/stop (level-triggered) • Gate start (edge-triggered) • Gate stop (edge-triggered) • Synchronization • Enable synchronization at signal N • Capture • **Digital input without function**	Channel
Input delay for digital inputs	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel
Edge selection for DI	• **At rising edge** • At falling edge • At rising and falling edge	Channel
Select level for DI	• **Active with high level** • Active with low level	Channel
Behavior of counter value after Capture with DI	• **Continue counting** • Set to start value and continue counting	Channel
Comparison value 0	-2147483648...**0**...2147483647	Channel
Comparison value 1	-2147483648...**10**...2147483647	Channel
Operating mode	• **Use count value as reference** • Use measured value as reference	Channel
Set output	• **Between comparison value and high limit / measured value >= comparison value** • Between comparison value and low limit / measured value <= comparison value • Between comparison value 0 and 1 • Not between comparison value 0 and 1 • At comparison value for a pulse duration • After set command from CPU until comparison value • Use by user program	Channel
Count direction of DQ function	• Up • Down • **In both directions**	Channel
Pulse duration	0...**500.0**...6553.5 ms	Channel
Substitute value for DQ0	• **0** • 1	Channel
Substitute value for DQ1	• **0** • 1	Channel
Hysteresis (in increments)	**0**...255	Channel

Parameter	Value range	Scope
Measured variable	• **Frequency** • Period • Velocity	Channel
Update time of the measuring function	0...**10**...25000 ms	Channel
Time base for velocity measurement	• 1 ms • 10 ms • 100 ms • 1 s • **60 s**	Channel
Increments per unit	**1**...65535	Channel

Explanation of parameters

You can find a detailed description of the parameters in function manual Counting, Measurement and Position Detection in sections Basic parameters and Configuring the High_Speed_Counter available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820).

4.1.4 Address space

Address space of the technology module

Table 2-1177 Size of input and output addresses of the TM Count 1x24V when operating with "Counting and measurement" technology object

	Inputs	Outputs
Range	16 bytes	12 bytes

4.1.5 Isochronous mode

The technology module supports the "Isochronous mode" system function. This system function enables counter values and measured values to be acquired in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. The output signals switch immediately if the relevant comparison condition is met. A status change of a digital input immediately triggers the specified reaction of the technology module and the change of the status bit of the digital input in the feedback interface.

Use an OB of type "Synchronous Cycle" (e.g. OB61) in this operating mode. The High_Speed_Counter instruction is called in the assigned OB.

The update time for the measured value is synchronized with the system cycle in a suitable ratio and, if necessary, adapted in length. If you set "0", the measured value is updated once per system cycle.

Data processing

The data that was transmitted to the technology module in the current bus cycle via the control interface takes effect when it is processed in the internal technology module cycle. At the time the input data is read in (T_i), the counter value and the measured value as well as status bits are acquired and made available in the feedback interface for retrieval in the current bus cycle.

Isochronous mode parameters

In isochronous mode, the "Filter frequency" parameter can affect the isochronous mode parameters of the sync domain.

Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameters in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

Additional information

You can find a detailed description of isochronous mode in the following:

- In the isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- Function manual PROFINET with STEP 7 available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856)

4.2 Position input for ""Motion Control"" technology object

4.2.1 Configuring

Introduction

You configure the technology module and assign its parameters with STEP 7 (TIA Portal).

The technology object is used to control and monitor the functions of the technology module.

System environment

The technology module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central operation with a CPU 151xSP	• ET 200SP automation system • TM Count 1x24V	STEP 7 (TIA Portal): • Device configuration with hardware configuration • Parameter setting with axis and measuring input technology objects	Motion Control instructions
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM Count 1x24V		

Additional information

You can find a detailed description of the use of Motion Control and its configuration in the following:

- Function manual S7-1500 Motion Control available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59381279)
- Function manual S7-1500T Motion Control available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109481326)
- Information system of STEP 7 (TIA Portal) under "Using technology functions > Motion Control > Motion Control (S7-1200, S7-1500)"

You can find a description of configuring the technology module for position detection in the following:

- Function manual Counting, Measurement and Position Detection available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820)
- Information system of STEP 7 (TIA Portal) under "Using technology functions > Counting, measurement and position input > Counting, measurement and position input (S7-1500)"

Hardware Support Packages (HSP)

If firmware version V2.0 of the module is not yet integrated in the TIA Portal version V15.1 you are using, you can integrate a corresponding module with HSP0300.

You can find the Hardware Support Packages (HSP) for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).

You can also access this download from the menu bar of STEP 7 (TIA Portal): "Options > Support packages > Download from the Internet".

4.2.2 Parameter setting

You specify the properties of the technology module using various parameters. Depending on the settings, not all parameters are available.

You set the parameters of the module as follows in this operating mode:

1. Insert the module from the hardware catalog under "Technology modules".
2. Set the operating mode "Position input for technology object "Motion Control"" and the other module parameters in the hardware configuration.

3. Insert the axis technology object and, if necessary, the measuring input technology object from the project tree in folder "Technology objects > Add new object > Motion Control". You can find information on configuring with axis technology objects in function manual S7-1500T Motion Control (https://support.industry.siemens.com/cs/ww/en/view/109481326).
4. Open the configuration of the axis technology object, e.g. using the Configuration button in the respective instruction for the technology object.
5. Set the parameters of the technology objects.
6. Download the project to the CPU.

Parameters of the TM Count 1x24V

The following parameter settings are possible. The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1178 Configurable parameters

Parameter	Value range	Scope
Potential group	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Signal type	• Pulse (A) • Pulse (A) and direction (B) • Count up (A), count down (B) • Incremental encoder (A, B phase-shifted) • **Incremental encoder (A, B, N)**	Channel
Invert direction (counter inputs)	• **Deactivated** • Activated	Channel
Signal evaluation for counter inputs	• **Single** • Double • Quadruple	Channel
Filter frequency for counter inputs	• 100 Hz • 200 Hz • 500 Hz • 1 kHz • 2 kHz • 5 kHz • 10 kHz • 20 kHz • 50 kHz • 100 kHz • **200 kHz**	Channel
Sensor type	• **Sourcing output** • Sinking output • Push-pull (sinking and sourcing output)	Channel
Signal selection for reference mark 0	• DI0 • **Signal N of incremental encoder**	Channel
Measuring input	**DI1**	Channel

Parameter	Value range	Scope
Encoder type	• Linear • **Rotary**	Channel
Increments per revolution / steps per revolution	**1**...65535	Channel
Reference speed	6.00...**3000.00**...210000.00 U/min	Channel
Distance between increments	250...**16000**...25000000	Channel
Fine-resolution increment distance	Automatically calculated (read-only)	Channel
Reference velocity	0.60...**16.00**...600.00 m/min	Channel
Enable diagnostic interrupt on wire break	• **Deactivated** • Activated	Channel
Enable additional diagnostic interrupts	• **Deactivated** • Activated	Channel

Explanation of parameters

You can find a detailed description of the parameters in function manual Counting, Measurement and Position Detection, section Module parameters (position input for Motion Control) available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820).

4.2.3 Address space

Address space of the technology module

Table 2-1179 Size of input and output addresses of the TM Count 1x24V with position input for "Motion Control" technology object

	Inputs	Outputs
Range	16 bytes	4 bytes

4.2.4 Control interface and feedback interface

4.2.4.1 Assignment of the control interface

The control interface is reserved for Motion Control instructions.

4.2.4.2 Assignment of the feedback interface

The feedback interface is reserved for Motion Control instructions with the exception of status information via the digital inputs.

Byte offset from start address ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reserved				STS_DI0	STS_DI1	Reserved	STS_DI2
1...15	Reserved							

4.2.5 Isochronous mode

The technology module supports the "Isochronous mode" system function. Counter values can be acquired in a fixed system cycle with this system function.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. A status change of a digital input immediately triggers the specified reaction of the technology module and the change of the status bit of the digital input in the feedback interface.

Use an OB of type "MC-Servo" in this operating mode. Isochronous mode is needed when using the output cam and cam track technology objects. When the measuring input technology is used in combination with hardware digital input DI1, isochronous mode is not needed.

Data processing

The data that was transmitted to the technology module in the current bus cycle via the control interface takes effect when it is processed in the internal technology module cycle. At the time the input data is read in (T_i), the counter value and the status bits are acquired and made available in the feedback interface for retrieval in the current bus cycle. In contrast to the other status bits, the STS_DI2 status bit is acquired in isochronous mode asynchronously to the time T_i.

Isochronous mode parameters

In isochronous mode, the "Filter frequency" parameter can affect the isochronous mode parameters of the sync domain.

Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameters in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

Additional information

You can find a detailed description of isochronous mode in the following:

- In the isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- Function manual PROFINET with STEP 7 available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856)

4.3 Manual operation (without technology object)

4.3.1 Configuring

Introduction

You configure the technology module and assign its parameters with the configuration software.

The functions of the technology module are controlled and checked by the user program via the control and feedback interface.

System environment

The technology module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central operation with a CPU 151xSP	• ET 200SP automation system • TM Count 1x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to control and feedback interface in the I/O data
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM Count 1x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	

Applications	Components required	Configuration software	In the user program
Distributed operation with an S7-1200 CPU	• S7-1200 automation system • ET 200SP distributed I/O system • TM Count 1x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to control and feedback interface in the I/O data
Distributed operation with an S7-300/400 CPU	• S7-300/400 automation system • ET 200SP distributed I/O system • TM Count 1x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration STEP 7: Device configuration and parameter setting with HSP	
Distributed operation in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Count 1x24V	Third-party configuration software: Device configuration and parameter setting with GSD file	

Additional information

You can find a detailed description of the counting and measurement functions and their configuration in the following:

- Function manual Counting, Measurement and Position Detection available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820)
- Information system of STEP 7 (TIA Portal) under "Using technology functions > Counting, measurement and position input > Counting, measurement and position input (S7-1500)"

Hardware Support Packages (HSP)

STEP 7 (TIA Portal)

If firmware version V2.0 of the module is not yet integrated in the TIA Portal version V15.1 you are using, you can integrate a corresponding module with HSP0300.

You can find the Hardware Support Packages (HSP) for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).

You can also access this download from the menu bar of STEP 7 (TIA Portal): "Options > Support packages > Download from the Internet".

STEP 7

You can find the Hardware Support Packages (HSP) for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/23183356).

GSD file

You can find the respective GSD file for the ET 200SP distributed I/O system for download on the Internet:

- GSD file for PROFINET IO (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD file for PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/73016883)

4.3.2 Reaction to CPU STOP

You set the response of the technology module to CPU STOP for each channel in the basic parameters of the device configuration.

Table 2-1180 Response of technology module to CPU STOP

Option	Meaning
Continue operation	The technology module remains fully functional. Incoming count pulses are processed. The digital outputs continue to switch according to the parameter assignment.
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the start value and the digital outputs switch according to the parameter assignment.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. If a digital output with the function "At comparison value for a pulse duration" is set at CPU stop, the digital output is reset after the pulse duration elapses. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the start value and the digital outputs switch according to the parameter assignment.

4.3.3 Parameter setting

You specify the properties of the technology module using various parameters. Depending on the settings, not all parameters are available. When parameters are assigned in the user program, the parameters are transferred to the module with the "WRREC" instruction and data record 128 (Page 78).

You set the parameters of the module as follows in this operating mode:

Parameter setting using...	Basic procedure
Hardware configuration in STEP 7 (TIA Portal)	1. Insert the module from the hardware catalog under "Technology modules". 2. Set the operating mode "Manual operation (without technology object) " and the other module parameters in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration in STEP 7 with HSP	1. Install the appropriate HSP file. You will then find the module in the hardware catalog under "ET 200SP". 2. Set the device configuration and the parameters in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFINET IO	1. Install the current PROFINET GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFINET IO > I/O". 2. Set the parameters in the hardware configuration. You can find information on the respective dependencies of the parameters in function manual Counting, Measurement and Position Detection (http://support.automation.siemens.com/WW/view/en/59709820). 3. Download the project to the CPU.

Parameter setting using...	Basic procedure
Hardware configuration with GSD file for distributed operation on PROFIBUS DP	1. Install the current PROFIBUS GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFIBUS DP > I/O". 2. Set the parameters in the hardware configuration. You can find information on the respective dependencies of the parameters in function manual Counting, Measurement and Position Detection (http://support.automation.siemens.com/WW/view/en/59709820). The parameters marked with [1] in the following tables are not configurable in the PROFIBUS GSD file. 3. Download the project to the CPU. The parameters marked with [1] in the following tables are downloaded with their default setting. 4. If necessary, set the parameters marked with [1] in the user program using data record 128.

Parameters of the TM Count 1x24V

The following parameter settings are possible. The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1181 Configurable parameters

Parameter	Value range	Scope
Potential group	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Operating mode[3]	• **Counting** • Measuring	Channel
Reaction to CPU STOP[1]	• **Output substitute value** • Keep last value • Continue operation	Channel
Substitute value for DQ0[1]	• **0** • 1	Channel
Substitute value for DQ1[1]	• **0** • 1	Channel
Enable diagnostic interrupt on wire break[2]	• **Deactivated** • Activated	Channel
Enable additional diagnostic interrupts	• **Deactivated** • Activated	Channel
Hardware interrupt: New Capture value available[1]	• **Deactivated** • Activated	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

3 When configuring with HSP for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

4 Not available with HSP for STEP 7

Parameter	Value range	Scope
Hardware interrupt: Synchronization of the counter by an external signal[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Gate start[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Gate stop[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Overflow (high counting limit violated)[1]	• **Deactivated** • Activated	Channel
Hardware interrupt:Underflow (low counting limit violated)[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Direction reversal[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Zero crossing[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Comparison event for DQ0 occurred[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Comparison event for DQ1 occurred[1]	• **Deactivated** • Activated	Channel
Signal type	• Pulse (A) • **Pulse (A) and direction (B)** • Count up (A), count down (B) • Incremental encoder (A, B phase-shifted) • Incremental encoder (A, B, N)	Channel
Invert direction[1] (counter inputs)	• **Deactivated** • Activated	Channel
Signal evaluation for counter inputs	• **Single** • Double • Quadruple	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

3 When configuring with HSP for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

4 Not available with HSP for STEP 7

Parameter	Value range	Scope
Filter frequency for counter inputs[1]	• 100 Hz • 200 Hz • 500 Hz • 1 kHz • 2 kHz • 5 kHz • 10 kHz • 20 kHz • 50 kHz • 100 kHz • **200 kHz**	Channel
Sensor type	• **Sourcing output** • Sinking output • Push-pull (sinking and sourcing output)	Channel
Reaction to signal N[1]	• **No reaction to signal N** • Synchronization at signal N • Capture at signal N	Channel
Frequency of synchronization[1]	• **Once** • Periodic	Channel
Frequency of Capture function[1,4]	• Once • **Periodic**	Channel
High counting limit[1]	-2147483648...**2147483647**	Channel
Start value[1]	-2147483648...**0**...2147483647	Channel
Counting low limit[1]	**-2147483648**...2147483647	Channel
Reaction to violation of a counting limit	• Stop counting • **Continue counting**	Channel
Reset when counting limit is violated	• **To opposite counting limit** • To start value	Channel
Reaction to gate start	• Set to start value • **Continue with current value**	Channel
Set function of DI	• Gate start/stop (level-triggered) • Gate start (edge-triggered) • Gate stop (edge-triggered) • Synchronization • Enable synchronization at signal N • Capture • **Digital input without function**	Channel
Select level for DI[1]	• **Active with high level** • Active with low level	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

3 When configuring with HSP for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

4 Not available with HSP for STEP 7

Parameter	Value range	Scope
Edge selection for DI[1]	• **At rising edge** • At falling edge • At rising and falling edge	Channel
Behavior of counter value after Capture with DI [1]	• **Continue counting** • Set to start value and continue counting	Channel
Input delay for digital inputs[1]	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel
Set output	• **Between comparison value and high limit / measured value >= comparison value** • Between comparison value and low limit / measured value <= comparison value • Between comparison value 0 and 1 • Not between comparison value 0 and 1 • At comparison value for a pulse duration • After set command from CPU until comparison value • Use by user program	Channel
Comparison value 0[1]	-2147483648...**0**...2147483647	Channel
Comparison value 1[1]	-2147483648...**10**...2147483647	Channel
Count direction of DQ function[1]	• Up • Down • **In both directions**	Channel
Pulse duration[1]	0...**500.0**...6553.5 ms	Channel
Hysteresis (in increments)[1]	**0**...255	Channel
Measured variable	• **Frequency** • Period • Velocity	Channel
Update time of the measuring function	0...**10**...25000 ms	Channel
Time base for velocity measurement[1]	• 1 ms • 10 ms • 100 ms • 1 s • **60 s**	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

3 When configuring with HSP for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

Parameter	Value range	Scope
Increments per unit[1]	**1**...65535	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

3 When configuring with HSP for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

4 Not available with HSP for STEP 7

Explanation of parameters

You can find a detailed description of the parameters in function manual Counting, Measurement and Position Detection, sections Basic parameters and Manual operation available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820).

4.3.4 Address space

Address space of the technology module

Table 2-1182 Size of input and output addresses of the TM Count 1x24V with manual operation

	Inputs	Outputs
Range	16 bytes	12 bytes

4.3.5 Control and feedback interface

NOTE

The control and feedback interface is compatible with the control and feedback interface of the TM Count 2x24V, TM PosInput 2 and TM PosInput 1 technology modules of the S7-1500 automation system.

4.3.5.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface

The following table shows the assignment of the control interface:

Byte offset from start address ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	SLOT_0: DINT or REAL: Load value (meaning of the value is specified in LD_SLOT_0) Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
4...7	SLOT_1: DINT or REAL: Load value (meaning of the value is specified in LD_SLOT_1) Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
8	LD_SLOT_1				LD_SLOT_0			
9	EN_ CAPTURE	EN_ SYNC_DN	EN_ SYNC_UP	SET_DQ1	SET_DQ0	TM_ CTRL_DQ1	TM_ CTRL_DQ0	SW_GATE
10	SET_DIR	Reserved					RES_ EVENT	RES_ ERROR
11	Reserved							

Explanations

Control bit/value	Explanations
SLOT_m	You specify the load value with this value. You specify the meaning of the value in LD_SLOT_m. If you want to load a comparison value in the "Measuring" operating mode, specify the load value as floating-point number (REAL). In all other cases, you specify the load value as an integer (DINT). Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$
LD_SLOT_m	Use this load request to specify the meaning of the value in SLOT_m: • 0000_B means: No action, idle • 0001_B means: Load counter value • 0010_B not permitted • 0011_B means: Load start value • 0100_B means: Load comparison value 0 • 0101_B means: Load comparison value 1 • 0110_B means: Load counting low limit • 0111_B means: Load counting high limit • 1000 to 1111_B not permitted The technology module executes the respective action as soon as LD_SLOT_m changes. If values are loaded simultaneously using LD_SLOT_0 and LD_SLOT_1, the value from SLOT_0 is internally applied first and then the value from SLOT_1 . This can produce unexpected intermediate states.
EN_CAPTURE	Use this bit to enable the Capture function. Resetting this bit resets a set EVENT_CAP in the feedback interface.

Control bit/value	Explanations
EN_SYNC_DN	Use this bit to enable the synchronization of the counter when counting down with an incremental encoder or pulse encoder. Resetting this bit resets a set EVENT_SYNC in the feedback interface.
EN_SYNC_UP	Use this bit to enable the synchronization of the counter when counting up with an incremental encoder or pulse encoder. Resetting this bit resets a set EVENT_SYNC in the feedback interface.
SET_DQ0	Use this bit to set digital output DQ0 when TM_CTRL_DQ0 is set to 0. In the case of the function "After set command from CPU until comparison value", SET_DQ0 is effective regardless of TM_CTRL_DQ0 as long as the counter value is not equal to the comparison value.
SET_DQ1	Use this bit to set digital output DQ1 when TM_CTRL_DQ1 is set to 0. In the case of the function "After set command from CPU until comparison value", SET_DQ1 is effective regardless of TM_CTRL_DQ1 as long as the counter value is not equal to the comparison value.
TM_CTRL_DQ0	Use this bit to enable the technological function of digital output DQ0. • 0 means: SET_DQ0 defines the state of DQ0 • 1 means: assigned function defines the state of DQ0
TM_CTRL_DQ1	Use this bit to enable the technological function of digital output DQ1. • 0 means: SET_DQ1 defines the state of DQ1 • 1 means: assigned function defines the state of DQ1
SW_GATE	Use this bit to open and close the software gate when using an incremental encoder or pulse encoder. Together, the software gate and the hardware gate form the internal gate. The technology module only counts when the internal gate is open. • 0 means: Software gate closed • 1 means: Software gate open The digital inputs of the technology module externally control the hardware gate. The hardware gate can be activated by parameter assignment. The software gate cannot be deactivated.
SET_DIR	Use this bit to specify the count direction for signal type "Pulse (A)". • 0 means: Up • 1 means: Down
RES_EVENT	Use this bit to trigger the reset of the saved events in the EVENT_ZERO, EVENT_OFLW, EVENT_UFLW, EVENT_CMP0, EVENT_CMP1 feedback bits.
RES_ERROR	Use this bit to trigger the reset of the saved error states LD_ERROR and ENC_ERROR .
Reserved	Reserved bits must be set to 0.

4.3.5.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module by means of the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Byte offset from start address ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	COUNT_VALUE: DINT: Current counter value							
4...7	CAPTURED_VALUE: DINT: The last acquired Capture value							
8...11	MEASURED_VALUE: REAL: Current measured value							
12	Reserved					LD_ERROR	ENC_ ERROR	POWER_ ERROR
13	Reserved		STS_ SW_GATE	STS_ READY	LD_STS_ SLOT_1	LD_STS_ SLOT_0	RES_EVENT_- ACK	Reserved
14	STS_DI2	STS_DI1	STS_DI0	STS_DQ1	STS_DQ0	STS_GATE	STS_CNT	STS_DIR
15	STS_M_ INTERVAL	EVENT_ CAP	EVENT_ SYNC	EVENT_ CMP1	EVENT_ CMP0	EVENT_ OFLW	EVENT_ UFLW	EVENT_ ZERO

Explanations

Feedback bit/value	Explanations
COUNT_VALUE	This DINT value displays the current counter value.
CAPTURED_VALUE	This DINT value indicates the last acquired Capture value. The following external signals can trigger the Capture function: • Rising or falling edge of a digital input • Both edges of a digital input The "Frequency of Capture function" parameter specifies whether the function is executed at each configured edge or only once after each enable.

Feedback bit/value	Explanations
MEASURED_VALUE	This value indicates the current measured value with data type REAL: • Frequency: The mean frequency is calculated from the time profile of the count pulses or position value changes in one measurement interval and returned as a floating-point number in the unit of hertz. • Period: The mean period is calculated from the time profile of the count pulses or position value changes in one measurement interval and returned as a floating-point number in the unit of seconds. • Velocity: The mean velocity is calculated from the time profile of the count pulses or position value changes in one measurement interval and returned as a floating-point number in the configured unit. The measured values are returned as a signed value. The sign indicates whether the counter value went up or down in the relevant time interval. The update time is asynchronous to the opening of the internal gate, i.e. the update time is not started when the gate opens. After the internal gate closes, the last calculated measured value continues to be returned.
LD_ERROR	This bit indicates that an error occurred (latching) during loading via the control interface. The loaded values were not applied. When using an incremental or pulse encoder, one of the following conditions is not fulfilled: • Low counting limit <= counter value <= high counting limit • Low counting limit <= start value <= high counting limit • Low counting limit <= comparison value 0/1 <= high counting limit The bit is reset once you have acknowledged the error with RES_ERROR .
ENC_ERROR	This bit indicates that one of the following errors has occurred at the encoder signals (retentive) for the respective technology module: • Wire break of digital input A, B or N (with push-pull encoder) • Invalid transition of A/B signals (with incremental encoder) If you have enabled the diagnostic interrupts, the respective diagnostic interrupt is triggered in the event of encoder signal errors. For information on the meaning of the diagnostics interrupts, refer to the section Diagnostics alarms (Page 65). The bit is reset once you have acknowledged the error with RES_ERROR .
POWER_ERROR	This bit indicates that supply voltage L+ is too low. If you have enabled the diagnostic interrupts, the diagnostics interrupt "Supply voltage missing" is triggered when an error occurs. For information on the meaning of the diagnostics interrupts, refer to the section Diagnostics alarms (Page 65). When supply voltage L+ is available at a sufficient level once again, POWER_ERROR is automatically set to 0.
STS_SW_GATE	This bit indicates the status of the software gate. • 0 means: Gate closed • 1 means: Gate open
STS_READY	This bit indicates that the technology module supplies valid user data. The technology module has been started up and configured.
LD_STS_SLOT_0	This bit indicates by a status change (toggling) that the load request for SLOT_0 (LD_SLOT_0) was detected and performed.
LD_STS_SLOT_1	This bit indicates by a status change (toggling) that the load request for SLOT_1 (LD_SLOT_1) was detected and performed.
RES_EVENT_ACK	This bit indicates that the reset of event bit EVENT_SYNC, EVENT_CMP0, EVENT_CMP1, EVENT_OFLW, EVENT_UFLW, EVENT_ZERO is active.
STS_DI0	This bit indicates the status of digital input DI0.
STS_DI1	This bit indicates the status of digital input DI1.
STS_DI2	This bit indicates the status of digital input DI2.
STS_DQ0	This bit indicates the status of digital output DQ0.

Feedback bit/value	Explanations
STS_DQ1	This bit indicates the status of digital output DQ1.
STS_GATE	This bit indicates the status of the internal gate when using an incremental or pulse encoder. • 0 means: Gate closed • 1 means: Gate open
STS_CNT	This bit indicates that at least one count pulse or a position value change has been detected in the last approx. 0.5 s.
STS_DIR	This bit indicates the count direction of the last count pulse or the direction of the last position value change. • 0 means: Down • 1 means: Up
STS_M_INTERVAL	This bit indicates that at least one count pulse or a position value change was detected in the previous measurement interval.
EVENT_CAP	This bit indicates that a Capture event has occurred and a counter value has been saved in CAPTURED_VALUE . You reset the state by resetting EN_CAPTURE .
EVENT_SYNC	This bit indicates the saved state that the counter was loaded with the start value by an external reference signal (synchronization) when using an incremental or pulse encoder. You reset the state by resetting EN_SYNC_UP or EN_SYNC_DN .
EVENT_CMP0	This bit indicates the saved state that a comparison event (state change) has occurred for the digital output DQ0 based on the selected comparison condition. You reset the state by acknowledgment with RES_EVENT. If the counter value is set to the start value in counting operating mode, EVENT_CMP0 is not set.
EVENT_CMP1	This bit indicates the saved state that a comparison event (state change) has occurred for the digital output DQ1 based on the selected comparison condition. You reset the state by acknowledgment with RES_EVENT. If the counter value is set to the start value in counting operating mode, EVENT_CMP1 is not set.
EVENT_OFLW	This bit indicates the saved state that there was a counter value overflow. You reset the state by acknowledgment with RES_EVENT.
EVENT_UFLW	This bit indicates the saved state that there was a counter value underflow. You reset the state by acknowledgment with RES_EVENT.
EVENT_ZERO	This bit indicates the saved state that the counter value or position value experienced a zero crossing. You reset the state by acknowledgment with RES_EVENT. If the "Zero crossing" hardware interrupt is enabled, it can also be triggered by the system if "0" is outside the configured value range.
Reserved	Reserved bits are set to 0.

4.3.6 Isochronous mode

The technology module supports the "Isochronous mode" system function. This system function enables counter values and measured values to be acquired in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. The output signals switch immediately if the relevant comparison condition is met. A status change of a digital input immediately triggers the specified reaction of the technology module and the change of the status bit of the digital input in the feedback interface.

Use an OB of type "Synchronous Cycle" (e.g. OB61) in this operating mode. The input and output data are processed in the assigned OB.

The update time for the measured value is synchronized with the system cycle in a suitable ratio and, if necessary, adapted in length. If you set "0", the measured value is updated once per system cycle.

Data processing

The data that was transmitted to the technology module in the current bus cycle via the control interface takes effect when it is processed in the internal technology module cycle. At the time the input data is read in (T_i), the counter value and the measured value as well as status bits are acquired and made available in the feedback interface for retrieval in the current bus cycle.

Isochronous mode parameters

In isochronous mode, the "Filter frequency" parameter can affect the isochronous mode parameters of the sync domain.

Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameters in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

Additional information

You can find a detailed description of isochronous mode in the following:

- In the isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- Function manual PROFINET with STEP 7 available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856)

4.4 Fast Mode

You can use the technology module in Fast Mode for very fast acquisition of the counter value with compressed functionality. A reduced feedback interface but no control interface is available in Fast Mode. This allows you to use a shorter send clock for the CPU.

The scope of functions of the technology module has the following additional restrictions in Fast Mode:

- Parameter change in RUN only possible with data record 128
- Count/position value range: 25 bits
- No measured value available
- No software gate available
- No Capture function available
- No hardware interrupts available
- Combined error message (feedback bit) that is acknowledged automatically

4.4.1 Configuring

Introduction

You configure the technology module and assign its parameters with the configuration software.

The functions of the technology module are controlled and checked by the user program via the feedback interface.

System environment

The technology module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central operation with a CPU 151xSP	• ET 200SP automation system • TM Count 1x24V	STEP 7 (TIA Portal): • Device configuration and parameter setting with hardware configuration	Direct access to feedback interface in the I/O data
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM Count 1x24V	STEP 7 (TIA Portal): • Device configuration and parameter setting with hardware configuration	
Distributed operation with an S7-1200 CPU	• S7-300/400 or S7-1200 automation system • ET 200SP distributed I/O system • TM Count 1x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	
Distributed operation with an S7-300/400 CPU	• S7-300/400 or S7-1200 automation system • ET 200SP distributed I/O system • TM Count 1x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration STEP 7: Device configuration and parameter setting with HSP	
Distributed operation in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Count 1x24V	Third-party configuration software: Device configuration and parameter setting with GSD file	

Additional information

You can find a detailed description of the counting and measurement functions and their configuration in the following:

- Function manual Counting, Measurement and Position Detection available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820)
- Information system of STEP 7 (TIA Portal) under "Using technology functions > Counting, measurement and position input > Counting, measurement and position input (S7-1500)"

Hardware Support Packages (HSP)

STEP 7 (TIA Portal)

If firmware version V2.0 of the module is not yet integrated in the TIA Portal version V15.1 you are using, you can integrate a corresponding module with HSP0300.

You can find the Hardware Support Packages (HSP) for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).

You can also access this download from the menu bar of STEP 7 (TIA Portal): "Options > Support packages > Download from the Internet".

STEP 7

You can find the Hardware Support Packages (HSP) for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/23183356).

GSD file

You can find the respective GSD file for the ET 200SP distributed I/O system for download on the Internet:

- GSD file for PROFINET IO (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD file for PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/73016883)

4.4.2 Reaction to CPU STOP

You set the response of the technology module to CPU STOP for each channel in the basic parameters of the device configuration.

Table 2-1183 Response of technology module to CPU STOP

Option	Meaning
Continue operation	The technology module remains fully functional. Incoming count pulses are processed. The digital outputs continue to switch according to the parameter assignment.
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the start value and the digital outputs switch according to the parameter assignment.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. If a digital output with the function "At comparison value for a pulse duration" is set at CPU stop, the digital output is reset after the pulse duration elapses. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the start value and the digital outputs switch according to the parameter assignment.

4.4.3 Parameter setting

You specify the properties of the technology module using various parameters. Depending on the settings, not all parameters are available. When parameters are assigned in the user program, the parameters are transferred to the module with the "WRREC" instruction and data record 128 (Page 78).

You set the parameters of the module as follows in this operating mode:

Parameter setting using...	Basic procedure
Hardware configuration in STEP 7 (TIA Portal)	1. Insert the module from the hardware catalog under "Technology modules". 2. Set the operating mode "Fast Mode" and the other module parameters in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration in STEP 7 with HSP	1. Install the appropriate HSP file. You will then find the module in the hardware catalog under "ET 200SP". 2. Set the device configuration and the parameters in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFINET IO	1. Install the current PROFINET GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFINET IO > I/O". 2. Set the parameters in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFIBUS DP	1. Install the current PROFIBUS GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFIBUS DP > I/O". 2. Set the parameters in the hardware configuration. The parameters marked with [1] in the following tables are not configurable in the PROFIBUS GSD file. 3. Download the project to the CPU. The parameters marked with [1] in the following tables are downloaded with their default setting. 4. If necessary, set the parameters marked with [1] in the user program using data record 128.

Parameters of the TM Count 1x24V

The following parameter settings are possible. The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1184 Configurable parameters

Parameter	Value range	Scope
Potential group	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Reaction to CPU STOP[1]	• **Output substitute value** • Keep last value • Continue operation	Channel
Substitute value for DQ0[1]	• **0** • 1	Channel
Substitute value for DQ1[1]	• **0** • 1	Channel
Enable diagnostic interrupt on wire break[2]	• **Deactivated** • Activated	Channel
Enable additional diagnostic interrupts	• **Deactivated** • Activated	Channel
Signal type	• Pulse (A) • **Pulse (A) and direction (B)** • Count up (A), count down (B) • Incremental encoder (A, B phase-shifted) • Incremental encoder (A, B, N)	Channel
Invert direction[1] (counter inputs)	• **Deactivated** • Activated	Channel
Signal evaluation for counter inputs	• **Single** • Double • Quadruple	Channel
Filter frequency for counter inputs[1]	• 100 Hz • 200 Hz • 500 Hz • 1 kHz • 2 kHz • 5 kHz • 10 kHz • 20 kHz • 50 kHz • 100 kHz • **200 kHz**	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

Parameter	Value range	Scope
Sensor type	• **Sourcing output** • Sinking output • Push-pull (sinking and sourcing output)	Channel
Reaction to signal N[1]	• **No reaction to signal N** • Synchronization at signal N	Channel
High counting limit[1]	1...**33554431**	Channel
Start value[1]	**0**...33554431	Channel
Counting low limit[1]	**0**...33554430	Channel
Reaction to violation of a counting limit	• Stop counting • **Continue counting**	Channel
Reset when counting limit is violated	• **To opposite counting limit** • To start value	Channel
Reaction to gate start	• Set to start value • **Continue with current value**	Channel
Set function of DI	• Gate start/stop (level-triggered) • Gate start (edge-triggered) • Gate stop (edge-triggered) • Synchronization • Enable synchronization at signal N • **Digital input without function**	Channel
Input delay for digital inputs[1]	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel
Select level for DI[1]	• **Active with high level** • Active with low level	Channel
Edge selection for DI[1]	• **At rising edge** • At falling edge	Channel
Frequency of synchronization[1]	• **Once** • Periodic	Channel
Count direction for synchronization	• Up • Down • **In both directions**	Channel

[1] Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

[2] When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

Parameter	Value range	Scope
Set output	• Between comparison value and high limit • Between comparison value and low limit • Between comparison value 0 and 1 • At comparison value for a pulse duration • **Digital output without function**	Channel
Comparison value 0[1]	**0**...33554431	Channel
Comparison value 1[1]	0...**10**...33554431	Channel
Count direction of DQ function[1]	• Up • Down • **In both directions**	Channel
Pulse duration[1]	0...**500.0**...6553.5 ms	Channel
Hysteresis (in increments)[1]	**0**...255	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

4.4.4 Explanation of parameters

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station that are supplied from a common supply voltage.

A potential group begins with a light BaseUnit, which feeds the required supply voltage for all modules of the potential group. The light BaseUnit interrupts the three self-configuring voltage bars P1, P2 and AUX to the neighboring modules on the left.

All other I/O modules of this potential group are plugged into dark BaseUnits. They take on the potentials of the self-configuring busbars P1, P2 and AUX from the neighboring modules on the left.

A potential group ends with the dark BaseUnit, which is followed by a light BaseUnit or server module in the station configuration.

Signal type

You can select from the following signal types:

Signal type	Meaning
Incremental encoder (A, B phase-shifted)	An incremental encoder with phase-shifted A and B signals is connected.
Incremental encoder (A, B, N)	An incremental encoder with phase-shifted signals A and B and a zero signal N is connected.

Signal type	Meaning
Pulse (A) and direction (B)	A pulse encoder (signal A) with direction signal (signal B) is connected.
Pulse (A)	A pulse encoder (signal A) without direction signal is connected.
Count up (A), count down (B)	Signals for counting up (signal A) and down (signal B) are connected.

Invert direction

You can invert the counting direction to adapt it to the process.

The inverting of the direction is configurable and active for the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Signal evaluation

With the parameter assignment of the signal evaluation, you specify which edges of the signals are counted.

You can select from the following options:

Signal evaluation	Meaning
Single	The edges of signal A are evaluated during a low level of signal B.
Double	Each edge of signal A is evaluated.
Quadruple	Each edge of signals A and B is evaluated.

The parameter can be assigned with the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Filter frequency

By configuring the filter frequency, you suppress interferences at the counting inputs A, B and N.

The selected filter frequency is based on a pulse/break ratio of between around 40:60 and around 60:40. This results in a specific minimum pulse/break time. Signal changes with a duration shorter than the minimum pulse/break time are suppressed.

You can select from the following filter frequencies:

Filter frequency	Minimum pulse/break time
100 Hz	4.0 ms
200 Hz	2.0 ms
500 Hz	800 µs

Filter frequency	Minimum pulse/break time
1 kHz	400 µs
2 kHz	200 µs
5 kHz	80 µs
10 kHz	40 µs
20 kHz	20 µs
50 kHz	8.0 µs
100 kHz	4.0 µs
200 kHz	2.0 µs

Reaction to signal N

You use this parameter to specify which reaction to signal N is triggered.

You can select from the following options:

Option	Meaning
No reaction to signal N	The counter is not affected by signal N.
Synchronization at signal N	The counter is set to the start value at signal N. If you select the function "Enable synchronization at signal N" for a digital input, the synchronization depends on the level at the digital input.

NOTE

You can only select the reaction to signal N if you have selected the "Incremental encoder (A, B, N)" signal type.

NOTE

If you select "Synchronization at signal N", you can choose the "Enable synchronization at signal N" function for a digital input.

Frequency of synchronization

This parameter is used to define the frequency of the following events:

- Synchronization at signal N
- Synchronization as function of a digital input

You can select from the following options:

Option	Meaning
Once	The counter is only set at the first signal N or the first configured edge of the digital input.
Periodic	The counter is set at each signal N or each configured edge of the digital input.

Count direction of the synchronization

You use this parameter to specify the count direction for which the following functions are enabled:

- Synchronization at signal N
- Synchronization as function of a digital input

You can select from the following options:

Option	Meaning
In both directions	Synchronization takes place regardless of the count direction.
Up	Synchronization only takes place when the counter is counting up.
Down	Synchronization only takes place when the counter is counting down.

Sensor type

With the parameter assignment of the sensor type, you specify how the counter inputs are switched.

You can select from the following options:

Option	Meaning
Sourcing output	The encoder or sensor switches the A, B and N inputs to 24 V DC.
Sinking output	The encoder or sensor switches the A, B and N inputs to M.
Push-pull (sinking and sourcing output)	The encoder or sensor switches the A, B and N inputs to alternately to M and 24 V DC.

"Push-pull" is usually selected when incremental encoders are used. If using 2-wire sensors, such as light barriers or proximity switches, you need to select the corresponding wiring "sourcing output" or "sinking output".

The data sheet of the encoder includes information on whether your incremental encoder is a push-pull encoder.

NOTE

If you use a push-pull encoder and the sensor type "Push-pull (sinking and sourcing output)" is configured, you can monitor the encoder signals for wire break.

High counting limit

With the parameter assignment of the counting high limit, you limit the counting range. You can enter a value up to 33554431 (2^{25}-1). You must enter a value above the counting low limit.

Counting low limit

With the parameter assignment of the counting low limit, you limit the counting range. You can enter a value starting with 0. You must enter a value below the counting high limit.

Start value

With the parameter assignment of the start value, you specify the value at which counting is begun and is to continue in the case of defined events. You must enter a value at or within the counting limits.

Reaction to violation of a counting limit

You can configure the following reaction to violation of a counting limit:

Reaction	Meaning
Stop counting	After violation of a counting limit, counting is stopped and the internal gate is closed. To restart counting, you must close and reopen the SW gate or HW gate, if necessary.
Continue counting	Counting is continued with the start value or at the opposite counting limit depending on the additional parameter assignment.

Reset when counting limit is violated

You can reset the counter when a counting limit is violated:

Reset the value	Meaning
To start value	The counter value is set to the start value.
To opposite counting limit	The counter value is set to the opposite counting limit in each case.

Reaction to gate start

You can configure the following reaction to gate start:

Reaction	Meaning
Set to start value	When the gate is opened, the counter value is set to the start value.
Continue with current value	When the gate is opened, counting is continued with the last counter value.

NOTE

The parameter is only effective when you have configured a HW gate.

Set function of DI

With the parameter assignment of a digital input, you specify which function the digital input triggers when switched.

You can select from the following options:

Function of a digital input	Meaning
Gate start/stop (level-triggered)	The level at the respective digital input opens and closes the HW gate.
Gate start (edge-triggered)	The configured edge at the respective digital input opens the HW gate.
Gate stop (edge-triggered)	The configured edge at the respective digital input closes the HW gate.
Synchronization	The configured edge at the respective digital input sets the counter to the start value.
Enable synchronization at signal N	The active level at the respective digital input enables synchronization of the counter at signal N.
Digital input without function	No technological function is assigned to the respective digital input. You can read the signal status of the digital input via the feedback interface.

NOTE

Each function, except "Digital input without function", can be used only once per counter and can no longer be selected for the other digital inputs in each case.

Input delay

You use this parameter to suppress signal noise at the digital inputs. Changes to the signal are only detected if they remain stable for longer than the configured input delay time.

NOTE

If you select the "None" or "0.05 ms" option, you must use shielded cables for connection of the digital inputs.

NOTE

You configure the input delay under "Behavior of DI0" for all digital inputs together. The input delay is also displayed under "Behavior of DI1" and "Behavior of DI2".

Select level

You use this parameter to specify the level at which the digital input is active.

You can select from the following options:

Level	Meaning
Active with high level	The respective digital input is active when it is set.
Active with low level	The respective digital input is active when it is not set.

The parameter can be configured for the following functions of a digital input:

- Gate start/stop (level-triggered)
- Enable synchronization at signal N

Edge selection

You use this parameter to specify the edge of the digital input at which the configured function is triggered.

You can select from the following options depending on the function selected:

- At rising edge
- At falling edge

The parameter can be configured for the following functions of a digital input:

- Gate start (edge-triggered)
- Gate stop (edge-triggered)
- Synchronization

Set output

With the parameter assignment of a digital output, you specify the condition upon which the digital output switches.

You can select from the following options:

Function of a digital output	Meaning
Between comparison value and high limit	The respective digital output is active if: Comparison value <= counter value <= counting high limit
Between comparison value and low limit	The respective digital output is active if: Low limit <= counter value <= comparison value
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= counter value <= comparison value 1
At comparison value for a pulse duration	The respective digital output is active once for the configured time and count direction when the counter value corresponds to the comparison value.
Digital output without function	The respective digital output is set to 0 irrespective of the reaction to CPU STOP.

NOTE

You can only set the "Between comparison value 0 and 1" function for digital output DQ1 and only if you have selected the "Digital output without function" function for digital output DQ0.

Comparison value 0

With the parameter assignment of the comparison value, you specify the counter value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter an integer (DINT) that is greater than or equal to the counting low limit. If you use the DQ function "Between comparison value 0 and 1", comparison value 0 must be less than comparison value 1.

Comparison value 1

With the parameter assignment of the comparison value, you specify the counter value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter an integer (DINT) that is less than or equal to the counting high limit. If you use the DQ function "Between comparison value 0 and 1", comparison value 0 must be less than comparison value 1.

Count direction

You use this parameter to specify the count direction for which the selected functions is valid:

You can select from the following options:

Count direction	Meaning
In both directions	The comparison and switching of the respective digital output takes places regardless of the count direction.
Up	The comparison and switching of the respective digital output only takes place when the counter counts up.
Down	The comparison and switching of the respective digital output only takes place when the counter counts down.

The parameter can be configured for the following functions:

- Between comparison value 0 and 1
- At comparison value for a pulse duration

Pulse duration

With the parameter assignment of the pulse duration for the "At comparison value for a pulse duration" function, you specify how many milliseconds the respective digital output is active.

If you enter "0" and the counter value corresponds to the respective comparison value, the digital output is active until the next count pulse.

Hysteresis (in increments)

With the parameter assignment of the hysteresis, you specify a range around the comparison values. Within the hysteresis range, the digital outputs cannot switch again before the counter value has left this range.

An encoder can stop at a certain position, and slight movements can cause the counter value to fluctuate around this position. If a comparison value or counting limit is within the fluctuation range and a hysteresis is not used, the associated digital output will switch on and off with corresponding frequency. The hysteresis prevents these unwanted switching actions.

Regardless of the hysteresis value, the hysteresis range ends at the low or counting high limit. If you enter "0", the hysteresis is turned off.

4.4.5 Address space

Address space of the technology module

Table 2-1185 Size of input and output addresses of the TM Count 1x24V with Fast Mode

	Inputs	Outputs
Range	4 bytes	0 bytes

4.4.6 Assignment of the feedback interface

The user program receives current values and status information from the technology module by means of the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Byte offset from start address ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	LS	STS_ READY	STS_DI2	EXT_F	STS_DI0	STS_DIR	STS_DI1	COUNT_ VALUE
1	COUNT_VALUE: DINT: Current counter value							
2								
3								

Explanation of feedback bits

Feedback bit	Explanations
LS	As a sign of life, this bit indicates through a state change (toggling) that isochronous mode is functioning and that the module has updated the feedback interface in the respective bus cycle. This bit is set to 0 in non-isochronous mode.
STS_READY	This bit indicates that the technology module supplies valid user data. The technology module has been started up and configured.
STS_DI2	This bit indicates the status of digital input DI2.
EXT_F	This bit indicates that one of the following errors has occurred at the encoder signals for the technology module: • Load voltage missing • Wire break of digital input A, B or N (with push-pull encoder) • Invalid transition of A/B signals (with incremental encoder) If you have enabled the diagnostic interrupts, the respective diagnostic interrupt is triggered in the event of encoder signal errors. For information on the meaning of the diagnostics interrupts, refer to the section Diagnostics alarms. The bit is reset automatically as soon as an error no longer exists.
STS_DI0	This bit indicates the status of digital input DI0.
STS_DIR	This bit indicates the count direction of the last count pulse. 0 means: Down 1 means: Up
STS_DI1	This bit indicates the status of digital input DI1.
COUNT_VALUE	This value returns the current counter value in the first 25 bits of a DINT value.

4.4.7 Isochronous mode

The technology module supports the "Isochronous mode" system function. Counter values can be acquired in a fixed system cycle with this system function.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. The output signals switch immediately if the relevant comparison condition is met. A status change of a digital input immediately triggers the specified reaction of the technology module and the change of the status bit of the digital input in the feedback interface.

This operating mode is especially well-suited for short send clocks of the CPU starting from 125 µs, because only input data is used.

Use an OB of type "Synchronous Cycle" (e.g. OB61) in this operating mode.

Data processing

At the time the input data is read in (T_i), the counter value and the status bits are acquired and made available in the feedback interface for retrieval in the current bus cycle.

Isochronous mode parameters

In isochronous mode, the "Filter frequency" parameter can affect the isochronous mode parameters of the sync domain.

Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameters in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

Additional information

You can find a detailed description of isochronous mode in the following:

- In the isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- Function manual PROFINET with STEP 7 available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856)

Interrupts/diagnostic messages

5

5.1 Status and error display

LEDs

The following figure shows you the LED displays (status and error displays) of TM Count 1x24V.

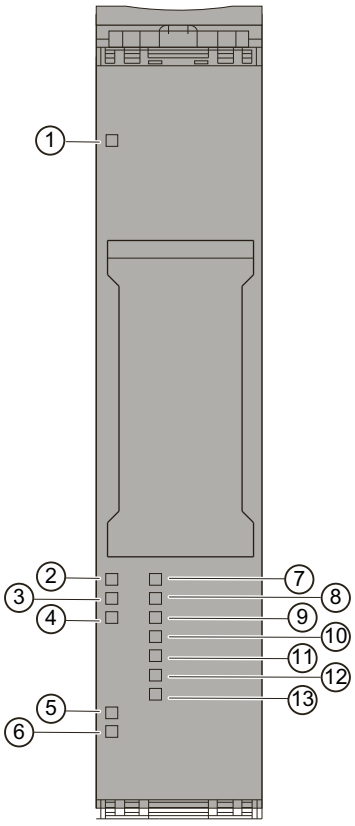

①	DIAG (green/red)	⑧	Status DI1 (green)
②	Status A (green)	⑨	Status of DI2 (green)
③	Status B (green)	⑩	Status DQ0 (green)
④	Status N (green)	⑪	Status DQ1 (green)
⑤	24VDC (green)	⑫	Status UP (green)
⑥	PWR (green)	⑬	Status DN (green)
⑦	Status DI0 (green)		

Figure 2-1068 LED displays of the TM Count 1x24V

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in section Diagnostic messages (Page 65).

Table 2-1186 Status and error displays DIAG

LED DIAG	Meaning	Remedy
□ Off	Backplane bus supply of the ET 200SP not OK	Check or switch on the supply voltage on the CPU or on the interface module.
☼ Flashes	Technology module parameters not set	---
■ On	Technology module parameters set and no module diagnostics	
☼ Flashes	Technology module parameters set and module diagnostics (at least one error is present)	Evaluate the diagnostic alarms and eliminate the error.

Table 2-1187 PWR/24VDC status displays

LEDs		Meaning	Remedy
PWR	24VDC		
□ Off	□ Off	Supply voltage missing	• Check the supply voltage. • Check the BaseUnit type and the wiring of the BaseUnit.
■ On	■ On	Supply voltage is present and OK. Encoder supply is OK.	---
■ On	□ Off	Short-circuit or overload at the encoder supply	• Check the encoder wiring. • Check the loads connected to the encoder supply.

Channel LEDs

The A, B, N and DIm LEDs indicate the current level of the associated signals. The LEDs of the DQm digital outputs indicate the desired state.

The UP and DN LEDs indicate the logical counting direction.

The flashing frequency of the channel LEDs is limited to approximately 12 Hz. If higher frequencies are present, the channel LEDs will flash at 12 Hz instead of indicating the current status.

Table 2-1188 Status displays A/B/N/DIm/DQm

LEDs A/B/N/DIm/DQm	Meaning
□ Off	Counter input/digital input/digital output at 0 level
■ On	Counter input/digital input/digital output at 1 level

Table 2-1189 Status displays UP/DN

LEDs		Meaning
UP	DN	
□ Off	□ Off	No count pulse has been detected for the last 0.5 s.
■ On	□ Off	The last count pulse has incremented the counter and took place no more than 0.5 s ago.
□ Off	■ On	The last count pulse has decremented the counter and took place no more than 0.5 s ago.

5.2 Diagnostic messages

Enabling of diagnostic interrupts

You enable the diagnostic interrupts in the device configuration with the basic parameters.

The technology module can trigger the following diagnostic interrupts:

Table 2-1190 Possible diagnostic interrupts

Diagnostic interrupt	Monitoring
• Parameter error • Hardware interrupt lost[1] • Channel/component temporarily unavailable • Internal error • Watchdog tripped. Module is defective.	Monitoring is always active. A diagnostic interrupt is triggered each time an error is detected.
• Wire break at digital input A, B or N	Monitoring is active if a push-pull switching encoder has been configured. When an error is detected, a diagnostic interrupt is only triggered if "Enable diagnostic interrupt on wire break" is activated in the device configuration.
• Error • Load voltage missing • Short-circuit / overload at external encoder supply • Error at digital outputs • Invalid transition of A/B signals	Monitoring is always active. When an error is detected, a diagnostic interrupt is only triggered if "Enable additional diagnostic interrupts" is activated in the device configuration.

[1] Not available in "Position input for "Motion Control"" technology object" and "Fast Mode" operating modes

Reactions to a diagnostic interrupt

The following happens when an event occurs that triggers a diagnostic interrupt:

- The DIAG LED flashes red.

  When you have eliminated all errors, the DIAG LED stops flashing red and turns green.
- The S7-1500 CPU interrupts the processing of the user program. The diagnostic interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.
- The S7-1500 CPU remains in RUN, even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible despite the error.

You can obtain detailed information on the error event in the error organization block with instruction "RALRM" (Read additional alarm information), in the information system of STEP 7 and in function manual Diagnostics (https://support.industry.siemens.com/cs/ww/en/view/59192926), section "System diagnostics in user program".

If the module is being operated as a distributed module in an ET 200SP system with PROFIBUS DP, you have the option of reading out diagnostic data with the RDREC or RD_REC instruction using data record 0 and 1. You can find the structure of the data records in the manual for the IM 155-6 DP HF interface module available for download on the Internet (https://support.industry.siemens.com/cs/ww/de/view/73098660).

Diagnostic alarms

The display of diagnostics is in plain text in STEP 7 (TIA Portal) in the online and diagnostics view. You can evaluate the error codes with the user program.

The following diagnostics can be signaled:

Table 2-1191 Diagnostic alarms, their meaning and remedies

Diagnostic alarm	Error code	Meaning	Remedy
Error	9_H	• Internal module error occurred • Possible cause: – Firmware update was aborted – Technology module defective	• Repeat firmware update • Replace technology module
Parameter error	10_H	• The received parameter data record is invalid • The configured BaseUnit is not the BaseUnit being used	• Check parameter data record • Check BaseUnit
Load voltage missing	11_H	• Missing or insufficient supply voltage L+ • Wiring of supply voltage L+ faulty • Possible cause: BaseUnit type incorrect	• Check BaseUnit type • Check supply voltage L+ at the BaseUnit • Check wiring of supply voltage L+ • Check total consumption of the load group
Hardware interrupt lost	16_H	• Module cannot issue interrupt because a preceding interrupt has not yet been processed • Possible cause: Too many hardware interrupts in too short a time	• Change interrupt processing in the CPU and re-assign technology module parameters correspondingly • Check frequency of interrupts from the process
Channel/component temporarily unavailable	$1F_H$	Firmware update in progress or update was aborted. The module reads no process values in this state.	• Wait for firmware update • If firmware update aborts: – Check minimum firmware version required – Check supply voltage – Repeat firmware update
Internal error	100_H	Technology module defective	Replace technology module
Watchdog tripped. Module is defective.	103_H	Firmware error	Run firmware update
		Technology module defective	Replace technology module
Short-circuit / overload at external encoder supply	$10E_H$	• Error at encoder supply • Possible causes: – Short circuit – Overload	• Check encoder wiring • Check consumers connected to encoder supply

Diagnostic alarm	Error code	Meaning	Remedy
Error at digital outputs	$10F_H$	• Error at the digital outputs • Possible causes: – Short circuit – Overload	• Check wiring at the digital outputs • Check consumers connected to the digital outputs
Invalid transition of A/B signals	500_H	• Time profile of signals A and B of the incremental encoder does not meet certain requirements (relative phase shift of the two signals is too small) • Possible causes: – Signal frequency too high – Encoder faulty – Process wiring faulty	• Check process wiring • Check encoder/sensor • Check parameter assignment
Wire break at digital input A, B or N	505_H	Channel not connected	Connect the channel
		Resistance of encoder circuit too high	• Use a different encoder type or modify the wiring, for example, use shorter cables with larger cross-sections • Check encoders
		Interruption of the line between technology module and encoder	Check process wiring
		Sensor used is sourcing output or sinking output only	Correct parameter assignment

5.3 Hardware interrupts

Introduction

For the technology module, you can configure which events are to trigger a hardware interrupt during operation.

What is a hardware interrupt?

The technology module will trigger a hardware interrupt as configured in response to specific events/states. When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the assigned hardware interrupt OB. The event that triggered the interrupt is entered in the start information of the assigned hardware interrupt OB by the CPU.

Lost hardware interrupt

If an event occurs that is to trigger a hardware interrupt and the preceding event has not yet been processed, another hardware interrupt cannot be triggered. The hardware interrupt is lost and the diagnostic interrupt "Lost hardware interrupt" is triggered.

Enabling of hardware interrupts

A hardware interrupt is triggered when the condition for the change of the respective status or event bit in the feedback interface is met.

You enable the hardware interrupts in the device configuration with the basic parameters. You can configure hardware interrupts to be triggered for the following event types:

- Opening of internal gate (gate start)
- Closing of internal gate (gate stop)
- Overflow (high counting limit violated)
- Underflow (low counting limit violated)
- Comparison event for DQ0 has occurred
- Comparison event for DQ1 has occurred
- Zero crossing[3]
- New Capture value available[1]
- Synchronization of the counter by an external signal
- Direction reversal[2]

[1] Only configurable in Counting mode

[2] Feedback bit STS_DIR is preassigned with "0". If the first counter value change occurs in the *downwards direction* directly after switching on the technology module, no hardware interrupt is triggered.

[3] When the "Zero crossing" hardware interrupt is enabled, for system-related reasons it can also be triggered if "0" is outside the configured value range.

You can activate any combination of events to trigger hardware interrupts.

You can obtain detailed information on the event in the hardware interrupt organization block with instruction "RALRM" (Read additional alarm information) and in the information system of STEP 7.

Which event has triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of the local data double word 8.

LB 8								LB 9								LB 10								LB 11							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	X	0	0	0	0	X	X	X	X

Bit no.
LD 8

User Structure Identifier (USI)

Event that triggered the hardware interrupt (EventType):

- 0001_B: Gate start
- 0010_B: Gate stop
- 0011_B: Overflow
- 0100_B: Underflow
- 0101_B: Comparison event for DQ0
- 0110_B: Comparison event for DQ1 occurred
- 0111_B: Zero crossing
- 1000_B: New capture value available
- 1001_B: Synchronization
- 1010_B: Direction reversal

Channel that triggered the hardware interrupt (IChannel):
0_B: Channel 0 of the technology module

Figure 2-1069 Start information of the organization block

Technical specifications

6

Article number	6ES7138-6AA01-0BA0
General information	
Product type designation	TM Count 1x24V
Firmware version	V2.0
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	STEP 7 V15 SP1 or higher
• STEP 7 configurable/integrated as of version	V5.6 and higher
• PROFIBUS as of GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET as of GSD version/GSD revision	GSDML V2.34
Supply voltage	
Load voltage L+	
• Rated value (DC)	24 V
• permissible range, lower limit (DC)	19.2 V
• permissible range, upper limit (DC)	28.8 V
• Reverse polarity protection	Yes
Input current	
Current consumption, max.	60 mA; without load
Encoder supply	
Number of outputs	1
24 V encoder supply	
• 24 V	Yes; L+ (-0.8 V)
• Short-circuit protection	Yes; electronic/thermal
• Output current, max.	300 mA
Power loss	
Power loss, typ.	1 W

Article number	6ES7138-6AA01-0BA0
Address area	
Address space per module	
• Inputs	16 byte; 4 bytes in Fast mode
• Outputs	12 byte; 4 bytes for Motion Control, 0 bytes for Fast mode
Digital inputs	
Number of digital inputs	3
Digital inputs, parameterizable	Yes
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Digital input functions, parameterizable	
• Gate start/stop	Yes
• Capture	Yes
• Synchronization	Yes
• Freely usable digital input	Yes
• Probe	Yes
Input voltage	
• Rated value (DC)	24 V
• for signal "0"	-5 ... +5 V
• for signal "1"	+11 to +30V
• permissible voltage at input, min.	-30 V; -5 V continuous, -30 V brief reverse polarity protection
• permissible voltage at input, max.	30 V
Input current	
• for signal "1", typ.	2.5 mA
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms
– at "0" to "1", min.	6 µs; for parameterization "none"
– at "1" to "0", min.	6 µs; for parameterization "none"
for technological functions	
– parameterizable	Yes
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Digital outputs	
Type of digital output	Transistor
Number of digital outputs	2

Article number	6ES7138-6AA01-0BA0
Short-circuit protection	Yes; electronic/thermal
• Response threshold, typ.	1 A
Limitation of inductive shutdown voltage to	L+ (-53 V)
Controlling a digital input	Yes
Digital output functions, parameterizable	
• Switching tripped by comparison values	Yes
• Freely usable digital output	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A; Per digital output
• on lamp load, max.	5 W
Load resistance range	
• lower limit	48 Ω
• upper limit	12 kΩ
Output voltage	
• for signal "1", min.	23.2 V; L+ (-0.8 V)
Output current	
• for signal "1" rated value	0.5 A; Per digital output
• for signal "1" permissible range, max.	0.6 A; Per digital output
• for signal "1" minimum load current	2 mA
• for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
• "0" to "1", max.	50 µs
• "1" to "0", max.	50 µs
Switching frequency	
• with resistive load, max.	10 kHz
• with inductive load, max.	0.5 Hz; Acc. to IEC 60947-5-1, DC-13; observe derating curve
• on lamp load, max.	10 Hz
Total current of the outputs	
• Current per module, max.	1 A
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Encoder	
Connectable encoders	
• 2-wire sensor	Yes
– permissible quiescent current (2-wire sensor), max.	1.5 mA

Article number	6ES7138-6AA01-0BA0
Encoder signals, incremental encoder (asymmetrical)	
• Input voltage	24 V
• Input frequency, max.	200 kHz
• Counting frequency, max.	800 kHz; with quadruple evaluation
• Cable length, shielded, max.	600 m; depending on input frequency, encoder and cable quality; max. 50 m at 200 kHz
• Signal filter, parameterizable	Yes
• Incremental encoder with A/B tracks, 90° phase offset	Yes
• Incremental encoder with A/B tracks, 90° phase offset and zero track	Yes
• Pulse encoder	Yes
• Pulse encoder with direction	Yes
• Pulse encoder with one impulse signal per count direction	Yes
Encoder signal 24 V	
– permissible voltage at input, min.	-30 V; -5 V continuous, -30 V brief reverse polarity protection
– permissible voltage at input, max.	30 V
Interface types	
• Source/sink input	Yes
• Input characteristic curve in accordance with IEC 61131, type 3	Yes
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	Yes
Interrupts/diagnostics/status information	
Substitute values connectable	Yes; Parameterizable
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• A/B transition error at incremental encoder	Yes
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; Green PWR LED
• Channel status display	Yes; Green LED

Article number	6ES7138-6AA01-0BA0
• for module diagnostics	Yes; green/red DIAG LED
• Status indicator backward counting (green)	Yes
• Status indicator forward counting (green)	Yes
Integrated Functions	
Number of counters	1
Counting frequency (counter) max.	800 kHz; with quadruple evaluation
Fast mode	Yes
Counting functions	
• Can be used with TO High_Speed_Counter	Yes
• Continuous counting	Yes
• Counter response parameterizable	Yes
• Hardware gate via digital input	Yes
• Software gate	Yes
• Event-controlled stop	Yes
• Synchronization via digital input	Yes
• Counting range, parameterizable	Yes
Comparator	
– Number of comparators	2
– Direction dependency	Yes
– Can be changed from user program	Yes
Position detection	
• Incremental acquisition	Yes
• Suitable for S7-1500 Motion Control	Yes
Measuring functions	
• Measuring time, parameterizable	Yes
• Dynamic measurement period adjustment	Yes
• Number of thresholds, parameterizable	2
Measuring range	
– Frequency measurement, min.	0.04 Hz
– Frequency measurement, max.	800 kHz
– Cycle duration measurement, min.	1.25 µs
– Cycle duration measurement, max.	25 s
Accuracy	
– Frequency measurement	100 ppm; depending on measuring interval and signal evaluation
– Cycle duration measurement	100 ppm; depending on measuring interval and signal evaluation
– Velocity measurement	100 ppm; depending on measuring interval and signal evaluation

Article number	6ES7138-6AA01-0BA0
Potential separation	
Potential separation channels	
• between the channels and backplane bus	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
• ceiling installation, min.	-30 °C
• ceiling installation, max.	50 °C
• floor installation, min.	-30 °C
• floor installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Decentralized operation	
to SIMATIC S7-300	Yes
to SIMATIC S7-400	Yes
to SIMATIC S7-1200	Yes
to SIMATIC S7-1500	Yes
to standard PROFIBUS master	Yes
to standard PROFINET controller	Yes
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	45 g

Derating information for total current of outputs

If the digital outputs of the TM Count 1x24V are operated with resistive or inductive loads, you should derate the total current of the loads at the digital outputs of the technology module. The total current is the sum of the load currents at all digital outputs of the module (without encoder supply).

The following derating curve shows the load capacity of the digital outputs depending on the ambient temperature and mounting position under the following conditions:

- Load resistance: 48 Ω (IEC 947-5-1)

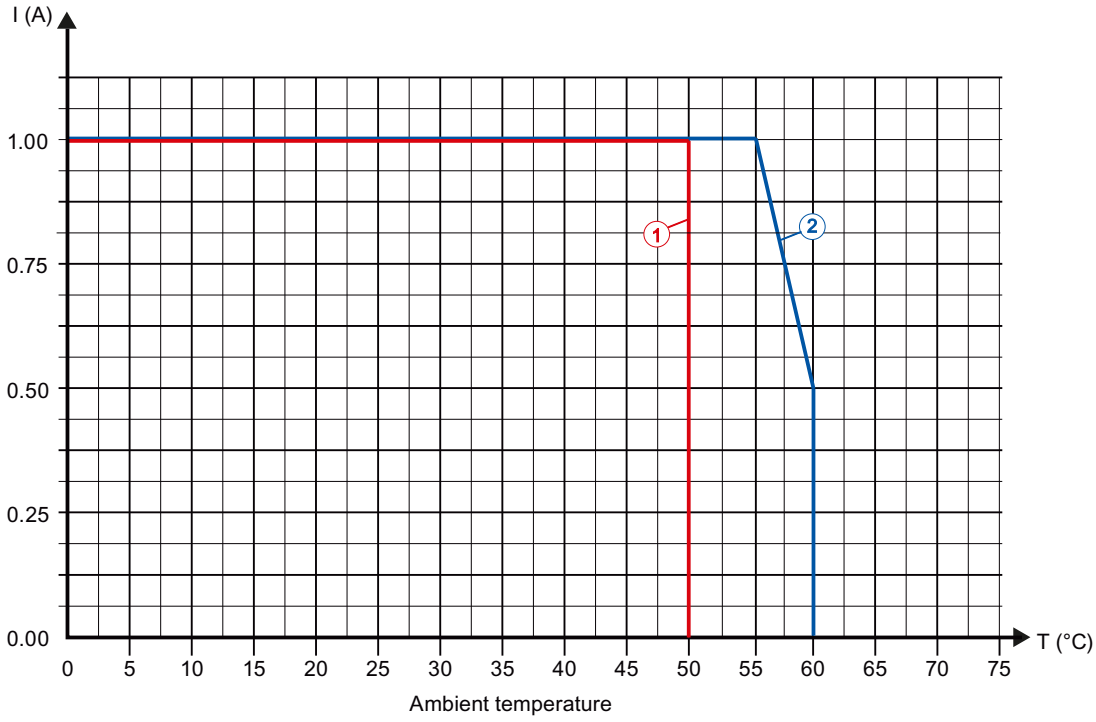

① Vertical installation of the system

② Horizontal installation of the system

Figure 2-1070 Total current depending on ambient temperature and mounting position for resistive loads

The following derating curve shows the load capacity of the digital outputs depending on the ambient temperature and mounting position under the following conditions:

- Maximum switching frequency at digital outputs of 0.5 Hz
- Load resistance: 48 Ω (IEC 947-5-1)
- Load inductance: 1150 mH (IEC 947-5-1)

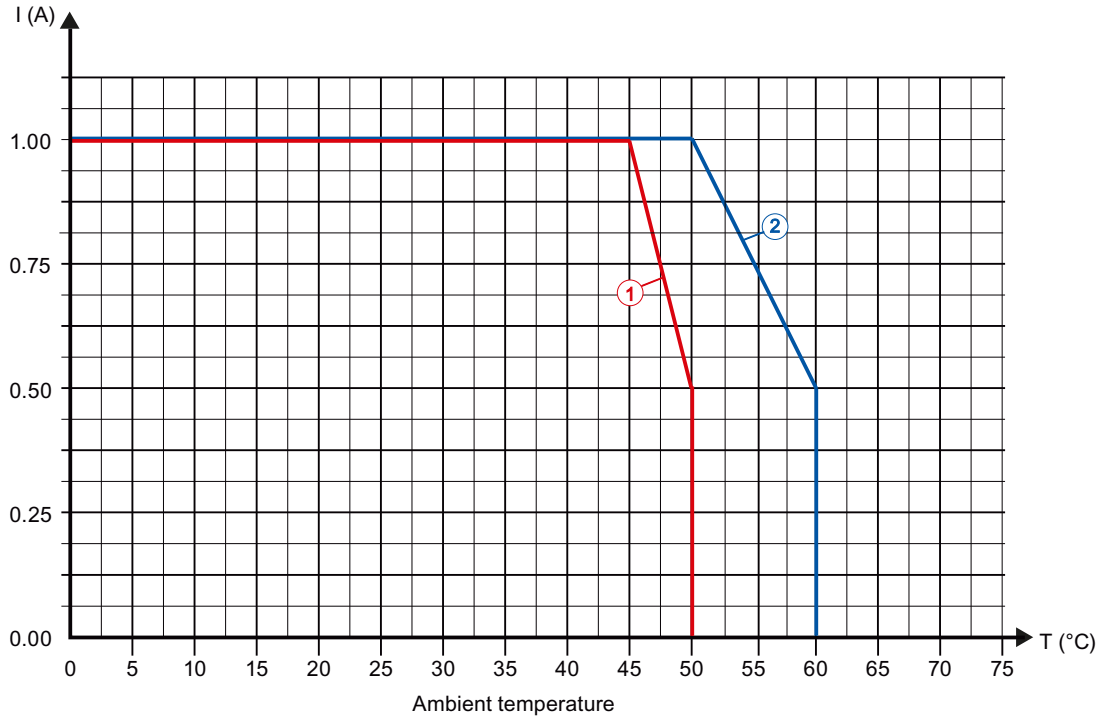

① Vertical installation of the system

② Horizontal installation of the system

Figure 2-1071 Total current depending on ambient temperature and mounting position for inductive loads

NOTE

If the switching frequency is greater than 0.5 Hz or there is greater inductance at the digital outputs, the total current must be reduced further.

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

You have the option of reassigning module parameters with the user program while the CPU is in RUN. The parameters are transferred to the module using data record 128, e.g. with the WRREC instruction.

If an error occurs while transferring or validating parameters with the WRREC instruction, the module continues operating with the existing parameter assignment. A corresponding error code is then written to the STATUS output parameter. If no errors occur, the STATUS output parameter contains the length of the actually transferred data.

You can find a description of the WRREC instruction and the error codes in section Parameter validation error (Page 86) or in the online help of STEP 7 (TIA Portal).

Structure of data record 128 for operation with technology object and manual operation

The following table shows you the structure of data record 128 for TM Count 1x24V for operation with technology object and manual operation without technology object. The values in byte 0 to byte 3 are fixed and must not be changed. The value in byte 4 can only be changed by means of new parameter assignment and not in RUN mode of the CPU.

NOTE

After each writing of data record 128, the module is set to its startup state and the counter value is set to the start value. If "Continue operation" is set for Reaction to CPU STOP, the module is then only set to its startup state when data record 128 has been changed.

Table 2-1192 Data record 128: Operating modes "Operating with technology object "Counting and measurement"", "Manual operation (without technology object)"

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	**Header**							
0	Major Version = 0				Minor Version = 2			
1	Length of the parameter data = 48							
2	Reserved[2]							
3	Reserved[2]							
4...51	**Counting channel**							
4	**Operating mode**							

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

4 Applies to: Set function of DI = 001_B; 010_B; 011_B; 101_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
4	Reserved[2]				Operating mode:			
					0000_B: Not permitted			
					0001_B: Counting			
					0010_B: Measuring			
					0011 to 1111_B: Not permitted			
5	**Basic parameters**							
5	Reserved[2]					Enable additional diagnostic interrupts[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Keep last value	
							10_B: Continue operation	
							11_B: Not permitted	
6...7	**Counter inputs**							
6	Sensor type:		Signal evaluation:		Signal type:			
	00_B: Sourcing output		00_B: Single		0000_B: Pulse (A)			
	01_B: Sinking output		01_B: Double		0001_B: Pulse (A) and direction (B)			
	10_B: Push-pull (sinking and sourcing output)		10_B: Quadruple		0010_B: Count up (A), count down (B)			
	11_B: Not permitted		11_B: Not permitted		0011_B: Incremental encoder (A, B phase-shifted)			
					0100_B: Incremental encoder (A, B, N)			
					0101 to 1111_B: Not permitted			
7	Reaction to signal N:		Invert direction[1]	Enable diagnostic interrupt on wire break[1]	Filter frequency[3]:			
	00_B: No reaction to signal N				0000_B: 100 Hz			
					0001_B: 200 Hz			
	01_B: Synchronization at signal N				0010_B: 500 Hz			
					0011_B: 1 kHz			
	10_B: Capture at signal N				0100_B: 2 kHz			
	11_B: Not permitted				0101_B: 5 kHz			
					0110_B: 10 kHz			
					0111_B: 20 kHz			
					1000_B: 50 kHz			
					1001_B: 100 kHz			
					1010_B: 200 kHz			
					1011 to 1111_B: Not permitted			

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

4 Applies to: Set function of DI = 001_B; 010_B; 011_B; 101_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
8...9	**Hardware interrupts**[1]							
8	Reserved[2]			Change of direction	Underflow (low counting limit violated)	Overflow (high counting limit violated)	Gate stop	Gate start
9	Synchronization of the counter by an external signal	New Capture value available	Reserved[2]	Zero crossing	Reserved[2]	Comparison event for DQ1 has occurred	Reserved[2]	Comparison event for DQ0 has occurred
10...15	**Behavior of DQ0/1**							
10	Set output (DQ1):				Set output (DQ0):			
	0000_B: Use by user program				0000_B: Use by user program			
	0001_B: Between comparison value and high limit; Measuring: Measured value >= comparison value				0001_B: Between comparison value and high limit; Measuring: Measured value >= comparison value			
	0010_B: Between comparison value and low limit; Measuring: Measured value <= comparison value				0010_B: Between comparison value and low limit; Measuring: Measured value <= comparison value			
	0011_B: At comparison value for a pulse duration				0011_B: At comparison value for a pulse duration			
	0100_B: Between comparison value 0 and 1				0100_B: Not permitted			
	0101_B: After set command from CPU until comparison value				0101_B: After set command from CPU until comparison value			
	0110_B: Not between comparison value 0 and 1				0110 to 1111_B: Not permitted			
	0111 to 1111_B: Not permitted							
11	Count direction (DQ1):		Count direction (DQ0):		Reserved[2]		Substitute value for DQ1	Substitute value for DQ0
	00_B: Not permitted		00_B: Not permitted					
	01_B: Up		01_B: Up					
	10_B: Down		10_B: Down					
	11_B: In both directions		11_B: In both directions					
12	Pulse duration (DQ0): WORD: Value range in ms/10: 0 to 65535_D							
13								
14	Pulse duration (DQ1): WORD: Value range in ms/10: 0 to 65535_D							
15								
16	**Behavior of DI0**							
16	Behavior of counter value after Capture (DI0):	Edge selection (DI0):		Select level (DI0):	Reserved[2]	Set function of DI (DI0):		
		00_B: Not permitted[4]				000_B: Gate start/stop (level-triggered)		
		01_B: At rising edge		0_B: Active		001_B: Gate start (edge-triggered)		

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

4 Applies to: Set function of DI = 001_B; 010_B; 011_B; 101_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
16	Behavior of counter value after Capture (DI0):	10_B: At falling edge		with high level	Reserved[2]	010_B: Gate stop (edge-triggered)		
	0_B: Continue counting	11_B: At rising and falling edge		1_B: Active with low level		011_B: Synchronization		
						100_B: Enable synchronization at signal N		
	1_B: Set to start value and continue counting					101_B: Capture		
						110_B: Digital input without function		
						111_B: Not permitted		
17	**Behavior of DI1**: See Byte 16							
18	**Behavior of DI2**: See Byte 16							
19	Frequency of synchronization:	Reserved[2]		Frequency of Capture function:	Input delay:			
					0000_B: None			
					0001_B: 0.05 ms			
	0_B: Once			0_B: Once	0010_B: 0.1 ms			
					0011_B: 0.4 ms			
	1_B: Periodic			1_B: Periodic	0100_B: 0.8 ms			
					0101_B: 1.6 ms			
					0110_B: 3.2 ms			
					0111_B: 12.8 ms			
					1000_B: 20 ms			
					1001 to 1111_B: Not permitted			
20...43	**Values**							
20...23	High counting limit: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
24...27	Comparison value 0: Operating mode Counting: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$; Measuring operating mode: REAL: Floating point number in the configured unit of the measured variable							
28...31	Comparison value 1: Operating mode Counting: DWORD: Value range: –2147483648 to 2147483647_D: or 80000000 to $7FFFFFFF_H$; Measuring operating mode: REAL: Floating point number in the configured unit of the measured variable							

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

4 Applies to: Set function of DI = 001_B; 010_B; 011_B; 101_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
32...35	Start value: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
36...39	Low counting limit: DWORD: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
40...43	Update time: DWORD: Value range in µs: 0 to 25000000_D							
44	**Counter behavior at limits and gate start**							
44	Reaction to gate start:		Reaction to violation of a counting limit:			Reset when counting limit is violated:		
	00_B: Set to start value		000_B: Stop counting			000_B: To opposite counting limit		
	01_B: Continue with current value		001_B: Continue counting			001_B: To start value		
	10 to 11_B: Not permitted		010 to 111_B: Not permitted			010 to 111_B: Not permitted		
45	**Specify measured value**							
45	Reserved[2]			Time base for velocity measurement:			Measured variable:	
				000_B: 1 ms			00_B: Frequency	
				001_B: 10 ms			01_B: Period	
				010_B: 100 ms			10_B: Velocity	
				011_B: 1 s			11_B: Not permitted	
				100_B: 60 s/1 min				
				101 to 111_B: Not permitted				
46 / **47**	Increments per unit: WORD: Value range: 1 to 65535_D							
48	Set hysteresis range: Value range: 0 to 255_D							
49...51	Reserved[2]							

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

4 Applies to: Set function of DI = 001_B; 010_B; 011_B; 101_B

Structure of the data record 128 in Fast Mode

The following table shows you the structure of data record 128 for TM Count 1x24V for Fast Mode. The values in byte 0 to byte 3 are fixed and must not be changed.

Table 2-1193 Parameter data record 128: "Fast Mode" operating mode

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	**Header**							
0	Major Version = 0				Minor Version = 2			
1	Length of the parameter data per channel = 48							
2	Reserved[2]							
3	Reserved[2]							
4	**Operating mode**							
4	Reserved[2]				Operating mode:			
					0000_B: Not permitted			
					0001_B: Counting / Position input			
					0010 to 1111_B: Not permitted			
5	**Basic parameters**							
5	Reserved[2]					Enable additional diagnostic interrupts[1)]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Keep last value	
							10_B: Continue operation	
							11_B: Not permitted	
6...7	**Counter inputs** (parameters for incremental and pulse encoders)							
6	Sensor type:		Signal evaluation:		Signal type:			
	00_B: Sourcing output		00_B: Single		0000_B: Pulse (A)			
	01_B: Sinking output		01_B: Double		0001_B: Pulse (A) and direction (B)			
	10_B: Push-pull (sinking and sourcing output)		10_B: Quadruple		0010_B: Count up (A), count down (B)			
	11_B: Not permitted		11_B: Not permitted		0011_B: Incremental encoder (A, B phase-shifted)			
					0100_B: Incremental encoder (A, B, N)			
					0101 to 1111_B: Not permitted			
7	Reaction to signal N:		Invert direction[1]	Enable diagnostic interrupt on wire break[1]	Filter frequency[3]:			
	00_B: No reaction to signal N				0000_B: 100 Hz			
					0001_B: 200 Hz			
	01_B: Synchronization at				0010_B: 500 Hz			

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

4 Applies to: Set function of DI = 001_B; 010_B; 011_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
7	signal N		Invert direction[1]	Enable diagnostic interrupt on wire break[1]	0011_B: 1 kHz			
	10 to 11_B: Not permitted				0100_B: 2 kHz			
					0101_B: 5 kHz			
					0110_B: 10 kHz			
					0111_B: 20 kHz			
					1000_B: 50 kHz			
					1001_B: 100 kHz			
					1010_B: 200 kHz			
					1011 to 1111_B: Not permitted			
8...9	Reserved[2]							
10...15	**Behavior of a DQ**							
10	Set output (DQ1):				Set output (DQ0):			
	0000_B: Digital output without function				0000_B: Digital output without function			
	0001_B: Between comparison value and high limit				0001_B: Between comparison value and high limit			
	0010_B: Between comparison value and low limit				0010_B: Between comparison value and low limit			
	0011_B: At comparison value for a pulse duration				0011_B: At comparison value for a pulse duration			
	0100_B: Between comparison value 0 and 1				0100_B to 1111_B: Not permitted			
	0101 to 1111_B: Not permitted							
11	Count direction (DQ1):		Count direction (DQ0):		Reserved[2]	Reserved[2]	Substitute value for DQ1	Substitute value for DQ0
	00_B: Reserved		00_B: Reserved					
	01_B: Up		01_B: Up					
	10_B: Down		10_B: Down					
	11_B: In both directions		11_B: In both directions					
12	Pulse duration (DQ0): UINT: Value range in ms/10: 0 to 65535_D							
13								
14	Pulse duration (DQ1): UINT: Value range in ms/10: 0 to 65535_D							
15								
16	**Behavior of DI0**							
16	Reserved[2]	Edge selection (DI0):		Select level (DI0):	Reserved[2]	Set function of DI (DI0):		
		00_B: Not permitted[4]				000_B: Gate start/stop (level-triggered)		
		01_B: At rising edge		0_B: Active with high level		001_B: Gate start (edge-triggered)		
		10_B: At falling edge				010_B: Gate stop (edge-triggered)		
		11_B: Not permitted		1_B: Active		011_B: Synchronization		

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

4 Applies to: Set function of DI = 001_B; 010_B; 011_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
16	Reserved[2]	11_B: Not permitted		with low level	Reserved[2]	100_B: Enable synchronization at signal N		
						101_B: Not permitted		
						110_B: Digital input without function		
						111_B: Not permitted		
17	**Behavior of DI1**: See Byte 16							
18	**Behavior of DI2**: See Byte 16							
19	Frequency of synchronization:	Count direction for synchronization		Reserved[2]	Input delay:			
	0_B: Once	00_B: Not permitted			0000_B: None			
	1_B: Periodic	01_B: Up			0001_B: 0.05 ms			
		10_B: Down			0010_B: 0.1 ms			
		11_B: In both directions			0011_B: 0.4 ms			
					0100_B: 0.8 ms			
					0101_B: 1.6 ms			
					0110_B: 3.2 ms			
					0111_B: 12.8 ms			
					1000_B: 20 ms			
					1001 to 1111_B: Not permitted			
20...43	**Values**							
20...23	High counting limit: DWORD: Value range: 1 to 33554431_D or 1 to $01FFFFFF_H$							
24...27	Comparison value 0: DWORD: Value range: 0 to 33554431_D or 0 to $01FFFFFF_H$							
28...31	Comparison value 1: DWORD: Value range: 0 to 33554431_D or 0 to $01FFFFFF_H$							
32...35	Start value: DWORD: Value range: 0 to 33554431_D or 0 to $01FFFFFF_H$							
36...39	Low counting limit: DWORD: Value range: 0 to 33554430_D or 0 to $01FFFFFE_H$							
40...43	Reserved[2]							
44	**Counter behavior at limits and gate start**							
44	Reaction to gate start:		Reaction to violation of a counting limit:			Reset when counting limit is violated:		

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

4 Applies to: Set function of DI = 001_B; 010_B; 011_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
44	00_B: Set to start value		000_B: Stop counting			000_B: To opposite counting limit		
	01_B: Continue with current value		001_B: Continue counting			001_B: To start value		
	10 to 11_B: Not permitted		010 to 111_B: Not permitted			010 to 111_B: Not permitted		
45...47	Reserved[2]							
48	Set hysteresis range: Value range: 0 to 255_D:							
49...51	Reserved[2]							

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

4 Applies to: Set function of DI = 001_B; 010_B; 011_B

A.2 Parameter validation error

If you make the parameter settings in STEP 7 (TIA Portal) or in STEP 7 , the parameter values are checked before they are transferred to the technology module. This process prevents parameter errors.

In other use cases, the technology module checks the transferred parameter data record. If the technology module finds invalid or inconsistent parameter values, it outputs an error code (see below). The new parameter data record is rejected in this case, and work continues with the current parameter values until a valid parameter data record has been transferred.

WRREC

When the CPU is in RUN, you can change the parameter data record with the instruction WRREC (Write Record). In case of errors, the WRREC instruction returns corresponding error codes in the STATUS parameter.

Example:

Let us assume that an invalid value, for example 9, is written to the module for the operating mode with WRREC. As a consequence, the module rejects the entire parameter data record. You can recognize this by evaluating the STATUS output parameter of the WRREC instruction. The STATUS output parameter is output as an ARRAY[1..4] of BYTE data with the value 16#DF80E111:

Example of WRREC STATUS data	Address	Meaning
DF_H	STATUS[1]	Error when writing a data record via PROFINET IO (IEC 61158-6)
80_H	STATUS[2]	Error when reading or writing a data record via PROFINET IO (IEC 61158-6)
$E1_H$	STATUS[3]	Module-specific error
11_H	STATUS[4]	Error code from the table below: The "Operating mode" parameter has an invalid value.

Error codes

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Table 2-1194 Error codes for parameter validation

Error code in STATUS parameter (hexadecimal)				Meaning	Remedy
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Data record number unknown	Enter valid number for data record.
DF	80	B1	01	Length of data record incorrect	Enter valid value for data record length.
DF	80	B2	00	Slot invalid or not accessible	• Check whether module is inserted or removed. • Check assigned values for parameters of the WRREC instruction.
DF	80	E0	01	Wrong version	• Check byte 0. • Enter valid values.
DF	80	E0	02	Error in the header information	• Check byte 1. • Correct the length of the parameter blocks.
DF	80	E1	00	Parameter invalid: No detailed information available	Check all parameter values.
DF	80	E1	11	"Operating mode" parameter invalid	Enter valid parameter value.
DF	80	E1	12	"Reaction to CPU STOP" parameter invalid	Enter valid parameter value.

1 Only for "Counting" operating mode

2 Only for "Position input for technology object "Motion Control"" operating mode

3 Only for DQ1 functions "Between comparison value 0 and 1" and "Not between comparison value 0 and 1"

4 Only for operating mode "Fast Mode"

5 Not for DQm function "Use by user program" or "Digital output without function"

Error code in STATUS parameter (hexadecimal)				Meaning	Remedy
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	13	"Signal type" parameter invalid	Enter valid parameter value.
DF	80	E1	14	"Sensor type" parameter invalid	Enter valid parameter value.
DF	80	E1	15	"Filter frequency" parameter invalid	Enter valid parameter value.
DF	80	E1	16	"Reaction to signal N" parameter invalid	Enter valid parameter value.
DF	80	E1	17	"Set function of DI" parameter invalid	Enter valid parameter value.
DF	80	E1	18	"Set function of DI" parameter configured the same for DI0 and DI1.	Enter different parameter values for DI0 and DI1.
DF	80	E1	19	• "Edge selection" parameter invalid • "Gate start (edge-triggered)" configured as function for DIm and "At rising and falling edge" • "Gate stop (edge-triggered)" configured as function for DIm and "At rising and falling edge" • "Synchronization" configured as function for DIm and "At rising and falling edge"	• Enter valid parameter value. • Only configure "Gate start (edge-triggered)" as function for DIm together with "At rising edge" or "At falling edge". • Only configure "Gate stop (edge-triggered)" as function for DIm together with "At rising edge" or "At falling edge". • Only configure "Synchronization" as function for DIm together with "At rising edge" or "At falling edge".
DF	80	E1	1A	"Input delay" parameter invalid	Enter valid parameter value.
DF	80	E1	1B	"Set output" parameter invalid	Enter valid parameter value.
DF	80	E1	1C	"Count direction" parameter invalid	Enter valid parameter value.
DF	80	E1	1D	"Reset when counting limit is violated" parameter invalid	Enter valid parameter value.
DF	80	E1	1E	"Reaction to violation of a counting limit" parameter invalid	Enter valid parameter value.
DF	80	E1	20	"Reaction to gate start" parameter invalid	Enter valid parameter value.
DF	80	E1	21[1,5]	• Low counting limit > comparison value 0 • Low counting limit > comparison value 1	• Low counting limit < comparison value 0 • Low counting limit < comparison value 1
DF	80	E1	22[1,5]	• Counting high limit < comparison value 0 • Counting high limit < comparison value 1	• High counting limit > comparison value 0 • High counting limit > comparison value 1
DF	80	E1	23	• "Start value" parameter invalid • "Low counting limit" parameter invalid	Enter valid parameter value: Start value > low counting limit
DF	80	E1	24	• "Start value" parameter invalid • "High counting limit" parameter invalid	Enter valid parameter value: Start value < high counting limit
DF	80	E1	25	"Update time" parameter invalid	Enter parameter value from range 0 to 25000000_D.
DF	80	E1	26[2]	"Reference speed" parameter invalid	Enter parameter value from range 6.00 to 210000.00_D.
DF	80	E1	27	"Measured variable" parameter invalid	Enter valid parameter value.
DF	80	E1	28	"Time base for velocity measurement" parameter invalid	Enter valid parameter value.
DF	80	E1	29	"Increments per unit" parameter invalid	Enter valid parameter value.
DF	80	E1	2A	• "High counting limit" parameter invalid • "Low counting limit" parameter invalid	Enter valid parameter value: Low counting limit < high counting limit
DF	80	E1	2B[3]	• "Comparison value 0" parameter invalid • "Comparison value 1" parameter invalid	Enter valid parameter value: Comparison value 0 < comparison value 1

1 Only for "Counting" operating mode

2 Only for "Position input for technology object "Motion Control"" operating mode

3 Only for DQ1 functions "Between comparison value 0 and 1" and "Not between comparison value 0 and 1"

4 Only for operating mode "Fast Mode"

5 Not for DQm function "Use by user program" or "Digital output without function"

Error code in STATUS parameter (hexadecimal)				Meaning	Remedy
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	2C	"Signal evaluation" parameter invalid	Enter valid parameter value.
DF	80	E1	2D	• "Between comparison value 0 and 1" configured for DQ0 • "Not between comparison value 0 and 1" configured for DQ0 • "Between comparison value 0 and 1" configured for DQ1, but "Use by user program" not configured for DQ0 • "Not between comparison value 0 and 1" configured for DQ1, but "Use by user program" not configured for DQ0	• Configure "Between comparison value 0 and 1" only for DQ1 • "Not between comparison value 0 and 1" configured only for DQ1 • Only configure "Between comparison value 0 and 1" for DQ1 when "Use by user program" is configured for DQ0 • Only configure "Not between comparison value 0 and 1" for DQ1 when "Use by user program" is configured for DQ0
DF	80	E1	2E	"Capture" configured for DIm in "Measuring" operating mode	Do not configure "Capture" for DIm in "Measuring" operating mode
DF	80	E1	36[4]	"Counting high limit" parameter invalid	Enter valid parameter value.
DF	80	E1	37[4,5]	• "Comparison value 0" parameter invalid • "Comparison value 1" parameter invalid	Enter valid parameter value.
DF	80	E1	38[4]	"Start value" parameter invalid	Enter valid parameter value.
DF	80	E1	39[4]	"Counting low limit" parameter invalid	Enter valid parameter value.
DF	80	E1	3A[4]	"Count direction for synchronization" parameter invalid	Enter valid parameter value.
DF	80	E1	F0	Reserved bit is not set to 0.	Set reserved bit to 0.

1 Only for "Counting" operating mode

2 Only for "Position input for technology object "Motion Control"" operating mode

3 Only for DQ1 functions "Between comparison value 0 and 1" and "Not between comparison value 0 and 1"

4 Only for operating mode "Fast Mode"

5 Not for DQm function "Use by user program" or "Digital output without function"

SIEMENS

SIMATIC

ET 200SP
Technology module TM PosInput 1 (6ES7138-6BA01-0BA0)

Equipment Manual

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Preface

Purpose of the documentation

This manual includes module-specific information on wiring, diagnostics and the technical specifications of the technology module.

General information regarding the design and commissioning of the ET 200SP is available in the ET 200SP system manual.

The counting and measuring functions as well as the position input of the TM PosInput 1 technology module are described in more detail in the Counting, measurement and position input (http://support.automation.siemens.com/WW/view/en/59709820) function manual.

Conventions

Please observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.

- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (https://support.industry.siemens.com).

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com) and in the Information and Download Center (https://www.siemens.com/automation/infocenter).

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions form one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

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Documentation guide

1

1.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

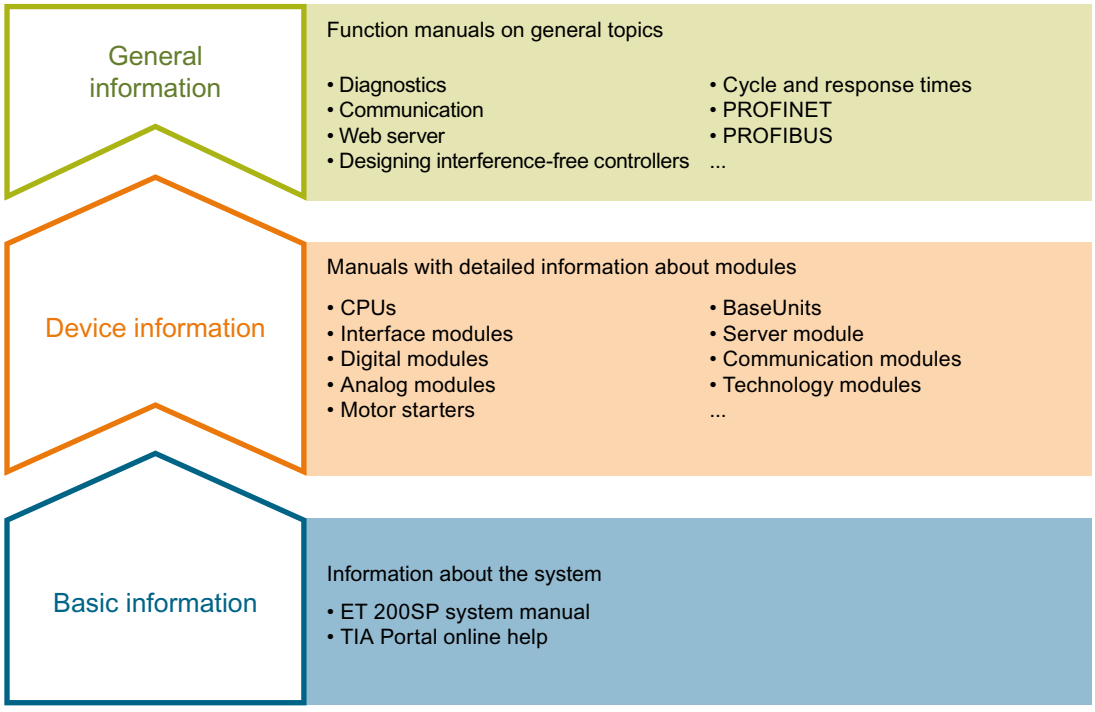

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/84133942).

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In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

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You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview 2

2.1 Properties

Article number

6ES7138-6BA01-0BA0 (packing unit: pack of 1)

6ES7138-6BA01-2BA0 (packing unit: pack of 10)

The TM PosInput 1 technology module with article number 6ES7138-6BA01-0BA0 and firmware version V2.0 is a compatible replacement for the TM PosInput 1 with article number 6ES7138-6BA00-0BA0.

Firmware version

This manual describes the properties of firmware version V2.0 of the module.

View of the module

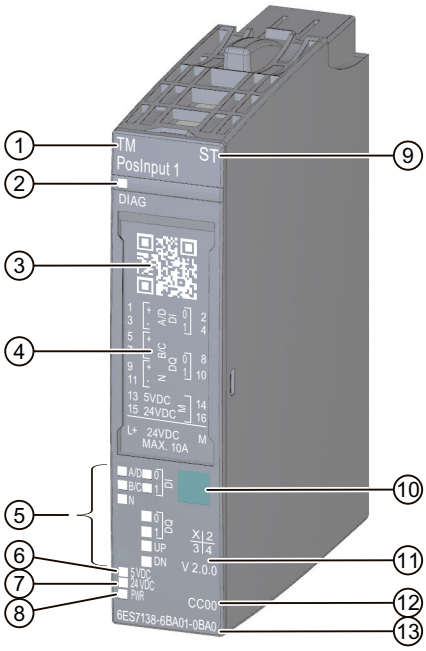

① Module type and designation
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ LEDs for channel status
⑥ LED for 5 V sensor supply
⑦ LED for 24 V sensor supply
⑧ LED for supply voltage
⑨ Function class
⑩ Module type color coding
⑪ Function and firmware version
⑫ Color code for selection of the color-coded labels and BaseUnit type
⑬ Article number

Figure 2-1072 View of the TM PosInput 1 module

Properties

The TM PosInput 1 technology module has the following properties:

- Technical properties
  - One channel
  - Interfaces:

    SSI encoder signals D und C or RS422/TTL encoder signals A, B and N

    5 V and 24 V sensor supply, short-circuit proof

    Digital inputs signals DI0 and DI1

    Digital output signals DQ0 and DQ1

    Supply voltage L+
  - Count range: 32 bits
  - Channel-by-channel monitoring of encoder signals for wire break, short-circuit and faulty supply voltage

  - Hardware interrupts configurable
  - Input filters for suppression of interferences at encoder inputs and digital inputs can be configured
- Supported encoder/signal types
  - SSI absolute encoder
  - RS422/TTL incremental encoder with N signal
  - RS422/TTL incremental encoder without N signal
  - RS422/TTL pulse encoder with direction signal
  - RS422/TTL pulse encoder without direction signal
  - RS422/TTL pulse encoder with up/down count signal

The module supports the following functions:

Table 2-1195 Version dependencies of the functions

Function	Firmware version of module	Configurable as of			
		STEP 7 (TIA Portal)	STEP 7	GSD	
				PROFINET IO	PROFIBUS DP
Firmware update	V1.0 or higher	V13	V5.5 SP4	X	—
I&M identification data	V1.0 or higher	V13	V5.5 SP4	X	X
Parameter reassignment in RUN	V1.0 or higher	V13	V5.5 SP4	X	X
Isochronous mode	V1.0 or higher	V13	V5.5 SP4	—	—
Counting/measuring	V1.0 or higher	V13	V5.5 SP4 or V5.5 SP3 with HSP0240 V1.0	X	X
Operating with "Counting and measurement" technology object	V1.0 or higher	V13	—	—	—
Position input for "Motion Control" technology object	V1.0 or higher	V13	—	—	—
Central operation on CPU 151xSP	V1.1 or higher	V13 SP1	—	—	—
Fast Mode	V1.2 or higher	V14 SP1 or V14 with HSP0199	V5.6 or V5.5 SP4 with HSP0240 V5.0	X	X

Function	Firmware version of module	Configurable as of			
		STEP 7 (TIA Portal)	STEP 7	GSD	
				PROFINET IO	PROFIBUS DP
Operating with "Measuring input" technology object	V1.3 or higher	V15 with HSP0256	—	—	—
Position value range of 32 bits	V1.3 or higher	V15 with HSP0256	—	X	X
Display of digital input states in the process image for position input for "Motion Control" technology object	V2.0 or higher	V16 with HSP0184	—	—	—

Firmware versions V1.x are available for the article number 6ES7138-6BA00-0BA0. Firmware version V2.0 is available for the article number 6ES7138-6BA01-xBA0.

Accessories

A **BaseUnit** of **type A0** is needed for operation of the technology module. You can find an overview of the BaseUnits that you can use with the technology module in the product information for the documentation of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/73021864).

For detailed information on the installation procedure, refer to the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2 Functions

2.2.1 Acquisition of encoder signals

2.2.1.1 Position input with SSI absolute encoder

You can use the TM PosInput 1 technology module with an SSI absolute encoder for position input. The technology module reads the position via a synchronous, serial interface from the SSI absolute encoder and sends it to the controller.

You can switch the digital outputs of the technology module exactly at defined position values, independently of the user program. Position input with an SSI absolute encoder does not involve gate control.

Gray-dual conversion

Gray-code and dual-code SSI absolute encoders are supported.

Range for position value

You can specify a frame length of 10 bits to 40 bits for the SSI absolute encoder. The configurable bit numbers of the LSB and the MSB of the position value in the frame define the value range. The technology module can read in a position value with a maximum length of 32 bits and transfer it to the controller.

Complete SSI frame

Instead of having a measured variable returned, you can choose to have the least significant 32 bit of the current unprocessed SSI frame returned. This provides you with encoder-specific additional bits, such as error bits, in addition to the position value. If the SSI frame is shorter than 32 bits, the complete SSI frame is returned right-aligned and the top unused bits are returned with "0" in the feedback interface.

Capture (Latch)

You can configure the edge of an external reference signal that triggers saving of the current position value as a Capture value. The following external signals can trigger the Capture function:

- Rising or falling edge of a digital input
- Both edges of a digital input

The "Frequency of Capture function" parameter specifies whether the function is executed at each configured edge or only once after each enable.

Measuring input

If you use Position input for Motion Control (Page 18), you can use the "Measuring input" technology object to execute a measuring input function with a hardware digital input.

Hardware interrupts

The technology module can trigger a hardware interrupt in the CPU when a comparison event, zero crossing and/or direction reversal occurs. You can specify which events during operation are to trigger a hardware interrupt.

2.2.1.2 Counting with incremental or pulse encoder

Counting is the detecting and adding up of events. The counters of the technology module detect encoder signals and pulses and evaluate them accordingly. The count direction can be specified using encoder or pulse signals or through the user program.

You can control the counting processes with the digital inputs. In addition, you can read the signal state of the respective digital input via the feedback interface.

You can specify the counter characteristics using the functions described below.

Counting limits

The counting limits define the counter value range used. The counting limits are configurable and can be modified during runtime with the user program.

You can configure the behavior of the counter at the counting limits.

Start value

You can configure a start value within the counting limits. The start value can be modified during runtime with the user program.

Gate control

You can define the time window in which the count signals are acquired with the hardware gate (HW gate) and software gate (SW gate).

Capture (Latch)

You can configure an external reference signal edge that triggers the saving of the current counter value as Capture value. The following external signals can trigger the Capture function:

- Rising or falling edge of a digital input
- Both edges of a digital input
- Rising edge of the N signal at the encoder input

The "Frequency of Capture function" parameter specifies whether the function is executed at each configured edge or only once after each enable.

Measuring input

If you use Position input for Motion Control (Page 18), you can use the "Measuring input" technology object to execute a measuring input function with a hardware digital input.

Hardware interrupts

The technology module can trigger a hardware interrupt in the CPU when a comparison event, zero crossing and/or direction reversal occurs. You can specify which events during operation are to trigger a hardware interrupt.

2.2.2 Measured value determination

The following high-accuracy measurement functions are available (accuracy up to 100 ppm):

- Frequency measurement with the unit of hertz
- Period measurement with the unit of seconds
- Velocity measurement with a flexibly adaptable unit
- Complete SSI frame instead of a measured quantity

Update time

You can configure the interval at which the technology module updates the measured values cyclically as the update time.

Gate control for incremental and pulse encoders

You can define the time window in which the count signals are acquired with the hardware gate (HW gate) and software gate (SW gate).

2.2.3 Switching the outputs at comparison values

The available digital outputs DQ0 and DQ1 can be directly activated/switched by the specified comparison values or via the user program. The comparison values are configurable and can be modified during runtime with the user program. This enables very fast reaction times to be achieved.

Comparison values in the Counting/Position input operating mode

In Counting/Position input operating mode you specify two position or counter values as comparison values depending on the encoder. If the current position or counter value meets the configured comparison condition, the corresponding digital output can be set to directly initiate control processes in the process.

Comparison values in the Measuring mode

You define two comparison values in the Measuring mode. If the current measured value meets the configured comparison condition, the corresponding digital output can be set to directly initiate control processes in the process.

2.2.4 Position input for Motion Control

You can use the technology module for position detection for the following axis technology objects of S7-1500 Motion Control :

- TO_PositioningAxis
- TO_SynchronousAxis
- TO_ExternalEncoder

In this operating mode, you can use the measuring input technology object (TO_MeasuringInput) to execute a measuring input function with hardware digital input DI1.

Additional information

You can find a detailed description of the use of Motion Control and its configuration in the following:

- Function manual S7-1500 Motion Control available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/59381279)
- Function manual S7-1500T Motion Control available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109481326)

2.2.5 Fast Mode

You can use the technology module in Fast Mode for very fast acquisition of counter or position value with compressed functionality. A reduced feedback interface but no control interface is available in Fast Mode. This allows you to use a shorter send clock for the CPU.

2.2.6 Additional functions

Synchronization for incremental and pulse encoder

You can configure the edge of an external reference signal that loads the counter with the specified start value. The following external signals can trigger a synchronization:

- Rising or falling edge of a digital input
- Rising edge of signal N at the encoder input
- Rising edge of signal N at the encoder input depending on the level of the assigned digital input

The "Frequency of synchronization" parameter specifies whether the function is executed at each configured edge or only once after each enable.

Hysteresis

You can specify a hysteresis for the comparison values within which a digital output will be prevented from switching again.

Diagnostic interrupt

The technology module can trigger diagnostic interrupts. You enable the diagnostic interrupts in the device configuration.

Input filter

To suppress interference, you can configure an input filter for the RS422/TTL encoder inputs and for the digital inputs.

Isochronous mode

The technology module supports the "Isochronous mode" system function. This system function enables position, counter and measured values to be acquired in a defined system cycle.

Wiring 3

The TM PosInput 1 technology module is used with a BaseUnit of type A0 (article number 6ES7193-6BPx0-0xA0).

You connect the encoder signals, digital input and output signals and the sensor supply to the BaseUnit of the technology module. The supply voltage feed on the light-colored BaseUnit BU...D of the associated potential group supplies the module and the digital outputs, and generates the encoder supply voltage.

BaseUnit

The BaseUnit is not included in the scope of delivery of the module and must be ordered separately.

You can find an overview of the BaseUnits that you can use with the technology module in the product information for the documentation of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/73021864).

You can find information about selecting a suitable BaseUnit in the ET 200SP Distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual.

You can find information on wiring the BaseUnit, connecting cable shields, etc. in the Wiring section of the ET 200SP Distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Supply voltage L+/M

With a light-colored BaseUnit, you connect the supply voltage to the L+ and M terminals. With a dark BaseUnit, the supply voltage of the left-hand module is used. An internal protection circuit protects the technology module from reverse polarity of the supply voltage. The technology module monitors whether the supply voltage is connected.

Encoder supply

For supplying the encoders and sensors connected to the digital inputs, the technology module provides supply voltages of 24 V DC (terminal 15) and 5 V DC (terminal 13) with reference to M (terminals 14 and 16). Both voltages are monitored for short circuits and overload.

You can find information on the derating information for the 5 V sensor supply in section Technical specifications (Page 93).

Digital inputs DI0 and DI1

The digital inputs are used for gate control, synchronization and the Capture function.

The digital inputs are not isolated from each other.

Input delay for digital inputs

In order to suppress noise you can configure an input delay for the digital inputs.

NOTE

If you select the "None" or "0.05 ms" option, you must use shielded cables for connection of the digital inputs.

Digital outputs DQ0 and DQ1

The digital outputs are not isolated from each other.

The digital outputs are 24 V sourcing outputs in reference to M and can carry a rated load current of 0.5 A per channel. They are protected against overload and short-circuit.

Relays and contactors can be directly connected without an external protective circuit. You can find information on the maximum possible operating frequencies and the inductive loads connected to the digital outputs in section Technical specifications (Page 93).

3.1 SSI encoder signals

SSI encoder signals

The TM PosInput 1 can process SSI encoder signals. These are designated with data and clock and use the RS422 signal standard.

An RS422 encoder signal uses a pair of wires and the information is transmitted as differential voltage. This ensures interference-free transmission of RS422 encoder signals even with high frequencies over long distances. The RS422 wire pairs must be twisted together in the cable.

The SSI encoder signals data and clock are connected via the D and C terminals. The N terminals remain unconnected. The inputs are not isolated from each other. The inputs are isolated from the backplane bus.

Terminal assignment of the BaseUnit

The table below shows the terminal assignment, using the BaseUnit BU15-P16+A0+2B as an example.

Table 2-1196 Terminal assignment of the BaseUnit BU15-P16+A0+2B

Designation	Signal name		View	Signal name		Designation
SSI data signal +D	+A/**D**	1		2	DI0	Digital input DI0
SSI data signal -D	-A/**D**	3		4	DI1	Digital input DI1

Designation	Signal name		View	Signal name		Designation
SSI clock signal +C	+B/**C**	5		6	—	—
SSI clock signal -C	-B/**C**	7	1 2	8	DQ0	Digital output DQ0
—	+N	9	3 4	10	DQ1	Digital output DQ1
—	-N	11	5 6	12	—	—
5 V DC sensor supply	5VDC	13	7 8	14	M	Ground for encoder supply, digital inputs and digital outputs
Encoder supply 24 V DC	24VDC	15	9 10 11 12	16	M	
Supply voltage DC 24 V	L+		13 14 15 16 L+ M		M	Ground for supply voltage

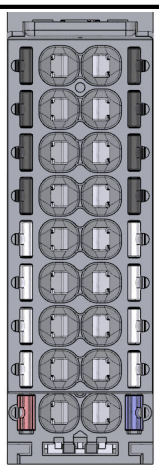

Block diagram

You must ground the shields of the cables between encoder and technology module both through the shield contact on the BaseUnit (shield bracket and terminal) and on the encoder.

The figure below shows the block diagram of the technology module with one connected SSI absolute encoder.

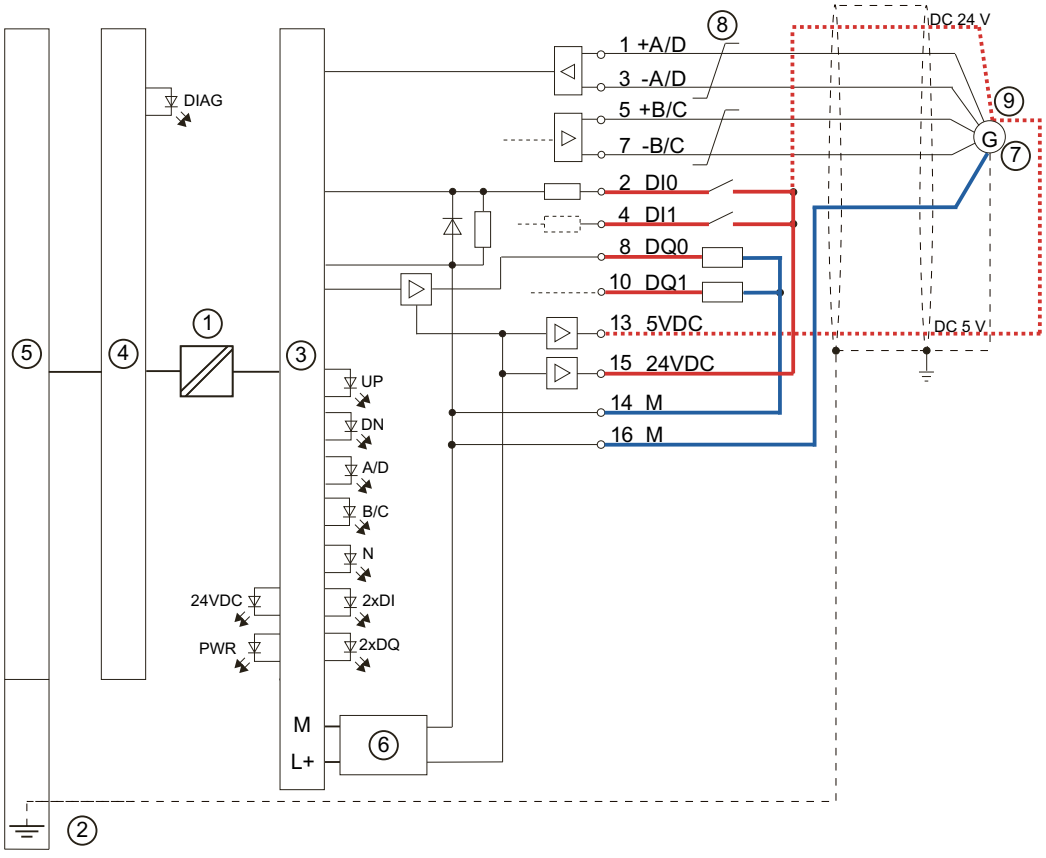

① Electrical isolation
② Shield contact on the BaseUnit
③ Technology
④ Backplane bus interface module of the technology module
⑤ Backplane bus
⑥ Input filter
⑦ SSI absolute encoder
⑧ Twisted in pairs
⑨ Sensor supply either 5 V DC or 24 V DC

Figure 2-1073 Block diagram with SSI absolute encoder

3.2 RS422 encoder signals

RS422 encoder signals/count signals

The TM PosInput 1 can process encoder signals that use the RS422 signal standard. These counting encoder signals are designated with the letters A, B and N.

An RS422 encoder signal uses a pair of wires and the counter information is transmitted as differential voltage. This ensures interference-free transmission of RS422 encoder signals even with high frequencies over long distances. The RS422 wire pairs must be twisted together in the cable.

You can connect the following encoder types:

- RS422 incremental encoder with N signal:

  The encoder signals A, B and N are connected using the correspondingly marked terminals. A and B are the two incremental signals phase-shifted by 90°. N is the zero mark signal that supplies one pulse per revolution.

- RS422 incremental encoder without N signal:

  The encoder signals A and B are connected using the correspondingly marked terminals. A and B are the two incremental signals phase-shifted by 90°. The N terminals remain unconnected.

- RS422 pulse encoder without direction signal:

  The counting signal is connected to the A terminals. The count direction can be specified via the control interface. The B and N terminals remain unconnected.

- RS422 pulse encoder with direction signal:

  The counting signal is connected to the A terminals. The direction signal is connected to the B terminals. Counting down takes place at a high level of the direction signal. The N terminals remain unconnected.

- RS422 pulse encoder with up/down count signal

  The up counting signal is connected to the A terminals. The down counting signal is connected to the B terminals. The N terminals remain unconnected.

The inputs are not isolated from each other. The inputs are isolated from the backplane bus.

NOTE

The RS422 signal standard offers greater interference immunity than the TTL signal standard. If your incremental encoder or pulse encoder supports the RS422 **and** the TTL signal standard, we recommend using the RS422 signal standard.

Terminal assignment of the BaseUnit

The table below shows the terminal assignment, using the BaseUnit BU15-P16+A0+2B as an example.

Table 2-1197 Terminal assignment of the BaseUnit BU15-P16+A0+2B

Designation					Signal name		View	Signal name		Designation
RS422 incremental encoder		RS422 pulse encoder								
with signal N	without signal N	with direction signal	without direction signal	up/down						
Encoder signal +A		Counting signal A		Up counting signal +A	+**A**/D	1	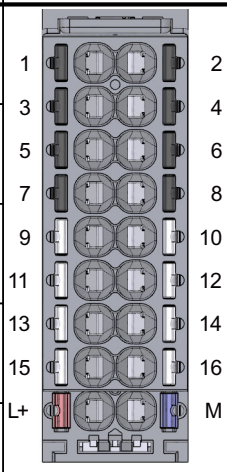	2	DI0	Digital input DI0
Encoder signal -A		Counting signal -A		Up counting signal -A	-**A**/D	3		4	DI1	Digital input DI1
Encoder signal +B		Direction signal +B	—	Down counting signal +B	+**B**/C	5		6	—	—
Encoder signal -B		Direction signal -B	—	Down counting signal -B	-**B**/C	7		8	DQ0	Digital output DQ0
Encoder signal +-N	—				+N	9		10	DQ1	Digital output DQ1
Encoder signal -N	—				-N	11		12	—	—
5 V DC sensor supply					5VDC	13		14	M	Ground for encoder supply, digital inputs and digital outputs
Encoder supply 24 V DC					24VDC	15		16	M	
Supply voltage DC 24 V					L+				M	Ground for supply voltage

Block diagram

You must ground the shields of the cables between encoder and technology module both through the shield contact on the BaseUnit (shield bracket and terminal) and on the encoder.

The figure below shows the block diagram of the technology module with one connected RS422 incremental encoder.

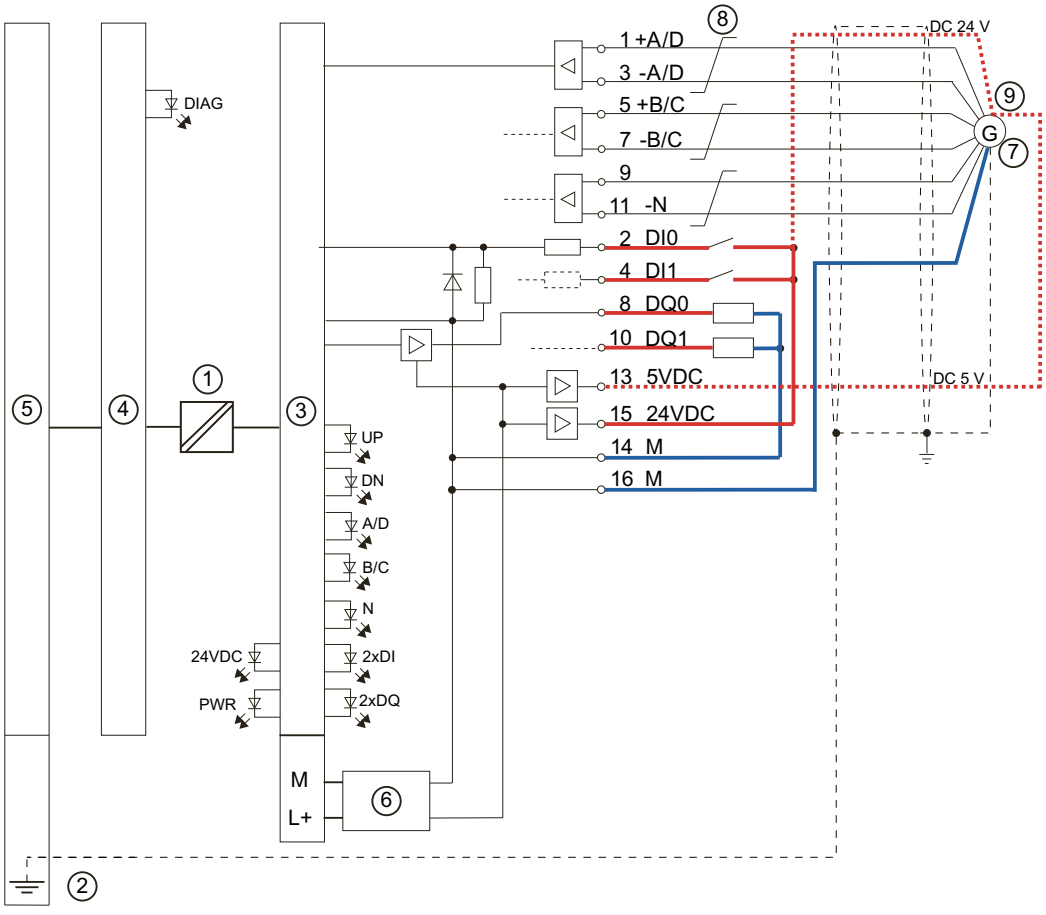

① Electrical isolation
② Shield contact on the BaseUnit
③ Technology
④ Backplane bus interface module of the technology module
⑤ Backplane bus
⑥ Input filter
⑦ RS422 incremental encoder
⑧ Twisted in pairs
⑨ Sensor supply either 5 V DC or 24 V DC

Figure 2-1074 Block diagram with RS422 incremental encoder

3.3 TTL encoder signals

TTL encoder signals/counting signals

The TM PosInput 1 can process encoder signals that use the TTL signal standard. The counting encoder signals are designated with the letters A, B and N. An encoder signal with TTL standard uses a single cable.

You can connect the following encoder types:

- TTL incremental encoder with N signal:

  The encoder signals A, B and N are connected using the correspondingly marked terminals. A and B are the two incremental signals phase-shifted by 90°. N is the zero mark signal that supplies one pulse per revolution.

- TTL incremental encoder without N signal:

  The encoder signals A and B are connected using the correspondingly marked terminals. A and B are the two incremental signals phase-shifted by 90°. The N terminal remains unconnected.

- TTL pulse encoder without direction signal:

  The counting signal is connected to the A terminal. The count direction can be specified via the control interface. The B and N terminals remain unconnected.

- TTL pulse encoder with direction signal:

  The counting signal is connected to the A terminal. The direction signal is connected to the B terminal. Counting down takes place at a high level of the direction signal. The N terminal remains unconnected.

- TTL pulse encoder with up/down counting signal

  The up counting signal is connected to the A terminal. The down counting signal is connected to the B terminal. The N terminal remains unconnected.

The inputs are not isolated from each other. The inputs are isolated from the backplane bus.

NOTE

The RS422 signal standard offers greater interference immunity than the TTL signal standard. If your incremental encoder or pulse encoder supports the RS422 **and** the TTL signal standard, we recommend using the RS422 signal standard.

Terminal assignment of the BaseUnit

The table below shows the terminal assignment, using the BaseUnit BU15-P16+A0+2B as an example.

Table 2-1198 Terminal assignment of the BaseUnit BU15-P16+A0+2B

Designation					Signal name		View	Signal name		Designation
TTL incremental encoder		TTL pulse encoder								
with signal N	without signal N	with direction signal	without direction signal	up/down						
Encoder signal A		Counting signal A		Up counting signal A	+**A**/D	1	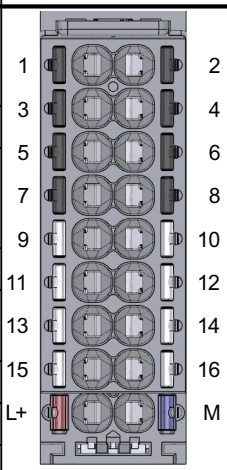	2	DI0	Digital input DI0
—					-**A**/D	3		4	DI1	Digital input DI1
Encoder signal B		Direction signal B	—	Down counting signal B	+**B**/C	5		6	—	—
—					-**B**/C	7		8	DQ0	Digital output DQ0
Encoder signal N	—				+N	9		10	DQ1	Digital output DQ1
—					-N	11		12	—	—
5 V DC sensor supply					5VDC	13		14	M	Ground for encoder supply, digital inputs and digital outputs
Encoder supply 24 V DC					24VDC	15		16	M	
Supply voltage DC 24 V					L+				M	Ground for supply voltage

Block diagram

You must ground the shields of the cables between encoder and technology module both through the shield contact on the BaseUnit (shield bracket and terminal) and on the encoder.

The figure below shows the block diagram of the technology module with one connected TTL incremental encoder.

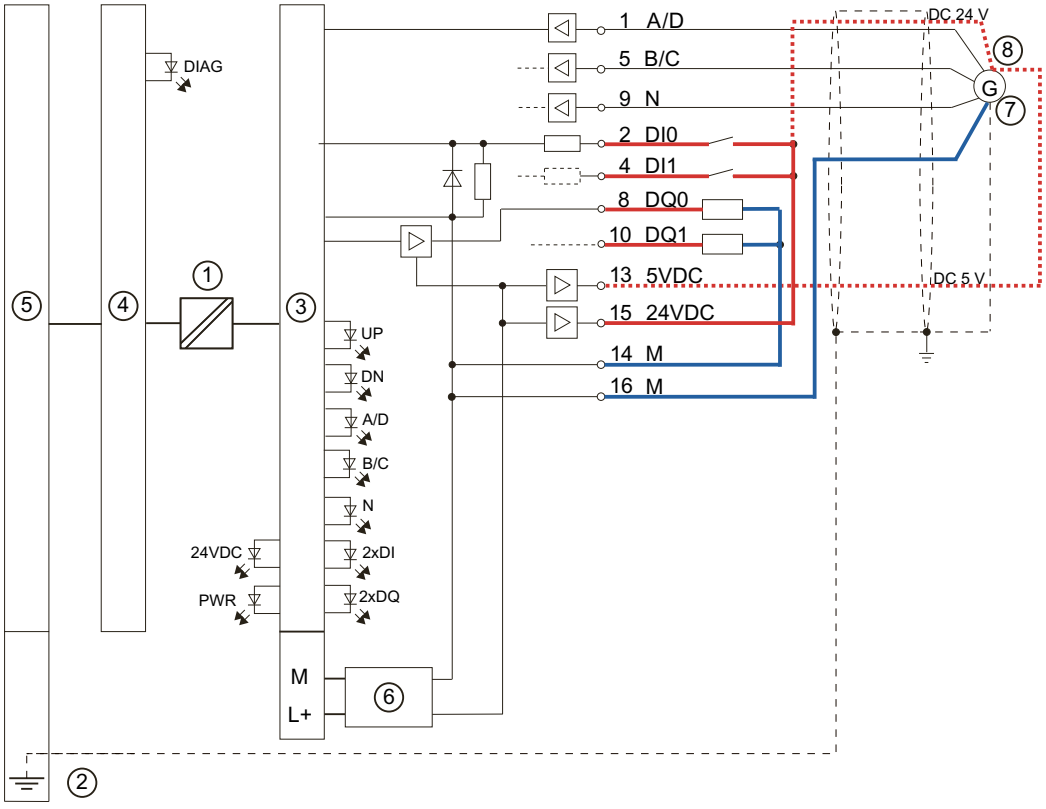

① Electrical isolation
② Shield contact on the BaseUnit
③ Technology
④ Backplane bus interface module of the technology module
⑤ Backplane bus
⑥ Input filter
⑦ TTL incremental encoder
⑧ Sensor supply either 5 V DC or 24 V DC

Figure 2-1075 Block diagram with TTL incremental encoder

Configuring/address space

4

4.1 Operating with "Counting and measurement" technology object

4.1.1 Configuring

Introduction

You configure the technology module and assign its parameters with STEP 7 (TIA Portal).

The technology object is used to control and monitor the functions of the technology module.

System environment

The technology module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central operation with a CPU 151xSP	• ET 200SP distributed I/O system • TM PosInput 1	STEP 7 (TIA Portal): • Device configuration with hardware configuration • Parameter setting with High_Speed_Counter or SSI_Absolute_Encoder technology object	For incremental/pulse encoder: High_Speed_Counter instruction For SSI absolute encoder: SSI_Absolute_Encoder instruction
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM PosInput 1		

Additional information

You can find a detailed description of the counting and measurement functions and their configuration in the following:

- Function manual Counting, Measurement and Position Detection available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820)
- Information system of STEP 7 (TIA Portal) under "Using technology functions > Counting, measurement and position input > Counting, measurement and position input (S7-1500)"

Hardware Support Packages (HSP)

If you are using TIA Portal version V16, firmware versions ≤V1.3 of the module (6ES7138-6BA00-0BA0) are integrated. You can configure the module with the article number 6ES7138-6BA01-xBA0 as replacement part compatible with firmware version V1.3. You integrate the firmware version V2.0 of the module (6ES7138-6BA01-0BA0) using HSP0184. Firmware version V2.0 of the module is integrated in the following TIA Portal versions.

You can find the Hardware Support Packages (HSP) for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).

You can also access this download from the menu bar of STEP 7 (TIA Portal): "Options > Support packages > Download from the Internet".

4.1.2 Reaction to CPU STOP

Reaction to CPU STOP

You set the response of the technology module to CPU STOP in the device configuration with the basic parameters.

Table 2-1199 Reaction of technology module to CPU STOP

Option	Meaning
Continue operation	The technology module remains fully functional. Incoming count pulses are processed or the position value is read in. The digital outputs continue to switch according to the parameter assignment.
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. If a digital output with the "At comparison value for a pulse duration" function is set at CPU STOP, the digital output is reset after the pulse duration elapses. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.

4.1.3 Parameter setting

You specify the properties of the technology module using various parameters. Depending on the settings, not all parameters are available. When parameters are assigned in the user program, the parameters are transferred to the module with the "WRREC" instruction and data record 128 (Page 103).

You set the parameters of the module as follows in this operating mode:

1. Insert the module from the hardware catalog under "Technology modules".
2. Set the mode "Operating with technology object "Counting and measurement"" and the further device configuration in the hardware configuration.
3. Insert the High_Speed_Counter or SSI_Absolute_Encoder technology object from the project tree in folder "Technology objects > Add new object > Counting and measurement".
   You can find information on configuring with a technology object in function manual Counting, Measurement and Position Detection (http://support.automation.siemens.com/WW/view/en/59709820).
4. Open the configuration of the respective technology object, e.g. using the Configuration button in the respective instruction for the technology object.
5. Set the parameters of the technology object.
6. Download the project to the CPU.

4.1.3.1 Parameters (SSI absolute encoder)

Parameters of the TM PosInput 1 with SSI absolute encoder

The following parameter settings are possible in the hardware configuration. The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1200 Adjustable parameters (SSI absolute encoder)

Parameter	Value range	Scope
Potential group	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Reaction to CPU STOP	• **Output substitute value** • Keep last value • Continue operation	Channel
Enable diagnostic interrupt on wire break	• **Deactivated** • Activated	Channel
Enable additional diagnostic interrupts	• **Deactivated** • Activated	Channel
Hardware interrupt: New Capture value available	• **Deactivated** • Activated	Channel
Hardware interrupt: Direction reversal	• **Deactivated** • Activated	Channel

Parameter	Value range	Scope
Hardware interrupt: Zero crossing	• **Deactivated** • Activated	Channel
Hardware interrupt: Comparison event for DQ0 occurred	• **Deactivated** • Activated	Channel
Hardware interrupt: Comparison event for DQ1 occurred	• **Deactivated** • Activated	Channel

The following parameter settings are possible in the technology object:

Table 2-1201 Adjustable parameters (SSI absolute encoder)

Parameter	Value range	Scope
Frame length	10...**13**...40 bits	Channel
Code type	• **Gray** • Dual	Channel
Transmission rate	• **125 kHz** • 250 kHz • 500 kHz • 1 MHz • 1.5 MHz • 2 MHz	Channel
Monoflop time	• **Automatically** • 16 µs • 32 µs • 48 µs • 64 µs	Channel
Parity	• **None** • Even • Odd	Channel
Bit number LSB of the position value	**0**...38	Channel
Bit number MSB of the position value	1...**12**...39	Channel
Invert direction (counter inputs)	• **Deactivated** • Activated	Channel
Set function of DI	• Capture • **Digital input without function**	Channel
Input delay for digital inputs	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel

Parameter	Value range	Scope
Edge selection for DI	• **At rising edge** • At falling edge • At rising and falling edge	Channel
Frequency of Capture function	• Once • **Periodic**	Channel
Comparison value 0	-2147483648...**0**...2147483647	Channel
Comparison value 1	-2147483648...**10**...2147483647	Channel
Operating mode	• **Use position value (SSI absolute value) as reference** • Use measured value as reference	Channel
Set output	• Use by user program • **Between comparison value and count high limit / measured value >= comparison value** • Between comparison value and count low limit / measured value <= comparison value • At comparison value for a pulse duration • After set command from CPU until comparison value • Between comparison value 0 and 1 • Not between comparison value 0 and 1	Channel
Count direction of DQ function	• Up • Down • **In both directions**	Channel
Pulse duration	0.1...**500.0**...6553.5 ms	Channel
Substitute value for DQ0	• **0** • 1	Channel
Substitute value for DQ1	• **0** • 1	Channel
Hysteresis (in increments)	**0**...255	Channel
Measured variable	• **Frequency** • Period • Velocity	Channel
Update time of the measuring function	0...**10**...25000 ms	Channel
Time base for velocity measurement	• 1 ms • 10 ms • 100 ms • 1 s • **60 s**	Channel
Increments per unit	**1**...65535	Channel

NOTICE

Excessive axis speed can provide wrong direction of rotation

If an axis connected to an SSI absolute encoder rotates so quickly that more than half of the value range is covered within one module cycle[1], the velocity and direction of rotation can no longer be determined correctly. As a result, the following may function incorrectly:

- DQ functions
- Feedback bits EVENT_OFLW, EVENT_UFLW, EVENT_ZERO, EVENT_CMP0, EVENT_CMP1 and STS_DIR

[1] Non-isochronous mode: 500 µs; isochronous mode: PROFINET cycle time

NOTE

If you use an SSI absolute encoder whose value range does not correspond to a power of 2, the calculated velocity measurement can be incorrect at the moment of the overflow.

Explanation of parameters

You can find a detailed description of the parameters in function manual Counting, Measurement and Position Detection in sections Basic parameters and Configuring the SSI_Absolute_Encoder available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820).

4.1.3.2 Parameters (incremental or pulse encoder)

Parameters of the TM PosInput 1 with incremental or pulse encoder

The following parameter settings are possible in the hardware configuration. The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1202 Adjustable parameters (incremental or pulse encoder)

Parameter	Value range	Scope
Potential group	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Reaction to CPU STOP	• **Output substitute value** • Keep last value • Continue operation	Channel
Enable diagnostic interrupt on wire break	• **Deactivated** • Activated	Channel
Enable additional diagnostic interrupts	• **Deactivated** • Activated	Channel
Hardware interrupt: New Capture value available	• **Deactivated** • Activated	Channel

Parameter	Value range	Scope
Hardware interrupt: Synchronization of the counter by an external signal	• **Deactivated** • Activated	Channel
Hardware interrupt: Gate start	• **Deactivated** • Activated	Channel
Hardware interrupt: Gate stop	• **Deactivated** • Activated	Channel
Hardware interrupt: Overflow (high counting limit violated)	• **Deactivated** • Activated	Channel
Hardware interrupt: Underflow (low counting limit violated)	• **Deactivated** • Activated	Channel
Hardware interrupt: Direction reversal	• **Deactivated** • Activated	Channel
Hardware interrupt: Zero crossing	• **Deactivated** • Activated	Channel
Hardware interrupt: Comparison event for DQ0 occurred	• **Deactivated** • Activated	Channel
Hardware interrupt: Comparison event for DQ1 occurred	• **Deactivated** • Activated	Channel

The following parameter settings are possible in the technology object:

Table 2-1203 Adjustable parameters (incremental or pulse encoder)

Parameter	Value range	Scope
Signal type	• Pulse (A) • **Pulse (A) and direction (B)** • Count up (A), count down (B) • Incremental encoder (A, B phase-shifted) • Incremental encoder (A, B, N)	Channel
Signal evaluation for counter inputs	• **Single** • Double • Quadruple	Channel
Invert direction (counter inputs)	• **Deactivated** • Activated	Channel
Filter frequency for counter inputs	• 100 Hz • 200 Hz • 500 Hz • 1 kHz • 2 kHz • 5 kHz • 10 kHz • 20 kHz • 50 kHz • 100 kHz • **200 kHz** • 500 kHz • 1 MHz	Channel

Parameter	Value range	Scope
Interface standard	• **RS422, symmetrical** • TTL (5 V), asymmetrical	Channel
Reaction to signal N	• **No reaction to signal N** • Synchronization at signal N • Capture at signal N	Channel
Frequency of synchronization	• **Once** • Periodic	Channel
Frequency of Capture function	• Once • **Periodic**	Channel
High counting limit	-2147483648...**2147483647**	Channel
Start value	-2147483648...**0**...2147483647	Channel
Counting low limit	**-2147483648**...2147483647	Channel
Reaction to violation of a counting limit	• Stop counting • **Continue counting**	Channel
Reset when counting limit is violated	• **To opposite counting limit** • To start value	Channel
Reaction to gate start	• Set to start value • **Continue with current value**	Channel
Set function of DI	• Gate start/stop (level-triggered) • Gate start (edge-triggered) • Gate stop (edge-triggered) • Synchronization • Enable synchronization at signal N • Capture • **Digital input without function**	Channel
Input delay for digital inputs	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel
Edge selection for DI	• **At rising edge** • At falling edge • At rising and falling edge	Channel
Select level for DI	• **Active with high level** • Active with low level	Channel
Behavior of counter value after Capture with DI	• **Continue counting** • Set to start value and continue counting	Channel
Comparison value 0	-2147483648...**0**...2147483647	Channel
Comparison value 1	-2147483648...**10**...2147483647	Channel
Operating mode	• **Use count value as reference** • Use measured value as reference	Channel

Parameter	Value range	Scope
Set output	• Use by user program • **Between comparison value and count high limit / measured value >= comparison value** • Between comparison value and count low limit / measured value <= comparison value • At comparison value for a pulse duration • After set command from CPU until comparison value • Between comparison value 0 and 1 • Not between comparison value 0 and 1	Channel
Count direction of DQ function	• Up • Down • **In both directions**	Channel
Pulse duration	0.0...**500.0**...6553.5 ms	Channel
Substitute value for DQ0	• **0** • 1	Channel
Substitute value for DQ1	• **0** • 1	Channel
Hysteresis (in increments)	**0**...255	Channel
Measured variable	• **Frequency** • Period • Velocity	Channel
Update time of the measuring function	0...**10**...25000 ms	Channel
Time base for velocity measurement	• 1 ms • 10 ms • 100 ms • 1 s • **60 s**	Channel
Increments per unit	**1**...65535	Channel

Explanation of parameters

You can find a detailed description of the parameters in function manual Counting, Measurement and Position Detection in sections Basic parameters and Configuring the High_Speed_Counter available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820).

4.1.4 Address space

Address space of the technology module

Table 2-1204 Size of input and output addresses of the TM PosInput 1 when operating with "Counting and measurement" technology object

	Inputs	Outputs
Range	16 bytes	12 bytes

The control and feedback interface is compatible with manual operation (Page 46) and is controlled by the High_Speed_Counter or SSI_Absolute_Encoder instruction.

4.1.5 Isochronous mode

The technology module supports the "Isochronous mode" system function. This system function enables position, counter and measured values to be acquired in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. The output signals switch immediately if the relevant comparison condition is met. A status change of a digital input immediately triggers the specified reaction of the technology module and the change of the status bit of the digital input in the feedback interface.

Use an OB of type "Synchronous Cycle" (e.g. OB61) in this operating mode. The High_Speed_Counter or SSI_Absolute_Encoder instruction is called in the assigned OB.

The update time for the measured value is synchronized with the system cycle in a suitable ratio and, if necessary, adapted in length. If you set "0", the measured value is updated once per system cycle.

Data processing

The data that was transmitted to the technology module in the current bus cycle via the control interface takes effect when it is processed in the internal technology module cycle. At the time the input data is read in (T_i), the position or counter value and the measured value as well as status bits are acquired and made available in the feedback interface for retrieval in the current bus cycle.

Isochronous mode parameters

In isochronous mode, the following parameter can affect the isochronous mode parameters of the sync domain.

- Filter frequency
- Frame length
- Transmission rate
- Monoflop time
- Parity

Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change one or more of the indicated parameters in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

Additional information

You can find a detailed description of isochronous mode in the following:

- In the Isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- Function manual PROFINET with STEP 7 available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856)

4.2 Position input for "Motion Control" technology object

4.2.1 Configuring

Introduction

You configure the technology module and assign its parameters with STEP 7 (TIA Portal).

The technology object is used to control and monitor the functions of the technology module.

System environment

The technology module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central operation with a CPU 151xSP	• ET 200SP distributed I/O system • TM PosInput 1	STEP 7 (TIA Portal): • Device configuration with hardware configuration • Parameter setting with axis and measuring input technology objects	Motion Control instructions
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM PosInput 1		

Additional information

You can find a detailed description of the use of Motion Control and its configuration in the following:

- Function manual S7-1500 Motion Control available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/59381279)
- Function manual S7-1500T Motion Control available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109481326)
- Information system of STEP 7 (TIA Portal) under "Using technology functions > Motion Control > Motion Control (S7-1200, S7-1500)"

You can find a description of configuring the technology module for position detection in the following:

- Function manual Counting, Measurement and Position Detection available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820)
- Information system of STEP 7 (TIA Portal) under "Using technology functions > Counting, measurement and position input > Counting, measurement and position input (S7-1500)"

Hardware Support Packages (HSP)

If you are using TIA Portal version V16, firmware versions ≤V1.3 of the module (6ES7138-6BA00-0BA0) are integrated. You can configure the module with the article number 6ES7138-6BA01-xBA0 as replacement part compatible with firmware version V1.3. You integrate the firmware version V2.0 of the module (6ES7138-6BA01-0BA0) using HSP0184. Firmware version V2.0 of the module is integrated in the following TIA Portal versions.

You can find the Hardware Support Packages (HSP) for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).

You can also access this download from the menu bar of STEP 7 (TIA Portal): "Options > Support packages > Download from the Internet".

4.2.2 Parameter setting

You specify the properties of the technology module using various parameters. Depending on the settings, not all parameters are available.

You set the parameters of the module as follows in this operating mode:

1. Insert the module from the hardware catalog under "Technology modules".
2. Set the mode "Position input for technology object "Motion Control"" and the other module parameters in the hardware configuration.
3. Insert the axis technology object and, if necessary, the measuring input technology object from the project tree in folder "Technology objects > Add new object > Motion Control". You can find information on configuring with axis technology objects in function manual S7-1500T Motion Control (https://support.industry.siemens.com/cs/ww/en/view/109481326).
4. Open the configuration of the axis technology object, e.g. using the Configuration button in the respective instruction for the technology object.
5. Set the parameters of the technology objects.
6. Download the project to the CPU.

4.2.2.1 Parameters (SSI absolute encoder)

Parameters of the TM PosInput 1 with SSI absolute encoder

The following parameter settings are possible. The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1205 Adjustable parameters (SSI absolute encoder)

Parameter	Value range	Scope
Potential group	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Invert direction (position value)	• **Deactivated** • Activated	Channel
Frame length	10...**13**...40 bits	Channel
Code type	• **Gray** • Dual	Channel
Transmission rate	• **125 kHz** • 250 kHz • 500 kHz • 1 MHz • 1.5 MHz • 2 MHz	Channel
Monoflop time	• **Automatically** • 16 µs • 32 µs • 48 µs • 64 µs	Channel
Parity	• **None** • Even • Odd	Channel
Bit number LSB of the position value	**0**...38	Channel
Bit number MSB of the position value	1...**12**...39	Channel
Measuring input	**DI1**	Channel
Encoder type	• Linear • **Rotary**	Channel
Steps per revolution	**1**...65535	Channel
Number of revolutions	is calculated automatically (read-only)	Channel
Reference speed	6.00...**3000.00**...210000.00 U/min	Channel
Distance between increments	**16000 nm**	Channel

Parameter	Value range	Scope
Reference velocity	0,60...**16,00**...600,00 m/min	Channel
Enable diagnostic interrupt on wire break	• **Deactivated** • Activated	Channel
Enable additional diagnostic interrupts	• **Deactivated** • Activated	Channel

NOTICE

Excessive axis speed can result in an incorrect position value

The function of an axis technology object is based on the assumption that the axis position within a module cycle[1] never changes by more than half of the value range.

Ensure that this condition is always met when configuring your system.

[1] Non-isochronous mode: 500 µs; isochronous mode: PROFINET cycle time

Explanation of parameters

You can find a detailed description of the parameters in function manual Counting, Measurement and Position Detection, section Module parameters (position input for Motion Control) available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820).

4.2.2.2 Parameters (incremental or pulse encoder)

Parameters of the TM PosInput 1 with incremental or pulse encoder

The following parameter settings are possible. The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1206 Adjustable parameters (incremental or pulse encoder)

Parameter	Value range	Scope
Potential group	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Signal type	• Pulse (A) • Pulse (A) and direction (B) • Count up (A), count down (B) • Incremental encoder (A, B phase-shifted) • **Incremental encoder (A, B, N)**	Channel
Invert direction (counter inputs)	• **Deactivated** • Activated	Channel
Signal evaluation for counter inputs	• **Single** • Double • Quadruple	Channel
Filter frequency	• 100 Hz	Channel

Parameter	Value range	Scope
for counter inputs	• 200 Hz • 500 Hz • 1 kHz • 2 kHz • 5 kHz • 10 kHz • 20 kHz • 50 kHz • 100 kHz • 200 kHz • 500 kHz • **1 MHz**	
Interface standard	• **RS422, symmetrical** • TTL (5 V), asymmetrical	Channel
Signal selection for reference mark 0	• DI0 • **Signal N of incremental encoder**	Channel
Measuring input	**DI1**	Channel
Encoder type	• Linear • **Rotary**	Channel
Increments per revolution / steps per revolution	**1**...65535	Channel
Reference speed	6.00...**3000.00**...210000.00 U/min	Channel
Distance between increments	1...**16000**...25000000 nm	Channel
Fine-resolution increment distance	is calculated automatically (read-only)	Channel
Reference velocity	0,60...**16,00**...600,00 m/min	Channel
Enable diagnostic interrupt on wire break	• **Deactivated** • Activated	Channel
Enable additional diagnostic interrupts	• **Deactivated** • Activated	Channel

Explanation of parameters

You can find a detailed description of the parameters in function manual Counting, Measurement and Position Detection, section Module parameters (position input for Motion Control) available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820).

4.2.3 Address space

Address space of the technology module

Table 2-1207 Size of input and output addresses of the TM PosInput 1 with position input for "Motion Control" technology object

	Inputs	Outputs
Range	16 bytes	4 bytes

4.2.4 Control interface and feedback interface

4.2.4.1 Assignment of the control interface

The control interface is reserved for Motion Control instructions.

4.2.4.2 Assignment of the feedback interface

The feedback interface is reserved for Motion Control instructions with the exception of status information via the digital inputs.

Byte offset from start address ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reserved				STS_DI0	STS_DI1	Reserved	
1...15	Reserved							

4.2.5 Isochronous mode

The technology module supports the "Isochronous mode" system function. Position and counter values can be acquired in a fixed system cycle with this system function.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. A status change of a digital input immediately triggers the specified reaction of the technology module and the change of the status bit of the digital input in the feedback interface.

Use an OB of type "MC-Servo" in this operating mode. Isochronous mode is needed when using the output cam and cam track technology objects. When the measuring input technology is used in combination with hardware digital input DI1, isochronous mode is not needed.

Data processing

The data that was transmitted to the technology module in the current bus cycle via the control interface takes effect when it is processed in the internal technology module cycle. At the time the input data is read in (T_i), the position or counter value as well as status bits are acquired and made available in the feedback interface for retrieval in the current bus cycle.

Isochronous mode parameters

In isochronous mode, the following parameter can affect the isochronous mode parameters of the sync domain.

- Filter frequency
- Frame length
- Transmission rate
- Monoflop time
- Parity

Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change one or more of the indicated parameters in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

Additional information

You can find a detailed description of isochronous mode in the following:

- In the Isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- Function manual PROFINET with STEP 7 available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856)

4.3 Manual operation (without technology object)

4.3.1 Configuring

Introduction

You configure the technology module and assign its parameters with the configuration software.

The functions of the technology module are controlled and checked by the user program via the control and feedback interface.

System environment

The technology module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central operation with a CPU 151xSP	• ET 200SP distributed I/O system • TM PosInput 1	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to control and feedback interface in the I/O data
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM PosInput 1	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	
Distributed operation with an S7-1200 CPU	• S7-1200 automation system • ET 200SP distributed I/O system • TM PosInput 1	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	
Distributed operation with an S7-300/400 CPU	• S7-300/400 automation system • ET 200SP distributed I/O system • TM PosInput 1	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration STEP 7: Device configuration and parameter setting with GSD file	
Distributed operation in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM PosInput 1	Third-party configuration software: Device configuration and parameter setting with GSD file	

Additional information

You can find a detailed description of the counting and measurement functions and their configuration in the following:

- Function manual Counting, Measurement and Position Detection available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820)
- Information system of STEP 7 (TIA Portal) under "Using technology functions > Counting, measurement and position input > Counting, measurement and position input (S7-1500)"

Hardware Support Packages (HSP)

STEP 7 (TIA Portal)

If you are using TIA Portal version V16, firmware versions ≤V1.3 of the module (6ES7138-6BA00-0BA0) are integrated. You can configure the module with the article number 6ES7138-6BA01-xBA0 as replacement part compatible with firmware version V1.3. You integrate the firmware version V2.0 of the module (6ES7138-6BA01-0BA0) using HSP0184. Firmware version V2.0 of the module is integrated in the following TIA Portal versions.

You can find the Hardware Support Packages (HSP) for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).

You can also access this download from the menu bar of STEP 7 (TIA Portal): "Options > Support packages > Download from the Internet".

STEP 7

The HSP for STEP 7 contains firmware version V1.2 of the module (6ES7138-6BA00-0BA0). You can configure the module with the article number 6ES7138-6BA01-xBA0 as replacement part compatible with firmware version V1.2.

You can find the Hardware Support Packages (HSP) for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/23183356).

GSD file

You can find the respective GSD file for the ET 200SP distributed I/O system for download on the Internet:

- GSD file for PROFINET IO (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD file for PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/73016883)

4.3.2 Reaction to CPU STOP

Reaction to CPU STOP

You set the response of the technology module to CPU STOP in the device configuration with the basic parameters.

Table 2-1208 Reaction of technology module to CPU STOP

Option	Meaning
Continue operation	The technology module remains fully functional. Incoming count pulses are processed or the position value is read in. The digital outputs continue to switch according to the parameter assignment.
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. If a digital output with the "At comparison value for a pulse duration" function is set at CPU STOP, the digital output is reset after the pulse duration elapses. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.

4.3.3 Parameter setting

You specify the properties of the technology module using various parameters. Depending on the settings, not all parameters are available. When parameters are assigned in the user program, the parameters are transferred to the module with the "WRREC" instruction and data record 128 (Page 103).

You set the parameters of the module as follows in this operating mode:

Parameter setting using...	Basic procedure
Hardware configuration in STEP 7 (TIA Portal)	1. Insert the module from the hardware catalog under "Technology modules". 2. Set the mode "Manual operation (without technology object) " and the other module parameters in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFINET IO	1. Install the current PROFINET GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFINET IO > I/O". 2. Set the parameters in the hardware configuration. You can find information on the respective dependencies of the parameters in function manual Counting, Measurement and Position Detection (http://support.automation.siemens.com/WW/view/en/59709820). 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFIBUS DP	1. Install the current PROFIBUS GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFIBUS DP > I/O". 2. Set the parameters in the hardware configuration. You can find information on the respective dependencies of the parameters in function manual Counting, Measurement and Position Detection (http://support.automation.siemens.com/WW/view/en/59709820). The parameters marked with [1] in the following tables are not configurable in the PROFIBUS GSD file. 3. Download the project to the CPU. The parameters marked with [1] in the following tables are downloaded with their default setting. 4. If necessary, set the parameters marked with [1] in the user program using data record 128.

4.3.3.1 Parameters (SSI absolute encoder)

Parameters of the TM PosInput 1 with SSI absolute encoder

The following parameter settings are possible. 7The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1209 Adjustable parameters (SSI absolute encoder)

Parameter	Value range	Scope
Potential group	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Operating mode[3]	• **Position input** • Measuring	Channel
Reaction to CPU STOP[1]	• **Output substitute value** • Keep last value • Continue operation	Channel
Substitute value for DQ0	• **0** • 1	Channel
Substitute value for DQ1	• **0** • 1	Channel
Enable diagnostic interrupt on wire break[2]	• **Deactivated** • Activated	Channel
Enable additional diagnostic interrupts	• **Deactivated** • Activated	Channel
Hardware interrupt: New Capture value available[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Direction reversal[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Zero crossing[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Comparison event for DQ0 occurred[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Comparison event for DQ1 occurred[1]	• **Deactivated** • Activated	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

3 When configuring with HSP for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

4 Not available with HSP for STEP 7

Parameter	Value range	Scope
Invert direction[1] (position value)	• **Deactivated** • Activated	Channel
Frame length	10...**13**...40 bits	Channel
Code type	• **Gray** • Dual	Channel
Transmission rate	• **125 kHz** • 250 kHz • 500 kHz • 1 MHz • 1.5 MHz • 2 MHz	Channel
Monoflop time[1]	• **Automatically** • 16 µs • 32 µs • 48 µs • 64 µs	Channel
Parity	• **None** • Even • Odd	Channel
Bit number LSB of the position value	**0**...38	Channel
Bit number MSB of the position value	1...**12**...39	Channel
Set function of DI	• Capture • **Digital input without function**	Channel
Input delay for digital inputs[1]	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel
Edge selection for DI[1]	• **At rising edge** • At falling edge • At rising and falling edge	Channel
Frequency of Capture function[1,4]	• Once • **Periodic**	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

3 When configuring with HSP for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

4 Not available with HSP for STEP 7

Parameter	Value range	Scope
Set output	• Use by user program • **Between comparison value and count high limit / measured value >= comparison value** • Between comparison value and count low limit / measured value <= comparison value • At comparison value for a pulse duration • After set command from CPU until comparison value • Between comparison value 0 and 1 • Not between comparison value 0 and 1	Channel
Comparison value 0[1]	-2147483648...**0**...2147483647	Channel
Comparison value 1[1]	-2147483648...**10**...2147483647	Channel
Count direction of DQ function[1]	• Up • Down • **In both directions**	Channel
Pulse duration[1]	0.1...**500.0**...6553.5 ms	Channel
Hysteresis (in increments)[1]	**0**...255	Channel
Measured variable	• **Frequency** • Period • Velocity • Complete SSI frame	Channel
Update time of the measuring function[1]	0...**10**...25000 ms	Channel
Time base for velocity measurement[1]	• 1 ms • 10 ms • 100 ms • 1 s • **60 s**	Channel
Increments per unit[1]	**1**...65535	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

3 When configuring with HSP for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

4 Not available with HSP for STEP 7

NOTICE

Excessive axis speed can provide wrong direction of rotation

If an axis connected to an SSI absolute encoder rotates so quickly that more than half of the value range is covered within one module cycle[1], the velocity and direction of rotation can no longer be determined correctly. As a result, the following may function incorrectly:

- DQ functions
- Feedback bits EVENT_OFLW, EVENT_UFLW, EVENT_ZERO, EVENT_CMP0, EVENT_CMP1 and STS_DIR

[1] Non-isochronous mode: 500 µs; isochronous mode: PROFINET cycle time

NOTE

If you use an SSI absolute encoder whose value range does not correspond to a power of 2, the calculated velocity measurement can be incorrect at the moment of the overflow.

Explanation of parameters

You can find a detailed description of the parameters in function manual Counting, Measurement and Position Detection, sections Basic parameters and Manual operation available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820).

4.3.3.2 Parameters (incremental or pulse encoder)

Parameters of the TM PosInput 1 with incremental or pulse encoder

The following parameter settings are possible. The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1210 Adjustable parameters (incremental or pulse encoder)

Parameter	Value range	Scope
Potential group	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Operating mode[3]	• **Counting** • Measuring	Channel
Reaction to CPU STOP[1]	• **Output substitute value** • Keep last value • Continue operation	Channel
Substitute value for DQ0[1]	• **0** • 1	Channel
Substitute value for DQ1[1]	• **0** • 1	Channel
Enable diagnostic interrupt on wire break[2]	• **Deactivated** • Activated	Channel
Enable additional diagnostic interrupts	• **Deactivated** • Activated	Channel
Hardware interrupt: New Capture value available[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Synchronization of the counter by an external signal[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Gate start[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Gate stop[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Overflow (high counting limit violated)[1]	• **Deactivated** • Activated	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

3 When configuring with HSP for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

4 Not available with HSP for STEP 7

Parameter	Value range	Scope
Hardware interrupt: Underflow (low counting limit violated)[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Direction reversal[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Zero crossing[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Comparison event for DQ0 occurred[1]	• **Deactivated** • Activated	Channel
Hardware interrupt: Comparison event for DQ1 occurred[1]	• **Deactivated** • Activated	Channel
Signal type	• Pulse (A) • **Pulse (A) and direction (B)** • Count up (A), count down (B) • Incremental encoder (A, B phase-shifted) • Incremental encoder (A, B, N)	Channel
Signal evaluation for counter inputs	• **Single** • Double • Quadruple	Channel
Filter frequency for counter inputs[1]	• 100 Hz • 200 Hz • 500 Hz • 1 kHz • 2 kHz • 5 kHz • 10 kHz • 20 kHz • 50 kHz • 100 kHz • 200 kHz • 500 kHz • **1 MHz**	Channel
Invert direction (counter inputs)[1]	• **Deactivated** • Activated	Channel
Reaction to signal N[1]	• **No reaction to signal N** • Synchronization at signal N • Capture at signal N	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

3 When configuring with HSP for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

4 Not available with HSP for STEP 7

Parameter	Value range	Scope
Frequency of synchronization[1]	• **Once** • Periodic	Channel
Frequency of Capture function[1,4]	• Once • **Periodic**	Channel
Interface standard	• **RS422, symmetrical** • TTL (5 V), asymmetrical	Channel
High counting limit[1]	-2147483648...**2147483647**	Channel
Start value[1]	-2147483648...**0**...2147483647	Channel
Counting low limit[1]	**-2147483648**...2147483647	Channel
Reaction to violation of a counting limit	• Stop counting • **Continue counting**	Channel
Reset when counting limit is violated	• **To opposite counting limit** • To start value	Channel
Reaction to gate start	• Set to start value • **Continue with current value**	Channel
Set function of DI	• Gate start/stop (level-triggered) • Gate start (edge-triggered) • Gate stop (edge-triggered) • Synchronization • Enable synchronization at signal N • Capture • **Digital input without function**	Channel
Select level for DI[1]	• **Active with high level** • Active with low level	Channel
Edge selection for DI[1]	• At rising edge • At falling edge • **At rising and falling edge**	Channel
Behavior of counter value after Capture with DI [1]	• **Continue counting** • Set to start value and continue counting	Channel
Input delay for digital inputs[1]	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

3 When configuring with HSP for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

4 Not available with HSP for STEP 7

Parameter	Value range	Scope
Set output	• Use by user program • **Between comparison value and count high limit / measured value >= comparison value** • Between comparison value and count low limit / measured value <= comparison value • At comparison value for a pulse duration • After set command from CPU until comparison value • Between comparison value 0 and 1 • Not between comparison value 0 and 1	Channel
Comparison value 0[1]	-2147483648...**0**...2147483647	Channel
Comparison value 1[1]	-2147483648...**10**...2147483647	Channel
Count direction of DQ function[1]	• Up • Down • **In both directions**	Channel
Pulse duration[1]	0.0...**500.0**...6553.5 ms	Channel
Hysteresis (in increments)[1]	**0**...255	Channel
Measured variable	• **Frequency** • Period • Velocity	Channel
Update time of the measuring function[1]	0...**10**...25000 ms	Channel
Time base for velocity measurement[1]	• 1 ms • 10 ms • 100 ms • 1 s • **60 s**	Channel
Increments per unit[1]	**1**...65535	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

3 When configuring with HSP for STEP 7 or with a GSD file, you determine the operating mode when you select the module name.

4 Not available with HSP for STEP 7

Explanation of parameters

You can find a detailed description of the parameters in function manual Counting, Measurement and Position Detection, sections Basic parameters and Manual operation available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820).

4.3.4 Address space

Address space of the technology module

Table 2-1211 Size of input and output addresses of the TM PosInput 1 with manual operation

	Inputs	Outputs
Range	16 bytes	12 bytes

4.3.5 Control and feedback interface

NOTE

The control and feedback interface is compatible with the control and feedback interface of the TM PosInput 2, TM Count 2x24V and TM Count 1x24V technology modules of the S7-1500 automation system.

4.3.5.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface

The following table shows the assignment of the control interface:

Byte offset from start address ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	SLOT_0: DINT or REAL: Load value (meaning of the value is specified in LD_SLOT_0) Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
4...7	SLOT_1: DINT or REAL: Load value (meaning of the value is specified in LD_SLOT_1) Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
8	LD_SLOT_1				LD_SLOT_0			
9	EN_ CAPTURE	EN_ SYNC_DN	EN_ SYNC_UP	SET_DQ1	SET_DQ0	TM_ CTRL_DQ1	TM_ CTRL_DQ0	SW_GATE
10	SET_DIR	Reserved					RES_ EVENT	RES_ ERROR
11	Reserved							

Explanations

Control bit/value	Explanations
SLOT_m	You specify the load value with this value. You specify the meaning of the value in LD_SLOT_m. If you want to load a comparison value in the "Measuring" operating mode, specify the load value as floating-point number (REAL). In all other cases, you specify the load value as an integer (DINT). Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$
LD_SLOT_m	Use this load request to specify the meaning of the value in SLOT_m: • 0000 means: No action, idle • 0001 means: Load counter value (for incremental or pulse encoder) • 0010 not permitted • 0011 means: Load start value (for incremental or pulse encoder) • 0100 means: Load comparison value 0 • 0101 means: Load comparison value 1 • 0110 means: Load counting low limit (for incremental or pulse encoder) • 0111 means: Load high counting limit (for incremental or pulse encoder) • 1000 to 1111 not permitted The technology module executes the respective action as soon as LD_SLOT_m changes. If values are loaded simultaneously using LD_SLOT_0 and LD_SLOT_1, the value from SLOT_0 is internally applied first and then the value from SLOT_1 . This can produce unexpected intermediate states.
EN_CAPTURE	Use this bit to enable the Capture function. Resetting this bit resets a set EVENT_CAP in the feedback interface.
EN_SYNC_DN	Use this bit to enable the synchronization of the counter when counting down with an incremental encoder or pulse encoder. Resetting this bit resets a set EVENT_SYNC in the feedback interface.
EN_SYNC_UP	Use this bit to enable the synchronization of the counter when counting up with an incremental encoder or pulse encoder. Resetting this bit resets a set EVENT_SYNC in the feedback interface.
SET_DQ0	Use this bit to set digital output DQ0 when TM_CTRL_DQ0 is set to 0. In the case of the function "After set command from CPU until comparison value", SET_DQ0 is effective regardless of TM_CTRL_DQ0 as long as the counter value is not equal to the comparison value.
SET_DQ1	Use this bit to set digital output DQ1 when TM_CTRL_DQ1 is set to 0. In the case of the function "After set command from CPU until comparison value", SET_DQ1 is effective regardless of TM_CTRL_DQ1 as long as the counter value is not equal to the comparison value.
TM_CTRL_DQ0	Use this bit to enable the technological function of digital output DQ0. • 0 means: SET_DQ0 defines the state of DQ0 • 1 means: assigned function defines the state of DQ0
TM_CTRL_DQ1	Use this bit to enable the technological function of digital output DQ1. • 0 means: SET_DQ1 defines the state of DQ1 • 1 means: assigned function defines the state of DQ1
SW_GATE	Use this bit to open and close the software gate when using an incremental encoder or pulse encoder. Together, the software gate and the hardware gate form the internal gate. The technology module only counts when the internal gate is open. • 0 means: Software gate closed • 1 means: Software gate open The digital inputs of the technology module externally control the hardware gate. The hardware gate can be activated by parameter assignment. The software gate cannot be deactivated.

Control bit/value	Explanations
SET_DIR	Use this bit to specify the count direction for signal type "Pulse (A)". • 0 means: Up • 1 means: Down
RES_EVENT	Use this bit to trigger the reset of the saved events in the EVENT_ZERO, EVENT_OFLW, EVENT_UFLW, EVENT_CMP0, EVENT_CMP1 feedback bits.
RES_ERROR	Use this bit to trigger the reset of the saved error states LD_ERROR and ENC_ERROR .
Reserved	Reserved bits must be set to 0.

4.3.5.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module by means of the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Byte offset from start address ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	COUNT_VALUE: DINT: Current counter value or position value							
4...7	CAPTURED_VALUE: DINT: The last acquired Capture value							
8...11	MEASURED_VALUE: REAL: Current measured value or DWORD: Complete SSI frame							
12	Reserved					LD_ERROR	ENC_ ERROR	POWER_ ERROR
13	Reserved		STS_SW_ GATE	STS_ READY	LD_STS_ SLOT_1	LD_STS_ SLOT_0	RES_EVENT_- ACK	Reserved
14	Reserved	STS_DI1	STS_DI0	STS_DQ1	STS_DQ0	STS_GATE	STS_CNT	STS_DIR
15	STS_M_ INTERVAL	EVENT_ CAP	EVENT_ SYNC	EVENT_ CMP1	EVENT_ CMP0	EVENT_ OFLW	EVENT_ UFLW	EVENT_ ZERO

NOTE

Validity of the position value

The position value of an SSI absolute encoder is valid when STS_READY is set to 1 and ENC_ERROR is set to 0. STS_READY is set to 0 while the module starts up.

Explanations

Feedback bit/value	Explanations
COUNT_VALUE	This DINT value indicates the current counter value or position value. If you use an SSI absolute encoder with a position value length up to 31 bits, the position value is treated as unsigned and as a positive value and can assume values between 0 and $2^{(MSB-LSB+1)}$-1. If you use an SSI absolute encoder with a position value length of 32 bits, the MSB of the position value corresponds to the sign and the position value can assume values between –2147483648 and 2147483647. If you use a 32-bit position value for the comparison function, the position value is interpreted as DINT.
CAPTURED_VALUE	This DINT value indicates the last acquired Capture value. The following external signals can trigger the Capture function: • Rising or falling edge of a digital input • Both edges of a digital input The "Frequency of Capture function" parameter specifies whether the function is executed at each configured edge or only once after each enable.
MEASURED_VALUE	This value indicates the current measured value with data type REAL or the complete SSI frame with data type DWORD: • Frequency: The mean frequency is calculated from the time profile of the count pulses or position value changes in one measurement interval and returned as a floating-point number in the unit of hertz. • Period: The mean period is calculated from the time profile of the count pulses or position value changes in one measurement interval and returned as a floating-point number in the unit of seconds. • Velocity: The mean velocity is calculated from the time profile of the count pulses or position value changes in one measurement interval and returned as a floating-point number in the configured unit. • Complete SSI frame: Instead of a measured quantity, the least significant 32 bits of the unprocessed current SSI frame are returned. This provides you with encoder-specific additional bits, such as error bits, in addition to the position value. If the SSI frame is shorter than 32 bits, the complete SSI frame is returned right-aligned and the top unused bits are returned with "0" in the feedback interface. The measured values are returned as a signed value. The sign indicates whether the counter value or position value went up or down in the relevant time interval. The update time is asynchronous to the opening of the internal gate, i.e. the update time is not started when the gate opens. After the internal gate closes, the last calculated measured value continues to be returned.
LD_ERROR	This bit indicates that an error occurred (latching) during loading via the control interface. The loaded values were not applied. When using an incremental or pulse encoder, one of the following conditions is not fulfilled: • Low counting limit <= counter value <= high counting limit • Low counting limit <= start value <= high counting limit • Low counting limit <= comparison value 0/1 <= high counting limit When using an SSI absolute encoder, one of the following conditions is not fulfilled: • 0 <= position value <= maximum position value • 0 <= comparison value 0/1 <= maximum position value The bit is reset once you have acknowledged the error with RES_ERROR .

Feedback bit/value	Explanations
ENC_ERROR	This bit indicates that one of the following errors has occurred at the encoder signals (retentive) for the respective technology module: • Invalid transition of A/B signals (with incremental encoder) • RS422/TTL error • SSI encoder error or SSI frame error (with SSI absolute encoder) If you have enabled the diagnostic interrupts, the respective diagnostic interrupt is triggered in the event of encoder signal errors. For information on the meaning of the diagnostic interrupts, refer to the section Diagnostic alarms (Page 88). The bit is reset once you have acknowledged the error with RES_ERROR .
POWER_ERROR	This bit indicates that supply voltage L+ is too low. If you have enabled the diagnostic interrupts (Page 88), the diagnostic interrupt "Load voltage missing" is triggered at a supply voltage error. When supply voltage L+ is available at a sufficient level once again, POWER_ERROR is automatically set to 0.
STS_SW_GATE	This bit indicates the status of the software gate. • 0 means: Gate closed • 1 means: Gate open
STS_READY	This bit indicates that the technology module supplies valid user data. The technology module has been started up and configured.
LD_STS_SLOT_0	This bit indicates by a status change (toggling) that the load request for SLOT_0 (LD_SLOT_0) was detected and performed.
LD_STS_SLOT_1	This bit indicates by a status change (toggling) that the load request for SLOT_1 (LD_SLOT_1) was detected and performed.
RES_EVENT_ACK	This bit indicates that the reset of event bit EVENT_SYNC, EVENT_CMP0, EVENT_CMP1, EVENT_OFLW, EVENT_UFLW, EVENT_ZERO is active.
STS_DI0	This bit indicates the status of digital input DI0.
STS_DI1	This bit indicates the status of digital input DI1.
STS_DQ0	This bit indicates the status of digital output DQ0.
STS_DQ1	This bit indicates the status of digital output DQ1.
STS_GATE	This bit indicates the status of the internal gate when using an incremental or pulse encoder. • 0 means: Gate closed • 1 means: Gate open Note: In order for the counting logic including the gate control to operate correctly, the startup of the technology module must finish correctly at least once with a connected incremental or pulse encoder (STS_READY auf 1). If a connected encoder is not yet ready during the startup, the function of feedback bit STS_GATE is delayed until the encoder for the technology module is available. When the technology module starts up without a connected encoder, the startup does not finish correctly and STS_READY as well as STS_GATE remain set to 0. As soon as an encoder is connected, the startup finishes and STS_GATE functions correctly. An encoder error after a finished startup has no effect on STS_GATE.
STS_CNT	This bit indicates that at least one count pulse or a position value change has been detected in the last approx. 0.5 s.
STS_DIR	This bit indicates the count direction of the last count pulse or the direction of the last position value change. • 0 means: Down • 1 means: Up
STS_M_INTERVAL	This bit indicates that at least one count pulse or a position value change was detected in the previous measurement interval.

Feedback bit/value	Explanations
EVENT_CAP	This bit indicates that a Capture event has occurred and a counter value has been saved in CAPTURED_VALUE . You reset the state by resetting EN_CAPTURE .
EVENT_SYNC	This bit indicates the saved state that the counter was loaded with the start value by an external reference signal (synchronization) when using an incremental or pulse encoder. You reset the state by resetting EN_SYNC_UP or EN_SYNC_DN .
EVENT_CMP0	This bit indicates the saved state that a comparison event (state change) has occurred for the digital output DQ0 based on the selected comparison condition. You reset the state by acknowledgment with RES_EVENT. If the counter value is set to the start value in counting operating mode, EVENT_CMP0 is not set.
EVENT_CMP1	This bit indicates the saved state that a comparison event (state change) has occurred for the digital output DQ1 based on the selected comparison condition. You reset the state by acknowledgment with RES_EVENT. If the counter value is set to the start value in counting operating mode, EVENT_CMP1 is not set.
EVENT_OFLW	This bit indicates the saved state which shows that there was a counter value overflow. You reset the state by acknowledgment with RES_EVENT.
EVENT_UFLW	This bit indicates the saved state which shows that there was a counter value underflow. You reset the state by acknowledgment with RES_EVENT.
EVENT_ZERO	This bit indicates the saved state that the counter value or position value experienced a zero crossing. You reset the state by acknowledgment with RES_EVENT. If the "Zero crossing" hardware interrupt is enabled, it can also be triggered by the system if "0" is outside the configured value range.
Reserved	Reserved bits are set to 0.

4.3.6 Isochronous mode

The technology module supports the "Isochronous mode" system function. This system function enables position, counter and measured values to be acquired in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. The output signals switch immediately if the relevant comparison condition is met. A status change of a digital input immediately triggers the specified reaction of the technology module and the change of the status bit of the digital input in the feedback interface.

Use an OB of type "Synchronous Cycle" (e.g. OB61) in this operating mode. The input and output data are processed in the assigned OB.

The update time for the measured value is synchronized with the system cycle in a suitable ratio and, if necessary, adapted in length. If you set "0", the measured value is updated once per system cycle.

Data processing

The data that was transmitted to the technology module in the current bus cycle via the control interface takes effect when it is processed in the internal technology module cycle. At the time the input data is read in (T_i), the position or counter value and the measured value as well as status bits are acquired and made available in the feedback interface for retrieval in the current bus cycle.

Isochronous mode parameters

In isochronous mode, the following parameter can affect the isochronous mode parameters of the sync domain.

- Filter frequency
- Frame length
- Transmission rate
- Monoflop time
- Parity

Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change one or more of the indicated parameters in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

Additional information

You can find a detailed description of isochronous mode in the following:

- In the Isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- Function manual PROFINET with STEP 7 available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856)

4.4 Fast Mode

You can use the technology module in Fast Mode for very fast acquisition of counter or position value with compressed functionality. A reduced feedback interface but no control interface is available in Fast Mode. This allows you to use a shorter send clock for the CPU.

The range of functions of the technology module has the following limitations in Fast Mode:

- Parameter change in RUN only possible with data record 128
- Count/position value range: 25 bits
- No measured value available
- No software gate available
- No complete SSI frame available
- No Capture function available
- No hardware interrupts available
- Combined error message (feedback bit) that is acknowledged automatically

4.4.1 Configuring

Introduction

You configure the technology module and assign its parameters with the configuration software.

The functions of the technology module are controlled and checked by the user program via the feedback interface.

System environment

The technology module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central operation with a CPU 151xSP	• ET 200SP distributed I/O system • TM PosInput 1	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to feedback interface in the I/O data
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM PosInput 1	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	
Distributed operation with an S7-1200 CPU	• S7-1200 automation system • ET 200SP distributed I/O system • TM PosInput 1	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	
Distributed operation with an S7-300/400 CPU	• S7-300/400 automation system • ET 200SP distributed I/O system • TM PosInput 1	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration STEP 7: Device configuration and parameter setting with GSD file	
Distributed operation in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM PosInput 1	Third-party configuration software: Device configuration and parameter setting with GSD file	

Additional information

You can find a detailed description of the counting and measurement functions and their configuration in the following:

- Function manual Counting, Measurement and Position Detection available for download on the Internet (http://support.automation.siemens.com/WW/view/en/59709820)
- Information system of STEP 7 (TIA Portal) under "Using technology functions > Counting, measurement and position input > Counting, measurement and position input (S7-1500)"

Hardware Support Packages (HSP)

STEP 7 (TIA Portal)

If you are using TIA Portal version V16, firmware versions ≤V1.3 of the module (6ES7138-6BA00-0BA0) are integrated. You can configure the module with the article number 6ES7138-6BA01-xBA0 as replacement part compatible with firmware version V1.3. You integrate the firmware version V2.0 of the module (6ES7138-6BA01-0BA0) using HSP0184. Firmware version V2.0 of the module is integrated in the following TIA Portal versions.

You can find the Hardware Support Packages (HSP) for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).

You can also access this download from the menu bar of STEP 7 (TIA Portal): "Options > Support packages > Download from the Internet".

STEP 7

The HSP for STEP 7 contains firmware version V1.2 of the module (6ES7138-6BA00-0BA0). You can configure the module with the article number 6ES7138-6BA01-xBA0 as replacement part compatible with firmware version V1.2.

You can find the Hardware Support Packages (HSP) for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/23183356).

GSD file

You can find the respective GSD file for the ET 200SP distributed I/O system for download on the Internet:

- GSD file for PROFINET IO (http://support.automation.siemens.com/WW/view/en/73016883)
- GSD file for PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/57138621)

4.4.2 Reaction to CPU STOP

Reaction to CPU STOP

You set the response of the technology module to CPU STOP in the device configuration with the basic parameters.

Table 2-1212 Reaction of technology module to CPU STOP

Option	Meaning
Continue operation	The technology module remains fully functional. Incoming count pulses are processed or the position value is read in. The digital outputs continue to switch according to the parameter assignment.
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.

Option	Meaning
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. If a digital output with the "At comparison value for a pulse duration" function is set at CPU STOP, the digital output is reset after the pulse duration elapses. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.

4.4.3 Parameter setting

You specify the properties of the technology module using various parameters. Depending on the settings, not all parameters are available. When parameters are assigned in the user program, the parameters are transferred to the module with the "WRREC" instruction and data record 128 (Page 103).

You set the parameters of the module as follows in this operating mode:

Parameter setting using...	Basic procedure
Hardware configuration in STEP 7 (TIA Portal)	1. Insert the module from the hardware catalog under "Technology modules". 2. Set "Fast Mode" and the other module parameters in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFINET IO	1. Install the current PROFINET GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFINET IO > I/O". 2. Set the parameters in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFIBUS DP	1. Install the current PROFIBUS GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFIBUS DP > I/O". 2. Set the parameters in the hardware configuration. The parameters marked with [1] in the following tables are not configurable in the PROFIBUS GSD file. 3. Download the project to the CPU. The parameters marked with [1] in the following tables are downloaded with their default setting. 4. If necessary, set the parameters marked with [1] in the user program using data record 128.

4.4.3.1 Parameters (SSI absolute encoder)

Parameters of the TM PosInput 1 with SSI absolute encoder

The following parameter settings are possible. The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1213 Adjustable parameters (SSI absolute encoder)

Parameter	Value range	Scope
Potential group	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Reaction to CPU STOP[1]	• **Output substitute value** • Keep last value • Continue operation	Channel
Substitute value for DQ0	• **0** • 1	Channel
Substitute value for DQ1	• **0** • 1	
Enable diagnostic interrupt on wire break[2]	• **Deactivated** • Activated	Channel
Enable additional diagnostic interrupts	• **Deactivated** • Activated	Channel
Invert direction[1] (position value)	• **Deactivated** • Activated	Channel
Frame length	10...**13**...40 bits	Channel
Code type	• **Gray** • Dual	Channel
Transmission rate	• **125 kHz** • 250 kHz • 500 kHz • 1 MHz • 1.5 MHz • 2 MHz	Channel
Monoflop time[1]	• **Automatically** • 16 µs • 32 µs • 48 µs • 64 µs	Channel
Parity	• **None** • Even • Odd	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

Parameter	Value range	Scope
Bit number LSB of the position value	**0**...38	Channel
Bit number MSB of the position value	1...**12**...39	Channel
Set function of DI	**Digital input without function**	Channel
Input delay for digital inputs[1]	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel
Set output	• Between comparison value and count high limit • Between comparison value and count low limit • At comparison value for a pulse duration • **Digital output without function**	Channel
Comparison value 0[1]	**0**...33554431	Channel
Comparison value 1[1]	0...**10**...33554431	Channel
Count direction of DQ function[1]	• Up • Down • **In both directions**	Channel
Pulse duration[1]	0.1...**500.0**...6553.5 ms	Channel
Hysteresis (in increments)[1]	**0**...255	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

NOTICE

Excessive axis speed can provide wrong direction of rotation

If an axis connected to an SSI absolute encoder rotates so quickly that more than half of the value range is covered within one module cycle[1], the velocity and direction of rotation can no longer be determined correctly. As a result, the following may function incorrectly:

- DQ functions
- Feedback bit STS_DIR

[1] Non-isochronous mode: 500 µs; isochronous mode: PROFINET cycle time

4.4.3.2 Parameters (incremental or pulse encoder)

Parameters of the TM PosInput 1 with incremental or pulse encoder

The following parameter settings are possible. The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1214 Adjustable parameters (incremental or pulse encoder)

Parameter	Value range	Scope
Potential group	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Reaction to CPU STOP[1]	• **Output substitute value** • Keep last value • Continue operation	Channel
Substitute value for DQ0[1]	• **0** • 1	Channel
Substitute value for DQ1[1]	• **0** • 1	Channel
Enable diagnostic interrupt on wire break[2]	• **Deactivated** • Activated	Channel
Enable additional diagnostic interrupts	• **Deactivated** • Activated	Channel
Signal type	• Pulse (A) • **Pulse (A) and direction (B)** • Count up (A), count down (B) • Incremental encoder (A, B phase-shifted) • Incremental encoder (A, B, N)	Channel
Invert direction[1] (counter inputs)	• **Deactivated** • Activated	Channel
Signal evaluation for counter inputs	• **Single** • Double • Quadruple	Channel
Filter frequency for counter inputs[1]	• 100 Hz • 200 Hz • 500 Hz • 1 kHz • 2 kHz • 5 kHz • 10 kHz • 20 kHz • 50 kHz • 100 kHz	Channel

Parameter	Value range	Scope
	• 200 kHz • 500 kHz • **1 MHz**	
Reaction to signal N[1]	• **No reaction to signal N** • Synchronization at signal N	Channel
Interface standard	• **RS422, symmetrical** • TTL (5 V), asymmetrical	Channel
High counting limit[1]	1...**33554431**	Channel
Start value[1]	**0**...33554431	Channel
Counting low limit[1]	**0**...33554430	Channel
Reaction to violation of a counting limit	• Stop counting • **Continue counting**	Channel
Reset when counting limit is violated	• **To opposite counting limit** • To start value	Channel
Reaction to gate start	• Set to start value • **Continue with current value**	Channel
Set function of DI	• Gate start/stop (level-triggered) • Gate start (edge-triggered) • Gate stop (edge-triggered) • Synchronization • Enable synchronization at signal N • **Digital input without function**	Channel
Input delay for digital inputs[1]	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel
Select level for DI[1]	• **Active with high level** • Active with low level	Channel
Edge selection for DI[1]	• **At rising edge** • At falling edge	Channel
Frequency of synchronization[1]	• **Once** • Periodic	Channel
Count direction for synchronization	• **Up** • Down • In both directions	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

Parameter	Value range	Scope
Set output	• Between comparison value and count high limit • Between comparison value and count low limit • At comparison value for a pulse duration • Between comparison value 0 and 1 • **Digital output without function**	Channel
Comparison value 0[1]	**0**...33554431	Channel
Comparison value 1[1]	0...**10**...33554431	Channel
Count direction of DQ function[1]	• Up • Down • **In both directions**	Channel
Pulse duration[1]	0.0...**500.0**...6553.5 ms	Channel
Hysteresis (in increments)[1]	**0**...255	Channel

1 Because the number of parameters is limited to a maximum of 244 bytes per station in the PROFIBUS GSD configuration, the possible parameter assignments are limited. The parameters are preassigned default settings in the module. If your PROFIBUS master supports the "Write/read data record" function, you can set these parameters using data record 128.

2 When a GSD file is used, this diagnostic interrupt is enabled with the "Enable additional diagnostic interrupts" parameter and is then not separately configurable.

4.4.3.3 Explanation of parameters

Potential group

A potential group consists of a group of directly adjacent I/O modules within an ET 200SP station that are supplied from a common supply voltage.

A potential group begins with a light-colored BaseUnit, which feeds in the required supply voltage for all modules of the potential group. The light-colored BaseUnit interrupts the three self-configuring voltage bars P1, P2 and AUX to the neighboring module on the left.

All other I/O modules of this potential group are plugged into dark BaseUnits. They take on the potentials of the self-configuring busbars P1, P2 and AUX from the neighboring modules on the left.

A potential group ends with the dark BaseUnit, which is followed by a light BaseUnit or server module in the station configuration.

Signal type

You can select from the following signal types:

Signal type	Meaning
Incremental encoder (A, B phase-shifted)	An incremental encoder with phase-shifted A and B signals is connected.
Incremental encoder (A, B, N)	An incremental encoder with phase-shifted signals A and B and a zero signal N is connected.

Signal type	Meaning
Pulse (A) and direction (B)	A pulse encoder (signal A) with direction signal (signal B) is connected.
Pulse (A)	A pulse encoder (signal A) without direction signal is connected.
Count up (A), count down (B)	Signals for counting up (signal A) and down (signal B) are connected.
Absolute encoder (SSI)	An SSI absolute encoder with signals D and C is connected.

Invert direction (incremental or pulse encoder)

You can invert the counting direction to adapt it to the process.

The inverting of the direction is configurable and active for the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Signal evaluation

With the parameter assignment of the signal evaluation, you specify which edges of the signals are counted.

You can select from the following options:

Signal evaluation	Meaning
Single	The edges of signal A are evaluated during a low level of signal B.
Double	Each edge of signal A is evaluated.
Quadruple	Each edge of signals A and B is evaluated.

The parameter can be assigned with the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Filter frequency

By configuring the filter frequency, you suppress interferences at the counting inputs A, B and N.

The selected filter frequency is based on a pulse/break ratio of between around 40:60 and around 60:40. This results in a specific minimum pulse/break time. Signal changes with a duration shorter than the minimum pulse/break time are suppressed.

You can select from the following filter frequencies:

Filter frequency	Minimum pulse/break time
100 Hz	4.0ms
200 Hz	2.0 ms

Filter frequency	Minimum pulse/break time
500 Hz	800 µs
1 kHz	400 µs
2 kHz	200 µs
5 kHz	80 µs
10 kHz	40 µs
20 kHz	20 µs
50 kHz	8.0 µs
100 kHz	4.0 µs
200 kHz	2.0 µs
500 kHz	0.8 µs
1 MHz	0.4 µs

Reaction to signal N

You use this parameter to specify which reaction to signal N is triggered.

You can select from the following options:

Option	Meaning
No reaction to signal N	The counter is not affected by signal N.
Synchronization at signal N	The counter is set to the start value at signal N. If you select the function "Enable synchronization at signal N" for a digital input, the synchronization depends on the level at the digital input.

NOTE

You can only select the reaction to signal N if you have selected the "Incremental encoder (A, B, N)" signal type.

NOTE

If you select "Synchronization at signal N", you can choose the "Enable synchronization at signal N" function for a digital input.

Frequency of synchronization

This parameter is used to define the frequency of the following events:

- Synchronization at signal N
- Synchronization as function of a digital input

You can select from the following options:

Option	Meaning
Once	The counter is only set at the first signal N or the first configured edge of the digital input.
Periodic	The counter is set at each signal N or each configured edge of the digital input.

Count direction for synchronization

You use this parameter to specify the count direction for which the following functions are enabled:

- Synchronization at signal N
- Synchronization as function of a digital input

You can select from the following options:

Option	Meaning
In both directions	Synchronization takes place regardless of the count direction.
Up	Synchronization only takes place when the counter is counting up.
Down	Synchronization only takes place when the counter is counting down.

Interface standard

You use this parameter to specify whether the encoder supplies symmetrical signals (RS422) or asymmetrical signals (TTL).

You can select from the following options:

Interface standard	Meaning
RS422, symmetrical	The encoder supplies symmetrical signals according to the RS422 standard.
TTL (5 V), asymmetrical	The encoder supplies asymmetrical 5 V signals according to the TTL standard.

NOTE

The RS422 standard provides greater interference immunity than the TTL standard. If your incremental or pulse encoder supports the RS422- **and** TTL standards, we recommend using the RS422 standard.

High counting limit

With the parameter assignment of the high counting limit, you limit the counting range. You can enter a value up to 33554431 (2^{25}-1). You must enter a value above the counting low limit.

Counting low limit

With the parameter assignment of the counting low limit, you limit the counting range. You can enter a value starting with 0. You must enter a value below the high counting limit.

Start value

With the parameter assignment of the start value, you specify the value at which counting is begun and is to continue in the case of defined events. You must enter a value at or within the counting limits.

Reaction to violation of a counting limit

You can configure the following reaction to violation of a counting limit:

Reaction	Meaning
Stop counting	After violation of a counting limit, counting is stopped and the internal gate is closed. To restart counting, you must close and reopen the SW gate or HW gate, if necessary.
Continue counting	Counting is continued with the start value or at the opposite counting limit depending on the additional parameter assignment.

Reset when counting limit is violated

You can reset the counter when a counting limit is violated:

Reset the value	Meaning
To start value	The counter value is set to the start value.
To opposite counting limit	The counter value is set to the opposite counting limit in each case.

Reaction to gate start

You can configure the following reaction to gate start:

Reaction	Meaning
Set to start value	When the gate is opened, the counter value is set to the start value.
Continue with current value	When the gate is opened, counting is continued with the last counter value.

NOTE

The parameter is only effective when you have configured a HW gate.

Set function of DI

With the parameter assignment of a digital input, you specify which function the digital input triggers when switched.

You can select from the following options:

Function of a digital input	Meaning
Gate start/stop (level-triggered)	The level at the respective digital input opens and closes the HW gate.
Gate start (edge-triggered)	The configured edge at the respective digital input opens the HW gate.
Gate stop (edge-triggered)	The configured edge at the respective digital input closes the HW gate.
Synchronization	The configured edge at the respective digital input sets the counter to the start value.
Enable synchronization at signal N	The active level at the respective digital input enables synchronization of the counter at signal N.
Digital input without function	No technological function is assigned to the respective digital input. You can read the signal status of the digital input via the feedback interface.

NOTE

Each function, except "Digital input without function", can be used only once per counter and can no longer be selected for the other digital inputs in each case.

Input delay

You use this parameter to suppress signal noise at the digital inputs. Changes to the signal are only detected if they remain stable for longer than the configured input delay time.

NOTE

If you select the "None" or "0.05 ms" option, you must use shielded cables for connection of the digital inputs.

NOTE

You configure the input delay under "Behavior of DI0" for all digital inputs together. The input delay is also displayed under "Behavior of DI1".

Select level

You use this parameter to specify the level at which the digital input is active.

You can select from the following options:

Level	Meaning
Active with high level	The respective digital input is active when it is set.
Active with low level	The respective digital input is active when it is not set.

The parameter can be configured for the following functions of a digital input:

- Gate start/stop (level-triggered)
- Enable synchronization at signal N

Edge selection

You use this parameter to specify the edge of the digital input at which the configured function is triggered.

You can select from the following options depending on the function selected:

- At rising edge
- At falling edge

The parameter can be configured for the following functions of a digital input:

- Gate start (edge-triggered)
- Gate stop (edge-triggered)
- Synchronization

Set output

With the parameter assignment of a digital output, you specify the condition upon which the digital output switches.

You can select from the following options:

Function of a digital output	Meaning
Between comparison value and count high limit	The respective digital output is active if: Comparison value <= counter value <= high counting limit
Between comparison value and count low limit	The respective digital output is active if: Low limit <= counter value <= comparison value
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= counter value <= comparison value 1
At comparison value for a pulse duration	The respective digital output is active once for the configured time and count direction when the counter value corresponds to the comparison value.
Digital output without function	The respective digital output is set to 0 irrespective of the reaction to CPU STOP.

NOTE

You can only set the "Between comparison value 0 and 1" function for digital output DQ1 and only if you have selected the "Digital output without function" function for digital output DQ0.

Comparison value 0

With the parameter assignment of the comparison value, you specify the counter value or position value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter an integer (DINT) that is greater than or equal to the counting low limit. If you use the DQ function "Between comparison value 0 and 1", comparison value 0 must be less than comparison value 1.

Comparison value 1

With the parameter assignment of the comparison value, you specify the counter value or position value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter an integer (DINT) that is less than or equal to the high counting limit. If you use the DQ function "Between comparison value 0 and 1", comparison value 0 must be less than comparison value 1.

Count direction

You use this parameter to specify the count direction for which the selected functions is valid:

You can select from the following options:

Count direction	Meaning
In both directions	The comparison and switching of the respective digital output takes places regardless of the count direction or whether the position value increases or decreases
Up	The comparison and switching of the respective digital output only takes place when the counter counts up or the position value increases.
Down	The comparison and switching of the respective digital output only takes place when the counter counts down or the position value decreases.

The parameter can be configured for the following functions:

- Between comparison value 0 and 1
- At comparison value for a pulse duration

Pulse duration (incremental or pulse encoder)

With the parameter assignment of the pulse duration for the "At comparison value for a pulse duration" function, you specify how many milliseconds the respective digital output is active.

If you enter "0" and the counter value corresponds to the respective comparison value, the digital output is active until the next count pulse.

Pulse duration (SSI absolute encoder)

With the parameter assignment of the pulse duration for the "At comparison value for a pulse duration" function, you specify how many milliseconds the respective digital output is active.

Hysteresis (in increments)

With the parameter assignment of the hysteresis, you specify a range around the comparison values. Within the hysteresis range, the digital outputs cannot switch again before the counter value or position value has left this range.

An encoder can stop at a certain position, and slight movements can cause the counter value or position value to fluctuate around this position. If a comparison value or counting limit is within the fluctuation range and a hysteresis is not used, the associated digital output will switch on and off with corresponding frequency. The hysteresis prevents these unwanted switching actions.

Regardless of the hysteresis value, the hysteresis range ends at the low or high counting limit. If you enter "0", the hysteresis is turned off.

Invert direction (SSI absolute encoder)

You use this parameter to invert the values supplied by the SSI absolute encoder. This allows you to adapt the detected direction of the encoder to the direction of rotation of the motor.

NOTE

This parameter acts only on the range from the LSB to the MSB of the position value in the frame.

Frame length

With the parameter assignment of the frame length, you specify the number of bits of an SSI frame of the SSI absolute encoder used. You can find the frame length of your SSI absolute encoder in the data sheet of the encoder. Special bits are also included in the frame length. A parity bit does not count in the frame length.

Code type

With the parameter assignment of the code type, you specify whether the encoder supplies Dual code or Gray code.

You can select from the following options:

Code type	Meaning
Gray	The position value supplied by the SSI absolute encoder in Gray code is converted to Dual code.
Dual	The value supplied by the SSI absolute encoder is not converted.

Transmission rate

With the parameter assignment of the transmission rate, you specify the data transmission rate between the technology module and SSI absolute encoder.

The maximum transmission rate depends on the cable length and the technical specifications of the SSI absolute encoder. For additional information, refer to the description of the encoder.

Monoflop time

With the parameter assignment of the monoflop time, you specify the idle time between two SSI frames.

The configured monoflop time must be at least equal to the monoflop time of the SSI absolute encoder used. You can find this value in the technical specifications of the SSI absolute encoder.

NOTE

If you select the "Automatically" option, the monoflop time automatically adapts to the encoder used.

In isochronous mode, the "Automatically" option corresponds to a monoflop time of 64 µs. If the monoflop time of the utilized SSI absolute encoder is less than 64 µs, you can select the value of the encoder to achieve faster isochronous times.

Parity

With the parameter assignment of the parity, you specify whether the SSI absolute encoder transfers a parity bit.

If, for example, a 25-bit encoder with parity is configured, the technology module reads 26 bits. A parity error is signaled in the feedback interface using bit EXT_F.

Bit number LSB of the position value

You use this parameter to specify the bit number of the LSB (least significant bit) of the position value in the frame of the SSI absolute encoder. In this way, you limit the range in the frame that supplies the position value.

The value must be less than the bit number of the MSB of the position value. The difference between the bit numbers of the MSB and the LSB of the position value must be less than 32.

NOTE

If you have selected "Gray" as the code type, only the range from the LSB to the MSB of the position value is converted to Dual code.

Bit number MSB of the position value

You use this parameter to specify the bit number of the MSB (most significant bit) of the position value in the frame of the SSI absolute encoder. In this way, you limit the range in the frame that supplies the position value.

The value must be less than the frame length and greater than the bit number of the LSB of the position value. The difference between the bit numbers of the MSB and the LSB of the position value must be less than 32.

NOTE

If you have selected "Gray" as the code type, only the range from the LSB to the MSB of the position value is converted to Dual code.

4.4.4 Address space

Address space of the technology module

Table 2-1215 Size of input and output addresses of the TM PosInput 1 with Fast Mode

	Inputs	Outputs
Range	4 bytes	0 bytes

4.4.5 Assignment of the feedback interface

The user program receives current values and status information from the technology module by means of the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Byte offset from start address ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	LS	STS_ READY	Reserved	EXT_F	STS_DI0	STS_DIR	STS_DI1	COUNT_ VALUE
1	COUNT_VALUE: DINT: Current counter value or position value							
2								
3								

Explanations

Feedback bit/value	Explanations
LS	As a sign of life, this bit indicates through a state change (toggling) that isochronous mode is functioning and that the module has updated the feedback interface in the respective bus cycle. This bit is set to 0 in non-isochronous mode.
STS_READY	This bit indicates that the technology module supplies valid user data. The technology module has been started up and configured.
EXT_F	This bit indicates that one of the following errors has occurred at the encoder signals for the technology module: • Load voltage missing • Invalid transition of A/B signals (with incremental encoder) • RS422/TTL error • SSI encoder error or SSI frame error (with SSI absolute encoder) If you have enabled the diagnostic interrupts, the respective diagnostic interrupt is triggered in the event of encoder signal errors. For information on the meaning of the diagnostic interrupts, refer to the section Diagnostic alarms (Page 88). The bit is reset automatically as soon as an error no longer exists.
STS_DI0	This bit indicates the status of digital input DI0.
STS_DIR	This bit indicates the count direction of the last count pulse or the direction of the last position value change. 0 means: Down 1 means: Up
STS_DI1	This bit indicates the status of digital input DI1.
COUNT_VALUE	This value returns the current counter value or position value in the first 25 bits of a DINT value.
Reserved	Reserved bits are set to 0.

4.4.6 Isochronous mode

The technology module supports the "Isochronous mode" system function. Position and counter values can be acquired in a fixed system cycle with this system function.

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized. The output signals switch immediately if the relevant comparison condition is met. A status change of a digital input immediately triggers the specified reaction of the technology module and the change of the status bit of the digital input in the feedback interface.

This operating mode is especially well-suited for short send clocks of the CPU starting from 125 µs, because only input data is used.

Use an OB of type "Synchronous Cycle" (e.g. OB61) in this operating mode.

Data processing

At the time the input data is read in (T_i), the position or counter value as well as status bits are acquired and made available in the feedback interface for retrieval in the current bus cycle.

Isochronous mode parameters

In isochronous mode, the following parameter can affect the isochronous mode parameters of the sync domain.

- Filter frequency
- Frame length
- Transmission rate
- Monoflop time
- Parity

Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change one or more of the indicated parameters in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

Additional information

You can find a detailed description of isochronous mode in the following:

- In the Isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- Function manual PROFINET with STEP 7 available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856)

Interrupts/diagnostic messages 5

5.1 Status and error display

LEDs

The following figure shows you the LED displays (status and error displays) of TM PosInput .

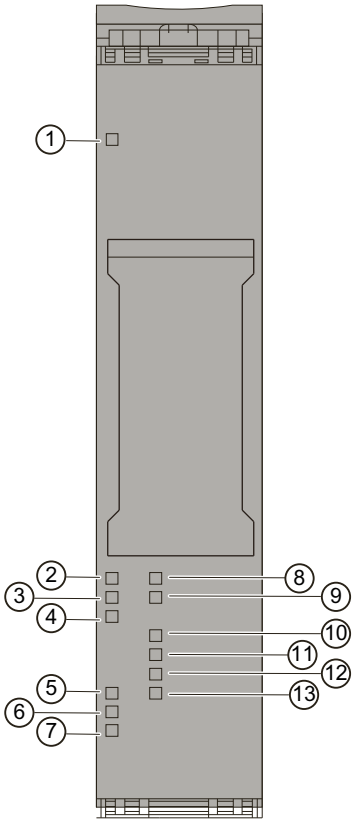

①	DIAG (green/red)	⑧	Status DI0 (green)
②	Status A/D (green)	⑨	Status DI1 (green)
③	Status B/C (green)	⑩	Status DQ0 (green)
④	Status N (green)	⑪	Status DQ1 (green)
⑤	5 V DC (green)	⑫	Status UP (green)
⑥	24 V DC (green)	⑬	Status DN (green)
⑦	PWR (green)		

Figure 2-1076 LED displays of the TM PosInput 1

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in section Diagnostic alarms (Page 88).

Table 2-1216 Status and error displays DIAG

LED DIAG	Meaning	Remedy
☐ Off	Backplane bus supply of the ET 200SP not OK	Check or switch on the supply voltage on the CPU or on the interface module.
☼ Flashes	Technology module parameters not set	---
■ On	Technology module parameters set and no module diagnostics	
☼ Flashes	Technology module parameters set and module diagnostics (at least one error is present)	Evaluate the diagnostic alarms and eliminate the error.

Table 2-1217 PWR/24VDC/5VDC status displays

LEDs		Meaning	Remedy
PWR	24VDC/ 5VDC		
☐ Off	☐ Off	Supply voltage missing	• Check the supply voltage. • Check the BaseUnit type and the wiring of the BaseUnit.
■ On	■ On	Supply voltage is present and OK. Sensor supply is OK.	---
■ On	☐ Off	Short-circuit or overload at the sensor supply	• Check the encoder wiring. • Check the loads connected to the encoder supply.

Channel LEDs

The A, B, N and DIm LEDs indicate the current level of the associated signals. The LEDs of the DQm digital outputs indicate the desired state.

The flashing frequency of the channel LEDs is limited to approximately 12 Hz. If higher frequencies are present, the channel LEDs will flash at 12 Hz instead of indicating the current status.

If you are using an SSI absolute encoder, the LEDs D and C light up green during the transmission of encoder frames. The LEDs D and C are off when an error has occurred.

Table 2-1218 Status displays A/B/N/DIm/DQm

LEDs A/B/N/DIm/DQm	Meaning
☐ Off	Counter input/digital input/digital output at 0 level
■ On	Counter input/digital input/digital output at 1 level

Table 2-1219 Status displays UP/DN

LEDs		Meaning
UP	DN	
□ Off	□ Off	No count pulse has been detected for the last 0.5 s.
■ On	□ Off	The last count pulse has incremented the counter and took place no more than 0.5 s ago.
□ Off	■ On	The last count pulse has decremented the counter and took place no more than 0.5 s ago.

5.2 Diagnostic alarms

Enabling of diagnostic interrupts

You enable the diagnostic interrupts in the device configuration with the basic parameters.

The technology module can trigger the following diagnostic interrupts:

Table 2-1220 Possible diagnostic interrupts

Diagnostic interrupt	Monitoring
• Parameter error • Hardware interrupt lost[1] • Channel/component temporarily unavailable • Error	Monitoring is always active. A diagnostic interrupt is triggered each time an error is detected.
• RS422/TTL error	Monitoring is always active. When an error is detected, a diagnostic interrupt is only triggered if "Enable diagnostic interrupt on wire break" is activated in the device configuration.
• Load voltage missing • Short-circuit / overload at external encoder supply • Error at digital outputs • SSI encoder error • Invalid transition of A/B signals	Monitoring is always active. When an error is detected, a diagnostic interrupt is only triggered if "Enable additional diagnostic interrupts" is activated in the device configuration.

[1] Not available in "Position input for "Motion Control"" technology object" and "Fast Mode" operating modes

Reactions to a diagnostic interrupt

The following happens when an event occurs that triggers a diagnostic interrupt:

- The DIAG LED flashes red.

  When you have eliminated all errors, the DIAG LED stops flashing red and turns green.
- The S7-1500 CPU interrupts the processing of the user program. The diagnostic interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.
- The S7-1500 CPU remains in RUN even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible despite the error.

You can obtain detailed information on the error event in the error organization block with instruction "RALRM" (Read additional alarm information), in the information system of STEP 7

and in function manual Diagnostics (https://support.industry.siemens.com/cs/ww/en/view/59192926), section "System diagnostics in user program".

If the module is being operated as a distributed module in an ET 200SP system with PROFIBUS DP, you have the option of reading out diagnostic data with the RDREC or RD_REC instruction using data record 0 and 1. You can find the structure of the data records in the manual for the IM 155-6 DP HF interface module available for download on the Internet (https://support.industry.siemens.com/cs/ww/de/view/73098660).

Diagnostic alarms

The display of diagnostics is in plain text in STEP 7 (TIA Portal) in the online and diagnostics view. You can evaluate the error codes with the user program.

The following diagnostics can be signaled:

Table 2-1221 Diagnostic alarms, their meaning and remedies

Diagnostic alarm	Error code	Meaning	Remedy
Error	9_H	• Internal module error occurred • Possible cause: – Firmware update was aborted – Technology module defective	• Repeat firmware update • Replace technology module
Parameter error	10_H	• The received parameter data record is invalid • The configured BaseUnit is not the BaseUnit being used	• Check parameter data record • Check BaseUnit
Load voltage missing	11_H	• Missing or insufficient supply voltage L+ • Wiring of supply voltage L+ faulty • Possible cause: BaseUnit type incorrect	• Check BaseUnit type • Check supply voltage L+ at the BaseUnit • Check wiring of supply voltage L+ • Check total consumption of the load group
Hardware interrupt lost	16_H	• Module cannot issue interrupt because a preceding interrupt has not yet been processed • Possible cause: Too many hardware interrupts in too short a time	• Change interrupt processing in the CPU and re-assign technology module parameters correspondingly • Check frequency of interrupts from the process
Channel/component temporarily unavailable	$1F_H$	Firmware update in progress or update was aborted. The module reads no process values in this state.	• Wait for firmware update • If firmware update aborts: – Check minimum firmware version required – Check supply voltage – Repeat firmware update
Short-circuit / overload at external encoder supply	$10E_H$	• Error at encoder supply • Possible causes: – Short circuit – Overload	• Check encoder wiring • Check consumers connected to encoder supply
Error at digital outputs	$10F_H$	• Error at the digital outputs • Possible causes: – Short circuit – Overload	• Check wiring at the digital outputs • Check consumers connected to the digital outputs

Diagnostic alarm	Error code	Meaning	Remedy
Invalid transition of A/B signals	500_H	• Time profile of signals A and B of the incremental encoder does not meet certain requirements (relative phase shift of the two signals is too small) • Possible causes: – Signal frequency too high – Encoder faulty – Process wiring faulty	• Check process wiring • Check encoder/sensor • Check parameter assignment
RS422/TTL error	502_H	• Error at connection of the RS 422, TTL encoder or SSI absolute encoder • Possible causes: – Wire break – No encoder connected – Cable too long – Short circuit – Overload – External voltage – Overtemperature – Parameter assignment error	• Check process wiring • Check encoder/sensor • Check parameter assignment
SSI encoder error	503_H	• Error at SSI absolute encoder connection • Possible causes: – Wire break – Cable too long – Frame error (error of the start bit or stop bit) – Parity error – Parameter assignment error	• Check process wiring • Check SSI absolute encoder • Check parameter assignment

5.3 Hardware interrupts

Introduction

For the technology module, you can configure which events are to trigger a hardware interrupt during operation.

What is a hardware interrupt?

The technology module will trigger a hardware interrupt as configured in response to specific events/states. When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the assigned hardware interrupt OB. The event that triggered the interrupt is entered in the start information of the assigned hardware interrupt OB by the CPU.

Lost hardware interrupt

If an event occurs that is to trigger a hardware interrupt and the preceding event has not yet been processed, another hardware interrupt cannot be triggered. The hardware interrupt is lost and the diagnostic interrupt "Lost hardware interrupt" is triggered.

Enabling of hardware interrupts

A hardware interrupt is triggered when the condition for the change of the respective status or event bit in the feedback interface is met.

You enable the hardware interrupts in the device configuration with the basic parameters. You can configure hardware interrupts to be triggered for the following event types:

- Opening of internal gate (gate start)[1]
- Closing of internal gate (gate stop)[1]
- Overflow (counting high limit violated)[1]
- Underflow (counting low limit violated)[1]
- Comparison event for DQ0 has occurred
- Comparison event for DQ1 has occurred
- Zero crossing[4]
- New Capture value available[2]
- Synchronization of the counter by an external signal[1]
- Direction reversal[3]

[1] Not for SSI absolute encoder

[2] Only configurable in Counting / Position input operating mode

[3] Feedback bit STS_DIR is preassigned with "0". If the first counter value change occurs in the *downwards direction* directly after switching on the technology module, no hardware interrupt is triggered.

[4] When the hardware interrupt is enabled, for system-related reasons it can also be triggered if "0" is outside the configured value range.

You can activate any combination of events to trigger hardware interrupts.

You can obtain detailed information on the event in the hardware interrupt organization block with instruction "RALRM" (Read additional alarm information) and in the information system of STEP 7.

Which event has triggered the hardware interrupt is entered in the start information of the organization block. The following figure shows the assignment to the bits of the local data double word 8.

LB 8								LB 9								LB 10								LB 11							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	X	0	0	0	0	X	X	X	X

Bit no.
LD 8

User Structure Identifier (USI)

Event that triggered the hardware interrupt (EventType):

- 0001_B: Gate start
- 0010_B: Gate stop
- 0011_B: Overflow
- 0100_B: Underflow
- 0101_B: Comparison event for DQ0
- 0110_B: Comparison event for DQ1 occurred
- 0111_B: Zero crossing
- 1000_B: New capture value available
- 1001_B: Synchronization
- 1010_B: Direction reversal

Channel that triggered the hardware interrupt (IChannel):
0_B: Channel 0 of the technology module

Figure 2-1077 Start information of the organization block

Technical specifications

6

Article number	6ES7138-6BA01-0BA0
General information	
Product type designation	TM PosInput 1
Firmware version	V2.0
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V16 or higher
• STEP 7 configurable/integrated from version	V5.6 (use previous version *6BA00*)
• PROFIBUS from GSD version/GSD revision	GSD Revision 5
• PROFINET from GSD version/GSD revision	GSDML V2.34
Supply voltage	
Load voltage L+	
• Rated value (DC)	24 V
• permissible range, lower limit (DC)	19.2 V
• permissible range, upper limit (DC)	28.8 V
• Reverse polarity protection	Yes
Input current	
Current consumption, max.	75 mA; without load
Encoder supply	
Number of outputs	2
5 V encoder supply	
• 5 V	Yes
• Short-circuit protection	Yes; electronic/thermal
• Output current, max.	300 mA; Total current of all encoders
24 V encoder supply	
• 24 V	Yes; L+ (-0.8 V)
• Short-circuit protection	Yes; electronic/thermal
• Output current, max.	300 mA; Total current of all encoders

Article number	6ES7138-6BA01-0BA0
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
• Inputs	16 byte; 4 bytes in Fast mode
• Outputs	12 byte; 4 bytes for Motion Control, 0 bytes for Fast mode
Hardware configuration	
Automatic encoding	
• Type of mechanical coding element	type B
Digital inputs	
Number of digital inputs	2
Digital inputs, parameterizable	Yes
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Digital input functions, parameterizable	
• Gate start/stop	Yes; only for pulse and incremental encoders
• Capture	Yes
• Synchronization	Yes; only for pulse and incremental encoders
• Freely usable digital input	Yes
Input voltage	
• Rated value (DC)	24 V
• for signal "0"	-5 ... +5 V
• for signal "1"	+11 to +30V
• permissible voltage at input, min.	-30 V; -5 V continuous, -30 V brief reverse polarity protection
• permissible voltage at input, max.	30 V
Input current	
• for signal "1", typ.	2.5 mA
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms
– at "0" to "1", min.	6 µs; for parameterization "none"
– at "1" to "0", min.	6 µs; for parameterization "none"
for technological functions	
– parameterizable	Yes
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m

Article number	6ES7138-6BA01-0BA0
Digital outputs	
Type of digital output	Transistor
Number of digital outputs	2
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes; electronic/thermal
• Response threshold, typ.	1 A
Limitation of inductive shutdown voltage to	L+ (-53 V)
Controlling a digital input	Yes
Digital output functions, parameterizable	
• Switching tripped by comparison values	Yes
• Freely usable digital output	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A; Per digital output
• on lamp load, max.	5 W
Load resistance range	
• lower limit	48 Ω
• upper limit	12 kΩ
Output voltage	
• for signal "1", min.	23.2 V; L+ (-0.8 V)
Output current	
• for signal "1" rated value	0.5 A; Per digital output
• for signal "1" permissible range, max.	0.6 A; Per digital output
• for signal "1" minimum load current	2 mA
• for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
• "0" to "1", max.	50 µs
• "1" to "0", max.	50 µs
Switching frequency	
• with resistive load, max.	10 kHz
• with inductive load, max.	0.5 Hz; Acc. to IEC 60947-5-1, DC-13; observe derating curve
• on lamp load, max.	10 Hz
Total current of the outputs	
• Current per module, max.	1 A
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Encoder signals, incremental encoder (symmetrical)	
• Input voltage	RS 422

Article number	6ES7138-6BA01-0BA0
• Input frequency, max.	1 MHz
• Counting frequency, max.	4 MHz; with quadruple evaluation
• Cable length, shielded, max.	32 m; at 1 MHz
• Signal filter, parameterizable	Yes
• Incremental encoder with A/B tracks, 90° phase offset	Yes
• Incremental encoder with A/B tracks, 90° phase offset and zero track	Yes
• Pulse encoder	Yes
• Pulse encoder with direction	Yes
• Pulse encoder with one impulse signal per count direction	Yes
Encoder signals, incremental encoder (asymmetrical)	
• Input voltage	5 V TTL (push-pull encoders only)
• Input frequency, max.	1 MHz
• Counting frequency, max.	4 MHz; with quadruple evaluation
• Signal filter, parameterizable	Yes
• Incremental encoder with A/B tracks, 90° phase offset	Yes
• Incremental encoder with A/B tracks, 90° phase offset and zero track	Yes
• Pulse encoder	Yes
• Pulse encoder with direction	Yes
• Pulse encoder with one impulse signal per count direction	Yes
Encoder signals, absolute encoder (SSI)	
• Input signal	to RS-422
• Telegram length, parameterizable	10 ... 40 bit
• Clock frequency, max.	2 MHz; 125 kHz, 250 kHz, 500 kHz, 1 MHz, 1.5 MHz or 2 MHz
• Binary code	Yes
• Gray code	Yes
• Cable length, shielded, max.	320 m; Cable length, RS-422 SSI absolute encoders, Siemens type 6FX2001-5, 24 V supply: 125 kHz, 320 meters shielded, max.; 250 kHz, 160 meters shielded, max.; 500 kHz, 60 meters shielded, max.; 1 MHz, 20 meters shielded, max. 1.5 MHz, 10 meters shielded, max.; 2 MHz, 8 meters shielded, max.
• Parity bit, parameterizable	Yes
• Monoflop time	16, 32, 48, 64 µs & automatic
• Multiturn	Yes

Article number	6ES7138-6BA01-0BA0
• Singleturn	Yes
Interface types	
• TTL 5 V	Yes; push-pull encoders only
• RS 422	Yes
Interrupts/diagnostics/status information	
Substitute values connectable	Yes; Parameterizable
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	Yes
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• A/B transition error at incremental encoder	Yes
• Telegram error at SSI encoder	Yes
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for module diagnostics	Yes; green/red DIAG LED
• Status indicator forward counting (green)	Yes
• Status indicator backward counting (green)	Yes
Integrated Functions	
Number of counters	1
Counting frequency (counter) max.	4 MHz; with quadruple evaluation
Fast mode	Yes
Counting functions	
• Can be used with TO High_Speed_Counter	Yes; only for pulse and incremental encoders
• Continuous counting	Yes
• Counter response parameterizable	Yes
• Hardware gate via digital input	Yes
• Software gate	Yes
• Event-controlled stop	Yes
• Synchronization via digital input	Yes
• Counting range, parameterizable	Yes
Comparator	
– Number of comparators	2

Article number	6ES7138-6BA01-0BA0
– Direction dependency	Yes
– Can be changed from user program	Yes
Position detection	
• Incremental acquisition	Yes
• Absolute acquisition	Yes
• Suitable for S7-1500 Motion Control	Yes
Measuring functions	
• Measuring time, parameterizable	Yes
• Dynamic measurement period adjustment	Yes
• Number of thresholds, parameterizable	2
Measuring range	
– Frequency measurement, min.	0.04 Hz
– Frequency measurement, max.	4 MHz
– Cycle duration measurement, min.	0.25 µs
– Cycle duration measurement, max.	25 s
Accuracy	
– Frequency measurement	100 ppm; depending on measuring interval and signal evaluation
– Cycle duration measurement	100 ppm; depending on measuring interval and signal evaluation
– Velocity measurement	100 ppm; depending on measuring interval and signal evaluation
Potential separation	
Potential separation channels	
• between the channels and backplane bus	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C; Observe derating
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C; Observe derating
• ceiling installation, min.	-30 °C
• ceiling installation, max.	50 °C; Observe derating
• floor installation, min.	-30 °C
• floor installation, max.	50 °C; Observe derating
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual

Article number	6ES7138-6BA01-0BA0
Decentralized operation	
to SIMATIC S7-300	Yes
to SIMATIC S7-400	Yes
to SIMATIC S7-1200	Yes
to SIMATIC S7-1500	Yes
to standard PROFIBUS master	Yes
to standard PROFINET controller	Yes
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	45 g

NOTE

Installation heights > 2000 m

You can find information on the restrictions when using the ET 200SP distributed I/O system at more than 2000 m above sea level in the "Mechanical and climatic environmental conditions" section of the ET 200SP Distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Derating information for the 5 V sensor supply

When encoders are supplied by the 5 V sensor supply of the TM PosInput 1 , derating of the output current of the encoder supply must be taken into consideration. The following derating curve shows the load capacity of the 5 V sensor supply depending on the ambient temperature and mounting position:

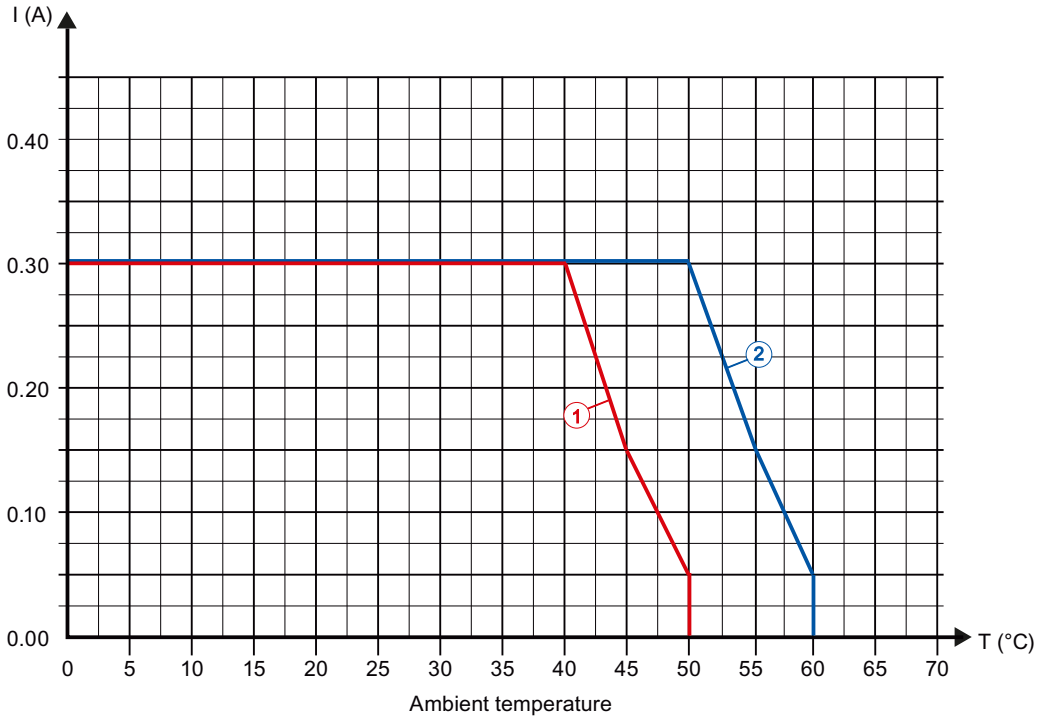

① Non-horizontal installation of the system

② Horizontal installation of the system

Figure 2-1078 Output current depending on ambient temperature and mounting position

Derating information for total current of digital outputs

If the digital outputs of the TM PosInput 1 are operated with resistive or inductive loads, you should derate the total current of the loads at the digital outputs of the technology module. The total current is the sum of the load currents at all digital outputs of the module (without encoder supply).

The following derating curve shows the load capacity of the digital outputs depending on the ambient temperature and mounting position under the following conditions:

- Load resistance: 48 Ω (IEC 947-5-1)

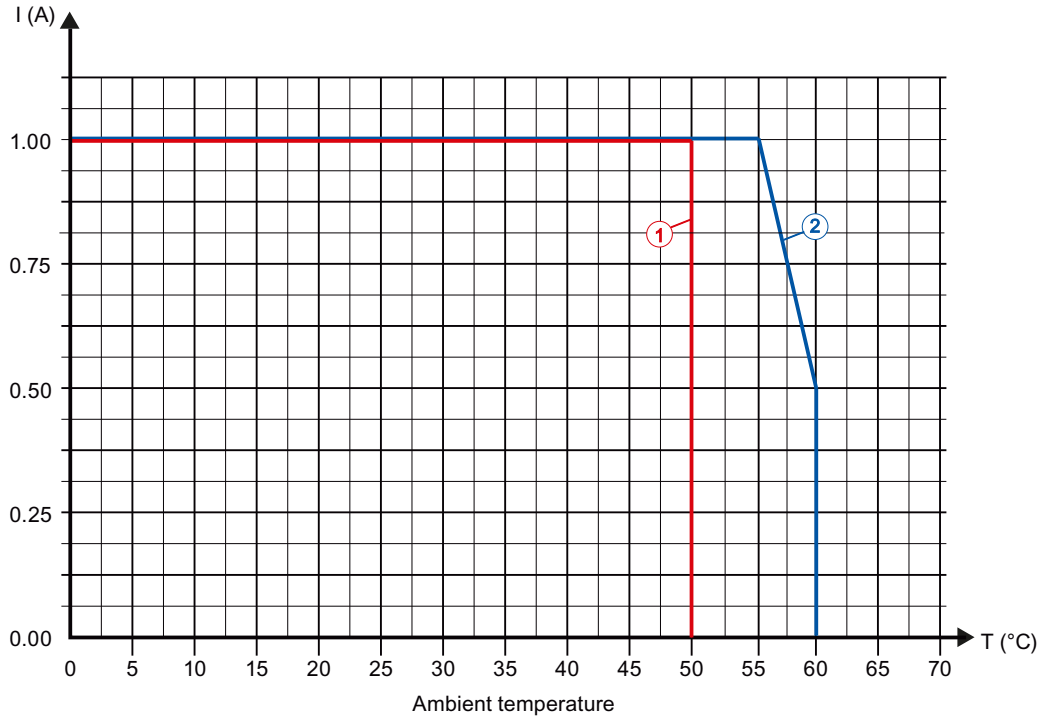

① Non-horizontal installation of the system

② Horizontal installation of the system

Figure 2-1079 Total current depending on ambient temperature and mounting position for resistive loads

The following derating curve shows the load capacity of the digital outputs depending on the ambient temperature and mounting position under the following conditions:

- Maximum switching frequency at digital outputs of 0.5 Hz
- Load resistance: 48 Ω (IEC 947-5-1)
- Load inductance: 1150 mH (IEC 947-5-1)

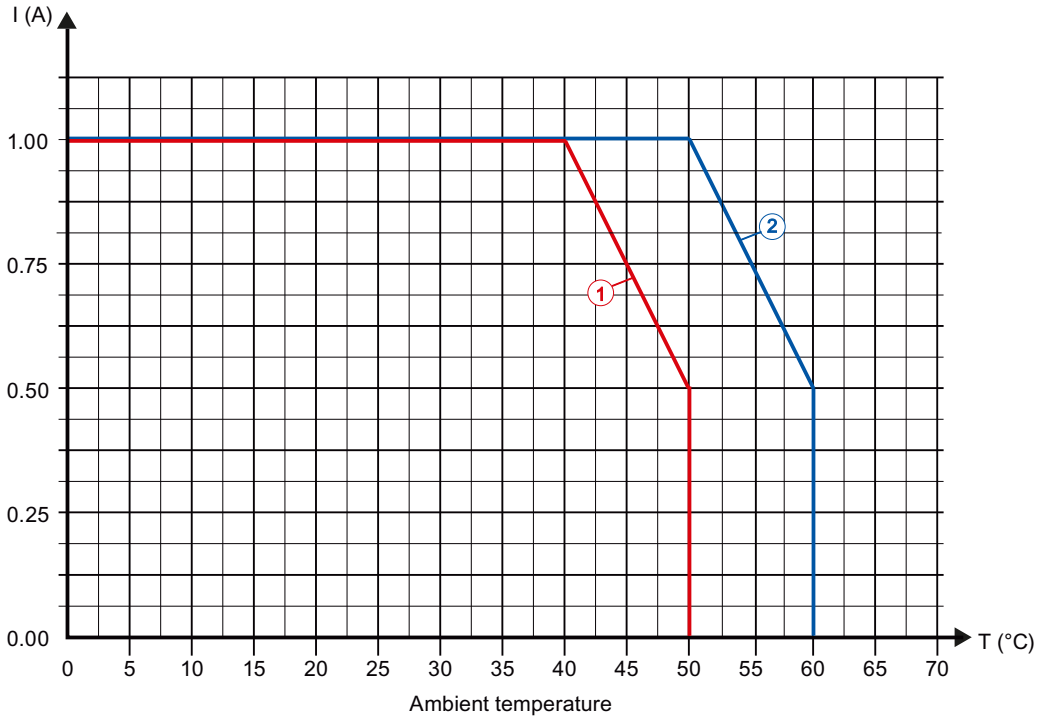

① Non-horizontal installation of the system

② Horizontal installation of the system

Figure 2-1080 Total current depending on ambient temperature and mounting position for inductive loads

NOTE

If the switching frequency is greater than 0.5 Hz or there is greater inductance at the digital outputs, the total current must be reduced further.

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

Parameter data record

A

A.1 Parameter assignment and structure of parameter data record

You have the option of reassigning module parameters with the user program while the CPU is in RUN. The parameters are transferred to the module using data record 128, e.g. with the WRREC instruction.

If an error occurs while transferring or validating parameters with the WRREC instruction, the module continues operating with the existing parameter assignment. A corresponding error code is then written to the STATUS output parameter. If no errors occur, the STATUS output parameter contains the length of the actually transferred data.

You can find a description of the WRREC instruction and the error codes in section Parameter validation error (Page 113) or in the online help of STEP 7 (TIA Portal).

Structure of data record 128 for operation with technology object and manual operation

The following table shows you the structure of data record 128 for TM PosInput 1 for operation with technology object and manual operation without technology object. The values in byte 0 to byte 3 are fixed and must not be changed. The value in byte 4 can only be changed by means of new parameter assignment and not in RUN mode of the CPU.

NOTE

After each writing of data record 128, the module is set to its startup state and the counter value is set to the start value. If "Continue operation" is set for Reaction to CPU STOP, the module is then only set to its startup state when data record 128 has been changed.

Table 2-1222 Data record 128: Operating modes "Operating with "Counting and measurement" technology object", "Manual operation (without technology object)"

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	**Header**							
0	Major Version = 0				Minor Version = 2			
1	Length of the parameter data per channel = 48							
2	Reserved[2]							
3	Reserved[2]							
4	**Operating mode**							

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 For signal type "Absolute encoder (SSI)", the following applies: Reserved[2]

4 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

5 Applies to: Set function of DI = 001_B; 010_B; 011_B; 101_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
4	Reserved[2]				Operating mode:			
					0000_B: Not permitted			
					0001_B: Counting / Position input			
					0010_B: Measuring			
					0011 to 1111_B: Not permitted			
5	**Basic parameters**							
5	Interface standard:	Reserved[2]				Enable additional diagnostic interrupts[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Keep last value	
	0_B: RS422, symmetrical						10_B: Continue operation	
	1_B: TTL (5 V), asymmetrical						11_B: Not permitted	
6...7	**Counter inputs** (parameters for incremental and pulse encoders)							
6	Reserved[2]		Signal evaluation:		Signal type:			
			00_B: Single		0000_B: Pulse (A)			
			01_B: Double		0001_B: Pulse (A) and direction (B)			
			10_B: Quadruple		0010_B: Count up (A), count down (B)			
			11_B: Not permitted		0011_B: Incremental encoder (A, B phase-shifted)			
					0100_B: Incremental encoder (A, B, N)			
					0101_B: Absolute encoder (SSI)			
					0110 to 1111_B: Not permitted			
7	Reaction to signal N:		Invert direction[1]	Enable diagnostic interrupt on wire break[1]	Filter frequency[4]:			
	00_B: No reaction to signal N				0000_B: 100 Hz			
	01_B: Synchronization at signal N				0001_B: 200 Hz			
	10_B: Capture at signal N				0010_B: 500 Hz			
	11_B: Not permitted				0011_B: 1 kHz			
					0100_B: 2 kHz			
					0101_B: 5 kHz			
					0110_B: 10 kHz			
					0111_B: 20 kHz			
					1000_B: 50 kHz			

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 For signal type "Absolute encoder (SSI)", the following applies: Reserved[2]

4 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

5 Applies to: Set function of DI = 001_B; 010_B; 011_B; 101_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
7			Invert direction[1]	Enable diagnostic interrupt on wire break[1]	1001_B: 100 kHz			
					1010_B: 200 kHz			
					1011_B: 500 kHz			
					1100_B: 1 MHz			
					1101 to 1111_B: Not permitted			
6...7	**Counter inputs** (parameters for SSI absolute encoder)							
6	Monoflop time[4]:			Code type:	Signal type:			
	000_B: Automatically			0_B: Gray	0000_B: Pulse (A)			
	001_B: 16 µs			1_B: Dual	0001_B: Pulse (A) and direction (B)			
	010_B: 32 µs				0010_B: Count up (A), count down (B)			
	011_B: 48 µs				0011_B: Incremental encoder (A, B phase-shifted)			
	100_B: 64 µs				0100_B: Incremental encoder (A, B, N)			
	101 to 111_B: Not permitted				0101_B: Absolute encoder (SSI)			
					0110 to 1111_B: Not permitted			
7	Parity[4]:		Invert direction[1]	Enable diagnostic interrupt on wire break[1]	Reserved[2]	Transmission rate[4]:		
	00_B: None					000_B: 125 kHz		
	01_B: Even					001_B: 250 kHz		
	10_B: Odd					010_B: 500 kHz		
	11_B: Not permitted					011_B: 1 MHz		
						100_B: 1.5 MHz		
						101_B: 2 MHz		
						110 to 111_B: Not permitted		
8...9	**Hardware interrupts**[1]							
8	Reserved[2]	Reserved[2]	Reserved[2]	Change of direction	Underflow (low counting limit violated)	Overflow (high counting limit violated)	Gate stop[3]	Gate start[3]
9	Synchronization of the counter by an external signal[3)]	New Capture value available	Reserved[2]	Zero crossing	Reserved[2]	Comparison event for DQ1 has occurred	Reserved[2]	Comparison event for DQ0 has occurred
10...15	**Behavior of a DQ**							
10	Set output (DQ1):				Set output (DQ0):			

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 For signal type "Absolute encoder (SSI)", the following applies: Reserved[2]

4 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

5 Applies to: Set function of DI = 001_B; 010_B; 011_B; 101_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
10	0000_B: Use by user program				0000_B: Use by user program			
	0001_B: Between comparison value and count high limit; Measuring: Measured value >= comparison value				0001_B: Between comparison value and count high limit; Measuring: Measured value >= comparison value			
	0010_B: Between comparison value and count low limit; Measuring: Measured value <= comparison value				0010_B: Between comparison value and count low limit; Measuring: Measured value <= comparison value			
	0011_B: At comparison value for a pulse duration				0011_B: At comparison value for a pulse duration			
	0100_B: Between comparison value 0 and 1				0100_B: Not permitted			
	0101_B: After set command from CPU until comparison value				0101_B: After set command from CPU until comparison value			
	0110_B: Not between comparison value 0 and 1				0110 to 1111_B: Not permitted			
	0111 to 1111_B: Not permitted							
11	Count direction (DQ1):		Count direction (DQ0):		Reserved[2]	Reserved[2]	Substitute value for DQ1	Substitute value for DQ0
	00_B: Not permitted		00_B: Not permitted					
	01_B: Up		01_B: Up					
	10_B: Down		10_B: Down					
	11_B: In both directions		11_B: In both directions					
12	Pulse duration (DQ0): Incremental and pulse encoder: UINT: Value range in ms/10: 0 to 65535_D SSI absolute encoder: UINT: Value range in ms/10: 1 to 65535_D							
13								
14	Pulse duration (DQ1): Incremental and pulse encoder: UINT: Value range in ms/10: 0 to 65535_D SSI absolute encoder: UINT: Value range in ms/10: 1 to 65535_D							
15								
16	**Behavior of DI0**							
16	Behavior of counter value after Capture[3] (DI0):	Edge selection (DI0):		Select level (DI0):	Reserved[2]	Set function of DI (DI0):		
		00_B: Not permitted[5]				000_B: Gate start/stop (level-triggered)[3]		
		01_B: At rising edge		0_B: Active with high level		001_B: Gate start (edge-triggered)[3]		
		10_B: At falling edge				010_B: Gate stop (edge-triggered)[3]		
	0_B: Continue counting	11_B: At rising and falling edge		1_B: Active with low level		011_B: Synchronization[3]		
						100_B: Enable synchronization at signal N[3]		
	1_B: Set to start value and continue counting					101_B: Capture		
						110_B: Digital input without function		
						111_B: Not permitted		
17	**Behavior of DI1**: See Byte 16							

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 For signal type "Absolute encoder (SSI)", the following applies: Reserved[2]

4 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

5 Applies to: Set function of DI = 001_B; 010_B; 011_B; 101_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
18	Reserved[2]							
19	Frequency of synchronization:	Reserved[2]		Frequency of Capture function:	Input delay:			
					0000_B: None			
					0001_B: 0.05 ms			
	0_B: Once			0_B: Once	0010_B: 0.1 ms			
					0011_B: 0.4 ms			
	1_B: Periodic			1_B: Periodic	0100_B: 0.8 ms			
					0101_B: 1.6 ms			
					0110_B: 3.2 ms			
					0111_B: 12.8 ms			
					1000_B: 20 ms			
					1001 to 1111_B: Not permitted			
20...43	**Values**							
20...23	High counting limit[3]: DINT: Value range: –2147483647 to 2147483647_D or –7FFFFFFF to $7FFFFFFF_H$							
24...27	Comparison value 0: Counting operating mode: DINT: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$; Measuring operating mode: REAL: Floating point number in the configured unit of the measured variable							
28...31	Comparison value 1: Counting operating mode: DINT: Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$; Measuring operating mode: REAL: Floating point number in the configured unit of the measured variable							
32...35	Start value[3]: DINT: Value range: –2147483648 to 2147483647_D or– 80000000 to $7FFFFFFF_H$							
36...39	Counting low limit[3] DINT: Value range: –2147483648 to 2147483646_D or 80000000 to $7FFFFFFE_H$							
40...43	Update time: DINT: Value range in µs: 0 to 25000000_D							
44	**Counter behavior at limits and gate start**							
44	Behavior at gate start[3]:		Reaction to violation of a counting limit[3]:			Reset when counting limit is violated[3]:		
	00_B: Set to start value		000_B: Stop counting			000_B: To opposite counting limit		
	01_B: Continue with current value		001_B: Continue counting			001_B: To start value		
	10 to 11_B: Not permitted		010 to 111_B: Not permitted			010 to 111_B: Not permitted		
45	**Specify measured value**							
45	Reserved[2]			Time base for velocity measurement:			Measured variable:	

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 For signal type "Absolute encoder (SSI)", the following applies: Reserved[2]

4 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

5 Applies to: Set function of DI = 001_B; 010_B; 011_B; 101_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
45	Reserved[2]			000_B: 1 ms			00_B: Frequency	
				001_B: 10 ms			01_B: Period	
				010_B: 100 ms			10_B: Velocity	
				011_B: 1 s			11_B: Complete SSI frame	
				100_B: 60 s/1 min				
				101 to 111_B: Not permitted				
46 / **47**	Increments per unit: UINT: Value range: 1 to 65535_D							
48	Set hysteresis range: Value range: 0 to 255_D							
49...51	**Parameters for SSI absolute encoder**							
49	Reserved[2]		Frame length[4]: 10 to 40_D: Value range					
50	Reserved[2]		Bit number LSB of the position value: 0 to 38_D: Value range					
51	Reserved[2]		Bit number MSB of the position value: 0 to 39_D: Value range					

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0

3 For signal type "Absolute encoder (SSI)", the following applies: Reserved[2]

4 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

5 Applies to: Set function of DI = 001_B; 010_B; 011_B; 101_B

Structure of the data record 128 in Fast Mode

The following table shows you the structure of data record 128 for TM PosInput 1 for Fast Mode. The values in byte 0 to byte 3 are fixed and must not be changed.

Table 2-1223 Parameter data record 128: Fast Mode operating mode

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	**Header**							
0	Major Version = 0				Minor Version = 2			

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

3 For signal type "Absolute encoder (SSI)", the following applies: Reserved[2]

4 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

5 Applies to: Set function of DI = 001_B; 010_B; 011_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
1	Length of the parameter data per channel = 48							
2	Reserved[2]							
3	Reserved[2]							
4	**Operating mode**							
4	Reserved[2]				Operating mode:			
					0000_B: Not permitted			
					0001_B: Counting / Position input			
					0010 to 1111_B: Not permitted			
5	**Basic parameters**							
5	Interface standard:	Reserved[2]				Enable additional diagnostic interrupts[1)]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Keep last value	
	0_B: RS422, symmetrical						10_B: Continue operation	
	1_B: TTL (5 V), asymmetrical						11_B: Not permitted	
6...7	**Counter inputs** (parameters for incremental and pulse encoders)							
6	Reserved[2]		Signal evaluation:		Signal type:			
			00_B: Single		0000_B: Pulse (A)			
			01_B: Double		0001_B: Pulse (A) and direction (B)			
			10_B: Quadruple		0010_B: Count up (A), count down (B)			
			11_B: Not permitted		0011_B: Incremental encoder (A, B phase-shifted)			
					0100_B: Incremental encoder (A, B, N)			
					0101_B: Absolute encoder (SSI)			
					0110 to 1111_B: Not permitted			
7	Reaction to signal N:		Invert direction[1]	Enable diagnostic interrupt on wire break[1]	Filter frequency[4]:			
	00_B: No reaction to signal N				0000_B: 100 Hz			
	01_B: Synchronization at signal N				0001_B: 200 Hz			
	10 to 11_B: Not permitted				0011_B: 1 kHz			
					0100_B: 2 kHz			
					0101_B: 5 kHz			
					0110_B: 10 kHz			

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

3 For signal type "Absolute encoder (SSI)", the following applies: Reserved[2]

4 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

5 Applies to: Set function of DI = 001_B; 010_B; 011_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
7			Invert direction[1]	Enable diagnostic interrupt on wire break[1]	0111_B: 20 kHz			
					1000_B: 50 kHz			
					1001_B: 100 kHz			
					1010_B: 200 kHz			
					1011_B: 500 kHz			
					1100_B: 1 MHz			
					1101 to 1111_B: Not permitted			
6...7	**Counter inputs** (parameters for SSI absolute encoder)							
6	Monoflop time[4]:			Code type:	Signal type:			
	000_B: Automatically			0_B: Gray	0000_B: Pulse (A)			
	001_B: 16 µs			1_B: Dual	0001_B: Pulse (A) and direction (B)			
	010_B: 32 µs				0010_B: Count up (A), count down (B)			
	011_B: 48 µs				0011_B: Incremental encoder (A, B phase-shifted)			
	100_B: 64 µs				0100_B: Incremental encoder (A, B, N)			
	101 to 111_B: Not permitted				0101_B: Absolute encoder (SSI)			
					0110 to 1111_B: Not permitted			
7	Parity[4]:		Invert direction[1]	Enable diagnostic interrupt on wire break[1]	Reserved[2]	Transmission rate[4]:		
	00_B: None					000_B: 125 kHz		
	01_B: Even					001_B: 250 kHz		
	10_B: Odd					010_B: 500 kHz		
	11_B: Not permitted					011_B: 1 MHz		
						100_B: 1.5 MHz		
						101_B: 2 MHz		
						110 to 111_B: Not permitted		
8...9	Reserved[2]							
10...15	**Behavior of a DQ**							
10	Set output (DQ1):				Set output (DQ0):			
	0000_B: Digital output without function				0000_B: Digital output without function			
	0001_B: Between comparison value and count high limit				0001_B: Between comparison value and count high limit			
	0010_B: Between comparison value and count low limit				0010_B: Between comparison value and count low limit			
	0011_B: At comparison value for a pulse duration				0011_B: At comparison value for a pulse duration			
	0100_B: Between comparison value 0 and 1				0100_B to 1111_B: Not permitted			

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

3 For signal type "Absolute encoder (SSI)", the following applies: Reserved[2]

4 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

5 Applies to: Set function of DI = 001_B; 010_B; 011_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
10	0101 to 1111_B: Not permitted				0100_B to 1111_B: Not permitted			
11	Count direction (DQ1):		Count direction (DQ0):		Reserved[2]	Reserved[2]	Substitute value for DQ1	Substitute value for DQ0
	00_B: Reserved		00_B: Reserved					
	01_B: Up		01_B: Up					
	10_B: Down		10_B: Down					
	11_B: In both directions		11_B: In both directions					
12	Pulse duration (DQ0): Incremental and pulse encoder: UINT: Value range in ms/10: 0 to 65535_D SSI absolute encoder: UINT: Value range in ms/10: 1 to 65535_D							
13								
14	Pulse duration (DQ1): Incremental and pulse encoder: UINT: Value range in ms/10: 0 to 65535_D SSI absolute encoder: UINT: Value range in ms/10: 1 to 65535_D							
15								
16	**Behavior of DI0**							
16	Reserved[2)]	Edge selection (DI0):		Select level (DI0):	Reserved[2]	Set function of DI (DI0):		
		00_B: Not permitted[5]				000_B: Gate start/stop (level-triggered)[3]		
		01_B: At rising edge		0_B: Active with high level		001_B: Gate start (edge-triggered)[3]		
		10_B: At falling edge				010_B: Gate stop (edge-triggered)[3]		
		11_B: Not permitted		1_B: Active with low level		011_B: Synchronization[3]		
						100_B: Enable synchronization at signal N[3]		
						101_B: Not permitted		
						110_B: Digital input without function		
						111_B: Not permitted		
17	**Behavior of DI1**: See Byte 16							
18	Reserved[2]							
19	Frequency of synchronization:	Count direction for synchronization		Reserved[2]	Input delay:			
	0_B: Once	00_B: Not permitted			0000_B: None			
	1_B: Periodic	01_B: Up			0001_B: 0.05 ms			
		10_B: Down			0010_B: 0.1 ms			
		11_B: In both directions			0011_B: 0.4 ms			
					0100_B: 0.8 ms			

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

3 For signal type "Absolute encoder (SSI)", the following applies: Reserved[2]

4 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

5 Applies to: Set function of DI = 001_B; 010_B; 011_B

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
19				Reserved[2]	0101_B: 1.6 ms			
					0110_B: 3.2 ms			
					0111_B: 12.8 ms			
					1000_B: 20 ms			
					1001 to 1111_B: Not permitted			
20...43	**Values**							
20...23	High counting limit[3]: Value range: 1 to 33554431_D or 1 to $01FFFFFF_H$							
24...27	Comparison value 0: Value range: 0 to 33554431_D or 0 to $01FFFFFF_H$							
28...31	Comparison value 1: Value range: 0 to 33554431_D or 0 to $01FFFFFF_H$							
32...35	Start value[3]: Value range: 0 to 33554431_D or 0 to $01FFFFFF_H$							
36...39	Counting low limit[3] Value range: 0 to 33554430_D or 0 to $01FFFFFE_H$							
40...43	Reserved[2]							
44	**Counter behavior at limits and gate start**							
44	Behavior at gate start[3]:		Reaction to violation of a counting limit[3]:			Reset when counting limit is violated[3]:		
	00_B: Set to start value		000_B: Stop counting			000_B: To opposite counting limit		
	01_B: Continue with current value		001_B: Continue counting			001_B: To start value		
	10 to 11_B: Not permitted		010 to 111_B: Not permitted			010 to 111_B: Not permitted		
45...47	Reserved[2)]							
48	Set hysteresis range: Value range: 0 to 255_D:							
49...51	**Parameters for SSI absolute encoder**							
49	Reserved[2]		Frame length[4]: 10 to 40_D: Value range					
50	Reserved[2]		Bit number LSB of the position value: 0 to 38_D: Value range					
51	Reserved[2]		Bit number MSB of the position value: 1 to 39_D: Value range					

1 You activate the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

3 For signal type "Absolute encoder (SSI)", the following applies: Reserved[2]

4 In isochronous mode, the parameter can affect the isochronous mode parameters of the sync domain. Because the isochronous mode parameters are not checked in RUN, overflows can occur if you change the parameter in RUN. To prevent overflows, select the option with the largest time required in the offline parameter assignment.

5 Applies to: Set function of DI = 001_B; 010_B; 011_B

A.2 Parameter validation error

If you make the parameter settings in STEP 7 (TIA Portal) or in STEP 7 , the parameter values are checked before they are transferred to the technology module. This process prevents parameter errors.

In other use cases, the technology module checks the transferred parameter data record. If the technology module finds invalid or inconsistent parameter values, it outputs an error code (see below). The new parameter data record is rejected in this case, and work continues with the current parameter values until a valid parameter data record has been transferred.

WRREC

When the CPU is in RUN, you can change the parameter data record with the instruction WRREC (Write Record). In case of errors, the WRREC instruction returns corresponding error codes in the STATUS parameter.

Example:

Let us assume that an invalid value, for example 9, is written to the module for the operating mode with WRREC. As a consequence, the module rejects the entire parameter data record. You can recognize this by evaluating the STATUS output parameter of the WRREC instruction. The STATUS output parameter is output as an ARRAY[1..4] of BYTE data with the value 16#DF80E111:

Example of WRREC STATUS data	Address	Meaning
DF_H	STATUS[1]	Error when writing a data record via PROFINET IO (IEC 61158-6)
80_H	STATUS[2]	Error when reading or writing a data record via PROFINET IO (IEC 61158-6)
$E1_H$	STATUS[3]	Module-specific error
11_H	STATUS[4]	Error code from the table below: The "Operating mode" parameter has an invalid value.

Error codes

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Table 2-1224 Error codes for parameter validation (incremental or pulse encoder)

Error code in STATUS parameter (hexadecimal)				Meaning	Remedy
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Data record number unknown	Enter valid number for data record.
DF	80	B1	01	Length of data record incorrect	Enter valid value for data record length.
DF	80	B2	00	Slot invalid or not accessible	• Check whether module is inserted or removed. • Check assigned values for parameters of the WRREC instruction.
DF	80	E0	01	Wrong version	• Check byte 0. • Enter valid values.
DF	80	E0	02	Error in the header information	• Check byte 1. • Correct the length of the parameter blocks.
DF	80	E1	00	Parameter invalid: No detailed information available	Check all parameter values.
DF	80	E1	11	"Operating mode" parameter invalid	Enter valid parameter value.
DF	80	E1	12	"Reaction to CPU STOP" parameter invalid	Enter valid parameter value.
DF	80	E1	13	"Signal type" parameter invalid	Enter valid parameter value.
DF	80	E1	14	"Sensor type" parameter invalid	Enter valid parameter value.
DF	80	E1	15	"Filter frequency" parameter invalid	Enter valid parameter value.
DF	80	E1	16	"Reaction to signal N" parameter invalid	Enter valid parameter value.
DF	80	E1	17	"Set function of DI" parameter invalid	Enter valid parameter value.
DF	80	E1	18	"Set function of DI" parameter configured the same for DI0 and DI1.	Enter different parameter values for DI0 and DI1.
DF	80	E1	19	• "Edge selection" parameter invalid • "Gate start (edge-triggered)" configured as function for DIm and "At rising and falling edge" • "Gate stop (edge-triggered)" configured as function for DIm and "At rising and falling edge" • "Synchronization" configured as function for DIm and "At rising and falling edge"	• Enter valid parameter value. • Only configure "Gate start (edge-triggered)" as function for DIm together with "At rising edge" or "At falling edge". • Only configure "Gate stop (edge-triggered)" as function for DIm together with "At rising edge" or "At falling edge". • Only configure "Synchronization" as function for DIm together with "At rising edge" or "At falling edge".
DF	80	E1	1A	"Input delay" parameter invalid	Enter valid parameter value.
DF	80	E1	1B	"Set output" parameter invalid	Enter valid parameter value.
DF	80	E1	1C	"Count direction" parameter invalid	Enter valid parameter value.
DF	80	E1	1D	"Reset when counting limit is violated" parameter invalid	Enter valid parameter value.
DF	80	E1	1E	"Reaction to violation of a counting limit" parameter invalid	Enter valid parameter value.
DF	80	E1	20	"Reaction to gate start" parameter invalid	Enter valid parameter value.

1 Only for "Counting" operating mode

2 Only for "Position input for technology object "Motion Control"" operating mode

3 Only for DQ1 functions "Between comparison value 0 and 1" and "Not between comparison value 0 and 1"

4 Only for operating mode "Fast Mode"

5 Not for DQm function "Use by user program" or "Digital output without function"

Error code in STATUS parameter (hexadecimal)				Meaning	Remedy
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	21[1,5]	• Low counting limit > comparison value 0 • Low counting limit > comparison value 1	• Low counting limit < comparison value 0 • Low counting limit < comparison value 1
DF	80	E1	22[1,5]	• Counting high limit < comparison value 0 • Counting high limit < comparison value 1	• High counting limit > comparison value 0 • High counting limit > comparison value 1
DF	80	E1	23	• "Start value" parameter invalid • "Low counting limit" parameter invalid	Enter valid parameter value: Start value > low counting limit
DF	80	E1	24	• "Start value" parameter invalid • "High counting limit" parameter invalid	Enter valid parameter value: Start value < high counting limit
DF	80	E1	25	"Update time" parameter invalid	Enter parameter value from range 0 to 25000000_D.
DF	80	E1	26[2]	"Reference speed" parameter invalid	Enter parameter value from range 6.00 to 210000.00_D.
DF	80	E1	27	"Measured variable" parameter invalid	Enter valid parameter value.
DF	80	E1	28	"Time base for velocity measurement" parameter invalid	Enter valid parameter value.
DF	80	E1	29	"Increments per unit" parameter invalid	Enter valid parameter value.
DF	80	E1	2A	• "High counting limit" parameter invalid • "Low counting limit" parameter invalid	Enter valid parameter value: Low counting limit < high counting limit
DF	80	E1	2B[3]	• "Comparison value 0" parameter invalid • "Comparison value 1" parameter invalid	Enter valid parameter value: Comparison value 0 < comparison value 1
DF	80	E1	2C	"Signal evaluation" parameter invalid	Enter valid parameter value.
DF	80	E1	2D	• "Between comparison value 0 and 1" configured for DQ0 • "Not between comparison value 0 and 1" configured for DQ0 • "Between comparison value 0 and 1" configured for DQ1, but "Use by user program" not configured for DQ0 • "Not between comparison value 0 and 1" configured for DQ1, but "Use by user program" not configured for DQ0	• Configure "Between comparison value 0 and 1" only for DQ1 • "Not between comparison value 0 and 1" configured only for DQ1 • Only configure "Between comparison value 0 and 1" for DQ1 when "Use by user program" is configured for DQ0 • Only configure "Not between comparison value 0 and 1" for DQ1 when "Use by user program" is configured for DQ0
DF	80	E1	2E	"Capture" configured for DIm in "Measuring" operating mode	Do not configure "Capture" for DIm in "Measuring" operating mode
DF	80	E1	36[4]	"Counting high limit" parameter invalid	Enter valid parameter value.
DF	80	E1	37[4,5]	• "Comparison value 0" parameter invalid • "Comparison value 1" parameter invalid	Enter valid parameter value.
DF	80	E1	38[4]	"Start value" parameter invalid	Enter valid parameter value.
DF	80	E1	39[4]	"Counting low limit" parameter invalid	Enter valid parameter value.
DF	80	E1	3A[4]	"Count direction for synchronization" parameter invalid	Enter valid parameter value.
DF	80	E1	F0	Reserved bit is not set to 0.	Set reserved bit to 0.

1 Only for "Counting" operating mode

2 Only for "Position input for technology object "Motion Control"" operating mode

3 Only for DQ1 functions "Between comparison value 0 and 1" and "Not between comparison value 0 and 1"

4 Only for operating mode "Fast Mode"

5 Not for DQm function "Use by user program" or "Digital output without function"

The following table shows the module-specific error codes and their meaning for parameter data record 128 when using an SSI absolute encoder.

Table 2-1225 Error codes for parameter validation (SSI absolute encoder)

Error code in STATUS parameter (hexadecimal)				Meaning	Remedy
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Data record number unknown	Enter valid number for data record.
DF	80	B1	01	Length of data record incorrect	Enter valid value for data record length.
DF	80	B2	00	Slot invalid or not accessible	• Check whether module is inserted or removed. • Check assigned values for parameters of the WRREC instruction.
DF	80	E0	01	Wrong version	• Check byte 0. • Enter valid values.
DF	80	E0	02	Error in the header information	• Check byte 1. • Correct the length of the parameter blocks.
DF	80	E1	00	Parameter invalid: No detailed information available	Check all parameter values.
DF	80	E1	11	"Operating mode" parameter invalid	Enter valid parameter value.
DF	80	E1	12	"Reaction to CPU STOP" parameter invalid	Enter valid parameter value.
DF	80	E1	13	"Signal type" parameter invalid	Enter valid parameter value.
DF	80	E1	18	"Set function of DI" parameter configured the same for DI0 and DI1.	Enter different parameter values for DI0 and DI1.
DF	80	E1	19	• "Edge selection" parameter invalid	Enter valid parameter value.
DF	80	E1	1A	"Input delay" parameter invalid	Enter valid parameter value.
DF	80	E1	1B	"Set output" parameter invalid	Enter valid parameter value.
DF	80	E1	1C	"Count direction" parameter invalid	Enter valid parameter value.
DF	80	E1	25	"Update time" parameter invalid	Enter parameter value from range 0 to 25000000_D.
DF	80	E1	26[1]	"Reference speed" parameter invalid	Enter parameter value from range 6.00 to 210000.00_D.
DF	80	E1	27	"Measured variable" parameter invalid	Enter valid parameter value.
DF	80	E1	28	"Time base for velocity measurement" parameter invalid	Enter valid parameter value.
DF	80	E1	29	"Increments per unit" parameter invalid	Enter valid parameter value.
DF	80	E1	2B[2]	• "Comparison value 0" parameter invalid • "Comparison value 1" parameter invalid	Enter valid parameter value: Comparison value 0 < comparison value 1
DF	80	E1	2D	• "Between comparison value 0 and 1" configured for DQ0 • "Not between comparison value 0 and 1" configured for DQ0 • "Between comparison value 0 and 1" configured for DQ1, but "Use by user program" not configured for DQ0 • "Not between comparison value 0 and 1" configured for DQ1, but "Use by user program" not configured for DQ0	• Configure "Between comparison value 0 and 1" only for DQ1 • "Not between comparison value 0 and 1" configured only for DQ1 • Only configure "Between comparison value 0 and 1" for DQ1 when "Use by user program" is configured for DQ0 • Only configure "Not between comparison value 0 and 1" for DQ1 when "Use by user program" is configured for DQ0
DF	80	E1	2E	"Capture" configured for DIm in "Measuring" operating mode	Do not configure "Capture" for DIm in "Measuring" operating mode
DF	80	E1	2F	"Set function of DI" parameter invalid	Enter valid parameter value.
DF	80	E1	30	"Monoflop time" parameter invalid	Enter valid parameter value.

1 Only for "Position input for "Motion Control"" technology object" operating mode

2 Only for DQ1 functions "Between comparison value 0 and 1" and "Not between comparison value 0 and 1"

3 Only for "Fast Mode" operating mode; not for DQm function "Digital output without function"

Error code in STATUS parameter (hexadecimal)				Meaning	Remedy
Byte 0	**Byte 1**	**Byte 2**	**Byte 3**		
DF	80	E1	31	"Transmission rate" parameter invalid	Enter valid parameter value.
DF	80	E1	32	"Parity" parameter invalid	Enter valid parameter value.
DF	80	E1	33	"Frame length" parameter invalid	Enter valid parameter value.
DF	80	E1	34	• Bit number LSB of the position value < 0 • Bit number LSB of the position value > Bit number MSB of the position value • (Bit number MSB of the position value) – (Bit number LSB of the position value) >= 31 • Bit number MSB of the position value > Frame length	• Bit number LSB of the position value >= 0 • Bit number LSB of the position value < Bit number MSB of the position value • (Bit number MSB of the position value) – (Bit number LSB of the position value) < 32 • Bit number MSB of the position value <= Frame length
DF	80	E1	35	"0" configured for "Pulse duration" parameter	Enter valid parameter value.
DF	80	E1	37[3]	• "Comparison value 0" parameter invalid • "Comparison value 1" parameter invalid	Enter valid parameter value.
DF	80	E1	F0	Reserved bit is not set to 0.	Set reserved bit to 0.

1 Only for "Position input for "Motion Control"" technology object" operating mode

2 Only for DQ1 functions "Between comparison value 0 and 1" and "Not between comparison value 0 and 1"

3 Only for "Fast Mode" operating mode; not for DQm function "Digital output without function"

SIEMENS

SIMATIC

ET 200SP
Technology module TM Timer DIDQ 10x24V (6ES7138-6CG00-0BA0)

Equipment Manual

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Connecting 3

Configuring/address space 4

Interrupts/diagnostic messages 5

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Parameter data record A

Open Source Software B

08/2014
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Preface

Purpose of the documentation

This manual includes module-specific information on wiring, diagnostics and the technical specifications of the technology module.

General information regarding the design and commissioning of the ET 200SP is available in the ET 200SP system manual.

The "Time-based IO" technology supported by the TM Timer DIDQ 10x24V technology module is described in detail in the function manual High-precision input/output with Time-based IO (http://support.automation.siemens.com/WW/view/en/82527590).

Conventions

Please observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the ET 200SP and S7-1500 systems consists of the respective system manuals, function manuals and device manuals.

The STEP 7 information system (TIA Portal) also helps you to configure and program your automation system.

Overview of the documentation for TM Timer DIDQ 10x24V technology module

The following table lists further documentation that you will need when using the TM Timer DIDQ 10x24V technology module.

Table 2-1226 Documentation for TM Timer DIDQ 10x24V technology module

Topic	Documentation	Most important contents
System description	System manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Commissioning
	S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792) system manual	
	Device manual Interface Module (http://support.automation.siemens.com/WW/view/en/55683316/133300)	• Connecting • Interrupts, diagnostics, error, and system messages • Technical specifications • Dimension drawing
	Device manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)	Technical specifications
Configuring interference-free controllers	Designing interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) Function Manual	• Basics • Electromagnetic compatibility • Lightning protection
Time-based IO	Function manual High-precision input/output with Time-based IO (http://support.automation.siemens.com/WW/view/en/82527590)	• Basics • Configuration • Programming • Diagnostics
Isochronous mode	PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856) function manual	• Benefits • Use • Parameter settings

SIMATIC manuals

All current manuals for the SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Product overview

2

2.1 Properties

Article number

6ES7138-6CG00-0BA0

View of the module

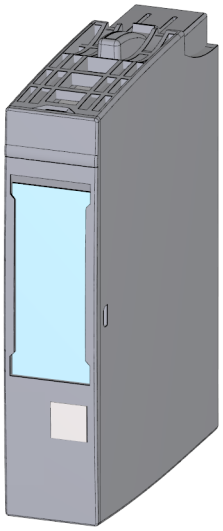

Figure 2-1081 View of the TM Timer DIDQ 10x24V module

Properties

The TM Timer DIDQ 10x24V technology module has the following properties:

- Technical properties
  - 4 Digital inputs and 6 digital outputs
  - Rated output voltage 24V DC
  - Rated output current 0.5 A or 0.1 A (high-speed operation) per digital output
  - 24 V encoder supply output, short-circuit proof
  - Configurable substitute values (per digital output)
  - Configurable diagnostics
  - Configurable input filters for suppression of interference at digital inputs

- Supported encoder/signal types for digital inputs
  - 24 V incremental encoder with A and B signals
  - 24 V pulse encoder with one signal
- Supported functions
  - Time stamp function for inputs and outputs (resolution 1 µs)
  - Counting (counting range 32-bit)
  - Oversampling for inputs and outputs
  - Pulse width modulation
- Supported system functions
  - Isochronous mode
  - Firmware Update
  - Identification data I&M

Accessories

The following accessories can be used with the module and are not included in the product package:

- Labeling strip
- Color identification labels
- Reference identification labels
- Shield connector

A BaseUnit of the A0 type is required to operate the technology module. For an overview of the BaseUnits to be used with the technology module, refer to the product information on the documentation for the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

For detailed information on the installation procedure, refer to the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2 Functions

2.2.1 Detection of the input signals

You can configure up to four digital inputs with the technology module. You can evaluate the signals at the digital inputs for the following functions:

Time stamp detection (Timer DI)

The technology module can detect an associated time stamp for an edge at a digital input. The time stamp indicates when the edge was detected in relation to a time base. These time stamps can be used, for example, to calculate a time difference.

The time stamp is based on the "Time-based IO" technology supported by the technology module and requires isochronous mode.

Hardware enable (HW enable)

You can configure a hardware enable by a digital input for the detection of time stamps. A hardware enable defines the time window in which the time stamps are acquired. You can override the hardware enable via the control interface (Page 23) with the respective SETEN bit.

The figure below shows an example for the detection of time stamps at rising and falling edges with enable of the DI2 through the high level of the DI3:

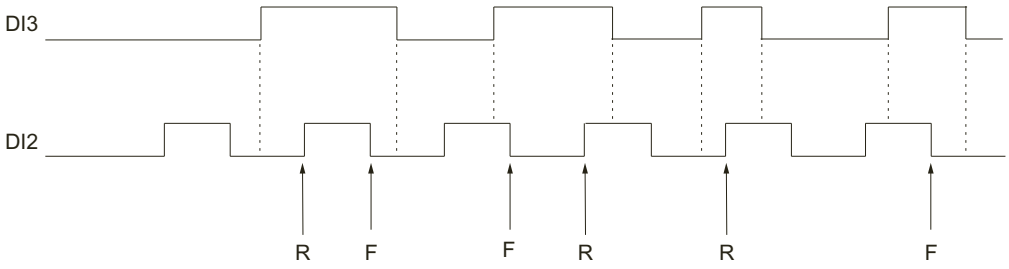

R Associated time stamp detected at rising DI2-edge

F Associated time stamp detected at falling DI2 edge

Counting

Counting refers to the recording and adding up of events. You can configure up to three counters for the technology module. You can use an incremental encoder as well as a pulse encoder at the digital inputs. The two phase-shifted signals from an incremental encoder are evaluated four times. Only the rising or falling edges are counted with the signal of a pulse encoder.

A counter starts at 0, goes up to 2^{32}-1 and starts again at 0 (overflow). The technology module can also count down if an incremental encoder is used. The counter value is returned in the feedback interface (Page 26) as a 32-bit value for each digital input.

Oversampling

The Oversampling function is used by the technology module to detect the status of the respective digital input for each application cycle (for example, OB61) at 32 points in time at regular intervals. The 32 states are returned together in the feedback interface (Page 26) as a 32-bit value.

Oversampling requires isochronous mode. If the OB of the type "Synchronous Cycle" works with a clock different than the send clock, you must use the TIO_SYNC instruction.

The figure below shows an example for Oversampling of DI0:

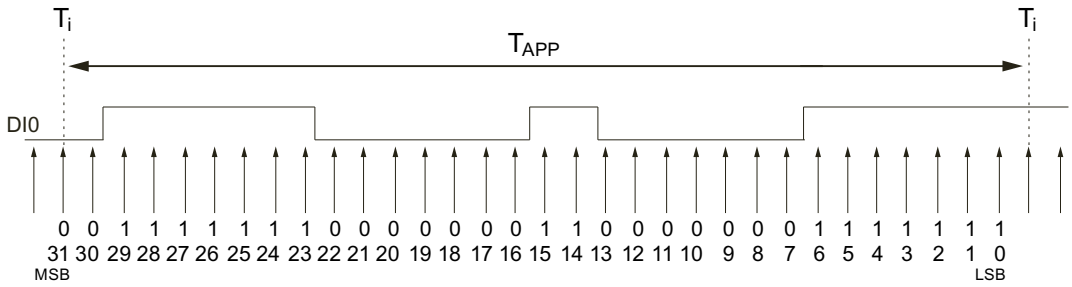

T_{APP}	Application cycle
MSB	Most significant bit
LSB	Least significant bit

2.2.2 Switching the outputs

You can configure up to six digital outputs for the technology module. You can configure the following functions for switching the digital outputs:

Time-controlled switching (Timer DQ)

The use of time stamps enables reproducibility of controlled operations with very accurate time. Using this function, the technology module outputs edges at the respective digital output at precisely defined points in time. For example, you can implement a defined reaction time between input and output in conjunction with a digital input.

The Timer function is based on Time-based IO and requires isochronous mode.

Hardware enable (HW enable)

You can configure a hardware enable by means of a digital input for a Timer digital output. A hardware enable defines the time window in which the respective digital output can be set. The resetting of the digital output is independent of the hardware enable. You can override the hardware enable via the control interface (Page 23) with the respective SETEN bit.

The figure below shows an example for the output of rising and falling edges with enable of the DQ0 through the high level of the DI0:

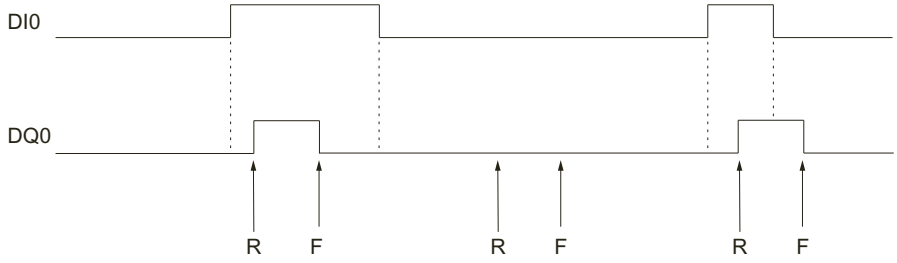

R Specified time of a rising DQ0-edge

F Specified time of a falling DQ0-edge

Pulse width modulation (PWM)

The Pulse width modulation function enables you to specify the time period in the hardware configuration and the pulse-pause ratio in the control interface (Page 23) for the respective digital output. The setpoint for the pulse-pause ratio is a percentage and is evaluated with an accuracy of about 3%.

Oversampling

The Oversampling function is used by the technology module to output 32 states at regular intervals for each application cycle (for example, OB61). This allows up to 32 edges at the respective digital output per application cycle.

The 32 states are sent via the control interface (Page 23) as a 32-bit string for the respective digital output to the technology module.

Oversampling requires isochronous mode. If the OB of the type "Synchronous Cycle" works with a clock different than the send clock, you must use the TIO_SYNC instruction.

The figure below shows an example for Oversampling of DQ0:

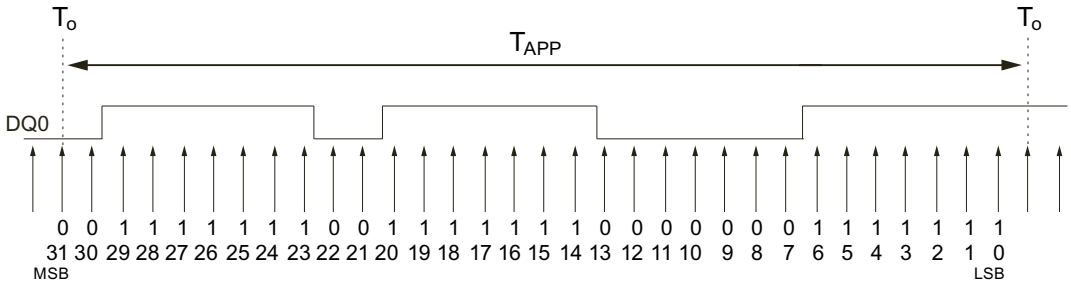

T_{APP}	Application cycle
MSB	Most significant bit
LSB	Least significant bit

NOTE

When you use the Oversampling function, make sure that the combination of application cycle and the 32-bit output sequence do not result in an output frequency which exceeds the maximum switching frequency for the digital outputs.

2.2.3 Additional functions

Isochronous mode

The technology module supports the system function "isochronous mode" in distributed mode on PROFINET. This system function is required for the following functions of the technology module:

- Time stamp detection (Timer DI)
- Time-controlled switching (Timer DQ)
- Oversampling of digital input
- Oversampling of digital output

In isochronous mode, the cycle of the user program, the transmission of the input signals and processing in the technology module are synchronized.

Data processing

The time stamp, counter values and Oversampling bit string as well as status bits are detected at the time T_i and made available in the feedback interface for retrieval in the current bus cycle. The output of the current Oversampling bit stings is started at the time T_o.

Diagnostic interrupt

The technology module can trigger a diagnostic interrupt (Page 31), among other things, if no supply voltage is available or if there is an error at the digital outputs.

Input filter

To suppress interferences, you can configure an input filter for the digital inputs.

Distributed application

You can use the technology module in a distributed system by means of an interface module in the ET 200SP distributed I/O device. The following applications are possible:

- Distributed operation in an S7-1500 system
- Distributed operation in an S7-300/400 system

Centralized application

You can use the technology module centrally in the ET 200SP distributed I/O system.

Connecting 3

3.1 Pin assignment

The TM Timer DIDQ 10x24V is used with a BaseUnit of the A0 type.

The encoder signals, the digital input and output signals and the encoder supply are connected to the BaseUnit of the technology module. The supply voltage feed on the light BaseUnit BU...D of the associated potential group supplies the module and the digital outputs, and generates the encoder supply voltage.

BaseUnit

The BaseUnit is not included in the product package of the module and must be ordered separately.

For an overview of the BaseUnits to be used with the technology module, refer to the product information on the documentation for the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

You can find information about selecting a suitable BaseUnit in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) device manual.

You can find information on wiring the BaseUnit, connecting cable shields, etc. in the Connecting section of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Pin assignment of the BaseUnit

The table below shows the pin assignment, using the BaseUnit BU15-P16+A0+2B as an example.

Table 2-1227 Pin assignment of the BaseUnit BU15-P16+A0+2B

Designation	Signal name		View	Signal name		Designation
Digital input DI0	DI0	1		2	DQ0	Digital output DQ0
Digital input DI1	DI1	3		4	DQ1	Digital output DQ1
Digital input DI2	DI2	5		6	DQ2	Digital output DQ2
Digital input DI3	DI3	7		8	DQ3	Digital output DQ3
Ground for encoder supply, digital inputs and digital outputs	M	9		10	DQ4	Digital output DQ4
	M	11		12	DQ5	Digital output DQ5

Designation	Signal name		View	Signal name		Designation
Ground for encoder supply, digital inputs and digital outputs	M	13	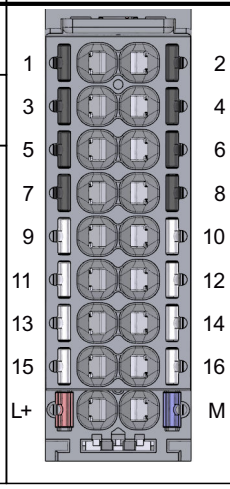	14	M	Ground for encoder supply, digital inputs and digital outputs
24 V encoder supply	24VDC	15		16	M	
DC 24 V supply voltage	L+			M		Ground for supply voltage

Block diagram

When you connect encoders you must, depending on the configured input delay and potential effect of interference, ground the shields of the cables between encoder and technology module both through the shield connection on the BaseUnit (shield connection element and terminal) and at the encoder.

The figure below shows the block diagram of the technology module to which an incremental encoder and a pulse encoder are connected.

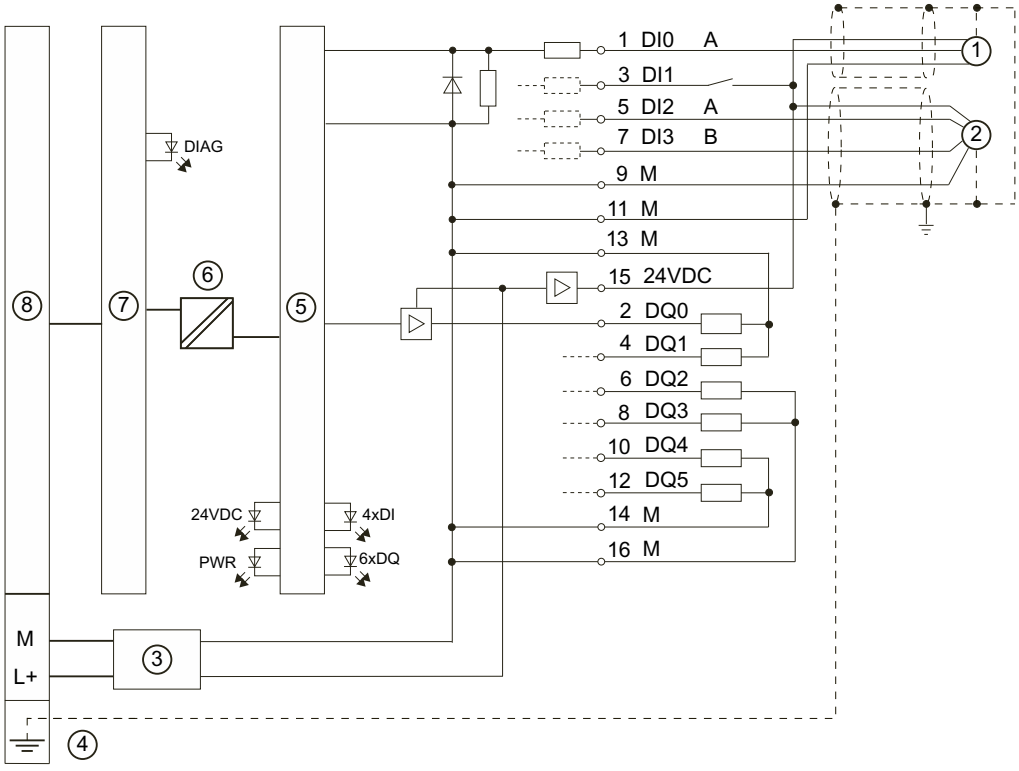

① Pulse encoder with signal A
② Incremental encoder with A and B signals
③ Input filter for supply voltage
④ Shield connection on the BaseUnit
⑤ Technology
⑥ Electrical isolation
⑦ Backplane bus interface module of the technology module
⑧ Backplane bus

Figure 2-1082 Block diagram with incremental encoder and pulse encoder

L+/M supply voltage

Connect the supply voltage (DC 24V) to the L+ and M connections. An internal protective circuit protects the technology module against damage due to reversed polarity of the supply voltage. Unexpected conditions can occur at the digital outputs with reversed polarity of the supply voltage. The technology module monitors the connection of the supply voltage.

24VDC encoder supply

To supply the encoders and sensors at the digital inputs, the technology module supplies the DC 24V supply voltage at the 24VDC output with reference to M. Voltage is supplied from the L+/M supply voltage and monitored for short-circuits and overload.

Digital inputs DI0 to DI3

You can use four digital inputs. The technology module can evaluate the edges at the digital inputs for the following functions:

Table 2-1228 Evaluation of the signals at the digital inputs

Evaluation of the signals for ...	Usable digital inputs			
	DI0	DI1	DI2	DI3
Time stamp detection	✓	✓	✓	✓
Hardware enable for time stamp detection	—	—	—	✓
Hardware enable for time-controlled switching	✓	✓	✓	—
Counting with incremental encoder with signals A and B	—	—	✓	✓
Counting with pulse encoder with signal A	✓	✓	✓	—
Oversampling	✓	✓	✓	✓

When you use the counting function, you can connect the following encoder types with 24 V signals to the digital inputs:

- Incremental encoder with signals A and B:

  Signals A and B are connected via the connections of the digital inputs DI2 and DI3. Signals A and B are the two incremental signals phase-shifted by 90°.

- Pulse encoder / sensor with signal A:

  Signal A is connected via the connection of the digital input DI0, DI1 or DI2.

The digital inputs are not electrically isolated from each other or from the digital outputs. The digital inputs are electrically isolated from the backplane bus.

Input filters for digital inputs

You can configure an input filter for each digital input to suppress interference. Signals with a pulse duration below the configured input delay are suppressed.

You can specify the following values for the input delay:

- None
  (input delay of 4 µs, minimum pulse width of 3 µs)
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms

The input delay has the following effect on the functions of the signal evaluation at the digital inputs:

Table 2-1229 Influence of the input delay

Function	Influence of the input delay
Time stamp detection	The detected time stamp is moved by the input delay.
Counting	The counter value that was valid at time T_i minus the input delay is returned.
Oversampling	The detected states are moved together by the input delay.

NOTE

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs. To increase the accuracy of the time stamp function, we recommend the use of shielded cables even for longer input delays. The use of shielded cables limits the jitter to maximum of 1 µs.

Digital outputs DQ0 to DQ5

You can use six digital outputs. The digital outputs can be switched directly at defined points in time or via the user program. Alternatively, you can output pulse width modulation or Oversampling at the respective digital output.

The digital outputs are not electrically isolated from each other or from the digital inputs. The digital outputs are electrically isolated from the backplane bus.

You can use each of the digital outputs as a high-speed output or as a sourcing output:

- High-speed output (default):
  The digital output works as fast push-pull switch and can carry a rated load current of 0.1 A. A push-pull switch is alternately switched to DC 24 V and ground. This makes for very steep edges.
- Sourcing output:
  The digital output works as 24 V sourcing output in reference to M and can carry a rated load current of 0.5 A.

The digital outputs are protected from overload and short-circuit.

NOTICE

Overtemperature from unsuitable loads

A high-speed output generates edges that are very steep. This creates very powerful charge reversals for the connected load, which can overheat the load at very high switching frequencies.

The connected load must therefore be approved for high input frequencies.

NOTE

If you use a digital output as sourcing output, the switch-off response / switch-off edge depends on the load. Thus, it is possible that very short pulses cannot be output correctly.

NOTE

Relays and contactors can be connected direct without external circuitry.

Configuring/address space

4

4.1 Configuring

Introduction

The technology module is configured and assigned parameters with the configuration software.

The technology module functions are controlled and monitored by the user program.

System environment

The technology module can be used in the following system environments:

Table 2-1230 Applications of the technology module with PROFINET IO

Applications	Components required	Configuration software	In the user program
Distributed operation in an S7-1500 system	• S7-1500 automation system • ET 200SP distributed I/O system • TM Timer DIDQ 10x24V	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN)	Time stamp functions: TIO instructions TIO_SYNC, TIO_DI and TIO_DQ Counting, PWM and Oversampling: Direct access to the control and feedback interface (Page 23) of the TM Timer DIDQ 10x24V in the I/O data
Central operation in an S7-1500 system	• S7-1500 automation system • ET 200SP distributed I/O system • TM Timer DIDQ 10x24V	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN)	Counting and PWM: Direct access to the control and feedback interface of the TM Timer DIDQ 10x24V in the I/O data
Distributed operation in an S7-300/400 system	• S7-300/400 automation system • ET 200SP distributed I/O system • TM Timer DIDQ 10x24V	STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN) STEP 7: Device configuration and parameter settings with HSP	Time stamp functions*, counting, PWM and Oversampling: Direct access to the control and feedback interface (Page 23) of the TM Timer DIDQ 10x24V in the I/O data

* on request

Additional information

You can find a detailed description of the time stamp functions and their configuration with the TIO instructions TIO_SYNC, TIO_DI and TIO_DQ in:

- High-precision input/output with Time-based IO function manual available as download on the Internet (http://support.automation.siemens.com/WW/view/en/82527590)
- In the STEP 7 (TIA Portal) information system under "Using technology functions > Counting, measurement and position input > Counting, measurement and position input (S7-1500)"

4.2 Reaction to CPU STOP

You set the response of the technology module to CPU STOP for each channel in the basic parameters.

Table 2-1231 Response of the technology module to CPU STOP depending on parameter assignment

Reaction to CPU STOP	Meaning
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: If you are using counters, the counter values are set to 0 and the digital outputs switch according to the parameter assignment and the setpoints.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. The last valid period duration with the last valid pulse-pause ratio is output for a configured pulse width modulation until the next STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: If you are using counters, the counter values are set to 0 and the digital outputs switch according to the parameter assignment and the setpoints.

4.3 Address space

Address space of the technology module

Table 2-1232 Range of the input addresses and output addresses of the TM Timer DIDQ 10x24V

	Inputs	Outputs
Range	26 bytes	32 bytes

Additional information

A description on how to use the control and feedback interface of TM Timer DIDQ 10x24V can be found in the chapter Control and feedback interface (Page 23).

4.4 Parameters

You can use various parameters to define the properties of the technology module in the hardware configuration. Depending on the settings, not all parameters are available. You can change the parameter assignment in the user program using data record 128 (Page 40).

If you use STEP 7 (TIA Portal), you can find the module in the Hardware catalog under "Technology modules". If you use STEP 7, you can find the module following installation of the corresponding HSP file in the Hardware catalog.

Parameters of the TM Timer DIDQ 10x24V

You can configure the following parameters:

Table 2-1233 Configurable parameters and their defaults

Parameter	Value range	Default setting
Basic parameters		
PWM period for the digital outputs	• 10 ms • 5 ms • 2 ms • 1 ms • 0.5 ms • 0.2 ms	10 ms
Reaction to CPU STOP	• Output substitute value • Keep last value	Output substitute value
Enable diagnostic interrupts	• Disabled • Enabled	Disabled
Channel parameters		
Configuration DQ/DI group (DQ0/DI0 or DQ1/DI1)	• Timer DQ with enable input • Use input/output individually	Timer DQ with enable input
Operating mode of the digital output	• Timer DQ • Oversampling • Pulse width modulation PWM	Timer DQ
Substitute value for the digital output	• 0 • 1	0
High-speed output (0.1 A)	• Disabled • Enabled	Enabled
Invert input or output signal	• Disabled • Enabled	Disabled
HW enable by the digital input	• Level-triggered • Edge-triggered	Level-triggered
Level selection for HW enable	• Active with high level • Active with low level	Active with high level
Configuration DQ/DI group (DQ2/DI2/DI3)	• Incremental encoder (A, B phase-shifted) • Timer-DI2 with enable input DI3 • Timer DQ2 with enable input DI2 • Use inputs individually	Incremental encoder (A, B phase-shifted)
Invert counting direction (incremental encoder)	• Disabled • Enabled	Disabled

Parameter	Value range	Default setting
Operating mode of the digital input	• Counter • Timer-DI • Oversampling	Timer-DI
Input delay for the digital input	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms	0.1 ms
Signal evaluation for counters	• At rising edge • At falling edge	At rising edge

4.5 Control and feedback interface

Direct access to the control and feedback interface on the PROFINET is not necessary for distributed operation in a S7-1500 system to use the time stamp functions. The TIO instructions TIO_SYNC, TIO_DI and TIO_DQ are available for this case. You can find a detailed description of the use of the TIO instructions in the High-precision input/output with Time-based IO function manual available as download on the Internet (http://support.automation.siemens.com/WW/view/en/82527590).

Additional information on using the control and feedback interface is available in the section Configuring (Page 20).

4.5.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface

The following table shows control interface assignment:

Table 2-1234 Control interface of the technology module

Offset to the start address	Parameter	Meaning
Byte 0	—	Bits 6 to 7: Reserved; bits must be set to 0
	SET_DQ (DQ0 ... DQ5)	Bit 5: Set DQ5
		Bit 4: Set DQ4
		Bit 3: Set DQ3
		Bit 2: Set DQ2
		Bit 1: Set DQ1
		Bit 0: Set DQ0
Byte 1	SETEN (DI0 ... DI3, DQ0 ... DQ3)	Bit 7: Override hardware enable for DQ3
		Bit 6: Override hardware enable for DQ2
		Bit 5: Override hardware enable for DQ1
		Bit 4: Override hardware enable for DQ0

Offset to the start address	Parameter		Meaning		
Byte 1	SETEN (DI0 ... DI3, DQ0 ... DQ3)		Bit 3: Override hardware enable for DI3		
			Bit 2: Override hardware enable for DI2		
			Bit 1: Override hardware enable for DI1		
			Bit 0: Override hardware enable for DI0		
Byte 2	SETEN (DQ4 ... DQ5)		Bits 2 to 7: Reserved; bits must be set to 0		
			Bits 0 to 1: Override hardware enable for DQ4 to DQ5		
Byte 3	—		Reserved; bits must be set to 0		
Bytes 4 to 7	TEC_OUT (DQ0)		For DQ operating mode "Timer DQ":	For DQ operating mode "Oversampling":	For DQ operating mode "Pulse width modulation PWM":
			Byte 0...1: OFF TIME: Starting time stamp of the module for resetting the DQ0	Bytes 0 to 3: 32 states for Over-sampling	Bytes 0 to 2: Reserved; bits must be set to 0
			Bytes 2 to 3: ON TIME: Starting time stamp of the module for setting the DQ0		Byte 3: Pulse-pause ratio for PWM as a percentage
Bytes 8 to 11	TEC_OUT (DQ1)		See bytes 4 to 7		
Bytes 12 to 15	TEC_OUT (DQ2)				
Bytes 16 to 19	TEC_OUT (DQ3)				
Bytes 20 to 23	TEC_OUT (DQ4)				
Bytes 24 to 27	TEC_OUT (DQ5)				
Byte 28	SEL (DI1)	EDGESEL	Bits 5...7: edge selection for time stamp detection DI1:		
			000_B: Reserved		
			001_B: Rising edges only		
			010_B: Falling edges only		
			011_B: Rising and falling edge (order depending on occurrence)		
			100_B: Reserved		
			101_B: First rising, then falling edge		
			110_B: First falling, then rising edge		
			111_B: Reserved		
		REARM	Bit 4: cyclic time stamp detection for DI1		
	SEL (DI0)	EDGESEL	Bits 0...3: See SEL (DI1)		
		REARM			
Byte 29	SEL (DI3)		See byte 28		
	SEL (DI2)				
Bytes 30 to 31	STW	MSL	Bits 12...15: sign of life counter (Master Sign of Life)		
		—	Bits 1...11: Reserved; bits must be set to 0		
		SYN	Bit 0: Synchronization of the module with the user program		

Notes on the control bits

Control bit	Notes
SEL (DIm)	This value is supplied by the TIO instruction TIO_DI.
SET_DQm	You can use this bit to set the DQm digital output in the DQ operating mode "Timer DQ".
SETEN (DIm/DQm)	You can use this bit to override the hardware enable that is configured for a digital input DIm or digital output DQm.
STW	This value is controlled by the TIO instruction TIO_SYNC. Detailed information is available on request.
TEC_OUT (DQm)	If you use the time stamp function for the respective digital output DQm, the TIO instruction TIO_DQ returns the two output time stamps for the module in this value. If you use the Oversampling function for the respective digital output DQm, you specify the 32 states with this value. If you use pulse width modulation for the respective digital output DQm, you specify the pulse-pause ratio with this value as percentage. The following overview shows how the technology module evaluates the specified percentage.

Pulse-pause ratio for PWM

You specify the setpoint for the pulse-pause ratio as a percentage. The technology module outputs the following pulse-pause ratio in each case:

Setpoint in %	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Output value in %	0		3.13			6.25			9.38			12.50				15.63			18.75			21.88		

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
25			28.13			31.25			34.38			37.50				40.63			43.75			46.88			50		

52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
53.13			56.25			59.38			62.50				65.63			68.75			71.88			75			78.13		

80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
81.25			84.38			87.50			90.63				93.75			96.88			100	

Additional information

Detailed information about the time stamp function is available from Technical Supporton request.

4.5.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module by means of the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Table 2-1235 Feedback interface of the technology module

Offset to the start address	Parameter	Meaning		
Byte 0	STS_DI (DI0 ... DI3)	Bits 4 to 7: Reserved		
		Bit 3: Status DI3		
		Bit 2: Status DI2		
		Bit 1: Status DI1		
		Bit 0: Status DI0		
Byte 1	QI (DI0 ... DI3)	Bits 4 to 7: Reserved		
		Bit 3: Quality Information DI3		
		Bit 2: Quality Information DI2		
		Bit 1: Quality Information DI1		
		Bit 0: Quality Information DI0		
Byte 2	QI (DQ0 ... DQ5)	Bits 6 to 7: Reserved		
		Bit 5: Quality Information DQ5		
		Bit 4: Quality Information DQ4		
		Bit 3: Quality Information DQ3		
		Bit 2: Quality Information DQ2		
		Bit 1: Quality Information DQ1		
		Bit 0: Quality Information DQ0		
Byte 3	—	Reserved		
Bytes 4 to 7	TEC_IN (DI0)	For DI operating mode "Timer DI":	For DI operating mode "Incremental encoder (A, B phase-shifted)" or "Counter":	For DI operating mode "Oversampling":
		Byte 0...1: 2nd TIME/OFF TIME: Second input time stamp of module	Current counter value	Oversampling value
		Byte 2...3: 1st TIME/ON TIME: First input time stamp of module		
Bytes 8 to 11	TEC_IN (DI1)	See bytes 4 to 7		
Bytes 12 to 15	TEC_IN (DI2)			
Bytes 16 to 19	TEC_IN (DI3)			
Byte 20	EN (DI1)	Bit 7: DI1 active as Timer DQ		
	LEC (DI1)	Bit 4...6: Lost edge counter for DI1		
	EN (DI0)	Bit 3: DI0 active as Timer DQ		
	LEC (DI0)	Bit 0...2: Lost edge counter for DI0		

Offset to the start address	Parameter		Meaning
Byte 21	EN (DI3)		See byte 20
	LEC (DI3)		
	EN (DI2)		
	LEC (DI2)		
Byte 22	—		Bits 6 to 7: Reserved
	EN (DQ5)		Bit 5: DQ5 active as Timer DQ
	EN (DQ4)		Bit 4: DQ4 active as Timer DQ
	EN (DQ3)		Bit 3: DQ3 active as Timer DQ
	EN (DQ2)		Bit 2: DQ2 active as Timer DQ
	EN (DQ1)		Bit 1: DQ1 active as Timer DQ
	EN (DQ0)		Bit 0: DQ0 active as Timer DQ
Byte 23	Layout Property		Module-specific value
Bytes 24 to 25	ZSW	SSL	Bits 12...15: sign of life counter (Slave Sign of Life)
		—	Bits 10 to 11: Reserved
		SYNC	Bit 8: Module is synchronized with the user program
		Channel address	Bits 4 to 7 and 9: Number of the respective DI or DQ
		Channel mode	Bits 0 to 3: Operating mode of the respective DI or DQ

Notes on the feedback bits

Table 2-1236 Feedback bits with notes

Feedback bit	Notes
STS_DI (DIm)	This bit indicates the status of respective digital input DIm.
EN (DIm/DQm)	This bit indicates that • The respective digital input is active as Timer DI and, if required, is enabled, or • The respective digital output is active as Timer DQ and, if required, is enabled. For digital inputs and digital outputs with the operating modes "Counter", "Oversampling", "Pulse Width Modulation PWM" and for level-controlled hardware enable, this bit is permanently "0".
Layout Property	This value is a module-specific constant and used by the TIO instructions for the recognition of the technology module.
LEC (DIm)	This value indicates the number of edges at the respective digital input DIm for which no time stamp could be stored. The module can count a maximum of seven edges per application cycle. The counter is reset with each new application cycle.
QI (DIm)	This bit indicates that an error has occurred at the respective digital input. 0 means: Supply voltage L+ not present or too low. 1 means: Supply voltage is present and OK If the diagnostic interrupts are enabled, a diagnostic interrupt is triggered when there is a problem with the L+ supply voltage. Refer to the section Diagnostic alarms (Page 31) for details on the diagnostic interrupts.

Feedback bit	Notes
QI (DQm)	This bit indicates that an error has occurred at the respective digital output. 0 means: Short-circuit, overload or overtemperature 1 means: Supply voltage is present and OK If the diagnostic interrupts are enabled, a diagnostic interrupt is triggered when there is a fault at the digital output. Refer to the section Diagnostic alarms (Page 31) for details on the diagnostic interrupts.
TEC_IN (DIm)	If you use the time stamp function for the respective digital input DIm, this value returns the two input time stamps for the module. The input time stamps are read by the TIO instruction TIO_DI and converted to the TIO_Time. If you use the counting function for the respective digital input DIm, this value returns the current counter value. If you use the Oversampling function for the respective digital input DIm, this value returns the 32 states of the DIm.
ZSW	This value is controlled by the technology module and is used for communication with the TIO instruction TIO_SYNC.

Additional information

Detailed information about the time stamp function is available from Technical Supporton request.

Interrupts/diagnostic messages 5

5.1 Status and error displays

LEDs

The figure below shows the LEDs (status and error displays) of the TM Timer DIDQ 10x24V.

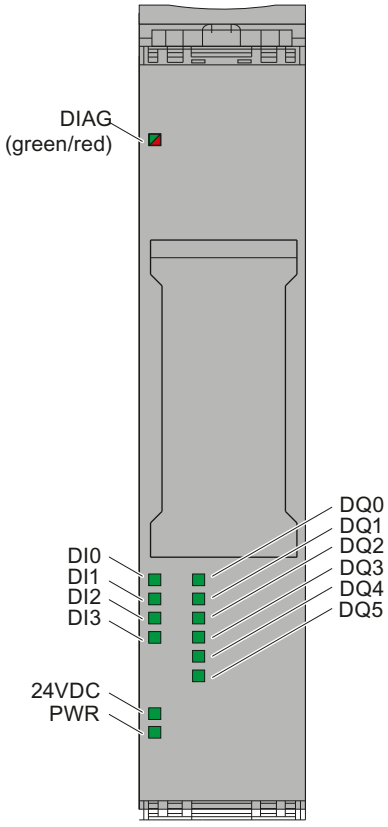

Figure 2-1083 LEDs of the TM Timer DIDQ 10x24V

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in the section Diagnostic alarms (Page 31).

Table 2-1237 Status and error displays DIAG

LED DIAG	Meaning	To correct or avoid errors
Off	Backplane bus supply of the ET 200SP not OK	Check or switch on the supply voltage on the interface module or on the CPU.
Flashes	Technology module not configured	—
On	Technology module configured but no module diagnostics	
Flashes	Technology module configured and module diagnostics (at least one error pending)	Evaluate the diagnostic alarms and eliminate the error.

Table 2-1238 PWR/24VDC status displays

LEDs		Meaning	To correct or avoid errors
PWR	24VDC		
Off	Off	No supply voltage	• Check the supply voltage. • Check the BaseUnit type and the wiring of the BaseUnit.
On	On	Supply voltage is present and OK	—
On	Off	Short-circuit or overload at the encoder supply or supply voltage too low	• Check the encoder wiring. • Check the loads connected to the encoder supply. • Check the supply voltage.

ChannelLEDs

TheDIm LEDs indicate the current level of the associated signals. The LEDs of the digital outputs DQm indicate the desired state.

The flashing frequency of the channel LEDs is limited to approximately 14 Hz. If higher frequencies are present, the channel LEDs will flash at 14 Hz instead of indicating the current status.

Table 2-1239 Status displays DIm/DQm

LEDs DIm/DQm	Meaning
Off	Digital input / digital output at 0 level
On	Digital input / digital output at 1 level

5.2 Trigger a diagnostic interrupt

Enabling the diagnostic interrupts

You enable the diagnostic interrupts at the basic parameters.

The technology module can trigger the following diagnostic interrupts:

Table 2-1240 Possible diagnostic interrupts

Diagnostic interrupt	Monitoring
• Internal error • Watchdog tripped. Module is defective.	Monitoring is always active. A diagnostic interrupt is triggered each time an error is detected.
• Error • Load voltage missing • Module temporarily unavailable • Short-circuit or overload at encoder supply • Error at the digital outputs • Supply voltage error • Overtemperature	Monitoring is always active. A detected error only triggers a diagnostic interrupt if "Enable diagnostic interrupts" has been enabled in the device parameters. The diagnostic interrupts are not enabled in the default setting.

Reactions to a diagnostic interrupt

The following happens when an event occurs that triggers a diagnostic interrupt:

- The DIAG LED flashes red.

  Once you have remedied the error, the DIAG LED goes out.
- The S7-1500 CPU interrupts processing of the user program. The diagnostic interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.
- The S7-1500 CPU remains in RUN even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible despite the error.

Detailed information on the error event is available with the instruction "RALRM" (read additional interrupt information).

5.3 Diagnostic alarms

Diagnostic alarms

If a diagnostic alarm is pending, the DIAG LED flashes red.

The diagnostics are displayed as plain text in STEP 7 (TIA Portal) in the online and diagnostics view. You can evaluate the error codes with the user program.

The technology module only has one channel as far as diagnostics is concerned. Channel number "0" is therefore displayed for each diagnostic with a few exceptions.

The following diagnostics can be signaled:

Table 2-1241 Diagnostic alarms, their meaning and remedies

Diagnostic alarm	Error code	Meaning	To correct or avoid errors
Error	9_H	• Internal module error occurred • Possible cause: Technology module defective	Replace technology module
Load voltage missing*	11_H	• No technology module L+ supply voltage • Possible cause: BaseUnit type wrong	• Check BaseUnit type • Check the wiring of the supply voltage L+ on the BaseUnit
Module temporarily unavailable*	$1F_H$	• No normal operation of the technology module possible • Possible cause: Technology module is performing a firmware update	Wait until technology module is available again
Internal error	100_H	Technology module defective	Replace technology module
Watchdog tripped. Module is defective.	103_H	Firmware error	Run firmware update
		Technology module defective	Replace technology module
Short-circuit or overload at encoder supply	$10E_H$	• Error at encoder supply • Possible causes: – Short-circuit – Overload	• Check encoder wiring • Check consumers connected to encoder supply
Error at the digital outputs	$10F_H$	• Error at the digital outputs • Possible causes: – Short-circuit – Overload	• Check wiring at the digital outputs • Check consumers connected to the digital outputs
Supply voltage error*	110_H	• Error at supply voltage L+ • Possible causes: – Low voltage – Wiring of L+ supply voltage defective	• Check the L+ supply voltage • Check the wiring of the supply voltage L+ on the BaseUnit
Overtemperature	506_H	• Short-circuit or overload at the digital outputs or outputs of the encoder supplies • Ambient temperature outside specifications	• Check process wiring • Improve cooling • Check connected loads

* This diagnostic alarm is displayed with the channel number "32768".

Technical specifications 6

	6ES7138-6CG00-0BA0
Product type designation	TM Timer DIDQ 10x24V
General information	
BaseUnits that can be used	BU type A0
Product function	
I&M data	Yes; I&M 0
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 Update 3
STEP 7 can be configured/integrated as of version	V5.5 SP3 / -
Supply voltage	
Load voltage L+	
Rated value (DC)	24 V
Low limit of valid range (DC)	19.2 V
High limit of valid range (DC)	28.8 V
Reverse polarity protection	Yes; against destruction
Input current	
Current consumption, max.	50 mA; without load
Encoder supply	
Number of outputs	1
24 V encoder supply	
24 V	Yes; L+ (-0.8 V)
Short-circuit protection	Yes
Output current, max.	500 mA; note derating
Power loss	
Power loss, typ.	1.5 W
Address area	
Occupied address area	
Inputs	26 bytes
Outputs	32 bytes
Digital inputs	
Number of inputs	4
Digital inputs, configurable	Yes
Input characteristics to IEC 61131, Type 3	Yes
Digital input functions, configurable	
Digital input with time stamp	Yes
Number, max.	4
Counter	Yes

	6ES7138-6CG00-0BA0
Number, max.	3
Counter for incremental encoder	Yes
Number, max.	1
Digital input with oversampling	Yes
Number, max.	4
Hardware enable for digital input	Yes
Number, max.	1
Hardware enable for digital output	Yes
Number, max.	3
Input voltage	
Type of input voltage	DC
Rated value, DC	24 V
For signal "0"	-30 V to +5 V
For signal "1"	+11 V to +30 V
Permitted voltage at input, min.	-30 V
Permitted voltage at input, max.	30 V
Input current	
for signal "1", typ.	2.5 mA
Input delay (at rated value of input voltage)	
Minimum pulse width for program reaction	3 µs; with parameter assignment "none"
For standard inputs	
Configurable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 ms)
at "0" to "1", min.	4 µs
at "1" to "0", min.	4 µs
Cable length	
Cable length shielded, max.	1000 m; depending on sensor, cable quality and edge slope
Cable length unshielded, max.	600 m; depending on sensor, cable quality and edge slope
Digital outputs	
Type of digital output	Transistor
Number of outputs	6
M switching	Yes; with high-speed output
Sourcing	Yes
Digital outputs, configurable	Yes
Short-circuit protection	Yes; electronic/thermal
Response threshold, typ.	1.7 A with standard output; 0.5 A with high-speed output
Limiting of inductive shutdown voltage to	-0.8 V
Control of a digital input	Yes
Digital output functions, configurable	
Digital output with time stamp	Yes
Number, max.	6

	6ES7138-6CG00-0BA0
PWM output	Yes
Number, max.	6
Digital output with oversampling	Yes
Number, max.	6
Output switching capacity	
With resistive load, max.	0.5 A; 0.1 A with high-speed output
With lamp load, max.	5 W; 1 W with high-speed output
Load resistance range	
Low limit	48 Ω; 240 Ohm with high-speed output
High limit	12 kΩ
Output voltage	
Type of output voltage	DC
for signal "0", max.	1 V; with high-speed output
for signal "1", min.	23.2 V; L+ (-0.8 V)
Output current	
for signal "1" rated value	0.5 A; 0.1 A with high-speed output, note derating
for signal "1" permissible range, max.	0.6 A; 0.12 A with high-speed output, note derating
for signal "1" minimum load current	2 mA
for signal "0" residual current, max.	0.5 mA
Output delay with resistive load	
"0" to "1", max.	1 µs; for high-speed output, 5 µs with standard output
"1" to "0", max.	1 µs; for high-speed output, 6 µs with standard output
Switching frequency	
With resistive load, max.	10 kHz
With lamp load, max.	10 Hz
Total current of outputs	
Max. current per module	3.5 A; note derating
Cable length	
Cable length shielded, max.	1000 m; depending on load and cable quality
Cable length unshielded, max.	600 m; depending on load and cable quality
Encoders	
Supported encoders	
Incremental encoder (asymmetric)	Yes
24 V initiator	Yes
2-wire sensor	Yes
Permitted quiescent current (2-wire sensor), max.	1.5 mA
Encoder signals, incremental encoders (asymmetrical)	
Input voltage	24 V
Input frequency, max.	50 kHz

	6ES7138-6CG00-0BA0
Counting frequency, max.	200 kHz; with quadruple evaluation
Cable length shielded, max.	600 m; depends on input frequency, encoder and cable quality; max. 200 m with 50 kHz
Incremental encoder with A/B tracks, phase-shifted by 90°	Yes
Pulse encoder	Yes
24 V encoder signal	
Permitted voltage at input, min.	-30 V
Permitted voltage at input, max.	30 V
Interface hardware	
Input characteristics to IEC 61131, Type 3	Yes
Isochronous mode	
Isochronous mode (application synchronized until terminal)	Yes
Bus cycle time (TDP), min.	375 µs
Jitter, max.	1 µs
Interrupts/diagnostics/status information	
Activation of substitute values	Yes
Interrupts	
Diagnostic interrupt	Yes
Diagnostic alarms	
Diagnostics	Yes
Monitoring of supply voltage	Yes
Short-circuit	Yes
LED diagnostics display	
Monitoring of supply voltage (PWR LED)	Yes, green PWR LED
For module diagnostics	Yes; green / red DIAG LED
Integrated functions	
Number of counters	3
Counting frequency (counters), max.	200 kHz; with quadruple evaluation
Counting functions	
Continuous counting	Yes
Electrical isolation	
Electrical isolation channels	
Between the channels and the backplane bus	Yes
Permitted potential difference	
Between different circuits	75 V DC / 60 V AC (basic isolation)
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Operating temperature	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C; note derating

	6ES7138-6CG00-0BA0
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C; note derating
Distributed operation	
At SIMATIC S7-300	Yes
At SIMATIC S7-400	Yes
At SIMATIC S7-1500	Yes
Dimensions	
Width	15 mm
Weights	
Weight, approx.	45 g

Derating information for standardized total current of outputs

If the digital outputs of the TM Timer DIDQ 10x24V are operated with resistive loads, you should derate the standardized total current of the loads at the outputs of the technology module. The standardized total current is the standardized total of the mean output currents at all digital outputs and encoder supply related to its nominal current in each case.

The following derating curve shows the load capacity of the digital outputs depending on the ambient temperature and mounting position:

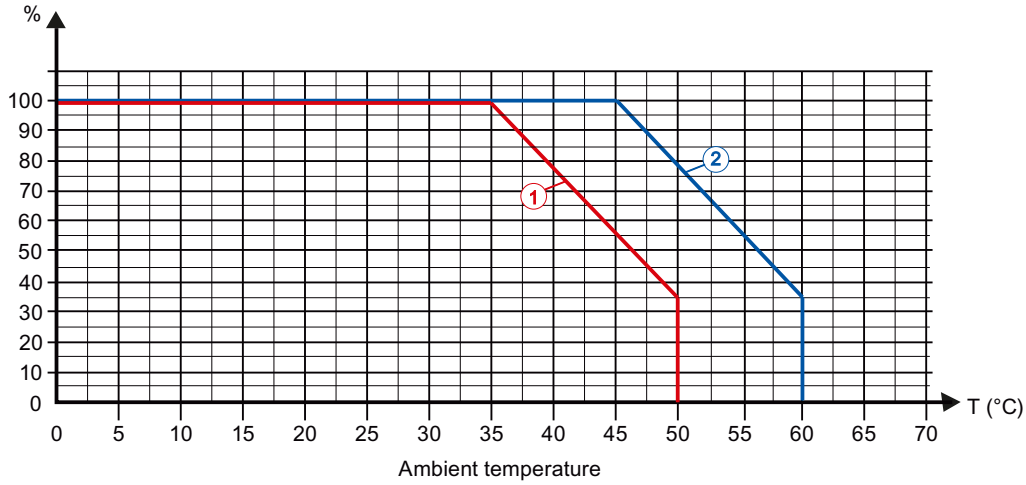

① Vertical installation of the system

② Horizontal installation of the system

Figure 2-1084 Standardized total current depending on ambient temperature and mounting position for resistive loads

NOTE

In the following cases, the voltage at the digital inputs and the load current supply L+ must not exceed DC 24 V + 5 %:

- When the system is mounted vertically, as of an ambient temperature of 35 °C
- When the system is mounted horizontally, as of an ambient temperature of 45 °C

Example

The following example shows the calculation of the standardized total current:

Table 2-1242 Calculation of the standardized total current

Digital output	High-speed output (0.1 A)	Output current		
		Nominal value according to parameter assignment	Mean value	Mean value in relation to the nominal value
DQ0	Yes	0.1 A	0.05 A	50 %
DQ1	Yes	0.1 A	0.08 A	80 %
DQ2	No	0.5 A	0.5 A	100 %
DQ3	No	0.5 A	0.1 A	20 %
DQ4	Yes	0.1 A	0.01 A	10 %
DQ5	No	0.5 A	0.15 A	30 %

Digital output	High-speed output (0.1 A)	Output current		
		Nominal value according to parameter assignment	Mean value	Mean value in relation to the nominal value
Encoder supply	—	0.5 A	0.2 A	40 %
Total				330 %
Standardized total current = total / number of outputs = 330 % / 7 outputs				**47 %**

With a standardized total current of 47 % and horizontal mounting of the system, the ambient temperature according to the derating curve may amount to a maximum of approx. 57 °C .

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

Parameter data record

A

You may edit the module parameters in RUN. The WRREC instruction is used to transfer the parameters to the module using data record 128.

If errors occur during the transfer or validation of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. A corresponding error code is then written to the STATUS output parameter. If no errors occur, the STATUS output parameter contains the length of the actually transferred data.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help (TIA Portal).

Structure of data record

The following table shows you the structure of data record 128 for TM Timer DIDQ 10x24V. The values in byte 0 to byte 3 are fixed and may not be changed.

Table 2-1243 Parameter data record 128

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	**Header**							
0	Reserved[2]		Major Version = 0		Minor Version = 1			
1	Length of the parameter data = 36							
2	Reserved[2]							
3								
4...7	**Basic parameters**							
4	Reserved[2]				PWM period for the digital outputs:			
					0000_B: 10 ms			
					0001_B: 5 ms			
					0010_B: 2 ms			
					0011_B: 1 ms			
					0100_B: 0.5 ms			
					0101_B: 0.2 ms			
					0110 to 1111_B: Reserved			
5	Reserved[2]					Enable diagnostic interrupt[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Keep last value	
							10 to 11_B: Reserved	
6	Reserved[2]							
7								

[1] You enable a specific parameter by setting the corresponding bit to 1.

[2] Must be set to 0.

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
8...9	**Channel parameters for DI0**							
8	Reserved[2]		Invert input signal[1]	Reserved[2]	Operating mode of the digital input:			
					0000_B: Timer-DI			
					0001_B: Reserved			
					0010_B: Oversampling			
					0011_B: Counter			
					0100 to 1111_B: Reserved			
9	Reserved[2]				Input delay / Filter frequency:			
					0000_B: None			
					0001_B: 0.05 ms			
					0010_B: 0.1 ms			
					0011_B: 0.4 ms			
					0100_B: 0.8 ms			
					0101 to 1110_B: Reserved			
					1111_B: 50 kHz			
10...11	**Channel parameters for DI1:** See bytes 8 and 9							
12...13	**Channel parameters for DI2**							
12	Reserved[2]		Invert input signal[1]	HW enable with DI3[1]	Operating mode of the digital input:			
					0000_B: Timer-DI			
					0001_B: Reserved			
					0010_B: Oversampling			
					0011_B: Counter			
					0100_B: Incremental encoder (A, B phase-shifted)			
					0101 to 1111_B: Reserved			
13	Reserved[2]				Input delay / Filter frequency:			
					0000_B: None			
					0001_B: 0.05 ms			
					0010_B: 0.1 ms			
					0011_B: 0.4 ms			
					0100_B: 0.8 ms			
					0101 to 1110_B: Reserved			
					1111_B: 50 kHz			
14...15	**Channel parameters for DI3**							
14	Reserved[2]		Invert input signal[1]	Reserved[2]	Operating mode of the digital input:			
					0000_B: Timer-DI			

[1] You enable a specific parameter by setting the corresponding bit to 1.

[2] Must be set to 0.

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
14	Reserved[2]		Invert input signal[1]	Reserved[2]	0001_B: Reserved			
					0010_B: Oversampling			
					0011 to 1111_B: Reserved			
15	Reserved[2]				Input delay:			
					0000_B: None			
					0001_B: 0.05 ms			
					0010_B: 0.1 ms			
					0011_B: 0.4 ms			
					0100_B: 0.8 ms			
					0101 to 1111_B: Reserved			
16...17	**Channel parameters for DQ0**							
16	High-speed output (0.1 A)[1]	Substitute value	Invert output signal[1]	HW enable with next digital input[1]	Operating mode of the digital output:			
					0000 to 0111_B: Reserved			
					1000_B: Timer DQ			
					1001_B: Reserved			
					1010_B: Oversampling			
					1011_B: PWM			
					1100 to 1111_B: Reserved			
17	Reserved[2]							
18...19	**Channel parameters for DQ1:** See bytes 16 and 17							
20...21	**Channel parameters for DQ2:** See bytes 16 and 17							
22...23	**Channel parameters for DQ3**							
22	High-speed output (0.1 A)[1]	Substitute value	Invert output signal[1]	Reserved[2]	Operating mode of the digital output:			
					0000 to 0111_B: Reserved			
					1000_B: Timer DQ			
					1001_B: Reserved			
					1010_B: Oversampling			
					1011_B: PWM			
					1100 to 1111_B: Reserved			
23	Reserved[2]							
24...25	**Channel parameters for DQ4:** See bytes 22 and 23							
26...27	**Channel parameters for DQ5:** See bytes 22 and 23							
28...39	Reserved[2]							

[1] You enable a specific parameter by setting the corresponding bit to 1.

[2] Must be set to 0.

Counting

The following table shows the properties for counting that you can set in the channel parameters of the respective digital input:

Operating mode for counting	Usable digital inputs	"Invert input signal" set to...	
		0	1
Counter (0011_B)	• DI0 • DI1 • DI2	Counting of **rising** edges	Counting of **falling** edges
Incremental encoder (A, B phase-shifted) (0100_B)	DI2 with DI3 (all bits of the channel parameters for DI3 are set to 0)	Counting direction **not inverted**	Counting direction **inverted**

Hardware enable (HW enable)

You can use a hardware enable by an enable input for the operating modes "Timer DI" and "Timer DQ". You set a hardware enable with bit 4 of the respective channel parameter.

You can set a hardware enable for the following inputs and outputs:

Digital input / digital output	Hardware enable by digital input...
DI2	DI3
DQ0	DI0
DQ1	DI1
DQ2	DI2

You set a hardware enable with the channel parameters of the enable input "Operating mode" and "Invert" signal input:

Operating mode	"Invert input signal" set to...	
	0	1
Oversampling (0010_B)	Hardware enable by **High** level	Hardware enable by **Low** level
Timer DI (0000_B)	When using the SIMOTION control system only	

Input filter

The following overview shows the input filters that can be set for specific operating modes of a digital input:

Table 2-1244 Setting options for the input filter

Operating mode of the digital input	Type of input filter	Assignable values
• Timer DI (0000_B) • Oversampling (0010_B)	Input delay	• None • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms

Operating mode of the digital input	Type of input filter	Assignable values
• Counter (0011_B) • Incremental encoder (A, B phase-shifted) (0100_B)	Filter frequency	50 kHz (cannot be changed)

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/**
* @file splay_tree_.hpp
* Contains an implementation class for splay_tree_.
*/
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SIEMENS

SIMATIC

ET 200SP
Technology module TM PTO 2x24V (6ES7138-6EB00-0BA0)

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Parameter data record A

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Preface

Purpose of the documentation

This manual includes module-specific information on wiring, diagnostics and the technical specifications of the technology module.

You can find information that pertains generally to the configuration and commissioning of the ET 200SP in the ET 200SP system manual.

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Documentation guide

1

1.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

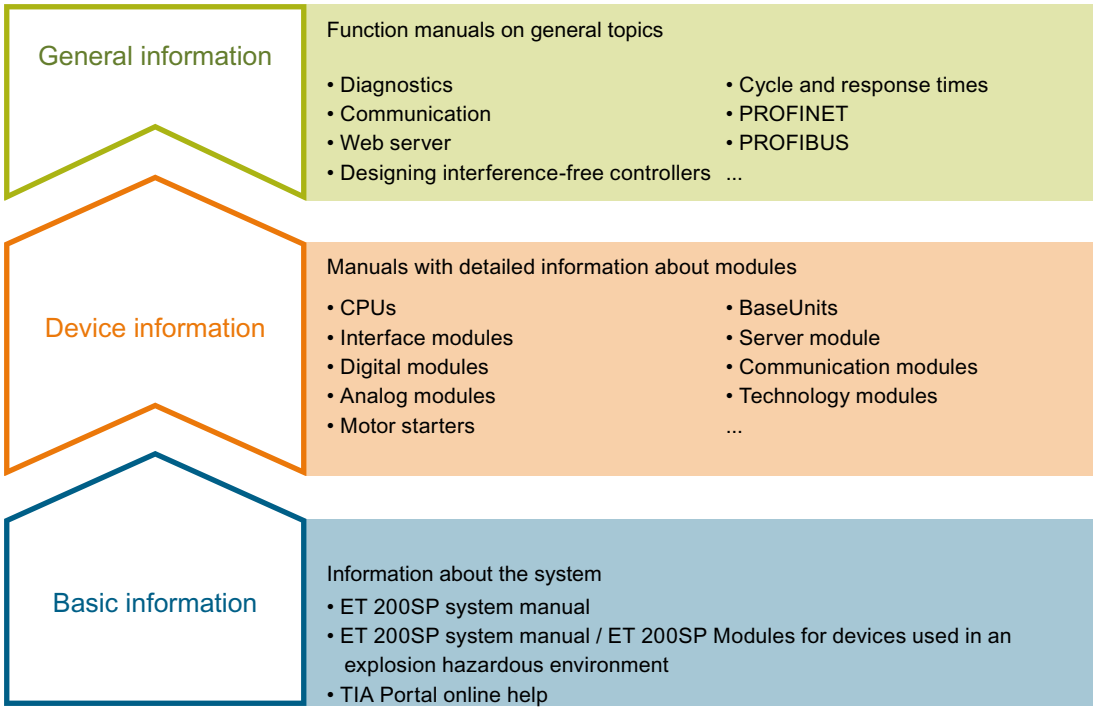

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

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"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

MultiFieldbus Configuration Tool (MFCT)

The MultiFieldbus Configuration Tool (MFCT) is used to configure and assign parameters for MultiFieldbus devices (e.g. IM 155-6 MF HF). You load the configuration and parameter assignment into the MF device with MFCT.

You can also use MFCT to update the firmware of MF devices and modules.

You can find MFCT on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109773881).

Product overview

2

2.1 Properties

Article number

6ES7138-6EB00-0BA0

View of the module

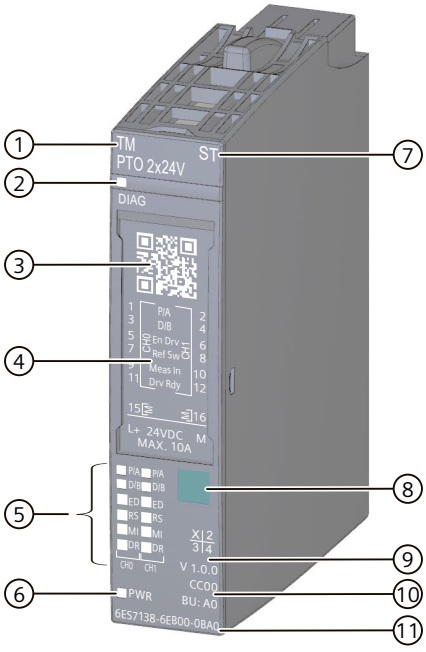

① Module type and designation
② LED for diagnostics
③ 2D matrix code for reading article and serial numbers
④ Terminal diagram
⑤ LEDs for channel status
⑥ LED for supply voltage
⑦ Function class
⑧ Module type color coding
⑨ Function and firmware version
⑩ Color code for selection of the color-coded labels and BaseUnit type
⑪ Article number

Figure 2-1085 View of the TM PTO 2x24V module

Introduction

The technology module offers you the possibility to connect up to two stepper motor axes to an ET 200SP system. The module is linked to technology objects by means of an implementation of the PROFIdrive telegrams 1 and 81 and forms the interface to the drive. The number of steps that are output is returned as the actual position value.

Properties

The TM PTO 2x24V technology module has the following properties:

- Technical properties
  - 2 channels, channel-by-channel configuration
  - Interfaces:

    24 V pulse output signals pulse (P), direction (D) or A, B for the PTO function (per channel, max. 200 kHz for single evaluation, max. 800 kHz for quadruple evaluation)

    Digital input signal RS for the reference switch function (per channel)

    Digital input signal MI for the measuring input function (per channel)

    Digital input signal DR for the Ready input function (per channel)

    Digital output signal ED for the drive enable function (per channel)

    Supply voltage L+
  - Configurable diagnostics (per channel)
  - Configurable pulse pause on reversal of direction
  - Configurable input delay: none, 0.05 ms ... 20 ms
- Supported signal types for pulse output
  - Pulse output with direction signal
  - Pulse output with forward signal and backward signal
  - Pulse output with two signals with a 90° phase shift

The module supports the following functions:

Table 2-1245 Configurability of the functions

Function	Firmware version of the module	Configurable as of		
		STEP 7 (TIA Portal) V17 with HSP0341	GSD	
			PROFINET IO	PROFIBUS DP
Firmware update	V1.0 or higher	X	X	—
I&M identification data	V1.0 or higher	X	X	X
Parameter reassignment in RUN	V1.0 or higher	X	X	X
Isochronous mode	V1.0 or higher	X	—	—

Function	Firmware version of the module	Configurable as of		
		STEP 7 (TIA Portal) V17 with HSP0341	GSD	
			PROFINET IO	PROFIBUS DP
Centralized operation on CPU 151xSP	V1.0 or higher	X	—	—
Pulse Train Output with single and quadruple evaluation	V1.0 or higher	X	X	X
Operating with technology objects TO_SpeedAxis, TO_PositioningAxis, TO_SynchronousAxis, TO_MeasuringInput:	V1.0 or higher	X	—	—

Accessories

A **BaseUnit** of **type A0** is needed for operation of the technology module. For an overview of the BaseUnits to be used with the technology module, refer to the product information on the documentation for the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

For additional information on the accessories, refer to the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.2 Functions

2.2.1 Pulse Train Output (PTO)

Applications

Pulse Train Output is a simple and universal interface between a SIMATIC controller and a drive. PTO is supported worldwide by many stepper and servo drives and is used in many positioning applications, such as for adjustment axes and feed axes.

PTO is also referred to as the pulse/direction interface. The pulse/direction interface comprises two signals. The frequency of the pulse output represents the speed and the number of pulses that are output represents the distance to be traversed. The direction output defines the traversing direction. The position specification is thereby accurate to within one increment. The pulse/direction interface is especially well-suited for operation with the technology objects TO_SpeedAxis, TO_PositioningAxis and TO_SynchronousAxis. TO_MeasuringInput can be used to detect measuring inputs on the drive axis.

Control

The control of the pulse output channels is provided above all with S7-1500 Motion Control by means of the technology objects TO_SpeedAxis, TO_PositioningAxis and TO_SynchronousAxis . The control and feedback interface (Page 25) of the channels is an implementation of the PROFIdrive interface with standard telegrams 1 and 81.

For a detailed description of configuring the technology module with the axis technology objects, see Function Manual S7-1500T Motion Control, section "Configuring", which is available for download on theInternet (https://support.industry.siemens.com/cs/ww/en/view/109481326).

Signal types

The technology module supports the following four signal types:

NOTE

The pulse width is fixed depending on the maximum pulse frequency set for the respective channel.

- PTO (Pulse (P) and direction (D)):
  One output (P) controls the pulses and one output (D) controls the direction. D is 'high' (active) when pulses are generated in the negative direction. D is 'low' (inactive) when pulses are generated in the positive direction.

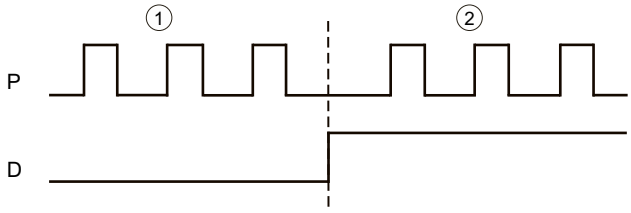

① Positive direction of rotation
② Negative direction of rotation

- PTO (count up (A), count down (B)):
  One output (A) outputs pulses for positive directions and another output (B) outputs pulses for negative directions.

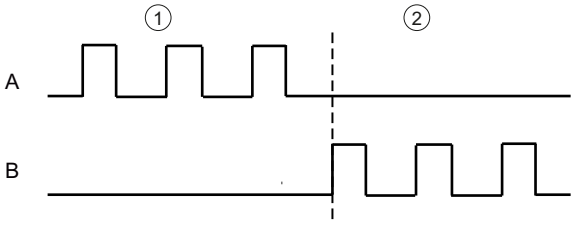

① Positive direction of rotation
② Negative direction of rotation

- PTO (A, B phase-shifted):
  Output pulses are output by both outputs at the specified velocity, but phase-shifted by 90 degrees. This involves a *single* pulse output in which the duration of the pulse is the time between two transitions of signal A while signal B is at low level.
  A positive direction of rotation is generated at a positive edge of signal A while signal B is in low state. A negative direction of rotation is generated at a negative edge of signal A while signal B is in low state.

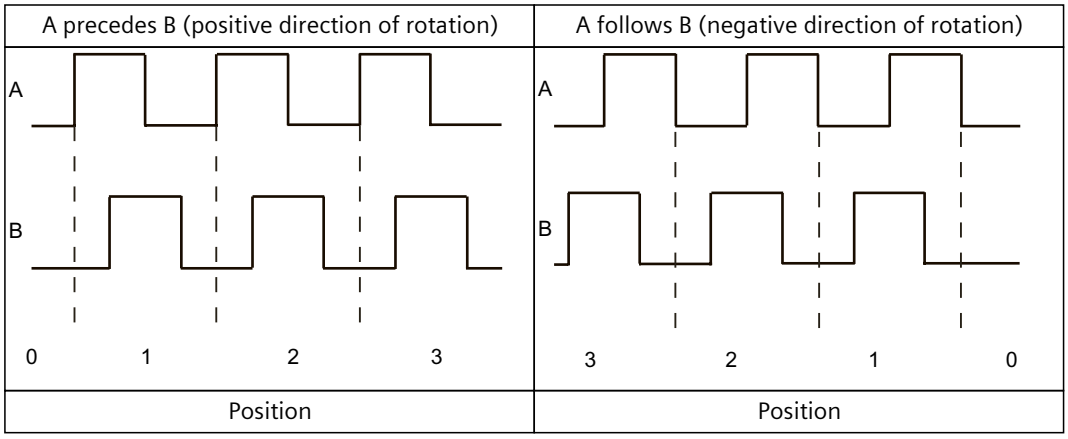

- PTO (A, B phase-shifted, quadruple)
  Output pulses are output by both outputs at the specified velocity, but phase-shifted by 90 degrees. This signal type involves a *quadruple* pulse output in which each edge transition corresponds to one increment. Therefore, a complete period of signal A contains four increments. In this way, it is possible, for example, to use two outputs, each with 100 kHz signal frequency, to output a control signal that supplies 400,000 increments per second.
  Whether count pulses are generated in the positive or negative direction of rotation depends on the edge direction of one signal and the logic state of the other signal in each case.

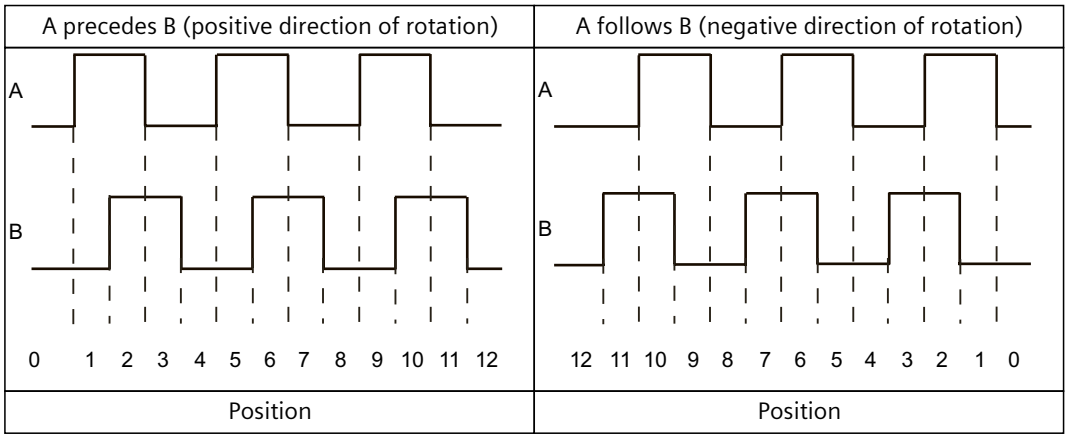

Connecting 3

3.1 Pin assignment

The TM PTO 2x24V technology module is used with a BaseUnit of type A0 (article number 6ES7193-6BPx0-0xA0).

Connect the pulse output signals, digital input signals and digital output signals to the BaseUnit of the technology module. The supply voltage feed on the light-colored BaseUnit BU...D of the associated potential group supplies the module and the digital outputs.

BaseUnit

The BaseUnit is not included in the scope of delivery of the module and must be ordered separately.

For an overview of the BaseUnits to be used with the technology module, refer to the product information on the documentation for the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

You can find information about selecting a suitable BaseUnit in the ET 200SP Distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) equipment manual.

You can find information on wiring the BaseUnit, connecting cable shields, etc. in the Wiring section of the ET 200SP Distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Supply voltage L+/M

With a light-colored BaseUnit, you connect the supply voltage to the L+ and M terminals. With a dark BaseUnit, the supply voltage of the left-hand module is used. An internal protective circuit protects the technology module from polarity reversal of the supply voltage. The technology module monitors the connection of the supply voltage.

Pin assignment of BaseUnit

The table below shows the terminal assignment, using the BaseUnit BU15-P16+A0+2B as an example.

Table 2-1246 Terminal assignment of the BaseUnit BU15-P16+A0+2B

Designation	Signal name		View	Signal name		Designation
Channel 0				**Channel 1**		
Pulse signal P/A	CH0.P/A	1		2	CH1.P/A	Pulse signal P/A
Pulse signal D/B	CH0.D/B	3		4	CH1.D/B	Pulse signal D/B

Designation	Signal name		View	Signal name		Designation
DQ Enable Drive	CH0.ED	5	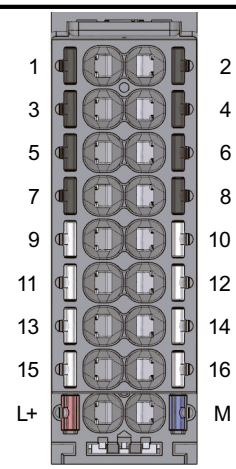	6	CH1.ED	DQ Enable Drive
DI Reference Switch	CH0.RS	7		8	CH1.RS	DI Reference Switch
DI Measuring Input	CH0.MI	9		10	CH1.MI	DI Measuring Input
DI Drive Ready	CH0.DR	11		12	CH1.DR	DI Drive Ready
Supply voltage and ground of both channels				**Ground of both channels**		
Ground for digital outputs, digital inputs and pulse signals of the technology module	M	13		14	M	Ground for digital outputs, digital inputs and pulse signals of the technology module
	M	15		16	M	
24 V DC supply voltage	L+				M	Ground for supply voltage

Behavior of the digital outputs following a wire break at the ground connection of the outputs

Due to the characteristics of the output driver used in the module, a wire break causes approximately 10 mA supply current to drain from the digital outputs via a parasitic diode. This behavior may lead to a high signal state even at outputs that are not set. Depending on the nature of the load, 10 mA may be enough to activate a load with high signal state.

Duplicate wiring of ground

To prevent unintended switching of the outputs in the event of a ground connection wire break, follow these steps:

1. Route the first ground connection from terminal M to the ground connection of the central power supply of the plant.
2. Route the second ground connection from terminal 16 to the ground connection of the central power supply of the plant.

If one of the two ground connection cables is interrupted, the outputs are maintained at the required potential by the remaining ground connection.

⚠ WARNING

Wire break at ground connection

Always connect *two* cables to the ground connection of the central power supply of the system.

Circuit diagram

You must ground the shields of the cables between the motor and the technology module via the shield connection to the BaseUnit (shield support and terminal).

The figure below shows the block diagram of the technology module with an example using both channels.

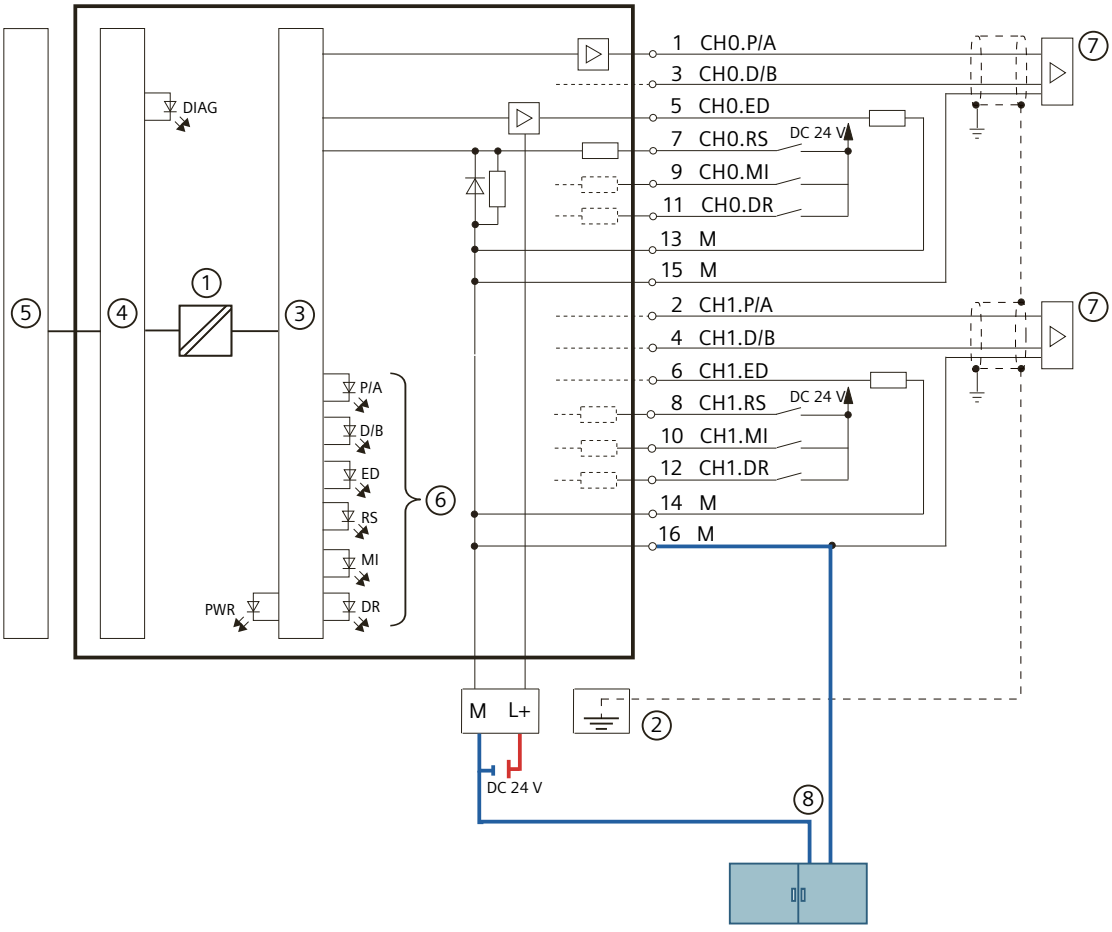

① Electrical isolation
② Shield support on the BaseUnit
③ Technology
④ Backplane bus interface module of the technology module
⑤ Backplane bus
⑥ LEDs per channel
⑦ Motor with drive stage
⑧ Duplicate wiring to the ground connection of the central power supply of the system

Figure 2-1086 Circuit diagram

24 V pulse output signals

The technology module can output the 24 V pulse signals P/A and D/B per channel.

For an overview of the signal types you can output, see section Pulse Train Output (PTO) (Page 11). Connect the P/A signal to the CHn.P/A digital output and the D/B signal to the digital output CHn.D/B.

The outputs of the channels are not electrically isolated from each other. The outputs are electrically isolated from the backplane bus.

NOTE

Use shielded cables for the pulse signals P/A and D/B.

Digital inputs RS, MI and DR

Three digital inputs are available per channel. The digital inputs are used for additional functions for the respective drive control:

Digital input	Function	Meaning
CHn.RS	Reference switch input (Reference Switch)	You can use a reference switch at digital input CHn.RS to synchronize the current position of the drive axis with the reference mark. CHn.RS is used by the axis technology object to perform the Homing function.
CHn.MI	Measuring input (Measuring Input)	You can use a measuring input at digital input CHn.MI to save the current position of the drive axis. CHn.MI is used by the TO_MeasuringInput technology object.
CHn.DR	"Drive ready" input (Drive Ready)	You can use the digital input CHn.DR as input for the ready signal of the drive. The signal at CHn.DR is included in the PROFIdrive telegram for feedback to the axis technology object.

The digital inputs of the channels are not electrically isolated from each other. The digital inputs are electrically isolated from the backplane bus.

Interpulse period following auto reverse

You can configure the minimum amount of time the technology module must pause the pulse output following reversal of the direction of rotation. After the interpulse period elapses, the pulse output is resumed.

You can specify the following values for the interpulse period:

- 0 ms (default)
- 1 ms
- 4 ms
- 10 ms

Input delay for digital inputs

To suppress interference, you can configure an input delay for the digital inputs.

NOTE

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

Digital output ED

One digital output per channel is available. You can use the digital output CHn.ED to enable the drive.

The digital outputs of both channels are not electrically isolated from each other. The digital output CHn.ED is electrically isolated against the backplane bus.

The digital outputs are 24 V sourcing outputs in reference to ground. CHn.ED can carry a rated load current of 0.5 A. The digital output is protected against overload and short-circuit.

If you enable the use of the CHn.ED, the axis technology object can use it to set the drive to ready. If the drive is to report readiness, connect the ready signal to the CHn.DR digital input for this.

Relays and contactors can be connected direct without external circuitry. You can find information on the maximum possible operating frequencies and the inductive loads at the digital outputs in the section Technical specifications (Page 40).

Configuring/address space

4

4.1 Configuring

Introduction

The technology module is configured and assigned parameters with the configuration software.

The user program controls and monitors the functions of the technology module via Motion Control instructions or via the control and feedback interface.

System environment

The technology module can be used in the following system environments:

Possible applications	Components required	Configuration software	In the user program
Centralized operation with a CPU 151xSP	• ET 200SP automation system • TM PTO 2x24V	STEP 7 (TIA Portal): • Device configuration and parameter setting with hardware configuration • Parameter setting with axis technology object for Motion Control	Motion Control instructions
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM PTO 2x24V	STEP 7 (TIA Portal): • Device configuration and parameter setting with hardware configuration • Parameter setting with axis technology object for Motion Control	
Distributed operation with an S7-1200 CPU	• S7-1200 automation system • ET 200SP distributed I/O system • TM PTO 2x24V	STEP 7 (TIA Portal): • Device configuration and parameter setting with hardware configuration • Parameter setting with TO_PositioningAxis technology object	
Distributed operation with an S7-300/400 CPU	• S7-300/400 automation system • ET 200SP distributed I/O system • TM PTO 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to control and feedback interface (Page 25) of the technology module
Distributed operation in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM PTO 2x24V	Third-party configuration software: Device configuration and parameter setting of the module with GSD file	

Control using a technology object

For a detailed description of configuring the technology module with the technology objects TO_SpeedAxis, TO_PositioningAxis, TO_SynchronousAxis and TO_MeasuringInput, refer to the following:

- Function Manual S7-1500T Motion Control, section "Configuring", which is available for download on theInternet (https://support.industry.siemens.com/cs/ww/en/view/109481326)
- Information system of STEP 7 (TIA Portal), under "Using technology functions > Motion Control > Motion Control (S7-1200, S7-1500, S7-1500T) > Configuring (S7-1500, S7-1500T) > Configuring technology modules for Motion Control (S7-1500, S7-1500T)"

Hardware Support Package (HSP)

If the technology module is not yet integrated in your TIA Portal version, you can integrate it as of TIA Portal V17 with HSP0341.

The Hardware Support Packages (HSP) are available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).

Alternatively, they can be accessed for downloading via the menu bar of STEP 7 (TIA Portal): "Options > Support Packages > Download from the Internet".

GSD file

The respective GSD file for the ET 200SP distributed I/O system is available for download on the Internet:

GSD file PROFINET IO (https://support.industry.siemens.com/cs/ww/en/view/68189683)

GSD file PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/73016883)

Control via user program without technology object

You can find a description of the control and feedback signals as well as a state diagram for enabling the pulse output without technology object in section Control and feedback interface (Page 25).

4.2 Parameter setting

You can use various parameters to define the properties of the technology module. Depending on the settings, not all parameters are available. When parameters are assigned in the user program, the parameters are transferred to the module with the "WRREC" instruction and data record 128 (Page 45).

You have the following options for setting the module's parameters:

Parameter setting via ...	Basic procedure
Hardware configuration in STEP 7 (TIA Portal)	1. Insert the module from the hardware catalog under "Technology modules". 2. Set the device configuration and the parameters of the module in the hardware configuration. 3. Set the parameters of the technology object. 4. Download the project to the CPU.
Hardware configuration using GSD file for distributed operation on the PROFINET IO	1. Install the latest PROFINET GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFINET IO > I/O". 2. Set the parameters in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration using GSD file for distributed operation on the PROFIBUS DP	1. Install the latest PROFIBUS GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFIBUS DP > I/O". 2. Set the parameters in the hardware configuration. Only the parameters marked with [1] in the following table can be set in the PROFIBUS GSD file. 3. Download the project to the CPU. The parameters that are not marked with [1] in the following table are downloaded with their default setting. 4. If necessary, set the parameters not marked with [1] in the user program using data record 128.

You will find the parameters in the following table.

Parameters of the TM PTO 2x24V

The following parameter settings are possible. The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1247 Programmable parameters

Parameter	Value range	Scope
Potential group[1]	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Signal type	• **PTO (Pulse (P) and direction (D))** • PTO (count up (A), count down (B)) • PTO (A, B phase-shifted) • PTO (A, B phase-shifted, quadruple)	Channel

[1] Due to the limited number of parameters at a maximum of 244 bytes per station with a PROFIBUS GSD configuration, the configuration options are restricted. This parameter is visible. The other parameters are preassigned in the module with the default setting. If your PROFIBUS master supports the "Read/write data record" function, you can set the other parameters using data record 128.

Parameter	Value range	Scope
Interpulse period following auto reverse	• **0 ms** • 1 ms • 4 ms • 10 ms	Channel
Enable diagnostic interrupts	• **Deactivated** • Enabled	Channel
Increments per revolution	1...**200**...1000000	Channel
Reference speed	1.0...**3000.0**...20000.0 rpm	Channel
Bits in incr. Actual value (G1_XIST1)	**0** (read-only)	Channel
Maximum speed	Depending on signal evaluation, increments per revolution and reference speed (see following table): **3000.0** rpm	Channel
Quick stop time (OFF3)	1...**1000**...65535 ms	Channel
Ramp stop time (OFF1)	1...**5000**...65535 ms	Channel
Use ED as Enable Drive	• **Deactivated** • Enabled	Channel
Use RS as reference switch	• **Deactivated** • Enabled	Channel
Reference switch edge selection	• **At positive edge** • At negative edge	Channel
Use MI as measuring input	• **Deactivated** • Enabled	Channel
Use DR as Drive Ready	• **Deactivated** • Enabled	Channel
Input delay	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel
Tolerated number of sign-of-life errors	0...**1**...65535	Channel

[1] Due to the limited number of parameters at a maximum of 244 bytes per station with a PROFIBUS GSD configuration, the configuration options are restricted. This parameter is visible. The other parameters are preassigned in the module with the default setting. If your PROFIBUS master supports the "Read/write data record" function, you can set the other parameters using data record 128.

The following table shows the calculation of the value range of the maximum speed:

Value range of the maximum speed			
Low limit		High limit (the smaller of the two values applies)	
Signal evaluation "Single"	Signal evaluation "Quadruple"	Signal evaluation "Single"	Signal evaluation "Quadruple"
0.1 Hz * 60 / (increments per revolution)	0.1 Hz * 60 *4 / (increments per revolution)	• 2 * reference speed • 200000 Hz * 60 / (increments per revolution)	• 2 * reference speed • 200000 Hz * 60 *4 / (increments per revolution)

Description of parameters

Parameter	Description
Potential group	A potential group consists of a group of I/O modules placed directly next to each other within an ET 200SP station, which are supplied via a common supply voltage. A potential group begins with a light-colored BaseUnit, which feeds in the required supply voltage for all modules of the potential group. The light-colored BaseUnit interrupts the three self-configuring voltage bars P1, P2 and AUX to the neighboring module on the left. All additional I/O modules of this potential group are placed on dark BaseUnits. They take over the potentials of the self-configuring voltage bus P1, P2 and AUX from the left neighbor. A potential group ends with the dark BaseUnit, which is followed by a light BaseUnit or server module in the station configuration.
Signal type	Selection of the type of PTO pulse output (Page 11).
Interpulse period following auto reverse	Selection of the minimum time between a change in direction and the output of the first pulse in the new direction.
Enable diagnostic interrupts	Enables the following diagnostic interrupts (Page 38): • Supply voltage missing: The detected error is displayed for the respective channel with the feedback bit (Page 28) Parking_Sensor_Active. • Error at digital outputs: The detected error is also displayed for the respective channel with the feedback bits (Page 28) Fault_Present and Sensor_Error.
Increments per revolution	Input of the number of steps (also micro steps) that correspond to one revolution of the drive. This parameter must match the "Increments per revolution" parameter in the "Data exchange with encoder" tab of the axis technology object.
Reference speed	Input of the speed at which the drive rotates with a speed setpoint of 100%. The permitted value range for the speed setpoint is -200% ... +200%. This parameter must match the "Reference speed" parameter in the "Data exchange with drive" tab of the axis technology object.
Maximum speed	Input of the maximum permitted speed for the application. The value must not exceed twice the reference speed. This parameter must match the "Maximum speed" parameter in the "Data exchange with drive" tab of the axis technology object.

Parameter	Description
Bits in incr. actual value (G1_XIST1)	Specifies the number of bits for the fine resolution coding in the incremental actual position value G1_XIST1. The value is always "0" for this module. This parameter must match the "Bits in incr. actual value (Gn_XIST1)" parameter in the "Data exchange with encoder" tab of the axis technology object.
Quick stop time (OFF3)	Input of the time taken to execute a fast stop from maximum speed to standstill.
Ramp stop time (OFF1)	Input of the time taken to execute a stop from maximum speed to standstill.
Use ED as Enable Drive	Enables use of the drive enable signal at the Digital output ED (Page 14).
Use RS as reference switch	Enables use of the reference switch signal at the Digital input RS (Page 14). You can synchronize the actual position of the drive axis with the reference mark via the reference switch signal.
Use MI as measuring input	Enables use of the measuring input signal at the Digital input MI (Page 14). You can save the current position of the drive axis using the measuring input signal with the technology object TO_MeasuringInput.
Use DR as Drive Ready	Enables use of the ready signal of the drive at Digital input DR (Page 14).
Input delay	Selection of the input delay for the signal at the respective digital input for noise suppression. Changes to the signal are only detected if they remain stable for longer than the configured input delay time. The input delay applies to all the used hardware inputs of the channel.
Tolerated number of sign-of-life errors	Input of how many Master Sign-Of-Life errors are tolerated by the module. If the number is exceeded, this triggers an error message via return bit (Page 28) Sensor_Error. 65535 means: No monitoring for sign-of-life errors

4.3 Address space

Address space of the technology module

Table 2-1248 Range of the input addresses and output addresses of the TM PTO 2x24V

	Inputs	Outputs
Range per channel	16 bytes	8 bytes
Total range	32 bytes	16 bytes

Additional information

For a description of the control and feedback interface of the technology module, see section Control and feedback interface (Page 25).

4.4 Control and feedback interface

Direct access to the control and feedback interface (input and output data) is not needed for use of the module in an ET 200SP, S7-1500 or S7-1200 system. For this case, an ET 200SP or S7-1500 system has the TO_SpeedAxis, TO_PositioningAxis and TO_SynchronousAxis technology objects, and an S7-1200 system has the TO_PositioningAxis technology object. For a detailed description of configuring the technology module with the axis technology objects, see Function Manual S7-1500T Motion Control, section "Configuring", which is available for download on theInternet (https://support.industry.siemens.com/cs/ww/en/view/109481326).

The control and feedback interface of the channels is a partial implementation of the PROFIdrive interfaces "Telegram 1" und "Telegram 81".

4.4.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface

The following table shows control interface assignment based on the PROFIdrive telegrams. Unsupported functions within PROFIdrive are marked accordingly.

Table 2-1249 Control interface of the technology module

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
		STW1: INT: Control word 1							
0	**8**	Reserved[1]					Control_by_PLC	Reserved[1]	
1	**9**	Fault_Acknowledge	Enable_Setpoint	Unfreeze_Ramp_Generator[6]	Enable_Ramp_Generator	Enable_Operation	No_Quick_Stop_OFF3	No_Coast_Stop_OFF2	On_OFF1
2 ... 3	**10 ... 11**	**NSOLL_A:** INT: Standardized speed setpoint in N2 format							

1 Must be set to 0.

2 This command is not supported by the module. If you set the bit, error code $F01_H$ is returned in G1_XIST2.

3 This command is not supported by the module. If you set the bit, error code 8_H is returned in G1_XIST2.

4 This command is not supported for the "Acquire measuring input value" function. If you set the bit, error code 6_H is returned in G1_XIST2.

5 This command is not supported for the "Detect reference mark" function. If you set the bit, error code 4_H is returned in G1_XIST2.

6 This command is not supported by the module. The bit is not evaluated.

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
		STW2_ENC: INT: Control word 2							
4	**12**	Master_Sign-Of-Life				Reserved[1]			
5	**13**	Reserved[1]							
		G1_STW: INT: Encoder control word							
6	**14**	Acknowledging_Sensor_Error	Activate_Parking_Sensor	Request_Absolute_value_Cyclically[3]	Request_Set_Home_Position[2]	Home_Position_Mode[2]	Reserved[1]		
7	**15**	Mode	Command_2-_Request	Command_1-_Request	Command_0-_Request	Function_4_Request [4,5]	Function_3_Request [4,5]	Function_2_Request [5]	Function_1_Request

1 Must be set to 0.

2 This command is not supported by the module. If you set the bit, error code $F01_H$ is returned in G1_XIST2.

3 This command is not supported by the module. If you set the bit, error code 8_H is returned in G1_XIST2.

4 This command is not supported for the "Acquire measuring input value" function. If you set the bit, error code 6_H is returned in G1_XIST2.

5 This command is not supported for the "Detect reference mark" function. If you set the bit, error code 4_H is returned in G1_XIST2.

6 This command is not supported by the module. The bit is not evaluated.

Description of control bits

Control bit/value	Description
STW1	
Control_by_PLC	0_B: Coast Stop (OFF2): Pulse output cannot be controlled by the user program on the CPU. 1_B: Valid values for control of the pulse output will be sent to the module from the user program on the CPU.
On_OFF1	0_B: OFF1: Depending on the speed, the drive stops at the latest within the configured ramp stop time. The pulse output returns to state S2 (Page 33). If you are using a drive enable, the digital output CHn.ED is reset next. 1_B: Pulse output is switched on.
No_Coast_Stop_OFF2	0_B: Coast Stop (OFF2): The pulse output is stopped and returns to state S1 (Page 33). If you are using a drive enable, the digital output CHn.ED is reset immediately. 1_B: The "Coast Stop (OFF2)" command is withdrawn.
No_Quick_Stop_OFF3	0_B: Quick stop (OFF3): Depending on the speed, the drive stops at the latest within the configured quick stop time. The pulse output is stopped and returns to state S1 (Page 33). If you are using a drive enable, the digital output CHn.ED is reset next. 1_B: The "Quick stop (OFF3)" command is withdrawn.

1 The exact maximum speed setpoint is $+(200 - 2^{-14})\%$

Control bit/value	Description
Enable_Operation	0_B: The pulse output returns to state S3 (Page 33). 1_B: Pulse output is enabled. The drive accelerates to the speed setpoint.
Enable_Ramp_Generator	0_B: The pulse output is stopped but remains in state S4 (Page 33). 1_B: Each speed change is controlled along on a ramp by the ramp generator.
Enable_Setpoint	0_B: The ramp generator stops the drive within the configured ramp stop time. State S4 (Page 33) is retained. 1_B: The speed setpoint is specified in NSOLL_A for the ramp generator.
Fault_Acknowledge	You use this bit to acknowledge an error.
NSOLL_A	
NSOLL_A	You use this INT value to specify the setpoint for the drive axis velocity as a percentage in N2 format. N2 is a data type used for PROFIdrive to standardize values. The permitted value range for the speed setpoint is -200% ... +200%[1] of the reference speed. The value is a linear representation of the value range. This means 100% corresponds to the value 4000_H. The resolution is 0.0061%.
STW2_ENC	
Master_Sign-Of-Life	You must set this value to 0.
G1_STW	
Activate_Parking_Sensor	You use this bit to activate a sensor pause. This causes the value "0" to be returned in G1_XIST1.
Acknowledging_Sensor_Error	You use this bit to acknowledge an error that occurred during feedback of the actual encoder value.
Mode	0_B: Reference mark search: Detect reference mark using the configured edge of reference switch input CHn.RS 1_B: Measurement on the fly: Acquire measuring input value via measuring input CHn.MI
Command_0_Request, Command_1_Request, Command_2_Request	You use this value to specify how the function selected with the Mode bit will be used: 000_B: Do nothing 001_B: Enable function 010_B: Read out value in G1_XIST2 011_B: Disable function 100 to 111_B: Invalid
Function_1_Request	Mode = 0 (Reference mark search): With the configured edge (Page 45) at CHn.RS, the reference mark is to be acquired and shown in G1_XIST2. Mode = 1 (Measurement on the fly): With the rising edge at CHn.MI, a measuring input value is to be acquired and shown in G1_XIST2.
Function_2_Request	You use this bit to specify that a measuring input value is to be acquired using the negative edge of digital input CHn.MI.

[1] The exact maximum speed setpoint is $+(200 - 2^{-14})\%$

4.4.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module by means of the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Table 2-1250 Feedback interface of the technology module

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
		ZSW1: INT: Status word 1							
0	**16**	Reserved					f_or_n_ reached_or_ exceeded	Control_ Requested	Reserved
1	**17**	Reserved	Switching_ On_ Inhibited	Quick_Stop_ Not_ Activated_ OFF3	Coast_Stop_ Not_ Activated_ OFF2	Fault_ Present	Operation_ Enabled	Ready_To_ Operate	Ready_To_ Switch_On
2 … 3	**18 … 19**	**NIST_A:** INT: Current standardized actual speed value in N2 format							
		ZSW2_ENC: INT: Status word 2							
4	**20**	Slave_Sign-Of-Life				Reserved			
5	**21**	Reserved							
		G1_ZSW: INT: Encoder status word							
6	**22**	Sensor_ Error	Parking_ Sensor_ Active	Transmit_ Absolute_ Value_ Cyclically[1]	Reserved	Require ment_of_ Acknow ledgement_ Detected	Reserved		Probe_1_ Deflected
7	**23**	Reserved		Value_2_ Active	Value_1_ Active	Reserved		Function_2_ Active	Function_1_ Active
8 … 11	**24 … 27**	**G1_XIST1:** DINT: Current actual encoder value							
12 … 15	**28 …. 31**	**G1_XIST2:** DINT: Error code or measuring input value or reference mark							

[1] Not supported by the module.

Description of feedback bits

Feedback bit/value	Description
ZSW1	
Control_Requested	This bit indicates that the module is ready to receive values from the user program for controlling the pulse output.
f_or_n_reached_or_exceeded	This bit indicates one of the following situations: • Actual speed value ≥ configured maximum speed • Actual speed value < 0.1 Hz
Ready_To_Switch_On	This bit indicates that the pulse output is ready to switch on.
Ready_To_Operate	This bit indicates that the pulse output is ready to operate.
Operation_Enabled	This bit indicates that operation of the drive is enabled and the speed setpoint is being output.
Fault_Present	This bit indicates that an error has occurred on a digital output. Error code 1_H is returned.
Coast_Stop_Not_Activated_OFF2	This bit indicates that the drive will not perform a Coast Stop (OFF2).
Quick_Stop_Not_Activated_OFF3	This bit indicates that the drive will not perform a Quick Stop (OFF3).
Switching_On_Inhibited	This bit indicates that the pulse output is not yet ready to switch on.
NIST_A	
NIST_A	This INT value indicates the actual value of the drive velocity as a percentage in N2 format relative to the reference speed. The N2 format is described with the NSOLL_A control value (Page 25).
ZSW2_ENC	
Slave_Sign-Of-Life	This value is set to 0.
G1_ZSW	
Probe_1_Deflected	With Mode = 1 (Measurement on the fly), this bit indicates the status of the digital input CHn.MI.
Requirement_of_Acknowledgement_Detected	This bit indicates that the acknowledgment of an error is being processed.
Parking_Sensor_Active	This bit indicates that one of the following situations has occurred: • The Activate_Parking_Sensor control bit is enabled. • The module does not supply a valid position, for example, because the internal logic is not yet ready or a fault occurred in the supply voltage. The Control_Requested bit is reset in this case.
Sensor_Error	This bit indicates that an error has occurred during feedback of position value G1_XIST1. The meaning of the returned error codes in G1_XIST2 can be found in the following table.
Function_1_Active	Mode = 0 (Reference mark search): This bit indicates that the use of the reference switch input CHn.RS is activated. Mode = 1 (Measurement on the fly): This bit indicates that the use of the rising edge of the CHn.MI measuring input is enabled.
Function_2_Active	This bit indicates that use of the negative edge of measurement sensing input CHn.MI is enabled.

Feedback bit/value	Description
Value_1_Active	Mode = 0 (Reference mark search): This bit indicates that the reference mark in G1_XIST2 has been read out via the reference switch input CHn.RS. Mode = 1 (Measurement on the fly): This bit indicates that a measuring input value has been read out in G1_XIST2 via the rising edge of digital input CHn.MI.
Value_2_Active	This bit indicates that a measuring input value was read out in G1_XIST2 via the falling edge of digital input CHn.MI.
G1_XIST1	
G1_XIST1	This value is the incremental actual position value. G1_XIST1 corresponds to the number of output pulses, which control the speed of the drive.
G1_XIST2	
G1_XIST2	With Mode = 0 (Reference mark search), this value supplies the detected reference mark. With Mode = 1 (Measurement on the fly), this value supplies the detected measuring input value. If an error has occurred, G1_XIST2 indicates the associated error code. For the meaning of the error codes, see the table below.

Error codes

G1_XIST2 can contain the following error codes:

Error code	Name	Meaning
1_H	Sensor group error	G1_XIST1 is invalid. A short-circuit or overload has occurred at the digital output.
3_H	Sensor pause failed	A sensor pause (Sensor parking) is not supported.
4_H	Reference mark detection aborted	• The Function_2_Request, Function_3_Request or Function_4_Request bit was set to 1 while "Reference mark search" was active. • The Mode bit was set to 1 while the "Reference mark search" was active. • CPU STOP while "Reference mark search" was active.
5_H	Read reference mark aborted	• The Mode bit was set to 1 while the reference mark was shown in G1_XIST2. • CPU STOP while the reference mark is displayed in G1_XIST2.
6_H	Measuring input value acquisition aborted	• The Function_3_Request or Function_4_Request bit was set to 1 while "Measurement on the fly" was active. • The Mode bit was set to 0 while the "Measurement on the fly" was active. • CPU STOP while "Measurement on the fly" was active.
7_H	Read measuring input value aborted	• The Mode bit was set to 0 while the measuring input value was shown in G1_XIST2. • CPU STOP while the measuring input value was displayed in G1_XIST2.

Error code	Name	Meaning
8_H	Absolute value acquisition aborted	The Request_Absolute_value_Cyclically bit is not supported by the module. The module returns only incremental encoder values.
$F01_H$	Command not supported	The command is not supported by the module.
$F02_H$	Sign-of-life error (Master Sign-Of-Life)	The number of tolerated errors of the Master sign-of-life (control value Master_Sign-Of-Life) was exceeded.

Reference mark search

The following figure shows an example of the sequence of the detection and readout of the reference mark:

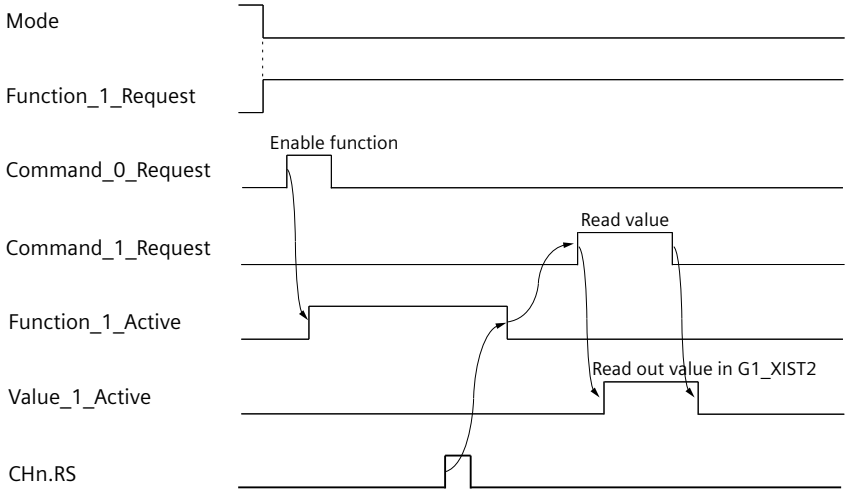

Figure 2-1087 Detecting the reference mark

Measurement on the fly

The following figure shows an example of the sequence of the acquisition and the readout of the measuring input value:

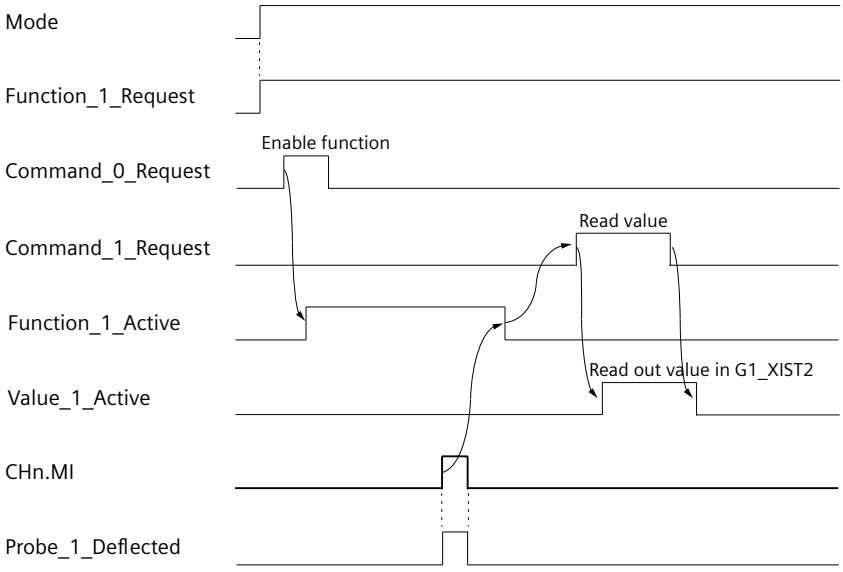

Figure 2-1088 Acquiring the measuring input value

4.4.3 Enabling the pulse output

State diagram

The following figure shows the state diagram for enabling the pulse output:

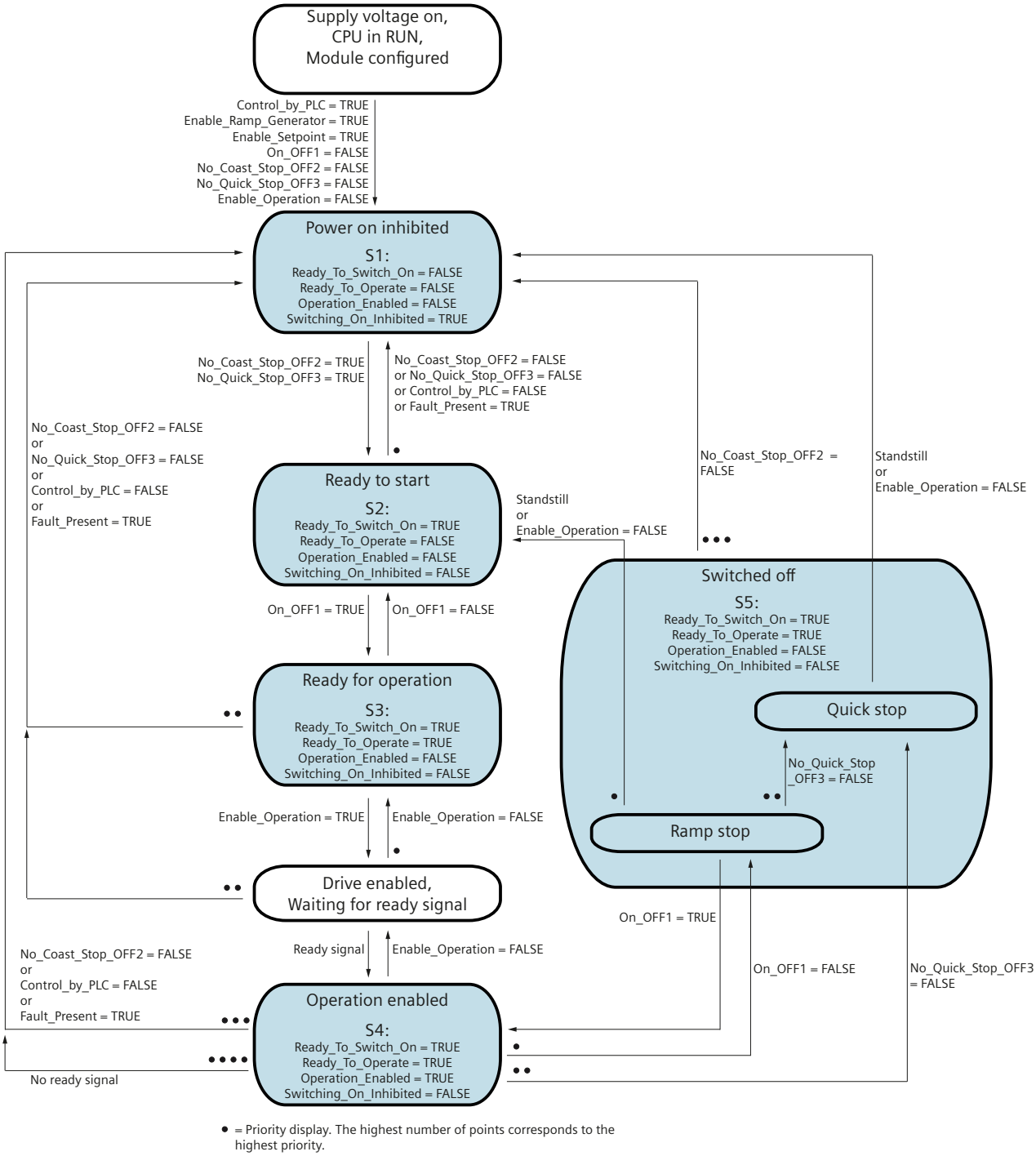

Figure 2-1089 State diagram for the operation enable

Procedure

To enable the pulse output, proceed as follows:

1. Set the Control_by_PLC, Enable_Setpoint and Enable_Ramp_Generator control bits to TRUE and the On_OFF1, No_Coast_Stop_OFF2, No_Quick_Stop_OFF3 and Enable_Operation bits to FALSE.
   State S1 is reached: Switching on of the pulse output is still inhibited. The feedback bit Switching_On_Inhibited is set to TRUE.
2. Set the No_Coast_Stop_OFF2 and No_Quick_Stop_OFF3 control bits to TRUE.
   Status S2 is reached: The pulse output is ready to switch on. The feedback bit Ready_To_Switch_On is set to TRUE. The feedback bit Switching_On_Inhibited is set to FALSE.
3. Set the On_OFF1 control bit to TRUE.
   State S3 is reached: The pulse output is ready to switch on. The feedback bit Ready_To_Operate is set to TRUE.
4. Set the Enable_Operation control bit to TRUE.
5. If you have configured a drive enable output, the module sets this to high level.
   The drive is enabled.
6. If you have configured a ready input, wait for the ready signal of the drive.
   As soon as the ready input is at high level, state S4 is reached: Operation is enabled. The pulse output starts. The feedback bit Operation_Enabled is set to TRUE. You can control the setpoint using the NSOLL_A control value.

4.4.4 Reaction to CPU STOP

The following overview shows the reaction of the technology module to a transition of the CPU to STOP. The reaction is not configurable.

Table 2-1251 Reaction of technology module to CPU STOP

	Reaction of technology module
RUN-STOP transition	The technology module executes a Coast Stop (OFF2), which causes the pulse output to stop and the drive to coast down. If you are using a drive enable, the digital output CHn.ED is reset immediately. The control interface is no longer evaluated. The feedback interface continues returning the last acquired values. The feedback interface continues signaling diagnostic information using the Fault_Present, Sensor_Error and Parking_Sensor_Active bits. Active functions, e.g. for the reference switch, are aborted. **Note:** These outputs can retain a high level since no more pulses are output and the current status of the pulse output signals CHn.P/A and CHn.D/B is maintained depending on the signal type.
STOP-RUN transition	The configuration of the technology module is not reset. The feedback interface keeps the last acquired position value (G1_XIST1).

4.5 Isochronous mode

The technology module supports the "Isochronous mode" system function on PROFINET.

In isochronous mode, the cycle of the user program, the transmission of the input and output data and the processing in the technology module are synchronized with each other.

Data processing

At time T_i the current position value is acquired and made available in the feedback interface for retrieval in the current bus cycle. At time T_o the pulse output is adjusted to the current speed setpoint.

Additional information

You can find a detailed description of isochronous mode:

- In the Isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- In the PROFINET with STEP 7 function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

Interrupts/diagnostic alarms

5

5.1 Status and error displays

LEDs

The figure below shows the LEDs (status and error displays) of the TM PTO 2x24V.

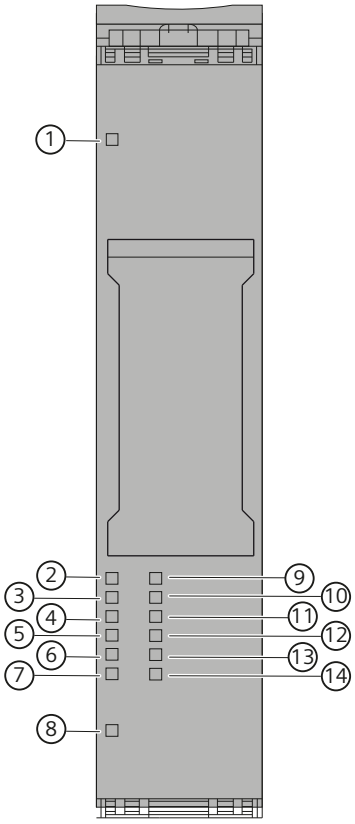

①	DIAG (green/red)	⑧	PWR (green)
②	Status CH0.P/A (green)	⑨	Status CH1.P/A (green)
③	Status CH0.D/B (green)	⑩	Status CH1.D/B (green)
④	Status CH0.ED (green)	⑪	Status CH1.ED (green)
⑤	Status CH0.RS (green)	⑫	Status CH1.RS (green)
⑥	Status CH0.MI (green)	⑬	Status CH1.MI (green)
⑦	Status CH0.DR (green)	⑭	Status CH1.DR (green)

Figure 2-1090 LED displays of TM PTO 2x24V

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in the section Diagnostic alarms (Page 38).

Table 2-1252 Status and error displays DIAG

DIAG LED	Meaning	To correct or avoid errors
□ Off	Backplane bus supply of the ET 200SP not OK	Check or switch on the supply voltage on the CPU or on the interface module.
☼ Flashes	Technology module not configured	—
■ On	Technology module configured but no module diagnostics	
☼ Flashes	Technology module configured and module diagnostics (at least one error pending)	Evaluate the diagnostic alarms and eliminate the error.

Table 2-1253 PWR status indicators

PWR LED	Meaning	To correct or avoid errors
□ Off	Supply voltage missing	• Check the supply voltage. • Check the BaseUnit type and the wiring of the BaseUnit.
■ On	Supply voltage is present and OK	—

Channel LEDs

The CHn.RS, CHn.MI and CHn.DR LEDs indicate the current level of the associated signals. The LEDs of the digital outputs CHn.P/A, CHn.D/B and CHn.ED indicate the desired state. If "Enable diagnostic interrupts" is activated, the associated LED is switched off in the event of an error at a digital output.

The flashing frequency of the channel LEDs is limited to approximately 24 Hz. If higher frequencies are present, the channel LEDs do not indicate the current status but instead flash at 24 Hz.

Table 2-1254 CHn.m status displays

LEDs CHn.m	Meaning
□ Off	Pulse output/digital input/digital output at 0 level
■ On	Pulse output/digital input/digital output at 1 level

5.2 Diagnostic alarms

Enabling the diagnostic interrupts

You enable the diagnostic interrupts at the basic parameters.

The technology module can trigger the following diagnostic interrupts:

Table 2-1255 Possible diagnostic interrupts

Diagnostic interrupt	Monitoring
• Error • Parameter assignment error • Channel/component temporarily unavailable	Monitoring is always active. A diagnostic interrupt is triggered each time an error is detected.
• Supply voltage missing • Error at the digital outputs	Monitoring is always active. A detected error only triggers a diagnostic interrupt if "Enable diagnostic interrupts" has been enabled during device configuration. The diagnostic interrupts are not enabled in the default setting.

Reactions to a diagnostic interrupt

The following happens when an event occurs that triggers a diagnostic interrupt:

- The DIAG LED flashes red.

  When you have eliminated all errors, the DIAG LED stops flashing red and turns green.
- The S7-1500 CPU interrupts the processing of the user program. The diagnostic interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.
- The S7-1500 CPU remains in RUN even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible despite the error.

You can obtain detailed information on the error event in the error organization block with instruction "RALRM" (Read additional alarm information), in the information system of STEP 7 and in function manual Diagnostics (https://support.industry.siemens.com/cs/ww/en/view/59192926), section "System diagnostics in user program".

If the module is being operated as a distributed module in an ET 200SP system with PROFIBUS DP, you have the option of reading out diagnostic data with the RDREC or RD_REC instruction using data record 0 and 1. You can find the structure of the data records in the manual for the IM 155-6 DP HF interface module available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/73098660).

Diagnostic alarms

The diagnostics are displayed as plain text in STEP 7 (TIA Portal) in the online and diagnostics view. You can evaluate the error codes with the user program. The respective channel number is shown for each diagnostic information.

The following diagnostics can be signaled:

Table 2-1256 Diagnostic alarms, their meaning and remedies

Diagnostic alarm	Error code	Meaning	To correct or avoid errors
Error	9_H	• Internal module error occurred • Possible cause: – Firmware update was aborted – Technology module defective	• Repeat firmware update • Replace technology module
Parameter assignment error	10_H	• The received parameter data record is invalid • The configured BaseUnit is not the BaseUnit being used	• Check parameter data record • Check BaseUnit
Supply voltage missing	11_H	• No or insufficient supply voltage L+ • Possible cause: – Wiring of supply voltage L+ faulty – BaseUnit type wrong	• Check BaseUnit type • Check supply voltage L+ at the BaseUnit • Check wiring of supply voltage L+ • Check total consumption of the load group
Channel/component temporarily unavailable	$1F_H$	Firmware update is in progress or has been aborted. The module reads no process values in this state.	• Wait for firmware update. • If firmware update aborts: – Check minimum firmware version required – Check the supply voltage – Repeat firmware update
Error at the digital outputs[1,2]	$10F_H$	• Error at the digital outputs • Possible causes: – Short-circuit – Overload	• Correct wiring at the digital outputs • Check consumers connected to the digital outputs

1 The digital outputs CH0.ED and CH1.ED have common diagnostics.

2 The module detects short-circuit and overload up to an output frequency of approx. 50 kHz and at a pulse width > 10 µs. No diagnostics are output for higher frequencies. However, the module is protected against destruction by short-circuits at the outputs in any case.
The pulse width is fixed depending on the maximum pulse frequency set for the respective channel. The maximum pulse frequency depends, for example, on the signal evaluation and the number of increments per revolution.

⚠ CAUTION

Cross-channel diagnostics of the digital outputs

The digital outputs of both channels have common diagnostics. As a result, when there is an error at one digital output, errors are automatically signaled for both channels. The pulse output of both channels is stopped in this case, regardless of whether "Enable diagnostic interrupts" is activated.

Ensure that this fault scenario is taken into consideration when using both channels.

Technical specifications

6

Article number	6ES7138-6EB00-0BA0
General information	
Product type designation	TM PTO 2x24V
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V17 with HSP or higher
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.35
Supply voltage	
Rated value (DC)	24 V
Load voltage L+	
• Rated value (DC)	24 V
• permissible range, lower limit (DC)	19.2 V
• permissible range, upper limit (DC)	28.8 V
• Reverse polarity protection	Yes
Input current	
Current consumption, max.	50 mA; without load
Power loss	
Power loss, typ.	1.5 W
Address area	
Address space per module	
• Inputs	32 byte
• Outputs	16 byte
Digital inputs	
Number of digital inputs	6; 3 per channel
Digital inputs, parameterizable	Yes
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Digital input functions, parameterizable	
• Synchronization	Yes
• Probe	Yes

Article number	6ES7138-6EB00-0BA0
• Drive ready	Yes
Input voltage	
• Rated value (DC)	24 V
• for signal "0"	-5 ... +5 V
• for signal "1"	+11 to +30V
• permissible voltage at input, min.	-30 V; -5 V continuous, -30 V brief reverse polarity protection
• permissible voltage at input, max.	30 V
Input current	
• for signal "1", typ.	2.5 mA
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms
– at "0" to "1", min.	6 µs; for parameterization "none"
– at "1" to "0", min.	6 µs; for parameterization "none"
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	600 m
Digital outputs	
Number of digital outputs	6; 3 per channel
Current-sinking	Yes; For 24 V PTO outputs
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes; electronic/thermal
• Response threshold, typ.	1 A
Controlling a digital input	Yes
Digital output functions, parameterizable	
• PTO (pulse train output) signal interface	Yes
– 24 V asymmetrical	Yes
• PTO (pulse train output) signal type	
– Pulse and direction	Yes
– Count up, count down	Yes
– Incremental encoder (A, B phase shift)	Yes
– Incremental encoder (A, B phase shift, quadruple)	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.1 A; 0.5 A for CHn.ED
• on lamp load, max.	1 W; 5 W for CHn.ED

Article number	6ES7138-6EB00-0BA0
Load resistance range	
• lower limit	240 Ω; 48 ohms for CHn.ED
• upper limit	12 kΩ
Output voltage	
• for signal "1", min.	23.2 V; L+ (-1.3 V), L+ (-0.8 V) for CHn.ED
Output current	
• for signal "1" rated value	0.1 A; 0.5 A for CHn.ED
• for signal "1" permissible range, max.	0.12 A; 0.6 A for CHn.ED
• for signal "1" minimum load current	2 mA
• for signal "0" residual current, max.	0.5 mA
Switching frequency	
• with resistive load, max.	10 kHz
• with inductive load, max.	0.5 Hz; According to IEC 60947-5-1, DC-13
• on lamp load, max.	10 Hz
• For signal interface 24 V asymmetrical	200 kHz; For 24 V PTO outputs
Total current of the outputs	
• Current per module, max.	1.4 A
Cable length	
• shielded, max.	600 m; Up to 10 kHz, 50 m at 200 kHz
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
Diagnoses	
• Monitoring the supply voltage	Yes
• Short-circuit	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels and backplane bus	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C; Observe derating
• vertical installation, min.	-30 °C

Article number	6ES7138-6EB00-0BA0
• vertical installation, max.	50 °C; Observe derating
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Decentralized operation	
to SIMATIC S7-300	Yes; Via control and feedback interface
to SIMATIC S7-400	Yes; Via control and feedback interface
to SIMATIC S7-1200	Yes
to SIMATIC S7-1500	Yes
to standard PROFIBUS master	Yes; Via control and feedback interface
to standard PROFINET controller	Yes; Via control and feedback interface
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	45 g

NOTE

Installation heights > 2000 m

You can find information on the restrictions when using the ET 200SP distributed I/O system at more than 2000 m above sea level in the "Mechanical and climatic environmental conditions" section of the ET 200SP Distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Derating information for total current of digital outputs

If the digital outputs of the TM PTO 2x24V are operated with resistive or inductive loads, you should derate the total current of the loads at the digital outputs of the technology module. The total current is the sum of the load currents at the two digital outputs CH0.ED and CH1.ED of the module.

The following derating curve shows the load capacity of the digital outputs depending on the ambient temperature and mounting position under the following conditions:

- Maximum switching frequency at digital outputs 0.5 Hz
- Load resistance: 48 Ω (IEC 947-5-1)
- Load inductance: 1150 mH (IEC 947-5-1)

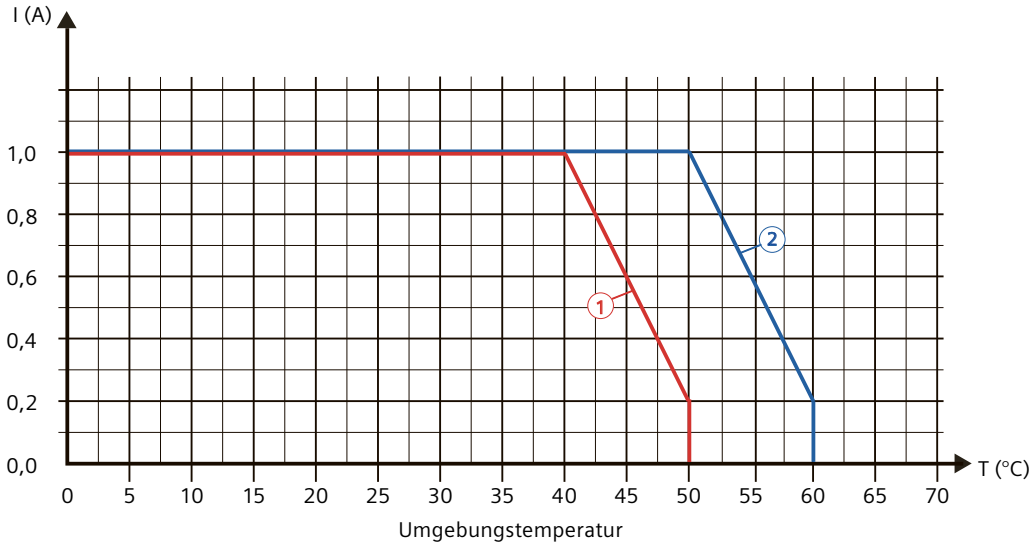

① Vertical installation of the system

② Horizontal installation of the system

Figure 2-1091 Total current (CHn.ED) by ambient temperature and mounting position for resistive or inductive loads

NOTE

If the switching frequency is greater than 0.5 Hz or there is greater inductance at the digital outputs (CHn.ED), the total current must be further reduced.

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

You have the option to change the parameter assignment of the module with the user program while the CPU is in RUN. The parameters are transferred to the module using the using data record 128, for example with the instruction WRREC.

If errors occur during the transfer or validation of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. A corresponding error code is then written to the STATUS output parameter. If no errors occur, the STATUS output parameter contains the length of the actually transferred data.

The description of the WRREC instruction and the error codes is available in the section Parameter validation error (Page 47) or in the online help of STEP 7 (TIA Portal).

Structure of data record 128

The following tables show you the structure of data record 128 for TM PTO 2x24V. The values in byte 0 to byte 3 are fixed and may not be changed. The channels are assigned in ascending order.

NOTE

The module resets itself when transmitting data record 128. For this reason, only transfer the data record when the drive is at a standstill.

Table 2-1257 Parameter data record 128: Overall module

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...3	**Header**							
0	Major Version = 0				Minor Version = 1			
1	Length of parameter data per channel = 28							
2	Reserved[1]							
3	Reserved[1]							
4...31	**Channel 0**							
32...59	**Channel 1**							

[1] Reserved bits must be set to 0.

Table 2-1258 Parameter data record 128: Channel parameters

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	Basic parameters							
4/32	Reserved[2]				Enable diagnostic interrupts[1]	Reserved[2]		
	Operating mode							
5/33	Reserved[2]		Signal evaluation:		Signal type:			
			00_B: Single		0000_B: Invalid			
			01_B: Invalid		0001_B: PTO (Pulse (P) and direction (D))			
			10_B: Quadruple[3]		0010_B: PTO (count up (A), count down (B))			
			11_B: Invalid		0011_B: PTO (A, B phase-shifted)			
					0100 to 1111_B: Invalid			
	Digital inputs							
6/34	Reference switch edge selection:	Reserved[2]			Input delay:			
					0000_B: None			
					0001_B: 0.05 ms			
	0_B: At positive edge				0010_B: 0.1 ms			
					0011_B: 0.4 ms			
	1_B: At negative edge				0100_B: 0.8 ms			
					0101_B: 1.6 ms			
					0110_B: 3.2 ms			
					0111_B: 12.8 ms			
					1000_B: 20 ms			
					1001 to 1111_B: Invalid			
	Values							
7/35	Pulse pause on reversal of direction: BYTE: Value range in ms: 0 to 255_D							
8...11/ 36...39	Reference speed: REAL: Value range in rpm: 1.0 to 20000.0_D:							
12...15/ 40...43	Increments per revolution: DINT: Value range in rpm: 1 to 1000000_D							
16...19/ 44...47	Maximum speed: REAL: Value range is dependent on signal interface, signal evaluation, increments per revolution and reference speed, see following table							
20...21/ 48...49	Quick stop time (OFF3): UINT: Value range in ms: 1 to 65535_D							
22...23/ 50...51	Ramp stop time (OFF1): UINT: Value range in ms: 1 to 65535_D							

1 You enable the respective parameter by setting the corresponding bit to 1.

2 Reserved bits must be set to 0.

3 Only available for signal type "PTO (A, B phase-shifted)"

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
	Hardware inputs/outputs							
24...25/ 52...53	Reserved[2]							
26/54	Use ED as Enable Drive[1]	Reserved[2]						
27/55	Use RS as reference switch[1]	Reserved[2]						
28/56	Use MI as measuring input[1]	Reserved[2]		Reserved, must be set to 00001_B				
29/57	Use DR as Drive Ready[1]	Reserved[2]		Reserved, must be set to 00010_B				
30...31/ 58...59	Tolerated number of sign-of-life errors: UINT: Value range: 0 to 65535_D 65535_D means: No monitoring for errors of Master sign-of-life							

1 You enable the respective parameter by setting the corresponding bit to 1.

2 Reserved bits must be set to 0.

3 Only available for signal type "PTO (A, B phase-shifted)"

Maximum speed

The following table shows the calculation of the value range of the maximum speed:

Value range of the maximum speed			
Low limit		**High limit (the smaller of the two values applies)**	
Signal evaluation "Single"	**Signal evaluation "Quadruple"**	**Signal evaluation "Single"**	**Signal evaluation "Quadruple"**
0.1 Hz * 60 / (increments per revolution)	0.1 Hz * 60 *4 / (increments per revolution)	• 2 * reference speed • 200000 Hz * 60 / (increments per revolution)	• 2 * reference speed • 200000 Hz * 60 *4 / (increments per revolution)

A.2 Parameter validation error

If you make the parameter settings in STEP 7 (TIA Portal) or in STEP 7, the parameter values are checked before they are transferred to the technology module. This process prevents parameter errors.

In other use cases, the technology module checks the transferred parameter data record. If the technology module finds invalid or inconsistent parameter values, it outputs an error code (see below). The new parameter data record is rejected in this case, and work continues with the current parameter values until a valid parameter data record has been transferred.

WRREC

When the CPU is in RUN, you can change the parameter data record with the instruction WRREC (Write Record). In case of errors, the WRREC instruction returns corresponding error codes in the STATUS parameter.

Example:

Let us assume that when WRREC is executed, an invalid value, for example 9_D, is written to the module for the signal type. As a consequence, the module rejects the entire parameter data record. You can recognize this by evaluating the STATUS output parameter of the WRREC instruction. The STATUS output parameter is output as an ARRAY[1..4] of BYTE data with the value $DF80E113_H$:

Example of WRREC STATUS data	Address	Meaning
DF_H	STATUS[1]	Error when writing a data record via PROFINET IO (IEC 61158-6)
80_H	STATUS[2]	Error when reading or writing a data record via PROFINET IO (IEC 61158-6)
$E1_H$	STATUS[3]	Module-specific error
13_H	STATUS[4]	Error code from the table below: The "Signal type" parameter has an invalid value.

Error codes

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Table 2-1259 Error codes for parameter validation

Error code in STATUS parameter (hexadecimal)				Meaning	To correct and avoid errors
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Data record number unknown	Enter valid number for data record
DF	80	B1	00	Length of data record incorrect	Enter valid value for data record length.
DF	80	B2	00	Slot invalid or not accessible	• Check whether module is inserted or removed. • Check assigned values for parameters of the WRREC instruction.
DF	80	E0	01	Wrong version	• Check byte 0. • Enter valid values.
DF	80	E0	02	Error in the header information	• Check byte 1. • Correct length of parameter blocks.
DF	80	E1	00	Parameter invalid: No detailed information available	Check all parameter values.
DF	80	E1	12	Value in byte 4/32 invalid	Enter value 000_B.
DF	80	E1	13	"Signal type" parameter invalid	Enter valid parameter value.
DF	80	E1	1A	"Input delay" parameter invalid	Enter valid parameter value.
DF	80	E1	26	"Reference speed" parameter invalid	Enter parameter value from range 1.0 to 20000.0_D taking into account the dependencies (Page 45).
DF	80	E1	29	"Increments per revolution" parameter invalid	Enter parameter value from range 1 to 1000000_D taking into account the dependencies (Page 45).
DF	80	E1	2C	"Signal evaluation" parameter invalid	Enter valid parameter value.

Error code in STATUS parameter (hexadecimal)				Meaning	To correct and avoid errors
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	2D	Value in byte 5/33 invalid	Enter value 0_B.
DF	80	E1	40	Value in byte 27/55 invalid	Enter value 00000_B.
DF	80	E1	41	Value in byte 28/56 invalid	Enter value 00001_B.
DF	80	E1	44	Value in byte 26/54 invalid	Enter value 00000_B.
DF	80	E1	45	Value in byte 29/57 invalid	Enter value 00010_B.
DF	80	E1	50	"Maximum speed" parameter invalid	Enter parameter value from the valid range (Page 45) in each case.
DF	80	E1	51	"Quick stop time (OFF3)" parameter invalid	Enter parameter value from range 1 to 65535_D.
DF	80	E1	52	"Ramp stop time (OFF1)" parameter invalid	Enter parameter value from range 1 to 65535_D.
DF	80	E1	FF	Conflict with the isochronous times configured in the hardware configuration.	Enter suitable isochronous times in the hardware configuration.

SIEMENS

SIMATIC

ET 200SP
Technology Module TM Pulse 2x24V (6ES7138-6DB00-0BB1)

Equipment Manual

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Preface

Purpose of the documentation

This manual contains module-specific information on the wiring, the diagnostics and the technical specifications of the technology module.

You can find information that pertains generally to the configuration and commissioning of the ET 200SP in the ET 200SP system manual.

Conventions

Observe the notes that are indicated as follows:

NOTE

A note contains important information regarding the product described in the documentation, the handling of the product or the part of the documentation to which particular attention should be paid.

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

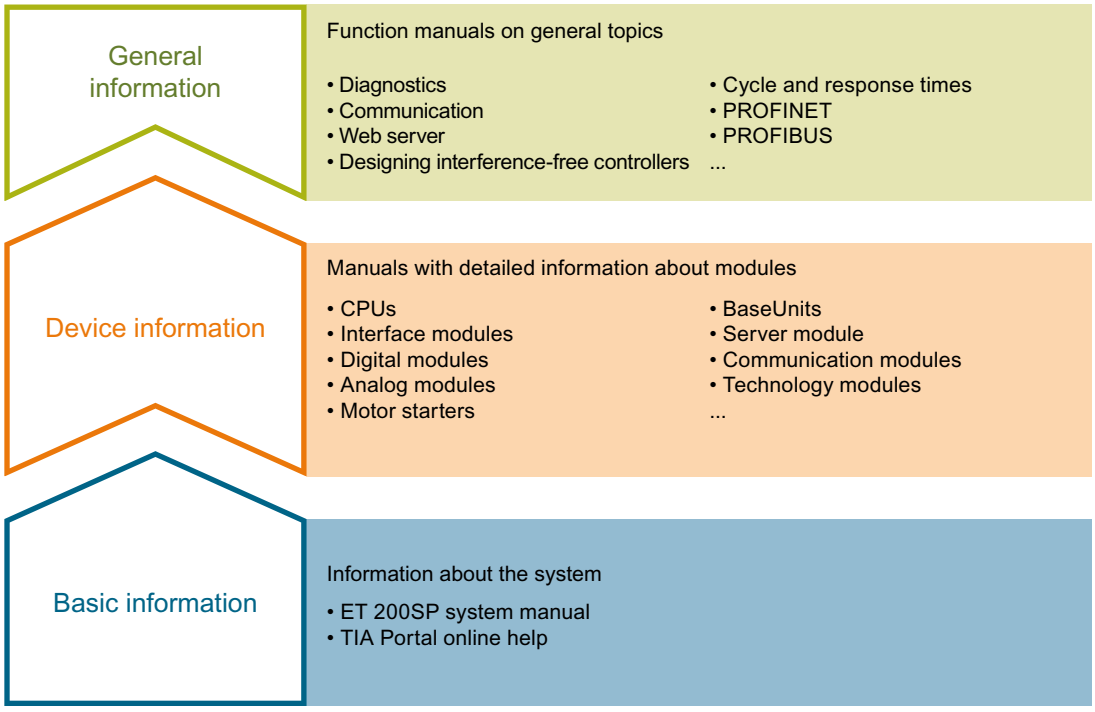

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/84133942).

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"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7138-6DB00-0BB1

View of the module

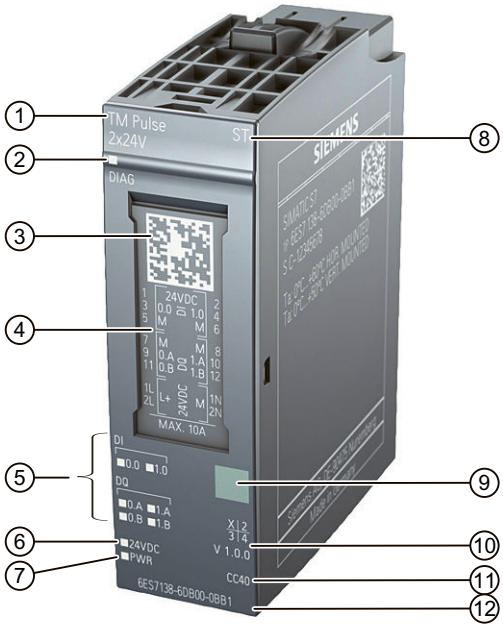

①	Module type and designation	⑦	LED for supply voltage
②	LED for diagnostics	⑧	Function class
③	2D matrix code	⑨	Module type color coding
④	Terminal diagram	⑩	Function and firmware version
⑤	LEDs for channel status	⑪	Color code for selection of the color-coded labels and BaseUnit type
⑥	LED for sensor supply	⑫	Article number

Figure 2-1092 View of the TM Pulse 2x24V module as an example

Properties

The TM Pulse 2x24V technology module has the following technical properties:

- 2 channels with up to 2 A output current per channel
- Parallel connection of channels: Enables one logical channel with up to 4 A output current (one-channel operation)
- High-speed output: Choice of high output frequency up to 100 kHz with output current of 0.1 A or higher current of 2 A / 4 A with frequency up to 10 kHz
- Interfaces (per channel):
  - 24 V sensor supply, short-circuit proof
  - Digital input signal DI0
  - Bipolar digital output signal DQA / DQB for DC motor
- Channel-by-channel monitoring for short-circuit and incorrect supply voltage
- Configurable input filters for suppression of interference at digital inputs
- Use of SW or HW enable to start the output sequence

Supported system functions

- Isochronous mode
- Firmware update
- I&M identification data
- Parameter reassignment in RUN

Accessories

A **BaseUnit** of **type B1** is needed for operation of the technology module. You will find an overview of the BaseUnits you can use with the technology module in Product information on the documentation of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/73021864).

You can find additional information on accessories in the ET 200SP Distributed I/O System system manual (http://support.automation.siemens.com/WW/view/en/58649293).

2.2 Operating modes

The technology module supports the following operating modes:

Operating mode	Meaning
Pulse output (Page 23)	output of a single pulse with defined On delay and variable pulse duration (e.g. for dosing using a switch valve)
Pulse width modulation PWM (Page 34)	• Closed-loop current control, e.g. for controlling the temperature in a heating resistor • Output of a frequency with defined period duration and variable duty cycle (e.g. for controlling a proportional valve) • Optional dithering: superimposition of a dither signal on the PWM signal for improving proportional valve control
Pulse train (Page 57)	output of a train of pulses with defined period duration and variable pulse count
On/Off delay (Page 70)	pulse output follows the signal at digital input DI0 after a defined switching delay (e.g. for delayed output with higher output current)
Frequency output (Page 83)	output of pulses with variable frequency and fixed mark-to-space ratio of 1:1
PWM with DC motor (Page 94)	Output of a bipolar PWM signal with variable duty cycle for controlling a brushed DC motor in both directions of rotation

Connecting 3

3.1 Terminal assignment and schematic circuit diagram

The TM Pulse 2x24V technology module is used with a BaseUnit of type B1 (article number 6ES7193-6BP20-0BB1).

You connect the digital input and output signals and the sensor supply to the BaseUnit of the technology module. The supply voltage connected to the BaseUnit supplies the module and the digital outputs and generates the sensor supply voltage.

BaseUnit

The BaseUnit is not included in the scope of delivery of the module and must be ordered separately.

You will find an overview of the BaseUnits you can use with the technology module in Product information on the documentation of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/73021864).

You can find information on selecting the right BaseUnit in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and the ET 200SP Base Units (http://support.automation.siemens.com/WW/view/en/58532597/133300) equipment manual.

You can find information, for example, on wiring the BaseUnit in the Wiring section of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Supply voltage L+/M

You connect the supply voltage to the L+ and M terminals of this BaseUnit. The supply voltage from the module on the left cannot be used for this BaseUnit. An internal protective circuit protects the technology module from polarity reversal of the supply voltage. The technology module monitors for connection of the supply voltage.

NOTE

Point-to-point and low-impedance wiring

High switching frequencies of the outputs and high output current combine to load the central power supply (24 V DC) of the plant. You should therefore observe the following when wiring the module:

- Connect the supply voltage to the module in a point-to-point manner and with as low impedance as possible (short cable with as large a cross-section as possible)
- If necessary, use a separate supply voltage

Sensor supply

To supply sensors connected to the digital inputs, the technology module supplies 24 V DC at the 24VDC output (terminals 1 and 2) with reference to M (terminals 5 and 7 as well as 6 and 8). The voltage is monitored for short-circuit and overload.

Digital input DI0

The digital input DI0 is used for the hardware enable.

The digital inputs of the module are not isolated from each other.

Input delay for digital input

To suppress interference, you can configure an input delay for the digital input.

NOTE

If you select the "None" or "0.05 ms" option, you must use a shielded cable for connection of the digital input.

Digital output DQA / DQB

The digital outputs of the module are not electrically isolated from each other or from the digital inputs.

The digital outputs of the module are 24 V current-sourcing switches in reference to M and can handle a rated load current of 2 A. They are protected against overload and short-circuit.

Relays and contactors can be connected directly without external circuitry. You can find information on the maximum possible operating frequencies and the inductive loads at the digital outputs in section Technical specifications (Page 125).

Digital outputs are equipped with integrated freewheeling diodes for preventing voltage overloads due to inductive loads. Additional external freewheeling diodes can impair proper operation.

DQ0.B and DQ1.B are used only in "PWM with DC motor" mode or are controlled using the SET_DQB bit in the control interface.

Response of digital outputs to wire break at ground connections

Due to the characteristics of the output driver used in the module, approx. 50 mA supply current drains through the digital outputs via a parasitic diode following a ground wire break. This behavior may cause the digital outputs to be set from 0 to 1.

To prevent unintended switching of the outputs following a wire break at a ground connection, follow these steps:

1. Route the first ground connection from terminal 14 to the ground connection of the central power supply of the plant.
2. Route the second ground connection from terminal 16 to the ground connection of the central power supply of the plant.

If a wire break interrupts one of the two ground connections, the outputs are maintained at the required potential via the remaining ground connection.

NOTICE
Wire break at ground connection Always route *two* cables to the central ground connection.

The following figure shows the wiring of the technology module in two-channel operation.

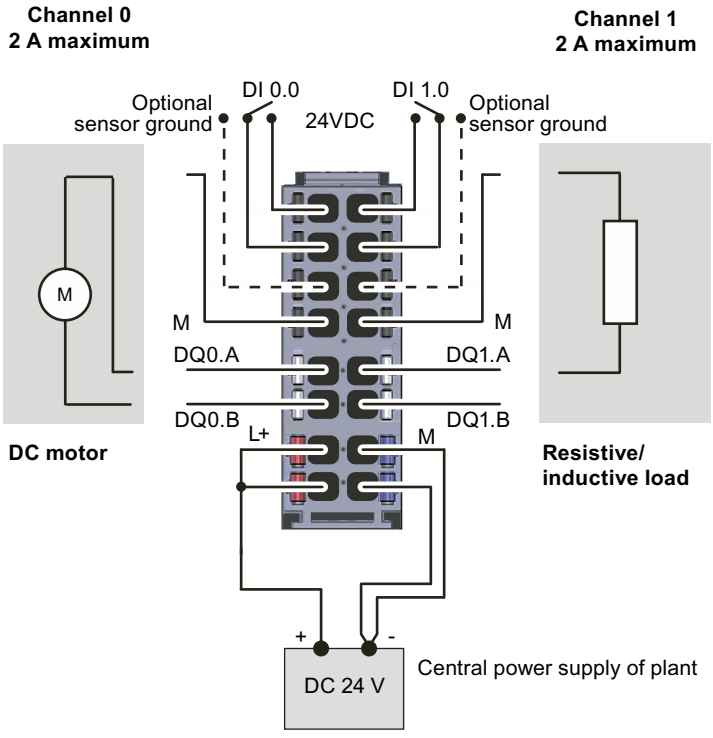

Figure 2-1093 Wiring in two-channel operation

The following figure shows the wiring of the technology module in one-channel operation.

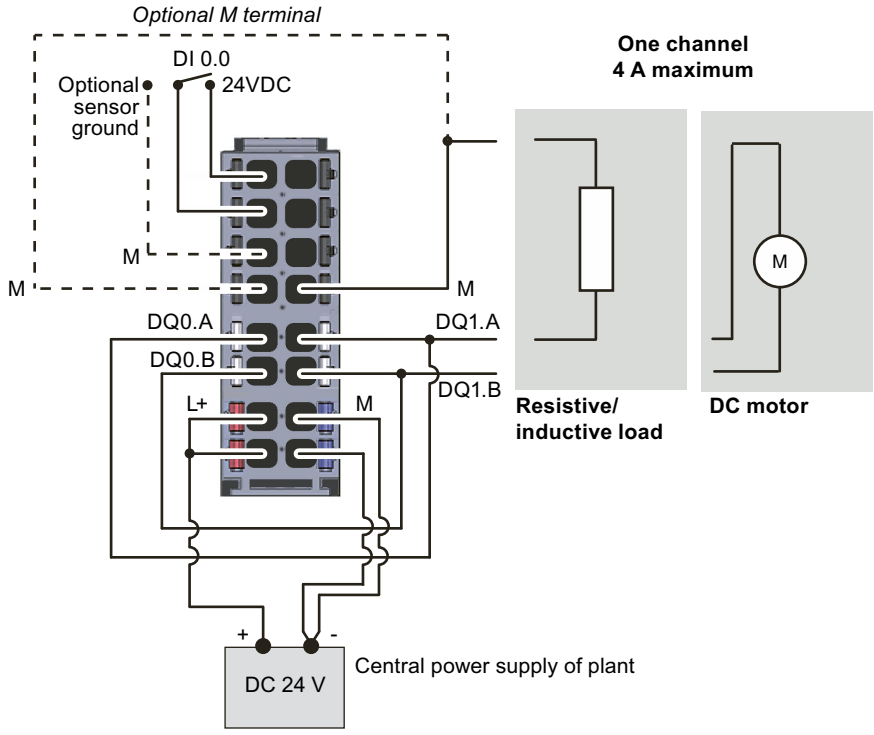

Figure 2-1094 Wiring in one-channel operation (parallel connection)

NOTE

Load wiring resistance

In one-channel operation, the cables for the DQ0.A and DQ1.A connections must have identical resistance (length and cross-section) to achieve optimal current distribution between the two outputs and to prevent errors in current measurement.

In "PWM with DC motor" mode, the cables for the DQ0.B and DQ1.B terminals must also have identical resistance.

NOTE

Overheating due to unsuitable loads

A high-speed output generates very steep edges. This produces a very severe load change of the connected load, which can result in overheating of the load under high switching frequencies.

The connected load must therefore be approved for high frequencies.

Terminal assignment of the BaseUnit

The table below shows the terminal assignment of the BaseUnit BU20-P12+A0+4B.

Table 2-1260 Terminal assignment of the BaseUnit BU20-P12+A0+4B

Description	Terminal name		View	Terminal name		Description
24 V DC sensor supply	24VDC	1		2	24VDC	24 V DC sensor supply

Description	Terminal name		View	Terminal name		Description
Channel 0 Digital input DI0	DI0.0	3	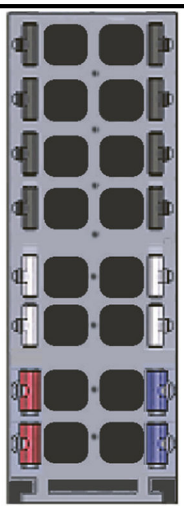	4	DI1.0	Channel 1 Digital input
Channel 0 Ground for digital inputs	M	5		6	M	Channel 1 Ground for digital inputs
Channel 0 Ground for digital outputs	M	7		8	M	Channel 1 Ground for digital inputs
Channel 0 Digital output DQA	DQ0.A	9		10	DQ1.A	Channel 1 Digital output DQA
Channel 0 Digital output DQB	DQ0.B	11		12	DQ1.B	Channel 1 Digital output DQB
24 V DC supply voltage	L+	13 (1L)		14 (1N)	M	Ground for supply voltage
	L+	15 (2L)		16 (2N)	M	

Cable shielding

You must ground the shields of the cables between sensors and the technology module and connect them to the DIN rail or the ground connection of the central power supply of the plant.

Schematic circuit diagram

The figure below shows the schematic circuit diagram of the technology module in two-channel operation.

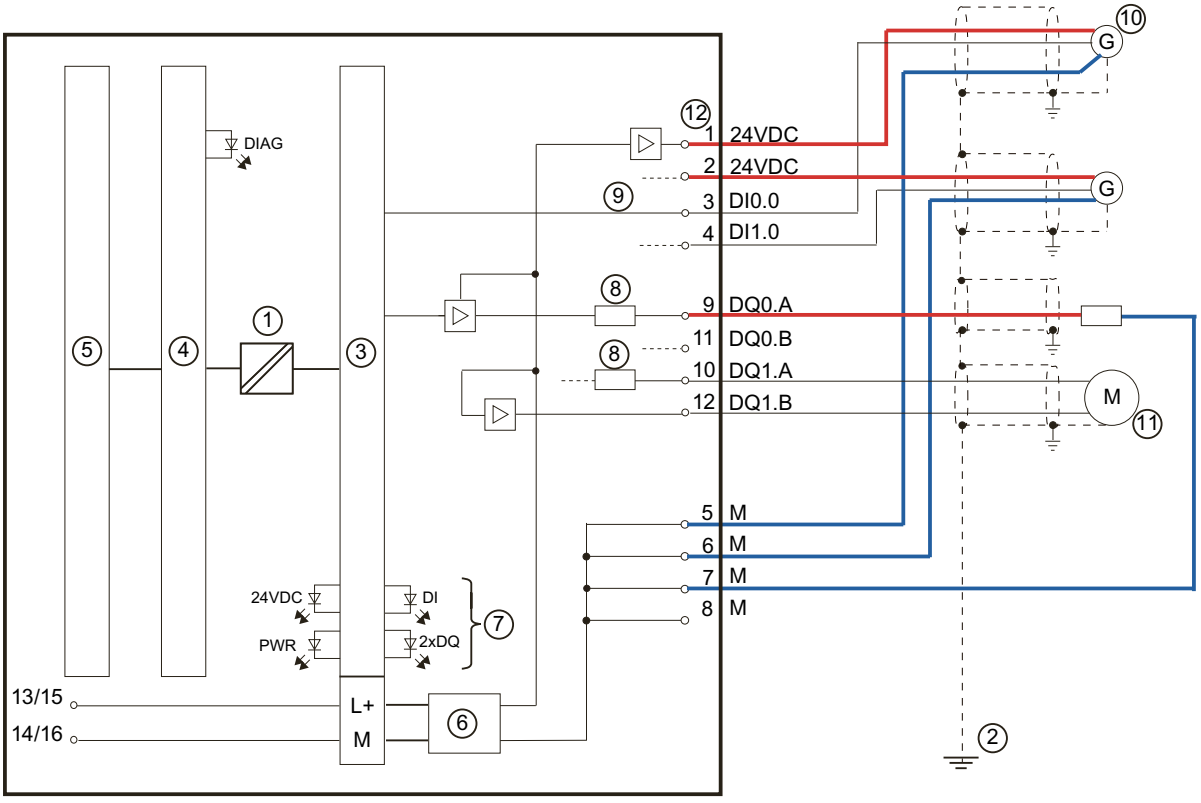

① Electrical isolation
② Shield connection (to DIN rail or ground connection of the plant)
③ Technology
④ Backplane bus interface of the technology module
⑤ Backplane bus
⑥ Input filter (internal 7 A fuse, reverse polarity protection)
⑦ LEDs per channel
⑧ Shunt for current measurement
⑨ Digital input type 3
⑩ Sensor (shielding dependent on configured On delay)
⑪ Motor
⑫ Terminals and terminal numbers on the BaseUnit

Figure 2-1095 Circuit diagram for two-channel operation (channel 0 with resistive or inductive load, channel 1 with DC motor)

In addition to the main setpoint OUTPUT_VALUE, you can change a setpoint for another parameter.

You specify the load value with the SLOT value in the control interface. You use the LD_SLOT load request to specify the meaning of the value in SLOT depending on the operating mode:

LD_SLOT	Meaning of the value in SLOT	Operating modes for use of the value	Data type of SLOT
0_D	No action, idle	All operating modes	—
1_D	Period duration	• Pulse width modulation PWM • Pulse train • PWM with DC motor	UDINT
2_D	On delay	• Pulse output • Pulse width modulation PWM • Pulse train • Frequency output • PWM with DC motor	
3_D	Off delay	• On/Off delay	
4_D	Duty cycle	• Pulse train	
5_D	Dithering ramp up, ramp down	• Pulse width modulation PWM	2 × INT
6_D	Dithering amplitude	• Pulse width modulation PWM	UDINT
7_D	Dithering period duration	• Pulse width modulation PWM	

In so doing, you use the MODE_SLOT control bit to choose whether you want to apply a change of the respective value once or cyclically.

MODE_SLOT

One-time change (MODE_SLOT = 0)

A one-time change is recommended when another parameter besides OUTPUT_VALUE must be changed occasionally. The module is not reset in this case. By contrast, if the change is made by transferring a new parameter data record (Page 131), the module is reset.

The following parameters are used in the case of the one-time change:

Control Parameters	• SLOT • LD_SLOT • MODE_SLOT • RES_ERROR
Feedback Parameters	• STS_LD_SLOT • ERR_LD

To make a one-time change, follow these steps:

1. Check if the previous job was successfully performed, which means whether STS_LD_SLOT has changed and ERR_LD is not set.
2. If ERR_LD is set:
   - Write LD_SLOT = 0 and acknowledge the error by setting RES_ERROR. Continue with step 1.
     or
   - Write a valid value in SLOT and LD_SLOT and acknowledge the error by setting RES_ERROR. Continue with step 1.
3. Enter a new value in SLOT.
4. Enter a changed value in LD_SLOT.

   NOTE

   In the case of a one-time change, it is assumed that, in contrast to the cyclic change, the same parameter is not changed twice in succession. If you want to change the same parameter twice in succession, you must insert an "Idle job" (LD_SLOT = 0) between both jobs.

5. Continue with step 1.

   NOTE

   The procedure is also shown in detail in a diagram in the appendix (Page 142).

NOTE

After a restart of the module, the value of the parameter concerned is overwritten in the module-internal data record with the value set in the hardware configuration.

Cyclic change (MODE_SLOT = 1)

A cyclic change is recommended when another parameter besides OUTPUT_VALUE is to be cyclically changed.

NOTE

You can stop the cyclic change during the output sequence by setting LD_SLOT and MODE_SLOT to 0. The values changed up to that point are retained.

Flowchart

The following figure shows an example of the basic sequence:

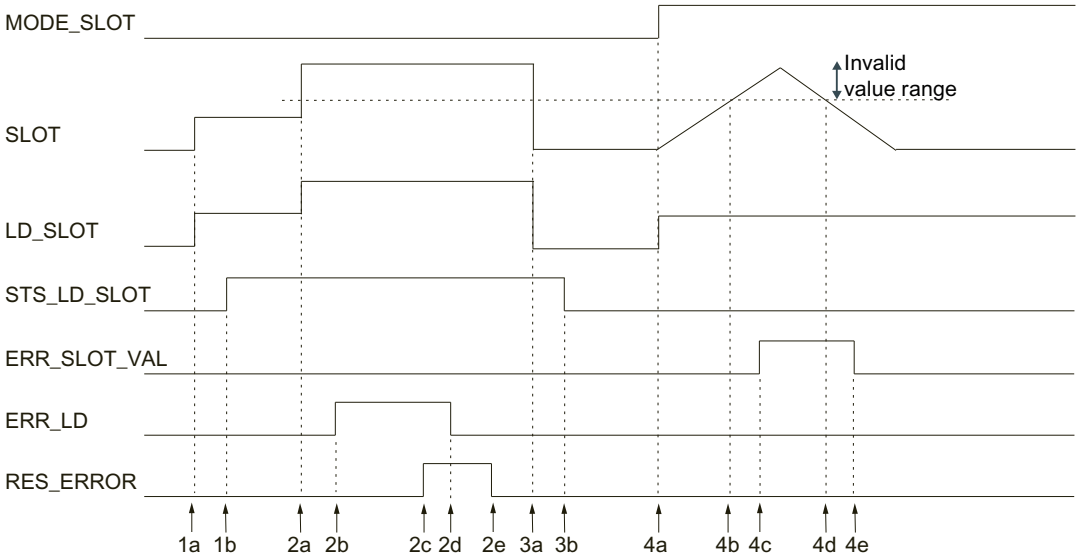

1a	You write a valid value in SLOT and LD_SLOT.
1b	The STS_LD_SLOT feedback bit is toggled because the LD_SLOT load request was recognized by the module and implemented. The value from SLOT is applied once and kept until the next change of LD_SLOT. The relevant parameter is updated in the module-internal data record and takes effect at the next output sequence.
2a	You write a changed and valid value in LD_SLOT and an invalid value in SLOT.
2b	The ERR_SLOT_LD feedback bit is set because the value in SLOT is invalid. The value is not applied.
2c	You set the RES_ERROR control bit in order to acknowledge the error.
2d	The feedback bit ERR_LD is reset.
2e	You reset the RES_ERROR control bit.
3a	You write a changed and valid value in SLOT and LD_SLOT.
3b	The STS_LD_SLOT feedback bit is toggled because the LD_SLOT load request was recognized by the module and implemented. The value from SLOT is applied once and kept until the next change of LD_SLOT. The relevant parameter is updated in the module-internal data record and takes effect at the next output sequence.
4a	You set MODE_SLOT and cyclically write valid values in SLOT and LD_SLOT. The value from SLOT is cyclically applied and takes effect at the next output sequence. However, the respective change is not saved.
4b	You cyclically write invalid values in SLOT.
4c	The ERR_SLOT_VAL feedback bit is set because the value in SLOT is invalid. The respective value from SLOT is not applied.
4d	You cyclically write valid values in SLOT.
4e	The ERR_SLOT_VAL feedback bit is automatically reset because the module has again received valid values.

4.1 Pulse output (single pulse) mode

4.1.1 Function

4.1.1.1 Introduction

In this operating mode, the respective channel of the technology module outputs a single pulse with the configured On delay and the pulse duration specified via the control interface.

4.1.1.2 Output sequence

Starting the output sequence

In order to output the output sequence at digital output DQn.A, the TM_CTRL_DQ control bit (Page 109) must be set. To start the output sequence using the software enable, you set the SW_ENABLE control bit (Page 31). The STS_SW_ENABLE feedback bit (Page 32) indicates that the software enable in the technology module is active.

You can additionally use the hardware enable via the respective digital input DIn.0. You can configure an input delay for DIn.0.

Pulse diagram

The following figure shows an example of an output sequence when DIn.0 is being used as a hardware enable.

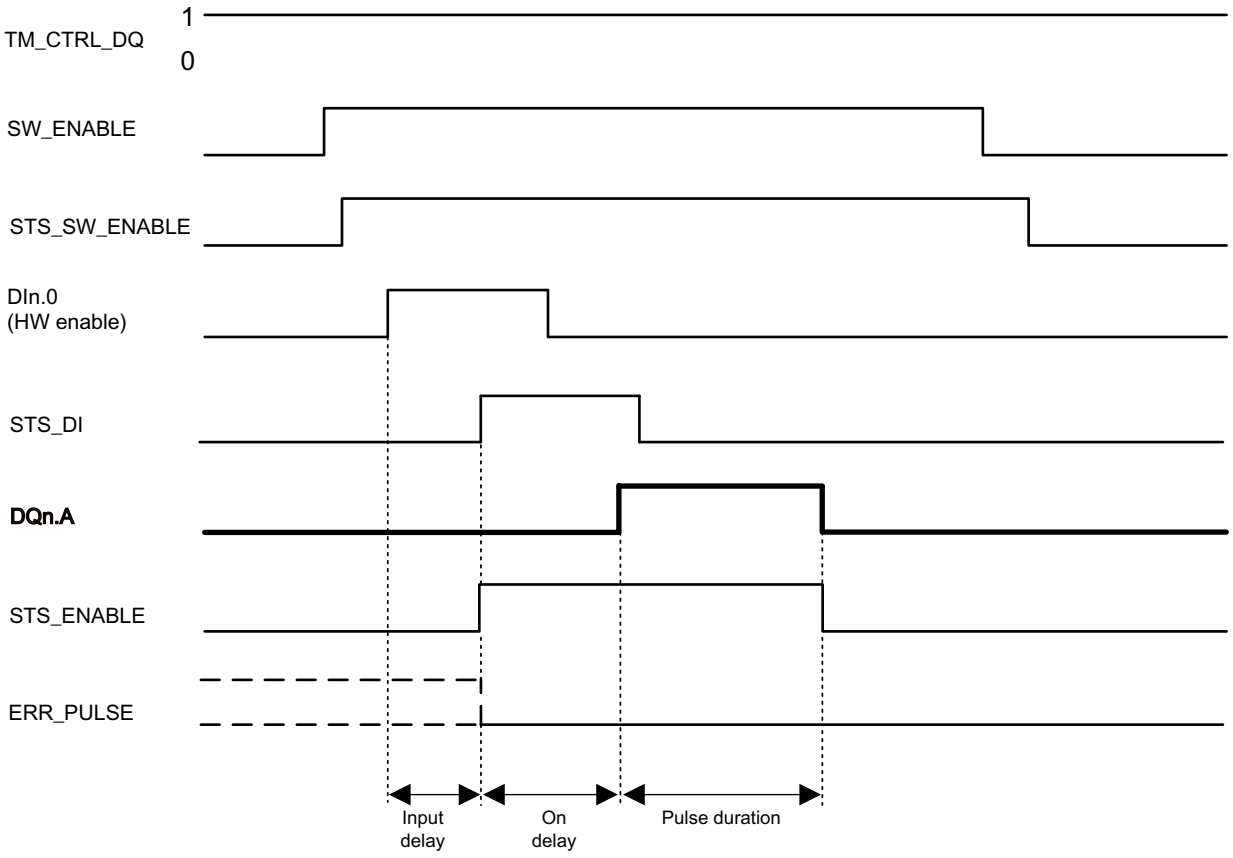

Figure 2-1096 Example of an output sequence

If you are using the hardware enable, it is combined with the software enable. When the software enable is active, the output sequence starts at the first positive edge of the hardware enable. Additional positive edges of the hardware enable during the output sequence are ignored. If the hardware enable is set and remains set for the duration of the input delay, the On delay is started and the STS_ENABLE feedback bit is set. As soon as the On delay has elapsed, the pulse is output with the assigned pulse duration at the respective digital output DQn.A. The output sequence is stopped at the end of the pulse duration, and STS_ENABLE is reset.

If you are not using a hardware enable, the On delay starts at the positive edge of SW_ENABLE.

Aborting the output sequence

If you reset the SW_ENABLE control bit, the software enable is deactivated and the current output sequence is aborted and not completed. The STS_ENABLE feedback bit and the digital output DQn.A are reset.

A renewed pulse output is only possible after a restart of the output sequence.

4.1.1.3 Pulse duration

The pulse duration is the time period that the digital output DQn.A remains set after the On delay has elapsed.

You set the pulse duration in µs in the control interface using OUTPUT_VALUE as integer (UDINT). The value range is dependent on whether or not the high-speed output function is being used:

High-speed output	Value range of OUTPUT_VALUE	Value range of the pulse duration
Activated	2 ... 85000000	2 ... 85000000 µs = 2 µs ... 85 s
Deactivated	10 ... 85000000	10 ... 85000000 µs = 10 µs ... 85 s

Pulse duration change while output sequence is active

If you change the pulse duration to a value that is greater than the pulse duration already elapsed, the change takes effect immediately. Thus, you can still adapt the pulse duration during the output sequence.

If you change the pulse duration to a value that is less than the portion of the pulse duration that already elapsed, the output sequence is aborted. In this case, the STS_ENABLE feedback bit and the digital output DQn.A are reset, and the ERR_PULSE feedback bit is set. To continue the pulse output, you must restart the output sequence. At the next start of the output sequence, the technology module resets the ERR_PULSE feedback bit again.

4.1.1.4 On delay

You set the On delay from 0 to 85 s with a precision of 1 µs in the hardware configuration.

In addition, you can change the On delay via the control interface by entering a new value in SLOT as integer (UDINT). In so doing, you use the MODE_SLOT control bit to choose whether you want to apply a change once or cyclically:

MODE_SLOT = 0	One-time change: As soon as you write the value 2_D in the corresponding output byte, the value from SLOT is applied once as the On delay and kept until the next change. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.
MODE_SLOT = 1	Cyclic change: When you write the value 18_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically as the On delay. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.

You can find additional information under Handling of the SLOT parameters (Page 20).

4.1.1.5 Sequence counter

The technology module has one sequence counter per channel, which counts the completed output sequences. Output sequences that were successfully completed as well those that were not successfully completed are counted. When the HW enable is being used, there is a possibility of very short output sequences that are not reliably detected by the CPU. With the help of the sequence counter, a check can be made in the user program to determine whether output sequences were initiated.

The number of output sequences is supplied in the feedback interface (Page 32) using the value SEQ_CNT. You can monitor the completion of an output sequence with this value.

When the HW enable is being used, the sequence counter counts from 0 to 15. When the HW enable is not being used, the output sequence is started exclusively by the SW_ENABLE control bit, and the sequence counter therefore counts only to 1.

The counter returns to 0 as soon as SW_ENABLE is reset as well as after an overflow.

4.1.1.6 High-speed output

The high-speed output function enables an output frequency of a maximum of 100 kHz with an output current of a maximum of 100 mA. A high-speed output generates very steep edges. The high-speed output generates signals at a higher frequency, but provides a lower maximum load current. The high-speed output is only available in two-channel operation.

The following table presents the value range of the pulse duration and frequency depending on whether or not the high-speed output function is activated:

	Minimum value		**Maximum value**	
	High-speed output deactivated	**High-speed output activated**	**High-speed output deactivated**	**High-speed output activated**
Pulse duration	10 µs	1,5 µs	85000000 µs (= 85 s)	
Frequency	0,02 Hz		10 kHz	100 kHz

4.1.2 Configuring

Introduction

You configure the technology module and assign its parameters with the configuration software.

The user program controls and monitors the functions of the technology module via the control interface and feedback interface.

System environment

The technology module can be used in the following system environments:

Possible use	Components needed	Configuration software	In the user program
Centralized operation with a CPU 151xSP	• ET 200SP automation system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to control interface and feedback interface in the I/O data
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	
Distributed operation with an S7-300/400 CPU	• S7-300/400 automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration STEP 7: Device configuration and parameter setting with HSP	
Distributed operation on the PROFINET IO in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	Third-party configuration software: Device configuration and parameter setting with GSD file	
Distributed operation on the PROFIBUS DP in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	Third-party configuration software: GSD file; device configuration and parameter setting using data record 128	

Hardware Support Packages (HSP)

STEP 7

The Hardware Support Packages (HSP) are available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/23183356).

GSD file

The respective GSD file for the ET 200SP distributed I/O system is available for download on the Internet:

- GSD file PROFINET IO (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD file PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/73016883)

4.1.3 Reaction to CPU STOP

You set the response of the channel to a CPU STOP in the parameters of the device configuration.

Table 2-1261 Response of channel to CPU STOP

Option	Meaning
Output substitute value	The channel outputs the configured substitute values at the digital outputs until the next STOP-RUN transition of the CPU. You can configure the substitute value 1 for only one of the two digital outputs. An active output sequence is stopped and the STS_ENABLE feedback bit is reset. The technology module is set to its startup state after a STOP-RUN transition. Before you can start a new pulse output, you must reset the SW_ENABLE control bit.
Continue operation	The channel continues to operate. The digital outputs continue to switch according to the parameter assignment. An active output sequence will thus be continued. If you have configured the hardware enable, you can also start additional output sequences using DIn.0. The configuration of the technology module is not reset after a STOP-RUN transition.

4.1.4 Parameter setting

You use various parameters to specify the properties of the technology module. Depending on the settings, not all parameters are available. When parameters are assigned in the user program, the parameters are transferred to the module with the "WRREC" instruction and data record 128 (Page 131).

You set the parameters of the module as follows in this operating mode:

Parameter setting via...	Basic procedure
Hardware configuration in STEP 7 (TIA Portal)	1. Insert the module from the hardware catalog under "Technology modules". 2. Set the "Pulse output" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration in STEP 7 with HSP	1. Install the corresponding HSP file. You will then find the module in the hardware catalog under "ET 200SP". 2. Set the "Pulse output" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFINET IO	1. Install the latest PROFINET GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFINET IO > I/O". 2. Set the "Pulse output" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.

Parameter setting via...	Basic procedure
Hardware configuration with GSD file for distributed operation on PROFIBUS DP	1. Install the latest PROFIBUS GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFIBUS DP > I/O". 2. Download the project to the CPU. The parameters of the module are also downloaded with their default settings (see table below). 3. Set the "Pulse output" mode and the further parameters in the user program using data record 128.

Parameters of the TM Pulse 2x24V in "Pulse output" mode

The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1262 Adjustable parameters

Parameter	Value range	Scope
Channel configuration[1]	• **2 channels (2 A)** • 1 channel (4 A)	Module
Reaction to CPU STOP	• **Output substitute value** • Continue operation	Channel
Substitute value for DQA	• **0** • 1	Channel
Substitute value for DQB	• **0** • 1	Channel
Group diagnostics	• **Deactivated** • Activated	Channel
Diagnostics DQA	• **Deactivated** • Activated	Channel
Diagnostics DQB	• **Deactivated** • Activated	Channel
High-speed output (0.1 A)	• **Deactivated** • Activated	Channel
Function DI	• **Input** • HW enable	Channel
Input delay for digital inputs	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel
Output format	• S7 analog output • **1/100** • 1/1000 • 1/10000	Channel

[1] When configuring with HSP for STEP 7 or with a GSD file, you define the channel configuration by the selection of the module name.

Parameter	Value range	Scope
On delay for pulse output	**0**...85000000 µs	Channel

[1] When configuring with HSP for STEP 7 or with a GSD file, you define the channel configuration by the selection of the module name.

NOTE

PROFIBUS GSD configuration

When configuring with a PROFIBUS GSD file, the possible parameter assignments are not available. The parameters are preassigned in the module with the default setting. Set the "Pulse output" mode and the further parameters in the user program using data record 128.

4.1.5 Address space

Address space of the technology module

Table 2-1263 Size of input and output addresses

	Inputs	Outputs
Size per technology channel	8 bytes	12 bytes
Size in one-channel operation	8 bytes	12 bytes
Size in two-channel operation	16 bytes	24 bytes

4.1.6 Control and feedback interface

NOTE

A library of PLC data types (LPD) for STEP 7 (TIA Portal) and SIMATIC S7-1200 / S7-1500 is available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109482396).

4.1.6.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface per channel

The following table shows the control interface assignment:

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 … 3	12 … 15	OUTPUT_VALUE UDINT: Pulse duration							
4 … 7	16 … 19	SLOT UDINT: Load value							
8	20	Reserved			MODE_ SLOT	LD_SLOT			
9	21	Reserved			SET_DQB	SET_DQA	Reserved	TM_ CTRL_DQ	SW_ ENABLE
10	22	Reserved							RES_ ERROR
11	23	Reserved							

NOTE

Channel 1 is only available in two-channel operation of the module.

Control bit/value	Explanations
OUTPUT_VALUE	You specify the pulse duration with this value. Value range: • Pulse duration in µs when high-speed output is deactivated: 10 to 85000000_D • Pulse duration in µs when high-speed output is activated: 2 to 85000000_D If the pulse duration setting is outside the value range, the ERR_OUT_VAL feedback bit is set and the last valid pulse duration is used.
SLOT	You specify the load value with this value. Value range: • On delay in µs: 0 to 85000000_D You specify whether to apply a change once or cyclically with MODE_SLOT. Invalid values trigger setting of feedback bit ERR_LD (when MODE_SLOT = 0) or ERR_SLOT_VAL (when MODE_SLOT = 1).
MODE_SLOT	You specify whether you want to apply a change in SLOT once or cyclically with this bit. 0 means: As soon as you write the value 2_D in the corresponding output byte, the value from SLOT is applied once as the On delay and kept until the next change. A change via SLOT takes

Control bit/value	Explanations
	effect at the next output sequence. After a restart of the module, the value is overwritten with the value set in the hardware configuration. 1 means: When you write the value 18_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically. A change via SLOT takes effect at the next output sequence.
LD_SLOT	You specify the meaning of the value in SLOT with this load request: • 0000_B means: No action, idle • 0010_B means: On delay in µs Values not listed are invalid and trigger setting of feedback bit ERR_LD (when MODE_SLOT = 0) or ERR_SLOT_VAL (when MODE_SLOT = 1).
SET_DQA	You use this bit to set digital output DQn.A when TM_CTRL_DQ and SET_DQB are set to 0.
SET_DQB	You use this bit to set digital output DQn.B when TM_CTRL_DQ and SET_DQA are set to 0.
TM_CTRL_DQ	You enable the technological function of the digital output with this bit. • 0 means: SET_DQA and SET_DQB define states of DQn.A and DQn.B • 1 means: Output sequence defines the state of DQn.A; DQn.B is always 0.
SW_ENABLE	You activate the software enable with this bit. If you are using the hardware enable, it is combined with the software enable. • 0 means: Stop output • 1 means: Start output Use of the HW enable is activated through parameter assignment. The HW enable is controlled externally using the digital input DIn.0.
RES_ERROR	You use this bit to reset the following feedback bits when errors are pending: • ERR_24V • ERR_DQA • ERR_DQB • ERR_LD
Reserved	Reserved bits must be set to 0.

4.1.6.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module via the feedback interface.

Feedback interface per channel

The following table shows the assignment of the feedback interface:

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8	ERR_ SLOT_VAL	ERR_ OUT_VAL	ERR_DQB	ERR_DQA	ERR_ PULSE	ERR_LD	ERR_24V	ERR_PWR
1	9	Reserved		STS_SW_ ENABLE	STS_ READY	Reserved	STS_LD_ SLOT	Reserved	

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
2	10	Reserved				STS_DI	STS_DQB	STS_DQA	STS_ ENABLE
3	11	Reserved				SEQ_CNT			
4 … 7	12 … 15	Reserved							

NOTE

Channel 1 is only available in two-channel operation of the module.

Feedback bit/value	Explanations
ERR_SLOT_VAL	This bit indicates that the value in SLOT or LD_SLOT is invalid (when MODE_SLOT = 1) and was not accepted. As soon as the module has received a valid value from the control interface, ERR_SLOT_VAL is automatically reset.
ERR_OUT_VAL	This bit indicates that the value in OUTPUT_VALUE is invalid. As soon as the module has received a valid value from the control interface, ERR_OUT_VAL is automatically reset.
ERR_DQA	This bit indicates a short-circuit or an overload at the output DQn.A. If you have enabled the diagnostics interrupt "Diagnostics DQA", the diagnostics interrupt "Error at digital outputs" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_DQB	This bit indicates a short-circuit or an overload at the output DQn.B or the attempted simultaneous setting of the SET_DQA and SET_DQB control bits. If you have enabled the diagnostics interrupt "Diagnostics DQB", the diagnostics interrupt "Error at digital outputs" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_PULSE	This bit indicates an error in the pulse output, e.g. new pulse duration value is too low.
ERR_LD	This bit indicates that the value in SLOT or LD_SLOT (when MODE_SLOT = 0) is invalid and was not accepted. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_24V	This bit indicates a short-circuit or an overload at output 24VDC If you have enabled diagnostic interrupts, the diagnostic interrupt "Short circuit / overload of the sensor supply voltage" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_PWR	This bit indicates that supply voltage L+ is too low. If you have enabled the diagnostic interrupts, the diagnostic interrupt "Supply voltage fault" is triggered when an error occurs. As soon as supply voltage L+ is sufficiently high again, ERR_PWR is automatically reset. The bit is not set if no supply voltage is present.

Feedback bit/value	Explanations
STS_SW_ENABLE	This bit indicates the status of the SW enable. • 0 means: SW enable not active • 1 means: SW enable active
STS_READY	This bit indicates that the module is supplying valid user data. The module is started and configured.
STS_LD_SLOT	A status change (toggling) of this bit indicates that the LD_SLOT load request was detected and executed (when MODE_SLOT = 0).
STS_DI	This bit indicates the status of the digital input DIn.0.
STS_DQA	This bit indicates the status of the digital output DQn.A.
STS_DQB	This bit indicates the status of the digital output DQn.B.
STS_ENABLE	This bit indicates that an output sequence is active.
SEQ_CNT	This value indicates the number of completed output sequences as sequence counter.
Reserved	Reserved bits are set to 0.

4.1.7 Isochronous mode

The technology module supports the "Isochronous mode" system function. If you are not using a hardware enable, the output sequence starts in isochronous mode at time T_o after the SW_ENABLE control bit has been set.

Further information

You will find a detailed description of isochronous mode in:

- In the isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- PROFINET with STEP 7 function manual available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

4.2 Pulse width modulation PWM mode

4.2.1 Function

4.2.1.1 Introduction

In this operating mode, the respective channel of the technology module outputs a pulse width modulated signal with the configured minimum pulse duration and the configured period duration. You can superimpose a dither signal on the PWM signal. The module also has an integrated PID controller that can be used to control the output current.

You specify the duty cycle or current setpoint via the control interface.

4.2.1.2 Output sequence

Starting the output sequence

In order to output the output sequence at digital output DQn.A, the TM_CTRL_DQ control bit (Page 109) must be set. To start the output sequence using the software enable, you set the SW_ENABLE control bit (Page 51). The STS_SW_ENABLE feedback bit (Page 53) indicates that the software enable in the technology module is active.

You can additionally use the hardware enable via the respective digital input DIn.0. You can configure an input delay for DIn.0.

Pulse diagram

The following figure shows an example of an output sequence when DIn.0 is being used as a hardware enable.

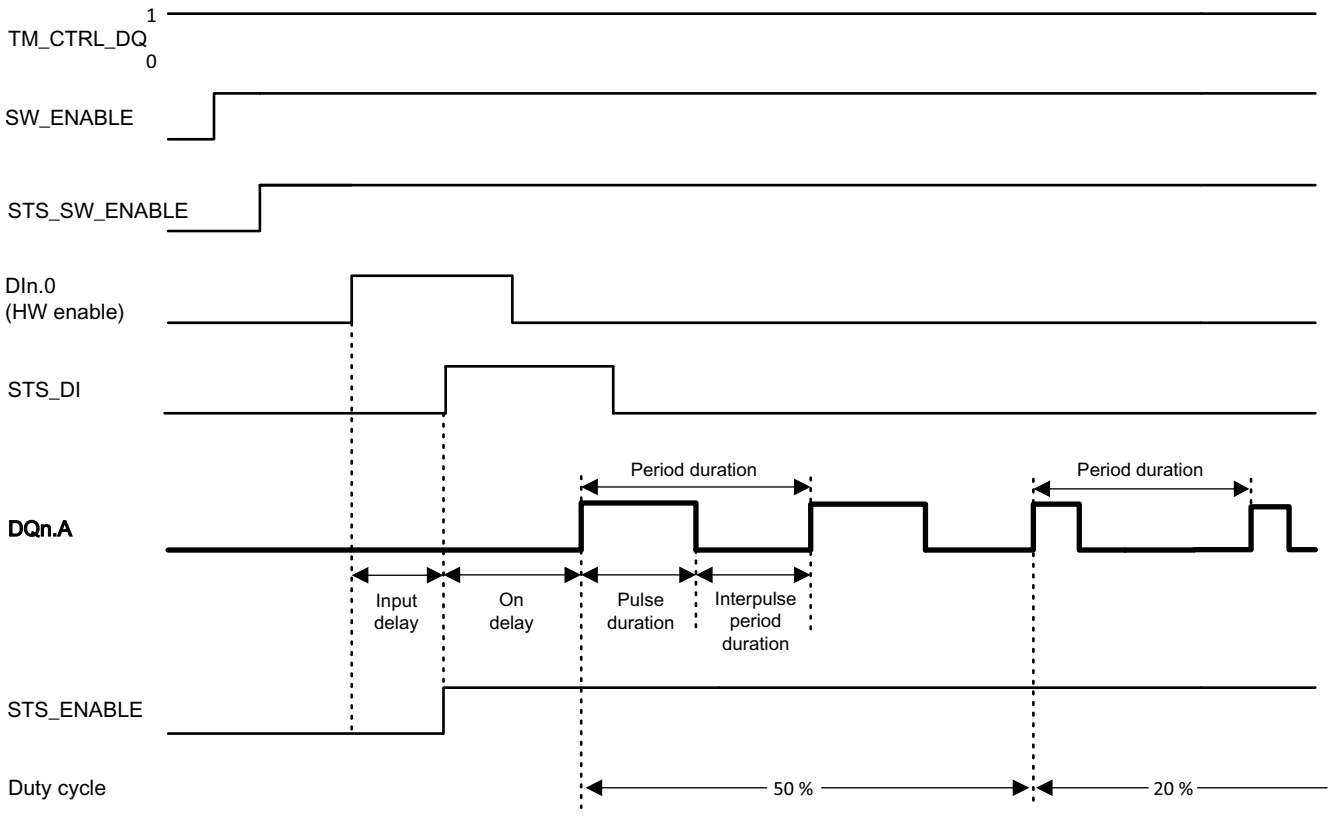

Figure 2-1097 Example of an output sequence

If you are using the hardware enable, it is combined with the software enable. When the software enable is active, the output sequence starts at the first rising edge of the hardware enable. Additional rising edges of the hardware enable during the output sequence are ignored. If the hardware enable is set and remains set for the duration of the input delay, the On delay is started and the STS_ENABLE feedback bit is set. As soon as the On delay has elapsed, the pulse width modulated signal is output with the assigned duty cycle at the respective digital output DQn.A. The duty cycle is the ratio of pulse duration to period duration. The output sequence runs continuously, as long as SW_ENABLE is set.

If you are not using a hardware enable, the On delay starts at the rising edge of SW_ENABLE. The hardware enable is not supported in isochronous mode.

Aborting the output sequence

If you reset the SW_ENABLE control bit, the software enable is deactivated and the current output sequence is aborted. The last period is not completed. The STS_ENABLE feedback bit and the digital output DQn.A are reset.

A renewed pulse output is only possible after a restart of the output sequence.

4.2.1.3 Duty cycle

The duty cycle corresponds to the ratio of pulse duration to period duration (also referred to as mark-to-space ratio).

You set the duty cycle in the control interface (Page 51) using OUTPUT_VALUE as integer (UDINT). The value range is dependent on the configured output format. If you set the value 0, the DQn.A is not set during the entire period duration. If you set the maximum value, the DQn.A is set during the entire period duration. If you set a value above the value range, the maximum value is used.

Output format	Value range of OUTPUT_VALUE	Pulse duration
1/100 (%)	0 ... 100	(OUTPUT_VALUE/100) × Period duration
1/1000 (‰)	0 ... 1000	(OUTPUT_VALUE/1000) × Period duration
1/10000	0 ... 10000	(OUTPUT_VALUE/10000) × Period duration
S7 analog output	0 ... 27648	(OUTPUT_VALUE/27648) × Period duration

A changed duty cycle takes effect with the next rising edge at DQn.A.

NOTE

Current control

If you are using current control (Page 41), the module controls the duty cycle, and the current setpoint is assigned using OUTPUT_VALUE.

4.2.1.4 Period duration

You set the period duration in µs in the hardware configuration. The value range is dependent on whether or not the high-speed output function is being used:

High-speed output	Value range of the period duration
Activated	10 ... 85000000 µs = 10 µs ... 85 s
Deactivated	100 ... 85000000 µs = 100 µs ... 85 s

In addition, you can change the period duration via the control interface by entering a new value in SLOT as integer (UDINT). In so doing, you use the MODE_SLOT control bit to choose whether you want to apply a change once or cyclically:

MODE_SLOT = 0	One-time change: As soon as you write the value 1_D in the corresponding output byte, the value from SLOT is applied once as the period duration and kept until the next change. A period duration that has been changed using SLOT takes effect at the next positive edge at DQn.A.
MODE_SLOT = 1	Cyclic change: When you write the value 17_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically as the period duration. A period duration that has been changed using SLOT takes effect at the next positive edge at DQn.A.

You can find additional information under Handling of the SLOT parameters (Page 20).

4.2.1.5 On delay

You set the On delay from 0 s to 85 s with a precision of 1 µs in the hardware configuration.

In addition, you can change the On delay via the control interface by entering a new value in SLOT as an integer (UDINT). In so doing, you use the MODE_SLOT control bit to choose whether you want to apply a change once or cyclically:

MODE_SLOT = 0	One-time change: As soon as you write the value 2_D in the corresponding output byte, the value from SLOT is applied once as the On delay and kept until the next change. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.
MODE_SLOT = 1	Cyclic change: When you write the value 18_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically as the On delay. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.

You can find additional information under Handling of the SLOT parameters (Page 20).

NOTE

In isochronous mode, a configured On delay has no effect.

4.2.1.6 Dithering

The dither function is specially designed for control of proportional valves. The dither function superimposes an adjustable symmetrical variation on the setpoint for control of the valve solenoid. This results in a minimal motion around the set position and prevents the valve from sticking due to stiction or hysteresis effect. This improves the reaction to setpoint changes.

You set the parameters for the dithering in the hardware configuration. You activate the dithering using the DITHER bit in the control interface (Page 51).

Dithering amplitude

The dithering amplitude is the amplitude of the dither signal in relation to the period duration of the output sequence. The value range is 0 to 50%. If you set a value above the value range, a dithering amplitude of 50% is used.

The module dynamically adjusts the dithering amplitude when the determined effective duty cycle is greater than 100% or less than 0% so that the dither signal remains symmetrical.

Examples:

With a dithering amplitude of 10% and a duty cycle of 50%, the effective duty cycle of the output sequence varies periodically between 40% and 60%.

With a dithering amplitude of 10% and a duty cycle of 95%, the effective duty cycle of the output sequence varies periodically between 90% and 100%.

In addition, you can change the dithering amplitude via the control interface by entering a new value in SLOT as integer (UDINT). In so doing, you can use the MODE_SLOT control bit to choose whether you want to apply a change once or cyclically:

MODE_SLOT = 0	One-time change: As soon as you write the value 6_D in the corresponding output byte, the value from SLOT is applied once as the dithering amplitude. A change using SLOT takes effect after a stop and restart of the dithering.
MODE_SLOT = 1	Cyclic change: When you write the value 22_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically as the dithering amplitude. A change using SLOT takes effect after a stop and restart of the dithering.

Dithering period duration

The dithering period duration is the period duration of the dither signal. The value must be at least 4 times the period duration of the PWM signal and greater than 2 ms. The maximum value is 100 ms. If you set a value above the value range, a dithering period duration of 100 ms is used.

The module uses only a multiple of the period duration of the PWM signal as the dithering period duration. The module adjusts the assigned value of the period duration in such a way that the next higher or lower multiple is used.

In addition, you can change the dithering period duration via the control interface by entering a new value in SLOT as integer (UDINT). In so doing, you can use the MODE_SLOT control bit to choose whether you want to apply a change once or cyclically:

MODE_SLOT = 0	One-time change: As soon as you write the value 7_D in the corresponding output byte, the value from SLOT is applied once as the dithering period duration. A change using SLOT takes effect after a stop and restart of the dithering.
MODE_SLOT = 1	Cyclic change: When you write the value 23_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically as the dithering period duration. A change using SLOT takes effect after a stop and restart of the dithering.

NOTE

If you increase the period duration of the PWM signal during an active output sequence in such a way that the dithering period duration is less than 4 times as large, the dither signal will be deactivated.

NOTE

Isochronous mode

In isochronous mode, for the best possible results you should set an integral multiple of the application cycle for the dithering period duration.

Incline of dithering ramp up and down

Incline of dithering ramp up: This parameter is the slope of the ramp up of the dithering amplitude for a theoretical increase of amplitude from 0% to 100%.

Incline of dithering ramp down: This parameter is the slope of the ramp down of the dithering amplitude for a theoretical decrease of amplitude from 100% to 0%.

The value range is 0 to 30000 ms in each case. If you set a value above the value range, a value of 30000 ms is used for the incline.

The respective incline influences the effective ramp time. Example: A dithering amplitude of 10% and an incline of 2500 ms/100% yields the following effective ramp time:

10 % × 2500 ms/100 % = 250 ms

In addition, you can change the incline of the ramp up and the ramp down jointly via the control interface by entering a new value in SLOT as integer (INT twice). In so doing, you can use the MODE_SLOT control bit to choose whether you want to apply a change once or cyclically:

MODE_SLOT = 0	One-time change: As soon as you write the value 5_D in the corresponding output byte, the value from SLOT (LOWWORD) is applied once as the incline of the ramp up and the value from SLOT (HIGHWORD) is applied once as the incline of the ramp down. A change using SLOT takes effect after a stop and restart of the dithering.

MODE_SLOT = 1	Cyclic change: When you write the value 21_D in the corresponding output byte, the current value from SLOT (LOWWORD) is applied cyclically in each case as incline of the ramp up and the value from SLOT (HIGHWORD) is applied in each case as incline of the ramp down. A change using SLOT takes effect after a stop and restart of the dithering.

Starting and stopping dithering

The dithering starts with the configured ramp up as soon as the DITHER bit is set in the control interface (Page 51) during an active output sequence and a new dithering period duration starts. After the start of the dithering, the STS_DITHER bit is set in the feedback interface (Page 53).

As soon as you reset the DITHER bit, the configured ramp down begins with the subsequent dithering period duration. After the ramp down finishes, the STS_DITHER bit is reset.

If the output sequence is aborted, the dithering is also aborted and the STS_DITHER bit is reset.

The following figure shows an example of an output sequence with a duty cycle of 50% without dithering.

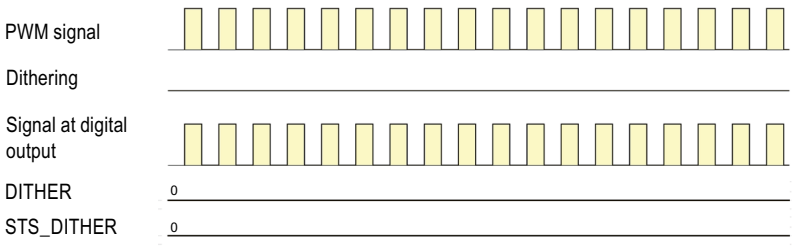

The following figure shows an example of an output sequence with the following properties:

- Duty cycle = 50%
- Dithering period duration = 6 × Period duration of the PWM signal
- No ramp up/down

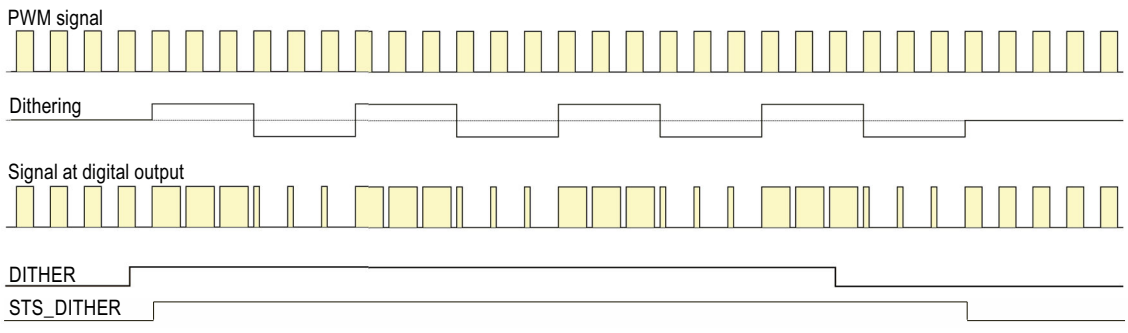

The following figure shows an example of an output sequence with the following properties:

- Duty cycle = 50%
- Dithering period duration = 6 × Period duration of the PWM signal
- With ramp up

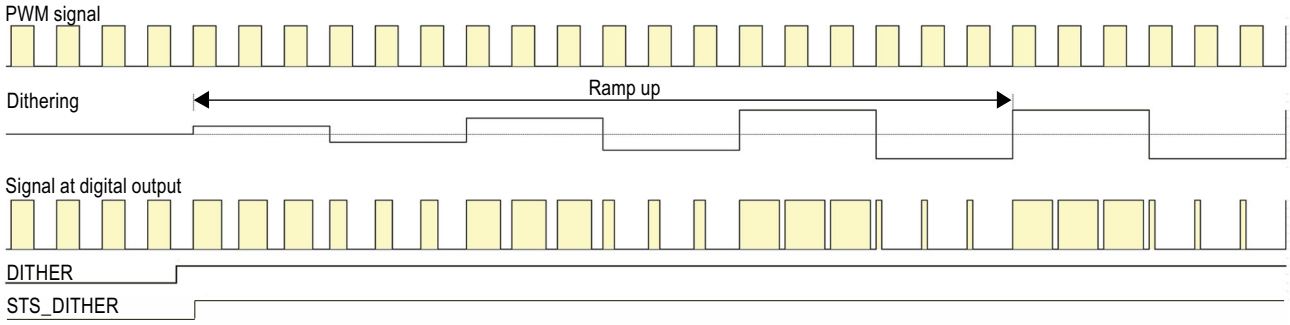

The following figure shows an example of an output sequence with the following properties:

- Duty cycle = 50%
- Dithering period duration = 6 × Period duration of the PWM signal
- With ramp down

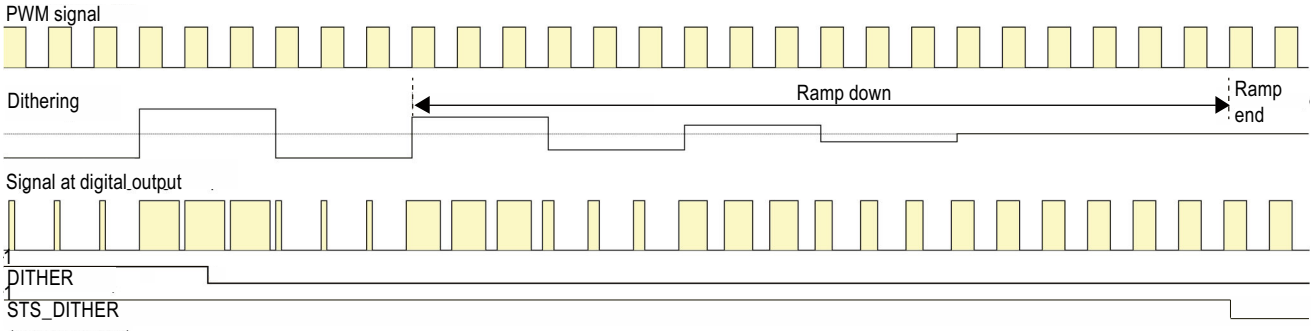

4.2.1.7 Current measurement/control

Current measurement

The technology module measures the load current at the digital output. The measured value of the current is returned as an S7 analog value in the MEASURED_CURRENT value in the feedback interface (Page 53).

A valid measured value is available when the STS_ENABLE feedback bit is set after the first period duration of the output sequence. The returned measured value is an average of the measured values that were acquired over a time period of at least one period duration. If a valid measured value is not available, the value 32767_D is returned.

When dithering is active, the average is for the time period of an entire dithering period duration.

NOTE

In order to use the current measurement, the high-speed output must be deactivated.

Measuring range and accuracy

The measuring range and accuracy are dependent on the channel configuration:

	Measured value 27648_D	Maximum measured value 32511_D	Accuracy[3]	
			Period duration > 333 µs	Period duration < 333 µs
Two-channel operation	2 A[1]	2.37 A[2]	±40 mA	-40 mA ... +100 mA
One-channel operation (parallel connection)	4 A[1]	4.74 A[2]	±80 mA	-80 mA ... +200 mA

[1] May only be exceeded for a short time.

[2] When this current value is exceeded, the ERR_DQA feedback bit will be set.

[3] With constant period duration in the respective measuring period.

Current control

You can use the current control function to proportionally control the power transferred to an inductive or resistive load. Thermal effects are automatically regulated out.

The setpoint of the current is specified by the user program. The module controls the duty cycle of the PWM signal according to the setpoint and the reaction depends on the PID parameters.

The PID controller compares the setpoint and the measured value of the load current to one another. If the resulting difference is outside a symmetrical dead band, a reaction of the controller is calculated by taking into account the enabled components of the PID controller (proportional, integral and/or differential).

The calculated manipulated variable value is subject to defined high and low limits. If the manipulated variable value reaches a limit, the user program reads this in the feedback interface (Page 53) via the QLMN_HLM and QLMN_LLM bits.

You set the parameters for the current control in the hardware configuration. The value of OUTPUT_VALUE in the control interface (Page 51) is interpreted as the current setpoint relative to the reference value of the current.

The figure below shows the principle of operation of the PID current control.

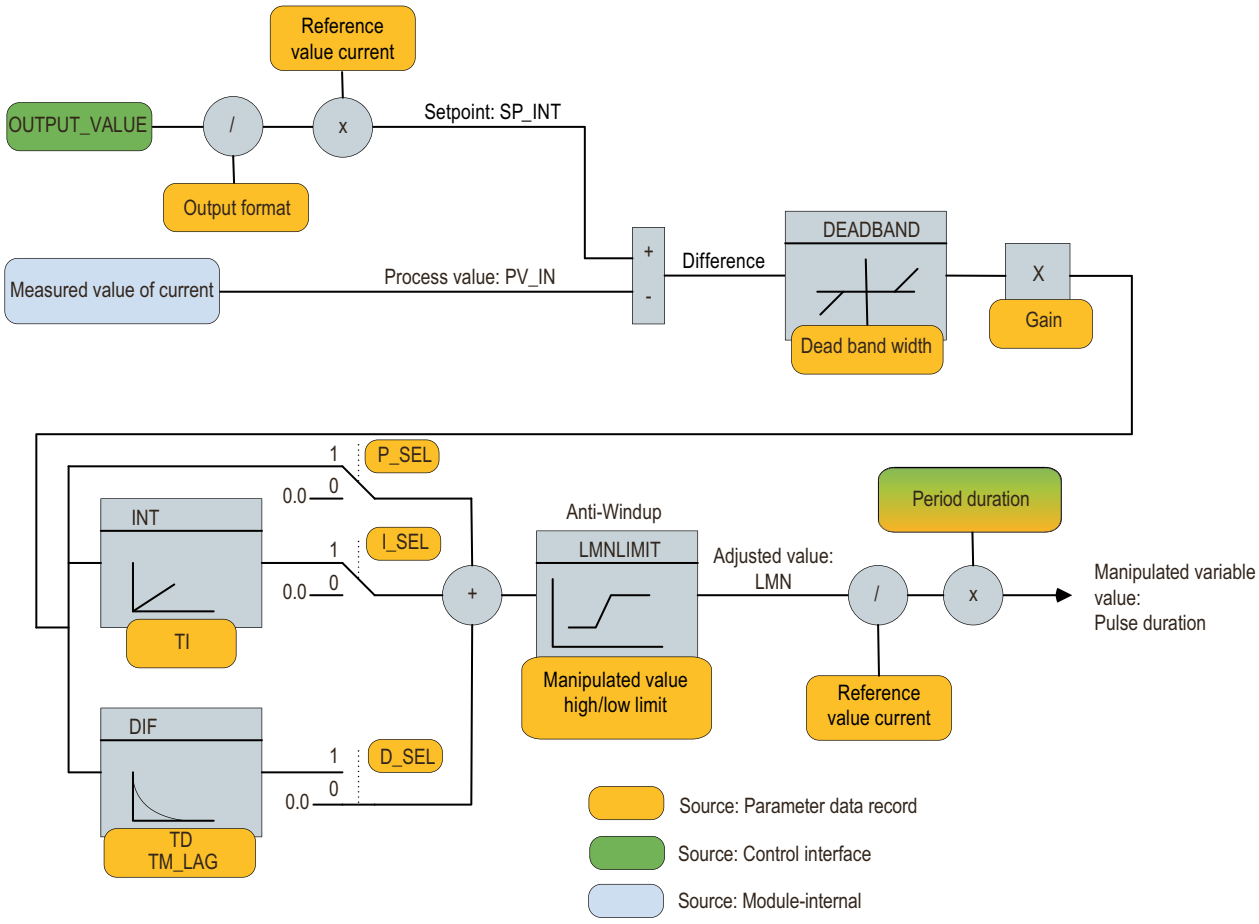

P_Sel	Enable proportional action of the PID algorithm
I_Sel	Enable integral action of the PID algorithm
D_Sel	Enable derivative action of the PID algorithm
Reference value current (mA)	Maximum value as reference value for the current setpoint. The recommended setting is the value of the load current that is measured when current control is deactivated and the duty cycle is 100%.
Dead band width (µA)	Deviation of the output current from the current setpoint within which no correction takes place. The deviation refers to a range above and below the current setpoint.
Manipulated value high limit (S7 analog value)	High control limit
Manipulated value low limit (S7 analog value)	Low control limit
Gain	Gain factor for P-component of the PID algorithm

TI (s)	Integration time; length of time used by the I-component of the PID algorithm. If TI is less than the controller cycle time, TI is set internally to the value of the cycle time.
TD (s)	Derivative action time; length of time used by the D-component of the PID algorithm. If TD is less than the controller cycle time, TI is set internally to the value of the cycle time.
TM_LAG (s)	Time lag of the D-component of the PID algorithm. If TI is less than half the controller cycle time, TI is set internally to half the value of the cycle time.

The default setting of the controller parameters is chosen conservatively to enable stable operation. For dynamic valve positioning, you optimize the individual parameters to fit your plant conditions. In particular, a higher gain factor and a lower integration time lead to faster reactions to a setpoint change.

Controller cycle time

When dithering is deactivated, the internal cycle time of the controller corresponds to the PWM period duration. When dithering is active, the internal cycle time of the controller corresponds to the dithering period duration.

Resetting the PID controller

The internal data of the controller is reset in the following cases:

- SW_ENABLE control bit is reset
- New parameter data record is sent to module

Further information

You can find further information on PID controllers in the PID Control (https://support.industry.siemens.com/cs/ww/en/view/108210036) function manual, e.g. in the CONT_C section.

4.2.1.8 Minimum pulse duration and minimum interpulse period

The minimum pulse duration and the minimum interpulse period are the minimum pulse duration and interpulse period that are to be output.

The module suppresses pulses and interpulse periods whose duration is less the minimum pulse duration. A pulse duration that is less than the period duration by an amount less than the minimum interpulse period is set by the module to the value of the period duration. In this way you can suppress undesired effects when the connected actuator is not able to react appropriately to such short signal changes.

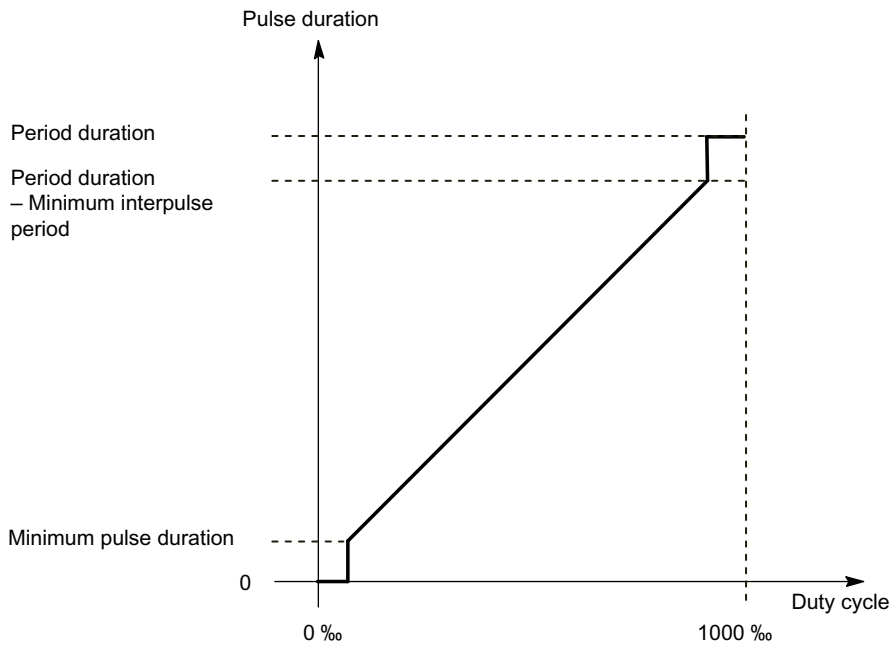

Figure 2-1098 Pulse duration modulation

You set the minimum pulse duration from 0 to 85 s with a precision of 1 µs in the hardware configuration. The set value applies simultaneously to the minimum interpulse period.

NOTE
Current control
If you are using current control, a configured minimum pulse duration has no effect.

NOTE
Dithering
If you are using dithering without current control, the configured minimum pulse duration is effective. In this case, the superimposition of the PWM signal is reduced so that the effective pulse duration is within the permissible range.

4.2.1.9 High-speed output

The high-speed output function enables an output frequency of a maximum of 100 kHz with an output current of a maximum of 100 mA. A high-speed output generates very steep edges. The high-speed output generates signals at a higher frequency, but provides a lower maximum load current.

The high-speed output is only available in two-channel operation and only without current control.

The following table presents the minimum and maximum pulse duration, period duration and frequency depending on whether or not the high-speed output is activated:

	Minimum value		Maximum value	
	High-speed output deactivated	**High-speed output activated**	**High-speed output deactivated**	**High-speed output activated**
Pulse duration	10 µs	1,5 µs	85000000 µs (= 85 s)	
Period duration	100 µs	10 µs		
Frequency	0,02 Hz		10 kHz	100 kHz

4.2.2 Configuring

Introduction

You configure the technology module and assign its parameters with the configuration software.

The user program controls and monitors the functions of the technology module via the control interface and feedback interface.

System environment

The technology module can be used in the following system environments:

Possible use	Components needed	Configuration software	In the user program
Centralized operation with a CPU 151xSP	• ET 200SP automation system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to control interface and feedback interface in the I/O data
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	

Possible use	Components needed	Configuration software	In the user program
Distributed operation with an S7-300/400 CPU	• S7-300/400 automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration STEP 7: Device configuration and parameter setting with HSP	Direct access to control interface and feedback interface in the I/O data
Distributed operation on the PROFINET IO in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	Third-party configuration software: Device configuration and parameter setting with GSD file	
Distributed operation on the PROFIBUS DP in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	Third-party configuration software: GSD file; device configuration and parameter setting using data record 128	

Hardware Support Packages (HSP)

STEP 7

The Hardware Support Packages (HSP) are available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/23183356).

GSD file

The respective GSD file for the ET 200SP distributed I/O system is available for download on the Internet:

- GSD file PROFINET IO (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD file PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/73016883)

4.2.3 Reaction to CPU STOP

You set the response of the channel to a CPU STOP in the parameters of the device configuration.

Table 2-1264 Response of channel to CPU STOP

Option	Meaning
Output substitute value	The channel outputs the configured substitute values at the digital outputs until the next STOP-RUN transition of the CPU. You can configure the substitute value 1 for only one of the two digital outputs. An active output sequence is stopped and the STS_ENABLE feedback bit is reset. The technology module is set to its startup state after a STOP-RUN transition. Before you can start a new pulse output, you must reset the SW_ENABLE control bit.

Option	Meaning
Continue operation	The channel continues to operate. The digital outputs continue to switch according to the parameter assignment. An active output sequence will thus be continued. If you have configured the hardware enable, you can also start additional output sequences using DIn.0. The configuration of the technology module is not reset after a STOP-RUN transition.

4.2.4 Parameter setting

You use various parameters to specify the properties of the technology module. Depending on the settings, not all parameters are available. When parameters are assigned in the user program, the parameters are transferred to the module with the "WRREC" instruction and data record 128 (Page 131).

You set the parameters of the module as follows in this operating mode:

Parameter setting via...	Basic procedure
Hardware configuration in STEP 7 (TIA Portal)	1. Insert the module from the hardware catalog under "Technology modules". 2. Set the "Pulse width modulation PWM" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration in STEP 7 with HSP	1. Install the corresponding HSP file. You will then find the module in the hardware catalog under "ET 200SP". 2. Set the "Pulse width modulation PWM" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFINET IO	1. Install the latest PROFINET GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFINET IO > I/O". 2. Set the "Pulse width modulation PWM" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFIBUS DP	1. Install the latest PROFIBUS GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFIBUS DP > I/O". 2. Download the project to the CPU. The parameters of the module are also downloaded with their default settings (see table below). 3. Set the parameters in the user program using data record 128.

Parameters of the TM Pulse 2x24V in "Pulse width modulation PWM" mode

The following table shows the parameters for the module.

The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1265 Adjustable parameters

Parameter	Value range	Scope
Channel configuration[1]	• **2 channels (2 A)** • 1 channel (4 A)	Module
Reaction to CPU STOP	• **Output substitute value** • Continue operation	Channel
Substitute value for DQA	• **0** • 1	Channel
Substitute value for DQB	• **0** • 1	Channel
Group diagnostics	• **Deactivated** • Activated	Channel
Diagnostics DQA	• **Deactivated** • Activated	Channel
Diagnostics DQB	• **Deactivated** • Activated	Channel
High-speed output (0.1 A)	• **Deactivated** • Activated	Channel
Function DI	• **Input** • HW enable	Channel
Input delay for digital inputs	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel
Output format	• S7 analog output • **1/100** • 1/1000 • 1/10000	Channel
Minimum pulse duration	**0**...85000000 µs	Channel
Period duration	10...**2000000**...85000000 µs	Channel
Actual period duration	Automatically calculated (read-only)	Channel
On delay for pulse output	**0**...85000000 µs	Channel
Dithering	• **Deactivated** • Activated	Channel
Incline of dithering ramp up	**0**...30000 ms	Channel

[1] When configuring with HSP for STEP 7 or with a GSD file, you define the channel configuration by the selection of the module name.

Parameter	Value range	Scope
Incline of dithering ramp down	**0**...30000 ms	Channel
Dithering amplitude	0.0...**5.0**...50%	Channel
Dithering period duration	2000...**50000**...100000 µs	Channel
Dithering frequency	Automatically calculated (read-only)	Channel
Current control	• **Deactivated** • Activated	Channel
Enable proportional action	• Deactivated • **Activated**	Channel
Enable integral action	• Deactivated • **Activated**	Channel
Enable derivative action	• **Deactivated** • Activated	Channel
Reference value current	**0**...2000 mA (two-channel operation); **0**...4000 mA (one-channel operation)	Channel
Dead band width	**0**...65535 µA	Channel
Manipulated value high limit	1...**27648**	Channel
Manipulated value low limit	**0**...27647	Channel
Proportional gain	0.0000...**2.0000**...7.9228×10^{28}	Channel
Integration time	0.0000...**20.0000**...7.9228×10^{28} s	Channel
Derivative action time	0.0000...**10.0000**...7.9228×10^{28} s	Channel
Delay time of derivative action	0.0000...**2.0000**...7.9228×10^{28} s	Channel

[1] When configuring with HSP for STEP 7 or with a GSD file, you define the channel configuration by the selection of the module name.

NOTE

PROFIBUS GSD configuration

When configuring with a PROFIBUS GSD file, the possible parameter assignments are not available. The parameters are preassigned in the module with the default setting. Set the parameters in the user program using data record 128.

4.2.5 Address space

Address space of the technology module

Table 2-1266 Size of input and output addresses

	Inputs	Outputs
Size per technology channel	8 bytes	12 bytes
Size in one-channel operation	8 bytes	12 bytes
Size in two-channel operation	16 bytes	24 bytes

4.2.6 Control interface and feedback interface

NOTE

A library of PLC data types (LPD) for STEP 7 (TIA Portal) and SIMATIC S7-1200 / S7-1500 is available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109482396).

4.2.6.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface per channel

The following table shows the control interface assignment:

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 … 3	12 … 15	OUTPUT_VALUE UDINT: Duty cycle or current setpoint							
4 … 7	16 … 19	SLOT UDINT: Load value							
8	20	Reserved			MODE_ SLOT	LD_SLOT			
9	21	Reserved		DITHER	SET_DQB	SET_DQA	Reserved	TM_ CTRL_DQ	SW_ ENABLE
10	22	Reserved							RES_ ERROR
11	23	Reserved							

NOTE

Channel 1 is only available in two-channel operation of the module.

Control bit/value	Explanations
OUTPUT_VALUE	If you are not using current control, you specify the duty cycle (mark-to-space ratio, duty factor) with this value. A changed duty cycle takes effect at the next rising edge at DQn.A. If you are using current control, the module controls the duty cycle, and you specify the current setpoint relative to the reference value current with OUTPUT_VALUE.

Control bit/value	Explanations
	Value range of the duty cycle or current setpoint: • Output format "1/100": 0 to 100_D • Output format "1/1000": 0 to 1000_D • Output format "1/10000": 0 to 10000_D • Output format "S7 analog output": 0 ... 27648_D If the setting is outside the value range, the ERR_OUT_VAL feedback bit is set and the maximum permissible value of the output format is used in each case.
SLOT	You specify the load value with this value. Value range: • Period duration in µs: 10 to 85000000_D • On delay in µs: 0 to 85000000_D • Dithering ramp up/ramp down in ms: 0 to 30000_D • Dithering amplitude in %: 0 to 500_D • Dithering period duration in µs: 2000 to 100000_D You specify whether to apply a change once or cyclically with MODE_SLOT. Invalid values trigger setting of feedback bit ERR_LD (when MODE_SLOT = 0) or ERR_SLOT_VAL (when MODE_SLOT = 1).
MODE_SLOT	You specify whether you want to apply a change in SLOT once or cyclically with this bit. 0 means: As soon as you write the respective value in the corresponding output byte, the value from SLOT is applied once and kept until the next change. A change via SLOT takes effect at the next output sequence. After a restart of the module, the value is overwritten with the value set in the hardware configuration. 1 means: When you write the respective value in the corresponding output byte, the current value from SLOT in each case is applied cyclically. A change via SLOT takes effect at the next output sequence.
LD_SLOT	You specify the meaning of the value in SLOT with this load request: • 0000_B means: No action, idle • 0001_B means: Period duration in µs • 0010_B means: On delay in µs • 0101_B means: Dithering ramp up (LOWWORD), ramp down (HIGHWORD) in ms • 0110_B means: Dithering amplitude in % • 0111_B means: Dithering period duration in µs Values not listed are invalid and trigger setting of feedback bit ERR_LD (when MODE_SLOT = 0) or ERR_SLOT_VAL (when MODE_SLOT = 1).
DITHER	You activate the superimposition of the dither signal on the PWM signal with this bit. • 0 → 1 means: Dithering starts with the configured ramp up • 1 → 0 means: Dithering ends with the configured ramp down
SET_DQA	You use this bit to set digital output DQn.A when TM_CTRL_DQ and SET_DQB are set to 0.
SET_DQB	You use this bit to set digital output DQn.B when TM_CTRL_DQ and SET_DQA are set to 0.
TM_CTRL_DQ	You enable the technological function of the digital output with this bit. • 0 means: SET_DQA and SET_DQB define states of DQn.A and DQn.B • 1 means: Output sequence defines the state of DQn.A; DQn.B is always 0.
SW_ENABLE	You activate the software enable with this bit. If you are using the hardware enable, it is combined with the software enable. • 0 means: Stop output • 1 means: Start output Use of the HW enable is activated through parameter assignment. The HW enable is controlled externally using the digital input DIn.0.

Control bit/value	Explanations
RES_ERROR	You use this bit to reset the following feedback bits when errors are pending: • ERR_24V • ERR_DQA • ERR_DQB • ERR_LD
Reserved	Reserved bits must be set to 0.

4.2.6.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module via the feedback interface.

Feedback interface per channel

The following table shows the assignment of the feedback interface:

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8	ERR_ SLOT_VAL	ERR_ OUT_VAL	ERR_DQB	ERR_DQA	Reserved	ERR_LD	ERR_24V	ERR_PWR
1	9	Reserved		STS_SW_ ENABLE	STS_ READY	Reserved	STS_LD_ SLOT	Reserved	
2	10	Reserved			STS_ DITHER	STS_DI	STS_DQB	STS_DQA	STS_ ENABLE
3	11	Reserved							
4 … 5	12 … 13	MEASURED_CURRENT							
6	14	Reserved						QLMN_HLM	QLMN_LLM
7	15	Reserved							

NOTE

Channel 1 is only available in two-channel operation of the module.

Feedback bit/value	Explanations
ERR_SLOT_VAL	This bit indicates that the value in SLOT or LD_SLOT is invalid (when MODE_SLOT = 1) and was not accepted. As soon as the module has received a valid value from the control interface, ERR_SLOT_VAL is automatically reset.
ERR_OUT_VAL	This bit indicates that the value in OUTPUT_VALUE is invalid. As soon as the module has received a valid value from the control interface, ERR_OUT_VAL is automatically reset.
ERR_DQA	This bit indicates a short-circuit or an overload at the output DQn.A. If you have enabled the diagnostics interrupt "Diagnostics DQA", the diagnostics interrupt "Error at digital outputs" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_DQB	This bit indicates a short-circuit or an overload at the output DQn.B or the attempted simultaneous setting of the SET_DQA and SET_DQB control bits. If you have enabled the diagnostics interrupt "Diagnostics DQB", the diagnostics interrupt "Error at digital outputs" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_LD	This bit indicates that the value in SLOT or LD_SLOT (when MODE_SLOT = 0) is invalid and was not accepted. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_24V	This bit indicates a short-circuit or an overload at output 24VDC If you have enabled diagnostic interrupts, the diagnostic interrupt "Short circuit / overload of the sensor supply voltage" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_PWR	This bit indicates that supply voltage L+ is too low. If you have enabled the diagnostic interrupts, the diagnostic interrupt "Supply voltage fault" is triggered when an error occurs. As soon as supply voltage L+ is sufficiently high again, ERR_PWR is automatically reset. The bit is not set if no supply voltage is present.
STS_SW_ENABLE	This bit indicates the status of the SW enable. • 0 means: SW enable not active • 1 means: SW enable active
STS_READY	This bit indicates that the module is supplying valid user data. The module is started and configured.
STS_LD_SLOT	A status change (toggling) of this bit indicates that the LD_SLOT load request was detected and executed (when MODE_SLOT = 0).
STS_DITHER	This bit indicates that the dither signal is active with ramp up started and ramp down not yet complete.
STS_DI	This bit indicates the status of the digital input DIn.0.
STS_DQA	This bit indicates the status of the digital output DQn.A.
STS_DQB	This bit indicates the status of the digital output DQn.B.
STS_ENABLE	This bit indicates that an output sequence is active.
MEASURED_ CURRENT	This value indicates the measured value of the current as an S7 analog value: • Two-channel operation: $27648_D \triangleq 2$ A • One-channel operation: $27648_D \triangleq 4$ A • 32767_D means: Valid measured value of current not available, e.g. during the first PWM period duration

Feedback bit/value	Explanations
QLMN_HLM	This bit indicates that the manipulated value high limit of the current control has been reached.
QLMN_LLM	This bit indicates that the manipulated value low limit of the current control has been reached.
Reserved	Reserved bits are set to 0.

4.2.7 Isochronous mode

The technology module supports the "Isochronous mode" system function. In isochronous mode, the output sequence starts at time T_o after the SW_ENABLE control bit has been set. The period duration is also adapted to the application cycle (T_{APP}) and synchronized with it. The synchronization is especially advantageous for setting up control loops.

The module adjusts the assigned value of the period duration in such a way that an integer ratio results. In the most unfavorable case, the difference amounts to half the application cycle.

Examples:

Application cycle T_{APP}	Assigned period duration $T_{Set-point}$	Actual period durationT_{Actual}	T_{APP}:T_{Actual}
10 ms (10000 µs)	1800 µs	1666 µs	6:1
	2000 µs	2000 µs	5:1
	3000 µs	3333 µs	3:1
	5000 µs	5000 µs	2:1
	6000 µs	5000 µs	2:1
	12000 µs	10000 µs	1:1
	16000 µs	20000 µs	1:2

The figure below shows an example of a 1:1 ratio of application cycle to period duration with a duty cycle of 50%.

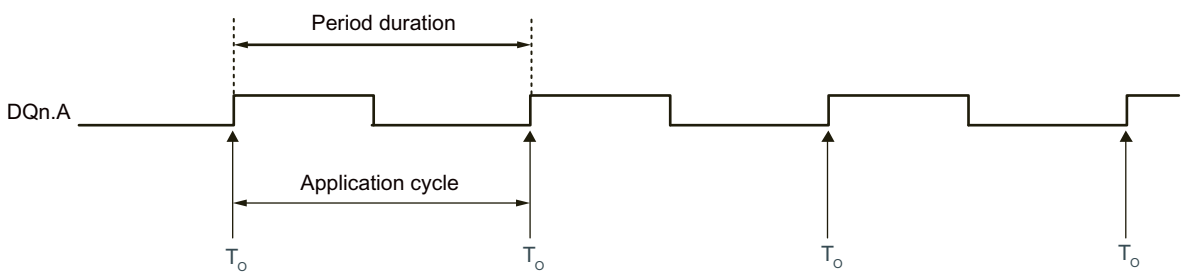

The figure below shows an example of a 3:1 ratio of application cycle to period duration with a duty cycle of 50%.

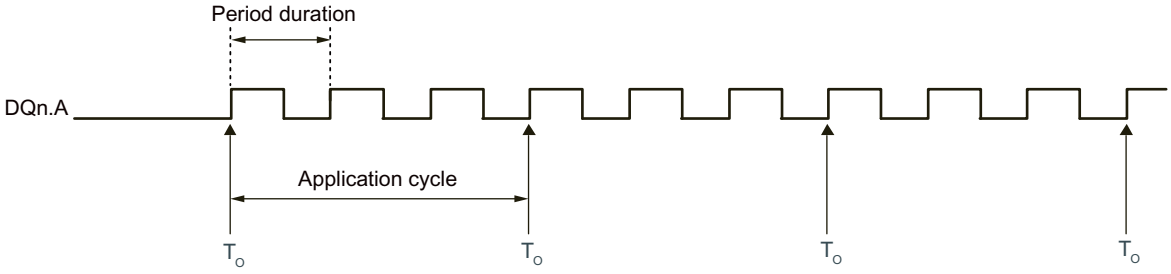

The figure below shows an example of a 1:3 ratio of application cycle to period duration with a duty cycle of 50%.

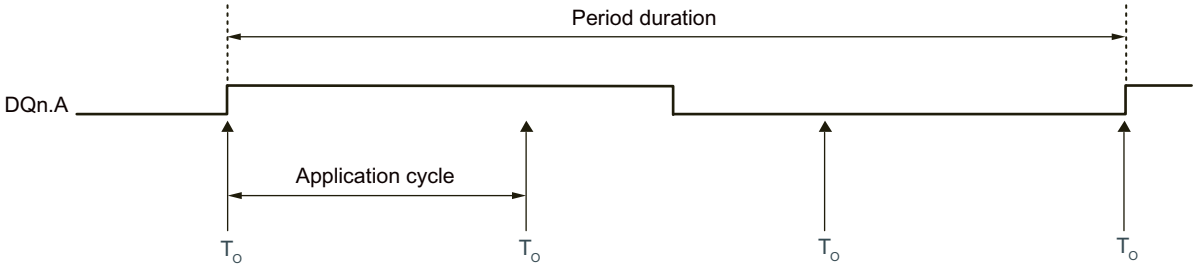

NOTE

No HW enable or On delay

No hardware enable or On delay can be used in isochronous mode.

Further information

You will find a detailed description of isochronous mode in:

- In the isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- PROFINET with STEP 7 function manual available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

4.3 Pulse train mode

4.3.1 Function

4.3.1.1 Introduction

In this operating mode, the respective channel of the technology module outputs a number of pulses with the configured period duration, duty cycle and On delay. You specify the number of pulses via the control interface.

Starting the output sequence

In order to output the output sequence at the digital output DQn.A, the TM_CTRL_DQ control bit (Page 109) must be set. To start the output sequence using the software enable, you set the SW_ENABLE control bit (Page 66). The STS_SW_ENABLE feedback bit indicates that the software enable in the technology module is active.

You can additionally use the hardware enable via the respective digital input DIn.0. You can configure an input delay for DIn.0.

Pulse diagram

The following figure shows an example of an output sequence when DIn.0 is being used as a hardware enable.

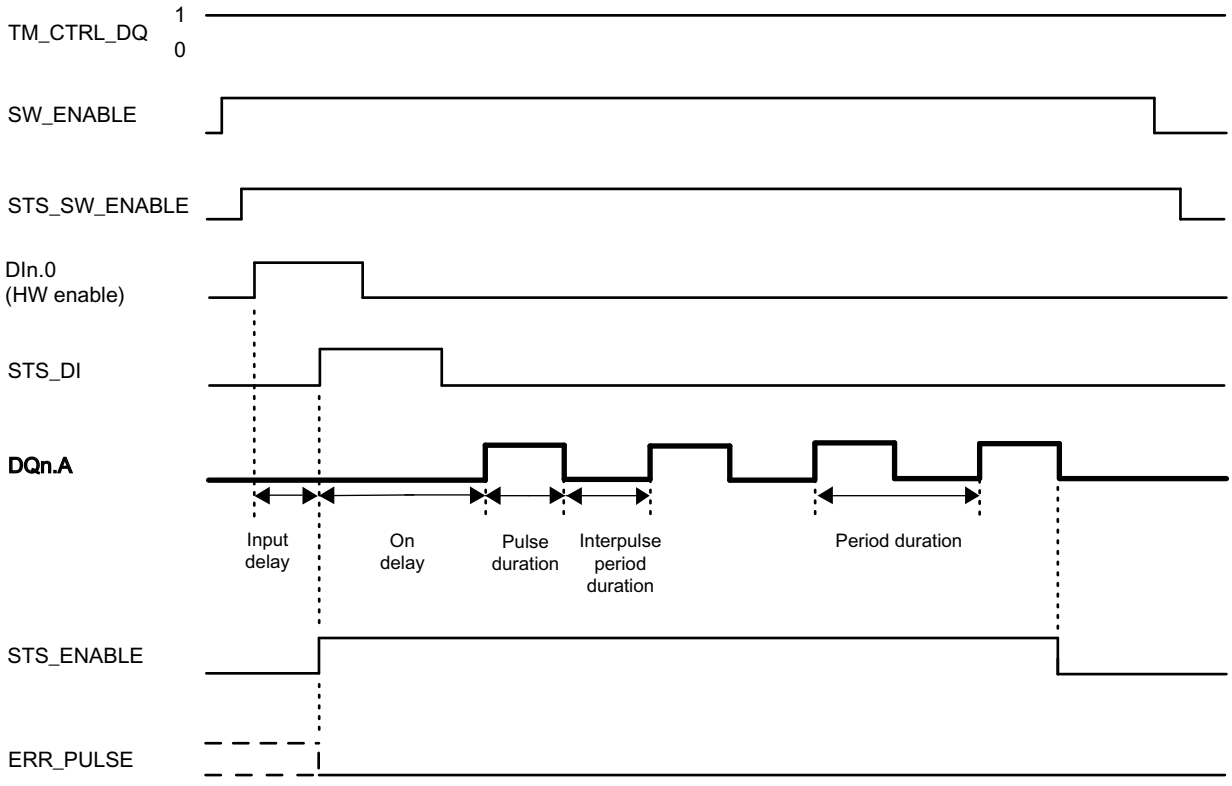

Figure 2-1099 Example of an output sequence

If you are using the hardware enable, it is combined with the software enable. When the software enable is active, the output sequence starts at the first positive edge of the

hardware enable. Additional positive edges of the hardware enable during the output sequence are ignored. If the hardware enable is set and remains set for the duration of the input delay, the On delay is started and the STS_ENABLE feedback bit is set. As soon as the On delay has elapsed, the pulse train with the assigned number of pulses is output at the respective digital output DQn.A. The output sequence is stopped at the end of the last pulse, and STS_ENABLE is reset.

If you are not using a hardware enable, the On delay starts at the positive edge of SW_ENABLE.

Aborting the output sequence

If you reset the SW_ENABLE control bit, the software enable is deactivated and the current output sequence is aborted. The last period is not completed. The STS_ENABLE feedback bit and the digital output DQn.A are reset.

A renewed pulse output is only possible after a restart of the output sequence.

4.3.1.2 Number of pulses

You set the number of pulses in the control interface (Page 66) using OUTPUT_VALUE as integer (UDINT). The value range is 1 to 4294967295 (2^{32}-1). A change takes effect immediately.

If you reduce the number of pulses to 0 or to an already output number of pulses, the output sequence is aborted. In this case, the STS_ENABLE feedback bit and the digital output DQn.A are reset, and the ERR_PULSE feedback bit is set. To continue the pulse output, you must restart the output sequence. At the next start of the output sequence, the technology module resets the ERR_PULSE feedback bit again.

4.3.1.3 Duty cycle

The duty cycle corresponds to the ratio of pulse duration to period duration (also referred to as mark-to-space ratio).

You set the period duration in the hardware configuration. The value range is dependent on the configured output format. If you set the value 0, the DQn.A is not set during the entire period duration. If you set the maximum value, the DQn.A is set during the entire period duration. If you set a value above the value range, the maximum value is used.

Output format	Value range of OUTPUT_VALUE	Pulse duration
1/100 (%)	0 ... 100	(OUTPUT_VALUE/100) × Period duration
1/1000 (‰)	0 ... 1000	(OUTPUT_VALUE/1000) × Period duration
1/10000	0 ... 10000	(OUTPUT_VALUE/10000) × Period duration
S7 analog output	0 ... 27648	(OUTPUT_VALUE/27648) × Period duration

In addition, you can change the duty cycle via the control interface (Page 66) by entering a new value in SLOT as integer (UDINT). In so doing, you use the MODE_SLOT control bit to choose whether you want to apply a change once or cyclically:

MODE_SLOT = 0	One-time change: As soon as you write the value 4_D in the corresponding output byte, the value from SLOT is applied once as the duty cycle and kept until the next change. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.
MODE_SLOT = 1	Cyclic change: When you write the value 20_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically as the duty cycle. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.

You can find additional information under Handling of the SLOT parameters (Page 20).

4.3.1.4 Period duration

You set the period duration in µs in the hardware configuration. The value range is dependent on whether or not the high-speed output function (Page 61) is being used:

High-speed output	Value range of the period duration
Activated	10 ... 85000000 µs = 10 µs ... 85 s
Deactivated	100 ... 85000000 µs = 100 µs ... 85 s

In addition, you can change the period duration via the control interface by entering a new value in SLOT as integer (UDINT). In so doing, you use the MODE_SLOT control bit to choose whether you want to apply a change once or cyclically:

MODE_SLOT = 0	One-time change: As soon as you write the value 1_D in the corresponding output byte, the value from SLOT is applied once as the period duration and kept until the next change. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.
MODE_SLOT = 1	Cyclic change: When you write the value 17_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically as the period duration. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.

You can find additional information under Handling of the SLOT parameters (Page 20).

4.3.1.5 On delay

You set the On delay from 0 to 85 s with a precision of 1 µs in the hardware configuration.

In addition, you can change the On delay via the control interface by entering a new value in SLOT as integer (UDINT). In so doing, you use the MODE_SLOT control bit to choose whether you want to apply a change once or cyclically:

MODE_SLOT = 0	One-time change: As soon as you write the value 2_D in the corresponding output byte, the value from SLOT is applied once as the On delay and kept until the next change. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.
MODE_SLOT = 1	Cyclic change: When you write the value 18_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically as the On delay. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.

You can find additional information under Handling of the SLOT parameters (Page 20).

4.3.1.6 Current measurement

The technology module measures the load current at the digital output. The measured value of the current is returned as an S7 analog value in the MEASURED_CURRENT value in the feedback interface (Page 68).

A valid measured value is available when the STS_ENABLE feedback bit is set after the first period duration of the output sequence. The returned measured value is an average of the measured values that were acquired over a time period of at least one period duration. If a valid measured value is not available, the value 32767_D is returned.

NOTE

In order to use the current measurement, the high-speed output must be deactivated.

Measuring range and accuracy

The measuring range and accuracy are dependent on the channel configuration:

	Measured value 27648_D	Maximum measured value 32511_D ≙ ...	Accuracy[3]	
			Period duration > 333 µs	Period duration < 333 µs
Two-channel operation	2 A[1]	2.37 A[2]	±40 mA	-40 mA ... +100 mA
One-channel operation (parallel connection)	4 A[1]	4.74 A[2]	±80 mA	-80 mA ... +200 mA

[1] May only be exceeded for a short time.

[2] When this current value is exceeded, the ERR_DQA feedback bit will be set.

[3] With constant period duration in the respective measuring period.

4.3.1.7 High-speed output

The high-speed output function enables an output frequency of a maximum of 100 kHz with an output current of a maximum of 100 mA. A high-speed output generates very steep edges. The high-speed output generates signals at a higher frequency, but provides a lower maximum load current. The high-speed output is only available in two-channel operation.

The following table presents the minimum and maximum pulse duration, period duration and frequency depending on whether or not the high-speed output is activated:

	Minimum value		Maximum value	
	High-speed output deactivated	High-speed output activated	High-speed output deactivated	High-speed output activated
Pulse duration	10 µs	1,5 µs	85000000 µs (= 85 s)	
Period duration	100 µs	10 µs		
Frequency	0,02 Hz		10 kHz	100 kHz

4.3.2 Configuring

Introduction

You configure the technology module and assign its parameters with the configuration software.

The user program controls and monitors the functions of the technology module via the control interface and feedback interface.

System environment

The technology module can be used in the following system environments:

Possible use	Components needed	Configuration software	In the user program
Centralized operation with a CPU 151xSP	• ET 200SP automation system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to control interface and feedback interface in the I/O data
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	
Distributed operation with an S7-300/400 CPU	• S7-300/400 automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration STEP 7: Device configuration and parameter setting with HSP	
Distributed operation on the PROFINET IO in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	Third-party configuration software: Device configuration and parameter setting with GSD file	
Distributed operation on the PROFIBUS DP in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	Third-party configuration software: GSD file; device configuration and parameter setting using data record 128	

Hardware Support Packages (HSP)

STEP 7

The Hardware Support Packages (HSP) are available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/23183356).

GSD file

The respective GSD file for the ET 200SP distributed I/O system is available for download on the Internet:

- GSD file PROFINET IO (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD file PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/73016883)

4.3.3 Reaction to CPU STOP

You set the response of the channel to a CPU STOP in the parameters of the device configuration.

Table 2-1267 Response of channel to CPU STOP

Option	Meaning
Output substitute value	The channel outputs the configured substitute values at the digital outputs until the next STOP-RUN transition of the CPU. You can configure the substitute value 1 for only one of the two digital outputs. An active output sequence is stopped and the STS_ENABLE feedback bit is reset. The technology module is set to its startup state after a STOP-RUN transition. Before you can start a new pulse output, you must reset the SW_ENABLE control bit.
Continue operation	The channel continues to operate. The digital outputs continue to switch according to the parameter assignment. An active output sequence will thus be continued. If you have configured the hardware enable, you can also start additional output sequences using DIn.0. The configuration of the technology module is not reset after a STOP-RUN transition.

4.3.4 Parameter setting

You use various parameters to specify the properties of the technology module. Depending on the settings, not all parameters are available. When parameters are assigned in the user program, the parameters are transferred to the module with the "WRREC" instruction and data record 128 (Page 131).

You set the parameters of the module as follows in this operating mode:

Parameter setting via...	Basic procedure
Hardware configuration in STEP 7 (TIA Portal)	1. Insert the module from the hardware catalog under "Technology modules". 2. Set the "Pulse train" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration in STEP 7 with HSP	1. Install the corresponding HSP file. You will then find the module in the hardware catalog under "ET 200SP". 2. Set the "Pulse train" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFINET IO	1. Install the latest PROFINET GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFINET IO > I/O". 2. Set the "Pulse train" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.

Parameter setting via...	Basic procedure
Hardware configuration with GSD file for distributed operation on PROFIBUS DP	1. Install the latest PROFIBUS GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFIBUS DP > I/O". 2. Download the project to the CPU. The parameters of the module are also downloaded with their default settings (see table below). 3. Set the "Pulse train" mode and the further parameters in the user program using data record 128.

Parameters of the TM Pulse 2x24V in "Pulse train" mode

The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1268 Adjustable parameters

Parameter	Value range	Scope
Channel configuration[1]	• **2 channels (2 A)** • 1 channel (4 A)	Module
Reaction to CPU STOP	• **Output substitute value** • Continue operation	Channel
Substitute value for DQA	• **0** • 1	Channel
Substitute value for DQB	• **0** • 1	Channel
Group diagnostics	• **Deactivated** • Activated	Channel
Diagnostics DQA	• **Deactivated** • Activated	Channel
Diagnostics DQB	• **Deactivated** • Activated	Channel
High-speed output (0.1 A)	• **Deactivated** • Activated	Channel
Function DI	• **Input** • HW enable	Channel
Input delay for digital inputs	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel
Output format	• S7 analog output • **1/100** • 1/1000 • 1/10000	Channel

[1] When configuring with HSP for STEP 7 or with a GSD file, you define the channel configuration by the selection of the module name.

Parameter	Value range	Scope
Period duration	10...**2000000**...85000000 µs	Channel
Actual period duration	Automatically calculated (read-only)	Channel
On delay for pulse output	**0**...85000000 µs	Channel
Duty cycle	Dependent on the output format	Channel

[1] When configuring with HSP for STEP 7 or with a GSD file, you define the channel configuration by the selection of the module name.

NOTE

PROFIBUS GSD configuration

When configuring with a PROFIBUS GSD file, the possible parameter assignments are not available. The parameters are preassigned in the module with the default setting. Set the "Pulse train" mode and the further parameters in the user program using data record 128.

4.3.5 Address space

Address space of the technology module

Table 2-1269 Size of input and output addresses

	Inputs	Outputs
Size per technology channel	8 bytes	12 bytes
Size in one-channel operation	8 bytes	12 bytes
Size in two-channel operation	16 bytes	24 bytes

4.3.6 Control interface and feedback interface

NOTE

A library of PLC data types (LPD) for STEP 7 (TIA Portal) and SIMATIC S7-1200 / S7-1500 is available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109482396).

4.3.6.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface per channel

The following table shows the control interface assignment:

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 … 3	12 … 15	OUTPUT_VALUE UDINT: Number of pulses							
4 … 7	16 … 19	SLOT UDINT: Load value							
8	20	Reserved			MODE_ SLOT	LD_SLOT			
9	21	Reserved			SET_DQB	SET_DQA	Reserved	TM_ CTRL_DQ	SW_ ENABLE
10	22	Reserved							RES_ ERROR
11	23	Reserved							

NOTE

Channel 1 is only available in two-channel operation of the module.

Control bit/value	Explanations
OUTPUT_VALUE	You specify the number of pulses with this value. Value range: 1 to 4294967295_D (2^{32}-1) If the setting is outside the value range, the ERR_OUT_VAL feedback bit is set and the last valid number of pulses is used.
SLOT	You specify the load value with this value. Value range: • Period duration in µs: 10 to 85000000_D • On delay in µs: 0 to 85000000_D • Duty cycle: – Output format "1/100": 0 to 100_D – Output format "1/1000": 0 to 1000_D – Output format "1/10000": 0 to 10000_D – Output format "S7 analog output": 0 … 27648_D You specify whether to apply a change once or cyclically with MODE_SLOT.

Control bit/value	Explanations
	Invalid values trigger setting of feedback bit ERR_LD (when MODE_SLOT = 0) or ERR_SLOT_VAL (when MODE_SLOT = 1).
MODE_SLOT	You specify whether you want to apply a change in SLOT once or cyclically with this bit. 0 means: As soon as you write the respective value in the corresponding output byte, the value from SLOT is applied once and kept until the next change. A change via SLOT takes effect at the next output sequence. After a restart of the module, the value is overwritten with the value set in the hardware configuration. 1 means: When you write the respective value in the corresponding output byte, the current value from SLOT in each case is applied cyclically. A change via SLOT takes effect at the next output sequence.
LD_SLOT	You specify the meaning of the value in SLOT with this load request: • 0000_B means: No action, idle • 0001_B means: Period duration in µs • 0010_B means: On delay in µs • 0100_B means: Duty cycle Values not listed are invalid and trigger setting of feedback bit ERR_LD (when MODE_SLOT = 0) or ERR_SLOT_VAL (when MODE_SLOT = 1).
SET_DQA	You use this bit to set digital output DQn.A when TM_CTRL_DQ and SET_DQB are set to 0.
SET_DQB	You use this bit to set digital output DQn.B when TM_CTRL_DQ and SET_DQA are set to 0.
TM_CTRL_DQ	You enable the technological function of the digital output with this bit. • 0 means: SET_DQA and SET_DQB define states of DQn.A and DQn.B • 1 means: Output sequence defines the state of DQn.A; DQn.B is always 0.
SW_ENABLE	You activate the software enable with this bit. If you are using the hardware enable, it is combined with the software enable. • 0 means: Stop output • 1 means: Start output Use of the HW enable is activated through parameter assignment. The HW enable is controlled externally using the digital input DIn.0.
RES_ERROR	You use this bit to reset the following feedback bits when errors are pending: • ERR_24V • ERR_DQA • ERR_DQB • ERR_LD
Reserved	Reserved bits must be set to 0.

4.3.6.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module via the feedback interface.

Feedback interface per channel

The following table shows the assignment of the feedback interface:

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8	ERR_ SLOT_VAL	ERR_ OUT_VAL	ERR_DQB	ERR_DQA	ERR_ PULSE	ERR_LD	ERR_24V	ERR_PWR
1	9	Reserved		STS_SW_ ENABLE	STS_ READY	Reserved	STS_LD_ SLOT	Reserved	
2	10	Reserved				STS_DI	STS_DQB	STS_DQA	STS_ ENABLE
3	11	Reserved				SEQ_CNT			
4 … 5	12 … 13	MEASURED_CURRENT							
6 … 7	14 … 15	Reserved							

NOTE

Channel 1 is only available in two-channel operation of the module.

Feedback bit/value	Explanations
ERR_SLOT_VAL	This bit indicates that the value in SLOT or LD_SLOT is invalid (when MODE_SLOT = 1) and was not accepted. As soon as the module has received a valid value from the control interface, ERR_SLOT_VAL is automatically reset.
ERR_OUT_VAL	This bit indicates that the value in OUTPUT_VALUE is invalid. As soon as the module has received a valid value from the control interface, ERR_OUT_VAL is automatically reset.
ERR_DQA	This bit indicates a short-circuit or an overload at the output DQn.A. If you have enabled the diagnostics interrupt "Diagnostics DQA", the diagnostics interrupt "Error at digital outputs" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.

Feedback bit/value	Explanations
ERR_DQB	This bit indicates a short-circuit or an overload at the output DQn.B or the attempted simultaneous setting of the SET_DQA and SET_DQB control bits. If you have enabled the diagnostics interrupt "Diagnostics DQB", the diagnostics interrupt "Error at digital outputs" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_PULSE	This bit indicates an error in the pulse output.
ERR_LD	This bit indicates that the value in SLOT or LD_SLOT (when MODE_SLOT = 0) is invalid and was not accepted. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_24V	This bit indicates a short-circuit or an overload at output 24VDC If you have enabled diagnostic interrupts, the diagnostic interrupt "Short circuit / overload of the sensor supply voltage" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_PWR	This bit indicates that supply voltage L+ is too low. If you have enabled the diagnostic interrupts, the diagnostic interrupt "Supply voltage fault" is triggered when an error occurs. As soon as supply voltage L+ is sufficiently high again, ERR_PWR is automatically reset. The bit is not set if no supply voltage is present.
STS_SW_ENABLE	This bit indicates the status of the SW enable. • 0 means: SW enable not active • 1 means: SW enable active
STS_READY	This bit indicates that the module is supplying valid user data. The module is started and configured.
STS_LD_SLOT	A status change (toggling) of this bit indicates that the LD_SLOT load request was detected and executed (when MODE_SLOT = 0).
STS_DI	This bit indicates the status of the digital input DIn.0.
STS_DQA	This bit indicates the status of the digital output DQn.A.
STS_DQB	This bit indicates the status of the digital output DQn.B.
STS_ENABLE	This bit indicates that an output sequence is active.
SEQ_CNT	This value indicates the number of completed output sequences as sequence counter.
MEASURED_ CURRENT	This value indicates the measured value of the current as an S7 analog value: • Two-channel operation: 27648_D ≙ 2 A • One-channel operation: 27648_D ≙ 4 A • 32767_D means: Valid measured value of current not available, e.g. during the first period duration
Reserved	Reserved bits are set to 0.

4.3.7 Isochronous mode

The technology module supports the "Isochronous mode" system function. If you are not using a hardware enable, the output sequence starts in isochronous mode at time T_o after the SW_ENABLE control bit has been set.

Further information

You will find a detailed description of isochronous mode in:

- In the isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- PROFINET with STEP 7 function manual available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

4.4 On/Off delay mode

4.4.1 Function

4.4.1.1 Introduction

In this operating mode, the respective channel of the technology module outputs pulses with a specified switching delay relative to digital input DIn.0. You specify the On delay via the control interface.

4.4.1.2 Output sequence

Starting the output sequence

In order to output the output sequence at the digital output DQn.A, the TM_CTRL_DQ control bit (Page 109) must be set. To start the output sequence using the software enable, you set the SW_ENABLE control bit (Page 79). The STS_SW_ENABLE feedback bit indicates that the software enable in the technology module is active.

Pulse diagram

The following figure shows an example of an output sequence for the case that you set SW_ENABLE while digital input DIn.0 is not set.

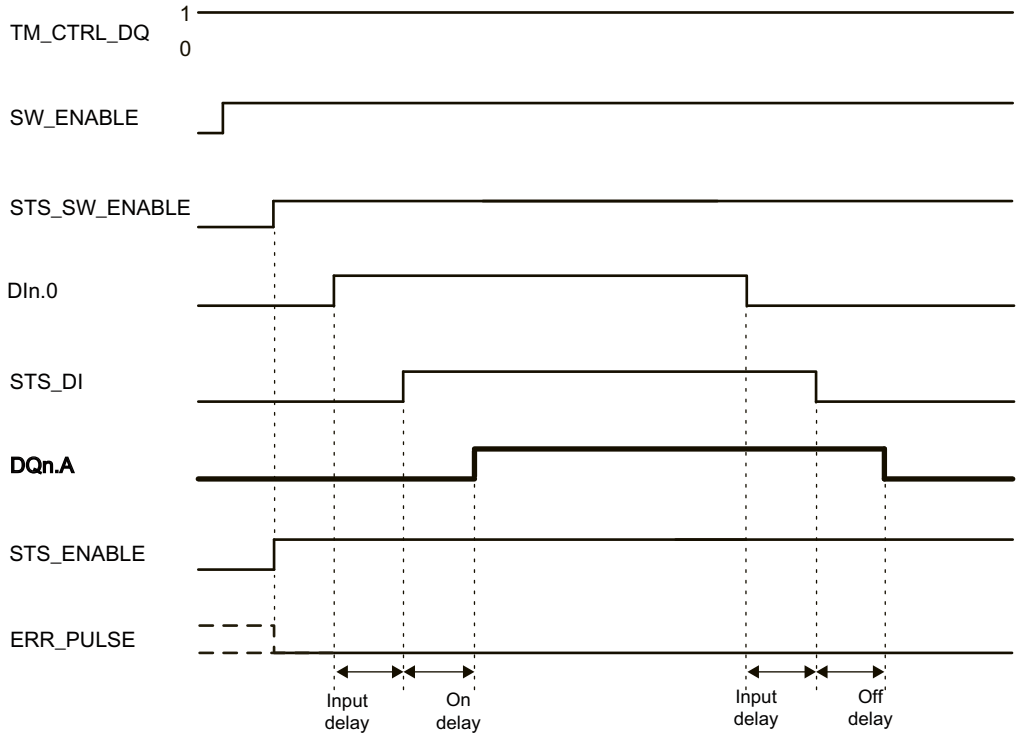

Figure 2-1100 Example 1 of an output sequence

The output sequence starts on a positive edge of SW_ENABLE, and the STS_SW_ENABLE and STS_ENABLE feedback bits are set. If digital input DIn.0 is set and remains set for the duration of the input delay, the On delay is started. As soon as the On delay has elapsed, the respective digital output DQn.A is set. If digital input DIn.0 is reset and remains set for the duration of the input delay, the Off delay is started. As soon as the Off delay has elapsed, the respective digital output DQn.A is reset.

The following figure shows an example of an output sequence for the case that you set SW_ENABLE while digital input DIn.0 is set.

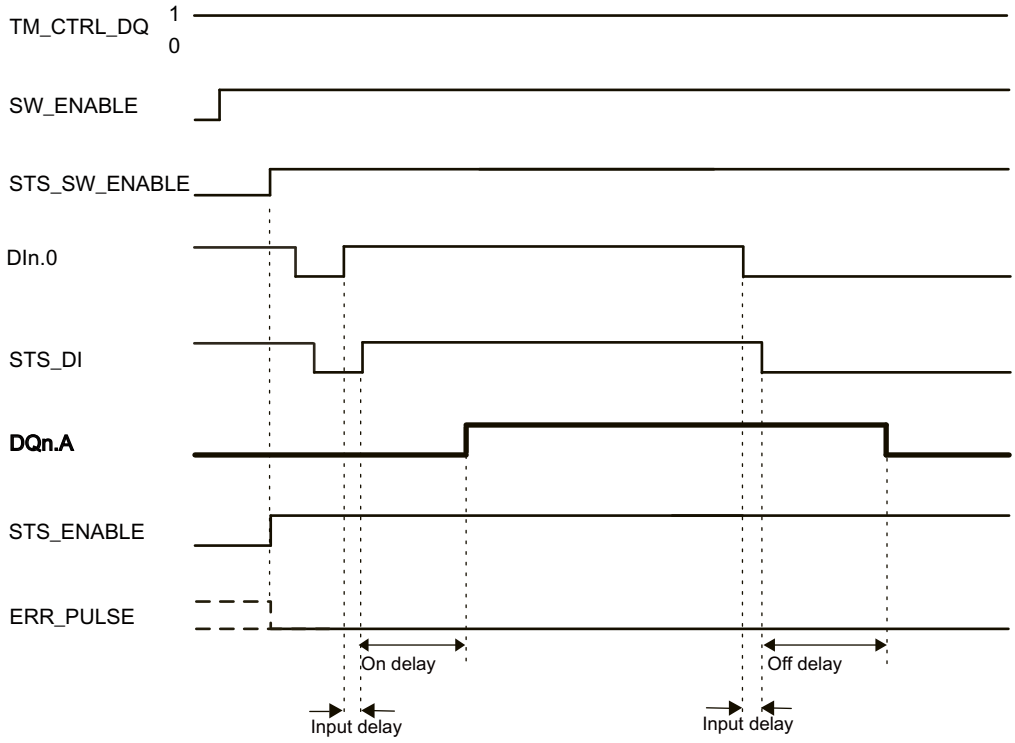

Figure 2-1101 Example 2 of an output sequence

If you set SW_ENABLE while digital input DIn.0 is set, the first (falling) edge of DIn.0 is ignored.

Aborting the output sequence

If you reset the SW_ENABLE control bit, the software enable is deactivated and the current output sequence is aborted. The STS_ENABLE feedback bit and the digital output DQn.A are reset.

A renewed pulse output is only possible after a restart of the output sequence.

Minimum pulse duration and minimum interpulse period

The minimum pulse duration and the minimum interpulse period are the minimum pulse duration and interpulse period that are to be output. Each amounts to 1.5 µs when the high-speed output (Page 75) is activated and 10 µs when the high-speed output is deactivated.

Pulses and interpulse periods of digital input DIn.0 whose duration is less than the minimum pulse duration are ignored by the module and are not output at the digital output DQn.A.

The pulse or the interpulse period of DIn.0 is also ignored in the following cases:

- Pulse duration < Input delay
- Pulse duration + Off delay ≤ On delay (ERR_PULSE is set)
- Pulse duration + Off delay + Minimum pulse duration < On delay (ERR_PULSE is set)
- Interpulse period < Input delay
- Interpulse period + On delay ≤ Off delay (ERR_PULSE is set)
- Interpulse period + On delay < Off delay + Minimum interpulse period (ERR_PULSE is set)

A set ERR_PULSE feedback bit is cleared on the next rising edge at DIn.0.

Retriggering the On delay

In the following case, the module cancels the current On delay and restarts it with the next rising edge at digital input DIn.0:

On delay > Pulse duration + Interpulse period

The following figure shows an example of the retriggering of the On delay:

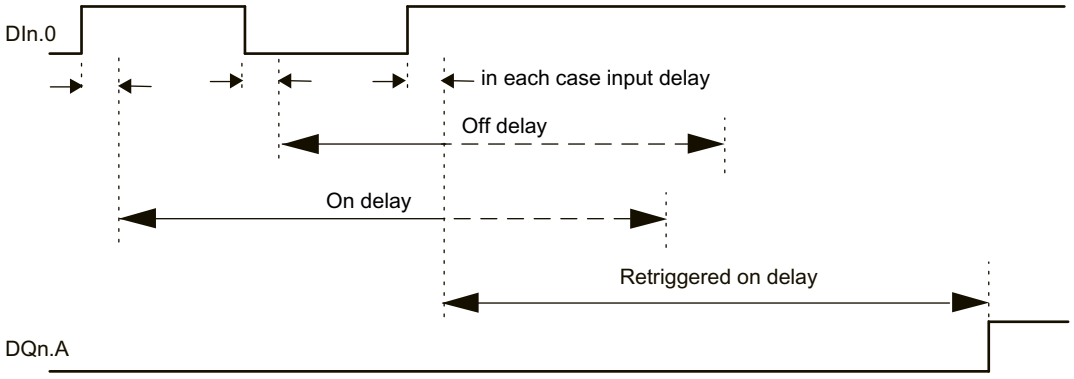

Figure 2-1102 Retriggering the On delay

Retriggering the Off delay

In the following case, the module cancels the current Off delay and restarts it with the next rising edge at digital input DIn.0:

Off delay > Pulse duration + Interpulse period

The following figure shows an example of the retriggering of the Off delay:

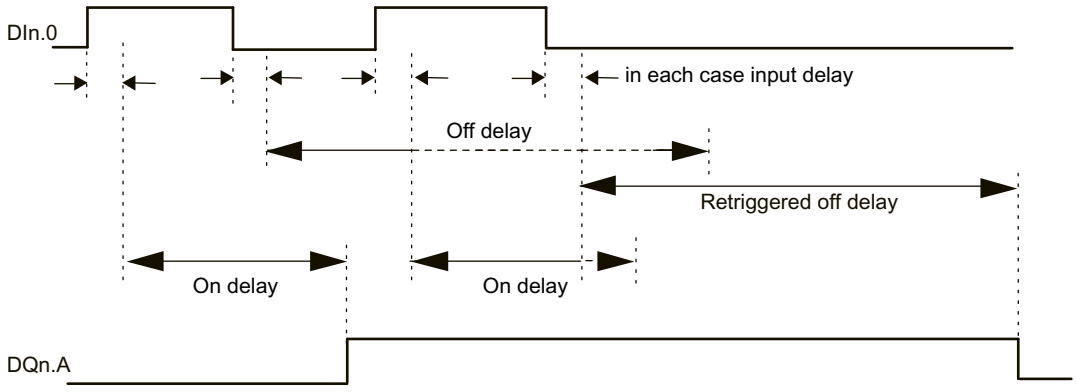

Figure 2-1103 Retriggering the Off delay

4.4.1.3 On delay

You set the duty cycle in the control interface (Page 79) using OUTPUT_VALUE as integer (UDINT). The value range is 0 to 85 s with a precision of 1 µs.

A change takes effect on the next rising edge at digital input DIn.0.

4.4.1.4 Off delay

You set the Off delay from 0 to 85 s with a precision of 1 µs in the hardware configuration.

In addition, you can change the OFF delay via the control interface by entering a new value in SLOT as integer (UDINT). In so doing, you use the MODE_SLOT control bit to choose whether you want to apply a change once or cyclically:

MODE_SLOT = 0	One-time change: As soon as you write the value 3_D in the corresponding output byte, the value from SLOT is applied once as the OFF delay and kept until the next change. A change using SLOT takes effect on the next falling edge at digital input DIn.0.
MODE_SLOT = 1	Cyclic change: When you write the value 19_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically as the Off delay. A change using SLOT takes effect on the next falling edge at digital input DIn.0.

You can find additional information under Handling of the SLOT parameters (Page 20).

4.4.1.5 High-speed output

The high-speed output function enables an output frequency of a maximum of 100 kHz with an output current of a maximum of 100 mA. A high-speed output generates very steep edges. The high-speed output generates signals at a higher frequency, but provides a lower maximum load current. The high-speed output is only available in two-channel operation.

The following table presents the minimum and maximum pulse duration, period duration and frequency depending on whether or not the high-speed output is activated:

	Minimum value		Maximum value	
	High-speed output deactivated	**High-speed output activated**	**High-speed output deactivated**	**High-speed output activated**
Pulse duration	10 µs	1,5 µs	85000000 µs (= 85 s)	
Period duration	100 µs	10 µs		
Frequency	0,02 Hz		10 kHz	100 kHz

4.4.2 Configuring

Introduction

You configure the technology module and assign its parameters with the configuration software.

The user program controls and monitors the functions of the technology module via the control interface and feedback interface.

System environment

The technology module can be used in the following system environments:

Possible use	Components needed	Configuration software	In the user program
Centralized operation with a CPU 151xSP	• ET 200SP automation system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to control interface and feedback interface in the I/O data
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	

Possible use	Components needed	Configuration software	In the user program
Distributed operation with an S7-300/400 CPU	• S7-300/400 automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration STEP 7: Device configuration and parameter setting with HSP	Direct access to control interface and feedback interface in the I/O data
Distributed operation on the PROFINET IO in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	Third-party configuration software: Device configuration and parameter setting with GSD file	
Distributed operation on the PROFIBUS DP in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	Third-party configuration software: GSD file; device configuration and parameter setting using data record 128	

Hardware Support Packages (HSP)

STEP 7

The Hardware Support Packages (HSP) are available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/23183356).

GSD file

The respective GSD file for the ET 200SP distributed I/O system is available for download on the Internet:

- GSD file PROFINET IO (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD file PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/73016883)

4.4.3 Reaction to CPU STOP

You set the response of the channel to a CPU STOP in the parameters of the device configuration.

Table 2-1270 Response of channel to CPU STOP

Option	Meaning
Output substitute value	The channel outputs the configured substitute values at the digital outputs until the next STOP-RUN transition of the CPU. You can configure the substitute value 1 for only one of the two digital outputs. An active output sequence is stopped and the STS_ENABLE feedback bit is reset. The technology module is set to its startup state after a STOP-RUN transition. Before you can start a new pulse output, you must reset the SW_ENABLE control bit.

Option	Meaning
Continue operation	The channel continues to operate. The digital outputs continue to switch according to the parameter assignment. An active output sequence will thus be continued. The configuration of the technology module is not reset after a STOP-RUN transition.

4.4.4 Parameter setting

You use various parameters to specify the properties of the technology module. Depending on the settings, not all parameters are available. When parameters are assigned in the user program, the parameters are transferred to the module with the "WRREC" instruction and data record 128 (Page 131).

You set the parameters of the module as follows in this operating mode:

Parameter setting via...	Basic procedure
Hardware configuration in STEP 7 (TIA Portal)	1. Insert the module from the hardware catalog under "Technology modules". 2. Set the "On/Off delay" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration in STEP 7 with HSP	1. Install the corresponding HSP file. You will then find the module in the hardware catalog under "ET 200SP". 2. Set the "On/Off delay" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFINET IO	1. Install the latest PROFINET GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFINET IO > I/O". 2. Set the "On/Off delay" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFIBUS DP	1. Install the latest PROFIBUS GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFIBUS DP > I/O". 2. Download the project to the CPU. The parameters of the module are also downloaded with their default settings (see table below). 3. Set the "On/Off delay" mode and the further parameters in the user program using data record 128.

Parameters of the TM Pulse 2x24V in "On/Off delay" mode

The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1271 Adjustable parameters

Parameter	Value range	Scope
Channel configuration[1]	• **2 channels (2 A)** • 1 channel (4 A)	Module
Reaction to CPU STOP	• **Output substitute value** • Continue operation	Channel
Substitute value for DQA	• **0** • 1	Channel
Substitute value for DQB	• **0** • 1	Channel
Group diagnostics	• **Deactivated** • Activated	Channel
Diagnostics DQA	• **Deactivated** • Activated	Channel
Diagnostics DQB	• **Deactivated** • Activated	Channel
High-speed output (0.1 A)	• **Deactivated** • Activated	Channel
Input delay for digital inputs	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel
Off delay for pulse output	**0**...85000000 µs	Channel

[1] When configuring with HSP for STEP 7 or with a GSD file, you define the channel configuration by the selection of the module name.

NOTE

PROFIBUS GSD configuration

When configuring with a PROFIBUS GSD file, the possible parameter assignments are not available. The parameters are preassigned in the module with the default setting. Set the "On/Off delay" mode and the further parameters in the user program using data record 128.

4.4.5 Address space

Address space of the technology module

Table 2-1272 Size of input and output addresses

	Inputs	Outputs
Size per technology channel	8 bytes	12 bytes
Size in one-channel operation	8 bytes	12 bytes
Size in two-channel operation	16 bytes	24 bytes

4.4.6 Control interface and feedback interface

NOTE

A library of PLC data types (LPD) for STEP 7 (TIA Portal) and SIMATIC S7-1200 / S7-1500 is available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109482396).

4.4.6.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface per channel

The following table shows the control interface assignment:

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 … 3	12 … 15	OUTPUT_VALUE UDINT: On delay							
4 … 7	16 … 19	SLOT UDINT: Load value							
8	20	Reserved			MODE_ SLOT	LD_SLOT			

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
9	21	Reserved			SET_DQB	SET_DQA	Reserved	TM_ CTRL_DQ	SW_ ENABLE
10	22	Reserved							RES_ ERROR
11	23	Reserved							

NOTE

Channel 1 is only available in two-channel operation of the module.

Control bit/value	Explanations
OUTPUT_VALUE	You specify the On delay with this value. Value range: • On delay in µs: 0 to 85000000_D If the setting is outside the value range, the ERR_OUT_VAL feedback bit is set and the last valid On delay is used.
SLOT	You specify the load value with this value. Value range: • Off delay in µs: 0 to 85000000_D You specify whether to apply a change once or cyclically with MODE_SLOT. Invalid values trigger setting of feedback bit ERR_LD (when MODE_SLOT = 0) or ERR_SLOT_VAL (when MODE_SLOT = 1).
MODE_SLOT	You specify whether you want to apply a change in SLOT once or cyclically with this bit. 0 means: As soon as you write the value 3_D in the corresponding output byte, the value from SLOT is applied once and kept until the next change. A change using SLOT takes effect on the next falling edge at DIn.0. After a restart of the module, the value is overwritten with the value set in the hardware configuration. 1 means: When you write the value 19_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically. A change using SLOT takes effect on the next falling edge at DIn.0.
LD_SLOT	You specify the meaning of the value in SLOT with this load request: • 0000_B means: No action, idle • 0011_B means: Off delay in µs: Values not listed are invalid and trigger setting of feedback bit ERR_LD (when MODE_SLOT = 0) or ERR_SLOT_VAL (when MODE_SLOT = 1).
SET_DQA	You use this bit to set digital output DQn.A when TM_CTRL_DQ and SET_DQB are set to 0.
SET_DQB	You use this bit to set digital output DQn.B when TM_CTRL_DQ and SET_DQA are set to 0.
TM_CTRL_DQ	You enable the technological function of the digital output with this bit. • 0 means: SET_DQA and SET_DQB define states of DQn.A and DQn.B • 1 means: Output sequence defines the state of DQn.A; DQn.B is always 0.

Control bit/value	Explanations
SW_ENABLE	You activate the software enable with this bit. If you are using the hardware enable, it is combined with the software enable. • 0 means: Stop output • 1 means: Start output Use of the HW enable is activated through parameter assignment. The HW enable is controlled externally using the digital input DIn.0.
RES_ERROR	You use this bit to reset the following feedback bits when errors are pending: • ERR_24V • ERR_DQA • ERR_DQB • ERR_LD
Reserved	Reserved bits must be set to 0.

4.4.6.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module via the feedback interface.

Feedback interface per channel

The following table shows the assignment of the feedback interface:

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8	ERR_ SLOT_VAL	ERR_ OUT_VAL	ERR_DQB	ERR_DQA	ERR_ PULSE	ERR_LD	ERR_24V	ERR_PWR
1	9	Reserved		STS_SW_ ENABLE	STS_ READY	Reserved	STS_LD_ SLOT	Reserved	
2	10	Reserved				STS_DI	STS_DQB	STS_DQA	STS_ ENABLE
3	11	Reserved				SEQ_CNT			
4 … 7	12 … 15	Reserved							

NOTE

Channel 1 is only available in two-channel operation of the module.

Feedback bit/value	Explanations
ERR_SLOT_VAL	This bit indicates that the value in SLOT or LD_SLOT is invalid (when MODE_SLOT = 1) and was not accepted. As soon as the module has received a valid value from the control interface, ERR_SLOT_VAL is automatically reset.
ERR_OUT_VAL	This bit indicates that the value in OUTPUT_VALUE is invalid. As soon as the module has received a valid value from the control interface, ERR_OUT_VAL is automatically reset.
ERR_DQA	This bit indicates a short-circuit or an overload at the output DQn.A. If you have enabled the diagnostics interrupt "Diagnostics DQA", the diagnostics interrupt "Error at digital outputs" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_DQB	This bit indicates a short-circuit or an overload at the output DQn.B or the attempted simultaneous setting of the SET_DQA and SET_DQB control bits. If you have enabled the diagnostics interrupt "Diagnostics DQB", the diagnostics interrupt "Error at digital outputs" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_PULSE	This bit indicates an error in the pulse output.
ERR_LD	This bit indicates that the value in SLOT or LD_SLOT (when MODE_SLOT = 0) is invalid and was not accepted. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_24V	This bit indicates a short-circuit or an overload at output 24VDC If you have enabled diagnostic interrupts, the diagnostic interrupt "Short circuit / overload of the sensor supply voltage" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_PWR	This bit indicates that supply voltage L+ is too low. If you have enabled the diagnostic interrupts, the diagnostic interrupt "Supply voltage fault" is triggered when an error occurs. As soon as supply voltage L+ is sufficiently high again, ERR_PWR is automatically reset. The bit is not set if no supply voltage is present.
STS_SW_ENABLE	This bit indicates the status of the SW enable. • 0 means: SW enable not active • 1 means: SW enable active
STS_READY	This bit indicates that the module is supplying valid user data. The module is started and configured.
STS_LD_SLOT	A status change (toggling) of this bit indicates that the LD_SLOT load request was detected and executed (when MODE_SLOT = 0).
STS_DI	This bit indicates the status of the digital input DIn.0.
STS_DQA	This bit indicates the status of the digital output DQn.A.
STS_DQB	This bit indicates the status of the digital output DQn.B.
STS_ENABLE	This bit indicates that an output sequence is active.
SEQ_CNT	This value indicates the number of completed output sequences as sequence counter.
Reserved	Reserved bits are set to 0.

4.4.7 Isochronous mode

The technology module supports the "Isochronous mode" system function. Isochronous mode has no effect in the "On/Off delay" mode.

Further information

You will find a detailed description of isochronous mode in:

- In the isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- PROFINET with STEP 7 function manual available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

4.5 Frequency output mode

4.5.1 Function

4.5.1.1 Introduction

In this operating mode, the respective channel of the technology module outputs a signal with a fixed duty cycle of 50% and the configured On delay. You specify the frequency via the control interface.

Starting the output sequence

In order to output the output sequence at the digital output DQn.A, the TM_CTRL_DQ control bit (Page 109) must be set. To start the output sequence using the software enable, you set the SW_ENABLE control bit (Page 90). The STS_SW_ENABLE feedback bit indicates that the software enable in the technology module is active.

You can additionally use the hardware enable via the respective digital input DIn.0. You can configure an input delay for DIn.0.

Pulse diagram

The following figure shows an example of an output sequence when DIn.0 is being used as a hardware enable.

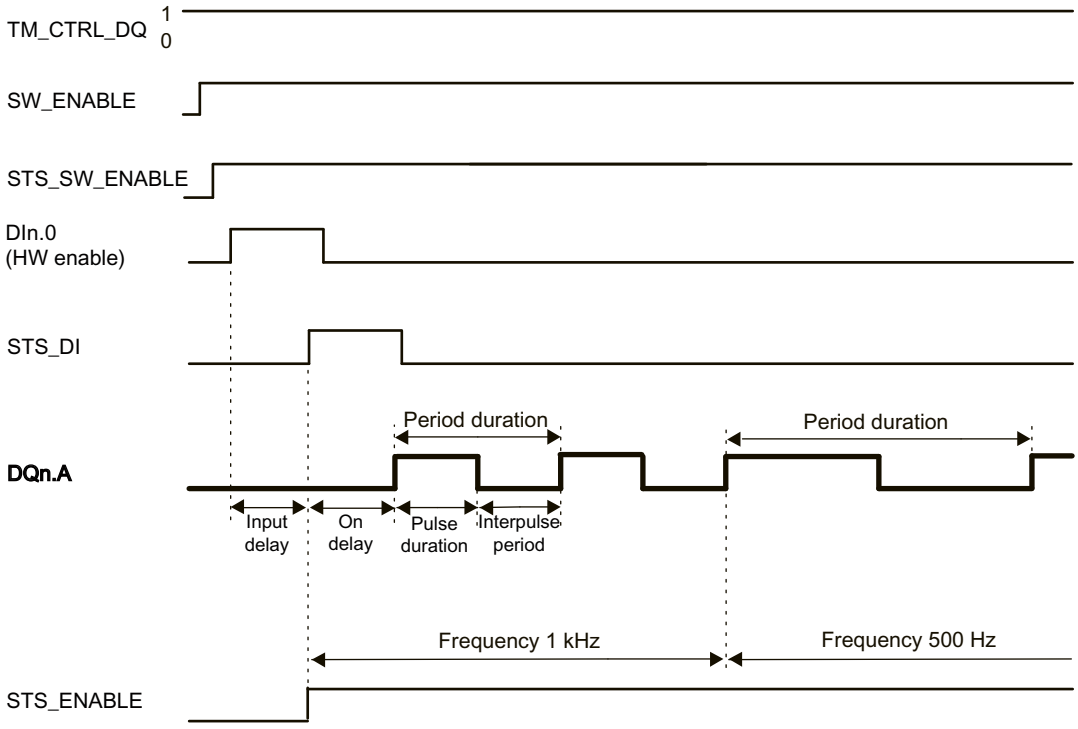

Figure 2-1104 Example of an output sequence

If you are using the hardware enable, it is combined with the software enable. When the software enable is active, the output sequence starts at the first rising edge of the hardware enable. Additional rising edges of the hardware enable during the output sequence are ignored. If the hardware enable is set and remains set for the duration of the input delay, the On delay is started and the STS_ENABLE feedback bit is set. As soon as the on delay has elapsed, the pulses with the assigned frequency are output at the respective digital output DQn.A. The output sequence runs continuously, as long as SW_ENABLE is set.

If you are not using a hardware enable, the On delay starts at the rising edge of SW_ENABLE.

Aborting the output sequence

If you reset the SW_ENABLE control bit, the software enable is deactivated and the current output sequence is aborted. The last period is not completed. The STS_ENABLE feedback bit and the digital output DQn.A are reset.

A renewed pulse output is only possible after a restart of the output sequence.

4.5.1.2 Frequency

You set the output frequency in the control interface using OUTPUT_VALUE as floating point number (REAL). The value range is dependent on whether or not the high-speed output function (Page 86) is being used:

High-speed output	Value range of OUTPUT_VALUE	Value range of the frequency
Activated	0.02 to 100000	0.02 Hz to 100000 Hz = 0.02 Hz to 100 kHz
Deactivated	0.02 to 10000	0.02 Hz to 10000 Hz = 0.02 Hz to 10 kHz

A changed frequency takes effect with the next rising edge at DQn.A.

Accuracy

The output sequence is output with an accuracy of ±100 ppm at DQn.A.

4.5.1.3 On delay

You set the On delay from 0 s to 85 s with a precision of 1 µs in the hardware configuration.

In addition, you can change the On delay via the control interface by entering a new value in SLOT as an integer (UDINT). In so doing, you use the MODE_SLOT control bit to choose whether you want to apply a change once or cyclically:

MODE_SLOT = 0	One-time change: As soon as you write the value 2_D in the corresponding output byte, the value from SLOT is applied once as the On delay and kept until the next change. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.
MODE_SLOT = 1	Cyclic change: When you write the value 18_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically as the On delay. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.

You can find additional information under Handling of the SLOT parameters (Page 20).

4.5.1.4 High-speed output

The high-speed output function enables an output frequency of a maximum of 100 kHz with an output current of a maximum of 100 mA. A high-speed output generates very steep edges. The high-speed output generates signals at a higher frequency, but provides a lower maximum load current. The high-speed output is only available in two-channel operation.

The following table presents the value range of the pulse duration and frequency depending on whether or not the high-speed output function is activated:

	Minimum value		Maximum value	
	High-speed output deactivated	**High-speed output activated**	**High-speed output deactivated**	**High-speed output activated**
Pulse duration	10 µs	1,5 µs	85000000 µs (= 85 s)	
Frequency	0,02 Hz		10 kHz	100 kHz

4.5.2 Configuring

Introduction

You configure the technology module and assign its parameters with the configuration software.

The user program controls and monitors the functions of the technology module via the control interface and feedback interface.

System environment

The technology module can be used in the following system environments:

Possible use	Components needed	Configuration software	In the user program
Centralized operation with a CPU 151xSP	• ET 200SP automation system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to control interface and feedback interface in the I/O data
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	

Possible use	Components needed	Configuration software	In the user program
Distributed operation with an S7-300/400 CPU	• S7-300/400 automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration STEP 7: Device configuration and parameter setting with HSP	Direct access to control interface and feedback interface in the I/O data
Distributed operation on the PROFINET IO in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	Third-party configuration software: Device configuration and parameter setting with GSD file	
Distributed operation on the PROFIBUS DP in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	Third-party configuration software: GSD file; device configuration and parameter setting using data record 128	

Hardware Support Packages (HSP)

STEP 7

The Hardware Support Packages (HSP) are available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/23183356).

GSD file

The respective GSD file for the ET 200SP distributed I/O system is available for download on the Internet:

- GSD file PROFINET IO (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD file PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/73016883)

4.5.3 Reaction to CPU STOP

You set the response of the channel to a CPU STOP in the parameters of the device configuration.

Table 2-1273 Response of channel to CPU STOP

Option	Meaning
Output substitute value	The channel outputs the configured substitute values at the digital outputs until the next STOP-RUN transition of the CPU. You can configure the substitute value 1 for only one of the two digital outputs. An active output sequence is stopped and the STS_ENABLE feedback bit is reset. The technology module is set to its startup state after a STOP-RUN transition. Before you can start a new pulse output, you must reset the SW_ENABLE control bit.

Option	Meaning
Continue operation	The channel continues to operate. The digital outputs continue to switch according to the parameter assignment. An active output sequence will thus be continued. If you have configured the hardware enable, you can also start additional output sequences using DIn.0. The configuration of the technology module is not reset after a STOP-RUN transition.

4.5.4 Parameter setting

You use various parameters to specify the properties of the technology module. Depending on the settings, not all parameters are available. When parameters are assigned in the user program, the parameters are transferred to the module with the "WRREC" instruction and data record 128 (Page 131).

You set the parameters of the module as follows in this operating mode:

Parameter setting via...	Basic procedure
Hardware configuration in STEP 7 (TIA Portal)	1. Insert the module from the hardware catalog under "Technology modules". 2. Set the "Frequency output" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration in STEP 7 with HSP	1. Install the corresponding HSP file. You will then find the module in the hardware catalog under "ET 200SP". 2. Set the "Frequency output" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFINET IO	1. Install the latest PROFINET GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFINET IO > I/O". 2. Set the "Frequency output" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFIBUS DP	1. Install the latest PROFIBUS GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFIBUS DP > I/O". 2. Download the project to the CPU. The parameters of the module are also downloaded with their default settings (see table below). 3. Set the "Frequency output" mode and the further parameters in the user program using data record 128.

Parameters of the TM Pulse 2x24V in "Frequency output" mode

The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1274 Adjustable parameters

Parameter	Value range	Scope
Channel configuration[1]	• **2 channels (2 A)** • 1 channel (4 A)	Module
Reaction to CPU STOP	• **Output substitute value** • Continue operation	Channel
Substitute value for DQA	• **0** • 1	Channel
Substitute value for DQB	• **0** • 1	Channel
Group diagnostics	• **Deactivated** • Activated	Channel
Diagnostics DQA	• **Deactivated** • Activated	Channel
Diagnostics DQB	• **Deactivated** • Activated	Channel
High-speed output (0.1 A)	• **Deactivated** • Activated	Channel
Function DI	• **Input** • HW enable	Channel
Input delay for digital inputs	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel
On delay for pulse output	**0**...85000000 µs	Channel

[1] When configuring with HSP for STEP 7 or with a GSD file, you define the channel configuration by the selection of the module name.

NOTE

PROFIBUS GSD configuration

When configuring with a PROFIBUS GSD file, the possible parameter assignments are not available. The parameters are preassigned in the module with the default setting. Set the "Frequency output" mode and the further parameters in the user program using data record 128.

4.5.5 Address space

Address space of the technology module

Table 2-1275 Size of input and output addresses

	Inputs	Outputs
Size per technology channel	8 bytes	12 bytes
Size in one-channel operation	8 bytes	12 bytes
Size in two-channel operation	16 bytes	24 bytes

4.5.6 Control interface and feedback interface

NOTE

A library of PLC data types (LPD) for STEP 7 (TIA Portal) and SIMATIC S7-1200 / S7-1500 is available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109482396).

4.5.6.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface per channel

The following table shows the control interface assignment:

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 … 3	12 … 15	OUTPUT_VALUE REAL: Frequency							
4 … 7	16 … 19	SLOT UDINT: Load value							
8	20	Reserved			MODE_ SLOT	LD_SLOT			

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
9	21	Reserved			SET_DQB	SET_DQA	Reserved	TM_ CTRL_DQ	SW_ ENABLE
10	22	Reserved							RES_ ERROR
11	23	Reserved							

NOTE

Channel 1 is only available in two-channel operation of the module.

Control bit/value	Explanations
OUTPUT_VALUE	You specify the frequency with this value. Value range: • Frequency in Hz, when High-speed output is deactivated: 0.02 to 10000_D • Frequency in Hz, when high-speed output is activated: 0.02 to 100000_D If the low limit or the high limit is violated, the feedback bit ERR_OUT_VAL is set and the last valid frequency is used.
SLOT	You specify the load value with this value. Value range: • On delay in µs: 0 to 85000000_D You specify whether to apply a change once or cyclically with MODE_SLOT. Invalid values trigger setting of feedback bit ERR_LD (when MODE_SLOT = 0) or ERR_SLOT_VAL (when MODE_SLOT = 1).
MODE_SLOT	You specify whether you want to apply a change in SLOT once or cyclically with this bit. 0 means: As soon as you write the value 2_D in the corresponding output byte, the value from SLOT is applied once and kept until the next change. A change via SLOT takes effect at the next output sequence. After a restart of the module, the value is overwritten with the value set in the hardware configuration. 1 means: When you write the value 18_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically. A change via SLOT takes effect at the next output sequence.
LD_SLOT	You specify the meaning of the value in SLOT with this load request: • 0000_B means: No action, idle • 0010_B means: On delay in µs Values not listed are invalid and trigger setting of feedback bit ERR_LD (when MODE_SLOT = 0) or ERR_SLOT_VAL (when MODE_SLOT = 1).
SET_DQA	You use this bit to set digital output DQn.A when TM_CTRL_DQ and SET_DQB are set to 0.
SET_DQB	You use this bit to set digital output DQn.B when TM_CTRL_DQ and SET_DQA are set to 0.
TM_CTRL_DQ	You enable the technological function of the digital output with this bit. • 0 means: SET_DQA and SET_DQB define states of DQn.A and DQn.B • 1 means: Output sequence defines the state of DQn.A; DQn.B is always 0.

Control bit/value	Explanations
SW_ENABLE	You activate the software enable with this bit. If you are using the hardware enable, it is combined with the software enable. • 0 means: Stop output • 1 means: Start output Use of the HW enable is activated through parameter assignment. The HW enable is controlled externally using the digital input DIn.0.
RES_ERROR	You use this bit to reset the following feedback bits when errors are pending: • ERR_24V • ERR_DQA • ERR_DQB • ERR_LD
Reserved	Reserved bits must be set to 0.

4.5.6.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module via the feedback interface.

Feedback interface per channel

The following table shows the assignment of the feedback interface:

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8	ERR_ SLOT_VAL	ERR_ OUT_VAL	ERR_DQB	ERR_DQA	Reserved	ERR_LD	ERR_24V	ERR_PWR
1	9	Reserved		STS_SW_ ENABLE	STS_ READY	Reserved	STS_LD_ SLOT	Reserved	
2	10	Reserved				STS_DI	STS_DQB	STS_DQA	STS_ ENABLE
3 … 7	11 … 15	Reserved							

NOTE

Channel 1 is only available in two-channel operation of the module.

Feedback bit/value	Explanations
ERR_SLOT_VAL	This bit indicates that the value in SLOT or LD_SLOT is invalid (when MODE_SLOT = 1) and was not accepted. As soon as the module has received a valid value from the control interface, ERR_SLOT_VAL is automatically reset.
ERR_OUT_VAL	This bit indicates that the value in OUTPUT_VALUE is invalid. As soon as the module has received a valid value from the control interface, ERR_OUT_VAL is automatically reset.
ERR_DQA	This bit indicates a short-circuit or an overload at the output DQn.A. If you have enabled the diagnostics interrupt "Diagnostics DQA", the diagnostics interrupt "Error at digital outputs" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_DQB	This bit indicates a short-circuit or an overload at the output DQn.B or the attempted simultaneous setting of the SET_DQA and SET_DQB control bits. If you have enabled the diagnostics interrupt "Diagnostics DQB", the diagnostics interrupt "Error at digital outputs" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_LD	This bit indicates that the value in SLOT or LD_SLOT (when MODE_SLOT = 0) is invalid and was not accepted. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_24V	This bit indicates a short-circuit or an overload at output 24VDC If you have enabled diagnostic interrupts, the diagnostic interrupt "Short circuit / overload of the sensor supply voltage" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_PWR	This bit indicates that supply voltage L+ is too low. If you have enabled the diagnostic interrupts, the diagnostic interrupt "Supply voltage fault" is triggered when an error occurs. As soon as supply voltage L+ is sufficiently high again, ERR_PWR is automatically reset. The bit is not set if no supply voltage is present.
STS_SW_ENABLE	This bit indicates the status of the SW enable. • 0 means: SW enable not active • 1 means: SW enable active
STS_READY	This bit indicates that the module is supplying valid user data. The module is started and configured.
STS_LD_SLOT	A status change (toggling) of this bit indicates that the LD_SLOT load request was detected and executed (when MODE_SLOT = 0).
STS_DI	This bit indicates the status of the digital input DIn.0.
STS_DQA	This bit indicates the status of the digital output DQn.A.
STS_DQB	This bit indicates the status of the digital output DQn.B.
STS_ENABLE	This bit indicates that an output sequence is active.
Reserved	Reserved bits are set to 0.

4.5.7 Isochronous mode

The technology module supports the "Isochronous mode" system function. If you are not using a hardware enable, the output sequence starts in isochronous mode at time T_o after the SW_ENABLE control bit has been set.

Further information

You will find a detailed description of isochronous mode in:

- In the isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- PROFINET with STEP 7 function manual available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

4.6 PWM with DC motor motor

4.6.1 Function

4.6.1.1 Introduction

In this operating mode, the respective channel of the technology module at the bipolar digital output sends a pulse width modulated signal to control a brushed DC motor in both directions of rotation. You specify the duty cycle via the control interface.

Each channel has a bipolar digital output DQn.A/DQn.B for the connection of a DC motor. The module works as four-quadrant actuator. DQn.A and DQn.B are connected inside the module as an H-bridge. For information on connecting the motor, refer to the section Connecting (Page 14).

The duty cycle acts like a voltage and thus determines the speed of the motor. The sign of the duty cycle specifies the direction of rotation. When you drive the motor in forward direction, DQn.A is set and DQn.B is reset. When you drive the motor in the reverse direction, DQn.A is reset and DQn.B is set.

You can stop the motor using one of the following signals:

- Reset the control bit SW_ENABLE in the control interface
- Falling edge of the HW enable (DIn.0)
- Rising edge of the limit switch (DIn.0)

Starting the output sequence

To start the output sequence using the software enable, you set the SW_ENABLE control bit (Page 102). The STS_SW_ENABLE feedback bit indicates that the software enable in the technology module is active.

You can additionally use the hardware enable via the respective digital input DIn.0. You can configure an input delay for DIn.0.

Pulse diagram

The following figure shows an example of an output sequence for the forward direction when DIn.0 is being used as a hardware enable.

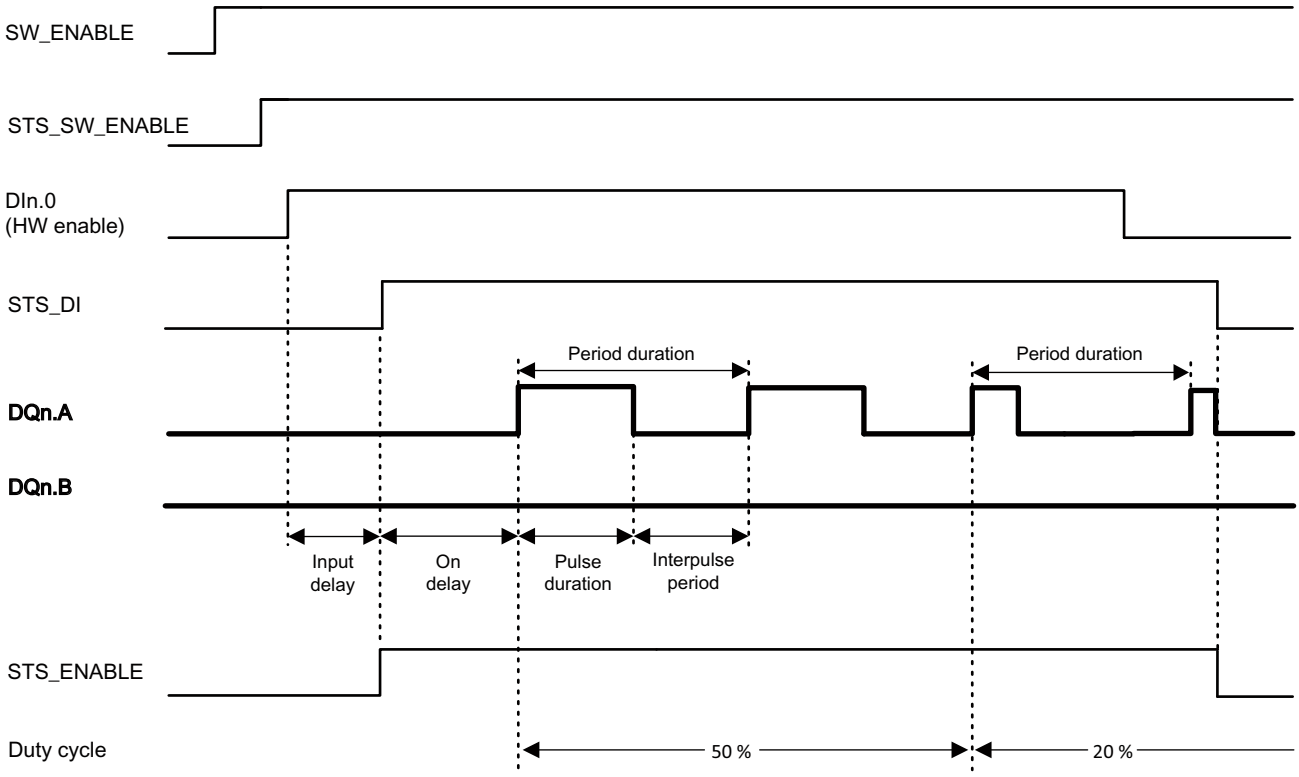

Figure 2-1105 Example of an output sequence (HW enable)

If you are using the hardware enable, it is combined with the software enable. When the software enable is active, the output sequence starts at the first rising edge of the hardware enable. If the hardware enable is set and remains set for the duration of the input delay, the On delay is started and the STS_ENABLE feedback bit is set. As soon as the On delay has elapsed, the pulse width modulated signal is output with the assigned duty cycle at the digital output DQn.A/DQn.B. The duty cycle is the ratio of pulse duration to period duration.

If you are not using a hardware enable, the On delay starts at the rising edge of SW_ENABLE. The hardware enable is not supported in isochronous mode. If you configure the hardware enable in isochronous mode, this is interpreted by the module as a limit switch.

The following figure shows an example of an output sequence for the forward direction when DIn.0 is being used as a limit switch.

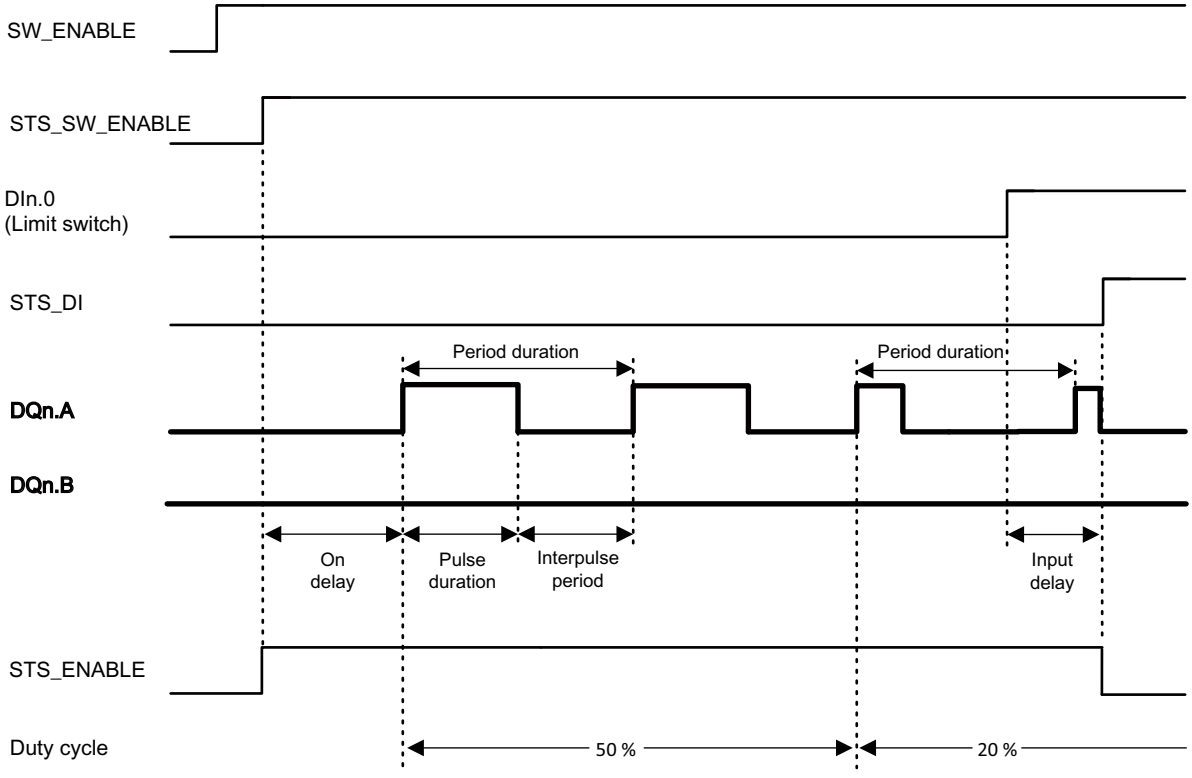

Figure 2-1106 Example of an output sequence (limit switch)

Aborting the output sequence

If you reset the SW_ENABLE control bit, the software enable is deactivated and the current output sequence is aborted. If canceled, the last period will not be completed. The feedback bit STS_ENABLE and DQn.A and DQn.B are reset (engine stop).

If you use the HW enable, you can alternatively cancel the output sequence with a falling edge at DIn.0. If you use the limit switch instead of the HW enable, you can alternatively cancel the output sequence with a rising edge at DIn.0.

A renewed pulse output is only possible after a restart of the output sequence.

4.6.1.2 Duty cycle

The duty cycle corresponds to the ratio of pulse duration to period duration (also referred to as mark-to-space ratio).

You set the duty cycle in the control interface (Page 102) using OUTPUT_VALUE in S7 analog format (DINT). The sign specifies the direction of rotation of the motor. A positive value means forward direction. If you set the value 0, the motor is stopped. If you set the minimum value, the DQn.B is set during the entire period duration. If you set the maximum value, the DQn.A is set during the entire period duration. If you set a value above or below the value range, the minimum or maximum value is used.

A changed duty cycle takes effect with the next rising edge at DQn.A or DQn.B.

Output format	Value range of OUTPUT_VALUE	Pulse duration
S7 analog output	–27648 ... 27648	(OUTPUT_VALUE/27648) × Period duration

Before changing the direction of rotation, it is recommended to set the value 0 for sufficiently long for OUTPUT_VALUE in order to first stop the motor. If the motor requires a ramp up or a ramp down, you must implement the ramp via a corresponding control of the duty cycle.

4.6.1.3 Period duration

You set the period duration from 100 µs to 85 s with a precision of 1 µs in the hardware configuration.

In addition, you can change the period duration via the control interface by entering a new value in SLOT as an integer (UDINT). In so doing, you use the MODE_SLOT control bit to choose whether you want to apply a change once or cyclically:

MODE_SLOT = 0	One-time change: As soon as you write the value 1_D in the corresponding output byte, the value from SLOT is applied once as the period duration and kept until the next change. A change via SLOT takes effect at DQn.A/DQn.B with the next rising edge.
MODE_SLOT = 1	Cyclic change: When you write the value 17_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically as the period duration. A change via SLOT takes effect at DQn.A/DQn.B with the next rising edge.

You can find additional information under Handling of the SLOT parameters (Page 20).

4.6.1.4 On delay

You set the On delay from 0 s to 85 s with a precision of 1 µs in the hardware configuration.

In addition, you can change the On delay via the control interface by entering a new value in SLOT as an integer (UDINT). In so doing, you use the MODE_SLOT control bit to choose whether you want to apply a change once or cyclically:

MODE_SLOT = 0	One-time change: As soon as you write the value 2_D in the corresponding output byte, the value from SLOT is applied once as the On delay and kept until the next change. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.
MODE_SLOT = 1	Cyclic change: When you write the value 18_D in the corresponding output byte, the current value from SLOT in each case is applied cyclically as the On delay. A change via SLOT takes effect at the next output sequence. An active output sequence is not affected by the change.

NOTE

In isochronous mode, a configured On delay has no effect.

You can find additional information under Handling of the SLOT parameters (Page 20).

4.6.2 Configuring

Introduction

You configure the technology module and assign its parameters with the configuration software.

The user program controls and monitors the functions of the technology module via the control interface and feedback interface.

System environment

The technology module can be used in the following system environments:

Possible use	Components needed	Configuration software	In the user program
Centralized operation with a CPU 151xSP	• ET 200SP automation system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to control interface and feedback interface in the I/O data
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	

Possible use	Components needed	Configuration software	In the user program
Distributed operation with an S7-300/400 CPU	• S7-300/400 automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration STEP 7: Device configuration and parameter setting with HSP	Direct access to control interface and feedback interface in the I/O data
Distributed operation on the PROFINET IO in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	Third-party configuration software: Device configuration and parameter setting with GSD file	
Distributed operation on the PROFIBUS DP in a third-party system	• Third-party automation system • ET 200SP distributed I/O system • TM Pulse 2x24V	Third-party configuration software: GSD file; device configuration and parameter setting using data record 128	

Hardware Support Packages (HSP)

STEP 7

The Hardware Support Packages (HSP) are available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/23183356).

GSD file

The respective GSD file for the ET 200SP distributed I/O system is available for download on the Internet:

- GSD file PROFINET IO (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD file PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/73016883)

4.6.3 Parameter setting

You use various parameters to specify the properties of the technology module. Depending on the settings, not all parameters are available. When parameters are assigned in the user program, the parameters are transferred to the module with the "WRREC" instruction and data record 128 (Page 131).

You set the parameters of the module as follows in this operating mode:

Parameter setting via...	Basic procedure
Hardware configuration in STEP 7 (TIA Portal)	1. Insert the module from the hardware catalog under "Technology modules". 2. Set the "PWM with DC motor" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.

Parameter setting via...	Basic procedure
Hardware configuration in STEP 7 with HSP	1. Install the corresponding HSP file. You will then find the module in the hardware catalog under "ET 200SP". 2. Set the "PWM with DC motor" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFINET IO	1. Install the latest PROFINET GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFINET IO > I/O". 2. Set the "PWM with DC motor" mode and the further parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration with GSD file for distributed operation on PROFIBUS DP	1. Install the latest PROFIBUS GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFIBUS DP > I/O". 2. Download the project to the CPU. The parameters of the module are also downloaded with their default settings (see table below). 3. Set the "PWM with DC motor" mode and the further parameters in the user program using data record 128.

Parameters of the TM Pulse 2x24V in "PWM with DC motor" mode

The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1276 Adjustable parameters

Parameter	Value range	Scope
Channel configuration[1]	• **2 channels (2 A)** • 1 channel (4 A)	Module
Group diagnostics	• **Deactivated** • Activated	Channel
Diagnostics DQA	• **Deactivated** • Activated	Channel
Diagnostics DQB	• **Deactivated** • Activated	Channel
Function DI	• **Input** • HW enable • Limit switch	Channel
Input delay for digital inputs	• None • 0.05 ms • **0.1 ms** • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms	Channel

[1] When configuring with HSP for STEP 7 or with a GSD file, you define the channel configuration by the selection of the module name.

Parameter	Value range	Scope
Period duration	100...**1000**...85000000 µs	Channel
Actual period duration	Automatically calculated (read-only)	Channel
On delay for pulse output	**0**...85000000 µs	Channel

[1] When configuring with HSP for STEP 7 or with a GSD file, you define the channel configuration by the selection of the module name.

NOTE

PROFIBUS GSD configuration

When configuring with a PROFIBUS GSD file, the possible parameter assignments are not available. The parameters are preassigned in the module with the default setting. Set the "PWM with DC motor" mode and the further parameters in the user program using data record 128.

4.6.4 Address space

Address space of the technology module

Table 2-1277 Size of input and output addresses

	Inputs	Outputs
Size per technology channel	8 bytes	12 bytes
Size in one-channel operation	8 bytes	12 bytes
Size in two-channel operation	16 bytes	24 bytes

4.6.5 Control interface and feedback interface

NOTE

A library of PLC data types (LPD) for STEP 7 (TIA Portal) and SIMATIC S7-1200 / S7-1500 is available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109482396).

4.6.5.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface per channel

The following table shows the control interface assignment:

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 … 3	12 … 15	OUTPUT_VALUE DINT: Duty cycle in the S7 analog format							
4 … 7	16 … 19	SLOT UDINT: Load value							
8	20	Reserved			MODE_ SLOT	LD_SLOT			
9	21	Reserved							SW_ ENABLE
10	22	Reserved							RES_ ERROR
11	23	Reserved							

NOTE

Channel 1 is only available in two-channel operation of the module.

Control bit/value	Explanations
OUTPUT_VALUE	You specify the duty cycle with this value. Value range: • Duty cycle: -27648 to 27648_D: If the low limit or the high limit is violated, the feedback bit ERR_OUT_VAL is set and the minimum or maximum value is used.
SLOT	You specify the load value with this value. Value range: • Period duration in µs: 100 to 85000000_D • On delay in µs: 0 to 85000000_D You specify whether to apply a change once or cyclically with MODE_SLOT. Invalid values trigger setting of feedback bit ERR_LD (when MODE_SLOT = 0) or ERR_SLOT_VAL (when MODE_SLOT = 1).

Control bit/value	Explanations
MODE_SLOT	You specify whether you want to apply a change in SLOT once or cyclically with this bit. 0 means: As soon as you write the respective value in the corresponding output byte, the value from SLOT is applied once and kept until the next change. A change of the On delay via SLOT takes effect at the next output sequence. A change of the period duration via SLOT takes effect at DQn.A/DQn.B with the next rising edge. After a restart of the module, the value is overwritten with the value set in the hardware configuration. 1 means: When you write the respective value in the corresponding output byte, the current value from SLOT in each case is applied cyclically. A change of the On delay via SLOT takes effect at the next output sequence. A change of the period duration via SLOT takes effect at DQn.A/DQn.B with the next rising edge.
LD_SLOT	You specify the meaning of the value in SLOT with this load request: • 0000_B means: No action, idle • 0001_B means: Period duration in µs • 0010_B means: On delay in µs Values not listed are invalid and trigger setting of feedback bit ERR_LD (when MODE_SLOT = 0) or ERR_SLOT_VAL (when MODE_SLOT = 1).
SW_ENABLE	You activate the software enable with this bit. If you are using the hardware enable, it is combined with the software enable. • 0 means: Stop output • 1 means: Start output Use of the HW enable is activated through parameter assignment. The HW enable is controlled externally using the digital input DIn.0.
RES_ERROR	You use this bit to reset the following feedback bits when errors are pending: • ERR_24V • ERR_DQA • ERR_DQB • ERR_LD
Reserved	Reserved bits must be set to 0.

4.6.5.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module via the feedback interface.

Feedback interface per channel

The following table shows the assignment of the feedback interface:

Byte offset relative to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	8	ERR_ SLOT_VAL	ERR_ OUT_VAL	ERR_DQB	ERR_DQA	Reserved	ERR_LD	ERR_24V	ERR_PWR
1	9	Reserved		STS_SW_ ENABLE	STS_ READY	Reserved	STS_LD_ SLOT	Reserved	
2	10	Reserved				STS_DI	STS_DQB	STS_DQA	STS_ ENABLE
3 … 7	11 … 15	Reserved							

NOTE

Channel 1 is only available in two-channel operation of the module.

Feedback bit/value	Explanations
ERR_SLOT_VAL	This bit indicates that the value in SLOT or LD_SLOT is invalid (when MODE_SLOT = 1) and was not accepted. As soon as the module has received a valid value from the control interface, ERR_SLOT_VAL is automatically reset.
ERR_OUT_VAL	This bit indicates that the value in OUTPUT_VALUE is invalid. As soon as the module has received a valid value from the control interface, ERR_OUT_VAL is automatically reset.
ERR_DQA	This bit indicates a short-circuit or an overload at the output DQn.A. If you have enabled the diagnostics interrupt "Diagnostics DQA", the diagnostics interrupt "Error at digital outputs" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_DQB	This bit indicates a short-circuit or an overload at the output DQn.B or the attempted simultaneous setting of the SET_DQA and SET_DQB control bits. If you have enabled the diagnostics interrupt "Diagnostics DQB", the diagnostics interrupt "Error at digital outputs" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_LD	This bit indicates that the value in SLOT or LD_SLOT (when MODE_SLOT = 0) is invalid and was not accepted. The bit is reset once you have acknowledged the error with RES_ERROR.

Feedback bit/value	Explanations
ERR_24V	This bit indicates a short-circuit or an overload at output 24VDC If you have enabled diagnostic interrupts, the diagnostic interrupt "Short circuit / overload of the sensor supply voltage" is triggered when this error occurs. The bit is reset once you have acknowledged the error with RES_ERROR.
ERR_PWR	This bit indicates that supply voltage L+ is too low. If you have enabled the diagnostic interrupts, the diagnostic interrupt "Supply voltage fault" is triggered when an error occurs. As soon as supply voltage L+ is sufficiently high again, ERR_PWR is automatically reset. The bit is not set if no supply voltage is present.
STS_SW_ENABLE	This bit indicates the status of the SW enable. • 0 means: SW enable not active • 1 means: SW enable active
STS_READY	This bit indicates that the module is supplying valid user data. The module is started and configured.
STS_LD_SLOT	A status change (toggling) of this bit indicates that the LD_SLOT load request was detected and executed (when MODE_SLOT = 0).
STS_DI	This bit indicates the status of the digital input DIn.0.
STS_DQA	This bit indicates the status of the digital output DQn.A.
STS_DQB	This bit indicates the status of the digital output DQn.B.
STS_ENABLE	This bit indicates that an output sequence is active.
Reserved	Reserved bits are set to 0.

4.6.6 Isochronous mode

The technology module supports the "Isochronous mode" system function. In isochronous mode, the output sequence starts at time T_o after the SW_ENABLE control bit has been set. The period duration is also adapted to the application cycle (T_{APP}) and synchronized with it. The synchronization is especially advantageous for setting up control loops.

The module adjusts the assigned value of the period duration in such a way that an integer ratio results. In the most unfavorable case, the difference amounts to half the application cycle.

Examples:

Application cycle T_{APP}	Assigned period duration $T_{Set-point}$	Actual period durationT_{Actual}	T_{APP}:T_{Actual}
10 ms (10000 µs)	1800 µs	1666 µs	6:1
	2000 µs	2000 µs	5:1
	3000 µs	3333 µs	3:1
	5000 µs	5000 µs	2:1
	6000 µs	5000 µs	2:1
	12000 µs	10000 µs	1:1
	16000 µs	20000 µs	1:2

The figure below shows an example of a 1:1 ratio of application cycle to period duration with a duty cycle of 50%.

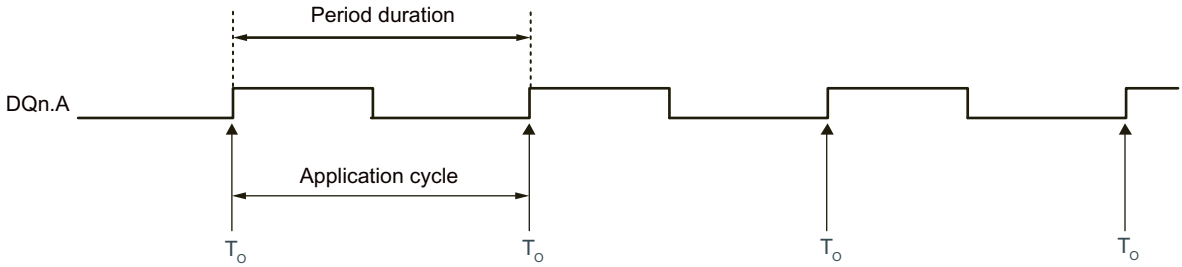

The figure below shows an example of a 3:1 ratio of application cycle to period duration with a duty cycle of 50%.

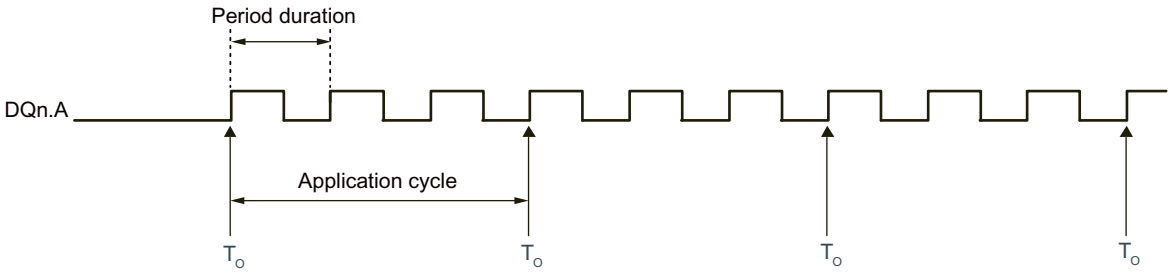

The figure below shows an example of a 1:3 ratio of application cycle to period duration with a duty cycle of 50%.

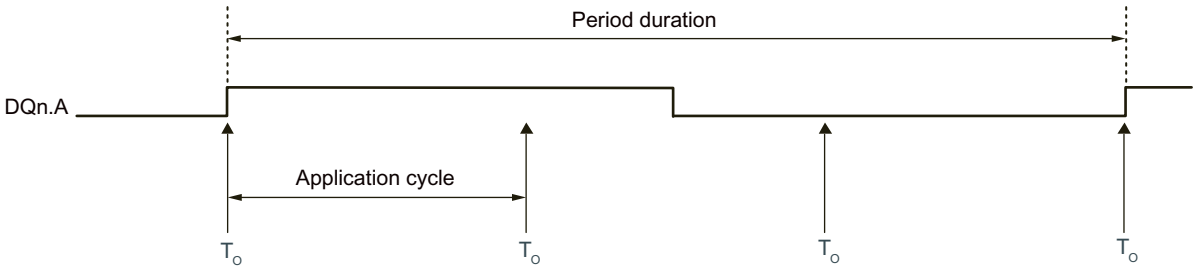

NOTE

No HW enable or On delay

No hardware enable or On delay can be used in isochronous mode.

If you configure the hardware enable in isochronous mode, this is interpreted by the module as a limit switch.

Further information

You will find a detailed description of isochronous mode in:

- In the isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- PROFINET with STEP 7 function manual available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

4.7 Parallel connection of channels

When the two channels are connected in parallel, you get a logical channel with an output current of up to 4 A.

The figure below shows two-channel operation in which the channels operate independent of each other and are separately configured.

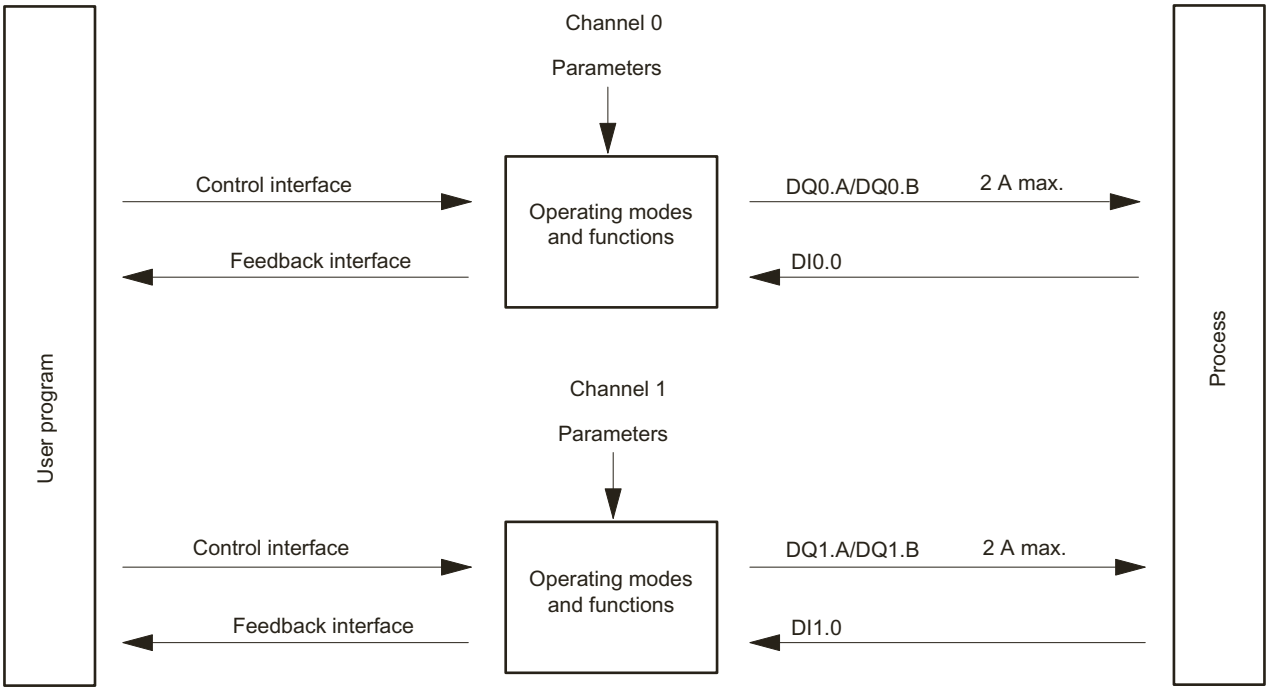

Figure 2-1107 Two-channel operation

The figure below shows one-channel operation in which you only configure Channel 0.

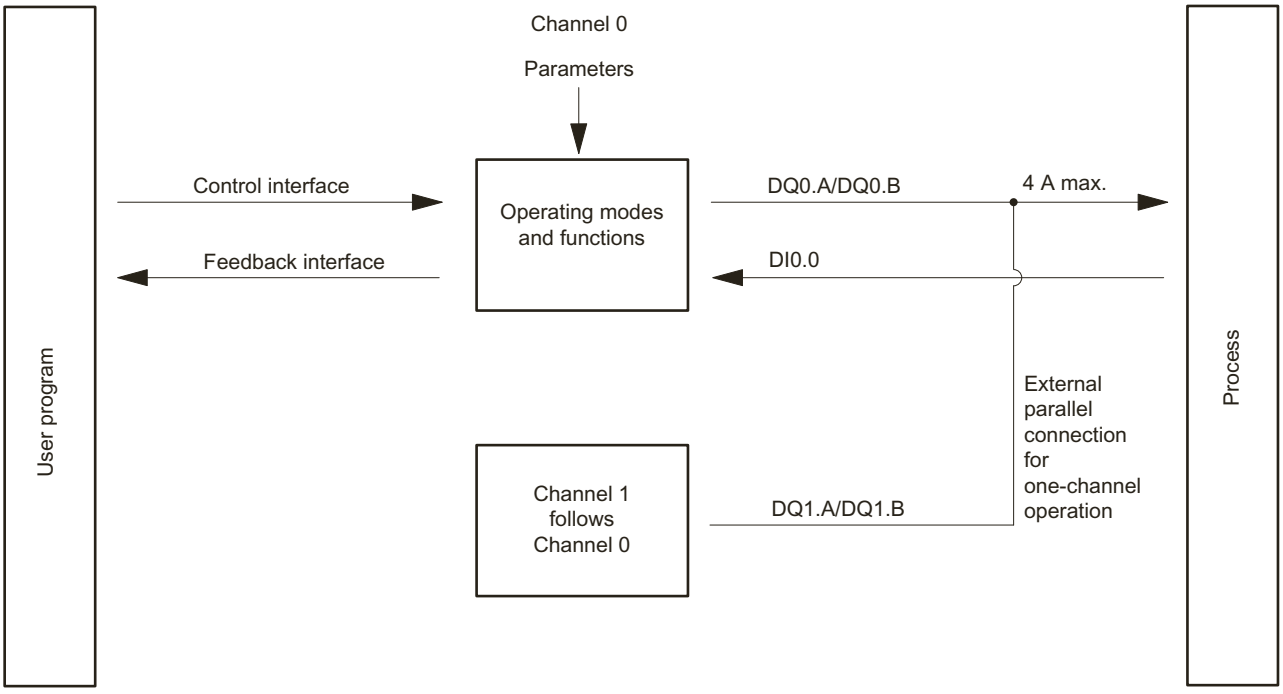

Figure 2-1108 One-channel operation (parallel connection)

The following table presents the possible load current depending on whether or not the high-speed output is activated:

	Maximum output current	
	High-speed output deactivated	**High-speed output activated**
Two-channel operation	2 A	100 mA
One-channel mode	4 A	Not permitted

You configure the function in the hardware configuration using the "Channel configuration" parameter.

4.8 Direct control of digital outputs

Controlling of the output sequence by the user program or module

You define how DQn.A and DQn.B are controlled using the TM_CTRL_DQ control bit:

TM_CTRL_DQ = 0	TM_CTRL_DQ = 1
You define the states of outputs DQn.A and DQn.B with the user program using the SET_DQA and SET_DQB control bits.	The output sequence of the configured operating mode defines the state of outputs DQn.A and DQn.B.

NOTE

No direct control available when using PWM with DC motor

In "PWM with DC motor" mode, the TM_CTRL_DQ, SET_DQA and SET_DQB control bits have no effect.

Pulse diagram

An active output sequence is not aborted by the setting of TM_CTRL_DQ. The module initiates the output sequences internally regardless of the state of TM_CTRL_DQ.

The following figure shows an example of an output sequence for direct control of DQn.A:

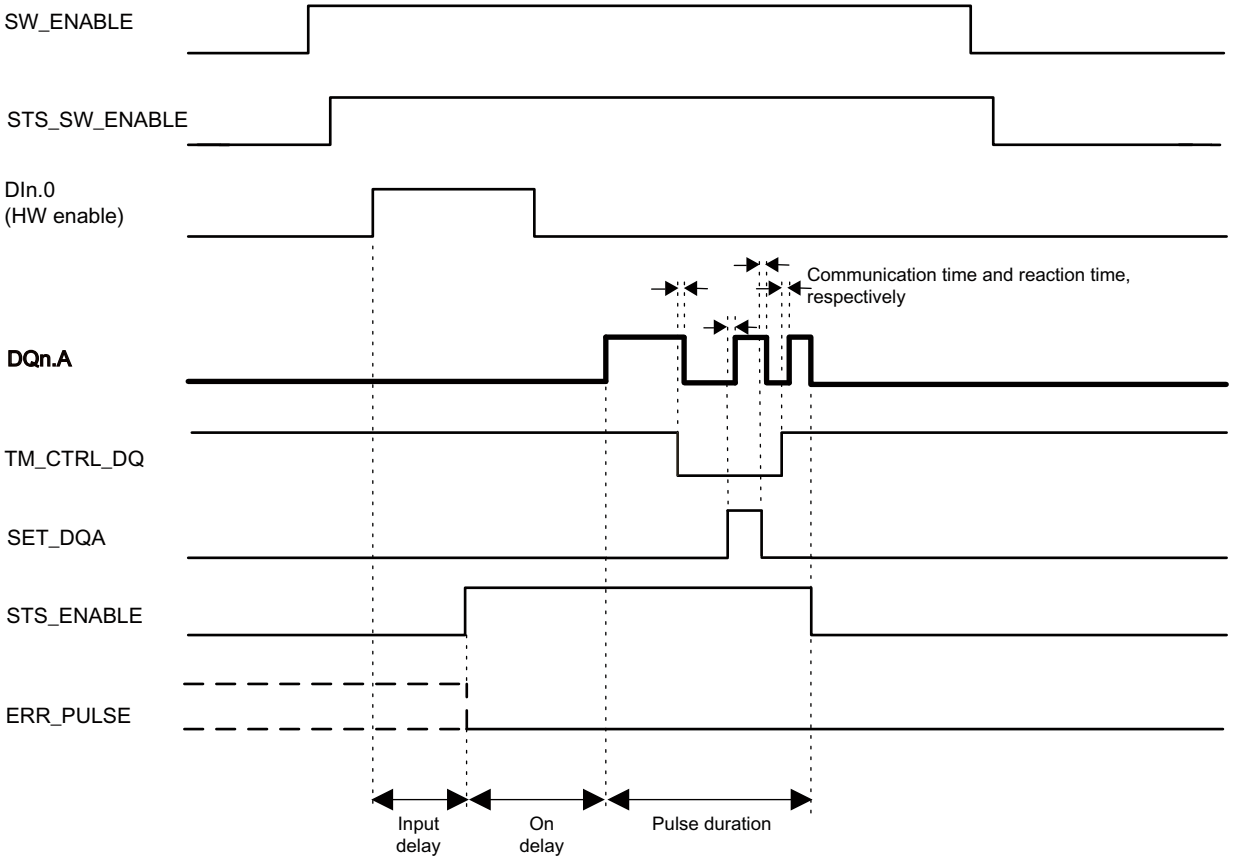

Figure 2-1109 Example of an output sequence for direct control of DQn.A (Pulse output mode)

NOTE

If you set the SET_DQA and SET_DQB control bits simultaneously, the ERR_DQB bit is set in the feedback interface and only the digital output DQn.A is set.

The ERR_DQB bit is reset once you have acknowledged the error by setting RES_ERROR.

4.9 Explanation of parameters

4.9.1 Channel configuration

Channel configuration

This parameter is used to specify whether both channels are to be connected in parallel.

Channel configuration	Meaning
2 channels (2 A) (default)	The two channels operate separately and each has a maximum output current of 2 A.
1 channel (4 A)	The two channels are connected in parallel and operate as a logical channel with a maximum output current of 4 A. All parameter settings and operations that use the control interface must use addresses with Channel 0. Feedback signals are only provided for Channel 0. The control and feedback interface is limited to one channel only. Channel 1 cannot be configured or operated. Current measurement adds the measured values of both channels.

NOTE

High-speed output

The "High-Speed Output (0.1 A)" can only be selected for the channel configuration "2 Channels (2 A)".

4.9.2 Operating mode

Operating mode

You use this parameter to specify the function for which the channel of the technology module is used. This defines the setting options under "Parameters".

Operating mode	Meaning	Mode-dependent parameters
Pulse output	The channel outputs a single pulse. You specify the pulse duration in the control interface.	• High-speed output (0.1 A) • Function DI • Input delay • On delay
Pulse width modulation PWM (default)	The channel outputs a pulse width modulated signal. You specify the duty cycle and/or the current setpoint in the control interface.	• High-speed output (0.1 A) • Function DI[1] • Input delay • Output format • Minimum pulse duration • Period duration • Actual period duration • On delay [1] • Dithering • Incline of dithering ramp up • Incline of dithering ramp down

Operating mode	Meaning	Mode-dependent parameters
		• Dithering amplitude • Dithering period duration • Current control • Enable proportional action • Enable integral action • Enable derivative action • Reference value current • Dead band width • Manipulated value high limit • Manipulated value low limit • Proportional gain • Integration time • Derivative action time • Delay time of derivative action
Pulse train	The channel outputs a number of pulses. You specify the number of pulses in the control interface.	• High-speed output (0.1 A) • Function DI • Input delay • Output format • Period duration • Actual period duration • On delay • Duty cycle
On/Off delay	The channel outputs pulses with specified switching delay with respect to DI0. You specify the On delay in the control interface.	• High-speed output (0.1 A) • Input delay • Off delay
Frequency output	The channel outputs a signal with a fixed duty cycle of 50%. You specify the frequency in the control interface.	• High-speed output (0.1 A) • Function DI • Input delay • Output format • On delay
PWM with DC motor	The channel outputs a pulse width modulated signal for controlling a DC motor in both directions of rotation. You specify the duty cycle in the control interface.	• Function DI[1] • Input delay • Output format • Period duration • Actual period duration • On delay [1]

[1] Parameters cannot be assigned in isochronous mode

4.9.3 Reaction to CPU STOP

Reaction to CPU STOP

You use this parameter to determine the response of the channel to the failure of a higher-level controller.

Reaction to CPU STOP	Meaning
Output substitute value (default)	The channel outputs the configured substitute values at the digital outputs until the next STOP-RUN transition of the CPU. You can configure the substitute value 1 for only one of the two digital outputs.

Reaction to CPU STOP	Meaning
	An active output sequence is stopped and the STS_ENABLE feedback bit is reset. The module is returned to its startup state after a STOP-RUN transition. Before you can start a new pulse output, you must reset the SW_ENABLE control bit.
Continue operation	The channel continues to operate. The digital outputs continue to switch according to the parameter assignment. An active output sequence will thus be continued. If you have configured the hardware enable, you can also start additional output sequences using DIn.0. The configuration of the technology module is not reset after a STOP-RUN transition.

Substitute value for DQA

This parameter lets you specify which value the technology module is to output to the digital output DQA in the event of a CPU STOP under "Output substitute value".

The default setting is "0".

Substitute value for DQB

This parameter lets you specify which value the technology module is to output to the digital output DQB in the event of a CPU STOP under "Output substitute value".

The default setting is "0".

NOTE

You can select the default value 1 for only one of the two digital outputs.

4.9.4 Diagnostics

The technology module can trigger additional diagnostic interrupts when you enable the diagnostic interrupts in the basic parameters. These diagnostic interrupts are processed in an interrupt OB.

Group diagnostics

You use this parameter to specify whether a diagnostic interrupt is to be triggered for following errors:

- Supply voltage fault (feedback bit ERR_PWR)
- Short-circuit or overload at sensor supply (feedback bit ERR_24V)
- Load voltage missing
- Overtemperature

The parameter is disabled in the default setting.

Diagnostics DQA

You use this parameter to specify whether a diagnostic interrupt "Error at digital outputs" is to be triggered in the event of an error at the digital output DQA. Regardless of this, the feedback bit ERR_DQA is set when an error occurs.

The parameter is disabled in the default setting.

Diagnostics DQB

You use this parameter to specify whether a diagnostic interrupt "Error at digital outputs" is to be triggered in the event of an error at the digital output DQB. Regardless of this, the feedback bit ERR_DQB is set when an error occurs.

The parameter is disabled in the default setting.

4.9.5 Parameter

High-speed output (0.1 A)

Use this parameter to specify whether or not the respective digital output works as a fast push-pull switch.

Option	Meaning
Activated	The digital outputs work as fast push-pull switches and each can carry a rated load current of 0.1 A. A push-pull switch is alternately switched to DC 24 V and ground. This makes for very fast edges.
Disabled (default)	The digital outputs work as fast push-pull switches and each can carry a rated load current of 2 A.

NOTE

Channel configuration

You can only select this parameter with the channel configuration "2 channels (2 A)".

NOTE

You cannot enable this parameter in the operating modes "PWM with DC motor" and "Pulse width modulation PWM" with current control.

Function DI

By configuring a digital input, you specify which functions the digital input triggers at switching.

You can select from the following options:

Function	Meaning
Input (pre-selected)	No function is assigned to the respective digital input. The signal status of the digital input can be read by the CPU by means of the feedback interface.
HW enable	The respective digital input is used as enable input for the output sequence.
Limit switch	The respective digital input is used as external limit switch for a DC motor in the "PWM with DC motor" mode.

Input delay

This parameter can be used to suppress signal noise at the digital inputs of a channel. Changes to the signal are only detected if they remain stable for longer than the configured input delay time.

You can select from the following input delays:

- None
  (input delay of 4 µs, minimum pulse width of 3 µs)
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

NOTE

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

Output format

Use this parameter to specify the format or the value range with which the duty cycle or the current setpoint is evaluated:

Output format	Value range
S7 analog output	"PWM with DC motor" mode: –27648 ... 27648 Other operating mode: 0 ... 27648 ("27648" corresponds to 100% of Reference value current)
1/100 (default)	0 ... 100
1/1000	0 ... 1000
1/10000	0 ... 10000

NOTE

In "Frequency output" mode, "1 Hz" is selected as output format and cannot be changed.

In "PWM with DC motor" mode, "S7 analog output" is selected as output format and cannot be changed.

Minimum pulse duration

This parameter is used to specify the minimum permitted pulse duration for the PWM signal.

Pulses and pauses which fall below the value are suppressed.

The default setting is "0 µs".

NOTE

The Minimum pulse duration is not effective if you have activated "Current control".

Period duration

This parameter is used to specify the period duration of the output signal.

In "PWM with DC motor" mode, the default setting is "1000 µs" (= 1 ms). In other operating modes the default setting is "2000000 µs" (= 2 s).

Actual period duration

The actual period duration is only displayed in isochronous mode.

The displayed value is the utilized period duration, which is calculated from the input period duration and the set application cycle.

On delay

This parameter is used to specify the delay with which the start of the output sequence effects the output of the pulse.

The default setting is "0 µs".

NOTE

Isochronous mode

In isochronous mode you cannot set the On delay in the "Pulse width modulation PWM" and "PWM with DC motor" modes.

Off delay

This parameter is used to specify the delay with which a falling edge of the digital input DIO effects the digital output DQA.

The default setting is "0 µs".

Duty cycle

This parameter is used to specify the pulse-pause ratio (also referred to as pulse duty factor or duty factor) of the output signal in the selected output format.

The default setting is "50%".

Dithering

You can use this parameter to specify whether the PWM signal will be overlaid by a dither signal:

No dithering is enabled in the default setting.

Incline of dithering ramp up

You can use this parameter to specify the incline of the ramp up of the dithering amplitude for a theoretical increase of 0% to 100%.

The incline influences the effective ramp time.

Example of calculation of the effective ramp time in the case of a dithering amplitude of 10% and an incline of 2500 ms/100%:

10 % x 2500 ms/100 % = 250 ms

The default setting is "0".

Incline of dithering ramp down

You can use this parameter to specify the incline of the ramp down of the dithering amplitude for a theoretical drop from 100% to 0%.

The incline influences the effective ramp time:

Example of calculation of the effective ramp time in the case of a dithering amplitude of 10% and an incline of 2500 ms/100%:

10% x 2500 ms/100% = 250 ms

The default setting is "0".

Dithering amplitude

You can use this parameter to specify the amplitude of the dither signal in relation to the period duration of the output signal.

The default setting is "5.0%".

Dithering period duration

This parameter is used to specify the period duration of the dither signal. The parameter can be set in a fixed grid depending on the period duration of the PWM signal.

The default setting is "50000 µs" (= 50 ms).

Dithering frequency

This value is calculated from the configured period duration of the dither signal.

The value cannot be changed (read only).

Current control

You can use this parameter to activate the PID algorithm for the control of the output current.

The parameter is disabled in the default setting.

NOTE

High-speed output

You can use current control with the associated parameters only in "Pulse width modulation PWM" mode with deactivated "High-speed output (0.1 A)".

Enable proportional action

You can use this parameter to activate the proportional action of the PID algorithm.

The parameter is enabled in the default setting.

Enable integral action

You can use this parameter to activate the integral action of the PID algorithm.

The parameter is enabled in the default setting.

Enable derivative action

You can use this parameter to activate the derivative action of the PID algorithm.

The parameter is disabled in the default setting.

Reference value current

You use this parameter to specify the maximum current as reference value for the current setpoint. A value of 100% for OUTPUT_VALUE in the control interface corresponds to a current setpoint in the magnitude of the reference value of the current.

The recommended setting is the value of the load current that is measured when current control is deactivated and the duty cycle is 100%.

The default setting is "0 mA".

Dead band width

You can use this parameter to specify the deviation of the output current from the current setpoint, within which there is no readjustment. The deviation refers to a range above and below the current setpoint.

The default setting is "0 µA".

Manipulated value high limit

You specify the high control limit with this parameter. "27648" corresponds to 100% of the duty cycle. The value must be greater than the "Manipulated variable low limit".

The default setting is "27648".

Manipulated value low limit

You specify the low control limit with this parameter. "0" corresponds to 0% of the duty cycle. The value must be less than the "Manipulated variable high limit".

The default setting is "0".

Proportional gain

This parameter is used to define the gain factor for the proportional action of the PID algorithm.

The default setting is "2.0000".

Integration time

This parameter defines the time used by the integral action of the PID algorithm.

The default setting is "20.0000" s.

Derivative action time

This parameter defines the time used by the derivative action of the PID algorithm.

The default setting is "10.0000 s".

Delay time of derivative action

This parameter is used to specify the delay time of derivative action of the PID algorithm.

The default setting is "2.0000 s".

Interrupts/diagnostic messages

5

5.1 Status and error displays

LED displays

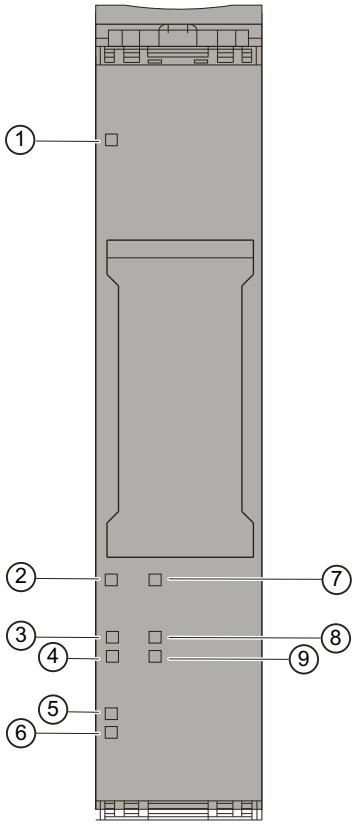

①	DIAG (green/red)	⑥	PWR (green)
②	Status of DI0.0 (green)	⑦	Status of DI1.0 (green)
③	Status of DQ0.A (green)	⑧	Status of DQ1.A (green)
④	Status of DQ0.B (green)	⑨	Status of DQ1.B (green)
⑤	24 V DC (green)		

Figure 2-1110 LED displays of the TM Pulse 2x24V

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Corrective measures for diagnostics alarms can be found in the section Diagnostic messages (Page 123).

Table 2-1278 Status and error displays DIAG

LED DIAG	Meaning	Solution
□ Off	Backplane bus supply of the ET 200SP not OK	Check or switch on the supply voltage on the CPU or on the interface module.
Flashes	Technology module parameters not assigned	—
■ On	Technology module parameters assigned but no module diagnostics	
Flashes	Technology module parameters assigned and module diagnostics (at least one error pending)	Evaluate the diagnostics alarms and eliminate the error.

Table 2-1279 Status displays PWR/24VDC

LEDs		Meaning	Solution
PWR	24VDC		
□ Off	□ Off	Supply voltage missing	• Check the supply voltage. • Check the BaseUnit type and the wiring of the BaseUnit.
■ On	■ On	Supply voltage is present and OK. Sensor supply is OK.	—
■ On	□ Off	Short-circuit or overload at the sensor supply or supply voltage too low	• Check the sensor wiring. • Check the loads connected to the sensor supply. • Check the supply voltage.

Channel LEDs

The DIn.0 LEDs indicate the current level of the associated signals. The LEDs of the digital outputs DQn.A and DQn.B indicate the desired state.

The flashing frequency of the channel LEDs is limited to approximately 12 Hz. If higher frequencies are present, the channel LEDs do not indicate the current status but instead flash at 12 Hz.

Table 2-1280 Status displays DIn.0/DQn.A/DQn.B

LEDs DIn.0/DQn.A/DQn.B	Meaning
□ Off	Digital input / digital output at 0 level
■ On	Digital input / digital output at 1 level

5.2 Diagnostic messages

Enabling of diagnostic interrupts

You enable the diagnostics interrupts in the device configuration.

The technology module can trigger the following diagnostics interrupts:

Table 2-1281 Possible diagnostic interrupts

Diagnostic interrupt	Monitoring
• Parameter error • Channel/component temporarily unavailable • Internal error • Watchdog tripped. Module is defective.	Monitoring is always active. A diagnostic interrupt is triggered each time an error is detected.
• Error at digital outputs	Monitoring is always active. An error detected only triggers a diagnostics interrupt if "Diagnostics DQA" or "Diagnostics DQB" has been enabled in the device configuration.
• Error • Load voltage missing • Short-circuit / overload at external sensor supply • Supply voltage fault • Overtemperature	Monitoring is always active. An error detected only triggers a diagnostics interrupt if "Group diagnostics" has been enabled in the device configuration.

Reactions to a diagnostic interrupt

The following happens when an event occurs that triggers a diagnostic interrupt:

- The DIAG LED flashes red.

  When you have eliminated all errors, the DIAG LED stops flashing red and turns green.
- The S7-1500 CPU interrupts the processing of the user program. The diagnostic interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.
- The S7-1500 CPU remains in RUN, even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible despite the error.

You can obtain detailed information on the error event in the error organization block with instruction "RALRM" (Read additional alarm information), in the information system of STEP 7 and in function manual Diagnostics (https://support.industry.siemens.com/cs/ww/en/view/59192926), section "System diagnostics in user program".

If the module is being operated as a distributed module in an ET 200SP system with PROFIBUS DP, you have the option of reading out diagnostic data with the RDREC or RD_REC instruction using data record 0 and 1. You can find the structure of the data records in the manual for the IM 155-6 DP HF interface module available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/73098660).

Diagnostics alarms

The diagnostics are displayed as plain text in STEP 7 (TIA Portal) in the online and diagnostics view. You can evaluate the error codes with the user program.

The following diagnostics can be signaled:

Table 2-1282 Diagnostics alarms, their meaning and corrective measures

Diagnostics alarm	Error code	Meaning	Solution
Error	9_H	• Internal module error occurred • Possible cause: – Firmware update was aborted – Technology module defective	• Repeat firmware update • Replace technology module
Parameter error	10_H	• The received parameter data record is invalid • The configured BaseUnit is not the BaseUnit being used	• Check parameter data record • Check BaseUnit
Load voltage missing	11_H	• Missing supply voltage L+ • Wiring of supply voltage L+ faulty • Possible cause: BaseUnit type incorrect	• Check BaseUnit type • Check supply voltage L+ at the BaseUnit • Check wiring of supply voltage L+
Channel/component temporarily unavailable	$1F_H$	Firmware update in progress or update was aborted. The module reads no process values in this state.	• Wait for firmware update • If firmware update aborts: – Check minimum firmware version required – Check supply voltage – Repeat firmware update
Internal error	100_H	Technology module defective	Replace technology module
Watchdog tripped. Module is defective.	103_H	Firmware error	Run firmware update
		Technology module defective	Replace technology module
Short-circuit / overload at external sensor supply	$10E_H$	• Error at sensor supply • Possible causes: – Short circuit – Overload	• Check sensor wiring • Check consumers connected to sensor supply
Error at digital outputs	$10F_H$	• Error at the digital outputs • Possible causes: – Short circuit – Overload	• Check the wiring at the digital outputs (see figures for two-channel operation and one-channel operation (parallel connection) in section Connecting (Page 14)) • Check consumers connected to the digital outputs
Supply voltage fault	110_H	• Error at supply voltage L+ • Possible causes: – Low voltage – Wiring of supply voltage L+ faulty	• Check supply voltage L+ at the BaseUnit • Check wiring of supply voltage L+
Overtemperature	506_H	Possible causes: • Short-circuit or overload at the digital outputs or output of the sensor supply • Ambient temperature outside specifications • Contamination in the module prevents cooling	• Check process wiring • Improve cooling • Check connected loads

Technical specifications

6

Article number	6ES7138-6DB00-0BB1
General information	
Product type designation	TM Pulse 2x24 V
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type B1
Color code for module-specific color identification plate	CC40
Product function	
• I&M data	Yes; I&M 0
• Isochronous mode	Yes
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V13 SP1 + HSP
• STEP 7 configurable/integrated as of version	V5.5 SP4 and higher
• PROFIBUS as of GSD version/GSD revision	GSD Revision 5
• PROFINET as of GSD version/GSD revision	GSDML V2.31
Supply voltage	
Load voltage L+	
• Rated value (DC)	24 V
• permissible range, lower limit (DC)	19.2 V
• permissible range, upper limit (DC)	28.8 V
• Short-circuit protection	Yes
• Reverse polarity protection	Yes; against destruction
Input current	
Current consumption, max.	70 mA; without load
Encoder supply	
Number of outputs	2; A common 24V encoder supply for both channels
24 V encoder supply	
• 24 V	Yes; L+ (-0.8 V)
• Short-circuit protection	Yes; per module, electronic
• Output current, max.	300 mA
Power loss	
Power loss, typ.	1.7 W

Article number	6ES7138-6DB00-0BB1
Address area	
Address space per module	
• Inputs	16 byte; 8 per channel
• Outputs	24 byte; 12 per channel
Digital inputs	
Number of digital inputs	2; 1 per channel
Digital inputs, parameterizable	Yes
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Digital input functions, parameterizable	
• Freely usable digital input	Yes
• HW enable for digital output	Yes
Input voltage	
• Type of input voltage	DC
• Rated value (DC)	24 V
• for signal "0"	-5 ... +5 V
• for signal "1"	+11 to +30V
• permissible voltage at input, min.	-30 V; -5 V continuous, -30 V brief reverse polarity protection
• permissible voltage at input, max.	30 V
Input current	
• for signal "1", typ.	2.5 mA
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes; none / 0.05 / 0.1 / 0.4 / 0.8 / 1.6 / 3.2 / 12.8 / 20 ms
– at "0" to "1", min.	4 µs; for parameterization "none"
– at "1" to "0", min.	4 µs; for parameterization "none"
Digital outputs	
Type of digital output	P- and M-switching
Number of digital outputs	2; 1 per channel
Current-sinking	Yes
Current-sourcing	Yes
Short-circuit protection	Yes; electronic/thermal
• Response threshold, typ.	6.8 A with Standard output, 2 A with High Speed output
Limitation of inductive shutdown voltage to	-0.8 V
Controlling a digital input	Yes
Accuracy of pulse duration	±100 ppm ±0.5 µs with High Speed output, ±100 ppm ±9 µs with Standard output
minimum pulse duration	1.5 µs; With High Speed output, 10 µs with Standard output

Article number	6ES7138-6DB00-0BB1
Digital output functions, parameterizable	
• Freely usable digital output	Yes
• PWM output	Yes
– Number, max.	2; 1 per channel
– Cycle duration, parameterizable	Yes; Max. 85 s
– ON period, min.	0 %
– ON period, max.	100 %
– Resolution of the duty cycle	0.0036 %; For S7 analog format, min. 20 ns
• Connection of a proportional valve	Yes
• Dithering	Yes
– Frequency adjustable	Yes
– Amplitude adjustable	Yes
• Current measurement	Yes
• Current control	Yes
• Connection of a DC motor	Yes
• ON-delay	Yes
• OFF-delay	Yes
• Frequency output	Yes
• Pulse train	Yes
• Pulse output	Yes
Switching capacity of the outputs	
• with resistive load, max.	2 A
• on lamp load, max.	10 W; 1 W with High Speed output
Load resistance range	
• lower limit	12 Ω; 240 ohm with High Speed output
• upper limit	12 kΩ
Output voltage	
• Type of output voltage	DC
• for signal "0", max.	1 V
• for signal "1", min.	23.2 V; L+ (-0.8 V)
Output current	
• for signal "1" rated value	2 A; 0.1 A with High Speed output, observe derating
Output delay with resistive load	
• "0" to "1", typ.	0 µs; With High Speed output, 4.5 µs with Standard output
• "0" to "1", max.	0.8 µs; With High Speed output, 9 µs with Standard output
• "1" to "0", typ.	0 µs; With High Speed output, 4.5 µs with Standard output

Article number	6ES7138-6DB00-0BB1
• "1" to "0", max.	0.8 µs; With High Speed output, 9 µs with Standard output
Parallel switching of two outputs	
• for uprating	Yes
Switching frequency	
• with resistive load, max.	100 kHz; With High Speed output, 10 kHz with standard output
• with inductive load, max.	100 kHz; With High Speed output, 10 kHz with standard output
• on lamp load, max.	10 Hz
Total current of the outputs	
• Current per channel, max.	2 A
• Current per group, max.	4 A
• Current per module, max.	4 A
Isochronous mode	
Isochronous operation (application synchronized up to terminal)	Yes
Bus cycle time (TDP), min.	250 µs; with 1 channel configuration, 375 µs with 2 channel configuration
Jitter, max.	1 µs; typically ±
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes; Parameterizable
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Short-circuit	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
Isolation	
Isolation tested with	707 V DC (type test)

Article number	6ES7138-6DB00-0BB1
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C; Observe derating
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C; Observe derating
Decentralized operation	
to SIMATIC S7-300	Yes
to SIMATIC S7-400	Yes
to SIMATIC S7-1200	Yes
to SIMATIC S7-1500	Yes
to standard PROFIBUS master	Yes
to standard PROFINET controller	Yes
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	50 g

Derating information for total current of outputs

If the digital outputs of the module are operated with resistive or inductive loads, you should derate the total current of the loads at the digital outputs of the technology module. The total current is the sum of the load currents at all digital outputs of the module (without sensor supply).

The derating specifications for one-channel operation (parallel connection) are twice the derating specifications for two-channel operation.

The following derating curve shows the load capacity of the digital outputs in two-channel operation depending on the ambient temperature and the frequency:

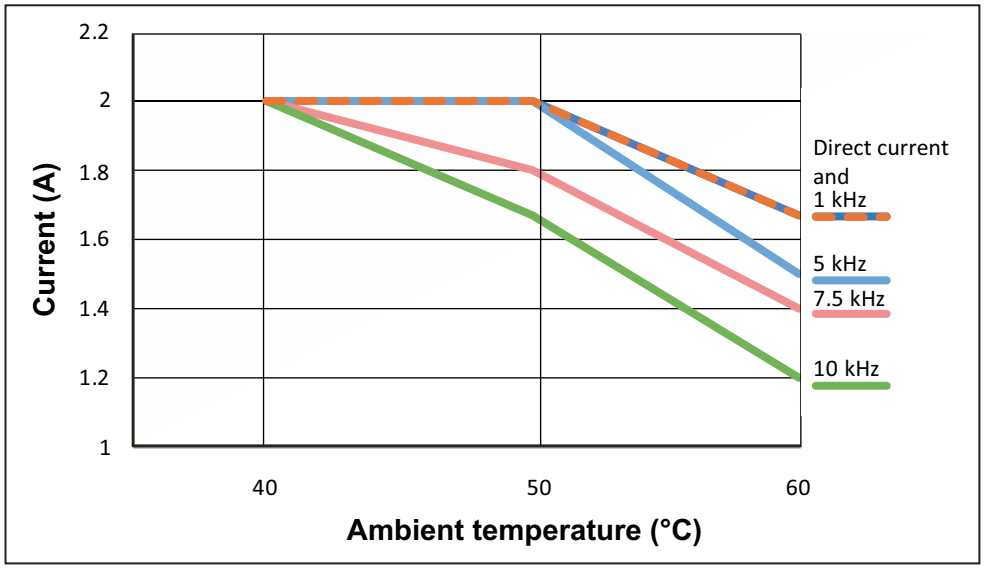

Figure 2-1111 Total current depending on the ambient temperature with direct current and a duty cycle of 90% (horizontal installation of the system)

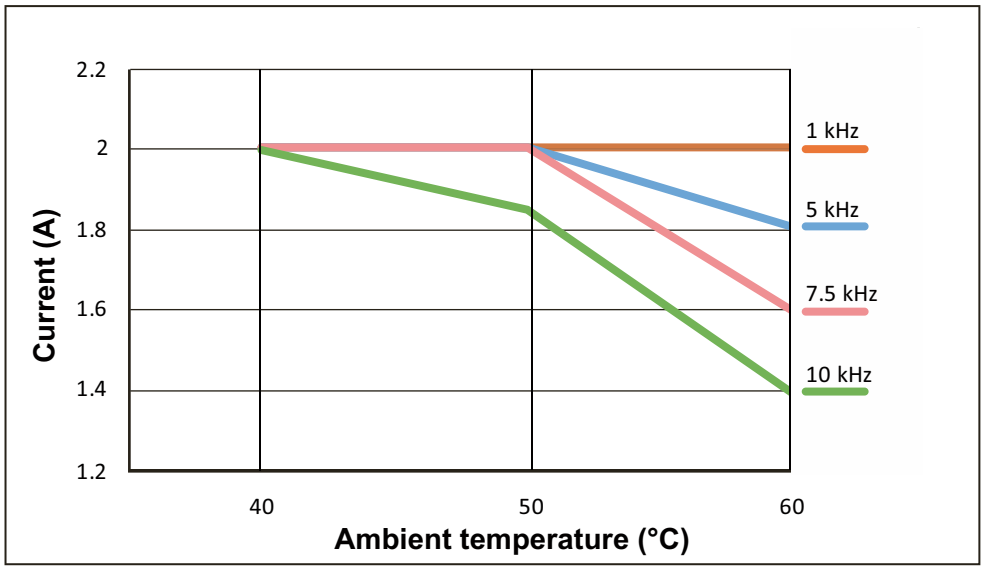

Figure 2-1112 Total current depending on the ambient temperature with a duty cycle of 50% (horizontal installation of the system)

The derating curves for a vertical installation of the system are shifted by 10 °C to the left.

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

Parameter data record

A

A.1 Parameter assignment and structure of the parameter data record

You have the option of reassigning module parameters with the user program while the CPU is in RUN. The parameters are transferred to the module using data record 128, for example with the WRREC instruction.

If errors occur during the transfer or validation of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. A corresponding error code is then written to the STATUS output parameter. If no errors occur, the STATUS output parameter contains the length of the actually transferred data.

The description of the WRREC instruction and the error codes is available in section Parameter validation errors (Page 139) or in the online help of STEP 7 (TIA Portal). A library of PLC data types (LPD) for STEP 7 (TIA Portal) and SIMATIC S7-1200 / S7-1500 is available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109482396).

Structure of data record 128

The following tables show you the structure of data record 128 for TM Pulse 2x24V per operating mode. The values in byte 0 to byte 3 are fixed and must not be changed.

In two-channel mode you use byte 0 to byte 107. In one-channel operation (parallel connection), use byte 0 to byte 55.

Table 2-1283 Parameter data record 128 in the "Pulse output" mode

Bit → / Byte channel 0/1 ↓	7	6	5	4	3	2	1	0
0...3	**Header**							
0	Major Version = 0				Minor Version = 1			
1	Length of parameter data per channel = 52							
2	Reserved[2]							
3								
4...55	**Channel 0**							
56...107	**Channel 1**							
4/56	Reserved[2]			High-speed output (0.1 A)[1]	Operating mode:			
					0000_B: Pulse output			
					0001_B: Pulse width modulation PWM			
					0010_B: Pulse train			
					0011_B: On/Off delay			

1 You enable the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

Bit → / Byte channel 0/1 ↓	7	6	5	4	3	2	1	0
4/56	Reserved[2]			High-speed output (0.1 A)[1]	0100_B: Frequency output			
					0101_B: PWM with DC motor			
					0101 to 1111_B: Invalid			
5/57	Reserved[2]					Group diagnostics[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Reserved	
							10_B: Continue operation	
							11_B: Reserved	
6/58	Reserved[2]		Input delay:				Function DI:	
			0000_B: None				00_B: Input	
			0001_B: 0.05 ms				01_B: HW enable	
			0010_B: 0.1 ms				10 to 11_B: Invalid	
			0011_B: 0.4 ms					
			0100_B: 0.8 ms					
			0101_B: 1.6 ms					
			0110_B: 3.2 ms					
			0111_B: 12.8 ms					
			1000_B: 20 ms					
			1001 to 1111_B: Invalid					
7/59	Reserved[2]				Diagnostics DQB[1]	Diagnostics DQA[1]	Substitute value for DQB	Substitute value for DQA
8...55/ 60...107	**Values**							
8...15/ 60...67	Reserved[2]							
16...19/ 68...71	On delay: UDINT: Value range in µs: 0 to 85000000_D or 0 to $510FF40_H$							
20...55/ 72...107	Reserved[2]							

1 You enable the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

Table 2-1284 Parameter data record 128 in the operating mode "Pulse width modulation PWM"

Bit → / Byte channel 0/1 ↓	7	6	5	4	3	2	1	0
0...3	**Header**							
0	Major Version = 0				Minor Version = 1			
1	Length of parameter data per channel = 52							
2	Reserved[2]							

1 You enable the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

Bit → / Byte channel 0/1 ↓	7	6	5	4	3	2	1	0
3								
4...55	**Channel 0**							
56...107	**Channel 1**							
4/56	Current control[1]	Dithering[1]	Reserved[2]	High-speed output (0.1 A)[1]	Operating mode:			
					0000_B: Pulse output			
					0001_B: Pulse width modulation PWM			
					0010_B: Pulse train			
					0011_B: On/Off delay			
					0100_B: Frequency output			
					0101_B: PWM with DC motor			
					0101 to 1111_B: Invalid			
5/57	Enable proportional action[1]	Enable integral action[1]	Enable derivative action[1]	Reserved[2]		Group diagnostics[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Reserved	
							10_B: Continue operation	
							11_B: Reserved	
6/58	Reserved[2]		Input delay:				Function DI:	
			0000_B: None				00_B: Input	
			0001_B: 0.05 ms				01_B: HW enable	
			0010_B: 0.1 ms				10 to 11_B: Invalid	
			0011_B: 0.4 ms					
			0100_B: 0.8 ms					
			0101_B: 1.6 ms					
			0110_B: 3.2 ms					
			0111_B: 12.8 ms					
			1000_B: 20 ms					
			1001 to 1111_B: Invalid					
7/59	Reserved[2]		Output format:		Diagnostics DQB[1]	Diagnostics DQA[1]	Substitute value for DQB	Substitute value for DQA
			00_B: S7 analog output					
			01_B: 1/100					
			10_B: 1/1000					
			11_B: 1/10000					
8...55/ 60...107	**Values**							
8...11/ 60...63	Minimum pulse duration: UDINT: Value range in µs: 0 to 85000000_D or 0 to $510FF40_H$							
12...15/ 64...67	Period duration: UDINT: Value range in µs: 10 to 85000000_D or A to $510FF40_H$							
16...19/ 68...71	On delay: UDINT: Value range in µs: 0 to 85000000_D or 0 to $510FF40_H$							
20...21/ 72...73	Incline of dithering ramp down: INT: Value range in ms: 0 to 30000_D or 0 to 7530_H							

1 You enable the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

Bit → / Byte channel 0/1 ↓	7	6	5	4	3	2	1	0
22...23/ 74...75	Incline of dithering ramp up: INT: Value range in ms: 0 to 30000_D or 0 to 7530_H							
24...27/ 76...79	Dithering amplitude: UDINT: Value range in ‰: 0 to 500_D or 0 to $1F4_H$							
28...31/ 80...83	Dithering period duration: UDINT: Value range in µs: 2000 to 100000_D or 0 to $186A0_H$							
32...33/ 84...85	Reference value current: Two-channel operation: INT: Value range in mA: 0 to 2000_D or 0 to $7D0_H$ One-channel operation: INT: Value range in mA: 0 to 4000_D or 0 to $FA0_H$							
34...35/ 86...87	Dead band width: INT: Value range in µA: 0 to 65535_D or 0 to $FFFF_H$							
36...37/ 88...89	Manipulated value high limit: INT: Value range in µA: 1 to 27648_D or 1 to $6C00_H$							
38...39/ 90...91	Manipulated value low limit: INT: Value range in µA: 0 to 27647_D or 0 to $6BFF_H$							
40...43/ 92...95	Proportional gain: REAL: Floating-point number							
44...47/ 96...99	Integration time: REAL: Floating-point number in s							
48...51/ 100... 103	Derivative action time: REAL: Floating-point number in s							
52...55/ 104... 107	Delay time of derivative action: REAL: Floating-point number in s							

1 You enable the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

Table 2-1285 Parameter data record 128 in the "Pulse train" mode

Bit → / Byte channel 0/1 ↓	7	6	5	4	3	2	1	0
0...3	**Header**							
0	Major Version = 0				Minor Version = 1			
1	Length of parameter data per channel = 52							
2	Reserved[2]							
3								
4...55	**Channel 0**							
56...107	**Channel 1**							
4/56	Reserved[2]			High-speed output (0.1 A)[1]	Operating mode:			
					0000_B: Pulse output			
					0001_B: Pulse width modulation PWM			

1 You enable the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

Bit → / Byte channel 0/1 ↓	7	6	5	4	3	2	1	0
4/56	Reserved[2]			High-speed output (0.1 A)[1]	0010_B: Pulse train			
					0011_B: On/Off delay			
					0100_B: Frequency output			
					0101_B: PWM with DC motor			
					0101 to 1111_B: Invalid			
5/57	Reserved[2]					Group diagnostics[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Reserved	
							10_B: Continue operation	
							11_B: Reserved	
6/58	Reserved[2]		Input delay:				Function DI:	
			0000_B: None				00_B: Input	
			0001_B: 0.05 ms				01_B: HW enable	
			0010_B: 0.1 ms				10 to 11_B: Invalid	
			0011_B: 0.4 ms					
			0100_B: 0.8 ms					
			0101_B: 1.6 ms					
			0110_B: 3.2 ms					
			0111_B: 12.8 ms					
			1000_B: 20 ms					
			1001 to 1111_B: Invalid					
7/59	Reserved[2]		Output format:		Diagnostics DQB[1]	Diagnostics DQA[1]	Substitute value for DQB	Substitute value for DQA
			00_B: S7 analog output					
			01_B: 1/100					
			10_B: 1/1000					
			11_B: 1/10000					
8...55/ 60...107	**Values**							
8...11/ 60...63	Reserved[2]							
12...15/ 64...67	Period duration: UDINT: Value range in µs: 10 to 85000000_D or A to $510FF40_H$							
16...19/ 68...71	On delay: UDINT: Value range in µs: 0 to 85000000_D or 0 to $510FF40_H$							
20...23/ 72...75	Duty cycle: UDINT: Value range in %: 1 to 27648_D or 1 to $6C00_H$							
24...55/ 76...107	Reserved[2]							

1 You enable the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

Table 2-1286 Parameter data record 128 in "On/Off delay" mode

Bit → / Byte channel 0/1 ↓	7	6	5	4	3	2	1	0
0...3	**Header**							
0	Major Version = 0				Minor Version = 1			
1	Length of parameter data per channel = 52							
2	Reserved[2]							
3								
4...55	**Channel 0**							
56...107	**Channel 1**							
4/56	Reserved[2]			High-speed output (0.1 A)[1]	Operating mode:			
					0000_B: Pulse output			
					0001_B: Pulse width modulation PWM			
					0010_B: Pulse train			
					0011_B: On/Off delay			
					0100_B: Frequency output			
					0101_B: PWM with DC motor			
					0101 to 1111_B: Invalid			
5/57	Reserved[2]					Group diagnostics[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Reserved	
							10_B: Continue operation	
							11_B: Reserved	
6/58	Reserved[2]		Input delay:				Function DI:	
			0000_B: None				00_B: Input	
			0001_B: 0.05 ms				01 to 11_B: Invalid	
			0010_B: 0.1 ms					
			0011_B: 0.4 ms					
			0100_B: 0.8 ms					
			0101_B: 1.6 ms					
			0110_B: 3.2 ms					
			0111_B: 12.8 ms					
			1000_B: 20 ms					
			1001 to 1111_B: Invalid					
7/59	Reserved[2]				Diagnostics DQB[1]	Diagnostics DQA[1]	Substitute value for DQB	Substitute value for DQA
8...55/ 60...107	**Values**							

1 You enable the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

Bit → / Byte channel 0/1 ↓	7	6	5	4	3	2	1	0
8...19/ 60...71	Reserved[2]							
20...23/ 72...75	Off delay: UDINT: Value range in µs: 0 to 85000000_D or 0 to $510FF40_H$							
24...55/ 76...107	Reserved[2]							

1 You enable the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

Table 2-1287 Parameter data record 128 in the "Frequency output" mode

Bit → / Byte channel 0/1 ↓	7	6	5	4	3	2	1	0
0...3	**Header**							
0	Major Version = 0				Minor Version = 1			
1	Length of parameter data per channel = 52							
2	Reserved[2]							
3								
4...55	**Channel 0**							
56...107	**Channel 1**							
4/56	Reserved[2]			High-speed output (0.1 A)[1]	Operating mode:			
					0000_B: Pulse output			
					0001_B: Pulse width modulation PWM			
					0010_B: Pulse train			
					0011_B: On/Off delay			
					0100_B: Frequency output			
					0101_B: PWM with DC motor			
					0101 to 1111_B: Invalid			
5/57	Reserved[2]					Group diagnostics[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Reserved	
							10_B: Continue operation	
							11_B: Reserved	
6/58	Reserved[2]		Input delay:				Function DI:	
			0000_B: None				00_B: Input	
			0001_B: 0.05 ms				01_B: HW enable	
			0010_B: 0.1 ms				10 to 11_B: Invalid	
			0011_B: 0.4 ms					
			0100_B: 0.8 ms					

1 You enable the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

Bit → / Byte channel 0/1 ↓	7	6	5	4	3	2	1	0
6/58	Reserved[2]		0101_B: 1.6 ms				10 to 11_B: Invalid	
			0110_B: 3.2 ms					
			0111_B: 12.8 ms					
			1000_B: 20 ms					
			1001 to 1111_B: Invalid					
7/59	Reserved[2]		Output format:		Diagnostics DQB[1]	Diagnostics DQA[1]	Substitute value for DQB	Substitute value for DQA
			00_B: Invalid					
			01_B: 1 Hz					
			10 to 11_B: Invalid					
8...55/ 60...107	**Values**							
8...15/ 60...67	Reserved[2]							
16...19/ 68...71	On delay: UDINT: Value range in µs: 0 to 85000000_D or 0 to $510FF40_H$							
20...55/ 72...107	Reserved[2]							

1 You enable the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

Table 2-1288 Parameters data record 128 in "PWM with DC motor" mode

Bit → / Byte channel 0/1 ↓	7	6	5	4	3	2	1	0
0...3	**Header**							
0	Major Version = 0				Minor Version = 1			
1	Length of parameter data per channel = 52							
2	Reserved[2]							
3								
4...55	**Channel 0**							
56...107	**Channel 1**							
4/56	Reserved[2]				Operating mode:			
					0000_B: Pulse output			
					0001_B: Pulse width modulation PWM			
					0010_B: Pulse train			
					0011_B: On/Off delay			
					0100_B: Frequency output			
					0101_B: PWM with DC motor			
					0101 to 1111_B: Invalid			

1 You enable the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

Bit → / Byte channel 0/1 ↓	7	6	5	4	3	2	1	0
5/57	Reserved[2]					Group diagnostics[1]	Reaction to CPU STOP:	
							00_B: Output substitute value	
							01_B: Reserved	
							10_B: Continue operation	
							11_B: Reserved	
6/58	Reserved[2]		Input delay:				Function DI:	
			0000_B: None				00_B: Input	
			0001_B: 0.05 ms				01_B: HW enable	
			0010_B: 0.1 ms				10_B: Limit switch	
			0011_B: 0.4 ms				11_B: Invalid	
			0100_B: 0.8 ms					
			0101_B: 1.6 ms					
			0110_B: 3.2 ms					
			0111_B: 12.8 ms					
			1000_B: 20 ms					
			1001 to 1111_B: Invalid					
7/59	Reserved[2]		Output format:		Diagnostics DQB[1]	Diagnostics DQA[1]	Substitute value for DQB	Substitute value for DQA
			00_B: S7 analog output					
			01 to 11_B: Invalid					
8...55/ 60...107	**Values**							
8...11/ 60...63	Reserved[2]							
12...15/ 64...67	Period duration: UDINT: Value range in µs: 100 to 85000000_D or 64 to $510FF40_H$							
16...19/ 68...71	On delay: UDINT: Value range in µs: 0 to 85000000_D or 0 to $510FF40_H$							
20...55/ 72...107	Reserved[2]							

1 You enable the respective parameter by setting the associated bit to 1.

2 Reserved bits must be set to 0.

A.2 Parameter validation errors

If you make the parameter settings in STEP 7 (TIA Portal) or in STEP 7 , the parameter values are checked before they are transferred to the technology module. This process prevents parameter errors.

In other use cases, the technology module checks the transferred parameter data record. If the technology module finds invalid or inconsistent parameter values, it outputs an error code (see below). The new parameter data record is rejected in this case, and work continues with the current parameter values until a valid parameter data record has been transferred.

WRREC

When the CPU is in the operating state RUN, you can change the parameter data record with the instruction WRREC (Write Record). In case of errors, the WRREC instruction returns corresponding error codes in the STATUS parameter.

Example:

Let us assume that an invalid value, for example 9, is written to the module for the operating mode with WRREC. As a consequence, the module rejects the entire parameter data record. You can recognize this by evaluating the STATUS output parameter of the WRREC instruction. The STATUS output parameter is output as an ARRAY[1..4] of BYTE data with the value 16#DF80E111:

Example of WRREC STATUS data	Address	Meaning
DF_H	STATUS[1]	Error when writing a data record via PROFINET IO (IEC 61158-6)
80_H	STATUS[2]	Error when reading or writing a data record via PROFINET IO (IEC 61158-6)
$E1_H$	STATUS[3]	Module-specific error
11_H	STATUS[4]	Error code from the table below: The "Operating mode" parameter has an invalid value.

Error codes

The following table shows the module-specific error codes and their meaning for parameter data record 128.

Table 2-1289 Error codes for parameter validation

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	B0	00	Data record number unknown	Enter valid number for data record.
DF	80	B1	01	Length of data record incorrect	Enter valid value for data record length.
DF	80	B2	00	Slot invalid or not available	• Check whether module is inserted or removed. • Check assigned values for parameters of the WRREC instruction.
DF	80	E0	01	Wrong version	• Check byte 0. • Enter valid values.
DF	80	E0	02	Error in the header information	• Check byte 1. • Correct the length of parameter blocks.
DF	80	E1	00	Parameter invalid: No detailed information available	Check all parameter values.
DF	80	E1	11	"Operating mode" parameter invalid	Enter valid parameter value.
DF	80	E1	12	"Reaction to CPU STOP" parameter invalid	Enter valid parameter value.
DF	80	E1	18	"Set function of DI" parameter configured the same for DI0 and DI1.	Enter different parameter values for DI0 and DI1.

Error code in STATUS parameter (hexadecimal)				Meaning	Solution
Byte 0	Byte 1	Byte 2	Byte 3		
DF	80	E1	19	• "Edge selection" parameter invalid • "Gate start (edge-triggered)" configured as function for DIm and "At rising and falling edge" • "Gate stop (edge-triggered)" configured as function for DIm and "At rising and falling edge" • "Synchronization" configured as function for DIm and "At rising and falling edge"	• Enter valid parameter value. • Configure "Gate start (edge-triggered)" as function for DIm only together with "At rising edge" or "At falling edge" • Configure "Gate stop (edge-triggered)" as function for DIm only together with "At rising edge" or "At falling edge" • Configure "Synchronization" as function for DIm only together with "At rising edge" or "At falling edge"
DF	80	E1	1A	"Input delay" parameter invalid	Enter valid parameter value.
DF	80	E1	1B	Value above the high limit of the parameter "Period duration"	Enter a parameter value of maximum 85000000_D.
DF	80	E1	1C	Value above high limit of parameter "On delay"	Enter a parameter value of maximum 85000000_D.
DF	80	E1	1D	Value above high limit of parameter "Minimum pulse duration"	Enter a parameter value of maximum 85000000_D.
DF	80	E1	1E	Value above high limit of parameter "Off delay"	Enter a parameter value of maximum 85000000_D.
DF	80	E1	20	Value above high limit of parameter "Reference value current"	Two-channel operation: Enter parameter value of maximum 2000_D. One-channel operation: Enter a parameter value of maximum 4000_D.
DF	80	E1	21	Value below low limit of the parameter "Period duration"	Without High-speed output: Enter a parameter value of at least 100_D. With high-speed output: Enter a parameter value of at least 10_D.
DF	80	E1	22	"Dithering" activated, although "Pulse width modulation PWM" mode is not configured	Disable "Dithering"
DF	80	E1	23	"High-speed output (0.1 A)" enabled in the "PWM with DC motor" mode or in one-channel operation	Disable "High-speed output (0.1 A)"
DF	80	E1	24	"Current control" activated, even though "Pulse width modulation PWM" mode is not configured	Deactivate "Current control"
DF	80	E1	25	"High-speed output (0.1 A)" and "Current control" enabled in "Pulse width modulation PWM" mode	Disable "High-speed output (0.1 A)" or "Current control"
DF	80	E1	26	"HW enable" for DIn.0 configured in "On/Off delay" mode	In the "On/Off delay" mode, do not configure "HW enable"
DF	80	E1	27	Manipulated value low limit >= Manipulated value high limit	Manipulated value low limit < Manipulated value high limit
DF	80	E1	28	• Dithering period duration < 4 × PWM period duration • Dithering period duration < 2 ms	• Dithering period duration >= 4 × PWM period duration • Dithering period duration > 2 ms
DF	80	E1	29	"1" is configured for both substitute values (DQn.A and DQn.B).	Only configure "1" for DQn.A or DQn.B.
DF	80	E1	F0	Reserved bit is not set to 0.	Set reserved bit to 0.

Flow chart: Handling of the SLOT parameters

B

The following figure shows a flow chart for the handling of the SLOT parameters with a one-time change (MODE_SLOT = 0).

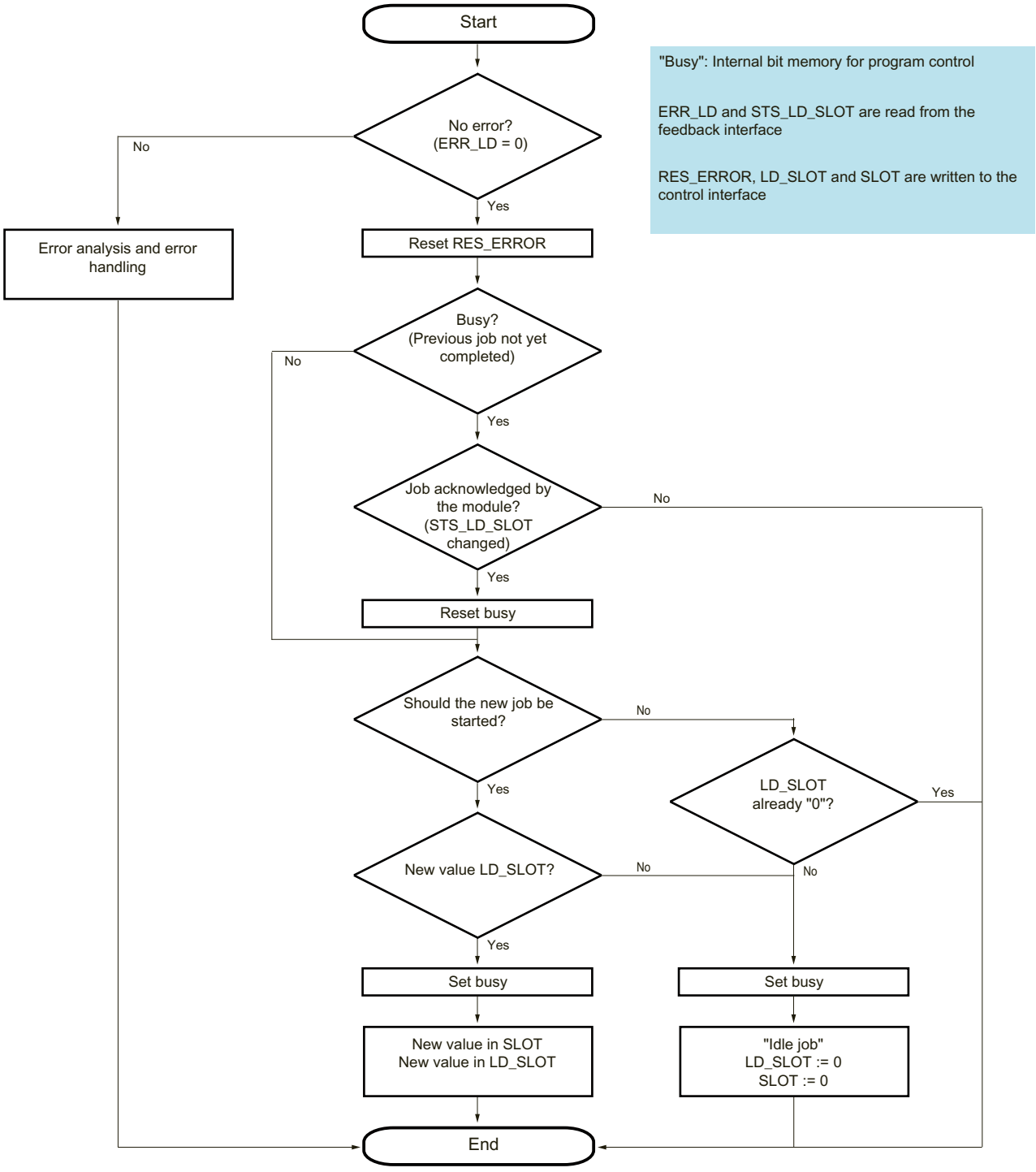

Figure 2-1113 **Flow chart for one-time change (MODE_SLOT = 0)**

SIEMENS

Weighing systems

Electronic weighing system SIMATIC ET 200SP SIWAREX technology module TM WP321 1x5VDC#1-4mV/V ST

Operating Instructions

7MH4138-6AA00-0BA0

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Introduction 1

1.1 Purpose of this documentation

These instructions contain all information required to commission and use the device. Read the instructions carefully prior to installation and commissioning. In order to use the device correctly, first review its principle of operation.

The instructions are aimed at persons mechanically installing the device, connecting it electronically, configuring the parameters and commissioning it, as well as service and maintenance engineers.

1.2 Use in hazardous area

⚠ WARNING

Use in hazardous area

Risk of explosion.

- Only use equipment that is approved for use in the intended hazardous area and labeled accordingly.
- Do not use devices that have been operated outside the conditions specified for hazardous areas. If you have used the device outside the conditions for hazardous areas, make all Ex markings unrecognizable on the nameplate.

⚠ WARNING

Incorrect installation

Risk of explosion in the hazardous area. For use in hazardous areas according to Class I, Division 2 or Class I, Zone 2 or for use in the EU according to ATEX 2014/34/EU, observe the following conditions:

- Install the device in a control cabinet or enclosure.
- The control cabinet or enclosure meets at least the requirements of IP54 according to IEC/EN 60079-7 and pollution degree 2 or better according to IEC/EN 60664-1.

⚠ WARNING

If the device is installed in a cabinet, the inner temperature of the cabinet corresponds to the ambient temperature of the device.

WARNING

Opening the device

DO NOT OPEN WHEN ENERGIZED.

WARNING

Replacing components

EXPLOSION HAZARD

SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2 OR ZONE 2.

WARNING

Impermissible repair of the device

- Repair must be carried out by Siemens authorized personnel only.

CAUTION

To prevent injury and damage, read the manual before using the device.

1.3 Document history

The most important changes in the documentation when compared with the respective previous edition are given in the following table.

Manual edition	Note
09/2021	Sec. AUTOHOTSPOT revised
10/2019	Min. value for adjustment weight parameter corrected

1.4 Product compatibility

The following table describes compatibility between manual edition, device revision, and the engineering system.

Manual edition	Comment	Device revision	Engineering system
09/2021	New characteristics	FW: 1.4.0 HW: FS 1 or higher	STEP 7 TIA Portal V15.1 or higher
10/2019	New characteristics	FW: 1.4.0 HW: FS 1 or higher	STEP 7 TIA Portal V15.1 or higher

1.5 Checking the consignment

1. Check the packaging and the delivered items for visible damages.
2. Report any claims for damages immediately to the shipping company.
3. Retain damaged parts for clarification.
4. Check the scope of delivery by comparing your order to the shipping documents for correctness and completeness.

⚠ WARNING

Using a damaged or incomplete device

Risk of explosion in hazardous areas.

– Do not use damaged or incomplete devices.

1.6 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

1.7 Transportation and storage

To guarantee sufficient protection during transport and storage, observe the following:

- Keep the original packaging for subsequent transportation.
- Devices/replacement parts should be returned in their original packaging.
- If the original packaging is no longer available, ensure that all shipments are properly packaged to provide sufficient protection during transport. Siemens cannot assume liability for any costs associated with transportation damages.

NOTICE
Insufficient protection during storage The packaging only provides limited protection against moisture and infiltration. – Provide additional packaging as necessary.

Special conditions for storage and transportation of the device are listed in Technical data (Page 119).

1.8 Notes on warranty

The contents of this manual shall not become part of or modify any prior or existing agreement, commitment or legal relationship. The sales contract contains all obligations on the part of Siemens as well as the complete and solely applicable warranty conditions. Any statements regarding device versions described in the manual do not create new warranties or modify the existing warranty.

The content reflects the technical status at the time of publishing. Siemens reserves the right to make technical changes in the course of further development.

1.9 Basic knowledge required

Knowledge of weighing technology as well as general knowledge of the SIMATIC system including the TIA Portal are necessary in order to understand the manual.

Safety notes 2

2.1 General safety instructions

WARNING

Non-compliance with warning notes or non-qualified handling of the system

Failure to observe the warning notes or handling of the device/system by non-qualified personnel can result in serious injury or damage to property. This means only qualified personnel are permitted to handle this device/system.

WARNING

Permission for installation in machines

Start-up/commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed fulfills the regulations/specifications of Machinery Directive 89/392/EEC.

NOTE

The specifications of the manual for the SIMATIC ET 200SP system apply for configuration, installation and commissioning in the SIMATIC environment. This chapter includes additional information on hardware configuration, installation and preparation for operation of the SIWAREX WP321.

The safety notes must be observed.

NOTE

The device was developed, manufactured, tested and documented in compliance with the relevant safety standards. The device does usually not pose any risks of material damage or personal injury.

Safety notices when using the device according to Hazardous Locations (HazLoc)

If you use the device under HazLoc conditions you must also keep to the following safety notices in addition to the general safety notices for protection against explosion:

This equipment is suitable for use in Class I, Zone 2, Group IIC or non-hazardous locations only.

This equipment is suitable for use in Class I, Division 2, Groups A, B, C and D or non-hazardous locations only.

Description

3

3.1 Product overview

SIWAREX WP321 is a versatile and flexible weighing module that can be operated as a static weighing instrument.

The electronic weighing system can be used in SIMATIC ET 200SP and uses all features of a modern automation system, such as integrated communication, operation and monitoring, the diagnostics system as well as the configuration tools in the TIA Portal or SIMATIC STEP, WinCC flexible and PCS7.

3.2 Area of application

The electronic weighing system described here is the perfect solution for applications in which signals from weighing or force sensors are acquired and processed. The SIWAREX WP321 is a very accurate electronic weighing system with high measuring speed.

It can be used in almost all industrial weighing applications not requiring official calibration. Use in potentially explosive atmospheres (with Ex interface SIWAREX IS) it's also possible.

3.3 System integration in SIMATIC

The electronic weighing system described here is a technology module for SIMATIC ET 200SP. It can be used as desired in the configuration of the automation solution, including the weighing application. You can create optimal solutions for small and medium-sized plants by combining the suitable SIMATIC modules. You can create customized or industry-specific solutions in no time with the help of the configuration package available under the "Ready for use" application for SIMATIC.

Solutions are possible with S7-300, S7-400, S7-1200 as well as S7-1500 CPUs. TIA Portal, Step 7 Classic or PCS7 can be used as the configuration software.

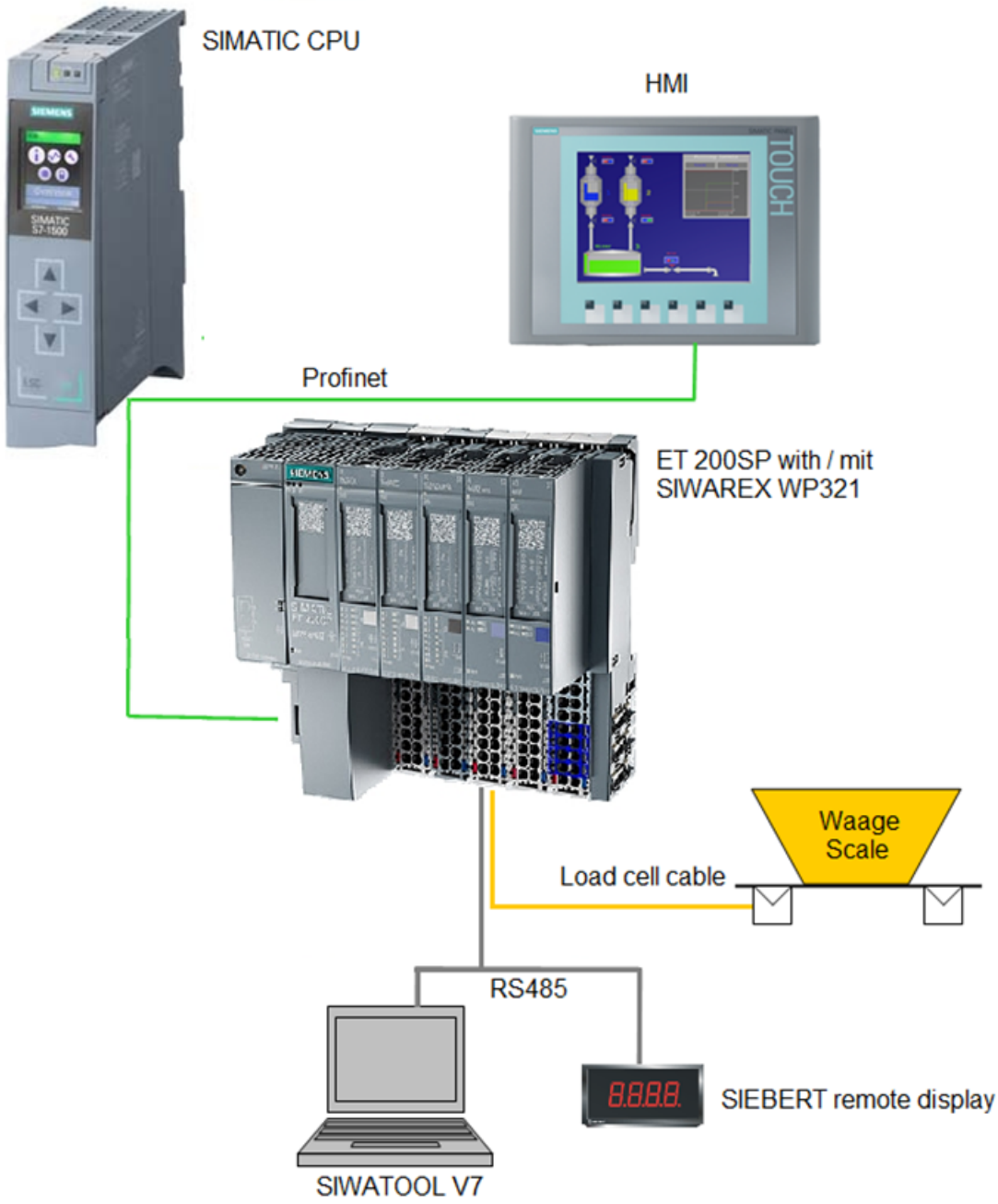

Figure 2-1114 System overview

3.4 Customer benefits

The electronic weighing system described here is characterized by decisive advantages:

- Uniform design technology and consistent communication in SIMATIC ET 200SP
- Parameter assignment by means of an operator panel, STEP7 user program or PC
- Uniform configuration option in the SIMATIC TIA Portal, SIMATIC STEP7 or PCS7
- Measuring of weight with a resolution of up to +/- 2 million parts
- High accuracy 0.05%
- High measuring rate of 100/120/600 Hz
- Limit monitoring
- Flexible adaptation to varying requirements
- Easy calibration of the scales using the SIWATOOL program
- Automatic calibration is possible without the need for calibration weights
- Module replacement is possible without recalibrating the scales
- Use in Ex Zone 2 / ATEX approval
- Intrinsically safe load cell supply for Ex Zone 1 (SIWAREX IS option)
- Diagnostics functions

Application planning

4

4.1 Functions

The primary task of the electronic weighing system is the measurement and registration of the current weight value. The integration in SIMATIC gives you the option to process the weight value directly in the PLC (**P**rogrammabel**L**ogic **C**ontroller).

The SIWAREX WP321 is calibrated at the factory. This allows for automatic calibration of the scale without the need for calibration weights and replacement of modules without the need for recalibrating the scale.

A PC for setting the parameters of the electronic weighing system can be connected via the RS485 interface.

The SIWAREX WP321 electronic weighing system can also be used in potentially explosive atmospheres (Zone 2). The load cells are supplied intrinsically safe in Zone 1 applications when you use the optional Ex interface SIWAREX IS.

4.2 Parameter assignment options

4.2.1 Parameter assignment with the PC

You can set the scale parameters with the convenience of the familiar Windows interface by using the "SIWATOOL" PC parameter assignment software.

You can use the program for commissioning the scale without any knowledge of automation technology. When servicing is required, you can analyze and test the processes in the scale independently of the automation system or Operator Panel with the help of the PC. You can read out the diagnostic buffer from the SIWAREX module to assist you in the event analysis.

The figure below illustrates the structure of the individual program windows.

Figure 2-1115 SIWATOOL overview

SIWATOOL does not only offer support when you set the scale but also when you analyze the diagnostic buffer that can be saved after being read out of the module together with the parameters. The display of the current scale status can be configured.

You can switch between several languages in the program.

You require an RS485/USB converter (see Ordering data (Page 124)).

4.2.2 Parameter assignment with the SIMATIC Panel

SIWAREX WP321 parameters can be assigned using a SIMATIC Panel connected to the SIMATIC CPU. The "Ready-for-use" application software is used for this.

Mounting 5

5.1 Basic safety notes

5.1.1 UL/FM Special conditions for use

Safety notices on use in hazardous areas

General safety notices relating to protection against explosion

⚠ WARNING
EXPLOSION HAZARD Replacing components may impair suitability for Class 1, Division 2 or Zone 2.

⚠ WARNING
Substitution of components may impair suitability of the equipment.

5.1.1.1 Safety information according to FM and UL

Safety information for use according to FM and UL

If you use the device under FM conditions you must also keep to the following safety notices in addition to the general safety notices for protection against explosion:

⚠ WARNING
Substitution of components may impair suitability for Division 2.

⚠ WARNING
Do not remove or replace while circuit is live when a flammable or combustible atmosphere is present.

WARNING

Explosion hazard

Do not disconnect equipment when a flammable or combustible atmosphere is present.

WARNING

EXPLOSION HAZARD

The device is designed for operation in closed housing or control cabinet. The inner service temperature of the enclosure/control cabinet corresponds to the ambient temperature of the module. Use cables with a maximum permitted operating temperature of at least 20 °C higher than the maximum ambient temperature.

5.1.2 ATEX/IECx special conditions for use

WARNING

Incorrect installation

Risk of explosion in the hazardous area. For use in hazardous areas according to Class I, Division 2 or Class I, Zone 2 or for use in the EU according to ATEX 2014/34/EU, observe the following conditions:

- Install the device in a control cabinet or enclosure.
- The control cabinet or enclosure meets at least the requirements of IP54 according to IEC/EN 60079-7 and pollution degree 2 or better according to IEC/EN 60664-1.

NOTE

You must not install the device on a wall in hazardous areas.

WARNING

Transient overvoltages

Take measures to ensure that temporary transient overvoltages of more than 119 V do not occur.

5.1.3 Safety notices for installation

Safety notices

When installing the device, keep to the safety notices listed below.

WARNING

If a device is operated in an ambient temperature of more than 50 °C, the temperature of the device housing may be higher than 70 °C. The device must therefore be installed so that it is only accessible to service personnel or users that are aware of the reason for restricted access and the required safety measures at an ambient temperature higher than 50 °C.

WARNING

If the device is installed in a cabinet, the inner temperature of the cabinet corresponds to the ambient temperature of the device.

5.2 Installation guideline

When assembling the SIMATIC components together with the electronic weighing system described here, the setup, installation and wiring guidelines for the SIMATIC ET 200SP must be observed (see system manual "SIMATIC ET 200SP, ET 200SP distributed I/O system", order no.: A5E03576848).

This manual describes additional installation and wiring aspects specific to the electronic weighing system.

5.3 EMC-compliant setup

5.3.1 Introduction

The electronic weighing system described here was developed for use in industrial environments and complies with high EMC requirements. It ensures safe operation even in harsh environmental conditions. Nevertheless, you should still carry out EMC planning before installing your devices in order to determine any sources of interference and include them in your considerations.

EMC

EMC (electromagnetic compatibility) describes the capability of electrical equipment to operate without errors in a given electromagnetic environment, without being subject to external influence and without influencing external devices in any way.

5.3.2 Possible effects of interference

Electromagnetic interferences can influence the electronic weighing system described here in various ways:

- Electromagnetic fields having a direct influence on the system
- Interferences transported by communication cables
- Interferences having an effect via process cables
- Interferences entering the system via the power supply and/or protective ground

Interferences can impair the fault-free functioning of the electronic weighing system.

5.3.3 Coupling mechanisms

Depending on the propagation medium (conducted or non-conducted) and the distance between the interference source and the device, interferences can enter the faulty device through four different coupling mechanisms:

- Electrical coupling
- Capacitive coupling
- Inductive coupling
- Radiation coupling

5.3.4 Five basic rules for securing EMC

Observe these five basic rules to secure EMC.

Rule 1: Large area grounding contact

- When installing the devices, make sure that the surfaces of inactive metal parts are properly bonded to chassis ground (see following sections).
- Bond all inactive metal parts to chassis ground, ensuring large area and low-impedance contact (large cross-sections).
- Make screw connections on painted or anodized metal parts either with special contact washers or remove the insulating protective layers at the contact points.
- Wherever possible, avoid the use of aluminum parts for ground bonding. Aluminum oxidizes very easily and is therefore less suitable for ground bonding.
- Provide a central connection between chassis ground and the ground/protective conductor system.

Rule 2: Proper cable routing

- Organize your wiring system into cable groups (high-voltage/power supply/signal/measurement/data cables).
- Always route high-voltage and data cables in separate ducts or in separate bundles.
- Install the measurement cables as close as possible to grounded surfaces (e.g. supporting beans, metal rails, steel cabinet walls).

Rule 3: Fixing the cable shielding

- Ensure proper fixation of the cable shielding.
- Always use shielded data cables. Always connect both ends of the data cable shielding to ground on a large area.
- Keep unshielded cable ends as short as possible.
- Always use metal/metalized connector housings only for shielded data cables.
- To connect the signal cables, use the corresponding SIMATIC ET 200SP shield supports with order number 6ES7193-6SC00-1AM0.

Rule 4: Special EMC measures

- All inductors that are to be controlled should be connected with suppressors.
- For cabinet lighting in the immediate range of your controller, use interference suppressed fluorescent lamps.

Rule 5: Homogeneous reference potential

- Create a homogeneous reference potential and ground all electrical equipment.
- Use sufficiently dimensioned equipotential bonding conductors if potential differences exist or are expected between your system components. Equipotential bonding is absolutely mandatory for applications in hazardous areas.

5.4 Mounting on the SIMATIC ET 200SP

The electronic weighing system described here is a module of the SIMATIC ET 200SP series and can be directly connected to the automation system's bus system. The 15 mm wide module has very low installation and cabling requirements.

The module is snapped onto the ET 200SP base unit (BU). You must use base units of type A0 (→ Industry Mall (https://mallstage.industry.siemens.com/mall/en/b0/Catalog/Products/10229887?tree=CatalogTree)).

The load cells, power supply and serial interfaces are connected via the terminal box.

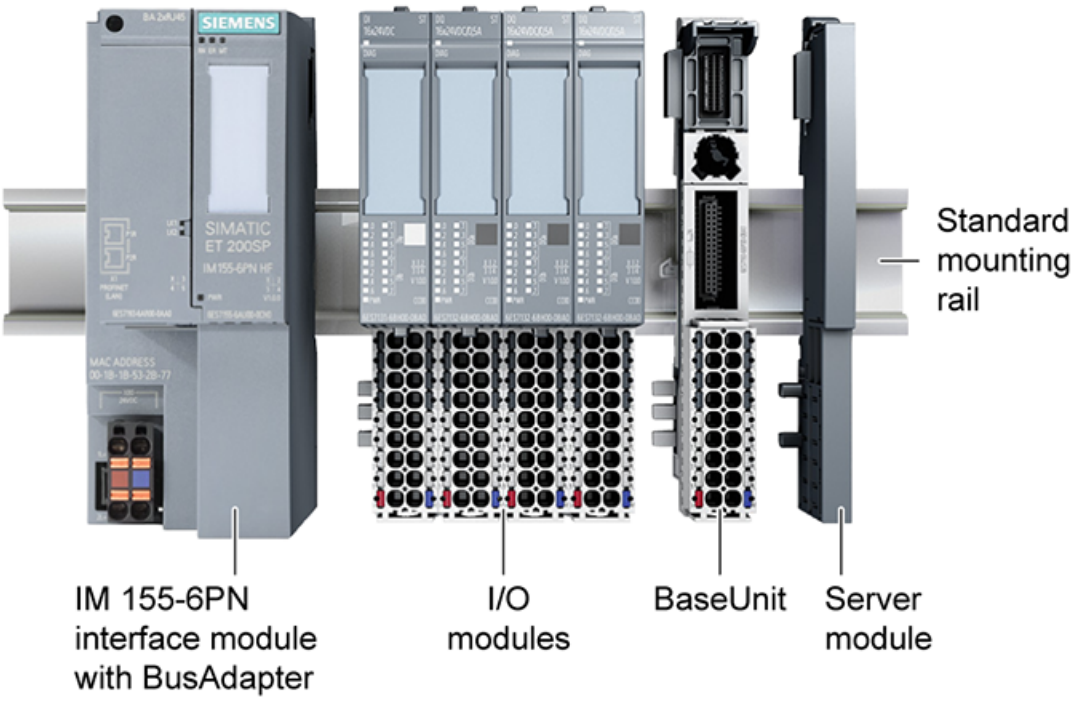

Figure 2-1116 Installation of the I/O or SIWAREX modules

5.5 Configuration of the hardware in SIMATIC

A station has a maximum width of 1 m, and you can use up to 64 modules depending on the type of PN head-end, or up to 15 modules with the Profibus version. Observe the system conditions when planning the configuration.

Each SIWAREX electronic weighing system requires 16 bytes of the I/O area. Address assignment is carried out in the TIA Portal or in the SIMATIC Manager during hardware configuration.

Connecting

6

All external connections are made via the terminal box.

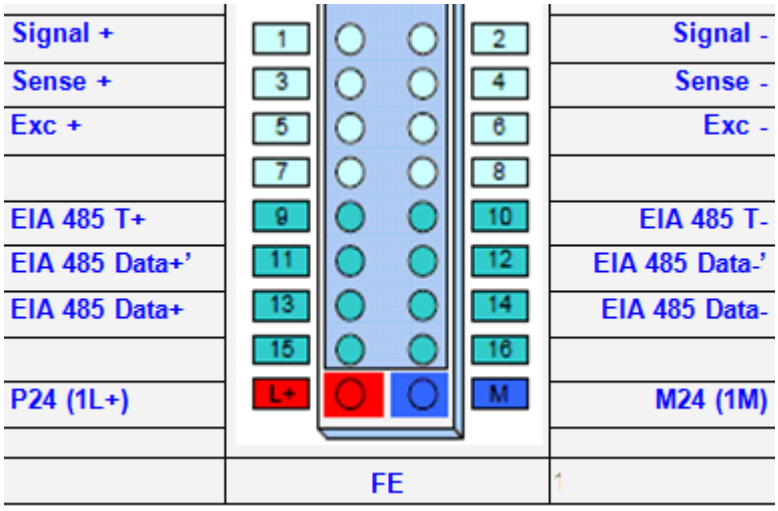

Figure 2-1117 SIWAREX WP321 process terminals on the base unit

6.1 Basic safety notes

⚠ WARNING

Safety extra low voltage

The equipment is designed for operation with a directly connectable safety extra low voltage (SELV) from a limited power source (LPS). (This does not apply to 100 V...240 V devices).

The power supply therefore needs to meet at least one of the following conditions:

- Only safety extra low voltage (SELV) with limited power source (LPS) complying with IEC 60950-1 / EN 60950-1 / VDE 0805-1 or IEC 62368-1 / EN 62368-1 / VDE 62368-1 may be connected to the power supply terminals.
- The power supply unit for the device must meet NEC Class 2 according to the National Electrical Code (r) (ANSI / NFPA 70).

There is an additional requirement if devices are operated with a redundant power supply:

If the equipment is connected to a redundant power supply (two separate power supplies), both must meet these requirements.

WARNING

Suitable cables at high ambient temperatures

If the temperature of the cable or housing socket exceeds 70 °C or the branching point of conductors exceeds 80 °C, special precautions must be taken.

If the device is operated at ambient temperatures of between 50 °C and 60 °C, only use cables with a maximum permitted operating temperature of at least 80 °C.

6.1.1 ATEX/IECx special conditions for use

WARNING

WARNING – EXPLOSION HAZARD:

DO NOT CONNECT OR DISCONNECT EQUIPMENT WHEN A FLAMMABLE OR COMBUSTIBLE ATMOSPHERE IS PRESENT.

WARNING

Transient overvoltages

Take measures to ensure that temporary transient overvoltages of more than 119 V do not occur.

6.2 24 V connection

The 24 V DC supply voltage is connected by means of the corresponding terminals on the base unit.

Table 2-1290 Connection of the 24 V supply

Labeling	Function
L +	+24 V voltage supply
M	Ground voltage supply

6.3 Connection of analog load cells

Sensors equipped with strain gauges (DMS full bridge) can be connected to the electronic weighing system. These sensors meet the requirements in section Technical data (Page 119).

Labeling	Function	Connection pin
Sig-	Measurement cable load cell -	2
Sig+	Measurement cable load cell +	1
Sen-	Sensor cable load cell -	4
Sen+	Sensor cable load cell +	3
Exc-	Supply load cell -	6
Exc+	Supply load cell +	5

6.3.1 Connecting SIWAREX JB to the electronic weighing system and load cell

Procedure

1. Open the cover of the SIWAREX JB.
2. Screw in an M16 x 1.5 cable gland for each load cell.
3. Screw in an M20 x 1.5 EMC cable gland for the signal cable to the electronic weighing system.
4. Wire the SIWAREX JB to the load cell and the electronic weighing system in accordance with Wiring diagrams (Page 28).

   To learn how to connect the cable, see section Connecting the cable (Page 30).
5. Close any unused opening in the enclosure with a blanking plug.
6. Connect the equipotential bonding conductor to the outside of the enclosure.

   Use shielded cable lugs.
7. Close the cover of the SIWAREX JB according to the tightening torque.

6.3.2 Wiring diagrams

6.3.2.1 Load cells with four-wire system

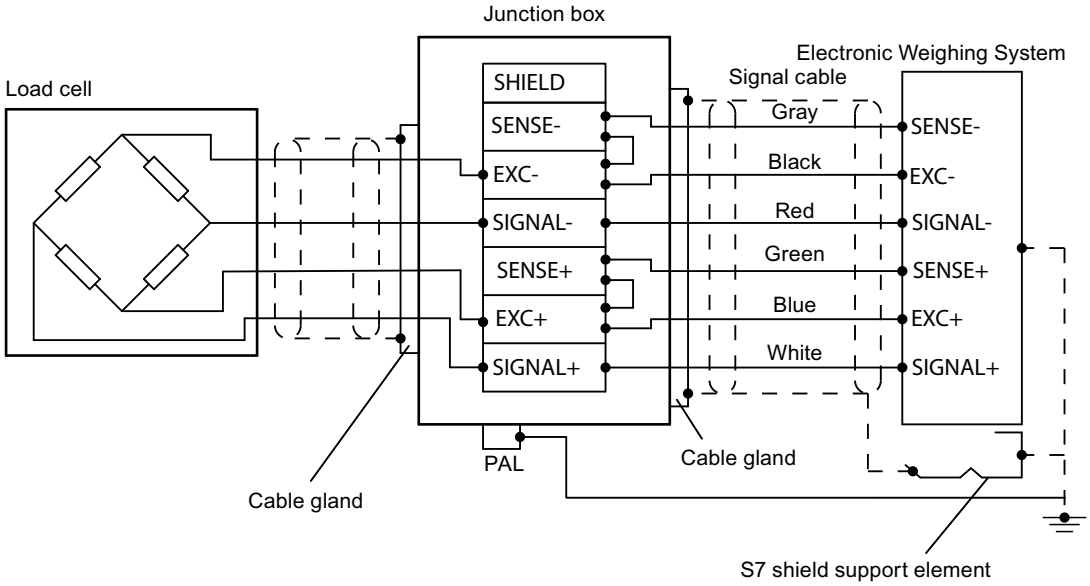

Figure 2-1118 Cable shield of the signal cable connected to EMC cable gland

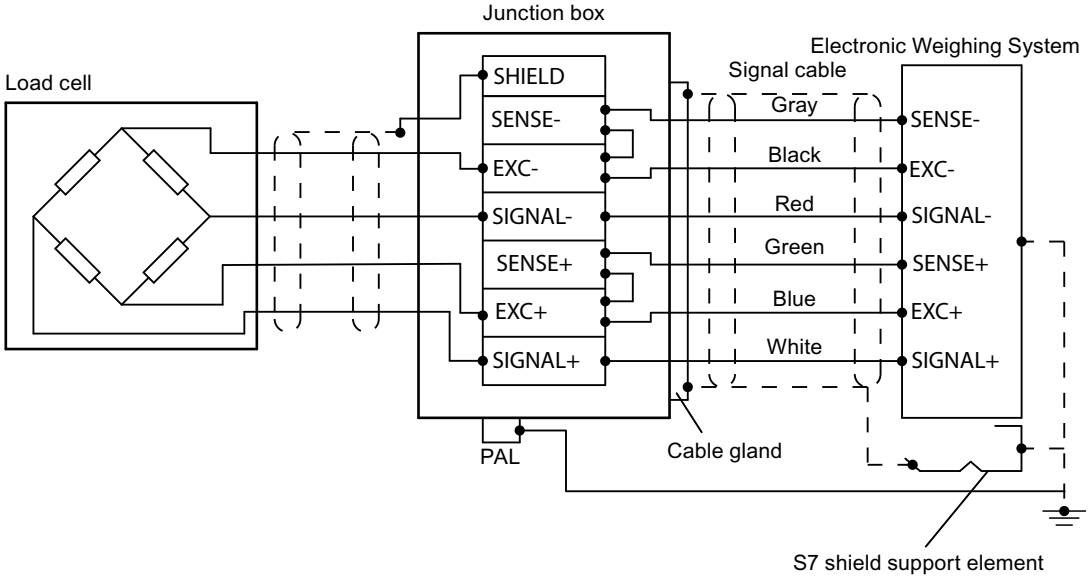

Figure 2-1119 Cable shield of the signal cable connected to shield terminal

The following wire jumpers are set by default:

Wire jumper	From terminal	To terminal
1	EXC-	SENSE-
2	EXC+	SENSE+

NOTE

If the wire jumpers are missing, the electronic weighing system reports a wire break.

6.3.2.2 Load cells with six-wire system

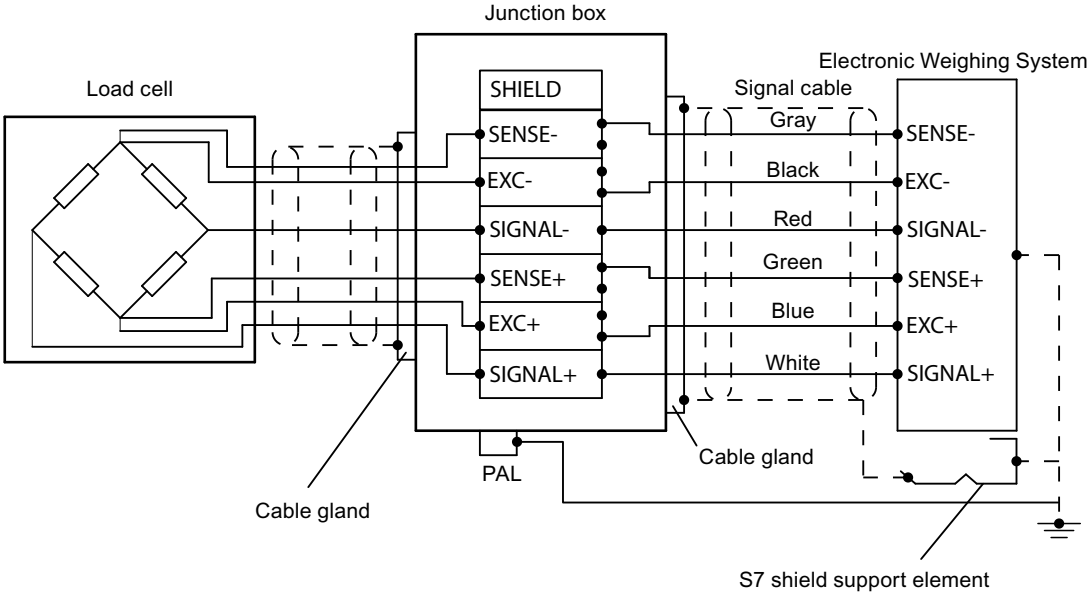

Figure 2-1120 Cable shield of load cell cable connected to EMC cable gland

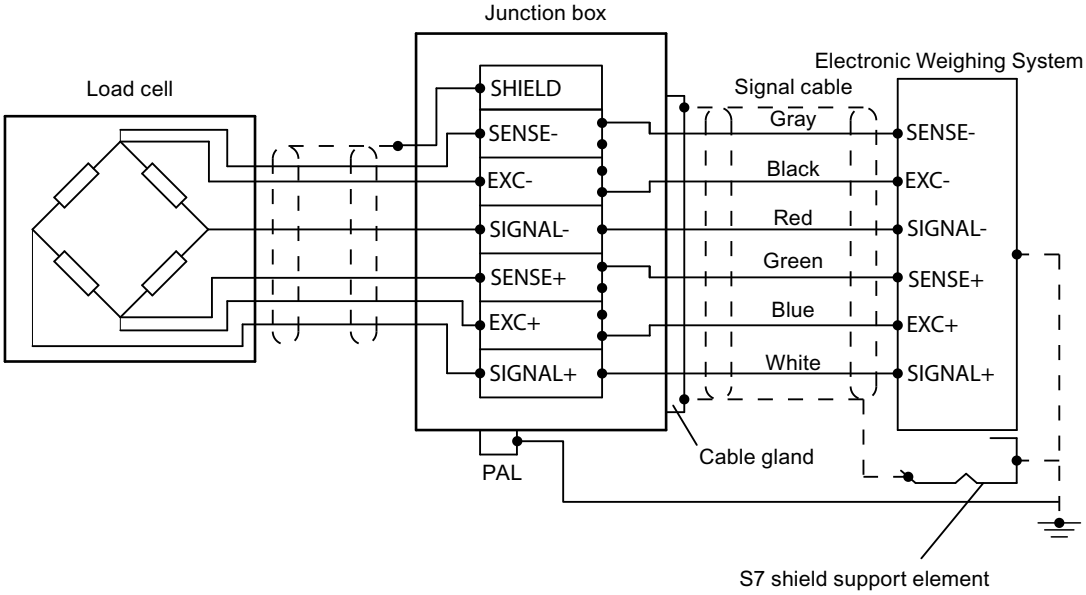

Figure 2-1121 Cable shield of load cell cable connected to shield terminal

- Disconnect the following wire jumpers:

Wire jumper	From terminal	To terminal
1	EXC-	SENSE-
2	EXC+	SENSE+

6.3.3 Connecting the cable

Requirement

You require a screwdriver with a maximum blade width of 3.5 mm.

Procedure

1. In EMC cable glands, lay the cable shielding over a large area.

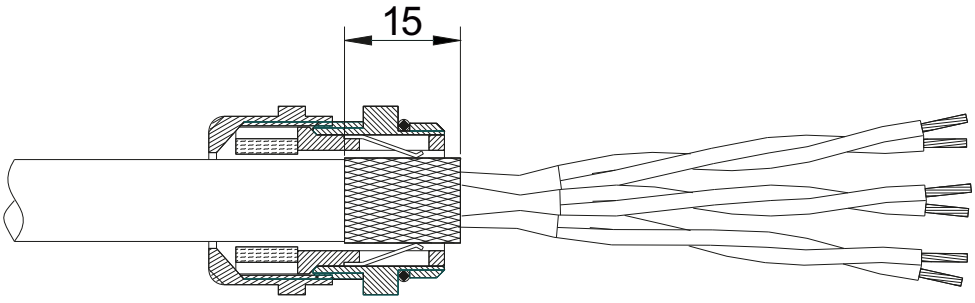

Figure 2-1122 Place the cable shield in the EMC cable gland

2. With plastic cable glands, place the corresponding wire of the SIWAREX load cell on the shield terminal.

3. Strip at least 6 mm of insulation from the load cell cable.

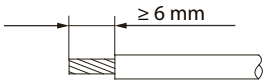

Figure 2-1123 Strip cable

4. Insert the stripped load cell cable into the square opening of the screw terminal as far as it will go.
5. Tighten the screws with the specified tightening torque.

Result

The tightened screw firmly holds the stripped wire and establishes the contact.

6.4 Shield connection

Make sure you observe the correct design of the shield support for the shielded cables. It is the only way to ensure immunity of the system.

A cable is shielded to attenuate the effects of magnetic, electrical and electromagnetic interference on the cable. Interference currents on cable shielding are diverted to ground by conductive isolation rails. To avoid interference as a result of these currents, it is imperative to provide a low-impedance connection to the ground.

Only use cables equipped with a shielding braid. Shielding density must be at least 80%.

Figure 2-1124 Shield connection and shield terminal

6.5 Connection of RS485 serial interface

Devices can be connected to the serial interface RS485 in accordance with the information in section AUTOHOTSPOT.

Table 2-1291 Termination of RS485 serial interface

Labeling	Function	Connection pin
RS485: T+	RS485 termination +: Is used at the physical end of the bus for inserting termination jumpers	9
RS485: T-	RS485 termination -: Is used at the physical end of the bus for inserting termination jumpers	10
RS485: D+'	RS485 data line +': Is used at the physical end of the bus for inserting termination jumpers and in between for looping through the bus cables	11
RS485: D-'	RS485 data line -': Is used at the physical end of the bus for inserting termination jumpers and in between for looping through the bus cables	12
RS485: D+	RS485 data cable +	13
RS485: D-	RS485 data cable -	14

If the electronic weighing system forms the termination of an RS485 network, insert a wire jumper between the D+' and T+ terminals and between the D-' and T- terminals for termination of the bus network.

6.6 Connection of Siebert display via RS485

A Siebert display S102 with the order no. S102-W6/14/0R-000/0B-SM can be connected to the RS485 interface of the weighing module. Connect a 24 V DC supply to the Siebert display. Connect the latter to the RS485 interface of the weighing module as shown in the figure below.

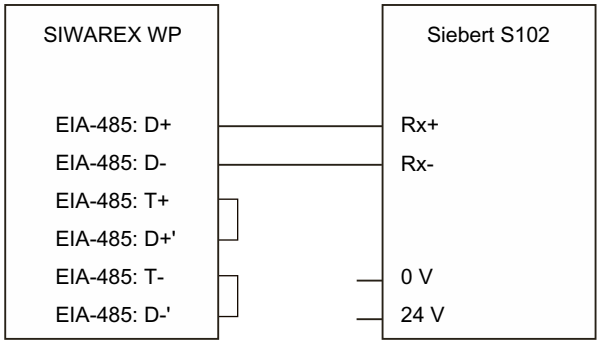

Figure 2-1125 Connection of Siebert display S102

The RS485 interface in the DR 13 of the SIWAREX WP is set as follows:

- RS485 protocol: Siebert display S102
- Baud rate: 9600 bps
- Character parity: Even

The S102 is set as follows:

Table 2-1292 Settings of Siebert display S102

Menu item	Setting	Meaning	
1 Interface	485	RS485 interface	
9 Station address	01	Address meaning:	
		Address	**Weight value**
		01	Weight
		02	Total
		03	Net
		04	Tare
t Timeout	2	e.g. timeout after 2 seconds	
C	0.0	No decimal point	
F Segment test	----*	No segment test when switching on	
	8.8.8	Segment test when switching on	

6.7 Connection of the SIWAREX DB

The digital junction box SIWAREX DB allows connection of up to 4 analog load cells. SIWAREX DB has 4 separate AD converters and thus digitizes each load cell separately.

In addition to the actual measured value, the following **extended diagnostics data** are available for each individual load cell:

- Current signal voltage in millivolts
- Wire-break monitoring
- Current input resistance in ohms
- Current "excitation current" in mA etc.

In the event of a defective load cell, the electronic weighing system reports the affected load cell. Service as well as commissioning are significantly facilitated and accelerated.

SIWAREX DB also enables digital adjustment of different load cell characteristics (corner load compensation).

6.7.1 Connecting SIWAREX DB

Procedure

1. Open the cover of the SIWAREX DB.
2. Screw in an M16 x 1.5 cable gland for each load cell.
3. Screw in an M20 x 1.5 EMC cable gland for the signal cable to the SIWAREX WP electronic weighing system.
4. Attach the cables from SIWAREX DB to the load cell and the SIWAREX WP electronic weighing system.

   Connect the cable (Page 35)

   The maximum distance between SIWAREX DB and the WP electronic weighing system is 1000 m when using the recommended cable 7MH4702-8AG.

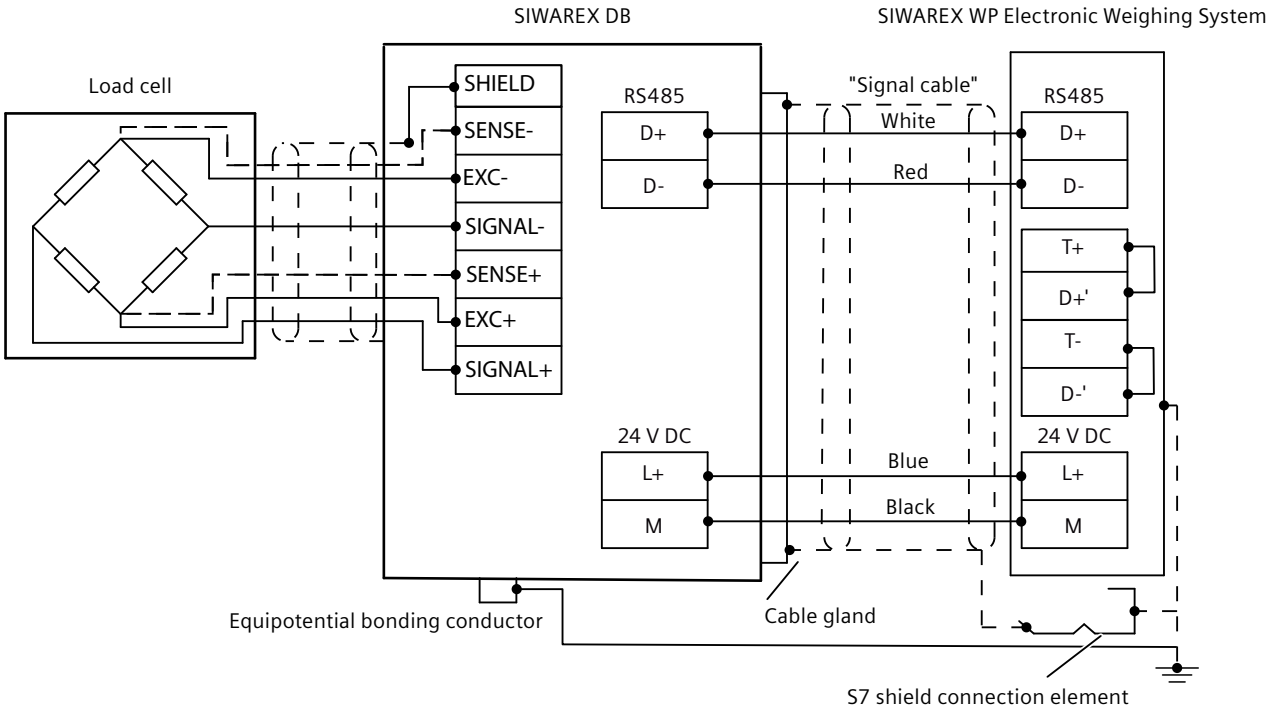

5. With SIWAREX WP weighing electronics, insert wire jumpers between terminals D+' and T+ and between terminals D-' and T- for termination of the bus network.
6. Close any unused opening in the enclosure with a blanking plug.
7. Connect the equipotential bonding conductor (functional grounding) to the enclosure exterior.

   Use shielded cable lugs.
8. Close the cover of the SIWAREX DB according to the tightening torque 1.5 to 2 Nm.

6.7.2 Connect the cable

Condition

You require a screwdriver with a maximum blade width of 2.5 mm.

You can use the SIWAREX cable for supply voltage and RS-485 communications. Ordering data (Page 124)

Procedure

1. Place the cable shield in the EMC cable gland over a large area.

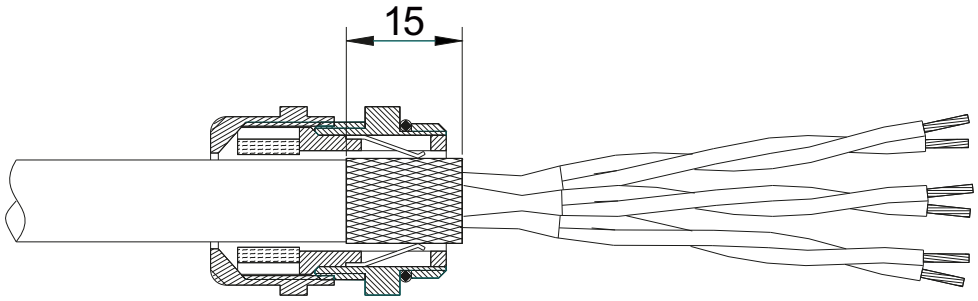

Figure 2-1126 Place the cable shield in the EMC cable gland.

2. For plastic cable glands, connect the corresponding wire of the SIWAREX load cell to the shield terminal.
3. Strip the cable ends at least 6 mm.
4. Push the screwdriver into the rectangular opening of the terminals.
5. Insert the stripped cable into the round opening as far as it will go.
6. Remove the screwdriver from the rectangular opening.

Commissioning 7

Commissioning essentially comprises:

- Checking the scale construction
- Specifying the parameters
- Calibration
- Verifying the envisaged functionality

7.1 Factory-set parameters

The electronic weighing system described here is provided with factory-set parameters. The parameters have been provided for a typical 100 kg scale based on three load cells. Parameters which can be entered in % or time are preset in such a way that they provide good results for most applications.

With these default parameters, commissioning can be carried out in 5 minutes (see chapter 5-minute quick start with the operator panel and the Ready-for-Use software (Page 37)).

7.2 Commissioning tools

Commission the electronic weighing system using the following alternatives:

- Touch panel und SIWAREX WP321 function block in S7-300/400/1200 or 1500

  A free example project is available for download online at TIA Portal project "Ready-for-use" for SIWAREX WP321 (https://support.industry.siemens.com/cs/ww/en/view/94109373).

- Commissioning with SIWATOOL V7

  SIWATOOL V7 is included in the WP configuration package available for purchase, Ordering data (Page 124). To communicate between SIWAREX WP and SIWATOOL V7, use an additional interface converter USB/RS485.

Use SIWATOOL V7 to commission the scale without SIMATIC expertise with a standard PC. Backup files can also be created and loaded. In the event of a fault, additional SIWATOOL diagnostics functions enable fast analysis of the cause.

7.3 5-minute quick start with the operator panel and the Ready-for-Use software

7.3.1 Start

The 5 minutes of quick start is performed in this example with a TP700 Comfort Panel connected directly to the electronic weighing system. The Panel communicates directly over MODBUS TCP/IP or via the SIMATIC S7-1200 CPU.

To carry out the quick start, select the "1.0 Setup" function in the main menu and then "1.2 Quick Start". You will be guided through the individual tasks for setting the most important parameters.

The remaining parameters are factory-set in such a way that they can be used in most cases without any changes.

You can download the HMI software used below as free TIA Portal project "Ready-for-use" for SIWAREX WP321 (https://support.industry.siemens.com/cs/ww/en/view/94109373).

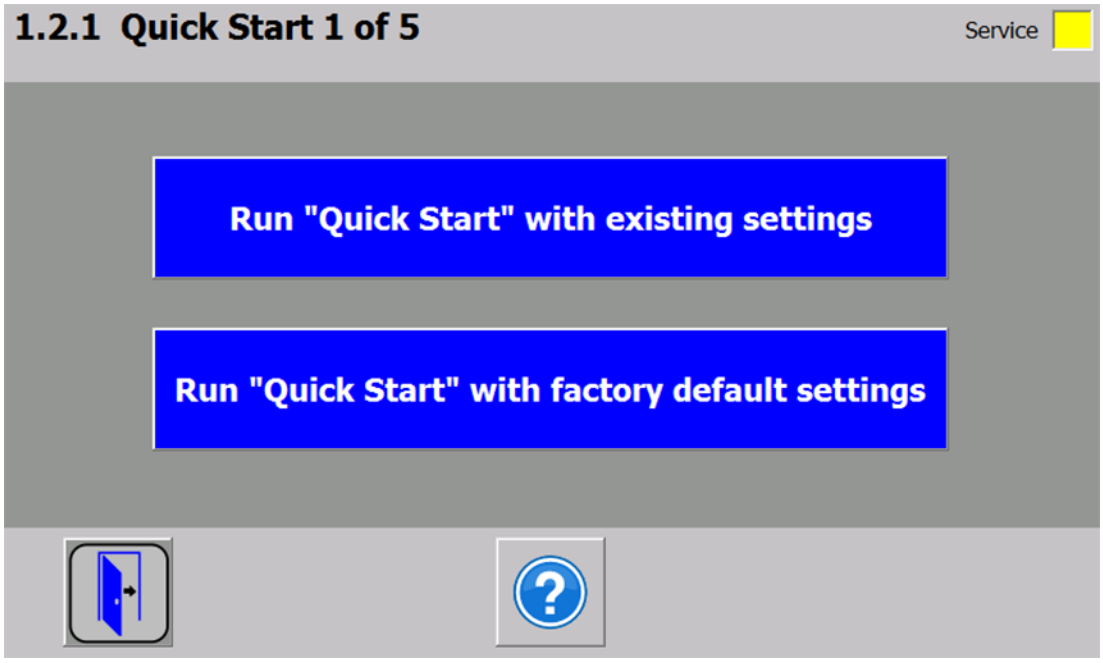

Figure 2-1127 Quick start step 1

7.3.2 Factory setting of the parameters

The quick start is based on the factory setting of the parameters. Therefore, the previous parameter settings must be reset prior to the quick setup. Service mode must be switched on first. Resetting to the factory setting can then be carried out.

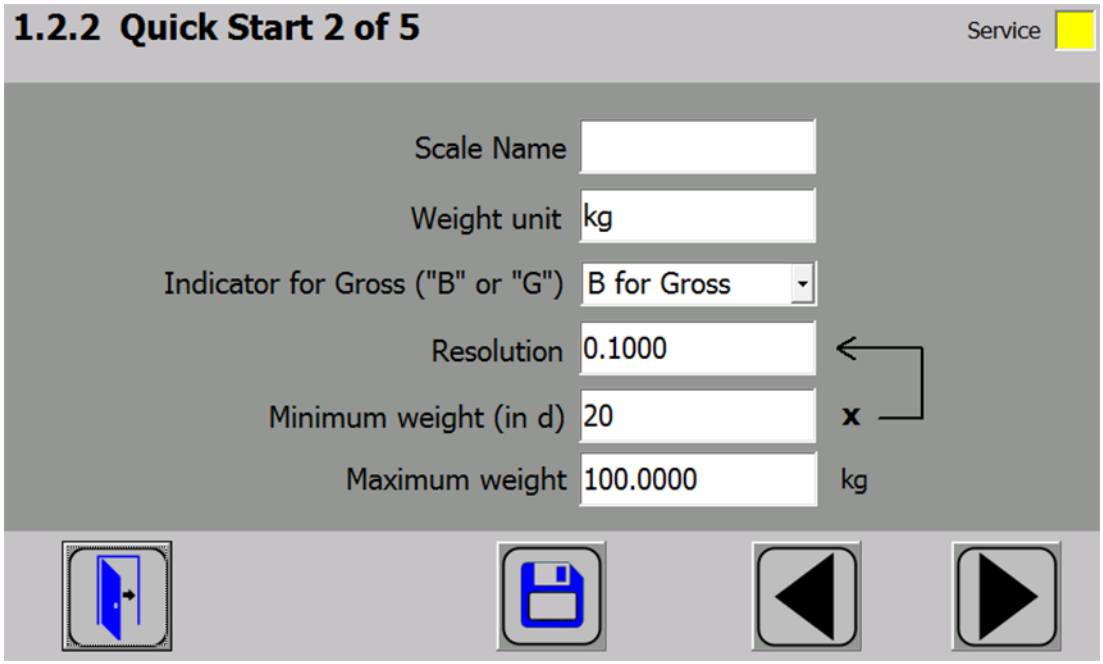

Figure 2-1128 Quick start step 2

7.3.3 Selecting the calibration method

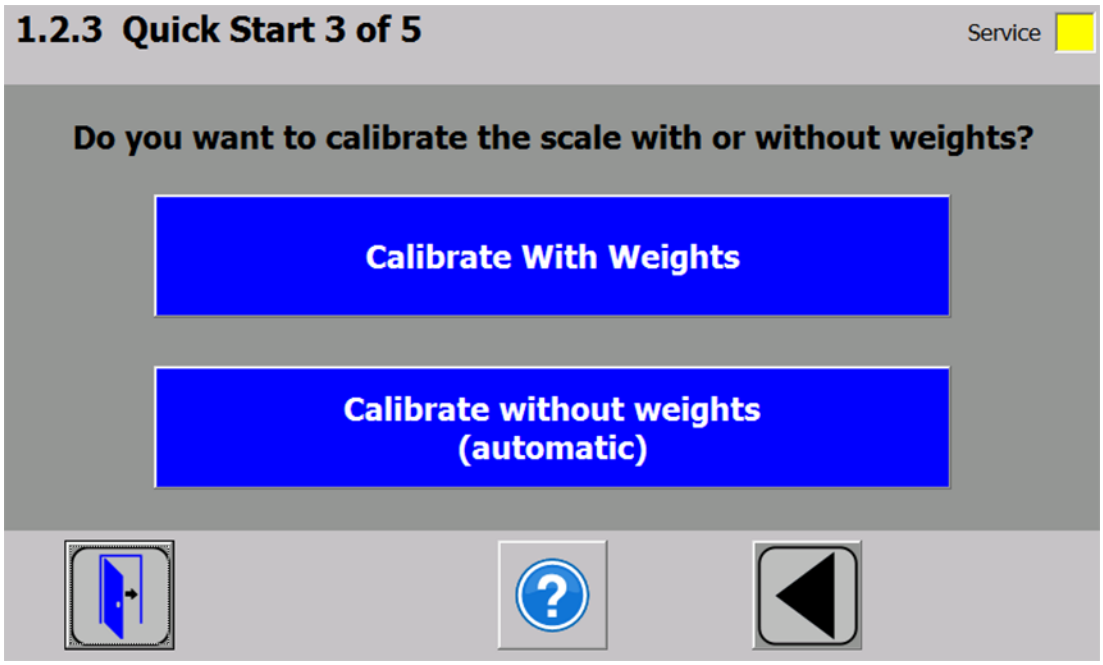

Figure 2-1129 Quick start step 3

The module can always be calibrated in two different ways:

- Using reference weights: in the case of a calibration with weights, mechanical influences of the scale construction are also partially taken into account.
- Without weights, using the technical specifications of the connected load cell(s): in the case of automatic calibration, the accuracy of the scale is influenced by the mechanical properties to a greater extent than with calibration using reference weights.

With both methods, make sure that the mechanical properties of the scale are flawless prior to calibration.

7.3.4 Defining the calibration weights

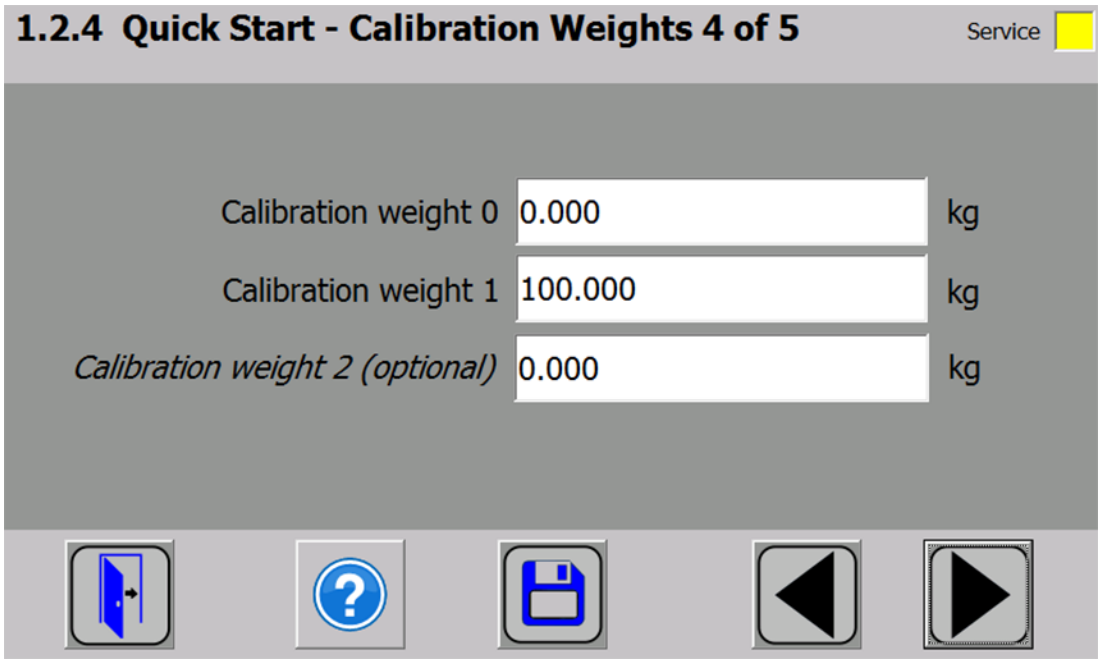

Figure 2-1130 Quick start step 4a

In step 4 you enter the calibration weights which are to be positioned on the scale during the calibration. If the scale is not empty and the current contents are known, you can define an "Calibration weight 0" with the current contents of the scale. With an empty scale, this parameter remains as 0 kg. "Calibration weight 1" usually defines the first reference point of the scale characteristic. A further reference point ("Calibration weight 2") can also be set in addition. This is optional, and may not be necessary depending on the mechanical properties of the scale.

Note that the interval between the calibration weights must be at least 2% of the nominal load of the scale. With a 1 000 kg scale, a calibration weight of at least 20 kg must therefore be used.

7.3.5 Setting calibration points

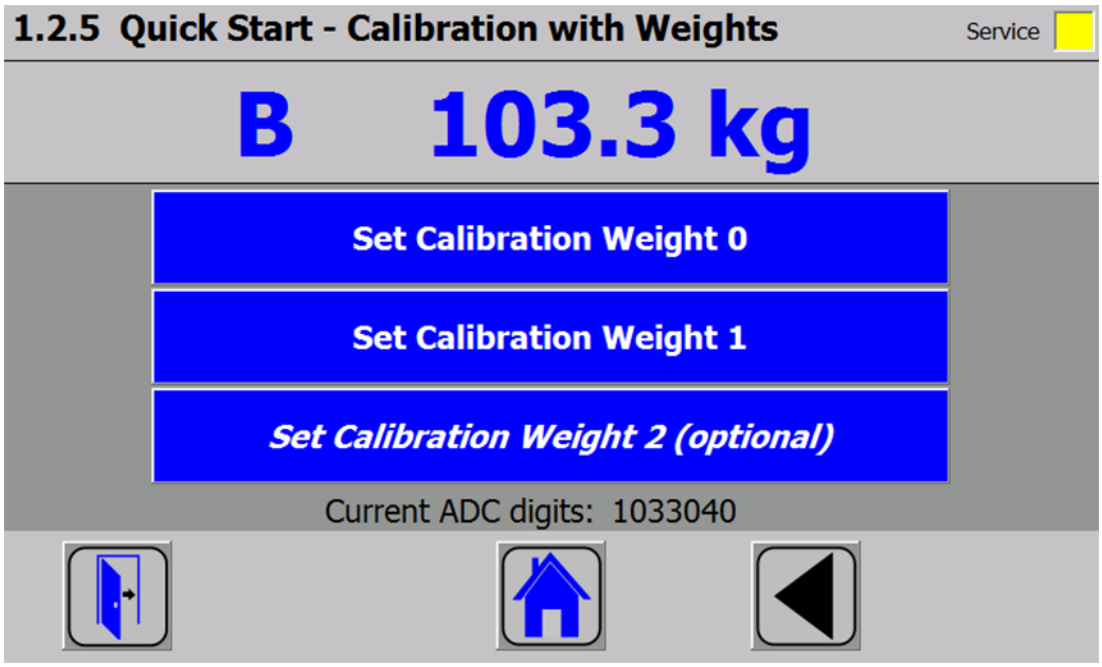

Figure 2-1131 Quick start step 5a

Carry out the calibration commands at the end of the quick start:

1. Carry out the "Set calibration weight 0" command. The "Calibration weight 0" defined in step 4 is now visible in the display.
2. Place the "Calibration weight 1" defined in step 4 on the scale construction, and execute the "Set calibration weight 1" command.
3. If an "Calibration weight 2" was selected:
   Place "Calibration weight 2" defined in step 4 on the scale construction, and execute the "Set calibration weight 2" command.
4. Calibration of the scale is now complete. Return to the start screen by clicking on the house icon.

7.3.6 Calibrating the scale automatically

The scale can also be calibrated without weights. To do this, it is necessary to enter data specific to the load cells. In addition, it is essential that the scale is empty.

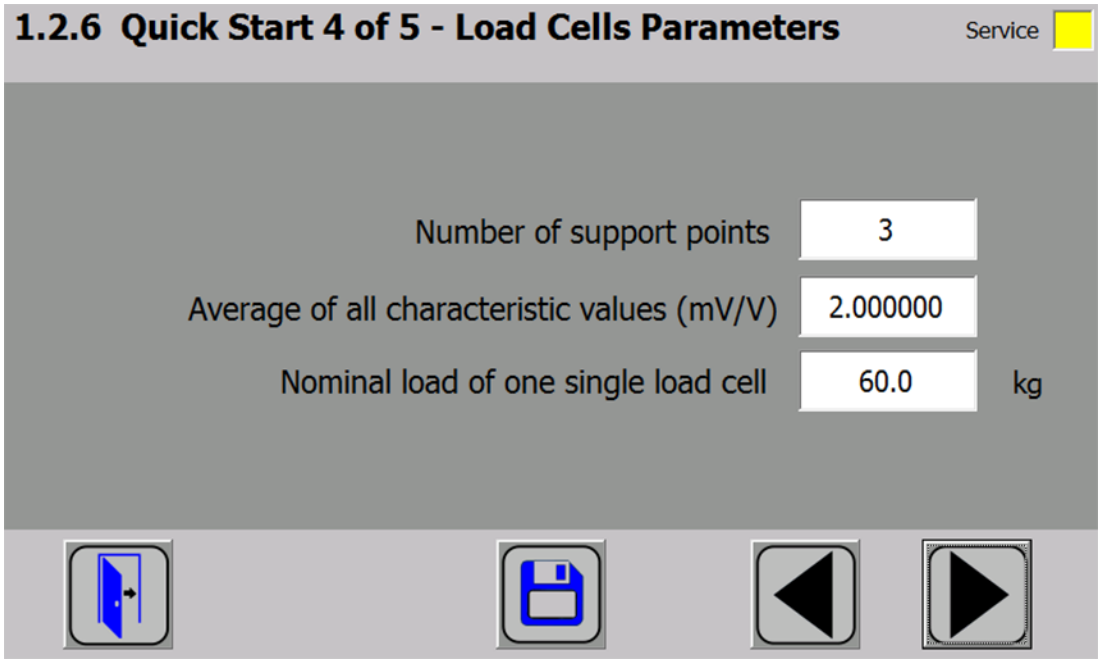

Figure 2-1132 Quick start step 4b

The number of points of support corresponds with a silo, for example, to the number of clamps or feet of the silo. A quadratic platform scale with a load cell at each corner has 4 support points. The characteristic values of the individual load cells are required to calculate the average characteristic value of the cells.

The equation for the calculation is as follows:
(characteristic of cell 1 + characteristic of cell 2 + characteristic of cell n) / n

If the exact characteristic values are unknown, it is permissible to also use rounded-off numbers (e.g. 1.0 mV/V, 2.0 mV/V). The nominal load of an individual load cell (not the nominal load of the complete scale!) must subsequently be defined.

7.3.7 Performing the automatic calibration

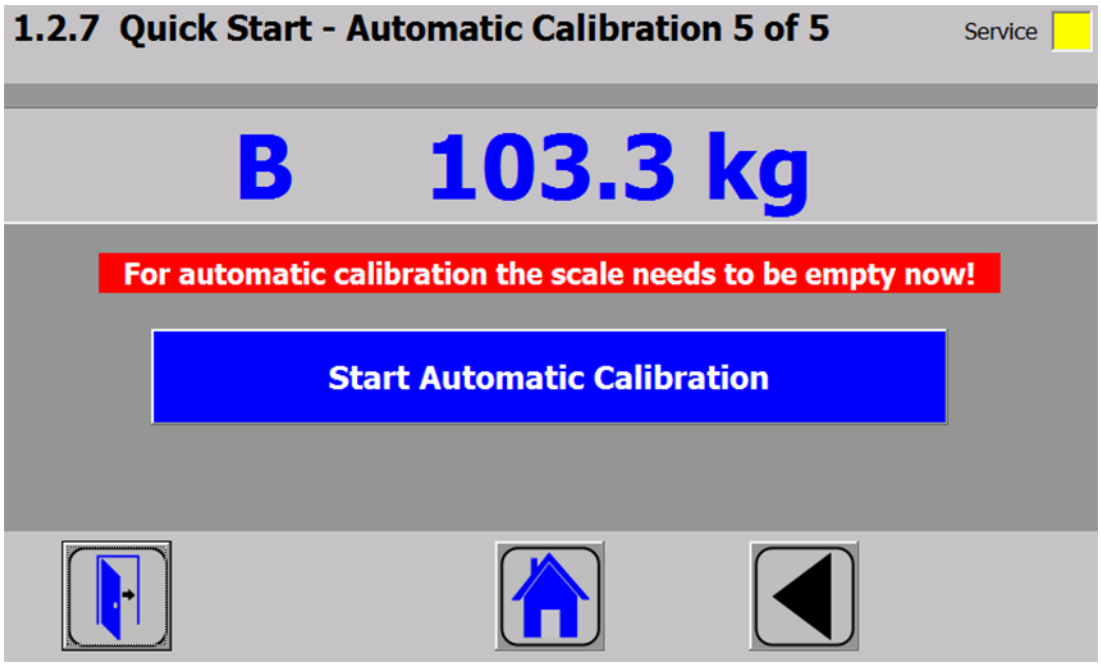

Figure 2-1133 Quick start step 5b

Subsequently enter the "Perform automatic calibration" command with the scale empty. The scale is calibrated directly, and clicking on the house icon returns you to the start screen.

7.3.8 Checking the scale following calibration

If the scale is only used for company-internal purposes, a simple check is sufficient.

Perform the following steps:

1. The scale is unloaded and shows "0 kg".
2. Place a known reference weight on the scale.
   Check the displayed value.
3. If a second known reference weight is available, place it on the scale in addition.
   Check whether the scale displays the sum of the reference weights.
4. Remove the reference weights from the scale.
   Check that the display is "0 kg" again.

7.4 Fast commissioning (Quick Start) with SIWATOOL

7.4.1 Service with the SIWATOOL program

You can use the SIWATOOL program to commission the scale independent of the SIMATIC automation system. The program is included in the configuration package.

Install the SIWATOOL program (SIWATOOL folder) on your PC for commissioning.

The SIWATOOL program is described in the sectionService with the SIWATOOL program (Page 56).

You require an RS485-USB converter from Siemens in order to connect the PC to the SIWAREX (see section Ordering data (Page 124)). You can then connect the RS485 interface of the SIWAREX to the USB port of the PC.

- Close the RS485-USB converter proposed by Siemens (see section Ordering data (Page 124)) at the base unit of SIWAREX WP321 as follows:

RS485-USB converter	Base unit of SIWAREX WP321
Terminal A	Terminal 13 (D+)
Terminal B	Terminal 14 (D-)
Terminal X	-
-	Bridge between terminals 9 (T+) and 11 (D+')
-	Bridge between terminals 10 (T-) and 12 (D-')

7.4.2 Establish communication to SIWAREX WP321

- After starting the SIWATOOL program, select the SIWAREX WP321 from the "Device selection" window.

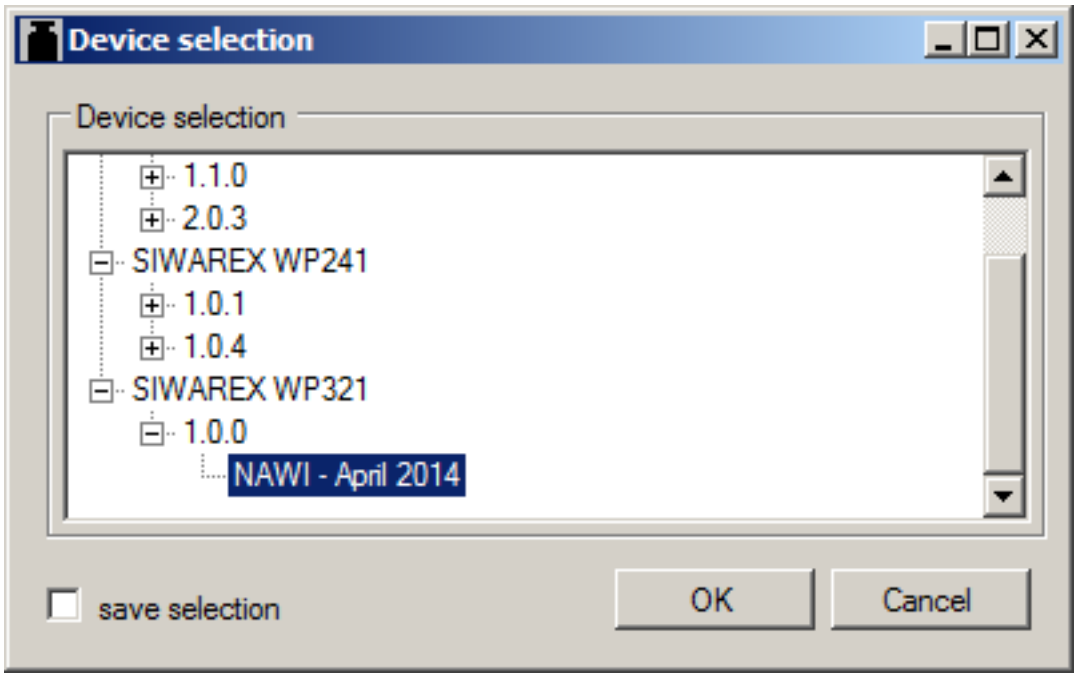

Figure 2-1134 SIWATOOL: Device selection window

- Select the menu command "Communication" > "Choose interface".

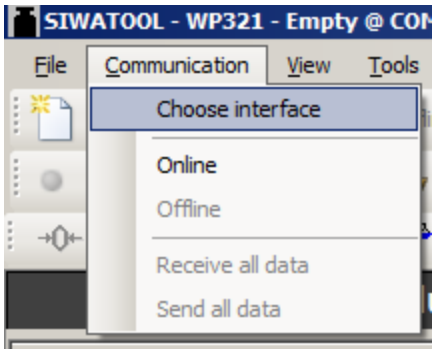

- Select the COM port of your PC used for the RS485-USB converter (for example: COM3).

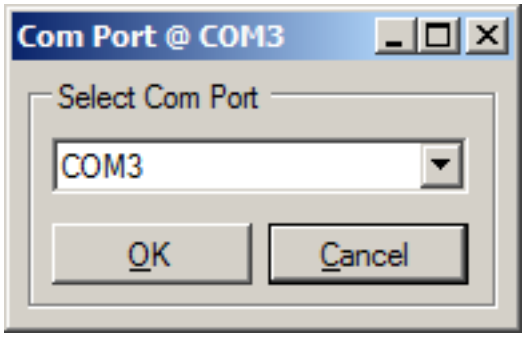

Figure 2-1135 SIWATOOL: Select Com port window

- Click on the "Online" button

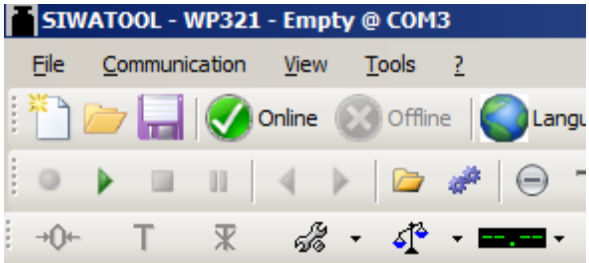

⇒ The communication to SIWAREX WP321 is established.

7.4.3 Calibration

7.4.3.1 Selecting the calibration method

You can calibrate the SIWAREX module in two different ways:

- Calibration with calibration weight (Page 47) When calibrating with calibration weights, mechanical influences of the scale construction are also taken into account.
- Automatic calibration (without calibration weight) (Page 51) When calibrating without calibration weights, the technical specifications of the connected load cell(s) are taken into account. With automatic calibration, the accuracy of the scale depends on the mechanical properties of the scale.

With both methods, make sure that the mechanical properties of the scale are flawless prior to calibration.

7.4.3.2 Calibration with calibration weight

Define calibration parameters

- Enter the marked and described calibration parameters.

	Calibration Parameter (DR3)	
	Info	
	Basic Parameters	
	Scale name	
①	**Weight unit**	kg
	Letter for gross weight	B for Gross
	Minimum weight (in d)	20
②	**Maximum weight**	100.0
③	**Resolution d**	0.1
	Calibration	
	Calibration weight 0	0.0
④	**Calibration weight 1**	100.0
	Calibration weight 2	0.0
	Calibration digits 0 (real)	0
	Calibration digits 1 (real)	2000000
	Calibration digits 2 (real)	0
	Additional Parameters	

① The defined weight unit applies to all weight specifications. You can specify a string with up to 4 digits as the weight unit, e.g.: t, kg, lbs.

② Exceeding the maximum weight (= maximum material to be weighed) is indicated in DS30, status 1-2, at parameter "Max 9e". If the maximum weight is exceeded, this bit is set to TRUE.

③ The resolution d is used for the weight display in the SIWATOOL program. You can set the resolution d in accordance with EN 45501 (0.0001 to 50).

④ Calibration weight 1 and its corresponding calibration digits define the characteristic curve of the scale.
Use a minimum calibration weight as calibration weight 1, with a load cell characteristic value of:
- 1 mV/V: 4 % of the total rated load of all load cells
- 2 mV/V: 2 % of the total rated load of all load cells
- 4 mV/V: 1 % of the total rated load of all load cells

Example
Number of load cells: 3
Nominal load of one single load cell: 100 kg
Load cell characteristic value: 2 mV/V
Use the following **minimum calibration weight** for calibration:
2 % x 3 x 100 kg = 6 kg

Figure 2-1136 SIWATOOL: Calibration parameters for calibration with calibration weight

Send calibration parameters

- Send the calibration parameters set on your PC to SIWAREX.
- Select "Service mode on" in the Service menu. The calibration parameter (DR3) can only be sent and the calibration commands executed with service mode switched on.

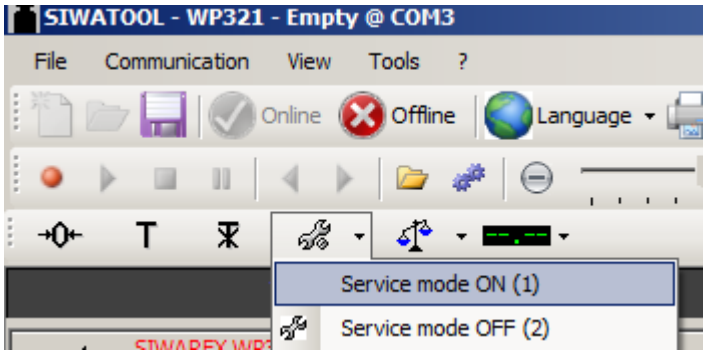

⇒ After switching on service mode, the following red wrench icon is displayed in the SIWATOOL next to the weight value.

Figure 2-1137 SIWATOOL: Symbol for service mode

NOTICE
Parameters overwritten It is not possible to send or receive individual parameters within a data record. The complete data record must initially be received for every change to parameters within it. The desired parameter can then be edited and the data record sent again. If not all the data can be received from the scale before the parameter change, the active offline parameters in the scale can be overwritten by the "Send data record" function. Therefore, proceed as follows: 1. Select the "Receive data record" function. 2. Change the parameters. 3. Select the "Send data record" function.

- Right-click on "Calibration parameter (DR3)" and select "Send data record".

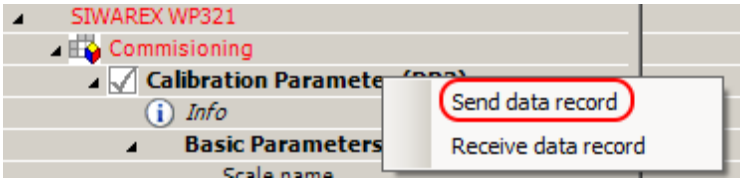

Figure 2-1138 SIWATOOL calibration parameters: Send data record

⇒ All parameter settings in DR3 are identical between PC and SIWAREX. All calibration parameters (DR3) are shown in black.

Assign calibration weight

- After sending the calibration parameters to SIWAREX, select "Set Calibration Point 0" in the Service menu with an empty scale. Empty scale means only the mechanical dead load (e.g. empty container) rests on the load cells.

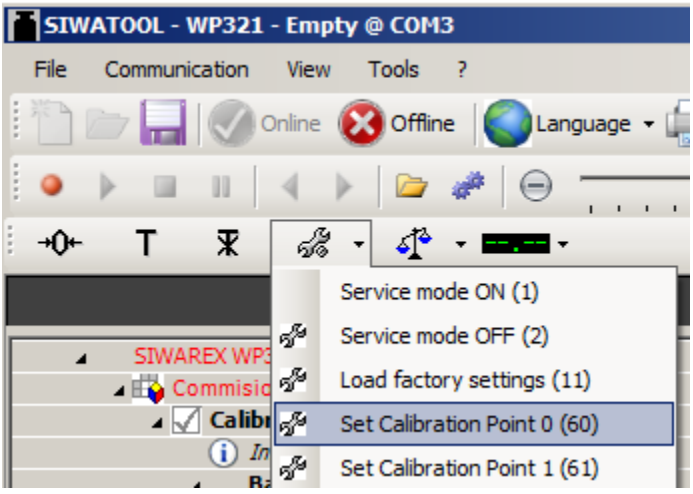

- Place the previously defined "Calibration weight 1" on the scale
- Select "Set Calibration Point 1" in the Service menu.

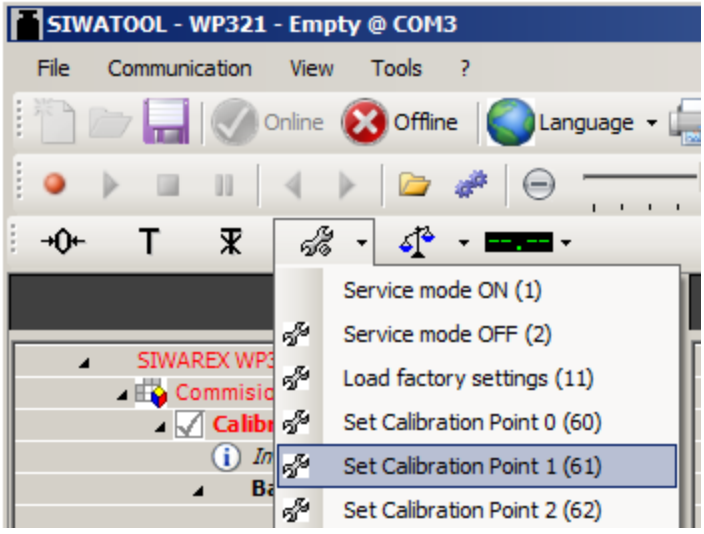

- Select "Service mode off" in the Service menu.

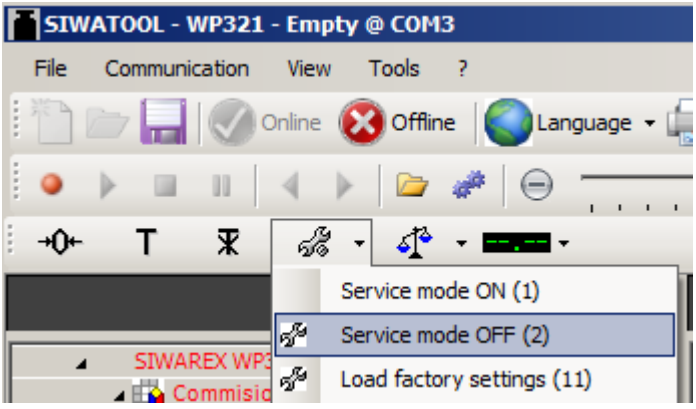

⇒ The calibration is finished and the correct weight value is now displayed in the SIWATOOL program.

Receiving calibration parameters

During the calibration, the SIWAREX internally changes its calibration digits. This means that SIWATOOL now has obsolete parameter values. Obsolete calibration parameters are marked in red.

The calibration parameter (DR3) must be read back in order once again obtain the calibration digits in the SIWATOOL which are consistent with the SIWAREX.

Calibration Parameter (DR3)	
Info	
Basic Parameters	
Calibration	
Calibration weight 0	0.0
Calibration weight 1	130.0
Calibration weight 2	0.0
Calibration digits 0 (real)	0
Calibration digits 1 (real)	2000000
Calibration digits 2 (real)	0

Figure 2-1139 SIWATOOL: Obsolete calibration parameters

- Right-click on "Calibration parameter (DR3)" and select "Receive data record".

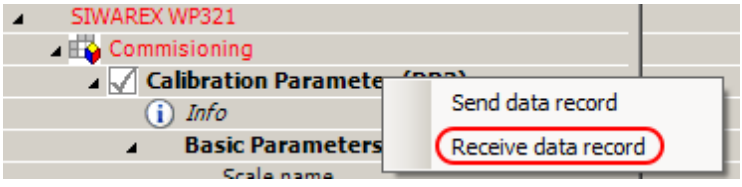

Figure 2-1140 SIWATOOL calibration parameters: Receive data record

Checking the scale following calibration

If the scale is to be used for business purposes only, check it as follows:

1. The scale is unloaded and the display shows "0 kg".
2. Place one or more known test weights on the scale. To check other weight points of the scale in addition to the calibration weight, do not use the calibration weight.
3. Check the displayed weight value in the SIWATOOL program.
4. Remove the test weights from the scale.
5. Check that the display of the scale is 0 kg again.

7.4.3.3 Automatic calibration (without calibration weight)

The scale can also be calibrated without a weight. To do this, the parameters marked in bold in DR3 / basic parameters are checked or entered, and the data specific to the load cells are specified in DR10.

Requirement:

The scale is empty.

Procedure

- Enter the marked and described calibration parameters.

	Calibration Parameter (DR3)		
	Info		
	Basic Parameters		
	Scale name		
①	**Weight unit**	kg	kg
	Gross indicator	B for Gross	B for Gross
	Minimum weight (in d)	20	20
②	**Maximum weight**	100.0	100.0
③	**Resolution d**	0.1	0.1
	Calibration		
④	**Calibration weight 0**	0.0	0.0

① The defined weight unit applies to all weight specifications. You can specify a string with up to 4 digits as the weight unit, e.g.: t, kg, lbs.

② Exceeding the maximum weight (= maximum material to be weighed) is indicated in DS30, status 1-2, at parameter "Max 9e". If the maximum weight is exceeded, this bit is set to TRUE.

③ The resolution d is used for the weight display in the SIWATOOL program. You can set the resolution d in accordance with EN 45501 (0.0001 to 50).

④ If the scale is not empty during automatic calibration, but the material weight on the scale is known (e.g. after conversion to SIWAREX WP321), the known material weight can be specified as calibration weight 0. This means the material weight is taken into account during automatic calibration.
NOTE: If the specified material weight is incorrect (old electronic weighing system was not calibrated correctly, for example), the weighing result of SIWAREX WP321 will be distorted or incorrect!

Figure 2-1141 SIWATOOL: Calibration parameters for automatic calibration (without calibration weight)

Send calibration parameters

- Send the calibration parameters set on your PC to SIWAREX.
- Select "Service mode on" in the Service menu. The calibration parameter (DR3) can only be sent and the calibration commands executed with service mode switched on.

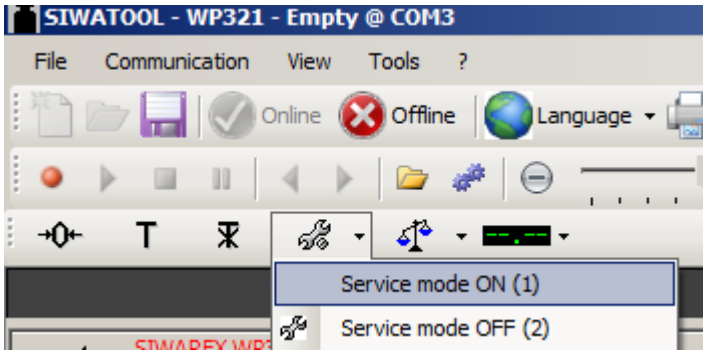

⇒ After switching on service mode, the following red wrench icon is displayed in the SIWATOOL next to the weight value.

Figure 2-1142 SIWATOOL: Symbol for service mode

NOTICE
Parameters overwritten It is not possible to send or receive individual parameters within a data record. The complete data record must initially be received for every change to parameters within it. The desired parameter can then be edited and the data record sent again. If not all the data can be received from the scale before the parameter change, the active offline parameters in the scale can be overwritten by the "Send data record" function. Therefore, proceed as follows: 1. Select the "Receive data record" function. 2. Change the parameters. 3. Select the "Send data record" function.

- Right-click on "Calibration parameter (DR3)" and select "Send data record".

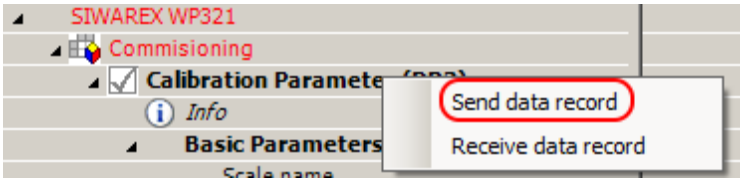

Figure 2-1143 SIWATOOL calibration parameters: Send data record

⇒ All parameter settings in DR3 are identical between PC and SIWAREX. All calibration parameters (DR3) are shown in black.

Defining load cell parameters

- Enter the marked and described load cell parameters (DR10) in DS10.

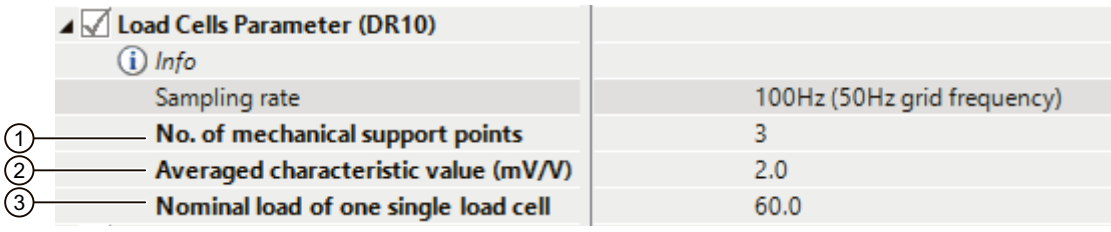

① The No. of mechanical support points corresponds with a silo, for example, to the number of clamps or feet of the silo. A quadratic platform scale with a load cell at each corner has four support points.

② Averaged characteristic value (mV/V) This parameter is the mean value of the characteristic values of all connected load cells (for example, Identifier = 2.018 mV/V). You can obtain the exact characteristic value of a load cell from its test report or read it directly at the load cell. If the characteristic values of the individual load cells are unknown, you can assume the value "1.0" for 1 mV/V load cells, the value "2.0" for 2 mV/V load cells, etc.

③ Specify the Nominal load of one single load cell.

Figure 2-1144 SIWATOOL load cell parameters (DR10)

- Right-click on "Load cells parameter (DR10)" and select "Send data record".

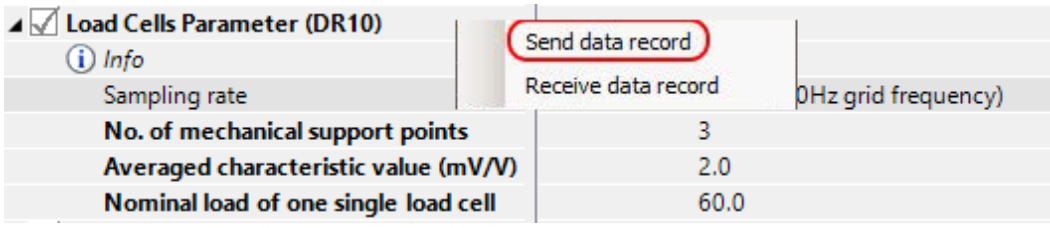

Figure 2-1145 SIWATOOL load cell parameters: Send data record

⇒ All parameter settings in DR10 are identical between PC and SIWAREX. All load cell parameters (DR10) are shown in black.

NOTICE
Parameters overwritten It is not possible to send or receive individual parameters within a data record. The complete data record must initially be received for every change to parameters within it. The desired parameter can then be edited and the data record sent again. If not all the data can be received from the scale before the parameter change, the active offline parameters in the scale can be overwritten by the "Send data record" function. Therefore, proceed as follows: 1. Select the "Receive data record" function. 2. Change the parameters. 3. Select the "Send data record" function.

Run automatic calibration

- After sending the calibration parameters to SIWAREX, select "Automatic calibration" in the Service menu with an empty scale. Empty scale means only the mechanical dead load (e.g. empty container) rests on the load cells.

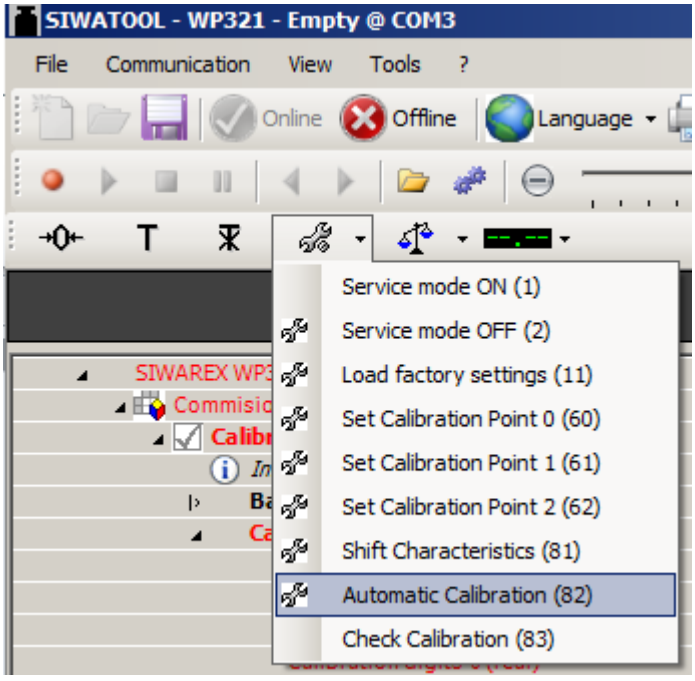

- Select "Service mode off" in the Service menu.

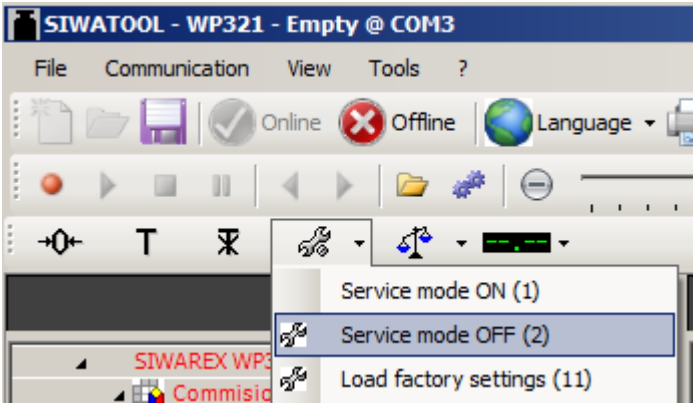

⇒ The calibration is finished and the correct weight value is now displayed in the SIWATOOL program.

Receiving calibration parameters

During the calibration, the SIWAREX internally changes its calibration digits. This means that SIWATOOL now has obsolete parameter values. Obsolete calibration parameters are marked in red.

The calibration parameter (DR3) must be read back in order once again obtain the calibration digits in the SIWATOOL which are consistent with the SIWAREX.

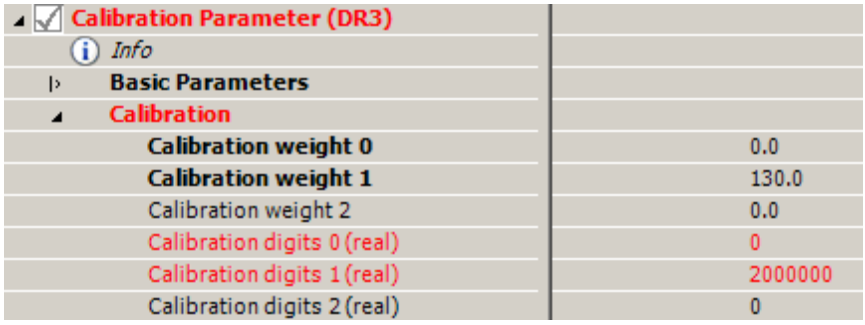

Figure 2-1146 SIWATOOL: Obsolete calibration parameters

- Right-click on "Calibration parameter (DR3)" and select "Receive data record".

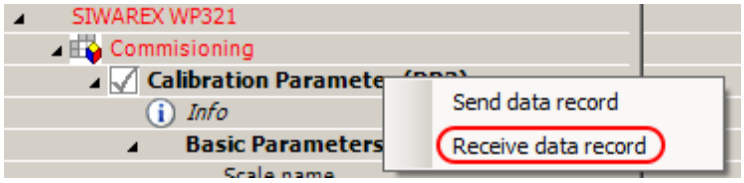

Figure 2-1147 SIWATOOL calibration parameters: Receive data record

Checking the scale following calibration

If the scale is to be used for business purposes only, check it as follows:

1. The scale is unloaded and the display shows "0 kg".
2. Place one or more known test weights on the scale. To check other weight points of the scale in addition to the calibration weight, do not use the calibration weight.
3. Check the displayed weight value in the SIWATOOL program.
4. Remove the test weights from the scale.
5. Check that the display of the scale is 0 kg again.

7.4.4 Receive all data

- Activate the "Receive all data" function in the "Communication" menu.

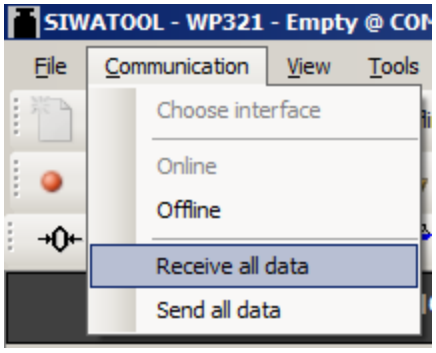

⇒ All parameters can be saved as a backup file on the hard disk. If a module is replaced, the backup file can be downloaded to the new module within a few seconds. The new module is right back to the calibrated state - without repeated calibration.

7.5 Service with the SIWATOOL program

You can use the SIWATOOL program to commission the scale independently of the SIMATIC automation system. You require an RS485/USB converter in order to connect the PC to the SIWAREX (see section Ordering data (Page 124)). You can then connect the RS485 interface of the SIWAREX to the USB port of the PC.

The SIWATOOL program is included in the configuration package.

Install SIWATOOL for commissioning (part of the SIWAREX WP321 configuration package, see section Ordering data (Page 124)) on your PC.

7.5.1 Windows and functions of SIWATOOL

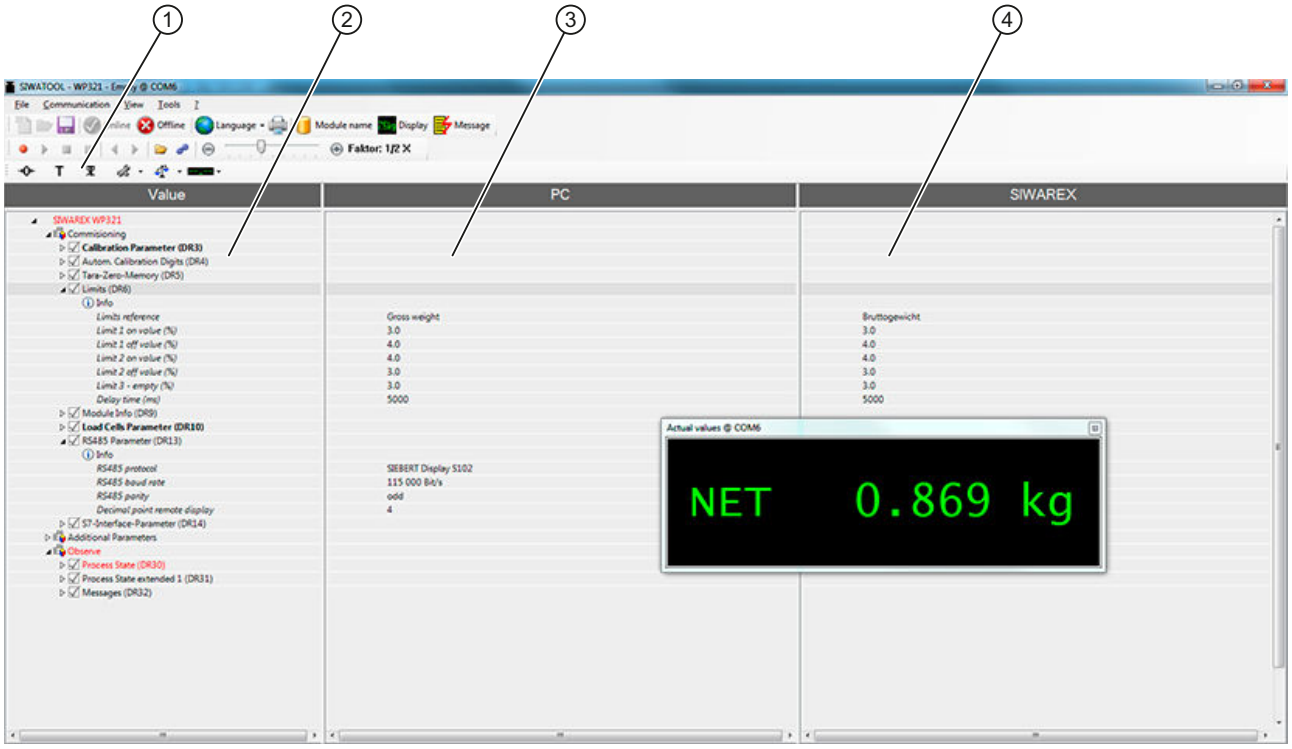

① Control elements for SIWATOOL and operation of the scale

② Parameter list of the SIWATOOL module

③ Offline values of the SIWAREX module

④ Online values of the connected SIWAREX module

Figure 2-1148 Layout of the SIWATOOL user interface

For sending, receiving and transferring, select the corresponding data record and call the command list with a right mouse click.

The complete data record (all parameters of the data record) is always transferred, not just individual parameters.

Parameters marked in bold are relevant for typical application cases.

7.5.2 Offline parameter assignment

All scale parameters can be edited and saved without an electronic weighing system.

This reduces the setup time. You can thus prepare the parameters for several scales in your office, and subsequently transfer them to the electronic weighing system during setup.

Data from one scale currently in operation can be exported and used to set up another scale.

7.5.3 Online parameter assignment

To switch to online mode, connect the PC to the SIWAREX module via an RS485/USB converter. Set the appropriate interface in the communication menu.

You can change all parameters in the SIWAREX module in online mode. The message window shows the current contents of the message buffer of the SIWAREX module. The current process values are displayed in the "Online" column.

For test purposes, you can send various commands to the SIWAREX module. Differences between the online/offline data are marked in red by SIWATOOL. This affects both the associated data record and the individual parameter.

In order to archive data, all data can be exported from the SIWAREX module and saved as a file or printed.

NOTE

You can edit all data in the SIWAREX module in online mode. The changes are not automatically imported to the corresponding scale data block in the SIMATIC CPU.

To download the data to the SIWAREX module, select the data record with a right mouse click and send it explicitly to the SIWAREX module.

Online parameter trends can be recorded and played back using the recorder function located at the top right-hand edge of SIWATOOL. You can use the "Configure recorder" button to select the data records to be recorded and to set the save parameters. The playback speed can be set using a slider.

7.5.4 Available help options

SIWATOOL offers various help options for operation:

- Info card

  You can select the "Info" item directly underneath the individual data records in the navigation tree. This info card explains how the data record influences the scale behavior.
- Tooltip

  If you move the mouse over a button or parameter, a corresponding help text is displayed.
- Help

  Click on the menu option "Help" to call up the SIWATOOL help. The Help can be opened separately.

7.5.5 Entering parameters with SIWATOOL

There is a defined procedure for handling parameters. The current parameters in the SIWAREX module are displayed in the right-hand window, while the parameter values on the PC are displayed in the left-hand window. The new parameter value is entered first in the left-hand window. If several parameters of the data record are to be changed, they are entered consecutively. The data record is subsequently selected in the tree view and sent to the SIWAREX modules using the right mouse button.

Parameters are always changed as complete data records, rather than individually.

Scale parameters and functions

8

8.1 Parameters and functions

All parameters are set to default values in the factory. You can restore the configuration to factory settings using the "Load factory settings" command.

The scales are ready for operation with the default parameter settings. You do not need to re-enter all parameters. The advantage of this solution is that you can decide the default values to be retain and the parameters that need to be adapted for your application.

All parameters are divided into data records (DR). The data records are organized in steps (tasks) to be implemented during commissioning or during the process.

The scale functions governed by the parameters are also described in the parameter description below.

First, the parameters of a given data record are displayed in a table. The detailed parameter description for the parameters of this data record then follows.

When it receives new parameters, the SIWAREX module runs a validation check. In the event of a parameter assignment error, the data record is not applied (not saved) by the SIWAREX module and a data/operator error is reported.

8.2 Assigning parameters to the electronic weighing system with SIWAREX DB

Introduction

You can assign parameters to the SIWAREX WP electronic weighing systems using the SIMATIC HMI, the SIWATOOL or the SIMATIC S7 control system. The procedure described for you is oriented to the data records (DS) from SIWATOOL and the SIMATIC S7 control system.

Procedure

1. Set the Load cell type parameter to SIWAREX DB in data record DR03. (Not relevant for SIWAREX WP321)
2. Set the RS 485 protocol parameter to SIWAREX DB and the RS 485 baud rate to 115 200 bits/s in data record DR13.
3. Activate the load cell input for every connected load cell in the data record DR70.
4. Specify whether 4- or 6-wire load cells are connected for the Sensor type parameter in data record DR70.

5. In order to identify the load cell type and the installation location of your load cells enter the Load cell manufacturer, Load cell order number and Location Designation of Sensor in the data record DR70.
6. The details of the data data records and parameters are specified in the parameter assignment tables.

8.3 DR 2 command code

DR 2 is a special data record used to transfer commands to the SIWAREX module by SIWATOOL.

8.4 DR 3 calibration parameters

The calibration parameters need to be checked and if necessary modified for all scales.

The scale is basically defined by calibration parameters and calibration operation.

Procedure

- Check all parameters and modify them as required.
- Transfer the DR 3 data record from SIWATOOL to the scale.
- Calibrate the scale.
- Transfer the DR 3 data record from the scale to SIWATOOL.

Table 2-1293 Assignment of data record 3

Variable	Note	Type	Length (bytes)	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	UINT	2	r	3	-	-
Length	Data record length information	UINT	2	r	124	-	-
Application	Information on which application the DR belongs to	UINT	2	r	201	-	-
Version identifier	Information on the current data record version	UINT	2	r	1	1	65 635
Scale name header	Maximum length and actual length of string for scale name	UBYTE[2]	2	rw	12,12	-	-
Scale name (Page 63)	Scale name specified by user	STRING[12]	12	rw	" "	-	-
Weight unit header	Maximum length and actual length of string for weight unit (for example, g, kg, t, ...)	UBYTE[2]	2	rw	04,04	-	-
Unit of weight (Page 63)[1)]	Weight unit	STRING[4]	4	rw	"kg••"	-	-

1) Parameter for calculation of calibration points

Variable	Note	Type	Length (bytes)	Rw	Default	Min.	Max.
Gross identifier header	Maximum length and actual length of string for weight unit	UBYTE[2]	2	rw	02,02	-	-
Gross identifier (Page 63)	Abbreviation of gross (B or G), only one byte is used!	STRING[2]	2	rw	"B"	"B"	"G"
Reserve	Reserve	UINT	8	rw	0	-	-
Maximum weighing range (Page 63) [1]	Maximum weight	REAL	4	rw	100	> wb_min* ZIF.step	maximum number range
Calibration weights 0, 1, 2 and calibration digits 0, 1, 2 (Page 63)	Calibration weight 0[1] (usually the zero point)	REAL	4	rw	0	0	9 999 999
	Calibration weight 1[1]	REAL	4	rw	100	0	9 999 999
	Calibration weight 2	REAL	4	rw	0	0	9 999 999
	Calibration digits 0 determined during calibration with calibration weight 0	DINT	4	rw	0	-3 999 999	+3 999 999
	Calibration digits 1 determined during calibration with calibration weight 1	DINT	4	rw	2 000 000	0	+3 999 999
	Calibration digits 2 determined during calibration with calibration weight 2	DINT	4	rw	0	0	+3 999 999
Scale interval (Page 63) [1]	Resolution weighing range 1 (1*10**k, 2*10**k, 5*10**k]; k: -3 ... 2)	REAL	4	rw	0.1	0.001	50
Reserve	Bit 1: Reserve	BIT	2	rw	0	0	1
Reserve	Bit 2: Reserve	BIT	0	rw	0	0	1
Automatic zero adjustment (Page 63)	Automatic zero tracking (zero tracking device) 0: Autom. zeroing off 1: Autom. zeroing on	BIT	0	rw	0	0	1
Reserve (13 bits)	Bit 3: Reserve	BIT	0	rw	0	0	1
Decimal places for process values (Page 64)	0: No rounding 1: Rounding to 1 decimal place 2: Rounding to 2 decimal places 3: Rounding to 3 decimal places 4: Rounding to 4 decimal places 5: Rounding to 5 decimal places 6: Rounding to 6 decimal places	UINT	2	rw	0	0	6
Maximum tare load (Page 64)	Range of subtractive tare unit [in % of max. weighing range]	REAL	4	rw	0	0	250
Reserve	Reserve	REAL	8	rw	1.0	0	100.0
Maximum negative zeroing limit (Page 64)	Negative range of semi-automatic zeroing device [in % of max. weighing range]	REAL	4	rw	1	0	100.0

[1] Parameter for calculation of calibration points

Variable	Note	Type	Length (bytes)	Rw	Default	Min.	Max.
Maximum positive zeroing limit (Page 65)	Positive range of semi-automatic zeroing device [in % of max. weighing range]	REAL	4	rw	3.0	0	100.0
Standstill range (Page 65)	Standstill range (in d)	REAL	4	rw	0.1	0	maximum number range+
Standstill time (Page 65)	Standstill time 1 in ms	TIME	4	rw	2 000	10	10 000
Standstill waiting time (Page 66)	Waiting time until standstill. 0: standstill-dependent scale command, if there is no standstill, immediately rejected. > 0: Maximum waiting time until command is executed	TIME	4	rw	2 000	0	10 000
Limit frequency low pass filter 1 (Page 66)	Low-pass filter cut-off frequency: 0: Filter disabled	REAL	4	rw	1	0.01	200
Order no. low pass filter 1 (Page 67)	Filter number	UINT	2	rw	4	0	4
Reserve	Reserve	UINT	2	rw	0	-	-
Limit frequency low pass filter 2 (Page 66)	Low-pass filter limit frequency: 0: Filter disabled	REAL	4	rw	0	0.01	200
Order no. low pass filter 2 (Page 67)	Filter number	UINT	2	rw	4	0	4
Mean value filter depth (Page 67)	Filter for digit values, Permissible filter depth: 0 ... 250	UINT	2	rw	10	0	500

1) Parameter for calculation of calibration points

8.4.1 Scale name

You can select any name, but it may not exceed 12 characters. You can enter any designation.

8.4.2 Unit of weight

A string with up to four digits can be specified as the unit of weight, e.g.: t, kg, lbs. The defined unit of weight applies to all weight specifications. Entries are not be converted if the unit of weight has changed. Entries must be left-aligned.

8.4.3 Gross identifier

The gross identifier specifies the letter, B (for brutto) or G (for gross), to be used in the display for gross weights.

8.4.4 Maximum weighing range

The weight can only be used with the defined scale interval below the maximum weight (+ 9 d, d = scale interval). The maximum weight is defined during commissioning. Exceeding the maximum weight is indicated in the status (DR30).

The maximum weight depends on the number and type of load cells used.

8.4.5 Calibration weights 0, 1, 2 and calibration digits 0, 1, 2

The calibration weights and corresponding calibration digits define the characteristic curve of the scales. A detailed description can be found in section Calibration procedure (Page 67).

8.4.6 Scale interval

The scale interval for the weighing range can be defined in accordance with EN 45501 (0.0001 to 50).

8.4.7 Automatic zero adjustment

If required, you can carry out semi-automatic zeroing of the scale using the "Zeroing" command.

The automatic adjustment sets the scale to zero without a further command in the event of slow zero drifting. Slow drift is assumed if the OIML R76 criteria are met.

NOTE

If this function is enabled, the scale may eventually read zero after a slow drift even if they are fully loaded. The function can, however, be limited by specifying a maximum and minimum weight for zeroing.

8.4.8 Decimal places for process values

This parameter is used to specify the number of decimal places to which the process values are to be rounded. This value decouples the main display of the weight values from the values used in the control software.

8.4.9 Maximum tare load

The weighing module accepts any external tare specification which is less than the maximum tare load (percentage of maximum weighing range). Tare commands are also accepted provided that the current gross weight is less than the configured maximum tare load.

8.4.10 Maximum negative zeroing limit

Zeroing defines the current weight of the scales as zero.

You can limit the effect of the zeroing function. The limitation is based not on the current gross weight, but rather on the weight which the scales would display had there been no zeroing (time of scale calibration).

8.4.11 Maximum positive zeroing limit

You can limit the effect of the zeroing function. The limitation is based not on the current weight, but rather on the weight which the scales would display had there been no zeroing (time of scale calibration).

8.4.12 Standstill range

Standstill monitoring checks whether the scales are correctly balanced. Scale standstill is registered if the weight changes by less than a specified fluctuation in d (standstill value) over a specified time (standstill time). Standstill monitoring is used in static scale mode (commands: zeroing, taring). The diagram below illustrates how standstill monitoring works.

The current weight can only be registered in legal trade applications if standstill is reached.

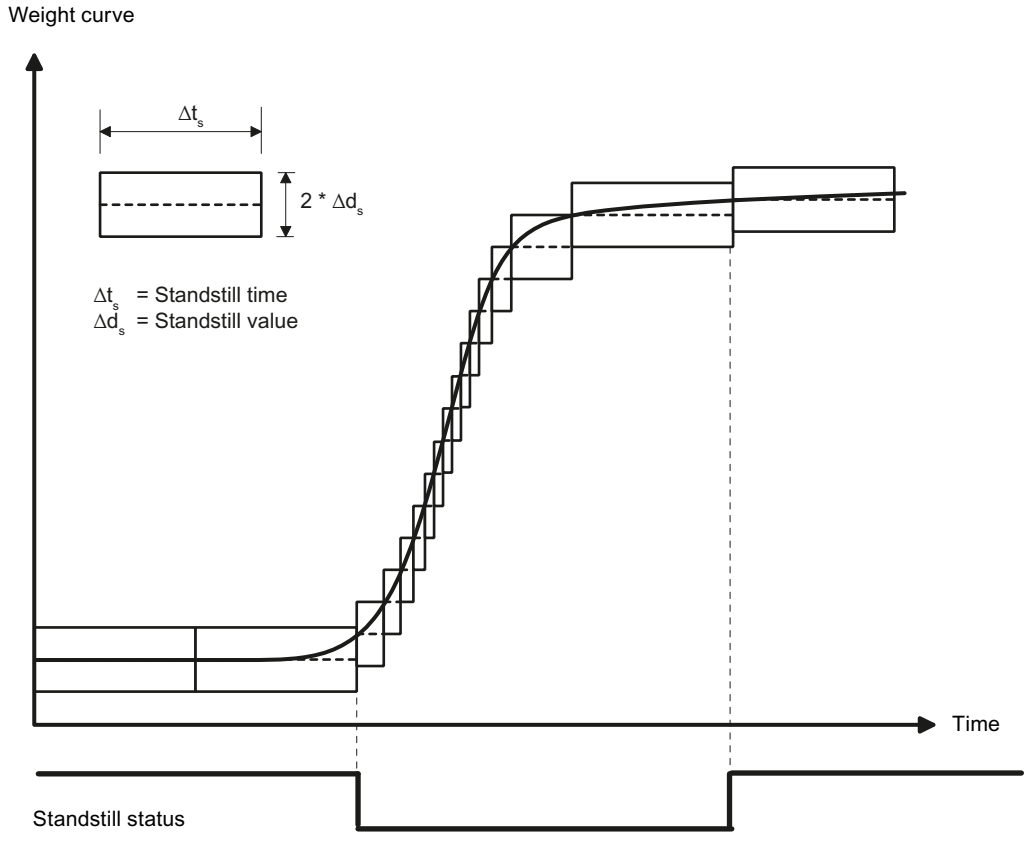

Figure 2-1149 Standstill monitoring

8.4.13 Standstill time

Standstill monitoring checks whether the scales are correctly balanced. Scale standstill is registered if the weight changes by less than a specified fluctuation in d (standstill value) over a specified time (standstill time). Standstill monitoring is used in static scale mode (with the following commands: zeroing, taring).

8.4.14 Standstill waiting time

Standstill waiting time is a maximum waiting time for standstill on execution of a command which depends on standstill (taring, zeroing). A technology message is generated if the command cannot be executed during the standstill waiting time because there is no standstill.

If the standstill waiting time is equal to zero, a command requiring standstill is rejected immediately if there is no standstill.

8.4.15 Low-pass filter limit frequency

There is a critically damped low-pass filter for suppressing faults. The diagram below shows the step response of the filter (f_g = 2 Hz). The entry "0" means that the filter is switched off. The setting range of the limit frequency is 0.01 to 50.0 Hz.

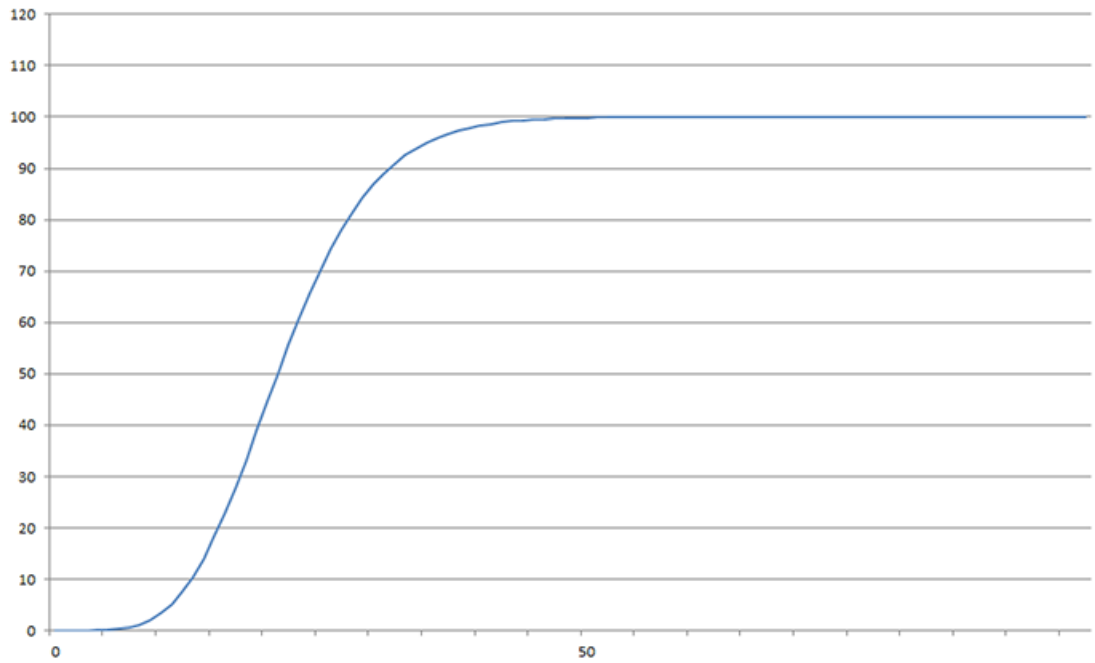

Figure 2-1150 Step response of the digital low-pass filter when f_g = 2 Hz

When you define the limit frequency, it is extremely important for the suppression of faults. Defining the limit frequency defines the "speed" of the scale's response to changes in the measured value.

A value of 5 Hz, for example, results in a relatively rapid response to a change in weight. A value of 0.5 Hz, for example, makes the scale "slower".

NOTE

Process values filtered with low-pass filter 1 are available at the SIMATIC I/O (DR 14) and in the DR 30. Process values filtered with low-pass filter 2 can only be set to the SIMATIC I/O with the corresponding selection in DR 14.

8.4.16 Low-pass filter number

The number of the filter defines the effect of damping. The values 2 and 4 can be set. The higher the selected filter number, the higher the effect.

8.4.17 Mean value filter depth

The mean value filter is used to steady the weight against random interference. The weight is the mean value of n (n = max. 250) weights which are recorded by the weighing module every 10 ms, e.g. when n = 10, the mean of 10 weights is calculated. Every 10 ms, the oldest value is discarded and the newest value included in the calculation.

8.5 Calibration procedure

8.5.1 Calibration with calibration weights

The incoming analog measured value from the load cells is converted into a digital value in an analog-to-digital converter. A weight is calculated using this digital value. This weight is then used by all weighing module functions for messages and for determining the status.

The characteristic curve of the measuring system must be defined before the weight can be calculated from the digital value. In the simplest case, the characteristic curve is defined with points 0 and 1. The first working point (point 0) is defined by the empty scale (no load) at their own weight. The load cells return a voltage measurement to the weighing module as a result of the weight of the scales themselves. Following analog-to-digital conversion of the measured voltage, the zero point is assigned to the digital value (calibration digits for the zero point).

If the scales are loaded with a defined standard weight (e.g. 50% of the measuring range), the new digital value returned by the analog-to-digital converter is assigned the standard weight.

The characteristic curve can also be determined with a third point, which must be higher than point 1.

Make sure that the difference between two calibration weights is at least 40 000 digits, as the calibration command may otherwise be rejected.

The calibration procedure involves the following steps:

- Activation of service mode using the "Service mode on" command.
- Define the calibration weight and other parameters of the DR 3 data record.
- Transfer the DR 3 data record to the scales.
- Trigger "Adjustment weight 0 valid" for empty scales.
- Load the scale with the defined standard weight.
- Trigger "Adjustment weight 1 valid".
- Transfer data record DR 3 from the scale to SIWATOOL and save the data on a data medium.

You must follow the correct calibration sequence with increasing calibration weights.

Example

Zero point = 0.0 kg (always)	equals 326348 digits
Calibration weight 1 = 100 kg	equals 1324765 digits

Load cell characteristic value	Calibration digit 1 (ca.) when rated load is
1 mV/V	500 000
2 mV/V	1 000 000
4 mV/V	2 000 000

This defines the characteristic curve and the scale can now calculate weights for the full measuring range.

The diagram below illustrates the relationship between calibration digits and the calibration weight.

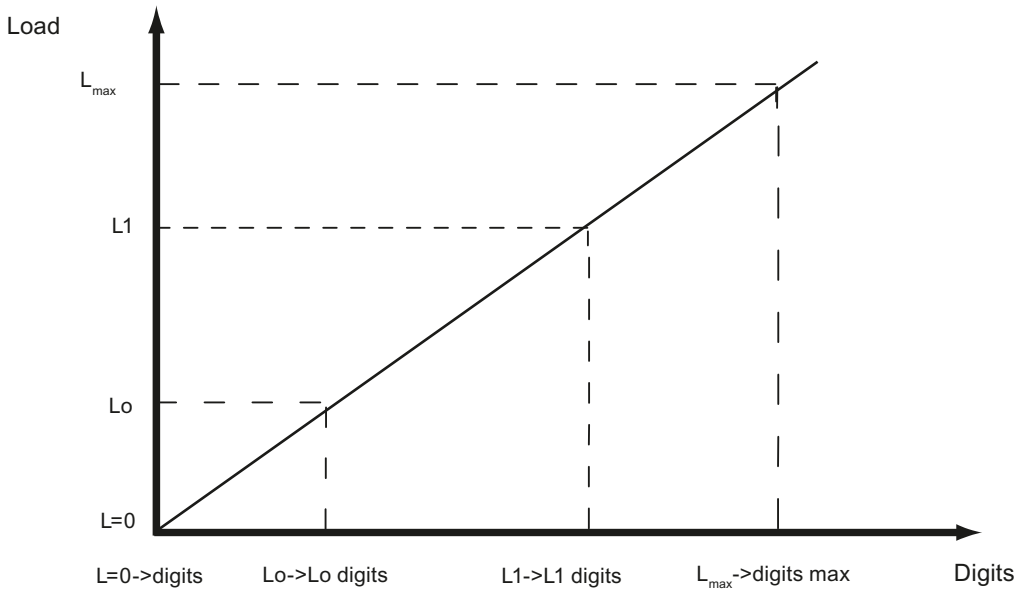

Figure 2-1151 Calibration digits and calibration weight

Load	Comment	Load	Digits
L=0	Load cells empty		Approx. 0
Lo	Calibration weight 0 "Zero point"	0 kg	e.g. 70 682 for calibration point 0
L1	Calibration weight 1	e.g. 60 kg	e.g. 308 452 for calibration digits 1
L_{max}	Rated load of the load cell(s)	e.g. 100 kg	1 000 000
L_{max} +10 %	Rated weight + approximately 10%	e.g. approximately 110 kg	1 090 000

You do not need to perform calibration if the calibration digits and the calibration weights are known to the weighing module described here. They are simply sent to SIWAREX by data record DR 3 and the scale is ready for use immediately.

The SIWATOOL program facilitates rapid calibration.

Following commissioning and calibration, all data records must be read from the weighing module and saved as a scale file.

Identical scales can be put into operation immediately. Connect the PC to the new scale and enable the "Send all data records" function in service mode. This transfers the parameters for calibration weights and calibration digits, and the characteristic curve is determined immediately. The same applies when you change a weighing module.

NOTE

Two working points are usually sufficient for determining the scale's characteristic curve. An additional working point is only required for non-linear systems.

Specification of negative calibration points is not possible. However, the characteristic can also be used in the negative range down to -2 000 000 digits. To achieve this, the characteristic curve generated in the positive range is extended into the negative range.

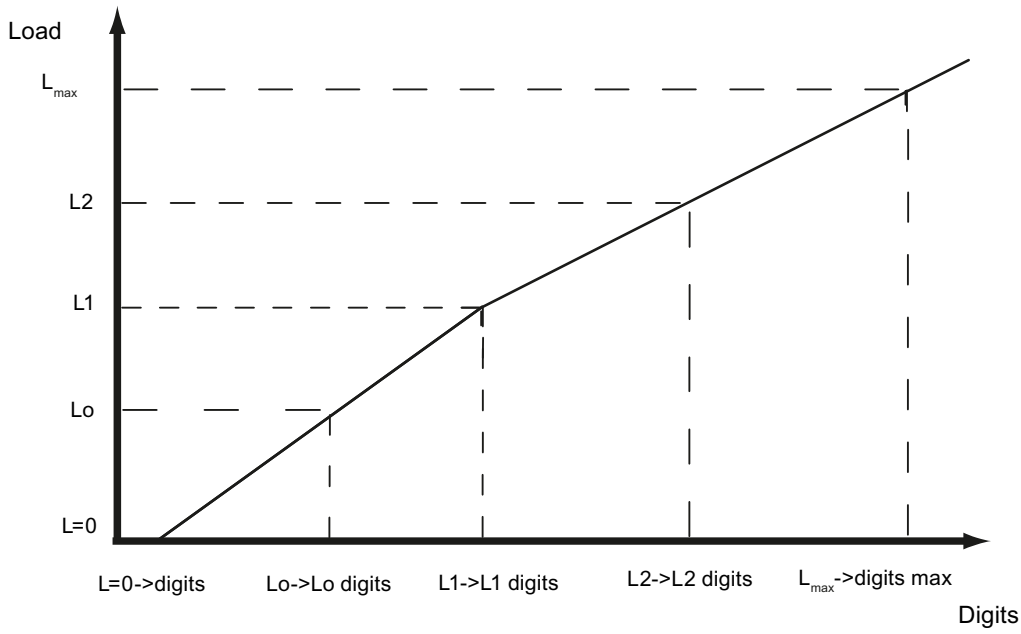

Figure 2-1152 Linearizing the scale's characteristic curve

Load	Comment	Load	Digits
L=0	Load cells empty		Approx. 0
Lo	Calibration weight 0 "Zero point"	0 kg	e.g. 76 082 for calibration point 0
L1	Calibration weight 1	e.g. 60 kg	e.g. 386 452 for calibration digits 1
L2	Calibration weight 2	e.g. 80 kg	e.g. 451 367 for calibration digits 2
L_{max}	Rated load of the load cell(s)	e.g. 100 kg	1 000 000
L_{max} +10 %	Rated weight + approximately 10%	e.g. approximately 110 kg	1 090 000

8.5.2 Automatic calibration

Scales can be rapidly commissioned with automatic calibration. The accuracy of the scale greatly depends on the entered parameters and the mechanical properties of the scale. However, you achieve the best level of accuracy for the scales by using calibration weights.

During initial commissioning with automatic calibration, you must reset the module using the "Load factory settings" command.

Subsequently specify the basic parameters in DR 3 and the load cell parameters in data record 10. See also the section: Automatic calibration (without calibration weight) (Page 51). Command 82 "Perform automatic calibration" then uses this data and the currently applied dead load to calculate the characteristic curve of the scale. The characteristic curve is active immediately.

NOTE

The characteristic curve data in data record 3 active prior to execution of command 82 is directly overwritten.

Automatic calibration requires the following criteria:

- Correct mechanical installation of the scale
- Scale is empty (only mechanical installation (= dead load) present on the cells) or the material weight in/on the scale is known (e.g. after conversion to WP321).
- Load cells are evenly loaded
- There are no shunt circuits

8.6 DR 4 Output of calculated calibration digits

Date record DR 4 outputs the digits calculated from automatic scale calibration.

This data record cannot be sent to the scale.

Table 2-1294 Assignment of data record 4

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	UINT	2	r	4	-	-
Length	Data record length information	UINT	2	r	28	-	-
Application	Information about which application the DR belongs to	UINT	2	r	201	-	-
Version identifier	Information on the current data record version	UINT	2	r	1	1	65635
Calibration digits 0, 1, 2 (calculated) (Page 71)	Calibration digits 0 (calculated): Calibration digits calculated in "Automatic Calibration"	DINT	4	r	?		

Variable	Note	Type	L	Rw	Default	Min.	Max.
Calibration digits 0, 1, 2 (calculated) (Page 71)	Calibration digits 1 (calculated): Calibration digits calculated in "Automatic Calibration"	DINT	4	r	0		
	Calibration digits 2 (calculated): Calibration digits calculated in "Automatic Calibration"	DINT	4	r	0		
Reserve 1	Reserve	INT	2	r	0	-	-
Reserve 2	Reserve	UINT	2	r	0	-	-
Reserve 3	Reserve	REAL	4	r	0	-	-

8.6.1 Calibration digits 0, 1, 2 (calculated)

The calculation is based on the parameters from DR 3 and DR 10 identified by bold font and is activated by the command no. 82.

8.7 DR 5 zeroing memory

Data record DR 5 displays the current values in the tare memory and the zeroing memory.

Procedure

- Check all parameters
- Transfer the data record to the scale

Table 2-1295 Assignment of data record 5

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	UINT	2	r	5	-	-
Length	Data record length information	UINT	2	r	40	-	-
Application	Information about which application the DR belongs to	UINT	2	r	201	-	-
Version identifier	Information on the current data record version	UINT	2	r	1	1	65635
Effective tare weight - from specification (Page 72)	Current tare weight from specification as process value	REAL	4	rw	0	0	Depends on specification in DR 3
Effective tare weight (semi-automatic) (Page 72)	Current tare weight from semi-automatic mode as process value	REAL	4	rw	0	0	Depends on specification in DR 3
Reserve	Reserve	REAL	4	rw	0	-	-

Variable	Note	Type	L	Rw	Default	Min.	Max.
Zero weight (semi-automatic) (Page 72)	Current zeroing weight (affected by zeroing)	REAL	4	rw	0	Depends on specification in DR 3	Depends on specification in DR 3
Current zero tracking weight (Page 73)	Zero point correction weight affected by automatic zeroing	REAL	4	rw	0	Depends on specification in DR 3	Depends on specification in DR 3
Dead load (Page 73)	Dead load determined during calibration	REAL	4	r	0	Depends on specification in DR 3	Depends on specification in DR 3
Reserve 1	Reserve	INT	2	rw	0	-	-
Reserve 2	Reserve	UINT	2	rw	0	-	-
Reserve 3	Reserve	REAL	4	rw	0	-	-

8.7.1 Effective tare weight - from specification

A tare weight can be specified in data record DR 15. You activate the specified tare weight with a command (see command 1013). From this point on, the activated tare weight is factored into the weight calculations. The "Delete tare" command deactivates the active tare weight. This does not delete the specification in data record DR 15.

8.7.2 Effective tare weight (semi-automatic)

The corresponding command (see command 1011) applies the current gross weight as the active tare weight. From this point on, the activated tare weight is factored into the weight calculations. The "Delete tare" command deactivates the active tare weight.

8.7.3 Zero weight (semi-automatic)

The zero weight command (see command 1001) entered by the user sets the current gross weight to "Zero" provided it is within the defined zero setting limits. The current gross weight is saved as the zero weight. The zeroing weight must be within the specified range (usually +3 / -1 % of the set zero point).

8.7.4 Current zero tracking weight

The current zero tracking weight is recorded in this parameter if automatic zero tracking is activated.

8.7.5 Dead load

The characteristic curve of the scales is determined during calibration. When there is no load, the main display returns "0". The dead load is the weight of the empty scales, i.e. the weight of the scales themselves.

8.8 DR 6 limit value settings

The switch-on and switch-off values for the limits are configured in data record DR 6.

Procedure

- Check all parameters and modify them as required
- Transfer the data record to the scale

Table 2-1296 Assignment of data record 6

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	UINT	2	r	6	-	-
Length	Data record length information	UINT	2	r	60	-	-
Application	Information on which application the DR belongs to	UINT	2	r	201	-	-
Version identifier	Information on the current data record version	UINT	2	r	1	1	65 635
Limit reference (Page 74)	Reference value for limits 0: Gross weight in % of max. weighing range 1: Net weight in % of max. weighing range 2: Gross weight, absolute 3: Net weight, absolute	UINT	2	rw	0	0	1
Reserve	Reserve	UINT	2	rw	0	0	-
Limit value 1 ON (Page 74)	Switch-on point for Limit 1	REAL	4	rw	0	maximum number range	maximum number range
Reserve	Reserve	TIME	4	rw	0	0	maximum number range+
Limit value 1 OFF (Page 74)	Switch-off point for Limit 1	REAL	4	rw	0	maximum number range	maximum number range
Reserve	Reserve	TIME	4	rw	0	0	maximum number range+

Variable	Note	Type	L	Rw	Default	Min.	Max.
Limit value 2 ON (Page 74)	Switch-on point for Limit 2	REAL	4	rw	0	maximum number range	maximum number range
Reserve	Reserve	TIME	4	rw	0	0	maximum number range+
Limit value 2 OFF (Page 74)	Switch-off point for Limit 2	REAL	4	rw	0	maximum number range	maximum number range
Reserve	Reserve	TIME	4	rw	0	0	maximum number range+
Limit value "Empty" ON (Page 75)	Limit value "empty" ON With limit reference 0 and 1: Based on the gross weight in % of max. weighing range With limit reference 2 and 3: in relation to absolute gross weight	REAL	4	rw	0	maximum number range	maximum number range
Delay time for limits (Page 75)	Uniform delay time for limits in ms	TIME	4	rw	0	0	maximum number range+
Reserve	Reserve	UINT	2	rw	0	-	-
Reserve	Reserve	UINT	2	rw	0	-	-
Reserve	Reserve	REAL	4	rw	0	-	-

8.8.1 Limit reference

Value	Limit values relate to
0	Gross weight in % of max. weighing range
1	Net weight in % of max. weighing range
2	Absolute gross weight
3	Absolute net weight

The limit value "Empty" always relates to gross weight zero.

8.8.2 Limit value 1 ON, limit value 2 ON, limit value 1 OFF, limit value 2 OFF

The switch-on and switch-off points can be specified separately for each limit as a percentage of the measuring range or as absolutely values (based on "Limit reference" parameter setting). This allows both minimum and maximum value violation monitoring with hysteresis. A delay time for switch-on and switch-off can also be specified. Either the current net weight or the current gross weight can be selected as the reference value for limits 1 and 2. Negative limits are only possible with input of absolute values. Negative limits as percentage are rejected.

Maximum value monitoring is implemented with the following specifications:

- Switch-on value > switch-off value

Minimum value monitoring is implemented with the following specification:

- Switch-on value < switch-off value

The diagram below illustrates the function of limit values 1 and 2.

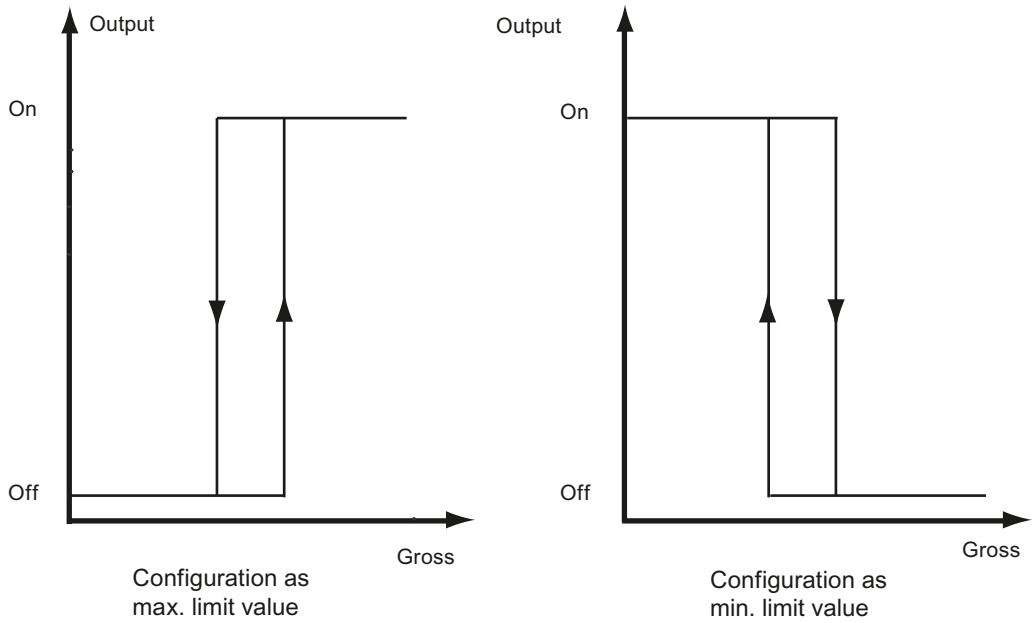

Figure 2-1153 Limit value configuration

8.8.3 Limit value "Empty" ON

The value for the empty range is a limit value below which the weighing module registers and returns the status "empty". The values are entered as a percentage of the measuring range. The "Empty" limit always refers to the current gross weight in the scale.

The setting, whether absolute or a percentage, also affects the "Empty" limit.

8.8.4 Delay time for limits

If the weight reaches the specified switch value, a delay time (defined in ms) is launched. Once the delay time is over, the limit switch changes status provided the weight still reaches the specified switch value.

This delay time applies to the switch-on and switch-off values 1 and 2 and to the switch-on limit for the empty value. The empty value does not have a switch-off delay.

8.9 DR 9 module information

No entries can be made in data record DR 9. This data record provides information on the inner workings of the SIWAREX module. This information is used to identify the module at the manufacturer plant (e.g. in the event of repairs). The entries in the data record are of no importance to the user for operation.

Table 2-1297 Assignment of data record 9

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	UINT	2	r	9	-	-
Length	Data record length information	UINT	2	r	68	-	-
Application	Information about which application the DR belongs to	UINT	2	r	201	-	-
Version identifier	Information on the current data record version	UINT	2	r	1	1	65635
Order number - header	Maximum and current string length for the order number	UBYTE[2]	2	r	16,16	-	-
Order number	Order number of the module 7MH ..	STRING[16]	16	r	"7MH ..."	-	-
Serial number - header	String header	UBYTE[2]	2	r	12,12	-	-
Serial number	Serial number " XXX00001"	STRING[12]	12	r	" "	-	-
Firmware type - header	String header	UBYTE[2]	2	r	2.2	-	-
Firmware type	Reference V - Release B - Test etc.	STRING[2]	2	r	'V '	-	-
FW version - 1st digit	Version 1.	UINT	2	r	1	-	-
FW version - 2nd digit	Version 2.	UINT	2	r	0	-	-
FW version - 3rd digit	Version 3.	UINT	2	r	0	-	-
Hardware version number	ES hardware version number (e.g. 03)	UINT	2	r	1	-	-
OS version header	String header	UBYTE[2]	2	r	2.2	-	-
OS version (loader) - designation	Reference V - Release B - Test etc.	STRING[2]	2	r	'V '	-	-

Variable	Note	Type	L	Rw	Default	Min.	Max.
OS version (loader) - designation	e.g. version n	UINT	2	r	'V '	-	-
Reserve	Reserve	UINT	6	r	0	-	-
Reserve 4	0	REAL	4	r	0	-	-

8.10 DR 10 load cell parameters

The parameters of the analog load cells must be checked prior to the automatic calibration and modified if necessary. Only the parameters identified by bold font and asterisk (*) need be entered.

Procedure

- Check the parameters and modify them as required
- Transfer the data record to the scale
- Adjust the scales

Table 2-1298 Assignment of data record 10

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	UINT	2	r	10	-	-
Length	Data record length information	UINT	2	r	44	-	-
Application	Information about which application the DR belongs to	UINT	2	r	201	-	-
Version identifier	Information on the current data record version	UINT	2	r	1	1	65635
Reserve		UINT	2	rw	1	1	6
Selection of the sampling rate (Page 78)	Parameter code 0: Sampling rate 100 Hz (preferably with line frequency of 50 Hz) Parameter code 1: 120 Hz (preferably with line frequency of 60 Hz) Parameter code 2: 600 Hz for fast measurements	UINT	2	rw	0	0	1
Number of support points (Page 79) [1]	Number of support points	UINT	2	rw	0	0	8
Reserve		UINT	2	rw	0	0	0
Load cell characteristic value (Page 79) [1]	Characteristic value of the load cell (n) [mV/V], the mean value is used if there is more than one cell.	REAL	4	rw	2	> 0.1	10
Reserve		REAL	4	rw	0		
Rated load of a load cell (Page 80) [1]	Rated load of a load cell	REAL	4	rw	60	-	-

[1] Parameter for calculation of calibration points with theoretical calibration

Variable	Note	Type	L	Rw	Default	Min.	Max.
Reserve	Reserve	REAL	4	rw	0	-	-
Reserve	Reserve	REAL	4	rw	0	-	-
Reserve	Reserve	INT	2	rw	0	-	-
Reserve	Reserve	UINT	2	rw	0	-	-
Reserve	Reserve	REAL	4	rw	0	-	-

1) Parameter for calculation of calibration points with theoretical calibration

8.10.1 Selection of the sampling rate

For better suppression of interferences, set the measuring rate and the line frequency as follows:

Measuring rate	Line frequency
100 Hz	50 Hz (parameter code 0)
120 Hz	60 Hz (parameter code 1)

Interferences can be caused by the power supply grid.

For fast measurements, you can select a measuring rate of 600 Hz (parameter code 2) as of firmware V1.2.0.

The setting has an effect on the frequency response of the signal path.

The following diagrams show the frequency response:

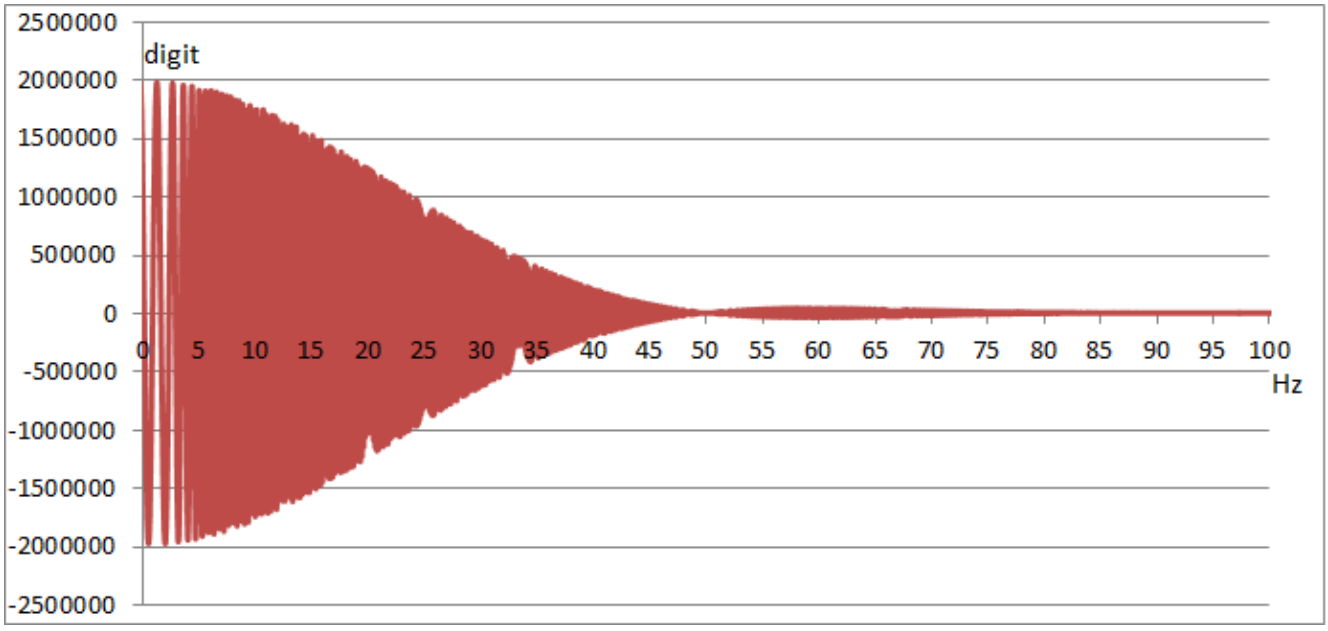

Figure 2-1154 Signal behavior SIWAREX WP321: Sampling rate 50 Hz (unfiltered)

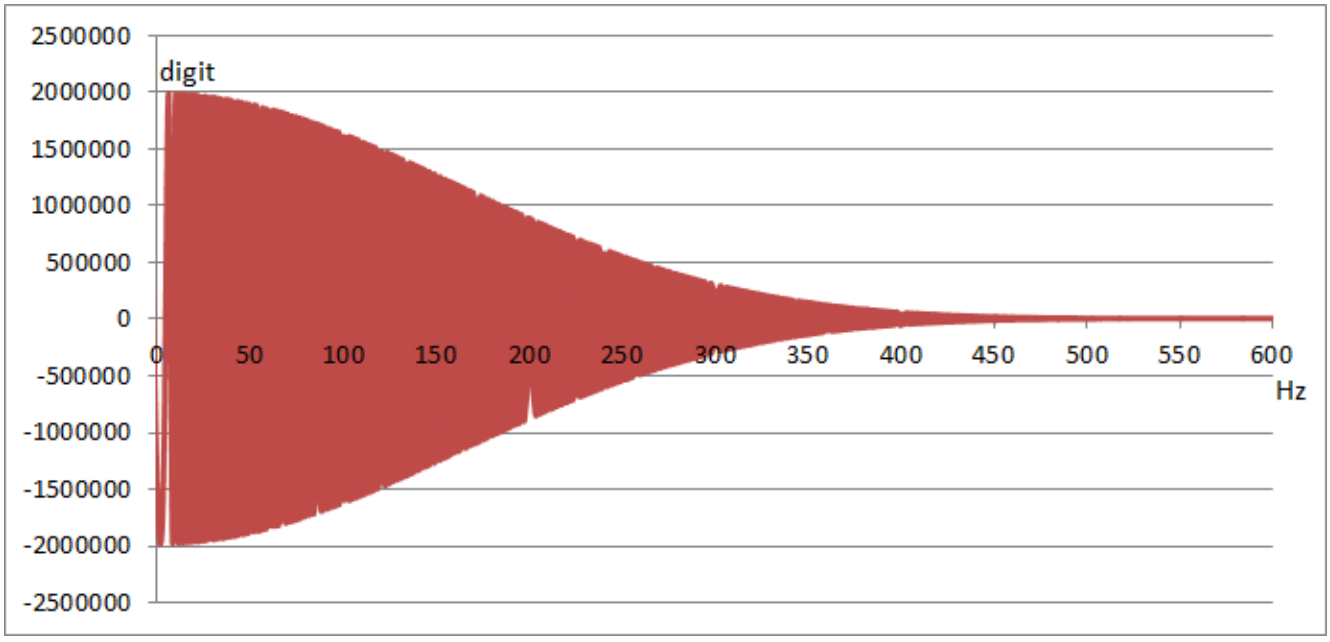

Figure 2-1155 Signal behavior SIWAREX WP321: Sampling rate 600 Hz (unfiltered)

8.10.2 Number of support points

If no anchor points are used, the number of support points is equal to the number of load cells.

If anchor points are used in addition to load cells, the number of support points is equal to the total number of load cells and fixed support points.

8.10.3 Load cell characteristic value

The load cell characteristic value is required to correctly interpret the output voltage from the load cell. This specification is also necessary for determining load cell overload. The exact value can be entered if the measurement log for the load cell is available. The mean value can be entered if there is more than one load cell.

Example

Characteristic value = 2.018 mV/V

8.10.4 Rated load of a load cell

The rated load of a load cell is required for checking the maximum weighing range of the scales. The rated load is entered in the specified units of weight.

8.11 DR 13 RS485 parameters

The parameters which define the response of the RS485 interface are specified in data record DR 13. If the interface is not used, the default values can be retained.

Procedure

- Check the parameters and modify them as required
- Transfer the data record to the scale

Table 2-1299 Assignment of data record 13

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	UINT	2	r	13	-	-
Length	Data record length information	UINT	2	r	24	-	-
Application	Information about which application the data record belongs to	UINT	2	r	201	-	-
Version identifier	Information on the current data record version	UINT	2	r	1	1	65635
RS485 protocol (Page 81)	0: No log 2: SIEBERT display 6: SIWAREX DB	UINT	2	rw	1	0	2
RS485 baud rate (Page 81)	0: 9 600 bps 1: 19 200 bps 2: 38 400 bps 3: 57 600 bps 4:115 200 bps (for SIWAREX DB)	UINT	2	rw	3	0	6
RS485 character parity (Page 81)	Character parity 0: even (for SIWAREX DB) 1: Odd	BIT	2	rw	0	0	1
Bit 1		BIT	0	rw	0	0	1
Bit 2		BIT	0	rw	0	0	1
Reserve (13 bits)	Reserve	BIT	0	rw	0	0	1
Reserve	Reserve	UINT	2	rw	20	1	255
Decimal place for Siebert indicator (Page 81)	Decimal place for Siebert display	INT	2	rw	0	-	-
Reserve	Reserve	UINT	2	rw	0	-	-
Reserve	Reserve	REAL	4	rw	0	-	-

8.11.1 RS485 protocol

This parameter defines the protocol for communication via the RS485 interface.

8.11.2 RS485 baud rate

This parameter defines the baud rate for the RS485 interface.

8.11.3 RS485 character parity

This parameter defines the character parity for the RS485 interface.

8.11.4 Decimal place for Siebert indicator

A fixed decimal place must be specified if a Siebert indicator is used. The following values are permitted: 0 ... 4

8.12 DR 14 SIMATIC interface parameters

The parameters which define the response of the SIMATIC interface are specified in data record DR 14. It is possible to define the process values to be output on the basis of the I/O area.

Procedure

- Check the parameters and modify them as required
- Transfer the data record to the scale

Table 2-1300 Assignment of data record 14

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	UINT	2	r	14	-	-
Length	Data record length information	UINT	2	r	16	-	-
Application	Information on which application the DR belongs to	UINT	2	r	201	-	-
Version identifier	Information on the current data record version	UINT	2	r	1	1	65 635
Selection of process value 1, 2 (Page 82)	Code for the selection of the process variable to be updated	UINT	2	rw	4	0	10

Variable	Note	Type	L	Rw	Default	Min.	Max.
Selection of process value 1, 2 (Page 82)	Code for the selection of the process variable to be updated	UINT	2	rw	3	0	10
Reserve 1	Reserve	INT	2	rw	0	0	-
Reserve 2	Reserve	UINT	2	rw	0	0	-

8.12.1 Selection of process value 1, 2

Read the current process values to the SIMATIC CPU with the DR 30 and DR 31 data records and the FB SIWA function block. The transfer of a larger data record is based on "acyclic services". It may take several SIMATIC CPU cycles and therefore have a negative effect on system performance.

The I/O interface of the SIWAREX module is the best option if a process value is to be rapidly transferred to the SIMATIC CPU as soon as it is created in the SIWAREX module. Data is applied cyclically by FB321 and provided as a tag in the scales data block.

The relevant code from the table below must be entered to define the tag for output via the I/O interface.

Table 2-1301 Selection table for process value 1,2

Process value	Decimal code	From DR	Format
No process selected	0	-	-
Gross process (after low-pass filter 1)	1	30	REAL
Net process (after low-pass filter 1)	2	30	REAL
Tare process	3	30	REAL
G/N weight (after low-pass filter 1)	4	30	REAL
G/N weight_x10	5	30	REAL
Unfiltered digit value	9	31	DINT
filtered digit value (after low-pass filter 1)	10	31	DINT
Refresh counter	12	30	UINT
Async. Error bits (32-bit): bits 0..15: operator error Bits 16..31: technology error	15	32	DINT
Gross process (after low-pass filter 2)	7	-	REAL
Net process (after low-pass filter 2)	8	-	REAL
Filtered digit value (after low-pass filter 2)	11	-	DINT

8.13 DR 15 manual tare specification

Data recorder DR 15 is used for an external specification of a tare weight.

Procedure

- Enter the tare weight
- Transfer the data record to the scale
- Enable the tare weight using command 1013

Table 2-1302 Assignment of data record 15

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	UINT	2	r	15	-	-
Length	Data record length inform-ation	UINT	2	r	16	-	-
Application	Information about which application the DR belongs to	UINT	2	r	201	-	-
Version identi-fier	Information on the current data record version	UINT	2	r	1	1	65635
Specification of tare weight (Page 83)	Tare specifica-tion memory (manual tare value)	REAL	4	rw	0	0	Depends on specification in DR 3
Reserve	Reserve	REAL	4	rw	0	0	-

8.13.1 Specification of tare weight

You can enter a tare weight. If a tare weight is to be applied, it must be enabled with the corresponding command. The tare weight must not exceed the maximum tare load specified in data record DR 3.

8.14 DR 30 current process values

Current states and process values in the scales can be monitored using process values and advanced process values from data record DR 31. Monitoring selected data during commissioning is extremely useful as it helps you to optimize parameters.

Procedure

- Read data record DR 30 cyclically or on a time-triggered basis
- Display/analyze the required tags

It is not always necessary to cyclically read data record DR 30. If the relevant process tags have already been selected in data record DR 14 (→ DR 14 SIMATIC interface parameters

(Page 81)), they are immediately transferred via the I/O interface. In this case, these tags and all status bits and messages are accessible without data record communication.

Table 2-1303 Assignment of data record 30

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	UINT	2	r	30	-	-
Length	Data record length information	UINT	2	r	44	-	-
Application	Information on which application the data record belongs to	UINT	2	r	201	-	-
Version identifier	Information on the current data record version	UINT	2	r	1	1	255
1/4d zero	Set if gross is less than ± 0.25e	BIT	2	r	0	-	-
9e max	Set if the weight has exceeded the gross weighing range by more than 9 display steps (d)	BIT	0	r	0	-	-
Tared	Set if tare memory is not equal to zero	BIT	0	r	0	-	-
Manual tare set (pT)	Set if the tare memory is assigned an external specified value	BIT	0	r	0	-	-
Reserve		BIT	0	r	0	-	-
Waiting for standstill	Set if module is waiting for standstill to execute command	BIT	0	r	0	-	-
Standstill	Set if standstill condition is met	BIT	0	r	0	-	-
Reserve		BIT	0	r	0	-	-
Empty	Set if "Empty" condition is met	BIT	0	r	0	-	-
Limit value 1	Limit value 1 has responded	BIT	0	r	0	-	-
Limit value 2	Limit value 2 has responded	BIT	0	r	0	-	-
Reserve (5 bits)		BIT	0	r	0	-	-
DS32 error status change	Is set interface-specific with each DS32 change	BIT	2	r	0	-	-
SIWAREX DB – EXC Error	Set if the supply voltage for the load cells is less than 4.7 V	BIT	0	r	0	-	-
SIWAREX DB – Impedance warning	Impedance value of the load cells outside the defined range	BIT	0	r	0	-	-
SIWAREX DB - Temperature warning	Temperature of SIWAREX DB outside the defined range	BIT	0	r	0	-	-
Reserve (4 bits)		BIT	0	r	0	-	-
Calibrated	SIWAREX is calibrated	BIT	0	r	0	-	-
Service mode	Service mode is enabled	BIT	0	r	0	-	-
Reserve (3 bits)		BIT	0	r	0	-	-

Variable	Note	Type	L	Rw	Default	Min.	Max.
SIMATIC connection inactive	Set if no connection to the SIMATIC exists on the part of the application	BIT	0	r	0	-	-
Startup	Startup has taken place (is deleted again after 5 seconds)	BIT	0	r	0	-	-
Fault status	Operating fault	BIT	0	r	0	-	-
Gross process weight (Page 86)	Gross weight (process value)	REAL	4	r	0	-	-
Net process weight (Page 88)	Net weight (process value)	REAL	4	r	0	-	-
Tare process weight (Page 88)	Tare weight (process value)	REAL	4	r	0	-	-
Gross / net weight (Page 88)	Gross or net weight	REAL	4	r	0	-	-
Gross / net weight with increased resolution (x 10) (Page 88)	Legal trade G/N weight with 10x resolution	REAL	4	r	0	-	-
Refresh counter for process values (Page 88)	Cycle counter incremented by 1 if weight values have been changed	UINT	2	r	0	-	-
Operating time (hours)	Total operating time of the module (hours)	UINT	2	r	0	-	-
Operating time (minutes)	Total operating time of the module (minutes)	UINT	2	r	0	-	-
Reserve 3	Reserve	REAL	4	r	0	-	-

8.14.1 Gross process weight

The current gross weight. Values are rounded as specified in data record DR 3 with the "Decimal places for process values" (Page 64) parameter.

8.14.2 Net process weight

The current net weight. Values are rounded as specified in data record DR 3 with the "Decimal places for process values" (Page 64) parameter.

8.14.3 Tare process weight

The current tare weight. Values are rounded as specified in data record DR 3 with the "Decimal places for process values" (Page 64) parameter.

8.14.4 Gross / net weight

The current weight for the main display. The resolution corresponds to the scale interval (Page 63) specified in data record DR 3.

8.14.5 Gross / net weight with increased resolution (x 10)

The current weight for the main display in higher resolution. The resolution corresponds to the scale interval specified in data record DR 3 x 10.

8.14.6 Tare weight

The current tare weight (scale interval from DR 3). The resolution corresponds to the scale interval specified in data record DR 3.

8.14.7 Refresh counter for process values

Measured values are calculated every 10 ms in the SIWAREX module. A counter is incremented by 1 each time. Once the counter reaches the value 65536, it starts again from zero. The counter can be used as a time stamp for data record DR 30.

8.15 DR 31 advanced current process values

Current states and process values in the scales can be monitored using advanced process values and process values (DR 30). This data is not required for standard operation of the scales.

Monitoring selected data during trial operation is extremely useful as it helps you to optimize parameters.

Procedure

- Read data record DR 31
- Display/analyze the required tags

Table 2-1304 Assignment of data record 31

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	UINT	2	r	31	-	-
Length	Data record length information	UINT	2	r	24	-	-
Application	Information about which application the data record belongs to	UINT	2	r	201	-	-
Version identifier	Information on the current data record version	UINT	2	r	1	1	65635
Unfiltered digit value (Page 90)	Unfiltered digit value of AD converters / digital load cells	DINT	4	r	0	-	-
Filtered digit value (Page 90)	Filtered digit value of AD converters or digital load cells after dig. filter 1	DINT	4	r	0	-	-
Reserve 1		INT	2	r	0	-100	100
Refresh counter for process values (Page 90)	Refresh counter incremented by 1 if weight values have been changed	UINT	2	r	0	-	-
Reserve 2		REAL	4	r	0	-	-

8.15.1 Unfiltered digit value

The unfiltered digit value is the internal measured value immediately before filtering.

8.15.2 Filtered digit value

The filtered digit value is the internal measured value immediately after filtering.

8.15.3 Refresh counter for process values

Measured values are calculated every 10 ms in the SIWAREX module. A counter is incremented by 1 each time. Once the counter reaches the value 65536, it starts again from zero. The counter can be used as a time stamp for data record DR 31.

8.16 DR 32 Message display

Data record 32 indicates all pending message bits. The bit "Error status changed" is present in the status bits of the DR30. If this bit is set, the message area of the DR32 has been changed.

The DR32 indicates which message has been newly added or deleted. The data record is automatically read by the SIMATIC FB in the event of an error. Following successful reading, the status bit is reset in DR30.

Table 2-1305 Assignment of data record 32

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	UINT	2	r	32	-	-
Length	Data record length information	UINT	2	r	26	-	-
Application	Information about which application the data record belongs to	UINT	2	r	101	-	-
Version identifier	Information on the current data record version	UINT	2	r	1	1	65635
1000	Operator error	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
1104	Undervoltage	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
1105	Overload	BIT		r	0	0	1
1106	Underload	BIT		r	0	0	1
1002	RAM error	BIT		r	0	0	1
1102	ADC error	BIT		r	0	0	1
1005	Hardware interrupt lost	BIT		r	0	0	1
1003	Checksum error data	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
1004	Checksum error program	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1

Variable	Note	Type	L	Rw	Default	Min.	Max.
1001	RESET / restart following error (watchdog)	BIT		r	0	0	1
1110	No communication with SIWAREX DB	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
2000	Technology error	BIT		r	0	0	1
2001	Taring or zeroing timeout	BIT		r	0	0	1
Reserve (3 bits)	-	BIT		r	0	0	1
2005	Cold restart after voltage recovery	BIT		r	0	0	1
Reserve (10 bits)		BIT		r	0	0	1
5000	Data or operating error exists	BIT		r	0	0	1
5001	Command code or data record unknown	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
5003	Leaving calibration mode not possible	BIT		r	0	0	1
5004	Command or data transmission only available in service mode	BIT		r	0	0	1
5005	Command or data transmission not possible because service mode is active	BIT		r	0	0	1
5006	Command or data transmission not possible because BUSY	BIT		r	0	0	1
5007	Command or data transmission not possible because module is faulty or ODIS is active	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
5101	Command is not permissible in this operating state	BIT		r	0	0	1
5102	Command not possible because not at standstill	BIT		r	0	0	1
5104	Command not possible because range is exceeded	BIT		r	0	0	1
5105	Load cell parameter not plausible	BIT		r	0	0	1
Reserve		BIT		r	0	0	1
5107	Shifting characteristic not possible	BIT		r	0	0	1
7000	Permitted number range violated	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
7002	Specifications of string lengths not plausible	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
7006	Command only possible in test field	BIT		r	0	0	1
7007	The calibration weights or calibration digits are not plausible	BIT		r	0	0	1

Variable	Note	Type	L	Rw	Default	Min.	Max.
7008	Zeroing/zero setting or tare parameter not plausible	BIT		r	0	0	1
7009	Standstill range / standstill wait time not plausible	BIT		r	0	0	1
7010	Scale interval / rounding not plausible	BIT		r	0	0	1
7011	Filter parameter not plausible	BIT		r	0	0	1
7014	Time input not plausible	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
Reserve	-	BIT		r	0	0	1
7019	RS485 parameter error	BIT		r	0	0	1
Reserve	-	UINT	2	r	0	-	-
Reserve	-	UINT	2	r	0	-	-
Reserve	-	UINT	2	r	0	-	-

8.16.1 Error bytes 0 to 7

In these areas, messages are represented by bits. A set bit means that the corresponding message is activated. The message bit is set following a data or operator error and automatically reset approximately 3 seconds later.
Message bits are analyzed by the operator panel message system.

The data/operator errors (error numbers 1xxx) are present in the first two bytes. These are followed by two bytes with technology errors (error numbers 2xxx) and six bytes with data and operator errors (error numbers 5xxx and 7xxx).

8.17 DR 34 ASCII main display value

The ASCII weight corresponds to the value on the main display of the scales and can be used for a supplementary display as well as the main display.

Table 2-1306 Assignment of data record 34

Variable	Note	Type	L	Rw	Default	Min.	Max.
Data record number	Contains no. of data record	UINT	2	r	34	-	-
Length	Data record length information	UINT	2	r	26	-	-
Application	Information about which application the DR belongs to	UINT	2	r	201	-	-
Version identifier	Information on the current data record version	UINT	2	r	1	1	65635
ASCII display string header	Maximum length and actual length of string	UBYTE[2]	2	r	16,2	-	-
Content of main display as ACII string (Page 93)	For display of the weight value and other current values (see below)	STRING[16]	16	r	" "	-	-

8.17.1 Content of main display as ACII string

The following values can be displayed:

Variable	Command
Switch on increased resolution	701
Current tare weight	705
Gross/net display	710
Net process value	714
Gross process value	715
Serial number	871
Firmware version	875

Below are some display examples. Commands are used to toggle the display values.

The values to be displayed are suppressed if a fault is present.

	Value designation		Blank	Display value									Unit of weight (from DR 3)
	N: Net, B/G: Gross, T: Tare, pT: Preset tare, S: Sum, ...												
Weight (Tare ≠ 0)	N	•	•	•	•	•	2	2	0	,	5	0	•kg•
Neg. weight (Tare = 0)	B	•	•	•	•	•	•	-	0	,	0	3	•t••
Weight in increased resolution	•	•	•	•	•	•	1	0	,	0	0	3	HIGH
Operator error	B	•	•	•	•	•	•	l	r	r	o	r	****
Tare display activated (pt)	p	T	•	•	•	•	•	5	0	,	5	0	•kg•
Tare display activated	T	•	•	•	•	•	•	5	0	,	5	0	•kg•

8.18 DR 70 SIWAREX DB parameter

The parameters which define the response in combination with SIWAREX DB are specified in data record DR 70.

If SIWAREX DB is not used, the default settings can be accepted.

Table 2-1307 Assignment of data record DR 70

Variable	Note	Data type	Length (bytes)	Rw	Default	Min.	Max.
Data record number [DR_NO]	Contains no. of data record	USHORT	2	R	70	-	-
Length [DR_LEN]	Data record length information	USHORT	2	R	180	-	-
Application [APPL_ID]	Information on which application the data record belongs to	USHORT	2	R	101	-	-
Version identifier [DR_VERSION]	Information on the current data record version	USHORT	2	r	1	1	65635
Load cell manufacturer [LOAD_CELL_MANUFACTURER]	Load cell manufacturer	CHAR[24]	24	r/w	„ „	-	-

Variable	Note	Data type	Length (bytes)	Rw	Default	Min.	Max.
Load cell order number [LOAD_CELL_ORDER_NUMBER]	Load cell order number	CHAR[24]	24	r/w	„ „	-	-
Load cell input 1: Location designation of sensor [LOAD_CELL_INPUT_1_LOCATION_TAG]	Location designation of sensor	CHAR[24]	24	r/w	„ „	-	-
Load cell input 2: Location designation of sensor		CHAR[24]	24	r/w	„ „	-	-
Load cell input 3: Location designation of sensor		CHAR[24]	24	r/w	„ „	-	-
Load cell input 4: Location designation of sensor		CHAR[24]	24	r/w	„ „	-	-
Channel active [LOAD_CELL_ENABLE]	Bit 0: Load cell input 1 [INPUT_1] Bit 1: Load cell input 2 [INPUT_2] Bit 2: Load cell input 3 [INPUT_3] Bit 3: Load cell input 4 [INPUT_4]	USHORT	2	r/w	15	0	15
Sensor type [SENSOR_TYPE]	0: 4-wire sensor 1: 6-wire sensor	USHORT	2	r/w	0	0	1
Total capacity of all load cells [NOMINAL_LOAD]	Total capacity of all load cells	FLOAT	4	r/w	1000	tbd	tbd

8.19 DR71 SIWAREX corner load adjustment

The parameters which define the response in combination with SIWAREX DB are specified in data record DR 71. The corner load factors for corner load adjustment are stored in DR 71.

If SIWAREX DB is not used, the default settings can be accepted.

Table 2-1308 **Assignment of the data record DR 71**

Variable	Note	Data type	Length [bytes]	Rw	Default	Min	Max
Data record number [DR_NO]	Contains no. of the data record	USHORT	2	r	71		
Length [DR_LEN]	Information on the length of the data record	USHORT	2	r	180		
Application [APPL_ID]	Information on the application to which the data record belongs	USHORT	2	r	201		
Version identifier [DR_VERSION]	Information on the current data record version	USHORT	2	r	1	1	65635
Corner load factor load cell input 1 [CORNER_LOAD_FACTOR_1]	Factors determined during the corner load correction. The corner load factors are relevant if you have per-	FLOAT	4	r/w	1	-	-

Variable	Note	Data type	Length [bytes]	Rw	Default	Min	Max
Corner load factor load cell input 2 [CORNER_LOAD_FACTOR-_2]	formed a corner load adjustment during commissioning. The procedure for corner load adjustment is described in chapter Command lists (Page 104) of command codes 151 to 160.	FLOAT	4	r/w	1	-	-
Corner load factor load cell input 3 [CORNER_LOAD_FACTOR-_3]		FLOAT	4	r/w	1	-	-
Corner load factor load cell input 4 [CORNER_LOAD_FACTOR-_4]		FLOAT	4	r/w	1	-	-

8.20 DR 80 SIWAREX DB process status

In data record DR 81, monitor the current statuses and process values in the scales with the help of the SIWAREX DB. To optimize the parameters, monitor selected data when commissioning the scales.

It is not always necessary to cyclically read data record DR 80. Messages and status bits are automatically read out by the function block when a change occurs.

Table 2-1309 Assignment of data record DR 80

Variable	Note	Type	Length (bytes)	Rw	Default	Min.	Max.
Data record number [DR_NO]	Contains no. of data record	USHORT	2	R	80	-	-
Length [DR_LEN]	Data record length information	USHORT	2	R	76	-	-
Application [APPL_ID]	Information on which application the data record belongs to	USHORT	2	R	101	-	-
Version identifier [DR_VERSION]	Information on the current data record version	USHORT	2	r	1	1	65635
Refresh counter [REFRESH_COUNTER]	Cycle counter of the SIWAREX DB incremented by 1 if process values have been changed.	USHORT	2	r	0	0	0xFFFF
Device status [MODULE_ERROR_INFORMATION]	Bit 0: QI flag Bit 1: Load cell input faulty Bit 2: Checksum error Bit 3: Checksum error (data) Bit 4: Watchdog error Bit 5: ADC error Bit 6: Temperature warning Bit 7: Firmware update error	USHORT	2	r	0	-	-

Variable	Note	Type	Length (bytes)	Rw	Default	Min.	Max.
Load cell input 1: Status [LOAD_CELL_INPUT_1_DIAG-NOSTIC_INFORMATION]	Bit 0: QI flag Bit 1: Underload Bit 2: Overload Bit 3: SEN error Bit 4: Impedance error Bit 5: EXC short circuit Bit 6: Power supply failure	USHORT	2	r	0	-	-
Load cell input 1: filtered digit value [LOAD_CELL_INPUT_1_DIGIT-S_FILTERED]	Filtered digit value of AD converter from SIWAREX DB to dig. filter 1	LONG	4	r	0x7FFF FFFF	0x8000 0000	0x7FFF FFFE
Load cell input 1: Load (%) [LOAD_CELL_INPUT_1_PERC-ENTAGE_LOAD]	Current percentual load of the load cell in relation to the rated load of the load cell	FLOAT	4	r	0	-200	200
Load cell input 1: Signal voltage SIG (mV) [LOAD_CELL_INPUT_1_LOAD-_CELL_SIGNAL]	Currently measured load cell signal	Float	4	r	0	-200	200
Load cell input 2: Status	Bit 0: QI flag Bit 1: Underload Bit 2: Overload Bit 3: SEN error Bit 4: Impedance error Bit 5: EXC short circuit Bit 6: Power supply failure	USHORT	2	r	0	-	-
Load cell input 2: Filtered digit value	Filtered digit value of AD converter from SIWAREX DB to dig. filter 1	LONG	4	r	0x7FFF FFFF	0x8000 0000	0x7FFF FFFE
Load cell input 2: Load (%)	Current percentual load of the load cell in relation to the rated load of the load cell	FLOAT	4	r	0	-200	200
Load cell input 2: Signal voltage SIG (mV)	Currently measured load cell signal	Float	4	r	0	-200	200
Load cell input 3: Status	Bit 0: QI flag Bit 1: Underload Bit 2: Overload Bit 3: SEN error Bit 4: Impedance error Bit 5: EXC short circuit Bit 6: Power supply failure	USHORT	2	r	0	-	-
Load cell input 3: filtered digit value [LOAD_CELL_INPUT_3_DIGIT-S_FILTERED]	Filtered digit value of AD converter from SIWAREX DB to dig. filter 1	LONG	4	r	0x7FFF FFFF	0x8000 0000	0x7FFF FFFE
Load cell input 3: Load (%)	Current percentual load of the load cell in relation to the rated load of the load cell	FLOAT	4	r	0	-200	200

Variable	Note	Type	Length (bytes)	Rw	Default	Min.	Max.
Load cell input 3: Signal voltage SIG (mV)	Currently measured load cell signal	Float	4	r	0	-200	200
Load cell input 4: Status	Bit 0: QI flag Bit 1: Underload Bit 2: Overload Bit 3: SEN error Bit 4: Impedance error Bit 5: EXC short circuit Bit 6: Power supply failure	USHORT	2	r	0	-	-
Load cell input 4: Filtered digit value	Filtered digit value of AD converter from SIWAREX DB to dig. filter 1	LONG	4	r	0x7FFF FFFF	0x8000 0000	0x7FFF FFFE
Load cell input 4: Load (%)	Current percentual load of the load cell in relation to the rated load of the load cell	FLOAT	4	r	0	-200	200
Load cell input 4: Signal voltage SIG (mV)	Currently measured load cell signal	Float	4	r	0	-200	200

8.21 DR 81 SIWAREX DB process status advanced

Current states and process values in the scales can be monitored using SIWAREX DB specific advanced process values and process values from data record DR 80.

Table 2-1310 Assignment of data record DR 81

Variable	Note	Type	Length (bytes)	Rw	Default	Min.	Max.
Data record number [DR_NO]	Contains no. of data record	USHORT	2	R	81	-	-
Length [DR_LEN]	Data record length information	USHORT	2	R	64	-	-
Application [APPL_ID]	Information on which application the data record belongs to	USHORT	2	R	101	-	-
Version identifier [DR_VERSION]	Information on the current data record version	USHORT	2	r	1	1	65635
Excitation voltage EXC (V) [EXCITATION_VOLTAGE]	Excitation voltage EXC (V) with which the load cells are supplied	FLOAT	4	r	0	0	10000
Load cell input 1: Impedance (Ohm) [LOAD_CELL_INPUT_1_IMPEDANCE]	Current impedance (Ohm) of connected load cell	FLOAT	4	r	0	0	20000
Load cell input 2: Impedance (Ohm)		FLOAT	4	r	0	0	20000
Load cell input 3: Impedance (Ohm)		FLOAT	4	r	0	0	20000

Variable	Note	Type	Length (bytes)	Rw	Default	Min.	Max.
Load cell input 4: Impedance (Ohm)	Current impedance (Ohm) of connected load cell	FLOAT	4	r	0	0	20000
Load cell input 1: Sense voltage SEN (V) [LOAD_CELL_INPUT_1_SENSE_VOLTAGE]	Current voltage (V) which is measured between SENSE+ and SENSE- of the load cell	FLOAT	4	r	0	0	10000
Load cell input 2: Sense voltage SEN (V)		FLOAT	4	r	0	0	10000
Load cell input 3: Sense voltage SEN (V)		FLOAT	4	r	0	0	10000
Load cell input 4: Sense voltage SEN (V)		FLOAT	4	r	0	0	10000
Load cell input 1: Excitation current (mA) [LOAD_CELL_INPUT_1_EXCITATION_CURRENT]	Current excitation current (mA) which is required for the supply of the load cell	FLOAT	4	r	0	0	1999
Load cell input 2: Excitation current (mA)		FLOAT	4	r	0	0	1999
Load cell input 3: Excitation current (mA)		FLOAT	4	r	0	0	1999
Load cell input 4: Excitation current (mA)		FLOAT	4	r	0	0	1999
Temperature (°C) [TEMPERATURE]	Current temperature (°C) of the SIWAREX DB electronic system	FLOAT	4	r	0.0	-50	+150.0

8.22 DR 82 SIWAREX DB device information

You cannot make any entries in data record DR 82. This data record only provides information on the inner workings of the SIWAREX DB. This information is used to identify SIWAREX DB at the manufacturer plant. The entries in the data record are of no importance to the user for operation.

Table 2-1311 Assignment of data record DR 82

Variable	Note	Type	Length (bytes)	Rw	Default	Min.	Max.
Data record number [DR_NO]	Contains no. of data record	USHORT	2	R	82	-	-
Length [DR_LEN]	Data record length information	USHORT	2	R	184	-	-
Application [APPL_ID]	Information on which application the data record belongs to	USHORT	2	R	101	-	-
Version identifier [DR_VERSION]	Information on the current data record version	USHORT	2	r	1	1	65635
Order number [ORDER_NO]	Order number SIWAREX DB	CHAR[32]	32	r	„ „	-	-

Variable	Note	Type	Length (bytes)	Rw	Default	Min.	Max.
Serial number [SERIAL_NO]	Serial number SIWAREX DB	CHAR[32]	32	r	„ „	-	-
FW version number [FW_VERSION]	FW version number SIWAREX DB	CHAR[16]	16	r	„ „	-	-
HW version [HW_VERSION]	HW version SIWAREX DB	CHAR[16]	16	r	„ „	-	-
Hardware device ID [HW_DEVICE_ID]	Hardware device ID SIWAREX DB	USHORT	2	r	0	0	31

Messages 9

9.1 Message types

The messages in the electronic weighing system described here are divided into three types.

System status messages

System status messages can be generated spontaneously at any time by an unexpected event. They include internal and external hardware problems which can occur spontaneously during weighing.

Data and operating errors

The data and operating errors are always a response to a command due to a plausibility check.

These are data errors if a plausibility error has been detected in a data packet which was sent to the module and receipt of the packet has been rejected by the module.

These are operating errors if the module cannot execute the sent command in its current operating state.

Technology errors

Technology errors occur spontaneously due to the process flow of a weighing.

Status bits, on the other hand, are not messages. The status displays describe the status of the scale during normal operation and can be monitored or evaluated at any time.

9.2 Message paths

You can read out the messages using different paths. You define the path for forwarding and processing of messages during configuration.

The messages are processed for two basic purposes:

- For display or recording on an operator panel for the operator
- For linking in the control software to control specific reactions in the process.

The following message paths are possible:

- Output of the message buffer to the SIWATOOL program (takes place automatically)
- Output by means of function block as bit field in Scale data block
- Certain operating errors can be transmitted as diagnostic interrupts to the SIMATIC CPU and evaluated by OB82

9.3 Evaluating messages with the help of SIWATOOL

The electronic weighing system has a message buffer that can hold up to 10 entries. If the number of alarms in the alarm buffer exceeds 10, the oldest entry is overwritten. The message buffer can be read out at any time with the help of SIWATOOL (menu item "Receive all data") and saved together with the scale parameters. This facilitates the detection, analysis and correction of errors in the system.

SIWAREX DB

If you use SIWAREX DB, the type of error of the load cell input affected is reported in SIWATOOL via Supplementary info 1.

9.4 Evaluating messages with the help of SIMATIC FB

All messages of the electronic weighing system can be completely detected and processed in the SIMATIC controller with the help of the SIWAREX WP321 function block (FB). The messages can be evaluated directly in a signaling system by means of a bit signaling area in the scale data block. The message texts are stored in the signaling system. The message text is output when a bit becomes "1".

9.5 Message list

The message list is an overview of all messages that the SIWAREX module can generate. A message can be quickly identified by the message code (number).

9.5.1 System status message list

Operator error (code 1000 to 1999)	Error code	Description and remedy
1000 operating error exists	1000	Group message, at least one operating error exists.
1001 Watchdog	1001	Watchdog, error is displayed for at least 10 seconds. A serious error has occurred in the function of the electronic weighing system, e.g. program error, severe electromagnetic influence on device, etc. Contact the SIWAREX Support if the error occurs multiple times.
1002 RAM error	1002	RAM error. An error has occurred in the memory; the memory content is no longer correct. The electronic weighing system must be switched off. If the error occurs again, the electronic weighing system is defective.
1003 Checksum incorrect parameter	1003	Checksum error at parameter. Critical error because the parameters are no longer safe.
1004 Checksum incorrect program	1004	Checksum error program code. Critical error because the program is no longer safe.
1102 ADU error	1102	AD converter error when reading in the measured value. If the error occurs again, make sure that the EMC recommendations are observed (chapter EMC-compliant setup (Page 21)).
1104 Undervoltage	1104	Undervoltage at sensor cables

Operator error (code 1000 to 1999)	Error code	Description and remedy
1105 Overload	1105	Overload of scale (ca. 110%)
1106 Underload	1106	Underload of scale (ca. -10%)
1110 No communication with SIWAREX DB	1110	No communication with SIWAREX DB

9.5.2 Technology error message list

Technology error (code 2000 to 4999)	Error code	Description and remedy
2000 Technology error exists	2000	Group message, at least one technology error exists
2001 Taring/zeroing timeout	2001	Taring of scale or set to zero is not possible because a standstill was not reached during the standstill time. The command was discarded.
2005 Reboot after power reset	2005	Reboot after voltage recovery or FW update

9.5.3 Data and operating errors message list

Data and command errors (code 5000 to 8999)	Error code	Description and remedy
5000 Data or comand error exists	5000	Group error, a bit is set in the data and operating error bits
5001 Data record or comand unknown	5001	Command code or data record is not known with current application
5003 Cannot exit service mode	5003	Cannot exit service mode; calibration incomplete
5004 Command or data transfer only permitted in service mode	5004	Activation of service mode is required to execute command or transmit data
5005 Command or data transmission not possible because service mode is active	5005	Command can currently not be executed because service mode is active
5006 Command or data transfer not possible while BUSY	5006	Command can currently not be executed because module is BUSY (data record or command transmission already active, ...)
5007 Command or data transmission not possible because module is faulty or SIMATIC CPU stop	5007	Command can currently not be executed because of a problem or SIMATIC CPU stop
5101 Command is not permissible in this operating state	5101	Command is not permissible in the current operating state
5102 Comand not possible while not standstill	5102	Scale command (set to zero, tare, log, ...) cannot be executed because standstill is missing.
5104 Command not possible while limit exceeded	5104	Command (e.g. set to zero, tare, calibrate command) cannot be executed because the permitted range has been exceeded.
5105 Load cell parameters not plausible	5105	Load cell parameters in data record DR 10(a) or data record DR 11(d) not plausible (number, supporting points, load specifications, etc.).
5107 Calibration charcteristic shift not possible	5107	Characteristic cannot be moved due to possibility of range violation.
7000 Permitted number range violated	7000	The permitted number range, such as for weight values, was violated.
7002 Length of ASCII string not plausible	7002	The string header in a specified string variable is not plausible.

Data and command errors (code 5000 to 8999)	Error code	Description and remedy
7007 Calibration weights / Calibration digits not plausible	7007	Specifications for calibration weights or digits in data record DR 3 are incorrect (minimum distance, reversal of incline).
7008 Zeroing or tare parameter not plausible	7008	The specifications (data record DR 3) or tare specifications (data record DR 15) are not plausible.
7009 Standstill range / standstill wait time	7009	Standstill range or standstill wait time are not plausible.
7010 Scale interval / rounding	7010	Resolution or selection for rounding to decimal places is not plausible.
7011 Filter parameters	7011	Specification of filter parameters is not plausible.

9.5.4 Messages by LEDs on the module

The LEDs on the front of the SIWAREX module signal the following status and error messages.

Item	Color	Labeling	Function
Line 1			
H1	red	**DIAG**	System fault
H2	Green		Ready
H11	yellow	1	Limit 1 responded
H12	yellow		Service mode
H13	yellow	2	Limit 2 responded
H14			Not used
H15	yellow	**{E}**	Empty message
H16			Not used
H17	Green		Standstill triggered
H18			Not used
H19	Green	**0**	¼ d zero status
H20			Not used
H21		**Max**	Weighing range exceeded
H22			Not used
H23	Green	**LC**	Load cell(s) ready for operation (LED off = load cells faulty)
H24			Not used
H25	yellow	**Rx/Tx**	EIA-RS485 communication active
H26			Not used
H40	Green	**PRW**	Status of local 24 V supply

Command lists

10

The commands for the electronic weighing system described here can be transmitted by several interfaces:

- From the operator panel via the controller to the SIWAREX module
- From SIWATOOL direct to the SIWAREX module

A data or command error is signaled if a command cannot be executed or if the sent data record is rejected.

Command code	Command	Description	Service
1... 99	**Service commands**		
1	Service mode On	Turn on service mode	x
2	Service mode Off	Turn off service mode	x
11	Load factory setting	The command resets the SIWAREX to the "Ex factory" status: - All parameters and saved data are loaded with the default values. - All message buffers are reset.	x
60	Set Calibration Point 0	Set Calibration Point 0 / save values for calibration point 0.	x
61	Set Calibration Point 1	Set Calibration Point 1 / save values for calibration point 1.	x
62	Set Calibration Point 2	Set Calibration Point 2 / save values for calibration point 2.	x
81	Characteristic shift	Move calibration characteristic. The command defines the current weight of the scale as the new zero point (0 kg) and shifts the complete characteristic without changing the gradient. The command can be used, for example, in order to compensate parts used for mounting calibration weights on the scale at the end of the calibration.	x
82	Perform automatic calibration	Calculating the scale characteristic curve with reference to the load cell from data record 10. The calculated characteristic curve is entered directly in data record 3 and 4, and thus activated immediately after executing the command.	x
83	Perform calibration check	The command calculates the theoretical digital values in relation to the calibration weights using the load cell parameters from data record 10 and the adjustment weights 0, 1 and 2 from data record 3. The output of these theoretical digits is made in data record 4. The function can be used to check the plausibility of adjustment digits in data record 3, which have been determined in a legal-for-trade calibration.	
151	Corner load adjustment load cell input 1	Calculate corner load factor at load cell input 1 Before executing the command, place a weight (at least 10%	x

Command code	Command	Description	Service
		of the rated load of the scale) over the load cell connected to channel 1 of SIWAREX DB. Then execute command 151. If you do not use the digital junction box SIWAREX DB, commands 151 - 160 are not relevant.	
152	Corner load adjustment load cell input 2	Calculate corner load factor at load cell input 2 Before executing the command, place the weight already used for channel 1 over the load cell connected to channel 2 of SIWAREX DB. Then execute the command 152.	x
153	Corner load adjustment load cell input 3	Calculate corner load factor at load cell input 3 Before executing the command, place the weight already used for channel 1 and 2 over the load cell connected to channel 3 of SIWAREX DB. Then execute the command 153. If you have connected only two load cells to SIWAREX DB , proceed with command 160.	x
154	Corner load adjustment load cell input 4	Calculate corner load factor at load cell input 4 Before executing the command, place the weight already used for channel 1, 2 and 3 over the load cell connected to channel 4 of SIWAREX DB. Then execute command 154. Complete the corner load adjustment with command 160.	x
160	Corner load adjustment complete	Calculate corner load factors and transfer to DR71.	x
700 ... 899	**HMI display switching**		
701	Increased resolution	Activate increased resolution on main display (x 10)	x
705	Display current tare weight	Display current tare weight on main display	x
710	Activate standard display	Activate standard display gross/net	x
711	G/N display	Display gross/net weight on main display	x
712	N display		
713	G display		
714	N process value	Display net process weight on main display	x
715	B process value	Display gross process weight on main display	x
871	Show serial number	The serial number of the module is displayed	
875	Display FW version	Show firmware version in current display	x
1000 ...	**Basic functions for weighing commands**		
1001	Set to zero	Set to zero	x
1011	Tare	Tare	x
1012	Delete tare	Delete current tare weight	x
1013	Tare specification valid	Activate specification of tare weight	x
1016	S7 tare specification valid	Activate specification of S7 tare weight	

The following commands can be triggered in the scale data block SCALE_DB in the area CMD1 to CMD3:

Table 2-1312 Command groups of the SIWAREX WP321

Command group	Description
1 ... 99	Commands are forwarded from the FB_SIWA via data record DR 2 to the module (scale commands, weighing commands, log commands). The meaning of the commands corresponds to the command list.
2000 + X	Reading of a data record, X corresponds to the data record number. Example: Data record 3 transmitted by SIWAREX module to the SIMATIC CPU → 2000 + 3 = command code 2003
4000 + X	Writing of a data record, X corresponds to the data record number. Example: Data record 3 transmitted by SIMATIC CPU to the SIWAREX module → 4000 + 3 = command code 4003
7001	Read all data records from SIWAREX into CPU (only for SIMATIC FB)
7002	Write all data records 3, 4, 5, 6, 10, 13, 14 and 15 from CPU into SIWAREX (module must be in service mode, only for SIMATIC FB)

Additional information on transmission of commands from the control program by means of the SIMATIC interface is available in chapter Communication in SIMATIC S7-300/400/1200/1500 (Page 107).

Communication in SIMATIC S7-300/400/1200/1500 11

11.1 General information

A SIWAREX WP321 occupies 16 bytes each in the I/O areas of the CPU. Communication between SIWAREX and SIMATIC CPU is supported by the FB.

Table 2-1313 Memory requirements of the function block

	FB 1, WP321DR
Read weight and status	YES
Send commands	YES
Send parameters	YES
Main memory requirements in CPU	11 600 byte + n x 1 232 byte
Load memory requirements in CPU	138 788 byte + n x 28 470 byte

n = number of WP321 modules

The function block described above including HMI configuring can be downloaded as a predefined example project ("Ready-for-use") from the Siemens Customer Support.

11.2 Structure of the program "Ready for use"

There is one program for Step 7 Classic and another for TIA Portal. The two programs each consist of two parts:

- STEP 7 software for the SIMATIC CPU
- WinCC project (integrated in SIMATIC Manager)

All messages are saved as bit information. The message system can thus directly access the bit fields and display the message texts.

See also

SIWAREX WP321 "Ready for use"
(https://support.industry.siemens.com/cs/ww/en/ps/17799/dl)

11.3 Advantages of task sharing

The weight is calculated in the SIWAREX module like in a separate electronic weighing system. However, thanks to integration in SIMATIC, it is possible to directly transfer the weight value to the PLC program. This results in sensible sharing of tasks: the weighing functions are performed in the SIWAREX module, while interlocking and signal linking are performed in the PLC.

SIWAREX "Ready for use" takes over the task of a standardized program in the SIMATIC S7.

An FB handle several tasks:

- It controls communication between the SIMATIC CPU and the SIWAREX module
- It transfers commands and adjustment values to the SIWAREX module according to the process trend
- It prepares the scale data for visualization

11.4 Hardware configuration of the electronic weighing system

The electronic weighing system can be found in the directory
PLC/SIMATIC ET 200SP/technology modules/weighing modules of the hardware catalog.

The following basic properties of the electronic weighing system are defined during hardware configuration in the TIA Portal. Ensure that the electronic weighing system is always completely in the process image of the CPU.

- Installation location of the electronic weighing system
- Address in I/O area
- Diagnostics interrupts
- Hardware interrupts
- I&M (Identification & Maintenance) data

The electronic weighing system occupies 16 bytes in the input/output area.

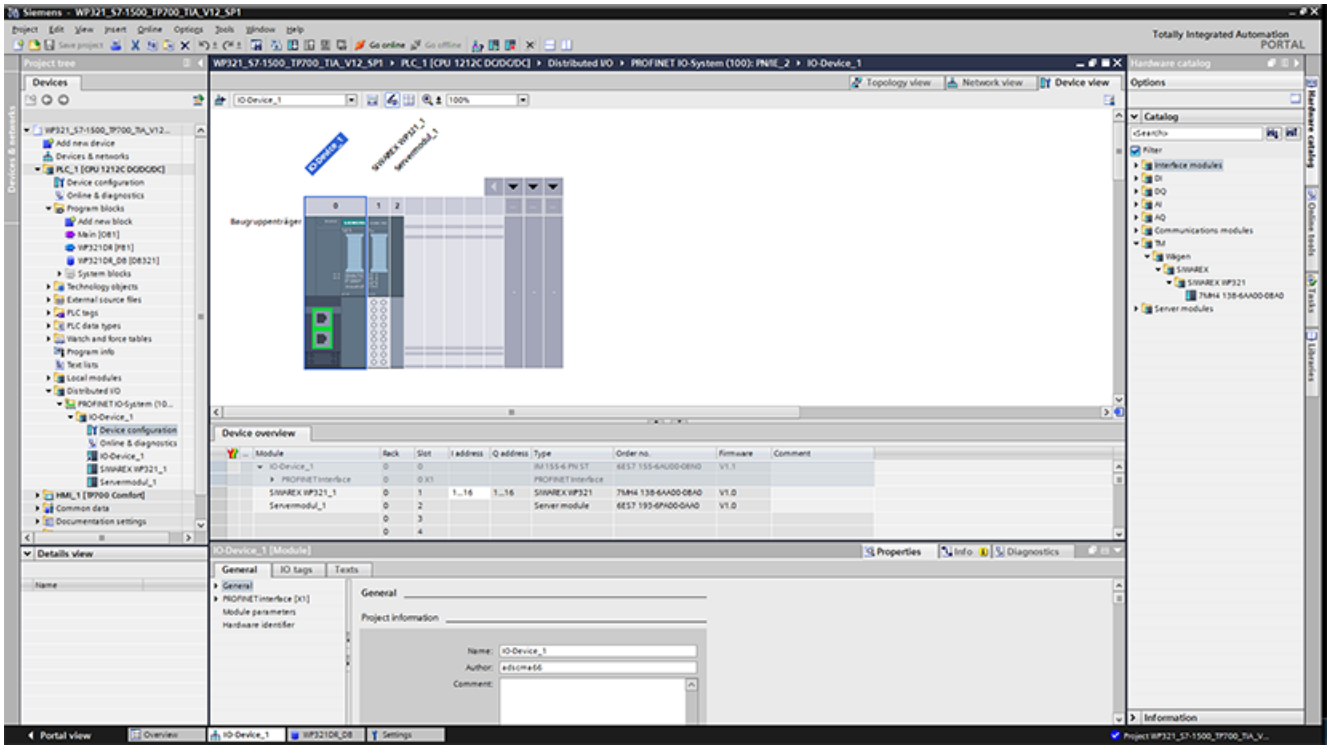

Figure 2-1156 Hardware configuration in the TIA Portal

TIA Portal automatically assigns a separate I/O start address and a HW ID for every electronic weighing system present in the project. These two parameters are relevant for calling the function block, and can be obtained from the properties of the respective electronic weighing system.

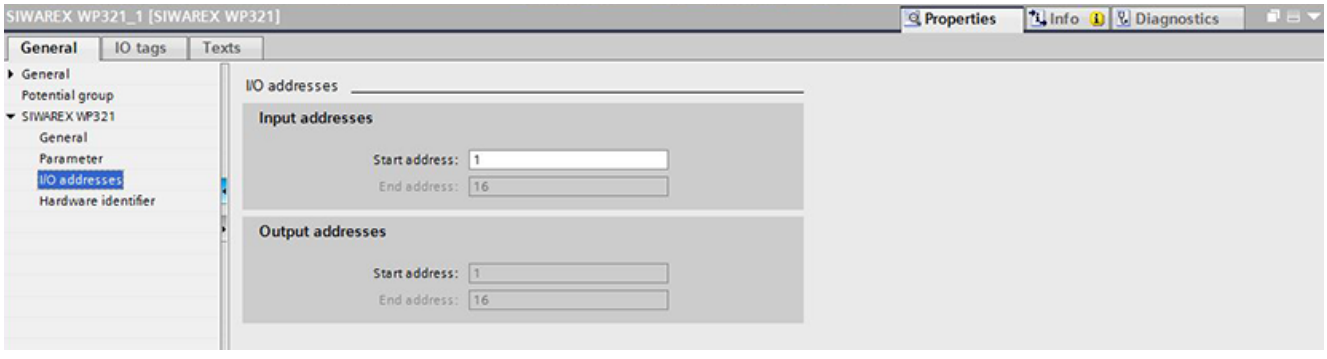

Figure 2-1157 Start address of the electronic weighting system in TIA Portal

Diagnostics interrupts can be optionally enabled or deactivated in the properties of the electronic weighing system. The configuration scope for diagnostics and hardware interrupts depends on the SIMATIC CPU used (S7-300, S7-400, S7-1200 or S7-1500) → Diagnostics interrupts (Page 116) and Hardware interrupts (Page 117)

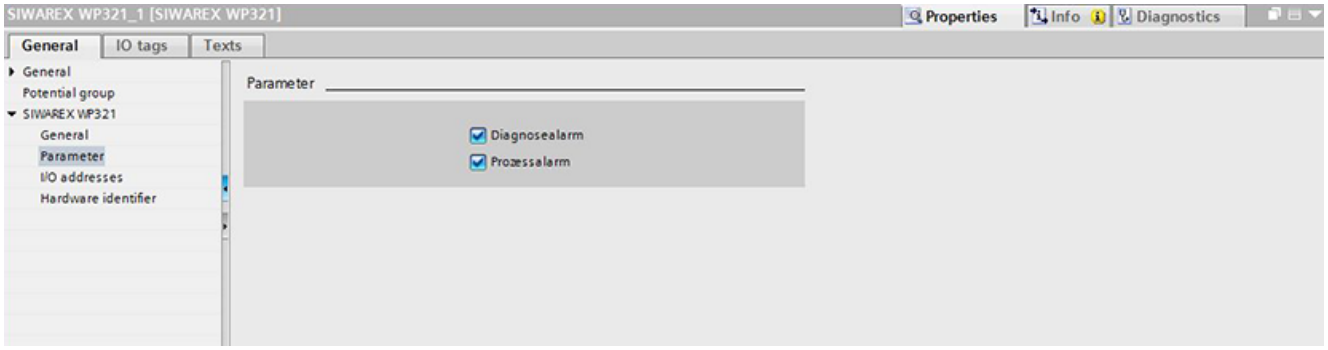

Figure 2-1158 Configuration of interrupts in TIA Portal

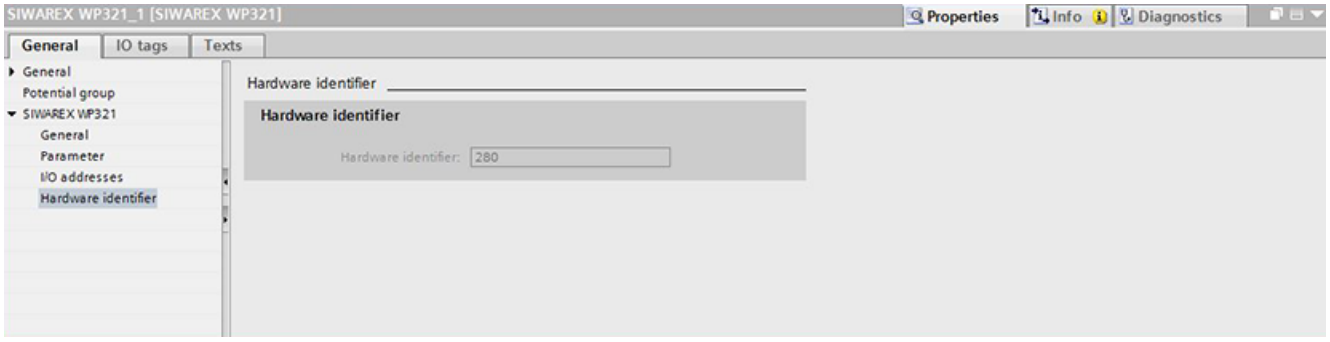

Figure 2-1159 HW ID of the electronic weighing system in TIA Portal (up to TIA Portal V14)

11.5 Calling of function block

This description is based on use of the WP321DR block with data record communication and the following data:

- **Start address** SIWAREX WP321: 1 (see → Hardware configuration of the electronic weighing system (Page 108))
- **HW ID** SIWAREX WP321: 280 (see → Hardware configuration of the electronic weighing system (Page 108))
- **Instance data block number** of SIWAREX WP321 function block: DB321

The function block can be integrated at the desired position in the user program using drag and drop. Calling of the FB must be carried out cyclically in the control program.

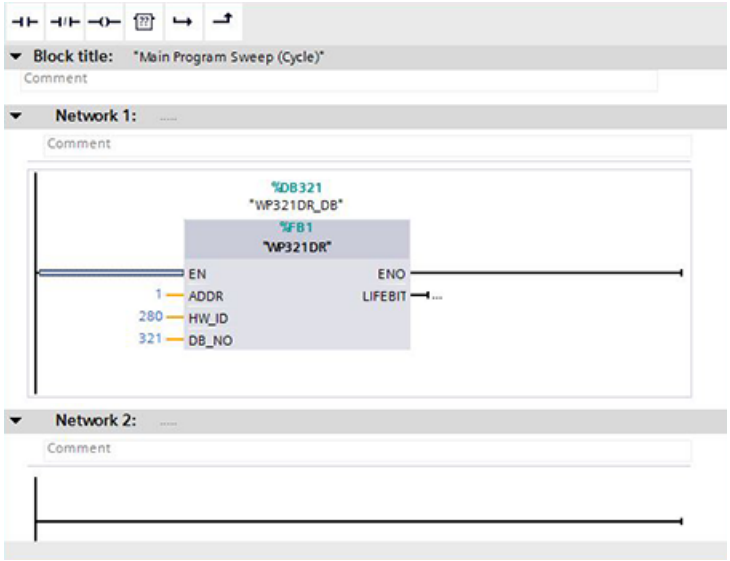

Figure 2-1160 Calling WP321 DR block (V1.x and V2.x) in the user program

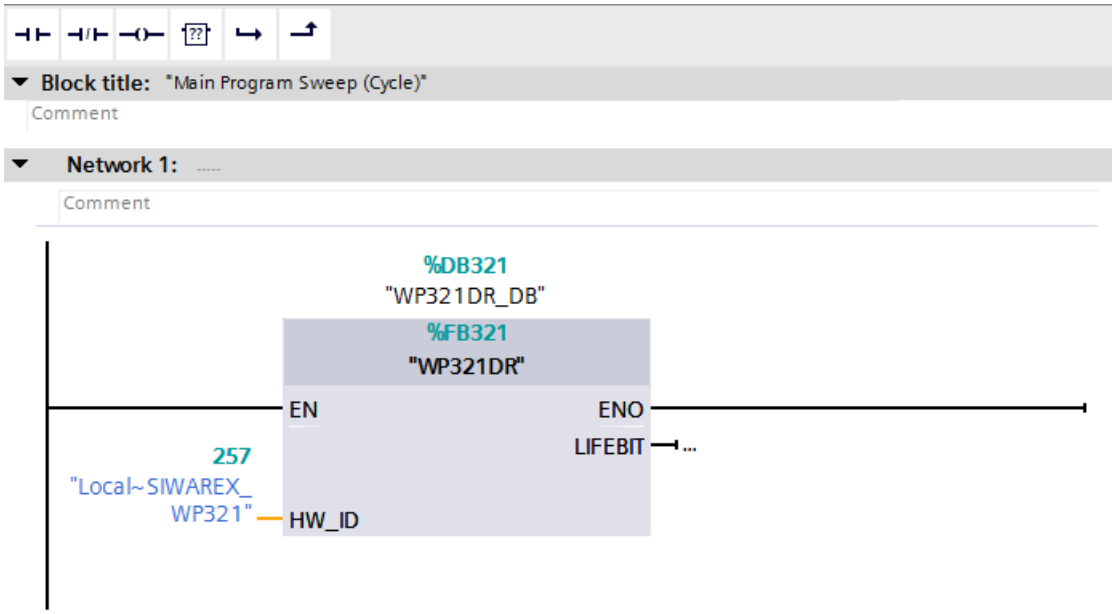

Figure 2-1161 Calling WP321 DR block (V3.x) in the user program

Function block parameter	Description
ADDR	Start address WP321 (see → Hardware configuration of the electronic weighing system (Page 108))
HW_ID	HW ID WP321 (see → Hardware configuration of the electronic weighing system (Page 108))
DB_NO	Number of FB-internal instance DB
LIFEBIT	Optional status bit can be used to monitor communication

The generated instance DB (WP321 in this case) contains all data records of the WP321 as well as all parameters required to exchange data between CPU and weighing module.

A separate FB call must be made in the user program for each weighing module. In this manner, each scale receives its own instance DB which provides the respective scale parameters. The input and output parameters of the FB must be matched to the respective WP321 for each call.

11.6 Working with the function block

Data records in SIWAREX weighing modules

All parameters in SIWAREX weighing modules are structured in data records. These data records must be considered as connected packages and can only be respectively read into the CPU or written to the SIWAREX as complete packages. Reading or writing of a single parameter within a data record is not possible. You can find a description of all data records and their parameters in chapter → Scale parameters and functions (Page 59).

Reading and writing of data records is performed using special command codes which can be sent with three command mailboxes handled according to priority within the instance DB:

WP321DR_DB

	Name	Data type	Offset	Start value
13	s_CMD1	Struct	446.0	
14	i_CMD_CODE	Int	0.0	0
15	bo_CMD_TRIGGER	Bool	2.0	false
16	bo_CMD_InProgress	Bool	2.1	false
17	bo_CMD_FinishedOK	Bool	2.2	false
18	bo_CMD_FinishedError	Bool	2.3	false
19	s_CMD2	Struct	450.0	
20	i_CMD_CODE	Int	0.0	0
21	bo_CMD_TRIGGER	Bool	2.0	false
22	bo_CMD_InProgress	Bool	2.1	false
23	bo_CMD_FinishedOK	Bool	2.2	false
24	bo_CMD_FinishedError	Bool	2.3	false
25	s_CMD3	Struct	454.0	
26	i_CMD_CODE	Int	0.0	0
27	bo_CMD_TRIGGER	Bool	2.0	false
28	bo_CMD_InProgress	Bool	2.1	false
29	bo_CMD_FinishedOK	Bool	2.2	false
30	bo_CMD_FinishedError	Bool	2.3	false
31	s_CMD_curr	Struct	458.0	
32	i_CMD_CODE	Int	0.0	0
33	bo_CMD_TRIGGER	Bool	2.0	false
34	bo_CMD_InProgress	Bool	2.1	false
35	bo_CMD_FinishedOK	Bool	2.2	false
36	bo_CMD_FinishedError	Bool	2.3	false
37	bo_CMD_ERR	Bool	462.0	false

Figure 2-1162 CMD command mailboxes

As shown in the graphics, a command mailbox always consists of a command code (Int) and four bits (Bool). A command is set by entering the desired command code in the "i_CMD_CODE" parameter and setting the respective command trigger "bo_CMD_TRIGGER". The status bits "bo_CMD_InProgress" (command being processed), "bo_CMD_FinishedOk" (command finished without errors) and "bo_CMD_FinishedError" (command rejected or finished with error) can be evaluated in the user program.

In addition, the three command mailboxes are managed and processed according to priority. CMD1 has the highest priority, CMD3 has the lowest priority. If all three command mailboxes are triggered simultaneously by the user program, for example, the function block initially processes CMD1, then CMD2, and finally CMD3. Cyclic triggering of command mailbox 3 is also interrupted by intermediate sending of a command in mailbox 2 or 1 for processing of the respective command.

NOTE

Cyclic triggering of the CMD1 command mailbox makes it impossible to send commands in mailbox 2 or 3.

A summary of all existing command codes can be found in chapter →Command lists (Page 104).

The following equation for generation of a corresponding command code applies to the reading of data records from the SIWAREX to the data block:

Command code = 2000 + X (X = desired data record number)

The following equation for generation of a corresponding command code applies to the writing of data records from the data block to the SIWAREX:

Command code = 4000 + X (X = desired data record number)

Example

The following example clarifies the actions with command mailboxes and data records:

"Calibration weight" is to be set to a value of 60.5 by the CPU. Since "Calibration weight" is a parameter of data record 3 (see chapter → Scale parameters and functions (Page 59)), service mode must first be activated. This is possible using command code "1" (see chapter → Command lists (Page 104)).

The variable "i_CMD_CODE" must therefore be assigned the value "1" and the associated "bo_CMD_TRIGGER" set to TRUE. Subsequently, the module is directly in service mode (DIAG LED flashes green):

i_CMD_CODE = 1

bo_CMD_TRIGGER = TRUE

Since only complete data records can be read or written, it is recommendable to now read data record 3 into the CPU. This is carried out using command code 2003 (see chapter → Command lists (Page 104)):

i_CMD_CODE = 2003

bo_CMD_TRIGGER = TRUE

All current data from data record 3 are now present in the data block. The calibration weight is then set as desired to a value of 60.5:

CALIBRATION_WEIGHT = 60.5

The modified data record 3 must now be written into the SIWAREX again. This is carried out using command code 4003 (see chapter → Command lists (Page 104)):

i_CMD_CODE = 4003

bo_CMD_TRIGGER = TRUE

The new calibration weight is now present in the SIWAREX and can be used. Service mode for the module should subsequently be switched off again using the command "2".

This procedure for reading and writing data records or parameters is identical for all data records.

11.7 I/O interface of function block

The following scale parameters are available cyclically in the data block in the controller without special reading of data records or can be sent to the scale without sending of data records:

Table 2-1314 I/O data of the function block

Parameter (read)	Meaning
SCALE_STATUS_1 (UINT)	Bytes 0 & 1 of the scale status (→ DR 30 current process values (Page 83))
SCALE_STATUS_2 (UINT)	Bytes 2 & 3 of the scale status (→ DR 30 current process values (Page 83))
Process value 1	Selection → Selection of process value 1, 2 (Page 82)
Process value 2	Selection → Selection of process value 1, 2 (Page 82)
Parameter (write)	
S7 tare specification	Specified value for tare weight. The value is applied by using the "Tare specification valid (1016)" command.

11.8 Error codes of function block

Table 2-1315 Statuses/errors when working with the function block

Error bit	Error description
bo_ApplIDError	Address module does not match the function block
bo_ApplIDDRError	Data record does not match the inserted module
bo_SFBError	Runtime error during transmission of data record
bo_RdPerError	Reading of I/O data failed
bo_LifeBitError	SIWAREX no longer responds
bo_StartUpError	Command was sent although StartUp is still TRUE
bo_WrongFW	Data record version does not match the firmware
bo_InvalidCMD	An invalid command code was sent
bo_DataOperationError	Synchronous data operation error has occurred
bo_StartUp	Startup synchronization of module running
bo_InvalidHW_ID	An invalid hardware ID was created at the function block call ("HW_ID" input).

NOTE

If execution of the function block is faulty, the variables shown do not correspond to the actual status in the module.

11.9 Diagnostics messages

The DIAG LED flashes red when a diagnostics message is present. Diagnostics messages are displayed as plain text in STEP 7 (TIA Portal) by means of online and diagnostics views. You can evaluate the error codes by means of the user program.

The following diagnostics messages can be signaled:

Table 2-1316 Diagnostics messages

Diagnostics message	Error code	Meaning	Remedy
Fault	9H	Internal module fault, defective	Replace technology module
Load voltage missing	11H	L+ for technology module missing	Check supply voltage on BaseUnit
Hardware interrupt lost	16H	Technology module cannot send an interrupt because the previous interrupt has not yet been processed	Change interrupt processing in the CPU, change technology module parameter settings.
Module temporarily not available	1FH	Normal operation of module not possible because, for example, a FW update is being carried out.	Wait until the module assumes normal operation.
Undervoltage	02H	Undervoltage of sense lines	Voltage drop up to the load cell is too large. Find out why.
Load high	07H	Upper limit for sensor voltage exceeded	Eliminate scale overload
Underload	08H	Lower limit for sensor voltage fallen below	Check mechanics of the scale, check the wiring of the sensor.
Checksum error in parameter	0DH	The checksum for the integrity of the parameters is incorrect	Download factory setting of the parameters.
Checksum error program	0EH	The checksum for the integrity of the parameters is incorrect	Download firmware again, replace module

11.10 Diagnostics interrupts

The enable for triggering of diagnostics interrupts is possible for all SIMATIC CPUs (S7-300, S7-400, S7-1200, S7-1500) and is assigned in the device configuration.

The diagnostics interrupts can be evaluated to detect fault events in the SIMATIC CPU.

Fault events (operating faults) are signaled by a diagnostics interrupt to the S7 CPU if the diagnostics interrupt is enabled (in the HW Config). You can evaluate the diagnostics messages using the local data of OB82. Contrary to the S7-1200 and S7-1500, the CPUs of the S7-300 and S7-400 systems enter the stop status following a diagnostics interrupt if the OB82 is not loaded.

Detailed information can be obtained using the "RALRM" instruction (read interrupt status).

11.11 Hardware interrupts

You can configure which events during operation are to trigger a hardware interrupt for the SIWAREX module. Based on the configuration, the SIWAREX module triggers a hardware interrupt for specific events/limits. When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the associated hardware interrupt OB. The event that triggered the interrupt is entered by the CPU into the start information of the associated hardware interrupt OB.

Activation of the hardware interrupts

For the device configuration of the SIWAREX module, activate the hardware interrupts in the TIA Portal under "Parameters".

Lost hardware interrupt

When an event that triggers a hardware interrupt occurs and a previous event of the same kind has not yet been processed, no further hardware interrupt is triggered. The hardware interrupt is lost. This may lead to the "Hardware interrupt lost" diagnostics interrupt, depending on the parameterization.

No hardware interrupts are activated by default. One result of triggering a hardware interrupt is that the following two variables are entered in the start information of the associated hardware interrupt OB:

- EventType: One byte with a set bit
- IChannel: Number of the channel that triggered the hardware interrupt

Table 2-1317 Table of event bits

Hardware interrupt	Event type bit
Limit 1 OFF → ON 0	0
Limit 1 ON → OFF 1	1
Limit 2 OFF → ON 2	2
Limit 2 ON → OFF 3	3

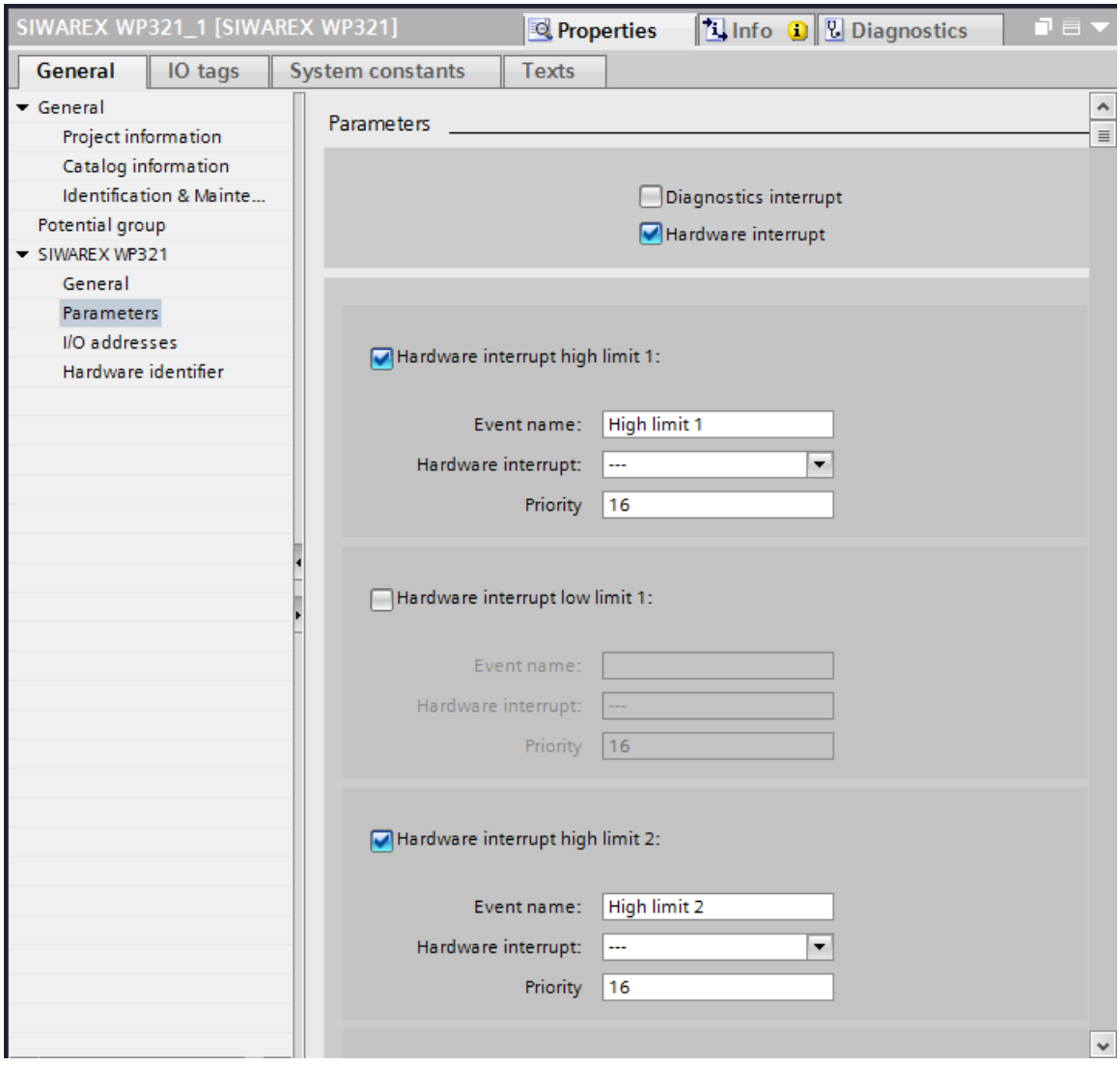

Figure 2-1163 Configuration of hardware interrupts for S7-1500

Technical data

12

Article number	7MH4138-6AA00-0BA0
General information	
Product type designation	TM SIWAREX WP321 ST
HW functional status	FS04
Firmware version	V1.4.3
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Adjustment of measuring range	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V14 or higher
• STEP 7 configurable/integrated from version	From STEP 7 V5.4 and higher
• PROFIBUS from GSD version/GSD revision	GSD Revision 5
• PROFINET from GSD version/GSD revision	GSDML V2.34
Supply voltage	
Load voltage L+	
• Rated value (DC)	24 V
• permissible range, lower limit (DC)	19.2 V
• permissible range, upper limit (DC)	28.8 V
• Short-circuit protection	Yes
• Reverse polarity protection	Yes
Input current	
Current consumption, max.	100 mA
Power	
Power available from the backplane bus	70 mW
Power loss	
Power loss, typ.	2 W
Address area	
Address space per module	
• Inputs	16 byte
• Outputs	16 byte

Article number	7MH4138-6AA00-0BA0
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	type B
Encoder	
Connection of signal encoders	
• For strain gauges (full bridges) with 4-conductor connection	Yes
• For strain gauges (full bridges) with 6-conductor connection	Yes
• Resistance of full bridge, min.	40 Ω; when using SIWAREX IS: 50 ohm for 7MH4710-5BA; 105 ohm when using 7MH4710-5CA
• Resistance of full bridge, max.	4 100 Ω
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %
Error limit according to DIN 1319-1	0.05 %; of full-scale value
Temperature coefficient, zero point	≤ ±0.1 µV/K
Temperature coefficient, span	≤ ±5 ppm/K
1. Interface	
Interface types	
• RS 485	Yes; 390 Ω, 220 Ω, 390 Ω connectable termination
Interface types	
RS 485	
• Transmission rate, max.	115.2 kbit/s
• Cable length, max.	1 000 m; ≤ 115 kbps, shielded cable
Interrupts/diagnostics/status information	
Diagnostics function	Yes; Diagnostic alarm
Substitute values connectable	No
Alarms	
• Diagnostic alarm	Yes; Parameterizable
• Hardware interrupt	Yes; Parameterizable
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
Diagnostics indication LED	
• ERROR LED	Yes; green/red DIAG LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED

Article number	7MH4138-6AA00-0BA0
Integrated Functions	
Load cell	
• Non-automatic weighing instrument	NAWI
• permissible input signal per verification interval, min.	0.5 µV/d (d=e)
• Sampling rate	600 Hz
• Resolution of input signal	±500 000 parts pro mV/V
• Common mode voltage, min.	0.25 V
• Common mode voltage, max.	4.75 V
• input resistance of signal line, typ.	4 MΩ
• input resistance of sense line, typ.	2 MΩ
• Cable length, max.	500 m; when using the SIWAREX 7MH4702-8AG cable
Measuring functions	
Measuring range	
– -1 mV/V to +1 mV/V	Yes; corresponds to a resolution of ±500 000 parts
– -2 mV/V to +2 mV/V	Yes; corresponds to a resolution of ±1 000 000 parts
– -4 mV/V to +4 mV/V	Yes; corresponds to a resolution of ±2 000 000 parts
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-25 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-25 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; more than 2 000 m above sea level, the ambient temperature is reduced by -1 °C per 100 m
• Ambient air temperature-barometric pressure-altitude	1 080 ... 795 hPa (-1 000 ... 5 000 m above sea level)
Decentralized operation	
to SIMATIC S7-300	Yes
to SIMATIC S7-400	Yes
to SIMATIC S7-1200	Yes
to SIMATIC S7-1500	Yes
to standard PROFIBUS master	Yes
to standard PROFINET controller	Yes

Article number	7MH4138-6AA00-0BA0
Dimensions	
Width	15 mm
Height	57 mm
Depth	72 mm
Weights	
Weight, approx.	31 g

12.1 Certificates and approvals

- All certificates are available online at Certificates (https://support.industry.siemens.com/cs/ww/en/ps/7MH4138-6AA00-0BA0/cert).
- The current approvals for your device can be found on the nameplate.
- When using the electronic weighing system, observe the requirements specified in the safety notes for hazardous areas.

	→ CE approval
	Explosion protection in accordance with c-UL-us (USA/Canada) Report No: E542221
	UL File Number OrdLoc: E503417
	FM approval for Zone 2 FM17US0318X under Customer No. 1000005027
	Explosion protection in accordance with ATEX DEKRA 19ATEX0094 X
	Explosion protection in accordance with UKCA DEKRA 21UKEX0016X
	Explosion protection in accordance with IECEx DEK 19.0054X IEC 60079-0 : 2017 (Ed.7) IEC 60079-7 : 2015 (Ed.5.1)
	→ EAC certificate

	→ Tick mark for Australia and New Zealand
	→ KCC approval
	→ The modules are RoHS-compliant according to EU Directive 2016/65/EU

Ordering data

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You can order accessories online: Industry Mall (https://mallstage.industry.siemens.com/mall/en/b0/Catalog/Products/10229887?tree=CatalogTree)

The following accessories are not included in the scope of delivery:

- **Digital remote display**

  The digital remote displays can be connected directly to the SIWAREX WP321 through the RS485 interface.

  Suitable remote display: S102
  Siebert Industrieelektronik GmbH
  Postfach 1180
  D-66565 Eppelborn, Germany
  Tel.: 06806/980-0
  Fax: +49 (0)6806/980-999
  Internet: Siebert (http://www.siebert-group.com)

  You can obtain more detailed information from the manufacturer.

- **RS485/USB converter**

  Commercially available converter with FTDI chip,
  e.g. USB-Nano-485 from CTI (http://www.cti-shop.com/RS485-Konverter/USB-Nano-485)

Product documentation and support

A

A.1 Product documentation

Product documentation for process instrumentation is available in the following formats:

- Certificates (http://www.siemens.com/processinstrumentation/certificates)
- Downloads (firmware, EDDs, software) (http://www.siemens.com/processinstrumentation/downloads)
- Catalogs and technical data sheets (http://www.siemens.com/processinstrumentation/catalogs)
- Manuals (http://www.siemens.com/processinstrumentation/documentation)

  You have the option to view, open, save or configure the manual.

  – "Display": The manual opens in HTML5 format.
  – "Configure": You can register and configure the specific documentation for your plant here.
  – "Download": The manual is opened or saved in PDF format.
  – "Download as html5, only PC": The manual is opened or saved in HTML5 view on your PC.

You can also find manuals at Industry Online Support (https://support.industry.siemens.com/cs/ww/de/sc/2067) using the mobile app. Download the app to your mobile device and scan the QR code.

See also

Generally applicable information/SIMATIC manual overview (https://support.industry.siemens.com/cs/ww/en/view/109742709)

A.2 Technical support

Technical support

If this documentation does not completely answer your technical questions, you can enter a Support Request (http://www.siemens.com/automation/support-request).

For help creating a support request, view this video here (www.siemens.com/opensr).

Additional information on our technical support can be found at Technical Support (http://www.siemens.com/automation/csi/service).

Service & support on the Internet

In addition to our technical support, Siemens offers comprehensive online services at Service & Support (http://www.siemens.com/automation/serviceandsupport).

Contact

If you have further questions about the device, contact your local Siemens representative at Personal Contact (http://www.automation.siemens.com/partner).

To find the contact for your product, go to "all products and branches" and select "Products & Services > Industrial automation > Process instrumentation".

Contact address for business unit:
Siemens AG
Digital Industries
Process Automation
Östliche Rheinbrückenstr. 50
76187 Karlsruhe, Germany

SIWAREX support

- Email (mailto:hotline.siwarex@siemens.com)
- Phone: +49 (721) 667-1200 CET 8:00 to 17:00

ESD guidelines

B

B.1 ESD Guidelines

Definition of ESD

All electronic modules are equipped with large-scale integrated ICs or components. Due to their design, these electronic elements are highly sensitive to overvoltage, and thus to any electrostatic discharge.

The electrostatic sensitive components/modules are commonly referred to as ESD devices. This is also the international abbreviation for such devices.

ESD modules are identified by the following symbol:

NOTICE
ESD devices can be destroyed by voltages well below the threshold of human perception. These static voltages develop when you touch a component or electrical connection of a device without having drained the static charges present on your body. The electrostatic discharge current may lead to latent failure of a module, that is, this damage may not be significant immediately, but in operation may cause malfunction.

Electrostatic charging

Anyone who is not connected to the electrical potential of their surroundings can be electrostatically charged.

The figure below shows the maximum electrostatic voltage which may build up on a person coming into contact with the materials indicated. These values correspond to IEC 801-2 specifications.

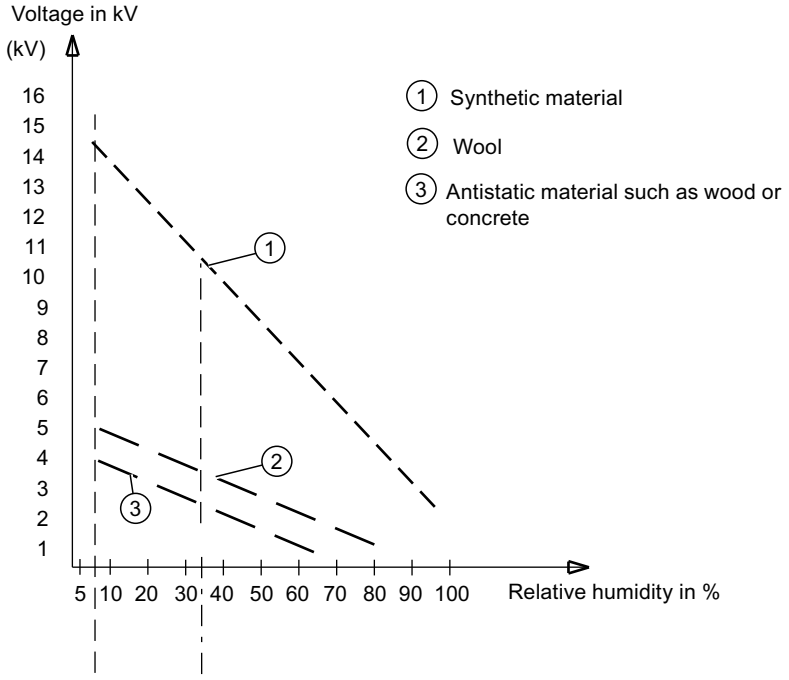

Figure 2-1164 Electrostatic voltages which an operator can be subjected to

Basic protective measures against electrostatic discharge

- Ensure good equipotential bonding:
  When handling electrostatic sensitive devices, ensure that your body, the workplace and packaging are grounded. This prevents electrostatic charge.
- Avoid direct contact:
  As a general rule, only touch electrostatic sensitive devices when this is unavoidable (e.g. during maintenance work). Handle the modules without touching any chip pins or PCB traces. In this way, the discharged energy can not affect the sensitive devices.

  Discharge your body before you start taking any measurements on a module. Do so by touching grounded metallic parts. Always use grounded measuring instruments.

Abbreviations

C

C.1 List of abbreviations

ASCII	American Standard Code for Information Interchange
B	Gross weight
CPU	Central processor, in this case SIMATIC CPU
DB	Data block
FB	SIMATIC S7 function block
HMI	Human machine interface (e.g. SIMATIC Operator Panel)
HW	Hardware
NAWI	Non-automatic weighing instrument
NAW	Non-automatic scales
OIML	Organisation Internationale de Metrologie Legale
OP	Operator Panel (SIMATIC)
PC	Personal computer
pT	Preset tare (predefined tare weight with manual taring)
RAM	Random access memory
PLC	Programmable logic controller
STEP 7	Programming device software for SIMATIC S7
T	Tare weight
TM	Technology module
TP	Touch Panel (SIMATIC)
UDT	Universal Data Type (S7)
WRP	Write protection
LC	Load cell(s)
NR	Numerical range

SIEMENS

SIMATIC

ET 200SP
SIMATIC ET 200SP SIWAREX technology module TM WP351 1x10VDC#1-4mV/V HF

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Introduction 1

1.1 Purpose of this document

These instructions contain the product-specific information you need for connecting, commissioning, parameter assignment/addressing, diagnostics, technical specifications and operation requiring official calibration of the technology module. The following text describes the technology module referred to as the electronic weighing system.

General information on installation and commissioning of ET 200SP is available in the ET 200SP System Manual. Generally applicable information/SIMATIC manual overview (https://support.industry.siemens.com/cs/ww/en/view/109742709)

1.2 Use in hazardous area

WARNING

Use in hazardous area

Risk of explosion.

- Only use equipment that is approved for use in the intended hazardous area and labeled accordingly.
- Do not use devices that have been operated outside the conditions specified for hazardous areas. If you have used the device outside the conditions for hazardous areas, make all Ex markings unrecognizable on the nameplate.

WARNING

Incorrect installation

Risk of explosion in the hazardous area. For use in hazardous areas according to Class I, Division 2 or Class I, Zone 2 or for use in the EU according to ATEX 2014/34/EU, observe the following conditions:

- Install the device in a control cabinet or enclosure.
- The control cabinet or enclosure meets at least the requirements of IP54 according to IEC/EN 60079-7 and pollution degree 2 or better according to IEC/EN 60664-1.

WARNING

If the device is installed in a cabinet, the inner temperature of the cabinet corresponds to the ambient temperature of the device.

WARNING

Opening the device

DO NOT OPEN WHEN ENERGIZED.

WARNING

Replacing components

EXPLOSION HAZARD

SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2 OR ZONE 2.

WARNING

Impermissible repair of the device

- Repair must be carried out by Siemens authorized personnel only.

1.3 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/global/en/products/services/cert.html.

The SIWAREX WP351 electronic weighing system is designed for use in secure, closed networks and does not have any protection against unauthorized data traffic.

1.4 Open Source Software

Open-source software is used in the firmware of the product described. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information on this on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109740777).

The license terms are stored on the device and available via the web server. For more on this, refer to section Calling the web server (Page 47). To view the license conditions, click the "OSS ReadMe" button.

To resellers: Pass the license conditions on to the buyer to avoid license violations by the reseller and the buyer.

Product overview

2

2.1 View

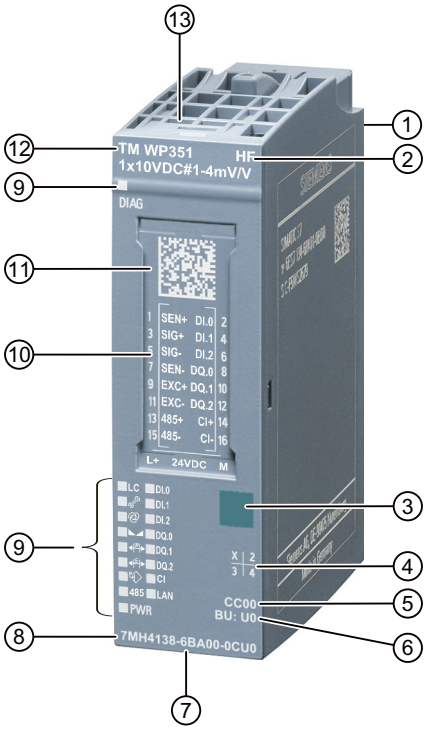

①	Rear: Write protection switch	⑧	Article number
②	Function class	⑨	LEDs (Page 155)
③	Color coding electronic weighing system type	⑩	Wiring diagram
④	Function version	⑪	2D matrix code
⑤	Color code for selection of the color-coded labels	⑫	Electronic weighing system type and designation
⑥	BaseUnit type	⑬	Button in enclosure for emergency access to the Web server
⑦	Below: Ethernet		

Figure 2-1165 View of the electronic weighing system

See also

ET 200SP Distributed I/O System
(http://support.automation.siemens.com/WW/view/en/58649293)

Product information on documentation for the ET 200SP Distributed I/O System
(http://support.automation.siemens.com/WW/view/en/73021864)

2.2 Properties

The electronic weighing system has the following properties:

- Technical properties
  - One channel
  - Interfaces:

    Load cell connection with 10 V DC supply voltage; 0.5 µV/e; 3x6000 d

    ±20,000,000 digit resolution at 1 kHz sampling rate

    Digital input signals DI.0, DI.1 and DI.2 24 V DC

    Digital output signals DQ.0, DQ.1 and DQ.2 24 V DC

    Counter input CI; up to 9 kHz; 24 V DC

    Supply voltage L+/M

    Serial interface RS485

    Ethernet interface (RJ45 socket)
- Monitoring of the load cell for impedance, wire break, short-circuit and faulty supply voltage
- Hardware interrupts configurable
- Input filters for suppression of interferences at encoder inputs and digital inputs can be configured
- Calibratable alibi memory for up to 1 000 000 entries.
- Supported load cell types
  - Analog strain gauge load cells with characteristic values of 1 to 4 mV/V
- Supported system functions
  - Firmware update
  - Identification data I&M

2.3 Version dependencies of the functions

The electronic weighing system supports the following functions:

Function	Firmware version of the electronic weighing system	Configurable as of		
		STEP 7 (TIA Portal)	GSD	
			PROFINET IO	PROFIBUS DP
Firmware update	V1.0 or higher	V15	X	—
I&M identification data	V1.0 or higher	V15	X	X
Centralized operation on CPU 151xSP	V1.0 or higher	V15	—	—

Installing

3

Mounting on the SIMATIC ET 200SP

Only use the electronic weighing system in conjunction with a SIMATIC ET 200SP distributed I/O system. Install the electronic weighing system in a control cabinet. Observe the information on the protection class and degree of pollution in the section Technical data (Page 159).

When installing the SIMATIC components with the electronic weighing system described herein, follow the setup, assembly and wiring guidelines for the SIMATIC ET 200SP. See system manual (https://support.industry.siemens.com/cs/ww/en/view/109742709) for the SIMATIC ET 200SP.

The electronic weighing system is snapped onto the SIMATIC ET 200SP BaseUnit (BU).

Connect the load cells, the digital input and digital output signals to the BaseUnit of the electronic weighing system. The infeed of the supply voltage at the light-colored BaseUnit of the associated potential group supplies the electronic weighing system and the digital outputs and generates the load cell supply voltage. All information about connecting is available in section Connection to electronic weighing system (Page 22)

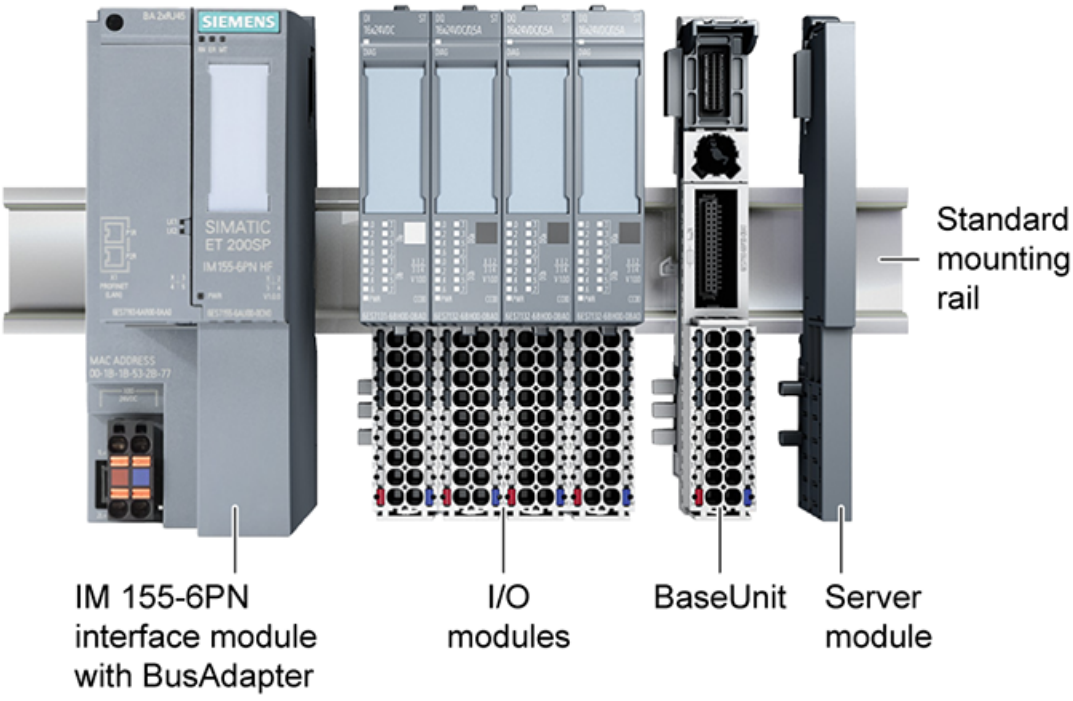

Figure 2-1166 Mounting on the SIMATIC ET 200SP

3.1 Basic safety notes

WARNING

Open equipment

The devices are "open equipment" according to the standard IEC 61010-2-201 or UL 61010-2-201 / CSA C22.2 No. 61010-2-201. To fulfill requirements for safe operation with regard to mechanical stability, flame retardation, stability, and protection against contact, the following alternative types of installation are specified:

- Installation in a suitable cabinet.
- Installation in a suitable enclosure.
- Installation in a suitably equipped, enclosed control room.

3.1.1 ATEX/IECx special conditions for use

WARNING

Incorrect installation

Risk of explosion in the hazardous area. For use in hazardous areas according to Class I, Division 2 or Class I, Zone 2 or for use in the EU according to ATEX 2014/34/EU, observe the following conditions:

- Install the device in a control cabinet or enclosure.
- The control cabinet or enclosure meets at least the requirements of IP54 according to IEC/EN 60079-7 and pollution degree 2 or better according to IEC/EN 60664-1.

NOTE

You must not install the device on a wall in hazardous areas.

WARNING

Transient overvoltages

Take measures to ensure that temporary transient overvoltages of more than 119 V do not occur.

3.2 EMC-compliant installation

3.2.1 Introduction

Overview

The electronic weighing system described here was developed for use in industrial environments and complies with high EMC requirements. Nevertheless, before installing your devices you should prepare an EMC plan and identify and take into consideration possible interference sources.

EMC

EMC (electromagnetic compatibility) describes the capability of electrical equipment to operate without errors in a given electromagnetic environment, without being subject to external influence and without influencing external devices in any way.

3.2.2 Possible effects of interference

Electromagnetic interferences can influence the electronic weighing system described here in various ways:

- Electromagnetic fields having a direct influence on the system
- Interferences transported by communication cables
- Interferences having an effect via process cables
- Interferences entering the system via the power supply and/or protective ground

Interferences can impair the fault-free functioning of the electronic weighing system.

3.2.3 Coupling mechanisms

Depending on the propagation medium (conducted or non-conducted) and the distance between the interference source and the device, interferences can enter the faulty device through four different coupling mechanisms:

- Electrical coupling
- Capacitive coupling
- Inductive coupling
- Radiation coupling

3.2.4 Five basic rules for securing EMC

Observe these five basic rules to secure EMC.

Rule 1: Large area grounding contact

- When installing the devices, make sure that the surfaces of inactive metal parts are properly bonded to chassis ground (see following sections).
- Bond all inactive metal parts to chassis ground, ensuring large area and low-impedance contact (large cross-sections).
- Make screw connections on painted or anodized metal parts either with special contact washers or remove the insulating protective layers at the contact points.
- Wherever possible, avoid the use of aluminum parts for ground bonding. Aluminum oxidizes very easily and is therefore less suitable for ground bonding.
- Provide a central connection between chassis ground and the ground/protective conductor system.

Rule 2: Proper cable routing

- Organize your wiring system into cable groups (high-voltage/power supply/signal/measurement/data cables).
- Always route high-voltage and data cables in separate ducts or in separate bundles.
- Install the measurement cables as close as possible to grounded surfaces (e.g. supporting beans, metal rails, steel cabinet walls).

Rule 3: Fixing the cable shielding

- Ensure proper fixation of the cable shielding.
- Always use shielded data cables. Always connect both ends of the data cable shielding to ground on a large area.
- Keep unshielded cable ends as short as possible.
- Always use metal/metalized connector housings only for shielded data cables.
- To connect the signal cables, use the corresponding SIMATIC ET 200SP shield supports with order number 6ES7193-6SC00-1AM0.

Rule 4: Special EMC measures

- All inductors that are to be controlled should be connected with suppressors.
- For cabinet lighting in the immediate range of your controller, use interference suppressed fluorescent lamps.

Rule 5: Homogeneous reference potential

- Create a homogeneous reference potential and ground all electrical equipment.
- Use sufficiently dimensioned equipotential bonding conductors if potential differences exist or are expected between your system components. Equipotential bonding is absolutely mandatory for applications in hazardous areas.

Connecting

4

4.1 Basic safety notes

WARNING

Safety extra low voltage

The equipment is designed for operation with a directly connectable safety extra low voltage (SELV) from a limited power source (LPS). (This does not apply to 100 V...240 V devices).

The power supply therefore needs to meet at least one of the following conditions:

- Only safety extra low voltage (SELV) with limited power source (LPS) complying with IEC 60950-1 / EN 60950-1 / VDE 0805-1 or IEC 62368-1 / EN 62368-1 / VDE 62368-1 may be connected to the power supply terminals.
- The power supply unit for the device must meet NEC Class 2 according to the National Electrical Code (r) (ANSI / NFPA 70).

There is an additional requirement if devices are operated with a redundant power supply:

If the equipment is connected to a redundant power supply (two separate power supplies), both must meet these requirements.

WARNING

Suitable cables at high ambient temperatures

If the temperature of the cable or housing socket exceeds 70 °C or the branching point of conductors exceeds 80 °C, special precautions must be taken.

If the device is operated at ambient temperatures of between 50 °C and 60 °C, only use cables with a maximum permitted operating temperature of at least 80 °C.

4.1.1 ATEX/IECx special conditions for use

WARNING

WARNING – EXPLOSION HAZARD:

DO NOT CONNECT OR DISCONNECT EQUIPMENT WHEN A FLAMMABLE OR COMBUSTIBLE ATMOSPHERE IS PRESENT.

> **⚠ WARNING**
>
> **Transient overvoltages**
>
> Take measures to ensure that temporary transient overvoltages of more than 119 V do not occur.

4.2 Connection to electronic weighing system

Table 2-1318 Terminal assignment of the BaseUnit

Designation	Signal name		View	Signal name		Designation
Load cell supply voltage monitoring +	SEN+	1		2	DI.0	Digital input DI.0
Load cell signal +	SIG+	3		4	DI.1	Digital input DI.1
Load cell signal -	SIG-	5		6	DI.2	Digital input DI.2
Load cell supply voltage monitoring -	SEN-	7		8	DQ.0	Digital output DQ.0
Load cell supply voltage +	EXC+	9		10	DQ.1	Digital output DQ.1
Load cell supply voltage -	EXC-	11		12	DQ.2	Digital output DQ.2
RS485 interface +	485+	13		14	CI+	Counter input CI +
RS485 interface -	485-	15		16	CI-	Counter input CI -
24 V DC supply voltage	L+				M	Ground for supply voltage

BaseUnit

The BaseUnit is not included in the scope of delivery of the electronic weighing system and must be ordered separately.

An overview of the BaseUnits that you can use with the electronic weighing system can be found in the Product Information for the documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

Information regarding selection of the suitable BaseUnit can be found in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual.

Information on wiring the BaseUnit, creating the cable shield, etc., can be found in the ET 200SP Distributed I/O System System Manual (http://support.automation.siemens.com/WW/view/en/58649293) in the section Connecting.

Supply voltage L+/M

With a dark BaseUnit, the supply voltage of the left BaseUnit is used.

The electronic weighing system monitors whether the supply voltage is connected.

Load cell connection

In case of 6-wire load cells, the supply voltage is measured over the terminals 1 (SEN+) and 7 (SEN-) and used as reference. A voltage drop on the load cell cable does not have an effect on the measurement.

You can connect 4-wire as well as 6-wire load cells. The electronic weighing system is set for operation with 6-wire load cells in the factory.

If the power of the electronic weighing system-internal power supply of the load cells is not sufficient, use an external power supply source to supply the load cells.

NOTE

Compensate for interferences when connecting 4-wire load cells

If you use 4-wire load cells, we recommend that you use a 6-wire cable between the electronic weighing system and the terminal box.

- Set a wire jumper in the terminal box between EXC+/SEN+ and EXC-/SEN-.

  The wire jumper compensates for interferences between the electronic weighing system and the terminal box.

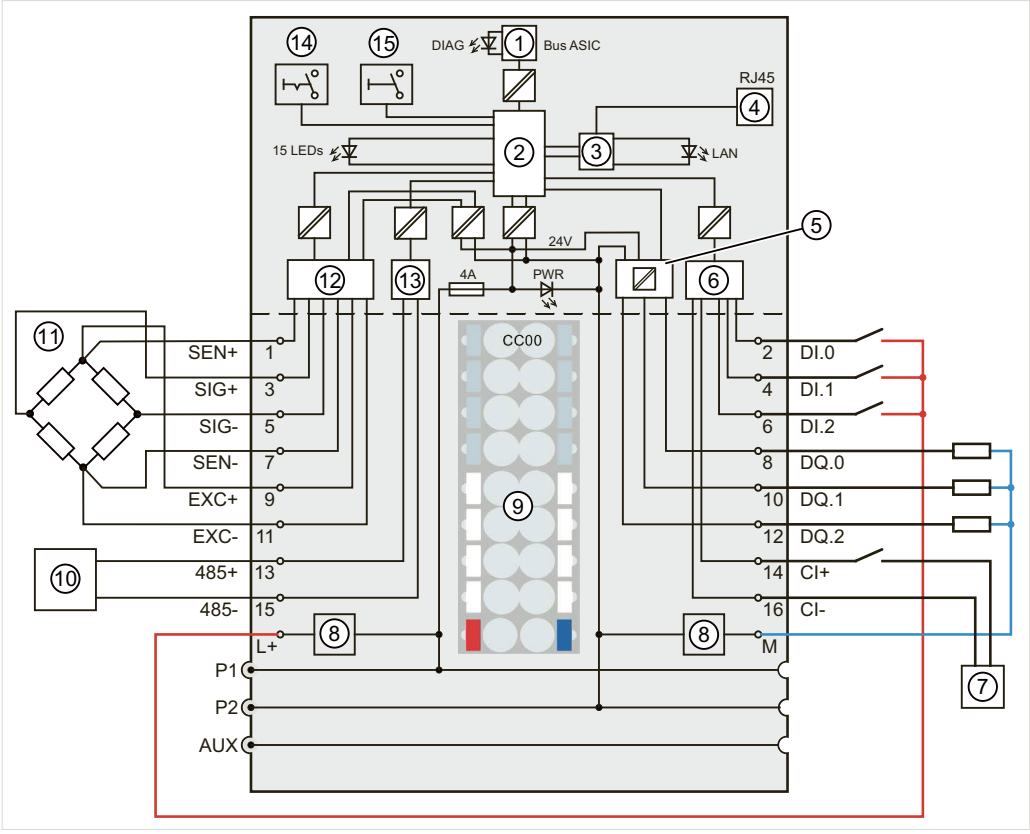

①	Backplane bus interface	⑨	Color identification label CCxx (optional)
②	MCU (microcontroller)	⑩	RS485 device
③	Ethernet sender/receiver (bus coupler)	⑪	Load cell
④	Ethernet	⑫	Filter and A/D converter
⑤	Output electronics	⑬	RS485 sender/receiver (bus coupler)

⑥	Input electronics	⑭	Write protection
⑦	External signal source for counter input CI	⑮	Setup mode
⑧	Filter connection supply voltage (only when light-colored BaseUnit is present)		

Figure 2-1167 Principle and pin assignment

Digital inputs DI.0 to DI.2

Assign to the digital inputs scale functions free and individually within the DR 7. No functions are assigned to the inputs at the factory.

The digital inputs are not isolated from each other.

Input delay for digital inputs

In order to suppress noise you can configure an input delay for the digital inputs.

NOTE

If you select the "None" or "0.0001 " option, you must use shielded cables for connection of the digital inputs.

Digital outputs DQ.0 to DQ.2

Assign to the digital inputs scale status free and individually within the DR 7. No functions are assigned to the outputs at the factory.

The digital outputs are not isolated from each other.

The digital outputs are 24 V sourcing with respect to M and with a nominal load current of 0.5 A. They are protected against overload and short-circuit.

Relays and contactors can be directly connected without an external protective circuit. You can find information about the maximum possible operating frequencies and the inductive loads at the digital outputs in the section Technical data (Page 159).

Counter input CI

The counting input CI is used for measuring 24 V signal frequency up to 9 kHz.

Ethernet

The Ethernet port is used to reach the Web server interface or provide access to the electronic weighing system using Modbus TCP/IP.

If you connect a calibratable main display over the Ethernet port, no additional programming is required in the CPU. Connect the electronic weighing system physically to the network of the SIMATIC HMI.

NOTE

Provide strain relief for the cables that are permanently connected to the Ethernet port.

The strain relief of the cable ensures secure hold of the electronic weighing system in the BaseUnit.

4.3 Connection of analog load cells

Sensors equipped with expansion measuring strips (EMS) can be connected to the electronic weighing system. These sensors meet the requirements in section Technical data (Page 159).

4.3.1 Connecting SIWAREX JB to the electronic weighing system and load cell

Procedure

1. Open the cover of the SIWAREX JB.
2. Screw in an M16 x 1.5 cable gland for each load cell.
3. Screw in an M20 x 1.5 EMC cable gland for the signal cable to the electronic weighing system.
4. Wire the SIWAREX JB to the load cell and the electronic weighing system in accordance with Wiring diagrams (Page 26).

   To learn how to connect the cable, see section Connecting cables to SIWAREX JB (Page 28).
5. Close any unused opening in the enclosure with a blanking plug.
6. Connect the equipotential bonding conductor to the outside of the enclosure.

   Use shielded cable lugs.
7. Close the cover of the SIWAREX JB according to the tightening torque.

4.3.2 Wiring diagrams

4.3.2.1 Load cells with four-wire system

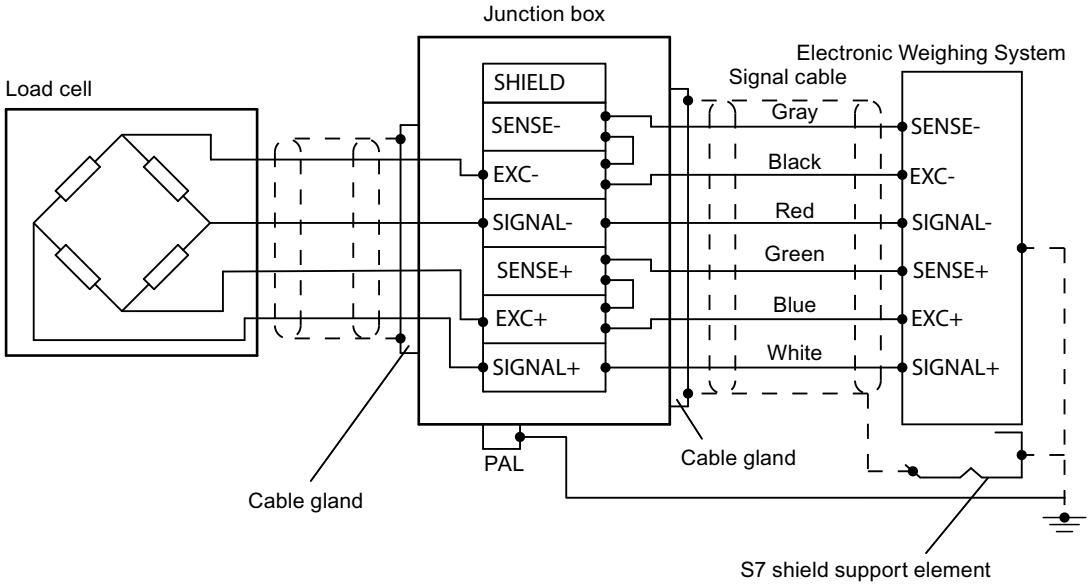

Figure 2-1168 Cable shield of the signal cable connected to EMC cable gland

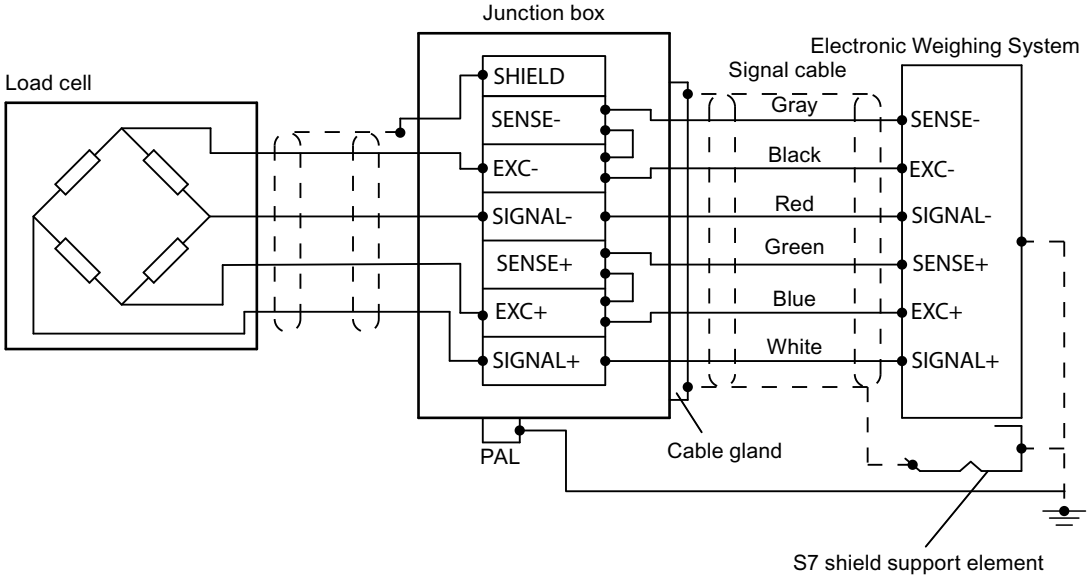

Figure 2-1169 Cable shield of the signal cable connected to shield terminal

The following wire jumpers are set by default:

Wire jumper	From terminal	To terminal
1	EXC-	SENSE-
2	EXC+	SENSE+

NOTE

If the wire jumpers are missing, the electronic weighing system reports a wire break.

4.3.2.2 Load cells with six-wire system

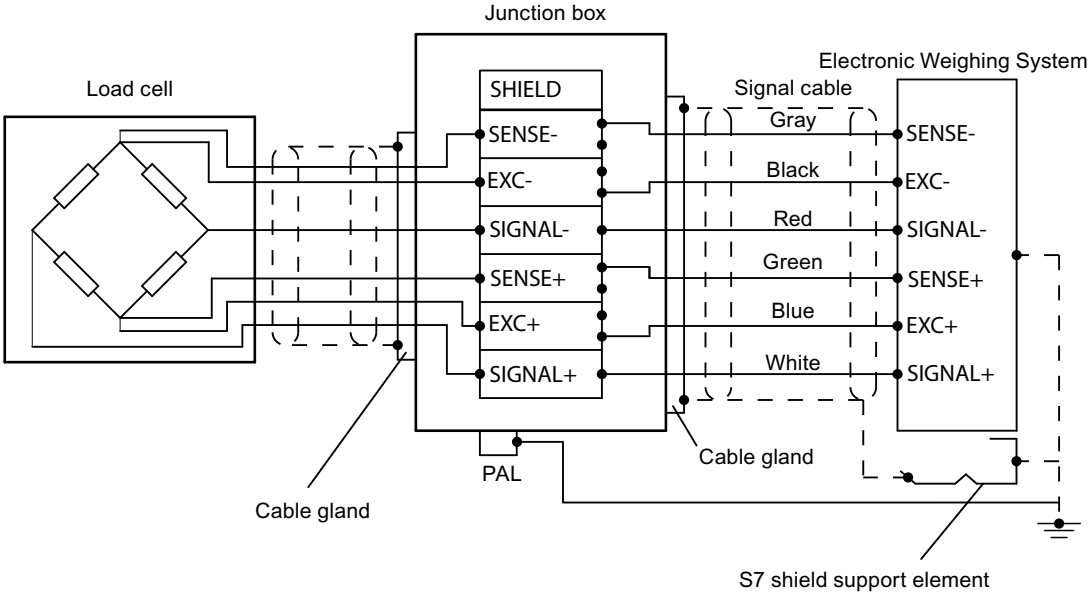

Figure 2-1170 Cable shield of load cell cable connected to EMC cable gland

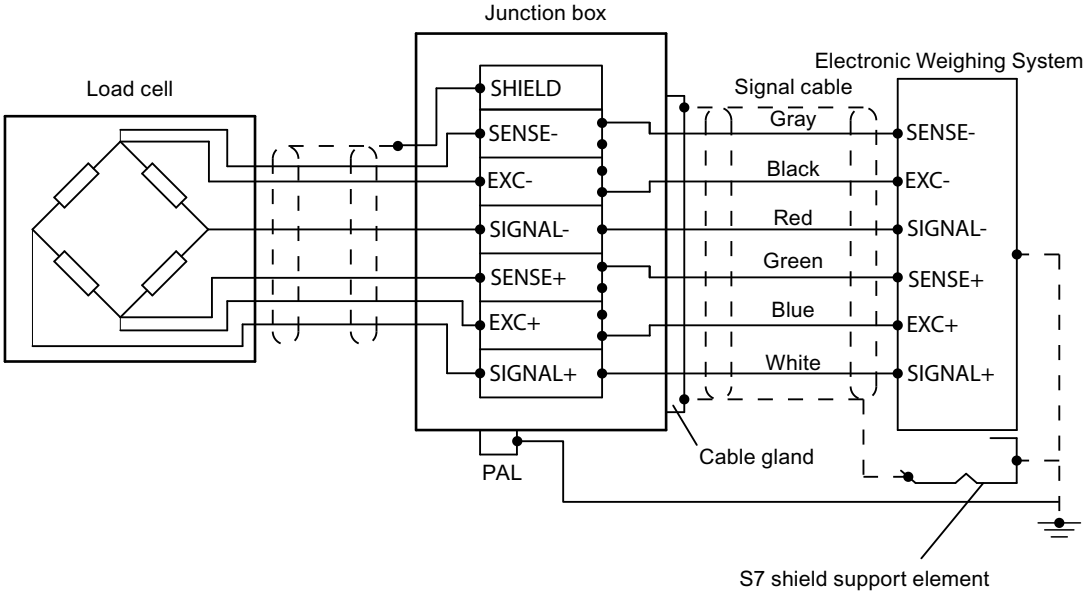

Figure 2-1171 Cable shield of load cell cable connected to shield terminal

- Disconnect the following wire jumpers:

Wire jumper	From terminal	To terminal
1	EXC-	SENSE-
2	EXC+	SENSE+

4.3.3 Connecting cables to SIWAREX JB

Requirement

You require a screwdriver with a maximum blade width of 3.5 mm.

Procedure

1. In EMC cable glands, lay the cable shielding over a large area.

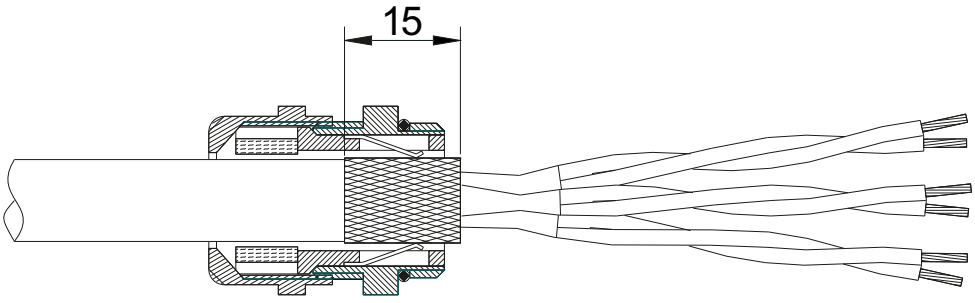

Figure 2-1172 Place the cable shield in the EMC cable gland

2. With plastic cable glands, place the corresponding wire of the SIWAREX load cell on the shield terminal.

3. Strip at least 6 mm of insulation from the load cell cable.

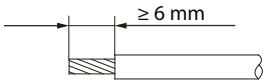

Figure 2-1173 Strip cable

4. Insert the stripped load cell cable into the square opening of the screw terminal as far as it will go.
5. Tighten the screws with the specified tightening torque.

Result

The tightened screw firmly holds the stripped wire and establishes the contact.

4.4 Connection of the SIWAREX DB

The digital junction box SIWAREX DB allows connection of up to 4 analog load cells. SIWAREX DB has 4 separate AD converters and thus digitizes each load cell separately.

In addition to the actual measured value, the following **extended diagnostics data** are available for each individual load cell:

- Current signal voltage in millivolts
- Wire-break monitoring
- Current input resistance in ohms
- Current "excitation current" in mA etc.

In the event of a defective load cell, the electronic weighing system reports the affected load cell. Service as well as commissioning are significantly facilitated and accelerated.

SIWAREX DB also enables digital adjustment of different load cell characteristics (corner load compensation).

4.4.1 Connecting the SIWAREX DB to WP341 and WP351

Procedure

1. Open the cover of the SIWAREX DB.
2. Screw in an M16 x 1.5 cable gland for each load cell.
3. Screw in an M20 x 1.5 EMC cable gland for the signal cable to the SIWAREX WP electronic weighing system.

4. Attach the cables from SIWAREX DB to the load cell and the SIWAREX WP electronic weighing system.

   Connect the cable (Page 30)

   The maximum distance between SIWAREX DB and the WP electronic weighing system is 1000 m when using the recommended cable 7MH4702-8AG.

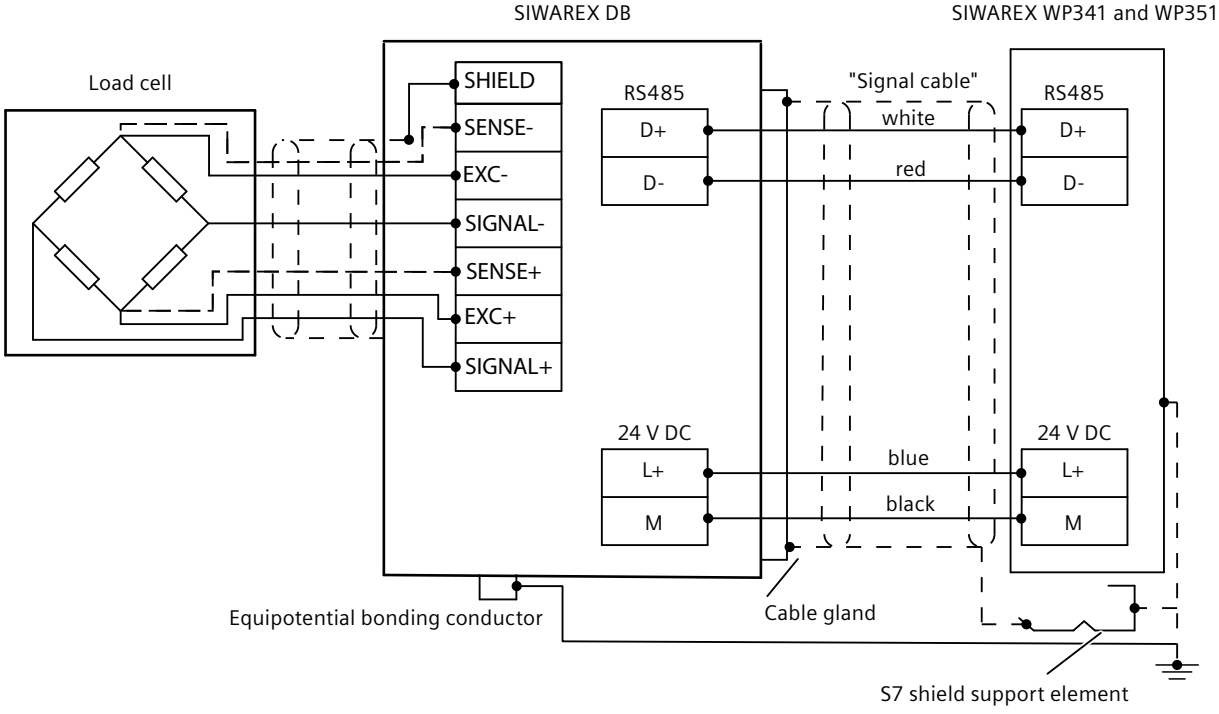

5. Close any unused opening in the enclosure with a blanking plug.
6. Connect the equipotential bonding conductor (functional grounding) to the enclosure exterior.

   Use shielded cable lugs.
7. Close the cover of the SIWAREX DB according to the tightening torque 1.5 to 2 Nm.

4.4.2 Connect the cable

Condition

You require a screwdriver with a maximum blade width of 2.5 mm.

You can use the SIWAREX cable for supply voltage and RS-485 communications. Accessories (Page 168)

Procedure

1. Place the cable shield in the EMC cable gland over a large area.

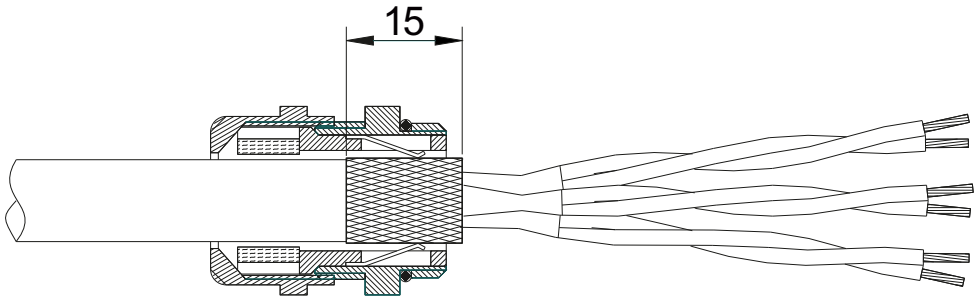

Figure 2-1174 Place the cable shield in the EMC cable gland.

2. For plastic cable glands, connect the corresponding wire of the SIWAREX load cell to the shield terminal.
3. Strip the cable ends at least 6 mm.
4. Push the screwdriver into the rectangular opening of the terminals.
5. Insert the stripped cable into the round opening as far as it will go.
6. Remove the screwdriver from the rectangular opening.

Commissioning 5

5.1 Calibration with calibration weights

Introduction

As a rule, the characteristic curve can be determined with 2 calibration points. Only determine additional calibration points for non-linear systems.

Requirement

The scale characteristic curve of the scale consisting of calibration weights and adjustment digits of the electronic weighing system is not known.

Procedure

1. Select the "Service mode ON (1)" command.
2. Read DR03.
3. Configure the Justagegewichte [calibrationWeight0 to calibrationWeight4] and other parameters in DR03.

   DR03 Calibration parameters (Page 56)
4. Write DR03.
5. Start the "Set calibration point 0 (60)" command with the scale empty.
6. Load the scale with the specified calibration weight.

   The difference between 2 calibration weights must be at least 40 000 adjustment digits, otherwise the calibration command can be rejected. This corresponds to approximately 2% of the nominal load of all load cells (2% of (number of load cells x nominal load of one single load cell)).

Load cell characteristic value	Adjustment digits (approx.) at nominal load
1 mV/V	20 000 000
2 mV/V	20 000 000
4 mV/V	20 000 000

7. Start the "Set calibration point 1 (61)" command.
8. If you want to define more than 2 calibration points, proceed in the same way with all calibration points.
9. Use increasing calibration weights during calibration.
10. Read DR03.

11. Save the calibration data as a backup.

12. Optional: Start the "Check calibration (83)" command.

13. Select the "Service mode OFF (2)" command.

Example

The diagram below illustrates the relationship between calibration digits and the calibration weight.

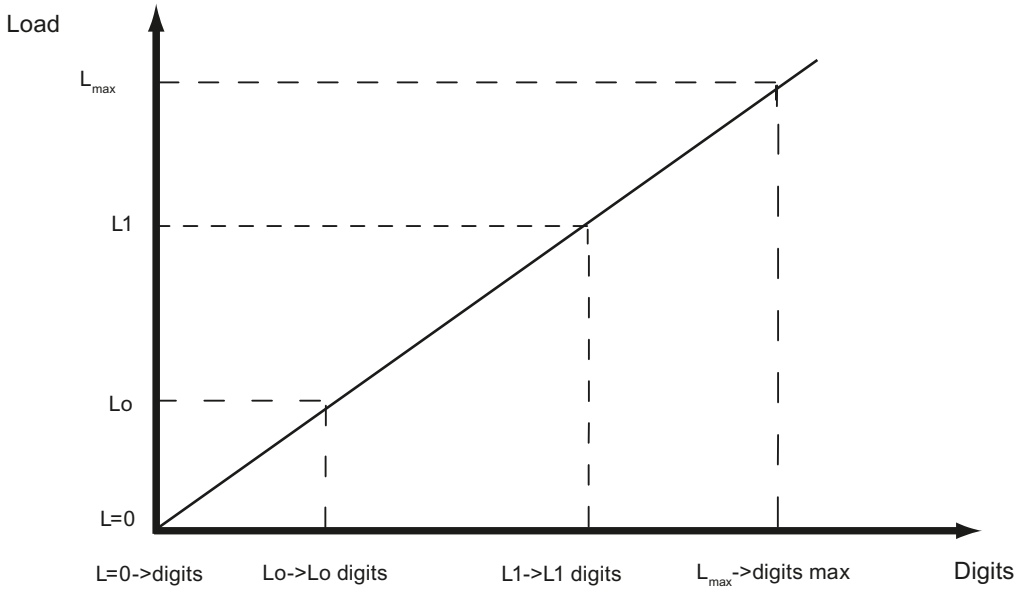

Load	Comment	Load	Digits
L=0	100 kg load cell (2 mV/V) not loaded		Approx. 0
L0	Mechanical installation on load cell (dead load)	25 kg	Approx. 5 000 000
L1	Calibration weight 1 placed onto scale	e.g. 60 kg	Approx. 12 000 000
L_{max}	Nominal weight of load cell	100 kg	20 000 000
L_{max}+10%	Nominal weight + approx. 10%	Approx. 110 kg	22 000 000

Figure 2-1175 Calibration digits and calibration weight

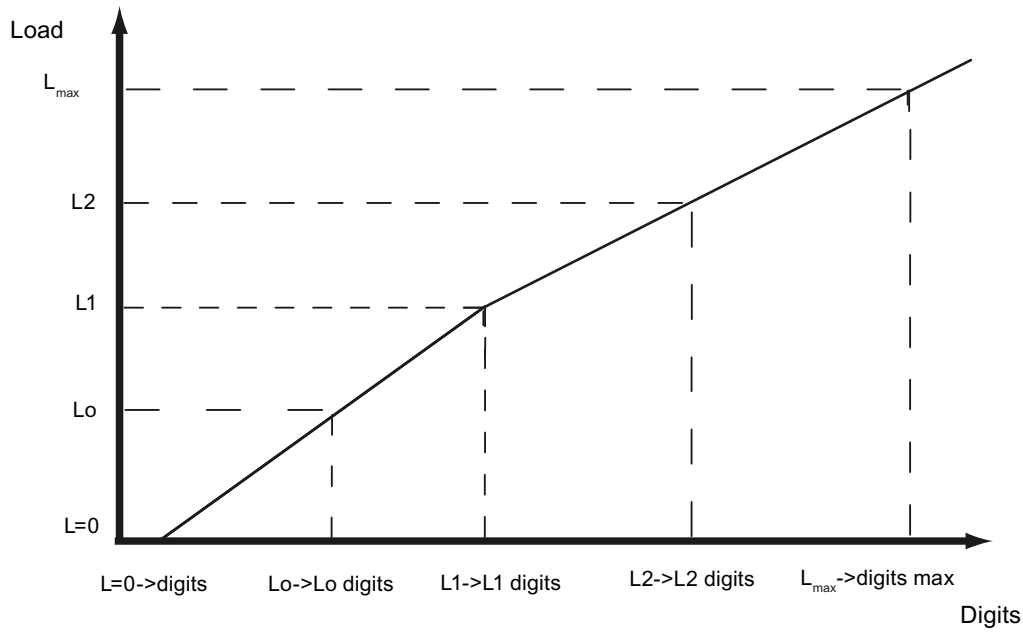

Load	Comment	Load	Digits
L=0	100 kg load cell (2 mV/V) not loaded		Approx. 0
L0	Mechanical installation on load cell (dead load)	For 25 kg	Approx. 5 000 000
L1	Calibration weight 1 placed onto scale	For 60 kg	Approx. 12 000 000
L2	Calibration weight 2 placed onto scale	For 80 kg	Approx. 16 500 000
L_{max}	Nominal weight of load cell	100 kg	Approx. 20 000 000

Figure 2-1176 Linearizing the scale characteristic curve

See also

Calibration weights 0, 1, 2, 3, 4 [calibrationWeight] and calibration digits [calibrationDigit] 0, 1, 2, 3, 4 (Page 60)

5.2 Automatic calibration

Introduction

Automatic calibration enables fast commissioning. The accuracy of the scale depends on the entered parameters and the mechanical properties of the scale.

The best level of accuracy for the scale can be achieved by calibrating with Calibration with calibration weights (Page 32).

Requirements

Automatic calibration requires the following criteria:

- Correct mechanical installation of the scale without shunt forces
- Scale is empty (only mechanical installation (= dead load) present on the cells)
- Installed load cells are evenly loaded

Procedure

1. During the first commissioning, reset using the electronic weighing system with the command "Load factory settings (11)" or "Load standard parameter (12)".
2. Select the "Service mode ON (1)" command.
3. Read DR10.
4. Specify the load cell parameters in DR10 (Page 77).
5. Write DR10.
6. Start the "Run automatic calibration (82)" command.
7. Select the "Service mode OFF (2)" command.

Result

The characteristic curve of the scale is calculated using the specified load cell parameters from DR10 and the currently applied dead load. The characteristic curve is active immediately.

The characteristic data from DR03 is overwritten with the command "Automatic calibration (82)".

Parameter assignment/addressing 6

6.1 Introduction

The following options are available for parameter assignment and addressing:

- STEP 7 (TIA Portal) user program
  - Commissioning the electronic weighing system with TIA Portal (Page 37)
  - Call function block FB WP351 [FB351]. (Page 39)
  - Executing commands (Page 42)
  - Cyclic data exchange via "cyclicIoData" (Page 45)
  - Reading/writing data records (Page 46)
- Web server
  - Calling the web server (Page 47)
  - Reading/writing data records (Page 49)
  - Parameter assignment
- Modbus TCP/IP commissioning and parameter assignment
  - Communication via Modbus (Page 128)

Parameter table

In addition to the parameter descriptions, the parameter table (https://support.industry.siemens.com/cs/ww/en/ps/7MH4138-6BA00-0CU0/dl) on the Internet provides information on:

- DR number
- Parameter name
- S7 name
- Data type
- Min. value
- Max. value
- Modbus address
- Write protection
- Access
- Status information from DR30

Table 2-1319 Example parameter table

DR	Parameter	S7 name	Type	Min. value	Max. value	Modbus address	Write protection	Access
4	Calibration digits 0 (calculated)	calibrationDigits0calculated	DINT	0	-	1200	x	r

6.2 TIA Portal user program

6.2.1 Commissioning the electronic weighing system with TIA Portal

Procedure

1. Download the "Ready to use" TIA Portal example project for the technology module TM SIWAREX WP351 HF (https://support.industry.siemens.com/cs/ww/en/ps/17781/dl) from the Internet.

   The example project must be compatible with your SIMATIC controller.
2. Navigate to the electronic weighing system in the hardware catalog task card: Technology modules > Weighing > SIWAREX > TM SIWAREX WP351 HF.
3. Drag-and-drop the electronic weighing system in the ET 200SP rack.
4. Click on the "General" sub-tab in the "Properties" tab.
5. In the left-hand tree, navigate to TM SIWAREX WP351 HF.

Web server	Activate the access for the Web server.
HTTPS	Function is not supported with FW version 1.0.0.
Logon name / Access right / Password	Create up to five different users. Assign the "Read" or "Read and write" permission individually to each user. **Read** means that the user has read-only access to the Web server and can create and download a backup of the current configuration. The user cannot change data or start commands. **Invalid combination of logon name and password** The following combination is intended exclusively for emergency access to the Web server. Logon name: admin Password: admin For more on this, see section: Calling the web server (Page 47) > Procedure in case of loss of user data.

IP address	IP address of the electronic weighing system (default: 192.168.0.21)
Subnet mask	Subnet mask of the electronic weighing system (default: 255.255.255.0)
Set IP address in the project	The IP address of the electronic weighing system is transmitted via the hardware configuration during CPU startup. The IP address is only specified via TIA Portal.

Permit adapting the IP address directly at the device	The IP address of the electronic weighing system is not assigned via the TIA Portal. – Assign the IP address via an external tool (e.g. PST Tool)
Use router	Defines whether or not a router is used.
Router address	IP address of the router
Device name	Network name of the electronic weighing system

6. Enable the desired diagnostic interrupts.

   Monitoring is always active. When an error is detected, a diagnostic interrupt is only triggered when the corresponding diagnostic interrupt is enabled in the device configuration.

7. Enable the desired hardware interrupts.

   With the help of the following event types, parameterize the triggering of a hardware interrupt if they are to be used for controlling dosing. If the dosing signals are to be switched in the cyclic program via the FB, the hardware interrupts can be ignored.

   – Coarse flow (incoming)
   – Coarse flow (outgoing)
   – Fine flow (incoming)
   – Fine flow (outgoing)
   – Emptying (incoming)
   – Emptying (outgoing)
   – Hardware interrupt 4 (event freely definable in DR07)
   – Hardware interrupt 5 (event freely definable in DR07)
   – Hardware interrupt 6 (event freely definable in DR07)
   – Hardware interrupt 7 (event freely definable in DR07)
   – Hardware interrupt 8 (event freely definable in DR07)

   You can select any combination of events for hardware interrupt triggering.

   You can obtain detailed information on the event in the hardware interrupt organization block with the instruction "RALRM" (read additional interrupt info) and in the information system of STEP 7 (TIA Portal).

The event that triggered the hardware interrupt is logged in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

LB 8								LB 9								LB 10								LB 11							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	X	0	0	0	X	X	X	X	X

Bit no.
LD 8

User Structure Identifier (USI)

Event that triggered the hardware interrupt (EventType):

00001_B: Coarse flow incoming
00010_B: Fine flow incoming
00011_B: Emptying incoming
00100_B: Hardware interrupt 4
00101_B: Hardware interrupt 5
00110_B: Hardware interrupt 6
00111_B: Hardware interrupt 7
01000_B: Hardware interrupt 8
10001_B: Coarse flow outgoing
10010_B: Fine flow outgoing
10011_B: Emptying outgoing

Channel that has triggered the hardware interrupt (IChannel):
0_B: Channel 0 of the technology module

Figure 2-1177 Start information of the organization block

6.2.2 Call function block FB WP351 [FB351].

Introduction

For each electronic weighing system, call the FB cyclically once in the user program. For each call of the FB, adapt the input parameters to the electronic weighing system. Each electronic weighing system has a unique HW ID and its own interface DB. The interface DB contains all weighing parameters. The PLC data types of the interface DB can be found in the TIA Portal example project. Copy the PLC data types from the example project into the target project.

Requirement

The following FW versions are required in the S7 controllers so that you can work with the FB:

CPU	FW version
S7-1200	≥ V4.2
S7-1500	≥ V2.0

Procedure

1. Copy the FB, the interface DB and the associated UDTs from the example project into the destination project.
2. Call the FB in the user program.
3. Assign the electronic weighing system for the parameter HW ID "HW_ID".
4. Assign the interface DB to the electronic weighing system for the parameter interface "Interface".

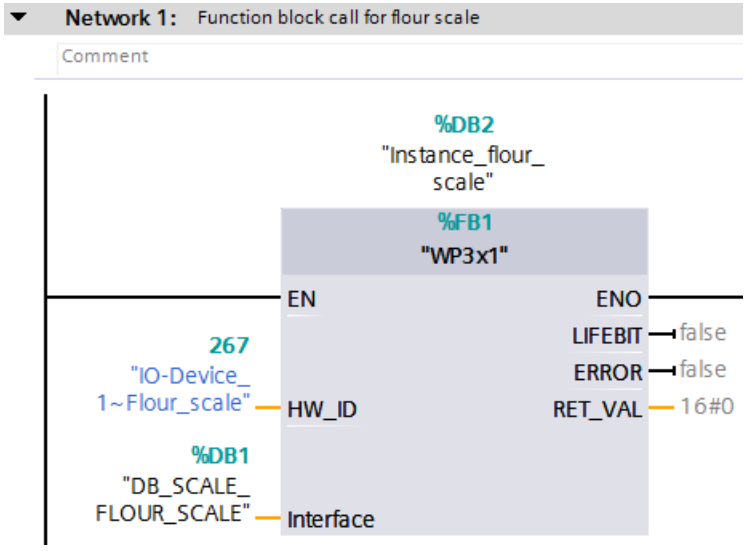

HW_ID	HW ID of the electronic weighing system
Interface	Interface DB of the electronic weighing system
ERROR	"true" = Error
RET_VAL	The meaning of the error codes can be found in the section: Operating errors (Page 138).
LIFEBIT	Optional status bit can be used to monitor communication

Figure 2-1178 FB

5. Copy the HMI or the required components from the example project into the destination project.

Example: 2 FBs for 2 electronic weighing systems

The following example shows the setup of 2 FBs in 2 networks for 2 electronic weighing systems.

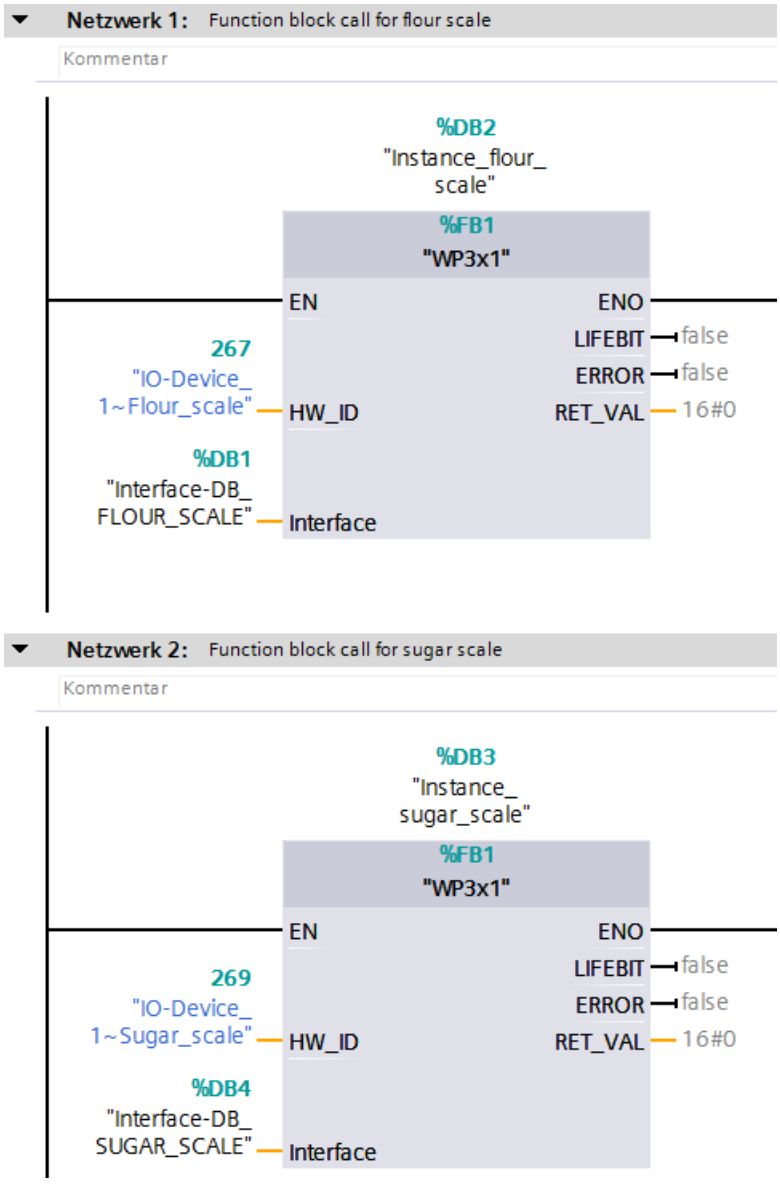

Network 1 "Network 1"	**FB1**	Interface DB of the flour scale "Instance_flour_scale"
		HW_ID of the flour scale "Flour_scale"
		Interface of the flour scale "DB_SCALE_FLOUR_SCALE"
Network 2 "Network 2"	**FB2**	Interface DB of the sugar scale "Instance_sugar_scale"
		HW_ID of the sugar scale "Sugar_scale"
		Interface of the sugar scale "DB_SCALE_SUGAR_SCALE"

Figure 2-1179 2 FBs for 2 electronic weighing systems

6.2.3 Executing commands

Introduction

Data records (DR) are read or written via specific command codes. There are three command mailboxes within the interface DB for this purpose.

The command mailboxes are managed and processed according to priority. When all three command mailboxes are triggered at the same time by the user program, the FB executes them in the following order:

Command mailbox	Priority	Description
Command1	Highest priority	If you run cyclic commands in the "Command1" command mailbox, this makes it impossible to run commands in the "Command2" or "Command3" command mailbox.
Command2	Medium priority	
Command3	Lowest priority	Cyclic commands from the "Command3" command mailbox are interrupted to run a command in the "Command2" or "Command1" command mailbox.

You can find a list of all commands in section: Commands (Page 120).

Requirement

You have called the FB (Page 39).

Procedure

1. Open the interface DB.
2. In one of the command mailboxes "Command1", "Command2" or "Command3", enter a command code for the parameter "code".
3. Set the associated command trigger [trigger] to "true".

4. Evaluate the associated status bits:

   Command in progress. [inProgress]

   Command finished without error. [finishedOk]

   Command rejected or finished with error. [finishedError] [errorCode (Page 142)] [errorAddInfo (Page 147)] You can find a list of data and operating errors in section Operating errors (Page 138).

Interface-DB_FLOUR_SCALE

	Name	Data type	Start value
4	CommandHandling	"Siwarex_WP3..	
5	Command1	"Siwarex_WP3..	
6	code	Int	0
7	trigger	Bool	FALSE
8	inProgress	Bool	FALSE
9	finishedOk	Bool	FALSE
10	finishedError	Bool	FALSE
11	errorCode	Int	0
12	errorAddInfo	Int	0
13	Command2	"Siwarex_WP3..	
14	code	Int	0
15	trigger	Bool	FALSE
16	inProgress	Bool	FALSE
17	finishedOk	Bool	FALSE
18	finishedError	Bool	FALSE
19	errorCode	Int	0
20	errorAddInfo	Int	0
21	Command3	"Siwarex_WP3..	
22	code	Int	0
23	trigger	Bool	FALSE
24	inProgress	Bool	FALSE
25	finishedOk	Bool	FALSE
26	finishedError	Bool	FALSE
27	errorCode	Int	0
28	errorAddInfo	Int	0

Figure 2-1180 Command mailboxes Command1, Command2 and Command3

Example: Parameterize the calibration weight

You want to set the value 12.5 for the parameter Calibration weight [calibrationWeight].

1. Switch on service mode by entering the command code 1 (= Service mode ON) for the "code" parameter in the "Command1" command mailbox.
2. Set the associated command trigger "trigger" to "true".

   ⇒ The "Wrench LED" on the electronic weighing system flashes orange.
3. Read DR03 by entering the command code 2003 for the "code" parameter in the "Command1" command mailbox.
4. Set the associated command trigger "trigger" to "true".

   ⇒ All current data from DR03 is present in the interface DB.
5. In DR03, enter the value 12.5 for calibration weight [calibrationWeight].

6. Write DR03 by entering the command code 4003 for the "code" parameter in the "Command1" command mailbox.
7. Set the associated command trigger "trigger" to "true".
8. Evaluate the associated status bits:

   Command finished without error. [finishedOk] is "true".

   ⇒ The new calibration weight is now present in the electronic weighing system and is used.
9. Disable service mode by entering command code 2 (= Service mode OFF) for the "code" parameter.
10. Set the associated command trigger "trigger" to "true".

6.2.4 Cyclic data exchange via "cyclicIoData"

The interface DB of the FB makes the "cyclicIoData" structure available. All parameters in this structure are updated cyclically by the electronic weighing system to the SIMATIC controller. All entered parameter values within the "cyclicIoData" structure are used directly – without reading or writing DRs.

The following parameters are available for use within the "cyclicIoData" structure on the factory side:

Interface-DB_FLOUR_SCALE

	Name	Data type	Start value
2	CyclicIoData	"Siwarex_WP35..	
3	input	"Siwarex_WP35..	
4	processValueReal1	Real	0.0
5	processValueReal2	Real	0.0
6	processValueReal3	Real	0.0
7	processValueReal4	Real	0.0
8	processValueDWord1	DWord	16#0000_
9	processValueDWord2	DWord	16#0000_
10	processValueDWord3	DWord	16#0000_
11	processValueDWord4	DWord	16#0000_
12	scaleStatus	"Siwarex_WP35..	
13	output	"Siwarex_WP35..	
14	processValue5	Real	0.0
15	processValue6	Real	0.0
16	processValue7	Real	0.0
17	processValue8	Real	0.0
18	transitions	"Siwarex_WP35..	
19	step0	Bool	false
20	step1	Bool	false
21	step2	Bool	false
22	step3	Bool	false
23	step4	Bool	false
24	step5	Bool	false
25	step6	Bool	false
26	step7	Bool	false
27	digitalOutputControl	"Siwarex_WP35..	
28	DQ0	Bool	false
29	DQ1	Bool	false
30	DQ2	Bool	false

Input

[inProcessValueReal1 to inProcessValueReal4]	I/O process values in Real format according to defined parameters in DR07 (Page 70).
[inProcessValueDWord1 to inProcessValueDWord4]	I/O process values in DWord format according to defined parameters in DR07 (Page 70).
[scaleStatus]	Weighing status of weighing steps according to parameters in DR30 (Page 110).

Output

[ioProcessValue5 to ioProcessValue8]	I/O process value according to defined parameters in DR07 (Page 70).

[transitions]	Interlock weighing steps [step0 to step7] with the following bits. Selection code 0 locks weighing step 0. Selection code 1 locks weighing step 1. Selection code 2 locks weighing step 2. Selection code 3 locks weighing step 3. Selection code 4 locks weighing step 4. Selection code 5 locks weighing step 5. Selection code 6 locks weighing step 6. Selection code 7 locks weighing step 7.
[digitalOutputControl]	Digital output (DQ) that is selected in DR07 (Page 70). Activate the digital output with the following bits: Selection code 0 activates DQ.0. Selection code 1 activates DQ.1. Selection code 2 activates DQ.2.
[errorCode]	Error according to Interrupts/diagnostic messages (Page 137).
[addInfo]	Error according to Interrupts/diagnostic messages (Page 137).

Figure 2-1181 "cyclicIoData" structure

6.2.5 Reading/writing data records

Introduction

Every data record (DR) can only be read fully from the electronic weighing system to the SIMATIC controller or written to the electronic weighing system. Transfer of a single parameter within a data record is not possible.

Data in the "cyclicIoData" structure is updated automatically without commands via cyclic communication.

Requirements

You have called the FB (Page 39).

Example: Reading and writing DR07

CAUTION

The number of system functions that can be called at the same time is limited.
Start the commands for reading and writing a data record only when necessary.

1. Switch on service mode by entering the command code 1 for the "code" parameter in the "Command1" command mailbox.
2. Open the interface DB.

3. Read DR07 by entering the command code 2007 for the "code" parameter in the "Command1" command mailbox.
4. Set the associated command trigger [trigger] to "true".

   ⇒ All current data from DR07 is present in the interface DB.
5. Set the scale parameters for DR07 (Page 70).
6. Write DR07 by entering the command code 4007 for the "code" parameter in the "Command1" command mailbox.
7. Set the associated command trigger "trigger" to "true".

6.2.6 Design of hardware configuration

An HSP0281 (Hardware Support Package) is available for download. The following table provides an overview of the possible usage scenarios of the electronic weighing system.

Possible applications	Required components	Configuration software	In the user program
Central operation with a CPU 151xSP	• S7-1500 (SP-CPU) automation system • TM SIWAREX WP351 HF	STEP 7 (TIA Portal as of V15.1): • Basic configuration using the hardware configuration • Web browser for reaching the web server interface	• TM SIWAREX WP351 HF FB for S7-1500/1200 controllers
Distributed operation with an S7-1500 CPU	• Automation System S7-1500 • ET 200SP distributed I/O system • TM SIWAREX WP351 HF		
Distributed operation with an S7-300/400 CPU	• Automation system S7-300/400 • ET 200SP distributed I/O system • TM SIWAREX WP351 HF	STEP 7 (TIA Portal as of V15.1): • Basic configuration using the hardware configuration • Web browser for reaching the web server interface	• TM SIWAREX WP351 HF FB for S7-300/400 controllers
External system	• ET 200SP distributed I/O system • TM SIWAREX WP351 HF	Web browser for reaching the web server interface	• GSD/GSDML file

6.3 Web server

6.3.1 Calling the web server

NOTICE

Low degree of protection against unauthorized access

If you activate the web server, you reduce protection against unauthorized access to functions and data of the electronic weighing system from outside and via the internal network.

- Follow the Cybersecurity information (Page 11).

Introduction

Using the web server of the electronic weighing system, you can start up the electronic weighing system in a completely autonomous way and without additional software tools. You do not need any specific SIMATIC knowledge. After commissioning the electronic weighing system, connect the automation system.

Procedure with TIA Portal

1. In the device view, select TM SIWAREX WP3x1 HF.
2. Click on the "General" sub-tab in the "Properties" tab.
3. Navigate to TM SIWAREX WP3x1 HF > Parameters.
4. Activate the web server.
5. Create at least one user.
   Do not create **any** user with the name "admin".
6. Compile the hardware configuration.
7. Transfer the hardware configuration to your system.
8. Enter the IP address of the electronic weighing system in the Mozilla Firefox or Google Chrome browser. (Default: 192.168.0.21)
9. Log in with the previously defined credentials.

Procedure in case of loss of user data

1. Press the ① pushbutton at the upper left in the enclosure for at least 3 seconds.

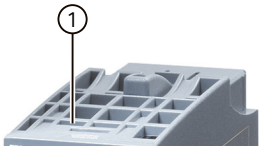

   ⇒ The LED lights up yellow.
2. Enter the IP address of the electronic weighing system in the Mozilla Firefox or Google Chrome browser within 2 minutes. (Default: 192.168.0.21)
3. Log on as follows:

   Logon name: admin

   Password: admin

See also

Commissioning the electronic weighing system with TIA Portal (Page 37)

6.3.2 Reading/writing data records

Introduction

Only the entire data record (DR) can be read from the electronic weighing system in the web server or written to the electronic weighing system. Transfer of a single parameter within a data record is not possible.

Example: Reading and writing DR06

1. Read DR06 by selecting "Online > Read data record" in the shortcut menu.

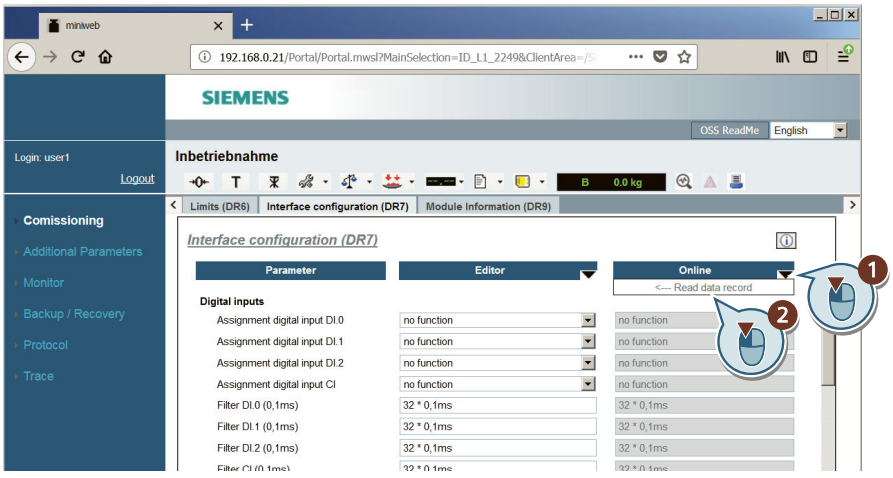

Figure 2-1182 Reading DR

2. Set the parameters for DR06 (Page 69) in the column "Editor".
3. Write DR06 by selecting "Editor > Write data record" in the shortcut menu.

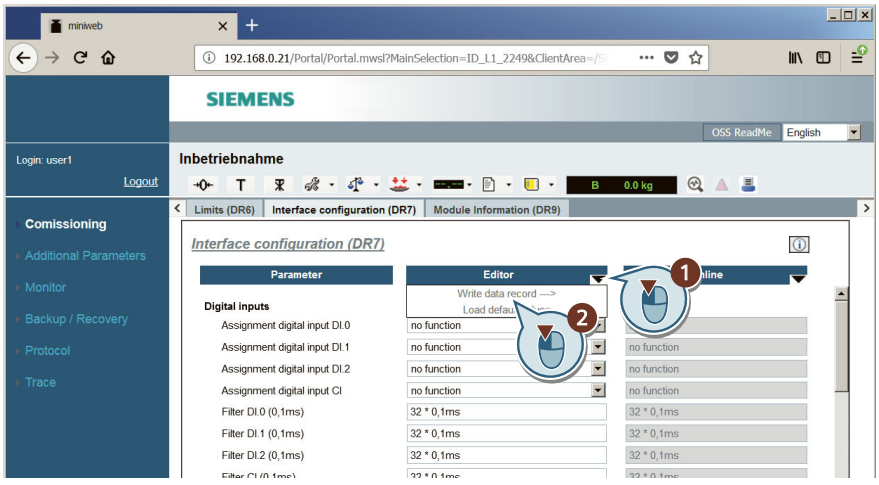

Figure 2-1183 Writing DR

6.4 Operating modes

6.4.1 Weighing steps

Dosing is always executed in weighing steps. These weighing steps involve the same task in each weighing operating mode and are presented below. The scale status in the interface DB of the "cyclicIoData" structure indicates the current weighing step of the scale.

Weighing step	Function
0	Scale waits for command
1	Taring/zeroing (based on dosing start settings from DR25)
2	Extra coarse/Coarse/Fine phase (based on settings from DR23)
3	Post-dosing (based on settings from DR22)
4	Checking (based on settings from DR22)
5	Emptying (based on settings from DR25)
6	Checking of actually emptied material Only for DTI Discontinuous totalizing automatic weighing instrument (Page 54) Modus B

6.4.2 NAWI - Non automatic weighing instrument

6.4.2.1 NAWI - Non-automatic weighing instrument - Filling

In this weighing operating mode, intervention by the operator is always required in the case of a legal-for-trade verified scale. The operator initiates logging of the current weight with a command. The operator can initiate the command from the SIMATIC HMI, for example. The material to be weighed is dosed into or placed on the scale.

The material to be weighed is placed on a platform weighing machine, for example, and an entry is made in the log memory of the electronic weighing system by a user command.

In NAWI mode, the electronic weighing system also allows a set point to be set. The set point is automatically dosed by means of the dosing functionality of the electronic weighing system. The user logs the dosed weight with a command. Manual logging is not included in the automatic weighing cycle.

The dosing signals "Coarse flow/Fine flow" can be used to directly control the corresponding dosing elements. After the set point is reached, the electronic weighing system jumps to "stopped" state in weighing step 4. The operator confirms the dosed weight using the "Continue weighing" (1141) command. The operator logs and ends the weighing operation and continues to weighing step 5 for emptying.

In practice, the dosing process may proceed as follows:

1. PLC sends set point (DR20) and material parameter (DR23) to the electronic weighing system
2. PLC sends "Start" command (e.g. 1101) to the electronic weighing system
3. The electronic weighing system performs zeroing or tares (based on DR25)
4. Coarse/fine dosing phase starts
5. If configured and necessary, post-dosing occurs (DR22)

6. The electronic weighing system jumps to the "Stopped" state and waits for the "Next" command (1141) by the operator
7. If the "Next" command is issued, the dosed weight is written in the log memory and the final tolerance check is performed.
8. The electronic weighing system jumps to weighing step 0 and waits for further commands.

6.4.2.2 NAWI - Non-automatic weighing instrument - Emptying

In this weighing operating mode, intervention by the operator is always required in the case of a legal-for-trade verified scale. The operator initiates logging of the current weight with a command. The operator can initiate the command from the SIMATIC HMI, for example.

"Removal" means that the product to be weighed is dosed from the scale (for example, a silo on load cells with discharge valves). In this case, the full scale is tared and the net weight increases with decreasing gross weight.

In NAWI mode, the electronic weighing system also allows a set point to be set, which the dosing functionality of the electronic weighing system then automatically doses.

The dosing signals "Coarse flow/Fine flow" can be used to directly control the corresponding dosing elements. After the set point is reached, the electronic weighing system jumps to "Stopped" state and the operator must confirm the dosed weight using the "Continue weighing" command. As a result of this, the dosed weight is logged and the weighing operation is concluded.

In practice, the dosing process may proceed as follows:

1. Scale is filled with sufficient material.
2. PLC sends set point (DR20) and material parameter (DR23) to the electronic weighing system
3. PLC sends "Start" command (e.g. 1101) to the electronic weighing system
4. The electronic weighing system tares (according to DR25)
5. Coarse/fine dosing phase starts
6. If configured and necessary, post-dosing occurs (DR22)
7. The electronic weighing system jumps to the "Stopped" state and waits for the "Next" command (1141) by the operator
8. If the "Next" command is issued, the dosed weight is written in the log memory and the final tolerance check is performed.
9. Emptying signal is set, if necessary (according to DR25) (weighing step 5)
10. The electronic weighing system jumps to weighing step 0 and waits for further commands.

6.4.3 GFI - Gravimetric filling instrument

In GFI mode, the electronic weighing system also allows a set point to be set, which the dosing functionality of the electronic weighing system then automatically doses.

The dosing signals "Coarse flow/Fine flow" can be used to directly control the corresponding dosing elements (e.g. valves). After the set point is reached, the electronic weighing system automatically logs the dosed weight in the log memory, performs a tolerance check (only in checked cycles), corrects the shut-off points of the dosing signals if necessary (only in checked cycles) and completes the weighing operation autonomously. Optionally, the electronic weighing system can also empty the scale.

In this weighing operating mode, the dosing is controlled by the electronic weighing system in a fully-automatic manner. In contrast to a NAWI scale, logging of the individual dosing operations by an operator command is not required (the electronic weighing system logs every weighing nevertheless). The scale is therefore tested during verification to see if the set point setting is always within the legally prescribed limits.

Typically, GFI scales dose continuously in continuous operation, which the electronic weighing system also supports. In this weighing operating mode, the option also exists to define cycles that are not zeroed/tared and not checked. This increases the throughput of the scale because the operations that require stability do not occur in every weighing cycle.

In practice, the dosing process may proceed as follows:

1. PLC sends set point (DR20) and material parameter (DR23) to the electronic weighing system
2. PLC sends "Start" command (e.g. 1101) to the electronic weighing system
3. The electronic weighing system performs zeroing or tares (based on DR25) (weighing step 1)
4. Coarse/fine dosing phase starts (weighing step 2)
5. If configured and necessary, post-dosing occurs (DR22) (weighing step 3)
6. Dosing result is automatically checked and logged (weighing step 4)
7. Scale is emptied, if necessary (based on setting in DR25) (weighing step 5)
8. The electronic weighing system jumps to weighing step 0 and waits for further commands or jumps directly back to step 1 (continuous operation).

6.4.4 CWI - Catchweighing instrument / CW - Automatic check weigher

6.4.4.1 CWI - Catchweighing instrument/ CW - Automatic check weigher - Filling

In CWI/CW mode, the electronic weighing system also allows a set point to be set, which the dosing functionality of the electronic weighing system then automatically doses.

The dosing signals "Coarse flow/Fine flow" can be used to directly control the corresponding dosing elements (e.g. valves). After the set point is reached, the electronic weighing system automatically logs the dosed weight in the log memory, performs a tolerance check, corrects the shut-off points of the dosing signals if necessary and completes the weighing operation autonomously. Optionally, the electronic weighing system can also empty the scale.

In contrast to the NAWI weighing operating mode, the logging of the dosed single weight is written automatically to the log memory without an operator intervention.

Dosing in continuous operation is possible.

In practice, the dosing process may proceed as follows:

1. PLC sends set point (DR 20) and material parameters (DR 23) to the electronic weighing system
2. PLC sends "Start" command (e.g. 1101) to the electronic weighing system
3. The electronic weighing system performs zero setting or tares (based on DR 25) (weighing step 1)
4. Coarse/fine dosing phase starts (weighing step 2)
5. If configured and necessary, post-dosing occurs (DR 22) (weighing step 3)
6. Dosing result is automatically checked and logged (weighing step 4)
7. Scale is emptied, if necessary (based on DR 25) (weighing step 5)
8. The electronic weighing system jumps to weighing step 0 and waits for further commands or jumps directly back to step 1 (continuous operation).

6.4.4.2 CWI - Catchweighing instrument/ CW - Automatic check weigher - Emptying

In CWI/CW mode, the electronic weighing system also allows a set point to be set, which the dosing functionality of the electronic weighing system then automatically doses.

In CWI/CW mode, the electronic weighing system also allows a set point to be set, which the dosing functionality of the electronic weighing system then automatically doses.

The dosing signals "Coarse flow/Fine flow" can be used to directly control the corresponding dosing elements (e.g. valves). After the set point is reached, the electronic weighing system automatically logs the dosed weight in the log memory and completes the weighing operation autonomously.

In contrast to the NAWI weighing operating mode, the logging of the dosed single weight is written automatically to the log memory without an operator intervention.

"Removal" means that the product to be weighed is dosed from the scale (for example, a silo on load cells with discharge valves). In this case, the full scale is tared and the net weight increases with decreasing gross weight. The "Dosing start" parameter in DR 25 should be set to "Tare" for correct operation.

Dosing in continuous operation is possible.

In practice, the dosing process may proceed as follows:

1. Scale is filled with sufficient material.
2. PLC sends set point (DR 20) and material parameters (DR 23) to the electronic weighing system
3. PLC sends "Start" command (e.g. 1101) to the electronic weighing system
4. The electronic weighing system tares (based on DR 25) (weighing step 1)
5. Coarse/fine dosing phase starts (weighing step 2)
6. If configured and necessary, post-dosing occurs (DR 22) (weighing step 3)
7. Dosing result is automatically checked and logged (weighing step 4)

8. Emptying signal is set, if necessary (based on DR 25) (weighing step 5)
9. The electronic weighing system jumps to weighing step 0 and waits for further commands or jumps directly back to step 1 (continuous operation).

6.4.5 DTI Discontinuous totalizing automatic weighing instrument

In THW weighing operating mode, you can use the electronic weighing system for loading or receiving mode. The difference between loading and receiving operation is the specification of a desired loading quantity (=total set point DR 21). This desired loading quantity is loaded automatically in single fillings (=set point DR 20). For example when loading a ship.

When the loading quantity is set to 0, the electronic weighing system works in receiving operation. Receiving operation means that "n" single fillings are automatically totaled. For example when unloading a ship.

Select mode A or B for the THW weighing operating mode.

Mode A	Mode B
If you are using a poorly flowing material, select mode A. The content of the weighing container may not be fully emptied.	If you are using a free flowing material, select mode B. The content of the weighing container is usually fully emptied.

Weighing step	Function	
	Mode A	Mode B
	PLC sends set point (DR 20), total set point (DR 21) and material parameters (DR 23) to the electronic weighing system.	
0	Waiting for command.	
	PLC sends "Start" command (e.g. 1103 or 1123) to the electronic weighing system.	
1	Taring/Zero setting (based on weighing start options from DR 25)	
2	Coarse/Fine phase (based on settings from DR 23)	
3	Post-dosing (based on settings from DR 22)	
4	Checking (based on settings from DR 22)	Checking (based on settings from DR 22) and totaling
5	Emptying (based on settings from DR 25)	
6	Waiting for stability 1 and totalizing	-
Consequence	• If the total set point has not been reached or the electronic weighing system is in receiving mode, the electronic weighing system automatically jumps to weighing step 1. • When the total set point has been reached, the status bit "Batch completed" is set in DR 30. The total 1 is automatically saved in the alibi memory. The total is reset and the electronic weighing system waits in weighing step 0 for a new command.	

6.4.6 CW - Automatic check weigher - static

You set the CW weighing operating mode in data record 3. The CW weighing operating mode enables you to implement a static automatic checkweigher with the electronic weighing system. Test objects are checked for a default set point; tolerance bits are set when the value is below or above the set point so that the PLC can sort accordingly.

If you want a legal-for-trade check with the electronic weighing system, it must be performed statically (at stability 2). Static means that the test object is not tested dynamically during throughput. In case of a conveyor belt, a static, legal-for-trade check means that the

weighing belt must be briefly stopped to perform the check. For checkweighers that are not legal-for-trade, the check can be made dynamically.
The electronic weighing system offers two options for checking:

1. Start manually triggered check with command 1101 (single weighing).

   The electronic weighing system waits in weighing step 0 for a command from the PLC/user. When the command xyz is sent to the electronic weighing system, the command jumps directly to weighing step 4 and waits for stability 2 (defined in DR 3). As soon as stability 2 has been reached, the current weight is measured and compared to the specified set point (DR 20). According to the tolerance settings in DR 22, corresponding tolerance feedback messages are made available by the electronic weighing system. The result is forwarded to the module-internal statistics (DR 39) and updated.

2. Start automatic continuous operation with command 1103 (continuous operation)

   After the command is triggered, the electronic weighing system waits in weighing step 0 until limit 3 (DR 6) is exceeded. As soon as the actual weight exceeds this threshold, the electronic weighing system automatically jumps to weighing step 4 and waits for stability 2. As soon as stability 2 has been reached, the current weight is measured and compared to the specified set point (DR 20). According to the tolerance settings in DR 22, corresponding tolerance feedback messages are made available by the electronic weighing system. The result is forwarded to the module-internal statistics (DR 39) and updated. Subsequently, limit 3 must be undershot again (discharging the test object) so that the electronic weighing system automatically jumps back to weighing step 0 and waits until the limit is exceeded once again. You can exit continuous operation at any time with command 1123 (Stop continuous mode).

6.4.7 CW - Automatic check weigher - dynamic

You set the CW dynamic weighing operating mode in data record 3. The CW dynamic weighing operating mode makes the realization of a dynamic automatic checkweigher possible with the electronic weighing system (cannot be calibrated). Test objects are checked for a default setpoint; tolerance bits are set when the value is below or above the set point so that the weighing electronics can sort or classify accordingly. In addition a statistic (data record DR39) which can be called from the PLC at any time is created automatically.

The product-specific parameters of the dynamic checkweigher are specified via data record 14. The device-specific parameters via the data record 17. Special automatic teaching-in functions are available for teaching in the scale, which greatly simplify and accelerate commissioning.

You need to complete the following steps for commissioning:

1. Specification of the device-specific checkweigher parameters and product parameters in DR14 and DR17.
2. Specification of the calibration weights in DR3.
3. Zero point calibration with empty scale (command 60) and calibration with calibration weight 1 (optionally 2, 3 and 4) (command 61 (optionally 62, 63, 64).
4. Teaching in the filters (command 1157 & 1159).
5. Starting continuous duty of the scale (command 1103).

The speed of the belt and a lifting correction can optionally be determined automatically via learning commands. The learning functions are described in more detail in the "Commands" section.

Light barriers at the inlet and/or outlet of the weighing belt of the checkweigher should be wired directly to a digital input of the weighing electronics and the input should be parameterized correctly accordingly (DR7). The eject signal is available cyclically both for the PLC as well as optionally via a digital output of the weighing electronics in as far as an output was parameterized accordingly. The direct connection to the weighing electronics has the advantage of being independent of the PLC cycle which in turn leads to highly reproducible results.

6.5 DR03 Calibration parameters

6.5.1 Overview

Data record DR03 summarizes the basic parameters of non-automatic scales. You can only transfer the parameters during active service mode of the electronic weighing system. You can read the DRs into the interface DB at any time.

DR03 contains the following parameters for the characteristic curve, for example:

- Calibration weight
- Calibration digits
- Stability parameters
- Tare and zeroing / zero setting options

See also

Commands (Page 120)

6.5.2 Scale name [scaleName]

You can select any name, but it may not exceed 12 characters. You can enter any designation.

NOTE

The scale name cannot be changed after official verification.

6.5.3 Weight unit [weightUnit]

Sets the weight units.

Selection code	Weight unit	
0	mg	Milligram
1	g	Gram
2 (default)	kg	Kilogram
3	t	Metric ton
4	oz	Ounce

Selection code	Weight unit	
5	lb	Pound
6	T	Short ton
7	TL	Long ton
8	N	Newton
9	No unit	

The weight unit selection has no effect on the internal weight calculation. It involves only ASCII characters. Thus, all parameters with weight must be specified with appropriate conversion when there is a change of weight unit.

6.5.4 Gross indicator [grossIndicator]

The gross identifier specifies the letter, B (for brutto) or G (for gross), to be used in the display for gross weights.

6.5.5 Restriction code [restrictionCode]

Activates a parameter check in accordance with OIML for operation requiring verification of the scales.

Selection code	
0 (default)	No regulations
1	OIML regulations

6.5.6 Set number of weighing ranges [numberOfWeighingRanges]

For legal trade scales, specify whether the scales are operated as single-, dual- or triple-range scales (3x6000d).

For scales not requiring official calibration, the parameter can be ignored and left to the default value single-range scales.

Selection code	
1 (default)	Single-range scales
2	Dual-range scales
3	Triple-range scales

Minimum weight weighing range 1 [minWeightWeighingRange1]

For scales not requiring official calibration, you can use the default value 0.

The weight value can be used above the minimum weighing range for legal trade registration with the specified scale interval. The parameter is defined during calibration/official verification and specified in the unit of weight.

Maximum weight weighing range 1 [maxWeightWeighingRange1]

For scales not requiring official calibration, you can specify the maximum capacity of the scales.

For scales requiring official calibration, the specification must be greater than the minimum load for weighing range 1 and is dependent on the number and type of connected load cell(s).

Minimum weight weighing range 2 [minWeightWeighingRange2]

For scales not requiring official calibration, you can use the default value 0.

Corresponds to the maximum weight for weighing range 1 for scales requiring official calibration.

The parameter is defined during calibration/official verification and specified in the unit of weight.

With multi-range scales requiring official calibration, 20 times the scale interval of weighing range 2 is usually entered.

Maximum weight weighing range 2 [maxWeightWeighingRange2]

For scales not requiring official calibration, you can use the default value 0.

For scales requiring official calibration, the specification must be greater than the minimum weight for weighing range 2 and is dependent on the number and type of connected load cell(s).

Minimum weight weighing range 3 [minWeightWeighingRange3]

For scales not requiring official calibration, you can use the default value 0.

For multi-interval scales requiring official calibration, the minimum load for weighing range 3 corresponds to the maximum load of weighing range 2. The parameter is defined during calibration/official verification and specified in the unit of weight.

With multi-range scales requiring official calibration, 20 times the scale interval of the weighing range 3 is usually entered.

Maximum weight weighing range 3 [maxWeightWeighingRange3]

For scales not requiring official calibration, you can use the default value 0.

For scales requiring official calibration, the specification must be greater than the minimum weight for weighing range 3 and is dependent on the number and type of connected load cell(s).

6.5.7 Multi range / multi interval scale [multiRangeMultiIntervalScale]

Defines whether the electronic weighing system is to operate as multi-range or multi-interval scales.

For scales not requiring official calibration, the parameter can be ignored.

Selection code	
0	Multi-range scales
1	Multi-interval scales

Multi-range scales

The electronic weighing system can be operated as single-, dual- or triple-range scales. The individual ranges differ in terms of the maximum load and the scale interval.

Example

Triple-range scales with an interval of 6000 steps in each weighing range:

Weighing range 1: 10 – 3000 kg / 0.5 kg

Weighing range 2: 20 – 6000 kg / 1.0 kg

Weighing range 3: 40 – 12000 kg / 2.0 kg

With the multi-range scales, the scales automatically change from the lower weighing range to the next higher weighing range when loaded if the respective maximum weight is exceeded.

A switch to the lower weighing range only takes place when the gross zero point is passed.

In this case, the scales automatically change back to weighing range 1.

When defining a multi-range scale, the maximum weights and scale intervals of the weighing ranges need to be defined in ascending order. The minimum weights generally correspond to 20 times the scale interval of the respective weighing range.

The maximum number of legal-for-trade scale intervals depends on the load cells used (e.g. 6000d with C6 load cells or 3000d with C3 load cells) and may not be exceeded in any of the set ranges in the case of legal-for-trade scales. Only when OIML is set in DR03.

Multi-interval scales

Single-range scales can be set as multi-interval scales with two or three different weighing ranges or scale intervals.

Example

Triple-division scales with:

Weighing range 1: 10 kg – 1500 kg / 0.5 kg

Weighing range 2: 1500 kg – 3000 kg / 1.0 kg

Weighing range 3: 3000 kg – 6000 kg / 2.0 kg

The weighing range and the corresponding scale interval is automatically changed depending on the load applied both during loading and unloading.

After taring, the net weight of the scales is displayed with the scale interval of the smallest weighing range, so that low weights can also be recorded with maximum precision with already loaded scales. The maximum tare value is limited to the maximum load of the smallest weighing range.

When defining a multi-interval scale, the individual ranges must seamlessly connect to one another:

Min2 = Max1; Min3 = Max2

6.5.8 Calibration weights 0, 1, 2, 3, 4 [calibrationWeight] and calibration digits [calibrationDigit] 0, 1, 2, 3, 4

The calibration weights with the associated calibration digits define the scale characteristic.

The calibration weights must be specified in ascending order. Normally, it is enough to calibrate the scale with two calibration points. Setting further calibration points is therefore optional.

Typically, calibration weight 0 = 0, because the calibration point 0 is normally set with the scale empty.

If a scale has been modified and the current content is known, this value can be entered and set as the calibration weight. A larger calibration weight 1 is then specified and set.

The calibration weights must be at least 5% of the nominal load of the scale and must differ from one another by an amount of at least 5% of the nominal load:

- Calibration weight 0 = 0 kg
- Calibration weight 1 = at least 5% of the nominal load of the scale
- Calibration weight 2 = at least 10% of the nominal load of the scale

The calibration digits are determined automatically by the calibration commands and assigned to the respective calibration weights. Therefore, the calibration digits do not have to be specified.

6.5.9 Scale interval for weighing range 1, 2, 3 [scaleIntervalWeighingRange]

The scale intervals for the weighing ranges 1, 2 and 3 can be defined in accordance with the standard EN 45501 (0.0001 to 50). It defines the smallest indicated weight change and conforms to the accuracy of the overall system for scales requiring official calibration.

6.5.10 Initial zero-setting [initialZeroSetting]

The scales can automatically be set to zero when the supply voltage is switched on (in legal trade operation, this is at the end of the startup waiting time). A weight of ±10% of the maximum measuring range can be set to zero by power-on for legal trade scales.

NOTE

If the scales are not being used in legal trade operation (no OIML restrictions), fully loaded scales can also be set to zero once this function is enabled. The function can, however, be limited by setting a maximum and minimum weight for zero-setting. See the section on maximum and minimum weights for zero setting by power-on.

6.5.11 Initial zero-setting if tared [initialZeroSettingIfTared]

Defines whether initial zeroing in tared state of the scales is to be carried out.

6.5.12 Automatic zero tracking device [automaticZeroTracking]

If necessary, the scales can be set semi-automatically to zero by the user by means of the "Zeroing" command.

The automatic adjustment sets the scale to zero without a further command in the event of slow zero drifting. Slow drift is assumed if the OIML R76 criteria for this are met.

NOTE

If the scales are not being used in legal trade operation (no OIML restrictions) and this function is enabled, the scales may eventually read zero after a slow drift even if they are fully loaded. The function can, however, be limited by setting a maximum and minimum weight for zeroing.

6.5.13 Tare device [subtractiveAdditiveTare]

Defines whether the scales work with additive or subtractive tare device.

Selection code	
0 (default)	Subtractive tare device
1	Additive tare device

The display value is hidden when a subtractive tare is enabled if the gross value exceeds the maximum weighing range by more than 9e.

With a subtractive tare device, a maximum of up to 100% of the maximum weighing range (see "Maximum tare load") can be tared.

With an additive tare device, a maximum of up to 250% of the maximum weighing range (see "Maximum tare load") can be tared. The load cells must satisfy the relevant requirements that have to be checked and proven in the certificate of compatibility.

The current tare value is deleted if you switch between additive and subtractive taring.

With scales not requiring official calibration, this parameter is irrelevant and can be left at default.

NOTE

There is no automatic evaluation of whether there is sufficient load cell measuring range capacity for an additive tare. The plant constructor is responsible for this evaluation.

6.5.14 Enable Weight simulation [weightSimulationEnabled]

The electronic weighing system is tested without connected load cells. The simulated weight value is passed on completely in the electronic weighing system through all signal filters and functions. The response of the electronic weighing system can be traced exactly.

Selection code	
0 (default)	Weight simulation not enabled
1	Enable weight simulation

6.5.15 Automatic zero-setting device [automaticZeroSetting]

If the function is active, the electronic weighing system attempts zeroing if the following conditions are met:

- Stability 1 exists
- Gross weight was stable below zero for at least 5 seconds

The function is restricted by the parameter "Negative limit semi-automatic zero-setting device".

Selection code	
0	Automatic zero-setting off
1	Automatic zero-setting on

6.5.16 Weighing range data in SecureDisplay [weighingRangeDataInSecureDisplay]

This parameter defines whether the weighing range data Min, Max and e are displayed in SecureDisplay or not.

In the operating modes SWA and SWT, it is not possible to have the data displayed in SecureDisplay in operation requiring official calibration.

6.5.17 Automatic zero tracking in dosing cycle [automaticZeroTrackingInCycle]

The parameter defines whether the zero tracking (if activated) is to be active only outside the automatic dosing cycle (only in weighing step 0) or also inside the dosing cycle.

6.5.18 Maximum Tare weight (% of max.) [maxTareWeight]

The parameter is specified as a percentage of the "Maximum weight" parameter. All tare values (semi-automatic, automatic, or preset tare) are checked for this limit and rejected if the limit is exceeded.

6.5.19 Initial zero-setting device limit negative (% of max.) [initialZeroSettingLimitNegative]

Requirement: The Initial zero-setting parameter is enabled.

Max. permissible negative deviation from the calibration zero point. The setting is made in % in reference to the maximum weight of the weighing range 1.

With scales requiring official calibration, the sum of the negative and positive limit value may not exceed 20%.

Example

Maximum weighing range = 100 kg
Maximum negative zeroing limit = 10%
→ Up to -10 kg (10% of 100 kg) can be set to zero by the function on power on.

See also

Initial zero-setting [initialZeroSetting] (Page 60)

6.5.20 Initial zero-setting device limit positive (% of max.) [initialZeroSettingLimitPositive]

Requirement: The Initial zero-setting parameter is enabled.

Max. permissible positive deviation from the calibration zero point if the "Initial zero-setting" function is used. The setting is made in % in reference to the maximum load of the weighing range 1.

With scales requiring official calibration, the sum of the negative and positive limit value may not exceed 20%.

Example

Maximum weighing range= 100 kg
Maximum positive zeroing limit = 10%
→ Up to 10 kg (10% of 100 kg) can be set to zero by the function on power on.

6.5.21 Semi-automatic zero-setting device limit negative (% of max.) [semiAutomaticZeroSettingLimitNegative]

Max. permissible negative deviation from the calibration zero point if the functions "Semi-automatic zero-setting" (command 21), "Automatic zero-setting device" and "Zero tracking device" are used. The setting is made in % in reference to the maximum load of the weighing range 1.

With scales requiring official calibration, the sum of the negative and positive limit value may not exceed 4%.

Example

Max. weighing range = 100 kg

Maximum negative zeroing limit = 3%
→ Up to 3 kg (3% of 100 kg) can be set to zero by the zero setting functions.

6.5.22 Semi-automatic zero-setting device limit positive (% of max.) [semiAutomaticZeroSettingLimitPositive]

Max. permissible positive deviation from the calibration zero point if the functions "Semi-automatic zero-setting" (command 21), "Automatic zero-setting device" and "Zero tracking device" are used. The setting is made in % in reference to the maximum load of the weighing range 1.

With scales requiring official calibration, the sum of the negative and positive limit value may not exceed 4%.

Example

Maximum weighing range = 100 kg
Maximum negative zeroing limit = 1%
→ Up to 1 kg (1% of 100 kg) can be set to zero by the zero setting functions.

6.5.23 Stability monitoring

The electronic weighing system monitors the weight for stability and reports the stability weight via a status signal (stability 1 and 2). The stability monitoring is defined via the stability weight and a stability time. The electronic weighing system uses the stability status as follows:

- Stability 1: Must exist to start commands such as zeroing or taring.
- Stability 2: Must exist to start automatic log printing, perform tolerance checks or totaling the weight.

Stability 1 applies to dosing steps 0, 1, 5, and 6;

Stability 2 applies to the remaining dosing steps 2 to 4.

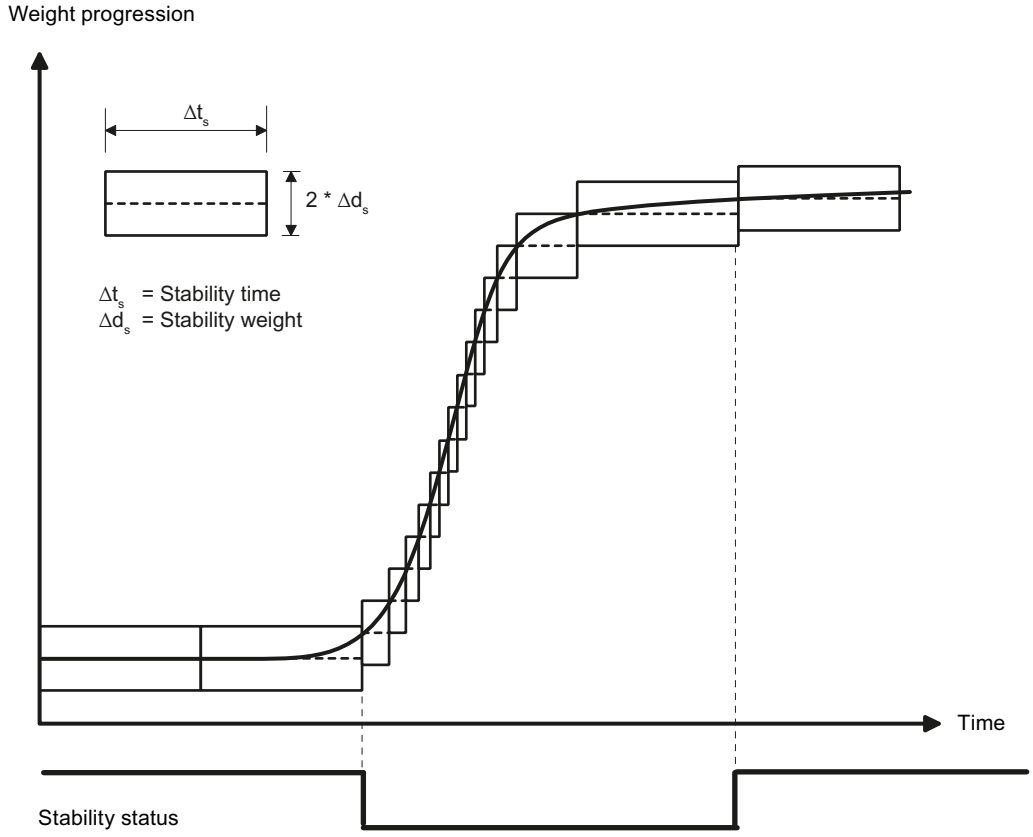

Figure 2-1184 Stability monitoring

Stability weight 1 [stabilityWeight1]

The parameter defines the permissible deviation (+/-) by which the weight is allowed to fluctuate within the stability time to detect stability. The input is made in the unit of weight.

Stability time 1 (s) [stabilityTime1]

This parameter defines the time window in which the current weight value may fluctuate within the stability weight (+/-) to report stability.

Maximum waiting time for stability 1 (s) [maximumWaitingTimeStability1]

Defines a maximum waiting time for stability on start of a command which depends on stability. If the command could not be started during the waiting time due to a lack of stability, a technology message is generated by the electronic weighing system. If the parameter is set to 0 , a data/operating error is directly reported in the event of a lack of stability.

Delay time before stability 1 (s) [delayTimeBeforeStability1]

Defines a delay time which expires before a check for stability is performed.

Stability weight 2 [stabilityWeight2]

The parameter defines the permissible deviation (+/-) at which the weight is allowed to fluctuate within the stability time to detect stability. The input is made in the unit of weight.

Stability time 2 (s) [stabilityTime2]

Defines the time window in which the current weight value may fluctuate only within the stability weight (+/-) to report stability.

Maximum waiting time for stability 2 (s) [maximumWaitingTimeStability2]

This parameter defines a maximum waiting time for stability on start of a command which depends on stability. If the command could not be started during the waiting time due to a lack of stability, a technology message is generated by the electronic weighing system. If the parameter is set to 0 , a data/operating error is directly reported in the event of a lack of stability.

Delay time before stability 2 (s) [delayTimeBeforeStability2]

Defines a delay time which expires before a check for stability is performed. In the case of stability 2, this time can be used, for example, to slowly capture material still flowing after closing of the dosing elements.

6.5.24 Digital signal filters

Filter 1 [filter1Period] and 2 period[filter2Period]

Defines in seconds the periods of the filters 1 and 2 to selectively filter out interference frequencies.

If the period is set to 0.1 s, for example, this has a suppression effect on interference frequencies comprising multiples of 10 Hz. If no other interference frequencies are known apart from the local network frequencies, we recommend leaving both periods at the default value (0.1 s).

Characteristic low pass filter [characteristicLowPassFilter]

Defines the characteristic of the low-pass filter. You have the following choices:

Selection code	Characteristics
0	Critically dampened
1	Bessel

Ordinal number low pass filter [ordinalNumberLowPassFilter]

Defines the effect of damping.

Selection code	
2, 4, 6, 8 add 10	The higher the selected filter number, the higher the effect.
0	Filter deactivated

Cut-off frequency low pass filter [cutOffFrequencyLowPassFilter]

Defines the limit frequency in Hz of the low pass filter in the range from 0.05 to 200 Hz.

Period of dosing filter [dosingFilterPeriod]

Defines the period of the dosing filter in seconds. The dosing filter has an additional effect on the weight value during the coarse feed or fine feed. The period should be no longer than the duration of the fine dosing phase.

6.5.25 Operating mode [scaleOperatingMode]

Defines the weighing mode of the scales.

The following weighing modes are available:

Selec-tion code	
0	NAWI - Non-automatic weighing instrument - Filling (Page 50)
1	NAWI - Non-automatic weighing instrument - Emptying (Page 51)
10	GFI - Gravimetric filling instrument (Page 52) - Filling
11	GFI - Gravimetric filling instrument (Page 52) - Emptying
20	CWI - Catchweighing instrument/ CW - Automatic check weigher - Filling (Page 52)
21	CWI - Catchweighing instrument/ CW - Automatic check weigher - Emptying (Page 53)
30	DTI Discontinuous totalizing automatic weighing instrument (Page 54) - Mode A
31	DTI Discontinuous totalizing automatic weighing instrument (Page 54) - Mode B
40	CW - Automatic check weigher - static (Page 54)
41	CW - Automatic checkweigher - dynamic (Page 55)

6.5.26 Totalization scale interval dt [TotalizationScaleIntervalDt]

This parameter defines the resolution of the totals 1 in DR30. In DTI mode, this parameter represents the totalization scale interval dt of the legal-for-trade total.

6.5.27 Minimum totalized load [minimumTotalizedLoad]

The parameter defines the minimum totalized load in THW mode.

6.5.28 SecureDisplay interface [legalDisplayInterface]

For legal-for-trade operation, the "SecureDisplay" software is used to display the legal-for-trade weight value. The parameter defines whether "SecureDisplay" communicates directly via the Ethernet port of the electronic weighing system or via the Ethernet port of the SIMATIC controller.

6.5.29 SecureDisplay version [secureDisplayVersion]

For applications requiring official calibration, the "SecureDisplay" software is used to display the calibratable weight value. The parameter defines the version of the "SecureDisplay" software that is running in the HMI device. If the version is not entered correctly, a weight value will not be output in "SecureDisplay", and the display stays in the "Start Up" step.

6.5.30 Smallest zoom factor of SecureDisplay (%) [smallestZoomFactorOfSecureDisplay]

The minimum display size defines the smallest zoom factor for the "SecureDisplay" calibratable display. If the parameter does not match the smallest zoom factor in the .xml file in the HMI device, "SecureDisplay" remains in the "StartUp "step and no weight value is output.

6.6 DR04 Calibration curve check

Calibration digits are calculated based on the parameters from DR10.

The theoretical calibration digits are compared with the measured calibration digits in DR03. The deviations are output in DR04 as percentages.

6.7 DR05 Tare and zero memory

Current preset-tare weight [presetTareWeight]

Current semi-automatic tare weight [semiAutomaticTareWeight]

Current initial zero-setting weight [initialZeroSettingWeight]

Current zero tracking weight [zeroTrackingWeight]

Dead load (calculated) [calculatedDeadLoad]

Theoretically calculated load of the scale construction or the empty scale.

See also

Initial zero-setting [initialZeroSetting] (Page 60)
Automatic zero tracking in dosing cycle [automaticZeroTrackingInCycle] (Page 63)
Commands (Page 120)

6.8 DR06 Configuration of limits

6.8.1 Reference (limits 1 and 2) [limitReference]

Defines the weight to which the limits 1 and 2 relate and the interpretation of the ON/OFF values.

Selection code	Interpretation of the ON/OFF values for limit 1 and limit 2 [limit1On] [limit2On] [limit1Off] [limit2Off]	Reference weight
0 (default)	% - in relation to maximum weighing range	Gross
1	% - in relation to maximum weighing range	Net
4	Absolute - in relation to maximum weighing range	Gross
5	Absolute - in relation to maximum weighing range	Net

Limit 1 and 2 ON value [limit1On] [limit2On]

Limit 1 and 2 OFF value [limit1Off] [limit2Off]

The ON/OFF values are interpreted depending on the set reference value.

For a percentage-based interpretation of limits, specify values between -200.0 and 200.0.

For an absolute interpretation, specify the ON/OFF values as absolute weight values.

6.8.2 Limit 3 - empty [emptyLimit]

This parameter defines the time starting from which the scale is empty. The unit is expressed either as a percentage of the maximum weight or in the weight unit depending on the "Limit reference" setting

Reference (limit 3 - empty) [emptyLimitReference]

Defines the weight to which limit 3 - empty [emptyLimit] relates and the interpretation of the limit value.

Selection code	Interpretation of Limit 3 - empty [emptyLimit]	Reference weight
2 (default)	% - in relation to maximum weighing range	Gross
3	% - in relation to maximum weighing range	Net
4	Absolute - in relation to maximum weighing range	Gross
5	Absolute - in relation to maximum weighing range	Net

6.8.3 Switch-on delay limit 3 (empty) (s) [delayTimeForEmptyLimit]

Switch-on delay limit 3 (empty) can be deliberately delayed by a delay time. This is helpful, for example, if the weight is undershot at the moment of opening when the scale is being emptied, which would cause Limit 3 to be fallen below already.

6.9 DR07 Interface parameters

6.9.1 Assignment DI.0, DI.1, DI.2, CI [functionDI0 to functionDI2] [functionCI]

Assign a command to each digital input (DI.0, DI.1, DI.2): → Commands (Page 121).

Use counter input CI optionally as a fourth digital input with its own reference potential.

Selection code [functionDI0] [functionDI1] [functionDI2] [functionCI]	**Function**
0 (default)	The input operates as highspeed counter.
1 to 32755	Command codes 1 to 32755 according to section Commands (Page 121). Triggered on transition from 0 → 1 at DI.x Example for command code 1121 → selection code = 1121
32756	External enabling signal CW dynamic (logic 0->1)
32757	Light barrier at the weighing belt inlet (logic 0->1)
32758	Light barrier at the weighing belt outlet (logic 0->1)
32760	Transition weighing step 0
32761	Transition weighing step 1
32762	Transition weighing step 2
32763	Transition weighing step 3
32764	Transition weighing step 4
32765	Transition weighing step 5
32766	Transition weighing step 6
32767	Transition weighing step 7
32768	No function assigned
32769 to 65523	Command codes 1 to 32755 (+32768) according to section Commands (Page 121). Triggered on transition from 1 → 0 at DI.x Example for command 1121 → selection code = 1121 + 32768 = 33889
65524	External enabling signal CW dynamic (logic 1->0)
65525	Light barrier at the weighing belt inlet (logic 1->0)
65526	Light barrier at the weighing belt outlet (logic 1->0)
65528	Transition weighing step 0 (inverted)
65529	Transition weighing step 1 (inverted)
65530	Transition weighing step 2 (inverted)
65531	Transition weighing step 3 (inverted)
65532	Transition weighing step 4 (inverted)
65533	Transition weighing step 5 (inverted)
65534	Transition weighing step 6 (inverted)
65535	Transition weighing step 7 (inverted)

6.9.2 Filtering DI.0, DI.1, DI.2 and CI

Specify the following values for filtering the digital inputs and the counter input:

Selection codes **Filter DI.0 [filterDI0]** **Filter DI.1 [filterDI1]** **Filter DI.2 [filterDI2]** **Filter CI [filterCI]**	**Function**
0 (default)	No filtering
1 ... 2500 [0.1 ms]	Filtering from 0.1 to 250 ms

6.9.3 Assignment DQ.0, DQ.1, DQ.2

Selection code **[functionDQ0]** **[functionDQ1]** **[functionDQ2]**	**Function**
0 ... 79	Corresponding bit of the scale status (see DR30)
80	Controlled via S7 I/O
81	Controlled via data record 18
100 ... 179	Corresponding inverted bit of the scale status (see DR30)
255 (default)	Output deactivated
1000 ... 1063	Corresponding operating error (see DR32)
1100 ... 1163	Corresponding inverted operating error (see DR32)
2000 ... 2063	Corresponding technology message (see DR32)
2100 ... 2163	Corresponding inverted technology message (see DR32)
3000 ... 3063	Corresponding data/operating error (see DR32)
3100 ... 3163	Corresponding inverted data/operating error (see DR32)

See also

Commands (Page 120)

6.9.4 Reaction to CPU stop / failure [behaviourOnCPUStopOrFailure]

Selection code	Function
0 (default)	Active dosing is stopped
1	Active dosing is continued

6.9.5 Monitoring of digital outputs [monitoringOfDQ]

Selection code	Function
0	Monitoring inactive
1	Monitoring active

6.9.6 Reaction of digital outputs to a CPU stop / failure [behaviourOfDQOnCPUStopOrFailure]

Selection code	Function
0	Set substitute values
1	Retain function

6.9.7 Behavior of digital outputs on error [behaviourOfDQOnError]

Selection code	Function
0 (default)	Set substitute values
1	Retain function

6.9.8 Substitute value for DQ.0 to DQ.3 on error

An output is set in the event of a fault.

Selection code 0 is preset and resets the outputs in the event of a fault (operating error) or on a SIMATIC STOP.

Procedure

NOTICE
Risk to the plant If an output is set following a fault (operating error), this can pose a risk for the plant. Ensure that the parameters are correctly set.

1. Set the "DQ behavior on failure" parameter [behaviourOfDQOnError] to "Set substitute values": Selection code 0.
2. Assign substitute values for the event of an error or stop to the digital outputs (DQ.0, DQ.1 and DQ.2).

Selection code [substituteValueDQ0] [substituteValueDQ1] [substituteValueDQ2] [substituteValueDQ3]	**Meaning**
0 (default)	Switch off output
1	Switch on output

See also

Reaction to CPU stop / failure [behaviourOnCPUStopOrFailure] (Page 72)

6.9.9 Trace memory mode [traceMemoryMode]

Defines the trace rate of scale data in s.

Selection code	**Function**
0 (default)	Ring memory
1	Stop when memory is full

6.9.10 Trace rate [traceRate]

PLACEHOLDER

6.9.11 Subnet mask, IP address, gateway, device name

Default parameter values

Subnet mask [deviceSubNetMask]: 255.255.255.0

IP address [deviceIpAddress]: 192.168.0.21

Gateway [gateway]: 192.168.0.21

Device name [deviceName]: siwarex.wp351

6.9.12 Activate Modbus communication [activateModbusConnection1] [activateModbusConnection2]

Activates the Modbus TCP/IP protocol of the electronic weighing system.

Selection code	Modbus TCP/IP protocol connection 1/2
0 (default)	Deactivated
1	Activated

6.9.13 Modbus TCP Unit Identifier, port, SWAP options

The following options are available for the Modbus TCP/IP interface:

Selection code [modbusUnitIdentifier1]	Function
-1 (default)	Unit Identifier is not evaluated

Modbus TCP port connection [modbusPort]
Defines the port for the Modbus connections.

6.9.14 Byte/Word swap options [byteSwap16Bit] [byteSwap32Bit] [wordSwap32Bit]

Defines the format used for transfer over the Ethernet interface (MODBUS TCP IP).

6.9.15 RS485 protocol

Configures the serial interface RS485.

Selection code	Protocol
0 (default)	Deactivated

6.9.16 I/O process values 1 to 4 [ioProcessValue1 to ioProcessValue4]

You can transfer up to four selectable I/O process values from the electronic weighing system to the CPU cyclically via the I/O. The following I/O process values can be selected:

Table 2-1320 Selection table for I/O process values 1, 2, 3 and 4

I/O process value	Selection code
No element is selected	0
Gross process weight 1	1
Net process weight 1	2
Tare process weight	3
Net weight	4

I/O process value	Selection code
Gross / net weight x10 (legal-for-trade)	5
Gross weight	6
Tare weight (legal-for-trade)	7
Gross process weight 2	8
Net process weight 2	9
Unfiltered digit value	10
Digits filtered by F1	11
Digits filtered by F2	12
Last net process weight	13
Last net weight [lastNetWeight]	14
Totalizer 2	15
Youngest protocol ID	16
Current dosing step / Number of dosings in continuous mode	17
Load cell impedance	19
Load cell signal voltage	20
Load cell sense voltage	21
Current fine weight	22
Current trailing weight	23
Current shut-off correction value	24
Remaining amount to be loaded	25
Total set point	26
Weighing cycle progress	27
Tolerance limit TH2 (weight unit)	28
Tolerance limit TH1 (weight unit)	29
Tolerance limit TL1 (weight unit)	30
Tolerance limit TL2 (weight unit)	31
Material flow rate	32
Totalizer 1 (high fraction)	33
Totalizer 1 (low fraction)	34
Current fine signal time	35
Operating error / Technology messages (Word 1)	39
Technology messages (Word 2-+3)	40
Data/operating error (Word 1) / Additional information	41
Data/operating error (Word 2+3)	42
Temperature internal / external	43

6.9.17 I/O process values 5 to 8 [ioProcessValue5 to ioProcessValue8]

You can transfer up to four selectable process values from the CPU to the electronic weighing system cyclically via the I/O. The following process values can be selected:

Selection code [ioProcessValue5 to ioProcessValue8]	Process values
0	Preset tare
1	Simulation weight
2	Weight offset
3	Weight correction factor

6.9.18 Event hardware interrupts 4 to 8 [hardwareInterrupt4 to hardwareInterrupt8]

1. Select the following defined events for up to five additional hardware interrupts [hardwareInterrupt4 to hardwareInterrupt8]:

Selection code [hardwareInterrupt4 to hardwareInterrupt8]	
0 ... 79	Scale status bits (see DR30)
100 ... 179	Scale status bits (see DR30) (inverted)
1000 ... 1063	Operating error (see DR32)
1100 ... 1163	Operating error (inverted) (see DR32)
2000 ... 2063	Technology messages (see DR32)
2100 ... 2163	Technology messages (inverted) (see DR32)
3000 ... 3063	Data/operating error (see DR32)
3100 ... 3163	Data/operating error (inverted) (see DR32)

2. Enable the hardware interrupts in the hardware configuration (Page 37).

6.9.19 Source for weight simulation [simulationSource]

Selection code	Process values
0	Simulation value from SIMATIC I/O
1	Simulation value from data record 16

6.10 DR09 Read out module information

Saves the firmware and hardware version of the electronic weighing system.

6.11 DR10 Load cell parameters

6.11.1 Load cell type [loadCellType]

Sets the connected load cell type.

Selection code	
0 (default)	Analog load cells
1	SIWAREX DB (medium speed)
2	SIWAREX DB (high speed)

6.11.2 Connection technology [fourSixWireSensor]

Selection code	
0	4-wire load cell
1	6-wire load cell

6.11.3 Load cell manufacturer [loadCellManufacturer] and load cell order number [loadCellOrderNumber]

- To be able to identify load cells for service operations, enter the load cell manufacturer [loadCellManufacturer] and load cell order number [loadCellOrderNumber].

6.11.4 No. of mechanical support points [numberOfSupportPoints]

The parameter is required for automatic calculation of the scale characteristic curve (command 82).

If no anchor points are used, the number of support points is equal to the number of load cells.

If anchor points are used in addition to load cells, the number of support points is equal to the total number of load cells and fixed support points.

Example

A tank is mounted on three load cells → Number of mechanical support points = 3

6.11.5 Averaged load cell characteristic (mV/V) [averagedCharacteristicValue]

The load cell characteristic value is required to correctly interpret the output voltage from the load cell. When Siemens WL series load cells are used, the exact characteristic value can be read from label on the cell. If the exact characteristic value of the utilized cell(s) is not available, a rounded value can also be specified. For scales with multiple load cells, the average of all load cells must be calculated and entered.

Example

Characteristic value according to load cell label = 2.018 mV/V
→ Characteristic value = 2.018 mV/V

If this exact value is not known, 2.0 mV/V could also be entered.

6.11.6 Nominal load of one single load cell [nominalLoadOfSingleLoadCell]

The nominal load is entered in the specified weight units The parameter is required for automatic calculation of the scale characteristic curve (command 82).

6.11.7 Power line frequency [powerLineFrequency]

The parameter defines the line frequency of the power supply grid. A selection between 50 Hz and 60 Hz can be made. By making the correct setting, interferences caused by the power supply grid can be better suppressed.

6.11.8 Using a power line filter [PowerLineFilterActivated]

Activates the line filter with selection code 1

Selection code	
0	Line filter deactivated
1	Line filter activated

6.11.9 External / internal sensor supply [internalExternalAdcSupply]

Activates the external supply of the load cell with selection code 1.

6.11.10 Impedance

Impedance reference (Ohm) [impedanceReference]

The impedance reference can be determined through command 907 after successful commissioning of the electronic weighing system. After this time, the electronic weighing system automatically monitors the current impedance with the reference value. When the maximum permitted deviation is violated, a corresponding bit (impedanceError) is set in the scale status.

Maximum impedance deviation (% of impedance reference) [maximumAllowedImpedanceDeviation]

This parameter defines the maximum permissible deviation of the currently measured impedance as compared to the reference impedance. It is specified as percentage in relation to the impedance reference value.

6.11.11 Maximum impedance deviation (% of impedance reference) [maximumAllowedImpedanceDeviation]

This parameter defines the maximum permissible deviation of the currently measured load cell impedance as compared to the impedance reference. If the limit is exceeded, the electronic weighing system sets a corresponding bit in the scale status.

6.12 DR14 Dynamic checkweigher parameters - product

The data record encompasses all product-relevant parameters. If several, different products are to be checked on a checkweigher, an own copy of this data record must be stored in the CPU for each respective product and loaded accordingly.

6.12.1 Product name [productName]

24 characters for unique naming of the product.

6.12.2 Product length [productLength]

Length of the product, specification in meters.

6.12.3 Setpoint value [setPoint]

Setpoint value which is to be checked and classified.

6.12.4 Parameter relation [parameterRelation]

The parameters define how you interpret the specified tolerance limits TH2, TH1, TL1 and TL2. The following options are available:

Selection code	Meaning
0 (default)	The tolerance limits are interpreted as percentages of the set point in DR20.
1	The tolerance limits are interpreted as absolute weight values
2	The tolerance limits are calculated based on OIML R61 "Limits of error on verification Class X1".
3	The tolerance limits are calculated based on OIML R61 "Maximum permissible errors in service Class X1".

In general, the currently valid tolerance limits in DR30 are output in the weight unit. When you select selection codes 2 and 3, the tolerance limits TH2, TH1, TL1 and TL2 entered in DR22 are ignored. The limits are calculated automatically in accordance with the OIML directive.

6.12.5 Tolerance limit TH2 (weight unit) [toleranceLimitTh2]

This parameter defines the limit of the second tolerance band above the set point. The setting conforms to the selected tolerance reference (percentage or absolute) and must be greater than or equal to tolerance limit TH1.

6.12.6 Tolerance limit TH1 (weight unit) [toleranceLimitTh1]

This parameter defines the limit of the first tolerance band above the set point. The setting conforms to the selected tolerance reference (percentage or absolute) and must be less than or equal to tolerance limit TH2.

6.12.7 Tolerance limit TL1 (weight unit) [toleranceLimitTl1]

This parameter defines the limit of the first tolerance band below the set point. The setting conforms to the selected tolerance reference (percentage or absolute) and must be less than or equal to tolerance limit TL2 as a positive value.

6.12.8 Tolerance limit TL2 (weight unit) [toleranceLimitTl2]

This parameter defines the limit of the first tolerance band below the set point. The setting conforms to the selected tolerance reference (percentage or absolute) and must be greater than or equal to tolerance limit TL1 as a positive value.

6.12.9 Monitoring product spacing [checkProductSpacing]

This function may only be used in as far as a light barrier is available at the inlet and/or outlet of the weighing belt and is wired on a respectively configured digital input of the weigh beam. As soon as the space between two consecutive products is too low (= two products touch the weighing belt simultaneously), both products are ejected.

6.12.10 Eject above tolerance TO2 [ejectAboveTh2]

Eject products above the tolerance limit TO2 (0=no, 1=yes).

6.12.11 Eject above tolerance TO1 [ejectAboveTh1]

Eject products above the tolerance limit TO1 (0=no, 1=yes).

6.12.12 Eject below setpoint [ejectBelowSetpoint]

Eject products below the setpoint (0=no, 1=yes).

6.12.13 Eject below tolerance TU1 [ejectBelowTl1]

Eject products below the tolerance limit TU1 (0=no, 1=yes).

6.12.14 Eject below tolerance TU2 [ejectBelowTl2]

Eject products below the tolerance limit TU2 (0=no, 1=yes).

6.12.15 Belt speed [beltSpeed]

Speed of weighing belt in m/s.

6.12.16 Lifting correction [liftingCorrection]

With very high speeds the lifting effect may lead to falsifications in weight measurement. The lifting correction factor can compensate for this effect. The weigh beam can determine the corresponding factor automatically by means of the learning function "Lifting correction" (see commands section).

Determining the signal filter settings takes place automatically in the operating mode "Dynamic checkweigher" through the learning function "Filter settings" (see commands section). The filter settings in data record 3 are irrelevant.

6.12.17 Filter 1 period (s) [filter1Period]

6.12.18 Filter 2 period (s) [filter2Period]

6.12.19 Filter 3 period (s) [stability1Period]

6.12.20 Characteristic of low pass filter [characteristicLowPassFilter]

6.12.21 Ordinal number of low pass filter [ordinalNumberLowPassFilter]

6.12.22 Cut-off frequency of low pass filter [cutOffFrequencyLowPassFilter]

6.13 DR15 Preset tare

Procedure for Web server and Modbus TCP

1. Read DR15.
2. Enter the preset tare in DR15.
3. Write DR15.
4. Activate the current preset tare value with an "Activate preset tare from DR15 (1013)" command.

TIA Portal procedure

1. Activate service mode: Command code 1.
2. Read DR07: Command code 2007.
3. Define an I/O process value [ioProcessValue5 to ioProcessValue8] as "Preset tare": Selection code 0.
4. Write DR07: Command code 4007.
5. Enter the preset tare for the I/O process value selected in DR07 in the "cyclicIoData > output" structure in the interface DB.
6. Activate the preset tare: Command code 1016.

6.14 DR16 Configuration of weight simulation

6.14.1 Simulate weight

Introduction

The electronic weighing system is tested without connected load cells. The simulated weight value is passed on completely in the electronic weighing system through all signal filters and functions. The response of the electronic weighing system can be traced exactly.

Requirement

Dosing time = 0

Web server procedure

1. Select the "Service mode ON (1)" command.
2. Read DR03.
3. Enable the weight simulation in DR03.
4. Write DR03.
5. Read DR07.
6. Select the simulation weight source in DR07: Simulation weight from DR16.
7. Write DR07.
8. Select the "Service mode OFF (2)" command.
9. Read DR16.
10. in DR16, enter a simulation weight in the measuring range of the scale.
11. Write DR16.

12. Start the simulation using the "Weight simulation ON (3)" command.
    ⇒ The notice "SIMULATION" is shown on the main display and a status bit is set.
    ⇒ From the start of simulation onward, all configured limits and interfaces refer to the simulation weight.
13. Stop the simulation using the "Weight simulation OFF (4)" command.

TIA Portal procedure

1. Activate service mode: Command code 1.
2. Read DR03: Command code 2003.
3. Enable the weight simulation [weightSimulationEnabled] in DR03: Selection code 1.
4. Write DR03: Command code 4003.
5. Read DR07: Command code 2007.
6. Assign the "simulation weight" function to the I/O process value 5, 6, 7 or 8 [ioProcessValue5 to ioProcessValue8]: Selection code 1.
7. Write DR07: Command code 4007.
8. Deactivate service mode: Command code 2.
9. Enter the simulation weight for the I/O process value selected in DR07 in the "cyclicIoData > output" structure in the interface DB.
10. Start simulation mode: Command code 3.
    ⇒ The notice "SIMULATION" is shown on the main display and a status bit is set.
    ⇒ From the start of simulation onward, all configured limits and interfaces refer to the simulation weight.
11. Stop simulation mode: Command code 4.

6.14.2 Simulating dosing

Introduction

When you specify a dosing time, a dosing cycle is simulated completely automatically. When you specify an emptying time, emptying of the scale is simulated completely automatically.

Example of dosing time

A dosing time of 4.5 ms and a set point of 100 kg has the result that the dosing cycle reaches a set point of 100 kg in a linear manner within 4.5 ms.

Example of emptying time

An emptying time of 1 s has the result with enabled simulation (DR03) that emptying at the end of an automatic dosing cycle is simulated within 1 s. Simulation takes place linearly from the dosed weight down to 0 weight units.

Requirement

You have configured a set point (Page 92).

Web server procedure

1. Select the "Service mode ON (1)" command.
2. Read DR03.
3. Enable the weight simulation in DR03.
4. Write DR03.
5. Select the "Service mode OFF (2)" command.
6. Read DR16.
7. Enter a maximum simulation dosing time and simulation emptying time in seconds in DR16.
8. Write DR16.
9. Start the simulation using the "Weight simulation ON (3)" command.
10. Start the dosing with the command "Start single weighing (1101)" or "Start continuous mode (1103)".
11. When you change parameters in simulation mode, start the "Simulation ON (3)" command again.

    ⇒ Parameter changes take effect.
12. Stop the simulation using the "Weight simulation OFF (4)" command.

6.14.3 Material flow, delay time and opening/closing time

NOTE

Transferring parameter changes

When you change parameters in simulation mode, start the "Simulation ON (3)" command again.

⇒ Parameter changes take effect.

Extra coarse/coarse/fine/empyting material flow

An explicit material flow can be specified for simulation for each phase of a dosing operation. Make sure to specify the correct sign.

Extra coarse/coarse/fine/empyting delay time

Delay time until the respective material flow is activated or deactivated by switch-on/switch-off.

Extra coarse/coarse/fine/empyting opening/closing time

Duration until the respective material flow is fully established or terminated.

6.15 DR17 Dynamic checkweigher parameters - device

6.15.1 Dynamic checkweigher parameters

The data record includes all device or weighing parameters. The parameters must be specified once for the checkweigher.

6.15.2 Length of weighing belt [lengthOfWeighBelt]

Length of the weighing belt, specification in meters.

6.15.3 Height of the weighing belt [heightOfWeighBelt]

Height of the weighting belt, specification in meters.

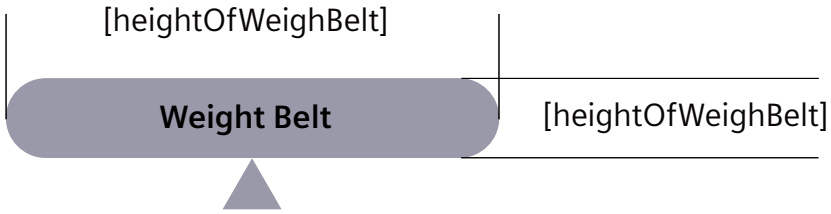

6.15.4 Distance from light barrier inlet to light barrier outlet [distanceOpticalSensorsEntryToExit]

If the scale is operated with both a light barrier at the inlet as well as at the outlet of the weighing belt, the distance of the two light barriers must be specified. The value is specified in meters.

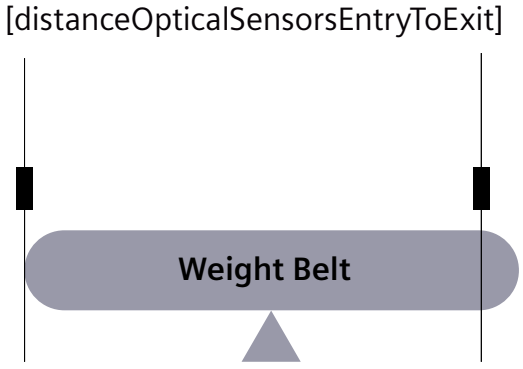

6.15.5 Distance from light barrier inlet to measurement point [distanceOpticalSensorsEntryToMeasurementPoint]

If the checkweigher is operated with only one light barrier at the belt inlet, the position for weight detection can be specified.
By default, the parameter is set to 0 which leads to the weight being detected automatically shortly before leaving the weighing belt. To this purpose, a correct setting of the parameter "Length of weighing belt" and "Height of weighing belt" is absolutely necessary.

[distanceOpticalSensorsEntryToMeasurementPoint]

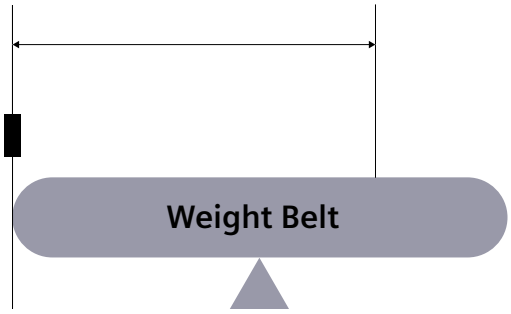

6.15.6 Distance of light barrier to ejection point [distanceOpticalSensorToEjectionPoint]

The parameter defines the distance between the light barrier and the ejection location. If the checkweigher has a light barrier at the input and the output of the weighing belt, the parameter defines the distance between the light barrier at the output and the ejection.

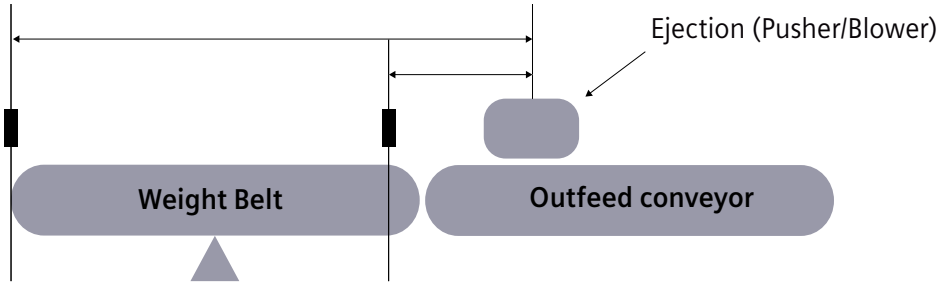

6.15.7 Delay time ejection signal [delayEjectionSignal]

Typically the ejection signal is assigned to a digital output of the weighing module.
Eject devices such as pushers have a technical inertia which can be taken into account through this delay time. If the time is 100 ms for example, the ejection signal is set 100 ms earlier by the weighing module.

6.15.8 Duration of ejection signal [durationEjectionSignal]

Defines the duration for which the ejection signal is set by the weighing module. When specifying, ensure that the time is short enough so that a subsequent product that is also to be ejected can also be ejected.

6.15.9 Speed sensor pulse constant [speedSensorPulses]

If the drive of the weighing belt provides a pulse output signal, it can be wired on the potential-free CI input of the weighing module. By specifying the pulse constants (pulses per meter) the module continuously calculates the speed by means of the measured pulses at the CI input.
Alternatively a constant speed can be specified.

6.15.10 Speed signal filter [speedSignalFilter]

When using a speed sensor, the option to filter the measured speed is available. You can carry out the following settings:

0 = very weak filtering (default)

1 = weak filtering

2 = middle filtering

3 = strong filtering

4 = very strong filtering

Note: The stronger the signal is filtered, the stronger the scale reacts to changes of speed.

6.15.11 Speed unit [speedUnit]

The parameter defines the unit of the speed. You can carry out the following settings:

0 = m/s (meters per second = default)

1 = m/min

2 = ft/s

3 = ft/min

For the units 0 and 1 all length-specific parameters have to be specified correspondingly in meters in the data records 14 and 17. For the units 2 and 3 correspondingly in feet.

6.15.12 Number of revolutions for calibration/zeroing [numberOfBeltRevolutionsForCalibrationAndZeroing]

Zero calibration and zeroing can take place while the weighing belt is running. In this case it is possible to determine a mean value of the load cell signal during n complete belt revolutions. This can lead to improved results of a measurement. The parameter defines the number of belt revolutions with which a mean value is to be formed.
If the parameter is set to 0, the currently pending load cell signal is evaluated directly.

6.16 DR18 Digital output and transition control

6.16.1 Controlling digital outputs

Introduction

Digital outputs 0 to 3 can be controlled using DR18 with this parameter. For example, you can control the digital outputs during commissioning.

The set values are not saved in non-volatile memory!

Web server procedure

1. Select the "Service mode ON (1)" command.
2. Read DR07.
3. In DR07, assign a function to each digital output.
   Assignment DQ.0, DQ.1, DQ.2 (Page 71)
4. Write DR07.
5. Select the "Service mode OFF (2)" command.
6. Read DR18.
7. Activate one to three digital outputs in DR18: Control value DQ.0, DQ.1 and DQ.2.
8. Write DR18.

TIA Portal procedure

1. Activate service mode: Command code 1.
2. Read DR07: Command code 2007.
3. In DR07, assign the "Control from SIMATIC" function to each digital output.
   Assignment DQ.0, DQ.1, DQ.2 (Page 71)
4. Write DR07: Command code 4007.
5. Deactivate service mode: Command code 2.
6. Control one to three digital outputs in the "cyclicIoData" structure:
   Selection code 0 activates DQ.0.
   Selection code 1 activates DQ.1.
   Selection code 2 activates DQ.2.

6.16.2 Enabling transitions

Introduction

When you do not want automatic passage from weighing step to weighing step, activate one or more transitions.

The transitions are not saved in non-volatile memory!

Web server procedure

1. Read DR18.
2. In DR18, enable the transition for the desired weighing steps.
3. Write DR18.

TIA Portal procedure

1. In the "cyclicIoData > output > transitions" structure of the interface DB, enable the transition for the desired weighing steps [weighingStep0 to weighingStep7]: Selection code 1.

Result

When one transition is enabled per weighing step, the weighing step is paused until you disable the transition.

Example

You have enabled the transition for weighing step 2. Once dosing starts, weighing step 1 is performed. The electronic weighing system then jumps to weighing step 2 but does not yet execute it. The electronic weighing system outputs the status bit "Step blocked" in DR30. Step 2 is not performed until you reset the "Transition for weighing step 2" status bit.

As an alternative to setting transitions via software, the digital inputs of the electronic weighing system can also be configured with transitions for the individual weighing steps. In this way, a 24 V DC signal can be used to disable or enable individual weighing steps.

See also

TIA Portal user program (Page 37)

6.17 DR20 Configuration of set point [setPoint]

Introduction

The set point in "CW - Automatic check weigher" defines the reference weight of an individual dosing to be checked with the defined weight unit (Page 56).

Procedure

1. Enter the set point [setPoint] in DR20.

   The set point is smaller than the maximum permissible set point (Page 104) from DR25.
2. Write DR20.

6.18 DR21 Configuration of total set point [totalSetPoint]

6.18.1 DR21 Configuration of total set point in DTI

Introduction

The total set point in "DTI - Discontinuous totalizing automatic weighing instruments" specifies the total weight to be loaded with the defined weight unit (Page 56).

Material in feed intake (pre-signal) [materialDisposed]
Specifies the material weight in the feed intake to the scale with the defined weight unit.

Maximum allowed total set point undercut [maxTotalSetPointDeviation]
Defines the maximum permissible underrun of the total weight to be loaded with the defined weight unit.

Requirement

You have selected the weighing operating mode DTI Discontinuous totalizing automatic weighing instrument (Page 54).

Procedure

1. Read DR21.
2. In DR21, define the following parameters with the defined weight unit:
   - **Total set point** [totalSetPoint]

     When you specify a total set point during continuous operation which is smaller than the weighing operations already carried out, continuous operation is stopped following the current weighing operation.

     When you set the total set point to 0, all single loadings are cumulated until you end continuous operation.
   - **Maximum allowed total set point undercut** [maxTotalSetPointDeviation]
   - **Material in feed intake (pre-signal)** [materialDisposed]
3. Write DR21.

6.18.2 DR21 Configuration of total set point GFI

Introduction

The total set point in "GFI - Gravimetric filling instrument" defines the number of containers to be dosed in continuous operation.

Requirement

You have selected the weighing operating mode GFI - Gravimetric filling instrument (Page 52).

Procedure

1. Read DR21.
2. Enter the total set point [totalSetPoint] in DR21.
3. Write DR21.

Example

For example, if you specify a total set point of 20 and have started continuous operation, the electronic weighing system doses 20 containers one after the other. Continuous operation is stopped after the 20th container. The "Loading finished" status bit is set in the scale status. If continuous operation is switched off in the interim or an active dosing is aborted, the counter is restarted.

See also

CWI - Catchweighing instrument / CW - Automatic check weigher (Page 52)

6.19 DR22 Tolerance parameters

6.19.1 Overview

In DR22, you specify the tolerance limits that are to be used in a tolerance check by the electronic weighing system. You can define two tolerance bands around the set point. After the tolerance check, the result of the check is available in the scale status.

The tolerance limits around the set point are as follows:

- TH 2
- TH 1
- SET POINT (DS 20)
- TL 1
- TL 2

Example: TH2 & TL2 is defined with 2 kg. TH1 & TL1 is defined with 1 kg.

When the weight was dosed with an accuracy of +/- 1 kg around the specified set point, dosing is evaluated with "Good". If the final weight differs by more than +/- 2 kg from the specified set point, the tolerance check returns "Bad".

You also define the reaction of the scale to a tolerance error in DR22.

6.19.2 Parameter relation [parameterRelation]

The parameters define how you interpret the specified tolerance limits TH2, TH1, TL1 and TL2. The following options are available:

Selection code	Meaning
0 (default)	The tolerance limits are interpreted as percentages of the set point in DR20.
1	The tolerance limits are interpreted as absolute weight values
2	The tolerance limits are calculated based on OIML R61 "Limits of error on verification Class X1".
3	The tolerance limits are calculated based on OIML R61 "Maximum permissible errors in service Class X1".

In general, the currently valid tolerance limits in DR30 are output in the weight unit. When you select selection codes 2 and 3, the tolerance limits TH2, TH1, TL1 and TL2 entered in DR22 are ignored. The limits are calculated automatically in accordance with the OIML directive.

6.19.3 Tolerance limit TH2 (weight unit) [toleranceLimitTh2]

This parameter defines the limit of the second tolerance band above the set point. The setting conforms to the selected tolerance reference (percentage or absolute) and must be greater than or equal to tolerance limit TH1.

6.19.4 Tolerance limit TH1 (weight unit) [toleranceLimitTh1]

This parameter defines the limit of the first tolerance band above the set point. The setting conforms to the selected tolerance reference (percentage or absolute) and must be less than or equal to tolerance limit TH2.

6.19.5 Tolerance limit TL1 (weight unit) [toleranceLimitTl1]

This parameter defines the limit of the first tolerance band below the set point. The setting conforms to the selected tolerance reference (percentage or absolute) and must be less than or equal to tolerance limit TL2 as a positive value.

6.19.6 Tolerance limit TL2 (weight unit) [toleranceLimitTl2]

This parameter defines the limit of the first tolerance band below the set point. The setting conforms to the selected tolerance reference (percentage or absolute) and must be greater than or equal to tolerance limit TL1 as a positive value.

6.19.7 Behavior in case of TH1 error [behaviorTh1Violated]

The parameter defines the module response following a tolerance error of class "Greater than TO1". The following options are available:

0: Weighing cycle is not stopped and is always completed with "Weighing cycle finished".

1: Weighing cycle is stopped. Check the tolerance again using the "Continue" command (code 1141). The cycle is subsequently always completed with "Dosing completed".

2: Weighing cycle is stopped. Check the tolerance again using the "Continue" command (code 1141). If a tolerance error is still present, the weighing cycle is stopped again. This procedure is repeated until the tolerance error is eliminated (e.g. by manually removing material).

6.19.8 Behavior in case of TL1 error [behaviorTl1Violated]

The parameter defines the module response following a tolerance error of class "Less than TU1". The following options are available:

0: Weighing cycle is not stopped and is always completed with "Dosing completed".

1: Weighing cycle is stopped. Check the tolerance again using the "Continue" command (code 1141). The cycle is subsequently always completed with "Dosing completed".

2: Weighing cycle is stopped. Check the tolerance again using the "Continue" command (code 1141). If a tolerance error is still present, the weighing cycle is stopped again. This procedure is repeated until the tolerance error is eliminated (e.g. by manually adding material).

3: Post-dosing with continuous fine signal. Switch the "Fine signal" on continuously until TU1 is exceeded. The tolerance check is performed again and the weighing cycle is completed with "Dosing completed" as long as a tolerance error is no longer present.

4: Post-dosing with pulsing. "Fine signal" is switched on in pulsing mode until TL1 is exceeded. The tolerance check is performed again and the weighing cycle is completed with "Dosing completed" as long as a tolerance error is no longer present. The pulse/pause ratio in pulsing mode is defined by the pulse duration (DR22) and the sum of "Stability time 2 + deceleration time before stability 2" (DR3). This total corresponds to the pause time.

6.19.9 Pulse duration for pulse post dosing (s) [pulseDuration]

This parameter defines how long the fine signal is switched on when post-dosing in pulsing mode was set as the response to a TL1 violation in the tolerance check (selection code 4). The pause time in pulsing mode corresponds to the total of "Stability time 2 + delay time before stability 2" (DR3).4: Post-dosing with pulsing. "Fine signal" is switched on in pulsing mode until TL1 is exceeded. The tolerance check is performed again and the weighing cycle is completed with "Dosing completed" as long as a tolerance error is no longer present. The pulse/pause ratio in pulsing mode is defined by the pulse duration (DR22) and the sum of "Stability time 2 + deceleration time before stability 2" (DR3). This total corresponds to the pause time.

As of firmware V2.x, the electronic weighing system offers the commands "1135" and "1136". The commands are triggered in the stopped weighing cycle or outside the weighing cycle. For both commands the duration of the pulse time is set for the respective dosing signal.

6.19.10 Number of unchecked weighing cycles [cyclesWithoutCheck]

This parameter defines how many dosing cycles will not be checked for tolerance during continuous operation in GFI mode. The first dosing cycle of the continuous operation is always checked for tolerance, however. The discontinuation of the check(s) starts only after a dosing with "Good" tolerance has been determined. Dosings that are not checked for tolerance are classified as "GOOD" in the statistics (DR 39).

NOTE

Unchecked dosing cycles

In unchecked cycles, there is no adjustment of the shut-off points by the proportional controller.

Every dosing that is not checked is classified as "Good" in the statistics and the specified set point (DS 20) is used in calculating the statistics.

6.19.11 Capture of weighings into statistics [statisticsData]

Defines, based on the tolerance evaluation, which dosing results are to be included in the statistics calculation.

Selection code	Meaning
0 (default)	All dosings (with tolerance check) are included following "Dosing completed" in the calculated statistics.
1	Dosings (with tolerance check) of "GOOD" class are included following "Dosing completed" in the calculated statistics.
2	Dosings (with tolerance check) of "BAD" class are not included following "Dosing completed" in the calculated statistics.

6.20 DR23 Material parameters

6.20.1 Parameter relation [parameterRelation]

The parameter defines how the specifications for the fine weight and trailing weight are to be interpreted. The following options are available for selection:

Selection code	Meaning
0 (default)	Fine and trailing weights are interpreted as specified percentages of the set point (DS 20).
1	Fine and trailing weights are interpreted as absolute weights in the weight unit.

6.20.2 Fine weight [fineWeight]

Defines how much material is to be dosed only in the fine dosing phase. Depending on the selected unit reference (DR23), the value must be interpreted as a percentage of the set point (DR20) or as an absolute weight value.

Example:

Set point (DR20) = 100 kg

Selection code for parameter relation (DR 23) = 0

Fine value (DR 23) = 20

→ As a result of this setting, 20 kg (20% of 100 kg) is dosed with fine flow only.

6.20.3 Trailing weight fine [trailingWeightFine]

This parameter defines how much material still flows onto the scale after the fine signal is shut off. Depending on the selected unit reference (DR23), the value must be interpreted as a percentage of the set point (DR20) or as an absolute weight value.

Example

Set point (DR20) = 100 kg

Selection code for parameter relation (DR 23) = 0

Fine weight (DR 23) = 5

Trailing weight (DR 23) = 2

→ With this setting, it is assumed during dosing that 2 kg (2% of 100 kg) still flows onto the scale after the fine signal is shut off.

In the example, this means specifically that the coarse and final signal are switched at the start of the dosing. When 93 kg is reached, the coarse signal is shut off; when 98 kg is reached, the fine signal is shut off. The following graphic explains the relationship.

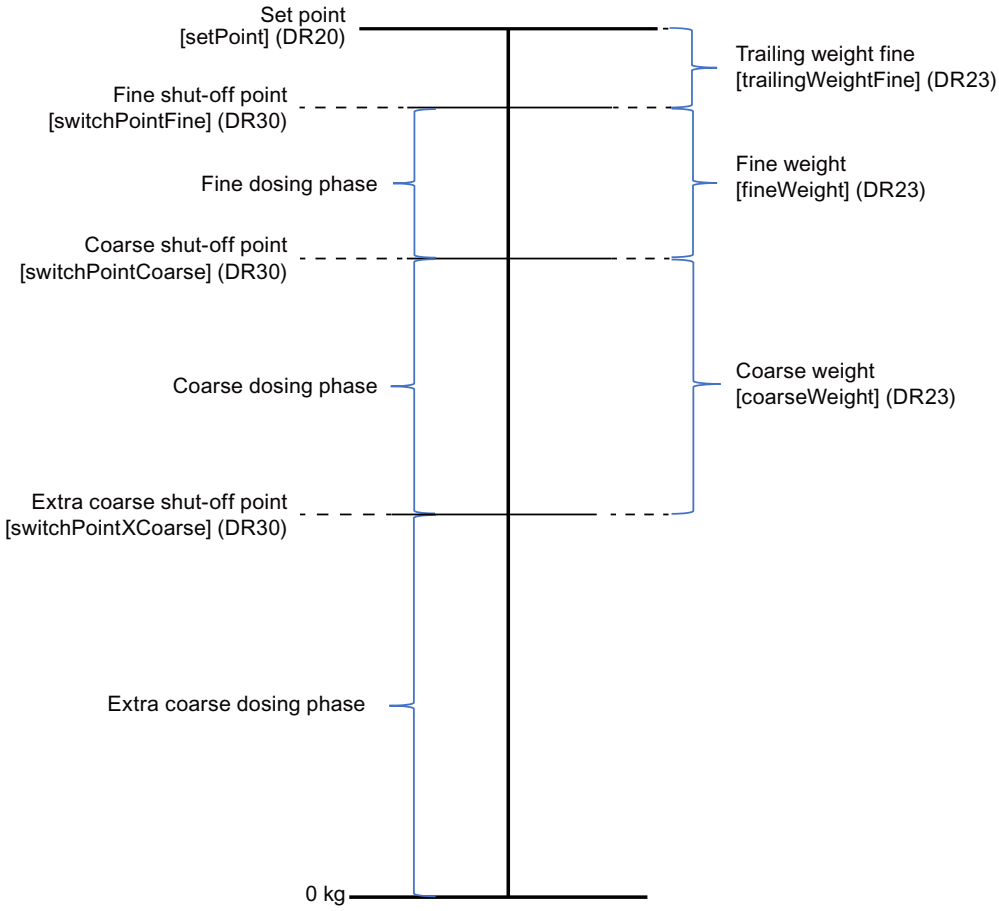

Figure 2-1185 Trailing weight

The shut-off points for the fine and coarse signals are corrected or optimized automatically during operation when the controller is activated (DR 24). The fine and trailing weights currently used by the electronic weighing system can be seen in DR30 (always expressed in DR30 in the weight unit).

6.20.4 Coarse weight [coarseWeight]

Relevant with dosing in three dosing steps (extra coarse, coarse and fine). In the case of classic coarse or fine dosing, the coarse weight remains at 0 (default setting). As soon as a value is specified, the shut-off points are calculated for the three dosing phases. Depending on the selected unit reference, the value must be interpreted as a percentage of the set point (DR20) or as an absolute weight value.

6.20.5 Trailing weight coarse [trailingWeightCoarse]

The parameter defines how much material still flows onto the scale after the coarse signal is shut off. Depending on the selected unit reference (DR23), the value must be interpreted as a percentage of the set point (DR20) or as an absolute weight value.

When dosing in DTI mode only takes place via coarse flow or via coarse flow with activated fine flow, the set weight of the single filling - coarse trailing weight represents the shut-off point of the coarse or fine flow.

In all other weighing operating modes, the parameter can be used as limit for the fine signal time controller. If the controller adjusts a fine weight that is less than the set coarse trailing weight, control is suspended, and the electronic weighing system issues a corresponding technology message.

6.20.6 Trailing weight extra coarse [trailingWeightXCoarse]

Defines how much material still flows onto the scale after the extra coarse signal is shut off. Depending on the selected unit reference (DR23), the value must be interpreted as a percentage of the set point (DR20) or as an absolute weight value.

6.20.7 Blocking time extra coarse (s) [blockingTimeXCoarse]

Defines a timer that begins at the start of three-stage dosing (with extra coarse, coarse and fine phase). While the timer is active, the electronic weighing system does not perform a check to determine whether the extra coarse shut-off point has been reached. At the start of dosing, the "coarse" and "fine" dosing signals are usually set simultaneously. The material may strike the scale hard, producing an overshoot that is higher than the extra coarse shut-off point, which would cause the extra coarse signal to be shut off too early. To prevent this premature shut-off, the "Blocking time extra coarse" can be defined in seconds.

6.20.8 Blocking time coarse signal (s) [blockingTimeCoarse]

This parameter defines a timer that starts when the coarse signal is switched. While the timer is active, the electronic weighing system does not perform a check to determine whether the coarse shut-off point has been reached.

At the start of dosing, the "coarse" and "fine" dosing signals are usually set simultaneously. The material may strike the scale hard, producing an overshoot that is higher than the coarse shut-off point, which would cause the coarse signal to be shut off too early. To prevent this premature shut-off, the "Blocking time coarse signal" can be defined.

6.20.9 Blocking time fine signal (s) [blockingTimeFine]

This parameter defines a timer that starts when the coarse signal is shut off. While the timer is active, the electronic weighing system does not perform a check to determine whether the fine shut-off point has been reached.

When the coarse signal is shut off, this may produce an overshoot that can be higher than the fine shut-off point, which would cause the fine signal to be shut off too early. To prevent this premature shut-off, the "Blocking time fine signal" can be defined.

6.20.10 Blocking time discharging (s) [blockingTimeDischarge]

Defines a timer that starts when the discharge signal is shut off. As long as the timer is active, the electronic weighing system does not perform a check to determine whether the dosing signals have been shut off. When the discharge signal is shut off, this can result in an overshoot that is higher than the coarse or fine shut-off point, for example. To prevent this premature shut-off, the "Blocking time discharging" can be defined in seconds.

6.20.11 External triggered blocking time (s) [externalBlockingTime]

Defines a timer that can be started by the user with command 1151. While the timer is active, the weight value is completely ignored by the electronic weighing system. In this way, significant foreseeable errors can be simply hidden. Using command 1152, the timer can also be stopped early before the specified time has elapsed. The "Blocking time active" status bit in the scale status shows whether a blocking time is currently active or not.

6.20.12 Shut-off correction weight [shutOffCorrectionWeight]

This parameter enables influences that occur during dosing (e.g. overpressure or underpressure) to be taken into account in determining when the set point weight is reached. The setting conforms to the "Parameter relation" setting and can thus be an absolute weight or a percentage of the set point. The shut-off correction weight currently in effect is always output in DR30 Read out process state (Page 110) in the weight unit.

6.20.13 Minimum material flow (weight/s) [minimumMaterialFlowRate]

The material flow is constantly being measured. The sign of the material flow is always positive for the selected weighing application.

Example: You have selected the weighing application "Non-automatic weighing instrument – Removal". In case of weight gain, the material flow gets a negative sign.

As soon as the determined material flow exceeds the limit, this violation is visible in the status display. Only one positive limit can be specified. A default of "0" permanently deactivates the status display.

6.21 DR24 Controller parameters

6.21.1 Parameter relation [parameterRelation]

This parameter defines the unit in which the "Maximum corrective action" and "Controller deadband - upper/lower limit" parameters (DR 24) must be interpreted. The following options are available:

Selection code	Meaning
0 (default)	"Maximum corrective action" and "Controller deadband - upper/lower limit" are interpreted as a percentage of the set point (DS 20).
1	"Maximum corrective action" and "Controller deadband - upper/lower limit" are interpreted in the weight unit.

6.21.2 Type of controller [controllerType]

A proportional controller and a fine time controller are available for optimization of the shut-off points.

Selection code	Meaning
0	No controller
1 (default)	Proportional controller without fine time controller
2	Proportional controller with fine time controller
3	Fine time controller without proportional controller

NOTE

Stop weighing cycle

If a weighing cycle has been stopped by a Stop command in the meantime, there is no corrective action by the controller for this dosing. The controller becomes active only for completed and checked cycles.

NOTE

Blocking time error

If blocking time errors occur in two consecutive dosing operations, the shut-off points of the next dosing are reset. The shut-off points are automatically reset to the values currently entered in DR 23. In addition, the module outputs the technology message "TM 2119 – Shut-off points reset due to blocking time error".

6.21.3 Control factor of proportional controller (%) [controlFactorPController]

When proportional controller is activated, its control factor can be defined. The parameter is specified as a percent.

6.21.4 Control factor of fine time controller (%) [controlFactorTController]

The controller changes the coarse shut-off point by changing the fine weight.

$F_{n+1} = F_n + (K * D_{Fine} * t_{Diff})$

F_n	Fine weight for current weighing
F_{n+1}	Fine weight of next weighing
K	Control factor for fine time controller
D_{Fine}	Material flow at time fine signal was switched off
t_{Diff}	Control deviation

6.21.5 Max. control access of proportional controller [maximumControllAccessPController]

When proportional controller is activated, the maximum possible correction of the shut-off points by the controller can be defined. Depending on the "Parameter relation" setting (DR 24), the value must be specified and interpreted as a percentage of the set point (DR 20) or as an absolute weight value.

6.21.6 Proportional controller deadband - upper limit [deadBandPControllerPlus]

When proportional controller is activated, a deadband for the controller can be defined. If the achieved final weight of a dosing (with check) is below the upper limit of the deadband, the controller does not correct the shut-off points. If both limits are at zero, the controller corrects after each checked dosing.

6.21.7 Proportional controller deadband - lower limit [deadBandPControllerMinus]

When proportional controller is activated, a deadband for the controller can be defined. If the achieved final weight of a dosing (with check) is above the lower limit of the deadband, the controller does not correct the shut-off points. If both limits are at zero, the controller corrects after each checked dosing.

6.21.8 Controller behavior in case of exceeding max. control access [controllerErrorBehavior]

This parameter defines the controller behavior when the maximum corrective action (DR 24) is exceeded in a cycle. The following options are available:

Selection code	Meaning
0	Control is discontinued for this cycle.
1 (default)	The controller controls with the maximum corrective action (DR 24).

6.21.9 Intervention of fine time controller [interventionTController]

This parameter defines the controller behavior in continuous operation.

Selection code	Meaning
0 (default)	Control only in checked weighing cycles
1	Controller works in any weighing cycle

6.21.10 Set point fine time controller (s) [setPointTController]

If the fine time controller was activated (see type of controller), the desired duration of the fine signal can be set.

The fine time controller optimizes the duration of the fine signal by adjusting the fine weight and thus the coarse flow shut-off point. The shut-off point is adjusted so that the actual duration of the fine signal corresponds to the default value in settled state. The control deviation is determined after fine dosing:

$t_{Diff} = t_{Set} - t_{Act}$

t_{Diff} Control deviation (s)

t_{Set} Fine set time (s) (= default)

t_{actual} Fine actual time (s)

The setpoint for the fine time is specified by the user.

6.21.11 Adopt corrected fine-/trailing values to DR23 automatically [adoptCorrectedValues]

At the initial start of a dosing with "Material A", the electronic weighing system calculates the shut-off points for the coarse/fine signal according to settings from DR23 (fine/trailing weight).

If the P-controller is active, the fine/trailing weight of "Material A" internally (DR30 or DR31) is corrected or optimized by the controller during operation if necessary.

If there is now a change to "Material B" that entails different parameters, the corrected fine/trailing weight of "Material A" would have to be read from DR30 or DR31 and copied to

DR23 before the change so that, at the next loading of "Material A", the optimized values would be used directly at the start.

To automate this copying, the "Adopt corrected fine/trailing value to DR 23 automatically" parameter can be set to "YES" or "1".

6.21.12 Max. control access of fine time controller [maximumControllAccessTController]

With activated fine time controller you can define to what maximum extent the fine weight can be adjusted. Depending on the "Parameter relation" setting (DR 24), the value must be specified and interpreted as a percentage of the setpoint (DR 20) or as an absolute weight value.

6.22 DR25 Dosing system parameters

6.22.1 Maximum single set point [maximumSingleSetPoint]

This parameter limits the set point in DR 20 and thus defines the maximum capacity of the scale. The setting must be less than or equal to the maximum weight (DR 3).

6.22.2 Minimum automatic tare weight (% of max.) [minimumAutomaticTareWeight]

This parameter defines a minimum weight that must be tared at the start of dosing. It applies only when a dosing start with taring is set in DR 25.

The parameter can be used to prevent dosing from being started even though, for example, no empty container is on the scale. In this case, the minimum tare weight should correspond to the empty weight of the container to be filled.

6.22.3 Maximum automatic tare weight (% of max.) [maximumAutomaticTareWeight]

This parameter defines a maximum weight that may be tared at the start of dosing; it applies only when a dosing start with taring is set in DR25.

The parameter can be used to prevent overfilling an already prefilled container.

6.22.4 Maximum weighing time (s) [maximumDosingTime]

This parameter represents a timer that is started at the start of an automatic dosing cycle. If the dosing cycle has not yet finished after expiration of the timer, the electronic weighing system outputs a corresponding technology message that has no further effect on the running dosing cycle. The message serves only as information for the operator.

6.22.5 Weighing start options [startOptions]

This parameter defines the first action of an automatic dosing cycle to be executed (weighing step 1). The following options are available:

Selection code	Meaning
0	The dosing starts directly without zero setting or taring
1	The electronic weighing system sets the scale to zero and then starts the dosing process
2 (default)	The electronic weighing system tares the scale and then starts the dosing process
3	The electronic weighing system tares the scale using the preset tare from DR15 and then starts the dosing process
4	The electronic weighing system tares the scale using the preset tare from the SIMATIC I/O and then starts the dosing process
5	The electronic weighing system performs taring using an averaged tare value

6.22.6 Cycle time for automatic zero setting (s) [cycleTimeAutomaticZeroSetting]

This parameter can be used to define a time after which zero setting or taring must have occurred. When "OIML" is set in DR 3, a zero setting/taring occurs at the latest as defined in the regulations. Dependent on the maximum time setting

6.22.7 Number of weighings without automatic taring/zero setting [numberOfCyclesWithoutZeroSetting]

This parameter defines a number of dosing cycles that are not zeroed or tared. It applies only during continuous operation. The first cycle of the continuous operation is always zeroed or tared (if configured for "Dosing start").

6.22.8 Check stop [checkStopAfterStep0 to checkStopAfterStep7]

This parameter enables, in contrast to transitions, the dosing cycle to be stopped after each individual weighing step. By setting bits 0 ... 7, corresponding check stops are set for weighing steps 0 ... 7. In addition, the "Activate check stop (1122)" command must be issued in order to stop the cycle at the first set check stop point.

Example:

- The check stop bits are set for weighing steps 1 and 2 and DR25 is transmitted to the electronic weighing system.

  The "Activate check stop (1122)" command is issued.
  → The "Check stop follows" bit is set in the AWI Status.

- Dosing is started (single dosing or continuous operation)
  → After weighing step 1 is complete, the electronic weighing system jumps to the "Stopped" state. The "Check stop active" bit is set in the AWI status. The "Check stop follows" bit is reset.

- The "Activate check stop (1122)" command notifies the electronic weighing system to stop again at the next check stop point.
  → The "Check stop follows" bit is set again in the AWI status.
- The "Continue weighing cycle (1141)" command continues the dosing cycle.
  → After weighing step 2 is complete, the electronic weighing system jumps to "Stopped" state. The "Check stop active" bit is set in the AWI status. The "Check stop follows" bit is reset.
- Because no other check stop points were defined, the dosing cycle is performed after "Continue weighing (1141)" to the end.

6.22.9 Automatic discharging [dischargeMode]

This parameter defines whether and in which form the scale is to be emptied by the electronic weighing system at the end of an automatic weighing cycle. The following options are available:

Selection code	Meaning
0 (default)	No emptying. After a tolerance check (if the weighing cycle is checked), the electronic weighing system ends the weighing cycle and jumps to weighing step 0.
1	Empty until limit 3 is fallen below. The electronic weighing system sets the "Discharge" bit (which can be placed directly on one of the digital outputs) until the gross weight falls below limit 3 (defined in DR6) and then resets the bit.
2	Empty according to specified time. The electronic weighing system sets the "Discharge" bit (which can be placed directly on one of the digital outputs) based on the discharge time specified in DR25 and then resets the bit automatically – regardless of whether or not the scale was completely emptied during this time!

NOTE

In DTI mode, the emptying step is always executed and cannot be deactivated. The selection codes 0 and 1 are both interpreted as "Empty until limit 3 is fallen below" in DTI mode.

6.22.10 Discharge time (s) [dischargeTime]

The parameter defines a fixed time during which the emptying signal is activated in the emptying step. It applies only when selection code 2 (Emptying according to specified time) is selected as the emptying option in DR25.

In DTI mode, the parameter has an additional function. If a residual quantity of the material is located in the weighing container that is less than the emptying limit (DR6) and no additional material flows, loading can be stopped with the "Rest weighing" command. In this configuration the emptying signal for the set emptying time is activated, even if the scale is emptied in normal operation until limit 3 is undershot (empty). The material located in the scale at this time is totaled, emptied and loading is stopped.

6.22.11 Maximum discharge time (s) [dischargeMonitoringTime]

This parameter defines a monitoring time for emptying option 1 in DR 25 (Emptying until limit 3 is fallen below). The time starts together with the emptying signal. If limit 3 has not yet been fallen below after expiration of the time, a corresponding technology message is issued that has no further effect on the weighing cycle or emptying. The message is purely informative.

6.22.12 Discharge overlapping time [dischargeOverlappingTime]

If the scale is emptied over time, the next dosing cycle can already be started with the discharge overlapping time even though the discharge time is still running.

Example

Discharge time = 0.8 s

Discharge overlapping time = 0.3 s

After 0.5 s of the discharge time, the next dosing cycle is started even though emptying will still take place for another 0.3 s.

6.22.13 No. of optimized loadings (OIML R-107) [NumberOfOptimizedLoadings]

The parameter defines whether and how many single fillings are to be made at the end of loading in THW mode definitive with coarse and fine flow. In addition, the individual setpoint is adjusted by optimized single fillings so that the total setpoint is reached as accurately as possible.

NOTE

The parameter 0 is accepted for compatibility reasons, but it is interpreted as 1 by the function. As a result, at least one filling is optimized each time it is loaded.

6.22.14 Dosing signals

Dosing signals during extra coarse phase [feedOptionsXCoarse]

Defines which signals are switched in the "Extra coarse" dosing phase in three-stage dosing (with extra coarse, coarse and fine phase).

Selection code	Meaning
0 (default)	Extra coarse phase is omitted
1	Only "Extra coarse signal"
3	"Extra coarse signal" + "Coarse signal"
7	"Extra coarse signal" + "Coarse signal" + "Fine signal"

Dosing signals during coarse phase [feedOptionsCoarse]

Defines which signals are switched in the "coarse" dosing phase.

Selection code	Meaning
1 (default)	Only with coarse signal
3	With coarse and fine signal

6.22.15 Delete tare in weighing step 0 [deleteTareStep0]

Selection code	Meaning
0 (default)	Do not delete tare
1	Delete tare memory automatically on transition to weighing step 0

6.23 DR28 Configuration of additional string for protocols

6.23.1 Log with additional string [addAdditionalText]

The freely definable additional string [additionalText] with 42 characters is transmitted from the CPU to the electronic weighing system. When you save the additional string in the protocol, extra information such as batch numbers or similar is saved in the scale protocols.

Selection code [addAdditionalText]	Meaning
0 (default)	Do not save additional string in protocol
1	Save additional string in protocol

6.23.2 Log single loadings (OIML R-107) [logSingleLoadings]

The parameter defines whether single fillings of a load are logged in THW mode in addition to the master totalizer.

If single fillings of a load are logged, the single fillings are permanently labeled with the string "delta n", whereby 'n' stands for the number of the current single filling.

The legal-for-trade subset is marked "T1" and is stored with the set additional signs 1, 2, 3 or 4 in the alibi memory. Not legal-for-trade loggings of the total T1 (e.g. T1 < Minimum totalized load (DR3)) are labeled "t1" in the protocol memory.

The measured actual weights are logged in CW mode.

6.23.3 Protocol storage method (International Organization of Legal Metrology) [protocolLoggingMode]

This parameter defines whether the internal legal-for-trade data memory works as a ring memory, or whether the electronic weighing system outputs the corresponding message when the protocol memory gets full and blocks further weighing (=default).

In operations requiring official calibration, the parameter can be changed at any time.

NOTE

In operations not requiring official calibration, the protocol memory automatically works as a ring memory, regardless of the setting selected here.

6.24 DR29 Configuration of technology messages

Introduction

In DR29, it is possible to suppress the technology messages from the electronic weighing system in a targeted manner as described in section Technology messages (Page 140).

Web server procedure

1. Read DR29.
2. Select "No message" for the desired technology messages.
3. Write DR29.

TIA Portal procedure

1. Read DR29: Command code 2029.
2. Enter "false" for the desired technology messages.
3. Write DR29: Command code 4029.

6.25 DR30 Read out process state

6.25.1 Overview

Internal states and process values of the scale can be monitored using the process values. This data is not required for standard operation of the scale.

The monitoring of selected data during trial operation is extremely useful as it helps you to optimize parameters and locate errors.

DR30 contains all weight values and related status information of the electronic weighing system. All values are read-only. You can find the status information in the parameter table (https://support.industry.siemens.com/cs/ww/en/ps/7MH4138-6BA00-0CU0/dl) on the Internet. See also section: Introduction (Page 36).

NOTE

Reading of DR30 to the PLC via command is not mandatory. In DR07 Interface parameters (Page 70), the user can freely select four process variables that are transmitted automatically via the S7-I/O to the CPU and are available there. In addition, the complete scale status is always available cyclically in the I/O (see section TIA Portal user program (Page 37)) and can thus be used directly in the PLC program. At the Modbus end, the parameters and status information from DR30 are always current and the registers can therefore be read immediately.

6.25.2 Digits unfiltered (linearized) [unfilteredDigitsNotLin]

The unfiltered digit value is the internal measured value before filtering.

6.25.3 Digits filtered by F1 [filteredDigits1]

The filtered digit value is the internal measured value after filtering with filters defined in DR 3.

6.25.4 Digits filtered by F2 [filteredDigits2]

The filtered digit value is the internal measured value after filtering with the average value low pass filter and dosing filter from DR03.

6.25.5 Digits filtered by F3 [filteredDigits3]

The filtered digit value is the internal measured value after filtering with the average value and low pass filter from DR03.

6.25.6 Status DI.0, DI.1, DI.2 and CI.0 [statusDI0] [statusDI1] [statusDI2] [statusCI0]

Current status of digital inputs DI.0 to DI.2 and CI.0.

6.25.7 Status DQ.0, DQ.1 and DQ.2 [statusDQ0 to statusDQ2]

Current status of digital outputs DQ.0 to DQ.3.

6.25.8 Refresh counter [refreshcounter]

The measured values are formed again every millisecond in the electronic weighing system. A counter is incremented by one each time. Once the counter reaches the value 65536, it starts again from zero. The counter can be used as a time stamp for DR30.

6.25.9 Current load cell signal voltage (mV) [loadCellSignalVoltage]

Display of currently measured signal voltage of the load cell(s) between the SIG+ and SIG- terminals in millivolts (mV).

6.25.10 Load cell impedance (Ohm) [loadCellImpedance]

The parameter shows the currently measured impedance of the connected load cells.

6.25.11 Current load cell SEN voltage (V) [loadCellSenseVoltage]

The parameter shows the currently measured SEN voltage of the connected load cells.

6.25.12 Current fine weight [currentFineWeight]

This parameter indicates the calculated fine weight currently used by the electronic weighing system. The value can differ from the specification in DR23 because it may have been adjusted by the proportional controller.

6.25.13 Current trailing weight [currentTrailingWeightFine]

This parameter indicates the calculated trailing weight currently used by the electronic weighing system. The value can differ from the specification in DR23 because it may have been adjusted by the proportional controller.

6.25.14 Tolerance limits (weight unit) [toleranceLimitTh2] [toleranceLimitTh1] [toleranceLimitTl1] [toleranceLimitTl2]

The tolerance limits specified in DR22 are always output in the weight unit because different options are available in DR22 for specifying the tolerance limits (absolute values, relative values or according to OIML R-61).

6.25.15 Gross process weight 1 [grossProcessWeight1], Net process weight 1 [netProcessWeight1], Tare process weight [tareProcessWeight]

These are the gross, net and tare weights in high-resolution process form.

6.25.16 Gross weight [grossWeight], Net weight [netWeight], Tare weight [tareWeight]

These are the gross, net and tare weights after rounding and filtering defined in data record 3.

6.25.17 Gross/net weight x10 [netWeightX10]

This is the gross and net weight after rounding according to settings in DR03 and a resolution raised by a factor of 10.

6.25.18 Gross process weight 2 [grossProcessWeight2], Net process weight 2 [netProcessWeight2]

These are the high-resolution, internal process values of the gross and net weight after filtering according to filters 1 and 2 (DR03).

6.25.19 Last net process weight [lastNetProcessWeight], Last net weight [lastNetWeight]

The parameters show the last dosed net process weight or net weight.

6.25.20 Totalizer 1 [totalizer1] and Totalizer 2 [totalizer2]

Two totalizer memories that you reset separately using a command. Delete totalizer 1: Command code: 651; Delete totalizer 2: Command code: 652. In NAWI and CWI modes, the dosed weight is added to the totalizers after the tolerance check. In weighing operating mode GFI, the actual weight determined by the tolerance check in checked cycles is cumulated. For cycles without tolerance check, the set point set in DR20 is included in the calculated totalizers.

In DTI mode, totalizer 1 represents the legal-for-trade totalizer.

6.25.21 Youngest protocol ID [youngestLogId]

After a successful logging, the "Youngest protocol-ID" parameter is incremented and represents the last protocol ID to be created.

6.25.22 Date & time

The Year, Month, Day, Hour, Minute, Second, Millisecond, and Day of the week parameters represent the current date and time set in the electronic weighing system. The electronic weighing system automatically synchronizes the time with the time of the connected CPU.

6.25.23 Current dosing step [subDosingStep]

This parameter provides information on the dosing step the scale is currently in. A list of the steps is available in section Weighing steps (Page 50).

6.25.24 Number of dosings in continuous mode [dosingsInContinuousMode]

The parameter provides information on how many dosing / single filling operations have been carried out since the last start of continuous operation.

6.25.25 Difference set point / actual value [differenceSetPointActualValue]

The parameter shows the difference between the set point and the actual value of the last check (CW mode).

6.26 DR32 Read out error messages

6.26.1 Overview

In the event of an error, the DR is read out automatically by the WP351 FB so that a connected SIMATIC HMI can generate messages accordingly. With data/operating errors and technology messages, the error bits remain for 3 seconds and do not need to be acknowledged to the electronic weighing system. Operating errors remain permanently until the error is resolved.

The individual error messages are presented and explained in detail in section Operating errors (Page 138). The following table is used only for breaking down the individual messages into their message bits.

6.26.2 Operating errors, technology messages, data/command errors

All available message bits are presented in the table above. For data/command errors, there is also "Additional information" available, which is described in more detail in section Interrupts/diagnostic messages (Page 137).

6.27 DR34 Weight indicator

DR 34 provides an ASCII string with 16 characters, that can be used as a weight display. The string contains the current gross or net weight after rounding according to DR03, as well as the weight unit. In addition additional parameters and weight values can be (temporarily) displayed or hidden via a command.

For applications requiring official calibration, DR 34 cannot be used as a main display. In this case, the "SecureDisplay" software must be used in order to represent the weight and additional information in a calibratable manner.

The corresponding registers are always currently available at the Modbus end. For operation with a SIMATIC CPU, DR34 must be read or requested by the electronic weighing system via a command.

See also

Commands (Page 120)

6.28 DR37 Training data dynamic checkweigher

While the automatic learn functions speed, signal filter or boost correction are active (commands 1156 to 1158) the data record correspondingly provides the currently calculated parameters.
With command 1159 (apply training data) the determined values are copied into data record 14 or 17.

6.29 DR38 Advanced diagnostic data

The DR contains the following advanced diagnostic data:

- Time stamps for all available calibration points
- Drag indicator of the gross weight incl. time stamp
- Cycles of operation counter for the dosing signals "extra coarse", "coarse" and "fine"
- Residence time for weighing steps 1 to 7
- Duration of "extra coarse dosing phase", "coarse dosing phase" and "fine dosing phase"

6.30 DR39 Statistical data

DR39 provides a variety of statistical data. You can reset the statistical data at any time with the "Reset statistics (442)" command.

When the electronic weighing system is in CW mode of operation, the statistical data is reset automatically as soon as a new set point is transferred via DR20 to the electronic weighing system. To save the statistical data, read DR39 into the SIMATIC controller/PC system before the set point is changed.

Set the acquisition of statistical data in DR22.

The statistics include the following data:

- Number of weighings of classes TH2, TH1, TL1 and TL2 (relative and absolute)
- Number of weighings of classes GOOD and BAD
- Net weight average value
- Standard deviation
- Performance per hour
- No. of weighings per hour
- Number of weighings

6.31 DR45 Protocol request

The protocol ID of the log to be displayed in data record 46 is entered here.

The protocol ID to be read is also used for the calibratable reading of the log via SecureDisplay. For example, if ID 129 is to be displayed, the value 129 must be entered in DR45 and sent to SIWAREX. The log with ID 129 can then be read from DR 46 and displayed in a calibratable manner in SecureDisplay using command 891.

If the protocol ID to be read in DR 45 is 0, data record DR 46 is automatically written with the last created log. Thus, after a logging, DR46 can be read directly into the PLC for further processing without having to request the last log beforehand.

6.32 DR46 Read out protocol content

6.32.1 Overview

Protocol data is provided in DR46.

The protocol memory of the electronic weighing system can hold up to 1,000,976 entries.

Depending on the weighing operating mode, the protocols have different structures. After changing the weighing operating mode (DR03), it is advisable to load the factory settings, so that incompatible protocols, if any, are deleted. Existing, incompatible protocols are deleted.

6.32.2 Oldest protocol ID [oldestLogId]

The ID of the first saved log is displayed here.

6.32.3 Youngest protocol ID [latestLogId]

The ID of the last saved log is displayed here.

6.32.4 Selected protocol ID, numerical [selectedLogId]

The ID of the log requested in data record 45 and shown in data record 46 is displayed here.

6.32.5 Protocol string [log]

The protocol string contains the following information depending on the scale type:

Weighing operating mode DTI - Discontinuous totalizing automatic weighing instruments

[Identifier];[Weight value];[Weight unit];[Additional string];[8 spaces]

Example: T1;100;kg;Wheat; ;

Designation	Data type	Length (bytes)
Identifier: T1: Totalizer 1 (legal-for-trade totalizer), t1: Totalizer 1 (non-legal-for-trade totalizer), dt: Single loading	BYTE	2
;	BYTE	1
Weight value	BYTE	11
;	BYTE	1
Weight unit	BYTE	4
;	BYTE	1
Additional string	BYTE	42
;	BYTE	1
8 spaces	BYTE	8
;	BYTE	1

All other weighing operating modes

[Gross/Net identifier];[Weight value];[Weight unit];[Tare identifier];[Tare weight value];[Additional string];

Example: N;10;kg;T;5;kg;Potatoes

Designation	Data type	Length (bytes)
Gross/Net	BYTE	2
;	BYTE	1
Weight value	BYTE	8

Designation	Data type	Length (bytes)
;	BYTE	1
Weight unit	BYTE	4
;	BYTE	1
Tare sign	BYTE	2
;	BYTE	1
Tare weight value	BYTE	8
;	UBYTE	1
Additional string	UBYTE	42
;	UBYTE	1

6.32.6 Checksum, date, time

The checksums, date and time of the selected protocol are displayed here.

6.33 DR47 Read out logbook content

Changes to the used software version of SecureDisplay of the legal-for-trade main display [HMI] and changes to the firmware of the electronic weighing system are recorded in the logbook.

Scrolling in the logbook is possible using commands 881 to 883.

Legal-for-trade reading of the logbook is carried out using the SecureDisplay legal-for-trade main display. Non-legal-for-trade reading is carried out using DR47.

6.34 DR 70 SIWAREX DB parameter

The parameters which define the response in combination with SIWAREX DB are specified in data record DR 70.

If SIWAREX DB is not used, the default settings can be accepted.

Load cell input

- Enter the location designation of the respective sensor for each load cell input.

  In the event of a fault, you can identify the affected sensor.

Channels

- Activate and deactivate the individual channels of SIWAREX DB.

  For correct operation, disable unused channels.
- By factory setting, all 4 channels of SIWAREX DB are activated.

Corner load factors

- The corner load factors of the individual channels are stored in DR 70.

  The corner load factors are relevant if you have performed a corner load compensation during commissioning. The procedure for corner load compensation is described in chapter Commands of command codes 151 to 160.

6.35 DR 80 / DR 81 / DR 82 SIWAREX DB process status and device information

The following diagnostic bits are available for each load cell input.

- QI-flag (0 = no error on the channel; 1 = channel disturbed)
- Underload of the load cell signal
- Overload of the load cell signal
- SEN error
- Impedance error (< 330 ohms or > 4100 ohms)
- EXC short circuit
- Error power supply

In addition, the following measured values are continuously recorded for each channel and made available in the data records:

- Filtered ADC raw value
- Percentage utilization of the connected sensor
- Signal voltage in mV

The current firmware and hardware version of the SIWAREX DB can also be read out.

6.36 DR156 Security Audit Log Entry

The Security Audit Log records all logins in the web server of the electronic weighing system. In addition to the user, commands executed in the web server and data record transfers are also logged. These events may be read retrospectively in the web server or in the connected CPU via data record DR156. Command codes 922 and 923 allow to scroll forward and backward in the audit log, respectively.

The audit log can only be reset by loading the factory settings.

The following is the breakdown of the information that is transmitted to the CPU in DR156:

Event ID [eventID]

Consecutive ID that is incremented with each new event.

Date and time [dateAndTime]

Event [event]

0	Successful login
1	Unsuccessful login attempt

2 Logout by user

3 Logout by system timeout

4 Write command/data record

User number [userNumber]

0 admin - with access via local button

5 Web server user 1 from TIA Portal hardware configuration

6 Web server user 2 from TIA Portal hardware configuration

7 Web server user 3 from TIA Portal hardware configuration

8 Web server user 4 from TIA Portal hardware configuration

9 Web server user 5 from TIA Portal hardware configuration

Username [userName]

Eventinfo [eventInformation]

1 Only read rights

2 Read/write rights

3 Action completed successfully

4 Action successfully rejected

Command [command]
Command code to be executed

6.37 Commands

6.37.1 Overview

The commands for the electronic weighing system described here can be transmitted by the following interfaces:

- From the SIMATIC HMI via the SIMATIC controller to the electronic weighing system
- From the SIMATIC HMI directly to the electronic weighing system via Modbus
- From the web server directly to the electronic weighing system
- Via the digital inputs after corresponding assignment in data record DR07

If an issued command is not accepted by the electronic weighing system, the cause of the rejection is always substantiated with a corresponding data/operating error.

Detailed descriptions of the commands can be found in the following tables:

→ Service commands

→ Protocol commands, statistics, logbook

→ Trace commands

→ Totalization commands

→ Display changeover for DR34 and SecureDisplay
→ Scale commands
→ Weighing commands

See also

Commands (Page 121)

6.37.2 Commands

Table 2-1321 Service commands

Command code	Command	Description	Write protection
1	Service mode ON	Turn on service mode	
2	Service mode OFF	Turn off service mode	
3	Weight Simulation on	Requirement: You have generally released simulation mode in DR03. Turn on test mode. The simulation value from DR16 is used instead of the measured value for calculation of the process values.	
4	Weight Simulation off	Switch off test mode.	
7	Stop webserver emergency access	When emergency access of the Web server was enabled using the button on the electronic weighing system, you can end emergency access.	
11	Load factory settings	The command resets the electronic weighing system to the "ex works" status. During this process: • All parameters and saved data (including log memory, logbook, IP addresses and Modbus addresses) • All message buffers (diagnostic buffer, trace memory, etc.) are reset • A configured recovery point, if any, is overwritten by the default values.	P
12	Load standard parameters	As "Load factory settings (11)". DR07 is not reset.	P
28	Display weighing operating mode	Shows the set weighing operating mode in the display.	
31	Load recovery parameter	The last recovery point created with command 51 is loaded.	P
51	Create recovery parameter	Backs up all scale parameters as a recovery point that can then be loaded when needed using command 31.	P
60	Set Calibration Point 0	Calibration point 0 valid / save values for calibration point 0. The current load cell signal or the currently measured digits are assigned to calibration weight 0 from DR03 and entered as "Calibration digit 0" in DR03.	P
61	Set Calibration Point 1	Calibration point 1 valid / save values for calibration point 1. The current load cell signal or the currently measured digits are assigned to calibration weight 1 from DR03 and entered as "Calibration digit 1" in DR03.	P
62	Set Calibration Point 2	Calibration point 2 valid / save values for calibration point 2. The current load cell signal or the currently measured digits are assigned to calibration weight 2 from DR03 and entered as "Calibration digit 2" in DR03.	P

Command code	Command	Description	Write protection
63	Set calibration point 3	Set calibration point 3 / save values for calibration point 1.	
64	Set calibration point 4	Set calibration point 4 / save values for calibration point 2.	
81	Shift characteristic curve	Move calibration characteristic. The command defines the current weight of the scale as the new zero point (0 kg) and shifts the complete characteristic without changing the gradient. The command can be used, for example, in order to compensate parts used for mounting calibration weights on the scale at the end of the calibration.	P
82	Automatic calibration	Calculating the scale characteristic curve based on the load cell parameters from DR10. The calculated characteristic curve is entered directly in DR03 and DR04, and thus activated immediately after executing the command. The scale must be empty when the command is executed. The accuracy of a scale that is automatically calibrated depends heavily on the mechanical setup!	P
83	Check calibration	The command calculates the theoretical digital values in relation to the calibration weights using the load cell parameters from DR10 and the calibration weights 1 to 4 from DR03. The output of these theoretical digits is made in DR04. The function can be used to compare the calibration digits in DR03 that were determined during a calibration with calibration weights (commands 61 to 64) with the theoretically expected digits.	
151	Corner load adjustment load cell input 1	Calculate corner load factor at load cell input 1 Before executing the command, place a weight (at least 10% of the rated load of the scale) over the load cell connected to channel 1 of SIWAREX DB. Then execute command 151. If you do not use the digital junction box SIWAREX DB, commands 151 - 160 are not relevant.	
152	Corner load adjustment load cell input 2	Calculate corner load factor at load cell input 2 Before executing the command, place the weight already used for channel 1 over the load cell connected to channel 2 of SIWAREX DB. Then execute command 152.	
153	Corner load adjustment load cell input 3	Calculate corner load factor at load cell input 3 Before executing the command, place the weight already used for channel 1 and 2 over the load cell connected to channel 3 of SIWAREX DB. Then execute command 153. If you have connected only two load cells to SIWAREX DB, proceed with command 160.	
154	Corner load adjustment load cell input 4	Calculate corner load factor at load cell input 4 Before executing the command, place the weight already used for channel 1, 2 and 3 over the load cell connected to channel 4 of SIWAREX DB. Then execute command 154. Complete the corner load adjustment with command 160.	
160	Corner load adjustment complete	Calculate corner load factors and transfer to DR70	
907	Set impedance reference	The currently measured impedance value (DR30) is transferred to DR10 as impedance reference.	
910	Trigger for monitoring of Modbus communication	Starts time-based monitoring of Modbus communication	

Table 2-1322 Protocol commands, statistics, logbook

Command code	Command	Description	Write protection
401	Generate protocol	Log current parameters relevant to the calibration	
405	Erase protocols	Delete all logs	P
440	Erase log book	Delete the logbook. Only permitted in non-calibrated state.	P
442	Reset statistical data	Deletes statistical data record DR39	
443	Delete drag indicator	Resets the drag indicator DR38	
444	Reset counter "cycles of operation - xCoarse feed"	Deletes the cycle counter of the extra coarse signal	
445	Reset counter "cycles of operation - coarse feed"	Deletes the cycle counter of the coarse signal	
446	Reset counter "cycles of operation - fine feed"	Deletes the cycle counter of the fine signal	

Table 2-1323 Trace commands

Command code	Command	Description	Write protection
451	Trace ON	Start cyclic trace recording	
452	Trace OFF	Stop trace recording	
453	Single trace element	Single recording (current state)	
454	Erase trace memory	Delete trace recording	

Table 2-1324 Totalization commands

Command code	Command	Description	Write protection
651	Delete total 1	Deletes total 1 in DR30 (not possible for THW in OIML mode)	
652	Delete total 2	Deletes total 2 in DR30	
653	Log and delete total 1	Logs total 1 in alibi memory and then deletes it (THW mode)	

Table 2-1325 Display changeover for DR34 and SecureDisplay

Command code	Command	Description	Write protection
701	High resolution on	Activate high resolution (factor 10) of the weight value on the main display (DR34) and the SecureDisplay for 5 s.	
705	Display Tare Process	Display current tare weight on the main display (DR34) and the SecureDisplay.	
706	Display current gross weight	Display current gross weight in SecureDisplay and DR34	
710	Display standard weight	Display standard gross/net weight display on the main display (DR34) and the SecureDisplay.	
714	Net process weight		

Command code	Command	Description	Write protection
715	Gross process weight		
716	Gross weight after F1		
721	Display single set point	Display currently set point setting from DR20 on the main display (DR34) and the SecureDisplay for 5 seconds.	
722	Display total set point	Display currently total set point setting from DR21 on the main display (DR34) and the SecureDisplay for 5 seconds.	
725	Display deviation set point/actual value	Display current difference between set point and actual value	
726	Display mean value	Display current mean value (from DR39)	
727	Display standard deviation	Display standard deviation (from DR39)	
728	Display number of weighings	Display current number of weighings (from DR39)	
771	Display Totalizer 1	Display Totalizer 1 from DR30	
772	Display Totalizer 2	Display Totalizer 2 from DR30	
773	Display summation 3	Display summation 3 (total in SWT operating mode)	
801	Display Current Restriction Code	Display restriction code set in DR3 on the main display (DR34) and the SecureDisplay for 5 seconds (command only relevant for scales requiring official calibration).	
802	Display weighing range information	Show weighing range information (min, max, resolution) in SecureDisplay for 10 seconds (command only relevant for scales requiring official calibration).	
860	Hide SecureDisplay	Places SecureDisplay in the background of the HMI (command only relevant for scales requiring official calibration).	
861	SecureDisplay position 1	Shows the SecureDisplay on the HMI in position 1 (see DisplayCali.xml).	
862	SecureDisplay position 2	Shows the SecureDisplay on the HMI in position 2 (see DisplayCali.xml).	
863	SecureDisplay position 3	Shows the SecureDisplay on the HMI in position 3 (see DisplayCali.xml).	
864	SecureDisplay position 4	Shows the SecureDisplay on the HMI in position 4 (see DisplayCali.xml).	
865	SecureDisplay position 5	Shows the SecureDisplay on the HMI in position 5 (see DisplayCali.xml).	
869	Close SecureDisplay	The command completely closes the SecureDisplay application. SecureDisplay must restarted in this case with a script call in the HMI/PC.	
870	Smallest SecureDisplay	Shows the SecureDisplay on the HMI with the smallest zoom factor (see DisplayCali.xml).	
871	Display serial number of the electronic weighing system	Display serial number of the electronic weighing system and in the SecureDisplay for 5 seconds.	
875	Display firmware version of the electronic weighing system	Display firmware version and checksums of the electronic weighing system in the main display (serial number only) and the SecureDisplay for 5 seconds.	
876	Display SecureDisplay Software Version	Display version of SecureDisplay in the main display and the SecureDisplay for 5 seconds.	
881	Show first log book entry	Shows the first log book entry in SecureDisplay (command only relevant for scales requiring official calibration).	

Command code	Command	Description	Write protection
882	Display last log book entry	Shows the last log book entry in SecureDisplay (command only relevant for scales requiring official calibration).	
883	Previous log book entry	Show the previous log book entry in SecureDisplay (command only relevant for scales requiring official calibration).	
884	Next log book entry	Show the next log book entry in SecureDisplay (command only relevant for scales requiring official calibration).	
891	Display protocol	Displays the last requested protocol from DR46 in a legal-for-trade manner in SecureDisplay.	

Table 2-1326 Scale commands

Command code	Command	Description	Write protection
1001	Zero	Set to zero (semi-automatic)	
1011	Tare	Taring (semi-automatic)	
1012	Delete Tare	Delete current tare weight	
1013	Activate Preset Tare	Preset tare value from DR15 is applied.	
1016	Active preset tare from SIMATIC controller	The preset tare is taken from the cyclic SIMATIC interface.	

Table 2-1327 Weighing commands

Command code	Command	Description	Write protection
1101	Start single weighing	Starts an individual dosing cycle.	
1103	Start continuous mode	Starts n dosing cycles in continuous succession Continuous operation ends automatically if a total set point (DR21) was specified and reached or alternatively using the "Stop continuous mode (1123)" command. If a dosing cycle is still active, it is completed. The "Abort weighing (1124)" command also ends continuous operation but does not terminate an active dosing cycle. The "Continuous mode active" bit in the AWI status (DR30) indicates whether or not the electronic weighing system is operating in continuous mode.	
1121	Stop weighing cycle	Current weighing cycle is stopped and the "Weighing cycle stopped" bit is set in the AWI status (DR30). The "Continue weighing (1141)" command can be used to continue and thus complete the cycle from this status.	
1122	Activate check stop	If check stop points have been defined (see section Check stop [checkStopAfterStep0 to checkStopAfterStep7] (Page 105)), these are activated by "Activate check stop" and the weighing cycle stops at the specified points.	
1123	Stop continuous mode	Continuous operation is stopped. If the command is issued within a weighing cycle, this weighing cycle is first completed, and the electronic weighing system then waits in weighing step 0. The "Continuous mode active" bit in the AWI status (DR30) is reset.	
1124	Abort weighing cycle	The current dosing cycle is directly aborted, and the electronic weighing system jumps immediately to weighing step 0.	

Command code	Command	Description	Write protection
1125	Rest weighing	The command can be issued within the weighing cycle or outside of it (=weighing step 0). Any active coarse or fine signal is directly reset, a tolerance check is performed, a log print is created and – if configured in DR25 –the scale is emptied. The electronic weighing system then waits in weighing step 0. In DTI mode, the command shuts down the dosing signals and starts the emptying process. The material in the scale is still totaled. Loading is then stopped and totalizer 1 is written to the alibi memory. When the weight in the scale at the time of the rest emptying command is less than the emptying limit from DR06, emptying takes place based on time. To do this, specify a corresponding "Discharge time (s)" in DR25.	
1126	Manual emptying ON	The command can be issued only in weighing step 0. The "Emptying signal" bit is then set to TRUE and a linked digital output, if any, is set. The command is used to clean the scale or to open it manually for service.	
1127	Manual emptying OFF	The command can be issued only in weighing step 0. The "Emptying signal" bit is then set to FALSE and a linked digital output, if any, is reset. The command is used to clean the scale or to close it manually after service.	
1128	Rest emptying	The command can only be accepted if an emptying option (emptying based on Limit 3 or time) is configured in DR25. Within a weighing cycle, the command causes the coarse and fine signal to be shut off immediately and the scale jumps directly to the emptying step. A log is not created and a tolerance check is not performed. If the command is issued outside the dosing cycle (in weighing step 0), the emptying signal is set for the specified time – if time-based emptying was configured in DR25. When "Emptying based on limit 3" is configured, the emptying signal is switched until limit 3 is fallen below. In DTI mode, the command shuts down the dosing signals and starts the emptying process. Loading is then stopped. When the weight in the scale at the time of the rest emptying command is less than the emptying limit from DR06, emptying takes place based on time. To do this, specify a corresponding "Emptying time" in DR25.	
1129	Semi-automatic emptying	The scale empties based on the setting from DR25.	
1130	Depleting ON	The command is only relevant for DTI mode. Active "depleting" has the result that a set total set point in DR21 is ignored and loading continues until there is no more material or loading is completed with the "Reset weighing" command.	
1131	Depleting OFF	Switch off active "depleting".	
1135	Jogging "FINE"	The fine signal is switched on for the specified pulse duration (DR22). The command is only accepted in stopped weighing cycle or in weighing step 0.	
1136	Jogging "COARSE"	The coarse signal is switched on for the specified pulse duration (DR22). The command is only accepted in stopped weighing cycle or in weighing step 0.	
1141	Continue weighing	If a dosing cycle is in the "stopped" state or in NAWI mode before a protocol is created, you can continue the dosing cycle using this command.	
1151	External blocking time ON	Enables the external blocking time set in DR23.	
1152	External blocking time OFF	Prematurely ends the external blocking time that is set in DR23 and activated with command 1151.	

Command code	Command	Description	Write protection
1153	Perform tolerance check	Enables check weighing for current weighing cycle The command is only relevant if the weighing cycle is not checked (GFI weighing operating mode).	
1156	Start "Speed" learning mode	The command is only available in the operating mode "Automatic checkweigher - dynamic" and only functions in case at least one light barrier was parameterized in DR7. Furthermore the correct product length of the test object used must be specified in DR14. If this is the case, the command must be executed with running belts and the test object must be transported several times over the scale. The calculated speed can be viewed in DR37. The learning mode is terminated by executing command 1159 and the calculated speed is copied automatically to data record 17.	
1157	Start "Signal filter" learning mode	The command is only available in the "Automatic checkweigher - dynamic" operating mode. In as far as the data records 14 and 17 are parameterized correctly and the scale was adjusted correctly, the command can be executed and a test object be transported several times over the scale. In the meantime the weighing electronics automatically determines the optimum filter settings, which can be viewed live in data record 37. The learning mode is terminated by executing command 1159 and the calculated filter settings are copied automatically into data record 14 to the other product parameters.	
1158	Start "Lifting correction" learning mode	The command is only available in the "Automatic checkweigher - dynamic" operating mode. In as far as the correct signal filters have already been determined, the command can be executed and a test object be transported several times over the scale. In the meantime the result of a measurement is checked against the setpoint value and a corresponding correction factor is determined. The calculated factor can be viewed in DR37. This function is only required for fast transport speeds and light test objects.	
1159	Apply learning data	The command is used as completion of the commands 1156 to 1158, provided that they could be performed without problems. The command leads to an application of the learned parameters from data record 37 to data record 14 or 17.	
1160	Abort learning mode	If an error occurred during the commands 1156 to 1158, the learning mode can be aborted by means of command 1160. In the process the learned data in data record 37 is rejected and not applied to the data records 14 or 17.	

See also

Tare device [subtractiveAdditiveTare] (Page 61)

6.37.3 Command groups of the electronic weighing system

You can execute the following commands: See also section: Executing commands (Page 42).

Command code	Description
1 ... 1999	The meanings of the commands correspond to the command list (see → Commands (Page 121)).
2000 + X	Reading/writing data records (Page 46)
4000 + X	Reading/writing data records (Page 46)
7001	Read all data records (7001) Read all data records from the electronic weighing system into the SIMATIC controller.
7002	Write all data records (7002) Write all data records from the SIMATIC controller into the electronic weighing system. **Requirement**: "Service mode On"

Additional information on transmission of commands from the control software by means of the SIMATIC interface is available in section TIA Portal user program (Page 37).

6.38 Communication via Modbus

6.38.1 Introduction

NOTICE
Low degree of protection against unauthorized access If you activate the Modbus interface, you reduce protection against unauthorized access to functions and data of the electronic weighing system from outside and via the internal network. • Observe the Cybersecurity information (Page 11).

You can exchange the current process values and parameters via Ethernet with Modbus TCP/IP. You can find the Modbus address in the parameter table (https://support.industry.siemens.com/cs/ww/en/ps/7MH4138-6BA00-0CU0/dl) on the Internet. See also section: Introduction (Page 36).

The following chapters describe the specifications for handling communication. You can perform the following functions:

- Export parameters from the electronic weighing system
- Write parameters
- Export current process values
- Monitor messages

6.38.2 Principle of data transmission

This description is valid for communication via Modbus TCP/IP.

The standardized Modbus protocol is used for communication. The connected communication partner always has the master function, while the electronic weighing system is always the slave.

Data transfer is bidirectional. The connected electronic weighing system always has the master function. The master function "controls" the communication with corresponding requests to the respective electronic weighing system address (request). The electronic weighing system is always the slave and responds to the requests of the master with a response frame, provided that the address matches.

Service	Selection code	Meaning
Read Holding Registers	03	Read one or more 16-bit parameter registers
Write Single Register	06	Write a single parameter register
Write Multiple Registers	16	Write multiple registers

If a request of the master is answered by the electronic weighing system (slave), the electronic weighing system sends a response frame with or without errors. In the case of a response without error message, the response frame contains the received selection code; in the case of errors, the highest bit of the selection code is set. This corresponds to the Modbus standard. Afterwards, the master requests DR32 to check which process-related data or command errors exist.

6.38.3 Data record concept

The register assignment is an image of the data records. The chapter → Parameter assignment/addressing (Page 36) describes the data records, variables and functions, including the register addresses. The data records are always checked as complete data packets for plausibility. For this reason, you must follow a specific procedure to change individual parameters.

6.38.4 Command mailboxes

Corresponding command codes must be sent in order to start commands and to read and write data records in the Modbus buffer memories. These are described in more detail in section → Commands (Page 120). The following tables list the Modbus registers used to process these commands:

Table 2-1328 Command mailbox 1: Highest priority

Variable	Note	Type	Modbus registers
CMD1_CODE	Code of command to be executed	USHORT	910
CMD1_TRIGGER	Trigger for starting the command	USHORT	911
CMD1_STATUS	0=job running; 1=job finished (1 cycle)	USHORT	912
CMD1_QUIT	0=no error; <>0=error code	USHORT	913

Table 2-1329 Command mailbox 2: Average priority

Variable	Note	Type	Modbus registers
CMD2_CODE	Code of command to be executed	USHORT	920
CMD2_TRIGGER	Trigger for starting the command	USHORT	921
CMD2_STATUS	0=job running; 1=job finished (1 cycle)	USHORT	922
CMD2_QUIT	0=no error; <>0=error code	USHORT	923

Table 2-1330 Command mailbox 3: Low priority

Variable	Note	Type	Modbus registers
CMD3_CODE	Code of command to be executed	USHORT	930
CMD3_TRIGGER	Trigger for starting the command	USHORT	931
CMD3_STATUS	0=job running; 1=job finished (1 cycle)	USHORT	932
CMD3_QUIT	0=no error; <>0=error code	USHORT	933

6.38.5 Reading registers

The method for reading registers depends on whether they belong to the writable data records (DR03 to DR29) or can only be read as current values (DR30 to DR39).

If you wish to read the registers from the data records DR03 to DR29, you must first export these as a complete data record to the internal output buffer.

All Modbus registers of the individual parameters can be found in section → Parameter table (https://support.industry.siemens.com/cs/ww/en/ps/17781/dl).

Example

A parameter is to be read from DR03.

- First, write register CMD3_CODE with 2003 (2000 plus the number of the data record = read data record).
- Then write CMD3_TRIGGER with "1". The DR 3 is then updated in the Modbus buffer memory.
- It is now possible to read one or more registers with the corresponding variable(s). The data consistency of the registers read at this time is guaranteed.

You can find all other command codes in section → Commands (Page 121).

Example

A current measured value is to be read out from DR30.

⇒ The register can be directly requested because its contents are automatically refreshed in the electronic weighing system at the specified measuring rate of 1000 Hz and are always available up-to-date.

6.38.6 Writing registers

If you wish to write registers from the data records DR03 to DR29, you must first export the corresponding data record to the internal output buffer using an appropriate command. Individual registers can then be written. The complete data record must subsequently be written internally using an appropriate command. A plausibility check of the complete data record is carried out in the process.

Example

A parameter from DR03 is to be written.

- First, write register CMD3_CODE with 2003 (2000 plus the number of the data record).
- Then write CMD3_TRIGGER with "1". The DR03 is then updated in the Modbus memory.
- It is now possible to write or modify one or more registers with the corresponding variable. If you want to transfer the written/changed register to the scale, you need to write the entire data record:
- First, write register CMD3_CODE with 4003 (4000 plus the number of the data record = write data record).
- Then write CMD3_TRIGGER with "1".
- The data record is then transferred to the process memory in the electronic weighing system. All registers of the data record are checked for plausibility in the process.

If the plausibility check fails, the complete data record is not written and a message is output to the user (from the area of data/operator errors).

You can find all other command codes in section → Commands (Page 120).

A document for working with the electronic weighing system and Modbus is also available online →Modbus communication of WP231 (https://support.industry.siemens.com/cs/ww/en/view/77913998).

Operation requiring official calibration 7

7.1 Prepare calibration of the scales

Introduction

This section describes the requirements for operation requiring calibration and how to prepare the scale verification.

The official verification officer will check, for example, the scales design and calibration-relevant parameters with the help of the prototype test certificate of the electronic weighing system.

For scales requiring official calibration, the following weighing modes (Page 50) of the electronic weighing system are permitted:

- NAWI - Non automatic weighing instrument - in accordance with OIML R-76
- CWI - Catchweighing instrument in acc. with OIML R-51
- GFI - Gravimetric filling instrument in acc. with OIML R-61
- DTI - Discontinuous totalizing automatic weighing instruments in acc. with OIML R-107
- CW - Automatic check weigher in acc. with OIML R-51

Requirements

- You have coordinated the scales type with the conformity assessment body.
- You have a certificate of conformity which confirms that the load cell in combination with the electronic weighing system meets the customer and legal requirements.
- You have ordered the calibration set (Page 168) and it is available. The calibration set contains the labeling foil for the ID labels, the protective foil and the unlock protection.
- You have printed the ID labels for the scales and the calibratable main display on the labeling foil.
  Templates ID labels (https://support.industry.siemens.com/cs/ww/en/view/109764526)
- You have commissioned the scales.
- You have installed SIMATIC HMI or the computer so that it is visible from the scales.

Procedure

1. Install and parameterize SIWAREX SecureDisplay for SIMATIC HMI.

   Use the SIWAREX SecureDisplay software to convert your SIMATIC HMI or computer into the calibratable main display of the scales.

   SIWAREX SecureDisplay software and description (https://support.industry.siemens.com/cs/ww/de/view/109477602)

2. Integrate the WP351 example project in your SIMATIC HMI project.

   - Or -

   Create your own visualization.

   – When you create your own visualization, take the "legal-for-trade verification" completely from the example project.

   – Document for the user how to reach the parameters and functions on the ready-for-trade main display.

3. Parameterize the scales.
4. Remove the electronic weighing system of the BaseUnit.
5. Push the write protection switch on the rear of the electronic weighing system to ON.

   View (Page 13)

   The electronic weighing system is protected against changes to parameters for operation requiring official calibration. Parameters that are not write protected can still be changed.

6. Place the electronic weighing system on the BaseUnit.
7. Hold the unlock protection in such a way that the recesses for the three fastening screws face upwards.
8. Guide the connecting cables from the top through the cable glands of the unlock protection.

9. Place the unlock protection on the BaseUnit in such a way that the top end of the unlock protection is placed in the housing of the electronic weighing system.

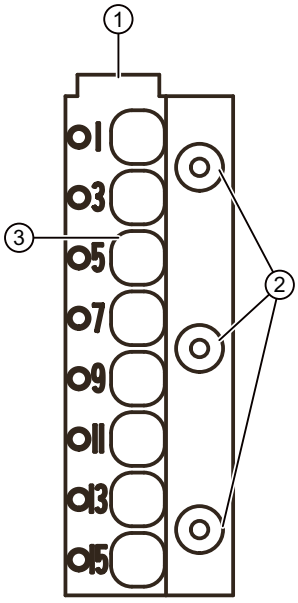

① Top end for inserting in the electronic weighing system

② Recesses for the fastening screws

③ Cable routing

Figure 2-1186 Secure the unlock protection

10. Secure the unlock protection with three fastening screws.

    The electronic weighing system can no longer be removed from the BaseUnit.

    The connecting cables of the electronic weighing system, load cells or terminal boxes can no longer be removed.

7.2 Checking parameters relevant to the calibration

Introduction

Verification of the scale according to Modul F of the corresponding directive by the conformity assessment table involves the following procedure.

Procedure

1. Check the following parameters in the legal-for-trade main display in the "legal-for-trade verification" view.
   - The **software ID** of the SIWAREX SecureDisplay (DisplayCali.exe function) corresponds to the requirements in the SIWAREX SecureDisplay test certificate (EC).
   - The **firmware ID** of the SIWAREX WP351 corresponds to the requirements in the EU construction license/type examination certificate.

- The **smallest zoom factor** meets the minimum requirement of readability and font size according to EN 45501: 2011 draft, section 4.2.1.
- **Logbook entries** for FW downloads of SIWAREX SecureDisplay or firmware of the electronic weighing system
- The **serial number** of the electronic weighing system corresponds to the identification labels.
- The **regulation code** "OIML" is set in the scale parameters.
- The **write protection symbol** is shown at the bottom right.

2. Check the Identification labels.
3. If you use an additive tare range, check the entire weighing range from the maximum load to the additive maximum tare load.
   - To do this, check up to the maximum load, and repeat this following taring.
   - Repeat this procedure until the upper limit of the range of the additive tare compensation unit has been reached.

Service and maintenance 8

NOTE

The device is maintenance-free.

8.1 Disposal

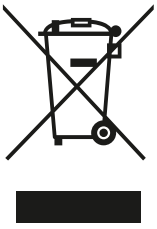

Devices described in this manual should be recycled. They may not be disposed of in the municipal waste disposal services according to the Directive 2012/19/EC on waste electronic and electrical equipment (WEEE).

Devices can be returned to the supplier within the EC, or to a locally approved disposal service for eco-friendly recycling. Observe the specific regulations valid in your country.

Further information about devices containing batteries can be found at: Information on battery/product return (WEEE) (https://support.industry.siemens.com/cs/document/109479891/)

NOTE

Special disposal required

The device includes components that require special disposal.

- Dispose of the device properly and environmentally through a local waste disposal contractor.

Interrupts/diagnostic messages 9

9.1 Message and error types

Three types are distinguished:

Operating errors

Operating errors can occur spontaneously at any time due to an unforeseen event. They include internal and external hardware problems which can occur spontaneously during weighing, e.g. wire break of the load cell cable.

Data and command errors

Data and command errors arise always as response to a command or a data record transfer.

A data error occurs when a plausibility error is identified in a data record sent to the electronic weighing system, causing the electronic weighing system to refuse acceptance of the data record.

A command error occurs when the electronic weighing system cannot execute the issued command in its current operating state.

For most data/command errors, the electronic weighing system outputs additional information for the error. This includes further details about the error and is described in detail in the error list in this section.

Technology messages

Technology messages occur spontaneously due to the process flow of a weighing/dosing operation. Messages provide information to the operator and have no further effect on the dosing operation.

In the event of an error, the error data record DR32 is read automatically from the WP351 FB into the CPU. Data and operating errors as well as technology messages remain set to "true" in DR32 for 3 seconds in each case. Operating errors remain until the error is resolved. It is not necessary to acknowledge the messages to the electronic weighing system.

9.2 Evaluating errors/messages using the Web server

The electronic weighing system has a message buffer that stores the last 100 entries including time stamp in non-volatile memory. If the number of messages in the message buffer exceeds 100, the oldest entry is overwritten. The message buffer can be read out at any time using the Web server (menu item "Read out all data records") and saved together with the scale parameters. This facilitates the detection, analysis and correction of errors in the system. The only way to completely clear the message buffer is with the "Load factory settings (11)" command. The message buffer is opened in the web server via the following icon:

9.3 Evaluating errors/messages using the FB

In the event of an error, the function block reads out DR32 automatically. Data/operating errors and technology messages are reported for 3 s. Operating errors remain permanently until the cause is resolved.

9.4 Operating errors

9.4.1 Operating errors

Operating errors	Error code	Description and remedy
1000 operating error exists	1000	Group message, there is at least one operating error.
1001 Watchdog	1001	Watchdog error. A serious error has occurred in the function of the electronic weighing system. Contact SIWAREX Support if the error continues to occur.
1003 Checksum error (parameters)	1003	The checksum of the parameters no longer matches. Remedy: Load factory settings. Contact SIWAREX Support if the error continues to occur.
1004 checksum error (firmware)	1004	The checksum of the electronic weighing system FW no longer matches. Remedy: Load factory settings. Contact SIWAREX Support if the error continues to occur.
1006 Log book full or defective	1006	Error when writing/clearing the logbook. Remedy: Load factory settings. Contact SIWAREX Support if the error continues to occur.
1008 Connection to S7 CPU interrupted	1008	Communication with S7 CPU not possible even though S7 bus controller (PER) power supply is present (=> incompatible SW versions (BTF only on K61 side, for S7 message, see below under S7 diagnostic alarms)
1102 ADC error	1102	AD converter error when reading the measured value. Remedy: Check and follow recommendations for installation meeting EMC requirements (section EMC-compliant installation (Page 18)).
1104 SENSE voltage too low	1104	Undervoltage on the SENSE cables. A voltage between 4.85 V DC and 10 V DC must be present between SEN+ and SEN-. If necessary, check the wiring of the load cells or, in the case of 4-wire load cells, the wire jumpers between EXC+&SEN+ and EXC-&SEN- in the terminal box.
1105 SIG voltage too high (load high)	1105	The maximum SIG input signal of the AD converter has been exceeded by more than 10%. Check the wiring of the load cell(s). If the wiring is correct, check the input and output resistances of the load cells. By checking the resistors, you can find out whether one or more load cells are defective.
1106 SIG voltage too low (load low)	1106	The minimum SIG input signal of the AD converter has been undershot by more than 10%. Check the wiring of the load cell(s). If the wiring is correct, check the input and output resistances of the load cells. By checking the resistors, you can find out whether one or more load cells are defective.

Operating errors	Error code	Description and remedy
1107 SecureDisplay failure	1107	The calibratable main display (SIWAREX SecureDisplay on SIMATIC HMI) no longer communicates with the electronic weighing system • Check the wiring between the SIMATIC HMI and the CPU or the electronic weighing system and the SIMATIC controller. • Check the IP addresses of the network components
1110 No communication to the digital load cell or SIWAREX DB	1110	Communication to the digital load cell or digital junction box SIWAREX DB is interrupted. Check the following: Wiring SIWAREX DB <-> SIWAREX WP Terminators and address of SIWAREX DB (see operating instructions of SIWAREX DB) Communication speed in DR10
1111 DQ short-circuit to ground	1111	Error at digital outputs (short-circuit to ground)
1201 Underload load cell input 1	1201	SIWAREX DB –The minimum input signal of load cell input 1 has been undershot. Check the wiring and the load cell.
1211 Underload load cell input 2	1211	SIWAREX DB –The minimum input signal of load cell input 2 has been undershot. Check the wiring and the load cell.
1221 Underload load cell input 3	1221	SIWAREX DB –The minimum input signal of load cell input 3 has been undershot. Check the wiring and the load cell.
1231 Underload load cell input 4	1231	SIWAREX DB –The minimum input signal of load cell input 4 has been undershot. Check the wiring and the load cell.
1202 Overload load cell input 1	1202	SIWAREX DB –The maximum input signal of load cell input 1 has been exceeded. Check the wiring and the load cell.
1212 Overload load cell input 2	1212	SIWAREX DB –The maximum input signal of load cell input 2 has been exceeded. Check the wiring and the load cell.
1222 Overload load cell input 3	1222	SIWAREX DB –The maximum input signal of load cell input 3 has been exceeded. Check the wiring and the load cell.
1232 Overload load cell input 4	1232	SIWAREX DB –The maximum input signal of load cell input 4 has been exceeded. Check the wiring and the load cell.
1203 Error SENSE voltage load cell input 1	1203	SIWAREX DB –The minimum permissible sense voltage of load cell input 1 has been undershot. Check the wiring and the load cell.
1213 Error SENSE voltage load cell input 2	1213	SIWAREX DB –The minimum permissible sense voltage of load cell input 2 has been undershot. Check the wiring and the load cell.
1223 Error SENSE voltage load cell input 3	1223	SIWAREX DB – The minimum permissible sense voltage of load cell input 3 has been undershot. Check the wiring and the load cell.
1233 Error SENSE voltage load cell input 4	1233	SIWAREX DB – The minimum permissible sense voltage of load cell input 4 has been undershot. Check the wiring and the load cell.
1204 Impedance error load cell input 1	1204	SIWAREX DB – The impedance at load cell input 1 lies outside the permitted range (< 330 Ohm or > 4100 Ohm)
1214 Impedance error load cell input 2	1214	SIWAREX DB – The impedance at load cell input 2 lies outside the permitted range (< 330 Ohm or > 4100 Ohm)
1224 Impedance error load cell input 3	1224	SIWAREX DB – The impedance at load cell input 3 lies outside the permitted range (< 330 Ohm or > 4100 Ohm)
1234 Impedance error load cell input 4	1234	SIWAREX DB – The impedance at load cell input 4 lies outside the permitted range (< 330 Ohm or > 4100 Ohm)
1205 EXC short circuit load cell input 1	1205	SIWAREX DB – Short circuit on load cell supply (excitation) at load cell input 1. Check the wiring and the load cell.

Operating errors	Error code	Description and remedy
1215 EXC short circuit load cell input 2	1215	SIWAREX DB – Short circuit on load cell supply (excitation) at load cell input 2. Check the wiring and the load cell.
1225 EXC short circuit load cell input 3	1225	SIWAREX DB – Short circuit on load cell supply (excitation) at load cell input 3. Check the wiring and the load cell.
1235 EXC short circuit load cell input 4	1235	SIWAREX DB – Short circuit on load cell supply (excitation) at load cell input 4. Check the wiring and the load cell.
1206 Error power supply load cell input 1	1206	SIWAREX DB – Error at power supply of load cell input 1
1216 Error power supply load cell input 2	1216	SIWAREX DB – Error at the power supply of load cell input 2
1226 Error power supply load cell input 3	1226	SIWAREX DB – Error on the power supply of load cell input 3
1236 Error power supply load cell input 4	1236	SIWAREX DB – Error on the power supply of load cell input 4
1250 Check sum error SIWAREX DB	1250	SIWAREX DB – Check sum error. If restarting the SIWAREX DB does not solve the problem, please contact the SIWAREX hotline.
1251 Watchdog error SIWAREX DB	1251	SIWAREX DB – Watchdog error. If restarting the SIWAREX DB does not solve the problem, please contact the SIWAREX hotline.
1252 ADC error SIWAREX DB	1252	SIWAREX DB – AD converter error. If restarting the SIWAREX DB does not solve the problem, please contact the SIWAREX hotline.
1254 FW update error SIWAREX DB	1254	SIWAREX DB – Firmware update failed

9.4.2 Technology messages

Table 2-1331 Technology messages

Technology messages	Error code	Description and remedy
2000 Technological error	2000	Group message, at least one technology message is present
2001 Timeout waiting for stability	2001	Taring, zero setting, post dosing or check weighing was not possible because stability was not reached during the stability waiting time. Check the stability criteria and the stability waiting time in DR03 and adjust the parameters as necessary. Check the scale mechanics for strong fluctuations / disturbances that prevent stability.
2002 Trace error	2002	The set recording cycle for tracing cannot be processed. Set a slower recording rate (Page 73) in DR07.
2003 Initial zero setting (Page 60) not possible	2003	The weight of the initial zero setting is out of range.
2004 Trace memory full	2004	The trace recording has been aborted because the internal trace memory is full.
Reboot after voltage recovery	2005	Diagnostic message for regular restart.
Download error	2006	A FW update was aborted or rejected, e.g. because a FW update is already running or communication with the S7 controller was interrupted.
2007 firmware file invalid	2007	FW update file (*.upd) was rejected because it is invalid. The FW update file is not suitable for the electronic weighing system or is defective, e.g. implausible length, structure, checksum or signature.

Technology messages	Error code	Description and remedy
2101 Risk of overfilling	2101	Current parameter assignment would lead to overfilling of the scale during dosing. • Check the specified set point in DR20 or the limits for taring / zero setting in DR03 and DR25.
2102 Coarse shut-off point already exceeded	2102	The current weight is already above the coarse shut-off point. Remedy: Adjust set point or empty scale.
2103 No stability	2103	Required stability not present the dosing process.
2104 CPU in Stop	2104	The electronic weighing system is not in stand-alone mode, the SIMATIC CPU is in STOP state and a dosing command has been issued. Remedy: Put the SIMATIC CPU in RUN state or activate the stand-alone mode of the electronic weighing system. **CAUTION:** Ensure the safety of the system before activating stand-alone mode because the electronic weighing system activates dosing elements, if necessary, despite the stopped SIMATIC CPU.
2105 Set point too small	2105	The currently specified set point is too small. Remedy: Check the set point setting in DR20.
2106 Error fine weight	2106	Trailing weight (DR23) and single set point (DR20) are incompatible. Check the two entries.
2107 Stop after tolerance error	2107	The weighing cycle was stopped due to a tolerance error according to the parameter assignment in DR22.
2108 Emptying parameter not plausible	2108	The emptying parameter assignment set in DR25 stops the weighing cycle. 1. Adjust the parameter assignment during the stopped cycle. 2. Conclude the weighing cycle with the "Continue weighing (1141)" command.
2109 Inhibition time violation "Coarse"	2109	After expiration of the blocking time coarse signal (DR23), the coarse shut-off point has already been exceeded. Remedy: Decrease the blocking time coarse signal in DR23.
2110 Inhibition time violation "Fine"	2110	After expiration of the blocking time fine signal (DR23), the fine shut-off point has already been exceeded. Remedy: Decrease the blocking time fine signal in DR23.
2111 Maximum weighing time exceeded	2111	The maximum weighing time specified in DR25 was exceeded.
2112 Logging not possible - no standstill	2112	The conditions required for automatic logging (e.g. stability) were not present at the time of the log print. Remedy: Check the stability criteria in DR03 and adapt them as necessary.
2113 Maximum emptying time exceeded	2113	The maximum emptying time configured in DR25 was exceeded during emptying. Remedy: Check the scale mechanics and any soiling. Adjust the maximum emptying time in DR25.
2114 Maximum corrective action of the proportional controller exceeded	2114	The corrective action of the proportional controller was greater than the maximum corrective action configured in DR24.
2115 Log error	2115	Error while reading a log in DR46.
2116 Set point too large	2116	The set point specified in DR20 is greater than the residual quantity on the scale (removal mode). Weighing can still be carried out using the "Continue weighing" and subsequent "Rest weighing" commands!
2117 Maximum corrective action of the fine signal time controller exceeded	2117	The maximum control access of the fine time controller was greater than the maximum corrective action configured in DR24.

Technology messages	Error code	Description and remedy
2118 Minimum fine weight reached	2118	Fine signal time controller cannot move the coarse flow shut-off point any further because the set coarse trailing weight would otherwise be undershot.
2119 Controller re-initialized	2119	Due to two successive disabling time violations, the controller with the start values from DR23 was re-initialized.
2120 Weight too small for totalizing	2120	The currently loaded / dosed material weighs less than the minimum weight and is not logged automatically. • Log the material with the "Rest weighing (1125)" command. Result: Loading is stopped and total T1 is logged.
2121 Autom. Tare/Zeroing not possible	2121	Weighing was canceled because automatic tare or zeroing was not possible. Check the zeroing limits and tare limits in DR03 and DR25.
2122 Inhibition time "extra coarse" error	2122	Inhibition time extra course. After expiration of the inhibition time extra coarse, the extra coarse shut-off point was already exceeded
2123 Extra coarse shut-off point already exceeded	2123	The extra coarse shut-off point is already exceeded before switching on the extra coarse signal
2096 Restore point set	2096	A recovery point was successfully set.
2094 Backup/snapshot set	2094	Backup/snapshot was successfully set.
2095 Backup loaded	2095	Backup (or default values, if no backup) has been successfully loaded.
2097 Restore point loaded	2097	A recovery point was successfully loaded.
2098 Standard parameters loaded	2098	The standard parameters were successfully loaded.
2099 Factory settings loaded	2099	The factory settings were successfully loaded.
2126 Please recalibrate the scale	2126	Please perform a zero and span calibration again, since a new corner load adjustment has been performed in the meantime.

9.4.3 Data and command errors

Table 2-1332 Data and command errors

Data and command errors	Error code [errorCode]	Add info [errorAddInfo]	Description
5000 Data/command errors	5000	-	Group error, at least one data/operating error present
6050 Unknown command	6050	-	Issued command code is unknown. Check the command code.
6051 Command not possible now	6051	-	The desired command could not be executed because, for example, another process is already active at this time. Additional information contains details.
		9500	Fault present
		9501	No stability
		9502	Waiting for stability
		9507	Dosing active
		9514	CPU is missing or not ready
		9541	Emptying active

Data and command errors	Error code [errorCode]	Add info [errorAddInfo]	Description
		9680	SecureDisplay is missing or not visible
		9681	Display command does not match the current display content of SecureDisplay
6052 Service command error	6052		Commands from the Service commands group could not be executed. Additional information contains details.
		9510	Service mode not active
		9511	Write protection enabled
		9507	Dosing active
		9512	Missing enable
		9522	Calibration not yet complete
6053 Calibration command error	6053		Command from the Calibration commands group could not be executed. Additional information contains details.
		9510	Service mode not active
		9511	Write protection enabled
		9520	Increment between calibration digits too small
		9521	Sequence of calibration points is not correct
		9522	Calibration not yet complete
		9523	Calibration digits out of valid range
		9524	Calibration weight is 0
		9527	Command not permitted in simulation mode
		9519	No test operation
6054 Scale command error	6054		Command from the Scale commands group (Zero, Tare, etc.) could not be executed. Additional information contains details.
		9500	Fault present
		9501	No stability
		9502	Waiting for stability
		9507	Dosing active
		9515	Not permitted in this weighing operating mode
		9530	Current weight is out of defined tare weight range
		9531	Current weight is out of defined zero setting range
6055 Weighing command error	6055		Command from the Weighing commands group (Start single weighing, Start continuous mode, etc.) could not be executed. Additional information contains details.
		9500	Fault present
		9501	No stability
		9502	Waiting for stability
		9508	Dosing is not active
		9509	Time not permitted within dosing

Data and command errors	Error code [errorCode]	Add info [errorAddInfo]	Description
		9513	Service mode is still active
		9515	Not possible in this weighing operating mode
		9539	Total set point already reached
		9540	Current weight is already above fine shut-off point
		9542	Set point too small
		9543	Set point too large
		9544	Tolerance limits implausible
		9545	Relation between fine/trailing weight and set point does not fit
		9546	Dosing would result in overfilling
		9547	Automatic emptying settings (DR25) are not plausible
		9548	No check stop defined
		9549	Scale is already empty
		9555	Jogging time is set to 0 in DR22
6056 Error trace/ protocol/ logging command	6056		Trace, logging or logbook command was rejected. Additional information contains details.
		9500	Fault present
		9501	No stability
		9502	Waiting for stability
		9511	Write protection enabled
		9532	Current weight is out of defined weighing range
		9533	Total too small
		9550	Trace memory full
		9551	Protocol memory full
		9552	Logging task is busy
		9553	Weight did not change since last logging
		9554	Logbook contains no entries
7050 Unknown data record	7050	-	Requested data record is unknown.
7051 Parameter input not possible now	7051		A parameter input is currently not possible. Additional information contains details.
		9507	Dosing active
		9510	Service mode is not active
		9511	Write protection enabled
7052 Parameter is write protected and cannot be changed	7052		A parameter input is currently not possible due to active write protection. Additional information contains details about the parameter involved.

Data and command errors	Error code [errorCode]	Add info [errorAd-dInfo]	Description
		Parameter ID	Parameter ID of the parameter involved
7053 Error in calibration parameter DR03	7053		Additional information indicates an implausible parameter in DR 3
		Parameter ID	Parameter ID of the affected parameter in DR 3
		9510	Service mode is not active
		9520	Increment between calibration digits too small
		9521	Sequence of calibration points is not correct
		9524	Calibration weight is 0
		9525	Falling characteristic curve not allowed by OIML
		9526	Alternating calibration characteristic curve is not allowed
		9610	Weighing range max - min error
		9611	Resolution not permitted
		9613	OIML and 6000d provision violated
		9614	Zeroing or zero setting limits are not OIML-compliant
7054 Parameter error DR05	7054		Additional information indicates an implausible parameter in DR05
		Parameter ID	Parameter ID of the affected parameter in DR05
		9510	Service mode not active
		9530	Weight is outside the permissible tare weight range
		9531	Weight is outside the permissible zero setting range
7055 Parameter error DR06	7055		Additional information indicates an implausible parameter in DR06
		Parameter ID	Parameter ID of the affected parameter in DR06
7056 Parameter error DR07	7056		Additional information indicates an implausible parameter in DR07
		Parameter ID	Parameter ID of the affected parameter in DR07
		9650	DQ.0 - assignment not possible
		9651	DQ.1 - assignment not possible
		9652	DQ.2 - assignment not possible
		9653	DQ.3 - assignment not possible
7057 Parameter error DR48	7057		Additional information indicates an implausible parameter in DR48
		Parameter ID	Parameter ID of the affected parameter in DR48

Data and command errors	Error code [errorCode]	Add info [errorAddInfo]	Description
7058 Parameter error in DR11	7058		Additional information indicates an implausible parameter in DR11
		Parameter ID	Parameter ID of the affected parameter in DR11
		9510	Service mode not active
7060 Error in extended parameters DR 15 - DR 19	7060		Additional information indicates an implausible parameter in DR 15 - DR 19
		Parameter ID	Parameter ID of the affected parameter in DR 15-19
		9530	, because weight is outside the permissible tare weight range
7061 Error set point DR 20 or DR 21	7061		Additional information indicates an implausible parameter in DR20/DR21
		Parameter ID	Parameter ID of the affected parameter in DR 20/DR 21
7062 Error in dosing system parameters DR 22/DR 23	7062		Additional information indicates an implausible parameter in DR22/DR23
		Parameter ID	Parameter ID of the affected parameter in DR 22/DR 23
		9071	Parameter relation not plausible
		5914	Fine flow, coarse/fine dribbling and set point are incompatible
		9191	Fine flow is less than the coarse dribbling value
		9192	Coarse dribbling is not plausible
		9183	Filter depth material flow is too high
		9182	Minimum material flow is negative
7063 Parameter error DR 24	7063		Additional information indicates an implausible parameter in DR 24
		Parameter ID	Parameter ID of the affected parameter in DR 24
7064 Parameter error DR 25	7064		Additional information indicates an implausible parameter in DR 25
		Parameter ID	Parameter ID of the affected parameter in DR 25
		9507	Dosing active
7067 Parameter error DR 28	7067		Additional information indicates an implausible parameter in DR 28
		Parameter ID	Parameter ID of the affected parameter in DR 28
	7068		Additional information indicates an implausible parameter in DR29

Data and command errors	Error code [errorCode]	Add info [errorAddInfo]	Description
7072 Parameter error DR 45	7072		Additional information indicates an implausible parameter in DR 45
		Parameter ID	Parameter ID of the affected parameter in DR 45
	7075		Additional information indicates an implausible parameter in DR10

9.4.4 Add info [errorAddInfo] for DR03

Additional information is available for most data/command errors. The cause of the error is described in detail with this information. If a data/command error bit is set, the additional information is also filled accordingly. Thus, the error bits and the additional information must be evaluated together in the program to identify the exact cause of the error.

If additional information not listed above appears for a data/operating error bit, it is a parameter ID. This defines the exact parameter that caused the error.

The following table presents the association between the parameter and parameter ID.

Table 2-1333 Add info [errorAddInfo] for DR03

Parameter	Add info [errorAddInfo]
Scale name header	301
Scale name	302
Weight unit	303
Restriction code	304
Number of weighing ranges	305
Minimum weight weighing range 1	306
Maximum weight weighing range 1	307
Minimum weight weighing range 2	308
Maximum weight weighing range 2	309
Minimum weight weighing range 3	310
Maximum weight weighing range 3	311
Calibration weight 0	312
Calibration weight 1	313
Calibration weight 2	314
Calibration weight 3	315
Calibration weight 4	316
Calibration digits 0 (measured)	317
Calibration digits 1 (measured)	318
Calibration digits 2 (measured)	319
Calibration digits 3 (measured)	320
Calibration digits 4 (measured)	321
Scale interval weighing range 1	322

Parameter	Add info [errorAddInfo]
Scale interval weighing range 2	323
Scale interval weighing range 3	324
Scale parameters	325
Initial zero-setting	326
Initial zero-setting if tared	327
Automatic zero tracking device	328
Tare device	329
Weight simulation	330
Multi range / multi interval scale	331
Automatic zero-setting device	332
Automatic zero tracking in dosing cycle	334
Weighing range data in SecureDisplay	336
Gross indicator	337
Switch between AGFI / DTI Mode A	339
Maximum tare weight (% of max.)	359
Initial zero-setting device limit negative (% of max.)	362
Initial zero-setting device limit positive (% of max.)	363
Semi-automatic zero-setting device limit negative (% of max.)	364
Semi-automatic zero-setting device limit positive (% of max.)	365
Stability weight 1	366
Stability time 1 (s)	367
Maximum waiting time for stability 1 (s)	368
Delay time before stability 1 (s)	369
Stability weight 2	370
Stability time 2 (s)	371
Maximum waiting time for stability 2 (s)	372
Delay time before stability 2 (s)	373
Filter 1 period (s)	374
Filter 2 period (s)	375
Characteristic low pass filter	376
Ordinal number low pass filter	377
Cut-off frequency low pass filter	378
Operating mode	380
Totalization scale interval dt	381
Minimum totalized load	382
SecureDisplay interface	383
Stringheader FW-Version SecureDisplay	384

Parameter	Add info [errorAddInfo]
Version SecureDisplay	385
Smallest zoom factor of SecureDisplay (%)	386
Period of dosing filter	388

9.4.5 Add info [errorAddInfo] for DR05 and DR06

Table 2-1334 Add info [errorAddInfo] for DR05 and DR06

Parameter	Add info [errorAddInfo]
Current preset-tare weight	501
Current semi-automatic tare weight	502
Current initial zero-setting weight	504
Current semi-automatic zero-setting weight	505
Current zero tracking weight	506
Dead load (calculated)	507
Reference (limits 1 and 2)	601
Limit 1 ON value	603
Limit 1 OFF value	605
Limit 2 ON value	607
Limit 2 OFF value	609
Reference (limit 3 - empty)	611
Limit 3 - empty	613
Switch-on delay limit 3 (empty) (s)	614

9.4.6 Add info [errorAddInfo] for DR07

Table 2-1335 Add info [errorAddInfo] for DR07

Parameter	Add info [errorAddInfo]
Assignment digital input DI.0	701
Assignment digital input DI.1	702
Assignment digital input DI.2	703
Assignment CI	704
Filter DI.0 (0.1ms)	705
Filter DI.1 (0.1ms)	706
Filter DI.2 (0.1ms)	707
Filter CI (0.1ms)	708
Assignment digital output DQ.0	709
Assignment digital output DQ.1	710
Assignment digital output DQ.2	711
DQ monitoring	712

Parameter	Add info [errorAddInfo]
DQ substitute values	714
DQ.0 substitute value on error / CPU-Stop	715
DQ.1 substitute value on error / CPU-Stop	716
DQ.2 substitute value on error / CPU-Stop	717
Behavior on CPU stop / failure	723
DQ behavior on CPU stop / failure	724
DQ behavior on failure	725
Trace rate (ms)	731
Trace settings	732
Trace memory type	733
IP address x.n.n.n	755
IP address n.x.n.n	756
IP address n.n.x.n	757
IP address n.n.n.x	758
Subnetmask x.n.n.n	759
Subnetmask n.x.n.n	760
Subnetmask n.n.x.n	761
Subnetmask n.n.n.x	762
Gateway x.n.n.n	763
Gateway n.x.n.n	764
Gateway n.n.x.n	765
Gateway n.n.n.x	766
Stringheader Device Name	767
Device name	768
Unit Ident. Modbus connection 1	769
Modbus TCP Port number connection 1	770
Modbus settings connection 1	771
Enable connection	772
Byte swap for text fields	780
Byte swap for 16 bit tags	781
Byte swap for 32 bit tags (1 # 2, 3 # 4)	782
Word swap for 32 bit tags (1, 2 # 3, 4)	783
Unit Ident. Modbus connection 2	788
Modbus TCP Port number connection 2	789
Modbus settings connection 2	790
Enable connection	791
Byte swap for text fields	799
Byte swap for 16 bit tags	800
Byte swap for 32 bit tags (1 # 2, 3 # 4)	801

Parameter	Add info [errorAddInfo]
Word swap for 32 bit tags (1, 2 # 3, 4)	802
I/O process value 1	807
I/O process value 2	808
I/O process value 3	809
I/O process value 4	810
I/O process value 5	811
I/O process value 6	812
I/O process value 7	813
I/O process value 8	814
Event hardware interrupt 4	815
Event hardware interrupt 5	816
Event hardware interrupt 6	817
Event hardware interrupt 7	818
Event hardware interrupt 8	819
RS485 protocol	820
Source for weight simulation	821

9.4.7 Add info [errorAddInfo] for DR10

Table 2-1336 Add info [errorAddInfo] for DR10

Parameter	Add info [errorAddInfo]
Load cell type	1001
AD converter settings	342
Power line frequency	343
Power line filter	344
Load cell parameter	1003
Connection technology	1004
External / internal sensor supply	1005
No. of mechanical support points	1020
Averaged load cell characteristic (mV/V)	1021
Nominal load of one single load cell	1022
Impedance reference (Ohm)	1023
Maximum impedance deviation (% of impedance reference)	1024
Stringheader load cell manufacturer	1026
Load cell manufacturer	1027
Stringheader load cell order number	1028
Load cell order number	1029

9.4.8 Add info [errorAddInfo] for DR20 to DR24

Table 2-1337 Add info [errorAddInfo] for DR20 to DR24

Parameter	Add info [errorAddInfo]
Set point	2001
Total set point	2101
Maximum allowed total set point undercut	2102
Material in feed intake (pre-signal)	2103
Tolerance relation	2201
Tolerance limit TH2	2203
Tolerance limit TH1	2204
Tolerance limit TL1	2205
Tolerance limit TL2	2206
Behavior in case of TH1 error	2208
Behavior in case of TL1 error	2209
Pulse duration for pulse post dosing (s)	2211
Number of unchecked weighing cycles	2212
Capture of weighings into statistics	2213
Parameter relation	2301
Fine weight	2305
Trailing weight fine	2306
Blocking time coarse signal (s)	2307
Blocking time fine signal (s)	2308
Blocking time discharging (s)	2309
External triggered blocking time (s)	2310
Shut-off correction weight	2311
Trailing weight coarse	2312
Minimum material flow (weight/s)	2313
Coarse weight	2317
Blocking time extra coarse (s)	2318
Trailing weight extra coarse	2320
Parameter relation	2401
Type of controller	2402
Control factor of proportional controller (%)	2403
Control factor of fine time controller (%)	2404
Max. control access of proportional controller	2405
Proportional controller deadband - upper limit	2406
Proportional controller deadband - lower limit	2407
Bitfield: Controller settings	2408
Controller behavior in case of exceeding max. control access	2409

Parameter	Add info [errorAddInfo]
Intervention of fine time controller	2410
Set point fine time controller (s)	2430
Adopt corrected fine-/trailing values to DR23 automatically	2431
Max. control access of fine time controller	2433

9.4.9 Add info [errorAddInfo] for DR25 and DR28

Table 2-1338 Add info [errorAddInfo] for DR25 and DR28

Parameter	Add info [errorAddInfo]
Maximum single set point	2501
Minimum automatic tare weight (% of max.)	2502
Maximum automatic tare weight (% of max.)	2503
Maximum weighing time (s)	2504
Reserve (for continuous mode, only relevant for GFI, is now triggered via commands)	2505
Weighing start options	2506
Cycle time for automatic zero setting (s)	2507
Number of weighings without automatic taring/zero setting	2508
Bitfield: Test stops	2509
Check stop after step 0	2510
Check stop after step 1	2511
Check stop after step 2	2512
Check stop after step 3	2513
Check stop after step 4	2514
Check stop after step 5	2515
Check stop after step 6	2516
Check stop after step 7	2517
Delete tare in weighing step 0	2529
Automatic discharging	2544
Discharge time (s)	2545
Discharge overlapping time (s)	2546
Maximum discharge time (s)	2547
No. of optimized loadings (OIML R-107)	2552
Dosing signals during extra coarse phase	2554
Dosing signals during coarse phase	2555
Additional string Stringheader	2801
Additional string	2802
Protocol settings	2803
Log with additional string	2804

9.5 Diagnostic messages

9.5.1 Error codes and corrective measures

Diagnostic results are displayed as plain text in STEP 7 (TIA Portal) via the online and diagnostic message view. Evaluate the error codes by means of the user program.

Error code	Message	Cause/Remedy
9_H	No supply voltage L+	An internal error has occurred. Possible cause: Electronic weighing system faulty. • Check the wiring of the 24 V connection on the BaseUnit. • Check the 24 V supply voltage.
10_H	Short circuit (EXC +/-)	Short-circuit at the load cell supply (EXC +/-). • Check the wiring of the load cells.
124_H	Undervoltage (SEN +/-)	The returned SEN voltage of the load cells is too low (< 5 V DC) • Check the wiring of the load cells. • Check the set load cell type; 4- or 6-conductor load cell type
7_H	Overload (SIG +/-)	The signal voltage of the load cells is ≥ +120% of the permissible range. • Check the wiring of the load cells. • Check the scale mechanics.
8_H	Underload (SIG +/-)	The signal voltage of the load cells is ≥ -+120% of the permissible range. • Check the wiring of the load cells. • Check the scale mechanics.
106_H	DQ short-circuit to ground	Short-circuit to ground at one of the digital outputs. • Check the wiring. • Check the connected actuator.

Reactions to a diagnostic interrupt

The following happens when an event occurs that triggers a diagnostic interrupt:

- The DIAG LED flashes red.

  When you have eliminated all errors, the DIAG LED stops flashing red and turns green.
- The S7-1500 CPU interrupts the processing of the user program. The diagnostic interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.
- The S7-1500 CPU remains in RUN even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible despite the error.

You can obtain detailed information on the error event in the error organization block with instruction "RALRM" (Read additional alarm information), in the information system of STEP 7 and in function manual Diagnostics (https://support.industry.siemens.com/cs/ww/en/view/59192926), section "System diagnostics in user program".

If the module is being operated as a distributed module in an ET 200SP system with PROFIBUS DP, you have the option of reading out diagnostic data with the RDREC or RD_REC instruction using data record 0 and 1. You can find the structure of the data records in the manual for the IM 155-6 DP HF interface module available for download on the Internet (https://support.industry.siemens.com/cs/ww/de/view/73098660).

9.5.2 Meaning of the LEDs

The following figure shows the LEDs (status and error displays) of the electronic weighing system.

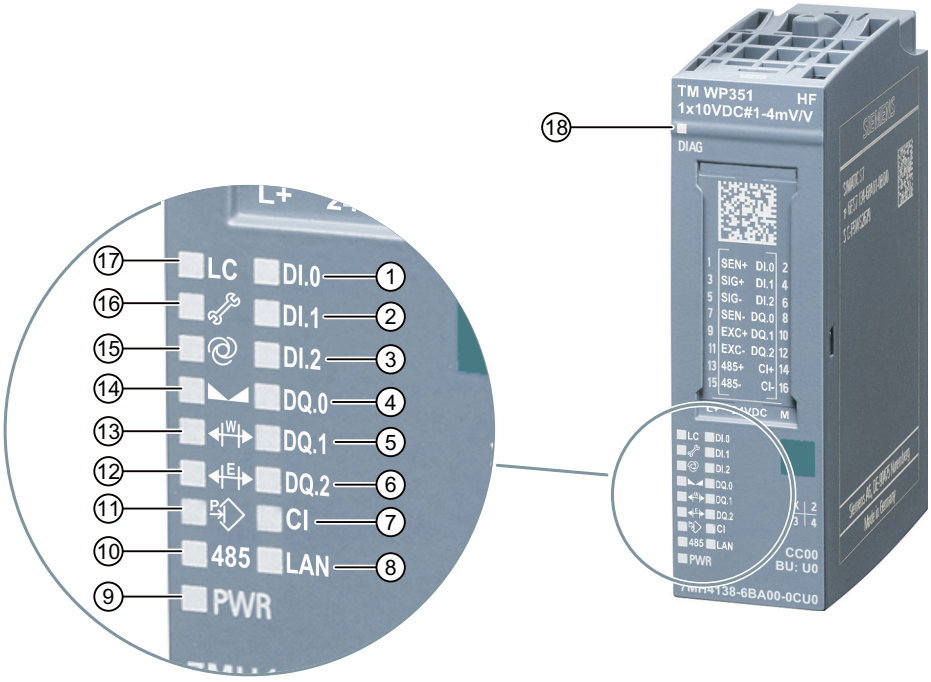

Figure 2-1187 LEDs on the electronic weighing system

Table 2-1339 Legend

LEDs			Meaning	Solution
①	DI.0	Green/off	Input is not active	-
		Green/on	Input is active	-
②	DI.1	Green/off	Input is not active	-
		Green/on	Input is active	-
③	DI.2	Green/off	Input is not active	-
		Green/on	Input is active	-
④	DQ.0	Green/off	Output is not active	-
		Green/on	Output is active	-
		Green/flashing	Fault at DQ.0, 1 or 2	• Check the wiring of the outputs.
⑤	DQ.1	Green/off	Output is not active	-
		Green/on	Output is active	-

LEDs			Meaning	Solution
⑤	DQ.1	Green/flashing	Fault at DQ.0, 1 or 2	• Check the wiring of the outputs.
⑥	DQ.2	Green/off	Output is not active	-
		Green/on	Output is active	-
		Green/flashing	Fault at DQ.0, 1 or 2	• Check the wiring of the outputs.
⑦	CI	Green/off	Input is not active	-
		Green/on	Input is active	-
⑧	LAN	Green/off	No Ethernet connection	-
		Green/on	Ethernet connection established	-
		Green/flashing	Ethernet connection is active	-
⑨	PWR	Green/off	No supply voltage L+	• Check the supply voltage. • Check the BaseUnit type and the wiring of the BaseUnit.
		Green/on	Supply voltage L+ present and OK	-
⑩	485	Green/off	Serial communication is not active	-
		Green/on	Serial communication is active	-
⑪		Green/off	Parameter write protection is not active	-
		Green/on	Parameter write protection is active	-
⑫		Yellow/off	Weight outside of the empty range	-
		Yellow/on	Weight within the empty range	-
⑬		Yellow/off	Weight within the weighing range	-
		Yellow/on	Weight outside of the weighing range	-
⑭		Green/flashing	Stability not available	-
		Green/on	Stability available	-
⑮		Green/off	No automatic weighing cycle is active	-
		Green/on	Automatic weighing cycle is active	-
		Green/flashing	Stopped automatic weighing cycle	-
⑯		Yellow/off	Service mode is not active	-
		Yellow/on	Local Web server access is enabled	-

LEDs			Meaning	Solution
⑯		Yellow/flashing	Service mode is active	-
⑰	LC Load cell	Green/off	Sensor connection faulty	Check the wiring of the load cells.
		Green/on	Sensor connection OK	-
⑱	DIAG	Green/off	Backplane bus supply of the ET 200SP not OK	Check or switch on the supply voltage on the interface module.
		Green/flashing	Electronic weighing system not parameterized	-
		Green/on	Electronic weighing system parameterized and no diagnostics	-
		Red/flashing	Electronic weighing system parameterized, there is at least one error.	Evaluate the diagnostic alarms and eliminate the error.

Corrective measures for diagnostics alarms can be found in section Error codes and corrective measures (Page 154).

9.6 Hardware interrupts

Introduction

Configure in DR07 which events during operation are to trigger a hardware interrupt. In addition, the corresponding hardware interrupt must be enabled in the hardware configuration by the electronic weighing system in TIA Portal.

What is a hardware interrupt?

In accordance with the parameters assigned, the electronic weighing system triggers a hardware interrupt when certain events or states occur.

When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the associated hardware interrupt organization block (OB). The event that triggered the interrupt is entered in the start information of the assigned hardware interrupt OB by the CPU.

Hardware interrupt lost

If the previous event was not yet processed, "Hardware interrupt lost" is triggered.

See also

Commissioning the electronic weighing system with TIA Portal (Page 37)

Technical data

10

Article number	7MH4138-6BA00-0CU0
General information	
Product type designation	TM SIWAREX WP351 HF
HW functional status	1
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type U0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Adjustment of measuring range	Yes; ±0 ... 4 mV/V
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V15.1
• STEP 7 configurable/integrated from version	- / -
• PROFIBUS from GSD version/GSD revision	GSD as of Revision 5
• PROFINET from GSD version/GSD revision	GSDML V2.34
Supply voltage	
Load voltage L+	
• Rated value (DC)	24 V
• permissible range, lower limit (DC)	19.2 V
• permissible range, upper limit (DC)	28.8 V
• Short-circuit protection	Yes
• Reverse polarity protection	Yes
Input current	
Current consumption, max.	140 mA; Without DQ
Power	
Power available from the backplane bus	94.5 mW
Power loss	
Power loss, typ.	1.7 W
Address area	
Address space per module	
• Inputs	32 byte
• Outputs	32 byte

Article number	7MH4138-6BA00-0CU0
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	type B
Digital inputs	
Number of digital inputs	3
Digital inputs, parameterizable	Yes
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Input voltage	
• Type of input voltage	24 V DC
• Rated value (DC)	24 V
• for signal "0"	< 5 V DC
• for signal "1"	+11 to +30V
• permissible voltage at input, min.	-30 V
• permissible voltage at input, max.	30 V
Input current	
• for signal "1", typ.	1.6 mA
Input delay (for rated value of input voltage)	
for technological functions	
– parameterizable	Yes
Cable length	
• shielded, max.	500 m
• unshielded, max.	150 m
Digital outputs	
Number of digital outputs	3
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes
Digital output functions, parameterizable	
• Freely usable digital output	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A
Output voltage	
• Type of output voltage	DC
Output delay with resistive load	
• "0" to "1", typ.	20 µs
• "1" to "0", typ.	30 µs

Article number	7MH4138-6BA00-0CU0
Parallel switching of two outputs	
• for uprating	No
Switching frequency	
• with resistive load, max.	500 Hz
Total current of the outputs	
• Current per channel, max.	0.5 A; the total current of all outputs ≥ 0.6 A, the ambient temperature is reduced by -1 °C per 100 mA
• Current per module, max.	1.5 A; Observe derating
Cable length	
• shielded, max.	500 m
• unshielded, max.	150 m
Encoder	
Connection of signal encoders	
• For strain gauges (full bridges) with 4-conductor connection	Yes
• For strain gauges (full bridges) with 6-conductor connection	Yes
• Resistance of full bridge, min.	56 Ω; when using SIWAREX IS 87 ohm for 7MH4710-5BA; 180 ohm when using 7MH4710-5CA
• Resistance of full bridge, max.	4 100 Ω
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.001 %
Error limit according to DIN 1319-1	0.002 %; of full-scale value
Accuracy class	III
Temperature coefficient, zero point	≤ ±0.015 µV/K
Temperature coefficient, span	≤ ±5 ppm/K
1. Interface	
Interface types	
• RS 485	Yes; Terminated internally with 390 Ω / 220 Ω / 390 Ω
2. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; 10/100 Mbit/s
• Number of ports	1
Protocols	
• IP protocol	Yes; IPv4
• Web server	Yes
Interface types	
RJ 45 (Ethernet)	
• Autonegotiation	Yes

Article number	7MH4138-6BA00-0CU0
• Autocrossing	Yes
RS 485	
• Transmission rate, max.	115.2 kbit/s
• Cable length, max.	1 000 m; ≤ 115 kbps, shielded cable
Protocols	
Web server	
• HTTP	Yes
• HTTPS	No
Interrupts/diagnostics/status information	
Diagnostics function	Yes; Diagnostic alarm
Substitute values connectable	No
Alarms	
• Diagnostic alarm	Yes; Parameterizable
• Hardware interrupt	Yes; Parameterizable
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• Group error	Yes; green/red DIAG LED
Diagnostics indication LED	
• ERROR LED	Yes; green/red DIAG LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
Integrated Functions	
Load cell	
• Automatic weighing instrument	SWA/AGFI; SWE/ACI; SKW/SCW; SWT/DTAWI
• Non-automatic weighing instrument	NAWI
• fraction of the error limit pi	0.4
• Number of verification intervals, max.	3x 6 000 d (d=e)
• permissible input signal per verification interval, min.	0.4 µV/e
• Sampling rate	1 024 Hz
• Resolution of input signal	±20 000 000 parts at 0 ... 4 mV/V
• Common mode voltage, min.	2.8 V
• Common mode voltage, max.	7.7 V
• input resistance of signal line, typ.	8 MΩ
• input resistance of sense line, typ.	300 MΩ
• Cable length, max.	500 m; when using the SIWAREX 7MH4702-8AG cable

Article number	7MH4138-6BA00-0CU0
Measuring functions	
Measuring range	
– -1 mV/V to +1 mV/V	Yes
– -2 mV/V to +2 mV/V	Yes
– -4 mV/V to +4 mV/V	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; more than 2 000 m above sea level, the ambient temperature is reduced by -1 °C per 100 m
• Ambient air temperature-barometric pressure-altitude	1 080 ... 533 hPa (-1 000 ... 5 000 m above sea level)
Decentralized operation	
to SIMATIC S7-300	Yes
to SIMATIC S7-400	Yes
to SIMATIC S7-1200	Yes
to SIMATIC S7-1500	Yes
to standard PROFIBUS master	Yes
to standard PROFINET controller	Yes
Dimensions	
Width	20 mm
Height	57 mm
Depth	72 mm
Weights	
Weight, approx.	50 g

10.1 Certificates and approvals

- All certificates are available online at Certificates (https://support.industry.siemens.com/cs/ww/en/ps/7MH4138-6BA00-0CU0/cert).
- The current approvals for your device can be found on the nameplate.
- When using the electronic weighing system, observe the requirements specified in the safety notes for hazardous areas.

Symbol	Standard	Marking
		→ CE approval
	Explosion protection in accordance with c-UL-us (USA/Canada)	ANSI / ISA 12.12.01 CSA C22.2 No. 213-M1987 CL. I, Div. 2 GP.A.B.C.D T.. T4 CL. I, Zone 2, GP. IIC, T.. T4 Report No.: E542221
	UL File Number OrdLoc	E503417
	Explosion protection in accordance with ATEX DEKRA 19ATEX0094 X EN IEC 60079-0 : 2018 EN 60079-7 : 2015 + A1 : 2018	II 3 G Ex ec IIC T.. Gc
	Explosion protection in accordance with UKCA DEKRA 21UKEX0016X	II 3 G Ex ec IIC T.. Gc
	Explosion protection in accordance with IECEx DEK 19.0054X IEC 60079-0 : 2017 (Ed.7) IEC 60079-7 : 2015 (Ed.5.1)	Ex ec IIC T.. Gc
		→ EAC certificate, available soon
		→ Tick mark for Australia and New Zealand

Symbol	Standard	Marking
		→ KCC approval
		→ The electronic weighing system is RoHS-compliant according to EU Directive 2016/65/EU
	→ EC type examination certificates	

See also

ATEX/IECx special conditions for use (Page 17)

Product documentation and support

A

A.1 Product documentation

Product documentation for process instrumentation is available in the following formats:

- Certificates (http://www.siemens.com/processinstrumentation/certificates)
- Downloads (firmware, EDDs, software) (http://www.siemens.com/processinstrumentation/downloads)
- Catalogs and technical data sheets (http://www.siemens.com/processinstrumentation/catalogs)
- Manuals (http://www.siemens.com/processinstrumentation/documentation)

  You have the option to view, open, save or configure the manual.

  – "Display": The manual opens in HTML5 format.

  – "Configure": You can register and configure the specific documentation for your plant here.

  – "Download": The manual is opened or saved in PDF format.

  – "Download as html5, only PC": The manual is opened or saved in HTML5 view on your PC.

You can also find manuals at Industry Online Support (https://support.industry.siemens.com/cs/ww/de/sc/2067) using the mobile app. Download the app to your mobile device and scan the QR code.

See also

Generally applicable information/SIMATIC manual overview (https://support.industry.siemens.com/cs/ww/en/view/109742709)

A.2 Technical support

Technical support

If this documentation does not completely answer your technical questions, you can enter a Support Request (http://www.siemens.com/automation/support-request).

For help creating a support request, view this video here (www.siemens.com/opensr).

Additional information on our technical support can be found at Technical Support (http://www.siemens.com/automation/csi/service).

Service & support on the Internet

In addition to our technical support, Siemens offers comprehensive online services at Service & Support (http://www.siemens.com/automation/serviceandsupport).

Contact

If you have further questions about the device, contact your local Siemens representative at Personal Contact (http://www.automation.siemens.com/partner).

To find the contact for your product, go to "all products and branches" and select "Products & Services > Industrial automation > Process instrumentation".

Contact address for business unit:
Siemens AG
Digital Industries
Process Automation
Östliche Rheinbrückenstr. 50
76187 Karlsruhe, Germany

SIWAREX support

- Email (mailto:hotline.siwarex@siemens.com)
- Phone: +49 (721) 667-1200 CET 8:00 to 17:00

Ordering data

B

B.1 Accessories

You can order accessories online: Industry Mall (https://mallstage.industry.siemens.com/mall/en/b0/Catalog/Products/10364709?tree=CatalogTree)

The following accessories are not included in the scope of delivery:

- **Mandatory**: BaseUnit of the type U0, article number 6ES7193-6BP00-0xU0

  An overview of the BaseUnits that you can use with the electronic weighing system can be found in the Product Information for the documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

  Information regarding selection of the suitable BaseUnit can be found in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual.
- Labeling strips
- Color-coded labels
- Equipment labeling plates
- Shield connection
- Calibration set, article number 7MH4138-6BA00-0AY0
  It contains three unlocking preventers (for calibrating three balances) and special foil for printing the labels.

SIEMENS

SIMATIC

ET 200SP
SIMATIC ET 200SP SIWAREX technology module TM WP341 1x10VDC#1-4mV/V HF

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7MH4138-6CA00-0CU0

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Introduction 1

1.1 Purpose of this document

These instructions contain the product-specific information you need for connecting, commissioning, parameter assignment/addressing, diagnostics, technical specifications and operation requiring official calibration of the technology module. The following text describes the technology module referred to as the electronic weighing system.

General information on installation and commissioning of ET 200SP is available in the ET 200SP System Manual. Generally applicable information/SIMATIC manual overview (https://support.industry.siemens.com/cs/ww/en/view/109742709)

1.2 Use in hazardous area

WARNING

Use in hazardous area

Risk of explosion.

- Only use equipment that is approved for use in the intended hazardous area and labeled accordingly.
- Do not use devices that have been operated outside the conditions specified for hazardous areas. If you have used the device outside the conditions for hazardous areas, make all Ex markings unrecognizable on the nameplate.

WARNING

Incorrect installation

Risk of explosion in the hazardous area. For use in hazardous areas according to Class I, Division 2 or Class I, Zone 2 or for use in the EU according to ATEX 2014/34/EU, observe the following conditions:

- Install the device in a control cabinet or enclosure.
- The control cabinet or enclosure meets at least the requirements of IP54 according to IEC/EN 60079-7 and pollution degree 2 or better according to IEC/EN 60664-1.

WARNING

If the device is installed in a cabinet, the inner temperature of the cabinet corresponds to the ambient temperature of the device.

WARNING

Opening the device

DO NOT OPEN WHEN ENERGIZED.

WARNING

Replacing components

EXPLOSION HAZARD

SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2 OR ZONE 2.

WARNING

Impermissible repair of the device

- Repair must be carried out by Siemens authorized personnel only.

1.3 Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit
https://www.siemens.com/industrialsecurity.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under
https://www.siemens.com/cert.

The SIWAREX WP351 electronic weighing system is designed for use in secure, closed networks and does not have any protection against unauthorized data traffic.

1.4 Open Source Software

Open-source software is used in the firmware of the product described. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information on this on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109740777).

The license terms are stored on the device and available via the web server. For more on this, refer to section Calling the web server (Page 48). To view the license conditions, click the "OSS ReadMe" button.

To resellers: Pass the license conditions on to the buyer to avoid license violations by the reseller and the buyer.

Product overview

2

2.1 View

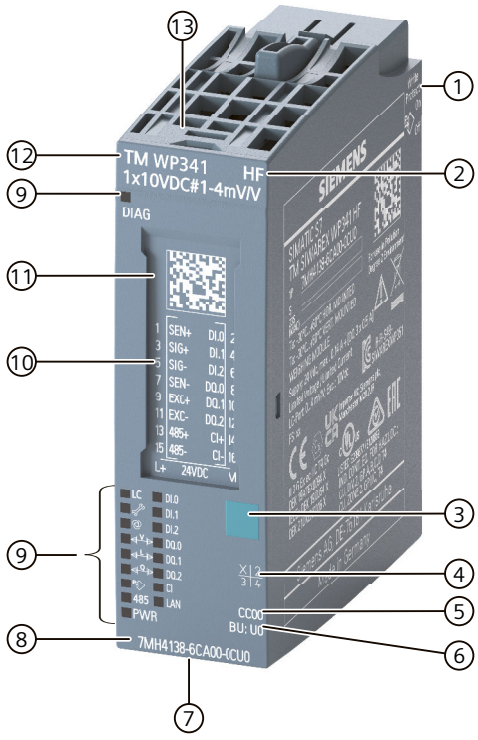

①	Rear: Write protection switch	⑧	Article number
②	Function class	⑨	LEDs (Page 102)
③	Color coding electronic weighing system type	⑩	Wiring diagram
④	Function version	⑪	2D matrix code
⑤	Color code for selection of the color-coded labels	⑫	Electronic weighing system type and designation
⑥	BaseUnit type	⑬	Button in enclosure for emergency access to the Web server
⑦	Below: Ethernet		

Figure 2-1188 View of the electronic weighing system

2.2 Properties

The electronic weighing system has the following properties:

- Technical properties
  - One channel
  - Interfaces:

    Load cell connection with 10 V DC supply voltage

    ±20,000,000 digit resolution at 1 kHz sampling rate

    Digital input signals DI.0, DI.1 and DI.2 24 V DC

    Digital output signals DQ.0, DQ.1 and DQ.2 24 V DC

    Counter input CI; up to 9 kHz; 24 V DC

    Supply voltage L+/M

    Serial interface RS485

    Ethernet interface (RJ45 socket)
- Monitoring of the load cell for impedance, wire break, short-circuit and faulty supply voltage
- Hardware interrupts configurable
- Input filter for suppression of interferences at encoder inputs and parameterizable digital inputs
- Internal protocol memory for up to 1 000 000 entries
- Supported load cell types
  - Analog strain gauge load cells with characteristic values of 1 to 4 mV/V
- Supported system functions
  - Firmware update
  - Identification data I&M

2.3 Version dependencies of the functions

The electronic weighing system supports the following functions:

Function	Firmware version of the electronic weighing system	Configurable as of		
		STEP 7 (TIA Portal)	GSD	
			PROFINET IO	PROFIBUS DP
Firmware update	V1.0 or higher	V16	X	—
I&M identification data	V1.0 or higher	V16	X	X
Centralized operation on CPU 151xSP	V1.0 or higher	V16	—	—

Installing

3

Mounting on the SIMATIC ET 200SP

Only use the electronic weighing system in conjunction with a SIMATIC ET 200SP distributed I/O system. Install the electronic weighing system in a control cabinet. Observe the information on the protection class and degree of pollution in the section Technical data (Page 105).

When installing the SIMATIC components with the electronic weighing system described herein, follow the setup, assembly and wiring guidelines for the SIMATIC ET 200SP. See system manual (https://support.industry.siemens.com/cs/ww/en/view/109742709) for the SIMATIC ET 200SP.

The electronic weighing system is snapped onto the SIMATIC ET 200SP BaseUnit (BU).

Connect the load cells, the digital input and digital output signals to the BaseUnit of the electronic weighing system. The infeed of the supply voltage at the light-colored BaseUnit of the associated potential group supplies the electronic weighing system and the digital outputs and generates the load cell supply voltage. All information about connecting is available in section Connecting (Page 17)

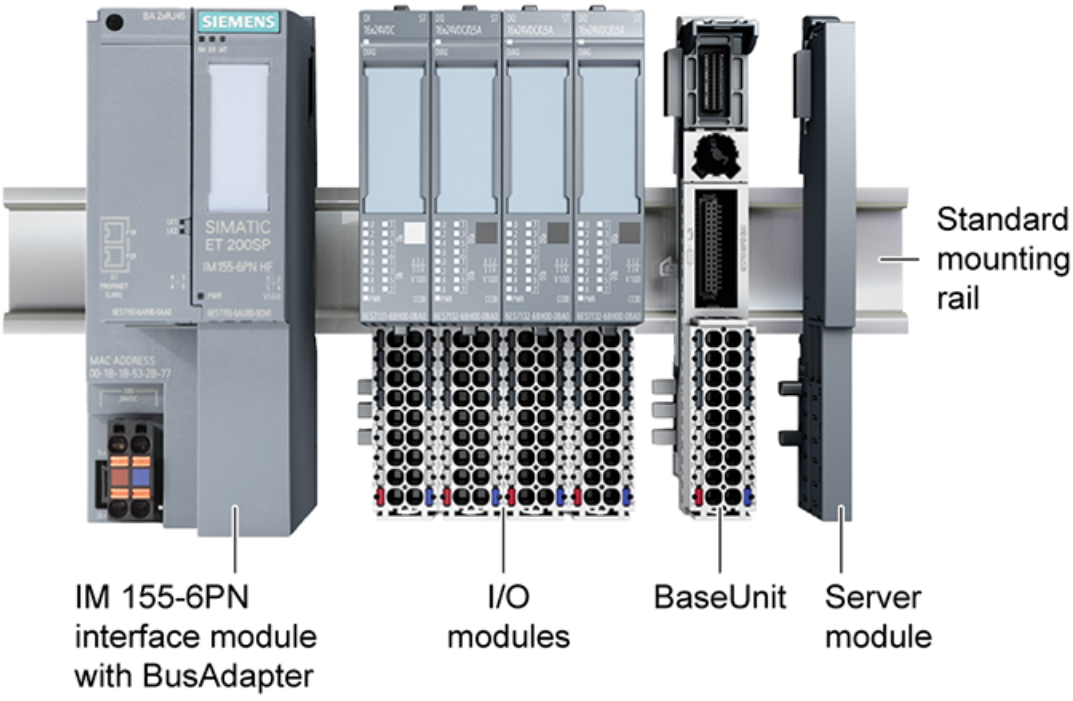

Figure 2-1189 Mounting on the SIMATIC ET 200SP

3.1 Basic safety notes

WARNING

Open equipment

The devices are "open equipment" according to the standard IEC 61010-2-201 or UL 61010-2-201 / CSA C22.2 No. 61010-2-201. To fulfill requirements for safe operation with regard to mechanical stability, flame retardation, stability, and protection against contact, the following alternative types of installation are specified:

- Installation in a suitable cabinet.
- Installation in a suitable enclosure.
- Installation in a suitably equipped, enclosed control room.

3.1.1 ATEX/IECx special conditions for use

WARNING

Incorrect installation

Risk of explosion in the hazardous area. For use in hazardous areas according to Class I, Division 2 or Class I, Zone 2 or for use in the EU according to ATEX 2014/34/EU, observe the following conditions:

- Install the device in a control cabinet or enclosure.
- The control cabinet or enclosure meets at least the requirements of IP54 according to IEC/EN 60079-7 and pollution degree 2 or better according to IEC/EN 60664-1.

NOTE

You must not install the device on a wall in hazardous areas.

WARNING

Transient overvoltages

Take measures to ensure that temporary transient overvoltages of more than 119 V do not occur.

3.2 EMC-compliant installation

3.2.1 Introduction

Overview

The electronic weighing system described here was developed for use in industrial environments and complies with high EMC requirements. Nevertheless, before installing your devices you should prepare an EMC plan and identify and take into consideration possible interference sources.

EMC

EMC (electromagnetic compatibility) describes the capability of electrical equipment to operate without errors in a given electromagnetic environment, without being subject to external influence and without influencing external devices in any way.

3.2.2 Possible effects of interference

Electromagnetic interferences can influence the electronic weighing system described here in various ways:

- Electromagnetic fields having a direct influence on the system
- Interferences transported by communication cables
- Interferences having an effect via process cables
- Interferences entering the system via the power supply and/or protective ground

Interferences can impair the fault-free functioning of the electronic weighing system.

3.2.3 Coupling mechanisms

Depending on the propagation medium (conducted or non-conducted) and the distance between the interference source and the device, interferences can enter the faulty device through four different coupling mechanisms:

- Electrical coupling
- Capacitive coupling
- Inductive coupling
- Radiation coupling

3.2.4 Five basic rules for securing EMC

Observe these five basic rules to secure EMC.

Rule 1: Large area grounding contact

- When installing the devices, make sure that the surfaces of inactive metal parts are properly bonded to chassis ground (see following sections).
- Bond all inactive metal parts to chassis ground, ensuring large area and low-impedance contact (large cross-sections).
- Make screw connections on painted or anodized metal parts either with special contact washers or remove the insulating protective layers at the contact points.
- Wherever possible, avoid the use of aluminum parts for ground bonding. Aluminum oxidizes very easily and is therefore less suitable for ground bonding.
- Provide a central connection between chassis ground and the ground/protective conductor system.

Rule 2: Proper cable routing

- Organize your wiring system into cable groups (high-voltage/power supply/signal/measurement/data cables).
- Always route high-voltage and data cables in separate ducts or in separate bundles.
- Install the measurement cables as close as possible to grounded surfaces (e.g. supporting beans, metal rails, steel cabinet walls).

Rule 3: Fixing the cable shielding

- Ensure proper fixation of the cable shielding.
- Always use shielded data cables. Always connect both ends of the data cable shielding to ground on a large area.
- Keep unshielded cable ends as short as possible.
- Always use metal/metalized connector housings only for shielded data cables.
- To connect the signal cables, use the corresponding SIMATIC ET 200SP shield supports with order number 6ES7193-6SC00-1AM0.

Rule 4: Special EMC measures

- All inductors that are to be controlled should be connected with suppressors.
- For cabinet lighting in the immediate range of your controller, use interference suppressed fluorescent lamps.

Rule 5: Homogeneous reference potential

- Create a homogeneous reference potential and ground all electrical equipment.
- Use sufficiently dimensioned equipotential bonding conductors if potential differences exist or are expected between your system components. Equipotential bonding is absolutely mandatory for applications in hazardous areas.

Connecting

4

4.1 Basic safety notes

⚠ WARNING

Safety extra low voltage

The equipment is designed for operation with a directly connectable safety extra low voltage (SELV) from a limited power source (LPS). (This does not apply to 100 V...240 V devices).

The power supply therefore needs to meet at least one of the following conditions:

- Only safety extra low voltage (SELV) with limited power source (LPS) complying with IEC 60950-1 / EN 60950-1 / VDE 0805-1 or IEC 62368-1 / EN 62368-1 / VDE 62368-1 may be connected to the power supply terminals.
- The power supply unit for the device must meet NEC Class 2 according to the National Electrical Code (r) (ANSI / NFPA 70).

There is an additional requirement if devices are operated with a redundant power supply:

If the equipment is connected to a redundant power supply (two separate power supplies), both must meet these requirements.

⚠ WARNING

Suitable cables at high ambient temperatures

If the temperature of the cable or housing socket exceeds 70 °C or the branching point of conductors exceeds 80 °C, special precautions must be taken.

If the device is operated at ambient temperatures of between 50 °C and 60 °C, only use cables with a maximum permitted operating temperature of at least 80 °C.

4.1.1 ATEX/IECx special conditions for use

⚠ WARNING

WARNING – EXPLOSION HAZARD:

DO NOT CONNECT OR DISCONNECT EQUIPMENT WHEN A FLAMMABLE OR COMBUSTIBLE ATMOSPHERE IS PRESENT.

> **WARNING**
>
> **Transient overvoltages**
>
> Take measures to ensure that temporary transient overvoltages of more than 119 V do not occur.

4.2 Connection to electronic weighing system

Table 2-1340 Terminal assignment of the BaseUnit

Designation	Signal name		View	Signal name		Designation
Load cell supply voltage monitoring +	SEN+	1		2	DI.0	Digital input DI.0
Load cell signal +	SIG+	3		4	DI.1	Digital input DI.1
Load cell signal -	SIG-	5		6	DI.2	Digital input DI.2
Load cell supply voltage monitoring -	SEN-	7		8	DQ.0	Digital output DQ.0
Load cell supply voltage +	EXC+	9		10	DQ.1	Digital output DQ.1
Load cell supply voltage -	EXC-	11		12	DQ.2	Digital output DQ.2
RS485 interface +	485+	13		14	CI+	Counter input CI +
RS485 interface -	485-	15		16	CI-	Counter input CI -
24 V DC supply voltage	L+				M	Ground for supply voltage

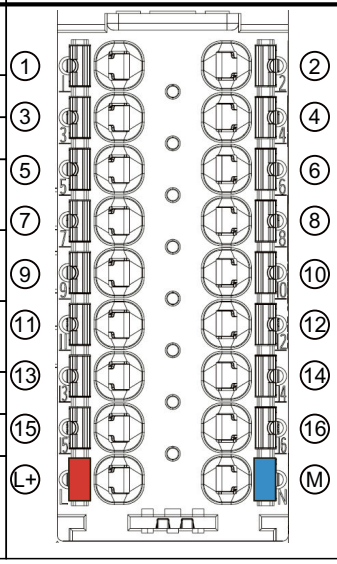

BaseUnit

The BaseUnit is not included in the scope of delivery of the electronic weighing system and must be ordered separately.

An overview of the BaseUnits that you can use with the electronic weighing system can be found in the Product Information for the documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

Information regarding selection of the suitable BaseUnit can be found in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864) system manual and in the ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual.

Information on wiring the BaseUnit, creating the cable shield, etc., can be found in the System Manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) in section Connecting.

Supply voltage L+/M

With a dark BaseUnit, the supply voltage of the left BaseUnit is used.

The electronic weighing system monitors whether the supply voltage is connected.

Load cell connection

In case of 6-wire load cells, the supply voltage is measured over the terminals 1 (SEN+) and 7 (SEN-) and used as reference. A voltage drop on the load cell cable does not have an effect on the measurement.

You can connect 4-wire as well as 6-wire load cells. The electronic weighing system is set for operation with 4-wire load cells in the factory.

If the power of the electronic weighing system-internal power supply of the load cells is not sufficient, use an external power supply source to supply the load cells.

NOTE

Compensate for interferences when connecting 4-wire load cells

If you use 4-wire load cells, we recommend that you use a 6-wire cable between the electronic weighing system and the terminal box.

- Set a wire jumper in the terminal box between EXC+/SEN+ and EXC-/SEN-.

  The wire jumper compensates for interferences between the electronic weighing system and the terminal box.

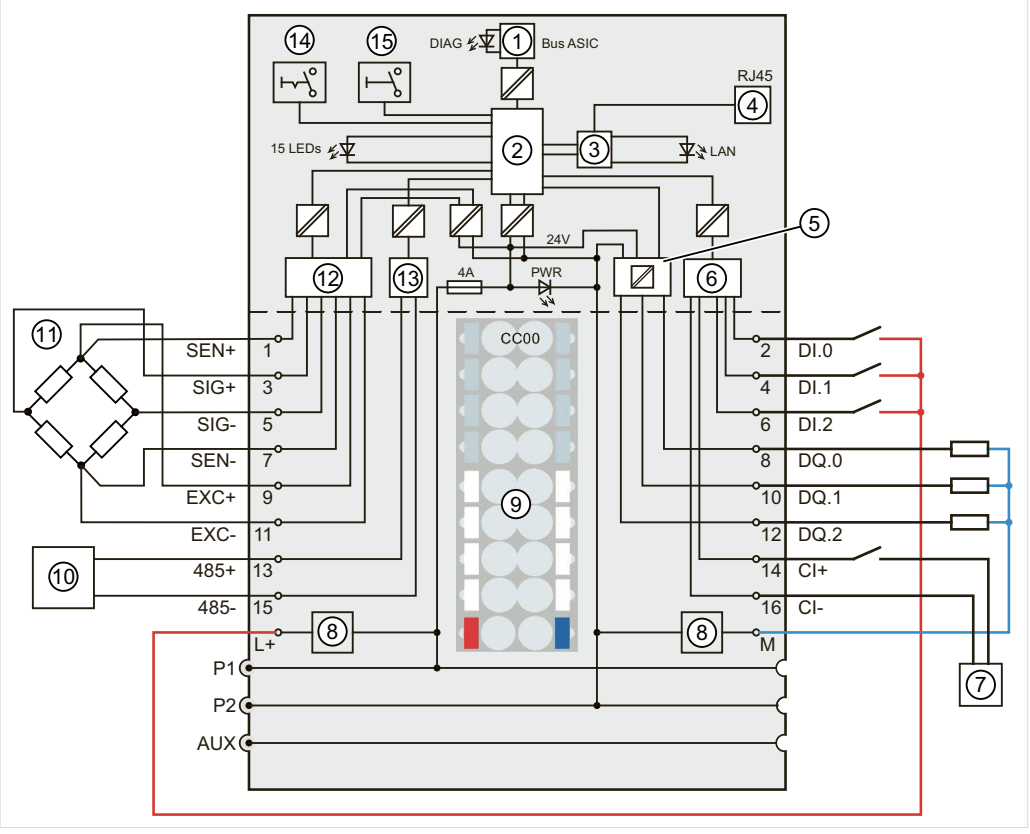

①	Backplane bus interface	⑨	Color identification label CCxx (optional)
②	MCU (microcontroller)	⑩	RS485 device
③	Ethernet sender/receiver (bus coupler)	⑪	Load cell
④	Ethernet	⑫	Filter and A/D converter

⑤	Output electronics	⑬	RS485 interface for the operation of SIWAREX DB
⑥	Input electronics	⑭	Write protection
⑦	Counter input for speed signal	⑮	Setup mode
⑧	Filter connection supply voltage (only when light-colored BaseUnit is present)		

Figure 2-1190 Principle and pin assignment

Digital inputs DI.0 to DI.2

Assign scale functions freely and individually to the digital inputs within DR 7. No functions are assigned to the inputs at the factory. Optionally, you can configure the inputs as standard inputs for the user program so that there is no direct reference to the belt scale.

The digital inputs are not isolated from each other.

Input delay for digital inputs

In order to suppress noise you can configure an input delay for the digital inputs.

NOTE

If you select the "None" or "0.0001 " option, you must use shielded cables for connection of the digital inputs.

Digital outputs DQ.0 to DQ.2

Assign scale status freely and individually to the digital inputs within the DS 7. No functions are assigned to the outputs at the factory.

The digital outputs are not isolated from each other.

The digital outputs are 24 V sourcing with respect to M and with a nominal load current of 0.5 A. They are protected against overload and short-circuit.

Relays and contactors can be directly connected without an external protective circuit. You can find information about the maximum possible operating frequencies and the inductive loads at the digital outputs in the section Technical data (Page 105).

Counter input CI

The counter input CI is used for measuring 24 V signal frequencies up to 9 kHz. Connect a speed sensor to the CI input.

In case of constant belt speed, a binary 24 V can be used as status signal "belt on" (=24 V) or "belt off" (0 V). The behavior of the CI input adapts according to the parameterization in DR3.

Ethernet

The Ethernet port is used to reach the Web server interface or provide access to the electronic weighing system using Modbus TCP/IP.

NOTE

To ensure a secure hold of the periphery module, there should be no permanent connection with an Ethernet cable.

4.3 Connection of analog load cells

Sensors equipped with expansion measuring strips (EMS) can be connected to the electronic weighing system. These sensors meet the requirements in section Technical data (Page 105).

4.3.1 Connecting SIWAREX JB to the electronic weighing system and load cell

Procedure

1. Open the cover of the SIWAREX JB.
2. Screw in an M16 x 1.5 cable gland for each load cell.
3. Screw in an M20 x 1.5 EMC cable gland for the signal cable to the electronic weighing system.
4. Wire the SIWAREX JB to the load cell and the electronic weighing system in accordance with Wiring diagrams (Page 22).

   To learn how to connect the cable, see section Connecting cables to SIWAREX JB (Page 24).
5. Close any unused opening in the enclosure with a blanking plug.
6. Connect the equipotential bonding conductor to the outside of the enclosure.

   Use shielded cable lugs.
7. Close the cover of the SIWAREX JB according to the tightening torque.

4.3.2 Wiring diagrams

4.3.2.1 Load cells with four-wire system

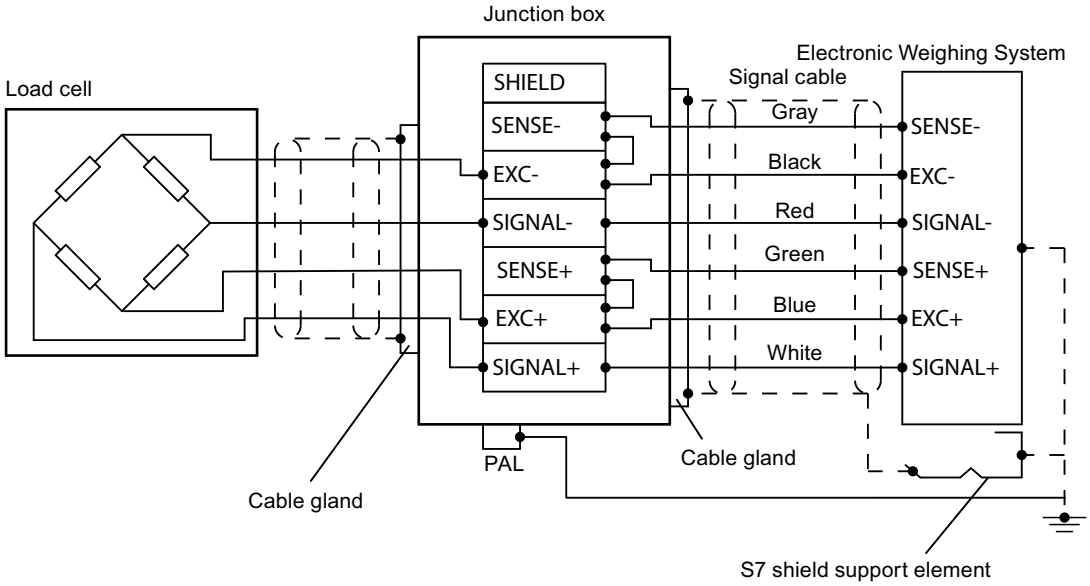

Figure 2-1191 Cable shield of the signal cable connected to EMC cable gland

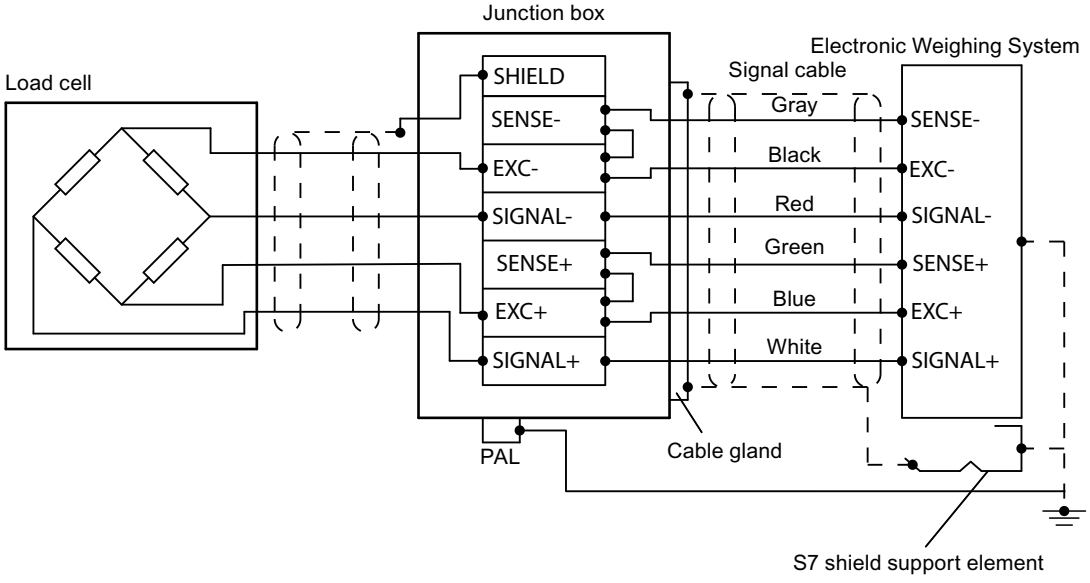

Figure 2-1192 Cable shield of the signal cable connected to shield terminal

The following wire jumpers are set by default:

Wire jumper	From terminal	To terminal
1	EXC-	SENSE-
2	EXC+	SENSE+

NOTE

If the wire jumpers are missing, the electronic weighing system reports a wire break.

4.3.2.2 Load cells with six-wire system

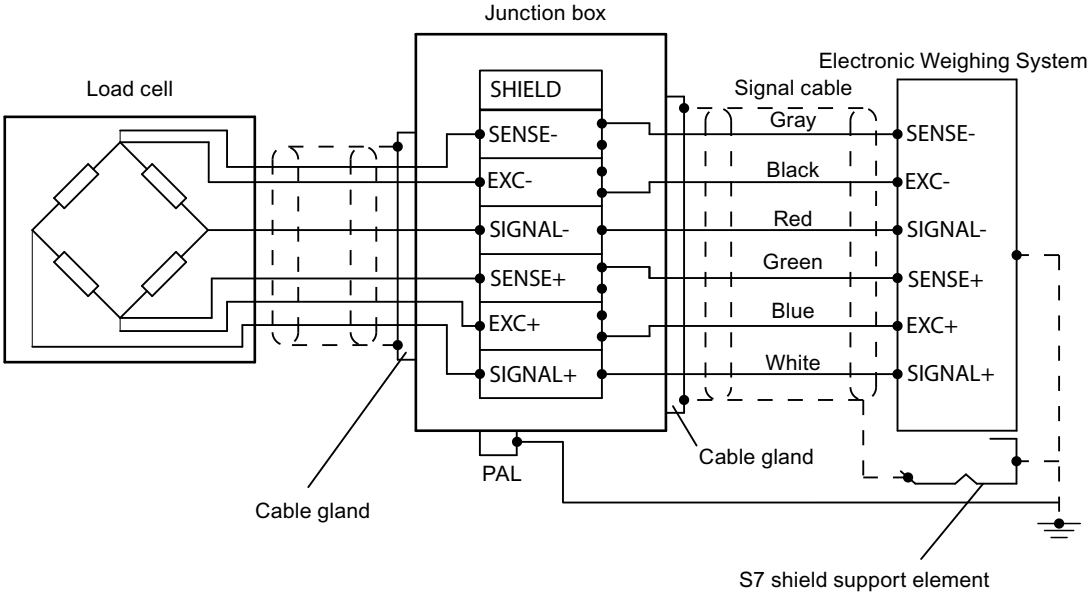

Figure 2-1193 Cable shield of load cell cable connected to EMC cable gland

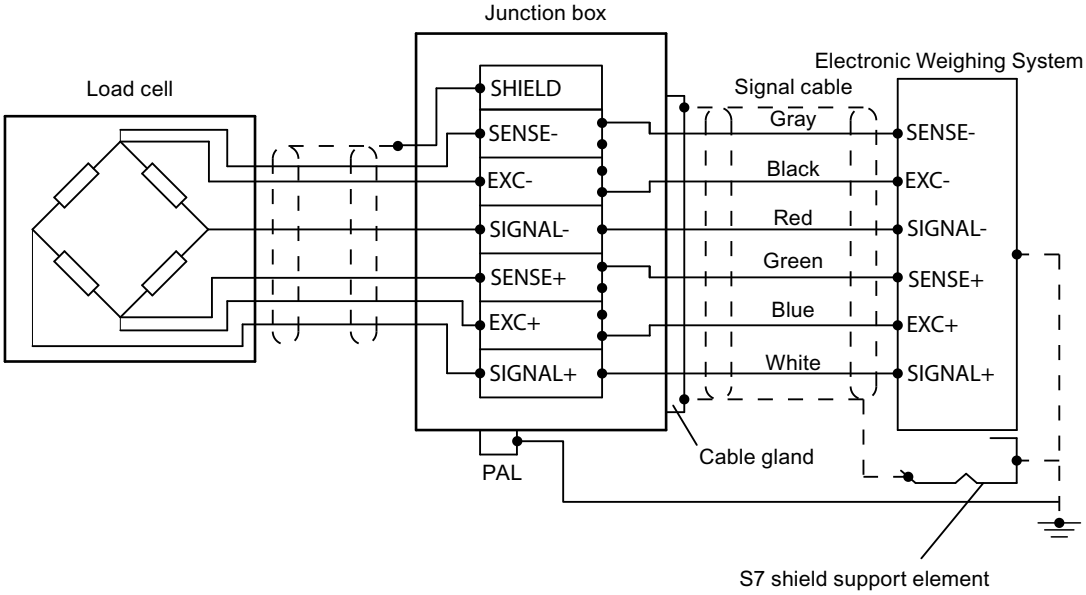

Figure 2-1194 Cable shield of load cell cable connected to shield terminal

- Disconnect the following wire jumpers:

Wire jumper	From terminal	To terminal
1	EXC-	SENSE-
2	EXC+	SENSE+

4.3.3 Connecting cables to SIWAREX JB

Requirement

You require a screwdriver with a maximum blade width of 3.5 mm.

Procedure

1. In EMC cable glands, lay the cable shielding over a large area.

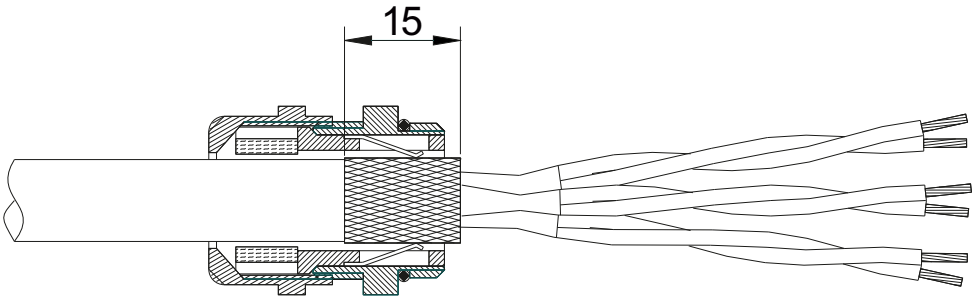

Figure 2-1195 Place the cable shield in the EMC cable gland

2. With plastic cable glands, place the corresponding wire of the SIWAREX load cell on the shield terminal.

3. Strip at least 6 mm of insulation from the load cell cable.

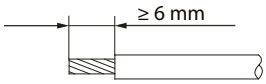

Figure 2-1196 Strip cable

4. Insert the stripped load cell cable into the square opening of the screw terminal as far as it will go.
5. Tighten the screws with the specified tightening torque (Page 105).

Result

The tightened screw firmly holds the stripped wire and establishes the contact.

4.4 Connection of the SIWAREX DB

The digital junction box SIWAREX DB allows connection of up to 4 analog load cells. SIWAREX DB has 4 separate AD converters and thus digitizes each load cell separately.

In addition to the actual measured value, the following **extended diagnostics data** are available for each individual load cell:

- Current signal voltage in millivolts
- Wire-break monitoring
- Current input resistance in ohms
- Current "excitation current" in mA etc.

In the event of a defective load cell, the electronic weighing system reports the affected load cell. Service as well as commissioning are significantly facilitated and accelerated.

SIWAREX DB also enables digital adjustment of different load cell characteristics (corner load compensation).

4.4.1 Connecting the SIWAREX DB to WP341 and WP351

Procedure

1. Open the cover of the SIWAREX DB.
2. Screw in an M16 x 1.5 cable gland for each load cell.
3. Screw in an M20 x 1.5 EMC cable gland for the signal cable to the SIWAREX WP electronic weighing system.

4. Attach the cables from SIWAREX DB to the load cell and the SIWAREX WP electronic weighing system.

   Connect the cable (Page 26)

   The maximum distance between SIWAREX DB and the WP electronic weighing system is 1000 m when using the recommended cable 7MH4702-8AG.

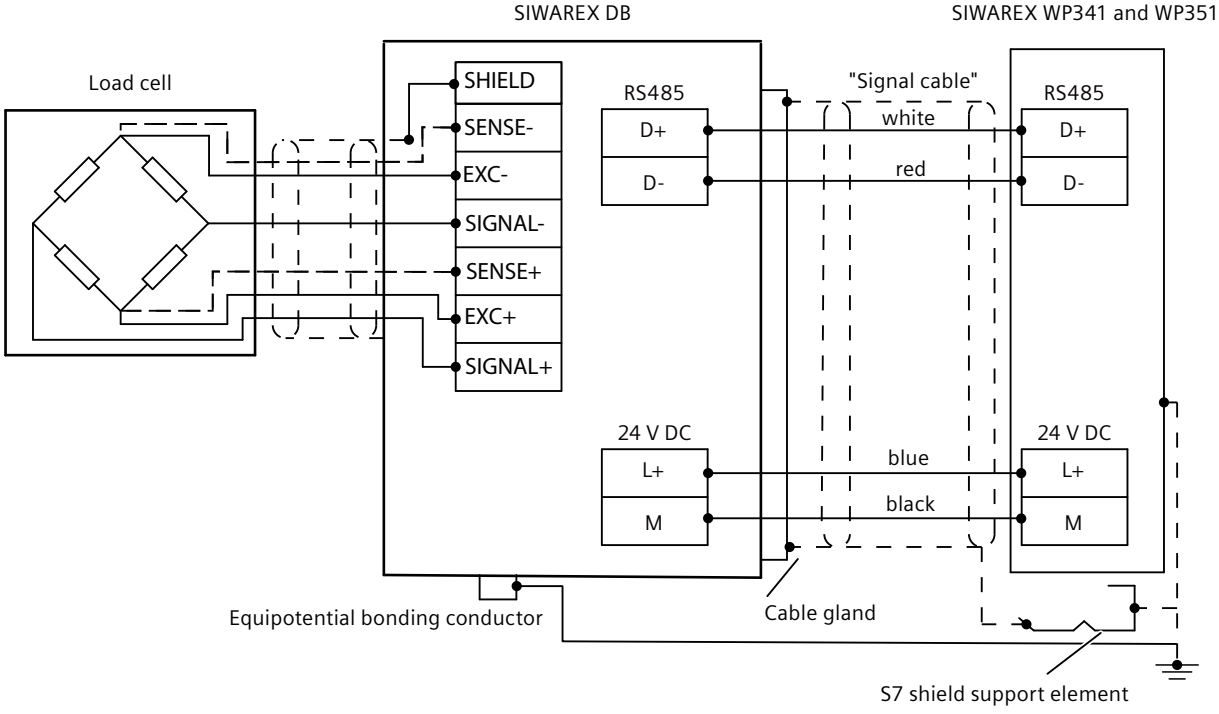

5. Close any unused opening in the enclosure with a blanking plug.
6. Connect the equipotential bonding conductor (functional grounding) to the enclosure exterior.

   Use shielded cable lugs.
7. Close the cover of the SIWAREX DB according to the tightening torque 1.5 to 2 Nm.

4.4.2 Connect the cable

Condition

You require a screwdriver with a maximum blade width of 2.5 mm.

You can use the SIWAREX cable for supply voltage and RS-485 communications. Accessories (Page 114)

Procedure

1. Place the cable shield in the EMC cable gland over a large area.

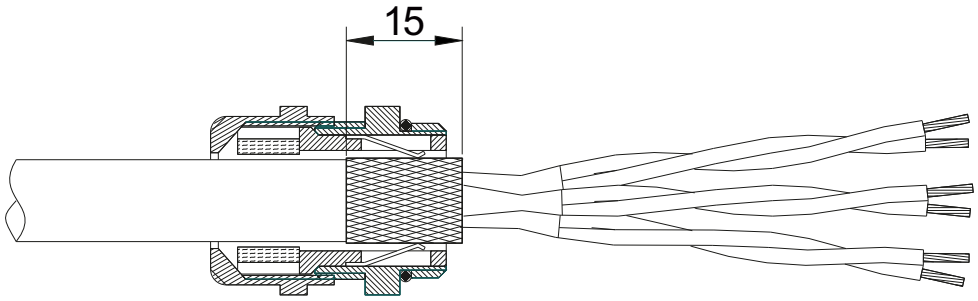

Figure 2-1197 Place the cable shield in the EMC cable gland.

2. For plastic cable glands, connect the corresponding wire of the SIWAREX load cell to the shield terminal.
3. Strip the cable ends at least 6 mm.
4. Push the screwdriver into the rectangular opening of the terminals.
5. Insert the stripped cable into the round opening as far as it will go.
6. Remove the screwdriver from the rectangular opening.

4.5

Connection of the various Siemens speed sensors is shown below. A wide range of pulse sensors can be used up to a clock frequency of 5 000 Hz. A level of at least +15 V DC is required for the High signal. The Low signal is reached at a voltage of +5 V DC. Detailed information on the various sensors can be obtained from the respective manual.

4.5.1 Siemens TASS

4.5.2 Siemens RBSS

The pulse constant of the encoder amounts to 150.4 pulses/m or 45.8 pulses/ft and must be specified accordingly in DR3.

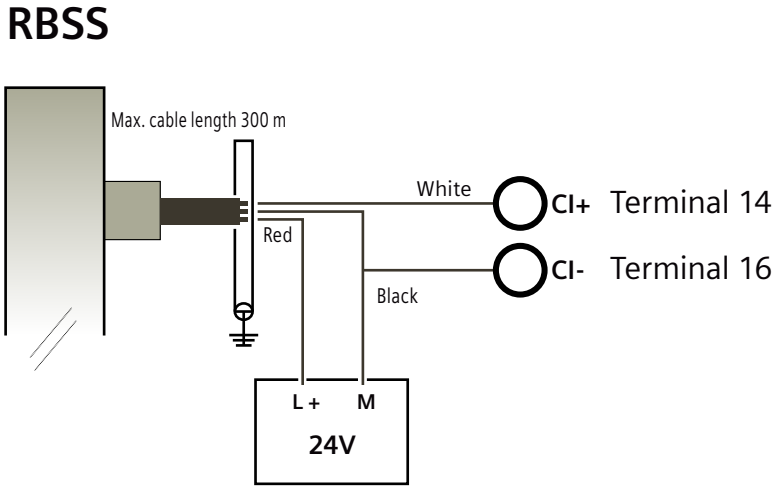

Figure 2-1198 Siemens RBSS

4.5.3 Siemens WS300

Depending on the type, the encoder WS300 supplies either 32, 256, 1000 or 2000 pulses per rotation. The pulse constant (DR3) must therefore be calculated as follows depending on the circumference of the guide pulley at which the WS300 is mounted:

- Pulses per meter = 32/C or 256/C or 1000/C or 2000/C
  or alternatively
- Pulses per meter = 32/(π x d) or 256/(π x d) or 1000/(π x d) or 2000/(π x d)
- C = Circumference of guide pulley in meters (can be easily determined by means of a cord!)
- π = 3.1416
- d = diameter of guide pulley in meters

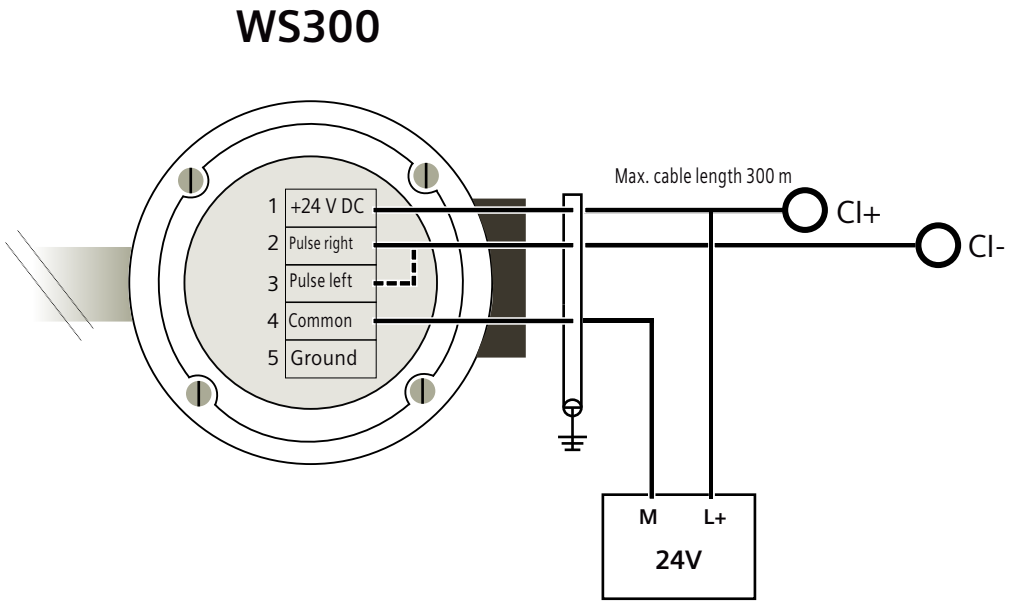

Figure 2-1199 Siemens WS300

Commissioning 5

5.1 Performing calibration

Introduction

Calibrate the scale via the web server or SIMATIC HMI.

Requirements

- In order for the conveyor to reach its rated operating conditions, the conveyor has been in operation for at least 30 minutes.
- You have integrated the Example project "Ready-to-use" (Page 38) into your CPU and the SIMATIC HMI or, alternatively, established a connection to the web server (Page 48).
- You know how to operate the web server.

Procedure

1. Select the "Service mode ON (1)" command.
2. Read DR03.
3. Set the following basic parameters in DR03 (Page 51):
   - Unit for the belt load
   - Unit for the flow rate
   - Design flow rate
   - Weigh length
   - Total length of conveyor belt
   - Speed sensor (pulse sensor) yes/no
   - Speed sensor pulses (pulses per length unit)
   - Test weight or chain load if a test chain is used for the calibration
4. When commissioning for the first time, initially calibrate the speed.

   Calibration can be carried out for scales with or without a speed sensor.

   Calibration of the speed (Page 31)
5. Calibrate the weight measurement.

   Calibration of weight measurement (Page 33)
6. Read DR03.
7. Select the "Service mode OFF (2)" command.

Result

All results of the individual calibration commands are initially displayed in DR36.

You can first check the results for plausibility in DR36 and then apply them to the parameter set or reject them. This ensures that the individual calibration steps do not take effect immediately and change the existing parameter set.

When calibrating the scale, you can switch off the totalizer using command "Stop totalizing" (652). All totalizers apart from totalizer 6 are then stopped. Calibration thus has no influence on material quantities that have already been totalized.

See also

TIA Portal user program (Page 38)
Web server (Page 48)

5.2 Calibration of the speed

5.2.1 Calibration of the speed

When using a speed sensor with a known pulse constant (pulses per length unit), go to chapter Specification of known speed parameters (Page 33).

When using a speed sensor with unknown pulse constant or for belt scale systems without speed sensor, you can calibrate the speed as per the following 3 steps.

Procedure in 3 steps

Calibrate the speed using the following steps:

Step 1

Use a tape measure or length measuring device to determine the exact conveyor belt length and enter these into DR03. You can usually measure the distance between the axes of the deflection pulleys. The length is then twice the distance between the axes plus half the circumference of the deflection pulley and half the circumference of the drive pulley. Exact determination of the belt length is the basis for good accuracy of the belt scale.

Step 2

Make a temporary marking on the conveyor belt, e.g. using chalk or adhesive tape.

This marking is used to measure one belt revolution. The conveyor belt has run for a certain warm-up time and is empty. Once the marking has passed a defined point, start the measurement of the belt revolution using the command "Start speed/pulse detection" (70). Terminate the measurement when the point is passed again (if only one belt revolution is parameterized for the measurement) using the command "Stop speed/pulse detection" (71). If several belt revolutions are required for the calibration commands, you have to parameterize this accordingly in data record DR 3 and let the marking pass a corresponding number of times before you stop the measurement.

The following parameters are calculated by SIWAREX as a result of the measurement, and output in DR36 Temporary data (Page 73) as a recommendation for acceptance:

- When using a speed sensor:
  - Design speed
  - Pulses per length unit
  - Pulses per belt revolution
- Without speed sensor:
  - Design speed

Using command 85 you can apply the determined (nominal) speed, using command 87 you can apply the determined pulse parameters.

NOTE

Starting and stopping of the belt measurement can be carried out exactly if an electric switching signal (+24 V) – for example from a proximity switch – is used to signal a belt revolution.

You can parameterize digital input DI.1 of the SIWAREX module as start/stop trigger (DR7 command "Trigger for belt revolution detection on DI" (75)) and use it to measure the belt revolution. After enabling via the "Enable belt revolution detection on DI (74)" command, the defined number of belt revolutions is recorded.

Step 3 (only for systems without speed sensor)

Following successful zero and span calibrations, you can optionally record and store a speed correction with loaded belt (commands "Start speed measurement belt loaded" (72) and "Stop speed measurement belt loaded" (73)). A coarse load characteristic of the drive can be recorded in this manner. It is then put into effect with the command "Accept speed parameters belt loaded" (86). Thus, the electronic weighing system corrects the belt speed as a function of the belt load even without a speed sensor, resulting in increased measuring accuracy.

5.2.2 Specification of known speed parameters

Calibration of the speed as described above is always recommended. This guarantees maximum accuracy for the speed calculation and thus maximum accuracy of the complete system.

If it is not possible to calculate the speed or pulse constant, you can also enter the data manually.

- When using a speed sensor, you must enter the following parameters manually:
  - DR3 → design speed = maximum speed of belt
  - DR3 → pulses per meter or per foot.
- When operating without a sensor, you must enter the following parameters manually:
  - DR3 → design speed = maximum speed of belt
- With an external speed value via the process representation, you must enter the following parameters manually:
  - DR3 → design speed = maximum speed of belt

5.3 Calibration of weight measurement

The incoming analog measured value from the load cells is converted by an analog-to-digital converter into a digital value ("Digits"). A weight is calculated using this digital value. All functions of the electronic weighing system use the weight value to calculate the material flow rate, totalizing, and the status.

The characteristic curve of the measuring system must be defined before the weight can be calculated from the digital value. The characteristic is defined by points 0 and 1. Working point "0" is defined by the dead weight of the empty scale (no load).

The ADC digits are subsequently determined for the scale loaded with a test weight.

5.3.1 Determination of zero point

The load cells return a voltage measurement to the electronic weighing system as a result of the weight of the scale itself, even if the belt is empty. Following analog-to-digital conversion of the signal, the zero point (displayed weight = 0) is assigned to the digital value (calibration digits for the zero point). The measurement is carried out with an empty, running, and warmed-up belt. At least one complete belt revolution is required. The zero point of the scale is determined more accurately if several belt revolutions are used.

The command "Start initial zero calibration" (60) is triggered with the empty belt. The zero point is then determined for the parameterized number of belt revolutions. The status display "Calibration / zero setting procedure" in DR30 indicates that the calibration is running.

The result is displayed in DR36 Temporary data (Page 73). You can apply the result using the command "Accept zero calibration digits" (88). The zero point is then imported in DR3.

5.3.2 Span calibration by weight

Carrying out the calibration

If the scale is loaded with a defined test weight (e.g. 50% of the measuring range), the test weight is assigned to the new digital value returned by the analog-to-digital converter.

Step 1

The belt is warmed-up and the zero point (Page 33) has been determined.

1. Stop the belt.
2. Enter a calibration weight appropriate to the measuring range in DR3 (e.g. 50% of the measuring range).
3. Attach this test weight to the scale or place it onto the scale.

Step 2

1. Switch the belt on again. The calibration weight is secured on the scale.
2. Start recording of the weight for the parameterized number of belt revolutions using the command "Start span calibration with test weight" (61). The status display "Calibration / zero setting procedure" in DR30 indicates that the calibration is running. The result is displayed in DR36 Temporary data (Page 73).
3. Apply the digits to DR3 using the command "Accept span calibration digits" (89). The characteristic curve has thus been determined. The scale can calculate the weight values for the complete load range.

5.3.3 Automatic span calibration with load cell data

Automatic scale calibration

The automatic scale calibration, as an alternative to calibration with test weight, permits very fast commissioning. However, the results are highly dependent on the correct mechanical scale construction and the entered parameters.

The best scale accuracy can be achieved by calibrating with test weights or a test chain. Following a certain period of operation, you can define further correction factors for the material flow rate by means of a material test.

Requirements

The following requirements must be fulfilled in order to achieve successful automatic calibration:

- Proper installation and alignment
- Load cells involved are equally and evenly loaded
- There are no shunt circuits

Step 1

The belt is warmed-up and the zero point (Page 33) has been determined. All relevant data has been entered in DR10 (load cell parameters) and sent to the scale.

Step 2

Start the calculation using the command "Start automatic span calibration" (63). The result is effective immediately and displayed in DR3 and DR4. Importing of the parameters to DR3 is omitted.

Step 3

If the belt scale has not been installed exactly horizontally, enter the incline angle of the belt in data record DR15 and send this to the scale. The characteristic curve has thus been determined. The scale can calculate the weight values for the complete measuring range.

5.3.4 Span calibration by test chain

Span calibration by test chain

If the scale is loaded with a chain (e.g. 50% of the nominal load), the weight is assigned to the new digital value returned by the analog-to-digital converter.

Step 1

The belt is warmed-up and the zero point (Page 33) has been determined.

1. Stop the belt.
2. Enter the load simulating your test chain in DR3.
3. Place the test chain onto the scale.

Step 2

1. Switch the belt on. The test chain is positioned on the scale.
2. Start recording of the weight for the parameterized number of belt revolutions using the command "Start span calibration with test chain" (65). The status display in DR30 indicates that the calibration is running. The result is displayed in DR36 Temporary data (Page 73).
3. Import the working point into DR3 using the command "Apply span calibration digits" (89). The characteristic curve has thus been determined. The scale can calculate the weight values for the complete load range.

5.3.5 Span calibration with known material flow

Span calibration with known material flow

The material test is usually used to determine the correction factor of a calibrated scale. However, a known quantity of material can also be used to carry out a scale calibration. The calibration is based on transportation of a known quantity of material, and comprises the following steps:

Step 1

The belt is warmed-up and the zero point (Page 33) has been determined.

Step 2

1. A specific quantity of material is now conveyed by the belt.
   Before the material reaches the scale, activate the command "Start span calibration (material batch)" (67).
2. The material flow is recorded. The status display indicates that the calibration is running. When the belt is empty, terminate the calibration using the command "Stop span calibration (material batch)" (68).
3. Enter the complete quantity of conveyed material before or after the calibration in DR3 in the parameter "Calibration quantity (span calibration with material batch)".

Step 3

1. Calculate the scale characteristic using the command "Calculate span calibration (material batch)" (69). The result is displayed in DR36 Temporary data (Page 73).
2. Import the working point into DR3 using the command "Apply span calibration digits" (89).
   The characteristic curve has thus been determined. The scale can calculate the weight values for the complete load range.

Parameter assignment/addressing 6

6.1 Introduction

The following options are available for parameter assignment and addressing:

- STEP 7 (TIA Portal) user program
  - Commissioning the electronic weighing system with TIA Portal (Page 38)
  - Call function block FB WP341 [FB341]. (Page 40)
  - Executing commands (Page 43)
  - Cyclic data exchange via "cyclicIoData" (Page 46)
  - Reading/writing data records (Page 47)
- Web server
  - Calling the web server (Page 48)
  - Reading/writing data records (Page 49)
  - Parameter assignment (Page 37)
- Modbus TCP/IP commissioning and parameter assignment
  - Communication via Modbus (Page 84)

Parameter table

In addition to the parameter descriptions, the parameter table (https://support.industry.siemens.com/cs/ww/en/ps/17252/dl) on the Internet provides information on:

- DR number
- Parameter name
- S7 name
- Data type
- Min. value
- Max. value
- Modbus address
- Write protection
- Access
- Status information from DR30

Table 2-1341 Example parameter table

DR	Parameter	S7 name	Type	Min. value	Max. value	Modbus address	Write protection	Access
4	Calibration digits 0 (calculated)	calibrationDigits0calculated	DINT	0	-	1200	x	r

6.2 TIA Portal user program

6.2.1 Commissioning the electronic weighing system with TIA Portal

Procedure

1. Download the "Ready to use" TIA Portal example project for the technology module TM SIWAREX WP341 HF (https://support.industry.siemens.com/cs/ww/en/ps/25196/dl) from the internet.

   The example project must be compatible with your SIMATIC controller.
2. Adjust the example project to match your configuration.

   - or-

   Copy the required components from the example project into your destination project.
3. Click on the "General" sub-tab in the "Properties" tab.
4. In the left-hand tree, navigate to TM SIWAREX WP341 HF.

Web server	If desired, activate access for the web server.
HTTPS	Function is not supported with FW version 1.0.0.
Logon name / Access right / Password	Create up to five different users. Assign the "Read" or "Read and write" permission individually to each user. **Read** means that the user has read-only access to the Web server and can create and download a backup of the current configuration. The user cannot change data or start commands. **Invalid combination of logon name and password** The following combination is intended exclusively for emergency access to the Web server. Logon name: admin Password: admin For more on this, see section: Calling the web server (Page 48) > Procedure in case of loss of user data.

IP address	IP address of the electronic weighing system (default: 192.168.0.21)
Subnet mask	Subnet mask of the electronic weighing system (default: 255.255.255.0)

Set IP address in the project	The IP address of the electronic weighing system is transmitted via the hardware configuration during CPU startup. The IP address is only specified via TIA Portal.
Permit adapting the IP address directly at the device	The IP address of the electronic weighing system is not assigned via the TIA Portal. – Assign the IP address via an external tool (e.g. PST Tool)
Use router	Defines whether or not a router is used.
Router address	IP address of the router
Device name	Network name of the electronic weighing system

5. Enable the desired diagnostic interrupts.

   Monitoring is always active. When an error is detected, a diagnostic interrupt is only triggered when the corresponding diagnostic interrupt is enabled in the device configuration.

6. Enable the desired hardware interrupts.

   With the help of the following event types, parameterize the triggering of a hardware interrupt.

   – Hardware interrupt 1 (event freely definable in DR07)
   – Hardware interrupt 2 (event freely definable in DR07)
   – Hardware interrupt 3 (event freely definable in DR07)
   – Hardware interrupt 4 (event freely definable in DR07)
   – Hardware interrupt 5 (event freely definable in DR07)
   – Hardware interrupt 6 (event freely definable in DR07)
   – Hardware interrupt 7 (event freely definable in DR07)
   – Hardware interrupt 8 (event freely definable in DR07)

   You can select any combination of events for hardware interrupt triggering.

   You can obtain detailed information on the event in the hardware interrupt organization block with the instruction "RALRM" (read additional interrupt info) and in the information system of STEP 7 (TIA Portal).

The event that triggered the hardware interrupt is logged in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

LB 8								LB 9								LB 10								LB 11								Bit # LD 8
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	X	0	0	0	X	X	X	X	X	

User Structure Identifier (USI)

Event that triggered the hardware interrupt (EventType):

00001_B: Hardware interrupt 1
00010_B: Hardware interrupt 2
00011_B: Hardware interrupt 3
00100_B: Hardware interrupt 4
00101_B: Hardware interrupt 5
00110_B: Hardware interrupt 6
00111_B: Hardware interrupt 7
01000_B: Hardware interrupt 8

Channel that has triggered the hardware interrupt (IChannel):
0_B: Channel 0 of the technology module

Figure 2-1200 Start information of the organization block

6.2.2 Call function block FB WP341 [FB341].

Introduction

For each electronic weighing system, call the FB cyclically once in the user program. For each call of the FB, adapt the input parameters to the electronic weighing system. Each electronic weighing system has a unique HW ID and its own interface DB. The interface DB contains all weighing parameters. The PLC data types of the interface DB can be found in the TIA Portal example project. Copy the PLC data types from the example project into the target project.

Requirement

The following FW versions are required in the S7 controllers so that you can work with the FB:

CPU	FW version
S7-1200	≥ V4.2
S7-1500	≥ V2.0

Procedure

1. Copy the FB, the interface DB and the associated UDTs from the example project into the destination project.
2. Call the FB in the user program.
3. Assign the electronic weighing system for the parameter HW ID "HW_ID".
4. Assign the interface DB to the electronic weighing system for the parameter interface "Interface".

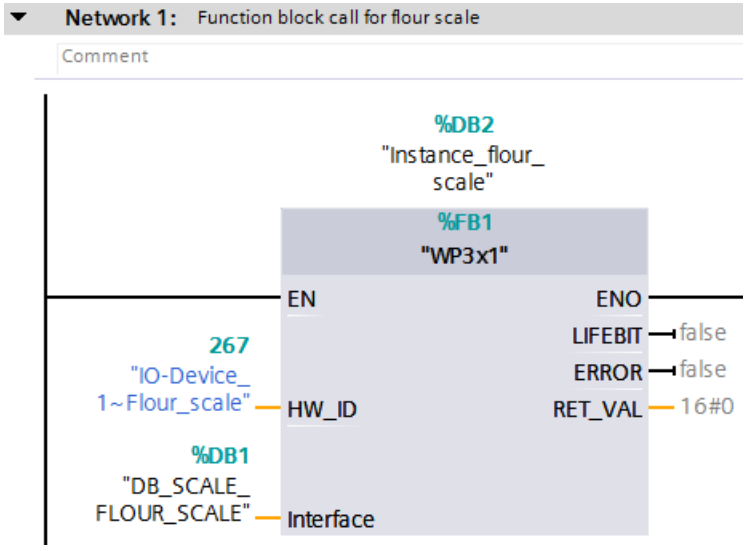

HW_ID	HW ID of the electronic weighing system
Interface	Interface DB of the electronic weighing system
ERROR	"true" = Error
RET_VAL	The meaning of the error codes can be found in the section: Operating errors (Page 90).
LIFEBIT	Optional status bit can be used to monitor communication

Figure 2-1201 FB

5. Copy the HMI or the required components from the example project into the destination project.

Example: 2 FBs for 2 electronic weighing systems

The following example shows the setup of 2 FBs in 2 networks for 2 electronic weighing systems.

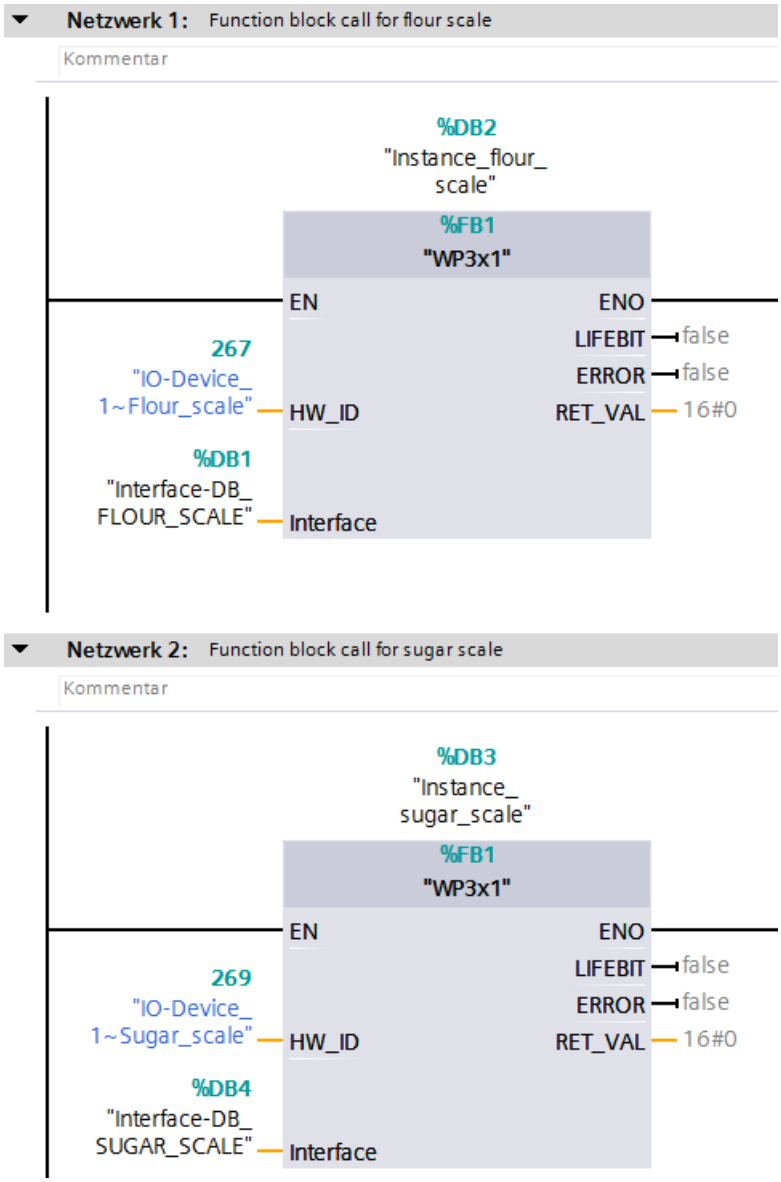

Network 1 "Network 1"	**FB1**	Interface DB of the flour scale "Instance_flour_scale"
		HW_ID of the flour scale "Flour_scale"
		Interface of the flour scale "DB_SCALE_FLOUR_SCALE"
Network 2 "Network 2"	**FB2**	Interface DB of the sugar scale "Instance_sugar_scale"
		HW_ID of the sugar scale "Sugar_scale"
		Interface of the sugar scale "DB_SCALE_SUGAR_SCALE"

Figure 2-1202 2 FBs for 2 electronic weighing systems

6.2.3 Executing commands

Introduction

Data records (DR) are read or written via specific command codes. There are three command mailboxes within the interface DB for this purpose.

The command mailboxes are managed and processed according to priority. When all three command mailboxes are triggered at the same time by the user program, the FB executes them in the following order:

Command mailbox	Priority	Description
Command1	Highest priority	If you run cyclic commands in the "Command1" command mailbox, this makes it impossible to run commands in the "Command2" or "Command3" command mailbox.
Command2	Medium priority	
Command3	Lowest priority	Cyclic commands from the "Command3" command mailbox are interrupted to run a command in the "Command2" or "Command1" command mailbox.

You can find a list of all commands in section: Commands (Page 78).

Requirement

You have called the FB (Page 40).

Procedure

1. Open the interface DB.
2. In one of the command mailboxes "Command1", "Command2" or "Command3", enter a command code for the parameter "code".
3. Set the associated command trigger [trigger] to "true".

4. Evaluate the associated status bits:

   Command in progress. [inProgress]

   Command finished without error. [finishedOk]

   Command rejected or finished with error. [finishedError] [errorCode (Page 90)] [errorAddInfo (Page 93)] You can find a list of data and operating errors in section Data and command errors (Page 93).

Interface-DB_FLOUR_SCALE

	Name	Data type	Start value
4	CommandHandling	"Siwarex_WP3..	
5	Command1	"Siwarex_WP3..	
6	code	Int	0
7	trigger	Bool	FALSE
8	inProgress	Bool	FALSE
9	finishedOk	Bool	FALSE
10	finishedError	Bool	FALSE
11	errorCode	Int	0
12	errorAddInfo	Int	0
13	Command2	"Siwarex_WP3..	
14	code	Int	0
15	trigger	Bool	FALSE
16	inProgress	Bool	FALSE
17	finishedOk	Bool	FALSE
18	finishedError	Bool	FALSE
19	errorCode	Int	0
20	errorAddInfo	Int	0
21	Command3	"Siwarex_WP3..	
22	code	Int	0
23	trigger	Bool	FALSE
24	inProgress	Bool	FALSE
25	finishedOk	Bool	FALSE
26	finishedError	Bool	FALSE
27	errorCode	Int	0
28	errorAddInfo	Int	0

Figure 2-1203 Command mailboxes Command1, Command2 and Command3

Example: Parameterize the calibration weight

You want to set the value 12.5 for the parameter Calibration weight [calibrationWeight].

1. Switch on service mode by entering the command code 1 (= Service mode ON) for the "code" parameter in the "Command1" command mailbox.
2. Set the associated command trigger "trigger" to "true".

   ⇒ The "Wrench LED" on the electronic weighing system flashes orange.
3. Read DR03 by entering the command code 2003 for the "code" parameter in the "Command1" command mailbox.
4. Set the associated command trigger "trigger" to "true".

   ⇒ All current data from DR03 is present in the interface DB.
5. In DR03, enter the value 12.5 for calibration weight [calibrationWeight].

6. Write DR03 by entering the command code 4003 for the "code" parameter in the "Command1" command mailbox.
7. Set the associated command trigger "trigger" to "true".
8. Evaluate the associated status bits:

   Command finished without error. [finishedOk] is "true".

   ⇒ The new calibration weight is now present in the electronic weighing system and is used.
9. Disable service mode by entering command code 2 (= Service mode OFF) for the "code" parameter.
10. Set the associated command trigger "trigger" to "true".

6.2.4 Cyclic data exchange via "cyclicIoData"

The interface DB of the FB makes the "cyclicIoData" structure available. All parameters in this structure are updated cyclically by the electronic weighing system to the SIMATIC controller. All entered parameter values within the "cyclicIoData" structure are used directly – without reading or writing the data records.

The following parameters are available for use within the "cyclicIoData" structure on the factory side:

Interface-DB_FLOUR_SCALE

	Name	Data type	Start value
2	CyclicIoData	"Siwarex_WP35..	
3	input	"Siwarex_WP35..	
4	processValueReal1	Real	0.0
5	processValueReal2	Real	0.0
6	processValueReal3	Real	0.0
7	processValueReal4	Real	0.0
8	processValueDWord1	DWord	16#0000_
9	processValueDWord2	DWord	16#0000_
10	processValueDWord3	DWord	16#0000_
11	processValueDWord4	DWord	16#0000_
12	scaleStatus	"Siwarex_WP35..	
13	output	"Siwarex_WP35..	
14	processValue5	Real	0.0
15	processValue6	Real	0.0
16	processValue7	Real	0.0
17	processValue8	Real	0.0
18	transitions	"Siwarex_WP35..	
19	step0	Bool	false
20	step1	Bool	false
21	step2	Bool	false
22	step3	Bool	false
23	step4	Bool	false
24	step5	Bool	false
25	step6	Bool	false
26	step7	Bool	false
27	digitalOutputControl	"Siwarex_WP35..	
28	DQ0	Bool	false
29	DQ1	Bool	false
30	DQ2	Bool	false

Input

[inProcessValueReal1 to inProcessValueReal4]	Cyclic I/O process values (reading) in real format according to defined parameters in DR07 (Page 58). Standard in DR7: Process Value 1: Flow rate Process Value 2: Belt load Process Value 3: Belt speed Process Value 4: Totalizer 2
[inProcessValueDWord1 to inProcessValueDWord4]	Cyclic I/O process values in DWord format according to defined parameters in DR07 (Page 58).
[scaleStatus]	Weighing status of weighing steps according to parameters in DR30 (Page 70).

Output

[ioProcessValue5 to ioProcessValue8]	Cyclic I/O process values (writing) according to defined parameters in DR07 (Page 58). Default in DR7: Process Value 5: not assigned Process Value 6: not assigned Process Value 7: not assigned Process Value 8: not assigned
[digitalOutputControl]	If a digital output DQ is configured for control from the CPU (DR07), the DQ may be controlled here via the according bit.
[errorCode]	Error according to Interrupts/diagnostic messages (Page 89).
[addInfo]	Error according to Interrupts/diagnostic messages (Page 89).

Figure 2-1204 "cyclicIoData" structure

6.2.5 Reading/writing data records

Introduction

Every data record (DR) can only be read fully from the electronic weighing system to the SIMATIC controller or written to the electronic weighing system. Transfer of a single parameter within a data record is not possible.

Data in the "cyclicIoData" structure is updated automatically without commands via cyclic communication.

Requirements

You have called the FB (Page 40).

Example: Reading and writing DR07

CAUTION

The number of system functions that can be called at the same time is limited.
Start the commands for reading and writing a data record only when necessary.

1. Switch on service mode by entering the command code 1 for the "code" parameter in the "Command1" command mailbox.
2. Open the interface DB.
3. Read DR07 by entering the command code 2007 for the "code" parameter in the "Command1" command mailbox.
4. Set the associated command trigger [trigger] to "true".

   ⇒ All current data from DR07 is present in the interface DB.
5. Set the scale parameters for DR07 (Page 58).

6. Write DR07 by entering the command code 4007 for the "code" parameter in the "Command1" command mailbox.
7. Set the associated command trigger "trigger" to "true".

6.2.6 Design of hardware configuration

An HSP2107 (Hardware Support Package) is available for download for this purpose. The following table provides an overview of the possible usage scenarios of the electronic weighing system.

Possible applications	Required components	Configuration software	In the user program
Central operation with a CPU 151xSP	• S7-1500 (SP-CPU) automation system • TM SIWAREX WP351 HF	STEP 7 (TIA Portal as of V16): • Basic configuration using the hardware configuration • Web browser for reaching the web server interface	• TM SIWAREX WP351 HF FB for S7-1500/1200 controllers
Distributed operation with an S7-1500 CPU	• Automation System S7-1500 • ET 200SP distributed I/O system • TM SIWAREX WP351 HF		
Distributed operation with an S7-300/400 CPU	• Automation system S7-300/400 • ET 200SP distributed I/O system • TM SIWAREX WP351 HF	STEP 7 (TIA Portal as of V16): • Basic configuration using the hardware configuration • Web browser for reaching the web server interface	• TM SIWAREX WP351 HF FB for S7-300/400 controllers
External system	• ET 200SP distributed I/O system • TM SIWAREX WP351 HF	Web browser for reaching the web server interface	• GSD/GSDML file

6.2.7 Automatic time synchronization

All logs and error messages, as well as numerous diagnostics data, are time-stamped by the electronic weighing system.

The function block of the electronic weighing system automatically synchronizes the time from the electronic weighing system with the CPU time. It is therefore not required to separately set the time in the electronic weighing system.

6.3 Web server

6.3.1 Calling the web server

NOTICE

Low degree of protection against unauthorized access

If you activate the web server, you reduce protection against unauthorized access to functions and data of the electronic weighing system from outside and via the internal network.

- Follow the Security information (Page 8).

Introduction

Using the web server of the electronic weighing system, you can start up the electronic weighing system in a completely autonomous way and without additional software tools. You do not need any specific SIMATIC knowledge. After commissioning the electronic weighing system, connect the automation system.

Procedure with TIA Portal

1. In the device view, select TM SIWAREX WP3x1 HF.
2. Click on the "General" sub-tab in the "Properties" tab.
3. Navigate to TM SIWAREX WP3x1 HF > Parameters.
4. Activate the web server.
5. Create at least one user.
   Do not create **any** user with the name "admin".
6. Compile the hardware configuration.
7. Transfer the hardware configuration to your system.
8. Enter the IP address of the electronic weighing system in the Mozilla Firefox or Google Chrome browser. (Default: 192.168.0.21)
9. Log in with the previously defined credentials.

Procedure in case of loss of user data

1. Press the ① pushbutton at the upper left in the enclosure for at least 3 seconds.

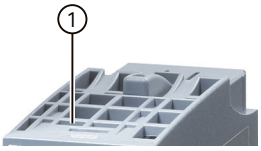

   ⇒ The LED lights up yellow.
2. Enter the IP address of the electronic weighing system in the Mozilla Firefox or Google Chrome browser within 2 minutes. (Default: 192.168.0.21)
3. Log on as follows:

   Logon name: admin

   Password: admin

6.3.2 Reading/writing data records

Introduction

Only the entire data record (DR) can be read from the electronic weighing system in the web server or written to the electronic weighing system. Transfer of a single parameter within a data record is not possible.

Example: Reading and writing DR06

1. Read DR06 by selecting "Online > Read data record" in the shortcut menu.

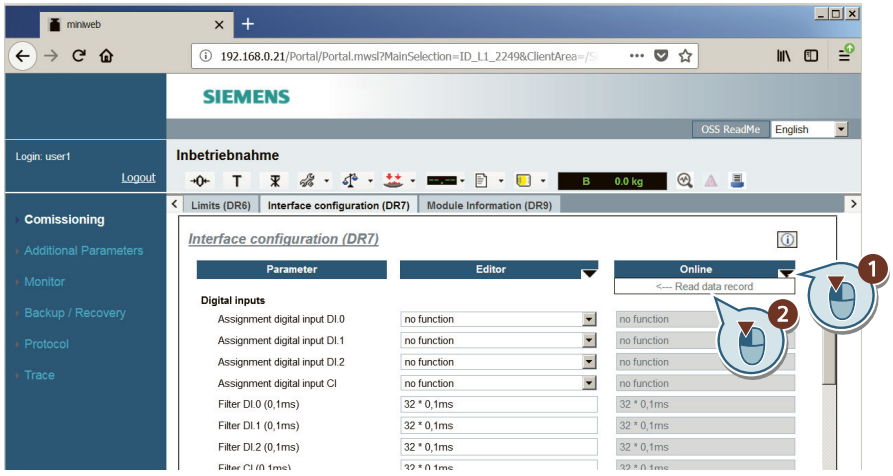

Figure 2-1205 Reading DR

2. Set the parameters for DR06 (Page 57) in the column "Editor".
3. Write DR06 by selecting "Editor > Write data record" in the shortcut menu.

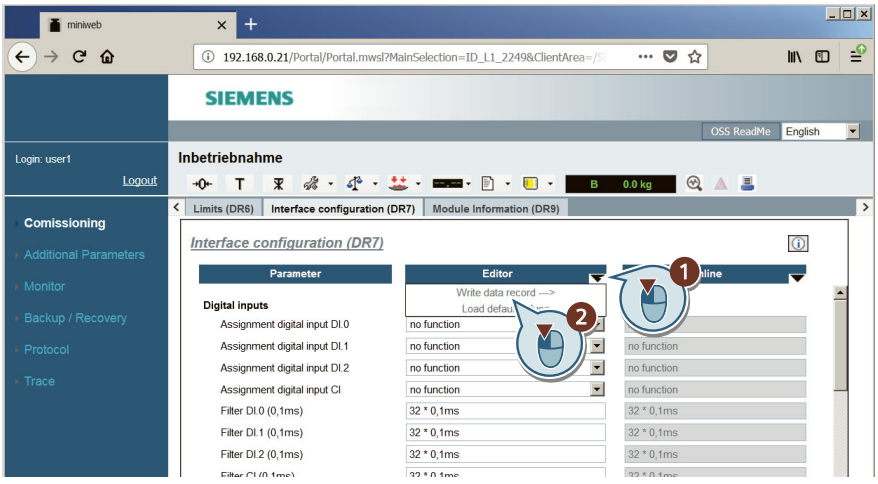

Figure 2-1206 Writing DR

6.4 DR03 Calibration parameters

6.4.1 Scale name [scaleName]

You can select any name, but it may not exceed 12 characters. You can enter any designation.

6.4.2 Measurement unit for load and speed [unitBeltLoad]

When setting parameters for the first time you must select between metric and imperial systems.

The following units can be selected for the belt load:

0 – kg/m + m/s (metric)

1 – lbs/foot + ft/s (imperial)

2 - lbs/foot + ft/min (imperial)

When 0 is selected, the material flow rate can be specified in t/h or kg/h.

When 1 or 2 is selected, the material flow rate can be specified in T/h, TL/h or lbs/h.

6.4.3 Unit for the flow rate [unitFlowRate]

The following units can be selected for the material flow rate:

0 – t/h (metric)

1 – kg/h (metric)

2 – T/h (imperial)

3 – TL/h (imperial)

4 – lbs/h (imperial)

6.4.4 Scale intervals of weight, belt load and totalizers

The scale intervals define the resolution at which the corresponding process variables are output by the electronic weighing system. Example: With a scale interval of 0.1 for totalizers T1 and T2, the totalizer values T1 and T2 are output with one decimal place.

- Scale interval of weight and belt load [scaleIntervalWeightAndLoad]
- Totalization and flow rate interval (totalizers T1..T2) [totalizationIntervalD]
- Totalization interval (totalizers T3..T6) [totalizationIntervalSubTotalizer]

6.4.5 Design flow rate [designFlowRate]

The design flow rate is entered during initial commissioning. It can be obtained from the data sheet for the belt scale. It corresponds to the maximum material flow rate (100%) for which the conveyor belt is designed.

The % values for the material flow rate limits refer to the rated flow rate.

6.4.6 Weigh length [weighLength]

In the case of a scale with a roller station, the weigh length corresponds to half the distance from the roller station to the adjacent rollers on the left and right which are located upstream and downstream of the roller station.

With two or more roller stations, the distance between the roller stations is added to this.

6.4.7 Belt length (1 complete revolution) [beltLength]

The length of the conveyor belt is measured during commissioning, and entered. This is usually twice the distance between the axes of the deflection pulleys plus the single circumference of the pulley. The input is made in the length unit from the belt load.

6.4.8 Number of belt revolutions for calibration [beltRevolutionsForCalibration]

At least one belt revolution is required for the calibration. You can increase the number of belt revolutions in order to increase the accuracy of the equipment.

6.4.9 Speed input [speedInput]

There are three options for determining the current speed:

0 – no speed sensor present. Specification of a constant belt speed or determination of it.

1 – speed sensor at digital input at CI

2 – external specification of belt speed from CPU

6.4.10 Speed input [speedInput]

There are three options for determining the current speed:

0 – no speed sensor present. Specification of a constant belt speed or determination of it.

1 – speed sensor at digital input DI.0

2 – external specification of belt speed from CPU (via DR19)

6.4.11 Design speed [designSpeed]

The design speed can be determined with the belt empty. To this end, the time for one or more belt revolutions is measured, and the speed determined from this.

6.4.12 Speed factor under load [speedFactorUnderLoad]

If a speed sensor is not used (speed detection = 0, see Speed input [speedInput] (Page 52)), a speed correction can be determined at a certain belt load factor (preferably the nominal load) in addition to the design speed. A load-dependent characteristic for the speed then results together with the design speed. This characteristic is determined by two working points: Design speed with empty belt and a speed factor correction with a certain belt load factor.

The specification is made in % of the design speed.

Using commands 72 (Start), 73 (Stop) and 86 (Apply), the point can be determined automatically during commissioning (with loaded belt) or during operation.

6.4.13 Load at 'Speed factor under load' [loadAtSpeedFactor]

The associated belt load factor (in % of nominal load) is specified for determination of the speed correction (→ Speed factor under load [speedFactorUnderLoad] (Page 53)).

You must observe the value in DR30 during the calculation and subsequently enter it.

6.4.14 Speed sensor pulses [speedSensorPulses]

If known, you can directly enter the pulse constant of the connected sensor. The input is made either in "Pulses per meter" or "Pulses per foot" depending on the selected unit. If the pulse constant is unknown, it can be calculated automatically by the electronic weighing system using an exactly defined total belt length. Commands 70 and 71 are used for this purpose.

6.4.15 Zero calibration digits [zeroCalibrationDigits]

Following calibration of the scale's zero point, the digit value from the A/D converter is stored as the average value for the set number of belt revolutions. When zeroing the scale during subsequent operation, a check is made to establish whether the deviation from this original zero point does not exceed the defined limit.

6.4.16 Span calibration digits [spanCalibrationDigits]

Following calibration of the loaded belt scale, the digit value from the A/D converter which corresponds to the calibration weight is stored as the average value for the set number of belt revolutions. The interval from the zero digits must be at least 40 000 digits.

6.4.17 Calibration weight (test weight) [calibrationTestWeight]

The calibration weight corresponds to the test weight used for the span calibration. With other calibration methods (test chain, quantity of material, or automatic), the weight is determined internally by the electronic weighing system in accordance with the reverse calculation.

6.4.18 Calibration load (test chain) [calibrationLoad]

If a test chain is used to calibrate the scale, its belt load value can be entered.

6.4.19 Calibration quantity (material test) [calibrationQuantity]

In order to calibrate the belt scale by means of a material test, a previously or subsequently weighed amount of material can be used. The specification depends on the selected belt loading unit in kg or lb.

You can calibrate the scale using the commands 67 (Start), 68 (Stop), 69 (Calculate span calibration point), and 89 (Apply span calibration digits).

6.4.20 Enable simulation

To enable a full system test without a scale and/or speed sensor, the electronic weighing system supplies all process variables as simulation values. Enable or disable simulation options via the mentioned parameters. The further procedure for simulating the process variables can be found in the description of DR16.

Load simulation [loadSimulationEnabled]

Speed simulation [speedSimulationEnabled]

Flow rate simulation [flowSimulationEnabled]

Inclince angle simulation [angleSimulationEnabled]

6.4.21 Operating mode [operatingMode]

Defines the operating mode of the scale.

The following operating modes are available:

Selec-tion code	
50	Belt Scale
51	Solids flowmeters

6.4.22 Belt load signal filter [loadSignalFilter] and speed [speedSignalFilter]

Strength of the filter for the weight and speed value.

Use the filter to attenuate or smooth unstable load cell and/or speed signals. The following 6 filter levels are available:

0: Off

1: Very weak

2: Weak

3: Medium

4: Strong

5: Very strong

6.4.23 Speed signal filter [speedSignalFilter]

Analog weight filter

6.5 DR04 Correction factor [correctionFactor]

Introduction

To further increase system accuracy, you can determine a characteristic curve consisting of 3 pairs of values. Assuming that the scale mechanics has different effects at different belt loads, a material test can be run at 25%, 50% and 75% of the load, for example. The 3 resulting correction factors can be stored in a characteristic curve with the associated percentage belt loads in DR05. Thus, the correction factor is automatically adjusted by the electronic weighing system depending on the current belt load.

The correction factor is calculated as follows:

Correction factor = reference quantity / quantity of material totalized by WP341.

This correction factor is calculated internally as follows:

Flow rate = belt load x belt speed x correction factor

Procedure

1. Reset the material test parameters with the "Reset material test (100)" command.
2. If known, specify the material test reference in DR14.
3. Start the material test with the command "Start material test (101)".
4. Convey material over the scale.
5. Stop the material test with the command "Stop material test (102)".
6. If the reference quantity is unknown, determine the weight with a reference scale and enter the reference quantity in DR14.

   ⇒ The correction factor is displayed in DR36.

7. Apply the correction factor according to DR04 with the command "Accept correction factor (104)".
8. Alternatively to step 7, you can use the "Put new correction factor into average (103)" command to convert the determined correction factor into an average value calculation.

   The electronic weighing system calculates an averaged correction factor from any number of material tests and finally copies the correction factor to DR04.
9. Repeat steps 2 to 8 (without step 7) as often as required.
10. Apply the averaged correction factor with the command "Accept correction factor (104)".

6.6 DR05 Correction curve

To further increase system accuracy, you can determine a characteristic curve consisting of 3 pairs of values.

Assuming that the scale mechanics has different effects at different belt loads, a material test can be run at 25%, 50% and 75% of the load, for example. The 3 resulting correction factors can be stored in a characteristic curve with the associated percentage belt loads in DR05. Thus, the correction factor is automatically adjusted by the WP341 depending on the current belt load.

- Correction factor curve enabled [curveEnabled]
- Belt load 1 [beltLoad1]
- Correction factor 1 [correctionFactor1]
- Belt load 2 [beltLoad2]
- Correction factor 2 [correctionFactor2]
- Belt load 3 [beltLoad3]
- Correction factor 3 [correctionFactor3]

6.7 DR06 Parameterize limits

6.7.1 Maximum negative zero setting range [zeroSettingLimitNegative] and maximum positive zero setting range [zeroSettingLimitPositive]

Zeroing sets the current weight of the scale and the belt load to zero. The specification is made in % of the nominal belt load. The range refers to the original zero point of the last calibration.

6.7.2 Minimum flow rate [minimumFlowRate]

Dropping below the minimum flow rate is displayed in the status area of the scale. The specification is made in % of the design flow rate.

6.7.3 Maximum flow rate [maximumFlowRate]

Exceeding the maximum flow rate is displayed in the status area of the scale. The specification is made in % of the design flow rate.

6.7.4 Delay time flow rate limits [delayTimeFlowRateLimits]

Reaching the maximum flow rate is displayed in the status area of the scale only following expiry of the delay. The specification is made in ms.

6.7.5 Minimum belt speed [minimumBeltSpeed]

Dropping below the minimum belt speed is displayed in the status area of the scale. The specification is made in % of the nominal belt speed which was specified during commissioning or calculated.

6.7.6 Maximum belt speed [maximumBeltSpeed]

Exceeding the maximum belt speed is displayed in the status area of the scale. The specification is made in % of the nominal belt speed which was specified during commissioning or calculated.

6.7.7 Delay time belt speed limits [delayTimeBeltSpeedLimits]

Violation of the limits for the belt speed is delayed by the specified time. The specification is made in ms.

6.7.8 Minimum belt load [minimumBeltLoad]

Dropping below the minimum belt load is displayed in the status area of the belt scale. The specification is made in % of the nominal belt load which was determined during commissioning.

6.7.9 Maximum belt load [maximumBeltLoad]

Exceeding the maximum belt load is displayed in the status area of the belt scale. The specification is made in % of the nominal belt load which was determined during commissioning.

6.7.10 Delay time belt load limits [delayBeltLoadLimits]

Violation of the limits for the belt load is delayed by the specified time. The specification is made in ms.

6.7.11 Minimum belt load for totalizing [minimumBeltLoadForTotalizing]

Totalizing is not carried out below this value. The specification is made in % of the belt load. If "0" is specified, totalizing is bidirectional.

6.8 DR07 Interface parameters

6.8.1 Digital inputs DI.0 to DI.2 [functionDI0 bis functionDI2]

Assign a command to each digital input (DI.0, DI.1, DI.2): → Commands (Page 78).

Use counter input CI optionally as a fourth digital input with its own reference potential.

Selection code [functionDI0] [functionDI1] [functionDI2]	**Function**
1 ... 32759	Command codes 1 to 32759 according to section Commands (Page 78). Triggered on transition from 0 → 1 at DI.x Example for command code 1121 → selection code = 1121

6.8.2 Filtering DI.0 to DI.2

Specify the following values for filtering the digital inputs:

Selection codes Filter DI.0 [filterDI0] Filter DI.1 [filterDI1] Filter DI.2 [filterDI2]	Function
0 (default)	No filtering
1 ... 2500 [0.1 ms]	Filtering from 0.1 to 250 ms

6.8.3 Digital output DQ.0 to DQ.2

Selection code [functionDQ0] [functionDQ1] [functionDQ2]	Function
0 ... 79	Corresponding bit of the scale status (see DR30)
80	Controlled via S7 process representation (ioData)
255 (default)	Output deactivated
1000 ... 1063	Corresponding operating error (see DR32)
1100 ... 1163	Corresponding inverted operating error (see DR32)
2000 ... 2063	Corresponding technology message (see DR32)

6.8.4 Signal logic DQ.0 to DQ.2 [signalLogicDQ0 bis signalLogicDQ2]

The parameter defines whether the output of the assigned status bit should be normal or inverted.

6.8.5 Signal logic DI.0 to DI.3 [signalLogicDI0 bis signalLogicDI2]

The parameter defines whether the function at the respective input is to be executed on a rising or a falling edge.

6.8.6 DQ monitoring [monitoringOfDQ]

The digital outputs of the electronic weighing system can be monitored for short circuits. An operating error is reported in case of short-circuit. Reporting of the error can be suppressed by the parameter.

Selection code	Function
0	Monitoring inactive
1	Monitoring active

6.8.7 Substitute value for DQ.0 to DQ.2 on error [substituteValueDQ0 to substituteValueDQ2]

An output is set in the event of a fault.

Selection code 0 is preset and resets the outputs in the event of a fault (operating error) or on a SIMATIC STOP.

Procedure

NOTICE
Risk to the plant If an output is set following a fault (operating error), this can pose a risk for the plant. Ensure that the parameters are correctly set.

1. Set the "DQ behavior on failure" parameter [behaviourOfDQOnError] to "Set substitute values": Selection code 0.
2. Assign substitute values for the event of an error or stop to the digital outputs (DQ.0, DQ.1 and DQ.2).

Selection code **[substituteValueDQ0]** **[substituteValueDQ1]** **[substituteValueDQ2]**	**Meaning**
0 (default)	Switch off output
1	Switch on output

6.8.8 Reaction to CPU stop / failure [behaviourOnCPUStopOrFailure]

Selection code	Function
0 (default)	Active output signals are switched off
1	Active output signals remain active

6.8.9 Reaction of digital outputs to a CPU stop / failure [behaviourOfDQOnCPUStopOrFailure]

Selection code	Function
0	Set substitute values
1	Retain function

6.8.10 Behavior of digital outputs on error [behaviourOfDQOnError]

Selection code	Function
0 (default)	Set substitute values
1	Retain function

6.8.11 Trace rate [traceRate]

The parameter defines in which grid the internal trace should record. The minimum recording time is 1 ms. The shorter the cycle is set, the lower the recording capacity of the trace function.

6.8.12 Trace memory mode [traceMemoryMode]

Defines the trace rate of scale data in s.

Selection code	Function
0 (default)	Ring memory
1	Stop when memory is full

6.8.13 Load per pulse [loadPerPulsRemoteTotalizer] [pulsDurationRemoteTotalizer] [pauseDurationRemoteTotalizer]

By parameterizing a corresponding digital output you can use one of the digital outputs as pulse sensor/quantity (see Digital output DQ.0 to DQ.2 (Page 59)).

In addition you must specify a load per pulse and a pulse duration for the signal. If the material flow rate is displayed e.g. in t/h, you must specify the quantity per pulse in t, or with kg/h in kg. The pulse duration is defined in ms.

Make sure when setting the parameters that you only enter plausible combinations → pulse duration > (amount per pulse / material flow rate)

6.8.14 Subnet mask, IP address, gateway, device name

Default parameter values

Subnet mask [deviceSubNetMask]: 255.255.255.0

IP address [deviceIpAddress]: 192.168.0.21

Gateway [gateway]: 192.168.0.21

Device name [deviceName]: siwarex.wp341

6.8.15 Unit Ident. Modbus connection 1 [modbusUnitIdentifier1]

The following options are available for the Modbus TCP/IP interface:

Selection code [modbusUnitIdentifier1]	Function
-1 (default)	Unit Identifier is not evaluated

Modbus TCP port connection [modbusPort]

Defines the port for the Modbus connections.

6.8.16 Modbus TCP enable connection 1 [modbusPort1]

Activates the Modbus TCP/IP protocol of the electronic weighing system.

Selection code	Modbus TCP/IP protocol connection 1/2
0 (default)	Deactivated
1	Activated

6.8.17 Byte/Word swap options [byteSwapTextFields] [byteSwap16Bit] [byteSwap32Bit] [wordSwap32Bit]

Defines the format used for transfer over the Ethernet interface (MODBUS TCP IP).

6.8.18 I/O process values 1 to 4 [ioProcessValue1 to ioProcessValue4]

You can transfer up to four selectable cyclic I/O process values from the electronic weighing system to the CPU cyclically via the I/O. The following cyclic I/O process values can be selected:

Table 2-1342 Selection table for cyclic I/O process values 1, 2, 3 and 4

Cyclic I/O process value	Selection code
No element is selected	0
Current weight	1
Current belt load	2
Current relative belt load	3
Current flow rate	4
Current relative flow rate	5
Current speed	6
Current relative speed	7
Current General Totalizer T1 (high share)	8
Current General Totalizer T1 (low share)	9
Current General Totalizer T1 (low resolution)	10
Current Main totalizer T2	11
Totalizer T3	12
Totalizer T4	13
Totalizer T5	14
Totalizer T6	15
Current CI frequency	16
Digits unfiltered	17
Digits unfiltered (linearised)	18
Digits filtered 1	19
Load cell impedance (Ohm)	20
Current load cell signal voltage (mV)	21
Current load cell SEN voltage (V)	22
Newest log ID	23
Drag indicator belt load	24
Current zero offset belt load	25
Current relative zero offset belt load	26
Stopwatch	27
Progress dynamic command	28

6.8.19 I/O process values 5 to 8 [ioProcessValue5 to ioProcessValue8]

You can transfer up to four selectable process values from the CPU to the electronic weighing system cyclically via the I/O. The following process values can be selected:

Selection code [ioProcessValue5 to ioProcessValue8]	Process values
0	Not assigned
1	Parameter/simulation value belt speed
2	Parameter belt incline angle
3	Parameter correction factor
4	Parameter/simulation value "flow rate"
5	Parameter/simulation value "belt load"

6.8.20 Hardware interrupt 1 to 8 [hardwareInterrupt1 to hardwareInterrupt8]

1. Select additional hardware interrupts for the following defined events:

Selection code [hardwareInterrupt1 to hardwareInterrupt8]	
0 ... 79	Scale status bits (see DR30)
100 ... 179	Scale status bits (see DR30) (inverted)
1000 ... 1063	Operating error (see DR32)
1100 ... 1163	Operating error (inverted) (see DR32)
2000 ... 2063	Technology messages (see DR32)
2100 ... 2163	Technology messages (inverted) (see DR32)
3000 ... 3063	Data/operating error (see DR32)
3100 ... 3163	Data/operating error (inverted) (see DR32)

2. Enable the hardware interrupts in the hardware configuration (Page 38).

6.8.21 Source for simulation values [simulationSource]

Selection code	Process values
0	Simulation value from SIMATIC peripheral process representation
1	Data record DR16

6.8.22 Signal logic hardware interrupt 1 to 8 [alarmLogic1 to alarmLogic8]

It can be defined whether the respective hardware interrupts are to be triggered on rising or falling signal edge.

6.9 DR09 Read out module information

Saves the firmware and hardware version of the electronic weighing system.

6.10 DR10 Load cell parameters

6.10.1 Load cell input [loadCellType]

Sets the connected load cell type.

Selection code	
0 (default)	Analog load cells
6	SIWAREX DB (medium speed)
7	SIWAREX DB (high speed)

6.10.2 Mains frequency [mainsFrequency]

The parameter defines the line frequency of the power supply grid. A selection between 50 Hz and 60 Hz can be made. By making the correct setting, interferences caused by the power supply grid can be better suppressed.

6.10.3 Mains frequency filter [mainsFrequencyFilterActivated]

Activates the line filter with selection code 1

Selection code	
0	Line filter deactivated
1	Line filter activated

6.10.4 4-wire / 6-wire sensor [fourSixWireSensor]

Selection code	
0	4-wire load cell
1	6-wire load cell

6.10.5 External / internal sensor supply [internalExternalAdcSupply]

Activates the external supply of the load cell with selection code 1. This may be necessary if the total impedance of all connected load cells is below the minimum permissible impedance.

6.10.6 No. of mechanical support points [numberOfSupportPoints]

The parameter is required for automatic calculation of the scale characteristic curve (command 82).

If no anchor points are used, the number of support points is equal to the number of load cells.

If anchor points are used in addition to load cells, the number of support points is equal to the total number of load cells and fixed support points.

Example

An idler is supported on a belt scale with two load cells → No. of mechanical support points = 2.

6.10.7 Averaged load cell characteristic value (mV/V) [averagedCharacteristicValue]

The load cell characteristic value is required to correctly interpret the output voltage from the load cell. When Siemens WL series load cells are used, the exact characteristic value can be read from the label on the cell. If the exact characteristic value of the utilized cell(s) is not available, a rounded value can also be specified. For scales with multiple load cells, the average of all load cell characteristic values must be calculated and entered.

Example

Characteristic value according to load cell label = 2.018 mV/V
→ Characteristic value = 2.018 mV/V

If this exact value is not known, 2.0 mV/V could also be entered.

6.10.8 Capacity of one single load cell [capacityOfOneSingleLoadCell]

The nominal load is entered in the specified weight units The parameter is required for automatic calculation of the scale characteristic curve (command 82).

6.10.9 Impedance reference (Ohm) [impedanceReference]

Impedance reference (Ohm) [impedanceReference]

The impedance reference can be determined through command 907 after successful commissioning of the electronic weighing system. After this time, the electronic weighing system automatically monitors the current impedance with the reference value. When the maximum permitted deviation is violated, a corresponding bit (impedanceError) is set in the scale status.

Maximum impedance deviation (% of impedance reference) [maximumAllowedImpedanceDeviation]

This parameter defines the maximum permissible deviation of the currently measured impedance as compared to the reference impedance. It is specified as percentage in relation to the impedance reference value.

6.10.10 Maximum impedance deviation (% of impedance reference) [maximumAllowedImpedanceDeviation]

This parameter defines the maximum permissible deviation of the currently measured load cell impedance as compared to the impedance reference. If the limit is exceeded, the electronic weighing system sets a corresponding bit in the scale status.

6.10.11 Load cell manufacturer [loadCellManufacturer] and load cell order number [loadCellOrderNumber]

- To be able to identify load cells for service operations, enter the load cell manufacturer [loadCellManufacturer] and load cell order number [loadCellOrderNumber].

6.11 DR14 Material test reference [referenceWeightForMaterialTest]

This parameter specifies the pre-weighed or post-weighed quantity of material determined during the material test on a reference scale. The input is necessary for the internal calculation of a correction factor.

6.12 DR15 Configuration of technology messages

Introduction

In DR15, it is possible to suppress the technology messages from the electronic weighing system in a targeted manner as described in section Technology messages (Page 92).

Web server procedure

1. Read DR15.
2. Select "No message" for the desired technology messages.
3. Write DR15.

TIA Portal procedure

1. Read DR15: Command code 2015.
2. Enter "false" for the desired technology messages.
3. Write DR15: Command code 4015.

6.13 DR16 Simulation

6.13.1 Simulating process values

Introduction

The basic process values of a belt scale can be simulated using an input via data record DR 16. These would be belt load, belt speed or flow rate. In addition, a ramp up and ramp down time can be defined for the speed value. All functions of the electronic weighing system behave as with the scale and speed sensor connected, which is why a complete function test is possible without any problems.

Procedure

- Enable simulation mode in DR 3
- Send command no. 3 (simulation ON) to the electronic weighing system
- Enter the belt load, speed or flow rate to be simulated in DR16
- Transfer the data record DR16 to the electronic weighing system
- Optionally, the simulation values can also be specified directly via process representation. For this purpose, process values 5 to 8 must be configured accordingly in DR7 and the source of the simulation values must be changed to SIMATIC.

6.14 DR17 Incline angle [inclineAngle]

Input of the angle is provided for belt scales where the inclination of the conveyor belt can be changed during operation. Calculation of the current belt load is corrected by entering the current angle.

The input is unnecessary if the inclination is always constant: the influence of the constant angle is compensated or automatically taken into consideration during the calibration with weights or test chain.

If the scale is automatically calibrated using the load cell parameters and if the scale is not installed exactly horizontally, you must subsequently enter the inclination angle of the belt. The input is made in degrees.

6.15 DR18 External speed value [externalSpeed]

The electronic weighing system should not determine the belt speed because the current speed is available externally in a controller, for example.

For the current belt speed to be calculated, transmit the belt speed to the electronic weighing system via the "External speed" data record.

However, it is generally recommended to specify an external speed directly via the process representation. For this purpose, a process value (process values 5 to 8) must be configured accordingly in DR7. With this variant of the specification, the permanent writing of data record 16 is not required (acyclic data record transfer).

6.16 DR28 Add user tag to log [userTag] [addLogTag]

The freely definable user tag [userTag] with 42 characters is transmitted from the CPU to the electronic weighing system. This user tag can be used for information such as batch number, material designation, license plate or similar. By setting that the user tag is to be stored in the log, it will be stored with the log impressions in the alibi memory.

Selection code [addLogTag]	Meaning
0 (default)	Do not save additional string in protocol
1	Save additional string in protocol

6.17 DR30 Scale status

Internal states and process values of the scale can be monitored using the process values. This data is not required for standard operation of the scale.

The monitoring of selected data during trial operation is extremely useful as it helps you to optimize parameters and locate errors.

DR30 contains all weight values and related status information of the electronic weighing system. All values are read-only. You can find the status information in the parameter table (https://support.industry.siemens.com/cs/ww/en/ps/7MH4138-6BA00-0CU0/dl) on the Internet. See also section: Introduction (Page 37).

NOTE

Reading of DR30 to the PLC via command is not mandatory. In DR07 Interface parameters (Page 58), the user can freely select four process variables that are transmitted automatically via the S7-I/O to the CPU and are available there. In addition, the complete scale status is always available cyclically in the I/O (see section TIA Portal user program (Page 38)) and can thus be used directly in the PLC program. At the Modbus end, the parameters and status information from DR30 are always current and the registers can therefore be read immediately.

6.18 DR31 Scale status extended

6.18.1 Drag indicator "belt load" (unfiltered) [dragIndicatorBeltLoad]

This data record provides extended process data.

- Zero setting value [zeroSettingValue]
- Zero setting value (% of Design belt load) [zeroSettingValuePerCentOfDesignLoad]
- Counter "zero settings" [counterZeroSettings]
- Counter "zero calibrations" [counterZeroCalibrations]

- Counter "span calibrations" [counterSpanCalibrations]
- Time stamp last "zero setting" [timeStampLastZeroSetting]
- Time stamp last "zero calibration" [timeStampLastZeroCalibration]
- Time stamp last "span calibration" [timeStampLastSpanCalibration]
- Time stamp "Change of correction factor DR4" [timeStampChangeInDR4]
- Time stamp "Accept new correction factor into DR4" [timeStampAcceptNewCorrectionFactor]
- Time stamp "Change of correction curve DR5" [timeStampChangeInDR5]
- Time stamp "Accept as point 1 to 3 in DR5" [timeStampNewPoint1InDR5 bis timeStampNewPoint3InDR5]

The values can only be reset via "Load factory settings".

6.19 DR32 Read out error messages

In the event of an error, the DR is read out automatically by the WP341 FB so that a connected SIMATIC HMI can generate messages accordingly. With data/operating errors and technology messages, the error bits remain for 3 seconds and do not need to be acknowledged to the electronic weighing system. Operating errors remain permanently until the error is resolved.

The individual error messages are presented and explained in detail in section Commands (Page 78). The following table is used only for breaking down the individual messages into their message bits.

6.20 DR33 Totalizers

Data record DR 33 contains the actual values of the totalizers.

Totalizing becomes active when the minimum belt load for the totalizer (parameter in DR6) has been exceeded. Command 652 can be used to stop all totalizers except T6. Command 651 starts totalizing again.

6.20.1 General Totalizer T1 [generalTotalizerT1]

This totalizer contains the total of conveyed material since commissioning of the scale. The master totalizer can only be reset by loading the factory settings. The Long-Real format is used as the data type.

6.20.2 Totalizer T2 [totalizerT2]

The totalizer contains the quantity of material transported since the last memory reset. You can reset the total using command 670 or use command 653 to first store it in the internal alibi memory and then reset it.

6.20.3 Totalizer T3 [totalizerT3], Totalizer T4 [totalizerT4], Totalizer T5 [totalizerT5]

The totalizers respond like the main totalizer T2.

You can reset the totals individually to 0 using the following commands:

- T3 using command 671 (or command 654 (log and reset))
- T4 using command 672 (or command 655 (log and reset))
- T5 using command 673 (or command 656 (log and reset))

6.20.4 Totalizer T6 [totalizerT6]

A special property of totalizer 6 is that it remains active even following the command "Stop totalizing (652)", and therefore indicates the total amount. You can therefore carry out material tests or calibrate the scale, for example, without recording the "transported material" (calibration weight, test chain) into the balance.

You can reset the totalizer T6 using command 674 (or command 656 (log and reset)).

6.21 DR34 Current display

The ASCII display value corresponds to the value on the scale's main display. The content can be controlled using display commands. If the data record is to be used in an HMI visualization, for example, the data record must be read cyclically via command.

6.21.1 Content of main display as ASCII string

Commands are used to toggle the display.

The following values can be displayed in belt scale applications:

Value	Command
Flow rate	710
Weight	715
Flow rate in %	735
Flow rate without correction	736

Value	Command
Belt load	740
Belt load in %	745
Speed	760
Speed in %	765
General Totalizer T1	771
Main totalizer T2	772
Totalizer T3	773
Totalizer T4	774
Totalizer T5	775
Totalizer T6	776
Official calibration	801
Serial number	871
Firmware version	875

6.22 DR36 Temporary data

This data record temporarily displays the results of the calibration commands. You can decide if you wish to apply the results and transfer them to the parameter set in DR 3. The new calibration results become effective following importing into the parameter set. The temporary parameters are not saved powerfail-proof.

6.22.1 Stop watch

The clock is reset when the stop watch is started, and the current time is displayed. The current time is also displayed during execution of a calibration command or when zeroing the scale.

The display is in milliseconds.

6.22.2 Progress dynamic command (%)

Display of how far a currently active, dynamic command (e.g. calibration command or zeroing) has progressed. The display is in percent. 100 % = command is completed. The display is reset to zero by starting a new command.

6.23 DR45 Protocol request

The protocol ID of the log to be displayed in data record 46 is entered here.

If the protocol ID to be read in DR45 is 0, data record DR46 is automatically written with the last created log. Thus, after a logging, DR46 can be read directly into the PLC for further processing without having to request the last log beforehand.

6.24 DR46 Read out protocol content

6.24.1 Overview

Protocol data is provided in DR46.

The protocol memory of the electronic weighing system can hold up to 1,000,976 entries.

6.24.2 Oldest protocol ID [oldestLogId]

The ID of the first saved log is displayed here.

6.24.3 Youngest protocol ID [latestLogId]

The ID of the last saved log is displayed here.

6.24.4 Selected protocol ID, numerical [selectedLogId]

The ID of the log requested in data record 45 and shown in data record 46 is displayed here.

6.24.5 Protocol string [log]

The protocol string contains the following information depending on the scale type:

Designation	Data type	Length (bytes)
Totalizer ID, for example "T2"	BYTE	2
Totalizer weight value	BYTE	11
Totalizer weight unit	BYTE	4
User tag from DR28 (if enabled)	BYTE	42

Example of a log: T2;548,7;t;quartz sand

6.24.6 Checksum, date, time

The checksums, date and time of the selected protocol are displayed here.

6.25 DR47 Read out logbook content

Changes to the firmware of the electronic weighing system are recorded in the logbook.

Scrolling in the logbook is possible using commands 881 to 883.

6.26 DR 70 SIWAREX DB parameter

The parameters which define the response in combination with SIWAREX DB are specified in data record DR 70.

If SIWAREX DB is not used, the default settings can be accepted.

Load cell input

- Enter the location designation of the respective sensor for each load cell input.

  In the event of a fault, you can identify the affected sensor.

Channels

- Activate and deactivate the individual channels of SIWAREX DB.

  For correct operation, disable unused channels.
- By factory setting, all 4 channels of SIWAREX DB are activated.

Corner load factors

- The corner load factors of the individual channels are stored in DR 70.

  The corner load factors are relevant if you have performed a corner load compensation during commissioning. The procedure for corner load compensation is described in chapter Commands (Page 78) of command codes 151 to 160.

6.27 DR 80 / DR 81 / DR 82 SIWAREX DB process status and device information

The following diagnostic bits are available for each load cell input.

- QI-flag (0 = no error on the channel; 1 = channel disturbed)
- Underload of the load cell signal
- Overload of the load cell signal
- SEN error
- Impedance error (< 330 ohms or > 4100 ohms)
- EXC short circuit
- Error power supply

In addition, the following measured values are continuously recorded for each channel and made available in the data records:

- Filtered ADC raw value
- Percentage utilization of the connected sensor
- Signal voltage in mV

The current firmware and hardware version of the SIWAREX DB can also be read out.

6.28 DR156 Security Audit Log Entry

The Security Audit Log records all logins in the web server of the electronic weighing system. In addition to the user, commands executed in the web server and data record transfers are also logged. These events may be read retrospectively in the web server or in the connected CPU via data record DR156. Command codes 922 and 923 allow to scroll forward and backward in the audit log, respectively.

The audit log can only be reset by loading the factory settings.

The following is the breakdown of the information that is transmitted to the CPU in DR156:

Event ID [eventID]
Consecutive ID that is incremented with each new event.

Date and time [dateAndTime]

Event [event]

0	Successful login
1	Unsuccessful login attempt
2	Logout by user
3	Logout by system timeout
4	Write command/data record

User number [userNumber]

0	admin - with access via local button
5	Web server user 1 from TIA Portal hardware configuration
6	Web server user 2 from TIA Portal hardware configuration
7	Web server user 3 from TIA Portal hardware configuration
8	Web server user 4 from TIA Portal hardware configuration
9	Web server user 5 from TIA Portal hardware configuration

Username [userName]

Eventinfo [eventInformation]

1 Only read rights

2 Read/write rights

3 Action completed successfully

4 Action successfully rejected

Command [command]
Command code to be executed

6.29 Commands

6.29.1 Overview

The commands for the electronic weighing system described here can be transmitted by the following interfaces:

- From the SIMATIC HMI via the SIMATIC controller to the electronic weighing system
- From the web server directly to the electronic weighing system
- Via the digital inputs after corresponding assignment in data record DR07

If an issued command is not accepted by the electronic weighing system, the cause of the rejection is always substantiated with a corresponding data/operating error.

Detailed descriptions of the commands can be found in the following tables:

→ Service commands

→ Log commands

→ Display commands

→ Scale commands

→ Other commands

See also

Commands (Page 78)

6.29.2 Commands

Table 2-1343 Service commands

Command code	Command	Description	Write protection
1	Service mode ON	Turn on service mode	
2	Service mode OFF	Turn off service mode	

Command code	Command	Description	Write protection
3	Simulation ON	Requirement: You have generally released simulation mode in DR03. Turn on test mode. The simulation value from DR16 is used instead of the measured value for calculation of the process values.	
4	Simulation OFF	Switch off test mode.	
7	Stop webserver emergency access	When emergency access of the Web server was enabled using the button on the electronic weighing system, you can end emergency access.	
11	Load factory settings	The command resets the electronic weighing system to the "ex works" status. During this process: • All parameters and saved data (including log memory, logbook, IP addresses and Modbus addresses) • All message buffers (diagnostic buffer, trace memory, etc.) are reset • A configured recovery point, if any, is overwritten by the default values.	P
12	Load standard parameters	As "Load factory settings (11)". DR07 is not reset.	P
28	Display weighing operating mode	Shows the set weighing operating mode in the display.	
31	Load recovery point	The last recovery point created with command 51 is loaded.	P
51	Create recovery point	Backs up all scale parameters as a recovery point that can then be loaded when needed using command 31.	P
60	Start zero calibration	Start the zero calibration. Requirements: WP341 correctly detects the belt speed (=speed sensor is correctly wired, pulse constant has been correctly specified or calibrated. Alternatively, at constant belt speed, a constant 24V provides the information that the belt is running or the software command code 1301 has been sent). There are no calibration weights on the belt scale & the conveyor belt runs empty. Initially, the result of the calibration is displayed temporarily in DR36 and is not yet active. After checking for plausibility, the result can be transferred to DR3 by means of command 88 and thus activated.	
61	Start span calibration (test weight)	Determine the span calibration point using the calibration weight. Requirements: Zero calibration has already been performed. The calibration weight / test weight specified in DR3 is applied to the belt scale & the conveyor belt runs empty. Initially, the result of the calibration is displayed temporarily in DR36 and is not yet active. After checking for plausibility, the result can be transferred to DR3 by means of command 89 and thus activated.	
63	Start span calibration (automatic calibration)	Automatic calibration without weights. Requirement: Zero calibration has already been performed. The load cell data are correctly specified in DR10. If the conveyor belt is not horizontal, the angle of the conveyor belt must be entered in DR17 after command 63. Initially, the result of the calibration is displayed temporarily in DR36 and is not yet active. After checking for plausibility, the result can be transferred to DR3 by means of command 89 and thus activated.	
65	Start span calibration (test chain)	Determine the span calibration point using a test chain. Requirements: Zero calibration has already been performed. The calibration load specified in DR3 is applied on the running conveyor belt in the form of a test chain.	

Command code	Command	Description	Write protection
67	Start span calibration (material batch)	Start the span calibration by material batch. Requirements: Zero calibration has already been performed. Before the material to be conveyed reaches the weighing range of the scale, the command must be sent.	
68	Stop span calibration (material batch)	Stop the span calibration using a known quantity of material. When the complete material has been conveyed over the scale and the belt runs empty again, the command must be sent.	
69	Calculate span calibration (material batch)	Calculate the span calibration point by material batch. Requirement: The quantity of material conveyed over the scale between the execution of command 67 and 68 is correctly specified in DR3. Initially, the result of the calibration is displayed temporarily in DR36 and is not yet active. After checking for plausibility, the result can be transferred to DR3 by means of command 89 and thus activated.	
70	Start speed/pulse detection	Measure the pulse constant of the speed sensor or the nominal speed. Requirement: the conveyor length must be correctly specified in DR3.	
71	Stop speed/pulse detection	Command to stop the determination of the pulse constant/speed. Note how many belt revolutions have been specified for the calibration commands in DR3. The corresponding number of revolutions must be completed before the command is sent. Initially, the result of the calibration is displayed temporarily in DR36 and is not yet active. After checking for plausibility, the result can be transferred to DR3 by means of command 85 and 87 and thus activated.	
72	Start speed measurement 'belt loaded'	Speed measurement with loaded belt. This command is only relevant for systems without speed sensor. Optionally, a speed measurement with a loaded belt can be calibrated, which then represents the characteristic curve of the actuator (loaded conveyor belt runs slower than empty belt). Requirement: the conveyor belt is running loaded.	
73	Stop speed measurement 'belt loaded'	Stops the speed measurement with loaded belt. After checking for plausibility, the result can be transferred to DR3 by means of command 86 and thus activated.	
74	Enable belt revolution detection on DI	Enable belt revolution trigger signal on a digital input. A 24V binary sensor capable of sensing belt revolution can be wired to an appropriately configured digital input. This means that the calibration commands are issued with high precision without knowledge of the length of the conveyor belt and without the belt speed having to be calibrated first.	
79	Abort calibration/zeroing/belt detection/speed measurement	Running calibration is aborted	
85	Accept (nominal) speed	Apply the speed parameters according to DR3.	
86	Accept speed parameters 'belt loaded'	Apply speed parameters (belt loaded) according to DR3.	
87	Accept pulse parameter	Apply the measured pulse constant according to DR3.	
88	Accept zero calibration digits	Apply the zero calibration digits according to DR3.	
89	Accept span calibration digits	Apply the span calibration digits according to DR3.	
93	Start stop watch		
94	Stop stop watch		

Command code	Command	Description	Write protection
100	Reset material test	Reset material test data in DR36	
101	Start material test	Start a new material test. Requirements: The scale is correctly calibrated. Before the material to be conveyed reaches the scale, the command must be sent.	
102	Stop material test	When all the material of the material test has been conveyed and the belt runs empty over the scale, the command must be sent. Afterwards, the quantity of material totalized by WP341 is temporarily available in DR36. The result of the reference scale must now be entered in DR14 (if the quantity is already known before the test, you can also enter this before starting the test). The determined correction factor is thereby temporarily output in DR36. It can then be transferred directly to DR4 via command 104 or to an average value calculation (command 103).	
103	Put new correction factor into average	Copies the correction factor currently calculated in DR36 into an average value, so that another material test can be run afterwards (commands 101 and 102), the result of which can then also be included in the average value calculation. This procedure can be repeated as often as required and finally completed with command 104.	
104	Accept correction factor	Transfers the correction factor to DR4 and calculates it with a factor that may already exist there.	
105	Accept correction factor as correction curve point 1	Transfer the averaged correction factor to DR5 as characteristic point 1	
106	Accept correction factor as correction curve point 2	Transfer the averaged correction factor to DR5 as characteristic point 2	
107	Accept correction factor as correction curve point 3	Transfer the averaged correction factor to DR5 as characteristic point 3	
151	Corner load compensation load cell input 1	Calculate the corner load factor load cell input 1 Before executing the command, place a weight (at least 10% of the rated load of the scale) over the load cell connected to channel 1 of SIWAREX DB. Then execute command 151. If you do not use the digital junction box SIWAREX DB, commands 151 - 160 are not relevant.	
152	Corner load compensation load cell input 2	Calculate the corner load factor load cell input 2 Before executing the command, place the weight already used for channel 1 over the load cell connected to channel 2 of SIWAREX DB. Then execute command 152.	
153	Corner load compensation load cell input 3	Calculate the corner load factor load cell input 3 Before executing the command, place the weight already used for channel 1 and 2 over the load cell connected to channel 3 of SIWAREX DB. Then execute command 153. If you have only two load cells connected to SIWAREX DB, proceed with command 160.	
154	Corner load compensation load cell input 4	Calculate the corner load factor load cell input 4 Before executing the command, place the weight already used for channel 1, 2 and 3 over the load cell connected to channel 4 of SIWAREX DB. Then execute command 154. Complete the corner load compensation with command 160.	
160	Corner load compensation complete	Calculate corner load factors and transfer to DR70	

Table 2-1344 Log commands

Command code	Command	Description	Write protection
401	Log general totalizer T1	Creates a log entry with general totalizer	
405	Delete log memory	Deletes the complete log memory	
443	Reset drag indicator (belt load)	Resets the drag indicator	
444	Reset zero setting counter	Resets the cycle counter of the extra coarse signal	
445	Reset zero calibration counter	Resets the cycle counter of the coarse signal	
446	Reset span calibration counter	Resets the cycle counter of the fine signal	
451	Trace ON	Start trace recording	
452	Trace OFF	Stop trace recording	
453	Single trace element	Record only one trace element	
454	Reset trace memory	Reset trace recording	
651	Enable totalizers	Activate the totalizers	
652	Disable totalizers	Switch off the totalizers	
653	Log and reset totalizer T2		
654	Log and reset totalizer T3		
655	Log and reset totalizer T4		
656	Log and reset totalizer T5		
657	Log and reset totalizer T6		
658	Log and reset totalizers T2 ... T6		
670	Reset totalizer T2		
671	Reset totalizer T3		
672	Reset totalizer T4		
673	Reset totalizer T5		
674	Reset totalizer T6		
675	Reset totalizer T3 ... T6		
676	Reset totalizers T2 ... T6		

Table 2-1345 Display commands

Command code	Command	Description	Write protection
704	Totalizer T6 (high resolution)	Increase resolution of totalizer 6 in DR33 by a factor of 100, but max. 4 decimal places.	
710	Display flow rate in DR34		
715	Display weight in DR34		
731	Display flow rate in DR34		

Command code	Command	Description	Write protection
735	Display flow rate (% of design flow rate) in DR34		
736	Display flow rate (without correction) in DR34		
740	Display belt load in DR34		
745	Display belt load (% of design load) in DR34		
760	Display speed in DR34		
765	Display speed (% of design speed) in DR34		
771	Display general totalizer T1 in DR34		
772	Display totalizer T2 in DR34		
773	Display totalizer T3 in DR34		
774	Display totalizer T4 in DR34		
775	Display totalizer T5 in DR34		
776	Display totalizer T6 in DR34		

Table 2-1346 Scale commands

Command code	Command	Description	Write protection
1001	Zero setting	Set to zero (semi-automatic)	
1002	Abort zero setting		
1003	Enable automatic zero tracking	With active zero tracking, the electronic weighing system attempts to zero as soon as it is within the defined zero setting range. If the zero setting range is exceeded during the zero setting process, the process is aborted	
1004	Disable automatic zero tracking		

Table 2-1347 Other commands

Command code	Command	Description	Write protection
907	Set impedance reference	The currently measured impedance value (DR30) is transferred to DR 3.	
910	Trigger for monitoring of Modbus communication	Starts time-based monitoring of Modbus communication	
922	Show previous security audit log entry	Display in DR156	

Command code	Command	Description	Write protection
923	Show next security audit log entry	Display in DR156	
1301	Set 'Conveyor ON'	Command to start the scale (=calculation of flow rate based on a constant belt speed), if there is no speed sensor. Alternatively, a 24V signal at the CI input can be used to start/stop the scale.	
1302	Reset 'Conveyor ON'	Command to stop the scale if there is no speed sensor. Alternatively, a 24V signal at the CI input can be used to start/stop the scale.	

6.29.3 Command groups of the electronic weighing system

You can execute the following commands: See also section: Executing commands (Page 43).

Command code	Description
1 ... 1999	The meanings of the commands correspond to the command list (see → Commands (Page 78)).
2000 + X	Reading/writing data records (Page 47)
4000 + X	Reading/writing data records (Page 47)
7001	Read all data records (7001) Read all data records from the electronic weighing system into the SIMATIC controller.
7002	Write all data records (7002) Write all data records from the SIMATIC controller into the electronic weighing system. **Requirement**: "Service mode On"

Additional information on transmission of commands from the control software by means of the SIMATIC interface is available in section TIA Portal user program (Page 38).

6.30 Communication via Modbus

6.30.1 Introduction

NOTICE

Low degree of protection against unauthorized access

If you activate the Modbus interface, you reduce protection against unauthorized access to functions and data of the electronic weighing system from outside and via the internal network.

- Observe the Security information (Page 8).

You can exchange the current process values and parameters via Ethernet with Modbus TCP/IP. You can find the Modbus address in the parameter table (https://support.industry.siemens.com/cs/ww/en/ps/7MH4138-6BA00-0CU0/dl) on the Internet. See also section: Introduction (Page 37).

The following chapters describe the specifications for handling communication. You can perform the following functions:

- Export parameters from the electronic weighing system
- Write parameters
- Export current process values
- Monitor messages

6.30.2 Principle of data transmission

This description is valid for communication via Modbus TCP/IP.

The standardized Modbus protocol is used for communication. The connected communication partner always has the master function, while the electronic weighing system is always the slave.

Data transfer is bidirectional. The connected electronic weighing system always has the master function. The master function "controls" the communication with corresponding requests to the respective electronic weighing system address (request). The electronic weighing system is always the slave and responds to the requests of the master with a response frame, provided that the address matches.

Service	Selection code	Meaning
Read Holding Registers	03	Read one or more 16-bit parameter registers
Write Single Register	06	Write a single parameter register
Write Multiple Registers	16	Write multiple registers

If a request of the master is answered by the electronic weighing system (slave), the electronic weighing system sends a response frame with or without errors. In the case of a response without error message, the response frame contains the received selection code; in the case of errors, the highest bit of the selection code is set. This corresponds to the Modbus standard. Afterwards, the master requests DR32 to check which process-related data or command errors exist.

6.30.3 Data record concept

The register assignment is an image of the data records. The chapter → Parameter assignment/addressing (Page 37) describes the data records, variables and functions, including the register addresses. The data records are always checked as complete data packets for plausibility. For this reason, you must follow a specific procedure to change individual parameters.

6.30.4 Command mailboxes

Corresponding command codes must be sent in order to start commands and to read and write data records in the Modbus buffer memories. These are described in more detail in section → Commands (Page 78). The following tables list the Modbus registers used to process these commands:

Table 2-1348 Command mailbox 1: Highest priority

Variable	Note	Type	Modbus registers
CMD1_CODE	Code of command to be executed	USHORT	910
CMD1_TRIGGER	Trigger for starting the command	USHORT	911
CMD1_STATUS	0=job running; 1=job finished (1 cycle)	USHORT	912
CMD1_QUIT	0=no error; <>0=error code	USHORT	913

Table 2-1349 Command mailbox 2: Average priority

Variable	Note	Type	Modbus registers
CMD2_CODE	Code of command to be executed	USHORT	920
CMD2_TRIGGER	Trigger for starting the command	USHORT	921
CMD2_STATUS	0=job running; 1=job finished (1 cycle)	USHORT	922
CMD2_QUIT	0=no error; <>0=error code	USHORT	923

Table 2-1350 Command mailbox 3: Low priority

Variable	Note	Type	Modbus registers
CMD3_CODE	Code of command to be executed	USHORT	930
CMD3_TRIGGER	Trigger for starting the command	USHORT	931
CMD3_STATUS	0=job running; 1=job finished (1 cycle)	USHORT	932
CMD3_QUIT	0=no error; <>0=error code	USHORT	933

6.30.5 Reading registers

The method for reading registers depends on whether they belong to the writable data records (DR03 to DR29) or can only be read as current values (DR30 to DR39).

If you wish to read the registers from the data records DR03 to DR29, you must first export these as a complete data record to the internal output buffer.

All Modbus registers of the individual parameters can be found in section → Parameter table (https://support.industry.siemens.com/cs/ww/en/ps/17252/dl).

Example

A parameter is to be read from DR03.

- First, write register CMD3_CODE with 2003 (2000 plus the number of the data record = read data record).
- Then write CMD3_TRIGGER with "1". The DR 3 is then updated in the Modbus buffer memory.
- It is now possible to read one or more registers with the corresponding variable(s). The data consistency of the registers read at this time is guaranteed.

You can find all other command codes in section → Commands (Page 78).

Example

A current measured value is to be read out from DR30.

⇒ The register can be directly requested because its contents are automatically refreshed in the electronic weighing system at the specified measuring rate of 1000 Hz and are always available up-to-date.

6.30.6 Writing registers

If you wish to write registers from the data records DR03 to DR29, you must first export the corresponding data record to the internal output buffer using an appropriate command. Individual registers can then be written. The complete data record must subsequently be written internally using an appropriate command. A plausibility check of the complete data record is carried out in the process.

Example

A parameter from DR03 is to be written.

- First, write register CMD3_CODE with 2003 (2000 plus the number of the data record).
- Then write CMD3_TRIGGER with "1". The DR03 is then updated in the Modbus memory.
- It is now possible to write or modify one or more registers with the corresponding variable. If you want to transfer the written/changed register to the scale, you need to write the entire data record:
- First, write register CMD3_CODE with 4003 (4000 plus the number of the data record = write data record).
- Then write CMD3_TRIGGER with "1".
- The data record is then transferred to the process memory in the electronic weighing system. All registers of the data record are checked for plausibility in the process.

If the plausibility check fails, the complete data record is not written and a message is output to the user (from the area of data/operator errors).

You can find all other command codes in section → Commands (Page 78).

A document for working with the electronic weighing system and Modbus is also available online →Modbus communication of WP231 (https://support.industry.siemens.com/cs/ww/en/view/77913998).

Service and maintenance 7

NOTE

The device is maintenance-free.

7.1 Disposal

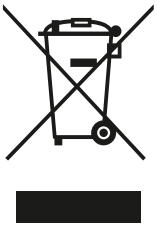

Devices described in this manual should be recycled. They may not be disposed of in the municipal waste disposal services according to the Directive 2012/19/EC on waste electronic and electrical equipment (WEEE).

Devices can be returned to the supplier within the EC, or to a locally approved disposal service for eco-friendly recycling. Observe the specific regulations valid in your country.

Further information about devices containing batteries can be found at: Information on battery/product return (WEEE) (https://support.industry.siemens.com/cs/document/109479891/)

NOTE

Special disposal required

The device includes components that require special disposal.

- Dispose of the device properly and environmentally through a local waste disposal contractor.

Interrupts/diagnostic messages 8

8.1 Message and error types

Three types are distinguished:

Operating errors

Operating errors can occur spontaneously at any time due to an unforeseen event. They include internal and external hardware problems which can occur spontaneously during weighing, e.g. wire break of the load cell cable.

Data and command errors

Data and command errors arise always as response to a command or a data record transfer.

A data error occurs when a plausibility error is identified in a data record sent to the electronic weighing system, causing the electronic weighing system to refuse acceptance of the data record.

A command error occurs when the electronic weighing system cannot execute the issued command in its current operating state.

For most data/command errors, the electronic weighing system outputs additional information for the error. This includes further details about the error and is described in detail in the error list in this section.

Technology messages

Technology messages occur spontaneously due to the process flow of a weighing/dosing operation. Messages provide information to the operator and have no further effect on the dosing operation.

8.2 Evaluating errors/messages using the Web server

The electronic weighing system has a message buffer that stores the last 100 entries including time stamp in non-volatile memory. If the number of messages in the message buffer exceeds 100, the oldest entry is overwritten. The message buffer can be read out at any time using the Web server (menu item "Read out all data records") and saved together with the scale parameters. This facilitates the detection, analysis and correction of errors in the system. The only way to completely clear the message buffer is with the "Load factory settings (11)" command. The message buffer is opened in the web server via the following icon:

8.3 Evaluating errors/messages using the FB

In the event of an error, the function block reads out DR32 automatically. Data/operating errors and technology messages are reported for 3 s. Operating errors remain permanently until the cause is resolved.

8.4 Operating errors

Operating errors	Error code	Description and remedy
Operation error existent	1000	Group message, there is at least one operating error.
Watch dog	1001	Watchdog error. A serious error has occurred in the function of the electronic weighing system. Contact SIWAREX Support if the error continues to occur.
Checksum error (Parameter)	1003	The checksum of the parameters no longer matches. Remedy: Load factory settings. Contact SIWAREX Support if the error continues to occur.
Checksum error (Firmware)	1004	The checksum of the electronic weighing system FW no longer matches. Remedy: Load factory settings. Contact SIWAREX Support if the error continues to occur.
Logbook full / defective	1006	Error when writing/clearing the logbook. Remedy: Load factory settings. Contact SIWAREX Support if the error continues to occur.
No communication to the digital load cell or SIWAREX DB	1110	Communication to digital load cell or digital junction box SIWAREX DB is interrupted. Check the following: • SIWAREX DB <-> SIWAREX WP wiring • Terminators and address of SIWAREX DB (see operating instructions of SIWAREX DB) • Communication speed in DR10
ADC error	1102	AD converter error when reading the measured value. Remedy: Check and follow recommendations for installation meeting EMC requirements (section EMC-compliant installation (Page 14)).
SENSE voltage too low	1104	Undervoltage on the SENSE cables. A voltage between 4.85 V DC and 10 V DC must be present between SEN+ and SEN-. If necessary, check the wiring of the load cells or, in the case of 4-wire load cells, the wire jumpers between EXC+&SEN+ and EXC-&SEN- in the terminal box.
SIG voltage too high (overload)	1105	The maximum SIG input signal of the AD converter has been exceeded by more than 10%. Check the wiring of the load cell(s). If the wiring is correct, check the input and output resistances of the load cells. By checking the resistors, you can find out whether one or more load cells are defective.
SIG voltage too low (underload)	1106	The minimum SIG input signal of the AD converter has been undershot by more than 10%. Check the wiring of the load cell(s). If the wiring is correct, check the input and output resistances of the load cells. By checking the resistors, you can find out whether one or more load cells are defective.

Operating errors	Error code	Description and remedy
SecureDisplay not connected / visible	1107	The calibratable main display (SIWAREX SecureDisplay on SIMATIC HMI) no longer communicates with the electronic weighing system • Check the wiring between the SIMATIC HMI and the CPU or the electronic weighing system and the SIMATIC controller. • Check the IP addresses of the network components
DQ short circuit to ground	1111	Error at digital outputs (short-circuit to ground)
Underload load cell input 1	1201	SIWAREX DB –The minimum input signal of load cell input 1 has been underrun. Check the wiring and the load cell.
Underload load cell input 2	1211	SIWAREX DB –The minimum input signal of load cell input 2 has been underrun. Check the wiring and the load cell.
Underload load cell input 3	1221	SIWAREX DB –The minimum input signal of load cell input 3 has been underrun. Check the wiring and the load cell.
Underload load cell input 4	1231	SIWAREX DB –The minimum input signal of load cell input 4 has been underrun. Check the wiring and the load cell.
Overload load cell input 1	1202	SIWAREX DB –The maximum input signal of load cell input 1 has been overrun. Check the wiring and the load cell.
Overload load cell input 2	1212	SIWAREX DB –The maximum input signal of load cell input 2 has been overrun. Check the wiring and the load cell.
Overload load cell input 3	1222	SIWAREX DB –The maximum input signal of load cell input 3 has been overrun. Check the wiring and the load cell.
Overload load cell input 4	1232	SIWAREX DB –The maximum input signal of load cell input 4 has been overrun. Check the wiring and the load cell.
Error SENSE voltage load cell input 1	1203	SIWAREX DB –The minimum permissible sense voltage of load cell input 1 has been underrun. Check the wiring and the load cell.
Error SENSE voltage load cell input 2	1213	SIWAREX DB –The minimum permissible sense voltage of load cell input 2 has been underrun. Check the wiring and the load cell.
Error SENSE voltage load cell input 3	1223	SIWAREX DB –The minimum permissible sense voltage of load cell input 3 has been underrun. Check the wiring and the load cell.
Error SENSE voltage load cell input 4	1233	SIWAREX DB –The minimum permissible sense voltage of load cell input 4 has been underrun. Check the wiring and the load cell.
Impedance error load cell input 1	1204	SIWAREX DB – The impedance at load cell input 1 is out of permitted range (< 330 ohms or > 4100 ohms)
Impedance error load cell input 2	1214	SIWAREX DB – The impedance at load cell input 2 is out of permitted range (< 330 ohms or > 4100 ohms)
Impedance error load cell input 3	1224	SIWAREX DB – The impedance at load cell input 3 is out of permitted range (< 330 ohms or > 4100 ohms)
Impedance error load cell input 4	1234	SIWAREX DB – The impedance at load cell input 4 is out of permitted range (< 330 ohms or > 4100 ohms)
EXC short circuit load cell input 1	1205	SIWAREX DB – Short circuit on load cell supply (excitation) at load cell input 1. Check the wiring and the load cell.
EXC short circuit load cell input 2	1215	SIWAREX DB – Short circuit on load cell supply (excitation) at load cell input 2. Check the wiring and the load cell.
EXC short circuit load cell input 3	1225	SIWAREX DB – Short circuit on load cell supply (excitation) at load cell input 3. Check the wiring and the load cell.
EXC short circuit load cell input 4	1235	SIWAREX DB – Short circuit on load cell supply (excitation) at load cell input 4. Check the wiring and the load cell.

Operating errors	Error code	Description and remedy
Error power supply load cell input 1	1206	SIWAREX DB – Error on the power supply of load cell input 1
Error power supply load cell input 2	1216	SIWAREX DB – Error on the power supply of load cell input 2
Error power supply load cell input 3	1226	SIWAREX DB – Error on the power supply of load cell input 3
Error power supply load cell input 4	1236	SIWAREX DB – Error on the power supply of load cell input 4
Check sum error SIWAREX DB	1250	SIWAREX DB – Check sum error. If restarting the SIWAREX DB does not solve the problem, please contact the SIWAREX hotline.
Watchdog error SIWAREX DB	1251	SIWAREX DB – Check sum error. If restarting the SIWAREX DB does not solve the problem, please contact the SIWAREX hotline.
ADC error SIWAREX DB	1252	SIWAREX DB – AD converter error. If restarting the SIWAREX DB does not solve the problem, please contact the SIWAREX hotline.
FW update error SIWAREX DB	1254	SIWAREX DB – Firmware update failed

8.4.1 Technology messages

Table 2-1351 Technology messages

Technology messages	Error code	Description and remedy
Technology error existent	2000	Group message, at least one technology message is present
Totalizing error	3001	Error during totalizing
Trace overloaded	2002	Trace recorder cannot record in the cycle time requested in DR7.
Zero setting procedure aborted	2003	Zero setting procedure was aborted because the specified zero setting limits were exceeded.
Trace memory full	2004	Internal trace memory is full and not configured as ring memory (DR7)
Reboot after power reset	2005	Restart of electronic weighing system after power failure
Download error	2006	Firmware download was aborted because the connection to the S7 CPU is disturbed or because a download process is already active.
Calibration aborted	3002	Zero or span calibration aborted because the values determined were out of the permitted range.
Backup created	2094	Backup file successfully created in the web interface.
Backup loaded	2095	Backup file successfully loaded in the web interface.
Firmware file invalid	2007	Loaded firmware file is invalid.
Modbus communication timeout	2104	The communication to a Modbus partner is disturbed.
Recovery point created	2096	Module internal recovery point set successfully.
Recovery point loaded	2097	Module internal recovery point loaded successfully.
Standard parameters loaded	2098	Standard parameters (all data records except DR7) were loaded successfully.
Factory settings loaded	2099	Factory settings were loaded successfully.
Logging not possible	2112	Logging not possible because the necessary conditions are not met (e.g. totalizers are active)

Technology messages	Error code	Description and remedy
Log error	2115	Error while reading a log from the log memory.
Log memory full	2124	Module internal log memory is full.
Please recalibrate the scale	2126	Please perform a zero and span calibration again, since a new corner load compensation has been performed in the meantime.

8.4.2 Data and command errors

Data and command errors	Error code [errorCode]	Description
Data or command error	5000	A data or command error exists.
Command not known	6050	The executed command number is not known.
Command not possible now	6051	The corresponding additional info can be found in the table "Additional info".
Error service command	6052	The corresponding additional info can be found in the table "Additional info".
Error calibration command	6053	The corresponding additional info can be found in the table "Additional info".
Error scale command	6054	The corresponding additional info can be found in the table "Additional info".
Error trace/ protocol/ log-ging/security audit command	6056	The corresponding additional info can be found in the table "Additional info".
Data record not known	7050	
Parameter input not possible	7051	The corresponding additional info can be found in the table "Additional info".
Parameter input not possible - write protection is set	7052	
Parameter error "Calibration Parameter" DR03	7053	The corresponding additional info can be found in the table "Additional info".
Parameter error "Correction factor" DR04	7054	The corresponding additional info can be found in the table "Additional info".
Parameter error "Correction Curve" DR05	7055	The corresponding additional info can be found in the table "Additional info".
Parameter error "Limits" DR06	7056	The corresponding additional info can be found in the table "Additional info".
Parameter error "process interfaces" DR07	7057	The corresponding additional info can be found in the table "Additional info".
Parameter error "Limits" DR06	7056	The corresponding additional info can be found in the table "Additional info".
Parameter error "process interfaces" DR07	7057	The corresponding additional info can be found in the table "Additional info".
Parameter error "Load Cell Parameters" DR10	7059	The corresponding additional info can be found in the table "Additional info".
Parameter error "Scale type" DR11	7060	The corresponding additional info can be found in the table "Additional info".

Data and command errors	Error code [errorCode]	Description
Parameter error "RS485" DR13	7061	The corresponding additional info can be found in the table "Additional info".
Parameter error "Correction factor reference" DR14	7062	The corresponding additional info can be found in the table "Additional info".
Parameter error "Configuration of technology messages" DR15	7063	The corresponding additional info can be found in the table "Additional info".
Parameter error "Simulation" DR16	7064	The corresponding additional info can be found in the table "Additional info".
Parameter error "Additional strings" DR28	7066	The corresponding additional info can be found in the table "Additional info".
Error during log request DR45	7067	The corresponding additional info can be found in the table "Additional info".
Parameter error "SIWAREX DB" DR70	7069	The corresponding additional info can be found in the table "Additional info".
Parameter error "Incline Angle" DR17	7070	The corresponding additional info can be found in the table "Additional info".
Parameter error "External speed value" DR18	7071	The corresponding additional info can be found in the table "Additional info".

8.4.3 Add info [errorAddInfo] for DR03

Additional information is available for most data/command errors. The cause of the error is described in detail with this information. If a data/command error bit is set, the additional information is also filled accordingly. Thus, the error bits and the additional information must be evaluated together in the program to identify the exact cause of the error.

If additional information not listed above appears for a data/operating error bit, it is a parameter ID. This defines the exact parameter that caused the error.

The following table presents the association between the parameter and parameter ID.

Table 2-1352 Add info [errorAddInfo] for DR03

Parameter	Add info [errorAddInfo]
Scale name	302
Metrological mode	303
Measurement units for load and speed	304
Measurement unit for flow rate	305
Scale interval of weight and belt load	306
Totalization and flow rate interval (totalizers T1..T2)	307
Totalization interval (totalizers T3..T6)	308
Design flow rate	309
Weigh length	310
Belt length (1 complete revolution)	311
Number of belt revolutions for calibration	312
Speed input	313

Parameter	Add info [errorAddInfo]
Design speed	314
Speed factor under load	315
Load at 'Speed factor under load'	316
Speed sensor pulses	317
Zero calibration digits	318
Span calibration digits	319
Calibration weight (test weight)	320
Calibration load (test chain)	321
Calibration quantity (material test)	322
Simulation	323
Load simulation	324
Speed simulation	325
Flow rate simulation	326
Incline angle simulation	327
Operating mode	340
SecureDisplay interface	341
Stringheader FW-Version SecureDisplay	342
Version SecureDisplay	343
Smallest zoom factor of SecureDisplay (%)	344
Belt load signal filter	350
Speed signal filter	351
Warm-up time	345

8.4.4 Add info [errorAddInfo] for DR04, DR05 and DR06

Table 2-1353 Add info [errorAddInfo] for DR04, DR05 and DR06

Parameter	Add info [errorAddInfo]
Correction factor	401
Correction Curve (DR5)	500
Correction curve parameter	501
Correction factor curve enabled	502
Belt load 1	519
Correction factor 1	520
Belt load 2	521
Correction factor 2	522
Belt load 3	523
Correction factor 3	524
Maximum negative zero setting range	601
Maximum positive zero setting range	602

Parameter	Add info [errorAddInfo]
Minimum totalized load	603
Minimum flow rate	604
Maximum flow rate	605
Delay time flow rate limits	606
Minimum belt speed	607
Maximum belt speed	608
Delay time belt speed limits	609
Minimum belt load	610
Maximum belt load	611
Delay time belt load limits	612
Minimum belt load for totalizing	614

8.4.5 Add info [errorAddInfo] for DR07

Table 2-1354 Add info [errorAddInfo] for DR07

Parameter	Add info [errorAddInfo]
Substitute value on error / CPU-Stop DQ.0	715
Substitute value on error / CPU-Stop DQ.1	716
Substitute value on error / CPU-Stop DQ.2	717
Behavior on CPU stop / failure	723
DQ behavior on CPU stop / failure	724
DQ behavior on failure	725
Trace rate	731
Trace settings	732
Trace memory mode	733
Load per pulse (remote totalizer)	749
Pulse duration (remote totalizer)	750
Pause duration (remote totalizer)	751
IP address x.n.n.n	758
IP address n.x.n.n	759
IP address n.n.x.n	760
IP address n.n.n.x	761
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Subnetmask n.n.x.n	764
Subnetmask n.n.n.x	765
Gateway x.n.n.n	766
Gateway n.x.n.n	767
Gateway n.n.x.n	768

Parameter	Add info [errorAddInfo]
Gateway n.n.n.x	769
Device name	771
Unit Ident. Modbus connection 1	772
Modbus TCP Port number connection 1	773
Modbus connection #1	774
Enable connection	775
Byte swap for text fields	783
Byte swap for 16 bit tags	784
Byte swap for 32 bit tags (1 # 2, 3 # 4)	785
Word swap for 32 bit tags (1, 2 # 3, 4)	786
Unit Ident. Modbus connection 2	791
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Word swap for 32 bit tags (1, 2 # 3, 4)	805
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Hardware interrupt 2	819
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Hardware interrupt 4	821
Hardware interrupt 5	822
Hardware interrupt 6	823
Hardware interrupt 7	824
Hardware interrupt 8	825
Source for simulation values	827
Signal logic alarm 1	849
Signal logic alarm 2	850
Signal logic alarm 3	851
Signal logic alarm 4	852

Parameter	Add info [errorAddInfo]
Signal logic alarm 5	853
Signal logic alarm 6	854
Signal logic alarm 7	855
Signal logic alarm 8	856

8.4.6 Add info [errorAddInfo] for DR10, DR11, DR14, DR16, DR17, DR18 and DR28

Table 2-1355 Add info [errorAddInfo] for DR10, DR11, DR14, DR16, DR17, DR18 and DR28

Parameter	Add info [errorAddInfo]
Load cell input	1001
AD converter settings	1002
Mains frequency	1003
Mains frequency filter	1004
Load cell parameter	1019
4-wire / 6-wire sensor	1020
External / internal sensor excitation	1021
No. of mechanical support points	1036
Averaged load cell characteristic value (mV/V)	1038
Capacity of one single load cell	1039
Impedance reference (Ohm)	1040
Maximum impedance deviation (% of impedance reference)	1041
Load cell manufacturer	1044
Load cell order number	1046
Scale type	1101
Reference weight of material test	1401
Belt load	1619
Speed	1620
Flow rate	1621
Incline angle	1622
Ramp up time speed	1623
Ramp down time speed	1624
Simulation configuration	1601
Incline angle	1701
External speed value	1801
User tag	2802
Add user tag to log	2804
Log memory mode	2806

8.4.7 Add info [errorAddInfo] for DR30

Table 2-1356 Add info [errorAddInfo] for DR30

Parameter	Add info [errorAddInfo]
Log-ID	4501
Year	4801
Month	4802
Day	4803
Hour	4804
Minute	4805
Second	4806
Millisecond	4807
Day of the week	4808
Location designation sensor 1	7006
Location designation sensor 2	7008
Location designation sensor 3	7010
Location designation sensor 4	7012
Load cell input 1	7014
Load cell input 2	7015
Load cell input 3	7016
Load cell input 4	7017

8.4.8 Add info [errorAddInfo] starting DR70

Table 2-1357 Add info [errorAddInfo] starting DR70

Parameter	Add info [errorAddInfo]
Corner load factor load cell input 1	7051
Corner load factor load cell input 2	7052
Corner load factor load cell input 3	7053
Corner load factor load cell input 4	7054
Belt is running	9501
Belt is not running	9502
Action not possible because an already active action is still in progress	9507
CPU failed or not ready (STOP)	9514
Command not possible because of current parameter setting	9682
Command not executable because totalizing is active	9683
Command not executable because no corner load compensation was performed at load cell input 1	9684
Command not executable because no corner load compensation was performed at load cell input 2	9685

Parameter	Add info [errorAddInfo]
Command not executable because no corner load compensation was performed at load cell input 3	9686
Command not executable because no corner load compensation was performed at load cell input 4	9687
Command not executable because the corner load compensation cannot be calculated. If necessary, use heavier weight for corner load compensation.	9688
Service mode is not active	9510
Write protection is enabled	9511
Enable is missing	9512
Calibration not finished completely	9522
Distance between calibration digits is too small. Please use a heavier calibration weight	9520
Sequence of calibration points is not correct	9521
Calibration digits out of valid range	9523
Calibration weight must not be zero	9524
Command in simulation mode not possible	9527
New parameters are not plausible	9534
Process cannot be completed, because it was not started.	9508
Service mode is still active	9513
In this scale operation mode not possible	9515
Module disturbed	9500
Trace memory full	9550
Log memory full	9551
Logging task is busy	9552
Logbook / security audit logging contains no or no more entries	9554
Number of belt revolutions is too small	9535
Totalizers error had occurred	9536

8.5 Diagnostic messages

8.5.1 Error codes and corrective measures

Diagnostic results are displayed as plain text in STEP 7 (TIA Portal) via the online and diagnostic message view. Evaluate the error codes by means of the user program.

Error code	Message	Cause/Remedy
9_H	No supply voltage L+	An internal error has occurred. Possible cause: Electronic weighing system faulty. • Check the wiring of the 24 V connection on the BaseUnit. • Check the 24 V supply voltage.

Error code	Message	Cause/Remedy
10_H	Short circuit (EXC +/-)	Short-circuit at the load cell supply (EXC +/-). • Check the wiring of the load cells.
124_H	Undervoltage (SEN +/-)	The returned SEN voltage of the load cells is too low (< 5 V DC) • Check the wiring of the load cells. • Check the set load cell type; 4- or 6-conductor load cell type
7_H	Overload (SIG +/-)	The signal voltage of the load cells is ≥ +120% of the permissible range. • Check the wiring of the load cells. • Check the scale mechanics.
8_H	Underload (SIG +/-)	The signal voltage of the load cells is ≥ -+120% of the permissible range. • Check the wiring of the load cells. • Check the scale mechanics.
106_H	DQ short-circuit to ground	Short-circuit to ground at one of the digital outputs. • Check the wiring. • Check the connected actuator.

Reactions to a diagnostic interrupt

The following happens when an event occurs that triggers a diagnostic interrupt:

- The DIAG LED flashes red.

  When you have eliminated all errors, the DIAG LED stops flashing red and turns green.
- The S7-1500 CPU interrupts the processing of the user program. The diagnostic interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.
- The S7-1500 CPU remains in RUN even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible despite the error.

You can obtain detailed information on the error event in the error organization block with instruction "RALRM" (Read additional alarm information), in the information system of STEP 7 and in function manual Diagnostics (https://support.industry.siemens.com/cs/ww/en/view/59192926), section "System diagnostics in user program".

If the module is being operated as a distributed module in an ET 200SP system with PROFIBUS DP, you have the option of reading out diagnostic data with the RDREC or RD_REC instruction using data record 0 and 1. You can find the structure of the data records in the manual for the IM 155-6 DP HF interface module available for download on the Internet (https://support.industry.siemens.com/cs/ww/de/view/73098660).

8.5.2 Meaning of the LEDs

The following figure shows the LEDs (status and error displays) of the electronic weighing system.

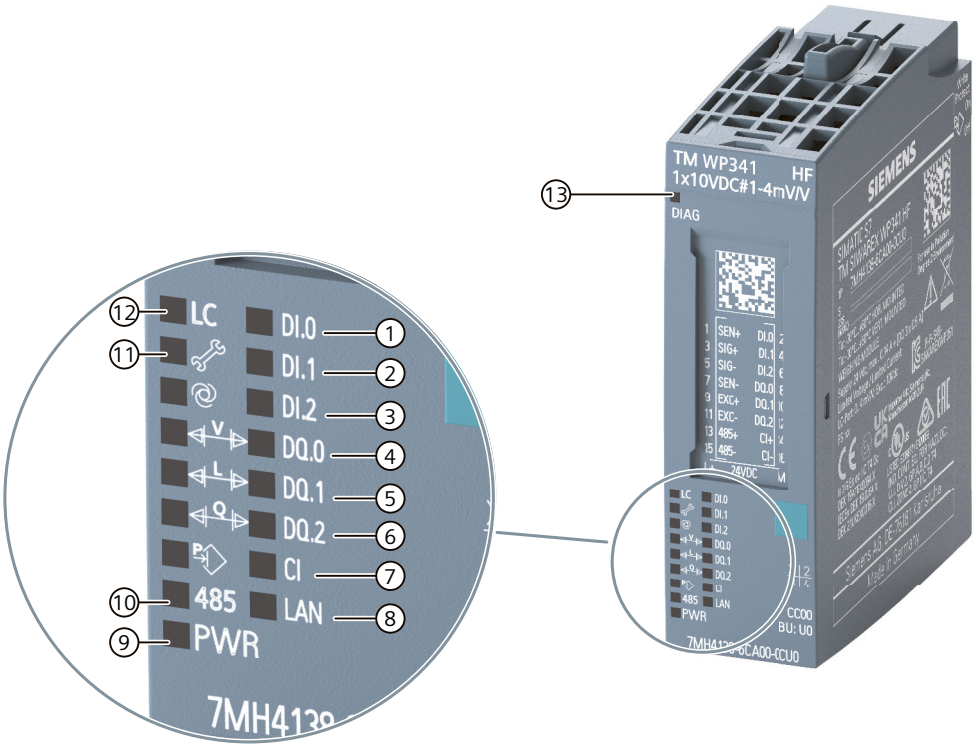

Figure 2-1207 LEDs on the electronic weighing system

Table 2-1358 Legend

LEDs			Meaning	Solution
1	DI.0	green/ off	Input is not active	-
		green/ on	Input is active	-
2	DI.1	green/ off	Input is not active	-
		green/ on	Input is active	-
3	DI.2	green/ off	Input is not active	-
		green/ on	Input is active	-
4	DQ.0	green/ off	Output is not active	-
		green/ on	Output is active	-
		green/ flashing	Fault at DQ.0, 1 or 2	• Check the wiring of the outputs.
	DQ.1	green/ off	Output is not active	-

LEDs			Meaning	Solution
⑤	DQ.1	green/ on	Output is active	-
		green/ flashing	Fault at DQ.0, 1 or 2	• Check the wiring of the outputs.
⑥	DQ.2	green/ off	Output is not active	-
		green/ on	Output is active	-
		green/ flashing	Fault at DQ.0, 1 or 2	• Check the wiring of the outputs.
⑦	CI	green/ off	Input is not active	-
		green/ on	Input is active	-
⑧	LAN	green/ off	No Ethernet connection	-
		green/ on	Ethernet connection established	-
		green/ flashing	Ethernet connection is active	-
⑨	PWR	green/ off	No supply voltage L+	• Check the supply voltage. • Check the BaseUnit type and the wiring of the BaseUnit.
		green/ on	Supply voltage L+ present and OK	-
⑩	485	green/ off	Serial communication is not active	-
		green/ on	Serial communication is active	-
⑪		yellow/ off	Service mode is not active	-
		yellow/ on	Local Web server access is enabled	-
		yellow/ flashing	Service mode is active	-
⑫	LC Load cell	green/ off	Sensor connection faulty	Check the wiring of the load cells.
		green/ on	Sensor connection OK	-
⑬	DIAG	green/ off	Backplane bus supply of the ET 200SP not OK	Check or switch on the supply voltage on the interface module.
		green/ flashing	Electronic weighing system not parameterized	-
		green/ on	Electronic weighing system parameterized and no diagnostics	-
		red/ flashing	Electronic weighing system parameterized, there is at least one error.	Evaluate the diagnostic alarms and eliminate the error.

Corrective measures for diagnostics alarms can be found in section Diagnostic messages (Page 100).

8.6 Hardware interrupts

Introduction

Configure in DR07 which events during operation are to trigger a hardware interrupt. In addition, the corresponding hardware interrupt must be enabled in the hardware configuration by the electronic weighing system in TIA Portal.

What is a hardware interrupt?

In accordance with the parameters assigned, the electronic weighing system triggers a hardware interrupt when certain events or states occur.

When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the associated hardware interrupt organization block (OB). The event that triggered the interrupt is entered in the start information of the assigned hardware interrupt OB by the CPU.

Hardware interrupt lost

If the previous event was not yet processed, "Hardware interrupt lost" is triggered.

Technical data

9

Article number	7MH4138-6CA00-0CU0
General information	
Product type designation	TM SIWAREX WP341 HF
HW functional status	1
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type U0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Adjustment of measuring range	Yes; ±0 ... 4 mV/V
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V16
• STEP 7 configurable/integrated from version	- / -
• PROFIBUS from GSD version/GSD revision	GSD as of Revision 5
• PROFINET from GSD version/GSD revision	GSDML V2.34
Supply voltage	
Load voltage L+	
• Rated value (DC)	24 V
• permissible range, lower limit (DC)	19.2 V
• permissible range, upper limit (DC)	28.8 V
• Short-circuit protection	Yes
• Reverse polarity protection	Yes
Input current	
Current consumption, max.	140 mA; Without DQ
Power	
Power available from the backplane bus	94.5 mW
Power loss	
Power loss, typ.	1.7 W
Address area	
Address space per module	
• Inputs	32 byte
• Outputs	32 byte

Article number	7MH4138-6CA00-0CU0
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	type B
Digital inputs	
Number of digital inputs	3
Digital inputs, parameterizable	Yes
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Input voltage	
• Type of input voltage	24 V DC
• Rated value (DC)	24 V
• for signal "0"	< 5 V DC
• for signal "1"	+11 to +30V
• permissible voltage at input, min.	-30 V
• permissible voltage at input, max.	30 V
Input current	
• for signal "1", typ.	1.6 mA
Input delay (for rated value of input voltage)	
for technological functions	
– parameterizable	Yes
Cable length	
• shielded, max.	500 m
• unshielded, max.	150 m
Digital outputs	
Number of digital outputs	3
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes
Digital output functions, parameterizable	
• Freely usable digital output	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A
Output voltage	
• Type of output voltage	DC
Output delay with resistive load	
• "0" to "1", typ.	20 µs
• "1" to "0", typ.	30 µs

Article number	7MH4138-6CA00-0CU0
Parallel switching of two outputs	
• for uprating	No
Switching frequency	
• with resistive load, max.	500 Hz
Total current of the outputs	
• Current per channel, max.	0.5 A; the total current of all outputs ≥ 0.6 A, the ambient temperature is reduced by -1 °C per 100 mA
• Current per module, max.	1.5 A; Observe derating
Cable length	
• shielded, max.	500 m
• unshielded, max.	150 m
Encoder	
Connection of signal encoders	
• For strain gauges (full bridges) with 4-conductor connection	Yes
• For strain gauges (full bridges) with 6-conductor connection	Yes
• Resistance of full bridge, min.	56 Ω; when using SIWAREX IS 87 ohm for 7MH4710-5BA; 180 ohm when using 7MH4710-5CA
• Resistance of full bridge, max.	4 100 Ω
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.001 %
Error limit according to DIN 1319-1	0.002 %; of full-scale value
Accuracy class	III
Temperature coefficient, zero point	≤ ±0.015 µV/K
Temperature coefficient, span	≤ ±5 ppm/K
1. Interface	
Interface types	
• RS 485	Yes; Terminated internally with 390 Ω / 220 Ω / 390 Ω
2. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; 10/100 Mbit/s
• Number of ports	1
Protocols	
• IP protocol	Yes; IPv4
• Web server	Yes
Interface types	
RJ 45 (Ethernet)	
• Autonegotiation	Yes

Article number	7MH4138-6CA00-0CU0
• Autocrossing	Yes
RS 485	
• Transmission rate, max.	115.2 kbit/s
• Cable length, max.	1 000 m; ≤ 115 kbps, shielded cable
Protocols	
Web server	
• HTTP	Yes
• HTTPS	Yes
Interrupts/diagnostics/status information	
Diagnostics function	Yes; Diagnostic alarm
Substitute values connectable	No
Alarms	
• Diagnostic alarm	Yes; Parameterizable
• Hardware interrupt	Yes; Parameterizable
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• Group error	Yes; green/red DIAG LED
Diagnostics indication LED	
• ERROR LED	Yes; green/red DIAG LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
Integrated Functions	
Counter	Yes
• Number of counters	1
• Counting frequency, max.	8 kHz
Load cell	
• permissible input signal per verification interval, min.	0.4 µV/e
• Sampling rate	1 024 Hz
• Resolution of input signal	±20 000 000 parts at 0 ... 4 mV/V
• Common mode voltage, min.	2.8 V
• Common mode voltage, max.	7.7 V
• input resistance of signal line, typ.	8 MΩ
• input resistance of sense line, typ.	300 MΩ
• Cable length, max.	500 m; when using the SIWAREX 7MH4702-8AG cable

Article number	7MH4138-6CA00-0CU0
Measuring functions	
Measuring range	
– -1 mV/V to +1 mV/V	Yes
– -2 mV/V to +2 mV/V	Yes
– -4 mV/V to +4 mV/V	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; more than 2 000 m above sea level, the ambient temperature is reduced by -1 °C per 100 m
• Ambient air temperature-barometric pressure-altitude	1 080 ... 533 hPa (-1 000 ... 5 000 m above sea level)
Decentralized operation	
to SIMATIC S7-300	Yes
to SIMATIC S7-400	Yes
to SIMATIC S7-1200	Yes
to SIMATIC S7-1500	Yes
to standard PROFIBUS master	Yes
to standard PROFINET controller	Yes
Dimensions	
Width	20 mm
Height	57 mm
Depth	72 mm
Weights	
Weight, approx.	50 g

9.1 Certificates and approvals

- All certificates are available online at Certificates (https://support.industry.siemens.com/cs/ww/en/ps/cert).
- The current approvals for your device can be found on the nameplate.
- When using the electronic weighing system, observe the requirements specified in the safety notes for hazardous areas.

NOTE

The current approvals for your device can be found on the nameplate.

Symbol	Standard	Marking
CE		→ CE approval
c UL us	Explosion protection in accordance with c-UL-us (USA/Canada)	ANSI / ISA 12.12.01 CSA C22.2 No. 213-M1987 CL. I, Div. 2 GP.A.B.C.D T.. T4 CL. I, Zone 2, GP. IIC, T.. T4 Report no.: E542221
UL	UL File Number OrdLoc: E503417	
Ex	Explosion protection in accordance with ATEX DEKRA 19ATEX0094 X EN IEC 60079-0: 2018 EN 60079-7: 2015 + A1: 2018	II 3 G Ex ec IIC T.. Gc
UK CA	Explosion protection in accordance with UKCA DEKRA 21UKEX0016X	II 3 G Ex ec IIC T.. Gc
IECEx	Explosion protection in accordance with IECEx DEK 19.0054X IEC 60079-0: 2017 (Ed.7) IEC 60079-7: 2015 (Ed.5.1)	Ex ec IIC T.. Gc
EAC		→ EAC certificate, available soon

Symbol	Standard	Marking
		→ Tick mark for Australia and New Zealand
		→ KCC approval
		→ The electronic weighing system is RoHS-compliant according to EU Directive 2016/65/EU

Product documentation and support

A

A.1 Product documentation

Product documentation for process instrumentation is available in the following formats:

- Certificates (http://www.siemens.com/processinstrumentation/certificates)
- Downloads (firmware, EDDs, software) (http://www.siemens.com/processinstrumentation/downloads)
- Catalogs and technical data sheets (http://www.siemens.com/processinstrumentation/catalogs)
- Manuals (http://www.siemens.com/processinstrumentation/documentation)

  You have the option to view, open, save or configure the manual.

  – "Display": The manual opens in HTML5 format.

  – "Configure": You can register and configure the specific documentation for your plant here.

  – "Download": The manual is opened or saved in PDF format.

  – "Download as html5, only PC": The manual is opened or saved in HTML5 view on your PC.

You can also find manuals at Industry Online Support (https://support.industry.siemens.com/cs/ww/de/sc/2067) using the mobile app. Download the app to your mobile device and scan the QR code.

See also

Generally applicable information/SIMATIC manual overview (https://support.industry.siemens.com/cs/ww/en/view/109742709)

A.2 Technical support

Technical support

If this documentation does not completely answer your technical questions, you can enter a Support Request (http://www.siemens.com/automation/support-request).

For help creating a support request, view this video here (www.siemens.com/opensr).

Additional information on our technical support can be found at Technical Support (http://www.siemens.com/automation/csi/service).

Service & support on the Internet

In addition to our technical support, Siemens offers comprehensive online services at Service & Support (http://www.siemens.com/automation/serviceandsupport).

Contact

If you have further questions about the device, contact your local Siemens representative at Personal Contact (http://www.automation.siemens.com/partner).

To find the contact for your product, go to "all products and branches" and select "Products & Services > Industrial automation > Process instrumentation".

Contact address for business unit:
Siemens AG
Digital Industries
Process Automation
Östliche Rheinbrückenstr. 50
76187 Karlsruhe, Germany

SIWAREX support

- Email (mailto:hotline.siwarex@siemens.com)
- Phone: +49 (721) 667-1200 CET 8:00 to 17:00

Ordering data

B

B.1 Accessories

You can order accessories online: Industry Mall (https://mallstage.industry.siemens.com/mall/en/b0/Catalog/Products/10364709?tree=CatalogTree)

The following accessories are not included in the scope of delivery:

- **Mandatory**: BaseUnit of the type U0, article number 6ES7193-6BP00-0xU0

  An overview of the BaseUnits that you can use with the electronic weighing system can be found in the Product Information for the documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

  Information regarding selection of the suitable BaseUnit can be found in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual.
- Labeling strips
- Color-coded labels
- Equipment labeling plates
- Shield connection

SIEMENS

SIMATIC

ET 200SP
SIMATIC ET 200SP SIWAREX technology module TM WP361 1x10VDC#1-4mV/V HF

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Introduction 1

1.1 Purpose of this document

These instructions contain the product-specific information you need for connecting, commissioning, parameter assignment/addressing, diagnostics, technical specifications and operation requiring official calibration of the technology module. The following text describes the technology module referred to as the electronic weighing system.

General information on installation and commissioning of ET 200SP is available in the ET 200SP System Manual. Generally applicable information/SIMATIC manual overview (https://support.industry.siemens.com/cs/ww/en/view/109742709)

⚠ WARNING

If the device is installed in a cabinet, the inner temperature of the cabinet corresponds to the ambient temperature of the device.

⚠ WARNING

Impermissible repair of the device

- Repair must be carried out by Siemens authorized personnel only.

1.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no

longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

1.3 Security-notes SIWAREX WP361

The SIWAREX WP361 weighing electronics is designed for use in secure, closed networks and does not have any protection against unauthorized data traffic.

1.4 Open Source Software

Open-source software is used in the firmware of the product described. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information on this on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109740777).

The license terms are stored on the device and available via the web server. For more on this, refer to section Calling the web server (Page 38). To view the license conditions, click the "OSS ReadMe" button.

To resellers: Pass the license conditions on to the buyer to avoid license violations by the reseller and the buyer.

Product overview

2

2.1 View

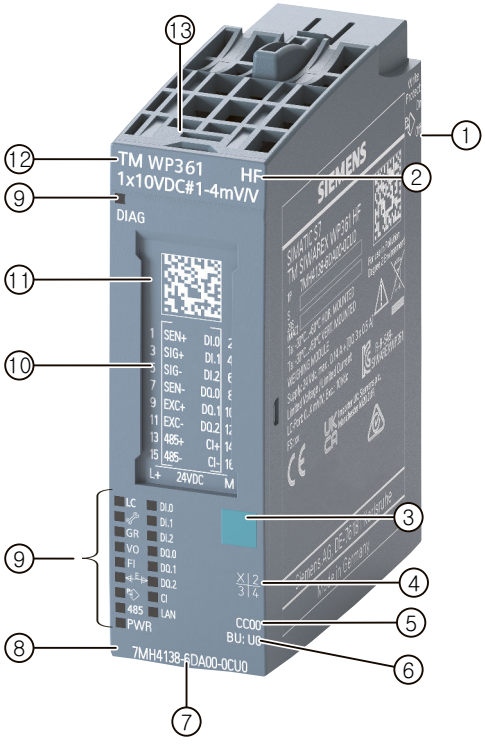

①	Rear: Write protection switch	⑧	Article number
②	Function class	⑨	LEDs
③	Color coding of weighing electronics type	⑩	Wiring diagram
④	Function version	⑪	2D matrix code
⑤	Color code for selection of the color-coded labels	⑫	Weighing electronics type and designation
⑥	BaseUnit type	⑬	Button in enclosure for emergency access to the Web server
⑦	Below: Ethernet		

Figure 2-1208 View of the weighing electronics

See also

ET 200SP Distributed I/O System
(http://support.automation.siemens.com/WW/view/en/58649293)

Product information on documentation for the ET 200SP Distributed I/O System
(http://support.automation.siemens.com/WW/view/en/73021864)

2.2 Properties

The electronic weighing system has the following properties:

- Technical properties
  - One channel
  - Interfaces:

    Load cell connection with 10 V DC supply voltage; 0.5 µV/e; 3x6000 d

    ±20,000,000 digit resolution at 1 kHz sampling rate

    Digital input signals DI.0, DI.1 and DI.2 24 V DC

    Digital output signals DQ.0, DQ.1 and DQ.2 24 V DC

    Counter input CI; up to 9 kHz; 24 V DC

    Supply voltage L+/M

    Serial interface RS485

    Ethernet interface (RJ45 socket)
- Monitoring of the load cell for impedance, wire break, short-circuit and faulty supply voltage
- Hardware interrupts configurable
- Input filters for suppression of interferences at encoder inputs and digital inputs can be configured
- Calibratable alibi memory for up to 1 000 000 entries.
- Supported load cell types
  - Analog strain gauge load cells with characteristic values of 1 to 4 mV/V
- Supported system functions
  - Firmware update
  - Identification data I&M

2.3 Version dependencies of the functions

The electronic weighing system supports the following functions:

Function	Firmware version of the electronic weighing system	Configurable as of		
		STEP 7 (TIA Portal)	GSD	
			PROFINET IO	PROFIBUS DP
Firmware update	V1.0 or higher	V15	X	—
I&M identification data	V1.0 or higher	V15	X	X
Centralized operation on CPU 151xSP	V1.0 or higher	V15	—	—

Installing

3

Mounting on the SIMATIC ET 200SP

Only use the electronic weighing system in conjunction with a SIMATIC ET 200SP distributed I/O system. Install the electronic weighing system in a control cabinet. Observe the information on the protection class and degree of pollution in the section Technical data (Page 91).

When installing the SIMATIC components with the electronic weighing system described herein, follow the setup, assembly and wiring guidelines for the SIMATIC ET 200SP. See system manual (https://support.industry.siemens.com/cs/ww/en/view/109742709) for the SIMATIC ET 200SP.

The electronic weighing system is snapped onto the SIMATIC ET 200SP BaseUnit (BU).

Connect the load cells, the digital input and digital output signals to the BaseUnit of the electronic weighing system. The infeed of the supply voltage at the light-colored BaseUnit of the associated potential group supplies the electronic weighing system and the digital outputs and generates the load cell supply voltage. All information about connecting is available in section Connection to electronic weighing system (Page 16)

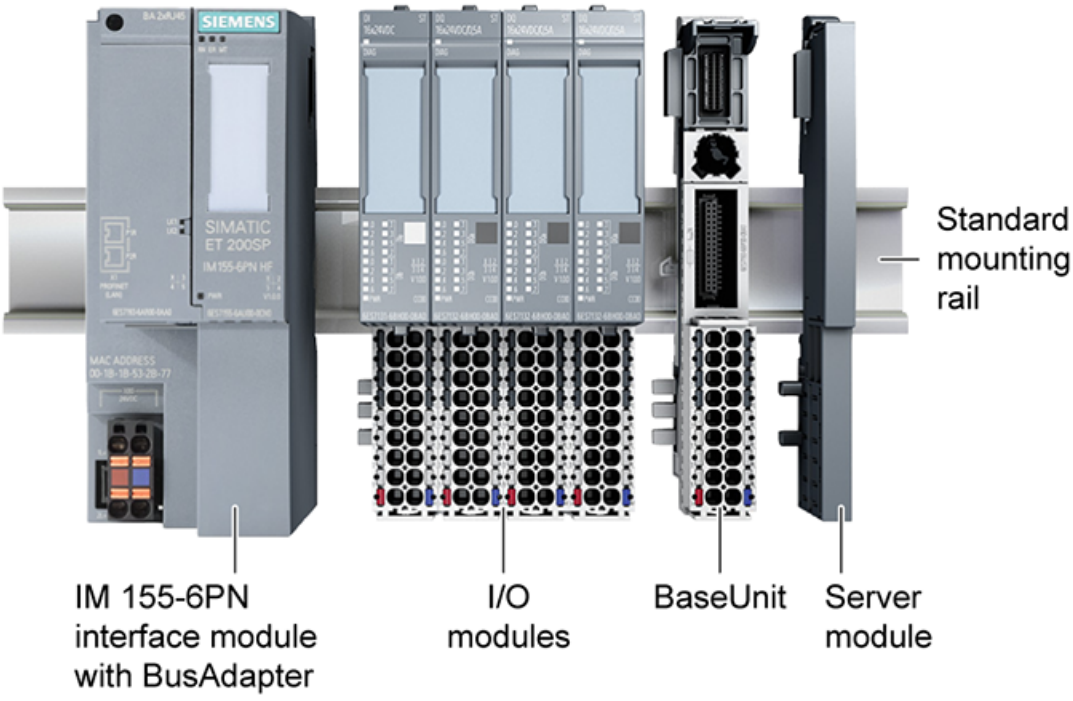

Figure 2-1209 Mounting on the SIMATIC ET 200SP

3.1 Basic safety notes

⚠ WARNING

Open equipment

The devices are "open equipment" according to the standard IEC 61010-2-201 or UL 61010-2-201 / CSA C22.2 No. 61010-2-201. To fulfill requirements for safe operation with regard to mechanical stability, flame retardation, stability, and protection against contact, the following alternative types of installation are specified:

- Installation in a suitable cabinet.
- Installation in a suitable enclosure.
- Installation in a suitably equipped, enclosed control room.

3.2 EMC-compliant installation

3.2.1 Introduction

Overview

The electronic weighing system described here was developed for use in industrial environments and complies with high EMC requirements. Nevertheless, before installing your devices you should prepare an EMC plan and identify and take into consideration possible interference sources.

EMC

EMC (electromagnetic compatibility) describes the capability of electrical equipment to operate without errors in a given electromagnetic environment, without being subject to external influence and without influencing external devices in any way.

3.2.2 Possible effects of interference

Electromagnetic interferences can influence the electronic weighing system described here in various ways:

- Electromagnetic fields having a direct influence on the system
- Interferences transported by communication cables
- Interferences having an effect via process cables
- Interferences entering the system via the power supply and/or protective ground

Interferences can impair the fault-free functioning of the electronic weighing system.

3.2.3 Coupling mechanisms

Depending on the propagation medium (conducted or non-conducted) and the distance between the interference source and the device, interferences can enter the faulty device through four different coupling mechanisms:

- Electrical coupling
- Capacitive coupling
- Inductive coupling
- Radiation coupling

3.2.4 Five basic rules for securing EMC

Observe these five basic rules to secure EMC.

Rule 1: Large area grounding contact

- When installing the devices, make sure that the surfaces of inactive metal parts are properly bonded to chassis ground (see following sections).
- Bond all inactive metal parts to chassis ground, ensuring large area and low-impedance contact (large cross-sections).
- Make screw connections on painted or anodized metal parts either with special contact washers or remove the insulating protective layers at the contact points.
- Wherever possible, avoid the use of aluminum parts for ground bonding. Aluminum oxidizes very easily and is therefore less suitable for ground bonding.
- Provide a central connection between chassis ground and the ground/protective conductor system.

Rule 2: Proper cable routing

- Organize your wiring system into cable groups (high-voltage/power supply/signal/measurement/data cables).
- Always route high-voltage and data cables in separate ducts or in separate bundles.
- Install the measurement cables as close as possible to grounded surfaces (e.g. supporting beans, metal rails, steel cabinet walls).

Rule 3: Fixing the cable shielding

- Ensure proper fixation of the cable shielding.
- Always use shielded data cables. Always connect both ends of the data cable shielding to ground on a large area.
- Keep unshielded cable ends as short as possible.
- Always use metal/metalized connector housings only for shielded data cables.
- To connect the signal cables, use the corresponding SIMATIC ET 200SP shield supports with order number 6ES7193-6SC00-1AM0.

Rule 4: Special EMC measures

- All inductors that are to be controlled should be connected with suppressors.
- For cabinet lighting in the immediate range of your controller, use interference suppressed fluorescent lamps.

Rule 5: Homogeneous reference potential

- Create a homogeneous reference potential and ground all electrical equipment.
- Use sufficiently dimensioned equipotential bonding conductors if potential differences exist or are expected between your system components. Equipotential bonding is absolutely mandatory for applications in hazardous areas.

Connecting

4

4.1 Basic safety notes

WARNING

Safety extra low voltage

The equipment is designed for operation with a directly connectable safety extra low voltage (SELV) from a limited power source (LPS). (This does not apply to 100 V...240 V devices).

The power supply therefore needs to meet at least one of the following conditions:

- Only safety extra low voltage (SELV) with limited power source (LPS) complying with IEC 60950-1 / EN 60950-1 / VDE 0805-1 or IEC 62368-1 / EN 62368-1 / VDE 62368-1 may be connected to the power supply terminals.
- The power supply unit for the device must meet NEC Class 2 according to the National Electrical Code (r) (ANSI / NFPA 70).

There is an additional requirement if devices are operated with a redundant power supply:

If the equipment is connected to a redundant power supply (two separate power supplies), both must meet these requirements.

WARNING

Suitable cables at high ambient temperatures

If the temperature of the cable or housing socket exceeds 70 °C or the branching point of conductors exceeds 80 °C, special precautions must be taken.

If the device is operated at ambient temperatures of between 50 °C and 60 °C, only use cables with a maximum permitted operating temperature of at least 80 °C.

4.2 Connection to electronic weighing system

Table 2-1359 Terminal assignment of the BaseUnit

Designation	Signal name		View	Signal name		Designation
Load cell supply voltage monitoring +	SEN+	1		2	DI.0	Digital input DI.0
Load cell signal +	SIG+	3		4	DI.1	Digital input DI.1
Load cell signal -	SIG-	5		6	DI.2	Digital input DI.2
Load cell supply voltage monitoring -	SEN-	7		8	DQ.0	Digital output DQ.0
Load cell supply voltage +	EXC+	9		10	DQ.1	Digital output DQ.1

Designation	Signal name		View	Signal name		Designation
Load cell supply voltage -	EXC-	11	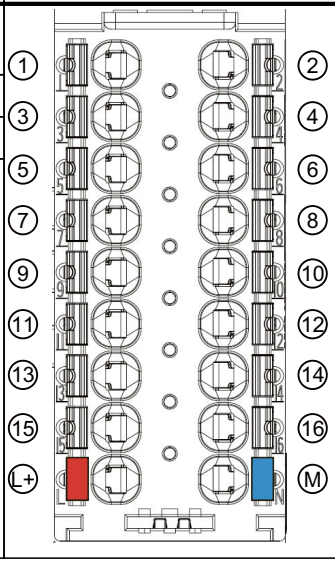	12	DQ.2	Digital output DQ.2
RS485 interface +	485+	13		14	CI+	Counter input CI +
RS485 interface -	485-	15		16	CI-	Counter input CI -
24 V DC supply voltage	L+				M	Ground for supply voltage

BaseUnit

The BaseUnit is not included in the scope of delivery of the electronic weighing system and must be ordered separately.

An overview of the BaseUnits that you can use with the electronic weighing system can be found in the Product Information for the documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

Information regarding selection of the suitable BaseUnit can be found in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual.

Information on wiring the BaseUnit, creating the cable shield, etc., can be found in the ET 200SP Distributed I/O System System Manual (http://support.automation.siemens.com/WW/view/en/58649293) in the section Connecting.

Supply voltage L+/M

With a dark BaseUnit, the supply voltage of the left BaseUnit is used.

The electronic weighing system monitors whether the supply voltage is connected.

Load cell connection

In case of 6-wire load cells, the supply voltage is measured over the terminals 1 (SEN+) and 7 (SEN-) and used as reference. A voltage drop on the load cell cable does not have an effect on the measurement.

You can connect 4-wire as well as 6-wire load cells. The electronic weighing system is set for operation with 6-wire load cells in the factory.

If the power of the electronic weighing system-internal power supply of the load cells is not sufficient, use an external power supply source to supply the load cells.

NOTE

Compensate for interferences when connecting 4-wire load cells

If you use 4-wire load cells, we recommend that you use a 6-wire cable between the electronic weighing system and the terminal box.

- Set a wire jumper in the terminal box between EXC+/SEN+ and EXC-/SEN-.

  The wire jumper compensates for interferences between the electronic weighing system and the terminal box.

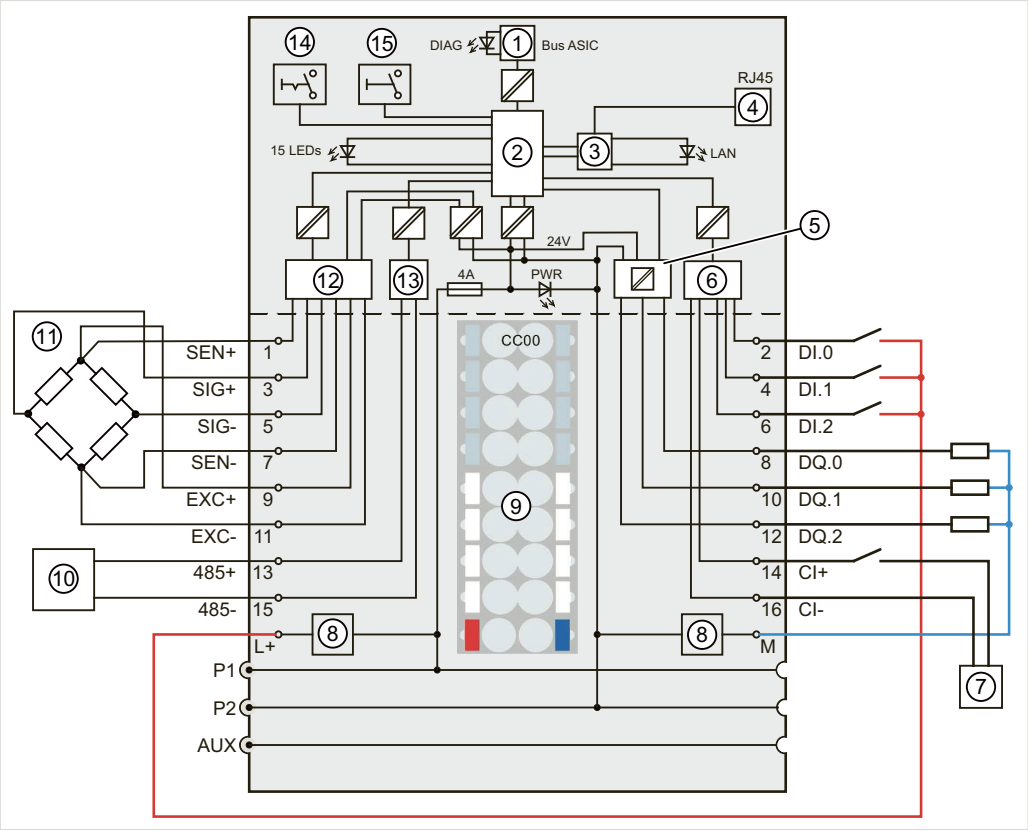

①	Backplane bus interface	⑨	Color identification label CCxx (optional)
②	MCU (microcontroller)	⑩	RS485 device
③	Ethernet sender/receiver (bus coupler)	⑪	Load cell
④	Ethernet	⑫	Filter and A/D converter
⑤	Output electronics	⑬	RS485 sender/receiver (bus coupler)
⑥	Input electronics	⑭	Write protection
⑦	External signal source for counter input CI	⑮	Setup mode
⑧	Filter connection supply voltage (only when light-colored BaseUnit is present)		

Figure 2-1210 Principle and pin assignment

Digital inputs DI.0 to DI.2

Assign to the digital inputs scale functions free and individually within the DR 7. No functions are assigned to the inputs at the factory.

The digital inputs are not isolated from each other.

Input delay for digital inputs

In order to suppress noise you can configure an input delay for the digital inputs.

NOTE

If you select the "None" or "0.0001 " option, you must use shielded cables for connection of the digital inputs.

Digital outputs DQ.0 to DQ.2

Assign to the digital inputs scale status free and individually within the DR 7. No functions are assigned to the outputs at the factory.

The digital outputs are not isolated from each other.

The digital outputs are 24 V sourcing with respect to M and with a nominal load current of 0.5 A. They are protected against overload and short-circuit.

Relays and contactors can be directly connected without an external protective circuit. You can find information about the maximum possible operating frequencies and the inductive loads at the digital outputs in the section Technical data (Page 91).

Counter input CI

The counting input CI is used for measuring 24 V signal frequency up to 9 kHz.

Ethernet

The Ethernet port is used to reach the Web server interface or provide access to the electronic weighing system using Modbus TCP/IP.

If you connect a calibratable main display over the Ethernet port, no additional programming is required in the CPU. Connect the electronic weighing system physically to the network of the SIMATIC HMI.

NOTE

Provide strain relief for the cables that are permanently connected to the Ethernet port.

The strain relief of the cable ensures secure hold of the electronic weighing system in the BaseUnit.

4.3 Connection of analog load cells

Sensors equipped with expansion measuring strips (EMS) can be connected to the electronic weighing system. These sensors meet the requirements in section Technical data (Page 91).

4.3.1 Connecting SIWAREX JB to the electronic weighing system and load cell

Procedure

1. Open the cover of the SIWAREX JB.
2. Screw in an M16 x 1.5 cable gland for each load cell.
3. Screw in an M20 x 1.5 EMC cable gland for the signal cable to the electronic weighing system.
4. Wire the SIWAREX JB to the load cell and the electronic weighing system in accordance with Wiring diagrams (Page 20).

   To learn how to connect the cable, see section Connecting cables to SIWAREX JB (Page 23).
5. Close any unused opening in the enclosure with a blanking plug.
6. Connect the equipotential bonding conductor to the outside of the enclosure.

   Use shielded cable lugs.
7. Close the cover of the SIWAREX JB according to the tightening torque.

4.3.2 Wiring diagrams

4.3.2.1 Load cells with four-wire system

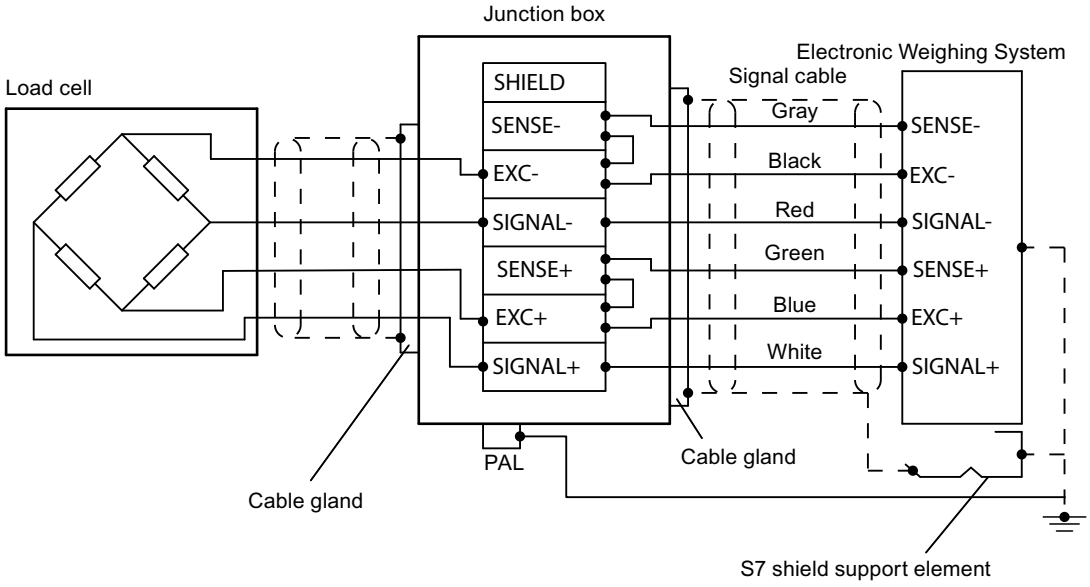

Figure 2-1211 Cable shield of the signal cable connected to EMC cable gland

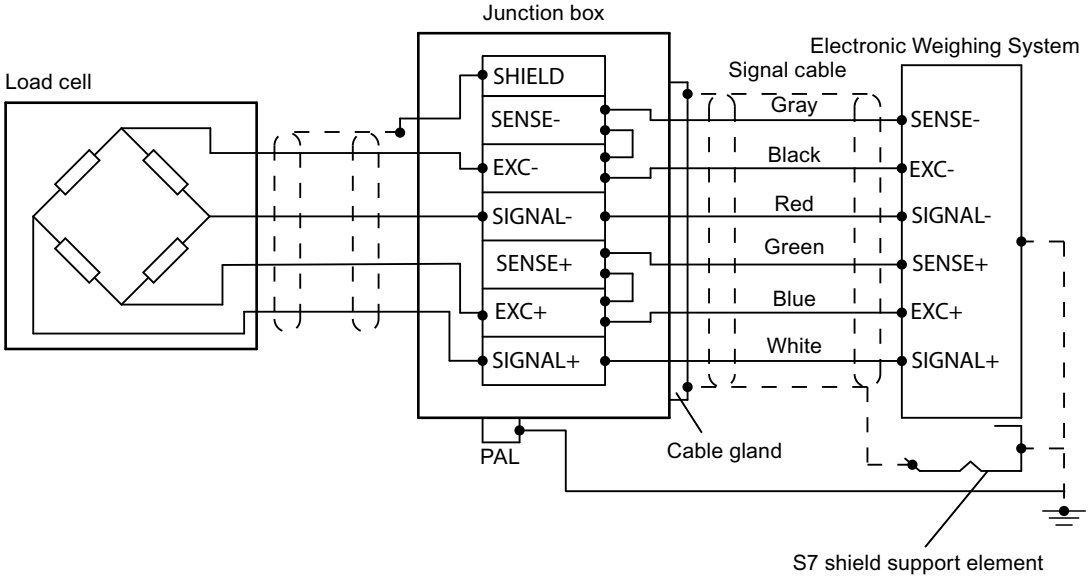

Figure 2-1212 Cable shield of the signal cable connected to shield terminal

The following wire jumpers are set by default:

Wire jumper	From terminal	To terminal
1	EXC-	SENSE-
2	EXC+	SENSE+

NOTE

If the wire jumpers are missing, the electronic weighing system reports a wire break.

4.3.2.2 Load cells with six-wire system

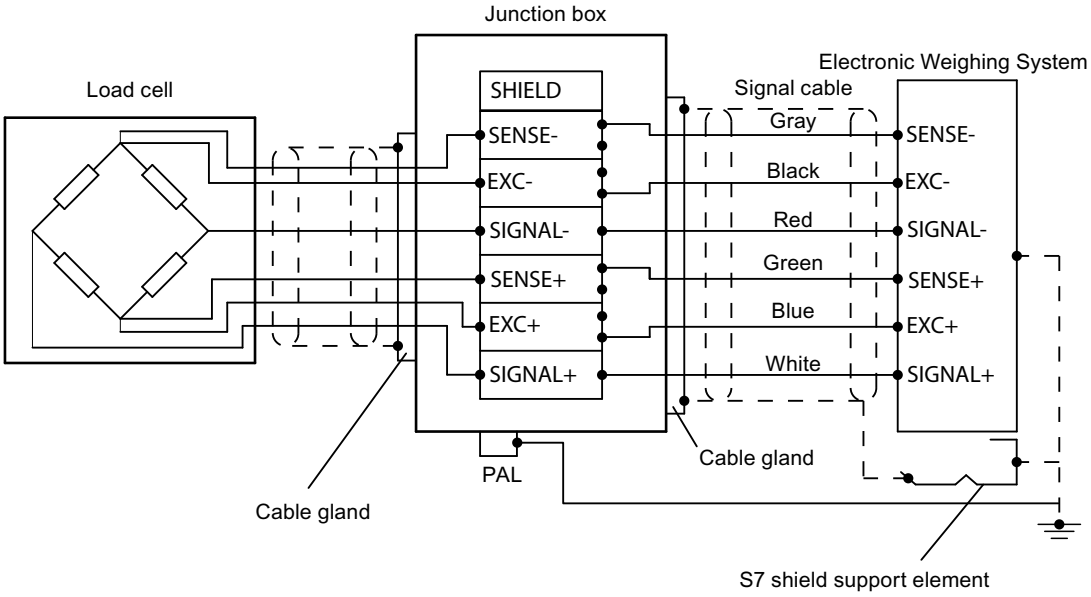

Figure 2-1213 Cable shield of load cell cable connected to EMC cable gland

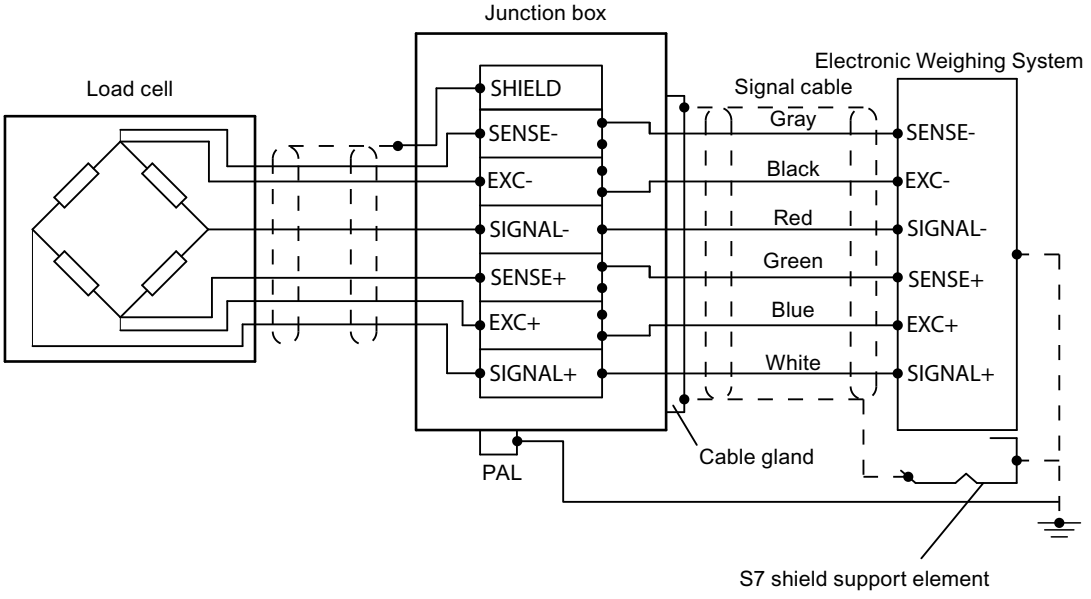

Figure 2-1214 Cable shield of load cell cable connected to shield terminal

- Disconnect the following wire jumpers:

Wire jumper	From terminal	To terminal
1	EXC-	SENSE-
2	EXC+	SENSE+

4.3.3 Connecting cables to SIWAREX JB

Requirement

You require a screwdriver with a maximum blade width of 3.5 mm.

Procedure

1. In EMC cable glands, lay the cable shielding over a large area.

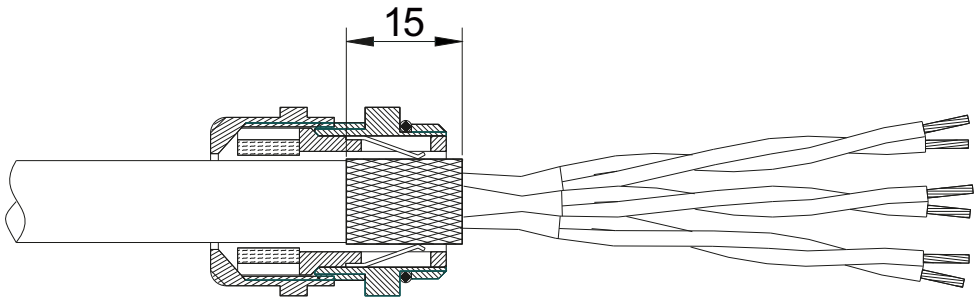

Figure 2-1215 Place the cable shield in the EMC cable gland

2. With plastic cable glands, place the corresponding wire of the SIWAREX load cell on the shield terminal.
3. Strip at least 6 mm of insulation from the load cell cable.

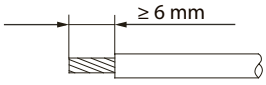

Figure 2-1216 Strip cable

4. Insert the stripped load cell cable into the square opening of the screw terminal as far as it will go.
5. Tighten the screws with the specified tightening torque.

Result

The tightened screw firmly holds the stripped wire and establishes the contact.

4.4 Connection of the SIWAREX DB

The digital junction box SIWAREX DB allows connection of up to 4 analog load cells. SIWAREX DB has 4 separate AD converters and thus digitizes each load cell separately.

In addition to the actual measured value, the following **extended diagnostics data** are available for each individual load cell:

- Current signal voltage in millivolts
- Wire-break monitoring
- Current input resistance in ohms
- Current "excitation current" in mA etc.

In the event of a defective load cell, the electronic weighing system reports the affected load cell. Service as well as commissioning are significantly facilitated and accelerated.

SIWAREX DB also enables digital adjustment of different load cell characteristics (corner load compensation).

4.4.1 Connecting the SIWAREX DB to WP341, WP351 and WP361

Procedure

1. Open the cover of the SIWAREX DB.
2. Screw in an M16 x 1.5 cable gland for each load cell.
3. Screw in an M20 x 1.5 EMC cable gland for the signal cable to the SIWAREX WP electronic weighing system.

4. Attach the cables from SIWAREX DB to the load cell and the SIWAREX WP electronic weighing system.

   Connect the cable (Page 25)

   The maximum distance between SIWAREX DB and the WP electronic weighing system is 1000 m when using the recommended cable 7MH4702-8AG.

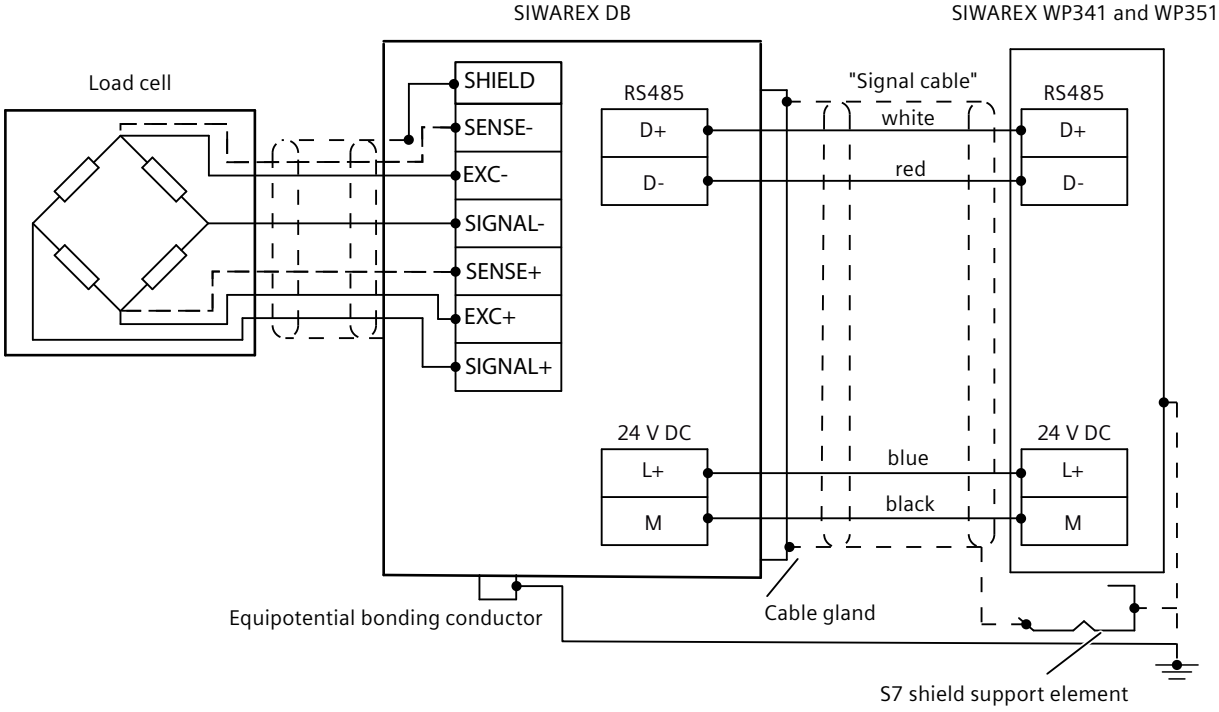

5. Close any unused opening in the enclosure with a blanking plug.
6. Connect the equipotential bonding conductor (functional grounding) to the enclosure exterior.

   Use shielded cable lugs.
7. Close the cover of the SIWAREX DB according to the tightening torque 1.5 to 2 Nm.

4.4.2 Connect the cable

Condition

You require a screwdriver with a maximum blade width of 2.5 mm.

You can use the SIWAREX cable for supply voltage and RS-485 communications. Accessories (Page 99)

Procedure

1. Place the cable shield in the EMC cable gland over a large area.

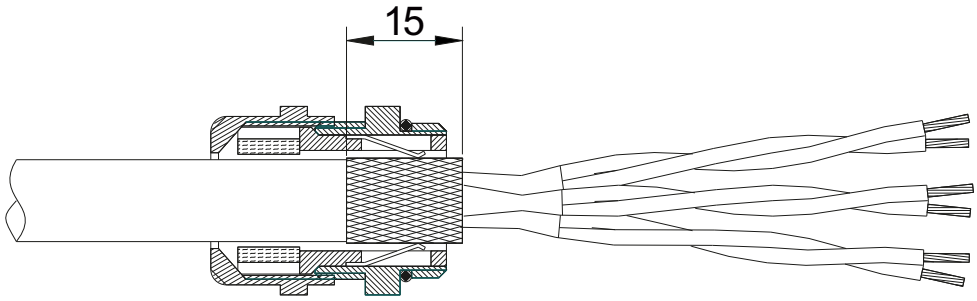

Figure 2-1217 Place the cable shield in the EMC cable gland.

2. For plastic cable glands, connect the corresponding wire of the SIWAREX load cell to the shield terminal.
3. Strip the cable ends at least 6 mm.
4. Push the screwdriver into the rectangular opening of the terminals.
5. Insert the stripped cable into the round opening as far as it will go.
6. Remove the screwdriver from the rectangular opening.

Parameter assignment/addressing 5

5.1 Introduction

The following options are available for parameter assignment and addressing:

- STEP 7 (TIA Portal) user program
  - TIA Portal user program (Page 28)
  - Calling the function block FB WP361 [FB361] (Page 30)
  - Executing commands (Page 33)
  - Cyclic data exchange via "cyclicIoData" (Page 36)
  - Reading/writing data records (Page 37)
- Web server
  - Calling the web server (Page 38)
  - Reading/writing data records (Page 40)
  - Parameter assignment (Page 27)

Parameter table

In addition to the parameter descriptions, the parameter table (https://support.industry.siemens.com/cs/ww/en/ps/17252/dl) on the Internet provides information on:

- DR number
- Parameter name
- S7 name
- Data type
- Min. value
- Max. value
- Modbus address
- Write protection
- Access
- Status information from DR30

Table 2-1360 Example parameter table

DR	Parameter	S7 name	Type	Min. value	Max. value	Modbus address	Write protection	Access
4	Calibration digits 0 (calculated)	calibrationDigits0calculated	DINT	0	-	1200	x	r

5.2 TIA Portal user program

5.2.1 Commissioning the electronic weighing system with TIA Portal

Procedure

1. Download the "Ready to use" TIA-Portal example project for the technology module TM SIWAREX WP361 HF (https://support.industry.siemens.com/cs/ww/en/ps/25196/dl) from the internet.

   The example project must be compatible with your SIMATIC controller.
2. Adjust the example project to match your configuration.

   - or-

   Copy the required components from the example project into your destination project.
3. Click on the "General" sub-tab in the "Properties" tab.
4. In the left-hand tree, navigate to TM SIWAREX WP361 HF.

Web server	If desired, activate access for the web server.
HTTPS	Function is not supported with FW version 1.0.0.
Logon name / Access right / Password	Create up to five different users. Assign the "Read" or "Read and write" permission individually to each user. **Read** means that the user has read-only access to the Web server and can create and download a backup of the current configuration. The user cannot change data or start commands. **Invalid combination of logon name and password** The following combination is intended exclusively for emergency access to the Web server. Logon name: admin Password: admin For more on this, see section: Calling the web server (Page 38) > Procedure in case of loss of user data.

IP address	IP address of the weighing electronics (default: 192.168.0.21)
Subnet mask	Subnet mask of the weighing electronics (default: 255.255.255.0)
Set IP address in the project	The IP address of the weighing electronics is transmitted via the hardware configuration during CPU startup. The IP address is only specified via TIA Portal.
Permit adapting the IP address directly at the device	The IP address of the weighing electronics is not assigned via the TIA Portal. – Assign the IP address via an external tool (e.g. PST Tool)
Use router	Defines whether or not a router is used.
Router address	IP address of the router
Device name	Network name of the weighing electronics

5. Enable the desired diagnostic interrupts.

   Monitoring is always active. When an error is detected, a diagnostic interrupt is only triggered when the corresponding diagnostic interrupt is enabled in the device configuration.

6. Enable the desired hardware interrupts.

   With the help of the following event types, parameterize the triggering of a hardware interrupt.

   – Hardware interrupt 1 (event freely definable in DR07)
   – Hardware interrupt 2 (event freely definable in DR07)
   – Hardware interrupt 3 (event freely definable in DR07)
   – Hardware interrupt 4 (event freely definable in DR07)
   – Hardware interrupt 5 (event freely definable in DR07)
   – Hardware interrupt 6 (event freely definable in DR07)
   – Hardware interrupt 7 (event freely definable in DR07)
   – Hardware interrupt 8 (event freely definable in DR07)

   You can select any combination of events for hardware interrupt triggering.

   You can obtain detailed information on the event in the hardware interrupt organization block with the instruction "RALRM" (read additional interrupt info) and in the information system of STEP 7 (TIA Portal).

   The event that triggered the hardware interrupt is logged in the start information of the organization block. The following figure shows the assignment to the bits of double word 8 in local data.

LB 8								LB 9								LB 10								LB 11								Bit # LD 8
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	X	0	0	0	X	X	X	X	X	

User Structure Identifier (USI)

Event that triggered the hardware interrupt (EventType):

00001_B: Hardware interrupt 1
00010_B: Hardware interrupt 2
00011_B: Hardware interrupt 3
00100_B: Hardware interrupt 4
00101_B: Hardware interrupt 5
00110_B: Hardware interrupt 6
00111_B: Hardware interrupt 7
01000_B: Hardware interrupt 8

Channel that has triggered the hardware interrupt (IChannel):
0_B: Channel 0 of the technology module

Figure 2-1218 Start information of the organization block

5.2.2 Calling the function block FB WP361 [FB361]

Introduction

For each electronic weighing system, call the FB cyclically once in the user program. For each call of the FB, adapt the input parameters to the electronic weighing system. Each electronic weighing system has a unique HW ID and its own interface DB. The interface DB contains all weighing parameters. The PLC data types of the interface DB can be found in the TIA Portal example project. Copy the PLC data types from the example project into the target project.

Requirement

The following FW versions are required in the S7 controllers so that you can work with the FB:

CPU	FW version
S7-1200	≥ V4.2
S7-1500	≥ V2.0

Procedure

1. Copy the FB, the interface DB and the associated UDTs from the example project into the destination project.
2. Call the FB in the user program.
3. Assign the electronic weighing system for the parameter HW ID "HW_ID".

4. Assign the interface DB to the electronic weighing system for the parameter interface "Interface".

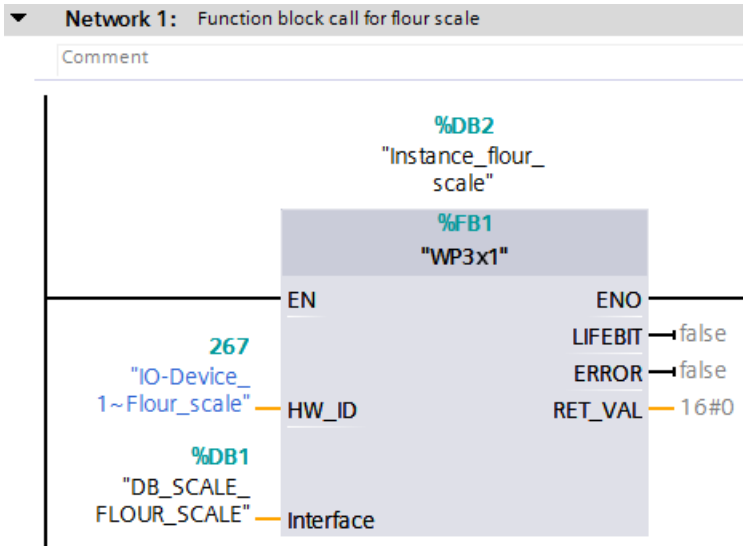

HW_ID	HW ID of the electronic weighing system
Interface	Interface DB of the electronic weighing system
ERROR	"true" = Error
RET_VAL	The meaning of the error codes can be found in the section: Operating errors (Page 76).
LIFEBIT	Optional status bit can be used to monitor communication

Figure 2-1219 FB

5. Copy the HMI or the required components from the example project into the destination project.

Example: 2 FBs for 2 electronic weighing systems

The following example shows the setup of 2 FBs in 2 networks for 2 electronic weighing systems.

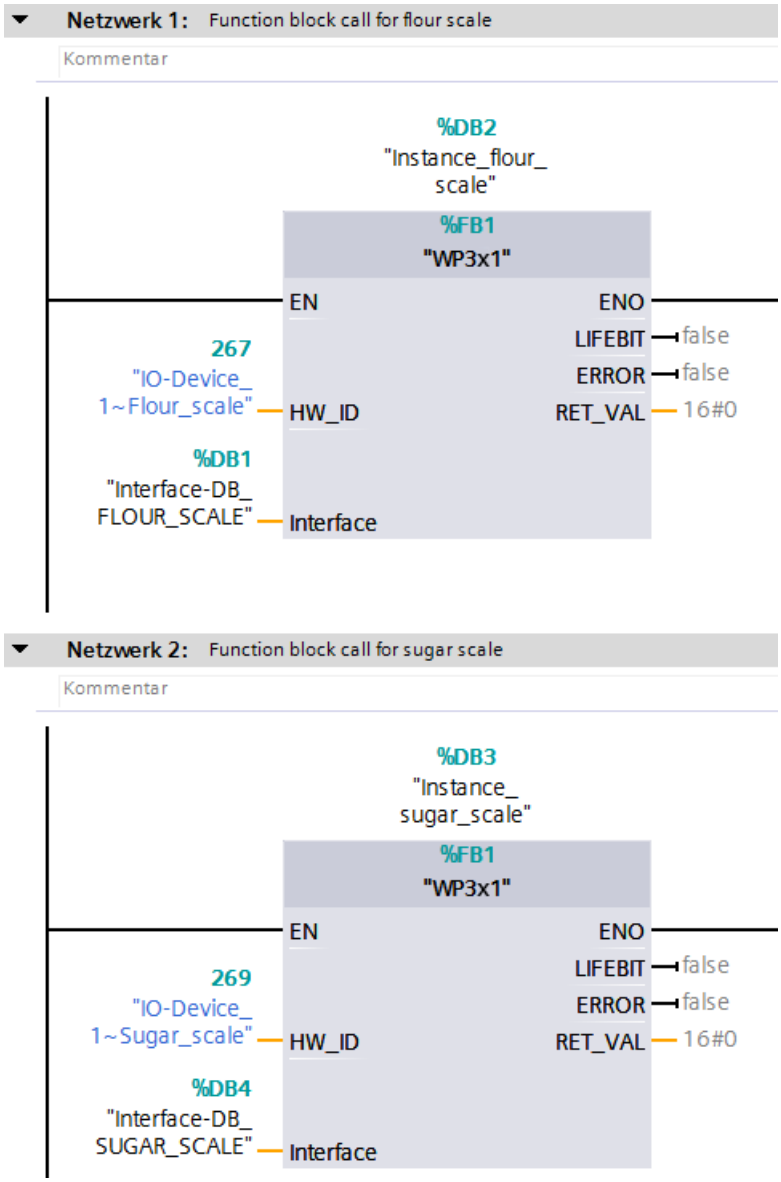

Network 1 "Network 1"	**FB1**	Interface DB of the flour scale "Instance_flour_scale"
		HW_ID of the flour scale "Flour_scale"
		Interface of the flour scale "DB_SCALE_FLOUR_SCALE"
Network 2 "Network 2"	**FB2**	Interface DB of the sugar scale "Instance_sugar_scale"
		HW_ID of the sugar scale "Sugar_scale"
		Interface of the sugar scale "DB_SCALE_SUGAR_SCALE"

Figure 2-1220 2 FBs for 2 electronic weighing systems

5.2.3 Executing commands

Introduction

Data records (DR) are read or written via specific command codes. There are three command mailboxes within the interface DB for this purpose.

The command mailboxes are managed and processed according to priority. When all three command mailboxes are triggered at the same time by the user program, the FB executes them in the following order:

Command mailbox	Priority	Description
Command1	Highest priority	If you run cyclic commands in the "Command1" command mailbox, this makes it impossible to run commands in the "Command2" or "Command3" command mailbox.
Command2	Medium priority	
Command3	Lowest priority	Cyclic commands from the "Command3" command mailbox are interrupted to run a command in the "Command2" or "Command1" command mailbox.

You can find a list of all commands in section: Commands (Page 70).

Requirement

You have called the FB (Page 30).

Procedure

1. Open the interface DB.
2. In one of the command mailboxes "Command1", "Command2" or "Command3", enter a command code for the parameter "code".
3. Set the associated command trigger [trigger] to "true".

4. Evaluate the associated status bits:

   Command in progress. [inProgress]

   Command finished without error. [finishedOk]

   Command rejected or finished with error. [finishedError] [errorCode] [errorAddInfo (Page 79)] You can find a list of data and operating errors in section Data and command errors (Page 79).

Interface-DB_FLOUR_SCALE

	Name	Data type	Start value
4	CommandHandling	"Siwarex_WP3..	
5	Command1	"Siwarex_WP3..	
6	code	Int	0
7	trigger	Bool	FALSE
8	inProgress	Bool	FALSE
9	finishedOk	Bool	FALSE
10	finishedError	Bool	FALSE
11	errorCode	Int	0
12	errorAddInfo	Int	0
13	Command2	"Siwarex_WP3..	
14	code	Int	0
15	trigger	Bool	FALSE
16	inProgress	Bool	FALSE
17	finishedOk	Bool	FALSE
18	finishedError	Bool	FALSE
19	errorCode	Int	0
20	errorAddInfo	Int	0
21	Command3	"Siwarex_WP3..	
22	code	Int	0
23	trigger	Bool	FALSE
24	inProgress	Bool	FALSE
25	finishedOk	Bool	FALSE
26	finishedError	Bool	FALSE
27	errorCode	Int	0
28	errorAddInfo	Int	0

Figure 2-1221 Command mailboxes Command1, Command2 and Command3

Example: Parameterize the calibration weight

You want to set the value 12.5 for the parameter Calibration weight [calibrationWeight].

1. Switch on service mode by entering the command code 1 (= Service mode ON) for the "code" parameter in the "Command1" command mailbox.
2. Set the associated command trigger "trigger" to "true".

   ⇒ The "Wrench LED" on the electronic weighing system flashes orange.
3. Read DR03 by entering the command code 2003 for the "code" parameter in the "Command1" command mailbox.
4. Set the associated command trigger "trigger" to "true".

   ⇒ All current data from DR03 is present in the interface DB.
5. In DR03, enter the value 12.5 for calibration weight [calibrationWeight].

6. Write DR03 by entering the command code 4003 for the "code" parameter in the "Command1" command mailbox.
7. Set the associated command trigger "trigger" to "true".
8. Evaluate the associated status bits:

   Command finished without error. [finishedOk] is "true".

   ⇒ The new calibration weight is now present in the electronic weighing system and is used.
9. Disable service mode by entering command code 2 (= Service mode OFF) for the "code" parameter.
10. Set the associated command trigger "trigger" to "true".

See also

Data and command errors (Page %getreference)

5.2.4 Cyclic data exchange via "cyclicIoData"

The interface DB of the FB makes the "cyclicIoData" structure available. All parameters in this structure are updated cyclically by the weighing electronics to the SIMATIC controller. All entered parameter values within the "cyclicIoData" structure are used directly – without reading or writing the data records.

The following parameters are available for use within the "cyclicIoData" structure on the factory side:

Interface-DB_FLOUR_SCALE

	Name	Data type	Start value
1	Static		
2	CyclicIoData	"Siwarex_WP361_cyclicIoData"	
3	input	"Siwarex_WP361_cyclicIoDataInputData"	
4	processValue1Real	Real	0.0
5	processValue2Real	Real	0.0
6	processValue3Real	Real	0.0
7	processValue4Real	Real	0.0
8	processValue1DWord	DWord	16#0000_0000
9	processValue2DWord	DWord	16#0000_0000
10	processValue3DInt	DInt	16#0000
11	processValue4DInt	DInt	16#0000
12	scaleStatus	"Siwarex_WP361_030_scaleStatus"	
13	output	"Siwarex_WP361_cyclicIoDataOutputData"	
14	processValue5	Real	0.0
15	processValue6	Real	0.0
16	processValue7	Real	0.0
17	processValue8	Real	0.0
18	enableFeeder	Bool	false
19	emptyFeeder	Bool	false
20	digitalOutputControl	"Siwarex_WP361_cyclicIoDataDQControl"	
21	DQ0	Bool	false
22	DQ1	Bool	false
23	DQ2	Bool	false

Input

[inProcessValueReal1 to inProcessValueReal4]	Cyclic I/O process values (reading) in real format according to defined parameters in DR07. Standard in DR7: Process Value 1: Control value [0-100%] Process Value 2: Flow rate Process Value 3: Level [% of filling weight] Process Value 4: Error signal
[inProcessValueDWord1 to inProcessValueDWord4]	Cyclic I/O process values in DWord format according to defined parameters in DR07.
[scaleStatus]	Weighing status of weighing steps according to parameters in DR30 (Page 64).

Output

[ioProcessValue5 to ioProcessValue8]	Cyclic I/O process values (writing) according to defined parameters in DR07. Default in DR7: Process Value 5: not assigned Process Value 6: not assigned Process Value 7: not assigned Process Value 8: not assigned

[digitalOutputControl]	If a digital output DQ is configured for control from the CPU (DR07), the DQ may be controlled here via the according bit.
[emptyFeeder]	If this bit is set to TRUE by the user program, automatic refilling is suppressed so that the feeder can run empty.
[enableFeeder]	This bit can be used for general enabling of the feeder provided this is to be done via software or the user program. To use the bit, set data record 7 accordingly to specify that enabling should be performed via the user program.
[errorCode]	Error according to Interrupts/diagnostic messages (Page 75).
[addInfo]	Error according to Interrupts/diagnostic messages (Page 75).

5.2.5 Reading/writing data records

Introduction

Every data record (DR) can only be read fully from the electronic weighing system to the SIMATIC controller or written to the electronic weighing system. Transfer of a single parameter within a data record is not possible.

Data in the "cyclicIoData" structure is updated automatically without commands via cyclic communication.

Requirements

You have called the FB (Page 30).

Example: Reading and writing DR07

CAUTION

The number of system functions that can be called at the same time is limited.
Start the commands for reading and writing a data record only when necessary.

1. Switch on service mode by entering the command code 1 for the "code" parameter in the "Command1" command mailbox.
2. Open the interface DB.
3. Read DR07 by entering the command code 2007 for the "code" parameter in the "Command1" command mailbox.
4. Set the associated command trigger [trigger] to "true".
   ⇒ All current data from DR07 is present in the interface DB.
5. Set the scale parameters for DR07.

6. Write DR07 by entering the command code 4007 for the "code" parameter in the "Command1" command mailbox.
7. Set the associated command trigger "trigger" to "true".

5.2.6 Design of hardware configuration

An HSP0467 (Hardware Support Package) is available for download for this purpose. The following table provides an overview of the possible usage scenarios of the weighing electronics.

Possible applications	Required components	Configuration software	In the user program
Central operation with a CPU 151xSP	• S7-1500 (SP-CPU) automation system • TM SIWAREX WP361 HF	STEP 7 (TIA Portal as of V20): • Basic configuration using the hardware configuration • Web browser for reaching the web server interface	• TM SIWAREX WP361 HF FB for S7-1500/1200 controllers
Distributed operation with an S7-1500 CPU	• Automation System S7-1500 • ET 200SP distributed I/O system • TM SIWAREX WP361 HF		
Distributed operation with an S7-300/400 CPU	• Automation system S7-300/400 • ET 200SP distributed I/O system • TM SIWAREX WP361 HF	STEP 7 (TIA Portal as of V20): • Basic configuration using the hardware configuration • Web browser for reaching the web server interface	
External system	• ET 200SP distributed I/O system • TM SIWAREX WP361 HF	Web browser for reaching the web server interface	• GSD/GSDML file

5.2.7 Automatic time synchronization

All logs and error messages, as well as numerous diagnostics data, are time-stamped by the electronic weighing system.

The function block of the electronic weighing system automatically synchronizes the time from the electronic weighing system with the CPU time. It is therefore not required to separately set the time in the electronic weighing system.

5.3 Web server

5.3.1 Calling the web server

NOTICE
Low degree of protection against unauthorized access If you activate the web server, you reduce protection against unauthorized access to functions and data of the electronic weighing system from outside and via the internal network. • Follow the Security-notes SIWAREX WP361 (Page 8).

Introduction

Using the web server of the electronic weighing system, you can start up the electronic weighing system in a completely autonomous way and without additional software tools. You do not need any specific SIMATIC knowledge. After commissioning the electronic weighing system, connect the automation system.

Procedure with TIA Portal

1. In the device view, select TM SIWAREX WP3x1 HF.
2. Click on the "General" sub-tab in the "Properties" tab.
3. Navigate to TM SIWAREX WP3x1 HF > Parameters.
4. Activate the web server.
5. Create at least one user.
   Do not create **any** user with the name "admin".
6. Compile the hardware configuration.
7. Transfer the hardware configuration to your system.
8. Enter the IP address of the electronic weighing system in the Mozilla Firefox or Google Chrome browser. (Default: 192.168.0.21)
9. Log in with the previously defined credentials.

Procedure in case of loss of user data

1. Press the ① pushbutton at the upper left in the enclosure for at least 3 seconds.

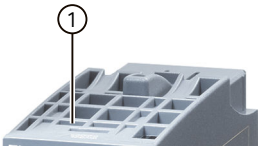

   ⇒ The LED lights up yellow.
2. Enter the IP address of the electronic weighing system in the Mozilla Firefox or Google Chrome browser within 2 minutes. (Default: 192.168.0.21)
3. Log on as follows:

   Logon name: admin

   Password: admin

See also

Security information (Page %getreference)

5.3.2 Reading/writing data records

Introduction

Only the entire data record (DR) can be read from the electronic weighing system in the web server or written to the electronic weighing system. Transfer of a single parameter within a data record is not possible.

Example: Reading and writing DR06

1. Read DR06 by selecting "Online > Read data record" in the shortcut menu.

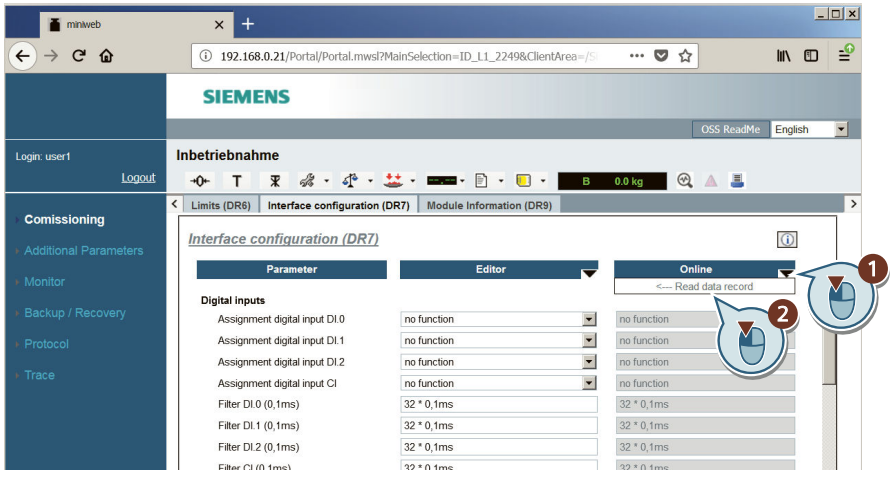

Figure 2-1222 Reading DR

2. Set the parameters for DR06 in the column "Editor".
3. Write DR06 by selecting "Editor > Write data record" in the shortcut menu.

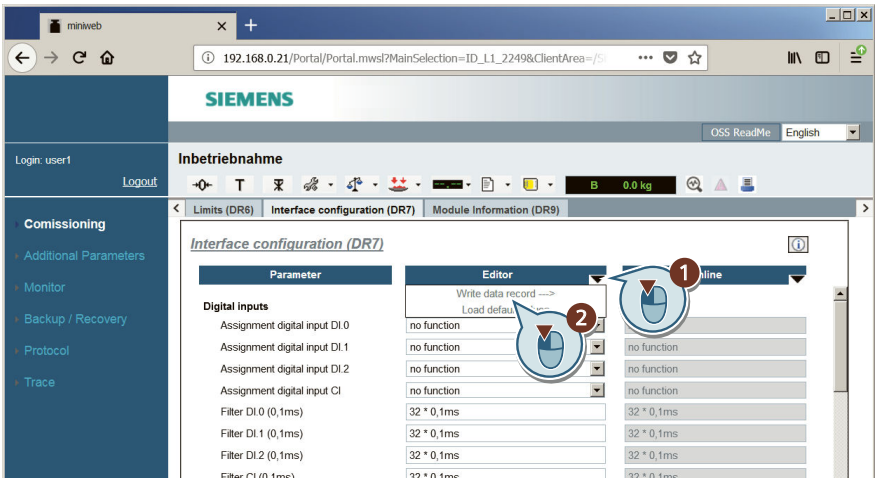

Figure 2-1223 Writing DR

5.4 Calibration Parameter (DR3)

5.4.1 Scale name [scaleName]

You can select any name, but it may not exceed 12 characters. You can enter any designation.

5.4.2 Weight unit for flow rate [unitWeightFlowRate]

The weight unit for calculating the flow rate can be selected as follows:

0: mg - milligram
1: g - gram
2: kg – kilogram (default)
3: t – metric ton
4: oz - ounce
5: lbs - pound
6: T – short ton
7: LT – long ton

5.4.3 Weight unit for totalizer [unitTotalizers]

The weight unit for the totalizers in data record 33 is selected independently of the weight unit for the flow rate as follows:

0: mg - milligram
1: g - gram
2: kg – kilogram
3: t – metric ton (default)
4: oz - ounce
5: lbs - pound
6: T – short ton
7: LT – long ton

5.4.4 Time unit for flow rate [unitTimeFlowRate]

The time unit for calculating the flow rate is selected as follows:

0: s - second
1: min - minute
2: h - hour

5.4.5 Scale interval of weight [scaleIntervalWeight]

The scale interval of weight can be defined from 0.0001 to 50. It defines the smallest displayed change in the weight value of the scale.

5.4.6 Scale interval of totalizers and flow rate [totalizationFlowRateInterval]

The scale interval of totalizers and flow rate can be set independently of the scale interval of weight from 0.0001 to 50. It defines the smallest displayed change in the totalizer and the flow rate.

5.4.7 Maximum scale capacity [maxWeight]

The following example shows how the maximum weight of the scale is defined:

- The differential dosing scale is mounted on 3 load cells with a weighing capacity of 100 kg and has a tare weight of 80 kg.
  - 3 x 100 kg = 300 kg scale capacity
  - 300 kg – 80 kg (tare weight of the feeder) = 220 kg (maximum scale capacity)

The maximum scale capacity serves as a reference value for the limits of the zero setting range and the threshold value for the weight average filter (see data record 5 (Page 47)).

It is necessary to specify the maximum scale capacity correctly to ensure that the scale functions properly.

5.4.8 Negative/ positive zero setting range [maxZeroSettingLimitNegative]/ [maxZeroSettingLimitPositive]<

The range in which a zero setting of the scale is permitted can be limited in both positive and negative directions. The limits are specified in % of the maximum scale capacity.
Example:
Maximum scale capacity = 200 kg

Positive limit = 10%

Negative limit = 5%

The "Zero setting" command can be executed within a range of +20 kg to -10 kg around the calibration zero point. The zero setting is not carried out and an error message is generated on exceeding or falling below the range. Thus, a zero setting of a full scale, for example, can be prevented.

5.4.9 Current zero-setting weight [zeroSettingWeight]

The current zero setting weight shows how large the current deviation from the calibration zero point is.

5.4.10 Empty limit [emptyLimit]

Specified in % of maximum scale capacity. When the value undershoots the empty limit, a corresponding status bit is set. The limit can be used to detect problems when filling the feeder. The limit must be set below the filling limit for this purpose (data record 5). If, in addition, the empty limit bit is set during filling, it can be assumed that filling did not function properly and appropriate steps can be initiated on the control side.

5.4.11 Calibration weight 0, 1 [calibrationWeight] and calibration digits [calibrationDigit] 0, 1

The calibration weights with the associated calibration digits define the scale characteristic curve. The calibration weights must be specified in ascending order.

Typically, the calibration weight 0 = 0, as the calibration point 0 is normally set when the scale is empty.
If a scale is modified and the current content is known, this value can be entered and set as calibration weight 0. A larger calibration weight 1 must then be specified and set.

The calibration weights must be at least 5% of the capacity of the scale and also

- Calibration weight 0 = 0 kg
- Calibration weight 1 = at least 5% of the capacity of the scale.

The calibration digits are determined automatically by the calibration commands and assigned to the respective calibration weights. Therefore, the calibration digits do not have to be specified.

5.4.12 Enable simulation [simulationEnabled]

0 = Simulation not enabled
1 = Simulation enabled

The simulation must also be controlled via corresponding commands (see Executing commands (Page 33)) and default values (data record 16 or process image).

5.5 Correction Factor (DR4)

5.5.1 Correction Factor (DR04) [correctionFactor]

It is possible to apply a correction factor to the calculated flow rate. This can be used, for example, to compensate for interference. The factor is multiplied by the currently calculated flow rate.

Example:

Flow rate = 80 kg/h with correction factor = 0.

During a reference measurement, a constant deviation between the reference scale and the module's totalizer is determined:

Reference scale 150 kg, totalizer 125 kg.

Correction factor = reference / totalizer = 150 kg / 125 kg = 1.2

If the correction factor of 1.2 is entered, the flow rate is increased by 20% so that the totalizers are again in line with the reference scale. The use of a correction factor should only be used for recurring, consistent deviations between the reference measurement and the totalizer.

5.6 Loss In Weight Parameter (DR5)

5.6.1 Weight and flow rate filter

Function:

In addition to the moving average value filters, an adaptive average value filter is available for both weight and flow rate. These filters automatically adapt to errors or unexpected situations without having to change the filter parameters.

Principle of operation:
An adjustable threshold value sets the difference between the input and output signal that causes the filter to operate using the weak filter factor. If the difference falls below the threshold value again, the filter adjusts to the strong filter factor via the recovery rate.

Filterparameters

1. **Factor for strong filtering [filterFactorStrong]**
   Defines the filter strength in normal operation.
2. **Factor for weak filtering**
   Defines the filter strength for errors or rapid changes.

   Effect of the filter factors:

   The following graphs show the step response of the adaptive filters for different factors (α):

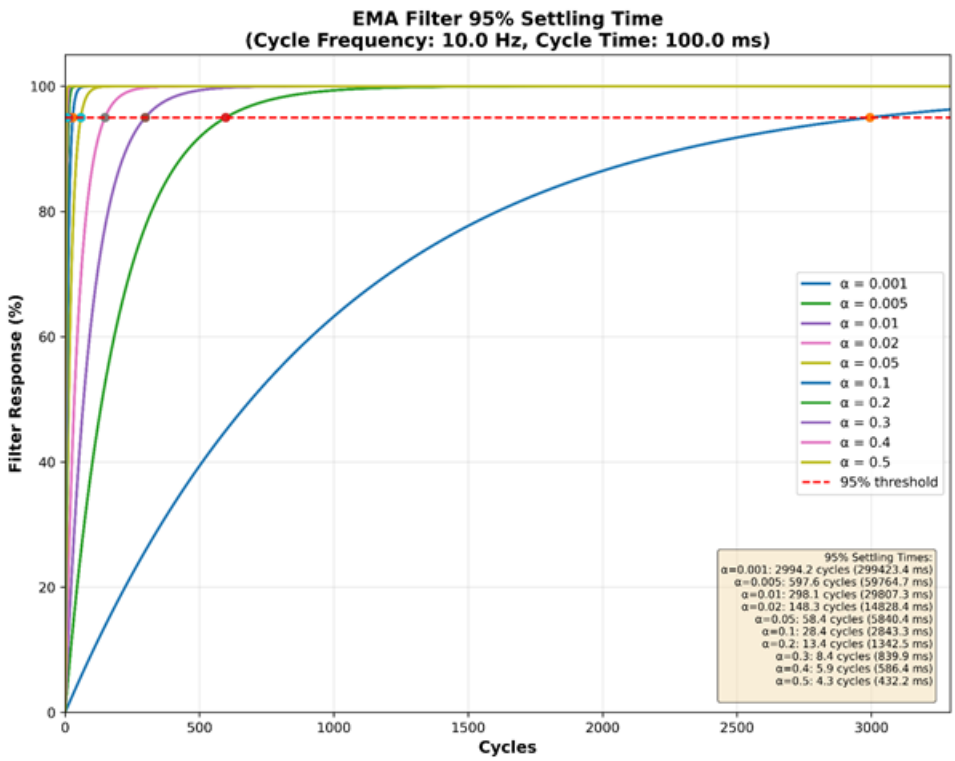

Figure 2-1224 Adaptive flow rate filter (call in 100 ms increments):

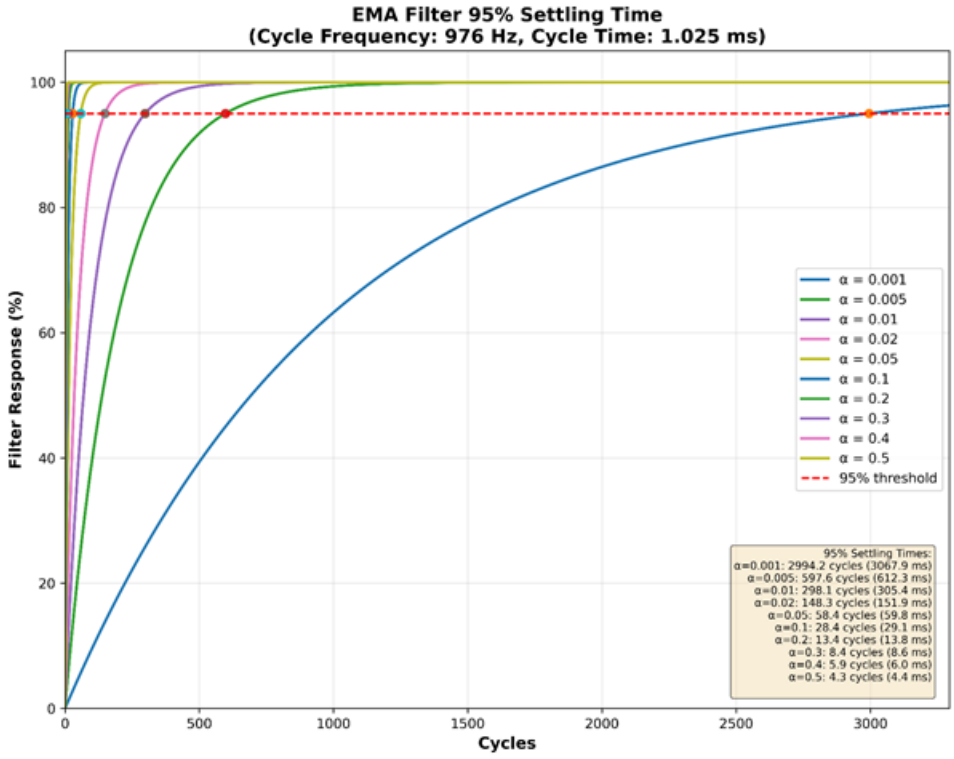

Figure 2-1225 Adaptive weight filter (call in 1.025 ms increments):

3. **Threshold for weak filtering [thresholdForWeakFiltering]**
   Default:
   - Adaptive weight filter: in % of the maximum weight (data record 3)
   - Adaptive flow rate filter: in % of design flow rate

   Example:
   - Maximum weight: 100 kg
   - Threshold: 5%
   - Result: Filter switches at a difference > 5 kg

   Principle of operation:
   1. The difference between the input and output of the weight filter exceeds 5 kg.
   2. The filter immediately switches to the weak filter factor.
   3. The difference falls below 5 kg.
   4. The filter approaches the strong filter factor again according to the set recovery rate.

4. **Recovery Rate [recoveryRate]**
   The recovery rate determines how quickly the adaptive mean value filter switches back from the weak to the strong filter factor.

   Determining the cycles:
   The resulting number of cycles (and therefore the time required) can be found in the filter charts above.

5.6.2 Loss-in-weight scale (DR05)

The data record encompasses all relevant loss-in-weight dosing parameters. If different materials are conveyed with the same feeder, a copy of data record 5 can be created in the control program for each material and loaded into the weighing module accordingly.

5.6.3 Material name [materialName]

Name of the material (up to 14 characters).

5.6.4 Maximum fill weight [fillWeight]

The maximum filling weight is used as reference value for the limits for automatic filling of the feeder. Enter the weight unit as an absolute value according to data record 3.

Consider the material density when defining the specification to avoid overfilling the feeder.

5.6.5 Design flow rate [designFlowRate]

The design flow rate indicates the maximum expected flow rate of the feeder, reached at a control value of 100%. This value is crucial for fast and correct start-up during initial commissioning. During operation, the value can be corrected automatically by enabling a corresponding function in data record 5.

5.6.6 Start/stop filling limit [startFillingLimit] / [stopFillingLimit]

The limits define the range for starting or stopping the automatic filling of the feeder. In data record 7, the corresponding "Filling" status bit can be assigned directly to a digital output and wired directly to the filling device. Alternatively, the status bit is available in the "cyclicIOData" structure of the function block for further processing in the controller.

5.6.7 Filling time [fillingTime]

As an alternative to filling based on the weight value, the feeder can also be filled over a fixed defined time. Specified in seconds. The "Filling" status bit is set for the specified time when the "Start filling" limit is reached.

5.6.8 Settling time after filling [settlingTimeAfterFilling]

Filling the feeder produces mechanical shocks that destabilize the scale. The settling time allows to define a period of time for the weighing module to continue dosing volumetrically after the filling process. After this time has elapsed, the system switches to gravimetric mode, provided the flow rate is stable at this point.

5.6.9 Displayed flow rate during filling [displayedFlowRateWhileFilling]

During the filling process, the weighing module offers the option of displaying the last valid flow rate before filling or alternatively the set point in the display string (data record 34).
0: Set point from DR20
1: Last flow rate

5.6.10 Dosing behaviour at operation error [dosingBehaviourDuringError]

An operating error is typically caused by faults in the sensor system (e.g. wire break in the load cell, overload/underload of the AD converter). Details can be found in Chapter "Error messages".

- Select the desired behavior:
  0: Switch to volumetric mode with last valid set point
  1: Stop dosing

NOTE

Set a time limit for option 0 via the "Maximum time with operation error" parameter (data record 5).

5.6.11 Exceeding min./max. Flow rate [handlingOfFlowRateLimits]

The parameter defines whether exceeding or undershooting the minimum or maximum flow rate limits (data record 5) should be handled as an operating error or not.

5.6.12 Automatic adaptation of the device characteristic curve [automaticAdoptionOfDeviceCurve]

The weighing module allows the device characteristic curve to be continuously optimized during operation. The function can be disabled if required.
0: disabled
1: activated

5.6.13 Automatic adaptation of the design flow rate [automaticAdoptionOfDesignFlowRate]

If the function "Automatic adaptation of the device characteristic curve" is activated, you can define separately whether or not the design flow rate in data record 5 should also be adapted as part of the device characteristic curve optimization.
0: disabled
1: activated

5.6.14 Automatic adaptation of the controller parameters [automaticAdoptionOfPIDParameter]

If the function "Automatic adaptation of the device characteristic curve" is activated, you can define separately whether or not the PID controller parameters in data record 5 should also be adapted as part of the device characteristic curve optimization.
0: disabled
1: activated

5.6.15 Stability range [StabilityRange]

Specify the stability range as a percentage of design flow rate. The parameter is used to detect a stable flow rate and is critical for dosing. Gravimetric mode requires a stable flow rate.

Example

Design flow rate = 100 kg/h
Stability range = 1%
If the current flow rate varies by less than ±1 kg/h, the weighing module sets the "Flow rate stable" status bit and enables gravimetric mode.

NOTE

Notes on parameter assignment:

Range too large: Errors are more difficult for the weighing module to detect.
Range too small: Even minor errors lead to a loss of stability and a switch to volumetric mode.

5.6.16 Duration of stability for switching to gravimetric mode [minimumStabilityDurationForGravimetric]

Define the minimum duration of stable flow required before the weighing module switches to gravimetric mode.

Parameter values:

- Value > 0: Delayed switch after reaching the set time
- Value = 0: Immediate switch with stable flow rate

NOTE

When starting up the feeder, a longer volumetric operating phase is beneficial to achieve stable flow rate for control purposes. Switching to gravimetric mode too quickly leads to undesirable control behavior.

5.6.17 Maximum time with operation error [maxTimeOperatingError]

The parameter defines a time period to ignore a pending operating error. If the operating error is still present after the time has expired, dosing is automatically stopped. If the parameter is set to 0, the time monitoring of operating errors is disabled.

5.6.18 Maximum waiting time for stability [maxWaitingTimeForStability]

Monitors how long the scale is in error-free volumetric mode and waits for stability. If stability is not reached after the time has elapsed, a corresponding technology message is sent. However, the scale remains in volumetric mode and waits for stability before switching to gravimetric mode.

5.6.19 Minimum / Maximum flow rate [minimumFlowRate / maximumFlowRate]

Specified in % of design flow rate. There are 2 bit variables available in the scale status respectively for evaluation / use in the control program.

5.6.20 Delay time minimum / maximum flow rate [delayTimeFlowRateLimits]

Delay time to prevent bouncing of the min. / max. flow rate monitoring.

5.6.21 Gain factor (P), Integration time (I), Differentiator time (D) [gainFactorPid, integrationTimePid, differentiatorTimePid]

The weighing module automatically determines the PID controller parameters during initial start-up. Parameters can be adjusted manually or updated by command at any time.

5.6.22 Deadzone PID controller [deadzonePID]

Specified in % of design flow rate. The deadzone is a range around the set point value. As soon as the current actual value is within the band, the controller functionality is interrupted.

Example:
Design flow rate = 50 t/h

Set point = 10 t/h

Deadzone = 2% (corresponds to 1 t/h relative to 50 t/h)

As soon as the actual value is between 9 t/h and 11 t/h, the control becomes more active.

5.6.23 Flow rate 1, 2, 3, 4, 5 [deviceCurveFlowRatePoint1, 2, 3, 4, 5] Control value 1, 2, 3, 4, 5 [deviceCurveControlValue1, 2, 3, 4, 5]

The flow rates and associated control values form the so-called device characteristic curve. It shows the correlation between control value <-> flow rate. The device characteristic curve is used in volumetric mode to provide the best possible flow rate even without control.
You can either specify the device characteristic curve manually or it can be automatically determined and continuously optimized by the weighing module (setting in data record DR5).

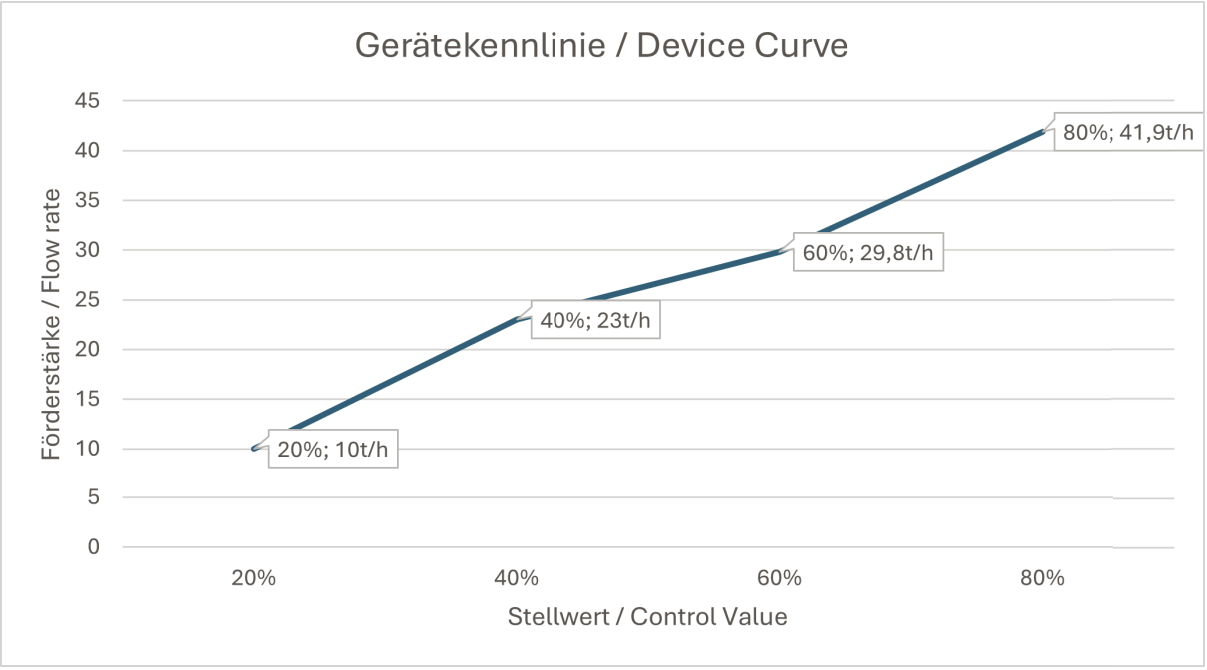

Figure 2-1226 Device characteristic curve

5.6.24 Average filter for weight, flow rate [averageFilter1, 2]

Use the average value filters to filter out periodic interference.

Example:
A trace recording shows a periodic oscillation of 4 Hz on the weight value. Set the average value filter to 0.25 s (1/4 Hz corresponds to a period duration of 0.25 s) to filter out this frequency from the signal.

5.6.25 Filter level [filterLevel]

In addition to the average value filters, special adaptive filters further filter the signal. Nine predefined filter levels are available for easy parameter assignment during commissioning.

Selecting the filter level:
If strong interference or turbulences are expected during the dosing process, select a filter level from the lower range (1-3). This leads to stronger filtering and provides the controller with a stable flow rate. However, the system reacts more slowly and possibly with a delay to spontaneously occurring interference.

Automatic adaption:
The selection of a filter level automatically assigns values to the subsequent filter parameters. If required, the weighing module automatically adjusts these settings when the feeder is initially started. The "Filter level" parameter then automatically changes to "Manual parameter setting" so that the adapted parameters can be easily fed into the PLC and restored.

Manual adaption:
To adjust weight or flow rate filter parameters manually, set the "Filter level" parameter to "Manual parameter setting".

Parameter values:

Filter level (selection code)	Description
1 ... 10	Very strong filtering (slow scale) ... very weak filtering (sensitive scale)
0	Manual parameter setting

5.7 DR07 Interface parameters

5.7.1 DQ monitoring [monitoringOfDQ]

The digital outputs of the electronic weighing system can be monitored for short circuits. An operating error is reported in case of short-circuit. Reporting of the error can be suppressed by the parameter.

Selection code	Function
0	Monitoring inactive
1	Monitoring active

5.7.2 Reaction to CPU stop / failure [behaviourOnCPUStopOrFailure]

Selection code	Function
0 (default)	Active output signals are switched off
1	Active output signals remain active

5.7.3 Trace rate [traceRate]

The parameter defines in which grid the internal trace should record. The minimum recording time is 1 ms. The shorter the cycle is set, the lower the recording capacity of the trace function.

5.7.4 Load per pulse [loadPerPulsRemoteTotalizer] [pulsDurationRemoteTotalizer] [pauseDurationRemoteTotalizer]

By parameterizing a corresponding digital output you can use one of the digital outputs as pulse sensor/quantity (see Digital inputs DI.0 to DI.2 [functionDI0 bis functionDI2] (Page 58)).

In addition you must specify a load per pulse and a pulse duration for the signal. If the material flow rate is displayed e.g. in t/h, you must specify the quantity per pulse in t, or with kg/h in kg. The pulse duration is defined in ms.

Make sure when setting the parameters that you only enter plausible combinations → pulse duration > (amount per pulse / material flow rate)

5.7.5 I/O process values 1 to 4 [ioProcessValue1 to ioProcessValue4]

You can transfer up to four selectable cyclic I/O process values from the electronic weighing system to the CPU cyclically via the I/O. The following cyclic I/O process values can be selected:

Table 2-1361 Selection table for cyclic I/O process values 1, 2, 3 and 4

Cyclic I/O process value	Selection code
No element is selected	0
Weight	1
Weight (% of maximum weight)	2
Fill level (% of feeder weight)	3
Flow rate (process)	4
Flow rate (% of design flow rate)	5
Flow rate (display)	6
Control value (%)	7
General Totalizer T1 (high share)	8
General Totalizer T1 (low share)	9
General Totalizer T1 (low resolution)	10
Main totalizer T2	11

Cyclic I/O process value	Selection code
Totalizer T3	12
Totalizer T4	13
Totalizer T5	14
Totalizer T6	15
CI Frequency	16
Digits unfiltered	17
Digits unfiltered (linearised)	18
Digits filtered by F1	19
Load cell impedance (Ohm)	20
Load cell signal voltage (mV)	21
Load cell SEN voltage (V)	22
Control value difference to device curve [%]	23
PID controller difference	24
Set point	25

5.7.6 I/O process values 5 to 8 [ioProcessValue5 to ioProcessValue8]

You can transfer up to four selectable process values from the CPU to the weighing electronics cyclically via the I/O. The following process values can be selected:

Selection code [ioProcessValue5 to ioProcessValue8]	Process values
0	Not assigned
1	Set point
2	Correction factor
3	Flow rate simulation value
4	Weight simulation
5	Weight
6	Digits

5.7.7 Source for simulation values [simulationSource]

Selection code	Process values
0	Simulation value from SIMATIC peripheral process representation
1	Data record DR16

5.7.8 Signal logic DQ.0 to DQ.2 [signalLogicDQ0 bis signalLogicDQ2]

The parameter defines whether the output of the assigned status bit should be normal or inverted.

5.7.9 Feeder enabled via user program

This parameter defines how to control the enabling of the feeder.

Parameter values:

Value	Function
0	Enable via digital inputDigital output DQ.0 to DQ.2 (Page 57)
1	Enable via user program (Statusbit dosingEnabled in cyclicIOData)

Principle of operation for value 1 (release via user program):

- The dosingEnabled status bit is transferred cyclically between the CPU and weighing module via the cyclicIOData structure.
- The feeder enable can be controlled directly from the PLC program.

Principle of operation for value 0 (release via digital input):

- The feeder is enabled via a configured digital input (DI.0, DI.1 or DI.2).
- The "Feeder enable" function is assigned to a digital input in DR07 (Page 53).

Recommendation:

- Value 1: Use this setting if you want to control the enabling flexibly in the PLC program.
- Value 0: Use this setting if you want to control the enabling via an external signal (e.g. button, sensor).

5.7.10 Hardware interrupt 1 to 8 [hardwareInterrupt1 to hardwareInterrupt8]

1. Select additional hardware interrupts for the following defined events:

Selection code [hardwareInterrupt1 to hardwareInterrupt8]	
0 ... 79	Scale status bits (see DR30)
100 ... 179	Scale status bits (see DR30) (inverted)

Selection code [hardwareInterrupt1 to hardwareInterrupt8]	
1000 ... 1063	Operating error (see DR32)
1100 ... 1163	Operating error (inverted) (see DR32)
2000 ... 2063	Technology messages (see DR32)
2100 ... 2163	Technology messages (inverted) (see DR32)
3000 ... 3063	Data/operating error (see DR32)
3100 ... 3163	Data/operating error (inverted) (see DR32)

2. Enable the hardware interrupts in the hardware configuration.

5.7.11 Signal logic hardware interrupt 1 to 8 [alarmLogic1 to alarmLogic8]

It can be defined whether the respective hardware interrupts are to be triggered on rising or falling signal edge.

5.7.12 Digital output DQ.0 to DQ.2

Selection code [functionDQ0] [functionDQ1] [functionDQ2]	Function
0 ... 79	Corresponding bit of the scale status (see DR30)
80	Controlled via S7 process representation (ioData)
255 (default)	Output deactivated
1000 ... 1063	Corresponding operating error (see DR32)
1100 ... 1163	Corresponding inverted operating error (see DR32)
2000 ... 2063	Corresponding technology message (see DR32)

5.7.13 Substitute value for DQ.0 to DQ.2 on error [substituteValueDQ0 to substituteValueDQ2]

An output is set in the event of a fault.

Selection code 0 is preset and resets the outputs in the event of a fault (operating error) or on a SIMATIC STOP.

Procedure

NOTICE
Risk to the plant If an output is set following a fault (operating error), this can pose a risk for the plant. Ensure that the parameters are correctly set.

1. Set the "DQ behavior on failure" parameter [behaviourOfDQOnError] to "Set substitute values": Selection code 0.
2. Assign substitute values for the event of an error or stop to the digital outputs (DQ.0, DQ.1 and DQ.2).

Selection code [substituteValueDQ0] [substituteValueDQ1] [substituteValueDQ2]	**Meaning**
0 (default)	Switch off output
1	Switch on output

5.7.14 Subnet mask, IP address, gateway, device name

Default parameter values

Subnet mask [deviceSubNetMask]: 255.255.255.0

IP address [deviceIpAddress]: 192.168.0.21

Gateway [gateway]: 192.168.0.21

Device name [deviceName]: siwarex.wp341

5.7.15 Digital inputs DI.0 to DI.2 [functionDI0 bis functionDI2]

Assign a command to each digital input (DI.0, DI.1, DI.2): → Commands (Page 70).

Use counter input CI optionally as a fourth digital input with its own reference potential.

Selection code [functionDI0] [functionDI1] [functionDI2]	**Function**
1 ... 32759	Command codes 1 to 32759 according to section Commands (Page 70). Triggered on transition from 0 → 1 at DI.x Example for command code 1121 → selection code = 1121
10000	Feeder enabled – the corresponding digital input must be active in order to start the dosing process. As an alternative to a digital input, a status bit in the WP361 function block can also be used for enabling - this must be enabled accordingly in DR7.
10001	Run feeder empty - If the corresponding digital input is active, automatic filling is blocked. This allows the feeder to run empty. As an alternative to a digital input, a status bit in the WP361 function block can also be used for running empty.

5.7.16 Filtering DI.0 to DI.2

Specify the following values for filtering the digital inputs:

Selection codes Filter DI.0 [filterDI0] Filter DI.1 [filterDI1] Filter DI.2 [filterDI2]	Function
0 (default)	No filtering
1 ... 2500 [0.1 ms]	Filtering from 0.1 to 250 ms

5.7.17 Signal logic DI.0 to DI.3 [signalLogicDI0 bis signalLogicDI2]

The parameter defines whether the function at the respective input is to be executed on a rising or a falling edge.

5.8 DR10 Load cell parameters

5.8.1 Load cell input [loadCellType]

Sets the connected load cell type.

Selection code	
0 (default)	Analog load cells
6	SIWAREX DB (medium speed)
7	SIWAREX DB (high speed)

5.8.2 Mains frequency [mainsFrequency]

The parameter defines the line frequency of the power supply grid. A selection between 50 Hz and 60 Hz can be made. By making the correct setting, interferences caused by the power supply grid can be better suppressed.

5.8.3 Mains frequency filter [mainsFrequencyFilterActivated]

Activates the line filter with selection code 1

Selection code	
0	Line filter deactivated
1	Line filter activated

5.8.4 4-wire / 6-wire sensor [fourSixWireSensor]

Selection code	
0	4-wire load cell
1	6-wire load cell

5.8.5 External / internal sensor supply [internalExternalAdcSupply]

Activates the external supply of the load cell with selection code 1. This may be necessary if the total impedance of all connected load cells is below the minimum permissible impedance.

5.8.6 No. of mechanical support points [numberOfSupportPoints]

The parameter is required for automatic calculation of the scale characteristic curve (command 82).

If no anchor points are used, the number of support points is equal to the number of load cells.

If anchor points are used in addition to load cells, the number of support points is equal to the total number of load cells and fixed support points.

Example

An idler is supported on a belt scale with two load cells → No. of mechanical support points = 2.

5.8.7 Averaged load cell characteristic value (mV/V) [averagedCharacteristicValue]

The load cell characteristic value is required to correctly interpret the output voltage from the load cell. When Siemens WL series load cells are used, the exact characteristic value can be read from the label on the cell. If the exact characteristic value of the utilized cell(s) is not available, a rounded value can also be specified. For scales with multiple load cells, the average of all load cell characteristic values must be calculated and entered.

Example

Characteristic value according to load cell label = 2.018 mV/V
→ Characteristic value = 2.018 mV/V

If this exact value is not known, 2.0 mV/V could also be entered.

5.8.8 Capacity of one single load cell [capacityOfOneSingleLoadCell]

The nominal load is entered in the specified weight units The parameter is required for automatic calculation of the scale characteristic curve (command 82).

5.8.9 Impedance reference (Ohm) [impedanceReference]

Impedance reference (Ohm) [impedanceReference]

The impedance reference can be determined through command 907 after successful commissioning of the electronic weighing system. After this time, the electronic weighing system automatically monitors the current impedance with the reference value. When the maximum permitted deviation is violated, a corresponding bit (impedanceError) is set in the scale status.

Maximum impedance deviation (% of impedance reference) [maximumAllowedImpedanceDeviation]

This parameter defines the maximum permissible deviation of the currently measured impedance as compared to the reference impedance. It is specified as percentage in relation to the impedance reference value.

5.8.10 Maximum impedance deviation (% of impedance reference) [maximumAllowedImpedanceDeviation]

This parameter defines the maximum permissible deviation of the currently measured load cell impedance as compared to the impedance reference. If the limit is exceeded, the electronic weighing system sets a corresponding bit in the scale status.

5.8.11 Load cell manufacturer [loadCellManufacturer] and load cell order number [loadCellOrderNumber]

- To be able to identify load cells for service operations, enter the load cell manufacturer [loadCellManufacturer] and load cell order number [loadCellOrderNumber].

5.9 DR15

5.9.1 DR15 Configuration of technology messages

In DR15, it is possible to suppress the technology messages from the weighing electronics in a targeted manner as described in section Technology messages (Page 78).

5.10 DR16 Simulation

5.10.1 Simulation

To be able to use the various simulation options, first of all enable simulation mode in data record 3 in general. The various simulation variables from data record 16 can then be activated using the Simulation ON and Simulation OFF commands. It is also possible to specify simulation values via the process image of the CPU. To do this, configure one of the process values 5 to 8 in data record 7 accordingly. The corresponding process value can then be written by the CPU via the data block.

5.10.2 Weight [weightSimulation]

Specification of a weight simulation value.

5.10.3 Design flow rate [designRateSimulation]

Design flow rate of the simulation. This value corresponds to the simulated dosing capacity at a control value of 100%.

5.10.4 Fluctuation of dosing flow [dosingFluctuationSimulation]

The parameter allows to simulate a randomized fluctuation of the dosing flow. Specified in % of the flow rate set in data record 16.

5.10.5 Filling flow rate [fillingFlowRateSimulation]

Flow rate used during simulated filling.

5.11 DR20 set point

5.11.1 Set point [setPoint]

Specification of the dosing set point. If continuous adjustment of the set point in the process is required, the set point can be specified via the process image. To do this, configure one of the process values 5 to 8 in data record 7 accordingly. Via the data block, the corresponding process value can then be transferred cyclically from the CPU to the weighing module with a setpoint value. This reduces the number of acyclic data record transfers, which are necessary when transferring data records but are limited by the CPU.

5.12 DR30 Scale status

5.12.1 Scale status DR30

Internal states and process values of the scale can be monitored using the process values. This data is not required for normal operation of the scale.
The monitoring of selected data during trial operation is extremely useful as it helps you to optimize parameters and locate errors.
DR30 contains all weight values and associated status information from the weighing electronics. All values are read-only.

NOTE

DR 30 does not have to be read into the PLC via a command! In interface parameter DR07 (see DR07 Interface parameters (Page 53)), the user can freely select 4 process variables that will be transmitted automatically via the S7-I/O to the CPU and be available there. In addition, the complete scale status is always available cyclically in the I/O (see TIA Portal user program (Page 28)) and can thus be used directly in the PLC program. At the Modbus end, the parameters and status information from DR30 are always up-to-date, and the registers can therefore be read immediately.

Table 2-1362 Scale status bits

Scale status	Variable in the data block
Within zero setting range	withinZeroSettingRange
Empty limit undershoot	weightBelowEmptyLimit
Minimum flow rate undershoot	minFlowRateUndershoot
Maximum flow rate exceeded	maxFlowRateExceeded
Remote totalizer output	remoteTotalizerOutput
Totalizers active	totalizersActive
Dosing	dosingOn
Fill feeder	fillingOn
Volumetric mode	volumetricMode
Gravimetric mode	gravimetricMode
Feeder enabled	dosingEnabled
Run feeder empty	feederDeplete
Flow rate stable	stableFlowRate
Settling time after filling	resettlingTime
Waiting for stable flow	waitForStability
Delay prior to gravimetric switch	delayForGravimetricSwitch
DS32 - state changed	dr32StateChanged
Emergency mode active	emergencyModeActive
Impedance error (load cells)	impedanceError
Error clock	clockError

Scale status	Variable in the data block
24V supply missing	supplyVoltageMissing
Command error on digital input	errorOnDigitalInput
No connection to SIMATIC PLC	noConnectionToCPU
Service mode	serviceMode
Modbus communication disturbed	noConnectionToModbusMaster
Write protection	writeProtection
Trace active	traceActive
Training mode active	trainingModeActive
Error	error
Calibration curve plausible	calibrationCurvePlausible
Webserver enabled	webserverEnabled
Local Webserver access	localWebserverAccess
Simulation mode	simulationMode
External weight	externalWeight
External digits	externalDigit
SIWAREX DB - Temperature warning	siwadbTemperaturError
Status DI.0	statusDI0
Status DI.1	statusDI1
Status DI.2	statusDI2
Status CI	statusCI

Table 2-1363 Process values

Weight	weight
Weight (% of maximum weight)	weightPerCentOfMax
Flow rate (process)	flowRate
Flow rate (% of design flow rate)	flowRatePerCentOfDesign
Flow rate (display)	flowRateDisplay
Control value (%)	controlValue
Control value difference to device curve [%]	controlValueDiffToDeviceCurve
PID controller difference	pidControllerDiff
Set point	actualSetPoint
Fill level (% of design feeder weight)	fillLevel
Current material flow rate (weight/s)	materialFlowRate
Active correction factor	activeCorrectionFactor
Frequency on CI input	frequencyOnCI
ADC digits unfiltered	unfilteredAdcDigits
ADC digits unfiltered (linearised)	unfilteredAdcDigitsLinearized
ADC digits filtered	filteredAdcDigits

Load cell impedance (Ohm)	loadCellImpedance
Load cell signal voltage (mV)	loadCellSignalVoltage
Load cell SEN voltage (V)	loadCellSenseVoltage

5.13 DR31 Scale status extended

5.13.1 Scale status extended DR31

Extended diagnostic data such as drag indicators, time stamps for calibration and zero setting commands and the number of zero calibrations performed are available in DR31.

5.14 DR32 Error messages

5.14.1 Error messages DR32

In the event of an error, the DR is read out automatically by the WP361 FB so that a connected SIMATIC HMI can generate messages accordingly. With data/command errors and technology messages, the error bits remain for 3 seconds and do not need to be acknowledged to the weighing electronics. Operating errors are permanently present until the error is resolved.
The individual error messages are presented and explained in detail in section Executing commands (Page 33). The following tables are used only for breaking down the individual messages into their message bits.

5.15 DR33 Totalizers

5.15.1 Totalizer DR33

Data record DR 33 contains the current values of the totalizer.
Command 652 can be used to stop all totalizers except T6. Command 651 starts totalizing again. The totals can be reset separately or simultaneously by command (see Executing commands (Page 33)).

5.15.2 General Totalizer T1 [generalTotalizerT1]

This totalizer contains the total of conveyed material since commissioning of the scale. The master totalizer can only be reset by loading the factory settings. The Long-Real format is used as the data type.

5.15.3 Totalizer T2 [totalizerT2]

The totalizer contains the quantity of material transported since the last memory reset. You can reset the total using command 670 or use command 653 to first store it in the internal alibi memory and then reset it.

5.15.4 Totalizer T3 [totalizerT3], Totalizer T4 [totalizerT4], Totalizer T5 [totalizerT5]

The totalizers respond like the main totalizer T2.

You can reset the totals individually to 0 using the following commands:

- T3 using command 671 (or command 654 (log and reset))
- T4 using command 672 (or command 655 (log and reset))
- T5 using command 673 (or command 656 (log and reset))

5.15.5 Totalizer T6 [totalizerT6]

A special property of totalizer 6 is that it remains active even following the command "Stop totalizing (652)", and therefore indicates the total amount. You can therefore carry out material tests or calibrate the scale, for example, without recording the "transported material" (calibration weight, test chain) into the balance.

You can reset the totalizer T6 using command 674 (or command 656 (log and reset)).

5.16 DR34

5.16.1 DR 34 ASCII main display value

The ASCII display value corresponds to the value on the scale's main display. The content can be controlled using display commands. If the data record is to be used in an HMI visualization, for example, the data record must be read cyclically via command.

5.16.2 Content of main display as ASCII string

Commands are used to toggle the display.

The following values can be displayed in belt scale applications:

Value	Command
Flow rate	710
Weight	715

Value	Command
Flow rate (process)	731
Flow rate (% of design flow rate)	735
Flow rate without correction	736
Set point	740
Error signal	741
Control value difference to device characteristic curve (%)	742
Fill quantity (% of maximum weight)	743
Control value	744
Dosing consistency	745
General Totalizer T1	771
Totalizer T2	772
Totalizer T3	773
Totalizer T4	774
Totalizer T5	775
Totalizer T6	776
About restore point	810
Serial number	871
Firmware version	875

5.17 DR70 SIWAREX DB parameter

5.17.1 DR 70 SIWAREX DB parameter

The parameters which define the response in combination with SIWAREX DB are specified in data record DR 70.

If SIWAREX DB is not used, the default settings can be accepted.

Load cell input

- Enter the location designation of the respective sensor for each load cell input.

  In the event of a fault, you can identify the affected sensor.

Channels

- Activate and deactivate the individual channels of SIWAREX DB.

  For correct operation, disable unused channels.
- By factory setting, all 4 channels of SIWAREX DB are activated.

Corner load factors

- The corner load factors of the individual channels are stored in DR 70.

  The corner load factors are relevant if you have performed a corner load compensation during commissioning. The procedure for corner load compensation is described in chapter Commands of command codes 151 to 160.

5.18 DR80, DR81, DR82 SIWAREX DB Process status and device information

5.18.1 DR 80 / DR 81 / DR 82 SIWAREX DB process status and device information

The following diagnostic bits are available for each load cell input.

- QI-flag (0 = no error on the channel; 1 = channel disturbed)
- Underload of the load cell signal
- Overload of the load cell signal
- SEN error
- Impedance error (< 330 ohms or > 4100 ohms)
- EXC short circuit
- Error power supply

In addition, the following measured values are continuously recorded for each channel and made available in the data records:

- Filtered ADC raw value
- Percentage utilization of the connected sensor
- Signal voltage in mV

The current firmware and hardware version of the SIWAREX DB can also be read out.

5.19 DR156 Security audit log entry

5.19.1 DR156 Security Audit Log Entry

The Security Audit Log records all logins in the web server of the electronic weighing system. In addition to the user, commands executed in the web server and data record transfers are also logged. These events may be read retrospectively in the web server or in the connected CPU via data record DR156. Command codes 922 and 923 allow to scroll forward and backward in the audit log, respectively.

The audit log can only be reset by loading the factory settings.

The following is the breakdown of the information that is transmitted to the CPU in DR156:

Event ID [eventID]
Consecutive ID that is incremented with each new event.

Date and time [dateAndTime]

Event [event]

0	Successful login
1	Unsuccessful login attempt

2 Logout by user
3 Logout by system timeout
4 Write command/data record

User number [userNumber]

0 admin - with access via local button
5 Web server user 1 from TIA Portal hardware configuration
6 Web server user 2 from TIA Portal hardware configuration
7 Web server user 3 from TIA Portal hardware configuration
8 Web server user 4 from TIA Portal hardware configuration
9 Web server user 5 from TIA Portal hardware configuration

Username [userName]

Eventinfo [eventInformation]

1 Only read rights
2 Read/write rights
3 Action completed successfully
4 Action successfully rejected

Command [command]
Command code to be executed

5.20 Commands

5.20.1 Service and trace commands

Service and trace commands

Command code	Command description
1	Service mode ON The command is required to edit data in calibration parameter data record 3 and to execute certain service and calibration commands. Service mode cannot be activated during active dosing.
2	Service mode OFF
3	Simulation ON Starts the simulation mode. In simulation mode, any error messages from the AD converter are ignored and the predefined simulation values are used. To be able to switch on simulation mode, it must generally be enabled in data record 3.
4	Simulation OFF

7	Stop web server emergency access If the web server's emergency access has been activated (press and hold the module's internal button for 3 seconds), it can be disabled by command. This means that the activation of emergency operation can be prevented via the user program.
11	Load factory settings
12	Load standard parameters Similar to loading factory settings, but the interface parameters are maintained.
31	Load recovery point
51	Set recovery point A backup of the current parameter assignment is created within the module. Command 31 can be used to restore it quickly and easily.
907	Set impedance reference If the load cells are connected directly to WP361 (no SIWAREX DB), the impedance of the load cell(s) can be determined and automatically saved in data record 10 as a reference. In addition, a maximum permissible deviation from the reference can be defined in data record 10. If this limit is exceeded, a corresponding status bit is set. This allows the connected load cells to be monitored.
922 / 923	Show previous / next security audit log entry The commands allow scrolling through the security audit log. The currently selected entry can be read / displayed via data record 156.
443	Reset weight drag indicator (data record 31)
444	Reset counter "zero settings" (data record 31)
445	Reset counter "calibration point 0" (data record 31)
446	Reset counter "calibration point 1" (data record 31)
451	Trace Recorder ON Starts trace recording within the module according to the trace settings in data record 7.
452	Trace Recorder OFF
453	Create a single trace element
454	Reset trace memory

5.20.2 Calibration and scale commands

Calibration and scale commands

Command code	Command description
60	Calibration Point 0 valid Command for setting the zero point (= typically empty feeder). The command must not be used to zero the scale, as this would manipulate the scale characteristic curve. For simple Zero setting during operation, use command 1001.

61	Calibration Point 1 valid Command for calibration of calibration point 1. At the time the command is executed, the calibration weight specified in data record 3 must be placed on the scale/feeder.
82	Perform automatic calibration The command automatically determines the scale characteristic curve based on the load cell data specified in data record 10. No physical weight is required. The accuracy of this type of calibration largely depends on the scale mechanics and the load cell data in data record 10. If possible, calibration using a physical reference weight is preferable for increased accuracy.
1001	Zero setting Command to set an already calibrated scale to zero. The command allows for zero setting in case of contamination or similar. The command execution range is defined in data record 3 via two corresponding limit values. This can, for example, prevent zero setting of a full feeder.

5.20.3 Loss-in-weight dosing commands

Loss-in-weight dosing commands

Command code	Command description
200	Starting gravimetric mode Command to start controlled (=gravimetric) mode
201	Starting volumetric mode Command to start uncontrolled (=volumetric) mode In this case, a theoretical control value is determined based on the device characteristic curve or the nominal flow rate in data record 5 and output as a fixed value.
202	Initialize dosing The command is used when dosing is started for the first time, when the material is changed and when mechanical changes are made to the feeder or scale. After starting the command, volumetric mode is started for 10 seconds. During this time, filter and PID parameters are automatically determined and entered in data record 5. The system then switches to gravimetric mode if the flow rate is stable. For this purpose, you must also parameterize the stability range in data record 5 correctly and realistically. If dosing has been successfully initialized, command 200 (start gravimetric mode) can be used directly at the next start.
203	Stop dosing Active dosing is stopped, but any active filling will be terminated.
204	Abort dosing Active dosing is stopped. Any active filling will also be terminated.
205	Start filling The command enables manual starting of the filling process, both during active dosing and outside of active dosing.

206	Stop filling The command enables manual stopping of the filling process, both during active dosing and outside of active dosing.
210	Update PID controller parameters If adjustments have been made to the filters and/or the device characteristic curve, it is possible to recalculate the basic PID parameter assignment by command.
222	Set device characteristic point The command allows you to manually set the current operating point in the device characteristic curve in data record 5.

5.20.4 Commissioning

The following basic steps must be carried out to perform an initial quick commissioning:

1. Calibration
   - Select the weight unit in data record 3.
   - Enter the calibration weight.
   - Set the calibration zero point with command 60 when the scale is empty (empty feeder).
   - Place the specified calibration weight on the scale or feeder.
   - Use command 61 to set calibration point 1.
2. Specification of the nominal flow rate (= flow rate by control value 100%) in data record 5.
3. Specification of the desired set point in data record 20.
4. If required, assign functions to the digital inputs or digital outputs in data record 7.
5. Execute command 202 to initially determine the filter and PID parameters.

NOTE
SIWAREX WP361 has no analog output
Procedure:
- The connected PLC must read the control value from the SIWAREX module.
- Forward the control value to the frequency converter, e.g:
  - via PROFINET or
  - via analog output card

Service and maintenance

6

NOTE

The device is maintenance-free.

6.1 Disposal

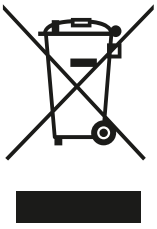

Devices described in this manual should be recycled. They may not be disposed of in the municipal waste disposal services according to the Directive 2012/19/EC on waste electronic and electrical equipment (WEEE).

Devices can be returned to the supplier within the EC, or to a locally approved disposal service for eco-friendly recycling. Observe the specific regulations valid in your country.

Further information about devices containing batteries can be found at: Information on battery/product return (WEEE) (https://support.industry.siemens.com/cs/document/109479891/)

NOTE

Special disposal required

The device includes components that require special disposal.

- Dispose of the device properly and environmentally through a local waste disposal contractor.

Interrupts/diagnostic messages 7

7.1 Message and error types

Three types are distinguished:

Operating errors

Operating errors can occur spontaneously at any time due to an unforeseen event. They include internal and external hardware problems which can occur spontaneously during weighing, e.g. wire break of the load cell cable.

Data and command errors

Data and command errors arise always as response to a command or a data record transfer.

A data error occurs when a plausibility error is identified in a data record sent to the electronic weighing system, causing the electronic weighing system to refuse acceptance of the data record.

A command error occurs when the electronic weighing system cannot execute the issued command in its current operating state.

For most data/command errors, the electronic weighing system outputs additional information for the error. This includes further details about the error and is described in detail in the error list in this section.

Technology messages

Technology messages occur spontaneously due to the process flow of a weighing/dosing operation. Messages provide information to the operator and have no further effect on the dosing operation.

7.2 Evaluating errors/messages using the Web server

The electronic weighing system has a message buffer that stores the last 100 entries including time stamp in non-volatile memory. If the number of messages in the message buffer exceeds 100, the oldest entry is overwritten. The message buffer can be read out at any time using the Web server (menu item "Read out all data records") and saved together with the scale parameters. This facilitates the detection, analysis and correction of errors in the system. The only way to completely clear the message buffer is with the "Load factory settings (11)" command. The message buffer is opened in the web server via the following icon:

7.3 Evaluating errors/messages using the FB

In the event of an error, the function block reads out DR32 automatically. Data/operating errors and technology messages are reported for 3 s. Operating errors remain permanently until the cause is resolved.

7.4 Operating errors

7.4.1 Operating errors

Operating errors	Error code	Description and remedy
Operation error existent	1000	Group message, there is at least one operating error.
Watch dog	1001	Watchdog error. A serious error has occurred in the function of the weighing electronics. Contact SIWAREX Support if the error continues to occur.
Checksum error (Parameter)	1003	The checksum of the parameters no longer matches. Remedy: Load factory settings. Contact SIWAREX Support if the error continues to occur.
Checksum error (Firmware)	1004	The checksum of the weighing electronics FW no longer matches. Remedy: Load factory settings. Contact SIWAREX Support if the error continues to occur.
Logbook full / defective	1006	Error when writing/clearing the logbook. Remedy: Load factory settings. Contact SIWAREX Support if the error continues to occur.
No communication to the digital load cell or SIWAREX DB	1110	Communication to digital load cell or digital junction box SIWAREX DB is interrupted. Check the following: • SIWAREX DB <-> SIWAREX WP wiring • Terminators and address of SIWAREX DB (see operating instructions of SIWAREX DB) • Communication speed in DR10
ADC error	1102	AD converter error when reading the measured value. Remedy: Check and follow recommendations for installation meeting EMC requirements (section EMC-compliant installation (Page 13)).
SENSE voltage too low	1104	Undervoltage on the SENSE cables. A voltage between 4.85 V DC and 10 V DC must be present between SEN+ and SEN-. If necessary, check the wiring of the load cells or, in the case of 4-wire load cells, the wire jumpers between EXC+&SEN+ and EXC-&SEN- in the terminal box.
SIG voltage too high (overload)	1105	The maximum SIG input signal of the AD converter has been exceeded by more than 10%. Check the wiring of the load cell(s). If the wiring is correct, check the input and output resistances of the load cells. By checking the resistors, you can find out whether one or more load cells are defective.
SIG voltage too low (underload)	1106	The minimum SIG input signal of the AD converter has been undershot by more than 10%. Check the wiring of the load cell(s). If the wiring is correct, check the input and output resistances of the load cells. By checking the resistors, you can find out whether one or more load cells are defective.

Operating errors	Error code	Description and remedy
DQ short circuit to ground	1111	Error at digital outputs (short-circuit to ground)
Underload load cell input 1	1201	SIWAREX DB –The minimum input signal of load cell input 1 has been underrun. Check the wiring and the load cell.
Underload load cell input 2	1211	SIWAREX DB –The minimum input signal of load cell input 2 has been underrun. Check the wiring and the load cell.
Underload load cell input 3	1221	SIWAREX DB –The minimum input signal of load cell input 3 has been underrun. Check the wiring and the load cell.
Underload load cell input 4	1231	SIWAREX DB –The minimum input signal of load cell input 4 has been underrun. Check the wiring and the load cell.
Overload load cell input 1	1202	SIWAREX DB –The maximum input signal of load cell input 1 has been overrun. Check the wiring and the load cell.
Overload load cell input 2	1212	SIWAREX DB –The maximum input signal of load cell input 2 has been overrun. Check the wiring and the load cell.
Overload load cell input 3	1222	SIWAREX DB –The maximum input signal of load cell input 3 has been overrun. Check the wiring and the load cell.
Overload load cell input 4	1232	SIWAREX DB –The maximum input signal of load cell input 4 has been overrun. Check the wiring and the load cell.
Error SENSE voltage load cell input 1	1203	SIWAREX DB –The minimum permissible sense voltage of load cell input 1 has been underrun. Check the wiring and the load cell.
Error SENSE voltage load cell input 2	1213	SIWAREX DB –The minimum permissible sense voltage of load cell input 2 has been underrun. Check the wiring and the load cell.
Error SENSE voltage load cell input 3	1223	SIWAREX DB –The minimum permissible sense voltage of load cell input 3 has been underrun. Check the wiring and the load cell.
Error SENSE voltage load cell input 4	1233	SIWAREX DB –The minimum permissible sense voltage of load cell input 4 has been underrun. Check the wiring and the load cell.
Impedance error load cell input 1	1204	SIWAREX DB – The impedance at load cell input 1 is out of permitted range (< 330 ohms or > 4100 ohms)
Impedance error load cell input 2	1214	SIWAREX DB – The impedance at load cell input 2 is out of permitted range (< 330 ohms or > 4100 ohms)
Impedance error load cell input 3	1224	SIWAREX DB – The impedance at load cell input 3 is out of permitted range (< 330 ohms or > 4100 ohms)
Impedance error load cell input 4	1234	SIWAREX DB – The impedance at load cell input 4 is out of permitted range (< 330 ohms or > 4100 ohms)
EXC short circuit load cell input 1	1205	SIWAREX DB – Short circuit on load cell supply (excitation) at load cell input 1. Check the wiring and the load cell.
EXC short circuit load cell input 2	1215	SIWAREX DB – Short circuit on load cell supply (excitation) at load cell input 2. Check the wiring and the load cell.
EXC short circuit load cell input 3	1225	SIWAREX DB – Short circuit on load cell supply (excitation) at load cell input 3. Check the wiring and the load cell.
EXC short circuit load cell input 4	1235	SIWAREX DB – Short circuit on load cell supply (excitation) at load cell input 4. Check the wiring and the load cell.
Error power supply load cell input 1	1206	SIWAREX DB – Error on the power supply of load cell input 1
Error power supply load cell input 2	1216	SIWAREX DB – Error on the power supply of load cell input 2
Error power supply load cell input 3	1226	SIWAREX DB – Error on the power supply of load cell input 3
Error power supply load cell input 4	1236	SIWAREX DB – Error on the power supply of load cell input 4

Operating errors	Error code	Description and remedy
Check sum error SIWAREX DB	1250	SIWAREX DB – Check sum error. If restarting the SIWAREX DB does not solve the problem, please contact the SIWAREX hotline.
Watchdog error SIWAREX DB	1251	SIWAREX DB – Check sum error. If restarting the SIWAREX DB does not solve the problem, please contact the SIWAREX hotline.
ADC error SIWAREX DB	1252	SIWAREX DB – AD converter error. If restarting the SIWAREX DB does not solve the problem, please contact the SIWAREX hotline.
FW update error SIWAREX DB	1254	SIWAREX DB – Firmware update failed

7.4.2 Technology messages

Table 2-1364 Technology messages

Technology messages	Error code	Description and remedy
Technology error existent	2000	Group message, at least one technology message is present
Totalizing error	3001	Error during totalizing
Trace overloaded	2002	Trace recorder cannot record in the cycle time requested in DR7.
Zero setting procedure aborted	2003	Zero setting procedure was aborted because the specified zero setting limits were exceeded.
Trace memory full	2004	Internal trace memory is full and not configured as ring memory (DR7)
Reboot after power reset	2005	Restart of weighing electronics after power failure
Download error	2006	Firmware download was aborted because the connection to the S7 CPU is disturbed or because a download process is already active.
Backup created	2094	Backup file successfully created in the web interface.
Backup loaded	2095	Backup file successfully loaded in the web interface.
Firmware file invalid	2007	Loaded firmware file is invalid.
Recovery point created	2096	Module internal recovery point set successfully.
Recovery point loaded	2097	Module internal recovery point loaded successfully.
Standard parameters loaded	2098	Standard parameters (all data records except DR7) were loaded successfully.
Factory settings loaded	2099	Factory settings were loaded successfully.
Logging not possible	2112	Logging not possible because the necessary conditions are not met (e.g. totalizers are active)
Log error	2115	Error while reading a log from the log memory.
Log memory full	2124	Module internal log memory is full.
Please recalibrate the scale	2126	Please perform a zero and span calibration again, since a new corner load compensation has been performed in the meantime.
Dosing is not enabled	2127	The dosing enabling signal parameterized in data record 7 is not present.
Refilling aborted because weight out of range	2129	Filling of the feeder was interrupted because the current weight exceeds the maximum weight of the scale (data record 3).
Time for refilling expired	2131	The maximum refill time (data record 5) has been exceeded.

Technology messages	Error code	Description and remedy
Maximum waiting time for stability expired	2133	The maximum waiting time for a stable flow (data record 5) was exceeded.
Empty limit undershoot	2134	The empty limit in data record 3 was undershot.
Device curve refreshed	2135	The device curve parameters in data record 5 were updated automatically.
PID parameters refreshed	2136	The PID parameters in data record 5 were updated automatically.
Signal filter	2137	The signal filter parameters in data record 5 were updated automatically.
Limit flow rate	2138	The flow rate limits in data record 5 were exceeded or undershot.

7.4.3 Data and command errors

Data and command errors	Error code [errorCode]	Description
Data or command error	5000	A data or command error exists.
Command not known	6050	The executed command number is not known.
Command not possible now	6051	The corresponding additional info can be found in the table "Additional info".
Error service command	6052	The corresponding additional info can be found in the table "Additional info".
Error calibration command	6053	The corresponding additional info can be found in the table "Additional info".
Error scale command	6054	The corresponding additional info can be found in the table "Additional info".
Error trace/ protocol/ logging/security audit command	6056	The corresponding additional info can be found in the table "Additional info".
Data record not known	7050	
Parameter input not possible	7051	The corresponding additional info can be found in the table "Additional info".
Parameter input not possible - write protection is set	7052	
Parameter error "Calibration Parameter" DR03	7053	The corresponding additional info can be found in the table "Additional info".
Parameter error "Correction factor" DR04	7054	The corresponding additional info can be found in the table "Additional info".
Parameter error "Loss-in-weight" DR05	7055	The corresponding additional info can be found in the table "Additional info".
Parameter error "process interfaces" DR07	7056	The corresponding additional info can be found in the table "Additional info".
Parameter error "Load Cell Parameters" DR10	7058	The corresponding additional info can be found in the table "Additional info".
Parameter error "Configuration of technology messages" DR15	7061	The corresponding additional info can be found in the table "Additional info".

Data and command errors	Error code [errorCode]	Description
Parameter error "Simulation" DR16	7064	The corresponding additional info can be found in the table "Additional info".
Error during log request DR45	7067	The corresponding additional info can be found in the table "Additional info".
Parameter error "SIWAREX DB" DR70	7066	The corresponding additional info can be found in the table "Additional info".

7.4.4 Add info [errorAddInfo] for DR03

Additional information is available for most data/command errors. The cause of the error is described in detail with this information. If a data/command error bit is set, the additional information is also filled accordingly. Thus, the error bits and the additional information must be evaluated together in the program to identify the exact cause of the error.

If additional information not listed above appears for a data/command error bit, it is a parameter ID. This defines the exact parameter that caused the error.

The following table presents the association between the parameter and parameter ID.

Table 2-1365 Add info [errorAddInfo] for DR03

Parameter	Add info [errorAddInfo]
Scale name	302
Measurement unit for flow rate	305
Scale interval of weight	306
Scale interval of totalizers	307
Design flow rate	309
Zero calibration digits	318
Span calibration digits	319
Calibration weight (test weight)	320
Weight unit and weight unit for totalizer do not match (metric/imperial)	9692

7.4.5 Add info [errorAddInfo] for DR05

Core statement

Table 2-1366 Add info [errorAddInfo] for DR05

Parameter	Add info [errorAddInfo]
Correction factor	401
Correction curve (DR5)	500
Correction curve parameter	501
Correction factor curve enabled	502
Belt load 1	519
Correction factor 1	520
Belt load 2	521

Parameter	Add info [errorAddInfo]
Correction factor 2	522
Belt load 3	523
Correction factor 3	524
Maximum negative zero setting range	601
Maximum positive zero setting range	602
Minimum totalized load	603
Minimum flow rate	604
Maximum flow rate	605
Delay time min./max. Flow rate	606
Minimum speed	607
Maximum speed	608
Delay time min./max. Speed	609
Minimum belt load	610
Maximum belt load	611
Delay time min./max. Belt load	612
Minimum belt load for totalizing	614
Curve point 1 replaced.	9563
Curve point 2 replaced.	9564
Curve point 3 replaced.	9565
Curve point 4 replaced.	9566
Curve point 5 replaced.	9567
Curve point 1 inserted.	9568
Curve point 2 inserted.	9569
Curve point 3 inserted.	9570
Curve point 4 inserted.	9571
Curve point 5 inserted.	9572
Curve point 1 removed	9573
Curve point 2 removed	9574
Curve point 3 removed	9575
Curve point 4 removed	9576
Curve point 5 removed	9577
Curve point not added - already on curve.	9578
Curve point not added - almost on curve.	9579
Curve point not added - control value not ascending.	9580
Curve point not added - no flow rate.	9581
The automatic device curve has to be activated.	9582
PID parameters have been updated.	9583
The filter parameter learning function has started.	9584

Parameter	Add info [errorAddInfo]
The learned filter parameters have been adopted.	9585
The learned filter parameters have not been adopted.	9586
The automatic parameters have been successfully learned.	9587

7.4.6 Add info [errorAddInfo] for DR07

Table 2-1367 Add info [errorAddInfo] for DR07

Parameter	Add info [errorAddInfo]
Substitute value on error / CPU-Stop DQ.0	715
Substitute value on error / CPU-Stop DQ.1	716
Substitute value on error / CPU-Stop DQ.2	717
Behavior on CPU stop / failure	723
DQ behavior on CPU stop / failure	724
DQ behavior on failure	725
Trace rate	731
Trace settings	732
Trace memory mode	733
Load per pulse (remote totalizer)	749
Pulse duration (remote totalizer)	750
Pause duration (remote totalizer)	751
IP address x.n.n.n	758
IP address n.x.n.n	759
IP address n.n.x.n	760
IP address n.n.n.x	761
Subnetmask x.n.n.n	762
Subnetmask n.x.n.n	763
Subnetmask n.n.x.n	764
Subnetmask n.n.n.x	765
Gateway x.n.n.n	766
Gateway n.x.n.n	767
Gateway n.n.x.n	768
Gateway n.n.n.x	769
Device name	771
Unit Ident. Modbus connection 1	772
Modbus TCP Port number connection 1	773
Modbus connection #1	774
Enable connection	775
Byte swap for text fields	783
Byte swap for 16 bit tags	784

Parameter	Add info [errorAddInfo]
Byte swap for 32 bit tags (1 # 2, 3 # 4)	785
Word swap for 32 bit tags (1, 2 # 3, 4)	786
Unit Ident. Modbus connection 2	791
Modbus TCP Port number connection 2	792
Modbus connection #2	793
Enable connection	794
Byte swap for text fields	802
Byte swap for 16 bit tags	803
Byte swap for 32 bit tags (1 # 2, 3 # 4)	804
Word swap for 32 bit tags (1, 2 # 3, 4)	805
Cyclic I/O process value 1	810
Cyclic I/O process value 2	811
Cyclic I/O process value 3	812
Cyclic I/O process value 4	813
Cyclic I/O process value 5	814
Cyclic I/O process value 6	815
Cyclic I/O process value 7	816
Cyclic I/O process value 8	817
Hardware interrupt 1	818
Hardware interrupt 2	819
Hardware interrupt 3	820
Hardware interrupt 4	821
Hardware interrupt 5	822
Hardware interrupt 6	823
Hardware interrupt 7	824
Hardware interrupt 8	825
Source for simulation values	827
Signal logic alarm 1	849
Signal logic alarm 2	850
Signal logic alarm 3	851
Signal logic alarm 4	852
Signal logic alarm 5	853
Signal logic alarm 6	854
Signal logic alarm 7	855
Signal logic alarm 8	856

7.4.7 Add info [errorAddInfo] for DR10, DR11, DR14, DR16, DR17, DR18 and DR28

Table 2-1368 Add info [errorAddInfo] for DR10, DR11, DR14, DR16, DR17, DR18 and DR28

Parameter	Add info [errorAddInfo]
Load cell input	1001
AD converter settings	1002
Mains frequency	1003
Mains frequency filter	1004
Load cell parameter	1019
4-wire / 6-wire sensor	1020
External / internal sensor excitation	1021
No. of mechanical support points	1036
Averaged load cell characteristic value (mV/V)	1038
Capacity of one single load cell	1039
Impedance reference (Ohm)	1040
Maximum impedance deviation (% of impedance reference)	1041
Load cell manufacturer	1044
Load cell order number	1046
User tag	2802
Add user tag to log	2804
Log memory mode	2806

7.4.8 Add info [errorAddInfo] for DR30

Table 2-1369 Add info [errorAddInfo] for DR30

Parameter	Add info [errorAddInfo]
Log-ID	4501
Year	4801
Month	4802
Day	4803
Hour	4804
Minute	4805
Second	4806
Millisecond	4807
Day of the week	4808
Location designation sensor 1	7006
Location designation sensor 2	7008
Location designation sensor 3	7010
Location designation sensor 4	7012
Load cell input 1	7014

Parameter	Add info [errorAddInfo]
Load cell input 2	7015
Load cell input 3	7016
Load cell input 4	7017

7.4.9 Add info [errorAddInfo] starting DR70

Table 2-1370 Add info [errorAddInfo] starting DR70

Parameter	Add info [errorAddInfo]
Corner load factor load cell input 1	7051
Corner load factor load cell input 2	7052
Corner load factor load cell input 3	7053
Corner load factor load cell input 4	7054
Belt is running	9501
Belt is not running	9502
Action not possible because an already active action is still in progress	9507
CPU failed or not ready (STOP)	9514
Command not possible because of current parameter setting	9682
Command not executable because totalizing is active	9683
Command not executable because no corner load compensation was performed at load cell input 1	9684
Command not executable because no corner load compensation was performed at load cell input 2	9685
Command not executable because no corner load compensation was performed at load cell input 3	9686
Command not executable because no corner load compensation was performed at load cell input 4	9687
Command not executable because the corner load compensation cannot be calculated. If necessary, use heavier weight for corner load compensation.	9688
Service mode is not active	9510
Write protection is enabled	9511
Enable is missing	9512
Calibration not finished completely	9522
Distance between calibration digits is too small. Please use a heavier calibration weight	9520
Sequence of calibration points is not correct	9521
Calibration digits out of valid range	9523
Calibration weight must not be zero	9524
Command in simulation mode not possible	9527
New parameters are not plausible	9534
Process cannot be completed, because it was not started.	9508
Service mode is still active	9513

Parameter	Add info [errorAddInfo]
In this scale operation mode not possible	9515
Module disturbed	9500
Trace memory full	9550
Log memory full	9551
Logging task is busy	9552
Logbook / security audit logging contains no or no more entries	9554
Curve point 1 replaced.	9563
Curve point 2 replaced.	9564
Curve point 3 replaced.	9565
Curve point 4 replaced.	9566
Curve point 5 replaced.	9567
Curve point 1 inserted.	9568
Curve point 2 inserted.	9569
Curve point 3 inserted.	9570
Curve point 4 inserted.	9571
Curve point 5 inserted.	9572
Curve point 1 removed	9573
Curve point 2 removed	9574
Curve point 3 removed	9575
Curve point 4 removed	9576
Curve point 5 removed	9577
Curve point not added - already on curve.	9578
Curve point not added - almost on curve.	9579
Curve point not added - control value not ascending.	9580
Curve point not added - no flow rate.	9581
The automatic device curve has to be activated.	9582
Parameters have been updated.	9583
The filter parameter learning function has started.	9584
The learned filter parameters have been adopted.	9585
The learned filter parameters have not been adopted.	9586
The automatic parameters have been successfully learned.	9587

7.5 Diagnostic messages

7.5.1 Error codes and corrective measures

Diagnostic results are displayed as plain text in STEP 7 (TIA Portal) via the online and diagnostic message view. Evaluate the error codes by means of the user program.

Error code	Message	Cause/Remedy
9_H	No supply voltage L+	An internal error has occurred. Possible cause: Weighing electronics faulty. • Check the wiring of the 24 V connection on the BaseUnit. • Check the 24 V supply voltage.
10_H	Short circuit (EXC +/-)	Short-circuit at the load cell supply (EXC +/-). • Check the wiring of the load cells.
124_H	Undervoltage (SEN +/-)	The returned SEN voltage of the load cells is too low (< 5 V DC) • Check the wiring of the load cells. • Check the set load cell type; 4- or 6-conductor load cell type
7_H	Overload (SIG +/-)	The signal voltage of the load cells is ≥ +120% of the permissible range. • Check the wiring of the load cells. • Check the scale mechanics.
8_H	Underload (SIG +/-)	The signal voltage of the load cells is ≥ -120% of the permissible range. • Check the wiring of the load cells. • Check the scale mechanics.
106_H	DQ short-circuit to ground	Short-circuit to ground at one of the digital outputs. • Check the wiring. • Check the connected actuator.

Reactions to a diagnostic interrupt

The following happens when an event occurs that triggers a diagnostic interrupt:

- The DIAG LED flashes red.

  When you have eliminated all errors, the DIAG LED stops flashing red and turns green.
- The S7-1500 CPU interrupts the processing of the user program. The diagnostic interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostic interrupt OB.
- The S7-1500 CPU remains in RUN even if no diagnostic interrupt OB is present in the CPU. The technology module continues working unchanged if this is possible despite the error.

You can obtain detailed information on the error event in the error organization block with instruction "RALRM" (Read additional alarm information), in the information system of STEP 7 and in function manual Diagnostics (https://support.industry.siemens.com/cs/ww/en/view/59192926), section "System diagnostics in user program".

If the module is being operated as a distributed module in an ET 200SP system with PROFIBUS DP, you have the option of reading out diagnostic data with the RDREC or RD_REC instruction using data record 0 and 1. You can find the structure of the data records in the manual for the IM 155-6 DP HF interface module available for download on the Internet (https://support.industry.siemens.com/cs/ww/de/view/73098660).

7.5.2 Meaning of the LEDs

The following figure shows the LEDs (status and error displays) of the electronic weighing system.

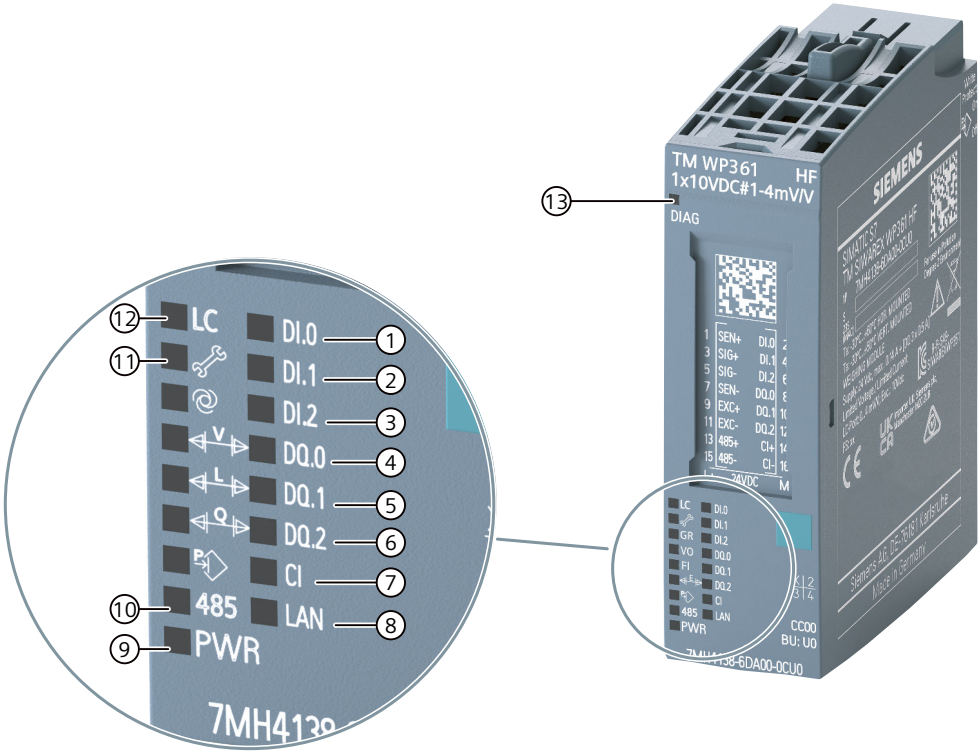

Figure 2-1227 LEDs on the electronic weighing system

Table 2-1371 Legend

LEDs			Meaning	Solution
1	DI.0	green/ off	Input is not active	-
		green/ on	Input is active	-
2	DI.1	green/ off	Input is not active	-
		green/ on	Input is active	-
3	DI.2	green/ off	Input is not active	-
		green/ on	Input is active	-
4	DQ.0	green/ off	Output is not active	-
		green/ on	Output is active	-
		green/ flashing	Fault at DQ.0, 1 or 2	• Check the wiring of the outputs.
5	DQ.1	green/ off	Output is not active	-
		green/ on	Output is active	-
		green/ flashing	Fault at DQ.0, 1 or 2	• Check the wiring of the outputs.
6	DQ.2	green/ off	Output is not active	-
		green/ on	Output is active	-

LEDs			Meaning	Solution
⑥	DQ.2	green/ flashing	Fault at DQ.0, 1 or 2	• Check the wiring of the outputs.
⑦	CI	green/ off	Input is not active	-
		green/ on	Input is active	-
⑧	LAN	green/ off	No Ethernet connection	-
		green/ on	Ethernet connection established	-
		green/ flashing	Ethernet connection is active	-
⑨	PWR	green/ off	No supply voltage L+	• Check the supply voltage. • Check the BaseUnit type and the wiring of the BaseUnit.
		green/ on	Supply voltage L+ present and OK	-
⑩	485	green/ off	Serial communication is not active	-
		green/ on	Serial communication is active	-
⑪		yellow/ off	Service mode is not active	-
		yellow/ on	Local Web server access is enabled	-
		yellow/ flashing	Service mode is active	-
⑫	LC Load cell	green/ off	Sensor connection faulty	Check the wiring of the load cells.
		green/ on	Sensor connection OK	-
⑬	DIAG	green/ off	Backplane bus supply of the ET 200SP not OK	Check or switch on the supply voltage on the interface module.
		green/ flashing	Electronic weighing system not parameterized	-
		green/ on	Electronic weighing system parameterized and no diagnostics	-
		red/ flashing	Electronic weighing system parameterized, there is at least one error.	Evaluate the diagnostic alarms and eliminate the error.

Corrective measures for diagnostics alarms can be found in section Diagnostic messages (Page 87).

7.6 Hardware interrupts

Introduction

Configure in DR07 which events during operation are to trigger a hardware interrupt. In addition, the corresponding hardware interrupt must be enabled in the hardware configuration by the electronic weighing system in TIA Portal.

What is a hardware interrupt?

In accordance with the parameters assigned, the electronic weighing system triggers a hardware interrupt when certain events or states occur.

When a hardware interrupt occurs, the CPU interrupts execution of the user program and processes the associated hardware interrupt organization block (OB). The event that triggered the interrupt is entered in the start information of the assigned hardware interrupt OB by the CPU.

Hardware interrupt lost

If the previous event was not yet processed, "Hardware interrupt lost" is triggered.

Technical data

8

Article number	7MH4138-6DA00-0CU0
General information	
Product type designation	TM SIWAREX WP361 HF
HW functional status	1
Firmware version	V1.0
• FW update possible	Yes
usable BaseUnits	BU type U0
Color code for module-specific color-coded label	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
• Adjustment of measuring range	Yes; ±0 ... 4 mV/V
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V19
• STEP 7 configurable/integrated from version	- / -
• PROFIBUS from GSD version/GSD revision	V04.02.174
• PROFINET from GSD version/GSD revision	GSDML V2.45
Supply voltage	
Rated value (DC)	24 V
Load voltage L+	
• Rated value (DC)	24 V
• permissible range, lower limit (DC)	19.2 V
• permissible range, upper limit (DC)	28.8 V
• Short-circuit protection	Yes
• Reverse polarity protection	Yes
Input current	
Current consumption, max.	140 mA; Without DQ
Power	
Power consumption from the backplane bus	94.5 mW
Power loss	
Power loss, typ.	1.7 W

Article number	7MH4138-6DA00-0CU0
Address area	
Address space per module	
• Inputs	32 byte
• Outputs	32 byte
Hardware configuration	
Automatic encoding	Yes
• Mechanical coding element	Yes
• Type of mechanical coding element	type B
Digital inputs	
Number of digital inputs	3
Digital inputs, parameterizable	Yes
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Input voltage	
• Type of input voltage	24 V DC
• Rated value (DC)	24 V
• for signal "0"	< 5 V DC
• for signal "1"	+11 to +30V
• permissible voltage at input, min.	-30 V
• permissible voltage at input, max.	30 V
Input current	
• for signal "1", typ.	1.6 mA
Input delay (for rated value of input voltage)	
for technological functions	
– parameterizable	Yes
Cable length	
• shielded, max.	500 m
• unshielded, max.	150 m
Digital outputs	
Number of digital outputs	3
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes
Digital output functions, parameterizable	
• Freely usable digital output	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A
Output voltage	
• Type of output voltage	DC

Article number	7MH4138-6DA00-0CU0
Output delay with resistive load	
• "0" to "1", typ.	20 µs
• "1" to "0", typ.	30 µs
Parallel switching of two outputs	
• for uprating	No
Switching frequency	
• with resistive load, max.	500 Hz
Total current of the outputs	
• Current per channel, max.	0.5 A; the total current of all outputs ≥ 0.6 A, the ambient temperature is reduced by -1 °C per 100 mA
• Current per module, max.	1.5 A; Observe derating
Cable length	
• shielded, max.	500 m
• unshielded, max.	150 m
Encoder	
Connection of signal encoders	
• For strain gauges (full bridges) with 4-conductor connection	Yes
• For strain gauges (full bridges) with 6-conductor connection	Yes
• Resistance of full bridge, min.	56 Ω; when using SIWAREX IS 87 ohm for 7MH4710-5BA; 180 ohm when using 7MH4710-5CA
• Resistance of full bridge, max.	4 100 Ω
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.001 %
Error limit according to DIN 1319-1	0.002 %; of full-scale value
Accuracy class	III
Temperature coefficient, zero point	≤ ±0.015 µV/K
Temperature coefficient, span	≤ ±5 ppm/K
Interfaces	
Number of RS 485 interfaces	1; SIWATOOL V7 or SIWAREX DB or SIEBERT remote display
1. Interface	
Interface types	
• RS 485	Yes; Terminated internally with 390 Ω / 220 Ω / 390 Ω
2. Interface	
Interface types	
• RJ 45 (Ethernet)	Yes; 10/100 Mbit/s
• Number of ports	1

Article number	7MH4138-6DA00-0CU0
Protocols	
• IP protocol	Yes; IPv4
• Web server	Yes
Interface types	
RJ 45 (Ethernet)	
• Autonegotiation	Yes
• Autocrossing	Yes
RS 485	
• Transmission rate, max.	115.2 kbit/s
• Cable length, max.	1 000 m; ≤ 115 kbps, shielded cable
Protocols	
Web server	
• HTTP	Yes
• HTTPS	Yes
Interrupts/diagnostics/status information	
Diagnostics function	Yes; Diagnostic alarm
Substitute values connectable	No
Alarms	
• Diagnostic alarm	Yes; Parameterizable
• Hardware interrupt	Yes; Parameterizable
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• Group error	Yes; green/red DIAG LED
Diagnostics indication LED	
• ERROR LED	Yes; green/red DIAG LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
Integrated Functions	
Counter	Yes
• Number of counters	1
• Counting frequency, max.	8 kHz
Load cell	
• permissible input signal per verification interval, min.	0.4 µV/e
• Sampling rate	1 024 Hz
• Resolution of input signal	±20 000 000 parts at 0 ... 4 mV/V
• Common mode voltage, min.	2.8 V
• Common mode voltage, max.	7.7 V

Article number	7MH4138-6DA00-0CU0
• input resistance of signal line, typ.	8 MΩ
• input resistance of sense line, typ.	300 MΩ
• Cable length, max.	500 m; when using the SIWAREX 7MH4702-8AG cable
Measuring functions	
Measuring range	
– -1 mV/V to +1 mV/V	Yes
– -2 mV/V to +2 mV/V	Yes
– -4 mV/V to +4 mV/V	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; more than 2 000 m above sea level, the ambient temperature is reduced by -1 °C per 100 m
• Ambient air temperature-barometric pressure-altitude	1 080 ... 533 hPa (-1 000 ... 5 000 m above sea level)
Decentralized operation	
to SIMATIC S7-300	Yes
to SIMATIC S7-400	Yes
to SIMATIC S7-1200	Yes
to SIMATIC S7-1500	Yes
to standard PROFIBUS master	Yes
to standard PROFINET controller	Yes
Dimensions	
Width	20 mm
Height	58 mm
Depth	73 mm
Weights	
Weight, approx.	50 g

8.1 Certificates and approvals

- All certificates are available online at Certificates (https://sieportal.siemens.com/su/bmpsJ).
- The current approvals for your device can be found on the nameplate.

Symbol	Standard	Marking
		→ CE approval
		→ Tick mark for Australia and New Zealand
		→ KCC approval
		→ The weighing electronics is RoHS-compliant according to EU Directive 2016/65/EU

Product documentation and support

A

A.1 Product documentation

Product documentation for process instrumentation is available in the following formats:

- Certificates (http://www.siemens.com/processinstrumentation/certificates)
- Downloads (firmware, EDDs, software) (http://www.siemens.com/processinstrumentation/downloads)
- Catalogs and technical data sheets (http://www.siemens.com/processinstrumentation/catalogs)
- Manuals (http://www.siemens.com/processinstrumentation/documentation)

  You have the option to view, open, save or configure the manual.

  – "Display": The manual opens in HTML5 format.

  – "Configure": You can register and configure the specific documentation for your plant here.

  – "Download": The manual is opened or saved in PDF format.

  – "Download as html5, only PC": The manual is opened or saved in HTML5 view on your PC.

You can also find manuals at Industry Online Support (https://support.industry.siemens.com/cs/ww/de/sc/2067) using the mobile app. Download the app to your mobile device and scan the QR code.

See also

Generally applicable information/SIMATIC manual overview (https://support.industry.siemens.com/cs/ww/en/view/109742709)

A.2 Technical support

Technical support

If this documentation does not completely answer your technical questions, you can enter a Support Request (http://www.siemens.com/automation/support-request).

For help creating a support request, view this video here (www.siemens.com/opensr).

Additional information on our technical support can be found at Technical Support (http://www.siemens.com/automation/csi/service).

Service & support on the Internet

In addition to our technical support, Siemens offers comprehensive online services at Service & Support (http://www.siemens.com/automation/serviceandsupport).

Contact

If you have further questions about the device, contact your local Siemens representative at Personal Contact (http://www.automation.siemens.com/partner).

To find the contact for your product, go to "all products and branches" and select "Products & Services > Industrial automation > Process instrumentation".

Contact address for business unit:
Siemens AG
Digital Industries
Process Automation
Östliche Rheinbrückenstr. 50
76187 Karlsruhe, Germany

SIWAREX support

Phone: +49 (721) 667-1200 CET 8:00 to 17:00

Ordering data

B

B.1 Accessories

You can order accessories online: Industry Mall (https://mallstage.industry.siemens.com/mall/en/b0/Catalog/Products/10364709?tree=CatalogTree)

The following accessories are not included in the scope of delivery:

- **Mandatory**: BaseUnit of the type U0, article number 6ES7193-6BP00-0xU0

  An overview of the BaseUnits that you can use with the electronic weighing system can be found in the Product Information for the documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

  Information regarding selection of the suitable BaseUnit can be found in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual.
- Labeling strips
- Color-coded labels
- Equipment labeling plates
- Shield connection
- Calibration set, article number 7MH4138-6BA00-0AY0
  It contains three unlocking preventers (for calibrating three balances) and special foil for printing the labels.

SIEMENS

SIMATIC

ET 200SP HF
Technology module TM FCT070

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7ME4138-6AA00-0BB1

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Introduction 1

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

1.1 Purpose of this document

These instructions contain the product-specific information you need for connecting, commissioning, parameter assignment/addressing, diagnostics and technical specifications of the technology module.

General information on installation and commissioning of ET 200SP HF is available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/109742709).

1.2 Use in hazardous area

WARNING

Use in hazardous area

Risk of explosion.

- Only use equipment that is approved for use in the intended hazardous area and labeled accordingly.
- Do not use devices that have been operated outside the conditions specified for hazardous areas. If you have used the device outside the conditions for hazardous areas, make all Ex markings unrecognizable on the nameplate.

WARNING

If the device is installed in a cabinet, the inner temperature of the cabinet corresponds to the ambient temperature of the device.

WARNING

Impermissible repair of the device

- Repair must be carried out by Siemens authorized personnel only.

1.3 Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit
https://www.siemens.com/industrialsecurity.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under
https://www.siemens.com/industrialsecurity.

1.4 Open Source Software

Open-source software is used in the firmware of the product described. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information on this on the *Internet* (https://support.industry.siemens.com/cs/ww/en/view/109740777).

Product overview

2

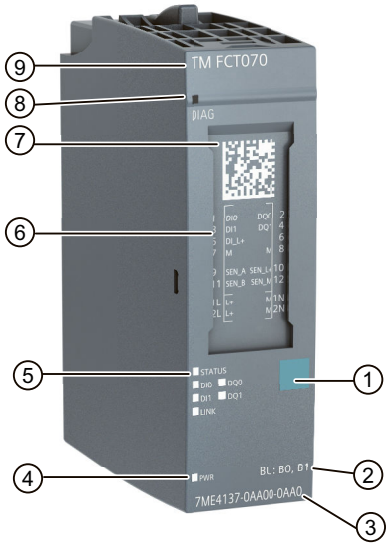

①	Color coding module type	⑥	Connection diagram
②	BaseUnit type	⑦	2D-Matrix Code
③	Article number	⑧	LED for diagnostics
④	LED for supply voltage	⑨	Module type and designation
⑤	Status LEDs		

Figure 2-1228 View of the TM FCT070 module

See also

SIMATIC ET 200SP Distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293)

SIMATIC ET 200SP Product information on the documentation of the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/73021864)

2.1 Properties

The FCT070 technology module has the following properties:

- Transmitter module for one Siemens four wired digital Coriolis flowmeter
- The module works with the digital Coriolis flow sensors SITRANS FCS400 and SITRANS FCS300 or with Siemens Digital Sensor Link (FC DSL) and analog Coriolis flow sensors SITRANS FC MASS 2100 and SITRANS FC300 DN 4
- Two configurable digital inputs
- Two configurable digital outputs
- High update rate (100 Hz) on all process values

- Measurement of the following process variables:
  - Mass flow
  - Volume flow
  - Standard volume flow
  - Density
  - Medium temperature
  - Fraction
- 3 Totalizers
- Dosing functionality
- Independent low flow cut-off settings for volume flow and mass flow
- Status LEDs

Operating modes

Transmitter for Coriolis flowmeter

Transfers the measuring signals from the flowmeter via the ET 200SP HF to STEP 7 (TIA Portal or PCS 7). It is possible to read values from the flowmeter but also to write configuration data to the flowmeter.

- Dosing

  Full automatic filling process for bottle filling. The filling process can be controlled via the digital inputs. With the outputs a fast and slow filling valve can be controlled. The dosing process can be also controlled via STEP 7 (TIA Portal).

  - 2 x digital input
    Digital input 1 and 2 for start, stop, resume and pause
  - 2 x digital output
    Digital output 1 for control valve one
    Digital output 2 for control valve two
- Status signal flow direction with a digital output

  Flow direction forward (off) or backward (on)

Configuration

SITRANS TM FCT070 configuration software options:

- TIA Portal V16 or higher SP1 with HSP 0331 (Hardware Support Package from the Internet)
- STEP 7 version V5.6 or higher SP2 with HSP 0303
- PCS 7 V9.0 SP3 or higher (download driver from PCS 7 Library)
- GSD file links:
  - PROFINET GSD files
    (https://support.industry.siemens.com/cs/document/57138621?dti=0&lc=en-US)

Firmware update

Firmware updates can be downloaded to the memory of the SITRANS TM FCT070 module by means of the STEP 7 Basic (TIA Portal) engineering software or STEP 7 - HW Config.

See also

PROFIBUS GSD files
(https://support.industry.siemens.com/cs/document/73016883?dti=0&lc=en-US)

Modes and Functions

3

3.1 Overview

Modes and functions

The TM FCT070 has two digital inputs and two digital outputs. You can assign a different mode for each in-/output.

Configuration of the operating mode is made using the TIA Portal or HW Config.

You can select one of the following operating modes:

- Status output
- Dosing on/off signal

Interfaces to the control program and the process under control

The TM FCT070 has the following I/O BaseUnit pin connections to the process under control:

- DI0 (digital input 0)
- DQ0 (digital output 0)
- DI1 (digital input 1)
- DQ1 (digital output 1)

3.2 Cut-off limits

The cut-off limits are used to suppress low flow rates.

It is possible to program the cut-off limit for mass flow, volume flow and standard volume flow.

In certain applications, as for instance dosing applications, 0% flow signals below a certain flowrate are desired. In these applications, the flow signal can be forced to zero, when the flow is lower than a predefined flow value (Low Flow Cut-Off). The device provides two parameters for setting the low flow cut-off:

- Low Mass Flow Cut-Off
- Low Volume Flow Cut-Off

Parameterization

The mode of the cut-off limits can be set via the Parameter data record (Page 60).

Byte Bit		Cut-off limit
	Mass flow cut-off limit	encoded as Float32 in mass units Default value = 0.0
	Volume flow cut-off limit	encoded as Float32 in volume units Default value = 0.0

3.3 Zero point adjustment

NOTE
Preconditions
Before a zero point adjustment is initiated, the sensor pipe must be flushed, filled and at an absolute flowrate of zero preferably also at operating pressure and temperature.

NOTE
Change of parameters during zero point adjustment
Do not change any other parameter during the zero point adjustment procedure.

Automatic zero point adjustment

The device measures and calculates the correct zero point automatically.

The automatic zero point adjustment of the flowmeter is set by the following parameters:

- Duration
- Start Zero Point Adjustment

When zero adjust is initiated by selecting "Start Zero Point Adjustment", the mass flow values are acquired and totalized for the configured period (Duration). The default zero point adjustment period (30 s.) is normally sufficient for a stable zero point measurement.

NOTE
Extremely low flow quantity
If the flow quantity is extremely small, extremely precise measurement is necessary. In this case, a long zero point adjustment period can be selected for improved zero point adjustment.

3.4 Digital output mode DQ0/DQ1

The TM FCT070 outputs offer different signals at the DQ0/DQ1 digital outputs.

The digital output can be used for status signals, flow direction or for control of valves in the dosing mode.

Parameterization

The mode of the outputs DQ0 and DQ1 can be set via the Parameter data record (Page 60).

3.4.1 Status signal

Output mode must be set to 1 to activate signal. Depending on the activation one or more status signals can be shown.

Status signal can show following status at DQ0 or/and DQ1:

- out of specification – measuring signal is out of range
- failure – sensor measuring failure
- maintenance required – the sensor needs maintenance
- function check – e.g. startup of the sensor, simulation active, force mode activated or frozen value active

3.4.2 Force value

Activates the output if force output is set at the input DI0 or DI1.

Possible with Step7 (TIA Portal) or activation via I/O data.

3.4.3 Flow direction

Displays the flow direction:

- Active: positive flow
- Inactive: negative flow

3.5 Digital input mode DI0/DI1

The TM FCT070 input can handle different signals at the DI0 and DI1 digital inputs.

Parameterization

The mode of the digital inputs DI0 and DI1 can be set via the Parameter data record (Page 60).

Following modes are available

Dosing

- Dosing function
- Start dosing on leading edge
- Stop dosing on leading edge
- Pause/resume dosing

Totalizer function

- Reset totalizer 1 on leading edge
- Reset totalizer 2 on leading edge
- Reset totalizer 3 on leading edge
- Reset all totalizers on leading edge
- Start/stop totalizer 1
- Start/stop totalizer 2
- Start/stop totalizer 3

Special functions

Force outputs is used to switch on both outputs. It can be used e.g. for a cleaning process

- Freeze process values
- Force outputs
- Zero adjust on leading edge

3.5.1 Function: Dosing

The TM FCT070 offers a dosing operation mode. The dosing mode can be used for filling processes, with control of one or two on/off valves and optional one or integrated two inputs for start, stop, pause and resume. The open and close of the second valve can be adjusted depending on the filling level. This valve is normally used for the fast filling.

Is the target dosing amount reached, the valves are closed.

The filling process can be controlled via STEP 7 (TIA Portal) or in- and outputs which are integrated in the FCT070 module. The control and function of the dosing process is determined by the configuration.

Parameterization

The dosing mode can be set via the Parameter data record (Page 60).

With the inputs DI0, DI1, and outputs DQ0 and DQ1 the customer can build a PLC independent dosing filling control process.

Output DQ0 low flow filling valve (main valve)

Output DQ1 fast flow filling valve

3.5.1.1 Filling with one valve

- DQ0 filling valve
- DI0 start signal of dosing

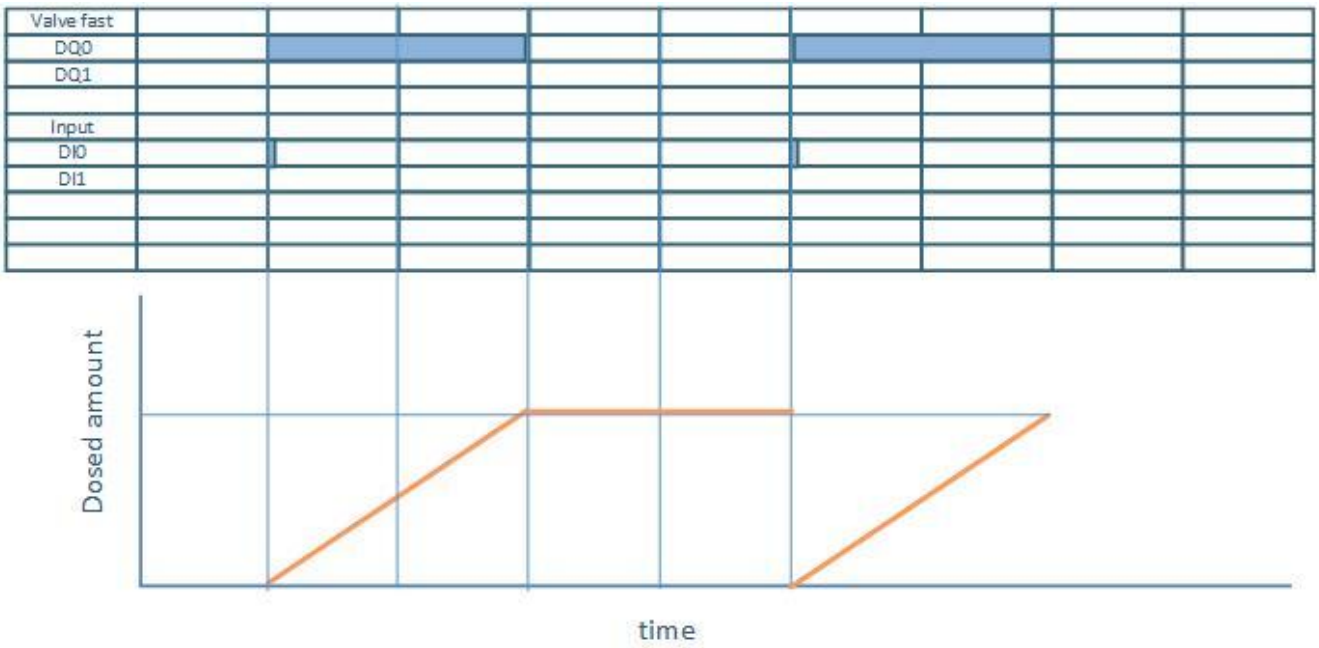

Dosing mode	1	one valve	
Target dosing amount		individual	
Mode input			
DI0	1	Start dosing	
DI1	0	No function	

3.5.1.2 Filling with two valves and external start

The maximum dosing amount can be determined depending on address 45.

Dosing amount DQ1 open and DQ1 close allows to adjust the filling range of the second valve.

- DQ0 low flow filling valve
- DQ1 fast flow filling valve
- DI0 start signal of the dosing

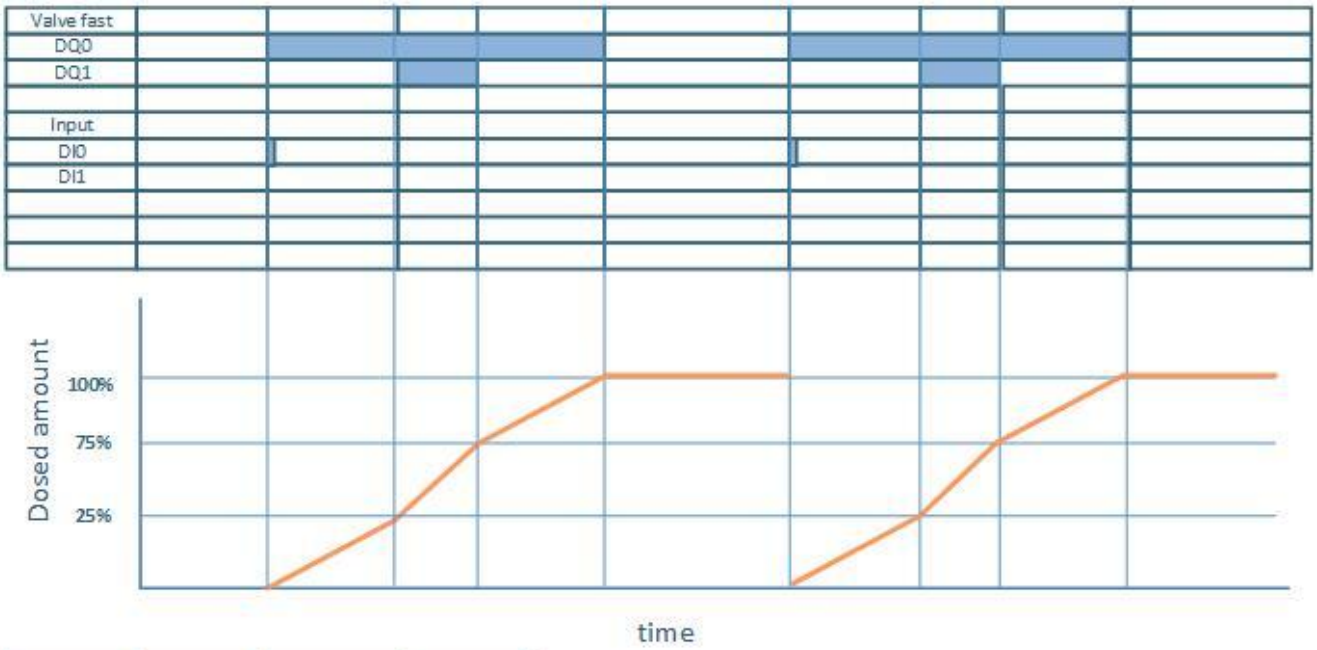

Dosing mode	2	two valves	
Target dosing amount		individual	
Mode input			
DI0	1	Start dosing	
DI1	0	No function	
Target dosing amount			
DQ1 close	75%		
DQ1 open	25%		

3.5.1.3 Filling with two valves and stop filling procedure

Stop signal via input DI1.

- DQ0 low flow filling valve
- DQ1 fast flow filling valve
- DI0 start signal for dosing
- DI1 stop signal for dosing

Signal only resumes when starting.

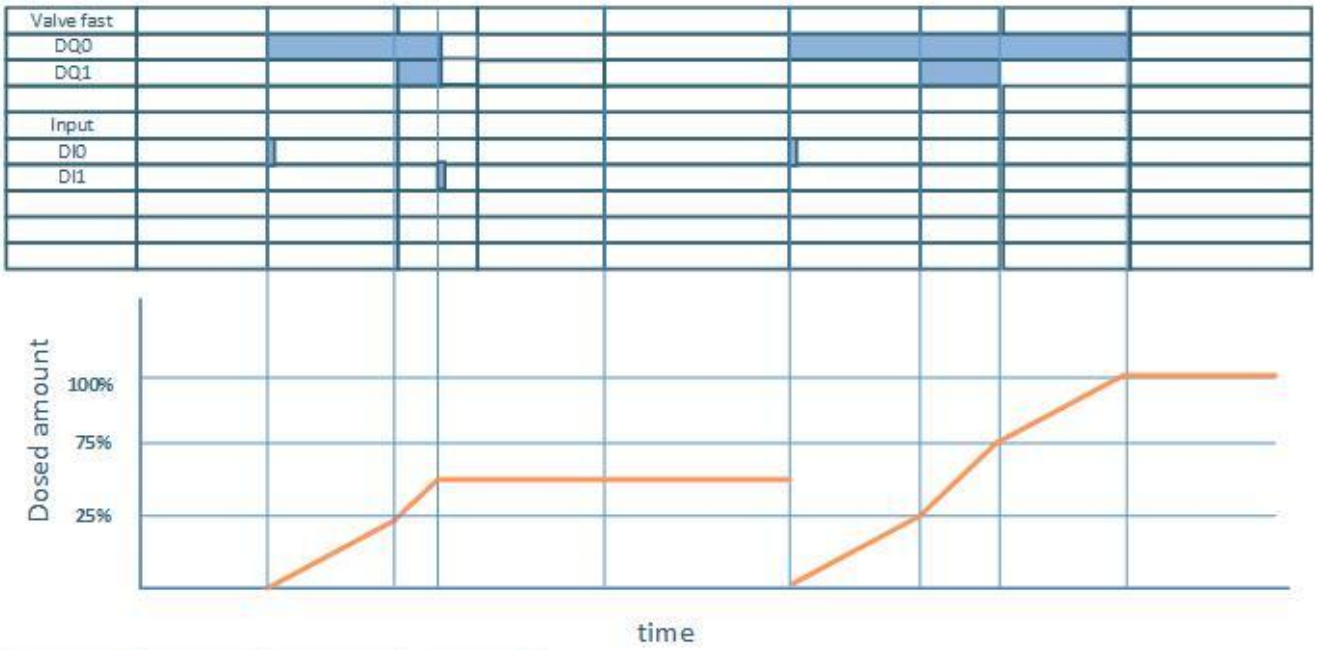

Dosing mode	2	two valves	
Target dosing amount		individual	
Mode input			
DI0	1	Start dosing	
DI1	2	Stop dosing	
Target dosing amount			
DQ1 close	75%		
DQ1 open	25%		

The stop signal can be sent, depending on the setup, via STEP 7 (TIA Portal) or external input.

3.5.1.4 Filling with two valves and interrupt filling procedure

Stop signal via input DI1.

- DQ0 low flow filling valve
- DQ1 fast flow filling valve
- DI0 start signal for dosing
- DI1 pause/resume signal for dosing

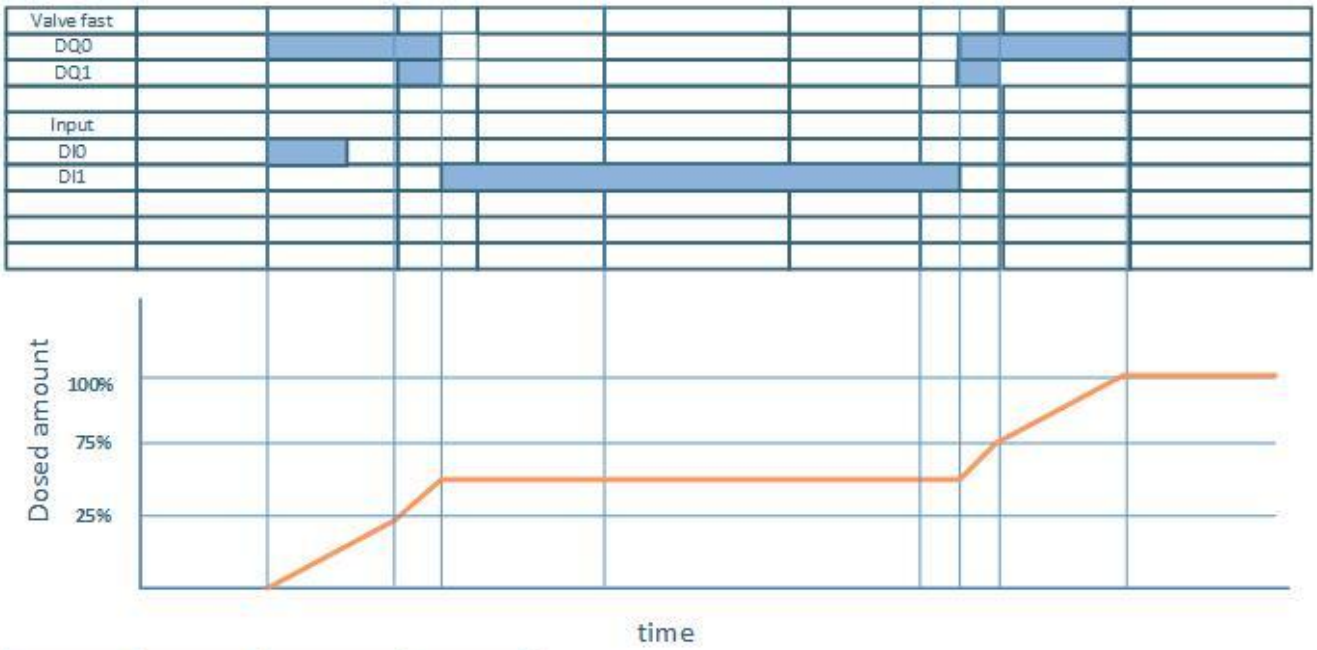

Dosing mode	2	two valves	
Target dosing amount		individual	
Mode input			
DI0	1	Start dosing	
DI1	8	Pause dosing	
Target dosing amount			
DQ1 close	75%		
DQ1 open	25%		

The pause signal can be sent, depending on the setup, via STEP 7 (TIA Portal) or external input.

3.5.2 Function: Totalizer

Definition

The TM FCT070 has a different totalizer integrated. The totalizer counts the volume and can be used for process control. The counting is done in the FCT070 and can be used in the PLC or shown on TIA Portal.

The reset of the totalizers can be done via STEP 7 (TIA Portal) or with the input DI0 or DI1.

Parameterization

The mode of the totalizer can be set via the Parameter data record (Page 60).

Depending on the mode set for the DI0/DI1 inputs, the totalizer can be started, stopped or reset with the inputs on the FCT070.

In case of failure in the system, the totalizer holds the last value before the failure occurred.

3.5.2.1 Freeze process values

Definition

The mode of the totalizer can be set via the Parameter data record (Page 60).

Is mode of DI0 or DI1 set to 10.

With the input the process values of the measuring value can be frozen to have a fixed measuring value for testing the PLC programming during commissioning.

3.5.2.2 Force outputs

Definition

The mode of the totalizer can be set via the Parameter data record (Page 60).

Is mode of DI0 or DI1 set to 9.

The inputs DI0 or DI1 can control the outputs DQ0 and DQ1 and switch them on and off.

To activate the outputs with the inputs the function DQ0 or DQ1 force value must be set to active.

3.5.2.3 Zero adjust on leading edge

Definition

The mode of the totalizer can be set via the Parameter data record (Page 60).

Is mode of DI0 or DI1 set to 7.

A zero-point adjustment of the flowmeter measuring is done. The actual measured flow value is set to zero when triggered.

Installation 4

4.1 Basic safety notes for ordinary location (electrical safety FM, UL)

WARNING

If a device is operated in an ambient temperature of more than 50 to 60 °C, the temperature of the device housing may be higher than 70 °C. The device must therefore be installed so that it is only accessible to service personnel or users that are aware of the reason for restricted access and the required safety measures at an ambient temperature higher than 60 °C.

WARNING

Open equipment

The devices are "open equipment" according to the standard IEC 61010-2-201 or UL 61010-2-201 / CSA C22.2 No. 61010-2-201. To fulfill requirements for safe operation with regard to mechanical stability, flame retardation, stability, and protection against contact, the following alternative types of installation are specified:

- Installation in a suitable cabinet.
- Installation in a suitable enclosure.
- Installation in a suitably equipped, enclosed control room.

4.1.1 Specific conditions for use in hazardous locations (ATEX, IECEx, UL)

WARNING

Incorrect installation

Risk of explosion in the hazardous area. For use in hazardous areas according to Class I, Division 2 or Class I, Zone 2 or for use in the EU according to ATEX 2014/34/EU, observe the following conditions:

- Install the device in a control cabinet or enclosure.
- The control cabinet or enclosure meets at least the requirements of IP54 according to IEC/EN 60079-7 and pollution degree 2 or better according to IEC/EN 60664-1.

NOTE

You must not install the device on a wall in hazardous areas.

WARNING

Take measures to prevent transient voltage surges of more than 40% of the rated voltage. This is the case if you only operate devices with SELV (safety extra-low voltage).

WARNING

Explosion hazard

Do not disconnect equipment when a flammable or combustible atmosphere is present.

WARNING

Substitution of components may impair suitability for Division 2.

This equipment is suitable only for use in Class I, Division 2, Groups A, B, C and D, Class I, Zone 2, Group IIC or non-hazardous locations.

4.1.2 Notes for use in hazardous areas according to FM

WARNING

Substitution of components may impair suitability for Division 2.

WARNING

Explosion hazard

Do not disconnect equipment when a flammable or combustible atmosphere is present.

WARNING

WARNING – EXPLOSION HAZARD:

DO NOT CONNECT OR DISCONNECT EQUIPMENT WHEN A FLAMMABLE OR COMBUSTIBLE ATMOSPHERE IS PRESENT.

CAUTION

Accessible hot surfaces

⚠ CAUTION
To prevent injury, read the manual before use.

This equipment is suitable only for use in Class I, Division 2, Groups A, B, C and D, Class I, Zone 2, Group IIC or non-hazardous locations.

This equipment is suitable only for use in Class I, Zone 2, Group IIC or non-hazardous locations.

4.2 Mounting on the SIMATIC ET 200SP HF

Only use the technology module FCT070 in conjunction with a SIMATIC ET 200SP HF distributed I/O system. Install the technology module in a control cabinet. Observe the information on the protection class and degree of pollution in the section Technical data (Page 40).

When installing the SIMATIC components with the technology module described herein, follow the setup, assembly and wiring guidelines for the SIMATIC ET 200SP HF. See system manual (https://support.industry.siemens.com/cs/ww/en/view/109742709) for the SIMATIC ET 200SP HF.

The technology module FCT070 is snapped onto the SIMATIC ET 200SP HF BaseUnit B0 (BU20-P12+A4+0B, order number 6ES7193-6BP20-0BB0) or B1 (BU20-P12+A0+4B, order number 6ES7193-6BP20-0BB1).

All information about connecting is available in section Connecting (Page 28).

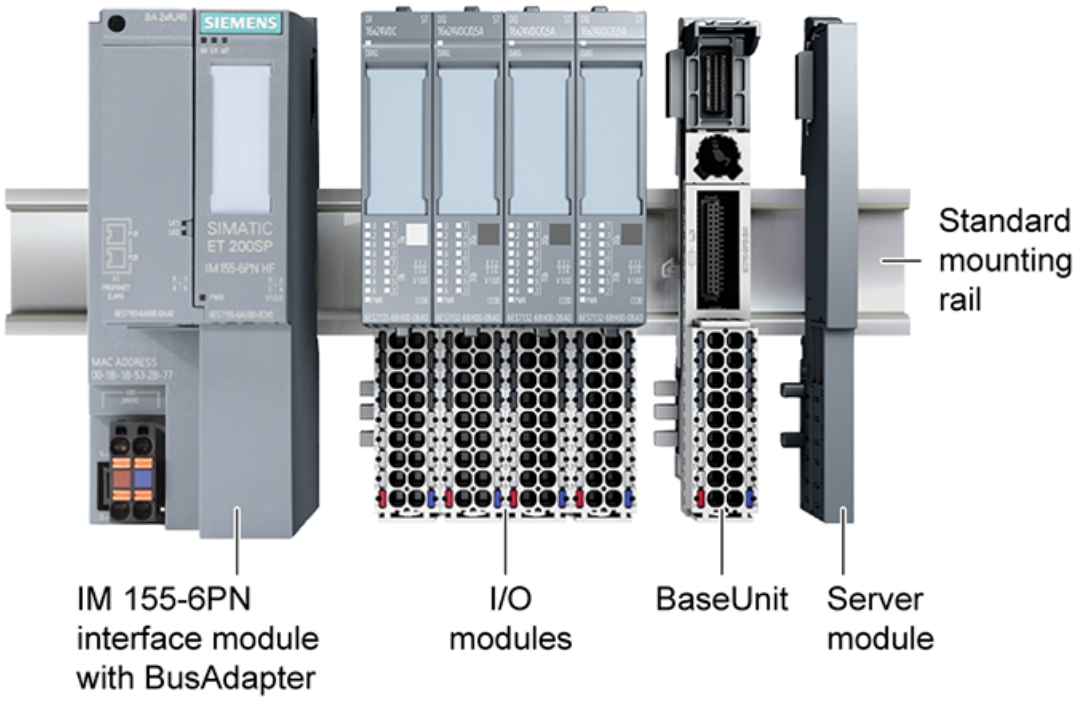

Figure 2-1229 Mounting on the SIMATIC ET 200SP HF

4.3 Installing FCT070 with isolating power supply

To use the sensor in explosion proof areas an isolating power supply must be installed. The SITRANS I300 can be used to isolate the power supply and the digital communication signal to the sensor.

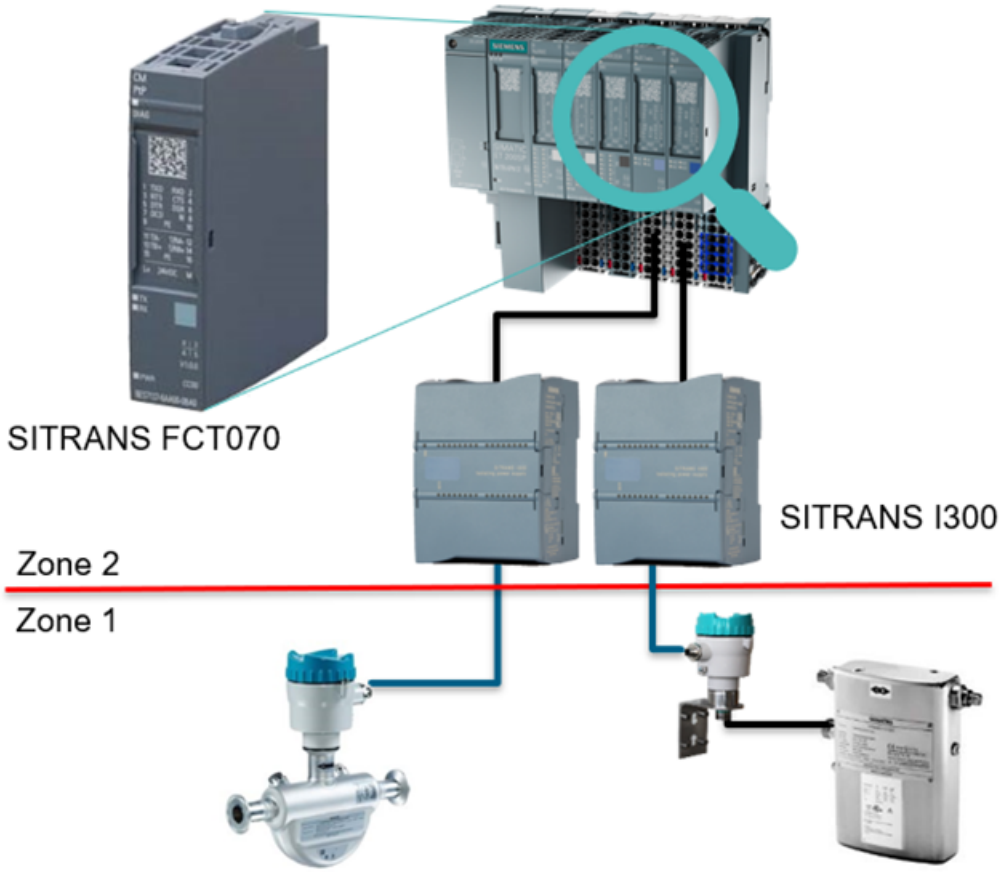

NOTICE
Transmission speed Change the transmission speed of the SITRANS I300 from standard to 460,8 kBit/s.

- **Sensor in Zone 1 or division 1 and ET 200SP HF in Zone 2 or division 2**

  I300 is needed.

  NOTE

  If the version of the FC DSL contains the “For Ex-d”, it is possible to connect the FC DSL via Ex-d-cable-gland or conduit-stop to the FCT070 without I300.

- **Sensor in Zone 2 and ET 200SP HF in Zone 2**

  I300 is needed.

  NOTE

  If the version of the FC DSL contains the “For Ex-d”, it is possible to connect the FC DSL via Ex-d-cable-gland or conduit-stop to the FCT070 without I300.

NOTE

NOT POSSIBLE: Sensor in Zone 1 or division 1 and ET 200SP HF in Zone 1 or division 1

NOTE

If sensor and FC DSL are divided, it is possible (in some cases) to install sensor in Zone 0.

4.4 EMC-compliant installation

4.4.1 Introduction

Overview

The technology module described here was developed for use in industrial environments and complies with high EMC requirements. Nevertheless, before installing your devices you should prepare an EMC plan and identify and take into consideration possible interference sources.

EMC

EMC (electromagnetic compatibility) describes the capability of electrical equipment to operate without errors in a given electromagnetic environment, without being subject to external influence and without influencing external devices in any way.

4.4.2 Possible effects of interference

Electromagnetic interferences can influence the technology module described here in various ways:

- Electromagnetic fields having a direct influence on the system
- Interferences transported by communication cables
- Interferences having an effect via process cables
- Interferences entering the system via the power supply and/or protective ground

Interferences can impair the fault-free functioning of the technology module.

4.4.3 Coupling mechanisms

Depending on the propagation medium (conducted or non-conducted) and the distance between the interference source and the device, interferences can enter the faulty device through four different coupling mechanisms:

- Electrical coupling
- Capacitive coupling
- Inductive coupling
- Radiation coupling

4.4.4 Five basic rules for securing EMC

Observe these five basic rules to secure EMC.

Rule 1: Large area grounding contact

- When installing the devices, make sure that the surfaces of inactive metal parts are properly bonded to chassis ground (see following sections).
- Bond all inactive metal parts to chassis ground, ensuring large area and low-impedance contact (large cross-sections).
- When using screw connections on varnished or anodized metal parts, support contact with special contact washers or remove the protective insulating finish on the points of contact.
- Wherever possible, avoid the use of aluminum parts for ground bonding. Aluminum oxidizes very easily and is therefore less suitable for ground bonding.
- Provide a central connection between chassis ground and the ground/protective conductor system.

Rule 2: Proper cable routing

- Organize your wiring system into cable groups (high-voltage/power supply/signal/measurement/data cables).
- Always route high-voltage and data cables in separate ducts or in separate bundles.
- Install the measurement cables as close as possible to grounded surfaces (e.g. supporting beans, metal rails, steel cabinet walls).

Rule 3: Fixing the cable shielding

- Ensure proper fixation of the cable shielding.
- Always use shielded data cables. Always connect both ends of the data cable shielding to ground on a large area.
- Keep unshielded cable ends as short as possible.
- Always use metal/metalized connector housings only for shielded data cables.

Rule 4: Special EMC measures

- All inductors that are to be controlled should be connected with suppressors.
- For cabinet or enclosure lighting in the immediate range of your controller, use incandescent lamps or interference suppressed fluorescent lamps.

Rule 5: Homogeneous reference potential

- Create a homogeneous reference potential and ground all electrical equipment.
- Use sufficiently dimensioned equipotential bonding conductors if potential differences exist or are expected between your system components. Equipotential bonding is absolutely mandatory for applications in hazardous areas.

Connecting 5

5.1 Basic safety notes for ordinary locations (electrtical safety FM, UL)

5.1.1 Safety extra low voltage

WARNING

Safety extra low voltage

The equipment is designed for operation with Safety Extra-Low Voltage (SELV) by a Limited Power Source (LPS). (This does not apply to 100 V...240 V devices.)

The power supply unit for the equipment power supply must comply with NEC Class 2, as described by the National Electrical Code (r) (ANSI / NFPA 70).

There is an additional requirement if devices are operated with a redundant power supply:

If the equipment is connected to a redundant power supply (two separate power supplies), both must meet these requirements.

WARNING

Suitable cables at high ambient temperatures

If the temperature of the cable or housing socket exceeds 70 °C or the branching point of conductors exceeds 80 °C, special precautions must be taken.

If the device is operated at ambient temperatures of between 50 °C and 60 °C, only use cables with a maximum permitted operating temperature of at least 80 °C.

5.1.2 Special conditions for use in hazardous locations (ATEX; IECEx, FM, UL)

WARNING

WARNING – EXPLOSION HAZARD:

DO NOT CONNECT OR DISCONNECT EQUIPMENT WHEN A FLAMMABLE OR COMBUSTIBLE ATMOSPHERE IS PRESENT.

WARNING

Take measures to prevent transient voltage surges of more than 40% of the rated voltage. This is the case if you only operate devices with SELV (safety extra-low voltage or Class 2 power supply).

5.2 Connection of inputs and outputs

The FCT070 has two digital inputs and two digital outputs which can be configured for different operation modes.

Table 2-1372 Pin assignment of the BaseUnit

Naming	Con.	PIN	BaseUnit BU20	PIN	Con.	Naming
Digital input	DI0	1		2	DQ0	Digital output
Digital input	DI1	3		4	DQ1	Digital output
+24 V DC supply voltage for digital inputs	DI_L+	5		6	nc	
Ground for digital outputs	M	7		8	M	Ground for digital outputs
RS-485 data line B for SEN communication	SEN_B	9		10	SEN_L+	+15 V DC supply voltage for SEN
RS-485 data line A for SEN communication	SEN_A	11		12	SEN_M	GND for SEN supply
+24 V DC supply voltage	L+	13		14	M	Ground for supply voltage
	L+	15		16	M	

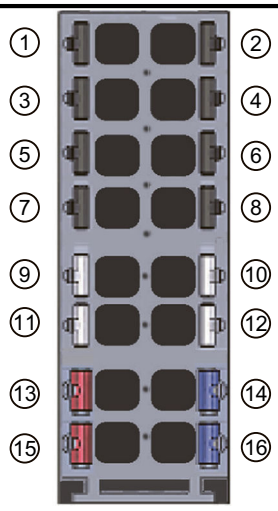

Digital outputs			Voltage switching load
Digital output DQ0	Control valve 1 or Status signal output or Flow direction indication depending on DQ0 mode	Active output	24 VDC 100 mA
Digital output DQ1	Control valve 2 or Status signal output or Flow direction indication depending on DQ1 mode	Active output	24 VDC 100 mA

Digital inputs			Voltage
Digital input DI0	Dosing, totalizer or special function	signal "0" 0 to +5V signal "1" +15 to +30V	24 VDC
Digital input DI1	Dosing, totalizer or special function	signal "0" 0 to +5V signal "1" +15 to +30V	24 VDC

WARNING

Supply voltage M connections

Connect both the M potential pins to the power supply return with separate wires. If one wire breaks, then the other wire maintains the electrical connection from M to the power supply return.

If the electrical connection between the M potential and the power supply return is broken, then unexpected conditions can occur and the digital outputs may go high even though your program is not setting a high state.

Connecting with or without SITRANS I300 Ex barrier

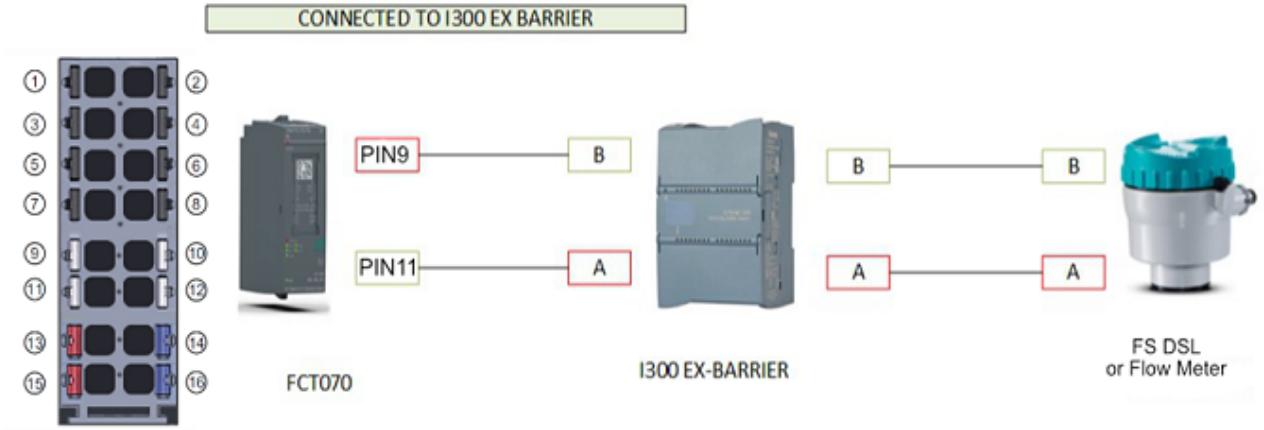

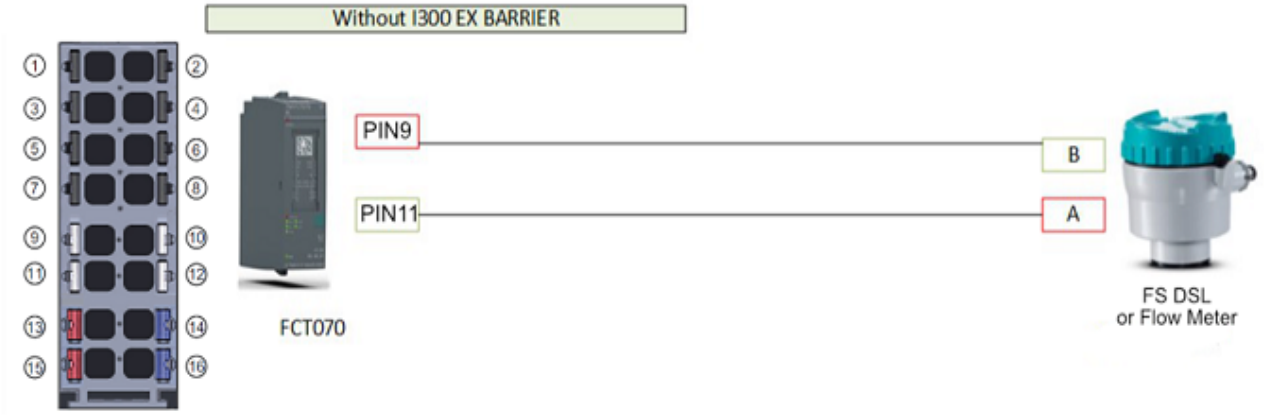

NOTE

L+ and M isolation on TM FCT070 module using BaseUnit type B0 or B1

The L+ and M connections on the type B1 BaseUnit are electrically isolated, from adjacent BaseUnits plugged in on the left-side or right-side. The L+ and M power bus passes through the BaseUnit type B0 or B1 (with no connections) and extends the power bus to connect left-side and right-side BaseUnits.

NOTE

Electromagnetic interference shielding for inputs

Input connections on the BaseUnit type B0 or B1 used by the TM FCT070 module do not have shield ground connections. You must connect cable shields to electrical ground at the DIN rail or the system cabinet.

Example installation of the dosing system

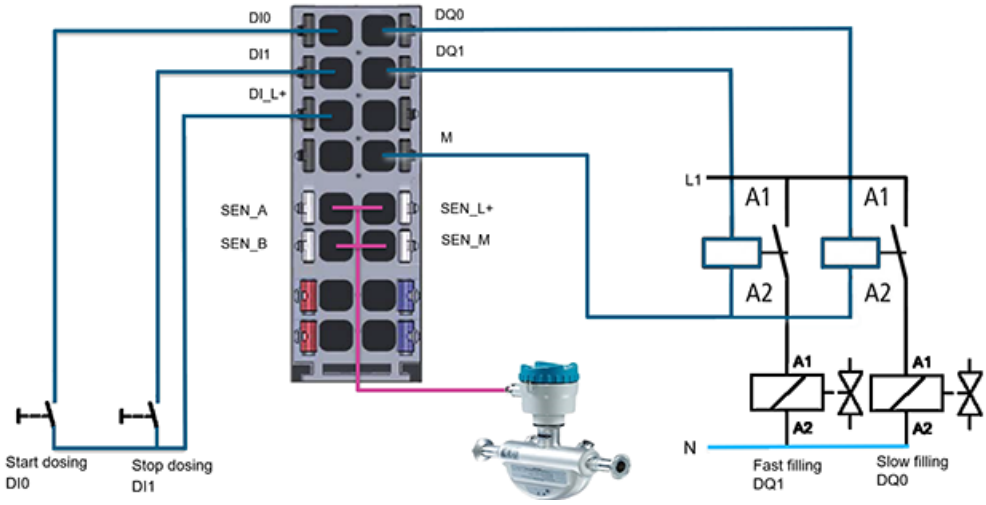

Figure 2-1230 Connection of the dosing system

NOTE

The digital output switch-off response / switch-off edge depends on the load. Thus, it is possible that very short pulses cannot be output correctly.

NOTE

Relays and contactors can be connected direct without external circuitry.

5.3 Start-up of FCT070

Introduction

The first connection and start-up of a new sensor has a plug and play function.

The connection of the sensor is done via the SSL cable. All sensor calibration data are automatically transferred during the first startup from the sensor to the TM FCT070 and stored in the TM FCT070 memory.

Starting up

1. Connect the sensor via the SSL cable.
2. Connect the power supply.

   The sensor data are transferred automatically from the sensor to the TM FCT070.

   The red STATUS LED flashes during start up.

   The green LINK LED is on when the sensor is connected.

Configuring

6

6.1 Configuration software

Introduction

The TM FCT070 module is configured and assigned parameters with the GSD file.

For service TM FCT070 has a special service port on board.

System environment

The technology module can be used in the following system environments:

Table 2-1373 Applications of the technology module with PROFINET I/O

Applications	Components required	Configuration software	In your program
Decentralized operation in an S7-1500 system	• S7-1500 automation system • ET 200SP HF decentralized I/O system • TM FCT070	STEP 7 (TIA Portal): Device configuration and parameter settings with HSP	Direct access to the control and feedback interface of the TM FCT070 in the I/O data
Centralized or decentralized operation in an ET 200SP HF system	• ET 200SP HF automation system • TM FCT070	STEP 7 (TIA Portal): Device configuration and parameter settings with HSP	Direct access to the control and feedback interface of the TM FCT070 in the I/O data
Decentralized operation in an S7-300/400 system	• S7-300/400 automation system • ET 200SP HF decentralized I/O system • TM FCT070	STEP 7 (TIA Portal): Device configuration and parameter settings with HSP STEP 7: Device configuration and parameter settings with hardware configuration (HWCN)	Direct access to the control and feedback interface of the TM FCT070 in the I/O data
Decentralized operation in a PROFINET controller	PROFINET controller • ET 200SP HF decentralized I/O system • TM FCT070	Engineering system with GSD file	Direct access to the control and feedback interface of the TM FCT070 in the I/O data

6.2 Configuration overview

You can use the STEP 7 (TIA Portal) or STEP 7 hardware configuration to set these parameters. Also, you can change the parameter assignment at runtime with your program using data record 128 (Page 60).

STEP 7 (TIA Portal) and STEP 7 assist you during parameter assignment by disabling keyboard input for invalid parameters and range checking your value assignments. Depending on previous parameter selections, other options will be disabled. For example, if you select the one channel operation (the parallel connection of the two output channels), then the parameter options for channel two and high-speed output are disabled.

When you make a runtime parameter assignment that uses the WRREC (Write Record) instruction to modify data record 128, you must ensure that you do not attempt to write an invalid record data. WRREC execution with invalid data fails and returns error code. For example, if you are using one channel operation and include parameter data for two channels, then the record length is too long and WRREC execution fails.

If you use STEP 7 (TIA Portal), you can find the module in the Hardware catalog under "Technology Modules". If you use STEP 7, you can find the module following installation of the corresponding HSP file in the Hardware catalog.

The following table shows how a channel's "Parameter" group is affected by mode selection.

6.3 Address space

Address space of the technology module

Table 2-1374 TM FCT070 I/O address space usage

Function	Byte output	Byte input
Address space	83 byte fix	7 byte

6.4 TIA portal Device configuration

Drag the TM FCT070 module from the hardware catalog and drop it in a rack image. The example rack below uses the TM FCT070 module in a decentralized I/O system. When you click on the TM FCT070 image in a rack, a blue line highlights the module and you can set parameters that appear on the Properties tab.

Enter the general project and identification & maintenance information.

6.4.1 General information

Enter the general project and identification & maintenance information.

Startup

To start a new output sequence after CPU/master STOP with STS_SW_ENABLE set, first reset SW_ENABLE. Keep SW_ENABLE reset until STS_SW_ENABLE is also reset.

If the "Continue working mode" option is used, then during a change from CPU-/Master-STOP to RUN (startup), the CPU/Master cannot clear the outputs.

Possible solution: In the part of your program that is executed during startup, set the "Software enable" (SW_ENABLE = 1) control bit.

Modified parameter assignment

The status assumed by the TM FCT070 at CPU/master STOP remains even in the case of parameter assignment or configuration of the ET 200SP HF station. This occurs, for example, at POWER ON of the CPU/master, or the IM 155-6, or at the resumption of DP transfer.

In "Continue working mode", however, and after loading changed parameters or configuration of the ET 200SP HF station to the CPU/master, the TM FCT070 terminates the process. As a result, the TM FCT070 resets the DQ digital outputs.

6.4.2 I/O addresses

You can assign the base addresses for the control interface (output addresses) and the feedback interface (input addresses). Your program logic uses the values stored in these addresses to control the TM FCT070 output and read feedback signals from the module. For details see IO data (Page 56).

Interrupts/diagnostic messages 7

7.1 Status and error displays

TM FCT070 front view

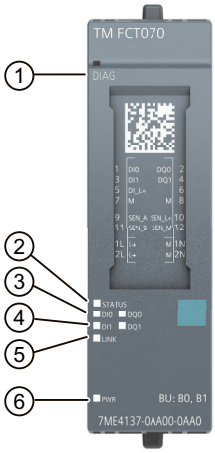

①	DIAG	green/red
②	STATUS	green/red
③	DI0, DQ0	green
④	DI1, DQ1	green
⑤	LINK	green
⑥	PWR	green

LED status display

The following tables explain the meaning of the status and error displays. Refer to Error correction and diagnostics (Page 39) for details.

Table 2-1375 DIAG LED

DIAG LED	Meaning	To correct or avoid errors
Off	Backplane bus supply of the ET 200SP HF not OK	Check or switch On the supply voltage of the head station. Ensure the TM FCT070 is correctly inserted in the BaseUnit.
Flashes green	Technology Module not configured	
On green	Technology Module configured and no module error exists	
Flashes red	Technology Module configured and module diagnostics (at least one error pending) Note:	Evaluate the diagnostic alarms and eliminate the error.

NOTE

The DIAG LED only shows an error if the Diagnostic alarm is activated during device configuration. By default, the Diagnostic alarm is not activated.

Table 2-1376 PWR LED status

PWR	Meaning	To correct or avoid errors
Off	No supply voltage	• Check the external 24 V DC power supply voltage connected between L+ and M.
On green	Supply voltage is present and OK	

Table 2-1377 STATUS LED

STATUS	Error code	Meaning	Description	To correct or avoid errors
Off		No warning No alarm		
On red	344	Failure	No process values from the sensor.	Check connection to Coriolis flow sensor.
Flashes red 2 Hz	345	Function check	Sensor startup	Wait until the startup is finished.
			Freezing of the process values is enabled either via a digital input or the output data.	Disable the freezing of the process values to return to normal operation.

STATUS	Error code	Meaning	Description	To correct or avoid errors
Flashes red 2 Hz	345	Function check	Forcing is enabled either via digital input or the output data.	Disable forcing to return to normal operation.
	346	Out of specification	Deviations from permissible ambient or process conditions determined by device (through self-monitoring, or warnings in device) indicate that measurement is uncertain, or deviations from set value in actuators is probably greater than expected under normal operating conditions.Process or ambient conditions could damage device or result in uncertain output.	Check ambient temperature or process conditions. If possible, relocate device.
Flash green 0.5 Hz	347	Maintenance required	Process values/Output signals are still valid. No functional restriction has been detected but maintenance is requested by the connected sensor.	Maintenance of the sensor should be planned.

The status signal is min 3 seconds available.

LINK	Meaning	To correct or avoid errors
Off	Sensor is not connected with TM FCT070.	
On green	Sensor is connected correctly to TM FCT070.	

Table 2-1378 DQ0 status LED

DQ0	Meaning	To correct or avoid errors
Off	DQ0 is switched off.	Check connection.
On green	DQ0 is switched on (+ 24V).	

Table 2-1379 DQ1 status LED

DQ1	Meaning	To correct or avoid errors
Off	DQ1 is switched off.	Check connection.
On green	DQ1 is switched on (+ 24V).	

Table 2-1380 DI0 status LED

DI0	Meaning	To correct or avoid errors
Off	Low level signal at input DI0.	0V at the input
On green	High level Input signal at DI0.	24V at the input

Table 2-1381 DI1 status LED

DI1	Meaning	To correct or avoid errors
□ Off	Low level signal at input DI1.	0V at the input
■ On green	High level Input signal at DI1.	24V at the input

7.2 Error detection and diagnostics

Diagnostic alarms

When a TM FCT070 error event triggers a diagnostic alarm, the following happens:

- The DIAG light flashes red when a diagnostics alarm is pending. Once you have remedied the error, the DIAG light changes to green.
- The diagnostics are displayed as plain text in the STEP 7 (TIA Portal) online and diagnostics view.
- Options for the reaction of a CPU running your control program
  - CPU goes to STOP and interrupts processing of the user program. The diagnostic interrupt OB (for example, OB 82) is called. The event that triggered the interrupt is written in the start information of the diagnostic interrupt OB.
  - CPU remains in RUN even if no diagnostic interrupt in present in the CPU. The technology module continues working unchanged if this is possible, while the error exists.

Technical data

8

8.1 General information

Article number	7ME4138-6AA00-0BB1
General information	
Product type designation	Technology module TM FCT070
Firmware version	V1.0
FW update possible	Yes
usable BaseUnits	BU20 type B0 or B1
ET 200SP HF	yes
ET 200SP HA	compatible and tested
Color code for module-specific color identification plate	CC40
Product function	
I&M data	Yes; I&M 0
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V16 or higher
• STEP 7 configurable/integrated as of version	V5.5 SP4 and higher
• PCS 7	V9.0 or higher
• PROFINET as of GSD version/GSD revision	GSDML V2.34
Cable	
Maximum cable length to FC DSL	75m
Supply voltage	
Load voltage L+	24 V DC
Rated value (DC)	24 V NEC-Class II
permissible range, lower limit (DC)	19,2 V
permissible range, upper limit (DC)	28,8 V
Short-circuit protection	Yes
Reverse polarity protection	Yes; against destruction
Input current	
Current consumption, max.	500 mA
Power loss	
Typical power loss	Max. 1,7 W
Protection class	
IP protection	IP20
EMV	
Electrostatic discharge according to IEC 61000-4-2	

Article number	7ME4138-6AA00-0BB1
Field-related interference according to IEC 61000-4-3	
Bursted interference due to Burst according to IEC 61000-4-4	
Conducted interference by surge according to IEC 61000-4-5	
Conducted interference by high-frequency radiation according to IEC 61000-4-6	
Decentralized operation	
to SIMATIC S7-300	Yes
to SIMATIC S7-400	Yes
to SIMATIC S7-1200	Yes
to SIMATIC S7-1500	Yes
to standard PROFINET controller	Yes

Usable with the following flowmeters:

- SITRANS FCS400
- SITRANS FCS300
- SITRANS FC MASS2100 and DSL (digital sensor link)
- SITRANS FC300 and DSL (digital sensor link)
- For ATEX Zone 1 SITRANS I300 (460,8 kBits/s)

BaseUnit technical specifications

Refer to the user manual for ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521).

8.2 Digital inputs

Article number	7ME4138-6AA00-0BB1
Supply	24 V, max. 35 mA, short-circuit protectet
Number of digital inputs	2
Digital inputs, parameterizable	Yes
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Digital input functions, parameterizable	
Freely usable digital input	Yes
Input voltage	
Type of input voltage	DC
Rated value (DC)	24 V
for signal "0"	-30 to +5 V
for signal "1"	+11 to +30 V
permissible voltage at input, min.	-30 V
permissible voltage at input, max.	30 V
Input current	
for signal "1", typ.	2,5 mA

Article number	7ME4138-6AA00-0BB1
Cable length	
shielded, max.	50 m; Depending on load and cable quality
unshielded, max.	25 m; Depending on load and cable quality

8.3 Digital outputs

Article number	7ME4138-6AA00-0BB1
Type of digital output	P- switching
Number of digital outputs	2
Current-sinking	No
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes; electronic/thermal
Digital output functions, parameterizable	
Freely usable digital output	Yes
Switching capacity of the outputs	
with resistive load, max.	300 mA
on lamp load, max.	8 W
Load resistance range	
lower limit	80 Ω
upper limit	10 kΩ
Output voltage	
Type of output voltage	DC
for signal "0", max.	1 V
for signal "1", min.	23,2 V; L+ (-0.8 V)
Output current	
for signal "1" rated value	300 mA
Parallel switching of 2 outputs	Yes
Cable length	
shielded, max.[1)]	50 m; Depending on load and cable quality
unshielded, max.	25 m; Depending on load and cable quality

1) Shielded cable required if the cable leaves the building.

8.4 Address area

Article number	7ME4138-6AA00-0BB1
Assigned address area	
• Inputs	83 byte
• Outputs	7 byte

8.5 Potential separation

Article number	7ME4138-6AA00-0BB1
Potential separation digital inputs	
between module and backplane bus	Yes
Potential separation digital outputs	
between module and backplane bus	Yes
Potential separation channels	
between the channels	No
between the channels and backplane bus	Yes
Permissible potential difference	
between different circuits	75 V DC/60 V AC (base isolation)
Isolation	
Pollution degree	2
Maximum cable length (FC DSL - Sensor)	150m

8.6 Interrupts/diagnostics/status information

Article number	7ME4138-6AA00-0BB1
Substitute values connectable	Yes; Parameterizable
Alarms	
Diagnostic alarm	Yes
Diagnostic messages	
Diagnostics	Yes
Control of the power supply	Yes
Shortage	No
Overload	Yes
Diagnostics indication LED	
Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
for sensor diagnostics	Yes; green/red STATUS LED
for module diagnostics	Yes; green/red DIAG LED

8.7 Dimensions and weight

Article number	7ME4138-6AA00-0BB1
Width	20 mm
Height	73 mm
Depth	58 mm
Weight, approx.	32 g

8.8 Electrical, EMC and climatic requirements

Article number	7ME4138-6AA00-0BB1
Product safety	
Safety regulations	IEC 61010-1:2016 ANSI/UL 61010-1:2018
Protection class	To maintain the safety characteristics of extra-low voltage circuits, external connections to communications ports, analog circuits, as well as all 24 V DC nominal power supplies and all I/O circuits must be powered by approved sources that fulfill the requirements according to the various standards for SELV, PELV, NEC Class 2, voltage limited or power limited. The ground connection for the DIN rail serves as a functional ground for dissipating interference currents.
IP degree of protection	IP 20: Protection against contact with standard probe Protection against solid bodies with diameters in excess of 12.5mm No special protection against water
Air gaps and creepage distances	Overvoltage category II Pollution degree 2
Isolation stability	Test voltage: 500 V AC or 707 V DC
Use in hazardous areas	When using the electronic weighing system in a hazardous area, observe the Special conditions for use in hazardous locations (ATEX; IECEx, FM, UL) (Page 28).
Electromagnetic compatibility	All shielded cables must be grounded at both ends to comply with the requirements for electromagnetic compatibility. If the shielded cable is routed out of the hazardous area for explosion-proof equipment, both ends of the cable shield must be connected to the potential equalization. To comply with the requirements for lightning strikes, additional measures are required for installation in Zone A according to IEC61131-2: 2007.

1) An external device must be provided to comply with this EMC requirement (e.g. Lightning conductor BVTAD24, Dehn & Söhne company)

2) An external device must be provided to comply with this EMC requirement (e.g. Lightning conductor BSPM4BE24, Dehn & Söhne company)

Article number	7ME4138-6AA00-0BB1
Electromagnetic compatibility	
Interference emission in industrial area in accordance with EN 61000-6-4	
Emission of radio interference (interference field strength)	Class A: Industrial environment 30 ... 230 MHz, 40 dB (mV/m) Q 230 ... 1000MHz, 47 dB (mV/m) Q -- 1 ... 3 GHz / 76 dB(mV/m) peak, 56 dB(mV/m) average 3 ... 6 GHz / 80 dB(mV/m)
Emission on power supply cables	Class A: Industrial environment 0.15 ... 0.5 MHz, 79 dB (µV) Q 0.15 ... 0.5 MHz, 66 dB (µV) M 0.5 ... 30 MHz, 73 dB (µV) Q 0.5 ... 30 MHz, 60 dB (µV) M
Interference immunity in industrial area in accordance with EN 61326-1, NAMUR NE21:2017	
Burst pulses on power supply cables (EN 6100-4-4)	±2.4 kV 5/50 ns/5 kHz ±2.4 kV 5/50 ns/100 kHz
Burst pulses on data and signal cables (EN 6100-4-4)	
Electrostatic discharge (ESD) (EN 6100-4-2)	2, 4, 6 kV direct/indirect
Electrostatic air discharge (ESD) (EN 6100-4-2)	2, 4, 6, 8 kV
Surge on power supply cables	ZONE A acc. to IEC 61131-2[1]: ±1.0 kV line to line ±2.0 kV line to earth ZONE B to IEC 61131-2: ±0.5 kV line to line ±1.0 kV line to earth
Surge on data and signal cables	ZONE A acc. to IEC 61131-2[2]: ±1.0 kV line to line ±2.0 kV line to earth ZONE B to IEC 61131-2: ±1.0 kV line to earth
Surge on data and signal cables shielded	±2.0 kV shield to ground
Surge on signal cables unshielded	0.5 kV/2kV[2]
Electromagnetic RF fields	80 MHz ... 6 GHz: 10 V/m
Induced conducted interference	10 kHz ... 80 MHz: 12 V_{eff}

1) An external device must be provided to comply with this EMC requirement (e.g. Lightning conductor BVTAD24, Dehn & Söhne company)

2) An external device must be provided to comply with this EMC requirement (e.g. Lightning conductor BSPM4BE24, Dehn & Söhne company)

8.9 Ambient conditions

Article number	7ME4138-6AA00-0BB1
Ambient temperature during operation	
Minimum installation	-25 °C
horizontal installation, max.	60 °C; Observe derating
vertical installation, max.	50 °C; Observe derating
Ambient temperature during storage / transport	
Storage, min.	-40 °C
Storage, max.	70 °C
Transport, min.	-40 °C
Transport, max.	70 °C
Relative humidity	
Operation, min.	5 %
Operation, max.	95 %; no condensation
Height in operation	
Ambient air pressure altitude (relative to sea level)	Tmin ... Tmax at 1080 hPa ... 795 hPa (-1000 m ... +2000 m)

8.10 Certificates and approvals

NOTE

The current approvals for your device can be found on the nameplate.

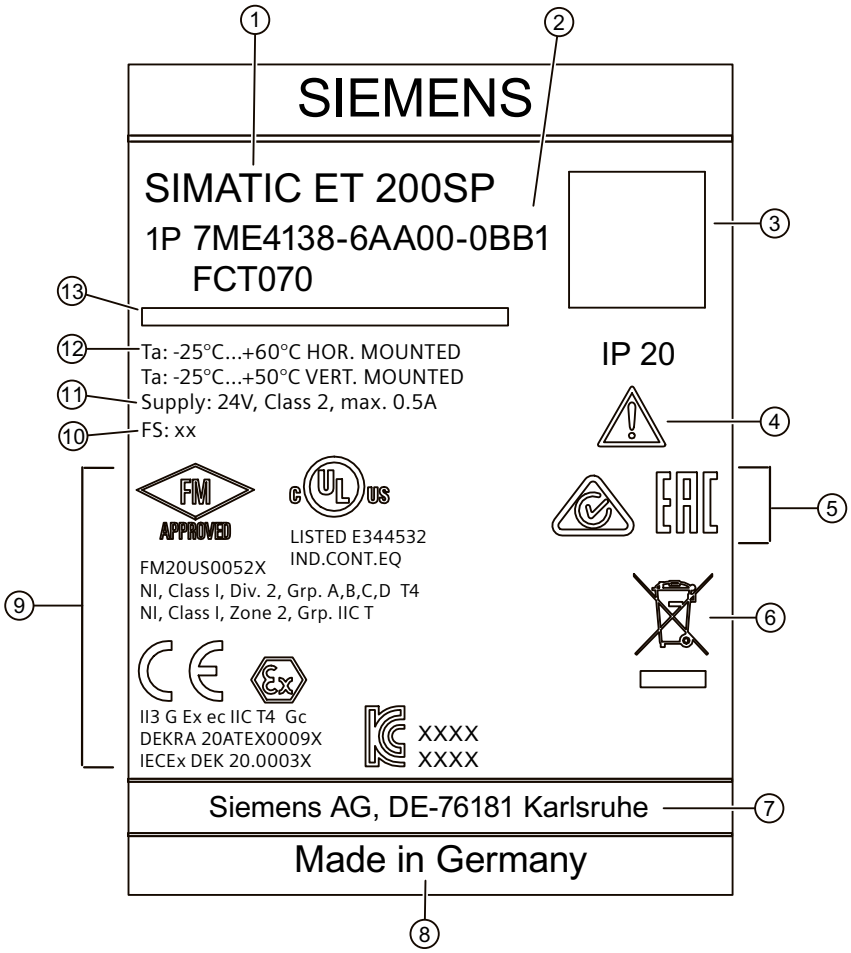

①	Product name	⑨	Approvals
②	Order number		II: Group II
③	QR code		3: Category 3 for use in Zone 2
④	Consult the operating instructions		G: for gas
⑤	Approvals		Ex: Ex type of protection
⑥	WEEE symbol		IIC: Gas group
⑦	Manufacturer name and location		T4: Temperature class
		⑩	Function state
⑧	Manufacturing country	⑪	Power supply
		⑫	Ambient temperature range
		⑬	Serial number

Figure 2-1231 Example nameplate

Symbol	Standard	Marking
		→ CE approval
	Explosion protection in accordance with UL 61010-1:2012 and CAN/CSA-C22.2 No. 61010-1-12	ANSI / ISA 12.12.01 CSA C22.2 No. 213-M1987 CL. I, Div. 2 GP.A.B.C.D T4
	Explosion protection in accordance with ATEX DEKRA 20ATEX0009X EN IEC 60079-0: 2018 EN 60079-7: 2015 + A1: 2018	II 3 G Ex ec IIC T4 Gc (see certificate)
	Explosion protection in accordance with IECEx DEK 20.0003X IEC 60079-0: 2017 (Ed.7) IEC 60079-7: 2015 (Ed.5.1)	Ex ec IIC T4 Gc (see certificate)
		→ EAC certificate, available soon
		→ Tick mark for Australia and New Zealand
		→ KCC approval
	Explosion protection in accordance with FM (USA) FM20US0052X Class No. 3600:2018 Class No. 3611:2018 Class No. 3810:2018 ANSI/UL 61010-1:2018 ANSI/UL 121201:2017	NI, Class I, Div.2, Groups A,B,C,D T4 NI, Class I, Zone 2, Groups IIC, T4 (see certificate)

8.11 Programming reference

Control interface: 2 channels, 24 output bytes (Q addresses)

CPU input address		Description
Channel 0	**Channel 1[1]**	
DWord 0	DWord 12	Depending on the mode: • Pulse output mode: Pulse duration in µs • PWM mode: Duty cycle On-ratio (Number range set by Output format configuration) – "Per 100": 0 to 100 – "Per 1000": 0 to 1,000 – "Per 10000": 0 to 10,000 – "S7 analog output": 0 to 27,648 • PWM mode with current control: Target current is assigned as a ratio of target current/reference current • Pulse train mode: Number of pulses to output as a DWord number value between 1 to 4,294,967,295 (2^{32}-1) • On/Off-delay mode: Off-delay in µs • Frequency output mode: Output frequency in Hz
DWord 4	DWord 16	SLOT value: Behavior depends on operating mode, MODE_SLOT(1 bit), and LD_SLOT (four bits).
Byte 8: Bits 0 to 3	Byte 20: Bits 0 to 3	LD_SLOT value controls interpretation of SLOT value. • 0 = No action / idle state • 1 = Period duration µs (PWM, Pulse train, and DC motor) • 2 = On-delay µs (Pulse output, PWM, Pulse train, Frequency output, and DC motor) • 3 = Off-delay µs (On/Off-delay) • 4 = Duty cycle On-ratio (Pulse train) • 5 = Dither ramp-up time and ramp-down time (PWM) • 6 = Dither amplitude (PWM) • 7 = Dither period (PWM)
Byte 8: Bit 4	Byte 20: Bit 4	MODE_SLOT value controls the SLOT update process. • 0 = single update (SLOT changed sometimes, prior to output sequence) • 1= permanent update (SLOT controlled continuously)
Byte 9: Bit 0	Byte 21: Bit 0	SW_ENABLE: Transition from 0 → 1 and remaining 1 during the input delay starts the output sequence. Only active for the first positive edge, additional positive edges are ignored and no start occurs.
Byte 9: Bit 1	Byte 21: Bit 1	TM_CTRL_DQ: Set DQ output source: Selects either CPU program or module's output sequence. • 0 = DQn.A and DQn.B are controlled by the CPU (in your program) using the SET_DQA and SET_DQB control bits. • 1 = DQn.A and DQn.B are controlled by the module's output sequence.
Byte 9: Bit 2	Byte 21: Bit 2	SET_DQA: Controls the value of the digital output DQn.A, if TM_CTRL_DQ = 0 • 0 = 0V on DQn.A • 1 = 24V on DQn.A
Byte 9: Bit 3	Byte 21: Bit 3	SET_DQB: Controls the value of the digital output DQn.B, if TM_CTRL_DQ = 0 • 0 = 0V on DQn.B • 1 = 24V on DQn.B
Byte 10: Bit 0	Byte 22: Bit 0	RES_ERROR: Reset pending errors (ERR_LD, ERR_DQA, ERR_DQB, and ERR_24V). • 0 = Reset of errors is not active. • 1 = Reset of errors is active.

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

Feedback Interface: 2 channels, 16 input bytes (I addresses)

CPU output address		Description
Channel 0	**Channel 1[1]**	
Byte 0: Bit 0	Byte 8: Bit 0	ERR_PWR: 1 = 24 V DC present, but is not in the correct range. 0 = no error
Byte 0: Bit 1	Byte 8: Bit 1	ERR_24V: 1 = Short-circuit/overload, in the 24 V DC sensor supply output. 0 = no error
Byte 0: Bit 2	Byte 8: Bit 2	ERR_LD: 1 = Error while loading a parameter value using single-update mode. 0 = no error
Byte 0: Bit 3	Byte 8: Bit 3	ERR_PULSE: 1 = Pulse duration reduced to smaller than the minimum allowed during operation. 0 = No error
Byte 0: Bit 4	Byte 8: Bit 4	ERR_DQA: 1 = Short-circuit/overload on the digital output DQn.A. 0 = no error
Byte 0: Bit 5	Byte 8: Bit 5	ERR_DQB: 1 = Short-circuit/overload on the digital output DQn.B or attempt to set both DQn.A and DQn.B to high. 0 = no error
Byte 0: Bit 6	Byte 8: Bit 6	ERR_OUT_VAL: 1 = The value in OUTPUT_VALUE is not valid. 0 = no error
Byte 0: Bit 7	Byte 8: Bit 7	ERR_SLOT_VAL: 1 = The value in SLOT is not valid where MODE_SLOT = 1 (permanent update). 0 = no error
Byte 1: Bit 2	Byte 9: Bit 2	STS_LD_SLOT: Toggle acknowledge bit for each action of the SLOT in single-update SLOT-mode Each toggle of this bit means a successful LD_SLOT action.
Byte 1: Bit 4	Byte 9: Bit 4	STS_READY: 1 = Module is parameterized correctly, running, and delivering valid data. 0 = not ready
Byte 1: Bit 5	Byte 9: Bit 5	ST_SW_ENABLE: 1 = SW_ENABLE active. 0 = SW_ENABLE not active
Byte 2: Bit 0	Byte 10: Bit 0	STS_ENABLE: 1 = Output sequence running. 0 = No output sequence running
Byte 2: Bit 1	Byte 10: Bit 1	STS_DQA: 1 = DQn.A output active. 0 = DQn.A output not active.
Byte 2: Bit 2	Byte 10: Bit 2	STS_DQB: 1 = DQn.B output active. 0 = DQn.B output not active.
Byte 2: Bit 3	Byte 10: Bit 3	STS_DI: 1 = DIn.0 digital input active. 0 = DIn.0 digital input not active.
Byte 3: Bit 0 to 3	Byte 11: Bit 0 to 3	SEQ_CNT: Sequence counter: Is incremented after completion of an output sequence (Range 0 to 15)
Word 4	Word 12	MEASURED_CURRENT: Current measurement uses a SIMATIC S7 analog value. Full-scale value depends on module configuration, as 2 channel (2 A) or 1 channel (4 A). • 2 channel (2 A): 0 to 32767 corresponds with 0 to 2.4 A • 1 channel (4 A): 0 to 32767 corresponds with 0 to 4.8 A
Byte 6: Bit 0	Byte 14: Bit 0	QLMN_LLM: The low limit of the manipulated value has been reached.
Byte 6: Bit 1	Byte 14: Bit 1	QLMN_HLM: The high limit of the manipulated value has been reached.

[1] Only if the module is configured as "2 channels (2 A)" and not "1 channel (4 A)"

NOTE

If the TM FCT070 external supply voltage is interrupted, then, 16#00000000 is returned as feedback value (substitute value).

Controlling the different operating modes

You select an output channel's operating mode during device configuration. Configuration data is stored in parameter data record 128.
The following table shows the program variables that the different operating modes use.

Program control variable	Notes
Software enable	
SW_ENABLE	Transition from 0 → 1 and remaining 1 during the input delay starts the output sequence. Only active for the first positive edge, additional positive edges are ignored and no start occurs. You must always issue the software enable in your control program. If you don't use a HW enable,

Program control variable	Notes
	the output sequence will be started by the positive edge of the software enable. If you reset the software enable, the current output sequence will be terminated.
Direct control of the digital output	
TM_CTRL_DQ	• If TM_CTRL_DQ = 1, then the TM FCT070 module has control and produces pulse sequences at the DQ outputs. • If TM_CTRL_DQ = 0, then the CPU has control and your program can set outputs DQn.A and DQn.B directly with the SET_DQA and SET_DQB control bits
SET_DQA SET_DQB	These control bits set/reset a channel's DQn.A and DQn.B outputs while TM_CTRL_DQ = 0. Note: You cannot set a channel's DQn.A and DQn.B to high at the same time. Otherwise, error ERR_DQB is set and only DQn.A is set high.
Pulse output operating mode	
Pulse duration	Assign the pulse duration directly with the control interface parameter OUTPUT_VALUE, as a DWord number value in µs.
On-delay	The time from the start of the output sequence to the start of the DQ output pulse. Assign the On-delay in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 2.
PWM operating mode	
Duty cycle or Target current (current control enabled)	**Current control disabled**: PWM: OUTPUT_VALUE assigns the duty cycle (On/Off ratio) for the current period duration. You select the range of the OUTPUT_VALUE control interface field with the "Output format" configuration. • Output format "Per 100 (%)": Value range between 0 and 100 Pulse duration = (OUTPUT_VALUE/100) x period duration. • Output format "Per 1,000": Value range between 0 and 1,000 Pulse duration = (OUTPUT_VALUE/1,000) x period duration. • Output format "Per 10,000": Value range between 0 and 10,000 Pulse duration = (OUTPUT_VALUE/10,000) x period duration. • "S7 analog output" output format: Value range between 0 and 27,648 Pulse duration = (OUTPUT_VALUE/27,648) x period duration. **Current control enabled:** OUTPUT_VALUE assigns the target current as a ratio of target current/reference current. The reference current value is used to define the maximum set point and the high and low limits of the controlled current. Typically, the maximum current can be measured in PWM mode with current control disabled and a duty cycle set to 100%. The value measured can be set as a reference for the current control. The maximum value is 4000 mA for single channel operation (parallel channel connection enabled) and 2000 mA per channel for dual channel operation (parallel connection disabled).
Period duration	The Period duration of an output PWM cycle. Assign the period duration value in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 1. When you assign the period duration, take into account the minimum pulse duration configuration and the response time of the control element connected to the DQ digital output.
On-delay	The time from the start of the output sequence to the start of the DQ output pulse. Assign the On-delay in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 2.
Pulse train operating mode	
Number of pulses	Number of pulses that are output at the DQ digital output on expiration of the On-delay. Your control program can set the pulse count directly with the control interface parameter (OUTPUT_VALUE). Set the number of pulses directly as a DWord number value between 0 to 4,294,967,295 (2^{32}-1).
Period duration	The Period duration of an output pulse cycle. Assign the period duration in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 1. When you assign the period duration take into account the minimum pulse duration configuration and the response time of the control element connected to the DQ digital output.
Duty cycle	Assign the duty cycle with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 4. The range of the duty cycle parameter is selected using the "Output format" configuration. If the number value you assign exceeds the upper limit, then a duty cycle of 100% of the period duration is used and this action does not cause an error.

Program control variable	Notes
	• Output format "Per 100 (%)": Value range 0 to 100 Pulse duration = (duty cycle/100) x period duration. • Output format "Per 1000": Value range 0 to 1,000 Pulse duration = (duty cycle/1,000) x period duration. • Output format "Per 10000": Value range 0 to 10,000 Pulse duration = (duty cycle/10,000) x period duration. • Output format "S7 analog output": Value range 0 to 27,648 Pulse duration = (duty cycle/27,648) x period duration.
On/Off-delay operating mode	
On-delay	The time between a positive edge of the DIn.0 digital input and DQn.A digital output (DQ follows DI state). Assign the On-delay in µs directly using the OUTPUT_VALUE control interface field.
Off-delay	The time between a negative edge of the DIn.0 digital input and its output on the DQn.A digital output (DQ follows DI state). Assign the Off-delay in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 3.
Frequency output operating mode	
Output frequency	Frequency output at the digital output DQ. Assign the frequency in real format as Hz using the OUTPUT_VALUE control interface field. The possible range is dependent on the "High Speed Output" configuration. • High Speed Output disabled Frequency (OUTPUT_VALUE): 0.02 Hz to 10,000 Hz • High Speed Output enabled Frequency (OUTPUT_VALUE): 0.02Hz to 100,000Hz
On-delay	The time from the start of the output sequence to the output of the frequency. Assign the On-delay in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 2.
DC motor operating mode	
OUTPUT_VALUE	The OUTPUT_VALUE determines the duty cycle (pulse duration/period duration ratio) within a period (PWM). The period duration can be adjusted. The new output value is applied at the next rising edge of the output. The sign indicates direction of rotation (positive for forward) and (negative for backward). S7 analog output format: value range is -27,648 to +27,648 DInt data type: Only 2 least significant bytes are used For channel 0: bytes 2 and 3 For channel 1: bytes 14 and 15
On-delay	The time from the start of the output sequence to the output of the frequency. Assign the On-delay in µs with control interface parameter SLOT, after setting up MODE_SLOT (0 or 1) and LD_SLOT = 2.
If "Function DI" is parameterized as "External stop":	A rising edge on DIn.0 will stop the output sequence and stop the DC motor.

Device configuration (Assignments stored in parameter data record 128)

Parameters	Value Range	Default
Channel configuration	• 2 channels (2 A) • 1 channel (4 A)	2 channels (2 A)
Channel (0 and 1)		
Reaction to CPU STOP	• Continue working mode • DQ substitute a value	DQ substitute a value
Substitute value DQA	0 or 1	0
Substitute value DQB	0 or 1	0
Group diagnostics	Disable/enable	Disabled
Diagnostics DQA		Disabled
Diagnostics DQB		Disabled

Parameters	**Value Range**			**Default**
Operating mode	• Pulse output • PWM • Pulse train • On/Off-delay • Frequency output • DC motor			PWM
High-speed output (0.1 A)	Disable/enable			Disabled
Current control (for PWM mode only)	Disable/enable			Disabled
Function DI HW enable option available for Pulse output, Pulse train, Frequency output and DC motor modes.	• Input • HW enable • External stop (DC motor only)			Input
Activate P	P-SEL: Add Proportional term for current control			Enabled
Activate I	I-SEL: Add Integral term for current control			Enabled
Activate D	D-SEL: Add Derivative term for current control			Disabled
Input delay	• Off (4µs) • 0.05 ms • 0.1 ms • 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 12.8 ms • 20 ms			0.1 ms
Output format: PWM and Pulse train modes DC motor mode, (only S7 analog output format is possible)	• S7 analog output format • Per 100 • Per 1000 • Per 10000			Per 100
Output format (in the "Frequency output" operating mode)	1 Hz			1 Hz
Dithering (PWM mode only): Superimpose dithering waveform on PWM output sequence.	Disable/enable			Disabled
	Minimum		Maximum	
	High-speed **disabled**	High-speed **enabled**		
DWord: Minimum pulse duration for PWM and DC motor modes	10 µs	1.5 µs	85,000,000 µs	0
DWord: Period duration for PWM, Pulse train, and DC motor modes	100 µs	10 µs		2,000,000 µs
DWord: On-delay for all modes except On/Off-delay	0 µs	0 µs		0
DWord: Value depends on mode				
PWM: Dither ramp	Low word: Dither ramp-up time 0 to 30000 ms High word: Dither ramp-down 0 to 30000 ms			0 ms 0 ms
Pulse train: Duty cycle	S7 analog output format: 0 to 27648			13824 (50%)
	Per 100 format: 0 to100			50 (50%)
	Per 1000 format: 0 to 1000			500 (50%)
	Per 10000 format: 0 to 10000			5000 (50%)
On/Off delay: Off delay	0 to 85,000,000 µs			0
DWord: Dither amplitude for PWM only	0 to 500 ‰ (per mill)			50 ‰

Parameters	Value Range	Default
DWord: Dither period for PWM only	From (4 times the PWM period µs) to 100000 µs (must be higher than 2000 µs)	50000 µs
Word: Reference value current for PWM with current control only	• 0 mA to 2000 mA for "2 channels (2 A)" operation • 0 mA to 4000 mA for "1 channel (4 A)" operation to 4000 mA for "1 channel (4 A)" operation	0 mA
Word: Dead band width (µA) for current control	0 µA to 65535 µA	0 µA
Word: High current limit for current control	S7-analog value relative to the reference value current: Range is 1 to 65535 (>= 27648 means 100%)	27648
Word: Low current limit for current control	S7-analog value relative to the reference value current: Range 0 to 27647 (Low limit must be less than the High limit)	0
Gain for current control	Real value (DWord size)	2.0 s
TI: Integration time (s) for current control	Real value (DWord size)	20.0 s
TD: Derivative action time (s) for current control	Real value (DWord size)	10 .0 s
TM LAG: Time lag of the derivative action (s)	Real value (DWord size)	2.0 s

IO data

A

Input data

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
0	**Mass flow** low flow cut-off filtered mass flow in mass flow units, see Parameter assignment and structure of the parameter data record (Page 60)								Float32
1									
2									
3									
4	**Quality code mass flow** coding according PROFIBUS-PA profile 4.0								Unsigned8
5	**Density** in density units, see Parameter assignment and structure of the parameter data record (Page 60)								Float32
6									
7									
8									
9	**Quality code density** coding according PROFIBUS-PA profile 4.0								Unsigned8
10	**Medium temperature** in temperature units, see Parameter assignment and structure of the parameter data record (Page 60)								Float32
11									
12									
13									
14	**Quality code medium temperature** coding according PROFIBUS-PA profile 4.0								Unsigned8
15	**Volume flow** low flow cut-off filtered volume flow in volume flow units, see Parameter assignment and structure of the parameter data record (Page 60)								Float32
16									
17									
18									
19	**Quality code volume flow** coding according PROFIBUS-PA profile 4.0								Unsigned8
20	**Fraction A** unit relation depends on the selected fraction table. Each fraction table calculates either a mass flow or a volume flow quantity. The Fraction unit type bit in byte 81 defines if the mass flow or volume flow unit setting is relevant.								Float32
21									
22									
23									
24	**Quality code fraction A** coding according PROFIBUS-PA profile 4.0								Unsigned8
25	**Fraction B** unit relation depends on the selected fraction table. Each fraction table calculates either a mass flow or a volume flow quantity. The Fraction unit type bit in byte 81 defines if the mass flow or volume flow unit setting is relevant.								Float32
26									
27									
28									
29	**Quality code fraction B** coding according PROFIBUS-PA profile 4.0								Unsigned8
30	**Fraction A %** in percent								Float32
31									
32									

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
33	**Fraction A %** in percent								Float32
34	**Quality code fraction A %** coding according PROFIBUS-PA profile 4.0								Unsigned8
35	**Fraction B %** in percent								Float32
36									
37									
38									
39	Quality code fraction B % coding according PROFIBUS-PA profile 4.0								Unsigned8
40	**Standard volume flow** in standard volume flow units, see Parameter assignment and structure of the parameter data record (Page 60)								Float32
41									
42									
43									
44	**Quality code standard volume flow** coding according PROFIBUS-PA profile 4.0								Unsigned8
45	**Sensor frame temperature** in temperature units, see Parameter assignment and structure of the parameter data record (Page 60)								Float32
46									
47									
48									
49	**Quality code sensor frame temperature** coding according PROFIBUS-PA profile 4.0								Unsigned8
50	**Total 1** Unit is depending on the selected Totalizer 1 process value and Totalizer 1 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 60)								Float32
51									
52									
53									
54	**Quality code total 1** coding according PROFIBUS-PA profile 4.0								Unsigned8
55	**Total 1 (high resolution)** Unit is depending on the selected Totalizer 1 process value and Totalizer 1 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 60)								Float64
56									
57									
58									
59									
60									
61									
62									
63	**Total 2** Unit is depending on the selected Totalizer 2 process value and Totalizer 2 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 60)								Float32
64									
65									
66									
67	**Quality code total 2** coding according PROFIBUS-PA profile 4.0								Unsigned8
68	**Total 3** Unit is depending on the selected Totalizer 3 process value and Totalizer 3 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 60)								Float32
69									
70									
71									

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
72	**Quality code total 3** coding according PROFIBUS-PA profile 4.0								Unsigned8
73 **74** **75** **76**	**Dosed amount** Unit is depending on the selected Dosing process value and Dosing amount mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 60)								Float32
77	**Quality code dosed amount** coding according PROFIBUS-PA profile 4.0								Unsigned8
78	**Dosing state** 0 = stopped 1 = running 2 = paused 3 = cleaning, all valves are set to "open valve"								Unsigned8
79	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	**DQ1** current signal state	**DQ0** current signal state	Unsigned8 (bit granular)
80	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	**DQ1 status** Validity of the DQ1 value in previous byte 0 = DQ1 is disabled (not controlled) 1 = DQ1 is enabled (controlled)	**DQ0 status** Validity of the DQ0 value in previous byte 0 = DQ0 is disabled (not controlled) 1 = DQ0 is enabled (controlled)	Unsigned8 (bit granular)
81	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	**DI1** current signal state	**DI0** current signal state	Unsigned8 (bit granular)
82	**Fraction unit type** returns information which unit is associated to the fraction values 0 = Mass flow units 1 = Volume flow units	*reserved*	*reserved*	*reserved*	*reserved*	outputs forced	process value frozen	zero point adjustment running	Unsigned8 (bit granular)

Ouput data

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
0	*reserved*	*reserved*	Reset totalizer 3	Reset totalizer 2	Reset totalizer 1	Force outputs	Freeze process values	Adjust zero point	Unsigned8 (bit granular)
1	**Dosing command** The value change triggers the command. 0 = do nothing 1 = start dosing 2 = stop dosing 3 = pause dosing 4 = resume dosing 5 = start cleaning								Unsigned8
2 3 4 5	**Dosing amount** The value is expected in the unit that is defined by the selected Dosing process value and Dosing amount mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 60)								Float32
6	**Active fraction table** Selects the built-in fraction table algorithm. Valid range is 0 (no fraction), 1...17								Unsigned8

Parameter data record

B

B.1 Parameter assignment and structure of the parameter data record

The TM FCT070 parameter data record is modified and stored for you by the TIA portal when you perform a Device configuration, successful configuration block compilation, and download a new configuration block to the system hardware.

You may also directly edit the module parameters with the CPU in RUN mode. The WRREC instruction is used to transfer parameters to the module using data record 128.

If errors occur during the transfer or validation of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. A corresponding error code is then written to the STATUS output parameter. If no errors occur, the STATUS output parameter contains the length of the data actually transferred.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help (TIA Portal).

Structure of data record 128

The following table shows you the structure of data record 128 for the TM FCT070. The values in byte 0 to byte 3 are fixed and may not be changed. Default values are indicated in **bold font**.

- A total of 108 bytes (4 header bytes + 2(52 channel bytes) is required for the 2 channel configuration (parallel connection disabled).
- A total of 56 byes (4 header bytes + 52 channel bytes) is required for the 1 channel configuration (parallel connection enabled).
- Bytes 4 to 55 are the channel 0 parameters
- Bytes 56 to 107 are the channel 1 parameters.
- Channel 1 parameters use the same data structure as channel 0. Add a 52 byte offset to the channel 0 byte numbers, to determine the channel 1 byte numbers.

Table 2-1382 Header and channel 0 basic configuration

Bit → **Byte ↓**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 to 1	**Header**							
0	*reserved*		Major version = 1		Minor version = 0			
1	Parameter data length = 58 bytes							
2 to 55	**Module parameter block**							
2 **3**	Mass flow units coding according PROFIBUS-PA profile. Supported values: 1322 1323 **1324** 1325..1341 1606..1609							
4	Density units							

Bit → / Byte ↓	7	6	5	4	3	2	1	0
5	coding according PROFIBUS-PA profile. Supported values: 1097..1102 **1103** 1104..1109 1430 1558 1559 1564 1566							
6 **7**	Temperature units coding according PROFIBUS-PA profile. Supported values: 1000 **1001** 1002 1003							
8 **9**	Volume flow units coding according PROFIBUS-PA profile. Supported values: 1347 1348 **1349** 1350..1359 1362..1374 1448..1514 1518..1520 1563 1577..1587 1633..1640 1642..1645 32768..32780							
10 **11**	Standard volume flow units coding according PROFIBUS-PA profile. Supported values: 1360 1361 1588..1595 **1596** 1597..1605							
12 **13** **14** **15**	Mass flow cut-off limit (mass flow units) encoded as Float32 Default value = **0.0**							
16 **17** **18** **19**	Volume flow cut-off limit (volume flow units) encoded as Float32 Default value = **0.0**							
20	*reserved*	*reserved*	*reserved*	*reserved*	Totalizer 1 process value Selection of the process value to be totalized: **0 = Mass flow** 1 = Volume flow 4 = Standard volume flow 5 = Fraction A 6 = Fraction B			
21 **22**	Totalizer 1 mass units Only relevant if the selected process value is a mass quantity. Supported values (coding according PROFIBUS-PA profile): **1088** 1089..1096 1567..1569							
23 **24**	Totalizer 1 volume units Only relevant if the selected process value is a volume quantity. Supported values (coding according PROFIBUS-PA profile): **1034** 1035..1052 1517 1570 1572 1641							
25 **26**	Totalizer 1 standard volume units Only relevant if the selected process value is a standard volume quantity. Supported values (coding according PROFIBUS-PA profile): 1053 1573 1574 **1575** 1576							
27	*reserved*	*reserved*	*reserved*	*reserved*	Totalizer 2 process value Selection of the process value to be totalized: 0 = Mass flow **1 = Volume flow** 4 = Standard volume flow 5 = Fraction A 6 = Fraction B			
28 **29**	Totalizer 2 mass units Only relevant if the selected process value is a mass quantity. Supported values (coding according PROFIBUS-PA profile): **1088** 1089..1096 1567..1569							
30 **31**	Totalizer 2 volume units Only relevant if the selected process value is a volume quantity. Supported values (coding according PROFIBUS-PA profile): **1034** 1035..1052 1517 1570 1572 1641							

Bit → / Byte ↓	7	6	5	4	3	2	1	0
32 **33**	Totalizer 2 standard volume units Only relevant if the selected process value is a standard volume quantity. Supported values (coding according PROFIBUS-PA profile): 1053 1573 1574 **1575** 1576							
34	*reserved*	*reserved*	*reserved*	*reserved*	Totalizer 3 process value Selection of the process value to be totalized: 0 = Mass flow 1 = Volume flow **4 = Standard volume flow** 5 = Fraction A 6 = Fraction B			
35 **36**	Totalizer 3 mass units Only relevant if the selected process value is a mass quantity. Supported values (coding according PROFIBUS-PA profile): **1088** 1089..1096 1567..1569							
37 **38**	Totalizer 3 volume units Only relevant if the selected process value is a volume quantity. Supported values (coding according PROFIBUS-PA profile): **1034** 1035..1052 1517 1570 1572 1641							
39 **40**	Totalizer 3 standard volume units Only relevant if the selected process value is a standard volume quantity. Supported values (coding according PROFIBUS-PA profile): 1053 1573 1574 **1575** 1576							
41	DI0 level selection 0 = "Active with low level" **1 = "Active with high level"**	*reserved*	*reserved*	DI0 mode **0 = off** 1 = Start dosing on leading edge 2 = Stop dosing on leading edge 3 = Reset totalizer 1 on leading edge 4 = Reset totalizer 2 on leading edge 5 = Reset totalizer 3 on leading edge 6 = Reset all totalizers on leading edge 7 = Zero adjust on leading edge 8 = Pause/resume dosing 9 = Force outputs 10 = Freeze process values 11 = Start/stop totalizer 1 12 = Start/stop totalizer 2 13 = Start/stop totalizer 3 14..31 = reserved				
42	DI1 level selection 0 = "Active with low level" **1 = "Active with high level"**	*reserved*	*reserved*	DI1 mode see "DI0 mode"				

Bit → / Byte ↓	7	6	5	4	3	2	1	0
43	DQ0 level selection 0 = "Active with low level" **1 = "Active with high level"**	DQ0 status signal "function check" **0 = "Deactivated"** 1 = "Activated"	DQ0 status signal "maintenance required" **0 = "Deactivated"** 1 = "Activated"	DQ0 status signal "failure" 0 = "Deactivated" **1 = "Activated"**	DQ0 status signal "out of specification" **0 = "Deactivated"** 1 = "Activated"	DQ0 force value 0 = "Deactivated" **1 = "Activated"**	DQ0 mode **0 = off** 1 = status signal 2 = flow direction (positive=active, negative=inactive) 3 = reserved Only valid if "Dosing mode" is not set to 1 and 2	
44	DQ1 level selection 0 = "Active with low level" **1 = "Active with high level"**	DQ1 status signal "function check" **0 = "Deactivated"** 1 = "Activated"	DQ1 status signal "maintenance required" **0 = "Deactivated"** 1 = "Activated"	DQ1 status signal "failure" 0 = "Deactivated" **1 = "Activated"**	DQ1 status signal "out of specification" **0 = "Deactivated"** 1 = "Activated"	DQ1 force value 0 = "Deactivated" **1 = "Activated"**	DQ1 mode **0 = off** 1 = status signal 2 = flow direction (positive=active, negative=inactive) 3 = reserved Only valid if "Dosing mode" is not set to 2	
45	*reserved*	*reserved*	Dosing mode **0 = off** 1 = Dosing with one valve controlled by DQ0. Overrides the DQ0 mode setting 2 = Dosing with two valves (DQ0/DQ1). Overrides the DQ0 and DQ1 mode settings 3 = reserved		Dosing process value Selection of the process value to be dosed: **0 = Mass flow** 1 = Volume flow 4 = Standard volume flow 5 = Fraction A 6 = Fraction B			
46 **47**	Dosing amount mass unit Only relevant if the selected process value is a mass quantity. Supported values (coding according PROFIBUS-PA profile): **1088** 1089..1096 1567..1569							
48 **49**	Dosing amount volume unit Only relevant if the selected process value is a volume quantity. Supported values (coding according PROFIBUS-PA profile): **1034** 1035..1052 1517 1570 1572 1641							
50 **51**	Dosing amount standard volume unit Only relevant if the selected process value is a standard volume quantity. Supported values (coding according PROFIBUS-PA profile): **1053** 1573..1576							
52 **53** **54** **55**	Dosing amount DQ1 open in percent. Only relevant when dosing mode is set to 2 Valid range = 0...100% **Default = 20%**							
56 **57** **58** **59**	Dosing amount DQ1 close in percent. Only relevant when dosing mode is set to 2 Valid range = 0...100% **Default = 80%**							

Measuring units

C

	Unit descriptions	Unit abbreviations	Volume flow	Mass flow	Standard Volume flow	Density	Temperature
1000	kelvins	K					x
1001	degrees Celsius	°C					x
1002	degrees Fahrenheit	°F					x
1003	degrees Rankine	°R					x
1034	cubic meters	m^3					
1035	cubic decimeters	dm^3					
1036	cubic centimeters	cm^3					
1037	cubic millimeters	mm^3					
1038	liters	l					
1039	centiliters	cl					
1040	milliliters	ml					
1041	hectoliters	hl					
1042	cubic inches	in^3					
1043	cubic feet	ft^3					
1044	cubic yards	yd^3					
1045	cubic miles	mi^3					
1046	US liquid pints	pt(liq)					
1047	US liquid quarts	qt(liq)					
1048	US gallons	gal					
1049	imperial gallons	gal(UK)					
1050	bushels	bu					
1051	42 US gallons barrels	bbl					
1052	31.5 US gallons barrels	bbl(US)					
1053	standard cubic feet	SCF					
1088	kilograms	kg					
1089	grams	g					
1090	megagrams	Mg					
1091	megagrams	Mg					
1092	metric tons	t					
1093	ounces avoirdupois	oz					
1094	pounds	lb					
1095	short tons	ton					
1096	long tons	ton(UK)					

	Unit descriptions	Unit abbrevi-ations	Volume flow	Mass flow	Standard Volume flow	Density	Temperature
1097	kilograms per cubic meter	kg/m³				x	
1098	megagrams per cubic meter	Mg/m³				x	
1099	kilograms per cubic decimeter	kg/dm³				x	
1100	grams per cubic centi-meter	g/cm³				x	
1101	grams per cubic meter	g/m³				x	
1102	metric tons per cubic meter	t/m³				x	
1103	kilograms per liter	kg/l				x	
1104	grams per milliliter	g/ml				x	
1105	grams per liter	g/l				x	
1106	pounds per cubic inch	lb/in³				x	
1107	pounds per cubic foot	lb/ft³				x	
1108	pounds per US gallon	lb/gal				x	
1109	short tons per cubic yard	ton/yd³				x	
1322	kilograms per second	kg/s			x		
1323	kilograms per minute	kg/min			x		
1324	kilograms per hour	kg/h			x		
1325	kilograms per day	kg/d			x		
1326	metric tons per second	t/s			x		
1327	metric tons per minute	t/min			x		
1328	metric tons per hour	t/h			x		
1329	metric tons per day	t/d			x		
1330	pounds per second	lb/s			x		
1331	pounds per minute	lb/min			x		
1332	pounds per hour	lb/h			x		
1333	pounds per day	lb/d			x		
1334	short tons per second	ton/s			x		
1335	short tons per minute	ton/min			x		
1336	short tons per hour	ton/h			x		
1337	short tons per day	ton/d			x		
1338	long tons per second	ton(UK)/s			x		
1339	long tons per minute	ton(UK)/mi-n		x			
1340	long tons per hour	ton(UK)/h			x		
1341	long tons per day	ton(UK)/d			x		

	Unit descriptions	Unit abbreviations	Volume flow	Mass flow	Standard Volume flow	Density	Temperature
1347	cubic meters per second	m^3/s	x				
1348	cubic meters per minute	m^3/min	x				
1349	cubic meters per hour	m^3/h	x				
1350	cubic meters per day	m^3/d	x				
1351	liters per second	l/s	x				
1352	liters per minute	l/min	x				
1353	liters per hour	l/h	x				
1354	liters per day	l/d	x				
1355	milliliters per day	ml/d	x				
1356	cubic feet per second	ft^3/s	x				
1357	cubic feet per minute	ft^3/min	x				
1358	cubic feet per hour	ft^3/h	x				
1359	cubic feet per day	ft^3/d	x				
1360	standard cubic feet per minute	SCF/min	x		x		
1361	standard cubic feet per hour	SCF/h	x		x		
1362	US gallons per second	gal/s	x				
1363	US gallons per minute	gal/min	x				
1364	US gallons per hour	gal/h	x				
1365	US gallons per day	gal/d	x				
1366	US milligallons per day	mgal/d	x				
1367	imperial gallons per second	gal(UK)/s	x				
1368	imperial gallons per minute	gal(UK)/min	x				
1369	imperial gallons per hour	gal(UK)/h	x				
1370	imperial gallons per day	gal(UK)/d	x				
1371	42 US gallons barrels per second	bbl/s	x				
1372	42 US gallons barrels per minute	bbl/min	x				
1373	42 US gallons barrels per hour	bbl/h	x				
1374	42 US gallons barrels per day	bbl/d	x				
1430	pounds per imperial gallon	lb/gal(UK)	x			x	

	Unit descriptions	Unit abbrevi-ations	Volume flow	Mass flow	Standard Volume flow	Density	Temperature
1448	US microgallons per second	µgal/s	x				
1449	US milligallons per second	mgal/s	x				
1450	US kilogallons per second	kgal/s	x				
1451	US milligallons per second	mgal/s	x				
1452	US microgallons per minute	µgal/min	x				
1453	US milligallons per minute	mgal/min	x				
1454	US kilogallons per minute	kgal/min	x				
1455	US milligallons per minute	mgal/min	x				
1456	US microgallons per hour	µgal/h	x				
1457	US milligallons per hour	mgal/h	x				
1458	US kilogallons per hour	kgal/h	x				
1459	US milligallons per hour	mgal/h	x				
1460	US microgallons per day	µgal/d	x				
1461	US milligallons per day	mgal/d	x				
1462	US kilogallons per day	kgal/d	x				
1463	imperial microgallons per second	µgal(UK)/s	x				
1464	imperial megagallons per second	Mgal(UK)/s	x				
1465	imperial kilogallons per second	kgal(UK)/s	x				
1466	imperial megagallons per second	Mgal(UK)/s	x				
1467	imperial microgallons per minute	µgal(UK)/ min	x				
1468	imperial megagallons per minute	Mgal(UK)/ min	x				
1469	imperial kilogallons per minute	kgal(UK)/m-in	x				
1470	imperial megagallons per minute	Mgal(UK)/ min	x				

	Unit descriptions	Unit abbreviations	Volume flow	Mass flow	Standard Volume flow	Density	Temperature
1471	imperial microgallons per hour	µgal(UK)/h	x				
1472	imperial megagallons per hour	Mgal(UK)/h	x				
1473	imperial kilogallons per hour	kgal(UK)/h	x				
1474	imperial megagallons per hour	Mgal(UK)/h	x				
1475	imperial microgallons per day	µgal(UK)/d	x				
1476	imperial megagallons per day	Mgal(UK)/d	x				
1477	imperial kilogallons per day	kgal(UK)/d	x				
1478	imperial megagallons per day	Mgal(UK)/d	x				
1479	millionth of a 42 US gallons barrel per second	µbbl/s	x				
1480	million 42 US gallons barrels per second	Mbbl/s					
1481	thousand 42 US gallons barrels per second	kbbl/s	x				
1482	million 42 US gallons barrels per second	Mbbl/s	x				
1483	millionth of a 42 US gallons barrel per minute	µbbl/min	x				
1484	million 42 US gallons barrels per minute	Mbbl/min	x				
1485	thousand 42 US gallons barrels per minute	kbbl/min	x				
1486	million 42 US gallons barrels per minute	Mbbl/min	x				
1487	millionth of a 42 US gallons barrel per hour	µbbl/h	x				
1488	million 42 US gallons barrels per hour	Mbbl/h	x				
1489	thousand 42 US gallons barrels per hour	kbbl/h	x				
1490	million 42 US gallons barrels per hour	Mbbl/h	x				
1491	millionth of a 42 US gallons barrel per day	µbbl/d	x				

	Unit descriptions	Unit abbrevi-ations	Volume flow	Mass flow	Standard Volume flow	Density	Temperature
1492	million 42 US gallons barrels per day	Mbbl/d	x				
1493	thousand 42 US gal-lons barrels per day	kbbl/d	x				
1494	million 42 US gallons barrels per day	Mbbl/d					
1495	cubic micrometers per second	$\mu m^3/s$	x				
1496	million cubic meters per second	Mm^3/s	x				
1497	cubic kilometers per second	km^3/s	x				
1498	million cubic meters per second	Mm^3/s	x				
1499	cubic micrometers per minute	$\mu m^3/min$	x				
1500	million cubic meters per minute	Mm^3/min	x				
1501	cubic kilometers per minute	km^3/min	x				
1502	million cubic meters per minute	Mm^3/min	x				
1503	cubic micrometers per hour	$\mu m^3/h$	x				
1504	million cubic meters per hour	Mm^3/h	x				
1505	cubic kilometers per hour	km^3/h	x				
1506	million cubic meters per hour	Mm^3/h					
1507	cubic micrometers per day	$\mu m^3/d$	x				
1508	million cubic meters per day	Mm^3/d	x				
1509	cubic kilometers per day	km^3/d	x				
1510	million cubic meters per day	Mm^3/d	x				
1511	cubic centimeters per second	cm^3/s	x				
1512	cubic centimeters per minute	cm^3/min	x				
1513	cubic centimeters per hour	cm^3/h	x				

	Unit descriptions	Unit abbreviations	Volume flow	Mass flow	Standard Volume flow	Density	Temperature
1514	cubic centimeters per day	cm^3/d	x				
1517	kiloliters	kl	x				
1518	kiloliters per minute	kl/min	x				
1519	kiloliters per hour	kl/h	x				
1520	kiloliters per day	kl/d	x				
1558	milligrams per liter	mg/l	x			x	
1559	micrograms per liter	µg/l	x			x	
1563	milliliters per minute	ml/min				x	
1564	milligrams per cubic decimeter	mg/dm^3	x			x	
1566	megagrams per cubic meter	Mg/m^3	x				
1567	carats	ct	x				
1568	troy pounds	lb t	x				
1569	ounces troy	oz t	x				
1570	US fluid ounces	fl oz	x				
1572	acre-feet	AF	x				
1573	normal cubic meters	Nm^3	x				
1574	normal liters	Nl	x				
1575	standard cubic meters	Sm^3	x				
1577	milliliters per second	ml/s	x		x		
1578	milliliters per hour	ml/h	x		x		
1579	milliliters per day	ml/d	x		x		
1580	acre-feet per second	AF/s	x		x		
1581	acre-feet per minute	AF/min	x		x		
1582	acre-feet per hour	AF/h	x		x		
1583	acre-feet per day	AF/d	x		x		
1584	US fluid ounces per second	fl oz/s	x		x		
1585	US fluid ounces per minute	fl oz/min	x		x		
1586	US fluid ounces per hour	fl oz/h	x		x		
1587	US fluid ounces per day	fl oz/d	x		x		
1588	normal cubic meters per second	Nm^3/s	x		x		
1589	normal cubic meters per minute	Nm^3/min	x		x		
1590	normal cubic meters per hour	Nm^3/h	x		x		

	Unit descriptions	Unit abbrevi-ations	Volume flow	Mass flow	Standard Volume flow	Density	Temperature
1591	normal cubic meters per day	Nm^3/d	x		x		
1592	normal liters per second	Nl/s	x		x		
1593	normal liters per minute	Nl/min	x		x		
1594	normal liters per hour	Nl/h	x		x		
1595	normal liters per day	Nl/d	x		x		
1596	standard cubic meters per second	Sm^3/s	x		x		
1597	standard cubic meters per minute	Sm^3/min	x		x		
1598	standard cubic meters per hour	Sm^3/h	x		x		
1599	standard cubic meters per day	Sm^3/d	x		x		
1600	standard liters per second	Sl/s	x		x		
1601	standard liters per minute	Sl/min	x		x		
1602	standard liters per hour	Sl/h	x		x		
1603	standard liters per day	Sl/d	x		x		
1604	standard cubic feet per second	SCF/s	x		x		
1605	standard cubic feet per day	SCF/d	x		x		
1606	ounces avoirdupois per second	oz/s	x		x		
1607	ounces avoirdupois per minute	oz/min	x		x		
1608	ounces avoirdupois per hour	oz/h	x		x		
1609	ounces avoirdupois per day	oz/d	x		x		
1633	hectoliters per second	hl/s	x		x		
1634	hectoliters per minute	hl/min	x		x		
1635	hectoliters per hour	hl/h	x		x		
1636	hectoliters per day	hl/d	x		x		
1637	31.5 US gallons barrels per second	bbl(US)/s	x		x		
1638	31.5 US gallons barrels per minute	bbl(US)/min	x		x		

	Unit descriptions	Unit abbreviations	Volume flow	Mass flow	Standard Volume flow	Density	Temperature
1639	31.5 US gallons barrels per hour	bbl(US)/h	x		x		
1640	31.5 US gallons barrels per day	bbl(US)/d	x		x		
1641	31 US gallons barrels	bbl-beer	x		x		
1642	31 US gallons barrels per second	bbl-beer/s	x		x		
1643	31 US gallons barrels per minute	bbl-beer/min	x		x		
1644	31 US gallons barrels per hour	bbl-beer/h	x		x		
1645	31 US gallons barrels per day	bbl-beer/d	x		x		
32768	bushels per second	bu/s	x		x		
32769	bushels per minute	bu/min	x		x		
32770	bushels per hour	bu/h	x		x		
32771	bushels per day	bu/d	x		x		
32772	cubic yards per second	yd^3/s	x		x		
32773	cubic yards per minute	yd^3/min	x		x		
32774	cubic yards per hour	yd^3/h	x		x		
32775	cubic yards per day	yd^3/d	x		x		
32776	cubic inches per second	in^3/s	x		x		
32777	cubic inches per minute	in^3/min	x		x		
32778	cubic inches per hour	in^3/h	x		x		
32779	cubic inches per day	in^3/d	x		x		
32780	million cubic feet per day	Mft^3/d	x		x		

Product documentation and support

D

D.1 Product documentation

Process instrumentation product documentation is available in the following formats:

- Certificates (http://www.siemens.com/processinstrumentation/certificates)
- Downloads (firmware, EDDs, software) (http://www.siemens.com/processinstrumentation/downloads)
- Catalog and catalog sheets (http://www.siemens.com/processinstrumentation/catalogs)
- Manuals (http://www.siemens.com/processinstrumentation/documentation)

  You have the option to show, open, save, or configure the manual.

  – "Display": Open the manual in HTML5 format
  – "Configure": Register and configure the documentation specific to your plant
  – "Download": Open or save the manual in PDF format
  – "Download as html5, only PC": Open or save the manual in the HTML5 view on your PC

You can also find manuals with the Mobile app at Industry Online Support (https://support.industry.siemens.com/cs/ww/en/sc/2067). Download the app to your mobile device and scan the device QR code.

Product documentation by serial number

Using the PIA Life Cycle Portal, you can access the serial number-specific product information including technical specifications, spare parts, calibration data, or factory certificates.

Entering a serial number

1. Open the PIA Life Cycle Portal (https://www.pia-portal.automation.siemens.com).
2. Select the desired language.
3. Enter the serial number of your device. The product documentation relevant for your device is displayed and can be downloaded.

To display factory certificates, if available, log in to the PIA Life Cycle Portal using your login or register.

Scanning a QR code

1. Scan the QR code on your device with a mobile device.
2. Click "PIA Portal".

To display factory certificates, if available, log in to the PIA Life Cycle Portal using your login or register.

D.2 Technical support

Technical support

If this documentation does not completely answer your technical questions, you can enter a Support Request (http://www.siemens.com/automation/support-request).

Additional information on our technical support can be found at Technical Support (http://www.siemens.com/automation/csi/service).

Service & support on the Internet

In addition to our technical support, Siemens offers comprehensive online services at Service & Support (http://www.siemens.com/automation/serviceandsupport).

Contact

If you have further questions about the device, contact your local Siemens representative at Personal Contact (http://www.automation.siemens.com/partner).

To find the contact for your product, go to "all products and branches" and select "Products & Services > Industrial automation > Process instrumentation".

Contact address for business unit:
Siemens AG
Digital Industries
Process Automation
Östliche Rheinbrückenstr. 50
76187 Karlsruhe, Germany

Ordering data

E

E.1 Accessories

You can order accessories online: Industry Mall (https://mallstage.industry.siemens.com/mall/en/b0/Catalog/Products/10020503?tree=CatalogTree)

The following accessories are not included in the scope of delivery:

- **Mandatory**: BaseUnit of the type B0 (order number 6ES7193-6BP20-0BB0) or B1 (order number 6ES7193-6BP20-0BB1)

  An overview of the BaseUnits that you can use with the technology module can be found in the Product Information for the documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

  Information regarding selection of the suitable BaseUnit can be found in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual.
- Labeling strips
- Color-coded labels
- Reference identification labels

SIEMENS

SIMATIC

ET 200SP
Technology module TM FST070

Operating Instructions

7ME3448-6AA00-0BB1

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Introduction 1

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

1.1 Purpose of this document

These instructions contain the product-specific information you need for connecting, commissioning, parameter assignment/addressing, diagnostics and technical specifications of the technology module.

General information on installation and commissioning of SIMATIC ET 200SP is available in the SIMATIC ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/109742709).

General information on installation and commissioning of SITRANS FSS200 is available in the SITRANS FSS200 Installation Manual (https://support.industry.siemens.com/cs/document/109803765/sitrans-fss200).

Specific information on setting up SITRANS TM FST070 with FS DSL11 and clamp-on sensors with SIMATIC PDM is available in Application Example (https://support.industry.siemens.com/cs/ae/en/view/109808468).

1.2 Document history

The following table shows the most important changes in the documentation compared to each previous edition.

Edition	Remarks	FW version	EDD version
03/2025	Support of SIMATIC ET 200SP HA together with PCS 7 V10 or higher	1.0.22	1.00.00-03
09/2022	• Updated device nameplate • Updated device properties • Adding compensation values 1 & 2	1.0.22	1.00.00-03
05/2022	First edition with product release	1.0.22	1.00.00-03

1.3 Use in hazardous area

WARNING

Use in hazardous area

Risk of explosion.

- Only use equipment that is approved for use in the intended hazardous area and labeled accordingly.
- Do not use devices that have been operated outside the conditions specified for hazardous areas. If you have used the device outside the conditions for hazardous areas, make all Ex markings unrecognizable on the nameplate.

WARNING

If the device is installed in a cabinet, the inner temperature of the cabinet corresponds to the ambient temperature of the device.

WARNING

Impermissible repair of the device

- Repair must be carried out by Siemens authorized personnel only.

1.4 Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit
https://www.siemens.com/industrialsecurity.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under
https://www.siemens.com/cert.

1.5 Open Source Software

Open-source software is used in the firmware of the product described. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information on this on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109740777).

Product overview

2

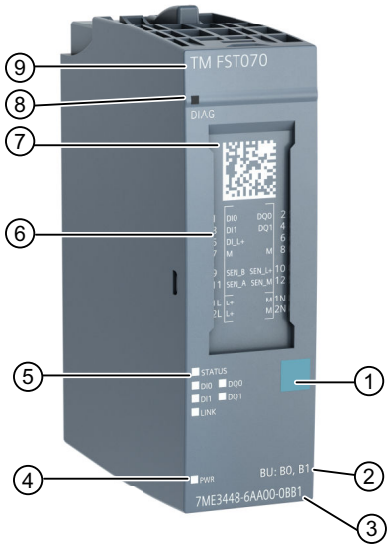

①	Color coding module type	⑥	Connection diagram
②	BaseUnit type	⑦	2D-Matrix Code
③	Article number	⑧	LED for diagnostics
④	LED for supply voltage	⑨	Module type and designation
⑤	Status LEDs		

Figure 2-1232 View of the SITRANS TM FST070

See also

SIMATIC ET 200SP Distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293)

SIMATIC ET 200SP Product information on the documentation of the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/73021864)

2.1 Properties

The SITRANS TM FST070 technology module has the following properties:

- Transmitter module for one digital ultrasonic flowmeter with Siemens Digital Sensor Link (FS DSL11)
- The module works via the FS DSL11 with ultrasonic clamp-on sensors
- Two configurable digital inputs
- Two configurable digital outputs
- High update rate (100 Hz) on all process values

- Measurement of the following process variables:
  - Volume flow rate
  - Mass flow
  - Flow velocity
  - Density
  - Temperature (by external input on FS DSL11 only)
  - Pressure (by external input on FS DSL11 only)
  - Kinematic viscosity
  - Standard volume flow (hydrocarbon, gas)
- 3 Totalizers
- Independent low flow cut-off settings for volume flow and standard volume flow
- Status LEDs

Operating modes

- Status signal flow direction with a digital output
  Flow direction forward (off) or backward (on)

Configuration

SITRANS TM FST070 with ET 200SP configuration software options:

- TIA Portal V17 or higher
- STEP 7 version V5.6 or higher
- PCS 7 V9.1 SP1 or higher

SITRANS TM FST070 with ET 200SP HA configuration software options:

- STEP 7 version V5.6 or higher
- PCS 7 V10 or higher

GSD file links:

- PROFINET GSD files

Firmware update

Firmware updates can be downloaded to the memory of the SITRANS TM FST070 module by means of the STEP 7 Basic (TIA Portal) engineering software or STEP 7 - HW Config.

NOTE

Disconnect the cable from the service port before starting the firmware update.

See also

PROFINET GSD files
(https://support.industry.siemens.com/cs/document/57138621?dti=0&lc=en-US)

Modes and Functions

3

Modes and functions

The SITRANS TM FST070 has two digital inputs and two digital outputs. You can assign a different mode for each in-/output.

Configuration of the operating mode is made using the TIA Portal or HW Config.

For each of the digital inputs you can select one of the following operating modes:

- Reset totalizer 1 on leading edge
- Reset totalizer 2 on leading edge
- Reset totalizer 3 on leading edge
- Reset all totalizers on leading edge
- Zero adjust on leading edge
- Force outputs
- Freeze process values
- Start/stop totalizer 1
- Start/stop totalizer 2
- Start/stop totalizer 3

For each of the digital outputs you can select one of the following operating modes:

- Status signals
- Flow direction

Interfaces to the control program and the process under control

The SITRANS TM FST070 has the following I/O BaseUnit pin connections to the process under control:

- DI0 (digital input 0)
- DQ0 (digital output 0)
- DI1 (digital input 1)
- DQ1 (digital output 1)

3.1 Cut-off limits

The cut-off limits are used to suppress low flow rates.

It is possible to program the cut-off limit for volume flow, mass flow, flow velocity and standard volume flow.

The device provides four parameters for setting the low flow cut-off:

- Low volume flow cut-off
- Low mass flow cut-of
- Low flow velocity cut-off
- Standard volume flow cut-off

Parameterization

The mode of the cut-off limits can be set via the Parameter data record (Page 52).

Byte Bit		Cut-off limit
5 ... 8	Low volume flow cut-off limit	encoded as Float32 in volume units Default value = 0.0
34 ... 37	Low Mass flow cut-off limit	encoded as Float32 in mass units Default value = 0.0
40 ... 43	Low flow velocity cut-off limit	encoded as Float32 in flow velocity units Default value = 0.0
54 ... 57	Standard volume flow cut-off limit	encoded as Float32 in standard volume flow units Default value = 0.0

3.2 Zero point adjustment

NOTE

Preconditions

Before a zero point adjustment is initiated, the pipe must be flushed, filled and at an absolute flowrate of zero preferably also at operating pressure and temperature.

NOTE

Change of parameters during zero point adjustment

Do not change any other parameter during the zero point adjustment procedure.

Automatic zero point adjustment

The device measures and calculates the correct zero point automatically.

The automatic zero point adjustment of the flowmeter is set by the following parameters:

- Duration
- Start Zero Point Adjustment

When zero adjust is initiated by selecting "Start Zero Point Adjustment", the volume flow values are acquired and totalized for the configured period (Duration). The default zero point adjustment period (30 s.) is normally sufficient for a stable zero point measurement.

3.3 Digital output mode DQ0/DQ1

3.3.1 Digital output mode DQ0/DQ1

The SITRANS TM FST070 outputs offer different signals at the DQ0/DQ1 digital outputs.

The digital output can be used for status signals or flow direction.

Parameterization

The mode of the outputs DQ0 and DQ1 can be set via the Parameter data record (Page 52).

3.3.2 Status signal

Output mode must be set to 1 to activate signal. Depending on the activation one or more status signals can be shown.

Status signal can show following status at DQ0 or/and DQ1:

- out of specification – measuring signal is out of range
- failure – sensor measuring failure
- maintenance required – the sensor needs maintenance
- function check – e.g. startup of the sensor, simulation active, force mode activated or frozen value active

3.3.3 Force value

Activates the output if force output is set at the input DI0 or DI1.
Possible with Step7 (TIA Portal) or activation via I/O data.

3.3.4 Flow direction

Displays the flow direction:

- Active: positive flow
- Inactive: negative flow

3.4 Digital input mode DI0/DI1

3.4.1 Digital input mode DI0/DI1

The SITRANS TM FST070 input can handle different signals at the DI0 and DI1 digital inputs.

Parameterization

The mode of the digital inputs DI0 and DI1 can be set via the Parameter data record (Page 52).
Following modes are available

Totalizer function

- Reset totalizer 1 on leading edge
- Reset totalizer 2 on leading edge
- Reset totalizer 3 on leading edge
- Reset all totalizers on leading edge
- Start/stop totalizer 1
- Start/stop totalizer 2
- Start/stop totalizer 3

Special functions

Force outputs is used to switch on both outputs. It can be used e.g. for a cleaning process

- Freeze process values
- Force outputs
- Zero adjust on leading edge

3.4.2 Function: Totalizer

Definition

The SITRANS TM FST070 has a different totalizer integrated. The totalizer counts the volume and can be used for process control. The counting is done in the SITRANS TM FST070 and can be used in the PLC or shown on TIA Portal.

The reset of the totalizers can be done via STEP 7 (TIA Portal) or with the input DI0 or DI1.

Parameterization

The mode of the totalizer can be set via the Parameter data record (Page 52).

Depending on the mode set for the DI0/DI1 inputs, the totalizer can be started, stopped or reset with the inputs on the SITRANS TM FST070.

In case of failure in the system, the totalizer holds the last value before the failure occurred.

3.4.2.1 Freeze process values

Definition

The mode of the totalizer can be set via the Parameter data record (Page 52).

Is mode of DI0 or DI1 set to 10.

With the input the process values of the measuring value can be frozen to have a fixed measuring value for testing the PLC programming during commissioning.

3.4.2.2 Force outputs

Definition

The mode of the totalizer can be set via the Parameter data record (Page 52).

Is mode of DI0 or DI1 set to 9.

The inputs DI0 or DI1 can control the outputs DQ0 and DQ1 and switch them on and off.

To activate the outputs with the inputs the function DQ0 or DQ1 force value must be set to active.

3.4.2.3 Zero adjust on leading edge

Definition

The mode of the totalizer can be set via the Parameter data record (Page 52).

Is mode of DI0 or DI1 set to 7.

A zero-point adjustment of the flowmeter measuring is done. The actual measured flow value is set to zero when triggered.

3.5 Compensation values 1 & 2

The SITRANS TM FST070 can be provided with process values from the PLC user program for compensation purposes.

Parameterization

The process value selection for compensation value 1 & 2 can be set via the Parameter data record (Page 52).

The actual process value has to be provided using the output data (see relevant Output data section (Page 41)*).*

The following modes are available:

- Disabled
- Pressure
- Density (only standard and hydrocarbon variant)
- Kinematic viscosity (only standard and hydrocarbon vaiant)
- Medium temperature
- Sensor temperature
- Auxiliary temperature

Installation

4

4.1 Basic safety notes

WARNING

If a device is operated in an ambient temperature of more than 50 to 60 °C, the temperature of the device housing may be higher than 70 °C. The device must therefore be installed so that it is only accessible to service personnel or users that are aware of the reason for restricted access and the required safety measures at an ambient temperature higher than 60 °C.

WARNING

Open equipment

The devices are "open equipment" according to the standard IEC 61010-2-201 or UL 61010-2-201 / CSA C22.2 No. 61010-2-201. To fulfill requirements for safe operation with regard to mechanical stability, flame retardation, stability, and protection against contact, the following alternative types of installation are specified:

- Installation in a suitable cabinet.
- Installation in a suitable enclosure.
- Installation in a suitably equipped, enclosed control room.

4.1.1 Specific conditions for use in hazardous locations

WARNING

Incorrect installation

Risk of explosion in the hazardous area. For use in hazardous areas according to Class I, Division 2 or Class I, Zone 2 or for use in the EU according to ATEX 2014/34/EU, observe the following conditions:

- Install the device in a control cabinet or enclosure.
- The control cabinet or enclosure meets at least the requirements of IP54 according to IEC/EN 60079-7 and pollution degree 2 or better according to IEC/EN 60664-1.

NOTE

You must not install the device on a wall in hazardous areas.

WARNING

Take measures to prevent transient voltage surges of more than 40% of the rated voltage. This is the case if you only operate devices with SELV (safety extra-low voltage).

WARNING

Explosion hazard

Do not disconnect equipment when a flammable or combustible atmosphere is present.

WARNING

Substitution of components may impair suitability for Division 2.

CAUTION

Accessible hot surfaces

CAUTION

To prevent injury, read the manual before use.

This equipment is suitable only for use in Class I, Division 2, Groups A, B, C and D, Class I, Zone 2, Group IIC or non-hazardous locations.

This equipment is suitable only for use in Class I, Zone 2, Group IIC or non-hazardous locations.

4.2 Mounting on the SIMATIC ET 200SP

Only use the technology module SITRANS TM FST070 in conjunction with a SIMATIC ET 200SP distributed I/O system. Install the technology module in a control cabinet. Observe the information on the protection class and degree of pollution in the section Technical specifications (Page 33).

When installing the SIMATIC components with the technology module described herein, follow the setup, assembly and wiring guidelines for the SIMATIC ET 200SP. See system manual (https://support.industry.siemens.com/cs/ww/en/view/109742709) for the SIMATIC ET 200SP.

The technology module SITRANS TM FST070 is snapped onto the SIMATIC ET 200SP BaseUnit (BU).

All information about connecting is available in section Connection (Page 24).

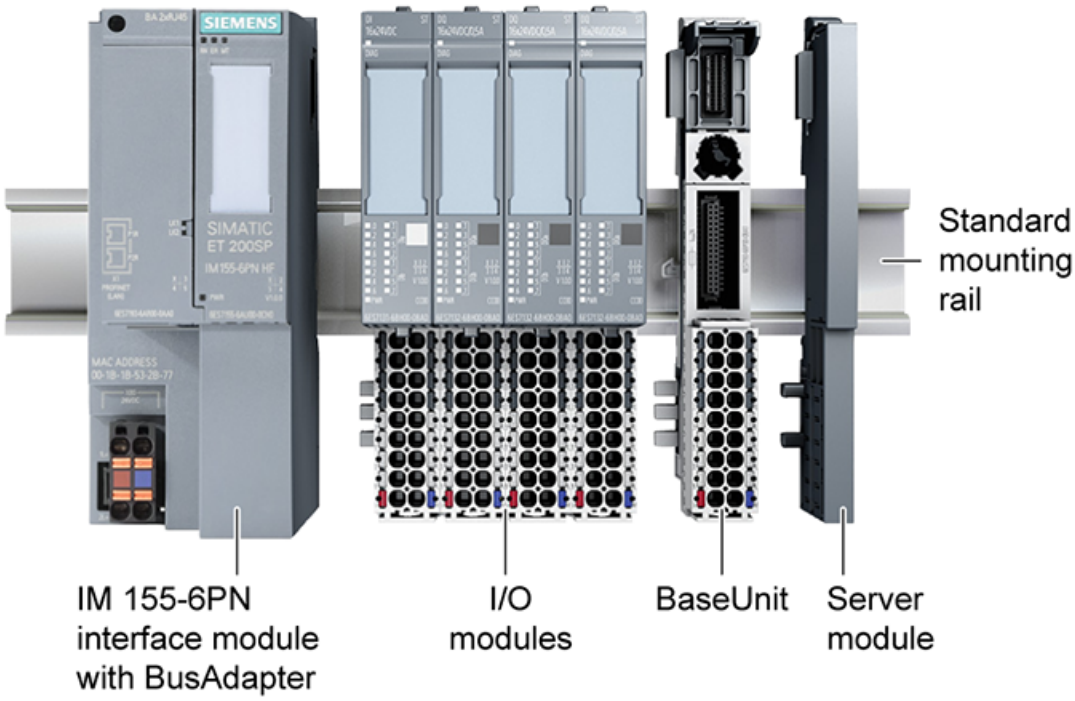

Figure 2-1233 Mounting on the SIMATIC ET 200SP

4.3 Installing SITRANS TM FST070 with isolating power supply

To use the sensor in explosion proof areas an isolating power supply as well as isolated communication lines must be installed. The SITRANS I300 can be used to isolate the power supply and the digital communication signal to the sensor.

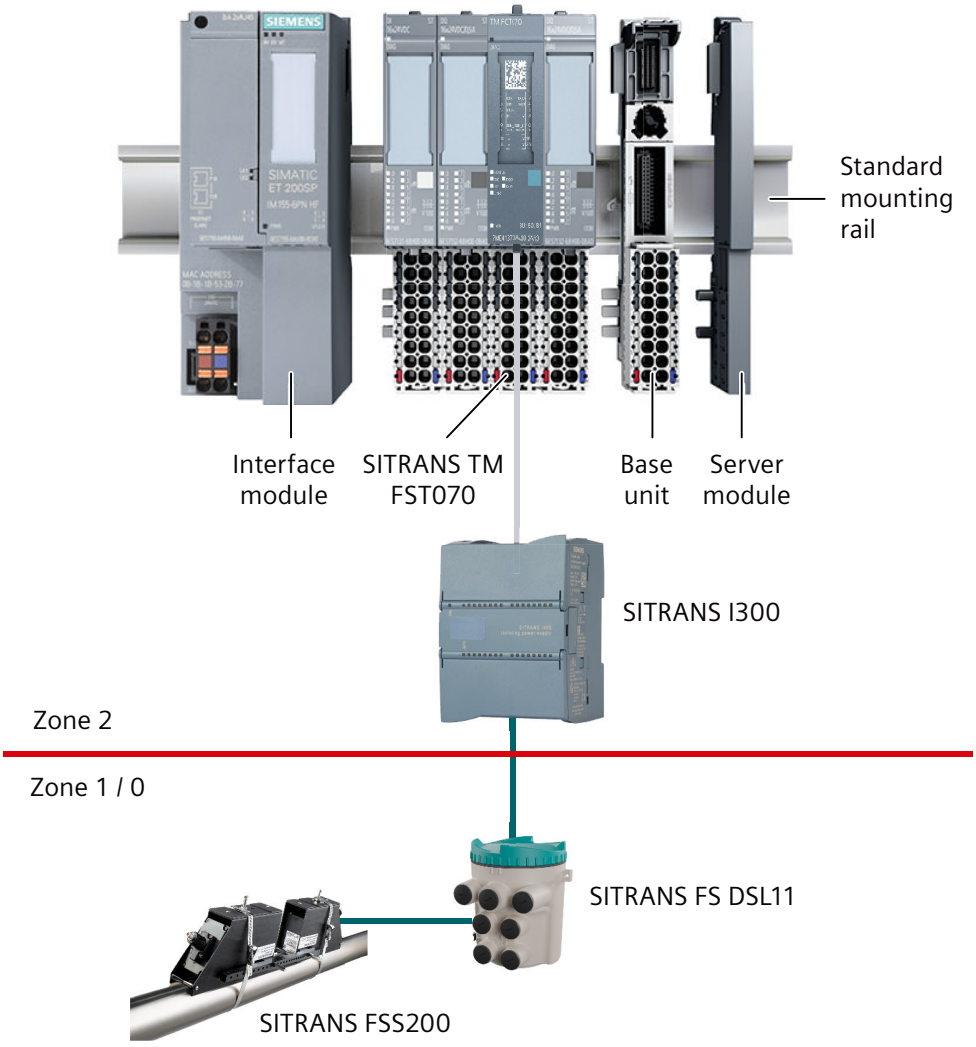

- **Sensor in Zone 1 or division 1 and SIMATIC ET 200SP in Zone 2 or division 2**
  SITRANS I300 is needed.
- **Sensor in Zone 2 and SIMATIC ET 200SP in Zone 2**
  SITRANS I300 is needed.

NOTE

NOT ALLOWED: Sensor in Zone 1 or division 1 and SIMATIC ET 200SP in Zone 1 or division 1

4.4 EMC-compliant installation

4.4.1 Introduction

Overview

The technology module described here was developed for use in industrial environments and complies with high EMC requirements. Nevertheless, before installing your devices you should prepare an EMC plan and identify and take into consideration possible interference sources.

EMC

EMC (electromagnetic compatibility) describes the capability of electrical equipment to operate without errors in a given electromagnetic environment, without being subject to external influence and without influencing external devices in any way.

4.4.2 Possible effects of interference

Electromagnetic interferences can influence the technology module described here in various ways:

- Electromagnetic fields having a direct influence on the system
- Interferences transported by communication cables
- Interferences having an effect via process cables
- Interferences entering the system via the power supply and/or protective ground

Interferences can impair the fault-free functioning of the technology module.

4.4.3 Coupling mechanisms

Depending on the propagation medium (conducted or non-conducted) and the distance between the interference source and the device, interferences can enter the faulty device through four different coupling mechanisms:

- Electrical coupling
- Capacitive coupling
- Inductive coupling
- Radiation coupling

4.4.4 Five basic rules for securing EMC

Observe these five basic rules to secure EMC.

Rule 1: Large area grounding contact

- When installing the devices, make sure that the surfaces of inactive metal parts are properly bonded to chassis ground (see following sections).
- Bond all inactive metal parts to chassis ground, ensuring large area and low-impedance contact (large cross-sections).
- When using screw connections on varnished or anodized metal parts, support contact with special contact washers or remove the protective insulating finish on the points of contact.
- Wherever possible, avoid the use of aluminum parts for ground bonding. Aluminum oxidizes very easily and is therefore less suitable for ground bonding.
- Provide a central connection between chassis ground and the ground/protective conductor system.

Rule 2: Proper cable routing

- Organize your wiring system into cable groups (high-voltage/power supply/signal/measurement/data cables).
- Always route high-voltage and data cables in separate ducts or in separate bundles.
- Install the measurement cables as close as possible to grounded surfaces (e.g. supporting beans, metal rails, steel cabinet walls).

Rule 3: Fixing the cable shielding

- Ensure proper fixation of the cable shielding.
- Always use shielded data cables. Always connect both ends of the data cable shielding to ground on a large area.
- Keep unshielded cable ends as short as possible.
- Always use metal/metalized connector housings only for shielded data cables.

Rule 4: Special EMC measures

- All inductors that are to be controlled should be connected with suppressors.
- For cabinet or enclosure lighting in the immediate range of your controller, use incandescent lamps or interference suppressed fluorescent lamps.

Rule 5: Homogeneous reference potential

- Create a homogeneous reference potential and ground all electrical equipment.
- Use sufficiently dimensioned equipotential bonding conductors if potential differences exist or are expected between your system components. Equipotential bonding is absolutely mandatory for applications in hazardous areas.

Connection 5

5.1 Basic safety notes

WARNING

Safety extra low voltage

The equipment is designed for operation with Safety Extra-Low Voltage (SELV) by a Limited Power Source (LPS). (This does not apply to 100 V...240 V devices.)

The power supply unit for the equipment power supply must comply with NEC Class 2, as described by the National Electrical Code (r) (ANSI / NFPA 70).

There is an additional requirement if devices are operated with a redundant power supply:

If the equipment is connected to a redundant power supply (two separate power supplies), both must meet these requirements.

WARNING

Suitable cables at high ambient temperatures

If the temperature of the cable or housing socket exceeds 70 °C or the branching point of conductors exceeds 80 °C, special precautions must be taken.

If the device is operated at ambient temperatures of between 50 °C and 60 °C, only use cables with a maximum permitted operating temperature of at least 80 °C.

5.1.1 Use in hazardous areas

WARNING

WARNING – EXPLOSION HAZARD:

DO NOT CONNECT OR DISCONNECT EQUIPMENT WHEN A FLAMMABLE OR COMBUSTIBLE ATMOSPHERE IS PRESENT.

WARNING

Take measures to prevent transient voltage surges of more than 40% of the rated voltage. This is the case if you only operate devices with SELV (safety extra-low voltage or Class 2 power supply).

5.2 Connection of inputs and outputs

The SITRANS TM FST070 has two digital inputs and two digital outputs which can be configured for different operation modes.

Table 2-1383 Pin assignment of the BaseUnit

Naming	Con.	PIN	BU20 type B1	PIN	Con.	Naming
Digital input	DI0	1	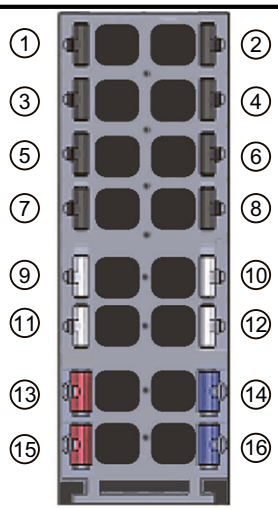	2	DQ0	Digital output
Digital input	DI1	3		4	DQ1	Digital output
+24 V DC supply voltage for digital inputs	DI_L+	5		6	nc	
Ground for digital outputs	M	7		8	M	Ground for digital outputs
RS-485 data line B for SEN communication	SEN_B	9		10	SEN_L+	+15 V DC supply voltage for SEN
RS-485 data line A for SEN communication	SEN_A	11		12	SEN_M	GND for SEN supply
+24 V DC supply voltage	L+	13		14	M	Ground for supply voltage
	L+	15		16	M	

Digital outputs			Voltage switching load
Digital output DQ0	Status signal output or Flow direction indication depending on DQ0 mode	Active output	24 VDC 300 mA
Digital output DQ1	Status signal output or Flow direction indication depending on DQ1 mode	Active output	24 VDC 300 mA

Digital inputs			Voltage
Digital input DI0	Totalizer or special function	signal "0" 0 to +5V signal "1" +15 to +30V	24 VDC
Digital input DI1	Totalizer or special function	signal "0" 0 to +5V signal "1" +15 to +30V	24 VDC

⚠ WARNING

Supply voltage M connections

Connect both the M potential pins to the power supply return with separate wires. If one wire breaks, then the other wire maintains the electrical connection from M to the power supply return.

If the electrical connection between the M potential and the power supply return is broken, then unexpected conditions can occur and the digital outputs may go high even though your program is not setting a high state.

Connecting the data lines with or without SITRANS I300 Ex barrier

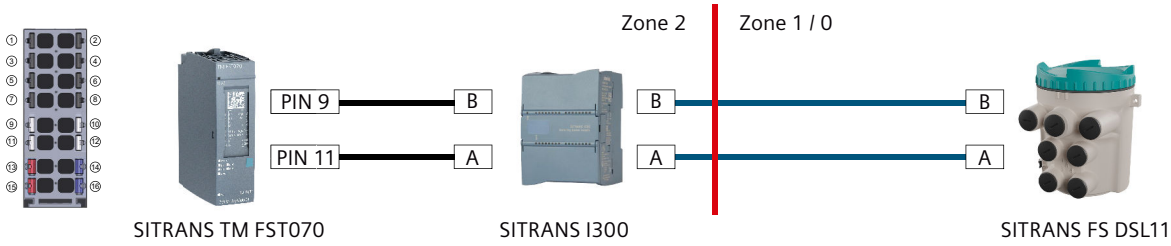

Figure 2-1234 Connected with Ex barrier I300

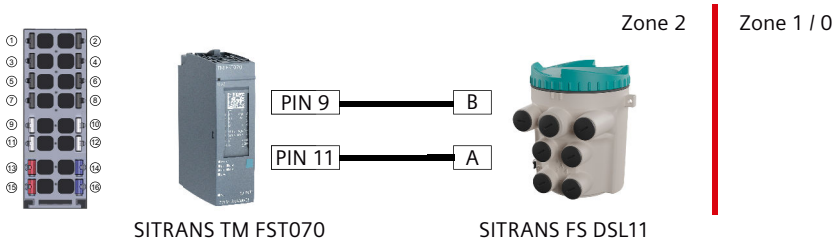

Figure 2-1235 Connected without Ex barrier I300

NOTE

L+ and M isolation on SITRANS TM FST070 module using BaseUnit type B1

The L+ and M connections on the type B1 BaseUnit are electrically isolated, from adjacent BaseUnits plugged in on the left-side or right-side. The L+ and M power bus passes through the type B1 BaseUnit (with no connections) and extends the power bus to connect left-side and right-side BaseUnits.

NOTE

Electromagnetic interference shielding for inputs

Input connections on the type B1 BaseUnit used by the SITRANS TM FST070 module do not have shield ground connections. You must connect cable shields to electrical ground at the DIN rail or the system cabinet.

5.3 Start-up of SITRANS TM FST070

Introduction

The connection of the FS DSL11 is done via the SSL cable. All sensor calibration data are automatically transferred during the first startup from the FS DSL11 to the SITRANS TM FST070 and stored in the SITRANS TM FST070 memory.

Starting up

1. Connect the FS DSL11 via the SSL cable.
2. Connect the power supply.

   The FS DSL11 data are transferred automatically from the FS DSL11 to the SITRANS TM FST070.

   The red STATUS LED flashes during start up.

   The green LINK LED is on when the FS DSL11 is connected.

Configuring 6

6.1 Configuration software

SITRANS TM FST070 is configured and assigned parameters with the GSD file.

For service SITRANS TM FST070 has a special service port on board.

System environment

SITRANS TM FST070 can be used in the following system environments:

Table 2-1384 Applications of the technology module with PROFINET I/O

Applications	Components required	Configuration software	In your program
Decentralized operation in an S7-1500 system	• S7-1500 automation system • SIMATIC ET 200SP decentralized I/O system • SITRANS TM FST070	STEP 7 (TIA Portal): Device configuration and parameter settings with HSP	Direct access to the control and feedback interface of the SITRANS TM FST070 in the I/O data
Centralized or decentralized operation in an SIMATIC ET 200SP system	• SIMATIC ET 200SP automation system • SITRANS TM FST070	STEP 7 (TIA Portal): Device configuration and parameter settings with HSP	Direct access to the control and feedback interface of the SITRANS TM FST070 in the I/O data
Decentralized operation in an S7-300/400 system	• S7-300/400 automation system • SIMATIC ET 200SP decentralized I/O system • SITRANS TM FST070	STEP 7 (TIA Portal): Device configuration and parameter settings with HSP STEP 7 (TIA Portal): Device configuration and parameter settings with hardware configuration (HWCN)	Direct access to the control and feedback interface of the SITRANS TM FST070 in the I/O data
Decentralized operation with a PROFINET controller	PROFINET controller • SIMATIC ET 200SP decentralized I/O system • SITRANS TM FST070	Engineering system with GSD file	Direct access to the control and feedback interface of the SITRANS TM FST070 in the I/O data

You can use the STEP 7 (TIA Portal) or STEP 7 hardware configuration to set these parameters. Also, you can change the parameter assignment at runtime with your program using data record 128 (Page 52).

STEP 7 (TIA Portal) and STEP 7 assist you during parameter assignment by disabling keyboard input for invalid parameters and range checking your value assignments. Depending on previous parameter selections, other options will be disabled. For example, if you select the one channel operation (the parallel connection of the two output channels), then the parameter options for channel two and high-speed output are disabled.

When you make a runtime parameter assignment that uses the WRREC (Write Record) instruction to modify data record 128, you must ensure that you do not attempt to write an invalid record data. WRREC execution with invalid data fails and returns error code. For example, if you are using one channel operation and include parameter data for two channels, then the record length is too long and WRREC execution fails.

If you use STEP 7 (TIA Portal), you can find the module in the Hardware catalog under "Technology Modules". If you use STEP 7, you can find the module following installation of the corresponding HSP file in the Hardware catalog.

The following table shows how a channel's "Parameter" group is affected by mode selection.

6.2 Address space

Table 2-1385 SITRANS TM FST070 I/O address space usage

Function	Type of config	Byte output	Byte input
Address space	Standard	82 byte	11 byte
	Hydrocarbon	132 byte	11 byte
	Gas	92 byte	11 byte

6.3 TIA portal Device configuration

Drag the SITRANS TM FST070 module from the hardware catalog and drop it in a rack image. The example rack below uses the SITRANS TM FST070 module in a decentralized I/O system. When you click on the SITRANS TM FST070 image in a rack, a blue line highlights the module and you can set parameters that appear on the Properties tab.

Enter the general project and identification & maintenance information.

6.3.1 General information

Enter the general project and identification & maintenance information.

Modified parameter assignment

The status assumed by the SITRANS TM FST070 at CPU/master STOP remains even in the case of parameter assignment or configuration of the SIMATIC ET 200SP station. This occurs, for example, at POWER ON of the CPU/master, or the IM 155-6, or at the resumption of DP transfer.

In "Continue working mode", however, and after loading changed parameters or configuration of the SIMATIC ET 200SP station to the CPU/master, the SITRANS TM FST070 terminates the process. As a result, the SITRANS TM FST070 resets the DQ digital outputs.

6.3.2 I/O addresses

You can assign the base addresses for the control interface (output addresses) and the feedback interface (input addresses). Your program logic uses the values stored in these addresses to control the SITRANS TM FST070 output and read feedback signals from the module. For details see I/O data (Page 41).

Interrupts/diagnostic messages

7

7.1 Status and error displays

SITRANS TM FST070 front view

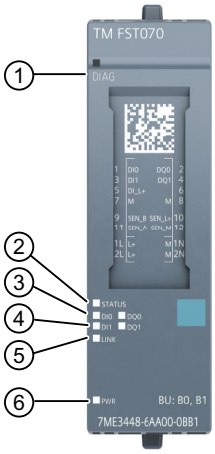

①	DIAG	green/red
②	STATUS	green/red
③	DI0, DQ0	green
④	DI1, DQ1	green
⑤	LINK	green
⑥	PWR	green

LED status display

The following tables explain the meaning of the status and error displays. Refer to Error correction and diagnostics (Page 32) for details.

Table 2-1386 DIAG LED

DIAG LED	Meaning	To correct or avoid errors
Off	Backplane bus supply of the SIMATIC ET 200SP not OK	Check or switch On the supply voltage of the head station. Ensure the SITRANS TM FST070 is correctly inserted in the BaseUnit.
Flashes green	Technology Module not configured	
On green	Technology Module configured and no module error exists	
Flashes red	Technology Module configured and module diagnostics (at least one error pending)	Evaluate the diagnostic alarms and eliminate the error.

NOTE

The DIAG LED only shows an error if the Diagnostic alarm is activated during device configuration. By default, the Diagnostic alarm is not activated.

Table 2-1387 PWR LED status

PWR	Meaning	To correct or avoid errors
Off	No supply voltage	• Check the external 24 V DC power supply voltage connected between L+ and M.
On green	Supply voltage is present and OK	

Table 2-1388 STATUS LED

STATUS	Error code	Meaning	Description	To correct or avoid errors
Off		No warning No alarm		
On red	344	Failure	No process values from the sensor.	Check connection to the flow sensor.

The status signal is min 3 seconds available.

LINK	Meaning	To correct or avoid errors
Off	Sensor is not connected with SITRANS TM FST070.	
On green	Sensor is connected correctly to SITRANS TM FST070.	

Table 2-1389 DQ0 status LED

DQ0	Meaning	To correct or avoid errors
Off	DQ0 is switched off.	Check connection.
On green	DQ0 is switched on (+ 24V).	

Table 2-1390 DQ1 status LED

DQ1	Meaning	To correct or avoid errors
□ Off	DQ1 is switched off.	Check connection.
■ On green	DQ1 is switched on (+ 24V).	

Table 2-1391 DI0 status LED

DI0	Meaning	To correct or avoid errors
□ Off	Low level signal at input DI0.	0V at the input
■ On green	High level Input signal at DI0.	24V at the input

Table 2-1392 DI1 status LED

DI1	Meaning	To correct or avoid errors
□ Off	Low level signal at input DI1.	0V at the input
■ On green	High level Input signal at DI1.	24V at the input

7.2 Error detection and diagnostics

Diagnostic alarms

When a SITRANS TM FST070 error event triggers a diagnostic alarm, the following happens:

- The DIAG light flashes red when a diagnostics alarm is pending. Once you have remedied the error, the DIAG light changes to green.
- The diagnostics are displayed as plain text in the STEP 7 (TIA Portal) online and diagnostics view.
- Options for the reaction of a CPU running your control program
  - CPU goes to STOP and interrupts processing of the user program. The diagnostic interrupt OB (for example, OB 82) is called. The event that triggered the interrupt is written in the start information of the diagnostic interrupt OB.
  - CPU remains in RUN even if no diagnostic interrupt in present in the CPU. The technology module continues working unchanged if this is possible, while the error exists.

Technical specifications

8

8.1 General information

Article number	7ME3448-6AA00-0BB1
General information	
Product type designation	Technology module SITRANS TM FST070
Firmware version	V1.0
FW update possible	Yes
usable BaseUnits	BU 20 type B1
Color code for module-specific color identification plate	CC40
Compatibility	
SIMATIC ET 200SP	PCS 7 V9.1 or higher TIA Portal V17 or higher
SIMATIC ET 200SP HA	PCS 7 V10 or higher TIA Portal not supported
Product function	
I&M data	Yes; I&M 0
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V17 or higher
• STEP 7 configurable/integrated as of version	V5.6 or higher
• PCS 7	V9.1 or higher
• PROFINET as of GSD version/GSD revision	GSDML V2.35
Cable	
Maximum cable length to FS DSL11	75m
Supply voltage	
Load voltage L+	24 V DC
Rated value (DC)	24 V NEC-Class II
permissible range, lower limit (DC)	19,2 V
permissible range, upper limit (DC)	28,8 V
Short-circuit protection	Yes
Reverse polarity protection	Yes; against destruction
Input current	
Current consumption, max.	900 mA
Power loss	
Typical power loss	Max. 21,6 W
Protection class	
IP protection	IP20

Article number	7ME3448-6AA00-0BB1
EMC	
Electrostatic discharge according to IEC 61000-4-2: 2008	
Field-related interference according to IEC 61000-4-3: 2006	
Bursted interference due to Burst according to IEC 61000-4-4: 2012	
Conducted interference by surge according to IEC 61000-4-5: 2014	
Conducted interference by high-frequency radiation according to IEC 61000-4-6: 2013	
Decentralized operation	
to SIMATIC S7-300	Yes
to SIMATIC S7-400	Yes
to SIMATIC S7-1200	Yes
to SIMATIC S7-1500	Yes
to standard PROFINET controller	Yes

BaseUnit technical specifications

Refer to the user manual for SIMATIC ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521).

8.2 Digital inputs

Article number	7ME3448-6AA00-0BB1
Supply	24 V, max. 35 mA, short-circuit protectet
Number of digital inputs	2
Digital inputs, parameterizable	Yes
Input characteristic curve in accordance with IEC 61131, type 3	Yes
Digital input functions, parameterizable	
Freely usable digital input	Yes
Input voltage	
Type of input voltage	DC
Rated value (DC)	24 V
for signal "0"	-30 to +5 V
for signal "1"	+11 to +30 V
permissible voltage at input, min.	-30 V
permissible voltage at input, max.	30 V
Input current	
for signal "1", typ.	2,5 mA
Cable length	
shielded, max.	50 m; Depending on load and cable quality
unshielded, max.	25 m; Depending on load and cable quality

8.3 Digital outputs

Article number	7ME3448-6AA00-0BB1
Type of digital output	P- switching
Number of digital outputs	2
Current-sinking	No
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes; electronic/thermal
Digital output functions, parameterizable	
Freely usable digital output	Yes
Switching capacity of the outputs	
with resistive load, max.	300 mA
on lamp load, max.	8 W
Load resistance range	
lower limit	80 Ω
upper limit	10 kΩ
Output voltage	
Type of output voltage	DC
for signal "0", max.	1 V
for signal "1", min.	23,2 V; L+ (-0.8 V)
Output current	
for signal "1" rated value	300 mA
Parallel switching of 2 outputs	Yes
Cable length	
shielded, max.	50 m; Depending on load and cable quality
unshielded, max.	25 m; Depending on load and cable quality

8.4 Address area

Article number	7ME3448-6AA00-0BB1
Assigned address area	
• Inputs	Standard: 82 byte; Hydrocarbon: 132 byte; Gas: 92 byte
• Outputs	11 byte

8.5 Potential separation

Article number	7ME3448-6AA00-0BB1
Potential separation digital inputs	
between module and backplane bus	Yes
Potential separation digital outputs	
between module and backplane bus	Yes
Potential separation channels	
between the channels	No
between the channels and backplane bus	Yes
Permissible potential difference	
between different circuits	75 V DC/60 V AC (base isolation)
Isolation	
Pollution degree	2

8.6 Interrupts/diagnostics/status information

Article number	7ME3448-6AA00-0BB1
Alarms	
Diagnostic alarm	Yes
Diagnostic messages	
Diagnostics	Yes
Control of the power supply	Yes
Shortage	No
Overload	Yes
Diagnostics indication LED	
Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
for sensor diagnostics	Yes; green/red STATUS LED
for module diagnostics	Yes; green/red DIAG LED

8.7 Dimensions and weight

Article number	7ME3448-6AA00-0BB1
Width	20 mm
Height	73 mm
Depth	58 mm
Weight, approx.	32 g

8.8 Electrical, EMC and climatic requirements

Article number	7ME3448-6AA00-0BB1
Product safety	
Safety regulations	IEC 61010-1:2016 ANSI/UL 61010-1:2018
Protection class	To maintain the safety characteristics of extra-low voltage circuits, external connections to communications ports, analog circuits, as well as all 24 V DC nominal power supplies and all I/O circuits must be powered by approved sources that fulfill the requirements according to the various standards for SELV, PELV, NEC Class 2, voltage limited or power limited. The ground connection for the DIN rail serves as a functional ground for dissipating interference currents.
IP degree of protection	IP 20: Protection against contact with standard probe Protection against solid bodies with diameters in excess of 12.5 mm No special protection against water
Air gaps and creepage distances	Overvoltage category II Pollution degree 2
Isolation stability	Test voltage: 500 V AC or 707 V DC
Use in hazardous areas	
Electromagnetic compatibility	All shielded cables must be grounded at both ends to comply with the requirements for electromagnetic compatibility. If the shielded cable is routed out of the hazardous area for explosion-proof equipment, both ends of the cable shield must be connected to the potential equalization. To comply with the requirements for lightning strikes, additional measures are required for installation in Zone A according to IEC 61131-2: 2007.
Electromagnetic compatibility	
Interference emission in industrial area in accordance with EN 61000-6-4	
Emission of radio interference (interference field strength)	30 ... 230 MHz, 40 dB (mV/m) Q 230 ... 1000 MHz, 47 dB (mV/m) Q 1 ... 3 GHz / 76 dB (mV/m) peak, 56 dB (mV/m) average 3 ... 6 GHz / 80 dB (mV/m)
Emission on power supply cables	Class A: Industrial environment 0.15 ... 0.5 MHz, 79 dB (µV) Q 0.15 ... 0.5 MHz, 66 dB (µV) M 0.5 ... 30 MHz, 73 dB (µV) Q 0.5 ... 30 MHz, 60 dB (µV) M
Interference immunity in industrial area in accordance with EN 61000-6-2	
Burst pulses on power supply cables	±2.4 kV 5/50 ns/5 kHz
Burst pulses on data and signal cables	±2.4 kV 5/50 ns/100 kHz

1) An external device must be provided to comply with this EMC requirement (e.g. Lightning conductor BVTAD24, Dehn & Söhne company)

2) An external device must be provided to comply with this EMC requirement (e.g. Lightning conductor BSPM4BE24, Dehn & Söhne company)

Article number	7ME3448-6AA00-0BB1
Electrostatic discharge (ESD)	2, 4, 6 kV direct/indirect
Electrostatic air discharge (ESD)	2, 4, 6, 8 kV
Surge on power supply cables	ZONE A acc. to IEC 61131-2[1]: ±1.0 kV line to line ±2.0 kV line to earth ZONE B to IEC 61131-2: ±0.5 kV line to line ±1.0 kV line to earth
Surge on data and signal cables	ZONE A acc. to IEC 61131-2[2]: ±1.0 kV line to line ±2.0 kV line to earth ZONE B to IEC 61131-2: ±1.0 kV line to earth
Surge on data and signal cables shielded	±2.0 kV shield to ground
Surge on signal cables unshielded	0.5 kV/2kV[2]
Electromagnetic RF fields	80 MHz ... 6 GHz: 10 V/m
Induced conducted interference	10 kHz ... 80 MHz: 12 V_{eff}

1) An external device must be provided to comply with this EMC requirement (e.g. Lightning conductor BVTAD24, Dehn & Söhne company)

2) An external device must be provided to comply with this EMC requirement (e.g. Lightning conductor BSPM4BE24, Dehn & Söhne company)

8.9 Ambient conditions

Article number	7ME3448-6AA00-0BB1
Ambient temperature during operation	
Minimum installation	-25 °C
horizontal installation, max.	60 °C; Observe derating
vertical installation, max.	50 °C; Observe derating
Ambient temperature during storage / transport	
Storage, min.	-40 °C
Storage, max.	70 °C
Transport, min.	-40 °C
Transport, max.	70 °C
Relative humidity	
Operation, min.	5 %
Operation, max.	95 %; no condensation
Height in operation	
Ambient air pressure altitude (relative to sea level)	Tmin ... Tmax at 1080 hPa ... 795 hPa (-1000 m ... +2000 m)

8.10 Certificates and approvals

NOTE

The current approvals for your device can be found on the nameplate.

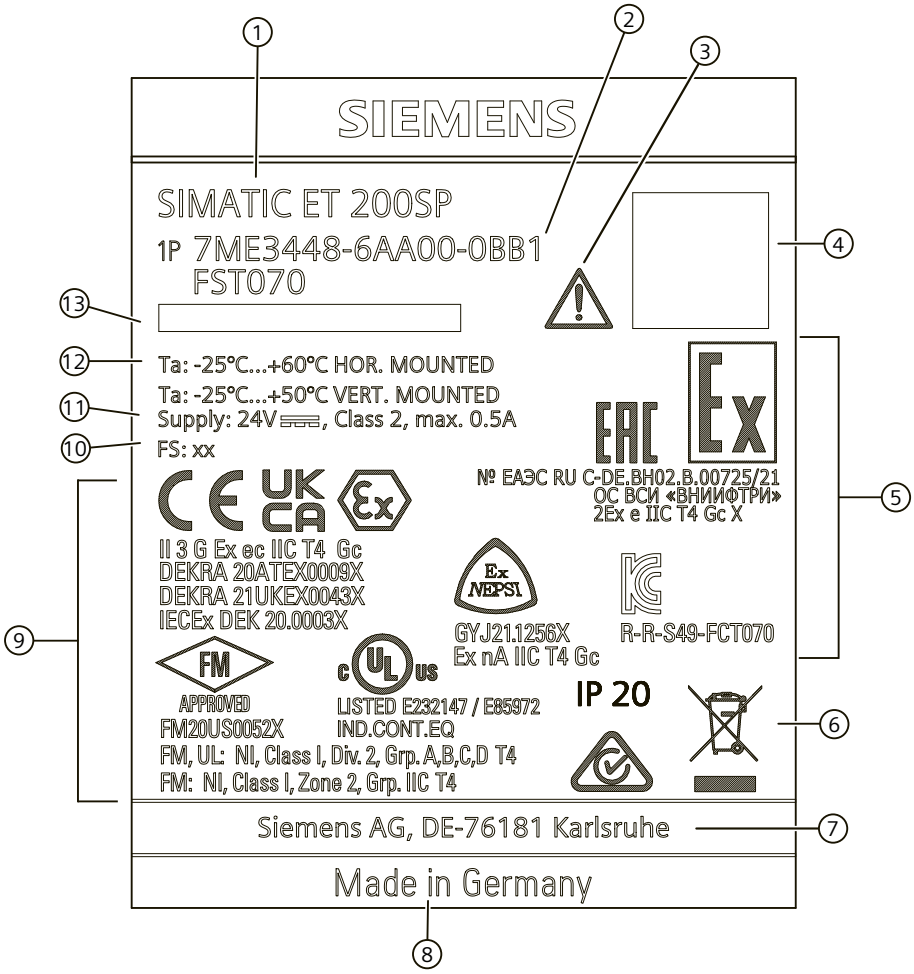

①	Product name	⑨	Approvals
②	Order number		II: Group II
③	Consult the operating instructions		3: Category 3 for use in Zone 2
④	QR code		G: For gas
⑤	Approvals		Ex: Ex type of protection
⑥	WEEE symbol		IIC: Gas group
⑦	Manufacturer name and location		T4: Temperature class
⑧	Manufacturing country	⑩	Function state
		⑪	Power supply

⑧ Manufacturing country

⑫ Ambient temperature range

⑬ Serial number

Figure 8-1 Example of the nameplate

Symbol	Certificate number	Marking
		→ CE approval
		→ UKCA approval
	Ord loc: E85972 Haz Loc: E232147	CL. I, Div. 2 GP.A.B.C.D T4
	DEKRA 20ATEX0009X DEKRA 21UKEX0043X	II 3 G Ex ec IIC T4 Gc
	IECEx DEK 20.0003X	Ex ec IIC T4 Gc
	№ ЕАЭС RU C-DE.ВН02.В.00725/21ВНИИФТРИ	2Ex e IIC T4 Gc X
	GYJ21.1256X	Ex nA IIC T4 Gc
		→ Tick mark for Australia and New Zealand
	R-R-S49-FCT070	
	FM20US0052X	NI, Class 1, Div.2, Groups A,B,C,D T4 NI, Class 1, Div. 2, Groups IIC T4

I/O data

A

A.1 Standard I/O data

Input data

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
0	**Volume flow** low flow cut-off filtered volume flow in volume flow units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
1									
2									
3									
4	**Quality code volume flow** coding according PROFIBUS-PA profile 4.0								Unsigned8
5	**Sound velocity** in sound velocity units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
6									
7									
8									
9	**Quality code sound velocity** coding according PROFIBUS-PA profile 4.0								Unsigned8
10	**Total 1** Unit is depending on the selected Totalizer 1 process value and Totalizer 1 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
11									
12									
13									
14	**Quality code total 1** coding according PROFIBUS-PA profile 4.0								Unsigned8
15	**Total 1** (high resolution) Unit is depending on the selected Totalizer 1 process value and Totalizer 1 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 52)								Float64
16									
17									
18									
19									
20									
21									
22									
23	**Total 2** Unit is depending on the selected Totalizer 2 process value and Totalizer 2 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
24									
25									
26									
27	**Quality code total 2** coding according PROFIBUS-PA profile 4.0								Unsigned8
28	**Total 3** Unit is depending on the selected Totalizer 3 process value and Totalizer 3 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
29									
30									

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
31	**Total 3** Unit is depending on the selected Totalizer 3 process value and Totalizer 3 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
32	**Quality code total** coding according PROFIBUS-PA profile 4.0								Unsigned8
33	**Mass flow** in mass flow units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
34									
35									
36									
37	**Quality code mass flow** coding according PROFIBUS-PA profile 4.0								Unsigned8
38	**Flow velocity** in flow velocity units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
39									
40									
41									
42	**Quality code flow velocity** coding according PROFIBUS-PA profile 4.0								Unsigned8
43	**Process density** in density units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
44									
45									
46									
47	**Quality code process density** coding according PROFIBUS-PA profile 4.0								Unsigned8
48	**Medium temperature** in temperature units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
49									
50									
51									
52	**Quality code medium temperature** coding according PROFIBUS-PA profile 4.0								Unsigned8
53	**Process pressure** in pressure units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
54									
55									
56									
57	**Quality code process pressure** coding according PROFIBUS-PA profile 4.0								Unsigned8
58	**Kinematic viscosity** in kinematic viscosity units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
59									
60									
61									
62	**Quality code kinematic viscosity** coding according PROFIBUS-PA profile 4.0								Unsigned8
63	**Temperature 1** in temperature units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
64									
65									
66									
67	**Quality code temperature 1** coding according PROFIBUS-PA profile 4.0								Unsigned8

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
68	**Temperature 2** in temperature units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
69									
70									
71									
72	**Quality code temperature 2** coding according PROFIBUS-PA profile 4.0								Unsigned8
73	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	**DQ1** current signal state	**DQ0** current signal state	Unsigned8 (bit granular)
74	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	**DQ1 status** Validity of the DQ1 value in previous byte 0 = DQ1 is disabled (not controlled) 1 = DQ1 is enabled (controlled)	**DQ0 status** Validity of the DQ0 value in previous byte 0 = DQ0 is disabled (not controlled) 1 = DQ0 is enabled (controlled)	Unsigned8 (bit granular)
75	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	**DI1** current signal state	**DI0** current signal state	Unsigned8 (bit granular)
76	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	outputs forced	process value frozen	zero point adjustment running	Unsigned8 (bit granular)

Ouput data

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
0	*reserved*	*reserved*	Reset totalizer 3	Reset totalizer 2	Reset totalizer 1	Force outputs	Freeze process values	Adjust zero point	Unsigned8 (bit granular)
1	**Process value 1** The value is expected in the related unit: pressure, density, kinematic viscosity or temperature unit, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
2									
3									
4									
5	**Quality code process value 1** coding according PROFIBUS-PA profile 4.0								Unsigned8
6	**Process value 2** The value is expected in the related unit: pressure, density, kinematic viscosity or temperature unit, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
7									
8									
9									
10	**Quality code process value 2** coding according PROFIBUS-PA profile 4.0								Unsigned8

A.2 Hydrocarbon I/O data

Input data

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
0	**Volume flow** low flow cut-off filtered volume flow in volume flow units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
1									
2									
3									
4	**Quality code volume flow** coding according PROFIBUS-PA profile 4.0								Unsigned8
5	**Sound velocity** in sound velocity units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
6									
7									
8									
9	**Quality code sound velocity** coding according PROFIBUS-PA profile 4.0								Unsigned8
10	**Total 1** Unit is depending on the selected Totalizer 1 process value and Totalizer 1 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
11									
12									
13									
14	**Quality code total 1** coding according PROFIBUS-PA profile 4.0								Unsigned8
15	**Total 1** (high resolution) Unit is depending on the selected Totalizer 1 process value and Totalizer 1 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 52)								Float64
16									
17									
18									
19									
20									
21									
22									
23	**Total 2** Unit is depending on the selected Totalizer 2 process value and Totalizer 2 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
24									
25									
26									
27	**Quality code total 2** coding according PROFIBUS-PA profile 4.0								Unsigned8
28	**Total 3** Unit is depending on the selected Totalizer 3 process value and Totalizer 3 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
29									
30									
31									
32	**Quality code total 3** coding according PROFIBUS-PA profile 4.0								Unsigned8
33	**Mass flow** in mass flow units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
34									
35									

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
36	**Mass flow** in mass flow units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
37	**Quality code mass flow** coding according PROFIBUS-PA profile 4.0								Unsigned8
38	**Flow velocity** in flow velocity units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
39									
40									
41									
42	**Quality code flow velocity** coding according PROFIBUS-PA profile 4.0								Unsigned8
43	**Process density** in density units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
44									
45									
46									
47	**Quality code process density** coding according PROFIBUS-PA profile 4.0								Unsigned8
48	**Medium temperature** in temperature units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
49									
50									
51									
52	**Quality code medium temperature** coding according PROFIBUS-PA profile 4.0								Unsigned8
53	**Process pressure** in pressure units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
54									
55									
56									
57	**Quality code process pressure** coding according PROFIBUS-PA profile 4.0								Unsigned8
58	**Kinematic viscosity** in kinematic viscosity units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
59									
60									
61									
62	**Quality code kinematic viscosity** coding according PROFIBUS-PA profile 4.0								Unsigned8
63	**Temperature 1** in temperature units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
64									
65									
66									
67	**Quality code temperature 1** coding according PROFIBUS-PA profile 4.0								Unsigned8
68	**Temperature 2** in temperature units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
69									
70									
71									
72	**Quality code temperature 2** coding according PROFIBUS-PA profile 4.0								Unsigned8

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
73	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	**DQ1** current signal state	**DQ0** current signal state	Unsigned8 (bit granular)
74	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	**DQ1 status** Validity of the DQ1 value in previous byte 0 = DQ1 is disabled (not controlled) 1 = DQ1 is enabled (controlled)	**DQ0 status** Validity of the DQ0 value in previous byte 0 = DQ0 is disabled (not controlled) 1 = DQ0 is enabled (controlled)	Unsigned8 (bit granular)
75	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	**DI1** current signal state	**DI0** current signal state	Unsigned8 (bit granular)
76	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	outputs forced	process value frozen	zero point adjustment running	Unsigned8 (bit granular)
82	**Standard volume flow**								Float32
83									
84									
85									
86	**Quality code standard volume flow** coding according PROFIBUS-PA profile 4.0								Unsigned8
87	**Standardizing factor**								Float32
88									
89									
90									
91	**Quality code standardizing factor** coding according PROFIBUS-PA profile 4.0								Unsigned8
92	**Standard density**								Float32
93									
94									
95									
96	**Quality code standard density** coding according PROFIBUS-PA profile 4.0								Unsigned8
97	**Standard viscosity**								Float32
98									
99									
100									
101	**Quality code standard viscosity** coding according PROFIBUS-PA profile 4.0								Unsigned8
102	**LiquIdent**								Float32
103									
104									
105									

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
106	**Quality code Liquldent** coding according PROFIBUS-PA profile 4.0								Unsigned8
107	**API gravity**								Float32
108									
109									
110									
111	**Quality code API gravity** coding according PROFIBUS-PA profile 4.0								Unsigned8
112	**Standard API gravity**								Float32
113									
114									
115									
116	**Quality code standard API gravity** coding according PROFIBUS-PA profile 4.0								Unsigned8
117	**Specific gravity**								Float32
118									
119									
120									
121	**Quality code specific gravity** coding according PROFIBUS-PA profile 4.0								Unsigned8
122	**Standard specific gravity**								Float32
123									
124									
125									
126	**Quality code standard specific gravity** coding according PROFIBUS-PA profile 4.0								Unsigned8
127	**Rate of change**								Float32
128									
129									
130									
131	**Quality code rate of change** coding according PROFIBUS-PA profile 4.0								Unsigned8

Ouput data

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
0	*reserved*	*reserved*	Reset totalizer 3	Reset totalizer 2	Reset totalizer 1	Force outputs	Freeze process values	Adjust zero point	Unsigned8 (bit granular)
1	**Process value 1** The value is expected in the related unit: pressure, density, kinematic viscosity or temperature unit, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
2									
3									
4									

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
5	**Quality code process value 1** coding according PROFIBUS-PA profile 4.0								Unsigned8
6	**Process value 2** The value is expected in the related unit: pressure, density, kinematic viscosity or temperature unit, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
7									
8									
9									
10	**Quality code process value 2** coding according PROFIBUS-PA profile 4.0								Unsigned8

A.3 Gas I/O data

Input data

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
0	**Volume flow** low flow cut-off filtered volume flow in volume flow units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
1									
2									
3									
4	**Quality code volume flow** coding according PROFIBUS-PA profile 4.0								Unsigned8
5	**Sound velocity** in sound velocity units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
6									
7									
8									
9	**Quality code sound velocity** coding according PROFIBUS-PA profile 4.0								Unsigned8
10	**Total 1** Unit is depending on the selected Totalizer 1 process value and Totalizer 1 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
11									
12									
13									
14	**Quality code total 1** coding according PROFIBUS-PA profile 4.0								Unsigned8
15	**Total 1** (high resolution) Unit is depending on the selected Totalizer 1 process value and Totalizer 1 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 52)								Float64
16									
17									
18									
19									
20									
21									
22									
23	**Total 2**								Float32
24									

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
25	Unit is depending on the selected Totalizer 2 process value and Totalizer 2 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
26									
27	**Quality code total 2** coding according PROFIBUS-PA profile 4.0								Unsigned8
28	**Total 3** Unit is depending on the selected Totalizer 3 process value and Totalizer 3 mass/volume/standard volume setting, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
29									
30									
31									
32	**Quality code total 3** coding according PROFIBUS-PA profile 4.0								Unsigned8
33	**Mass flow** in mass flow units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
34									
35									
36									
37	**Quality code mass flow** coding according PROFIBUS-PA profile 4.0								Unsigned8
38	**Flow velocity** in flow velocity units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
39									
40									
41									
42	**Quality code flow velocity** coding according PROFIBUS-PA profile 4.0								Unsigned8
43	**Process density** in density units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
44									
45									
46									
47	**Quality code process density** coding according PROFIBUS-PA profile 4.0								Unsigned8
48	**Medium temperature** in temperature units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
49									
50									
51									
52	**Quality code medium temperature** coding according PROFIBUS-PA profile 4.0								Unsigned8
53	**Process pressure** in pressure units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
54									
55									
56									
57	**Quality code process pressure** coding according PROFIBUS-PA profile 4.0								Unsigned8
58	**Kinematic viscosity** in kinematic viscosity units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
59									
60									
61									
62	**Quality code kinematic viscosity** coding according PROFIBUS-PA profile 4.0								Unsigned8
63	**Temperature 1**								Float32

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
64	in temperature units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
65									
66									
67	**Quality code temperature 1** coding according PROFIBUS-PA profile 4.0								Unsigned8
68	**Temperature 2** in temperature units, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
69									
70									
71									
72	**Quality code temperature 2** coding according PROFIBUS-PA profile 4.0								Unsigned8
73	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	**DQ1** current signal state	**DQ0** current signal state	Unsigned8 (bit granular)
74	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	**DQ1 status** Validity of the DQ1 value in previous byte 0 = DQ1 is disabled (not controlled) 1 = DQ1 is enabled (controlled)	**DQ0 status** Validity of the DQ0 value in previous byte 0 = DQ0 is disabled (not controlled) 1 = DQ0 is enabled (controlled)	Unsigned8 (bit granular)
75	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	**DI1** current signal state	**DI0** current signal state	Unsigned8 (bit granular)
76	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	outputs forced	process value frozen	zero point adjustment running	Unsigned8 (bit granular)
77	**Standard volume flow**								Float32
78									
79									
80									
81	**Quality code standard volume flow** coding according PROFIBUS-PA profile 4.0								Unsigned8
82	**Standardizing factor**								Float32
83									
84									
85									
86	**Quality code standardizing factor** coding according PROFIBUS-PA profile 4.0								Unsigned8
87	**Standard density**								Float32
88									
89									
90									
91	**Quality code standard density** coding according PROFIBUS-PA profile 4.0								Unsigned8

Ouput data

Bit → / Byte ↓	7	6	5	4	3	2	1	0	data type
0	*reserved*	*reserved*	Reset totalizer 3	Reset totalizer 2	Reset totalizer 1	Force outputs	Freeze process values	Adjust zero point	Unsigned8 (bit granular)
1	**Process value 1** The value is expected in the related unit: pressure, density, kinematic viscosity or temperature unit, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
2									
3									
4									
5	**Quality code process value 1** coding according PROFIBUS-PA profile 4.0								Unsigned8
6	**Process value 2** The value is expected in the related unit: pressure, density, kinematic viscosity or temperature unit, see Parameter assignment and structure of the parameter data record (Page 52)								Float32
7									
8									
9									
10	**Quality code process value 2** coding according PROFIBUS-PA profile 4.0								Unsigned8

Parameter data record

B

B.1 Parameter assignment and structure of the parameter data record

The SITRANS TM FST070 parameter data record is modified and stored for you by the TIA portal when you perform a Device configuration, successful configuration block compilation, and download a new configuration block to the system hardware.

You may also directly edit the module parameters with the CPU in RUN mode. The WRREC instruction is used to transfer parameters to the module using data record 128.

If errors occur during the transfer or validation of parameters with the WRREC instruction, the module continues operation with the previous parameter assignment. A corresponding error code is then written to the STATUS output parameter. If no errors occur, the STATUS output parameter contains the length of the data actually transferred.

The description of the WRREC instruction and the error codes is available in the STEP 7 online help (TIA Portal).

Structure of data record 128

The following table shows you the structure of data record 128 for the SITRANS TM FST070. Default values are indicated in **bold font**.

Table 2-1393 Header and channel 0 basic configuration

Bit → **Byte ↓**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0 to 1	**Header**							
0	*reserved*		Major version = 1		Minor version = 0			
1	Parameter data length = 61 bytes							
2 to 62	**Module parameter block**							
2	*reserved*	*reserved*	*reserved*	*reserved*	*reserved*	Sensor type		
3 **4**	Volume flow units Coding according PROFIBUS-PA profile. Supported values: 1347 1348 **1349** 1350 ... 1359 1362 ... 1374 1448 ... 1514 1518 1519 1520 1563 1577 ... 1587 1633 ... 1640 1642 ... 1645 32768 ... 32780							
5 **6** **7** **8**	Volume flow cut-off limit (volume flow units) encoded as Float32 Default value = **0.0**							
9 **10**	Sound velocity units Coding according PROFIBUS-PA profile. Supported values: **1061** 1062 ... 1075							
11	*reserved*	*reserved*	*reserved*	*reserved*	Totalizer 1 process value			
12	Totalizer 1 volume units							

Bit → / Byte ↓	7	6	5	4	3	2	1	0
13	Only relevant if the selected process value is a volume quantity. Coding according PROFIBUS-PA profile. Supported values: **1034** 1035 ... 1052 1517 1570 1572 1641							
14 **15**	Totalizer 1 mass units Only relevant if the selected process value is a mass quantity. Coding according PROFIBUS-PA profile. Supported values: **1088** 1089 ... 1569							
16 **17**	Totalizer 1 standard volume units Only relevant if the selected process value is a standard volume quantity. Coding according PROFIBUS-PA profile. Supported values: 1053 1573 1574 **1575** 1576							
18	*reserved*	*reserved*	*reserved*	*reserved*	Totalizer 1 process value			
19 **20**	Totalizer 2 volume units Only relevant if the selected process value is a volume quantity. Coding according PROFIBUS-PA profile. Supported values: **1034** 1035 ... 1052 1517 1570 1572 1641							
21 **22**	Totalizer 2 mass units Only relevant if the selected process value is a mass quantity. Coding according PROFIBUS-PA profile. Supported values: **1088** 1089 ... 1569							
23 **24**	Totalizer 2 standard volume units Only relevant if the selected process value is a standard volume quantity. Coding according PROFIBUS-PA profile. Supported values: 1053 1573 1574 **1575** 1576							
25	*reserved*	*reserved*	*reserved*	*reserved*	Totalizer 3 process value			
26 **27**	Totalizer 3 volume units Only relevant if the selected process value is a volume quantity. Coding according PROFIBUS-PA profile. Supported values: **1034** 1035 ... 1052 1517 1570 1572 1641							
28 **29**	Totalizer 3 mass units Only relevant if the selected process value is a mass quantity. Coding according PROFIBUS-PA profile. Supported values: **1088** 1089 ... 1569							
30 **31**	Totalizer 3 standard volume units Only relevant if the selected process value is a standard volume quantity. Coding according PROFIBUS-PA profile. Supported values: 1053 1573 1574 **1575** 1576							
32 **33**	Mass flow units Coding according PROFIBUS-PA profile. Supported values: 1322 1323 **1324** 1325 ... 1341 1606 ... 1609							
34 **35** **36** **37**	Mass flow cut-off limit (mass flow units) encoded as Float32 Default value = **0.0**							
38 **39**	Flow velocity units Coding according PROFIBUS-PA profile. Supported values: **1061** 1062 ... 1075							
40 **41** **42** **43**	Flow velocity cut-off limit (flow velocity units) encoded as Float32 Default value = **0.0**							

Bit → / Byte ↓	7	6	5	4	3	2	1	0
44	Density units Coding according PROFIBUS-PA profile. Supported values: 1097 ... 1102 **1103** 1104 ... 1109 1430 1558 1559 1564 1566							
45								
46	Temperature units Coding according PROFIBUS-PA profile. Supported values: 1000 **1001** 1002 1003							
47								
48	Pressure units Coding according PROFIBUS-PA profile. Supported values: **1130** 1131 ... 1141 1144 1145 1147 1148 1150 1151 1153 1154 1156 1158							
49								
50	Kinematic viscosity units Coding according PROFIBUS-PA profile. Supported values: **1160** 1163 1164							
51								
52	Standard volume flow units Coding according PROFIBUS-PA profile. Supported values: 1360 1361 1588 ... 1595 **1596** 1597 ... 1605							
53								
54	Standard volume flow cut-off limit (standard volume flow units) encoded as Float32 Default value = **0.0**							
55								
56								
57								
58	DI0 level selection	*reserved*	*reserved*	DI0 mode				
59	DI1 level selection	*reserved*	*reserved*	DI1 mode				
60	DQ0 level selection	DQ0 status signal "function check"	DQ0 status signal "maintenance required"	DQ0 status signal "failure"	DQ0 status signal "out of specification"	DQ0 forced value	DQ0 mode	
61	DQ1 level selection	DQ1 status signal "function check"	DQ1 status signal "maintenance required"	DQ1 status signal "failure"	DQ1 status signal "out of specification"	DQ1 forced value	DQ1 mode	
62	Process value selection for Process value 2				Process value selection for Process value 1			

Measuring units

C

C.1 Measuring units

	Unit descriptions	Unit abbre-vi-ations	Volume flow	Mass flow	Stand-ard Volume flow	Density	Tem-perat-ure	Sound velocity	Flow velocity	Pres-sure	Kin-ematic viscos-ity
1000	kelvins	K					x				
1001	degrees Celsius	°C					x				
1002	degrees Fahrenheit	°F					x				
1003	degrees Rankine	°R					x				
1034	cubic meters	m^3	x								
1035	cubic decimeters	dm^3	x								
1036	cubic centimeters	cm^3	x								
1037	cubic millimeters	mm^3	x								
1038	liters	l	x								
1039	centiliters	cl	x								
1040	milliliters	ml	x								
1041	hectoliters	hl	x								
1042	cubic inches	in^3	x								
1043	cubic feet	ft^3	x								
1044	cubic yards	yd^3	x								
1045	cubic miles	mi^3	x								
1046	US liquid pints	pt(liq)	x								
1047	US liquid quarts	qt(liq)	x								
1048	US gallons	gal	x								
1049	imperial gallons	gal(UK)	x								
1050	bushels	bu	x								
1051	42 US gallons bar-rels	bbl	x								
1052	31.5 US gallons bar-rels	bbl(US)	x								
1053	standard cubic feet	SCF	x								
1061	meters per second	m/s						x	x		
1062	millimeters per second	mm/s						x	x		
1063	meters per hour	m/h						x	x		
1064	kilometers per hour	km/h						x	x		

	Unit descriptions	Unit abbre-vi-ations	Volume flow	Mass flow	Stand-ard Volume flow	Density	Tem-perat-ure	Sound velocity	Flow velocity	Pres-sure	Kin-ematic viscos-ity
1065	knots	kn						x	x		
1066	inches per second	in/s						x	x		
1067	feet per second	ft/s						x	x		
1068	yards per second	yd/s						x	x		
1069	inches per minute	in/min						x	x		
1070	feet per minute	ft/min						x	x		
1071	yards per minute	yd/min						x	x		
1072	inches per hour	in/h						x	x		
1073	feet per hour	ft/h						x	x		
1074	yards per hour	yd/h						x	x		
1075	miles per hour	mi/h						x	x		
1088	kilograms	kg		x							
1089	grams	g		x							
1090	megagrams	Mg		x							
1091	megagrams	Mg		x							
1092	metric tons	t		x							
1093	ounces avoirdupois	oz		x							
1094	pounds	lb		x							
1095	short tons	ton		x							
1096	long tons	ton(UK)		x							
1097	kilograms per cubic meter	kg/m^3				x					
1098	megagrams per cubic meter	Mg/m^3				x					
1099	kilograms per cubic decimeter	kg/dm^3				x					
1100	grams per cubic centimeter	g/cm^3				x					
1101	grams per cubic meter	g/m^3				x					
1102	metric tons per cubic meter	t/m^3				x					
1103	kilograms per liter	kg/l				x					
1104	grams per milliliter	g/ml				x					
1105	grams per liter	g/l				x					
1106	pounds per cubic inch	lb/in^3				x					
1107	pounds per cubic foot	lb/ft^3				x					

	Unit descriptions	Unit abbre-vi-ations	Volume flow	Mass flow	Stand-ard Volume flow	Density	Tem-perat-ure	Sound velocity	Flow velocity	Pres-sure	Kin-ematic viscos-ity
1108	pounds per US gal-lon	lb/gal				x					
1109	short tons per cubic yard	ton/yd³				x					
1130	pascals	Pa								x	
1131	gigapascals	GPa								x	
1132	megapascals	MPa								x	
1134	millipascals	µPa								x	
1135	micropascals	bar								x	
1136	hectopascals	hPa								x	
1137	bars	bar								x	
1138	millibars	mbar								x	
1139	millimeters of mer-cury	torr								x	
1140	standard atmo-spheres	atm								x	
1141	pounds per square inch	psi								x	
1144	grams-force per square centimeter	gf/cm²								x	
1145	kilograms-force per square centimeter	kgf/cm²								x	
1147	inches of water at 4 °C	inH2O (4°C)								x	
1148	inches of water at 68 °F	inH2O								x	
1150	millimeters of water at 4 °C	mmH2 O (4°C)								x	
1151	millimeters of water at 68 °F	mmH2-O								x	
1153	feet of water at 4 °C	ftH2O (4°C)								x	
1154	feet of water at 68 °F	ftH2O								x	
1156	inches of mercury at 0 °C	inHg								x	
1158	millimeters of mer-cury at 0° C	mmHg								x	
1160	square meters per second	m²/s									x
1163	stokes	stokes									x

	Unit descriptions	Unit abbre-vi-ations	Volume flow	Mass flow	Stand-ard Volume flow	Density	Tem-perat-ure	Sound velocity	Flow velocity	Pres-sure	Kin-ematic viscos-ity
1164	centistokes	centis-tokes									x
1322	kilograms per second	kg/s			x						
1323	kilograms per minute	kg/min			x						
1324	kilograms per hour	kg/h			x						
1325	kilograms per day	kg/d			x						
1326	metric tons per second	t/s			x						
1327	metric tons per minute	t/min			x						
1328	metric tons per hour	t/h			x						
1329	metric tons per day	t/d			x						
1330	pounds per second	lb/s			x						
1331	pounds per minute	lb/min			x						
1332	pounds per hour	lb/h			x						
1333	pounds per day	lb/d			x						
1334	short tons per second	ton/s			x						
1335	short tons per minute	ton/min			x						
1336	short tons per hour	ton/h			x						
1337	short tons per day	ton/d			x						
1338	long tons per second	ton(UK-)/s			x						
1339	long tons per minute	ton(UK-)/min		x							
1340	long tons per hour	ton(UK-)/h			x						
1341	long tons per day	ton(UK-)/d			x						
1347	cubic meters per second	m^3/s	x								
1348	cubic meters per minute	m^3/min	x								
1349	cubic meters per hour	m^3/h	x								
1350	cubic meters per day	m^3/d	x								
1351	liters per second	l/s	x								

	Unit descriptions	Unit abbre-vi-ations	Volume flow	Mass flow	Stand-ard Volume flow	Density	Tem-perat-ure	Sound velocity	Flow velocity	Pres-sure	Kin-ematic viscos-ity
1352	liters per minute	l/min	x								
1353	liters per hour	l/h	x								
1354	liters per day	l/d	x								
1355	milliliters per day	ml/d	x								
1356	cubic feet per second	ft^3/s	x								
1357	cubic feet per minute	ft^3/min	x								
1358	cubic feet per hour	ft^3/h	x								
1359	cubic feet per day	ft^3/d	x								
1360	standard cubic feet per minute	SCF/min	x		x						
1361	standard cubic feet per hour	SCF/h	x		x						
1362	US gallons per second	gal/s	x								
1363	US gallons per minute	gal/min	x								
1364	US gallons per hour	gal/h	x								
1365	US gallons per day	gal/d	x								
1366	US milligallons per day	mgal/d	x								
1367	imperial gallons per second	gal(UK)-/s	x								
1368	imperial gallons per minute	gal(UK)/min	x								
1369	imperial gallons per hour	gal(UK)-/h	x								
1370	imperial gallons per day	gal(UK)-/d	x								
1371	42 US gallons bar-rels per second	bbl/s	x								
1372	42 US gallons bar-rels per minute	bbl/min	x								
1373	42 US gallons bar-rels per hour	bbl/h	x								
1374	42 US gallons bar-rels per day	bbl/d	x								
1430	pounds per imperial gallon	lb/gal(-UK)	x			x					
1448	US microgallons per second	µgal/s	x								

	Unit descriptions	Unit abbre-vi-ations	Volume flow	Mass flow	Stand-ard Volume flow	Density	Tem-perat-ure	Sound velocity	Flow velocity	Pres-sure	Kin-ematic viscos-ity
1449	US milligallons per second	mgal/s	x								
1450	US kilogallons per second	kgal/s	x								
1451	US milligallons per second	mgal/s	x								
1452	US microgallons per minute	µgal/mi-n	x								
1453	US milligallons per minute	mgal/-min	x								
1454	US kilogallons per minute	kgal/mi-n	x								
1455	US milligallons per minute	mgal/-min	x								
1456	US microgallons per hour	µgal/h	x								
1457	US milligallons per hour	mgal/h	x								
1458	US kilogallons per hour	kgal/h	x								
1459	US milligallons per hour	mgal/h	x								
1460	US microgallons per day	µgal/d	x								
1461	US milligallons per day	mgal/d	x								
1462	US kilogallons per day	kgal/d	x								
1463	imperial microgal-lons per second	µgal(U-K)/s	x								
1464	imperial megagal-lons per second	Mgal(U-K)/s	x								
1465	imperial kilogallons per second	kgal(U-K)/s	x								
1466	imperial megagal-lons per second	Mgal(U-K)/s	x								
1467	imperial microgal-lons per minute	µgal(U-K)/min	x								
1468	imperial megagal-lons per minute	Mgal(U-K)/min	x								
1469	imperial kilogallons per minute	kgal(U-K)/min	x								
1470	imperial megagal-lons per minute	Mgal(U-K)/min	x								

	Unit descriptions	Unit abbre-vi-ations	Volume flow	Mass flow	Stand-ard Volume flow	Density	Tem-perat-ure	Sound velocity	Flow velocity	Pres-sure	Kin-ematic viscos-ity
1471	imperial microgal-lons per hour	µgal(U-K)/h	x								
1472	imperial megagal-lons per hour	Mgal(U-K)/h	x								
1473	imperial kilogallons per hour	kgal(U-K)/h	x								
1474	imperial megagal-lons per hour	Mgal(U-K)/h	x								
1475	imperial microgal-lons per day	µgal(U-K)/d	x								
1476	imperial megagal-lons per day	Mgal(U-K)/d	x								
1477	imperial kilogallons per day	kgal(U-K)/d	x								
1478	imperial megagal-lons per day	Mgal(U-K)/d	x								
1479	millionth of a 42 US gallons barrel per second	µbbl/s	x								
1480	million 42 US gal-lons barrels per second	Mbbl/s									
1481	thousand 42 US gal-lons barrels per second	kbbl/s	x								
1482	million 42 US gal-lons barrels per second	Mbbl/s	x								
1483	millionth of a 42 US gallons barrel per minute	µbbl/m-in	x								
1484	million 42 US gal-lons barrels per minute	Mbbl/-min	x								
1485	thousand 42 US gal-lons barrels per minute	kbbl/mi-n	x								
1486	million 42 US gal-lons barrels per minute	Mbbl/-min	x								
1487	millionth of a 42 US gallons barrel per hour	µbbl/h	x								
1488	million 42 US gal-lons barrels per hour	Mbbl/h	x								

	Unit descriptions	Unit abbre-vi-ations	Volume flow	Mass flow	Stand-ard Volume flow	Density	Tem-perat-ure	Sound velocity	Flow velocity	Pres-sure	Kin-ematic viscos-ity
1489	thousand 42 US gal-lons barrels per hour	kbbl/h	x								
1490	million 42 US gal-lons barrels per hour	Mbbl/h	x								
1491	millionth of a 42 US gallons barrel per day	µbbl/d	x								
1492	million 42 US gal-lons barrels per day	Mbbl/d	x								
1493	thousand 42 US gal-lons barrels per day	kbbl/d	x								
1494	million 42 US gal-lons barrels per day	Mbbl/d									
1495	cubic micrometers per second	$\mu m^3/s$	x								
1496	million cubic meters per second	Mm^3/s	x								
1497	cubic kilometers per second	km^3/s	x								
1498	million cubic meters per second	Mm^3/s	x								
1499	cubic micrometers per minute	$\mu m^3/min$	x								
1500	million cubic meters per minute	Mm^3/min	x								
1501	cubic kilometers per minute	km^3/min	x								
1502	million cubic meters per minute	Mm^3/min	x								
1503	cubic micrometers per hour	$\mu m^3/h$	x								
1504	million cubic meters per hour	Mm^3/h	x								
1505	cubic kilometers per hour	km^3/h	x								
1506	million cubic meters per hour	Mm^3/h									
1507	cubic micrometers per day	$\mu m^3/d$	x								
1508	million cubic meters per day	Mm^3/d	x								
1509	cubic kilometers per day	km^3/d	x								

	Unit descriptions	Unit abbre-vi-ations	Volume flow	Mass flow	Stand-ard Volume flow	Density	Tem-perat-ure	Sound velocity	Flow velocity	Pres-sure	Kin-ematic viscos-ity
1510	million cubic meters per day	Mm^3/d	x								
1511	cubic centimeters per second	cm^3/s	x								
1512	cubic centimeters per minute	cm^3/min	x								
1513	cubic centimeters per hour	cm^3/h	x								
1514	cubic centimeters per day	cm^3/d	x								
1517	kiloliters	kl	x								
1518	kiloliters per minute	kl/min	x								
1519	kiloliters per hour	kl/h	x								
1520	kiloliters per day	kl/d	x								
1558	milligrams per liter	mg/l	x			x					
1559	micrograms per liter	µg/l	x			x					
1563	milliliters per minute	ml/min				x					
1564	milligrams per cubic decimeter	mg/dm^3	x			x					
1566	megagrams per cubic meter	Mg/m^3	x								
1567	carats	ct	x								
1568	troy pounds	lb t	x								
1569	ounces troy	oz t	x								
1570	US fluid ounces	fl oz	x								
1572	acre-feet	AF	x								
1573	normal cubic meters	Nm^3	x								
1574	normal liters	Nl	x								
1575	standard cubic meters	Sm^3	x								
1577	milliliters per second	ml/s	x		x						
1578	milliliters per hour	ml/h	x		x						
1579	milliliters per day	ml/d	x		x						
1580	acre-feet per second	AF/s	x		x						
1581	acre-feet per minute	AF/min	x		x						
1582	acre-feet per hour	AF/h	x		x						

	Unit descriptions	Unit abbre-vi-ations	Volume flow	Mass flow	Stand-ard Volume flow	Density	Tem-perat-ure	Sound velocity	Flow velocity	Pres-sure	Kin-ematic viscos-ity
1583	acre-feet per day	AF/d	x		x						
1584	US fluid ounces per second	fl oz/s	x		x						
1585	US fluid ounces per minute	fl oz/min	x		x						
1586	US fluid ounces per hour	fl oz/h	x		x						
1587	US fluid ounces per day	fl oz/d	x		x						
1588	normal cubic meters per second	Nm^3/s	x		x						
1589	normal cubic meters per minute	Nm^3/min	x		x						
1590	normal cubic meters per hour	Nm^3/h	x		x						
1591	normal cubic meters per day	Nm^3/d	x		x						
1592	normal liters per second	Nl/s	x		x						
1593	normal liters per minute	Nl/min	x		x						
1594	normal liters per hour	Nl/h	x		x						
1595	normal liters per day	Nl/d	x		x						
1596	standard cubic meters per second	Sm^3/s	x		x						
1597	standard cubic meters per minute	Sm^3/min	x		x						
1598	standard cubic meters per hour	Sm^3/h	x		x						
1599	standard cubic meters per day	Sm^3/d	x		x						
1600	standard liters per second	Sl/s	x		x						
1601	standard liters per minute	Sl/min	x		x						
1602	standard liters per hour	Sl/h	x		x						
1603	standard liters per day	Sl/d	x		x						
1604	standard cubic feet per second	SCF/s	x		x						

	Unit descriptions	Unit abbre-vi-ations	Volume flow	Mass flow	Stand-ard Volume flow	Density	Tem-perat-ure	Sound velocity	Flow velocity	Pres-sure	Kin-ematic viscos-ity
1605	standard cubic feet per day	SCF/d	x		x						
1606	ounces avoirdupois per second	oz/s	x		x						
1607	ounces avoirdupois per minute	oz/min	x		x						
1608	ounces avoirdupois per hour	oz/h	x		x						
1609	ounces avoirdupois per day	oz/d	x		x						
1633	hectoliters per second	hl/s	x		x						
1634	hectoliters per minute	hl/min	x		x						
1635	hectoliters per hour	hl/h	x		x						
1636	hectoliters per day	hl/d	x		x						
1637	31.5 US gallons bar-rels per second	bbl(US)-/s	x		x						
1638	31.5 US gallons bar-rels per minute	bbl(US)/min	x		x						
1639	31.5 US gallons bar-rels per hour	bbl(US)-/h	x		x						
1640	31.5 US gallons bar-rels per day	bbl(US)-/d	x		x						
1641	31 US gallons bar-rels	bbl-beer	x		x						
1642	31 US gallons bar-rels per second	bbl-beer/s	x		x						
1643	31 US gallons bar-rels per minute	bbl-beer/m-in	x		x						
1644	31 US gallons bar-rels per hour	bbl-beer/h	x		x						
1645	31 US gallons bar-rels per day	bbl-beer/d	x		x						
32768	bushels per second	bu/s	x		x						
32769	bushels per minute	bu/min	x		x						
32770	bushels per hour	bu/h	x		x						
32771	bushels per day	bu/d	x		x						
32772	cubic yards per second	yd^3/s	x		x						
32773	cubic yards per minute	yd^3/min	x		x						

	Unit descriptions	Unit abbre-vi-ations	Volume flow	Mass flow	Stand-ard Volume flow	Density	Tem-perat-ure	Sound velocity	Flow velocity	Pres-sure	Kin-ematic viscos-ity
32774	cubic yards per hour	yd^3/h	x		x						
32775	cubic yards per day	yd^3/d	x		x						
32776	cubic inches per second	in^3/s	x		x						
32777	cubic inches per minute	in^3/min	x		x						
32778	cubic inches per hour	in^3/h	x		x						
32779	cubic inches per day	in^3/d	x		x						
32780	million cubic feet per day	Mft^3/d	x		x						

Product documentation and support

D

D.1 Product documentation

Process instrumentation product documentation is available in the following formats:

- Certificates (http://www.siemens.com/processinstrumentation/certificates)
- Downloads (firmware, EDDs, software) (http://www.siemens.com/processinstrumentation/downloads)
- Catalog and catalog sheets (http://www.siemens.com/processinstrumentation/catalogs)
- Manuals (http://www.siemens.com/processinstrumentation/documentation)

  You have the option to show, open, save, or configure the manual.

  – "Display": Open the manual in HTML5 format
  – "Configure": Register and configure the documentation specific to your plant
  – "Download": Open or save the manual in PDF format
  – "Download as html5, only PC": Open or save the manual in the HTML5 view on your PC

You can also find manuals with the Mobile app at Industry Online Support (https://support.industry.siemens.com/cs/ww/en/sc/2067). Download the app to your mobile device and scan the device ID link.

Product documentation by serial number

Using the PIA Life Cycle Portal, you can access the serial number-specific product information including technical specifications, spare parts, calibration data, or factory certificates.

Entering a serial number

1. Open the PIA Life Cycle Portal (https://www.pia-portal.automation.siemens.com).
2. Select the desired language.
3. Enter the serial number of your device. The product documentation relevant for your device is displayed and can be downloaded.

To display factory certificates, if available, log in to the PIA Life Cycle Portal using your login or register.

Scanning an ID link

1. Scan the ID link on your device with a mobile device.
2. Click "PIA Portal".

To display factory certificates, if available, log in to the PIA Life Cycle Portal using your login or register.

D.2 Technical support

Technical support

If this documentation does not completely answer your technical questions, you can enter a Support Request (http://www.siemens.com/automation/support-request).

For help creating a support request, view this video here.

Additional information on our technical support can be found at Technical Support (http://www.siemens.com/automation/csi/service).

Service & support on the Internet

In addition to our technical support, Siemens offers comprehensive online services at service & support (http://www.siemens.com/automation/serviceandsupport).

Contact

If you have further questions about the device, contact your local Siemens representative, by doing the following:

1. Visit Contact at Siemens (http://www.automation.siemens.com/partner).
2. Select "All Products and Branches" > "Products & Services" > "Industrial automation".
3. Choose either "Process analytics" or "Process instrumentation", depending on your product.
4. Select the product category ("Pressure measurement", for example), then select your product.
5. Click "Search".

   The contacts for your product in all regions display.

Contact address for business unit:
Siemens AG
Digital Industries
Process Automation
Östliche Rheinbrückenstr. 50
76187 Karlsruhe, Germany

Remote operation

E

E.1 SIMATIC PDM

E.1.1 Overview SIMATIC PDM

SIMATIC PDM (Process Device Manager) is a general-purpose, manufacturer-independent tool for the configuration, parameter assignment, commissioning, diagnostics and maintenance of intelligent field devices and field components. Follow-up installations and additional information on SIMATIC PDM are available on the Internet at SIMATIC PDM (https://www.siemens.com/simatic-pdm).

SIMATIC PDM monitors the process values, alarms and status signals of the device. It allows you to display, compare, adjust, verify, and simulate process device data; also to set schedules for calibration and maintenance.

For information on, for example, how to install and integrate devices, commission the software, see Operating Manual 'Help for SIMATIC PDM'. The manual is delivered with SIMATIC PDM software. Once the SIMATIC PDM is installed on your computer you find the manual under: Start > All programs > Siemens Automation > SIMATIC > Documentation. Link at our website: SIMATIC PDM instructions and manuals (https://support.industry.siemens.com/cs/ww/en/ps/16983/man).

NOTE

Field device parameters

- For a list of parameters and additional information, consult section "Parameter assignment and structure of the parameter data record (Page 52)".
- The field device remains in measurement mode during the time you configure the field device.

E.1.2 Check SIMATIC PDM version

Procedure

1. Go to SIMATIC PDM Download (http://www.siemens.com/simaticpdm/downloads).
2. Check the support page to make sure you have:
   - The latest version of SIMATIC PDM
   - The most recent Service Pack (SP)
   - The most recent hot fix (HF)

E.1.3 Updating the Electronic Device Description (EDD)

Procedure

1. Check that the EDD revision match the Firmware revision in the device.
2. Go to the support page Software downloads (https://www.siemens.com/processinstrumentation/downloads).
3. Enter the product name in the field "Enter search term...".
4. Download the most current EDD of your device.
5. Save files to your computer in an easily accessed location.
6. Launch SIMATIC PDM – Device Integration Manager.

   From the File menu, click "Read device descriptions from compressed source...".
7. Browse to the zipped EDD file, select and open it.
8. Use the "Integration" function to integrate the EDD into the device catalog. The EDD is now accessible via SIMATIC Manager.

Ordering data

F

F.1 Accessories

You can order accessories online: Industry Mall (https://mallstage.industry.siemens.com/mall/en/b0/Catalog/Products/10020504?tree=CatalogTree)

The following accessories are not included in the scope of delivery:

- **Mandatory**: BaseUnit of the type B1, article number 6ES7193-6BP20-0BB

  An overview of the BaseUnits that you can use with the technology module can be found in the Product Information for the documentation of the SIMATIC ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

  Information regarding selection of the suitable BaseUnit can be found in the SIMATIC ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual and in the SIMATIC ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual.
- Labeling strips
- Color-coded labels
- Reference identification labels

SIEMENS

SIMATIC

ET 200SP
Technology module TM ECC 2xPWM ST
(6FE1242-6TM10-0BB1)

Equipment Manual

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Wiring 3

Configuring/address space 4

Programming 5

Interrupts/diagnostic messages 6

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Preface

Preface

Purpose of the documentation

This manual contains module-specific information on wiring, diagnostics as well as the technical specifications of the technology module.

General information on installation and commissioning of the ET 200SP is available in the ET 200SP System Manual.

Conventions

Please take into account the notes marked as follows:

NOTE

A note contains important information on the product described in this documentation, its handling and to a section of the documentation to which you should pay particular attention.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under.

See also

IndustrialSecurity (http://www.siemens.com/industrialsecurity)
http://support.automation.siemens.com (http://support.automation.siemens.com)

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The documentation for the SIMATIC S7-1500 automation system and the SIMATIC ET 200MP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

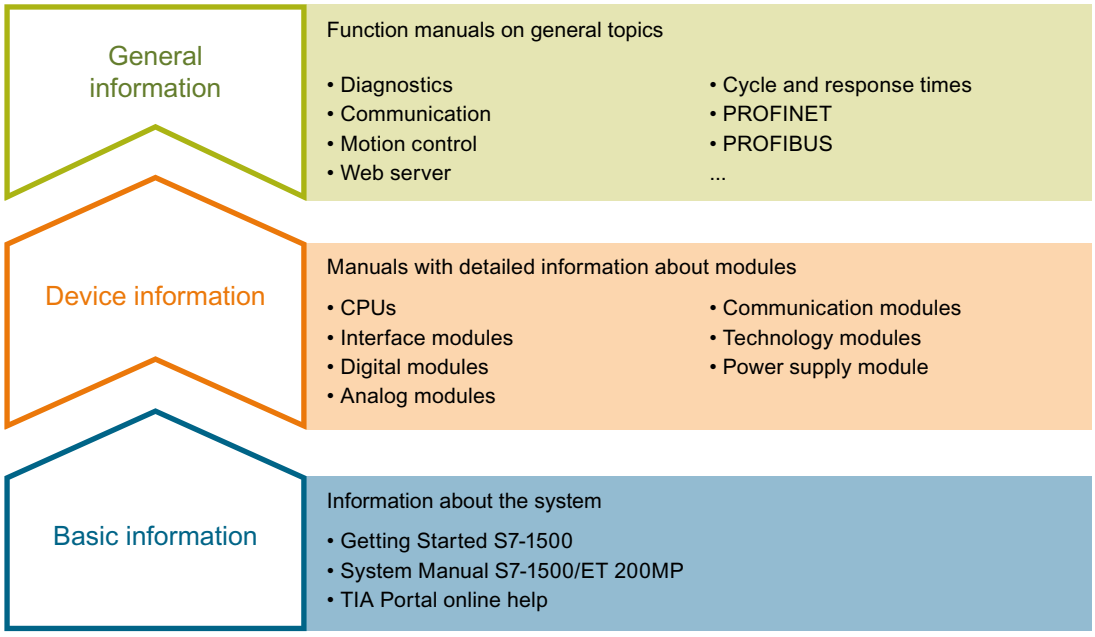

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC S7-1500 and ET 200MP systems, e.g. diagnostics, communication, motion control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/68052815).

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86140384).

SIMATIC S7-1500 comparison list for programming languages

The comparison list contains an overview of which instructions and functions you can use for which controller families.

You can find the comparison list on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86630375).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area in "mySupport" you can combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area in "mySupport", you can access the current product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of the TIA Portal.

General function overview:

- Network browsing and creation of a table showing the accessible devices in the network.
- Flashing of device LEDs or HMI display to locate a device
- Downloading of addresses (IP, subnet, gateway) to a device
- Downloading the PROFINET name (station name) to a device
- Placing a CPU in RUN or STOP mode
- Setting the time in a CPU to the current time of your PG/PC
- Downloading a new program to a CPU or an HMI device
- Downloading from CPU, downloading to CPU or deleting recipe data from a CPU
- Downloading from CPU or deleting data log data from a CPU
- Backup/restore of data from/to a backup file for CPUs and HMI devices
- Downloading service data from a CPU
- Reading the diagnostics buffer of a CPU
- Performing a CPU memory reset
- Resetting devices to factory settings
- Downloading a firmware update to a device

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the PROFINET network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET network and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

SIMATIC ET 200SP TM ECC 2xPWM ST 6FE1242-6TM10-0BB1

Validity

This manual is valid as of firmware version V1.02 and function block ECC4100 V1.1.

View of the module

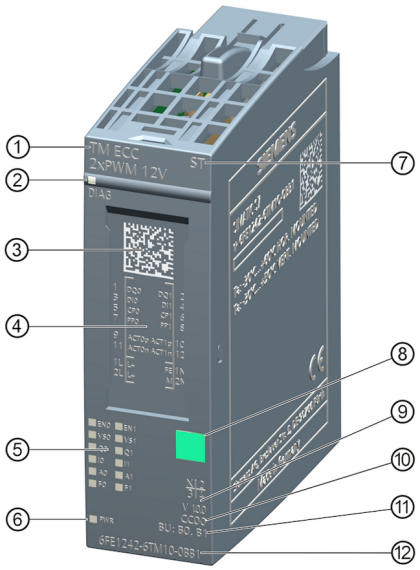

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color labeling module type
③	2D matrix code	⑨	Function state of the device
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-1236 View of the SIMATIC ET 200SP TM ECC 2xPWM ST module

Properties

The SIMATIC ET 200SP TM ECC 2xPWM ST technology module is used for control and monitoring of conductive charging of electric vehicles on the three-phase AC grid according to the standard IEC 61851-1, charging mode Mode 3. It provides two charging outlets for this purpose.

The TM ECC 2xPWM ST is intended to control the contactor that is used to establish the connection between power grid and electric vehicle.

In addition, it generates and monitors the CP signal (Control Pilot Signal) and evaluates the resistance at the PP (Plug Present or Proximity) connector.

The Control Pilot signal (CP), among other things, has the following functions:

- Evaluation of the vehicle status (vehicle connected/not connected - vehicle in different stages ready for charging - error)
- Transfer of information for maximum available charging current over a PWM signal
- Modulation of the TRIP line function (quick shutdown of exposed dangerous voltages on the charging cable)

The technology module determines the resistance at the PP terminal (resistance coding in the connector of the charging cable). This value helps determine the current carrying capacity of the charging cable and whether the connector is plugged between charging station and charging cable.

You can use the TM ECC 2xPWM ST technology module to enabled or disable the electromotive or electromagnetic locking of the charging connector in the charging station depending on the status (ACT). In addition, the locking process can be controlled and monitored by means of the control and feedback interface (Page 30) externally without using the ACT outputs.

The technology module can evaluate the configured feedback information to determine whether or not the requested function was executed.

The following feedback information is available:

- Feedback contactor
- Feedback locking
- Feedback ventilation

If the required state and the achieved state do not match, a diagnostics alarm to that effect is triggered after three seconds.

You can configure a corresponding feedback contact in TIA Portal as of version V14 SP1 / "HSP0234 ET200SP ECC 2xPWM" or in the GSDML.

If you are using the technology module in "IEC61851-1 mode" and plug the charging cable into the charging station, the current carrying capacity of the charging cable is detected and connector locking is activated when the current carrying capacity of the cable is sufficient. The locking mechanism is not unlocked until the charging cable is unplugged from the vehicle. You can configure electromotive locking and its control in TIA Portal as of version V14 SP1 / "HSP0234 ET200SP ECC 2xPWM" or in the GSDML.

Inputs and outputs

- 2x Control Pilot (CP)
- 2x Plug Present (PP)
- 2x Digital Out (DQ) as open collector
- 2x Digital In (DI)
- 2x connector for electromotive or electromagnetic connector locking (ACTp, ACTn)

NOTICE
You must not connect an external voltage to the PP connector, because it could destroy the internal circuitry of the connector. This also applies if the module is operated in accordance with the SAE J1772 standard. In this operating mode, you must **not** connect the PP conductor to the module. This will result in an error message. If you have configured the technology module with "electromagnetic connector locking", the ACTn connector functions as open collector. The load (the locking electromagnets in this case) connected to this connector must be supplied by a voltage source with limited voltage and/or power rating (SELV, PELV according to EN61010-1 and EN61010-2-201, Class 2). Maximum 12 V DC / 1.3 A. In general, you must not connect an external voltage >12 V to the ACTp and ACTn connectors.

System environment

Distributed operation in an S7-1500 system:

- TIA Portal as of version V14 SP1

Distributed operation in a system from a different manufacturer:

- PROFINET GSD files (https://support.industry.siemens.com/cs/document/57138621?dti=0&lc=en-US)

Accessories

The following accessories can be used with the module and is not included in the scope of delivery:

- Labeling strips
- Color-coded labels
- Reference identification labels

A BaseUnit of the BU type B1 or BU type B0 is required to operate the technology module. You can find an overview of the BaseUnits that are compatible with the technology module in the Product information for documentation of the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/document/73021864?dti=0&lc=en-US).

You will find additional information on installation in the ET 200SP distributed I/O system System Manual (https://support.industry.siemens.com/cs/document/58649293?dti=0&lc=en-US).

Disposal

Electric and electronic devices do not belong in household waste. Dispose of the product according to the valid legal regulations at the end of its service life. By doing so you will meet the legal obligations and help protect the environment. WEEE Reg. No. DE 23691322

Configuration example

The charging controller described here is a technology module for SIMATIC ET 200SP. Solutions for S7-1500 CPUs are possible. TIA Portal can be used as the configuration software.

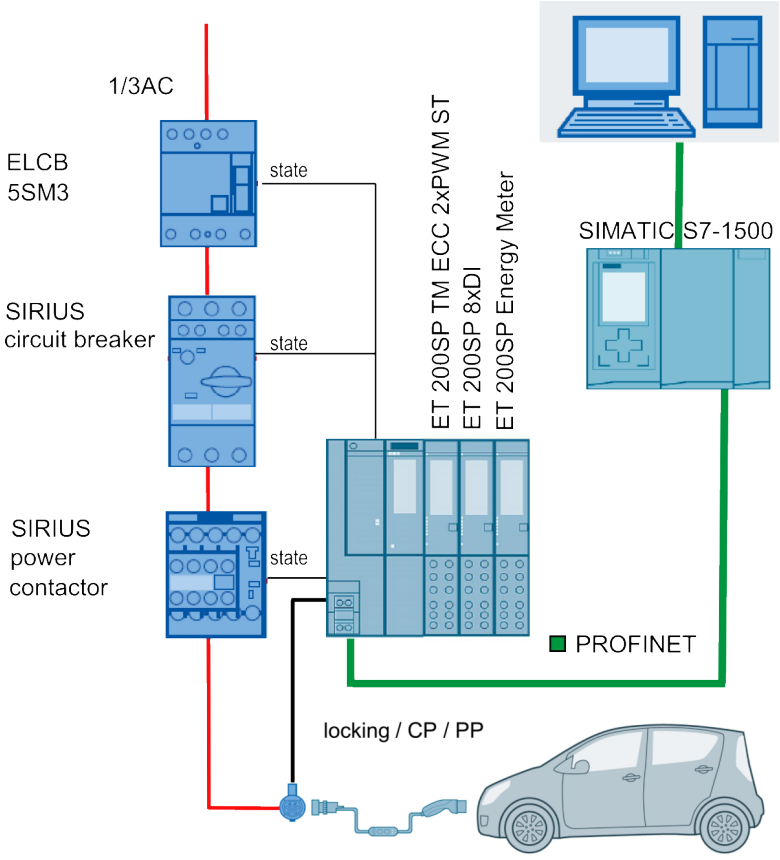

Figure 2-1237 Configuration example with one charging outlet

Firmware update

NOTE

Firmware update

Note that a firmware update can only be performed in STOP mode. When you trigger the update in TIA Portal, you must switch the CPU to STOP manually. No dialog prompting you to do so appears in this case. If the CPU is not switched to STOP, the update is not executed and the progress bar remains at "0%".

Wiring

3

3.1 Terminal assignment and power supply

A BaseUnit of the BU type B1 or BU type B0 must be used for the SIMATIC ET 200SP TM ECC 2xPWM ST.

Connect all required inputs and outputs (DI, DQ, CP, PP, ACT) - and in the case of a BaseUnit BU type B1 also an external 24 V DC voltage source - to the BaseUnit of the technology module.

NOTICE
The two charging outlets are not galvanically isolated from each other. All external connectors of the BaseUnit are referenced to the same ground potential. For the charging equipment to function without problems, you need a ground rod at the charging station as reference for this ground potential. Galvanic isolation exists to the system bus of the ET 200SP.

NOTE

Ensure a low resistance connection of the standard mounting rail to the ground potential (FE). Design according to VDE 0100-600.

You must also regularly check the functioning of the functional ground connection during the proof tests that are performed for the charging equipment.

BaseUnit

The BaseUnit is not included in the scope of delivery of the SIMATIC ET 200SP TM ECC 2xPWM ST technology module. It must be ordered separately.

You can find an overview of the BaseUnits that are compatible with the technology module in the Product information for documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

Information regarding selection of a suitable BaseUnit can be found in the ET 200SP Distributed I/O System System Manual (http://support.automation.siemens.com/WW/view/en/58649293) and in the ET 200SP BaseUnits Manual (http://support.automation.siemens.com/WW/view/en/58532597/133300).

Pin assignment of the BaseUnit BU type B1

The table shows the pin assignment of the BaseUnit BU20-P12+A0+4B (6ES7193-6BP20-0BB1). The power supply of this BaseUnit is not looped through, which means downstream BaseUnits are not supplied by this BaseUnit. The same downstream BU requires its own power supply. This means the BaseUnit is its own potential group.

The BaseUnit BU type B1 must be supplied with safety extra-low voltage (SELV) or protective extra-low voltage (PELV).

All 24 V nominal power supplies of the I/O circuits must only be powered by approved sources that fulfill the requirements according to EN61010-2-201 for SELV, PELV, Class 2, voltage limited and/or power limited sources.

Designation	I/O name		View	I/O name		Designation
Contactor switching contact	DQ0	1	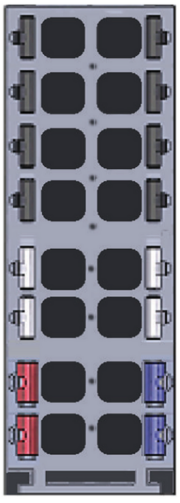	2	DQ1	Contactor switching contact
Read-back contact contactor / connector locking	DI0	3		4	DI1	Read-back contact contactor / connector locking
Control Pilot	CP0	5		6	CP1	Control Pilot
Plug Present signal	PP0	7		8	PP2	Plug Present signal
Actuator locking control, p-connection	ACT0p	9		10	ACT1p	Actuator locking control, p-connection
Actuator locking control, n-connection	ACT0n	11		12	ACT1n	Actuator locking control, n-connection
External 24 V DC supply input Pins 13 and 15 are connected internally.	L+	13		14	FE	FE and ground for supply voltage Pins 14 and 16 are connected internally.
		15		16	M	

Pin assignment of the BaseUnit BU type B0

To connect to or use an existing potential group, you must use the following BaseUnit.

A new potential group is not created with the BaseUnit BU type B0 (BU20-P12+A4+0B / 6ES7193-6BP20-0BB0). It continues the potential group. The self-establishing voltage busbars P1, P2 and the AUX rail are looped through to the neighboring module (BaseUnit) on the left.

All 24 V nominal power supplies of the I/O circuits must only be powered by approved sources that fulfill the requirements according to EN61010-2-201 for SELV, PELV, Class 2, voltage limited and/or power limited sources.

Designation	I/O name		View	I/O name		Designation
Contactor switching contact	DQ0	1		2	DQ1	Contactor switching contact
Read-back contact contactor / connector locking	DI0	3		4	DI1	Read-back contact contactor / connector locking
Control Pilot	CP0	5		6	CP1	Control Pilot
Plug Present signal	PP0	7		8	PP1	Plug Present signal
Actuator locking control, p-connection	ACT1p	9		10	ACT1p	Actuator locking control, p-connection

Designation	I/O name		View	I/O name		Designation
Actuator locking control, n-connection	ACT0n	11	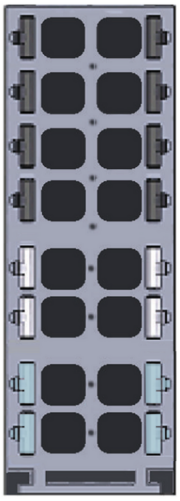	12	ACT1n	Actuator locking control, n-connection
	AUX	13		14	AUX	
		15		16		

Contactor switching contact DQ0 and DQ1

- There is no galvanic isolation between the digital outputs from each other or from the digital inputs. However, galvanic isolation exists between the digital outputs and the ET 200SP system bus.
- The digital outputs are protected against overload and short-circuit.
- For their own protection, the digital outputs are equipped with protective diodes.

NOTE

Connect an external protection element to the relays or contactors to suppress self-inductance when switching off inductive loads.

We recommend using contactors with integrated protection elements.

You must supply the contactors with a voltage source with limited voltage and/or power rating (SELV, PELV according to EN61010-1 and EN61010-2-201, Class 2).

Read-back input for the contactor or the connector locking DI0 and DI1

Galvanic isolation does not exist between the digital inputs nor between the digital inputs and the digital outputs. Galvanic isolation does, however, exist between the digital inputs and the ET 200SP system bus.

You can configure these inputs in 24 V or 12 V logic. In the 24 V configuration, the low level is defined from 0 V to 5 V and the high level from 11 V to 24 V. In the 12 V configuration, the low level is defined from 0 V to 2.5 V and the high level from 5.5 V to 12 V.

You can configure the read-back input via TIA Portal.

Control Pilot CP0 and CP1

The SIMATIC ET 200SP TM ECC 2xPWM ST technology module can operate two conductive charging outlets in accordance with the standard IEC61851-1. The device forms a Control Pilot signal for every charging outlet. This signal is a square signal with 1 kHz frequency and an amplitude of +/-12 V. The duty ratio of the Control Pilot signal indicates the current which the charging station can deliver as charging current:

Table 2-1394 Control Pilot (PWM)

Control Pilot (PWM)	Meaning / available charging current
< 8%	Charging not permitted
≥ 8% .. < 10%	6 A
≥ 10% .. < 85%	available current = PWM [%] × 0.6 A/% Example: PWM = 50% → 50% × 0.6 A/% = 30 A
≥ 85% .. < 96%	available current = (PWM [%] - 64) × 2.5 A/%
≥ 96% .. ≤ 97%	80 A
> 97%	Charging not permitted

This module does not support power-line communication.

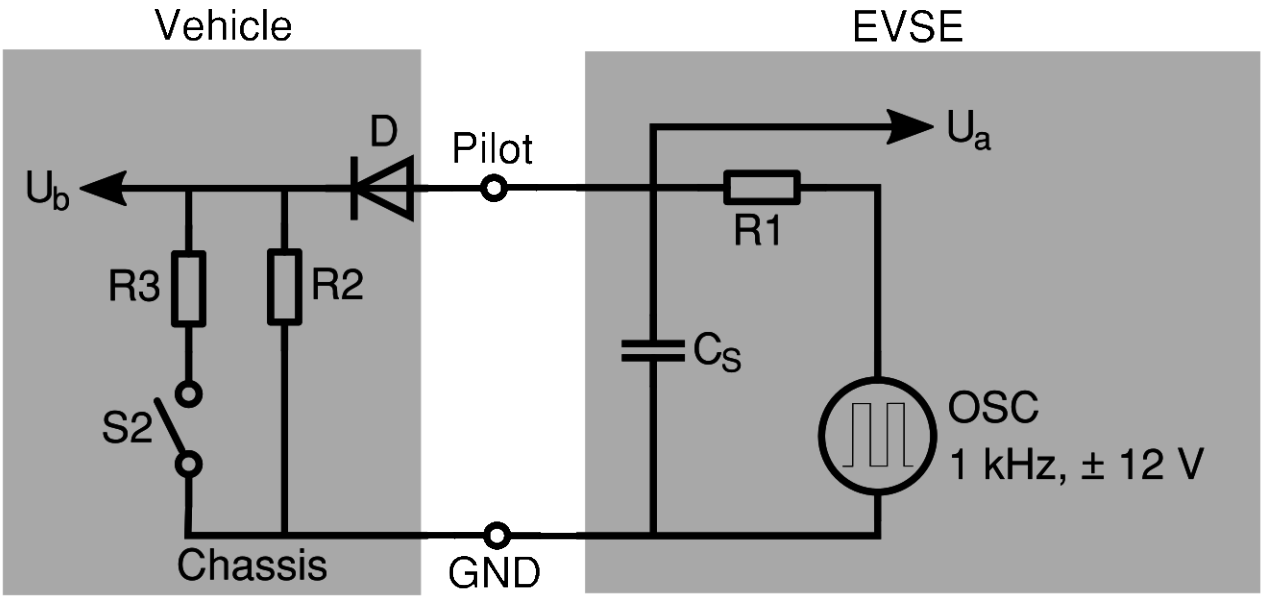

EVSE	Charging station
Vehicle	Vehicle
Chassis	Chassis
R1	1000 Ω ± 3%
R2	2740 Ω ± 3%
R3	1300 Ω ± 3% (state C) or 270 Ω ± 3 % (state D)
C_S	300 pF
U_a	Voltage measurement of the station
U_b	Voltage measurement (level, frequency, duty cycle) of the vehicle

Figure 2-1238 Typical pilot circuit

The vehicle shows its state via the connection of corresponding resistances. To determine the vehicle status, the positive component of the PWM signal is recorded as a peak value (U_a) and read in:

Table 2-1395 States and level U_a

State	Vehicle connected	S2	Charging is possible	U_a [a]	Comment
A	No	Open	No	12 V	U_b = 0 V
B	Yes	Open	No	9 V [b]	R2 determined
C	Yes	Closed	Vehicle ready	6 V [c]	R3 = 1.3 kΩ ± 3% Ventilation not required
D				3 V [c]	R3 = 270 Ω ± 3% Ventilation of charging area required
E	Yes	Open	No	0 V	U_b = 0 V: EVSE, grid problem or grid not available, pilot conductor short circuit to earth, etc.
F	Yes	Open	No	-12 V	EVSE not available

[a] All voltages are measured after the stabilization phase, tolerance ±1 V.

[b] The generator of the ESVE can use a stable direct voltage or a ±12 V square wave signal during this phase.

[c] The measured voltage is a function of the R3 value.

Plug Present signal PP0 and PP1

The technology module determines for every charging outlet the current carrying capacity of the connected charging cable via the Plug Present interface (also referred to as the Proximity interface). Also note the adjustable parameters

Table 2-1396 Coding of the permitted current in the charging cable or charging connector

Resistance R_C	1.5 kΩ, 0.5 W, ± 3%	680 Ω, 0.5 W, ± 3%	220 Ω, 0.5 W, ± 3%	100 Ω, 0.5 W, ± 3%
Current carrying capacity	13 A	20 A	32 A	63 A

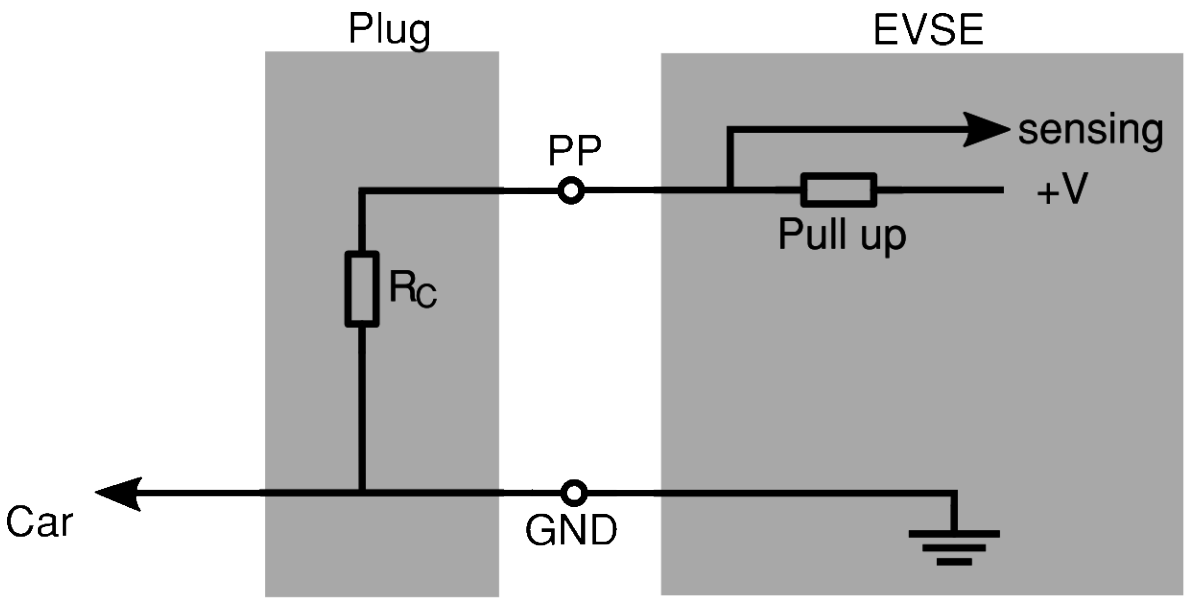

Pull up 330 Ω

Figure 2-1239 Plug Present circuit

The technology module assigns a current carrying capacity to the resistance value measured at the PP terminal (R_C) according to the following table.

Table 2-1397 Permitted current in the charging cable or charging connector

Resistance R_C	**1000 .. 2200 Ω**	**330 .. < 1000 Ω**	**150 .. < 330 Ω**	**75 .. < 150 Ω**
Current carrying capacity	13 A	20 A	32 A	63 A

Measured values for R_C outside of the values define here will result in an error. A charging operation cannot be started. The permissible current in the charging cable is set to 0 A in this case.

NOTE

If the SAE J1772 standard has been selected, the PP resistance is not evaluated!

Do not connect any potential PP conductor of the charging cable to the PP terminal!

The maximum charging current is only limited here by the configuration of the module in TIA.

NOTE

As of firmware version 1.03, the PP resistance is determined in the states A to D.

Measurement in state A recognizes when the charging cable is still connected to the charging station but has already been disconnected from the vehicle.

Up to firmware version 1.02, the resistance was only measured in states B to D. In state A (charging cable is not connected to the vehicle), the permissible current in the charging cable is set to 0 A.

Connector locking ACT0p/n and ACT1p/n

The technology module enables you to use either electromotive or electromagnetic connector locking and to monitor it over the associated read-back input (DI) of the charging outlet.

- Locking: The connector of the charging cable is locked in the charging station after the vehicle has changed to STATE B (vehicle connected) and the Plug Present evaluation has determined a sufficient current carrying capacity of the cable.
- Unlocking: The locking mechanism is not unlocked until the charging cable is unplugged from the vehicle.

When you configure **electromotive locking** , you must connect the actuator (manufacturer-specific locking module for control of the actuator) with correct polarity to ACTp (positive terminal) or ACTn (negative terminal) for locking. The technology module changes the polarity of these connections when the direction of actuation is changed.

- Unlocked: ACTp = 12 V; ACTn = 0 V; max. current 10 mA
- Locked: ACTp = 0 V; ACTn = 12 V; max. current 10 mA

The tolerance of the 12 V voltage between ACTp and ACTn is ± 6%.

As of firmware version 1.0.4, the outputs ACT0p/n and ACT1p/n can be controlled directly via the process image PIQ (see section Assignment of the control interface (Page 30)), if the "Interlock" parameter in the HSP or the GSDML file is set to "No interlock" or "External (via PII)" (see table Adjustable parameters and their default settings).

These outputs can also be controlled by the FC4100 function if FW version 1.0.4 is installed and TIA Library version 1.2 or higher is used.

Furthermore, as of firmware version 1.0.4, an unlocking process is perform as soon as the "Enable" input in the FC4100 function changes from True to False and the "Interlock" parameter in the HSP or the GSDML file is set to "Polarity reversal pulse 800 s" (see table Adjustable parameters and their default settings). In this case an unlocking also takes place via direct control of the process image of the outputs (PAE) according to the description in the section Assignment of the control interface (Page 30).

NOTE

When the selected electromotive connector locking consumes a current greater than 10 mA, you must install a suitable interlock module (actuator) in between.

Note that due to the potentially high motor blocking currents, repeated interlock or unlock pulses in quick succession can lead to an increased load (theoretically up to overheating) on the interlock/unlock motor.

Comment: If you use an actuator with reverse logic, you must wire the connectors accordingly.

In case of **electromagnetic connector locking** (e.g. by means of a solenoid), the ACTn connectors work as an open collector. This means you must connect the actuating magnet involved in the locking process to a suitable power supply (12 V, SELV/PELV) and connect the negative connector of the actuating magnet to the ACTn of the respective charging outlet. See Block diagram. The maximum permitted current is 1.3 A in this case.

External L+ power supply (only for BaseUnit type B1)

Connect an external 24 V DC power supply of the type SELV/PELV (according to EN61010-2-201, Class 2) to the L+ and M connectors to supply the SIMATIC ET 200SP TM ECC 2xPWM ST technology module with voltage. The voltage input of the technology module has an electrical reverse polarity protection.

The technology module monitors *its* supply voltage.

NOTE

L+- and M isolation on the SIMATIC ET 200SP TM ECC 2xPWM ST technology module provided by the BaseUnit type B1.

The L+ and M connectors on the BaseUnit of type B1 are galvanically isolated from the neighboring BaseUnits to the left and right. The L+ and M busbars run through the BaseUnit type B1 (without connectors) and expand the busbar with connectors for BaseUnits on the left and right.

See also

Connection examples (Page 21)

Parameter (Page 28)

3.2 Connection examples

Block diagrams

The circuit diagrams below show the schematic wiring of the technology module with the typical options for use of the feedback input.

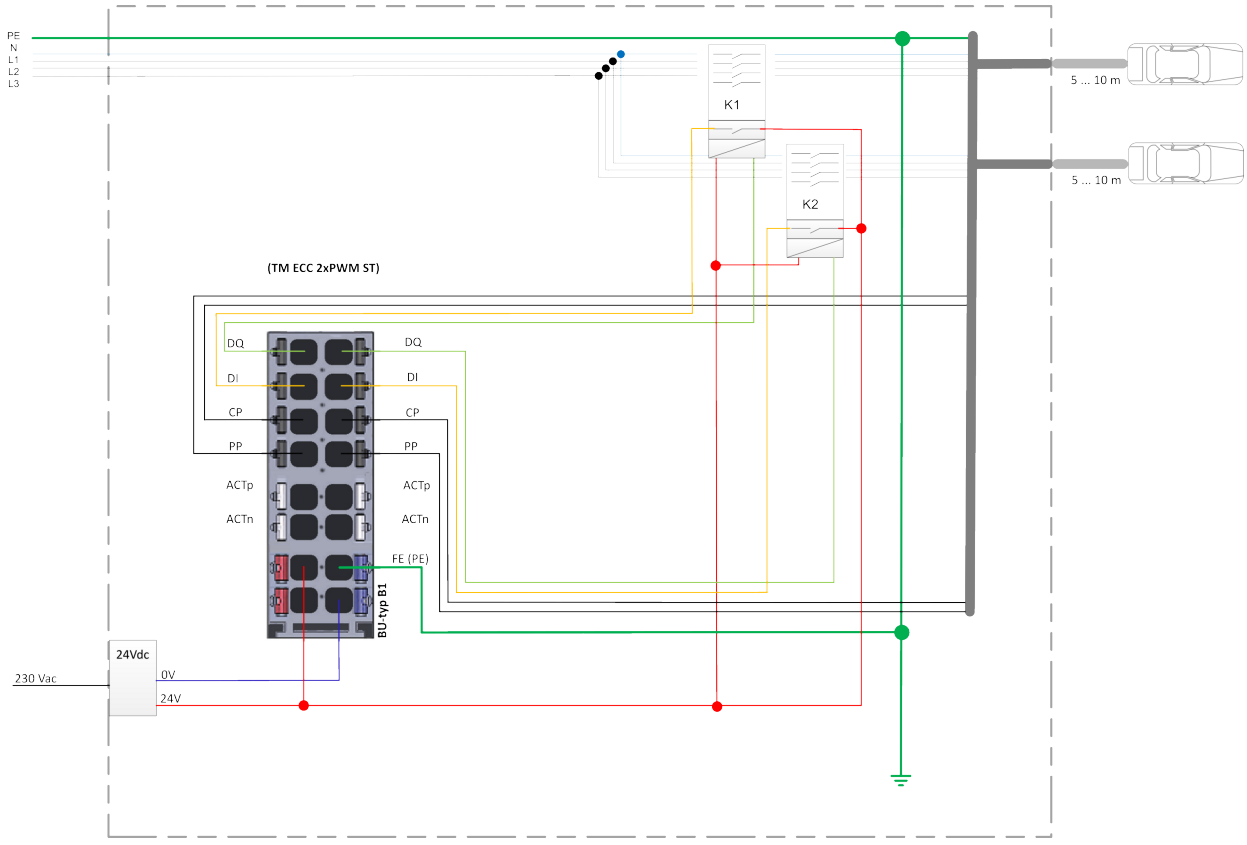

Figure 2-1240 Connecting the technology module with feedback from contactor status (when using a BU type B1)

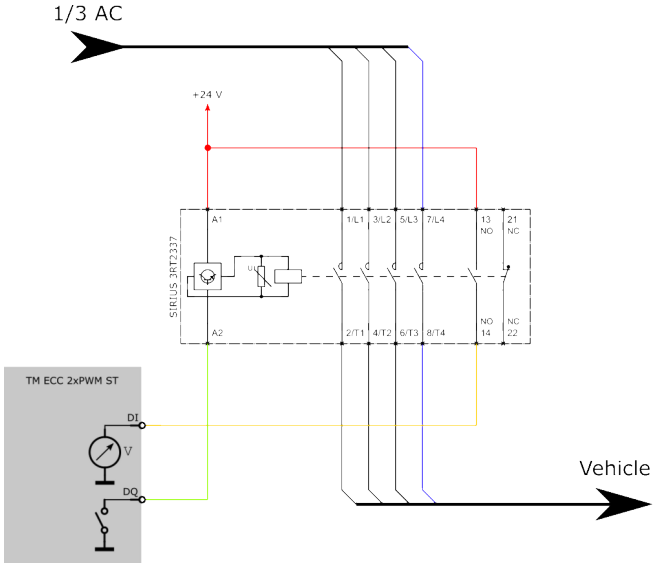

Figure 2-1241 Detail view contactor circuit

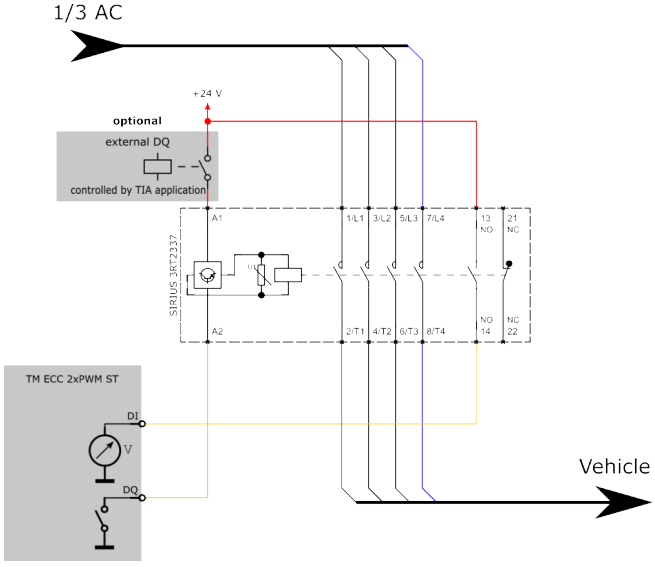

Figure 2-1242 Detail view of protective wiring with optional DQ in the supply line

NOTE

We recommend supplying the output contactor via an additional standard DQ

To ensure the best possible protection during shutdown of the charging system, we recommend supplying the output contactor via a standard DQ (see above).

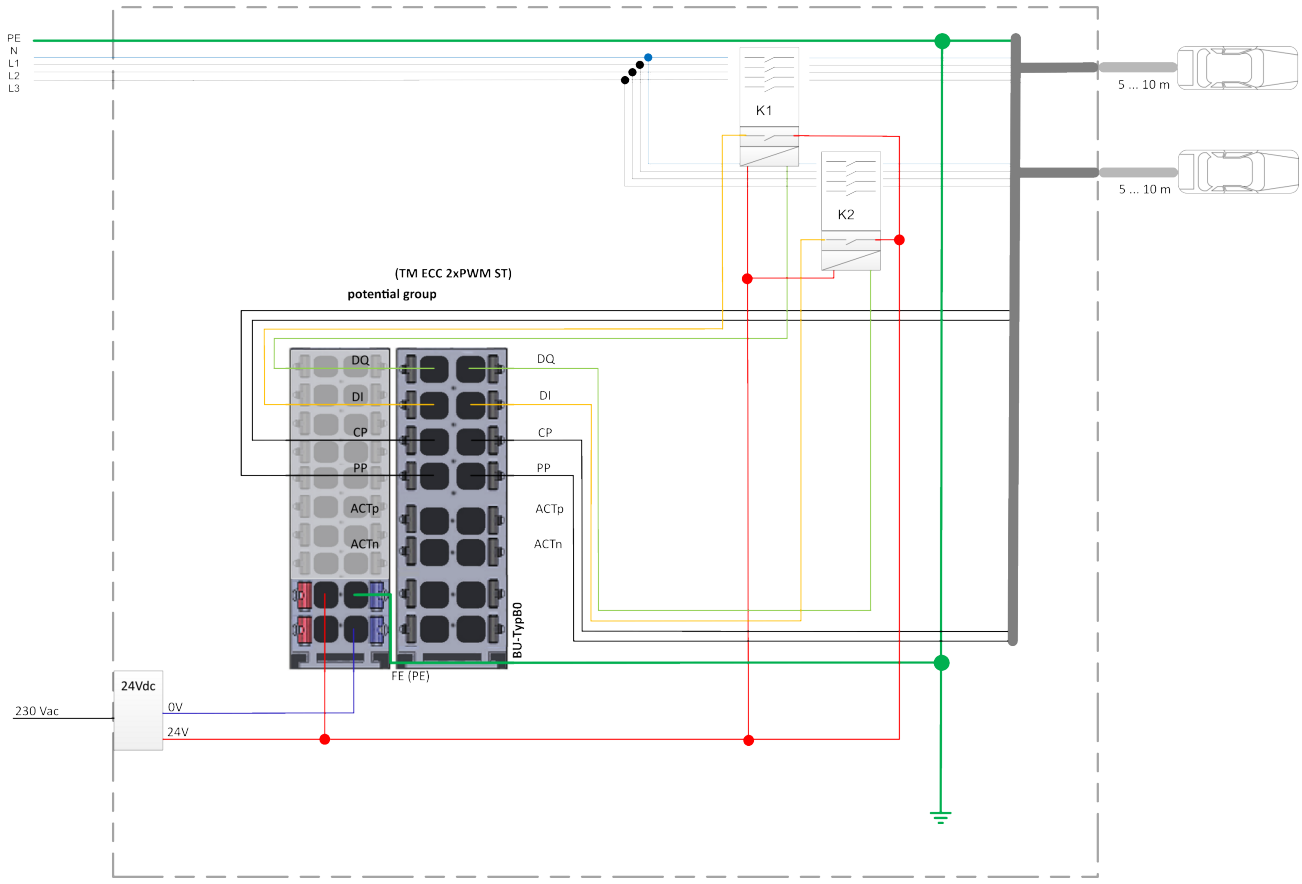

Figure 2-1243 Connecting the technology module with feedback from contactor status (when using a BU type B0)

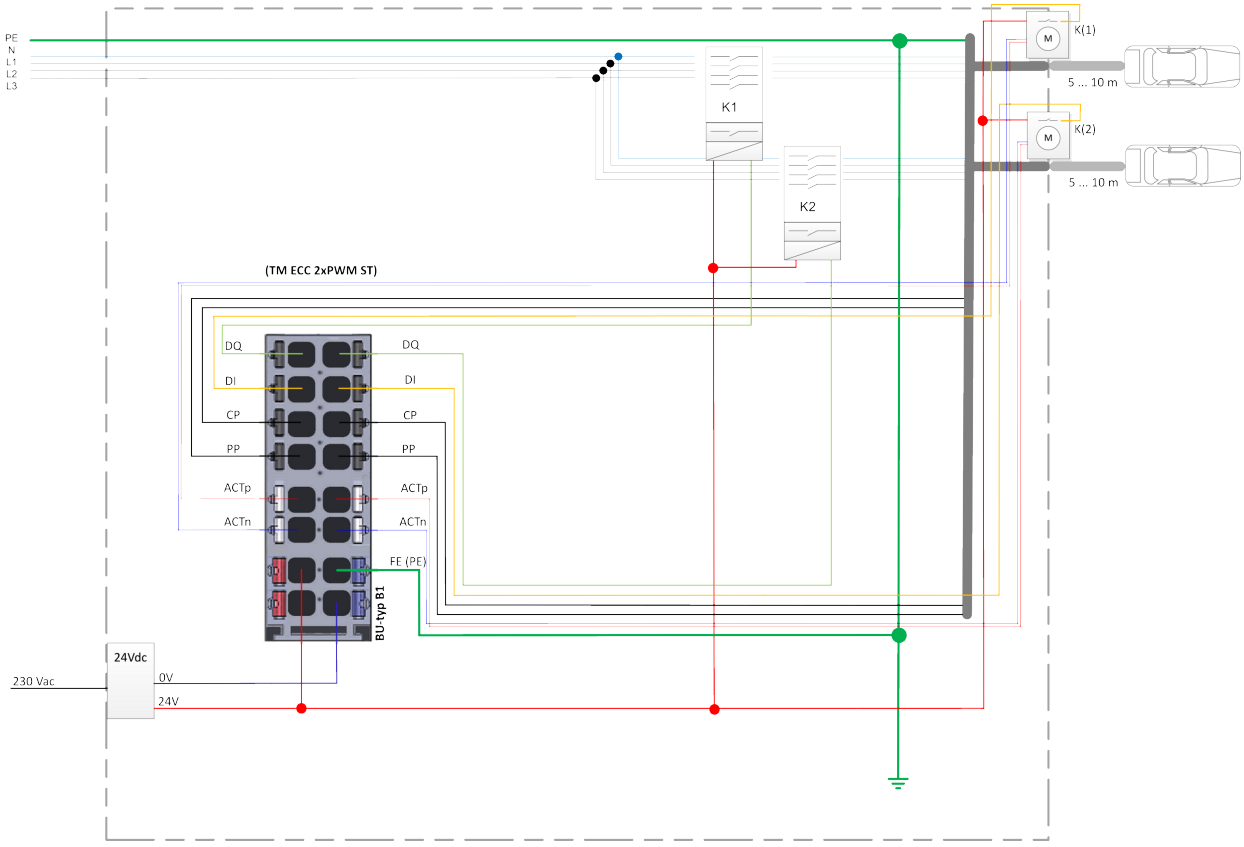

Figure 2-1244 Connecting the technology module with electromotive connector locking and its feedback

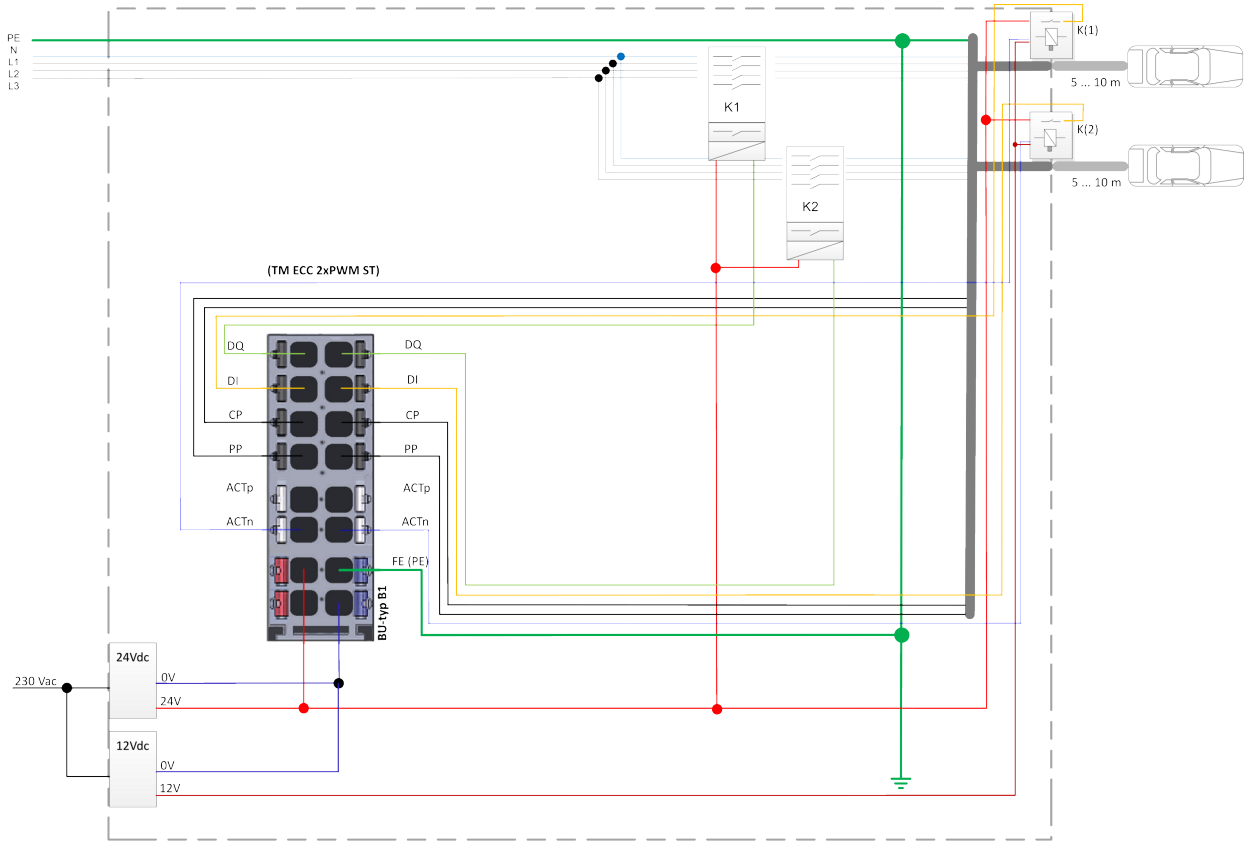

Figure 2-1245 Connecting the technology module with electromagnetic connector locking (in the example via ACTn) and its feedback.

Configuring/address space

4

4.1 Configuring

Introduction

You can configure and parameterize the technology module SIMATIC ET 200SP TM ECC 2xPWM ST with configuration software. The functions of the technology module are controlled and monitored by the user program.

System environment

You can use the technology module in the following system environments:

Table 2-1398 Possible applications of the technology module with PROFINET I/O

Applications	Required components	Configuration software	In your program
Distributed operation in an S7-1500 system	• S7-1500 Automation system • ET 200SP Distributed I/O System • SIMATIC ET 200SP TM ECC 2xPWM ST technology module	STEP 7 (TIA Portal): Device configuration and parameter settings with the hardware configuration (HWCN)	Direct access to the control and feedback interface (Page 30) of the SIMATIC ET 200SP TM ECC 2xPWM ST technology module in the I/O data
Centralized or distributed operation in an ET 200SP system	• ET 200SP automation system • SIMATIC ET 200SP TM ECC 2xPWM ST technology module	STEP 7 (TIA Portal): Device configuration and parameter settings with the hardware configuration (HWCN)	Direct access to the control and feedback interface of the SIMATIC ET 200SP TM ECC 2xPWM ST technology module in the I/O data
Distributed operation in a PROFINET controller	PROFINET controller • ET 200SP Distributed I/O System • SIMATIC ET 200SP TM ECC 2xPWM ST technology module	Engineering system with GSDML file	Direct access to the control and feedback interface of the SIMATIC ET 200SP TM ECC 2xPWM ST technology module in the I/O data

Hardware Support Package (HSP)

If you cannot find the SIMATIC ET 200SP TM ECC 2xPWM ST technology module in the hardware catalog of the TIA Portal, you must install the corresponding HSP file (HSP0234 ET200SP ECC 2xPWM).

The Hardware Support Package (HSP) is available as download (http://support.automation.siemens.com/WW/view/en/72341852) on the Internet.

GSD file

The respective GSD file for the ET200SP Distributed I/O System can be downloaded from the Internet:

- GSD file PROFINET IO (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD file PROFIBUS DP
  PROFIBUS DP is not supported.

4.2 Reaction to CPU STOP

In the case of a CPU STOP, an active charging process is aborted after three seconds. This means the PWM signal on the CP connection switches to "-12 V" (EVSE status not available). The associated contactor (DQx output) and the corresponding ACTx output are disabled. In this case, the lock is automatically unlocked (even if the "LockActive" bit is set).

Breakdowns in communication, such as an interruption of the PROFINET connection, are treated as CPU STOPs.

4.3 Required I/O address space

Address space of the technology module

Table 2-1399 Range of the I/O addresses of the SIMATIC ET 200SP TM ECC 2xPWM ST technology module

	Inputs	Outputs
Range	16 bytes	8 bytes

Further information

You can find a description of the control and feedback interface of the SIMATIC ET 200SP TM ECC 2xPWM ST technology module in the section Control and feedback interface (Page 30).

4.4 Parameter

Parameter

You specify the properties of the technology module using various parameters. These can be assigned by using the HSP or the GSDML file. Depending on the settings, not all parameters are available. You cannot change the parameter assignment in the user program.

You have the following options for setting the parameters of the module:

Table 2-1400 Parameter assignment options

Parameter settings using the ...	Basic procedure
Hardware configuration in STEP 7 with HSP file	1. Install the respective HSP file. The module is subsequently available in the hardware catalog under "ET 200SP". 2. Set the device configuration and the parameters in the hardware configuration. 3. Download the parameter assignment to the module.
Hardware configuration with GSD file for distributed operation on PROFINET IO	1. Install the latest PROFINET GSD file. The module is subsequently available in the hardware catalog under "Additional field devices". 2. Set the parameters of the PROFINET GSD file in the hardware configuration. 3. Download the parameter assignment to the module.

Adjustable parameters

Table 2-1401 Configurable parameters and their defaults

Parameter	Value range	Default setting	Configuration in RUN
ECC standard [a] (**EC**ar **C**harging)	• IEC 61851-1 • SAE J1772	IEC 61851-1	No
Charging outlet active	• Yes • No	Yes	No
Integrated charging cable	• Yes • No	No	No

[a] If "SAE J1772" is selected in the hardware configuration, the parameter "Integrated charging cable" is automatically set to "Yes". Electromotive locking is not possible in this case.
Any PP resistor possibly plugged in is not evaluated! The maximum charging current is limited here by the configuration of the module in TIA and by the "Maximum permissible charging current" parameter or, when using the FC4100, by the "MaxCurr" parameter.
Any potential PP conductor of the charging cable must not be connected to the PP terminal, otherwise an error is output.

[b] Note that both feedbacks cannot be set to the internal module DI at the same time.

[c] Low level: 0 ..2.5 V; High level: 5.5 .. 12 V

[d] Low level: 0 ..5 V; High level: 11 .. 24 V

Parameter	Value range	Default setting	Configuration in RUN
Cable locking	• No locking • External (via PII) • Pole reversal pulse 800 ms • Polarity reversal permanent • Open collector	Pole reversal pulse 800 ms	No
Cable locking feedback [b)]	• No feedback • Internal module DI • External (via PIQ)	Internal module DI	No
Contactor feedback [b)]	• No feedback • Internal module DI • External (via PIQ)	External (via PIQ)	No
Maximum charging current [A]	6 .. 80	13	No
DI input voltage	• 12 V input [c)] • 24 V input [d)]	24 V input	No

[a)] If "SAE J1772" is selected in the hardware configuration, the parameter "Integrated charging cable" is automatically set to "Yes". Electromotive locking is not possible in this case.
Any PP resistor possibly plugged in is not evaluated! The maximum charging current is limited here by the configuration of the module in TIA and by the "Maximum permissible charging current" parameter or, when using the FC4100, by the "MaxCurr" parameter.
Any potential PP conductor of the charging cable must not be connected to the PP terminal, otherwise an error is output.

[b)] Note that both feedbacks cannot be set to the internal module DI at the same time.

[c)] Low level: 0 ..2.5 V; High level: 5.5 .. 12 V

[d)] Low level: 0 ..5 V; High level: 11 .. 24 V

4.5 Control and feedback interface

4.5.1 Assignment of the control interface

The user program uses the control interface to manipulate the behavior of the technology module.

Control interface

Table 2-1402 Assignment of the control interface

Charging outlet	Byte	Bit	Default	Min	Max	Meaning
0	0	0	0	0	1	Charging outlet enable 0 = inactive; 1 = active Expanded as of FW version 1.0.4: Execution of an unlocking process at edge transition "1 → 0", if the "Interlock" parameter in the HSP or the GSDML file is set to "Polarity reversal pulse 800 s" (see table Adjustable parameters and their default settings)
		1	0	0	1	PWM enable 0 = Charging blocked; 1 = Charging enabled
		2	0	0	0	System reserve
		3	0	0	1	Feedback ventilation 0 = disabled; 1 = enabled
		4 - 6	0	0	0	System reserve
		7	0	0	1	PIQ valid must always be set to "1" by the TIA application to signal "valid values" to the TM ECC 2xPWM ST. [a)]
	1	0	0	0	1	Feedback locking 0 = unlocked; 1 = locked (is used for the "Locking feedback" parameter and the setting "External via PIQ")
		1	0	0	1	Contactor feedback 0 = disabled; 1 = enabled (is used for the "Contactor feedback" parameter and the setting "External via PIQ")
		2	0	0	1	Switch off contactor actively 0 = no; 1 = yes If the bit is set to "1", a pending charging process is terminated and the contactor is switched off after four seconds.
		3	0	0	1	Cable lock disable active [b)] 0 = no; 1 = yes The charging plug is not unlocked on the charging station side as long as the cable lock disable is active (even if the charging plug has been removed on the vehicle side).
		4	0	0	0	System reserve

[a)] If the "PIQ valid bit" is not set, the technology module reacts as with a communication fault; consequently, the associated EN-LED flashes with 2 Hz.

[b)] The "Charging cable lock disable active bit" must be set to "0" beforehand (before plugging in the charging cable) and after completion of the charging process. This also applies if the cable lock via the HSP is disabled!

Charging outlet	Byte	Bit	Default	Min	Max	Meaning
0	1	5	0	0	1	Expanded as of FW version 1.0.4 (otherwise reserved) ACT outputs 0 = ACT outputs ACT0p and ACT0n high resistance 1 = ACT outputs corresponding to bit 6 and bit 7, provided that the "Interlock" parameter in the HSP or GSDML file is set to "No interlock" or "External (via PII)" (see table Adjustable parameters and their default settings)
		6	0	0	1	Expanded as of FW version 1.0.4 (otherwise reserved) Voltage at ACT output ACT0p 0 = Output voltage 0V 1 = Output voltage 12V
		7	0	0	1	Expanded as of FW version 1.0.4 (otherwise reserved) Voltage at ACT output ACT0n 0 = Output voltage 0V 1 = Output voltage 12V
	2 - 3	-	0	0	2^{16}-1	Maximum permitted charging current [in 0.01 A] (example: Value "100" corresponds to 1.00 A) (minimum of the three values "FC input MaxCurr", "Current carrying capacity of the cable" and the parameter "Maximum charging current") If the specified charging current is less than 6 A, the PWM signal is disabled.
1	4	0	0	0	1	Charging outlet enable 0 = inactive; 1 = active Expanded as of FW version 1.0.4: Execution of an unlocking process at edge transition "1 → 0", if the "Interlock" parameter in the HSP or the GSDML file is set to "Polarity reversal pulse 800 s" (see table Adjustable parameters and their default settings)
		1	0	0	1	PWM enable 0 = Charging blocked; 1 = Charging enabled
		2	0	0	0	System reserve
		3	0	0	1	Feedback ventilation 0 = disabled; 1 = enabled
		4 - 6	0	0	0	System reserve
		7	0	0	1	PIQ valid must always be set to "1" by the TIA application to signal "valid values" to the TM ECC 2xPWM ST. [a)]
	5	0	0	0	1	Feedback locking 0 = unlocked; 1 = locked (is used for the "Locking feedback" parameter and the setting "External via PIQ")
		1	0	0	1	Contactor feedback 0 = disabled; 1 = enabled (is used for the "Contactor feedback" parameter and the setting "External via PIQ")

[a)] If the "PIQ valid bit" is not set, the technology module reacts as with a communication fault; consequently, the associated EN-LED flashes with 2 Hz.

[b)] The "Charging cable lock disable active bit" must be set to "0" beforehand (before plugging in the charging cable) and after completion of the charging process. This also applies if the cable lock via the HSP is disabled!

Charging outlet	Byte	Bit	Default	Min	Max	Meaning
1	5	2	0	0	1	Switch off contactor actively 0 = no; 1 = yes If the bit is set to "1", a pending charging process is terminated and the contactor is switched off after four seconds.
		3	0	0	1	Cable lock disable active [b)] 0 = no; 1 = yes The charging plug is not unlocked on the charging station side as long as the cable lock disable is active (even if the charging plug has been removed on the vehicle side).
		4	0	0	0	System reserve
		5	0	0	1	Expanded as of FW version 1.0.4 (otherwise reserved) ACT outputs 0 = ACT outputs ACT0p and ACT0n high resistance 1 = ACT outputs corresponding to bit 6 and bit 7, provided that the "Interlock" parameter in the HSP or GSDML file is set to "No interlock" or "External (via PII)" (see table Adjustable parameters and their default settings)
		6	0	0	1	Expanded as of FW version 1.0.4 (otherwise reserved) Voltage at ACT output ACT0p 0 = Output voltage 0V 1 = Output voltage 12V
		7	0	0	1	Expanded as of FW version 1.0.4 (otherwise reserved) Voltage at ACT output ACT0n 0 = Output voltage 0V 1 = Output voltage 12V
	6 - 7	-	0	0	2^{16}-1	Maximum permitted charging current [in 0.01 A] (example: Value "100" corresponds to 1.00 A) (minimum of the three values "FC input MaxCurr", "Current carrying capacity of the cable" and the parameter "Maximum charging current") If the specified charging current is less than 6 A, the PWM signal is disabled.

[a)] If the "PIQ valid bit" is not set, the technology module reacts as with a communication fault; consequently, the associated EN-LED flashes with 2 Hz.

[b)] The "Charging cable lock disable active bit" must be set to "0" beforehand (before plugging in the charging cable) and after completion of the charging process. This also applies if the cable lock via the HSP is disabled!

See also

Parameter (Page 28)

4.5.2 Assignment of the feedback Interface

The user program receives the current values and status information from the technology module over the feedback interface.

Feedback interface

Table 2-1403 Assignment of the feedback Interface

Charging outlet	Byte	Bit	Default	Min	Max	Meaning
0	0	0 - 2	0	0	7	ECC State [a)] 0: Charging outlet inactive 1: State "A" (no vehicle connected) 2: State "B" (vehicle connected) 3: State "C" (vehicle can be charged; ventilation not required) 4: State "D" (vehicle can be charged; ventilation required) 5: State "E" (CP conductor short circuit to earth) 6: State "F" (charging station not available) 7: Reserved
		3 - 6	0	0	0	System reserve
		7	0	0	1	PII -Valid is set to 1 by the TM ECC 2xPWM ST
	1	0	0	0	1	Status of locking requirements 0: Unlocking requested 1: Interlock requested (can be used in a TIA application, for example, when the control of the interlock is realized outside the module)
		1	0	0	1	Status of contactor control 0: Disable requested 1: Enable requested
		2	0	0	1	Status of feedback input DI 0: DI = 0 1: DI = 1
		3	0	0	1	Validity DI 0: DI value invalid 1: DI value valid
		4	0	0	1	Status of ventilation 0: No ventilation required 1: Ventilation required

[a)] The described states largely correspond to IEC 61851-1 (in decimal representation).

[b)] In these cases the error is acknowledged automatically as soon as the charging cable is unplugged from the charging station.

[c)] In these cases bit 0.0 (charging outlet enable) must be set to "0" in the control interface for charging outlet 0. After subsequent checking of this error state, the bit must be reset to "1"; otherwise the corresponding charging outlet remains locked. Likewise, bit 4.0 (charging outlet enable) must be set to "0" for charging outlet 1. After subsequent checking of this error state, the bit must be reset to "1"; otherwise the corresponding charging outlet remains locked.

[d)] This fault scenario is also reported if SAE J1772 operating mode is selected and the PP conductor of the charging cable is incorrectly connected to the module.

[e)] In the SAE J1772 operating mode, you must enter the value set in TIA Portal here.

Charging outlet	Byte	Bit	Default	Min	Max	Meaning
0	1	5	0	0	1	Status of PWM 0: disabled 1: enabled
		6 - 7	0	0	0	System reserve
	2 - 3					Diagnostics
	2	0	0	0	1	CP signal level impermissible [b)]
		1	0	0	0	System reserve
		2	0	0	1	Resistance at PP terminal too low [b), d)]
		3	0	0	1	Resistance at PP terminal too high [b)]
		4	0	0	1	Incorrect feedback for locking [b)]
		5	0	0	1	Incorrect feedback for unlocking [b)]
		6	0	0	1	Incorrect feedback for contactor ON [b)]
		7	0	0	1	Incorrect feedback for contactor OFF [b)]
	3	0	0	0	1	No ventilation despite requirement [b)]
		1	0	0	1	Overload ACT
		2	0	0	1	Vandalism diagnostics [c)]
		3 - 4	0	0	0	System reserve
		5	0	0	0	System reserve
		6	0	0	0	System reserve
		7	0	0	1	Internal error [c)]
	4	-	0	-127	128	Voltage level CP [in 0.1 V] EXAMPLE: 90 = 9.0 V; -120 = -12.0 V
	5	-	0	0	255	Current carrying capacity of charging cable [in A] [e)]
	6 - 7	-	0	0	2^{16}-1	Charging current signaled to vehicle using PWM [in 0.01 A] EXAMPLE: 1300 = 13 A
1	8	0 - 2	0	0	7	ECC State [a)] 0: Charging outlet inactive 1: State "A" (no vehicle connected) 2: State "B" (vehicle connected) 3: State "C" (vehicle can be charged; ventilation not required) 4: State "D" (vehicle can be charged; ventilation required) 5: State "E" (CP conductor short circuit to earth) 6: State "F" (charging station not available) 7: Reserved

[a)] The described states largely correspond to IEC 61851-1 (in decimal representation).

[b)] In these cases the error is acknowledged automatically as soon as the charging cable is unplugged from the charging station.

[c)] In these cases bit 0.0 (charging outlet enable) must be set to "0" in the control interface for charging outlet 0. After subsequent checking of this error state, the bit must be reset to "1"; otherwise the corresponding charging outlet remains locked. Likewise, bit 4.0 (charging outlet enable) must be set to "0" for charging outlet 1. After subsequent checking of this error state, the bit must be reset to "1"; otherwise the corresponding charging outlet remains locked.

[d)] This fault scenario is also reported if SAE J1772 operating mode is selected and the PP conductor of the charging cable is incorrectly connected to the module.

[e)] In the SAE J1772 operating mode, you must enter the value set in TIA Portal here.

Charging outlet	Byte	Bit	Default	Min	Max	Meaning
1	8	3 - 6	0	0	0	System reserve
		7	0	0	1	PII -Valid is set to 1 by the TM ECC 2xPWM ST
	9	0	0	0	1	Status of locking requirements 0: Unlocking requested 1: Locking requested (can be used in a TIA application, for example, when the locking control is realized outside the module)
		1	0	0	1	Status of contactor control 0: Disable requested 1: Enable requested
		2	0	0	1	Status of feedback input DI 0: DI = 0 1: DI = 1
		3	0	0	1	Validity DI 0: DI value invalid 1: DI value valid
		4	0	0	1	Status of ventilation 0: No ventilation required 1: Ventilation required
		5	0	0	1	Status of PWM 0: disabled 1: enabled
		6 - 7	0	0	0	System reserve
	10 - 11					Diagnostics
	10	0	0	0	1	CP signal level impermissible [b)]
		1	0	0	0	System reserve
		2	0	0	1	Resistance at PP terminal too low [b), d)]
		3	0	0	1	Resistance at PP terminal too high [b)]
		4	0	0	1	Incorrect feedback for locking [b)]
		5	0	0	1	Incorrect feedback for unlocking [b)]
		6	0	0	1	Incorrect feedback for contactor ON [b)]
		7	0	0	1	Incorrect feedback for contactor OFF [b)]
	11	0	0	0	1	No ventilation despite requirement [b)]
		1	0	0	1	Overload ACT

[a)] The described states largely correspond to IEC 61851-1 (in decimal representation).

[b)] In these cases the error is acknowledged automatically as soon as the charging cable is unplugged from the charging station.

[c)] In these cases bit 0.0 (charging outlet enable) must be set to "0" in the control interface for charging outlet 0. After subsequent checking of this error state, the bit must be reset to "1"; otherwise the corresponding charging outlet remains locked. Likewise, bit 4.0 (charging outlet enable) must be set to "0" for charging outlet 1. After subsequent checking of this error state, the bit must be reset to "1"; otherwise the corresponding charging outlet remains locked.

[d)] This fault scenario is also reported if SAE J1772 operating mode is selected and the PP conductor of the charging cable is incorrectly connected to the module.

[e)] In the SAE J1772 operating mode, you must enter the value set in TIA Portal here.

Charging outlet	Byte	Bit	Default	Min	Max	Meaning
1	11	2	0	0	1	Vandalism diagnostics [c)]
		3 - 4	0	0	0	System reserve
		5	0	0	0	System reserve
		6	0	0	0	System reserve
		7	0	0	1	Internal error [c)]
	12	-	0	-127	128	Voltage level CP [in 0.1 V] EXAMPLE: 90 = 9.0 V; -120 = -12.0 V
	13	-	0	0	255	Current carrying capacity of charging cable [in A] [e)]
	14 - 15	-	0	0	2^{16}-1	Charging current signaled to vehicle using PWM [in 0.01 A] EXAMPLE: 1300 = 13 A

[a)] The described states largely correspond to IEC 61851-1 (in decimal representation).

[b)] In these cases the error is acknowledged automatically as soon as the charging cable is unplugged from the charging station.

[c)] In these cases bit 0.0 (charging outlet enable) must be set to "0" in the control interface for charging outlet 0. After subsequent checking of this error state, the bit must be reset to "1"; otherwise the corresponding charging outlet remains locked. Likewise, bit 4.0 (charging outlet enable) must be set to "0" for charging outlet 1. After subsequent checking of this error state, the bit must be reset to "1"; otherwise the corresponding charging outlet remains locked.

[d)] This fault scenario is also reported if SAE J1772 operating mode is selected and the PP conductor of the charging cable is incorrectly connected to the module.

[e)] In the SAE J1772 operating mode, you must enter the value set in TIA Portal here.

Programming 5

5.1 General information

You can use the function "ECC4100" to integrate the SIMATIC ET 200SP TM ECC 2xPWM ST technology module in the TIA environment. This description is based on the function "ECC4100, Version V1.1".

You can download this function from the SIEMENS Customer Support (https://support.industry.siemens.com/cs/de/en/ps/6FE1242-6TM10-0BB1). It is available in form of the TIA library "ET200SP TM ECC". There you can find it in the folder Types\PWM.

5.2 "ECC4100" functions

Introduction

Below you can see the inputs and outputs of the ECC4100 function.

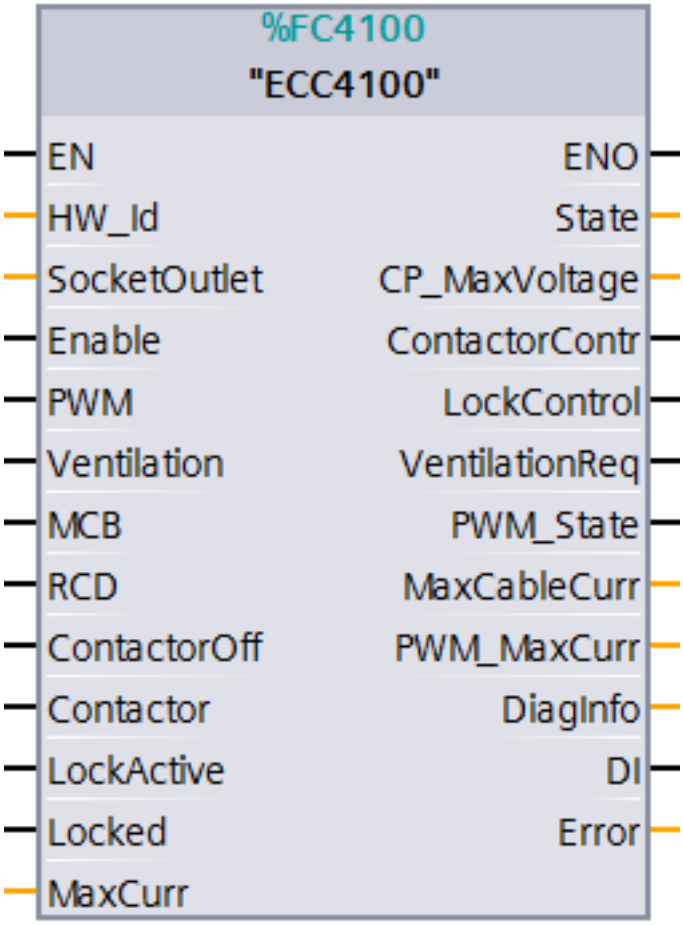

Figure 2-1246 Function "ECC4100 (V1.1)"

5.3 FC ECC4100 parameters

The "ECC4100" function has the following input and output parameters.

Input parameters

Table 2-1404 List of input parameters

Parameter	Data type	Description
HW_Id	HW_IO	Hardware ID of the SIMATIC ET 200SP TM ECC 2xPWM ST technology module to determine the offset of the process image of the inputs/outputs. If an invalid HW ID is entered, bit 0 is set to "1" at the "Error" output.
SocketOutlet	USInt	Number of the associated charging outlet (0 = charging outlet 0, 1 = charging outlet 1) If an invalid number is entered, bit 1 is set to "1" at the "Error" output.
Enable	Bool	Charging outlet enable (True = yes, False = no) This input is ANDed with the inputs MCB and RCD. If one of these inputs is set to "0", the CP output signal is set to -12 V in the module. If the inputs Enable, MCB and RCD are set to "1", the CP output signal changes to +12 V. Expanded as of FW version 1.0.4: Execution of an unlocking process at edge transition "True → False", if the "Interlock" parameter in the HSP or the GSDML file is set to "Polarity reversal pulse 800 s" (see table Adjustable parameters and their default settings)
PWM	Bool	PWM modulation enable (True = yes, False = no) When charging of the vehicle is enabled, this input must be set to "1" (e.g. after valid authentication or payment). This signals to the vehicle that charging is now possible. If the charging process is to be ended by the charging station (e.g. after the maximum amount of energy has been dispensed), this input must be set back to "0".
Ventilation	Bool	Read-back signal ventilation (True = on, False = off) If ventilation is required (State D according to IEC 61851-1), the feedback input of the fan can be connected here. If configured, the charging process is interrupted after three seconds if this input is not set to 1.
MCB	Bool	Miniature circuit breaker tripped (True = no, False = yes) This input is ANDed with the inputs Enable and RCD. If one of these inputs is set to "0", the CP output signal is set to -12 V in the module. If the inputs Enable, MCB and RCD are set to "1", the CP output signal changes to +12 V. If no miniature circuit breaker is to be linked to this input, it must be set to "1".
RCD	Bool	Residual current operated circuit breaker tripped (True = no, False = yes) This input is ANDed with the inputs Enable and MCB. If one of these inputs is set to "0", the CP output signal is set to -12 V in the module. If the inputs Enable, MCB and RCD are set to "1", the CP output signal changes to +12 V. If no residual current operated circuit breaker is to be linked to this input, it must be set to "1".
ContactorOff	Bool	Contactor is opened (True = yes, False = no) If this bit is set to "True", the PWM signal is switched off if a charging process is active. The contactor opens after four seconds. This bit must be reset to "False" before the next charging process. If this bit is permanently "False", opening or closing is controlled by the module. This input is useful for charging vehicles that do not know a "B" charging state.

Parameter	Data type	Description
Contactor	Bool	Contactor closed (True = yes, False = no) If the feedback does not take place directly over the module (can be configured with HSP or GSDML), you can connect the feedback input of the contactor here. The charging process is interrupted after three seconds if this input is not set to "1". A corresponding error is output at the DiagInfo output. The CP output signal changes to -12 V. The same is true when the contactor is opened and this input does not change to "0" in three seconds. (can be configured with HSP or GSDML)
LockActive	Bool	Cable lock active (True = yes, False = no) As long as this bit is set to "True", the charging plug is locked on the charging station side. Unlocking by the module is only enabled when this bit is set to "False". Basically, a new charging process can only be started if this bit is "False". Otherwise the LA is locked (without feedback to the user). If this parameter is permanently "False", unlocking is controlled by the module. This input parameter is especially useful when using Type 1 connectors (vehicle side), since the Type 1 connector is not automatically locked. Otherwise the charging cable could be stolen.
Locked	Bool	Locked (True = yes, False = no) If the feedback does not take place directly over the module (can be configured with HSP or GSDML), you can connect the feedback input of the locking process here. The charging process is canceled after three seconds if this input is not set to "1". A corresponding error is output at the DiagInfo output. The same is true for unlocking and when this input does not change to "0" in three seconds.
MaxCurr	Real	Maximum current of the charging source in ampere. If the specified charging current is less than 6 A or greater than 80 A, the PWM signal is disabled and the value of "MaxCurr" is set internally to "0" in the process image. This includes negative currents (< 0 A).
ACT_HIGH	Bool	Expanded as of FW version 1.0.4 and TIA Library as of version 1.2 ACT outputs False = ACT outputs ACT0p (or ACT1p) and ACT0n (or ACT1n) high resistance (depends on the "SocketOutlet" input parameter) True = ACT outputs corresponding to bit 6 and bit 7, provided that the "Interlock" parameter in the HSP or GSDML file is set to "No interlock" or "External (via PII)" (see table Adjustable parameters and their default settings)
ACT_P	Bool	Expanded as of FW version 1.0.4 and TIA Library as of version 1.2 Voltage at ACT output ACT0p (or ACT1p) (depends on the "SocketOutlet" input parameter) 0 = Output voltage 0V 1 = Output voltage 12V
ACT_N	Bool	Expanded as of FW version 1.0.4 and TIA Library as of version 1.2 Voltage at ACT output ACT0n (or ACT1n) (depends on the "SocketOutlet" input parameter) 0 = Output voltage 0V 1 = Output voltage 12V

Output parameters

Table 2-1405 List of output parameters

Parameter	Data type	Description
State	Byte	Charging state The state is output at this output largely according to IEC 61851-1. • 0: Charging outlet blocked (no state according to IEC 61851-1) • 1: State A (state according to IEC 61851-1) • 2: State B (state according to IEC 61851-1) • 3: State C (state according to IEC 61851-1) • 4: State D (state according to IEC 61851-1) • 5: State E (state according to IEC 61851-1, but is also displayed in case of CP error; the voltage at the CP output remains at +12 V, PWM is disabled in this case) • 6: State F (state according to IEC 61851-1)
CP_MaxVoltage	Real	Max. CP voltage value (in Volt)
ContactorContr	Bool	Load contactor state (module DQ state) (True = contactor on; False = contactor off) This output can be used for additional evaluations of the load contactor state in the TIA application (e.g. counting switching cycles for maintenance purposes).
LockControl	Bool	Locking (True = yes), Unlocking (False = no) This output can be used for additional evaluations of the locking state in the TIA application (e.g. for external control of locking the charging cable connector).
VentilationReq	Bool	Ventilation required (True = yes, False = no) This output signals that ventilation must be connected (State D according to IEC 61851-1).
PWM_State	Bool	PWM enabled (True = on, False = off) This output indicates whether PWM is switched on or off. PWM is disabled in case of CP voltage errors, locking feedback errors or ventilation feedback errors. This signals to the vehicle that charging is not possible under these circumstances.
MaxCableCurr	Real	Maximum detected current carrying capacity of the cable in ampere based on PP evaluation
PWM_MaxCurr	Real	Charging current [in ampere] signaled to the vehicle using PWM (minimum of the three values "FC input MaxCurr", "Current carrying capacity of the cable" and the parameter "Maximum charging current")
DiagInfo	Word	Diagnostic information of the charging outlet This output displays the error messages from the SIMATIC ET 200SP TM ECC 2xPWM ST technology module: • Bit 00: CP voltage level impermissible [a)] (may be vehicle problem; change to state E) • Bit 01: Reserved • Bit 02: Resistance at PP terminal too low [a), b)] (possibly inadmissible cable or wrong cable wiring for SAE J1772)

Parameter	Data type	Description
		• Bit 03: Resistance at PP terminal too high [a)] (may be impermissible cable) • Bit 04: No feedback after locking [a)] (may be connector problem) • Bit 05: No feedback after unlocking (CP output voltage goes to -12 V, change to state F) • Bit 06: No feedback after contactor ON [c)] (CP output voltage goes to -12 V, change to state F) • Bit 07: No feedback after contactor OFF [c)] (CP output voltage goes to -12 V, change to state F) • Bit 08: No ventilation active in case of request by vehicle • Bit 09: Overload ACT • Bit 10: Vandalism diagnostics • Bit 11..14: Reserved • Bit 15: Module-internal error [c)] (CP output voltage goes to -12 V, change to state F)
DI	Bool	Value of the digital input
Error	USInt	Bit 0 = invalid HW_ID Bit 1 = invalid value at SocketOutlet input Bit 2= invalid values PII

[a)] In these cases the error is acknowledged automatically as soon as the charging cable is unplugged from the charging station.

[b)] This error is also set if SAE J1772 operating mode is selected and the PP conductor of the charging cable is incorrectly connected to the module.

[c)] In these cases, the "Enable" input must be set to "0". After subsequent checking of this error state, this input must be reset to "1"; otherwise the corresponding charging outlet remains locked.

See also

Parameter (Page 28)

Interrupts/diagnostic messages

6

6.1 Status and error displays

Front view of the SIMATIC ET 200SP TM ECC 2xPWM ST technology module

Figure 2-1247 Device front with LEDs

Meaning of the LEDs

The following tables show the meaning of the status and error displays. You can find details for troubleshooting in the section "Diagnostics alarms (Page 46)".

DIAG LED

DIAG LED	Meaning	To remove and prevent errors
☐ Off	Backplane bus supply of the ET 200SP not OK	Check and switch on supply voltage of the head-end station. Make sure that the SIMATIC ET 200SP TM ECC 2xPWM ST technology module in inserted correctly into the BaseUnit.
☼ Flashing	Technology module not parameterized	Download a configuration that contains the technology module.
■ On	Technology module configured but no module diagnostics (no error present)	
☼ Flashing	Technology module configured and module diagnostics (at least one error present)	Check the configuration and parameter assignment in your engineering tool (e.g. TIA Portal) or evaluate the diagnostic interrupts and remedy the error.

NOTE

The DIAG LED only shows an error when you have enabled the corresponding diagnostic interrupt in the device configuration. By default, it is not enabled.

PWR LED

PWR LED	Meaning	To remove and prevent errors
☐ Off	No supply voltage L+	• BU type B1: Check the external 24 V DC supply voltage between L+ and M. • BU type B0: Check the 24 V DC supply voltage of the supplying potential group.
■ On	Supply voltage L+ present	

Status LEDs

LEDs	Meaning
EN0/EN1	**Charging outlet state (enable)**
☐ Off	Charging outlet 0 (EN0) or charging outlet 1 (EN1) disabled. The corresponding VS0/VS1-LED and error LED F0/F1 is also off in this case.
■ On	Charging outlet 0 (EN0) or charging outlet 1 (EN1) enabled.
☼ flashes, 1 Hz	Charging outlet 0 (EN0) or charging outlet 1 (EN1) blocked by user program.

LEDs	Meaning
☼ flashes, 2 Hz	Communications fault for charging outlet 0 (EN0) or charging outlet 1 (EN1). CPU is in STOP or the PIQ valid bit is not set.
VS0/VS1	**Vehicle state**
□ Off	No vehicle is connected to the charging station. (State "A") if no error is pending (see LED F0/F1) (State "F") if error is pending (see LED F0/F1)
■ On	A vehicle is connected to the charging station and ready for charging. (State "B")
☼ flashes, 1 Hz	Vehicle charging (State "C")
☼ flashes, 2 Hz	Vehicle charging, ventilation required (State "D")
Q0/Q1	**Contactor control**
□ Off	Contactor for charging outlet 0 (DQ0) or charging outlet 1 (DQ1) not controlled.
■ On	Contactor for charging outlet 0 (DQ0) or charging outlet 1 (DQ1) not controlled. (This is not a functional check for the corresponding contactor; it only shows whether it is activated. Only readback of the affected feedback input provides certainty.)
I0/I1	**Status/feedback DI**
□ Off	Status of the feedback input for charging outlet 0 (DI0) or charging outlet 1 (DI1)
■ On	Status of the feedback input for charging outlet 0 (DI0) or charging outlet 1 (DI1)
A0/A1	**Locking status**
□ Off	Status of connector locking for charging outlet 0 (A0) or charging outlet 1 (A1) "Connector unlocked" or no locking active (If no feedback is configured with GSDML or HSP, this LED always stays "off")
■ On	Status of connector locking for charging outlet 0 (A0) or charging outlet 1 (A1) "Connector locked"

Status LEDs

F0/F1	Error message	To remove and prevent errors
□ Off	No error	
■ On	External error Possible causes: • Short circuit of the CP conductor to earth • PP error • Locking feedback error • Ventilation feedback error	Please evaluate the corresponding diagnostic information in the feedback interface. It also provides detailed information. If you are using the "ECC4100 function", you can find the corresponding detailed information on the "DiagInfo" output parameter in the table "List of output parameters".

F0/F1	Error message	To remove and prevent errors
☼ Flashing	Internal error Possible causes: • Contactor feedback error • Hardware error in the module • Unlocking feedback error • PP error during parameter assignment "Charging cable permanently connected to the station"	Please evaluate the corresponding diagnostic information in the feedback interface. It also provides detailed information. If you are using the "ECC4100 function", you can find the corresponding detailed information on the "DiagInfo" output parameter in the table "List of output parameters".

See also

FC ECC4100 parameters (Page 39)

6.2 Interrupts

The TM ECC 2xPWM ST technology module does not have any hardware interrupts.

6.3 Diagnostics alarms

The DIAG LED flashes red when a diagnostics alarm is present.

In STEP 7 (TIA Portal), the diagnostic results are displayed by means of the Online and Diagnostics view. You can evaluate the error codes with the user program.

The following diagnostics alarms can be signaled:

Table 2-1406 Diagnostics alarms, their meaning and remedies

Diagnostics alarms	Error code	Meaning	Corrective measures
Error	9_H	An internal module error has occurred.	Replace module
No load voltage	11_H	No supply voltage L+ of the technology module	• Check BaseUnit type • Check wiring of the supply voltage L+ on the BaseUnit

Diagnostics alarms	Error code	Meaning	Corrective measures
External error	$1A_H$	This error can be caused by: • CP level not permitted The voltage value is not in the tolerance band specified in IEC61851. • Impermissible resistance at the PP terminal The resistance value in the connector of the charging cable does not correspond to the specified tolerance band. See (Page 37) paragraph "Plug Present signal PP0 and PP1". • Vandalism detected Vandalism is detected when the affected charging outlet is considered locked, but the resistance value at the associated PP terminal has become high resistance (e.g. when the charging connector was forcefully pulled out of the charging station socket). • No feedback after locking The signal of the feedback input does not match the "Locked" state. • No feedback after unlocking The signal of the feedback input does not match the "Unlocked" state. • No feedback after contactor "On" or "Off" The signal of the feedback input does not match the contactor state. • No feedback after ventilation "On" or "Off" The signal of the feedback input does not match the ventilation state.	• Check the wiring • Replace defective components
Channel / component temporarily unavailable	$1F_H$	Update of the firmware is being performed or has been canceled. The module does not read any process values in this state.	• Wait for firmware update • Restart the firmware update
Errors at digital outputs	4_H	This error can be caused by: • Overload at outputs ACT0n, ACT0p, ACT1n, ACT1p	• Check process wiring

6.4 Device defect

Repairs

Repairs by the user or service engineers are not permitted. In case of error please contact Service&Support (https://support.industry.siemens.com/cs/ww/en/sc/3098).

⚠ WARNING

Electric shock hazard

May cause death or serious injury

Unauthorized opening of the device might place the user in danger or result in substantial damage to property.

Technical specifications 7

7.1 Technical specifications

	6FE1242-6TM10-0BB1
General Information	
Product brand name	SIMATIC
Product family	ET 200SP
Product category	Technology module
Product type designation	TM ECC 2xPWM ST
Product designation	Charging controller for conductive charging of electric vehicles
Firmware version	V1.04
• FW update possible	Yes
Type of product	Technology module
Number of channels	2; according to IEC 61851 and SAE J1772
Product function	
I&M data	Yes; I&M 0 to 3
isochronous mode	No
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	STEP 7 V14 SP1 and higher
Installation type/mounting	
Mounting type	Standard mounting rail
Mounting position	vertical or horizontal
Supply voltage	
Voltage type of supply voltage	DC
Rated value (DC)	24 V
Permitted range, low limit (DC)	19.2 V
Permitted range, high limit (DC)	28.8 V
Reverse polarity protection	Yes; against destruction
Input current	
Current consumption, typ.	40 mA
Current consumption, max.	90 mA
Digital inputs	
Number of inputs	2; 1 per channel
Digital inputs parameterizable	Yes; 12 V/24 V
Functions of digital inputs, parameterizable	
Freely usable digital input	No, read-back contact contactor / connector locking

	6FE1242-6TM10-0BB1
Input voltage	
Type of input voltage	DC
For signal "0"	< 0.2x $U_{nominal}$
For signal "1"	> 0.6x $U_{nominal}$
Permitted voltage at input, min.	0 V
Permitted voltage at input, max.	30 V
Cable length	
Unshielded, max.	30 m
Digital outputs	
Type of digital output	Transistor
Number of outputs	2; 1 per channel
Short-circuit proof	Yes
Short-circuit protection	Yes; electronic / thermal
Functions of digital outputs, parameterizable	
PWM output	Yes; according to IEC 61851 and SAE J1772
• Number, max.	2; 1 per channel
• Time period, parameterizable	No; 1 kHz
Output switching capacity	
With resistance load, max.	1.3 A
Output voltage	
Type of output voltage	DC
Output voltage	24 V
Cable length	
Unshielded, max.	30 m
Protocols	
Bus communication	Yes
Vehicle communication according to IEC 61851	Yes; MODE 3
Vehicle communication according to SAE J1772	Yes
Interrupts/diagnostics/status information Interrupts	
Diagnostic interrupt	Yes
Diagnostics alarms	
Monitoring of supply voltage	Yes
Short circuit	No
Overload	Yes
Diagnostics indicator LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage (PWR LED)	Yes; green PWR LED
Channel status display	Yes; green LED
For module diagnostics	Yes; green/red DIAG LED

	6FE1242-6TM10-0BB1
Galvanic isolation **Galvanic isolation of channels**	
Between channels	No
Between channels and backplane bus	Yes
Insulation	
Insulation test voltage	707 V DC
Degree of pollution	2
EMC	
Electrostatic discharge according to IEC 61000-4-2: 2008	
Field-based interference according to IEC 61000-4-3: 2006	
Conducted interference / due to burst / according to IEC 61000-4-4: 2012	
Conducted interference / due to surge / according to IEC 61000-4-5: 2014	
Conducted interference / due to high-frequency radiation / according to IEC 61000-4-6: 2013	
Degree of protection and protection class	
IP degree of protection	IP20
Standards, approvals, certificates	
Proof of suitability	CE
Ambient conditions **Ambient temperature during operation**	
Minimum	-30 °C
Horizontal mounting position, max.	60 °C
Vertical mounting position, max.	50 °C
Ambient temperature during storage/transport	
Storage, min.	-40 °C
Storage, max.	70 °C
Transport, min.	-40 °C
Transport, max.	70 °C
Relative humidity	
Operation, min.	5%
Operation, max.	95%, no condensation
Extended range of ambient conditions	
with reference to ambient temperature, air pressure and altitude	T_{min} ... T_{max} at 1080 hPa ... 795 hPa (-1000 m ... +2000 m)
Distributed operation	
on SIMATIC S7-1500	Yes
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weight	32 g

Technical specifications of the BaseUnit

See ET 200SP BaseUnits Manual
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

SIEMENS

SIMATIC

ET 200SP
Technology module TM ECC PL ST (6FE1242-6TM20-0BB1)

Equipment Manual

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Preface

Preface

Purpose of the documentation

This manual contains module-specific information on wiring, diagnostics as well as the technical specifications of the technology module.

General information on installation and commissioning of the ET 200SP is available in the ET 200SP System Manual.

Conventions

Please take into account the notes marked as follows:

NOTE

A note contains important information on the product described in this documentation, its handling and to a section of the documentation to which you should pay particular attention.

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

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Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no

longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

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The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

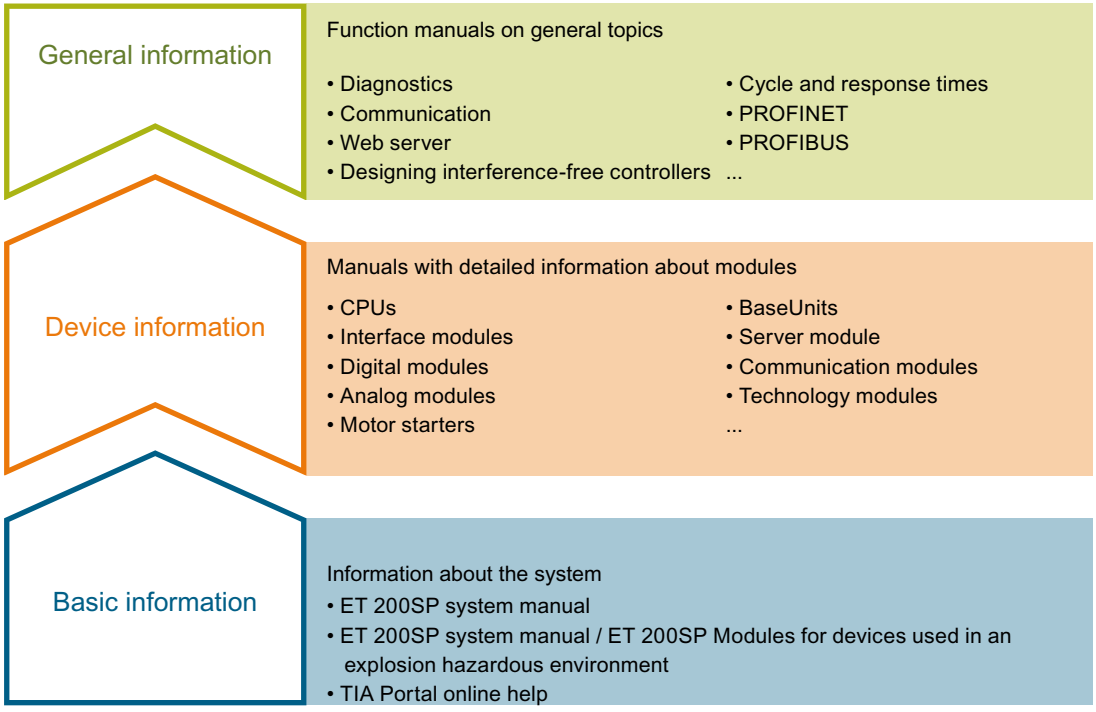

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

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You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet.

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant, incl. fail-safe inputs and outputs.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

See also

My Documentation Manager
(https://support.industry.siemens.com/My/ww/en/documentation)

Product overview

2

2.1 Properties

Article number

SIMATIC ET 200SP TM ECC PL ST 6FE1242-6TM20-0BB1

View of the module

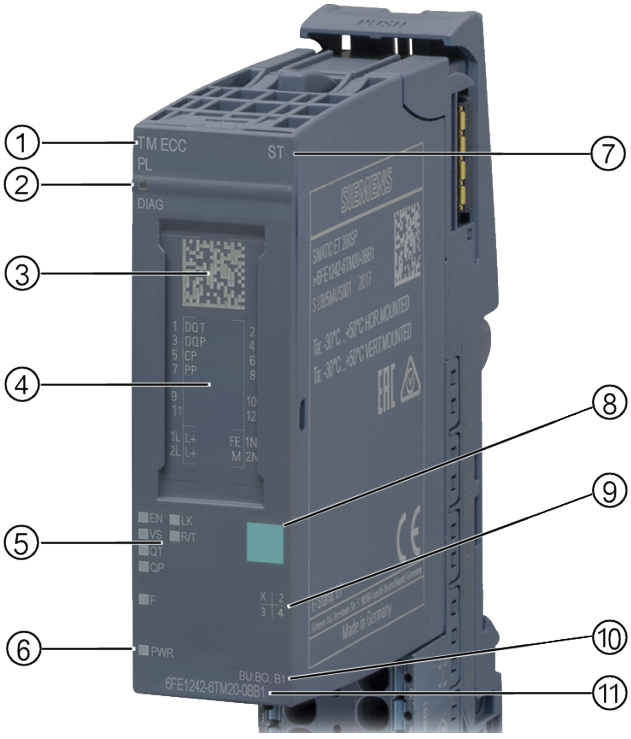

① Module type and name
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ Status LEDs
⑥ LED for supply voltage
⑦ Function class
⑧ Color labeling module type
⑨ Function state of the device
⑩ BU type
⑪ Article number

Figure 2-1248 View of the module SIMATIC ET 200SP TM ECC PL ST

Properties

The SIMATIC ET 200SP TM ECC PL ST technology module is used for control and monitoring of conductive direct current charging of electric vehicles in accordance with the standards DIN SPEC 70121 and ISO 15118-2, charging mode 4. To this purpose it provides a charging outlet.

NOTE

This manual does not describe the functional design of a charging station.

The module generates and monitors a CP signal (Control Pilot signal) according to IEC 61851-1.

Communication between the vehicle and the charging station takes place based on "PowerLine Green Phy" (HPGP). This overlays the "Control Pilot Signal". In accordance with the standard the "duty cycle" of the PWM signal is set fixed to 5%.

Its TRIP function is intended to ensure that the charging voltage (dangerous to touch) is only applied to the connected charging cable when:

- The charging cable is connected correctly
- The vehicle is ready to be charged or is charging (Charging state C or D)

In addition, this TRIP function enables you to switch off voltages on the charging cable that are dangerous to touch (e.g. by pulling the charging plug).

In addition the proximity contact PP (Plug Present) is monitored by means of the PP function (Page 19). As soon as the button is pressed at the charging plug or the plug is removed from the vehicle, the associated DQ P is set to "False". This means that the Open Collector output is high-impedance (see "Example circuitry of the switching contacts" in the section "Switching contact DQ T and DQ P").

To integrate the SIMATIC ET 200SP TM ECC PL ST technology module into the TIA environment, you need to use either function block "DIN_70121" (Page 39) or function block "ISO_15118" (Page 62), depending on the application. The selected function block monitors the respective breakers, initiates the cable check and makes the relevant current and voltage settings of the vehicle available to the associated frequency converters.

If an insulation monitor exists, it is evaluated (warning/fault). If a fault occurs at the insulation monitor, the frequency converter is shut down in a controlled manner - in as far as possible. The CP voltage level goes to -12 V.

If an emergency shutdown is required, the frequency converter is shut down in a controlled manner - in as far as possible. The CP voltage level goes to -12 V.

Note the following:

- After a charging process (even if terminated with error) a plug out must take place before a further charging process is possible.
- No vehicle must be connected during the module start-up.

Inputs and outputs

- 1x Control Pilot (CP)
- 1x Plug Present (PP) Relevant for Type 1 plugs in accordance with SAE-J1772
- 1x Digital Out (DQ) as Open Collector as TRIP function. Maximum 0.6 A.
  (Control Pilot signaling status)
- 1x Digital Out (DQ P) as Open Collector as PP function. Maximum 0.6 A.
  Relevant for Type 1 plugs in accordance with SAE-J1772.
  (Plug Present signaling status)

Diagnostics interface

The device has an interface inside the housing that can be used locally by customers for diagnostic purposes according to precise Siemens instructions. Use of this interface for other purposes is not permitted.

System environment

Firmware version 1.1 or higher:

- TIA Portal V17 or higher

Distributed operation in an S7-1500 system and as of FW version 1.0.3 also in an S7-1200 system:

- TIA Portal V15 or higher

Distributed operation in a system of third-party manufacturers is not possible.

Central operation with an:

- ET 200SP CPU
- Open Controller

Accessories

The following accessories can be used with the module and is not included in the scope of delivery:

- Labeling strips
- Color-coded labels
- Reference identification labels

A BaseUnit of the BU type B1 or BU type B0 is required to operate the technology module. You can find an overview of the BaseUnits that are compatible with the technology module in the Product information for documentation of the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/document/73021864?dti=0&lc=en-US).

You will find additional information on installation in the ET 200SP distributed I/O system System Manual (http://support.automation.siemens.com/WW/view/en/58649293).

Disposal

Electric and electronic devices do not belong in household waste. Dispose of the product at the end of its service life in accordance with the applicable legal requirements. By doing so you will meet the legal obligations and help protect the environment. WEEE Reg. No. DE 23691322

Configuration example

The charge controller described here is a technology module for SIMATIC ET 200SP. TIA Portal must be used as the configuration software.

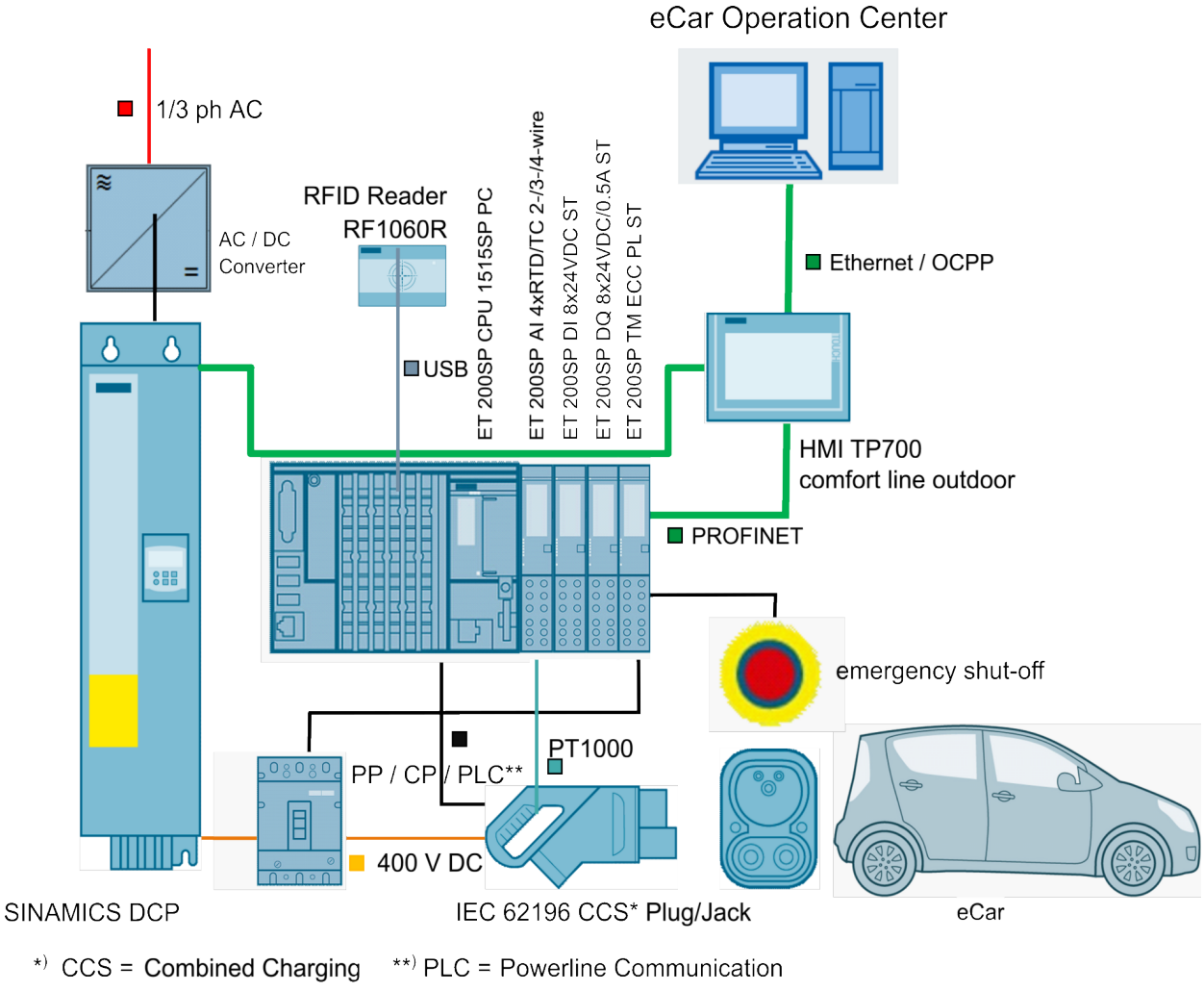

*) CCS = Combined Charging **) PLC = Powerline Communication

Figure 2-1249 Configuration example with one charging outlet

Updating the firmware

Information about carrying out the firmware update is provided in the ET 200SP System Manual. It is recommended to use at least TIA Portal V17.

NOTE

Firmware update

Note that an update to a version 1.1.x is only possible from version V1.0.11.

Note that a firmware update can only be performed in STOP mode.

NOTE

Duration of the firmware update

Note that the time it takes to update the firmware depends on the system environment.

The progress indicator in the TIA Portal dialog only changes to a value > 0% after approx. 5 minutes.

Update duration depends on the system environment:

- Central operation: approx. 120 minutes
- Distributed operation with an S7-1500: approx. 180 minutes
- Distributed operation "Stations accessible online in STEP 7 via firmware update": approx. 240 minutes

NOTICE

Supply voltage during the firmware update

The supply voltage of the ET 200SP station as well as the external voltage supply when using Base Unit B1 or the voltage supply of the feeding potential module when using Base Unit B0, must not be switched off during a firmware update.

Premature disconnection of the supply voltage may put the TM ECC PL ST technology module into an inoperative state which cannot be repaired.

2.2 Control Pilot

Control Pilot CP

The module generates a Control Pilot signal for the charging outlet. This signal is a square wave signal with 1 kHz frequency and an amplitude of +/-12 V. The duty cycle of the Control Pilot signal is set fixed to 5%. This signals to the vehicle that power line communication (HPGP) is possible. At the same time, the voltage level is monitored. This is evaluated by means of the firmware on the module. In parallel the signal is monitored by means of a hardware circuit in the form of the TRIP function. This guarantees low response times as soon as the charging state "C" or "D" is left.

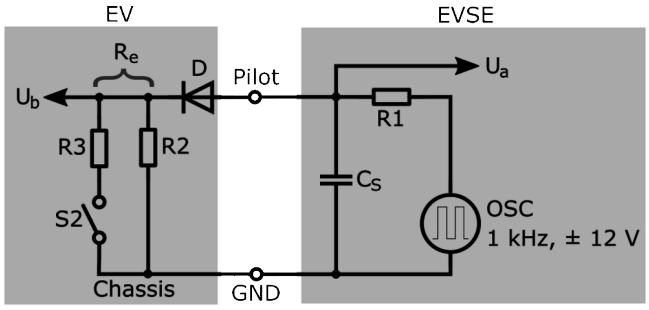

EVSE	Charging station
EV	Vehicle
R1	1000 Ω ± 3%
R2	2740 Ω ± 3%
R3	1300 Ω ± 3% (State C) or 270 Ω ± 3% (State D)
R_e	Input resistance of the vehicle CP interface
C_S	300 pF
U_a	Voltage measurement of the column
U_b	Voltage measurement (level, frequency, duty cycle) of the vehicle

Figure 2-1250 Typical pilot current

The vehicle indicates its state by applying corresponding resistances. In order to determine the vehicle state the positive component of the PWM signal is acquired as the peak value (U_a) and is read in:

Table 2-1407 States and level U_a

State	PWM	S2	Vehicle connected with charging station	Vehicle ready for charging	Charging station ready for charging	U_a	Remark [a)]
A1	Off	N/A	No	No	No	11 V ... 13 V	U_b = 0 V
A2	On				Yes		
B1	Off	Open	Yes	No	No	8 V ... 10 V	R_e = R2 = 2.74 kΩ [a)]
B2	On				Yes		
C1	Off	Closed	Yes	Yes	No	5 V ... 7 V	R_e = R2||$R3_C$ = 882 Ω [a)] Ventilation not required
C2	On				Yes		

[a)] The resistance R_e is the input resistance of the CP interface of the vehicle.

State	PWM	S2	Vehicle connected with charging station	Vehicle ready for charging	Charging station ready for charging	U_a	Remark [a)]
D1	Off	Closed	Yes	Yes	No	2 V ... 4 V	R_e = R2||$R3_D$ = 246 Ω [a)] Ventilation required
D2	On				Yes		
E	Off	N/A	N/A	N/A	No	-1 V ... 1 V	U_b = 0 V: EVSE, mains problem or mains not available, pilot wire short-circuit to ground, etc.
Invalid					No	-11 V ... -1 V	Invalid CP voltage
F					No	-13 V ... -11 V	E.g. charging station error, charging station in maintenance, etc.

[a)] The resistance R_e is the input resistance of the CP interface of the vehicle.

TRIP function

The amplitude of the CP (Control Pilot) pilot signal is evaluated. As soon as the Charge state C or the Charge state D (for the definition of the states please refer to IEC 61851-1) is reached, the associated Open Collector output (DQ T) becomes conductive. Otherwise it is high-impedance.

NOTE

Since the TRIP function is executed to a great extent in the hardware, state transitions in the charging process can be recognized and signaled very rapidly.

You can use the TRIP signal to observe the switch-off times required by the standard. Use application means to ensure that after the TRIP signal is deactivated (DQ T becomes high-impedance), the power flow is interrupted within the switch-off times required by the standard and that the charging cable is deenergized.

The shutdown delay of the DC output via the function blocks "DIN_70121" or "ISO_15118" is not suitable for guaranteeing the shutdown times required by the standards.

⚠ WARNING

To ensure that a fault state (see IEC 61851-23) is sustained after an interruption of the CP signal as required by the standard, you must prevent, on the application level, the unwanted changeover to standby mode after the CP fault.

2.3 Plug Present

Plug Present (relevant for Type 1 plug in accordance with SAE-J1772)

The state of the proximity contact (Plug Present; PP) is monitored. This is evaluated on the module. At the same time, the signal is monitored via a hardware circuit in the form of the PP function. This guarantees low response times as soon as the charging connector has been disconnected from the vehicle.

The following states are theoretically possible:

- Plug disconnected
- Plug connected and switch operated;
- Plug connected and switch not operated;

These states are additionally output at the associated function block "DIN_70121" or "ISO_15118".

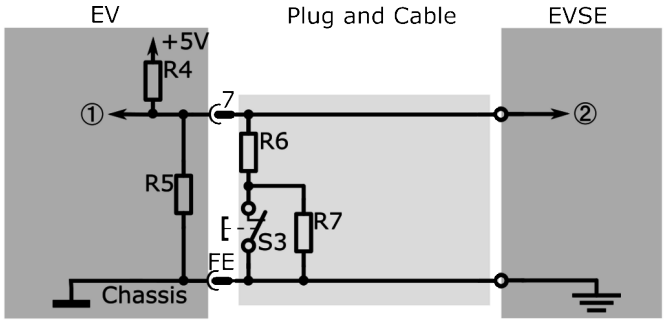

EVSE	Charging station
EV	Vehicle
Chassis	Chassis
R4	330 Ω ± 10%
R5	2740 Ω ± 10%
R6	150 Ω ± 10%
R7	330 Ω ± 10%
①	Recognition logic
②	EVSE control station

Figure 2-1251 Plug Present circuit

Table 2-1408 Plug Present signal

Voltage between terminal (7) and (FE)	Min [V]	Nominal [V]	Max [V]
On the vehicle, if the charging cable is not plugged in.	4.13	4.46	4.78
On the charging plug, if the charging cable is plugged in and the S3 button is not pressed (closed).	1.23	1.53	1.82
On the charging plug, if the charging cable is plugged in and the S3 button is pressed (opened).	2.38	2.77	3.16
On the charging station, if the charging cable is not plugged in.	-0.1	0	0.1

PP function

To this purpose the amplitude of the PP (Plug Present) voltage is evaluated. As soon as the PP plug is no longer connected to the PP socket, the associated Open Collector output (DQ P) becomes high-impedance; otherwise it is conductive.

NOTE

Since this trip function is executed to a great extent in the hardware, state transitions in the charging process can be recognized and signaled very rapidly.

To observe the switch-off times required by the standard you can use the PP signal. Use application means to ensure that after deactivation of the PP signal (DQ-P becomes high-impedance) the power flow is interrupted within the switch-off times required by the standard and that the charging cable is deenergized.

2.4 Charging communication according to DIN SPEC 70121

The DIN SPEC 70121 describes the digital communication between a direct current charging station and an electric vehicle for regulating the direct current charge in the combined charging system. This standard does not include the functions "Value added Service", "Plug&Charge", "V2G Energy Transfer" and "TLS encryption".

The Plug&Charge and TLS encryption enhancements are described in section "Enhancements relating to ISO 15118 as of FW Version V1.1.0 (Page 26)".

The charging controller TM ECC PL ST communicates with the vehicle in accordance with DIN SPEC 70121 using "PowerLine Green Phy" (HPGP). The power line communication is modulated to the Control Pilot (CP).

The module assumes the modulation or demodulation of the Ethernet data packages. These themselves are packed in an XML structure and transferred in the EXI format. The advantage of the EXI format is that the data can be packed more densely than in XML format.

Communication between the vehicle (EV) and the charging station (EVSE) is divided into different phases in the standard. Communication takes place in the form that the vehicle always sends a request (Req) and the charging station responds with a response (Res). A response code is always added to each response. This is described in DIN SPEC 70121 and ISO 15118.

NOTE

After completing a charging process, the charging plug must be removed from the vehicle before a new charging process can be started.

The charging station itself cannot send a request according to the standards.

The individual charge phases are:

- Session Setup
- Service Discovery
- Service and Payment Selection
- Contract Authentication
- Charge Parameter Discovery

- Cable Check
- Pre Charge
- Power Delivery
- Current Demand
- Welding Detection (if required by the vehicle)
- Session Stop

The following figure shows the individual phases chronologically.

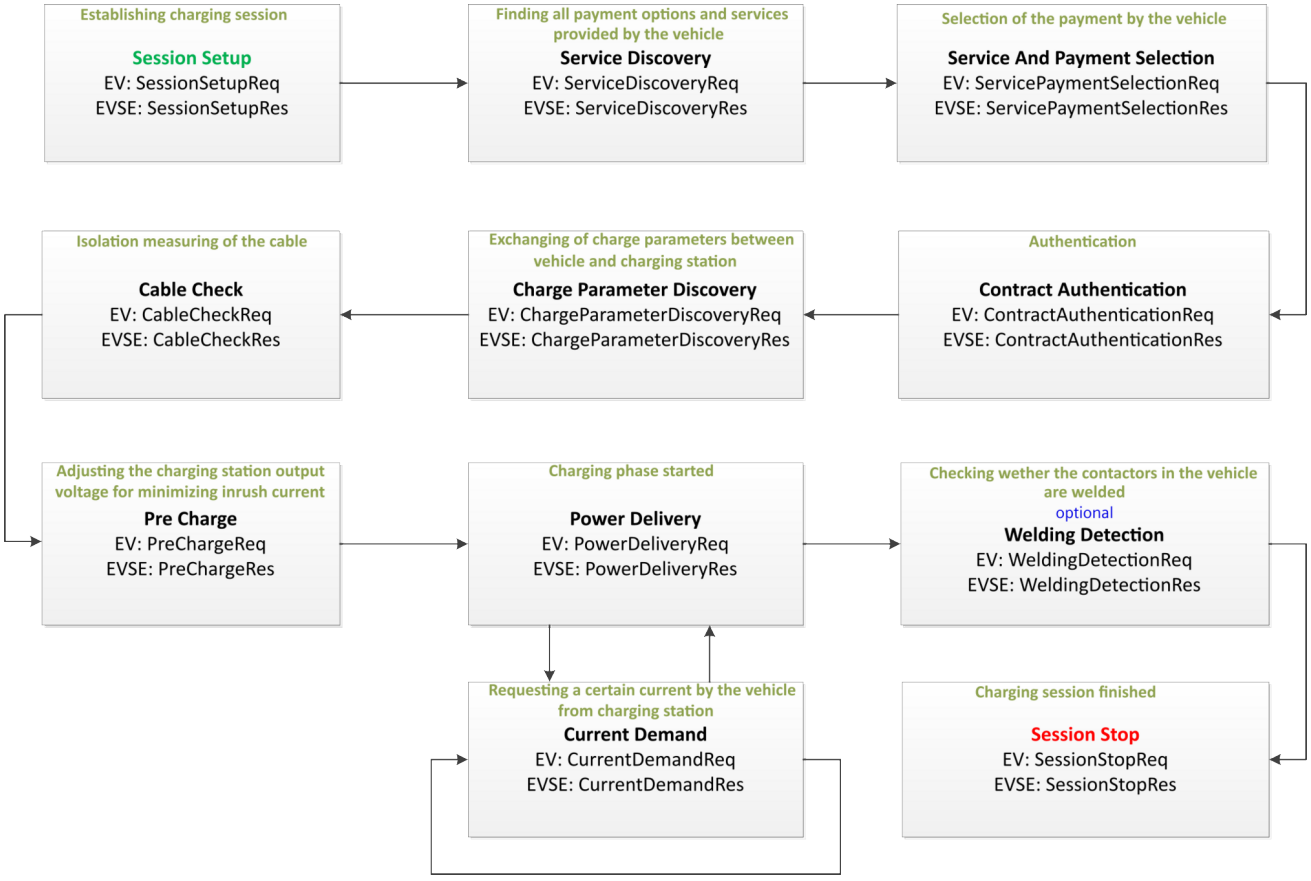

Figure 2-1252 Charge phases in accordance with DIN SPEC 70121

NOTE

The parameters are only listed as an example in the following descriptions of the charge phases. Refer to DIN SPEC 70121 for more information.

2.4.1 Session Setup

The communication starts with the setup of a session (Session Setup). To this purpose the vehicle sends a SessionSetupReq message to the charge column. This message contains the EVCCID (EV Charge Controller ID). This consists of the MAC address of the vehicle. The charge column confirms that a session has been set up by sending a SessionSetupRes message. This includes among other things the unique identifier of the charge column (EVSEID).

2.4.2 Service Discovery

After a session has been established successfully the vehicle starts with the search of the offered services. However, DIN SPEC 70121 does not support the search. Therefore no applicable data are exchanged between the vehicle and the charge column in this phase. The vehicle nevertheless sends a ServiceDiscoveryReq message to the charge column. The charge column confirms this by sending a ServiceDiscoveryRes message. This includes, among other things, the payment options of the charge column (in accordance with DIN SPEC 70121 only "External Payment" is supported) and the charge types supported by the charge column.

External Payment

"External Payment" means that the users of the vehicle must authenticate themselves directly for a charging process via the charging station (e.g. using RFID).

2.4.3 Service and Payment Selection

After going through the Service Discovery phase, the vehicle sends the payment method and the desired services to the charging station.

The DIN SPEC 70121 does not provide any services and only the "External Payment" payment option is available. Therefore no corresponding data are exchanged between the vehicle and the charge column during this phase.

The vehicle nevertheless sends a ServicePaymentSelectionReq message to the charge column. The charge column confirms it by sending a ServicePaymentSelectionRes message.

2.4.4 Contract Authentication

During this phase the authentication data for the payment process are exchanged between the vehicle and the charge column. Since only "External Payment" is available in DIN SPEC 70121, no relevant data is exchanged here.

The vehicle nevertheless sends a ContractAuthenticationReq message to the charge column. The charge column confirms it by sending a ContractAuthenticationRes message.

2.4.5 Charge Parameter Discovery

Once the charging contract has been concluded, the basic data relevant to the charging process is exchanged.

The vehicle sends a ChargeParameterDiscoveryReq message to the charging station. This contains the vehicle-specific data, such as:

- Charging method to be used
- Maximum charging current
- Maximum charging voltage
- Maximum charging power during the complete charging process
- Current state of the vehicle
  (the possible states are described in DIN SPEC 70121)

The charging station answers these by sending a ChargeParameterDiscoveryRes message.

This includes for example:

- Maximum charging current
- Maximum charging voltage
- Maximum charging power
- Minimum voltage
- Minimum current
- Current state of the charging station
  (the possible states are described in DIN SPEC 70121)

2.4.6 Cable Check

In the Cable Check phase the check of the charging cable used (among other things the insulation resistances) has to be initiated for the DC charge. The check is carried out by the charge column and the result is communicated to the vehicle.

The vehicle sends a CableCheckReq message to the charge column. This initiates a corresponding cable check.

The charge column responds by sending a CableCheckRes message.

This message exchange can be repeated several times until the Cable Check has been completed or a fault has occurred.

2.4.7 Pre Charge

This is followed by the what is referred to as a Pre-charge phase. In this phase the output voltage of the frequency converter is matched as close as possible to the input voltage of the vehicle. This avoids high inrush currents.

The vehicle sends a PreChargeReq message to the charge column.

This includes for example:

- Current state of the vehicle
- Target voltage of the frequency converter
- Target current of the frequency converter

The charge column responds by sending a PreChargeRes message.

This includes for example:

- Current state of the charge column
- Current voltage of the frequency converter

This message exchange can be repeated several times until the vehicle accepts the voltage of the frequency converter that is offered.

2.4.8 Power Delivery

The Power Delivery phase marks the moment as of which the vehicle is connected to the charging station from the point of view of the current flow (the DC breakers in the vehicle are closed) and charging of the battery can be started. On the other hand it marks the moment at which the charging process ends and the current flow is disconnected (the DC breakers in the vehicle are opened).

The vehicle sends a PowerDeliveryReq message to the charging station. This includes the "Ready to Charge" state. If this status is "True", this identifies the start time of the actual charging process. If this bit is "False", it identifies the termination of the actual charging process.

The charging station responds by sending a PowerDeliveryRes message.

2.4.9 Current Demand

After passing through the power delivery phase (the "Ready to charge" status has to be "True" here), the current demand phase takes place. In this phase the charging of the vehicle takes place. To this purpose the vehicle sends the target voltage and the target current to the charge column. The charge column transfers the current voltage and current values of the frequency converter.

The vehicle sends a CurrentDemandReq message to the charge column.

This includes for example:

- Current state of the vehicle
- Target current of the frequency converter
- Target voltage of the frequency converter
- 100% charge of the vehicle reached

The charge column responds by sending a CurrentDemandRes message.

This includes for example:

- Current state of the charge column
- Current voltage of the frequency converter
- Actual current of the frequency converter
- Maximum voltage of the frequency converter reached
- Maximum current of the frequency converter reached
- Maximum power of the frequency converter reached

2.4.10 Welding Detection

After completion of the charge process the DC breakers in the vehicle are checked for "welding". This check is optional and is initiated by the vehicle.

The vehicle sends a WeldingDetectionReq message to the charge column. This includes the current state of the vehicle.

The charge column responds by sending a WeldingDetectionRes message.

This includes for example:

- Current voltage at the charging cable

2.4.11 Session Stop

After completion of the Welding Detection phase the charging session is completed.

Information: If the Welding Detection is not requested by the vehicle, the "Session Stop" is started by the vehicle directly after the PowerDelivery phase.

To this purpose the vehicle sends a SessionSetupReq message to the charge column. This does not contain further data.

The charge column responds by sending a SessionStopRes message. It contains the ResponseCode.

2.5 Enhancements relating to ISO 15118 as of FW Version V1.1.0

ISO 15118 represents an extension of DIN SPEC 70121. This means that all statements regarding the "DIN_70121" FB similarly apply to the "ISO_15118" FB as well.

As of FW V1.1.0, payment using "Plug and Charge" (PnC) is possible according to ISO 15118. The corresponding contract data for this is stored in the vehicle. PnC requires encrypted communication (TLS) between the vehicle (EV) and charging station (in this case, the TM ECC PL ST module). On-site payment, e.g. using an RFID card reader, is still possible if this is implemented in the charging station (EVSE).

NOTE

If encrypted communication between the EV and EVSE is to be supported, you must set the time and date on the associated controller correctly.

No optional services (Value Added Services) are supported

This manual does not describe the Open Charge Point Protocol (OCPP) in detail.

The following figure shows the individual phases chronologically.

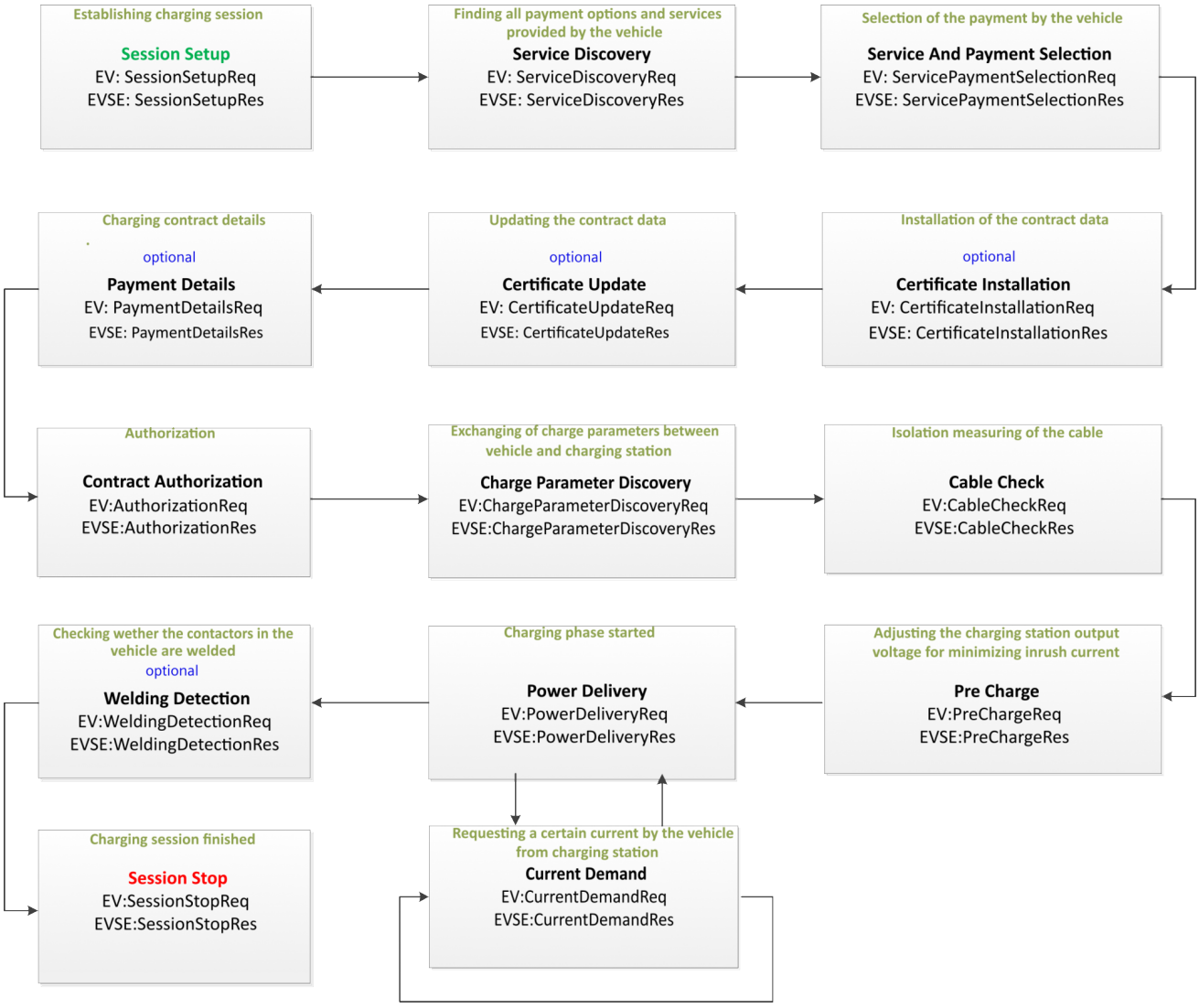

Figure 2-1253 Charge phases according to ISO 15118 (relevant phases for PnC)

The following functionalities have been implemented for payment using PnC:

- Certificate Signing Request (CSR)
  Certificate handling relating to TLS encryption (installation or update)
- Contract Certificate (CC)
  Transfer of the contract certificate of a vehicle to the backend

NOTE

If you only want support for DIN SPEC 70121, you can still use the "DIN_70121" function block (see section ""DIN_70121" function block (Page 39)").

2.5.1 Certificate signing request (CSR)

For encrypted communication using TLS, a valid certificate must exist on the TM ECC PL ST module. A basic distinction is made here between a certificate installation and a certificate update.

- Certificate installation:
  No certificate exists yet. It must be created and stored in the module.
- Certificate update:
  A certificate exists on the module but its validity must be renewed (these certificates have only a limited period of validity).

The certificate must be created in PEM format and include the following in the described order:

- leaf certificate (signed certificate)
- sub2 certificate (optional)
- sub1 certificate (optional)
- root certificate

A TLS certificate in PEM format is a Base64-encoded text file, identified by specific delimiter lines (Header and Footer).

The installation or update is triggered by the module and signaled accordingly at the output of the function block "ISO_15118". As soon as a corresponding certificate is available, it can be loaded into the module via the function block (see section "Triggering the CSR by the TM ECC PL ST module (Page 69)").

However, the CSR can also be triggered by the back end, for example (see section "External triggering of the CSR (Page 70)").

NOTE

This process is independent of a pending charging process and can be initiated at any time. This procedure is not described in ISO 15118.

2.5.2 Contract Certificate (CC)

The contract data is transferred, in accordance with ISO 15118, from the vehicle to the module in the PaymentDetailReq() frame. These are then made available at the output of the "ISO_15118" function block and must subsequently be validated.

The validation takes place in the backend. The Open Charge Point Protocol (OCPP) is normally used for the communication between the charging station and backend.

The result of the validation is applied at the input of the FB and transferred to the vehicle using AuthorizationRes() and PaymentDetailRes() (see also section "Check of the contract of a vehicle (Page 66)")

Wiring 3

3.1 Terminal assignment and power supply

You have to use a BaseUnit of the BU type B1 or BU type B0 for the SIMATIC ET 200SP TM ECC PL ST.

Connect all the required inputs/outputs (CP, PP, DQ T, DQ P) - and in the case of a BaseUnit BU type B1 also a 24 V DC voltage source - to the BaseUnit of the technology module.

NOTE

Note that interferences with particularly high voltage levels can occur at cables that are routed outside buildings due to environmental factors.

The SIMATIC ET 200SP TM ECC PL ST is designed for overvoltages in industrial environments within buildings.

The supply of several charging stations with a shared 24 V supply is not recommended.

When selecting the locally mounted 24 V power supply unit take into account that it has to be suitable to bridge voltage drops possibly existing on the supply line of the charging station.

NOTICE
All the external connections of the BaseUnit are sourced to the same ground potential For the charging equipment to function without problems, you need a ground rod at the charging station as reference for this ground potential. Galvanic isolation exists to the system bus of the ET 200SP.

NOTE

Ensure a low resistance connection of the standard mounting rail to the ground potential (FE). Design according to VDE 0100-600.

You must also regularly check the functioning of the functional ground connection during the proof tests that are performed for the charging equipment.

BaseUnit

The BaseUnit is not included in the scope of delivery of the technology module SIMATIC ET 200SP TM ECC PL ST. It must be ordered separately.

You can find an overview of the BaseUnits that are compatible with the technology module in the Product information for documentation of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/73021864).

Information regarding selection of a suitable BaseUnit can be found in the ET 200SP Distributed I/O System System Manual

(http://support.automation.siemens.com/WW/view/en/58649293) and in the ET 200SP BaseUnits Manual (https://support.industry.siemens.com/cs/ww/en/ps/14070/man).

Pin assignment of the BaseUnit BU type B1

The table shows the pin assignment of the BaseUnit BU20-P12+A0+4B (6ES7193-6BP20-0BB1). The power supply of this BaseUnit is not looped through, which means downstream BaseUnits are not supplied by this BaseUnit. The same downstream BU requires its own power supply. This means the BaseUnit is its own potential group.

The BaseUnit BU type B1 must be supplied with safety extra-low voltage (SELV) or protective extra-low voltage (PELV).

All 24 V nominal power supplies of the I/O circuits must only be powered by approved sources that fulfill the requirements according to EN61010-2-201 for SELV, PELV, Class 2, voltage limited and/or power limited sources.

Designation	I/O name		View	I/O name		Designation
DQ for TRIP line	DQ T	1	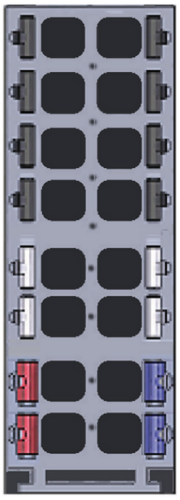	2	-	Not used
DQ for PP	DQ P	3		4	-	Not used
Control Pilot	CP	5		6	-	Not used
Plug Present signal	PP	7		8	-	Reserved
Not used	-	9		10	-	Not used
Not used	-	11		12	-	Not used
External 24 V DC power supply input Pins 13 and 15 are connected internally.	L+	13		14	FE	FE and ground for supply voltage Pins 14 and 16 are connected internally.
		15		16	M	

Pin assignment of the BaseUnit BU type B0

To connect to or use an existing potential group, you must use the following BaseUnit.

A new potential group is not created with the BaseUnit BU type B0 (BU20-P12+A4+0B / 6ES7193-6BP20-0BB0). It continues the potential group. The self-establishing voltage busbars P1, P2 and the AUX rail are looped through to the neighboring module (BaseUnit) on the left.

All 24 V nominal power supplies of the I/O circuits must only be powered by approved sources that fulfill the requirements according to EN61010-2-201 for SELV, PELV, Class 2, voltage limited and/or power limited sources.

NOTE

The ground of the voltage supply must be connected to the potential group with PE.

Designation	I/O name		View	I/O name		Designation
DQ for TRIP line	DQ T	1	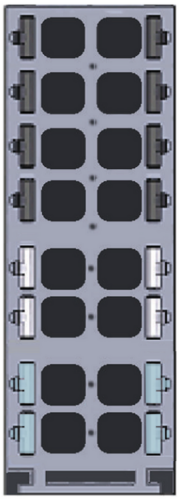	2	-	Not used
DQ for PP	DQ P	3		4	-	Not used
Control Pilot	CP	5		6	-	Not used
Plug Present signal	PP	7		8	-	Reserved
Not used	-	9		10	-	Not used
Not used	-	11		12	-	Not used
	AUX	13		14	AUX	
		15		16		

Switching contact DQ P, DQ T

- The digital outputs are protected against short-circuit.
- The digital outputs are equipped for switching inductive loads with a protective diode.

NOTE

Connect an external protection element to the relays or contactors to suppress self-inductance when switching off inductive loads.

We recommend using contactors with integrated protection elements.

You must supply the contact blocks with a voltage source with limited voltage and/or power (SELV, PELV according to EN61010-1 and EN61010-2-201, Class 2).

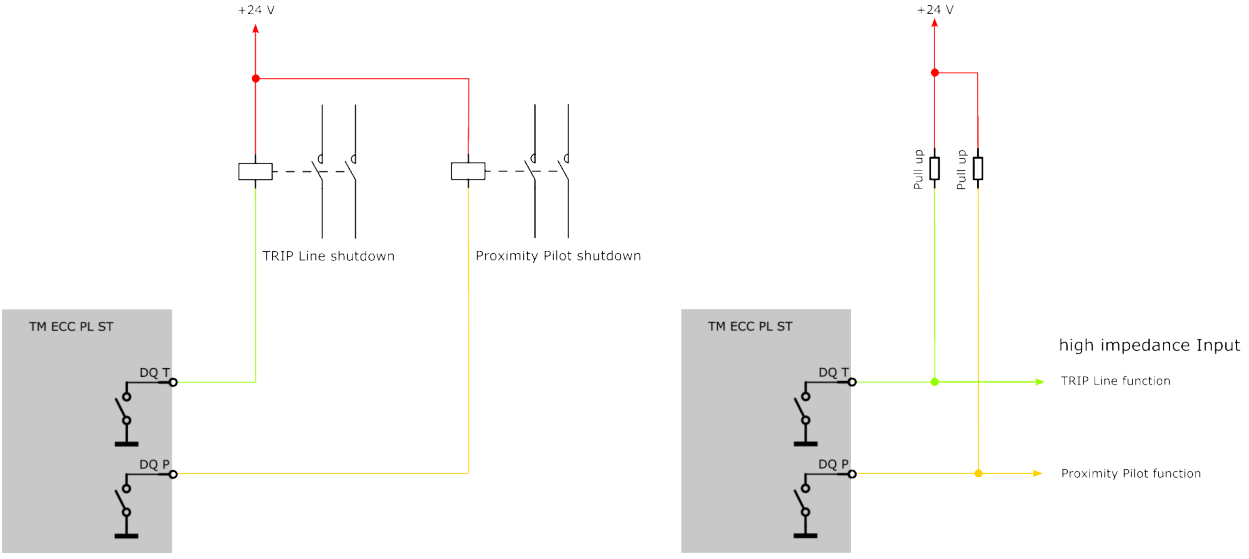

Figure 2-1254 Example circuits for the switching contacts

Table 2-1409 Behavior of the outputs DQ T and DQ P

Output	Scenario	Behavior
DQ T	CPU STOP during a charging process (state C)	High resistance
	Module is pulled during a charging process (state C)	High resistance
	PROFINET interruption between CPU and interface module (IM) during a charging process (state C)	High resistance
DQ P	CPU STOP during a charging process (state C)	High resistance
	Module is pulled during a charging process (state C)	High resistance
	PROFINET interruption between CPU and interface module (IM) during a charging process (state C)	Low resistance

External L+ power supply (only for BaseUnit type B1)

Connect an external 24 V DC voltage supply of the type SELV/PELV (to EN61010-2-201, Class 2) to the connections L+ and M in order to supply voltage to the technology module SIMATIC ET 200SP TM ECC PL ST. The voltage input of the technology module has electrical reverse polarity protection.

The technology module monitors only its supply voltage.

NOTE

L+- and M insulation at the technology module SIMATIC ET 200SP TM ECC PL ST with help of the BaseUnit type B1.

The L+ and M connectors on the BaseUnit of type B1 are galvanically isolated from the neighboring BaseUnits to the left and right. The L+ and M busbars run through the BaseUnit type B1 (without connectors) and expand the busbar with connectors for BaseUnits on the left and right.

3.2 Connection examples

Block diagrams

The circuit diagrams below show the schematic wiring of the technology module with the typical options for use of the feedback input.

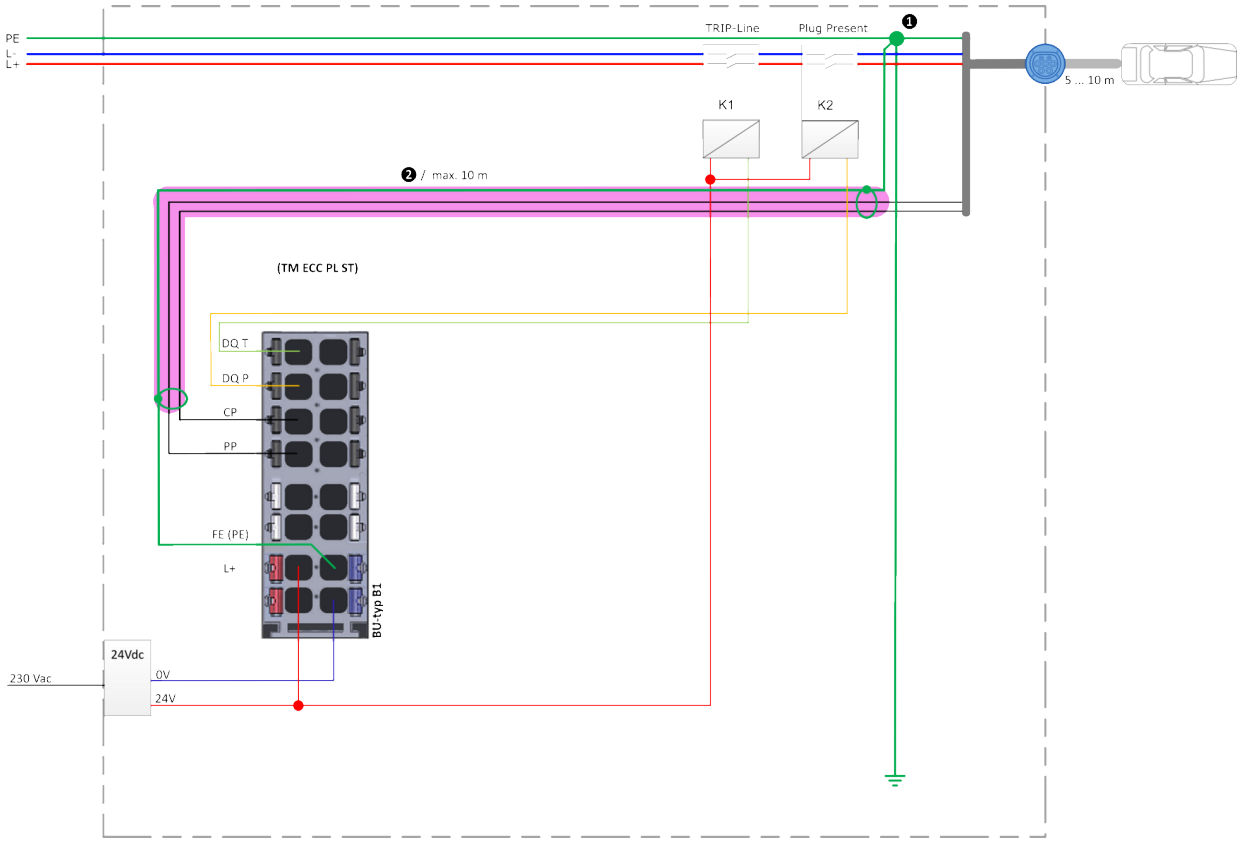

Figure 2-1255 Connection example of the technology module with fast shutdown (when a BU type B1 is used)

NOTE

Wiring

The CP signal uses a bandwidth of 0 Hz ... 30 MHz. For the best possible signal quality we recommend setting the charge controller as close as possible to the connection point ① of the charging cable. If this is not possible due to the spatial layout, use a shielded connection cable for the CP and PP signal in the case of cable lengths exceeding 1.0 m.

We recommend the use of a PROFIBUS cable (6XV1830...) ②. One wire must carry the CP signal and the other the PP signal and the ground potential must be carried from the star point ① via the shield of the cable to the BaseUnit / charge controller.

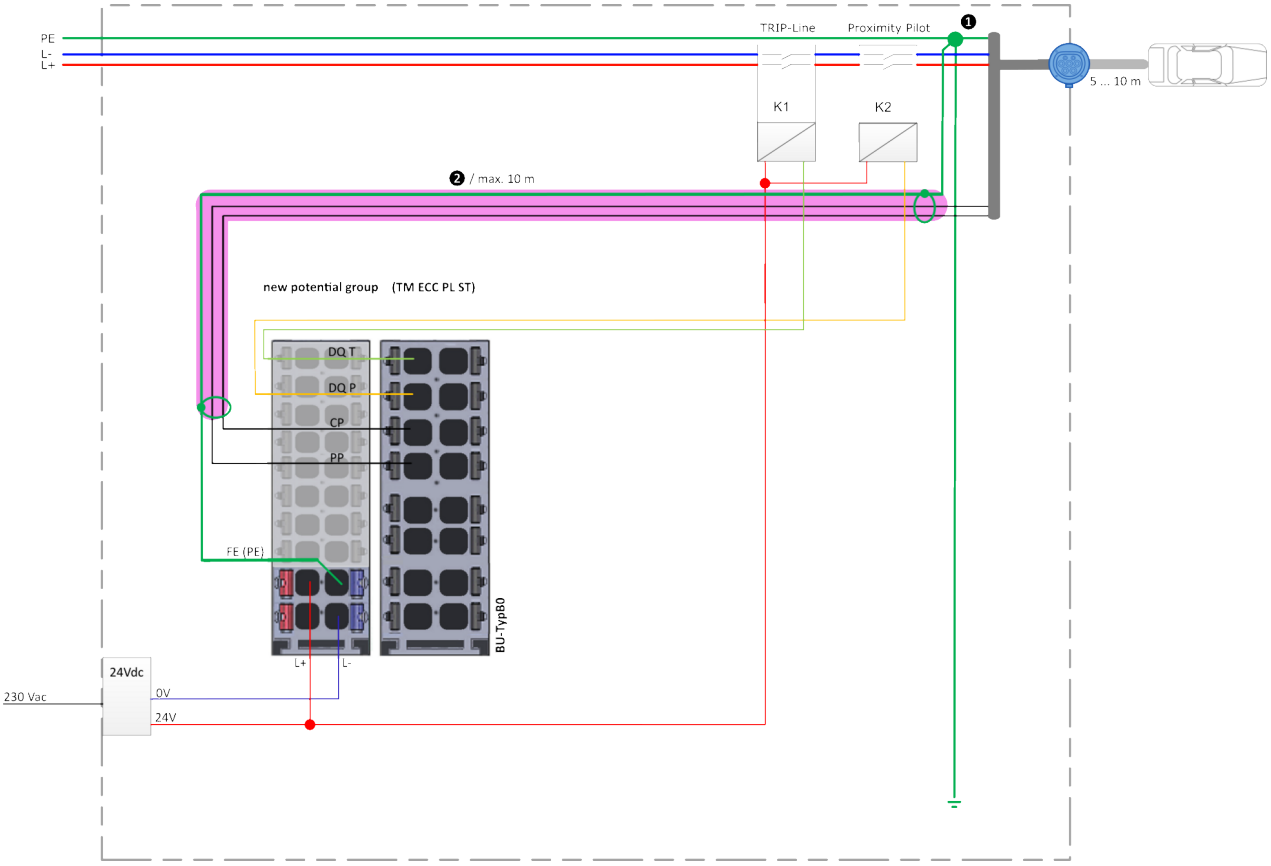

Figure 2-1256 Connection example of the technology module with fast shutdown (when a BU type B0 is used)

3.3 Installation instruction

Notes on IT security

To prevent manipulation of the module, measures must be taken by the owner-operator or person responsible for the system so that unauthorized access is prevented. An effective physical/mechanical access restriction to the module and its interfaces is absolutely mandatory.

Configuring / Address space

4

4.1 Configuring

Introduction

You can configure the SIMATIC ET 200SP TM ECC PL ST technology module with the configuration software or use the configuration software to assign parameters.

System environment

You can use the technology module in the following system environments:

Table 2-1410 Possible applications of the technology module with PROFINET I/O

Applications	Required components	Configuration software	In your program
Distributed operation in an S7-1500 system	• S7-1500 Automation system • ET 200SP Distributed I/O System • Technology module SIMATIC ET 200SP TM ECC PL ST	STEP 7 (TIA Portal): Device configuration and parameter settings with the hardware configuration (HWCN)	Access only via function block "DIN_70121" / "ISO_15118"
Distributed operation in an S7-1200 system (as of FW version 1.0.3)	• S7-1200 Automation system • ET 200SP Distributed I/O System • SIMATIC ET 200SP TM ECC PL ST technology module	STEP 7 (TIA Portal): Device configuration and parameter settings with the hardware configuration (HWCN)	Access only via function block "DIN_70121" / "ISO_15118"
Centralized or distributed operation in an ET 200SP system	• ET 200SP automation system • Technology module SIMATIC ET 200SP TM ECC PL ST	STEP 7 (TIA Portal): Device configuration and parameter settings with the hardware configuration (HWCN)	Access only via function block "DIN_70121" / "ISO_15118"

Hardware Support Package (HSP)

If you cannot find the SIMATIC ET 200SP TM ECC PL ST technology module in the hardware catalog of the TIA Portal, you must install the corresponding HSP file (HSP0261 ET200SP ECC PL can be used up to Firmware Version 1.0; use HSP0351 ET200SP ECC PL for FW Version 1.1 or higher).

The Hardware Support Package (HSP) is available for download at (https://support.industry.siemens.com/cs/ww/en/view/72341852).

4.2 Reaction to CPU STOP

At CPU STOP an active charging process is terminated immediately. This means the PWM signal on the CP switches to "-12 V" (EVSE status not available).

Breakdowns in communication, such as an interruption of the PROFINET connection, are treated as CPU STOPs.

4.3 Required I/O address space

Address space of the technology module

Table 2-1411 Scope of the I/O addresses of the technology module SIMATIC ET 200SP TM ECC PL ST

	Inputs	Outputs
Scope	32 bytes	32 bytes

4.4 Parameter

Parameter

You specify the properties of the technology module using various parameters. These can be assigned via the HSP. You cannot change the parameter assignment in the user program.

You have the following options for setting the parameters of the module:

Table 2-1412 Parameter assignment options

Parameter settings using the ...	Basic procedure
Hardware configuration in STEP 7 with HSP file	1. Install the corresponding HSP file. You can then find the module in the hardware catalog under "Distributed IO devices \ ET 200SP \ Technology modules \ Charging \ TM ECC PL 12V ST". 2. Set the device configuration and the parameters in the hardware configuration. 3. Download the parameter assignment to the module.

Adjustable parameters

Table 2-1413 Configurable parameters and their defaults

Parameter	Value range	Default setting	Configuration in RUN
Charge standard	DIN SPEC 70121 / ISO 15118	DIN SPEC 70121 / ISO 15118	No

4.5 Control and feedback interface

4.5.1 Assignment of the control interface

The module must be used with function block "DIN_70121" or function block "ISO_15118".

4.5.2 Assignment of the feedback Interface

The module must be used with function block "DIN_70121" or function block "ISO_15118".

4.5.3 System functions used

The "RDREC" and "WRREC" system functions are used for communication with the technology module.

Programming 5

5.1 General information

To operate the SIMATIC ET 200SP TM ECC PL ST technology module in your user program, you must use the "DIN_70121" or "ISO_15118" function block.

The "ISO_15118" function block supports charging in accordance with DIN SPEC 70121 and ISO 15118.

The function blocks can be downloaded from SIEMENS Customer Support (https://support.industry.siemens.com/cs/de/en/ps/18330/dl). They are available in the form of the TIA library "ET 200SP TM ECC". There the FB involved can be found in the folder Types/DIN_70121 or Types/ISO_15118.

NOTE

You can insert the following blocks with SIMATIC 1500 CPUs as of FW version 2.0 and SIMATIC 1200 CPUs as of FW version 4.2.

5.2 "DIN_70121" function block

Introduction

This section presents the properties of the "DIN_70121" function block. It exists in three versions:

- DIN_70121_1500 (for CPU15xx)
- DIN_70121_1200 (for CPU12xx)
- DIN_70121_OC (for Open Controller)

The three function blocks behave identically. For the sake of clarity, only the "DIN_70121" function block is referred to in the following.

The following figure shows the inputs/outputs of the "DIN_70121" function block.

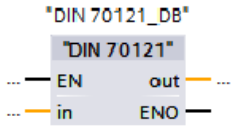

Figure 2-1257 "DIN_70121" function block

The "DIN_70121" function block appears in the structure of the TIA library.

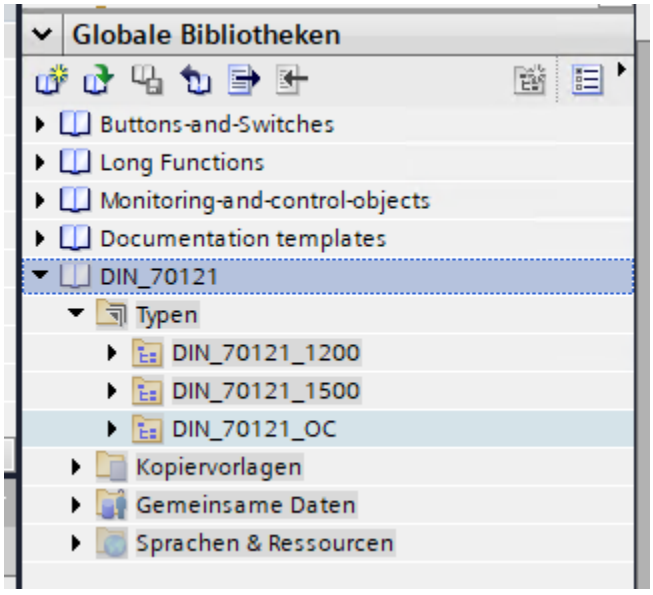

Figure 2-1258 Structure of the TIA library "DIN_70121"

The "DIN_70121_1200" folder contains the blocks for the S7-1200 controllers, and the "DIN_70121_1500" folder contains the blocks for the S7-1500 controllers. The blocks for the "Open Controller" are contained in the "DIN_70121_OC" folder.

For configuring, you can only use the "DIN_70121" function block itself. The "DIN_70121 Support" folder contains internal auxiliary functions.

5.2.1 Required memory of the "DIN_70121" function block

Memory requirement

The memory requirement of FB "DIN_70121" is shown below:

Table 2-1414 Memory requirement of the "DIN_70121" function block

	Load memory	Code work memory	Data work memory
First instance	1.04 MB	50.72 KB	3.25 KB
Additional memory required for each additional instance	14.9 KB	0	3.25 KB

5.2.2 Principle of operation of the "DIN_70121" function block

This function block represents the interface between the technology module and the TIA application of the charging station. The block checks the voltage on the charging cable (external voltage check) before the actual cable check takes place. It controls the frequency converter for the cable check and evaluates the result of the associated current measurement. In the "PreCharge" phase the voltage of the frequency converter is increased correspondingly. In the "CurrentDemand" phase the frequency converter is controlled correspondingly with the actual current and voltage specifications of the vehicle and monitored whether the frequency converter has followed the specifications of the vehicle within a defined response time.

The associated breakers are closed or opened respectively in accordance with the individual charge phases for different versions of frequency converters or their circuitry.

NOTE

The function block transfers the setpoints (out.setpoints), but does not check their plausibility with regard to the actual values (in.values) at its input.

5.2.2.1 Startup characteristics of the function block

The hardware state "hwState" is set to 2 (wait state) after the associated controller is switched on or after a STOP⇒RUN transition of the controller. The I/O modules must be switched on so that the breakers, if closed, can be opened.

The startup is finished after 10 seconds. A charging process can be started.

There is no time monitoring of the breakers and the hardware status during start-up.

5.2.2.2 Response to errors

If an error has occurred, the SW state (out.swState) is initially set to "-1" (an error has occurred; the charging column is currently ramping down). The frequency converter is then ramped down, if necessary, and the breakers are opened.

After the frequency converter has ramped down and the breakers are opened, the SW state is set to "-2" (an error has occurred; the charging column has ramped down). After 10 seconds the SW state is set to "-3" (an error has occurred; the charging column has ramped down). Errors not requiring acknowledgment are automatically acknowledged.

Errors requiring acknowledgement can now be acknowledged via "in.ackErrors". For acknowledgment "in.ackErrors" must be set to "True". After acknowledgment, "in.ackErrors" must be set to "False" because all other errors are still acknowledged as long as this input is "True".

5.2.2.3 Possible circuitry of a frequency converter

The "DIN_70121" function block has been prepared for various variants of frequency converters. From the "DIN_70121" function block, it is possible to control the DC breaker, a breaker required for the precharge phase and the breaker for a shunt (if a minimum current is necessary to start up the frequency converter). The closing operation or opening operation of the breaker is time-monitored. To this purpose a feedback contact is required.

Controlling of the breakers is respectively optional. The breakers configured at the function block are then closed or opened depending on the pending charging phase.

The voltage and current value of the installed measuring instruments is evaluated in the "DIN_70121" function block according to the individual charging phases or is transferred to the vehicle.

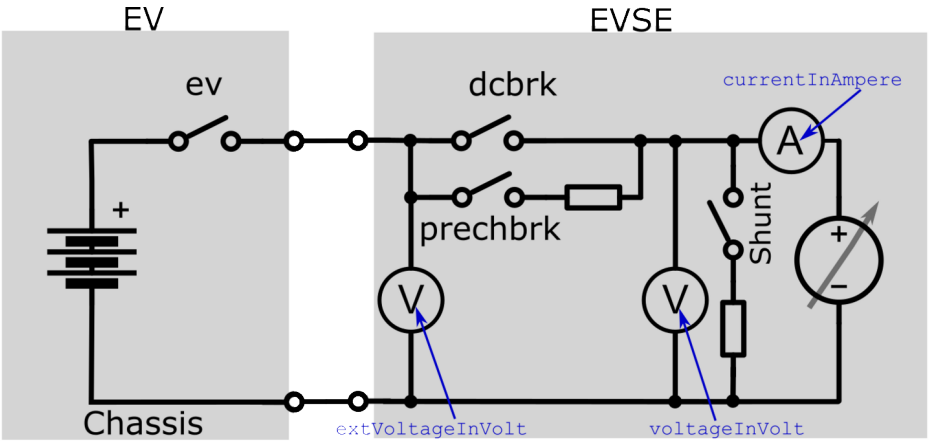

Figure 2-1259 Maximum configuration of the circuitry of the frequency converter

Corresponding parameters at the function block:

- DC breaker activated:
  in.evseCfg.dcbrkIsUsed
- PreCharge breaker activated:
  in.evseCfg.prechbrkIsUsed
- Shunt breaker activated:
  in.evseCfg.shuntIsUsed
- Resistance of the Shunt in ohm:
  in.evseCfg.shuntValueInOhm
- Time monitoring of breakers:
  in.evseCfg.maxSwitchTimeBreaker
- Feedback signal of the DC breaker:
  in.values.dcbrk
- Feedback signal of the PreCharge breaker:
  in.values.prechbrk
- Feedback signal of the shunt breaker:
  in.values.shunt
- Voltage measured value at the frequency converter:
  in.values.voltageInVolt

- Voltage measured value between the DC breaker and the vehicle:
  in.values.extVoltageInVolt
- Current measured value:
  in.values.currentInAmpere
- DC breaker control
  out.setpoints.dcbrk
- Pre Charge breaker control
  out.setpoints.prechbrk
- Shunt breaker control:
  out.setpoints.shunt

5.2.2.4 Authentication phase

The input parameter "authAccepted" indicates whether the charging station has been activated for the charging process of a vehicle. It is relevant in the authentication phase.

Here, the vehicle owner must be activated for the charging process, e.g. via RFID.

The status of the authentication is defined by the following three states:

- 0: Authentication is taking place
  There is no feedback signal yet
- 1: Authentication has failed
  The charging process is not started
- 2: Authentication successful
  The charging process can begin

If no explicit activation is required (e.g. free charging), the parameter can remain permanently set to "2".

NOTE

This input is only evaluated during the authentication phase. As soon as state "1" or "2" is applied, a change to the next charge phase takes place. Subsequent changing of this state does not have any effect.

During the authentication phase the vehicle ID is available at the output of the "DIN_70121" function block.

- evccId: Vehicle ID (max. 8 characters)
  (HEX characters in ASCII representation; for example 0xF ⇒ "F")
- evccIdLength: Length of the vehicle ID

5.2.2.5 "Parameter Discovery" phase

In this phase the following data is delivered by the vehicle and mapped at the output (out.ev.limits) of the "DIN_70121" function block.

- maxCurrentInAmpere: The maximum charging current permitted by the vehicle (in A)
- maxPowerInkW: The maximum charging power permitted by the vehicle (in kW)
- maxVoltageInVolt: The maximum charging voltage permitted by the vehicle (in V).

The following data is sent by the charging station to the vehicle via the function block inputs (in.evseCfg):

- minVoltageInVolt: The minimum charging voltage (in V) of the charging station
- Maximum voltage: Minimum of the maximum voltage (in V) of the charging station (in.evseCfg.maxVoltageInVolt) and the maximum permitted voltage of the vehicle (in V) (out.ev.limits.maxVoltageInVolt).
- Maximum current: Minimum of the maximum current (in A) of the charging station (in.evseCfg.maxCurrentInAmpere) and the maximum permitted current of the vehicle (in A) (out.ev.limits.maxCurrentInAmpere).
- Maximum power: Minimum of the maximum power (in kW) of the charging station (in.evseCfg.maxPowerinkW) and the maximum permitted power of the vehicle (in kW) (out.ev.limits.maxPowerInkW).
- minCurrentInAmpere: The minimum charging current (in A) of the charging station.
- peakCurrentRippleInAmpere: Maximal current ripple (in A) on the charging current
- maxPowerInkW: Maximum available power (in kW) of the charging station
- supportedEnergyTransferType: Energy transfer version supported by the vehicle (according to DIN SPEC 70121 only "DC_Core" and "DC_Extended" are permitted)

The Shunt breaker is closed (in as far as the function is activated).

The frequency converter is started in this phase because, according to the standard, a maximum of 40 seconds is available for the cable check. This means that the charging process has to be aborted after 40 seconds if the "Cable check" has not been terminated by then.

The hwState output parameter now signals with the value "3" (ready) that the frequency converter has to be started.

5.2.2.6 Checking safe isolation from supply on the charging cable (External Voltage Check)

Before the cable check (insulation measurement) is carried out, a check can optionally be carried out whether the voltage of the charging cable is de-energized. All breakers are open. The voltage of the corresponding voltmeter at the "in.values.extVoltageInVolt" input is evaluated. If the voltage is less than or equal to the maximum voltage value set on the function module "DIN_70121" plus the voltage tolerance "in.evseCfg.emvInVolt", the function module goes into the cable check. If the value is greater, a corresponding error is triggered.

If the voltage value is greater than the maximum value, it is possible that the DC breaker in the vehicle is already closed!

Corresponding parameters at the function block:

- Check activated:
  in.evseCfg.extVoltageCheckIsSupported
- Maximum permissible voltage:
  in.evseCfg.maxExtVoltageInVolt
- Maximum absolute voltage tolerance (in V) of the used measuring instrument.
  in.evseCfg.emvInVolt
- Measured voltage according to the DC breaker
  in.values.extVoltageInVolt

5.2.2.7 Carrying out the Cable Check

The insulation of the cable is checked. The cable insulation is considered faulty if a maximum leakage current is exceeded when the CableCheck voltage (in.values.extVoltageInVolt) of the frequency converter is applied.

In this phase the breakers of the vehicle are open. This can be ensured by checking for external voltage (see section Checking the de-energized state on the charging cable (Page 44)).

Parallel to the cable check described below, the error output of a mounted insulation monitor is checked. This can be created at the hwError input.

- Bit 0: Insulation warning
- Bit 1: Insulation fault

.

The cable check is carried out in the following steps in the "DIN_70121" function block:

1. Closing of the breakers
   If the PreCharge breaker is activated, it is now closed. The DC breaker remains open. However, if the precharge breaker is deactivated, the DC breaker is closed instead. Even if the DC breaker is deactivated by the function block, the check will still proceed to the next step. The test now assumes that the DC breaker is activated externally.
2. Determining the CableCheck voltage to be set (out.setpoints.voltageInVolt) at the frequency converter by the FB:
   Calculation of the target voltage:
   = Min (in.evseCfg.maxVoltageInVolt, out.ev.limits.maxVoltageInVolt)
3. Setting the frequency converter to CableCheck voltage
   The frequency converter is switched to voltage control (enableCurrentControl=false) and the CableCheck voltage to be set is applied to the frequency converter. The specified target current is parameterized at the "DIN_70121" function block and is transferred to the frequency converter. A time monitoring is performed in the function block to check whether the actual voltage value has followed the setpoint within the time configurable in "in.evseCfg.maxTimeRampUpDown".
   The maximum voltage is considered reached when in.values.extVoltageInVolt ≥ (out.setpoints.voltageInVolt - in.evseCfg.emvInVolt)

4. Measuring the current for 10 seconds
   After the frequency converter has reached the specified maximum voltage, a 10 second measurement phase begins in which the measured current is checked by the "DIN_70121" function block. In the process a constant check is carried out whether the maximum permitted DC leakage current has been exceeded. If the shunt is activated, its current flow is deducted from the measurement.
5. Shutting down the frequency converter
   After the 10 seconds have expired, the frequency converter is reduced to the minimal voltage. The current specification for the frequency converter is 1 ampere if the target current is greater than 1 ampere. Otherwise the specified target current is used for the current specification.
   The minimum voltage is reached when
   U ≤ (in.evseCfg.minVoltageInVolt + in.evseCfg.emvInVolt)

Corresponding parameters at the "DIN_70121" function block:

• Maximum charging voltage in volts of the frequency converter:
in.evseCfg.maxVoltageInVolt

• Minimum charging voltage in volts of the frequency converter:
in.evseCfg.minVoltageInVolt

Monitoring time for reaching the CableCheck voltage:
in.evseCfg.maxTimeRampUpDown

• Maximum permitted leakage current in amperes in the Cable Check
in.evseCfg.maxCableCheckLeakCurrentInAmpere

• Maximum charging voltage of the vehicle
out.ev.limits.maxVoltageInVolt

• CableCheck voltage to be set in volts for frequency converter:
out.setpoints.voltageInVolt

• Maximum absolute voltage tolerance (in V) of the measuring device used.
in.evseCfg.emvInVolt

• Target current in amperes for frequency converter:
out.setpoints.currentInAmpere

• Current/voltage control of the frequency converter
out.setpoints.enableCurrentControl

• Measured voltage after the DC breaker
in.values.extVoltageInVolt

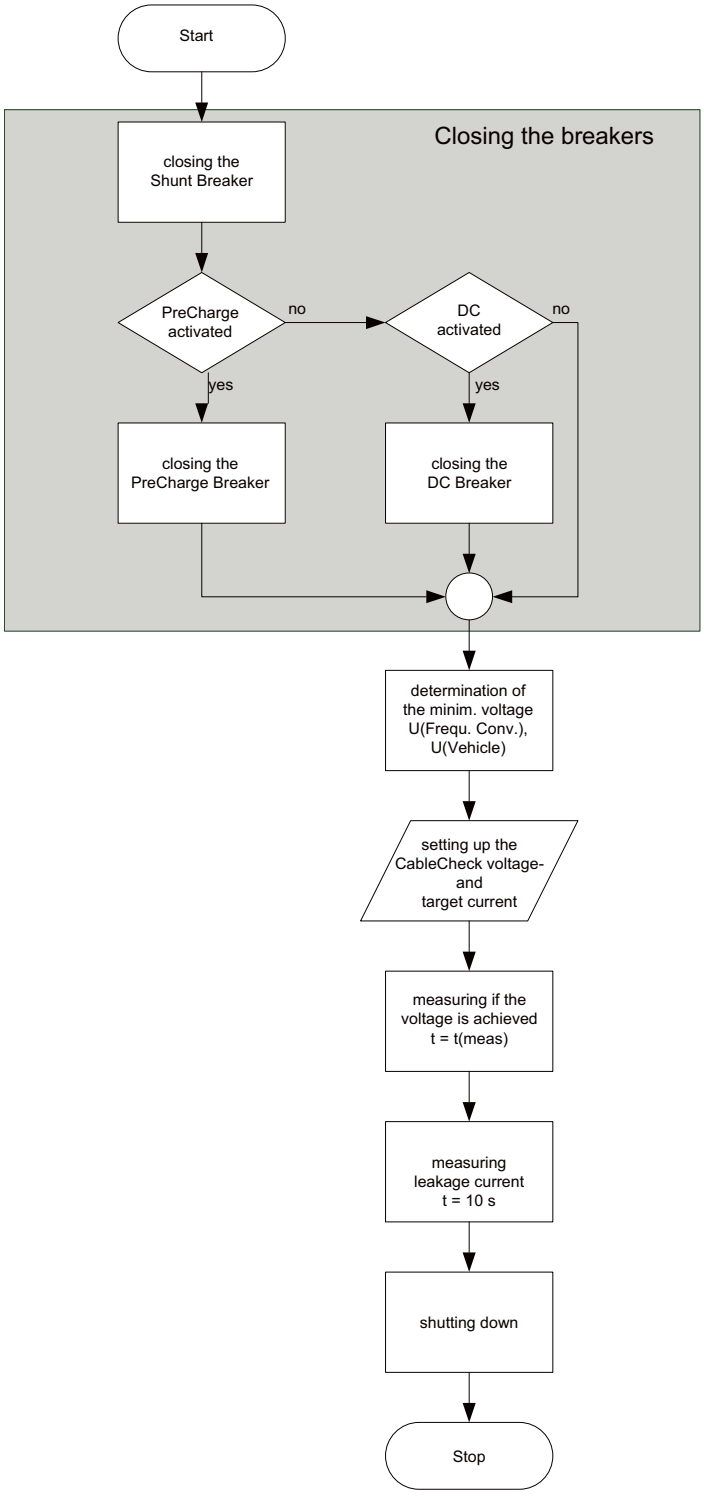

Figure 2-1260 "Cable Check" flow diagram

5.2.2.8 Carrying out the voltage equalization of the frequency converter (PreCharge)

In this phase the target voltage and target current for frequency converter are specified by the vehicle.

A check is carried out when the voltage required by the vehicle lies within the valid range.

- Low limit:
  in.evseCfg.minVoltageInVolt
- High limit:
  Min(in.evseCfg.maxVoltageInVolt, out.ev.limits.maxVoltageInVolt)

A check is carried out whether the output voltage of the frequency converter lies within the valid range.

- Low limit:
  in.evseCfg.minVoltageInVolt - in.evseCfg.emvInVolt
- High limit:
  Min(in.evseCfg.maxVoltageInVolt, out.ev.limits.maxVoltageInVolt) + in.evseCfg.emvInVolt)

An error is triggered if the voltages lie outside the valid range for longer than the time period defined in the "in.evseCfg.maxTimeInvalidParametersOrRampCharge" parameter.

The voltage equalization continues until the vehicle switches to the power delivery phase.

Corresponding parameters at the "DIN_70121" function block:

- Maximum charging voltage in Volt of the frequency converter:
  in.evseCfg.maxVoltageInVolt
- Monitoring time for the check of the voltage/current value:
  in.evseCfg.maxTimeInvalidParamsOrRampCharge
- Target voltage in Volt for the frequency converter:
  out.setpoints.voltageInVolt
- Target current in Ampere for the frequency converter:
  out.setpoints.currentInAmpere
- Voltage control of the frequency converter
  out.setpoints.enableCurrentControl:=false
- Measured voltage at the frequency converter
  in.values.voltageInVolt
- Voltage tolerance in Volts:
  in.evseCfg.emvInVolt

5.2.2.9 Implementation of the PowerDelivery phase (start charging)

In this phase the DC breaker is switched on and the frequency converter is switched to current control. The target current is set to 0 ampere. Subsequently the PreCharge breaker is opened. The shunt breaker is also opened. The opening or closing operation of the breaker is time-monitored.

5.2.2.10 Execution of the charge process (Current Demand)

In this phase the frequency converter is controlled by the vehicle with the latest current/voltage specifications.

The "DIN_70121" function block monitors whether the voltage, current and power values lie within defined limits. An error is triggered if one of the values to be checked lies outside the valid range for longer than the time period defined in the "in.evseCfg.maxTimeInvalidParametersOrRampCharge" parameter.

The following values are checked permanently:

- The voltage "out.setpoints.voltageInVolt" required by the vehicle
  Low limit:
  in.evseCfg.minVoltageInVolt
  High limit:
  Min(in.evseCfg.maxVoltageInVolt, out.ev.limits.maxVoltageInVolt)
- The output voltage of the frequency converter "in.values.voltageInVolt"
  Low limit:
  in.evseCfg.minVoltageInVolt - in.evseCfg.emvInVolt
  High limit:
  Min(in.evseCfg.maxVoltageInVolt, out.ev.limits.maxVoltageInVolt) + in.evseCfg.emvInVolt)
- The current requested by the vehicle "out.setpoints.currentInAmpere"
  High limit:
  Min(in.evseCfg.maxCurrentInAmpere,out.ev.limits.maxCurrentInAmpere)
- The output current of the frequency converter "in.currentInAmpere"
  Low limit:
  in.evseCfg.minCurrentInAmpere - in.evseCfg.emcInAmpere
  High limit:
  Min(in.evseCfg.maxCurrentInAmpere, out.ev.limits.maxCurrentInAmpere) + in.evseCfg.emcInAmpere)
- The maximum charging capacity of the frequency converter
  High limit:
  Min(in.evseCfg.maxPowerInkW, out.ev.limits.maxPowerInkW)
  Calculation of the charging capacity of the converter:
  (in.values.voltageInVolt - in evseCfg.emvinVolt) * (in.values.currentInAmpere - in.evseCfg.emcInAmpere)

The converter continues to run in voltage control mode.

Corresponding parameters at the function block:

- Maximum charging voltage in Volt of the frequency converter:
  in.evseCfg.maxVoltageInVolt
- Maximum charging current in Ampere of the frequency converter:
  in.evseCfg.maxCurrentInAmpere
- Monitoring time for the reaching of the target voltage:
  in.evseCfg.maxTimeInvalidParametersOrRampCharge
- Target voltage in Volt for the frequency converter:
  out.setpoints.voltageInVolt
- Target current in Ampere for the frequency converter:
  out.setpoints.currentInAmpere
- Current/voltage control of the frequency converter:
  out.setpoints.enableCurrentControl
- Measured voltage at the frequency converter
  in.values.voltageInVolt
- Voltage tolerance in Volts:
  in.evseCfg.emvInVolt
- Voltage tolerance in Amperes:
  in.evseCfg.emcInAmpere

5.2.2.11 Termination of the charging process

At the end of the charge process there is a final PowerDelivery request from the vehicle. The frequency converter is ramped down and the contactor is open. The individual actions are time-monitored. This is performed in the following steps:

The termination of the charging process is carried out in the following steps in the "DIN_70121" function block:

1. Setting the target current value for the converter to 0 amperes.
2. Waiting until the current value set at the frequency converter meets the following condition:
   Current value (in.values.currenInAmpere) ≤ Specified current value for opening the DC breakers (evseCfg.stopChargingCurrentInAmpere) + Current tolerance (emcInAmpere)
3. Subsequently the DC breakers are open
4. The frequency converter is switched to voltage control. The target voltage at the converter is set to the minimum voltage (in.evseCfg.minVoltageInVolt)
5. In as far as the shunt is activated, it is closed.
6. As soon as the voltage falls below the minimum voltage at the voltmeter, the breaker is opened for the shunt.
   The minimum voltage U_{min} is calculated as follows:
   U_{min} = Minimum voltage frequency converter (in.evseCfg.minVoltageInVolt) + Voltage tolerance (in.evseCfg.emvInVolt)

7. The charging process is now regarded as complete
8. The frequency converter is switched off. hwState:=2 (wait state)

Corresponding parameters at the function block:

- Specification current value for opening the DC breaker (minimum current value of the frequency converter):
  in.evseCfg.stopChargingCurrentInAmpere
- Minimum charging voltage in Volt of the frequency converter:
  in.evseCfg.minVoltageInVolt
- Voltage tolerance in volt:
  in.evseCfg.emvInVolt
- Current tolerance in ampere:
  in.evseCfg.emcInAmpere
- Monitoring time for reaching the target voltage or the target current:
  in.evseCfg.maxTimeRampUpDown
- Target voltage in Volt for the frequency converter:
  out.setpoints.voltageInVolt
- Target current in Ampere for the frequency converter:
  out.setpoints.currentInAmpere
- Current/voltage control of the converter:
  out.setpoints.enableCurrentControl
- Voltage measured at the converter:
  in.values.voltageInVolt
- Measured current at the converter:
  in.values.currenInAmpere

Welding Detection

If "Welding Detection" is requested by the vehicle, the applied voltage "extVoltageInVolt" is transferred to the vehicle. This is important since the "voltageInVolt" voltage directly at the frequency converter is always 0. Only by this means you can check whether the breakers in the vehicle are welded.

5.2.2.12 Hardware states

The "DIN_70121" function block can process four different HW states of the charging station and respond accordingly. Furthermore, the "DIN_70121" function block calls for a specific state of the hardware at defined points. If this is not assumed by the hardware within a defined monitoring time, the ongoing charging process is aborted. The hardware status requested by the function block must be taken on by the hardware. The hardware indicates via the following states that it has reached the required state. Exactly this state has to be reached respectively, with the exception of the undefined state (0).

The following 4 states are defined:

- 0: Undefined state
  for example whether the charging station is switched on
- 1: Idle state
  Converter is off, I/O modules for the breakers are off
- 2: Wait state
  Converter is off, I/O modules for the breakers are on
- 3: Ready
  Converter is on, I/O modules for the breakers are on

The individual phases as well as the state to be assumed are represented below.

- Initial state (no charging process active):
  swState = 2 (System in idle state)
  hwState = 1 (Idle state)
- Transition to charging phase:
  swState = 3 (the I/O modules are on, all breakers are opened)
  hwState = 2 (wait state)
  as soon as hwState = 2 (wait state) is reached, a switch to swState = 4 (system ready for charging) takes place
- Contract Authentication:
  swState = 5 (Authentication phase)
  hwState = 2 (Wait status)
- Charge Parameter Discovery:
  swState = 6 (Phase "Parameter Discovery")
  hwState = 3 (Ready)
- External Voltage Check:
  swState = 7 (Phase "External Voltage Check")
  hwState = 3 (Ready)
- Cable Check:
  swState = 8 (Phase "Cable Check")
  hwState = 3 (Ready)
- Pre Charging:
  swState = 9 (Phase "Pre Charge")
  hwState = 3 (Ready)
- Power Delivery (start of the charging process):
  swState = 10 (Phase "Power Delivery/Current Demand")
  hwState = 3 (Ready)
- Current Demand:
  swState = 10 (Phase "Power Delivery/Current Demand”)
  hwState = 3 (Ready)
- Stop Charging: Wait state (2)
  swState = 11 (Phase "Power Delivery/Current Demand")
  hwState = 3 (Ready)
- Transition to the initial state: Wait state (2)
  swState = 3 (The I/O modules are on, all breakers are open)
  hwState = 2 (wait state)
  as soon as hwState = 2 (wait state) is reached, a switch to the initial state takes place

If no charge phase is pending the initial state is taken.

Corresponding parameters at the function block:

- Current hardware state of the charging station (0, 1, 2, 3):
  in.value.hwState
- Monitoring time for reaching the required HW state:
  in.evseCfg.maxSwitchTimeHwState
- Hardware status requested by the function block:
  out.setpoints.hwState
- SW state of the function block
  out.swState

5.2.3 DIN_70121 parameter

All parameters have been created in the form of UDTs (User defined data types).

The "in" input is mapped in form of the UDT "UDT_Charger_In".

The "out" output is mapped in form of the UDT "UDT_Charger_Out".

5.2.3.1 UDT_Charger_In

The UDT_Charger_In has the following structure:

Table 2-1415 List of input parameters for the UDT_Charger_In

Parameter	Data type	Description
ackErrors	Bool	Error acknowledgment In the "True" state, all pending errors are acknowledged.
enable	Bool	Charging outlet enable (True = yes, False = no) If this input is set to "False", an ongoing charging process is canceled and the frequency converter is shut down in a controlled manner. Subsequently the CP output signal in the module is set to -12 V. If the Enable input is set to "True", the CP output signal changes to +12 V.
evseCfg	UDT_Charger_E-vseCfg (Page 54)	Input parameter for the configuration of the charging station
hw_Id	HW_IO	Hardware ID of the technology module SIMATIC ET 200SP TM ECC PL ST for the determination of the offset of the process image of the inputs/outputs. If an invalid HW ID is entered, a corresponding error bit at the output is set to "True" (Error messages (Page 93)).
hwError	Byte	Pending HW errors / warnings of the charging station: • Bit 0: Insulation monitor "Warning" • Bit 1: Insulation monitor "Error" • Bit 2: An emergency-off of the charging station has taken place (for example by pressing the emergency-off button) If Bit 1 or Bit 2 is set to "True", the converter is ramped down in a controlled manner if possible. The CP output level is set to "-12 V".
values	UDT_Charger_Values (Page 57)	Currently pending parameters of the charging station that are relevant for the charging process.

5.2.3.2 UDT_Charger_EvseCfg

The UDT_Charger_EvseCfg has the following structure:

Table 2-1416 List of input parameters for the UDT_Charger_EvseCfg

Parameter	Data type	Description
cableCheckCurrentInAmpere	UInt	Current setpoint (in A) during the "Cable check" phase. This parameter is relevant for converters that need a minimum current value to start up. This current must be greater than the value of "maxCableLeakCurrentInAmpere"; otherwise the error message bit 1 (parameterization error) is set. (see chapter on Cable Check (Page 45))
dcbrkIsUsed	Bool	Monitoring of the feedback from the "DC breaker" and control of the corresponding output. (True = yes, False = no) (see chapter on Protective circuit of the frequency converter (Page 42))
emcInAmpere	UInt	Maximum absolute current tolerance (in A) of the used measuring instrument. (relevant in Cable Check phase and when terminating the charging process)
emvInVolt	UInt	Maximum absolute voltage tolerance (in V) of the used measuring instrument. (relevant in External Voltage Check, Cable Check, PreCharge phase and termination of the charging process)
evseId	Array [0...31] of Byte	Unique ID of the charge column. The structure of the ID is defined in the DIN SPEC 91286. Details of the structure can also be found in the DIN SPEC 70121.
evseIdLength	USINT	Length of the evseId address in bytes If this value is greater than "32", the error message bit 1 (parameterization error) is set.
extVoltageCheckIsSupported	Bool	Activation of the check of the applied voltage before the pending phase "Cable check". (True = Yes, False = No) (see the chapter on Checking the de-energized state (Page 44)) The voltage "maxExtVoltageInVolt" must be less than or equal to the value of "maxVoltageInVolt", otherwise the error message bit 1 (parameterization error) is set (see Error Messages (Page 93) section).
maxCableCheckLeakCurrentI-nAmpere	UInt	The maximum leakage current allowed during the cable check (see section Cable check (Page 45)). If the leakage current is greater, a corresponding error bit at the output is set to "True" (see section Error messages (Page 93)). This current must be less than or equal to the value of "maxCurrentInAmpere"; otherwise the error message bit 1 (parameterization error) is set.
maxCurrentInAmpere	UInt	The currently available maximum current which can be delivered by the charge column. This current must be greater than the value of "minCurrentInAmpere"; otherwise the error message bit 1 (parameterization error) is set.
maxExtVoltageInVolt	UInt	The maximum permitted voltage on the cable (external voltage check) before the cable check (see chapter Checking the de-energized state (Page 44)). If exceeded, a corresponding error bit at the output is set to "True" (see section Error messages (Page 93))
maxPowerInkW	UInt	Maximum available power (in kW) of the charge column.

maxSwitchTimeBreaker	Time	The maximum time has been exceeded in which the feedback signal of the DC/Precharge or shunt breaker has to be performed. If this time is exceeded, a corresponding error bit at the output is set to "True" (see Error messages (Page 93)). This time must be greater than "0 ms"; otherwise the error message bit 1 (parameterization error) is set.
maxSwitchTimeHwState	Time	Maximum time available for switching from one HW state to the next (see section HW states (Page 51)) If this time is exceeded, a corresponding error bit at the output is set to "True" (see section Error messages (Page 93)). This time must be greater than "0 ms"; otherwise the error message bit 1 (parameterization error) is set.
maxTimeInvalidParamsOr-RampCharge	Time	The maximum time in which the charging column must follow the specifications of the vehicle (target voltage, target current). If this time is exceeded, a corresponding error bit at the output is set to "True" (see section Error messages (Page 93)). This time must be greater than or equal to the value of "maxTimeRampUpDown"; otherwise the error message bit 1 (parameterization) is set.
maxTimeRampUpDown	Time	The maximum time in which the converter must have reached the desired value (charging voltage or charging current). Affects all charging phases except the "PreCharge" and "CurrentDemand" phase. If this time is exceeded, a corresponding error bit at the output is set to "True" (see section Error messages (Page 93)). This time must be greater than "0 ms"; otherwise the error message bit 1 (parameterization error) is set. The time must be less than or equal to the time parameterized under "maxTimeInvalidParamsOrRampCharge".
maxVoltageInVolt	UInt	The maximum charging voltage (in V) of the charging column. This voltage must be greater than the value of "minVoltageInVolt"; otherwise the error message bit 1 (parameterization error) is set.
minCurrentInAmpere	UInt	The minimum charging current (in A) of the charging station. This current must be less than the value of "maxCurrentInAmpere"; otherwise the error message bit 1 (parameterization error) is set.
minVoltageInVolt	UInt	The minimum voltage (in V) of the charge column. This voltage must be less than the value of "maxVoltageInVolt"; otherwise the error message bit 1 (parameterization error) is set.
peakCurrentRippleInAmpere	UInt	Maximum current ripple (in A) on the charging current.
preChargeCurrentInAmpere	UInt	The maximum allowed charging current (in A) in the "PreCharge" phase. If a minimum current value is required by the frequency converter to start, its high limit is defined here. This current must be less than or equal to the value of "maxCurrentInAmpere"; otherwise the error message bit 1 (parameterization error) is set.
prechbrkIsUsed	Bool	Monitoring the feedback of the "PreCharge breaker" and control of the corresponding output (see section on Wiring of the frequency converter (Page 42)). (True = yes, False = no) If "False" is set, the corresponding output "prechbrk" is also set permanently to "False".

shuntIsUsed	Bool	Monitoring the feedback of the "Shunt breaker" and control of the corresponding output (see the section on Wiring of the frequency converter (Page 42)). (True = yes, False = no) The "shuntValueInOhm" value must be unequal to "0"; otherwise the error message bit 1 (parameterization error) is set.
shuntValueInOhm	UInt	Resistance value of shunt in Ohm (see the chapter on Protective circuit of a converter (Page 42))
stopChargingCurrentIn-Ampere	UInt	If this value is undershot when the charging process is terminated, the DC disconnector opens. This current must be less than or equal to the value of "maxCurrentInAmpere"; otherwise the error message bit 1 (parameterization error) is set.
supportedEnergyTransfer-Types	Word	With this parameter you select the energy transfer variants supported by the charging station (True = selected; False = not selected). The designations of the types are taken directly from the DIN SPEC 70121. • Bit 0 = AC_single_phase_core is not supported in DIN SPEC 70121 • Bit 1 = AC_three_phase_core is not supported in DIN SPEC 70121 • Bit 2 = DC_core DC charging via the pins in the Type1/Type2 connector is supported • Bit 3 = DC_extended Charging via the extended pins of the CCS connector (Type1/Type2) is supported • Bit 4 = DC_combo_core is not supported in DIN SPEC 70121 • Bit 5 = DC_dual is not supported in DIN SPEC 70121 • Bit 6 = AC_core1p_DC_extended is not supported in DIN SPEC 70121 • Bit 7 = AC_single_DC_core is not supported in DIN SPEC 70121 • Bit 8 = AC_single_phase_three_phase_core_DC_extended is not supported in DIN SPEC 70121 • Bit 9 = AC_core3p_DC_extended is not supported in DIN SPEC 70121 The "DIN_70121" function block supports only DC_core (bit 2) and DC_extended (bit 3). The error message bit 1 (parameterization error) is set for all other variants (bit values). In addition, at least one of these two bits must be set. The variants supported by the charge column are compared to the variants required by the vehicle. If the vehicle requires a variant which is not supported by the charge column, the charge process is aborted.

5.2.3.3 UDT_Charger_Values

The UDT_Charger_Values has the following structure:

Table 2-1417 List of input parameters to the UDT_Charger_Values

Parameter	Data type	Description
authAccepted	Byte	This parameter indicates whether the charging station is authorized for the charging of a vehicle. It is relevant in the authentication phase. Here the vehicle owner has to, for example, authorize the charging process via RFID. The status of the authentication is defined by the following three states: • 0: Authentication is taking place There is no feedback signal yet • 1: Authentication has failed The charging process is not started • 2: Authentication successful The charging process can begin • 3 ... 255: Authentication has failed The charging process is canceled. If no explicit activation is required (e.g. free charging), the parameter can be permanently set to "2".
currentInAmpere	Int	Currently measured voltage of the current measuring unit (in A)
dcbrk	Bool	The feedback contact of the DC breaker (False = Open; True = Closed). This parameter is only used if the control of the DC breaker is activated (see section Possible circuitry of a frequency converter (Page 42)).
extVoltageInVolt	Int	Currently measured voltage of the voltage measuring unit (in V) at the charging outlet.
hwState	Int	HW state of the charging station (see section Hardware states (Page 51)). The following 4 states are defined: • 0: Undefined state When the charging station is switched on • 1: Idle state Converter is off, IO modules for the breakers are switched off • 2: Wait state Converter is off, IO modules for the breakers are on • 3: Ready Converter is on, IO modules for the breakers are on
prechbrk	Bool	The feedback contact of the PreCharge breaker (False = Open; True = Closed). This parameter is only used when the control of the PreCharge breaker is activated (see section Possible circuitry of a frequency converter (Page 42)).
shunt	Bool	The feedback contact of the shunt breaker (False = Open; True = Closed). This parameter is only used when the control of the shunt breaker is activated (see section Possible circuitry of a frequency converter (Page 42)).
stopCharging	Bool	Setting this bit to "True" indicates to the vehicle that the charging procedure is to be ended. The vehicle decides whether and when the charging process is terminated. If "stopCharging" is set to "True" for longer than the current charging process, no other charging process can be started until this bit has been reset to "False".
voltageInVolt	Int	Currently measured voltage of the voltage measuring unit (in V) at the frequency converter output.

5.2.3.4 UDT_Charger_Out

The UDT_Charger_Out has the following structure:

Table 2-1418 List of input parameters to the UDT_Charger_Out

Parameter	Data type	Description
ev	UDT_Charger_Ev	Information with regard to the vehicle
pilotState	USINT	Charging state At this output the state is output according to IEC 61851-1. • 0: Status A1 (100% PWM) Charging station not ready for charging / vehicle not connected (Status according to IEC 61851-1) • 1: Status B1 (100% PWM) Charging station not ready for charging / vehicle not ready for charging (Status according to IEC 61851-1) • 2: Status B2 (5% PWM) Charging station ready for charging / vehicle not ready for charging (Status according to IEC 61851-1) • 3: Status C1 (100% PWM) Charging station not ready for charging / vehicle ready for charging (Status according to IEC 61851-1) • 4: Status C2 (5% PWM) Charging station ready for charging / vehicle ready for charging (Status according to IEC 61851-1) • 5: Status D1 (100% PWM) Charging station not ready for charging / vehicle ready for charging / ventilation required (Status according to IEC 61851-1) • 6: Status D2 (5% PWM) Charging station ready for charging / vehicle ready for charging / ventilation required (status according to IEC 61851-1) • 7: Status E (100% PWM) e.g. if charging station is de-energized or short-circuit between CP and protective conductor (status according to IEC 61851-1) • 8: State F Charging station not ready for charging e.g. Error occurred or charging station in maintenance - charging outlet locked (State according to IEC 61851-1) • 9: Invalid state CP current outside the permitted range
ppState	USINT	State of Plug Present (only relevant for Type 1 connector) • 0: Vehicle is not connected to the charging station. • 1: Vehicle is connected to the charging station, the button at the connector is pressed • 2: Vehicle is connected to the charging station, the button at the connector is not pressed • 0xFF: Invalid voltage at Plug Present (U > 3.5 V)
setpoints	UDT_Charger_Setpoints	Current manipulated variables for the charging station.
swError (for TIA library version 1.0)	LWord	Pending SW errors

swError1 (for TIA library version > 1.0)	DWord	Pending SW errors corresponds to swError bits no 0 to 31
swError2 (for TIA library version > 1.0)	DWord	Pending SW errors corresponds to swError bits no 32 to 63
swState	Int	SW states • -3: An error has occurred. The error can be acknowledged. The status "-2" automatically changes to the status "-3" after 10 seconds. • -2: An error has occurred. The charging station has shut down. • -1: An error has occurred. The charging station is shutting down. • 0: Initialization phase (after cold restart). The basic HW checks are performed. Are all the modules on and the breakers open? • 1: System ready • 2: System in idle state (no charging process active). The IO modules are off, all the breakers are open. • 3: The I/O modules are on, all breakers are open. • 4: System is ready for charging (communication with the vehicle has started). This phase is very short and therefore not always visible at the output. • 5: Authentication phase (in accordance with DIN SPEC 70121) • 6: Parameter discovery (in accordance with DIN SPEC 70121) • 7: ExtVoltageCheck This phase is very short and therefore not always visible at the output. • 8: Cable Check (in accordance with DIN SPEC 70121) • 9: PreCharge/Power Delivery (according to DIN SPEC 70121) • 10: Current Demand (according to DIN SPEC 70121) • 11: Termination of the charging process (according to DIN SPEC 70121)

5.2.3.5 UDT_Charger_Ev

The UDT_Charger_Ev has the following structure:

Table 2-1419 List of input parameters for the UDT_Charger_Ev

Parameter	Data type	Description
Diagnostics	UDT_Charger_Ev_Diagnostics	Status and diagnostic information with regard to the vehicle.
evccId	Array [0..7] of Byte	Unique ID of the vehicle. Details on structure can be found in DIN SPEC 70121.
evccIdLength	USINT	Length of the vehicle ID
Limits	UDT_Charger_Ev_Limits	Electrical limiting values of the vehicle.

5.2.3.6 UDT_Charger_Ev_Diagnostics

The UDT_Charger_Ev_Diagnose has the following structure:

Table 2-1420 List of input parameters to the UDT_Charger_Ev_Diagnose

Parameter	Data type	Description
cabinConditioning	Bool	Information by the vehicle (e.g. heating is on) According to DIN SPEC 70121
evEnergyTransferType	Int	Energy transfer type supported by the vehicle The designations of the types are taken directly from the DIN SPEC 70121. • 0 = AC_single_phase_core is not supported in DIN SPEC 70121 • 1 = AC_three_phase_core is not supported in DIN SPEC 70121 • 2 = DC_core DC charging via the pins in Type 1/Type 2 plug-in connectors is required • 3 = DC_extended charging via the extended pins of the CCS connector (Type1/Type2) is required • 4 = DC_combo_core is not supported in DIN SPEC 70121 • 5 = DC_dual is not supported in DIN SPEC 70121 • 6 = AC_core1p_DC_extended is not supported in DIN SPEC 70121 • 7 = AC_single_DC_core is not supported in DIN SPEC 70121 • 8 = AC_single_phase_three_phase_core_DC_extended is not supported in DIN SPEC 70121 • 9 = AC_core3p_DC_extended is not supported in DIN SPEC 70121
remainingTimeToBulkSoC	Time	Information from the vehicle: Estimated duration until the vehicle battery is 80% charged.
remainingTimeToFullSoC	Time	Information from vehicle; estimated duration until the vehicle battery is charged to 100 %.
ressConditioning	Bool	Information from the vehicle: The battery is in the service mode and is therefore charging with reduced performance
stateOfChargeInPercent	USINT	Information from the vehicle: Current charge state (in %)

5.2.3.7 UDT_Charger_Ev_Limits

The UDT_Charger_Ev_Limits has the following structure:

Table 2-1421 List of input parameters for the UDT_Charger_Ev_Limits

Parameter	Data type	Description
maxCurrentInAmpere	UInt	The maximum charging current permitted by the vehicle (in A)
maxPowerInkW	UInt	The maximum charging power permitted by the vehicle (in kW)
maxVoltageInVolt	UInt	The maximum charging voltage permitted by the vehicle (in V).

5.2.3.8 UDT_Charger_Setpoints

The UDT_Charger_Setpoints has the following structure:

Table 2-1422 List of input parameters to the UDT_Charger_Setpoints

Parameter	Data type	Description
currentInAmpere	DInt	The current (in A) which is required by the vehicle or the maximum current. Depends on whether the current regulation or voltage control is required via the function block of the frequency converter.
dcbrk	BOOL	Required state of the DC breaker (see section Possible circuitry of a frequency converter (Page 42)). (False = Open; True = Closed).
enableCurrentControl	BOOL	Determination current/voltage control for the frequency converter • True: The converter must be set to current control. (The "currentInAmpere" parameter defines the current specification, the "voltageInVolt" parameter defines the maximum voltage) • False: The converter must be set to voltage control. (The "currentInAmpere" parameter defines the maximum current, the "voltageInVolt" parameter defines the voltage specification)
hwState	Int	The setpoint HW status of the charging station requested by the function block. The following 4 states are defined (see section Hardware states (Page 51)): • 0: Undefined state for example whether the charging station is switched on • 1: Idle state Converter is off, I/O modules for the breakers are off • 2: Wait state Converter is off, I/O modules for the breakers are on • 3: Ready Converter is on, I/O modules for the breakers are on
prechbrk	BOOL	Required state of the PreCharge breaker (see section Possible circuitry of a frequency converter (Page 42)). (False = Open; True = Closed).
shunt	BOOL	Required state of the shunt breaker (see section Possible circuitry of a frequency converter (Page 42)). (False = Open; True = Closed).
voltageInVolt	DInt	The voltage (in V) which is required by the vehicle or the maximum current. Depends on whether the current regulation or voltage control is required via the function block of the frequency converter.

5.3 Function block "ISO_15118"

NOTE

Note that the FB "ISO_15118" is incompatible to FW versions 1.0.x.

The "ISO_15118" function block supports charging in accordance with DIN SPEC 70121 and ISO 15118.

Introduction

In this section, we show you the properties of the function block "ISO_15118". It exists in three versions:

- ISO_15118_1500 (for CPU15xx)
- ISO_15118_1200 (for CPU12xx)
- ISO_15118_OC (for Open Controller)

The three function blocks behave identically. For the sake of clarity, we will simply refer to FB "ISO_15118" in the following.

The following figure shows the inputs/outputs of the "ISO_15118" function block:

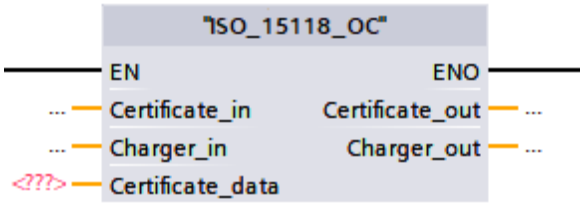

Figure 2-1261 Function block "ISO_15118"

The "ISO_15118" function block appears in the structure of the TIA library.

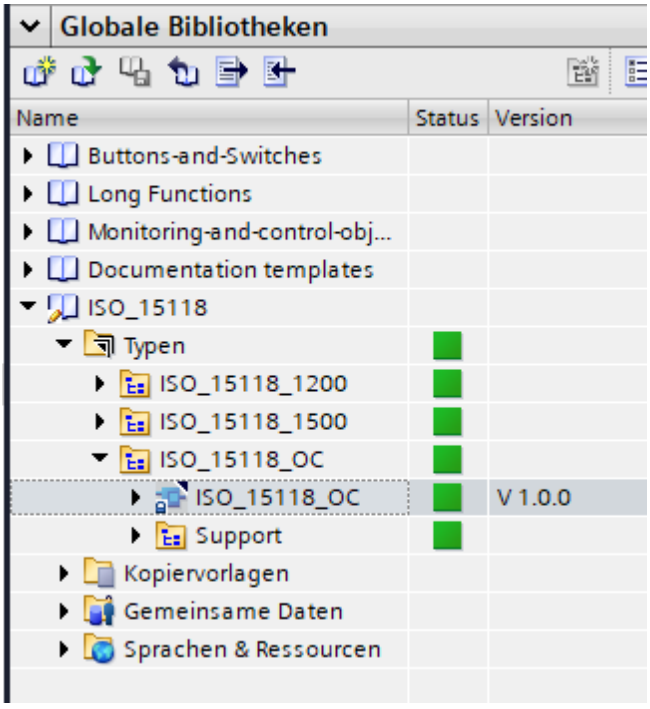

Figure 2-1262 Structure of the TIA library ISO_15118

The "ISO_15118_1200" folder contains the blocks for the 1200 controllers and, similarly, the "ISO_15118_1500" folder contains theme for the 1500 controllers. The blocks for the "Open Controller" are located in the "ISO_15118_OC" folder.

You can only use the "ISO_15118" function block itself for the configuration. The "ISO_15118 Support" folder contains internal help functions.

5.3.1 Required memory of the "ISO_15118" function block

Memory requirement

The following shows the memory requirements of the "ISO_15118" FB:

Table 2-1423 Memory requirement of the "ISO_15118" function block

	Load memory	Code work memory	Data work memory
First instance	1.41 MB	57.26 KB	25.52 KB
Additional memory required for each additional instance	41.88 KB	0	25.52 KB

5.3.2 Mode of operation of the "ISO_15118" function block

The principle of operation of this block basically corresponds to that of FB "DIN_70121" (see section "Principle of operation of the "DIN_70121" function block (Page 41)") and includes the communication defined in DIN SPEC 70121.

The "ISO_15118" function block also contains all the features that enable payment by PnC. These are:

- Certificate handling relating to TLS encryption (installation or update)
  Certificate Signing Request (CSR)
- Transfer of the contract certificate of a vehicle to the backend
  Contract Certificate (CC)

The inputs under "Certificate_in", the outputs under "Certificate_out" and the "Certificate_data" inputs/outputs contain the parameters that are relevant for the TLS encryption (between charging station and vehicle) and the contract data handling (between vehicle and backend).

These extensions are described in the following sections:

NOTE

The function block transfers the setpoints (out.setpoints), but does not check their plausibility with regard to the actual values (in.values) at its input.

5.3.2.1 "UDT_Charger_In" extensions with regard to FB "DIN_70121"

The function block "ISO_15118" is extended by the input parameter "evseCfg.paymentVar" (Byte data type). You can use this to specify the supported payment variants. You can allow payment for the charging process through an external identification or using automatic identification over a TLS-encrypted connection (PnC), or both. EIM with TLS encryption is also possible. The corresponding backend infrastructure must then be available independent of EIM or PnC. See also table "List of additional input parameters for UDT_Charger_In".

As of version V1.2, the function block "ISO_15118" has been extended by the input parameter "in.evseCfg.maxVoltageCorr" (UInt data type). With this parameter, the maximum voltage sent to the vehicle (see chapter Phase "Discovery parameters" (Page 44)) can be increased as a percentage accordingly. The maximum voltage sent to the vehicle is limited to in.evseCfg.maxVoltageInVolt.

Examples:

Maximum voltage of the charging station (in.evseCfg.maxVoltageInVolt): 500 V

Maximum voltage of the vehicle (out.ev.limits.maxVoltageInVolt): 400 V

1. in.evseCfg.maxVoltageCorr = 0 (corresponds to 0 %)
   Calculated voltage: Min. (400 V, 500 V) (1 + 0) = 400 V
   Voltage sent to the vehicle: 400 V (Same behavior as before)
2. in.evseCfg.maxVoltageCorr = 100 (corresponds to 10 %)
   Calculated voltage: Min. (400 V, 500 V)* (1 + 0.1) = 400 V+40 V =440 V
   Voltage sent to the vehicle: 440 V
3. in.evseCfg.maxVoltageCorr = 1000 (corresponds to 100 %)
   Calculated voltage: Min. (400 V, 500 V)* (1 + 1) = 400 V+400 V =800 V
   Voltage sent to the vehicle: 500 V, as the maximum voltage of the column is 500 V.

As of version V1.5, the FB "ISO_15118" has been extended with the input parameter "in.evseCfg.noCharIN " (Bool data type). It affects the communication behavior during DIN charging processes:

TRUE: The communication with the EV is handled strictly according to DIN 70121.

FALSE: The slightly modified procedures according to CharIN are used.

As of version V1.6, the FB "ISO_15118" has been extended with the input parameter "in.evseCfg.addTimeStamp " (Bool data type). It can be used to insert the optional parameter EVSETimeStamp into the sessionSetupResponse telegram to the EV.

As of version V1.6, the FB "ISO_15118" has been extended with the input parameter "in.evseCfg.noAuthenticationTimeout " (Bool data type). With this parameter, the standard timeout in the authorization phase of 55 seconds can be switched off to make handling more comfortable for the end user. The behavior of an EV after the TO has expired is unpredictable.

As of version V1.6, the FB "ISO_15118" has been extended with the input parameter "in.evseCfg.useOnlyDin " (Bool data type). With this parameter, the charging station can be instructed to offer only charging standard DIN 70121.

As of version V.1.6, the FB "ISO_15118" has been extended with the input parameter "in.values.currentInAmpereReal" (Real data type). This is an alternative to in.values.currentInAmpere with higher accuracy. The old input is retained for compatibility reasons.

As of version V1.6, the FB "ISO_15118" has been extended with the input parameter "in.values.currentUseReal " (Bool data type). This allows selection between in.values.currentInAmpere and in.values.currentInAmpereReal. Only one input is valid at a time; the other is ignored.

5.3.2.2 "UDT_Charger_Out" extensions with regard to FB "DIN_70121"

The "ISO_15118" FB is extended by the "setpoints.paymentType" output parameter (data type byte). The vehicle (EV) uses this to signal which payment variant is used.

You can find the values that the output parameter "setpoints.paymentType" can assume in table "List of additional output parameters for UDT_Charger_Out".

The "FB ISO_15118" is extended by the output parameter "setpoints.usedStandard" (data type byte). The vehicle (EV) uses this to signal which charging standard is used.

You can find the values that the output parameter "usedStandard" can assume in table "List of additional output parameters for UDT_Charger_Out".

As of version V1.4, the FB "ISO_15118" has been extended with the output parameter "setpoints.currentInAmpereReal" (Real data type). It corresponds to setpoints.currentInAmpere with higher resolution. The original parameter setpoints.currentInAmpere is retained for compatibility reasons and will continue to be supplied.

5.3.2.3 Payment using external identification (e.g. RFID card reader)

The input parameter "authAccepted" indicates whether the charging station has been activated for the charging process of a vehicle. It is relevant in the authentication phase.

Here, the vehicle owner must be activated for the charging process, e.g. via RFID.

The status of the authentication is defined by the following three states:

- 0: Authentication is taking place
  There is no feedback signal yet
- 1: Authentication has failed
  The charging process is not started
- 2: Authentication successful
  The charging process can begin

If no explicit activation is required (e.g. free charging), the parameter can remain permanently set to "2".

NOTE

This input is only evaluated during the authentication phase. As soon as state "1" or "2" is applied, a change to the next charge phase takes place. Subsequent changing of this state does not have any effect.

5.3.2.4 Payment by means of automatic identification (PnC)

In order for an automatic payment (PnC) through the vehicle to take place, the existing contract in the vehicle must be checked. The contract data is available in the form of a certificate. The input "authAccepted" is not evaluated here.

An edge change from "0" to "1" (false to true) of the "Certificate_out.reqCCDataAvailable" output signals that the contract data of the vehicle must be checked. When the edge change occurs, the contract data to be checked is in "Certificate_data.reqCCData" and the length of the data (in bytes) in "Certificate_data.reqCCDataLength". The EMAID and its length can be found in "Certificate_data.reqCCEMAID" and "Certificate_data.reqCCEMAIDLength", respectively.

As soon as the check has been started by the user program, you must set the "Certificate_in.resCCManagement" input to "1" (Processing). The check can, but does not have to, be carried out in two steps.

- In the first step, you check the certificate in the charging station for consistency, without a connection to the backend.
  - If the check was successful, you enter information (e.g. Accepted = 2) at the "Certificate_in.resCertCheck" input and transfer the contract data to the backend.
  - If the check was not successful, you enter the result (e.g. Certificate unknown = 7) in "Certificate_in.resCertCheck". You can skip the following step (check by the backend) and set "Certificate_in.resCCManagement" to "3" (Finished Error) right away.
- If the contract check in the backend was successful, you must set the "Certificate_in.resCCManagement" input to "2" (Finished OK) and "Certificate_In.resContCheck" to "2" (Accepted).
- If the contract check in the backend was not successful, you must set the "Certificate_in.resCCManagement" input to "3" (Finished OK) and "Certificate_In.resContCheck" to the check result (e.g. Error = 1).
- If the module cancels the CC (e.g. due to a timeout), the FB sets "Certificate_out.reqCCDataAvailable" to "false".

Regardless of the result, the FB now sets the "Certificate_out.reqCCDataAvailable" output to "false". To finish, you must set the inputs "Certificate_in.resCCManagement", "Certificate_in.resCertCeck" and "Certificate_in.resContCheck" to "0" (Idle/Not Checked).

The EV monitors the Contract Certificate process (CC) for adherence to the following time limits: Time allowed from initiation by the EV until "resCCManagement = 1": 1.7 seconds; until "resCertCheck" is received: 4.5 seconds; until "resContCheck" is received: total of 55 seconds. After that, you can expect the EV to cancel the charging process.

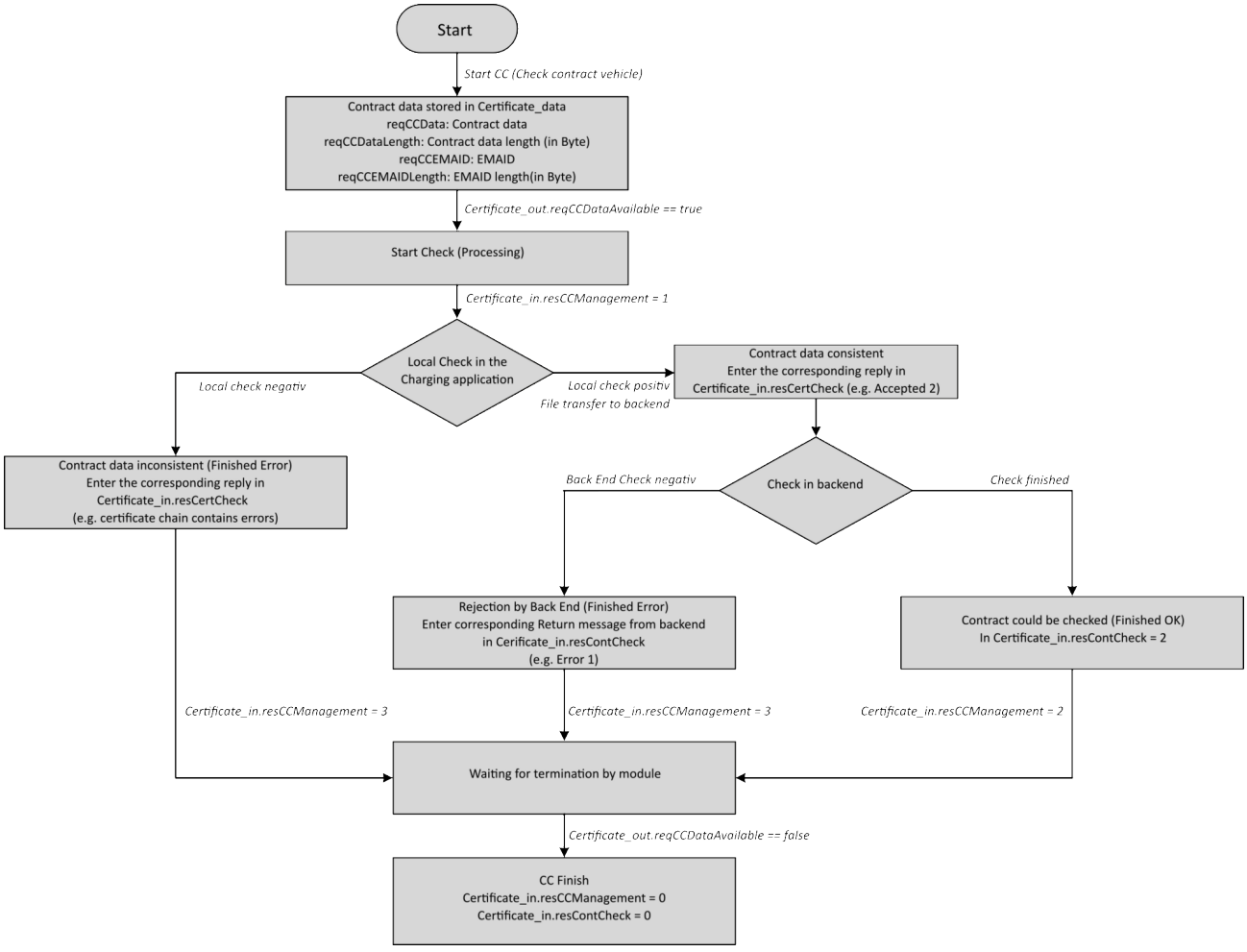

Figure 2-1263 Status diagram for CC

5.3.2.5 Certificate signing request (CSR)

Precondition for encrypted communication according to the TLS standard is the existence of a valid certificate in the TM ECC PL ST module. This can be installed or updated.

The installation and update of a certificate are the same process from the perspective of the module. For this reason, only the update is described here.

The update takes place independent of an active charging process. However, the new certificate is not used until the next charging process.

The CSR can be initiated by the module itself or externally (e.g. from the backend).

Both variants are described in detail in the following.

NOTE

A stored certificate can be deleted by a firmware update. After a firmware update, ensure that a connection to the backend exists before the next charging process with TLS encryption. In this case, the technology module independently requests a new certificate, as described here.

Initiation of the CSR by the TM ECC PL ST module

You are signaled that the TLS certificate must be updated via an edge transition from "0" to "1" (false to true) of the "Certificate_out.reqCSRDataAvailable" output. When the edge change occurs, the certificate request is in "Certificate_data.reqCSRData". Its length is stored in "Certificate_data.reqCSRDataLength".

This certificate request must now be processed (e.g. by the backend).

As soon as the update has been started by the user program, you must set the "Certificate_in.resCCManagement" input to "1" (Processing).

- If the update of the TLS certificate was successful, you must store it in "Certificate_data.resCSRData" and its length in "Certificate_data.resCSRDataLength". You must set the "Certificate_in.resCSRManagement" input to "2" (Finished OK). The module now adopts the new certificate.
- If the certificate could not be updated (e.g. because the certificate chain contains errors or is unknown to the backend), you must set the "Certificate_in.resCSRManagement" input to "3" (Finished Error).
- If the module cancels the CSR (e.g. due to a timeout), the FB sets "Certificate_out.reqCSRDataAvailable" to "false".

Regardless of the result, the FB now sets the "Certificate_out.reqCSRDataAvailable" output to "false". To finish, you must set the "Certificate_in.resCCManagement" input to "0" (Idle).

The CSR is monitored for adherence to time limits. A maximum of 50 seconds is permitted to elapse between the rising edge of "Certificate_out.reqCSRDataAvailable" and "Certificate_in.resCSRManagement" = 2.

NOTE

If the CSR is not supported by the infrastructure, "resCSRManagement = 3" must be set.

NOTE

If the CSR fails, the module repeats the CSR automatically, at variable intervals.

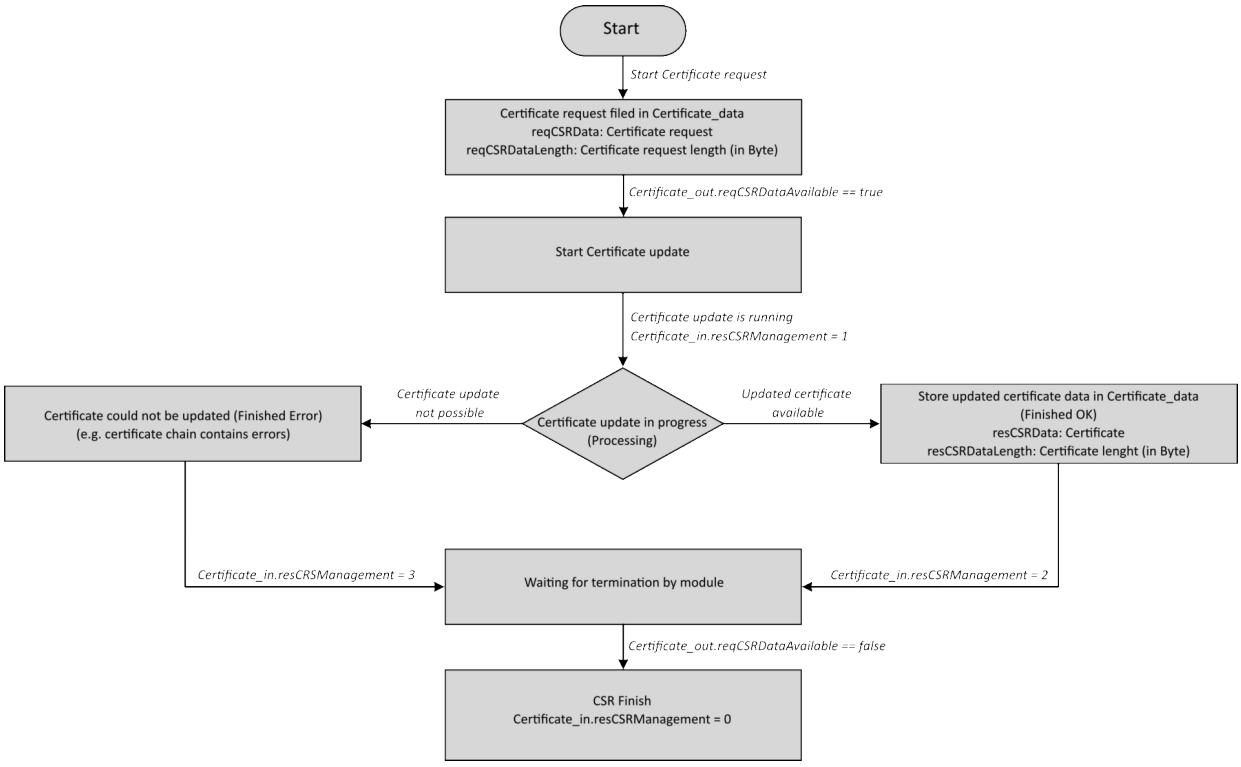

Figure 2-1264 Status diagram for "Module-internal" CSR

External initiation of the CSR

The behavior is essentially the same as when initiated by the module.

Here, the external initiation takes place via an edge change of "Certificate_in.reqCSRUser" from "0" to "1" (false to true).

You are signaled at the "Certificate_out.reqCSRDataAvailable" output that the TLS certificate request has been stored in the FB. When the edge change occurs, the certificate request is in "Certificate_data.reqCSRData". Its length is stored in "Certificate_data.reqCSRDataLength".

This certificate must now be updated (e.g. by the backend).

As soon as the update has been started by the user program, you must set the "Certificate_in.resCCManagement" input to "1" (Processing).

- If the update of the TLS certificate was successful, you must store it in "Certificate_data.resCSRData" and its length in "Certificate_data.resCSRDataLength". You must set the "Certificate_in.resCSRManagement" input to "2" (Finished OK). The module now adopts the new certificate.
- If the certificate could not be updated (e.g. because the certificate chain contains errors or is unknown to the backend), you must set the "Certificate_in.resCSRManagement" input to "3" (Finished Error).
- If the module cancels the CSR (e.g. due to a timeout), the FB sets "Certificate_out.reqCSRDataAvailable" to "false".

Regardless of the result, the FB now sets the "Certificate_out.reqCSRDataAvailable" output to "false". You must then set the "Certificate_in.resCCManagement" input to "0" (Idle).

To finish, the FB outputs the result of the overall CSR request (result from the backend and transfer to the module) in "Certificate_out.reqCSRManagement". Then, please revoke "Certificate_in.reqCSRUser" (false).

The CSR is monitored for adherence to time limits. A maximum of 50 seconds is permitted to elapse between the rising edge of "Certificate_out.reqCSRDataAvailable" and "Certificate_in.resCSRManagement" = 2.

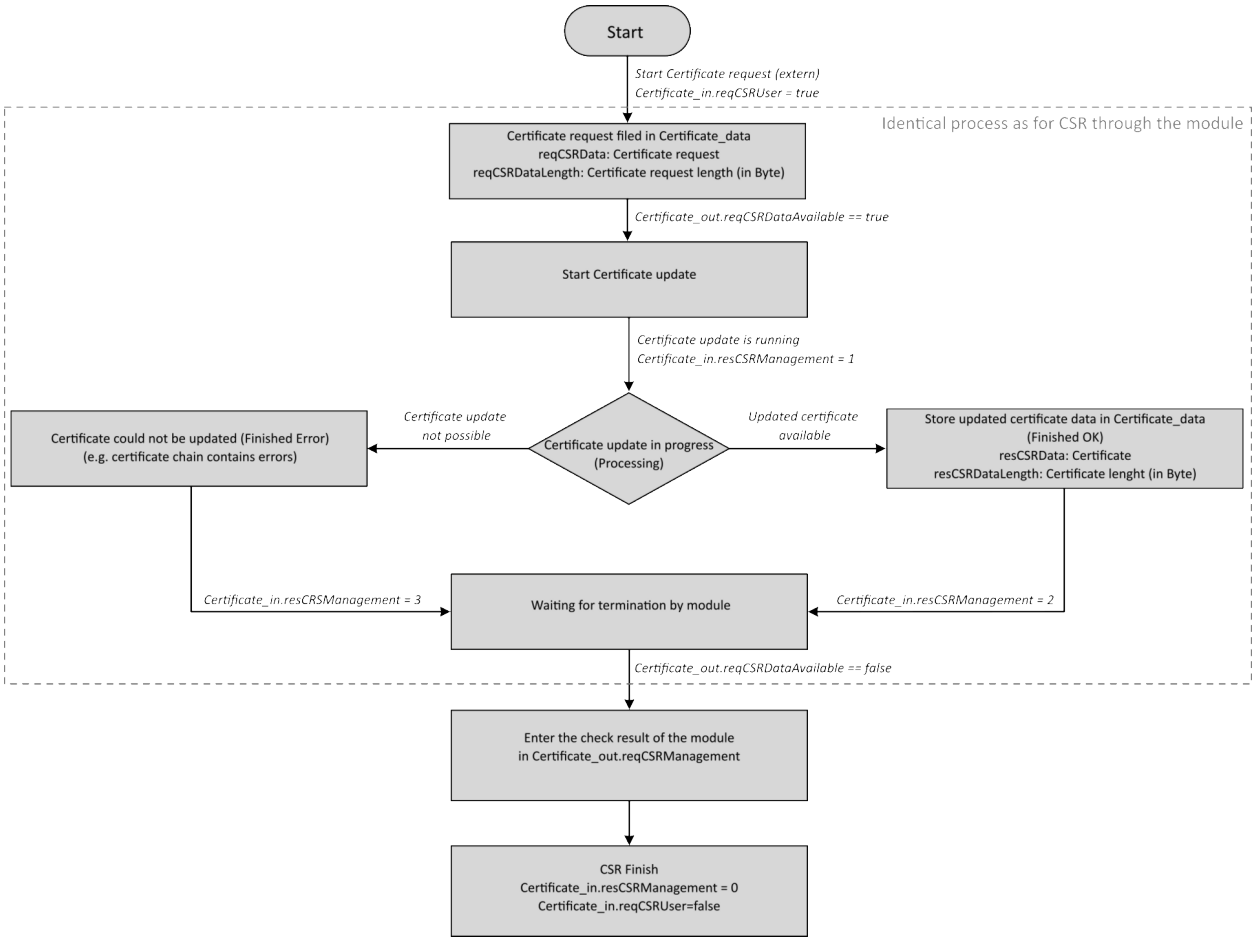

Figure 2-1265 Status diagram for "Module-external" CSR

5.3.2.6 Cable Check extensions

The insulation of the cable is checked. The cable insulation is considered faulty if a maximum leakage current is exceeded when the CableCheck voltage (in.values.extVoltageInVolt) of the frequency converter is applied.

In this phase, the breakers in the vehicle are open. This can be ensured by checking for external voltage (see Checking safe isolation from supply on the charging cable (External Voltage Check) (Page 44))

Parallel to the cable check described below, the error output of a mounted insulation monitor is checked. This can be created at the hwError input

- Bit 0: Insulation warning
- Bit 1: Insulation fault

.

The cable check proceeds in the function block "ISO_15118" in the following steps:

1. Closing of the breakers
   If the PreCharge breaker is activated, it is now closed. The DC breaker remains open. However, if the pre-charge breaker is deactivated, the DC breaker is closed instead. Even if the DC breaker is deactivated by the function block, the check will still proceed to the next step. The test now assumes that the DC breaker is activated externally.
2. Determining the CableCheck voltage to be set (out.setpoints.voltageInVolt) at the frequency converter by the FB:
   = Min (in.evseCfg.maxVoltageInVolt, out.ev.limits.maxVoltageInVolt)
   As of TIA Library "ET 200SP TM ECC" V1.6: The target voltage is calculated according to IEC 61851-23.
   Maximum voltage for vehicle less than or equal to 500V:
   = Min (out.ev.limits.maxVoltageInVolt+50V, in.evseCfg.maxVoltageInVolt)
   Maximum voltage for vehicle greater than 500V:
   = Min (1.1*out.ev.limits.maxVoltageInVolt, in.evseCfg.maxVoltageInVolt)
3. Setting the frequency converter to the CableCheck voltage
   The frequency converter is switched to voltage control (out.setpoints.enableCurrentControl) and the CableCheck voltage to be set is applied to the frequency converter. The specified target current is configured at the function block "ISO_15118" and transferred to the frequency converter. A time monitoring is performed in the function block to check whether the actual voltage value has followed the setpoint within the time configurable in "in.evseCfg.maxTimeRampUpDown".
   The maximum voltage is considered to be reached if in.values.extVoltageInVolt ≥ (out.setpoints.voltageInVolt - in.evseCfg.emvInVolt).
4. Perform current measurement for 10 seconds.
   After the converter reaches the specified maximum voltage, a 10-second measuring phase begins, during which the measured current is checked by the "ISO_15118" function block. In the process a constant check is carried out whether the maximum permitted leakage current has been exceeded. If the shunt is activated, its current flow is deducted from the measurement.

5. Ramping down the frequency converter
   After the 10 seconds have expired, the frequency converter is reduced to the minimum voltage. The current specification for the frequency converter is 1 ampere if the target current is greater than 1 ampere. Otherwise, the specified target current is used for the current specification.
   The minimum voltage is considered to be reached when in.values.extVoltageInVolt ≤ (in.evseCfg.minVoltageInVolt + in.evseCfg.emvInVolt)
   Corresponding parameters in the "ISO_15118" function block:
   - Maximum charging voltage in volts of the frequency converter:
     in.evseCfg.maxVoltageInVolt
   - Minimum charging voltage in volts of the frequency converter:
     in.evseCfg.minVoltageInVolt
   - Monitoring time for reaching the CableCheck voltage:
     in.evseCfg.maxTimeRampUpDown
   - Maximum permitted leakage current in amperes in Cable Check
     in.evseCfg.maxCableCheckLeakCurrentInAmpere
   - Maximum charging voltage of the vehicle
     out.ev.limits.maxVoltageInVolt
   - CableCheck voltage to be set in volts for frequency converter:
     out.setpoints.voltageInVolt
   - Maximum absolute voltage tolerance (in V) of the measuring device used.
     in.evseCfg.emvInVolt
   - Target current in amperes for frequency converter:
     out.setpoints.currentInAmpere
   - Current/voltage control of the frequency converter
     out.setpoints.enableCurrentControl
   - Measured voltage after the DC breaker
     in.values.extVoltageInVolt

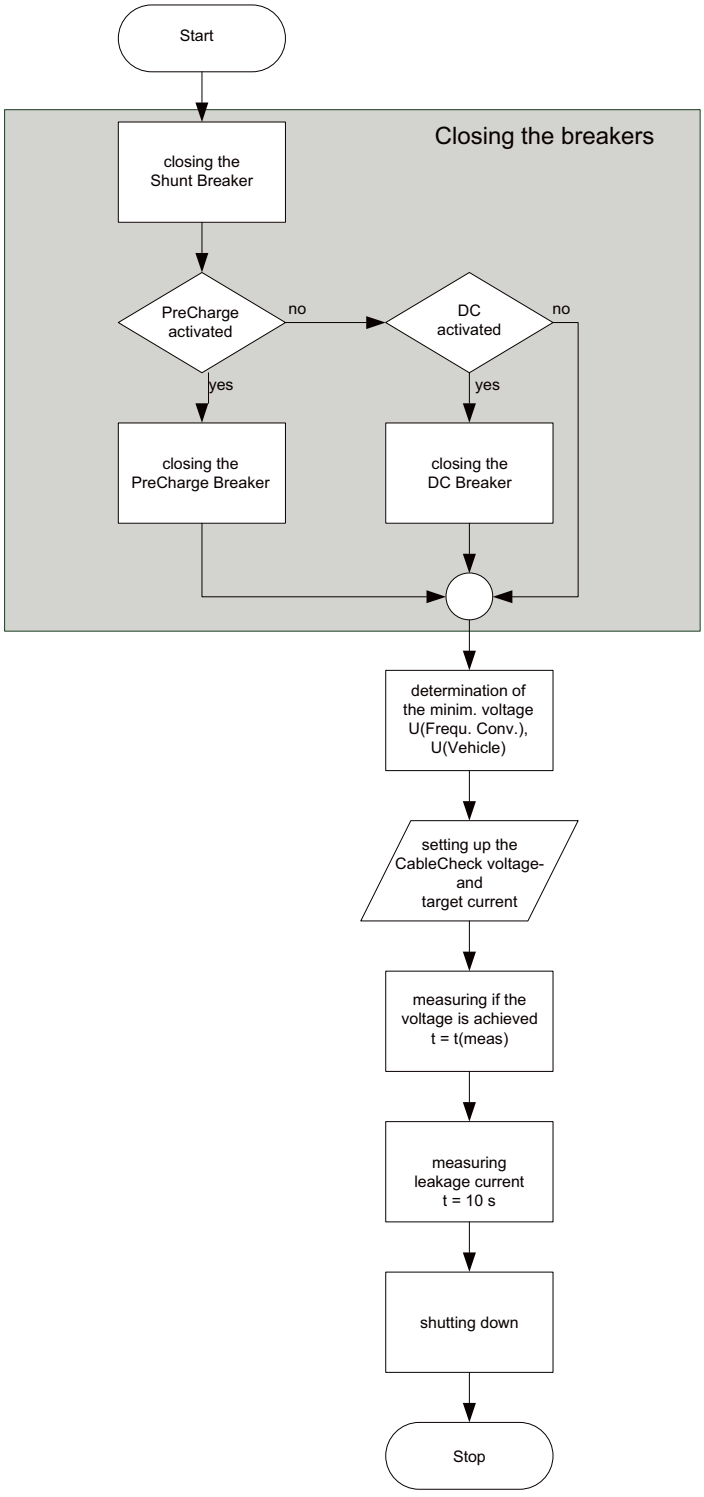

Figure 2-1266 "Cable Check" flowchart

5.3.3 ISO_15118 Parameter

All parameters have been created in the form of UDTs (User defined data types).

The "Charger_in" input is mapped in the form of the UDT "UDT_Charger_In". This input corresponds essentially to the inputs "in" of FB "DIN_70121".

The "Certificate_in" input is mapped in the form of the UDT "UDT_Certificate_In".

The "Charger_out" output is mapped in the form of the UDT "UDT_Charger_Out". This output corresponds essentially to the outputs "out" of FB "DIN_70121".

The "Certificate_out" output is mapped in the form of the UDT "UDT_Certificate_Out".

The "Certificate_data" input/output is mapped in the form of the UDT "UDT_Certificate_InOut".

5.3.3.1 UDT_Charger_In

The UDT_Charger_In has the following structure:

Table 2-1424 List of input parameters for the UDT_Charger_In

Parameter	Data type	Description
ackErrors	Bool	Error acknowledgment In the "True" state, all pending errors are acknowledged.
enable	Bool	Charging outlet enable (True = yes, False = no) If this input is set to "False", an ongoing charging process is canceled and the frequency converter is shut down in a controlled manner. Subsequently the CP output signal in the module is set to -12 V. If the Enable input is set to "True", the CP output signal changes to +12 V.
evseCfg	UDT_Charger_E-vseCfg (Page 76)	Input parameter for the configuration of the charging station
hw_Id	HW_IO	Hardware ID of the technology module SIMATIC ET 200SP TM ECC PL ST for the determination of the offset of the process image of the inputs/outputs. If an invalid HW ID is entered, a corresponding error bit at the output is set to "True" (Error messages (Page 93)).
hwError	Byte	Pending HW errors / warnings of the charging station: • Bit 0: Insulation monitor "Warning" • Bit 1: Insulation monitor "Error" • Bit 2: An emergency-off of the charging station has taken place (for example by pressing the emergency-off button) If Bit 1 or Bit 2 is set to "True", the converter is ramped down in a controlled manner if possible. The CP output level is set to "-12 V".
values	UDT_Charger_Values (Page 79)	Currently pending parameters of the charging station that are relevant for the charging process.

5.3.3.2 UDT_Charger_EvseCfg

The UDT_Charger_EvseCfg has the following structure:

Table 2-1425 List of input parameters for the UDT_Charger_EvseCfg

Parameter	Data type	Description
addTimeStamp	BOOL	True: In sessionSetupResponse, the current time (Unix Time Stamp) is also transmitted False: in sessionSetupResponse, the current time is not transmitted Notwendige Versionen: As of TIA Library V1.6 and Firmware Version V1.1.21
cableCheckCurrentInAmpere	UInt	Current setpoint (in A) during the "Cable check" phase. This parameter is relevant for converters that need a minimum current value to start up. This current must be greater than the value of "maxCableLeakCurrentInAmpere"; otherwise the error message bit 1 (parameterization error) is set. (see section on Cable check (Page 45))
dcbrkIsUsed	BOOL	Monitoring of the feedback from the "DC breaker" and control of the corresponding output. (True = yes, False = no) (see section on Protective circuit of the frequency converter (Page 42))
currentUseReal	BOOL	True: The value in currentInAmpereReal is valid and used False: The value in currentInAmpere is valid and used Required versions: From TIA Library V1.6 and Firmware Version V1.1.21
emcInAmpere	UInt	Maximum absolute current tolerance (in A) of the used measuring instrument. (relevant in Cable Check phase and when terminating the charging process)
emvInVolt	UInt	Maximum absolute voltage tolerance (in V) of the used measuring instrument. (relevant in External Voltage Check, Cable Check, PreCharge phase and termination of the charging process)
evseId	Array [0...31] of Byte	Unique ID of the charging station. The structure of the ID is defined in the charging standard used.
evseIdLength	USINT	Length of the evseId address in bytes If this value is greater than "32", the error message bit 1 (parameterization error) is set.
extVoltageCheckIsSupported	BOOL	Activation of the check of the applied voltage before the pending phase "Cable check". (True = yes, False = no) (see the section on Checking the de-energized state (Page 44)) The voltage "maxExtVoltageInVolt" must be less than or equal to the value of "maxVoltageInVolt", otherwise the error message bit 1 (parameterization error) is set (see Error Messages (Page 93) section).
maxCableCheckLeakCurrentI-nAmpere	UInt	The maximum leakage current allowed during the cable check (see section Cable check (Page 45)). If the leakage current is greater, a corresponding error bit at the output is set to "True" (see section Error messages (Page 93)). This current must be less than or equal to the value of "maxCurrentInAmpere"; otherwise the error message bit 1 (parameterization error) is set.

maxCurrentInAmpere	UInt	The currently available maximum current which can be delivered by the charging station. This current must be greater than the value of "minCurrentInAmpere"; otherwise the error message bit 1 (parameterization error) is set.
maxExtVoltageInVolt	UInt	The maximum permitted voltage on the cable (external voltage check) before the cable check (see section Checking the de-energized state (Page 44)). If exceeded, a corresponding error bit at the output is set to "True" (see section Error messages (Page 93))
maxPowerInkW	UInt	Maximum available power (in kW) of the charging station.
maxSwitchTimeBreaker	Time	The maximum time has been exceeded in which the feedback signal of the DC/Precharge or shunt breaker has to be performed. If this time is exceeded, a corresponding error bit at the output is set to "True" (see section Error messages (Page 93)). This time must be greater than "0 ms"; otherwise the error message bit 1 (parameterization error) is set.
maxSwitchTimeHwState	Time	Maximum time available for switching from one HW state to the next (see section HW states (Page 51)) If this time is exceeded, a corresponding error bit at the output is set to "True" (see section Error messages (Page 93)). This time must be greater than "0 ms"; otherwise the error message bit 1 (parameterization error) is set.
maxTimeInvalidParamsOr-RampCharge	Time	The maximum time in which the charging station must follow the specifications of the vehicle (target voltage, target current). If this time is exceeded, a corresponding error bit at the output is set to "True" (see section Error messages (Page 93)). This time must be greater than or equal to the value of "maxTimeRampUpDown"; otherwise, the error message bit 1 (parameterization error) is set.
maxTimeRampUpDown	Time	The maximum time in which the converter must have reached the desired value (charging voltage or charging current). Affects all charging phases except the "PreCharge" and "CurrentDemand" phase. If this time is exceeded, a corresponding error bit at the output is set to "True" (see section Error messages (Page 93)). This time must be greater than "0 ms"; otherwise the error message bit 1 (parameterization error) is set. The time must be less than or equal to the time parameterized under "maxTimeInvalidParamsOrRampCharge".
maxVoltageCorr	UInt	In 0.1 % Factor by which the maximum vehicle voltage is increased when calculating the maximum charging station voltage. A value of "0" corresponds to the behavior of version V1.1 and older versions of the function block.
maxVoltageInVolt	UInt	The maximum charging voltage (in V) of the charging station. This voltage must be greater than the value of "minVoltageInVolt"; otherwise the error message bit 1 (parameterization error) is set.
minCurrentInAmpere	UInt	The minimum charging current (in A) of the charging station. This current must be less than the value of "maxCurrentInAmpere"; otherwise, the error message bit 1 (parameterization error) is set.
minVoltageInVolt	UInt	The minimum voltage (in V) of the charging station. This voltage must be less than the value of "maxVoltageInVolt"; otherwise the error message bit 1 (parameterization error) is set.

noAuthenticationTimeout	BOOL	True: The assembly remains in the Authentication state for any length of time. The EV may abort the charging process on its own. False: The module goes into error after 55s in authentication without any reaction from the user. Standard-compliant behavior Required versions: From TIA Library V1.6 and Firmware Version V1.1.21
noCharIN	BOOL	Communication behavior True: In accordance with the DIN SPEC 70121 standard False: According to CharIN Required versions: From TIA Library V1.5 and Firmware Version V1.1.17
paymentVar	Byte	Possible payment variants of the charging station • 1 = Only payment via EIM without TLS possible. • 2 = Only payment via PnC possible. • 3 = Payment via EIM without TLS and PnC possible. • 5 = Only payment via EIM including with TLS possible. • 7 = Payment via EIM, including with TLS and PnC possible. • 0, 4, 6, 8 .. 255 result in a configuration error (swError1.1)
peakCurrentRippleInAmpere	UInt	Maximum current ripple (in A) on the charging current.
preChargeCurrentInAmpere	UInt	The maximum allowed charging current (in A) in the "PreCharge" phase. If a minimum current value is required by the frequency converter to start, its high limit is defined here. This current must be less than or equal to the value of "maxCurrentInAmpere"; otherwise the error message bit 1 (parameterization error) is set.
prechbrkIsUsed	BOOL	Monitoring the feedback of the "PreCharge breaker" and control of the corresponding output (see section on Wiring of the frequency converter (Page 42)). (True = yes, False = no) If "False" is set, the corresponding output "prechbrk" is also set permanently to "False".
shuntIsUsed	BOOL	Monitoring the feedback of the "Shunt breaker" and control of the corresponding output (see the section on Wiring of the frequency converter (Page 42)). (True = yes, False = no) The "shuntValueInOhm" value must be unequal to "0"; otherwise the error message bit 1 (parameterization error) is set.
shuntValueInOhm	UInt	Resistance value of shunt in Ohm (see the section on Protective circuit of a frequency converter (Page 42))
stopChargingCurrentIn-Ampere	UInt	If this value is undershot when the charging process is terminated, the DC disconnector opens. This current must be less than or equal to the value of "maxCurrentInAmpere"; otherwise the error message bit 1 (parameterization error) is set.
supportedEnergyTransfer-Types	Word	With this parameter you select the energy transfer variants supported by the charging station (True = selected; False = not selected).

		The names of the variants are taken directly from ISO 15118. • Bit 0 = AC_single_phase_core • Bit 1 = AC_three_phase_core • Bit 2 = DC_core DC charging via the pins in the Type1/Type2 connector is supported • Bit 3 = DC_extended Charging via the extended pins of the CCS connector (Type1/Type2) is supported • Bit 4 = DC_combo_core • Bit 5 = DC_dual The "ISO 15118" function block only supports DC_core (Bit 2) and DC_extended (Bit 3). The error message bit 1 (parameterization error) is set for all other variants (bit values). In addition, at least one of these two bits must be set. The variants supported by the charging station are compared to the variants required by the vehicle. If the vehicle requires a variant which is not supported by the charging station, the charging process is aborted.
useOnlyDin	BOOL	• True: The assembly offers an EV charging only according to DIN70121 • False: The assembly offers EV charging to DIN70121 and ISO15118 Required versions: From TIA Library V1.6 and Firmware Version V1.1.21

5.3.3.3 UDT_Charger_Values

The UDT_Charger_Values has the following structure:

Table 2-1426 List of input parameters to the UDT_Charger_Values

Parameter	Data type	Description
authAccepted	Byte	This parameter indicates whether the charging station is authorized for the charging of a vehicle. It is relevant in the authentication phase. Here the vehicle owner has to, for example, authorize the charging process via RFID. The status of the authentication is defined by the following three states: • 0: Authentication is taking place There is no feedback signal yet • 1: Authentication has failed The charging process is not started • 2: Authentication successful The charging process can begin • 3 ... 255: Authentication has failed The charging process is canceled. If no explicit activation is required (e.g. free charging), the parameter can be permanently set to "2".
currentInAmpere	Int	Currently measured current of the amperemeter (in A)
currentInAmpereReal	Real	Currently measured current of the amperemeter as a floating point number (in A) Required versions: From TIA Library V1.6 and Firmware Version V1.1.21
dcbrk	Bool	The feedback contact of the DC breaker (False = Open; True = Closed). This parameter is only used if the control of the DC breaker is activated (see section Possible circuitry of a frequency converter (Page 42)).
extVoltageInVolt	Int	Currently measured voltage of the voltage measuring unit (in V) at the charging outlet.

hwState	Int	HW state of the charging station (see section Hardware states (Page 51)). The following 4 states are defined: • 0: Undefined state When the charging station is switched on • 1: Idle state Converter is off, IO modules for the breakers are switched off • 2: Wait state Converter is off, IO modules for the breakers are on • 3: Ready Converter is on, IO modules for the breakers are on
prechbrk	Bool	The feedback contact of the PreCharge breaker (False = Open; True = Closed). This parameter is only used when the control of the PreCharge breaker is activated (see section Possible circuitry of a frequency converter (Page 42)).
shunt	Bool	The feedback contact of the shunt breaker (False = Open; True = Closed). This parameter is only used when the control of the shunt breaker is activated (see section Possible circuitry of a frequency converter (Page 42)).
stopCharging	Bool	Setting this bit to "True" indicates to the vehicle that the charging procedure is to be ended. The vehicle decides whether and when the charging process is terminated. If "stopCharging" is set to "True" for longer than the current charging process, no other charging process can be started until this bit has been reset to "False".
voltageInVolt	Int	Currently measured voltage of the voltage measuring unit (in V) at the frequency converter output.

5.3.3.4 UDT_Certificate_In

UDT_Certificate_In is structured as follows:

Table 2-1427 List of input parameters for UDT_Certificate_In

Name	Data type	Description
reqCSRUser	Bool	Initiate CSR by the user
resCCManagement	Byte	Feedback to the FB regarding the processing status of the CC (see Contract Certificate (Page 66)) • Coding same as for resCSRManagement
resCertCheck	Byte	Result of the local contract certificate check in the CC (see Contract Certificate (Page 66)) • 0: Not checked / Check not yet complete • 1: Error, only in conjunction with resCCManagement = 3 • 2: Accepted • 3: Accepted, certificate expires "soon" • 5: Rejected, certificate is valid but has expired • 6: Rejected, error in the signature • 7: Rejected, the certificate does not exist • 9: Rejected, error in the certificate chain • 10: Rejected, certificate not permitted at this charging point • 11: Rejected, certificate invalidated before expiration • 4, 8, 12 .. 255: Not permissible. Handled like "Error"

Name	Data type	Description
resContCheck	Byte	Result of the backend check of the contract certificate in the CC (see Contract Certificate (Page 66)) • 0: Not checked / Check not yet complete • 1: Error, only in conjunction with resCCManagement = 3 • 2: Accepted • 3: Rejected, processing canceled • 4 .. 255: Not permissible. Handled like "Error"
resCSRManagement	Byte	Feedback to the function block on the processing status of the CSR (see Certificate Signing Request (Page 68)) • 0: Idle • 1: Processing • 2: Finished OK • 3: Finished Error • 4 .. 255: Not allowed. Handled like "Finished Error"

5.3.3.5 UDT_Charger_Out

The UDT_Charger_Out has the following structure:

Table 2-1428 List of input parameters for UDT_Charger_Out

Parameter	Data type	Description
ev	UDT_Charger_Ev (Page 83)	Information about the vehicle
pilotState	USINT	Charge state The status according to IEC 61851-1 is output at this output. • 0: Status A1 (100% PWM) Charging station not ready for charging / vehicle not connected (Status according to IEC 61851-1) • 1: Status B1 (100% PWM) Charging station not ready for charging / vehicle not ready for charging (Status according to IEC 61851-1) • 2: Status B2 (5% PWM) Charging station ready for charging / vehicle not ready for charging (Status according to IEC 61851-1) • 3: Status C1 (100% PWM) Charging station not ready for charging / vehicle ready for charging (Status according to IEC 61851-1) • 4: Status C2 (5% PWM) Charging station ready for charging / vehicle ready for charging (Status according to IEC 61851-1) • 5: Status D1 (100% PWM) Charging station not ready for charging / vehicle ready for charging / ventilation required (Status according to IEC 61851-1) • 6: Status D2 (5% PWM) Charging station ready for charging / vehicle ready for charging / ventilation required (status according to IEC 61851-1) • 7: Status E (100% PWM) e.g. if charging station is de-energized or short-circuit between CP and protective conductor (status according to IEC 61851-1)

		• 8: Status F Charging station not ready for charging e.g. Error occurred or charging station under maintenance - charging outlet blocked (status according to IEC 61851-1) • 9: Invalid status CP voltage outside the permitted range
ppState	USINT	Status of the Plug Present (only relevant for type 1 plugs) • 0: Vehicle is not connected to charging station • 1: Vehicle is connected to the charging station, the button on the plug is pressed • 2: Vehicle is connected to the charging station, the button on the plug is not pressed • 0xFF: Invalid voltage at Plug Present (U > 3.5 V)
setpoints	UDT_Charger_Setpoints (Page 84)	Current manipulated variables for the charging station.
swError1	DWord	Pending SW error corresponds to swError bit no. 0 to 31
swError2	DWord	Pending SW error corresponds to swError bit no. 32 to 63
swState	Int	SW states • -3: An error has occurred. The error can be acknowledged. The "-2" state automatically changes to the "-3" state after 10 s • -2: An error has occurred. The charging station is shut down. • -1: An error has occurred. The charging station is shutting down. • 0: Initialization phase (after cold restart). The basic hardware checks are carried out. Are all modules on and the disconnectors open? • 1: System ready for operation • 2: System in idle state (no charging process active). The IO modules are off, all disconnectors are open. • 3: The IO modules are on, all disconnectors are open. • 4: System is ready for charging (communication with the vehicle has started). This phase is very short and is therefore not always visible at the output. • 5: Authentication phase • 6: Parameter discovery • 7: ExtVoltageCheck This phase is very short and is therefore not always visible at the output. • 8: Cable Check • 9: PreCharge/Power Delivery • 10: Current Demand • 11: Termination of the charging process

If no current charging process is pending or the "Authentication" phase has not yet been reached, the output is set to "0".

5.3.3.6 UDT_Charger_Ev

The UDT_Charger_Ev has the following structure:

Table 2-1429 List of output parameters to the UDT_Charger_Ev

Parameter	Data type	Description
Diagnostics	UDT_Charger_Ev_Diagnostics	Status and diagnostic information with regard to the vehicle.
evccId	Array [0..7] of Byte	Unique ID of the vehicle.
evccIdLength	USINT	Length of the vehicle ID
evccMac	Array [0..5] of Byte	MAC address of the EV
Limits	UDT_Charger_Ev_Limits	Electrical limiting values of the vehicle.

5.3.3.7 UDT_Charger_Ev_Diagnostics

The UDT_Charger_Ev_Diagnose has the following structure:

Table 2-1430 List of output parameters to the UDT_Charger_Ev_Diagnostics

Parameter	Data type	Description
cabinConditioning	Bool	Information by the vehicle (e.g. heating is on)
evEnergyTransferType	Int	Energy transfer type supported by the vehicle The names of the variants are taken directly from ISO 15118. • 0 = AC_single_phase_core • 1 = AC_three_phase_core • 2 = DC_core DC charging via the pins in Type 1/Type 2 plug-in connectors is required • 3 = DC_extended charging via the extended pins of the CCS connector (Type1/Type2) is required • 4 = DC_combo_core • 5 = DC_dual
remainingTimeToBulkSoC	Time	Information from the vehicle: Estimated duration until the vehicle battery is 80% charged.
remainingTimeToFullSoC	Time	Information from vehicle; estimated duration until the vehicle battery is charged to 100 %.
ressConditioning	Bool	Information from the vehicle: The battery is in the service mode and is therefore charging with reduced performance
stateOfChargeInPercent	USINT	Information from the vehicle: Current charge state (in %)

5.3.3.8 UDT_Charger_Ev_Limits

The UDT_Charger_Ev_Limits has the following structure:

Table 2-1431 List of output parameters to the UDT_Charger_Ev_Limits

Parameter	Data type	Description
maxCurrentInAmpere	UInt	The maximum charging current permitted by the vehicle (in A)
maxPowerInkW	UInt	The maximum charging power permitted by the vehicle (in kW)
maxVoltageInVolt	UInt	The maximum charging voltage permitted by the vehicle (in V).

5.3.3.9 UDT_Charger_Setpoints

The UDT_Charger_Setpoints has the following structure:

Table 2-1432 List of output parameters to the UDT_Charger_Setpoints

Parameter	Data type	Description
currentInAmpere	DInt	The current (in A) that is to be set at the converter. **Note**: The value can also be less than the value configured in in.evseCfg.minCurrentInAmpere in the CurrentDemand Phase, as currentInAmpere is specified by the vehicle in this phase.
currentInAmpereReal	Real	The current (in A) that is to be set at the frequency converter as received by the vehicle, with 10 mA precision. Required versions: As of TIA Library V1.4 and Firmware Version V1.1.15. **Note**: The value can also be less than the value configured in in.evseCfg.minCurrentInAmpere in the CurrentDemand Phase, as currentInAmpere is specified by the vehicle in this phase.
dcbrk	BOOL	Required state of the DC breaker (see section Possible circuitry of a frequency converter (Page 42)). (False = Open; True = Closed).
enableCurrentControl	BOOL	Determination current/voltage control for the frequency converter • True: The converter must be set to current control. (The "currentInAmpere" parameter defines the current specification, the "voltageInVolt" parameter defines the maximum voltage) • False: The converter must be set to voltage control. (The "currentInAmpere" parameter defines the maximum current, the "voltageInVolt" parameter defines the voltage specification)
hwState	Int	The setpoint HW status of the charging station requested by the function block. The following 4 states are defined (see section Hardware states (Page 51)): • 0: Undefined state for example whether the charging station is switched on • 1: Idle state Converter is off, I/O modules for the breakers are off • 2: Wait state Converter is off, I/O modules for the breakers are on • 3: Ready Converter is on, I/O modules for the breakers are on

paymentType	Byte	Payment option selected by the vehicle • 0: No decision yet by the EV regarding the payment option • 1: Payment by means of external identification (e.g. RFID card reader) • 2: Payment by automatic identification (PnC) • 3 .. 255: Reserve
prechbrk	BOOL	Required state of the PreCharge breaker (see section Possible circuitry of a frequency converter (Page 42)). (False = Open; True = Closed).
shunt	BOOL	Required state of the shunt breaker (see section Possible circuitry of a frequency converter (Page 42)). (False = Open; True = Closed).
usedStandard	Byte	Charging norm used by the vehicle • 0: Charging norm not yet set (If no current charging process is pending or the "Authentication" phase has not yet been reached, the output is set to "0"). • 1: DIN 70121 is used • 2: ISO 15118 is used • 3 .. 255: Reserve
voltageInVolt	DInt	The voltage (in V) that is to be set at the converter.

5.3.3.10 UDT_Certificate_Out

The UDT_Certificate_Out is structured as follows:

Table 2-1433 List of parameters for UDT_Certificate _Out

Name	Data type	Description
encCommunication	Bool	Communication via an encrypted connection between EV and EVSE
errorStateCC	Bool	Error state of the last CC transaction
errorStateCSR	Bool	Error status of the last CSR transaction
reqCCDataAvailable	Bool	Message to the user: There is a CC request through the TM
reqCSRDataAvailable	Bool	Message to the user: There is a CSR by the TM
reqCSRManagement	Byte	Feedback of the FB on the processing status of the CSR in the module (see also Certificate Signing Request (Page 70)) Coding like "resCSRManagement" (see "List of input parameters for UDT_Certificate_In")
tlsCertificatePresent	Bool	Valid TLS certificate available in TM

5.3.3.11 UDT_Certificate_InOut

The UDT_Certificate_InOut is structured as follows:

Table 2-1434 List of parameters for UDT_Certificate _InOut

Name	Data type	Description
reqCCData	Array of Byte	Container for CC data to the backend
reqCCDateLength	UInt	Valid length of the CC data for the Back End
reqCCEMAID	Array of Byte	Vehicle identification (EMAID) at the CC to the back end
reqCCEMAIDLength	UInt	Valid length of the EMAID.

Name	Data type	Description
reqCSRData	Array of Byte	Container for CSR data to the backend
reqCSRDateLength	UInt	Valid length of the CSR data to the backend
resCSRData	Array of Byte	Container for CSR data from the backend (TLS certificate)
reqCSRDateLength	UInt	Valid length of the CSR data from the backend

5.4 "Update_PL_ST" function block

Introduction

This section presents the properties of the "Update_PL_ST" function block. It exists in three versions:

- Update_PL_ST_1500 (for CPU15xx)
- Update_PL_ST_1200 (for CPU12xx)
- Update_PL_ST_OC (for Open Controller)

The three function blocks behave identically. For the sake of clarity, only the "Update_PL_ST" function block is referred to in the following.

The following figure shows the inputs/outputs of the "Update_PL_ST" function block:

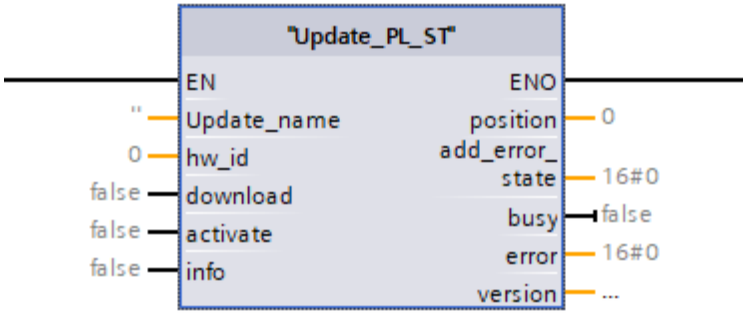

Figure 2-1267 "Update_PL_ST" function block

The "Update_PL_ST" and "Log_PL_ST " function blocks are available for download as their own TIA library:

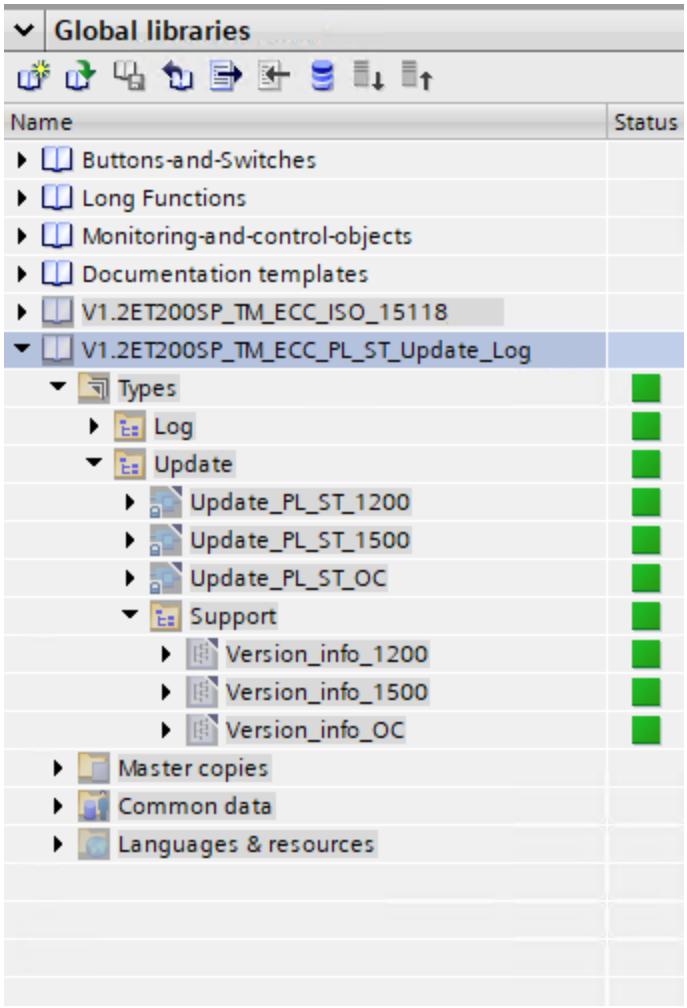

Figure 2-1268 Structure of the library Update_PL_ST

The "Update_PL_ST_1200" folder contains the blocks for the S7-1200 controllers, and the "Update_PL_ST_1500" folder contains the blocks for the S7-1500 controllers. The blocks for the "Open Controller" are contained in the "Update_PL_ST_OC" folder.

5.4.1 Required memory of the "Update_PL_ST" function block

Memory requirement

The memory requirement is shown below:

Table 2-1435 Memory requirement of the "Update_PL_ST" function block

	Load memory	Code work memory	Data work memory
First instance	77.95 KB	3.75 KB	12.55 KB
Additional memory required for each additional instance	1.27 KB	0	12.55 KB

5.4.2 Principle of operation of the "Update_PL_ST" function block

In contrast to "DIN_70121" or the "ISO_15118", the "Update_PL_ST" FB is not mandatory for the operation of the ET 200SP TM ECC PL ST technology module. You can configure it additionally in order to make use of additional update options and information.

- Transfer of the interim updates provided by Siemens AG (minor function update or corrections) that are suitable for the current basic FW version on the technology module (even during a charging process).
- Activation of previously transferred interim updates at a time of your choosing.
- Query of information regarding the current basic FW version (TIA), a currently active interim update and the size of a previously downloaded interim update.

NOTE

The function block can be used starting from FW Version V1.1.

Inputs

Parameter	Data type	Description
update_name	String	Name and path of the interim update on the CPU MMC
hw_id	HW_IO	Hw_id of the ET 200SP TM ECC PL ST as used in the DIN/ISO FB
download	Bool	Start/cancel download of the interim update
activate	Bool	Activate previously downloaded interim update
info	Bool	Query information

Outputs

Parameter	Subparameter	Data type	Description
position		UDint	Transferred bytes of an interim update
add_error_state		Word	Additional error information
busy		Bool	Download/activation/information query active
error		Byte	Error during the last action
version		version_info	
	type	Char	Letter of the TIA version, normally "V"

Parameter	Subparameter	Data type	Description
version	major	Byte	First digit of the TIA version number
	minor	Byte	Second digit of the TIA version number
	increment	Byte	Third digit of the TIA version number
	updateSize	Dint	Size of an interim update that is waiting for activation, or zero
	linux	Dword	Identifier of an active interim update or corresponding identifier of a basic version

As a precondition for an interim update, the update file concerned must be on the MMC inserted in the CPU. You can copy it to there, e.g. using the web server of the CPU. Ensure that the parameter "hw_id" has been set correctly and the parameter "update_name" contains the name and path of the interim update.

- A positive edge at the "info" input loads the status information from the technology module and makes it available at the "version" output. During this process, "busy" is high and then changes to low.
- A positive edge at the "activate" input attempts to activate an interim update located on the technology module. During this process, "busy" is high and changes after the message is sent to low. There is no direct response of the technology module, especially if no interim update is available. You can check the result by using "info" to read out the version (see above).

NOTE

When an interim update has been activated successfully, the TM behaves the same as at the end of a regular TIA update. You must heed the notes regarding the firmware update (Page 11), especially those regarding the power supply.

Ignore all error messages of an active function block (DIN_70121 or ISO_15118) during this operation.

- A positive edge at the "download" input starts the transfer of the interim update stored under "update_name" to the technology module. During this process, "busy" is high. The portion of the update already transferred, in bytes, is displayed in "position". The process can be canceled with a negative edge at "download".

If an error occurs during one of these actions, this is indicated at a falling edge at the "busy" output by a non-zero value at the "error" output. If necessary, you can obtain more information of subordinate system functions from the "add_error_state" output:

error		See system function
0	No error, action successful	-
1	Error when writing to the TM	WRREC output "Status" Bytes 1 and 2
2	Error when reading from the TM	RDREC output "Status" Bytes 1 and 2
3	Error when reading from the MMC	FileReadC output "Status"
4	TM signals an error	-

See also

Properties (Page 11)

5.5 "Log_PL_ST" function block

Introduction

This section presents the properties of the "Log_PL_ST" function block. It exists in three versions:

- Log_PL_ST_1500 (for CPU15xx)
- Log_PL_ST_1200 (for CPU12xx)
- Log_PL_ST_OC (for Open Controller)

The three function blocks behave identically. For the sake of clarity, only the "Log_PL_ST" function block is referred to in the following.

NOTE

Description of the function block depending on the TIA library versions

The following descriptions refer to TIA library versions from V1.2.

The descriptions of the function block for TIA library versions prior to V1.2 can be found in the ET 200SP technology module TM ECC PL ST Equipment Manual, issue 08/2023. (https://support.industry.siemens.com/cs/de/de/view/109754091/en)

The following figure shows the inputs/outputs of the "Log_PL_ST" function block:

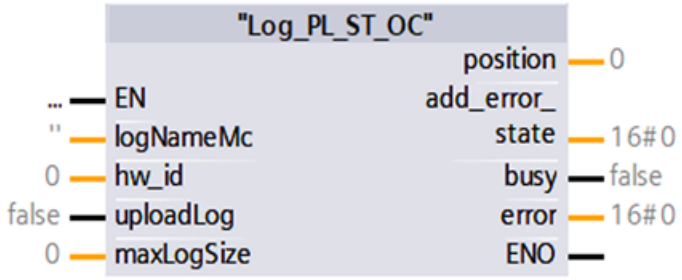

Figure 2-1269 "Log_PL_ST" function block

The "Update_PL_ST" and "Log_PL_ST " function blocks are available for download as their own TIA library:

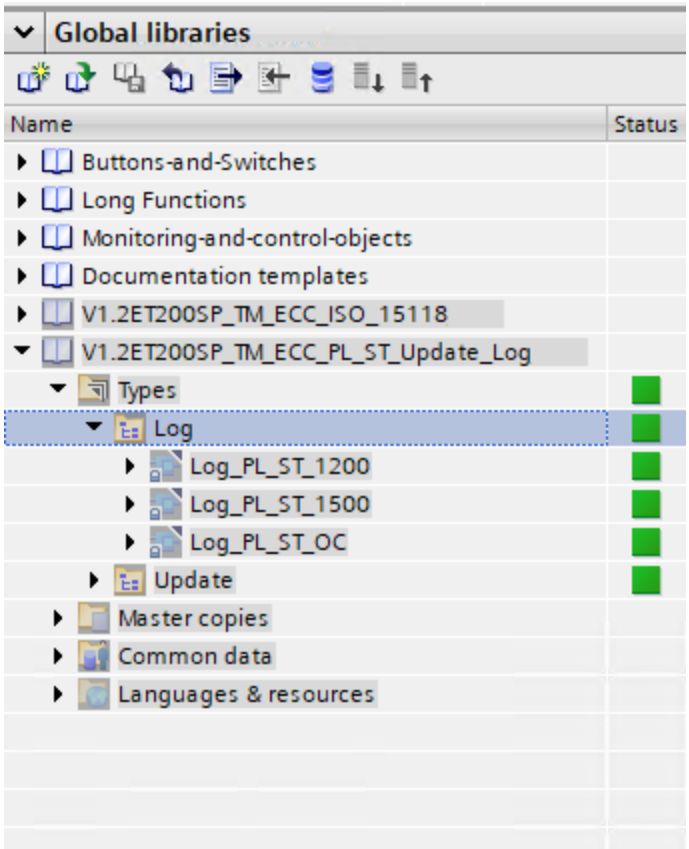

Figure 2-1270 Structure of the library Log_PL_ST

The "Log_PL_ST_1200" folder contains the blocks for the S7-1200 controllers, and the "Log_PL_ST_1500" folder contains the blocks for the S7-1500 controllers. The blocks for the "Open Controller" are contained in the "Log_PL_ST_OC" folder.

5.5.1 Principle of operation of the "Log_PL_ST" function block

In contrast to FB "DIN_70121" or "ISO_15118", the "Log_PL_ST" FB is not mandatory for the operation of the ET 200SP TM ECC PL ST technology module. You can configure it additionally in order to gain access to log information.

You can

- set the maximum size of a log file to be transferred,
- upload the current log file from the technology module

NOTE

The function block can be used starting from FW Version V1.1.

Inputs

Parameter	Data type	Description
logNameMc	String	Name and path of the log file on the CPU-MMC. Note that the path starts with "UserFiles" so that the file is visible via the web server under "UserFiles". Rename the downloaded log file to <Log file>.gz, because it is an archive (zip file).
hw_id	HW_IO	Hw_id of the ET 200SP TM ECC PL ST as used in the DIN/ISO FB
uploadLog	Bool	Start/cancel upload of the log
maxLogSize	UInt	Maximum size of the log file in KBytes • The maximum size of a log file amounts to 1 MB. • The minimum size of a log file is 10 KB, even if the value is < 10 KB. • The default value is also 1 MB.

Outputs

Parameter	Data type	Description
position	UDint	Transferred bytes of a log file
add_error_state	Word	Additional error information
busy	Bool	Status parameter • 0: Execution of the instruction completed or not yet started. • 1: Execution of the upload not yet completed.
error	Byte	Error during the last action

To be able to carry out the log upload, you must ensure that there is sufficient free memory space on the MMC inserted in the CPU.

NOTE

Activate the web server on the CPU so that the log file is downloaded via the web server.

Unzip the downloaded file. You can rename the unzipped file to <Log file>.txt and read it with a text editor.

Note that any "LogNameMc" file located on the MMC is overwritten even if the upload is interrupted prematurely.

- A positive edge at the "uploadLog" input starts the transfer of the current log file on the technology module to the CPU MMC. During this process "busy" is true. The portion of the update already transferred, in bytes, is displayed in "position". The process can be aborted with a negative edge at "uploadLog".

If an error occurs during this action, this is indicated by a value unequal to zero at the "error" output together with a falling edge at the "busy" output. If necessary, you can obtain more information of subordinate system functions from the "add_error_state" output:

error	Description	See system function
0	No error, action successful	-
1	Error when writing to the TM	WRREC output "Status" Bytes 1 and 2
2	Error when reading from the TM	RDREC output "Status" Bytes 1 and 2
3	Error when reading from the MMC	FileReadC output "Status"
4	TM signals an error	-

5.5.2 Required memory of the "Log_PL_ST" function block

Memory requirement

The memory requirement is shown below:

Table 2-1436 Memory requirement of the "Log_PL_ST" function block

	Load memory	Code work memory	Data work memory
First instance	80.73 KB	3.94 KB	12.53 KB
Additional memory required for each additional instance	15.86 KB	0	12.53 KB

5.6 Error messages

The error messages of the function block are described in the following table.

When the function block "DIN_70121" is used

- These error messages refer to the output parameter "out.swError1" (Bit no. 0 ... 31) and "out.swError2" (bit no. 0 ... 31)

When the function block "ISO_15118" is used

- These error messages refer to the output parameter "Charger_out.swError1" (Bit no. 0 ... 31) and "Charger_out.swError2" (bit no. 0 ... 31)

Table 2-1437 List of error messages "out.swError1" & "Charger_out.swError1"

Bit no.	Acknowledgment required	Description	Remark
0	No	Hardware (communication module) not ready	The communication module does not report back, for example, because of a PROFINET fault or a fault of the ET 200SP backplane bus communication. The frequency converter is ramped down in a controlled manner.
1	Yes	Invalid configuration (in.evseCfg)	An invalid configuration exists at the function block input. Possible causes of the fault: • "EVSEID" is greater than "32" • "maxCurrentInAmpere" is greater than "minCurrentInAmpere" • "maxVoltageInVolt" is less than "minVoltagetInVolt" • "maxSwitchTimeBreaker" is less than 0 ms • "maxSwitchTimeHwState" is less than 0 ms • "maxTimeInvalidParamsOrRampCharge" is less than 0 ms • "maxTimeRampUpDown" is less than 0 ms • "maxTimeInvalidParamsOrRampCharge" is less than "maxTimeRampUpDown" • "cableCheckCurrentInAmpere" is greater than "maxCurrentInAmpere" • "preChargeCurrentInAmpere" is greater than" maxCurrentInAmpere" • "stopChargingCurrentInAmpere" is greater than "maxCurrentInAmpere" • If the voltage "maxExtVoltageInVolt" is greater than "maxVoltageInVolt" during the check "extVoltageCheckIsSupported" • If the resistance "shuntValueInOhm" is "0" during the check "shuntIsUsed" • "cableCheckCurrentInAmpere" is less than or equal to "maxCableCheckLeakCurrentInAmpere"

Bit no.	Acknow-ledgment required	Description	Remark
			• "maxCableCheckLeakCurrentInAmpere" is greater than "maxCurrentInAmpere" • "supportedEnergyTransferTypes" is not equal to "Bit 2" or "Bit 3" (The function blocks "DIN_70121" and "ISO_15118" only support DC_core (Bit 2) and DC_extended (Bit 3)): • No possible payment variant parameterized in "paymentVar" • "useOnlyDin" is parameterized, but not payment variant "EIM"
2	No	Module not ready	• The module is not ready yet for the next charging process. • The communication module does not report back. Possible causes of the fault: External 24 V supply of the module is faulty. If possible, the frequency converter is ramped down in a controlled manner. • This bit can also occur in combination with other error bits.
3	-	Reserved	-
4	No	Cable Check	External voltage too high • Before the Cable Check phase, a voltage is measured that is greater than the value set in the "in.evseCfg.maxExtVoltageInVolt" parameter. • This error is vehicle-related and is acknowledged automatically. The charging process is canceled.
5	Yes		Target voltage could not be reached • The target voltage required by the vehicle could not be reached or lies outside the allowed range. The frequency converter is ramped down in a controlled manner.
6	Yes		DC leakage current too high • The measured leakage current is higher than the value set by the "in.evseCfg.cableCheckCurrentInAmpere" parameter. The frequency converter is ramped down in a controlled manner.
7	Yes		Voltage could not be ramped down. • The voltage could not be ramped down at the end of the CableCheck phase. If possible, the frequency converter is shut down in a controlled manner.
8	Yes	Pre Charge	Target voltage could not be reached • The output voltage of the frequency converter "in.values.voltageInVolt lies outside the valid range. The frequency converter is ramped down in a controlled manner.
9	-	Reserved	-
10	Yes	Current Demand	Range errors current, voltage, power • The "out.setpoints.voltageInVolt" voltage required by the vehicle lies outside the valid range. • The "out.setpoints.currentInAmpere" current required by the vehicle lies outside the valid range. • The output voltage of the frequency converter "in.values.voltageInVolt" lies outside the valid range. • The output current of the frequency converter "in.values.currentInAmpere" lies outside the valid range. • The maximum charging capacity is exceeded. If possible, the frequency converter is shut down in a controlled manner.

Bit no.	Acknow-ledgment required	Description	Remark
11	Yes	Current Demand	Invalid parameters The maximum values required by the vehicle (current, voltage) are outside the permitted range. • The maximum voltage of the vehicle (out.ev.limits.maxVoltageInVolt) is below the minimum voltage of the charging station (in.evseCfg.minVoltageInVolt) • The maximum current of the vehicle (out.ev.limits.maxCurrentInAmpere) is below the minimum current of the charging station (in.evseCfg.minCurrentInAmpere) The frequency converter is ramped down in a controlled manner.
12	Yes	Termination of the charging process	The current could not be ramped down. Possible causes of the fault: • Frequency converter errors • Time "in.evseCfg.maxTimeRampUpDown" set too low • Maximum charging current set too small when opening the "in.evseCfg.stopChargingCurrentInAmpere" breaker If possible, the frequency converter is shut down in a controlled manner.
13	Yes	Timeout error	The PreCharge breaker has not opened or closed within the response time defined in "in.evseCfg.maxSwitchTimeBreaker". The frequency converter is ramped down in a controlled manner.
14	Yes		The DC breaker has not closed or opened within the response time defined in "in.evseCfg.maxSwitchTimeBreaker". The frequency converter is ramped down in a controlled manner.
15	Yes		The Shunt breaker has not opened or closed within the reaction time defined in "in.evseCfg.maxSwitchTimeBreaker". The frequency converter is ramped down in a controlled manner.
16	Yes		The frequency converter does not reach the corresponding "out.setpoints.hwState" HW state within the response time defined in "in.evseCfg.maxSwitchTimeHwState". If possible, the frequency converter is shut down in a controlled manner.
17	Yes		The I/O modules do not reach the corresponding HW state "out.setpoints.hwState" within the response time defined in "in.evseCfg.maxSwitchTimeHwState".
18	Yes		The hardware state "in.values. hwState" has not adjusted to the corresponding HW state "out.setpoints.hwState" within the response time defined in "in.evseCfg.maxSwitchTimeHwState".
19	Yes		The maximum time "in.evseCfg.maxSwitchTimeBreaker" in which the feedback of the DC/PreCharge or Shunt circuit breaker has to occur has been exceeded. This error bit is set if you cannot differentiate which breaker caused the error. In part several breakers are opened and closed at the same time. The frequency converter is ramped down in a controlled manner.
20	Yes	The hardware of the charging station has reported an error.	• An error is set at input "in.hwError". Bit 1 (insulation fault) or Bit 2 (emergency off). • At the input, "in.values.hwState" changes the status without a change of "out.setpoints.hwState". The frequency converter is ramped down in a controlled manner.
21	Yes	Hardware ID "in.hw_Id" of the technology module is incorrect.	The frequency converter is ramped down in a controlled manner.

Bit no.	Acknowledgment required	Description	Remark
22	No	Errors when reading/writing data record	The frequency converter is ramped down in a controlled manner.
23	-	Serious internal error	Remedy only possible through reinitialization of the block or through Stop⇒Run transition of the associated CPU.
24	Yes	Faulty feedback by the DC breaker, PreCharge breaker or Shunt breaker.	• If e.g. "setpoint.dcbrk" = "true" & "values.dcbrk" = "true" is present and then suddenly (due to a HW error) "values.dcbrk" changes to "false" without this having been requested by function block "DIN_70121" or "ISO_15118". The frequency converter is ramped down in a controlled manner.
25	Yes	During termination of the charging process, the voltage could not be reduced.	If possible, the frequency converter is shut down in a controlled manner.
26	No	Time monitoring is not possible. If the system time of the S7 could not be determined.	Remedy only possible through reinitialization of the block or through Stop⇒Run transition of the associated CPU.
27	-	An unexpected charge interruption by the vehicle or the technology module has happened.	The frequency converter is ramped down in a controlled manner.
28…31	-	Reserved	-

Table 2-1438 List of error messages "out.swError2" & "Charger_out.swError2"

Bit no.	Acknowledgment required	Description	Remark
0	No	CP error	Malfunction of the CP hardware. The current pilot status cannot be determined. If the HW error allows it, the pilot is switched off.
1	No	Timeout during status change of the CP from B to C	The charging protocol provides for a CP transition from State B to State C at this point. This bit is set if the transition is not made within 1.5 s.
2	No	Timeout during state change of the CP from C to B	The charging protocol provides for a CP transition from State C to State B at this point. This bit is set if the transition is not made within 1.5 s.
3	No	Unexpected change of the CP to B	The CP is in State B. This is not allowed in the current status within the charging procedure.
4	No	Unexpected change of the CP to C	The CP is in State B. This is not allowed in the current state within the charging procedure.
5	No	SLAC error	Error during the PLC connection setup (SLAC process).
6	No	Timeout for V2G message	Vehicle does not send a message package within the specified time (e.g. 60 s). The frequency converter is shut down in a controlled manner.
7	No	Unexpected V2G request from vehicle	The vehicle sends a request that is not permitted at this time (e.g. EVSE expects CableCheck, EV sends PreCharge). The frequency converter is shut down in a controlled manner.

Bit no.	Acknowledgment required	Description	Remark
8	No	V2G connection between module and vehicle interrupted	The response package could not be sent, e.g. because the socket connection to the EV has been terminated. The frequency converter is shut down in a controlled manner.
9	No	Charging process canceled	The EVSE has detected an error that makes continuation of charging impossible. An error response is sent to the vehicle. The frequency converter is shut down in a controlled manner.
10	No	Unexpected change of pilot state from B or C to A	For example, if the charging cable is disconnected before the charging process is properly completed. The frequency converter is shut down in a controlled manner.
11 ... 15	-	Reserved	-
16	No	Messages of the vehicle These messages are only passed through and have no direct influence on the currently pending charging processes. (For further information, refer to the DIN SPEC 70121)	FAILED_RESSTemperatureInhibit
17	No		FAILED_EVShiftPosition
18	No		FAILED_ChargerConnectorLockFault
19	No		FAILED_EVRESSMalfunction
20	No		FAILED_ChargingCurrentDifferential
21	No		FAILED_ChargingVoltageOutOfRange
22	No		Reserved A
23	No		Reserved B
24	No		Reserved C
25	No		INFO_EVNotReadyToCharge - or FAILED_ChargingSystemIncompatibility
26	No		NoData
27	No	No TLS encryption possible	The module does not support TLS encryption, although requested by the vehicle.
28	No	No suitable payment variant	Charging process not possible as payment options (charging station, vehicle) are different.
29... 31	-	Reserved	-

Calibration of the power line signal

6

6.1 Introduction and mode of operation

The "Calibration Kit TM ECC CCS2" (6FE1244-0AD10-0AA0) in connection with the "ECC_Calibration" function block enables you to calibrate the power line signal to the individual characteristics of your charging station.

Please note that calibration is only possible as of firmware version 1.0.3.

NOTE

When installing a firmware update, the calibration data may be reset to the default values. See the comments for the pending firmware updates.

We recommend backing up the calibration data prior to a firmware update.

Reason for calibration

Data is exchanged between the vehicle and the charging station via so-called power line communication. There, communication takes place via the CP connection in the frequency band of 2 MHz to 32 MHz. DIN SPEC 70121 (and ISO 15118 (Page 64)) stipulates a signal level -75 dBm ± 2 dBm over all communication frequencies. To ensure the correct level, we recommend calibrating your setup, because significantly different attenuations of the individual frequencies occur depending on the wiring in the charging station and the length of the connected charging cable.

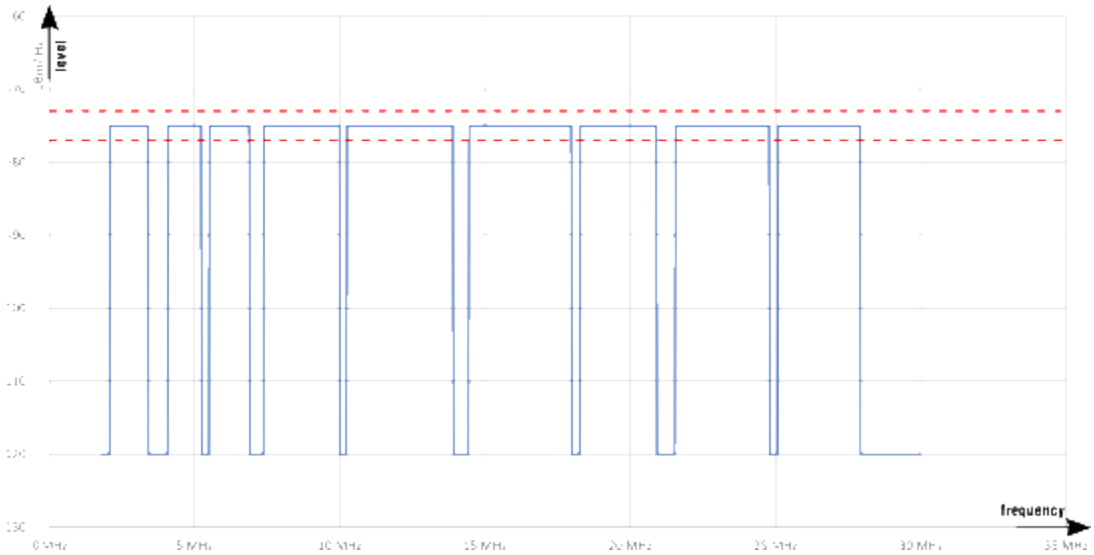

Figure 2-1271 Signal level after calibration

The calibration data consists of 1155 individual values of 1 byte each. Each byte stands for one carrier each and contains a combination of level and calibration values.

After the calibration, the calibration result can be read out using the "ECC_Calibration" function block and the calibration quality can be evaluated using the values in psdDiff.

The values in psdDiff hereby describe the deviation of the signal level (after the calibration) from the -75 dBm/Hz required according to DIN SPEC 70121/ISO 15118. They are coded as signed tenth dBm/Hz. A value of -25 for the carrier 500, for example, thus corresponds to a deviation of -2.5 dBm/Hz for the carrier 500. The resulting output power spectral density is therefore 2.5 dBm/Hz too low at the carrier 500.

NOTE

In a multi-station charging system, no calibration or charging process may take place on any other charging outlet during a calibration process

This applies also to directly adjacent charging systems.

No charging may take place on the charging system parallel to the calibration.

NOTE

De-energize the respective module after successful calibration before you use it.

Calibration requirements

The Calibration Kit TM ECC CCS2 loads the CP signal in the frequency range from 2 .. 30 MHz with ca. 50 ohms.

NOTE

Note that, if you measure with a measuring instrument whose input resistance is not 50 ohms (for example, a high-impedance spectrum analyzer or a power line sniffer), the measurement signal is distorted.

Valid measurements, therefore, are only possible with measuring instruments with an input resistance of 50 ohms.

6.2 "ECC_Calibration" function block

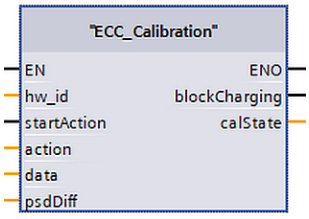

Figure 2-1272 "ECC_Calibration" function block

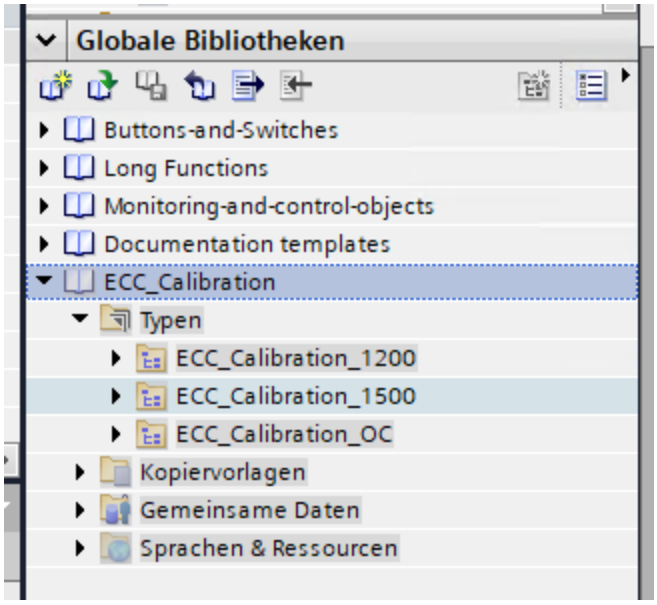

Figure 2-1273 Structure of the TIA library

Introduction

This function block (short form: FB) represents the interface between the TIA application and the calibration function of the technology module.

With the "ECC_Calibration" function block, you can perform the calibration in individual steps. Furthermore, the FB indicates any errors that occur.

Calibration scenarios

Two different calibration scenarios can be handled with the FB.

- **Calibration with the Calibration Kit TM ECC CCS2**
  In this case, the "Calibration Kit TM ECC CCS2" (6FE1244-0AD10-0AA0) is required in addition to the module to be calibrated. You need to connect the supplied power supply unit and the charging station (module) to be calibrated with the Calibration Kit. After successful completion, the calibration data on the module is set optimally for this charging station setup (including cables, connectors, transitions, etc.). Calibration with the "Calibration Kit TM ECC CCS2" is triggered by a rising edge at the "startAction" input and a "1" at the "action" input (see Parameter list for "ECC_Calibration" function block). When the calibration data is read out afterward, the calibration quality can be evaluated based on the values in "psdDiff".
- **Calibration with calibration data**
  For calibration with calibration data, you do not need a Calibration Kit, but a module that has already been calibrated (e.g. with the Calibration Kit on the reference setup). The calibration data can be read out of this module. The module to be calibrated is also connected to an "ECC_Calibration" FB and the calibration data is transferred. Reading and writing of the calibration data does not necessarily need to take place in the same setup or the same configuration. You can save and archive the calibration data and use it later. Only use this data when the setup of the charging station to be calibrated is identical to the reference setup.

Performing the calibration function

The "action" input is requested and the function is triggered with a rising edge at the "startAction" input, in calState "IDLE". All values not defined here result in the error code 16#8086 (see table Error codes). Changing the value at "action" later has no effect on the running calibration. Re-evaluation, and possibly generation of an error, only takes place at the next rising edge at "startAction", in state "IDLE".

The error code 16#8086 is also set when the data area at the "data" and "psdDiff" inputs is too small for an attempted data transfer.

ECC_Calibration parameters

Table 2-1439 List of parameters for the "ECC_Calibration" function block

Parameter	Declaration	Data type	Default	Description
hw_id	Input	HW_IO	0	Hardware ID of the TM ECC PL ST technology module to determine the offset of the process image inputs/outputs. The number is assigned automatically and is stored in the properties of the component or the interface in the hardware configuration.
startAction[2]	Input	Bool	False	A rising edge triggers the corresponding calibration action according to the value at the "action" input. With a falling edge, the "ECC_Calibration" FB • is reset after a calibration from the VALID state or an error state back to the IDLE state (acknowledgment).
action	Input	USInt	0	Selection of the calibration action to be performed. 1: Start calibration with Calibration Kit 2: Activating the calibration data on the module 3: Transfer calibration data to the module (but do not activate) 4: Read calibration data and the deviation of the signal level (psdDiff) from the module [1] 0, 5-255: Results in error: 16#8086
blockCharging	Output	Bool	False	1: Calibration running You must ensure that no charging process is initiated. For this, this output can be connected negated to the input "enable" of a charge FB "DIN_70121"/"ISO_15118".
calState [2]	Output	Word	0	This parameter indicates the state of the module. 0: **IDLE** No calibration is currently taking place and no error has occurred. 1: **PENDING** A calibration request by the user has been recognized and the state of the module (correct type, correct charge status) is being verified. A calibration is only possible in charge status "A" or "F" (see explanations of charge status (pilotState). 2: **DATA_ACCESS** Access to calibration data is running. Waiting for completed message from module.

[1] If new calibration data has been written since the last startup of the module without being activated, this is read back instead of the currently active parameters. Otherwise, the currently valid calibration data is read out.

[2] In the states 3, 4, 6, 8, 9 and 10, the module processes the action independently. The FB monitors and reports the progress. Cancellation with "startAction" is NO LONGER possible.

[3] The buffer sizes are only verified if they are actually needed. Otherwise, you can also connect smaller dummy arrays (e.g. Array [0...0] of Byte/Word) in the project.

Parameter	Declaration	Data type	Default	Description
				3 / 8 / 9 / 10: **RUNNING** Calibration with the Calibration Kit is running. Waiting for reset of the module. 4: **ACTIVATING** Activation of the calibration data is running. Waiting for reset of the module. 6: **RESETTING** Module reset detected. Waiting for restart. 7: **VALID** Calibration/data transfer successfully completed. Waiting for acknowledgment by falling edge at "startAction". With values 16#80xx, an error has been detected. For details, see table Error codes.
data [3]	InOut	Array [*] of Byte		Source/destination for data access. Calibration data: 1155 bytes
psdDiff [3]	InOut	Array [*] of Word		Target for the values to deviate from the required -75 dBm/Hz per carrier. The minimum size of the range, if used, is 1155 words.

1) If new calibration data has been written since the last startup of the module without being activated, this is read back instead of the currently active parameters. Otherwise, the currently valid calibration data is read out.

2) In the states 3, 4, 6, 8, 9 and 10, the module processes the action independently. The FB monitors and reports the progress. Cancellation with "startAction" is NO LONGER possible.

3) The buffer sizes are only verified if they are actually needed. Otherwise, you can also connect smaller dummy arrays (e.g. Array [0...0] of Byte/Word) in the project.

Description

With the "ECC_Calibration" instruction, you access the calibration functions of an ECC PL ST technology module addressed via HW ID. This can be a centrally inserted module or a distributed component.

NOTE

You can only calibrate the ECC PL ST technology module with the "ECC_Calibration" FB if it has a FW version 1.0.3 (or higher).

You can use the "ECC_Calibration" FB with SIMATIC 1500 CPUs as of FW version 2.0 and with SIMATIC 1200 CPUs as of FW version 4.2.

- Using the "hw_id" parameter, you select the module for which calibration should be carried out. Use the hardware ID (HW ID) of the module for the "hw_id" parameter. You can find the hardware ID of the module under "PLC tags" → System constants. It is displayed as "Name of the TM ECC module" with the data type "Hw_SubModule".
- You start and end a calibration/read/write operation via the "startAction" input.
- You define the calibration action via the "action" input.

Module fault

If an error occurs during an active calibration process, this error is displayed at the "calState" output. See Error codes table and Parameter list table.

NOTE

Please note that the following state of the block is undefined if an error occurs during a calibration action.

In this case, repeat the calibration process.

Table 2-1440 List of error codes of the FB

Error code	Cause of error
16#8082	No modules could be found under the HW ID "hw_id".
16#8083	The module indicated an error during the calibration process or the module itself was not recognized. Check the module, the entire cabling and the Calibration Kit. If the error cannot be resolved in this way, proceed as described under error code "16#8088".
16#8084	The module has rejected calibration data as invalid.
16#8086	Value at "action" input not permissible (at rising edge of "startAction") or buffer at "data" or "psdDiff" is too small for the selected "action".
16#8087	The FB is in an unforeseen state.
16#8088	The module indicated an error during the calibration process. Restart the module. If the error continues to occur, the module is defective.

Reading and writing of calibration data uses the SFBs "RDREC" and "WRREC". These can generate error messages themselves (in the format 0x80xx). If such error messages occur, the "ECC_Calibration" function block switches to the error state and outputs the corresponding message at "calState". The error numbers generated by the FB itself are in "gaps" of the system messages. This means that, if an error code is not listed in the Error codes table, it has been passed through by the SFB and you need to refer to the help documents of the "RDREC" and "WRREC" SFBs for its meaning.

NOTE

The status of a RDREC or WRREC call is 4 bytes long. The important information is contained in the middle two bytes. These are included in the "calState".

Example:

Status RDREC: 0xDE**80B1**00 → calState: 0x80B1

6.3 Calibration Kit TM ECC CCS2

6.3.1 Description

The Calibration Kit must be ordered separately.

Version	Order number (MLFB)
Calibration Kit TM ECC CCS2	6FE1244-0AD10-0AA0

Task of the Calibration Kit

Using the Calibration Kit, the charging controller measures the power line signal level arriving at the charging plug. The signal levels of all relevant frequencies are then adjusted for this setup.

Figure 2-1274 Calibration Kit TM ECC CCS2

LEDs of the Calibration Kit

Status LEDs

LEDs	Meaning
EN	**Status Calibration Kit (enable)**
□ Off	Calibration Kit is not ready
■ On	Calibration Kit is ready
VS	
□ Off	No function

Startup of the Calibration Kit

Startup of the Calibration Kit takes about 20 seconds.

Connections of the Calibration Kit

The Calibration Kit has a CCS Type 2 charging socket for receiving the charging cable. Interlocking of the connector is not supported here. The power supply connection can be found on the side. Connect the supplied power supply unit here.

6.3.2 Technical specifications of the Calibration Kit TM ECC CCS2

Table 2-1441 **Technical specifications of the Calibration Kit**

	6FE1244-0AD10-0AA0
General information	
Product family	ECC4000
Product designation	Calibration Kit TM ECC CCS2
Installation type/mounting	
Mounting type	DIN rail
Supply voltage	
Type of supply voltage	24 V
Rated value (DC)	24 V; optional: external infeed
Permitted range, low limit (DC)	19.2 V
Permitted range, high limit (DC)	28.8 V
Reverse polarity protection	Yes
Load voltage L+	
Short-circuit protection	Yes
Reverse polarity protection	Yes
Input current	
Current consumption, max.	0.5 A
Interfaces	

	6FE1244-0AD10-0AA0
Number of other interfaces	2; 1x CCS (Combined Charging System) according to IEC 62196 1x power supply DC adapter 24 V (for hollow connectors ∅ 5.50 / 2.10 mm x 9.5 mm)
Protocols	
Vehicle communication according to IEC 61851	Yes; Mode 4
EMC	
Electrostatic discharge in accordance with IEC 61000-4-2	4 kV contact discharging / 8 kV air discharging
Field-based interference in accordance with IEC 61000-4-3	10 V/m (80 ... 1 000 MHz), 3 V/m (1.4 ... 2.0 GHz), 1 V/m (2.0 ... 2.7 GHz)
Degree of protection and protection class	
IP degree of protection	IP30 (when all connectors are inserted)
Standards, approvals, certificates	
Certificate of suitability	CE
Ambient conditions	
Ambient temperature during operation	
Min.	0 °C
Max.	40 °C
Ambient temperature during storage/transport	
Storage, min.	-30 °C
Storage, max.	85 °C
Operating height in relation to sea level	
Installation altitude above sea level, max.	2000 m
Ambient temperature, air pressure and altitude	Max. 2000 m
Relative humidity	
Operation, max.	95%
Mechanics/material	
Enclosure material	Plastic: Polycarbonate, symbol: PC-GF 10 FR
Dimensions	
Width	250 mm
Height	122 mm
Depth	160 mm
Weights	
Weight, approx.	1.5 kg

Alarms / diagnostics alarms

7

7.1 State and error displays

Front view of the technology module SIMATIC ET 200SP TM ECC PL ST

Figure 2-1275 Device front with LED displays

Meaning of the LED displays

The following table shows the meaning of the state and error displays. You can find details on troubleshooting in the section Diagnostics alarms (Page 109).

LED DIAG

☐ Off	Backplane bus supply of the ET 200SP not OK.	Check or switch on the supply voltage of the head station. Ensure that the SIMATIC ET 200SP TM ECC PL ST technology module is correctly plugged into the BaseUnit.
☼ Flashes	Technology module not ready to operate (not parameterized)	
■ On	Technology module parameterized and no module diagnostics (no error exists)	
☼ Flashes	• Technology module parameterized and module diagnostics (at least one error exists)	Check the configuration and parameter assignment in your Engineering Tool (e.g. TIA Portal) or evaluate the diagnostic interrupts and correct the error.

LED PWR

☐ Off	Supply voltage L+ missing	• BU type B1: Check the external 24 V DC supply voltage between L+ and M. • BU type B0: Check the 24 V DC supply voltage of the supplying potential group.
■ On	Supply voltage L+ available	

Status LEDs

LEDs	Meaning
EN	**Enable state**
☐ Off	Charging outlet (EN) locked by user program. The corresponding VS LED and Status LED F are also off in this case.
■ On	Charging outlet (EN) activated
☼ flashes, 1 Hz	• S7 communication fault at the charging outlet (EN) • CPU stop.
VS	**Vehicle state**
☐ Off	No vehicle is connected to the charging station. (State "A") in as far as LED F = "off" (State "F") in as far as LED F = "on"
■ On	A vehicle is connected to the charging station and ready for charging. (State "B")
☼ flashes, 1 Hz	Vehicle charging (State "C")

☼ flashes, 2 Hz	Vehicle charging, ventilation required (State "D")
QT	**TRIP function** (see in section Control Pilot (Page 17))
□ Off	Output (DQ T) switched off (see Example circuits for the switching contacts)
■ On	Output (DQ T) switched on.
QP	**PP function** (see in section Plug Present (Page 19))
□ Off	Output (DQ P) switched off (compare Example circuits for the switching contacts)
■ On	Output (DQ P) switched on.
LK	**Power line link** (EV)
□ Off	No link available.
■ On	Link exists
R/T	**Power line traffic** (receive/transmit) (EV)
□ off	No data communication
■ On	Data communication available.
F	**Status CP**
□ Off	CP state A, B, C or D
■ On	CP state E, F or invalid

See also

Terminal assignment and power supply (Page 29)

7.2 Alarms

The TM ECC PL ST technology module does not have process alarms.

7.3 Diagnostic messages

The DIAG LED flashes red when a diagnostics alarm is pending.

The diagnostics are displayed in the online and diagnostics view in STEP 7 (TIA Portal). You can evaluate the error codes via the user program.

The following diagnostics can be reported:

Table 2-1442 Diagnostic messages, their meaning and corrective measures

Diagnostic messages	Error code	Meaning	Remedial measures
Error	9H	Communication error (is briefly displayed during ramp-up)	
Load voltage is missing	11H	Supply voltage L+ the technology module is missing	• Checking BaseUnit type • Checking wiring at the supply voltage L+ at the BaseUnit
Channel / components temporarily not available	1FH	Update of the firmware was just performed or was canceled. The module in this state does not read process values.	• Waiting for firmware update • Starting firmware update again

7.4 Device defect

Repairs

Repairs by the user or service engineers are not permitted. In case of error please contact Service&Support (https://support.industry.siemens.com/cs/ww/en/sc/3098).

WARNING

Electric shock hazard

May cause death or serious injury

Unauthorized opening of the device might place the user in danger or result in substantial damage to property.

Technical specifications 8

8.1 Technical specifications

	6FE1242-6TM20-0BB1
General information	
Product brand name	SIMATIC
Product range	ET 200SP
Product category	Technology module
Product type designation	TM ECC PL ST
Product designation	Charge controller for conductive charging of electric vehicles
Firmware version	V1.1 or later
• FW update possible	Yes
Type of product	Technology module
Number of channels	1; in accordance with DIN SPEC 70121/ISO 15118-2
Product function	
I&M data	Yes; I&M 0
Isochronous mode	No
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of Version	STEP 7 V15 and higher (starting from FW1.1: STEP 7 V17 and higher)
Structure/mounting	
Mounting type	Mounting rail
Mounting position	Vertical or horizontal
Supply voltage	
Type of supply voltage	DC
Rated value (DC)	24 V
Permissible range, lower limit (DC)	19.2 V
Permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes; against irreparable damage
Input current	
Current consumption, typ.	40 mA
Current consumption, max.	100 mA
Digital inputs	
Number of inputs	0
Functions digital inputs, parameterizable	
Freely usable digital input	0
Digital outputs	
Type of digital output	Transistor
Number of outputs	2

	6FE1242-6TM20-0BB1
Short-circuit proof	Yes
Short-circuit protection	Yes, electronic / thermal
Functions digital outputs, parameterizable	
PWM output	Yes; according to IEC 61851
• Max. number	1
• Cycle duration parameterizable	No; 1 kHz
Switching capacity of the outputs	
With resistive load, max.	0.6 A
Output voltage	
Type of output voltage	DC
Output voltage	24 V
Cable length	
unshielded, max.	10 m
Protocols	
Bus communication	Yes (backplane bus)
Vehicle communication in accordance with DIN SPEC 70121 / ISO 15118-2	Yes; MODE 4
Alarms/Diagnostics/State information **Alarms**	
Diagnostic interrupt	No
Diagnostic messages	
Supply voltage monitoring	Yes
Short circuit	No
Overload	Yes
Diagnostics indicator LED	
Supply voltage monitoring (PWR-LED)	Yes; green PWR-LED
Channel status display	Yes; green LED
For module diagnostics	Yes; green / red DIAG-LED
Electrical isolation **Electrical isolation channels**	
Between the channels	No (only one channel available)
Between the channels and backplane bus	Yes
Isolation	
Isolation tested with	DC 707 V
Degree of pollution	2
EMC	
Electrostatic discharge in accordance with IEC 61000-4-2: 2008	
Field-related interference to IEC 61000--4-3: 2006	
Conducted interference, through burst according to IEC 61000-4-4: 2012	
Conducted interference, through surge according to IEC 61000-4-5: 2014	
Conducted interference by high-frequency interference according to IEC 61000-4-6: 2013	
Test degree and evaluation criteria according to IEC 61000-6-1: 2007	

	6FE1242-6TM20-0BB1
E DIN EN 61851-21-2: 2013 EMC requirements for external charge systems for electric vehicles	
DIN EN 61851-21-1: 2018 EMC requirements for on-board chargers for electric vehicles for the conductive connection to an AC/DC power supply	
Degree of protection and protection class	
IP degree of protection	IP20
Standards, approvals, certificates	
Certificate of suitability	CE
Ambient conditions **Ambient temperature during operation**	
Minimum	-30 °C
Horizontal mounting position, max.	60 °C
Vertical mounting position, max.	50 °C
Ambient temperature during storage/transportation	
Storage min.	-40 °C
Storage max.	70 °C
Min. transportation	-40 °C
Max. transportation	70 °C
Relative humidity	
Operation min.	5%
Operation max.	95%; no condensation
Height in operation	
Ambient temperature air pressure installation altitude (referenced to mean sea level)	T_{min} ... T_{max} at 1080 hPa ... 795 hPa (-1000 m ... +2000 m)
Distributed operation	
on SIMATIC S7-1500	Yes
on SIMATIC S7-1200 (as of FW version 1.0.3)	Yes
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weight	32 g

Technical specifications related to the BaseUnit

See Manual of the ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/ps/14070/man).

SIEMENS

SIMATIC

ET 200SP HA / ET 200SP Ex-AI 4xTC/2xRTD 2-/3-/4-wire

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6DL1134-6JD00-0HX1

04/2021
A5E50743878-AA

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Security information 1

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit
https://www.siemens.com/industrialsecurity.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under
https://www.siemens.com/industrialsecurity.

Preface

2

Validity of the documentation

This documentation describes the following I/O module:

System	Module type	Article number
Distributed I/O System; ET 200SP HA and ET 200SP	Ex-AI 4xTC/2xRTD 2-/3-/4-wire	6DL1134-6JD00-0HX1

This documentation supplements the following documentation:

- System manual *Distributed I/O System, ET 200SP* HA / *ET 200SP Modules for Devices in the Hazardous Area*

Functions that generally relate to the ET 200SP HA and ET 200SP are described in the respective system documentation:

- System manual Distributed I/O System ET 200SP HA (https://support.industry.siemens.com/cs/ww/en/view/109761547)
- System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)

The information in this manual and the system/function manuals enables you to put the modules for hazardous areas into operation.

Appendices

The appendices provide information that is relevant for using the modules for potentially explosive atmospheres outside the PCS 7 environment.

Conventions

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

These documentation contain a description of the components that was valid at the time the operating instructions were published. We reserve the right to include product information with information updates with new components and components with a new product status.

Product overview

3

3.1 Properties of the I/O module Ex-AI 4TC/2RTD 2-/3-/4-wire

View of the module

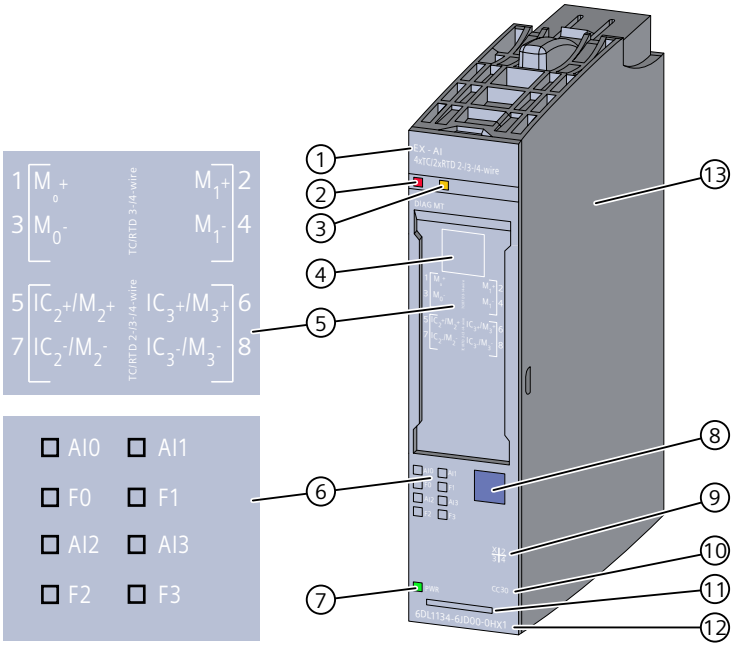

① Module type and designation
② LED for diagnostics
③ LED for maintenance
④ 2D matrix code
⑤ Wiring diagram
⑥ LEDs for channel status/channel fault
⑦ LED for supply voltage
⑧ Module type color coding
⑨ Function version
⑩ Color code for selection of the color-coded labels
⑪ Serial number
⑫ Article No.
⑬ Labeling surface (symbols and standards)

Figure 2-1276 View of Ex-AI 4TC/2RTD 2-/3-/4-wire

You can find information on the LEDs in section "Status and fault displays of the I/O module Ex-AI 4TC/2RTD 2-/3-/4-wire (Page 32)".

Properties

The I/O module is used for intrinsically safe connection of thermocouples, thermistors and ohmic resistances and for measuring voltages.

The I/O module has the following technical properties:

- 4 analog inputs for the connection of thermocouples (TC) and voltages (U)
- Alternatively, two analog inputs for the connection of resistance temperature detectors (RTD) and resistors (R)
- The analog inputs have the following channel-specific configurable properties:
  - Resolution:
    - S7 format: 16 bits including sign
    - REAL format: 24 bits including sign
  - Measurement type voltage
  - Measurement type resistance, 2-, 3-, 4-wire connection
  - Measurement type resistance temperature detector, 2-, 3-, 4-wire connection
  - Thermocouple (TC) measurement type can be set per channel
  - Smoothing
  - Interference frequency suppression 16.6 Hz, 50 Hz or 60 Hz
  - Diagnostics
- Module-specific configurable diagnostics

You can find additional information in section "Technical specifications (Page 36)".

The module supports the following functions

The I/O module supports the following functions:

- Firmware update
- I&M identification data
- Re-assign parameters in RUN
- Value status QI
- Module-internal Shared Input (MSI)

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color-coded labels
- Reference identification label
- Shield connector

3.2 2D Matrix code (QR code / EAN code)

The 2D matrix code on the product is a coded representation of the product-specific article number.

Access to product-related information

For reading the 2D matrix code, SIEMENS offers an app for mobile use.
Information about the app and the download can be found on the Internet: "Mobile use via app (https://support.industry.siemens.com/cs/ww/en/sc/2067)".

The app provides direct access to the technical forum and product-related posts, such as:

- FAQs
- Application examples
- Manuals
- Certificates
- Product notices

Wiring

4

4.1 Ex BaseUnit

You can operate the I/O module with the following Ex BaseUnit:

- Ex-BU Type X1 (6DL1 193-6BP00-0BX1)

The Ex BaseUnit is not included in the scope of delivery of the Ex I/O module and must be ordered separately.

NOTE

You can find additional information on the configuration in the system manual.

The terminal block for connecting the I/O signals is part of the Ex BaseUnit for Ex I/O modules and cannot be mounted separately.

Connections on the slot and Ex I/O module

The following figure shows the connections on the Ex BaseUnit and the I/O module.

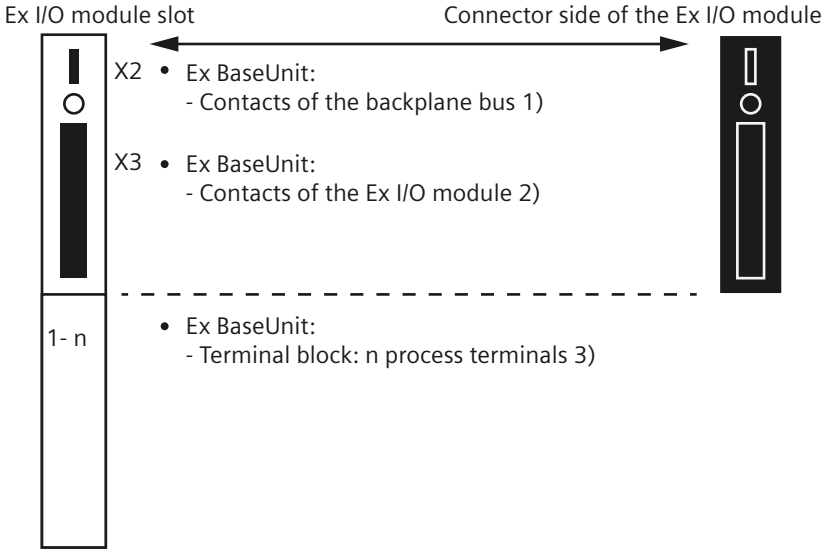

1) Ex BaseUnit contacts of the backplane bus (max. 50 mA; 3.3 V DC ⎓)

2) Ex BaseUnit contacts for process signal transmission (for maximum voltages and currents, refer to the documentation of the respective I/O module)

3) Process terminals on the terminal block (number, maximum/permissible voltages and currents, refer to the documentation of the respective I/O module).

Information on the pin assignment of the I/O module (terminal block) can be found in the following sections.

4.2 Pin assignment of the I/O module Ex-AI 4TC/2RTD 2-/3-/4-wire

General pin assignment

The measurement types for resistance measurement (incl. PTC) and resistance thermal measurement are only possible on Channels 2 and 3. If a measurement type with 3-wire or 4-wire connection is configured for channel n (n = 2 or 3), then channel y (y = n-2) must be disabled.

Table 2-1443 Pin assignment of Ex-AI 4TC/2RTD 2-/3-/4-wire

Terminal	Assignment	Terminal	Assignment	Terminal block	Explanations
1	M_0+	**2**	M_1+	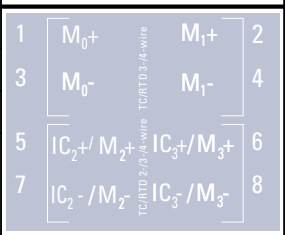	Terminals 1; 2 M_n+: Measurement input positive, channel n (0;1) Terminals 3; 4 M_n-: Measurement input negative, channel n (0;1) Terminals 5; 6 IC_n+: Constant current line positive, channel n (2;3) M_n+: Measurement input positive, channel n (2;3) Terminals 7; 8 M_n-: Measuring input negative, channel n (2;3) IC_n-: Constant current line negative, channel n (2;3)
3	M_0-	**4**	M_1-		
5	IC_2+/M_2+	**6**	IC_3+/M_3+		
7	IC_2-/M_2-	**8**	IC_3-/M_3-		

Connections via all sensor types

You can find information on connecting the sensors in the following sections:

- Pin assignment for RTD 2-wire (Page 11)
- Pin assignment for RTD 3-wire (Page 11)
- Pin assignment for RTD 4-wire (Page 11)
- Pin assignment for thermocouple TC (Page 12)

4.3 Pin assignment

4.3.1 Pin assignment for RTD 2-wire

Pin assignment (2-wire connection system)

RTD 2-wire connection	Channel n (n= 2, 3)
	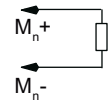

4.3.2 Pin assignment for RTD 3-wire

Pin assignment (3-wire connection system)

RTD 3-wire connection	Channel n (n= 2 and 3)
	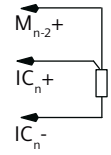

4.3.3 Pin assignment for RTD 4-wire

Pin assignment (4-wire connection system)

RTD 4-wire connection	Channel n (n= 2 and 3)
	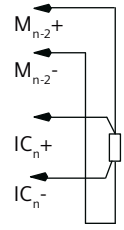

4.3.4 Pin assignment for thermocouple TC

Pin assignment

TC	n = 0 to 3 M_n+ M_n-

4.4 Schematic circuit diagram

The following figure shows the schematic circuit diagram of the Ex I/O module.

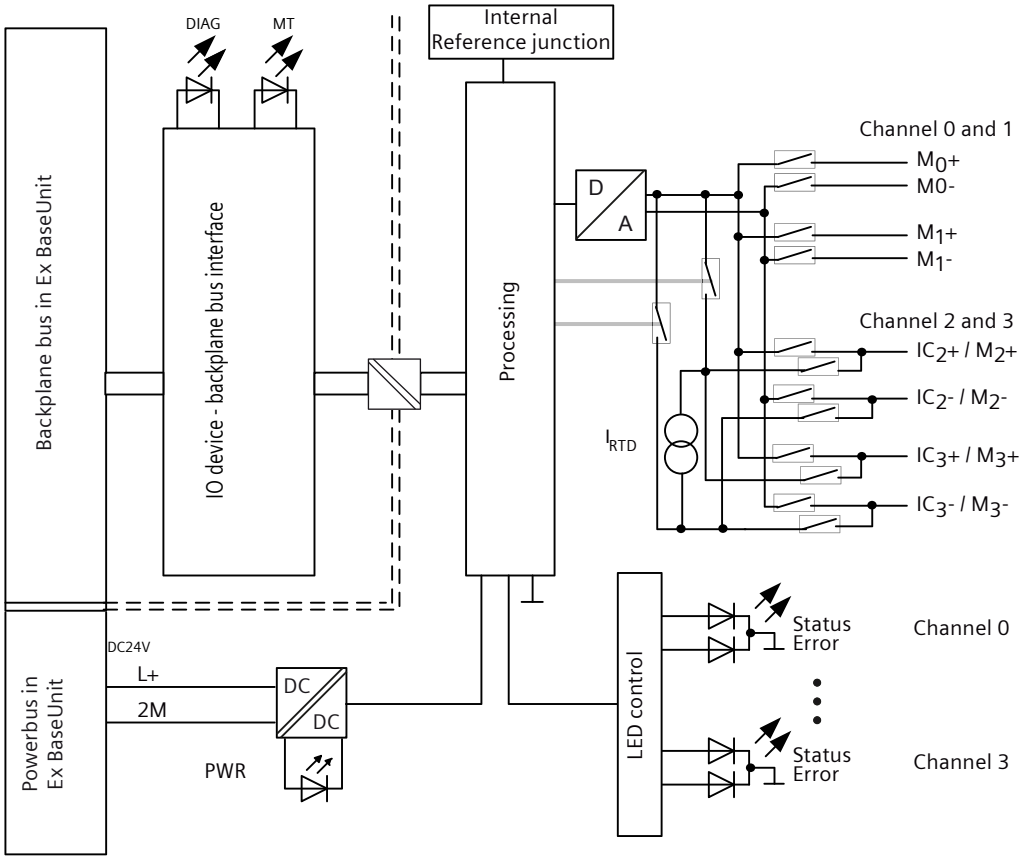

Figure 2-1277 Schematic circuit diagram Ex-AI 4TC/2RTD 2-/3-/4-wire

Supply voltage

The supply voltage L+/2M is generated and monitored by the Ex power module. The Ex I/O module receives its supply voltage L+ via the power bus. Further monitoring of the supply voltage is performed in the Ex I/O module. During parameter assignment, you can specify whether a diagnostic message is to be output in the event of failure of the supply voltage.

Firmware update

The supply voltage L+ must be available on the Ex I/O module at the start of firmware updates and during the update.

4.5 Potential group in hazardous areas

Potential group

With the modules for hazardous areas, the Ex power module and the Ex I/O module plugged into the right of the Ex power module form a potential group.

The potential group ends when one of the following modules is plugged in to the right of an Ex I/O module:

- Ex power module
- Server module

Configuring 5

5.1 Configurations of I/O module Ex-AI 4TC/2RTD 2-/3-/4-wire

Requirements

You configure the I/O module

- in the TIA Portal
- with PCS 7
- with PCS neo
- with STEP 7

The version required in each case is specified in the technical specifications

Configuration via GSD/GSDML

Notes for configuration using a GSD/GSDML file (Page 16)

Restrictions when using in ET 200SP

- When used with a standard IM, its firmware must be at least at version V3.3.
- No MSI is available for a PROFIBUS DP station.
- TIA Portal:
  - TIA Portal as of V17.0
    The module can be centrally configured on the following CPUs:
    - CPU 1510SP-1 (as of V2.6)
    - CPU 1512SP-1 PN (as of V2.6)
    - CPU 1515SP-1 PN (as of V2.6)
  - The module cannot be used behind fail-safe controllers.

Configurations

Depending on the desired configuration, you have to select the required version of the I/O module from the hardware catalog.

The following configurations are possible:

Configuration [1]	Version of the I/O module in the hardware catalog of the engineering tool.	Required parameter assignment of the module	Format of process values
Analog mode AI 4 without QI	**Ex - AI 4TC/RTD 2-/3-/4-wire**	• Process values in REAL format disabled • "Value status" parameter deactivated	Process values in S7 format (each channel occupies 2 bytes of input data)
Analog mode AI 4 with QI [2]		• Process values in REAL format disabled • "Value status" parameter activated • Optional configuration: "MSI with QI" [3] You can find information on MSI in the section "Module-internal Shared Input (MSI) (Page 25)".	
Analog mode AI 4 Real without QI [2]	**Ex - AI 4 REAL**	• Process values in REAL format enabled • "Value status" parameter deactivated	Process values in REAL format (each channel occupies 4 bytes of input data)
Analog mode AI 4 Real with QI [2]	**Ex - AI 4 REAL with QI**	• Process values in REAL format enabled • "Value status" parameter activated	

[1] When configuring via GSDML, all configurations can be directly selected in the hardware catalog of the engineering tool.

[2] Not available for configuration using a GSD file.

[3] Not available for configuration using a GSD/GSDML file.

NOTE

Changing the configuration in CPU RUN

You can re-configure the I/O module when the CPU is in RUN as long as the loaded configuration (version of the I/O module in the hardware catalog) is maintained.

If you want to define a different configuration in CPU RUN, the following steps are required:

1. Remove the I/O module from the loaded configuration in CPU RUN.
2. Configure the I/O module including the required configuration-specific parameters.
3. Load the new configuration in CPU RUN.

Note that changing the configuration changes the I/O address range.

REAL format and S7 format

- For configuration in REAL format, process values are provided directly in the corresponding physical unit (base unit, e.g. volt, °C etc.) of the channel by the I/O module. An exception is the parameter assignment of the PTC measuring range.
- The hardware interrupt limits adjustable via the parameters are always in S7 format.
- For configuration in S7 format, process values are supplied in 2 bytes of input data (decimal or hexadecimal).

Parameters

You define the operating mode of the I/O module via channel/technology parameters (data record 128).

5.2 Notes for configuration using a GSD/GSDML file

Files for configuration using GSD/GSDML

If you need the GSD/GSDML files for configuration, you can download them on the Internet:

- PROFINET GSD file (GSDML) for ET 200SP HA (http://support.industry.siemens.com/cs/ww/en/view/109781191)
- PROFINET GSD files for ET 200SP (http://support.automation.siemens.com/WW/view/en/57138621)
- PROFIBUS GSD files for ET 200SP (http://support.automation.siemens.com/WW/view/en/73016883)

Restrictions when using a GSDML file for PROFINET configuration

The following functions are not available in the process image of the I/O module:

- MSI

Restrictions when using a GSD file for PROFIBUS configuration

The following functions are not available in the process image of the I/O module:

- MSI
- Value status
- REAL format for process values

5.3 Module/channel parameters

Parameters of Ex-AI 4xTC/2xRTD 2-/3-/4-wire

You have the following setting options:

Table 2-1444 Adjustable parameters and their default setting

Parameter	Value range	Default	CiR [1]	Efficiency range		
				HSP [2]	GSDML [3]	GSD [4]
Diagnostics, Missing supply voltage L+	• Enabled • Disabled	Disabled	Yes	Module	Module	Module
Diagnostics reference junction	• Enabled • Disabled	Disabled	Yes	Channel	Channel	Module
Diagnostics Overflow	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Module
Diagnostics underflow	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Module
Diagnostics wire break	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Measurement type	• Disabled • Voltage • Resistor (2-, 3-, 4-wire connection) • Thermal resistance (2-, 3-, 4-wire connection) • Thermocouple	Thermocouple	Yes	Channel	Channel	Channel
Measuring range	You can find information on the measuring range in relation to the selected measurement type in: Measurement types and measuring ranges (Page 27)		Yes	Channel	Channel	Channel
Temperature coefficient	You can find information on the temperature coefficient range in relation to the selected measurement type in: Measurement types and measuring ranges (Page 27)		Yes	Channel 2; Channel 3	Channel 2; Channel 3	Channel 2; Channel 3
Temperature unit	• Degrees Celsius • Degrees Fahrenheit • Kelvin	Degrees Celsius	Yes	Channel	Channel	Module

1) CiR = Configuration in RUN

2) HSP = Configuration via Hardware Support Package (HSP) of the process control

3) GSDML = Configuration using a GSDML file

4) GSD = Configuration using a GSD file

Parameter	Value range	Default	CiR [1]	Efficiency range		
				HSP [2]	GSDML [3]	GSD [4]
Reference junction	• No reference channel mode • Reference channel of the module • Internal reference junction • Reference channel of group 0 to 3 • Fixed reference temperature	Fixed reference temperature	Yes	Channel	Channel	Module
Reference junction active	• Disable • Enable	Enable	Yes	-	-	Channel
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel	Channel
Interference frequency suppression	• 60 Hz • 50 Hz • 16.6 Hz At 50 Hz, the interference signals of 400 Hz are also filtered automatically.	50 Hz	Yes	Channel	Channel	Module
Fixed reference temperature	• 0 °C	0 °C	No	Channel	Channel	-
Wire resistance (only with 2-wire connection)	• 0 to 50 Ω (in steps of 0.01 Ω)	0	Yes	Channel 2; Channel 3	Channel 2; Channel 3	-
Hardware interrupt high limit 1/2	• Enabled • Disabled	Disabled	Yes	Channel	Channel	-
Hardware interrupt low limit 1/2	• Enabled • Disabled	Disabled	Yes	Channel	Channel	-
High limit 1/2	• Value	13720	Yes	Channel	Channel	-
Low limit 1/2	• Value	-2700	Yes	Channel	Channel	-
Potential group	Potential group of the left intrinsically safe power module	Potential group of the left intrinsically safe power module	No	Module	Module	Module

1) CiR = Configuration in RUN

2) HSP = Configuration via Hardware Support Package (HSP) of the process control

3) GSDML = Configuration using a GSDML file

4) GSD = Configuration using a GSD file

NOTE

Unused channels

"Deactivate" unused analog inputs in the parameter configuration. This improves the cycle time of the module.

A deactivated channel provides the following value depending on the configured format of the process values:

- Process values in S7 format: $7FFF_H$
- Process values in REAL format: $7F800000_H$

5.4 Explanation of parameters

5.4.1 Diagnostics Missing supply voltage L+

Defines whether a diagnostic interrupt is generated when the supply voltage L+ is missing or is too low.

The supply voltage is generated by the Ex power module. Other internal defects can be detected and reported via the additional diagnostics for the Ex I/O module.

5.4.2 Diagnostics: Reference junction

Enables the reference junction diagnostics. A fault in acquiring the reference temperature is signaled as a diagnostic message of the operated TC channel.

5.4.3 Diagnostics: Overflow

Enabling the diagnostics which are generated when the measured value falls below the underrange.

5.4.4 Diagnostics: Underflow

For measuring ranges with underrange: Enables diagnostics when the measured value falls below the underrange.

5.4.5 Diagnostics: Wire break

Specifies whether a diagnostic interrupt is generated when the wire break test current is undershot.

A test current of approx. 330 µA is generated if there is a "0" signal. This enables a wire break to be detected independently of the level and the QI bit to be influenced. A diagnostic interrupt is also generated.

5.4.6 Measurement type/measuring range

See section Measurement types and measuring ranges (Page 27)

5.4.7 Temperature coefficient

The temperature coefficient depends on the chemical composition of the material. The temperature coefficient (α value) indicates by how much the resistance of a specific material changes relatively if the temperature increases by 1 °C. The other values facilitate a sensor-specific setting of the temperature coefficient and enhance accuracy.

NOTE

In Europe, only one value is used per sensor type (default value).

5.4.8 Temperature unit

Selection for chosen measuring range between:

- Degrees Celsius
- Degrees Fahrenheit
- Kelvin

5.4.9 Reference junction

You can choose from the following possibilities as the reference junction for the TC measurement:

- Internal temperature sensors on the Ex BaseUnit.
- The reference channel of group 0, 1, 2, 3
  If the sender has configured the measuring range as "Thermal resistance Pt100 climatic range" and the temperature unit as "Degrees Celsius".
- The "Reference channel of the module"
  If the measuring range was configured as "Thermal resistance Pt100 climatic range" and the temperature unit as "Degrees Celsius" for channel 3.
- Fixed reference temperature (0 °C)

NOTE

Using a PROFIBUS GSD file

When a PROFIBUS GSD file is used, the "Reference junction active" parameter is also available.

A possible parameter assignment is represented below:

NOTE

Thermocouples of the types B and C

The characteristic curves of thermocouples of type B and type C are not defined below 0°C. For this reason, the reference temperature is never below 0 °C during operation when using type B and type C. At a reference temperature below 0°C, a valid process value cannot be determined.

Thermocouples of the types R and S

The characteristic curves of thermocouples of the types R and S are not defined below -50 °C. For this reason, the reference temperature must never be below -50 °C during operation when using types R and S. At a reference temperature below -50 °C, a valid process value cannot be determined.

Table 2-1445 RTD channel

Setting	Description
No reference channel mode	Applied temperature value at channel 3 can be used as a module-wide reference value.
Reference channel of group 0, 1, 2, 3	The RTD channel acts as a **sender** for the reference junction temperature of a group. The distribution is performed via the interface module. Restriction: This is not possible when the module with the channel that serves as the sender for the reference junction temperature provides the process values in REAL format. The RTD channel must be configured as follows: • Measuring range "Thermal resistance Pt100 climatic range" • Temperature unit "Degrees Celsius"
Reference junction active (associated parameter: Only available when using a PROFIBUS GSD file)	Settings: • Disable: Channel x is configured with the setting "No reference channel mode". • Enable: Channel x is configured with the setting selected for the "Reference junction" parameter.

Table 2-1446 TC channel

Setting	Description
Reference channel of the module	The corresponding TC channel uses Channel 3 of the same module as the reference junction temperature. This channel must be configured as follows: • Measuring range "Thermal resistance Pt100 climatic range" • Temperature unit "Degrees Celsius" • Reference junction: "No reference channel mode"
Internal reference junction	The reference junction temperature is read from the internal temperature sensors on the BaseUnit.
Reference channel of group 0, 1, 2, 3	The TC channel acts as a **receiver** for the reference junction temperature of a group. The RTD channel as the sender must be configured as follows: • Measuring range "Thermal resistance Pt100 climatic range" • Temperature unit "Degrees Celsius" • Reference junction: Must be the same reference channel of the group
Fixed reference temperature	The reference temperature of the thermocouple is set to 0 °C. As a result, no temperature compensation is performed.
Reference junction active (associated parameter: Only available when using a PROFIBUS GSD file)	Settings: • Disable: Channel x is configured with the setting "Fixed reference temperature". • Enable: Channel x is configured with the setting selected for the "Reference junction" parameter.

5.4.10 Smoothing

The individual measured values are filtered to smooth them. Smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This specification is valid for all signal changes at the analog input.

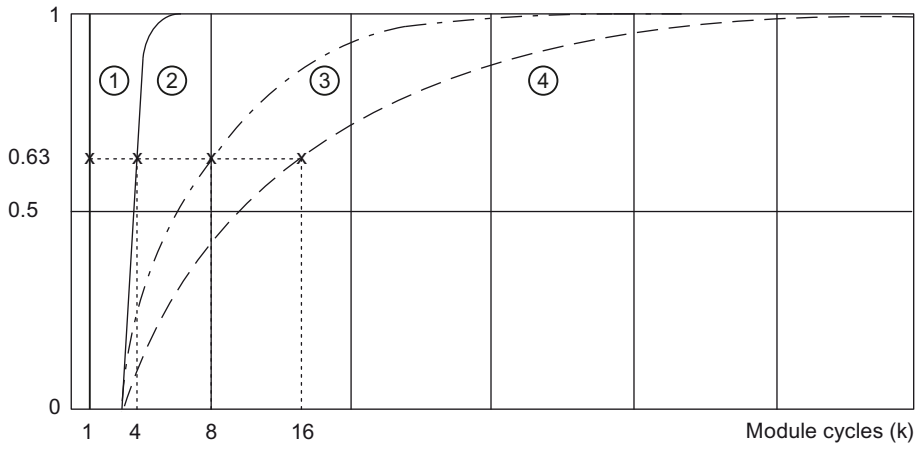

① No smoothing (k = 1)

② Weak (k = 4)

③ Medium (k = 8)

④ Strong (k = 16)

Figure 2-1278 Smoothing of the analog value

5.4.11 Interference frequency suppression

Suppresses the interference that is caused by the frequency of the alternating voltage network used.

The frequency of the AC voltage network is likely to have a negative effect on measured values particularly with measurement in the low voltage range and on thermocouples. With this parameter, you specify the line frequency that acts in your system.

5.4.12 Fixed reference temperature

The reference temperature of the thermocouple is set to 0 °C. As a result, no temperature compensation is performed.

5.4.13 Conductor resistance

Parameters for the measurement types resistor and thermal resistor (2-wire connection).

Used to compensate for the conductor resistance without having to interfere with the sensor wiring. The conductor resistance can be parameterized in steps of 0.01 Ω.

See also

Address space in digital mode with counter/frequency measurement modes without QI (Page %getreference)

Address space in digital mode with counter/frequency measurement modes with QI (Page %getreference)

5.4.14 Hardware interrupt high limit 1 / 2

A hardware interrupt is enabled if high limit 1 / 2 is exceeded.

5.4.15 Hardware interrupt low limit 1 / 2

A hardware interrupt is enabled if low limit 1 / 2 is violated.

5.4.16 High limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

5.4.17 Low limit 1 / 2

Specify a threshold which triggers a hardware interrupt when violated.

5.4.18 Potential group

A potential group consists of a group of directly adjacent Ex IO modules within a station of the distributed I/O (IO device), which are supplied via a common Ex power module.

A potential group begins with an Ex power module, via which the required supply voltage for all Ex I/O modules of the potential group is supplied. The Ex power module interrupts the self-assembling voltage buses to the left neighbor.

The Ex I/O modules take the potential of the self-assembling voltage buses from the left neighbor.

A potential group ends with the BaseUnit, which follows an Ex power module or a server module in the station configuration.

You can find additional information on the configuration of the potential group in the system manual *Distributed I/O System; ET 200SP and ET 200SP HA, Modules for hazardous areas*.

5.5 Module-internal Shared Input (MSI)

The function enables several IO controllers to access the input data of the I/O module.

- With MSI, the input data of the I/O module (the basic submodule) are copied to up to three further MSI submodules.
  All process values of the I/O module are thus present with identical input values in all submodules.
- Each of the four submodules can be assigned to an IO controller, whereby these can be different or identical IO controllers.
- IO controllers have read-only access to the data of each submodule
- Only the basic submodule is configured and can return diagnostic interrupts and hardware interrupts.
  MSI submodules are not configurable and do not return interrupts.

The following figure shows an analog input module with the basic submodule and three MSI submodules. Each submodule is assigned to an IO controller. The diagnostics and parameter assignment of the analog input module is possible via the basic submodule from the IO controller 1.

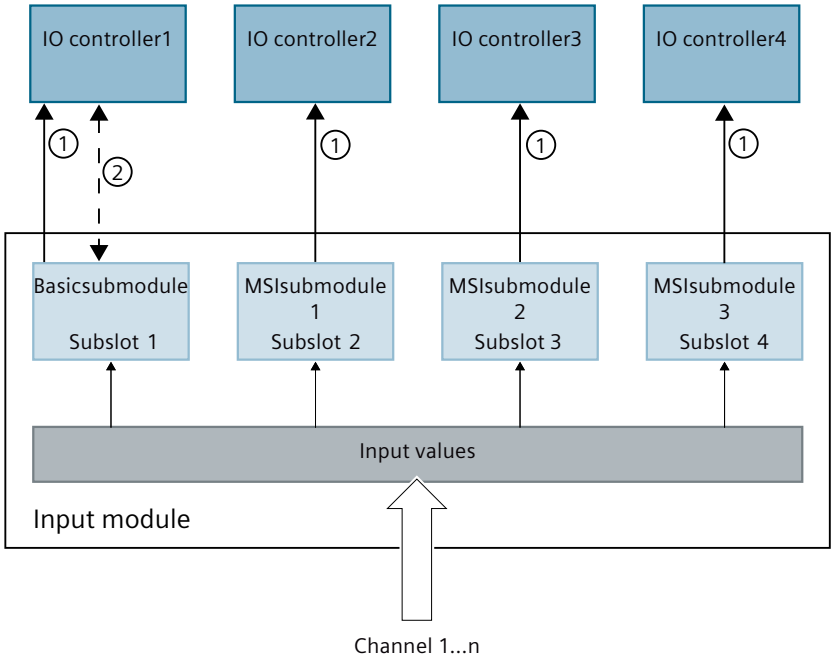

① Read access

② Parameter assignment and system diagnostics

Figure 2-1279 Input module with MSI configuration

Value status (Quality Information, QI)
If QI = "bad" (QI = 0), then the process value is not valid.

NOTE
Restrictions

- **PROFINET required**
  MSI is only available with configuration with PROFINET.
- **No configuration with PCS 7**
  No support for configuration with PCS 7.
- **No configuration via GSD/GSDML**
  No support of MSI during configuration via GSD/GSDML.
  Notes for configuration using a GSD/GSDML file (Page 16)

Configure MSI for an I/O module

Input module with MSI configuration

You set the configuration on the basic submodule (subslot 1).

NOTE

If "MSI" is configured for an I/O module, this applies to all channels of the I/O module.

If MSI is to be configured, the value status QI must always be configured as well.

---

1. Select the configuration based on the following table.
2. Select the number of MSI submodules in the properties of the I/O module. This parameter assignment can be performed in CPU RUN.

You can find additional information in section "Address space in analog mode (Page 58)".

Changing the MSI configuration in RUN

The parameter "Value status" must always be activated.

Configuration	Version of the I/O module in the module catalog (HW Config)	Configuration of the I/O module
Analog mode AI 4 with QI	Ex-AI 4TC/RTD 2-/3-/4-wire	Number of additional submodules: (Change in CPU RUN possible) • 1 to 3: MSI is enabled • 0: MSI is disabled

Additional information

- Find out how to assign MSI submodules to an IO controller in the documentation *SIMATIC; Distributed I/O System ET 200SP/ET 200SP HA, Modules for uses in hazardous areas*.
- How to configure access to a shared device and the function MSI / MSO in STEP 7 can be found in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109736536).

5.6 Measurement types and measuring ranges

Measurement types and channels

The measurement types for resistance measurement (incl. PTC) and resistance thermal measurement are only possible on Channels 2 and 3. If a measurement type with 3-wire or 4-wire connection is configured for channel n (n = 2 or 3), then channel y (y = n-2) must be disabled.

Measurement types and measuring ranges

The following table describes the measuring range and the temperature coefficients you can configure for each measurement type:

Table 2-1447 Measurement types and measuring ranges

Measurement type	Channel	Measuring range	Temperature coefficient	Default
Disabled	0...3	–	–	–
Voltage	0...3	±50 mV / ±80 mV / ±250 mV / ±1 V	-	**±80 mV**
Resistance (2-, 3-, 4-wire connection)	2...3	150 Ω / 300 Ω / 600 Ω / 3 kΩ / 6 kΩ	–	**600 Ω**
Resistance (2-wire connection)	2...3	PTC	–	**PTC**
Thermal resistor (Cu RTD 3-wire connection only)	2...3	Climatic / Standard Cu 10	Cu 0.00427[1]	**Pt 100 Standard range**
Thermal resistor (RTD with 2, 3, 4-wire connection)	2...3	Climatic / Standard Pt 100 Pt 200 Pt 500 Pt 1000	**Pt 0.00385055** Pt 0.003916 Pt 0.003902 Pt 0.00392 Pt 0.00385	
		Climatic / Standard Ni 100 Ni 120 Ni 200 Ni 500 Ni 1000	**Ni 0.00618** Ni 0.00672	
		Climatic[2] / Standard[2] LG-Ni 1000	**LG-Ni 0.005**	

1 The preset temperature coefficients are valid for Europe.

2 For sensors LG-Ni 1000 from Siemens Building Ltd (Landis & Stäfa).

Measurement type	Channel	Measuring range	Temperature coeffi-cient	Default
Thermocouple (TC)	0...3	Type B (PtRh-PtRh) Type N (NiCrSi-NiSi) Type E (NiCr-CuNi) Type R (PtRh-Pt) Type S (PtRh-Pt) Type J (Fe-CuNi) Type L (Fe-CuNi) Type T (Cu-CuNi) **Type K (NiCr-NiAl)** Type U (Cu-CuNi) Type C (WRe-WRe) Type TXK	-	**Type K (NiCr-NiAl)**

1 The preset temperature coefficients are valid for Europe.

2 For sensors LG-Ni 1000 from Siemens Building Ltd (Landis & Stäfa).

Application areas of thermocouples

The following figure shows several thermocouples and their temperature ranges.

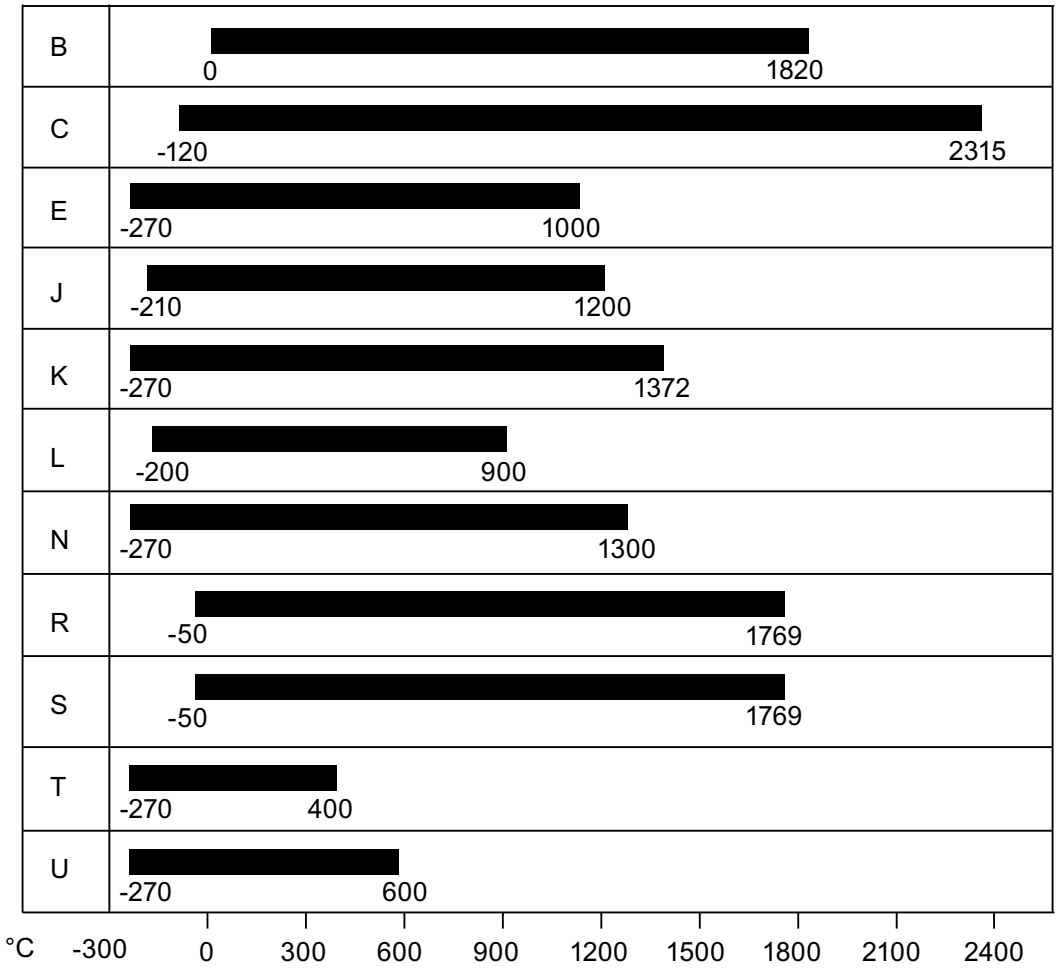

Figure 2-1280 Thermocouples and their ranges

Special features of ohmic resistance and resistance thermometer

Due to its principle, the complete conductor resistance as well as the transfer resistances in the wiring are included in the measurement with 2-wire connection. You can compensate this error via the "Line resistance" parameter. The following procedure is recommended to determine the actual line resistance: In the resistance measurement type (2-wire connection), short-circuit the connections at the sensor end and configure the resistance value determined by the module as the line resistance.

Special features when using Cu10 sensors

- Choose "Thermal resistor (3-wire connection)" and "Cu10" in the parameter assignment.
- Wire the Cu10 sensor into the 3-wire connection technology.
- During operation, automatic, internal compensation of the conductor resistance of the missing measuring line takes place.

NOTE

To ensure optimum line compensation with Cu10, please observe the following:

– An accurate measured value is only attained if the cable resistance of the positive constant current line to the Cu10 sensor and the cable resistance of the negative measuring line are identical in value.
– Recommendation: Keep the measuring line as short as possible.
– Different resistance values may also occur due to the connection method used.

Special features when using PTC resistors

PTCs are suitable for monitoring temperature and/or as thermal protection devices of complex drives or transformer windings.

- Choose "Thermal resistor (2-wire)" and "PTC" in the parameter assignment.
- Connect the PTC to the 2-wire connection technology.
- Use the PTC resistors, type A (PTC thermistor) in accordance with DIN/VDE 0660, part 302.
- If "Underflow" diagnostic is enabled, a "Low limit violated" diagnostic is generated for resistance values < 18 Ω, indicating a short-circuit.
- Sensor data for the PTC resistor:

Table 2-1448 Using PTC resistors

Property	Technical specifications	Comment
Switching points	**Reaction to rising temperature**	
	< 550 Ω	**Normal range**
	550 Ω to 1650 Ω	**Prewarning range**
	> 1650 Ω	**Response range**
	Reaction to falling temperature	
	> 750 Ω	**Response range**
	750 Ω to 540 Ω	**Prewarning range**
	< 540 Ω	**Normal range**

Property	Technical specifications	Comment
Switching points	**Reaction to short-circuit**	
	< 18 Ω	**Short-circuit**
(RRT-5) °C (RRT+5) °C (RRT+15) °C Measuring voltage/ voltage at the PTC	max. 550 Ω min. 1330 Ω min. 4000 Ω max. 7.5 V	TNF = Rated response temperature of the sensor (according to DIN/VDE 0660)

See also

Technical specifications (Page 36)

Displays and interrupts

6

6.1 Status and fault displays of the I/O module Ex-AI 4TC/2RTD 2-/3-/4-wire

6.1.1 Status and error displays of the I/O module

LED displays

The following figure shows the LED displays of the I/O module:

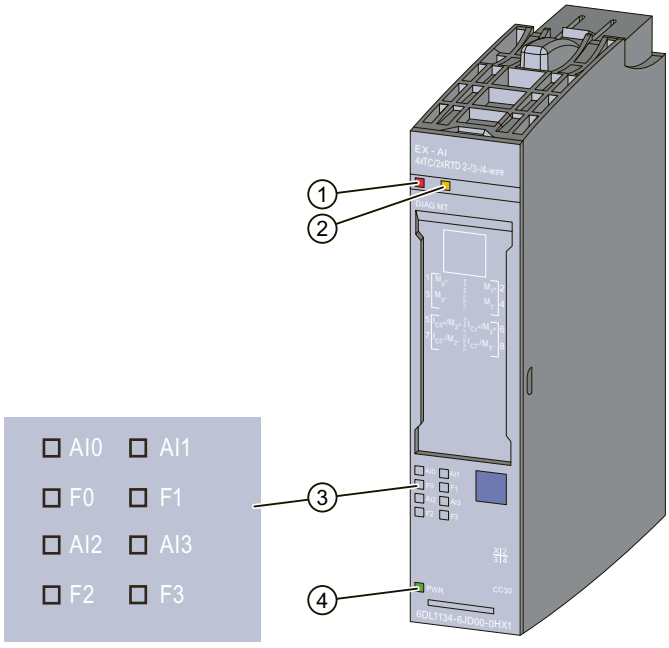

① DIAG LED (green/red)

② MT LED (yellow)

③ LED channel status n (green) and LED channel fault Fn (red) - channel n (n = 0 to 3)

④ PWR LED (green)

Figure 2-1281 LED displays

Meaning of the LED displays

The tables below explain the meaning of the status, error and maintenance displays.

You can learn about corrective measures for messages as well as possible causes in the following section:

Diagnostic and maintenance messages (Page 55)

6.1.2 Diagnostics display of the DIAG LED

DIAG LED

Table 2-1449 Diagnostics display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the system is disrupted or switched off.
Flashes	Module is not configured.
On	Module is configured, a diagnostics message is not pending.
Flashes	Module is configured, at least one diagnostic message is pending.

6.1.3 Diagnostics display of the MT LED

MT LED

Table 2-1450 Status display of the LED MT

MT LED	Meaning
Off	No maintenance required.
On	Maintenance is required, i.e. at least one maintenance event has occurred.

6.1.4 Diagnostics display of the Channel status/channel fault LED

Channel status/channel error LED

The green channel status LED indicates whether the channel is enabled. The green LED does not light up if a channel diagnostic or a module diagnostic result is pending for an activated channel.

The red channel fault LED is lit when channel diagnostics for an enabled channel is pending.

Table 2-1451 Status and error display of the LEDs channel status and channel error

LED channel status	LED channel error	Meaning
Off	Off	• Channel disabled or module switched off • Module diagnostics pending
On	Off	• Channel enabled and no channel/module diagnostics pending
Off	On	• Channel enabled and channel diagnostics pending

6.1.5 Diagnostics display of the PWR LED

PWR LED

Table 2-1452 Status display of the PWR LED

PWR LED	Meaning
□ Off	The supply voltage L+ is missing for the potential group.
■ On	The supply voltage L+ is available for the potential group.

6.2 Interrupts

The I/O module supports diagnostic interrupts and hardware interrupts. Diagnostic and maintenance messages are output via diagnostic interrupts.

You can find more information on this in the appendix:

- Diagnostic and maintenance messages (Page 55)
- Hardware interrupts (Page 57)

Diagnostic messages

The I/O module generates a diagnostic message at the following events:

- Supply voltage missing
- High limit violated
- Low limit violated
- Wire break
- Channel/component temporarily unavailable
- Parameter assignment error
- Reference channel error
- Hardware interrupt lost
- Module is faulty
- Retentive memory in BaseUnit defective
- Invalid BaseUnit

NOTE

A pending "Module is defective" diagnostics is not deleted by the module until a restart.

Maintenance messages

The I/O module generates a maintenance message when the following events occur:

- Retentive memory in BaseUnit defective

Technical specifications 7

Technical specifications of Ex-AI 4TC/2RTD 2-/3-/4-wire

Article number	6DL1134-6JD00-0HX1
General information	
Product type designation	Ex-AI 4xTC/2xRTD 2-/3-/4-wire
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type X1
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V17 or higher
• STEP 7 configurable/integrated from version	STEP 7 V5.6 SP2 or higher
• PCS 7 configurable/integrated from version	V9.1
Operating mode	
• MSI	Yes
Redundancy	
• Redundancy capability	No
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
Input current	
Current consumption (rated value)	33 mA
Current consumption, max.	40 mA
Power loss	
Power loss, typ.	0.8 W
Address area	
Address space per module	
• Address space per module, max.	16 byte; + 1 byte for QI information
• Inputs	16 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	
• Mechanical coding element	Yes

Article number	6DL1134-6JD00-0HX1
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type X1
• 3-wire connection	BU type X1
• 4-wire connection	BU type X1
Analog inputs	
Number of analog inputs	
• For voltage measurement	4
• For resistance/resistance thermometer measurement	2
• For thermocouple measurement	4
Constant measurement current for resistance-type transmitter, typ.	0.5 mA
Technical unit for temperature measurement adjustable	Yes; °C/°F/K
Input ranges (rated values), voltages	
• -1 V to +1 V	Yes; 16 bit incl. sign
– Input resistance (-1 V to +1 V)	1 MΩ
• -250 mV to +250 mV	Yes; 16 bit incl. sign
– Input resistance (-250 mV to +250 mV)	1 MΩ
• -50 mV to +50 mV	Yes; 16 bit incl. sign
– Input resistance (-50 mV to +50 mV)	1 MΩ
• -80 mV to +80 mV	Yes; 16 bit incl. sign
– Input resistance (-80 mV to +80 mV)	1 MΩ
Input ranges (rated values), thermocouples	
• Type B	Yes; 16 bit incl. sign
– Input resistance (Type B)	1 MΩ
• Type C	Yes; 16 bit incl. sign
– Input resistance (Type C)	1 MΩ
• Type E	Yes; 16 bit incl. sign
– Input resistance (Type E)	1 MΩ
• Type J	Yes; 16 bit incl. sign
– Input resistance (type J)	1 MΩ
• Type K	Yes; 16 bit incl. sign
– Input resistance (Type K)	1 MΩ
• Type L	Yes; 16 bit incl. sign
– Input resistance (Type L)	1 MΩ
• Type N	Yes; 16 bit incl. sign
– Input resistance (Type N)	1 MΩ

Article number	6DL1134-6JD00-0HX1
• Type R	Yes; 16 bit incl. sign
– Input resistance (Type R)	1 MΩ
• Type S	Yes; 16 bit incl. sign
– Input resistance (Type S)	1 MΩ
• Type T	Yes; 16 bit incl. sign
– Input resistance (Type T)	1 MΩ
• Type U	Yes; 16 bit incl. sign
– Input resistance (Type U)	1 MΩ
• Type TXK/TXK(L) to GOST	Yes; 16 bit incl. sign
– Input resistance (Type TXK/TXK(L) to GOST)	1 MΩ
Input ranges (rated values), resistance thermometer	
• Cu 10	Yes; 16 bit incl. sign
– Input resistance (Cu 10)	1 MΩ
• Ni 100	Yes; 16 bit incl. sign
– Input resistance (Ni 100)	1 MΩ
• Ni 1000	
– Input resistance (Ni 1000)	1 MΩ
• LG-Ni 1000	Yes; 16 bit incl. sign
• Ni 120	Yes; 16 bit incl. sign
– Input resistance (Ni 120)	1 MΩ
• Ni 200	Yes; 16 bit incl. sign
– Input resistance (Ni 200)	1 MΩ
• Ni 500	Yes; 16 bit incl. sign
– Input resistance (Ni 500)	1 MΩ
• Pt 100	Yes; 16 bit incl. sign
– Input resistance (Pt 100)	1 MΩ
• Pt 1000	Yes; 16 bit incl. sign
– Input resistance (Pt 1000)	1 MΩ
• Pt 200	Yes; 16 bit incl. sign
– Input resistance (Pt 200)	1 MΩ
• Pt 500	Yes; 16 bit incl. sign
– Input resistance (Pt 500)	1 MΩ
Input ranges (rated values), resistors	
• 0 to 150 ohms	Yes; 15 bit
– Input resistance (0 to 150 ohms)	1 MΩ

Article number	6DL1134-6JD00-0HX1
• 0 to 300 ohms	Yes; 15 bit
– Input resistance (0 to 300 ohms)	1 MΩ
• 0 to 600 ohms	Yes; 15 bit
– Input resistance (0 to 600 ohms)	1 MΩ
• 0 to 3000 ohms	Yes; 15 bit
– Input resistance (0 to 3000 ohms)	1 MΩ
• 0 to 6000 ohms	Yes; 15 bit
– Input resistance (0 to 6000 ohms)	1 MΩ
• PTC	Yes; 15 bit
– Input resistance (PTC)	1 MΩ
Thermocouple (TC)	
Temperature compensation	
– parameterizable	Yes
– internal comparison point	Yes; BU type X1
– Reference channel of the group	Yes
– Number of reference channel groups	4
– fixed reference temperature	Yes
Cable length	
• shielded, max.	200 m; Ex characteristic values must be observed; line resistance at RTD (simple) max. 25 ohm; loop resistance at TC max. 8 kOhm
Analog value generation for the inputs	
Measurement principle	integrating (Sigma-Delta)
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes; Channel-by-channel, results from the selected interference frequency suppression
• Basic conversion time, including integration time (ms)	
– additional processing time for wire-break check	20 ms; In the ranges resistance thermometers, resistors and thermocouples
– additional power line wire-break check	20 ms, for 3/4-wire transducer (resistance thermometer and resistor)
• Interference voltage suppression for interference frequency f1 in Hz	16.6 / 50 / 60 Hz, channel-by-channel
• Conversion time (per channel)	180 / 60 / 50 ms, results from the selected interference frequency suppression
Smoothing of measured values	
• parameterizable	Yes; none, weak, medium, strong, channel-by-channel

Article number	6DL1134-6JD00-0HX1
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %; ±0.1 % for resistance thermometers and resistance
Temperature error (relative to input range), (+/-)	0.0009 %/K; ±0.005 % / K at thermocouple
Crosstalk between the inputs, min.	50 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Voltage, relative to input range, (+/-)	0.1 %
• Resistance, relative to input range, (+/-)	0.1 %
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to input range, (+/-)	0.05 %
• Resistance, relative to input range, (+/-)	0.05 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	70 dB
• Common mode voltage, max.	60 V; Applicable for use in non-hazardous areas; no common mode voltage permissible in hazardous areas
• Common mode interference, min.	90 dB
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes; two upper and two lower limit values in each case
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; channel by channel
• Overflow/underflow	Yes; channel by channel
Diagnostics indication LED	
• MAINT LED	Yes; Yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED

Article number	6DL1134-6JD00-0HX1
Ex(i) characteristics	
maximum values for connecting terminals for gas group IIC	
• Uo (no-load voltage), max.	5.9 V
• Io (short-circuit current), max.	18 mA
• Po (power output), max.	27 mW
• Co (permissible external capacity), max.	43 µF
• Lo (permissible external inductivity), max.	110 mH
• Um (voltage at non-intrinsically safe connecting terminals), max.	60 V
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes; Electrical isolation between the channels and input voltage PME
Isolation	
Isolation tested with	further information on insulation can be found in the "ET 200SP HA / ET 200SP modules for devices in hazardous areas" System Manual
insulation of the field circuits to local ground acc. to IEC/EN 60079-11 tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-40 °C
• horizontal installation, max.	70 °C
• vertical installation, min.	-40 °C
• vertical installation, max.	60 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	55 g

Cycle time

The cycle time describes the period of time in which signals at the inputs are acquired and processed.

The cycle time is the sum of the channel processing times (independent of parameter assignment):

Measurement type	**Processing time per channel [ms]**		
Interference frequency suppression	16.6 Hz	50 Hz	60 Hz
Disabled	0	0	0
Voltage	205	85	75
Thermocouple	295	175	165
Thermal resistor/resistance 2-wire connection	290	170	160
Thermal resistor/resistance 3-wire connection	580	340	320
Thermal resistor/resistance 4-wire connection	335	215	205

Operational and basic error limits for resistance thermometers

Error limits for resistance thermometers	
Operational limit (in the entire temperature range, in relation to input range)	Accuracy
• Pt 100, Pt 200, Pt 500, Pt 1000 standard	±1.0 K
• Pt 100, Pt 200, Pt 500, Pt 1000 climatic	± 0.25 K
• Ni 100, Ni 120, Ni 200, Ni 500, Ni 1000 standard and climatic	±0.4 K
• Cu 10	±1.5 K
Basic error limit (operational limit at 25 °C, in relation to input range)	Accuracy
• Pt 100, Pt 200, Pt 500, Pt 1000 standard	± 0.6 K
• Pt 100, Pt 200, Pt 500, Pt 1000 climatic	± 0.13 K
• Ni 100, Ni 120, Ni 200, Ni 500, Ni 1000 standard and climatic	± 0.2 K
• Cu 10	±1.0 K

Operational and basic error limits for thermocouples

Operational limit (in the entire temperature range -40...70 °C) **Note: This limit does not cover fluctuations in the reference junction temperature.**			
Thermocouple	Min.	Max.	Accuracy
Type T	-200 °C	+400 °C	± 0.6 K
	-230 °C	-200 °C	±1.6 K
Type U	-200 °C	+600 °C	±1.5 K

Operational limit (in the entire temperature range -40...70 °C) **Note: This limit does not cover fluctuations in the reference junction temperature.**			
Type E	-200 °C	+1000 °C	±0.5 K
	-230 °C	-200 °C	±1.3 K
Type J	-150 °C	+1200 °C	±0.5 K
Type L	-150 °C	+900 °C	±0.9 K
Type K	-150 °C	+1372 °C	±0.8 K
	-220 °C	-150 °C	±1.5 K
Type N	-150 °C	+1300 °C	±1 K
	-220 °C	-150 °C	±1.5 K
Type R	+100 °C	+1769 °C	±1.5 K
	-50 °C	+100 °C	±2.5 K
Type S	+100 °C	+1769 °C	±1.5 K
	-50 °C	+100 °C	±2.5 K
Type B	+700 °C	+1820 °C	±1.5 K
	+500 °C	+700 °C	±2 K
	+200 °C	+500 °C	±4 K
Type C	+100 °C	+2315 °C	±2.5 K
Type TxK	-150 °C	+800 °C	±1.0 K
	-200 °C	-150 °C	±1.5 K

Basic error limit (operational limit at 25 °C) **Note: This limit does not cover fluctuations in the reference junction temperature.**			
Thermocouple	Min.	Max.	Accuracy
Type T	-200 °C	+400 °C	±0.4 K
	-230 °C	-200 °C	±1 K
Type U	-150 °C	+600 °C	±0.5 K
Type E	-200 °C	+1000 °C	±0.4 K
	-230 °C	-200 °C	±1 K
Type J	-150 °C	+1200 °C	±0.4 K
Type L	-150 °C	+900 °C	±0.5 K
Type K	-150 °C	+1372 °C	±0.4 K
	-220 °C	-150 °C	±1 K
Type N	-150 °C	+1300 °C	±0.8 K
	-220 °C	-150 °C	±1.2 K
Type R	+100 °C	+1769 °C	±1 K
	-50 °C	+100 °C	±1.5 K
Type S	+100 °C	+1769 °C	±1 K
	-50 °C	+100 °C	±1.5 K
Type B	+700 °C	+1820 °C	±1 K
	+500 °C	+700 °C	±1.5 K

Basic error limit (operational limit at 25 °C) Note: This limit does not cover fluctuations in the reference junction temperature.			
Type B	+200 °C	+500 °C	±3 K
Type C	+100 °C	+2315 °C	±1 K
Type TxK	-150 °C	+800 °C	±0.5 K
	-200 °C	-150 °C	±1 K

Accuracy of temperature measurement

The accuracy of the temperature measurement when using internal compensation (terminal temperature) is composed of:

- Error for the analog input of the utilized thermocouple type
- Measuring accuracy for the temperature of the internal reference junction ±1.5 K

The accuracy of temperature measurement when using external compensation, either by means of locally connected thermal resistances or via remote access by way of an external RTD module, is composed of:

- Error for the analog input of the utilized thermocouple type
- Measuring accuracy of the thermal resistance used for compensation
- Error for the compensation input (see operational and basic error limits for resistance thermometers)

Drivers, parameters, diagnostics messages and address space

A

A.1 Concept of the driver and diagnostics blocks

Use with PCS 7

The following information shows you advantages of using the process control system. In the process control system, the engineering system automatically handles many important parameter assignments and interconnections of modules.

If you want to use the Ex I/O outside these process control systems, refer to the following sections:

- Parameter assignment and structure of the module/channel parameters (Page 47)
- Address space in analog mode (Page 58)

Tasks of the driver and diagnostics blocks (driver blocks)

In process control systems, certain demands are placed on the diagnostics/signal processing. This includes the monitoring of modules, IO devices and PROFINET IO systems for malfunctions and failures.

To make this possible, blocks are provided in the libraries of the engineering system which implement the interface to the hardware, including test functionality.

These blocks perform two basic tasks:

- They provide signals from the process to the AS for further processing.
- They monitor modules, IO devices and PROFINET IO system for failure.

When the process signals are read in, these blocks access the process image input (or process image partition) (PII) and when the process signals are output, they access the process image output (or process image partition) (PIQ).

Concept

The concept of the driver and diagnostic blocks at the process control systems is characterized by the following:

- The separation between user data processing (CHANNEL blocks) and diagnostics data processing (MODULE blocks)
- The symbolic addressing of the I/O signals
- The automatic generation of the MODULE blocks by CFC

This block concept supports all modules from the list of approved modules.
When new Siemens or non-Siemens module types are integrated, the meta-knowledge for the driver generator can be extended by additional XML files (object and action lists).

NOTE

Note the following:

- The library with the driver blocks has to installed using the Setup program on the PC. This is the only method of ensuring that the meta-knowledge required for the driver generator is available. You must not copy the library from another computer.
- You can also use driver blocks from another library (for example, your own blocks from your own library). You can specify this additional library in the "Generate module drivers" dialog box. The driver generator then searches for the block to be imported in the library specified here. If the block is not found here, it is searched for in the library specified in the control file (XML file).
- If the S7 program contains a signal-processing block, but none from one of the engineering system libraries, the following is required:
  You must specify the version of the driver library from which the driver blocks are to be imported in the "Generate module drivers" dialog box.

Time-optimized processing

To enable time-optimized processing during runtime, the organization blocks for error handling (for example, OB85, OB86) are automatically divided into runtime groups and the driver blocks are integrated in the corresponding runtime groups.

If an error occurs, the SUBNET block, for example, activates the relevant runtime group. The RACK block or MODULE block detects the error, evaluates it and sends a process control message to the operator control and monitoring system.

The diagnostics information of the module block (OMODE_xx output) is also transferred to the corresponding CHANNEL block (MODE input). If required, this information can be displayed in a process picture via a block that can be controlled and observed in the operator control and monitoring system or a user block (color change of the measured value or flashing display, etc.).

A.2 Parameter assignment and structure of the module/channel parameters

A.2.1 Parameter assignment

Parameter assignment in the user program

You can reconfigure individual channels of the I/O module in RUN without affecting the other channels.

Changing parameters in RUN

The parameters are only transferred to the I/O module via data record 128 with the "WRREC" instruction. The parameters set via the configuration are not changed in the CPU in this case, i.e. after startup the parameters set in the CPU are valid again.

STATUS output parameter

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The STATUS output parameter is 4 bytes long and is configured as followed:

- Byte1: Function_Num, general error code
- Byte2: Error_Decode, location of the error code
- Byte3: Error_Code_1, error code
- Byte4: Error_Code_2, manufacturer-specific extension of the error code

Module-specific errors are displayed via Error_Decode = 0x80 and Error_Code_1 / Error_Code_2.

Error_ Code_1	Error_ Code_2	Cause	Remedy
0xB0	variable	Number of the data record unknown (Error_Code_2 returns internal identifiers)	Enter valid number for data record.
0xB1	0x01	Length of the data record is incorrect	Enter valid value for data record length.
0xB2	variable	Module cannot be reached (Error_Code_2 returns internal identifiers)	• Check station - is the module plugged in correctly? • Check the parameters of the WRREC instruction.
0xE0	0x01	Header error (version or defined bits incorrect)	Correct the version number or defined bits.
0xE0	0x02	Header error (incorrect length or number of parameter blocks)	Correct the length and number of the parameter blocks.
0xE1	0x01	Reserved bit set	Write all reserved bits with a 0.
0xE1	0x02	Invalid diagnostics enable bit set for operating mode	Check the diagnostic enables

Error_ Code_1	Error_ Code_2	Cause	Remedy
0xE1	0x03	Invalid hardware interrupt enable bit set for operating mode	Check and correct the parameters
0xE1	0x04	Invalid value for hardware interrupt limit	
0xE1	0x08	Invalid coding for interference frequency suppression / integration time	
0xE1	0x09	Invalid coding for smoothing	
0xE1	0x0F	Invalid parameter assignment of the reference temperature (Pt100 climatic)	
0xE1	0x10	Code for measurement type invalid	
0xE1	0x11	Code for measuring range invalid	
0xE1	0x22	Invalid parameter assignment of the reference temperature for configuration AI 4 REAL with QI	

Valid parameters

Only the values specified in the following are permitted. Values that are not listed are rejected by the module.

Every parameter data record is checked by the module. If an incorrect parameter is detected, the entire data record is rejected and the parameters of the module remain unchanged.

A.2.2 Parameter assignment and structure of the module and channel parameters

Structure of data record 128

The data record contains the module parameters as well as the channel or technology parameters of the 4 channels.

Main components of the data record:

- Header information (module), module parameters, header information (channel)
- Channel parameters (channel or technology parameters) which affect the actual analog value input
- Parameters which enable diagnostics

Table 2-1453 Structure of data record 128 in analog mode (96 bytes in length)

Byte	Length	Parameter	Efficiency range
0 ... 3	4 bytes	Header information (module)	Module
4 ... 5	2 bytes	Module parameters	

Byte	Length	Parameter	Efficiency range
6 ... 7	2 bytes	Header information (channels)	AI channel n (n = 0 to 3) • Analog value input • Enable diagnostics
8 ... 29	22 bytes	Channel parameter (channel 0)	
30 ... 51	22 bytes	Channel parameter (channel 1)	
52 ... 73	22 bytes	Channel parameter (channel 2)	
74 ... 95	22 bytes	Channel parameter (channel 3)	

NOTE

Legend for the following detailed screens

The following detailed screens show the assignment of the individual bytes in data record 128 based on the configuration.

- Any unused bits and bits or bytes marked with "reserved" must be set to "0".
- Activate a parameter by setting the corresponding bit to "1" or to the appropriate value.

Header information and module parameters

The following figure shows the structure of the header information and module parameters.

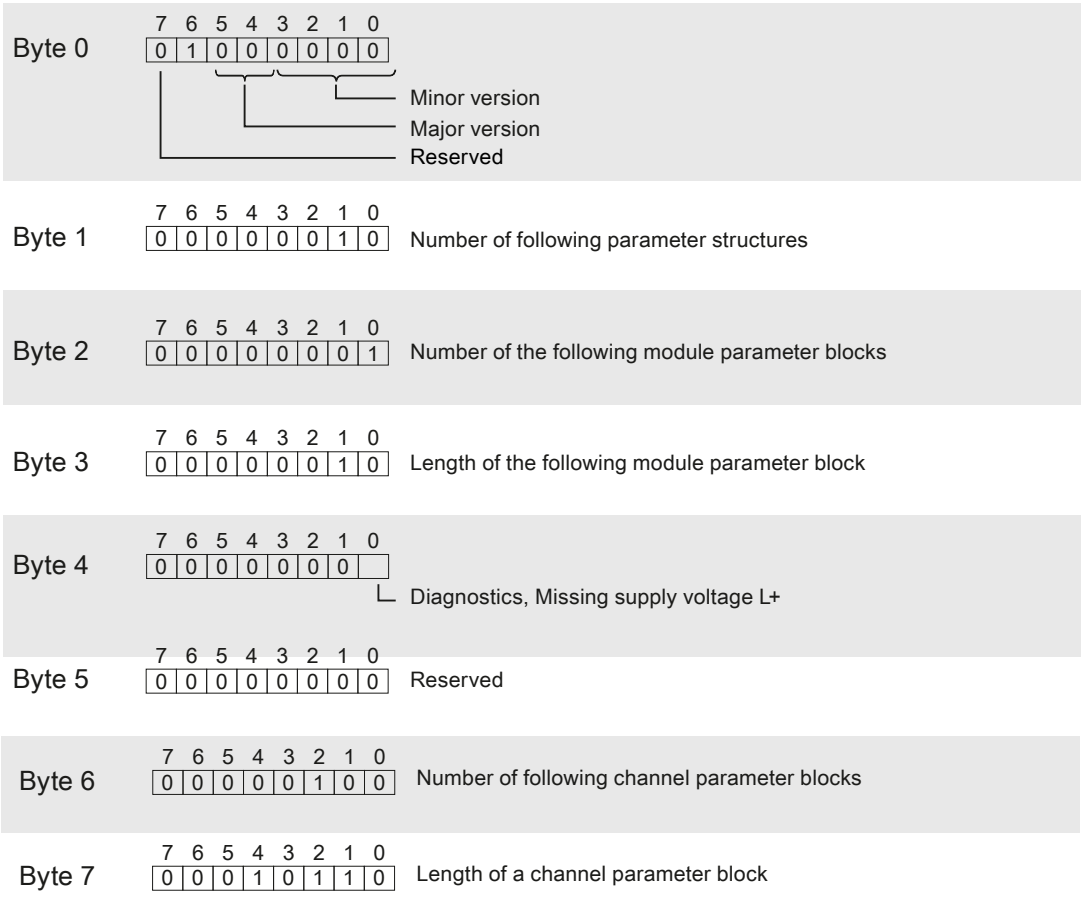

Figure 2-1282 Header information and module parameters of data record 128

Channel parameters

The figures below show the structure of the channel parameters for channels 0...3. You set the individual parameters by setting the corresponding bits.

x = 8 + (channel number * 22); channel number = 0 to 3

Any unused bits and bits or bytes marked with "reserved" must be set to "0".

	7	6	5	4	3	2	1	0	
Byte x									Measurement type, see table Coding for measurement type
Byte x+1									Measuring range, see table Coding for measuring range
Byte x+2									Temperature coefficient, see table Coding for temperature coefficient
Byte x+3									Smoothing: 0000 = None 0001 = Weak 0010 = Medium 0011 = Strong Interference frequency suppression: 0001 = 60 Hz 0010 = 50 Hz 0100 = 16.6 Hz
Byte x+4					0	0			Temperature unit: 00 = degrees Celsius 01 = degrees Fahrenheit 10 = Kelvin (not for measuring range climate) Reference junction: (for RTD as reference channel sender, for TC as reference channel receiver) 0000 = No reference channel operation 0010 = Reference channel of the module 0011 = Internal reference junction 1000 = Reference channel of Group 0 1001 = Reference channel of Group 1 1010 = Reference channel of Group 2 1011 = Reference channel of Group 3 1111 = Fixed reference temperature
Byte x+5					0	0	0	0	Enable hardware interrupt, high limit 2 Enable hardware interrupt, low limit 2 Enable hardware interrupt, high limit 1 Enable hardware interrupt, low limit 1

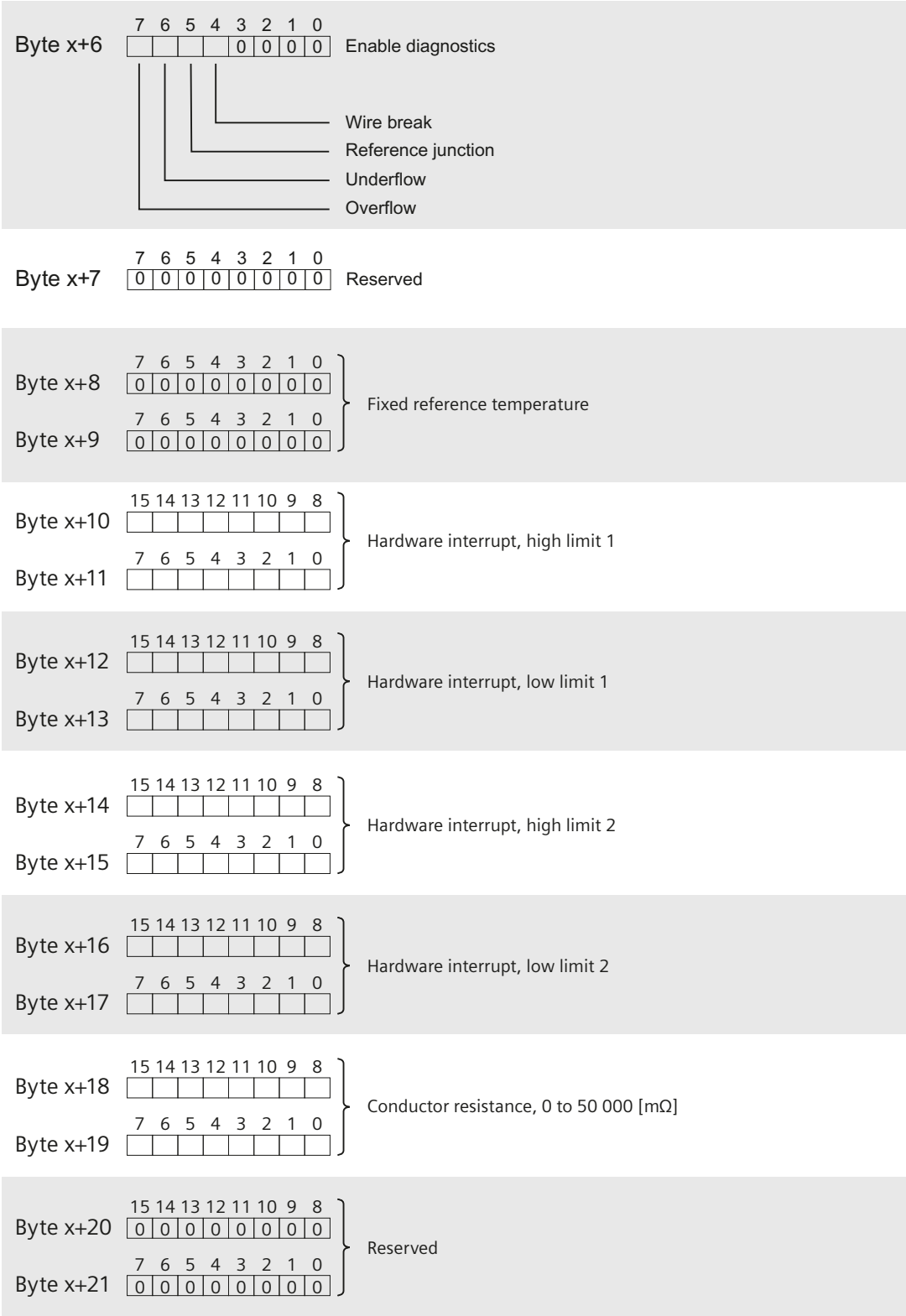

Figure 2-1283 Structure of byte x to x+21 for channel 0 to 3

NOTE

The "Conductor resistance" parameter is only activated for 2-wire connection.

Codes for measurement type

The following table contains the codes for the measurement types of the analog input module. You must enter these codes in byte x (see channel parameters).

Table 2-1454 Codes for measurement type

Measurement type	Code
Disabled	0000 0000
Voltage	0000 0001
Resistor, 4-wire connection	0000 0100
Resistor, 3-wire connection	0000 0101
Resistor, 2-wire connection	0000 0110
Thermal resistor, 4-wire connection	0000 0111
Thermal resistor, 3-wire connection	0000 1000
Thermal resistor, 2-wire connection	0000 1001
Thermocouple	0000 1010

Codes for measuring range

The following table contains the codes for the measuring ranges of the analog input module. You must enter these codes in byte x+1 (see channel parameters).

Table 2-1455 Codes for measuring range

Measurement type	Measuring range	Code
Voltage	• 50 mV • 80 mV • 250 mV • 1 V	• 0000 0001 • 0000 0010 • 0000 0011 • 0000 0101
Resistor	• 150 Ω • 300 Ω • 600 Ω • 3 kΩ • 6 kΩ • PTC	• 0000 0001 • 0000 0010 • 0000 0011 • 0000 0100 • 0000 0101 • 0000 1111
Thermal resistor climatic	• Pt 100 • Pt 200 • Pt 500 • Pt 1000	• 0000 0000 • 0000 0111 • 0000 1000 • 0000 1001

Measurement type	Measuring range	Code
Thermal resistor standard	• Pt 100 • Pt 200 • Pt 500 • Pt 1000	• 0000 0010 • 0000 1011 • 0000 0100 • 0000 0101
Thermal resistor climatic	• Ni 100 • Ni 120 • Ni 200 • Ni 500 • Ni 1000 • LG-Ni 1000	• 0000 0001 • 0000 1101 • 0001 0001 • 0001 0011 • 0000 1010 • 0001 1101
Thermal resistor standard	• Ni 100 • Ni 120 • Ni 200 • Ni 500 • Ni 1000 • LG-Ni 1000	• 0000 0011 • 0000 1100 • 0001 0000 • 0001 0010 • 0000 0110 • 0001 1100
Thermal resistor	• Cu 10 climatic • Cu 10 standard	• 0000 1110 • 0000 1111
Thermocouple	• Type B • Type N • Type E • Type R • Type S • Type J • Type L • Type T • Type K • Type U • Type C • Type TXK	• 0000 0000 • 0000 0001 • 0000 0010 • 0000 0011 • 0000 0100 • 0000 0101 • 0000 0110 • 0000 0111 • 0000 1000 • 0000 1001 • 0000 1010 • 0000 1011

Codes for temperature coefficient for temperature measurement

The following table contains the codes for the temperature coefficients of the analog input module. You must enter these codes in byte x+2 (see channel parameters).

Table 2-1456 Codes for temperature coefficient for temperature measurement

Temperature coefficient	Code
• Pt 0.00385055 • Pt 0.003916 • Pt 0.003902 • Pt 0.00392 • Pt 0.00385	• 0000 0000 • 0000 0001 • 0000 0010 • 0000 0011 • 0000 0100
• Ni 0.00618 • Ni 0.00672	• 0000 1000 • 0000 1001
• LG-Ni 0.005	• 0000 1010
• Cu 0.00427	• 0000 1100

Limits for hardware interrupts

The following tables contain the permitted limits for hardware interrupts (in each case, the usable value is given).

The limits depend on the selected measurement type and the selected measuring range.

The value for the "High limit" parameter must be larger than the value for the "Low limit" parameter.

Table 2-1457 Limits for voltage and resistance ("High limit" parameter and "Low limit" parameter)

Value range	Voltage (all possible measuring range settings)	Resistance (all possible measuring range settings)
from	-32511	1
to	32510	32510

Table 2-1458 Limits for thermocouple types B, C, and E ("High limit" parameter and "Low limit" parameter)

Value range	Thermocouple type B			Thermocouple type C			Thermocouple type E		
	°C	°F	K	°C	°F	K	°C	°F	K
from	-1199	-1839	1533	-1199	-1839	1533	-2699	-4539	33
to	20699	32765	23431	24999	32765	27731	11999	21919	14731

Table 2-1459 Limits for thermocouple types R, S, J, and L ("High limit" parameter and "Low limit" parameter)

Value range	Thermocouple type R, S			Thermocouple type J			Thermocouple type L		
	°C	°F	K	°C	°F	K	°C	°F	K
from	-1699	-2739	1033	-2099	-3459	633	-1999	-3279	733
to	20189	32765	22921	14499	26419	17231	11499	21019	14231

Table 2-1460 Limits for thermocouple types T, K, and U ("High limit" parameter and "Low limit" parameter)

Value range	Thermocouple type T			Thermocouple type K			Thermocouple type U		
	°C	°F	K	°C	°F	K	°C	°F	K
from	-2699	-4539	33	-2699	-4539	33	-1999	-3279	733
to	5399	10039	8131	16219	29515	18951	8499	15619	11231

Table 2-1461 Limits for thermocouple types N and TXK ("High limit" parameter and "Low limit" parameter)

Value range	Thermocouple type N			Thermocouple type TXK		
	°C	°F	K	°C	°F	K
from	-2699	-4539	33	-1999	-3279	733
to	15499	28219	18231	10499	19219	13231

Table 2-1462 Limits for thermal resistance Cu ("High limit" parameter and "Low limit" parameter)

Value range	Thermal resistor Cu standard			Thermal resistor Cu climatic	
	°C	°F	K	°C	°F
from	-2399	-3999	333	-5999	-7599
to	3119	5935	5851	17999	32765

Table 2-1463 Limits for thermal resistance Pt ("High limit" parameter and "Low limit" parameter)

Value range	Thermal resistor Pt standard			Thermal resistor Pt climatic	
	°C	°F	K	°C	°F
from	-2429	-4053	303	-14499	-22899
to	9999	18319	12731	15499	31099

Table 2-1464 Limits for thermal resistance Ni ("High limit" parameter and "Low limit" parameter)

Value range	Thermal resistor Ni, Ni-LG standard			Thermal resistor Ni, Ni-LG climatic	
	°C	°F	K	°C	°F
from	-1049	-1569	1683	-10499	-15699
to	2949	5629	5681	29499	32765

A.2.3 Diagnostic and maintenance messages

Diagnostics messages

A diagnostic message is output for each enabled diagnostic event, and the DIAG LED on the I/O module flashes red.

The diagnostics messages can be read in the diagnostics buffer of the CPU.

The following applies for assigning diagnostic messages:

- A module message is assigned to all channels.
- A channel-specific message is assigned to one channel only, the other channels are not affected.
  The diagnostic result is indicated by the corresponding channel fault LED.

Table 2-1465 Diagnostics messages, their meaning and possible remedies

Diagnostics message	Error code	Assignment	Meaning	Remedy
Wire break	6_H	Channel	• Impedance of encoder circuitry is too high • Wire break between the module and sensor • Channel not connected (open)	• Use another type of encoder or wiring, for example, use conductors with a larger cross-section • Connect the cable • Disable diagnostics • Connect the encoder contacts

[1] For resistance and thermal resistance measuring ranges, the "High limit exceeded" diagnostic is signaled at a wire break when "Wire break" diagnostics is disabled.

Diagnostics message	Error code	Assignment	Meaning	Remedy
High limit violated[1]	7_H	Channel	• The analog value lies above the overrange • Wire break	• Correct the module/encoder tuning • Check the wiring
Low limit violated[1]	8_H	Channel	The analog value lies below the underrange	Correct the module/encoder tuning
Parameter assignment error	10_H	Module	Incorrect parameter assignment	Correct the parameter assignment
Supply voltage missing	11_H	Module	Missing or insufficient supply voltage L+	• Check Ex power module • Check wiring of the supply voltage L+ on the Ex power module
Reference channel error (reference junction)	15_H	Channel	Reference temperature of the reference junction for the operated TC channel with compensation is invalid	• Check type of the Ex BaseUnit • Check whether the reference junction parameters are correctly assigned • Check whether the reference junction (reference channel of group 0, 1, 2, 3) has been assigned exactly once in each case as a sender within the station. • Check whether the sender of the reference junction (reference channel of group 0, 1, 2, 3) is operating error-free • When a type B or type C thermocouple is used, the reference temperature may not be less than 0 degrees Celsius
Hardware interrupt lost	16_H	Module	Error is reported because the events occur faster than they can be processed in the system.	
Channel/component temporarily unavailable	$1F_H$	Module	Firmware update is in progress or has been canceled during the update. The module stops acquiring process values during this time.	• Restart firmware update • Wait for firmware update
Module is faulty	100_H	Module	Internal module error has occurred	Replace I/O module
Invalid BaseUnit	151_H	Module	The module was plugged into an impermissible BaseUnit.	Replace Ex BaseUnit
The retentive memory in the BaseUnit is defective.	153_H	Module	An error in the RAM on the BaseUnit was detected during startup.	Replace Ex BaseUnit

[1] For resistance and thermal resistance measuring ranges, the "High limit exceeded" diagnostic is signaled at a wire break when "Wire break" diagnostics is disabled.

Maintenance messages

Whenever it is detected that maintenance is required, a maintenance message is generated and the MT LED lights up yellow on the I/O module.

Maintenance messages have no direct effect on the function of the I/O module or the analog value acquisition.

Table 2-1466 Maintenance messages, their meaning and possible remedies

Maintenance message	Error code	Assignment	Meaning / Cause	Remedy
The retentive memory in the BaseUnit is defect-ive.	153_H	Module	A memory block error on the BaseUnit was detected during operation	Replace Ex BaseUnit

A.2.4 Hardware interrupts

Hardware interrupts

The I/O module generates a hardware interrupt depending on the analog input signal when the following events occur:

- Violation of the low limit 1
- Violation of the high limit 1
- Violation of the low limit 2
- Violation of the high limit 2

The assigned OB4x (x=0...7) is called automatically in the CPU if an interrupt occurs.

The channel of the I/O module that triggered the hardware interrupt is recorded in the start information of the OB4x in the OB4x_POINT_ADDR variable. The following figure shows the assignment to the bits of the local data double word 8.

You can find detailed information on the event in the hardware interrupt organization block with the "RALRM" instruction (read additional interrupt information).

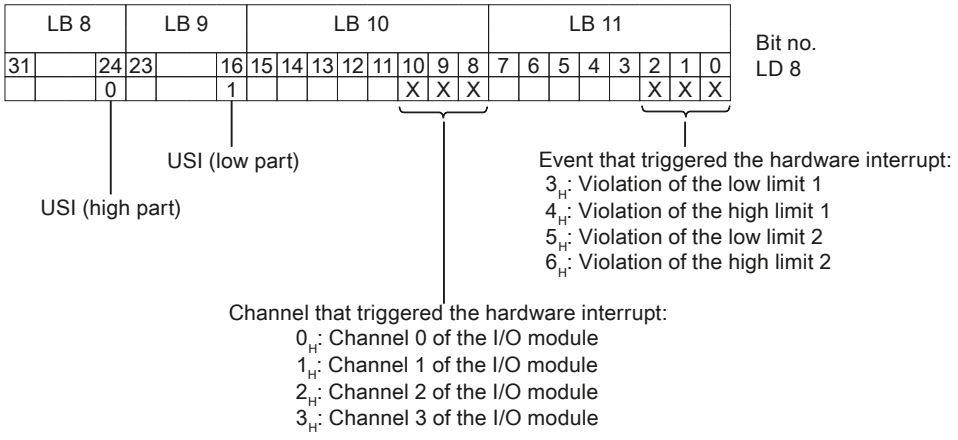

Figure 2-1284 Start information of the organization block

A.3 Address space

A.3.1 Address space in analog mode

Address space

The following tables show the allocation of the address space of the I/O module based on the configuration.

Address space in analog mode AI 4 without QI (Page 58)

Address space in the analog mode AI 4 with QI and optional MSI (Page 59)

Address space in the analog mode AI 4 Real without QI (Page 60)

Address space in the analog mode AI 4 Real with QI (Page 60)

Input range when using PTC resistors (Page 61)

Evaluating information

Evaluating the value status (Page 62)

A.3.2 Address space in analog mode AI 4 without QI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input range
- "QAIn" stands for value status (QI) of analog input n

Address space in the configuration analog mode AI 4 without QI

The following table shows the mapping of the address space of the I/O module.

The process values are shown in S7 format.

Input area

Table 2-1467 Input area of the Ex-AI 4xTC/2xRTD 2-/3-/4-wire (AI 4 without QI)

IB x +	7	6	5	4	3	2	1	0
0...1	Analog value, analog input 0							
: :								
6...7	Analog value, analog input 3							

A.3.3 Address space in the analog mode AI 4 with QI and optional MSI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input range
- "QAIn" stands for value status (QI) of analog input n
  You can find additional information in section "Evaluating the value status (Page 62)".

Address space in the configuration analog mode AI 4 with QI und optional MSI

The following table shows the mapping of the address space of the I/O module.

The process values are shown in S7 format.

Input area

NOTE
Configuration with MSI
The following applies when an I/O module is configured with MSI:

- Each subslot has its own **start address** (IB x +).
- Each MSI submodule occupies its own address area with identical structure in the input area.
- The process input signals of the basic submodule (subslot 1) are mirrored to the MSI submodules as input signals.

Table 2-1468 Input area of the Ex-AI 4xTC/2xRTD 2-/3-/4-wire (AI 4 with QI or with MSI for every subslot)

IB x +	7	6	5	4	3	2	1	0
0...1	Analog value, analog input 0							
: :								
6...7	Analog value, analog input 3							
8	-	-	-	-	QAI3	QAI2	QAI1	QAI0

A.3.4 Address space in the analog mode AI 4 Real without QI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input range
- "QAIn" stands for value status (QI) of analog input n

Address space in the configuration analog mode AI 4 Real without QI

The following table shows the mapping of the address space of the I/O module.

The process values are shown in REAL format.

Input area

Table 2-1469 Input area of the Ex-AI 4xTC/2xRTD 2-/3-/4-wire (AI 4 Real without QI)

IB x +	7	6	5	4	3	2	1	0
0...3	Analog value, analog input 0							
: :								
12...15	Analog value, analog input 3							

A.3.5 Address space in the analog mode AI 4 Real with QI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input range
- "QAIn" stands for value status (QI) of analog input n
  You can find additional information in section "Evaluating the value status (Page 62)".

Address space in the configuration analog mode AI 4 Real with QI

The following table shows the mapping of the address space of the I/O module.

The process values are shown in REAL format.

Input area

Table 2-1470 Input area of the Ex-AI 4xTC/2xRTD 2-/3-/4-wire (AI 4 Real with QI)

IB x +	7	6	5	4	3	2	1	0
0...3	Analog value, analog input 0							
: :								
12...15	Analog value, analog input 3							
16	-	-	-	-	QAI3	QAI2	QAI1	QAI0

A.3.6 Input range when using PTC resistors

Allocation of the input area

For resistance measurement (2-wire connection) PTC, the input range of a channel is allocated as follows:

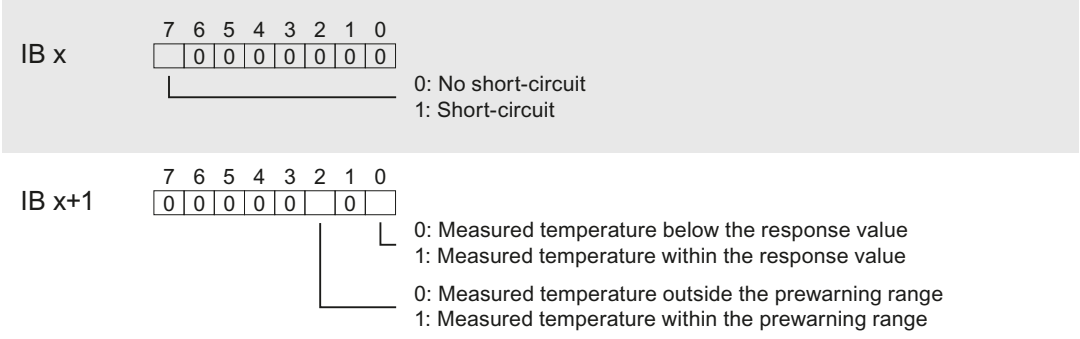

Figure 2-1285 Allocation of input range when using PTC resistors

Process image input

Observe the following during programming:

- Input byte IB x (process error); bit 7 indicates a short-circuit.
- Input byte IB x+1 (process state); only bits 0 and 2 are relevant for the evaluation.
  These bits can be used to monitor the temperature of a motor, for example.
  The following is valid for the bits of the process state:
  - The bits can never be set simultaneously, but rather are set one after the other.
  - The bits of the process state are not latching.
    Take this into account in the parameter assignment, for example, by providing a check for the motor startup (via an acknowledgment).

NOTICE
No measurement is possible in the following cases: • When I/O modules are removed • When the supply voltage of the I/O module has failed • Following a wire break or short circuit of the measuring lines • For resistance values < 18 Ω, the corresponding channels (IB x/IB x+1) signal a short-circuit. • In case of errors (such as "Missing supply voltage L+") in which measured value acquisition with PTC resistors is not possible, the corresponding channels signal an overflow. In both cases, the corresponding QI bit is set to "bad" (=0). For this reason, always evaluate the diagnostic entries of the I/O module.

A.3.7 Evaluating the value status

The following applies in the configurations with evaluation of the value status:

The input address space contains one value status (QI) bit for each analog input.

Notes for configuration using a GSD/GSDML file (Page 16)

Evaluating value status

Irrespective of the diagnostics enables, each value status (each QI bit) provides information on the validity of the corresponding process value.

- Value status = 1: Process value okay, "good"
- Value status = 0: Process value not okay, "bad"

Basically, the value status is set to "good" when the analog value can be acquired without error. The value status is set to "bad" in the following cases:

- The analog value cannot be acquired due to an error, e.g. faulty wiring.
- The analog input is disabled.

Analog value display

B

This appendix specifies the analog values for all the measuring ranges that you can use with the I/O input module.

REAL format (floating point)

If a configuration of the I/O module with REAL format is selected, each channel occupies 32 bits for the analog value in the input range.

The bits are distributed as follows:

Sign	Exponent	Significand
Bit 31	Bit 30 to 22	Bit 21 to 0

Detailed information for representation of floating-point numbers in the simple, exact IEEE format can be found in the IEEE standard 754.

Process value "Overflow" or process value "Underflow"

For certain events, as in the case of errors for example, the process value "Overflow" or "Underflow" is output:

Process value displayed depending on the configuration of the I/O module		Signaled event
Configuration with S7 format	Configuration with REAL format	
$7FFF_H$	$7F800000_H$	Overflow
8000_H	$FF800000_H$	Underflow

B.1 Representation of analog values in voltage measuring ranges

The following tables list the decimal and hexadecimal values (codes) of the possible voltage measuring ranges.

NOTE

Values when configuring the module for use with REAL format

For configuration of the module in REAL format, all voltage values are provided in the base unit "Volt".

Table 2-1471 Voltage measuring range ±1 V

Values		Voltage measuring range	Range
Dec.	Hex.	±1 V	
32767	7FFF	> 1.176 V	Overflow

Values		Voltage measuring range	Range
32511	7EFF	1.176 V	Overrange
27649	6C01		
27648	6C00	1 V	Nominal range
20736	5100	0.75 V	
1	1	36.17 µV	
0	0	0 V	
-1	FFFF		
-20736	AF00	-0.75 V	
-27648	9400	-1 V	
-27649	93FF		Underrange
-32512	8100	-1.176 V	
-32768	8000	<-1.176 V	Underflow

Table 2-1472 Voltage measuring range ±250 mV to ±50 mV

Values		Voltage measuring range			Range
Dec.	Hex.	±250 mV	±80 mV	±50 mV	
32767	7FFF	> 294.0 mV	> 94.1 mV	> 58.8 mV	Overflow
32511	7EFF	294.0 mV	94.1 mV	58.8 mV	Overrange
27649	6C01				
27648	6C00	250 mV	80 mV	50 mV	Nominal range
20736	5100	187.5 mV	60 mV	37.5 mV	
1	1	9.04 µV	2.89 µV	1.81 µV	
0	0	0 mV	0 mV	0 mV	
-1	FFFF				
-20736	AF00	-187.5 mV	-60 mV	-37.5 mV	
-27648	9400	-250 mV	-80 mV	-50 mV	
-27649	93FF				Underrange
-32512	8100	-294.0 mV	-94.1 mV	-58.8 mV	
-32768	8000	<-294.0 mV	<-94.1 mV	<-58.8 mV	Underflow

B.2 Representation of analog values for resistance-type sensors

The following tables list the decimal and hexadecimal values (codes) of the possible resistance-type sensor ranges.

NOTE

Values when configuring the module for use with REAL format

For configuration of the module in REAL format, all resistance values are provided in the base unit "Ohm".

Table 2-1473 Resistance-type sensors from 150 Ω to 6000 Ω

Values		Resistance-type sensor range					Range
Dec.	Hex.	150 Ω	300 Ω	600 Ω	3000 Ω	6000 Ω	
32767	7FFF	> 176.38 Ω	> 352.77 Ω	> 705.53 Ω	> 3527.7 Ω	> 7055.3 Ω	Overflow
32511	7EFF	176.38 Ω	352.77 Ω	705.53 Ω	3527.7 Ω	7055.3 Ω	Overrange
27649	6C01						
27648	6C00	150 Ω	300 Ω	600 Ω	3000 Ω	6000 Ω	Nominal range
20736	5100	112.5 Ω	225 Ω	450 Ω	2250 Ω	4500 Ω	
1	1	5.43 mΩ	10.85 mΩ	21.70 mΩ	108.5 mΩ	217 mΩ	
0	0	0 Ω	0 Ω	0 Ω	0 Ω	0 Ω	
-32768	8000	(negative values are physically impossible)					Underflow[1]

[1] At faulty connection of the resistors or line resistances that are parameterized too high (for example at different resistance values of the three connection conductors at the 3-wire connection)

B.3 Representation of analog values for thermal resistors

The tables below list the decimal and hexadecimal values (codes) of the thermal resistors.

NOTE

Values when configuring the module for use with REAL format

For configuration of the module in the REAL format, all temperature values, both for the "Standard" and the "Climatic" parameter assignment, are provided in one of the following base units:

- Degrees Celsius
- Degrees Fahrenheit
- Kelvin

Table 2-1474 Thermal resistor Pt 100, 200, 500, 1000 standard

Pt x00 Standard in °C (1 digit = 0.1 °C) [1)]	Values in S7 format		Pt x00 Standard in °F (1 digit = 0.1 °F)	Values in S7 format		Pt x00 standard in K (1 digit = 0.1 K)	Values in S7 format		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1000.0	32767	7FFF	> 1832.0	32767	7FFF	> 1273.2	32767	7FFF	Overflow
1000.0 : 850.1	10000 : 8501	2710 : 2135	1832.0 : 1562.1	18320 : 15621	4790 : 3D05	1273.2 : 1123.3	12732 : 11233	31BC : 2BE1	Overrange

[1)] Depending on the base unit (degrees Celsius: 1 digit = 0.1°C; degrees Fahrenheit: 1 digit = 0.1°F; Kelvin: 1 digit = 0.1 K)

Pt x00 Standard in °C (1 digit = 0.1 °C) [1]	Values in S7 format		Pt x00 Standard in °F (1 digit = 0.1 °F)	Values in S7 format		Pt x00 standard in K (1 digit = 0.1 K)	Values in S7 format		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
850.0 : -200.0	8500 : -2000	2134 : F830	1562.0 : -328.0	15620 : -3280	3D04 : F330	1123.2 : 73.2	11232 : 732	2BE0 : 2DC	Nominal range
-200.1 : -243.0	-2001 : -2430	F82F : F682	-328.1 : -405.4	-3281 : -4054	F32F : F02A	73.1 : 30.2	731 : 302	2DB : 12E	Underrange
< -243.0	-32768	8000	< -405.4	-32768	8000	< 30.2	32768	8000	Underflow

[1] Depending on the base unit (degrees Celsius: 1 digit = 0.1°C; degrees Fahrenheit: 1 digit = 0.1°F; Kelvin: 1 digit = 0.1 K)

Table 2-1475 Thermal resistor Pt 100, 200, 500, 1000 climatic

Pt x00 Climatic in °C (1 digit = 0.01 °C) [1]	Values in S7 format		Pt x00 climatic in °F (1 digit = 0.01 °F)	Values in S7 format		Range
	Dec.	Hex.		Dec.	Hex.	
> 155.00	32767	7FFF	> 311.00	32767	7FFF	Overflow
155.00 : 130.01	15500 : 13001	3C8C : 32C9	311.00 : 266.01	31100 : 26601	797C : 67E9	Overrange
130.00 : -120.00	13000 : -12000	32C8 : D120	266.00 : -184.00	26600 : -18400	67E8 : B820	Nominal range
-120.01 : -145.00	-12001 : -14500	D11F : C75C	-184.01 : -229.00	-18401 : -22900	B81F : A68C	Underrange
< -145.00	-32768	8000	< -229.00	-32768	8000	Underflow

[1] Depending on the base unit (degrees Celsius: 1 digit = 0.01°C; degrees Fahrenheit: 1 digit = 0.01°F)

Table 2-1476 Thermal resistor Ni 100, 120, 200, 500, 1000, LG-Ni 1000 standard

Ni x00 Standard in °C (1 digit = 0.1 °C) [1]	Values in S7 format		Ni x00 standard in °F (1 digit = 0.1 °F)	Values in S7 format		Ni x00 standard in K (1 digit = 0.1 K)	Values in S7 format		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 295.0	32767	7FFF	> 563.0	32767	7FFF	> 568.2	32767	7FFF	Overflow
295.0 : 250.1	2950 : 2501	B86 : 9C5	563.0 : 482.1	5630 : 4821	15FE : 12D5	568.2 : 523.3	5682 : 5233	1632 : 1471	Overrange
250.0 : -60.0	2500 : -600	9C4 : FDA8	482.0 : -76.0	4820 : -760	12D4 : FD08	523.2 : 213.2	5232 : 2132	1470 : 854	Nominal range
-60.1 : -105.0	-601 : -1050	FDA7 : FBE6	-76.1 : -157.0	-761 : -1570	FD07 : F9DE	213.1 : 168.2	2131 : 1682	853 : 692	Underrange
< -105.0	-32768	8000	< -157.0	-32768	8000	< 168.2	32768	8000	Underflow

[1] Depending on the base unit (degrees Celsius: 1 digit = 0.1°C; degrees Fahrenheit: 1 digit = 0.1°F; Kelvin: 1 digit = 0.1 K)

Table 2-1477 Thermal resistor Ni 100, 120, 200, 500, 1000, LG-Ni 1000 climatic

Ni x00 Climatic in °C (1 digit = 0.01 °C) [1]	Values in S7 format		Ni x00 climatic in °F (1 digit = 0.01 °F)	Values in S7 format		Range
	Dec.	Hex.		Dec.	Hex.	
> 295.00	32767	7FFF	> 327.66	32767	7FFF	Overflow
295.00 : 250.01	29500 : 25001	733C : 61A9	327.66 : 280.01	32766 : 28001	7FFE : 6D61	Overrange
250.00 : -60.00	25000 : -6000	61A8 : E890	280.00 : -76.00	28000 : -7600	6D60 : E250	Nominal range
-60.01 : -105.00	-6001 : -10500	E88F : D6FC	-76.01 : -157.00	-7601 : -15700	E24F : C2AC	Underrange
< -105.00	-32768	8000	< -157.00	-32768	8000	Underflow

[1] Depending on the base unit (degrees Celsius: 1 digit = 0.1°C; degrees Fahrenheit: 1 digit = 0.1°F; Kelvin: 1 digit = 0.1 K)

Table 2-1478 Thermal resistor Cu 10 standard

Cu 10 Standard in °C (1 digit = 0.1 °C) [1]	Values in S7 format		Cu 10 standard in °F (1 digit = 0.01 °F)	Values in S7 format		Cu 10 standard in K (1 digit = 0.01 K)	Values in S7 format		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 312.0	32767	7FFF	> 593.6	32767	7FFF	> 585.2	32767	7FFF	Overflow
312.0 : 260.1	3120 : 2601	C30 : A29	593.6 : 500.1	5936 : 5001	1730 : 12D5	585.2 : 533.3	5852 : 5333	16DC : 14D5	Overrange
260.0 : -200.0	2600 : -2000	A28 : F830	500.0 : -328.0	5000 : -3280	1389 : F330	533.2 : 73.2	5332 : 732	14D4 : $2DC_H$	Nominal range
-200.1 : -240.0	-2001 : -2400	F82F : F6A0	-328.1 : -400.0	-3281 : -4000	F32F : F060	73.1 : 33.2	731 : 332	2DB : $14C_H$	Underrange
< -240.0	-32768	8000	< -400.0	-32768	8000	< 33.2	32768	8000	Underflow

[1] Depending on the base unit (degrees Celsius: 1 digit = 0.1°C; degrees Fahrenheit: 1 digit = 0.1°F; Kelvin: 1 digit = 0.1 K)

Table 2-1479 Thermal resistor Cu 10 climatic

Cu 10 Climatic in °C (1 digit = 0.01 °C)[1]	Values in S7 format		Cu 10 climatic in °F (1 digit = 0.01 °F)	Values in S7 format		Range
	Dec.	Hex.		Dec.	Hex.	
> 180.00	32767	7FFF	> 325.11	32767	7FFF	Overflow
180.00 : 150.01	18000 : 15001	4650 : 3A99	327.66 : 280.01	32766 : 28001	7FFE : 6D61A	Overrange

[1] Depending on the base unit (degrees Celsius: 1 digit = 0.1°C; degrees Fahrenheit: 1 digit = 0.1°F; Kelvin: 1 digit = 0.1 K)

Cu 10 Climatic in °C (1 digit = 0.01 °C)[1]	Values in S7 format		Cu 10 climatic in °F (1 digit = 0.01 °F)	Values in S7 format		Range
	Dec.	Hex.		Dec.	Hex.	
150.00 : -50.00	15000 : -5000	3A98 : EC78	280.00 : 58.00	28000 : -5800	6D60 : $E958_H$	Nominal range
-50.01 : -60.00	-5001 : -6000	EC77 : E890	-58.01 : -76.00	-5801 : -7600	E957 : E250	Underrange
< 60.00	-32768	8000	< 76.00	-32768	8000	Underflow

[1] Depending on the base unit (degrees Celsius: 1 digit = 0.1°C; degrees Fahrenheit: 1 digit = 0.1°F; Kelvin: 1 digit = 0.1 K)

B.4 Representation of analog values for thermocouples

The tables below list the decimal and hexadecimal values (codes) of the thermocouples.

NOTE

Values when configuring the module for use with REAL format

For configuration of the module in REAL format, all temperature values are provided in the following base units:

- Degrees Celsius
- Degrees Fahrenheit
- Kelvin

Table 2-1480 Thermocouple type B

Type B in °C	Values		Type B in °F	Values		Type B in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2070.0	32767	7FFF	> 3276.6	32767	7FFF	> 2343.2	32767	7FFF	Overflow
2070.0 : 1820.1	20700 : 18201	50DC : 4719	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2343.2 : 2093.3	23432 : 20933	5B88 : 51C5	Overrange
1820.0 : 0.0	18200 : 0	4718 : 0000	2786.5 : 32.0	27865 : 320	6CD9 : 0140	2093.2 : 273.2	20932 : 2732	51C4 : 0AAC	Nominal range
-0.1 : -120.0	-1 : -1200	FFFF : FB50	31.9 : -184.0	319 : -1840	013F : F8D0	273.1 : 153.2	2731 : 1532	0AAB : 05FC	Underrange
< -120.0	-32768	8000	< -184.0	-32768	8000	< 153.2	-32768	8000	Underflow

Table 2-1481 Thermocouple type C

Type C in °C	Values		Type C in °F	Values		Type C in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2500.0	32767	7FFF	> 3276.6	32767	7FFF	> 2773.2	32767	7FFF	Overflow
2500.0 : 2315.1	25000 : 23151	61A8 : 5A6F	3276.6 : 2786.6	32766 : 27866	7FFE : 6CDA	2773.2 : 2588.3	27732 : 25883	6C54 : 651B	Overrange
2315.0 : 0.0	23150 : 0	5A6E : 0000	2786.5 : 32.0	27865 : 320	6CD9 : 0140	2588.2 : 273.2	25882 : 2732	651A : 0AAC	Nominal range
-0.1 : -120.0	-1 : -1200	FFFF : FB50	31.9 : -184.0	319 : -1840	013F : F8D0	273.1 : 153.2	2731 : 1532	0AAB : 05FC	Underrange
< -120.0	-32768	8000	< -184.0	-32768	8000	< 153.2	-32768	8000	Underflow

Table 2-1482 Thermocouple type E

Type E in °C	Values		Type E in °F	Values		Type E in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1200.0	32767	7FFF	> 2192.0	32767	7FFF	> 1473.2	32767	7FFF	Overflow
1200.0 : 1000.1	12000 : 10001	2EE0 : 2711	2192.0 : 1832.1	21920 : 18321	55A0 : 4791	1473.2 : 1273.3	14732 : 12733	398C : 31BD	Overrange
1000.0 : -270.0	10000 : -2700	2710 : F574	1832.0 : -454.0	18320 : -4540	4790 : EE44	1273.2 : 3.2	12732 : 32	31BC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-1483 Thermocouple type J

Type J in °C	Values		Type J in °F	Values		Type J in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1450.0	32767	7FFF	> 2642.0	32767	7FFF	> 1723.2	32767	7FFF	Overflow
1450.0 : 1200.1	14500 : 12001	38A4 : 2EE1	2642.0 : 2192.1	26420 : 21921	6734 : 55A1	1723.2 : 1473.3	17232 : 14733	4350 : 398D	Overrange
1200.0 : -210.0	12000 : -2100	2EE0 : F7CC	2192.0 : -346.0	21920 : -3460	55A0 : F27C	1473.2 : 63.2	14732 : 632	398C : 0278	Nominal range
< -210.0	-32768	8000	< -346.0	-32768	8000	< 63.2	-32768	8000	Underflow

Table 2-1484 Thermocouple type K

Type K in °C	Values		Type K in °F	Values		Type K in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1622.0	32767	7FFF	> 2951.6	32767	7FFF	> 1895.2	32767	7FFF	Overflow
1622.0 : 1372.1	16220 : 13721	3F5C : 3599	2951.6 : 2501.7	29516 : 25017	734C : 61B9	1895.2 : 1645.3	18952 : 16453	4A08 : 4045	Overrange
1372.0 : -270.0	13720 : -2700	3598 : F574	2501.6 : -454.0	25016 : -4540	61B8 : EE44	1645.2 : 3.2	16452 : 32	4044 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-1485 Thermocouple type L

Type L in °C	Values		Type L in °F	Values		Type L in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1150.0	32767	7FFF	> 2102.0	32767	7FFF	> 1423.2	32767	7FFF	Overflow
1150.0 : 900.1	11500 : 9001	2CEC : 2329	2102.0 : 1652.1	21020 : 16521	521C : 4089	1423.2 : 1173.3	14232 : 11733	3798 : 2DD5	Overrange
900.0 : -200.0	9000 : -2000	2328 : F830	1652.0 : -328.0	16520 : -3280	4088 : F330	1173.2 : 73.2	11732 : 732	2DD4 : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow

Table 2-1486 Thermocouple type N

Type N in °C	Values		Type N in °F	Values		Type N in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1550.0	32767	7FFF	> 2822.0	32767	7FFF	> 1823.2	32767	7FFF	Overflow
1550.0 : 1300.1	15500 : 13001	3C8C : 32C9	2822.0 : 2372.1	28220 : 23721	6E3C : 5CA9	1823.2 : 1573.3	18232 : 15733	4738 : 3D75	Overrange
1300.0 : -270.0	13000 : -2700	32C8 : F574	2372.0 : -454.0	23720 : -4540	5CA8 : EE44	1573.2 : 3.2	15732 : 32	3D74 : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-1487 Thermocouples R and S

Types R, S in °C	Values		Types R, S in °F	Values		Types R, S in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 2019.0	32767	7FFF	> 3276.6	32767	7FFF	> 2292.2	32767	7FFF	Overflow
2019.0 : 1769.1	20190 : 17691	4EDE : 451B	3276.6 : 3216.3	32766 : 32163	7FFE : 7DA3	2292.2 : 2042.3	22922 : 20423	598A : 4FC7	Overrange

Types R, S in °C	Values		Types R, S in °F	Values		Types R, S in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
1769.0 : -50.0	17690 : -500	451A : FE0C	3216.2 : -58.0	32162 : -580	7DA2 : FDBC	2042.2 : 223.2	20422 : 2232	4FC6 : 08B8	Nominal range
-50.1 : -170.0	-501 : -1700	FE0B : F95C	-58.1 : -274.0	-581 : -2740	FDBB : F54C	223.1 : 103.2	2231 : 1032	08B7 : 0408	Underrange
< -170.0	-32768	8000	< -274.0	-32768	8000	< 103.2	< 1032	8000	Underflow

Table 2-1488 Thermocouple type T

Type T in °C	Values		Type T in °F	Values		Type T in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 540.0	32767	7FFF	> 1004.0	32767	7FFF	> 813.2	32767	7FFF	Overflow
540.0 : 400.1	5400 : 4001	1518 : 0FA1	1004.0 : 752.1	10040 : 7521	2738 : 1D61	813.2 : 673.3	8132 : 6733	1FC4 : 1AAD	Overrange
400.0 : -270.0	4000 : -2700	0FA0 : F574	752.0 : -454.0	7520 : -4540	1D60 : EE44	673.2 : 3.2	6732 : 32	1AAC : 0020	Nominal range
< -270.0	-32768	8000	< -454.0	-32768	8000	< 3.2	-32768	8000	Underflow

Table 2-1489 Thermocouple type U

Type U in °C	Values		Type U in °F	Values		Type U in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 850.0	32767	7FFF	> 1562.0	32767	7FFF	> 1123.2	32767	7FFF	Overflow
850.0 : 600.1	8500 : 6001	2134 : 1771	1562.0 : 1112.1	15620 : 11121	2738.0 : 2B71	1123.2 : 873.3	11232 : 8733	2BE0 : 221D	Overrange
600.0 : -200.0	6000 : -2000	1770 : F830	1112.0 : -328.0	11120 : -3280	2B70 : F330	873.2 : 73.2	8732 : 732	221C : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow

Table 2-1490 Thermocouple type TXK (GOST)

Type TXK in °C	Values		Type TXK in °F	Values		Type TXK in K	Values		Range
	Dec.	Hex.		Dec.	Hex.		Dec.	Hex.	
> 1050.0	32767	7FFF	> 1922.0	32767	7FFF	> 1323.2	32767	7FFF	Overflow
1050.0 : 800.1	10500 : 8001	2904 : 1F41	1922.0 : 1472.1	19220 : 14721	4B14 : 3981	1323.2 : 1073.3	13232 : 10733	33B0 : 29ED	Overrange
800.0 : 0.0 : -200.0	8000 : 0 : -2000	1F40 : 0000 : F830	1472.0 : 32.0 : -328.0	14720 : 320 : -3280	3980 : 0140 : F330	1073.2 : 273 : 73.2	10732 : 2730 : 732	29EC : 0AAA : 02DC	Nominal range
< -200.0	-32768	8000	< -328.0	-32768	8000	< 73.2	-32768	8000	Underflow

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ET 200SP HA / ET 200SP Ex-AI 2xI 2-wire HART

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Security information 1

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit
https://www.siemens.com/industrialsecurity.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under
https://www.siemens.com/industrialsecurity.

Preface

2

Validity of the documentation

This documentation describes the following I/O module:

System	Module type	Article number
Distributed I/O System; ET 200SP and ET 200SP HA	Ex-AI 2xI 2-wire HART	6DL1134-6TB00-0HX1

This documentation supplements the following documentation:

- System manual *Distributed I/O System, ET 200SP | ET 200SP HA; Modules for devices in the hazardous area*

Functions that generally relate to the ET 200SP and ET 200SP HA are described in the respective system documentation:

- System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)
- System manual Distributed I/O System ET 200SP HA (https://support.industry.siemens.com/cs/ww/en/view/109761547)

The information in this manual and the system/function manuals enables you to put the modules for hazardous areas into operation.

Conventions

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

These documentation contain a description of the components that was valid at the time the operating instructions were published. We reserve the right to include product information with information updates with new components and components with a new product status.

Product overview

3

3.1 Properties of the I/O module Ex-AI 2xI 2-wire HART

View of the module

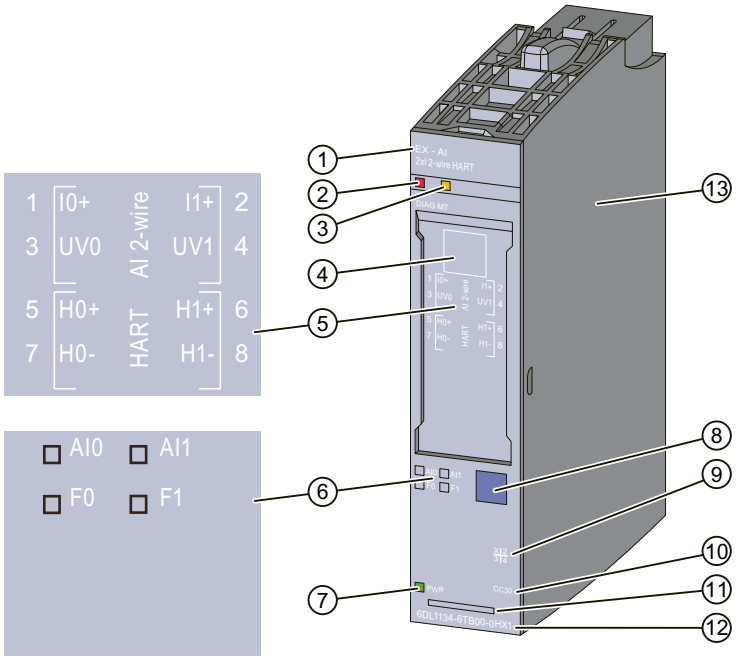

① Module type and designation
② LED for diagnostics
③ LED for maintenance
④ 2D matrix code
⑤ Wiring diagram
⑥ LEDs for channel status/channel fault
⑦ LED for supply voltage
⑧ Module type color coding
⑨ Function version
⑩ Color code for selection of the color-coded labels
⑪ Serial number
⑫ Article number
⑬ Labeling surface (symbols and standards)

Figure 2-1286 View of EX-AI 2xI 2-wire HART

You can find information on the LEDs in section Status and fault displays of the I/O module Ex-AI 2xI 2-wire HART (Page 27).

Properties

The I/O module is used to connect intrinsically safe 2-wire transducers and HART field devices.

The I/O module has the following technical properties:

2 analog inputs with the following properties that can be configured for each channel:

- Current input in measuring ranges 0 to 20 mA, 4 to 20 mA and 4 to 20 mA HART
- Connection options for supply of 2-wire transducers
- Diagnostics
- Module-specific configurable diagnostics

The module supports the following functions

The I/O module supports the following functions:

- Firmware update
- I&M identification data
- Parameter reassignment in RUN
- Value status QI
- Module-internal Shared Input (MSI)
- HART communication (Rev. 5 to Rev. 7)
- Up to 4 HART variables directly in the input address range
- A multiHART range in the input/output range

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color-coded labels
- Reference identification label
- Shield connector

3.2 2D Matrix code (QR code / EAN code)

The 2D matrix code on the product is a coded representation of the product-specific article number.

Access to product-related information

For reading the 2D matrix code, SIEMENS offers an app for mobile use.
Information about the app and the download can be found on the Internet: "Mobile use via app (https://support.industry.siemens.com/cs/ww/en/sc/2067)".

The app provides direct access to the technical forum and product-related posts, such as:

- FAQs
- Application examples
- Manuals
- Certificates
- Product notices

Wiring

4

4.1 Ex BaseUnit

You can operate the I/O module with the following Ex BaseUnit:

- Ex-BU Type X1 (6DL1 193-6BP00-0BX1)

The Ex BaseUnit is not included in the scope of delivery of the Ex I/O module and must be ordered separately.

NOTE

You can find additional information on the configuration in the system manual.

The terminal block for connecting the I/O signals is part of the Ex BaseUnit for Ex I/O modules and cannot be mounted separately.

Connections on the slot and Ex I/O module

The following figure shows the connections on the Ex BaseUnit and the I/O module.

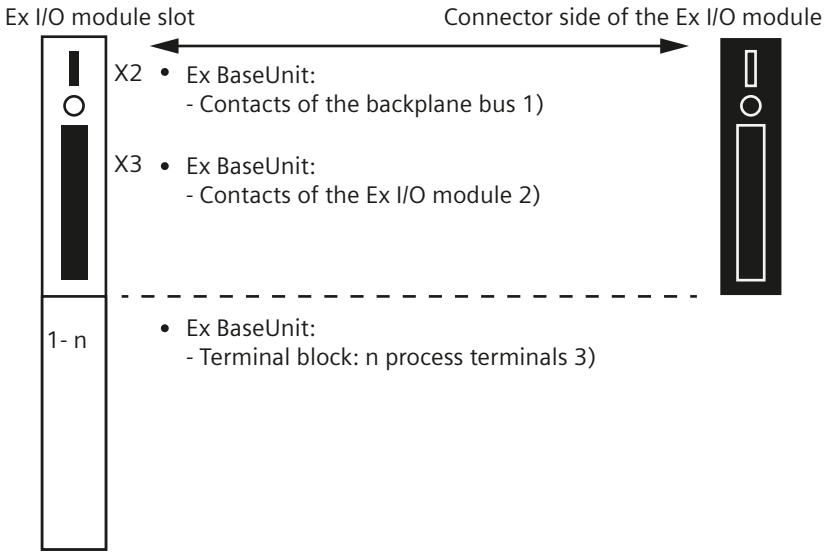

1) Ex BaseUnit contacts of the backplane bus (max. 50 mA; 3.3 V DC ⎓)

2) Ex BaseUnit contacts for process signal transmission (for maximum voltages and currents, refer to the documentation of the respective I/O module)

3) Process terminals on the terminal block (number, maximum/permissible voltages and currents, refer to the documentation of the respective I/O module).

Information on the pin assignment of the I/O module (terminal block) can be found in the following sections.

4.2 Pin assignment of the I/O module Ex-AI 2xI 2-wire HART

General pin assignment

Table 2-1491 Pin assignment of EX-AI 2xI 2-wire HART

Terminal	Assignment	Terminal	Assignment	Terminal block	Explanations
1	I_0+	**2**	I_1+	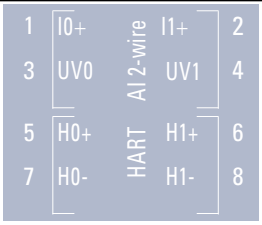	Terminal 1 and 2: I_n+: Input signal "+", channel n (0;1) Terminal 3 to 4: U_{Vn}: Sensor supply, Channel n (0;1) Terminal 5 to 8: H_n: HART test terminals Hn+/Hn- (note operating mode)
3	Uv_0	**4**	Uv_1		
5	H_0+	**6**	H_1+		
7	H_0-	**8**	H_1-		

NOTE

Use shielded cables to ensure safe operation in environments susceptible to interference. When using unshielded cables, you must note that the input value may be affected by external electromagnetic interference.

Examples

You can find information on connecting the measuring transducers in section "Connection 2-wire (Page 12)".

4.3 Pin assignment

4.3.1 Connection 2-wire

Pin assignment channel 0

2-wire connection	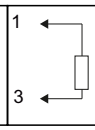

4.3.2 Connection of external handheld device

Pin assignment of external handheld device

External handheld device	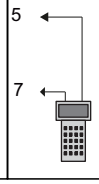

NOTE

Here you can connect a handheld device for diagnostics and parameter assignment of the sensors. The diagnostic terminals are directly electrically connected to the input terminals. The plant operator is responsible for the calculation of and adherence to the Ex characteristic values in the plant.

4.4 Schematic circuit diagram

The following figure shows the schematic circuit diagram of the Ex I/O module.

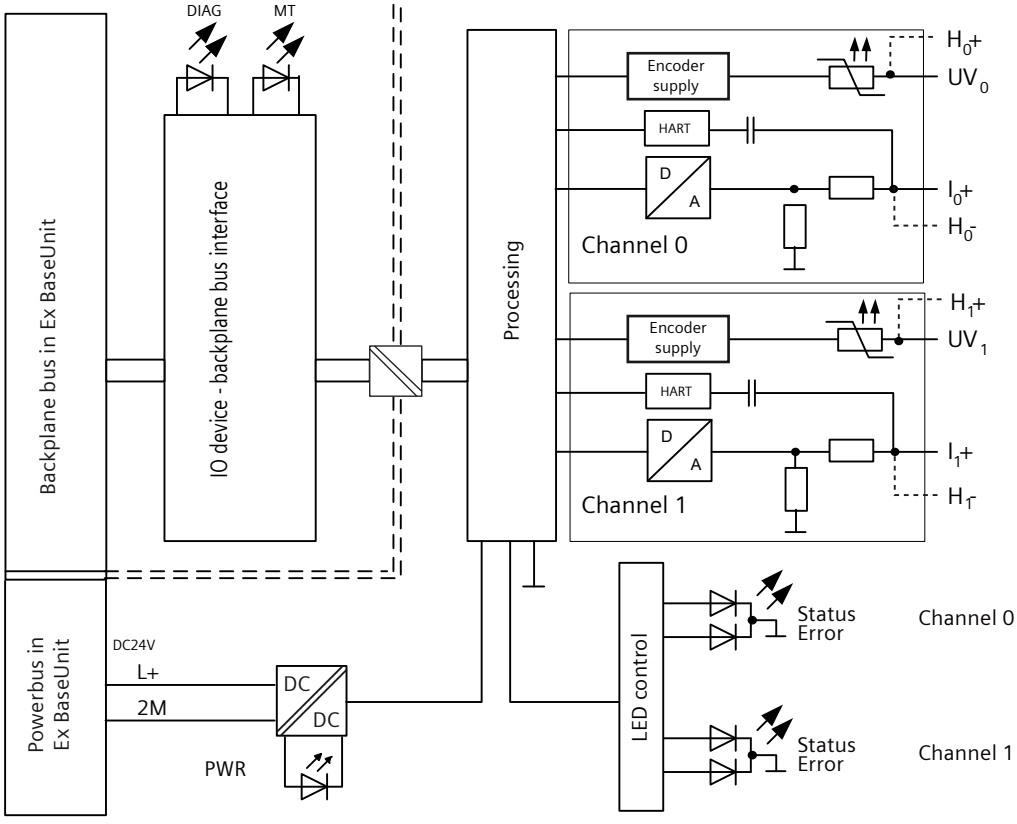

Figure 2-1287 Schematic circuit diagram Ex-AI 2xI 2-wire HART

Supply voltage

The supply voltage L+/2M is generated and monitored by the Ex power module. The Ex I/O module receives its supply voltage L+ via the power bus. Further monitoring of the supply voltage is performed in the Ex I/O module. During parameter assignment, you can specify whether a diagnostic message is to be output in the event of failure of the supply voltage.

Firmware update

The supply voltage L+ must be available on the Ex I/O module at the start of firmware updates and during the update.

4.5 Potential group in hazardous areas

Potential group

With the modules for hazardous areas, the Ex power module and the Ex I/O module plugged into the right of the Ex power module form a potential group.

The potential group ends when one of the following modules is plugged in to the right of an Ex I/O module:

- Ex power module
- Server module

Configuring

5

5.1 Configurations of the I/O module Ex-AI 2xI 2-wire HART

Requirements

You configure the I/O module

- in the TIA Portal
- with PCS 7
- with PCS neo
- with STEP 7

The version required in each case is specified in the technical specifications

Configuration via GSD/GSDML

Notes on configuring when using a GSD/GSDML file (Page 17)

Restrictions when using in ET 200SP

- For use with a standard IM, its firmware must be at least of version V3.3.
- No MSI is available for a PROFIBUS DP station.
- TIA Portal:
  - TIA Portal as of V17.0
    The module can be centrally configured on the following CPUs:
    - CPU 1510SP-1 (as of V2.6)
    - CPU 1512SP-1 PN (as of V2.6)
    - CPU 1515SP-1 PN (as of V2.6)
  - The module cannot be used behind fail-safe controllers.

Configurations

Depending on the desired configuration, you must select the required I/O module version from the hardware catalog.

The following configurations are possible:

Configuration [1]	Version of the I/O module in the hardware catalog of the engineering tool	Required parameter assignment of the module
Analog mode AI 2 without QI	**Ex - AI 2xI 2-wire HART**	• "Value status" parameter deactivated
Analog mode AI 2 + 1 multiHART without QI [2]		• "Value status" parameter deactivated • "HART variables" parameter: 1 multiHART
Analog mode AI 2 + 4 HART without QI [3]		• "Value status" parameter deactivated • "HART variables" parameter: 4 HART
Analog mode AI 2 + 1 multiHART with QI [2]		• "Value status" parameter activated • "HART variables" parameter: 1 multiHART
Analog mode AI 2 + 4 HART with QI [3]		• "Value status" parameter activated • "HART variables" parameter: 4 HART
Analog mode AI 2 with QI [3]		• "Value status" parameter activated • Optional configuration: "MSI with QI" [2] Configuration change is possible in RUN. You can find information on MSI in section "Module-internal Shared Input (MSI) (Page 24)".

[1] For the configuration using GSDML, all configurations can be selected directly in the hardware catalog of the engineering tool.

[2] Not available for configuration using a GSD/GSDML file.

[3] Not available for configuration using a GSD file.

NOTE

Changing the configuration in CPU RUN

You can re-configure the I/O module when the CPU is in RUN in the following cases:

- When the loaded configuration (version of the I/O module in the hardware catalog) is maintained.
- When an MSI subslot is added or removed

If you want to define a different configuration in CPU RUN, the following steps are required:

1. Remove the I/O module from the loaded configuration in CPU RUN.
2. Configure the I/O module including the required configuration-specific parameters.
3. Load the new configuration in CPU RUN.

Note that changing the configuration changes the I/O address range.

Parameters

You define the operating mode of the I/O module via channel/technology parameters (data record 128).

5.2 Notes on configuring when using a GSD/GSDML file

Files for the configuration using GSD/GSDML

If you need the GSD/GSDML files for configuration, you can download them on the Internet:

- PROFINET GSD file (GSDML) for ET 200SP HA (http://support.industry.siemens.com/cs/ww/en/view/109781191)
- PROFINET GSD files for ET 200SP (http://support.automation.siemens.com/WW/view/en/57138621)
- PROFIBUS GSD files for ET 200SP (http://support.automation.siemens.com/WW/view/en/73016883)

Restrictions when using a GSDML file for the PROFINET configuration

The following functions are not available in the process image of the I/O module:

- MSI
- multiHART

Restrictions when using a GSD file for the PROFIBUS configuration

The following functions are not available in the process image of the I/O module:

- MSI
- Value status
- HART variables
- multiHART

5.3 Module/channel parameters

Parameters of Ex-AI 2xI 2-wire HART

You have the following setting options:

Table 2-1492 Adjustable parameters and their default setting

Parameter	Value range	Default	CiR [1]	Efficiency range		
				HSP [2]	GSDML [3]	GSD [4]
Diagnostics, Missing supply voltage L+	• Enabled • Disabled	Disabled	Yes	Module	Module	Module
Measurement type/measuring range	• Disabled • Current (2-wire transmitter) 0 ... 20 mA • Current (2-wire transmitter) 4 ... 20 mA • Current (2-wire transmitter) 4 ... 20 mA HART There is no underrange in the measuring range 0 ... 20 mA. That is, the smallest analog value is zero.	Current (2-wire transmitter) 4 ... 20 mA HART	Yes	Channel	Channel	Channel
Smoothing	• None • Weak • Medium • Strong	None	Yes	Channel	Channel	Channel
Interference frequency suppression	• 60 Hz (integration time 16.6 ms) • 50 Hz (integration time 20 ms) • 10 Hz (integration time 100 ms) When 50 Hz is set, the interference signals of 400 Hz are also filtered automatically.	10 Hz	Yes	Channel	Channel	Channel
Failure monitoring	• Enabled • Disabled	Disabled	Yes	Channel	Channel	-
Diagnostics Short-circuit	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Diagnostics Overflow	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Diagnostics Underflow	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel

1) CiR = Configuration in RUN

2) HSP = Configuration using the Hardware Support Package (HSP) of the process control

3) GSDML = Configuration when using a GSDML file

4) GSD = Configuration when using a GSD file

Parameter	Value range	Default	CiR [1]	Efficiency range		
				HSP [2]	GSDML [3]	GSD [4]
Diagnostics Wire break	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Diagnostics HART	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Number of HART frame repetitions	0 ... 10	5	Yes	Channel	Channel	-
Hardware interrupt high limit 1	• Enabled • Disabled	Disabled	Yes	Channel	Channel	-
High limit 1	Value	27648	Yes	Channel	Channel	-
Hardware interrupt low limit 1	• Enabled • Disabled	Disabled	Yes	Channel	Channel	-
Low limit 1	Value	0	Yes	Channel	Channel	-
Hardware interrupt high limit 2	• Enabled • Disabled	Disabled	Yes	Channel	Channel	-
High limit 2	Value	27648	Yes	Channel	Channel	-
Hardware interrupt low limit 2	• Enabled • Disabled	Disabled	Yes	Channel	Channel	-
Low limit 2	Value	0	Yes	Channel	Channel	-
Potential group	Potential group of the left intrinsically safe power module	Potential group of the left intrinsically safe power module	No	Module	Module	Module

1) CiR = Configuration in RUN

2) HSP = Configuration using the Hardware Support Package (HSP) of the process control

3) GSDML = Configuration when using a GSDML file

4) GSD = Configuration when using a GSD file

NOTE

Unused channels

"Disable" an unused channel in the configuration, this improves the cycle time of the module. A disabled channel always supplies the analog value $7FFF_H$.

5.4 Explanation of parameters

5.4.1 Diagnostics Missing supply voltage L+

Defines whether a diagnostic interrupt is generated when the supply voltage L+ is missing or is too low.

The supply voltage is generated by the Ex power module. Other internal defects can be detected and reported via the additional diagnostics for the Ex I/O module.

5.4.2 Measurement type/measuring range

Measurement type/measuring ranges

The I/O module supports the following measuring ranges:

Measurement type	Measuring range	Resolution with interference frequency suppression		
		10 Hz	50 Hz	60 Hz
Disabled	--	--	--	--
Current (2-wire transducer)	0 mA to 20 mA	15 bits plus sign	15 bits plus sign	15 bits plus sign
	4 ... 20 mA			
	4 ... 20 mA HART [1]			

[1] HART mode is only possible in the measuring range "4 ... 20 mA HART". HART communication is not interrupted even at currents below 4 mA.

An overview of the measuring range and the overflow, overrange, etc. can be found in section Representation of analog values in the current measuring ranges (Page 81).

5.4.3 Smoothing

The individual measured values are filtered to smooth them. Smoothing can be set in 4 levels.

Smoothing time = number of module cycles (k) x cycle time of the module.

The following figure shows how many module cycles it takes for the smoothed analog value to approach 100%, depending on the configured smoothing. This specification is valid for all signal changes at the analog input.

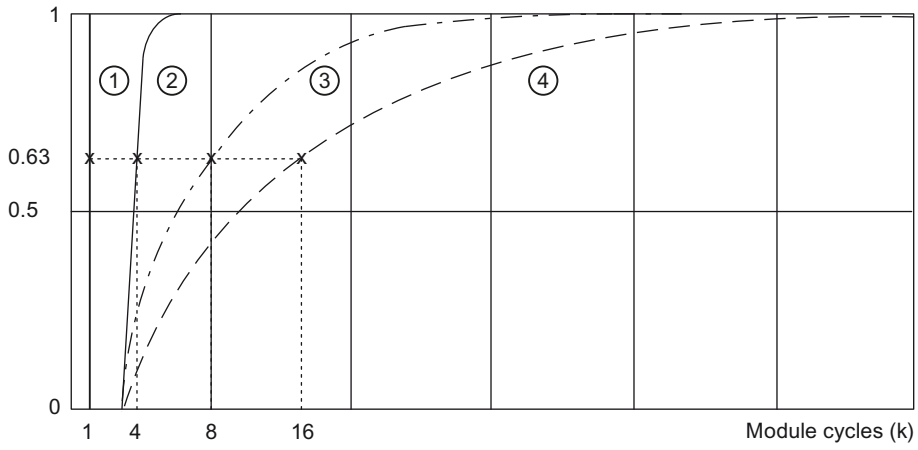

① No smoothing (k = 1)

② Weak (k = 4)

③ Medium (k = 8)

④ Strong (k = 16)

Figure 2-1288 Smoothing of the analog value

5.4.4 Interference frequency suppression

Suppresses the interference that is caused by the frequency of the alternating voltage network used.

The frequency of the AC voltage network can interfere with the measured value, in particular in low voltage ranges. With this parameter, you specify the line frequency that acts in your system.

When HART operation is activated, an interference frequency suppression of 10 Hz is recommended to prevent the HART signal from influencing the analog value.

5.4.5 Failure monitoring (according to NE43)

You use this to specify the current limit for detecting the failure of transmitters.

- Failure monitoring can be configured for the measuring range 4...20 mA.
- The following range is monitored: 3.8 mA < valid measuring range < 20.5 mA
  - Low failure range <= 3.6 mA (hysteresis 0.2 mA)
  - High failure range >= 21 mA (hysteresis 0.5 mA)

- Within the failure ranges, QI=bad and the process values in the overflow at 0x7FFF and in the overflow at 0x8000.
  Optionally, you can activate the diagnostics "Underflow" / "Overflow" for reaching the failure ranges.
- If you additionally enable the diagnostics "wire break", you will receive the following messages:
  – Instead of the "Underflow" diagnostics, the "Wire break" diagnostics is reported and the process value 0x7FFF appears instead of the process value 0x8000.

5.4.6 Short circuit diagnostics

Enables monitoring for a short-circuit of the analog input to sensor supply.

The short-circuit and overflow diagnostics can be activated at the same time. If both diagnostics occur simultaneously, the short-circuit diagnostics is output.

5.4.7 Diagnostics: Overflow

Enabling of the diagnostics which are generated when the measured value falls below the underrange.

5.4.8 Diagnostics: Underflow

You can enable underflow diagnostics for measuring range 4 to 20 mA or 4 to 20 mA HART. The diagnostics are generated when the measured value falls below the underrange.

There is no underrange in the measuring range 0 to 20 mA.

5.4.9 Diagnostics: Wire break

You can enable wire break diagnostics for a measuring range of 4 mA to 20 mA or 4 mA to 20 mA HART. The diagnostics are generated when the current flow falls below the assigned wire break limit.

The wire break and underflow diagnostics can be activated at the same time. If both diagnostics occur simultaneously, the wire break diagnostics is output.

5.4.10 Diagnostics: HART

Enables diagnostics for HART frame-specific monitoring and the status information provided by the connected field device in a HART frame (HART device status).

HART diagnostics are reported as maintenance messages.

5.4.11 Number of HART frame repetitions

Specifies the number of HART frame repetitions. If the module receives no response or a response with errors to a HART frame sent to the field device, the frame is repeated i.e. sent to the field device again.

NOTE

Because HART communication of the individual channels is multiplexed, faulty HART frames will influence the other channel if the number of HART repetitions is high. In other words, the other channel is accordingly processed less frequently.

5.4.12 Hardware interrupt high limit 1 / 2

A hardware interrupt is enabled if high limit 1 / 2 is exceeded.

5.4.13 High limit 1/2

Specify a threshold which triggers a hardware interrupt when violated.

5.4.14 Hardware interrupt low limit 1 / 2

A hardware interrupt is enabled if low limit 1 / 2 is violated.

5.4.15 Low limit 1 / 2

Specify a threshold which triggers a hardware interrupt when violated.

5.4.16 Potential group

A potential group consists of a group of directly adjacent Ex IO modules within a station of the distributed I/O (IO device), which are supplied via a common Ex power module.

A potential group begins with an Ex power module, via which the required supply voltage for all Ex I/O modules of the potential group is supplied. The Ex power module interrupts the self-assembling voltage buses to the left neighbor.

The Ex I/O modules take the potential of the self-assembling voltage buses from the left neighbor.

A potential group ends with the BaseUnit, which follows an Ex power module or a server module in the station configuration.

You can find additional information on the configuration of the potential group in the system manual *Distributed I/O System; ET 200SP and ET 200SP HA, Modules for hazardous areas*.

5.5 Module-internal Shared Input (MSI)

The function enables several IO controllers to access the input data of the I/O module.

- With MSI, the input data of the I/O module (the basic submodule) are copied to up to three further MSI submodules.
  All process values of the I/O module are thus present with identical input values in all submodules.
- Each of the four submodules can be assigned to an IO controller, whereby these can be different or identical IO controllers.
- IO controllers have read-only access to the data of each submodule
- Only the basic submodule is configured and can return diagnostic interrupts and hardware interrupts.
  MSI submodules are not configurable and do not return interrupts.

The following figure shows an analog input module with the basic submodule and three MSI submodules. Each submodule is assigned to an IO controller. The diagnostics and parameter assignment of the analog input module is possible via the basic submodule from the IO controller 1.

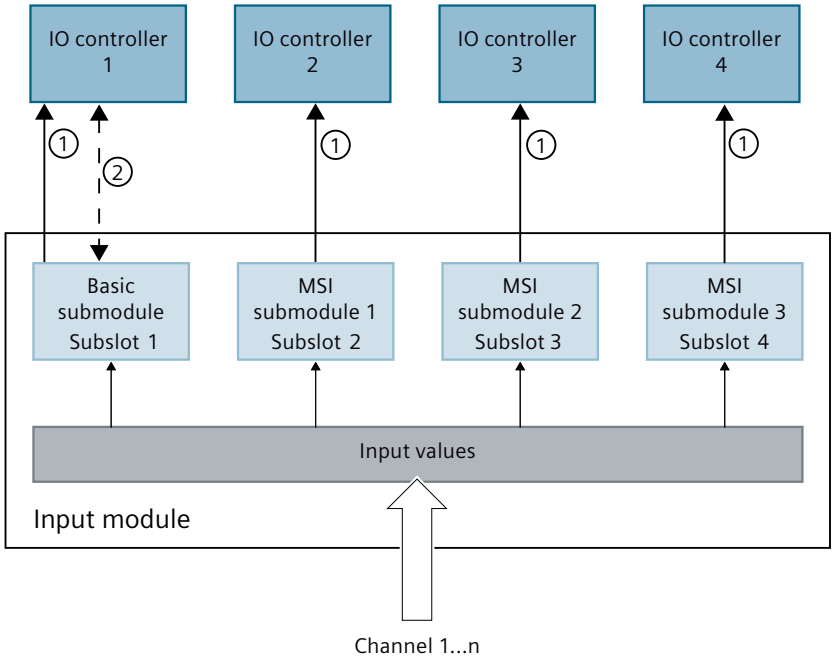

① Read access

② Parameter assignment and system diagnostics

Figure 2-1289 Input module with MSI configuration

Value status (Quality Information, QI)
If QI = "bad" (QI = 0), then the process value is not valid.

NOTE
Restrictions

- **PROFINET required**
  MSI is only available with configuration with PROFINET.
- **No configuration with PCS 7**
  No support for configuration with PCS 7.
- **No configuration per GSD/GSDML**
  No support of MSI with configuration via GSD/GSDML.
  Notes on configuring when using a GSD/GSDML file (Page 17)

Configure MSI for an I/O module

You set the configuration on the basic submodule (subslot 1).

NOTE
If "MSI" is configured for an I/O module, this applies to all channels of the I/O module.
If MSI is to be configured, the value status QI must always be configured as well.

---

1. Select the configuration based on the following table.
2. Select the number of MSI submodules in the properties of the I/O module. This parameter assignment can be performed in CPU RUN.

You can find information on the address space in section "Address space in analog mode (Page 62)".

Changing the MSI configuration in RUN

The parameter "Value status" must always be activated.

Configuration	Version of the I/O module in the module catalog (HW Config)	Configuration of the I/O module
Analog mode AI 2 with QI	Ex-AI 2xI 2-wire HART	Number of additional submodules: (Change in CPU RUN possible) • 1 to 3: MSI is enabled • 0: MSI is disabled

Additional information

- Find out how to assign MSI submodules to an IO controller in the documentation *SIMATIC; Distributed I/O System ET 200SP/ET 200SP HA, Modules for uses in hazardous areas*.
- How to configure access to a shared device and the function MSI / MSO in STEP 7 can be found in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109736536).

5.6 HART mapping parameters

A maximum of 4 HART variables can be configured (mapped) to the address space of the I/O module with the HART mapping parameters.

If you want to use a maximum of 4 HART variables in the input range of the I/O module, configure these parameters in the properties dialog of the I/O module.

HART mapping is not supported with configuration via a PROFIBUS GSD file.

Parameters

Table 2-1493 HART mapping parameters of the I/O module

Parameter		Value range	Default	Parameter reassignment in RUN
Variable 1	Channel	0...1	0	Yes
	Type	• Non / CiR • Primary • Secondary • Tertiary • Quaternary	Non / CiR	Yes
: :				
Variable 4	Channel	0...1	0	Yes
	Type	• Non / CiR • Primary • Secondary • Tertiary • Quaternary	Non / CiR	Yes

See also

Parameter assignment and structure of the HART mapping parameters (Page 57)

Displays and interrupts

6

6.1 Status and fault displays of the I/O module Ex-AI 2xI 2-wire HART

6.1.1 Status and error displays of the I/O module

LED displays

The figure below shows the status and error displays of I/O module.

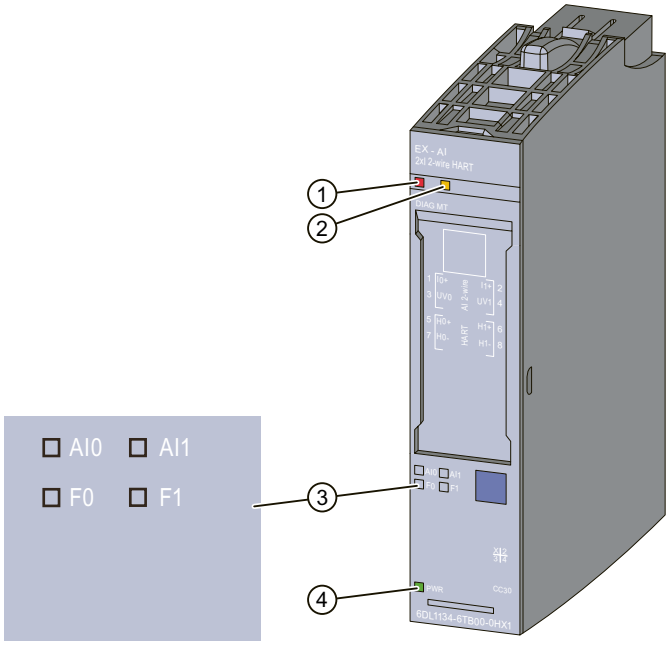

① DIAG LED (green/red)

② MT LED (yellow)

③ LED channel status AIn (green) and LED channel fault Fn (red) - channel n (n = 0 to 1)

④ PWR LED (green)

Figure 2-1290 LED displays

Meaning of the LED displays

The tables below explain the meaning of the status, error and maintenance displays.

You can learn about corrective measures for messages as well as possible causes in the following sections:

- Diagnostic and maintenance messages (Page 59)
- Hardware interrupts (Page 61)

6.1.2 Diagnostics display of the DIAG LED

DIAG LED

Table 2-1494 Diagnostics display of the DIAG LED

DIAG LED	Meaning
□ Off	Backplane bus supply of the system is disrupted or switched off.
☼ Flashes	Module is not configured.
■ On	Module is configured, a diagnostics message is not pending.
☼ Flashes	Module is configured, at least one diagnostic message is pending.

6.1.3 Diagnostics display of the MT LED

MT LED

Table 2-1495 Status display of the LED MT

MT LED	Meaning
□ Off	No maintenance required.
■ On	Maintenance is required, that is, at least one maintenance event has occurred.

6.1.4 Diagnostics display of the Channel status/channel fault LED

Channel status/channel error LED

The green channel status LED indicates whether the channel is enabled. The green LED does not light up if a channel diagnostic or a module diagnostic result is pending for an activated channel.

The red channel fault LED is lit when channel diagnostics for an enabled channel is pending.

Table 2-1496 Status and error display of the LEDs channel status and channel error

LED channel status	LED channel error	Meaning
□ Off	□ Off	• Channel disabled or module switched off • Module diagnostics pending
■ On	□ Off	Channel enabled and no channel/module diagnostics pending
□ Off	■ On	Channel enabled and channel diagnostics pending

6.1.5 Diagnostics display of the PWR LED

PWR LED

Table 2-1497 Status display of the PWR LED

PWR LED	Meaning
□ Off	The supply voltage L+ is missing for the potential group.
■ On	The supply voltage L+ is available for the potential group.

6.2 Interrupts

The I/O module supports diagnostic interrupts and hardware interrupts. Diagnostic and maintenance messages are output via diagnostic interrupts.

You can find more information on this in the appendix:

- Diagnostic and maintenance messages (Page 59)
- Hardware interrupts (Page 61)

Diagnostic messages

The I/O module generates a diagnostic message for the following events:

- No supply voltage
- Short-circuit
- Wire break
- High limit violated
- Low limit violated
- Parameter assignment error
- Module is faulty
- Hardware interrupt lost
- Retentive memory in the BaseUnit is defective.
- Invalid BaseUnit
- Channel/component temporarily unavailable

NOTE

A pending diagnosis "Module is defective" is not deleted by the module until a restart.

Maintenance messages

The I/O module generates a maintenance message when the following events occur:

- HART communication error
- HART primary variable outside of limits
- HART analog output current of field device saturated
- HART output current of the field device specified
- HART additional status information available
- HART configuration changed
- HART malfunction in the field device
- HART secondary variable outside the limits
- Retentive memory in the BaseUnit is defective.

HART function

7

7.1 Application

7.1.1 Useful information on use

Reference is made to the functions and use of HART in the following.

Use of HART

The use of HART modules enables you to exchange additional data with the connected HART field devices.

Only one HART field device may be connected to a channel of the HART modules.

You can commission and re-configure the HART field devices.

HART (Page 32)

Advantages of HART

Using the I/O module with HART offers the following advantages:

- Connection compatibility with standard analog modules: Current loop 4 - 20 mA
- Numerous field devices with HART functions are in use
- Application of HART devices on an IO device based on the ET 200SP HA or ET 200SP HA
- Additional digital communication using the HART protocol

  HART protocol (Page 32)

HART applications

The following applications are typical:

- Commissioning of field devices (centralized parameter assignment)
- Online modification of field device parameters
- Information, maintenance and diagnostic displays for the field devices
- Integration of configuration tools for field devices via the HART interface

Commissioning a HART field device

To minimize the startup time of a HART field device, the HART field device should be set to the short address 0.

After switching on the module, the module searches for HART field devices via the short address.

- The search always starts at the short address 0.
- If a field device with a short address not equal to 0 is found, its short address is automatically re-configured to 0 (HART command 6).

During the startup time, the module reports a HART communication error.

7.1.2 HART

Definition

"HART" (Highway Addressable Remote Transducer) refers to remote controlled field devices such as sensor or transmitter or actuator that can be addressed via communication.

The HART functionality also enables you to use the I/O module to exchange data with the connected field devices. The HART protocol is generally accepted as a standard protocol for communication with intelligent field devices.

HART is a registered trademark of the HART Communication Foundation (HCF), which owns all the rights to the HART protocol.
You can find detailed information about HART in the HART specification.

7.1.3 HART protocol

Definition

The HART protocol describes the physical form of the transfer:

- Transmission procedures
- Message structure
- Data formats
- Commands

Description

Each HART telegram (request frame) sent from the module to the connected field device and each HART telegram (response frame) received by the field device has the following basic structure:

PREAMBLE	STRT	ADDR	COM	BCNT	STATUS	DATA	CHK

PREAMBLE:	Bytes (0xFF) for synchronizing. 5 to 20 bytes depending on parameter assignment
STRT:	Start character (start delimiter)
ADDR:	Address of the field device (1 byte; short address or 5 bytes; long address)
COM:	HART command number
BCNT:	Byte count, number of bytes to follow without checksum
STATUS:	HART device status (1st and 2nd status byte). Only present for a response frame. HART device status (Page 36)
DATA:	Transferred user data / parameters, quantity depending on command (0...230 bytes)
CHK:	Checksum

With the exception of the preamble bytes, this structure is contained in the communication data of the HART command interface.

HART job and response data records (Page 72)

- HART responses always contain data.
- Status information (HART device status; 1st and 2nd status bytes) is always sent together with a HART response.
- You should evaluate this information to make sure the response is correct.

7.2 System connection

7.2.1 Useful information about system connection

The system connection and the parameter assignment of the field devices is described below.

System environment

To use an intelligent field device with HART functionality, you require the following system environment:

- 4 to 20 mA current loop
- Connecting field devices to the I/O module

The system connection is shown as follows:

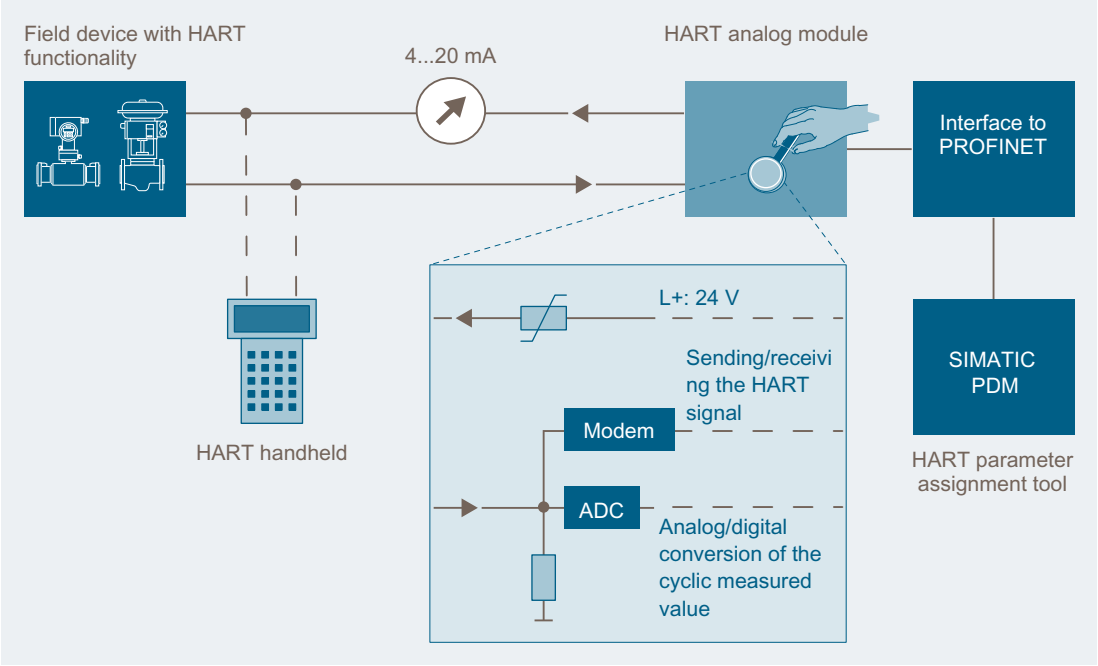

Figure 2-1291 System environment for the use of HART

The I/O module is used in an IO device. You can connect a HART field device to each channel (monodrop operation). The I/O module operates as a HART master and the field devices as HART slaves.

The I/O module receives the commands e.g. from the HART configuration tool, forwards the commands to the intelligent field device and returns the responses. The interface of the I/O module are data records. These data records must be generated or interpreted by the client.

- HART configuration tool (Page 35) (e.g. SIMATIC PDM)
- HART signal (Page 36)
- HART device status (Page 36)

Configuration

You configure the I/O module using the SIMATIC engineering tool. You configure the individual channels with respect to the actual analog value output and the use of the HART variables in the input address space of the I/O module.

- You can use the SIMATIC engineering tool to configure one field device per channel.
- The configuration/parameter assignment of the connected field device is performed with the HART configuration tool or the EDD for the respective distributed I/O.

Parameter reassignment of the field devices

A field device connected to the I/O module can be re-configured. The following tools are suitable for re-configuration:

- HART configuration tool
- HART handheld

The I/O module generally accepts triggered reconfigurations for field devices.

The assignment of access rights is only possible with the HART configuration tool.

You trigger re-configuration of a field device that is connected to an I/O module with a HART command entered using the HART configuration tool.

The corresponding bit is set in the HART device status of the connected field device (in the 2nd status byte) after re-configuration of a field device is completed.

NOTE

"Configuration changed" maintenance message

- If the "Configuration changed" maintenance message is enabled, the I/O module triggers this maintenance message when the field device is re-configured.
- This maintenance message should be regarded as a notice and not an error. It is automatically deleted again by the I/O module after approximately 1 minute.

Additional information on this: Diagnostic and maintenance messages (Page 59)

7.2.2 HART configuration tool

Definition

The HART parameters can be set either using an external hand-held device (HART Handheld) or a HART configuration tool (PDM). Both assume the function of a "client":

The parameter assignment tool affects the entire I/O module; the HART handheld is connected in parallel to the field device.

7.2.3 HART signal

Definition

A HART signal consists of sine waves of 1200 Hz and 2200 Hz and has an average value of 0.

Description

The following figure shows the analog signal with the modulated HART signal (FSK method). It can be filtered out using an input filter so that the original analog signal is available again.

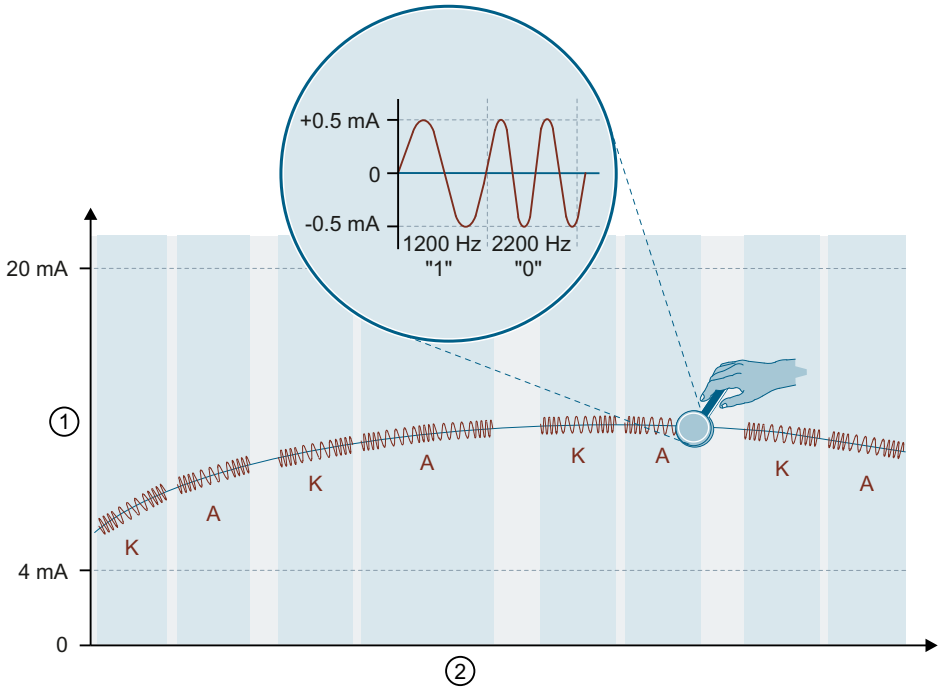

1	Analog signal
2	Time (seconds)
K	Command
A	Response

7.2.4 HART device status

Definition

The two HART status bytes (HART device status) that are transferred with each response of the field device contain error information about the HART communication, HART command and device status.
Among other things, this information is evaluated by the I/O module and signaled to the CPU via maintenance messages.

Description

The 1st and 2nd status byte is structured as follows:

Table 2-1498 1st status byte

When bit 7 = 1: Communication error	
Bit 6 = 1	Parity error
Bit 5 = 1	Overflow
Bit 4 = 1	Framing error
Bit 3 = 1	Checksum error
Bit 2 = 0	Reserved
Bit 1 = 1	Overflow in the receive buffer
Bit 0 = 0	Reserved
When Bit 7 = 0: Bit 0 to 6 Specific according to the response frame	

Table 2-1499 2nd status byte

Bit 7 = 1	Device fault
Bit 6 = 1	Configuration changed
Bit 5 = 1	Startup (cold start)
Bit 4 = 1	Additional status information available
Bit 3 = 1	Fixed analog output current setting
Bit 2 = 1	Analog output current saturated
Bit 1 = 1	Secondary variable outside the limits
Bit 0 = 1	Primary variable outside the range

7.3 Communication

7.3.1 Useful information about communication

Reference is made to communication with HART in the following.

HART communication

With enabled HART operation, the analog module independently sends HART commands to the connected field devices. This always occurs alternately on a channel-specific basis with any pending external HART commands that arrive via the command interface of the module.

- HART command (Page 38)
- HART command interface (Page 71)

The I/O module is used in the following operation:

Multiplex operation (Page 40)

Fast mode

When processing HART commands as an SHC sequence (Successive HART Command), HART processing is reserved for the current channel.

If a HART command with set SHC bit is recognized by the I/O module for a channel, the complete HART command processing on the I/O module is reserved for this channel for

approx. 2 seconds. There is no processing of internal HART requests, and there is no HART command processing for all other channels of the I/O module during this time.

SHC sequence (Page 40)

NOTE

- While a HART channel of the I/O module is processing an SHC sequence, and thus the complete HART processing is reserved for this channel, the HART variables of all HART channels are no longer updated. They remain unchanged in terms of value and quality code.
- HART commands for other channels are not processed and are acknowledged correspondingly.

Burst mode

The I/O module does not support burst mode. HART commands with set burst bit are ignored and are not forwarded to the connected field device.

7.3.2 HART command

Definition

HART commands are used to set the configurable properties of HART field devices (HART parameters). HART responses are used to read out the HART parameters.

Description

The HART commands and their parameters are divided into three groups:

- Universal HART commands (Page 39)
- General purpose HART commands (Page 39)
- Device-specific HART commands (Page 40)

7.3.3 Explanation of the HART commands

7.3.3.1 Universal HART commands

Definition

Universal commands must be supported by all manufacturers of HART field devices.

Description

Examples of universal HART commands:

Command	Function
0	Reads manufacturer and device type - only with this command 0 can field devices be addressed by means of a short frame address
11	Reads manufacturer and device type
1	Reads primary variable and unit
2	Reads current and percentage of range, digitally as floating-point number (IEEE 754)
3	Reads up to four pre-defined, dynamic variables (primary variables, secondary variables, etc.)
9	Reads up to four pre-defined, dynamic variables (primary variables, secondary variables, etc.)
13, 18	Reads or writes process tag name ("tag"), description and date (dates are also sent)

7.3.3.2 General purpose HART commands

Definition

General purpose commands should be supported by all manufacturers of HART field devices.

Description

Examples of usable HART commands:

Command	Function
36	Sets high range limit
37	Sets low range limit
41	Perform self-test
43	Sets the primary variable to zero

7.3.3.3 Device-specific HART commands

Definition

Device-specific commands only apply to the respective field device.

7.3.4 SHC sequence

Definition

If a HART command with set SHC bit is sent to the I/O module, this channel is reserved for HART commands for 2 seconds.

For each additional HART command with SHC bit set, the I/O module reserves this channel again for HART commands for an additional 2 seconds. Command 3 or 9 for reading the HART variables starts being sent cyclically to the field device again if a HART command without a set SHC bit is detected for this channel, or if no further command is received for the channel within 2 seconds of the previous HART command.

7.3.5 Multiplex operation

Definition

The I/O module processes the HART communication in multiplex mode, i.e. one channel after the other. HART commands of the individual channels therefore influence the speed of HART processing of the other channels.

7.4 Tags

7.4.1 Useful information about HART variables

HART variables, the properties dialog and address assignment are explained below.

Properties dialog of the I/O module

In the properties dialog of the I/O module, you can configure up to 4 HART variables directly in the input address area of the I/O module. You select these from the four HART variables provided by each channel:

HART variables (Page 41)

You can refer to the quality code for information on the process status of a HART variable.

Quality code (Page 42)

The HART variables are assigned to a channel in the properties dialog of the module. The HART variables are configured via parameter data record 130. This allows you to process measured values directly from the field device as input data in the automation device.

Parameter assignment and structure of the HART mapping parameters (Page 57)

You also determine the use of the multiHART range and its properties in the properties dialog box of the I/O module.

multiHART range (Page 44)

Address assignment

You can choose to configure the following:

- Maximum 4 HART variables

  Each HART variable occupies 5 bytes of input data. As soon as you configure (map) at least one HART variable in the input address space, the addresses for all 4 tags are assigned (20 bytes).

- A multiHART range

  If the multiHART range is used, an additional 6 bytes of input address space and 1 byte of output address space is allocated.

7.4.2 HART variables

Definition

Each HART variable consists of a 4-byte real value and a 1-byte quality code. A maximum of four HART variables supported by the connected field device are read cyclically for each channel with enabled HART functionality. The HART variables are read automatically via the HART command 3 (for field devices with HART Rev. 5 and 6) or via command 9 (for field devices with HART Rev. 7 or later).

These four HART variables are always stored in the HART variable data record 121 for each channel and can be read at any time.

HART variable data record (Page 79)

Description

The following HART variables are available:

- PV (Primary Variable)
- SV (Secondary Variable)
- TV (Tertiary Variable)
- QV (Quaternary Variable)

7.4.3 Quality code

Definition

The quality code describes the process status of the corresponding HART variable.

Description

The quality code is structured as follows:

Bit	7....6	5....2	1...0
	Quality 0 0: Bad 0 1: Uncertain 1 0: Good 1 1: Good	Sub-status Coded according to "PROFIBUS PA Profile for Process Control Devices"	Limits 0 0: OK 0 1: Low limit 1 0: High limit 1 1: Constant

The quality codes generated by the I/O module conform to the HART revision of the field device used.

- Field devices with HART revision 5 and 6 (Page 42)
- Field devices with HART revision 7 and higher (Page 43)

7.4.4 HART revision

7.4.4.1 Field devices with HART revision 5 and 6

Definition

The quality code is formed exclusively from the 1st and 2nd status byte (HART device status) of the response frames (HART command 3).

Description

The quality code of field devices with HART revision 5 and 6 is structured as follows:

Quality code	Meaning (process status)	
80_H	Value is okay	Also applies when the following bits are set in the 2nd status byte of the HART response frame: • Configuration changed • Startup (cold start) • Fixed analog output current setting

[1] A channel is in standby mode when a redundancy failover occurs due to a fault in an IO-redundant module.

Quality code	Meaning (process status)	
78_H	Value is uncertain	Also applies when the following bits are set in the 2nd status byte of the HART response frame: • Additional status information available • Analog output current saturated • Secondary variable outside the limits • Primary variable outside the range
84_H	Response code RC8: Update error	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	After module start-up, after incorrect operation of the multiHART interface or after redundancy failover to the standby channel[1]
00_H	Initialization value from system	

[1] A channel is in standby mode when a redundancy failover occurs due to a fault in an IO-redundant module.

7.4.4.2 Field devices with HART revision 7 and higher

Definition

The quality code is formed from the 1st status byte (HART device status) and the "Device variable status" (DVS) of the response frames (HART command 9).

Description

The quality code of field devices with HART revision 7 or higher is structured as follows:

Quality code	Meaning (process status)	
80_H	Value is okay	
89_H	"Good" with "low limit"	Process status, formed from the "Device variable status" (DVS) of the response frames with corresponding limits (see above).
$8A_H$	"Good" with "high limit"	
28_H...$2B_H$	"Bad"	
68_H...$6B_H$	"Poor accuracy"	
78_H...$7B_H$	"Manual" or "Fixed" (manually controlled or fixed value)	
88_H...$8B_H$	"More device variable state available" (additional status information available)	
84_H	Response code RC8: Update error	

[1] A channel is in standby mode when a redundancy failover occurs due to a fault in an IO-redundant module.

Quality code	Meaning (process status)	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	After module start-up, after incorrect operation of the multiHART interface or after redundancy failover to the standby channel[1]
40_H	Read alternatively via command 3	
00_H	Initialization value from system	

[1] A channel is in standby mode when a redundancy failover occurs due to a fault in an IO-redundant module.

7.4.5 multiHART range

Definition

You can access any of the configured HART variables in the I/O module via the multiHART range.

When HART mode is enabled, the I/O module cyclically reads the variables provided by the connected field devices itself and makes them available in the configured input address space. You can request and read one of these HART variables via the multiHART range.

Technical specifications

8

Technical specifications of Ex-AI 2xI 2-wire HART

Article number	6DL1134-6TB00-0HX1
General information	
Product type designation	Ex-AI 2xI 2-wire HART
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type X1
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V17 or higher
• STEP 7 configurable/integrated from version	STEP 7 V5.6 SP2 or higher
• PCS 7 configurable/integrated from version	V9.1
Operating mode	
• MSI	Yes
Redundancy	
• Redundancy capability	No
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
Input current	
Current consumption (rated value)	74 mA
Current consumption, max.	92 mA; Peak load (all channels in short-circuit)
24 V encoder supply	
• 24 V	Yes
• Short-circuit protection	Yes; Electronic disconnection in case of short-circuit, current limitation from 27 mA
• Output current per channel, max.	28 mA
Power loss	
Power loss, typ.	1.2 W
Power loss, max.	2.3 W; Peak load (all channels in short-circuit)

Article number	6DL1134-6TB00-0HX1
Address area	
Address space per module	
• Address space per module, max.	4 byte; + 0/1 byte for QI information
• Address space per module with HART, max.	24 byte; + 0/1 byte for QI information
• Address space per module with MultiHART, max.	11 byte; + 0/1 byte for QI information
Hardware configuration	
Automatic encoding	
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type X1
Analog inputs	
Number of analog inputs	2; Differential inputs
• For current measurement	2
Cycle time (all channels), min.	3 ms
Input ranges (rated values), currents	
• 0 to 20 mA	Yes
• 4 mA to 20 mA	Yes; 15 bit + sign
– Input resistance (4 mA to 20 mA)	400 Ω; At 20 mA input current
Cable length	
• shielded, max.	500 m; Ex characteristic values must be observed
• unshielded, max.	300 m; Ex characteristic values must be observed
Analog value generation for the inputs	
Measurement principle	integrating (Sigma-Delta)
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes; channel by channel
• Interference voltage suppression for interference frequency f1 in Hz	10 / 50 / 60 Hz
Smoothing of measured values	
• Number of smoothing levels	4; None; 4/8/16 times
• parameterizable	Yes
Encoder	
Connection of signal encoders	
• for current measurement as 2-wire transducer	Yes
– Burden of 2-wire transmitter, max.	750 Ω; At 20 mA input current
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.01 %

Article number	6DL1134-6TB00-0HX1
Temperature error (relative to input range), (+/-)	0.005 %/K
Crosstalk between the inputs, min.	60 dB
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.05 %
Operational error limit in overall temperature range	
• Current, relative to input range, (+/-)	0.3 %
Basic error limit (operational limit at 25 °C)	
• Current, relative to input range, (+/-)	0.2 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	60 dB
Protocols	
HART protocol	Yes
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; channel by channel
• Short-circuit	Yes; channel by channel
• Group error	Yes
• Overflow/underflow	Yes; channel by channel
Diagnostics indication LED	
• MAINT LED	Yes; Yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Ex(i) characteristics	
maximum values for connecting terminals for gas group IIC	
• Uo (no-load voltage), max.	26 V
• Io (short-circuit current), max.	93 mA
• Po (power output), max.	605 mW
• Co (permissible external capacity), max.	99 nF

Article number	6DL1134-6TB00-0HX1
• Lo (permissible external inductivity), max.	4 mH
• Ui (intrinsically safe input voltage), max.	10 V
• Um (voltage at non-intrinsically safe connecting terminals), max.	60 V
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes; Electrical isolation between the channels and input voltage PME
Isolation	
Isolation tested with	further information on insulation can be found in the "ET 200SP HA / ET 200SP modules for devices in hazardous areas" System Manual
insulation of the field circuits to local ground acc. to IEC/EN 60079-11 tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-40 °C
• horizontal installation, max.	70 °C
• vertical installation, min.	-40 °C
• vertical installation, max.	60 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	55 g

NOTE

Short-circuit protection of Ex-AI 2xI 2-wire HART

In the event of a short-circuit, the module limits the output current of the sensor supply to approx. 27 mA and temporarily switches the sensor supply on and off until the short-circuit has been eliminated.

Cycle time

The cycle time describes the time slice in which signals from the inputs are acquired and processed.

The cycle time depends on the parameter assignment and can be different for each channel.

Operating mode	Cycle time
Analog inputs for 60 Hz interference frequency suppression	100 ms
Analog inputs for 50 Hz interference frequency suppression	125 ms
Analog inputs for 10 Hz interference frequency suppression	600 ms

Drivers, parameters, diagnostics messages and address space

A

A.1 Concept of the driver and diagnostics blocks

Use with PCS 7

The following information shows you the benefits of using the process control system. In the process control system, the engineering system automatically handles many important parameter assignments and interconnections of modules.

If you want to use the Ex I/O outside of these process control systems, pay attention to the following sections:

- Parameter assignment and structure of the module/channel parameters (Page 52)
- Address space in analog mode (Page 62)

Tasks of the driver and diagnostics blocks (driver blocks)

In process control systems, certain demands are placed on the diagnostics/signal processing. This includes the monitoring of modules, IO devices and PROFINET IO systems for malfunctions and failures.

To enable this, blocks are available in the libraries of the engineering system that implement the interface to the hardware including test functions.

These blocks perform two basic tasks:

- They provide signals from the process to the AS for further processing.
- They monitor modules, IO devices and PROFINET IO system for failure.

When the process signals are read in, these blocks access the process image input (or process image partition) (PII) and when the process signals are output, they access the process image output (or process image partition) (PIQ).

Concept

The concept of the driver and diagnostics blocks for process control systems is characterized by the following:

- The separation between user data processing (CHANNEL blocks) and diagnostics data processing (MODULE blocks)
- The symbolic addressing of the I/O signals
- The automatic generation of the MODULE blocks by CFC

This block concept supports all modules from the list of approved modules.
When new Siemens or non-Siemens module types are integrated, the meta-knowledge for the driver generator can be extended by additional XML files (object and action lists).

NOTE

Note the following:

- You must install the library with the driver blocks using the Setup program on the PC. This is the only method of ensuring that the meta-knowledge required for the driver generator is available. You must not copy the library from another computer.
- You can also use driver blocks from another library (for example, your own blocks from your own library). You can specify this additional library in the "Generate module drivers" dialog box. The driver generator then searches for the block to be imported in the library specified here. If the block is not found here, it is searched for in the library specified in the control file (XML file).
- If the S7 program contains a signal-processing block but not from one of the engineering system libraries, the following is required:
  You have to specify the version of the driver library from which the driver blocks are to be imported in the "Generate module drivers" dialog box.

Time-optimized processing

To enable time-optimized processing during runtime, the organization blocks for error handling (for example, OB85, OB86) are automatically divided into runtime groups and the driver blocks are integrated in the corresponding runtime groups.

If an error occurs, the SUBNET block, for example, activates the relevant runtime group. The RACK block or MODULE block detects the error, evaluates it and outputs a process control message to the operator control and monitoring system.

The diagnostics information of the module block (OMODE_xx output) is also transferred to the corresponding CHANNEL block (MODE input). If necessary, this information can be displayed using a block that can be operated and monitored in the operator control and monitoring system or through a user block in a process picture (color change of the measured value or flashing display, etc.).

A.2 Parameter assignment and structure of the module/channel parameters

A.2.1 Parameter assignment

Parameter assignment in the user program

You can reconfigure individual channels of the I/O module and HART variable mapping in RUN without this affecting the other channels.

Changing parameters in RUN

The parameters are only transferred to the I/O module with the "WRREC" instruction.

- Module/channel parameters using data record 128
- HART mapping via data record 130

The parameters set with the configuration are not changed in the CPU in the process, which means the parameters set in the CPU are once again valid after startup.

STATUS output parameter

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The STATUS output parameter is 4 bytes long and is configured as followed:

- Byte1: Function_Num, general error code
- Byte2: Error_Decode, location of the error code
- Byte3: Error_Code_1, error code
- Byte4: Error_Code_2, manufacturer-specific extension of the error code

Module-specific errors are displayed via Error_Decode = 0x80 and Error_Code_1 / Error_Code_2.

Error_ Code_1	Error_ Code_2	Cause	Remedy
0xB0	variable	Number of the data record unknown (Error_Code_2 returns internal identifiers)	Enter valid number for data record.
0xB1	0x01	Length of the data record is incorrect	Enter valid value for data record length.
0xB2	variable	Module cannot be reached (Error_Code_2 returns internal identifiers)	• Check station - is the module plugged in correctly? • Check the parameters of the WRREC instruction.
0xE0	0x01	Header error (version or defined bits incorrect)	Correct the version number or defined bits.
0xE0	0x02	Header error (incorrect length or number of parameter blocks)	Correct the length and number of the parameter blocks.
0xE1	0x01	Reserved bit set	Write all reserved bits with a 0.

Error_ Code_1	Error_ Code_2	Cause	Remedy
0xE1	0x02	Invalid diagnostics enable bit set for operating mode	Check the diagnostics enable
0xE1	0x04	Invalid value for hardware interrupt limit	Check and correct the parameters
0xE1	0x08	Invalid coding for interference frequency suppression / integration time	
0xE1	0x09	Invalid coding for smoothing	
0xE1	0x10	Code for measurement type invalid	
0xE1	0x11	Code for measuring range invalid	
0xE1	0x21	Incorrect number of HART repetitions	

Valid parameters

Only the values specified in the following are permitted. Values that are not listed are rejected by the module.

Every parameter data record is checked by the module. If the module detects an incorrect parameter, the entire data record is rejected and the parameters of the module remain unchanged.

A.2.2 Parameter assignment and structure of the module/channel parameters

Structure of data record 128

The data record contains the module parameters and all channel or technology parameters of the two channels.

Main components of the data record:

- Header information (module), module parameters, header information (channel)
- Channel parameters (channel or technology parameters) which affect the actual analog value acquisition
- Parameters which enable diagnostics
- Basic parameters of HART communication.

You can specify and change other parameters and HART-specific settings with data records 131 to 146. See section HART-specific settings (Page 79).

Table 2-1500 Structure of data record 128 in analog mode (36 bytes in length)

Byte	Length	Parameter	Efficiency range
0 ... 3	4 bytes	Header information (module)	Module
4 ... 5	2 bytes	Module parameters	Module parameters

Byte	Length	Parameter	Efficiency range
6 ... 7	2 bytes	Header information (channels)	AI channel n (n = 0 to 1) • Analog value input • Enable diagnostics • HART
8 ... 21	14 bytes	Channel parameter (channel 0)	
22 ... 35	14 bytes	Channel parameter (channel 1)	

NOTE

Legend for the following detailed screens

The following detailed screens show the configuration-dependent assignment of the individual bytes in data record 128.

- Any unused bits and bits or bytes marked with "reserved" must be set to "0".
- Activate a parameter by setting the corresponding bit to "1" or to the appropriate value.

Header information and module parameters

The following figure shows the structure of the header information and module parameters.

	7	6	5	4	3	2	1	0	
Byte 0	0	1	0	0	0	0	0	0	Minor version Major version Reserved
Byte 1	0	0	0	0	0	0	1	0	Number of the following parameter structures
Byte 2	0	0	0	0	0	0	0	1	Number of the following module parameter blocks
Byte 3	0	0	0	0	0	0	1	0	Length of the following module parameter block
Byte 4	0	0	0	0	0	0	0		Diagnostics, Missing supply voltage L+
Byte 5	0	0	0	0	0	0	0	0	Reserved
Byte 6	0	0	0	0	0	0	1	0	Number of the following channel parameter blocks
Byte 7	0	0	0	0	1	1	1	0	Length of a channel parameter block

Figure 2-1292 Header information and module parameters of data record 128

Channel parameters

Each channel parameter block contains the channel parameters for the analog output including HART (14 bytes).

The following figure shows the structure of the channel parameters for channels 0 to 1.

x = 8 + (channel number * 14);with channel number 0...1

All unused bits and the bits or bytes marked as "reserved" must be set to "0".
You activate a channel parameter by setting the corresponding bit to "1" or the corresponding value.

Byte x

7	6	5	4	3	2	1	0

Measurement type
0000 0000 = Analog input deactivated
0000 0011 = Current (2-wire transmitter)

Byte x+1

7	6	5	4	3	2	1	0

Measuring range
0000 0010 = 0..20 mA
0000 0011 = 4..20 mA
0000 0111 = 4..20 mA HART

Byte x+2

7	6	5	4	3	2	1	0

Smoothing:
0000 = None
0001 = Weak
0010 = Medium
0011 = Strong

Interference frequency suppression:
0001 = 60 Hz
0010 = 50 Hz
0011 = 10 Hz

Byte x+3

7	6	5	4	3	2	1	0
				0			0

Enable diagnostics HART
Failure monitoring (according to NE43)
Enable hardware interrupt, low limit 2
Enable hardware interrupt, low limit 2
Enable hardware interrupt, low limit 1
Enable hardware interrupt, low limit 1

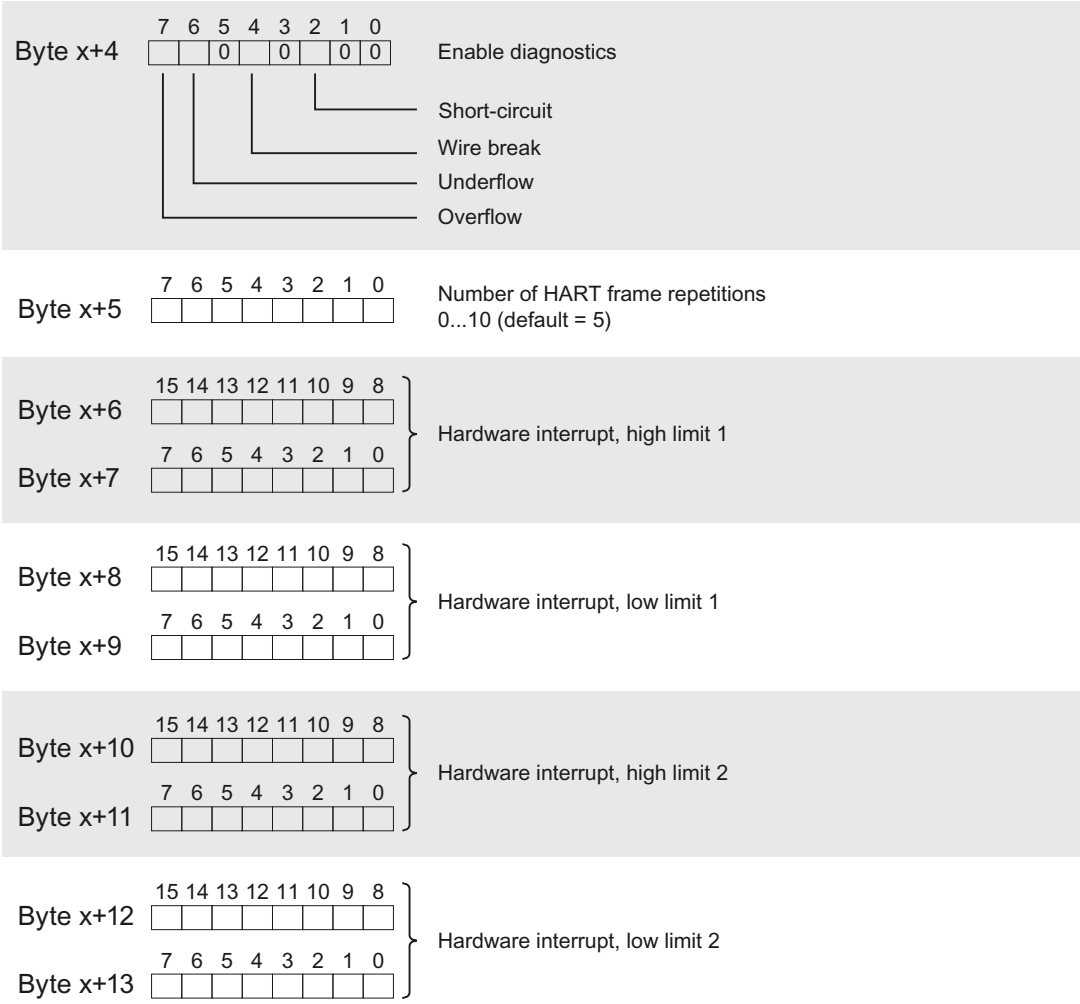

Figure 2-1293 Structure of byte x to x+n for channels 0 to 1

A.2.3 Parameter assignment and structure of the HART mapping parameters

Structure of data record 130

Data record 130 has a total length of 12 bytes.

You can use the parameters of data record 130 to configure/map up to 4 HART variables of the individual channels to the input address space of the I/O module, provided you have selected configuration with HART variables in the input range, see section Configurations of the I/O module Ex-AI 2xI 2-wire HART (Page 15).

Header information

The figure below shows the structure of the header information.

	7	6	5	4	3	2	1	0	
Byte 0	0	0	0	0	0	0	0	0	Version = 0
Byte 1	0	0	0	0	1	0	1	1	Block length = 11
Byte 2	0	1	0	0	1	0	1	1	Block type = 75
Byte 3	0	0	0	0	0	0	0	0	Reserved = 0

Figure 2-1294 Header information of data record 130

Parameters

The figure below shows the parameter assignment of the 4 HART variables.

x = 4, 6, 8, 10

	7	6	5	4	3	2	1	0	
Byte x	0	0	0	0	0	0	0		Channel number: 0 = Channel 0 1 = Channel 1
Byte x+1	0	0	0	0					Variable identifier: 0001 = Primary 0010 = Secondary 0011 = Tertiary 0100 = Quaternary 1111 = non / CiR

Figure 2-1295 Parameters of data record 130

The variable ID 15 = non/CiR prevents the I/O module from configuring/mappping a HART variable; that is, the corresponding memory area in the input address area remains unallocated.

A.2.4 Diagnostic and maintenance messages

Diagnostic messages

A diagnostic message is generated for each diagnostic event and the DIAG LED flashes red on the module. The diagnostic messages can be read in the diagnostic buffer of the CPU. The following applies for the assignment of diagnostic messages:

- A module message is assigned to all channels.
- A channel-specific message is only assigned to one channel and has no effect on the other channels.
  The diagnostics is displayed through the corresponding channel fault LED.

Table 2-1501 Diagnostics messages, their meaning and possible remedies

Diagnostics message	Error code	Assignment	Meaning	Remedy
Short-circuit	1_H	Analog input	Short-circuit of the input	• Check the wiring
Wire break	6_H	Analog input	• Impedance of encoder circuitry is too high • Wire break between the module and sensor • Channel not connected (open)	• Use a different encoder type or modify the wiring, for example, using cables with a larger cross-section • Connect the cable • Disable diagnostics • Connect the encoder contacts
High limit violated	7_H	Analog input	• The analog value is above the overrange.	Correct the module/encoder tuning
Low limit violated	8_H	Analog input	The analog value is below the underrange.	Correct the module/encoder tuning
Parameter assignment error	10_H	Module	Incorrect parameter assignment	Correct the parameter assignment
Supply voltage missing	11_H	Module	Missing or insufficient supply voltage L+	• Check Ex power module • Check wiring of the supply voltage L+ on the Ex power module
Hardware interrupt lost	16_H	Module	Error is reported because the events occur faster than they can be processed in the system.	
Channel/component temporarily unavailable	$1F_H$	Module	Firmware update is in progress or has been canceled during the update. The module stops acquiring process values during this time.	• Restart firmware update • Wait for firmware update
Module is faulty	100_H	Module	Internal module error has occurred	Replace the module
Invalid BaseUnit	151_H	Module	The module was plugged into an impermissible BaseUnit	Replace Ex BaseUnit
The retentive memory in the BaseUnit is defective.	153_H	Module	A memory block error on the BaseUnit was detected during startup.	Replace Ex BaseUnit

Maintenance messages

A maintenance message is generated for each maintenance required and the MT LED lights up yellow on the module.

Maintenance messages are assigned channel-specific to a channel (HART error) or as a module message to all channels.

Maintenance messages do not directly affect the function of the module or the analog value acquisition.

Maintenance messages of the HART communication do not affect the analog value acquisition of the module.

Table 2-1502 Maintenance messages, their meaning and possible remedies

Maintenance message	Error code	Assignment	Meaning / Cause	Remedy
HART communication error	141_H	Analog input	• HART field device is not responding • Timing error • HART field device did not understand the command that was sent (1st status byte)	• Check the process wiring • Correct the parameter assignment • Set current ≥4 mA • Increase number of configured repetitions
HART primary variable outside of limits	142_H	Analog input	• Incorrect parameters in the HART field device • HART field device is set to "Primary variable outside of limits" in simulation mode • Incorrect measuring point • Parameter assignment of primary variable outside of limits	• Check the parameter assignment of the HART device • Correct the simulation • Check whether the correct measuring transducer is connected
HART analog output current of field device saturated	143_H	Analog input	• The output current of the HART field device is saturated: • Incorrect parameters in the HART field device • HART field device is set to a measured value that is too high in simulation mode • Incorrect measuring point	
HART output current of the field device specified	144_H	Analog input	• The output current of the HART field device is fixed: • Incorrect parameters in the HART field device • HART field device is set to a measured value that is too high in simulation mode • Incorrect measuring point	

[1] **Response of the "HART configuration changed" maintenance message**

If the HART field device signals "Parameter reassignment" (configuration changed) in the 2nd status byte, the module generates the maintenance message "HART configuration changed".

If the field device withdraws the message in the 2nd status byte within a minute, the maintenance message is also deleted again by the module.

If the message in the 2nd status byte is still set after a minute, the module then independently sends HART command 38 for resetting the message in the field device.

Maintenance message	Error code	Assignment	Meaning / Cause	Remedy
HART additional status information available	145_H	Analog input	In the HART device status (in the 2nd status byte), the HART field device identifier for "further status information available" has been set	Read out status with HART command 48 and clear error/cause if necessary
HART configuration changed[1]	146_H	Analog input	In the HART device status (in the 2nd status byte), the identifier for "parameter reassignment" of the HART field device has been set	If you do not want the re-configuration to trigger a diagnostic interrupt, the HART diagnostics may not be enabled.
HART malfunction in the field device	147_H	Analog input	In the HART device status (in the 2nd status byte) the field device reports a malfunction	• Read out status with HART command 48 and clear error/cause if necessary • Replace field device
HART secondary variable outside the limits	149_H	Analog input	• Incorrect parameters in the HART field device • HART field device is set to "Non-primary variable outside limits" in simulation mode • Incorrect measuring point • Parameter assignment of non-primary variable is outside the limits	• Check the parameter assignment of the HART device • Correct the simulation • Check whether the correct measuring transducer is connected
The retentive memory in the BaseUnit is defective.	153_H	Module	A memory block error on the BaseUnit was detected during operation.	Replace Ex BaseUnit

[1] **Response of the "HART configuration changed" maintenance message**

If the HART field device signals "Parameter reassignment" (configuration changed) in the 2nd status byte, the module generates the maintenance message "HART configuration changed".

If the field device withdraws the message in the 2nd status byte within a minute, the maintenance message is also deleted again by the module.

If the message in the 2nd status byte is still set after a minute, the module then independently sends HART command 38 for resetting the message in the field device.

A.2.5 Hardware interrupts

Hardware interrupts

The I/O module can initiate hardware interrupts when limit violations of analog input signals occur.

Interrupt OBs are called automatically if an interrupt occurs.

You can find detailed information on the event in the hardware interrupt organization block with the "RALRM" instruction (read additional interrupt information).

The I/O module generates a hardware interrupt depending on the analog input signal when the following events occur:

- Violation of the low limit 1
- Violation of the high limit 1
- Violation of the low limit 2
- Violation of the high limit 2

The analog input (channel) of the I/O module that has triggered the hardware interrupt is entered in the start information of OB40 in the variable OB40_POINT_ADDR. The figure below shows the assignment to the bits of local data double word 8.

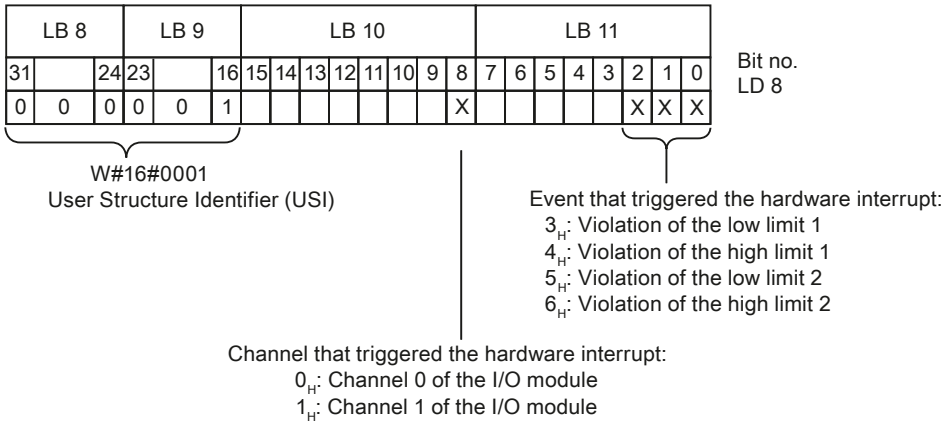

A.3 Address space

A.3.1 Address space in analog mode

Address space

The following tables show the allocation of the address space of the I/O module based on the configuration.

- Address space in analog mode AI 2 without QI (Page 63)
- Address space in analog mode AI 2 + 1 multiHART without QI (Page 63)
- Address space in analog mode AI 2 + 4 HART without QI (Page 65)
- Address space in analog mode AI 2 + 1 multiHART with QI (Page 66)
- Address space in analog mode AI 2 + 4 HART with QI (Page 67)
- Address space in analog mode AI 2 with QI and optional MSI (Page 68)

The module can be configured in different ways. Depending on the configuration, additional/different addresses are assigned in the process image of the outputs/inputs.

Addresses for the HART area are not available if there are no HART variables or no multiHART area configured in the properties dialog of the module.

Evaluating information

- Evaluating HART variables (Page 70)
- Evaluating the multiHART range (Page 69)
- Evaluating the value status (Page 70)

A.3.2 Address space in analog mode AI 2 without QI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input range
- "QI" stands for value status (QI) of analog input n

Address space in the configuration analog mode AI 2 without QI

The following tables show the allocation of the address space of the I/O module.

Input area

The process values are shown in S7 format.

Table 2-1503 Input area of the Ex-AI 2xI 2-wire HART (AI 2 without QI)

IB x +	7	6	5	4	3	2	1	0
0...1	Analog value, analog input 0							
2...3	Analog value, analog input 1							

A.3.3 Address space in analog mode AI 2 + 1 multiHART without QI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input range
- "QB" stands for output byte, that is the module start address in the output range
- "QI" stands for value status (QI) of analog input n
- "QC"stands for Quality Code

Address space in the configuration analog mode AI 2 + 1 multiHART without QI

The following tables show the allocation of the address space of the I/O module.

Addresses for the HART range are only available if no multiHART range has been configured in the properties dialog of the module.

Input area

The process values are shown in S7 format.

Table 2-1504 Input area of the Ex-AI 2xI 2-wire HART (AI 2 + 1 multiHART without QI)

IB x +	7	6	5	4	3	2	1	0
0...1	Analog value, analog input 0							
2...3	Analog value, analog input 1							
4	HART range							
: :								

HART range

When the multiHART range is used, the HART range is arranged directly aligned after the bytes of the analog inputs.

There are 6 bytes in the input area for the configuration with a multiHART area.

Table 2-1505 Address range for configurations with multiHART range

IB x +	HART range		
4	Acknowledgment		multiHART range
5 : 8	Value	HART variable	
9	QC		

Output range

There is one byte in the output area for the configuration with a multiHART area.

Table 2-1506 Output area of the Ex-AI 2xI 2-wire HART (AI 2 + 1 multiHART without QI)

QB x	Command	multiHART range

Evaluating the multiHART range

You can find information on this in section "Evaluating the multiHART range (Page 69)".

A.3.4 Address space in analog mode AI 2 + 4 HART without QI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input range
- "QI" stands for value status (QI) of analog input n
- "QC"stands for Quality Code

Address space in the configuration analog mode AI 2 + 4 HART without QI

The following tables show the allocation of the address space of the I/O module.

Addresses for the HART range are only available if no iHART variables have been configured in the properties dialog of the module.

Input area

The process values are shown in S7 format.

Table 2-1507 Input area of the Ex-AI 2xI 2-wire HART (AI 2 + 4 HART without QI)

IB x +	7	6	5	4	3	2	1	0
0...1	Analog value, analog input 0							
2...3	Analog value, analog input 1							
4	HART range							
: :								

HART range

When the HART variables are used, the HART range is arranged directly aligned after the bytes of the analog inputs.

In the configuration with 4 HART variables in the input area, the area has a length of 20 bytes and always contains 4 HART variables, each with a 4-byte value and a 1-byte quality code (QC).

IB x +	HART range	
4 + 5n : 7 + 5n	Value	Configured HART variable n (n= 0 to 3)
8 + 5n	QC	

Double word n (n= 0 to 3); example: HART variable 3 = Byte (5 +3*5) = configured HART variable starts from Byte 20

Evaluating HART variables

You can find information on this in section "Evaluating HART variables (Page 70)".

A.3.5 Address space in analog mode AI 2 + 1 multiHART with QI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input range
- "QB" stands for output byte, that is the module start address in the output range
- "QC"stands for Quality Code
- "QAIn" stands for value status (QI) of analog input n
  You can find additional information in section "Evaluating the value status (Page 70)".

Address space in the configuration analog mode AI 2 + 1 multiHART with QI

The following tables show the allocation of the address space of the I/O module.

Addresses for the HART range are only available if no multiHART range has been configured in the properties dialog of the module.

Input area

The process values are shown in S7 format.

Table 2-1508 Input area of the Ex-AI 2xI 2-wire HART (AI 2 + 1 multiHART with QI)

IB x +	7	6	5	4	3	2	1	0
0...1	Analog value, analog input 0							
2...3	Analog value, analog input 1							
4	-	-	-	-	-	-	QAI1	QAI0
5	HART range							
: :								

HART range

When multiHART range is used, the HART range is arranged directly aligned after the byte with the QI bits of the analog inputs.

There are 6 bytes in the input area for the configuration with a multiHART area.

Table 2-1509 Address range for configurations with multiHART range

IB x +	HART range		
5	Acknowledgment		multiHART range
6 : 9	Value	HART variable	
10	QC		

Output range

There is one byte in the output area for the configuration with a multiHART area.

Table 2-1510 Output area of the Ex-AI 2xI 2-wire HART (AI 2 + 1 multiHART with QI)

QB x	Command	multiHART range

Evaluating the multiHART range

You can find information on this in section "Evaluating the multiHART range (Page 69)".

A.3.6 Address space in analog mode AI 2 + 4 HART with QI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input range
- "QC"stands for Quality Code
- "QAIn" stands for value status (QI) of analog input n
  You can find additional information in section "Evaluating the value status (Page 70)".

Address space in the configuration analog mode AI 2 + 4 HART with QI

The following tables show the allocation of the address space of the I/O module.

Addresses for the HART range are only available if no iHART variables have been configured in the properties dialog of the module.

Input area

The process values are shown in S7 format.

Table 2-1511 Input area of the Ex-AI 2xI 2-wire HART (AI 2 + 4 HART with QI)

IB x +	7	6	5	4	3	2	1	0
0...1	Analog value, analog input 0							
2...3	Analog value, analog input 1							
4	-	-	-	-	-	-	QAI1	QAI0
5	HART range							
: :								

HART range

When the HART variables are used, the HART range is arranged directly aligned after the byte with the QI bits of the analog inputs.

In the configuration with 4 HART variables in the input area, the area has a length of 20 bytes and always contains 4 HART variables, each with a 4-byte value and a 1-byte quality code (QC).

IB x +	HART range	
5 + 5n : 8 + 5n	Value	Configured HART variable n (n= 0 to 3)
9 + 5n	QC	

Double word n (n= 0 to 3); example: HART variable 3 = Byte (5 +3*5) = configured HART variable starts from Byte 20

Evaluating HART variables

You can find information on this in section "Evaluating HART variables (Page 70)".

A.3.7 Address space in analog mode AI 2 with QI and optional MSI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input range
- "QAIn" stands for value status (QI) of analog input n
  You can find additional information in section "Evaluating the value status (Page 70)".

Address space in the configuration analog mode AI 2 with QI / optional MSI with QI

The following tables show the allocation of the address space of the I/O module.

Input area

The process values are shown in S7 format.

NOTE
Configuration with MSI
The following applies when an I/O module is configured with MSI:

- Each subslot has its own **start address** (IB x +)**.**
- Each MSI submodule occupies its own address area with identical structure in the input area.
- The process input signals of the basic submodule (subslot 1) are mirrored to the MSI submodules as input signals.

Table 2-1512 Input area of the Ex-AI 2xI 2-wire HART (AI 2 with QI or with MSI for each subslot)

IB x +	7	6	5	4	3	2	1	0
0...1	Analog value, analog input 0							
2...3	Analog value, analog input 1							
4	-	-	-	-	-	-	QAI1	QAI0

A.3.8 Evaluating the multiHART range

You can select the multiHART range in the parameter assignment dialog.

The multiHART range occupies 1 byte in the output range (command) and 6 bytes in the input range (1 byte acknowledgment + 5 bytes HART variable).

You can read all HART variables available in the module using the multiHART area. To do so, you must request a HART variable from the module via the command byte in the output range.

The command byte identifies the requested HART variable (HART variable reference):

HART variable reference	
Bit 0...3: Variable identifier 1 = Primary 2 = Secondary 3 = Tertiary 4 = Quaternary	Bit 4...7: Channel number 0...1

The command is acknowledged via the acknowledgment byte in the input range. The requested HART variable can be evaluated as soon as the HART variable reference requested with the command can be read in the acknowledgment byte.

If you leave the command byte of the multiHART range unchanged, the module will continuously update the corresponding HART variable.

If an invalid HART variable reference is requested, this is also acknowledged accordingly. In this case, the value of the HART variable is zero and the quality code is output with $0x37_H$ (initialization value of the analog module).

Example:
The primary variable of channel 1 is to be read.

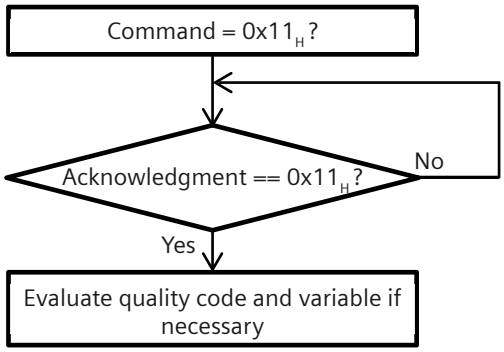

Figure 2-1296 Command = $0x11_H$

A.3.9 Evaluating HART variables

If you have configured (mapped) HART variables for the I/O module, then 4 HART variables with 5 bytes each are stored in the input address space.

Each HART variable consists of a 4-byte real value and a 1-byte quality code. The quality code describes the validity of the value.

The assigned HART variables are automatically updated by the I/O module and can be used directly in the user program.

A.3.10 Evaluating the value status

The following applies in the configurations with evaluation of the value status:

The input address space contains one value status (QI) bit for each analog input.

Notes on configuring when using a GSD/GSDML file (Page 17)

Evaluating the value status

Irrespective of the diagnostics enables, each value status (each QI bit) provides information on the validity of the corresponding process value.

- Value status = 1: Process value okay, "good"
- Value status = 0: Process value not okay, "bad"

Basically, the value status is set to "good" when the analog value can be acquired without error. The value status is set to "bad" in the following cases:

- The analog value cannot be acquired due to an error, e.g. faulty wiring.
- The analog input is disabled.

HART operating data records

B

B.1 HART command interface

Data records

The HART commands are sent as so-called external HART requests from the client (e.g. PDM) to the connected field device using data records. The response of the field device is provided again in the system using data records.

The HART communication may only be handled by one client per channel. If a channel is handled by several clients, the response made available by the I/O module cannot be allocated to one client with certainty. The I/O module does not support client management.

Rules

- After having written a request data record, a client must read the response data record before it may write another request data record.
- The client can evaluate the "processing status" in the response data record: If the "processing status" indicates "successful" or "error," the response data record contains current response data or error indications, respectively.
- The response data record must always be read completely because the I/O module may modify the data record after the initial reading with "successful" or "error" status.
  If the processing status in the response data record indicates "successful" or "error", the data record contains current response data or error displays.
- The client may only write a request data record to the I/O module again when it has read the response to the previously written request data record via the corresponding response data record. Otherwise, the response from the I/O module is overwritten.
- The STATUS component in the response frame (HART device status in the response data) provides information on whether errors have occurred and, if so, which errors.

Each request is stored on a channel-specific basis, and the corresponding request data record is locked. Another writing of the same request data record is thus not possible and is acknowledged with BUSY.
The lock of the request data record is reset after the termination or completion of the requested HART command.

SHC sequence

If a HART command with set SHC bit is sent to the I/O module, this channel is reserved for HART commands for 2 seconds. That is, no more internal HART commands are sent to the field device for this channel.

For each additional HART command with SHC bit set, the I/O module reserves this channel again for HART commands for an additional 2 seconds. Command 3 or 9 for reading the HART

variables starts being sent cyclically to the field device again if a HART command without a set SHC bit is detected for this channel, or if no further command is received for the channel within 2 seconds of the previous HART command.

Reading/writing data in RUN

HART operating data records are transferred to the module with the instruction "WRREC" and read by the module with the instruction "RDREC".

Errors during the transfer are indicated at output parameter STATUS of the "WRREC" or "RDREC".

The following HART operating data records are available:

Data record number	Description	Length (bytes)	Writable	Readable
80	HART job channel 0	240	Yes	Yes
81	HART response channel 0	240	No	Yes
82	HART job channel 1	240	Yes	Yes
83	HART response channel 1	240	No	Yes
121	HART variables	160	No	Yes
131	HART parameter channel 0	8	Yes	Yes
132	HART parameter channel 1	8	Yes	Yes
148	HART directory	25	No	Yes
149	HART feature data	3	No	Yes

B.2 HART job and response data records

HART commands are processed on a channel-specific basis via a separate command interface with one request data record and one response data record in each case.

Channel	Data record number	
	Request to the field device	Response from the field device
0	80	81
1	82	83

Structure of request data records 80 and 82

Byte	Meaning	Comment
0	Request control	
1	Number of preamble bytes	5...20, 255
2...239	Communication data according to HART specification	

Coding "Request control":

Bit 0...1: Reserved = 0

Bit 2: 0 = Parameters are not checked

Bit 3...4: Reserved = 0

Bit 5: 0 = Transparent format *
1 = Compact format

Bit 6: 1 = Enable SHC mode

Bit 7: 0 = HART Request

* HART commands are processed by the I/O module in transparent message format and in compact message format. However, the response data from the I/O module is always made available in transparent message format.

NOTE

When "Number of Preamble Bytes" = 255, the number of preambles set with the parameters is used. The default setting is five. You can reconfigure the number of preamble bytes using the HART-specific settings (see section HART-specific settings (Page 79)).

Structure of response data records 81 and 83

In case of response error

Byte	Meaning	Comment
0	Response control	
1	HART group error display	
2	Protocol error	
3...239	Response data according to HART specification	Only present when "Response result" = 6 = "Error, with data"

In case of error-free response

Byte	Meaning	Comment
0	Response control	
1	HART group error display	
2...239	Response data according to HART specification	Only present when "Response result" = 4 = "Successful, with data"

Coding "Response control":

Bits 0-2: Response result (processing status)

0 = Inactive
1 = Inactive (reserved)
2 = Waiting
3 = Waiting, executing
4 = Successful, with data
5 = Successful, without data
6 = Error, with data
7 = Error, without data

Bit 3: 0 = Burst mode not active;

Bit 4: 0 = Response data come directly from the HART device

Bit 5: 0 = Response data in transparent message format

Bit 6: 0 = SHC mode not active
1 = SHC mode active

Bit 7: 0 = HART response

Coding "HART group error display"

Bit number	Meaning	Explanation
0	Additional status information available	(2nd HART status byte) You obtain additional status information, if required, with HART command 48.
1	HART communication error	The field device has detected a communication error when receiving the command. The error information is in the first HART status byte
2	Parameter check	0: HMD parameters unchanged 1: Check HMD parameters
3	Reserved	Always 0
4...7	HART protocol error during response	0: Unspecified error 1: HMD error 2: Channel fault 3: Command error 4: Query error 5: Response error 6: Query rejected 7: Profile query rejected 8: Manufacturer-specific query rejected 9 - 15: Not used

Coding "HART protocol error during response"

HART protocol error during response	Meaning	Explanation
0	Unspecified error	Always 0
1	HMD error	0: Not specified 1: Internal communication error 2: Parameter assignment error 3: HW fault 4: Wait time expired 5: HART timer expired 6...127: Reserved 128...255: Manufacturer-specific
2	Channel fault	0: Not specified 1: Line fault 2: Short-circuit 3: Open line 4: Low current output 5: Parameter assignment error 6...127: Reserved 128...255: Manufacturer-specific
3	Command error	0-127: HART protocol, Bit 7 = Always 0
4	Query error	Bit 0 = 0: Reserved Bit 1 = 1: Receive buffer overflow Bit 2 = 0: Reserved Bit 3 = 1: Checksum error Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved
5	Response error	Bit 0 = 1: GAP timeout Bit 1 = 1: Receive buffer overflow Bit 2 = 1: Timeout Bit 3 = 1: Checksum error Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved
6	Query rejected	0: Unspecified 1: Compact format not supported 2: SHC not supported 3: Impermissible command 4: No resources 5: Channel in standby operation [1] 6 to 127: Reserved 128 to 255: Manufacturer-specific
7	Profile query rejected	0: Not specified (not supported)
8	Manufacturer-specific query rejected	0: Not specified (not supported)

[1] An external HART request was refused because the channel is not the active channel of a redundancy pair. The request must be sent to the connected field device via the partner module

Example of HART programming (HART command interface)

For HART channel 0, command 01 is to be sent in transparent message format to the HART field device with address "98 CF 38 84 F0".
A positive edge at input 4.0 of a digital input module leads to the writing of the HART command.

The following assumptions are made:

- The module address of the I/O module is 512 (200_H).
- The data record is stored in DB80: starting from address 0.0, length of 11 bytes.
- In this example, DB80 (request data record for channel 0) consists of 11 bytes.

```
                                        Explanation
    A I 4.0
    FP M 101.0
    = M 104.0
m2: CALL SFB53, DB53
    REQ :=M104.0                        Write request
    ID :=DW#16#200                      Module address
    INDEX :=80                          Data record number 80
    LEN :=11                            Length 11 bytes
    DONE :=M51.7
    BUSY :=M51.0
    ERROR :=M51.6
    STATUS :=MD92                       Block status or error information
    RECORD :=P#DB80.DBX0.0 BYTE 11      Source area in DB80
    A M 51.0
    SPB m2
    BE
```

Table 2-1513 DB80: Transparent message format

Byte	Initial value (hex)	Comment (Hex)
0	00	Req_Control (00 = Transparent message format. 40 = Transparent message format with SHC sequence)
1	05	Number of preamble bytes (05-14)
2	82	Start character (02 = Short Frame with command 0) (82 = Long Frame with other commands)
3	98	Address (with command 0, the address is exactly 1 byte long and has the value 0.)
4	CF	
5	38	
6	84	
7	F0	
8	01	Command (CMD)
9	00	Length in bytes
10	98	Checksum (CHK) (calculated as EXOR addition starting from byte 2 "Start character" up to the last byte of the command) The checksum must not be sent with the job.)

A HART command can also be sent in compact message format. In this case, the data transmitted via DB 80 is reduced to 4 bytes.

Table 2-1514 DB80: Compact message format

Byte	Initial value (hex)	Comment (Hex)
0	20	Req_Control (20 = Compact message format 60 = Compact message format with SHC string)
1	05	Number of preamble bytes (5...20, 255)
2	01	Command (CMD)
3	00	Length in bytes

You can learn when the response from the field device was received by cyclically reading data record DS81 for HART channel 0. The response is always supplied in transparent message format.

Table 2-1515 FC81: Reading of the response to DB81 with SFB 52

```
                                        Explanation
m3: CALL SFB52, DB52
    REQ :=M1                            Read request
    ID :=DW#16#200                      Module address
    INDEX :=81                          Data record number 81
    MLEN :=200                          Target length
    VALID :=M49.7
    BUSY :=M49.1
    ERROR :=M49.6
    STATUS :=MD100                      Block status or error information
    LEN :=MW104
    RECORD :=P#DB81.DBX0.0 BYTE 200     Target area in DB81
    A M 49.1
    SPB m3
    BE
```

The program part A M 49.1 to SPB m3 is only required if reading is to occur within a block cycle.

As long as the processing status (byte 0 of DB81) is at 3 (waiting, executing), the response has not yet been received from the field device. As soon as the processing status changes to greater than 3, the HART request is finished.

With a processing status of 4, the request finished without errors and the response data can be evaluated.

With a processing status of 5, the request also finished without errors but without response data from the field device.

With a processing status of 6 or 7, the request finished with errors. You can find more detailed information in byte 1 of DB81 (see table "HART group fault display") and for a HART protocol error also in byte 2 of DB81 (see table "HART protocol error during response").

B.3 HART directory

Structure of the HART directory

Byte	Meaning	Comment
0	Profile Revision Number	= 2, 0 (Revision 2.0)
1		
2	Index of Client Management	= 255 (not relevant)
3	Number of Clients	= 1
4	Number of Channels	= 2
5	Write Read Index Offset	= 1 (The response to a job data record is made with the data record number of the request data record + 1)
6	Index of HMD Feature Parameter	= 149
7	Index of HMD Module Parameter	= 255 (not relevant)
8	Start Index of Burst Buffer Area	= 255 (not relevant)
9+n	Index of HMD Channel Parameter (Channel n)	= 131+n
9+n+4	Index of HART Client Channel Message Data	= 80+(2*n) The HART request data records cannot be configured. Data records starting from data record number 80 (80, 82) are always used.

B.4 HART feature data

Structure of the HART feature data

Byte	Meaning	Comment
0	Byte 0	= 0x62 Bit 1 = 1: "Parameter check result is given with a read response" Bit 5 = 1: "Compact format is supported"
1	Byte 1	= 0
2	Max Length Data Unit	= 240 (maximum length of the HART request data records)

B.5 HART variable data record

The I/O module supports a maximum of 4 HART variables per channel, which are read cyclically, provided that this is supported by the connected field device.
These HART variables are readable in HART variable data record 121.

Each HART variable consists of a 4-byte real value and a 1-byte quality code.

Structure of the HART variable data record

Byte	Meaning	
Channel 0		
0...3	Value	Primary Variable (PV)
4	Quality code	
5...8	Value	Secondary Variable (SV)
9	Quality code	
10...13	Value	Tertiary Variable (TV)
14	Quality code	
15...18	Value	Quaternary Variable (QV)
19	Quality code	
Channel 1		
20...39	HART variables same as for channel 0	

If HART is not enabled or the respective HART variable is not supplied from the connected field device, the corresponding variable = 0 and the QC = 0x37 (initialization value from the analog module).

B.6 HART-specific settings

HART communication is available via standard parameter assignment.

You can define additional HART-specific settings on a channel-specific basis using data records 131 to 132.

The parameters set in the CPU are not changed and are also valid after a startup.

Every new parameter assignment of the analog module resets the HART-specific settings back to the initial values from parameter data record 128.

The I/O module does not apply the HART-specific settings if there is no supply voltage L+.

Channel	Data record number
0	131
1	132

Structure of the HART-specific settings

Byte 0	7 6 5 4 3 2 1 0 Must be 128	Bit 7 is reset after evaluation of data record by module
Byte 1	7 6 5 4 3 2 1 0 Must be 5	Offset for manufacturer-specific parameters according to HART specification
Byte 2	7 6 5 4 3 2 1 0 	Number of HART repetitions (0...10) Initial value from parameter data record 128
Byte 3	7 6 5 4 3 2 1 0 	Number of HART preamble bytes (0, 5...20, 255) Initial value = 5*
Byte 4	7 6 5 4 3 2 1 0 Must be 0	Field device mode according to HART specification
Byte 5	7 6 5 4 3 2 1 0 	Client timeout in s (1...255 s) Initial value = 60 s
Byte 6	7 6 5 4 3 2 1 0 0 0 0 0 0 0 | | 1 = Enable HART 0 = Disable HART 1 = Primary master 0 = Secondary master	Initial value corresponding to HART activation from parameter data record 128 Always as primary master
Byte 7	7 6 5 4 3 2 1 0 Must be 0	Reserved

Figure 2-1297 Settings

* When the number of HART preamble bytes = 0, the number of preamble bytes required by the connected field device are used, but no fewer than 5.
When the number of HART preamble bytes = 255, then 20 preamble bytes are used.

Analog value display

C

C.1 Representation of analog values in the current measuring ranges

Display/measuring range

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table 2-1516 Current measuring ranges 0 to 20 mA

Values		Measuring range	Range
Hex.	**Dec.**	**0 to 20 mA**	
7FFF	32767	>23.52 mA	Overflow
7EFF	32511	23.52 mA	Overrange
6C01	27649		
6C00	27648	20 mA	Nominal range
5100	20736	15 mA	
1	1	723.4 nA	
0	0	0 mA	

Table 2-1517 Current measuring ranges 4 to 20 mA and 4 to 20 mA HART

S7 definition				**Values**		**Measuring range**	**NE43**			
Interrupt	**QI**		**Ranges**	**Hex.**	**Dec.**	**mA**	**Ranges**		**QI**	**Interrupt**
Overflow	bad	7FFF	Overflow range	7FFF	32767	>22.81 mA	High failure range	7FFF	bad	Overflow
	good	Process values	Overrange	7EFF	32511	22.81				
				72C0		21				
							Hysteresis			
				6F60		20.5				
							Measuring range	Process values	good	
			Nominal range	6C00	27648	20				
				1	1	4 mA + 578.7 nA				
				0	0	4				
			Under-range	FFFF	-1	3.9994				
				FEA6		3.8	Hysteresis			

S7 definition				Values		Measuring range	NE43			
Interrupt	**QI**		**Ranges**	**Hex.**	**Dec.**	**mA**	**Ranges**		**QI**	**Interrupt**
	good	Process values	Under-range	FD4D		3.6	Low failure range	8000 / 7FFF	bad	Underflow / Wire break
				ED00	-4864	1.185				
Underflow / Wire break	bad	8000	Underflow range	8000	-32768	< 1.185 mA				

SIEMENS

SIMATIC

ET 200SP HA / ET 200SP Ex-AQ 2xI HART

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Security information 1

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

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Preface

2

Validity of the documentation

This documentation describes the following I/O module:

System	Module type	Article number
Distributed I/O System; ET 200SP and ET 200SP HA	Ex-AQ 2xI HART	6DL1135-6TB00-0HX1

This documentation supplements the following documentation:

- System manual *Distributed I/O System, ET 200SP | ET 200SP HA; Modules for devices in the hazardous area*

Functions that generally relate to the ET 200SP and ET 200SP HA are described in the respective system documentation:

- System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)
- System manual Distributed I/O System ET 200SP HA (https://support.industry.siemens.com/cs/ww/en/view/109761547)

The information in this manual and the system/function manuals enables you to put the modules for hazardous areas into operation.

Conventions

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

These documentation contain a description of the components that was valid at the time the operating instructions were published. We reserve the right to include product information with information updates with new components and components with a new product status.

Product overview

3

3.1 Properties of the I/O module Ex-AQ 2xI HART

View

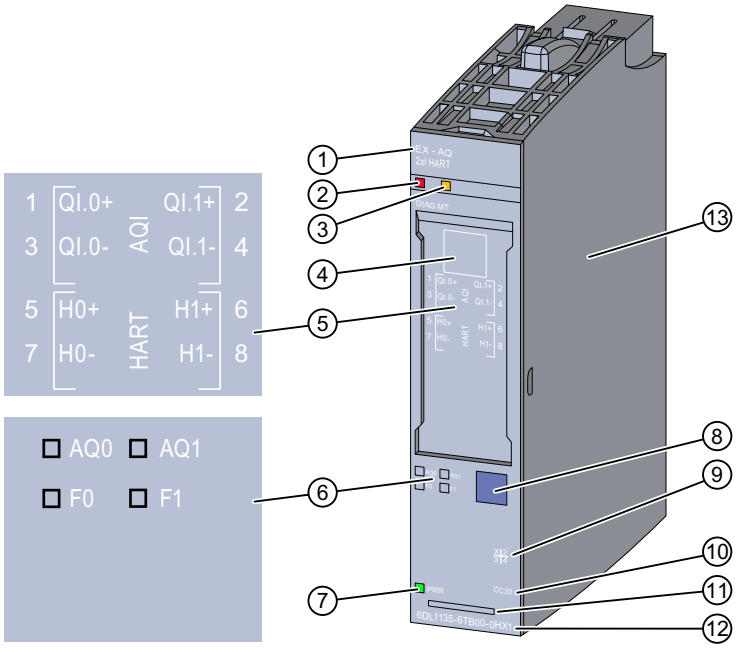

①	Module type and designation	⑧	Module type color coding
②	LED for diagnostics	⑨	Function version
③	LED for maintenance	⑩	Color code for selection of the color-coded labels
④	2D matrix code	⑪	Serial number
⑤	Wiring diagram	⑫	Article No.
⑥	LEDs for channel status/channel fault	⑬	Labeling surface (symbols and standards)
⑦	LED for supply voltage		

Figure 2-1298 View of the Ex-AQ 2xI HART

You can find information on the LEDs in section Status and fault displays of the I/O module Ex-AQ 2xI HART (Page 27).

Properties

The I/O module is used to connect intrinsically safe actuators and HART field devices.

The I/O module has the following technical properties:

Two analog outputs with the following configurable properties

- Current output in output areas 0 to 20 mA, 4 to 20 mA and 4 to 20 mA HART
- Diagnostics
- Substitute values

Module-specific configurable diagnostics

The module supports the following functions

The I/O module supports the following functions:

- Firmware update
- I&M identification data
- Parameter reassignment in RUN
- Value status QI
- Module Shared Output (MSO)
- HART communication (Rev. 5 to Rev. 7)
- Up to 4 HART variables directly in the input area
- A multiHART area in the input/output area

Accessories

The following accessories must be ordered separately:

- Labeling strips
- Color-coded labels
- Reference identification label
- Shield connector

3.2 2D Matrix code (QR code / EAN code)

The 2D matrix code on the product is a coded representation of the product-specific article number.

Access to product-related information

For reading the 2D matrix code, SIEMENS offers an app for mobile use.
Information about the app and the download can be found on the Internet: "Mobile use via app (https://support.industry.siemens.com/cs/ww/en/sc/2067)".

The app provides direct access to the technical forum and product-related posts, such as:

- FAQs
- Application examples
- Manuals
- Certificates
- Product notices

Wiring

4

4.1 Ex BaseUnit

You can operate the I/O module with the following Ex BaseUnit:

- Ex-BU Type X1 (6DL1 193-6BP00-0BX1)

The Ex BaseUnit is not included in the scope of delivery of the Ex I/O module and must be ordered separately.

NOTE

You can find additional information on the configuration in the system manual.

The terminal block for connecting the I/O signals is part of the Ex BaseUnit for Ex I/O modules and cannot be mounted separately.

Connections on the slot and Ex I/O module

The following figure shows the connections on the Ex BaseUnit and the I/O module.

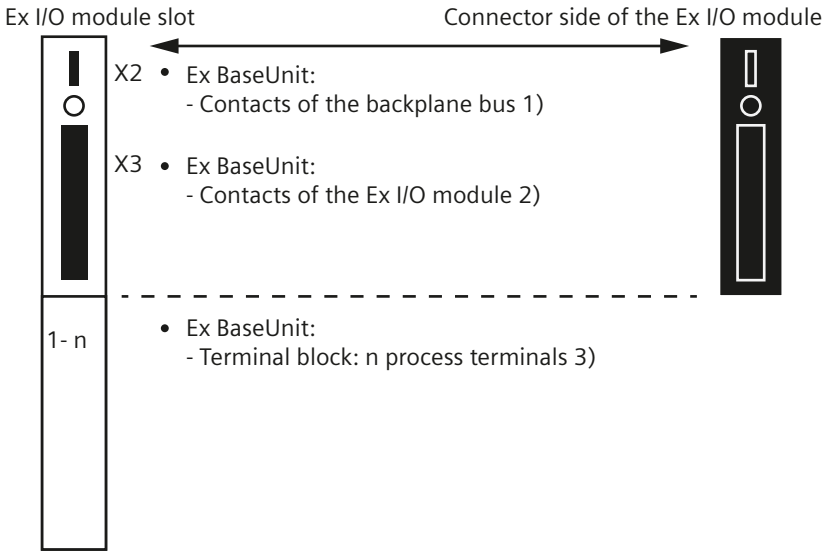

1) Ex BaseUnit contacts of the backplane bus (max. 50 mA; 3.3 V DC ⎓)

2) Ex BaseUnit contacts for process signal transmission (for maximum voltages and currents, refer to the documentation of the respective I/O module)

3) Process terminals on the terminal block (number, maximum/permissible voltages and currents, refer to the documentation of the respective I/O module).

Information on the pin assignment of the I/O module (terminal block) can be found in the following sections.

4.2 Pin assignment of the I/O module Ex-AQ 2xI HART

General pin assignment

Table 2-1518 Pin assignment of Ex-AQ 2xI HART

Terminal	Assignment	Terminal	Assignment	Terminal block	Explanations
1	QI_0+	**2**	QI_1+	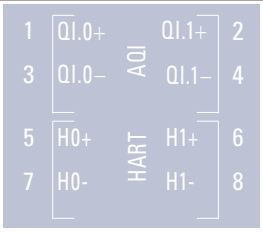	Terminal 1 and 2: QI_n+: Output signal "+", channel n (0;1) Terminal 3 and 4: QI_n-: Output signal "-", channel n (0;1) Terminal 5 to 8: Hn: HART test terminals Hn+/Hn- (note operating mode)
3	QI_0-	**4**	QI_1-		
5	H0+	**6**	H1+		
7	H0-	**8**	H1-		

NOTE

Use shielded cables to ensure safe operation in environments susceptible to interference. If you use unshielded cables, you need to note that the output value may be affected by external electromagnetic interference.

Examples

You can find information on connecting an actuator in section "Connection of an actuator (Page 11)".

4.3 Pin assignment

4.3.1 Connection of an actuator

Pin assignment channel 0

2-wire connection	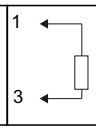

NOTE

Parallel connection of the outputs to increase the power is not permitted.

Each actuator must be connected separately to the corresponding terminals (QIn+ and QIn-) (no common cable routing).

4.3.2 Connection of external handheld device

Pin assignment of external handheld device

External handheld device (optional)	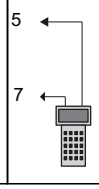

NOTE

Here you can connect a handheld device for diagnostics and parameter assignment of the actuators. The diagnostic terminals are directly electrically connected to the output terminals. The calculation of and adherence to the Ex characteristic values in the plant is the responsibility of the plant operator.

4.4 Schematic circuit diagram

The following figure shows the schematic circuit diagram of the Ex I/O module.

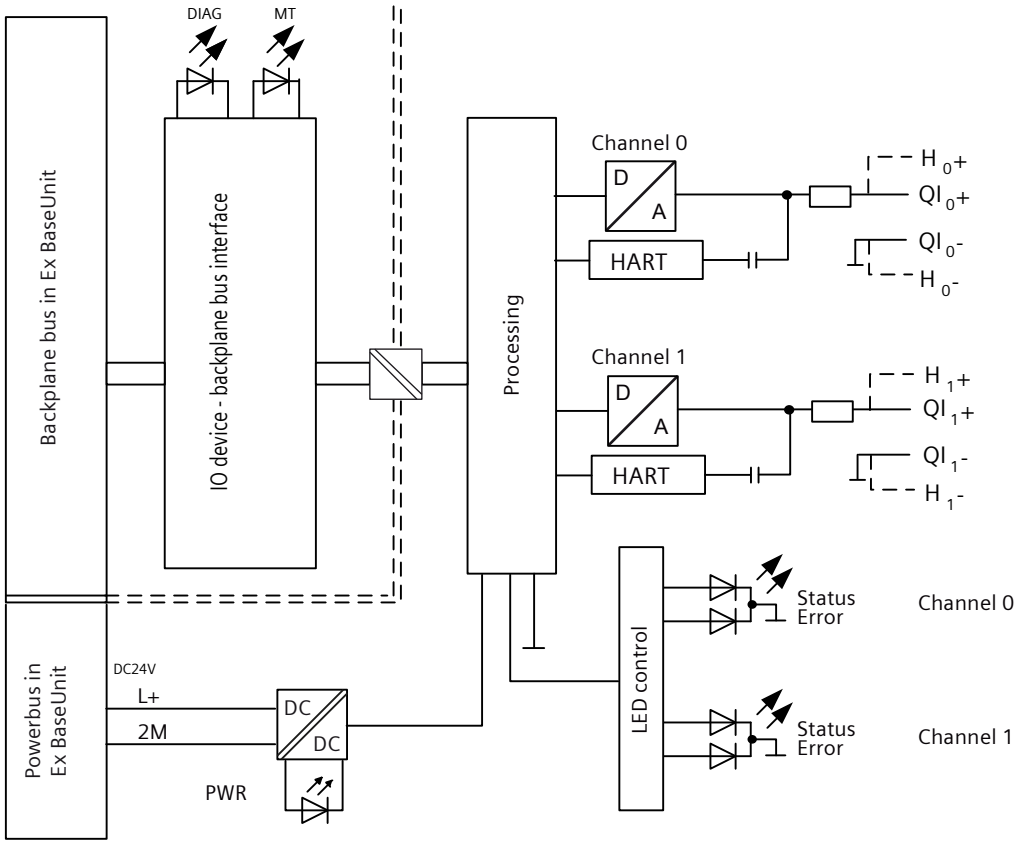

Figure 2-1299 Schematic circuit diagram Ex-AQ 2xI HART

Supply voltage

The supply voltage L+/2M is generated and monitored by the Ex power module. The Ex I/O module receives its supply voltage L+ via the power bus. Further monitoring of the supply voltage is performed in the Ex I/O module. During parameter assignment, you can specify whether a diagnostic message is to be output in the event of failure of the supply voltage.

Firmware update

The supply voltage L+ must be available on the Ex I/O module at the start of firmware update and during the update.

4.5 Potential group in hazardous areas

Potential group

With the modules for hazardous areas, the Ex power module and the Ex I/O module plugged into the right of the Ex power module form a potential group.

The potential group ends when one of the following modules is plugged in to the right of an Ex I/O module:

- Ex power module
- Server module

Configuring

5

5.1 Configurations of the I/O module Ex-AQ 2xI HART

Requirements

You configure the I/O module

- in the TIA Portal
- with PCS 7
- with PCS neo
- with STEP 7

The version required in each case is specified in the technical specifications

Configuration via GSD/GSDML

Notes for configuration using a GSD/GSDML file (Page 17)

Restrictions when using in ET 200SP

- When used with a standard IM, its firmware must be at least at version V3.3.
- No MSI is available for a PROFIBUS DP station.
- TIA Portal:
  - TIA Portal as of V17.0
    The module can be centrally configured on the following CPUs:
    - CPU 1510SP-1 (as of V2.6)
    - CPU 1512SP-1 PN (as of V2.6)
    - CPU 1515SP-1 PN (as of V2.6)
  - The module cannot be used behind fail-safe controllers.

Configurations

Depending on the desired configuration, you have to select the required version of the I/O module from the hardware catalog.

The following configurations are possible:

Configuration [1]	Version of the I/O module in the hardware catalog of the engineering tool.	Required parameter assignment of the module
Analog mode AQ 2 without QI	**Ex - AQ 2xI HART**	• "Value status" parameter deactivated
Analog mode 2 AQ AQ 2 + 1 multiHART without QI [2]		• "Value status" parameter deactivated • "HART variables" parameter: 1 multiHART
Analog mode AQ 2 + 4 HART without QI [3]		• "Value status" parameter deactivated • "HART variables" parameter: 4 HART
Analog mode AQ 2 + 1 multiHART with QI [2]		• "Value status" parameter activated • "HART variables" parameter: 1 multiHART
Analog mode AQ 2 + 4 HART with QI [3]		• "Value status" parameter activated • "HART variables" parameter: 4 HART
Analog mode AQ 2 with QI [3]		• "Value status" parameter activated • Optional configuration: "MSO with QI" [2] Configuration change is possible in RUN. You can find information on MSO in section "Module-internal Shared Output (MSO) (Page 22)".

[1] When configuring via GSDML, all configurations can be directly selected in the hardware catalog of the engineering tool.

[2] Not available for configuration using a GSD/GSDML file.

[3] Not available for configuration using a GSD file.

NOTE

Changing the configuration in CPU RUN

You can re-configure the I/O module when the CPU is in RUN in the following cases:

- When the loaded configuration (version of the I/O module in the module catalog) is maintained
- When a MSO subslot is added or removed

If you want to define a different configuration in CPU RUN, the following steps are required:

1. Remove the I/O module from the loaded configuration in CPU RUN.
2. Configure the I/O module including the required configuration-specific parameters.
3. Load the new configuration in CPU RUN.

Note that changing the configuration changes the I/O address range.

Parameters

You define the operating mode of the I/O module via channel/technology parameters (data record 128).

5.2 Notes for configuration using a GSD/GSDML file

Files for configuration using GSD/GSDML

If you need the GSD/GSDML files for configuration, you can download them on the Internet:

- PROFINET GSD file (GSDML) for ET 200SP HA (http://support.industry.siemens.com/cs/ww/en/view/109781191)
- PROFINET GSD files for ET 200SP (http://support.automation.siemens.com/WW/view/en/57138621)
- PROFIBUS GSD files for ET 200SP (http://support.automation.siemens.com/WW/view/en/73016883)

Restrictions when using a GSDML file for PROFINET configuration

The following functions are not available in the process image of the I/O module:

- MSO
- multiHART

Restrictions when using a GSD file for PROFIBUS configuration

The following functions are not available in the process image of the I/O module:

- MSO
- Value status
- HART variables
- multiHART

5.3 Module/channel parameters

Parameters of Ex-AQ 2xI HART

You have the following setting options:

Table 2-1519 Adjustable parameters and their default setting

Parameter	Value range	Default	CiR [1]	Efficiency range		
				HSP [2]	GSDML [3]	GSD [4]
Diagnostics Missing supply voltage L+	• Enabled • Disabled	Disabled	Yes	Module	Module	Module
Output type/range	• Disabled • Current 0 ... 20 mA • Current 4 ... 20 mA • Current 4 ... 20 mA HART	Current 4 ... 20 mA HART	Yes	Channel	Channel	Channel
Diagnostics Short-circuit	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Diagnostic Wire break	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Diagnostics Underflow	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Diagnostics overflow	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Diagnostics HART	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Reaction to CPU STOP	• Shut down • Keep last value • Output substitute value	Shut down	Yes	Channel	Channel	Module
Substitute value	The value range depends on the set output area. The substitute value must be in the nominal range or in the overrange/underrange.	0	Yes	Channel	Channel	Channel
Number of HART frame repetitions	0 ... 10	5	Yes	Channel	Channel	-
Potential group	Potential group of the left intrinsically safe power module	Potential group of the left intrinsically safe power module	No	Module	Module	Module

1) CiR = Configuration in RUN

2) HSP = Configuration via Hardware Support Package (HSP) of the process control

3) GSDML = Configuration using a GSDML file

4) GSD = Configuration using a GSD file

NOTE
Unused channels
"Disable" an unused channel in the configuration; this improves the cycle time of the module.
A disabled channel always returns the output value 0 mA.

5.4 Explanation of parameters

5.4.1 Diagnostics Missing supply voltage L+

Defines whether a diagnostic interrupt is generated when the supply voltage L+ is missing or is too low.

The supply voltage is generated by the Ex power module. Other internal defects can be detected and reported via the additional diagnostics for the Ex I/O module.

5.4.2 Output types and output ranges

Output type/range

The I/O module has the following output areas:

Table 2-1520 Output areas

Output type	Output area	Resolution
Disabled	-	-
Current	0 ... 20 mA	15 bits
Current	4 ... 20 mA	15 bits
Current	4 ... 20 mA HART [1)]	15 bits

[1)] HART mode is only possible in the 4 to 20 mA HART output area. HART communication is not interrupted even at currents below 4 mA.

An overview of the output areas, overflow and overrange etc. can be found in the appendix "Representation of analog values in the current output ranges (Page 81)".

Settling time dependent on the activation of HART communication

If no HART communication is activated for the output area, the settling time of the output value is up to 1 ms.

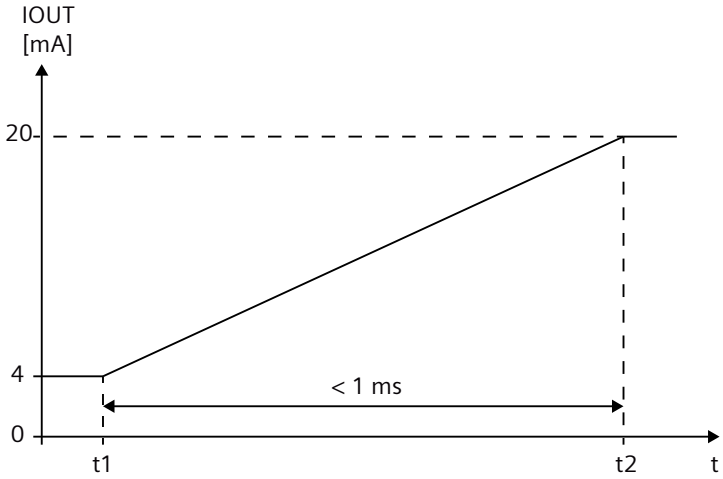

Figure 2-1300 Example diagram of settling time without HART communication

If HART communication is activated for the output area, the settling time of the output value is increased to 50 ms so that the modulated HART frame is not interrupted.

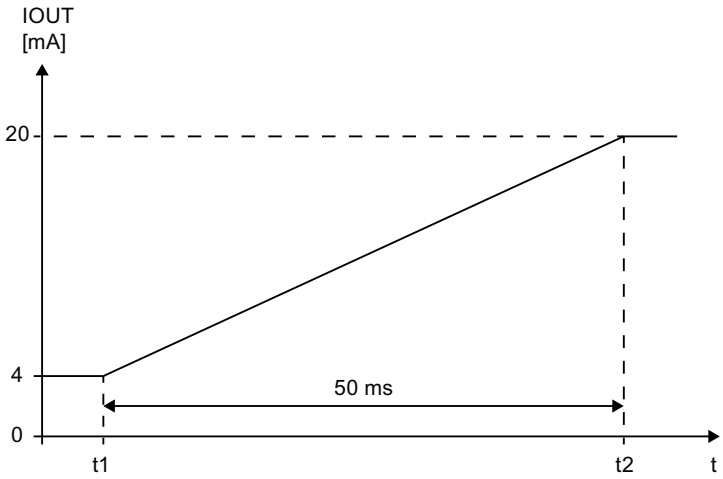

Figure 2-1301 Example diagram of settling time with HART communication

5.4.3 Diagnostics Short-circuit

Enable or disable diagnostics Short-circuit.

Short-circuit detection is possible for all current output ranges (short-circuit of output QI_n+ to QI_n-).

Monitoring is effective from an output current of at least 1 mA.

The diagnostics short-circuit applies from a connected load of < 20 Ω. From a load of > 30 Ω, the short-circuit is reported as outgoing again.

5.4.4 Diagnostics: Wire break

Specifies whether a diagnostic interrupt is generated when the wire break test current is undershot.

Monitoring is effective from an output current of ≥ 240 µA.

If the output current drops below 240 µA when the "Wire break" diagnostic message is pending, the diagnostic message cannot be canceled until the output current is set above 240 µA again and the error has been eliminated.

5.4.5 Diagnostics: Underflow

Enable or disable diagnostics Underflow.

An underflow diagnostic message occurs if diagnostics is activated and the default output value falls below the limit of the underrange.

The current output is limited to this value if the limit of the underrange is violated.

5.4.6 Diagnostics: Overflow

Enable or disable diagnostics Overflow.

An overflow diagnostic message occurs if diagnostics is activated and the default output value exceeds the limit of the overrange.

The current output is limited to this value if the limit of the overrange is violated.

5.4.7 Diagnostics: HART

Enable or disable diagnostics for HART frame-specific monitoring and the status information provided by the connected field device in a HART frame (HART device status).

HART diagnostics are reported as maintenance messages.

5.4.8 Reaction to CPU STOP

Specifies the behavior of the analog output as a reaction to CPU STOP or to failure of communication between the interface module and CPU.

5.4.9 Substitute value

The substitute value is output by the module at CPU STOP if you set the "Reaction to CPU STOP" parameter to "Substitute value".
The substitute value must not exceed the overrange and must not fall below the underrange.

5.4.10 Number of HART frame repetitions

Specifies the number of HART frame repetitions. If the module receives no response or a response with errors to a HART frame sent to the field device, the frame is repeated i.e. sent to the field device again.

NOTE

Because HART communication of the individual channels is multiplexed, faulty HART frames will influence the other channel if the number of HART repetitions is high. In other words, the other channel is accordingly processed less frequently.

5.4.11 Potential group

A potential group consists of a group of directly adjacent Ex IO modules within a station of the distributed I/O (IO device), which are supplied via a common Ex power module.

A potential group begins with an Ex power module, via which the required supply voltage for all Ex I/O modules of the potential group is supplied. The Ex power module interrupts the self-assembling voltage buses to the left neighbor.

The Ex I/O modules take the potential of the self-assembling voltage buses from the left neighbor.

A potential group ends with the BaseUnit, which follows an Ex power module or a server module in the station configuration.

You can find additional information on the configuration of the potential group in the system manual *Distributed I/O System; ET 200SP and ET 200SP HA, Modules for hazardous areas*.

5.5 Module-internal Shared Output (MSO)

The function enables several IO controllers to access the output data of the I/O module.

- With MSO, the following data of the I/O module (basic submodule) is copied to up to three MSO submodules as input data of the MSO submodules:
  - Output data of the basic submodule
  - The QI information of the basic submodule
- Each of the four submodules can be assigned to an IO controller, whereby these can be different or identical IO controllers.
  - This IO controller assigned to the basic submodule has write access to the outputs of the I/O module and read access to the QI information of the basic submodule.
    The basic submodule therefore occupies input and output addresses in the process image of the IO controller.
  - The IO controllers to which the MSO submodules are assigned have read access to the outputs and the QI information of the basic submodule. MSO submodules therefore only occupy input addresses in the IO controller's process image.
- Only the basic submodule is configured and can return diagnostic interrupts.
  MSO submodules are not configurable and do not return interrupts.

The following figure shows an analog output module with the basic submodule and three MSO submodules. Each submodule is assigned to an IO controller. The diagnostics and parameter assignment of the analog output module is possible via the basic submodule from the IO controller 1.

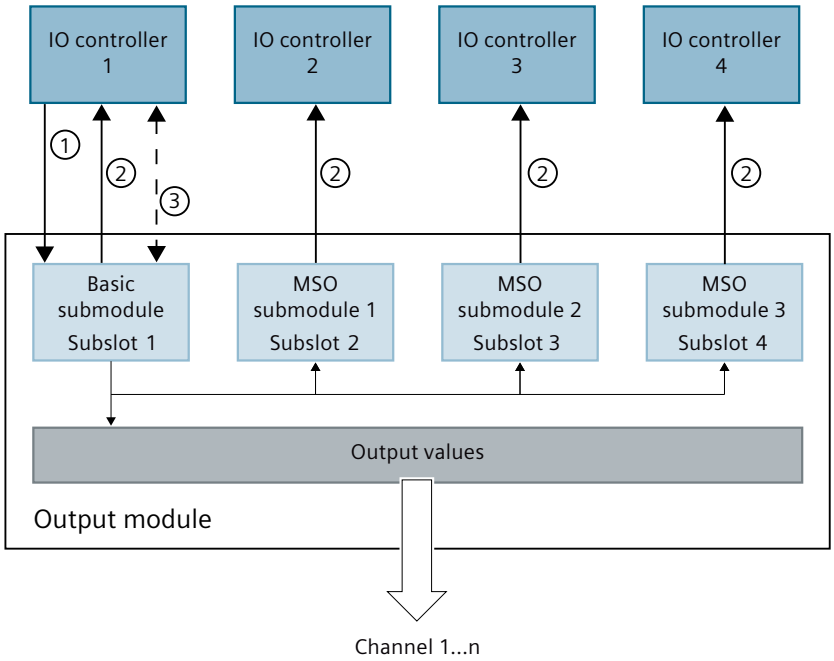

① Write access

② Read access

③ Parameter assignment and system diagnostics

Figure 2-1302 Input module with MSO configuration

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule in question.

With the basic submodule (= subslot 1), the value status "0" indicates that the value is incorrect.

With an MSO submodule (= subslot 2 to 4), the value status "0" indicates that the value is incorrect or that one of the following errors has occurred:

- The basic submodule is not yet parameterized (not ready).
- The connection between the PROFINET IO controller and the basic submodule is interrupted.
- The IO controller of the basic submodule is in STOP mode or POWER OFF.

NOTE

Restrictions

- **PROFINET required**
  MSO is only available with configuration with PROFINET.
- **No configuration with PCS 7**
  No support for configuration with PCS 7.
- **No configuration via GSD/GSDML**
  No support of MSO during configuration via GSD/GSDML.
  Notes for configuration using a GSD/GSDML file (Page 17)

Configure MSO for an I/O module

You set the configuration on the basic submodule (subslot 1).

NOTE

If "MSO" is configured for an I/O module, this applies to all channels of the I/O module.

If MSO is to be configured, the value status QI must always be configured as well.

---

1. Select the configuration based on the following table.
2. Select the number of MSO submodules in the properties of the I/O module. This parameter assignment can be performed in CPU RUN.

You can find additional information on this in the section "Address space in analog mode (Page 60)".

NOTE

Configuration of the controllers

Please note that you have to perform the configuration of the signals for the IO controllers which are not directly connected to the IO device separately.

Changing the MSO configuration in RUN

The parameter "Value status" must always be activated.

Configuration	Version of the I/O module in the module catalog (HW Config)	Parameter assignment of the module
Analog mode AQ 2 with QI (optional "MSO with QI")	**Ex - AQ 2xI HART**	Number of additional submodules: (Change in CPU RUN possible) • 1 to 3: MSO is enabled • 0: MSO is disabled

Additional information

- Find out how to assign MSO submodules to an IO controller in the documentation *SIMATIC; Distributed I/O System ET 200SP/ET 200SP HA, Modules for uses in hazardous areas*.
- How to configure access to a shared device and the function MSI / MSO in STEP 7 can be found in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109736536).

5.6 HART mapping parameters

A maximum of 4 HART variables can be configured (mapped) to the address space of the module with the HART mapping parameters.

If you want to use the maximum of 4 HART variables directly in the input area of the I/O module, assign these parameters in the properties dialog of the I/O module.

HART mapping is not supported with configuration via PROFIBUS GSD file.

Parameters

Table 2-1521 HART mapping parameters of the I/O module

Parameter		Value range	Default	Parameter reassignment in RUN
Variable 1	Channel	0...1	0	Yes
	Type	• Non / CiR • Primary • Secondary • Tertiary • Quaternary	Non / CiR	Yes
: :				
Variable 4	Channel	0...1	0	Yes
	Type	• Non / CiR • Primary • Secondary • Tertiary • Quaternary	Non / CiR	Yes

See also

Parameter assignment and structure of the HART mapping parameters (Page 56)

Displays and interrupts

6

6.1 Status and fault displays of the I/O module Ex-AQ 2xI HART

6.1.1 Status and error displays of the I/O module

LED displays

The following figure shows the LED displays of the I/O module.

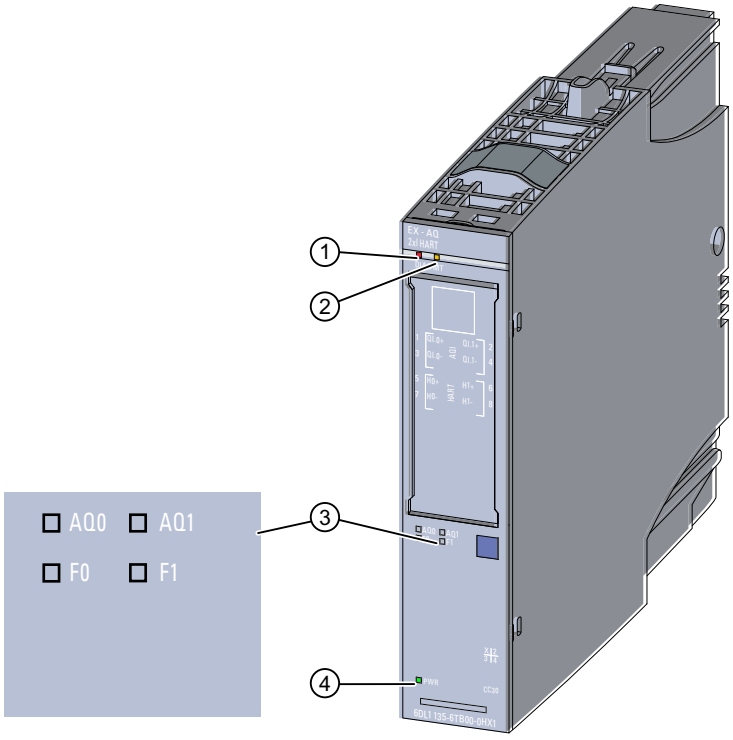

① DIAG LED (green/red)

② MT LED (yellow)

③ LED channel status AQn (green) and LED channel fault Fn (red) - channel n (n = 0 and 1)

④ PWR LED (green)

Figure 2-1303 LED displays

Meaning of the LED displays

The tables below explain the meaning of the status, error and maintenance displays.

You can learn about corrective measures for messages as well as possible causes in the following section:

Diagnostic and maintenance messages (Page 57).

6.1.2 Diagnostics display of the DIAG LED

DIAG LED

Table 2-1522 Diagnostics display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the system is disrupted or switched off.
Flashes	Module is not configured.
On	Module is configured, a diagnostic message is not pending.
Flashes	Module is configured, at least one diagnostic message is pending.

6.1.3 Diagnostics display of the MT LED

MT LED

Table 2-1523 Maintenance display of the MT LED

MT LED	Meaning
Off	No maintenance required.
On	Maintenance is required, that is, at least one maintenance event has occurred.

6.1.4 Diagnostics display of the Channel status LED / channel fault LED

Channel status/channel error LED

The green channel status LED indicates whether the channel is enabled. The green LED does not light up if a channel diagnostic or a module diagnostic result is pending for an activated channel.

The red channel fault LED is lit when channel diagnostics for an enabled channel is pending.

Table 2-1524 Status and error displays of the channel status/channel fault LEDs

Channel status LED	Channel fault LED	Meaning
□ Off	□ Off	• Channel disabled or module switched off • Module diagnostics pending
■ On	□ Off	Channel enabled and no channel/module diagnostics pending
□ Off	■ On	Channel enabled and channel diagnostics pending

6.1.5 Diagnostics display of the PWR LED

PWR LED

Table 2-1525 Status display of the PWR LED

PWR LED	Meaning
□ Off	The supply voltage L+ is missing for the potential group.
■ On	The supply voltage L+ is available for the potential group.

6.2 Interrupts

The I/O module supports diagnostic interrupts. Diagnostic and maintenance messages are output via diagnostic interrupts.

You can find more information on this in the appendix:

- Diagnostic and maintenance messages (Page 57)

Diagnostic messages

The I/O module generates a diagnostic message at the following events:

- No supply voltage
- Overflow
- Short-circuit
- Wire break

- Parameter assignment error
- Module is faulty
- Retentive memory in the BaseUnit is defective.
- Invalid BaseUnit
- Channel/component temporarily unavailable
- Overtemperature
- Underflow

NOTE
A pending "Module is defective" diagnostic is not deleted by the module until a restart.

Maintenance messages

The I/O module generates a maintenance message when the following events occur:

- HART communication error
- HART primary variable outside limits
- HART analog output current of field device saturated
- HART output current of the field device specified
- HART additional status information available
- HART configuration changed
- HART malfunction in the field device
- HART secondary variable outside the limits
- Retentive memory in the BaseUnit is defective.

HART function

7

7.1 Application

7.1.1 Useful information on use

Reference is made to the functions and use of HART in the following.

Use of HART

The use of HART modules enables you to exchange additional data with the connected HART field devices.

Only one HART field device may be connected to a channel of the HART modules.

You can commission and re-configure the HART field devices.

HART (Page 32)

Advantages of HART

Using the I/O module with HART offers the following advantages:

- Connection compatibility with standard analog modules: Current loop 4 - 20 mA
- Numerous field devices with HART functions are in use
- Application of HART devices on an IO device based on the ET 200SP HA or ET 200SP HA
- Additional digital communication using the HART protocol

  HART protocol (Page 32)

HART applications

The following applications are typical:

- Commissioning of field devices (centralized parameter assignment)
- Online modification of field device parameters
- Information, maintenance and diagnostic displays for the field devices
- Integration of configuration tools for field devices via the HART interface

Commissioning a HART field device

To minimize the startup time of a HART field device, the HART field device should be set to the short address 0.

After switching on the module, the module searches for HART field devices via the short address.

- The search always starts at the short address 0.
- If a field device with a short address not equal to 0 is found, its short address is automatically re-configured to 0 (HART command 6).

During the startup time, the module reports a HART communication error.

7.1.2 HART

Definition

"HART" (Highway Addressable Remote Transducer) refers to remote controlled field devices, such as sensors, transmitters or actuators, that can be addressed via communication.

The HART functionality also enables you to use the I/O module to exchange data with the connected field devices. The HART protocol is generally accepted as a standard protocol for communication with intelligent field devices.

HART is a registered trademark of the HART Communication Foundation (HCF), which owns all the rights to the HART protocol.
You can find detailed information about HART in the HART specification.

7.1.3 HART protocol

Definition

The HART protocol describes the physical form of the transfer:

- Transmission procedures
- Message structure
- Data formats
- Commands

Description

Each HART telegram (request frame) sent from the module to the connected field device and each HART telegram (response frame) received by the field device has the following basic structure:

PREAMBLE	STRT	ADDR	COM	BCNT	STATUS	DATA	CHK

PREAMBLE:	Bytes (0xFF) for synchronizing. 5 to 20 bytes depending on parameter assignment
STRT:	Start character (start delimiter)
ADDR:	Address of the field device (1 byte; short address or 5 bytes; long address)
COM:	HART command number
BCNT:	Byte count, number of bytes to follow without checksum
STATUS:	HART device status (1st and 2nd status byte). Only present for a response frame. HART device status (Page 36)
DATA:	Transferred user data / parameters, quantity depending on command (0...230 bytes)
CHK:	Checksum

With the exception of the preamble bytes, this structure is contained in the communication data of the HART command interface.

HART job and response data records (Page 72)

- HART responses always contain data.
- Status information (HART device status; 1st and 2nd status bytes) is always sent together with a HART response.
- You should evaluate this information to make sure the response is correct.

7.2 System connection

7.2.1 Useful information about system connection

The system connection and the parameter assignment of the field devices is described below.

System environment

To use an intelligent field device with HART functionality, you require the following system environment:

- 4 to 20 mA current loop
- Connecting field devices to the I/O module

The system connection is shown as follows:

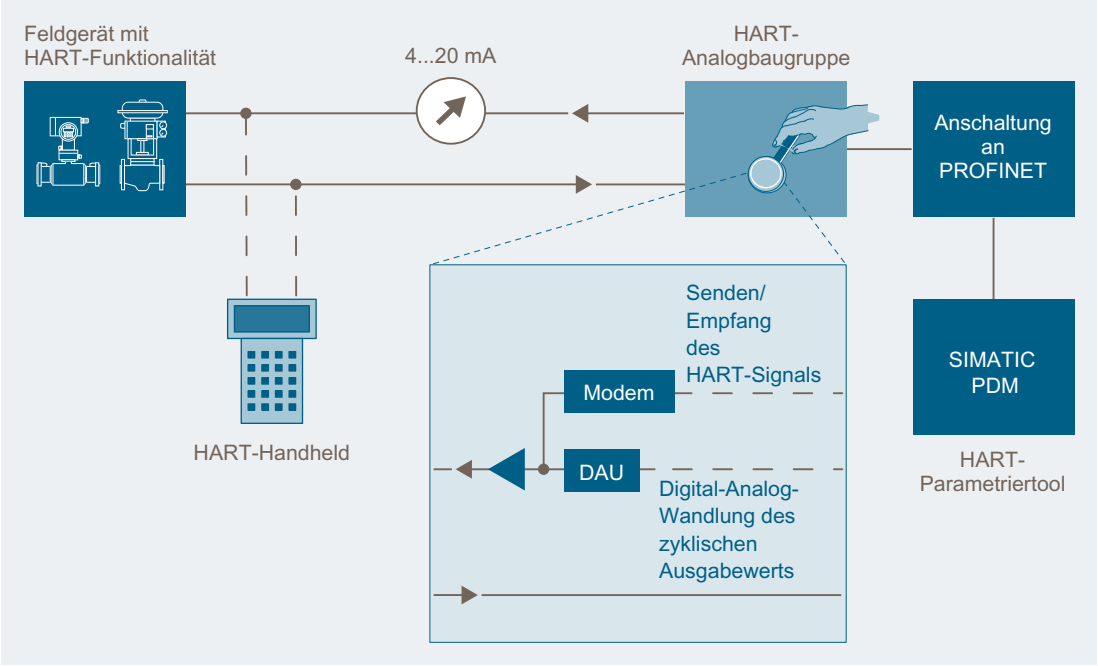

The I/O module is used in an IO device. You can connect a HART field device to each channel (monodrop operation). The I/O module operates as a HART master and the field devices as HART slaves.

The I/O module receives the commands from the HART configuration tool, for example, forwards the commands to the intelligent field device and returns the responses. Data records are the interface of the I/O module. These data records must be generated or interpreted by the client.

- HART configuration tool (Page 35) (e.g. SIMATIC PDM)
- HART signal (Page 36)
- HART device status (Page 36)

Configuration

You configure the I/O module using the SIMATIC engineering tool. You configure the individual channels with respect to the actual analog value output and the use of the HART variables in the input address space of the I/O module.

- You can use the SIMATIC engineering tool to configure one field device per channel.
- The configuration/parameter assignment of the connected field device is performed with the HART configuration tool or the EDD for the respective distributed I/O.

Re-configuration of the field devices

A field device connected to the I/O module can be re-configured. The following tools are suitable for re-configuration:

- HART configuration tool
- HART handheld

The I/O module generally accepts triggered reconfigurations for field devices.

The assignment of access rights is only possible with the HART configuration tool.

You trigger re-configuration of a field device that is connected to an I/O module with a HART command entered using the HART configuration tool.

The corresponding bit is set in the HART device status of the connected field device (in the 2nd status byte) after re-configuration of a field device is completed.

NOTE

"Configuration changed" maintenance message

- If the "Configuration changed" maintenance message is enabled, the I/O module triggers this maintenance message when the field device is re-configured.
- This maintenance message should be regarded as a notice and not an error. It is automatically deleted again by the I/O module after approximately 1 minute.

Additional information on this: Diagnostic and maintenance messages (Page 57)

7.2.2 HART configuration tool

Definition

The HART parameters can be set either using an external hand-held device (HART Handheld) or a HART configuration tool (PDM). Both assume the function of a "client":

The parameter assignment tool affects the entire I/O module; the HART handheld is connected in parallel to the field device.

7.2.3 HART signal

Definition

A HART signal consists of sine waves of 1200 Hz and 2200 Hz and has an average value of 0.

Description

The following figure shows the analog signal with the modulated HART signal (FSK method). It can be filtered out using an input filter so that the original analog signal is available again.

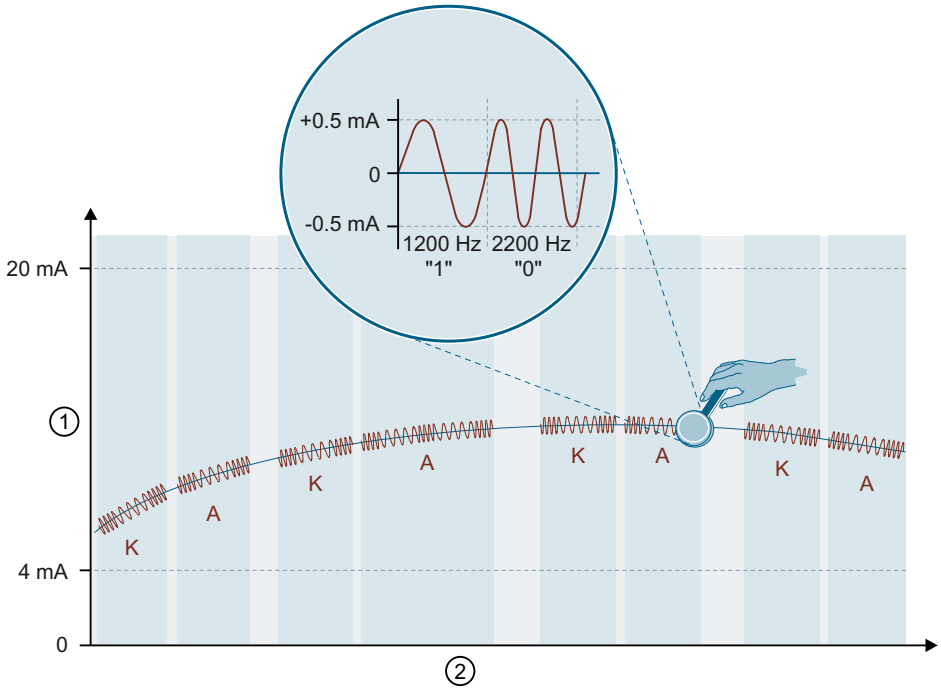

1	Analog signal
2	Time (seconds)
K	Command
A	Response

7.2.4 HART device status

Definition

The two HART status bytes (HART device status) that are transferred with each response of the field device contain error information about the HART communication, HART command and device status.
Among other things, this information is evaluated by the I/O module and signaled to the CPU via maintenance messages.

Description

The 1st and 2nd status byte is structured as follows:

Table 2-1526 1st status byte

When bit 7 = 1: Communication error	
Bit 6 = 1	Parity error
Bit 5 = 1	Overflow
Bit 4 = 1	Framing error
Bit 3 = 1	Checksum error
Bit 2 = 0	Reserved
Bit 1 = 1	Overflow in the receive buffer
Bit 0 = 0	Reserved
When Bit 7 = 0: Bit 0 to 6 Specific according to the response frame	

Table 2-1527 2nd status byte

Bit 7 = 1	Device fault
Bit 6 = 1	Configuration changed
Bit 5 = 1	Startup (cold start)
Bit 4 = 1	Additional status information available
Bit 3 = 1	Fixed analog output current setting
Bit 2 = 1	Analog output current saturated
Bit 1 = 1	Secondary variable outside the limits
Bit 0 = 1	Primary variable outside the range

7.3 Communication

7.3.1 Useful information about communication

Reference is made to communication with HART in the following.

HART communication

With enabled HART operation, the analog module independently sends HART commands to the connected field devices. This always occurs alternately on a channel-specific basis with any pending external HART commands that arrive via the command interface of the module.

- HART command (Page 38)
- HART command interface (Page 71)

The I/O module is used in the following operation:

Multiplex operation (Page 40)

Fast mode

When processing HART commands as an SHC sequence (Successive HART Command), HART processing is reserved for the current channel.

If a HART command with set SHC bit is recognized by the I/O module for a channel, the complete HART command processing on the I/O module is reserved for this channel for

approx. 2 seconds. There is no processing of internal HART requests, and there is no HART command processing for all other channels of the I/O module during this time.

SHC sequence (Page 40)

NOTE

- While a HART channel of the I/O module is processing an SHC sequence, and thus the complete HART processing is reserved for this channel, the HART variables of all HART channels are no longer updated. They remain unchanged in terms of value and quality code.
- HART commands for other channels are not processed and are acknowledged correspondingly.

Burst mode

The I/O module does not support burst mode. HART commands with set burst bit are ignored and are not forwarded to the connected field device.

7.3.2 HART command

Definition

HART commands are used to set the configurable properties of HART field devices (HART parameters). HART responses are used to read out the HART parameters.

Description

The HART commands and their parameters are divided into three groups:

- Universal HART commands (Page 39)
- General purpose HART commands (Page 39)
- Device-specific HART commands (Page 40)

7.3.3 Explanation of the HART commands

7.3.3.1 Universal HART commands

Definition

Universal commands must be supported by all manufacturers of HART field devices.

Description

Examples of universal HART commands:

Command	Function
0	Reads manufacturer and device type - only with this command 0 can field devices be addressed by means of a short frame address
11	Reads manufacturer and device type
1	Reads primary variable and unit
2	Reads current and percentage of range, digitally as floating-point number (IEEE 754)
3	Reads up to four pre-defined, dynamic variables (primary variables, secondary variables, etc.)
9	Reads up to four pre-defined, dynamic variables (primary variables, secondary variables, etc.)
13, 18	Reads or writes process tag name ("tag"), description and date (dates are also sent)

7.3.3.2 General purpose HART commands

Definition

General purpose commands should be supported by all manufacturers of HART field devices.

Description

Examples of usable HART commands:

Command	Function
36	Sets high range limit
37	Sets low range limit
41	Perform self-test
43	Sets the primary variable to zero

7.3.3.3 Device-specific HART commands

Definition

Device-specific commands only apply to the respective field device.

7.3.4 SHC sequence

Definition

If a HART command with set SHC bit is sent to the I/O module, this channel is reserved for HART commands for 2 seconds.

For each additional HART command with SHC bit set, the I/O module reserves this channel again for HART commands for an additional 2 seconds. Command 3 or 9 for reading the HART variables starts being sent cyclically to the field device again if a HART command without a set SHC bit is detected for this channel, or if no further command is received for the channel within 2 seconds of the previous HART command.

7.3.5 Multiplex operation

Definition

The I/O module processes the HART communication in multiplex mode, i.e. one channel after the other. HART commands of the individual channels therefore influence the speed of HART processing of the other channels.

7.4 Tags

7.4.1 Useful information about HART variables

HART variables, the properties dialog and address assignment are explained below.

Properties dialog of the I/O module

In the properties dialog of the I/O module, you can configure up to 4 HART variables directly in the input address area of the I/O module. You select these from the four HART variables provided by each channel:

HART variables (Page 41)

You can refer to the quality code for information on the process status of a HART variable.

Quality code (Page 42)

The HART variables are assigned to a channel in the properties dialog of the module. The HART variables are configured via parameter data record 130. This allows you to process measured values directly from the field device as input data in the automation device.

Parameter assignment and structure of the HART mapping parameters (Page 56)

You also determine the use of the multiHART area and its properties in the properties dialog box of the I/O module.

multiHART range (Page 44)

Address assignment

You can choose to configure the following:

- Maximum 4 HART variables

  Each HART variable occupies 5 bytes of input data. As soon as you configure (map) at least one HART variable in the input address space, the addresses for all 4 variables are assigned (20 bytes).

- A multiHART area

  If the multiHART area is used, an additional 6 bytes of input address space and 1 byte of output address space is allocated.

7.4.2 HART variables

Definition

Each HART variable consists of a 4-byte real value and one byte of quality code. A maximum of four HART variables supported by the connected field device are read cyclically for each channel with enabled HART functionality. The HART variables are read automatically via the HART command 3 (for field devices with HART Rev. 5 and 6) or via command 9 (for field devices with HART Rev. 7 or later).

These four HART variables are always stored in the HART variable data record 121 for each channel and can be read at any time.

HART variable data record (Page 79)

Description

The following HART variables are available:

- PV (Primary Variable)
- SV (Secondary Variable)
- TV (Tertiary Variable)
- QV (Quaternary Variable)

7.4.3 Quality code

Definition

The quality code describes the process status of the corresponding HART variable.

Description

The quality code is structured as follows:

Bit	7....6	5....2	1...0
	Quality 0 0: Bad 0 1: Uncertain 1 0: Good 1 1: Good	Sub-status Coded according to "PROFIBUS PA Profile for Process Control Devices"	Limits 0 0: OK 0 1: Low limit 1 0: High limit 1 1: Constant

The quality codes generated by the I/O module conform to the HART revision of the field device used.

- Field devices with HART revision 5 and 6 (Page 42)
- Field devices with HART revision 7 and higher (Page 43)

7.4.4 HART revision

7.4.4.1 Field devices with HART revision 5 and 6

Definition

The quality code is formed exclusively from the 1st and 2nd status byte (HART device status) of the response frames (HART command 3).

Description

The quality code of field devices with HART revision 5 and 6 is structured as follows:

Quality code	Meaning (process status)	
80_H	Value is okay	Also applies when the following bits are set in the 2nd status byte of the HART response frame: • Configuration changed • Startup (cold start) • Fixed analog output current setting

[1] A channel is in standby mode when a redundancy failover occurs due to a fault in an IO-redundant module.

Quality code	Meaning (process status)	
78_H	Value is uncertain	Also applies when the following bits are set in the 2nd status byte of the HART response frame: • Additional status information available • Analog output current saturated • Secondary variable outside the limits • Primary variable outside the range
84_H	Response code RC8: Update error	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	After module start-up, after incorrect operation of the multiHART interface or after redundancy failover to the standby channel[1]
00_H	Initialization value from system	

[1] A channel is in standby mode when a redundancy failover occurs due to a fault in an IO-redundant module.

7.4.4.2 Field devices with HART revision 7 and higher

Definition

The quality code is formed from the 1st status byte (HART device status) and the "Device variable status" (DVS) of the response frames (HART command 9).

Description

The quality code of field devices with HART revision 7 or higher is structured as follows:

Quality code	Meaning (process status)	
80_H	Value is okay	
89_H	"Good" with "low limit"	Process status, formed from the "Device variable status" (DVS) of the response frames with corresponding limits (see above).
$8A_H$	"Good" with "high limit"	
28_H...$2B_H$	"Bad"	
68_H...$6B_H$	"Poor accuracy"	
78_H...$7B_H$	"Manual" or "Fixed" (manually controlled or fixed value)	
88_H...$8B_H$	"More device variable state available" (additional status information available)	
84_H	Response code RC8: Update error	

[1] A channel is in standby mode when a redundancy failover occurs due to a fault in an IO-redundant module.

Quality code	Meaning (process status)	
24_H	Response code RC16: Access restricted	Request from field device refused
23_H	Communication error or HART variable not present in the field device	
37_H	Initialization value from analog module	After module start-up, after incorrect operation of the multiHART interface or after redundancy failover to the standby channel[1]
40_H	Read alternatively via command 3	
00_H	Initialization value from system	

[1] A channel is in standby mode when a redundancy failover occurs due to a fault in an IO-redundant module.

7.4.5 multiHART range

Definition

You can access any of the configured HART variables in the I/O module via the multiHART range.

When HART mode is enabled, the I/O module cyclically reads the variables provided by the connected field devices itself and makes them available in the configured input address space. You can request and read one of these HART variables via the multiHART range.

Technical specifications

8

Technical specifications of Ex-AQ 2xI HART

Article number	6DL1135-6TB00-0HX1
General information	
Product type designation	Ex-AQ 2xI HART
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type X1
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V17 or higher
• STEP 7 configurable/integrated from version	STEP 7 V5.6 SP2 or higher
• PCS 7 configurable/integrated from version	V9.1
Operating mode	
• MSO	Yes
Redundancy	
• Redundancy capability	No
CiR - Configuration in RUN	
Reparameterization possible in RUN	Yes
Calibration possible in RUN	No
Input current	
Current consumption (rated value)	65 mA
Current consumption, max.	70 mA
Power loss	
Power loss, typ.	1.2 W
Power loss, max.	1.3 W
Address area	
Address space per module	
• Address space per module, max.	4 byte; + 0/1 byte for QI information
• Address space per module with HART, max.	24 byte; + 0/1 byte for QI information
• Address space per module with MultiHART, max.	11 byte; + 0/1 byte for QI information

Article number	6DL1135-6TB00-0HX1
Hardware configuration	
Automatic encoding	
• Mechanical coding element	Yes
Analog outputs	
Number of analog outputs	2
Cycle time (all channels), min.	3 ms
Output ranges, current	
• 0 to 20 mA	Yes; 15 bit
• 4 mA to 20 mA	Yes; 16 bit incl. sign
Connection of actuators	
• for current output two-wire connection	Yes
Load impedance (in rated range of output)	
• with current outputs, max.	500 Ω
• with current outputs, inductive load, max.	Ex characteristic values must be observed
Cable length	
• shielded, max.	500 m; Ex characteristic values must be observed
• unshielded, max.	300 m; Ex characteristic values must be observed
Settling time	
• for resistive load	1 ms; 500 ohms
Errors/accuracies	
Output ripple (relative to output range, bandwidth 0 to 50 kHz), (+/-)	0.02 %
Linearity error (relative to output range), (+/-)	0.01 %
Temperature error (relative to output range), (+/-)	0.005 %/K
Crosstalk between the outputs, min.	-70 dB
Repeat accuracy in steady state at 25 °C (relative to output range), (+/-)	0.02 %
Operational error limit in overall temperature range	
• Current, relative to output range, (+/-)	0.5 %; 0 ... 60 °C: 0.3%
Basic error limit (operational limit at 25 °C)	
• Current, relative to output range, (+/-)	0.2 %
Protocols	
HART protocol	Yes
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
Diagnoses	
• Monitoring the supply voltage	Yes; Module-wise

Article number	6DL1135-6TB00-0HX1
• Wire-break	Yes; From output value > 240 µA
• Short-circuit	Yes; < 20 ohms as of 1 mA output value
• Group error	Yes
• Overflow/underflow	Yes; channel by channel
Diagnostics indication LED	
• MAINT LED	Yes; Yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Ex(i) characteristics	
maximum values for connecting terminals for gas group IIC	
• Uo (no-load voltage), max.	22 V
• Io (short-circuit current), max.	91 mA
• Po (power output), max.	501 mW
• Co (permissible external capacity), max.	151 nF
• Lo (permissible external inductivity), max.	4.1 mH
• Ui (intrinsically safe input voltage), max.	10 V
• Um (voltage at non-intrinsically safe connecting terminals), max.	60 V
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes; Electrical isolation between the channels and input voltage PME
Isolation	
Isolation tested with	further information on insulation can be found in the "ET 200SP HA / ET 200SP modules for devices in hazardous areas" System Manual
insulation of the field circuits to local ground acc. to IEC/EN 60079-11 tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-40 °C
• horizontal installation, max.	70 °C
• vertical installation, min.	-40 °C
• vertical installation, max.	60 °C

Article number	6DL1135-6TB00-0HX1
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	55 g

Cycle time

The cycle time describes the time slice in which new process values are output.

The cycle time is the sum of the basic cycle times and the channel processing times (independent of parameter assignment).

	Without HART protocol	With HART protocol and multiHART	With HART protocol and 4 HART variables
Basic cycle time	4.7 ms	4.9 ms	7.8 ms
Channel processing time	0.75 ms	0.875 ms	1.5 ms

Cycle time = Basic cycle time + n × Channel processing time

Drivers, parameters, diagnostics messages and address space

A

A.1 Concept of the driver and diagnostics blocks

Use with PCS 7

The following information shows you advantages of using the process control system. In the process control system, the engineering system automatically handles many important parameter assignments and interconnections of modules.

If you want to use the Ex I/O outside these process control systems, refer to the following sections:

- Parameter assignment and structure of the module/channel parameters (Page 52)
- Address space in analog mode (Page 60)

Tasks of the driver and diagnostics blocks (driver blocks)

In process control systems, certain demands are placed on the diagnostics/signal processing. This includes the monitoring of modules, IO devices and PROFINET IO systems for malfunctions and failures.

To make this possible, blocks are provided in the libraries of the engineering system which implement the interface to the hardware, including test functionality.

These blocks perform two basic tasks:

- They provide signals from the process to the AS for further processing.
- They monitor modules, IO devices and PROFINET IO system for failure.

When the process signals are read in, these blocks access the process image input (or process image partition) (PII) and when the process signals are output, they access the process image output (or process image partition) (PIQ).

Concept

The concept of the driver and diagnostic blocks at the process control systems is characterized by the following:

- The separation between user data processing (CHANNEL blocks) and diagnostics data processing (MODULE blocks)
- The symbolic addressing of the I/O signals
- The automatic generation of the MODULE blocks by CFC

This block concept supports all modules from the list of approved modules.
When new Siemens or non-Siemens module types are integrated, the meta-knowledge for the driver generator can be extended by additional XML files (object and action lists).

NOTE

Note the following:

- The library with the driver blocks has to installed using the Setup program on the PC. This is the only method of ensuring that the meta-knowledge required for the driver generator is available. You must not copy the library from another computer.
- You can also use driver blocks from another library (for example, your own blocks from your own library). You can specify this additional library in the "Generate module drivers" dialog box. The driver generator then searches for the block to be imported in the library specified here. If the block is not found here, it is searched for in the library specified in the control file (XML file).
- If the S7 program contains a signal-processing block, but none from one of the engineering system libraries, the following is required:
  You must specify the version of the driver library from which the driver blocks are to be imported in the "Generate module drivers" dialog box.

Time-optimized processing

To enable time-optimized processing during runtime, the organization blocks for error handling (for example, OB85, OB86) are automatically divided into runtime groups and the driver blocks are integrated in the corresponding runtime groups.

If an error occurs, the SUBNET block, for example, activates the relevant runtime group. The RACK block or MODULE block detects the error, evaluates it and sends a process control message to the operator control and monitoring system.

The diagnostics information of the module block (OMODE_xx output) is also transferred to the corresponding CHANNEL block (MODE input). If required, this information can be displayed in a process picture via a block that can be controlled and observed in the operator control and monitoring system or a user block (color change of the measured value or flashing display, etc.).

A.2 Parameter assignment and structure of the module/channel parameters

A.2.1 Parameter assignment

Parameter assignment in the user program

You can reconfigure individual channels of the module and HART variable mapping in RUN without affecting the other channels.

Changing parameters in RUN

The parameters are only transferred to the I/O module with the "WRREC" instruction.

- Module/channel parameters using data record 128
- HART mapping via data record 130

The parameters set via the configuration are not changed in the CPU in this case, that is, after startup the parameters set in the CPU are valid again.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The STATUS output parameter is 4 bytes long and is configured as followed:

- Byte1: Function_Num, general error code
- Byte2: Error_Decode, location of the error code
- Byte3: Error_Code_1, error code
- Byte4: Error_Code_2, manufacturer-specific extension of the error code

Module-specific errors are displayed via Error_Decode = 0x80 and Error_Code_1 / Error_Code_2.

Error_ Code_1	Error_ Code_2	Cause	Remedy
0xB0	variable	Number of the data record unknown (Error_Code_2 returns internal identifiers)	Enter valid number for data record
0xB1	0x01	Length of the data record is incorrect	Enter permissible value for data record length
0xB2	variable	Module cannot be reached (Error_Code_2 returns internal identifiers)	• Check station - is the module plugged in correctly? • Check the parameters of the WRREC instruction
0xE0	0x01	Header error (version or defined bits incorrect)	Correct version number or defined bits.
0xE0	0x02	Header error (incorrect length or number of parameter blocks)	Correct length and number of parameter blocks
0xE1	0x01	Reserved bit set	Write all reserved bits with a 0.

Error_ Code_1	Error_ Code_2	Cause	Remedy
0xE1	0x06	Invalid coding for substitute value reaction	Use valid coding for "Reaction to CPU STOP".
0xE1	0x0A	Invalid value for substitute value	Check and correct the parameters
0xE1	0x10	Coding for output type invalid	
0xE1	0x11	Coding for output area invalid	
0xE1	0x21	Incorrect number of HART repetitions	

Valid parameters

Only the values specified in the following are permitted. Values that are not listed are rejected by the module.

Each parameter data record is checked by the analog module. If an incorrect parameter is detected, the entire data record is rejected and the parameters of the module remain unchanged.

A.2.2 Parameter assignment and structure of the module/channel parameters

Structure of data record 128

The data record contains the module parameters as well as the channel or technology parameters of the two channels.

Main components of the data record:

- Header information (module), module parameters, header information (channel)
- Channel parameters (channel or technology parameters), which influence the actual analog value output.
- Parameters which enable diagnostics
- Basic parameters of HART communication.

You can specify and change other parameters and HART-specific settings with data records 131 to 132. See section HART-specific settings (Page 79).

Table 2-1528 Structure of data record 128 in analog mode (24 bytes in length)

Byte	Length	Parameter	Efficiency range
0 ... 3	4 bytes	Header information (module)	Module
4 ... 5	2 bytes	Module parameters	Module parameters
6 ... 7	2 bytes	Header information (channels)	AQ channel n (n = 0 to 1) • Analog value output • Enable diagnostics • HART
8 ... 15	8 bytes	Channel parameters	
16 .. 23	8 bytes	Channel parameters	

NOTE

Legend for the following detailed screens

The following detailed screens show the assignment of the individual bytes in data record 128 based on the configuration.

- All unused bits, as well as the bits or bytes marked "reserved" must be set to "0".
- Activate a parameter by setting the corresponding bit to "1" or to the appropriate value.

Header information and module parameters

The following figure shows the structure of the header information and module parameters.

	7	6	5	4	3	2	1	0	
Byte 0	0	1	0	0	0	0	0	0	Minor version Major version Reserved
Byte 1	0	0	0	0	0	0	1	0	Number of following parameter structures
Byte 2	0	0	0	0	0	0	0	1	Number of the following parameter blocks
Byte 3	0	0	0	0	0	0	1	0	Length of the following module parameter block
Byte 4	0	0	0	0	0	0	0		Diagnostics, Missing supply voltage L+
Byte 5	0	0	0	0	0	0	0	0	Reserved

Figure 2-1304 Structure of DS128 module parameters

	7	6	5	4	3	2	1	0	
Byte 6	0	0	0	0	0	0	1	0	Number of the following channel parameter blocks
Byte 7	0	0	0	0	1	0	0	0	Length of a channel parameter block

Figure 2-1305 Structure of DS128 header information (channel)

Channel parameters

The following figure shows the structure of the channel parameters for channels 0 to 1.

x = 8 + (channel number * 8); with channel number 0...1

All unused bits and the bits or bytes marked as "reserved" must be set to "0".
You activate a channel parameter by setting the corresponding bit to "1" or the corresponding value.

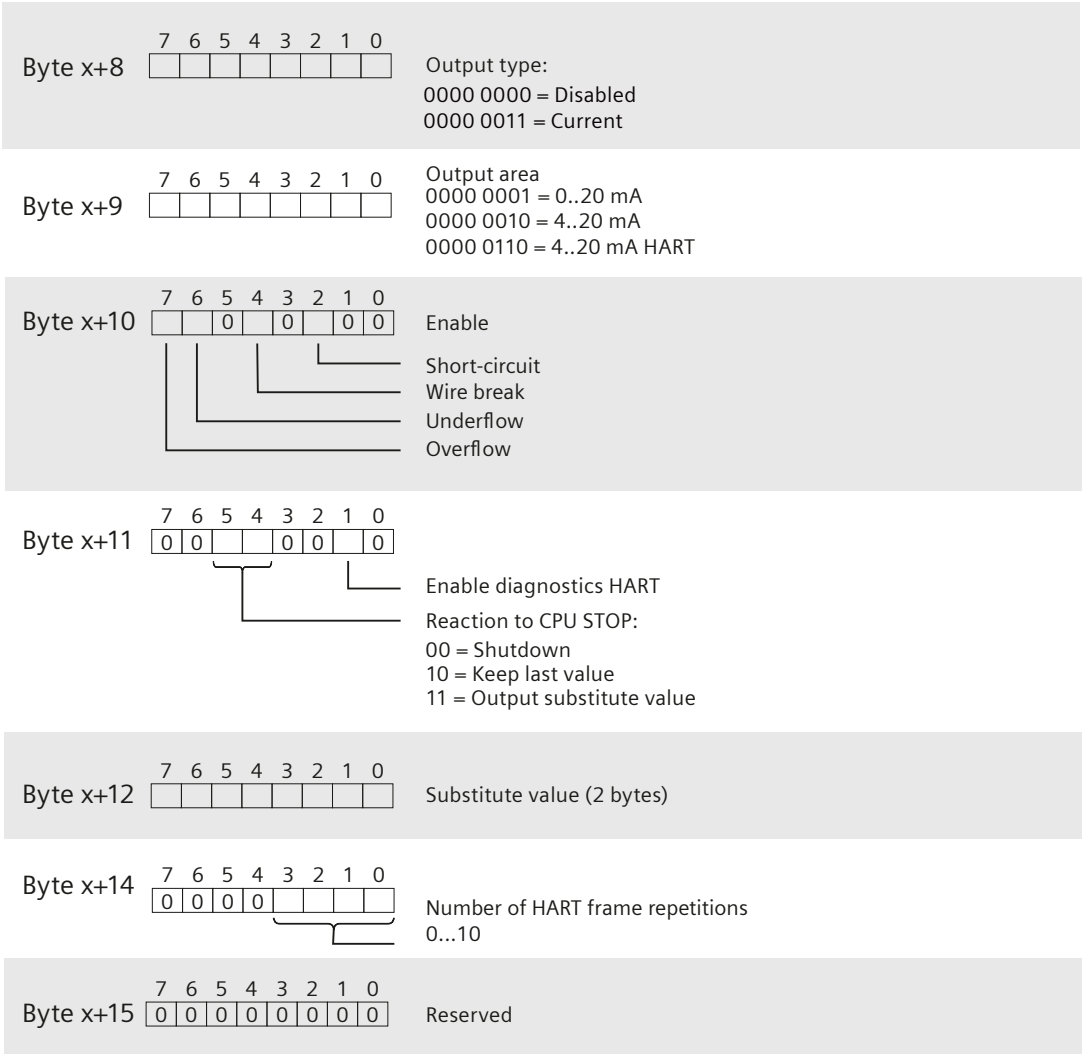

Figure 2-1306 Structure of byte x to x+n for channels 0 to 1

A.2.3 Parameter assignment and structure of the HART mapping parameters

Structure of data record 130

Data record 130 has a total length of 12 bytes.

A maximum of 4 HART variables can be configured (mapped) to the address space of the module with the HART mapping parameters.

Each HART variable occupies 5 bytes of input data. As soon as you configure (map) at least one HART variable in the input address space, the addresses for all four variables are allocated (20 bytes).

With PROFIBUS DP GSD configuration with HART variables, the HART variables cannot be directly configured. The four secondary variables are supplied in ascending channel order in the address space of the module.

Header information

The figure below shows the structure of the header information.

	7	6	5	4	3	2	1	0	
Byte 0	0	0	0	0	0	0	0	0	Version = 0
Byte 1	0	0	0	0	1	0	1	1	Block length = 11
Byte 2	0	1	0	0	1	0	1	1	Block type = 75
Byte 3	0	0	0	0	0	0	0	0	Reserved = 0

Figure 2-1307 Header information of data record 130

Parameters

The figure below shows the parameter assignment of the 4 HART variables.

x = 4, 6, 8, 10

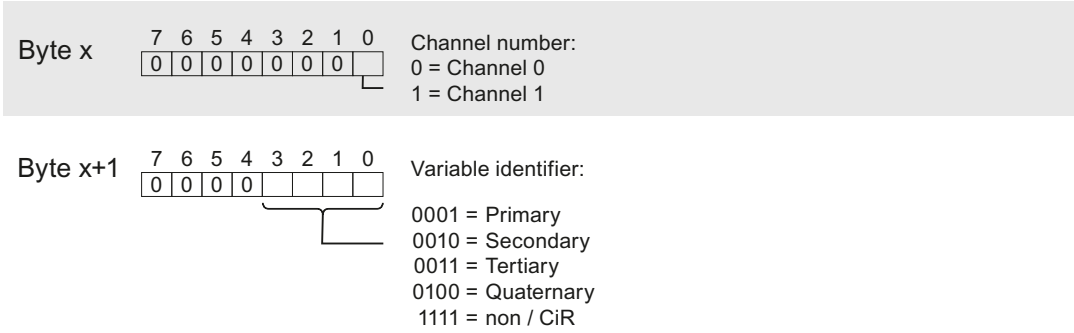

Figure 2-1308 Parameters of data record 130

The effect of variable identifier 15 = non / CiR on the I/O module is that no HART variable is configured or mapped; that is, the corresponding memory area in the input address area remains unallocated.

See also

Configurations of the I/O module Ex-AQ 2xI HART (Page 15)

A.2.4 Diagnostic and maintenance messages

Diagnostic messages

A diagnostic message is output for each enabled diagnostic event, and the DIAG LED on the module flashes red.

The diagnostic messages can be read in the diagnostic buffer of the CPU.

The following applies for assigning diagnostic messages:

- A module message is assigned to all channels.
- A channel-specific message is assigned to one channel only, the other channels are not affected.
  The diagnostic result is indicated by the corresponding channel fault LED.

Table 2-1529 Diagnostic messages, their meaning and possible remedies

Diagnostic message	Error code	Assignment	Meaning/cause	Remedy
Short-circuit	1_H	Analog output	Short-circuit of cable to the actuator or actuator impedance too low	• Correct the process wiring • Check the connected actuator
Overtemperature	5_H	Module	• Ambient temperature is too high • Total current of the analog outputs too high • Short circuit of one or more analog outputs • Module defective	• Check wiring • Replace module

Diagnostic message	Error code	Assignment	Meaning/cause	Remedy
Wire break	6_H	Analog output	• Wire break between the module and actuator • Channel not connected (open)	• Connect the cable • Disable diagnostics
High limit violated	7_H	Analog output	The analog value is above the overrange.	Correct the output value
Low limit violated	8_H	Analog output	The analog value is below the underrange.	Correct the output value
Parameter assignment error	10_H	Module	Incorrect parameter assignment	Correct the parameter assignment
Supply voltage missing	11_H	Module	Missing or insufficient supply voltage L+	• Check Ex power module • Check wiring of the supply voltage L+ on the Ex power module
Channel/component temporarily unavailable	$1F_H$	Module	Firmware update is in progress or has been canceled during the update. The module does not output any process or substitute values in this state.	• Restart firmware update • Wait for firmware update
Module is faulty *	100_H	Module	Internal module error has occurred	Replace the module
Invalid BaseUnit	151_H	Module	The module was plugged into an impermissible BaseUnit.	Replace Ex BaseUnit
The retentive memory in the BaseUnit is defective.	153_H	Module	A memory block error on the BaseUnit was detected during startup.	Replace Ex BaseUnit

Maintenance messages

Whenever it is detected that maintenance is required, a maintenance message is generated, and the MT LED lights up yellow on the I/O module.

Maintenance messages are either assigned to a specific channel (HART error) or assigned to all channels as a module message.

Maintenance messages have no direct effect on the function of the module or the analog value output.

Maintenance messages of the HART communication do not affect the analog value output of the module.

Table 2-1530 Maintenance messages, their meaning and possible remedies

Maintenance message	Error code	Assignment	Meaning / Cause	Remedy
HART communication error	141_H	Analog output	• HART field device is not responding • Timing error • HART field device did not understand the command that was sent (1st status byte)	• Check the process wiring • Correct the parameter assignment • Set current ≥4 mA • Increase number of configured repetitions
HART primary variable outside of limits	142_H	Analog output	• Incorrect parameters in the HART field device • HART field device is set to "Primary variable outside of limits" in simulation mode • Parameter assignment of primary variable outside of limits	• Check the parameter assignment of the HART device • Correct the simulation • Check if the correct actuator is connected
HART analog output current of field device saturated	143_H	Analog output	• The output current of the HART field device is saturated: • Incorrect parameters in the HART field device • HART field device is set to an output value that is too high in simulation mode	
HART output current of the field device specified	144_H	Analog output	• The output current of the HART field device is fixed: • Incorrect parameters in the HART field device • HART field device is set to an output value that is too high in simulation mode	
HART additional status information available	145_H	Analog output	In the HART device status (in the 2nd status byte), the HART field device identifier for "further status information available" has been set	Read out status with HART command 48 and clear error/cause if necessary
HART configuration changed[1]	146_H	Analog output	In the HART device status (in the 2nd status byte), the identifier for "parameter reassignment" of the HART field device has been set	If you do not want the re-configuration to trigger a diagnostic interrupt, the HART diagnostics may not be enabled.

[1] **Response of the "HART configuration changed" maintenance message**

If the HART field device signals "re-configuration" (configuration changed) in the 2nd status byte, the module generates the maintenance message "HART configuration changed".

If the field device withdraws the message in the 2nd status byte within a minute, the maintenance message is also deleted again by the module.

If the message in the 2nd status byte is still set after a minute, the module then independently sends HART command 38 for resetting the message in the field device.

Maintenance message	Error code	Assignment	Meaning / Cause	Remedy
HART malfunction in the field device	147_H	Analog output	In the HART device status (in the 2nd status byte) the field device reports a malfunction	• Read out status with HART command 48 and clear error/cause if necessary • Replace field device
HART secondary variable outside the limits	149_H	Analog output	• Incorrect parameters in the HART field device • HART field device is set to "Non-primary variable outside limits" in simulation mode • Parameter assignment of non-primary variable is outside the limits	• Check the parameter assignment of the HART device • Correct the simulation • Check if the correct actuator is connected
The retentive memory in the BaseUnit is defective.	153_H	Module	A memory block error on the BaseUnit was detected during operation.	Replace Ex BaseUnit

[1] **Response of the "HART configuration changed" maintenance message**

If the HART field device signals "re-configuration" (configuration changed) in the 2nd status byte, the module generates the maintenance message "HART configuration changed".

If the field device withdraws the message in the 2nd status byte within a minute, the maintenance message is also deleted again by the module.

If the message in the 2nd status byte is still set after a minute, the module then independently sends HART command 38 for resetting the message in the field device.

A.3 Address space

A.3.1 Address space in analog mode

Address space

The following tables show the allocation of the address space of the I/O module based on the configuration.

- Address space in analog mode AQ 2 without QI (Page 61)
- Address space in analog mode AQ 2 + 1 multiHART without QI (Page 61)
- Address space in analog mode AQ 2 + 4 HART without QI (Page 63)
- Address space in analog mode AQ 2 + 1 multiHART with QI (Page 64)
- Address space in analog mode AQ 2 + 4 HART with QI (Page 66)
- Address space in analog mode AQ 2 with QI and optional MSO (Page 67)

The module can be configured in different ways. Depending on the configuration, additional/different addresses are assigned in the process image of the outputs/inputs.

Addresses for the HART area are not available if there are no HART variables or no multiHART area configured in the properties dialog of the module.

Evaluating information

- Evaluate multiHART range (Page 69)
- Evaluating HART variables (Page 68)
- Evaluating the value status (Page 70)

A.3.2 Address space in analog mode AQ 2 without QI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input area
- "QB" stands for output byte, that is the module start address in the output area
- "AQ" stands for analog output
- "QI" stands for value status (QI) of analog output n
- "QC"stands for Quality Code

Address space in the configuration analog mode AQ 2 without QI

The following tables show the allocation of the address space of the I/O module.

Output area

Table 2-1531 Output area of the Ex-AQ 2xI HART (AQ 2 without QI)

QB x +	Meaning
0...1	Analog value of analog output 0 (AQ0)
2...3	Analog value of analog output 1 (AQ1)

A.3.3 Address space in analog mode AQ 2 + 1 multiHART without QI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input area
- "QB" stands for output byte, that is the module start address in the output area
- "AQ" stands for analog output
- "QAQn" stands for value status (QI) of the analog output n
- "QC"stands for Quality Code

Address space in the configuration analog mode AQ 2 + 1 multiHART without QI

The following tables show the allocation of the address space of the I/O module.

Addresses for the HART area are only available if no multiHART area has been configured in the properties dialog of the module.

Input area

The process values are shown in S7 format.

Table 2-1532 Input area of the Ex-AQ 2xI HART (AQ 2 + 1 multiHART without QI)

IB x +	7	6	5	4	3	2	1	0
0	HART area							
: :								

HART area

There are 6 bytes in the input area for the configuration with a multiHART area.

Table 2-1533 Address range for configurations with multiHART area

IB x +	HART area		
0	Acknowledgment		multiHART area
1 : : 4	Value	HART variable	
5	QC		

Output area

Table 2-1534 Output area of the Ex-AQ 2xI HART (AQ 2 + 1 multiHART without QI)

QB x +	Meaning
0...1	Analog value of analog output 0 (AQ0)
2...3	Analog value of analog output 1 (AQ1)
4	HART area

There is one byte in the output area for the configuration with a multiHART area.

Table 2-1535 HART area

QB x	Command	multiHART area

Evaluate multiHART area

You can find information on this in section "Evaluate multiHART range (Page 69)".

A.3.4 Address space in analog mode AQ 2 + 4 HART without QI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input area
- "QB" stands for output byte, that is the module start address in the output area
- "AQ" stands for analog output
- "QAQn" stands for value status (QI) of the analog output n
- "QC" stands for Quality Code

Address space in the configuration analog mode AQ 2 + 4 HART without QI

The following tables show the allocation of the address space of the I/O module.

Addresses for the HART area are only available if no Hart variables have been configured in the properties dialog of the module.

Input area

The process values are shown in S7 format.

Table 2-1536 Input area of the Ex-AQ 2xI HART (AQ 2 + 4 HART without QI)

IB x +	7	6	5	4	3	2	1	0
0	HART area							
: :								

You can find information on the HART area in following paragraph: HART area"

HART area

In the configuration with 4 HART variables in the input area, the area has a length of 20 bytes and always contains 4 HART variables, each with a 4-byte value and a 1-byte quality code (QC).

Table 2-1537 Address area for configurations with HART variables

IB x +	HART area	
0 + 5n : 3 + 5n	Value	Configured HART variable n (n= 0 to 3)
4 + 5n	QC	

Double word n (n= 0 to 3);
Example: HART variable 3 = Byte (0 +3*5) = configured HART variable starts from Byte 15

Output area

Table 2-1538 Output area of the Ex-AQ 2xI HART (AQ 2 + 4 HART without QI)

QB x +	Meaning
0...1	Analog value of analog output 0 (AQ0)
2...3	Analog value of analog output 1 (AQ1)

Evaluating HART variables

You can find information on this in section "Evaluating HART variables (Page 68)".

A.3.5 Address space in analog mode AQ 2 + 1 multiHART with QI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input area
- "QB" stands for output byte, that is the module start address in the output area
- "AQ" stands for analog output
- "QC"stands for Quality Code
- "QAQn" stands for value status (QI) of analog output n
  You can find additional information in section "Evaluating the value status (Page 70)".

Address space in the configuration analog mode AQ 2 + 1 multiHART with QI

The following tables show the allocation of the address space of the I/O module.

Addresses for the HART area are only available if no multiHART area has been configured in the properties dialog of the module.

Input area

The process values are shown in S7 format.

If the multiHART area is configured, these variables follow directly after the value status.

Table 2-1539 Input area of the Ex-AQ 2xI HART (AQ 2 + 1 multiHART with QI)

IB x +	7	6	5	4	3	2	1	0
0	-	-	-	-	-	-	QAI1	QAI0
1	HART area							
: :								

HART area

When the multiHART area is used, the HART area is arranged directly aligned with the QI bits of the analog inputs.

There are 6 bytes in the input area for the configuration with a multiHART area.

Table 2-1540 Address range for configurations with multiHART area

IB x +	HART area		
0	Acknowledgment		multiHART area
1 : : 4	Value	HART variable	
5	QC		

Output area

Table 2-1541 Output area of the Ex-AQ 2xI HART (AQ 2 + 1 multiHART with QI)

QB x +	Meaning
0...1	Analog value of analog output 0 (AQ0)
2...3	Analog value of analog output 1 (AQ1)
4	HART area

In the configuration with a multiHART area, there is one byte in the output area.

Table 2-1542 HART area

QB x	Command	multiHART area

Evaluate multiHART area

You can find information on this in section "Evaluate multiHART range (Page 69)".

A.3.6 Address space in analog mode AQ 2 + 4 HART with QI

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input area
- "QB" stands for output byte, that is the module start address in the output area
- "AQ" stands for analog output
- "QAQn" stands for value status (QI) of the analog output n
- "QC" stands for Quality Code
  You can find additional information in section "Evaluating the value status (Page 70)".

Address space in the configuration analog mode AQ 2 + 4 HART with QI

The following tables show the allocation of the address space of the I/O module.

Addresses for the HART area are only available if no Hart variables have been configured in the properties dialog of the module.

Input area

The process values are shown in S7 format.

- If the configuration contains the value status then the input area **always** begins with a byte in which the value status (QI) of the analog outputs is displayed.
- If the HART variables are configured, these variables follow directly after the value status.

Table 2-1543 Input area of the Ex-AQ 2xI HART (AQ 2 + 4 HART with QI)

IB x +	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	-	-	-	-	-	-	QAI1	QAI0
1	HART area							
: :								

HART area

When HART variables are used, the HART area is located directly aligned after the byte containing the QI bits of the analog outputs.

In the configuration with 4 HART variables in the input area, the area has a length of 20 bytes and always contains 4 HART variables, each with a 4-byte value and a 1-byte quality code (QC).

Table 2-1544 Address area for configurations with HART variables

IB x +	HART area	
1 + 5n : 4 + 5n	Value	Configured HART variable n (n= 0 to 3)
5 + 5n	QC	

Double word n (n= 0 to 3);
Example: HART variable 3 = Byte (1 +3*5) = configured HART variable starts from Byte 20

Output area

Table 2-1545 Output area of the Ex-AQ 2xI HART (AQ 2 + 4 HART with QI)

QB x +	Meaning
0...1	Analog value of analog output 0 (AQ0)
2...3	Analog value of analog output 1 (AQ1)

Evaluating HART variables

You can find information on this in section "Evaluating HART variables (Page 68)".

A.3.7 Address space in analog mode AQ 2 with QI and optional MSO

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input area
- "QB" stands for output byte, that is the module start address in the output area
- "AQ" stands for analog output
- "QC"stands for Quality Code
- "QAQn" stands for value status (QI) of analog output n
  You can find additional information in section "Evaluating the value status (Page 70)".

Address space in the configuration analog mode AQ 2 with QI / optional MSO with QI

The following tables show the allocation of the address space of the I/O module.

Input area

The process values are shown in S7 format.

NOTE
Configuration with MSO
During configuration of the I/O module with MSO submodule, each subslot has its own **start address** (IB x + ; QB x +)**.**
The process output signals of subslot 1 are mirrored to the MSO subslots as input signals.

The following tables show the mapping of the address space for the I/O module:

Table 2-1546 Input area of the Ex-AQ 2xI HART (AQ 2 with QI / optional MSO with QI, subslot 1)

IB x +	Meaning							
0	-	-	-	-	-	-	QAQ1	QAQ0

When configuring MSO, the following is required for each MSO submodule:

Table 2-1547 Input area of the Ex-AQ 2xI HART (AQ 2 with QI / with MSO und QI, subslot 2 to 4)

IB x +	Meaning							
0...1	MSO copy of submodule (n): Analog value of analog output 0 (AQ0)							
2...3	MSO copy of submodule (n): Analog value of analog output 1 (AQ1)							
5	-	-	-	-	-	-	QAQ1	QAQ0

Output area

Table 2-1548 Output area of the Ex-AQ 2xI HART (AQ 2 with QI / optional MSO with QI)

QB x +	Meaning
0...1	Analog value of analog output 0 (AQ0)
2...3	Analog value of analog output 1 (AQ1)

A.3.8 Evaluating HART variables

If you have configured (mapped) HART variables for the I/O module, then 4 HART variables with 5 bytes each are stored in the input address space.

Each HART variable consists of a 4-byte real value and a 1-byte quality code. The quality code describes the validity of the value.

The assigned HART variables are automatically updated by the I/O module and can be used directly in the user program.

A.3.9 Evaluate multiHART range

You can select the multiHART area in the parameter assignment dialog.

The multiHART area occupies 1 byte in the output area (command) and 6 bytes in the input area (1 byte acknowledgment + 5 bytes HART variable).

You can read all HART variables available in the module using the multiHART area. To do so, you must request a HART variable from the module via the command byte in the output area.

The command byte identifies the requested HART variable (HART variable reference):

HART variable reference	
Bit 0...3: Variable identifier 1 = Primary 2 = Secondary 3 = Tertiary 4 = Quaternary	Bit 4...7: Channel number 0...1

The command is acknowledged via the acknowledgment byte in the input area. The requested HART variable can be evaluated as soon as the HART variable reference requested with the command can be read in the acknowledgment byte.

If you leave the command byte of the multiHART area unchanged, the module will continuously update the corresponding HART variable.

If an invalid HART variable reference is requested, this is also acknowledged accordingly. In this case, the value of the HART variable is zero and the quality code is output with $0x37_H$ (initialization value of the analog module).

Example:
The primary variable of channel 1 is to be read.

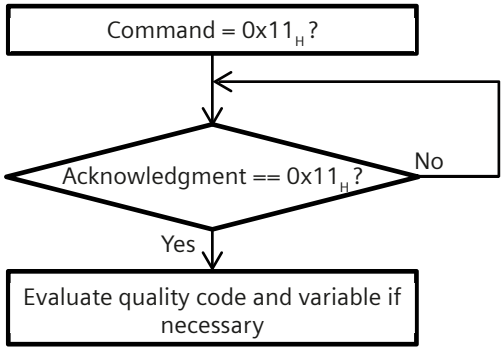

Figure 2-1309 Command = $0x11_H$

A.3.10 Evaluating the value status

The following applies in the configurations with evaluation of the value status:

The input address space contains one value status (QI) bit for each analog input.

Notes for configuration using a GSD/GSDML file (Page 17)

Evaluating the value status

Irrespective of the diagnostics enables, each value status (each QI bit) provides information on the validity of the corresponding process value.

- Value status = 1: Process value okay, "good"
- Value status = 0: Process value not okay, "bad"

Generally, the value status is set to "good" if the analog value can be output without errors. The value status is set to "bad" in the following cases:

- The analog value cannot be output due to an error, e.g. due to faulty wiring.
- The analog output is deactivated.
- The substitute value is output at the analog output.

Value status for MSO

NOTE

If a channel is configured as MSO in an I/O module, the entire I/O module is then configured to MSO.

The meaning of the value status depends on the submodule in question.

- With the basic submodule (= subslot 1), the value status 0 indicates that the value is incorrect or that the IO controller of the basic submodule is in STOP mode.
- With an MSO submodule (= subslot 2 to 4), the value status 0 indicates that the value is incorrect or that one of the following errors has occurred:
  - The basic submodule is not yet parameterized (not ready).
  - The connection between the PROFINET IO controller and the basic submodule is interrupted.
  - The IO controller of the basic submodule is in STOP mode or POWER OFF.

The output data of channels 0 to 1 of the I/O module can be mirrored in up to 3 further MSO subslots in each case.

Configure MSO in the properties of the I/O module via the "Submodules" tab.

HART operating data records

B

B.1 HART command interface

Data records

The HART commands are sent as so-called external HART requests from the client, e.g. PDM, to the connected field device via data records. The response of the field device is made available again in the system via data records.

HART communication may only be handled by one client per channel. If a channel is handled by several clients, the response made available by the module cannot be allocated to one client with certainty. The I/O module does not support client management.

Rules

- After having written a request data record, a client must read the response data record before it may write another request data record.
- The client can evaluate the "processing status" in the response data record: If the "processing status" indicates "successful" or "error," the response data record contains current response data or error indications, respectively.
- The response data record must always be read completely because the I/O module may modify the data record after the initial reading with "successful" or "error" status.
  If the processing status in the response data record indicates "successful" or "error", the data record contains current response data or error displays.
- The client may only write a request data record to the I/O module again when it has read the response to the previously written request data record via the corresponding response data record. Otherwise, the response from the I/O module is overwritten.
- The STATUS component in the response frame (HART device status in the response data) provides information on whether errors have occurred and, if so, which errors.

Each request is stored on a channel-specific basis, and the corresponding request data record is locked. Another writing of the same request data record is thus not possible and is acknowledged with BUSY.
The disable of the request data record is reset after the termination or completion of the requested HART command.

SHC sequence

If a HART command with set SHC bit is sent to the I/O module, this channel is reserved for HART commands for 2 seconds. That is, if the module detects a HART command with SHC bit set for a channel, the complete HART interface of the I/O module is reserved for this channel for approximately 2 seconds. There is no processing of internal HART requests, and there is no HART command processing for all other channels of the I/O module during this time.

For each additional HART command with SHC bit set, the I/O module reserves this channel again for HART commands for an additional 2 seconds. If a HART command without SHC bit set is detected for this channel or if no other command for this channel occurs within 2 seconds after the previous HART command, the I/O module returns to "normal" HART operation. I.e. all HART channels are processed again.

Reading/writing data in RUN

HART operating data records are transferred to the module with the instruction "WRREC" and read by the module with the instruction "RDREC".

Errors during the transfer are indicated at output parameter STATUS of the "WRREC" or "RDREC".

The following HART operating data records are available:

Data record number	Description	Length (bytes)	Writable	Readable
80	HART job channel 0	240	Yes	Yes
81	HART response channel 0	240	No	Yes
82	HART job channel 1	240	Yes	Yes
83	HART response channel 1	240	No	Yes
121	HART variables	40	No	Yes
131	HART parameter channel 0	8	Yes	Yes
132	HART parameter channel 1	8	Yes	Yes
148	HART directory	13	No	Yes
149	HART feature data	3	No	Yes

B.2 HART job and response data records

HART commands are processed on a channel-specific basis via a separate command interface with one request data record and one response data record in each case.

Channel	Data record number	
	Request to the field device	Response from the field device
0	80	81
1	82	83

Structure of request data records 80 and 82

Byte	Meaning	Comment
0	Request control	
1	Number of preamble bytes	5...20, 255
2...239	Communication data according to HART specification	

Coding "Request control":

Bit 0...1: Reserved = 0

Bit 2: 0 = Parameters are not checked

Bit 3...4: Reserved = 0

Bit 5: 0 = Transparent format [1]
1 = Compact format

Bit 6: 1 = Enable SHC mode [2]

Bit 7: 0 = HART Request

[1] HART commands are processed by the I/O module in both transparent message format and compact message format. However, the response data from the module is always made available in transparent message format.

[2] Processing of a sequence of HART commands as an SHC sequence affects all other channels with HART enabled. See section HART command interface (Page 71).

NOTE

When "Number of Preamble Bytes" = 255, the number of preambles set with the parameters is used. The default setting is five. You can reconfigure the number of preamble bytes using the HART-specific settings (see section HART-specific settings (Page 79)).

Structure of response data records 81 and 83

In case of response error

Byte	Meaning	Comment
0	Response control	
1	HART group error display	
2	Protocol error	
3...239	Response data according to HART specification	Only present when "Response result" = 6 = "Error, with data"

In case of error-free response

Byte	Meaning	Comment
0	Response control	
1	HART group error display	
2...239	Response data according to HART specification	Only present when "Response result" = 4 = "Successful, with data"

Coding "Response control":

Bits 0-2: Response result (processing status)

0 = Inactive
1 = Inactive (reserved)
2 = Waiting
3 = Waiting, executing
4 = Successful, with data
5 = Successful, without data
6 = Error, with data
7 = Error, without data

Bit 3: 0 = Burst mode not active;

Bit 4: 0 = Response data come directly from the HART device

Bit 5: 0 = Response data in transparent message format

Bit 6: 0 = SHC mode not active
1 = SHC mode active

Bit 7: 0 = HART response

Coding "HART group error display"

Bit number	Meaning	Explanation
0	Additional status information available	(2nd HART status byte) You obtain additional status information, if required, with HART command 48.
1	HART communication error	The field device has detected a communication error when receiving the command. The error information is in the first HART status byte
2	Parameter check	0: HMD parameters unchanged 1: Check HMD parameters
3	Reserved	Always 0
4...7	HART protocol error during response	0: Unspecified error 1: HMD error 2: Channel fault 3: Command error 4: Query error 5: Response error 6: Query rejected 7: Profile query rejected 8: Manufacturer-specific query rejected 9 - 15: Not used

Coding "HART protocol error during response"

HART protocol error during response	Meaning	Explanation
0	Unspecified error	Always 0
1	HMD error	0: Not specified 1: Internal communication error 2: Parameter assignment error 3: HW fault 4: Wait time expired 5: HART timer expired 6...127: Reserved 128...255: Manufacturer-specific
2	Channel fault	0: Not specified 1: Line fault 2: Short-circuit 3: Open line 4: Low current output 5: Parameter assignment error 6...127: Reserved 128...255: Manufacturer-specific
3	Command error	0-127: HART protocol, Bit 7 = Always 0
4	Query error	Bit 0 = 0: Reserved Bit 1 = 1: Receive buffer overflow Bit 2 = 0: Reserved Bit 3 = 1: Checksum error Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved
5	Response error	Bit 0 = 1: GAP timeout Bit 1 = 1: Receive buffer overflow Bit 2 = 1: Timeout Bit 3 = 1: Checksum error Bit 4 = 1: Framing error Bit 5 = 1: Overflow error Bit 6 = 1: Parity error Bit 7 = 1: Reserved
6	Query rejected	0: Unspecified 1: Compact format not supported 2: SHC not supported 3: Impermissible command 4: No resources 6...127: Reserved 128...255: Manufacturer-specific
7	Profile query rejected	0: Not specified (not supported)
8	Manufacturer-specific query rejected	0: Not specified (not supported)

Example of HART programming (HART command interface)

For HART channel 0, command 01 is to be sent in transparent message format to the HART field device with address "98 CF 38 84 F0".
A positive edge at input 0.0 of a digital input module leads to the writing of the HART command.

The following assumptions are made:

- The module address of the I/O module is 512 (200_H).
- The data record is stored in DB80: starting from address 0.0, length of 11 bytes.
- In this example, DB80 (request data record for channel 0) consists of 11 bytes.

```
                                        Explanation
    A I 4.0
    FP M 101.0
    = M 104.0
m2: CALL SFB53, DB53
    REQ :=M104.0                        Write request
    ID :=DW#16#200                      Module address
    INDEX :=80                          Data record number 80
    LEN :=11                            Length 11 bytes
    DONE :=M51.7
    BUSY :=M51.0
    ERROR :=M51.6
    STATUS :=MD92                       Block status or error information
    RECORD :=P#DB80.DBX0.0 BYTE 11      Source area in DB80
    A M 51.0
    SPB m2
    BE
```

Table 2-1549 DB80: Transparent message format

Byte	Initial value (hex)	Comment (Hex)
0	00	Req_Control (00 = Transparent message format. 40 = Transparent message format with SHC sequence)
1	05	Number of preamble bytes (05-14)
2	82	Start character (02 = Short Frame with command 0) (82 = Long Frame with other commands)
3	98	Address (with command 0, the address is exactly 1 byte long and has the value 0.)
4	CF	
5	38	
6	84	
7	F0	
8	01	Command (CMD)
9	00	Length in bytes
10	98	Checksum (CHK) (calculated as EXOR addition starting from byte 2 "Start character" up to the last byte of the command) The checksum must not be sent with the job.)

A HART command can also be sent in compact message format. In this case, the data transmitted via DB 80 is reduced to 4 bytes.

Table 2-1550 DB80: Compact message format

Byte	Initial value (hex)	Comment (Hex)
0	20	Req_Control (20 = Compact message format 60 = Compact message format with SHC string)
1	05	Number of preamble bytes (5...20, 255)
2	01	Command (CMD)
3	00	Length in bytes

You can learn when the response from the field device was received by cyclically reading data record DS81 for HART channel 0. The response is always supplied in transparent message format.

Table 2-1551 FC81: Read the response with SFB 52 to DB81

```
                                        Explanation
m3: CALL SFB52, DB52
    REQ :=M1                            Read request
    ID :=DW#16#200                      Module address
    INDEX :=81                          Data record number 81
    MLEN :=200                          Target length
    VALID :=M49.7
    BUSY :=M49.1
    ERROR :=M49.6
    STATUS :=MD100                      Block status or error information
    LEN :=MW104
    RECORD :=P#DB81.DBX0.0 BYTE 200     Target area in DB81
    A M 49.1
    SPB m3
    BE
```

The program part A M 49.1 to SPB M3 is only required if reading is to occur within a block cycle.

As long as the processing status (byte 0 of DB81) is at 3 (waiting, executing), the response has not yet been received from the field device. As soon as the processing status changes to greater than 3, the HART request is finished.

With a processing status of 4, the request finished without errors and the response data can be evaluated.

With a processing status of 5, the request also finished without errors but without response data from the field device.

With a processing status of 6 or 7, the request finished with errors. You can find more detailed information in byte 1 of DB81 (see table "HART group fault display") and for a HART protocol error also in byte 2 of DB81 (see table "HART protocol error during response").

B.3 HART directory

Structure of the HART directory

Byte	Meaning	Comment
0	Profile Revision Number	= 2, 0 (Revision 2.0)
1		
2	Index of Client Management	= 255 (not relevant)
3	Number of Clients	= 1
4	Number of Channels	= 2
5	Write Read Index Offset	= 1 (The response to a job data record is made with the data record number of the request data record + 1)
6	Index of HMD Feature Parameter	= 149
7	Index of HMD Module Parameter	= 255 (not relevant)
8	Start Index of Burst Buffer Area	= 255 (not relevant)
9+n	Index of HMD Channel Parameter (Channel n)	= 131+n
9+n+4	Index of HART Client Channel Message Data	= 80+(2*n) The HART request data records cannot be configured. Data records starting from data record number 80 (80, 82) are always used.

B.4 HART feature data

Structure of the HART feature data

Byte	Meaning	Comment
0	Byte 0	= 0x62 Bit 1 = 1: "Parameter check result is given with a read response" Bit 5 = 1: "Compact format is supported"
1	Byte 1	= 0
2	Max Length Data Unit	= 240 (maximum length of the HART request data records)

B.5 HART variable data record

The I/O module supports a maximum of 4 HART variables per channel, which are read cyclically, provided that this is supported by the connected field device.
These HART variables are readable in HART variable data record 121.

Each HART variable consists of a 4-byte real value and a 1-byte quality code byte.

Structure of the HART variable data record

Byte	Meaning	
Channel 0		
0...3	Value	Primary Variable (PV)
4	Quality code	
5...8	Value	Secondary Variable (SV)
9	Quality code	
10...13	Value	Tertiary Variable (TV)
14	Quality code	
15...18	Value	Quaternary Variable (QV)
19	Quality code	
Channel 1		
20...39	HART variables same as for channel 0	

If HART is not enabled or the respective HART variable is not supplied from the connected field device, the corresponding variable = 0 and the QC = 0x37 (initialization value from the analog module).

B.6 HART-specific settings

HART communication is available via standard parameter assignment.

You can define additional HART-specific settings on a channel-specific basis using data records 131 and 132.

The parameters set in the CPU are not changed and are also valid after a startup.

Every new parameter assignment of the analog module resets the HART-specific settings back to the initial values from parameter data record 128.

If there is missing supply voltage L+, the HART-specific settings are not adopted by the module.

Channel	Data record number
0	131
1	132

Structure of the HART-specific settings

Byte 0	7 6 5 4 3 2 1 0 Must be 128	Bit 7 is reset after evaluation of data record by module
Byte 1	7 6 5 4 3 2 1 0 Must be 5	Offset for manufacturer-specific parameters according to HART specification
Byte 2	7 6 5 4 3 2 1 0 	Number of HART repetitions (0...10) Initial value from parameter data record 128
Byte 3	7 6 5 4 3 2 1 0 	Number of HART preamble bytes (0, 5...20, 255) Initial value = 5*
Byte 4	7 6 5 4 3 2 1 0 Must be 0	Field device mode according to HART specification
Byte 5	7 6 5 4 3 2 1 0 	Client timeout in s (1...255 s) Initial value = 60 s
Byte 6	7 6 5 4 3 2 1 0 0 0 0 0 0 0 ( ) ( ) ( ): 1 = Enable HART, 0 = Disable HART ( ): 1 = Primary master, 0 = Secondary master	Initial value corresponding to HART activation from parameter data record 128 Always as primary master
Byte 7	7 6 5 4 3 2 1 0 Must be 0	Reserved

Figure 2-1310 Settings

* When the number of HART preamble bytes = 0, the number of preamble bytes required by the connected field device are used, but no fewer than 5.
When the number of HART preamble bytes = 255, then 20 preamble bytes are used.

Analog value display

C

C.1 Representation of analog values in the current output ranges

In the following tables, you can find the digitized representation of the unipolar output ranges.

Display of analog value of current output ranges

The tables below list the decimal and hexadecimal values (codes) of the possible current output ranges.

Table 2-1552 Current output range 0 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	0 to 20 mA	
118.5149%	32767	7FFF	21 mA	Overflow
	29031	7167		
105%	29030	7166	21 mA	Overrange
	27649	6C01	20 mA + 723.4 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	15 mA	
0.003617%	1	1	723.4 nA	
0%	0	0	0 mA	
	-1	FFFF	0 mA	Underflow
-118.519%	-32768	8000		

Table 2-1553 Current output ranges 4 to 20 mA

Values			Current output range	Range
	Dec.	Hex.	4 to 20 mA	
118.5149%	32767	7FFF	21 mA	Overflow
	29377	72C1		
106.25%	29376	72C0	21 mA	Overrange
	27649	6C01	20 mA + 578.7 nA	
100%	27648	6C00	20 mA	Nominal range
75%	20736	5100	16 mA	
0.003617%	1	1	4 mA + 578.7 nA	
0%	0	0	4 mA	
	-1	FFFF	4 mA – 578.7 nA	Underrange

Values			Current output range	Range
-25%	-6912	E500	0 mA	Underrange
	-6913	E4FF	0 mA	Underflow
-118.519%	-32768	8000		

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ET 200SP HA / ET 200SP Ex-DI 4xNAMUR

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Security information 1

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit
https://www.siemens.com/industrialsecurity.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under
https://www.siemens.com/industrialsecurity.

Preface

2

Validity of the documentation

This documentation describes the following I/O module:

System	Module type	Article number
Distributed I/O System; ET 200SP and ET 200SP HA	Ex-DI 4xNAMUR	6DL1131-6TD00-0HX1

This documentation supplements the following documentation:

- System manual *Distributed I/O System, ET 200SP | ET 200SP HA; Modules for devices in the hazardous area*

Functions that generally relate to the ET 200SP and ET 200SP HA are described in the respective system documentation:

- System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)
- System manual Distributed I/O System ET 200SP HA (https://support.industry.siemens.com/cs/ww/en/view/109761547)

The information in this manual and the system/function manuals enables you to put the modules for hazardous areas into operation.

Conventions

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

These documentation contain a description of the components that was valid at the time the operating instructions were published. We reserve the right to include product information with information updates with new components and components with a new product status.

Product overview

3

3.1 Properties of the I/O module Ex-DI 4xNAMUR

View of the module

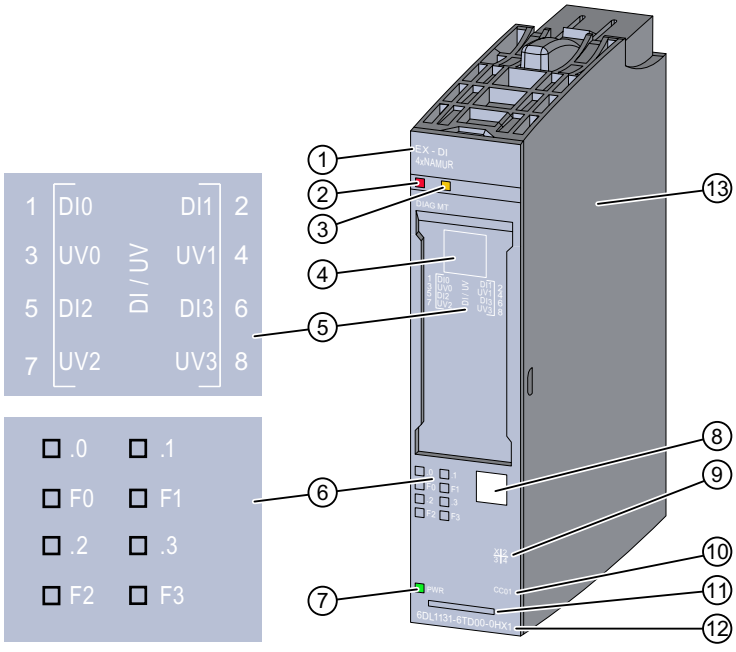

①	Module type and designation	⑧	Module type color coding
②	LED for diagnostics	⑨	Function version
③	LED for maintenance	⑩	Color code for selection of the color-coded labels
④	2D matrix code	⑪	Serial number
⑤	Wiring diagram	⑫	Article No.
⑥	LEDs for channel status/channel fault	⑬	Labeling surface (symbols and standards)
⑦	LED for supply voltage		

Figure 2-1311 View of the Ex-DI 4xNAMUR

You can find information on the LEDs in section "Status and error displays of the I/O module (Page 41)".

Possible configurations

The I/O module has 4 digital inputs.

The functions of the I/O module and its system integration differ depending on the configuration.

You can use the I/O module in the following configurations:

- Digital mode
- Digital mode with counter/frequency measurement modes

You can find additional information on this in the section "Configurations of the I/O module Ex-DI 4xNAMUR (Page 15)".

Properties

The I/O module is used to connect intrinsically safe NAMUR encoders as well as wired and unwired mechanical contacts.

The I/O module has the following technical properties:

- 4 digital inputs with the following properties that can be individually configured for each channel:
  - Pulse stretching
  - Hardware interrupts for positive and negative edges
  - Flutter monitoring
  - Diagnostics
- Counter/frequency measurement modes (channel 0 to 1)
  - 32-bit up-counter with parametrizable count limit and gate control
  - Configurable comparison value
  - Frequency measurement in REAL format
- Module-specific configurable diagnostics

You can find additional information in section "Technical specifications (Page 45)".

The module supports the following functions

The I/O module supports the following functions:

- Firmware update
- I&M identification data
- Parameter reassignment in RUN
- Value status QI
- Module-internal Shared Input (MSI)

Accessories

The following accessories can be ordered separately:

- Labeling strips
- Reference identification label
- Shield connector

3.2 2D Matrix code (QR code / EAN code)

The 2D matrix code on the product is a coded representation of the product-specific article number.

Access to product-related information

For reading the 2D matrix code, SIEMENS offers an app for mobile use.
Information about the app and the download can be found on the Internet: "Mobile use via app (https://support.industry.siemens.com/cs/ww/en/sc/2067)".

The app provides direct access to the technical forum and product-related posts, such as:

- FAQs
- Application examples
- Manuals
- Certificates
- Product notices

Wiring

4

4.1 Ex BaseUnit

You can operate the I/O module with the following Ex BaseUnit:

- Ex-BU Type X1 (6DL1 193-6BP00-0BX1)

The Ex BaseUnit is not included in the scope of delivery of the Ex I/O module and must be ordered separately.

NOTE

You can find additional information on the configuration in the system manual.

The terminal block for connecting the I/O signals is part of the Ex BaseUnit for Ex I/O modules and cannot be mounted separately.

Connections on the slot and Ex I/O module

The following figure shows the connections on the Ex BaseUnit and the I/O module.

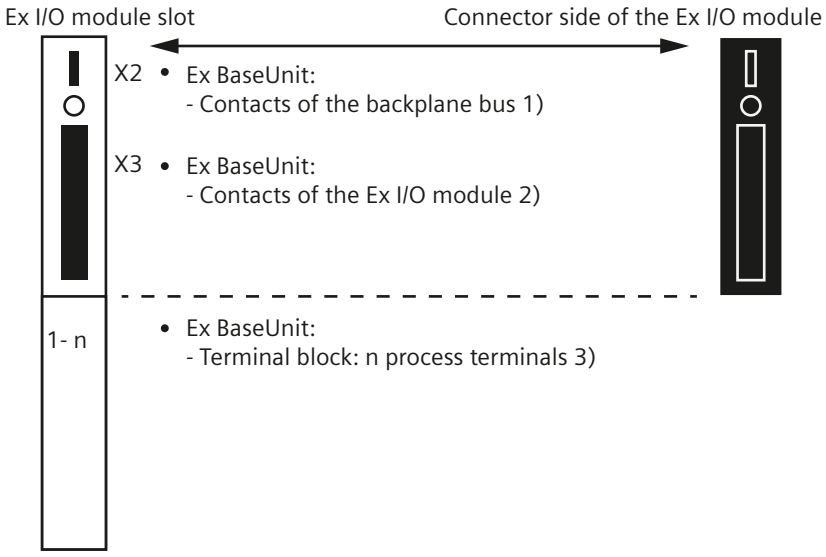

1) Ex BaseUnit contacts of the backplane bus (max. 50 mA; 3.3 V DC ⎓)

2) Ex BaseUnit contacts for process signal transmission (for maximum voltages and currents, refer to the documentation of the respective I/O module)

3) Process terminals on the terminal block (number, maximum/permissible voltages and currents, refer to the documentation of the respective I/O module).

Information on the pin assignment of the I/O module (terminal block) can be found in the following sections.

4.2 Pin assignment of the I/O module Ex-DI 4xNAMUR

General pin assignment

Table 2-1554 Pin assignment of Ex-DI 4xNAMUR

Terminal	Assignment	Terminal	Assignment	Terminal block	Explanations
1	DI_0+	**2**	DI_1+	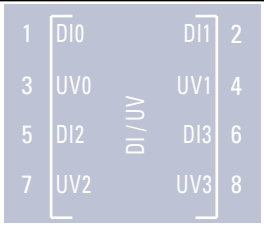	Terminals 1;2;5;6: DI_n+: Input signal, channel n Terminals 3;4;7;8: UV_n: Sensor supply, channel n
3	UV_0	**4**	UV_1		
5	DI_2+	**6**	DI_3+		
7	UV_2	**8**	UV_3		

Connections via all sensor types

You can find information on connecting the sensors in the following sections:

- Pin assignment for NAMUR sensors or IEC 60947-5-6 sensors (Page 11)
- Pin assignment for single contact connected with 10 kΩ (mechanical normally open contact) (Page 12)
- Pin assignment for single contact, unconnected (mechanical normally open contact with single contact) (Page 12)

4.3 Pin assignment for sensors

4.3.1 Pin assignment for NAMUR sensors or IEC 60947-5-6 sensors

Pin assignment channel 0

NAMUR sensors / IEC 60947-5-6 sensors	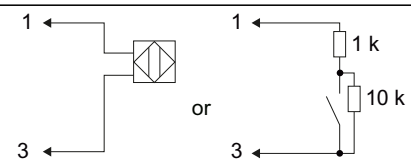

4.3.2 Pin assignment for single contact connected with 10 kΩ (mechanical normally open contact)

Pin assignment channel 0

Single contact connected with 10 kΩ (mechanical normally open contact)	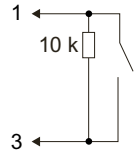

4.3.3 Pin assignment for single contact, unconnected (mechanical normally open contact with single contact)

Pin assignment channel 0

Single contact, unconnected (mechanical normally open contact with single contact)	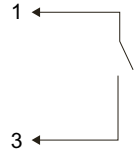

4.4 Schematic circuit diagram

The following figure shows the schematic circuit diagram of the Ex I/O module.

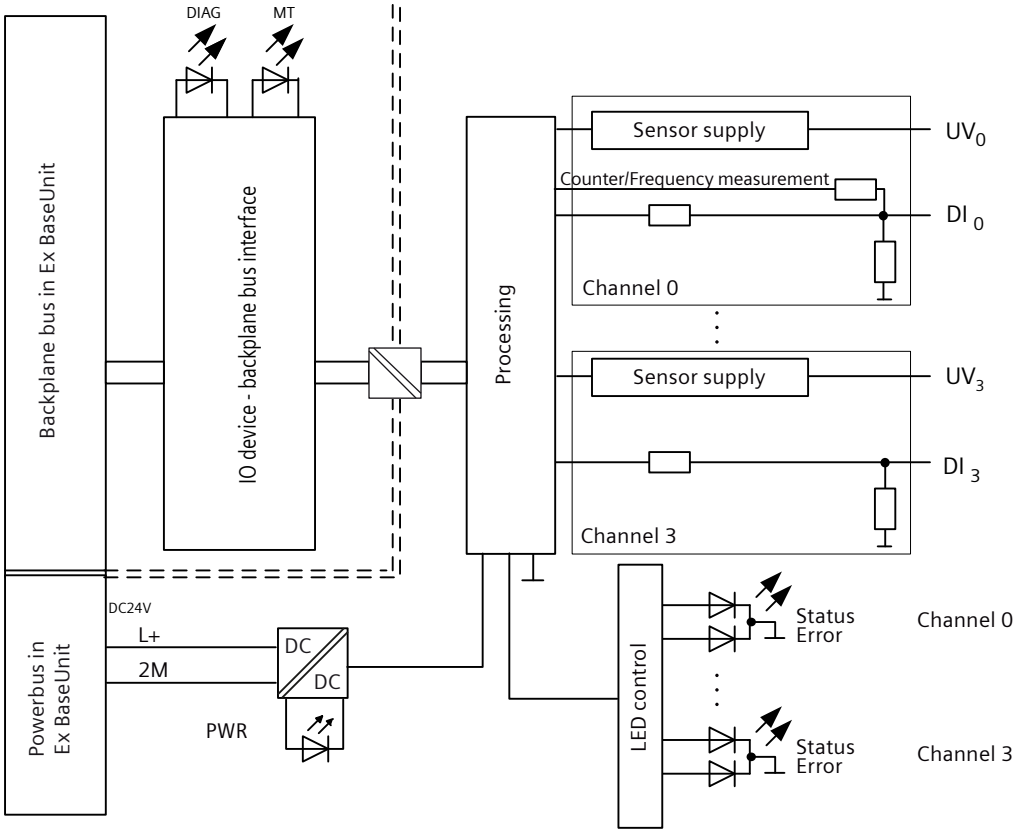

Figure 2-1312 Schematic circuit diagram Ex-DI 4xNAMUR

Supply voltage

The supply voltage L+/2M is generated and monitored by the Ex power module. The Ex I/O module receives its supply voltage L+ via the power bus. Further monitoring of the supply voltage is performed in the Ex I/O module. During parameter assignment, you can specify whether a diagnostic message is to be output in the event of failure of the supply voltage.

Firmware update

The supply voltage L+ must be available on the Ex I/O module at the start of firmware updates and during the update.

4.5 Potential group in hazardous areas

Potential group

With the modules for hazardous areas, the Ex power module and the Ex I/O module plugged into the right of the Ex power module form a potential group.

The potential group ends when one of the following modules is plugged in to the right of an Ex I/O module:

- Ex power module
- Server module

Configuring

5

5.1 Configurations of the I/O module Ex-DI 4xNAMUR

Requirements

You configure the I/O module

- in the TIA Portal
- with PCS 7
- with PCS neo
- with STEP 7

The version required in each case is specified in the technical specifications

Configuration via GSD/GSDML

Notes for configuration using a GSD/GSDML file (Page 17)

Restrictions when using in ET 200SP

- When used with a standard IM, its firmware must be at least at version V3.3.
- Value status is not available for a PROFIBUS DP station.
- TIA Portal:
  - TIA Portal as of V17.0
    The module can be centrally configured on the following CPUs:
    - CPU 1510SP-1 (as of V2.6)
    - CPU 1512SP-1 PN (as of V2.6)
    - CPU 1515SP-1 PN (as of V2.6)
  - The module cannot be used behind fail-safe controllers.

Configurations

Depending on the desired configuration, you have to select the required version of the I/O module from the hardware catalog.

The following configurations are possible:

Configuration [1]	Version of the I/O module in the hardware catalog of the engineering tool.	Required parameter assignment of the module
Digital mode without QI	**Ex-DI 4xNAMUR**	"Value status" parameter deactivated
Digital mode with QI [2]		• "Value status" parameter activated • Optional [3] "MSI with QI" You can find information on MSI in the section "Module-internal Shared Input (MSI) (Page 30)".
Digital mode with counter/frequency measurement modes without QI [2]	**Ex-DI 4xNAMUR CNT**	"Value status" parameter deactivated You can find additional information on the operating mode in the section ""Counter" and "Frequency measurement" operating modes (Page 33)".
Digital mode with counter/frequency measurement modes with QI [2]		"Value status" parameter activated You can find additional information on the operating mode in the section ""Counter" and "Frequency measurement" operating modes (Page 33)".

[1] When configuring via GSDML, all configurations can be directly selected in the hardware catalog of the engineering tool.

[2] Not available for configuration using a GSD file.

[3] Not available for configuration using a GSD/GSDML file.

NOTE

Changing the configuration in CPU RUN

You can re-configure the I/O module when the CPU is in RUN as long as the loaded configuration (version of the I/O module in the hardware catalog) is maintained.

If you want to define a different configuration in CPU RUN, the following steps are required:

1. Remove the I/O module from the loaded configuration in CPU RUN.
2. Configure the I/O module including the required configuration-specific parameters.
3. Load the new configuration in CPU RUN.

Note that changing the configuration changes the I/O address range.

Parameters

You define the operating mode of the I/O module via channel/technology parameters (data record 128).

5.2 Notes for configuration using a GSD/GSDML file

Files for configuration using GSD/GSDML

If you need the GSD/GSDML files for configuration, you can download them on the Internet:

- PROFINET GSD file (GSDML) for ET 200SP HA (http://support.industry.siemens.com/cs/ww/en/view/109781191)
- PROFINET GSD files for ET 200SP (http://support.automation.siemens.com/WW/view/en/57138621)
- PROFIBUS GSD files for ET 200SP (http://support.automation.siemens.com/WW/view/en/73016883)

Restrictions when using a GSDML file for PROFINET configuration

The following functions are not available in the process image of the I/O module:

- MSI

Restrictions when using a GSD file for PROFIBUS configuration

The following functions are not available in the process image of the I/O module:

- MSI
- Value status
- Counters
- Frequency measurement

5.3 Module/channel parameters in digital mode

Parameters in digital mode

If the I/O module is configured for digital mode, you have the following setting options:

Table 2-1555 Adjustable parameters and their default setting with Ex-DI 4xNAMUR configuration

Parameters	Value range	Default	CiR [1]	Efficiency range		
				HSP [2]	GSDML [3]	GSD [4]
Diagnostics Missing supply voltage L+ (Page 22)	• Enabled • Disabled	Disabled	Yes	Module	Module	Module
Diagnostics: Short-circuit (Page 22)	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Diagnostics: Wire break (Page 22)	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Diagnostics: Flutter error (Page 22) [5]	• Enabled • Disabled	Disabled	Yes	Channel	Channel	-
Sensor type (Page 22)	• Disabled • NAMUR sensor • Single contact, unconnected • Single contact with 10 Kilohm	NAMUR sensor	Yes	Channel	Channel	Channel
Pulse stretching (Page 23)	• None • 0.5 s • 1 s • 2 s	None	Yes	Channel	Channel	-
Digital input (Page 25)	• Normal • Inverted	Normal	Yes	Channel	Channel	Channel
Flutter monitoring (Page 26)	• Disabled • 2 signal changes ... • 17 signal changes ... • 32 signal changes	Disabled	Yes	Channel	Channel	-
Monitoring window (Page 26) [5]	• 0.5 s • 1 s • 2 s ... • 50 s ... • 100 s	0.5 s	Yes	Channel	Channel	-

1) CiR = Configuration in RUN

2) HSP = Configuration via Hardware Support Package (HSP) of the process control

3) GSDML = Configuration using a GSDML file

4) GSD = Configuration using a GSD file

5) Only available when the Flutter monitoring parameter is set to <n> signal change (not "disabled").

Parameters	Value range	Default	CiR [1]	Efficiency range		
				HSP [2]	GSDML [3]	GSD [4]
Hardware interrupt rising edge (Page 26)	• Enabled • Disabled	Disabled	Yes	Channel	Channel	-
Hardware interrupt falling edge (Page 26)	• Enabled • Disabled	Disabled	Yes	Channel	Channel	-
Potential group (Page 27)	Potential group of the left intrinsically safe power module	Potential group of the left intrinsically safe power module	No	Module	Module	Module

1) CiR = Configuration in RUN

2) HSP = Configuration via Hardware Support Package (HSP) of the process control

3) GSDML = Configuration using a GSDML file

4) GSD = Configuration using a GSD file

5) Only available when the Flutter monitoring parameter is set to <n> signal change (not "disabled").

5.4 Module/channel parameter in digital mode with counter/frequency measurement modes

The parameters are only available with the following configuration:
Digital mode with counter/frequency measurement modes (Ex-DI 4xNAMUR CNT)

"Frequency measurement" mode parameter

If you set the "Frequency measurement" mode, no additional parameter settings are required.

"Counting" mode parameter

- The counter parameters are only available for the channels 0 to 1.
- For channels 2 and 3, the parameter settings as in digital mode of the I/O module apply, see section "Module/channel parameters in digital mode (Page 18)".

If the I/O module is configured in the "Digital mode with counting/frequency measurement modes" configuration, you have the following setting options:

Table 2-1556 Adjustable parameters and their default setting with Ex-DI 4xNAMUR CNT configuration

Parameters	Value range	Default	CiR [1]	Efficiency range		
				HSP [2]	GSDML [3]	GSD [4]
Diagnostics Missing supply voltage L+ (Page 22)	• Enabled • Disabled	Disabled	Yes	Module	Module	-
Diagnostics: Short-circuit (Page 22)	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	-
Diagnostics: Wire break (Page 22) [5]	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	-
Diagnostics: Flutter error (Page 22)	• Enabled • Disabled	Disabled	Yes	Channel	Channel	-
Sensor type (Page 22)	• Disabled • NAMUR sensor • Single contact, unconnected • Single contact with 10 Kilohm	NAMUR sensor	Yes	Channel	Channel	-
Pulse stretching (Page 23)	• None • 0.5 s • 1 s • 2 s	None	Yes	Channel	Channel	-
Digital input (Page 25)	• Normal • Inverted	Normal	Yes	Channel	Channel	-
Flutter monitoring (Page 26)	• Disabled • 2 signal changes ... • 17 signal changes ... • 32 signal changes	Disabled	Yes	Channel	Channel	-

1) CiR = Configuration in RUN

2) HSP = Configuration via Hardware Support Package (HSP) of the process control

3) GSDML = Configuration using a GSDML file

4) GSD = Configuration using a GSD file

5) Only available when the Flutter monitoring parameter is set to <n> signal change (not "disabled").

6) Value must be smaller or equal to the value for the count high limit.

Parameters	Value range	Default	CiR [1]	Efficiency range		
				HSP [2]	GSDML [3]	GSD [4]
Monitoring window (Page 26) [5]	• 0.5 s • 1 s • 2 s ... • 50 s ... • 100 s	0.5 s	Yes	Channel	Channel	-
Hardware interrupt rising edge (Page 26)	• Enabled • Disabled	Disabled	Yes	Channel	Channel	-
Hardware interrupt falling edge (Page 26)	• Enabled • Disabled	Disabled	Yes	Channel	Channel	-
Operating mode (Page 26)	• Counting • Measure frequency	Counting	Yes	Channel 0 / Channel 1	Channel 0 / Channel 1	-
Edge selection (Page 26)	• Rising edge • Falling edge	Rising edge	Yes	Channel 0 / Channel 1	Channel 0 / Channel 1	-
Reaction to violation of a count high limit (Page 36)	• Stop counter • Resume counter	Stop counter	Yes	Channel 0 / Channel 1	Channel 0 / Channel 1	-
Set output DQ (Page 27)	• Between comparison value and count high limit • Between comparison value and count low limit	Between comparison value and count high limit	Yes	Channel 0 / Channel 1	Channel 0 / Channel 1	-
Hardware interrupt comparison result DQ (Page 27)	• Enabled • Disabled	Disabled	Yes	Channel 0 / Channel 1	Channel 0 / Channel 1	-
Comparison value (Page 27)	1 ... 4294967295 [6]	1	Yes	Channel 0 / Channel 1	Channel 0 / Channel 1	-
Count high limit (Page 27)	1 ... 4294967295	2147483647	Yes	Channel 0 / Channel 1	Channel 0 / Channel 1	-
Potential group (Page 27)	Potential group of the left intrinsically safe power module	Potential group of the left intrinsically safe power module	No	Module	Module	-

1) CiR = Configuration in RUN

2) HSP = Configuration via Hardware Support Package (HSP) of the process control

3) GSDML = Configuration using a GSDML file

4) GSD = Configuration using a GSD file

5) Only available when the Flutter monitoring parameter is set to <n> signal change (not "disabled").

6) Value must be smaller or equal to the value for the count high limit.

5.5 Explanation of parameters

5.5.1 Diagnostics Missing supply voltage L+

Defines whether a diagnostic interrupt is generated when the supply voltage L+ is missing or is too low.

The supply voltage is generated by the Ex power module. Other internal defects can be detected and reported via the additional diagnostics for the Ex I/O module.

5.5.2 Diagnostics: Short-circuit

Defines whether a diagnostic interrupt is generated when a short-circuit occurs between the leads of the sensor.

You can use the short-circuit diagnostics with the following setting of the sensor:

- NAMUR sensor

5.5.3 Diagnostics: Wire break

Specifies whether a diagnostic interrupt is generated when the wire break test current is undershot.

You can use the wire break diagnostics with the following setting of the sensor:

- NAMUR sensor
- Single contact with 10 kΩ

5.5.4 Diagnostics: Flutter error

Defines whether a diagnostic interrupt is generated when a flutter error occurs.

5.5.5 Sensor type

Specifies the type of sensor to be connected for the channel. The module supports the following sensor types:

- NAMUR sensor according to IEC 60947-5-6
- Single contact, unconnected
- Single contact, connected with 10 kΩ

5.5.6 Pulse stretching

Pulse stretching

Pulse stretching is a function for changing a digital input signal. A pulse on a digital input is extended to at least the configured length. If the input pulse is already longer than the configured length, the pulse is not changed.

If hardware interrupts are supported, the pulse-stretched signal is the signal that triggers a hardware interrupt.

The pulse-stretched signal is the input signal for flutter monitoring.

Principle of pulse stretching

The figure below uses examples to show whether and how input pulses are changed.

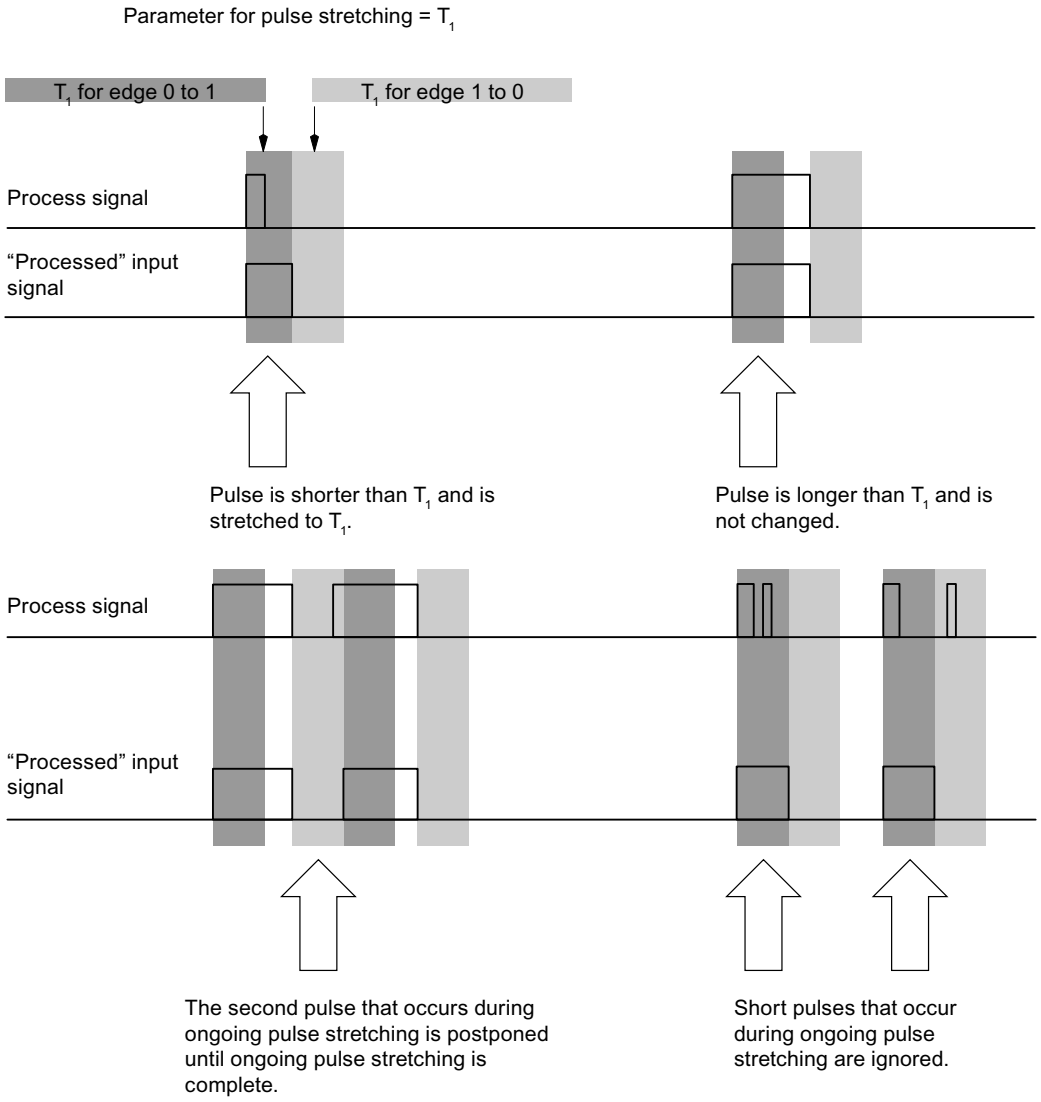

Figure 2-1313 Principle of pulse stretching

Pulse stretching affects active flutter monitoring

If you configure pulse stretching for an input channel, it also affects flutter monitoring enabled for this channel. The "pulse-stretched" signal is the input signal for flutter monitoring. You therefore need to adapt the parameter settings of pulse stretching and flutter monitoring to each other. You can adapt the functions to your process by selecting the appropriate values for the parameters.

Value status bad

Ongoing pulse stretching is reset with value status bad (QI = 0, for example wire break).

5.5.7 Digital input

Specifies whether or not the input signal is to be inverted.

You can use the parameter for the following sensor types:

- NAMUR sensor
- Single contact, unconnected
- Single contact with 10 kΩ

5.5.8 Flutter monitoring

Specifies whether the input signal is to be monitored for flutter errors. Flutter monitoring is enabled if the number is other than 0. The number of tolerated signal changes within the configured time is monitored (monitoring window).

5.5.9 Monitoring window

Specifies a time period for monitoring of the input signal (monitoring window). The configured time is started with the first signal change of the input signal. You can set the duration for each channel.

5.5.10 Hardware interrupt rising edge

Specifies whether a rising edge at the digital input generates a hardware interrupt.

5.5.11 Hardware interrupt falling edge

Specifies whether a falling edge at the digital input generates a hardware interrupt.

5.5.12 Operating mode

Defines the operating mode of the channel:

- Counting
- Measure frequency

5.5.13 Edge selection

Specifies the edge direction of the pulses at the counter input that are counted in the "Counting" mode.

- Rising edge
- Falling edge

5.5.14 Reaction to violation of a count high limit

Specifies the response of the counter when the count limit is violated in "Counting" mode:

- Stop counting
- Resume counting

5.5.15 Set output DQ

Determines the range in which the "STS_DQ" status bit is set in the "Counting" mode.

- Between comparison value and count high limit
- Between comparison value and count low limit

5.5.16 Hardware interrupt comparison result DQ

Specifies in "Counting" mode that a hardware interrupt is generated when the "STS_DQ" status bit changes from 0 to 1.

5.5.17 Comparison value

Specifies in "Counting" mode the count value at which the "STS_DQ" bit of the feedback interface switches due to the comparison.

For additional information, see parameter "Set output DQ (Page 27)".

5.5.18 Count high limit

Limits the count range for "Counting" mode.

Counting range		Overflow
32 bit	0 to 4 294 967 295 0 to FFFF FFFFH	When counter status changes from 4 294 967 295 to 0

NOTE

Display may be limited by the "DINT" data type. However, the settings of the count limits are permitted up to 32 bits without sign.

Additional information:

- Address space in digital mode with counter/frequency measurement modes without QI (Page 66)
- Address space in digital mode with counter/frequency measurement modes with QI (Page 68)

5.5.19 Potential group

A potential group consists of a group of directly adjacent Ex I/O modules within a station of the distributed I/O (IO device), which are supplied via a common Ex power module.

A potential group begins with an Ex power module, via which the required supply voltage for all Ex I/O modules of the potential group is supplied. The Ex power module interrupts the self-assembling voltage buses to the left neighbor.

The Ex I/O modules take the potential of the self-assembling voltage buses from the left neighbor.

A potential group ends with the Ex BaseUnit, which follows an Ex power module or a server module in the station configuration.

You can find additional information on the configuration of the potential group in the system manual *Distributed I/O System; ET 200SP and ET 200SP HA, Modules for Hazardous Areas*.

5.6 Flutter monitoring function

Description

Flutter monitoring is a process control function for digital input signals. If flutter monitoring is active, monitoring of the number of signal changes within a time period is performed for a digital input. This period is referred to as the monitoring window. If an unusually high number of signal changes occur in the monitoring window, it is a sign that the sensors are faulty or that there are instabilities from a process engineering viewpoint. A diagnostic interrupt can be enabled for this status.

Flutter monitoring parameters

The following parameters must be set for using flutter monitoring:

- Flutter monitoring (Page 26)
- Monitoring window (Page 26)
- Diagnostics: Flutter error (Page 22)

Detecting a flutter error

Requirements:

- Error-free detection of the input signal.
- The monitoring of the input signal is enabled if a value other than 0 is set for the "Flutter monitoring Number of signal changes" parameter.

Monitoring:

- The monitoring window is started the first time the signal changes.

  If the number of detected signal changes is lower than the configured number of signal changes within the monitoring window, the signal is error-free with regard to the detection of a flutter error.
- The monitoring window and counting of the signal changes is automatically restarted on the next signal change.

Diagnostics: Encoder signal flutters

The diagnostics "Sensor signal flutters" applies to a digital input as soon as the following occurs:
The configured number of signal changes is exceeded within the monitoring window.

Responses on detection of a flutter error:

- The current signal state is entered in the process image and the value status of the signal is set to invalid (QI = 0).
- When flutter error diagnostics is enabled:
  The flutter error diagnostics information is entered and an incoming diagnostic interrupt "Sensor signal flutters" - "INCOMING" is generated.

Resetting a flutter error

NOTE

Active flutter monitoring is reset if there is an error in the input signal (value status QI = 0).

If **after** a flutter error no further flutter of the input signal is detected within three monitoring windows:

- The current signal state is entered in the process image.
- The value status of the signal is set to valid (QI = 1).
- The diagnostic information Flutter error is deleted.
- The diagnostic interrupt "Sensor signal flutters" - "OUTGOING" is generated.

Principle

The following figure gives you another graphic illustration of the principle of flutter monitoring.

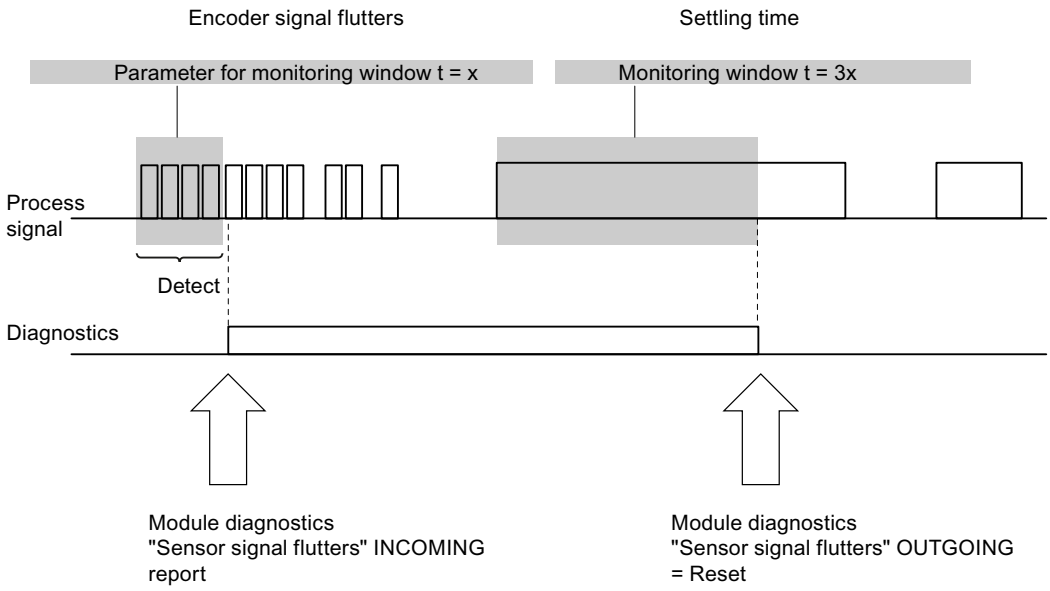

Figure 2-1314 The principle of flutter monitoring

5.7 Module-internal Shared Input (MSI)

The function enables several IO controllers to access the input data of the I/O module.

- With MSI, the input data of the I/O module (the basic submodule) is copied to up to three further MSI submodules.
  All process values of the I/O module are thus present with identical input values in all submodules.
- Each of the four submodules can be assigned to an IO controller, whereby these can be different or identical IO controllers.
- IO controllers have read-only access to the data of each submodule
- Only the basic submodule is configured and can return diagnostic interrupts and hardware interrupts.
  MSI submodules are not configurable and do not return interrupts.

The following figure shows a digital input module with the basic submodule and three MSI submodules. Each submodule is assigned to an IO controller. The diagnostics and parameter assignment of the digital input module is possible via the basic submodule from the IO controller 1.

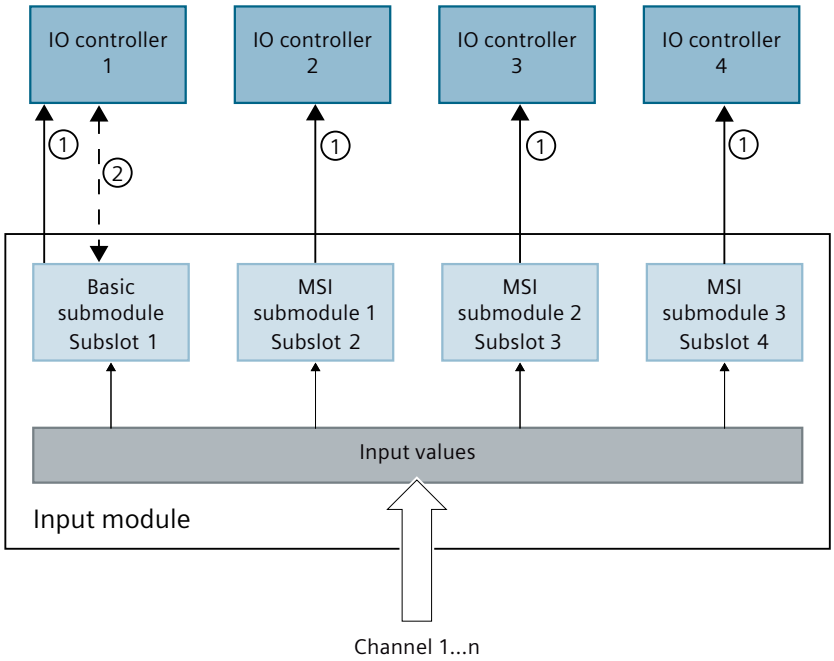

① Read access

② Parameter assignment and system diagnostics

Figure 2-1315 Input module with MSI configuration

Value status (Quality Information, QI)

If QI = "bad" (QI = 0), then the process value is not valid.

NOTE

Restrictions

- **PROFINET required**
  MSI is only available with configuration with PROFINET.
- **No configuration with PCS 7**
  No support for configuration with PCS 7.
- **No configuration via GSD/GSDML**
  No support of MSI during configuration via GSD/GSDML.
  Notes for configuration using a GSD/GSDML file (Page 17)

Configure MSI for an I/O module

You set the configuration on the basic submodule (subslot 1).

NOTE

If "MSI" is configured for an I/O module, this applies to all channels of the I/O module.

If MSI is to be configured, the value status QI must always be configured as well.

1. Select the configuration based on the following table.
2. Select the number of MSI submodules in the properties of the I/O module. This parameter assignment can be performed in CPU RUN.

You can find additional information on this in the section "Address space (Page 64)".

Changing the MSI configuration in RUN

The parameter "Value status" must always be activated.

Configuration	Version of the I/O module in the module catalog of the engineering tool	Configuration of the I/O module
Digital mode DI 4 with QI	**Ex-DI 4xNAMUR**	Number of additional submodules: (Change in CPU RUN possible) • 1 to 3: MSI is enabled • 0: MSI is disabled

Additional information

- Find out how to assign MSI submodules to an IO controller in the documentation *SIMATIC; Distributed I/O System ET 200SP/ET 200SP HA, Modules for uses in hazardous areas*.
- How to configure access to a shared device and the function MSI in STEP 7 can be found in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109736536).

"Counter" and "Frequency measurement" operating modes

6

6.1 "Counter" and "Frequency measurement" introduction

In this configuration, the channels 0 to 3 operate unchanged as digital channels. The "Counter" and "Frequency measurement" modes are also available for the channels 0 and 1.

Overview of channel functions

The following figure shows the pin assignment for channel n (digital inputs channels 0 and 1) for the configuration "Digital mode with counter/frequency measurement modes":

- In "Counter" mode, a 32-bit forward counter works in parallel to the digital input.
  You can find information on this in the section "Counters (Page 34)".
- In "Frequency measurement" mode, a frequency meter works in parallel to the digital input.
  You can find information on this in the section "Frequency measurement (Page 40)".

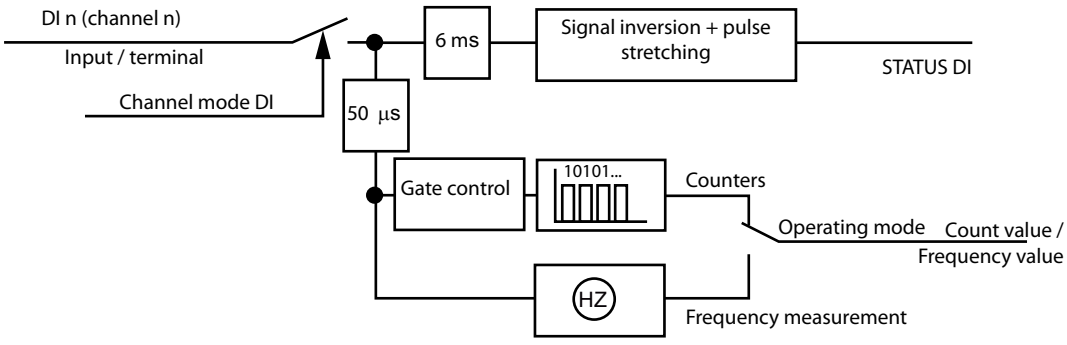

Figure 2-1316 Counters and frequency meters working in parallel to the digital input

You can find information on the process image in section "Address space (Page 64)".

You can find additional information in section "Technical specifications (Page 45)".

NOTE

Consistency between the DI values (DI status / QI)

Due to the different and independent processing of the input signals, there is no consistency between the DI values (DI status / QI) and the count values.

6.2 Counters

"Counter" mode

In "Counter" mode, a 32-bit forward counter works in parallel to the digital input. The functions of the digital input remain available.

Operating principle in "Counter" mode

You can find information on the counter parameters in the section "Module/channel parameter in digital mode with counter/frequency measurement modes (Page 19)".

You can read the count value in the feedback interface. The count value is displayed in S7 format.

Function	Explanation and setting	
Start counter	The counter starts with count value = 0 after the following events: • I/O module is switched on • Hot restart of the CPU • Connection to the CPU is restored	
Pulse counting	The pulses at the digital input are counted and evaluated according to the parameter assignment.	"Edge selection" parameter: • Rising edge • Falling edge
Count limit	The count high limit is configurable.	"Count limit" parameter; range: 1 ... 4294967295 (2^{32}-1)
Reaction to violation of the count high limit	When the count value violates the count high limit, the further behavior of the counter depends on the parameter assignment.	Parameter "Reaction to violation of a count high limit (Page 36)" • Stop counter • Resume counter
Stop counter	The counter stops at the following events: • Stop via gate control • CPU changes to stop • Connection to the CPU is terminated (for example, PN cable disconnected)	Gate control via the control bit SW_GATE (bit in the control interface of the I/O module)
Load counter	A value (load value) can be loaded as a count value to resume counting via the control interface (LD_SLOT).	Load count value via control interface (Page 39): • Control interface (LD_SLOT) • "Load value" data word; range; 0 to 4294967295 (2^{32}-1)
Comparison value	A comparison value can be configured.	"Comparison value" parameter; range: 1 ... 4294967295 (2^{32}-1)
Show range of count value	The range in which the current count value is located as compared to the count limits and the comparison value can be queried via the STS_DQ status bit (bit in the feedback interface).	The status of STS_DQ depends on the setting of the "Set output DQ (Page 37)" parameter: • Between comparison value and count high limit • Between comparison value and count low limit
Hardware interrupt	It is possible to generate a hardware interrupt when status bit STS_DQ changes from 0 to 1.	Enable "Hardware interrupt comparison result DQ" parameter

6.2.1 Gate control

One software gate (SW gate) is available per counter channel for controlling the counter.

Gate control and status bit STS_Gate

The control bit SW_GATE controls the counter via the internal gate.

The status of the internal gate is displayed at status bit STS_Gate.

Counting controlled via internal gate

SW gate = closed	SW gate = open
Internal gate closed	Internal gate open as long as the limit has not yet been exceeded. • Resume counting Internal gate open • Stop counting Internal gate open as long as the limit has not been exceeded yet.

As soon as the internal gate is closed, incoming pulses are ignored.

See also

Reaction to violation of a count high limit (Page 36)

6.2.2 Count operation (startup and stop)

The following behavior applies to the configured I/O module with assigned parameters.

Start

The counter starts at 0 after the following events:

- When the high count limit has been reached.
- Startup of I/O module
- Restart of the CPU (STOP -> RUN).
- Connection to the CPU is restored.

Stop

The count value is frozen after the following events:

- The internal gate is closed.
- CPU changes to stop
- Connection to the CPU is terminated (for example, PN cable disconnected)

Behavior of the counter during operation

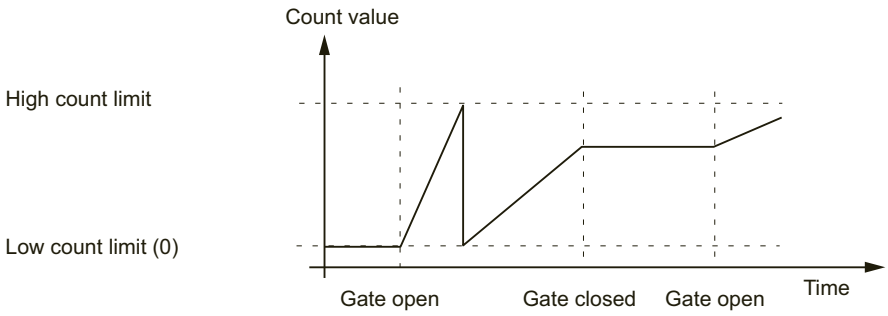

Figure 2-1317 Example: Counting process with gate control

6.2.3 Reaction to violation of a count high limit

Introduction

You can configure the count high limit for the counting range.

Behavior

The behavior of the counter when the high limit is violated depends on the setting of the parameter "Reaction to violation of a count limit".

Table 2-1557 Reaction of the counter to violation of the count high limit

Parameter	Setting	Description
Reaction to violation of a count high limit	Stop counting	With this parameter setting, the counter records the pulses until the count high limit is exceeded. The internal gate is closed automatically. Note: To start the counting process again, you must close and open the SW gate again.
	Resume counting	With this parameter setting, the counter records the pulses. When the count high limit is exceeded, the counter reading is automatically set to 0. The counter continues the counting process with the next pulse. The internal gate remains open.

See also

Module/channel parameter in digital mode with counter/frequency measurement modes (Page 19)

6.2.4 Status bit STS_DQ

Comparison and status bit STS_DQ

You can specify a value within the counting range for which a comparison with the counter reading is carried out.

The STS_DQ status bit is activated directly when you configure the comparison value. You can change the comparison value at any time.

You can configure the following behavior for the comparison result:

- Evaluation of the comparison value: **"Set output DQ" parameter**
  For the settings, see the following table "Configure evaluation of the comparison value"
- Generate a hardware interrupt when the STS_DQ status bit changes from 0 to 1.

Configure evaluation of the comparison value

With the "Set output DQ" parameter, you determine when the STS_DQ status bit is set.

The parameter affects the status bit STS_DQ. You can set up the parameter channel-specifically

Table 2-1558 "Set output DQ" parameter

Value	Setting	Behavior; condition
1	"Between comparison value and count high limit"	• Status bit STS_DQ = 0; if counter reading < comparison value • Status bit STS_DQ = 1; if counter reading >= comparison value See the following figure "STS_DQ bit between comparison value and count high limit"
2	"Between comparison value and count low limit"	• Status bit STS_DQ = 0; if counter reading > comparison value • Status bit STS_DQ = 1; if counter reading <= comparison value See the following figure "STS_DQ bit between comparison value and count low limit"

Setting the STS_DQ status bit between the comparison value and count high limit

If the setting "Between comparison value and count high limit" is selected for the parameter "Set output DQ", the status bit STS_DQ is set in the following case:

- Counter reading >= Comparison value

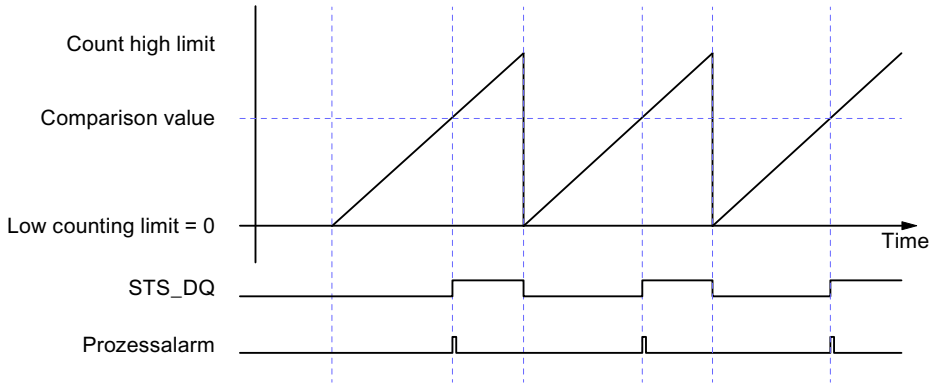

Figure 2-1318 STS_DQ bit between comparison value and count high limit

Setting the STS_DQ status bit between the comparison value and count low limit

If the setting "Between comparison value and count low limit" is selected for the parameter "Set output DQ", the status bit STS_DQ is set in the following case:

- Counter reading <= Comparison value

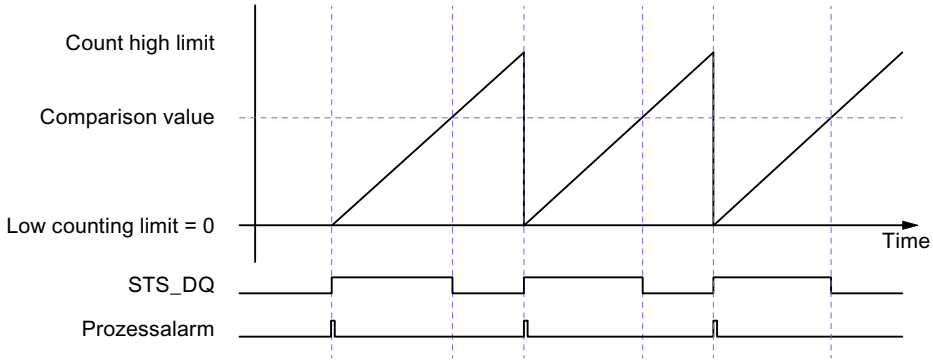

Figure 2-1319 STS_DQ bit between comparison value and count low limit

Generate hardware interrupt by comparison result

With the "Hardware interrupt comparison result DQ" parameter, you determine whether a hardware interrupt is generated.

Table 2-1559 Hardware interrupt comparison result DQ

Parameter	Parameter setting	Behavior
Hardware interrupt comparison result DQ	• 1 = Enabled • 0 = Disabled	When the comparison is enabled, a hardware interrupt is generated when the STS_DQ status bit changes from 0 to 1.

6.2.5 Loading the count value

Introduction

You can specify the value from which counting is continued for a digital input parameterized as a counter.

Load counter

You can specify the load value for counting via the user program:

- Load value
- LD_SLOT: Apply load value with rising edge of LD_SLOT as current count value
- SW_GATE: 0 = Stop counter / 1 = Counter enabled (active)

The following figure shows the change of the count value with control via the user program (load value) and the effects on the comparison event.

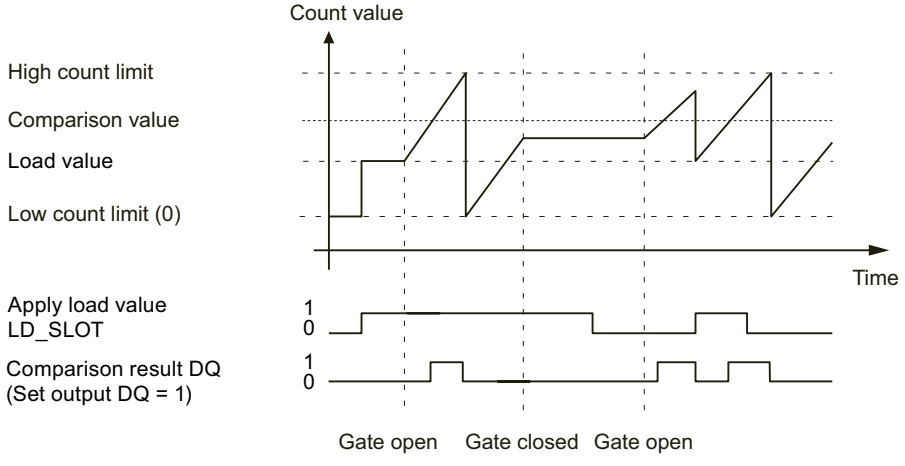

Figure 2-1320 Example: Counting process controlled via user program (load value) and effects on the comparison result

Additional information

Information on the address space

- Section "Address space in digital mode with counter/frequency measurement modes without QI (Page 66)"
- Section "Address space in digital mode with counter/frequency measurement modes with QI (Page 68)"
- Section "Data record 128 with configuration digital mode with counter/frequency measurement modes (Page 57)"

6.3 Frequency measurement

In "Frequency measurement" mode, the function works in parallel to the digital input. The functions of the digital input remain available.

Operating principle in "Frequency measurement" mode

The I/O module determines the frequency applied in Hz. The frequency value is provided in the unit Hz in REAL format. You can read the frequency value in the feedback interface.

- The measuring window is 2 seconds long. Pulses are counted within the measuring window and a new frequency value is determined on expiry of a measuring window.
- With frequencies less than 0.5 Hz, the measuring window is increased cyclically and the frequency value is adjusted accordingly. A new frequency value is formed on arrival of a new pulse.
- Frequencies down to minimum 0.1 Hz are measured.

Additional information

Information on the address space

- Section "Address space in digital mode with counter/frequency measurement modes without QI (Page 66)"
- Section "Address space in digital mode with counter/frequency measurement modes with QI (Page 68)"

Displays and interrupts

7

7.1 Status and error displays of the I/O module Ex-DI 4xNAMUR

7.1.1 Status and error displays of the I/O module

Definition

The LED displays are status and fault displays.

LED displays

The following figure shows the LED displays of the I/O module:

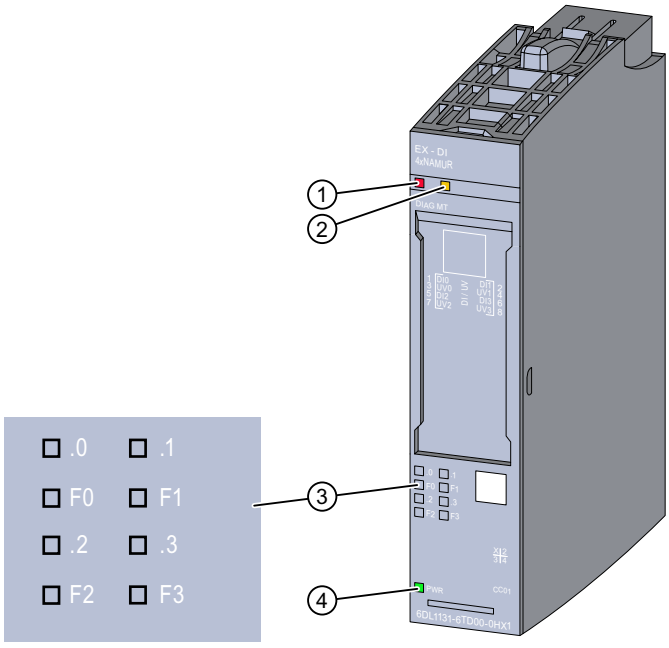

① DIAG LED (green/red)

② MT LED (yellow)

③ LED channel status n (green) and LED channel fault Fn (red) - channel n (n = 0 to 3)

④ PWR LED (green)

Figure 2-1321 LED displays

Meaning of the LED displays

The tables below explain the meaning of the status, error and maintenance displays.

You can learn about corrective measures for messages as well as possible causes in the following sections:

- Diagnostic and maintenance messages (Page 62)
- Hardware interrupts (Page 63)

7.1.2 Diagnostics display of the DIAG LED

DIAG LED

Table 2-1560 Diagnostics display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the system is disrupted or switched off.
Flashes	Module is not configured.
On	Module is configured, a diagnostic message is not pending.
Flashes	Module is configured, at least one diagnostic message is pending.

7.1.3 Diagnostics display of the MT LED

MT LED

Table 2-1561 Status display of the LED MT

MT LED	Meaning
Off	No maintenance required.
On	Maintenance is required, i.e. at least one maintenance event has occurred.

7.1.4 Diagnostics display of the Channel status/channel fault LED

Channel status/channel error LED

The green channel status LED shows the signal state of the active channel. If signal inversion is active, the LED indicates the inverted state of the terminal.

The red channel fault LED is lit when channel diagnostics for an enabled channel are pending.

Table 2-1562 Status and error display of the LEDs channel status and channel error

LED channel status	LED channel error	Meaning
□ Off	□ Off	• Channel disabled or module switched off • Process signal = 0, channel enabled and no channel diagnostics pending • Module diagnostics pending
■ On	□ Off	Process signal = 1, channel enabled and no channel diagnostics pending
□ Off	■ On	Process signal = 0, channel enabled and channel diagnostics pending
■ On	■ On	Process signal = 1, channel enabled and channel diagnostics pending

7.1.5 Diagnostics display of the PWR LED

PWR LED

Table 2-1563 Status display of the PWR LED

PWR LED	Meaning
□ Off	The supply voltage L+ is missing for the potential group.
■ On	The supply voltage L+ is available for the potential group.

7.2 Interrupts

The I/O module supports diagnostic interrupts and hardware interrupts. Diagnostic and maintenance messages are output via diagnostic interrupts.

You can find more information on this in the appendix:

- Diagnostic and maintenance messages (Page 62)
- Hardware interrupts (Page 63)

Diagnostic messages

The I/O module generates a diagnostic message at the following events:

- Short-circuit (NAMUR sensors only)
- Channel/component temporarily unavailable
- Wire break (NAMUR sensor or single contact, connected with 10 kΩ)
- Parameter assignment error
- Supply voltage missing
- Hardware interrupt lost
- Module is faulty
- Encoder signal flutters
- Retentive memory in the BaseUnit is defective.
- Invalid BaseUnit

NOTE

A pending "Module is defective" diagnostics is not deleted by the module until a restart.

Maintenance messages

The I/O module generates a maintenance message when the following events occur:

- Retentive memory in the BaseUnit is defective.

Technical specifications

8

Technical specifications of Ex-DI 4xNAMUR

Article number	6DL1131-6TD00-0HX1
General information	
Product type designation	Ex-DI 4xNAMUR
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type X1
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V17 or higher
• STEP 7 configurable/integrated from version	STEP 7 V5.6 SP2 or higher
• PCS 7 configurable/integrated from version	V9.1
Operating mode	
• DI	Yes
• Counter	Yes
• MSI	Yes
Redundancy	
• Redundancy capability	No
Input current	
Current consumption (rated value)	50 mA
Current consumption, max.	55 mA
Encoder supply	
Number of outputs	4
Output voltage (DC)	8.2 V
Short-circuit protection	Yes
Power loss	
Power loss, typ.	1.2 W
Address area	
Address space per module	
• Inputs	10 byte; + 1 byte for QI information
• Outputs	10 byte

Article number	6DL1131-6TD00-0HX1
Hardware configuration	
Automatic encoding	
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type X1
Digital inputs	
Number of digital inputs	4; NAMUR
Digital inputs, parameterizable	Yes
Pulse extension	Yes; 0.5 s, 1 s, 2 s
Time stamping	No
Edge evaluation	Yes; Positive edge, negative edge
Signal change flutter	Yes; 2 to 32 signal changes
Flutter observation window	Yes; 0.5 s, 1 s to 100 s in 1-s steps
Digital input functions, parameterizable	
• Counter	
– Number, max.	2; Channel 0 and 1
– Counting frequency, max.	5 kHz
– Counting direction up/down	Yes; Up
Input voltage	
• Rated value (DC)	8.2 V
Input current	
for 10 k switched contact	
– for signal "0"	Max. 1.2 mA
– for signal "1"	Min. 2.1 mA
for unswitched contact	
– for signal "0", max. (permissible quiescent current)	0.5 mA
– for signal "1"	typ. 8 mA
for NAMUR encoders	
– for signal "0"	0.35 to 1.2 mA
– for signal "1"	2.1 ... 6.4 mA
for NAMUR inputs	
– at "0" to "1", max.	12 ms
– at "1" to "0", max.	12 ms
Cable length	
• shielded, max.	500 m; Ex characteristic values must be observed; without shield applied on both sides and cable lengths of more than 200 m, measured value distortions can occur when using the inputs as counter/ frequency meter

Article number	6DL1131-6TD00-0HX1
• unshielded, max.	300 m; Ex characteristic values must be observed; without shield applied on both sides and cable lengths of more than 200 m, measured value distortions can occur when using the inputs as counter/ frequency meter
Encoder	
Connectable encoders	
• NAMUR encoder/changeover contact according to EN 60947	Yes
• Single contact / changeover contact unconnected	Yes
• Single contact / changeover contact connected with 10 kΩ	Yes
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Maintenance interrupt	Yes
• Hardware interrupt	Yes; channel by channel
Diagnoses	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Monitoring of encoder power supply	Yes
• Wire-break	Yes; channel by channel
• Short-circuit	Yes; channel by channel
• Group error	Yes
Diagnostics indication LED	
• MAINT LED	Yes; Yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Integrated Functions	
Measuring functions	
Accuracy	
– Frequency measurement	1 %
Ex(i) characteristics	
maximum values for connecting terminals for gas group IIC	
• Uo (no-load voltage), max.	9.6 V

Article number	6DL1131-6TD00-0HX1
• Io (short-circuit current), max.	61 mA; applies for up to four circuits connected in parallel
• Po (power output), max.	145 mW; applies for up to four circuits connected in parallel
• Co (permissible external capacity), max.	3.6 µF; applies for up to four circuits connected in parallel
• Lo (permissible external inductivity), max.	13 mH; applies for up to four circuits connected in parallel
• Um (voltage at non-intrinsically safe connecting terminals), max.	60 V
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes; Electrical isolation between the channels and input voltage PME
Isolation	
Isolation tested with	further information on insulation can be found in the "ET 200SP HA / ET 200SP modules for devices in hazardous areas" System Manual
insulation of the field circuits to local ground acc. to IEC/EN 60079-11 tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-40 °C
• horizontal installation, max.	70 °C
• vertical installation, min.	-40 °C
• vertical installation, max.	60 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	55 g

Cycle time

The cycle time describes the time interval in which the NAMUR input signals are acquired and the process values of the digital inputs (status of inputs and QI) are formed as a result.

The cycle time of the I/O module is 2 ms.

The cycle time has no influence on the formation of the counter values or the frequency values.

Minimum pulse length

In order for a pulse or an edge transition of the NAMUR inputs to be reliably detected by the I/O module, the signal status must be active for at least the duration of the minimum pulse length.

Minimum pulse length = Input delay + cycle time

Each edge transition is detected after a delay of no more than the specified minimum pulse length.

NAMUR sensors and connected contacts

Monitoring for short-circuit and wire break only for NAMUR sensors and connected contacts. The response ranges of the diagnostics correspond to IEC 60947-5-6.

Drivers, parameters, diagnostics messages and address space

A

A.1 Concept of the driver and diagnostics blocks

Use with PCS 7

The following information shows you advantages of using the process control system. In the process control system, the engineering system automatically handles many important parameter assignments and interconnections of modules.

If you want to use the Ex I/O outside these process control systems, refer to the following sections:

- Parameter assignment and structure of the module and channel parameters (Page 52)
- Address space (Page 64)

Tasks of the driver and diagnostics blocks (driver blocks)

In process control systems, certain demands are placed on the diagnostics/signal processing. This includes the monitoring of modules, IO devices and PROFINET IO systems for malfunctions and failures.

To make this possible, blocks are provided in the libraries of the engineering system which implement the interface to the hardware, including test functionality.

These blocks perform two basic tasks:

- They provide signals from the process to the AS for further processing.
- They monitor modules, IO devices and PROFINET IO system for failure.

When the process signals are read in, these blocks access the process image input (or process image partition) (PII).

When the process signals are output, these blocks access the process image output (or process image partition) (PIQ).

Concept

The concept of the driver and diagnostic blocks at the process control systems is characterized by the following:

- The separation between user data processing (CHANNEL blocks) and diagnostics data processing (MODULE blocks)
- The symbolic addressing of the I/O signals
- The automatic generation of the MODULE blocks by CFC

This block concept supports all modules from the list of approved modules.
When new Siemens or non-Siemens module types are integrated, the meta-knowledge for the driver generator can be extended by additional XML files (object and action lists).

NOTE

Note the following:

- The library with the driver blocks has to installed using the Setup program on the PC. This is the only method of ensuring that the meta-knowledge required for the driver generator is available. You must not copy the library from another computer.
- You can also use driver blocks from another library (for example, your own blocks from your own library). You can specify this additional library in the "Generate module drivers" dialog box. The driver generator then searches for the block to be imported in the library specified here. If the block is not found here, it is searched for in the library specified in the control file (XML file).
- If the S7 program contains a signal-processing block, but none from one of the engineering system libraries, the following is required:
  You must specify the version of the driver library from which the driver blocks are to be imported in the "Generate module drivers" dialog box.

Time-optimized processing

To enable time-optimized processing during runtime, the organization blocks for error handling (for example, OB85, OB86) are automatically divided into runtime groups and the driver blocks are integrated in the corresponding runtime groups.

If an error occurs, the SUBNET block, for example, activates the relevant runtime group. The RACK block or MODULE block detects the error, evaluates it and sends a process control message to the operator control and monitoring system.

The diagnostics information of the module block (OMODE_xx output) is also transferred to the corresponding CHANNEL block (MODE input). If required, this information can be displayed in a process picture via a block that can be controlled and observed in the operator control and monitoring system or a user block (color change of the measured value or flashing display, etc.).

A.2 Parameter assignment and structure of the module and channel parameters

A.2.1 Parameter assignment

Parameter assignment in the user program

You can reconfigure individual channels of the module in RUN without this having an effect on the other channels.

Changing parameters in RUN

The parameters are only transferred to the I/O module via data record 128 with the "WRREC" instruction. The parameters set via the configuration are not changed in the CPU in this case, i.e. after startup the parameters set in the CPU are valid again.

STATUS output parameter

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The STATUS output parameter is 4 bytes long and is configured as followed:

- Byte1: Function_Num, general error code
- Byte2: Error_Decode, location of the error code
- Byte3: Error_Code_1, error code
- Byte4: Error_Code_2, manufacturer-specific extension of the error code

Module-specific errors are displayed via Error_Decode = 0x80 and Error_Code_1 / Error_Code_2.

Table 2-1564 Possible error codes for parameter data record R/W operations

Error_ Code_1	Error_ Code_2	Cause	Remedy
0xB0	variable	Number of the data record unknown (Error_Code_2 returns internal identifiers)	Enter valid number for data record.
0xB1	0x01	Length of the data record is incorrect	Enter valid value for data record length.
0xB2	variable	Module cannot be reached (Error_Code_2 returns internal identifiers)	• Check station - is the module plugged in correctly? • Check the parameters of the WRREC block.
0xE0	0x01	Header error (version or defined bits incorrect)	Correct the version number or defined bits.
0xE0	0x02	Header error (incorrect length or number of parameter blocks)	Correct the length and number of the parameter blocks.
0xE1	0x01	Reserved bit set	Write all reserved bits with a 0.
0xE1	0x02	Invalid diagnostics enable bit set for operating mode	Correct diagnostics enables.

Error_ Code_1	Error_ Code_2	Cause	Remedy
0xE1	0x05	Invalid encoding for encoder type	Check and correct the parameters
0xE1	0x0B	Invalid coding for pulse stretching	
0xE1	0x20	Incorrect call length or incorrect data record number or data record not permissible	
0xE1	0x22	Invalid coding of flutter monitoring	
0xE1	0x25	Invalid edge selection (counter)	
0xE1	0x26	Invalid coding set output DQ (counter)	
0xE1	0x27	Invalid reaction to exceeding the count limit (counter)	
0xE1	0x28	Invalid count high limit (counter)	
0xE1	0x29	Invalid comparison value (counter)	
0xE1	0x2A	Invalid operating mode	

Valid parameters

Only the values specified in the following are permitted. Values that are not listed are rejected by the module.

Every parameter data record is checked by the module. If the module detects an incorrect parameter, the entire data record is rejected and the parameters of the module remain unchanged.

A.2.2 Parameter assignment and structure of the module and channel parameters

A.2.2.1 Configuration-dependent length of the data record 128.

Structure of data record 128

Data record 128 has a configuration-dependent length:

Configuration	Length of data record
Digital mode	32 bytes
Digital mode with counter/frequency measurement modes	54 bytes

The data record contains the module parameters as well as the channel or technology parameters of the 4 channels.

Main components of the data record:

- Header information (module), module parameters, header information (channel)
- Channel parameters (channel or technology parameters)
  The channel or technology parameters are divided into parameters that affect or set the actual signal acquisition and diagnostics enables.

Additional information

Detailed structure of the header information (module), module parameters, header information (channel) and configuration-dependent channel parameters

- Data record 128 with configuration digital mode (Page 54)
- Data record 128 with configuration digital mode with counter/frequency measurement modes (Page 57)

A.2.2.2 Data record 128 with configuration digital mode

Configuration

Data record 128 contains module parameters and all channel or technology parameters of the 4 channels.

The data record consist of the following main components:

- Header information (module), module parameters, header information (channel)
- Channel parameters (channel or technology parameters) which affect the actual digital value input
- Parameters which enable diagnostics

Table 2-1565 Structure of data record 128 in digital mode (32 bytes in length)

Byte	Length	Parameter	Efficiency range
0 ... 3	4 bytes	Header information (module)	Module
4 ... 5	2 bytes	Module parameters	
6 ... 7	2 bytes	Header information (channels)	DI channel n (n = 0 to 3)
8 ... 13	6 bytes	Channel parameter (channel 0)	
14 ... 19	6 bytes	Channel parameter (channel 1)	
20 ... 25	6 bytes	Channel parameter (channel 2)	
26 ... 31	6 bytes	Channel parameter (channel 3)	

NOTE

Legend for the following detailed screens

The following detailed screens show the configuration-dependent assignment of the individual bytes in data record 128.

- Any unused bits and bits or bytes marked with "reserved" must be set to "0".
- Activate a parameter by setting the corresponding bit to "1" or to the appropriate value.

Header information (module) and module parameters

The following detailed screen shows the structure of the header information and module parameters.

	7	6	5	4	3	2	1	0	
Byte 0	0	1	0	0	0	0	0	0	Minor version Major version Reserved
Byte 1	0	0	0	0	0	0	1	0	Number of following parameter structures
Byte 2	0	0	0	0	0	0	0	1	Number of following module parameter blocks
Byte 3	0	0	0	0	0	0	1	0	Length of the following module parameter block
Byte 4	0	0	0	0	0	0	0		Diagnostics, Missing supply voltage L+
Byte 5	0	0	0	0	0	0	0	0	Reserved

Figure 2-1322 Data record 128 - Header information (module) and module parameters

Header information channels

The following detailed screen shows the structure of the header information for channels 0 to 3.

	7	6	5	4	3	2	1	0	
Byte 6	0	0	0	0	0	1	0	0	Number of following channel parameter blocks
Byte 7	0	0	0	0	0	1	1	0	Length of a channel parameter block

Figure 2-1323 Data record 128 - Header information (DI channels - Channel 0 to 3 (Byte 6 and 7)

Start of channel parameters

The address offset of the channel parameters of each channel parameter block is defined as follows:

If the I/O module is operated in digital mode, each channel parameter block only contains the channel parameters for the digital input (6 bytes).
Address offset Byte x = 8 + 6 * channel number; with channel number 0 ...3

Channel parameters (channel 0 to 3, DI)

The following detailed screen shows the structure of the channel parameters for channel n (n =l 0 to 3).

- Channel 0 (Byte 8 to 13)
- Channel 1 (Byte 14 to 19)
- Channel 2 (Byte 20 to 25)
- Channel 3 (Byte 26 to 31)

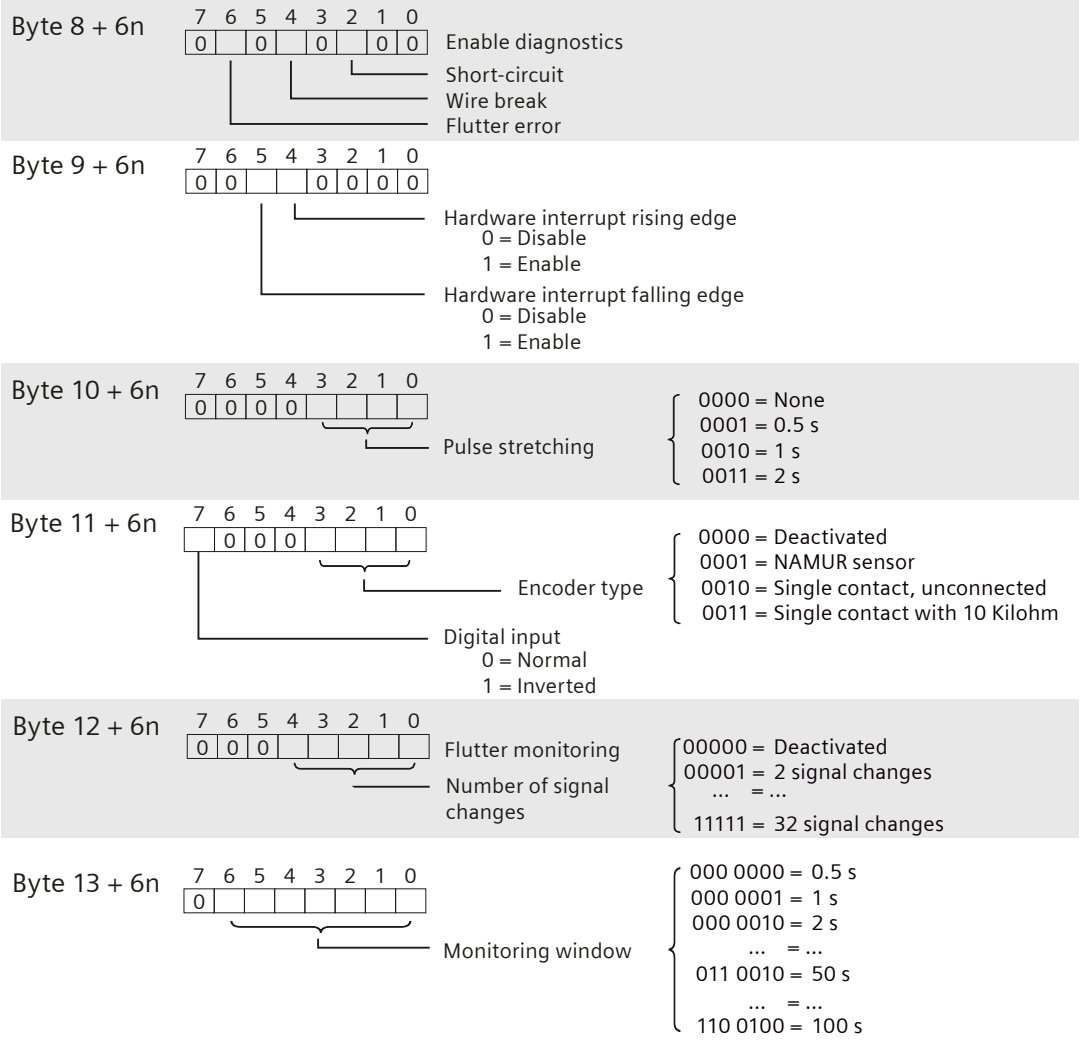

Figure 2-1324 Data record 128 - Channel parameter (DI channels - channel n (n = 0 to 3)

A.2.2.3 Data record 128 with configuration digital mode with counter/frequency measurement modes

Configuration

Data record 128 contains module parameters and all channel or technology parameters of the 4 channels.

The data record consist of the following main components:

- Header information (module), module parameters, header information (channel)
- Channel parameters (channel or technology parameters) which affect the actual digital value input
- Parameters which enable diagnostics

Table 2-1566 Structure of data record 128 in digital mode with counter/frequency measurement modes (54 bytes in length)

Byte	Length	Parameter	Efficiency range
0 ... 3	4 bytes	Header information (module)	Module
4 ... 5	2 bytes	Module parameters	
6 ... 7	2 bytes	Header information (channels 0 and 1)	DI channel n (n = 0 and 1) Counters Frequency measurement
8 ... 23	16 bytes	Channel parameter (channel 0)	
24 ... 39	16 bytes	Channel parameter (channel 1)	
40 ... 41	2 bytes	Header information (channels 2 and 3)	DI channel n (n = 2 and 3)
42 ... 47	6 bytes	Channel parameter (channel 2)	
48 ... 53	6 bytes	Channel parameter (channel 3)	

NOTE

Legend for the following detailed screens

The following detailed screens show the configuration-dependent assignment of the individual bytes in data record 128.

- Any unused bits and bits or bytes marked with "reserved" must be set to "0".
- Activate a parameter by setting the corresponding bit to "1" or to the appropriate value.

Header information (module)

The following detailed screens show the structure of the header information and module parameters.

	7	6	5	4	3	2	1	0	
Byte 0	0	1	0	0	0	0	0	0	Minor version Major version Reserved
Byte 1	0	0	0	0	0	0	1	1	Number of following parameter structures
Byte 2	0	0	0	0	0	0	0	1	Number of following module parameter blocks
Byte 3	0	0	0	0	0	0	1	0	Length of the following module parameter block
Byte 4	0	0	0	0	0	0	0		Diagnostics, Missing supply voltage L+
Byte 5	0	0	0	0	0	0	0	0	Reserved

Figure 2-1325 Data record 128 - Header information (module)

The header information of the channels is divided into 2 blocks

	7	6	5	4	3	2	1	0	
Byte 6	0	0	0	0	0	0	1	0	Number of following channel parameter blocks
Byte 7	0	0	0	1	0	0	0	0	Length of a channel parameter block

Figure 2-1326 Data record 128 - Header information (DI/counter channels - Channel 0 and 1 (Byte 6 and 7)

	7	6	5	4	3	2	1	0	
Byte 40	0	0	0	0	0	0	1	0	Number of following channel parameter blocks
Byte 41	0	0	0	0	0	1	1	0	Length of a channel parameter block

Figure 2-1327 Data record 128 - Header information (DI/counter 2 channels - Channel 2 and 3 (Byte 40 and 41)

Start of channel parameters

The start byte of the channel parameters of each channel parameter block is defined as follows:

If the I/O module is operated in digital mode with "Counter"/"Frequency measurement" modes, there are two parameter structures for the channel parameter blocks:

- For channels 0 and 1, each channel parameter block contains the channel parameters for the digital input with "Counter"/"Frequency measurement" modes (16 bytes).
  Start byte x = 8 + 16 * channel number; with channel number 0 to 1
- For channels 2 and 3, each channel parameter block contains the channel parameters for the digital input (6 bytes).
  Start byte x = 42 + 6 * (channel number -2); with channel number 2 to 3

Channel parameters (channel 0 and 1; DI/counter)

The following detailed screen shows the structure of the channel parameters for Channel 0 and 1.

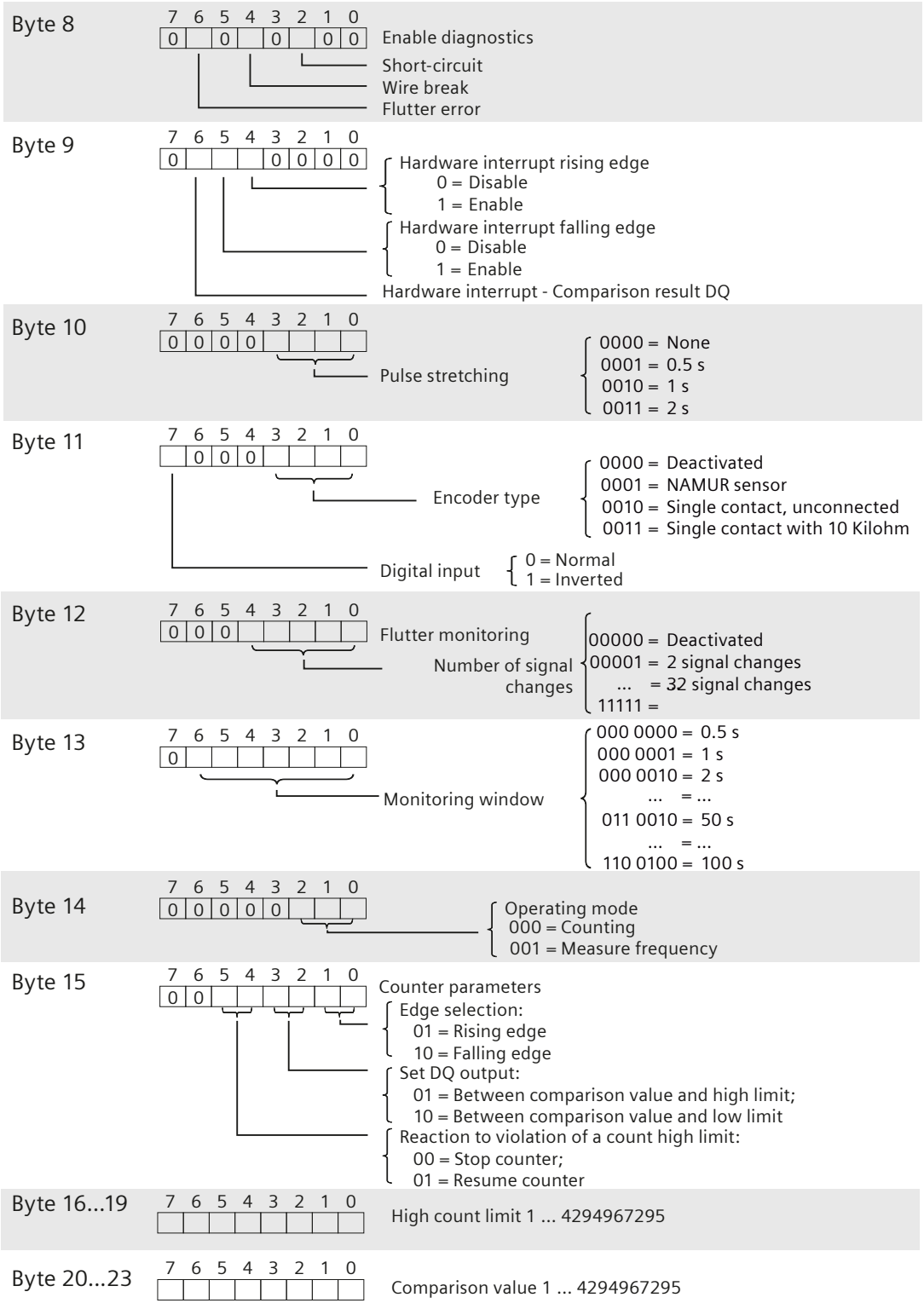

Figure 2-1328 Data record 128 - Channel parameter (DI/counter channels - channel 0 (Byte 8 to 23); channel 1 (Byte in the screen +16 = Byte 24 to 39)

Channel parameters (channel 2 and 3; DI)

The following detailed screen shows the structure of the channel parameters for 2 and 3.

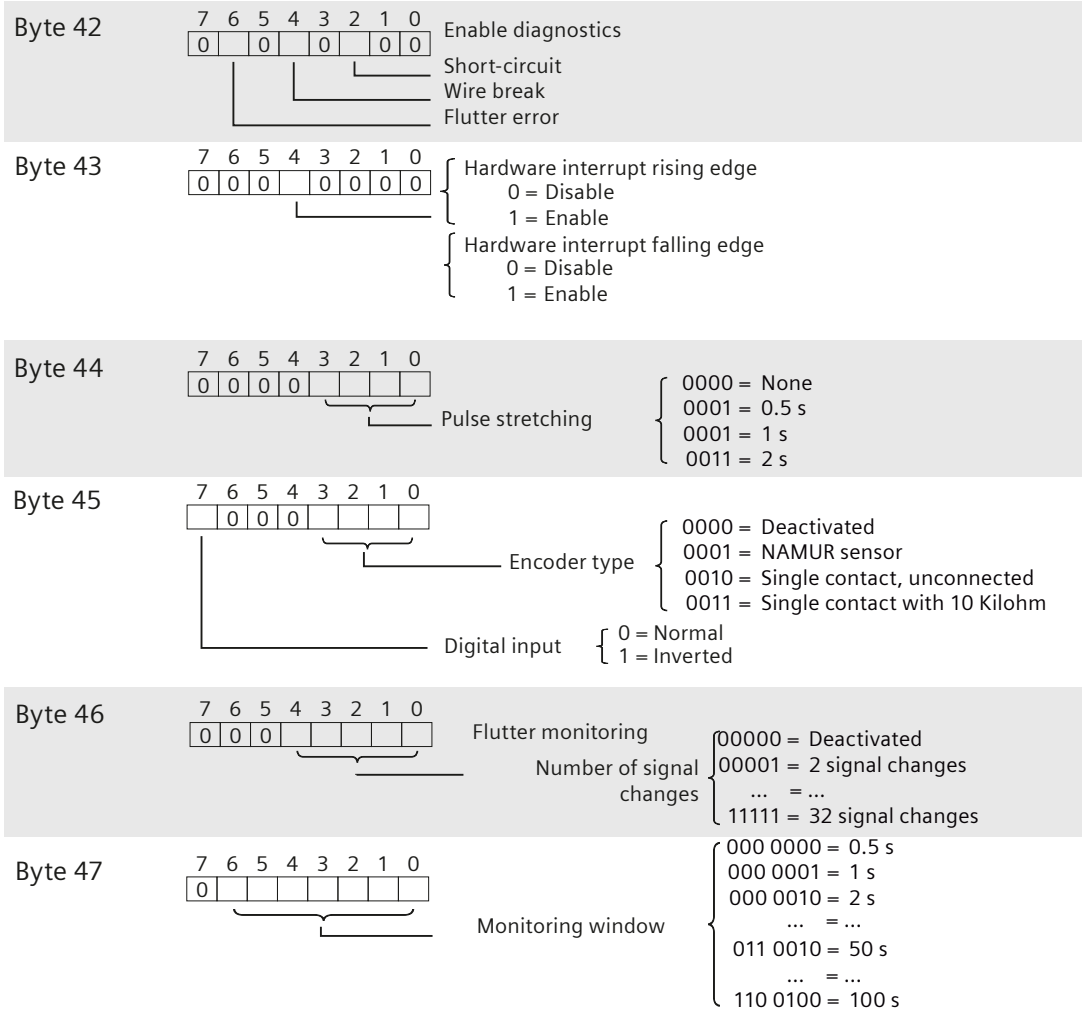

Figure 2-1329 Data record 128 - Channel parameter (DI - channel 2 (Byte 42 to 47); channel 3 (Byte in the screen +6 = Byte 48 to 53)

A.2.3 Diagnostic and maintenance messages

Diagnostic messages

A diagnostic message is output for each enabled diagnostic event, and the DIAG LED on the module flashes red.

The diagnostic messages can be read in the diagnostic buffer of the CPU.

The following applies for assigning diagnostic messages:

- A module message is assigned to all channels.
- A channel-specific message is assigned to one channel only, the other channels are not affected.
  The diagnostic result is indicated by the corresponding channel fault LED.

Table 2-1567 Diagnostic messages, their meaning and possible remedies

Diagnostic message	Error code	Assignment	Meaning / Cause	Remedy
Short-circuit (NAMUR sensors only)	1_H	Channel	Short-circuit on signal line to the encoder	Correction of the process wiring
			Encoder is defective	Replace the encoder
			Wrong encoder type configured	Correction of the parameter assignment
			Load impedance too low	Use an encoder with higher impedance
Wire break (NAMUR sensor or single contact, connected with 10 kΩ)	6_H	Channel	Signal line to an encoder interrupted	Correction of the process wiring
			Encoder is defective	Replace the encoder
			Wrong encoder type configured	Correction of the parameter assignment
			Load impedance too high	Use another type of encoder or wiring, for example, use conductors with a larger cross-section
			Channel not connected (open)	Deactivate diagnostics, wire encoder contacts
Parameter assignment error	10_H	Module	Incorrect parameter assignment	Correct the parameter assignment
Supply voltage missing	11_H	Module	Missing or insufficient supply voltage L+	• Check Ex power module • Check wiring of the supply voltage L+ on the Ex power module
Hardware interrupt lost	16_H	Module	Error is reported because the events occur faster than they can be processed in the system.	
Channel/component temporarily unavailable	$1F_H$	Module	Firmware update is in progress or has been canceled during the update. The module stops acquiring process values during this time.	• Restart firmware update • Wait for firmware update
Module is faulty	100_H	Module	Internal module error has occurred	Replace the module

Diagnostic message	Error code	Assignment	Meaning / Cause	Remedy
Invalid BaseUnit	151_H	Module	The module was plugged into an impermissible BaseUnit	Replace Ex BaseUnit
The retentive memory in the BaseUnit is defective.	153_H	Module	A memory block error on the BaseUnit was detected during startup.	Replace Ex BaseUnit
Encoder signal flutters	310_H	Channel	Flutter error: Signal changes too frequently within the monitoring window When the input signal stops fluttering over three cycles of the monitoring window, an outgoing diagnostics interrupt is triggered. The value state of the current signal in the process image is set to "valid".	• Check flutter monitoring parameter assignment • Check the process wiring, replace encoder if necessary

Maintenance messages

Whenever it is detected that maintenance is required, a maintenance message is generated and the MT LED lights up yellow on the module.

Maintenance messages have no direct effect on the function of the module or the digital inputs.

Table 2-1568 Maintenance messages, their meaning and possible remedies

Maintenance message	Error code	Assignment	Meaning / Cause	Remedy
The retentive memory in the BaseUnit is defect-ive.	153_H	Module	A memory block error on the BaseUnit was detected during operation.	Replace Ex BaseUnit

A.2.4 Hardware interrupts

Evaluating digital input hardware interrupts

The I/O module generates a hardware interrupt depending on the digital input signal when the following events occur:

- At a rising edge (signal change from 0 to 1)
- At a falling edge (signal change from 1 to 0)
- When a comparison value is exceeded (only during counting)

The module digital input (channel) that has triggered the hardware interrupt is entered in variable "OB40_POINT_ADDR" in the start information of OB40. The following figure shows the assignment to the bits of the local data double word 8.

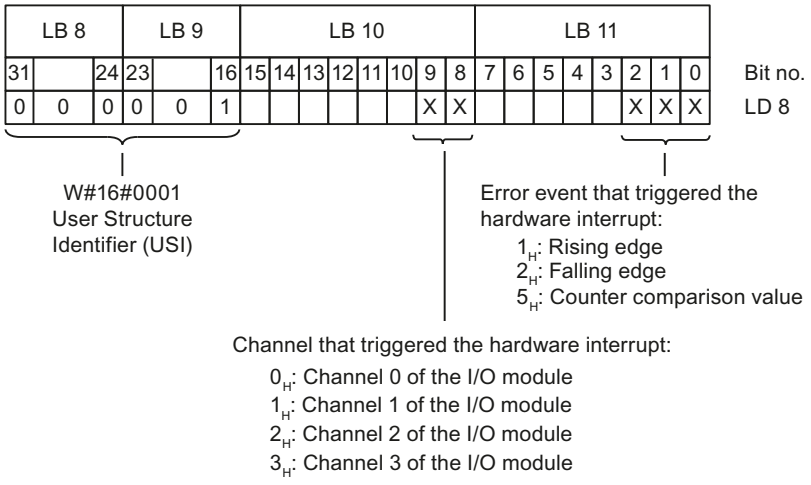

Figure 2-1330 Start information of the organization block

A.3 Address space

A.3.1 Address space in digital mode DI without QI

Abbreviations

- "IB" stands for input byte in the input area
- "DIn" stands for digital input n

Configuration

Digital mode with counter/frequency measurement modes without QI

- Parameter: **DI NAMUR** or Selection in the hardware catalog: **Ex-DI 4xNAMUR**
- "Value status" parameter: Disabled

Address space in the configuration digital mode DI without QI

The following table shows the mapping of the address space of the I/O module.

Input area

Table 2-1569 Input area of Ex-DI 4xNAMUR (configuration digital mode DI without QI)

IB x +	7	6	5	4	3	2	1	0
0	-	-	-	-	DI3	DI2	DI1	DI0

A.3.2 Address space in digital mode DI with QI (also with MSI)

Abbreviations

- "IB" stands for input byte in the input area
- "DIn" stands for digital input n
- "QDIn" stands for value status (QI) of digital input n
  Information on this can be found in section "Evaluating the value status (Page 70)".

Configuration

Digital mode with counter/frequency measurement modes with QI

- Parameter: **DI NAMUR** or Selection in the hardware catalog: **Ex-DI 4xNAMUR**
- "Value status" parameter: Enabled

Address space in the configuration digital mode DI with QI

NOTE
Configuration with MSI
The following applies when an I/O module is configured with MSI:

- Each subslot has its own **start address** (IB x +).
- Each MSI submodule occupies its own address range with identical structure in the input area.
- The process input signals of the basic submodule (subslot 1) are mirrored to the MSI submodules as input signals.

The following table shows the mapping of the address space of the I/O module.

Input area

Table 2-1570 Input area of the Ex-DI 4xNAMUR (configuration digital mode DI with QI or for each subslot with MSI).

IB x +	7	6	5	4	3	2	1	0
0	-	-	-	-	DI3	DI2	DI1	DI0
1	-	-	-	-	QDI3	QDI2	QDI1	QDI0

A.3.3 Address space in digital mode with counter/frequency measurement modes without QI

Abbreviations

- "IB" stands for input byte in the input area
- "QB" stands for output byte in the output area
- "DIn" stands for digital input n

Configuration

Digital mode with counter/frequency measurement modes without QI

- Parameter: **DI NAMUR COUNTER** or Selection in the hardware catalog: **Ex-DI 4xNAMUR CNT**
- "Value status" parameter: Disabled

Information on configuration: Configurations of the I/O module Ex-DI 4xNAMUR (Page 15)

Address space

The following tables show the allocation of the address space of the I/O module.

Input area

The table shows the allocation of the address space of the feedback interface. You will find an explanation of the parameters in the following table.

Table 2-1571 Address space in the configuration digital mode with "Counter"/"Frequency measurement" modes without QI **(feedback interface)**

IB x +	7	6	5	4	3	2	1	0
0	-	-	-	-	DI3	DI2	DI1	DI0
1 + 5n [1]	Count value n[1] / Frequency value n[1]							
2 + 5n [1]								

[1] Feedback bytes for count value: n = channel number (0 to 1; example: Count value channel 1 = byte (1 +1*5) = double word, starts from byte 6

[2] Feedback byte counter control, n = channel number (0 to 1; example channel 1= byte (5 +1*5) = byte 10

IB x +	7	6	5	4	3	2	1	0
3 + 5n [1]	Count value n[1] / Frequency value n[1]							
4 + 5n [1]								
5 + 5n [1]	LD_ERROR	LD_STS_SLOT	STS_M_INTERVAL	STS_SW_GATE	-	-	STS_GATE	STS_DQ

[1] Feedback bytes for count value: n = channel number (0 to 1; example: Count value channel 1 = byte (1 +1*5) = double word, starts from byte 6

[2] Feedback byte counter control, n = channel number (0 to 1; example channel 1= byte (5 +1*5) = byte 10

Table 2-1572 Feedback byte counter control

Action	Meaning
LD_ERROR	Error in the control byte of the control interface or loading with a load value that is greater than the count high limit.
LD_STS_SLOT	A status change of LD_STS_SLOT shows that a valid load request (LD_SLOT) has been detected and executed. The action NOP does not result in a status change. A valid LD_SLOT with an invalid load value does not result in a status change of LD_STS_SLOT, but in an LD_ERROR.
STS_M_INTERVAL	Status of the frequency value: (0 = frequency value is invalid; 1 = frequency value is valid).
STS_SW_GATE	Status of the SW_GATE mirrored
STS_GATE	Status of the internal gate (0 = gate closed, 1 = gate open)
STS_DQ	Logic for the comparison result DQ from the parameters

Output area

The table shows the allocation of the address space of the control interface. You will find an explanation of the parameters in the following table.

Table 2-1573 Address space in the configuration digital mode with "Counter" mode without QI **(control interface)**

QB x +	7	6	5	4	3	2	1	0
0 + 5n [1]	Load value n [1]							
1 + 5n [1]								
2 + 5n [1]								
3 + 5n [1]								
4 + 5n [2]	-	-	-	-	SW_GATE	LD_SLOT		

[1] Control bytes for load value: n = channel number (0 to 1; example: Load value channel 1= byte (0 +1*5) = double word, starts from Byte 5

[2] Control byte counter control: n = channel number (0 to 1; example channel 1= Byte (4 +1*5) = Byte 9

Counter control	Action	Meaning
0.xxx	STOP (SW_GATE=0) with command xxx	Stop counter and execute command xxx
1.xxx	START (SW_GATE=1) with command xxx	Start counter or continue to work and execute command xxx
x.**000**	NOP	No action
x.**001**	Counter = load value	Load counter with load value

A.3.4 Address space in digital mode with counter/frequency measurement modes with QI

Abbreviations

- "IB" stands for input byte in the input area
- "DI" stands for digital input
- "QDIn" stands for value status (QI) of digital input n
  Information on this can be found in section "Evaluating the value status (Page 70)".

Configuration

Digital mode with counter/frequency measurement modes with QI

- Parameter: **DI NAMUR COUNTER** or Selection in the hardware catalog: **Ex-DI 4xNAMUR CNT**
- "Value status" parameter: Enabled

Information on configuration: Configurations of the I/O module Ex-DI 4xNAMUR (Page 15)

Address space

The following tables show the allocation of the address space of the I/O module.

Input area

The table shows the allocation of the address space of the feedback interface. You will find an explanation of the parameters in the following table.

Table 2-1574 Address space in the configuration digital mode with "Counter"/"Frequency measurement" modes with QI **(feedback interface)**

IB x +	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	-	-	-	-	DI3	DI2	DI1	DI0
1	-	-	-	-	QDI3	QDI2	QDI1	QDI0
2 + 5n [1]	Count value n[1] / Frequency value n[1]							
3 + 5n [1]								
4 + 5n [1]								
5 + 5n [1]								
6 + 5n [2]	LD_ERROR	LD_STS_SLOT	STS_M_INTERVAL	STS_SW_GATE	-	-	STS_GATE	STS_DQ

[1] Feedback bytes for count value: n = channel number (0 to 1; example: Count value channel 1= byte (2 +1*5) = double word, starts from byte 7

[2] Feedback byte counter control, n = channel number (0 to 1; example channel 1= byte (6 +1*5) = byte 11

Table 2-1575 Feedback byte counter control

Action	Meaning
LD_ERROR	Error in the control byte of the control interface or loading with a load value that is greater than the count high limit.
LD_STS_SLOT	A status change of LD_STS_SLOT shows that a valid load request (LD_SLOT) has been detected and executed. The action NOP does not result in a status change. A valid LD_SLOT with an invalid load value does not result in toggling (status change of LD_STS_SLOT), but in an LD_ERROR.
STS_M_INTERVAL	Status of the frequency value: (0 = frequency value is invalid; 1 = frequency value is valid).
STS_SW_GATE	Status of the SW_GATE mirrored
STS_GATE	Status of the internal gate (0 = gate closed, 1 = gate open)
STS_DQ	Logic for the comparison result DQ from the parameters

Output area

The table shows the allocation of the address space of the control interface. You will find an explanation of the parameters in the following table.

Table 2-1576 Address space in the configuration digital mode with "Counter" mode with QI **(control interface)**

QB x +	7	6	5	4	3	2	1	0
0 + 5n [1]	Load value n [1]							
1 + 5n [1]								
2 + 5n [1]								
3 + 5n [1]								
4 + 5n [2]	-	-	-	-	SW_GATE	LD_SLOT		

[1] Control bytes for load value: n = channel number (0 to 1; example: Load value channel 1= byte (0 +1*5) = double word, starts from Byte 5

[2] Control byte counter control: n = channel number (0 to 1; example channel 1= Byte (4 +1*5) = Byte 9

Counter control	Action	Meaning
0.xxx	STOP (SW_GATE=0) with command xxx	Stop counter and execute command xxx
1.xxx	START (SW_GATE=1) with command xxx	Start counter or continue to work and execute command xxx
x.**000**	NOP	No action
x.**001**	Counter = load value	Load counter with load value

A.3.5 Evaluating the value status

The following applies in the configurations with evaluation of the value status:

- There is a bit value status (QI) for each digital input in the input address space.
- Counting / frequency measurement is independent of the value status

Notes for configuration using a GSD/GSDML file (Page 17)

Evaluating the value status

Irrespective of the diagnostics enables, each value status (each QI bit) provides information on the validity of the corresponding process value.

- Value status = 1: Process value ok, acquired/output correctly, "good"
- Value status = 0: Process value not OK, acquired/output incorrectly or channel disabled, "bad"

Setting the value status

- Basically, the value status is set to "good" if the digital value can be detected without error.
- The value status is set to "bad" in the following cases:
  - The digital value cannot be detected due to an error.
    Example of the error: Bad wiring
  - The digital input is disabled.

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ET 200SP HA / ET 200SP Ex-DQ 2x17.4VDC/27mA

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Security information 1

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit
https://www.siemens.com/industrialsecurity.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under
https://www.siemens.com/industrialsecurity.

Preface

2

Validity of the documentation

This documentation describes the following I/O module:

System	Module type	Article number
Distributed I/O System; ET 200SP and ET 200SP HA	Ex-DQ 2x17.4VDC/27mA	6DL1132-6CB00-0HX1

This documentation supplements the following documentation:

- System manual *Distributed I/O System, ET 200SP I ET 200SP HA; Modules for devices in the hazardous area*

Functions that generally relate to the ET 200SP and ET 200SP HA are described in the respective system manual:

- ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)
- Distributed I/O System ET 200SP HA (https://support.industry.siemens.com/cs/ww/en/view/109761547)

The information in this manual and the system/function manuals enables you to put the modules for hazardous areas into operation.

Conventions

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

These documentation contain a description of the components that was valid at the time the operating instructions were published. We reserve the right to include product information with information updates with new components and components with a new product status.

Product overview

3

3.1 Properties of Ex-DQ 2x17.4VDC/27mA I/O module

View of the module

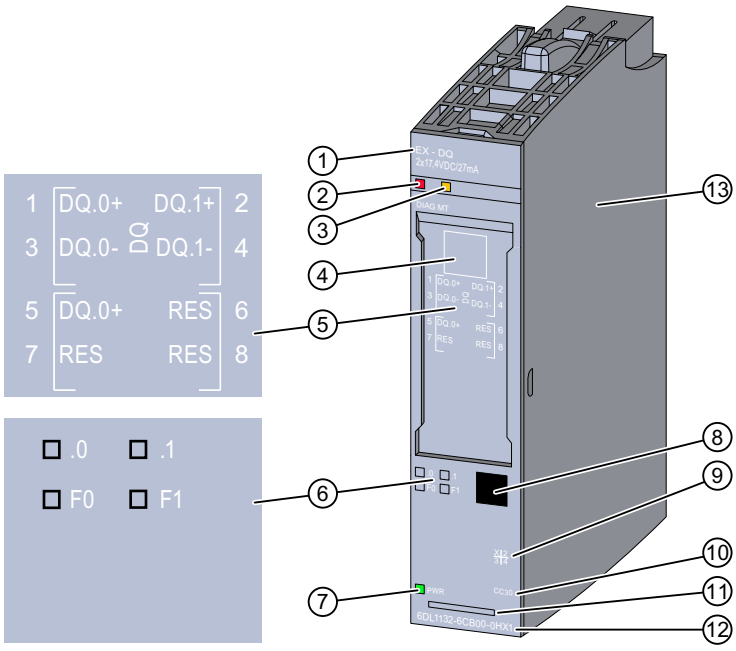

①	Module type and designation	⑧	Module type color coding
②	LED for diagnostics	⑨	Function version
③	LED for maintenance	⑩	Color code for selection of the color-coded labels
④	2D matrix code	⑪	Serial number
⑤	Wiring diagram	⑫	Article No.
⑥	LEDs for channel status/channel fault	⑬	Labeling surface (symbols and standards)
⑦	LED for supply voltage		

Figure 2-1331 View of the Ex-DQ 2x17.4VDC/27mA

You can find information on the LEDs in section "Status and error displays of the Ex-DQ 2x17.4VDC/27mA I/O module (Page 22)".

Properties

The I/O module is used to connect intrinsically safe actuators.

The I/O module has the following technical properties:

- 2 digital outputs with the following properties that can be individually configured for each channel
  - Diagnostics
  - Substitute values
- Module-specific configurable diagnostics
- To increase performance, the two channels can be connected in parallel.

You can find additional information in section Technical specifications (Page 26)

The module supports the following functions

The I/O module supports the following functions:

- Firmware update
- I&M identification data
- Parameter reassignment in RUN
- Value status QI
- Module-internal Shared Output (MSO)

Accessories

The following accessories can be ordered separately:

- Labeling strips
- Reference identification label
- Shield connector

3.2 2D Matrix code (QR code / EAN code)

The 2D matrix code on the product is a coded representation of the product-specific article number.

Access to product-related information

For reading the 2D matrix code, SIEMENS offers an app for mobile use.
Information about the app and the download can be found on the Internet: "Mobile use via app (https://support.industry.siemens.com/cs/ww/en/sc/2067)".

The app provides direct access to the technical forum and product-related posts, such as:

- FAQs
- Application examples
- Manuals
- Certificates
- Product notices

Wiring

4

4.1 Ex BaseUnit

You can operate the I/O module with the following Ex BaseUnit:

- Ex-BU Type X1 (6DL1 193-6BP00-0BX1)

The Ex BaseUnit is not included in the scope of delivery of the Ex I/O module and must be ordered separately.

NOTE

You can find additional information on the configuration in the system manual.

The terminal block for connecting the I/O signals is part of the Ex BaseUnit for Ex I/O modules and cannot be mounted separately.

Connections on the slot and Ex I/O module

The following figure shows the connections on the Ex BaseUnit and the I/O module.

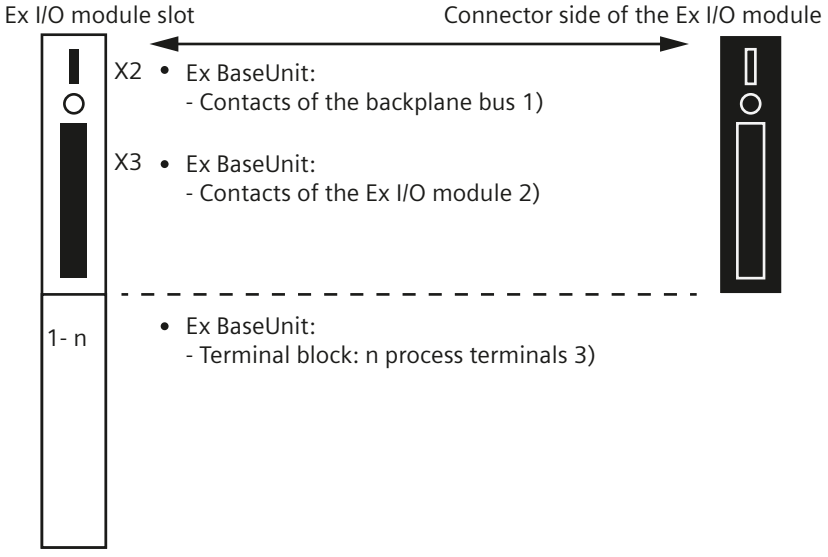

1) Ex BaseUnit contacts of the backplane bus (max. 50 mA; 3.3 V DC ⎓)

2) Ex BaseUnit contacts for process signal transmission (for maximum voltages and currents, refer to the documentation of the respective I/O module)

3) Process terminals on the terminal block (number, maximum/permissible voltages and currents, refer to the documentation of the respective I/O module).

Information on the pin assignment of the I/O module (terminal block) can be found in the following sections.

4.2 Pin assignment of the Ex-DQ 2x17.4VDC/27mA I/O module

General pin assignment

Table 2-1577 Pin assignment of the Ex-DQ 2x17.4VDC/27mA

Terminal	Assignment	Terminal	Assignment	Terminal block	Explanations
1	DQ.0+	**2**	DQ.1+	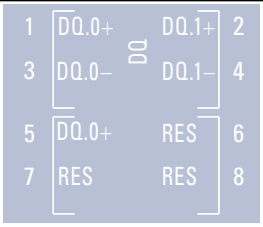	Terminals 1; 2; 5 DQ.n+: Output signal, channel n (0;1) Terminals 3; 4 DQ.n-: Mass, channel n (0;1) Terminals 6; 7; 8 Res: Reserve
3	DQ.0-	**4**	DQ.1-		
5	DQ.0+	**6**	Res		
7	Res	**8**	Res		

Connections via all actuator types

You can find information on the connection of actuators in the following section:

- Pin assignment for actuators - 2-wire (Page 10)

Parallel connection of both channels

To increase performance, the two channels can be connected in parallel. You then obtain a rated current of 54 mA. This enables you to also operate actuators with higher power requirements directly on the Ex-DQ 2x17.4VDC/27mA.

For parallel connection of the channels, you connect terminal 1 "DQ.0+" to terminal 2 "DQ.1+".
You then connect the actuator between terminal 5 "DQ.0+" and terminal 3 "DQ.0-".

4.3 Pin assignment for actuators - 2-wire

Pin assignment channel 0

2-wire connection	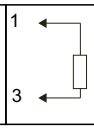

2-wire connection with parallel connection	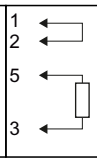

4.4 Schematic circuit diagram

The following figure shows the schematic circuit diagram of the Ex I/O module.

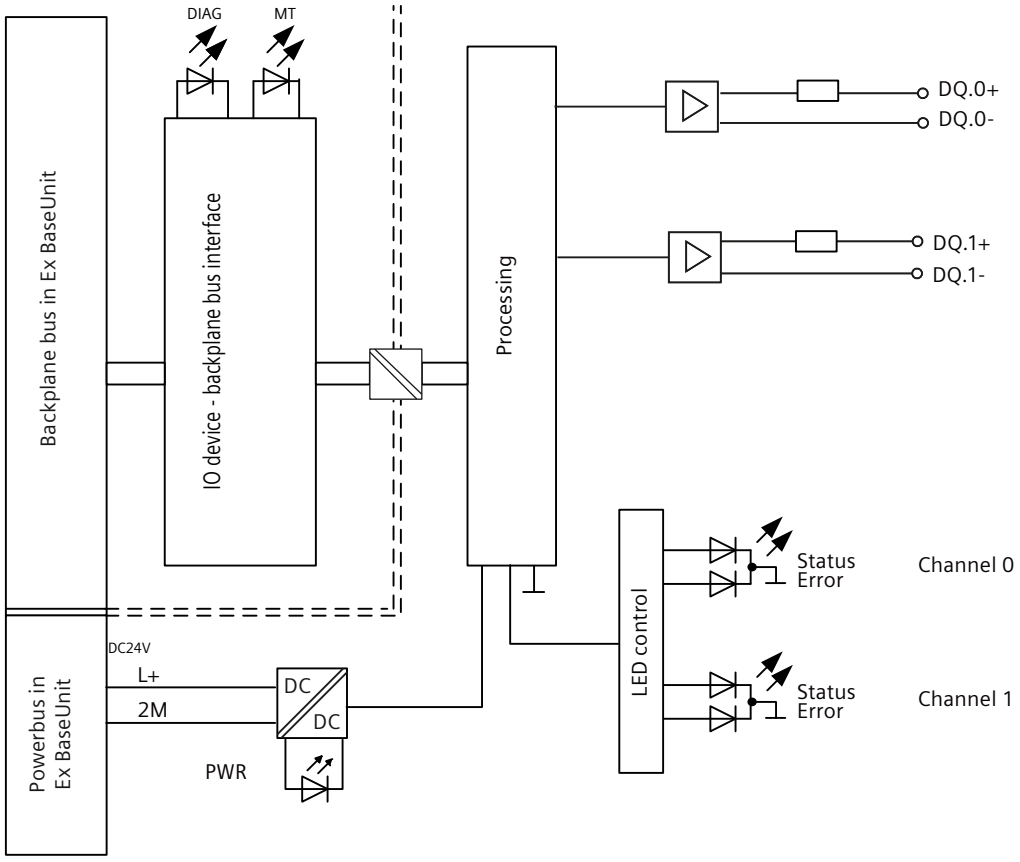

Figure 2-1332 Schematic circuit diagram Ex-DQ 2x17.4VDC/27mA

Supply voltage

The supply voltage L+/2M is generated and monitored by the Ex power module. The Ex I/O module receives its supply voltage L+ via the power bus. Further monitoring of the supply voltage is performed in the Ex I/O module. During parameter assignment, you can specify whether a diagnostic message is to be output in the event of failure of the supply voltage.

Firmware update

The supply voltage L+ must be available on the Ex I/O module at the start of firmware update and during the update.

4.5 Potential group in hazardous areas

Potential group

With the modules for hazardous areas, the Ex power module and the Ex I/O module plugged into the right of the Ex power module form a potential group.

The potential group ends when one of the following modules is plugged in to the right of an Ex I/O module:

- Ex power module
- Server module

Configuring 5

5.1 Configurations of the I/O module Ex-DQ 2x17.4VDC/27mA

Requirements

You configure the I/O module

- in the TIA Portal
- with PCS 7
- with PCS neo
- with STEP 7

The version required in each case is specified in the technical specifications.

Configuration via GSD/GSDML

Notes for configuration using a GSD/GSDML file (Page 15)

Restrictions when using in ET 200SP

- For use with a standard IM, its firmware must be at least of version V3.3.
- No MSI is available for a PROFIBUS DP station.
- TIA Portal:
  - TIA Portal as of V17.0
    The module can be centrally configured on the following CPUs:
    - CPU 1510SP-1 (as of V2.6)
    - CPU 1512SP-1 PN (as of V2.6)
    - CPU 1515SP-1 PN (as of V2.6)
  - The module cannot be used behind fail-safe controllers.

Configurations

Depending on the desired configuration, you must select the required I/O module version from the hardware catalog.

The following configurations are possible:

Configuration [1]	Version of the I/O module in the hardware catalog of the engineering tool	Required parameter assignment of the module
Digital mode without QI	**Ex - DQ 2x17.4VDC/27mA**	"Value status" parameter deactivated
Digital mode with QI [2]		• "Value status" parameter activated • Optional configuration [3] "MSO with QI": You can find information on MSO in section: "Module-internal Shared Output (MSO) (Page 19)".

[1] For the configuration using GSDML, all configurations can be selected directly in the hardware catalog of the engineering tool.

[2] Not available for configuration using an GSD file.

[3] Not available for configuration using an GSD/GSDML file.

NOTE

Changing the configuration in CPU RUN

You can re-configure the I/O module when the CPU is in RUN as long as the loaded configuration (version of the I/O module in the hardware catalog) is maintained.

If you want to define a different configuration in CPU RUN, the following steps are required:

1. Remove the I/O module from the loaded configuration in CPU RUN.
2. Configure the I/O module including the required configuration-specific parameters.
3. Load the new configuration in CPU RUN.

Note that changing the configuration changes the I/O address range.

Parameters

You define the operating mode of the I/O module via channel/technology parameters (data record 128).

5.2 Notes for configuration using a GSD/GSDML file

Files for the configuration using GSD/GSDML

If you need the GSD/GSDML files for configuration, you can download them on the Internet:

- PROFINET GSD file (GSDML) for ET 200SP HA (http://support.industry.siemens.com/cs/ww/en/view/109781191)
- PROFINET GSD files for ET 200SP (http://support.automation.siemens.com/WW/view/en/57138621)
- PROFIBUS GSD files for ET 200SP (http://support.automation.siemens.com/WW/view/en/73016883)

Restrictions when using a GSDML file for the PROFINET configuration

The following functions are not available in the process image of the I/O module:

- MSO

Restrictions when using a GSD file for the PROFIBUS configuration

The following functions are not available in the process image of the I/O module:

- MSO
- Value status

5.3 Module/channel parameters

Parameters of Ex-DQ 2x17.4VDC/27mA

You have the following setting options:

Table 2-1578 Adjustable parameters and their default setting

Parameter	Value range	Default	CiR [1]	Efficiency range		
				HSP [2]	GSDML [3]	GSD [4]
Diagnostics, Missing supply voltage L+	• Enabled • Disabled	Disabled	Yes	Module	Module	Module
Switch channels in parallel	• Enabled • Disabled	Disabled	Yes	Module	Module	Module
Diagnostics Short-circuit	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Wire break check	• Enabled • Disabled	Enabled	Yes	Channel	Channel	Channel
Diagnostics, Wire break [5]	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Channel activated	• Enabled • Disabled	Enabled	Yes	Channel	Channel	Channel
Reaction to CPU STOP	• Shutdown • Keep last value • Output substitute value	Shutdown	Yes	Channel	Channel	Module
Substitute value [6]	• 0 • 1	0	Yes	Channel	Channel	Channel
Potential group	Potential group of the left intrinsically safe power module	Potential group of the left intrinsically safe power module	No	Module	Module	Module

1) CiR = Configuration in RUN

2) HSP = Configuration using the Hardware Support Package (HSP) of the process control

3) GSDML = Configuration when using a GSDML file

4) GSD = Configuration when using a GSD file

5) The wire break diagnostics can only be enabled when the "Check for wire break" parameter is enabled.

6) The substitute value parameter only has an effect if the "Output substitute value" setting is selected for the "Reaction to CPU STOP:" parameter.

5.4 Explanation of parameters

5.4.1 Diagnostics Missing supply voltage L+

Defines whether a diagnostic interrupt is generated when the supply voltage L+ is missing or is too low.

The supply voltage is generated by the Ex power module. Other internal defects can be detected and reported via the additional diagnostics for the Ex I/O module.

5.4.2 Parallel connection of channels

You can connect the two digital outputs in parallel to increase power.

5.4.3 Diagnostics: Short-circuit

When the digital output is enabled, you can enable diagnostics that report a short circuit to between the digital output (DQ.n+) and ground (DQ.n-).

A short-circuit can only be detected if there is a 1 signal at the corresponding output.

5.4.4 Wire break check

Enables the wire break check. The wire break check must be enabled in order for the I/O module to detect a wire break.

If the wire break test is enabled, a test current of approx. 250 µA is fed into the channel with a "0" signal. This enables a wire break to be detected independently of the signal level and the QI bit to be influenced. If wire break diagnostics is enabled, a diagnostic interrupt is also generated. If the test current is not wanted in the presence of a "0" signal, you can suppress it by disabling the wire break check. A wire break is then no longer detected, neither for the "1" nor for the "0" signal.

5.4.5 Diagnostics: Wire break

Specifies whether a diagnostic interrupt is generated when the wire break test current is undershot.

Requirement: Wire break check is enabled.

5.4.6 Channel activated

Specifies whether a channel is activated or deactivated.

5.4.7 Reaction to CPU STOP

Determines the reaction of the digital output to CPU STOP or to failure of communication between the interface module and CPU.

5.4.8 Substitute value

The substitute value is output by the module at CPU STOP if you set the "Reaction to CPU STOP" parameter to "Substitute value".

5.4.9 Potential group

A potential group consists of a group of directly adjacent Ex IO modules within a station of the distributed I/O (IO device), which are supplied via a common Ex power module.

A potential group begins with an Ex power module, via which the required supply voltage for all Ex I/O modules of the potential group is supplied. The Ex power module interrupts the self-assembling voltage buses to the left neighbor.

The Ex I/O modules take the potential of the self-assembling voltage buses from the left neighbor.

A potential group ends with the BaseUnit, which follows an Ex power module or a server module in the station configuration.

You can find additional information on the configuration of the potential group in the system manual *Distributed I/O System; ET 200SP and ET 200SP HA, Modules for hazardous areas*.

5.5 Module-internal Shared Output (MSO)

The function enables several IO controllers to access the output data of the I/O module.

- With MSO, the following data of the I/O module (basic submodule) is copied to up to three MSO submodules as input data of the MSO submodules:
  - Output data of the basic submodule
  - The QI information of the basic submodule
- Each of the four submodules can be assigned to an IO controller, whereby these can be different or identical IO controllers.
  - The IO controller assigned to the basic submodule has write access to the outputs of the I/O module and read access to the QI information of the basic submodule.
    The basic submodule therefore occupies input and output addresses in the process image of the IO controller.
  - The IO controllers to which the MSO submodules are assigned have read access to the outputs and the QI information of the basic submodule. MSO submodules therefore only occupy input addresses in the IO controller's process image.
- Only the basic submodule is configured and can return diagnostic interrupts.
  MSO submodules are not configurable and do not return interrupts.

The following figure shows a digital output module with the basic submodule and three MSO submodules. Each submodule is assigned to an IO controller. The diagnostics and parameter assignment of the digital output module is possible via the basic submodule from the IO controller 1.

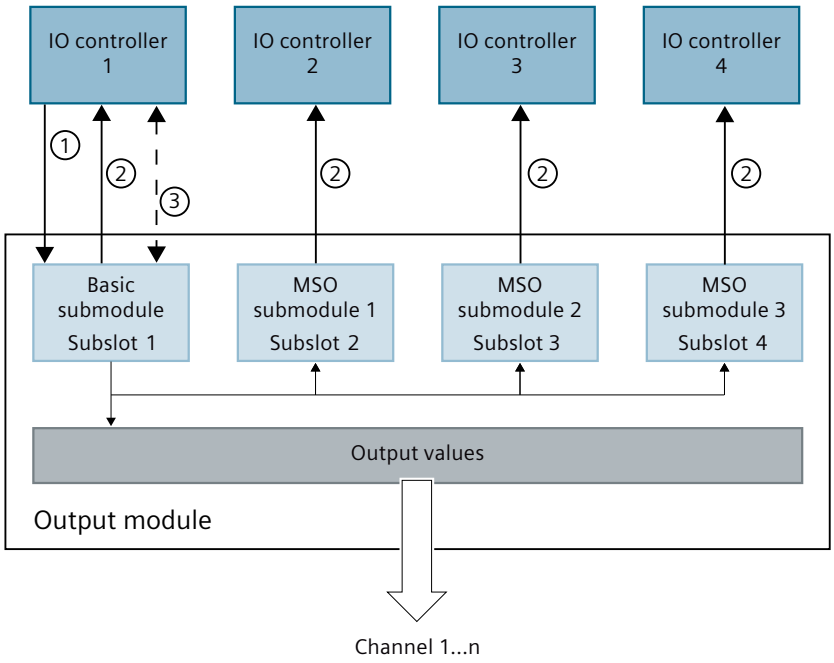

① Write access

② Read access

③ Parameter assignment and system diagnostics

Figure 2-1333 Input module with MSO configuration

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule in question.

With the basic submodule (= subslot 1), the value status "0" indicates that the value is incorrect or the assigned IO controller is in STOP mode.

With an MSO submodule (= subslot 2 to 4), the value status "0" indicates that the value is incorrect or that one of the following errors has occurred:

- The basic submodule is not yet parameterized (not ready).
- The connection between the PROFINET IO controller and the basic submodule is interrupted.
- The IO controller of the basic submodule is in STOP mode or POWER OFF.

NOTE

Restrictions

- **PROFINET required**
  MSO is only available with configuration with PROFINET.
- **No configuration with PCS 7**
  No support for configuration with PCS 7.
- **No configuration via GSD/GSDML**
  No support of MSO during configuration via GSD/GSDML.
  Notes for configuration using a GSD/GSDML file (Page 15)

Configure MSO for an I/O module

You set the configuration on the basic submodule (subslot 1).

NOTE

If "MSO" is configured for an I/O module, this applies to all channels of the I/O module.

If MSO is to be configured, the value status QI must always be configured as well.

---

1. Select the configuration based on the following table.
2. Select the number of MSO submodules in the properties of the I/O module. This parameter assignment can be performed in CPU RUN.

You can find additional information on this in the section "Address space with MSO (Page 39)".

NOTE

Configuration of the controllers

Please note that you have to perform the configuration of the signals for the IO controllers which are not directly connected to the IO device separately.

Changing the MSO configuration in RUN

The parameter "Value status" must always be activated.

Configuration	Version of the I/O module in the module catalog (HW Config)	Parameter assignment of the module
Digital mode DI 2 with QI	Ex-DQ 2x17.4VDC/27mA	Number of additional submodules: (Change in CPU RUN possible) • 1 to 3: MSO is enabled • 0: MSO is disabled

Additional information

- Find out how to assign MSO submodules to an IO controller in the documentation *SIMATIC; Distributed I/O System ET 200SP/ET 200SP HA,* Modules for devices in hazardous areas.
- How to configure access to a shared device and the function MSI / MSO in STEP 7 can be found in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109736536).

Displays and interrupts

6

6.1 Status and error displays of the Ex-DQ 2x17.4VDC/27mA I/O module

6.1.1 Status and error displays of the I/O module

LED displays

The following figure shows the LED displays of the I/O module:

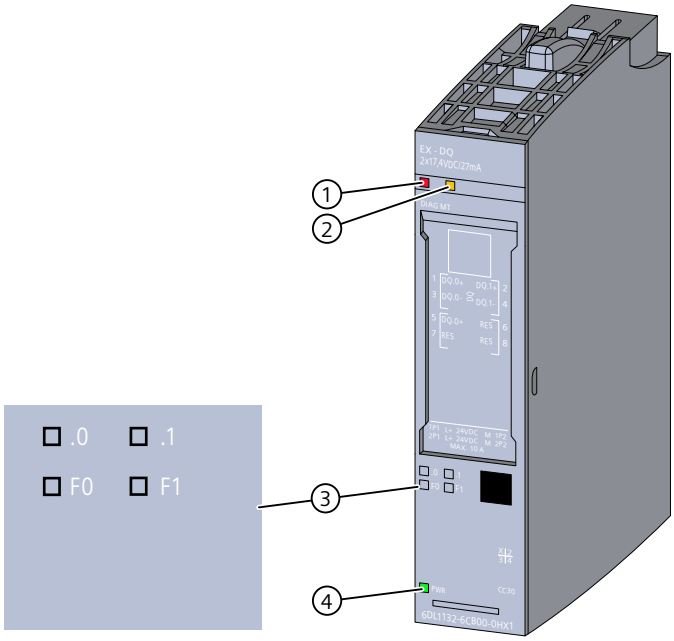

① DIAG LED (green/red)

② MT LED (yellow)

③ LED channel status n (green) and LED channel fault Fn (red) - channel n (n = 0 and 1)

④ PWR LED (green)

Figure 2-1334 LED displays

Meaning of the LED displays

The tables below explain the meaning of the status, error and maintenance displays.

You can learn about corrective measures for messages as well as possible causes in the following section:

Diagnostic and maintenance messages (Page 36)

6.1.2 Diagnostics display of the DIAG LED

DIAG LED

Table 2-1579 Diagnostics display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the system is disrupted or switched off.
Flashes	Module is not configured.
On	Module is configured, a diagnostic message is not pending.
Flashes	Module is configured, at least one diagnostic message is pending.

6.1.3 Diagnostics display of the MT LED

MT LED

Table 2-1580 Status display of the LED MT

MT LED	Meaning
Off	No maintenance required.
On	Maintenance is required, that is, at least one maintenance event has occurred.

6.1.4 Diagnostics display of the Channel status/channel fault LED

Channel status/channel error LED

The green channel status LED shows the signal state of the output when the channel is enabled.

The red channel fault LED is lit when channel diagnostics for an enabled channel is pending.

Table 2-1581 Status and error display of the LEDs channel status and channel error

LED channel status	LED channel error	Meaning
□ Off	□ Off	• Channel disabled or module switched off • Process signal = 0, channel enabled and no channel diagnostics pending • Module diagnostics pending
■ On	□ Off	Process signal = 1, channel enabled and no channel diagnostics pending
□ Off	■ On	Process signal = 0, channel enabled and channel diagnostics pending
■ On	■ On	Process signal = 1, channel enabled and channel diagnostics pending

6.1.5 Diagnostics display of the PWR LED

PWR LED

Table 2-1582 Status display of the PWR LED

PWR LED	Meaning
□ Off	The supply voltage L+ is missing for the potential group.
■ On	The supply voltage L+ is available for the potential group.

6.2 Interrupts

The I/O module supports diagnostic interrupts. Diagnostic and maintenance messages are output via diagnostic interrupts.

You can find more information in the appendix:

- Diagnostic and maintenance messages (Page 36)

Diagnostic messages

The I/O module generates a diagnostic message for the following events:

- Wire break
- Parameter assignment error
- Supply voltage missing
- Channel/component temporarily unavailable
- Short-circuit (to ground)
- Retentive memory in the BaseUnit is defective
- Invalid BaseUnit
- Module is faulty

NOTE

A pending "Module is defective" diagnostic is not deleted by the module until a restart.

Maintenance messages

The I/O module generates a maintenance message for the following events:

- Retentive memory in the BaseUnit is defective

Technical specifications 7

Technical specifications of the Ex-DQ 2x17.4VDC/27mA

Article number	6DL1132-6CB00-0HX1
General information	
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type X1
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V17 or higher
• STEP 7 configurable/integrated from version	STEP 7 V5.6 SP2 or higher
• PCS 7 configurable/integrated from version	V9.1
Operating mode	
• DQ	Yes
• MSO	Yes
Redundancy	
• Redundancy capability	No
Input current	
Current consumption (rated value)	80 mA; at 27 mA per channel
Current consumption, max.	80 mA; at 27 mA per channel
Output voltage	
Rated value (DC)	17.4 V; See output characteristic in manual
Power loss	
Power loss, typ.	1.2 W
Address area	
Address space per module	
• Address space per module, max.	1 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type X1

Article number	6DL1132-6CB00-0HX1
Digital outputs	
Number of digital outputs	2
Current-sinking	No
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes
Open-circuit detection	Yes; capacitive loads can cause wire-break diagnostics when the channel is switched off
Overload protection	Yes
Limitation of inductive shutdown voltage to	DQ.n- (-1 V)
Switching capacity of the outputs	
• with resistive load, max.	27 mA; See output characteristic in manual
• with inductive load, max.	27 mA; See output characteristic in manual
Load resistance range	
• lower limit	480 Ω; parallel operation 240 ohm, see output characteristic in manual
• upper limit	10 kΩ; parallel operation 5 kOhm, see output characteristic in manual
Output current	
• for signal "1" rated value	27 mA
• for signal "0" residual current, max.	100 µA; 250 µA test current for wire break diagnostics, parallel operation 500 µA
Output delay with resistive load	
• "0" to "1", typ.	50 µs
• "1" to "0", typ.	100 µs
Parallel switching of two outputs	
• for uprating	Yes
Switching frequency	
• with resistive load, max.	500 Hz
• with inductive load, max.	500 Hz
Total current of the outputs	
• Current per channel, max.	27 mA
• Current per module, max.	54 mA
Total current of the outputs (per module)	
horizontal installation	
– up to 70 °C, max.	54 mA
vertical installation	
– up to 60 °C, max.	54 mA
Cable length	
• shielded, max.	500 m; Ex characteristic values must be observed
• unshielded, max.	500 m; Ex characteristic values must be observed

Article number	6DL1132-6CB00-0HX1
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
• Maintenance interrupt	Yes
Diagnoses	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Wire-break	Yes; channel by channel
• Short-circuit	Yes; channel by channel
• Group error	Yes
Diagnostics indication LED	
• MAINT LED	Yes; Yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Ex(i) characteristics	
maximum values for connecting terminals for gas group IIC	
• Uo (no-load voltage), max.	19.4 V
• Io (short-circuit current), max.	133 mA; parallel operation 266 mA
• Po (power output), max.	645 mW; parallel operation 1 290 mW
• Co (permissible external capacity), max.	232 nF; parallel operation 220 nF
• Lo (permissible external inductivity), max.	1.9 mH; parallel operation 328 uH
• Um (voltage at non-intrinsically safe connecting terminals), max.	60 V
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes; Electrical isolation between the channels and input voltage PME

Article number	6DL1132-6CB00-0HX1
Isolation	
Isolation tested with	further information on insulation can be found in the "ET 200SP HA / ET 200SP modules for devices in hazardous areas" System Manual
insulation of the field circuits to local ground acc. to IEC/EN 60079-11 tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-40 °C
• horizontal installation, max.	70 °C
• vertical installation, min.	-40 °C
• vertical installation, max.	60 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	55 g

Output characteristic

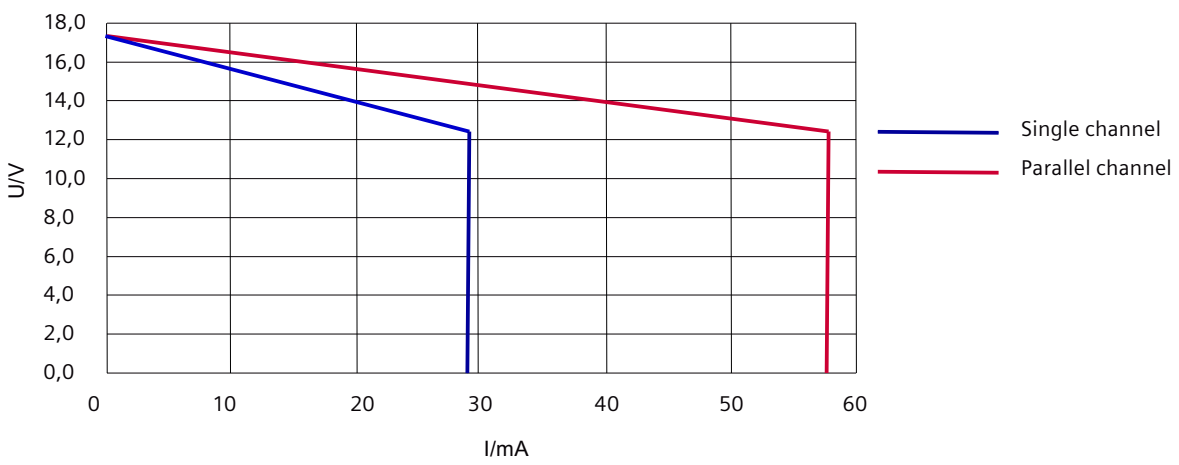

Test current for signal state "0"

NOTE

If the "Wire break check" parameter is activated, a test current flows, even if the signal state for the output is "0" (in single operation: approx. 250 µA, in parallel mode: approx. 500 µA).

Drivers, parameters, diagnostics messages and address space

A

A.1 Concept of the driver and diagnostics blocks

Use with PCS 7

The following information shows you the benefits of using the process control system. In the process control system, the engineering system automatically takes over many of the parameter assignments and interconnections of blocks.

If you want to use the Ex I/O outside of these process control systems, pay attention to the following sections:

- Section "Parameter assignment and structure of the module/channel parameters (Page 33)"
- Section "Address space (Page 38)"

Tasks of the driver and diagnostic blocks (driver blocks)

In process control systems, certain demands are placed on the diagnostics/signal processing. This includes the monitoring of modules, IO devices and PROFINET IO systems for malfunctions and failures.

To enable this, blocks are available in the libraries of the engineering system that implement the interface to the hardware including test functions.

These blocks perform two basic tasks:

- They provide signals from the process to the AS for further processing.
- They monitor modules, IO devices and PROFINET IO system for failure.

When the process signals are read in, these blocks access the process image input (or process image partition) (PII).

When the process signals are output, these blocks access the process image output (or process image partition) (PIQ).

Concept

The concept of the driver and diagnostic blocks for process control systems is characterized by the following:

- The separation between user data processing (CHANNEL blocks) and diagnostics data processing (MODULE blocks)
- The symbolic addressing of the I/O signals
- The automatic generation of the MODULE blocks by CFC

This block concept supports all modules from the list of approved modules.
When new Siemens or non-Siemens module types are integrated, the meta-knowledge for the driver generator can be extended by additional XML files (object and action lists).

NOTE

Note the following:

- You must install the library with the driver blocks using the Setup program on the PC. This is the only method of ensuring that the meta-knowledge required for the driver generator is available. You must not copy the library from another computer.
- You can also use driver blocks from another library (for example, your own blocks from your own library). You can specify this additional library in the "Generate module drivers" dialog box. The driver generator then searches for the block to be imported in the library specified here. If the block is not found here, it is searched for in the library specified in the control file (XML file).
- If the S7 program contains a signal-processing block but not from one of the engineering system libraries, the following is required:
  You have to specify the version of the driver library from which the driver blocks are to be imported in the "Generate module drivers" dialog box.

Time-optimized processing

To enable time-optimized processing during runtime, the organization blocks for error handling (for example, OB85, OB86) are automatically divided into runtime groups and the driver blocks are integrated in the corresponding runtime groups.

If an error occurs, the SUBNET block, for example, activates the relevant runtime group. The RACK block or MODULE block detects the error, evaluates it and outputs a process control message to the operator control and monitoring system.

The diagnostics information of the module block (OMODE_xx output) is also transferred to the corresponding CHANNEL block (MODE input). If necessary, this information can be displayed using a block that can be operated and monitored in the operator control and monitoring system or through a user block in a process picture (color change of the measured value or flashing display, etc.).

A.2 Parameter assignment and structure of the module/channel parameters

A.2.1 Parameter assignment

Parameter assignment in the user program

You can reconfigure individual channels of the module in RUN without this having an effect on the other channels.

Changing parameters in RUN

The parameters are only transferred to the I/O module via data record 128 with the "WRREC" instruction. The parameters set with the configuration are not changed in the CPU in the process, which means the parameters set in the CPU are once again valid after startup.

STATUS output parameter

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The STATUS output parameter is 4 bytes long and is configured as followed:

- Byte1: Function_Num, general error code
- Byte2: Error_Decode, location of the error code
- Byte3: Error_Code_1, error code
- Byte4: Error_Code_2, manufacturer-specific extension of the error code

Module-specific errors are displayed via Error_Decode = 0x80 and Error_Code_1 / Error_Code_2.

Error_ Code_1	Error_ Code_2	Cause	Remedy
0xB0	variable	Number of the data record unknown (Error_Code_2 returns internal identifiers)	Enter valid number for data record.
0xB1	0x01	Length of the data record is incorrect	Enter valid value for data record length.
0xB2	variable	Module cannot be reached (Error_Code_2 returns internal identifiers)	• Check station - is the module plugged in correctly? • Check the parameters of the WRREC instruction.
0xE0	0x01	Header error (version or defined bits incorrect)	Correct the version number or defined bits.
0xE0	0x02	Header error (incorrect length or number of parameter blocks)	Correct the length and number of the parameter blocks.
0xE1	0x01	Reserved bit set	Write all reserved bits with a 0.
0xE1	0x02	Invalid diagnostics enable bit set for operating mode	Enable parameter "Wire break check".
0xE1	0x06	Invalid coding for substitute value reaction	Use valid coding for "Reaction to CPU STOP".

Valid parameters

Only the values specified in the following are permitted. Values that are not listed are rejected by the module.

Every parameter data record is checked by the module. If an incorrect parameter is detected, the entire data record is rejected and the parameters of the module remain unchanged.

A.2.2 Parameter assignment and structure of the module and channel parameters

Structure of data record 128

The data record contains the module parameters and all channel or technology parameters of the two channels.

Main components of the data record:

- Header information (module), module parameters, header information (channel)
- Channel parameters (channel or technology parameters), which influence the actual digital value output.
- Parameters which enable diagnostics

Table 2-1583 Structure of data record 128 in digital mode (12 bytes in length)

Byte	Length	Parameter	Efficiency range
0 ... 3	4 bytes	Header information (module)	Module
4 ... 5	2 bytes	Module parameters	Module parameters
6 ... 7	2 bytes	Header information (channels)	DQ channel n (n = 0 to 1)
8 ... 9	2 bytes	Channel parameter (channel 0)	
10 ... 11	2 bytes	Channel parameter (channel 1)	

NOTE

Legend for the following detailed screens

The following detailed screens show the configuration-dependent assignment of the individual bytes in data record 128.

- Any unused bits and bits or bytes marked with "reserved" must be set to "0".
- Activate a parameter by setting the corresponding bit to "1" or to the appropriate value.

Header information and module parameters

The following figure shows the configuration of the header information and module parameters.

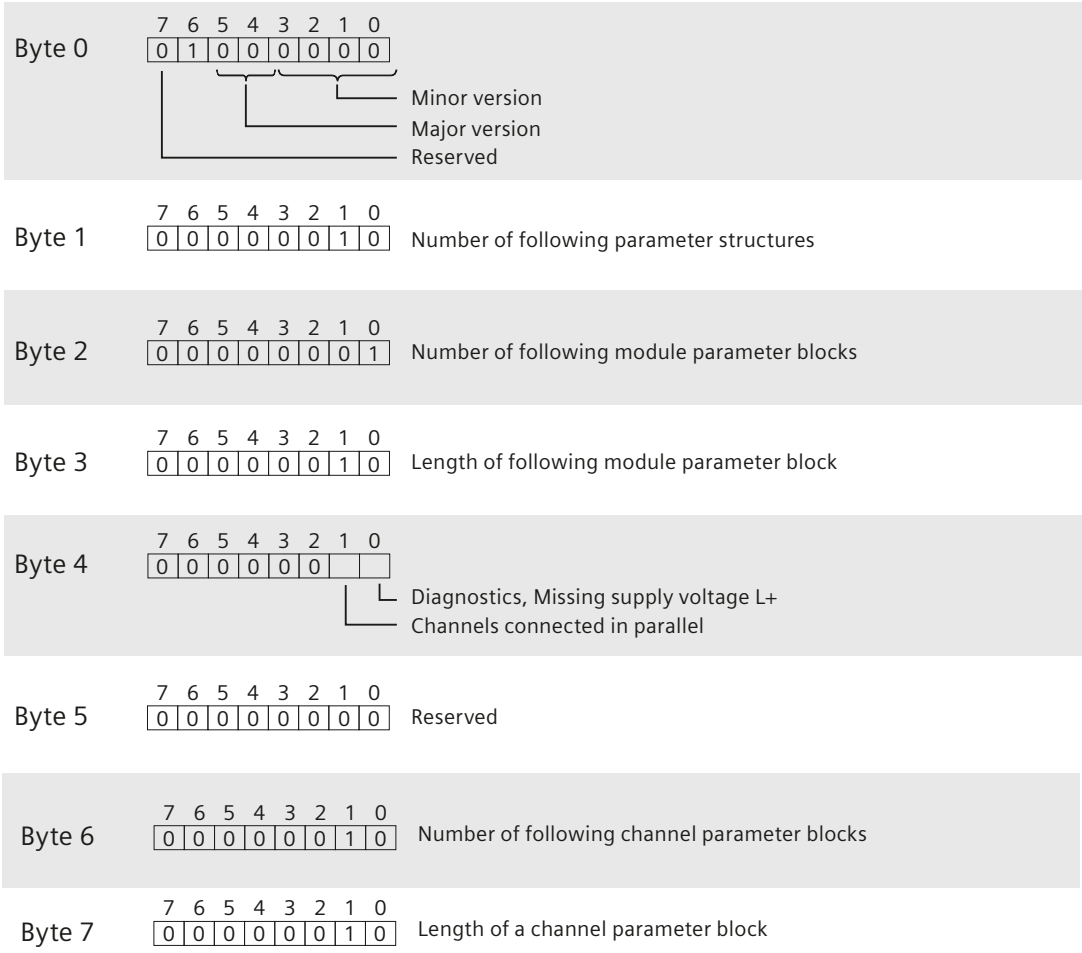

Figure 2-1335 Header information and module parameters of data record 128

Channel parameters

Each channel parameter block contains the channel parameters for the digital output (2 bytes).

The following figure shows the structure of the channel parameters for channels 0 to 1.

x = 8 + (channel number * 2); with channel number 0 to 1

All unused bits and the bits or bytes marked as "reserved" must be set to "0".
You activate a channel parameter by setting the corresponding bit to "1" or the corresponding value.

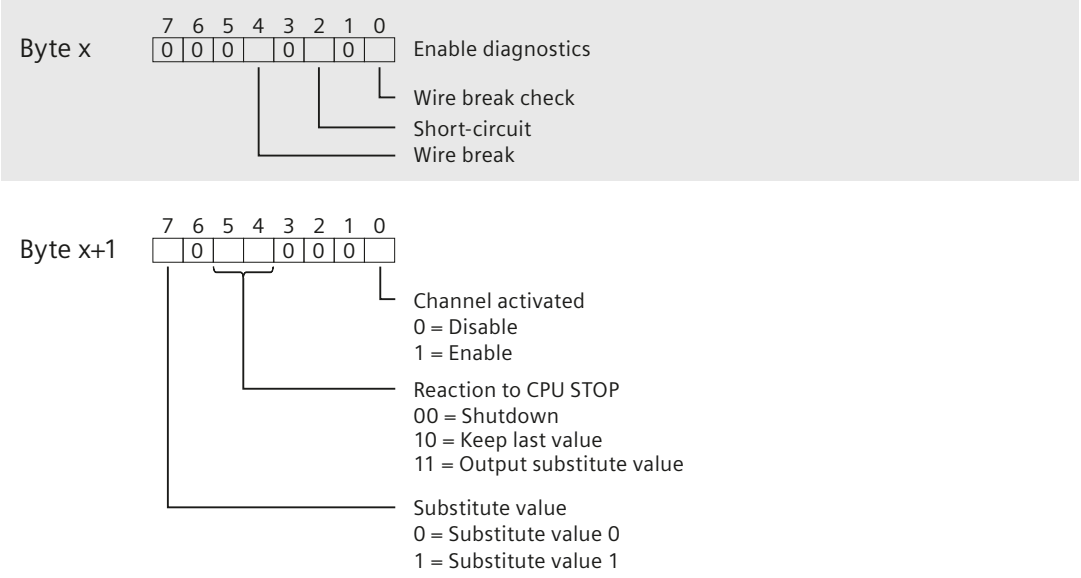

Figure 2-1336 Structure of byte x and x+1 for channels 0 to 1

A.2.3 Diagnostic and maintenance messages

Diagnostic messages

A diagnostic message is generated for each diagnostic event and the DIAG LED flashes red on the module.

The diagnostic messages can be read in the diagnostic buffer of the CPU.

The following applies for the assignment of diagnostic messages:

- A module message is assigned to all channels.
- A channel-specific message is only assigned to one channel and has no effect on the other channels.
  The diagnostics is displayed through the corresponding channel fault LED.

Table 2-1584 Diagnostic messages, their meaning and possible remedies

Diagnostic message	Error code	Assignment	Meaning	Remedy
Short-circuit	1_H	Channel	Short-circuit of the actuator supply	Correct the process wiring
Wire break	6_H	Channel	Actuator connection has impedance too high	Use another type of actuator or wiring, for example, use conductors with a larger cross-section
			Wire break between the module and actuator	Connect the cable

Diagnostic message	Error code	Assignment	Meaning	Remedy
Wire break	6_H	Channel	Channel not connected (open)	• Disable diagnostics • Wire actuator contacts to a resistor in the load resistance area • Switch off wire break check
Parameter assignment error	10_H	Module	Incorrect parameter assignment	Correct the parameter assignment
Supply voltage missing	11_H	Module	Missing or insufficient supply voltage L+	• Check Ex power module • Check the wiring of the supply voltage L+ on the power module
Channel/component temporarily unavailable	$1F_H$	Module	Firmware update is in progress or has been canceled during the update.	• Restart firmware update • Wait for firmware update
Module is faulty	100_H	Module	Internal module error has occurred	Replace module
Invalid BaseUnit	151_H	Module	The module was plugged into an impermissible BaseUnit.	Replace Ex BaseUnit
The retentive memory in the BaseUnit is defective.	153_H	Module	A memory block error on the BaseUnit was detected during startup.	Replace Ex BaseUnit

Maintenance messages

A maintenance message is generated for each maintenance required and the MT LED lights up yellow on the module.

Maintenance messages do not directly affect the function of the module or the digital outputs.

Table 2-1585 Maintenance messages, their meaning and possible remedies

Maintenance message	Error code	Assignment	Meaning / Cause	Remedy
The retentive memory in the BaseUnit is defective.	153_H	Module	A memory block error on the BaseUnit was detected during operation.	Replace Ex BaseUnit

A.3 Address space

A.3.1 Address space in digital mode

Abbreviations

- "QB" stands for output byte, that is the module start address in the output range
- "DQn" stands for digital output n

Address space in the configuration digital mode without QI

The following table shows the mapping of the address space of the I/O module.

Table 2-1586 Address space of the Ex-DQ 2x17.4VDC/27mA

QB x +	7	6	5	4	3	2	1	0
0	-	-	-	-	-	-	DQ1	DQ0

A.3.2 Address space in digital mode with value status

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input range
- "QB" stands for output byte, that is the module start address in the output range
- "DQn" stands for digital output n
- "QDQn" stands for value status (QI) of digital input n
  You can find additional information in section "Evaluating the value status (Page 39)".

Address space in the configuration digital mode with QI

The following table shows the mapping of the address space of the I/O module.

The MSO with QI option is disabled.

Table 2-1587 Address space of the Ex-DQ 2x17.4VDC/27mA

IB x +	7	6	5	4	3	2	1	0
0	-	-	-	-	-	-	QDQ1	QDQ0

Table 2-1588 Address space of the Ex-DQ 2x17.4VDC/27mA

QB x +	7	6	5	4	3	2	1	0
0	-	-	-	-	-	-	DQ1	DQ0

A.3.3 Address space with MSO

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input range
- "QB" stands for output byte, that is the module start address in the output range
- "DQn" stands for digital output n
- "QDQn" stands for value status (QI) of digital input n
  You can find additional information in section "Evaluating the value status (Page 39)".

Address space in the configuration digital mode with QI (MSO with QI is enabled)

The following tables show the allocation of the address space of the I/O module.

NOTE

Configuration with MSO

During configuration of the I/O module with MSO submodule, each subslot has its own **start address** (IB x + ; QB x +)**.**

The process output signals of subslot 1 are mirrored to the MSO subslots as input signals.

Table 2-1589 Address space of the Ex-DQ 2x17.4VDC/27mA (digital operation with QI / MSO, subslot 1)

IB x +	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	-	-	-	-	-	-	QDQ1	QDQ0

Table 2-1590 Address space of the Ex-DQ 2x17.4VDC/27mA (digital operation with QI / MSO, subslot 2 to 4)

IB x +	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	-	-	-	-	-	-	DQ1	DQ0
1	-	-	-	-	-	-	QDQ1	QDQ0

Table 2-1591 Address space of the Ex-DQ 2x17.4VDC/27mA (digital operation with QI / MSO, subslot 1)

QB x +	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	-	-	-	-	-	-	DQ1	DQ0

A.3.4 Evaluating the value status

Evaluating the value status

There is a bit value status for each digital output in the input address space.

Irrespective of the diagnostics enables, each value status (each QI bit) provides information on the validity of the corresponding process value.

- Value status = 1: Process value okay, "good"
- Value status = 0: Process value not okay, "bad"

Basically, the value status is set to "good" if the digital value can be output without error. The value status is set to "bad" in the following cases:

- The digital value cannot be output due to an error, e.g. due to faulty wiring.
- The digital channel is deactivated
- The substitute value is output at the digital output.

Notes for configuration using a GSD/GSDML file (Page 15)

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ET 200SP HA / ET 200SP Ex-DQ 2x23.1VDC/20mA

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Security information 1

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit
https://www.siemens.com/industrialsecurity.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under
https://www.siemens.com/industrialsecurity.

Preface

2

Validity of the documentation

This documentation describes the following I/O module:

System	Module type	Article number
Distributed I/O System; ET 200SP and ET 200SP HA	Ex-DQ 2x23.1VDC/20mA	6DL1132-6EB00-0HX1

This documentation supplements the following documentation:

- System manual *Distributed I/O System, ET 200SP I ET 200SP HA; Modules for devices in the hazardous area*

Functions that generally relate to the ET 200SP and ET 200SP HA are described in the respective system documentation:

- System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)
- System manual Distributed I/O System ET 200SP HA (https://support.industry.siemens.com/cs/ww/en/view/109761547)

The information in this manual and the system/function manuals enables you to put the modules for hazardous areas into operation.

Conventions

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

These documentation contain a description of the components that was valid at the time the operating instructions were published. We reserve the right to include product information with information updates with new components and components with a new product status.

Product overview

3

3.1 Properties of the I/O module Ex-DQ 2x23.1VDC/20mA

View of the module

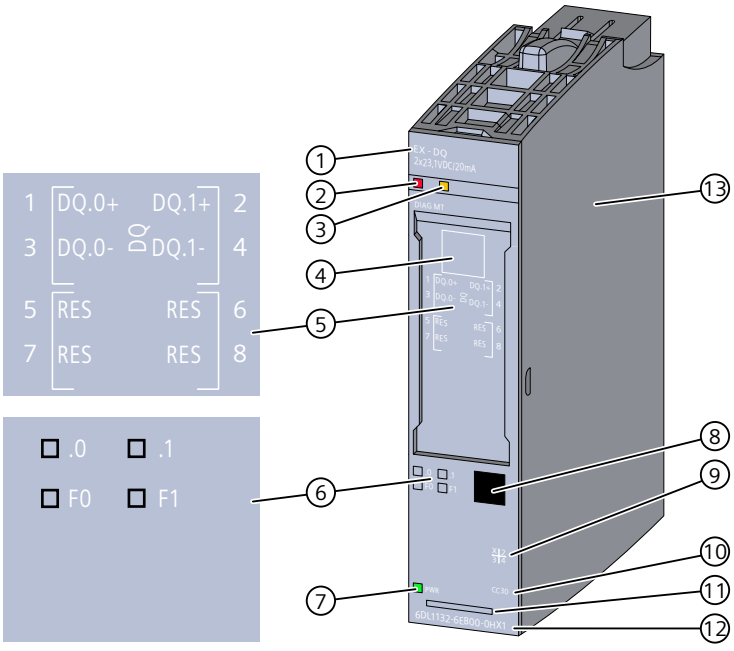

① Module type and designation
② LED for diagnostics
③ LED for maintenance
④ 2D matrix code
⑤ Wiring diagram
⑥ LEDs for channel status/channel fault
⑦ LED for supply voltage
⑧ Module type color coding
⑨ Function version
⑩ Color code for selection of the color-coded labels
⑪ Serial number
⑫ Article number
⑬ Labeling surface (symbols and standards)

Figure 2-1337 View of the Ex-DQ 2x23.1VDC/20mA

You can find information on the LEDs in section "Status and error displays of the I/O module (Page 22)".

Properties

The I/O module is used to connect intrinsically safe actuators.

The I/O module has the following technical properties:

- 2 digital outputs with the following properties that can be individually configured for each channel
  - Diagnostics
  - Substitute values
- Module-specific configurable diagnostics

You can find additional information in section "Technical specifications (Page 26)".

The module supports the following functions

The I/O module supports the following functions:

- Firmware update
- I&M identification data
- Parameter reassignment in RUN
- Value status QI
- Module-internal Shared Output (MSO)

Accessories

The following accessories can be ordered separately:

- Labeling strips
- Reference identification label
- Shield connector

3.2 2D Matrix code (QR code / EAN code)

The 2D matrix code on the product is a coded representation of the product-specific article number.

Access to product-related information

For reading the 2D matrix code, SIEMENS offers an app for mobile use.
Information about the app and the download can be found on the Internet: "Mobile use via app (https://support.industry.siemens.com/cs/ww/en/sc/2067)".

The app provides direct access to the technical forum and product-related posts, such as:

- FAQs
- Application examples
- Manuals
- Certificates
- Product notices

Wiring

4

4.1 Ex BaseUnit

You can operate the I/O module with the following Ex BaseUnit:

- Ex-BU Type X1 (6DL1 193-6BP00-0BX1)

The Ex BaseUnit is not included in the scope of delivery of the Ex I/O module and must be ordered separately.

NOTE

You can find additional information on the configuration in the system manual.

The terminal block for connecting the I/O signals is part of the Ex BaseUnit for Ex I/O modules and cannot be mounted separately.

Connections on the slot and Ex I/O module

The following figure shows the connections on the Ex BaseUnit and the I/O module.

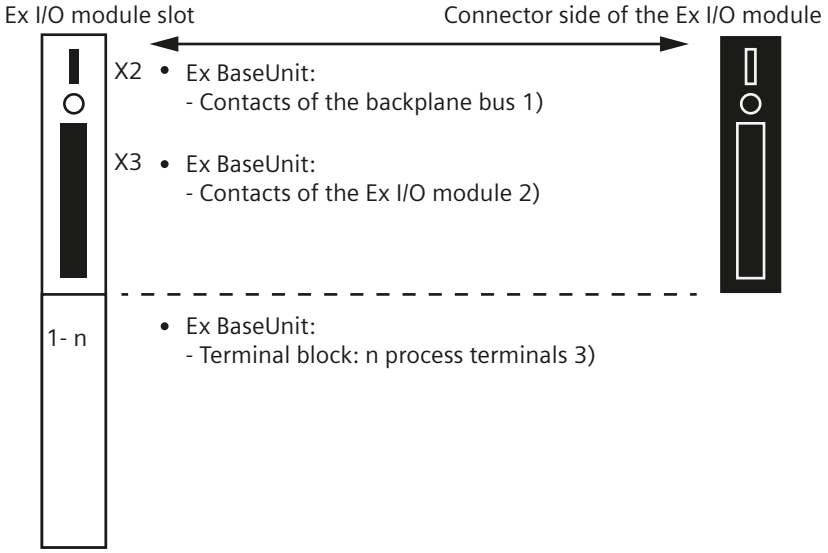

1) Ex BaseUnit contacts of the backplane bus (max. 50 mA; 3.3 V DC ⎓)

2) Ex BaseUnit contacts for process signal transmission (for maximum voltages and currents, refer to the documentation of the respective I/O module)

3) Process terminals on the terminal block (number, maximum/permissible voltages and currents, refer to the documentation of the respective I/O module).

Information on the pin assignment of the I/O module (terminal block) can be found in the following sections.

4.2 Pin assignment of the I/O module Ex-DQ 2x23.1VDC/20mA

General pin assignment

Table 2-1592 Pin assignment of the Ex-DQ 2x23.1VDC/20mA

Terminal	Assignment	Terminal	Assignment	Terminal block	Explanations
1	DQ.0+	**2**	DQ.1+	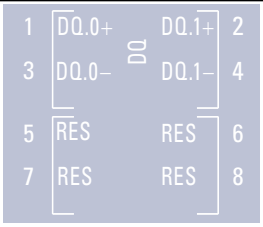	Terminals 1, 2 DQ.n+: Output signal, channel n (0;1) Terminals 3; 4 DQ.n-: Mass, channel n (0;1) Terminals 5; 6; 7; 8 Res: Reserve
3	DQ.0-	**4**	DQ.1-		
5	Res	**6**	Res		
7	Res	**8**	Res		

Connections via all actuator types

You can find information on the connection of actuators in the following section:

- Pin assignment for actuators - 2-wire (Page 11)

4.3 Pin assignment for actuators - 2-wire

Pin assignment channel 0

2-wire connection	1 3

4.4 Schematic circuit diagram

The following figure shows the schematic circuit diagram of the Ex I/O module.

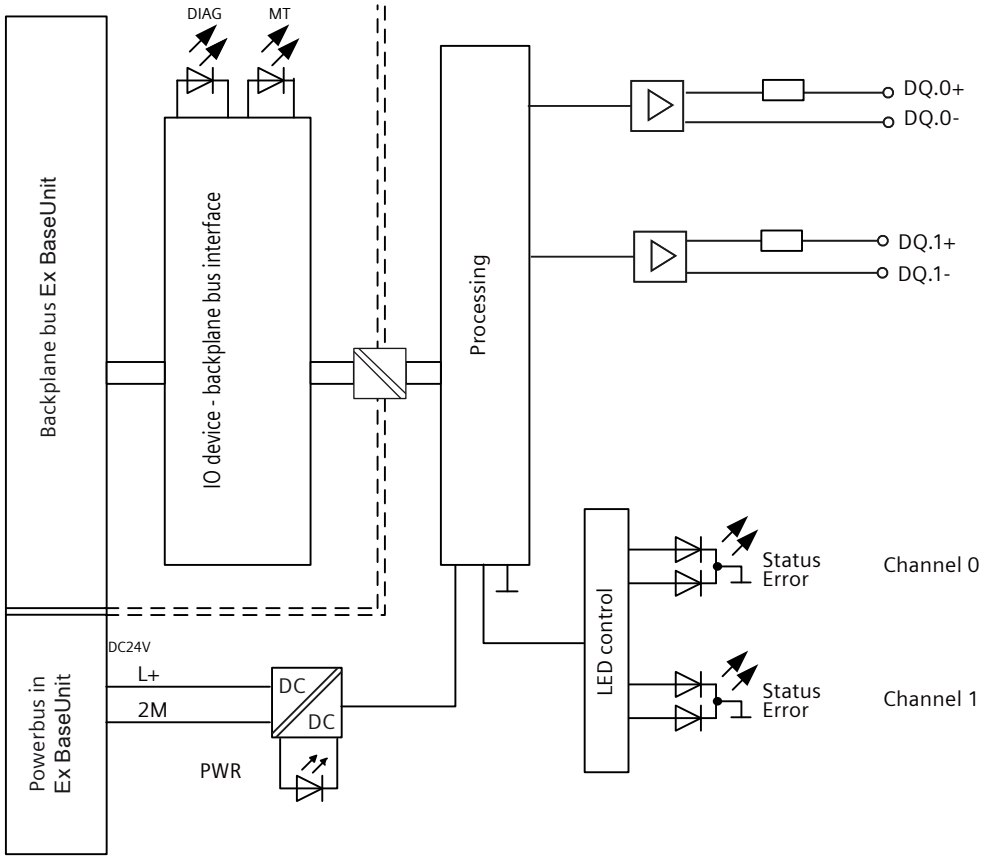

Figure 2-1338 Schematic circuit diagram Ex-DQ 2x23.1VDC/20mA

Supply voltage

The supply voltage L+/2M is generated and monitored by the Ex power module. The Ex I/O module receives its supply voltage L+ via the power bus. Further monitoring of the supply voltage is performed in the Ex I/O module. During parameter assignment, you can specify whether a diagnostic message is to be output in the event of failure of the supply voltage.

Firmware update

The supply voltage L+ must be available on the Ex I/O module at the start of firmware update and during the update.

4.5 Potential group in hazardous areas

Potential group

With the modules for hazardous areas, the Ex power module and the Ex I/O module plugged into the right of the Ex power module form a potential group.

The potential group ends when one of the following modules is plugged in to the right of an Ex I/O module:

- Ex power module
- Server module

Configuring 5

5.1 Configurations of the I/O module Ex-DQ 2x23.VDC/20mA

Requirements

You configure the I/O module

- in the TIA Portal
- with PCS 7
- with PCS neo
- with STEP 7

The version required in each case is specified in the technical specifications.

Configuration via GSD/GSDML

Notes for configuration using a GSD/GSDML file (Page 15)

Restrictions when using in ET 200SP

- For use with a standard IM, its firmware must be at least of version V3.3.
- No MSI is available for a PROFIBUS DP station.
- TIA Portal:
  - TIA Portal as of V17.0
    The module can be centrally configured on the following CPUs:
    - CPU 1510SP-1 (as of V2.6)
    - CPU 1512SP-1 PN (as of V2.6)
    - CPU 1515SP-1 PN (as of V2.6)
  - The module cannot be used behind fail-safe controllers.

Configurations

Depending on the desired configuration, you must select the required version of the I/O module from the hardware catalog.

The following configurations are possible:

Configuration	Version of the I/O module in the hardware catalog of the engineering tool	Required parameter assignment of the module
Digital mode without QI	**Ex-DQ 2x23.1VDC/20mA**	"Value status" parameter deactivated
Digital mode with QI [2]		• "Value status" parameter activated • Optional [3] "MSO with QI": You can find information about MSO in the section "Module-internal Shared Output (MSO) (Page 19)".

[1] For the configuration using GSDML, all configurations can be selected directly in the hardware catalog of the engineering tool.

[2] Not available when configuring using a GSD file.

[3] Not available when configuring using a GSD/GSDML file.

NOTE

Changing the configuration in CPU RUN

You can re-configure the I/O module when the CPU is in RUN when the loaded configuration (version of the I/O module in the hardware catalog) is maintained.

If you want to define a different configuration in CPU RUN, the following steps are required:

1. Remove the I/O module from the loaded configuration in CPU RUN.
2. Configure the I/O module including the required configuration-specific parameters.
3. Load the new configuration in CPU RUN.

Note that changing the configuration changes the I/O address range.

Parameters

You define the operating mode of the I/O module via channel/technology parameters (data record 128).

5.2 Notes for configuration using a GSD/GSDML file

Files for configuration using GSD/GSDML

If you need the GSD/GSDML files for configuration, you can download them on the Internet:

- PROFINET GSD file (GSDML) for ET 200SP HA (http://support.industry.siemens.com/cs/ww/en/view/109781191)
- PROFINET GSD files for ET 200SP (http://support.automation.siemens.com/WW/view/en/57138621)
- PROFIBUS GSD files for ET 200SP (http://support.automation.siemens.com/WW/view/en/73016883)

Restrictions when using a GSDML file for the PROFINET configuration

The following functions are not available in the process image of the I/O module:

- MSO

Restrictions when using a GSD file for the PROFIBUS configuration

The following functions are not available in the process image of the I/O module:

- MSO
- Value status

5.3 Module/channel parameters

Parameters of Ex-DQ 2x23.1VDC/20mA

You have the following setting options:

Table 2-1593 Adjustable parameters and their default setting

Parameter	Value range	Default	CiR [1]	Efficiency range		
				HSP [2]	GSDML [3]	GSD [4]
Diagnostics, Missing supply voltage L+	• Enabled • Disabled	Disabled	Yes	Module	Module	Module
Diagnostics Short-circuit	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Wire break check	• Enabled • Disabled	Enabled	Yes	Channel	Channel	Channel
Diagnostics, Wire break [5]	• Enabled • Disabled	With ET 200SP in the HSP (TIA Portal): Disabled, otherwise enabled	Yes	Channel	Channel	Channel
Channel activated	• Enabled • Disabled	Enabled	Yes	Channel	Channel	Channel
Reaction to CPU STOP	• Shutdown • Keep last value • Output substitute value	Shutdown	Yes	Channel	Channel	Module
Substitute value [6]	• 0 • 1	0	Yes	Channel	Channel	Channel
Potential group	Potential group of the left intrinsically safe power module	Potential group of the left intrinsically safe power module	No	Module	Module	Module

1) CiR = Configuration in RUN

2) HSP = Configuration via Hardware Support Package (HSP) of the process control

3) GSDML = Configuration using a GSDML file

4) GSD = Configuration using a GSD file

5) The wire break diagnostics can only be enabled when the "Wire break check" parameter is enabled.

6) The substitute value parameter only has an effect when the "Output substitute value" setting is selected for the "Reaction to CPU STOP" parameter.

5.4 Explanation of parameters

5.4.1 Diagnostics Missing supply voltage L+

Defines whether a diagnostic interrupt is generated when the supply voltage L+ is missing or is too low.

The supply voltage is generated by the Ex power module. Other internal defects can be detected and reported via the additional diagnostics for the Ex I/O module.

5.4.2 Diagnostics: Short-circuit

When the digital output is activated, you can enable diagnostics that report a short circuit between the digital output (DQ.n+) and ground (DQ.n-).

A short-circuit can only be detected if there is a 1 signal at the corresponding output.

5.4.3 Wire break check

Enables the wire break check. The wire break check must be enabled in order for the I/O module to detect a wire break.

If the wire break test is enabled, a test current of approx. 250 µA is fed into the channel with a "0" signal. This enables a wire break to be detected independently of the signal level and the QI bit to be influenced. If wire break diagnostics is enabled, a diagnostic interrupt is also generated. If the test current is not wanted in the presence of a "0" signal, you can suppress it by disabling the wire break check. A wire break is then no longer detected, neither for the "1" nor for the "0" signal.

5.4.4 Diagnostics: Wire break

Specifies whether a diagnostic interrupt is generated when the wire break test current is undershot.

Requirement: Wire break check is enabled.

5.4.5 Channel activated

Specifies whether a channel is activated or deactivated.

5.4.6 Reaction to CPU STOP

Determines the reaction of the digital output to CPU STOP or to failure of communication between the interface module and CPU.

5.4.7 Substitute value

The substitute value is output by the module at CPU STOP if you set the "Reaction to CPU STOP" parameter to "Substitute value".

5.4.8 Potential group

A potential group consists of a group of directly adjacent Ex IO modules within a station of the distributed I/O (IO device), which are supplied via a common Ex power module.

A potential group begins with an Ex power module, via which the required supply voltage for all Ex I/O modules of the potential group is supplied. The Ex power module interrupts the self-assembling voltage buses to the left neighbor.

The Ex I/O modules take the potential of the self-assembling voltage buses from the left neighbor.

A potential group ends with the BaseUnit, which follows an Ex power module or a server module in the station configuration.

You can find additional information on the configuration of the potential group in the system manual *Distributed I/O System; ET 200SP and ET 200SP HA, Modules for hazardous areas*.

5.5 Module-internal Shared Output (MSO)

The function enables several IO controllers to access the output data of the I/O module.

- With MSO, the following data of the I/O module (basic submodule) is copied to up to three MSO submodules as input data of the MSO submodules:
  - Output data of the basic submodule
  - The QI information of the basic submodule
- Each of the four submodules can be assigned to an IO controller, whereby these can be different or identical IO controllers.
  - The IO controller assigned to the basic submodule has write access to the outputs of the I/O module and read access to the QI information of the basic submodule.
    The basic submodule therefore occupies input and output addresses in the process image of the IO controller.
  - The IO controllers to which the MSO submodules are assigned have read access to the outputs and the QI information of the basic submodule. MSO submodules therefore only occupy input addresses in the process image of the assigned IO controller.
- Only the basic submodule is configured and can return diagnostic interrupts.
  MSO submodules are not configurable and do not return interrupts.

The following figure shows a digital output module with the basic submodule and three MSO submodules. Each submodule is assigned to an IO controller. The diagnostics and parameter assignment of the digital output module is possible via the basic submodule from the IO controller 1.

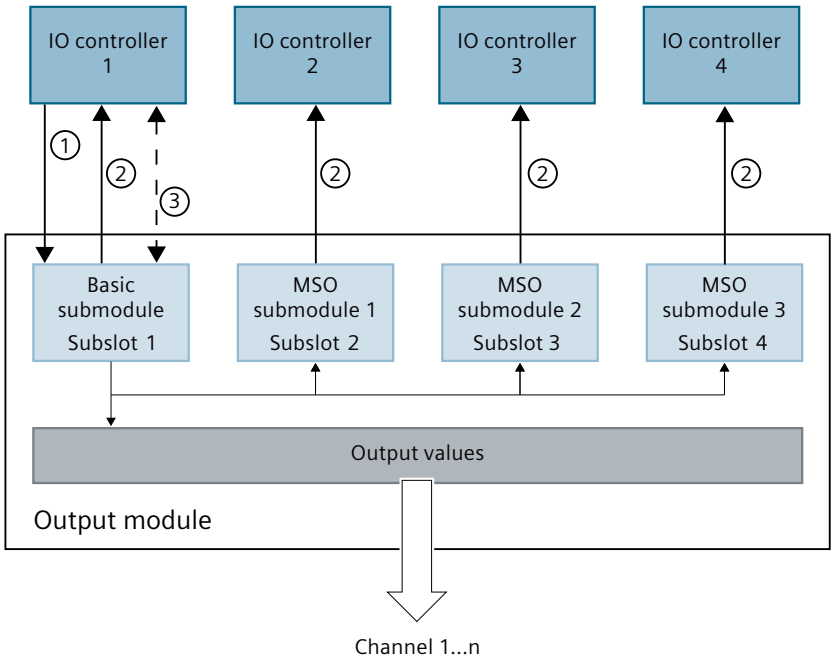

① Write access

② Read access

③ Parameter assignment and system diagnostics

Figure 2-1339 Input module with MSO configuration

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule in question.

With the basic submodule (= subslot 1), the value status "0" indicates that the value is incorrect.

With an MSO submodule (= subslot 2 to 4), the value status "0" indicates that the value is incorrect or that one of the following errors has occurred:

- The basic submodule is not yet parameterized (not ready).
- The connection between the PROFINET IO controller and the basic submodule is interrupted.
- The IO controller of the basic submodule is in STOP mode or POWER OFF.

NOTE

Restrictions

- **PROFINET required**
  MSO is only available with configuration with PROFINET.
- **No configuration with PCS 7**
  No support for configuration with PCS 7.
- **No configuration via GSD/GSDML**
  No support of MSO during configuration via GSD/GSDML.
  Notes for configuration using a GSD/GSDML file (Page 15)

Configure MSO for an I/O module

You set the configuration on the basic submodule (subslot 1).

NOTE

If "MSO" is configured for an I/O module, this applies to all channels of the I/O module.

If MSO is to be configured, the value status QI must always be configured as well.

---

1. Select the configuration based on the following table.
2. Select the number of MSO submodules in the properties of the I/O module. This parameter assignment can be performed in CPU RUN.

You can find additional information on this in the section "Address space with MSO (Page 38)".

NOTE

Configuration of the controllers

Please note that you have to perform the configuration of the signals for the IO controllers which are not directly connected to the IO device separately.

Changing the MSO configuration in RUN

The parameter "Value status" must always be activated.

Configuration	Version of the I/O module in the module catalog (HW Config)	Configuration of the I/O module
Digital mode DI 2 with QI	**Ex-DQ 2x23.1VDC/20mA**	Number of additional submodules: (Change in CPU RUN possible) • 1 to 3: MSO is enabled • 0: MSO is disabled

Additional information

- Find out how to assign MSO submodules to an IO controller in the documentation *SIMATIC; Distributed I/O System ET 200SP/ET 200SP HA,* Modules for devices in hazardous areas.
- How to configure access to a shared device and the function MSI / MSO in STEP 7 can be found in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109736536).

Displays and interrupts

6

6.1 Status and error displays of the Ex-DQ 2x23.1VDC/20mA I/O module

6.1.1 Status and error displays of the I/O module

LED displays

The following figure shows the LED displays of the I/O module:

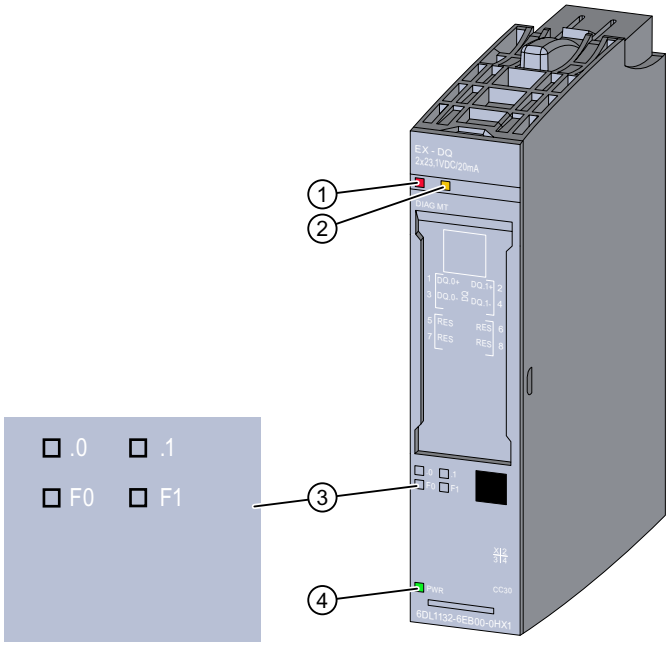

① DIAG LED (green/red)

② MT LED (yellow)

③ LED channel status n (green) and LED channel fault Fn (red) - channel n (n = 0 and 1)

④ PWR LED (green)

Figure 2-1340 LED displays

Meaning of the LED displays

The tables below explain the meaning of the status, error and maintenance displays.

You can learn about corrective measures for messages as well as possible causes in the following section:

Diagnostic and maintenance messages (Page 35)

6.1.2 Diagnostics display of the DIAG LED

DIAG LED

Table 2-1594 Diagnostics display of the DIAG LED

DIAG LED	Meaning
Off	Backplane bus supply of the system is disrupted or switched off.
Flashes	Module is not configured.
On	Module is configured, a diagnostic message is not pending.
Flashes	Module is configured, at least one diagnostic message is pending.

6.1.3 Diagnostics display of the MT LED

MT LED

Table 2-1595 Status display of the LED MT

MT LED	Meaning
Off	No maintenance required.
On	Maintenance is required, that is, at least one maintenance event has occurred.

6.1.4 Diagnostics display of the Channel status/channel fault LED

Channel status/channel error LED

The green channel status LED shows the signal state of the output when the channel is enabled.

The red channel fault LED is lit when channel diagnostics for an enabled channel is pending.

Table 2-1596 Status and error display of the LEDs channel status and channel error

LED channel status	LED channel error	Meaning
□ Off	□ Off	• Channel disabled or module switched off • Process signal = 0, channel enabled and no channel diagnostics pending • Module diagnostics pending
■ On	□ Off	Process signal = 1, channel enabled and no channel diagnostics pending
□ Off	■ On	Process signal = 0, channel enabled and channel diagnostics pending
■ On	■ On	Process signal = 1, channel enabled and channel diagnostics pending

6.1.5 Diagnostics display of the PWR LED

PWR LED

Table 2-1597 Status display of the PWR LED

PWR LED	Meaning
□ Off	The supply voltage L+ is missing for the potential group.
■ On	The supply voltage L+ is available for the potential group.

6.2 Interrupts

The I/O module supports diagnostic interrupts. Diagnostic and maintenance messages are output via diagnostic interrupts.

You can find more information on this in the appendix:

Diagnostic and maintenance messages (Page 35)

Diagnostic messages

The I/O module generates a diagnostic message for the following events:

- Wire break
- Parameter assignment error
- Supply voltage missing
- Channel/component temporarily unavailable
- Short-circuit (to ground)
- Retentive memory in the BaseUnit is defective.
- Invalid BaseUnit
- Module is faulty

NOTE

A pending "Module is defective" diagnostic is not deleted by the module until a restart.

Maintenance messages

The I/O module generates a maintenance message when the following events occur:

- Retentive memory in the BaseUnit is defective.

Technical specifications 7

Technical specifications of Ex-DQ 2x23.1VDC/20mA

Article number	6DL1132-6EB00-0HX1
General information	
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type X1
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V17 or higher
• STEP 7 configurable/integrated from version	STEP 7 V5.6 SP2 or higher
• PCS 7 configurable/integrated from version	V9.1
Operating mode	
• DQ	Yes
• MSO	Yes
Redundancy	
• Redundancy capability	No
Input current	
Current consumption (rated value)	80 mA; At 20 mA per channel
Current consumption, max.	80 mA; At 20 mA per channel
Output voltage	
Rated value (DC)	23.1 V; See output characteristic in manual
Power loss	
Power loss, typ.	1.3 W
Address area	
Address space per module	
• Address space per module, max.	1 byte; + 1 byte for QI information
Hardware configuration	
Automatic encoding	
• Mechanical coding element	Yes
Selection of BaseUnit for connection variants	
• 2-wire connection	BU type X1

Article number	6DL1132-6EB00-0HX1
Digital outputs	
Number of digital outputs	2
Current-sinking	No
Current-sourcing	Yes
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes
Open-circuit detection	Yes; capacitive loads can cause wire-break diagnostics when the channel is switched off
Overload protection	Yes
Limitation of inductive shutdown voltage to	DQ.n- (-1 V)
Switching capacity of the outputs	
• with resistive load, max.	20 mA; See output characteristic in manual
• with inductive load, max.	20 mA; See output characteristic in manual
Load resistance range	
• lower limit	872 Ω; See output characteristic in manual
• upper limit	10 kΩ; See output characteristic in manual
Output current	
• for signal "1" rated value	20 mA
• for signal "0" residual current, max.	100 µA; 250 µA test current for wire break diagnostics
Output delay with resistive load	
• "0" to "1", typ.	50 µs
• "1" to "0", typ.	100 µs
Parallel switching of two outputs	
• for uprating	No
Switching frequency	
• with resistive load, max.	500 Hz
• with inductive load, max.	500 Hz
Total current of the outputs	
• Current per channel, max.	20 mA
• Current per module, max.	40 mA
Total current of the outputs (per module)	
horizontal installation	
– up to 70 °C, max.	40 mA
vertical installation	
– up to 60 °C, max.	40 mA
Cable length	
• shielded, max.	500 m; Ex characteristic values must be observed
• unshielded, max.	500 m; Ex characteristic values must be observed
Interrupts/diagnostics/status information	
Diagnostics function	Yes

Article number	6DL1132-6EB00-0HX1
Substitute values connectable	Yes
Alarms	
• Diagnostic alarm	Yes
• Maintenance interrupt	Yes
Diagnoses	
• Diagnostic information readable	Yes
• Monitoring the supply voltage	Yes
– parameterizable	Yes
• Wire-break	Yes; channel by channel
• Short-circuit	Yes; channel by channel
• Group error	Yes
Diagnostics indication LED	
• MAINT LED	Yes; Yellow LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Ex(i) characteristics	
maximum values for connecting terminals for gas group IIC	
• Uo (no-load voltage), max.	24.8 V
• Io (short-circuit current), max.	99 mA
• Po (power output), max.	614 mW
• Co (permissible external capacity), max.	100 nF
• Lo (permissible external inductivity), max.	3.5 mH
• Um (voltage at non-intrinsically safe connecting terminals), max.	60 V
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes; Electrical isolation between the channels and input voltage PME
Isolation	
Isolation tested with	further information on insulation can be found in the "ET 200SP HA / ET 200SP modules for devices in hazardous areas" System Manual
insulation of the field circuits to local ground acc. to IEC/EN 60079-11 tested with	707 V DC (type test)

Article number	6DL1132-6EB00-0HX1
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-40 °C
• horizontal installation, max.	70 °C
• vertical installation, min.	-40 °C
• vertical installation, max.	60 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	55 g

Output characteristic

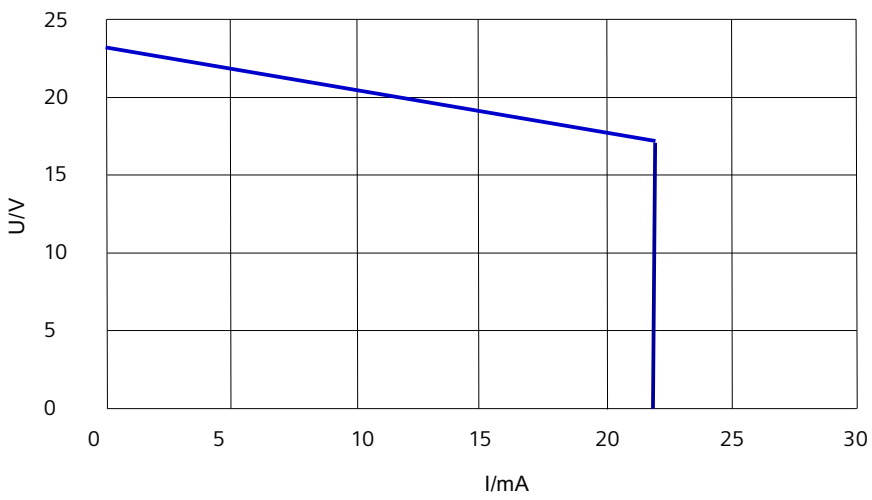

Test current for signal state "0"

NOTE

If the "Wire break check" parameter is activated, a test current of approx. 250 µA flows, even if the signal state for the output is "0".

Drivers, parameters, diagnostics messages and address space

A

A.1 Concept of the driver and diagnostics blocks

Use with PCS 7

The following information shows you advantages of using the process control system. In the process control system, the engineering system automatically handles many important parameter assignments and interconnections of modules.

If you want to use the Ex I/O outside these process control systems, refer to the following sections:

- Parameter assignment and structure of the module/channel parameters (Page 32)
- Address space (Page 37)

Tasks of the driver and diagnostics blocks (driver blocks)

In process control systems, certain demands are placed on the diagnostics/signal processing. This includes the monitoring of modules, IO devices and PROFINET IO systems for malfunctions and failures.

To make this possible, blocks are provided in the libraries of the engineering system which implement the interface to the hardware, including test functionality.

These blocks perform two basic tasks:

- They provide signals from the process to the AS for further processing.
- They monitor modules, IO devices and PROFINET IO system for failure.

When the process signals are read in, these blocks access the process image input (or process image partition) (PII) and when the process signals are output, they access the process image output (or process image partition) (PIQ).

Concept

The concept of the driver and diagnostic blocks in the process control systems is characterized by the following:

- The separation between user data processing (CHANNEL blocks) and diagnostics data processing (MODULE blocks)
- The symbolic addressing of the I/O signals
- The automatic generation of the MODULE blocks by CFC

This block concept supports all modules from the list of approved modules.
When new Siemens or non-Siemens module types are integrated, the meta-knowledge for the driver generator can be extended by additional XML files (object and action lists).

NOTE

Note the following:

- The library with the driver blocks must be installed using the Setup program on the PC. This is the only method of ensuring that the meta-knowledge required for the driver generator is available. You must not copy the library from another computer.
- You can also use driver blocks from another library (for example, your own blocks from your own library). You can specify this additional library in the "Generate module drivers" dialog box. The driver generator then searches for the block to be imported in the library specified here. If the block is not found here, it is searched for in the library specified in the control file (XML file).
- If the S7 program contains a signal-processing block but none from one of the engineering system libraries, the following is required:
  You must specify the version of the driver library from which the driver blocks are to be imported in the "Generate module drivers" dialog box.

Time-optimized processing

To enable time-optimized processing during runtime, the organization blocks for error handling (for example, OB85, OB86) are automatically divided into runtime groups and the driver blocks are integrated in the corresponding runtime groups.

If an error occurs, the SUBNET block, for example, activates the relevant runtime group. The RACK block or MODULE block detects the error, evaluates it and outputs a process control message to the operator control and monitoring system.

The diagnostics information of the module block (OMODE_xx output) is also transferred to the corresponding CHANNEL block (MODE input). If required, this information can be displayed in a process picture via a block that can be controlled and observed in the operator control and monitoring system or a user block (color change of the measured value or flashing display, etc.).

A.2 Parameter assignment and structure of the module/channel parameters

A.2.1 Parameter assignment

Parameter assignment in the user program

You can reconfigure individual channels of the module in RUN without this having an effect on the other channels.

Changing parameters in RUN

The parameters are only transferred to the I/O module via data record 128 with the "WRREC" instruction. The parameters set with the configuration are not changed in the CPU in the process, which means the parameters set in the CPU are once again valid after startup.

STATUS output parameter

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

The STATUS output parameter is 4 bytes long and is configured as followed:

- Byte1: Function_Num, general error code
- Byte2: Error_Decode, location of the error code
- Byte3: Error_Code_1, error code
- Byte4: Error_Code_2, manufacturer-specific extension of the error code

Module-specific errors are displayed via Error_Decode = 0x80 and Error_Code_1 / Error_Code_2.

Error_ Code_1	Error_ Code_2	Cause	Remedy
0xB0	variable	Number of the data record unknown (Error_Code_2 returns internal identifiers)	Enter valid number for data record.
0xB1	0x01	Length of the data record is incorrect	Enter valid value for data record length.
0xB2	variable	Module cannot be reached (Error_Code_2 returns internal identifiers)	• Check station - is the module plugged in correctly? • Check the parameters of the WRREC instruction.
0xE0	0x01	Header error (version or defined bits incorrect)	Correct the version number or defined bits.
0xE0	0x02	Header error (incorrect length or number of parameter blocks)	Correct the length and number of the parameter blocks.
0xE1	0x01	Reserved bit set	Write all reserved bits with a 0.
0xE1	0x02	Invalid diagnostics enable bit set for operating mode	Enable parameter "Wire break check".
0xE1	0x06	Invalid coding for substitute value reaction	Use valid coding for "Reaction to CPU STOP".

Valid parameters

Only the values specified in the following are permitted. Values that are not listed are rejected by the module.

Every parameter data record is checked by the module. If an incorrect parameter is detected, the entire data record is rejected and the parameters of the module remain unchanged.

A.2.2 Parameter assignment and structure of the module/channel parameters

Structure of data record 128

The data record contains the module parameters and all channel or technology parameters of the two channels.

Main components of the data record:

- Header information (module), module parameters, header information (channel)
- Channel parameters (channel or technology parameters) that influence the actual digital value output.
- Parameters which enable diagnostics

Table 2-1598 Structure of data record 128 in digital mode (12 bytes in length)

Byte	Length	Parameter	Efficiency range
0 ... 3	4 bytes	Header information (module)	Module
4 ... 5	2 bytes	Module parameters	Module parameters
6 ... 7	2 bytes	Header information (channels)	DQ channel n (n = 0 to 1)
8 ... 9	2 bytes	Channel parameter (channel 0)	
10 ... 11	2 bytes	Channel parameter (channel 1)	

NOTE

Legend for the following detailed screens

The following detailed screens show the assignment of the individual bytes in data record 128 based on the configuration.

- All unused bits, as well as the bits or bytes marked as "reserved" must be set to "0".
- Activate a parameter by setting the corresponding bit to "1" or to the appropriate value.

Header information and module parameters

The following figure shows the configuration of the header information and module parameters.

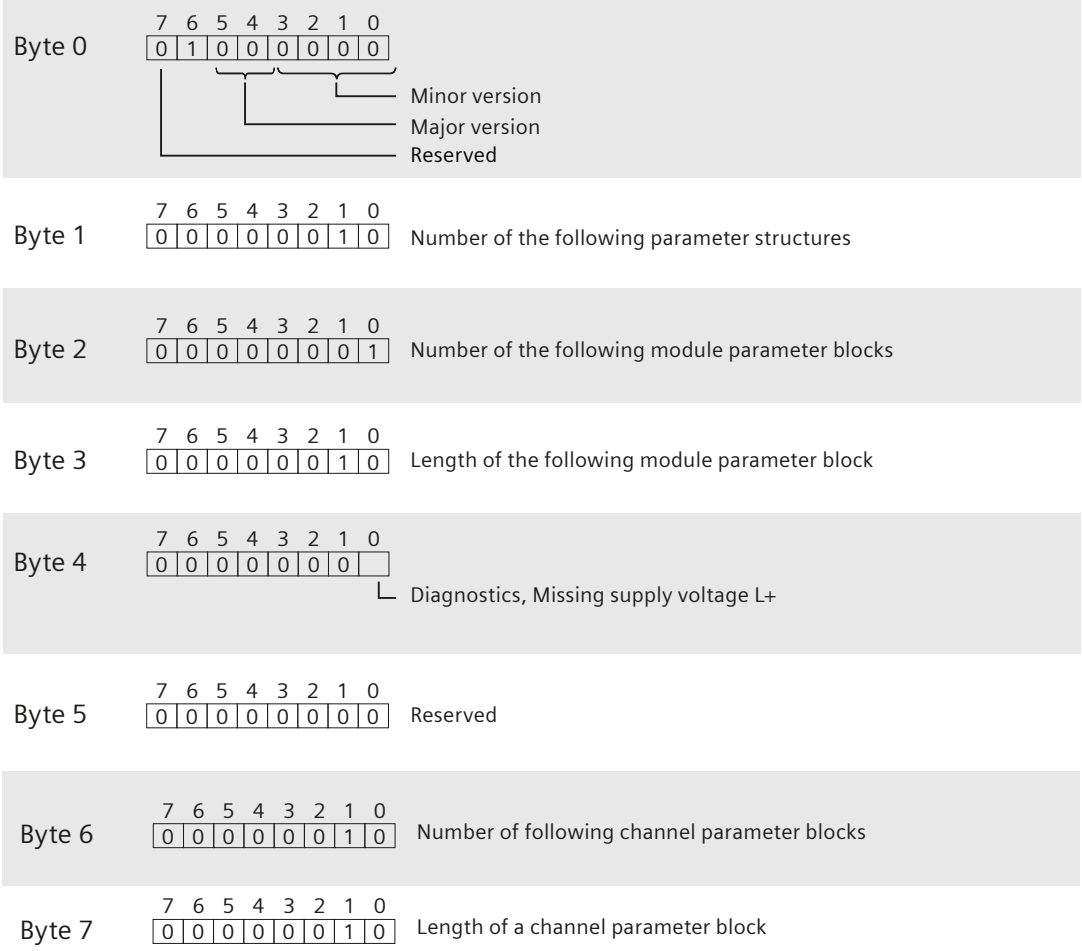

Figure 2-1341 Header information and module parameters of data record 128

Channel parameters

Each channel parameter block contains the channel parameters for the digital output (2 bytes).

The following figure shows the structure of the channel parameters for channels 0 to 1.

x = 8 + (channel number * 2); with channel number 0 to 1

All unused bits and the bits or bytes marked as "reserved" must be set to "0".
You activate a channel parameter by setting the corresponding bit to "1" or the corresponding value.

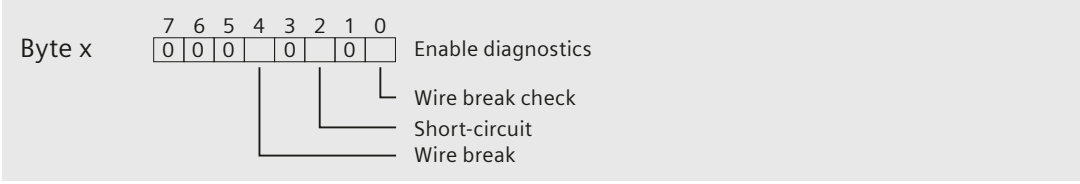

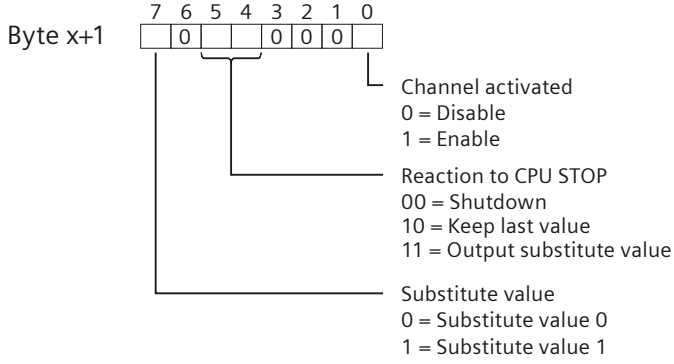

Figure 2-1342 Structure of byte x and x+1 for channels 0 to 1

A.2.3 Diagnostic and maintenance messages

Diagnostic messages

A diagnostic message is generated for each diagnostic event and the DIAG LED flashes red on the module.

The diagnostic messages can be read in the diagnostic buffer of the CPU.

The following applies for assigning diagnostic messages:

- A module message is assigned to all channels.
- A channel-specific message is only assigned to one channel and has no effect on the other channels.
  The diagnostics is displayed through the corresponding channel fault LED.

Table 2-1599 Diagnostic messages, their meaning and possible remedies

Diagnostic message	Error code	Assignment	Meaning	Remedy
Short-circuit	1_H	Channel	Short-circuit of the actuator supply	Correct the process wiring
Wire break	6_H	Channel	Actuator connection has impedance too high	Use another type of actuator or wiring, for example, use conductors with a larger cross-section
			Wire break between the module and actuator	Connect the cable

Diagnostic message	Error code	Assignment	Meaning	Remedy
Wire break	6_H	Channel	Channel not connected (open)	• Disable diagnostics • Wire actuator contacts to a resistor in the load resistance area • Switch off wire break check
Parameter assignment error	10_H	Module	• Incorrect parameter assignment	• Correct the parameter assignment
Supply voltage missing	11_H	Module	Missing or insufficient supply voltage L+	• Check Ex power module • Check the wiring of the supply voltage L+ on the Ex power module
Channel/component temporarily unavailable	$1F_H$	Module	Firmware update is in progress or has been canceled during the update. The module does not output any process or substitute values in this state.	• Restart firmware update • Wait for firmware update
Module is faulty	100_H	Module	Internal module error has occurred	Replace module
Invalid BaseUnit	151_H	Module	The module was plugged into an impermissible BaseUnit.	Replace Ex BaseUnit
Retentive memory in the BaseUnit is defective.	153_H	Module	A memory block error on the BaseUnit was detected during startup.	Replace Ex BaseUnit

Maintenance messages

A maintenance message is generated for each maintenance required and the MT LED lights up yellow on the module.

Maintenance messages do not directly affect the function of the module or the digital outputs.

Table 2-1600 Maintenance messages, their meaning and possible remedies

Maintenance message	Error code	Assignment	Meaning / Cause	Remedy
Retentive memory in the BaseUnit is defective.	153_H	Module	A memory block error on the BaseUnit was detected during operation.	Replace Ex BaseUnit

A.3 Address space

A.3.1 Address space in digital mode

Abbreviations

- "QB" stands for output byte, that is the module start address in the output range
- "DQn" stands for digital output n

Address space

The following table shows the mapping of the address space of the I/O module.

Table 2-1601 Address space of the Ex-DQ 2x23.1VDC/20mA

QB x +	7	6	5	4	3	2	1	0
0	-	-	-	-	-	-	DQ1	DQ0

A.3.2 Address space in digital mode with value status

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input range
- "QB" stands for output byte, that is the module start address in the output range
- "DQn" stands for digital output n
- "QDQn" stands for value status (QI) of digital input n
  You can find additional information in section "Evaluating the value status (Page 38)".

Address space in the configuration digital mode with QI

The following table shows the mapping of the address space of the I/O module.

The MSO with QI option is disabled.

Table 2-1602 Address space of the Ex-DQ 2x23.1VDC/20mA

IB x +	7	6	5	4	3	2	1	0
0	-	-	-	-	-	-	QDQ1	QDQ0

Table 2-1603 Address space of the Ex-DQ 2x23.1VDC/20mA

QB x +	7	6	5	4	3	2	1	0
0	-	-	-	-	-	-	DQ1	DQ0

A.3.3 Address space with MSO

Abbreviations

- "IB" stands for input byte, that is, the module start address in the input area
- "QB" stands for output byte, that is the module start address in the output area
- "DQn" stands for digital output n
- "QDQn" stands for value status (QI) of digital input n
  You can find additional information in section "Evaluating the value status (Page 38)".

Address space in the configuration digital mode with QI (MSO with QI is enabled)

NOTE
Configuration with MSO
During configuration of the I/O module with MSO submodule, each subslot has its own **start address** (IB x + ; QB x +)**.**
The process output signals of subslot 1 are mirrored to the MSO subslots as input signals.

The following tables show the mapping of the address space for the I/O module:

Table 2-1604 Address space of the Ex-DQ 2x23.1VDC/20mA (digital operation with QI / MSO, subslot 1)

IB x +	7	6	5	4	3	2	1	0
0	-	-	-	-	-	-	QDQ1	QDQ0

Table 2-1605 Address space of the Ex-DQ 2x23.1VDC/20mA (digital operation with QI / MSO, subslot 2 to 4)

IB x +	7	6	5	4	3	2	1	0
0	-	-	-	-	-	-	DQ1	DQ0
1	-	-	-	-	-	-	QDQ1	QDQ0

Table 2-1606 Address space of the Ex-DQ 2x23.1VDC/20mA (digital operation with QI / MSO, subslot 1)

QB x +	7	6	5	4	3	2	1	0
0	-	-	-	-	-	-	DQ1	DQ0

A.3.4 Evaluating the value status

Evaluating the value status

There is a bit value status for each digital output in the input address space.

Irrespective of the diagnostics enables, each value status (each QI bit) provides information on the validity of the corresponding process value.

- Value status = 1: Process value okay, "good"
- Value status = 0: Process value not okay, "bad"

Basically, the value status is set to "good" if the digital value can be output without error. The value status is set to "bad" in the following cases:

- The digital value cannot be output due to an error, e.g. due to faulty wiring.
- The digital channel is deactivated.
- The substitute value is output at the digital output.

Notes for configuration using a GSD/GSDML file (Page 15)

SIEMENS

SIMATIC

ET 200SP
Communication module CM DP (6ES7545-5DA00-0AB0)

Equipment Manual

ET 200SP Documentation Guide 1

Product overview 2

Wiring 3

Programming 4

Diagnostics, error and system alarms 5

Technical specifications 6

Dimension drawing A

12/2014

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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that generally relate to the system are described in this system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

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To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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ET 200SP Documentation Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

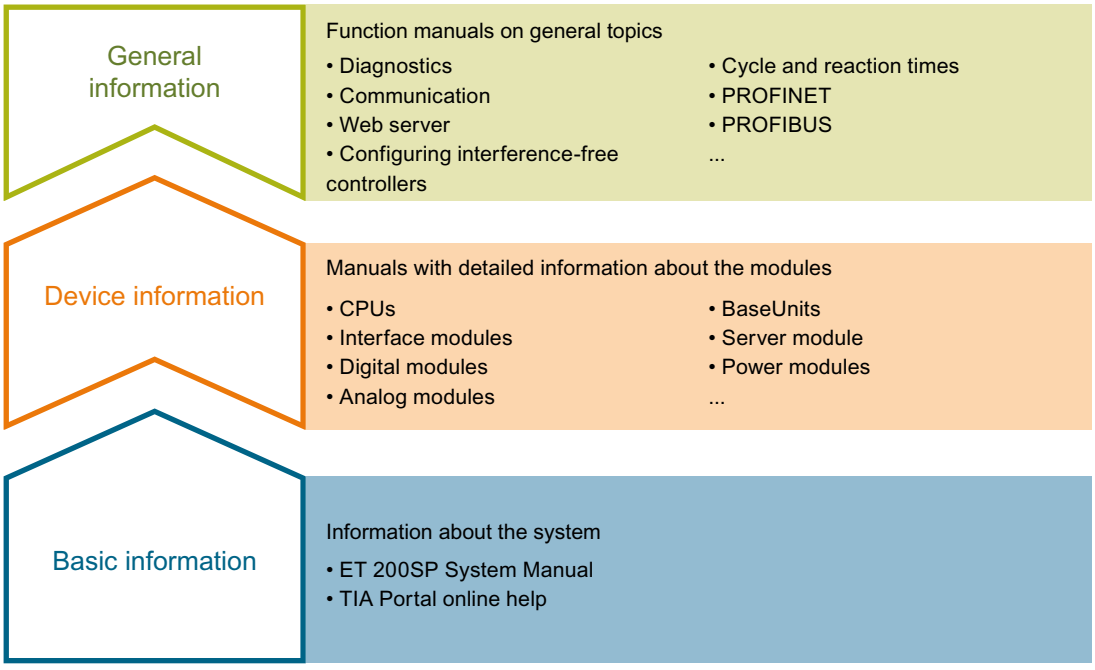

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, designing interference-free controllers.

You can download the documentation free of charge from the Internet (http://w3.siemens.com/mcms/industrial-automation-systems-simatic/en/manual-overview/tech-doc-et200/Pages/Default.aspx).

Changes and supplements to the manuals are documented in a Product Information.

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

My Documentation Manager

The My Documentation Manager is used to combine entire manuals or only parts of these to your own manual.
You can export the manual as PDF file or in a format that can be edited later.

You can find the My Documentation Manager on the Internet (http://support.automation.siemens.com/WW/view/en/38715968).

Applications & Tools

Applications & Tools supports you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find Applications & Tools on the Internet (http://support.automation.siemens.com/WW/view/en/20208582).

CAx Download Manager

The CAx Download Manager is used to access the current product data for your CAx or CAe systems.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find the CAx Download Manager on the Internet (http://support.automation.siemens.com/WW/view/en/42455541).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

Product overview

2

2.1 Properties

Article number

6ES7545-5DA00-0AB0

View of the module

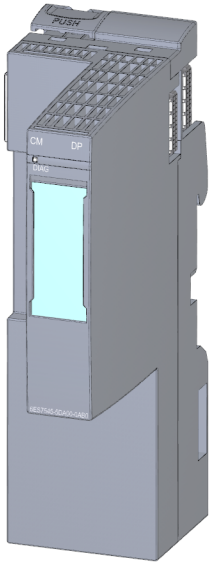

Figure 2-1343 View of the CM DP communication module

Properties

The communication module CM DP can be used with the ET 200SP CPUs. You insert the communication module to the right next to the CPU.

The communication module has the following properties:

- Technical properties
  - Connects the CPU of the ET 200SP distributed I/O system with PROFIBUS DP
  - Bus connection via RS485 interface
- Supported functions
  - Operation as DP master or DP slave
  - Enable/disable DP slave
  - Diagnostics requirements
  - Identify the bus topology in a DP master system
  - Identification data I&M 0
  - Time-of-day synchronization
  - Line diagnostics
  - S7 services

Supported communication services

The communication module supports the following communication services:

- PROFIBUS DP-Master, as of STEP 7 V13, Update 3
  - PROFIBUS DP according to IEC 61158 and 61784 DPV1, DP master for DP slaves according to PROFIBUS DP and DPV1 standard
- PROFIBUS DP slave, as of STEP 7 V13, SP1
  - PROFIBUS DP according to IEC 61158 and 61784 DPV1, DP slave and I-slave

NOTE
DP master or DP slave
Note however: The CM DP only supports alternative operation as DP master or DP slave.

Maximum configuration as DP Master

Table 2-1607 General characteristics of DP mode

Feature	Explanation/values
Number of operable DP slaves	125
Max. size of the input area over all DP slaves	8 KB
Max. size of the output area via all DP slaves	8 KB

Feature	Explanation/values
Maximum number of inputs per DP slave	244 bytes
Maximum number of outputs per DP slave	244 bytes
Max. size of the consistency area for a module	128 bytes

NOTE

Setting the PROFIBUS DP address on the communication module CM DP

The communication module CM DP does not have a DIP switch. You set the PROFIBUS DP address via STEP 7 (TIA Portal). You can find more information on this topic in the STEP 7 online help.

Accessories

A detailed list of the available accessories can be found in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Additional information

You can obtain detailed information on the topic of PROFIBUS in the function manual PROFIBUS (http://support.automation.siemens.com/WW/view/de/59193579/0/en)

2.2 Operating and display elements

Operating and connection elements

The following figure shows the operating and connection elements of the CM DP communication module.

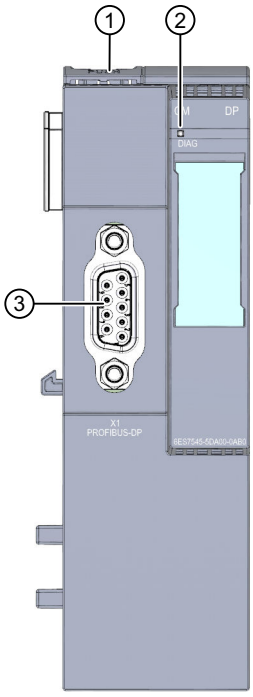

① Mounting rail release

② DIAG LED

③ DP interface

Figure 2-1344 Operating and display elements of the communication module CM DP

Wiring

3

3.1 Pin assignment

PROFIBUS DP with RS485 interface

The following table shows the signal names and the designations of the pin assignment for the PROFIBUS DP interface.

Table 2-1608 Pin assignment PROFIBUS DP with RS485 interface

View		Signal name	Designation
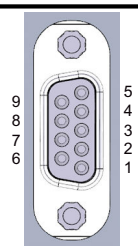	1	-	-
	2	-	-
	3	RxD/TxD-P	Data line B
	4	RTS	Request To Send
	5	M5V2	DP data reference potential (from station)
	6	P5V2	Supply plus (from station)
	7	-	-
	8	RxD/TxD-N	Data line A
	9	-	-

3.2 Block diagram

The following figure shows the block diagram of the CM DP communication module.

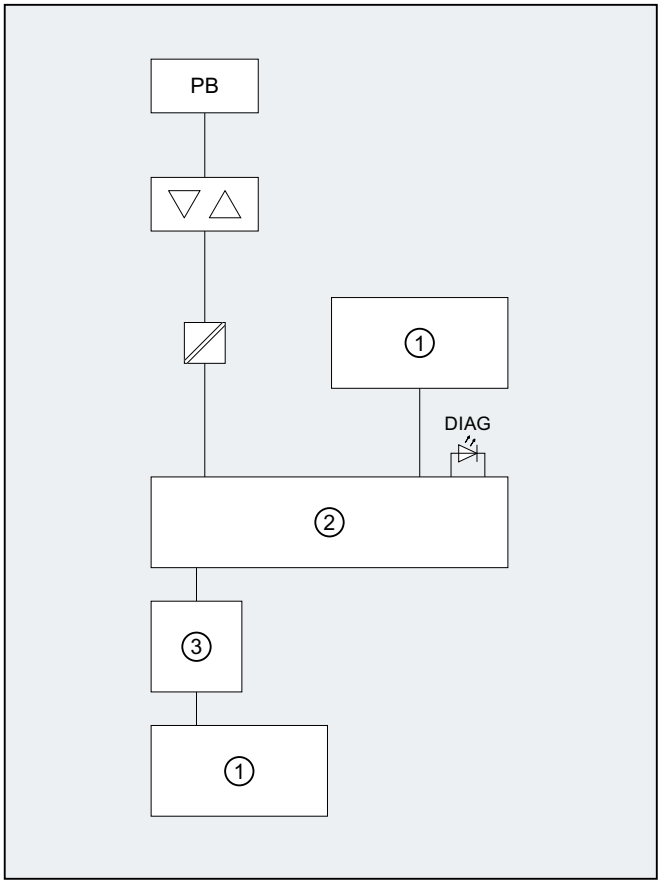

①	Backplane bus	PB	PROFIBUS interface
②	ET 200SP PROFIBUS interface and backplane bus transmission	DIAG	LED diagnostics (green/red)
③	Internal power supply		

Figure 2-1345 Block diagram of the CM DP

Programming

4

Instructions

Pre-written instructions are available as an interface in your STEP 7 user program for communication services.

Table 2-1609 Instructions for PROFIBUS DP

Instructions	Meaning when used with CM DP	
	DP master	**DP slave (I-slave)**
DPSYC_FR	Synchronize DP slaves/Freeze inputs (SYNC/FREEZE instruction)	-
DPNRM_DG	Read diagnostics data of a DP slave	-
DP_TOPOL	Determine topology for DP master system	-
WRREC	Write data record of a DP slave	-
RDREC	Read data record of a DP slave	-
GETIO	Read process image of a DP standard slave	Read process image
SETIO	Transfer process image of a DP standard slave	Transfer process image
GETIO_PART	Read process image area of a DP standard slave	Read process image area
SETIO_PART	Transfer process image area of a DP standard slave	Transfer process image area
D_ACT_DP	Enable/disable DP slaves	-
DPRD_DAT	Read consistent data of a module (user data)	
DPWR_DAT	Write consistent data of a module	
RALRM	Event-driven reading of alarm information (diagnostics, pull/plug, hardware interrupt) as well as DPV1-specific interrupts (update, status, vendor-specific interrupt)	Event-driven reading of interrupt information (diagnostic interrupt)

Read the documentation for the instructions in the STEP 7 online help

Calling instructions for distributed I/O

Multiple calls are required for the instructions of the distributed I/O.

The duration of the call processing is dependent on the load, bus cycle time and transmission rate. Timeouts may occur if these instructions are called in a loop within a cycle.

Exceptions:

- Only one call is necessary for the RALRM instruction "Receive interrupt".

Program blocks for DPV1 (according to PNO standard) [1]:

- "Read data record from a DP slave" RDREC instruction is functionally equivalent to SFC59 (write record)
- "Write data record to a DP slave" WRREC instruction is functionally equivalent to SFC58 (read record)
- "Read interrupt information from a DP slave" RALRM instruction call is made within an interrupt OB

[1] PNO: PROFIBUS user organization

Diagnostics, error and system alarms 5

5.1 Status and error displays

Introduction

Diagnostics by means of LEDs is an initial tool for error localization. In order to localize errors still further, you usually evaluate the display of the module status in STEP 7 or the diagnostics buffer of the CPU. The buffer contains plain text information on the error that has occurred. For example, you will find the number of the relevant error OB in the plain text information.

LED display

The figure below shows the LED display on the CM DP communication module.

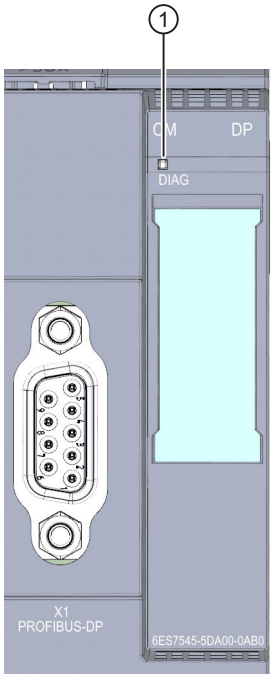

① DIAG (green/red)

Figure 2-1346 LED display on the CM DP communication module

Meaning of the DIAG LED display on the communication module

The CM DP communication module has an LED for monitoring the diagnostics.

DIAG LED

Table 2-1610 DIAG LED fault display

DIAG LED	Meaning
Flashes	Module parameters not assigned
On	Module parameters assigned and no diagnostics
Flashes	Diagnostics of subordinate modules (as of firmware version V1.7)

Additional information

You can find more information on diagnostics in the Diagnostics function manual (http://support.automation.siemens.com/WW/view/de/59192926/0/en) for diagnostic options that are available for SIMATIC systems S7-1500, ET 200MP, ET 200SP and ET 200AL.

5.2 DP slave diagnostics

DP V1 slave: Diagnostic interrupt

Transmission of diagnostic data is made as a diagnostic interrupt. Diagnostic interrupts must be acknowledged by the DP master.

Supported diagnostic functions

The CM DP supports the following blocks of the DP diagnostics:

- Standard diagnostics (6 bytes)
- Identifier-related diagnostics (2...17 bytes depending on the number of configured transfer areas)
- Module status (5...35 bytes depending on the number of configured transfer areas)
- Diagnostic interrupt (8 bytes, if any)

User program (DP master)

The "DPNRM_DG" instruction is used to read the diagnostic data of a DP slave (DP single diagnostics) in the DP master.

The diagnostic interrupts for DP V1 slaves are periodically evaluated in the user program of the master via the "RALRM" instruction.

You can find the required parameter assignment for the instruction in the STEP 7 online help.

The following is a structural overview of the diagnostic data.

Overview of standard diagnostics

Standard diagnostics	
Byte	**Meaning**
0	Station status 1
1	Station status 2
2	Station status 3
3	Master address
4...5	Manufacturer ID of the slave

Overview of device-specific diagnostics

The device-specific diagnostics data depends on the protocol variant in which the DP slave is operated:

- **DP-V1 slave**

Table 2-1611 Overview of device-specific diagnostics of the CM DP for DP V1 slaves

Device-specific diagnostics		
Byte	**Meaning**	
0	Header	
1	Variant Interrupt type	Variant Status type
2	Slot number	
3	Variant Interrupt specifier	Variant Status specifier
4...62	Module-specific diagnostic data	

5.3 Standard diagnostics

Standard diagnostics

The coding of the standard diagnostic bytes is explained below.

Byte 0: Station status 1

Table 2-1612 Structure of station status byte 1

Bit no.	Name	Explanation
7	Master_Lock	The DP slave was configured by a different DP master. The DP slave can only be accessed read-only by the DP master configured as productive. This bit is set by the DP master when its bus address does not match the configured address.
6	Parameter_Fault	The most recently received parameter frame was corrupt or not permitted. This bit is set by the DP slave. Remedy: Check the parameter assignment with respect to invalid parameters.
5	Invalid_Slave_Response	This bit is set by the DP master if an implausible response has been received by the DP slave.
4	Service_Not_Supported	This bit is set by the DP master if a function is called by the master that is not supported by the DP slave. Remedy: Disable the parameter assignment of the required function at the master.
3	Ext_Diag	This bit is set by the slave. • Bit =1: Diagnostic data is available in the diagnostic area specific to the slave. The diagnostic data can be evaluated in the user program of the master. • Bit =0: A status message can be available in the diagnostic area specific to the slave. The status message can be evaluated in the user program of the master.
2	Slave_Config_Check_Fault	The configuration data sent by the DP master is rejected by the DP slave. Cause: Configuration error. Remedy: Change the configuration.
1	Station_Not_Ready	The DP slave is not yet ready for productive data exchange. This is a temporary condition and cannot be influenced by the DP master.
0	Station_Non_Existent	The DP slave is not responding on the bus. This bit is set by the DP master 1 (the slave permanently sets this bit to 0). If the bit is set, the diagnostic bits contain the status of the last diagnostic alarm or the initial value.

Byte 1: Station status 2

Table 2-1613 Structure of station status byte 2

Bit no.	Name	Explanation
7	Deactivated	The DP slave was shown as inactive in the local parameter set and will not be cyclically queried.
6	Reserved	- Reserved -
5	Sync_Mode	The DP slave is in SYNC mode. The bit is set by the slave.
4	Freeze_Mode	The DP slave is in FREEZE mode. The bit is set by the slave.
3	Watchdog_On	The watchdog is activated on the DP slave. The bit is set by the slave.

Bit no.	Name	Explanation
2	Status_From_Slave	Bit =1: The diagnostics comes from the DP slave. The bit is permanently set by the slave to 1.
1	Static_Diag	Static diagnostics If the DP slave sets this bit, the DP master must fetch the diagnostic data from the DP slave until the DP slave resets this bit. The DP slave sets this bit, for example, if it cannot perform data transfer.
0	Parameter_Request	The DP slave sets this bit when it has to be re-parameterized and configured. If bit 0 and bit 1 are both set, bit 0 has the higher priority.

Byte 2: Station status 3

Table 2-1614 Structure of station status byte 3

Bit no.	Name	Explanation
7	Ext_Data_Overflow	If this bit is set, there is more diagnostic information than is specified in the diagnostics data. This data cannot be viewed.
6...0	Reserved	- Reserved -

Byte 3: Master address

The address of the DP master that has configured this DP slave is entered in the "Master_Add" byte.

If the DP slave was not configured by a DP master, the DP slave sets address 255 in this byte.

Bytes 4 and 5: Manufacturer ID of the slave ("Ident_Number")

The manufacturer ID ("Ident_Number") for the DP slave type is entered in the bytes 4 and 5. This identifier can be used to identify the slave.

The most significant part of the value is in byte 5.

5.4 Device-specific diagnostics with DP-V1

Device-specific diagnostics

The device-specific diagnostics of DP V1 slaves is available in two variants:

- Interrupt type
- Status type

The two variants differ in the coding of byte 1, bit 7 of the device-specific diagnostic data. The distinction is component-specific.

Byte 0: Header

The two most significant bits have the value 00. This identifies the "Module-specific diagnostic data" block as a whole (see bytes 4...62).

The remaining six bits indicate the length of the data block including byte 0.

Byte 1: "Interrupt type" variant

Table 2-1615 Structure of byte 1 of the device-specific diagnostics ("Interrupt type" variant)

Bit no.	Meaning	
7	Value	Meaning
	0	**Interrupt**
6...0	**Alarm_Type**	
	0	- Reserved -
	1	Diagnostic interrupt
	2	Process interrupt
	3	Pull interrupt
	4	Plug interrupt
	5	Status interrupt
	6	Update interrupt
	7...31	- Reserved -
	32...126	Manufacturer-specific
	127	- Reserved -

Older status interrupts can be overwritten by newer ones when status interrupts occur in rapid succession.

Byte 1: "Status type" variant

Table 2-1616 Structure of byte 1 of the device-specific diagnostics ("Status type" variant)

Bit no.	Meaning	
7	Value	Meaning
	1	**Status message**
6...0	**Status_Type**	
	0	- Reserved -
	1	Status message
	2	Module_Status (see also bytes 4...62)
	3...31	- Reserved -
	32...126	Vendor-specific
	127	- Reserved -

Byte 2: Slot number

Slot number (1...n) of the slave module

0 is the placeholder for the overall device.

Byte 3: "Interrupt specifier" variant

Table 2-1617 Structure of byte 3 of the device-specific diagnostics ("Interrupt specifier" variant)

Bit no.	Meaning	
7...3	Seq_No	Unique identification of an alarm message
2	Add_Ack	If this bit is set, the DP V1 master indicates that this interrupt expects an acknowledgment in the form of a WRITE job.
1...0	Alarm_Specifier	
	0	No further distinction
	1	Interrupt appears, slot is disrupted The slot generates an interrupt due to an error.
	2	Interrupt disappears, slot is OK The slot generates an interrupt and indicates that there is no other error.
	3	Interrupt disappears, slot is still disrupted The slot generates an interrupt and indicates that errors remain.

Byte 3: "Status specifier" variant

Table 2-1618 Structure of byte 3 of the device-specific diagnostics ("Status specifier" variant)

Bit no.	Meaning	
7...2	- Reserved -	
1...0	Status_Specifier	
	0	No further distinction
	1	Status appears
	2	Status disappears
	3	- Reserved -

Bytes 4...62: Module-specific diagnostic data: General coding

This byte contains data with module-specific information that is described in the respective module documentation. The particular module is identified by the slot (byte 2).

Bytes 4...62: Module-specific diagnostics for "Status type" and "Modul_Status"

In the case of the "Status type" variant of device-specific diagnostics from DP V1 slaves (see byte 1, bit 7) and the "Module_Status" setting (see byte 1, bits 0...6) two status bits are provided here for each slot (= module). Unneeded bits are set to 0.

Table 2-1619 Structure of the bytes for the module-specific diagnostic data

Byte	Bit assignment							
Bit	7	6	5	4	3	2	1	0
4	Module status 4		Module status 3		Module status 2		Module status 1	
5	Module status 8		Module status 7		Module status 6		Module status 5	
...	...		...		...		...	
62	Module status 236		Module status 235		Module status 234		Module status 233	

The respective status bits are coded as follows:

Table 2-1620 Meaning of the values of the status bits

Value	Meaning
00	Data valid
01	Data invalid - error (e.g. short-circuit)
10	Data invalid - wrong module
11	Data invalid - no module plugged

Technical specifications

6

6.1 Technical specifications

Technical specifications of the CM DP (6ES7545-5DA00-0AB0) communication module

	6ES7545-5DA00-0AB0
Product type designation	ET 200SP, CM DP
General information	
Hardware version	FS01
HW functional status	FS01
Engineering with	
STEP 7 TIA Portal can be configured/integrated as of version	V13 Update 3
Installation type/mounting	
Rack mounting possible	No
Rail mounting possible	Yes; standard DIN rail
Supply voltage	
Type of supply voltage	24 VDC
Rated value (DC)	24 V
Valid range low limit (DC)	19.2 V
Valid range high limit (DC)	28.8 V
Reverse polarity protection	Yes
Interfaces	
Number of interfaces PROFIBUS	1
1. interface	
Interface hardware	
RS 485	Yes
Protocols	
SIMATIC communication	Yes
PROFIBUS DP master	Yes
PROFIBUS DP slave	Yes
Interface hardware	
RS 485	
Transmission rate, max.	12 Mbps
Max. cable length	100 m
Protocols	
PROFIBUS DP master	
Services	
PG/OP communication	Yes

	6ES7545-5DA00-0AB0
S7 routing	Yes
Data record routing	Yes
Isochronous mode	No
Constant bus cycle time	No
Number of DP slaves	125
Activation/deactivation of DP slaves	Yes
PROFIBUS DP slave	
Transmission rate, max.	12 Mbps
Automatic baud rate search	Yes
Address area, max.	120
User data per address area, max.	128 bytes
Services	
PG/OP communication	Yes, only with active interface
Routing	Yes, only with active interface
S7 communication	Yes, only with active interface
Direct data exchange (data exchange broadcast)	Yes, no subscriber possible - only passive publisher
DPV1	Yes
Transfer memory	
Inputs	244 bytes
Outputs	244 bytes
Interrupts/diagnostics/status information	
Diagnostic alarms	
Diagnostics	Yes
Diagnostic indicator LED	
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Between backplane bus and interface	Yes
Ambient conditions	
Ambient temperature in operation	
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Dimensions	
Width	35 mm
Height	117 mm
Depth	75 mm
Weights	
Weight, approx.	80 g

Dimension drawing

A

A.1 Dimension drawing of the CM DP communication module

This section contains a dimension drawing of the module mounted on a mounting rail. Observe the dimensions when installing in cabinets, control rooms, etc.

Dimension drawing of the CM DP communication module

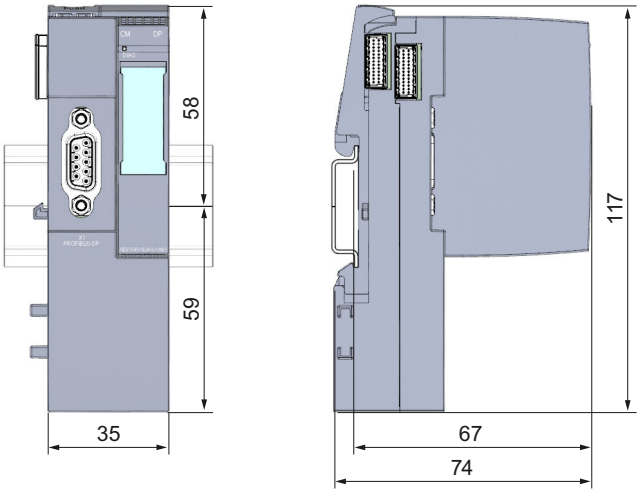

Figure 2-1347 Dimension drawing CM DP

SIEMENS

SIMATIC

ET 200SP
CM PtP communications module (6ES7137-6AA01-0BA0)

Equipment Manual

Documentation guide 1

Product overview 2

Connecting 3

Parameters/address space 4

Programming 5

Interrupts/diagnostics alarms 6

Technical specifications 7

03/2021
A5E03790792-AB

Preface

Purpose of the documentation

This documentation provides important information on installing, wiring and commissioning the ET 200SP point-to-point communications module.

This device manual complements the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293). General functions of the ET 200SP are described in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Conventions

This documentation contains figures of the described device. The figures may differ slightly from the devices supplied.

Please also observe notes marked as follows:

NOTE

A note contain important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Document history

The following table shows the most important changes to the documentation compared to the previous edition.

Manual edition	Comments
03/2021	The following sections have been revised: • Product overview (Page 10) • Connecting (Page 16) • Parameters/address space (Page 22) • Programming (Page 30) • Interrupts/diagnostics alarms (Page 32) • Technical specifications (Page 36)
01/2013	First edition

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You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com) and in the Information and Download Center (https://www.siemens.com/automation/infocenter).

Security information

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

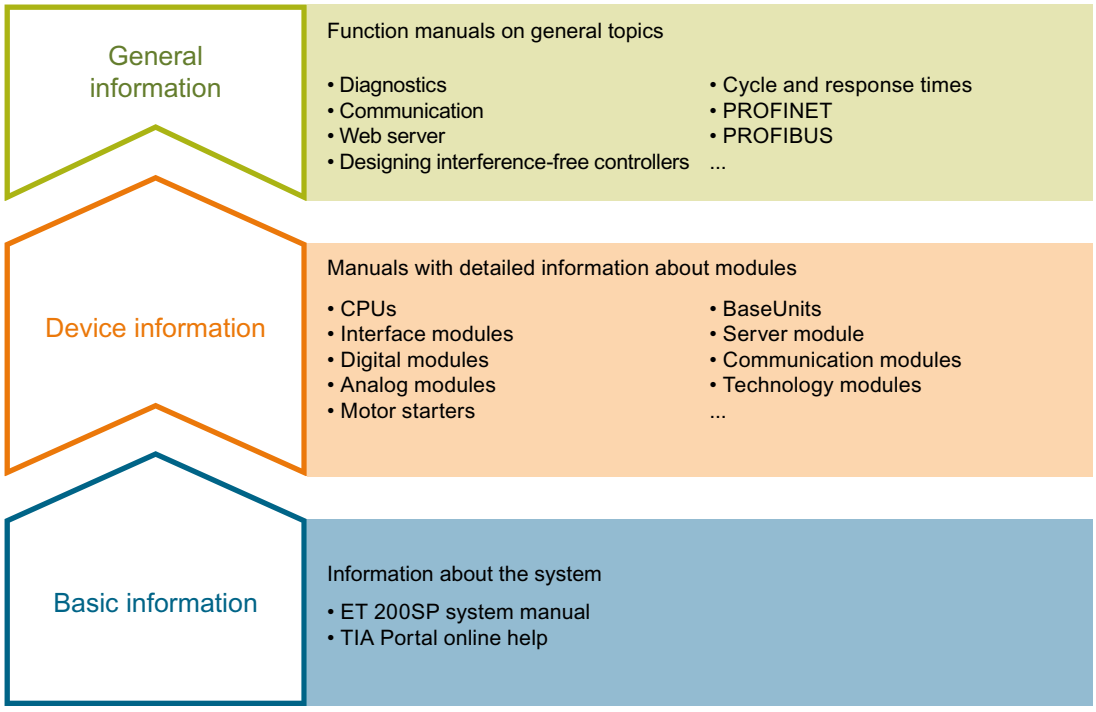

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/84133942).

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With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

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In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview 2

2.1 Properties

Article number

6ES7137-6AA01-0BA0 (packing unit: pack of 1)

6ES7137-6AA01-2BA0 (packing unit: pack of 10)

The CM PtP communications module with article number 6ES7137-6AA01-0BA0 and firmware version V2.0 replaces the CM PtP with article number 6ES7137-6AA00-0BA0.

Firmware version

This manual describes the properties of firmware version V2.0 of the module.

View of the module

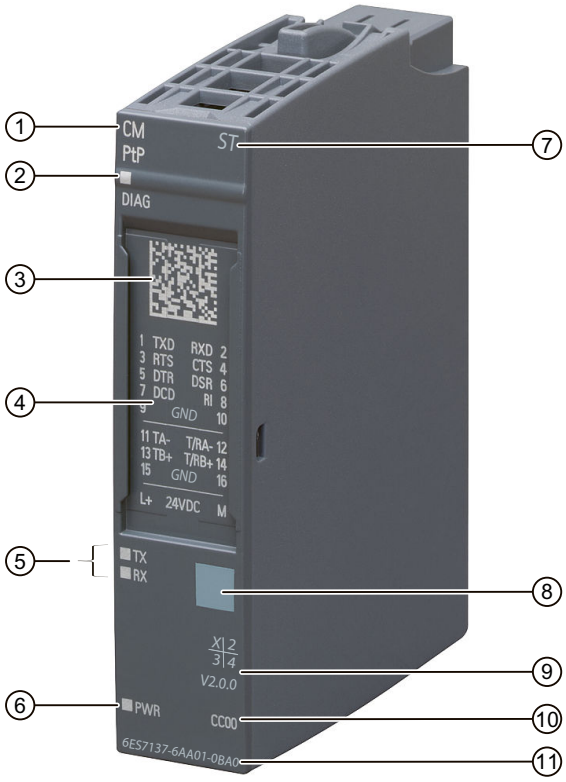

①	Module type and designation	⑦	Function class
②	LED for diagnostics	⑧	Module type color coding
③	2D matrix code	⑨	Function and firmware version
④	Terminal diagram	⑩	Color code for selection of the color-coded labels and BaseUnit type
⑤	LED for status indicators	⑪	Article number
⑥	LED for supply voltage		

Figure 2-1348 View of the CM PtP module as an example

Properties

The communications module has the following properties:

- Technical properties
  - RS232 interface (via BaseUnit)
  - RS422/485 interface (via BaseUnit)
  - short-circuit proof
  - electrically disconnected
  - Protocols: 3964(R), Modbus master (RTU), Modbus slave (RTU), Freeport and USS with instructions

The module supports the following functions:

Table 2-1621 Version dependencies of the functions

Function	Firmware version of the module	Configurable as of		
		STEP 7 (TIA Portal)	GSD	
			PROFINET IO	PROFIBUS DP
Firmware update	V1.0 or higher	V12	X	—
Identification data I&M0	V1.0 or higher	V12	X	X
Parameter reassignment in RUN (using instructions)	V1.0 or higher	V12	X	X
Diagnostics interrupts	V1.0 or higher	V12	X	X
Data transmission rate up to 250 kbit/s[1] with RS485; DMX512 protocol	V1.0.5 or higher	V17	X	X
Option for performance optimization	V2.0 or higher	V17	X	X

[1] 250 kbit/s with firmware versions <V2.0 can only be configured with instructions or data records

Firmware versions V1.0 to V1.0.5 are available for the article number 6ES7137-6AA00-0BA0. Firmware version V2.0 is available for the article number 6ES7137-6AA01-0BA0.

Accessories

A **BaseUnit** of **type A0** is needed for operation of the communications module. You will find an overview of the BaseUnits you can use with the communications module in Product information on the documentation of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/73021864).

You can find additional information on the accessories in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Additional information

Additional information on the properties of the CM PtP can be found in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093).

You can find additional information on the design of the ET 200SP and the associated modules in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

Additional information on using the CM PtP without the prepared instruction libraries is available in the programming and operating manual CM PtP operation with PROFINET controller (http://support.automation.siemens.com/WW/view/en/59062563).

2.2 Functions

Introduction

The communications module allows you to exchange data between your own and other programmable controllers or computers by means of a point-to-point connection, and to connect various devices from a variety of manufacturers.

Functionality of the CM PtP

The CM PtP communications module offers the following functionality:

- RS232 and RS422/485 interface
- Data transmission rate: 300 to 250000 bit/s
- Maximum frame length:
  - Without performance optimization: 2 kbyte
  - With performance optimization: 24 bytes for receiving, 30 bytes for sending
- Transmission protocols: Freeport, 3964(R) and Modbus RTU

NOTE

The USS protocol can be implemented with instructions included in STEP 7 (TIA Portal).

Hardware components of a point-to-point connection

You require certain hardware components for a point-to-point connection with the CM PtP.

Components	Function
Automation system	... contains the CPU and PROFINET interface, and the central I/O, if applicable, and executes the user program.
ET 200SP Distributed I/O System	... contains the distributed I/O.
Interface module (IM)	... connects the ET 200SP distributed I/O system with PROFINET IO or any other fieldbus system and supports all ET 200SP I/O modules.
CM PtP communications module	... communicates via the interface with one or more communication partners (point-to-point or multipoint connection).
BaseUnit (6ES7193-6BPx0-0xA0)	... connects the communications module with the I/O system and the supply voltage.
Server module	... completes the setup of the ET 200SP.

Additional information

Information on configuration and programming of the CM PtP communications module is available in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) and in the information system of STEP 7 (TIA Portal).

2.3 Properties of the interfaces

Interfaces of the CM PtP

The CM PtP has the following interfaces, which are connected (Page 16) by means of the associated BaseUnit:

- RS232 interface
- RS422/485 interface

2.3.1 Properties of the RS232 interface

Definition

The RS232 interface is a voltage interface used for serial data transmission.

Properties

The RS232 interface has the following properties and meets the following requirements:

Type	Voltage interface
BaseUnit terminals	Terminals connected to the electronics module (see RS232 interface of the communications module (Page 16) for assignment)
RS232 signals	TXD, RXD, RTS, CTS, DTR, DSR, RI, DCD, GND; all signals isolated against the backplane bus and load voltage
Max. data transmission rate	115.2 kbps
max. cable length	15 m, cable type LIYCY 9 x 0.14
Standard	DIN 66020, DIN 66259, EIA-RS 232C, CCITT V.24/V.28

RS232 signals

The table below shows the meaning of the individual RS232 accompanying signals.

Table 2-1622 Signals of the RS232 interface

Signal	Designation	Meaning
TXD	Transmit Data	Transmit data; transmit cable logically held to "1" by communications module in idle state.
RXD	Receive Data	Receive data; receive cable logically held to "1" by communication partner in idle state.
RTS	Request To Send	Request to send RTS set to "ON": communications module ready to send; signals to the communication partner that there is data ready to send RTS set to "OFF": communications module does not send
CTS	Clear To Send	Clear to send CTS set to "ON": Signals "clear to send" to the communication partner CTS set to "OFF": Signals "Not clear to send" to the communication partner

Signal	Designation	Meaning
DTR	Data Terminal Ready	DTR set to "ON": Communications module switched on, ready for operation DTR set to "OFF": Communications module not switched on, not ready for operation
DSR	Data Set Ready	DSR set to "ON": Communication partner signals "ready for operation" DSR set to "OFF": Communication partner not switched on, not ready for operation
RI	Ring Indicator	Incoming call when connecting a modem
DCD	Data Carrier Detect	Carrier signal when connecting a modem. The communication partner signals with a high level that it detects incoming data on the cable.

2.3.2 Properties of the RS422/485 interface

Definition

The RS422/485 (X27) interface is a differential voltage interface for serial data transmission.

Properties

The RS422/485 (X27) interface has the following properties and meets the following requirements:

Type	Differential voltage interface
BaseUnit terminals	Terminals connected to the electronics module (see RS422/485 interface of the communications module (Page 19) for assignment)
RS422 signals	T (A), R (A), T (B), R (B), GND; all signals are isolated against the backplane bus and the load voltage
RS485 signals	R/T (A), R/T (B), GND; all signals isolated against backplane bus and load voltage
Max. data transmission rate	250 kbps
Max. cable length	1200 m for 0.3...19.2 kbps, 500 m for 38.4 kbps, 350 m for 76.8 kbps, 250 m for 115.2 kbps, 200 m for 250 kbps; cable type LIYCY 3 x 2 x 0.14. T(A)/T(B) and R(A)/R(B) twisted in pairs To ensure interference-free operation for cable lengths > 50 m, you must install a terminating resistor of approx. 330 Ω at the receiver end.
Standard	DIN 66259 Parts 1 and 3, EIA-RS422/485, CCITT V.11

Connecting 3

3.1 Introduction

The CM PtP communications module is used with a BaseUnit of type A0 (article number 6ES7193-6BPx0-0xA0).

You connect the input and output signals to the BaseUnit of the communications module. The supply voltage feed on the light-colored BaseUnit BU...D of the associated potential group supplies the module.

BaseUnit

The BaseUnit is not included in the scope of delivery of the module and must be ordered separately.

You will find an overview of the BaseUnits you can use with the communications module in Product information on the documentation of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/73021864).

You can find information about selecting a suitable BaseUnit in the ET 200SP Distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual and ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual.

You can find information on wiring the BaseUnit, connecting cable shields, etc. in the Wiring section of the ET 200SP Distributed I/O system (http://support.automation.siemens.com/WW/view/en/73021864) system manual.

Supply voltage L+/M

With a light-colored BaseUnit, you connect the supply voltage to the L+ and M terminals. With a dark BaseUnit, the supply voltage of the left-hand module is used. An internal protective circuit protects the communications module from polarity reversal of the supply voltage. The communications module monitors the connection of the supply voltage.

3.2 RS232 interface of the communications module

RS232 interface

The RS232 interface is a voltage interface used for serial data transmission.

The inputs and outputs are not isolated from each other. The inputs and outputs are electrically isolated from the backplane bus.

Terminal assignment of the BaseUnit

Table 2-1623 RS232 connection

Terminal assignment of the BaseUnit of the communications module	Pin	Designation	Input/output	Meaning
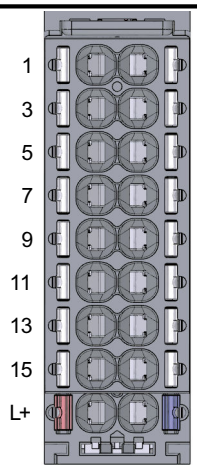	1	TXD Transmit Data	Output	Transmit data
	2	RXD Receive Data	Input	Receive data
	3	RTS Request To Send	Output	Request to send
	4	CTS Clear To Send	Input	Clear to send
	5	DTR Data Terminal Ready	Output	Data terminal ready
	6	DSR Data Set Ready	Input	Data set ready
	7	DCD Data Carrier Detect	Input	Received signal level
	8	RI Ring Indicator	Input	Incoming call
	9	GND Ground	---	Shared ground reference (ground)
	10			
Front view				

Block diagram

You must ground the shields of the cables between communication partner and communications module both through the shield contact on the BaseUnit (shield bracket and terminal) and on the communication partner.

The figure below shows the block diagram of the communications module for operation at the RS232 connection.

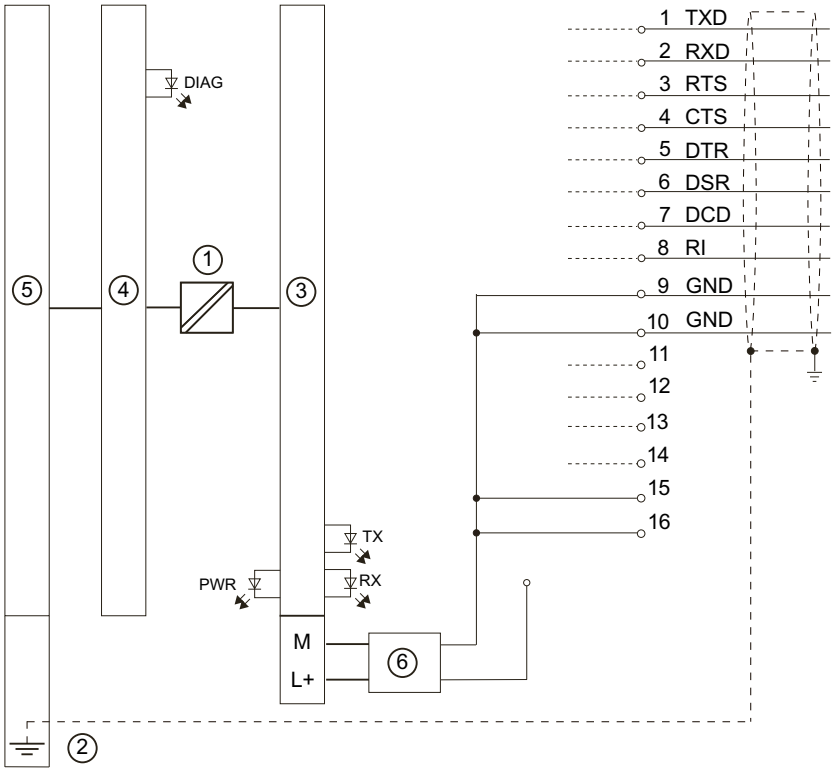

① Electrical isolation
② Shield terminal on the BaseUnit
③ Technology
④ Backplane bus interface module of the CM
⑤ Backplane bus
⑥ Input filter

Figure 2-1349 Block diagram for RS232 operation

⚠ CAUTION

Never connect cable shield with GND

Never connect the cable shield with the GND, as this could destroy the interfaces. GND must always be connected with the communications module *and* communication partner; otherwise the submodules could again be destroyed.

NOTE

Ensure the power supply is disconnected before you wire the communications module.

Additional information

Information on connecting the modules can be found in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.3 RS422/485 interface of the communications module

RS422/485 interface

The RS422/485 (X27) interface is a differential voltage interface for serial data transmission.

The inputs and outputs are not isolated from each other. The inputs and outputs are electrically isolated from the backplane bus.

Terminal assignment of the BaseUnit

Table 2-1624 RS422/485 connection

Terminal assignment of the BaseUnit of the communications module	Pin	Designation	Input/output	Meaning
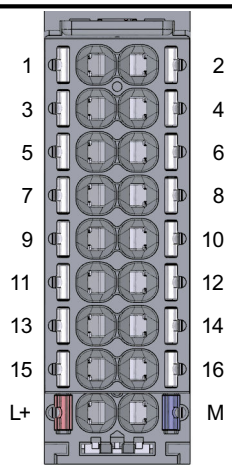	11	T (A)-	Output	Send data (four-wire mode)
	12	R (A)- T(A)/R(A)	Input Input/output	Receive data (four-wire mode) Receive/send data (two-wire mode)
	13	T (B)+	Output	Send data (four-wire mode)
	14	R (B)+ T(B)/R(B)	Input Input/output	Receive data (four-wire mode) Receive/send data (two-wire mode)
	15	GND Ground	---	Shared ground reference (ground)
	16			
Front view				

Block diagram

You must ground the shields of the cables between communication partner and communications module both through the shield contact on the BaseUnit (shield bracket and terminal) and on the communication partner.

The figure below shows the block diagram of the communications module for operation at the RS422/485 connection.

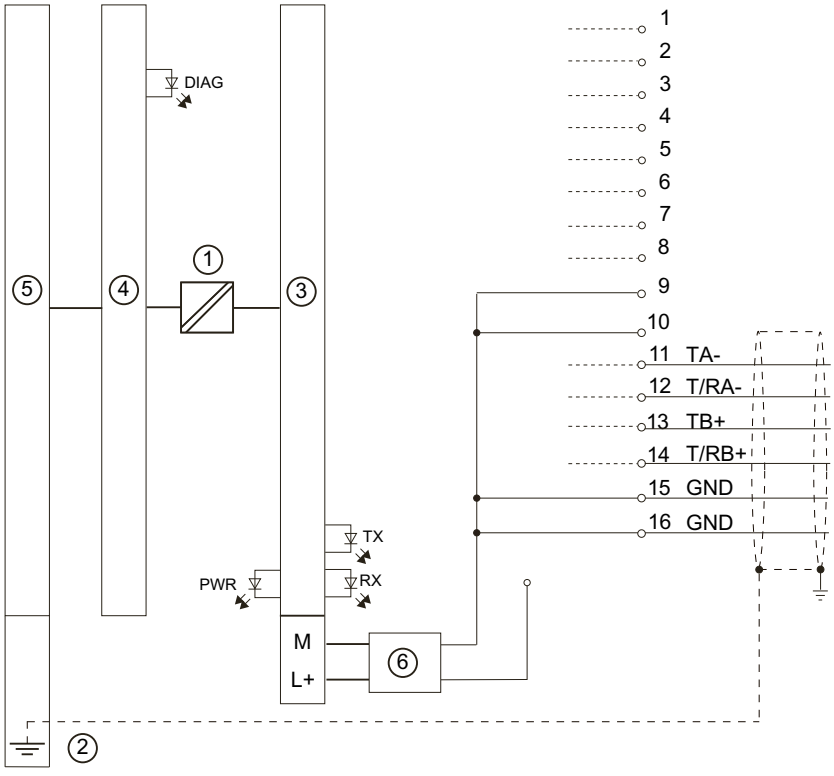

① Electrical isolation
② Shield terminal on the BaseUnit
③ Technology
④ Backplane bus interface module of the CM
⑤ Backplane bus
⑥ Input filter

Figure 2-1350 Block diagram for RS422/485 operation

CAUTION

Never connect cable shield with GND

Never connect the cable shield with the GND, as this could destroy the interfaces. GND must always be connected with the communications module *and* communication partner; otherwise the submodules could again be destroyed.

NOTE

Ensure the power supply is disconnected before you wire the communications module.

NOTE

To ensure interference-free operation for cable lengths > 50 m, you must install a terminating resistor of approx. 330 Ω at the receiver end.

Additional information

Information on connecting the modules can be found in the FAQ with the entry ID 109736665 (https://support.industry.siemens.com/cs/ww/en/view/109736665) and in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

3.4 Installation guidelines

To take into consideration

The general installation guidelines must be taken into consideration (see the EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566) Function Manual).

To comply with the required EMC values (electromagnetic compatibility), the cable shields must be connected to the shield terminal.

Parameters/address space

4

4.1 Configuring

Introduction

You configure and assign the parameters of the communications module with STEP 7 (TIA Portal).

System environment

The communications module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Centralized operation with a CPU 151xSP	• ET 200SP automation system • CM PtP	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Instruction libraries PtP Communication, USS Communication and MODBUS (RTU) (Page 30)
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200SP distributed I/O system • CM PtP	STEP 7 (TIA Portal): Device configuration and parameter setting with -configuration	
Distributed operation with an S7-300/400 CPU	• S7-300/400 automation system • ET 200SP distributed I/O system • CM PtP	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	
		STEP 7: Device configuration and parameter setting with GSD file	Instruction libraries PtP Communication, USS Communication and MODBUS (RTU) with the entry ID 75226762 (https://support.industry.siemens.com/cs/ww/en/view/75226762) in the Siemens Industry Online Support
Distributed operation in a third-party system[1]	• Third-party automation system • ET 200SP distributed I/O system • CM PtP	Third-party configuration software: Device configuration and parameter setting with GSD file	Instructions for control and parameter assignment according to the programming manual[1]

[1] Information on using the communications module in a third-party system is available in the programming and operating manual CM PtP operation with PROFINET controller (http://support.automation.siemens.com/WW/view/en/59062563).

Additional information

A detailed description of the point-to-point connections and their configuration is available:

- In the Function Manual CM PtP - Configurations for point-to-point connections as download on the Internet (http://support.automation.siemens.com/WW/view/en/59057093)
- In the STEP 7 (TIA Portal) information system under "Edit devices and networks > Configuring devices and networks > Create configurations > Configurations for point-to-point connections (S7-1500)"
- In the FAQ with the entry ID 109477693 (https://support.industry.siemens.com/cs/ww/en/view/109477693) in the Siemens Industry Online Support

GSD file

The respective GSD file for the ET 200SP distributed I/O system is available for download on the Internet:

- GSD file PROFINET IO (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD file PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/73016883)

4.2 Reaction to CPU STOP

Ongoing transmissions are aborted when the higher-level control (CPU) goes to STOP.

Frames will continue to be received and are retained in the receive buffer. Information about this is forwarded to the CPU only after a STOP-RUN transition, provided you have configured in the properties of the communications module that the receive buffer is not cleared.

4.3 Parameter setting

You can use various parameters to define the properties of the communications module. Depending on the settings, not all parameters are available.

You set the parameters of the module as follows:

Parameter setting via ...	Basic procedure
Hardware configuration in STEP 7 (TIA Portal)	1. Insert the module from the hardware catalog under "Communications modules". 2. Set the parameters of the module in the hardware configuration. 3. Download the project to the CPU.
Hardware configuration using GSD file for distributed operation on the PROFINET IO	1. Install the latest PROFINET GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFINET IO > I/O". 2. Set the parameters in the hardware configuration. 3. Download the project to the CPU.

Parameter setting via ...	Basic procedure
Hardware configuration using GSD file for distributed operation on the PROFIBUS DP	1. Install the latest PROFIBUS GSD file. You will then find the module in the hardware catalog under "Other field devices > PROFIBUS DP > I/O". 2. Set the parameters in the hardware configuration. Only the parameters marked with [1] in the following table can be set in the PROFIBUS GSD file. 3. Download the project to the CPU. The parameters that are not marked with [1] in the following table are downloaded with their default setting. 4. If necessary, set the parameters not marked with [1] in the user program using the corresponding data records.

Parameters of CM PtP

The following parameter settings are possible. The default settings of the parameters are shown in bold in the "Value range" column.

Table 2-1625 Programmable parameters

Parameter	Value range	Scope
Potential group[1]	• Use **potential group of the left module (dark BaseUnit)** • Enable new potential group (light BaseUnit)	Module
Specification of the operating mode	• **RS232C** • Full duplex (RS422) 4-wire operation (point-to-point) • Full duplex (RS422) four wire mode (multipoint master) • Full duplex (RS 422) four wire mode (multipoint slave) • Half duplex (RS485) two-wire operation	Channel
Receive line initial state	• **None** • Signal R(A)=5 V, signal R(B)=0 V (break detection) • Signal R(A)=0 V, Signal R(B)=5 V	Channel
Protocol	• **Freeport/Modbus** • 3964(R)	Channel
Performance optimized for many short frames[2]	• **Deactivated** • Activated	Channel

[1] Due to the limited number of parameters at a maximum of 244 bytes per station with a PROFIBUS GSD configuration, the configuration options are restricted. This parameter is visible. The other parameters are preassigned in the module with the default setting. If your PROFIBUS master supports the "Read/write data record" function, you can set the other parameters using the respective data records.

[2] When configuring with GSD file, you specify the option by selecting the module name.

Parameter	Value range	Scope
Data transmission rate	• 300 bps • 600 bps • 1200 bps • 2400 bps • 4800 bps • **9600 bps** • 19200 bps • 38400 bps • 57600 bps • 76800 bps • 115200 bps • 250000 bps	Channel
Parity	• **None** • Even • Odd • Mark: Set parity bit to 1 • Space: Set parity bit to 0 • Any	Channel
Data bits	• **8 bits** • 7 bits	Channel
Stop bits	• **1** • 2	Channel
Data flow control	• **None** • XON/XOFF • Hardware RTS always ON • Hardware RTS always ON, ignore DTR/DSR • Hardware RTS always switched	Channel
XON character	0...**11**...FF	Channel
XOFF character	0...**13**...FF	Channel
Wait for XON after XOFF	0...**20000**...65535 ms	Channel
Activate break detection	• **Deactivated** • Activated	Channel
Enable diagnostics interrupt	• Deactivated • **Activated**	Channel
Missing supply voltage L+	• **Deactivated** • Activated	Channel
Send break before frame start	• **Deactivated** • Activated	Channel
Break duration	0...**12**...65535 bit times	Channel
Send idle line	• Deactivated • **Activated**	Channel

[1] Due to the limited number of parameters at a maximum of 244 bytes per station with a PROFIBUS GSD configuration, the configuration options are restricted. This parameter is visible. The other parameters are preassigned in the module with the default setting. If your PROFIBUS master supports the "Read/write data record" function, you can set the other parameters using the respective data records.

[2] When configuring with GSD file, you specify the option by selecting the module name.

Parameter	Value range	Scope
Duration of the idle line	0...**384**...65535 bit times	Channel
RTS ON delay	**0**...65535 ms	Channel
RTS OFF delay	**0**...65535 ms	Channel
Send up to and including the end delimiter	• **Deactivated** • Activated	Channel
No. of end delimiters	0...**1**...2	Channel
1st end delimiter (Hex)	**0**...FF	Channel
2nd end delimiter (Hex)	**0**...FF	Channel
Number of appended characters	**0**...5	Channel
Frame default settings	• **Start on any character** • Start on special condition	Channel
After detection of a line break	• **Deactivated** • Activated	Channel
After detection of an idle line	• Deactivated • **Activated**	Channel
Duration of the idle line	0...**40**...65535 bit times	Channel
After receipt of a start character	• **Deactivated** • Activated	Channel
Start character (Hex)	**0**...FF	Channel
After detection of a start sequence	• **Deactivated** • Activated	Channel
Number of sequences to be defined	• **1** • 2 • 3 • 4	Channel
Recognize message end by message timeout	• **Deactivated** • Activated	Channel
Message timeout	1...**200**...65535 ms	Channel
Recognize message end by response timeout	• **Deactivated** • Activated	Channel
Response timeout	1...**200**...65535 ms	Channel
After character delay time elapses	• Deactivated • **Activated**	Channel
Character delay time	1...**288**...65535 bit times	Channel
After receipt of a fixed frame length	• **Deactivated** • Activated	Channel
Frame length	**1**...2048 bytes	Channel

[1] Due to the limited number of parameters at a maximum of 244 bytes per station with a PROFIBUS GSD configuration, the configuration options are restricted. This parameter is visible. The other parameters are preassigned in the module with the default setting. If your PROFIBUS master supports the "Read/write data record" function, you can set the other parameters using the respective data records.

[2] When configuring with GSD file, you specify the option by selecting the module name.

Parameter	Value range	Scope
After receipt of a maximum number of characters	• **Deactivated** • Activated	Channel
Frame length	**1**...2048 bytes	Channel
Read message length from message	• **Deactivated** • Activated	Channel
Offset of length field in message	**0**...2047 bytes	Channel
Size of length field	• **1 byte** • 2 bytes • 4 bytes	Channel
Number of characters not counted in length specification	**0**...255 bytes	Channel
After receipt of an end sequence	• **Deactivated** • Activated	Channel
Buffered received frames	1...**255**	Channel
Prevent overwriting	• Deactivated • **Activated**	Channel
Clear receive buffer on startup	• **Deactivated** • Activated	Channel
Priority	• **High** • Low	Channel
With block check (3964R)	• Deactivated • **Activated**	Channel
Use default values	• Deactivated • **Activated**	Channel
Connection attempts	1...**6**...255	Channel
Transmission attempts	1...**6**...255	Channel
Character delay time	20...**220**...65535 ms	Channel
Acknowledgment delay	20...**2000**...65535 ms	Channel

[1] Due to the limited number of parameters at a maximum of 244 bytes per station with a PROFIBUS GSD configuration, the configuration options are restricted. This parameter is visible. The other parameters are preassigned in the module with the default setting. If your PROFIBUS master supports the "Read/write data record" function, you can set the other parameters using the respective data records.

[2] When configuring with GSD file, you specify the option by selecting the module name.

Using the GSD file for PROFIBUS DP

For parameter assignment of the communications module, depending on the protocol use, you must call the following instructions (Page 30) in GSD mode:

Freeport communication:

- Port_Config (Port configuration record - data record 57)
- Send_Config (Send configuration record - data record 59)
- Receive_Config (Receive configuration record - data record 60)
- Set_Features (Activate special function - data record 58)

3964 communication:

- Port_Config (Port configuration record - data record 57)
- P3964_Config (3964 protocol configuration - data record 61)
- Set_Features (Activate special function - data record 58)

NOTE

The Set_Features instruction must always be called as the last configuration instruction.

Additional information

The device manual of the communications module is supplemented by the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) and the STEP 7 (TIA Portal) information system. There you will find information on the following topics:

- Operating modes
- Performance optimization
- Receive buffer
- Data flow control
- Transmission integrity
- Data transmission - protocol specific
- Programming/configuring in STEP 7 (TIA Portal)
- Module-specific instructions
- Diagnostics

Information on using the communications module in a third-party system is available in the programming and operating manual CM PtP operation with PROFINET controller (http://support.automation.siemens.com/WW/view/en/59062563).

To use the communications modules in a third-party system, the CPU must support communication by means of data records.

Information on reparameterization after failure and return of the power or the PROFINET/PROFIBUS connection is available in the FAQ with the entry ID 109783576 (https://support.industry.siemens.com/cs/ww/en/view/109783576) in the Siemens Industry Online Support.

4.4 Address space

Address space of the communications module

The size of the input and output addresses of the communications module depends on whether the performance optimization option (Page 30) is enabled.

Table 2-1626 Size of the input and output addresses

	Inputs	Outputs
Size without performance optimization (Universal)	8 bytes	0 bytes
Size with performance optimization	32 bytes	32 bytes

Programming 5

5.1 Programming

Data communication

Two types of data exchange between the CPU and the communications module are possible:

- Acyclic data exchange (Universal)

  The point-to-point instructions communicate with the communications module asynchronously by reading or writing data records.

  Data transmission takes place across several cycles.

  NOTE

  CPU configuration limits

  When using the instructions with asynchronous communication, you should take into account the configuration limits of the respective CPU for reading and writing data records. If multiple instructions need to read or write data records simultaneously on a CPU, there may need to be a gap between the calls of each instruction by the user program.

- Cyclic data exchange (Performance optimized for many short frames)

  The point-to-point instructions communicate with the communications module synchronously with the application cycle via the IO data of the communications module.

  The input data comprises 32 bytes, of which 24 bytes are available for the frame. The output data comprises 32 bytes, of which 30 bytes are available for the frame. Using cyclic data optimizes the reaction time, especially if you are using several CM PtPs in parallel.

  NOTE

  Cyclic data exchange is available with the instruction library PtP-Communication as of V4.0.

Overview of the instructions

Communication between the CPU, the communications module and a communication partner takes place by means of special instructions and protocols that support the corresponding communications modules.

The instructions process the exchange of data between the CPU and the communications module. They must be called cyclically from the user program. When the instruction library PtP-Communication as of V4.0 is used, the instructions detect independently whether the Performance option is active and adapt the method for the data exchange.

The transmission protocols are implemented on the communications module. The protocol is used to adapt the interface of the communications module to the interface of the communication partner.

Instruction	Meaning
Port_Config	Dynamically assigning the basic interface parameters
Send_Config	Send configuration Dynamically assigning serial send parameters of a port
Receive_Config	Receive configuration Dynamically assigning serial receive parameters of a port
P3964_Config	Protocol configuration Dynamically configuring the parameters of procedure 3964(R)
Send_P2P	Send data to a communication partner
Receive_P2P	Receive data from a communication partner
Receive_Reset	Clear receive buffer of the communications module
Signal_Get	Read RS232 accompanying signals
Signal_Set	Set RS232 accompanying signals
Get_Features	Read the extended functions supported by the communications module
Set_Features	Set the extended functions supported by the communications module
USS_Port_Scan	Communication via the USS
USS_Drive_Control / USS_Drive_Control_31	Exchange data with a drive
USS_Read_Param / USS_Read_Param_31	Readout parameters from the drive
USS_Write_Param / USS_Write_Param_31	Change parameters in the drive
Modbus_Comm_Load	Configure the port of the communications module for Modbus RTU
Modbus_Master	Communicate as Modbus master via the PtP port
Modbus_Slave	Communicating as Modbus slave via the PtP port

The instructions are part of STEP 7 (TIA Portal). The instructions are available in the "Instructions" task card under Communication > Communication processor.

Additional information

Additional information on programming the communications modules is available in the function manual CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) and in the STEP 7 (TIA Portal) information system.

Interrupts/diagnostics alarms

6

6.1 Status and error displays

LEDs

The figure below shows the LEDs (status and error displays) of the CM PtP.

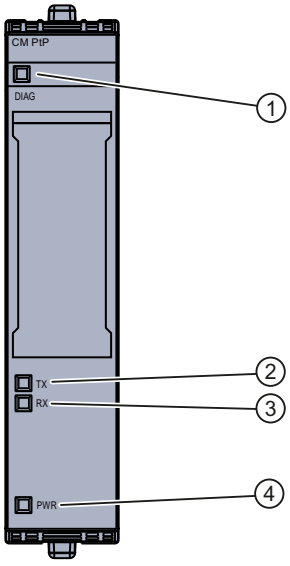

① DIAG (green/red)

② TX (green)

③ RX (green)

④ PWR (green)

Figure 2-1351 LED displays CM PtP (without BaseUnit)

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostics alarms can be found in the section Diagnostic alarms (Page 34).

Table 2-1627 Status and error displays DIAG

LED DIAG	Meaning	Solution
Off	Backplane bus supply of the ET 200SP not OK	Check or switch on the supply voltage on the CPU or on the interface module.
Flashes	CM not configured	---
On	CM parameters assigned and no module diagnostics	
Flashes	CM parameters assigned and module diagnostics (at least one error pending)	Evaluate the diagnostics alarms and eliminate the error.[1]

[1] Information on communications module startup and diagnostics is available in the CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) function manual

Table 2-1628 Status displays TXD/RXD

LED		Meaning	Solution
TX	RX		
Flashes	Off	Interface is transmitting	---
Off	Flashes	Interface is receiving	---

Table 2-1629 PWR status indicators

PWR LED	Meaning	Solution
Off	Supply voltage missing	• Check the supply voltage. • Check the BaseUnit type and the wiring of the BaseUnit.
On	Supply voltage is present and OK.	---

Additional information

Information on communications module startup and diagnostics is available in the CM PtP - Configurations for point-to-point connections (http://support.automation.siemens.com/WW/view/en/59057093) function manual.

6.2 Diagnostic alarms

Enabling of diagnostics interrupts

You enable the diagnostics interrupts in the device configuration with the basic parameters.

The communications module can trigger the following diagnostics interrupts:

Table 2-1630 Possible diagnostics interrupts

Diagnostics interrupt	Monitoring
• Parameter assignment error • Error	Monitoring is always active. A diagnostics interrupt is triggered each time an error is detected.
• Wire break	Monitoring is always active. An error detected only triggers a diagnostics interrupt if "Activate break detection" and "Enable diagnostics interrupt" have been enabled in the device configuration.
• No load voltage	Monitoring is always active. An error detected only triggers a diagnostics interrupt if "Missing supply voltage L+" has been enabled in the device configuration.

Reactions to a diagnostics interrupt

The following happens when an event occurs that triggers a diagnostics interrupt:

- The DIAG LED flashes red.

  When you have eliminated all errors, the DIAG LED stops flashing red and turns green.
- The S7-1500 CPU interrupts the processing of the user program. The diagnostics interrupt OB (e.g. OB 82) is called. The event that triggered the interrupt is entered in the start information of the diagnostics interrupt OB.
- The S7-1500 CPU remains in RUN even if no diagnostics interrupt OB is present in the CPU. The communications module continues working unchanged if this is possible despite the error.

You can obtain detailed information on the error event in the error organization block with instruction "RALRM" (Read additional alarm information), in the information system of STEP 7 and in function manual Diagnostics (https://support.industry.siemens.com/cs/ww/en/view/59192926), section "System diagnostics in user program".

If the module is being operated as a distributed module in an ET 200SP system with PROFIBUS DP, you have the option of reading out diagnostic data with the RDREC or RD_REC instruction using data record 0 and 1. You can find the structure of the data records in the manual for the IM 155-6 DP HF interface module available for download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/73098660).

Diagnostic messages

The diagnostics are displayed as plain text in STEP 7 (TIA Portal) in the online and diagnostics view. You can evaluate the error codes with the user program.

The following diagnostics can be signaled:

Table 2-1631 Diagnostic messages, their meaning and remedies

Diagnostic message	Error code	Meaning	Solution
Wire break	6_H	Interruption of the line between communications module and communication partner	Check process wiring
Error	9_H	• Internal module error occurred • Possible cause: – Firmware update was aborted – communications module defective	• Repeat firmware update • Replace communications module
Parameter assignment error	10_H	• The received parameter data record is invalid • The configured BaseUnit is not the BaseUnit being used	• Check parameter data record • Check BaseUnit
No load voltage	11_H	• No or insufficient supply voltage L+ • Wiring of supply voltage L+ faulty • Possible cause: BaseUnit type incorrect	• Check BaseUnit type • Check supply voltage L+ at the BaseUnit • Check wiring of supply voltage L+ • Check total consumption of the load group

Technical specifications 7

Article number	6ES7137-6AA01-0BA0
General information	
Product type designation	CM PtP
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V17 or higher
• STEP 7 configurable/integrated from version	via GSD as of V5.6 HF4
• PROFIBUS from GSD version/GSD revision	GSD as of Revision 5
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	31 mA
Current consumption, max.	35 mA
Power loss	
Power loss, typ.	0.7 W
Address area	
Address space per module	
• Inputs	8 byte; performance mode: 32 byte
• Outputs	0 byte; performance mode: 32 byte
1. Interface	
Interface types	
• RS 485	Yes
• RS 422	Yes
• RS 232	Yes
• Design of the connection	Push-in terminal
Interface types	
RS 232	
• Transmission rate, max.	115.2 kbit/s

Article number	6ES7137-6AA01-0BA0
• Cable length, max.	15 m
• RS 232 auxiliary signals	RTS, CTS, DTR, DSR, RI, DCD
RS 485	
• Transmission rate, max.	250 kbit/s
• Cable length, max.	1 200 m; 100 to 1200 m, depending on transmission speed
RS 422	
• Transmission rate, max.	115.2 kbit/s
• Cable length, max.	1 200 m
• 4-wire full duplex connection	Yes
• 4-wire multipoint connection	Yes
Integrated protocols	
Freeport	
– Telegram length, max.	2 kbyte; performance mode: receive data max. 24 byte and send data max. 30 byte
– Bits per character	7 or 8
– Number of stop bits	1 or 2 bit
– Parity	None, even, odd, always 1, always 0, any
3964 (R)	
– Telegram length, max.	2 kbyte; performance mode: receive data max. 24 byte and send data max. 30 byte
– Bits per character	7 or 8
– Number of stop bits	1 or 2 bit
– Parity	None, even, odd, always 1, always 0, any
Modbus RTU master	
– Address area	1 to 247, extended 1 to 65535
– Number of slaves, max.	32
MODBUS RTU slave	
– Address area	1 to 247, extended 1 to 65535
Telegram buffer	
• Buffer memory for telegrams	4 kbyte
• Number of telegrams which can be buffered	255
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	No
Diagnoses	
• Wire-break	Yes

Article number	6ES7137-6AA01-0BA0
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• for module diagnostics	Yes; green/red DIAG LED
• Receive RxD	Yes; green LED
• Transmit TxD	Yes; green LED
Potential separation	
between backplane bus and interface	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m
Decentralized operation	
to SIMATIC S7-300	Yes
to SIMATIC S7-400	Yes
to SIMATIC S7-1200	Yes
to SIMATIC S7-1500	Yes
to standard PROFINET controller	Yes
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

NOTE

Installation heights > 2000 m

You can find information on the restrictions when using the ET 200SP distributed I/O system at more than 2000 m above sea level in the "Mechanical and climatic environmental conditions" section of the ET 200SP Distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Additional general technical specifications for SIMATIC ET 200SP can be found in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

SIEMENS

SIMATIC NET

ET 200SP - Industrial Ethernet SIMATIC CP 154xSP-1

Operating Instructions

Application and functions 1

LEDs and connectors 2

Installation, wiring, commissioning 3

Configuration 4

Program blocks 5

Diagnostics and maintenance 6

Technical specifications 7

Approvals A

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Accessories C

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Documentation references E

CP 1542SP-1
CP 1542SP-1 IRC
CP 1543SP-1

11/2024
C79000-G8976-C426-08

Preface

Validity of this manual

This document contains information on the following modules:

- **CP 1542SP-1**
  Article number **6GK7542-6UX00-0XE0**
  Hardware version 3
  Firmware version V2.4
  Communications processor for connecting a SIMATIC ET 200SP CPU to Industrial Ethernet
- **CP 1542SP-1 IRC**
  Article number **6GK7542-6VX00-0XE0**
  Hardware version 3
  Firmware version V2.4
  Communications processor for connecting a SIMATIC ET 200SP CPU via Industrial Ethernet to a control center (TCSB, ST7, DNP3, IEC 60870-5-104)
- **CP 1543SP-1**
  Article number **6GK7543-6WX00-0XE0**
  Hardware product version 3
  Firmware version V2.4
  Communications processor for connecting a SIMATIC ET 200SP CPU to Industrial Ethernet, Security

Figure 2-1352 CP 1542SP-1 with plugged in BusAdapter (here BA 2xRJ45)

On the front of the module at the right edge, the hardware version is printed as a placeholder "X". If the printed text is, for example, "X 2 3 4", "X" would be the placeholder for hardware product version 1.

Directly below, you will find the firmware version of the CP as it shipped.

The MAC address of the interface is printed on the front at the bottom left, above the connectors for the power supply:

- 00:1B:1B:xx:xx:01 (interface)

You can learn the MAC addresses of the ports via the online functions of STEP 7 (assessible devices):

- 00:1B:1B:xx:xx:02 (port X1P1)
- 00:1B:1B:xx:xx:03 (port X1P2)

New in this edition

- New firmware version V2.4 with new functions:
  - Expansion of online diagnostics in relation to time synchronization
  - Extensions for the protocol IEC 60870-5
  - Extensions for the protocol DNP3

    For a description of the functions, refer to the respective configuration manual under "Structure of the documentation" below
  - Various error corrections and optimizations
- Editorial revision

Replaced editions

Edition 02/2024

Current manual edition on the Internet

You will also find the current edition of this manual on the Internet pages of Siemens Industry Online Support (SIOS):

- CP 1542SP-1 / CP 1543SP-1
  Link: (https://support.industry.siemens.com/cs/ww/en/ps/22144/man)
- CP 1542SP-1 IRC
  Link: (https://support.industry.siemens.com/cs/ww/en/ps/22143/man)

With the "E-mail on update" option, you an enable an automatic notification when new documents are published in SIOS for the selection you have made in the project tree.

Structure of the documentation

The documentation for the three CP types consists of the following manuals and contents:

- **Operating instructions**

  Valid for all three CP types

  – Application and functions
  – Requirements (CPUs, configuration software, etc.)
  – Hardware description
  – Installation, wiring, commissioning, operation
  – Configuration of the CP 1542SP-1 and CP 1543SP-1

    Complete configuration for these two CPs is described in this manual.

    You will find the complete description of the configuration for the CP 1542SP-1 IRC in the respective telecontrol configuration manual; see below.
  – Diagnostics, maintenance
  – Technical specifications, approvals, accessories

- **Telecontrol configuration manuals (CP 1542SP-1 IRC)**

  Depending on the telecontrol protocol used, the configuration of the CP 1542SP-1 IRC is described in the following documents:

  – **SINAUT ST7 system manual**

    Volume 3 - Configuration under STEP 7 Professional (TIA Portal)
  – **Configuration manual Telecontrol Basic**

    Configuration and diagnostics in STEP 7 Professional (TIA Portal)
  – **Configuration manual DNP3**

    Configuration and diagnostics in STEP 7 Professional (TIA Portal)
  – **Configuration manual IEC**

    Configuration and diagnostics in STEP 7 Professional (TIA Portal)

You can find the Internet links for the manuals in the appendix Documentation references (Page 115).

Required experience

To install, commission and operate the CP, you require experience in the following areas:

- Automation engineering
- Setting up the SIMATIC ET 200SP
- SIMATIC STEP 7 Professional

Notes on this document

Product name

- **CP / module / device**

  When properties listed in this manual are valid for all three types of CP, these names are used in place of the complete product names of all three types of CP.

  If information is only valid for specific types of CP, the respective CP names are listed in the text or in the section header.

Cross-references

In this manual, there are often cross-references to other sections.

To return to the original page after jumping to a cross-reference, some PDF readers support the command <Alt>+<Left arrow>.

Search

To display all instances of a search term in a list, some PDF readers support the command <Ctrl>+<Shift>+<F>.

See also

BusAdapter (Page 107)

License conditions

NOTE

Open source software

Read the license conditions for open source software carefully before using the product.

You will find license conditions in the following document on the supplied data medium:

- OSS_CP-ET200SP_99.pdf

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

See also

See also:
Security functions (CP 1542SP-1 IRC, CP 1543SP-1) (Page 18)
Security recommendations (Page 48)

Firmware

The firmware is signed and encrypted. This ensures that only firmware created by Siemens can be downloaded to the device.

Note on firmware/software support

Check regularly for new firmware/software versions or security updates and apply them. After the release of a new version, previous versions are no longer supported and are not maintained.

Device defective

If a fault develops, please send the device to your Siemens representative for repair. Repairs on-site are not possible.

Decommissioning

Shut down the device properly to prevent unauthorized persons from accessing confidential data in the device memory.

To do this, restore the factory settings on the device.

You achieve this by resetting the CPU using the online functions of STEP 7.

Recycling and disposal

The product is low in pollutants, can be recycled and meets the requirements of the WEEE directive 2012/19/EU "Waste Electrical and Electronic Equipment".

Do not dispose of the product at public disposal sites. For environmentally friendly recycling and the disposal of your old device contact a certified disposal company for electronic scrap or your Siemens contact.

Keep to the local regulations.

You will find information on returning the product on the Internet pages of Siemens Industry Online Support:
Link: (https://support.industry.siemens.com/cs/ww/en/view/109479891)

SIMATIC NET glossary

The SIMATIC NET glossary describes terms that may be used in this document.

Explanations of many of the specialist terms used in this documentation can be found in the SIMATIC NET glossary.

You will find the SIMATIC NET glossary here:

- On the accompanying DVD
- In the Siemens Industry Online Support at the following address:
  Link: (https://support.industry.siemens.com/cs/ww/en/view/50305045)

Training, Service & Support

You will find information on training, service and support in the multilanguage document "DC_support_99.pdf" on the Internet pages of Siemens Industry Online Support:
Link: (https://support.industry.siemens.com/cs/ww/en/view/38652101)

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Application and functions

1

1.1 Components of the product

The following components are supplied with the product:

- CP 154xSP-1
- Plug for the socket of the power supply (24VDC) of the CP
- DVD with documentation and license texts

A BusAdapter for the Ethernet connection of the CP does not ship with the product.

1.2 Application

Application of the CP variants

The CP is used to connect the ET 200SP to Industrial Ethernet via a copper cable or fiber-optic cable. It can be used as an additional Ethernet interface of the CPU for S7 communication.

The interface of the CP is designed as a 2-port switch for the integration of the CP in a line or a ring or for connecting an additional Ethernet device.

For the Ethernet connection, the CP requires a BusAdapter. The BusAdapter is not supplied with the CP. For information on the compatible BusAdapters, refer to the section BusAdapter (Page 107).

The three CP types are intended for the following communication tasks:

- **CP 1542SP-1**

  The CP 1542SP-1 allows the ET 200SP a further Ethernet connection.

- **CP 1543SP-1**

  The CP 1543SP-1 has Security functions for network security, such as a firewall and VPN. This makes protected access to the ET 200SP possible.

- **CP 1542SP-1 IRC**

  The CP 1542SP-1 IRC supports telecontrol communication for connecting the ET 200SP CPU to a control center. One of the following telecontrol protocols can be used as an alternative:

  – TeleControl Basic

    For connection of the ET 200SP CPU to a control center with telecontrol server (TCSB)

  – ST7

    For connection of the ET 200SP CPU to a control center with SINAUT ST7

  – DNP3

    For connection of the ET 200SP CPU to DNP3 master

  – IEC 60870-5-104

    For connection of the ET 200SP CPU to IEC master

1.3 Communications services

Communications services

The following communications services are supported:

- **S7 communication and PG/OP communication with the following functions:**
  – PUT/GET as client and server for data exchange with S7 stations
  – USEND/URCV for uncoordinated data exchange with a remote partner
  – BSEND/BRCV for exchanging large volumes of data with a partner
  – PG functions
  – Operator control and monitoring functions (HMI)

  For fully specified S7 connections, the CP requires a fixed IP address.
- **S7 routing**
  – Routing of S7 connections via the backplane bus and the CPU to other S7 stations
- **SINEMA Remote Connect (SINEMA RC)**

  As of firmware version V2.0, the following CP types support communication via SINEMA RC as of software version V1.3:

  – CP 1542SP-1 IRC
  – CP 1543SP-1

  See section Communication via SINEMA RC (CP 1542SP-1 IRC, CP 1543SP-1) (Page 16).

  For the manual, see /8/ SINEMA Remote Connect - Server (Page 117).
- **Open User Communication (OUC)**

  OUC via program blocks with the following protocols:

  – TCP/IP
  – ISO-on-TCP
  – UDP

The CP 1543SP-1 supports Secure OUC.

You will find the program blocks supported by the three CP types in the section Program blocks (Page 79).

- **HTTP / HTTPS**

  Via HTTP / HTTPS you can access the Web server of the CPU.

- **E-mail using program block "TMAIL_C"**
- **E-mail via message editor (**CP 1542SP-1 IRC **/** CP 1543SP-1**)**

For telecontrol communication of the CP 1542SP-1 IRC, see section Telecontrol communication (CP 1542SP-1 IRC) (Page 14).

For information on the Security functions of the CP 1543SP-1, refer to the section Security functions (CP 1542SP-1 IRC, CP 1543SP-1) (Page 18).

1.4 PUT/GET: Restrictions in the CPU

Communications services without connections

The CPU can be a server for a series of communications services without connections being configured for the CPU. Other communications partners can access CPU data. This means that it is no longer possible for the local CPU to control communication with the clients.

You need to grant permission for these communications services at the following location in the CPU configuration:

- Parameter group "Protection & Security > Connection mechanisms"

  Enable the option "Permit access with PUT/GET communication from remote partner".

A prerequisite for enabling this option is enabling an access option in the "Access control > Access level" parameter group. Set the option "Read access" or "Full access".
Note: This setting is connected with security restrictions.

When the "No access (complete protection)" option is enabled, PUT/GET communication cannot be enabled.

"Permit access with PUT/GET communication from remote partner"

Parameter group "Protection & Security > Connection mechanisms" > option "Permit access with PUT/GET communication from remote partner"

The activation of communication services described below applies to the use of the communications module together with a CPU V2.x to V3.0.

- Option enabled

  Access to CPU data from the client side via the communications module using PUT/GET is possible.

- Option disabled

  Access to CPU data from the client side via the communications module using PUT/GET is not possible.

  Read and write access to CPU data is only possible with communication connections that require configuration or programming both for the local CPU and for the communications partner.

  Connections for which the local CPU is only a server (no configuration/programming of communication with the partner) are not possible.

Configuring PUT/GET

You can find additional information on the following Siemens Industry Customer Support page and in the documentation specified in the "Download" section:
Link: (https://support.industry.siemens.com/cs/ww/en/view/82212115)

1.5 Telecontrol communication (CP 1542SP-1 IRC)

Telecontrol protocols

In addition to the communications services named above, the CP 1542SP-1 IRC supports the following telecontrol protocols for communication with a master station and other telecontrol stations:

- **TeleControl Basic ***

  Proprietary protocol for telecontrol applications. The IP-based protocol is used to connect the CP to the application TCSB.

  TCSB is installed on a PC in the master station, the telecontrol server. Via the OPC-DA or OPC-UA server of TCSB, an OPC client can access the process data of the CP.

  TCSb is supported as of the following version: V3.0 + SP3

  For the TCSB manual, see /4/ TeleControl Server Basic (Page 116).

- **ST7**

  Proprietary protocol for telecontrol applications in the SINAUT ST7 system. The protocol is used to connect the CP to ST7 control centers.

  The SINAUT ST7 supports the following functions, among others:

  – Communication with the master station
  – Communication with other stations

- MSC transmission protocol

  Under SINAUT ST7, the CP uses the following variants of the MSC transmission protocol on OSI layer 3:

  - MSC (default setting)

  - MSCsec when security requirements are higher ("Security" activated)

- Communication using mobile wireless

  Communication via a mobile wireless network combined with the Internet is made possible by a SCALANCE M router. The SCALANCE M product series provides various VPN routers with IPsec, encryption software and their own firewall.

  You will find a list of routers in the appendix IP-based routers (Page 110).

- **DNP3 ***

  The CP functions as a DNP3 station (outstation).

  Communication is based on the DNP3 SPECIFICATION Version 2.11 (2007/2009).

  You will find a detailed overview of the attributes and properties of the DNP3 protocol that are supported by the CP in the DNP3 device profile; see:
  Link: (https://support.industry.siemens.com/cs/ww/en/ps/22143/man)

  Communications partners of the CP can be:

  DNP3 master:

  - SIMATIC PCS 7 TeleControl
  - SIMATIC WinCC TeleControl
  - SIMATIC WinCC OA
  - A TIM module with DNP3 capability (TIM 1531 IRC / TIM 3V IE DNP3 / TIM 4R IE DNP3)

    For the manual of the TIM DNP3, see /5/ TIM DNP3 (Page 116).
  - Third-party systems that support the DNP3 specification named above.

  DNP3 stations (outstation):

  - CPUs in stations

    For direct communication, frames can be sent from the station to a partner.

- **IEC 60870-5-104 ***

  The CP functions as a substation (slave).

  Communication is based on the specification IEC 60870-5 Part 104 (2006).

  You will find a detailed overview of the attributes and properties of the IEC specification that are supported by the CP in the IEC device profile; see:
  Link: (https://support.industry.siemens.com/cs/ww/en/ps/22143/man)

  Communications partners of the CP can be:

  IEC master:

  - SIMATIC PCS 7 TeleControl
  - SIMATIC WinCC TeleControl
  - SIMATIC WinCC OA
  - A TIM module with IEC capability (TIM 1531 IRC)
  - Third-party systems that support the IEC specification named above.

Stations:

– CPUs in stations

For direct communication, frames can be sent from the station to a partner.

* Optional telecontrol communication with the master station via SINEMA Remote Connect, see section Communication via SINEMA RC (CP 1542SP-1 IRC, CP 1543SP-1) (Page 16).

Further properties of the CP 1542SP-1 IRC

- **Data point configuration**

  The process values are configured as data points for the communication.

  No program blocks need to be programmed for the CP 1542SP-1 IRC to transfer user data between the station and communications partner.

  The data areas in the memory of the CPU intended for communication with the partner are configured for the specific data points in the CP. Each data point addresses a PLC tag or element in a data block of the CPU.

  The data points can be processed individually in the control system.

- **Messages / e-mail**

  With configurable events in the process image of the CPU, the CP can send messages as e-mails. The data sent by e-mail is configured using PLC tags.

- **Send buffer**

  The CP saves the values of data points configured as an event in the send buffer. It transmits the data from the send buffer spontaneously or bundled to the communications partner.

  The data is not saved retentively. It is lost in the event of a power failure.

- **Analog value processing**

  Analog values can be preprocessed on the CP according to various methods.

You can find additional information in the telecontrol configuration manuals, refer to /10/ TeleControl configuration manuals (Page 117).

1.6 Communication via SINEMA RC (CP 1542SP-1 IRC, CP 1543SP-1)

Validity

The following types of communication via SINEMA Remote Connect are supported by the CPs:

- CP 1543SP-1
  - Remote maintenance via SINEMA Remote Connect
- CP 1542SP-1 IRC
  - Remote maintenance via SINEMA Remote Connect
  - Telecontrol communication via SINEMA Remote Connect

Consider this in the applications described below.

Communication via SINEMA Remote Connect (SINEMA RC)

The "SINEMA RC Server" application provides end-to-end connection management of distributed networks via the Internet. This also includes secure remote access to lower-level stations. Communication between SINEMA RC Server and the remote devices takes place via a VPN tunnel with consideration of the stored access rights.

SINEMA RC uses OpenVPN for encryption of the data. The center of the communication is SINEMA RC Server via which communication runs between the subscribers and that manages the configuration of the communications system.

SCALANCE M routers, which you can use for the connection, also support OpenVPN and connection to SINEMA Remote Connect.

For the CP firmware version required for communication via SINEMA RC see section Communications services (Page 12).

Parameter groups

You configure communication via SINEMA RC and telecontrol communication via SINEMA RC in two parameter groups:

- Communication via SINEMA RC:

  > "Security > VPN"

- Telecontrol communication via SINEMA RC:

  > "Communication types"

  For information on the configuration, refer to the telecontrol configuration manuals /10/ TeleControl configuration manuals (Page 117).

Applications

The following application options result from the combination of the parameters for telecontrol communication and SINEMA RC.

Application example:

- (1) No telecontrol and no SINEMA RC (CP for network separation only)
- (2) CP only for remote maintenance via SINEMA RC
- (3) CP for telecontrol communication only
- (4) CP uses telecontrol communication, but SINEMA RC only for remote maintenance.
- (5) CP uses SINEMA RC for telecontrol communication and remote maintenance.

The table provides an overview of the applications with the respective parameter settings.

- "On" means that the parameter is activated.
- "Off" means that the parameter is deactivated.

Table 2-1632 Use cases and parameters to be activated

Use case	Parameter settings (Parameters abbreviated) *		
	SRC	TC	TC-SRC
(1)	Off	Off	Off
(2)	On	Off	Off
(3)	Off	On	Off
(4)	On	On	Off
(5)	On	On	On

* Explanation of the parameter abbreviations:

SRC - Security > VPN (activated) > "VPN connection type":
"Automatic OpenVPN configuration via SINEMA Remote Connect Server"

TC - Communication types > Telecontrol communication enabled

TC-SRC - Communication types >
"Activate telecontrol communication via SINEMA Remote Connect"

1.7 Security functions (CP 1542SP-1 IRC, CP 1543SP-1)

Security functions are available for the following CP types:

- CP 1543SP-1

  The security functions are enabled in the configuration of the CP.
- CP 1542SP-1 IRC

  You will find the detailed description of the security functions in the telecontrol configuration manuals, see /10/ TeleControl configuration manuals (Page 117).

For information on the security functions of the Open User Communication program blocks, see section Program blocks (Page 79).

For information on the encryption methods used, see appendix Encryption methods (Ciphers) (Page 111).

NOTE

Recommendation for critical security plants

Refer to the information in the section Security recommendations (Page 48).

With Industrial Ethernet Security, individual devices, automation cells or network segments of an Ethernet network can be protected. The data transfer via the CP can be protected from the following attacks by a combination of different security measures:

- Data espionage
- Data manipulation
- Unauthorized access

Secure underlying networks can be operated via additional Ethernet/PROFINET interfaces of the CPU.

As a result of using the CP, as a security module, the following security functions are accessible to the ET 200SP station on the interface to the Ethernet network:

CP 1543SP-1 / CP 1542SP-1 IRC

The CP supports the following security functions:

- **Firewall**

  The firewall protects the device with:

  – IP firewall with stateful packet inspection (layer 3 and 4)

  – Firewall also for "non-IP" Ethernet frames according to IEEE 802.3 (layer 2)

  – Limitation of the transmission speed to restrict flooding and DoS attacks ("Define IP packet filter rules")

- **Certificates**

  Certificates are used for the secure authentication of the communications partners.

- **VPN**

  The following alternatives can be used:

  – **OpenVPN via SINEMA Remote Connect**

    It is not necessary and not possible to create a VPN group for communication via a SINEMA RC server. The SINEMA RC Server manages the communication between the devices and the security mechanisms (OpenVPN).

    For information on the configuration, see section SINEMA Remote Connect (Page 66).

  – **IPsec (CP 1543SP-1)**

    VPN communication allows the establishment of secure IPsec tunnels for communication with one or more security modules. The CP can be grouped together with other modules to form VPN groups during configuration. IPsec tunnels are created between all security modules of a VPN group.

- **Logging**

  Sending of events can be enabled for monitoring. The events can be read out using STEP 7 or sent to a Syslog server.

- **Encrypted e-mails**

  For secure transfer of information with encrypted e-mails, you can use the following as an alternative:

  – SSL/TLS

  – STARTTLS

  For information on the configuration, see section E-mail configuration (Page 64).

- **NTP (secure)**

  NTP with support of RFC5905 and RFC5906 with shared key for secure transfer during time-of-day synchronization

- **SNMPv3**

  For secure transmission of network analysis information safe from eavesdropping

For information on configuring the security functions, refer to the section Security (CP 1543SP-1) (Page 61).

You will find additional information on the functionality and configuration of the security functions in the STEP 7 information system.

CP 1542SP-1 IRC

The CP also supports the security functions of the telecontrol protocols.

- **TeleControl Basic**

  As an integrated security function, the telecontrol protocol encrypts the data for transfer between the CP and telecontrol server. The interval for the key exchange between the CP and telecontrol server can be set.

  The telecontrol password is used to authenticate the CP on the telecontrol server.

  If the security functions are enabled, the CP can process telecontrol communication via SINEMA Remote Connect.

- **ST7**

  The transmission protocols that can be used by the CP for telecontrol communication via the ST7 protocol support the following security functions:

  – MSC

    The MSC protocol supports authentication of the communications partners and simple encryption of data. A user name and a password are included in the encryption. A tunnel is established between the MSC station and MSC master station.

  – MSCsec

    In addition to MSC, with MSCsec, the shared automatically generated key is renewed between the communications partners at configurable intervals.

- **DNP3**

  The CP supports the use of TLS connections as well as secure authentication according to IEEE 1815.

  If the security functions are enabled, the CP can process telecontrol communication via SINEMA Remote Connect.

- **IEC 60870-5-104**

  The CP supports the use of TLS connections as well as secure authentication according to IEC 60870-5-7.

  If the security functions are enabled, the CP can process telecontrol communication via SINEMA Remote Connect.

For information on communication via SINEMA Remote Connect, see section Communication via SINEMA RC (CP 1542SP-1 IRC, CP 1543SP-1) (Page 16).

1.8 Other services and properties

Further services and properties of the CP

- **IP configuration**
  - Address types

    The CP supports IP addresses according to IPv4 and IPv6.
  - Addressing

    The IP address, the subnet mask and the address of a gateway can be set manually in the configuration. As an alternative, the IP address can be obtained using program blocks.
  - DHCP: As an alternative, the IP address can be obtained from a DHCP server.
  - DCP (Discovery and Configuration Protocol) is supported.
- **Time-of-day synchronization**
  - NTP

    The CP can synchronize its time of day via NTP.

    CP 1543SP-1: If the Security functions are enabled, the secure method NTP (secure) can be used.
  - CP 1542SP-1 IRC: Time from partner

    If telecontrol communication is enabled, the CP can also obtain its time of day via from the communications partner.

    UTC time is used for TeleControl Basic and DNP3.

    The local time of the partner PC is used for ST7 and IEC in the default setting. This is configurable.

  For more detailed information, refer to section Time-of-day synchronization (Page 55).
- **SNMP**

  As SNMP agent, the CP supports queries via SNMPv1.

  CP 1543SP-1 and CP 1542SP-1 IRC support SNMPv3 in addition.

  For more detailed information, refer to section SNMP (Page 61).

1.9 Configuration limits and performance data

Number of CPs per station

In each ET 200SP station, up to three special modules can be plugged in and configured; this allows a maximum of two CP 154xSP-1 modules.

For details of the permitted special modules and the slot rules, refer to section Installing the CP (Page 41).

Connection resources (all CP variants)

Connection resources

Number of connections via Industrial Ethernet, maximum of 32 in total, of which:

- S7: Max. 16 (including connections for S7 routing)
- TCP/IP: Max. 32
- ISO-on-TCP: Max. 32
- UDP: Max. 32

Also:

- Online connections of the engineering station (STEP 7): Max. 2
- TCP connections for HTTP

  For HTTP access upp to 12 TCP connection resources are available that are used by one or more Web browsers to display data of the CP.
- PG/OP connections (HMI): In total maximum of 16,
  of which:
  - Connection resources for PG connections: Max. 16
  - Connection resources for OP connections: Max. 16

Communication with the CPU

Subscriptions

Subscriptions are a mechanism by which DB tags can be subscribed to in order to monitor their state changes. In contrast to cyclic requests, the CPU actively transfers value changes to the communications module in a timely manner which a change occurs. A subscription is created automatically when, for example, event triggers, spontaneous read cycles, time synchronization or general requests are configured.

- Max. number of Subscriptions: 500

CP 1543SP-1

Security functions of the CP 1543SP-1

- **VPN tunnel (IPsec)**

  A maximum of four IPsec tunnels can be established for secure communication with other security modules.
- **Firewall rules**

  The maximum number of firewall rules in advanced firewall mode is limited to 256. The firewall rules are divided up as follows:
  - Maximum 226 rules with individual addresses
  - Maximum 30 rules with address ranges or network addresses
    (e.g. 140.90.120.1 - 140.90.120.20 or 140.90.120.0/16)
  - Maximum 128 rules with limitation of the transmission speed ("Bandwidth limitation")

- **E-mail (via message editor)**

  Up to 10 e-mails to be sent can be configured.

  Maximum number of characters that can be transferred per e-mail: 256 ASCII characters including any value sent at the same time

CP 1542SP-1 IRC

Telecontrol functions of the CP 1542SP-1 IRC

- **Telecontrol connections**
  - TeleControl Basic

    A connection can be established to a single or redundant telecontrol server.

    Additional Inter-station communication

    The inter-station communication between the CPs of two stations takes place via the telecontrol server. It is configured in the "Partner stations" > "Partner for inter-station communication" parameter group.

    Configuration limits for inter-station communication: A total of max. 15, of which:

    - Send to partner: Max. 3 ("Send buffer" parameter enabled)

    - Receive from partners: Max. 15 ("Send buffer" parameter disabled)
  - SINAUT ST7

    The CP can establish up to eight ST7 connections, of which maximum:

    - 8 individual connections with partners

    - 4 redundant connections with partners

    - 8 connections for inter-station communication between ST7 stations

    - A combination of the three options
  - DNP3 / IEC 60870-5-104

    The CP can establish connections to up to 4 communications partners.

    A partner is a single or redundant master or a station (Direct communication).

    Communication between stations is configured via the telecontrol connections.
- **E-mail (via message editor)**

  Up to 10 e-mails to be sent can be configured.

  Maximum number of characters that can be transferred per e-mail: 256 ASCII characters including any value sent at the same time
- **Frame memory (send buffer)**

  The CP has a frame memory (send buffer) for the values of data points configured as an event.

  The volume of the send buffer is divided equally among all configured communications partners. The size of the send buffer can be configured in STEP 7 ("Communication with the CPU" parameter group).

The maximum size of the send buffer with the respective remote control protocol is:

– TeleControl Basic
  64000 events
– SINAUT ST7
  32000 frames
– DNP3
  100000 events
– IEC 60870-5-104
  100000 events

For details of how the send buffer works such as storing events as well as the options for transferring the data, see /10/ TeleControl configuration manuals (Page 117).

- **Data points**

  The data to be transferred by the CP is assigned to various data points in the STEP 7 configuration. The size of the user data per data point depends on the data type of the relevant data point. For details, see /10/ TeleControl configuration manuals (Page 117).

  – Telecontrol Basic: 500
  – ST7: 1500
  – DNP3: 1500
  – IEC: 1500

1.10 Requirements for use

1.10.1 Hardware requirements

BusAdapter

To connect to the Ethernet network, the CP requires a BusAdapter. A BusAdapter does not ship with the CP.

You can find the BusAdapters supported by the CP in the appendix BusAdapter (Page 107).

CPUs of the ET 200SP

A CPU V2.9 is required to use the full range of functions of the current firmware of the CP.

The CP supports operation in stations that contain one of the following CPUs:

- CPU 1510SP-1 PN
  Article number: 6ES7510-1DJ01-0AB0
  Article number: 6ES7510-1DK03-0AB0
- CPU 1510SP F-1 PN
  Article number: 6ES7510-1SJ01-0AB0
  Article number: 6ES7510-1SK03-0AB0

- CPU 1512SP-1 PN
  Article number: 6ES7512-1DK01-0AB0
  Article number: 6ES7512-1DM03-0AB0
- CPU 1512SP F-1 PN
  Article number: 6ES7512-1SK01-0AB0
  Article number: 6ES7512-1SM03-0AB0
- CPU 1514SP-2 PN
  Article number: 6ES7514-2DN03-0AB0
- CPU 1514SP F-2 PN
  Article number: 6ES7514-2SN03-0AB0
- CPU 1514SP T-2 PN
  Article number: 6ES7514-2VN03-0AB0
- CPU 1514SP TF-2 PN
  Article number: 6ES7514-2WN03-0AB0

The respective SIPLUS CPUs are also supported.

NOTE

Keep the firmware version of the CPUs and communications modules up to date

To avoid possible problems when using newer CPUs together with older communications modules, you should keep the firmware of both your communications modules and your CPUs up to date.

Other components of the ET 200SP

Further parts and modules that are also required to set up the ET 200SP station, such as rails, I/O modules or cabling are not listed here. See also /3/ ET 200SP Manual Collection (Page 116) for information on this.

Components of the communications partner

Components required by the communications partners of the CP 1542SP-1 IRC are not listed here. You will find references to other products (e.g. TCSB) in the list of references in the appendix of the manual.

1.10.2 Software requirements

Configuration software

To configure the CP, the following configuration tool is required:

- STEP 7 Professional V20

Software for online functions

To use the online functions, the following software is required:

- STEP 7 Professional V20

CPU firmware

To use the CP, a CPU 151xSP with a minimum firmware version V2.0 is required.

To use the full range of functions of the CP, you need the current CPU firmware version. Check regularly for new firmware versions or security updates and apply them.

1.11 Configuration examples

You will find example system configurations as intended operating environment for use of the three CP types below.

For protection of the company and plant network, the following security components are recommended:

- External firewalls with Intrusion Detection System (IDS) protect the company network against external attacks.
- DMZ firewalls in the backbone level protect the plant network.
- Security modules protect each individual automation cell.

NOTE

Security information

To protect your system, refer to the information in the section Security recommendations (Page 48).

CP 1542SP-1 - Network separation

The CP is used in the ET 200SP to operate lower-level networks separately or to achieve separation from the higher-level network.

The ET 200SP can be expanded flexibly with further Ethernet interfaces via the CP. The network separation allows the setting up of identical machines with the same IP address. The CP takes over the communication and relieves the CPU.

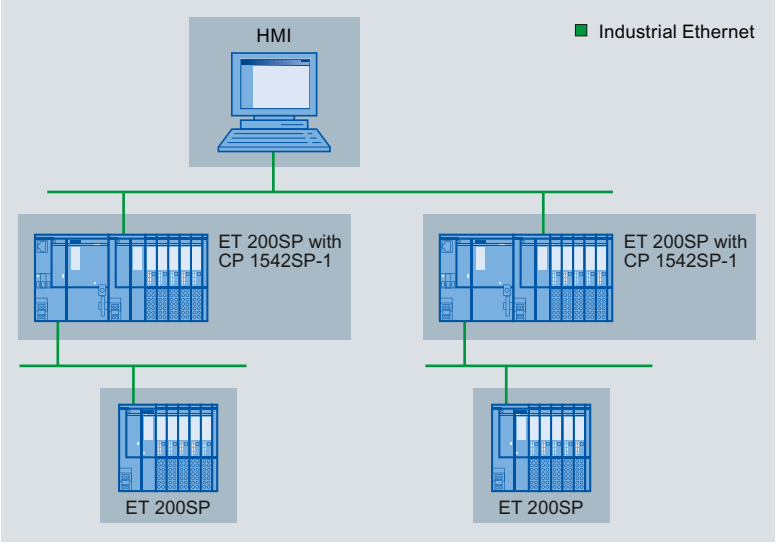

Figure 2-1353 Configuration example of an ET 200SP with CP 1542SP-1

CP 1543SP-1 - Cell protection with security functions

The CP communicates encrypted with communications partners in the connected network. The firewall monitors the access to the ET 200SP and therefore protects lower-level networks. This avoids data loss, disruptions of production and damage to machines.

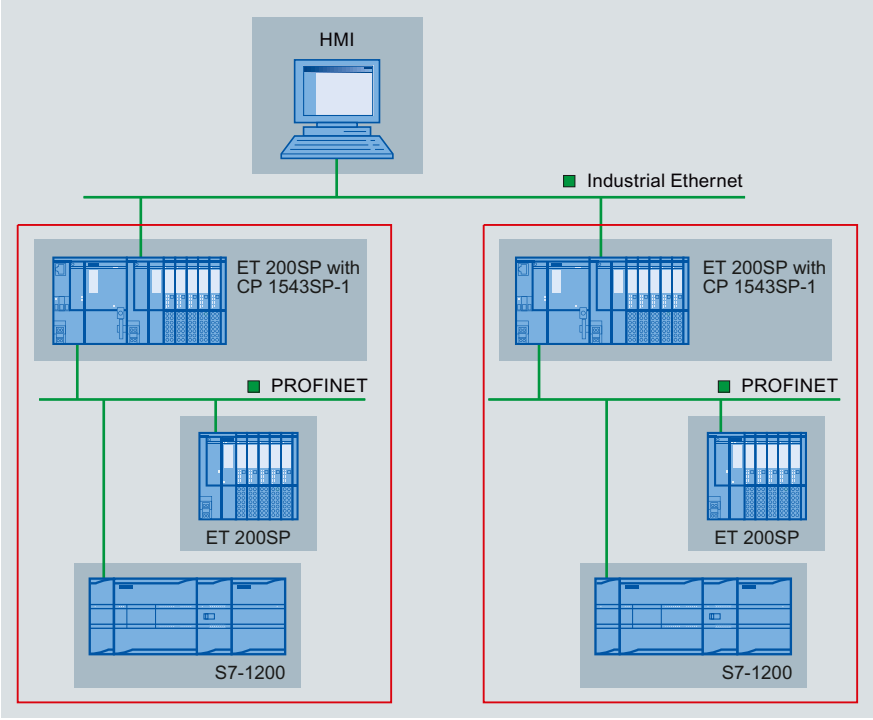

Figure 2-1354 Configuration example of an ET 200SP with CP 1543SP-1

CP 1542SP-1 IRC - Connection to control centers

By using the CP the ET 200SP can be used as a remote terminal unit. The following protocols can be used for telecontrol communication:

- TeleControl Basic
- SINAUT ST7
- IEC 60870-5-104
- DNP3

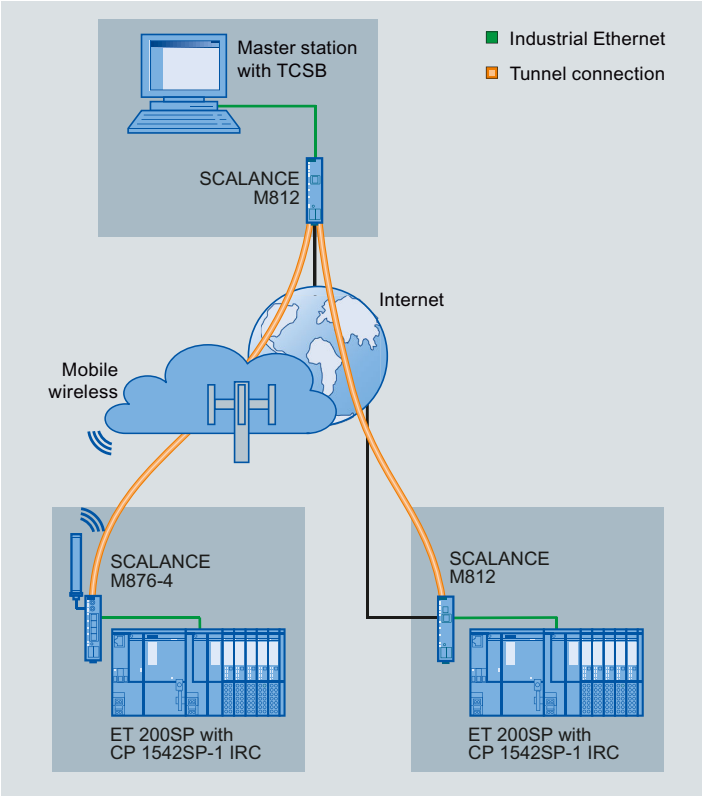

Figure 2-1355 Configuration example of an ET 200SP with CP 1542SP-1 IRC; protocol: TeleControl Basic

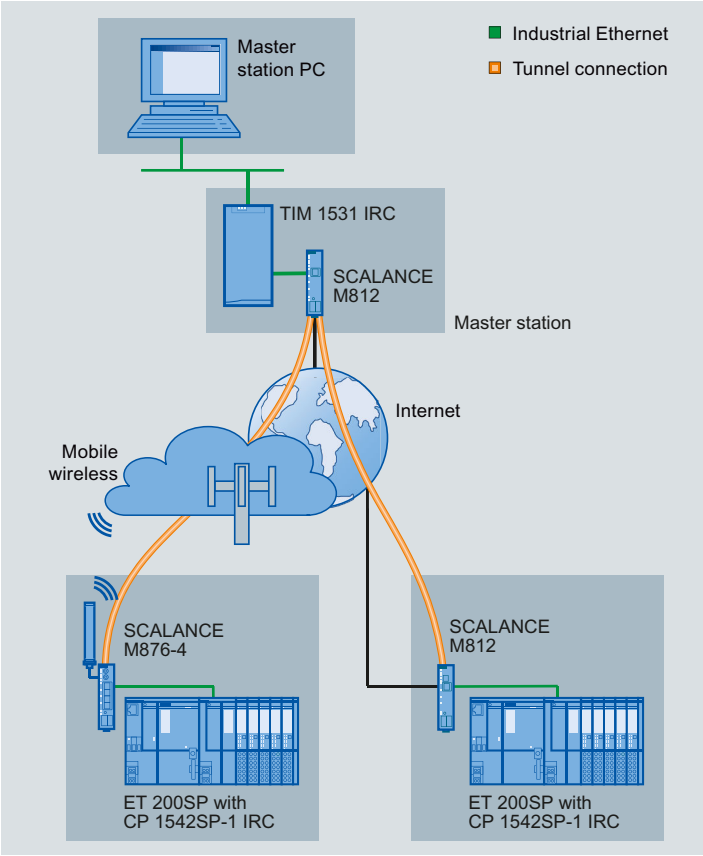

Figure 2-1356 Configuration example of an ET 200SP with CP 1542SP-1 IRC; protocol: ST7

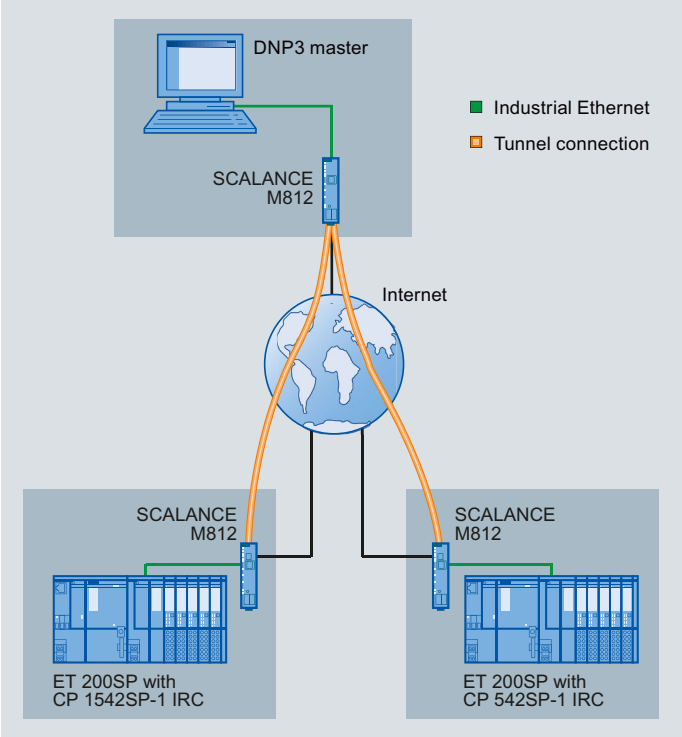

Figure 2-1357 Configuration example of an ET 200SP with CP 1542SP-1 IRC; protocol: DNP3

A configuration with which the protocol IEC 60870-5-104 is used could look similar.

Telecontrol via SINEMA Remote Connect

The following figure shows a configuration in which the CP 1542SP-1 IRC communicates with the master station via a SINEMA Remote Connect Server. In this example, the CP uses the protocol IEC 60870-5-104.

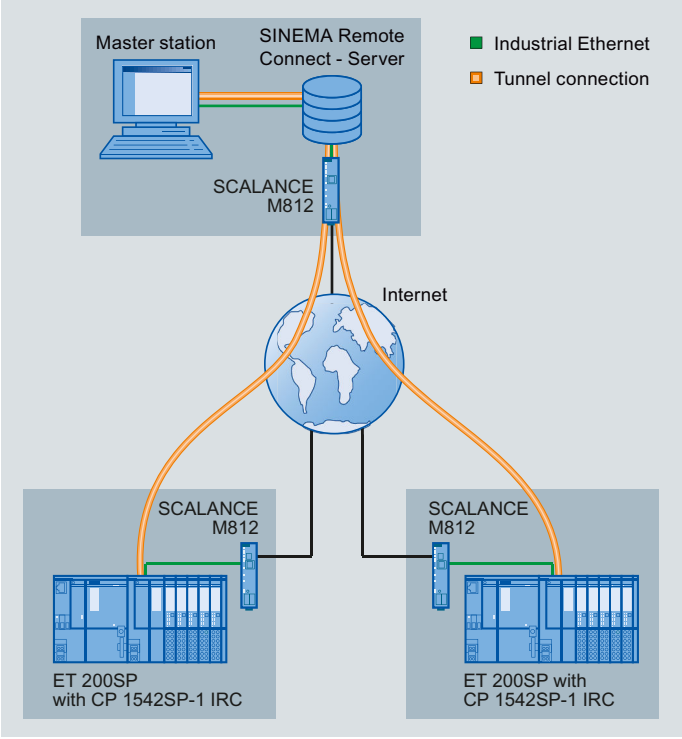

Figure 2-1358 Configuration example of an ET 200SP with CP 1542SP-1 IRC for telecontrol communication via SINEMA RC

Remote maintenance with SINEMA RC

The following figure shows the connection of different stations with Security CP to an engineering station via SINEMA Remote Connect - Server.

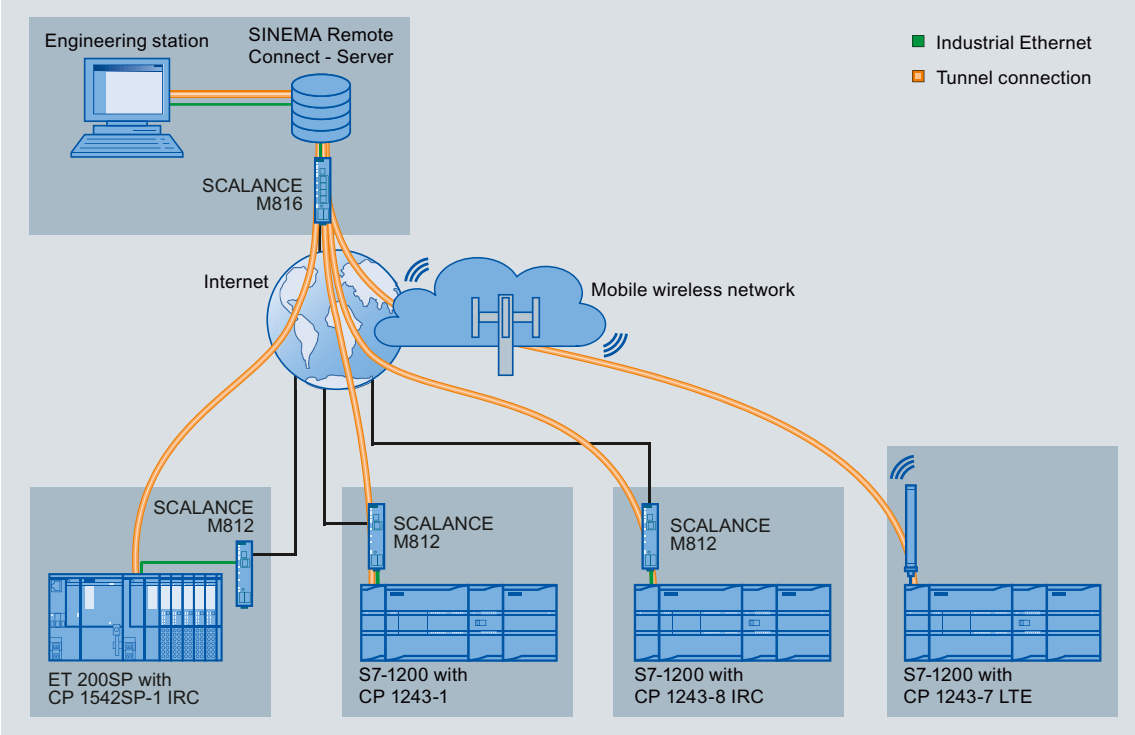

Figure 2-1359 Connection of stations to engineering station via SINEMA RC

LEDs and connectors

2

2.1 LEDs

Meaning of the LED displays of the CP

The CP has the following light emitting diodes (LEDs) on the front:

LED name	Meaning
PWR	Power supply
RN	Operating mode
ER	Error
MT	Maintenance

Table 2-1633 Legend for the following tables

Symbol	● ● ●	○	☼ ☼ ☼	-
Meaning / LED status	ON (LED lit)	OFF	LED flashes	Any

Table 2-1634 Meaning of the LED displays of the CP

PWR (green)	RN (green)	ER (red)	MT (yellow)	Meaning
○	○	○	○	No supply voltage on the CP or supply voltage too low
●	●	●	●	CP startup
●	●	○	○	CP in RUN mode
●	●	☼	○	Error. LED display with the following events: • Duplicate IP address • Bus adapter not plugged in or pulled • No telecontrol connection (CP 1542SP-1 IRC)
●	☼	☼	☼	Error: CP defective
●	☼	○	○	• Startup • Missing configuration data
●	●	○	☼	Firmware update running
●	●	○	●	There is a maintenance request from the CP. Example: • End of the firmware update

LEDs of the bus adapter

Every port of a bus adapter has an LED "LKx" that informs about the connection status with Ethernet and the frame traffic of the port.

Table 2-1635 Meaning of the LED displays of the bus adapters

LK (green)	Meaning
○	No Ethernet connection. Possible causes: • No physical connection to the network • Port disabled in the configuration
☼	LED flashing test
●	There is an Ethernet connection between the port and communications partner.

2.2 Power supply

External power supply required

The connector for the external 24 VDC power supply is located on the front of the CP.

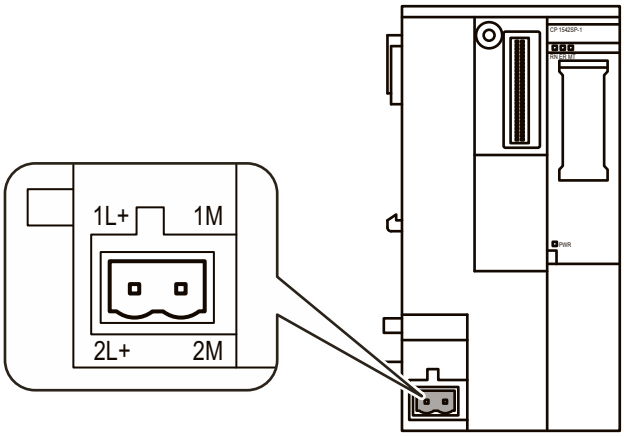

Figure 2-1360 Power supply of the CP

Connector X80 is intended for connection to a single or redundant power supply. The power supply is connected to the CP with the supplied plug-in terminal block. The terminal block is plugged in to the socket X80 of the CP.

For information on installing and connecting up, refer to the sections Installing the CP (Page 41) and Connecting the CP (Page 45).

Reverse polarity protection

The plug-in terminal block for connector X80 is designed so that it can only be plugged in in one position. This provides constructional reverse polarity protection.

The connector X80 also has electronic reverse polarity protection.

You will find further data on the power supply in section Technical specifications of the CP 154xSP-1 (Page 96).

2.3 Connector for the BusAdapter

Operation of the device only with BusAdapter

For connecting to Ethernet the CP requires a BusAdapter. A BusAdapter does not ship with the CP.

The slot is on the front of the device:

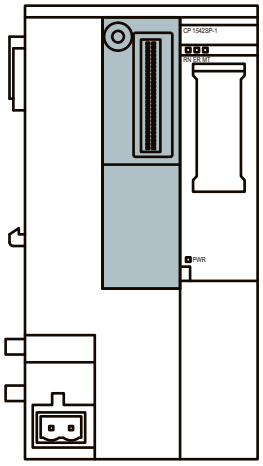

Figure 2-1361 Front of the CP, the slot for the bus adapter is marked gray.

You will find the bus adapters supported by the CP in section BusAdapter (Page 107).

For information on installing and connecting up, refer to the sections Installing the CP (Page 41) and Connecting the CP (Page 45).

You will find the pinout of the Ethernet interface in section BusAdapter (Page 107). You will find further technical specifications of the bus adapter in the manual /3/ ET 200SP Manual Collection (Page 116).

Installation, wiring, commissioning 3

3.1 Important notes on using the device

Safety notices on the use of the device

Note the following safety notices when setting up and operating the device and during all associated work such as installation, connecting up or replacing the device.

Overvoltage protection

NOTICE
Protection of the external power supply If power is supplied to the module or station over longer power cables or networks, the coupling in of strong electromagnetic pulses onto the power supply cables is possible. This can be caused, for example by lightning strikes or switching of higher loads. The connector of the external power supply is not protected from strong electromagnetic pulses. To protect it, an external overvoltage protection module is necessary. The requirements of EN61000-4-5, surge immunity tests on power supply lines, are met only when a suitable protective element is used. A suitable device is, for example, the Dehn Blitzductor BVT AVD 24, article number 918 422 or a comparable protective element. Manufacturer: DEHN+SOEHNE GmbH+Co.KG Hans Dehn Str.1 Postfach 1640 D-92306 Neumarkt, Germany

3.1.1 Notes on use in hazardous areas

⚠ WARNING
The device may only be operated in an environment with pollution degree 1 or 2 as described in EN/IEC 60664-1, GB/T 16935.1.

⚠ WARNING
EXPLOSION HAZARD You may only connect or disconnect cables carrying electricity when the power supply is switched off or when the device is in an area without inflammable gas concentrations.

3.1.2 Notes on use in hazardous areas according to ATEX / UKEX / IECEx / CCC-Ex

WARNING

Requirements for the cabinet

To comply with EU Directive 2014/34 EU (ATEX 114), UK Regulation SI 2016/1107 or the conditions of IECEx or CCC-Ex, the housing or cabinet must meet the requirements of at least IP54 (according to EN/IEC 60529, GB/T 4208) in compliance with EN IEC/IEC 60079-7, GB 3836.3.

WARNING

Suitable cables at high ambient temperatures in hazardous area

Use heat-resistant cables with an ambient temperature ≥ 60 °C; these cables must be rated for an ambient temperature that is at least 20 °C higher. The cable entries used on the housing must comply with the IP degree of protection required by EN IEC 60079-0 / GB 3836.1.

WARNING

Transient overvoltages

Take measures to prevent transient surges of more than 40% of the rated voltage. Under no circumstances may transient surges exceed 119 V. This is the case if you only operate devices with SELV (safety extra low voltage).

3.1.3 Notes on use in hazardous areas according to UL HazLoc and FM

This equipment is suitable for use in Class I, Division 2, Groups A, B, C and D or non-hazardous locations only.

This equipment is suitable for use in Class I, Zone 2, Group IIC or non-hazardous locations only.

WARNING

EXPLOSION HAZARD

Replacing components may impair suitability for Class 1, Division 2 or Zone 2.

WARNING

When used in hazardous environments corresponding to Class I, Division 2 or Class I, Zone 2, the device must be installed in a cabinet or a suitable enclosure.

WARNING

If the device is installed in a cabinet, the inner temperature of the cabinet corresponds to the ambient temperature of the device.

WARNING

EXPLOSION HAZARD

The equipment is intended to be installed within an ultimate enclosure. The inner service temperature of the enclosure corresponds to the ambient temperature of the module. Use installation wiring connections with admitted maximum operating temperature of at least 30 °C higher than maximum ambient temperature.

3.2 Installation, removal and repairs in hazardous areas

WARNING

Impermissible accessories and spare parts

Risk of explosion in hazardous areas

- Only use original accessories and original spare parts.
- Observe all relevant installation and safety instructions described in the manuals for the device or supplied with the accessories or spare parts.

WARNING

Unsuitable cables or connectors

Risk of explosion in hazardous areas

- Only use connectors that meet the requirements of the relevant type of protection.
- If necessary, tighten the connector screw connections, device fastening screws, grounding screws, etc. according to the specified torques.
- Close unused cable openings for electrical connections.
- Check the cables for a tight fit after installation.

WARNING

Improper installation of shielded cables

There is a risk of explosion due to equalizing currents between the hazardous area and the non-hazardous area.

- Ground shielded cables that cross hazardous areas at one end only.
- Lay a potential equalization conductor when grounding at both ends.

WARNING

Lack of equipotential bonding

If there is no equipotential bonding in hazardous areas, there is a risk of explosion due to equalizing current or ignition sparks.

- Ensure that equipotential bonding is available for the device.

WARNING

Unprotected cable ends

There is a risk of explosion due to unprotected cable ends in hazardous areas.

- Protect unused cable ends according to IEC/EN 60079-14.

WARNING

Insufficient isolation of intrinsically safe and non-intrinsically safe circuits

Risk of explosion in hazardous areas

- When connecting intrinsically safe and non-intrinsically safe circuits, ensure that the galvanic isolation is performed properly in compliance with local regulations (e.g. IEC 60079-14).
- Observe the device approvals applicable for your country.

WARNING

Unauthorized repair of devices in explosion-proof design

Risk of explosion in hazardous areas

- Repair work may only be performed by personnel authorized by Siemens.
- For function checks, maintenance and servicing work, you need to observe the requirements on checking and maintaining plants in hazardous areas according to the standards EN / IEC 60079-17.

3.3 Installing, connecting and commissioning

NOTICE

Improper mounting

Improper mounting may damage the device or impair its operation.

- Before mounting the device, always ensure that there is no visible damage to the device.
- Mount the device using suitable tools. Observe the information in the respective section about mounting.

WARNING

Open equipment

The devices are "open equipment" acc. to the standard IEC 61010-2-201 or UL 61010-2-201 / CSA C22.2 No. 61010-2-201. To fulfill requirements for safe operation with regard to mechanical stability, flame retardation, stability, and protection against contact, the following alternative types of installation are specified:

- Installation in a suitable cabinet.
- Installation in a suitable enclosure.
- Installation in a suitably equipped, enclosed control room.

3.3.1 Installing the CP

NOTICE

Install and remove the CP only when the power is off.

Switch off the power supply of the ET 200SP and the CP before you install or remove modules. Installing and removing modules with the power supply on can lead to damage to the modules and to loss of data.

NOTE

Observe installation guidelines

When installing and connecting up the CP note the instructions in the manual /3/ ET 200SP Manual Collection (Page 116).

NOTICE

Installation location - Dependency of the temperature range

The module must be installed so that its upper and lower ventilation slits are not covered, allowing adequate ventilation. Above and below the modules, there must be a clearance of 25 mm to allow air to circulate and prevent overheating.

Note the dependency of the permitted temperature range on the installation location:

- Horizontal installation of the rack (DIN rail) means vertical position of the CP.
- Vertical installation of the rack (DIN rail) means horizontal position of the CP.

You will find the permitted temperature ranges in the section Technical specifications of the CP 154xSP-1 (Page 96).

Installation of the rack	Installation position of the CP
Horizontal installation of the rack	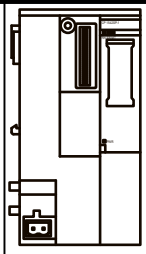
Vertical installation of the rack	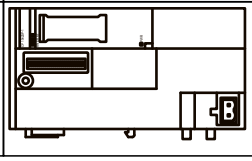

Slot rules

The CPU always occupies slot 1. In an ET 200SP you can plug in up to three of the following modules in slots 2 ... 4 (see figure) to the right of the CPU:

- CMs
- CPs
- BusAdapter Send

Of these three modules, up to two CP 154xSP-1 modules can be plugged in. These two CPs can be of the same type or different.

The CM DP can only be plugged in directly next to the CPU.

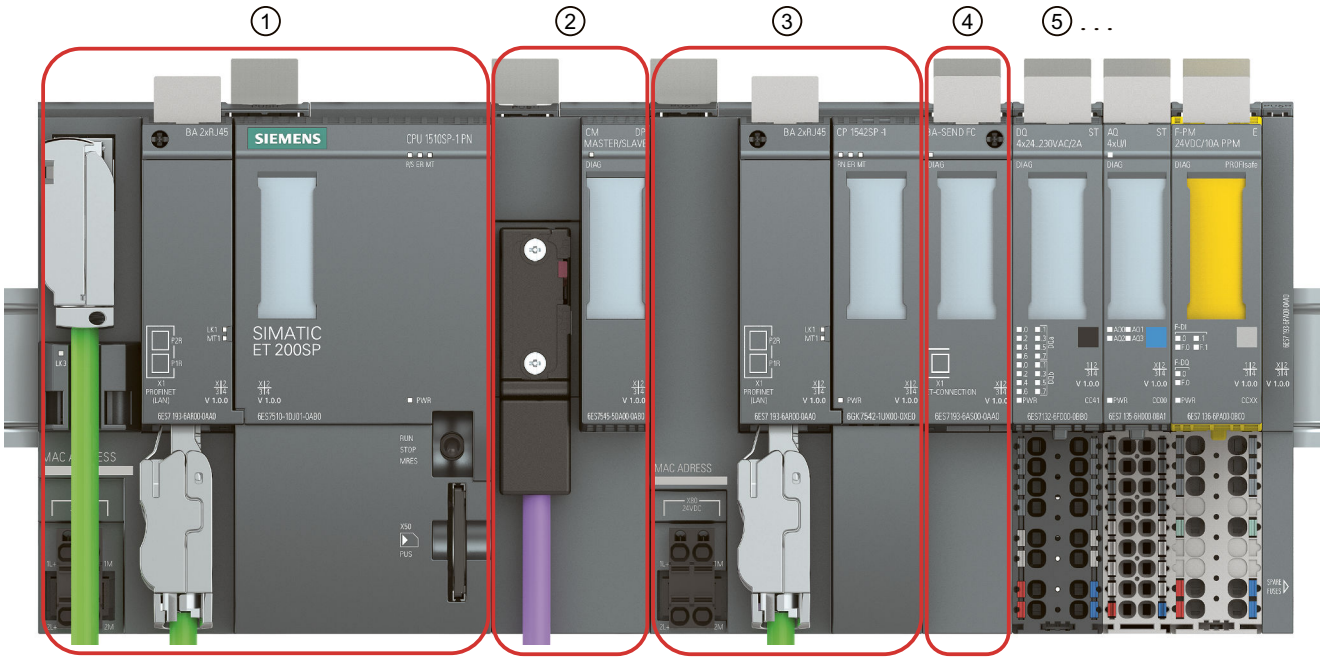

① Slot 1 - only permitted for the CPU.

② Slot 2 - for CM / CP / BusAdapter Send *
If you use a PROFIBUS CM, you must plug this in directly beside the CPU in slot 1.

③ Slot 3 - for CM / CP / BusAdapter Send *

④ Slot 4 - for CM / CP / BusAdapter Send *

⑤ Slot 5 ff for IO modules

* If you use a BusAdapter Send, this must be plugged in to the slot directly beside the IO modules.

Figure 2-1362 Slots of the ET 200SP

Installation on a DIN rail

NOTE

Protecting the modules from slipping on the DIN rail

If you install the modules in an area with mechanical load, use suitable clamping devices at both ends of the device group to secure the modules on the DIN rail, e.g. Siemens and retainer 8WA1808.

The end retainers prevent the modules separating under mechanical load.

When using the device in the areas of application ATEX or IECEx, note the information on the DIN rai in section Notes on use in hazardous areas according to ATEX / UKEX / IECEx / CCC-Ex (Page 38).

The ET 200SP system is suitable for installation on a mounting rail according to EN 60715 (35 × 7.5 mm or 35 × 15 mm)

1. Hang the CPU / the interface module on the mounting rail.
2. Tilt the CPU / the interface module to the back until the mounting rail release audibly locks in place.
3. Hang the CP to the right next to the CPU.
4. Tilt the CP to the back until the mounting rail release audibly locks in place.
5. Move the CP to the left until it audibly locks in place in the CPU.
6. Mount the other base units and modules accordingly.

   See manual /3/ ET 200SP Manual Collection (Page 116) for information on this.

Plugging in the bus adapter

NOTICE
Touching the plug-in contacts Do not touch the plug-in contacts when no bus adapter is plugged in.

1. Connect the appropriate cable to the bus adapter if you use a bus adapter with optical or direct electrical or optical connection (without plug).
2. Plug the bus adapter into the slot of the CP.

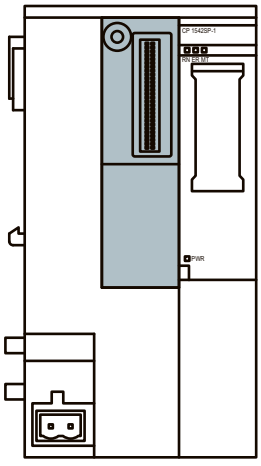

Figure 2-1363 Front of the CP, the slot for the bus adapter is marked gray.

3. Screw the bus adapter to the CP.

   The securing screw is located at the top left on the front of the bus adapter.

   To do this use a screwdriver with 3 to 3.5 mm blade width or a suitable Torx screwdriver (T15).

   The maximum tightening torque is 0.25 Nm.
4. Plug the connector of the connecting cable into the socket of the bus adapter if you use a bus adapter with plug.

For information on plugging in the bus adapter and fitting cables see also the manual /3/ ET 200SP Manual Collection (Page 116).

WARNING

Power supply

The device is designed for operation with a directly connectable safety extra low voltage (SELV) from a limited power source (LPS).

The power supply therefore needs to meet at least one of the following conditions:

- Only safety extra low voltage (SELV) with limited power source (LPS) complying with IEC 60950-1 / EN 60950-1 / VDE 0805-1 or IEC 62368-1 / EN 62368-1 / VDE 62368-1 may be connected to the power supply terminals.

If the equipment is connected to a redundant power supply (two separate power supplies), both must meet these requirements.

3.3.2 Connecting the CP

Order of the work

NOTICE

Connection only with power off

Connect the CP only when the power is off. Refer to the information in the system manual, see /2/ ET 200SP system manual (Page 116).

The bus adapter is already connected to the relevant cable, see section Installing the CP (Page 41).

1. Connect the external power supply to the terminal block of connector X80.

   Use the same power supply as the CPU.
2. Turn the power supply on only after the CP has been completely wired and connected.

Power supply at connector X80

You will find the location of the connector X80 four the power supply to the CP in section Power supply (Page 35). There, you will also find notes on reverse polarity protection..

The 2-terminal plug-in terminal block has the following pin assignment for the socket:

Terminal	Assignment
1L+ / 2L+	24 VDC
1M / 2M	Ground

The two terminals 1L+/L2+ and 1M/2m of the terminal block are each bridged internally so that you can connect either a single or a redundant power supply.

Connectable cable cross-section

- Without wire end ferrule 0.2 .. 2.5 mm^2 / AWG 24 .. 13
- With wire end ferrule 0.25 .. 1.5 mm^2 / AWG 24 .. 16
- With TWIN wire end ferrule: 0.5 .. 1.0 mm^2 / AWG 20 .. 17

You will find information about the power consumption and further technical details of the connectors in section Technical specifications (Page 96).

3.3.3 Commissioning the CP

Requirement: Configuration prior to commissioning

A prerequisite for full commissioning of the module is the completeness of the STEP 7 project data.

Commissioning the module

Further commissioning involves the following steps:

1. Compiling the project data
2. Downloading the STEP 7 project data to the device

   The STEP 7 project data of the CP is transferred when you load to the station.

   To load the station, connect the engineering station on which the project data is located to the CPU.

You will find more details in the STEP 7 information system in the section "Compiling and downloading project data".

NOTE

Time-of-day synchronization when using SINEMA RC

When the CP obtains the time from the CPU, set the CPU time manually during commissioning when using SINEMA Remote Connect; see note in section Commissioning the CP (Page 46).

Manual setting the time of day during commissioning

NOTE

Time-of-day synchronization when using Security / SINEMA RC

When using security functions, such as SINEMA Remote Connect, the CP needs the current time for authentication on the partner or on the SINEMA RC Server.

The CP receives the time from the CPU or from an NTP server before the connection is established for the first time.

Recommendation:

During commissioning, set the time of the CPU manually at least once using the STEP 7 online functions. This is necessary especially if you have configured the "Time from partner" option for the time synchronization. In this way, you ensure that the CPU has a valid time of day when the station starts up and that the CP can exchange the required certificates with the partner or the SINEMA RC Server.

3.4 Disassembly

⚠ WARNING

Improper disassembly

Improper disassembly may result in a risk of explosion in hazardous areas.

For proper disassembly, observe the following:

- Before starting work, ensure that the electricity is switched off.
- Secure remaining connections so that no damage can occur as a result of disassembly if the system is accidentally started up.

Removal from the DIN rail

Follow the steps below to remove a CP from the DIN rail:

1. Turn off the power supply to the entire station including the CP and CPU.
2. Activate the mounting rail release of the modules to be moved (CPU, CPs) and move them parallel to the left until they are released from the remaining module group (free space approx. 16 mm).

   Press the locking slide marked "PUSH" on the top of a module down to be able to move the module in the DIN rail.
3. Activate the mounting rail release on the CP and move it to the right until it is released from the CPU (free space approx. 8 mm).
4. While holding the mounting rail release on the CP, swing the CP out of the mounting rail.

Configuration 4

4.1 Security recommendations

Observe the following security recommendations to prevent unauthorized access to the system.

NOTE

Security functions of the CP types

Depending on the supported function, the following notes do not apply to every CP type.

General

- You should make regular checks to make sure that the device meets these recommendations and other internal security guidelines if applicable.
- Evaluate your plant as a whole in terms of security. Use a cell protection concept with suitable products.
- Do not connect the device directly to the Internet. Operate the device within a protected network area.
- Check regularly for new features on the Siemens Internet pages.
  - You can find information on Industrial Security here:
    Link: (http://www.siemens.com/industrialsecurity)
  - You can find a selection of documentation on the topic of network security here:
    Link: (https://support.industry.siemens.com/cs/ww/en/view/92651441)
- Keep the firmware up to date. Check regularly for security updates of the firmware and use them.

  Information regarding product news and new firmware versions is available at the following address:
  Link: (https://support.industry.siemens.com/cs/ww/en/ps/22144/dl)
  Link: (https://support.industry.siemens.com/cs/ww/en/ps/22143/dl)

Physical access

Restrict physical access to the device to qualified personnel.

Network attachment

Do not connect the PC directly to the Internet. If a connection from the CP to the Internet is required, arrange for suitable protection before the CP, for example a SCALANCE S with firewall or use the CP 1543SP-1.

Security functions of the product

Use the options for security settings in the configuration of the product. These includes among others:

- Protection levels and security functions of the CPU

  Configure access to the CPU under "Protection and Security".

  Use the other security functions of the CPU to prevent unauthorized access to the station.

  You will find information on this in the information system of STEP 7.
- Disabling BusAdapter ports

  In the configuration, disable a port of the BusAdapter being used that is not required.
- Security function of the communication
  - Enable the security functions of the CP and set up the firewall.

    If you connect to public networks, you should use the firewall. Think about the services you want to allow access to the station via public networks. By limiting the "transmission speed" via IP packet filter rules in the firewall, you make use of the possibility of restricting flooding and DoS attacks.
  - Use the secure protocol variants NTP (secure) and SNMPv3.
  - Use the security functions of the telecontrol protocols, e.g. the DNP3 security options.
  - Use the secure Open User Communication (Secure OUC) via the appropriate program blocks.
  - Leave access to the Web server of the CPU deactivated.
- Protection of the passwords for access to program blocks

  Protect the passwords stored in data blocks for the program blocks from being viewed. You will find information on the procedure in the STEP 7 information system under the keyword "Know-how protection".
- Logging function

  Enable the function in the security configuration and check the logged events regularly for unauthorized access.

Passwords

- Define rules for the use of devices and assignment of passwords.
- Regularly update the passwords to increase security.
- Only use passwords with a high password strength. Avoid weak passwords for example "password1", "123456789" or similar.
- Make sure that all passwords are protected and inaccessible to unauthorized personnel.

  See also the preceding section for information on this.
- Do not use one password for different users and systems.

Protocols

Secure and non-secure protocols

- Only activate protocols that you require to use the system.
- Use secure protocols when access to the device is not prevented by physical protection measures.

  The NTP protocol provides a secure alternative with NTP (secure).

Table: Meaning of the column titles and entries

The following table provides you with an overview of the open ports on this device.

- **Protocol / function**

  Protocols that the device supports.
- **Port number (protocol)**

  Port number assigned to the protocol.
- **Default of the port**
  - Open

    The port is open at the start of the configuration.
  - Closed

    The port is closed at the start of the configuration.
- **Port status**
  - Open

    The port is always open and cannot be closed.
  - Open after configuration

    The port is open if it has been configured.
  - Open (login, when configured)

    As default the port is open. After this port is configured, the communications partner needs to log in.
  - Closed after configuration

    The port is closed because the CP is always client for this service.
- **Authentication**

  Specifies whether or not the protocol authenticates the communications partner during access.

Table 2-1636 Server ports (all three CP types)

Protocol / function	Port number (protocol)	Default of the port	Port status	Authentication
S7 and online connections	102 (TCP)	Open	Open	No
HTTP	80 (TCP)	Closed	Open after configuration	Yes
HTTPS	443 (TCP)	Closed	Open after configuration	Yes
SNMP	161 (UDP)	Open	Open after configuration	No

Table 2-1637 Additional server ports with CP 1542SP-1 IRC and CP 1543SP-1

Protocol / function	Port number (protocol)	Default of the port	Port status	Authentication
SNMP	161 (UDP)	Open	Open after configuration	Yes (SNMPv3)
Communication via SINEMA RC	443 (TCP), 5243 (UDP)	Closed	Open after configuration	Yes
Online security diagnostics	8448 (TCP)	Closed *	Open after configuration *	Yes

* Some service providers consider the opening of port 102 a security vulnerability.
To avoid opening the port during online diagnostics, see section Online security diagnostics via port 8448 (CP 1542SP-1 IRC, CP 1543SP-1) (Page 87).

Table 2-1638 Additional server port with CP 1543SP-1

Protocol / function	Port number (protocol)	Default of the port	Port status	Authentication
IPsec	500 (UDP)	Closed	Open after configuration	Yes
	4500 (UDP)	Closed	Open after configuration	Yes

Table 2-1639 Additional server ports with CP 1542SP-1 IRC

Protocol / function	Port number (protocol)	Default of the port	Port status	Authentication
DNP3	20000 (TCP/UDP) Can be set	Closed	Open after configuration	Yes, when Secure Authentication is enabled.
DNP3 with TLS	19999 (TCP) Can be set	Closed	Open after configuration	Yes, when Secure Communication is enabled.
IEC 60870-5-104	2404 (TCP) Can be set	Closed	Open after configuration	Yes, when Secure Authentication is enabled.
IEC 60870-5-104 with TLS	19998 (TCP) Can be set	Closed	Open after configuration	Yes, when Secure Communication is enabled.

Ports of communication partners and routers

Make sure that you enable the required client ports in the corresponding firewall on the communication partners of the CP and in intermediary security modules.

These can be:

- TeleControl Basic / 55097 (TCP) - Can be set
- ST7 with MSC protocol / 26382 (TCP) - can be set
- DNS / 53 (UDP)
- DHCP / 67, 68 (UDP)
- SMTP / 25 (TCP)
- STARTTLS / 587 (TCP)
- SSL/TLS / 465 (TCP)
- NTP / NTP (secure) / 123 (UDP)

- SINEMA RC Autoconfiguration / 443 (TCP) - can be set
- SINEMA RC and OpenVPN / 1194 (UDP) - can be set in SINEMA RC
- IPSec / 500 (TCP) / 4500 (UDP)
- OpenVPN / 1194 (UDP)
- Syslog / 514 (UDP)

4.2 Configuration in STEP 7

Configuration in STEP 7

You configure the modules and networks in SIMATIC STEP 7. You will find the required version in the section Software requirements (Page 26).

NOTE

Configuration of the CP 1542SP-1 IRC

You will find a description of the basic configuration of the CP 1542SP-1 IRC in the following sections.

You will find a description of the configuration of telecontrol communication of the CP 1542SP-1 IRC in the relevant configuration manual, see /10/ TeleControl configuration manuals (Page 117).

Overview of configuration of the CP

Follow the steps below when configuring:

1. Create a STEP 7 project.
2. Insert the required SIMATIC stations from the following catalog directory:

   Controller > SIMATIC ET200 CPU > ET 200SP CPU
3. Insert the CPs and the input and output modules from the following catalog directory into the stations:

   Distributed I/O > ET 200SP

   You can configure a maximum of two CP 154xSP-1 for an ET 200SP.
4. Create an Ethernet network.
5. Connect the stations to the Ethernet subnet.
6. Configure the inserted CPs.

   When the device view of the CP is open, you can find the BusAdapters in a separate catalog directory.

   You will find detailed information about the security functions in the section Security (CP 1543SP-1) (Page 61).
7. Optional: Create the program blocks for the Open User Communication.
8. Save and compile the project.

Here you will find information on individual parameter groups in the following sections. You will find information on parameters not described in this manual in the information system of STEP 7.

Downloading the configuration data

When you load the station, the project data of the station including the configuration data of the CP is stored on the CPU.

You will find information on loading the station in the STEP 7 information system.

4.3 Communication types (CP 1543SP-1)

Validity: CP 1543SP-1

You will find the description of the CP 1542SP-1 IRC in the relevant configuration manual.

"Communication types" parameter group

To minimize the risk of unauthorized access to the station via Ethernet, you need to enable the following communications services for the CP.

- **Activate online functions**

  Enables access to the CPU for the online functions via the CP (diagnostics, loading project data etc.). If the function is enabled, the engineering station can access the CPU via the CP.

  If the option is disabled, you have no access to the CPU via the CP with the online functions. Online diagnostics of the CPU with a direct connection to the interface of the CPU however remains possible.

- **Enabling S7 communication**

  Enables the functions of S7 communication between the engineering station and the station CPU, as well as S7 routing.

  If you configure S7 connections to this station, and these run via the communications module, you need to enable this option for the communications module.

  Please note:
  Disabling this function means no security measure. To protect the station, use suitable security functions such as firewall, VPN or password protection of the CPU.

Open User Commmunication does not need to be enabled since you then need to create the relevant program blocks. Unintended access to the CP is therefore not possible.

4.4 Ethernet interface

4.4.1 Configuration and notes on operation

Configuration

Configure the generally available parameters just as for every other Ethernet interface:

- General data (name etc.)
- Addresses and possibly routers

  Note:
  When using SINEMA Remote Connect, the CP requires fixed IP addresses (IPv4/IPv6).
- Port settings
- Access to the Web server

Operation

NOTE

Sporadic IO device failures

If the internal switch of the CP interface is used for cyclic PROFINET communication, sporadic failures of the IO devices can occur.

4.4.2 IPv6

Manual configuration of IPv6 addresses

If you configure additional IPv6 addresses ("Manual configuration" option), make sure that the two IPv6 addresses belong to different subnets.

You will find information on configuration in the STEP 7 information system.

Communication partner and IPv6

NOTE

Internet communication via IPv6

If you want to use IPv6 addresses and connect the CP to the Internet, make sure that the router connected to the Internet and the providers of the Internet services used (e.g. e-mail) also support IPv6 addresses.

OUC communication via IPv6

When you use the Open User Communication blocks and activate IPv6, make sure that the communication partners support IPv6. In case of queries to the DNS server, the returned addresses primarily use IPv6 addresses before they use the IPv4 addresses.

4.4.3 Advanced options

Telecontrol-specific transmission settings of the CP 1542SP-1 IRC

You can find a description of telecontrol-specific transmission settings of the CP 1542SP-1 IRC in the relevant configuration manual, see Documentation references (Page 115).

BA ... (BusAdapter)

To connect to the Ethernet network, the CP requires a BusAdapter. A BusAdapter does not ship with the CP.

You will find the supported BusAdapters in appendix BusAdapter (Page 107).

Inserting a BusAdapter

As default setting, the CP uses a "BA 2xRJ45" BusAdapter.

If you are using a different BusAdapter, first go to the device view of the CP.

Open the "BusAdapter" directory on the right in the catalog and drag the BusAdapter to be used onto the interface of the CP. Insert the new BusAdapter via the "Change device" dialog.

Configuring the BusAdapter

In the "Ethernet interface > Advanced options > BA ..." parameter group of the CP, you configure the settings of the network connection via the BusAdapter.

If you do not use both ports of the BusAdapter, you can disable one of the two ports in the "Activate" parameter group.

4.4.4 Access to the Web server

Access to the Web server of the CPU

The Web server is located in the CPU. Via the CP, you have access to the Web server of the CPU.

From a PC you can access the Web server of the station if the PC is connected to the system network via LAN.

You will find information on the Web server of the ET 200SP in the manual /2/ ET 200SP system manual (Page 116).

4.5 Time-of-day synchronization

NOTE

Recommendation for setting the time

With Ethernet connections, synchronization with an external clock is recommended at intervals of approximately 10 seconds. This achieves as small a deviation as possible between the internal time and the UTC time.

NOTE

Consistent time-of-day synchronization via NTP / NTP (secure)

Up to firmware version V2.0 of the CP, both the CPU and CP can have the time of day synchronized using NTP. In this case, only have the time of day of the station from an external time source synchronized by a single module of the station so that a consistent time of day is maintained within the station.

Depending on the firmware version of the modules involved, the time-of-day of the CP is forwarded to the CPU in different ways:

- Forwarding of the CP time to the CPU using a PLC tag
- Forwarding of the CP time to the CPU via the backplane bus

Observe the section "Forwarding the time to the CPU" below.

Time-of-day synchronization of the CPs

The CPs support the following methods of time-of-day synchronization:

- CP 1542SP-1
  - NTP

    Configurable at the Ethernet interface
- CP 1543SP-1
  - NTP

    NTP with support of RFC5905

    NTP servers can be configured manually in the table.
  - NTP (secure)

    NTP with support of RFC5905 and RFC5906 with shared key

    NTP servers of the type NTP (secure) are configured in the global security settings and can be selected for the CP in the "Security > Time-of-day synchronization" parameter group.
- CP 1542SP-1 IRC
  - NTP
  - From WAN
  - From local station

  For details, refer to the configuration manuals Documentation references (Page 115).

Forwarding the time to the CPU

The forwarding of the CP time to the CPU depends on the firmware version of the CP and the CPU. Note the following behavior.

- **CP firmware ≤ V2.0**

  With this firmware version, the CP can make the time of day available to the CPU as an option via a PLC tag. When this PLC tag is read cyclically by the CPU, the CPU adopts the CP time.

  In the parameter group "Communication with the CPU", you can set whether or not the current time of day of the CP will be made available to the CPU via a PLC tag. For PLC tags, see parameter group "Communication with the CPU" of the CP.

  See section Communication with the CPU (Page 59) for more on this.

  When the CPU takes the time from the CP using a PLC tag, disable the CPU's time-of-day synchronization.

- **CP firmware ≥ V2.1**

  As of this firmware version of the CP, only one module in the station can be time master. This module distributes the time of day within the station.

  Since the CPU automatically adopts the CP time, you no longer require the forwarding option using the PLC tag for these firmware versions.

If you want to have the time of the station synchronized via the CPU, disable the time-of-day synchronization for the CP.

Time-of-day synchronization with NTP

Configure the following parameters:

- The addresses of the NTP server(s)
- The "Accept time from non-synchronized NTP servers" option
- Synchronization cycle

Time-of-day synchronization with enabled security functions

NOTE

Ensuring a valid time of day

If you use security functions, a valid time of day is required. It is recommended to use the NTP (secure) method with support of RFC5905 and RFC5906.

NOTE

Manually setting the time of day during commissioning

If you use security functions or SINEMA RC, set the time manually during commissioning; see section Commissioning the CP (Page 46).

- **NTP / NTP (secure)**

  The secure method NTP (secure) uses authentication with symmetrical keys. Various configurable hash algorithms are available for the integrity check.

  In the global security settings, you can create and manage NTP servers of the type NTP (secure).

"Time" parameter group: UTC and time zone settings

Validity:

The functions of this parameter group are valid for:

- CP 1542SP-1 / CP 1542SP-1 IRC / CP 1543SP-1 as of firmware version V2.3

Parameters:

- Take time zone values with daylight saving time from PLC

  When the option is enabled, the communications module takes the time zone from the CPU.

  When the option is disabled, the time zone of the communications module can be configured independent of the CPU.
- Time zone

  Here you set the UTC time zone that the communications module will use.
- Use UTC

  Only valid for CP 1542SP-1 IRC with ST7 or IEC 60870-5 protocol; see configuration manual.

If the communications module does not take the time from the CPU, you can configure the changeover between daylight saving time and standard time:

- Activate daylight saving time

  Enables the time changeover (daylight saving/standard time)
- Difference between standard and daylight saving time

  Time difference in minutes between standard and daylight-saving time

  Default setting: 60 minute time offset for daylight-saving time
- Start of daylight saving time / standard time

  Here you configure when each time changeover starts:

  – Week of the month

    Example:
    "First" means "First Sunday in March", if "Sunday" is configured as weekday and "March" as month.

  – Weekday

  – "in" = Month

  – "at" = time of changeover

4.6 DNS configuration

DNS server

A DNS server may be required when the module itself, a communications partner, or an NTP or e-mail server, for example, should be reachable via the host name (FQDN).

When addressing a communications partner as FQDN, you need to configure a DNS server. The IP address (IPv4/IPv6) of the communications partner is then determined via the configured DNS server.

When using IPv6 addresses, make sure to configure the DNS servers accordingly.

4.7 Communication with the CPU

Validity: CP 1542SP-1 / CP 1543SP-1

You will find the description of the CP 1542SP-1 IRC in the relevant configuration manual.

Watchdog bit

- **CP monitoring**

  The CP checks the connection with the CPU via the watchdog bit.

  The CP transfers the bit to the CPU every 5 seconds and resets it in the next CPU sampling cycle. The bit is not transferred in the event of connection faults. This signals the connection fault to the CPU.

  The PLC tag of the watchdog bit must be evaluated by the user program.

CP time

- **CP time to CPU**

  The function allows the CPU to read the time of day of the CP. Using this approach, the CP can synchronize the CPU time.

  Procedure:

  – The CPU sets the input "Time trigger variable" (BOOL) to 1 with the user program.
  – The CP then writes its time to the "CP time variable" (DTL) and resets the "Time trigger variable" value to 0.
  – The user program reads the "CP time variable" to set the CPU time.

  Recommendation:
  Set the "Time trigger variable" no more frequently than once per second to avoid placing an unnecessary communication load on the backplane bus.

NOTE

Refer to the information in the section Time-of-day synchronization (Page 55).

CP diagnostics

With the parameter group, you have the option of reading out advanced diagnostics data from the CP.

- **Enable advanced CP diagnostics**

  Enable the option to use advanced CP diagnostics.

  If the option is enabled, at least the "Diagnostics trigger tag" must be configured.

  The following PLC tags for the individual items of diagnostics data can be enabled selectively.

- **Diagnostics trigger tag**

  If the PLC tag (BOOL) from the user program of the CPU is set to 1, the CP updates the values of the following PLC tags for the advanced diagnostics.

  After writing the current values to the following PLC tags, the CP sets the "Diagnostics trigger tag" to 0, signaling to the CPU that the updated values can be read from the PLC tags.

NOTE

Fast setting of the diagnostics trigger tag

Trigger should not be set more often than once per second.

Variable for CP 1542SP-1 and CP 1543SP-1:

- **Current IP address**

  PLC tag (data type String) for the current IP address of the interface of the CP.

Variables only for CP 1543SP-1:

- **VPN IPsec status**

  The PLC tag (BOOL) indicates whether a VPN IPsec tunnel is established:

  – 0 = No tunnel established

  – 1 = Tunnel established

- **Connection to SINEMA Remote Connect**

  The PLC tag (BOOL) indicates whether an OpenVPN tunnel to SINEMA RC is established:

  – 0 = No tunnel established

  – 1 = Tunnel established

4.8 SNMP

"SNMP" parameter group

- "**Enable SNMP**" parameter group

  Releases the function of the SNMP agent on the CP.

Scope of performance of the CPs

The CPs support the following SNMP version:

- **CP 1542SP-1**
  - SNMPv1
- **CP 1543SP-1, CP 1542SP-1 IRC**
  - SNMPv1
  - SNMPv3 (with activated Security functions)

  If the security functions are enabled, you will find the parameter group "SNMP" under "Security".

Traps are not supported by the CP.

You will find detailed information about the supported functions in the section Diagnostics with SNMP (Page 88).

4.9 Security (CP 1543SP-1)

Security functions of the CP 1542SP-1 IRC

You can find a description of the security functions of the CP 1542SP-1 IRC in the configuration manual of the respective telecontrol protocol, see Documentation references (Page 115).

Security functions of the CP 1543SP-1

The following description of the security functions only applies to the CP 1543SP-1.

For an overview of the functions, refer to the section Application and functions (Page 11).

To be able to configure the security functions, you need to create a security user; see section Security user (Page 62).

4.9.1 Security user

Creating a security user

You need the relevant configuration rights to be able to configure security functions. For this purpose, you need to create at least one security user with the corresponding rights.

Navigate to the global security settings > "User and roles" > "Users" tab.

1. Create a user and configure the parameters.
2. Assign this user the role "NET Administrator" in the "Assigned roles" area below.

After logging on, this user can make the necessary settings in the STEP 7 project.

In the future, continue to log on as this user when working on security parameters.

4.9.2 Firewall

4.9.2.1 Pre-check of messages by the MAC firewall.

Each incoming or outgoing frame initially runs through the MAC firewall (layer 2). If the frame is discarded at this level, it will not be checked by the IP firewall (layer 3). This means that with suitable MAC firewall rules, IP communication can be restricted or blocked.

4.9.2.2 Settings for online security diagnostics and downloading to station with the firewall activated

NOTE

Additional services for online security diagnostics and download

If you wish to use the "Online security diagnostics" or "Download to device" functions, you need to create additional rules or disable the "Echo Request" / "Echo Reply" services.

Setting the firewall for online functions

With the security functions enabled, follow the steps outlined below.

Global security functions:

1. Select the entry "Firewall > Services > Define services for IP rules".
2. Select the "ICMP" tab.
3. Insert a new entry of the type "Echo Reply" and another of the type "Echo Request".

Local security functions of the CP:

Now select the CP in the S7 station.

1. Enable the advanced firewall mode in the local security settings of the CP in the "Security > Firewall" parameter group.
2. Open the "IP rules" parameter group.

3. In the table, insert a new IP rule for the previously created global services as follows:
   - Action: Accept; From:: External; To: Station; Service > ICMPv4/6 service > Echo Request (the previously globally created service)
   - Action: Accept; From:: Station; To: External; Service > ICMPv4/6 service > Echo Reply (the previously globally created service)
4. For the IP rule for the "Echo Request" service, enter the IP address of the engineering station under "Source IP address".

With these rules, the CP can only be reached from the engineering station with ICMP packets (ping) via the firewall.

4.9.2.3 Notation for the source IP address (advanced firewall mode)

If you specify an address range for the source IP address in the advanced firewall settings of the CP, make sure that the notation is correct:

- Separate the two IP addresses only using a hyphen.

  Correct: 192.168.10.0-192.168.10.255
- Do not enter any other characters between the two IP addresses.

  Incorrect: 192.168.10.0 - 192.168.10.255

If you enter the range incorrectly, the firewall rule will not be used.

4.9.2.4 Firewall settings for S7 connections via a VPN tunnel

IP rules in advanced firewall mode

If you set up configured connections (S7, OUC) with a VPN tunnel between the CP and a communications partner, you will need to adapt the local firewall settings of the CP:

In advanced firewall mode ("Security > Firewall > IP rules") select the action "Allow*" for both communications directions of the VPN tunnel.

4.9.3 Log settings - Filtering of the system events

Communications problems if the value for system events is set too high

If the value for filtering the system events is set too high, you may not be able to achieve the maximum performance for the communication. The high number of output error messages can delay or prevent the processing of the communications connections.

In "Security > Log settings > Configure system events", set the "Level:" parameter to the value "3 (Error)" to ensure the reliable establishment of the communications connections.

4.9.4 E-mail configuration

Requirements and necessary information

Note the following requirements in the CP configuration for the transfer of e-mails:

- The security functions are enabled.
- The time of the CP is synchronized.

For the configuration, you require the data of the SMTP server and the user account:

- Server address, port number, user name, password, e-mail address of the sender (CP)
- With encrypted transfer: Server certificate

E-mail configuration

- **No configuration**

  As default, the sending of e-mails is disabled.
- **Activate SMTP**

  Enable this option if you want to use the sending of unencrypted e-mails via SMTP port 25.
- **Enable SSL/TLS**

  If your e-mail service provider only supports encrypted transfer, enable this option. Select the protocol via the port number:

  – Port no. 587

    When using STARTTLS the CP sends encrypted e-mails.

  – Port no. 465

    When using SSL/TLS (SMTPS) the CP sends encrypted e-mails.

  Ask your e.mail service provider which option is supported.

  If you want to use an Internet connection with an IPv6 infrastructure, note the information in the section IPv6 (Page 54).

See also

Character set for e-mail server and messages (CP 1543SP-1) (Page 78)

4.9.5 VPN

4.9.5.1 VPN (Virtual Private Network)

VPN - IPsec

Virtual Private Network (VPN) is a technology for secure transportation of confidential data in public IP networks, for example the Internet. With VPN, a secure connection (IPsec tunnel) is set up and operated between two secure IT systems or networks via a non-secure network.

The IPsec tunnel forwards all data even from protocols of higher layers (HTTP, FTP, etc.).

The data traffic between two network components is transported unrestricted through another network. This allows entire networks to be connected together via a neighboring or intermediate network.

Properties

- VPN forms a logical subnet that is embedded in a neighboring (assigned) network. VPN uses the usual addressing mechanisms of the assigned network, however in terms of the data, it transports its own frames and therefore operates independent of the rest of this network.
- VPN allows communication of the VPN partners with the assigned network.
- VPN is based on tunnel technology and can be individually configured.
- Communication between the VPN partners is protected from eavesdropping or manipulation by using passwords, public keys or a digital certificate (authentication).

Areas of application

- Local area networks can be connected together securely via the Internet ("site-to-site" connection).
- Secure access to a company network ("end-to-site" connection)
- Secure access to a server ("end-to-end" connection)
- Communication between two servers without being accessible to third parties (end-to-end or host-to-host connection)
- Ensuring information security in networked automation systems
- Securing the computer systems including the associated data communication within an automation network or secure remote access via the Internet
- Secure remote access from a PC/programming device to automation devices or networks protected by security modules via public networks.

Cell protection concept

With Industrial Ethernet Security, individual devices or network segments of an Ethernet network can be protected:

- Access to individual devices and network segments protected by security modules is allowed.
- Secure connections via non-secure network structures becomes possible.

Due to the combination of different security measures such as firewall, NAT/NAPT routers and VPN via IPsec tunnels, security modules protect against the following:

- Data espionage
- Data manipulation
- Unwanted access

4.9.5.2 SINEMA Remote Connect

Remote maintenance with SINEMA Remote Connect (SINEMA RC)

The application "SINEMA Remote Connect" (SINEMA RC) is available for remote maintenance purposes.

SINEMA RC uses OpenVPN for encryption of the data. The center of the communication is SINEMA RC Server via which communication runs between the subscribers and that manages the configuration of the communications system.

Preparatory steps

Execute the following steps before start configuring the SINEMA RC connection of the module in STEP 7. They are the prerequisite for a consistent STEP 7 project.

- Configuration of SINEMA Remote Connect Server

  Configure SINEMA RC Server as necessary (not in STEP 7). The communications module and its communications partners must be configured in the SINEMA RC Server.

- Exporting the CA certificate (optional)

  If you want to use the server certificate as authentication method of the communications module during connection establishment, export the CA certificate from SINEMA RC Server.

  Then import the CA certificate from SINEMA RC Server to the engineering station.

  Alternatively, you can use the fingerprint of the server certificate as authentication method of the communications module. The fingerprint's duration of validity may be shorter than that of the certificate.

  Please note that you need to repeat the import of a certificate in the event of a module replacement.

Configuration of SINEMA Remote Connect

Importing your own certificate

1. On the CP, navigate to the parameter group "Security > Certificate manager > Certificates of the partner devices".
2. Open the certificate selection dialog with a double-click on the first free table row.
3. Select the CA certificate of SINEMA RC Server.

Then navigate to the parameter group "Security > VPN".

VPN > General

1. Activate VPN
2. As "VPN connection type", select the option "Automatic OpenVPN configuration via SINEMA Remote Connect Server" if you wish to use communication via SINEMA Remote Connect.

SINEMA Remote Connect Server

Enter the address and port number of the server.

Server Verification

Here you select the authentication method of the communications module during connection establishment.

- CA Certificate

  Under "CA certificate", select the CA certificate from SINEMA RC Server that was previously imported and assigned in the local certificate manager.

  The module generally checks the CA certificate of the server and its validity period. The two options cannot be changed.

- Fingerprint

  When you select this authentication method, you enter the fingerprint of the server certificate of SINEMA RC Server.

Authentication

- Device ID

  Enter the device ID generated for the module in SINEMA RC.

- Device password

  Enter the device password of the module configured in SINEMA RC.

  Max. number of characters: 127

Optional settings

The connection establishment is configured in the "Security > VPN > Optional settings" parameter group with the parameter "Connection type".

- **Update interval**

  With this parameter you set the interval at which the CP queries the configuration on the SINEMA RC Server.

  Note that with the setting 0 (zero) changes to the configuration of the SINEMA RC Server may result in the CP no longer being capable of establishing a connection to the SINEMA RC Server.

- **"Connection type"**

  The two options of the parameter have the following effect on the connection establishment:

  – Auto

    The module establishes a connection to the SINEMA RCServer. The OpenVPN connection is retained until the connection parameters are changed by the SINEMA Remote Connect Server. If the connection is interrupted, the CP automatically re-establishes the connection.

    If the connection parameters are changed by the SINEMA Remote Connect Server, the CP requests the new connection data after the update interval configured above has elapsed.

  – PLC trigger

    The option is intended for sporadic communication of the module via the SINEMA RC Server.

    You can use this option when you want to establish temporary connections between the module and a PC. The temporary connections are established via a PLC tag and can be used in servicing situations, for example.

NOTE

Connection abort

With a STOP of the CPU, for example due to a firmware update or "Download to device", the OpenVPN connection is aborted.

These functions can only be used when the "Auto" option is enabled.

- **PLC tag for connection establishment**

  If the option "PLC trigger" is selected, the module establishes a connection when the PLC tag (Bool) changes to the value 1. During operation the PLC tag can be set when necessary, for example using an HMI panel.

  When the PLC tag is reset to 0, the connection is terminated again.

4.9.5.3 Creating a VPN tunnel for S7 communication between stations

Requirements

To allow a VPN tunnel to be created for S7 communication between two S7 stations or between an S7 station and an engineering station with a security CP, the following requirements must be met:

- The two stations have been configured.
- The CPs in both stations must support the security functions.
- The Ethernet interfaces of the two stations must be networked.

NOTE

Communication also possible via an IP router

Communication between the two stations is also possible via an IP router. To use this communications path, however, you need to make further settings.

Procedure

To create a VPN tunnel, you need to work through the following steps:

1. Creating a security user

   If the security user has already been created: Log on as this user.
2. Enable the "Activate security features" option
3. Creating the VPN group and assigning security modules
4. Configure the properties of the VPN group
5. Configure local VPN properties of the two CPs

You will find a detailed description of the individual steps in the following paragraphs of this section.

Enable security functions

After logon, enable the "Activate security features" option on both CPs under "Security".

You now have the security functions available for both CPs.

Creating the VPN group and assigning security modules

1. In the global security settings, navigate to "VPN groups" > "Add new VPN group".
2. Double-click on the entry "Add new VPN group", to create a VPN group.

   Result: A new VPN group is displayed below the selected entry.
3. Double-click on the "VPN groups" > "Assign module to a VPN group" entry.
4. Assign the security modules between which VPN tunnels will be established to the VPN group.

NOTE

Current date and current time on the CP for VPN connections

To establish a VPN connection and for the associated recognition of the certificates to be exchanged, the current date and the current time are required on both stations.

Configure the properties of the VPN group

1. Double-click on the newly created VPN group.

   Result: The properties of the VPN group are displayed under "Authentication".
2. Enter a name for the VPN group. Configure the settings of the VPN group in the properties.

   These properties define the default settings of the VPN group that you can change at any time.

NOTE

Specifying the VPN properties of the CPs

You specify the VPN properties of the CPs in the "Security" > "Firewall" > "VPN" parameter group of the relevant module.

Result

You have created a VPN tunnel. The firewalls of the CPs are activated automatically: The "Activate firewall" check box is selected by default when you create a VPN group. You cannot disable the option.

Download the configuration to all modules that belong to the VPN group.

4.9.5.4 VPN communication with SOFTNET Security Client (engineering station)

VPN tunnel communication works only if the internal node is disabled

Under certain circumstances the establishment of VPN tunnel communication between SOFTNET Security ClientSOFTNET Security Client and the CP fails.

SOFTNET Security Client also attempts to establish VPN tunnel communication to a lower-level internal node. This communication establishment to a non-existing node prevents the required communication being established to the CP.

To establish successful VPN tunnel communication to the CP, you need to disable the internal node.

Use the procedure for disabling the node as explained below only if the described problem occurs.

Disable the node in the SOFTNET Security Client tunnel overview:

1. Remove the checkmark in the "Enable active learning" check box.

   The lower-level node initially disappears from the tunnel list.
2. In the tunnel list, select the required connection to the CP.
3. With the right mouse button, select "Enable all members" in the shortcut menu.

   The lower-level node appears again temporarily in the tunnel list.
4. Select the lower-level node in the tunnel list.
5. With the right mouse button, select "Delete entry" in the shortcut menu.

Result: The lower-level node is now fully disabled. VPN tunnel communication to the CP can be established.

4.9.5.5 Establishment of VPN tunnel communication between the CP and SCALANCE M

Create a VPN tunnel between the CP and a SCALANCE M router as described for the stations.

VPN tunnel communication will only be established if you have selected the check box "Perfect Forward Secrecy" in the global security settings of the created VPN group ("VPN groups > Authentication").

If the check box is not selected, the CP rejects establishment of the tunnel.

4.9.5.6 CP as passive subscriber of VPN connections

Setting permission for VPN connection establishment with passive subscribers

If the CP is connected to another VPN subscriber via a gateway, you need to set the permission for VPN connection establishment to "Responder".

This is the case in the following typical configuration:

VPN subscriber (active) ⇔ gateway (dyn. IP address) ⇔ Internet ⇔ gateway (fixed IP address) ⇔ CP (passive)

Configure the permission for VPN connection establishment for the CP as a passive subscriber as follows:

1. In STEP 7, go to the devices and network view.
2. Select the CP.
3. Open the parameter group "VPN" in the local security settings.
4. For each VPN connection with the CP as a passive VPN subscriber, change the default setting "Initiator/Responder" to the setting "Responder".

4.9.6 SNMP

SNMP

You will find the range of functions of the device for SNMP in the section Diagnostics with SNMP (Page 88).

If the security functions are enabled, you have the following selection and setting options.

SNMP

- **"Enable SNMP"**

  If the option is enabled, communication via SNMP is released on the device. As default, SNMPv1 is enabled.

  If the option is disabled, queries from SNMP clients are not replied to either via SNMPv1 or via SNMPv3.

- **"Use SNMPv1"**

  Enables the use of SNMPv1 for the device. For information on the configuration of the required community strings see below (SNMPv1).

- **"Use SNMPv3"**

  Enables the use of SNMPv3 for the device. For information on the configuration of the required algorithms see below (SNMPv3).

SNMPv1

The community strings need to be sent along with queries to the device via SNMPv1.

Note the use of lowercase letters with the preset community strings!

- **"Reading community string"**

  The string is required for read access.

  Leave the preset string "public" or configure a string.
- **"Allow write access"**

  If the option is enabled write access to the device is released and the corresponding community string can be edited.
- **"Writing community string"**

  The string is required for write access and can also be used for read access.

  Leave the preset string "private" or configure a string.

NOTE

Security of the access

For security reasons, change the preset and generally known strings "public" and "private".

SNMPv3

The algorithms need to be configured for encrypted access to the device via SNMPv3.

- **"Authentication algorithm"**

  Select the authentication method to be used from the drop-down list.
- **"Encryption algorithm"**

  Select the encryption method to be used from the drop-down list.

User management

In the user management that you will find in the global security settings, assign the various users their role.

Below the properties of the roles you can see the rights list of the particular role, for example the various types of access using SNMP. For new roles, you can freely configure individual rights.

You will find information on users, roles and the password policy in the information system of STEP 7.

4.9.7 Certificate manager

If the security functions are enabled, the certificates for all security modules involved are generated in the STEP 7 project, for example to allow communication via VPN connections.

Certificates generated by STEP 7 such as SSL certificates or VPN group certificates are automatically assigned to the corresponding modules and do not need to be assigned using the local security settings.

The local certificate manager

Certificates that were imported via the certificate manager in the global security settings are not automatically assigned to the corresponding modules. Imported certificates must be included in the list of trustworthy partner certificates manually via the "Certificate manager" entry in the local security settings. When assigning a CA certificate the module is also assigned the certificates derived from it.

Adding certificates

Via the local certificate manager, assign certificates of the partners to the CP for certain services, e.g. secure sending of e-mails.

1. To do this, click the table cell "Add new".
2. Click on the button on a white background "...".
3. In the certificate list that opens, you can either add a new certificate using the "Add" button or select an existing certificate of the project using the check mark symbol.

   You can recognize the properties of the displayed certificates in the global certificate manager.

Certificates for the CP 1543SP-1

Before certificates can be referenced in the program blocks for Secure Communication, these certificates must be assigned to the Security module as device certificates via the local certificate manager.

Requirement in the global security settings

To be able to assign the CP certificate of a communications partner, you need to first import the certificates of the partner in the global certificate manager (Global security settings).

To make the assigned certificate known to the partner module, this certificate must be entered in the list of trustworthy partner certificates after import.

Assign the certificates in the CP configuration

Select the following certificates in the CP configuration:

- Table "Device certificates":

  The device certificate of the CP generated by STEP 7
- Table "Certificates of the partner devices":

  The imported certificate of the partner

4.10 Messages: E-mails (CP 1542SP-1 IRC / CP 1543SP-1)

Validity

Validity: CP 1543SP-1

You will find the description of the CP 1542SP-1 IRC in the relevant configuration manual.

NOTE

E-mails via the message editor

The following information applies to e-mails configured with the message editor.

Sending e-mails via OUC program blocks is not affected.

Requirements

If important events occur, the CP can send e-mails to communications partners.

Note the following requirements in the CP configuration for the transfer of e-mails:

- The security functions are enabled.
- The time of the CP is synchronized.
- Configuring the "E-mail configuration" parameter group

You require the recipient addresses to configure the messages.

Open the message editor

You configure the individual messages (e-mails) in the message editor in STEP 7.
Alternatively, you can open the editor:

- By selecting the CP

  Shortcut menu "Open the data point and messages editor"
- Via the project navigation:

  Station > "Local modules" > CP > Messages

  Double-clicking on the "Messages" entry opens the editor.

Creating messages

You create a new message by double clicking "<Add>" in the first table row with the grayed-out entry.

You can change the default name of an e-mail, "Alarm", but it must be unique within the module.

Message parameters

Here you configure the recipient, the subject and the text of the message.

Trigger: Triggering e-mail transfer

In the "Trigger" tab, you configure when sending of an e-mail is triggered and whether additional information is sent with it.

- **E-mail trigger**

  Specifies the event on which the sending of the e-mail is triggered:

  – Use PLC tag

    For the trigger signal to send the e-mail, the edge change (0 → 1) of the trigger bit "PLC tag for trigger" that is set by the user program is evaluated. When necessary, a separate trigger bit can be configured for each e-mail. For information on the trigger bit, see below.

    Resetting the trigger bit:
    If the memory area of the trigger bit is in the memory area or in a data block, the trigger bit is reset to zero when the message is sent.
    In all other cases, you need to reset the trigger bit with the user program.

    NOTE
    Fast setting of the diagnostics trigger tag
    Trigger should not be set more often than once per second.

  – CPU changes to STOP

  – CPU changes to RUN

  The following entries can be selected depending on the VPN configuration:

  – VPN connection established

  – VPN connection terminated

  or

  – SINEMA RC connection established

  – SINEMA RC connection terminated

- **PLC tag for trigger**

  Variable (Bool) for the e-mail trigger "Use PLC tag"

- **Enable identifier for processing status**

  If the option is enabled, every attempt to send returns a status with information about the processing status of the sent message.

  The status is written to the "PLC tag for processing status" (DWORD). If there are problems delivering messages, you can determine the status via the Web server of the CPU by displaying the value of the PLC tag there.

  For information on the significance of the individual statuses, see section Processing status of e-mails (CP 1543SP-1) (Page 91).

- **Include value**

  If you enable the option, the CP sends a value for the placeholder $$ from the memory area of the CPU in the message.

  Select a PLC tag whose value is integrated in the message. $$ can be the placeholder for a variable with a simple data type up to a size of 32 bits.

The respective current value is entered in the message text instead of the placeholder $$. To do this enter "$$" as a placeholder for the value to be sent in the message text.

Editor view: Arranging columns and rows

As with many other programs, you can also arrange the columns and sort the table according to your needs in the message editor:

- Arranging columns

  If you click on a column header with the left mouse button pressed, you can move the column.

- Sorting objects

  If you click briefly with the left mouse button on a column header, you can sort the objects of the table in ascending or descending order according to the entries in this column. The sorting is indicated by an arrow in the column header.

  After sorting in descending order of a column the sorting can be turned off by clicking on the column header again.

- Adapting the column width

  You can reach this function with the following actions:

  – Using the shortcut menu that opens when you right-click on a column header:

    "Optimize width", "Optimize width of all columns"

  – If you move the cursor close to the limit of a column header, the following symbol appears:

    When it does, double-click immediately on the column header. The column width adapts itself to the broadest entry in this column.

- Showing/hiding columns

  You call this function using the shortcut menu that opens when you right-click on a column header.

Copy messages

If you right-click in the row of an object in the table, you can access the following copy functions from the shortcut menu:

- Cut
- Copy
- Paste

  You can paste cut or copied objects within the table or in the first free row below the table.

  You can also paste cut or copied objects into tables of other communications modules of the same type.

- Delete

If you hold down the <Ctrl> key, you can select several rows that are not contiguous.

If you hold down the <Shift> key, you can select the beginning and the end of a contiguous area.

4.11 Character set for e-mail server and messages (CP 1543SP-1)

Character set for message texts

The following ASCII character set (hexadecimal value and character name) is supported for the texts:

- 0x0A

  LF (line feed)
- 0x0D

  CR (carriage return)
- 0x20

  Space
- 0x21 ... 0x5A

  ! " # $ % & ' ( ) * + , - . / 0 1 2 3 4 5 6 7 8 9 : ; < = > ? @ A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
- 0x5F

  £
- 0x61 ... 0x7A

  a b c d e f g h i j k l m n o p q r s t u v w x y z

Program blocks

5

5.1 Program blocks for OUC

Program blocks for Open User Communication (OUC)

Connections of Open User Communication are not configured.

For TCP / UDP / ISO-on-TCP communication via Ethernet, the blocks of Open User Communication (OUC) listed below are used. For this, create a suitable program blocks. You will find details on the program blocks in the information system of STEP 7.

NOTE

Program block versions

Note that in STEP 7 you cannot use different versions of a program block in a station.

NOTE

Personal data unencrypted in TMAIL_C

Note that TMAIL_C uses personal data, such as user name and password, in its parameters. This data is stored unencrypted in a data block.

Program blocks

Together with the three CP types, the following OUC blocks with the specified minimum version are available to the CPU:

- **TSEND_C V3.0 / TRCV_C V3.0**

  Compact blocks for:

  – Connection establishment/termination and sending data

  – Connection establishment/termination and receiving data

As an alternative, use:

- **TCON V4.0 / TDISCON V2.1**

  Connection establishment / connection termination

- **TUSEND V4.0 / TURCV V4.0**

  Sending and receiving data via UDP

- **TSEND V4.0 / TRCV V4.0**

  Sending and receiving data via TCP or ISOonTCP
- **TMAIL_C V4.0**

  Sending e-mails

  To transfer encrypted e-mails with this block, the precise time of day is required on the CP. Configure the time-of-day synchronization.

For changing configuration data of the CP during runtime:

- **T_CONFIG V1.0**

  Program-controlled configuration of the IP parameters

  See section Changing the IP parameters during runtime (Page 82) for more on this.

The program block can be found in STEP 7 in the "Instructions > Communication > Open User Communication" window.

Connection descriptions in system data types (SDTs)

For the connection description, the blocks listed above use the parameter CONNECT (or MAIL_ADDR_PARAM with TMAIL_C). The connection description is stored in a data block whose structure is specified by the system data type (SDT).

Creating an SDT for the data blocks

Create the SDT required for every connection description as a data block (global DB).

The SDT type is not created by selecting an entry from the "Data type" drop-down list in the declaration table of the block, but by entering the name manually in the "Data type" box, for example "TCON_IP_V4". The corresponding SDT is then created with its parameters.

SDTs

Depending on the CP-specific security functions, the three CP types support the following SDTs:

- **SDTs for all three CP types**
  - **TCON_IP_V4**

    For transferring data via TCP or UDP
  - **TCON_QDN**

    For TCP or UDP communication via the fully qualified domain name (FQDN) (IPv4 / IPv6)
  - **TCON_IP_RFC**

    For transferring data via ISO-on-TCP (direct communication between two S7 stations)
  - **TADDR_Param**

    For transferring data via UDP
  - **TMail_V4**

    For transferring e-mails addressing the e-mail server using an IPv4 address

  - **TMail_V6**

    For transferring e-mails addressing the e-mail server using an IPv6 address
  - **TMail_FQDN**

    For transferring e-mails addressing the e-mail server using its name (FQDN)
- **Additionally for CP 1542SP-1 IRC and CP 1543SP-1**
  - **TMail_V4_SEC**

    For secure transfer of e-mails addressing the e-mail server using an IPv4 address
  - **TMail_V6_SEC**

    For secure transfer of e-mails addressing the e-mail server using an IPv6 address
  - **TMail_QDN_SEC**

    For secure transfer of e-mails addressing the e-mail server using the host name

  Note on TMail_Vx_SEC / TMail_QDN_SEC:
  With these SDTs, the mail server certificate is checked, but not the ID of the "TLSServerCertRef" (STEP 7 internal reference) certificate.
- **Additionally for CP 1543SP-1**
  - **TCON_IP_V4_SEC**

    For the secure transfer of data via TCP
  - **TCON_QDN_SEC**

    For the secure transfer of data via the host name

You will find the description of the SDTs with their parameters in the STEP 7 information system under the relevant name of the SDT.

Connection establishment and termination

Connections are established using the program block TCON. Note that a separate program block TCON must be called for each connection.

A separate connection must be established for each communications partner even if identical blocks of data are being sent.

After a successful transfer of the data, a connection can be terminated. A connection is also terminated by calling TDISCON.

NOTE

Connection abort

If an existing connection is aborted by the communications partner or due to disturbances on the network, the connection must also be terminated by calling TDISCON. Make sure that you take this into account in your programming.

5.2 Changing the IP parameters during runtime

Changing the IP address during runtime

NOTE
Changing the IP parameters with a dynamic IP address
Note the effects of program-controlled changes to the IP parameters if the CP obtains a dynamic IP address from the connected router: In this case, the CP can no longer be reached by communication partners.

As of STEP 7 V14, you can change the following address parameters of the CP program-controlled during runtime with temporary validity using T_CONFIG:

- IP address
- Subnet mask
- Router address

Requirement in the CP configuration
To be able to change the IP parameters program-controlled, the option "IP address is set directly at the device" must be enabled in the configuration of the IP address of the Ethernet interface of the CP.

Program blocks

Program-controlled changing of the IP parameters is supported by program blocks. The program blocks access address data stored in a suitable system data type (SDT).

Apart from the address parameters of the CP, with T_CONFIG the address parameters of DNS servers (IF_CONF_DNS) and NTP servers (IF_CONF_NTP) can also be changed program controlled.

The following program blocks and system data types can be used:

- **T_CONFIG**

  Together with the following SDTs:

  – IF_CONF_V4
  – IF_CONF_V6
  – IF_CONF_NTP
  – IF_CONF_DNS

The address parameters can only be configured with temporary validity in the CP. In the respective "IF_CONF_..." SDT, the "Mode" = 2 parameter must be set.

You can find detailed information on the blocks and SDTs in the STEP 7 information system.

5.3 MODBUS blocks

MODBUS (TCP)

All three CP types support the program blocks for MODBUS (TCP):

- MB_CLIENT
- MB_SERVER

You can find detailed information in the STEP 7 information system.

Diagnostics and maintenance 6

CAUTION

Hot surfaces

Risk of burns during maintenance work on parts with a surface temperature above 70 °C (158 °F).

- Take appropriate protective measures, for example, wear protective gloves.
- Once maintenance work is complete, restore the touch protection measures.

WARNING

Cleaning the housing

- **In hazardous areas**
  Only clean the outer parts of the housing with a damp, but not wet, cloth.
- **In non-hazardous areas**
  Only clean the outer parts of the housing with a dry cloth.

Do not use any liquids or solvents.

6.1 Diagnostics options

The following diagnostics options are available.

LEDs of the module

For information on the LED displays, refer to the section LEDs (Page 34).

STEP 7: The "Diagnostics" tab in the Inspector window

Here, you can obtain the following information about the online status of the selected module.

STEP 7: Diagnostics functions in the "Online > Online and diagnostics" menu

Using the online functions, you can read diagnostics information from the CP from an engineering station on which the project with the CP is stored.

CP 1542SP-1 IRC / CP 1543SP-1: If you want to operate online diagnostics with the station via the CP, you need to activate the "Enable online functions" option under "Communication types" as a prerequisite.

"Diagnostics" group

The diagnostics pages are divided into the following groups:

- **General**

  This group displays general information on the module.

- **Diagnostics status**

  This group displays status information of the module from the view of the CPU.

  – Device-specific events

    Information on internal module events are displayed for modules with security or telecontrol functions.

- **Ethernet interface**

  Address and statistical information

- **Industrial Remote Communication**

  For the CP 1542SP-1 IRC, you receive telecontrol-specific information here. The group has the following diagnostics pages:

  – Partner

    Information about the address settings of the partner, connection statistics, configuration data of the partner and other diagnostics information.

  – Data point list

    Various information on the data points such as configuration data, value, connection status etc.

  – Protocol diagnostics

    With the button "Enable protocol trace", the frames received and sent by the module are logged for several seconds.

    With the function "Disable protocol trace", the logging is stopped and the data is written to a log file.

    With the function "Save", you can save the log file on the engineering station and then analyze it.

- **Time of day**

  Information on the time on the device

- **Security**

  This group is available for modules with security functions.

  – Status

    This diagnostics page displays the most important security settings, the time of day, and data relating to the configuration.

  – System log

    You can start logging system entries on this diagnostics page if a connection to a SCALANCE S module is established. You can save the entries.

  – Audit log

    You can start logging the log data of the module on this diagnostics page. You can save the entries.

– Communication status

  This diagnostics page shows the states of the known security modules of the VPN groups, their endpoints and the tunnel properties.

– SINEMA RC - automatic VPN configuration

  This diagnostics page shows the status of the automatic OpenVPN configuration and the OpenVPN connections.

"Functions" group

- **Firmware update**

  For a description, see section Downloading firmware (Page 93).

- **Assign IP address**
- **Assign PROFINET device name**
- **Save service data**

  The function is used for logging of internal module processes in situations in which you cannot eliminate unexpected or unwanted behavior of the module yourself.

  The log file is created with the "Save service data" button. The data is saved in a file with the format "*.dmp" that can be evaluated by Siemens Customer Support.

Web server of the CPU

Via the CP you can access the Web server of the CPU and the information available there. For access, refer to the section Web server of the CPU (Page 89).

SNMP

For information on the functions, refer to the section Diagnostics with SNMP (Page 88).

Diagnostics e-mail

Validity: CP 1542SP-1 IRC / CP 1543SP-1

The two CPs can send a diagnostics e-mail if configurable events occur, for example a partner cannot be reached or CPU STOP.

The configuration is described in section Messages: E-mails (CP 1542SP-1 IRC / CP 1543SP-1) (Page 75).

Telecontrol diagnostics

Validity: CP 1542SP-1 IRC

- Partner status

  The CP can signal the status of the connection to the communications partner to the CPU via a PLC tag.

  For information on the configuration, refer to the telecontrol configuration manuals /10/ TeleControl configuration manuals (Page 117).

- CP diagnostics

  The CP can store extended diagnostic data in PLC tags.

  For information on the configuration, see section Communication with the CPU (Page 59).

You can display the states of the PLC tags via the Web server of the CPU or via a watch table, for example.

6.2 Online security diagnostics via port 8448 (CP 1542SP-1 IRC, CP 1543SP-1)

Security diagnostics via port 8448

Requirements:

- With an activated firewall, access must be enabled.

If you want to perform security diagnostics in STEP 7 Professional, follow the steps below:

1. Select the CP in STEP 7.
2. Open the "Online & Diagnostics" shortcut menu.
3. In the "Security" parameter group, click the "Connect online" button.

In this way, you perform the security diagnostics via port 8448.

For more information, refer to section Settings for online security diagnostics and downloading to station with the firewall activated (Page 62).

6.3 Diagnostics with SNMP

Requirement

The requirement for using SNMP is the enabling of the function in the configuration, see section SNMP (Page 61).

SNMP (Simple Network Management Protocol)

SNMP is a protocol for diagnostics and managing networks and nodes in the network. To transmit data, SNMP uses the connectionless UDP protocol.

The information on the properties of SNMP-compliant devices is stored in MIB files (MIB = Management Information Base).

You will find detailed information on SNMP and the Siemens Automation MIB in the manual /6/ SNMP (Page 116).

Scope of performance of the CPs

The CPs support the following SNMP version:

- **CP 1542SP-1**
  - SNMPv1
- **CP 1543SP-1, CP 1542SP-1 IRC**
  - SNMPv1
  - SNMPv3 (with activated Security functions)

  For information on configuring SNMPv3, see section SNMP (Page 72).

Traps are not supported by the CP.

Supported MIBs in SNMPv1

The CPs support the following MIBs:

- **MIB II (acc. to RFC1213)**

  The CP supports the following groups of MIB objects:
  - System
  - Interfaces
  - IP
  - ICMP
  - TCP
  - UDP
  - SNMP
- **LLDP MIB**

Supported MIB objects in SNMPv3

If SNMPv3 is enabled, the CP returns the contents of the following MIB objects:

- **MIB II (acc. to RFC1213)**

  The CP supports the following groups of MIB objects:

  – System
  – Interfaces

    The "Interfaces" MIB object provides status information about the CP interfaces.
  – IP (IPv4/IPv6)
  – ICMP
  – TCP
  – UDP
  – SNMP

  The following groups of the standard MIB II are not supported:

  – Adress Translation (AT)
  – EGP
  – Transmission
- **LLDP MIB**

Access rights using community names (SNMPv1)

As default setting, the CP uses the following community strings to control the permissions for access to the SNMP agent:

Table 2-1640 Access rights in the SNMP agent

Type of access	Community string *)
Read access	public
Read and write access	private

*) Note the use of lowercase letters!

The community strings can be configured when the security functions are enabled.

6.4 Web server of the CPU

The Web server of the CPU

The CPU has a Web server which you can access from a PC using HTTP/HTTPS via the CP.

The Web server of the CPU provides a wide variety of functions for diagnostics and service purposes. You will find detailed information in the system manual /2/ ET 200SP system manual (Page 116) and in the information system of STEP 7 in the topic and under the heading "Web server".

Requirements for access to the Web server

Permitted web browsers

You will find the Web browsers supported on the PC for access to the Web server of the CPU in the STEP 7 information system under the heading "Web server".

Requirements in the CPU configuration

1. Open the corresponding project on the engineering station.
2. Select the CPU of the station involved in STEP 7.
3. Select the "Web server" entry.
4. In the parameter group "General", select the "Enable Web server for this interface" option.
5. In the user management create a user with suitable rights on the CPU.

   To load firmware you need to assign this user the right to perform firmware updates in the access level.

   The user name and password are required later for access.
6. Configuration of the option "Allow access only using HTTPS" in the parameter group "General"

   Depending on whether you want to access the Web server using HTTP or HTTPS, the configuration of the parameter differs:

   – "Allow access only using HTTPS" enabled

     Connection establishment is possible only using HTTPS.

   – "Allow access only using HTTPS" disabled

     Connection establishment is possible using HTTP and HTTPS.

Additional requirements in the configuration of the CP 1543SP-1

Activate the firewall in the "Security" parameter group.

Depending on the protocol used you need to make the following further settings in the parameter group of the firewall "From external to station".

- With connection establishment using HTTP
  - Enable the "Allow HTTP" option.
  - Enable the "Allow HTTPS" option
    Reason: There is a switch to HTTPs after authentication on the Web server.
- With connection establishment using HTTPS
  - Disable the "Allow HTTP" option
  - Enable the "Allow HTTPS" option.

Establishing a connection to the Web server

Follow the steps below to connect to the Web server of the CPU from the PC.

These two variants are described in the following sections.

Connection establishment with HTTP

1. Connect the PC to the CP via the Ethernet interface.
2. Enter the address of the CP in the address box of your web browser:
   http://<IP address>
3. Press the Enter key.

   The start page of the Web server opens.
4. Click on the "Download certificate" entry at the top right of the window.

   The "Certificate" dialog opens.
5. Download the certificate to your PC by clicking the "Install certificate ..." button.

   The certificate is loaded on your PC.

   You will find information on downloading a certificate in the help of your Web browser and in the STEP 7 information system under the keyword "Certificates for Web server".

When the connection has changed to the secure mode HTTPS ("https://<IP address>/..." in the address box of the Web server), you can operate the Web server.

When you terminate the connection to the Web server, you can log in the next time with the Web server without downloading the certificate using HTTP.

Connection establishment with HTTPS

1. Connect the PC to the CP or the CPU via the Ethernet interface.
2. Enter the address of the CP in the address box of your web browser:
   https://<IP address>
3. Press the Enter key.

   The start page of the Web server opens.

You can work with the Web server.

6.5 Processing status of e-mails (CP 1543SP-1)

Processing status of e-mails

The following status identifiers apply to e-mails configured with the message editor of the CP, see also section Messages: E-mails (CP 1542SP-1 IRC / CP 1543SP-1) (Page 75).

E-mails sent via program blocks of Open User Communication return a different status via the block (see block help).

Processing status of e-mails of the message editor

The meaning of the status of the "PLC tag for processing status" is as follows:

Table 2-1641 Meaning of the status ID output in hexadecimal format

Status	Meaning
0000	Transfer completed free of errors
82xx	Other error message from the e-mail server Apart from the leading "8", the message corresponds to the three-digit error number of the SMTP protocol.
8401	No channel available. Possible cause: There is already an e-mail connection via the CP. A second connection cannot be set up at the same time.
8403	No TCP/IP connection could be established to the SMTP server.
8405	The SMTP server has denied the login request.
8406	An internal SSL error or a problem with the structure of the certificate was detected by the SMTP client.
8407	Request to use SSL was denied.
8408	The client could not obtain a socket for creating a TCP/IP connection to the mail server.
8409	It is not possible to write via the connection. Possible cause: The communications partner reset the connection or the connection aborted.
8410	It is not possible to read via the connection. Possible cause: The communications partner terminated the connection or the connection was aborted.
8411	Sending the e-mail failed. Cause: There was not enough memory space for sending.
8412	The configured DNS server could not resolve specified domain name.
8413	Due to an internal error in the DNS subsystem, the domain name could not be resolved.
8414	An empty character string was specified as the domain name.
8415	An internal error occurred in the cURL module. Execution was aborted.
8416	An internal error occurred in the SMTP module. Execution was aborted.
8417	Requests to SMTP on a channel already being used or invalid channel ID. Execution was aborted.
8418	Sending the e-mail was aborted. Possible cause: Execution time exceeded.
8419	The channel was interrupted and cannot be used before the connection is terminated.
8420	Certificate chain from the server could not be verified with the root certificate of the CP.
8421	Internal error occurred. Execution was stopped.
8450	Action not executed: Mailbox not available / unreachable. Try again later.
84xx	Other error message from the e-mail server Apart from the leading "8", the message corresponds to the three-digit error number of the SMTP protocol.
8500	Syntax error: Command unknown. This also includes the error of having a command chain that is too long. The cause may be that the e-mail server does not support the LOGIN authentication method. Try sending e-mails without authentication (no user name).
8501	Syntax error. Check the following configuration data: Alarm configuration > E-mail data (Content): • Recipient address ("To" or "Cc").

Status	Meaning
8502	Syntax error. Check the following configuration data: Alarm configuration > E-mail data (Content): • Email address (sender)
8535	SMTP authentication incomplete. Check the "User name" and "Password" parameters in the CP configuration.
8550	SMTP server cannot be reached. You have no access rights. Check the following configuration data: • CP configuration > E-mail configuration: – User name – Password – Email address (sender) • Alarm configuration > E-mail data (Content): – Recipient address ("To" or "Cc").
8554	Transfer failed
85xx	Other error message from the e-mail server Apart from the leading "8", the message corresponds to the three-digit error number of the SMTP protocol.

6.6 Downloading firmware

New firmware versions of the CP

If a new firmware version is available for the CP, you will find this on the Internet pages of Siemens Industry Online Support:

Link: (https://support.industry.siemens.com/cs/ww/en/ps/22144/dl)

Link: (https://support.industry.siemens.com/cs/ww/en/ps/22143/dl)

There are three different ways of loading a new firmware file on the CP:

- Saving the firmware file on the memory card of the CPU

  You will find a description of the procedure for loading on the memory card of the CPU on the Internet page of Industry Online Support shown above.

- Loading the firmware with the online functions of STEP 7 via Ethernet / Internet

  You will find the description below.

NOTE

Duration of the firmware update

Downloading a new firmware file can take several minutes.

Note that the procedure takes longer the larger the station due to I/O modules.

Always wait until the completion of the firmware update can be recognized from the LEDs (LED pattern "Maintenance demanded" - End of the firmware update).

Loading the firmware with the online functions of STEP 7 via Ethernet

Requirements:

- The CP or the CPU can be reached via the IP address.
- The engineering station and the CP are located in the same subnet.
- The new firmware file is stored on your engineering station.
- The engineering station is connected to the network.
- The relevant STEP 7 project is open on the engineering station.

Procedure:

1. Select the CP or the CPU of the station whose CP you want to update with new firmware.
2. Enable the online functions using the "Connect online" icon.
3. In the "Connect online" dialog, select the Ethernet interface in the "Type of PG/PC interface" list box.
4. Select the slot of the CP or the CPU.

   Both methods are possible.
5. Click on "Start search" to search for the module in the network and to specify the connection path.

   When the module is found it is displayed in the table.
6. Connect using the "Connect" button.

   The "Connect online" wizard guides you through the remaining steps in installation.
7. In the network view, select the CP and select the "Online & Diagnostics" shortcut menu (right mouse button).
8. In the navigation panel of the Online & Diagnostics view, select the entry "Functions > Firmware update".
9. Using the "Browse" button (parameter group "Firmware loader"), search for the new firmware file in the file system of the engineering station.
10. Start the firmware download with the "Start update" button when the correct version of the signed firmware is displayed in the "Status" output box.

You will find further information on the online functions in the STEP 7 information system.

6.7 Module replacement

⚠ CAUTION

Read the system manual "SIMATIC ET 200SP Distributed I/O System"

Prior to installation, connecting up and commissioning, read the relevant sections in the system manual "SIMATIC ET 200SP Distributed I/O System" refer to the documentation in the Appendix.

When installing and connecting up, keep to the procedures described in the system manual "SIMATIC ET 200SP Distributed I/O System".

Make sure that the power supply is turned off when installing/uninstalling the devices.

Module replacement

The STEP -7 project data of the CP is stored on the local CPU. If there is a fault on the device, this allows simple replacement of the CP without needing to download the project data to the station again.

When the station starts up again, the new CP reads the project data from the CPU.

Exception:
The data of the SINEMA RC configuration and the certificate of the SINEMA RC server are saved in the CP. They cannot be read from the CPU.

Technical specifications 7

7.1 Technical specifications of the CP 154xSP-1

Technical specifications		
Article numbers	CP 1542SP-1	6GK7542-6UX00-0XE0
	CP 1542SP-1 IRC	6GK7542-6VX00-0XE0
	CP 1543SP-1	6GK7543-6WX00-0XE0
Attachment to Industrial Ethernet		
Quantity	1	
Design	Slot for bus adapter	
Properties	For information on the properties of the BusAdapters and the permissible cable lengths, see /3/ ET 200SP Manual Collection (Page 116).	
Electrical data		
External power supply (X80), design	Socket Terminal block for socket	Two terminals with reverse polarity protection 2 x two terminal for single or redundant power supply
Power supply (external)	• Type of voltage • Permitted low limit • Permitted high limit	• 24 VDC • 19.2 V • 28.8 V
Current consumption	From backplane bus (3.3 V)	4 mA (typ.)
	From 24 V DC (external) • With BusAdapter BA 2xRJ45 – typ. – max. • With BusAdapter BA 2xLC – typ. – max. • With BusAdapter BA SCRJ – typ. – max. • With BusAdapter BA 2xVD – typ. – max.	Plugged in BusAdapter: • BA 2xRJ45 – 115 mA – 140 mA • BA 2xLC – 185 mA – 225 mA • BA SCRJ – 150 mA – 240 mA • BA 2xVD – 150 mA – 180 mA
Maximum Inrush current	(Rated value)	12 A
Effective power loss	(typical)	6 W
Overvoltage category according to IEC / EN 60664-1	Category I	
Permitted ambient conditions		
Ambient temperature *	During operation with the rack installed horizontally	-30 .. + 60 °C
	During operation with the rack installed vertically	-30 .. + 50 °C

Technical specifications		
Ambient temperature *	During storage	-40 .. +70 °C
	During transportation	-40 .. +70 °C
	Comment	without condensation or ice
Relative humidity	During operation	≤ 95% at 25°C, no condensation
Permitted contaminant concentration	Corrosive gas test according to ISA-S71.04 severity level G1, G2, G3	
Design, dimensions and weight		
Module format	Compact module ET 200SP	
Degree of protection	IP20	
Weight • Without bus adapter • With bus adapter 2xRJ45	 • 180 g • 230 g	
Dimensions (W x H x D)	60 x 117 x 74 mm	
Installation options	DIN rail (35 mm)	
Mean Time Between Failures (MTBF)		
• At + 40 °C • At + 60 °C	• 56.87 years • 24.78 years	
Product functions	You will find additional properties and performance data in the section Application and functions (Page 11).	

* Also read the information in the Ambient temperature (Page 97) section.

7.2 Ambient temperature

Restrictions of the maximum specified ambient temperature

The maximum permissible temperatures of the module for altitudes up to 2000 m can be found above in the technical specifications.

When using the module at higher altitudes, the decrease in the cooling effect due to convection as a result of the lower air pressure must be taken into account. According to IEC 61010-2-201 CD2 2015, the temperature at altitudes > 2000 m must be reduced.

The following derating factors and maximum ambient temperatures apply.

Table 2-1642 Restrictions of the maximum permissible ambient temperature in relation to the installation altitude

Installation altitude (Height above mean sea level)	Derating factor [1]	Maximum ambient temperature when the rack is mounted horizontally
-1000 m to 2000 m	1.00	60 °C
2000 m to 3000 m	0.93	56 °C
3000 m to 4000 m	0.86	52 °C
4000 m to 5000 m	0.78	47 °C

[1] Basic value for applying the derating factor is the maximum permissible ambient temperature in °C for 2000 m.

NOTE

- The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.
- Linear interpolation between altitudes is permissible.

Approvals

A

Approvals issued

NOTE

Issued approvals on the type plate of the device

The specified approvals apply only when the corresponding mark is printed on the product. You can check which of the following approvals have been granted for your product by the markings on the type plate.

Scope of validity of the approvals

The approvals listed below are valid for the CP.

The tests required for the approvals were performed with a plugged-in bus adapter.

The bus adapters have their own approvals, that are not listed here.

Documents on the Internet

You will find the declarations of conformity listed below and certificates of the product on the Internet at the following address:
Link: (https://support.industry.siemens.com/cs/ww/en/ps/)

You can view the considered standards in the respective certificate, which is available on the Internet at the address listed above.

Address for declarations of conformity

The EU and the UK declarations of conformity are available to all responsible authorities at:

Siemens Aktiengesellschaft
Digital Industries
P.O. Box 48 48
90026 Nuremberg
Germany

EC declaration of conformity

The CP meets the requirements and safety objectives of the following EU directives and it complies with the harmonized European standards (EN) for programmable logic controllers which are published in the official documentation of the European Union.

- **2014/34/EU (ATEX explosion protection directive)**

  Directive of the European Parliament and the Council of 26 February 2014 on the approximation of the laws of the member states concerning equipment and protective systems intended for use in potentially explosive atmospheres, official journal of the EU L96, 29/03/2014, pages. 309-356

- **2014/30/EU (EMC)**

  EMC directive of the European Parliament and of the Council of 26 February 2014 on the approximation of the laws of the member states relating to electromagnetic compatibility; official journal of the EU L96, 29/03/2014, p. 79-106

- **2011/65/EU (RoHS)**

  Directive of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, official journal of the EC L174, 01/07/2011, page 88-110

UK Declaration of Conformity

Importer UK:

Siemens plc
Sir William Siemens House
Princess Road
Manchester
M20 2UR

The product meets the requirements of the following directives:

- UKEX Regulations

  SI 2016/1107 The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016, and related amendments.

- EMC Regulations

  SI 2016/1091 The Electromagnetic Compatibility Regulations 2016, and related amendments.

- RoHS Regulations

  SI 2012/3032 The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012, and related amendments.

ATEX / IECEx / UKEX / CCC-Ex

Observe the information in the "Use of subassemblies/modules in a Zone 2 Hazardous Area" document, which you will find here:

- On the documentation DVD supplied with the product, under:
  "All documents" >"Use of subassemblies/modules in a Zone 2 Hazardous Area"
- On the Internet at the following address:
  Link: (https://support.industry.siemens.com/cs/ww/en/view/78381013)

The conditions must be met for safe usage of the product according to the section Notes on use in hazardous areas according to ATEX / UKEX / IECEx / CCC-Ex (Page 38).

The product meets the explosion protection requirements outlined below.

IECEx

Classification: Ex ec IIC T4 Gc, Certificate no.: IECEx DEK 18.0019X

The product meets the requirements of the standards:

- IEC 60079-0 - Explosive atmospheres - Part 0: Equipment - General requirements
- IEC 60079-7 - Explosive Atmospheres - Part 7: Equipment protection by increased safety 'e'

ATEX

Classification: II 3 G Ex ec IIC T4 Gc, Certificate no.: DEKRA 18ATEX0027 X

The product meets the requirements of the standards:

- EN IEC 60079-0 - Explosive atmospheres - Part 0: Equipment - General requirements
- EN 60079-7 - Explosive Atmospheres - Part 7: Equipment protection by increased safety 'e'

UKEX

Classification: II 3 G Ex ec IIC T4 Gc, Certificate no.: DEKRA 21UKEX0003 X

The product meets the requirements of the standards:

- EN IEC 60079-0 - Explosive atmospheres - Part 0: Equipment - General requirements
- EN 60079-7 - Explosive Atmospheres - Part 7: Equipment protection by increased safety 'e'

Importer UK: Siemens plc (see above)

CCC-Ex

Classification: Ex ec IIC T4 Gc

The product meets the requirements of the following standards:

- GB 3836.1

  Hazardous areas - Part 0: Equipment - General requirements
- GB 3836.3

  Explosive atmospheres - Part 3: Equipment protection by increased safety 'e'

EMC

The CP meets the requirements of the EU Directive 2014/30/EU "Electromagnetic Compatibility" (EMC directive).

Applied standards:

- EN 61000-6-4

  Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments

- EN 61000-6-2

  Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity for industrial environments

RoHS

The CP meets the requirements of the EC directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

Applied standard:

- EN IEC 63000

c(UL)us

Applied standards:

- Underwriters Laboratories, Inc.: UL 61010-1 (Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements)
- IEC/UL 61010-2-201 (Safety requirements for electrical equipment for measurement, control and laboratory use. Particular requirements for control equipment)
- Canadian Standards Association: CSA C22.2 No. 142 (Process Control Equipment)

Report / UL file: E85972 (NRAG, NRAG7)

cULus Hazardous (Classified) Locations

Underwriters Laboratories, Inc.: CULUS Listed E223122 IND. CONT. EQ. FOR HAZ. LOC.

Applied standards:

- ANSI ISA 12.12.01
- CSA C22.2 No. 213-M1987

APPROVED for Use in:

- Cl. 1, Div. 2, GP. A, B, C, D T4
- Cl. 1, Zone 2, GP. IIC T4

Ta: Refer to the temperature class on the type plate of the CP

Report / UL file: E223122 (NRAG, NRAG7)

Observe the conditions for safe usage of the CP according to the section Notes on use in hazardous areas according to UL HazLoc and FM (Page 38).

FM

Factory Mutual Approval Standard Class Number 3600, 3611, 3810, ANSI/ISA-61010-1

Equipment rating:
Class I, Division 2, Group A, B, C, D, Temperature Class T4, Ta = 60 °C
Class I, Zone 2, Group IIC, Temperature Class T4, Ta = 60 °C

Ta: Refer to the temperature class on the type plate of the CP

Report Number: 3059889

Observe the conditions for safe usage of the CP according to the section Notes on use in hazardous areas according to UL HazLoc and FM (Page 38).

Australia - RCM

The CP meets the requirements of the AS/NZS 2064 standards (Class A).

Marking for the customs union

EAC (Eurasian Conformity)

Customs union of Russia, Belarus and Kazakhstan

Declaration of the conformity according to the technical regulations of the customs union (TR CU)

MSIP 요구사항 - For Korea only

Registration Number: MSIP-REI-S7M-ET200SPCP

A급 기기(업무용 방송통신기자재)

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며, 가정 외의 지역에서 사용하는것을 목적으로 합니다.

Current approvals

SIMATIC NET products are regularly submitted to the relevant authorities and approval centers for approvals relating to specific markets and applications.

If you require a list of the current approvals for individual devices, consult your Siemens contact or check the Internet pages of Siemens Industry Online Support:

Link: (https://support.industry.siemens.com/cs/ww/en/ps/22144/cert)

Dimension drawings

B

All dimensions in the dimension drawings are in millimeters.

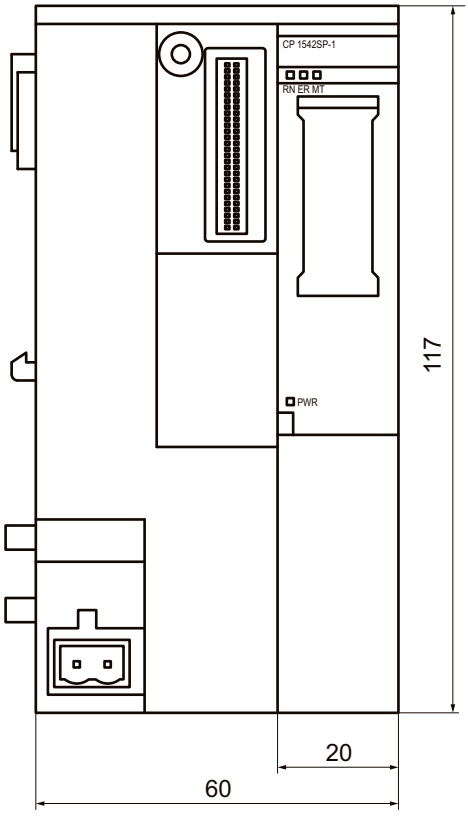

Figure 2-1364 Front view of the CP

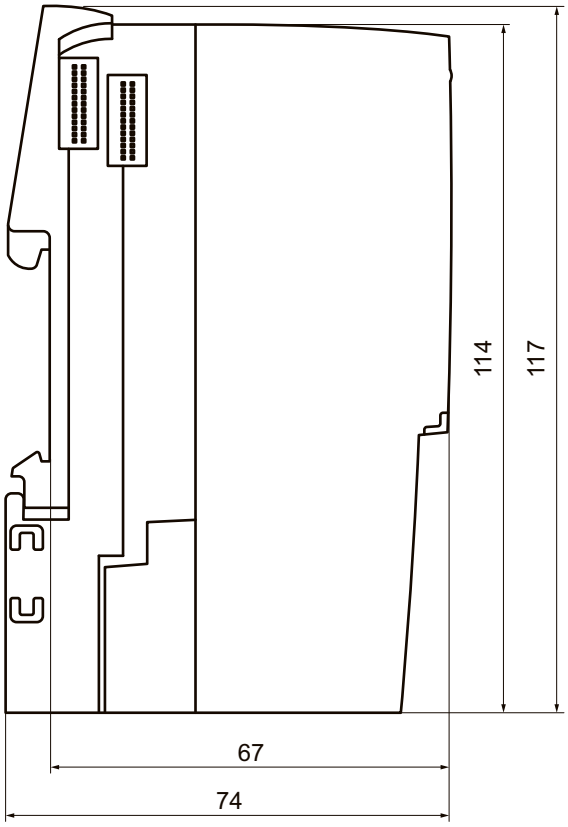

Figure 2-1365 Side view (left) of the CP

Accessories

C

C.1 BusAdapter

Compatible BusAdapter

To connect to the Ethernet network, the CP requires a BusAdapter. A BusAdapter does not ship with the CP.

Figure 2-1366 Example of a BusAdapter, here BA SCRJ/RJ45

The CP supports the following BusAdapters:

SIMATIC ET 200SP

- SIMATIC BA 2×RJ45

  PROFINET BusAdapter with the following connectors:

  – 2 x Ethernet jack RJ45

  Article number: 6ES7193-6AR00-0AA0
- SIMATIC BA 2xFC

  PROFINET BusAdapter with the following connectors:

  – 2 x connection of the bus cable (FastConnect)

  Article number: 6ES7193-6AF00-0AA0
- SIMATIC BA 2xSCRJ

  PROFINET BusAdapter with the following connectors:

  – 2 x fiber-optic cable POF/PCF

  Article number: 6ES7193-6AP00-0AA0
- SIMATIC BA SCRJ/RJ45

  PROFINET BusAdapter, media converter FO - copper with the following connectors:

  – 1 x fiber-optic cable POF/PCF

  – 1 x Ethernet jack RJ45

  Article number: 6ES7193-6AP20-0AA0

- SIMATIC BA SCRJ/FC
  PROFINET BusAdapter, media converter FO - copper with the following connectors:
  – 1 x fiber-optic cable POF/PCF
  – 1 x connection of the bus cable (FastConnect)
  Article number: 6ES7193-6AP40-0AA0
- SIMATIC BA 2xLC
  SIMATIC BusAdapter with the following connectors:
  – 2 x glass fiber-optic cables LC
  Article number: 6ES7193-6AG00-0AA0
- SIMATIC BA LC/RJ45
  SIMATIC BusAdapter with the following connectors:
  – 1 x glass fiber-optic cables LC FO
  – 1 x Ethernet jack RJ45
  Article number: 6ES7193-6AG20-0AA0
- SIMATIC BA LC/FC
  SIMATIC BusAdapter with the following connectors:
  – 1 x glass fiber-optic cables LC FO
  – 1 x connection of the bus cable (FastConnect)
  Article number: 6ES7193-6AG40-0AA0
- SIMATIC BA 2xLC-LD
  SIMATIC BusAdapter with the following connectors:
  – 2 x glass fiber-optic cables LC-LD port (single-mode glass fiber-optic cable)
  Article number: 6ES7193-6AG50-0AA0
- SIMATIC BA LC-LD/RJ45
  SIMATIC BusAdapter with the following connectors:
  – 1 x glass fiber-optic cable LC-LD port (single-mode glass fiber-optic cable)
  – 1 x Ethernet jack RJ45
  Article number: 6ES7193-6AG60-0AA0

- SIMATIC BA LC-LD/M12

  SIMATIC BusAdapter with the following connectors:

  – 1 x glass fiber-optic cable LC-LD port (single-mode glass fiber-optic cable)

  – 1 x M12 socket, D-coded

  Article number: 6ES7193-6AG70-0AA0

- SIMATIC BA 2xRJ45VD HA

  SIMATIC BusAdapter VD (Variable Distance) for Ethernet communication and PROFINET, extended temperature range, conformal coating, with the following connectors:

  – 2 x Ethernet jack RJ45

  Article number: 6GK5991-2VA00-8AA2

The corresponding SIPLUS BusAdapters are also supported.

You can find additional details in the manual /2/ ET 200SP system manual (Page 116) and on the following Siemens web pages.

Siemens Industry Online Support:
Link: (https://support.industry.siemens.com/cs/ww/en/ps/14072)

Siemens Industry Mall at:
Link:
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10147556?tree=CatalogTree)
Link:
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10412114?tree=CatalogTree)

SIMATIC ET 200SP HA

- SIMATIC BA 2xFC

  PROFINET BusAdapter with the following connectors:

  – 2 x connection of the bus cable (FastConnect)

  Article number: 6DL1193-6AF00-0AA0

- SIMATIC BA 2xLC

  SIMATIC BusAdapter with the following connectors:

  – 2 x glass fiber-optic cables LC

  Article number: 6DL1193-6AG00-0AA0

- SIMATIC BA 2×RJ45

  PROFINET BusAdapter with the following connectors:

  – 2 x Ethernet jack RJ45

  Article number: 6DL1193-6AR00-0AA0

See also Siemens Industry Mall at:
Link:
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10290278?tree=CatalogTree)

Pinout of the Ethernet interface

The table below shows the pin assignment of the Ethernet interface. The pin assignment corresponds to the Ethernet standard 802.3-2005, 100BASE-TX version.

Table 2-1643 Pin assignment of the Ethernet interface

View of the RJ-45 jack	Pin	Signal name	Assignment
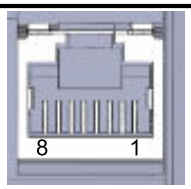	1	TD	Transmit Data +
	2	TD_N	Transmit Data -
	3	RD	Receive Data +
	4	GND	Ground
	5	GND	Ground
	6	RD_N	Receive Data -
	7	GND	Ground
	8	GND	Ground

C.2 IP-based routers

Routers for IP-based communication

To connect a communications module to IP-based infrastructure networks, various routers are available from Siemens.

Information on the devices can be found on the following Siemens Internet pages.

Siemens Industry Online Support:
Link: (https://support.industry.siemens.com/cs/ww/en/ps/15982)

Siemens Industry Mall at:
Link:
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10215915?tree=CatalogTree)

Encryption methods (Ciphers) D

The following tables list the encryption methods (ciphers) used by the CP.

The tables are valid for all three CP variants in the firmware version specified in the preface.

Meaning of the table columns

- **Category**
  - Cipher: Cipher suite (encryption methods)
  - DSA: Signature algorithm
  - SEA: Signature and encryption algorithm
- **Name**

  Name of the category according to IANA

  You can find an overview of the TLS parameters and Cipher Suites on the following page: Link: (https://www.iana.org/assignments/tls-parameters/tls-parameters.xhtml#tls-parameters-4)
- **Value**

  Value (hexadecimal) of the suite according to IANA
- **TLS**

  TLS version with which the respective category is used.
- **FW**

  Configured firmware version of the CP
- **Security**
  - ✓

    Ciphers considered secure
  - Legacy

    Ciphers no longer considered secure
- **Protocol**

  Communication protocols that use the respective category.
  - All

    All communication services and protocols including telecontrol communication (DNP3 / IEC 60870-5) and OUC
  - No TC

    All communication services and protocols except telecontrol communication
  - OUC

    Open User Communication (OUC) only

TLS versions used by the CP

TLS version	Firmware	Security
TLS Version 1.0	≤ V2.1	Legacy
TLS Version 1.1	≤ V2.1	Legacy
TLS Version 1.2	≤ V2.4	✓
TLS Version 1.3	≤ V2.4	✓

Ciphers used by the CP

Category	Name	Value	TLS	FW	Security	Protocol
Cipher	TLS_AES_128_GCM_SHA256	0x13,0x01	TLS 1.3	≤ V2.4	✓	All
Cipher	TLS_AES_256_GCM_SHA384	0x13,0x02	TLS 1.3	≤ V2.4	✓	All
Cipher	TLS_CHACHA20_POLY1305_SHA256	0x13,0x03	TLS 1.3	≤ V2.4	✓	All
Cipher	TLS_AES_128_CCM_SHA256	0x13,0x04	TLS 1.3	≤ V2.4	✓	All
Cipher	TLS_DHE_DSS_WITH_AES_128_GCM_SHA256	0x00,0xA2	≤ TLS 1.2	≤ V2.4	✓	All
Cipher	TLS_DHE_DSS_WITH_AES_256_GCM_SHA384	0x00,0xA3	≤ TLS 1.2	≤ V2.4	✓	All
Cipher	TLS_DHE_RSA_WITH_AES_128_CCM	0xC0,0x9E	≤ TLS 1.2	≤ V2.4	✓	All
Cipher	TLS_DHE_RSA_WITH_AES_128_GCM_SHA256	0x00,0x9E	≤ TLS 1.2	≤ V2.4	✓	All [1]
Cipher	TLS_DHE_RSA_WITH_AES_256_CCM	0xC0,0x9F	≤ TLS 1.2	≤ V2.4	✓	All
Cipher	TLS_DHE_RSA_WITH_AES_256_GCM_SHA384	0x00,0x9F	≤ TLS 1.2	≤ V2.4	✓	All [1]
Cipher	TLS_DHE_RSA_WITH_CHACHA20_POLY1305_SHA256	0xCC,0xAA	≤ TLS 1.2	≤ V2.4	✓	All
Cipher	TLS_ECDHE_ECDSA_WITH_AES_128_CCM	0xC0,0xAC	≤ TLS 1.2	≤ V2.4	✓	All
Cipher	TLS_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256	0xC0,0x2B	≤ TLS 1.2	≤ V2.4	✓	All
Cipher	TLS_ECDHE_ECDSA_WITH_AES_256_CCM	0xC0,0xAD	≤ TLS 1.2	≤ V2.4	✓	All
Cipher	TLS_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384	0xC0,0x2C	≤ TLS 1.2	≤ V2.4	✓	All
Cipher	TLS_ECDHE_ECDSA_WITH_CHACHA20_POLY1305_SHA256	0xCC,0xA9	≤ TLS 1.2	≤ V2.4	✓	All
Cipher	TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256	0xC0,0x2F	≤ TLS 1.2	≤ V2.4	✓	All
Cipher	TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384	0xC0,0x30	≤ TLS 1.2	≤ V2.4	✓	All
Cipher	TLS_ECDHE_RSA_WITH_CHACHA20_POLY1305_SHA256	0xCC,0xA8	≤ TLS 1.2	≤ V2.4	✓	All
Cipher	TLS_RSA_WITH_AES_128_CCM	0xC0,0x9C	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_RSA_WITH_AES_128_CCM_8	0xC0,0xA0	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_RSA_WITH_AES_128_GCM_SHA256	0x00,0x9C	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_RSA_WITH_AES_128_CBC_SHA	0x00, 0x2F	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_RSA_WITH_AES_128_CBC_SHA256	0x00, 0x3C	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_RSA_WITH_AES_256_CCM	0xC0, 0x9D	≤ TLS 1.2	≤ V2.1	Legacy	All

[1] These ciphers are excluded for connections to SINEMA RC and for the security online diagnostics.

Category	Name	Value	TLS	FW	Security	Protocol
Cipher	TLS_RSA_WITH_AES_256_CCM_8	0xC0, 0xA1	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_RSA_WITH_AES_256_GCM_SHA384	0x00,0x9D	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_RSA_WITH_AES_256_CBC_SHA	0x00, 0x35	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_RSA_WITH_AES_256_CBC_SHA256	0x00, 0x3D	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_RSA_WITH_ARIA_128_GCM_SHA256	0xC0, 0x50	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_RSA_WITH_ARIA_256_GCM_SHA384	0xC0, 0x51	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_DHE_RSA_WITH_AES_128_CCM_8	0xC0,0xA2	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_DHE_RSA_WITH_AES_128_CBC_SHA	0x00,0x33	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_DHE_RSA_WITH_AES_128_CBC_SHA256	0x00,0x67	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_DHE_RSA_WITH_AES_256_CCM_8	0xC0,0xA3	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_DHE_RSA_WITH_AES_256_CBC_SHA	0x00,0x39	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_DHE_RSA_WITH_AES_256_CBC_SHA256	0x00,0x6B	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_DHE_RSA_WITH_ARIA_128_GCM_SHA256	0xC0,0x52	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_DHE_RSA_WITH_ARIA_256_GCM_SHA384	0xC0,0x53	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_RSA_WITH_ARIA_128_GCM_SHA25-6	0xC0,0x60	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_RSA_WITH_ARIA_256_GCM_SHA38-4	0xC0, 0x61	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_ECDSA_WITH_AES_128_CCM_8	0xC0,0xAE	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_ECDSA_WITH_AES_128_CBC_SHA	0xC0,0x09	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_ECDSA_WITH_AES_128_CBC_SHA2-56	0xC0,0x23	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_ECDSA_WITH_AES_256_CCM_8	0xC0,0xAF	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_ECDSA_WITH_AES_256_CBC_SHA	0xC0,0x0A	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_ECDSA_WITH_AES_256_CBC_SHA3-84	0xC0,0x24	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_ECDSA_WITH_ARIA_128_GCM_SHA-256	0xC0,0x5C	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_ECDSA_WITH_ARIA_256_GCM_SHA-384	0xC0,0x5D	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_RSA_WITH_AES_128_CBC_SHA	0xC0,0x13	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_RSA_WITH_AES_128_CBC_SHA256	0xC0, 0x27	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA	0xC0,0x14	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA384	0xC0, 0x28	≤ TLS 1.2	≤ V2.1	Legacy	All
Cipher	TLS_DHE_DSS_WITH_AES_128_CBC_SHA	0x00,0x32	≤ TLS 1.2	≤ V2.1	Legacy	OUC
Cipher	TLS_DHE_DSS_WITH_AES_128_CBC_SHA256	0x00,0x40	≤ TLS 1.2	≤ V2.1	Legacy	OUC
Cipher	TLS_DHE_DSS_WITH_AES_256_CBC_SHA	0x00,0x38	≤ TLS 1.2	≤ V2.1	Legacy	OUC
Cipher	TLS_DHE_DSS_WITH_AES_256_CBC_SHA256	0x00,0x6A	≤ TLS 1.2	≤ V2.1	Legacy	OUC
Cipher	TLS_DHE_DSS_WITH_ARIA_128_GCM_SHA256	0xC0,0x56	≤ TLS 1.2	≤ V2.1	Legacy	OUC
Cipher	TLS_DHE_DSS_WITH_ARIA_256_GCM_SHA384	0xC0,0x57	≤ TLS 1.2	≤ V2.1	Legacy	OUC

1) These ciphers are excluded for connections to SINEMA RC and for the security online diagnostics.

Category	Name	Value	TLS	FW	Security	Protocol
SEA	DSA_SHA256	0x0402		≤ V2.4	✓	All
SEA	DSA_SHA384	0x0502		≤ V2.4	✓	All
SEA	DSA_SHA512	0x0602		≤ V2.4	✓	All
SEA	ecdsa_secp256r1_sha256	0x0403		≤ V2.4	✓	All
SEA	ecdsa_secp384r1_sha384	0x0503		≤ V2.4	✓	All
SEA	ecdsa_secp521r1_sha512	0x0603		≤ V2.4	✓	All
SEA	ed25519	0x0807		≤ V2.4	✓	All
SEA	ed448	0x0808		≤ V2.4	✓	All
SEA	rsa_pss_pss_sha256	0x0804		≤ V2.4	✓	All
SEA	rsa_pss_pss_sha384	0x0805		≤ V2.4	✓	All
SEA	rsa_pss_pss_sha512	0x0806		≤ V2.4	✓	All
SEA	rsa_pss_rsae_sha256	0x0809		≤ V2.4	✓	All
SEA	rsa_pss_rsae_sha384	0x080A		≤ V2.4	✓	All
SEA	rsa_pss_rsae_sha512	0x080B		≤ V2.4	✓	All
SEA	rsa_pkcs1_sha256	0x0401		≤ V2.4	✓	All
SEA	rsa_pkcs1_sha384	0x0501		≤ V2.4	✓	All
SEA	rsa_pkcs1_sha512	0x0601		≤ V2.4	✓	All
DSA	DSA_SHA1	0x0202		≤ V2.1	Legacy	All
DSA	DSA_SHA224	0x0302		≤ V2.1	Legacy	All
SEA	ecdsa_sha1	0x0203		≤ V2.1	Legacy	All
SEA	ecdsa_sha224	0x0303		≤ V2.1	Legacy	All
SEA	rsa_pkcs1_sha1	0x0201		≤ V2.1	Legacy	All
SEA	rsa_pkcs1_sha224	0x0301		≤ V2.1	Legacy	All

1) These ciphers are excluded for connections to SINEMA RC and for the security online diagnostics.

Documentation references

E

Structure of the documentation

Note the structure of the documentation for the devices, see Preface (Page 2).

Where to find Siemens documentation

- Article numbers

  You will find the article numbers for the Siemens products of relevance here in the following catalogs:

  – SIMATIC NET - Industrial Communication / Industrial Identification, catalog IK PI

  – SIMATIC - Products for Totally Integrated Automation and Micro Automation, catalog ST 70

  You can request the catalogs and additional information from your Siemens representative. You will also find the product information in the Siemens Industry Mall at the following address:

  Link: (https://mall.industry.siemens.com)

- Manuals on the Internet

  You will find SIMATIC NET manuals on the Internet pages of Siemens Industry Online Support:

  Link: (https://support.industry.siemens.com/cs/ww/en/ps/15247/man)

  Go to the required product in the product tree and make the following settings:

  Entry type “Manuals”

- Manuals on the data medium

  You will find manuals of SIMATIC NET products on the data medium that ships with many of the SIMATIC NET products.

E.1 /1/ CP 1542SP-1, CP 1542SP-1 IRC, CP 1543SP-1

SIMATIC
CP 1542SP-1, CP 1542SP-1 IRC, CP 1543SP-1
Operating instructions
Siemens AG
Link: (https://support.industry.siemens.com/cs/ww/en/ps/22144/man)
Link: (https://support.industry.siemens.com/cs/ww/en/ps/22143/man)

E.2 /2/ ET 200SP system manual

SIMATIC
ET 200SP - Distributed I/O System
system manual
Siemens AG
Link: (http://support.automation.siemens.com/WW/view/en/58649293)

E.3 /3/ ET 200SP Manual Collection

SIMATIC
ET 200SP
Manual Collection
Siemens AG
Link: (https://support.industry.siemens.com/cs/ww/en/view/84133942)

E.4 /4/ TeleControl Server Basic

SIMATIC NET
TeleControl Server Basic (Version V3)
Operating Instructions
Siemens AG
Link: (https://support.industry.siemens.com/cs/ww/en/ps/15918/man)

E.5 /5/ TIM DNP3

SIMATIC NET
TIM DNP3
System manual
Siemens AG
Link: (https://support.industry.siemens.com/cs/ww/en/ps/15940/man)

E.6 /6/ SNMP

SIMATIC NET
Diagnostics and configuration with SNMP
Diagnostics manual
Siemens AG
Link: (https://support.industry.siemens.com/cs/ww/en/ps/15392/man)

E.7 /7/ Industrial Ethernet system manual

SIMATIC NET
Industrial Ethernet
System manual
Siemens AG

- Volume 1: Industrial Ethernet
  Link: (https://support.industry.siemens.com/cs/ww/de/view/27069465)
- Volume 2: Passive network components
  Link: (https://support.industry.siemens.com/cs/ww/en/view/84922825)

E.8 /8/ SINEMA Remote Connect - Server

SIMATIC NET
SINEMA Remote Connect - Server
Operating Instructions
Siemens AG
Link: (https://support.industry.siemens.com/cs/ww/en/ps/21816/man)

E.9 /9/ SINAUT ST7 system manual

SIMATIC NET
SINAUT ST7
System Manual
- Volume 1: System and hardware
- Volume 2: Configuration in STEP 7 V5
- Volume 3: Configuration in STEP 7 Professional
Siemens AG
Link: (https://support.industry.siemens.com/cs/ww/en/ps/21771/man)

E.10 /10/ TeleControl configuration manuals

SIMATIC NET - TeleControl
Siemens AG
Configuration manuals of the protocols:
- TeleControl Basic
- SINAUT ST7
- DNP3
- IEC 60870-5
Link: (https://support.industry.siemens.com/cs/ww/en/ps/22143/man)

SIEMENS

SIMATIC

ET 200SP Communication module IO-Link Master CM 4xIO-Link (6ES7137-6BD00-0BA0)

Equipment Manual

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Parameters/address space 4

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Parameter data record A

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Preface

Purpose of the documentation

This manual supplements the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual. It describes functions that generally affect the ET 200SP distributed I/O system.

The information provided in this manual and in the system manual and function manuals supports you in commissioning the ET 200SP distributed I/O system.

Conventions

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/cert).

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Documentation guide

1

1.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/84133942)

Product overview

2

2.1 Properties

Article number

6ES7137-6BD00-0BA0

View of the module

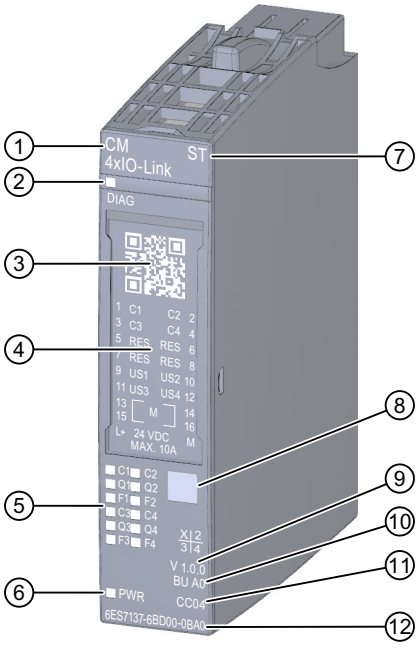

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	QR code	⑨	Function and firmware version
④	Connection diagram	⑩	BU type
⑤	LEDs for status and error displays	⑪	Color code for selecting the color-coded labels
⑥	LED for supply voltage	⑫	Article number

Figure 2-1367 View of the IO-Link Master CM 4xIO-Link communication module

Properties

The module has the following technical properties:

- IO-Link master according to IO-Link specification V1.1
- Serial communication module with 4 ports (channels)
- Data transmission rate COM1 (4.8 kbaud), COM2 (38.4 kbaud), COM3 (230.4 kbaud)
- SIO mode (standard IO mode)
- Suitable for connecting up to 4 IO-Link devices (3-wire connection) or 4 standard actuators or encoders
- Programmable diagnostics function by port
- Automatic backup of the master and device parameters via electronic coding element

The module supports the following functions:

Table 2-1644 Version dependencies of the module functions

Function	Firmware version of the module
Firmware update	V1.0 or higher
Identification and maintenance data (I&M)	V1.0 or higher
PROFIenergy	V1.0 or higher
IO-Link port configuration with S7-PCT	V1.0 or higher
Module replacement with automatic data recovery without engineering for IO-Link master and IO-Link device	V1.0 or higher
Time-based IO (time stamping)	V2.0 or higher
Variable address range of I/O data with up to 32-byte inputs and 32-byte outputs	V2.0 or higher
Variable address range of I/O data with up to 144-byte inputs and 128-byte outputs	V2.1 or higher
IO-Link port configuration without S7-PCT	V2.2 or higher
Master backup with function block "LIOLink_Master"	V2.2 or higher
PortQualifierInformation (PQI)	V2.2 or higher

The module can be used with the following engineering tools:

Table 2-1645 Engineering tools depending on the firmware version of the module

Firmware version of the module	S7-PCT	STEP 7 (TIA Portal)	STEP 7 V5.5	GSD file
V1.0 (in PROFINET station)	V3.0 or higher	V12 SP1 or higher	As of V5.5 SP3 with HSP0231 as of V1.0	X
V1.0.3 (in PROFIBUS station)	V3.1 or higher	V13 or higher	As of V5.5 SP3 with HSP0231 as of V1.0	X

Firmware version of the module	S7-PCT	STEP 7 (TIA Portal)	STEP 7 V5.5	GSD file
V2.0	V3.2 or higher	As of V13 (Time-based IO only with CPU S7-1500)	As of V5.5 SP3 with HSP0231 as of V1.0 (without Time-based IO)	X (without time-based IO)
V2.1	As of V3.3 and SupportedModules .xml V1.2	As of V13 SP1 with HSP0136 as of V1.0 (Time-based IO only with CPU S7-1500)	As of V5.5 SP4 with HSP0231 as of V4.0 (without Time-based IO)	X (without time-based IO)
V2.2	V3.5 or higher	V15 or higher (without time-based IO)	V5.5 SP4 or higher with HSP0231, V4.1 or higher (without time-based IO)	X (without time-based IO)

Accessories/spare parts

The following accessories / replacement parts are available for the module and are not included in the scope of delivery:

- Labeling strips
- Color-coded labels
- Reference identification label
- Electronic coding element type H

See also

You can find more information on accessories in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual in the Accessories/Spare parts section.

2.2 Functions

IO-Link is a point-to-point connection between a master and a device. Both conventional and intelligent sensors/actuators can be used as devices at the IO-Link via unshielded standard cables using proven 3-wire technology. IO-Link is backward compatible with conventional digital sensors and actuators. The circuit state and data channel are designed in proven 24 V DC technology.

Reference

Additional information can be found in the IO-Link System (http://support.automation.siemens.com/WW/view/en/65949252) function manual.

2.3 Replacement of the IO-Link Master CM 4xIO-Link communication module with an electronic coding element type H

If you remove the communication module from the BaseUnit, part of the electronic coding element remains in the BaseUnit. The parameters of the IO-Link Master CM 4xIO-Link and of the IO-Link devices are stored in this part. A newly inserted (but not yet configured) IO-Link master takes over the parameters from the electronic coding element.

CAUTION

Removal and insertion

Plugging in the IO-Link Master CM 4xIO-Link communication module when the load is switched on can result in dangerous conditions in your plant.

The ET 200SP distributed I/O system may be damaged as a result.

The IO-Link Master CM 4xIO-Link communication module should only be plugged in or pulled out when the load is switched off.

Master Backup

In addition to saving the parameters in the electronic coding element, you can back up the parameters of your module, firmware version V2.2 or higher, with the function block "LIOLink_Master".

The "LIOLink_Master" function block is used to read all relevant IO-Link device and IO-Link master parameters. These can be stored retentively at a central location, such as in a data block in the IO controller.

The status of the IO-Link devices or IO-Link ports stored in the IO-Link master can be restored with the "LIOLink_Master" function block.
As a result, the IO-Link ports and the IO-Link master are configured with the values stored in the master backup.

A typical application is restoring the parameters after replacement of the IO-Link master.

NOTE

Availability

Note that the Master Backup function is available only for IO-Link devices that are specified for the IO-Link Standard as of V1.1.

You will find further information on the Master Backup functions in section "Master backup" of chapter "Integration into the automation system" of the IO-Link System (https://support.industry.siemens.com/cs/ww/en/view/65949252) function manual.

Reference

For more information on the topic of "Coding element", refer to the Changing the type of an I/O module chapter of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

2.4 Time-based IO

Time-based IO ensures that signals are output with a precisely defined response time. A combination of inputs and outputs allows, for example, passing products to be measured precisely or liquids to be dosed optimally.

As of firmware version V2.0.0, the IO-Link master supports the Time-based IO function. You configure the connected IO-Link devices with time stamp functionality as normal with the SIMATIC S7 Port Configuration Tool (S7-PCT). In the "Ports" tab in S7-PCT, set the necessary parameters in the "Operating mode" section:

- IO-Link_Time_based_IO_IN
- IO-Link_Time_based_IO_OUT
- IO-Link_Time_based_IO_INOUT

The Time-based IO function can be used for IO-Link master with 32 bytes I/O data. Larger I/O data ranges are not supported by Time-based IO.

NOTE

Time stamp function

The time stamp function requires defined address assignment (mapping).

If the address area you require is already occupied, you must modify the user data arrangement of the IO-Link devices in the address space of the IO-Link master.

The "High-precision input/output with Time-based IO" function manual describes how to move user data in the address space.

Reference

You can find more information about Time-based IO in the High-precision input/output with Time-based IO (http://support.automation.siemens.com/WW/view/en/82527590) function manual.

2.5 Reset communication module to factory settings

Effects of resetting to the factory settings

Use the "Reset to factory settings" function to restore the parameter assignments of your IO-Link Master CM 4xIO-Link communication module made with S7-PCT to the factory state.

After a "Reset to factory settings", the parameters of the IO-Link Master CM 4xIO-Link communication module are assigned as follows:

- The ports are in DI mode
- The ports are mapped to the relative addresses 0.0 ... 0.3
- The PortQualifier is disabled
- I&M data 1 to 3 is deleted
- The electronic coding element (if it exists) is deleted

NOTE

The device parameters are deleted and the factory state is restored.

You should reset a removed IO-Link Master CM 4xIO-Link communication module to the factory settings before you place it in storage.

Procedure

To perform a "Reset to factory settings", proceed as described in the S7-PCT online help.

Connecting

3

3.1 Wiring and block diagram

This section includes the block diagram of the communication module IO-Link Master CM 4xIO-Link with the terminal assignments for 3-wire and 5-wire connection of IO-Link devices or 2-wire and 3-wire connection in DI or DQ operating mode.

You can use and combine the different wiring options for all channels.

You can find information on wiring the BaseUnit in the system manual Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293).

NOTICE
Internal encoder supply Use only the supply voltage (US_n/M) made available by the IO-Link Master CM 4xIO-Link communication module to supply the IO-Link device (L+/L-).

Wiring: 3-wire and 5-wire connection of IO-Link devices

The following figure shows an example of the terminal assignment of the communication module IO-Link Master CM 4xIO-Link on the BaseUnit BU type A0 without AUX terminals (3-wire and 5-wire connection of IO-Link devices).

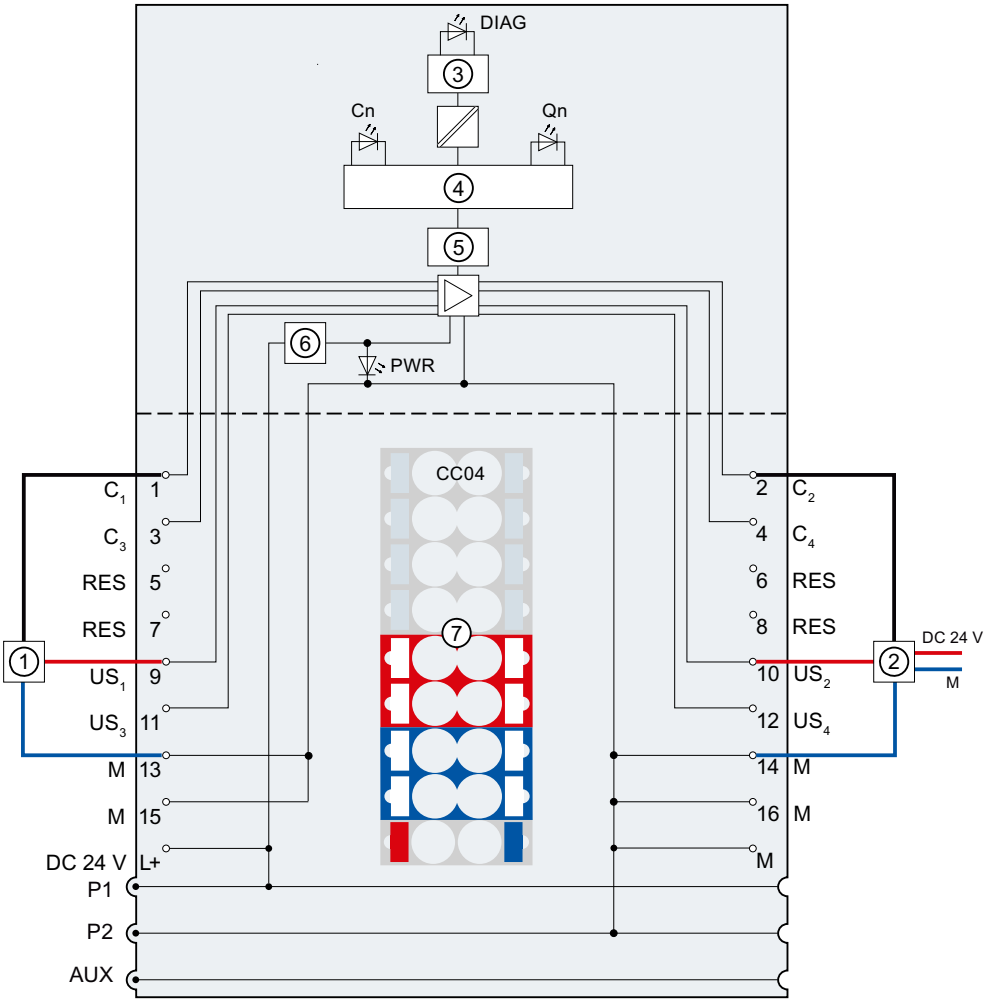

①	3-wire connection	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
②	5-wire connection	C_n	Communication signal, DI, DQ
③	Backplane bus interface	RES	Reserved, must not be assigned
④	Microprocessor	US_n	Supply voltage (positive)
⑤	IO-Link circuitry	DIAG	Error or diagnostics LED (green, red)
⑥	Polarity reversal protection	Cn	LED port status IO-Link mode (green)
⑦	Color-coded label with color code CC04 (optional)	Qn	LED port status SIO mode
24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)	Fn	LED port error
M	Ground	PWR	Power LED (green)

Figure 2-1368 Block diagram and terminal assignment for 3-wire and 5-wire connection of IO-Link devices

Wiring: 2-wire and 3-wire connection in DI operating mode

The following figure shows an example of the terminal assignment of the communication module IO-Link Master CM 4xIO-Link on the BaseUnit BU type A0 with AUX terminals (2-wire and 3-wire connection) in DI operating mode.

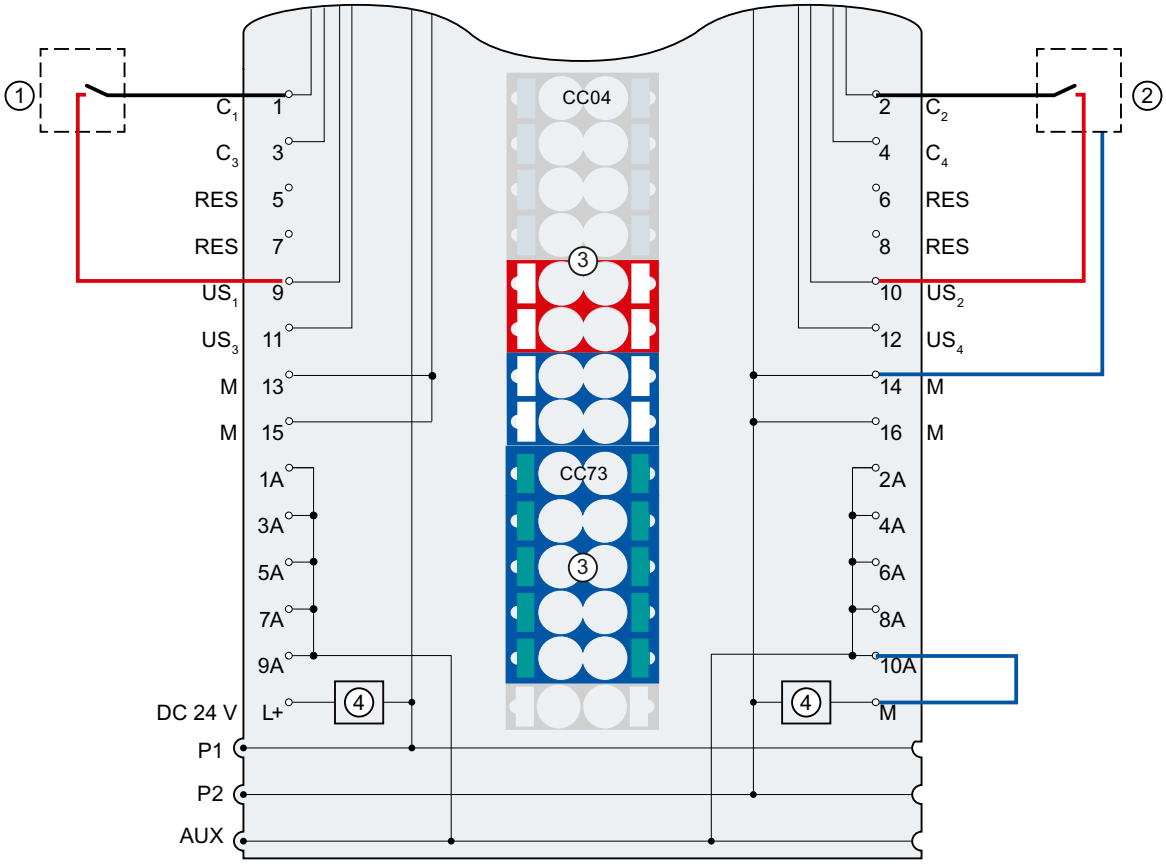

①	2-wire connection	1 A to 10 A	AUX terminals
②	3-wire connection	PE (AUX)	Protective conductor connection
③	Color-coded labels with color code CC04 and CC73 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
④	Filter connection supply voltage (only when light-colored BaseUnit is present)	C_n	Communication signal, DI, DQ
24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)	RES	Reserved, must not be assigned
M	Ground	US_n	Supply voltage (positive)

Figure 2-1369 Terminal assignment for 2-wire and 3-wire connection in DI operating mode

Wiring: 2-wire and 3-wire connection in DQ operating mode

The following figure shows an example of the terminal assignment of the communication module IO-Link Master CM 4xIO-Link on the BaseUnit BU type A0 with AUX terminals (2-wire and 3-wire connection) in DQ operating mode.

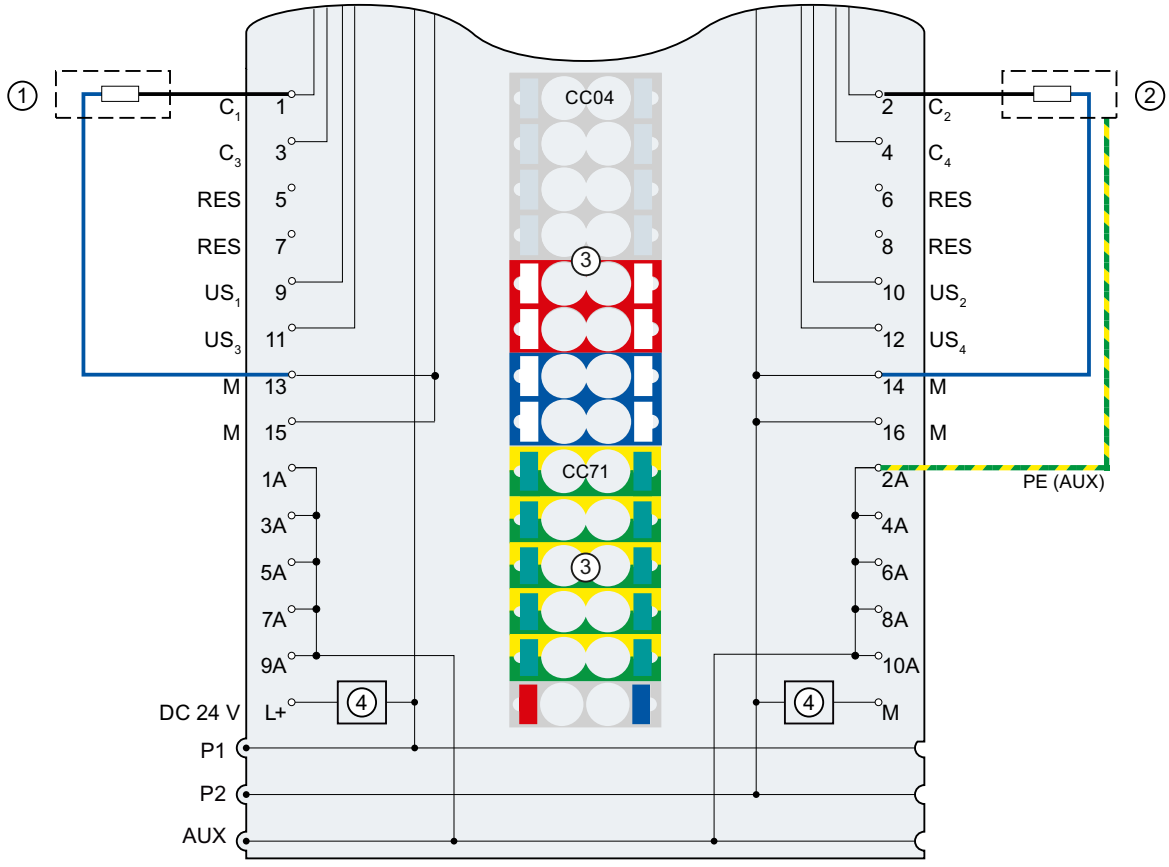

①	2-wire connection	1 A to 10 A	AUX terminals
②	3-wire connection	PE (AUX)	Protective conductor connection
③	Color-coded labels with color code CC04 and CC71 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
④	Filter connection supply voltage (only when light-colored BaseUnit is present)	C_n	Communication signal, DI, DQ
24 V DC	Supply voltage L+ (infeed for light-colored BaseUnit only)	RES	Reserved, must not be assigned
M	Ground	US_n	Supply voltage (positive)

Figure 2-1370 Terminal assignment for 2-wire and 3-wire connection in DQ operating mode

Parameters/address space

4

4.1 Parameters

Parameters (GSD file)

The following table shows the general parameters for the IO-Link Master CM 4xIO-Link communication module.

Table 2-1646 General parameters (GSD file)

Parameters	Value range	Default	Configuration in RUN	Efficiency range
Diagnostics				
Diagnostics: No supply voltage L+	• disable • enable	disable	Yes	Module
Diagnostics port 1	• disable • enable	disable	Yes	Port (channel)
Diagnostics port 2	• disable • enable	disable	Yes	Port (channel)
Diagnostics port 3	• disable • enable	disable	Yes	Port (channel)
Diagnostics port 4	• disable • enable	disable	Yes	Port (channel)
Potential group	• Use potential group of the left module (dark-colored BaseUnit) • Enable new potential group (light-colored BaseUnit)	Use potential group of the left module (dark-colored BaseUnit)	No	Module
Master parameter				
PortQualifierInformation (PQI)	• Disable • Enable	Enable	No	Module
Port configuration without P7-PCT	• Disable • Enable	Disable	No	Module

The following table shows the port parameters for the IO-Link Master CM 4xIO-Link communication module.

Table 2-1647 Port parameter (GSD file)

Parameters	Value range	Default
Port configuration		
Operating mode	• IO-Link Autostart • IO-Link manual • DI • DQ • Deactivated	IO-Link Autostart
Length of input data	depending on the selected I/O type*	depending on the selected I/O type*
Length of output data	depending on the selected I/O type*	depending on the selected I/O type*
VendorID**	Manufacturer ID of the connected IO-Link devices	0
DeviceID**	Device ID of the connected IO-Link devices	0
Test level / Data storage**	• Identical type (V1.0) without Backup&Restore • Type-compatible (V1.1) without Backup&Restore • Type-compatible (V1.1) with Backup&Restore • Type-compatible (V1.1) with Restore	Type-compatible (V1.1) with Backup&Restore

* Ensure that you do not exceed the maximum length of the input and output data for all ports.
Example:
You have selected the configuration 32I/32O. You have assigned 16 bytes of input data to the first port. You can still assign a total of 16 bytes of input data to the remaining three ports.

** Only effective if you use the "IO-Link Manual" port mode.

Reference

Additional information on the VendorID and DeviceID can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109748852).

4.2 Declaration of parameters

Diagnostics: No supply voltage L+

Enabling the diagnostic alarm for missing or insufficient supply voltage L+.

Diagnostics port

This parameter allows the enabling of the diagnostics for the selected port.
The possible diagnostics are dependent on the IO-Link device used. Additional information about the diagnostic interrupts can be found in the description of the utilized IO-Link device.

Potential group

With the "Potential group" parameter, you specify whether the module is inserted on a light-colored or dark-colored BaseUnit.

A potential group always starts with an I/O module that is inserted on a light-colored BaseUnit. All modules inserted to the right of this on dark-colored BaseUnits belong to the same potential group, because the dark-colored BaseUnits are supplied via the light-colored BaseUnits.

The potential group ends with a new light-colored BaseUnit or the end of the station.

PortQualifierInformation

This parameter enables the PortQualifierInformation (PQI).
The PQI provides information on the port and IO-Link device status.

Port configuration without P7-PCT

This parameter enables the port configuration without S7-PCT for the module.

Operating mode

This parameter specifies in which mode the selected port is to be operated.
You can select from the following options:

- IO-Link Autostart
- IO-Link manual
- DI
- DQ
- Deactivated

IO-Link Autostart

The connected IO-Link device starts automatically (Plug&Play functionality). The IO-Link device is immediately available to you and operational.

IO-Link manual

The connected IO-Link devices are **not** started automatically.
You must store the VendorID and DeviceID of the connected IO-Link devices in STEP 7.
In addition, you can select the test level for the data storage:

- Identical type (V1.0) without Backup&Restore
- Type-compatible (V1.1) without Backup&Restore
- Type-compatible (V1.1) with Backup&Restore
- Type-compatible (V1.1) with Restore

The VendorID and DeviceID can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109748852).

DI

The port operates as standard digital input.

DQ

The port operates as standard digital output.

Deactivated

The port is deactivated.

4.3 Address space

Configuration options of the communication module IO-Link Master CM 4xIO-Link

The size of the input and output addresses of the IO-Link Master CM 4xIO-Link communication module with firmware version V1.0 is 32 bytes in each case. As of firmware version V2.0, the modules support a variable address space for I/O data.

As of firmware version V2.2, you can configure the port directly in STEP 7.

The following table provides an overview of the configuration options of the supported address areas for I/O data:

Module configuration/ supported address space for I/O data	IO-Link master with firmware V1.0	IO-Link master with firmware V2.0	IO-Link master with firmware V2.1	IO-Link master with firmware V2.2
1 byte input/1 byte output		X	X	
2-byte inputs/2-byte outputs		X	X	
4-byte inputs/4-byte outputs				X*
8-byte inputs/0-byte outputs				X
8-byte inputs/8-byte outputs		X	X	X

* No PortQualifierInformation is transferred with this configuration.

** The 144-byte input address range covers additional quality information (PortQualifier) in addition to the 128-byte process data.

Module configuration/ supported address space for I/O data	IO-Link master with firmware V1.0	IO-Link master with firmware V2.0	IO-Link master with firmware V2.1	IO-Link master with firmware V2.2
12-byte inputs/8-byte outputs				X
12-byte inputs/12-byte outputs				
16-byte inputs/16-byte outputs		X	X	X
20-byte inputs/16-byte outputs				X
32-byte inputs/32-byte outputs	X	X	X	X
36-byte inputs/32-byte outputs				X
64-byte inputs/64-byte outputs			X	X
68-byte inputs/64-byte outputs				X
144-byte inputs**/128-byte outputs			X	X

* No PortQualifierInformation is transferred with this configuration.

** The 144-byte input address range covers additional quality information (PortQualifier) in addition to the 128-byte process data.

NOTE

Use of the IO-Link Master CM 4xIO-Link with I/O data > 32 bytes

IM 155-6 PN HF/ST interface modules with firmware versions up to V3.0 only support I/O data up to 32 bytes. If you are using IO-Link Master CM 4xIO-Link with I/O data > 32 bytes, you need the IM 155-6 PN HF/ST interface module with firmware version as of V3.1.

Port configuration

With a IO-Link Master CM 4xIO-Link as of firmware version V2.2, you can commission the IO-Link port of the IO-Link master and the connected IO-Link devices in two different ways:

- Port configuration without S7-PCT
- Port configuration with S7-PCT

Port configuration without S7-PCT

Requirements

You have activated the "Port configuration without S7-PCT" check box in the configuration of the IO-Link master in STEP 7.

Procedure

You configure the IO-Link master directly in STEP 7:

- Activate the diagnostics
- Configuration of the I/O data lengths for each port

- Activate the PortQualifierInformation (PQI)
- Port mode:
  - Operation in "IO-Link Autostart" mode (default)
  - Operation in "IO-Link Manual" mode
  - Operated as DI
  - Operated as DQ
  - Deactivated

Port configuration with S7-PCT

Requirements

You have **de**activated the "Port configuration without S7-PCT" check box in the configuration of the IO-Link master in STEP 7.

Procedure

You configure the IO-Link master with the Port Configuration Tool S7-PCT, V3.2 or higher.

PortQualifierInformation (PQI)

You can activate the PortQualifierInfortion (PQI) for your IO-Link master, firmware version V2.2 or higher.

NOTE

PortQualifierInformation (PQI)

If you have activated the PortQualifierInformation (PQI), these are always transferred with the size 1 byte together with the input data of the IO-Link device.

The figure below shows the structure of the PQI byte.

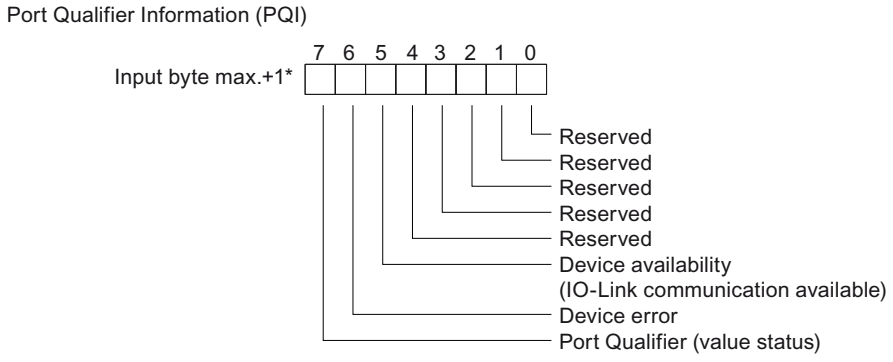

* The PQI byte is always located after the last input byte of the port.

Figure 2-1371 Structure of the PQI byte

Reference

For more information, please refer to the IO-Link system (http://support.automation.siemens.com/WW/view/en/65949252) function manual.

Diagnostic alarms

5

5.1 Status and error displays

LED display

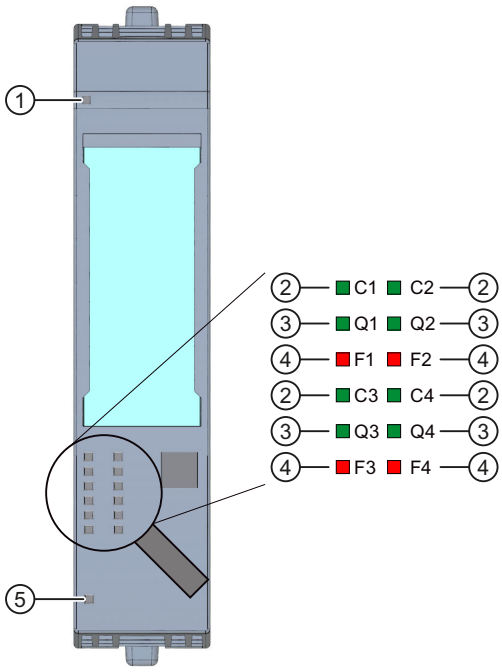

①	Diagnostics (DIAG)	(green/red)
②	Port status / IO-Link status (Cn)	(green)
③	Channel status in SIO mode (Qn)	(green)
④	Port error (Fn)	(red)
⑤	Supply voltage L+ (PWR)	(green)

n - Channel number

Figure 2-1372 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in the Diagnostic alarms (Page 27) chapter.

LED DIAG

Table 2-1648 DIAG LED fault display

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not OK
Flashes	Module is not configured
On	Module parameterized and no module diagnostics
Flashes	Module parameterized and module diagnostics

Cn LEDs

Table 2-1649 Status displays of C1, C2, C3 and C4 LEDs

C1, C2, C3 or C4	Meaning
Off	Port disabled or in SIO mode
Flashes	Port in IO-Link mode, device not connected or port not connected with the configured device
On	Port in IO-Link mode, device not connected

Qn LEDs

Table 2-1650 Status displays of Q1, Q2, Q3 and Q4 LEDs

Q1, Q2, Q3 or Q4	Meaning
Off	Process signal = 0 in SIO mode, deactivated or in IO-Link mode
On	Process signal = 1 in SIO mode

Fn LEDs

Table 2-1651 F1, F2, F3 and F4 LED error displays

F1, F2, F3 or F4	Meaning
Off	No error
On	Error

LED PWR

Table 2-1652 Status display of the PWR LED

PWR	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ present

5.2 Diagnostic alarms

For each diagnostics event, a diagnostic alarm is issued and the DIAG LED flashes red on the communication module. You can read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. You can evaluate the error codes with the user program.

Table 2-1653 Error types

Diagnostic alarm	Error code	Meaning (IO-Link error code)	IO-Link master	IO-Link device
Short-circuit	1_H	• Short-circuit in the process cables on the IO-Link device (1804_H)	X	
		• Short-circuit on IO device (7710_H)		X
Undervoltage	2_H	• Supply voltage too low (5111_H, 5112_H)		X
Overvoltage	3_H	• Supply voltage too high (5110_H)		X
Overheating	5_H	• Temperature exceeded on master (1805_H)	X	
		• Temperature exceeded on device (4000_H, 4210_H)		X
Wire break	6_H	• No IO-Link device connected • There is a break in the signal line to the IO-Link device • IO-Link device cannot communicate due to another error (1800_H)	X	
Overflow	7_H	• Process tag range exceeded ($8C10_H$) • Measuring range exceeded ($8C20_H$)		X
Underflow	8_H	• Process tag range too low ($8C30_H$)		X
Error	9_H	• All IO-Link error codes which are not listed here are mapped to this PROFIBUS DP error		X
Configuration error	10_H	• Incorrect device (1802_H) • Vendor ID and Device ID not defined (1817_H) • Process data length of the IO-Link device exceeded (1818_H) • No cycle time configured (1819_H) • Cannot configure IO-Link master (1882_H, 1883_H) • Storage error (1886_H) • Process data length exceeded (1887_H) • PQI not supported (1889_H)	X	
		• Device was not configured correctly (6320_H, 6321_H, 6350_H)		X
Supply voltage missing	11_H	• L+ supply voltage for device missing (1806_H) • L+ supply voltage for device too low (<20 V) (1807_H)	X	

Diagnostic alarm	Error code	Meaning (IO-Link error code)	IO-Link master	IO-Link device
Defective fuse	12_H	• Fuse on device is defective (5101_H)		X
Safety shutdown	19_H	• Serious error (master has to be replaced) (1880_H)	X	
External fault	$1A_H$	• Error in data storage (1809_H, $180A_H$, $180B_H$, $180C_H$, $180D_H$) • More than 6 errors are pending simultaneously on the IO-Link device (1808_H) • Consistency error in electronic coding element (1885_H) • Process data length exceeded (1887_H)	X	

Technical specifications

6

Technical specifications of the IO-Link Master CM 4xIO-Link communication module

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7137-6BD00-0BA0/td?dl=de).

Article number	6ES7137-6BD00-0BA0
General information	
Product type designation	CM 4 x IO-Link ST
HW functional status	FS20
Firmware version	V2.2.2
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC04
Product function	
• I&M data	Yes; I&M0 to I&M3
• Isochronous mode	No; Only for PROFINET and configuration as version with FW V2.0 or V2.1
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V15 or higher
• STEP 7 configurable/integrated from version	STEP 7 V5.5 or higher
• PROFIBUS from GSD version/GSD revision	One GSD file each, Revision 3 and 5 and higher
• PROFINET from GSD version/GSD revision	GSDML V2.3
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V; 20.5 V if IO-Link is used, as the supply voltage for IO-Link devices has to be at least 20 V at the master.
permissible range, upper limit (DC)	28.8 V
power supply according to NEC Class 2 required	No
Input current	
Current consumption, max.	45 mA; without load
Encoder supply	
Number of outputs	4
Output current	
• Rated value	700 mA; Per channel

Article number	6ES7137-6BD00-0BA0
24 V encoder supply	
• Short-circuit protection	Yes
• Output current, max.	2.1 A
Power loss	
Power loss, typ.	1 W
Hardware configuration	
Automatic encoding	Yes
• Electronic coding element type H	Yes
Digital outputs	
Cable length	
• unshielded, max.	20 m; Also applies for shielded cables
IO-Link	
Number of ports	4
• of which simultaneously controllable	4
IO-Link protocol 1.0	Yes
IO-Link protocol 1.1	Yes
Transmission rate	4.8 kBaud (COM1); 38.4 kBaud (COM2), 230.4 kBaud (COM3)
Cycle time, min.	2 ms; dynamic, depending on user data length
Size of process data, input per port	32 byte; max.
Size of process data, input per module	144 byte; max.
Size of process data, output per port	32 byte; max.
Size of process data, output per module	128 byte; max.
Memory size for device parameter	2 kbyte; for each port
Master backup	Yes
Configuration without S7-PCT	Yes
Cable length unshielded, max.	20 m
Operating modes	
• IO-Link	Yes
• DI	Yes
• DQ	Yes; max. 100 mA per channel
Time Based IO	
– TIO IO-Link IN	No; Only for PROFINET and configuration as version with FW V2.0 or V2.1
– TIO IO-Link OUT	No; Only for PROFINET and configuration as version with FW V2.0 or V2.1
– TIO IO-Link IN/OUT	No; Only for PROFINET and configuration as version with FW V2.0 or V2.1
Connection of IO-Link devices	
• Port type A	Yes
• Port type B	Yes; 24 V DC via external terminal
• via three-wire connection	Yes

Article number	6ES7137-6BD00-0BA0
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes; The port diagnosis is available in the IO-Link mode only.
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• Group error	Yes
Diagnostics indication LED	
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; one green LED for channel status Qn (SIO mode) and port status Cn (IO-Link mode) per channel
• for channel diagnostics	Yes; red Fn LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	13 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

Power reduction (derating)

The following derating curves show the load capacity of the transducer supply outputs in relation to the mounting position and the ambient temperature.

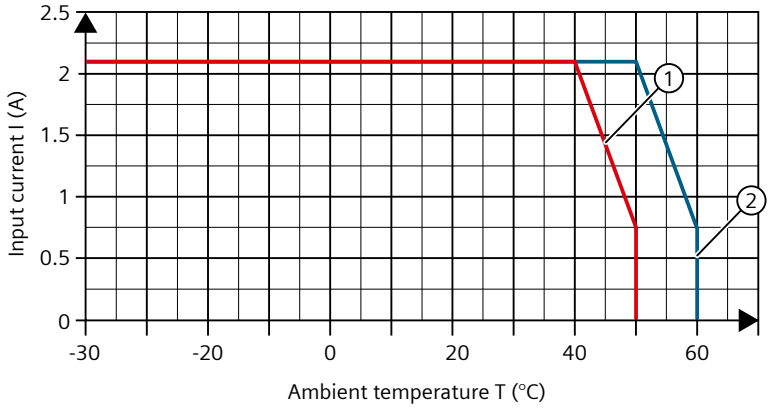

① Mounting position other than horizontal

② Horizontal mounting position

Figure 2-1373 Derating curve, IO-Link master CM 4xIO-Link

Overview of the response time

The following figure shows the response time for IO-Link without Time-based IO.

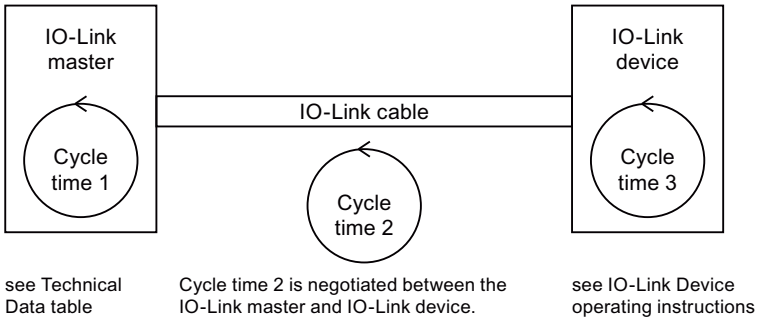

Figure 2-1374 Cycle time for IO-Link without Time-based IO

Dimensional drawing

See manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)

Parameter data record

A

A.1 Parameter assignment and structure of parameter data set

The data record of the module has an identical structure, regardless of whether you configure the module with PROFIBUS DP or PROFINET IO. With data record 128, you can reconfigure the module in your user program regardless of your programming.

The following describes the structure of data record 128 as of firmware version V2.2.

Configuration in the user program

You can configure the modules in runtime.

Changing parameters in RUN

The "WRREC" instruction is used to transfer the parameters to the module using data record 128. The parameters set in STEP 7 are not changed in the CPU, which means that the parameters set in STEP 7 will be valid again after a restart.

Output parameter STATUS

If errors occur when transmitting parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Error message

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The instruction WRREC for writing data records returns corresponding error codes when errors occur in the parameter STATUS.

The following table shows the module-specific error codes and their meaning for the parameter data record 128:

Table 2-1654 Error message

Error code	Meaning
$80B1_H$	Error in data length
$80E0_H$	Error in header information
$80E1_H$	Parameter error

Structure of data record 128

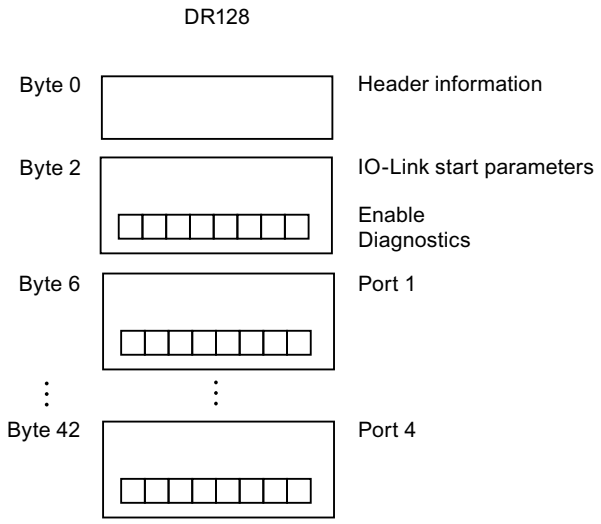

Figure 2-1375 Structure of data record 128

Header information

The figure below shows the structure of the header information.

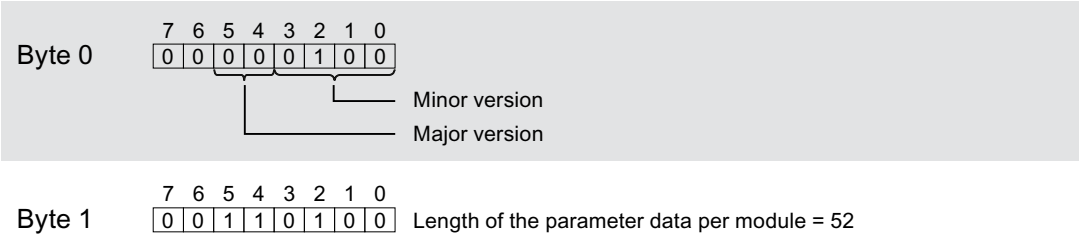

Figure 2-1376 Header information

IO-Link start parameters

The following figure shows the structure of the IO-Link start parameter.
Activate a parameter by setting the corresponding bit to "1".

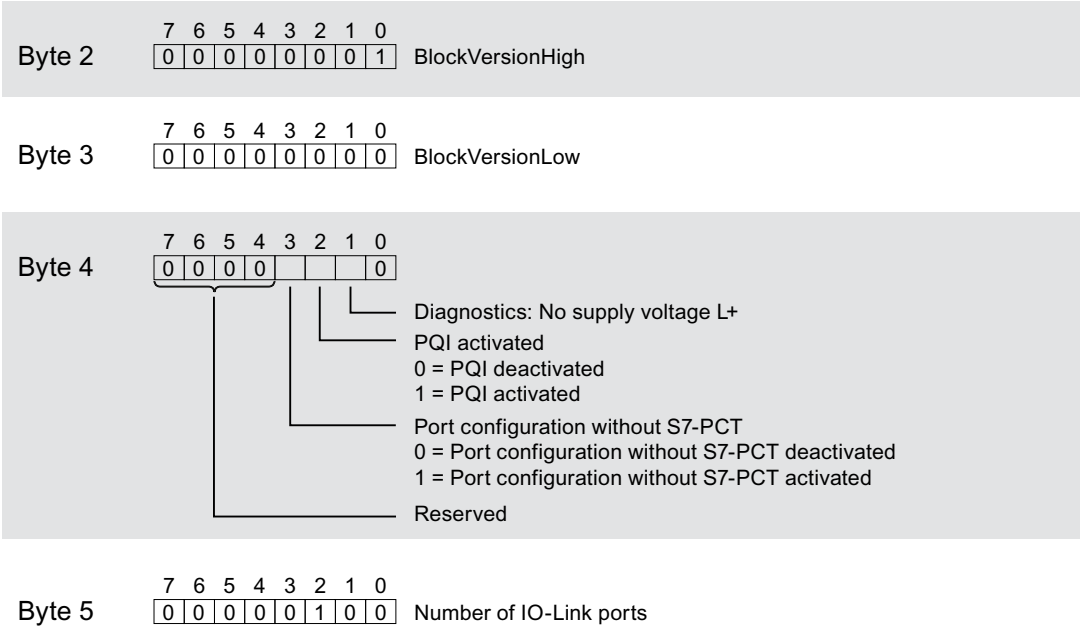

Figure 2-1377 IO-Link start parameters

Port parameter

The following figure shows an extract from the structure of the port parameter.
Activate a parameter by setting the corresponding bit to "1".

If you have selected IO-Link Manual operating mode, you must enter the Vendor ID (byte x+5 and x+6) and Device ID (byte x+7 to x+10) yourself.
You can find the Vendor ID and Device ID in the IODD of the IO-Link device being used.

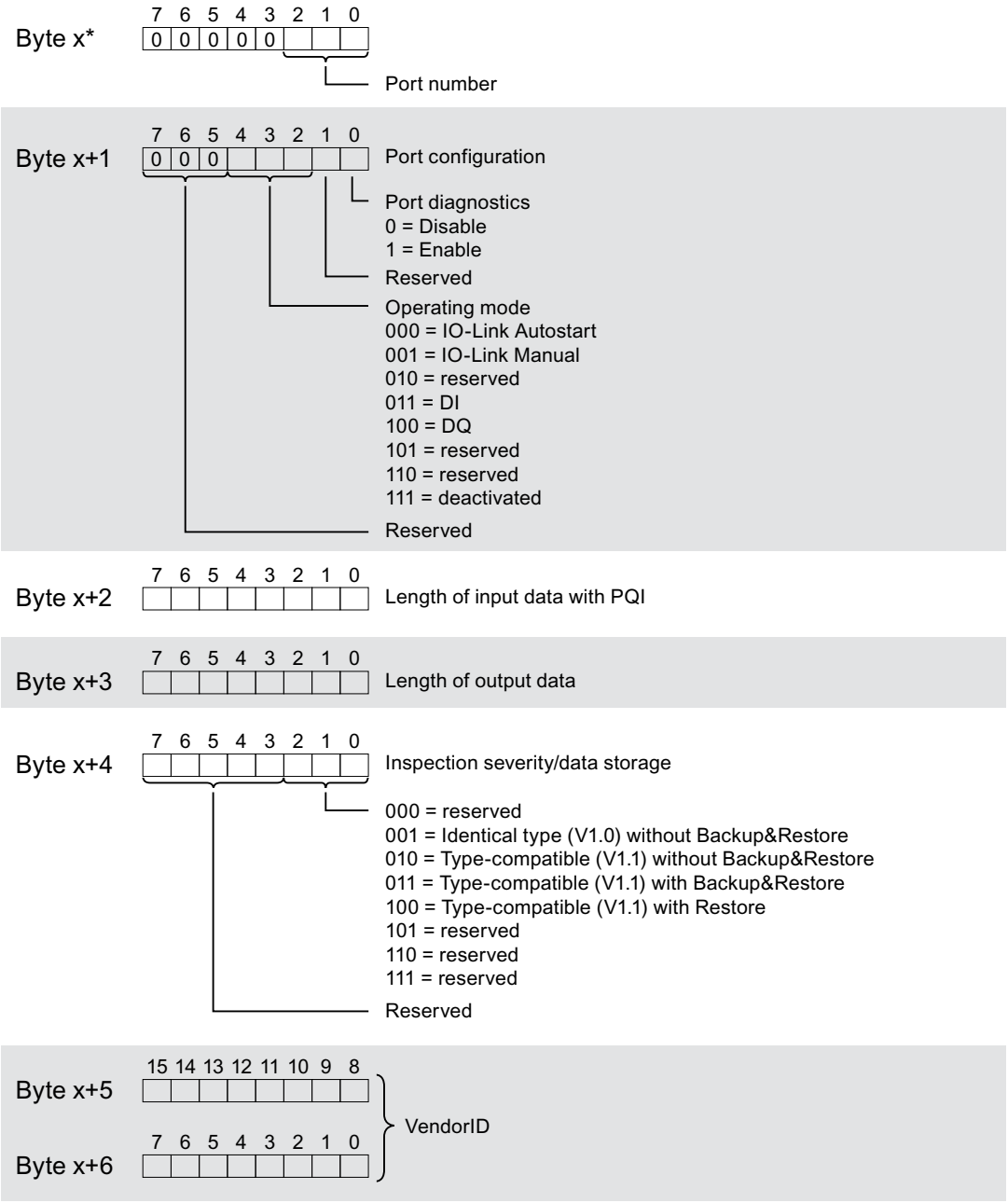

* x = 6 + ((port number-1) x 12); port numbers = 1 to 4.

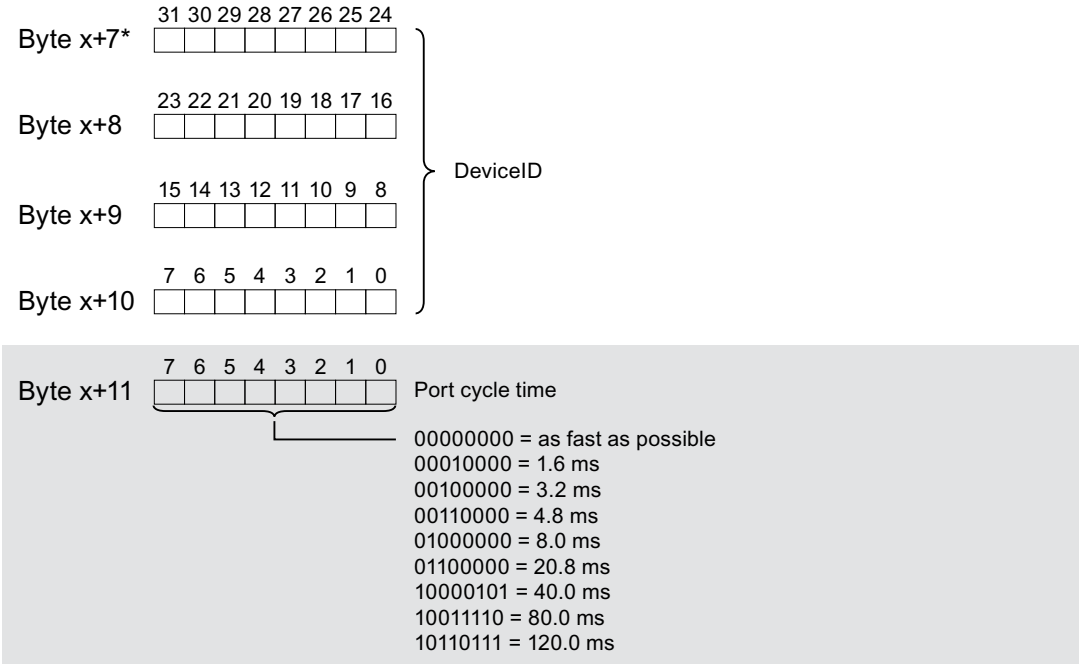

* x = 6 + ((port number-1) x 12); port numbers = 1 to 4.

Figure 2-1378 Port parameter

SIEMENS

SIMATIC

ET 200SP
AS-Interface master CM AS-i Master ST (3RK7137-6SA00-0BC1)

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Siemens Industry Support 1

1.1 Documentation guide

This Equipment Manual supplements the "ET 200SP Distributed I/O System" System Manual. General ET 200SP functions can be found in the "Distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293)" System Manual.

The information provided in this Equipment Manual and the System Manual enables you to commission the ET 200SP distributed I/O system.

The following paragraph gives you an overview of the additional documentation you need to use the CM AS-i Master ST.

The documentation for the SIMATIC ET 200SP distributed I/O system is subdivided into three areas.

This enables you to access the required content quickly.

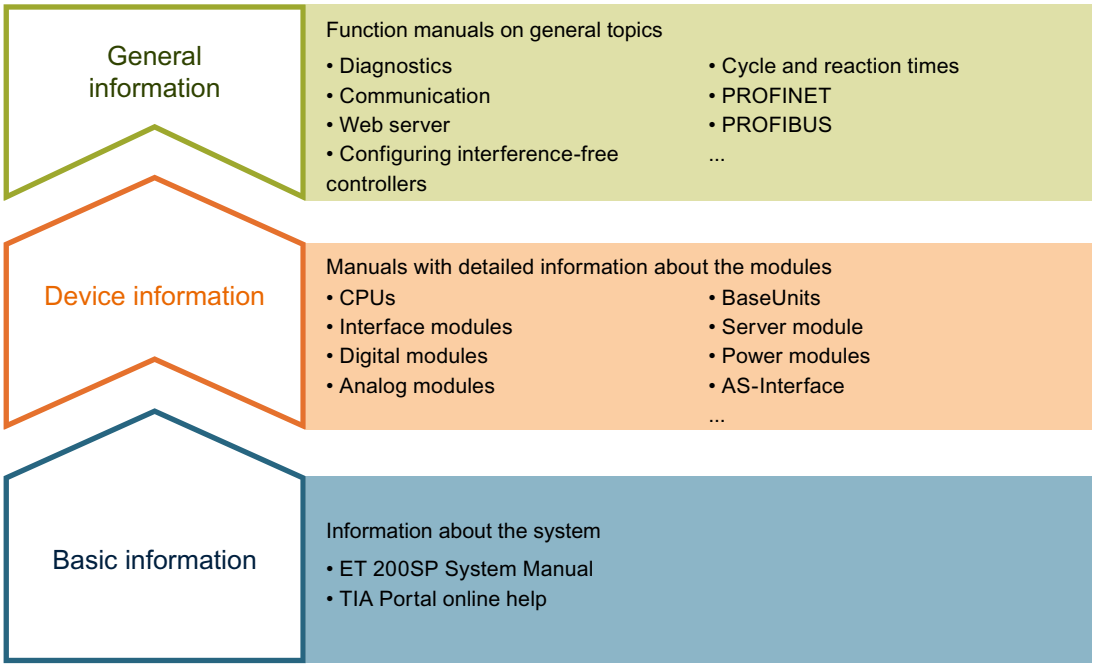

Basic information

The System Manual describes configuration, assembly, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The *STEP 7* online help supports you with configuration and programming.

Device information

Manuals contain a compact description of the module-specific information, such as properties, connection diagrams, characteristics and technical specifications.

General information

The Function Manuals contain detailed descriptions on topics relating to the SIMATIC ET 200SP environment, such as configuring diagnostics, communications, web servers and controllers for problem-free operation.

The following paragraph gives you an overview of the additional documentation you need to use the CM AS-i Master ST.

Documentation for the ET 200SP distributed I/O system with the CM AS-i master ST

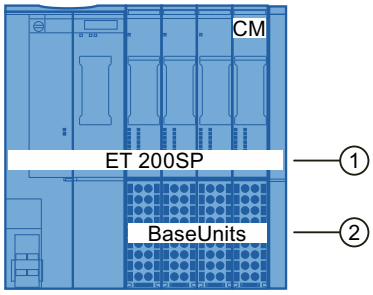

Figure 2-1379 Example of a system structure

Table 2-1655 Documentation for the ET 200SP distributed I/O system with the CM AS-i master ST

No.	Component	Documentation	Most important contents
1	System	SIMATIC ET 200SP Distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) SIMATIC ET 200SP Manual Collection (https://support.industry.siemens.com/cs/ww/en/view/84133942)	• Application planning • Installation • Connecting • Commissioning • Technical specifications
2	BaseUnits	SIMATIC ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521)	• Connecting • Technical specifications

1.2 Siemens Industry Online Support

Information and service

At Siemens Industry Online Support you can obtain up-to-date information from our global support database:

- Product support
- Application examples
- Forum
- mySupport

Link: Siemens Industry Online Support (https://support.industry.siemens.com/cs/de/en)

Product support

You can find information and comprehensive know-how covering all aspects of your product here:

- **FAQs**

  Answers to frequently asked questions
- **Manuals/operating instructions**

  Read online or download, available as PDF or individually configurable.
- **Certificates**

  Clearly sorted according to approving authority, type and country.
- **Characteristics**

  For support in planning and configuring your system.
- **Product announcements**

  The latest information and news concerning our products.
- **Downloads**

  Here you will find updates, service packs, HSPs and much more for your product.
- **Application examples**

  Function blocks, background and system descriptions, performance statements, demonstration systems, and application examples, clearly explained and represented.
- **Technical data**

  Technical product data for support in planning and implementing your project

Link: Product support (https://support.industry.siemens.com/cs/ww/en/ps)

mySupport

The following functions are available in your personal work area "mySupport":

- **Support Request**

  Search for request number, product or subject
- **My filters**

  With filters, you limit the content of the online support to different focal points.
- **My favorites**

  With favorites you bookmark articles and products that you need frequently.
- **My notifications**

  Your personal mailbox for exchanging information and managing your contacts. You can compile your own individual newsletter in the "Notifications" section.
- **My products**

  With product lists you can virtually map your control cabinet, your system or your entire automation project.
- **My documentation**

  Configure your individual documentation from different manuals.

- **CAx data**

  Easy access to CAx data, e.g. 3D models, 2D dimension drawings, EPLAN macros, device circuit diagrams

- **My IBase registrations**

  Register your Siemens products, systems and software.

1.3 Siemens Industry Online Support app

Siemens Industry Online Support app

The Siemens Industry Online Support app provides you access to all the device-specific information available on the Siemens Industry Online Support portal for a particular article number, such as operating instructions, manuals, data sheets, FAQs etc.

The Siemens Industry Online Support app is available for Android and iOS:

Android

iOS

1.4 Support Request

After you have registered, you can use the Support Request form in the online support to send your question directly to Technical Support:

Support Request:	Internet (https://www.siemens.com/support-request)

Safety instructions 2

2.1 Safety instructions

Important safety instructions

WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

For use in Pollution Degree 2 Environment.

WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

When used in hazardous environments corresponding to Class I, Division 2 or Class I, Zone 2, the device must be installed in a cabinet or a suitable enclosure. To comply with EU Directive 2014/34/EU relating to equipment and protective systems intended for use in potentially explosive atmospheres, Statutory Instrument 2016 No. 1107 and relevant amendments, the enclosure must meet the requirements of at least IP54 according to EN 60529.

WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Do not disconnect equipment when a flammable or combustible atmosphere is present.

WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Do not disconnect while circuit is live unless area is known to be non-hazardous.

WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Substitution of components may impair suitability for class I, division 2 or zone 2.

WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Do not open when energized.

WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

The equipment is designed for operation with directly connectable Safety Extra Low Voltage (SELV) by a Limited Power Source (LPS).

This means that only SELV / LPS complying with IEC 60950-1, EN 60950-1, VDE 0805-1 must be connected to the power supply terminals.

The power supply unit for the equipment power supply must comply with NEC Class 2, as described by the National Electrical Code (r) (ANSI / NFPA 70).

WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 40 %. This criteria is fulfilled if supples are derived from SELV (Safety Extra-Low Voltage) only.

CAUTION

Failure to observe this information may result in property damage and bodily injury

This equipment is suitable for use in Class I, Zone 2, Groups A, B, C, and D, or non-hazardous locations only.

CAUTION

Failure to observe this information may result in property damage and bodily injury

This equipment is suitable for use in Class I, Zone 2, Group IIC or non-hazardous locations only.

2.2 Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary

and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit
https://www.siemens.com/industrialsecurity.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under
https://www.siemens.com/cert.

Description

3

3.1 Characteristics of the CM AS-i Master ST

Article number

3RK7137-6SA00-0BC1

Brief introduction to AS-Interface

AS-Interface or Actuator-Sensor-Interface (AS-i for short) is a fieldbus system for industrial use that is used to transmit digital and analog signals between a controller and machine or process in real-time. The system can be used for standard signals as well as for safety-related signals.

AS-Interface is designed to connect actuators and sensors to the controller as easily, flexibly and efficiently as possible.

The system consists of an AS-i master and up to 62 AS-i slaves that are simply plugged onto the yellow AS-i flat ribbon cable at any point or connected via terminals. The AS-i cable can be up to 100 m long with free choice of topology. A length of up to 200 m is possible with an additional extension plug. The system can be extended beyond that through the use of repeaters.

In addition, an AS-i power supply unit is connected to the cable such that the slaves and their connected sensors are supplied with operating voltage without additional cabling. Actuators are usually supplied with voltage by means of a 24 V cable, because they generally need more power than sensors.

A typical digital AS-i slave has up to 4 inputs and 4 outputs. The slaves are installed directly in the plant as close as possible to the sensors or actuators so that the connecting cables can be kept very short. The insulation displacement method is the preferred method for connection to the AS-i flat ribbon cable so that assembly can be completed without errors in the least amount of time. For safety-related signals, safety slaves and modules are available for safety-related processing of signals. In addition, analog slaves and complete switchgear with integrated AS-i slave are offered.

The default voltage fed in from the AS-i power supply unit is 30 V DC. As a result, sensors with a rated voltage of 24 V can be used without any problems despite the voltage drop on a longer AS-i cable. Because the AS-i cable transmits both operating DC voltage and modulated communication signals, the AS-i power supply unit contains a data decoupling unit for separating the two voltage waveforms.

A standard power supply can be used in place of the easy-to-use AS-i power supply if the AS-i cable is connected via a separate data decoupling module. When a standard power supply with 24 V DC is used, it must be ensured that the connected AS-i components and sensors are designed for operation with the corresponding lower voltage.

You will find more information on the Internet at: AS-Interface (https://www.siemens.com/as-interface).

Use of the module

The CM AS-i Master ST module is a communication module for use in the SIMATIC ET 200SP Distributed I/O System.

The CM AS-i Master ST features a 20 mm wide ET 200SP module housing. A BaseUnit (BU) is required for use in the ET 200SP. The CM AS-i Master ST can be plugged into C0-type BaseUnits (BU).

You can plug several CM AS-i Master ST modules into one SIMATIC ET 200SP station. Each CM AS-i master occupies 32 bytes of I/O address space in the basic setting. To adapt the number and type of AS-i slaves used, the I/O address space can be reduced, or expanded up to 288 bytes. From firmware version V1.1 onwards, the CM AS-i Master ST supports up to 288 bytes of I/O address space. The number of possible AS-i master modules depends on the maximum address space of the utilized Interface Module (IM) of the ET 200SP or the utilized ET 200SP CPU.

In a SIMATIC ET 200SP station with an IM 155-6 PN ST standard interface module and a maximum address space of 256 bytes, up to eight CM AS-i Master ST modules can be plugged in (when the I/O address space is configured as 32 bytes).

Significantly more modules can be plugged into a SIMATIC ET 200SP station with High Feature Interface Module IM 156-6 PN HF and a maximum address space of 1440 bytes.

If the ET 200SP contains other modules, the available address space is reduced and the maximum number of AS-i master modules is reduced accordingly. The maximum number of modules can be increased by shortening the I/O address space of the CM AS-i Master ST module.

For more information, see the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/84133942).

The CM AS-i Master ST module can generally be combined with all ET 200SP interface modules. Any exceptions to this are documented in the delivery release product announcement(s) of the interface module.

The CM AS-i Master ST module can generally be combined with all ET 200SP CPU modules with firmware V1.8 or higher. Any exceptions to this are documented in the CPU module delivery release product announcements.

The interface modules und CPU modules differ, among other things, in terms of the maximum number of I/O modules, the length of the I/O process image in the station and the length of the I/O process image for each I/O module. The technical specifications of the interface modules and CPU modules can limit the selection of possible parameters of the CM AS-i Master ST module. Note, in particular, that the length of the I/O process image of the CM AS-i Master ST module must be selected in such a way that the maximum length of the I/O process image of the interface module or CPU module is not exceeded.

View of the module

Figure 2-1380 View of the CM AS-i Master ST

Properties

- Technical properties
  - AS-i master acc. to AS-Interface Specification 3.0
  - Transmission of digital I/O values in the cyclic process image
  - Transmission of analog I/O values in the cyclic process image or via acyclic data record communication.
  - Configuration button can be connected to terminals
- Supported functions
  - I&M identification data
  - Firmware update
  - Configuration of the AS-i master and AS-i slaves via data records (Read / Write or command interface)

The module can be used with the following engineering versions:

Table 2-1656 Version dependence of the CM AS-i Master ST engineering versions

Firmware version of the module	*STEP 7* (TIA portal)	*STEP 7* V5.5	GSD file
V1.0	V12 and higher	V5.5 SP3 HF5 and higher	X
V1.1	V13 SP1 and higher	V5.5 SP3 HF5 and higher	X

For more information, see the product announcement for: CM AS-i Master ST (https://support.industry.siemens.com/cs/ww/en/view/72865595)

Table 2-1657 Version dependence of the CM AS-i Master ST functions

Function	Firmware version of the module
Configuring in *STEP 7* (TIA Portal) V12 and higher	V1.0 and higher
GSD file (PROFIBUS)	V1.0 and higher
GSD file (PROFINET)	V1.0 and higher
Access via command data records	V1.0 and higher

Function	Firmware version of the module
Structure of the process image: 32 bytes	V1.0 and higher
Transmission of digital I/O values in the cyclic process image	V1.0 and higher
Transmission of analog I/O values via data record transfer	V1.0 and higher
Firmware update	V1.0 and higher
Duplicate address detection	V1.0 and higher
Automatic address programming with manual writing of the ID1 code	V1.0 and higher
Write ID1 code to AS-i address "0"	V1.0 and higher
Configuring in *STEP 7* (TIA Portal) V13 SP1 and higher	V1.1 and higher
Status information for all slaves of the AS-i master system (TIA Portal)	V1.1 and higher
Detailed, device-specific diagnostics (TIA Portal)	V1.1 and higher
Configuring in *STEP 7* V5.5 and higher	V1.1 and higher
Option handling	V1.1 and higher
Proxy slave	V1.1 and higher
Structure of the process image: Up to 288 bytes, adjustable length	V1.1 and higher
Transmission of analog I/O values via process data	V1.1 and higher
Variable address area for I/O data	V1.1 and higher
Automatic address programming with automatic writing of the ID1 code	V1.1 and higher
AS-i slave_ID1_write_with_target_address	V1.1 and higher
Automatic duplicate address detection for AS-i voltage of either 24 V or 30 V	V1.1 and higher

Accessories

The following components can be used with the module:

- Labeling strips
- Reference identification label

3.2 Operating modes of the CM AS-i Master ST

The AS-i master has two operating modes:

- "Configuration mode"
- "Protected mode"

"Configuration mode"

"Configuration mode" can be used for commissioning an AS-i installation. You can also use "configuration mode" for productive operation. The AS-i bus configuration is not defined in this case. This means that error messages for a change of bus configuration are not possible.

You can switch the AS-i master from "protected mode" to "configuration mode" in *STEP 7*. The "CM" LED (Configuration Mode) then lights up green.

In "configuration mode", the AS-i master can exchange data with every AS-i slave that is connected to the AS-i cable. This does not apply to AS-i slaves with the address "0". The AS-i master immediately detects and activates newly added AS-i slaves and includes them in cyclic data exchange. The digital process data of the connected AS-i slaves are stored according to a fixed scheme in the process image starting from a configurable start address. See "Special characteristics of AS-i Safety slaves (Page 54)". The digital process image for the inputs of non-existent slaves is filled with the substitute value "0". Analog process data can only be accessed by means of data record communication.

In "configuration mode", configuration errors of AS-i slaves are not signaled to the higher-level station via an alarm and are not indicated by the "DIAG" LED.

"Protected mode"

In "protected mode", the AS-i master only exchanges data with the configured AS-i slaves. In case of changes to the bus configuration, error messages are automatically generated if diagnostics is enabled. See "Parameter assignment/addressing (Page 42)".

You can configure in one of the following ways:

- Configuration of the AS i slaves in the *STEP 7* project (Configuration of the AS-i slaves in STEP 7 (Page 28))
- Applying the slave configuration with the online "ACTUAL → EXPECTED" function in *STEP 7* (Applying the slave configuration (Page 37))
- Calling the command interface in the SIMATIC user program with the following commands:
  - No. 07: Store_Actual_Configuration (Page 101)
  - No. BA: Write_overall_configuration (Page 117)
- Using the connected "SET" button (Configuration of the AS-i slaves using the "SET" button (Page 33))

If you have configured the AS-i slave in the *STEP 7* project, the changeover to "protected mode" occurs automatically.

Changeover between "configuration mode" and "protected mode"

You can change between "configuration mode" and "protected mode" in one of the following ways:

- By switching the operating mode using the "Online functions in the TIA Portal (Page 35)".
- By calling the command interface in the user program of SIMATIC with command "No. 0C: Set_Operation_Mode (Page 105)".
- Using the connected "SET" button (Configuration of the AS-i slaves using the "SET" button (Page 33)).

Changeover is not possible if the AS-i slaves have been configured in the *STEP 7* project and the CPU is in RUN mode (except by calling the command interface).

3.3 Firmware update

Performing a firmware update

Information about updating the firmware can be found in the ET 200SP System Manual.

NOTE

Following a firmware update, mark the current firmware version on the housing of the CM AS-i Master ST.

Current firmware updates are available on the Internet for download (https://support.industry.siemens.com/cs/ww/en/view/108742051).

Pay careful attention to the information on performing the firmware update contained in the download entry.

When a firmware update is performed, any existing configuration that was determined via the online function "ACTUAL -> EXPECTED" or using the "SET" button is deleted in the master. The configuration must be repeated in this case, i.e. the online function "ACTUAL -> EXPECTED" must be performed or the "SET" button pressed. If the AS-i modules are configured in the TIA project, configuration is performed automatically.

From product version 20 of the CM AS-i Master ST, only firmware version V2.0 or higher can be used.

With product versions < 20, only firmware versions < V2.0 can be used.

LED behavior during a firmware update

During a firmware update, the LEDs exhibit the following behavior:

- DIAG flashes red
- PWR is lit green
- Remaining AS-i LEDs are off

NOTE

Supply voltage during a firmware update

The AS-i voltage and the supply voltage of the ET 200SP station must not be switched off during a firmware update.

LED behavior after a successfully completed firmware update

When the TIA Portal is used, an error-free firmware update is indicated by the message that the firmware was successfully transferred.

NOTE

Confirming a message after an error-free firmware update

You must confirm the message using the button before you continue. Without confirmation, the LED status remains unchanged so that the firmware update is incomplete and must be repeated.

When *STEP 7* V5.5 (classic) is used, there is no concluding message and the LED status changes autonomously.

If the firmware is updated without errors, the LED status is updated:

- DIAG flashes red until the AS-i voltage is switched off and back on again
- PWR is lit green
- Remaining AS-i LEDs are lit

WARNING

Required intermediate step for firmware update of a CM AS-i Master ST with FW V1.0 using an ET 200SP CPU.

Failure to perform this step causes the CM AS-i Master ST to become permanently inoperable.

If you want to perform an update to a higher firmware version for a CM AS-i Master ST module with FW V1.0 and are using an ET 200SP configuration with an ET 200SP CPU in place of an interface module (IM), you must always perform the following intermediate step:

After the update of the LED status, the CM AS-i master ST module must be removed from the ET 200SP BaseUnit. Instead of removing the module, it is also sufficient to switch off the AS-i voltage and the 24 V voltage of the ET 200SP. A TIA Portal error message appears approximately one minute after the module has been removed indicating that online access to the module is no longer possible. Confirm the error message. Then plug the module onto the BaseUnit again or switch the voltages back on.

Now repeat the firmware update. In this case, the intermediate step described here can be skipped.

The intermediate step is not required for:

- Firmware update of a CM AS-i Master ST module with active FW V1.1 or higher
- Use of an ET 200SP configuration with a PROFINET interface module (IM) and PROFINET connection to a released SIMATIC CPU
- Use of an ET 200SP configuration with a PROFIBUS interface module (IM) and PROFIBUS connection to a released SIMATIC CPU.

NOTE

For operation of the CM AS-i Master ST module in an ET 200SP configuration with an ET 200SP CPU in place of an interface module (IM), the following minimum requirements of the firmware and software versions apply:

- CM AS-i Master ST with FW V1.1 or higher, and
- ET 200SP CPU with FW V1.8 or higher (CPU 1510SP-1 PN, CPU 1510SP F-1 PN, CPU 1512SP-1 PN, CPU 1512SP F-1 PN, Open Controller CPU 1515SP PC)
- Configuration with *STEP 7* V13 SP 1 Update 4 or higher

NOTE

Restart after a firmware update

Following a firmware update, the AS-i voltage must be switched off and back on again in order for the new firmware to be activated.

Wait for the LED status to update before performing the restart. Otherwise the firmware update is not complete and must be repeated.

LED behavior in the event of an error during a firmware update

If an error occurs during the firmware update, the LEDs assume the following status:

- DIAG flashes red
- PWR is lit green
- Remaining AS-i LEDs indicate the status of the AS-i and are not relevant here.

In this case, switch the AS-i voltage off and back on again and repeat the firmware update.

LED behavior when an incompatible firmware version is used

CM AS-i Master ST modules with product versions < 20 are only permissible for firmware versions < V2.0.

If a firmware version V2.0 or higher is loaded into a CM AS-i Master ST module with product version < 20 during the firmware update, the LEDs enter the following states:

- DIAG flashes green
- PWR is lit green
- The remaining AS-i LEDs are not relevant here

In this case, switch the AS-i voltage off and back on again, and repeat the firmware update with a compatible firmware version.

Connecting

4

4.1 Terminal assignment

Requirements

For connecting, you require a BaseUnit:

- Type C0 (light BaseUnit, e.g., item number 6ES7193-6BP20-0DC0)

Note that, within a BaseUnit group for AS-i consisting of light and dark BaseUnits, only the AS-i modules CM AS-i Master ST and F-CM AS-i Safety ST may be combined. Other I/O module types of the ET 200SP must always be separated from the BaseUnit group for AS-i using light BaseUnits.

Exception:

BaseUnits with power busbars without connection to the terminals of the plug-in I/O module can be used within a BaseUnit group for AS-i. These BaseUnits include the following dark BaseUnits with 20 mm width:

- BU20-P12+A0+4B (BU type B1)
- BU20-P12+A0+0B (BU type D0)
- BU20-P8+A4+0B (BU type F0)

NOTICE

Make sure that external voltage from adjacent BaseUnits cannot under any circumstances be connected to the AS-i modules.

⚠ WARNING

Connection of the BaseUnit only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition

Failure to observe this information may result in death, severe injury, and serious property damage.

Connect the BaseUnit only to an AS-i power supply unit that meets the conditions indicated in Section "Schematic circuit diagram (Page 23)", "Power supply units for AS-Interface". Connection to a higher voltage may result in death, severe injury, and serious property damage.

General terminal assignment

Table 2-1658 Terminal assignment of the CM AS-i Master ST

Terminal	Assignment	Description
1	SET1	Connection of the "SET" button (optional), see "Configuration of the AS-i slaves using the "SET" button (Page 33)"
2	SET2	
3	RES	Reserved
4	RES	Reserved
5	RES	Reserved
6	RES	Reserved
1L, 2L [1)]	ASI+	Connection of the AS-i cable, positive polarity
1N, 2N [1)]	ASI-	Connection of the AS-i cable, negative polarity

1) The terminals are connected through in the BaseUnit.

Connecting an external "SET" button

You can connect a "SET" button to terminals "SET1" and "SET2" of the AS-i master. This enables you to apply the ACTUAL configuration of the connected AS-i slaves as the CONFIGURED configuration. This function is activated by closing the button contact on the SET1 and SET2 terminals.

The maximum cable length between the terminal and "SET" button is 0.5 m.

Use two wires routed in parallel for connecting the button (not included in the scope of delivery).

See also

"ET 200SP Distributed I/O System" System Manual
(https://support.industry.siemens.com/cs/ww/de/view/58649293)
"ET 200SP BaseUnits" Manual
(https://support.industry.siemens.com/cs/ww/en/view/59753521)

4.2 Schematic circuit diagram

Schematic circuit diagram

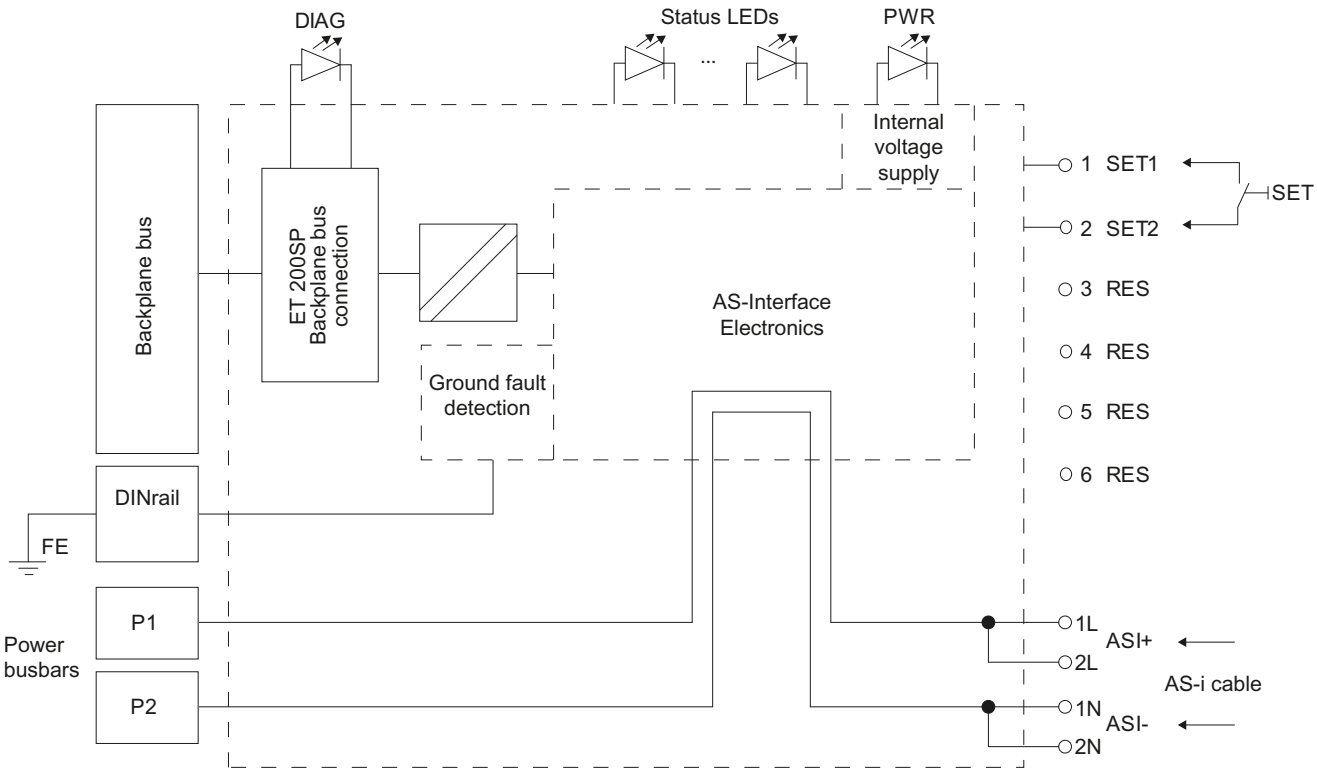

Figure 2-1381 Circuit diagram of the CM AS-i Master ST

1L, 2L are connected through in the BaseUnit.

1N, 2N are connected through in the BaseUnit.

Connection to power busbars

The following are connected via the CM AS-i Master ST:

- 1L and power busbar P1
- 1N and power busbar P2

The maximum permitted current here is 4 A. For a conducted current of 4 A, the reduced ambient temperature range applies:

- Max. 55 °C for a horizontally mounted rail
- Max. 50 °C for a vertically mounted rail

If safety-related signals are to be processed on the AS-i cable, you can arrange a dark BaseUnit type C1 to the right of the light BaseUnit type C0 with the CM AS-i Master ST module and plug a safety-related F-CM AS-i Safety ST module onto this dark BaseUnit. The AS-i cable is continued from the light BaseUnit to the dark BaseUnit via the power busbars so that the F-CM AS-i Safety ST module is connected to the AS-i network of the master without additional wiring.

It is not permitted to transmit the AS-i voltage from the connecting terminals on the front of the dark BaseUnit because a current draw of this type may cause an overload in the modules.

Connect the AS-i cable with AS-i power supply unit and AS-i slaves only to terminals 1L, 2L (ASI+) and 1N, 2N (ASI-) of the light BaseUnit.

You can find more information on safety-related processing in the "Fail-safe module F-CM AS-i Safety ST (https://support.industry.siemens.com/cs/ww/en/view/90265988)" Equipment Manual.

Power supply units supported for AS-Interface

A connected power supply unit must have the following properties:

- Rated output voltage 30 V DC (AS-Interface Standard) or 24 V DC (AS-i Power24V)
- according to ES1 (IEC 62368-1) or
  PELV (Protective Extra Low Voltage)/SELV (Safety Extra Low Voltage)
- Residual ripple < 250 mVpp
- Limiting of output voltage to max. 40 V in the event of a fault

The Siemens power supply units for AS-Interface meet these requirements (see operating instructions of the power supply unit).

Use an AS-Interface power supply unit (with integrated data decoupling) or a combination of a standard power supply unit and a data decoupling module.

When AS-i Power24V is used, there are constraints on the cable length (max. 50 m AS-i cable) and usability of AS-i components and connected sensors/actuators due to the reduced voltage.

Additional notes:

- AS-Interface System Manual
  (https://support.industry.siemens.com/cs/ww/en/view/26250840)
- FAQ "Compatibility for AS-i Power24V"
  (https://support.industry.siemens.com/cs/ww/en/view/42806066)

Power supply

The CM AS-i Master ST is fully powered from the AS-i voltage. Only the internal backplane bus interface for the ET 200SP station (including the DIAG LED) is powered from the operating voltage of the ET 200SP station.

If the operating voltage of the ET 200SP station fails, the communication between the AS-i master and AS-i slaves continues without interruption, in which case the outputs of the AS-i slave are reset to zero.

Configuring 5

5.1 Requirements

Introduction

You configure the ET 200SP station and its CM AS-i Master ST and assign their parameters using *STEP 7* or the configuration software of another manufacturer.

Configuring the CM AS-i Master ST

Configuring in *STEP 7* or another configuration software is required in order to use the CM AS-i Master ST in an ET 200SP. A distinction is made here between the necessary basic configuration of the AS-i master and the optional configuration of the AS-i slaves.

You can configure the module using *STEP 7* or with a GSD file. Version dependencies:

Version dependence of the CM AS-i Master ST engineering versions

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NOTE

CM AS-i Master ST in the hardware catalog of *STEP 7*

If the CM AS-i Master ST module in the applicable firmware version is not listed in the hardware catalog of *STEP 7* , you will need a "Hardware Support Package". You can install this HSP from the Internet using the corresponding function in *STEP 7*.

More information can be found in the documentation and in the online help for *STEP 7*.

Installing the HSP in *STEP 7* V5.5 (classic)	"HW Config" > "Options" menu > "Install HW Updates"
Installing the HSP in *STEP 7* V13 (TIA Portal):	"Options" menu > "Support packages"

You can find more information on the HSP and download it in Internet (https://support.industry.siemens.com/cs/ww/en/view/108742051).

Download the GSD file from the internet:

PROFINET GSD file (https://support.industry.siemens.com/cs/ww/en/view/57138621)

PROFIBUS GSD file (https://support.industry.siemens.com/cs/ww/en/view/73016883)

Observe the *STEP 7* online help or the documentation of the configuration software manufacturer.

Configuring the AS-i system requires two steps:

1. Basic configuration of the AS-i master (Basic configuration of the CM AS-i Master ST (Page 27))
2. Configuration of the AS-i slaves

Configuring the AS-i slaves includes defining the slave modules and, if necessary, assigning the slave operating parameters.

Compatibility of firmware and hardware versions

The firmware version loaded in the hardware must be equal to or higher than the firmware version of the CM AS-i Master ST module set in the STEP 7 project.

If parts have to be replaced, a hardware module can be replaced by a new module with a higher firmware version without upgrading the STEP 7 project.

To configure the CM AS-i Master ST module with product version 20 or higher (corresponds to firmware version V2.0 or higher), it is possible to choose firmware version V1.1 in the TIA Portal hardware configuration if no higher version is offered for selection.

The following information may be displayed in this case in the TIA Portal online diagnostic status for the CM AS-i Master ST module: "Differences were found between the loaded configuration and the offline project. The online and offline configuration data of the module are different. The installed firmware version (online) is not the same as the configured firmware version (offline)." This information is not an error message and can be ignored.

NOTE

Generally, the newer module or firmware is compatible with the older module, or contains new functions or bug fixes. However, it cannot be completely ruled out that the behavior of the module may change. New firmware or hardware can have a better performance and therefore speed up data communication between the AS-i master and CPU so that the reaction speed of the system is higher.

If the firmware version loaded in the hardware is lower than the firmware version of the CM AS-i Master ST module set in the STEP 7 project, operation of the AS-i master is usually not possible. The DIAG LED flashes green. The online diagnostics in the TIA Portal may display the message: "Module exists. Input/output data not available. Error in lower-level component". "Module exists. Input/output data not available. Error in lower-level component".)

Use with a redundant IM 155-6 PN R1 interface module

If the CM AS-i Master ST module is used in a configuration with PROFINET system redundancy R1 and CPU S7-1500R/H, the AS-i master must be configured without the AS-i network in the basic configuration. Alternatively: When configuring with the AS-i network, the "Distributed devices" module parameter must be set to "Show AS-i module diagnostics on the AS-i master" on the AS-i master (TIA Portal V18 update required).

For bumpless switchover, firmware version V1.1.11 or higher is required in the CM AS-i Master ST module.

NOTE

In a configuration with PROFINET system redundancy S2, the redundancy function is implemented with the IM 155-6 PN interface module used. The CM AS-i Master ST module can be used without any constraints in this case.

See also

Configuration of the AS-i slaves in STEP 7 (Page 28)
Configuration of the AS-i slaves using the "SET" button (Page 33)
Configuration of the AS-i slaves via the control panel in the TIA Portal (Page 34)
Configuration of the AS-i slaves using the PLC program (Page 35)
Characteristics of the CM AS-i Master ST (Page 13)

5.2 Basic configuration of the CM AS-i Master ST

The following is carried out as a result of the basic configuration:

- The AS-i master is made known with the system.
- The length of the cyclic process image is made known.
- The operating parameters of the AS-i master are assigned.

Procedure

The basic configuration is performed by inserting the AS-i master module into the project of the configuration software.

Change the operating parameters according to their use. You will find information on operating parameters in the Sections:

- Parameters (Page 42)
- Explanation of the parameters (Page 42)

If the need arises, you can change the size of the process image to be transferred as follows:

- In *STEP 7* in the "Properties" dialog of the AS-i master
- When the GSD file is used, by selecting the respective module variant from the GSD selection list

More information on the process image:

- Address space (Page 43)

See also

Configuration of the AS-i slaves in STEP 7 (Page 28)

5.3 Configuration of the AS-i slaves

5.3.1 Configuration of the AS-i slaves in STEP 7

During configuration of the AS-i slaves, you specify the stations that the AS-i master is to communicate with in *STEP 7*.

Configuration in *STEP 7* provides the following advantages:

- AS-i slaves are displayed graphically in the network view along with their AS-i addresses (*STEP 7* (TIA Portal)) or displayed as a list (*STEP 7* V5.5 and higher).
- The assigned I/O addresses of an AS-i slave are displayed in the Properties window of the AS-i slave.
- The slave parameters can be configured in the *STEP 7* user interface.
- The configuration of the slaves is stored in the *STEP 7* project, which makes documentation easier.
- The configuration data is stored in the PLC and transferred automatically when the AS-i master is replaced.
- During power-up, the AS-i master switches automatically to "protected mode".
- The diagnostic status of the slave is displayed in *STEP 7* (TIA Portal) in the network view as a symbol (not possible in combination with S7-1200 CPU).

NOTE

If you do not configure any AS-i slaves in *STEP 7* or when configuring using a GSD file, AS-Interface uses the EXPECTED configuration saved in the AS-i master. The following sections describe how you can create the EXPECTED configuration:

- Configuration of the AS-i slaves using the "SET" button (Page 33)
- Configuration of the AS-i slaves via the control panel in the TIA Portal (Page 34)

  This does not apply when configuring with a GSD file.
- Configuration of the AS-i slaves using the PLC program (Page 35)

Procedure

You activate configuration of the AS-i slaves in *STEP 7* as follows:

- In *STEP 7* (TIA Portal): by connecting at least one AS-i slave to the AS-i master over an AS-i network in the network view.
- In *STEP 7* V5.5: by inserting at least one AS-i slave in the configuration table of the AS-i master (FW V1.1 and higher).

When the AS-i slaves are configured in *STEP 7*, configuration is not possible using the "SET" button, via the online function or the PLC program.

This configuration switches the AS-i master automatically to "protected mode".

NOTE

Slave configuration table

In current TIA Portal versions, you can configure the AS-i slaves not only using the graphical network view, but also in tabular form using the slave configuration table of the AS-i master.

In the slave configuration table, you can use the functions for selecting rows (by clicking the column on the left of a row), copying (Ctrl C), and pasting (Ctrl V) to add slaves. AS-i field devices can be dragged into the slave configuration table from the hardware catalog, too.

The entries can be modified directly in the table. The entire table can be selected (by clicking top left in the table), copied with Ctrl C, and transferred to another AS-i master with Ctrl V.

The slave configuration table makes it possible to manage an AS-i network very quickly and clearly.

In the basic configuration without AS-i slaves in the TIA project, the slave configuration table shows an overview of the digital I/O addresses that are assigned automatically during configuration of the AS-i slaves with the "SET" button.

Option 1: Selection from the hardware catalog

To configure the AS-i slaves, open the hardware catalog in *STEP 7*.

STEP 7 (TIA Portal):

In *STEP 7* (TIA Portal), you will find the AS-i slaves under "Field devices".

1. Select a module from the hardware catalog.
2. Drag the module to the network view.
3. Connect the AS-i interface of the module (yellow square in the slave symbol) to the AS-i interface of the AS-i master (yellow square in the master) or directly to the yellow line of the AS-i subnet. When a connection is made to the AS-i subnet, a free AS-i address is automatically assigned in the configuration.

   You can change this AS-i address in the properties dialog of the AS-i slave in the "AS-Interface" area.

STEP 7 V5.5:

1. Open the "Object properties" dialog of the CM AS-i Master ST in the ET 200SP. To do so, select "Object properties" in the context menu.
2. Click the "Slave configuration" tab (FW V1.1 and higher) in the "Properties..." dialog of the CM AS-i Master ST (FW V1.1 and higher) to open it.
3. Double-click the desired AS-i address (1A, B, 2A, B, etc.) to open the "Configuration" of the AS-i slave.
4. Click the "Select" button to open the "Slave selection dialog".
5. Select a slave in this dialog.

   Alternatively: Select a slave from the "Module" list box.

Option 2: Reading out an existing AS-i configuration

If an AS-i cable with AS-i slaves is connected to the AS-i master, you can transfer the connected slaves to the configuration of *STEP 7*. The connected AS-i slaves must have addresses other than "0".

Procedure:

1. Switch on the AS-i voltage.
2. Compile the project and download it to the station.
3. *STEP 7* (TIA Portal):
   – Right click the AS-i master.
   – Select > "Hardware detection (AS-i slaves)" in the context menu.

   STEP 7 V5.5:
   – Select the ET 200SP.
   – Open the "Properties" dialog of the CM AS-i Master ST by double-clicking the slot of the CM AS-i Master ST, for example.
   – Change to the "Options AS-i slaves" tab.
   – Click the "Upload to PG" button.
4. The detected slaves are applied as universal slaves in the project.

   NOTE

   Automatic reading out of article numbers is not possible.

   Slave addresses already present in the project are not overwritten. If you want to transfer a slave address that is already present, you must delete the existing slave in the hardware detection before the readout.
5. You can now edit the slaves applied to the project as if you had taken them directly from the hardware catalog.

The following basic types are available:

- Siemens AS-i slave
- Universal slave with the following forms:
  – AS-i F Slave Universal for safety-related applications
  – AS-i Standard Slave Universal, for configuring with standard address or extended address (A/B slaves)
  – Universal AS-i Proxy Slave

The article numbers for the slaves are only saved in the offline project. Comparison of the article numbers in the offline project with those of the slaves on the AS-i cable is not performed. The AS-i master uses the configuration data of the slave profile (IO.ID.ID2) and ID1 code of the AS-i slave comparing the actual status with the expected status.

NOTE

Distributed devices on an S7-1500 CPU

When configuring the AS-i slaves in STEP 7, each configured AS-i module is managed as a distributed device in the IO system of the assigned S7-1500 CPU. How many distributed devices can be managed in total is stated in the technical specifications of the S7-1500 CPU. If the maximum number is exceeded, compilation of the project is aborted with a corresponding error message.

The administration of the AS-i modules can be changed using the "Distributed devices" module parameter in the hardware configuration of the AS-i master (as of TIA Portal V17 Update 5). With the setting "Show AS-i module diagnostics on the AS-i module", each configured AS-i module is managed as a distributed device, as described above.

With the setting "Show AS-i module diagnostics on the AS-i master", the configured AS-i modules are not managed as distributed devices. This means that the total number of managed distributed devices is reduced and compilation is enabled, even with very large projects. With the setting "Show AS-i module diagnostics on the AS-i master", however, the diagnostic icon for "The configured module does not support display of the diagnostic status" ∅ is displayed in the online mode of the network view on each AS-i slave. The diagnostic information of the AS-i slaves is instead displayed in the TIA Portal online channel diagnostics of the CM AS-i Master ST module. The diagnostic messages of the AS-i slaves are automatically entered in the diagnostic buffer of the CPU in both settings without any constrictions.

Configuring the properties of Siemens AS-i slaves

When you use an AS-i slave from Siemens, you select the slave directly from the hardware catalog.

This selection offers the following properties:

- The device type is represented in *STEP 7* (TIA Portal) using an image.
- The meaning of the slave parameters is displayed as text.
- The underlying slave profile is already set. The IO, ID and ID2 identifiers do not need to be entered.

Parameter bits that are irrelevant for the Siemens slave are set to the default value "1". They cannot be changed.

The ID1 code is preassigned according to the factory setting of the Siemens slave. If you change the ID1 code of the slave, you must also change the setting in the slave configuration.

See also the command "No. D1: AS-i-Slave_ID1_schreiben_mit_Zieladresse (Write ID1 code with destination address) (Page 142)".

Configuring the properties of universal AS-i slaves

When configuring with the universal AS-i slave or universal AS-i F slave, you must make the following settings:

- Profile identification of the AS-i slave (IO, ID, ID2)
- Parameters of the AS-i slave

You will find the profile identification, the ID1 code, and the meaning of the AS-i slave parameters in the documentation for the AS-i slave.

The I/O assignment of the slave is shown, depending on the specified profile identification, in the "Configuration" section.

Displaying AS-i addresses

Use the "Show addresses" option in the TIA Portal network view to display the AS-i addresses of all configured slaves. To do this, click on the button with the eye icon in the menu bar of the network view.

Using the context menu

The context menu of the AS-i master and the AS-i slaves contains the following options (from TIA Portal V18):

- Assign an AS-i slave to an AS-i master

For faster connection of the AS-i slave to the AS-i network instead of graphical connection using the mouse.

- Disconnect an AS-i slave from the AS-i network

For effective disconnection of the AS-i slave from the AS-i network.

- Highlight the AS-i network

For an improved overview when multiple AS-i networks are used in a project.

Highlighting of the AS-i network is also possible by clicking the yellow AS-i connecting line.

In addition, the name of the connected AS-i master is displayed on the AS-i slave.

See also

Applying the slave configuration (Page 37)

No. 07: Store_Actual_Configuration (Page 101)

5.3.2 Configuration of the AS-i slaves using the "SET" button

Functional principle

You can connect a "SET" button to terminals "SET1" and "SET2" of the AS-i master. This supports the teaching procedure for the connected AS-i slaves. This function is activated by closing the button contact on the SET1 and SET2 terminals.

Behavior in "configuration mode" and in "protected operation"

Table 2-1659 "Configuration mode"/"Protected operation"

Mode of the CM AS-i Master ST	Behavior of the "CM" LED
"Configuration mode"	The "CM" LED lights up.
"Protected operation"	The "CM" LED does not light up.

When the AS-i master is in "configuration mode", the AS-i master is configured automatically when the "SET" button is pressed. Configuration is carried out as follows:

1. The CM AS-i Master ST saves the AS-i slave configuration present on the AS-i cable as the CONF configuration in non-volatile memory.
2. The AS-i master then switches over to "protected operation".

If the AS-i master is in "protected operation", it will switch to "configuration mode" when the "SET" button is pressed.

The "SET" button is only activated when the CPU is in "STOP" state or after disconnecting the bus from the IM module of the ET 200SP.

Requirements

Ensure the following states exist:

1. The CPU is in "STOP" state or the bus is disconnected from the IM module of the ET 200SP.
2. The AS-i master and all AS-i slaves are connected to the AS-Interface and supplied with voltage.
3. No AS-i slave with address 0 is connected to AS-Interface. The AS-i slaves have unique addresses that differ from one another.

Procedure

1. Check whether the AS-i master is in "configuration mode". (The "CM" LED lights up.)

   If the "CM" LED does not light up, switch the AS-i master to "configuration mode" by pressing the "SET" button once.

2. Press the "SET" button. This configures the AS-i master. In so doing, the ACTUAL configuration detected is saved as the CONF configuration in non-volatile memory in the CM AS-i Master ST. At the same time, the AS-i master switches over to "protected operation". The "CM" LED goes out.

NOTE

Parameter setting when configuring with the "SET" button

If no AS-i slaves are connected, all internal lists are set to default values. In particular, the following are set: all AS-i parameters = F_{Hex} and bit "AutoAdress_Enable = 1".

When configuring is performed using the "SET" button, the parameter value in the volatile memory of the AS-i master for each slave applied to the CONF configuration is saved as a non-volatile parameter. For slaves that are not present, the default value F_H is applied to the non-volatile memory. This corresponds to the function of the No. 00: Set_Permanent_Parameter (Page 96) command.

NOTE

The existing configuration can be overwritten using the "SET" button

Note regarding the CM AS-i Master ST:

A configuration of AS-i slaves specified using *STEP 7* and downloaded to the S7 station is transferred to the AS-i master again during S7 station start-up or after station recovery of the head module. Any configuration implemented using the "SET" button will be overwritten.

When configuring with the "SET" button, if no slaves are connected to AS-Interface, the CONFIGURED configuration in the master is deleted along with the profile definition for proxy slaves (see Section "AS-i proxy slave (Page 41)"). The AS-i voltage must be present.

See also

Terminal assignment (Page 21)

5.3.3 Configuration of the AS-i slaves via the control panel in the TIA Portal

You can also execute the functionality of the "SET" button described in Section "Configuration of the AS-i slaves using the "SET" button (Page 33)" via the control panel in *STEP 7*.

For how to proceed further, see Section Applying the slave configuration (Page 37) and Section Switching from one operating mode to another (Page 36).

5.3.4 Configuration of the AS-i slaves using the PLC program

You can use the PLC program to completely define the configuration of the AS-i slaves.

The command interface of the AS-i master is available for this. You use the No. BA: Write_overall_configuration (Page 117) command to specify the CONF configuration of the AS-i slaves in the AS-i master, similarly as when configuring the slave in the TIA Portal.

The No. 07: Store_Actual_Configuration (Page 101) command allows you to save the ACTUAL configuration as the CONF configuration in the AS-i master, similarly as when using the "SET" button for this.

5.4 Online functions in the TIA Portal

NOTE

In current TIA Portal versions, frequently required online functions can be directly called up via the context menu of the AS-i master.

– Right-click the AS-i master.

– Select > "Control panel - Set AS-i address" in the context menu.

5.4.1 Switching from one operating mode to another

In *STEP 7* "Online" > "Diagnostics", you can switch between "protected operation" and "configuration mode" under "Functions". There are two buttons:

- "Configuration mode"
- "Protected operation"

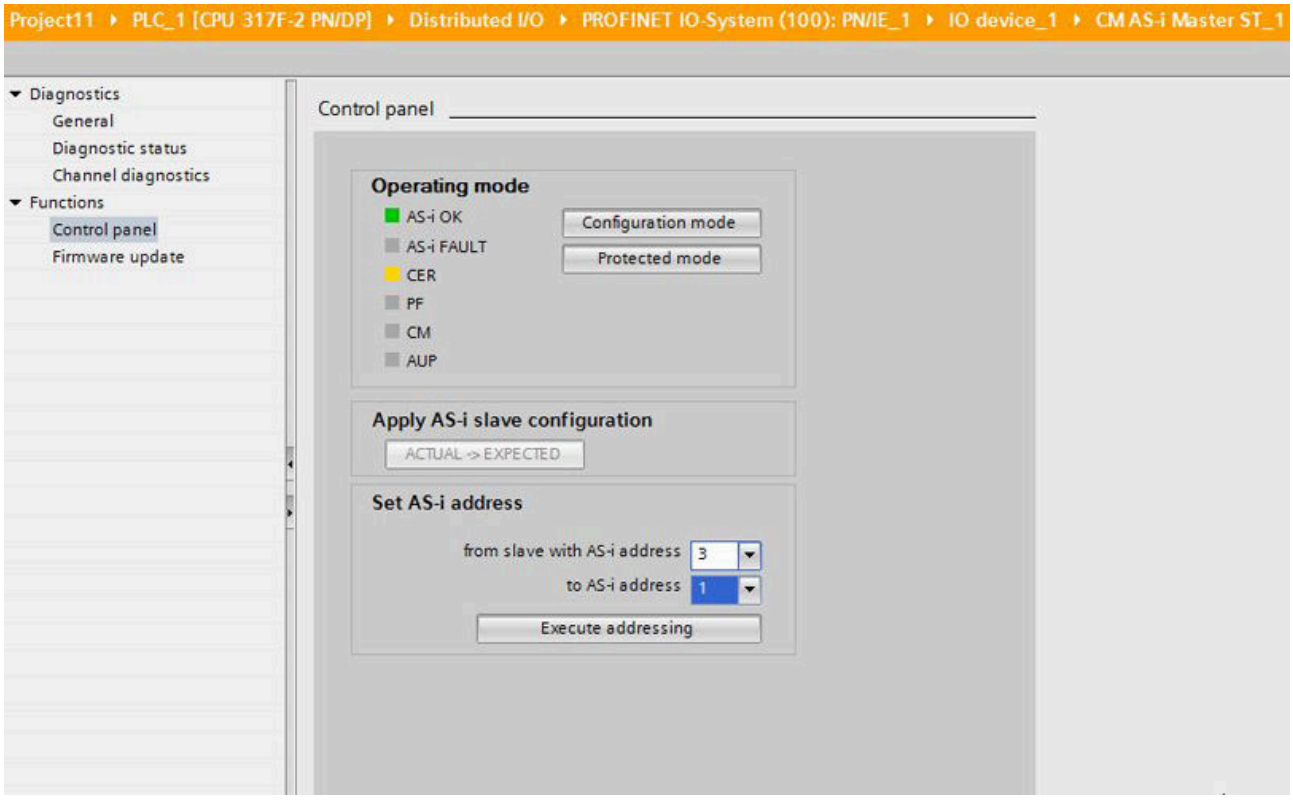

The LEDs on the AS-i master and in *STEP 7* indicate the current operating mode of the AS-i master. You will find additional information in Section "Meaning of the LEDs (Page 62)".

The operating mode can only be switched when the CPU is in "STOP" state.

NOTE

Online functions

The online functions can only be performed when at least the basic configuration has been completed and the configuration has been loaded into the ET 200SP station.

5.4.2 Applying the slave configuration

Application

This step is only necessary if AS-i slaves have not been configured in *STEP 7* and the configuration of the AS-i slaves is not performed using the "SET" button.

If AS-i slaves have already been configured in *STEP 7* and the slave configuration has been downloaded to the AS-i master, the system deactivates the function for applying the slave configuration. It is then no longer possible for this function to be called.

Requirements

The following requirements must be satisfied to do this:

- The CPU is in "STOP" state.
- The AS-i master and all AS-i slaves are connected to the AS-Interface and supplied with voltage.
- No AS-i slave with address 0 is connected to AS-Interface. The AS-i slaves have unique addresses that differ from one another.
- The AS-i master is in "configuration mode".

Applying the slave configuration

The "ACTUAL → EXPECTED" button in the "Online" > "Diagnostics" window can be used by the AS-i master to apply the slave configuration connected to the master.

The following data of the AS-i slaves is saved in non-volatile memory in the AS-i master:

- AS-i addresses
- The slave profile for each AS-i slave: IO code, ID code, ID2 code
- ID1 code for each AS-i slave

It is not possible to apply the slave configuration via the "ACTUAL -> EXPECTED" button if AS-i slaves have already been configured in *STEP 7* and downloaded to the AS-i master or if the CPU is in "RUN" state. You can reactivate the "ACTUAL → EXPECTED" function by reloading the AS-i master in *STEP 7* with the basic configuration only – that is, without configured AS-i slaves.

NOTE

Parameter setting when applying the slave configuration

When configuring is performed using the "ACTUAL → EXPECTED" button, the volatile parameter value for the respective slave in the AS-i master is saved as a non-volatile parameter for the slaves adopted into the EXPECTED configuration. For slaves that are not present, the default value F_H is applied to the non-volatile memory. This corresponds to the function of the No. 00: Set_Permanent_Parameter (Page 96) command.

If configuration of the AS-i slaves is performed with the "ACTUAL → EXPECTED" button while no slaves are connected to the AS-i cable, the EXPECTED configuration in the master is

deleted completely along with the profile definition for proxy slaves (see Section "AS-i proxy slave (Page 41)"). The AS-i voltage must be present.

5.4.3 Setting the address of an AS-i slave

In the "Online" > "Diagnostics" window, you can assign a new address to an AS-i slave using a selection menu and the "Execute addressing" button. Only free AS-i addresses are available here.

5.5 Variable configuration

Option handling and proxy slaves can be combined.

5.5.1 Option handling

A machine consists of a basic configuration and several expansion stages. The overall configuration is configured in the *STEP 7* project. The slaves that belong to an expansion stage are configured as optional slaves. When the system is commissioned, the user program (PLC) defines which expansion stages are installed. The configuration in *STEP 7* remains unchanged.

You can use option handling to activate and deactivate AS-i slaves that you have defined in HW Config in the user program during operation.

You configure the AS-i slaves in the AS-i master as described in Section "Configuration of the AS-i slaves in STEP 7 (Page 28)":

1. Activate option handling.

   STEP 7 (TIA Portal):

   – Select "Options > Option handling" in the slave properties dialog.
   – Select the "Option handling" check box.

   STEP 7 V5.5:

   – Select the "Slave configuration" tab in the "Properties..." dialog of the CM AS-i Master ST.
   – Double-click the desired AS-i address (1A, B, 2A, B, etc.) to open the "Configuration" of the AS-i slave.
   – Select the "Option handling" check box.

   This activates the option handling for this slave.

2. Activate the slave using the user program (PLC).

   You can also deactivate the slave in the user program.

The AS-i master treats an optional slave that is not activated like a slave that is not configured. The AS-i master treats an activated optional slave like a slave that is configured without option handling.

Procedure

1. Define the AS-i slaves in *STEP 7* (TIA Portal) > Network view or in *STEP 7* V5.5 > "HW Config".
2. Specify whether option handling is enabled for each AS-i slave.
3. In the user program, you can activate or deactivate AS-i slaves for which option handling is activated during runtime. To do this, a combination of 2 bits must be set or reset in data record DS 131.

NOTE

Option handling and safe AS-i slaves

When data record DS 131 is written to the CM AS-i Master ST module, the signals of the safety-related slaves on the same bus are reset. Before transferring the option data record DS 131, ensure that the system is in an operating state in which a safety signal reset will not adversely affect the course of operation. Before restarting, error acknowledgement or reintegration must be performed for the safe AS-i inputs and, where applicable, the safe AS-i outputs. The correct procedure for the fail-safe evaluation system used must be observed.

See also

DS 131 Activate/deactivate optional slaves (Page 39)
DS 131 Read status of option handling (Page 40)
No. D0: Set_Configuration_Online (Page 141)

5.5.1.1 DS 131 Activate/deactivate optional slaves

Description

By writing this data record, you activate or deactivate slaves configured as optional on the AS-i bus.

Table 2-1660 Structure of DS 131 write

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
0 ... 1	Reserved							
2 ... 9	List of slaves to be activated							
	Bit = 0	No action						
	Bit = 1	The slave will be activated.						
10 ... 17	List of slaves to be deactivated							
	Bit = 0	The slave will not be deactivated.						
	Bit = 1	The slave will be deactivated.						

NOTE

Identical entries in each list

If a "1" is entered for an AS-i slave in both lists, the slave will be deactivated.

NOTE

Activated/deactivated status of the optional slaves

The activated/deactivated status of the optional slaves is stored in non-volatile memory of the master and is retained even if a new configuration is downloaded to the master. The status of an optional slave is set to deactivated if the slave is not set as optional in a configuration.

If a configuration contains slaves without option handling, the status stored internally in the master for these slaves is reset (bit = 0).

See also

Address space (Page 43)
Option handling (Page 38)

5.5.1.2 DS 131 Read status of option handling

Description

The current status of the slaves configured as optional is returned by reading this data record.

Table 2-1661 Structure of DS 131 read

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
0 ... 1	Reserved							
2 ... 9	List of activated, optional slaves							
	Bit = 0	The optional slave is deactivated or the optional slave is not an optional slave.						
	Bit = 1	The optional slave is activated.						
10 ... 17	List of configured, optional slaves							
	Bit = 0	The slave is not configured as an optional slave or it is not contained in the configuration.						
	Bit = 1	The slave is configured as an optional slave.						

If a slave is configured as not optional, then the associated bit in the list of activated optional slaves in the non-volatile memory of the master is reset to the value 0.

See also

Option handling (Page 38)

5.5.2 AS-i proxy slave

Description

A proxy slave is used to represent any given slave. This means you define the I/O addresses in the PLC program in advance. You define the slave itself at runtime.

Procedure

- Configure a proxy slave in "*STEP 7* > HW Config" with the associated digital and / or analog I/O addresses. You can then use these I/O addresses in the user program to access the data of the proxy slave once you have defined the slave profile at runtime.

  To do this, select the proxy slave from the universal AS-i slaves in the hardware catalog.
- At runtime, specify in the PLC program which slave type should be operated under this address.
- You define the slave profile of the proxy slave by changing the overall configuration ("No. D0: Set_Configuration_Online (Page 141)" command). In this case, the AS-i branch is not reset.
- The slave type defined in the user program is retained in the CM AS-i Master ST module, even after the power supply has been switched off.
- The slave type of a proxy slave defined in the user program is retained in the CM AS-i Master ST module, even after the hardware configuration has been reloaded into the station.

Applications

- Variable machine configurations that can be changed at runtime.
- Flexible expansion of the system in the future, without the need to specify the actual type of slave beforehand.

Parameter assignment/addressing 6

6.1 Parameters

Parameters of the AS-i master

Table 2-1662 Assignable parameters and their default setting (GSD file)

Parameters	Value range	Default
Diagnostic interrupt in case of errors in AS-i configuration	• Enable • Disable	Enable
Diagnostic interrupt in case of AS-i cable fault	• Enable • Disable	Enable
Automatic address programming	• Enable • Disable	Enable
Ground-fault monitoring activated	• Enable • Disable	Enable
Automatic ID1 code assignment (Firmware V1.1 and higher)	• Enable • Disable	Disable
Duplicate address detection[1) 2)]	• Enable for AS-i voltage 24 V • Enable for AS-i voltage 30 V • Disable	Disable

1) This parameter is divided into "Deactivate duplicate address detection" and "Duplicate address detection for 24 V" depending on the GSD variant.

2) When using the CM AS-i Master ST module from product version 20 (corresponding to firmware from V2.0), no distinction is necessary between "Enable for AS-i voltage 24 V" and "Enable for AS-i voltage 30 V" for duplicate address detection. To activate the duplicate address detection, either of the options for enabling can be chosen, irrespective of the AS-i voltage actually used.

6.2 Explanation of the parameters

Diagnostic interrupt if AS-i configuration error:

With this parameter, you specify whether AS-i configuration errors will be signaled to the higher-level system. The following are signaled as a configuration error:

- A surplus slave
- A missing slave
- A slave of the wrong type

Diagnostic interrupt if AS-i cable fault:

This parameter is used to specify whether faults concerning the AS-i cable should be reported to the higher-level system. Possible AS-i cable faults are:

- Ground fault
- Insufficient AS-i voltage
- Peripheral fault of an AS-i slave

Automatic address programming:

When a defective AS-i slave is being replaced, you use this parameter to specify whether the configured AS-i address will be automatically assigned to the new device.

For details on this functionality, see Section "Replacing a defective AS-i slave / automatic address programming (Page 70)"

Ground-fault monitoring activated:

This parameter is used to specify whether ground faults on the AS-i cable should be detected by the AS-i master. Deactivate this setting if you are using an external unit for ground fault detection.

Automatic ID1 code assignment:

When you activate this parameter, in the case of automatic address programming the ID1 code of a slave is written to the value specified during configuring.

Duplicate address detection:

The duplicate address detection function can identify inadvertent duplicate addressing. When you activate it, you must select the AS-i line voltage in use.

This parameter is divided into "Deactivate duplicate address detection" and "Duplicate address detection for 24 V" depending on the GSD variant.

6.3 Address space

The assignment of the address space is described in the following Section:

Data exchange between the user program and AS-i slaves (Page 44)

Data exchange between the user program and AS-i slaves 7

7.1 Access to AS-Interface

The distributed I/O system communicates with the AS-i slaves via the CM AS-i Master ST. The AS-i communication objects are mapped onto a continuous data area for input and output data.

What's new in firmware V1.1 and higher

The following options are available as of firmware V1.1:

- You can design the process image flexibly according to your needs.
- You can reduce the length of the reserved I/O area (depending on the configuration software version).

What's new in firmware V2.0 and higher

From product version 20 of the CM AS-i Master ST module, only firmware version V2.0 or higher can be used.

The functionality of firmware version V2.0.0 is essentially the same as in firmware V1.1.

To configure firmware version V2.0.0, it is possible to choose firmware version V1.1 in the TIA Portal hardware configuration if no higher version is offered for selection. See also Section Requirements (Page 25).

Designing the process image flexibly.

You can design the process image in the following way:

- Reduce or increase the process image (default length 32 bytes):
  - If the AS-i slaves are configured in STEP 7: the length can be set in steps in the range 4 ... 288 bytes. In this case, the maximum length of the process image depends on the ET 200SP interface module (IM) or ET 200SP CPU used.
  - If the AS-i slaves are not configured in STEP 7 length can be set to 16 or 32 bytes

- Variable division of the process image if AS-i slaves are configured in STEP 7:
  - Analog values and digital values can be mapped in one process image.
  - The slave address is not bound to a specific position in the process image.

  Constriction: The digital I/O addresses must be within the first 64 bytes of the process image.
  - The number of bits per slave can vary. For example, the digital input data of the slave at address 1 can be one bit long and the analog data of the slave at address 5 can be two bytes long.

Length of the reserved I/O area can be reduced

If your configuration contains fewer AS-i slaves, you may reduce the length of the reserved I/O area (depending on the configuration software version). This reduces the volume of data to be transmitted on PROFIBUS or PROFINET.

You set the length of the I/O area in *STEP 7* (TIA Portal) in the properties of the AS-i master. This does not change the assignment of the slave address to the offset.

This means: When the length is reduced, the higher AS-i bus addresses can no longer be addressed.

Address overview

In the Properties dialog box of module CM AS-i master ST under "I/O Addresses", you can call up an address overview in which the I/O addresses are assigned to the AS-i slaves (as of TIA Portal V14 SP1 extended for any configuration)

7.2 Transmitting AS-i digital values

A missing or failed digital slave results in the substitute value 0 in the input data. In the output direction, the non-assigned values have no effect.

Refer to the information about display of transparent values / digital values in Section Accessing AS-i analog data via the process image (Page 56).

7.2.1 I/O addresses when configuring AS-i slaves in STEP 7

Process image transmission time

The time it takes to transmit a process image depends on its size:

- If the length of the process image is set to up to 32 bytes, the I/O data in the ET 200SP station are transmitted within 1 backplane bus cycle. This setting results in the shortest transmission time on the backplane bus.
- If the length of the process image is set to more than 32 bytes, the I/O data of the CM AS-i master°ST in the ET 200SP station are transmitted in several consecutive backplane bus cycles. Data consistency is maintained from the point of view of the IM or the CPU. Division into several backplane bus cycles is performed automatically by the ET 200SP system. The number of required backplane bus cycles is automatically determined and depends on the set length of the process image. In this case, the maximum length of the process image depends on the ET 200SP interface module (IM) or ET 200SP CPU used. For more detailed information, see the technical specifications of the IM or CPU.

CM AS-i Master ST with configured AS-i slaves

If you configure the AS-i slaves as described in Section "Configuration of the AS-i slaves in STEP 7 (Page 28)", you will set the I/O addresses of the slaves using the Properties dialog box of the AS-i slave. The I/O address can be set individually in the area of the defined process image of the AS-i master. The input/output bits x.4 to x.7 in the first byte of the process image of the AS-i°master cannot be used for AS-i slaves. The process image can contain input/output data of digital and analog slaves. The bit length of a slave depends on the configured profile. The digital I/O addresses must be within the first 64 bytes of the process image.

If the option "Reserve 4 bits length" is activated, 4 input bits and 4 output bits will be reserved for the slave. In this case, the real I/O data of the AS-i slave fall within the 4 bit range as described in Table 7-6 "Standard assignment table for inputs/outputs of digital AS-i slaves" in SectionI/O addresses without configuration of the AS-i slaves in STEP 7 (Page 49).

Arrangement of the AS-i slaves in the process image (Sort)

In TIA Portal V14 SP1 and higher, the arrangement of the AS-i slaves in the process image can be sorted automatically. 3 options are offered in the Properties of the AS-i master under "I/O Addresses > Arrangement":

- Sort - CLASSIC:
  The digital inputs/outputs of the slaves are sorted into the process image as described in Table 7-1 "Bit assignment per digital slave (CLASSIC sorting)", starting from the set start address of module CM AS-i master ST. CLASSIC sorting is the same as that described in SectionI/O addresses without configuration of the AS-i slaves in STEP 7 (Page 49).
  After the digital inputs/outputs, the analog inputs/outputs are sorted into the process image. The status information (EFD, CM, CFGOK, DIAG) is displayed if the option "Process image for status information" (FW V1.1 and higher) is activated, see Table 7-3 "Overview of status information".

- Sort - LINEAR:
  The digital inputs/outputs of the slaves are sorted into the process image as described in Table 7-2 "Bit assignment per digital slave (LINEAR sorting)": The digital inputs/outputs of the slaves with a standard address or A address are mapped in bits 0 ... 3, whereas the digital inputs/outputs of the slaves with a B address are mapped in bits 4 ... 7.
  After the digital inputs/outputs, the analog inputs/outputs are sorted into the process image. The status information (EFD, CM, CFGOK, DIAG) is displayed if the option "Process image for status information" (FW V1.1 and higher) is activated, see Table 7-3 "Overview of status information".
- Packing:
  Address usage for the inputs/outputs of the slaves is optimized, i.e. all gaps are eliminated and the length of the I/O area is adapted. You can see the selected I/O addresses directly in the address overview of the I/O addresses in the configuration of the CM AS-i master ST.

Table 2-1663 Bit assignment per digital slave (CLASSIC sorting)

Byte number [1]		**Bit 7 ... 4**				**Bit 3 ... 0**			
		Bit 3	Bit 2	Bit 1	Bit 0	Bit 3	Bit 2	Bit 1	Bit 0
n+0		Reserved				Slave 1 or 1A			
n+1		Slave 2 or 2A				Slave 3 or 3A			
n+2		Slave 4 or 4A				Slave 5 or 5A			
n+3		Slave 6 or 6A				Slave 7 or 7A			
n+4		Slave 8 or 8A				Slave 9 or 9A			
n+5		Slave 10 or 10A				Slave 11 or 11A			
n+6		Slave 12 or 12A				Slave 13 or 13A			
n+7		Slave 14 or 14A				Slave 15 or 15A			
n+8		Slave 16 or 16A				Slave 17 or 17A			
n+9		Slave 18 or 18A				Slave 19 or 19A			
n+10		Slave 20 or 20A				Slave 21 or 21A			
n+11		Slave 22 or 22A				Slave 23 or 23A			
n+12		Slave 24 or 24A				Slave 25 or 25A			
n+13		Slave 26 or 26A				Slave 27 or 27A			
n+14		Slave 28 or 28A				Slave 29 or 29A			
n+15		Slave 30 or 30A				Slave 31 or 31A			
n+16	FW V1.0	Reserved				Slave 1B			
	FW V1.1 and higher	EFD	CM	CFGOK	DIAG				
n+17		Slave 2B				Slave 3B			
n+18		Slave 4B				Slave 5B			
n+19		Slave 6B				Slave 7B			
n+20		Slave 8B				Slave 9B			
n+21		Slave 10B				Slave 11B			
n+22		Slave 12B				Slave 13B			
n+23		Slave 14B				Slave 15B			

1) n = Start address

Byte number [1]	**Bit 7 ... 4**				**Bit 3 ... 0**			
n+24	Slave 16B				Slave 17B			
n+25	Slave 18B				Slave 19B			
n+26	Slave 20B				Slave 21B			
n+27	Slave 22B				Slave 23B			
n+28	Slave 24B				Slave 25B			
n+29	Slave 26B				Slave 27B			
n+30	Slave 28B				Slave 29B			
n+31	Slave 30B				Slave 31B			
	Bit 3	Bit 2	Bit 1	Bit 0	Bit 3	Bit 2	Bit 1	Bit 0

1) n = Start address

Table 2-1664 Bit assignment per digital slave (LINEAR sorting)

Byte number [1]		**Bit 7 ... 4**				**Bit 3 ... 0**			
		Bit 3	Bit 2	Bit 1	Bit 0	Bit 3	Bit 2	Bit 1	Bit 0
n+0	FW V1.0	Reserved				Reserved			
	FW V1.1 and higher					EFD	CM	CFGOK	DIAG
n+1		Slave 1B				Slave 1 or 1A			
n+2		Slave 2B				Slave 2 or 2A			
n+3		Slave 3B				Slave 3 or 3A			
n+4		Slave 4B				Slave 4 or 4A			
n+5		Slave 5B				Slave 5 or 5A			
n+6		Slave 6B				Slave 6 or 6A			
n+7		Slave 7B				Slave 7 or 7A			
n+8		Slave 8B				Slave 8 or 8A			
n+9		Slave 9B				Slave 9 or 9A			
n+10		Slave 10B				Slave 10 or 10A			
n+11		Slave 11B				Slave 11 or 11A			
n+12		Slave 12B				Slave 12 or 12A			
n+13		Slave 13B				Slave 13 or 13A			
n+14		Slave 14B				Slave 14 or 14A			
n+15		Slave 15B				Slave 15 or 15A			
n+16		Slave 16B				Slave 16 or 16A			
n+17		Slave 17B				Slave 17 or 17A			
n+18		Slave 18B				Slave 18 or 18A			
n+19		Slave 19B				Slave 19 or 19A			
n+20		Slave 20B				Slave 20 or 20A			
n+21		Slave 21B				Slave 21 or 21A			
n+22		Slave 22B				Slave 22 or 22A			

1) n = Start address

Byte number [1]	Bit 7 ... 4				Bit 3 ... 0			
n+23	Slave 23B				Slave 23 or 23A			
n+24	Slave 24B				Slave 24 or 24A			
n+25	Slave 25B				Slave 25 or 25A			
n+26	Slave 26B				Slave 26 or 26A			
n+27	Slave 27B				Slave 27 or 27A			
n+28	Slave 28B				Slave 28 or 28A			
n+29	Slave 29B				Slave 29 or 29A			
n+30	Slave 30B				Slave 30 or 30A			
n+31	Slave 31B				Slave 31 or 31A			
	Bit 3	Bit 2	Bit 1	Bit 0	Bit 3	Bit 2	Bit 1	Bit 0

1) n = Start address

Status information in input process image

To provide a quick summary diagnosis, the following status information can optionally be transferred to a selectable address in the input process image (FW V1.1 and higher).

Table 2-1665 Overview of status information

EFD	0 = No ground fault detected 1 = Ground fault detected
CM	0 = Master in protected mode 1 = Master in configuration mode
CFGOK	0 = Configuration not OK or slave exists with address 0 1 = Configuration OK
DIAG	0 = No diagnostics pending 1 = Diagnostics pending. This information is set for the following events: -The AS-i master is in "offline" mode. - The AS-i voltage is not OK. - Multiple addressing was detected. - An I/O error was detected. - A configuration error was detected. - A slave with address 0 exists.

7.2.2 I/O addresses without configuration of the AS-i slaves in STEP 7

I/O addresses of the slaves in the process image

If you configure according to Sections "Configuration of the AS-i slaves using the "SET" button (Page 33)" to "Configuration of the AS-i slaves using the PLC program (Page 35)", the I/O addresses of digital slaves in the process image of the AS-i master are located at a fixed position according to the following table. The I/O data of analog slaves can be accessed via a data record.

Input data and output data of the AS-i slaves are exchanged with the controller via an I/O area of 16 or 32 bytes. As a result, the digital values of up to 62 AS-i slaves are transmitted. In

doing so, 4 bits are assigned to each digital slave. The offset for accessing this data depends on the AS-i address of the AS-i slave.

In a project in which the AS-i slaves are not configured in STEP 7, the standard length of the process image is 32 bytes. In firmware V1.1 and higher, the length can be set to 16 or 32 bytes.

In an I/O address area of 16 bytes, you can only assign standard addresses or A addresses for slaves. In an I/O address area of 32 bytes, you can also assign B addresses for slaves.

NOTE

In the current TIA Portal versions, the slave configuration table of the AS-i master shows an overview of the digital I/O addresses that are automatically assigned during configuration of the AS-i slaves with the "SET" button.

Table 2-1666 Bit assignment per digital slave

Byte number [1]		**Bit 7 ... 4**				**Bit 3 ... 0**			
		Bit 3	Bit 2	Bit 1	Bit 0	Bit 3	Bit 2	Bit 1	Bit 0
n+0		Reserved				Slave 1 or 1A			
n+1		Slave 2 or 2A				Slave 3 or 3A			
n+2		Slave 4 or 4A				Slave 5 or 5A			
n+3		Slave 6 or 6A				Slave 7 or 7A			
n+4		Slave 8 or 8A				Slave 9 or 9A			
n+5		Slave 10 or 10A				Slave 11 or 11A			
n+6		Slave 12 or 12A				Slave 13 or 13A			
n+7		Slave 14 or 14A				Slave 15 or 15A			
n+8		Slave 16 or 16A				Slave 17 or 17A			
n+9		Slave 18 or 18A				Slave 19 or 19A			
n+10		Slave 20 or 20A				Slave 21 or 21A			
n+11		Slave 22 or 22A				Slave 23 or 23A			
n+12		Slave 24 or 24A				Slave 25 or 25A			
n+13		Slave 26 or 26A				Slave 27 or 27A			
n+14		Slave 28 or 28A				Slave 29 or 29A			
n+15		Slave 30 or 30A				Slave 31 or 31A			
n+16	FW V1.0	Reserved				Slave 1B			
	FW V1.1 and higher	EFD	CM	CFGOK	DIAG				
n+17		Slave 2B				Slave 3B			
n+18		Slave 4B				Slave 5B			
n+19		Slave 6B				Slave 7B			
n+20		Slave 8B				Slave 9B			
n+21		Slave 10B				Slave 11B			

1) n = Start address

Byte number [1]	Bit 7 ... 4				Bit 3 ... 0			
n+22	Slave 12B				Slave 13B			
n+23	Slave 14B				Slave 15B			
n+24	Slave 16B				Slave 17B			
n+25	Slave 18B				Slave 19B			
n+26	Slave 20B				Slave 21B			
n+27	Slave 22B				Slave 23B			
n+28	Slave 24B				Slave 25B			
n+29	Slave 26B				Slave 27B			
n+30	Slave 28B				Slave 29B			
n+31	Slave 30B				Slave 31B			
	Bit 3	Bit 2	Bit 1	Bit 0	Bit 3	Bit 2	Bit 1	Bit 0

1) n = Start address

Status information for process image with 32 bytes

For a process image that is 32 bytes long, the following information is transferred in byte n+16 (FW V1.1 and higher):

Table 2-1667 Status information in byte n+16 for a process image that is 32 bytes long:

Bit 7: EFD	0 = No ground fault detected 1 = Ground fault detected
Bit 6: CM	0 = Master in protected mode 1 = Master in configuration mode
Bit 5: CFGOK	0 = Configuration not OK or slave exists with address 0 1 = Configuration OK
Bit 4: DIAG	0 = No diagnostics pending 1 = Diagnostics pending. This information is set for the following events: -The AS-i master is in "offline" mode. - The AS-i voltage is not OK. - Multiple addressing was detected. - An I/O error was detected. - A configuration error was detected. - A slave with address 0 exists.

The status information provides a quick summary diagnosis.

If a process image is 16 bytes long, only the first 16 bytes (byte n to byte n+15) are transferred.

Bit assignment of the process image

In a project in which the AS-i slaves are not configured in STEP 7, 4 bits of digital input data and 4 bits of digital output data are assigned to the process image. I/O bits that are not assigned by the slave contain the substitute value 0. The assignment of the process image depends on the AS-i slave type. For digital slaves with up to 4-bit inputs and 4-bit outputs, the following standard assignment table applies:

Table 2-1668 Standard assignment table for inputs/outputs of digital AS-i slaves

IO code	Number	Input process image				Output process image			
(Hex value)	Inputs/outputs	Bit 3	Bit 2	Bit 1	Bit 0	Bit 3	Bit 2	Bit 1	Bit 0
0	4 DI	IN 3	IN 2	IN 1	IN 0	-	-	-	-
1	3 DI / 1 DQ	-	IN 2	IN 1	IN 0	OUT 0	-	-	-
2	4 DI / 1 DQ	IN 3	IN 2	IN 1	IN 0	OUT 0	-	-	-
3	2 DI / 2 DQ	-	-	IN 1	IN 0	OUT 1	OUT 0	-	-
4	4 DI / 2 DQ	IN 3	IN 2	IN 1	IN 0	OUT 1	OUT 0	-	-
5	1 DI / 3 DQ	-	-	-	IN 0	OUT 2	OUT 1	OUT 0	-
6	4 DI / 3 DQ	IN 3	IN 2	IN 1	IN 0	OUT 2	OUT 1	OUT 0	-
7	4 DI/4 DQ	IN 3	IN 2	IN 1	IN 0	OUT 3	OUT 2	OUT 1	OUT 0
8	4 DQ	-	-	-	-	OUT 3	OUT 2	OUT 1	OUT 0
9	1 DI / 3 DQ	IN 0	-	-	-	-	OUT 2	OUT 1	OUT 0
A	1 DI / 4 DQ	IN 0	-	-	-	OUT 3	OUT 2	OUT 1	OUT 0
B	2 DI / 2 DQ	IN 1	IN 0	-	-	-	-	OUT 1	OUT 0
C	2 DI / 4 DQ	IN 1	IN 0	-	-	OUT 3	OUT 2	OUT 1	OUT 0
D	3 DI / 1 DQ	IN 2	IN 1	IN 0	-	-	-	-	OUT 0
E	3 DI / 4 DQ	IN 2	IN 1	IN 0	-	OUT 3	OUT 2	OUT 1	OUT 0

Information about the table:

DI: Digital input
DQ: Digital output

The actual numbering of the inputs/outputs of the AS-i slaves depends on the manufacturer of the slave.

In the case of slaves with extended addressing (A/B slaves), column "Bit 3" of the output process image is not assigned data. Exception: In the case of slaves with profile IO.ID.ID2 = 7.A.7, "Bit 3" of the output process image is also assigned.

In particular, the table does not apply to slaves of Combined Transaction Type (CTT) with profiles 6.0, 7.3, 7.4, 7.5.5, 7.A.5, 7.A.8, 7.A.9, 7.A.A, B.A.5 (IO.ID or IO.ID.ID2), see data sheet of slave. For assignment of safety slaves (profile 0.B and 7.B), see Section 7.2.3 "Special characteristics of AS-i Safety Slaves".

Configuration example

The following graphic shows an example of addressing 4 digital slaves. In the example, you configure the start addresses n = 40 for the I/O data in *STEP 7* .

The bits with a gray background are relevant for the user program. The bits with a white background are not relevant for the user program, because AS-i slave bits are not assigned here.

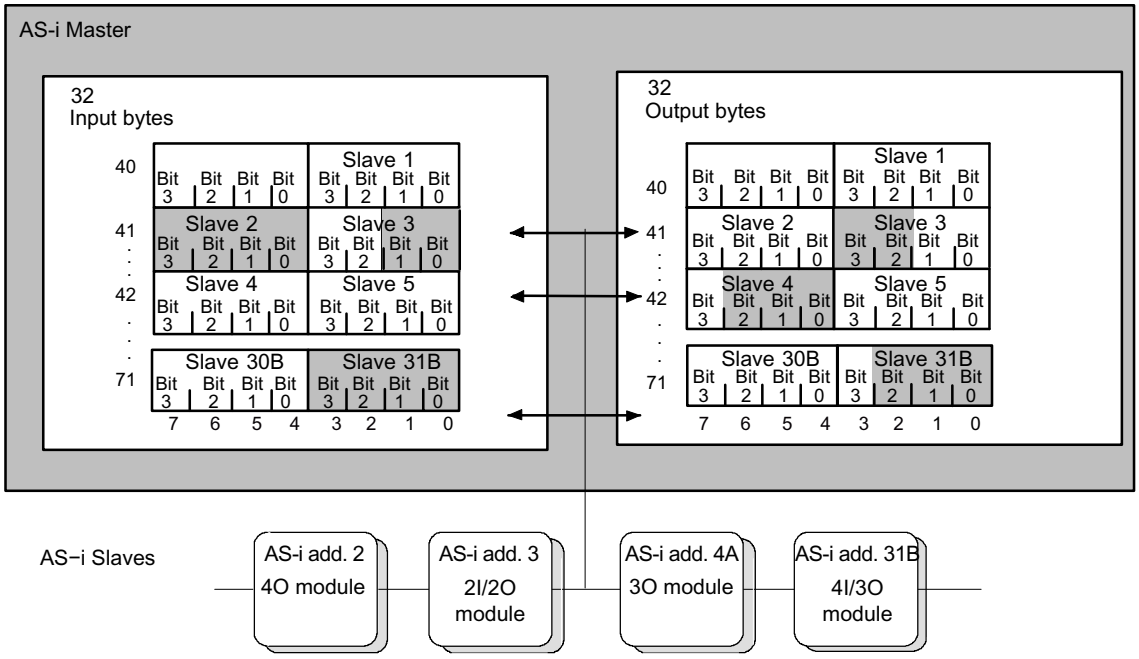

Figure 2-1382 Example of addressing 4 digital slaves

The AS-i slave with address 3 and with two inputs and two outputs, referred to as a 2I/2O module, occupies bits 0 and 1 in input byte 41 and bits 2 and 3 in output byte 41 in the graphic, for example.

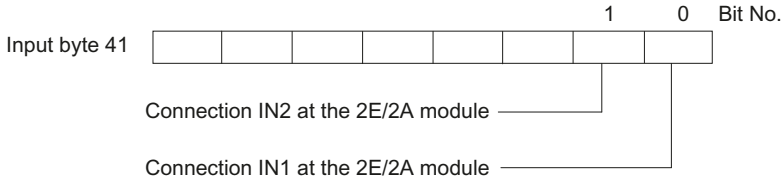

Figure 2-1383 Example to show assignment of the AS-i connections of the 2I/2O modules to the data bits of the input bytes for slave with address 3

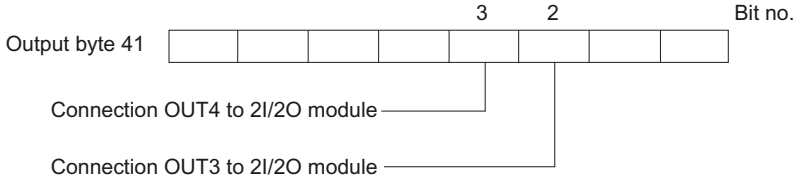

Figure 2-1384 Example to show assignment of the AS-i connections of the 2I/2O modules to the data bits of the output bytes for slave with address 3

7.2.3 Special characteristics of AS-i Safety slaves

The AS-i master performs a non-safe evaluation for the data of safe input slaves. The evaluation is represented in the process image of a Safety input slave as follows:

Table 2-1669 Input process image of a Safety input slave

Bit 3	Bit 2	Bit 1	Bit 0	Meaning
0	0	0	0	All contacts are open.
0	0	0	1	F-IN1 is closed.
0	1	0	0	F-IN2 is closed.
0	1	0	1	F-IN1 and F-IN2 are closed.

In addition, the AS-i master evaluates in a non-safe manner how a safe AS-i output is to be addressed. The information is in the input process image of the standard controller:

Table 2-1670 Input process image of the control unit for a safe AS-i output.

Bit 3	Bit 2	Bit 1	Bit 0	Meaning
0	0	0	0	The safe AS-i output is controlled with status OFF position.
1	1	1	1	The safe AS-i output is controlled with status ON position.

NOTE

This involves a non-safe evaluation of the safe signals for diagnostic purposes.

Non-safe evaluation must not be used for safety-related switching.

See also

List of abbreviations (Page 156)

7.3 Transferring AS-i analog values and transparent/digital values more than 4 bits in length

The following information only applies to AS-i slaves whose data is stored as analog values or as transparent or digital values more than 4 bits in length.

NOTE

The CM AS-i Master ST does not support the transmission of analog values in accordance with AS-i Slave Profile 7.1 / 7.2. Transmission of analog values must be implemented in the software for these slaves.

Analog interface between the CPU and the CM AS-i Master ST

In the user program, you use the process image (Firmware V1.1 and higher) or data records to access I/O data of analog slaves.

For more detailed information, refer to Section "Accessing AS-i analog data via the process image (Page 56)".

Representation of the analog values or the transparent values

The analog values are to be interpreted as 16-bit values in two's complement.

The transparent/digital values must be interpreted as two independent bytes.

In the case of AS-i slave profiles for transparent/digital data, the AS-i master passes through the data of the AS-i slave to the controller without interpreting the content.

For universal AS-i slaves, the following is displayed in the "Configuration" field in *STEP 7*:

- Information about the number of channels
- Information about the resolution
- Information about the data frame of transparent I/O data

In the documentation for the respective AS-i slave, you will find further information about:

- Value range
- Measuring range
- Accuracy of analog slaves
- Meaning of transparent data

Special cases in analog value transfer

- In the input direction, the AS-i master sends a substitute value in the event of a slave failure or AS-i communication error:
  - For slaves with analog transmission, the AS-i master always supplies the substitute value $7FFF_H$, if the slave fails after power-up of the master.

    "Transparent" mode exception:

    For slaves according to the following profiles, the AS-i master supplies the substitute value 0000_H:

    7.3.0 to 7.3.3 (Type CTT1, output slave 16 DO in "Transparent" mode)

    7.3.8 to 7.3.A (Type CTT1, input slave 16 DI in "Transparent" mode)

    7.A.A (CTT3, 8 DI / 8 DO slave with A/B address)

    7.A.8 (ID1 = 3, 4, 5) (Type CTT4, max. 16 DI slave with A/B address)

    7.A.5, 7.5.5 and B.A.5, if you have transparent input (Type CTT2)

    6.0.x where x = 2 ... 7 (Type CTT5, in "Transparent" mode)
- In the output direction, the AS-i master sends logic "0" to all slaves in the event of a failure or in "STOP" state.
- If the AS-i master or the communication between the AS-i master and PLC fails, data record access to the analog values or transparent/digital input values is not possible. Note that the analog input values and transparent/digital input values are not updated in your user program in this case, and ensure a substitute value processing via the program.

NOTICE
Behavior in the event of a slave failure If the slave fails prior to or during the power-up of the AS-i master, the substitute value $7FFF_H$ may also be supplied. That is, the input bits of these transparent or digital slaves have the substitute value 1. For this reason, check whether the diagnostic data of these slaves indicate a slave failure and, if required, ensure an appropriate substitute value processing via the program.

Special characteristics of combined transaction type slaves

When using slaves in accordance with CTT 1 to 5, all or some I/O bits are used for special transfer functions in the process image for AS-i digital values. For further details, please refer to the documentation of the respective AS-i slave.

The following applies to these protocol bits:

- In the input direction, the AS-i master sets the value "0".
- In the output direction, the AS-i master ignores the bits.

7.3.1 Accessing AS-i analog data via the process image

If you assigned I/O addresses to the analog slaves when configuring, you can access the AS-i analog values with word commands (Firmware V1.1 and higher).

Analog and transparent I/O addresses for configured AS-i slaves

The analog and transparent I/O addresses of an AS-i slave can be freely assigned within the overall process image of the CM AS-i Master ST. This is regardless of the size of the process image. If you only require a few analog inputs and outputs in the process image and want to save space, you can change the length of the I/O data of an AS-i slave. If the set length is less than the actual length of the I/O data of the AS-i slaves, you cannot access the data at addresses greater than the set length via the process image. You can also deactivate the process image for analog inputs/outputs. Please also see the description of the options "Sorting" and "Packing" in Section I/O addresses when configuring AS-i slaves in STEP 7 (Page 46).

Access to analog I/O data is also possible via data records independent of the process image. You can find more detailed information on this in Section "Accessing AS-i analog data via acyclic services (Page 56)".

7.3.2 Accessing AS-i analog data via acyclic services

Representation of the analog values in the data records

Analog values are transferred in the data records numbered from 140 to 147.

- You access the analog input values using system functions for reading data records.
- You output analog values using system functions for writing data records.

In combination with SIMATIC S7, system function blocks SFB 52 "RDREC" and SFB 53 "WRREC" enable this.

Access to analog data via acyclic services can also be selected, for example, if there is a need to save I/O address space in SIMATIC S7.

NOTICE

Simultaneous write access via cyclic and acyclic services not possible

Simultaneous write access to analog data of a slave is not permissible with different process values either via cyclic or acyclic services. If both services are used the analog output values that are output via cyclic and acyclic services to the same slave address must be synchronized with each other via the user program.

You can use data record lengths ranging from 2 bytes to 240 bytes for each data record number. For each slave address, an area of 8 bytes is available to address 4 analog channels.

The table below shows which data record is used by each AS-i slave to transfer the analog values. The subsequent table shows the assignment of analog values to the respective analog slaves.

The tables are applicable to analog inputs and analog outputs.

Table 2-1671 Access to analog values via data records

AS-i address of the slave	Start addresses for analog values in the data record							
	DS 140	DS 141	DS 142	DS 143	DS 144	DS 145	DS 146	DS 147
1	**0**	—	—	—	—	—	—	—
2	**8**	—	—	—	—	—	—	—
3	**16**	—	—	—	—	—	—	—
4	**24**	—	—	—	—	—	—	—
5	**32**	**0**	—	—	—	—	—	—
6	**40**	**8**	—	—	—	—	—	—
7	**48**	**16**	—	—	—	—	—	—
8	**56**	**24**	—	—	—	—	—	—
9	**64**	**32**	**0**	—	—	—	—	—
10	**72**	**40**	**8**	—	—	—	—	—
11	**80**	**48**	**16**	—	—	—	—	—
12	**88**	**56**	**24**	—	—	—	—	—
13	**96**	**64**	**32**	**0**	—	—	—	—
14	**104**	**72**	**40**	**8**	—	—	—	—
15	**112**	**80**	**48**	**16**	—	—	—	—
16	**120**	**88**	**56**	**24**	—	—	—	—
17	**128**	**96**	**64**	**32**	**0**	—	—	—
18	**136**	**104**	**72**	**40**	**8**	—	—	—
19	**144**	**112**	**80**	**48**	**16**	—	—	—
20	**152**	**120**	**88**	**56**	**24**	—	—	—
21	**160**	**128**	**96**	**64**	**32**	**0**	—	—
22	**168**	**136**	**104**	**72**	**40**	**8**	—	—
23	**176**	**144**	**112**	**80**	**48**	**16**	—	—

AS-i address of the slave	Start addresses for analog values in the data record							
	DS 140	DS 141	DS 142	DS 143	DS 144	DS 145	DS 146	DS 147
24	**184**	**152**	**120**	**88**	**56**	**24**	—	—
25	**192**	**160**	**128**	**96**	**64**	**32**	**0**	—
26	**200**	**168**	**136**	**104**	**72**	**40**	**8**	—
27	**208**	**176**	**144**	**112**	**80**	**48**	**16**	—
28	**216**	**184**	**152**	**120**	**88**	**56**	**24**	—
29	**224**	**192**	**160**	**128**	**96**	**64**	**32**	**0**
30	**232**	**200**	**168**	**136**	**104**	**72**	**40**	**8**
31	—	**208**	**176**	**144**	**112**	**80**	**48**	**16**

Examples / notes on reading this table:

The subsequent table shows the assignment of analog values to the respective analog slaves.

For additional information, refer to the operating instructions of the slaves.

Table 2-1672 Address range for the analog values of an AS-i slave

Byte no. (start address + offset)	Analog value channel
Start address + 0	Channel 1 / high byte
Start address + 1	Channel 1 / low byte
Start address + 2	Channel 2 / high byte
Start address + 3	Channel 2 / low byte
Start address + 4	Channel 3 / high byte
Start address + 5	Channel 3 / low byte
Start address + 6	Channel 4 / high byte
Start address + 7	Channel 4 / low byte

Analog A/B slaves with 2 channels only reserve half the address range. A slaves occupy bytes 0 to 3 and B slaves bytes 4 to 7.

Examples of the configuration:

1. Configuration:

   Analog slaves have the AS-i addresses 1 to 6.

   You use data record 140 and enter 48 as data record length.

2. Configuration:

   1 analog slave with AS-i address 7 is used.

   You use data record 141 and enter 24 as data record length. Only bytes 16 to 23 are relevant.

3. Configuration:

   The full address range for 31 analog slaves is used.

   You use data record 140 and enter 224 as data record length. You can then address analog slaves 1 to 28.

   For the remaining analog slaves 29 to 31, you use data record 147 in a second job and enter 24 as data record length.

4. Configuration:

   Analog slaves have the addresses 29 to 31.

   You use data record 147 and enter 24 as data record length.

Mixed access:

- Configuration:

  You want to access slaves 1 to 12 using I/O commands and slaves 13 to 31 using data records.

  You use data record 143 for slaves 13 to 31.

Alarms, faults and system events 8

8.1 Overview

Diagnostics options

The following diagnostics options are available for the AS-i master:

- LEDs on the module
- Diagnostics in *STEP 7*:
  - Online presentation of the network and device view
  - Diagnostic buffer
- Alarm messages in user program
- Creation of user-specific web pages via the web server of a connected SIMATIC controller

You will find information on the LEDs in Section "Meaning of the LEDs (Page 62)".

The diagnostic possibilities in *STEP 7* and in the user program are described in the following sections.

8.2 Diagnostics in STEP 7

Diagnostics in STEP 7

For diagnostics of the AS-i master and the AS-i slave, use the "Go online" function to switch *STEP 7* to "Online" status.

If you have configured AS-i slaves in *STEP 7*, the diagnostic information about slaves can be displayed in *STEP 7*.

The diagnostics of the AS-i slaves in STEP 7 V13 SP1 (TIA Portal) are not displayed via the online network view function. The information of the AS-i master is displayed symbolically in the device view. The status of these devices will also be displayed to the right of the device in the project navigation by means of a symbol. For an explanation of the different status symbols, please refer to the relevant tool tip.

STEP 7 offers several possibilities for requesting the diagnostic information of the AS-i master:

- Special diagnostic symbols indicate the status of the AS-i master in the network view of the device configuration. Red symbols signal an error, and green symbols indicate that the devices are OK.
- In *STEP 7* V13 SP1 (TIA Portal), you can call up information about the status of the AS-i master and AS-i slaves. To do so, open the diagnostics as follows:
  - Select the AS-i master.
  - Select "Online & diagnostics" in the context menu.
  - In the "Online & diagnostics" view, select "Detailed diagnostics > Error overview".

    Here you see the current status of every AS-i slave address.

  To analyze sporadic errors, you can read out the error counter for the AS-i network.

  Diagnostics are also available in *STEP 7* V5.5 HSP 2092 V3.0 and higher.
- The control panel of the AS-i master can also be called up in this display. This shows the status of the LEDs.
- All the relevant events are stored in the diagnostic buffer of the CPU. You can display the diagnostic buffer in the "Online & Diagnostics" window for a selected CPU.

NOTE

Using the context menu

In current TIA Portal versions, frequently required online functions can be directly called up via the context menu of the AS-i master.

– Right-click the AS-i master.

– Choose > "AS-i network diagnostics" in the context menu.

The context menu can also be called up on any AS-i slave.

8.3 LED statuses

8.3.1 Arrangement of the LEDs on the CM AS-i Master ST

Introduction

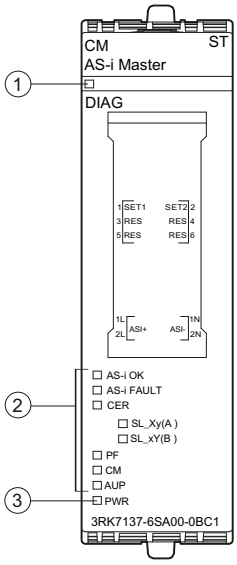

① DIAG (green/red)

② Status LEDs (AS-Interface)

③ PWR (green)

Figure 2-1385 Arrangement of the LEDs on the CM AS-i Master ST

8.3.2 Meaning of the LEDs

Meaning of the LEDs

The tables below explain the status and fault indications. Remedies for the diagnostic messages are in Section "Diagnostic messages (Page 66)".

"PWR" LED

Table 2-1673 Meaning of the "PWR" LED

PWR	Meaning
☐ OFF	The AS-i voltage is not provided (terminals L+, M).
■ Green ON	The AS-i voltage is provided (terminals L+, M).

"DIAG" LED

Table 2-1674 Meaning of the DIAG LED

DIAG	Meaning
☐ OFF	The supply voltage for the interface module of the ET 200SP is not provided.
✻ Green flashes	The AS-i master parameters have not been assigned.
■ Green ON	The AS-i master parameters have been assigned and are error-free. No diagnostic message of the AS-i master is pending.
✻ Red flashes	The AS-i master parameters have been assigned and the AS-i master signals diagnostic errors for the AS-i master or an AS-i slave or an active firmware update.

"AS-i OK" LED

Table 2-1675 Meaning of the AS-i OK LED

AS-i OK	Meaning
☐ OFF	An error has occurred (see AS-i FAULT LED) or the AS-i master is offline. This means: No I/O data exchange is taking place, e.g. during power-up.
■ Green ON	The AS-i bus is fault-free. I/O data exchange takes place.

"AS-i FAULT" LED

Table 2-1676 Meaning of the AS-i FAULT LED

AS-i FAULT	Meaning
☐ Red OFF	No AS-i cable faults have occurred. The AS-i master is in "Offline" mode.
■ Red ON	The AS-i bus has failed, e.g. the supply voltage for AS-Interface is too low, ground fault.
✻ Red "flashes"	A fault has occurred, e.g. a duplicate address or parameterization error has been detected.

"PF" LED

This LED indicates peripheral faults.

Table 2-1677 Meaning of the "PF" LED

PF	Meaning
Red OFF	No peripheral fault is being signaled.
Red ON	At least one AS-i slave is signaling a peripheral fault. Refer to the operating instructions for the respective slave for the meaning of the peripheral fault, e.g. overload at the standard outputs and/or overload of the sensor power supply of the standard inputs.

Firmware update (Page 18)

"CER" LED

This LED indicates configuration errors. It lights when the slave configuration detected on the AS-i cable does not match the EXPECTED configuration in the AS-i master.

Table 2-1678 Meaning of the "CER" LED

CER	Meaning
Yellow OFF	No AS-i configuration error.
Yellow ON	Failure of an AS-i slave: • A configured AS-i slave is not present on the AS-i cable. • An excess slave not configured beforehand is present on the AS-i cable. • A connected slave has different configuration data (IO, ID, ID1, ID2) than the slave configured in the AS-i master. • A slave with address "0" is in "Configuration mode" on the AS-i bus. • Duplicate address detection has found an AS-i address that is used multiple times.

"CM" LED

This LED indicates the operating status, in this case configuration mode.

Table 2-1679 Meaning of the "CM" LED

CM	Meaning
Green OFF	The AS-i master is in "protected mode".
Green ON	The AS-i master is in "configuration mode".
Green flashes	During a firmware update: Errors have occurred during the firmware update.

"AUP" LED

This LED indicates whether automatic address programming is possible or not.

Table 2-1680 Meaning of the "AUP" LED

AUP	Meaning
☐ Green OFF	Automatic address programming is not possible. This LED is always off in configuration mode.
■ Green ON	When the AS-i master is in "protected mode", this LED indicates that automatic address programming of an AS-i slave is possible. Automatic address programming makes it easier to replace a defective AS-i slave on the AS-i cable. For more detailed information, refer to Section "Replacing a defective AS-i slave / automatic address programming (Page 70)".

"SL_Xy(A)" and "SL_xY(B)" LEDs

These LEDs indicate the slave addresses to which an error is signaled. The following states are taken into account:

- The slave has failed.
- The slave is an excess slave.
- The slave type is incorrect.
- Duplicate addressing detected.

The following diagram shows the indication sequence:

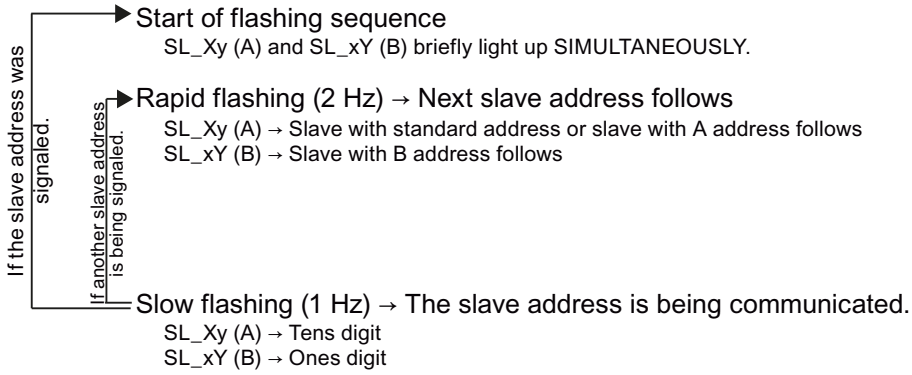

Figure 2-1386 Indication sequence

Example: Slave 15 and 21B have failed

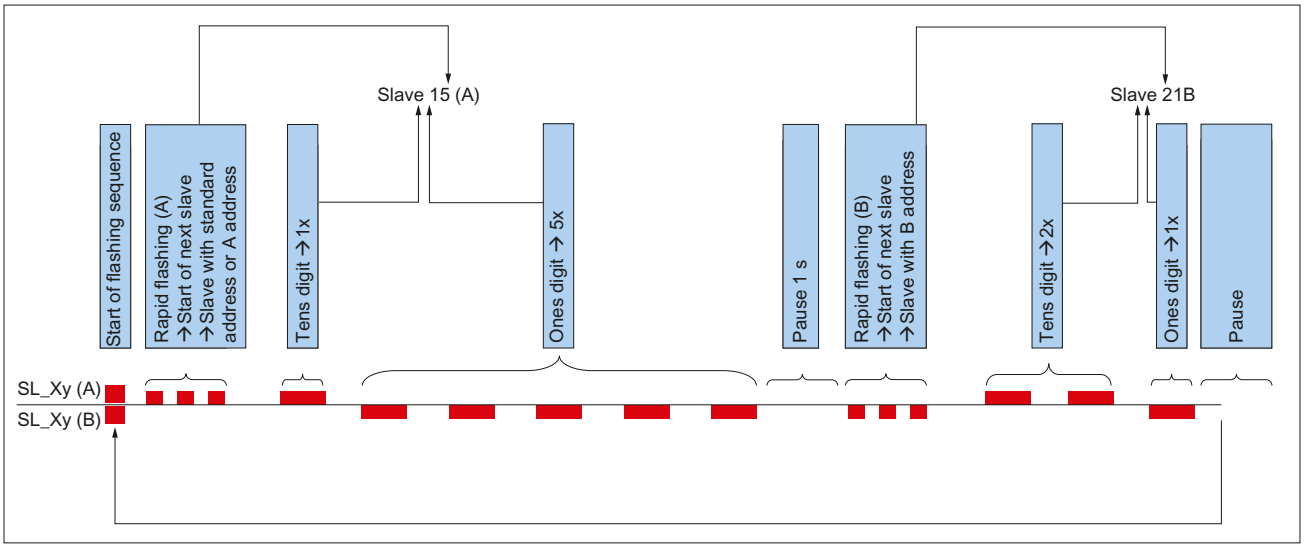

Figure 2-1387 Example: Slave 15 and 21B have failed

8.4 Diagnostic messages

8.4.1 Alarms

The AS-i master sends a diagnostic interrupt request to the CPU in the following situations:

- The AS-i master has detected a problem, e.g. failure of a slave (incoming event).
- The problem was rectified or no longer exists (outgoing event).

If there is no OB 82 in the user program, a CPU of the S7-300 / S7-400 product range will switch to "STOP".

If an OB 82 exists, the operating system responds to an incoming event by calling the OB 82. The S7 CPU then interrupts the cyclic user program and enters the event in the system diagnostic buffer as a "Module fault" message.

Some diagnostic information is made available to the user in the local data of the OB 82, e.g.: Which module triggered the interrupt? What type of error has occurred?

Following execution of the OB 82, the S7 CPU continues the cyclic program from the point of interruption.

When parameterizing the CM AS-i Master ST, you can specify whether and in what cases a diagnostics interrupt should be triggered.

See Section "Parameter assignment/addressing (Page 42)"

See Section "Fault indications/fault remedies (Page 74)" for a list of possible error cases.

8.4.2 Possible response to the diagnostic interrupt

Diagnostic events of the AS-i master and all AS-i slaves are signaled by means of OB82, e.g. No voltage on AS-Interface, peripheral fault

NOTE
Diagnostic buffer
All AS-i slave errors are recorded in the diagnostic buffer of the CPU.

The cause of the interrupt can be determined by reading out data records with diagnostic data during execution of the OB 82 block or during cyclic program execution. See Section "Data records for diagnostics (Page 76)".

8.4.3 Error messages

AS-i-specific faults

The following AS-i-specific faults are possible:

Channel / Fault type	Fault		Cause	Remedial measures
	No.	Message		
0400_H	1024	AS-i slave failed	An AS-i slave on an A address or a slave with standard address has failed. The channel number of the message shows the address of the affected AS-i slave. Possible causes: • The slave is defective. • There is a break in the cable • An overload of the sensor supply at the input slave or an overload of the actuator supply • Overload at the output for some slaves	Check: • AS-i slave • Connecting cables • Overload • EMC environment • Connected sensors and actuators
0401_H	1025	AS-i slave on B address failed	An AS-i slave on a B address has failed. The channel number of the message shows the address of the affected AS-i slave. Possible causes: • The slave is defective. • The cable is interrupted. • An overload of the sensor supply at the input slave or an overload of the actuator supply • Overload at the output for some slaves	Check: • AS-i slave • Connecting cables • Overload • EMC environment • Connected sensors and actuators

Channel / Fault type	Fault		Cause	Remedial measures
	No.	Message		
0402_H	1026	Peripheral fault in AS-i slave	An AS-i slave on an A address or a slave with a standard address signals a peripheral fault. The channel number of the message shows the address of the affected AS-i slave. Possible cause: • An overload at the output of a digital slave or an overload at the actuator • Measuring range exceeded for analog input slaves • Overload of the sensor supply at the input slave (only for some slave types) • Group fault message for M200D motor starters	Note the information in the manual for the AS-i slave. Check: • Slave • Overload • Connected sensors and actuators
0403_H	1027	Peripheral fault in AS-i slave on B address	An AS-i slave on a "B" address signals a peripheral fault. The channel number of the message shows the address of the affected AS-i slave. Possible cause: • An overload at the output of a digital slave or an overload at the actuator • Measuring range exceeded for analog input slaves • Overload of the sensor supply at the input slave (only for some slave types) • Group fault message for M200D motor starters	Note the information in the manual for the AS-i slave. Check: • Slave • Overload • Connected sensors and actuators
0404_H	1028	AS-i address used multiple times	Multiple AS-i slaves with the same profile and address are located on the AS-i bus. The affected slaves have a standard address or A address. The channel number of the message shows the address of the affected AS-i slave.	Change the addresses of the AS-i slaves to addresses that are unique in the network.
0405_H	1029	AS-i B address used multiple times	Multiple AS-i slaves with the same profile and address are located on the AS-i bus. The affected slaves have a B address. The channel number of the message shows the address of the affected AS-i slave.	Change the addresses of the AS-i slaves to addresses that are unique in the network.
0406_H	1030	No or erroneous voltage on the AS-i cable	The AS-i master has detected insufficient voltage on the AS-i cable. Data exchange on the AS-Interface has been stopped.	Check: • Voltage • Polarity on AS-i cable • Power supply

Channel / Fault type	Fault		Cause	Remedial measures
	No.	Message		
0407_H	1031	AS-i configuration error (CER)	The ACTUAL configuration of the AS-i slaves on the AS-i cable differs from the CONFIGURED configuration saved in the AS-i master. Possible causes of short-term failures: • High levels of electromagnetic interference are affecting the AS-i installation. Other possible causes: • The functional ground connection to the AS-i power supply unit or AS-i data decoupling module is not connected to ground potential. • Protected operation: A configured slave has failed or there is an excess slave on the bus. • Configuration mode: A slave with address "0" has been detected on the bus.	Check: • AS-i slave failure • Overload • Excess slave • Incorrect address • Incorrect slave type • EMC environment Remove the electromagnetic interference.
0408_H	1032	Ground fault on AS-i cable	A ground fault is present between AS-i+ and ground or between AS-i- and ground. Possible consequences: • Disruption of communication • Slave failure • Configuration error • Hazard as a result of secondary faults	Check: • Insulation fault on AS-i cable • Sensor/actuator cable Ensure that the ground fault is rectified.
$040A_H$	1034	Excess AS-i slave	There is an unconfigured AS-i slave with a default address or an A address on the AS-i bus. The channel number of the message shows the address of the affected AS-i slave.	Change the CONFIGURED configuration in the AS-i master or remove the AS-i slave.
$040B_H$	1035	Excess AS-i slave at B address	On the AS-i bus there is an unconfigured AS-i slave with a B address. The channel number of the message indicates the B address of the affected AS-i slave	Change the CONFIGURED configuration in the AS-i master or remove the AS-i slave.
$040C_H$	1036	Incorrect AS-i slave	On the AS-i bus there is an incorrect AS-i slave with a default address or an A address. The channel number of the message shows the address of the AS-i slave involved.	• Use the correct slave type. • Set the ID1 code on the slave in accordance with the CONFIGURED configuration.
$040D_H$	1037	Incorrect AS-i slave at B address	There is an incorrect AS-i slave with a B address on the AS-i bus. The channel number indicates the B address of the affected slave.	• Use the correct slave type. • Set the ID1 code on the slave in accordance with the CONFIGURED configuration.

8.5 Replacing a defective AS-i slave / automatic address programming

Automatic address programming after failure of one or more AS-i slaves - replacement of AS-i slave

The "Automatic address programming" function allows you to easily replace defective AS-i slaves.

NOTE

Automatic address programming

Automatic address programming is only possible if the AS-i master is operating in "protected operation" and **one or more** AS-i slaves have failed.

If several AS-i slaves have failed, you must uniquely identify the failed slaves in the configuration using the slave profile:

- IO code
- ID code
- ID2 code
- ID1 code

The automatic address programming function also supports slaves with the "CTT5" profile (multi-address slaves) and AS-i devices that contain multiple internal slave addresses. This requires each internal slave to have different identifications (IO code, ID code, ID2 code, and ID1 code).

NOTE

The automatic address programming function does not work if two identical slaves have failed.

Examples of devices with multiple internal slave addresses which support automatic address programming:

- Module K60 with 8DI/2DO (3RK2400-1HQ00-0AA3)
- Motor Starter M200D AS-i Standard (3RK1325-...).

If no address has yet been assigned to these devices (delivery state), only **one** address "0" is visible on the bus. The device automatically suppresses the other internal "0" addresses.

NOTE

Exceptions

The automatic address programming function is not available for the following devices, because the identifications of each internal slave are identical (IO code, ID code, ID2 code, and ID1 code).

- Module K60 with 8 DI (3RK1200-0DQ00-0AA3, 3RK2200-0DQ00-0AA3, 3RK2200-1DQ00-1AA3)
- Safety-related module K45 with 4 F-DI (3RK1205-0CQ00-0AA3).

Detection of a defective AS-i slave

An illuminated "AUP" LED signals the following in "protected operation":

- Slave failure was detected:
  - Exactly **one** slave has failed, or
  - A device containing multiple different slaves has failed, **or**
  - Multiple slaves or devices have failed, each of the failed slaves having a different configuration
- Automatic address programming by the AS-i master is possible.

If an AS-i slave fails, the AS-i master indicates the address of the failed slave via the "SL_Xy (A)" and "SL_xY (B)" LEDs.

If a device with multiple internal slave addresses fails, the AS-i master indicates the failure of multiple slaves.

Replacement of a defective AS-i slave

- Replace the defective AS-i slave with an **identical** AS-i slave with address "0" (setting in delivery state).
- Replace the defective AS-I device containing multiple internal slave addresses with an identical AS-i device with address "0" on all internal slaves (setting in delivery state).

NOTE

Replacement of a defective AS-i slave

Only one address "0" may be configured on the bus at any one time. If you want to replace several slaves or devices, you must replace them one after the other with the AS-i master switched on.

For the new slave or device, the AS-i master programs the address or addresses of the original failed device.

The LEDs "AUP" and "CER" go out once all slaves have been correctly replaced.

8.6 Duplicate address detection

To ensure that the AS-Interface system functions correctly, all the AS-i slaves must have a unique AS-i address on the bus.

If the same AS-i address is assigned to one or more slaves, this incorrect assignment is referred to herein as a duplicate address.

NOTE

For slaves without cyclic data communication, the duplicate address detection function of the CM AS-i master ST cannot be executed.

Duplicate addresses where slave types are different and where the states at the inputs are different.

As part of standard operation, the AS-i master monitors the data exchange for errors and thus often excludes slaves with a duplicate address automatically from the cyclic data exchange. This is the case for duplicate addresses in which the slave types are different (profile identification IO code, ID code, ID2 code, and ID1 code) and duplicate addresses for slaves having a different status at their inputs.

In "protected mode", this error state condition is displayed on the AS-i master as a configuration error with the relevant AS-i address and the affected slaves detect a communication error.

Duplicate addresses where the slave types are identical and where the states at the inputs are identical or there are no inputs.

The duplicate address detection function of the CM AS-i Master ST also detects cases of slaves with duplicate address in which the cyclic data exchange is not excluded by standard mechanisms. Such cases include duplicate addresses in which the slave types are identical (profile identification, IO code, ID code, ID2 code, and ID1 code) and in which the slaves either have the same status at their inputs or have no inputs (output slaves).

When a duplicate address is detected, the AS-i master signals a duplicate address error and automatically resets the output data of the address concerned to "0" so that the outputs of the affected slaves are switched off. Communication with the affected slaves is not interrupted, i.e. the slaves do not signal a communication error.

NOTE

System behavior according to AS-i specification

If you connect a slave with duplicate address to the AS-i cable while the bus is operating, the added slave is initially excluded from cyclic data communication and its LEDs indicate a communication error. According to the specification, the AS-i master does not activate an AS-i slave until its address is recognized as a new address on the bus, e.g. when a power-up of the bus takes place. If the bus contains an active slave, no further automatic slave activation occurs on the same address during operation, even if an additional slave with the same address (duplicate address) is added.

However, manual activation of the slave can be initiated via the command interface by writing parameters to the slave address.

For physical reasons, the duplicate address detection function of the CM AS-i Master ST cannot detect a duplicate address during cyclic data exchange in every configuration. Therefore, like for any AS-i system, it is essential to ensure when assigning AS-i addresses that each AS-i slave contains a unique AS-i address on the bus, e.g. by using addressing device 3RK1904-2AB02.

The duplicate address detection function can assist in identifying inadvertent duplicate addressing. To enable duplicate address detection, select an AS-i network configuration in which the AS-i power supply unit is connected in the immediate vicinity of the AS-i master.

The duplicate address detection of the CM AS-i Master ST from firmware V1.1 and higher has been optimized for an AS-i cable length up to 100 m without branches.

The duplicate address detection function of firmware V1.0 is designed for shorter cable lengths.

The duplicate address detection function can be used in the specified and additional configurations, but it cannot be guaranteed that duplicate addresses will be uniquely detected in every case.

For configurations with an AS-i repeater, the duplicate address detection function does not work due to the separation of the cable into multiple segments.

Enabling the duplicate address detection function

For the CM AS-i master ST with firmware V1.1 and higher, the duplicate address detection function is activated in the configuration via HW Config or the GSD setting. After a start or restart of the CM AS-i Master ST V1.1 and higher, the setting is accepted from HW Config or the GSD setting.

For the CM AS-i master ST with firmware V1.0 and higher, the duplicate address detection function is deactivated when the AS-i master is switched on and can be set by writing data record DS 100, see Section "DS 100 Switch duplicate address detection on/off (Page 151)". The activation status is saved in volatile memory of the AS-i master. After a startup or restart of the CM AS-i Master ST V1.0, the duplicate address detection function must be activated via the user program, if required.

Function description

The duplicate address detection function assists you in identifying inadvertent duplicate addressing.

When commissioning the AS-i system, check that duplicate address detection can be used for the AS-i configuration used.

- Install the complete AS-i system and ensure that the specified addresses of the slaves are correct and unique.
- Enable the duplicate address detection function. In firmware V1.1 and higher, you can do this for AS-i voltages of either 24 V or 30 V.
- When the CM AS-i Master ST module from product version 20 (corresponding to firmware from V2.0) is used, no distinction is necessary between "Enable for AS-i 24 V" and "Enable for AS-i 30 V" for duplicate address detection. To activate the duplicate address detection, either of the options for enabling can be chosen, irrespective of the AS-i voltage actually used.
- Check whether the CM AS-i Master ST signals a duplicate address in spite of correct slave address assignment. If a duplicate address is signaled on the AS-i master even though the bus configuration is correct, this means that duplicate address detection cannot be used for this bus configuration. Should this occur, disable the duplicate address detection function.
- Note that when the duplicate address detection function is enabled, the presence of a duplicate address may not be detected, depending on the bus configuration.

NOTE

The activation status is saved in volatile memory of the AS-i master. After a startup or restart of the CM AS-i Master ST, duplicate address detection must be activated again via the user program, if required.

The CM AS-i Master ST signals a detected duplicate address as follows:

- The "CER" LED lights up to indicate a configuration error.
- The "SL_Xy (A)" and "SL_xY (B)" LEDs signal the AS-i address concerned.
- The message "AS-i address used multiple times" is output.

To rectify the fault, check and change the address of the affected AS-i slave, e.g. using the addressing unit. Via the online function of *STEP 7* it is not possible to change the AS-i address of an individual slave if there are multiple slaves with the same address on the AS-i cable.

See also

DS 100 Read setting for duplicate address detection (Page 152)

8.7 Diagnosis via the web server

Web server functionality

Many SIMATIC controllers provide integrated web server functionality. This enables access via a web browser to the data of the CPU and its connected components, e.g. the AS-i master.

A *STEP 7* library is available as a download for diagnosing the AS-i master via a web browser. It presents the most important diagnostic information in a clear overview. The package is based on the concept of user-defined web pages. You can obtain the package from the Siemens Service & Support Portal under the following link:

Service and support portal (https://support.industry.siemens.com/cs/ww/en/view/50897766)

8.8 Fault indications/fault remedies

Fault indications/remedies for faults on the CM AS-i Master ST

Below are possible fault indications during operation of the AS-i master and potential remedial measures.

Table 2-1681 Fault indications and remedies for faults on the AS-i Master

Fault	Possible cause	Remedy
"AS-i fault" LED lights up red	The current consumption of the AS-i slaves is too high. Result: Voltage on the AS-i cable is too low.	Check the current consumption of the AS-i slaves.
	No voltage is present on the AS-i cable or the voltage is too low.	Check the connection with the AS-i power supply unit.
	Short-circuit on the AS-i cable	Check the AS-i cable and the connected AS-i slaves.
"DIAG" LED not lit	There is no supply over the communications bus.	Check whether the module is inserted correctly.
"DIAG" LED flashes green, but does not switch to constant green light	The AS-i master is not configured.	Configure the AS-i master in *STEP 7*.

Fault	Possible cause	Remedy
"CER" LED is lit.	A configured AS-i slave has failed. • Evaluate the slave indication.	Replace the defective AS-i slave or configure the AS-i master again if the AS-i slave is not required.
	A non-configured AS-i slave was connected to the AS-i cable.	Remove the AS-i slave or configure the AS-i master again.
	An AS-i slave has been connected whose configuration data, e.g. IO code, ID codes, does not match the values of the configured AS-i slave.	Check whether an incorrect AS-i slave has been connected. Configure the AS-i master again, if necessary.
	Duplicate address detection has found an AS-i address that is used multiple times.	Check whether two or more AS-i slaves have been connected with the same AS-i address. Correct the AS-i addresses.
"CER" LED flashes erratically , i.e. a configured AS-i slave fails sporadically.	Loose connection	Check the connections of the AS-i slaves.
	Injection of interference on the AS-i cable.	Check that the grounding of the AS-i master and routing of the AS-i cable are correct. Check whether the shield of the AS-i power supply unit is connected correctly.
	The connected sensor is causing an overload.	Check the sensor and the sensor cable for damage.
The AS-i master does not switch from "configuration mode" to "protected mode".	An AS-i slave with address 0 is connected to the AS-i cable. The AS-i master is unable to switch to "protected mode" as long as this slave is connected.	Remove the AS-i slave with address 0 or set the correct address using the AS-i addressing device.
In *STEP 7* it is not possible to switch between "configuration mode" and "protected mode".	The automation system is in the "RUN" state.	Switch the automation system to the "STOP" state.
The AS-i master does not switch from "protected mode" to "configuration mode".	The automation system is in the "RUN" state.	Switch the automation system to the "STOP" state.
Automatic address programming does not take place.	The configuration data, e.g. IO code, ID code, ID2 code, and ID1 code, of the replaced AS-i slave does not match the values of the original slave.	Check that the correct replacement slave was used. Compare the manufacturer's information with regard to configuration data. If the original slave is to be replaced by a different type, assign the address with the AS-i addressing device and configure the AS-i master again.
	Replaced AS-i slave does not have the address "0".	Set the address of the replaced slave with the AS-i addressing device.
	Replaced AS-i slave is not correctly connected or is defective.	Check the connections of the slave. Replace the slave, if necessary.
	The AS-i master is in "configuration mode".	Program the address of the new AS-i slave with the AS-i addressing device or via the command interface of the AS-i master.

Fault	Possible cause	Remedy
Automatic address programming does not take place.	Several slaves with the same profile have failed.	Program the addresses of the new AS-i slaves with the AS-i addressing device.
No LEDs are lit, except possibly for the "DIAG" LED	The AS-i voltage is missing.	
"PF" LED is lit	One or more AS-i slaves signal a fault in the connected I/O.	Check the I/O components connected to the AS-i slaves and the cabling for wire break or short-circuit.

Reference

You will find more information about the LEDs on the AS-i master in Section "Meaning of the LEDs (Page 62)".

8.9 Data records for diagnostics

8.9.1 DS 92 Diagnostic data record (FW V1.1 and higher)

The operating status of the AS-i master, the connected AS-i network and the AS-i slave is stored as diagnostic data record DS 92 in the CM AS-i Master ST module.

Description

This data record provides information about the status of an AS-i network.

Table 2-1682 Structure of diagnostic data record DS 92, read

Byte	Description							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
0	Reserved							
1	Reserved							
2	MA30V	MA24V	Res.	Res.	Res.	MADDR	PF	CER
3	Reserved				EFD	CM	CFGOK	DIAG
4	**Flags_1** (See Table "AS-i master flags")							
5	**Flags_2** (See Table "AS-i master flags")							
6	Reserved							
7	Reserved							
Slave diagnostics								
8 ... 15	List of active slaves (see Table "Structure of bit fields")							
	Bit = 0	Slave is not in the list of active slaves.						
	Bit = 1	Slave is in the list of active slaves.						
16 ... 23	List of failed slaves (see Table "Structure of bit fields")							
	Bit = 0	The configured slave has not failed.						
	Bit = 1	The configured slave has failed.						

Byte	Description							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
24 ... 31	List of incorrect slaves (see Table "Structure of bit fields")							
	Bit = 0	The profile of the connected slave is correct.						
	Bit = 1	The profile of the connected slave is incorrect.						
32 ... 39	List of excess slaves (see Table "Structure of bit fields")							
	Bit = 0	The connected slave is configured or no slave is connected.						
	Bit = 1	The connected slave is not configured.						
40 ... 47	List of multiple addressing (see Table "Structure of bit fields")							
	Bit = 0	The AS-i address is not assigned or is only assigned once.						
	Bit = 1	The AS-i address is assigned more than once.						
48 ... 55	List of I/O errors (see Table "Structure of bit fields")							
	Bit = 0	The slave at the AS-i address does not have an I/O error.						
	Bit = 1	The slave at the AS-i address°has an I/O error.						
56 ... 63	List of configured ID = A (see Table "Structure of bit fields")							
	Bit = 0	A standard slave is configured at the AS-i address.						
	Bit = 1	An A/B slave is configured at the AS-i°address.						
64 ... 71	List of actual ID = A (see Table "Structure of bit fields")							
	Bit = 0	A standard slave is connected at the AS-i address.						
	Bit = 1	An A/B slave is connected at the AS-i°address.						
72 ... 79	List of detected slaves (see Table "Structure of bit fields")							
	Bit = 0	No slave detected at the AS-i°address.						
	Bit = 1	Slave detected at the AS-i°address.						
80 ... 87	List of configured slaves (see Table "Structure of bit fields")							
	Bit = 0	No slave configured at the AS-i°address.						
	Bit = 1	Slave configured at the AS-i°address.						

Structure of the bit fields:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	SLAVE 7/7A	SLAVE 6/6A	SLAVE 5/5A	SLAVE 4/4A	SLAVE 3/3A	SLAVE 2/2A	SLAVE 1/1A	SLAVE 0/Reserved
1	SLAVE 15/15A	SLAVE 14/14A	SLAVE 13/13A	SLAVE 12/12A	SLAVE 11/11A	SLAVE 10/10A	SLAVE 9/9A	SLAVE 8/8A
2	SLAVE 23/23A	SLAVE 22/22A	SLAVE 21/21A	SLAVE 20/20A	SLAVE 19/19A	SLAVE 18/18A	SLAVE 17/17A	SLAVE 16/16A
3	SLAVE 31/31A	SLAVE 30/30A	SLAVE 29/29A	SLAVE 28/28A	SLAVE 27/27A	SLAVE 26/26A	SLAVE 25/25A	SLAVE 24/24A
4	SLAVE 7B	SLAVE 6B	SLAVE 5B	SLAVE 4B	SLAVE 3B	SLAVE 2B	SLAVE 1B	Reserved

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
5	SLAVE 15B	SLAVE 14B	SLAVE 13B	SLAVE 12B	SLAVE 11B	SLAVE 10B	SLAVE 9B	SLAVE 8B
6	SLAVE 23B	SLAVE 22B	SLAVE 21B	SLAVE 20B	SLAVE 19B	SLAVE 18B	SLAVE 17B	SLAVE 16B
7	SLAVE 31B	SLAVE 30B	SLAVE 29B	SLAVE 28B	SLAVE 27B	SLAVE 26B	SLAVE 25B	SLAVE 24B

Explanation of bit information in bytes 2 and 3:

MA30V = 0 Multiple address detection for AS-i 30 V is deactivated.

= 1 Multiple address detection for AS-i 30 V is activated.

MA24V = 0 Multiple address detection for Power24V is deactivated.

= 1 Multiple address detection for Power24V is activated.

MADDR = 0 No multiple addresses detected on the AS-i°cable.

= 1 Multiple addressing detected for at least one AS-i address on the AS-i cable. This means that multiple slaves have the same AS-i address.

PF = 0 No I/O errors detected.

= 1 I/O errors detected.

CER = 0 No AS-i configuration errors detected.

= 1 AS-i configuration errors detected.

EFD 0 = No ground fault detected

1 = Ground fault detected

CM 0 = Master in protected operation

1 = Master in configuration mode

CFGOK 0 = Configuration not OK or slave exists with address 0.

1 = Configuration OK

DIAG 0 = No diagnostics pending

1 = Diagnostics pending. It is set when:

- The AS-i master is in "offline" mode.
- The AS-i voltage is not OK.
- Multiple addresses were detected.
- An I/O error was detected.
- A configuration error was detected.
- A slave with address 0 exists.

AS-i master flags:

Flag	Bit	Name of the bit	Meaning
Flag_1	0	`Config_OK`	The flag is set when the CONFIGURED configuration and the ACTUAL configuration match.
	1	`LDS.0`	The flag is set when an AS-i slave with address 0 is present. (List of Detected Slaves)
	2	`Auto_Address_Assign`	The flag is set if automatic address programming is possible. This means that AUTO_ADDR_ENABLE = 1 and no "incorrect" AS-i slaves is connected to AS-Interface.
	3	`Auto_Address_Available`	The flag is set when automatic address programming is performed as soon as a slave with a valid configuration is connected at address zero.
	4	`Configuration_Active`	The flag is set in "configuration mode" and reset in "protected operation".
	5	`Normal_Operation_Active`	The flag is set when the AS-i master is in "protected operation".
	6	`APF`	The flag is set when the voltage on the AS-i cable is too low, or a power down was detected during data transmission. (AS-i Power Fail)
	7	`Offline_Ready`	The flag is set if the offline phase is active.
Flag_2	0	`Periphery_OK`	The flag is set if none of the AS-i slaves signal a peripheral fault. All bits in the LPF are zero.
	1	`Data_Exchange_Active`	Controlling: When the flag is set, data transfer starts between the master and slave.
	2	`Off_Line`	Controlling: When the flag is set, the device is switched "OFFLINE" or is "Offline".
	3	`AUTO_ADDR_ENABLE`	The flag is set when automatic address programming is enabled by the user.
	4	`GROUND FAULT`	The flag is set if a ground fault has been detected on the AS-i cable.
	5	`EEPROM_OK`	The flag is set if the test of the internal EEPROM was successful.
	6	`EFD_Disable`	The flag indicates whether ground fault detection is switched on (BIT = 0) or off (BIT = 1).
	7	Reserved	--

8.9.2 DS 96 Read AS-i master error counters and status messages (FW V1.1 and higher)

Meaning

This data record reads out error counters that pertain to the overall AS-i network.

If the AS-i power supply is missing, the overall device fails. This leads to all counters being reset. The count starts again each time the device is powered up.

Table 2-1683 Meaning of error counter

Count value / Information	Meaning
AS-i Power Fail	The count value is incremented when the AS-i power supply drops to a value that is too low.
Ground fault	The count value is increased when a ground fault has been detected on the AS-i cable.

Count value / Information	Meaning
Slave failure	The count value is increased when an active slave fails, that is, when process data transmission has been interrupted. An active slave only fails when it does not respond to six consecutive master calls.
Missing slave message frame	The count value is increased when a slave does not respond to a master call or the master does not receive the response. Process data transmission is not interrupted in this case.
Erroneous slave message frame	The count value is increased when the master receives an incomplete slave response, such as when slaves are added during operation. Process data transmission is not interrupted in this case.
I/O fault	The count value is increased when a slave signals an I/O error.
Protocol error	The count value is increased when the master detects a transmission error for a slave that needs multiple cycles for transmission of data, e.g. for analog data.
Erroneous master frame	The count value is incremented when a master call cannot be sent correctly, e.g. in the event of strong interfering signals on the AS-i cable. Process data transmission is not interrupted in this case.
Sent master frames	Number of master frames This counter counts all frames sent by the master, regardless of whether or not a slave response was received. The total number of master frames is calculated as follows: MT_CNT_TOTAL = (MT_CNT_HIGH x MT_CNT_BASE) + MT_CNT_LOW The error count starts over each time the device is powered up. By dividing the absolute values of the error counters by the number of master frames, it is possible to calculate the percentage of errors and thus the error frequency.

Table 2-1684 Structure of the data record

Byte	Meaning	
0	Reserved	High byte
1		Low byte
2	Summation counter: AS-i Power Fail	High byte
3		Low byte
4	Summation counter: Ground fault	High byte
5		Low byte
6	Summation counter: Slave failure	High word, high byte
7		High word, low byte
8		Low word, high byte
9		Low word, low byte
10	Summation counter: Missing slave frame	High word, high byte
11		High word, low byte
12		Low word, high byte
13		Low word, low byte
14	Summation counter: Erroneous slave frame	High word, high byte
15		High word, low byte
16		Low word, high byte
17		Low word, low byte

The counters are integer values (2 bytes or 4 bytes).

Byte	Meaning		
18	Summation counter: Slave peripheral fault		High word, high byte
19			High word, low byte
20			Low word, high byte
21			Low word, low byte
22	Summation counter: Slave protocol error (for slaves according to CTT1 ... CTT5)		High word, high byte
23			High word, low byte
24			Low word, high byte
25			Low word, low byte
26	Summation counter: Erroneous master frame		High word, high byte
27			High word, low byte
28			Low word, high byte
29			Low word, low byte
30 ... 37	List of count values > 0 (see "Structure of bit fields")		
	Bit = 0	Count value = 0 for all error counters of the AS-i address	
	Bit = 1	Count value > 0 for at least one error counter of the AS-i address	
38	Summation counter: Sent master frames, less significant part (MT_CNT_LOW)		High word, high byte
39			High word, low byte
40			Low word, high byte
41			Low word, low byte
42	Summation counter: Sent master frames, more significant part (MT_CNT_HIGH)		High word, high byte
43			High word, low byte
44			Low word, high byte
45			Low word, low byte
46	Summation counter: Sent master frames, factor (MT_CNT_BASE)		High word, high byte
47			High word, low byte
48			Low word, high byte
49			Low word, low byte
50	Reserved		Bit 0 = MADDR
51	Reserved		
52 ... 59	List of multiple addressing (see Table "Structure of bit fields")		
	Bit = 0	The AS-i address is assigned once or is not present.	
	Bit = 1	The AS-i address is assigned more than once.	

The counters are integer values (2 bytes or 4 bytes).

Structure of the bit fields:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	SLAVE 7/7A	SLAVE 6/6A	SLAVE 5/5A	SLAVE 4/4A	SLAVE 3/3A	SLAVE 2/2A	SLAVE 1/1A	SLAVE 0/Reserved
1	SLAVE 15/15A	SLAVE 14/14A	SLAVE 13/13A	SLAVE 12/12A	SLAVE 11/11A	SLAVE 10/10A	SLAVE 9/9A	SLAVE 8/8A

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
2	SLAVE 23/23A	SLAVE 22/22A	SLAVE 21/21A	SLAVE 20/20A	SLAVE 19/19A	SLAVE 18/18A	SLAVE 17/17A	SLAVE 16/16A
3	SLAVE 31/31A	SLAVE 30/30A	SLAVE 29/29A	SLAVE 28/28A	SLAVE 27/27A	SLAVE 26/26A	SLAVE 25/25A	SLAVE 24/24A
4	SLAVE 7B	SLAVE 6B	SLAVE 5B	SLAVE 4B	SLAVE 3B	SLAVE 2B	SLAVE 1B	Reserved
5	SLAVE 15B	SLAVE 14B	SLAVE 13B	SLAVE 12B	SLAVE 11B	SLAVE 10B	SLAVE 9B	SLAVE 8B
6	SLAVE 23B	SLAVE 22B	SLAVE 21B	SLAVE 20B	SLAVE 19B	SLAVE 18B	SLAVE 17B	SLAVE 16B
7	SLAVE 31B	SLAVE 30B	SLAVE 29B	SLAVE 28B	SLAVE 27B	SLAVE 26B	SLAVE 25B	SLAVE 24B

Explanation of the status bits

MADDR = 0 No multiple addressing detected on the AS-i°cable.

= 1 Multiple addressing detected for at least one AS-i address on the AS-i cable. This means that multiple slaves have the same AS-i address.

8.9.3 DS 97 Read and reset AS-i master error counters (FW V1.1 and higher)

Description

This data record functions in the same manner as the "DS 96 Read AS-i slave error counters" data record. After the DS 97 data record is read, all error counters in the AS-i master are reset to "0".

The structure of the DS 97 data record is identical to the structure of the DS 96 data record. For an explanation of the error counter see Section "DS 96 Read AS-i master error counters and status messages (FW V1.1 and higher) (Page 79)".

8.9.4 DS 150 to DS 153 Read AS-i error counters

These data records read the error counters of the AS-i slaves. Data records DS 150 and DS 151 access the standard addresses and the A addresses. Data records DS 152 and DS 153 access the B addresses. The counters for addresses 16 / 16A exist identically in data records DS 150 and DS 151. The counters for address 16B exist identically in data records DS 152 and DS 153.

Error counter

The CM AS-i Master ST module manages several counters internally which log the number of master frames sent and the number of different error occurrences.

These counter values can be read out using data records DS 150 to DS 153:

- DS 150 contains counter values for slave addresses 1(A) to 16(A).
- DS 151 contains counter values for slave addresses 16(A) to 31(A).
- DS 152 contains counter values for slave addresses 1B to 16B
- DS 153 contains counter values for slave addresses 16B to 31B

Each data record also contains the total count of master frames sent. To determine a relative error rate, divide the count of error occurrences by the number of master frames sent.

The bus system allows the automatic sending of repeat message frames. This ensures that the process data is reliably transferred between master and slave in the industrial environment, even in the case of brief interruptions in transmission, e.g. due to switching operations. If the fault limit value is exceeded, or the slave is not functioning correctly due to a defect, communication to the slave cannot be performed within the defined time period. In this case, transmission of the process data is interrupted. The master signals failure of the slave address and tries to establish communication again.

Under error-free conditions, one master frame is sent to every available slave address for cyclic data transfer per AS-i bus cycle. The addressed slave responds with a corresponding slave frame. Depending on the configuration of the bus, between 1 and 31 slaves are addressed in each AS-i bus cycle. This results in a maximum bus cycle time of 5 ms. When two slaves with extended addressing have the same numerical address, but one is the A address and one the B address, these two slaves are automatically addressed in two consecutive bus cycles. It can be assumed that around 64 000 master frames are sent per second.

Table 2-1685 Meaning of error counter

Count value / Information	Meaning
Slave failure	The count value is increased when an active slave fails, that is, when process data transmission has been interrupted. An active slave only fails when it does not respond to six consecutive master calls.
Missing slave frame	The count value is increased when a slave does not respond to a master call or the master does not receive the response. Transmission of process data is not interrupted in this case.
Erroneous slave frame	The count value is increased when the master receives an incomplete slave response, such as when slaves are added during operation. Transmission of process data is not interrupted in this case.
I/O fault	The count value is increased when a slave signals an I/O error.

Count value / Information	Meaning
Protocol error	The count value is increased when the master detects a transmission error for a slave that needs multiple cycles for transmission of data, e.g. for analog data.
Erroneous master frame	The count value is incremented when a master call cannot be sent correctly, e.g. in the event of strong interfering signals on the AS-i cable. Transmission of process data is not interrupted in this case.
Sent master frames	Number of master frames This counter counts all frames sent by the master, regardless of whether or not a slave response was received. The total number of master frames is calculated as follows: MT_CNT_TOTAL = (MT_CNT_HIGH x MT_CNT_BASE) + MT_CNT_LOW The error count starts over each time the device is powered up. By dividing the absolute values of the error counters by the number of master frames, it is possible to calculate the percentage of errors and thus the error frequency.

Table 2-1686 Slave address structure of the counters

Byte	Counter	
0	Counter: Slave failure	High byte
1		Low byte
2	Counter: Missing slave frame	High byte
3		Low byte
4	Counter: Erroneous slave frame	High byte
5		Low byte
6	Counter: I/O fault	High byte
7		Low byte
8	Counter: Protocol error	High byte
9		Low byte
10	Counter: Erroneous master frame	High byte
11		Low byte

The counters are integer values (2 bytes).

Table 2-1687 Master frame structure of the counters

Byte	Meaning	
0	Summation counter: Sent master frames, less significant part (MT_CNT_LOW)	High word, high byte
1		High word, low byte
2		Low word, high byte
3		Low word, low byte
4	Summation counter: Sent master frames, more significant part (MT_CNT_HIGH)	High word, high byte
5		High word, low byte
6		Low word, high byte
7		Low word, low byte
8	Summation counter: Sent master frames, factor (MT_CNT_BASE)	High word, high byte

The counters are integer values (4 bytes).

Byte	Meaning	
9	Summation counter: Sent master frames, factor (MT_CNT_BASE)	High word, low byte
10		Low word, high byte
11		Low word, low byte

The counters are integer values (4 bytes).

8.9.4.1 DS 150 Read AS-i slave error counters 1/1A to 16/16A

Table 2-1688 Structure of data record DS 150

Byte	Meaning
0	Version High
1	Version Low
2 ... 13	Counter for slave address 1 / 1A
14 ... 25	Counter for slave address 2 / 2A
26 ... 37	Counter for slave address 3 / 3A
38 ... 49	Counter for slave address 4 / 4A
50 ... 61	Counter for slave address 5 / 5A
62 ... 73	Counter for slave address 6 / 6A
74 ... 85	Counter for slave address 7 / 7A
86 ... 97	Counter for slave address 8 / 8A
98 ... 109	Counter for slave address 9 / 9A
110 ... 121	Counter for slave address 10 / 10A
122 ... 133	Counter for slave address 11 / 11A
134 ... 145	Counter for slave address 12 / 12A
146 ... 157	Counter for slave address 13 / 13A
158 ... 169	Counter for slave address 14 / 14A
170 ... 181	Counter for slave address 15 / 15A
182 ... 193	Counter for slave address 16 / 16A
194 ... 205	Master frame counter

8.9.4.2 DS 151 Read AS-i slave error counters 16/16A to 31/31A

Table 2-1689 Structure of data record DS 151

Byte	Meaning
0	Version High
1	Version Low
2 ... 13	Counter for slave address 16 / 16A
14 ... 25	Counter for slave address 17 / 17A
26 ... 37	Counter for slave address 18 / 18A
38 ... 49	Counter for slave address 19 / 19A

Byte	Meaning
50 ... 61	Counter for slave address 20 / 20A
62 ... 73	Counter for slave address 21 / 21A
74 ... 85	Counter for slave address 22 / 22A
86 ... 97	Counter for slave address 23 / 23A
98 ... 109	Counter for slave address 24 / 24A
110 ... 121	Counter for slave address 25 / 25A
122 ... 133	Counter for slave address 26 / 26A
134 ... 145	Counter for slave address 27 / 27A
146 ... 157	Counter for slave address 28 / 28A
158 ... 169	Counter for slave address 29 / 29A
170 ... 181	Counter for slave address 30 / 30A
182 ... 193	Counter for slave address 31 / 31A
194 ... 205	Master frame counter

8.9.4.3 DS 152 Read AS-i slave error counters 1B to 16B

Table 2-1690 Structure of data record DS152

Byte	Meaning
0	Version High
1	Version Low
2 ... 13	Counter for slave address 1B
14 ... 25	Counter for slave address 2B
26 ... 37	Counter for slave address 3B
38 ... 49	Counter for slave address 4B
50 ... 61	Counter for slave address 5B
62 ... 73	Counter for slave address 6B
74 ... 85	Counter for slave address 7B
86 ... 97	Counter for slave address 8B
98 ... 109	Counter for slave address 9B
110 ... 121	Counter for slave address 10B
122 ... 133	Counter for slave address 11B
134 ... 145	Counter for slave address 12B
146 ... 157	Counter for slave address 13B
158 ... 169	Counter for slave address 14B
170 ... 181	Counter for slave address 15B
182 ... 193	Counter for slave address 16B
194 ... 205	Master frame counter

8.9.4.4 DS 153 Read AS-i slave error counters 16B to 31B

Table 2-1691 Structure of data record DS 153

Byte	Meaning
0	Version High
1	Version Low
2 ... 13	Counter for slave address 16B
14 ... 25	Counter for slave address 17B
26 ... 37	Counter for slave address 18B
38 ... 49	Counter for slave address 19B
50 ... 61	Counter for slave address 20B
62 ... 73	Counter for slave address 21B
74 ... 85	Counter for slave address 22B
86 ... 97	Counter for slave address 23B
98 ... 109	Counter for slave address 24B
110 ... 121	Counter for slave address 25B
122 ... 133	Counter for slave address 26B
134 ... 145	Counter for slave address 27B
146 ... 157	Counter for slave address 28B
158 ... 169	Counter for slave address 29B
170 ... 181	Counter for slave address 30B
182 ... 193	Counter for slave address 31B
194 ... 205	Master frame counter

8.9.5 DS 154 Delete AS-i error counters (from FW V1.1)

Description

When writing this data record all the error counters are reset.

The content of the data record has to be filled with zero values.

Table 2-1692 Structure of DS 154 write

Byte	Meaning
0	0
1	0
2	0
3	0

Using the command interface 9

9.1 Introduction

You control the behavior of the AS-i master in your user program entirely through the command interface.

This chapter contains the information you need for accessing the command interface of the CM AS-i Master ST.

9.2 Command interface with SIMATIC S7

Instruction "ASI_CTRL"

The instruction "ASI_CTRL" is available for controlling the command interface. You will find this instruction in *STEP 7* in the task card "Instructions" under "Advanced instructions" > "Distributed I/O" > "Others" > "ASI".

For detailed instructions on using the instruction "ASI_CTRL", see: ASI_CTRL (https://support.industry.siemens.com/cs/ww/en/view/51678777).

9.3 Command interface with controllers of other manufacturers

Functional principle

AS-i commands are read and written via the acyclic services of PROFINET/PROFIBUS. You use the "Read_data_record" and "Write_data_record" (data record 2) services in the user program of the IO controller/DP master for this.

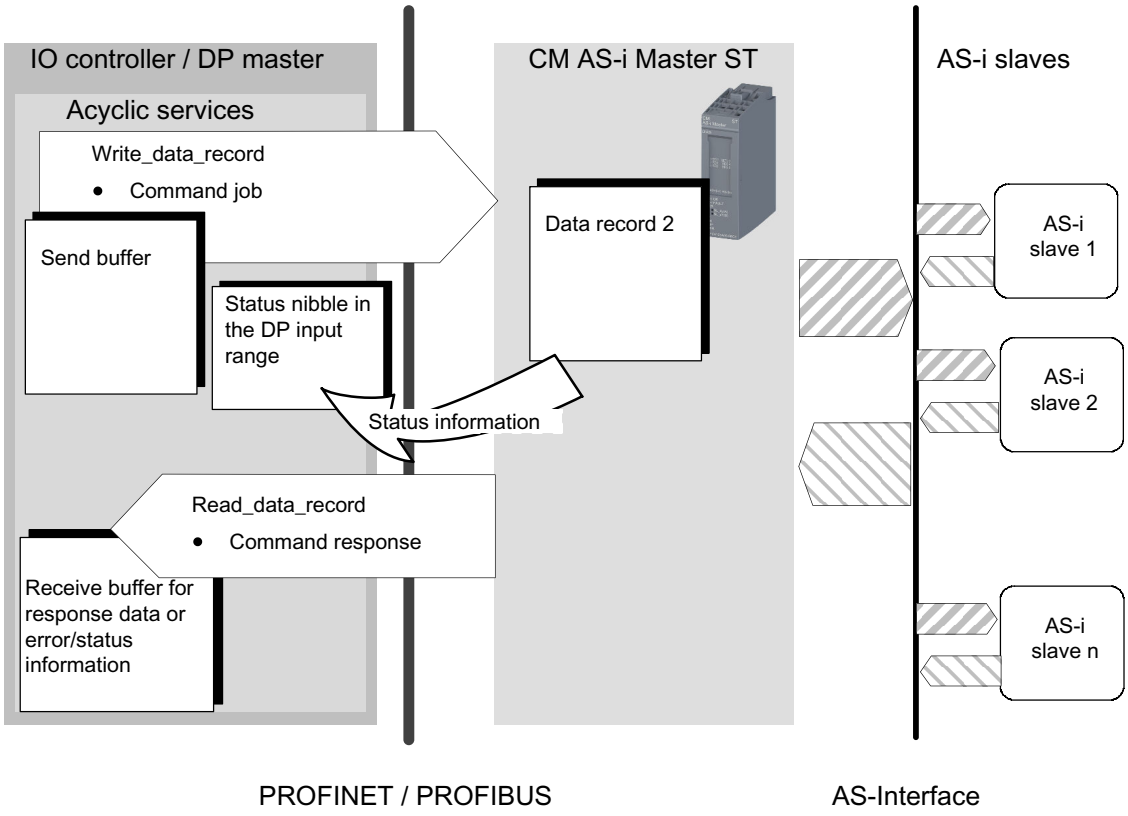

Figure 2-1388 Functional principle

Job parameters

You assign parameters for the "Read_data_record" and "Write_data_record" jobs. The following parameters control the issuance of the commands:

- Index:

  Defines the data record number = 2
- Length:
  - With "Write_data_record", you specify the length of the send data depending on the command.
  - With "Read_data_record", the CM AS-i Master ST signals the length of the receive data via the status nibble.

Command processing in the user program

Structure the command processing in the user program as follows:

1. Specify the command call (Page 93) in a send buffer in the user program.
2. Send this data record call to the CM AS-i Master ST with Write_data_record (data record 2).
3. Then, query the status of the command processing in the input range for digital values (cyclic services). The status information is stored in the first byte reserved for it (byte 0) in bits 4 to 7 of the input range (status nibble).
4. Different reactions occur depending on the result of the status evaluation. You can find these in the following sequence chart. Details on the meaning of the status nibble can be found in the "Coding of the status nibble" table.

   To complete the command processing, you must always issue a Read_data_record (data record 2) job either to obtain further information or to apply the response data.

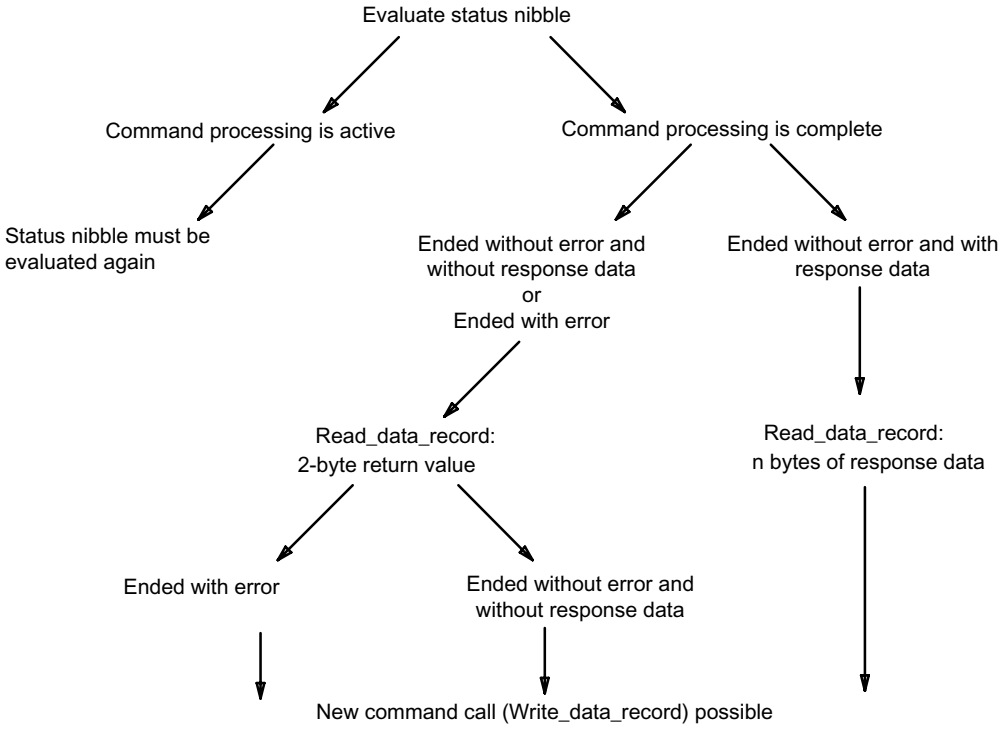

Figure 2-1389 Flowchart

Table 2-1693 Coding of the status nibble

Status nibble (byte 1 of the digital input data)				Meaning
Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	
1	0	0	0	Startup detection 1: The status nibble switches between the values 1000_B and 1110_B following a startup/restart of the AS-i master. Initiation of a command by the user program is possible.
1	1	1	0	Startup detection 2: The status nibble switches between the values 1000_B and 1110_B following a startup/restart of the AS-i master. Initiation of a command by the user program is possible.

Status nibble (byte 1 of the digital input data)				Meaning
Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	
1	1	0	0	Reserved for SIMATIC S7 use FB ASI_CTRL Initiation of a command by the user program is possible.
0	0	1	0	The command processing is active Initiation of a command by the user program is not possible.
0	0	0	1	Command processing has ended. An asynchronous read access can be used to retrieve a **2-byte** return value from the AS-i master. Two cases are distinguished here: • The return value is 0: A command without response data has been ended without errors. • The return value is a value **other than 0**: The command has been ended **with error** (see "Return value in response buffer" table). Initiation of a new command by the user program is possible.
0	0	1	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **1 byte** of response data from the AS-i master. Initiation of a new command by the user program is possible.
0	1	0	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **4 bytes** of response data from the AS-i master. Initiation of a new command by the user program is possible.
0	1	1	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **14 bytes** of response data from the AS-i master. Initiation of a new command by the user program is possible.
1	0	0	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **16 bytes** of response data from the AS-i master. Initiation of a new command by the user program is possible.
1	0	1	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **32 bytes** of response data from the AS-i master. Initiation of a new command by the user program is possible.
1	1	0	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **56 bytes** of response data from the AS-i master. Initiation of a new command by the user program is possible.
1	1	1	1	Command processing has been ended without errors. An asynchronous read access can be used to retrieve **221 bytes** of response data from the AS-i master. Initiation of a new command by the user program is possible.
0	1	0	0	Job processing is complete. The response data or return value of the previous job has already been read by the user. Initiation of a new command by the user program is possible.

Example

The table below indicates the behavior of the status nibble display as a result of the device status and the command processing in the user program:

	Action	Response in the status nibble
1.	Switching on the AS-i voltage of the CM AS-i Master ST.	1110_B ... 1000_B ... 1110_B ...
2.	The user program transfers a command (e.g., Write_parameter) to the CM AS-i Master ST with an asynchronous write access.	0010_B (briefly, dependent on command)
3.	The AS-i master ends the command. The user program can read the return value	0001_B
4.	The user program reads the 2 byte return value with an asynchronous read access.	0100_B
5.	... Further program processing ...	...
6.	The user program transfers a command (e.g., Read_expanded_lists_and_flags) to the CM AS-i Master ST with an asynchronous write access.	0010_B (briefly, dependent on command)
7.	The AS-i master ends the command without errors. The user program can read the response data.	1011_B
8.	The user program reads 32 bytes of response data with an asynchronous read access.	1011_B

Return value

Processing errors are itemized in the return value of the response buffer, if necessary. An error indication exists when "ended without error and without response data or ended with error" is displayed in the status nibble (coding: 0001_H).

Table 2-1694 Return value in the response buffer

STATUS	Meaning
0000_H	**Job completed without errors**
8381_H	The AS-i slave address is incorrect.
8382_H	The AS-i slave is not activated (not in LAS).
8383_H	Error on the AS-Interface
8384_H	The command is not permitted in the current state of the AS-i master.
8385_H	An AS-i slave with address 0 exists.
8386_H	The AS-i slave has impermissible configuration data (IO, ID, ID2, or ID1 code).
$83A1_H$	The referenced AS-i slave was not found on the AS-Interface.
$83A2_H$	An AS-i slave with address 0 exists.
$83A3_H$	An AS-i slave with the new address already exists on the AS-Interface.
$83A4_H$	The AS-i slave address cannot be deleted.
$83A5_H$	The AS-i slave address cannot be set.
$83A6_H$	The AS-i slave address cannot be permanently saved.
$83A7_H$	Error while reading the ID1 code
$83A8_H$	The destination address is not plausible: e.g. a B slave address is used for a standard slave.

STATUS	Meaning
$83B1_H$	A length error occurred during the string transfer in accordance with Profile 7.4.
$83B2_H$	A protocol error occurred during the string transfer in accordance with Profile 7.4.
$83C0_H$	The AS-i slave has an invalid profile, e.g. the standard slave or A slave is configured at a B address.
$83C1_H$	The standard slave cannot be configured, because the B address is already assigned.
$83F8_H$	The job number or the job parameter is not known.
$83F9_H$	The AS-i master has detected an EEPROM error.

NOTE

Errors that occur during processing of acyclic services and are reported via call parameters, such as "Return Value", can be found in the documentation of the relevant programming interface.

9.4 Description of the AS-i commands

Overview

The commands that the user program can issue to the CM AS-i Master ST are described below. With these commands, the AS-i master makes available the complete functionality of the M4 master profile of the AS-i master specification.

NOTE

Adaptations when using existing user programs

Please observe the following adaptations when using existing user programs:

For some commands of the CM AS-i Master ST, the command numbers have been changed and the data structures belonging to the command have been optimized compared to other AS-i masters (e.g., DP/AS-i LINK Advanced).

The following table provides an overview of the modified command numbers:

Command name	Coding for DP/AS-i LINK Advanced	Coding for CM AS-i Master ST
No. A5: Set_Permanent_Configuration (Page 100)	25_H	$A5_H$
No. A6: Get_Permanent_Configuration (Page 101)	26_H	$A6_H$
No. A8: Read_Actual_Configuration (Page 102)	28_H	$A8_H$
No. A9: Set_LPS (Page 103)	29_H	$A9_H$
No. B0: Get_LPS, Get_LAS, Get_LDS, Get_Flags (Page 108)	30_H	$B0_H$
No. B9: Read_overall_configuration (Page 111)	39_H	$B9_H$
No. BA: Write_overall_configuration (Page 117)	$3A_H$	BA_H
No. BE: Get_LPF (Page 131)	$3E_H$	BE_H
No. CA: Read_Error_Counter (Page 136)	$4A_H$	CA_H

Command name	Coding for DP/AS-i LINK Advanced	Coding for CM AS-i Master ST
No. CB: Read_and_Delete_AS-i-Master_Error_Counter (Page 138)	$4B_H$	CB_H
No. CC: Read_AS-i_error_counter (Page 139)	$4C_H$	CC_H
No. CD: Read_and_delete_AS-i_Slave_error_counter (Page 140)	$4D_H$	CD_H

The following table lists the commands that can be executed with the CM AS-i Master ST.

Table 2-1695 AS-i commands

Name	Parameters	Return value	Coding
No. 00: Set_Permanent_Parameter (Page 96)	Slave address, parameter	—	00_H
No. 01: GET_Permanent_Parameter (Page 97)	Slave address	Parameter	01_H
No. 02: Write_Parameter (Page 98)	Slave address, parameter	Optional: Parameter echo	02_H
No. 03: Read_Parameter (Page 99)	Slave address	Parameter value	03_H
No. 04: Store_Actual_Parameters (Page 99)	—	—	04_H
No. A5: Set_Permanent_Configuration (Page 100)	Slave address, configuration data to be configured	—	$A5_H$
No. A6: Get_Permanent_Configuration (Page 101)	Slave address	Configured configuration data	$A6_H$
No. 07: Store_Actual_Configuration (Page 101)	—	—	07_H
No. A8: Read_Actual_Configuration (Page 102)	Slave address	ACTUAL configuration	$A8_H$
No. A9: Set_LPS (Page 103)	LPS	—	$A9_H$
No. 0A: SET_Offline_Mode (Page 104)	Mode	—	$0A_H$
No. 0B: Set_Auto_Address_Enable (Page 105)	Mode	—	$0B_H$
No. 0C: Set_Operation_Mode (Page 105)	Mode	—	$0C_H$
No. 0D: Change_AS-i-Slave_Address (Page 106)	Address 1, Address 2	—	$0D_H$
No. 0F: Read_Status (Page 107)	Slave address	Error data record of AS-i slave	$0F_H$
No. B0: Get_LPS, Get_LAS, Get_LDS, Get_Flags (Page 108)	—	LDS, LAS, LPS, flags	$B0_H$
No. B9: Read_overall_configuration (Page 111)	—	ACTUAL configuration data, actual parameters, LAS, flags	$B9_H$
No. BA: Write_overall_configuration (Page 117)	Overall configuration	—	BA_H
No. 3C: Set_PI (Page 123)	Parameter list	—	$3C_H$
No. 33: AS-i Parameter Echolist (Page 126)	—	Parameter echo list	33_H
No. 44: Read_Write_CTT2_String (Page 127)	Slave address CTT2 string	CTT2 string	44_H
No. 14: Read_Version (Page 128)	—	Version string	14_H
No. 17: Read ID_Code (Page 129)	Slave address	ID code	17_H
No. 37: Read_ID1-Code (Page 129)	Slave address	ID1 code	37_H
No. 3F: Write ID1-Code (Page 130)	ID1 code	—	$3F_H$

Name	Parameters	Return value	Coding
No. 38: Read_ID2-Code (Page 130)	Slave address	ID2 code	38_H
No. 18: Read_IO-Code (Page 131)	Slave address	IO code	18_H
No. BE: Get_LPF (Page 131)	—	LPF	BE_H
No. 40: Write_Parameter_String (Page 132)	Slave address, parameter string	—	40_H
No. 41: Read_String (Page 133)	Slave address	Parameter string	41_H
No. 42: Read_String (Page 134)	Slave address	Identification string	42_H
No. 43: Read_String (Page 135)	Slave address	Diagnostics string	43_H
No. CA: Read_Error_Counter (Page 136)	—	—	CA_H
No. CB: Read_and_Delete_AS-i-Master_Error_Counter (Page 138)	—	—	CB_H
No. CC: Read_AS-i_error_counter (Page 139)	Slave address	—	CC_H
No. CD: Read_and_delete_AS-i_Slave_error_counter (Page 140)	Slave address	—	CD_H
No. 13: Activate_ground fault detection (reset EFD) (Page 141)	Mode	—	13_H
No. D0: Set_Configuration_Online (Page 141)	Slave address, configuration data to be configured, parameters	—	$D0_H$
No. D1: AS-i-Slave_ID1_schreiben_mit_Zieladresse (Write ID1 code with destination address) (Page 142)	Address, ID1 code	—	$D1_H$

General structure of the send buffer

The basic structure of the send buffer for commands is shown below.

The length of the job data depends on the respective command. Some commands do not require any job data. In this case, the send buffer only has one byte (byte 0).

Table 2-1696 Basic structure of the send buffer for commands

Byte	Meaning
0	Number of the command
1	**Job data**
...	**Job data**

General structure of the receive buffer

The basic structure of the receive buffer for commands is shown below. The length of the response data depends on the respective command.

Some commands do not supply any response data. In this case, there is no receive buffer.

Table 2-1697 Basic structure of the receive buffer

Byte	Meaning
0	**Response data**
1	**Response data**
...	**Response data**

General operating state of the AS-i slave address

If an AS-i slave must be addressed in a command or in a response, it must be addressed as follows:

Table 2-1698 Structure of the AS-i slave address

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	Select bit	Slave address				

The Select bit for the selection of the slave type is specified as follows:

- Select bit = 0

  AS-i slave with standard-address (0 to 31) or AS-i slave with extended address in address area A (1A to 31A)
- Select bit = 1:

  AS-i slave with extended address in address area B (1B to 31B)

9.4.1 No. 00: Set_Permanent_Parameter

Meaning

This command configures a parameter value for the specified AS-i slave in the AS-i master. The value is stored in the non-volatile EEPROM of the CM AS-i Master ST. The parameter value is additionally forwarded to the addressed AS-i slave.

However, the "parameter echo" of the AS-i slave cannot be read out with this command (see No. 02: Write_Parameter (Page 98) command).

NOTE

Use of other Siemens AS-i masters

Other Siemens AS-i masters do not transfer the configured parameters to the AS-i slave immediately.

For AS-i slaves that meet the AS-i standard slave profile 7.4, this command is not permitted. For these slaves, the AS-i master itself administers the parameter assignment of the AS-i slave. In this case, the configured parameters are always equal to F_H.

NOTE

Configuration data are overwritten

If you configure the AS-i slaves using HW Config, there is normally no need to use the command described here.

If you use this command, you will overwrite the respective configuration data that resulted from SET button configuration or HW Config configuration.

When this command is executed, the AS-i master switches to the offline phase and then switches back to "normal operation". The AS-i master restarts.

Structure of the job data in the send buffer

Table 2-1699 Structure of the job data in the send buffer

Byte	Meaning			
	Bit 7	**Bit 4**	**Bit 3**	**Bit 0**
0	Command number: 00_H			
1	Slave address			
2	0		Parameters	

9.4.2 No. 01: GET_Permanent_Parameter

Significance

This command reads a slave-specific parameter value that has been saved in EEPROM of the CM AS-i Master ST.

Structure of the job data in the send buffer

Table 2-1700 Structure of the job data in the send buffer

Byte	Significance
0	Command number: 01_H
1	Slave address

Structure of the reply data in the receive buffer

Table 2-1701 Structure of the reply data in the receive buffer

Byte	Significance			
	Bit 7	Bit 4	Bit 3	Bit 0
0	0		Configured parameters	

9.4.3 No. 02: Write_Parameter

Meaning of the command

The command transfers an AS-i slave parameter value. The AS-i master subsequently makes a parameter call to the addressed AS-i slave and passes the parameter value to the AS-i slave in this call. The slave sends the parameter echo as receipt acknowledgment to the master. The value of the parameter echo is sent in the reply data of the command.

The parameter value is only stored in the volatile memory of the AS-i master and is not transferred to the EEPROM as a configured parameter!

The AS-i slave can provide any parameter echo value. As a general rule, the returned parameter echo value is not a "mirror image" of the parameter value that is sent by the master to the slave. If necessary, refer to the documentation of the AS-i slave to ascertain whether the echo value has a special meaning.

This command is not permissible for AS-i slaves that meet AS-i slave standard profile 7.4. For these slaves, the AS-i master itself administers the AS-i slave parameter assignment.

Structure of the job data in the send buffer

Table 2-1702 Structure of the job data in the send buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	Command number: 02_H			
1	Slave address			
2	0		Parameter value	

Structure of the response data in the receive buffer

Table 2-1703 Structure of the response data in the receive buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	0		Parameter echo	

9.4.4 No. 03: Read_Parameter

Meaning

This command returns the parameter value (ACT parameter) active in the slave.

The returned parameter value corresponds to the value that was transferred from the master to the slave in the last parameter call. Because read-back of the parameter value from the AS-i slave is not possible according to the AS-i specification, the master stores the parameter values of all slaves internally in a volatile memory as "ACT parameters". The command reads out the ACT parameter value from the memory, so that the command is executed without a query from the AS-i slave.

You must not confuse this value with the parameter echo that the AS-i slave supplies as reply to Write_Parameter.

Structure of the job data in the send buffer

Table 2-1704 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 03_H
1	Slave address

Structure of the response data in the receive buffer

Table 2-1705 Structure of the response data in the receive buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	0		Parameters	

9.4.5 No. 04: Store_Actual_Parameters

Meaning

This command overwrites the configured parameters stored in the EEPROM with the current ACTUAL parameters stored in volatile memory of the AS-i slave. As a result, the ACTUAL parameters in the non-volatile memory of the master are stored as the configuration definition for the next time the slaves are powered up.

The AS-i master parameterizes the AS-i slaves itself in the case of AS-i slaves that meet AS-i slave standard profile 7.4. The configured parameters for these AS-i slaves are always equal to F_H.

Structure of the job data in the send buffer

Table 2-1706 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 04_H

9.4.6 No. A5: Set_Permanent_Configuration

Meaning

With this command, the following configuration data are configured for the addressed AS-i slave:

- IO code
- ID code
- ID1 code
- ID2 code

The configuration data are stored in the non-volatile EEPROM of the CM AS-i Master ST. The AS-i master uses these configuration data as the specified expected configuration data for "protected operation". The configuration data are defined by the manufacturer of the AS-i slave. The meaning of the configuration data is described in the "AS-Interface Complete Specification".

If the addressed AS-i slave does not support ID code 1 or ID code 2, the value F_H must be specified for this in the command.

When this command is executed, the AS-i master switches to the offline phase and then switches back to "normal operation". The AS-i master restarts.

This command is not executed in "protected operation".

NOTE

Configuration data are overwritten

If you configure the AS-i slaves using HW Config, there is normally no need to use the command described here.

If you use this command, you will overwrite the respective configuration data that resulted from SET button configuration or HW Config configuration.

Structure of the job data in the send buffer

Table 2-1707 Structure of the job data in the send buffer

Byte	Meaning			
	Bit 7	**Bit 4**	**Bit 3**	**Bit 0**
0	Command number: $A5_H$			
1	Slave address			
2	IO code		ID code	
3	ID1 code		ID2 code	

9.4.7 No. A6: Get_Permanent_Configuration

Meaning

The configuration data (configured CONF data) of an addressed AS-i slave stored on the EEPROM of the AS-i master are read with this command:

- IO code
- ID code
- ID1 code
- ID2 code

The configuration data are defined by the manufacturer of the AS-i slave. The meaning of the configuration data is described in the "AS-Interface Complete Specification".

Structure of the job data in the send buffer

Table 2-1708 Structure of the job data in the send buffer

Byte	Meaning
0	Command number $A6_H$
1	Slave address

Structure of the response data in the receive buffer

Table 2-1709 Structure of the response data in the receive buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	IO code		ID code	
1	ID1 code		ID2 code	
2	0			
3	0			

9.4.8 No. 07: Store_Actual_Configuration

Meaning

The following ACTUAL configuration data of all AS-i slaves is obtained from the AS-i master:

- Slave profile (IO, ID, ID2 codes)
- ID1 code

This command saves the obtained ACTUAL configuration data as CONF configuration data in the non-volatile EEPROM. The List of activated AS-i slaves (LAS) is also loaded into the List of configured AS-i slaves (LPS).

When this command is executed, the AS-i master switches to the offline phase and then switches back to "protected operation". The AS-i master restarts.

This command is not executed in "protected operation".

The slave parameter values in volatile memory of the AS-i master and the content of the non-volatile memory for the parameters are not changed. The "Set_Permanent_Parameter" command must be executed, if necessary.

NOTE

Configuration data are overwritten

If you configure the AS-i slaves using HW Config, there is normally no need to use the command described here.

If you use this command, you will overwrite the respective configuration data that resulted from SET button configuration or HW Config configuration.

Structure of the job data in the send buffer

Table 2-1710 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 07_H

9.4.9 No. A8: Read_Actual_Configuration

Meaning

This command reads the following configuration data of an addressed AS-i slave obtained from the AS-i master on the AS-Interface:

- IO code
- ID code
- ID1 code
- ID2 code

The configuration data are defined by the manufacturer of the AS-i slave. The meaning of the configuration data is described in the "AS-Interface Complete Specification".

Structure of the job data in the send buffer

Table 2-1711 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: $A8_H$
1	Slave address

Structure of the response data in the receive buffer

Table 2-1712 Structure of the response data in the receive buffer

Byte	Meaning			
	Bit 7	Bit 4	Bit 3	Bit 0
0	IO code		ID code	
1	ID1 code		ID2 code	
2	Reserved			
3	Reserved			

9.4.10 No. A9: Set_LPS

Meaning

This command transfers the list of configured AS-i slaves for non-volatile storage in the EEPROM of the master.

When this command is executed, the AS-i master switches to the offline phase and then switches back to "normal operation". The AS-i master restarts.

This command is not executed in "protected operation".

NOTE

Configuration data are overwritten

If you configure the AS-i slaves using HW Config, there is normally no need to use the command described here.

If you use this command, you will overwrite the respective configuration data that resulted from SET button configuration or HW Config configuration.

Structure of the job data in the send buffer

Table 2-1713 Structure of the job data in the send buffer

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Command number: $A9_H$							
1	00_H							
2	Slave 7(A)	Slave 6(A)	Slave 5(A)	Slave 4(A)	Slave 3(A)	Slave 2(A)	Slave 1(A)	0
3	Slave 15(A)	Slave 14(A)	Slave 13(A)	Slave 12(A)	Slave 11(A)	Slave 10(A)	Slave 9(A)	Slave 8(A)
4	Slave 23(A)	Slave 22(A)	Slave 21(A)	Slave 20(A)	Slave 19(A)	Slave 18(A)	Slave 17(A)	Slave 16(A)
5	Slave 31(A)	Slave 30(A)	Slave 29(A)	Slave 28(A)	Slave 27(A)	Slave 26(A)	Slave 25(A)	Slave 24(A)
6	Slave 7B	Slave 6B	Slave 5B	Slave 4B	Slave 3B	Slave 2B	Slave 1B	0

The bits have the following meanings in the LPS data:

0: AS-i slave is not configured

1: AS-i slave is configured

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
7	Slave 15B	Slave 14B	Slave 13B	Slave 12B	Slave 11B	Slave 10B	Slave 9B	Slave 8B
8	Slave 23B	Slave 22B	Slave 21B	Slave 20B	Slave 19B	Slave 18B	Slave 17B	Slave 16B
9	Slave 31B	Slave 30B	Slave 29B	Slave 28B	Slave 27B	Slave 26B	Slave 25B	Slave 24B

The bits have the following meanings in the LPS data:

0: AS-i slave is not configured

1: AS-i slave is configured

9.4.11 No. 0A: SET_Offline_Mode

Meaning

This command switches between online and offline mode.

Online mode is the normal mode for the AS-i master. The following jobs are processed in online mode:

1. In the data exchange phase, the fields of the output data are transferred to the slave outputs for all AS-i slaves of the LAS. In error-free transmission, the addressed AS-i slaves transfer the values of the slave inputs to the master.
2. In the loading phase, a search is conducted for the existing AS-i slaves. Newly added AS-i slaves are inserted in the LDS or LAS.
3. In the management phase, jobs forwarded by the user, such as writing parameters, are executed.

In offline mode, the AS-i master only processes jobs from the user. Jobs that immediately activate an AS-i slave are rejected with an error. Cyclic data exchange is not performed with the AS-i slaves.

The bit OFFLINE=TRUE is not stored permanently. This means that after startup or restart, the AS-i master is in online mode again.

Structure of the job data in the send buffer

Table 2-1714 Structure of the job data in the send buffer

Byte	Meaning		
	Bit 7	**Bit 1**	**Bit 0**
0	Command number: $0A_H$		
1	0		Mode 0 = Online 1 = Offline

9.4.12 No. 0B: Set_Auto_Address_Enable

Meaning

This command enables or disables the "Automatic address programming" function.

The bit AUTO_ADDR_ENABLE is stored in non-volatile memory. It is retained even after startup or warm restart of the AS-i master.

Structure of the job data in the send buffer

Table 2-1715 Structure of the job data in the send buffer

Byte	Meaning		
	Bit 7	**Bit 1**	**Bit 0**
0	Command number: $0B_H$		
1	0		Value for AUTO_ADDR_ENABLE 1 = Automatic address programming enabled 0 = Automatic address programming disabled

9.4.13 No. 0C: Set_Operation_Mode

Meaning

This command chooses between "configuration mode" and "protected operation".

In **"protected operation"**, only the AS-i slaves that are flagged in the LPS and whose CONFIGURED and ACTUAL configurations match are activated. This is the case when the I/O code and the ID codes of the detected AS-i slaves are identical to the configured values.

In **"configuration mode**", all the detected AS-i slaves are activated - with the exception of AS-i slave "0". This also applies to AS-i slaves that differ in their CONFIGURED and ACTUAL configurations.

The "OPERATING MODE" bit is saved in **non-volatile** memory. As a result, this bit is retained in the event of startup or restart.

On switching from "configuration mode" to "protected operation", the AS-i master restarts. It enters the offline phase and then switches to online mode.

NOTE

AS-i slave with address 0 prevents switchover to "protected operation"

If an AS-i slave with address 0 is present on the AS-i bus, the AS-i master cannot switch from "configuration mode" to "protected operation".

Structure of the job data in the send buffer

Table 2-1716 Structure of the job data in the send buffer

Byte	Meaning		
	Bit 7	Bit 1	Bit 0
0	Command number: $0C_H$		
1	0		Operating mode 0 = "Protected operation" 1 = "Configuration mode"

9.4.14 No. 0D: Change_AS-i-Slave_Address

Meaning of the command

This command changes the AS-i slave address of an AS-i slave.

This command is used predominantly for adding a new AS-i slave with the default address "0". In this case, the address is changed from "AS-i slave address, old" = 0 to "AS-i slave address, new".

The change is only executed if the following conditions are met:

1. An AS-i slave with "AS-i slave address, old" must exist.
2. If "AS-i address, old" is not equal to "0", an AS-i slave with the address "0" must not be connected at the same time.
3. "AS-i slave address, new" must have a valid value.
4. An AS-i slave with "AS-i slave address, new" must not already exist.

NOTE

When changing the AS-i slave address, the AS-i slave is not reset. The output data of the AS-i slave are retained until the slave resets its data automatically by internal time watchdog monitoring or the slave receives new data at the new address.

Today's AS-i slaves mostly feature watchdog monitoring that reset the internal I/O data of the slave when cyclic communication with the AS-i master is interrupted. Check the technical data of the slave to find out whether it features watchdog monitoring.

Structure of the job data in the send buffer

Table 2-1717 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: $0D_H$
1	Slave address, old
2	Slave address, new

9.4.15 No. 0F: Read_Status

Meaning

This command reads the status register for the addressed AS-i slave. Generally, this command is not required because the slave status is automatically managed by the AS-i master. The following functions are available for detecting an I/O fault: alarm message, read diagnostic data sets, execution of command "Get_LPS, Get_LAS, Get_LDS, Get_Flags" command number B0 hex.

The flags of the status register have the following meaning depending on the type of the AS-i slave:

Table 2-1718 Meaning of the flags of the status register depending on the type of the AS-i slave

Status bit	AS-i slave according to AS-i specification V2.0	AS-i slave AS-i specification V2.1 and higher
S0	**Address volatile**	**Address/ID code volatile**
	This flag is set if • The internal routine of the AS-i slave for permanent storage of the AS-i slave address is running. This can last up to 15 ms and must not be interrupted by another addressing call. • The internal address comparison of the AS-i slave determines that the permanently saved address is not identical to the entry in the address register.	
S1	**Parity error detected** This flag is set if the AS-i slave has detected a parity error in a receive frame since the last "Read and delete status" job.	**Peripheral fault detected** An AS-i slave can set this flag if it detects a fault, e.g. wire break, on the connected I/O.
S2	**End bit error detected** This flag is set if the AS-i slave has detected an end bit error in a message frame since the last "Read and delete status" job.	Reserved
S3	**Read error in non-volatile memory (EEPROM)** This bit is set if the AS-i slave has discovered a read error when reading the non-volatile memory.	

Structure of the job data in the send buffer

Table 2-1719 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: $0F_H$
1	Slave address

Structure of the job data in the receive buffer

Table 2-1720 Structure of the response data in the receive buffer

Byte	Meaning					
	Bit 7	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0		S 3	S 2	S 1	S 0

9.4.16 No. B0: Get_LPS, Get_LAS, Get_LDS, Get_Flags

Meaning

This command reads the following entries from the AS-i master:

- List of activated AS-i slaves, LAS
- List of detected AS-i slaves, LDS
- List of configured AS-i slaves, LPS
- The flags in accordance with the AS-i slave specification

Structure of the job data in the send buffer

Table 2-1721 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: $B0_H$

Structure of the response data in the receive buffer

Table 2-1722 Structure of the response data in the receive buffer

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	LAS Slave 7(A)	LAS Slave 6(A)	LAS Slave 5(A)	LAS Slave 4(A)	LAS Slave 3(A)	LAS Slave 2(A)	LAS Slave 1(A)	Reserved
1	LAS Slave 15(A)	LAS Slave 14(A)	LAS Slave 13(A)	LAS Slave 12(A)	LAS Slave 11(A)	LAS Slave 10(A)	LAS Slave 9(A)	LAS Slave 8(A)
2	LAS Slave 23(A)	LAS Slave 22(A)	LAS Slave 21(A)	LAS Slave 20(A)	LAS Slave 19(A)	LAS Slave 18(A)	LAS Slave 17(A)	LAS Slave 16(A)
3	LAS Slave 31(A)	LAS Slave 30(A)	LAS Slave 29(A)	LAS Slave 28(A)	LAS Slave 27(A)	LAS Slave 26(A)	LAS Slave 25(A)	LAS Slave 24(A)
4	LAS Slave 7B	LAS Slave 6B	LAS Slave 5B	LAS Slave 4B	LAS Slave 3B	LAS Slave 2B	LAS Slave 1B	Reserved
5	LAS Slave 15B	LAS Slave 14B	LAS Slave 13B	LAS Slave 12B	LAS Slave 11B	LAS Slave 10B	LAS Slave 9B	LAS Slave 8B
6	LAS Slave 23B	LAS Slave 22B	LAS Slave 21B	LAS Slave 20B	LAS Slave 19B	LAS Slave 18B	LAS Slave 17B	LAS Slave 16B
7	LAS Slave 31B	LAS Slave 30B	LAS Slave 29B	LAS Slave 28B	LAS Slave 27B	LAS Slave 26B	LAS Slave 25B	LAS Slave 24B
8	LDS Slave 7(A)	LDS Slave 6(A)	LDS Slave 5(A)	LDS Slave 4(A)	LDS Slave 3(A)	LDS Slave 2(A)	LDS Slave 1(A)	LDS Slave 0
9	LDS Slave 15(A)	LDS Slave 14(A)	LDS Slave 13(A)	LDS Slave 12(A)	LDS Slave 11(A)	LDS Slave 10(A)	LDS Slave 9(A)	LDS Slave 8(A)
10	LDS Slave 23(A)	LDS Slave 22(A)	LDS Slave 21(A)	LDS Slave 20(A)	LDS Slave 19(A)	LDS Slave 18(A)	LDS Slave 17(A)	LDS Slave 16(A)

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
11	LDS Slave 31(A)	LDS Slave 30(A)	LDS Slave 29(A)	LDS Slave 28(A)	LDS Slave 27(A)	LDS Slave 26(A)	LDS Slave 25(A)	LDS Slave 24(A)
12	LDS Slave 7B	LDS Slave 6B	LDS Slave 5B	LDS Slave 4B	LDS Slave 3B	LDS Slave 2B	LDS Slave 1B	Reserved
13	LDS Slave 15B	LDS Slave 14B	LDS Slave 13B	LDS Slave 12B	LDS Slave 11B	LDS Slave 10B	LDS Slave 9B	LDS Slave 8B
14	LDS Slave 23B	LDS Slave 22B	LDS Slave 21B	LDS Slave 20B	LDS Slave 19B	LDS Slave 18B	LDS Slave 17B	LDS Slave 16B
15	LDS Slave 31B	LDS Slave 30B	LDS Slave 29B	LDS Slave 28B	LDS Slave 27B	LDS Slave 26B	LDS Slave 25B	LDS Slave 24B
16	LPS Slave 7(A)	LPS Slave 6(A)	LPS S Slave 5(A)	LPS Slave 4(A)	LPS Slave 3(A)	LPS Slave 2(A)	LPS Slave 1(A)	Reserved
17	LPS Slave 15(A)	LPS Slave 14(A)	LPS Slave 13(A)	LPS Slave 12(A)	LPS Slave 11(A)	LPS Slave 10(A)	LPS Slave 9(A)	LPS Slave 8(A)
18	LPS Slave 23(A)	LPS Slave 22(A)	LPS Slave 21(A)	LPS Slave 20(A)	LPS Slave 19(A)	LPS Slave 18(A)	LPS Slave 17(A)	LPS Slave 16(A)
19	LPS Slave 31(A)	LPS Slave 30(A)	LPS Slave 29(A)	LPS Slave 28(A)	LPS Slave 27(A)	LPS Slave 26(A)	LPS Slave 25(A)	LPS Slave 24(A)
20	LPS Slave 7B	LPS Slave 6B	LPS Slave 5B	LPS Slave 4B	LPS Slave 3B	LPS Slave 2B	LPS Slave 1B	Reserved
21	LPS Slave 15B	LPS Slave 14B	LPS Slave 13B	LPS Slave 12B	LPS Slave 11B	LPS Slave 10B	LPS Slave 9B	LPS Slave 8B
22	LPS Slave 23B	LPS Slave 22B	LPS Slave 21B	LPS Slave 20B	LPS Slave 19B	LPS Slave 18B	LPS Slave 17B	LPS Slave 16B
23	LPS Slave 31B	LPS Slave 30B	LPS Slave 29B	LPS Slave 28B	LPS Slave 27B	LPS Slave 26B	LPS Slave 25B	LPS Slave 24B
24	Flag 1							
25	Flag 2							
26 ... 31	Reserved							

Meaning of the bits in Byte 0 to 23

- Bit = 0:

  The AS-i slave is **not** activated, detected or configured.
- Bit = 1:

  The AS-i slave **is** activated, detected or configured.

Table 2-1723 Structure of flag 1 and flag 2

Flag 1			**Flag 2**	
Bit	**Meaning**		**Bit**	**Meaning**
0	Config_OK		0	Periphery_OK
1	LDS.0		1	Data_Exchange_Active
2	Auto_Address_Assign		2	Off_Line
3	Auto_Address_Available		3	AUTO_ADDR_ENABLE

Flag 1			Flag 2	
Bit	**Meaning**		**Bit**	**Meaning**
4	Configuration_Active		4	Earth_Fault
5	Normal_Operation_Active		5	EEPROM_OK
6	APF		6	EFD-ENABLE
7	Offline_Ready		7	Reserved

Table 2-1724 Meaning of the flags

Flag	Meaning
Config_OK	The flag is set when the CONFIGURED configuration and the ACTUAL configuration match.
LDS.0	The flag is set when an AS-i slave with address 0 is present. (List of Detected Slaves)
Auto_Address_Assign	The flag is set if automatic address programming is possible. This means that AUTO_ADDR_ENABLE = 1 and no "incorrect" AS-i slaves are connected to AS-Interface.
Auto_Address_Available	The flag is set if automatic address programming can be performed. This means that one AS-i slave has failed.
Configuration_Active	The flag is set in "configuration mode" and reset in "protected operation".
Normal_Operation_Active	The flag is set when the AS-i master is in "protected operation".
APF	The flag is set when the voltage on the AS-i cable is too low (AS-i Power Fail).
Offline_Ready	The flag is set if the offline phase is active.
Periphery_OK	The flag is set if none of the AS-i slaves signal a peripheral fault.
Data_Exchange_Active	The "Data_Exchange_Active" flag is set when cyclic data exchange is in "protected operation".
Off_Line	The flag is set if the "OFFLINE" operating status is to be adopted or has already been adopted.
AUTO_ADDR_ENABLE	The flag indicates whether automatic address programming is disabled (BIT = 0) or enabled (BIT = 1) by the user.
Earth_Fault	The flag is set if a ground fault has been detected on the AS-i cable.
EEPROM_OK	The flag is set if the test of the internal EEPROM was successful.
EFD Disable	The flag indicates whether ground fault detection is enabled (BIT = 0) or disabled (BIT = 1) by the user.

9.4.17 No. B9: Read_overall_configuration

Meaning

This command reads the following data from the AS-i master:

- List of activated AS-i slaves (LAS).
  It specifies which of the connected AS-i slaves are activated
- The current configuration data for the connected AS-i slaves:
  - IO code
  - ID code
  - ID1 code
  - ID2 code
- The current parameters of the AS-i slaves (ACTUAL parameters)
- The current status of the AS-i master (Flag 1, Flag 2)

After commissioning, you can use this command, for example, to determine the configuration of the stations connected to the AS-i cable. You can modify this read-in configuration data if required and store it as the CONFIGURED configuration in the AS-i master with the "Write_overall_configuration" command.

No. BA: Write_overall_configuration (Page 117)

Structure of the job data in the send buffer

Table 2-1725 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: $B9_H$

Structure of the response data in the receive buffer

Table 2-1726 Structure of the response data in the receive buffer

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	00_H							
1	00_H							
2	LAS Slave 7(A)	LAS Slave 6(A)	LAS Slave 5(A)	LAS Slave 4(A)	LAS Slave 3(A)	LAS Slave 2(A)	LAS Slave 1(A)	Reserved
3	LAS Slave 15(A)	LAS Slave 14(A)	LAS Slave 13(A)	LAS Slave 12(A)	LAS Slave 11(A)	LAS Slave 10(A)	LAS Slave 9(A)	LAS Slave 8(A)
4	LAS Slave 23(A)	LAS Slave 22(A)	LAS Slave 21(A)	LAS Slave 20(A)	LAS Slave 19(A)	LAS Slave 18(A)	LAS Slave 17(A)	LAS Slave 16(A)
5	LAS Slave 31(A)	LAS Slave 30(A)	LAS Slave 29(A)	LAS Slave 28(A)	LAS Slave 27(A)	LAS Slave 26(A)	LAS Slave 25(A)	LAS Slave 24(A)

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
6	LAS Slave 7B	LAS Slave 6B	LAS Slave 5B	LAS Slave 4B	LAS Slave 3B	LAS Slave 2B	LAS Slave 1B	Reserved
7	LAS Slave 15B	LAS Slave 14B	LAS Slave 13B	LAS Slave 12B	LAS Slave 11B	LAS Slave 10B	LAS Slave 9B	LAS Slave 8B
8	LAS Slave 23B	LAS Slave 22B	LAS Slave 21B	LAS Slave 20B	LAS Slave 19B	LAS Slave 18B	LAS Slave 17B	LAS Slave 16B
9	LAS Slave 31B	LAS Slave 30B	LAS Slave 29B	LAS Slave 28B	LAS Slave 27B	LAS Slave 26B	LAS Slave 25B	LAS Slave 24B
10	IO code Slave 0				ID_CODE Slave 0			
11	ID1 Slave 0				ID2 Slave 0			
12	IO code Slave 1 / 1A				ID_CODE Slave 1 / 1A			
13	ID1 Slave 1 / 1A				ID2 Slave 1 / 1A			
14	IO code Slave 2 / 2A				ID_CODE Slave 2 / 2A			
15	ID1 Slave 2 / 2A				ID2 Slave 2 / 2A			
16	IO code Slave 3 / 3A				ID_CODE Slave 3 / 3A			
17	ID1 Slave 3 / 3A				ID2 Slave 3 / 3A			
18	IO code Slave 4 / 4A				ID_CODE Slave 4 / 4A			
19	ID1 Slave 4 / 4A				ID2 Slave 4 / 4A			
20	IO code Slave 5 / 5A				ID_CODE Slave 5 / 5A			
21	ID1 Slave 5 / 5A				ID2 Slave 5 / 5A			
22	IO code Slave 6 / 6A				ID_CODE Slave 6 / 6A			
23	ID1 Slave 6 / 6A				ID2 Slave 6 / 6A			
24	IO code Slave 7 / 7A				ID_CODE Slave 7 / 7A			
25	ID1 Slave 7 / 7A				ID2 Slave 7 / 7A			
26	IO code Slave 8 / 8A				ID_CODE Slave 8 / 8A			
27	ID1 Slave 8 / 8A				ID2 Slave 8 / 8A			
28	IO code Slave 9 / 9A				ID_CODE Slave 9 / 9A			
29	ID1 Slave 9 / 9A				ID2 Slave 9 / 9A			
30	IO code Slave 10 / 10A				ID_CODE Slave 10 / 10A			
31	ID1 Slave 10 / 10A				ID2 Slave 10 / 10A			
32	IO code Slave 11 / 11A				ID_CODE Slave 11 / 11A			
33	ID1 Slave 11 / 11A				ID2 Slave 11 / 11A			
34	IO code Slave 12 / 12A				ID_CODE Slave 12 / 12A			
35	ID1 Slave 12 / 12A				ID2 Slave 12 / 12A			
36	IO code Slave 13 / 13A				ID_CODE Slave 13 / 13A			
37	ID1 Slave 13 / 13A				ID2 Slave 13 / 13A			
38	IO code Slave 14 / 14A				ID_CODE Slave 14 / 14A			
39	ID1 Slave 14 / 14A				ID2 Slave 14 / 14A			
40	IO code Slave 15 / 15A				ID_CODE Slave 15 / 15A			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
41	ID1 Slave 15 / 15A				ID2 Slave 15 / 15A			
42	IO code Slave 16 / 16A				ID_CODE Slave 16 / 16A			
43	ID1 Slave 16 / 16A				ID2 Slave 16 / 16A			
44	IO code Slave 17 / 17A				ID_CODE Slave 17 / 17A			
45	ID1 Slave 17 / 17A				ID2 Slave 17 / 17A			
46	IO code Slave 18 / 18A				ID_CODE Slave 18 / 18A			
47	ID1 Slave 18 / 18A				ID2 Slave 18 / 18A			
48	IO code Slave 19 / 19A				ID_CODE Slave 19 / 19A			
49	ID1 Slave 19 / 19A				ID2 Slave 19 / 19A			
50	IO code Slave 20 / 20A				ID_CODE Slave 20 / 20A			
51	ID1 Slave 20 / 20A				ID2 Slave 20 / 20A			
52	IO code Slave 21 / 21A				ID_CODE Slave 21 / 21A			
53	ID1 Slave 21 / 21A				ID2 Slave 21 / 21A			
54	IO code Slave 22 / 22A				ID_CODE Slave 22 / 22A			
55	ID1 Slave 22 / 22A				ID2 Slave 22 / 22A			
56	IO code Slave 23 / 23A				ID_CODE Slave 23 / 23A			
57	ID1 Slave 23 / 23A				ID2 Slave 23 / 23A			
58	IO code Slave 24 / 24A				ID_CODE Slave 24 / 24A			
59	ID1 Slave 24 / 24A				ID2 Slave 24 / 24A			
60	IO code Slave 25 / 25A				ID_CODE Slave 25 / 25A			
61	ID1 Slave 25 / 25A				ID2 Slave 25 / 25A			
62	IO code Slave 26 / 26A				ID_CODE Slave 26 / 26A			
63	ID1 Slave 26 / 26A				ID2 Slave 26 / 26A			
64	IO code Slave 27 / 27A				ID_CODE Slave 27 / 27A			
65	ID1 Slave 27 / 27A				ID2 Slave 27 / 27A			
66	IO code Slave 28 / 28A				ID_CODE Slave 28 / 28A			
67	ID1 Slave 28 / 28A				ID2 Slave 28 / 28A			
68	IO code Slave 29 / 29A				ID_CODE Slave 29 / 29A			
69	ID1 Slave 29 / 29A				ID2 Slave 29 / 29A			
70	IO code Slave 30 / 30A				ID_CODE Slave 30 / 30A			
71	ID1 Slave 30 / 30A				ID2 Slave 30 / 30A			
72	IO code Slave 31 / 31A				ID_CODE Slave 31 / 31A			
73	ID1 Slave 31 / 31A				ID2 Slave 31 / 31A			
74	Reserved				Reserved			
75	Reserved				Reserved			
76	IO code Slave 1B				ID_CODE Slave 1B			
77	ID1 Slave 1B				ID2 Slave 1B			
78	IO code Slave 2B				ID_CODE Slave 2B			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
79	ID1 Slave 2B				ID2 Slave 2B			
80	IO code Slave 3B				ID_CODE Slave 3B			
81	ID1 Slave 3B				ID2 Slave 3B			
82	IO code Slave 4B				ID_CODE Slave 4B			
83	ID1 Slave 4B				ID2 Slave 4B			
84	IO code Slave 5B				ID_CODE Slave 5B			
85	ID1 Slave 5B				ID2 Slave 5B			
86	IO code Slave 6B				ID_CODE Slave 6B			
87	ID1 Slave 6B				ID2 Slave 6B			
88	IO code Slave 7B				ID_CODE Slave 7B			
89	ID1 Slave 7B				ID2 Slave 7B			
90	IO code Slave 8B				ID_CODE Slave 8B			
91	ID1 Slave 8B				ID2 Slave 8B			
92	IO code Slave 9B				ID_CODE Slave 9B			
93	ID1 Slave 9B				ID2 Slave 9B			
94	IO code Slave 10B				ID_CODE Slave 10B			
95	ID1 Slave 10B				ID2 Slave 10B			
96	IO code Slave 11B				ID_CODE Slave 11B			
97	ID1 Slave 11B				ID2 Slave 11B			
98	IO code Slave 12B				ID_CODE Slave 12B			
99	ID1 Slave 12B				ID2 Slave 12B			
100	IO code Slave 13B				ID_CODE Slave 13B			
101	ID1 Slave 13B				ID2 Slave 13B			
102	IO code Slave 14B				ID_CODE Slave 14B			
103	ID1 Slave 14B				ID2 Slave 14B			
104	IO code Slave 15B				ID_CODE Slave 15B			
105	ID1 Slave 15B				ID2 Slave 15B			
106	IO code Slave 16B				ID_CODE Slave 16B			
107	ID1 Slave 16B				ID2 Slave 16B			
108	IO code Slave 17B				ID_CODE Slave 17B			
109	ID1 Slave 17B				ID2 Slave 17B			
110	IO code Slave 18B				ID_CODE Slave 18B			
111	ID1 Slave 18B				ID2 Slave 18B			
112	IO code Slave 19B				ID_CODE Slave 19B			
113	ID1 Slave 19B				ID2 Slave 19B			
114	IO code Slave 20B				ID_CODE Slave 20B			
115	ID1 Slave 20B				ID2 Slave 20B			
116	IO code Slave 21B				ID_CODE Slave 21B			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
117	ID1 Slave 21B				ID2 Slave 21B			
118	IO code Slave 22B				ID_CODE Slave 22B			
119	ID1 Slave 22B				ID2 Slave 22B			
120	IO code Slave 23B				ID_CODE Slave 23B			
121	ID1 Slave 23B				ID2 Slave 23B			
122	IO code Slave 24B				ID_CODE Slave 24B			
123	ID1 Slave 24B				ID2 Slave 24B			
124	IO code Slave 25B				ID_CODE Slave 25B			
125	ID1 Slave 25B				ID2 Slave 25B			
126	IO code Slave 26B				ID_CODE Slave 26B			
127	ID1 Slave 26B				ID2 Slave 26B			
128	IO code Slave 27B				ID_CODE Slave 27B			
129	ID1 Slave 27B				ID2 Slave 27B			
130	IO code Slave 28B				ID_CODE Slave 28B			
131	ID1 Slave 28B				ID2 Slave 28B			
132	IO code Slave 29B				ID_CODE Slave 29B			
133	ID1 Slave 29B				ID2 Slave 29B			
134	IO code Slave 30B				ID_CODE Slave 30B			
135	ID1 Slave 30B				ID2 Slave 30B			
136	IO code Slave 31B				ID_CODE Slave 31B			
137	ID1 Slave 31B				ID2 Slave 31B			
138	Reserved				Parameter Slave 1 / 1A			
139	Parameter Slave 2 / 2A				Parameter Slave 3 / 3A			
140	Parameter Slave 4 / 4A				Parameter Slave 5 / 5A			
141	Parameter Slave 6 / 6A				Parameter Slave 7 / 7A			
142	Parameter Slave 8 / 8A				Parameter Slave 9 / 9A			
143	Parameter Slave 10 / 10A				Parameter Slave 11 / 11A			
144	Parameter Slave 12 / 12A				Parameter Slave 13 / 13A			
145	Parameter Slave 14 / 14A				Parameter Slave 15 / 15A			
146	Parameter Slave 16 / 16A				Parameter Slave 17 / 17A			
147	Parameter Slave 18 / 18A				Parameter Slave 19 / 19A			
148	Parameter Slave 20 / 20A				Parameter Slave 21 / 21A			
149	Parameter Slave 22 / 22A				Parameter Slave 23 / 23A			
150	Parameter Slave 24 / 24A				Parameter Slave 25 / 25A			
151	Parameter Slave 26 / 26A				Parameter Slave 27 / 27A			
152	Parameter Slave 28 / 28A				Parameter Slave 29 / 29A			
153	Parameter Slave 30 / 30A				Parameter Slave 31 / 31A			
154	Reserved				Parameter Slave 1B			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
155	Parameter Slave 2B				Parameter Slave 3B			
156	Parameter Slave 4B				Parameter Slave 5B			
157	Parameter Slave 6B				Parameter Slave 7B			
158	Parameter Slave 8B				Parameter Slave 9B			
159	Parameter Slave 10B				Parameter Slave 11B			
160	Parameter Slave 12B				Parameter Slave 13B			
161	Parameter Slave 14B				Parameter Slave 15B			
162	Parameter Slave 16B				Parameter Slave 17B			
163	Parameter Slave 18B				Parameter Slave 19B			
164	Parameter Slave 20B				Parameter Slave 21B			
165	Parameter Slave 22B				Parameter Slave 23B			
166	Parameter Slave 24B				Parameter Slave 25B			
167	Parameter Slave 26B				Parameter Slave 27B			
168	Parameter Slave 28B				Parameter Slave 29B			
169	Parameter Slave 30B				Parameter Slave 31B			
170	Flag 1							
171	Flag 2							
172 ... 218	Reserved							

Table 2-1727 Structure of flag 1 and flag 2

Flag 1			Flag 2	
Bit number	Meaning		Bit number	Meaning
0	Config_OK		0	Periphery_OK
1	LDS.0		1	Data_Exchange_Active
2	Auto_Address_Assign		2	Off_Line
3	Auto_Address_Available		3	AUTO_ADDR_ENABLE
4	Configuration_Active		4	Earth_Fault
5	Normal_Operation_Active		5	EEPROM_OK
6	APF		6	EFD-ENABLE
7	Offline_Ready		7	Reserved

For the meanings of flags, refer to Chapter:

No. B0: Get_LPS, Get_LAS, Get_LDS, Get_Flags (Page 108)

9.4.18 No. BA: Write_overall_configuration

Meaning

This command transfers the desired overall configuration of AS-Interface to the AS-i master and saves it as the CONFIGURED configuration in the non-volatile EEPROM. This configures the AS-i master.

When this command is executed, the AS-i master changes to the offline phase and then switches back over to "normal operation". The AS-i master restarts.

The "Protected operation" or "Configuration mode" operating mode of the AS-i master after execution of the command is determined by the "Configuration_Active" flag (see Table "Structure of Flag 1 and Flag 2").

This command is permissible both in "Protected operation" and "Configuration mode.

NOTE

Configuration data are overwritten

If you configure the AS-i slaves using *STEP 7*, there is normally no need to use the command described here. If you have configured proxy slaves, you can specify the configuration data of the proxy slaves with this command. To avoid the offline changeover, the configuration data of the proxy slaves can be specified preferentially with the "No. D0: Set_Configuration_Online (Page 141)" command.

If you use this command, you will overwrite the corresponding configuration data that resulted from configuring the AS-i master using the "SET" button or configuring using *STEP 7*.

Specifically, the following data are transferred:

- List of configured AS-i slaves

  This specifies which AS-i slaves are permitted to be activated by the AS-i master in "protected operation".
- List of configuration data.

  This specifies the ID codes and the IO code that the connected AS-i slaves must have.
- The list of the AS-i slave parameters that have been configured in the AS-i master and stored in non-volatile memory. These parameters are transferred to the AS-i slaves when the AS-i master starts up.
- The flags that determine the operating state of the AS-i master after startup.

The AS-i master parameterizes the AS-i slaves itself in the case of AS-i slaves that comply with standard profile 7.4. For slaves in accordance with standard profile 7.4, the AS-i master ignores the parameter values specified in the command.

NOTICE
Note the size of the I/O image If you have configured the AS-i slaves in *STEP 7*, the size of the I/O image of the individual slaves is defined using *STEP 7*. When using this command, ensure that the I/O image of the individual slaves corresponds to the slaves configured using the command. If the size of the I/O image does not match, only the lower-order data will be transferred. The data that do not fit into the image are truncated or are filled with substitute value "0" in the case of digital values and with substitute value 7FFF (Hex) in the case of analog values.

Structure of the job data in the send buffer

Table 2-1728 Structure of the job data in the send buffer

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Command number: BA_H							
1	00_H							
2	LPS Slave 7(A)	LPS Slave 6(A)	LPS Slave 5(A)	LPS Slave 4(A)	LPS Slave 3(A)	LPS Slave 2(A)	LPS Slave 1(A)	0
3	LPS Slave 15(A)	LPS Slave 14(A)	LPS Slave 13(A)	LPS Slave 12(A)	LPS Slave 11(A)	LPS Slave 10(A)	LPS Slave 9(A)	LPS Slave 8(A)
4	LPS Slave 23(A)	LPS Slave 22(A)	LPS Slave 21(A)	LPS Slave 20(A)	LPS Slave 19(A)	LPS Slave 18(A)	LPS Slave 17(A)	LPS Slave 16(A)
5	LPS Slave 31(A)	LPS Slave 30(A)	LPS Slave 29(A)	LPS Slave 28(A)	LPS Slave 27(A)	LPS Slave 26(A)	LPS Slave 25(A)	LPS Slave 24(A)
6	LPS Slave 7B	LPS Slave 6B	LPS Slave 5B	LPS Slave 4B	LPS Slave 3B	LPS Slave 2B	LPS Slave 1B	0
7	LPS Slave 15B	LPS Slave 14B	LPS Slave 13B	LPS Slave 12B	LPS Slave 11B	LPS Slave 10B	LPS Slave 9B	LPS Slave 8B
8	LPS Slave 23B	LPS Slave 22B	LPS Slave 21B	LPS Slave 20B	LPS Slave 19B	LPS Slave 18B	LPS Slave 17B	LPS Slave 16B
9	LPS Slave 31B	LPS Slave 30B	LPS Slave 29B	LPS Slave 28B	LPS Slave 27B	LPS Slave 26B	LPS Slave 25B	LPS Slave 24B
10	IO code Slave 0				ID_CODE Slave 0			
11	ID1 Slave 0				ID2 Slave 0			
12	IO code Slave 1 / 1A				ID_CODE Slave 1 / 1A			
13	ID1 Slave 1 / 1A				ID2 Slave 1 / 1A			
14	IO code Slave 2 / 2A				ID_CODE Slave 2 / 2A			
15	ID1 Slave 2 / 2A				ID2 Slave 2 / 2A			
16	IO code Slave 3 / 3A				ID_CODE Slave 3 / 3A			
17	ID1 Slave 3 / 3A				ID2 Slave 3 / 3A			
18	IO code Slave 4 / 4A				ID_CODE Slave 4 / 4A			
19	ID1 Slave 4 / 4A				ID2 Slave 4 / 4A			
20	IO code Slave 5 / 5A				ID_CODE Slave 5 / 5A			
21	ID1 Slave 5 / 5A				ID2 Slave 5 / 5A			
22	IO code Slave 6 / 6A				ID_CODE Slave 6 / 6A			
23	ID1 Slave 6 / 6A				ID2 Slave 6 / 6A			
24	IO code Slave 7 / 7A				ID_CODE Slave 7 / 7A			
25	ID1 Slave 7 / 7A				ID2 Slave 7 / 7A			
26	IO code Slave 8 / 8A				ID_CODE Slave 8 / 8A			
27	ID1 Slave 8 / 8A				ID2 Slave 8 / 8A			
28	IO code Slave 9 / 9A				ID_CODE Slave 9 / 9A			
29	ID1 Slave 9 / 9A				ID2 Slave 9 / 9A			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
30	IO code Slave 10 / 10A				ID_CODE Slave 10 / 10A			
31	ID1 Slave 10 / 10A				ID2 Slave 10 / 10A			
32	IO code Slave 11 / 11A				ID_CODE Slave 11 / 11A			
33	ID1 Slave 11 / 11A				ID2 Slave 11 / 11A			
34	IO code Slave 12 / 12A				ID_CODE Slave 12 / 12A			
35	ID1 Slave 12 / 12A				ID2 Slave 12 / 12A			
36	IO code Slave 13 / 13A				ID_CODE Slave 13 / 13A			
37	ID1 Slave 13 / 13A				ID2 Slave 13 / 13A			
38	IO code Slave 14 / 14A				ID_CODE Slave 14 / 14A			
39	ID1 Slave 14 / 14A				ID2 Slave 14 / 14A			
40	IO code Slave 15 / 15A				ID_CODE Slave 15 / 15A			
41	ID1 Slave 15 / 15A				ID2 Slave 15 / 15A			
42	IO code Slave 16 / 16A				ID_CODE Slave 16 / 16A			
43	ID1 Slave 16 / 16A				ID2 Slave 16 / 16A			
44	IO code Slave 17 / 17A				ID_CODE Slave 17 / 17A			
45	ID1 Slave 17 / 17A				ID2 Slave 17 / 17A			
46	IO code Slave 18 / 18A				ID_CODE Slave 18 / 18A			
47	ID1 Slave 18 / 18A				ID2 Slave 18 / 18A			
48	IO code Slave 19 / 19A				ID_CODE Slave 19 / 19A			
49	ID1 Slave 19 / 19A				ID2 Slave 19 / 19A			
50	IO code Slave 20 / 20A				ID_CODE Slave 20 / 20A			
51	ID1 Slave 20 / 20A				ID2 Slave 20 / 20A			
52	IO code Slave 21 / 21A				ID_CODE Slave 21 / 21A			
53	ID1 Slave 21 / 21A				ID2 Slave 21 / 21A			
54	IO code Slave 22 / 22A				ID_CODE Slave 22 / 21A			
55	ID1 Slave 22 / 22A				ID2 Slave 22 / 22A			
56	IO code Slave 23 / 23A				ID_CODE Slave 23 / 23A			
57	ID1 Slave 23 / 23A				ID2 Slave 23 / 23A			
58	IO code Slave 24 / 24A				ID_CODE Slave 24 / 24A			
59	ID1 Slave 24 / 24A				ID2 Slave 24 / 24A			
60	IO code Slave 25 / 25A				ID_CODE Slave 25 / 25A			
61	ID1 Slave 25 / 25A				ID2 Slave 25 / 25A			
62	IO code Slave 26 / 26A				ID_CODE Slave 26 / 26A			
63	ID1 Slave 26 / 26A				ID2 Slave 26 / 26A			
64	IO code Slave 27 / 27A				ID_CODE Slave 27 / 27A			
65	ID1 Slave 27 / 27A				ID2 Slave 27 / 27A			
66	IO code Slave 28 / 28A				ID_CODE Slave 28 / 28A			
67	ID1 Slave 28 / 28A				ID2 Slave 28 / 28A			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
68	IO code Slave 29 / 29A				ID_CODE Slave 29 / 29A			
69	ID1 Slave 29 / 29A				ID2 Slave 29 / 29A			
70	IO code Slave 30 / 30A				ID_CODE Slave 30 / 30A			
71	ID1 Slave 30 / 30A				ID2 Slave 30 / 30A			
72	IO code Slave 31 / 31A				ID_CODE Slave 31 / 31A			
73	ID1 Slave 31 / 31A				ID2 Slave 31 / 31A			
74	0				0			
75	0				0			
76	IO code Slave 1B				ID_CODE Slave 1B			
77	ID1 Slave 1B				ID2 Slave 1B			
78	IO code Slave 2B				ID_CODE Slave 2B			
79	ID1 Slave 2B				ID2 Slave 2B			
80	IO code Slave 3B				ID_CODE Slave 3B			
81	ID1 Slave 3B				ID2 Slave 3B			
82	IO code Slave 4B				ID_CODE Slave 4B			
83	ID1 Slave 4B				ID2 Slave 4B			
84	IO code Slave 5B				ID_CODE Slave 5B			
85	ID1 Slave 5B				ID2 Slave 5B			
86	IO code Slave 6B				ID_CODE Slave 6B			
87	ID1 Slave 6B				ID2 Slave 6B			
88	IO code Slave 7B				ID_CODE Slave 7B			
89	ID1 Slave 7B				ID2 Slave 7B			
90	IO code Slave 8B				ID_CODE Slave 8B			
91	ID1 Slave 8B				ID2 Slave 8B			
92	IO code Slave 9B				ID_CODE Slave 9B			
93	ID1 Slave 9B				ID2 Slave 9B			
94	IO code Slave 10B				ID_CODE Slave 10B			
95	ID1 Slave 10B				ID2 Slave 10B			
96	IO code Slave 11B				ID_CODE Slave 11B			
97	ID1 Slave 11B				ID2 Slave 11B			
98	IO code Slave 12B				ID_CODE Slave 12B			
99	ID1 Slave 12B				ID2 Slave 12B			
100	IO code Slave 13B				ID_CODE Slave 13B			
101	ID1 Slave 13B				ID2 Slave 13B			
102	IO code Slave 14B				ID_CODE Slave 14B			
103	ID1 Slave 14B				ID2 Slave 14B			
104	IO code Slave 15B				ID_CODE Slave 15B			
105	ID1 Slave 15B				ID2 Slave 15B			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
106	IO code Slave 16B				ID_CODE Slave 16B			
107	ID1 Slave 16B				ID2 Slave 16B			
108	IO code Slave 17B				ID_CODE Slave 17B			
109	ID1 Slave 17B				ID2 Slave 17B			
110	IO code Slave 18B				ID_CODE Slave 18B			
111	ID1 Slave 18B				ID2 Slave 18B			
112	IO code Slave 19B				ID_CODE Slave 19B			
113	ID1 Slave 19B				ID2 Slave 19B			
114	IO code Slave 20B				ID_CODE Slave 20B			
115	ID1 Slave 20B				ID2 Slave 20B			
116	IO code Slave 21B				ID_CODE Slave 21B			
117	ID1 Slave 21B				ID2 Slave 21B			
118	IO code Slave 22B				ID_CODE Slave 22B			
119	ID1 Slave 22B				ID2 Slave 22B			
120	IO code Slave 23B				ID_CODE Slave 23B			
121	ID1 Slave 23B				ID2 Slave 23B			
122	IO code Slave 24B				ID_CODE Slave 24B			
123	ID1 Slave 24B				ID2 Slave 24B			
124	IO code Slave 25B				ID_CODE Slave 25B			
125	ID1 Slave 25B				ID2 Slave 25B			
126	IO code Slave 26B				ID_CODE Slave 26B			
127	ID1 Slave 26B				ID2 Slave 26B			
128	IO code Slave 27B				ID_CODE Slave 27B			
129	ID1 Slave 27B				ID2 Slave 27B			
130	IO code Slave 28B				ID_CODE Slave 28B			
131	ID1 Slave 28B				ID2 Slave 28B			
132	IO code Slave 29B				ID_CODE Slave 29B			
133	ID1 Slave 29B				ID2 Slave 29B			
134	IO code Slave 30B				ID_CODE Slave 30B			
135	ID1 Slave 30B				ID2 Slave 30B			
136	IO code Slave 31B				ID_CODE Slave 31B			
137	ID1 Slave 31B				ID2 Slave 31B			
138	0				Parameter Slave 1 / 1A			
139	Parameter Slave 2 / 2A				Parameter Slave 3 / 3A			
140	Parameter Slave 4 / 4A				Parameter Slave 5 / 5A			
141	Parameter Slave 6 / 6A				Parameter Slave 7 / 7A			
142	Parameter Slave 8 / 8A				Parameter Slave 9 / 9A			
143	Parameter Slave 10 / 10A				Parameter Slave 11 / 11A			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
144	Parameter Slave 12 / 12A				Parameter Slave 13 / 13A			
145	Parameter Slave 14 / 14A				Parameter Slave 15 / 15A			
146	Parameter Slave 16 / 16A				Parameter Slave 17 / 17A			
147	Parameter Slave 18 / 18A				Parameter Slave 19 / 19A			
148	Parameter Slave 20 / 20A				Parameter Slave 21 / 21A			
149	Parameter Slave 22 / 22A				Parameter Slave 23 / 23A			
150	Parameter Slave 24 / 24A				Parameter Slave 25 / 25A			
151	Parameter Slave 26 / 26A				Parameter Slave 27 / 27A			
152	Parameter Slave 28 / 28A				Parameter Slave 29 / 29A			
153	Parameter Slave 30 / 30A				Parameter Slave 31 / 31A			
154	0				Parameter Slave 1B			
155	Parameter Slave 2B				Parameter Slave 3B			
156	Parameter Slave 4B				Parameter Slave 5B			
157	Parameter Slave 6B				Parameter Slave 7B			
158	Parameter Slave 8B				Parameter Slave 9B			
159	Parameter Slave 10B				Parameter Slave 11B			
160	Parameter Slave 12B				Parameter Slave 13B			
161	Parameter Slave 14B				Parameter Slave 15B			
162	Parameter Slave 16B				Parameter Slave 17B			
163	Parameter Slave 18B				Parameter Slave 19B			
164	Parameter Slave 20B				Parameter Slave 21B			
165	Parameter Slave 22B				Parameter Slave 23B			
166	Parameter Slave 24B				Parameter Slave 25B			
167	Parameter Slave 26B				Parameter Slave 27B			
168	Parameter Slave 28B				Parameter Slave 29B			
169	Parameter Slave 30B				Parameter Slave 31B			
170	Flag 1							
171	Flag 2							

Table 2-1729 Structure of flag 1 and flag 2

Flag 1			Flag 2	
Bit number	**Meaning**		**Bit number**	**Meaning**
0	Config_OK		0	Periphery_OK
1	LDS.0		1	Data_Exchange_Active
2	Auto_Address_Assign		2	Off_Line
3	Auto_Address_Available		**3**	**AUTO_ADDR_ENABLE** [1)]

1) The "Configuration_Active" and "AUTO_ADDR_ENABLE" flags change the operating mode of the AS-i master. The values of the remaining flags are insignificant for the command "Set_LPS, Set_PCD, Set_PP, Set_Flags" and cannot be modified in the AS-i master by this call.

Flag 1			Flag 2	
Bit number	**Meaning**		**Bit number**	**Meaning**
4	**Configuration_Active** [1)]		4	Earth_Fault
5	Normal_Operation_Active		5	EEPROM_OK
6	APF		6	EFD-ENABLE
7	Offline_Ready		7	Reserved

1) The "Configuration_Active" and "AUTO_ADDR_ENABLE" flags change the operating mode of the AS-i master. The values of the remaining flags are insignificant for the command "Set_LPS, Set_PCD, Set_PP, Set_Flags" and cannot be modified in the AS-i master by this call.

Configuration_Active	"0" means: After the command has been executed, the AS-i master will switch to "protected operation". "1" means: The AS-i master runs in "configuration mode" after completion of the job.
AUTO_ADDR_ENABLE	"0" means: Automatic address programming is disabled. "1" means: Automatic address programming is enabled.

For the meanings of flags, refer to Chapter:

No. B0: Get_LPS, Get_LAS, Get_LDS, Get_Flags (Page 108)

9.4.19 No. 3C: Set_PI

Meaning

This command passes parameter values for all AS-i°slaves to the AS-i master. The AS-i master only sends a parameter call to the slaves whose parameter value passed in the command deviates from the ACTUAL parameter value of the slave. If all parameter values passed in the command are identical to the current parameter values (ACT parameters) of the AS-i slaves, no parameters are passed from the AS-i master to the AS-i slaves.

Control via the function code

The behavior of the command can be set using the value of the "function code" in byte 1 of the job data (firmware V1.1.6 and higher):

- As of firmware V1.1.6, the function code is defined for values 0, 1, and 2.
- For firmware versions up to and including V1.1.5, the function code is only defined for the value 0.

Other values are not permissible.

The function code determines the behavior of the command as described below.

The new parameter values are transferred via 3 subfunctions in byte 1 with different behavior.

Function code = 0:

The passed parameter values are stored in the non-volatile EEPROM of the CM AS-i master ST.

If the passed parameter value of at least one AS-i slave differs from the parameter value previously active in the slave, the AS-i master powers up on the AS-i bus (offline-online transition). This resets and restarts all slaves with the parameter values currently stored in the EEPROM.

If there are no changes in the passed parameter values, the master does not power up.

Function code = 1 (from firmware V1.1.6):

The passed parameter values are only stored in the volatile memory of the CM AS-i master ST module, i.e. the EEPROM remains unchanged.

For every AS-i slave, the AS-i master checks whether the passed parameter value differs from the parameter value previously active in the slave (ACT parameter). If it does differ, the AS-i master calls a parameter from that AS-i slave and returns a new parameter value.

The AS-i master does not call a parameter from the AS-i slave if the passed parameter value is identical to the parameter value previously active in the slave.

The AS-i master does not perform a power-up on the AS-i bus.

The command is considered completed without errors when the parameter values have been passed to the master. Subsequently, the parameters are passed to the slaves in parameter calls with no time monitoring.

Function code = 2 (firmware V1.1.16 and higher):

The passed parameter values are stored in the non-volatile EEPROM of the CM AS-i master ST.

For every AS-i slave, the AS-i master checks whether the passed parameter value differs from the parameter value previously active in the slave (ACT parameter). If it does differ, the AS-i master calls a parameter from that AS-i slave and returns a new parameter value.

The AS-i master does not call a parameter from the AS-i slave if the passed parameter value is identical to the parameter value previously active in the slave.

The AS-i master does not perform a power-up on the AS-i bus.

The command is considered completed without errors when the parameter values have been passed to the master. Subsequently, the parameters are passed to the slaves in parameter calls with no time monitoring.

NOTE

Limited number of write accesses to an EEPROM

If function code = 0 and function code = 2, the EEPROM is written to. Because the number of write accesses to an EEPROM is in principle limited (100 000 write accesses), these function codes should not be used in cyclic mode. Write access always means the actual change of a value in the EEPROM.

Structure of the job data in the send buffer

Table 2-1730 Structure of the job data

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Command number: $3C_H$							
1	Function code							
2	0				Parameter value slave 1 / 1A			
3	Parameter value slave 2 / 2A				Parameter value slave 3 / 3A			
4	Parameter value slave 4 / 4A				Parameter value slave 5 / 5A			
5	Parameter value slave 6 / 6A				Parameter value slave 7 / 7A			
6	Parameter value slave 8 / 8A				Parameter value slave 9 / 9A			
7	Parameter value slave 10 / 10A				Parameter value slave 11 / 11A			
8	Parameter value slave 12 / 12A				Parameter value slave 13 / 13A			
9	Parameter value slave 14 / 14A				Parameter value slave 15 / 15A			
10	Parameter value slave 16 / 16A				Parameter value slave 17 / 17A			
11	Parameter value slave 18 / 18A				Parameter value slave 19 / 19A			
12	Parameter value slave 20 / 20A				Parameter value slave 21 / 21A			
13	Parameter value slave 22 / 22A				Parameter value slave 23 / 23A			
14	Parameter value slave 24 / 24A				Parameter value slave 25 / 25A			
15	Parameter value slave 26 / 26A				Parameter value slave 27 / 27A			
16	Parameter value slave 28 / 28A				Parameter value slave 29 / 29A			
17	Parameter value slave 30 / 30A				Parameter value slave 31 / 31A			
18	0				Parameter value slave 1B			
19	Parameter value slave 2B				Parameter value slave 3B			
20	Parameter value slave 4B				Parameter value slave 5B			
21	Parameter value slave 6B				Parameter value slave 7B			
22	Parameter value slave 8B				Parameter value slave 9B			
23	Parameter value slave 10B				Parameter value slave 11B			
24	Parameter value slave 12B				Parameter value slave 13B			
25	Parameter value slave 14B				Parameter value slave 15B			
26	Parameter value slave 16B				Parameter value slave 17B			
27	Parameter value slave 18B				Parameter value slave 19B			
28	Parameter value slave 20B				Parameter value slave 21B			
29	Parameter value slave 22B				Parameter value slave 23B			
30	Parameter value slave 24B				Parameter value slave 25B			
31	Parameter value slave 26B				Parameter value slave 27B			
32	Parameter value slave 28B				Parameter value slave 29B			
33	Parameter value slave 30B				Parameter value slave 31B			

9.4.20 No. 33: AS-i Parameter Echolist

Meaning

This command returns the parameter echo values of all AS-i slaves. The parameter echo of an AS-i slave originates in the last parameter call that was sent to this AS-i slave. The AS-i slave can provide any parameter echo value. As a general rule, the returned parameter echo value is not a "mirror image" of the parameter value that is sent by the master to the slave. If necessary, refer to the documentation of the AS-i slave to ascertain whether the echo value has a special meaning.

Structure of the job data in the send buffer

Table 2-1731 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 33_H
1	00_H

Structure of the reply data in the receive buffer f(ParEcho = parameter echo)

Table 2-1732 Structure of the job data in the receive buffer

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reserved				Par.Echo Slave 1			
1	Par.Echo Slave 2				Par.Echo Slave 3			
2	Par.Echo Slave 4				Par.Echo Slave 5			
3	Par.Echo Slave 6				Par.Echo Slave 7			
4	Par.Echo Slave 8				Par.Echo Slave 9			
5	Par.Echo Slave 10				Par.Echo Slave 11			
6	Par.Echo Slave 12				Par.Echo Slave 13			
7	Par.Echo Slave 14				Par.Echo Slave 15			
8	Par.Echo Slave 16				Par.Echo Slave 17			
9	Par.Echo Slave 18				Par.Echo Slave 19			
10	Par.Echo Slave 20				Par.Echo Slave 21			
11	Par.Echo Slave 22				Par.Echo Slave 23			
12	Par.Echo Slave 24				Par.Echo Slave 25			
13	Par.Echo Slave 26				Par.Echo Slave 27			
14	Par.Echo Slave 28				Par.Echo Slave 29			
15	Par.Echo Slave 30				Par.Echo Slave 31			
16	Reserved				Par.Echo Slave 1B			
17	Par.Echo Slave 2B				Par.Echo Slave 3B			
18	Par.Echo Slave 4B				Par.Echo Slave 5B			

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
19	Par.Echo Slave 6B				Par.Echo Slave 7B			
20	Par.Echo Slave 8B				Par.Echo Slave 9B			
21	Par.Echo Slave 10B				Par.Echo Slave 11B			
22	Par.Echo Slave 12B				Par.Echo Slave 13B			
23	Par.Echo Slave 14B				Par.Echo Slave 15B			
24	Par.Echo Slave 16B				Par.Echo Slave 17B			
25	Par.Echo Slave 18B				Par.Echo Slave 19B			
26	Par.Echo Slave 20B				Par.Echo Slave 21B			
27	Par.Echo Slave 22B				Par.Echo Slave 23B			
28	Par.Echo Slave 24B				Par.Echo Slave 25B			
29	Par.Echo Slave 26B				Par.Echo Slave 27B			
30	Par.Echo Slave 28B				Par.Echo Slave 29B			
31	Par.Echo Slave 30B				Par.Echo Slave 31B			

9.4.21 No. 44: Read_Write_CTT2_String

Meaning

This command sends a CTT2 request according to the AS-i slave profile "CombinedTransactionType2" to the AS-i master with a byte string. The master forwards the string bytes to the AS-i slave address specified in the send buffer.

This command transfers a send buffer with up to 222 bytes to the AS-i master. The AS-i master calculates the actual number of string bytes to be sent to the AS-i slave from byte 2 of the send buffer.

The addressed AS-i slave answers the CTT2 request with a CTT2 response. The AS-i master communicates this response as a byte string in the receive buffer. The strings are transmitted by the AS-i master with the response.

The structure of the CTT2 request or CTT2 response (code, index, etc.) starts with string byte 1 in each case. You will find details about this in the respective AS-i slave description.

NOTE

While transmission of the strings is being executed on AS-i, there is no cyclic data transfer with the addressed AS-i slave. The type of protocol used means that transfer of up to 200 bytes can take up to half a minute.

Structure of the job data in the send buffer

Table 2-1733 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 44_H
1	Slave address
2	Number of string bytes
3	String byte 1
4	String byte 2
...	—
n + 1	String byte n-1
n + 2	String byte n

Maximum value for n = 220

Structure of the response data in the receive buffer

Table 2-1734 Structure of the response data in the receive buffer

Byte	Meaning
0	Number of string bytes
1	String byte 1
2	String byte 2
...	...
m - 1	String byte m - 1
m	String byte m

Maximum value for m = 220

9.4.22 No. 14: Read_Version

Meaning

This command reads the version ID for the firmware of the AS-i master.

Structure of the job data in the send buffer

Table 2-1735 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 14_H

Structure of the response data in the receive buffer

Table 2-1736 Structure of the response data in the receive buffer

Byte	Meaning
0 ... 31	Versions string [1)]

1) "Siemens AG CM ASi M Vaa.bb.cc.dd"

9.4.23 No. 17: Read ID_Code

Significance

This command reads the ID code of an AS-i slave directly over the AS-i cable.

Structure of the job data in the send buffer

Table 2-1737 Structure of the job data in the send buffer

Byte	Significance
0	Command number: 17_H
1	Slave address

Structure of the reply data in the receive buffer

Table 2-1738 Structure of the reply data in the receive buffer

Byte	Significance			
	Bit 7	Bit 4	Bit 3	Bit 0
0	Reserved		ID code	

9.4.24 No. 37: Read_ID1-Code

Meaning

This command reads the ID1 code of an AS-i slave directly over the AS-i cable.

Structure of the job data in the send buffer

Table 2-1739 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 37_H
1	Slave address

Structure of the response data in the receive buffer

Table 2-1740 Structure of the response data in the receive buffer

Byte	Meaning			
	Bit 7	**Bit 4**	**Bit 3**	**Bit 0**
0	Reserved		ID1 code	

9.4.25 No. 3F: Write ID1-Code

Meaning

This command writes the ID1 code of an AS-i slave with the address "0" directly over the AS-i cable.

The AS-i master forwards the ID1 code to the AS-i slave without a plausibility check.

Structure of the job data in the send buffer

Table 2-1741 Structure of the job data in the send buffer

Byte	Meaning	
0	Command number: $3F_H$	
1	Not relevant	ID1 code

9.4.26 No. 38: Read_ID2-Code

Meaning

This command reads the ID2 code of an AS-i slave directly over the AS-i cable.

Structure of the job data in the send buffer

Table 2-1742 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 38_H
1	Slave address

Structure of the response data in the receive buffer

Table 2-1743 Structure of the response data in the receive buffer

Byte	Meaning			
	Bit 7	**Bit 4**	**Bit 3**	**Bit 0**
0	Reserved		ID2 code	

9.4.27 No. 18: Read_IO-Code

Meaning

This command reads the IO code of an AS-i slave directly over the AS-i cable.

Structure of the job data in the send buffer

Table 2-1744 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 18_H
1	Slave address

Structure of the response data in the receive buffer

Table 2-1745 Structure of the response data in the receive buffer

Byte	Meaning			
	Bit 7	**Bit 4**	**Bit 3**	**Bit 0**
0	Reserved		IO code	

9.4.28 No. BE: Get_LPF

Meaning

This command reads the list of I/O faults (periphery faults) (LPF) signaled by the AS-i slaves from the AS-i master. The AS-i master updates the LPF cyclically. Refer to the description of the AS-i slave to learn whether the slave can detect a fault in the connected I/O, e.g. wire break, and when it signals the fault.

Structure of the job data in the send buffer

Table 2-1746 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: BE_H

Structure of the responses in the receive buffer

Table 2-1747 Structure of the responses in the receive buffer

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
0	Slave 7(A)	Slave 6(A)	Slave 5(A)	Slave 4(A)	Slave 3(A)	Slave 2(A)	Slave 1(A)	Reserved
1	Slave 15(A)	Slave 14(A)	Slave 13(A)	Slave 12(A)	Slave 11(A)	Slave 10(A)	Slave 9(A)	Slave 8(A)
2	Slave 23(A)	Slave 22(A)	Slave 21(A)	Slave 20(A)	Slave 19(A)	Slave 18(A)	Slave 17(A)	Slave 16(A)
3	Slave 31(A)	Slave 30(A)	Slave 29(A)	Slave 28(A)	Slave 27(A)	Slave 26(A)	Slave 25(A)	Slave 24(A)
4	Slave 7B	Slave 6B	Slave 5B	Slave 4B	Slave 3B	Slave 2B	Slave 1B	Reserved
5	Slave 15B	Slave 14B	Slave 13B	Slave 12B	Slave 11B	Slave 10B	Slave 9B	Slave 8B
6	Slave 23B	Slave 22B	Slave 21B	Slave 20B	Slave 19B	Slave 18B	Slave 17B	Slave 16B
7	Slave 31B	Slave 30B	Slave 29B	Slave 28B	Slave 27B	Slave 26B	Slave 25B	Slave 24B
8 ... 13	Reserved							

The bits have the following meanings in the LPF data:

Bit = 0: The slave signals no I/O fault.

Bit = 1: The slave signals I/O fault.

9.4.29 No. 40: Write_Parameter_String

Meaning

This command sends a parameter string in accordance with AS-i slave profile 7.4 to the AS-i master. The master forwards the parameter string to the AS-i slave address specified in the send buffer.

This command transfers a send buffer with up to 223 bytes to the AS-i master. The AS-i master calculates the actual number of parameter bytes to be sent to the AS-i slave from byte 2 of the send buffer.

The AS-i master does not evaluate any other information in the parameter string. It transfers this to the AS-i slave transparently. While transmission of the parameter string is being executed, there is no transfer of user data / analog data with the addressed AS-i slave.

Structure of the job data in the send buffer

Table 2-1748 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 40_H
1	Slave address
2	Number of parameter bytes
3	Parameter string byte 1
4	Parameter string byte 2

Maximum value for n = 220

Byte	Meaning
...	...
n + 1	Parameter string byte n - 1
n + 2	Parameter string byte n

Maximum value for n = 220

9.4.30 No. 41: Read_String

Meaning

This command causes the AS-i slave to read a parameter string in accordance with AS-i slave profile 7.4 with the AS-i slave address specified in the send buffer.

The AS-i master supplies up to 221 bytes of response data. The AS-i master signals the actual number of parameter bytes sent by the AS-i slave in Byte 0 of the receive buffer.

If the AS-i slave sends a parameter string longer than 220 bytes, the AS-i master aborts string transfer and terminates the job with an error. The received data is not made available to the job program.

While transmission of the parameter string is being executed, there is no transfer of user data / analog data with the addressed AS-i slave.

Structure of the job data in the send buffer

Table 2-1749 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 41_H
1	Slave address

Structure of the response data in the receive buffer

Table 2-1750 Structure of the response data in the receive buffer

Byte	Meaning
0	Number of parameter bytes
1	Parameter string byte 1
2	Parameter string byte 2
...	...
n - 1	Parameter string byte n - 1
n	Parameter string byte n

Maximum value for n = 220

9.4.31 No. 42: Read_String

Meaning

This command causes the AS-i slave to read an identification string in accordance with AS-i slave profile 7.4 with the AS-i slave address specified in the send buffer. The AS-i master supplies up to 221 bytes of reply data. The AS-i master signals the actual number of ID bytes sent by the AS-i slave in Byte 0 of the receive buffer.

If the AS-i slave sends an ID string longer than 220 bytes, the AS-i master aborts string transfer and terminates the job with an error. The received data is not made available to the user program.

As long as the transmission of the identification string is running, there is no transfer of user/analog data with the addressed AS-i slave.

NOTE

In a deviation from normal procedure, this command also transfers the bytes that contain the bits "Follows" and "Valid".

For further details, refer to AS-i slave profile 7.4

Structure of the job data in the send buffer

Table 2-1751 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: 42_H
1	Slave address

Structure of the reply data in the receive buffer

Table 2-1752 Structure of the reply data in the receive buffer

Byte	Meaning
0	Number of ID bytes
1	ID string byte 1
2	ID string byte 2
...	...
n - 1	ID string byte n - 1
n	ID string byte n

Maximum value for n = 220

9.4.32 No. 43: Read_String

Significance

This command causes the AS-i slave to read a diagnostics string in accordance with AS-i slave profile 7.4 with the AS-i slave address specified in the send buffer. The AS-i master supplies up to 221 bytes of reply data. The AS-i master signals the actual number of diagnostics bytes sent by the AS-i slave in Byte 0 of the receive buffer.

If the AS-i slave sends a diagnostics string longer than 220 bytes, the AS-i master aborts string transfer and terminates the job with an error. The received data is not made available to the user program.

While transmission of the diagnostics string is being executed, there is no transfer of user data / analog data with the addressed AS-i slave.

Structure of the job data in the send buffer

Table 2-1753 Structure of the job data in the send buffer

Byte	Significance
0	Command number: 43_H
1	Slave address

Structure of the reply data in the receive buffer

Table 2-1754 Structure of the reply data in the receive buffer

Byte	Significance
0	Number of diagnostics bytes
1	Diagnostic string byte 1
2	Diagnostic string byte 2
...	...
n - 1	Diagnostic string byte n - 1
n	Diagnostic string byte n

Maximum value for n = 220

9.4.33 No. CA: Read_Error_Counter

NOTE

With Firmware V1.1 or higher, use data record "DS 96 Read AS-i master error counters and status messages (FW V1.1 and higher) (Page 79)" for reading out the error counters. The Read_AS-i_Master_Error_Counters command continues to exist for compatibility reasons.

Meaning

This command reads out error counters that concern the overall AS-i network.

If the AS-i power supply is missing, the overall device fails. This leads to all counters being reset. The counting starts over each time the device is powered up.

For the meaning of the error counters, refer to Table "Meaning of error counter".

Structure of the job data in the send buffer

Table 2-1755 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: CA_H

Structure of the responses in the receive buffer

Table 2-1756 Structure of the data record

Byte	Meaning	
0	Summation counter: AS-i Power Fail	High byte
1		Low byte
2	Summation counter: Ground fault	High byte
3		Low byte
4	Summation counter: Slave failure	High word, high byte
5		High word, low byte
6		Low word, high byte
7		Low word, low byte
8	Summation counter: Missing slave frame	High word, high byte
9		High word, low byte
10		Low word, high byte
11		Low word, low byte
12	Summation counter: Erroneous slave frame	High word, high byte
13		High word, low byte
14		Low word, high byte

The counters are integer values (2 bytes or 4 bytes).

Byte	Meaning		
15	Summation counter: Erroneous slave frame		Low word, low byte
16	Summation counter: Slave peripheral fault		High word, high byte
17			High word, low byte
18			Low word, high byte
19			Low word, low byte
20	Summation counter: Slave protocol error (for slaves according to CTT1 ... CTT5)		High word, high byte
21			High word, low byte
22			Low word, high byte
23			Low word, low byte
24	Summation counter: Erroneous master frame		High word, high byte
25			High word, low byte
26			Low word, high byte
27			Low word, low byte
28 ... 35	List of count values > 0 (see Table "Structure of bit fields")		
	Bit = 0	Count value = 0 for all error counters of the AS-i address	
	Bit = 1	Count value > 0 for at least one error counter of the AS-i address	
36	Summation counter: Sent master frames, less significant part (MT_CNT_LOW)		High word, high byte
37			High word, low byte
38			Low word, high byte
39			Low word, low byte
40	Summation counter: Sent master frames, more significant part (MT_CNT_HIGH)		High word, high byte
41			High word, low byte
42			Low word, high byte
43			Low word, low byte
44	Summation counter: Sent master frames, factor (MT_CNT_BASE)		High word, high byte
45			High word, low byte
46			Low word, high byte
47			Low word, low byte
48	Reserved		Bit 0 = MADDR
49	Reserved		
50 ... 57	List of multiple addressing (see Table "Structure of bit fields")		
	Bit = 0	The AS-i address is assigned once or is not present.	
	Bit = 1	The AS-i address is assigned more than once.	
58 ... 220	Reserved		

The counters are integer values (2 bytes or 4 bytes).

Multiple addressing has been detected for at least one AS-i address on the AS-i cable. This means that multiple slaves have the same AS-i address.

Structure of the bit fields

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	SLAVE 7/7A	SLAVE 6/6A	SLAVE 5/5A	SLAVE 4/4A	SLAVE 3/3A	SLAVE 2/2A	SLAVE 1/1A	Reserved
1	SLAVE 15/15A	SLAVE 14/14A	SLAVE 13/13A	SLAVE 12/12A	SLAVE 11/11A	SLAVE 10/10A	SLAVE 9/9A	SLAVE 8/8A
2	SLAVE 23/23A	SLAVE 22/22A	SLAVE 21/21A	SLAVE 20/20A	SLAVE 19/19A	SLAVE 18/18A	SLAVE 17/17A	SLAVE 16/16A
3	SLAVE 31/31A	SLAVE 30/30A	SLAVE 29/29A	SLAVE 28/28A	SLAVE 27/27A	SLAVE 26/26A	SLAVE 25/25A	SLAVE 24/24A
4	SLAVE 7B	SLAVE 6B	SLAVE 5B	SLAVE 4B	SLAVE 3B	SLAVE 2B	SLAVE 1B	Reserved
5	SLAVE 15B	SLAVE 14B	SLAVE 13B	SLAVE 12B	SLAVE 11B	SLAVE 10B	SLAVE 9B	SLAVE 8B
6	SLAVE 23B	SLAVE 22B	SLAVE 21B	SLAVE 20B	SLAVE 19B	SLAVE 18B	SLAVE 17B	SLAVE 16B
7	SLAVE 31B	SLAVE 30B	SLAVE 29B	SLAVE 28B	SLAVE 27B	SLAVE 26B	SLAVE 25B	SLAVE 24B

9.4.34 No. CB: Read_and_Delete_AS-i-Master_Error_Counter

NOTE

With Firmware V1.1 or higher, use data record "DS 97 Read and reset AS-i master error counters (FW V1.1 and higher) (Page 82)" for reading out the error counters. The Read_and_Reset_AS-i_Master_Error_Counters command continues to exist for compatibility reasons.

Meaning

This command functions like the "Read_AS-i-Master_Error_Counter" command. In addition, the AS-i master then sets all error counters to 0.

Structure of the job data in the send buffer

Table 2-1757 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: CB_H

Structure of the responses in the receive buffer

The receive buffer is identical to the receive buffer of the "No. CA: Read_Error_Counter (Page 136)" command.

9.4.35 No. CC: Read_AS-i_error_counter

NOTE

With Firmware V1.1 or higher, use data records "DS 150 to DS 153 Read AS-i error counters (Page 83)". The Read_AS-i_Slave_Error_Counters command continues to exist for compatibility reasons.

Meaning

This command reads out AS-i slave-specific error counters. For the meaning of the error counters, refer to Section "Meaning of error counter".

Structure of the job data in the send buffer

Table 2-1758 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: CC_H
1	AS-i slave address

Structure of the responses in the receive buffer

Table 2-1759 Structure of the responses in the receive buffer

Byte	Meaning	
0	Counter: Slave failure	High byte
1		Low byte
2	Counter: Missing slave frame	High byte
3		Low byte
4	Counter: Faulty slave frame	High byte
5		Low byte
6	Counter: Peripheral fault	High byte
7		Low byte
8	Counter: Protocol error	High byte
9		Low byte
10	Counter: Faulty master frame	High byte
11		Low byte
12	Summation counter: Sent master frames, less significant part (MT_CNT_LOW)	High word / high byte
13		High word / low byte
14		Low word / high byte
15		Low word / low byte
16	Summation counter: Sent master frames, more significant part (MT_CNT_HIGH)	High word / high byte

Byte	Meaning	
17	Summation counter: Sent master frames, more significant part (MT_CNT_HIGH)	High word / low byte
18		Low word / high byte
19		Low word / low byte
20	Summation counter: Sent master frames, factor (MT_CNT_BASE)	High word / high byte
21		High word / low byte
22		Low word / high byte
23		Low word / low byte
24 ... 31	Reserved	

9.4.36 No. CD: Read_and_delete_AS-i_Slave_error_counter

NOTE

With Firmware V1.1 or higher, use data records "DS 150 to DS 153 Read AS-i error counters (Page 83)" and "DS 154 Delete AS-i error counters (from FW V1.1) (Page 87)". The Read_and_Reset_AS-i_Slave_Error_Counters command continues to exist for compatibility reasons.

Meaning

This command reads out the error counters of the AS-i slaves. Data records DS 150 and DS 151 access the standard addresses and the A addresses. Data records DS 152 and DS 153 access the B addresses. The counters for addresses 16 / 16A exist identically in data records DS 150 and DS 151. The counters for address 16B exist identically in data records DS 152 and DS 153. Data record DS 154 resets all AS-i slave error counters.

Structure of the job data in the send buffer

Table 2-1760 Structure of the job data in the send buffer

Byte	Meaning
0	Command number: CD_H
1	AS-i slave address

Structure of the responses in the receive buffer

The receive buffer is identical to the receive buffer of the "No. CC: Read_AS-i_error_counter (Page 139)" command.

9.4.37 No. 13: Activate_ground fault detection (reset EFD)

Meaning

The setting for enabling the integrated ground fault detection is always made when configuring the CM AS-i Master.
This command is used to enable or disable the ground fault detection via the user program so as to overwrite the configured setting.
After a startup or restart, the configured setting is applied again.

Structure of the job data in the send buffer

Table 2-1761 Structure of the job data in the send buffer

Byte	Meaning							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Command number 13_H							
1	0							0 = Ground fault detection is enabled 1 = Ground fault detection is disabled

9.4.38 No. D0: Set_Configuration_Online

Meaning

The following configuration data for the addressed AS-i slave is configured with this command:

- IO code
- ID code
- ID1 code
- ID2 code
- Parameter value

The configuration data is stored in the non-volatile EEPROM of the CM AS-i Master ST. The AS-i master uses this configuration data as the specified expected configuration for "protected operation". The configuration data are defined by the manufacturer of the AS-i slave. The meaning of the configuration data is described in the "AS-Interface Complete Specification". If the addressed AS-i slave does not support an ID1 code or ID2 code, ID1 code = F (hex) and ID2 code = F (hex) must be used as the preset values. When this command is executed, the AS-i master remains in the online phase. This means that the AS-i master is not restarted. The command can be executed in "Protected operation".

The command can be executed for any slaves including proxy slaves. Ensure that you have defined an adequate length for the I/O image when configuring the slave. If the the I/O image for the slave is not long enough, surplus input data are truncated and surplus output data are transmitted with substitute value 0. This applies to a digital I/O image and an analog I/O image.

If the value F (hex) is written to a proxy slave for all four codes (IO code, ID code, ID1 code and ID2 code), any slave type at this AS-i address is activated by the AS-i master.

NOTE

Configuration data are overwritten

If you use this command, you will overwrite the corresponding configuration data that resulted from configuring using the "SET" button or configuring using HW Config.

NOTE

The configuration data for all proxy slaves can be reset to value F (hex) in the CM AS-i Master ST module by configuring the AS-i slaves using the "SET" button with no slaves connected (see Section "Configuration of the AS-i slaves using the "SET" button (Page 33)").

Structure of the job data in the send buffer

Table 2-1762 Structure of the job data in the send buffer

Byte	Meaning			
	Bit 7	**Bit 4**	**Bit 3**	**Bit 0**
0	Command: $D0_H$			
1	Slave address			
2	IO code		ID code	
3	ID1 code		ID2 code	
4	0		Parameter	

9.4.39 No. D1: AS-i-Slave_ID1_schreiben_mit_Zieladresse (Write ID1 code with destination address)

Meaning

This command writes the ID1 code of an AS-i slave with the specified address directly via the AS-i cable.

The AS-i master forwards the ID1 code to the AS-i slave without a plausibility check.

Requirements

- The AS-i slave at the target address must support writing of the ID1 code.
- There are no AS-i slaves on the AS-i bus with address "0".

Structure of the job data in the send buffer

Table 2-1763 Structure of the job data in the send buffer

Byte	Meaning			
	Bit 7	**Bit 4**	**Bit 3**	**Bit 0**
0	Command: $D1_H$			
1	AS-i slave address			
2	0		ID1 code	

Technical data

10

10.1 Technical data in Siemens Industry Online Support

Technical data sheet

You can also find the technical data of the product at Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/15756/td).

1. Enter the full article number of the desired device in the "Product" field, and confirm with the Enter key.
2. Click the "Technical data link.

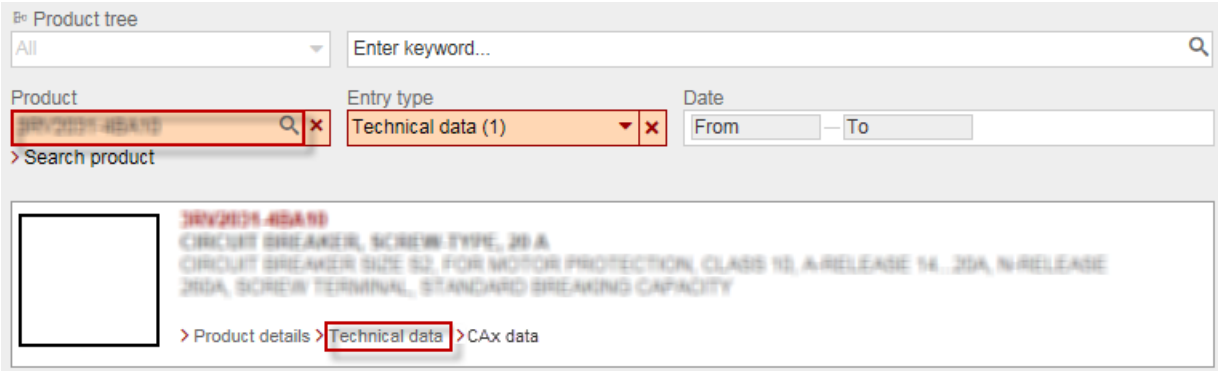

AS-Interface Protocol Implementation Conformance Statements

A

A.1 AS-Interface Protocol Implementation Conformance Statement (PICS)

PICS for the CM AS-i Master ST

Vendor	SIEMENS AG
Product name	CM AS-i Master ST
Article number	3RK137-6SA00-0BC1
Firmware version	V1.0 or higher
Master profile	M4
Date	—

List of available master functions

Character	Meaning
X	Function available
—	Function not available

No.	Function or command to the host interface (symbolic representation)	M4	Remark / implementation of the function with
1	Image, Status = Read_IDI()	X	Through automation system access to the I/O data of the AS-i master
2	Status = Write_ODI(Image)	X	Through automation system access to the I/O data of the AS-i master
3	Status = Set_Permanent_Parameter (Addr, Param)	X	See Section "Description of the AS-i commands (Page 93)"
4	Param, Status = Get_Permanent_Parameter (Addr)	X	
5	Status, Param = Write_Parameter (Addr, Param)	X	
6	Status, Param = Read_Parameter(Addr)	X	
7	Status = Store_Actual_Parameters()	X	
8	Status = Set_Permanent_Configuration (Addr, Config)	X	
9	Status, Config = Get_Permanent_Configuration (Addr)	X	
10	Status = Store_Actual_Configuration()	X	In *STEP 7*, by pressing the "ACTUAL → EXPECTED" button in the control panel.
11	Status, Config = Read_Actual_Configuration (Addr)	X	See Section "Description of the AS-i commands (Page 93)". Access to data record 84.
12	Status = Set_LPS(List31)	X	
13	Status, LPS = Get_LPS()	X	
14	Status, LAS = Get_LAS()	X	

No.	Function or command to the host interface (symbolic representation)	M4	Remark / implementation of the function with
15	Status, LDS = Get_LDS()	X	See Section "Description of the AS-i commands (Page 93)". Access to data record 84.
16.0	Status = Get_Flags()	X	
16.1	Status, Flag = Get_Flag_Config_OK()	X	
16.2	Status, Flag = Get_Flag_LDS.0()	X	
16.3	Status, Flag = Get_Flag_Auto_Address_Assign()	X	
16.4	Status, Flag = Get_Flag_Auto_Prog_Available()	X	
16.5	Status, Flag = Get_Flag_Configuration_Active()	X	
16.6	Status, Flag = Get_Flag_Normal_Operation_Active()	X	
16.7	Status, Flag = Get_Flag_APF()	X	CP error bit, LED indication (see Section "Description of the AS-i commands (Page 93)"). Access to data record 84.
16.8	Status, Flag = Get_Flag_Offline_Ready()	X	Access to data record 84.
16.9	Status, Flag = Get_Flag_Periphery_OK()	X	
17	Status = Set_Operation_Mode(Mode)	X	By pressing the "Configuration mode" or "Protected mode" button in the control panel of *STEP 7*.
18	Status = Set_Offline_Mode(Mode)	X	See Section "Description of the AS-i commands (Page 93)".
19	Status = Activate_Data_Exchange(Mode)	-	Optional command; not implemented
20	Status = Change_Slave_Address (Addr1, Addr2)	X	See Section "Description of the AS-i commands (Page 93)".
21.1	Status = Set_Auto_Address_Enable	X	
21.2	Status = Get_Auto_Address_Enable	X	
22.1	Status, Resp = Cmd_Reset_ASI_Slave (Addr, RESET)	-	
22.2	Status, Resp = Cmd_Read_IO_Configuration (Addr, CONF)	X	
22.3	Status, Resp = Cmd_Read_Identification_Code(Addr, IDCOD)	X	
22.4	Status, Resp = Cmd_Read_Status (Addr, STAT)	X	
22.5	Status, Resp = Cmd_Read_Reset_Status (Addr, STATRES)	-	Not relevant for AS-i master acc. to profile M4; not implemented
22.6	Status, Resp = Cmd_Read_ID–Code_1(Addr, IDCOD1)	X	Not implemented
22.7	Status, Resp = Cmd_Read_ID–Code_2(Addr, IDCOD2)	X	
23	Status, S_List = Get_LPF()	X	See Section "Description of the AS-i commands (Page 93)". Access to data record 84.
24	Status = Write_ID–Code_11(S_ID–Code_1)	X	See Section "Description of the AS-i commands (Page 93)". Not implemented
25	AImage, Status = Read_AIDI()	X	See Section Description of the AS-i commands (Page 93). Through automation system access to the I/O data of the AS-i master
26	Status = Write_AODI(AImage)	X	
27	String, Status = Read_ParamStr(S_Addr)	X	See "Read_Parameter_String" in Section Description of the AS-i commands (Page 93)

No.	Function or command to the host interface (symbolic representation)	M4	Remark / implementation of the function with
28	Status = Write_ParamStr(S_Addr, String)	X	See Section Description of the AS-i commands (Page 93)
29	String, Status = Read_DiagStr(S_Addr)	X	See Section Description of the AS-i commands (Page 93)
30	String, Status = Read_IdentStr(S_Addr)	X	See Section Description of the AS-i commands (Page 93)
B	Supported slave profiles		
1	Support of extended address mode	X	—
2	Support of Combined transaction type 1 integrated (S–7.3 only)	X	—
3	Full support of Combined transaction type 1 integrated	X	Support for profiles 7.3 and 7.4 only.
4	Support of Combined transaction type 2 integrated	X	—
5	Support of Combined transaction type 3 integrated	X	—
6	Support of Combined transaction type 4 integrated	X	—
7	Support of Combined transaction type 5 integrated	X	—

Readme Open Source Software

B

B.1 Read_me OSS

NOTE

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In the product "CM AS-i Master ST" (hereinafter referred to as "product"), the following open-source software is used in unmodified form or in a form we have modified, as well as other software requiring a license listed below:

Table 2-1764 Summary of licenses

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Data sets

C

C.1 DS 100 Switch duplicate address detection on/off

Description

The duplicate address detection function can be activated/deactivated via the user program by means of write access to data record DS 100.

For the CM AS-i Master firmware V1.0 the status is stored in the AS-i Master volatile memory, i.e. if the AS-i voltage fails, duplicate address detection is deactivated.

For the CM AS-i Master firmware V1.0 and higher, duplicate address detection is adopted according to the setting in HW Config or GSD after failure of the AS-i voltage.

NOTE

From firmware V1.1 onwards use the setting option via HW Config or GSD to activate duplicate address detection. Data record DS 100 continues to exist for compatibility reasons.

Table 2-1765 Structure of DS 100 write

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
0	0							
1	0							
2	0							0 / 1
3	0							

Bit 0 = 0 Duplicate address detection is activated.

= 1 Duplicate address detection is deactivated (default setting for FW V1.0).

The setting for which AS-i voltage duplicate address detection is activated (possible for FW V1.1 and higher) cannot be changed in this case.

See also

Duplicate address detection (Page 71)

C.2 DS 100 Read setting for duplicate address detection

Description

Via read access to data record DS 100 the enable status of duplicate address detection can be read back.

Table 2-1766 Structure of DS 100 read

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
0 ... 1	Reserved							
2	Reserved							0 / 1
3	Reserved							

Bit 0 = 0 Duplicate address detection is activated

= 1 Duplicate address detection is deactivated (default setting for FW V1.0).

The setting for which AS-i voltage duplicate address detection is activated (possible for FW V1.1 and higher) cannot be read out in this case.

See also

Duplicate address detection (Page 71)

C.3 DS 101 Read version identifier

Description

This data record reads the version identifier.

Table 2-1767 Structure of data record DS 101

Byte	Meaning							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
0 ... 1	Reserved							

2 ... 33	Version identifier as a string
	e. g.:
	`Siemens AG CM ASi M V01.00.00`
	`1.....1.....1.....1..`							

Approvals

D

This chapter contains a selection of information about certificates and approvals.

You can find more information on the Internet at (https://support.industry.siemens.com/cs/ww/en/ps/3RK7137-6SA00-0BC1).

Select the entry type "Certificate".

D.1 Ex certificates

ATEX

Table 2-1768 DEKRA 20ATEX0042 X

II 3 G Ex ec IIC T4 Gc or
II 3 G Ex ec nC IIC T4 Gc

EN IEC 60079-0 : 2018 EN 60079-7 : 2015 + A1 : 2018 EN 60079-15 : 2019

Specific conditions of use

1. The equipment shall only be used in an area of not more than pollution degree 2, as defined in EN 60664-1.
2. The modules shall be installed in a suitable enclosure providing a degree of protection of at least IP54 according to EN 60079-7, taking into account the environmental conditions under which the equipment will be used.
3. Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119 V.

For more information, see (https://support.industry.siemens.com/cs/ww/en/view/109783172)

UKEX

Table 2-1769 DEKRA 21UKEX0213 X

II 3 G Ex ec IIC T4 Gc or
II 3 G Ex ec nC IIC T4 Gc

EN IEC 60079-0 : 2018 EN 60079-7 : 2015 + A1 : 2018 EN 60079-15 : 2019

Specific conditions of use

1. The equipment shall only be used in an area of not more than pollution degree 2, as defined in EN 60664-1.
2. The modules shall be installed in a suitable enclosure providing a degree of protection of at least IP54 according to EN 60079-7, taking into account the environmental conditions under which the equipment will be used.
3. Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119 V.

Importer UK

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Princess Road
Manchester
M20 2UR
United Kingdom

For more information, see (https://support.industry.siemens.com/cs/ww/en/view/109815522)

IECEx

Table 2-1770 IECEx DEK 20.0026X

IEC 60079-0 : 2017 (Ed.7) IEC 60079-7 : 2015 (Ed.5.1) IEC 60079-15 : 2017 (Ed. 5)

Specific conditions of use

1. The equipment shall only be used in an area of not more than pollution degree 2, as defined in EN 60664-1.
2. The modules shall be installed in a suitable enclosure providing a degree of protection of at least IP54 according to EN 60079-7, taking into account the environmental conditions under which the equipment will be used.
3. Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119 V.

For more information, see (https://support.industry.siemens.com/cs/ww/en/view/109783171)

CCC-Ex

The product has been tested and certified according to CNCA-C23-01 : 2019

China Compulsory Certification

Implementation Rules - Explosion-proof Electrical Products

For more information, see (https://support.industry.siemens.com/cs/us/en/view/109815161)

FM

For more information, see (https://support.industry.siemens.com/cs/us/en/view/109750842)

List of abbreviations

E

E.1 List of abbreviations

Meaning of abbreviations

Abbreviation	Meaning
AI	Analog input
APF	AS-i power fail (problem with the AS-i supply voltage)
AQ	Analog output (AO)
AS-i	AS-Interface
ATEX	Atmosphere Explosive
AUP	Automatic address programming
AWP	Automation Web Pages
CER	Configuration error
CBA	Component Based Automation
CDI	Configuration data image
CFGOK	Configuration OK
CM	Communication module
	Configuration mode (operating mode in the AS-i master, opposite of "protected mode")
CPU	Central processing unit
CTT	Combined transaction type, see also Glossary
DI	Digital input
DIAG	Diagnostics
DIN	Deutsches Institut für Normierung e.V. (German national standard)
DP	Distributed I/O
DQ	Digital output (DO)
DS	Data record
I/O	Input/output
EEPROM	Electrically erasable programmable read-only memory
EFD	Ground fault detection
EN	Europäische Norm (European standard)
FB	Function block (program block in the SIMATIC user program)
FC	Function (program block in the SIMATIC user program)
F-DI, F-IN	Failsafe digital input, safety-oriented input
GSD	Device master data
GSDML	Generic station description markup language

Abbreviation	Meaning
HSP	Hardware support package
HW	Hardware
HW ID	Hardware identifier
I&M	Identification and maintenance
ID	Identifier, identification number (e.g. ID code, see also glossary)
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IO	Input output
IP	Ingress protection (enclosure class)
ISO	International Organization for Standardization
LAS	List of activated (AS-i) slaves
LDS	List of detected (AS-i) slaves
LED	Light emitting diode
LPF	List of peripheral faults (list of peripheral faults signaled by AS-i slaves)
LPS	List of configured AS-i slaves
MPO	Master power On
NEC	National Electrical Code
NFPA	National Fire Protection Association
OB	Organization block
PIQ	Process image output
PII	Process image input
PCD	Permanent configuration data
PELV	Protective extra low voltage
PF	Peripheral fault
PI	Parameter image
PP	Permanent parameter
RDREC	Read record
RQ	Relay output (RO)
SELV	Safety extra low voltage
SIL	Safety Integrity Level
GF, CF	System fault
SFB	System function block
PLC	Programmable logic controller
SNMP	Simple Network Management Protocol
TCP/IP	Transmission Control Protocol / Internet Protocol
TIA	Totally Integrated Automation
USB	Universal Serial Bus
WRREC	Write record

SIEMENS

SIMATIC

ET 200SP Communication Module CAN (6ES7137-6EA00-0BA0)

Equipment Manual

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01/2023

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Preface

Purpose of the documentation

This manual supplements the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual. Functions that generally relate to the ET 200SP system are described in the system manual.

The information in this equipment manual and the system/function manuals enable you to commission the CAN communication module.

Conventions

SIMATIC S7 controller: When the term "SIMATIC S7" controller is used hereafter, it applies to the central modules of the S7-1200/1500 automation system, of the Open Controller and of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/cert).

Open Source Software

Open-source software is used in the firmware of the product described. Open Source Software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open source software over and above the intended program sequence, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices. Please read the information relating to this on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109740777).

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ET 200SP Documentation Guide

1

1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.2 Basic tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

mySupport

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Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
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Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
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CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

New properties/functions 2

2.1 Version overview

HSP/FW versions

TIA Portal version	HSP required	HSP version	FW version	Note
V15; V15.1	Yes	HSP_V15_1_0310_001_ET200SP_CM_-CAN_1.0	V1.0	
V16	Yes	HSP_V16_0310_002_ET200SP_CM_C-AN_1.0	V1.0; V1.1	"Simple slave functionality" included
V17	No	-	V1.0; V1.1	"Simple slave functionality" included
V17 Update 6	No	-	V1.0; V1.1; V1.2	OD index entry range extended, "Block Error passive alarm" function included
V18 Update 1	No	-	V1.0; V1.1; V1.2	OD index entry range extended, "Block Error passive alarm" function included
V19	No	-	V1.0; V1.1; V1.2	OD index entry range extended, "Block Error passive alarm" function included

2.2 Changes compared to previous version

What's new as of firmware version V1.2

There are now three entries in the HW catalog for the CM CAN module with firmware versions V1.0, V1.1 and V1.2. Version V1.2 includes all functions of Version V1.1 plus a new "Block Error passive alarm" function. The OD index entry range has been extended to 0x6FFF. These functions are available as of TIA Portal V17 Update 6.

NOTE

Backward compatibility

An existing configuration of CM CAN module V1.2 cannot be downgraded from V1.2 to V1.1 within a TIA Portal project. The same applies to a downgrade to Version V1.0 from a higher version (V1.1 and higher). If a downgrade to Version V1.0 is required, you must recreate the CM CAN module for Version V1.0 within a TIA Portal project. In this case, however, you do not have access to any of the functions that have been added in the higher versions.

An update of Version V1.0 to a higher version (V1.1 and higher) within a TIA Portal project is possible. In addition, you can upgrade Version V1.1 to V1.2.

You can perform a firmware update/firmware downgrade in the device without any restrictions.

What's new as of firmware version V1.1

There are now two entries in the HW catalog for the CM CAN module with firmware versions V1.0 and V1.1. The difference between the CM CAN module V1.0 and V1.1 is the "Simple Slave functionality" that is included in the CM CAN module V1.1.

This functionality is available as of TIA Portal V16 and enables the CM CAN module to work with CANopen devices that do not fully comply with the CANopen standards defined by the CiA group (https://www.can-cia.org/). You can find additional information below.

NOTE

Backward compatibility

An existing configuration of CM CAN module V1.1 cannot be downgraded from V1.1 to V1.0 within a TIA Portal project. If a downgrade is required, you must recreate the CM CAN module for V1.0 within a TIA Portal project. In this case, however, the "Simple Slave functionality" is not available.

You can perform a firmware update/firmware downgrade without any restrictions.

New parameters

Under "General > Module parameters > Diagnostics"

• Check box Block Error passive alarm

This option can be selected in any operating mode.

If you select this option and the CM CAN module receives an Error Passive alarm, the error passive state of the CAN bus is not reported as an alarm in the diagnostic buffer. The ERROR LED remains off.

If you deselect this option and the CM CAN module receives an error passive alarm, the Error Passive state of the CAN bus is reported as an alarm in the diagnostic buffer. The ERROR LED on the device flashes red.

This option is enabled by default.

NOTE

If the "Enable additional diagnostic alarms" check box is deselected, the "Block Error passive alarm" check box is disabled.

Under "General > Module parameters > Diagnostics"

• Check box Enable diagnostic alarms for not mandatory nodes

The option can only be selected in the CANopen Manager mode and applies only to nodes that are non-mandatory.

When you select this option, error messages from such nodes are also displayed in the diagnostic buffer and the ERROR LED lights up. All other nodes on the CAN bus are not affected by this option.

If you deselect this option, the disconnecting of nodes from the CAN bus and any pending error messages in the CANopen network are not sent to the diagnostic buffer, and the ERROR LED remains off.

Under "CANopen Manager > General > Communication"

• max. SDO Timeout

Some "simple slave" devices are slow to respond to commands of the CANopen Manager. Such devices work on other, more important tasks and CANopen communication has low priority. The reaction to the command from the manager is therefore delayed. In this case, the manager waits for the "max SDO timeout" (ms). The SDO request is aborted when the preset time has elapsed. There is also a 1 second delay before a new request is sent.

The SDO Timeout is only displayed to the user when an SDO with the data record number 0x200 - 0x20F is requested. The timeout is displayed instead of the 4-byte code "Additional error information code" as 0x05040000 (code number taken from CiA standard "CiA 301"). This code occupies the 6th to 9th byte of the data record read.

• max. BootUp Timeout

The max. bootup timeout gives the maximum response time in seconds for the startup process of a node. When a node does not respond to the requests of the manager within the specified time, the diagnostic message "BootUp, node not responding" is sent to the PLC. The diagnostic message is deleted as soon as the node responds correctly to the manager.

Under "CANopen Manager > Receive process data objects (PDOs) > Receive PDO definition"

• Disable checking of PDO length

When you select this option, the data length (number of received bytes) of the received PDOs is adjusted. Error, warning or diagnostic messages are not generated. The value is adjusted to the correct data length as follows:

- Data below the defined length are supplemented with the value 0.
- If data exceeds the defined length, the more significant bytes are deleted.

When you disable this option, all data from a received PDO with a length deviating from the standard is discarded and replaced with the value of the last valid PDO (last received PDO with the correct length). The CANopen Manager calls up an error message in the diagnostic buffer.

Under "CANopen Manager > CANopen node > Communication"

• No NMT / Layer 2 slave

When you select this option, the NMT status of the node is not evaluated. The CANopen configuration phase is completely skipped for this node including NMT commands. The configuration menus for EMCY, Heartbeat and Node Guarding as well as the PDOs are blocked (write-protected) and show the values from the object dictionary (EDS file).

Exception: A node can be monitored by the manager using the Heartbeat/Node Guarding functions. An error is only signaled to the CPU when the Heartbeat/Node Guarding message is not received in time. The NMT status of the message is not evaluated; any status is accepted.

Typical use case for this option are slave nodes that do not require NMT commands for their commissioning and use. After power-on, such devices immediately enter the operating mode and start sending the PDO messages configured by default.

If you have made parameter changes before setting the "No NMT / Layer 2 slave" option, these values are retained. However, they have no effect on the actual configuration of the node in the system.

• Loose configuration

The main purpose of this option is to ignore unexpected errors during the configuration phase. The configuration of the node is always completed.

This option only affects the configuration phase after startup or after resetting the bus or node. The status of a node is read by the master during the configuration phase, although it is ignored. In this way, the master can work with devices that are in operating mode immediately after power-on or with devices that communicate differently, contrary to the definition in their EDS file.

When a node of one of the mandatory objects 1000, 1018.01, 1018.02, 1018.03 is not supported, this check box is always selected and cannot be cleared.

Editable OD table (manually defined object dictionary)

You can find additional information in the section "Handling of the OD table" in the section Configuration in the TIA Portal (Page 71).

Disabling a configured node temporarily

You can find additional information in the section "Disabling a node temporarily" in the section Configuration in the TIA Portal (Page 71).

Implementation of the 0x1F82 object - NMT request

The object 0x1F82 NMT request is accessible from another CANopen device via the CANopen network upon RD-SDO request. Contrary to the definition in the CiA standard "CiA 302 Part 2", this object is implemented read-only. Write access is not permitted. When the manager itself wants to read data of this object, it must use the RDREC instruction with data record number 0x211 for this.

NOTE

This functionality is only available in the "CANopen Manager" operating mode.

It returns an array of 127 bytes for the status of the node ID from 1 to 127.

RET ARRAY[0] = Status of node 1

RET ARRAY[1] = Status of node 2

...

RET ARRAY[126] = Status of node 127

NOTE

Reading from 0x1F82 OD with the SDO command only returns a status byte of a node instead of an array of bytes. For each node, therefore, an SDO command must be sent with the ID of the requested node as an input parameter.

The status of a node can have the following values (according to CiA standard "CiA 302 Part 2"):

- 0 = unknown state
- 1 = node missing
- 4 = NMT/STOPPED
- 5 = NMT/OPERATIONAL
- 127 = NMT/PRE-OPERATIONAL

Product overview

3

3.1 Properties

Article number

6ES7 137-6EA00-0BA0

View of the module

Figure 2-1390 SIMATIC ET 200SP CM CAN

The CAN communication module can be used in the ET 200SP distributed I/O system. You connect the module directly to the ET 200SP CPU or to the ET 200SP interface module.

You can find additional information on the configuration of the ET 200SP and the associated modules in the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

General properties

The CAN communication module has the following properties:

- CAN interface according to ISO 11898-2 (High Speed CAN)
- The CAN protocol and CANopen protocol are implemented in the module. The module assumes the function of a CANopen slave or CANopen manager in the CANopen network. The module can operate in the following three modes:
  - CANopen manager
  - CANopen slave
  - CAN transparent
- The operating mode for the module is set using the associated HSP in the TIA Portal.
- The module supports both the standard format (CAN 2.0A) and the extended CAN format (CAN 2.0B).
- The module can operate up to 60 nodes in the CAN network in CANopen manager mode.
- Data transmission rates of 10, 20, 50, 125, 250, 500, 800 and 1 000 kbit/s are supported on the CAN bus side. The data transmission rate 33.333 kbit/s is only supported in "CAN transparent" mode.
- The maximum allowable cable length of the CAN network is up to 1 000 m. The cable length is dependent on:
  - Data transmission rate
  - Cable cross-section
  - Number of nodes

CANopen manager

- CANopen implementation according to CANopen specification "CiA 301"
- The mode can operate up to 60 slaves as CANopen manager in the CANopen network.
- Network management functions according to CiA standard "CiA 302 Part 2".
  When the module is operated as CANopen manager, it takes on the following functions:
  - NMT Master: The module controls the NMT state of the other CAN devices and executes the boot-up procedure according to the CiA standard "CiA 302 Part 2".
  - Configuration Manager: The module configures the CANopen slaves during the boot-up procedure by means of SDO write access.

  - The CM CAN also supports the following CANopen standards:

    CiA 303 Part 1 - Cabling and pin assignment V1.8.0

    CiA 303 Part 3 - LED control - Display specification, V1.4.0

    CiA 309 Part 4 - Mapping of data types and their conversion (Amendment 7 to Fieldbus Integration into PROFINET IO, V1.0.0)
  - The CM CAN does not support the following standards:

    CiA 305 - regarding LSS functionality

    CiA 306 - regarding XDD files

    CiA 1301+CiA 601 - regarding CANopen FD (Flexible Data)
- I/O data is transmitted on the CANopen side with the help of process data objects (PDOs).
- All PDO transmission types specified in the CiA 301 standard are supported.
- Segmented SDO data transmission is supported.
- SYNC function as producer (transmitter) as well as consumer (receiver)
- "Heartbeat" function as producer (transmitter) as well as consumer (receiver)
- "Node Guarding" function as producer (transmitter) as well as consumer (receiver)
- "EMCY" (Emergency) function

CANopen slave

- The module can be used as an "NMT slave" according to "CiA 302 Part 2".
  When the module is an NMT slave, another CANopen manager performs the following processes:
  - Checks the communication and the state of the slaves via NMT protocol.
  - Creates and records PDO messages.
  - Initiates SDO transmission.
  - Determines what was exchanged on the CAN bus.

CAN transparent

- You can operate the module in "CAN transparent" mode.
- All CANopen functions are disabled.
- Control and status information are exchanged cyclically between the module and the SIMATIC S7 controller.
- Messages can be used in standard format and in extended CAN format.
- Configured CAN messages with fixed message ID and fixed length can be used.
- It is possible to use CAN messages in which the message ID and the length (max. 8 bytes) are changed at runtime.
- The user can send and receive CAN messages in the user program. For this purpose, "Transmit proxy modules" and "Receive proxy modules" can be configured in the TIA Portal.

3.2 System requirements

System requirements

- ET 200SP CM CAN
- Controller: SIMATIC S7-1200, SIMATIC S7-1500, SIMATIC ET 200SP, SIMATIC Open Controller are supported.
- Interface module: ET 200SP, if you do not use a controller.
- Light-colored or dark-colored BaseUnit type A0
- 24 V voltage supply
- CAN bus
- Windows PC (for configuring, commissioning and diagnostics)
- TIA Portal V15.1, you can find the required HSP in the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852). In TIA Portal V17, the required HSP is already integrated. You can find the required library with the function block in Library (https://support.industry.siemens.com/cs/de/en/view/109775840).
- A LAN switch is recommended for configuration, commissioning and diagnostics.

3.3 Design

CM CAN design

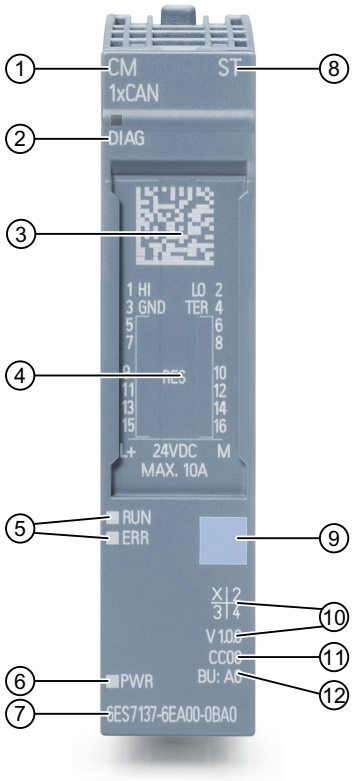

① Module type
② LED for diagnostics
③ 2D matrix code
④ Wiring diagram
⑤ Status LEDs
⑥ LED for supply voltage
⑦ Article number
⑧ Function class
⑨ Color coding module type
⑩ Function version and firmware version of the module
⑪ Color code for selecting the color-coded labels
⑫ BU type

Figure 2-1391 SIMATIC ET 200SP CM CAN

Functions

4

4.1 CANopen

4.1.1 Basic functions

Overview

The following overview diagram shows the relations in the communication between the SIMATIC S7 controller and the communication module.

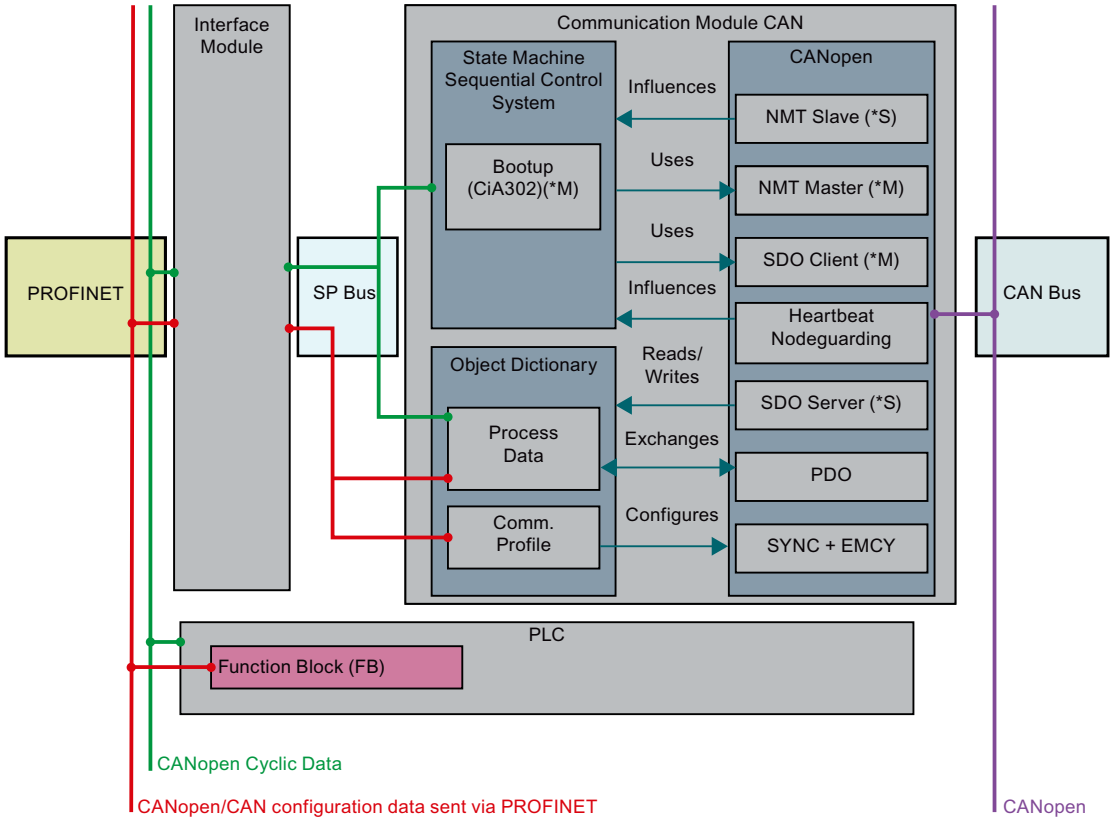

*M Only available in Manager mode

*S Only available in slave mode

Figure 2-1392 Communication principle of the CM CAN with CANopen

4.1.1.1 Object Dictionary

Structure of the Object Dictionary (OD)

All communication objects and all user objects are organized in the object dictionary (OD).

The following table describes the areas used by the module:

Table 2-1771 Ranges

OD entry	Meaning
0x1000 ... 0x1FFF	Communication profile
0x2000 ... 0x6FFF	Process data

Default settings and initialization

The default values specified for process data in the TIA Portal are used only for initialization of the values in the OD. The OD entries are created by HSP in the form of a data block. To transmit the configuration data of the data block, use a function block that transmits the configuration data to the module at runtime. You can find more information on the function block in the section Programming (Page 106).

In "CANopen manager" mode, the module remembers for all OD entries whether a PDO with the data has already been received since the last reset to the default values. This applies to the OD entries with content that is being transmitted as cyclic data to the SIMATIC S7 controller. Monitoring is performed in "CANopen slave" mode:

- Whether the entries were written at least once per SDO.
- Whether a matching PDO was received.

This information is compressed into one bit and transmitted cyclically as a group status of all data to the SIMATIC S7 controller.

According to the CiA standard "CiA 301", the default values are always applied to the OD in the NMT state "Initialization", sub-state "Reset Application".

This state is passed through in the following cases:

- After configuration/reconfiguration of the module by the SIMATIC S7 controller
- After reset of the module via a "reset bit" from the SIMATIC S7 controller
- After receiving the NMT command "Reset Node" (only in "CANopen slave" mode)
- After resetting the module and all nodes due to a Heartbeat error (only in "CANopen manager" mode and only when the error response is configured accordingly). You can find additional information on the monitoring functions in the section Heartbeat / Node Guarding (Page 26).

The following actions are being executed in the process:

- The default value is written to the OD.
- The information on whether the OD entry has already been written once by the CANopen side is reset.

Process data objects

Process data is transferred on the CANopen side by PDOs.

The module supports 128 PDOs for transmitting/receiving.

One entry for the "Communication parameters" and one entry for the "Mapping parameters" exists in the OD for each Receive PDO (RX PDO) and each Transmit PDO (TX PDO).

In the configuration you specify:

- The COB ID of the CAN message
- The format of the COB ID (11b or 29b)
- The transmission mode (synchronous, event-controlled with timer, RTR)
- Whether or not the PDO is active
- The OD entries onto which the data of the transmitted or received PDOs are mapped.

Transmission types

The module supports the following PDO transmission types:

Table 2-1772 PDO transmission types

Transmission type	Description
Acyclic synchronous	PDO is transmitted during the next "SYNC" after a value change.
Cyclic synchronous	Depending on the parameter assignment, PDO is transmitted during every 1st to 240th "SYNC", independent of value changes.
RTR only	Only on request (RTR message synchronous/asynchronous) PDO is only transmitted after an RTR message with the COB ID of the PDO has been received. The module supports the "RTR only" transmission mode only for Transmit PDOs and not for Receive PDOs.
Manufacturer-specific event control Application-specific event control	These transmission types are event-controlled (asynchronous). PDO is sent when an event occurs, independent of "SYNC": • If value has changed • After a configurable timeout has elapsed - event time and inhibit time Event-controlled Transmit PDOs with transmission type 254 (manufacturer-specific) and transmission type 255 (application-specific) are also transmitted immediately after the transition to NMT state "Operational".

4.1.1.2 Service Data Objects (SDO)

The module allows write/read access to the OD of other CANopen nodes by SDO from the user program.

The module provides 16 data records which can be accessed by the user program with the communication blocks RDREC (read data record) and WRREC (write data record).

NOTE

This functionality is only available in the "CANopen manager" operating mode.

For additional information, see section CANopen manager - Control and Status Information (Page 31).

EMCY messages

The module transmits the following EMCY messages:

Table 2-1773 EMCY messages

Error-Code	Meaning
8Fxxh	Heartbeat error or Node Guarding error for <xx> nodes. Transmitted when the module is in "CANopen slave" operating mode and the heartbeat for a monitored node fails.
8130h	General Heartbeat error or Node Guarding error. Sent if the module is in "CANopen slave" mode, Node Guarding is enabled and the monitoring by the master fails.
FF90h	Sent if the connection to the SIMATIC S7 controller fails in the following cases: • The connection (Application Relation) is terminated • The data from the SIMATIC S7 controller has the IO provider status "Bad" Transmitted when the module is being operated as a "CANopen slave" and the NMT Manager attempts to put the module into "Operational" state.
FF91h	Transmitted when the module is being operated as a "CANopen slave" and the desired state transmitted in the cyclic data from the SIMATIC S7 controller changes to "OFF". Transmitted when the NMT Manager tries to put the module into "Operational" state while the desired state transmitted in the cyclic data from the SIMATIC S7 controller is still "OFF".

The EMCY messages always use the default COB ID intended for this purpose.

4.1.1.3 Heartbeat / Node Guarding

The module supports the Heartbeat and Node Guarding monitoring functions both as producer (transmitter) and consumer (receiver).

- "CANopen manager" operating mode: The parameters for Heartbeat and Node Guarding are defined during configuration.
- "CANopen slave" operating mode: The settings for these two functions are written to the OD (100Ch, 100Dh, 1016h and 1017h) of the module via SDO access by the CANopen manager responsible for the configuration and management of the CANopen network.

The HSP ensures that either Heartbeat or Node Guarding are configured in "CANopen manager" mode.

NOTE

The setting of the monitoring function made in the HSP applies to the entire network with all CANopen nodes. Mixed operation with different monitoring functions is not possible. Nevertheless, slave nodes without the Heartbeat or Node Guarding functions can also be put into operation.

NOTE

If a node does not support monitoring functions (or if Heartbeat and Node Guarding are disabled), a failure or fault of the node is **not** recognized by the CM CAN as CANopen Manager. Even when you select the "Node is mandatory on the network" option for this node, you must ensure that the required monitoring is in place.

Fault reaction

When a monitored CANopen device fails, the module signals corresponding diagnostic information to the SIMATIC S7 controller. In addition, an EMCY message is sent on the CANopen side and the fault reaction that is configured or defined in the OD (1029h) is executed.

The possible error responses for manager/slave are available in the following sections:

- CANopen manager: CANopen manager (Page 28)
- CANopen slave: CANopen slave (Page 40)

4.1.1.4 SYNC messages

The module supports the SYNC protocol as transmitter (producer) and as receiver (consumer).

The SYNC receiver function is required for PDOs with "synchronous" transmission types. For additional information, see section Object Dictionary (Page 23).

In the configuration, you specify whether the module is a SYNC transmitter or SYNC receiver as well as the transmission interval. In "CANopen manager" mode, a different CANopen slave can be configured as SYNC transmitter. In "CANopen slave" mode, the COB ID to be used for

this can be changed by the manager through SDO. In "CANopen manager" mode, the COB ID is preset to the fixed value 0x80.

NOTE

The SYNC function only has an effect on the CANopen side.

4.1.1.5 Data exchange between the SIMATIC S7 controller and the module

Cyclic data exchange: Process data, control and status information

The process data configured in the HSP is transmitted cyclically between the SIMATIC S7 controller and the module.

The exchanged process data is stored in the module as entries in the object dictionary (OD) (at index 2000h to 6FFFh). The module writes the values of the process data received from the SIMATIC S7 controller to the transmit data OD. The values of the process data to be transmitted to the SIMATIC S7 controller are read from the receive data OD.

Control information and status information is cyclically exchanged between the module and the SIMATIC S7 controller in "CANopen manager" and in "CANopen slave" mode.

The following control information is cyclically transmitted from the SIMATIC S7 controller to the module:

- **Control bit for the state of the module**
  The user can influence the data transmission in the module from the user program using a control bit.
- **Reset bit**
  The user can reset the CANopen side in the module from the user program using a reset bit.

Detailed information on the control and status information is available here:

CANopen manager (Page 28)

CANopen slave (Page 40)

Acyclic data exchange

The module provides 16 data records which can be accessed by the user program with the communication blocks RDREC (read data record) and WRREC (write data record).

For additional information, see section CANopen manager - Control and Status Information (Page 31).

Conversion of data formats between SIMATIC S7 controller and CANopen

The process data is automatically converted from SIMATIC S7 controller to CANopen data format and vice versa according to the configured data type.

The SIMATIC S7 controller interprets data in "Big Endian" format. CANopen and the processors used in the module use the "Little Endian" format. Therefore, the order of the Bytes is adjusted for all data types that occupy more than 1 Byte.

The conversion is performed in the following cases:

- Before the process data received from the SIMATIC S7 controller is written to the transmit data OD
- Before the process data read from the receive data OD is transmitted to the SIMATIC S7 controller

The following table shows the data types supported by the module and their conversion:

Table 2-1774 Conversion of the data types

PROFINET data type	CANopen data type	Conversion
Integer 8	INTEGER 8	None
Integer 16	INTEGER 16	Byte order is automatically converted.
Integer 32	INTEGER 32	
Integer 64	INTEGER 64	
Unsigned 8	UNSIGNED 8	None
Unsigned 16	UNSIGNED 16	Byte order is automatically converted.
Unsigned 32	UNSIGNED 32	
Unsigned 64	UNSIGNED 64	
Float 32 / float	REAL 32	
Float 64 / double	REAL 64	
Bool	Bool	None

4.1.2 CANopen manager

4.1.2.1 Overview

The module can be used as a CANopen manager according to CiA 302 Part 2.

If the module is operated as CANopen manager, the module in CANopen takes over the functions:

- NMT Master: The module controls the NMT state of the other CAN nodes and executes the Boot-Up procedure according to the CiA standard CiA 302 Part 2.
- Configuration Manager: The module configures the nodes during the Boot-Up procedure via SDO write access.

4.1.2.2 CANopen manager - State Model

State model

The state model in "CANopen manager" operating mode is based on the NMT state model described in the CiA standard "CiA 301", taking into account the network management function.

The following figure shows the states of the module in "CANopen manager" mode.

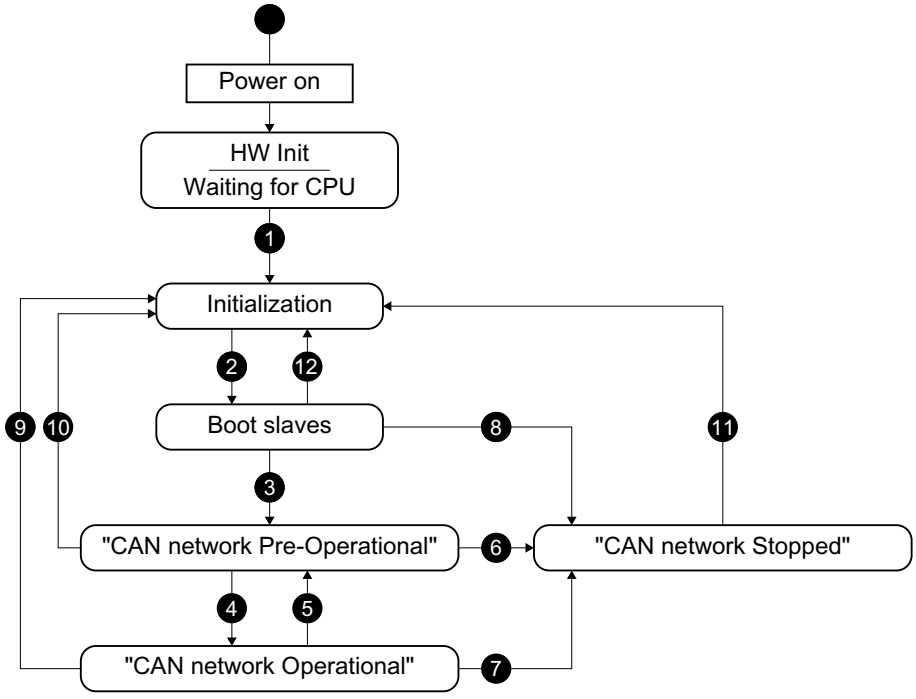

Figure 2-1393 CANopen manager state model

Module states

The following table describes the states in the mode "CANopen manager".

Table 2-1775 "CANopen manager" module states

Module state	Meaning
HW Init / Waiting for SIMATIC S7 controller	The state of the module during booting and when the module is not yet fully configured by the SIMATIC S7 controller.
Initialization	Initialization state: Resetting the OD to the values configured in the HSP and resetting the communication. The state is not "visible" on the CANopen side because there is no CAN communication in this state. The NMT state of the slaves connected via CANopen does not change.

Boot slaves	The module performs the Boot Up procedure according to the CiA standard "CiA 302 Part 2" and configures the CANopen slaves via SDO. The module has the NMT state "Pre Operational". After booting, the NMT state of the slaves connected via CANopen is "Pre-Operational ".
CAN network Pre-Operational	The module as well as all slaves connected via CANopen are in the "Pre Operational" state.
CAN network Operational	The module as well as all slaves connected via CANopen are in the "Operational" state.
CAN network Stopped	The module as well as all slaves connected via CANopen are in the "Stopped" state.

State transitions

The following table describes the state transitions in "CANopen Manager" mode.

Table 2-1776 State transitions "CANopen manager":

Transition	Meaning / trigger
1	Takes place when the module is configured the first time by the SIMATIC S7 controller since booting.
2	Takes place automatically. A "Boot Up" message is sent because the module changes to the state NMT "Pre-Operational ".
3	This occurs when all configured "required" CANopen slaves are present and successfully booted.
4	Takes place when the control bit in the cyclic data from the SIMATIC S7 controller is set to "ON". During this transition, all fully booted CANopen slaves are set to "Operational" through NMT.
5	Takes place when the control bit in the cyclic data from the SIMATIC S7 controller is set to "OFF". During this transition, all CANopen slaves are set to "Pre-Operational" through NMT.
6, 7, 8	Triggered by Heartbeat / Node Guarding error of an appropriately configured "required" slave (NMT master error reaction is "Stop module and all nodes"). During this transition, all CANopen slaves are set to "Stopped" through NMT.
9, 10, 11, 12	Triggered by: • Heartbeat / Node Guarding error of an appropriately configured "required" slave, if (NMT master error reaction is "Restart module") • Reset bit contained in the cyclic data from the SIMATIC S7 controller • Reconfiguration by the SIMATIC S7 controller • Error during booting (except Heartbeat / Node Guarding error)

4.1.2.3 CANopen manager - Control and Status Information

Control information

The following control information is transmitted from the SIMATIC S7 controller to the ET 200SP CAN communication module:

Table 2-1777 Structure of control information in the PROFINET IO data (from the SIMATIC S7 controller to the module, 1 byte)

Bit		Value	Meaning
7 ... 3	Reserved	Must be "0"	--
2	Configuration bit	1	The manager configures nodes in the boot-up state. A successfully configured node can switch to the "Pre-Operational" state.
		0	The manager cannot configure nodes (the NMT status with the boot-up state has been received by the node).
1	Reset bit	1	The CANopen side is reset when the bit changes to "1". With the NMT command "Reset node", all nodes are reset to the initial values and the startup procedure is restarted. All OD entries are reset to initial values. The module acknowledges the receipt of the reset command by setting the reset acknowledgment bit in the data for the SIMATIC S7 controller to "1". The SIMATIC S7 controller can then set the reset bit to "0".
		0	When the reset has been performed and the reset bit is "0", the module sets the reset acknowledgment bit to "0". Only then can a reset be performed again.
0	Control bit	0	CANopen network is not in the state "Operational". If the current state of the CANopen network is "Operational", the CANopen network switches to the "CAN network Pre Operational" state. This means that the module and all nodes are set to "Pre Operational" by an NMT command.
		1	CANopen network is in the state "Operational". If the current state of the CANopen network is "Pre Operational", the CANopen network switches to the "CAN network Operational" state. This means that all nodes and the module are set to the "Operational" state with an NMT command. It is possible that not all slaves have finished booting at this state transition, if: • The reaction to the failure of a mandatory node is set to "Restart of triggering node" in TIA Portal or • Slaves are not configured as "mandatory". In this case, the slaves are not started with one NMT command "to all". An NMT command is sent instead to each fully booted slave individually. As soon as the other slaves are completely booted, they are also switched to "Operational" with an NMT command.

Status information

The following status information is transferred from the ET 200SP CAN communication module to the SIMATIC S7 controller:

Table 2-1778 Structure of status information in the PROFINET IO data (from the module to the SIMATIC S7 controller, 1 byte)

Bit		Values	Meaning	
7	NMT status feedback	0	One or more slaves are rebooted or the module state is not "CAN network Pre-Operational" or "CAN network Operational".	Bit indicates whether all slaves have already returned the NMT status matching the module.
		1	Module state is "CAN network Pre-Operational" or "CAN network Operational" and all nodes have the module state that is signaled in bit 5 ... 3.	--
6	Reset acknowledgment bit	0	The module is ready for reset.	In order to give feedback to the SIMATIC S7 controller about the reset of the CANopen side, a reset acknowledgment bit is used in the data cyclically transmitted from the module to the SIMATIC S7 controller. As soon as the command for resetting the CANopen side has been received, this bit is set to "1". Afterwards, the SIMATIC S7 controller must set the reset bit to "0". When the reset of the CANopen side is complete, the module sets the reset acknowledgment bit to "0"
		1	The module is currently performing or has performed a reset but the reset bit of the SIMATIC S7 controller is still set to "1".	--
5 ... 3	Module state	0	Boot slaves	--
		1	Status "Pre-Operational"	--
		2	Status "Operational"	--
		3	Status "Stopped"	--
		4	Waiting for boot-up enable	Currently not in use; if the status continuously signals bit 2, then it must be set to "1" in the control bit.
		5	State "Not configured"	Ready to receive the extended parameter assignment.
		6	Status "Bad parameterization"	Extended parameter assignment failed. Re-configuration required.
		7	Reserved	--

[1] The error counters customary in CAN and their associated thresholds are internal functions that are not visible to the user.

Bit		Values	Meaning	
2	Group status of all data	0	OD entries with value that have not yet been updated by a corresponding PDO since the last reset.	--
		1	All OD entries have been updated at least once by a PDO or SDO since the last reset.	--
1 ... 0	State of the CAN controller	0	Off	When specified accordingly by the SIMATIC S7 controller
		1	Bus-Off	Error counter[1] has exceeded the specified second threshold. As a result, the module can no longer transmit/receive any packets. Note: "Bus Off" is also signaled when the module needs more than 2 seconds to synchronize with the CAN bus.
		2	Error Passive	Error counter[1] has exceeded the specified first threshold. The module transmits/receives packets nevertheless.
		3	Error Active	Error counter[1] is below a specified threshold. The module transmits/receives packets. This is the normal state. Everything is okay.

[1] The error counters customary in CAN and their associated thresholds are internal functions that are not visible to the user.

NOTE

For values made up of multiple bits, the first bit is the MSB and the last bit is the LSB.
Example: Bit 1 ... 0 = "2" means that bit 0 = "0" and bit 1 = "1".

See also

Configuration in the TIA Portal (Page 71)

Acyclic data exchange

The module provides several data records at the CANopen manager module, which can be accessed by the user program with the communication blocks RDREC (read data record) and WRREC (write data record). Such data records are not available at the configured CANopen slaves.

16 data records are offered for SDO reading and SDO writing.

The data record indexes used are 0x200 to 0x20F.

NOTE

A data record on a module is uniquely defined by an index that specifies the data record number. The index is a 32-bit integer. Different data records differ in their index.

Each data record represents an independent communication channel that can be used independently of the other channels. Via the corresponding data record, SDO communication is initiated with the communication blocks RDREC (read data record) and WRREC (write data record). The RDREC may have to be repeated multiple times if the module returns information that the SDO access has not yet finished (status code = "Busy").

A maximum of 128 bytes of data are transmitted in one SDO access.

Write data record

In this case, there is always first a RDREC on the same index to fetch the result and then a WRREC to transfer the desired SDO command to the module.

Table 2-1779 Structure of the configuration data of the data to be written

Byte	Read value for "SDO" (RDREC)	Write value for "SDO" (WRREC)
0	Command = 0x52 = 82 ('R')	Command = 0x57 = 87 ('W')
1	Node ID	
2 ... 3	OD index (Big Endian, i.e. MSB of value in byte 2 and LSB in byte 3)	
4	OD subindex	
5 ... 6	Number of bytes to be read by SDO (Big Endian), permitted: 1 ... 128	Number of bytes to be written by SDO (Big Endian)
7 ... <END>	<missing>	Bytes to be written

The WRREC access can be successful or return one of the following error codes.

The error codes standardized in PROFINET are used adapted for the transmission of SDOs.

Table 2-1780 Error codes

Error code (Hex)	Meaning
DF80B200	Module is incorrect (data record must be called on "CANopen manager" submodule)
DF80B000	Data record index is incorrect (not 0x200 ... 0x20F)
DF80B100	Written size of data record from SIMATIC S7 controller is too small
DF80B800	"Code" field not "R" or "W"
DF80B800	"NodeID" field invalid (node not configured)
DF80B800	"Number of bytes" field invalid (permitted: 1 ... 128)
DF80B500	No completely and validly configured PROFINET connection Application Relation is established

Error code (Hex)	Meaning
DF80A900	The module is not "CANopen manager".
DF80C300	Node not completely booted or Heartbeat / Node Guarding error after booting
DF80C200	Communication channel (data record index) is already "busy". The module first expects a RDREC before it permits a new WRREC.

If an error is detected, the SDO access will not be initiated.

Read data record

Data record size: 12 + <data length> bytes for SDO read access, 10 bytes for SDO write access

A WRREC always takes place first in order to transfer the desired SDO command to the module. Then, a RDREC takes place on the same index in order to retrieve the result.

The values of the SDO command, i.e. values of the previous WRREC, are returned in the first 5 bytes. This ensures on the SIMATIC S7 controller side that a data record is not used concurrently at several places in the SIMATIC S7 controller application.

Byte	Value for "Read SDO"	Value for "Write SDO"
0	Command = 0x52 = 82 ('R')	Command = 0x57 = 87 ('W')
1	Node ID	
2 ... 3	OD index (Big Endian, i.e. MSB of value in byte 2 and LSB in byte 3)	
4	OD subindex	
5	Status code	
6 ... 9	Additional error information code (Big Endian, i.e. MSB of value in byte 6 and LSB in byte 9)	
10 ... 11	Number of read bytes Big (Endian) (only available when status code = OK)	<missing>
12 ... <END>	Data (only available when status code = OK)	<missing>

The RDREC access itself can be successful or return one of the following error codes.

Table 2-1781 Error codes

Error code (Hex)	Meaning
DE80B200	Module is incorrect (data record must be called on the CANopen manager submodule)
DE80B000	Data record index is incorrect (not 0x200 to 0x20F)
DE80B500	No completely and validly configured PROFINET connection (Application Relation) is established
DE80A900	The module is not CANopen manager
DE80C300	No previous successful WRREC
DE80B700	Read buffer too small

If RDREC returns no error, the user program can evaluate the data transmitted by the module. The "Status-Code" field can have the following values:

Table 2-1782 Values of the "Status code" field

Status code	Meaning
0	OK, SDO successfully completed.
1	SDO aborted or not started because a reset was triggered from PROFINET or the boot operation for the node was restarted.
2	SDO aborted or not yet started because once the node was successfully booted it had a Heartbeat or Node Guarding error.
3	SDO started but aborted by the module (cause according to CiA 301 in additional error information code).
4	SDO started but SDO abort received (received cause according to CiA 301 in additional error information code).
255	Busy = SDO access not complete yet. RDREC must be repeated.

Following an abort of the SDO access (triggered by the module itself or by the slave addressed by the SDO), the "Additional error information code" field is filled with the SDO abort code according to CiA 301.

When the RDREC is finished, the SDO access for the module is complete. The device is then ready for a new SDO command. An additional RDREC without a preceding successful WRREC returns an error code.

See also

Service Data Objects (SDO) (Page 25)

Data exchange between the SIMATIC S7 controller and the module (Page 27)

Changes compared to previous version (Page 13)

4.1.2.4 CANopen manager - Monitoring Functions

The module supports the "Heartbeat" and "Node Guarding" functions both as transmitter (producer) and as receiver (consumer). One of these two monitoring functions must be activated in the HSP.

Heartbeat

The module can be operated as a heartbeat producer and a heartbeat consumer simultaneously.

The required monitoring times (Transmit interval, Monitoring time) can be configured in the HSP.

NOTE

As of firmware version V1.1

The "Heartbeat" function can be disabled by setting the Transmit interval and the Monitoring time to "0".

Node Guarding

Node Guarding monitoring can be configured. You can set the needed parameters "Monitoring time" and "Repetition factor". The module can be operated as a transmitter and a receiver simultaneously.

NOTE

As of firmware version V1.1

The "Node Guarding" function can be disabled by setting the Repetition factor or the Monitoring time to "0".

Error responses

The module saves the current state of the slaves configured in the HSP. If a monitored CANopen slave fails or changes to an unexpected state, the module signals corresponding diagnostic information to the SIMATIC S7 controller. If the slave is configured as "required in the network", the defined error reaction is performed.

The following reactions can be set for the failure of a mandatory node:

Reaction	Description
Restart of triggering node	The CANopen slave is reset by NMT and the boot-up procedure including configuration is repeated for this slave. The state of the module and the state of the other CANopen slaves does not change.
Restart of the device (CM CAN) and all nodes	All CANopen slaves are reset via NMT and the boot-up procedure including configuration is repeated for all slaves.
Stop the device (CM CAN) and all nodes	The state of the module switches to "CAN network Stopped" and all CANopen slaves are put into "Stopped" state via NMT. The state can only be exited by a reset as follows: • By the reset bit in the cyclic data of the SIMATIC S7 controller • By re-configuration of the module by the SIMATIC S7 controller

NOTE

- CANopen slaves that are not configured by the user as "mandatory" do not trigger the set error response. When such a slave fails or signals an unexpected state, the slave is reset by NMT and the boot-up procedure including configuration is repeated for this slave. The module state and the state of the other CANopen slaves does not change.
- If the error response is "Restart of the device (CM CAN) and all nodes" or "Stop the device (CM CAN) and all nodes", the following applies: The triggered error response affects both the "mandatory" slaves and the slaves that are not configured as "mandatory" by the user.

As of firmware version V1.1:

- When the "Enable diagnostic alarms for not mandatory nodes" check box is selected, the master works exactly as the original device version 1.0. This means all error messages are sent to the diagnostics buffer and the ERROR LED lights up.
- When the "Enable diagnostic alarms for not mandatory nodes" check box is cleared, no error messages are sent to the diagnostics buffer and the ERROR LED remains off.

As of firmware version V1.2:

The following behavior supplements the error response behavior of V1.1:

- If the "Enable diagnostic interrupts for not mandatory nodes" check box and "Block Error passive alarm" check box are both selected at once and a node that you have selected as not mandatory triggers an Error Passive alarm, this alarm is not sent to the diagnostic buffer.

  If the "Enable diagnostic alarms for not mandatory nodes" check box is selected and the "Block Error passive alarm" check box is deselected and a passive error occurs in the device, this error is sent to the diagnostic buffer. The ERROR LED flashes red.
- If the "Enable diagnostic alarms for not mandatory nodes" check box is deselected, the "Error Block passive alarm" check box has no effect: No error messages are set to the diagnostic buffer, and the ERROR LED remains off for nodes that you have selected as not mandatory.

4.1.3 CANopen slave

4.1.3.1 Overview

When the module is operated in "CANopen slave" mode, the module does not take over the following functions in the CANopen network:

- Function of the NMT master
- Function of the Configuration Manager

If you operate the module in "CANopen slave" mode, most of the configuration settings are not defined in the TIA Portal, but instead during startup, e.g. configuration settings for Heartbeat or for the PDOs. During startup, the configuration settings are written to the OD of the module by the responsible CANopen manager using SDO commands.

NOTE

The module in the "CANopen slave" mode obtains a configuration from a "CANopen manager", whose remanent storage in the module is not supported.

4.1.3.2 CANopen slave - Object Dictionary

In "CANopen slave" mode, the module offers the following OD entries. The "Access type" column specifies whether the entry can be read (R) or written (W) via SDO.

OD entry	Access type	Meaning
1000h	R	Device type (always "0")
1001h	R	Current error state.
1003h	R	List of errors that occurred (max. 4 entries).
1005h	RW	COB-ID for SYNC message together with the setting of whether the module is a SYNC transmitter.
1006h	RW	Interval for SYNC messages.
1008h	R	Device name as character string. Default: "ET 200SP CM CAN Slave"; the entry can be edited, you can find more information in section Configuration in the TIA Portal (Page 71) under Setting communication parameters > Vendor device name
1009h	R	Hardware version as character string. Corresponds to the HW version that can also be read out via PROFINET by IM0.
100Ah	R	Software version as character string. Corresponds to the SW version that can also be read out via PROFINET by IM0, e.g. "V 1.0.0 [Build xxx]".
100Ch	RW	"Monitoring time" for the Node Guarding protocol
100Dh	RW	"Repetition factor" for the Node Guarding protocol
1014h	RW	"COB ID" for the EMCY messages transmitted by the module

1016h	RW	Field for "Receiver Heartbeat Time", i.e. the setting that the module monitors the CANopen nodes via a Heartbeat .
1017h	RW	"Sender Heartbeat Time". Interval at which the module transmits heartbeat messages.
1018h	R	Identity Object, identifies the device
1029h	RW	Determines the error response of the module. Only the entry for "Communication errors" is implemented.
1200h	R	SDO Server Channel
1400h-15FFh	RW	RX-PDO Communication parameters
1600h-17FFh	RW	RX-PDO Mapping parameters
1800h-19FFh	RW	TX-PDO Communication parameters
1A00h-1BFFh	RW	TX-PDO Mapping parameters
2000h-6FFFh	RW	Entries for the process data to be exchanged with the SIMATIC S7 controller. Entries for input data that comes from the SIMATIC S7 controller are in CANopen "Read Only".

4.1.3.3 CANopen slave - State Model

State model of the "CANopen slave" mode

The state model in "CANopen slave" mode is based on the NMT state model described in the CiA standard "CiA 301".

The following figure shows the states of the module in "CANopen slave" mode.

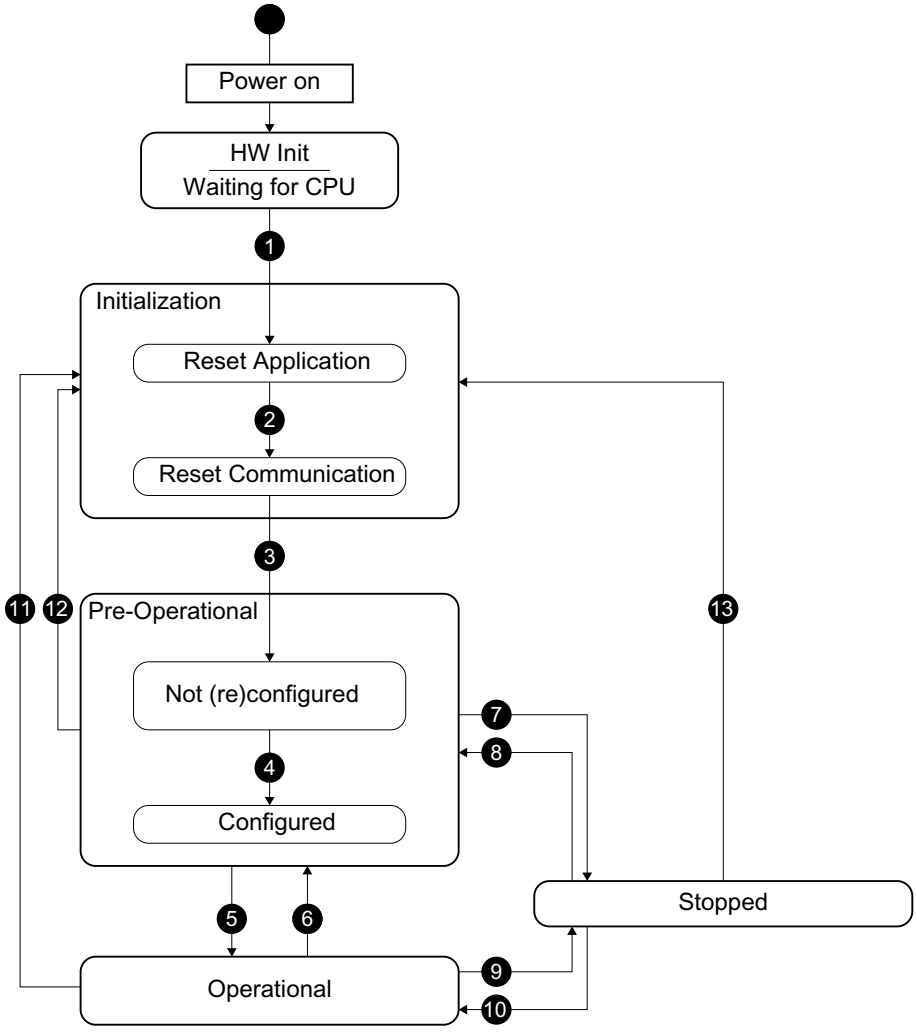

Figure 2-1394 State model CANopen slave

Module states

The following table describes the states in "CANopen slave" mode.

Table 2-1783 "CANopen slave" module states

Module state	Meaning
HW Init / Waiting for SIMATIC S7 controller.	The state of the module during booting and when the module is not yet fully configured by the SIMATIC S7 controller. This is not a defined NMT state in CANopen standard.
Initialization	Initialization state. The entries in the "Communication parameters" are reset to factory settings. All parameters configured in the HSP are reset to the values set in the HSP. Communication is reset as well. CANopen distinguishes between the following sub-states: • "Reset Application": The OD entries not equal to 1xxxh are reset. For the module, this is the process data that is exchanged with the SIMATIC S7 controller. • "Reset Communication": The OD entries of the "Communication Profile Area" (OD 1xxxh) and thus the CANopen communication are reset.
Pre-Operational	In this state, the CANopen manager can configure the Slaves and synchronize them via SYNC. Except for PDOs, all other types of communication are active, e.g. SYNC, SDO, Heartbeat.
Operational	Normal operation, all communication types are active.
Stopped	Only Heartbeat / Node-Guarding are active but device can still be controlled via NMT, "applicative OFF state".

State transitions

The following table describes the state transitions in "CANopen slave" mode.

Table 2-1784 State transitions "CANopen slave":

Transition	Meaning / trigger
1	Takes place automatically if the module has been configured for the first time since boot-up of the SIMATIC S7 controller.
2	Takes place automatically.
3	Takes place automatically. A "Boot-up" message is transmitted.
4	No "real" transition, does not know "configured" / "not configured" state. But: During configuration by the CANopen manager, the communication behavior of the module changes, for example, when the manager has configured "Heartbeat".
5	Triggered by an NMT command from the CANopen manager.
6	Triggered by an NMT command from the CANopen manager, by a "Communication Error" if OD 1029h was configured accordingly, or by a change of the control bit transmitted by the SIMATIC S7 controller in the cyclic data to "OFF".
7	Triggered by an NMT command from the CANopen manager or by a "Communication Error" if OD 1029h was configured accordingly.
8	Triggered by an NMT command from the CANopen manager.

9	Triggered by an NMT command from the CANopen manager or by a "Communication Error" if OD 1029h was configured accordingly.
10	Triggered by an NMT command from the CANopen manager.
11, 12, 13	Can be triggered by: • An NMT command from the CANopen Manager (transition to sub-state "Reset Application" or "Reset Communication", depending on the command) • The Reset Bit from the SIMATIC S7 controller (transition to "Reset Application" sub-state) • Reconfiguration by the SIMATIC S7 controller (transition to "Reset Application" sub-state)

4.1.3.4 CANopen slave - Control and Status Information

Control information

The following control information is transmitted from the SIMATIC S7 controller to the ET 200SP CM CAN communication module:

Table 2-1785 Structure of control information in the PROFINET IO data (from the SIMATIC S7 controller to the module, 1 byte)

Bit		Value	Meaning
7 ... 2	Reserved	Must be "0"	--
1	Reset bit	1	The CANopen side is reset when the bit changes to "1". All OD entries are reset to initial values and the startup message is sent. In this case, the CANopen manager must configure and start the CM CAN again. The module acknowledges the receipt of the reset command by setting the reset acknowledgment bit in the data for the SIMATIC S7 controller to "1". The SIMATIC S7 controller can then set the reset bit to "0" .
		0	When the reset has been performed and the reset bit is "0", the module sets the reset acknowledgment bit to "0".
0	Control bit	0	The module must not be in "Operational" NMT state. If the current state is "Operational", the module switches to the "Pre-Operational" state. Commands from the NMT master to switch to the "Operational" state are ignored.
		1	The NMT master can set the module to the "Operational" state with the NMT command.

Status information

The following status information is transferred from the ET 200SP CM CAN to the SIMATIC S7-controller:

Table 2-1786 Structure of status information in the PROFINET IO data (from the module to the SIMATIC S7 controller, 1 byte)

Bit	Meaning	Possible values		Note
7	Reserved	--		--
6	Reset acknowledgment bit	0	The module is ready for reset.	In order to give feedback to the SIMATIC S7 controller about the reset of the CANopen side, the reset acknowledgment bit is used in the data cyclically transmitted from the module to the SIMATIC S7 controller. As soon as the command for resetting the CANopen side has been received, this bit is set to "1". Afterwards, the SIMATIC S7 controller must set the reset bit to "0". When the reset of the CANopen side is complete, the module sets the reset acknowledgment bit to "0".
		1	The module is currently performing or has performed a reset but the reset bit of the SIMATIC S7 controller is still set to "1".	--
5 ... 3	Module state	0	Reserved	--
		1	Status "Pre-Operational"	--
		2	Status "Operational"	--
		3	Status "Stopped"	--
		4	Reserved	--

1) The error counters customary in CAN and their associated thresholds are internal functions that are not visible to the user.

Bit	Meaning	Possible values		Note
5 ... 3	Module state	5	Status "Not configured"	Ready to receive the extended parameter assignment
		6	Status "Bad parameterization"	The extended parameter assignment failed. Re-configuration required.
		7	Reserved	--
2	Group status of all data	0	OD entries whose values have not yet been updated by a corresponding PDO since the last reset.	--
		1	All OD entries have been updated at least once since the last reset via PDO or SDO.	--
1 ... 0	State of the CAN controller	0	Off	When specified accordingly by the SIMATIC S7 controller.

1) The error counters customary in CAN and their associated thresholds are internal functions that are not visible to the user.

Bit	Meaning	Possible values		Note
1 ... 0	State of the CAN controller	1	Bus-Off	Error counter[1)] has exceeded the specified threshold. The module can then no longer transmit/receive packets. Note: "Bus Off" is also signaled when the module needs more than 2 seconds to synchronize with the CAN bus.
		2	Error Passive	Error counter[1)] has reached the specified threshold. The module continues to transmit/receive packets.
		3	Error Active	Error counter[1)] is below a specified threshold. The module transmits/receives packets. This is the normal state. Everything is okay.

1) The error counters customary in CAN and their associated thresholds are internal functions that are not visible to the user.

NOTE

For values made up of multiple bits, the first bit is the MSB and the last bit is the LSB.

Example: Bit 1 ... 0 = "2" means that bit 0 = "0" and bit 1 = "1".

4.1.3.5 CANopen slave - Monitoring Functions

The device supports Heartbeat and Node Guarding as transmitter (producer) as well as receiver (consumer). The settings for these two functions are written to the OD of the module via SDO access by the "CANopen manager" responsible for the CANopen network.

When a monitored CANopen device fails, the module signals corresponding diagnostic information to the SIMATIC S7 controller. In addition, an EMCY message is transmitted on the CANopen side and the configured error response specified in the OD entry "ErrorBehaviour" at address 1029h, subindex 01h is executed.

Error responses

The following error responses are supported:

Subindex value	Description
00h	Change to the state "Pre-Operational" only when the current state is "Operational".
01h	Current state is retained, i.e. no response
02h	Change to the state "Stopped"

4.1.4 Response to error

Diagnostic information

When an error occurs, the corresponding error LED on the CAN side (ERR LED) is activated. The diagnostic message can be read out with the TIA Portal.

Information on the events that trigger a diagnostics alarm is available in the section Service Data Objects (SDO) (Page 25). Section Diagnostics alarms (Page 116) includes a detailed description of the error that triggers the diagnostic message and possible measures. This information is also stored in the TIA Portal .

As of firmware version V1.2

If the "Block Error passive alarm" check box is selected and a node triggers an Error Passive alarm, this alarm is not sent to the diagnostic buffer. The ERROR LED remains off.

If the "Block Error passive alarm" check box is deselected and a passive error occurs in the device, this error is sent to the diagnostic buffer. The ERROR LED flashes red.

Failure of communication via PDOs

When communication via PDOs fails, the values in the corresponding OD entries remain valid. Data contents remain valid until a new value is present.

Failure of a CAN node

The failure of a fieldbus node as well as "bus problems" on the CAN side are signaled to the SIMATIC S7 controller using diagnostic information.

Error Register

The Error Register entry (OD 1001h) indicates the current error state of the device.

The module uses the following bits from this entry:

Table 2-1787 Bits in the Error Register entry

Bit		Meaning
7	Manufacturer-specific error	Bit is set when the module is configured as "CANopen slave" and the control bit transmitted by the SIMATIC S7 controller in the cyclic data is set to "OFF".
4	Communication error	Bit is set when: • SIMATIC S7 controller connection fails. • The data from the SIMATIC S7 controller has the IO provider status "Bad".
0	Generic error	Bit is set in "any error situation", according to CiA standard "CiA 301", which means when a specific error bit is set as well as for errors that are not mapped to specific error bits.

EMCY messages

The EMCY messages to be sent when errors occur are permanently specified and cannot be configured by the user.

In "CANopen manager" mode, users can configure whether diagnostic information is sent to the SIMATIC S7 controller by the module when an error occurs.

Received EMCY messages are signaled to the IO controller in advanced PROFINET diagnostics. This function can be activated or deactivated through configuration. You can find more information in section Service Data Objects (SDO) (Page 25).

LED displays

The module signals its state in both "CANopen manager" mode and "CANopen slave" mode with the LEDs on the front of the enclosure. The meaning of the LEDs is described in section Status and error display (Page 112).

4.2 CAN transparent

4.2.1 Overview

In "CAN transparent" mode, all CANopen functions are disabled. Over the bus, the module only communicates with the CAN2.0A(B) protocol according to ISO standard 11898 (ISO 11898-2). The operating mode for the module is set using the associated HSP in the TIA Portal.

4.2.2 CAN transparent - state model

In "CAN transparent" mode, the module knows only the two states "OFF" and "ON".

Module state "OFF"

No CAN frames are transmitted or received in this state. The module does not participate in the CAN Bus communication and does not transmit or receive messages or any error frames.

The module assumes the "OFF" state when

- The module is not connected to a SIMATIC S7 controller.
- The data from the SIMATIC S7 controller has the IO Provider status "Bad".

Module state "ON"

In this state, the module participates in the CAN Bus communication. The module transmits and receives CAN frames except when the CAN controller is in Bus-Off state.

Dependency of the module state on the status of the SIMATIC S7 controller

Event	Reaction
The module has never been connected to the SIMATIC S7 controller or has not been configured since boot-up.	Module state is "OFF".
SIMATIC S7 controller connected / not yet completely configured	The module receives the necessary configuration data from the SIMATIC S7 controller. For the "receive message modules" the input data is preassigned according to the parameter assignment. Module state is "OFF".
SIMATIC S7 controller connected / completely configured / data from the SIMATIC S7 controller has the IO Provider Status "Bad".	Module state is "OFF".
Data from the SIMATIC S7 controller has the IO Provider Status "Good"	The module takes on its state based on the control bits ("OFF" or "ON"). The control bits are contained in the cyclic data that comes from the SIMATIC S7 controller.
SIMATIC S7 controller goes to STOP	Module state is "OFF".

Event	Reaction
SIMATIC S7 controller goes to RUN	The module takes on its state based on the control bits ("OFF" or "ON"). The control bits are contained in the cyclic data that comes from the SIMATIC S7 controller.
Termination of the SIMATIC S7 controller connection (after the module has already been configured once by the SIMATIC S7 controller)	Module state is "OFF".
Reconfiguration by the SIMATIC S7 controller	The module receives the necessary configuration data from the SIMATIC S7 controller. For the "receive message modules" the input data is preassigned according to the parameter assignment. Module state is "OFF".

4.2.3 CAN transparent - CAN messages

In "CAN transparent" mode, data can be exchanged using configurable or programmable messages, both of which can be used simultaneously.

Configurable CAN messages

The configurable CAN messages have a fixed message ID and a fixed length. The "Transmit message" and "Receive message" submodules are available in the TIA Portal for configuring. For more information, see section Configuring CAN transparent (Page 100).

You can use message IDs in the following formats:

- Standard format CAN 2.0A (11-bit message ID)
- Extended CAN format CAN 2.0B (29-bit message ID)

NOTE

Flow control is not provided. Intermediate values may be overwritten in the following cases:

- When data arrives via CAN messages faster than it can be sent via PROFINET.
- When data is changed by PROFINET faster than it can be sent via CAN.

Changes on the CAN bus may not be visible in this process.

The operating principle of the fixed CAN messages is based on a data image. This means a loss of intermediate values is acceptable.

Fixed messages can be transmitted as follows:

- When the data to be transmitted changes
- Time-controlled, i.e. as soon as the configured cycle time has elapsed

With this transmission mode, the user data of the CAN messages is transmitted between the SIMATIC S7 controller and the module in the cyclic IO image.

Programmable CAN messages (proxy)

In "CAN transparent" mode, the use of CAN messages for which the message ID and the length (max. 8 bytes) is only defined by the user program during runtime is possible.

With this transmission mode, protocol information in addition to the actual user data is transmitted between the SIMATIC S7 controller and the module in the cyclic IO image.

The message ID format (11 bits or 29 bits) is determined by bit 29 in the message ID. If this bit is set, use the message ID format with 29 bits.

The transmitting and receiving of CAN messages from the user program is possible using transmit and receive proxy modules. For additional information, see section Cyclical data exchange between the SIMATIC S7 controller and the module with programmed CAN messages (proxy) (Page 54)

4.2.4 CAN transparent - control and status information

CAN transparent

The following control information is transmitted from the SIMATIC S7 controller to the ET 200SP CM CAN communication module:

Table 2-1788 Control information in the PROFINET IO data (from the SIMATIC S7 controller to the module, 1 byte)

Bit	Meaning	Possible values		Note
7 ... 1	Reserved	0	Values must be "0"	---
0	Control bit	0	No CAN communication	The CAN controller should be "OFF".
		1	CAN communication active	The CAN controller should be "ON".

The following status information is transferred from the ET 200SP CM CAN communication module to the SIMATIC S7 controller:

Table 2-1789 Status information in the PROFINET IO data (from the module to the SIMATIC S7 controller, 1 byte)

Bit	Meaning	Possible values		Note
7 ... 6	Reserved	--	--	--
5 ... 3	Module state	0 ... 4	Reserved	--
		5	Status "Not configured"	Ready to receive the extended parameter assignment.
		6	Status "Bad parameterization"	Extended parameter assignment failed. Re-configuration required.
		7	Reserved	--
2	Group status of all data	0	Not all configured receive messages have been received at least once since the last transition to "ON".	--

1) The error counters customary in CAN and their associated thresholds are internal functions that are not visible to the user.

Bit	Meaning	Possible values		Note
2	Group status of all data	1	All configured receive messages have been received at least once since the last transition to "ON".	--
1 ... 0	State of the CAN controller	0	Off	As specified by the SIMATIC S7 controller.
		1	Bus-off	Error counter[1)] has exceeded the specified threshold or the module needs more than 2 seconds to synchronize with the CAN Bus. The module no longer transmits/receives any packets.
		2	Error Passive	Error counter[1)] has reached the specified threshold. The module continues to transmit/receive packets.
		3	Error Active	Error counter[1)] is below a specified threshold. This is the normal state. Everything is okay.

1) The error counters customary in CAN and their associated thresholds are internal functions that are not visible to the user.

NOTE

For values made up of multiple bits, the first bit is the MSB and the last bit is the LSB.

Example: Bit 1 ... 0 = 2 means: Bit 0 = "0" and Bit 1 = "1".

4.2.5 Cyclical data exchange between the SIMATIC S7 controller and the module with configured CAN messages

CAN messages with output data (transmit message)

The "transmit messages" can be configured in the TIA Portal. Each of these messages has its own message ID, which is configured in the TIA Portal, and its own data, which is transmitted cyclically to the module in the output process image of the SIMATIC S7 controller.

The module sends a CAN message with the message ID and the current data:

- When the data changes
- When a CAN RTR frame (Remote Transmit Request) with the matching message ID has been received.
- During transition of the module to "ON" state
- Cyclically, if configured accordingly.

The triggers are independent of each other. That is, the configured transmit cycle is retained even if a message based on a data change or an RTR has been sent in the interim.

If configured, the module changes the order of specific data bytes for fixed CAN messages prior to sending to compensate for the different "endianness" of PROFINET and CAN.

PROFINET uses "Big Endian", CAN usually uses "Little Endian". For programmed CAN messages, however, the order of the data bytes is not changed.

CAN messages with input data (receive messages)

The "receive messages" can be configured in the TIA Portal. Each of these messages has its own message ID, which is configured in the TIA Portal, and its own data, which is transmitted cyclically from the module to the SIMATIC S7 controller as part of the input process image.

The values of the input data are assigned during configuration of the module by the SIMATIC S7 controller according to the configuration.

If a CAN frame with the configured message ID has been received, the order of the data bytes is first changed, if necessary, to correct the "endianness" before the data is transferred to the input data for the SIMATIC S7 controller.

A setting can be made during configuration so that the module transmits an RTR frame with the configured message ID on the CAN bus during transition to module state "ON". This frame requests that the associated counterpart sends the corresponding data message.

As soon as a module changes to "ON" state, it monitors the receipt of CAN messages of all configured message IDs and transmits information about them, compressed into one status bit, to the SIMATIC S7 controller. As long as there is at least one configured message ID from which a CAN message has not yet been received, a zero is transmitted to the SIMATIC S7 controller in the status bit.

4.2.6 Cyclical data exchange between the SIMATIC S7 controller and the module with programmed CAN messages (proxy)

"Transmit proxies" and "Receive proxies" can be set up in the TIA Portal.

These proxies serve as a "communication channel" that enables the user program to send and receive any CAN messages not configured beforehand.

The use of multiple transmit / receive proxies facilitates programming of the user program because they are independent of the communication channels.

Example of a transmit proxy:

Two code locations want to transmit CAN messages. When you set up two transmit proxies, these messages do not have to be synchronized or matched. Each code location uses its own proxy.

Example of a receive proxy:

Since each receive proxy has its own "receive filter list", you can use several proxies to pre-filter messages according to the CAN ID, e.g. a receive proxy only for "commands" and a receive proxy for "status messages".

Max. number of send/receive proxies

The boundary condition for defining the proxy messages is the size of the IO data.

A transmit proxy message (Tx) has the size of 1 input byte and 13 output bytes.

A receive proxy message (Rx) has the size of 13 input bytes and 1 output byte.

The maximum number of free IO data for the CM CAN module is 255 (256 - 1) bytes per direction.

Thus you can configure the following proxies:

- 19 Tx (or Rx): 255 / 13 = 19 (8 bytes left)
- And 8 Rx (or Tx): the rest of 8 bytes

The maximum number of proxies in a mixed configuration of Tx and Rx proxies is 18 (255 / 14) in one direction. This configuration contains a total of 36 proxies:

- 18 Tx: 255 / 14
- And 18 Rx: 255 / 14

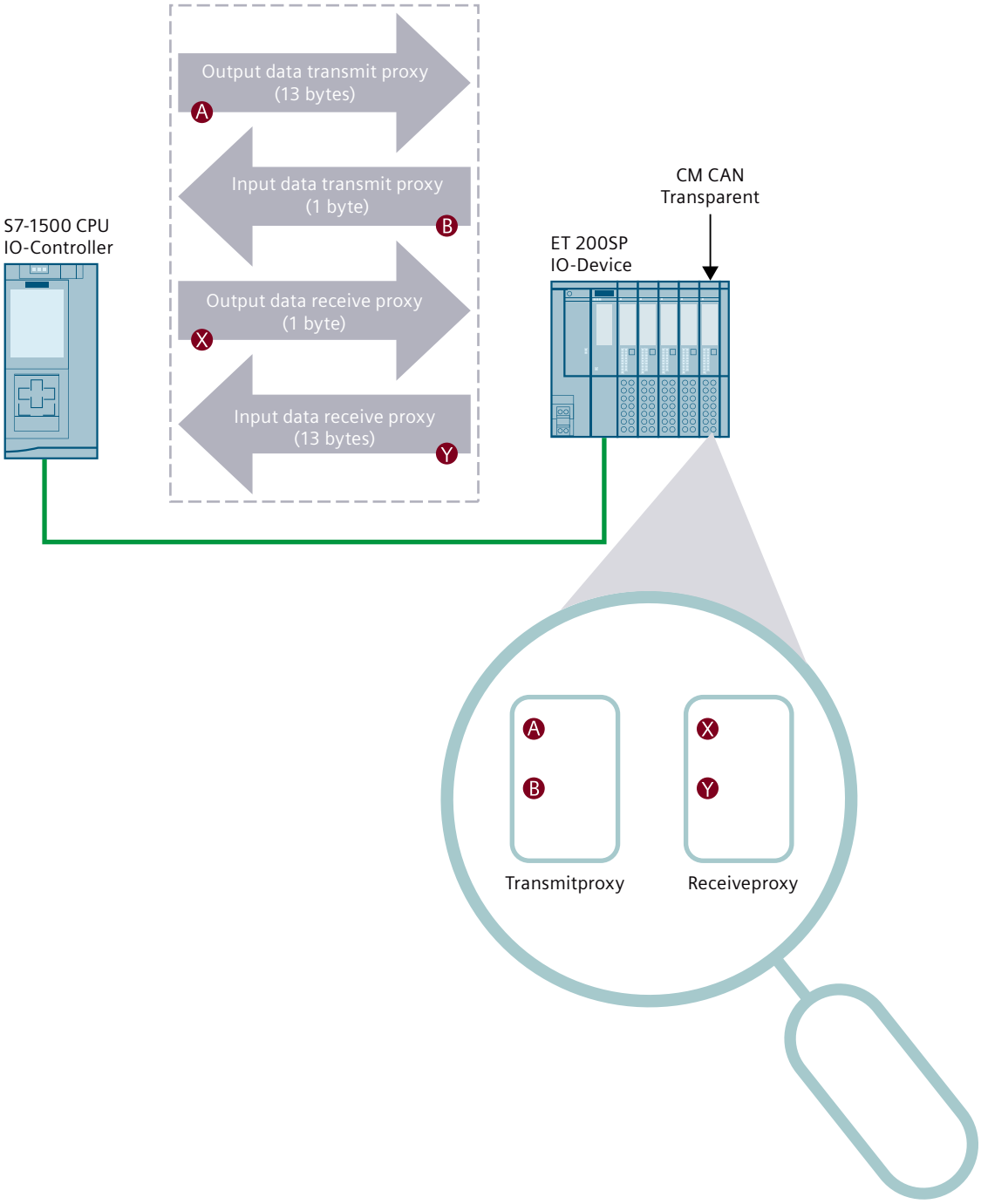

Figure 2-1395 Cyclic data exchange

Transmit proxy

CAN messages can be transmitted from the user program with the transmit proxy. The transmit proxy contains cyclic PROFINET input and output data.

In the output data from the SIMATIC S7 controller to the module, the following information is transmitted for the frame to be sent to the module:

- Message ID
- Length
- User data
- Flag, whether RTR or data CAN message

In the input data from the module to the SIMATIC S7 controller, the module acknowledges the entry of the message in the CAN transmit buffer in the module. This does not always mean, however, that the message has been transmitted on the CAN bus.

NOTE

The order of the data bytes in the CAN messages to be sent is not changed in the module. Any necessary adaptation to compensate for "endianness" must be made in the user program.

NOTE

For values made up of multiple bits, the first bit is the MSB and the last bit is the LSB.

Example: Byte.Bit 3.0 ... 4.6 = 2 means: Byte 3 Bit 0 = "0", Byte 4 Bit 7 = "1" and Byte 4 Bit 6 = "0"

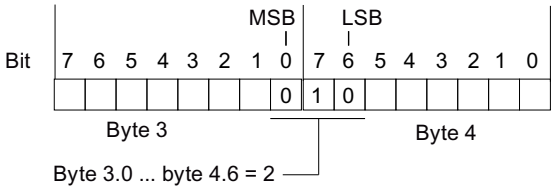

Table 2-1790 Structure of the output data for send proxy (from the SIMATIC S7 controller to the module, 13 bytes)

Byte.Bit	Meaning
0.7 ... 0.5	Reserved, must be "0"
0.4 ... 0.1	**Number of data bytes** Permitted values are 0 to 8. Values 9 to 15 cause the CAN message to be discarded and the "Last data faulty bit" to be set.
0.0	**Send** When the bit changes to 1, the other data is applied and a corresponding CAN message is entered in the transmit buffer. The module acknowledges the receipt of the transmit command by setting the transmit acknowledgment bit in the data for the SIMATIC S7 controller to "1". The SIMATIC S7 controller can then set the transmit bit to "0" and must wait until the module has also set the transmit acknowledgment bit to "0". Only then can a new transmit command be issued.

Byte.Bit	Meaning
	Note: If the control bit is "0", the CAN messages are not entered in the transmit buffer but are discarded instead.
1.7	Reserved, must be "0"
1.6	**RTR-Flag** 0 = Normal data frame transmission 1 = RTR frame transmission
1.5	**11/29-bit message ID** 0 = 11 Message ID bit 1 = 29 Message ID bit
1.4 ... 4.0	**Message ID (in Big Endian)** For 11-bit message IDs, byte 3 bit 2 is the most significant bit and byte 4 bit 0 the least significant bit. The remaining bits are ignored. For 29 bit message IDs, byte 1 bit 4 is the most significant bit and byte 4 bit 0 the least significant bit.
5-12	**Data bytes** In the order in which they are going to be sent

Table 2-1791 Structure of the input data for send proxy (from the SIMATIC S7 controller to the module, 1 bytes)

Byte.Bit	Meaning
0.7 ... 0.3	Reserved, must not be evaluated
0.2	**Transmit buffer overflow** Set to "1" by the module when a CAN message could not be entered in the transmit buffer because it is full. A corresponding diagnostic information is also sent in this case. The bit is reset to "0" when the transmit acknowledgment bit is set to "0".
0.1	**Last data faulty** Set to "1" by the module when "Number of data bytes" > 8. The bit is reset to "0" when the transmit acknowledgment bit is set to "0".
0.0	**Transmit acknowledgment** Set to "1" by the module as soon as the transmit bit is "1". When the transmit bit changes to "0", the module sets the transmit acknowledgment bit to "0" as soon as it has transmitted the message to be sent to the transmit buffer of the CAN controller.

Receive proxy

CAN messages can be received from the user program with the receive proxy. The module manages a list of message IDs ("filters") on the module side that it receives on the CAN bus.

The list can be preassigned during configuration and changed at runtime from the user program by writing a corresponding data record.

If a corresponding CAN message is received, it is entered in a receive buffer. The message is transmitted from this buffer to the SIMATIC S7 controller in the cyclic input data. The size of the receive buffer is specified in the configuration.

Using the output data (from the SIMATIC S7 controller to the module), the user program can:

- Acknowledge the successful transmission of a CAN message from the module to the SIMATIC S7 controller
- Instruct the module to ignore the receive filter. Then all CAN messages are copied into the receive buffer.
- Instruct the module to delete all CAN messages in the receive buffer.

In the input data from the module to the SIMATIC S7 controller , the module transmits received CAN messages and information on whether there was a receive buffer overflow. Such an overflow occurs when too many CAN messages with matching message IDs were received before they could be transmitted to the SIMATIC S7 controller.

NOTE

The order of the data bytes in the received CAN messages is not changed in the module. Any necessary adaptation to compensate for "endianness" must be made in the user program.

NOTE

For values made up of multiple bits, the first bit is the MSB and the last bit is the LSB.

Example: Byte.Bit 3.0 ... 4.6 = 2 means that Byte 3 Bit 0 = "0", Byte 4 Bit 7 = "1" and Byte 4 Bit 6 = "0".

Table 2-1792 Structure of the output data for receive proxy (from the SIMATIC S7 controller to the module, 1 byte)

Byte.Bit	Meaning
0.7	**Receive buffer** 0 = No action. 1 = All CAN messages in the receive buffer are deleted.
0.6	**Receive filter** 0 = Only received CAN messages that match the receive filter are entered in the receive buffer and forwarded to the SIMATIC S7 controller later. 1 = All received CAN messages are entered into the receive buffer and later forwarded to the SIMATIC S7 controller.
0.5 ... 0.1	Reserved, must be 0
0.0	**Receive enable** If the bit has the value 1 and the module has a CAN message in the receive buffer of the receive proxy, the module enters the message in the data for the SIMATIC S7 controller and sets the "Message exists" bit to "1". The SIMATIC S7 controller must then set the receive enable bit to "0" and must wait until the module has also set the "Message exists" bit to "0". Only then may the SIMATIC S7 controller set the receive enable bit to "1" again.

Table 2-1793 Structure of the input data for receive proxy (from the SIMATIC S7 controller to the module, 13 bytes)

Byte.Bit	Meaning
0.7	**Message exists** 0 = No message in the receive buffer 1 = Message(s) in the receive buffer Bit is always "1" when the transfer bit = 1 because the message stays "in the buffer" until the transfer is "completed".
0.6	**Receive filter** 0 = A valid receive filter is set. 1 = No valid receive filter was set. If the receive filter bit is set to "0", no messages at all are forwarded to the SIMATIC S7 controller.
0.5	**Receive buffer overflow** 1 = The receive buffer is full. At least one message was discarded. Note: May only be evaluated when the transfer bit is "1".
0.4 ... 0.1	**Number of data bytes in the received CAN message** Value range is 0 to 8. Note: May only be evaluated when the transfer bit is "1".
0.0	**Transfer** If the bit is "1", a received message is currently being transferred. The SIMATIC S7 controller should then set the receive enable bit to "0".
1.7	Reserved, must be "0"
1.6	**RTR-Flag of the received CAN message** 0 = Normal data message 1 = RTR message Note: May only be evaluated when the transfer bit is "1".
1.5	**11/29-bit message ID of the received CAN message** 0 = 11 Message ID bit 1 = 29 Message ID bit Note: May only be evaluated when the transfer bit is "1".
1.4 ... 4.0	**Message ID of the received CAN message (in Big Endian)** For 11-bit message IDs, byte 3 bit 2 is the most significant bit and byte 4 bit 0 the least significant bit (the other bits are ignored) For 29 bit message IDs, byte 1 bit 4 is the most significant bit and byte 4 bit 0 the least significant bit. Note: May only be evaluated when the transfer bit is "1".
5-12	**Data bytes of the received CAN message** In the order in which they were received. Only the corresponding "Number of data bytes in the received CAN message" may be evaluated. Note: May only be evaluated when the transfer bit is "1".

Note on the use of a receive proxy

Representation of bits

1. "Receive enable" is a bit that can be used to copy data to the SIMATIC S7 controller (you can control this bit).
2. "Message exists" is a bit that signals that there is a message in the input buffer.
3. "Transfer" signals that the current position from the input buffer is actively transferred to the SIMATIC S7 controller.

Procedure

1. Set "Receive enable" to "1" and wait until "Message exists" is also "1".
2. When this happens, the first message is copied to the SIMATIC S7 controller and "Transfer" is set to "1".
3. Set "Receive enable" to "0" and wait until "Transfer" is set to "0".
4. Repeat the operation starting at step 1.

Changing the receive filters during runtime

By writing a record set (with WRREC) with the index 0x210 into the module, the receive filters may be changed by the user program during runtime.

The module makes the corresponding data record available on the respective receive proxy.

The data record consists of:

- 1 byte long index of receive proxy

- n*8 byte long filters

The data record overwrites all filters of the receive proxy. After the first index byte, filters from 1 to 16 are sent to the data record.

Each individual filter consists of a 32-bit value "Criterion" and a 32-bit value "Mask".

If a bit in "Mask" is "0", the received CAN messages are **not** checked against the corresponding bit in the "Criterion".

To ensure that a bit set in "Criterion" acts as a filter, the corresponding bit in the "Mask" must be set to "1".

Structure of the data to be written with WRREC

Data record size: 1+8*n bytes; n = Number of filters = 1 to 16.

```
Index of the receive proxy (8-bit)
Criterion filter 1 (32-bit, Big Endian)
Mask filter 1 (32-bit, Big Endian)
Criterion filter 2 (32-bit, Big Endian)
Mask filter 2 (32-bit, Big Endian)
...
Criterion filter 16 (32-bit, Big Endian)
Mask filter 16 (32-bit, Big Endian)
```

NOTE

If the number of written bytes is not a multiple of "8", the extra bytes are ignored. A maximum of 16 filters with 4 bytes each for Criterion and Mask are permitted. If the number of written bytes is > 128, write access (WRREC) is rejected with error code 0xDF80B100 and the filters remain unchanged.

Coding of the bits in "Criterion" and "Mask"

The bits in "Criterion" and "Mask" are coded as follows.

NOTE

For values made up of multiple bits, the first bit is the MSB and the last bit is the LSB.
Example: Bit 28 ... 27 = "2" means that bit 28 = "1" and bit 27 = "0"

Bit	Meaning
31	**Filter valid (only with "Criterion")** 0 = Filter is valid 1 = Filter is invalid and is ignored by the module For "Mask" the bit is reserved and must always be 0.
30	**RTR** 0 = Only data messages are entered in the receive buffer 1 = Only RTR messages are entered in the receive buffer
29	**11/29-bit message ID** 0 = Only CAN messages with 11-bit message ID are entered in the receive buffer. 1 = Only CAN messages with 29-bit message ID are entered in the receive buffer.
28 ... 0	**Message ID** Only CAN messages with the message ID are entered in the receive buffer. Note: For received CAN messages with 11-bit message ID, bits 28 ...11 in the message are accepted as "0". If one of the bits 28 ... 11 is set in "Criterion" as well as "Filter", the filter will not match any of the received 11-bit messages.

Example:
If a filter is to be set so that only 29-bit data messages with message ID "0x?????9" are received, the following conditions must be met:

- RTR for "Criterion" = 0 and for "Mask" = 1
- 29/11-bit message ID for "Criterion" = 1 and for "Mask" = 1
- Message ID for "Criterion" = 0x9 and for "Mask" = 0xF

This means "Criterion" = 0x20000009 and "Mask" = 0x6000000F

The bytes to be written as data record are therefore "0x20 0x00 0x00 0x09 0x60 0x00 0x00 0x0F"

NOTE

If less than 8 bytes are written or if bit 31 = "1" is true for "Criterion" for all filters, the receive proxy has "no valid receive filter". This is reported to the SIMATIC S7 controller in the corresponding bit in the input data.

4.2.7 CAN transparent - Reaction to fault

Configured CAN messages

If communication fails when communicating via configured CAN messages, the last transmitted values continue to be valid. Data contents remain valid until a new value is present.

If the length of a received CAN package does not match the configured length, the data are not applied and a corresponding diagnostics alarm is sent to the SIMATIC S7 controller.

Diagnostic information

The module sends diagnostics to the SIMATIC S7 controller.

When an error occurs, the corresponding error LED on the CAN side (ERR-LED) is triggered. The diagnostic message can be read out with the TIA Portal.

Information on the events that trigger a diagnostics alarm, the cause of the error and a possible solution is available in the section Diagnostics alarms (Page 116). This information is also stored in the TIA Portal.

As of firmware version V1.2

If the "Block Error passive alarm" check box is selected and a node triggers an Error Passive alarm, this alarm is not sent to the diagnostic buffer. The ERROR LED remains off.

If the "Block Error passive alarm" check box is deselected and a passive error occurs in the device, this error is sent to the diagnostic buffer. The ERROR LED flashes red.

LED displays

In "CAN transparent" mode, the module signals its status via the fieldbus LEDs on the front of the enclosure. The meaning of the LEDs is described in section Status and error display (Page 112).

Connecting 5

5.1 Wiring

Requirements

For the connections, you need a BaseUnit:

- Type A0, BaseUnit light-colored
- Type A0, BaseUnit dark-colored

The BaseUnit is not included in the scope of delivery of the module. Order the BaseUnit separately.

You can find more information on connecting the module in the system manual ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Terminal assignment on the BaseUnit

The designations of the individual terminals in the following table correspond to the labelling on the front of the module.

Table 2-1794 CAN connection

Terminal assignment of the BaseUnits of the module	Terminal	Designation	Terminal function	Meaning
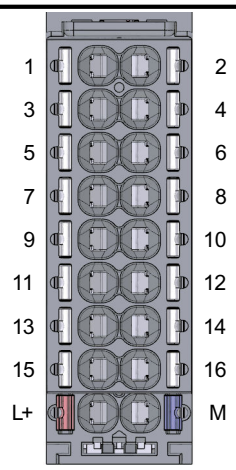	1	HI	CAN_H	CAN_H bus cable (dominant high)
	2	LO	CAN_L	CAN_L bus cable (dominant low)
	3	GND	CAN_GND	CAN Ground
	4	TER	Terminating	Terminating resistor 120 Ω (install jumper from pin 2 to pin 4 for use)
	5-16	RES	Reserved	Reserve remains unconnected for future expansions
Front view				

NOTICE
The electromagnetic compatibility (EMC) is only maintained with shielded CAN cables.

Address space

6

6.1 Address space

Address space

The input and output addresses of the communication module use an address space of 1-256 bytes. The input and output addresses are automatically assigned for each communication module when the device configuration is specified in TIA Portal.

Hardware identifier (not freely configurable)

The hardware identifier (HW identifier) is automatically assigned when the device configuration is defined in the TIA Portal.

The HW identifier is included in diagnostics alarms so that the module involved can be located. The SIMATIC S7 controller requires the HW identifier in communication instructions in order to identify the module involved.

See also

Interface module (https://support.industry.siemens.com/cs/ww/en/ps/14034/man)

CPU (https://support.industry.siemens.com/cs/ww/en/ps/13889/man)

Parameter assignment 7

7.1 Overview

The following section contains compact descriptions of the configuration steps for the 3 operating modes of the CAN communication module:

- CANopen manager
- CANopen slave
- CAN transparent

The descriptions are not based on a concrete example configuration. They are intended to illustrate the basic method for configuring the module and provide a quick introduction to configuring the module.

Firmware version V1.2 supports new functions, which are available as of the following TIA Portal versions:

- TIA Portal V17 Update 6
- TIA Portal V18 Update 1
- TIA Portal V19

Firmware version V1.1 supports new functions that are made available with the following Hardware Support Package (HSP): HSP_V16_0310_003_ET200SP_CM_CAN_1.0 (HSP_V16_0310_002_ET200SP_CM_CAN_1.0.isp16)

In order to work with firmware version V1.1, you must use HSP_V16_0310_003_ET200SP_CM_CAN_1.0. You can configure a module with firmware version V1.0 using HSP 0310 ET200SP CM CAN V2.0.

HSP_V16_0310_003_ET200SP_CM_CAN_1.0 is available for TIA Portal version V16 only.

You must use the latest HSP_V16_0310_003_ET200SP_CM_CAN_1.0.

The new functions mainly refer to using the CANopen Manager mode.

NOTE

TIA Portal Openness

The ET 200SP CAN communications module only supports mandatory attributes in TIA Portal Openness.

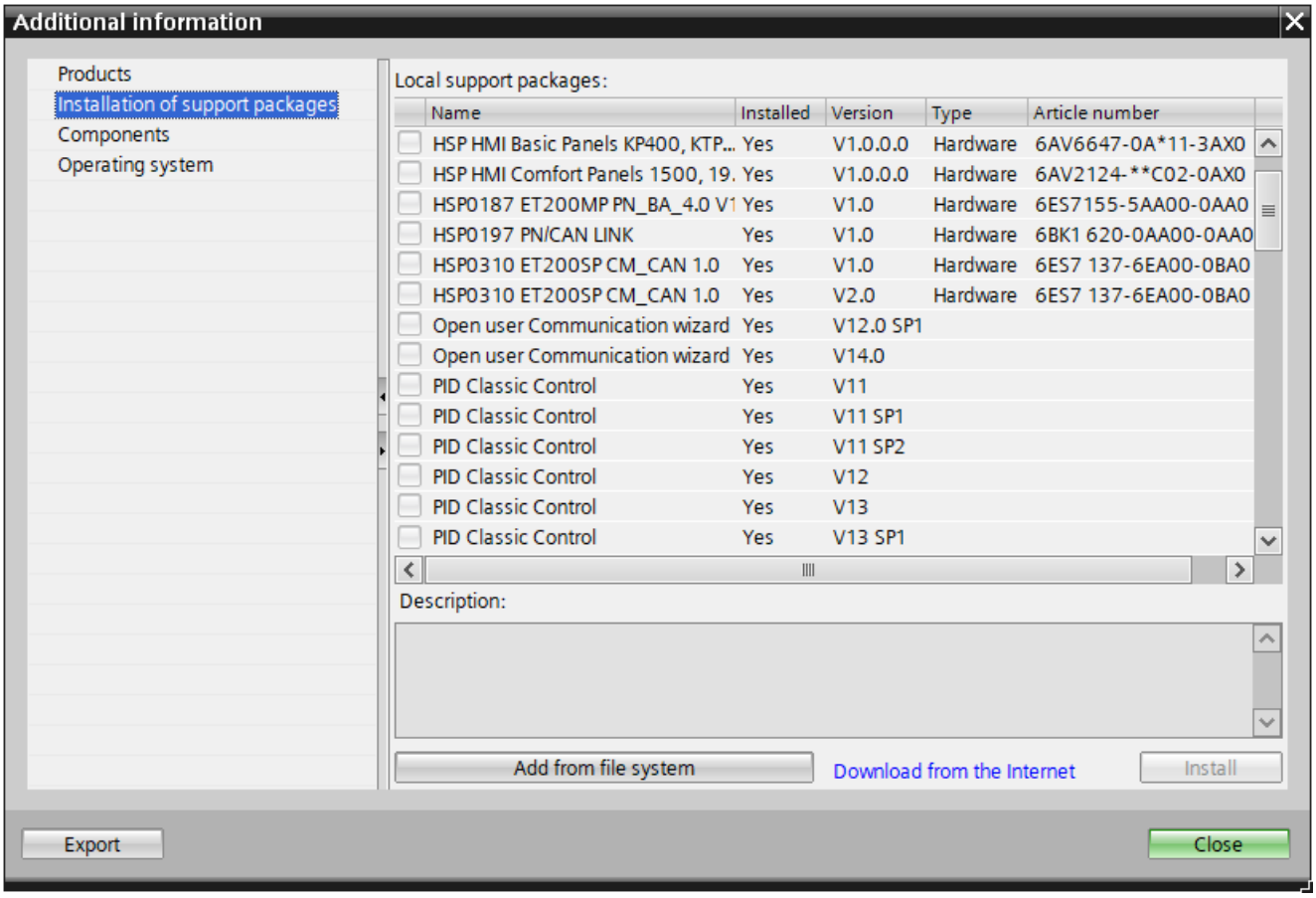

Figure 2-1396 Selecting an HSP

When selecting the module, you can choose the desired firmware version in the HW catalog.

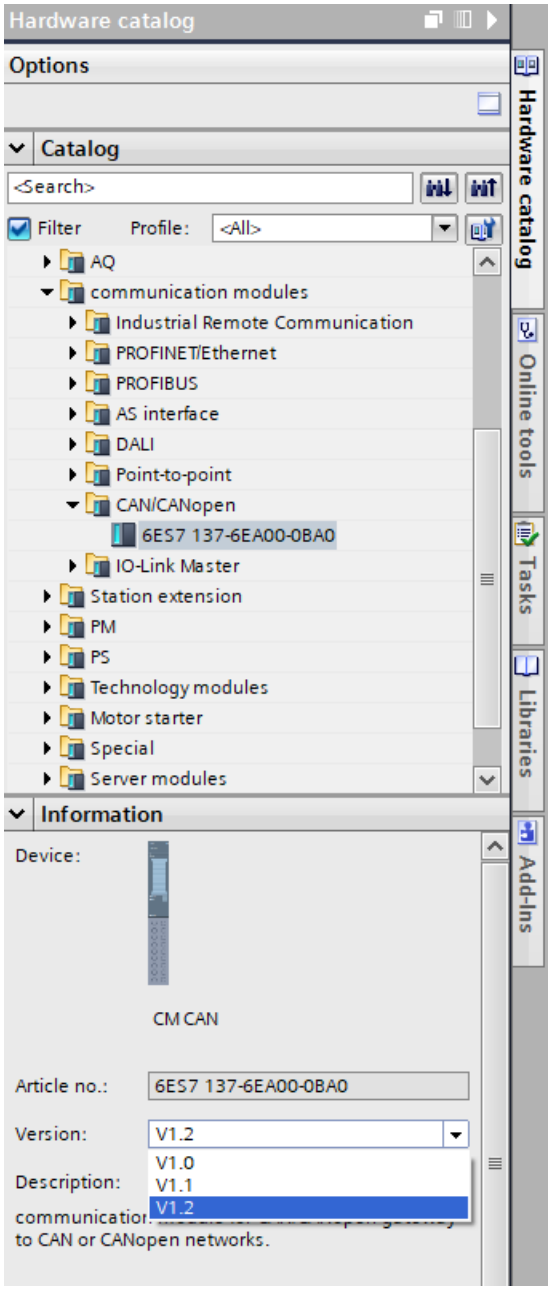

Figure 2-1397 Selecting a firmware version in the HW catalog

Or you can select the "Change firmware version" option for a module that has already been configured.

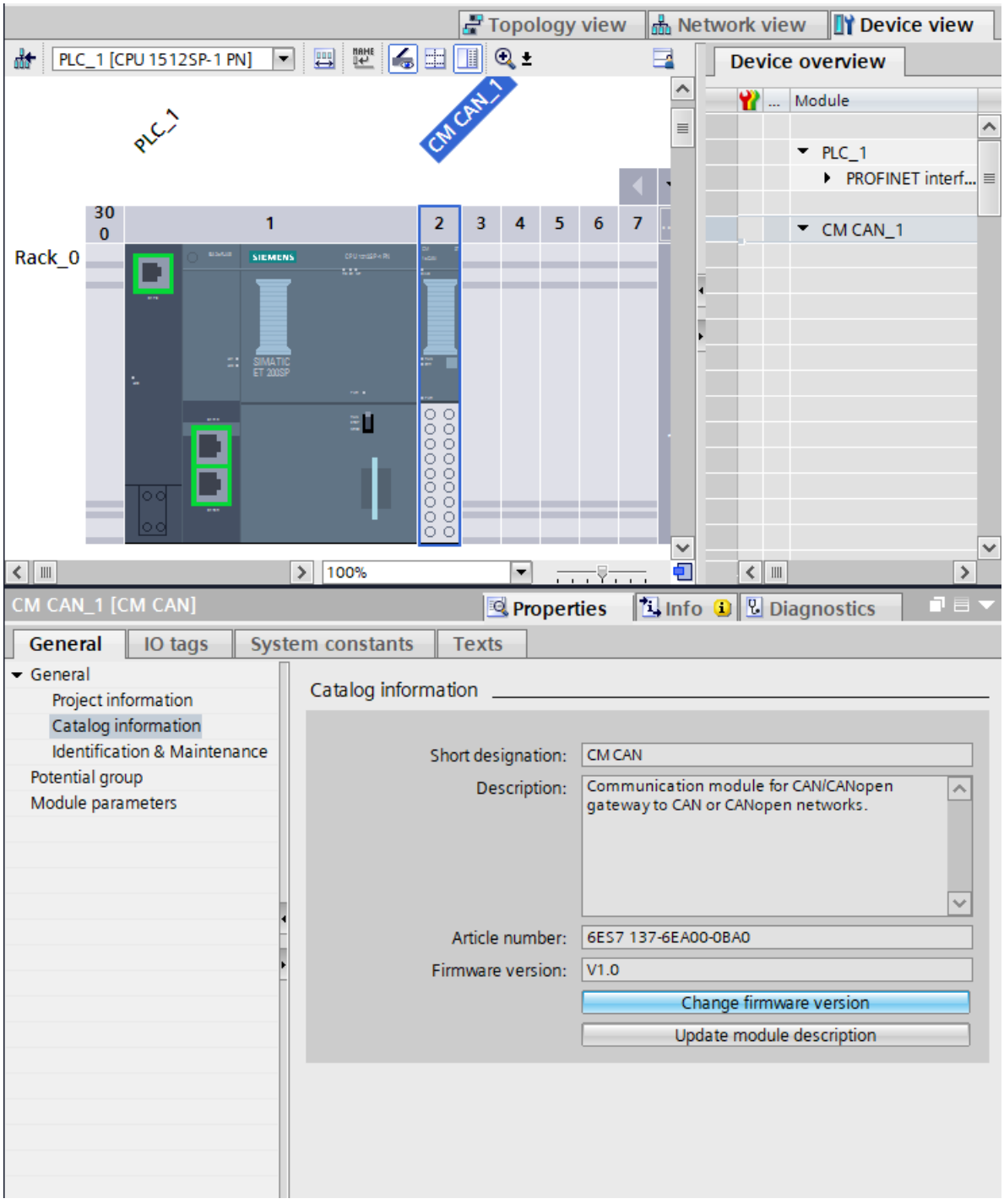

Figure 2-1398 Changing the firmware version

Version dependencies of the firmware update/firmware downgrade

A firmware update is possible in the following cases:

- Update of firmware version V1.0 to higher versions (V1.1, V1.2)
- Update of firmware version V1.1 to version V1.2

A firmware downgrade to an earlier version is not possible.

If a firmware update/firmware downgrade is not possible, the "Change firmware version" option is disabled automatically.

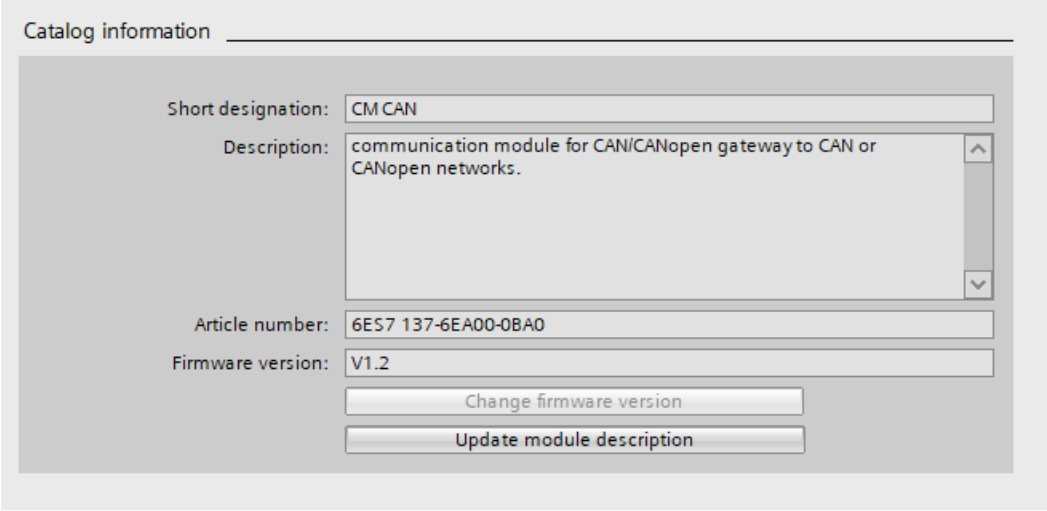

Figure 2-1399 "Change firmware version" option disabled

7.2 Configuring CANopen manager

7.2.1 Overview

The module is configured in the TIA Portal. For "CANopen manager" operating mode, configuring consists mainly of the following steps:

1. Drag the communication module CAN from the hardware catalog onto an IM or SIMATIC ET 200SP.
2. Define the mode of the module ("CANopen manager" here).
3. Set the bus-specific parameters, e.g. node ID and transmission rate.
4. Integrate additional CAN nodes; import the EDS files or define the Object Dictionary (OD) manually.
5. Define transmit and receive PDOs of the node.
6. Create OD entries for the transmit and receive data to be exchanged in the Manager module.
7. Define corresponding receive and transmit PDOs in the Manager module.
8. If required, make further settings, e.g. Heartbeat, Node Guarding and SYNC.
9. Check and compile the configuration.

7.2.2 Configuration in the TIA Portal

TIA Portal: Devices & networks

Proceed as follows:

1. Select the CAN/CANopen module with its specific article number from the HW catalog. ①
2. Select the firmware version (V1.0, V1.1 or V1.2) of your module. ② This step is only possible if
   - you have installed HSP_V16_0310_003_ET200SP_CM_CAN_1.0, or
   - you are using the corresponding TIA Portal version (into which the device has been integrated)

3. Drag the communication module to a free slot in the ET 200SP system. ③ The module is a part of the modular IO system connected to the fieldbus.

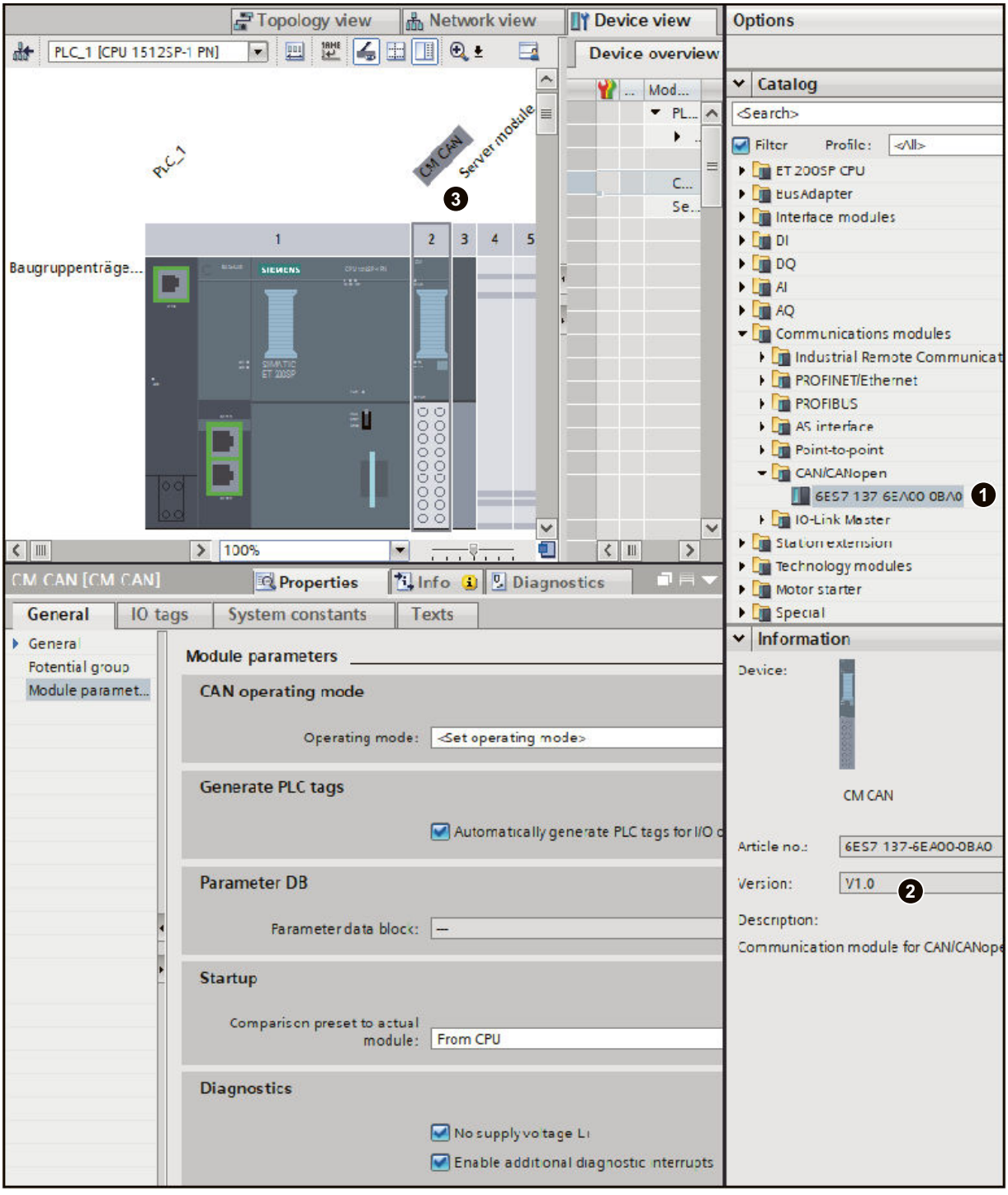

Figure 2-1400 TIA Portal Devices&Networks

Selecting CAN operating mode for the module

The CAN operating mode is selected using the "Set operating mode" drop-down list, which contains the following selection options:

- CANopen manager
- CANopen slave
- CAN transparent

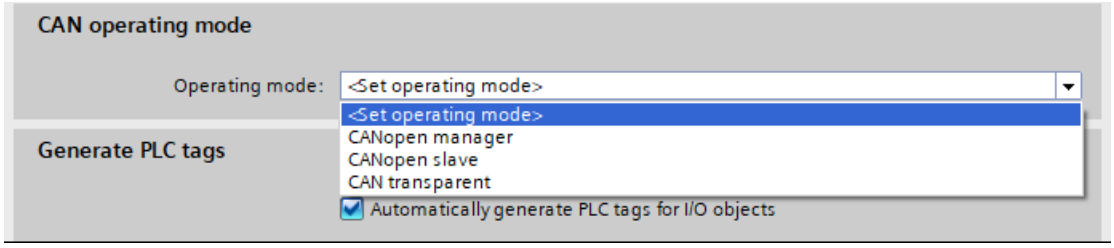

Figure 2-1401 Selecting an operating mode

Select the "CANopen manager" operating mode.
Set the appropriate parameters for the selected operating mode. All settings at the CANopen manager are done in the "CANopen manager Menu" of the module.

Setting the communication parameters

Set the bus-specific parameters, for example, node ID and transmission rate. ①

As of firmware version 1.1, you can set the parameters "max. SDO Timeout" and "max. BootUp Timeout" ②.

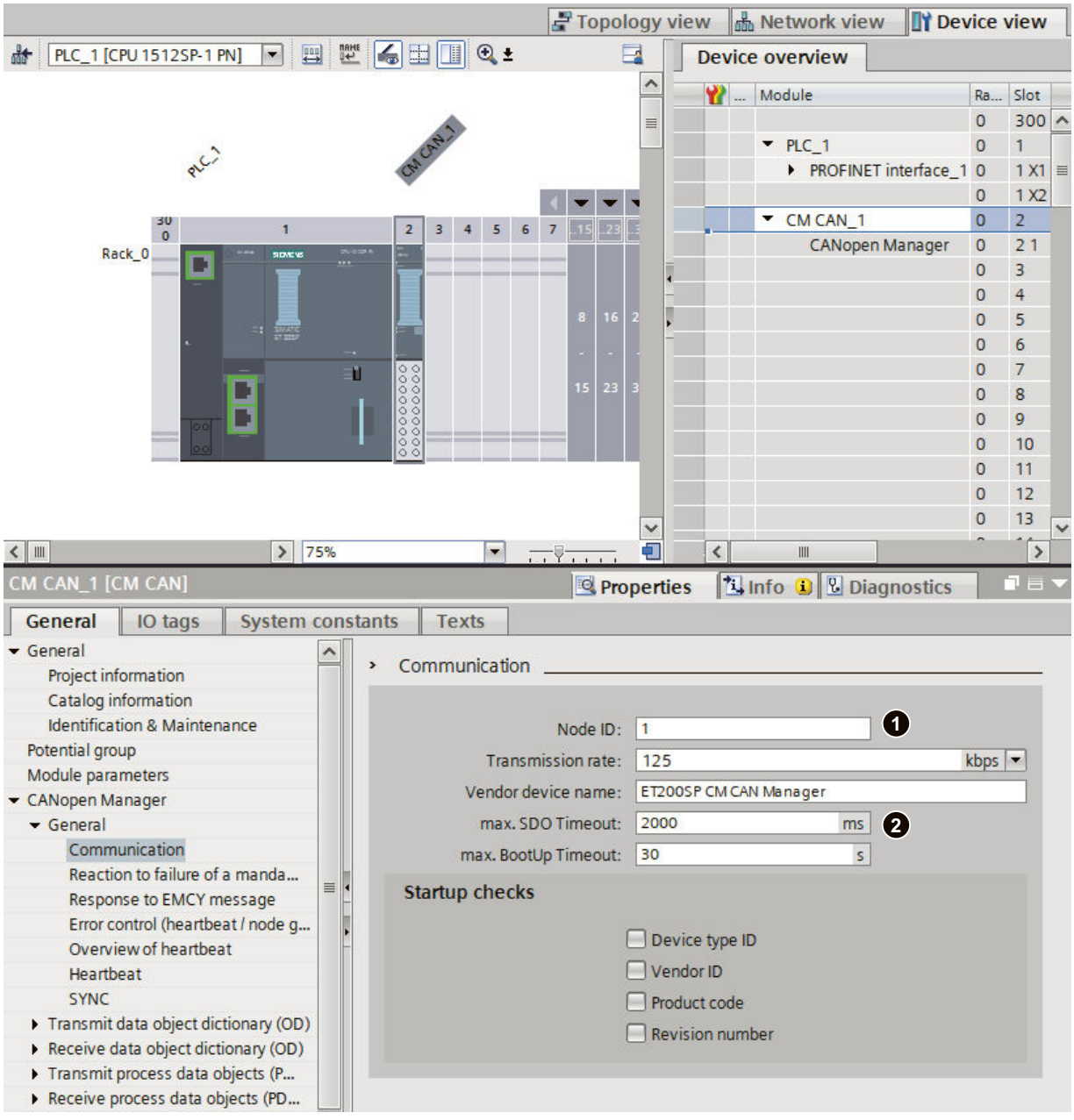

Figure 2-1402 Setting the communication parameters

Adding CAN nodes

CAN nodes are placed in the "CANopen nodes" (Node submenu) under the CANopen manager in the CM CAN module.

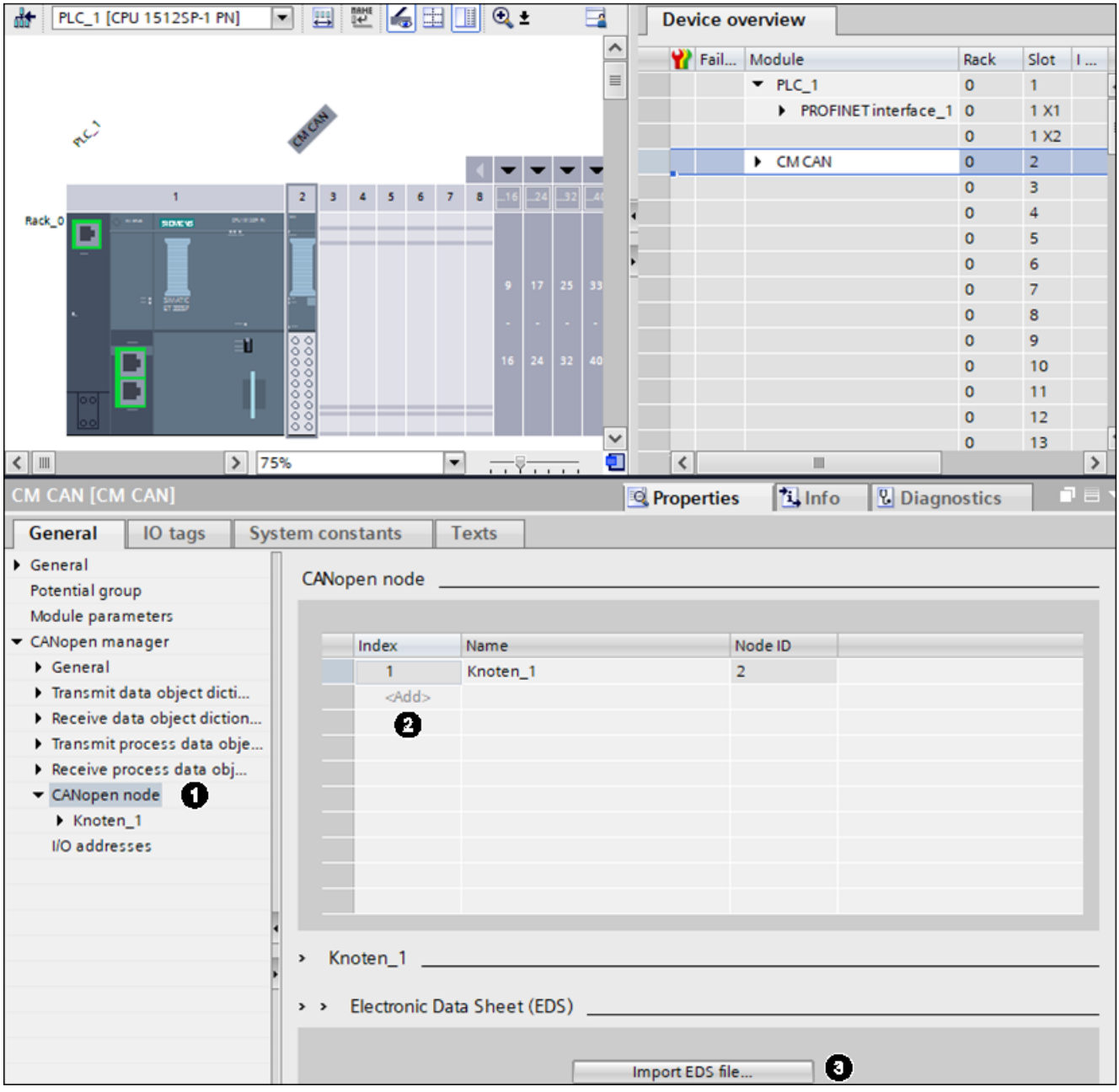

Figure 2-1403 Adding CAN nodes

1. Add a "CAN node" to the list of nodes in the "CANopen manager" table. ① Create a new node by double-clicking the "Add" button in the index column. ②
2. Import the EDS (Electronic Data Sheet) file belonging to the CAN device. Select the EDS file in the menu "CANopen Manager CANopen node". Click the "Import EDS file" button ③ to open the corresponding file selection dialog.

3.

As of firmware version 1.1 you can manually define the object dictionary (OD). For additional information about this function, refer to section "Handling of the OD table" below.

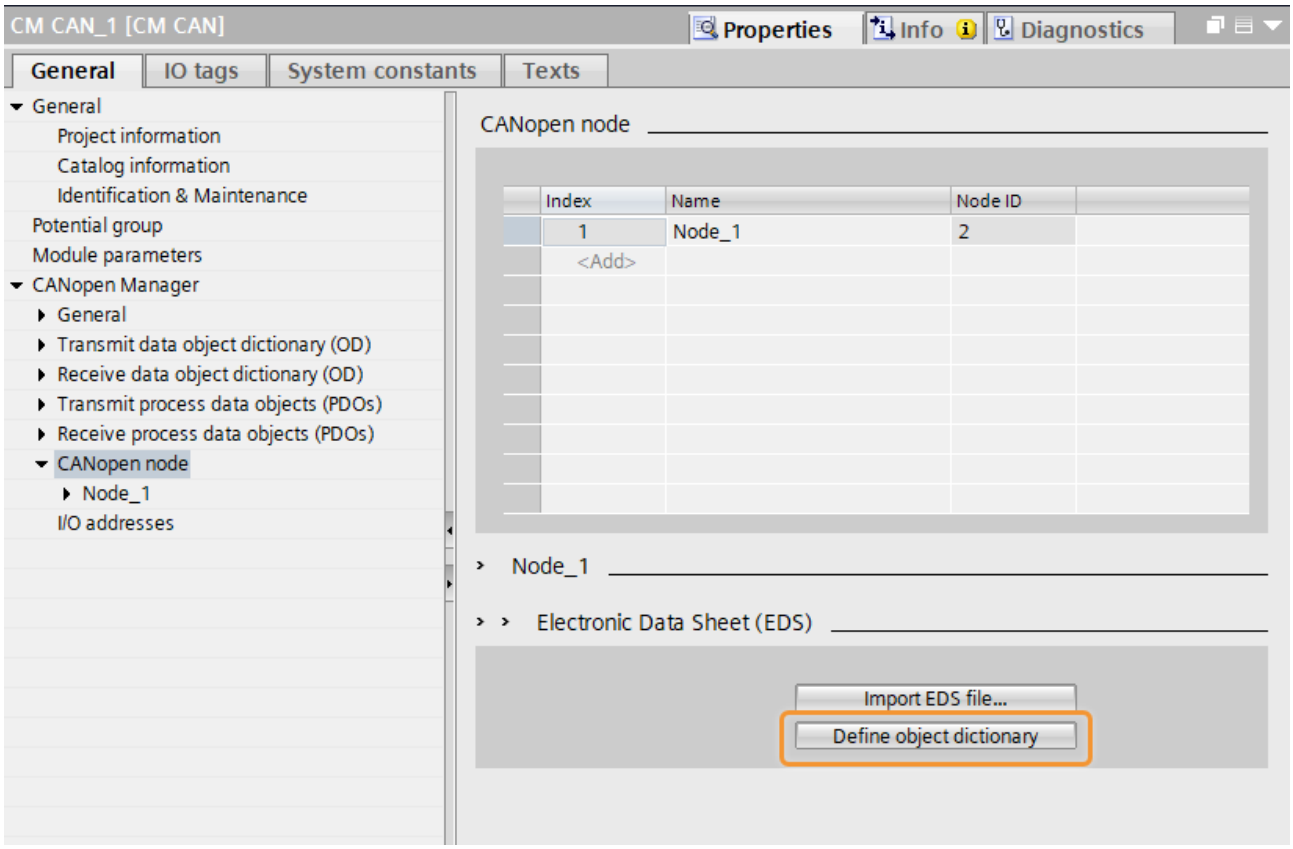

Figure 2-1404 Define object dictionary (as of firmware version 1.1)

NOTE

General information

- The basis for working with the CANopen node is the object dictionary (OD) of a node that is usually made available by the manufacturer as an EDS file.
- You can import an existing EDS file by clicking on the "Import EDS file..." button. If no EDS file is available yet, create the object dictionary (OD) manually. To do this, use the "Define object dictionary" button. Both steps will result in an object dictionary (OD).
- The import of an EDS file can take several minutes depending on the size and complexity of the file. You can significantly shorten the time required for the import by reducing the EDS file to just the entries that are actually needed.

For users of the firmware version V1.0

- Once the EDS file is imported, all necessary information is part of the TIA Portal project so that the EDS file is no longer needed.
- To edit an EDS file properly, you need to know the structure of the EDS file well or use a specific EDS editor.
- Data from the EDS file cannot be updated at a later time. If the EDS file needs to be imported again due to changes (e.g. corrections), you must delete the node and create it again.
- Check the object dictionary (OD) of the CAN device for completeness and correctness. We assume hereafter that the OD can be used without changes.

For users of the firmware version V1.1

- The object dictionary (OD) is no longer write-protected so that you can edit, add and delete entries.
- An imported EDS-file creates an object dictionary (OD) that can be used immediately. However, you must confirm a manually created object dictionary (OD) by pressing the "Apply and check data" button.
- As of V1.1, you can correct any incorrect OD entry directly without deleting the node.
- Relationship between an OD and configuration menus:

You perform the entire configuration in the corresponding menus and **not** in the OD table. Settings from the menus are **not** visible in the OD table. You can find additional information in the section "Handling of the OD table" below.

For users of firmware version V1.2

- The OD index entry range has been extended to 2000h-6FFFh.

Handling of the OD table

After you have added a CAN node, you have two options in the "Electronic Data Sheet (EDS)" menu:

1. Using an existing EDS file via the "Import EDS file..." button

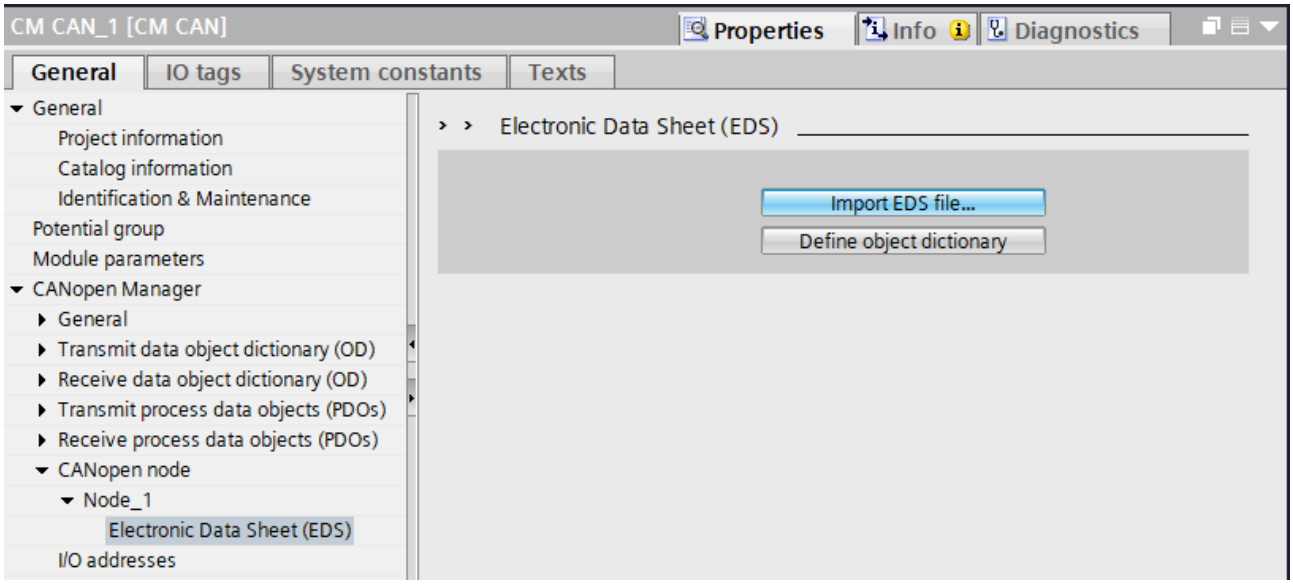

Figure 2-1405 Importing the EDS file

2. Manual creation of an object dictionary (OD) using the "Define object dictionary" button:

A template is displayed in the "Object dictionary (OD)" menu.

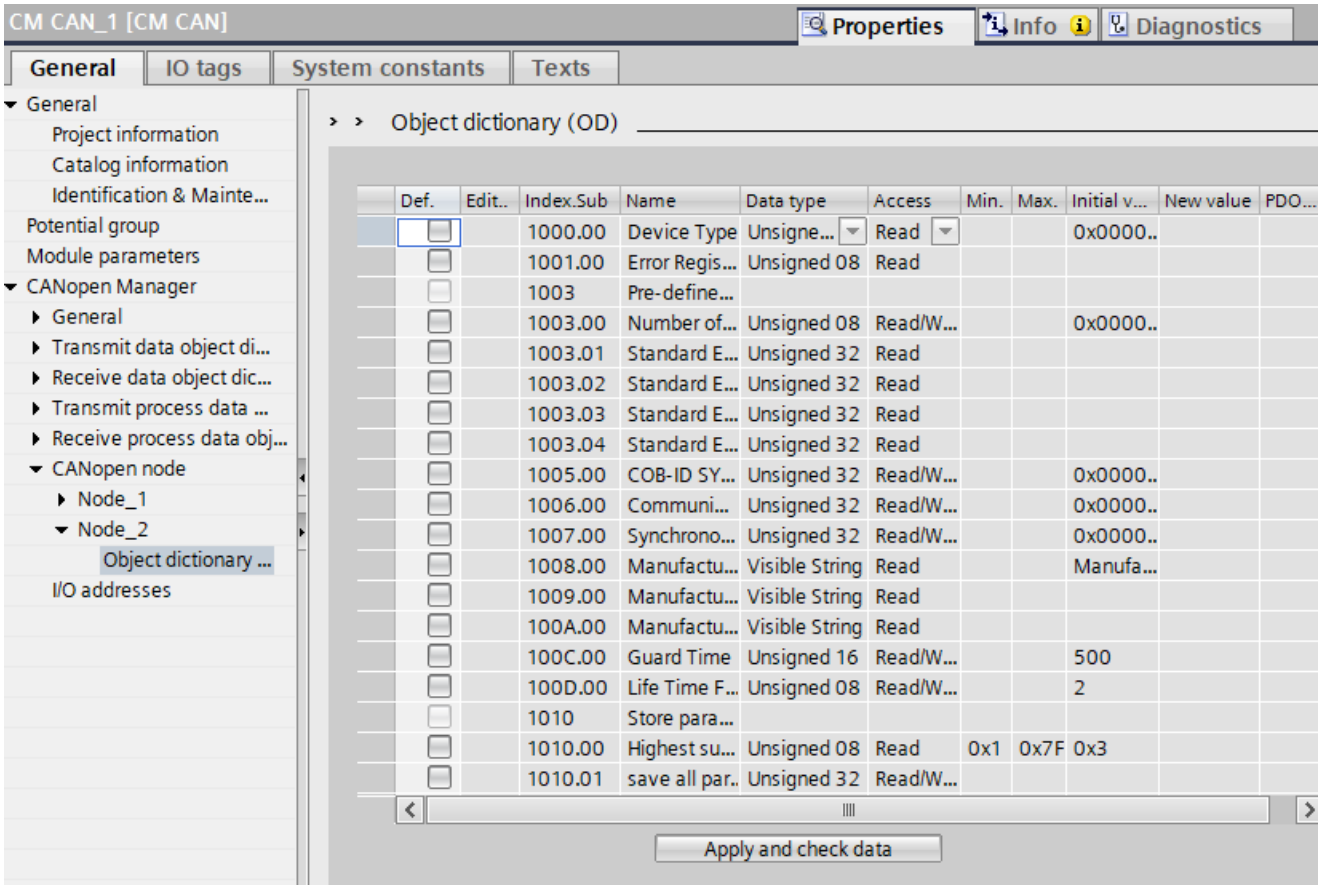

Figure 2-1406 Defining the object dictionary

Here you can describe all objects that are available in your device. To do this, select the check box in the "Def." column or add a new entry at the end of the table.

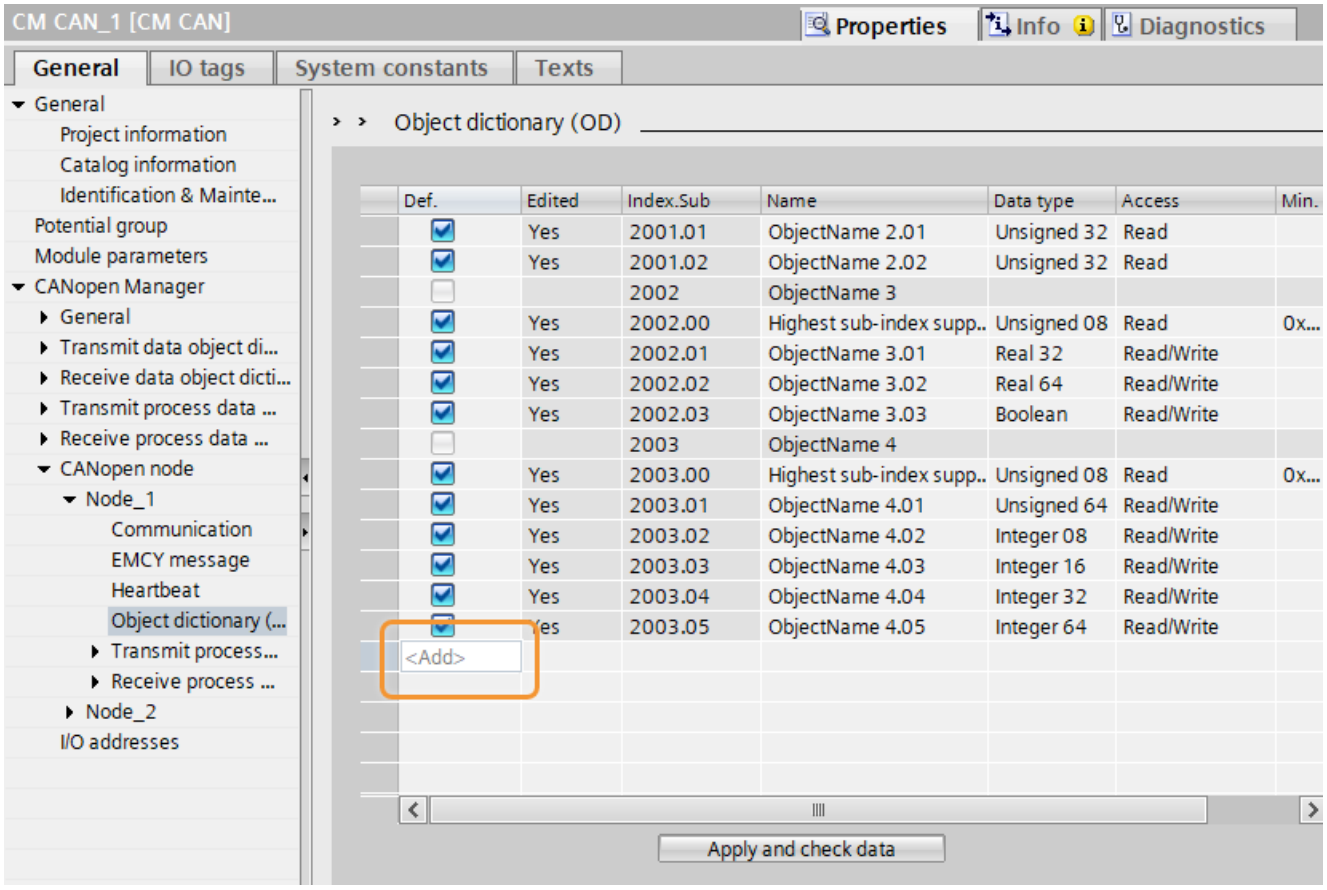

Figure 2-1407 Add new entry

To add new rows, double-click the selected cell.

You can delete existing rows by using the shortcut menu of a table row. If you are not sure whether you want to delete an entry, disable it. The entry will be ignored during the next configuration.

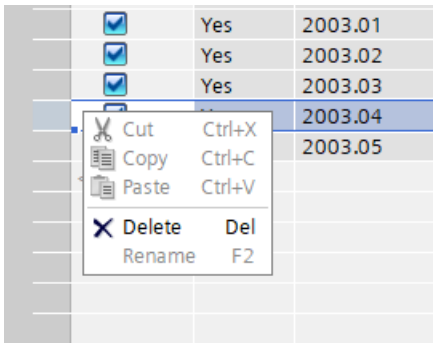

Figure 2-1408 Shortcut menu of a table row

You must complete the finished OD table by clicking on the "Apply and check data" button. Once the data are applied, the other menus will become active and visible.

As soon as the OD table is completed by clicking on the "Apply and check data" button, you use it as you would an imported and manually defined EDS.

The following rules apply:

- The OD can be changed at any time but this may invalidate settings that were valid before the change.
- Changes in the OD table must be confirmed with the "Apply and check data" button to have an effect on the menus.
- Settings in the menus are **not** visible in the corresponding OD entries of the OD table (changes in the menus are not transferred to the OD table).
- You cannot bypass the menus and make corresponding configuration settings directly in the OD. This does **not** work.
- Only new object values that are not subject to a configuration menu can be set directly in the OD (these entries can be edited).
- Only entries with a selected check box in the "Def." column are considered to be available in the node device.
- You can add any object that is missing in the template or your EDS file.
- The "Apply and check data" button is hidden by default. It appears only when you make a change in the OD table.

Details on the individual columns

"**Def.**" column (Define):

- Entries can be edited depending on the "Def." column.
- When an EDS file is read in (similar to firmware version V 1.0), the default setting is Def.=True (enabled) for all entries. When "Define object dictionary" is selected, the default value is Def.=False (disabled) for all entries.
- When the "Def." option is selected, the CANopen node supports this object.

"**Edited**" column:

- "Yes" in the "Edited" column indicates that you have made a change in this row since the last check ("Apply and check data" button).
- The column is always write-protected.
- After you have pressed the "Apply and check data" button, the marking for a "valid" row is removed.
- After you have successfully checked everything, "Yes" is no longer displayed in the column and the "Apply and check data" button disappears again.

Editing an entry

You can edit any entry with a fully defined field in the Index.Subindex column. There is also a type of row where only one index is defined. Such a row can **never** be edited. It only involves a header with a name of OD.

You can only edit entries when the check box in the "Def." column is selected.

Editable columns:

- Name
- Data type
- Access
- Min.
- Max.
- Initial value
- New value
- PDO assignable
- Index.Subindex - You can only edit this column when you have added a new entry. It can no longer be edited once you press the "Apply and check data" button.

The following consistency checks are performed between the columns during editing:

- Data type ↔ Min./Max. ↔ Initial value/New value
- Access ↔ PDO assignable

These changes are only local for the OD table until you press the "Apply and check data" button. No other menu is affected.

Pressing the "Apply and check data" button initiates the following checks and updates:

1. A test is performed to see whether entries were added. These entries are then placed at the correct location in the list. Only the newly added entries are taken into account during sorting. You can only edit the "Index.Sub" field when you have added an entry. The field remains editable until the entry is sorted in the table. After that, you can no longer change the "Index.Sub" field. If you want to change it, you have to delete the entry and add it again.
2. A check is performed to determine whether the object can be read or written to so that data exchange is possible.

3. Checking the mandatory ODs:
   - The OD entries (OD 1000, OD 1018.01, OD 1018.02, OD 1018.03) are checked regardless of whether an EDS file is imported or the object dictionary (OD table) is edited.
   - When one of these ODs is not available in the EDS file or is not selected in the OD table, the "Loose configuration" check box is selected and disabled in the "Node > Communication" menu.

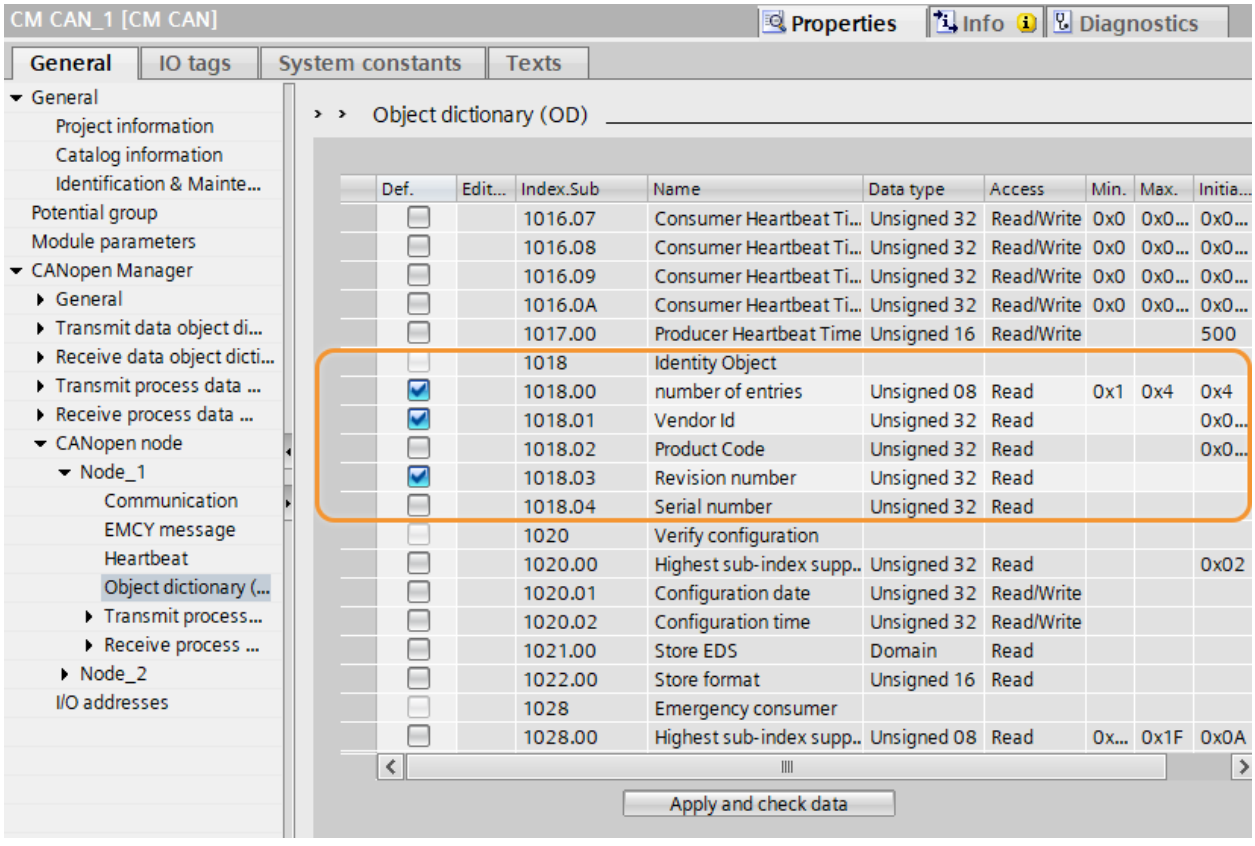

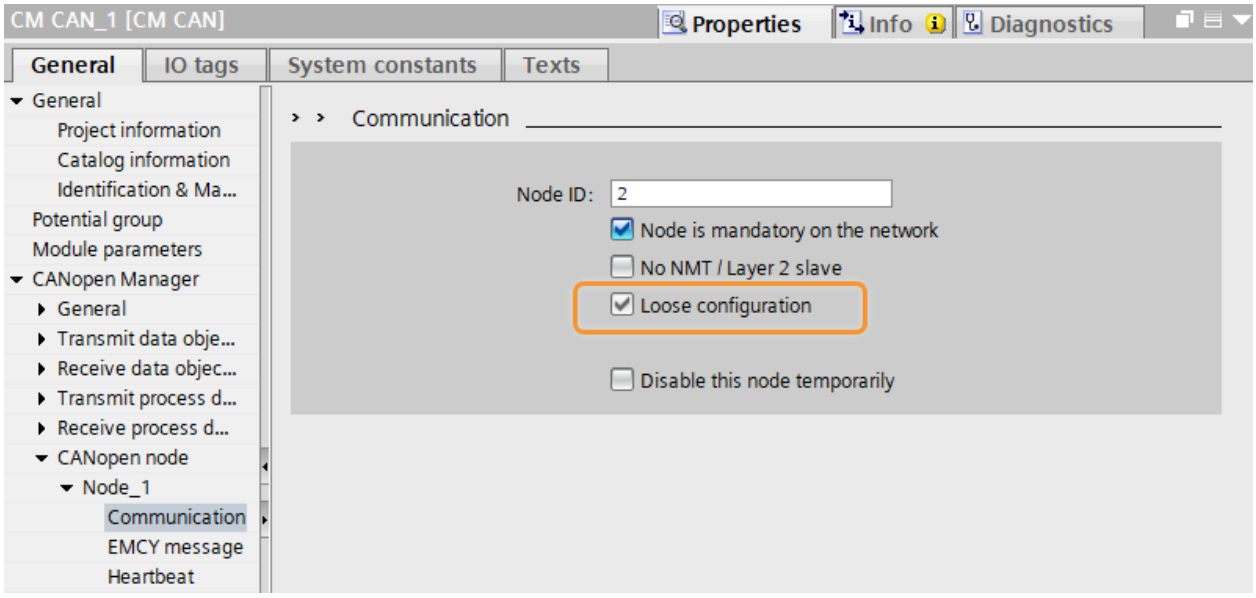

Figure 2-1409 Loose configuration

4. Creating new temporary lists for RX-PDOs and TX PDOs according to the entries in the OD. When entries are incomplete (missing subindex or mapping entry), the PDO is rejected (this can have an effect on the previously correctly defined PDO).
5. A check is performed to determine whether changes were made that require an update of the list of mappable objects or objects actually mapped. All affected lists are updated.

NOTE

When you make changes to OD entries that have an effect on a previously configured PDO, these configurations are lost. You must make this configuration again.

Creating an OD index entry for transmit data in the manager

1. Open "Transmit Data Object Dictionary (OD)" ① in "CANopen manager". Select "Transmit ODs".
2. Double-click the "Add" button to create a new table entry. ②

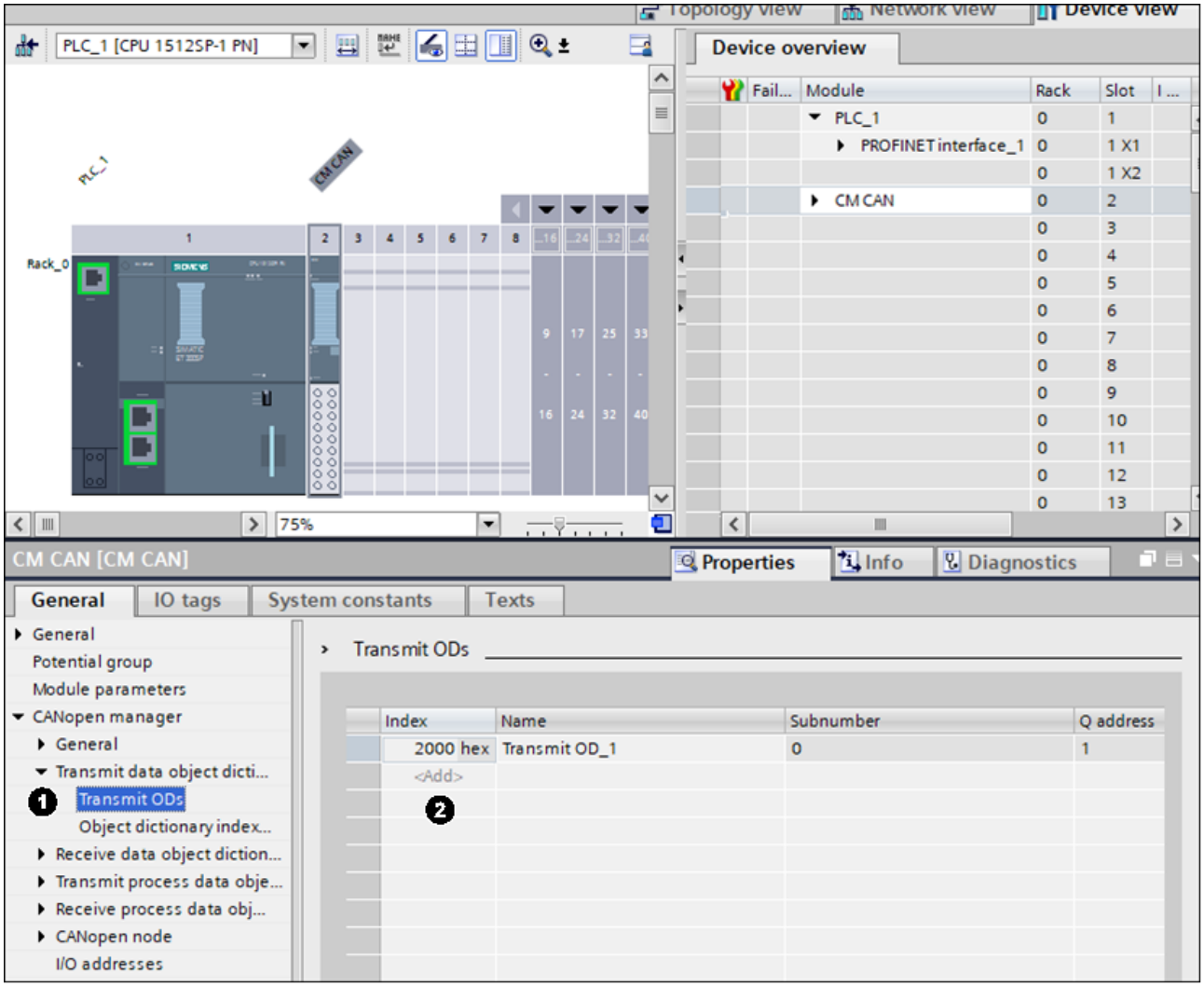

Figure 2-1410 Create OD index entry

Define transmit subindex

1. Select "Transmit Data Object Dictionary (OD)" and then "Object Dictionary Index Definition" in the CANopen manager menu.①
2. Create the subindexes belonging to the OD index.
   To create additional subindex entries, double-click "Add".②

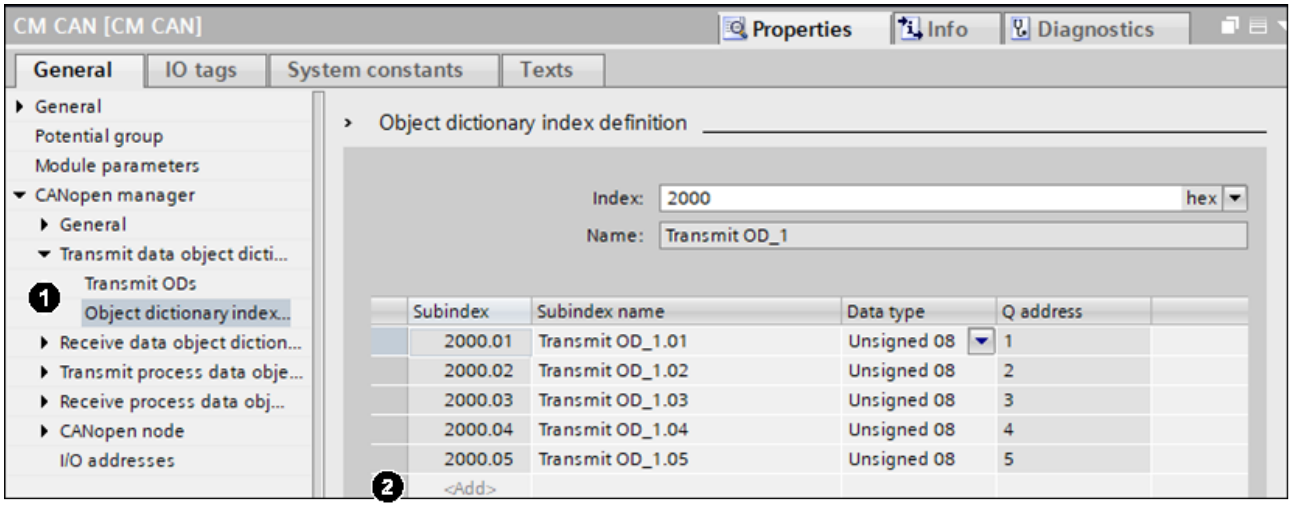

Figure 2-1411 Object dictionary index definition

Creating additional OD entries for transmit data in the Manager

Repeat the above steps until all desired transmit data has been created in the OD of the Manager.

NOTE

Limited number of OD and subindex entries

You can create a maximum of 100 OD entries (indexes). This maximum number is independent of the distribution of entries between the transmit data OD and receive data OD.

The number of subindex entries is also limited. You can create up to 256 subindexes for all indexes together if the subindexes are 1 byte long (256 byte memory limit).

At least 1 subindex must be defined for each index. This means when 100 indexes are defined, one index can have 156 subindexes with a length of 1 byte and the remaining indexes can have only one subindex with a length of 1 byte.

Defining transmit PDO in the Manager

1. Select the "Transmit PDO definition" window ①.
2. Select a free PDO number to which a COB ID has not yet been assigned in the "PDO" line ② and click on the "Define PDO" button.③
   Set the COB ID to the same value that is used by the corresponding Receive PDO in the slave. ④

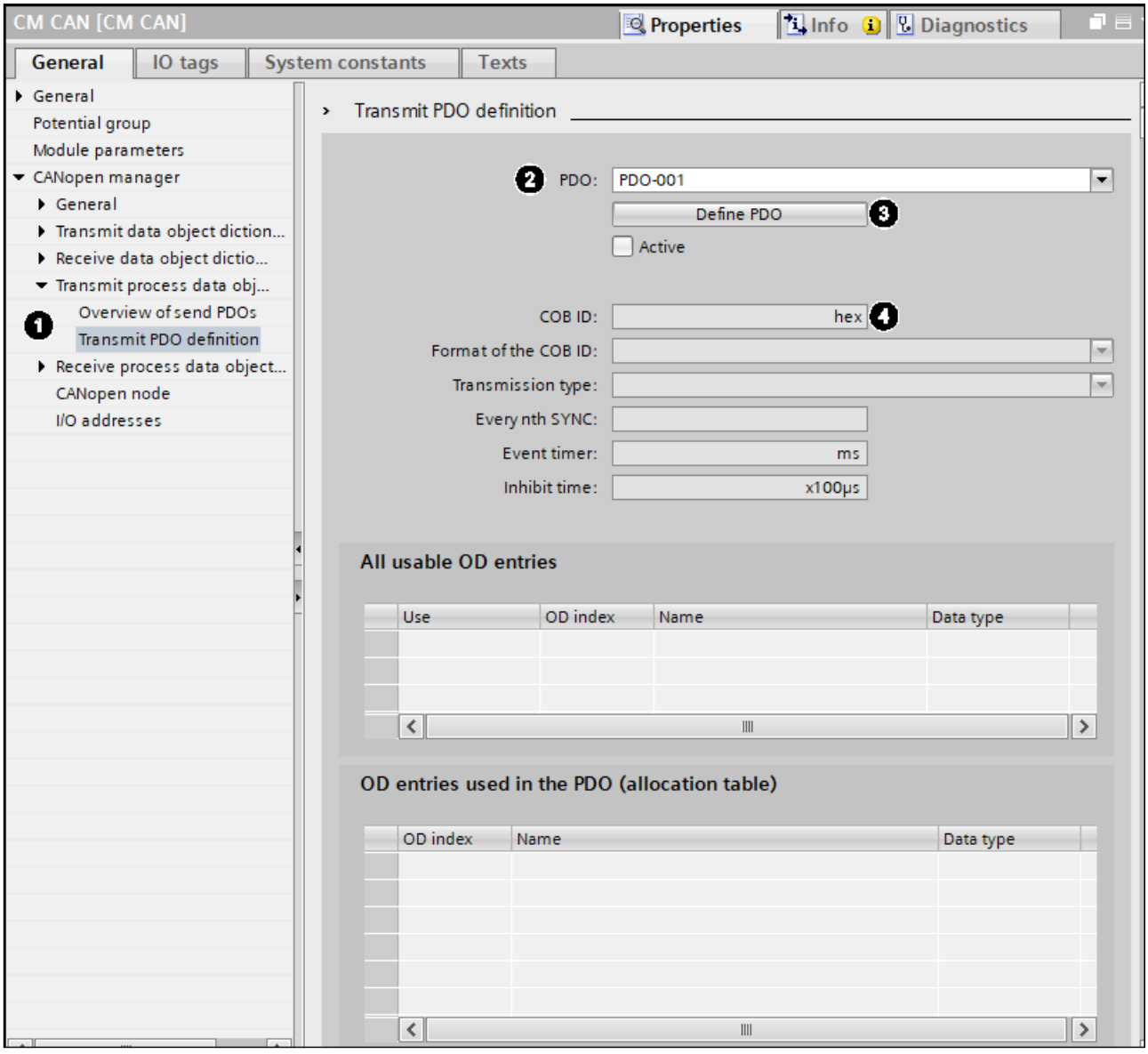

Figure 2-1412 Transmit PDO definition_1Part

3. Assign transmit data to the transmit PDO.
   To assign the transmit data, select the data that is to be transmitted in the transmit PDO from the "All usable OD entries" table with the buttons in the "Use" column ⑤.

4. The selected OD entries now appear in the table "OD entries used in the PDO". ⑥
Two additional tables below allow easy reference to see how any previously defined receive PDOs with the same COB-ID are structured.

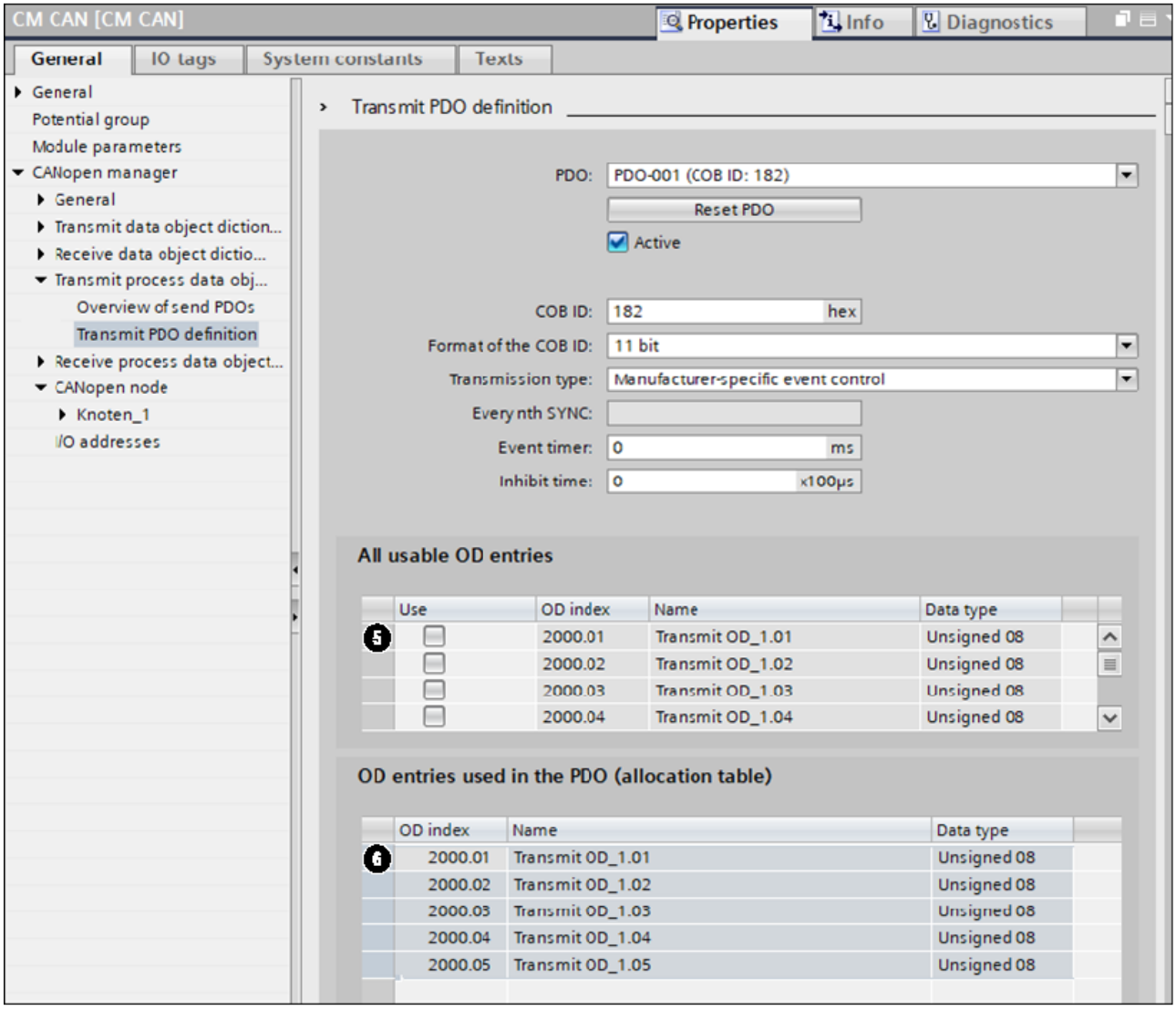

Figure 2-1413 Assignment of transmit data

NOTE

The length of the transmit data assigned to a Transmit PDO must match the length of the receive data in the corresponding Receive PDO in each case at the end of configuring.

Defining a receive data OD and assigning Receive PDOs

The steps for defining and assigning the receive data are analogous to those for transmit data:

1. Create receive data object directory
2. Define a receive OD index and subindex
3. Define Receive PDOs
4. Assign the OD entries used in the PDO

NOTE

The length of the receive data assigned to a Receive PDO must match the length of the transmit data in the corresponding Transmit PDO in each case at the end of configuring. If necessary, the length of the Receive PDO must be adapted by using predefined dummy OD entries.

Disable checking of PDO length (for configuration with HSP_V16_0310_003_ET200SP_CM_CAN_1.0)

As of firmware version 1.1, you can select the "Disable checking of PDO length" option (see figure below).

Option enabled

When you select this option, the data length (number of received bytes) of the received PDOs is adapted. Error, warning or diagnostic messages are not generated.

The value is adjusted to the correct data length as follows:

- Data below the defined length are supplemented with the value 0.
- If data exceeds the defined length, the more significant bytes are deleted.

Option disabled

If you disable this option, all data from a received PDO with a length deviating from the standard is discarded and replaced with the value of the last valid PDO (last received PDO with the correct length). The CANopen Manager calls up an error message in the diagnostic buffer.

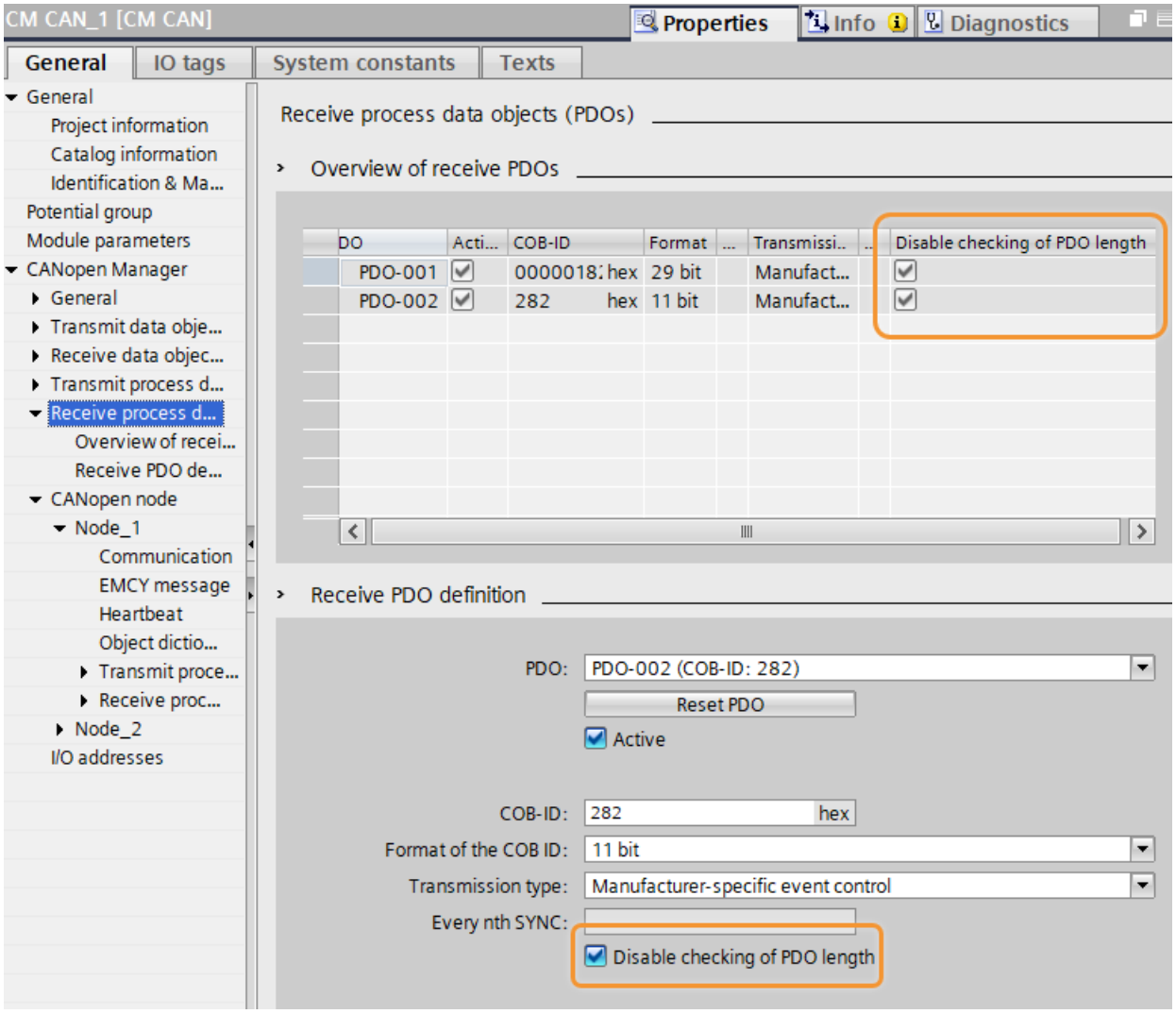

Figure 2-1414 Disable checking of PDO length

Adapting I/O addresses

Except for the start of the I/O ranges, you cannot adapt the I/O addresses automatically assigned by the TIA Portal.

The first I/O addresses assigned to the module are control and status information. The control and status information is exchanged with the user program via these addresses. It is important for startup of the module that the control information transferred here from the user program is set correctly.

Disabling a node temporarily (for configuration with HSP_V16_0310_003_ET200SP_CM_CAN_1.0)

You have configured a series of nodes in the TIA Portal, but one node does not physically exist in the CAN network. To work with the "reduced" network, you can temporarily disable one or more nodes. Such a CANopen node with its entire configuration remains in the project but is **not** downloaded to the CM CAN module. The node **does not exist** in the configuration that is used by the CM CAN module. No errors or warnings are generated by the module.

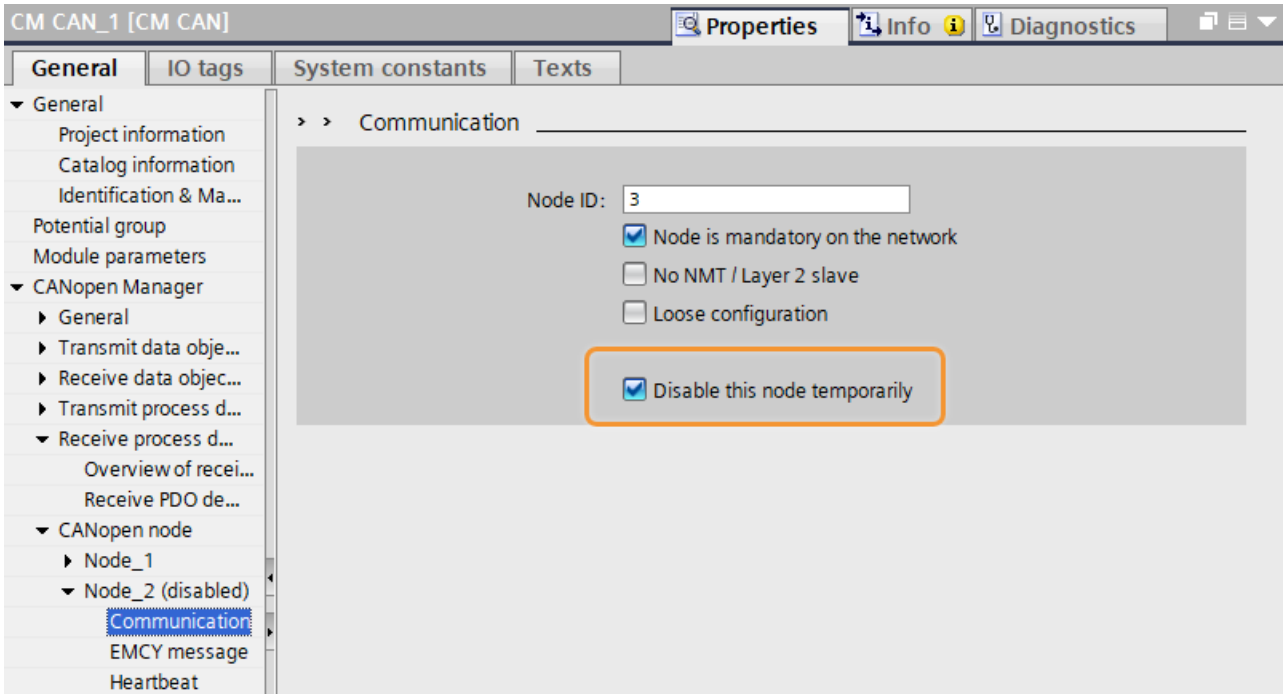

Figure 2-1415 Disabling a node temporarily

When such a node appears in the menu, it is marked as "(disabled)".

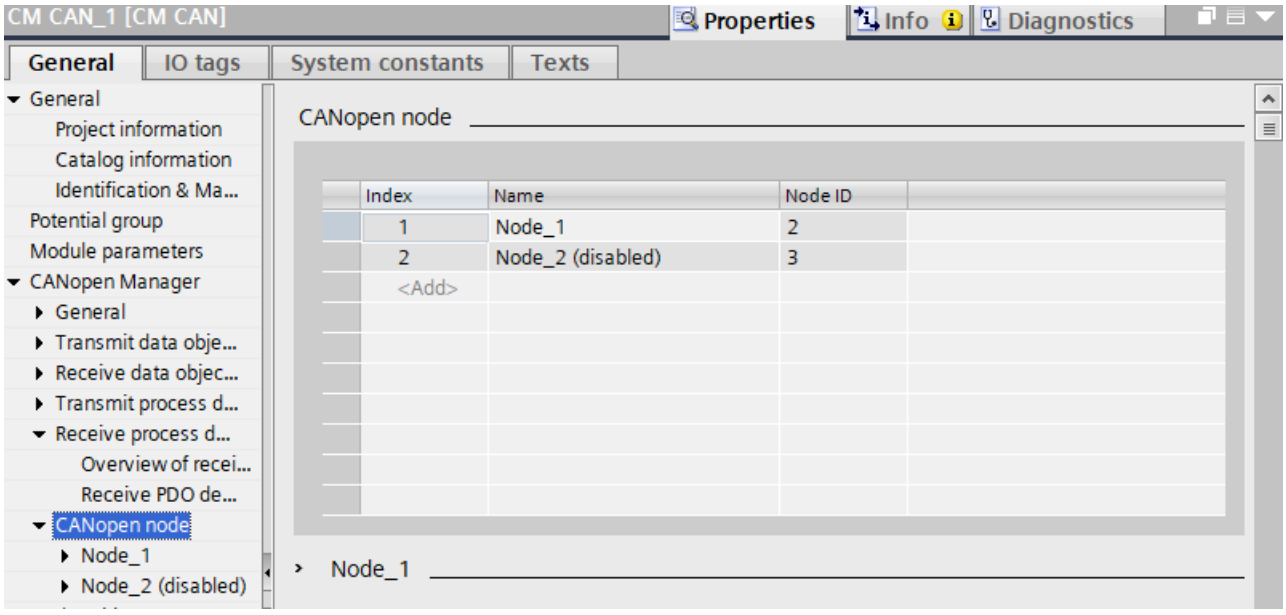

Figure 2-1416 Node disabled

Checking data consistency

You can check the consistency of the assignments for the receive data and transmit data as well as the data types used with a compilation.

Setting the module to "Operational" with the user program

To enable data to be transferred between the SIMATIC S7 controller and the module, you must set the control bit to "1" with the user program. This control bit is transmitted cyclically from the SIMATIC S7 controller to the module as part of the IO data.

NOTE

In "CANopen manager" mode, bit 2 must also be set to "1" in the control information transmitted from the SIMATIC S7 controller to the module. You can find additional information on the effect of the control bits under Control and Status Information (Page 31).

7.3 Configuring CANopen slave

7.3.1 Overview

Configuration with the HSP in the TIA Portal (CM CAN is NMT slave).

The module is configured in the TIA Portal. The configuration for "CANopen slave" operating mode mainly consists of the following steps:

- Import the HSP of the CM CAN module to the TIA Portal.
- Drag the module from the HW catalog to the project.
- Set the "CANopen slave" operating mode.
- Set bus-specific parameters for the "CANopen slave" module:
  - Node ID
  - Transmission rate
- Create OD entries for the process data to be exchanged between the SIMATIC S7 controller and the CANopen network.
- Check and compile the configuration.
- Export the EDS file.

7.3.2 Configuration in the TIA Portal

TIA Portal: Devices & networks

Follow these steps:

1. Select the module with its specific article number from the HW catalog. ①
2. Drag the communication module to a free slot in the ET 200SP system. ② The module is a part of the modular IO system. The IO system is connected to the fieldbus.

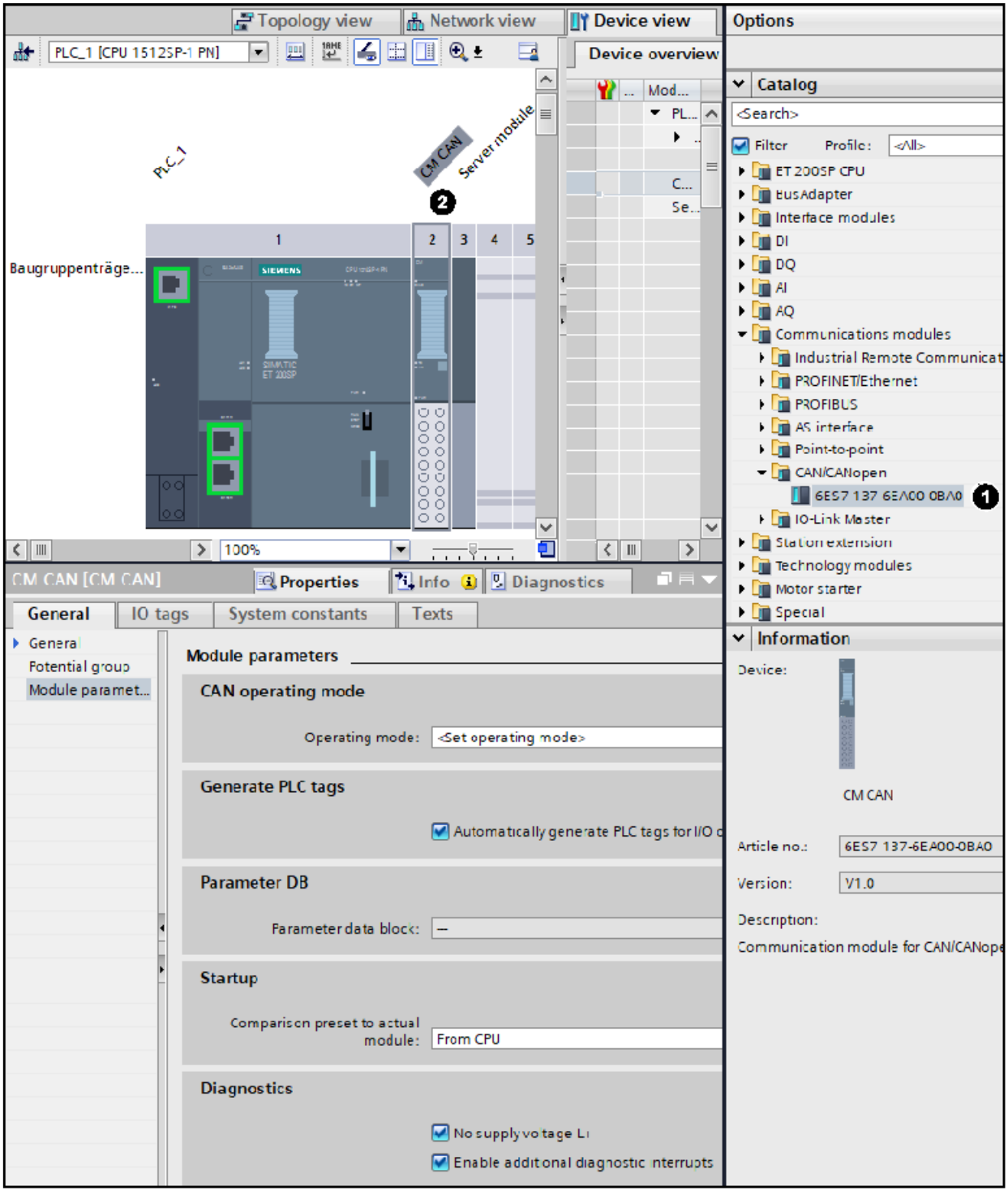

Figure 2-1417 TIA Portal: Devices & networks

Selecting CAN operating mode of the module

The CAN operating mode is selected using the "Set operating mode" drop-down list with the following selection options:

- CANopen manager
- CANopen slave
- CAN transparent

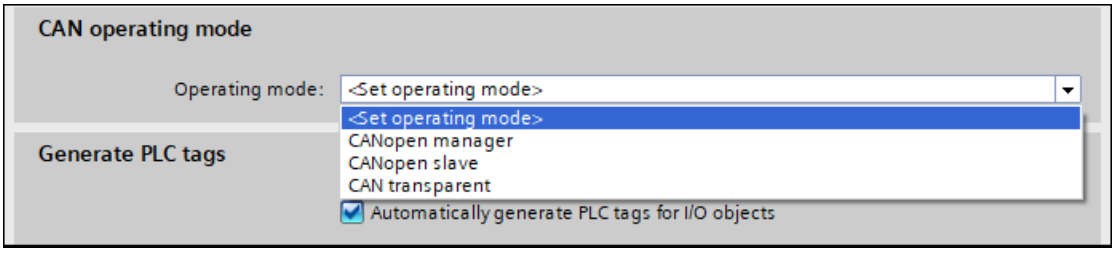

Figure 2-1418 Selecting an operating mode

Select the "CANopen slave" operating mode.

After selection of the operating mode the parameters associated with the selected mode can be set.

Setting the communication parameters

Set the bus-specific parameters for the CANopen slave module: Node ID, transmission rate and the number of desired process data objects. ①

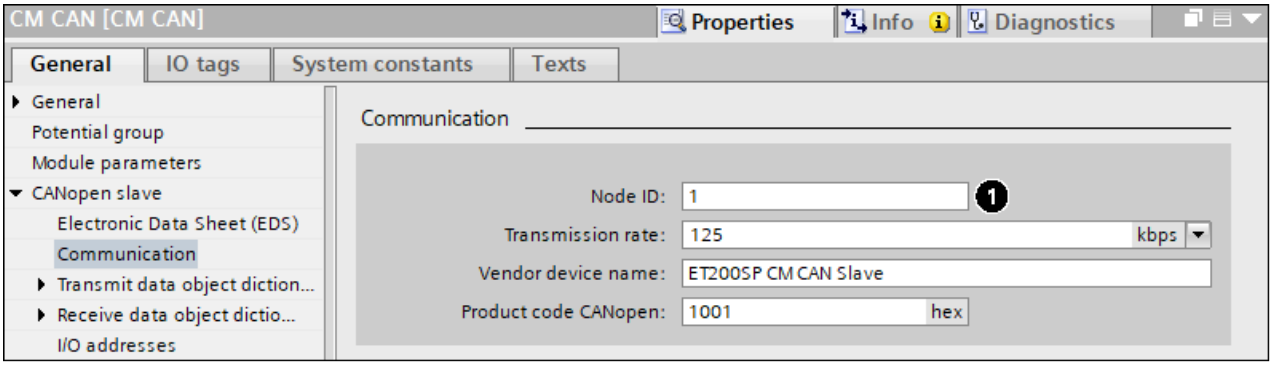

Figure 2-1419 Setting the communication parameters

Creating an OD index entry for transmit data in the slave

1. Open "Transmit Data Object Dictionary (OD)" in the "CANopen slave" module and then select "Transmit ODs". ①
2. Double-click the "Add" button to create a new table entry. ②

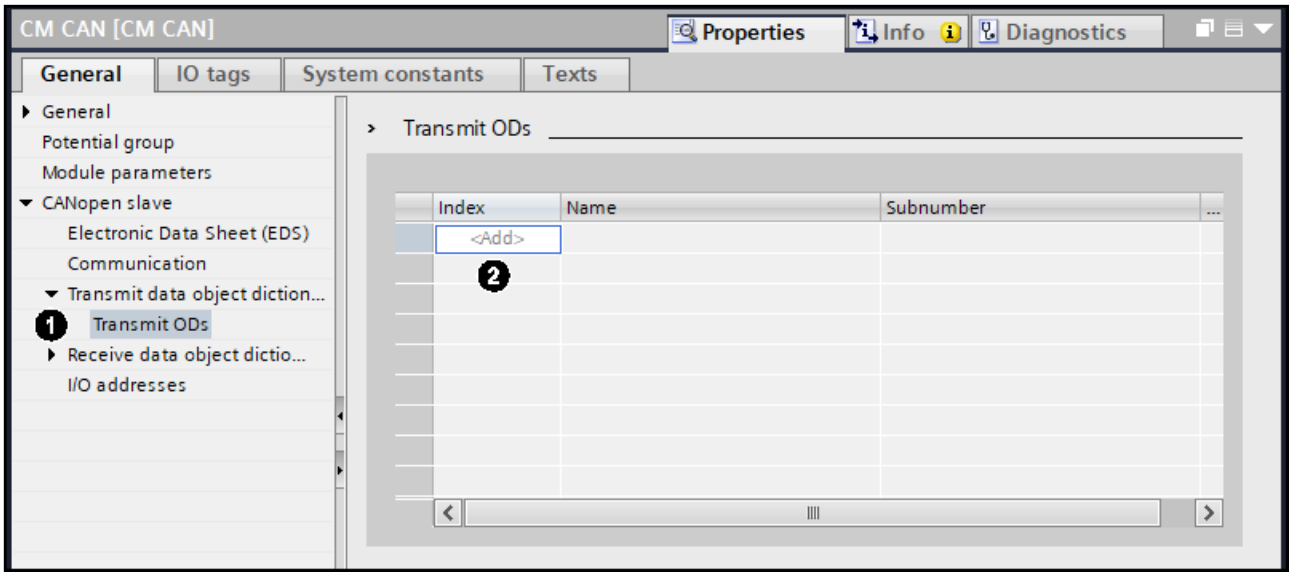

Figure 2-1420 Creating a transmit data object dictionary

Define transmit data subindex

1. Select "Transmit Data Object Dictionary (OD) - "Object Dictionary Index Definition" in "CANopen slave". ①
2. Create the subindexes belonging to the OD index.
   To create additional subindex entries, double-click "Add" ②.

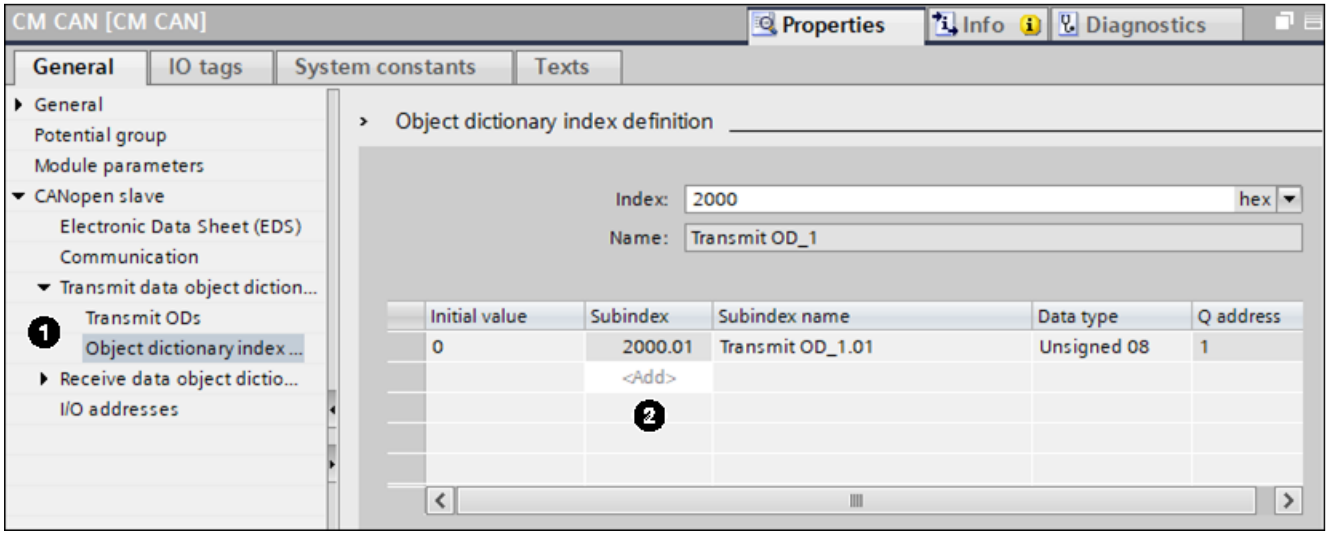

Figure 2-1421 Object dictionary index definition

Creating additional OD entries for transmit data in the Manager

Repeat the above steps until all desired transmit data has been created in the OD of the Manager.

NOTE

Limited number of OD and subindex entries

You can create a maximum of 100 OD entries (indexes). This maximum number is independent of the distribution of entries between the transmit data OD and receive data OD.

The number of subindex entries is also limited. You can create up to 256 subindexes for all indexes together if the subindexes are 1 byte long (256 byte memory limit).

At least 1 subindex must be defined for each index. This means when 100 indexes are defined, one index can have 156 subindexes with a length of 1 byte and the remaining indexes can have only one subindex with a length of 1 byte.

Defining a receive data OD

The steps for defining and assigning the receive data ODs are similar to those for transmit data ODs:

1. Create receive data object dictionary
2. Define receive OD index and subindex

Adapting I/O addresses

The input and output addresses of the communication module use an address space of 1-256 bytes. The I/O addresses are automatically assigned for each communication module when the device configuration is specified in TIA Portal.

Checking data consistency

Subsequent compilation allows you to check the consistency of the assignments and the data types used.

Exporting the EDS file

Export the EDS file of the module.

1. Select electronic data sheet (EDS). ①
2. By clicking the "Export EDS file" button, the corresponding file selection dialog opens. ②

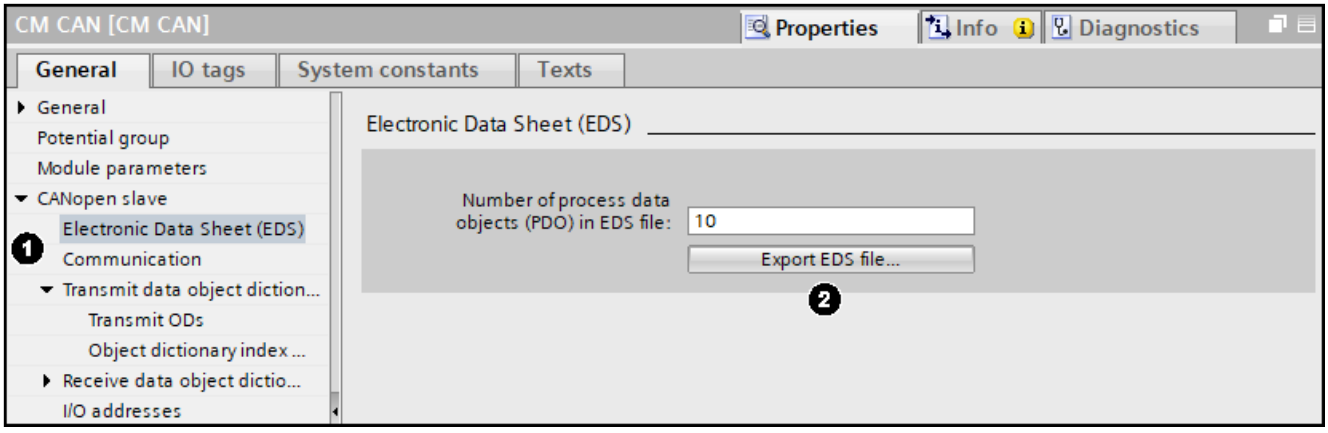

Figure 2-1422 Exporting the EDS file

Allow module to transition to "Operational" via the S7 user program

To allow the transition of the module to "Operational" state and thus the transmission of data between the SIMATIC S7 controller and the module, you must set the control bit to "1" via the S7 user program. This control bit is transmitted cyclically from the SIMATIC S7 controller to the module as part of the IO data. However, the actual state transition must be triggered by the current NMT master.

7.4 Configuring CAN transparent

7.4.1 Overview

Configuration with the HSP in the TIA Portal

The module is configured in the TIA Portal. The configuration for "CAN transparent" operating mode mainly consists of the following steps:

- Import the HSP for the module into the TIA Portal.
- Drag the module from the HW catalog to the project.
- Set specific parameters.
- Set the "CAN transparent" operating mode.
- Set the transmission rate.
- Set the transmit/receive messages and transmit/receive proxies.
- Check and compile the configuration.

7.4.2 Configuration in the TIA Portal

TIA Portal: Devices & networks

Proceed as follows:

1. Drag the communication module CAN from the HW Catalog ① to the ET 200SP CPU or to the ET 200SP interface module. ②
2. Specify the "CAN transparent" operating mode.
3. Set the bus-specific parameters: The transmission rate.
4. Define the transmit and receive messages / proxy messages.

5. Check and compile the configuration.

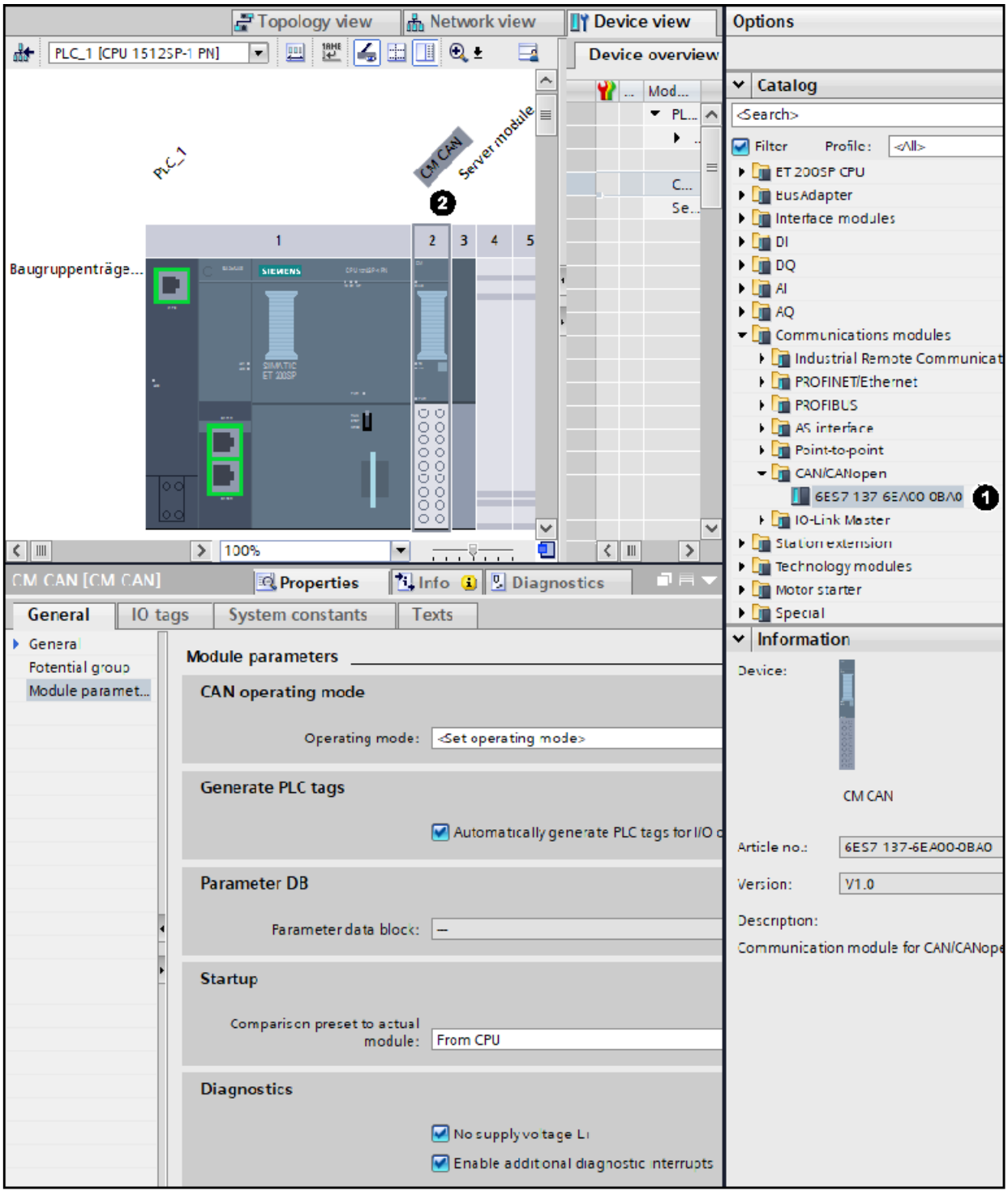

Figure 2-1423 TIA Portal: Devices & networks

Selecting CAN operating mode of the module

The CAN operating mode is selected using the "Set operating mode" drop-down list with the following selection options:

- CANopen manager
- CANopen slave
- CAN transparent

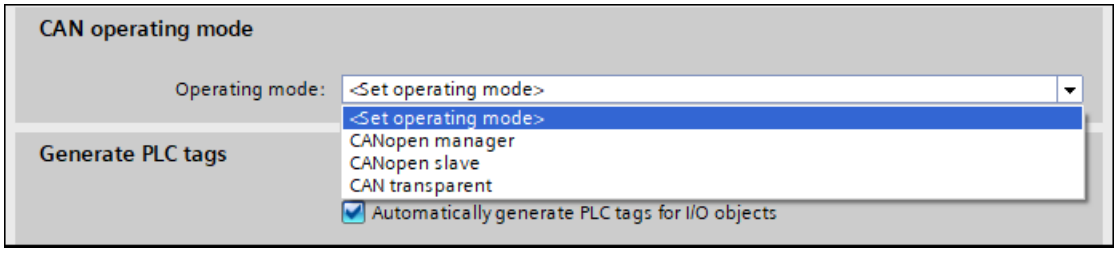

Figure 2-1424 Selecting the CAN operating mode

1. Select the "CAN transparent" operating mode.
   After selection of the operating mode the parameters associated with the selected mode can be set. All settings for the "CAN transparent" module of the module are made in slot 1.

Setting the communication parameters

Select the transmission rate for the communication. ①

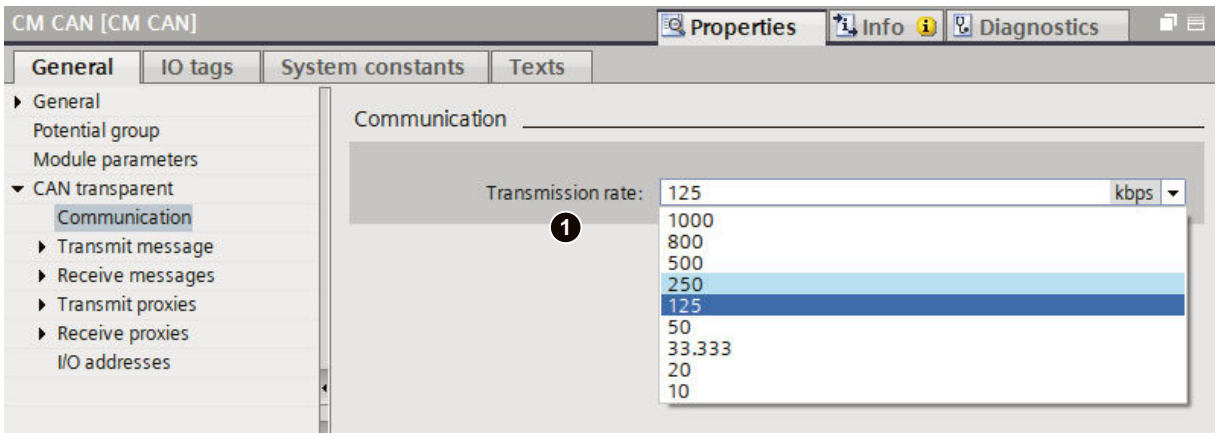

Figure 2-1425 Selecting the transmission rate

Configuring transmit/receive messages

1. Open "Transmit messages" in the CAN transparent menu. Select the "Message definition" ① and create a transmit message by double-clicking the "Add" button. ②
2. Select "Message index definition" ③ and create the necessary message definitions. ④

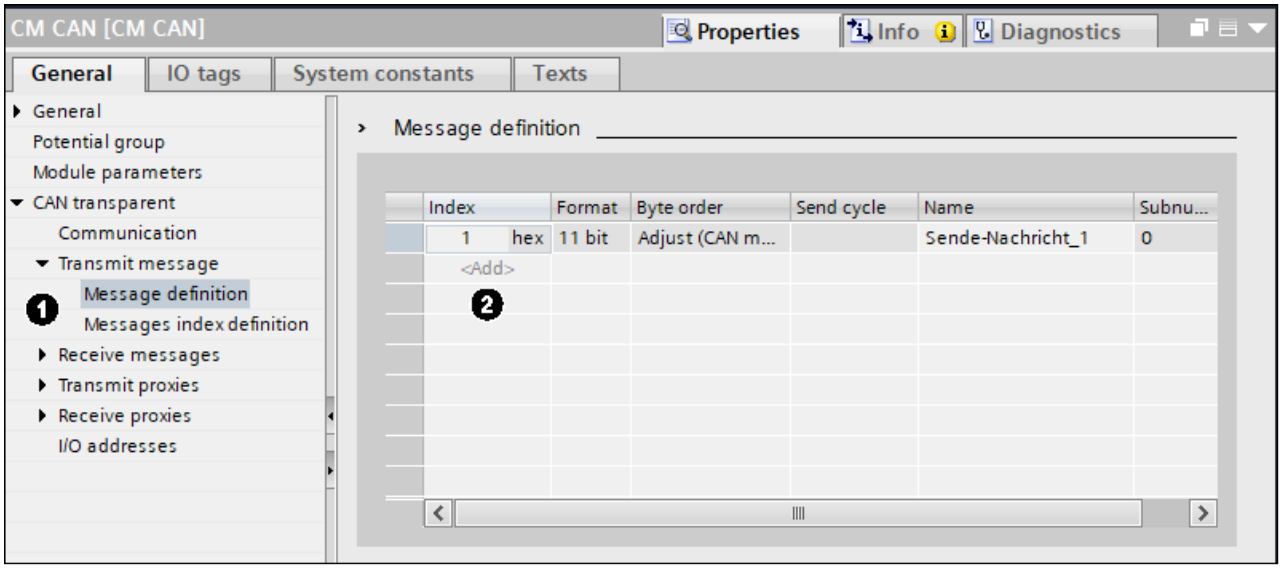

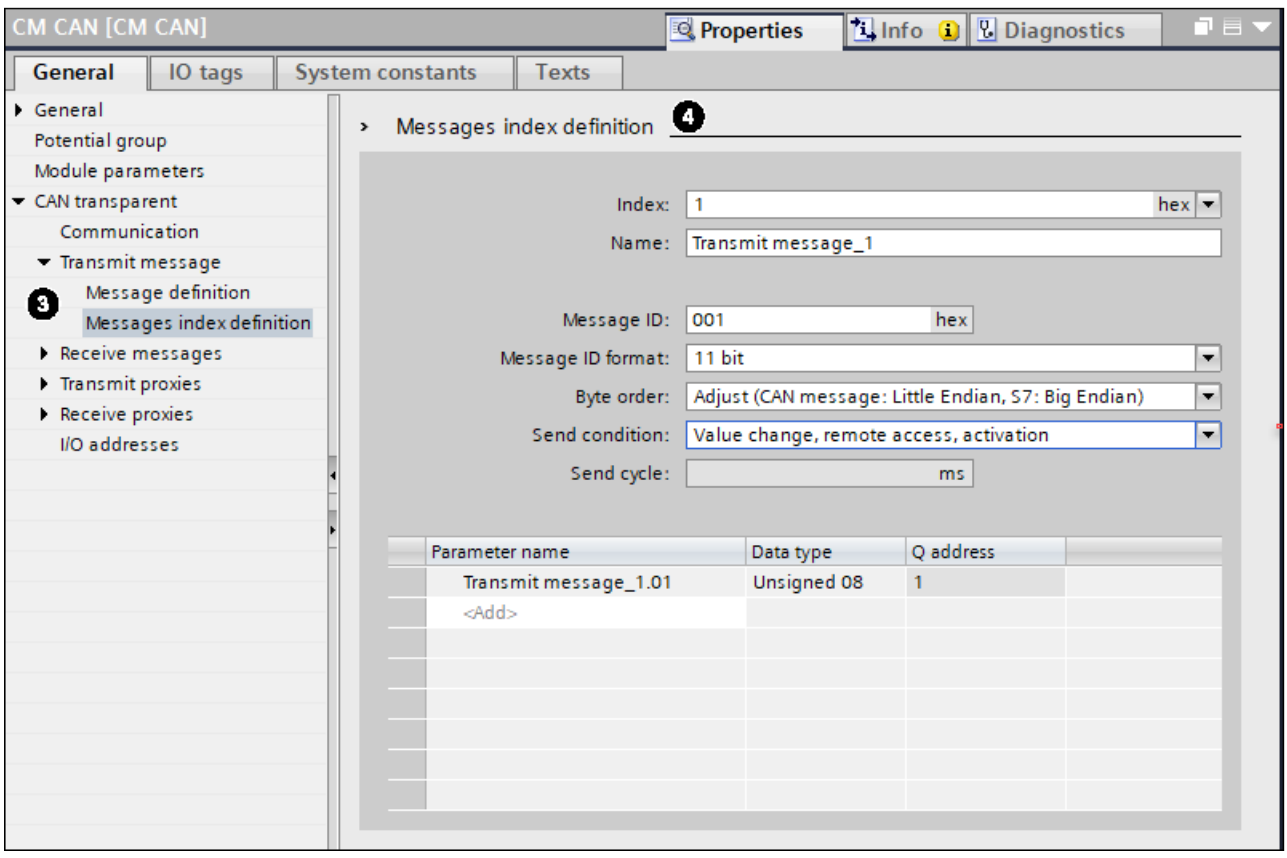

Figure 2-1426 Transmit and receive messages

Creating and setting transmit proxies and receive proxies

1. In the "CAN transparent menu", open the "Transmit proxies" and select the "Proxy definition". ①.
2. Double-click on the "Add" button to create a new transmit proxy. ②

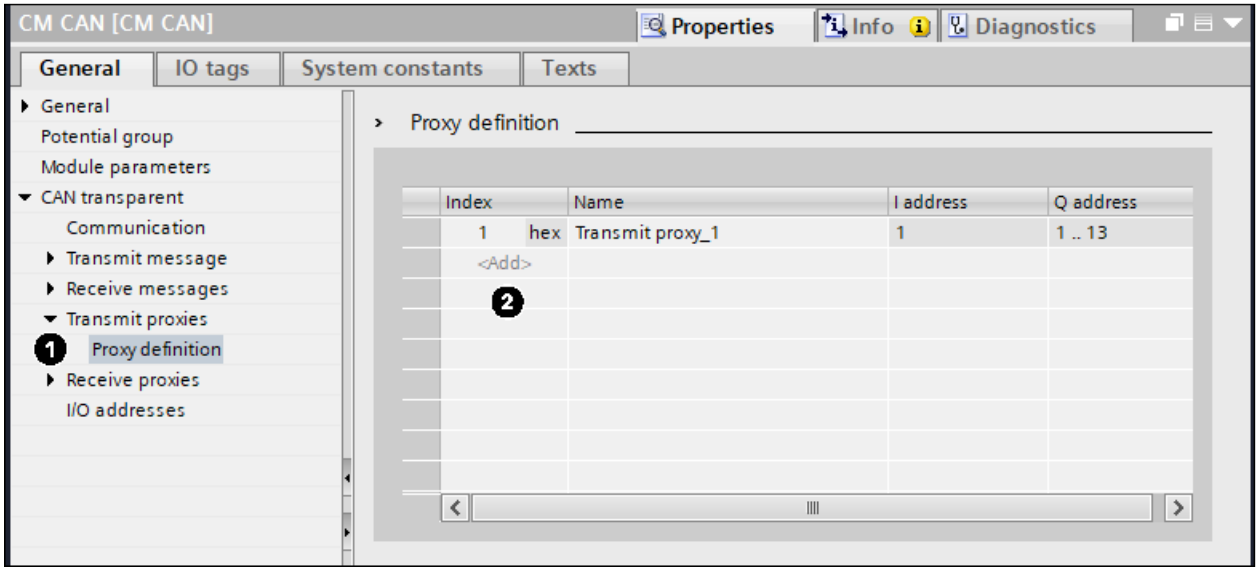

Figure 2-1427 Creating and setting up transmit proxies

1. In the "CAN transparent menu" open the "Receive proxies" and select the "Proxy definition". ①.
2. Double-click on the "Add" button to create a new receive proxy. ②

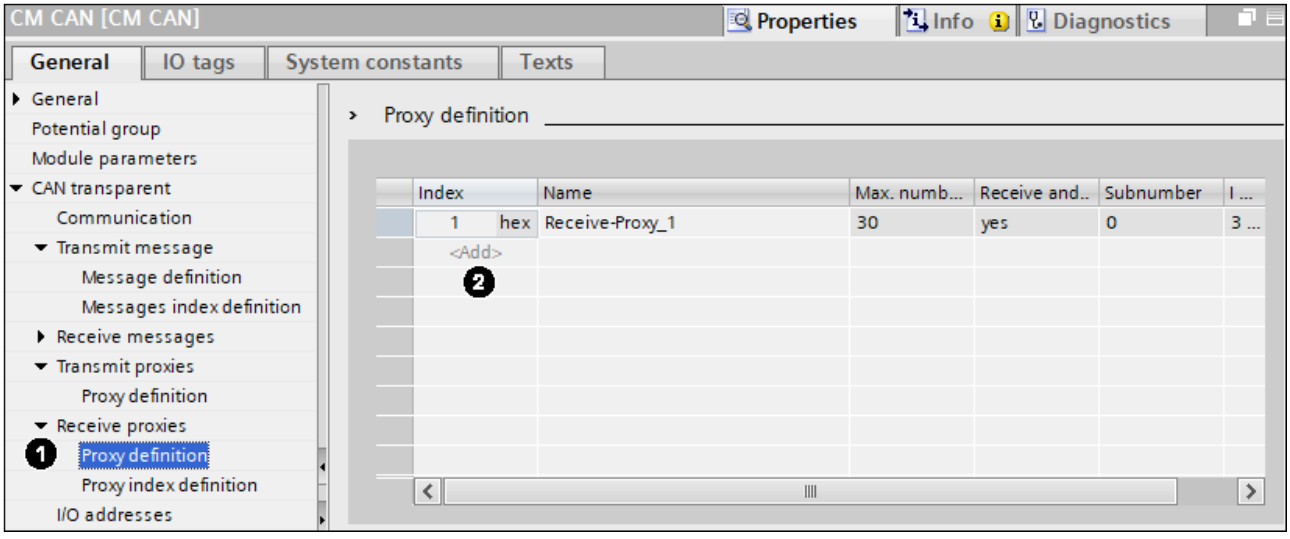

Figure 2-1428 Creating and setting receive proxies

For receive proxies, you can specify the maximum number of messages the receive buffer can accommodate. You can use a message filter to define which messages are to be processed.

1. In the "CAN transparent menu", open the "Receive proxies" and select the "Proxy index definition" ①.
2. Define the maximum number of messages the receive buffer should hold. ②

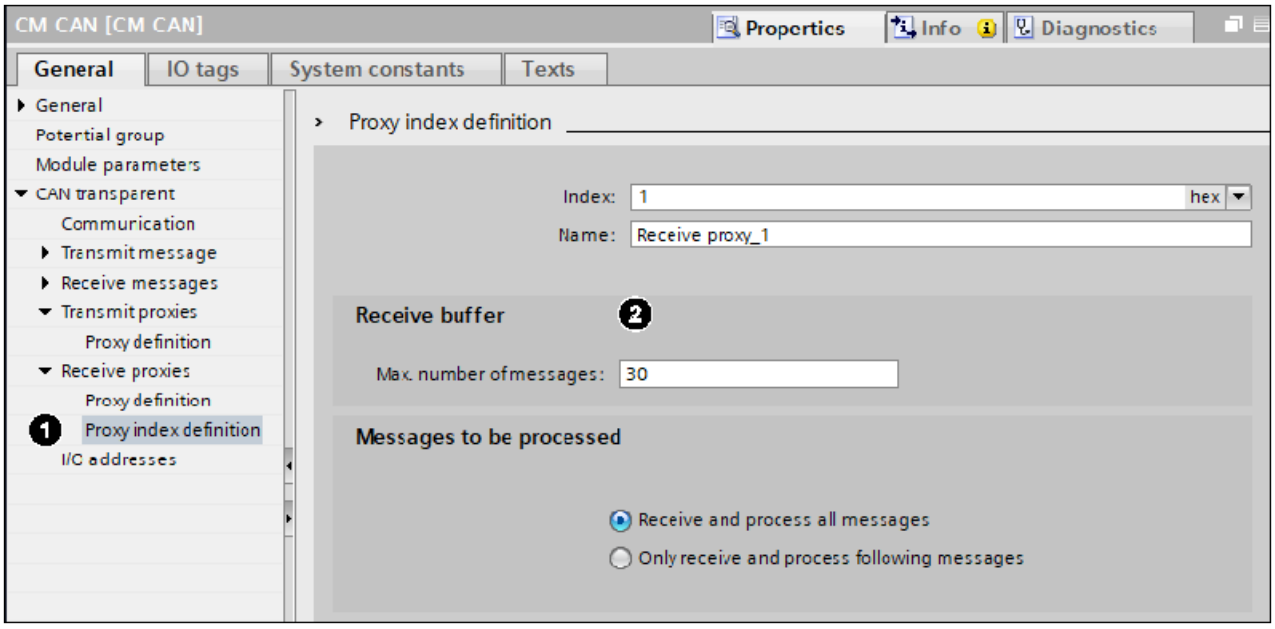

Figure 2-1429 Set proxy index definition

Adapting I/O addresses

The input and output addresses of the communication module use an address space of 1-256 bytes. The I/O addresses are automatically assigned for each communication module when the device configuration is specified in TIA Portal.

Checking data consistency

You can check the consistency of the assignments for the receive data and transmit data as well as the data types used with a compilation.

Setting CAN communication to "ON" via S7 user program

To allow transmission of data between the SIMATIC S7 controller and the module, you must set a control bit to "1" with the S7 user program. This control bit is transmitted cyclically from the SIMATIC S7 controller to the module as part of the IO data.

Programming 8

8.1 PLC tags

The PLC tags are automatically created by the HSP when the module is configured in the TIA Portal. You can use the PLC tags in the user program to access the cyclic I/O image. This means the parts of the I/O image allocated to the module can be accessed from the user program using logical names. The use of explicit addresses in the user program is therefore not required.

NOTE

To improve the performance, switch off the "Automatic generation of PLC tags for I/O objects" when creating large configurations.

When configuration is complete, switch on the "Automatic generation of PLC tags for I/O objects" to generate the PLC tags. This process applies to all ports.

The automatically generated PLC tags of the communication module (all modes) are not deleted:

- When the copied set (IM155 and CM CAN) is switched off by the subnet or I/O system
- When the copied set (IM155 and CM CAN) is deleted

You must delete the tags manually.

The mechanism of the tag generation does not reflect switch-off of the interface module from PROFINET. You must delete the tags manually.

Naming scheme of the created PLC tags

Table 2-1795 Naming scheme of the created PLC tags

Module/ submodule		IO data	Naming scheme	Data type	S7 address Mnemonics
CANopen manager CANopen slave			**Prefix:**<IO_DeviceName>.<ModuleName>.<OperatingMode>		
		Status	<*Prefix*>.Status	Byte	%IB<*ByteAdr*>
		Control	<*Prefix*>.Control	Byte	%QB<*ByteAdr*>
	Transmit data object dictionary		**Prefix**: <IO_DeviceName>.<ModuleName>.<OperatingMode>.<TransmitDataObjectDictionaryName>		
		Unsigned 08	<*Prefix*>.<Subindex name>	USInt	%QB<*ByteAdr*>
		Unsigned 16	<*Prefix*>.<Subindex name>	UInt	%QW<*ByteAdr*>

I/Q: Input/output bit address

IB/QB: Input/output byte address

ID/QD: Input/output double word address

***** The S7-1200 CPUs do not support 64-bit data types, so the generated tags cannot be used for the S7-1200.

Module/ submodule		IO data	Naming scheme	Data type	S7 address Mnemonics
		Unsigned 32	*<Prefix>*.<Subindex name>	UDInt	%QD*<ByteAdr>*
		Unsigned 64 *	*<Prefix>*.<Subindex name>	ULInt	%Q*<ByteAdr>*.0
		Integer 08	*<Prefix>*.<Subindex name>	SInt	%QB*<ByteAdr>*
		Integer 16	*<Prefix>*.<Subindex name>	Int	%QW*<ByteAdr>*
		Integer 32	*<Prefix>*.<Subindex name>	DInt	%QD*<ByteAdr>*
		Integer 64 *	*<Prefix>*.<Subindex name>	LInt	%Q*<ByteAdr>*.0
		Real 32	*<Prefix>*.<Subindex name>	Real	%QD*<ByteAdr>*
		Real 64 *	*<Prefix>*.<Subindex name>	LReal	%Q*<ByteAdr>*.0
		Bool	*<Prefix>*.<Subindex name>	Bool	%Q*<ByteAdr>*.0
	Receive data object dictionary		**Prefix**: <IO_DeviceName>.<ModuleName>.<OperatingMode>.<ReceiveDataObjectDictionaryName>		
		Unsigned 08	*<Prefix>*.<Subindex name>	USInt	%IB*<ByteAdr>*
		Unsigned 16	*<Prefix>*.<Subindex name>	UInt	%IW*<ByteAdr>*
		Unsigned 32	*<Prefix>*.<Subindex name>	UDInt	%ID*<ByteAdr>*
		Unsigned 64 *	*<Prefix>*.<Subindex name>	ULInt	%I*<ByteAdr>*.0
		Integer 08	*<Prefix>*.<Subindex name>	SInt	%IB*<ByteAdr>*
		Integer 16	*<Prefix>*.<Subindex name>	Int	%IW*<ByteAdr>*
		Integer 32	*<Prefix>*.<Subindex name>	DInt	%ID*<ByteAdr>*
		Integer 64 *	*<Prefix>*.<Subindex name>	LInt	%I*<ByteAdr>*.0
		Real 32	*<Prefix>*.<Subindex name>	Real	%ID*<ByteAdr>*
		Real 64 *	*<Prefix>*.<Subindex name>	LReal	%I*<ByteAdr>*.0
		Bool	*<Prefix>*.<Subindex name>	Bool	%I*<ByteAdr>*.0
CAN transparent			**Prefix:** <IO_DeviceName>.<ModuleName>.<OperatingMode>		
		Status	*<Prefix>*.Status	Byte	%IB*<ByteAdr>*
		Control	*<Prefix>*.Control	Byte	%QB*<ByteAdr>*
	Transmit message		**Prefix**: <IO_DeviceName>.<ModuleNamee>.<OperatingMode>.<TransmitMessageName>		
		Unsigned 08	*<Prefix>*.<Parameter name>	USInt	%QB*<ByteAdr>*
		Unsigned 16	*<Prefix>*.<Parameter name>	UInt	%QW*<ByteAdr>*
		Unsigned 32	*<Prefix>*.<Parameter name>	UDInt	%QD*<ByteAdr>*
		Unsigned 64 *	*<Prefix>*.<Parameter name>	ULInt	%Q*<ByteAdr>*.0
		Integer 08	*<Prefix>*.<Parameter name>	SInt	%QB*<ByteAdr>*
		Integer 16	*<Prefix>*.<Parameter name>	Int	%QW*<ByteAdr>*

I/Q: Input/output bit address

IB/QB: Input/output byte address

ID/QD: Input/output double word address

***** The S7-1200 CPUs do not support 64-bit data types, so the generated tags cannot be used for the S7-1200.

Module/ submodule		IO data	Naming scheme	Data type	S7 address Mnemonics
		Integer 32	<*Prefix*>.<Parameter name>	DInt	%QD<*ByteAdr*>
		Integer 64 *	<*Prefix*>.<Parameter name>	LInt	%Q<*ByteAdr*>.0
		Real 32	<*Prefix*>.<Parameter name>	Real	%QD<*ByteAdr*>
		Real 64 *	<*Prefix*>.<Parameter name>	LReal	%Q<*ByteAdr*>.0
		Bool	<*Prefix*>.<Parameter name>	Bool	%Q<*ByteAdr*>.0
	Receive message		**Prefix**: <IO_DeviceName>.<ModuleName>.<OperatingMode>.<ReceiveMessageName>		
		Unsigned 08	<*Prefix*>.<Parameter name>	USInt	%IB<*ByteAdr*>
		Unsigned 16	<*Prefix*>.<Parameter name>	UInt	%IW<*ByteAdr*>
		Unsigned 32	<*Prefix*>.<Parameter name>	UDInt	%ID<*ByteAdr*>
		Unsigned 64 *	<*Prefix*>.<Parameter name>	ULInt	%I<*ByteAdr*>.0
		Integer 08	<*Prefix*>.<Parameter name>	SInt	%IB<*ByteAdr*>
		Integer 16	<*Prefix*>.<Parameter name>	Int	%IW<*ByteAdr*>
		Integer 32	<*Prefix*>.<Parameter name>	DInt	%ID<*ByteAdr*>
		Integer 64 *	<*Prefix*>.<Parameter name>	LInt	%I<*ByteAdr*>.0
		Real 32	<*Prefix*>.<Parameter name>	Real	%ID<*ByteAdr*>
		Real 64 *	<*Prefix*>.<Parameter name>	LReal	%I<*ByteAdr*>.0
		Bool	<*Prefix*>.<Parameter name>	Bool	%I<*ByteAdr*>.0

I/Q: Input/output bit address

IB/QB: Input/output byte address

ID/QD: Input/output double word address

***** The S7-1200 CPUs do not support 64-bit data types, so the generated tags cannot be used for the S7-1200.

Function block

A special function block was developed to assign parameters to the CM CAN. Install the supplied HSP and the additional TIA Portal library (function block).

The HSP generates a data block with the configuration of the module. The function block then transfers the configuration in the runtime process.

The configuration is transferred as follows:

- Automatically, if the status byte is used as input parameter "CAN_STATE" of the function block.
- Manually, if you set the "REQ" parameter of the function block to "1". The parameter is then set to "0".

Drag the corresponding function block from the global library to your program blocks according to the selected CPU:

- CPUs 1500: ET200SPCM_CANConfig
- CPUs 1200: ET200SPCM_CANConfig_1200
- Open Controller: ET200SPCM_CANConfig_1515_PC

The function block appears as ET200SP_CAMConfig[FB1500].

Drag the corresponding function block (ET200SPCM_CANConfig) from the program blocks into your organization blocks.

Enter the parameters as follows:

DB_NO: Configuration data block of the CAN communication module generated by the HSP

CAN_STATE: Generated PLC tag of the status byte information

REQ: Trigger of manual download

ABORT: Cancelation of download

NOTE

Create an independent instance of the function block that transfers the configuration for each communication module in the module.

Function description

The transfer is started with REQ=TRUE. All data records included in the "DB_NO" configuration block are written one after the other. BUSY is set to TRUE during execution of the command.

If all data records are transferred without an error, the message DONE=TRUE appears.

If a data record cannot be transferred due to a temporary error, the request is automatically repeated.

If a data record cannot be transferred due to a static error, execution of the command is stopped and displayed in ERROR and STATUS.

After the instruction is started, the bit for the activation of the REQ instruction is automatically reset. The transfer of the current data is started with ABORT=TRUE.

If the status byte of the communication module is placed in the CAN_STATE parameter, the data records for an unconfigured module are automatically written.

Send new hardware configuration

You need to send a new hardware configuration if:

- The extended parameter assignment fails. The function block shows ERROR=TRUE
- The status byte of the communication module indicates "bad parameterization" for bit setting in the module status.

You send a new hardware configuration as follows:

1. Right-click "PLC".
2. Select "Compile"
3. Click "Hardware (rebuild all)"
4. Select "Download to device"
5. Click "Software (all)"
6. Select "Download to device"
7. Click "Hardware configuration"

After successful sending of the hardware configuration, the module can receive the extended parameter assignment again. The status byte of the module shows "not configured" for bit setting in the "Module status".

Parameters

The following table shows the parameters:

Parameters	Information	Data type	Memory area	Description
DB_NO	Input	Variant	D	Data block with data records that are to be written (symbolic name or "%DBxy")
CAN_STATE	Input	Byte	I, Q, M, D, L	Status byte of the CAN module
REQ	InOut	Bool	I, Q, M, D, L	TRUE: Start of the data transfer
ABORT	InOut	Bool	I, Q, M, D, L	TRUE: Data transfer interrupted
BUSY	Output	Bool	I, Q, M, D, L	TRUE: Data transfer active
DONE	Output	Bool	I, Q, M, D, L	TRUE: All data records are transferred
ERROR	Output	Bool	I, Q, M, D, L	TRUE: At least one data record was not transferred
STATUS	Output	DWORD	I, Q, M, D, L	Information about an error

Status parameters

The following table shows the status parameters:

Error code	Description
0000 8001	The instruction is already running.
0000 8002	The block in parameter DB_NO is not a global data block. You enter a global data block with a symbolic name or "%DBxy".
0000 8003	Configure a data block number in parameter DB_NO.
0000 8004	The data block is too short.
0000 8005	There are too few data records in the data block. There needs to be at least one data record.
0000 8006	The data record is too large. Maximum size of a data record is 4096 bytes.

Error code	Description
DF80 B500	Extended parameter assignment is ignored because the module was not in "not configured" state.
DF80 B800	Incorrect parameter assignment data was received.
DF80 B600	The data record was not accepted.

Interrupts/diagnostics alarms

9

9.1 Status and error display

LED display

The figure below shows the LED displays (status and error displays) of the CM CAN.

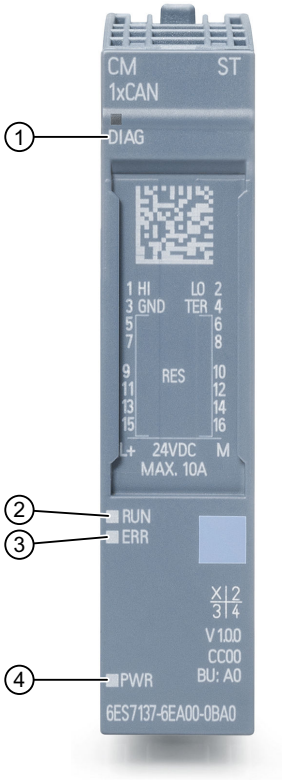

① DIAG LED (green/red)
② RUN LED (green)
③ ERROR LED (red)
④ PWR LED (green)

Figure 2-1430 SIMATIC ET 200SP CM CAN

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Measures for dealing with diagnostics alarms can be found in the section Diagnostics alarms (Page 116).

DIAG LED

Table 2-1796 Behavior of the DIAG LED

DIAG LED	Meaning
Off	• Supply voltage of the ET 200SP via the backplane bus is not present.
Flashes	• Module parameters are not assigned.
On	• Module parameters are assigned and there are no diagnostics.
Flashes	• Module parameters are assigned and there are diagnostics.

RUN LED

Table 2-1797 Behavior of the RUN LED

RUN LED	Meaning	Note
Off	• The module is in the initialization phase.	After power-on of the device or after reset
Flashes	• The NMT state of the module is "Pre-Operational".	-
One-time brief flashing	• The NMT state of the module is "Stopped".	-
On	• The NMT state of the module is "Operational".	-

ERR LED

Table 2-1798 Behavior of the ERR LED

ERR LED	Meaning	Note
Off	• No error on the CANopen bus	-
One-time brief flashing	• At least one error counter in the CAN controller has reached its warning threshold.	-
Two-time brief flashing	• A Heartbeat or Node Guarding error has occurred.	-
On	• The CAN controller is in "Bus-Off" state.	-

PWR LED

Table 2-1799 Behavior of the PWR LED

PWR LED	Meaning
□ Off	• Supply voltage L+ is too low or missing. • Invalid BaseUnit (A1) used
■ On	• Supply voltage L+ present

9.2 Interrupts

Diagnostics

The module sends diagnostic information to the SIMATIC S7 controller.

A distinction is made here between diagnostic messages that refer to the entire ET 200SP CM CAN communication module and those that refer to individual modules.

Many diagnostic messages are the result of error events and not error states. Therefore, the diagnostics are removed immediately after they have been reported to the SIMATIC S7 controller ("Incoming" message and "Outgoing" message).

The tables below provide an overview of the following for the various modes of the module:

- The events that trigger a diagnostic message
- The events that cause a pending diagnostic message to be withdrawn
- The associated component

The diagnostic messages including description are listed in the section Diagnostics alarms (Page 116). The descriptions also include instructions and information on error correction.

Diagnostics-relevant events in "CANopen manager" operating mode

Table 2-1800 Diagnostics-relevant events in "CANopen manager" operating mode

Event for triggering	Event for withdrawal	Reference	Additional information*
Transition of the CAN controller to "Bus Off" state	CAN controller exits "Bus Off" state again	Module	---
Transition of the CAN controller to "Error Passive" state	CAN controller exits "Error Passive" state again	Module	---
Internal communication error	Diagnostic information was transmitted to the SIMATIC S7 controller	Module	---
Buffer overflow when sending CAN packets	Diagnostic information was transmitted to the SIMATIC S7 controller	Module	---
Buffer overflow when receiving CAN packets	Diagnostic information was transmitted to the SIMATIC S7 controller	Module	---

Event for triggering	Event for withdrawal	Reference	Additional information*
Receipt of PDO with incorrect length	Diagnostic information was transmitted to the SIMATIC S7 controller	Module	COB ID of the PDO
Heartbeat / Node Guarding error	When the slave is available again and in the expected state	Corresponding slave module	---
Unexpected slave state	When the slave is in the expected state again	Corresponding slave module	---
Error during boot-up of a slave	When the slave was booted successfully	Corresponding slave module	Cause of error, if known
Receipt of an EMCY message	Diagnostic information was transmitted to the SIMATIC S7 controller	Corresponding slave module	Error codes of the EMCY message

* Additional information can only be read with the special data record, as described in the section Advanced diagnostics alarms (Page 118).

Diagnostics-relevant events in "CANopen slave" operating mode

Table 2-1801 Diagnostics-relevant events in "CANopen slave" operating mode

Event for triggering	Event for withdrawal	Reference	Additional information
Transition of the CAN controller to "Bus Off" state	CAN controller exits "Bus Off" state again	Module	---
Transition of the CAN controller to "Error Passive" state	CAN controller exits "Error Passive" state again	Module	---
Internal communication error	Diagnostic information was transmitted to the SIMATIC S7 controller	Module	---
Buffer overflow when sending CAN packets	Diagnostic information was transmitted to the SIMATIC S7 controller	Module	---
Buffer overflow when receiving CAN packets	Diagnostic information was transmitted to the SIMATIC S7 controller	Module	---
Receipt of PDO with incorrect length	Diagnostic information was transmitted to the SIMATIC S7 controller	Module	COB ID of the PDO
Heartbeat / Node Guarding error	Diagnostic information was transmitted to the SIMATIC S7 controller	Module	ID of failed node

Diagnostic-relevant events in "CAN transparent" mode

Table 2-1802 Diagnostic-relevant events in "CAN transparent" mode

Event for triggering	Event for withdrawal	Reference
Transition of the CAN controller to "Bus Off" state	CAN controller exits "Bus Off" state again	Module
Transition of the CAN controller to "Error Passive" state	CAN controller exits "Error Passive" state again	Module
Internal communication error	Diagnostic information was transmitted to the SIMATIC S7 controller	Module
Buffer overflow when sending CAN packets	Diagnostic information was transmitted to the SIMATIC S7 controller	Module
Buffer overflow when receiving CAN packets	Diagnostic information was transmitted to the SIMATIC S7 controller	Module
Receipt of a CAN packet with incorrect length	Diagnostic information was transmitted to the SIMATIC S7 controller	Corresponding input module

9.3 Diagnostics alarms

Diagnostics

ID	Channel diagnostics error	Cause of error and possible solution	Mode
1232, 0x4D0	CAN in "Bus Off" mode	No more CAN messages can be sent or received. Check for errors in the hardware installation (e.g. terminating resistor, etc.) or communication settings (e.g. transmission rate, etc.).	Manager, Slave, Transparent
1233, 0x4D1	CAN in "Error Passive" mode	In this state, the device can no longer initiate repetition of defective CAN messages. Check for errors in the hardware installation (e.g. terminating resistor, etc.) or communication settings (e.g. transmission rate, etc.). The error may also occur if no other devices are connected to the CAN bus.	Manager, Slave, Transparent
1234, 0x4D2	CAN receive buffer overflow	Received CAN messages were lost. Reduce the CAN transmission rate, increase the PROFINET cycle time or reduce the PROFINET IO data to be transmitted.	Manager, Slave, Transparent
1235, 0x4D3	CAN transmit buffer overflow	The CAN messages to be transmitted could not be sent and were discarded because: • CAN communication volume too high • Further problems in CAN communication ("Bus Off" or "Error Passive" state). If neither "Bus off" nor "Error passive" state is present, try reducing the amount of communication traffic or increasing the CAN bit rate.	Manager, Slave, Transparent
1236, 0x4D4	Received PDO with wrong length	The received PDO has a length that differs from the one configured and will therefore be discarded. Correct the configuration of the PDOs.	Manager, Slave

ID	Channel diagnostics error	Cause of error and possible solution	Mode
1237, 0x4D5	Heartbeat error	No heartbeat message was received from node within the specified time. The error reaction configured in OD 1029 will be performed. Check whether: • Whether the node has failed • Whether the monitoring time is correctly configured.	Slave
1238, 0x4D6	Node Guarding error	No Node Guarding request was received from the manager within the specified time. The error reaction configured in OD 1029 will be performed. Check whether: • Whether the master has failed • Whether the monitoring time is correctly configured.	Slave
1239, 0x4D7	Heartbeat or Node Guarding error	No heartbeat message has been received from the node within the specified time or the node has not responded to a Node Guarding request within the set monitoring time. If the message occurred during startup, the start procedure is repeated for all nodes. In all other cases the reaction configured under "Reaction to failure of node" is executed.	Manager
1240, 0x4D8	Incorrect NMT status	The node reports an unexpected network status (NMT status). The reported NMT status can be read from the advanced diagnostics data record. If the message occurred during startup, the start procedure is repeated for all nodes. In all other cases the reaction configured under "Reaction to failure of node" is executed.	Manager
1241, 0x4D9	Error when booting	Errors were detected when starting the node. Details are output in one or more additional diagnostic messages. Depending on the setting "Node is required in the network", the node or all nodes are restarted.	Manager
1242, 0x4DA	Booting: Node is not responding	The node has not responded to a request within 30 seconds (OD 1000). Check if the node is correctly connected to the CAN bus and is not in the "Stopped" state. The start operation is continued.	Manager
1243, 0x4DB	Booting	Additional information on diagnostic message "Error when booting". Read the information from the advanced diagnostics data record.	Manager
1244, 0x4DC	Receive EMCY message	An EMCY message was received from the node. The emergency error code and the reported value of the error register can be read from the advanced diagnostics data record. Note: If too many EMCY messages are received in too short a time, not all messages are displayed in the diagnostic message.	Manager
1245, 0x4DD	Received message has incorrect length	The received CAN message has a different length than the configured length and is therefore discarded. Correct the configured length.	Transparent

ID	Channel diagnostics error	Cause of error and possible solution	Mode
1246, 0x4DE	Error in extended parameter assignment	An error occurred when executing the extended parameter assignment with a function block. Check whether the device configuration is valid.	Manager, Slave, Transparent
9, 0x009	Faulty module	The SSI communication is missing, but not the external power supply. STM32 seems to be faulty. Remedy: Switch off the power supply and replace the module.	Manager, Slave, Transparent
16, 0x010	Invalid parameter assign-ment	The module has detected a parameter assignment error. Parameter assignment errors are: -The module cannot evaluate any parameters, e.g. due to unknown parameters, invalid parameter combination. -The module does not yet have configured para-meters. -The user calibration does not match the parameter assignment. -Calibration error Remedy: Check and correct the parameters. Then load the parameters into the module.	Manager, Slave, Transparent
17, 0x011	Missing supply voltage	No encoder or supply voltage present. Remedy: Check the encoder connection or the supply voltage connection. Correct the wrong connection. Ensure that the power supply is switched on.	Manager, Slave, Transparent
22, 0x016	Hardware interrupt lost	The module signals the loss of the hardware inter-rupt. The hardware interrupt cannot be signaled because the previous hardware interrupt was not acknowledged. An error may occur in the configur-ation. Remedy: Change the alarm behavior in the CPU. If needed, change the parameter settings of the module. Note: The error can be corrected, for example, by restarting the module (the module receives the new parameters from the restart).	Manager, Slave, Transparent
31, 0x01F	Firmware update	The channel is temporarily not available. Wait until the firmware update is finished.	Manager, Slave, Transparent

9.4 Advanced diagnostics alarms

Advanced diagnostics alarms

Advanced diagnostics data record

Since the ET 200SP module cannot write the advanced diagnostics, a workaround has been created. A special advanced diagnostics data record has been created so that the user receives the advanced diagnostics data. When the advanced diagnostics is signaled, the user automatically sees only the normal diagnostics ID and its description. To get the advanced diagnostics ID and the advanced diagnostics data, the user must manually read the advanced diagnostics data record.

The user reads the advanced diagnostics alarms with RDREC no. 0x212.

The structure of the receive data is as follows:

Table 2-1803 Structure of the receive data

Item no.	Data record user data
Element [0]	2 bytes: Normal diagnostic ID
	2 bytes: Advanced diagnostics ID
	4 bytes: Advanced diagnostics data
Element [1]	2 bytes: Normal diagnostic ID
	2 bytes: Advanced diagnostics ID
	4 bytes: Advanced diagnostics data
Element [2]	2 bytes: Normal diagnostic ID
	2 bytes: Advanced diagnostics ID
	4 bytes: Advanced diagnostics data
Up to element [31]	2 bytes: Normal diagnostic ID
	2 bytes: Advanced diagnostics ID
	4 bytes: Advanced diagnostics data

Each advanced diagnostics requires 8 bytes. The data record contains a maximum of 32 advanced diagnostics, which the user can read simultaneously.

If a higher number of advanced diagnostics is signaled at the same time, only the first 32 diagnostic items are written to the data record.

Additional diagnostics

Table 2-1804 Definition of the advanced diagnostics alarms

Diagnostics ID	Advanced diagnostics ID				Structure of the advanced diagnostics data
	Data type	Bit	Value	Meaning	
1236, 0x4D4	Unsigned 16-bit integer:	15 ... 0	Must be "1"	Received PDO with wrong length	Unsigned 32-bit integer: COB ID (the COB ID of the PDO with the wrong length)
1237, 0x4D5	Unsigned 16-bit integer:	15 ... 0	Must be "1"	Heartbeat error	Unsigned 32-bit integer: Node ID (the ID of the node in which the error occurred)
1238, 0x4D6	Unsigned 16-bit integer:	15 ... 0	Must be "1"	Node Guarding error	Unsigned 32-bit integer: Node ID (the ID of the node in which the error occurred)
1239, 0x4D7	Unsigned 16-bit integer:	15 ... 0	Must be "1"	Heartbeat or Node Guarding error	Unsigned 32-bit integer: Node ID (the ID of the node in which the error occurred)
1240, 0x4D8	Unsigned 16-bit integer:	15 ... 0	Must be "1"	Incorrect NMT status	Unsigned 32-bit integer: 31 ... 24: NMT status (the NMT status reported by the node) 23 ... 16: Node ID (the ID of the node in which the error occurred) 15 ... 0: Reserved
1241, 0x4D9	Unsigned 16-bit integer:	15 ... 0	Must be "1"	Error when booting	Unsigned 32-bit integer: Node ID (the ID of the node in which the error occurred)

Diagnostics ID	Advanced diagnostics ID				Structure of the advanced diagnostics data
	Data type	Bit	Value	Meaning	
1242, 0x4DA	Unsigned 16-bit integer:	15 ... 0	Must be "1"	Booting: Node is not responding	Unsigned 32-bit integer: Node ID (the ID of the node in which the error occurred)
1243, 0x4DB	Unsigned 16-bit integer:	7 ... 0	Must be "1"	Booting: Other error	Unsigned 32-bit integer: Additional error code
		15 ... 8	1 ... 127	Node ID	
1243, 0x4DB	Unsigned 16-bit integer:	7 ... 0	Must be "2"	Booting: Heartbeat / Guarding - no reaction	Unsigned 32-bit integer: Reserved
		15 ... 8	1 ... 127	Node ID	
1243, 0x4DB	Unsigned 16-bit integer:	7 ... 0	Must be "3"	Booting: Different device type ID	Unsigned 32-bit integer: Reserved
		15 ... 8	1 ... 127	Node ID	
1243, 0x4DB	Unsigned 16-bit integer:	7 ... 0	Must be "4"	Booting: Different vendor ID	Unsigned 32-bit integer: Reserved
		15 ... 8	1 ... 127	Node ID	
1243, 0x4DB	Unsigned 16-bit integer:	7 ... 0	Must be "5"	Booting: Different product code	Unsigned 32-bit integer: Reserved
		15 ... 8	1 ... 127	Node ID	
1243, 0x4DB	Unsigned 16-bit integer:	7 ... 0	Must be "6"	Booting: Deviating revision number	Unsigned 32-bit integer: Reserved
		15 ... 8	1 ... 127	Node ID	
1243, 0x4DB	Unsigned 16-bit integer:	7 ... 0	Must be "7"	Booting: Different serial number	Unsigned 32-bit integer: Reserved
		15 ... 8	1 ... 127	Node ID	
1243, 0x4DB	Unsigned 16-bit integer:	7 ... 0	Must be "8"	Booting: SDO abort for OD	Unsigned 32-bit integer: Reserved
		15 ... 8	1 ... 127	Node ID	
1243, 0x4DB	Unsigned 16-bit integer:	7 ... 0	Must be "9"	Booting: SDO timeout for OD	Unsigned 32-bit integer: Reserved
		15 ... 8	1 ... 127	Node ID	
1244, 0x4DC	Unsigned 16-bit integer:	15 ... 0	Must be "1"	Receive EMCY message	Unsigned 32-bit integer: 31 ... 16: EMCY code 15 ... 8: Error register 7 ... 0: The first byte of the manufacturer error
1245, 0x4DD	Unsigned 16-bit integer:	15 ... 0	Must be "1"	Received message has incorrect length	Unsigned 32-bit integer: Wrong length

Technical specifications 10

10.1 Technical specifications

Technical specifications of the CAN communications module

The following table shows the technical specifications as of 02/2020. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7137-6EA00-0BA0/td?dl=en).

Article number	6ES7137-6EA00-0BA0
General information	
Product type designation	CM 1x CAN ST
Firmware version	V1.0.0
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
• Module swapping during operation (hot swapping)	Yes
• Isochronous mode	No
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	STEP 7 V15.1 or higher
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption, typ.	20 mA
Current consumption, max.	25 mA
Power loss	
Power loss, typ.	0.5 W
Address area	
Address space per module	
• Address space per module, max.	256 byte
1. Interface	
Interface type	CAN according to CiA 303-1

Article number	6ES7137-6EA00-0BA0
Isolated	Yes; 500 V AC or 707 V DC
Interface types	
• Number of ports	1
• Design of the connection	Push-in terminal
CAN	
• CAN operating modes	CAN Standard CAN 2.0A/B; CANopen Manager / Slave acc. to CiA
• Specification acc. to CiA	CiA 301 & CiA 302
• Transmission rate, min.	10 kbit/s
• Transmission rate, max.	1 000 kbit/s
• Number of slaves, max.	60
• Number of SDOs in parallel	16; Parallel
• Number of PDOs	128; Send / receive
Services	
– Node/life-guarding	Yes
– Heartbeat	Yes
– SYNC	Yes
Interrupts/diagnostics/status information	
Alarms	Yes
Diagnostics function	Yes
Diagnostics indication LED	
• RUN LED	Yes
• ERROR LED	Yes
• MAINT LED	No
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
Potential separation	
between backplane bus and interface	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
CE mark	Yes
UL approval	Yes
RCM (formerly C-TICK)	Yes
KC approval	Yes; Reg. No.: R-R-S49-ET200SPCMCAN
EAC (formerly Gost-R)	Yes
RoHS conformity	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C

Article number	6ES7137-6EA00-0BA0
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
• ceiling installation, min.	-30 °C
• ceiling installation, max.	50 °C
• floor installation, min.	-30 °C
• floor installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m
Decentralized operation	
to SIMATIC S7-300	No
to SIMATIC S7-400	No
to SIMATIC S7-1200	Yes
to SIMATIC S7-1500	Yes
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	32 g

Dimension drawing

See Equipment Manual ET 200SP BaseUnits
(https://support.industry.siemens.com/cs/ww/en/view/59753521)

SIEMENS

SIMATIC

ET 200SP
ET 200SP Communication module CM 1xDALI (6ES7137-6CA00-0BU0)

Equipment Manual

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Preface

Purpose of the documentation

This manual supplements the system manual ET 200SP distributed I/O system. Functions that generally relate to the system are described in this manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the DALI system controlled by the ET 200 SP CM 1xDALI.

Conventions

- STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".
- In a DALI system many input devices are sensors. Therefore in this documentation the terms “sensor” and “input device” are used as synonyms to improve readability.

This documentation contains figures of the described device. The figures may differ slightly from the devices supplied.

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

NOTE

To prevent injury, read the manual before use.

⚠

The manual is delivered online, you can download the document from Central technical support (https://support.industry.siemens.com/cs/ww/en/).

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

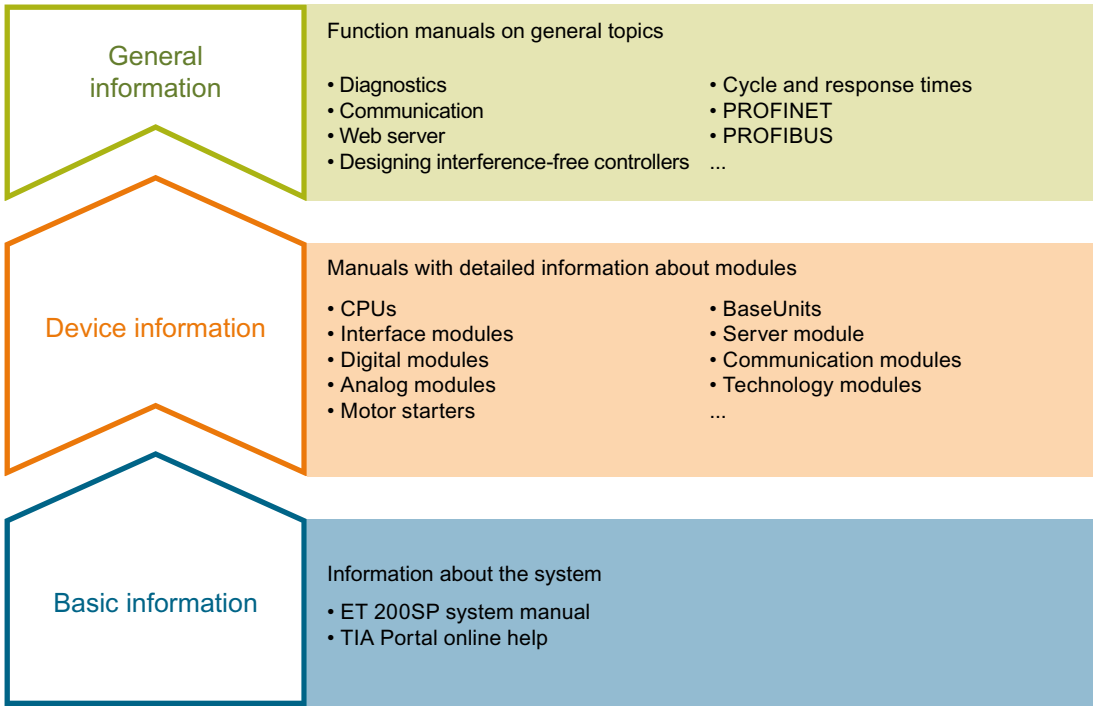

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/84133942).

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Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

Product overview

2

2.1 Properties

Article number

6ES7137-6CA00-0BU0

View of the module

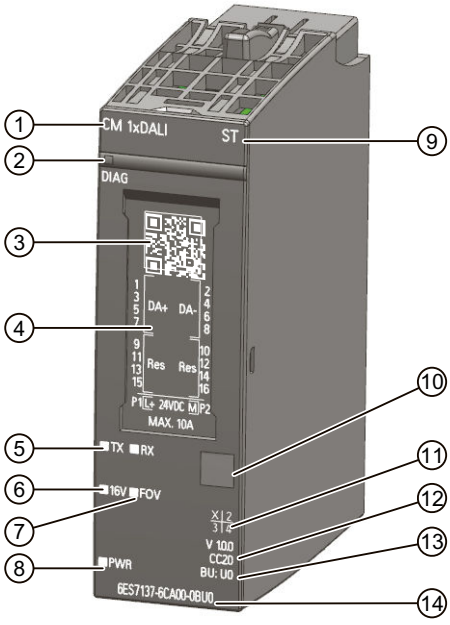

①	Module type and name	⑧	LED for the supply voltage
②	LED for diagnostics	⑨	Function class
③	2D matrix code	⑩	Color coding module type
④	Wiring diagram	⑪	Function and firmware version
⑤	LEDs for transmitting and receiving status	⑫	Color code for color-coded labels
⑥	LED for integrated DALI bus power supply	⑬	BU type
⑦	LED for fault over voltage on DALI bus	⑭	Article number

Figure 2-1431 View of the CM 1xDALI (without the BaseUnit)

Properties

The CM 1xDALI connects one DALI bus to the automation system and has the following properties:

- Technical properties:
  - DALI application controller (Multi-master)
  - 1xDALI bus with 4 pairs DALI+ and DALI- terminals (non-polarity)
  - 64 DALI control gears
  - 63 DALI input devices
  - 16 groups
  - 16 scenes
  - Integrated DALI bus power supply (can be disabled (Page 20))
  - Supports external DALI power supply when you disable the integrated DALI power supply
  - DALI bus short circuit diagnostic behavior (Page 92)
  - DALI bus fault over voltage protection which can protect DALI bus against accidental connection of the main voltage (up to 250 V AC)
  - Compliant with IEC 62386-101,103
  - Support of device types according to IEC 62386- 201, 202, 203, 204, 205, 205, 206, 207, 208, 209 and others as generic type
  - Support of input device types according to IEC 62386-301, 302, 303, 304
- Supported system functions:
  - Firmware update
  - Diagnostic
  - I&M data (identification and maintenance data): I&M0 to I&M3
- Supported functions:
  - Scan of the DALI bus and automatic assign of short addresses
  - Integrated operation hours counting for each control gear
  - Exchange two short addresses
  - Commands to devices and to groups or as broadcast
  - Control of groups and scenes
  - Receive event messages from input devices
  - Cyclic read of the status of the lamps
  - CM 1xDALI can receive messages from sensors (multi-master). You can read these messages from the command "DALI_CTRL". The other commands and queries to or from DALI devices are called by the user program.
- Supported control gear types and input device types:
  - Fluorescent (control gear type 00)
  - Emergency lamp (control gear type 01)
  - Discharge lamp (control gear type 02)

- Halogen (control gear type 03)
- Incandescent (control gear type 04)
- Voltage converter (control gear type 05)
- LED (control gear type 06)
- Switch function (control gear type 07)
- Color control (control gear type 08)
- Push button (input device type 01)
- Absolute input device (input device type 02)
- Occupancy sensor (input device type 03)
- Light sensor (input device type 04)
- Other types by generic commands

CM 1xDALI Functionality

- CM 1xDALI controls the DALI bus and holds the parameters of the DALI devices. The parameters are stored in the module even if power is off. The parameters can be read from the CPU and deployed to the devices. There can be connected more than 64 sensor instances in 1 DALI bus, but a maximum of 64 instance data sets can be stored in the module.
- CM 1xDALI sends all received CPU commands from the CPU to the DALI bus, more complex CPU commands (like setting parameters) are split into several DALI commands by the module.
- CM 1xDALI has an operating hour counter for every device that can be read and set from the CPU.
- If necessary, the module can scan the bus and assign short addresses to a newly installed device on DALI bus with one command.
- CM 1xDALI queries the status of the devices cyclically, this action is called "background detection". The CM 1xDALI periodically sends DALI commands to query the status of all the devices on the bus and stores the information in the module. The query period can be set by module parameters. The program blocks of the CPU have a higher priority when accessing the DALI bus. If the program blocks of the CPU continuously access the DALI bus, the background detection may be blocked. The background detection can detect the following results:
  - Whether each DALI device has a short address
  - For control gear: the information of basic status, control gear type and extended status
  - For sensor: the information of device status, number of instances and type of each instance

2.2 Compatibility

Connection to the system

Through BaseUnit type U0, you can assemble a CM 1xDALI to the CPU, open controller, or IM of the ET 200SP distributed I/O system.

Supported DALI devices

You can only use the input device which meets the standard of DALI-2, IEC 62386-103.

You can only use the control gear which meets the standard of DALI-1 or DALI-2. But on DALI-1 control gears, you cannot use the new functionalities which are added in DALI-2 standard.

Library

The CM 1xDALI library is compatible with the S7-1500 based CPUs (CPU 15xx).

Wiring 3

3.1 Important notes on using the device

WARNING

The equipment is designed for operation with Safety Extra-Low Voltage (SELV) or Protective Extra-Low Voltage (PELV).

This means that electrical circuit in which the voltage cannot exceed 30 V AC (RMS), 42.4 V AC peak or 60 V DC under NORMAL CONDITIONS and CONDITIONS OF A SINGLE FAULT, including ground faults in other circuits.

Notes on use in hazardous areas according to ATEX / IECEx

WARNING

Requirement for the installing enclosure

The modules shall be installed in a suitable enclosure providing a degree of protection of at least IP54 according to EN 60079-15, taking into account the environmental conditions under which the equipment will be used.

WARNING

Provision against transient disturbances

Provisions shall be made to prevent the rated voltage from being exceeded by transient disturbances of more than 119 V.

WARNING

Hazardous location

The equipment shall only be used in an area of not more than pollution degree 2, as defined in EN 60664-1.

General notices on use in hazardous areas according to FM

WARNING

Requirement for the installing enclosure

If the equipment is installed within an ultimate enclosure, the inner service temperature of the enclosure corresponds to the ambient temperature of the module.

WARNING

Risk of burn injury

If a device is operated in an ambient temperature of more than 50 °C, the temperature of the device housing may be higher than 70 °C. The device must therefore be installed so that it is only accessible to service personnel or users that are aware of the reason for restricted access and the required safety measures at an ambient temperature higher than 50 °C.

WARNING

Explosion hazard

Do not disconnect equipment unless power has been switched off or the area is known to be non-hazardous.

WARNING

Cable

The equipment is intended to be installed within an enclosure/control cabinet. The inner service temperature of the enclosure/control cabinet corresponds to the ambient temperature of the module. Use cables with a maximum permitted operating temperature of at least 30 °C higher than the maximum ambient temperature.

WARNING

Hazardous location

The equipment shall only be used in an area of not more than pollution degree 2.

3.2 Installing position

NOTE

When installing and connecting up the CM 1xDALI, refer to the instructions in the system manual SIMATIC ET 200SP Distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) note the information in the document "Use of subassemblies/modules in a Zone 2 Hazardous Area" that you will find on the Internet at the following address:

Link: (https://support.industry.siemens.com/cs/ww/en/view/78381013)

NOTICE
Installation location - Dependency of the temperature range The upper and lower ventilation slits of CM 1xDALI cannot be covered, allowing adequate ventilation. Above and below the module, there must be a clearance of 25 mm to allow air to circulate and prevent overheating.

Installation position	**Installation position of the CM 1xDALI**
Horizontal installation of the CM 1xDALI	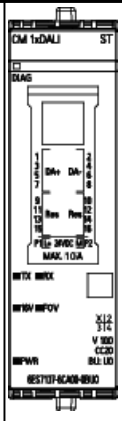
Vertical installation of the CM 1xDALI	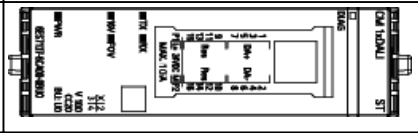

3.3 DALI bus cable

Pay attention to the following requirements when you set up a DALI system.

Requirement for DALI cable

- The voltage drop between the DALI power supply and any DALI device on the DALI bus must be less than 2 V.
- The cable length between DALI power supply and the DALI device should be less than 300 m. The recommend minimum-cross-section of the conductors depends on the cable length.

Material	Cable length	Conductor cross section (Minimum)
Copper	< 100 m	0.5 mm^2
	100 m to 150 m	0.75 mm^2
	> 150 m	1.5 mm^2

Conductor cross section depending on the cable length

NOTE

It is not necessary to use special bus cables (twisted or shielded).

Maximum current permitted for integrated DALI power

When use the integrated DALI power, the DALI bus load $\sum I_{DALI}$ cannot exceeds 160 mA. You can calculate the DALI bus load with the following formula:

$\sum I_{DALI} = I_{DALI_1} + I_{DALI_2} + I_{DALI_3} + ... + I_{DALI_n}$

$\sum I_{DALI}$: Load of the DALI supply including all extension terminals

I_{DALI_1}: Load of the first device on DALI bus

n: Total number of the devices on DALI bus

Example

You need to set up a DALI system with some control gears and sensors. At first, you add 64 control gears whose respective current consumption is 2 mA. Then you need to add a kind of sensor whose respective current consumption is 5 mA.

The number of sensor you can add is:

(160 mA - 64 x 2 mA) / 5 mA = 6.4

So the maximum number of this kind sensor you can add in this DALI system is 6.

DALI bus topology

CM 1xDALI is a gateway between automation system and DALI system. At the CPU side, CM 1xDALI works as a communication module and gateway to the system. At DALI side, CM 1xDALI works as an application controller. You can use line, tree, star or mixed structures to set up the DALI system.

NOTICE
Important notes on setting up DALI system • Do not use ring structure to set up a DALI system. • Use the input devices which fulfill the DALI-2 standard. • CM 1xDALI module cannot work until CPU and IM are ready. Make sure CPUs are ready before you start up the DALI communication.

The following figure shows an example of a DALI topology containing 4 DALI systems.

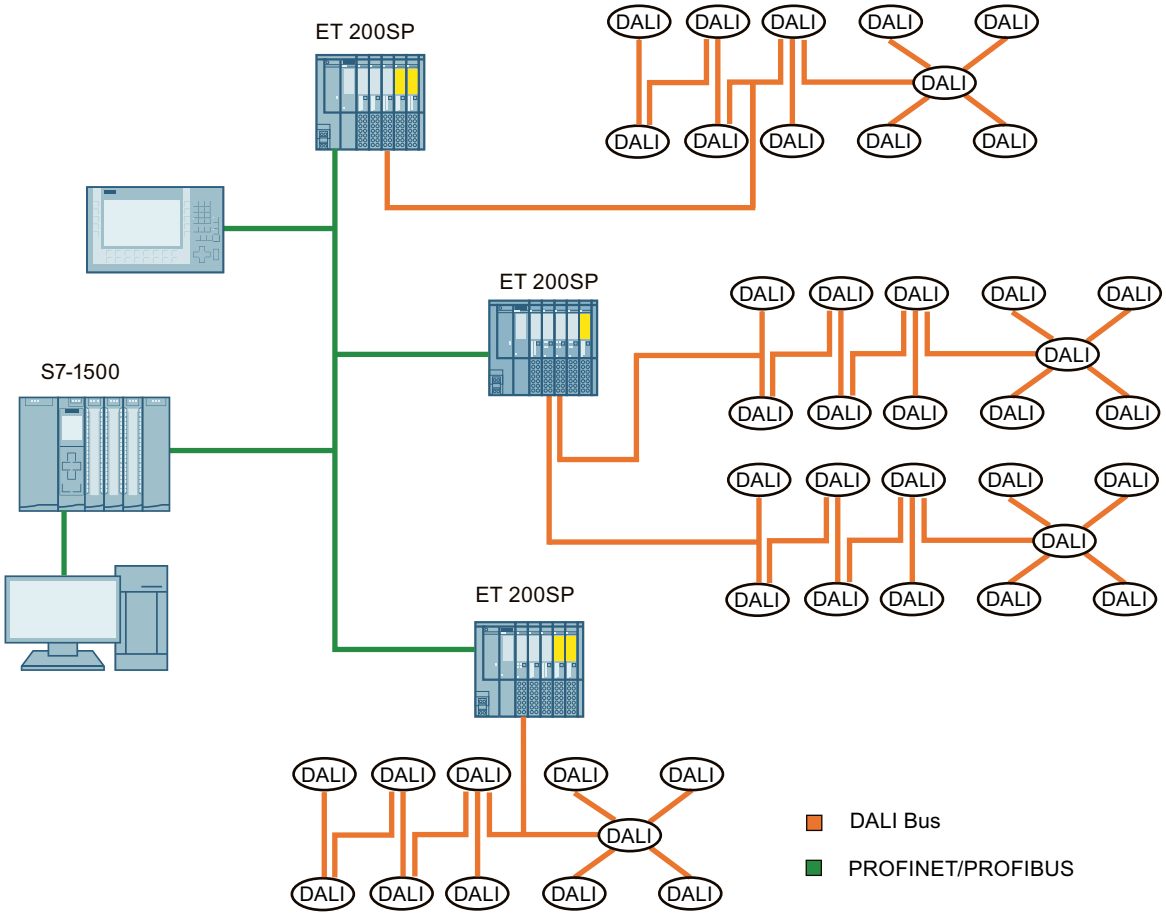

Figure 2-1432 DALI Topology

3.4 Block diagram

Requirements

For connecting, you require a BaseUnit:

- Type U0, Light color BaseUnit, article number 6ES7193-6BP00-0DU0
- Type U0, Dark color BaseUnit, article number 6ES7193-6BP00-0BU0

BaseUnit

The BaseUnit is not included in the scope of delivery of the module and must be ordered separately.

You can find an overview of the BaseUnits that you can use with the technology module in the product information for the documentation of the ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/73021864).

You can find information about selecting a suitable BaseUnit in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual and ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) manual.

You can find information on wiring the BaseUnit, connecting cable shields, etc. in the Connecting section of the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

Block diagram

The following figure shows the block diagram and the terminal assignment of the CM 1xDALI.

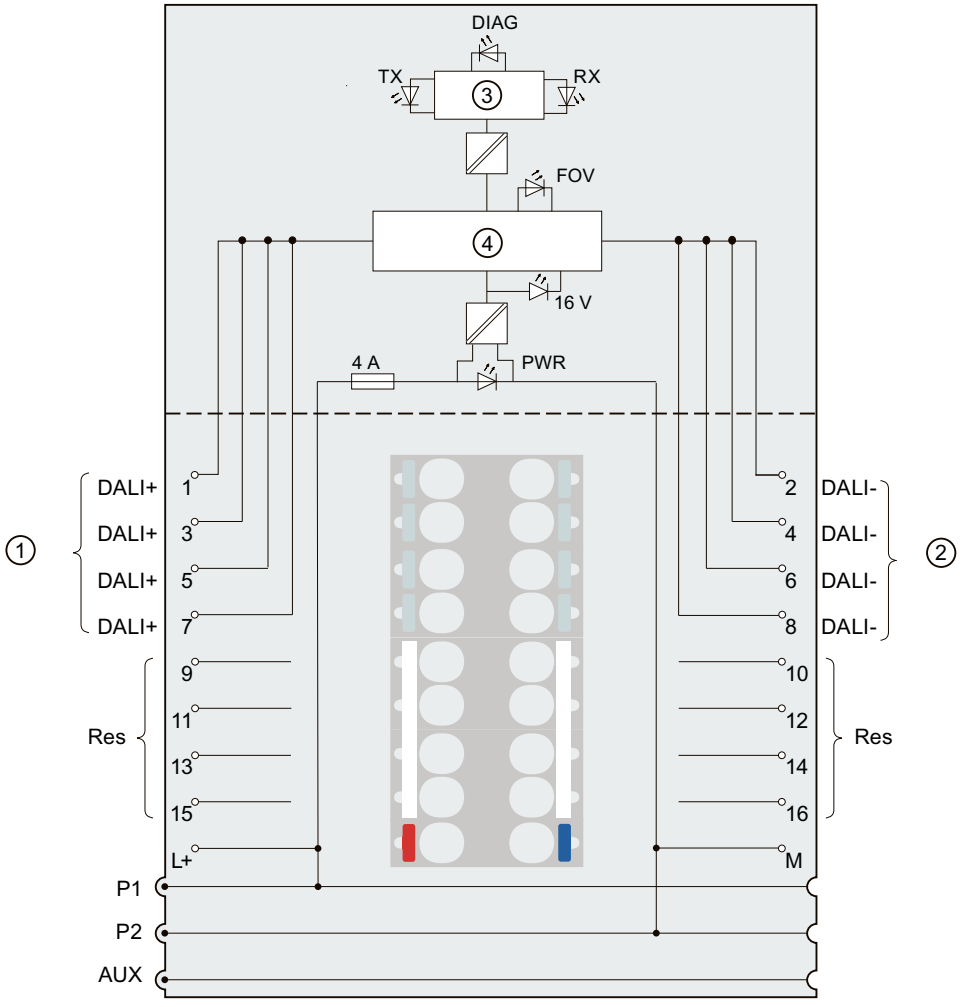

①	DALI+ connection	TX	Transmit LED (green)
②	DALI- connection	RX	Receive LED (green)
③	Backplane bus interface	FOV	Fault over voltage LED (red)
④	DALI driver electronics	PWR	POWER LED (green)
DIAG	Error or Diagnostics LED (green, red)	L+	24 VDC supply voltage
P1, P2, AUX	Internal self-configuring voltage buses Connection to the left (dark BaseUnit) Connection to the left interrupted (light BaseUnit)	M	Ground

Figure 2-1433 Wiring and block diagram for CM 1xDALI

L+/M supply voltage

You connect the supply voltage (DC 24 V) to terminals L+ and M on a light BaseUnit. For a dark BaseUnit, it uses the supply voltage of the module on its left. An internal protection circuit protects the CM 1xDALI from reverse polarity of the supply voltage. The CM 1xDALI monitors whether the supply voltage is connected.

Parameters

4

4.1 Parameter assignment

Introduction

You configure and assign the parameters of the communication module with STEP 7 V15.1 or later versions.

In the CM 1xDALI project, you assign the parameters in the device view of STEP 7 and in the properties tab of the communication module DALI.

4.2 CM 1xDALI Module Parameters

Module Parameters

Each CM 1xDALI has the following DALI parameters in **Module Parameters**. According to your request, you can configure any of these parameters.

The following table shows the module parameters for the CM 1xDALI.

Table 2-1805 Module Parameters

Module Parameters	Description	Value range	Default value	Configuration in RUN
Basic parameter				
Enable integrated DALI bus power supply	Enable or disable the DALI bus power supply. • Enable: Use the integrated DALI bus power in the CM 1xDALI. • Disable: Do not use the integrated DALI bus power in the CM 1xDALI.	• Enable • Disable	Enable	Yes
Enable DALI Application Controller	Enable or disable DALI Application Controller. • Enable: The CM 1xDALI can send any forward frame or receive any backward frame to the DALI bus. • Disable: The CM 1xDALI cannot send any forward frame or receive any backward frame to the DALI bus.	• Enable • Disable	Enable	Yes
Diagnostics				
Diagnostics: Over voltage on DALI bus	Enable or disable the diagnostic message on DALI bus. • Enable: When the DALI bus is connected to a fault over voltage (FOV) by mistake, the CM 1xDALI reports an error of over voltage and the FOV LED (Page 90) is on. • Disable: When the DALI bus is connected to a fault over voltage by mistake, only the FOV LED is on.	• Enable • Disable	Enable	Yes

Module Parameters	Description	Value range	Default value	Configuration in RUN
Diagnostics: Short circuit on DALI bus	Monitor the short circuit on DALI bus. This function is only available when the integrated DALI bus power supply is enabled: • Enable: When a short circuit occurs on the DALI bus, the module reports a diagnostic error and shuts down the bus power. • Disable: When a short circuit occurs on the DALI bus, the module only shuts down the bus power.	• Enable • Disable	Disable	Yes
Period				
Background detection period (s)	The CM 1xDALI periodically sends DALI commands to query the status of all the devices on the bus and stores the information in the module. As a result, the status that is saved in CM 1xDALI cannot be updated in time to get the latest status information in the CM 1xDALI. The program blocks of the CPU have a higher priority when accessing the DALI bus. If the program blocks of the CPU continuously access the DALI bus, the background detection may be blocked. The background detection can detect the following results: • Whether each DALI device has a short address • For control gear: the information of basic status, control gear type and extended status • For sensor: the information of device status, number of instances and type of each instance You can set the frequency of the detection. The status saved in the DALI device update during every detection.	60 to 3600 (second)	60 (second)	Yes

Programming 5

CM 1xDALI library is a SIMATIC CPU program library. You use the CM 1xDALI library to program for the CM 1xDALI. It helps you easily access CM 1xDALI from the SIMATIC CPU.

CM 1xDALI library can be used on S7-1500 based CPUs (CPU 15xx).

CM 1xDALI library contains several CM 1xDALI function blocks (FB) in the STEP 7. The CM 1xDALI function blocks are collected in several functions groups, such as Addressing function blocks (Page 30), Control gear dimming function blocks (Page 36), Diagnostic function blocks (Page 46) and Configuration function blocks (Page 57).

Download the CM 1xDALI library from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109767048). For more information about using libraries, refer to STEP 7 online help.

5.1 CM 1xDALI data storage model

CM 1xDALI data storage model

A DALI device can be a control gear or input device. The term "sensor" refers to the input device in this documentation.

Each of the CM 1xDALI and DALI devices has its own database to store status and address information.

The following figure shows the CM 1xDALI data storage model and data flow.

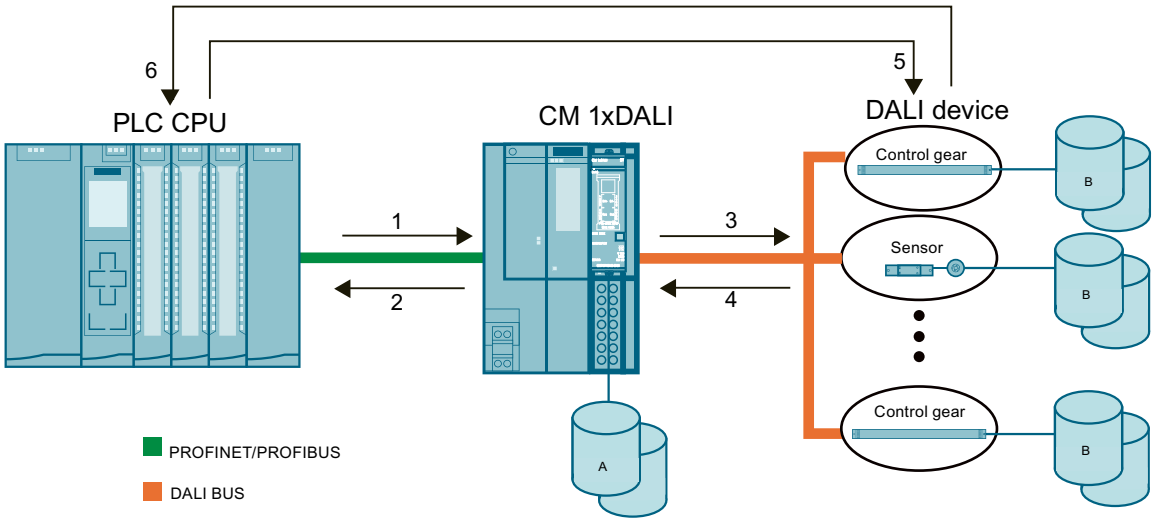

A CM 1xDALI Database

B DALI device Database

1 CPU sends data to CM 1xDALI, and CM 1xDALI stores the data. For example, the CPU uses **DALI_ECG_SET_OPHOUR** (Page 51) to set the operating hour of control gear in CM 1xDALI.

2 CPU receives data from CM 1xDALI. For example, the CPU uses **DALI_DEV_QUERY_ADDR** (Page 34) to obtain the address status and device status which are saved in CM 1xDALI.

3 CM 1xDALI sends data to the DALI device. For example, the CPU uses **DALI_DEV_DOWNLOAD** (Page 84) to deploy the configuration parameters stored in the CM 1xDALI to the DALI device.

4 CM 1xDALI receives data from the DALI device, and stores the data in CM 1xDALI. For example, the CM 1xDALI queries the device status of each DALI device by background detection.

5 CPU sends data to the DALI device. For example, the CPU uses **DALI_SENSOR_SET_INST_PARAM** (Page 81) to send the instance configuration parameters to the DALI device

6 CPU receives data from DALI device. For example, the CPU uses **DALI_DEV_GTIN** (Page 46) to query the global trade item number from the DALI device.

Figure 2-1434 CM 1xDALI data storage model and data flow

For the detailed parameter information on CM 1xDALI database and DALI device database, refer to the following table.

Table 2-1806 Description for database parameters

Parameters	Storage location		Read-only	Description
	CM 1xDALI	DALI devices		
DALI device status	✓	✓	✓	The basic status and extended status of control gears, and device status of sensors.
Address status	✓		✓	The address status of DALI device on the bus. CM 1xDALI cyclic queries all the address status of DALI devices on the bus through the background detection, and detects the following results: • Whether each DALI device has a short address • For control gear: the information of basic status, control gear type and extended status • For sensor: the information of device status, number of instances and type of each instance

Parameters	Storage location		Read-only	Description
	CM 1xDALI	DALI devices		
Configuration parameters	✓	✓		The basic parameters, extended parameters, group and scene parameters of control gears and device parameters, instance parameters of sensors. The CM 1xDALI does not store the read-only parameters of the DALI devices.
Operating hour of control gears	✓			The CM 1xDALI stores the operating hour of configured control gears.

5.2 General information for programming

The following general information is useful for programming a DALI application:

About function block (FB)

- All the FBs in CM 1xDALI library are asynchronous instructions. It is recommended to use the FBs in the same cyclic organization block (OB).
- Most of the FBs in the CM 1xDALI library are triggered by a rising edge, except for **DALI_CTRL** (Page 25)and **DALI_ECG_SWITCH_DIM** (Page 38).
- If you call several FBs at the same time, they are queued. You can check the output parameters in each FB.

About DALI_CTRL

- **DALI_CTRL** (Page 25) is the basic FB of CM 1xDALI. **DALI_CTRL** must be called in a cyclic OB, and be executed in every cycle. Do not use it in an interrupt OB.
- Each CM 1xDALI works with only one instance of **DALI_CTRL** FB.
- Specify the hardware ID of connected CM 1xDALI at the **DALI_CTRL** FB, and then connect the **DALI_CTRL** DB with the other FBs through the InOut parameter of CM_DALI.

About output parameter

- The outputs of the FBs are kept when the processing of job is done:
  - For the FBs with an input of CANCEL, only when both the trigger and input of CANCEL turn to zero, their output is reset.
  - For the FBs without the input CANCEL, when the trigger turns to zero, the output of these FBs is reset.
- If the triggering input is reset before the FB has finished, the output parameters are set at least for one cycle.
- The output of **DALI_ECG_SWITCH_DIM** (Page 38) can be triggered by a positive level at the inputs ON_UP or OFF_DOWN; the output of this FB will not be reset all of the time.

- Most of the FBs have the following output parameters:
  - BUSY: Shows whether the FB is being committed. When BUSY = 1, the FB is triggered but not finished yet.
  - ACTIVE: Shows whether the FB is being executed. When ACTIVE = 1, the FB is communicating with the CM 1xDALI.
  - DONE: Shows whether the FB is executed without errors. When DONE = 1, the FB is executed without any error. You can check the result of execution in the output of this FB.
  - ERROR: Shows whether an error occurs during the process. When ERROR = 1, the FB is stopped with some errors. You can check the error code in STATUS of this FB.
  - STATUS: Shows the FB progress or detailed error code. When ERROR = 0, STATUS shows the FB progress; when ERROR = 1, STATUS shows the detailed error code.

5.3 System function blocks

System function blocks are the basic function blocks of the CM 1xDALI, and they are used for sending all DALI commands.

5.3.1 DALI_CTRL

Description

DALI_CTRL is used as the interface for the CM 1xDALI. Through this function block, all of the other DALI function blocks can communicate with the CM 1xDALI.

- **DALI_CTRL** is the basic function block of CM 1xDALI. **DALI_CTRL** must be called in a cyclic OB, and be executed in every cycle. Do not use it in an interrupt OB.
- Each CM 1xDALI works with only one instance of **DALI_CTRL** FB.
- Specify the hardware ID of connected CM 1xDALI at the **DALI_CTRL** FB, and then connect the **DALI_CTRL** DB with the other FBs through the InOut parameter of CM_DALI.
- The FB receives and reports the event messages which are sent be the DALI-2 input devices.
- When Bit 1 or Bit 2 of the CM_STATUS show "1", all the other DALI function blocks cannot be executed. You can choose any of the following actions to resume the status of CM 1xDALI.
  - Set the input CM_RESET to 1.
  - Send the DALI command "STOP QUIESCENT MODE" or "ENABLE APPLICATION CONTROLLER" (refer to IEC 62386-103) to the CM 1xDALI through other DALI application controllers.
- A defined set of messages and their content are shown at the inputs EVENT_MSG, EVENT_SCHEME, EVENT_SRC_1, EVENT_SRC_2 and EVENT_INFO.
- Other generic event messages are shown at the outputs RSV_MSG, RSV_MSG_LEN and RSV_MSG_VAL. The content is shown without interpretation at the output RSV_MSG_VAL.

Parameter

The following table shows the parameters of the function block.

Parameter	Declaration	Data type	Memory area	Description
HW_ID	Input	HW_IO	I, Q, M, D, L or Constant	The hardware identifier of the CM 1xDALI
CM_RESET		BOOL	I, Q, M, D, L or Constant	Stop quiescent mode and re-enable the DALI application controller upon a raising edge. After this action, Bit 1 and Bit 2 of the CM_STATUS will be reset to 0.
CONN_ERR	Output	BOOL	I, Q, M, D, L	The status of CPU communication with CM 1xDALI: • CONN_ERR = 0: No error when the CPU communicates with CM 1xDALI. • CONN_ERR = 1: Error occurs when the CPU communicates with CM 1xDALI.
CM_STATUS		DWORD	I, Q, M, D, L	Indicate the status of the CM 1xDALI: 16#00000000: The status of the CM 1xDALI is OK. For the detailed explanation for each Bit of the CM_STATUS, refer to the following section "Parameter CM_STATUS".
EVENT_MSG		BOOL	I, Q, M, D, L	The status of the sensor event. When the CM 1xDALI receives a sensor event, the EVENT_MSG remains true for one cycle: • EVENT_MSG = 0: No sensor event • EVENT_MSG = 1: A sensor event is received.
EVENT_SCHEME		USInt	I, Q, M, D, L	Event characterization that identifies the source of the event: • 0~4: Normal event message • 255: Power cycle event

Scheme of the event	0	1	2	3	4	255
EVENT_SRC_1	USInt	I, Q, M, D, L	First event source information	Instance type	Short address	Short address	Device group	Instance group	Group [1]
EVENT_SRC_2	USInt	I, Q, M, D, L	Second event source information	Instance number	Instance type	Instance number	Instance type	Instance type	Short address [2]
EVENT_INFO	WORD	I, Q, M, D, L	When EVENT_SCHEME ≤ 4, the lower 10 bits of EVENT_INFO indicate the event data. When EVENT_SCHEME = 255, EVENT_INFO shows "16#0000". For the detailed meaning of EVENT_INFO in DALI standard, refer to the following section "Parameter EVENT_INFO".						
RSV_MSG		BOOL	I, Q, M, D, L	The status of the reserved message. When the CM 1xDALI receives a reserved message, the RSV_MSG remains true for one cycle: • RSV_MSG = 0: No reserved message • RSV_MSG = 1: A reserved message is received.						
RSV_MSG_LEN		USInt	I, Q, M, D, L	The bit length of the reserved message						
RSV_MSG_VAL		DWORD	I, Q, M, D, L	The bit stream of the reserved message						

[1] For a valid device group, group of EVENT_SRC_1 indicates the lowest group; otherwise it shows "16#FF".

[2] For a valid short address, short address of EVENT_SRC_2 indicates the short address of the device; otherwise, it shows "16#FF".

Parameter CM_STATUS

Each Bit of the CM_STATUS indicates the different status:

Bit	Explanation of status
Bit 0	The CM 1xDALI is initializing.
Bit 1	The CM 1xDALI is set to quiescent mode by DALI command "START QUIESCENT MODE".
Bit 2	The CM 1xDALI is disabled by DALI command "DISABLE APPLICATION CONTROLLER".[3]
Bit 3	The application controller is disabled by module parameters.[4]
Bit 4	The DALI bus is over voltage.
Bit 5	Missing Voltage (MV)[5] of module input
Bit 6	The DALI bus is short-circuited.
Bit 7	Integrated DALI bus power is disabled in CM 1xDALI, and there is no external DALI bus power on DALI bus.
Bit 8	Several error frames on the bus.
Bit 9 to Bit 31	Reserved

3 When the module is disabled by other DALI application controllers, the CM 1xDALI cannot send out any forward frame (16-bits or 24-bits) to the bus, but it can send out the response frame (8-bits) to other DALI application controllers.

4 When the module is disabled by the module parameters, the CM 1xDALI cannot send out any forward frame or response frame to the bus.

5 When the input voltage 24 VDC is lower than 16V±1V, the PWR LED changes from green to off.

Parameter EVENT_INFO

EVENT_INFO of push button (instance type 1)

Event information	Event name	Description
2#00_0000_0000	Button released	The button is released.
2#00_0000_0001	Button pressed	The button is pressed.
2#00_0000_0010	Short press [6]	Press the button and release quickly.
2#00_0000_0101	Double press	Press the button twice in rapid succession.
2#00_0000_1001	Long press start [6]	Press the button and hold for longer than the T_{short}.
2#00_0000_1011	Long press repeat [6]	The button is still pressed after a long press. The event occurs at regular intervals as long as the condition holds.
2#00_0000_1100	Long press stop [6]	The button is released after a long press.
2#00_0000_1110	Button free	The button is restored from getting stuck.
2#00_0000_1111	Button stuck	The button is pressed for a very long time and is assumed stuck.
Others	Reserved	

6 To configure instance related parameters for push button, refer to DALI_SENSOR_SET_INST_PARAM (Page 81).

EVENT_INFO of absolute input devices (instance type 2)

Event information	Event name	description
positionEvent	Position report	A position report contains the actual position of the sensor. Refer to the DALI Device Manual from the manufacturer for details.

EVENT_INFO of occupancy sensor (instance type 3)

Event information	Event name	description
2#00_0000_***0	No movement	Does not detect movement.
2#00_0000_***1	Movement	Detects movement.
2#00_0000_*00*	Vacant	The area is vacant.
2#00_0000_*10*	Still vacant	The area is still vacant. The event occurs at regular intervals as long as the vacant condition holds.
2#00_0000_*01*	Occupied	The area is occupied.
2#00_0000_*11*	Still occupied	The area is still occupied. The event occurs at regular intervals as long as the occupied condition holds.
2#00_0000_0***	Presence sensor	The current event is triggered by a presence based sensor.
2#00_0000_1***	Movement sensor	The current event is triggered by a movement based sensor.
Others	Reserved	

EVENT_INFO of light sensor (instance type 4)

Event information	Event name	description
illuminanceEvent	illuminance level report	An illuminance level report contains the actual illuminance level of the sensor. For detailed information, refer to the DALI Device Manual from the manufacturer.

5.3.2 DALI_SEND_CMD

Description

DALI_SEND_CMD can send a user-defined command to the DALI bus and receive the response message of the command. This function block does not interpret the input command code and sends the command to the DALI bus directly. You can send the commands, which are defined in the DALI standard or defined by the device manufacturer.

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
SEND	Input	BOOL	I, Q, M, D, L or Constant	Send the DALI command upon a rising edge.
CMD_CODE		DWord	I, Q, M, D, L or Constant	The bit stream of the DALI command

Parameter	Declaration	Data type	Memory area	Description
CMD_BIT_L-EN	Input	USInt	I, Q, M, D, L or Constant	The bit length of the DALI command. Only 16 and 24 are valid.
SEND_TWI-CE		BOOL	I, Q, M, D, L or Constant	SEND_TWICE = 1: Send the DALI command twice.
WAIT_RESP		BOOL	I, Q, M, D, L or Constant	• WAIT_RESP = 0: Do not wait for the response. DONE is set to 1 immediately after the DALI command is sent. • WAIT_RESP = 1: Wait for the response of the command. DONE is set to 1 when CM 1xDALI receives the response byte, and the response byte is shown in "CMD_ACK".
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has the following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
CMD_ACK		BYTE	I, Q, M, D, L	When WAIT_RESP = 1, this function block is completed successfully and shows the response byte of the sent command.

5.4 Addressing function blocks

Addressing function blocks are used for assigning short address, identifying devices, changing short address, or querying the address status of the DALI devices.

5.4.1 DALI_DEV_SCAN

Description

DALI_DEV_SCAN is used for scanning the DALI devices (control gears or input devices) on the bus through random address. The address status of DALI devices are saved in CM 1xDALI (refer to data flow path 4 (Page 22)).

If a device has a short address which is unique compared to other devices, the device keeps its short address. If a device does not have a short address or its short address is not unique, the system assigns a new short address to it.

It takes about 6 seconds to search for one device. If there are 64 devices or more devices on the bus, it takes more than 6 minutes.

This function block can only scan 64 devices, so if there are more than 64 devices on the DALI bus, the result changes every period, and this result is not determinate after each procedure. The result can be queried through function block **DALI_DEV_QUERY_ADDR** (Page 34).

NOTE

The output resets, only if both the CANCEL and SCAN are set to 0.

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
SCAN	Input	BOOL	I, Q, M, D, L or Constant	Start the scan procedure upon a rising edge.
DEV_TYPE		USInt	I, Q, M, D, L or Constant	Select the device type: • 1: Control gear • 2: Input device (Sensor)
ADDRESS		USInt	I, Q, M, D, L or Constant	Select the address information of scanned devices: • 0 to 63: Scan one single short address, it is generally used to solve the conflict of short address. • 253: Only scan the unaddressed devices. • 255: Scan all the devices.
CANCEL		BOOL	I, Q, M, D, L or Constant	CANCEL = 1: Stop current scan procedure, and return an error.
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.

Parameter	Declaration	Data type	Memory area	Description	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has the following values: • 16#00: Idle • 16#01 to 16#40: Scanning devices. The value will be increased when the CM 1xDALI scan a device. • 16#41: Assigning short address. • 16#42: Updating address status. • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.4.2 DALI_DEV_IDENTIFY

Description

DALI_DEV_IDENTIFY is used for identifying devices.

If the control gear does not support the DALI command IDENTIFY, this function provides a light flicker method to identify the device by setting the level to maximum and minimum alternately.

NOTE

The output resets, only if both the CANCEL and IDENTIFY are set to 0.

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
IDENTIFY	Input	BOOL	I, Q, M, D, L or Constant	Identify the devices upon a rising edge.	
DEV_TYPE		USInt	I, Q, M, D, L or Constant	Select the device type: • 1: Control gear • 2: Input device (Sensor)	
GROUP		BOOL	I, Q, M, D, L or Constant	Specify the short address or group address of the control gear: • GROUP = 0: ADDRESS indicates the short address or broadcast. • GROUP = 1: ADDRESS indicates the group address.	
ADDRESS		USInt	I, Q, M, D, L or Constant	Identify the address information of the CM 1xDALI.	
				When GROUP = 0, ADDRESS indicates the short address or broadcast: • 0 to 63: Specify the short address of the device • 253: Broadcast the unaddressed devices • 255: Broadcast all the devices	When GROUP = 1, ADDRESS indicates the group address: • 0 to 15: Group address
FLICKER		BOOL	I, Q, M, D, L or Constant	Specify the type of identification process: • FLICKER = 0: Identify the device by DALI command IDENTIFY. The identifying process is specified by manufacturer. • FLICKER = 1: Flicker the control gear to identify the device by setting the level, only valid for control gears. After the identification, the level of control gears is set to "MIN_LEVEL".	
CANCEL		BOOL	I, Q, M, D, L or Constant	CANCEL = 1: Stop current identify procedure, and return an error.	
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.4.3 DALI_DEV_CHG_ADDR

Description

DALI_DEV_CHG_ADDR is used for changing the short address of one device. If the new address is assigned to another device, the two devices exchange their short addresses.

This function block only changes the short address of the physical devices. The data in the CM 1xDALI is not influenced by this short address changing (refer to data flow path 5 (Page 22)).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
CHANGE	Input	BOOL	I, Q, M, D, L or Constant	Change the short address of the specific device upon a rising edge.	
DEV_TYPE		USInt	I, Q, M, D, L or Constant	Select the device type: • 1: Control gear • 2: Input device (Sensor)	
OLD_ADDR		BOOL	I, Q, M, D, L or Constant	The current short address of the device.	
NEW_ADDR		USInt	I, Q, M, D, L or Constant	The short address to be assigned to the device.	
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.4.4 DALI_DEV_QUERY_ADDR

Description

DALI_DEV_QUERY_ADDR is used for querying the address information of the DALI bus.

- When you set the input DET_ALL to 0, the FB queries the address information which is saved directly in the CM 1xDALI (refer to data flow path 2 (Page 22)).
- When you set the input DET_ALL to 1, the FB detects all devices on the bus and then returns the latest address information (refer to data flow path 4 and data flow path 2 (Page 22)).

CM 1xDALI cyclic queries all the address status of DALI devices on the bus through the background detection (Page 20), and detects the following results:

- Whether each DALI device has a short address
- For control gear: the information of basic status, control gear type and EXT_STATUS
- For sensor: the information of device status, NUM_OF_INST and type of each instance

These results are saved in the CM 1xDALI (refer to data flow path 4 (Page 22)).

NOTE

The output resets, only if both the CANCEL and QUERY are set to 0.

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
QUERY	Input	BOOL	I, Q, M, D, L or Constant	Query the address information upon a rising edge.
DEV_TYPE		USInt	I, Q, M, D, L or Constant	Select the device type: • 1: Control gear • 2: Input device (Sensor)
DET_ALL		BOOL	I, Q, M, D, L or Constant	• DET_ALL = 0: Query the address information which is saved directly in the CM 1xDALI. • DET_ALL = 1: Detect all devices on the bus and then return the latest address information.
CANCEL		BOOL	I, Q, M, D, L or Constant	CANCEL = 1: Stop the scanning/querying procedure, and return an error.
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.

Parameter	Declaration	Data type	Memory area	Description
DONE	Output	BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following four values: • 16#00: Idle • 16#01 to 16#40: Detecting the status from DALI devices. • 16#41: Querying the information from CM 1xDALI. • 16#7F: Completed When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
ADDR_INFO		AddrInfoDetail	D, L	Address information
UNADDR		BOOL		UNADDR =1: At least one unaddressed device is detected on the DALI bus.
EXCEED		BOOL		EXCEED =1: More than 64 control gears or input devices are scanned by using DALI_DEV_SCAN (Page 30).
CONFIGURED		Array[0..63] of BOOL		CONFIGURED = 1: The short address has been configured by using DALI_ECG_ADD (Page 57), DALI_SENSOR_ADD (Page 74) or DALI_DEV_UPLOAD (Page 83). The index of the array indicates the short address.
ADDR_CHANGED		Array[0..63] of BOOL		• ADDR_CHANGED = 0: The short address of the device is not changed. • ADDR_CHANGED = 1: The device is assigned a new short address after scanning. The index of the array indicates the short address.
ADDR_STATUS [1]		Array[0..63] of USInt		Show the status of short address: • 0: Unknown status [2] • 1: Normal status • 2: No device with the short address • 3: The DALI device displays an error frame. This error may be caused by the short address conflict or the problem of DALI device. • 4: Type mismatch. The configured type is not the same as the physical device's. • 5: Instance number mismatch. The configured instance number of the sensor is not the same as the actual instance number. This status is only for sensors. • 15: This short address of sensor device is assigned to CM 1xDALI. The index of the array indicates the short address.

[1] Not every short address conflict can be detected. Even if there is a short address conflict on the DALI bus, the status of DALI_CTRL might show "1".

[2] When you use the DALI_ECG_STATUS (Page 47) or DALI_SENSOR_STATUS (Page 53) to query the status of the DALI device, or the DALI device is queried by background detection (Page 20), this unknown status change to another status.

5.5 Control gear dimming function blocks

Control gear dimming function blocks are used for querying or setting the level and color of the control gears.

5.5.1 DALI_ECG_SWITCH

Description

DALI_ECG_SWITCH is used for switching on or off control gear, and you can also define the on and off level with this switch. The on and off levels are neither saved in the CM 1xDALI nor in the DALI device (refer to data flow path 5 (Page 22)).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
ON	Input	BOOL	I, Q, M, D, L or Constant	Switch on upon a rising edge.
OFF		BOOL	I, Q, M, D, L or Constant	Switch off upon a rising edge.
GROUP		BOOL	I, Q, M, D, L or Constant	Specify the short address or group address of the control gear: • GROUP = 0: ADDRESS indicates the short address or broadcast. • GROUP = 1: ADDRESS indicates the group address.
ADDRESS		USint	I, Q, M, D, L or Constant	Identify the address information of the CM 1xDALI. When GROUP = 0, ADDRESS indicates the short address or broadcast: • 0 to 63: Specify the short address of the device • 253: Broadcast the unaddressed devices • 255: Broadcast all the devices When GROUP = 1, ADDRESS indicates the group address: • 0 to 15: Group address
ON_TYPE		USint	I, Q, M, D, L or Constant	Switch to the required level: • 0: Switch to the maximum level. • 1: Switch to the last active level. • 2: Switch to the user defined level, which is given by input of ON_LEVEL.
ON_LEVEL		USint	I, Q, M, D, L or Constant	When ON_TYPE = 2, the value of ON_LEVEL is available. The control gear's target level sets to this level when the switch is on. Range: 0 to 254
OFF_TYPE		USint	I, Q, M, D, L or Constant	Switch off or switch to the required level: • 0: Switch off. • 1: Switch to the minimum level. • 2: Switch to user defined level, which is given by input of OFF_LEVEL.

Parameter	Declaration	Data type	Memory area	Description	
OFF_LEVEL	Input	USint	I, Q, M, D, L or Constant	When OFF_TYPE = 2, the value of OFF_LEVEL is available. The control gear's target level sets to this level when the switch is off. Range: 0 to 254	
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.5.2 DALI_ECG_SWITCH_DIM

Description

DALI_ECG_SWITCH_DIM is used for controlling the control gear (refer to data flow path 5 (Page 22)), and has the following features:

- If ON_UP sets to 1 and remains for the time which is shorter than the value of SHORT_PRESS, and then resets to 0, the control gear is switched on.
- If OFF_DOWN sets to 1 and remains for the time which is shorter than the value of SHORT_PRESS, and then resets to 0, the control gear is switched off.
- If ON_UP sets to 1 and remains for the time which is longer than the value of SHORT_PRESS, the control gear is dimming up until the ON_UP sets to 0.
- If OFF_DOWN sets to 1 and remains for the time which is longer than the value of SHORT_PRESS, the control gear is dimming down until the OFF_DOWN sets to 0.
- If the level of the control gear is 0, the level cannot be changed by dimming up.
- If the level of the control gear is MIN_LEVEL, the level cannot be set to 0 by dimming down.

NOTE

Do not set the "ON_UP" and "OFF_DOWN" to 1 at the same time. Otherwise the error code "16#88" is shown in the output parameter STATUS.

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
ON_UP	Input	BOOL	I, Q, M, D, L or Constant	Switch on or dim up upon a rising edge. • If ON_UP sets to 1 and remains for the time which is shorter than the value of SHORT_PRESS, and then resets to 0, the control gear switches on. • If ON_UP sets to 1 and remains for the time which is longer than the value of SHORT_PRESS, the control gear is dimming up until the ON_UP sets to 0.
OFF_DOWN		BOOL	I, Q, M, D, L or Constant	Switch off or dim down upon a rising edge. • If OFF_DOWN sets to 1 and remains for the time which is shorter than the value of SHORT_PRESS, and then resets to 0, the control gear switches off. • If OFF_DOWN sets to 1 and remains for the time which is longer than the value of SHORT_PRESS, the control gear is dimming down until the OFF_DOWN sets to 0.
GROUP		BOOL	I, Q, M, D, L or Constant	Specify the short address or group address of the control gear: • GROUP = 0: ADDRESS indicates the short address or broadcast. • GROUP = 1: ADDRESS indicates the group address.
ADDRESS		USint	I, Q, M, D, L	Identify the address information of the CM 1xDALI.

Parameter	Declaration	Data type	Memory area	Description	
ADDRESS	Input	USint	or Constant	When GROUP = 0, ADDRESS indicates the short address or broadcast: • 0 to 63: Specify the short address of the device • 253: Broadcast the unaddressed devices • 255: Broadcast all the devices	When GROUP = 1, ADDRESS indicates the group address: • 0 to 15: Group address
DIM_ONLY		BOOL	I, Q, M, D, L or Constant	DIM_ONLY = 1: The dimming is only performed by the inputs ON_UP and OFF_DOWN.	
ON_TYPE		USint	I, Q, M, D, L or Constant	Switch to the required level: • 0: Switch to the maximum level. • 1: Switch to the last active level. • 2: Switch to the user defined level, which is given by input ON_LEVEL.	
ON_LEVEL		USint	I, Q, M, D, L or Constant	When ON_TYPE = 2, the value of ON_LEVEL is available. The control gear's target level sets to the required level when the switch is on. Range: 0 to 254	
OFF_TYPE		USint	I, Q, M, D, L or Constant	Switch off or switch to the required level: • 0: Switch off. • 1: Switch to the minimum level. • 2: Switch to the user defined level, which is given by input OFF_LEVEL.	
OFF_LEVEL		USint	I, Q, M, D, L or Constant	When OFF_TYPE = 2, the value of OFF_LEVEL is available. The control gear's target level sets to this level when the switch is off. Range: 0 to 254	
SHORT_PRESS		TIME	I, Q, M, D, L or Constant	The time threshold for distinguishing the switching on/off action or dimming up/down action. The default value is 300 ms.	
CM_DALI	InOut	"DALI_CTRL"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.5.3 DALI_ECG_QUERY_LEVEL

Description

DALI_ECG_QUERY_LEVEL is used for querying the actual level of DALI control gears (refer to data flow path 6 (Page 22)).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
QUERY	Input	BOOL	I, Q, M, D, L or Constant	Query actual level upon a rising edge.	
ADDRESS		USint	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63	
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
LEVEL		USInt	I, Q, M, D, L	The actual level is queried from the control gear.	

5.5.4 DALI_ECG_SET_LEVEL

Description

DALI_ECG_SET_LEVEL is used for setting the target level of DALI control gears (refer to data flow path 5 (Page 22)).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
SET	Input	BOOL	I, Q, M, D, L or Constant	Set the level upon a rising edge.	
GROUP		BOOL	I, Q, M, D, L or Constant	Specify the short address or group address of the control gear: • GROUP = 0: ADDRESS indicates the short address or broadcast. • GROUP = 1: ADDRESS indicates the group address.	
ADDRESS		USint	I, Q, M, D, L or Constant	Identify the address information of the CM 1xDALI.	
				When GROUP = 0, ADDRESS indicates the short address or broadcast: • 0 to 63: Specify the short address of the device • 253: Broadcast the unaddressed devices • 255: Broadcast all the devices	When GROUP = 1, ADDRESS indicates the group address: • 0 to 15: Group address
LEVEL		USint	I, Q, M, D, L or Constant	Set the target level. Range: 0 to 254	
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When the ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When the ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.5.5 DALI_ECG_QUERY_COLOR

Description

DALI_ECG_QUERY_COLOR is used for querying the actual color of DALI control gears that are compliant with IEC-62386-209, device type 8 (color control) (refer to data flow path 6 (Page 22)).

When you query a control gear that does not support color control, the error code “16#87” (Not supported) is shown in the output parameter of STATUS.

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
QUERY	Input	BOOL	I, Q, M, D, L or Constant	Query actual color upon a rising edge.
ADDRESS		USint	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
COLOR		DALIColor-Detail	D, L	Color information of the control gear
COLOR_T-YPE		USInt		Set the color type: • 16#10: Color xy-coordinate • 16#20: Color temperature

Parameter		Declaration	Data type	Memory area	Description
	COORDINATE_X	Output	UInt	D, L	The x-coordinate value of the point in the CIE color space chromaticity diagram. X-coordinate = "COORDINATE_X" * 1/65536. Range: 0 to 65534
	COORDINATE_Y		UInt		The y-coordinate value of the point in the CIE color space chromaticity diagram. Y-coordinate = "COORDINATE_Y" * 1/65536. Range: 0 to 65534
	TEMPERATURE		UInt		The color value of temperature. T_C(K) = 1000000 / "TEMPERATURE" Range: 1 to 65534

5.5.6 DALI_ECG_SET_COLOR

Description

DALI_ECG_SET_COLOR is used for setting the actual color of DALI control gears that are compliant with IEC-62386-209, device type 8 (color control) (refer to data flow path 5 (Page 22)).

If you use this FB to set color to a control gear which does not support color control, the command cannot take effect and does not report an error.

Parameter

The following table shows the parameters of the function block:

Parameter		Declaration	Data type	Memory area	Description	
SET		Input	BOOL	I, Q, M, D, L or Constant	Set the color upon a rising edge.	
GROUP			BOOL	I, Q, M, D, L or Constant	Specify the short address or group address of the control gear: • GROUP = 0: ADDRESS indicates the short address or broadcast. • GROUP = 1: ADDRESS indicates the group address.	
ADDRESS			USint	I, Q, M, D, L or Constant	Identify the address information of the CM 1xDALI.	
					When GROUP = 0, ADDRESS indicates the short address or broadcast: • 0 to 63: Specify the short address of the device • 253: Broadcast the unaddressed devices • 255: Broadcast all the devices	When GROUP = 1, ADDRESS indicates the group address: • 0 to 15: Group address
COLOR			DALIColorDetail	D, L	Color information of the control gear	
	COLOR_TYPE		USInt		Set the color type: • 16#10: xy-coordinate • 16#20: Color temperature	

Parameter		Declaration	Data type	Memory area	Description	
	COORDINATE_X	Input	UInt	D, L	The x-coordinate value of the point in the CIE color space chromaticity diagram. X-coordinate = "COORDINATE_X" * 1/65536. Range: 0 to 65534	
	COORDINATE_Y		UInt		The y-coordinate value of the point in the CIE color space chromaticity diagram. Y-coordinate = "COORDINATE_Y" * 1/65536. Range: 0 to 65534	
	TEMPERATURE		UInt		The color value of temperature. T_C(K) = 1000000 / "TEMPERATURE" Range: 1 to 65534	
CM_DALI		InOut	"DALI_CTRL"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY		Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE			BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE			BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR			BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: An error occurs during processing.	
STATUS			BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.5.7 DALI_ECG_GOTO_SCENE

Description

DALI_ECG_GOTO_SCENE is used for setting control gears to go to the specified scene (refer to data flow path 5 (Page 22)). You can also query or configure the scene information by using DALI_ECG_QUERY_SCENE (Page 71) or DALI_ECG_SET_SCENE (Page 73).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
GOTO	Input	BOOL	I, Q, M, D, L or Constant	Go to the specified scene upon a rising edge.	
GROUP		BOOL	I, Q, M, D, L or Constant	Specify the short address or group address of the control gear: • GROUP = 0: ADDRESS indicates the short address or broadcast. • GROUP = 1: ADDRESS indicates the group address.	
ADDRESS		USint	I, Q, M, D, L or Constant	Identify the address information of the CM 1xDALI.	
				When GROUP = 0, ADDRESS indicates the short address or broadcast: • 0 to 63: Specify the short address of the device • 253: Broadcast the unaddressed devices • 255: Broadcast all the devices	When GROUP = 1, ADDRESS indicates the group address: • 0 to 15: Group address
SCENE_NUM		USint	I, Q, M, D, L or Constant	Go to the specified scene. Range: Less than 16	
CM_DALI	InOut	"DALI_CTRL"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.6 Diagnostic function blocks

Diagnostic function blocks are used for querying the status information of all the DALI devices.

5.6.1 DALI_DEV_GTIN

Description

DALI_DEV_GTIN is used for querying the GTIN (Global Trade Item Number) of device (refer to data flow path 6 (Page 22)).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
READ	Input	BOOL	I, Q, M, D, L or Constant	Query the GTIN of device upon a rising edge.	
DEV_TYPE		USInt	I, Q, M, D, L or Constant	Select the device type: • 1: Control gear • 2: Input device (Sensor)	
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63	
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
GTIN		Array[0..5] of BYTE	I, Q, M, D, L	Show the global trade item number of the device. Each GTIN has 6 bytes.	

5.6.2 DALI_ECG_STATUS

Description

DALI_ECG_STATUS is used for querying the status of one control gear. The status information is queried from the physical DALI device (refer to data flow path 6 (Page 22)). The status information saved in the CM 1xDALI will be updated (refer to data flow path 4 (Page 22)).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
READ	Input	BOOL	I, Q, M, D, L or Constant	Query the status of one control gear upon a rising edge.
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
ECG_STATUS		ECGStatus-Detail	D, L	The status information of control gear
CON-FIGURED		BOOL		CONFIGURED = 1: The short address is configured by using DALI_ECG_ADD (Page 57) or DALI_DEV_UPLOAD (Page 83).
ADDR_CH-ANGED		BOOL		• ADDR_CHANGED = 0: The short address of control gear is not changed. • ADDR_CHANGED = 1: The short address of control gear is changed during the scan procedure.

[1] For the detailed description about each bit of **Control Gear EXT_STATUS**, refer to the following table.

Parameter	Declaration	Data type	Memory area	Description
ADDR_STATUS	Output	BYTE	D, L	Show the status of short address: • 1: Normal status • 2: No device with the short address • 3: The DALI device displays an error frame. This error may be caused by the short address conflict or the problem of the DALI device. • 4: Type mismatch. The configured type is not the same as the physical device's.
BASIC_STATUS		BYTE		Show the status of the control gear. For the detailed explanation for each Bit of BASIC_STATUS, refer to the following section "Parameter BASIC_STATUS".
CONFIG_TYPE		BYTE		• CONFIGURED = 0, the value of CONFIG_TYPE is 16#FF. • CONFIGURED = 1, the value of CONFIG_TYPE is the same as the value of ECG_TYPE in DALI_ECG_ADD (Page 57).
ACTUAL_TYPE		BYTE		The actual device type of the control gear.
EXT_STATUS [1]		BYTE		Show the type-related failure status of the control gear which compliant with the IEC62386-20x. When 1 ≤ ACTUAL_TYPE ≤ 8, each Bit of EXT_STATUS indicates the different error types. Otherwise, the value of EXT_STATUS is 0.
ACTUAL_LEVEL		USInt		The actual level of the control gear.

[1] For the detailed description about each bit of **Control Gear EXT_STATUS**, refer to the following table.

Bit	Type 1 (emergency)	Type 2 (discharge)	Type 3 (halogen)	Type 4 (incandescent)	Type 5 (converter)	Type 6 (LED)	Type 7 (switch)	Type 8 (color control)
0	Circuit failure	Mains voltage too low	Short circuit	Load over-current shut-down	Output fault detected	Short circuit	Load error	XY-coordinate color point out of range
1	Battery duration failure	Mains voltage too high	Open circuit	Open circuit	Reserved	Open circuit	Error detection in hold off	Color temperature out of range
2	Battery failure	Converter thermal overload	Load decrease	Load decrease		Load decrease	Last threshold acted upon • ‘00’ up switch-on • ‘01’ up switch-off • ‘10’ down switch on • ‘11’ down switch off	Auto calibration running
3	Emergency lamp failure	Reserved	Load increase	Load increase		Load increase		Auto calibration successful
4	Function test max delay exceeded	Ignition time out	Current protector active	Reserved		Current protector active	Reserved	Color type XY-coordinate active

Bit	Type 1 (emergency)	Type 2 (discharge)	Type 3 (halogen)	Type 4 (incandescent)	Type 5 (converter)	Type 6 (LED)	Type 7 (switch)	Type 8 (color control)
5	Duration test max delay exceeded	Reserved	Thermal shutdown	Thermal shutdown	Reserved	Thermal shutdown	Reserved	Color type color temperature active
6	Function test failed	Lamp voltage out of spec	Thermal overload	Thermal overload		Thermal overload		Color type primary N active
7	Duration test failed	Lamp cycling failure	Reference measurement failed	Reference measurement failed		Reference measurement failed	Reference measurement failed	Color type RGBWAF active

Parameter BASIC_STATUS

Each Bit of the BASIC_STATUS indicates the different status:

Bit	Status	Explanation
Bit 0	Control gear failure	The control gear cannot be operated as intended.
Bit 1	Lamp failure	The lamp cannot operate as intended.
Bit 2	Lamp on	The lamp is on.
Bit 3	Limit error	The last requested target level is modified in accordance with limitations of "MIN_LEVEL" or "MAX_LEVEL".
Bit 4	Fade running	The fade timer is running.
Bit 5	Reset state	All the parameters of this device are at their reset value.
Bit 6	No short address	No short address is assigned to this device.
Bit 7	Power cycle seen	An external power cycle is occurred.

5.6.3 DALI_ECG_STATUS_CHECK

Description

DALI_ECG_STATUS_CHECK is used for checking the status of control gears. For the detailed status bits description, refer to BASIC_STATUS and EXT_STATUS in DALI_ECG_STATUS (Page 47).

You can set the status mask of all the control gears, compare with the actual status that is stored in the CM 1xDALI, and then return the matching result. The function block checks the status information which is saved in the CM 1xDALI (refer to data flow path 2 (Page 22)). The CM 1xDALI queries the actual device status in the "Background detection period" which is set in the Module Parameters (Page 20).

For example, for the control gear whose short address is 5, if you want to monitor whether the bit 1 of BASIC_STATUS in **DALI_ECG_STATUS** (Page 47) set to 1, you can set input EXT_STATUS to 0 and set STATUS_MASK[5] to 16#02.

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
CHECK	Input	BOOL	I, Q, M, D, L or Constant	Compare the specified status mask with the control gears upon a rising edge.
EXT_STAT-US		BOOL	I, Q, M, D, L or Constant	Show the status of control gear: • EXT_STATUS = 0: Basic status of the control gear • EXT_STATUS = 1: Type-related failure status of the control gear
STATUS_M-ASK		Array[0..6-3] of BYTE	I, Q, M, D, L or Constant	Show the status mask of all the control gears. The index of the array indicates the short address.
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communic-ates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has fol-lowing three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
MATCH		Array[0..6-3] of BOOL	I, Q, M, D, L	Check result of devices on all the short addresses. MATCH = 1: The status of the control gear which is matched with the specified status mask. The index of the array indicates the short address.

5.6.4 DALI_ECG_QUERY_OPHOUR

Description

DALI_ECG_QUERY_OPHOUR is used for querying the operation hour of DALI control gear. The operation hour accumulates when the control gear remains on for one hour. The operation hour is stored in the CM 1xDALI (refer to data flow path 2 (Page 22)). If you change short adresses of two control gears, the operating hours of these two control gears are not be changed, you exchange the related operation hours of these two control gears by using DALI_ECG_SET_OPHOUR (Page 51).

Before calling this function block, make sure that the control gear is configured by using DALI_ECG_ADD (Page 57) or DALI_DEV_UPLOAD (Page 83).

When you query the operating hour of the control gear, the following occurs:

- If the control gear is not configured before, the error code “16#8D” is shown in the output parameter of STATUS.
- If the control gear is configured, but the type of control gear is mismatched, the error code “16#8B” is shown in the output parameter of STATUS.

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
QUERY	Input	BOOL	I, Q, M, D, L or Constant	Query the operation hour of control gear upon a rising edge.	
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63	
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.6.5 DALI_ECG_SET_OPHOUR

Description

DALI_ECG_SET_OPHOUR is used for setting the operation hour of DALI control gear. The operation hour accumulates when the control gear remains on for one hour. The operation hour is stored in the CM 1xDALI (refer to data flow path 1 (Page 22)).

Before calling this function block, make sure that the control gear is configured by using DALI_ECG_ADD (Page 57) and DALI_DEV_UPLOAD (Page 83).

When you set the operating hour of the control gears, the following occurs:

- If the control gear is not configured before, the error code “16#8D” is shown in the output parameter of STATUS.
- If the control gear is configured, but the type of control gear is mismatched, the error code “16#8B” is shown in the output parameter of STATUS.

It is recommended to reset the operation hour after exchanging the physical control gear device.

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
SET	Input	BOOL	I, Q, M, D, L or Constant	Set the operation hour upon a rising edge.	
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63	
OPHOUR		UInt	I, Q, M, D, L or Constant	Set the operation hour to the control gear.	
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.6.6 DALI_SENSOR_STATUS

Description

DALI_SENSOR_STATUS is used for querying the status of one sensor (input device). The status information is queried from the physical DALI device (refer to data flow path 6 (Page 22)). The status information saved in CM 1xDALI will be updated (refer to data flow path 4 (Page 22)).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
READ	Input	BOOL	I, Q, M, D, L or Constant	Query the status of sensor upon a rising edge.
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
SENSOR_STATUS		Sensor-StatusDetail	D, L	The status information of sensor
CONFIGURED		BOOL		CONFIGURED = 1: The short address is configured by using DALI_SENSOR_ADD (Page 74) or DALI_DEV_UPLOAD (Page 83).
ADDR_CHANGED		BOOL		• ADDR_CHANGED = 0: The short address of sensor is not changed. • ADDR_CHANGED = 1: The short address of sensor is changed during the scan procedure.

Parameter	Declaration	Data type	Memory area	Description
ADDR_STATUS	Output	BYTE	D, L	Show the control status of the device: • 1: Normal status • 2: No device with the short address • 3: The DALI device displays an error frame. This error may be caused by the short address conflict or the problem of the DALI device. • 4: Type mismatch. The configured type is not the same as the actual one. • 5: The number of instances mismatch. The configured number of instances is different from the physical device. • 15: This short address of sensor device is assigned to CM 1xDALI.
DEV_STATUS		BYTE		Show the status of the input devices. For the detailed explanation for each Bit of DEV_STATUS, refer to the following section "Parameter DEV_STATUS".
CFG_NUM_OF_INST		BYTE		• When CONFIGURED = 0, the value of CFG_NUM_OF_INST is 0. • When CONFIGURED = 1, the value of CFG_NUM_OF_INST is the configured number of instances.
NUM_OF_INST		USInt		The actual number of sensor instances in the device. Range: 0 to 32
INST_ERR		Array[0..31] of BOOL		INST_ERR = 1: Error occurs in the instance. The index of the array indicates the instance number.
INST_ACTIVE		Array[0..31] of BOOL		INST_ACTIVE = 1: The instance is active. The index of the array indicates the instance number.
CFG_INST_TYPE		Array[0..31] of USInt		Configured instance type of each sensor instance. The index of the array indicates the instance number.
INST_TYPE		Array[0..31] of USInt		Actual instance type of each sensor instance. The index of the array indicates the instance number.

Parameter DEV_STATUS

Each Bit of the DEV_STATUS indicates the different status:

Bit	Status	Explanation
Bit 0	Input device error	The input device or its instances has an error.
Bit 1	Quiescent mode	The input device does not produce any forward frame.
Bit 2	Short address is mask (255)	No short address is assigned to this device.
Bit 3	Application active	The application controller is active
Bit 4	Application controller error	This application controller has an error.
Bit 5	Power cycle seen	An external power cycle is occurred.
Bit 6	Reset state	All the parameters of this device are at their reset value.
Bit 7	Unused	Unused

5.6.7 DALI_SENSOR_INPUT

Description

DALI_SENSOR_INPUT is used for querying the input value of one instance in the input device (sensor). The input value is queried from the physical DALI device (refer to data flow path 6 (Page 22)).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
READ	Input	BOOL	I, Q, M, D, L or Constant	Query status of sensor upon a rising edge.	
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63	
INST_NUM		USint	I, Q, M, D, L or Constant	Specify the instance number of the sensor. Range: 0 to 32	
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
RESOLUTION		USint	I, Q, M, D, L	The resolution of the input value. It indicates the range of INPUT_VALUE.	
INPUT_VALUE		UDInt	I, Q, M, D, L	The input value of sensor.	

5.6.8 DALI_SENSOR_STATUS_CHECK

Description

DALI_SENSOR_STATUS_CHECK is used for checking the status of input device (sensor). For the detailed status bits description, refer to DEV_STATUS in DALI_SENSOR_STATUS (Page 53).

You can set the status mask of all the sensors, compare with the actual status that is stored in the CM 1xDALI, and then return the matching result. The function block checks the status information which is saved in the CM 1xDALI (refer to data flow path 2 (Page 22)). The CM 1xDALI queries the actual device status in the "Background detection period" which is set in the Module Parameters (Page 20).

For example, for the sensor whose short address is 4, if you want to check whether the bit 0 of DEV_STATUS in DALI_SENSOR_STATUS (Page 53) is set to 1, you can set input STATUS_MASK[4] to 16#01.

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
CHECK	Input	BOOL	I, Q, M, D, L or Constant	Compare the specified status mask with sensors upon a rising edge.	
STATUS_MASK		Array[0..63] of BYTE	I, Q, M, D, L or Constant	Show the status mask of all the sensors.	
CM_DALI	InOut	"DALI_CTRL"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
MATCH		Array[0..63] of BOOL	I, Q, M, D, L	Check result of devices on all the short addresses. MATCH = 1: The status of the sensor which is matched with the specified status mask. The index of the array indicates the short address.	

5.7 Configuration function blocks

Configuration function blocks are used for configuring the parameters of all the DALI devices.

These function blocks allow to store configuration data in the CM 1xDALI module.

The configuration in the modules database can be built up by uploading the physical devices or by configuring from the CPU. A stored configuration can be easily queried and modified by these function blocks.

5.7.1 DALI_ECG_ADD

Description

DALI_ECG_ADD is used for adding or modifying one configured control gear.

- In order to add one configured control gear, you must set the device type of the control gear.
- This function block does not send any command to the DALI bus, and the CM 1xDALI saves the data of the added devices (refer to data flow path 1 (Page 22)).
- After adding the device by this function block, the parameters you set by other function blocks (for example, DALI_ECG_SET_BASIC_PARAM (Page 61) and DALI_ECG_SET_GROUP (Page 70)) are saved in the CM 1x DALI.
- The device is marked as configured after the device type is set. Refer to the output parameter CONFIGURED of DALI_DEV_QUERY_ADDR (Page 34).
- All of the setting parameters are saved in the CM 1xDALI until the device is deleted by using DALI_ECG_DELETE (Page 58) or reset by using DALI_DEV_RESET (Page 86).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
ADD	Input	BOOL	I, Q, M, D, L or Constant	Add or modify one configured control gear upon a rising edge.
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
ECG_TYPE		USInt	I, Q, M, D, L or Constant	Specify the device type of the control gear which is added or modified. Refer to Electric control gear (ECG) type (Page 88).
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.

Parameter	Declaration	Data type	Memory area	Description	
DONE	Output	BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.7.2 DALI_ECG_DELETE

Description

DALI_ECG_DELETE is used for deleting one configured control gear.

This function block does not send any command to the DALI bus, but deletes the device which is added by using DALI_ECG_ADD (Page 57) and the data which is saved in the CM 1xDALI (refer to data flow path 1 (Page 22)).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
DELETE	Input	BOOL	I, Q, M, D, L or Constant	Delete one configured control gear upon a rising edge.
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.

Parameter	Declaration	Data type	Memory area	Description	
DONE	Output	BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.7.3 DALI_ECG_QUERY_BASIC_PARAM

Description

DALI_ECG_QUERY_BASIC_PARAM is used for querying the basic parameters of DALI control gears.

- When you set the input "PHY_DEV" to 1, this function block queries the parameters from the physical device (refer to data flow path 6 (Page 22)).
- When you set the input "PHY_DEV" to 0, this function block queries the parameters which are saved in CM 1xDALI (refer to data flow path 2 (Page 22)).

You can set the basic parameter of control gear by using DALI_ECG_SET_BASIC_PARAM (Page 61).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
QUERY	Input	BOOL	I, Q, M, D, L or Constant	Query basic parameters of the control gear upon a rising edge.
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
PHY_DEV		BOOL	I, Q, M, D, L or Constant	Specify the location of parameters: • PHY_DEV = 1 : Query the parameters from the physical device by sending commands. • PHY_DEV = 0 : Query the parameters which are saved in CM 1xDALI.
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.

Parameter	Declaration	Data type	Memory area	Description
ACTIVE	Output	BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
BASIC_PRM_-QRY		BasicPrm-QryDetail	D, L	The basic parameters of control gear
PWR_ON_-LEVEL		USInt		Power on level Range: 0 to 255 **Note:** If PWR_ON_LEVEL is set to 255, the control gear sets the level to the last active level when power on.
SYS_FAIL-_LEVEL		USInt		System failure level Range: 0 to 255 **Note:** If SYS_FAIL_LEVEL is set to 255, the control gear has no response to the system failure.
MIN_LEV-EL		USInt		Minimum level of the brightness Range: 1 to the value of MAX_LEVEL
MAX_LEV-EL		USInt		Maximum level of the brightness Range: The value of MIN_LEVEL to 254
FADE_RA-TE		USInt		The fading speed for dimming. The fade rate is used by DALI_ECG_SWITH_DIM (Page 38) for dimming up or down function. $fade\ rate = \frac{506}{\sqrt{2^{FADE_RATE}}}\ step/s$ Range: 1 to 15
FADE_TI-ME		USInt		The fade time use for setting level or go to scene. The fade time is used by DALI_ECG_SET_LEVEL (Page 41), DALI_ECG_SWITCH (Page 36) and DALI_ECG_SWTICH_DIM (Page 38) for setting the level. $fade\ time = \begin{cases} use\ extended\ fade\ time, & FADE_TIME=0 \\ \frac{1}{2} \cdot \sqrt{2^{FADE_TIME}} \cdot 1\ s, & FADE_TIME > 0 \end{cases}$ Range: 0 to 15
EXT_FAD-E_BASE		USInt		Base of the extend fade time extendedFadeTimeBase = EXT_FADE_BASE + 1 Range: 0 to 15
EXT_FAD-E_MUL		USInt		Multiplier of the extend fade time Range: 0 to 5

Parameter		Declaration	Data type	Memory area	Description	
	EXT_FAD-E_MUL	Output	USInt	D, L	**EXT_FADE_MUL**	**extemdedFadeTimeMultiplier**
					0	0 ms
					1	100 ms
					2	1 s
					3	10 s
					4	1 min
					In case FADE_TIME = 0, extended fade time is used, fade time = extendedFadeTimeBase * extemdedFadeTimeMultiplier **Note**: Extended fade time is only supported by devices compliant with DALI 2.0. If the device doses not support extended fade time, the value of EXT_FADE_TIME_BASE and EXT_FADE_TIME_MUL shows 0.	
	ECG_TYPE		USInt		Device type of control gears. Refer to Electric control gear (ECG) type (Page 88).	
	DEV_VER		USInt		The device version. If you set the input PHY_DEV to 0, the value of DEV_VER is 0. The version is in the format "x.y". The major version number x is placed in bits 7 to 2, and the minor version number y is placed in bits 1 to 0.	
	PHM		USInt		Physical minimum level. If PHY_DEV = 0, the value of PHM is 0.	

5.7.4 DALI_ECG_SET_BASIC_PARAM

Description

DALI_ECG_SET_BASIC_PARAM is used for setting the basic parameters of DALI control gears.

- If the status of control gear is configured (for example, control gear is added by using DALI_ECG_ADD (Page 57)), the parameters are saved in the CM 1xDALI (refer to data flow path 1 (Page 22)) and sent to the physical device (refer to data flow path 5 (Page 22)).
- If the status of control gear is not configured, the parameters are only sent to the physical device (refer to data flow path 5 (Page 22)).

You can query the basic parameter of control gear by using DALI_ECG_QUERY_BASIC_PARAM (Page 59).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
SET	Input	BOOL	I, Q, M, D, L or Constant	Set basic parameters of the control gear upon a rising edge.
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
BASIC_PRM_SET		BasicPrmSetDetail	D, L	The basic parameters of control gear which is used for setting.
PWR_ON_LEVEL		USInt		Power on level. Range: 0 to 255 **Note:** If PWR_ON_LEVEL is set to 255, the control gear sets the level to the last active level when power was on.
SYS_FAIL_LEVEL		USInt		System failure level Range: 0 to 255 **Note:** If SYS_FAIL_LEVEL is set to 255, the control gear has no response to the system failure.
MIN_LEVEL		USInt		Minimum level of the brightness Range: 1 to the value of MAX_LEVEL
MAX_LEVEL		USInt		Maximum level of the brightness Range: The value of MIN_LEVEL to 254
FADE_RATE		USInt		The fading speed for dimming. The fade rate is used by DALI_ECG_SWITCH_DIM (Page 38) for dimming up or down function. $fade\ rate = \frac{506}{\sqrt{2^{FADE_RATE}}}\ step/s$ Range: 1 to 15
FADE_TIME		USInt		The fade time use for setting level or go to scene. The fade time is used by DALI_ECG_SET_LEVEL (Page 41), DALI_ECG_SWITCH (Page 36) and DALI_ECG_SWITCH_DIM (Page 38) for setting the level. $fade\ time = \begin{cases} use\ extended\ fade\ time, & FADE_TIME=0 \\ \frac{1}{2}\cdot\sqrt{2^{FADE_TIME}}\cdot 1\ s, & FADE_TIME > 0 \end{cases}$ Range: 0 to 15
EXT_FADE_BASE		USInt		Base of the extend fade time extendedFadeTimeBase = EXT_FADE_BASE + 1 Range: 0 to 15
EXT_FADE_MUL		USInt		Multiplier of the extended fade time Range: 0 to 5

EXT_FADE_MUL	extemdedFadeTimeMultiplier
0	0 ms
1	100 ms
2	1 s
3	10 s
4	1 min

Parameter	Declaration	Data type	Memory area	Description	
EXT_FADE_MUL	Input	USInt	D, L	In case FADE_TIME = 0, extended fade time is used, fade time = extendedFadeTimeBase * extemdedFadeTimeMultiplier **Note**: Extended fade time is only supported by devices compliant with DALI-2. If the device does not support extended fade time, the value of EXT_FADE_TIME_BASE and EXT_FADE_TIME_MUL are ignored by DALI device.	
CM_DALI	InOut	"DALI_CTRL"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL		Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL		Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL		Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL		Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE		When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.7.5 DALI_ECG_QUERY_EXT_PARAM

Description

DALI_ECG_QUERY_EXT_PARAM is used for querying the extended parameters of DALI control gears.

- When you set the input "PHY_DEV" to 1, this function block queries the extended parameters from the physical device (refer to data flow path 6 (Page 22)).
- When you set the input "PHY_DEV" to 0, this function block queries the parameters which are saved in CM 1xDALI (refer to data flow path 2 (Page 22)).

The extended parameters have the following features:

- The extended parameters are type-related.
- The extended parameters in the physical device can only be queried from the control gears whose type range is from 1 to 8; Otherwise, the error code “16#87” (Not supported) is shown in the output parameter of STATUS.
- The extended parameters which are saved in CM 1xDALI can only be queried from the control gear whose type is 1, or 4 to 8.

You can set the extended parameters of control gear by using DALI_ECG_SET_EXT_PARAM (Page 67).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
QUERY	Input	BOOL	I, Q, M, D, L or Constant	Query the extended parameters of the control gear upon a rising edge.	
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63	
PHY_DEV		BOOL	I, Q, M, D, L or Constant	Specify the location of parameters: • PHY_DEV = 0 : Query the parameters which are saved in CM 1xDALI. • PHY_DEV = 1 : Query the parameters from the physical device by sending commands.	
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
ECG_TYPE		USInt	I, Q, M, D, L	Device type of the control gear.	
EXT_PRM_-QRY [1]		Array[0..3-0] of BYTE	I, Q, M, D, L	The type-related parameters of the control gear.	

[1] For the detailed description of the extended parameters for DALI control gears, refer to the following table.

Table 2-1807 The extended parameters of DALI control gears

Attributes	BYTE	Type 1 (emergency)	Type 2 (discharge)	Type 3 (halogen)	Type 4 (incandescent)	Type 5 (converter)	Type 6 (LED)	Type 7 (switch)	Type 8 (color control)			
Read/Write	0	Emergency level	Not used	Not used	Dimming curve	Dimming curve	Dimming curve	Up switch-on threshold	Power on color	Color type		
	1	Prolong time			Not used	Output rage	Fast fade time	Up switch-off threshold		Color value	Coordinate x	Color temperature
	2	Function test delay				Internal pullup		Down switch-off threshold				
	3					Physical Min level		Down switch-on threshold			Coordinate y	Not used
	4	Duration test delay				Not used		Error hold-off time				
	5							Not used	System failure color	Color type		
	6	Function test interval								Color value	Coordinate x	Color temperature
	7	Duration test interval										
	8	Test execute timeout									Coordinate y	Not used
	9	Not used										
	10								Color temperature physical coolest			
	11											
	12								Color temperature physical warmest			
	13											
	14								Color temperature coolest			
	15											
	16								Color temperature warmest			
	17											
Read only	18	Extend version	Extend version	Extend version	Extend version	Extend version	Extend version	Extend version	Extend version			

Attributes	BYTE	Type 1 (emergency)	Type 2 (discharge)	Type 3 (halogen)	Type 4 (incandescent)	Type 5 (converter)	Type 6 (LED)	Type 7 (switch)	Type 8 (color control)
Read only	19	Features	Features	Features	Features byte 0	Features	Features	Features	Color type features
	20	Emergency min level	HID status	Failure status	Features byte 1	Converter status	Failure state	Switch status	Color status
	21	Emergency max level	Actual failure	Not used	Features byte 2	Output level	Min fast fade time	Gear type	Not used
	22	Duration test result	Stored failure		Dimmer status	Not used	Gear type	Not used	
	23	Rated duration	Thermal overload time		Dimmer temperature		Possible operation mode		
	24	Battery charge			RMS supply voltage		Operation mode		
	25	Emergency time	Thermal load		Supply frequency		Not used		
	26	Total operation time	Not used		RMS load voltage				
	27	Emergency mode			RMS load current				
	28	Failure status			Real load power				
	29	Emergency status							
	30	Not used			Load rating				

5.7.6 DALI_ECG_SET_EXT_PARAM

Description

DALI_ECG_SET_EXT_PARAM is used for setting the extended parameters of DALI control gears. The extended parameters are type-related.

- If the status of control gear is configured (for example, control gear is added by using DALI_ECG_ADD (Page 57)), the parameters are saved in the CM 1xDALI (refer to data flow path 1 (Page 22)) and sent to the physical device (refer to data flow path 5 (Page 22)).
- If the status of control gear is not configured, the parameters are only sent to the physical device (refer to data flow path 5 (Page 22)).
- This function block does not check whether the input parameter EXT_PRM_SET is valid for the specified control gear.

You can query the extended parameters of control gear by using DALI_ECG_QUERY_EXT_PARAM (Page 63).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
SET	Input	BOOL	I, Q, M, D, L or Constant	Set extended parameters of the control gear upon a rising edge.
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
ECG_TYPE		USInt	I, Q, M, D, L or Constant	Device type of the control gears. Refer to Electric control gear (ECG) type (Page 88). Range:1, 4 to 8
EXT_PRM_-SET [1]		Array[0..1-7] of BYTE	I, Q, M, D, L or Constant	The parameters are set to the control gear.
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.

[1] For the detailed description of the extended parameters for DALI control gears, refer to the following table.

Parameter	Declaration	Data type	Memory area	Description	
DONE	Output	BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

[1] For the detailed description of the extended parameters for DALI control gears, refer to the following table.

Table 2-1808 The extended parameters of DALI control gears

Attributes	BYTE	Type 1 (emergency)	Type 4 (incandescent)	Type 5 (converter)	Type 6 (LED)	Type 7 (switch)	Type 8 (color control)			
Read/Write	0	Emergency level	Dimming curve	Dimming curve	Dimming curve	Up switch-on threshold	Power on color	Color type		
	1	Prolong time	Not used	Output rage	Fast fade time	Up switch-off threshold		Color value	Coordinate x	Color temperature
	2	Function test delay		Internal pullup		Down switch-off threshold				
	3			Physical Min level		Down switch-on threshold			Coordinate y	Not used
	4	Duration test delay		Not used		Error hold-off time				
	5					Not used	System failure color	Color type		
	6	Function test interval						Color value	Coordinate x	Color temperature
	7	Duration test interval								
	8	Test execute timeout							Coordinate y	Not used
	9	Not used								
	10						Color temperature physical coolest			
	11									
	12						Color temperature physical warmest			
	13									

Attributes	BYTE	Type 1 (emergency)	Type 4 (incandescent)	Type 5 (converter)	Type 6 (LED)	Type 7 (switch)	Type 8 (color control)
Read/Write	14	Not used	Not used	Not used		Not used	Color temperature coolest
	15						
	16						Color temperature warmest
	17						

5.7.7 DALI_ECG_QUERY_GROUP

Description

DALI_ECG_QUERY_GROUP is used for querying the group membership of DALI control gears.

- When you set the input "PHY_DEV" to 1, this function block queries the group membership from the physical device (refer to data flow path 6 (Page 22)).
- When you set the input "PHY_DEV" to 0, this function block queries the parameters which are saved in CM 1xDALI (refer to data flow path 2 (Page 22)).

You can set the group membership of control gear by using DALI_ECG_SET_GROUP (Page 70).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
QUERY	Input	BOOL	I, Q, M, D, L or Constant	Query the group membership of the control gear upon a rising edge.
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
PHY_DEV		BOOL	I, Q, M, D, L or Constant	Specify the location of parameters: • PHY_DEV = 0 : Query the parameters which are saved in CM 1xDALI. • PHY_DEV = 1 : Query the parameters from the physical device by sending commands.
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.

Parameter	Declaration	Data type	Memory area	Description	
ERROR	Output	BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
GROUP_BITS		Array[0..15] of BOOL	I, Q, M, D, L	The group membership of the control gear. The index of the array indicates the group address. • GROUP_BITS = 0: Not in group • GROUP_BITS = 1: In group	

5.7.8 DALI_ECG_SET_GROUP

Description

DALI_ECG_SET_GROUP is used for setting the group membership of DALI control gears.

- If the status of control gear is configured (for example, control gear is added by using DALI_ECG_ADD (Page 57)), the parameters are saved in the CM 1xDALI (refer to data flow path 1 (Page 22)) and sent to the physical device (refer to data flow path 5 (Page 22)).
- If the status of control gear is not configured, the parameters are only sent to the physical device (refer to data flow path 5 (Page 22)).

You can query the group membership of control gear by using DALI_ECG_QUERY_GROUP (Page 69).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
SET	Input	BOOL	I, Q, M, D, L or Constant	Set the group membership of the control gear upon a rising edge.
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
GROUP_BITS		Array[0..15] of BOOL	I, Q, M, D, L or Constant	The group membership of the control gear. The index of the array indicates the group address. • GROUP_BITS = 0: Remove from group • GROUP_BITS = 1: Add to group
CM_DALI	InOut	"DALI_CTRL"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.

Parameter	Declaration	Data type	Memory area	Description	
ACTIVE	Output	BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.7.9 DALI_ECG_QUERY_SCENE

Description

DALI_ECG_QUERY_SCENE is used for querying the scene configuration of the control gear.

- When you set the input "PHY_DEV" to 1, this function block queries the scene information from the physical device (refer to data flow path 6 (Page 22)).
- When you set the input "PHY_DEV" to 0, this function block queries the parameters which are saved in CM 1xDALI (refer to data flow path 2 (Page 22)).

You can set the scene configuration of control gear by using DALI_ECG_SET_SCENE (Page 73).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
QUERY	Input	BOOL	I, Q, M, D, L or Constant	Query the scene configuration of the control gear upon a rising edge.
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
SCENE_NUM		USInt	I, Q, M, D, L or Constant	Specify the scene number. Range: 0 to 15
PHY_DEV		BOOL	I, Q, M, D, L or Constant	Specify the location of parameters: • PHY_DEV = 0 : Query the parameters which are saved in CM 1xDALI. • PHY_DEV = 1 : Query the parameters from the physical device by sending commands.
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.

Parameter	Declaration	Data type	Memory area	Description
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
SCENE_INFO		SceneInfoDetail	D, L	The scene information of control gear
LEVEL		USInt	I, Q, M, D, L	Scene level. Range: 0 to 255 **Note**: When LEVEL= 255: The scene is not configured.
COLOR		DALIColorDetail	D, L	The color information of the scene
COLOR_TYPE		USInt	I, Q, M, D, L	Set the color type: • 16#00: No color, only set the scene level, ignore the scene color. • 16#10: xy-coordinate • 16#20: Color temperature
COORDINATE_X		UInt	Constant	The x-coordinate value of the point in the CIE color space chromaticity diagram. X-coordinate = "COORDINATE_X" * 1/65536. Range: 0 to 65534
COORDINATE_Y		UInt	Constant	The y-coordinate value of the point in the CIE color space chromaticity diagram. Y-coordinate = "COORDINATE_Y" * 1/65536. Range: 0 to 65534
TEMPERATURE		UInt	Constant	The color value of temperature. T_C(K) = 1000000 / "TEMPERATURE" Range: 1 to 65534

5.7.10 DALI_ECG_SET_SCENE

Description

DALI_ECG_SET_SCENE is used for setting the scene configuration of the control gear.

- You can set the scene level and scene color of one scene.
- If the control gear does not support the color control function, only scene level can be set. In this case, the input COLOR_TYPE under the "SCENE_INFO" is set to 16#00.
- If the status of control gear is configured (for example, control gear is added by using DALI_ECG_ADD (Page 57)), the parameters are saved in the CM 1xDALI (refer to data flow path 1 (Page 22)) and sent to the physical device (refer to data flow path 5 (Page 22)).
- If the status of control gear is not configured, the parameters are only sent to the physical device (refer to data flow path 5 (Page 22)).

You can query the scene configuration of control gear by using DALI_ECG_QUERY_SCENE (Page 71).

Parameter

The following table shows the parameters of the function block:

Parameter			Declaration	Data type	Memory area	Description
SET			Input	BOOL	I, Q, M, D, L or Constant	Set the scene configuration of the control gear upon a rising edge.
ADDRESS				USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
SCENE_NUM				USInt	I, Q, M, D, L or Constant	Specify the scene number. Range: 0 to 15
SCENE_INFO				SceneIn-foDetail	D, L	The scene information of the control gear
	LEVEL			USInt		Scene level. Write scene level to 255 means remove scene. Range: 0 to 255
	COLOR					The color information of the scene
		COLOR_-TYPE		USInt		Set the color type: • 16#00: No color, only set the scene level, ignore the scene color. • 16#10: xy-coordinate • 16#20: Color temperature
		COORDI-NATE_X		UInt		The x-coordinate value of the point in the CIE color space chromaticity diagram. X-coordinate = "COORDINATE_X" * 1/65536. Range: 0 to 65534
		COORDI-NATE_Y		UInt		The y-coordinate value of the point in the CIE color space chromaticity diagram. Y-coordinate = "COORDINATE_Y" * 1/65536. Range: 0 to 65534

Parameter			Declaration	Data type	Memory area	Description	
		TEMPER-ATURE	Input	UInt	D, L	The color value of temperature. T_C(K) = 1000000 / "TEMPERATURE" Range: 1 to 65534	
CM_DALI			InOut	"DALI_C-TRL"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY			Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE				BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE				BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR				BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS				BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.7.11 DALI_SENSOR_ADD

Description

DALI_SENSOR_ADD is used for adding or modifying one configured sensor, including its instances.

- In order to add one configured sensor, you must set the sensor type of the instance.
- The total number of instances within all sensors which you can add is limited to 64. If the total number of instance exceeds the limitation, this function block returns an error of 16#87 (not supported).
- This function block does not send any command to the DALI bus, and the CM 1xDALI saves the data of the added devices (refer to data flow path 1 (Page 22)).
- After adding the device using this function block, the parameters you set using other function blocks (for example, DALI_SENSOR_SET_DEV_PARAM (Page 78) and DALI_SENSOR_SET_INST_PARAM (Page 81)) are saved in the CM 1xDALI.
- The device is marked as configured after the device type is set. Refer to the output CONFIGURED of function block **DALI_DEV_QUERY_ADDR** (Page 34).
- All the setting parameters are saved in the CM 1xDALI until the device is deleted by using DALI_SENSOR_DELETE (Page 75) or reset by using DALI_DEV_RESET (Page 86).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
ADD	Input	BOOL	I, Q, M, D, L or Constant	Add or modify one configured sensor upon a rising edge.	
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63	
NUM_OF_INST		USInt	I, Q, M, D, L or Constant	Specify the number of instances of the sensor. Range: 1 to 32	
INST_TYPES		Array[0..31] of USInt	I, Q, M, D, L or Constant	Specify the instance type of sensor which is added or modified. Refer to Instance type of input device (Page 88). Range: 0 to 255 The index of the array indicates the instance number.	
CM_DALI	InOut	"DALI_CTRL"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.7.12 DALI_SENSOR_DELETE

Description

DALI_SENSOR_DELETE is used for deleting one configured sensor, including its instances.

This function block does not send any command to the DALI bus, but deletes the device which is added by using DALI_SENSOR_ADD (Page 74) and the data which is saved in the CM 1xDALI (refer to data flow path 1 (Page 22)).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
DELETE	Input	BOOL	I, Q, M, D, L or Constant	Delete one configured sensor upon a rising edge.	
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63	
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.7.13 DALI_SENSOR_QUERY_DEV_PARAM

Description

DALI_SENSOR_QUERY_DEV_PARAM is used for querying the device parameters of the input device (sensor).

- When you set the input "PHY_DEV" to 1, this function block queries the parameters from the physical device (refer to data flow path 6 (Page 22)).
- When you set the input "PHY_DEV" to 0, this function block queries the parameters which are saved in CM 1xDALI (refer to data flow path 2 (Page 22)).

You can set the device parameters of sensor by using DALI_SENSOR_SET_DEV_PARAM (Page 78).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
QUERY	Input	BOOL	I, Q, M, D, L or Constant	Query device parameters of the sensor upon a rising edge.	
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63	
PHY_DEV		BOOL	I, Q, M, D, L or Constant	Specify the location of parameters. • PHY_DEV = 1 : Query the parameters from the physical device by sending commands. • PHY_DEV = 0 : Query the parameters which are saved in CM 1xDALI.	
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
OPER_MODE		BYTE	I, Q, M, D, L	Operating mode of the sensor device which is defined by the device manufacturer.	
PWR_CYCLE		BOOL	I, Q, M, D, L	Power cycle notification flag. PWR_CYCLE = 1: After completing its external power cycle, the sensor generates a power cycle event message.	

5.7.14 DALI_SENSOR_SET_DEV_PARAM

Description

DALI_SENSOR_SET_DEV_PARAM is used for setting the device parameters of the input device (sensor).

- If the status of sensor is configured (for example, sensor is added by using DALI_SENSOR_ADD (Page 74)), the parameters are saved in the CM 1xDALI (refer to data flow path 1 (Page 22)) and sent to the physical device (refer to data flow path 5 (Page 22)).
- If the status of sensor is not configured, the parameters are only sent to the physical device (refer to data flow path 5 (Page 22)).

You can query the device parameter of sensor by using DALI_SENSOR_QUERY_DEV_PARAM (Page 76).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
SET	Input	BOOL	I, Q, M, D, L or Constant	Set device parameters of the sensor upon a rising edge.
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
OPER_MO-DE		BYTE	I, Q, M, D, L	Operating mode of the sensor device which is defined by the device manufacturer.
PWR_CYCLE		BOOL	I, Q, M, D, L	Power cycle notification flag. PWR_CYCLE = 1: After completing its external power cycle, the sensor generates a power cycle event message.
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.

Parameter	Declaration	Data type	Memory area	Description	
DONE	Output	BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.7.15 DALI_SENSOR_QUERY_INST_PARAM

Description

DALI_SENSOR_QUERY_INST_PARAM is used for querying the instance parameters of the input device (sensor).

- When you set the input "PHY_DEV" to 1, this function block queries the parameters from the physical device (refer to data flow path 6 (Page 22)).
- When you set the input "PHY_DEV" to 0, this function block queries the parameters which are saved in CM 1xDALI (refer to data flow path 2 (Page 22)).

You can set the instance parameters of sensor by using DALI_SENSOR_SET_INST_PARAM (Page 81).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
QUERY	Input	BOOL	I, Q, M, D, L or Constant	Query the instance parameters of the sensor upon a rising edge.
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
INST_NUM		USInt	I, Q, M, D, L or Constant	Specify the instance number. Range: 0 to 31
PHY_DEV		BOOL	I, Q, M, D, L or Constant	Specify the location of parameters: • PHY_DEV = 0 : Query the parameters which are saved in CM 1xDALI. • PHY_DEV = 1 : Query the parameters from the physical device by sending commands.
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.

[1] For the detailed description of sensor instance type-related parameters, refer to the following table.

Parameter	Declaration	Data type	Memory area	Description
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).
INST_PRM_QRY		InstPrmQryDetail	D, L	The instance parameters of input device (sensor)
INST_TYPE		USInt		Refer to Instance type of input device (Page 88) to query the Instance type.
INST_ACTIVE		BOOL		Activation of the instance.
EVENT_SCHEME		USInt		An instance of an input device uses the selected event source addressing according to the following scheme: • 0: Instance type and instance number • 1: Short address and instance type • 2: Short address and instance number • 3: Device group and instance number • 4: Instance group and instance type
EVENT_FILTER		BYTE		The event message filter is used to enable and disable specific events. Refer to Description for EVENT_FILTER (Page 89) for detailed description.
EVENT_PRIO		USInt		The sending priority of the event message. The system reactions are sent according to the set priority. The system reactions with high priority take precedence over the system reactions with low priority.
TYPE_PRM_QRY [1]		Array[0..6] of BYTE		The type-related parameters of the instance.

[1] For the detailed description of sensor instance type-related parameters, refer to the following table.

Table 2-1809 Sensor instance type-related parameters

Attributes	BYTE	Type 1 (push button)	Type 2 (absolute input)	Type 3 (occupancy)	Type 4 (light sensor)
Read/Write	0	*tShort*	Deadtime	Hold time	Hysteresis
	1	*tDouble*	Report time	Report time	Hysteresis min
	2	*tRepeat*	Not used	Deadtime	Report time
	3	*tStuck*		Not used	Deadtime

Attributes	BYTE	Type 1 (push button)	Type 2 (absolute input)	Type 3 (occupancy)	Type 4 (light sensor)
Read only	4	Resolution			
	5	tShortMin	Not used	Not used	Not used
	6				

5.7.16 DALI_SENSOR_SET_INST_PARAM

Description

DALI_SENSOR_INST_PARAM is used for setting the instance parameters of the input device (sensor).

- If the status of the sensor is configured (for example, sensor is added by using DALI_SENSOR_ADD (Page 74)), the parameters are saved in the CM 1xDALI (refer to data flow path 1 (Page 22)) and sent to the physical device (refer to data flow path 5 (Page 22)).
- If the status of the sensor is not configured, the parameters are only sent to the physical device (refer to data flow path 5 (Page 22)).

You can query the instance parameters of the sensor by using DALI_SENSOR_QUERY_INST_PARAM (Page 79).

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
SET	Input	BOOL	I, Q, M, D, L or Constant	Set the instance parameters of the sensor upon a rising edge.
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
INST_NUM		USInt	I, Q, M, D, L or Constant	Specify the instance number. Range: 0 to 31
INST_PRM_SET		InstPrmSet-Detail	D, L	The instance parameters of the input device (sensor).
INST_TYPE		USInt		Refer to the Instance type of input device (Page 88) to set the instance type. Range: 1 to 4
INST_ACTIVE		BOOL		Activation of the instance.

[1] For the detailed description of sensor instance type-related parameters for configuring **DALI_SENSOR_INST_PARAM**, refer to the following table.

Parameter	Declaration	Data type	Memory area	Description
EVENT_SCHEME	Input	USInt	D, L	An instance of an input device uses the selected event source addressing according to the scheme: • 0: Instance type and instance number • 1: Short address and instance type • 2: Short address and instance number • 3: Device group and instance number • 4: Instance group and instance type
EVENT_FILTER		BYTE		The event message filter can be used to enable and disable specific events. Refer to Description for EVENT_FILTER (Page 89) for the detailed description. • INST_TYPE = 1 (push button), EVENT_FILTER is in the range of 0 to 16#FF. • INST_TYPE = 2 (absolute input device), EVENT_FILTER is in the range of 0 to 16#01. • INST_TYPE = 3 (occupancy sensor), EVENT_FILTER is in the range of 0 to 16#1F. • INST_TYPE = 4 (light sensor), EVENT_FILTER is in the range of 0 to 16#01.
EVENT_PRIO		USInt		The sending priority of the event message. The system reactions are sent according to the set priority. The system reactions with high priority take precedence over the system reactions with low priority.
TYPE_PRM_SET [1]		Array[0..6] of BYTE		The type-related parameters of the instance.
CM_DALI	InOut	"DALI_CTRL"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

[1] For the detailed description of sensor instance type-related parameters for configuring **DALI_SENSOR_INST_PARAM**, refer to the following table.

Table 2-1810 Sensor instance type-related parameters for configuring **DALI_SENSOR_INST_PARAM**

Attributes	BYTE	Type 1 (push button)	Type 2 (absolute input)	Type 3 (occupancy)	Type 4 (light sensor)
Read/Write	0	*tShort*	Deadtime	Hold time	Hysteresis
	1	*tDouble*	Report time	Report time	Hysteresis min
	2	*tRepeat*	Not used	Deadtime	Report time
	3	*tStuck*		Not used	Deadtime

5.7.17 DALI_DEV_UPLOAD

Description

DALI_DEV_UPLOAD is used for uploading all the parameters of the DALI device and saving them in the CM 1xDALI (refer to data flow path 4 (Page 22)).

After this function block is executed without errors, the DALI device is marked as configured, and the setting parameters are saved in the CM 1xDALI.

It takes some time to execute this function block. If needed, you can use CANCEL to stop the procedure before it is finished.

NOTE

The output resets, only if both the CANCEL and UPLOAD are set to 0.

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
UPLOAD	Input	BOOL	I, Q, M, D, L or Constant	Upload parameters from the device upon a rising edge.
DEV_TYPE		USInt	I, Q, M, D, L or Constant	Select the device type: • 1: Control gear • 2: Input device (Sensor)
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
CANCEL		BOOL	I, Q, M, D, L or Constant	CANCEL = 1: Stop this function block, and return an error.
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.

[1] For the detailed description of STATUS on upload process, refer to the following table.

Parameter	Declaration	Data type	Memory area	Description	
ACTIVE	Output	BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • > 16#00 and < 16#7F: Upload progress [1] • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

[1] For the detailed description of STATUS on upload process, refer to the following table.

Table 2-1811 Description of STATUS on upload process

Device type	STATUS	Comment
Control gear	16#01	Querying basic parameters
	16#02	Querying extended parameters
	16#03	Querying group configuration
	16#04	Querying scene configuration
	16#05	Saving all parameters
Input device (Sensor)	16#11	Querying sensor parameters and saving
	16#12~16#31	Querying sensor instances parameters and saving: • 16#12: The function block is dealing with the Instance 0. • 16#13: The function block is dealing with the Instance 1. • ... • 16#31: The function block is dealing with the Instance 31.

5.7.18 DALI_DEV_DOWNLOAD

Description

DALI_DEV_DOWNLOAD is used for downloading all the parameters that are saved in the CM 1xDALI to the DALI device (refer to data flow path 3 (Page 22)). The control gear type or sensor instance type are saved in CM 1xDALI, and these types must be the same as the physic device's. This function block does not check whether the parameter saved in CM 1xDALI is valid for this DALI device.

It takes some time to execute this function block. If needed, you can use CANCEL to stop the procedure before it is finished.

NOTE

The output resets, only if both the CANCEL and DOWNLOAD are set to 0.

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description	
DOWN-LOAD	Input	BOOL	I, Q, M, D, L or Constant	Download parameters from the device upon a rising edge.	
DEV_TYPE		USInt	I, Q, M, D, L or Constant	Select the device type: • 1: Control gear • 2: Input device (Sensor)	
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63	
CANCEL		BOOL	I, Q, M, D, L or Constant	CANCEL = 1: Stop this function block, and return an error.	
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.	
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.	
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.	
DONE		BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • > 16#00 and < 16#7F: Download progress [1] • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

[1] For the detailed description of STATUS on download process, refer to the following table.

Table 2-1812 Description of STATUS on download process

Action	PROC	Comment
Control Gear	16#01	Querying status of the control gear
	16#02	Setting basic parameters

Action	PROC	Comment
Control Gear	16#03	Setting type-related parameters
	16#04	Setting group configuration
	16#05	Setting scene configuration
Input device (Sensor)	16#11	Querying status of the sensor
	16#12	Setting parameters of the sensor device
	16#13~16#32	Setting parameters of the sensor instances: • 16#13: The function block is dealing with the Instance 0. • 16#14: The function block is dealing with the Instance 1. • ... • 16#32: The function block is dealing with the Instance 31.

5.7.19 DALI_DEV_RESET

Description

DALI_DEV_RESET is used for resetting all the parameters of the device.

After this function block is executed without errors, the physical device is reset and the parameters which are saved in CM 1xDALI are all deleted. But the value of output CONFIGURED in DALI_ECG_STATUS (Page 47) or DALI_SENSOR_STATUS (Page 53) remains.

When you set the input "DEL_ADDR" to 1, the short address of the physical device is deleted.

Parameter

The following table shows the parameters of the function block:

Parameter	Declaration	Data type	Memory area	Description
RESET	Input	BOOL	I, Q, M, D, L or Constant	Reset the parameters upon a rising edge.
DEL_ADDR		BOOL	I, Q, M, D, L or Constant	DEL_ADDR =1: Delete the short address of the device.
DEV_TYPE		USInt	I, Q, M, D, L or Constant	Select the device type: • 1: Control gear • 2: Input device (Sensor)
ADDRESS		USInt	I, Q, M, D, L or Constant	Specify the short address of the device. Range: 0 to 63
CM_DALI	InOut	"DALI_CTRL-"		The data block of **DALI_CTRL** specifies the CM 1xDALI which communicates with the current function block.
BUSY	Output	BOOL	I, Q, M, D, L	Status parameter: • BUSY = 0: Processing of job is terminated. • BUSY = 1: Job is still being committed.
ACTIVE		BOOL	I, Q, M, D, L	Status parameter: • ACTIVE = 0: Job is not yet started. • ACTIVE = 1: Job is being executed.

Parameter	Declaration	Data type	Memory area	Description	
DONE	Output	BOOL	I, Q, M, D, L	Status parameter: • DONE = 0: Job is not yet started or still executing. • DONE = 1: Job is executed without errors.	
ERROR		BOOL	I, Q, M, D, L	Status parameter: • ERROR = 0: No error occurs. • ERROR = 1: Error occurs during processing.	
STATUS		BYTE	I, Q, M, D, L	When ERROR = 0, STATUS has following three values: • 16#00: Idle • 16#01: Executing • 16#7F: Completed	When ERROR = 1, STATUS shows the detailed error code. For the detailed meaning of each error code, refer to Parameter STATUS (Page 87).

5.8 Parameter STATUS

The following table shows the explanation of each STATUS value:

- When the value of STATUS is greater than 16#80: It shows the detailed error code.
- When the value of STATUS is less than 16#80: It indicates the progress of the function block.

Table 2-1813 STATUS message

Value of STATUS	Explanation
16#00	The function block is not started.
16#01~16#7E	For the detailed description, refer to each function block.
16#7F	The function block is completed successfully and the output parameters are ready.
16#82	The CM 1xDALI is busy with the last command.
16#83	Timeout. The function block does not get the response from CM 1xDALI.
16#84	Cancel. The function block is cancelled by command.
16#85	CM 1xDALI receives an error response frame after sending the query command. This might be caused by a short address confliction or a DALI device failure. **Note**: Not every short address conflict can be detected. It can only be detected when the conflicted devices send the response frame at the same time.
16#87	Not supported. This action is not supported by CM 1xDALI.
16#88	Invalid parameters. The input of the function block is not correct.
16#89	No data. There is no data saved in CM 1xDALI or no response on the DALI bus.
16#8A	Status error. The CM 1xDALI is not in the normal state. For the detailed information, refer to the output "STATUS" of **DALI_CTRL** (Page 25).
16#8B	Configuration mismatch. The actual device is not matched with the control gear or input device (sensor) which is added by **DALI_ECG_ADD** (Page 57) or **DALI_SENSOR_ADD.** (Page 74)
16#8C	The short address is not configured, and there is no device with this short address on the DALI bus.
16#8D	No device is configured with this short address.
16#8E	No physical device with the specified short address is on the DALI bus.
16#8F	The scan procedure is stopped abnormally.

Value of STATUS	Explanation
16#90	CM 1xDALI cannot send commands to the DALI bus.
16#91	The input type of control gear or input device (sensor) is not matched with the physical device.
16#F0	Communication failure between CPU and CM 1xDALI.

5.9 Electric control gear (ECG) type

The following table shows the detailed device types of the control gears:

Table 2-1814 Device type of the electric control gear

Type ID	Device type
16#00	Fluorescent
16#01	Emergency lamp
16#02	Discharge lamp
16#03	Halogen
16#04	Incandescent
16#05	Voltage converter
16#06	LED
16#07	Switch function
16#08	Color control
16#FF	General type
Others	Unknown type

5.10 Instance type of input device

The following table shows the detailed instance type of the input devices:

Table 2-1815 Instance type of input devices

Type ID	Device type
16#01	Push button
16#02	Absolute input device
16#03	Occupancy sensor
16#04	Light sensor
Others	Unknown type

5.11 Description for EVENT_FILTER

Push button (type 1)

Bit	Description	Value
0	Button released event enabled?	"1" = "Yes"
1	Button pressed event enabled?	"1" = "Yes"
2	Short press event enabled?	"1" = "Yes"
3	Double press event enabled?	"1" = "Yes"
4	Long press start event enabled?	"1" = "Yes"
5	Long press repeat event enabled?	"1" = "Yes"
6	Long press stop event enabled?	"1" = "Yes"
7	Button stuck/free event enabled?	“1” = “Yes”

Absolute input device (type 2)

Bit	Description	Value
0	Position event enabled?	"1" = "Yes"
1~7	Reserved	

Occupancy sensor (type 3)

Bit	Description	Value
0	Occupied event enabled?	"1" = "Yes"
1	Vacant event enabled?	"1" = "Yes"
2	Repeat event enabled?	"1" = "Yes"
3	Movement event enabled?	"1" = "Yes"
4	No movement event enabled?	"1" = "Yes"
5~7	Reserved	

Light sensor (type 4)

Bit	Description	Value
0	Illuminance level event enabled?	"1" = "Yes"
1~7	Reserved	

Diagnostic alarms

6

6.1 Status and error displays

LED display

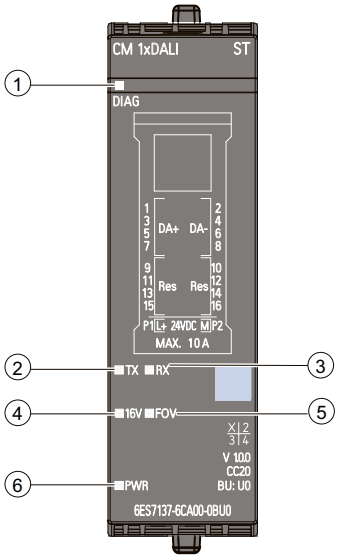

① LED display DIAG
② LED display TX
③ LED display RX
④ LED display integrate DALI power 16 V
⑤ LED display detected over voltage on DALI Bus (Threshold value: 45 V)
⑥ LED display PWR

Figure 2-1435 LED displays

Table 2-1816 Meaning of DIAG LED displays

LED DIAG	Meaning	Solution
■ On	CM configured and ready for operation	---
☼ Flashes	CM in startup, parameters not assigned yet	---
☼ Flashes	Error information; diagnostic interrupt	Evaluate the diagnostics data and eliminate the error.

Table 2-1817 Meaning of the TX/RX LED displays

LED		Meaning	Solution
TX	RX		
Flashes	Off	Interface is transmitting	---
Off	Flashes	Interface is receiving	---

When the CM 1xDALI receives an "IDENTIFY DEVICE" command (IEC 62386-103), the LED Rx and Tx flash simultaneously at a frequency of 1 Hz and last about 10 seconds.

Table 2-1818 Meaning of the 16V displays

LED	Meaning	Solution
16V		
On	CM 1xDALI integrated DALI power 16 V power on	---
Off	CM 1xDALI integrated DALI power 16 V power off	---

Table 2-1819 Meaning of FOV (Fault over voltage) displays

LED	Meaning	Solution
FOV		
On	Detected over voltage on the DALI bus (between 38 V and 353 V (250 V AC))	Check the wiring and supply voltage of DALI bus For example, check if you connected the city power to the DALI bus by mistake.
Off	The voltage on DALI bus is less than or equal to 20.5 V	---

Table 2-1820 Meaning of the PWR LED displays

LED	Meaning	Solution
PWR		
On	Power on (supply voltage present)	---
Off	Power off (supply voltage missing)	Check the supply voltage

6.2 Diagnostics alarms

A diagnostics alarm is generated and the DIAG-LED flashes on the module for each diagnostics event. Read out the diagnostics alarms, for example, in the diagnostics buffer of the CPU. Evaluate the error codes with the user program.

Diagnostic alarm	Error code	Meaning	Solution
Internal error	100_H	Communication module is defective	Replace communication module
Parametrization Fault	103_H	Possible causes: • The received parametrization record is not valid. • The configured BaseUnit is not the actual BaseUnit.	• Check the parametrization record. • Check the BaseUnit.
Short circuit	1_H	Short circuit of DALI bus. Only occurs when the integrated DALI bus power is enabled.	Correct the DALI bus wiring.
Fault over voltage	3_H	The supply voltage of the module exceeds the permission.	Check the supply voltage on the BaseUnit. For example, Check whether you connected the city power to the DALI bus by mistake.
Component temporarily unavailable	$1F_H$	Firmware update is currently in progress or has been canceled. The module does not output any process or substitute values in this state.	• Wait for firmware update. • Restart the firmware update.

Short circuit behavior

On detection of a short circuit which exists for longer than the shutdown delay time (650 ms), the bus power supply may shut down for a period up to the restart period (14 s). On each restart the power supply turns on the output for the retry time (650 ms).

Technical specification 7

7.1 Technical specifications

Article number	6ES7137-6CA00-0BU0
General information	
Product type designation	CM 1xDALI
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type U0
Color code for module-specific color identification plate	CC20
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	STEP 7 V15.1 or higher
• PROFIBUS as of GSD version/GSD revision	GSD Revision 5
• PROFINET as of GSD version/GSD revision	GSDML V2.34
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	163 mA
Current consumption, typ.	92 mA
Current consumption, max.	250 mA
Power loss	
Power loss, typ.	1.7 W
Address area	
Address space per module	
• Inputs	16 byte
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
Diagnostic messages	
• Short-circuit	Yes; On DALI bus

Article number	6ES7137-6CA00-0BU0
Diagnostics indication LED	
• ERROR LED	Yes
• Monitoring of the supply voltage (PWR-LED)	Yes; Green PWR LED
• Receive RxD	Yes; Green LED
• Transmit TxD	Yes; Green LED
Potential separation	
between backplane bus and interface	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Decentralized operation	
to SIMATIC S7-1500	Yes
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	50 g

Appendix A Parameter data record

A

Parameter assignment and structure of parameter data record

You have the option of reassigning module parameters with the user program while the CPU is in RUN. The parameters are transferred to the module using data record 128, for example, with the WRREC instruction.

Table 2-1821 Structure of data record

Bit Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reserved [2]		Major version = 0		Minor version = 1			
1	Length of DALI module parameters = 4							
2	Reserved [2]				Enable DALI bus short circuit diagnostic [1]	Enable DALI bus over voltage diagnostics [1]	Enable DALI app controller [1]	Enable integrated DALI bus power [1]
3	Reserved [2]							
4	The period of background detection [3] Value range in second: 60 to 3600							
5								

[1] You activate the respective parameter by setting the associated bit to 1.

[2] Reserved bits must be set to 0.

[3] The high byte of the period is in byte 4 and the low byte of the period is in byte 5.

Output parameter STATUS

If errors occur when transferring parameters with the "WRREC" instruction, the module continues operation with the previous parameter assignment. The STATUS output parameter contains a corresponding error code.

You will find a description of the "WRREC" instruction and the error codes in the STEP 7 online help.

Error messages

The module always checks all the values of the transferred data record. Only if all the values were transferred without errors does the module apply the values from the data record.

The instruction WRREC for writing data records returns corresponding error codes when errors occur in the parameter STATUS.

The following table shows the module-specific error codes and their meaning for the parameter data record 128:

Table 2-1822 Error message

Error code	Meaning
$80B1_H$	Error in data length
$80E0_H$	Error in header information
$80E1_H$	Parameter error

Appendix B Approvals

B

This chapter lists the approval for ET 200SP CM 1xDALI specifically.

Detailed references to the other approvals of CM 1xDALI are listed in the document *ET 200SP Distributed I/O system*.

NOTE

Information of the ET 200SP CM 1xDALI

The currently valid markings and approvals are printed on the components of the ET 200SP CM 1xDALI.

DALI-2

The CM 1xDALI meets the requirements of the DALI-2 standards.

IECEx

The CM 1xDALI meet the requirements of explosion protection according to IECEx.

IECEx classification: Ex nA IIC T4 Gc

IECEx certificate: IECEx DEK 19.0024X

The CP meets the requirements of the following standards:

- IEC 60079-0

  Hazardous areas - Part 0: Equipment - General requirements
- EN 60079-15

  Explosive atmospheres - Part 15: Equipment protection by type of protection 'n'

ATEX

The CP meets the requirements of the EC directive 2014/34/EU "Equipment and Protective Devices for Use in Potentially Explosive Atmospheres".

Applied standards:

- EN 60079-0

  Hazardous areas - Part 0: Equipment - General requirements
- EN 60079-15

  Explosive atmospheres - Part 15: Equipment protection by type of protection 'n'

The current versions of the standards can be seen in the EC Declaration of Conformity, see above.

ATEX approval: II 3 G Ex nA IIC T4 Gc

Test number: DEKRA 19ATEX0045 X

You should also note the information in the document "Use of subassemblies/modules in a Zone 2 Hazardous Area" that you will find on the Internet at the following address:

Link (https://support.industry.siemens.com/cs/ww/en/view/78381013):

c(UL)us

Applied standards:

- Underwriters Laboratories, Inc.: UL 61010-1 (Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements)
- IEC/UL 61010-2-201 (Safety requirements for electrical equipment for measurement, control and laboratory use. Particular requirements for control equipment)
- Canadian Standards Association: CSA C22.2 No. 142 (Process Control Equipment)

Report / UL file: E472609

FM

c FM us

Factory Mutual Research (FM) in accordance with

Approval Standard Class Number 3611, 3600, 3810

ANSI/UL61010-1, ANSI/UL 121201

CAN/CSA-C22.2 No. 0-10

CSA C22.2 No. 213

CSA C22.2 No. 1010-1

APPROVED for use in Class I, Division 2, Group A, B, C, D Tx;

Class I, Zone 2, Group IIC Tx

Installation Instructions for FM

- WARNING – Explosion Hazard – Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.
- WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

cULus Hazardous (Classified) Locations

Underwriters Laboratories, Inc.: CULUS Listed E472610 IND. CONT. EQ. FOR HAZ. LOC.

Applied standards:

- ANSI ISA 12.12.01
- CSA C22.2 No. 213-M1987

APPROVED for Use in:

- Cl. 1, Div. 2, GP. A, B, C, D T4
- Cl. 1, Zone 2, GP. IIC T4

Report / UL file: E472610

Installation Instructions for cULus haz.loc.

- WARNING – Explosion Hazard – Do not disconnect while circuit is live unless area is known to be non-hazardous.
- WARNING - Explosion Hazard - Substitution of components may impair suitability for Class I, Division 2 or Zone 2.
- This equipment is suitable for use in Class I, Division 2, Groups A, B, C, D; Class I, Zone 2, Group IIC; or non-hazardous locations.

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE RELAYS.

Korea certificate

This product meets the requirements of Korean certification.

Registration Number: R-R-S53-ET200SP

Note that this device conforms to Limit Class A for emission of radio interference. This device can be used in all areas except the residential area.

이 기기는 업무용(A급) 전자파 적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정 외의 지역에서 사용하는 것을 목적으로 합니다.

SIEMENS

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CM 1xDALI communication model 2

CM 1xDALI command list 3

SIMATIC

ET 200SP CM 1xDALI Communication Model Description

Programming Manual

12/2019

A5E47581955-AA

Preface

Purpose of the documentation

This manual describes the communication model of CM 1xDALI. It helps you access CM 1xDALI from the CPU through PROFINET or PROFIBUS. This manual supplements the manual ET 200SP Communication module CM 1xDALI (https://support.industry.siemens.com/cs/ww/en/view/109769428) which describes the functions and technical specification.

The information provided in this manual and in Communication module CM 1xDALI manual supports you commissioning the DALI system.

Conventions

- CPU: In this manual, "CPU" means the device which support PROFIBUS/PROFINET and communicates with CM 1xDALI.

Please observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

NOTE

To prevent injury, read the manual before use.

⚠

The manual is delivered online, you can download the document from Central technical support (https://support.industry.siemens.com/cs/ww/en/).

History

Edition	Comment
09/2019	First Edition

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

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Documentation Guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

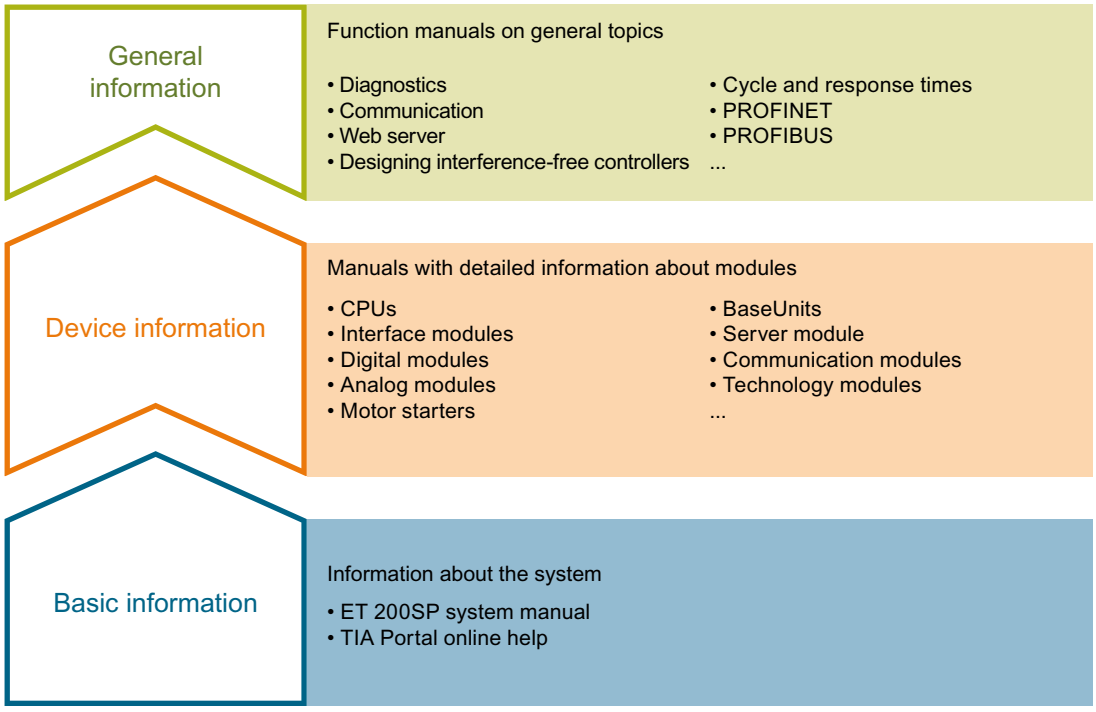

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet.

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet.

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet.

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet.

CM 1xDALI communication model 2

2.1 Configuring the CM 1xDALI

Before using a CM 1xDALI, configure it with the power on. Use the GSD file in the engineering system for configuring or do a reconfiguring via the parameter data record.

For how to configuring the CM 1xDALI, refer to *Appendix A Parameter data record* of the manual ET 200SP Communication module CM 1xDALI (https://support.industry.siemens.com/cs/ww/en/view/109769428).

2.2 Structure of CM command/response

Through CM commands, the CPUs communicate with the CM 1xDALI module to configure or query DALI devices. A DALI device can be a control gear or input device. When a CPU sends a CM command to a CM 1xDALI module, the CM 1xDALI module replies with a CM response.

Only CPUs can send a CM command to the CM 1xDALI module.

Structure of the CM command/response

The structure of the CM commands and CM responses are the same. The maximum length of the CM command/response is 100 bytes.

Byte	**0**	**1**	**2**	**3**		**4~99**
Bit				**Bit 7**	**Bit 6 to Bit 0**	
Description	Version	Checksum	Length	Response Flag	Command ID	Parameters
Value	16#A0	The checksum of the whole message[1]	Total bytes of the CM command/response.	Response flag of the CM command. The flag of the CM commands sent from the CPU must be set to 0. The flag of the CM response from the CM 1xDALI modules must be set to 1.	ID of the CM command or response. The CM command and its response have the same ID.	The parameters of the CM command or the CM response.

[1] The algorithm of the checksum is as follows.

```
#tempSum := 0;
FOR #idx := 2 TO #length - 1 DO
#tempSum += #message[#idx];
END_FOR;
#checksum := 16#FF XOR #tempSum
```

2.3 Sending/receiving CM commands

To send the CM command, use Process Image or Data Record.

CM commands over Process Image

The CM 1xDALI module has 16 bytes for Process Image input and 16 bytes for Process Image output. Due to this limitation, only the CM commands with a length of 15 bytes or less can be performed over Process Image. If you perform a CM command with a length is longer than 15 bytes with Process Image, CM 1xDALI replies to the command with an error message in a CM response.

Table 2-1823 Structure of Process Image

	Byte	0	1 to 15
Output	Description	CM command index [1]	CM command [3]
Input	Description	CM response index [2]	CM response [3]

1 The CPU must set an index for every CM command it sends. The index must be different from the last sent command and the index cannot be 0.

2 If the received CM response is the same as the CM command index, the CPU receives the CM response of the command sent before.

3 For the detailed description for CM command/response, refer to CM 1xDALI command list (Page 15).

Example

The following example shows how to poll the status and event of module, and then query the level of a control gear.

1. Input data over Process image to poll the status and event information

Byte	Value	Description
0	16#01	Command index: it starts with 1 and cannot be set to 0.
1	16#A0	Version: it must be 16#A0.
2	16#F9	Checksum: the total length of this command is 5 bytes, so the calculation is: (byte 3 + byte 4 + byte 5) XOR 16#FF = 16#F9.
3	16#05	Length: total length of this command. Byte 0 is the command index and is not counted in.
4	16#00	Bit 7: always 0 from CPU Bit 6 to 0: Command ID. 0 is “poll status and event of CM 1xDALI”.
5	16#01	Input parameters of this command. 1 is for querying status and events.
6	16#00	Not used in this command
7	16#00	
8	16#00	
9	16#00	
10	16#00	
11	16#00	

12	16#00	Not used in this command
13	16#00	
14	16#00	
15	16#00	

2. Response data CPU gets from the input Process Image

Byte	Value	Description
0	16#01	Command index: the response has the same index.
1	16#A0	Version: it must be 16#A0.
2	16#76	Checksum: the total length of this command is 15 bytes, so the calculation is: (byte 3 + byte 4 + ... + byte 15) XOR 16#FF = 16#76.
3	16#0F	Length: total length of this command. Byte 0 is the command index and is not counted in.
4	16#80	Bit 7: always 1 from CM 1xDALI Bit 6 to 0: Command ID. 0 is “poll status and event of CM 1xDALI”.
5	16#00	Response parameters - Return code: 0 indicates that the command is completed successfully.
6	16#00	Response parameters - CM 1xDALI status: 0 indicates that CM 1xDALI is working normally.
7	16#00	
8	16#00	
9	16#00	
10	16#FF	Response parameters – Event message 1: 16#FFFFFF indicates that no event message is received.
11	16#FF	
12	16#FF	
13	16#FF	Response parameters – Event message 2: 16#FFFFFF indicates that no event message is received.
14	16#FF	
15	16#FF	

3. Input data over Process image to query the level of a control gear

Byte	Value	Description
0	16#02	Command index: it must be different with the previous command.
1	16#A0	Version: it must be 16#A0.
2	16#E9	Checksum: the total length of this command is 5 bytes, so the calculation is: (byte 3 + byte 4 + ... + byte 15) XOR 16#FF = 16#E9.
3	16#05	Length: total length of this command. Byte 0 is the command index and is not counted in.
4	16#01	Bit 7: always 0 from CPU Bit 6 to 0: Command ID. 1 is “query level”.
5	16#10	Input parameter – short address: query the control gear whose short address is 16.
6	16#00	Not used in this command
7	16#00	

8	16#00	Not used in this command
9	16#00	
10	16#00	
11	16#00	
12	16#00	
13	16#00	
14	16#00	
15	16#00	

4. Response for querying level CPU gets from the input Process Image

Byte	Value	Description
0	16#02	Command index: the response has the same index with the command index.
1	16#A0	Version: it must be 16#A0
2	16#14	Checksum: the total length of this command is 6 bytes, so the calculation is: (byte 3 + byte 4 + ... + byte 6) XOR 16#FF = 16#14.
3	16#06	Length: total length of this command. Byte 0 is the command index and is not counted in.
4	16#81	Bit 7: always 1 from CM 1xDALI Bit 6 to 0: Command ID. 1 is “query level”.
5	16#00	Response parameters - Return code: 0 indicates the command is completed successfully.
6	16#64	Response parameters – Actual level: the actual level of control gear is 100 (25%).
7	16#00	Not used in this command
8	16#00	
9	16#00	
10	16#FF	
11	16#FF	
12	16#FF	
13	16#FF	
14	16#FF	
15	16#FF	

CM commands over Data Record

You can use the "Write data record" instruction to send an entire CM commands and use the "Read data record" instruction to receive the CM command response.

Send CM command – data record 50

By writing the CM command data into the data record number 50, the CPU sends the CM command to the CM 1xDALI module.

The CPU can only send another CM command to the CM 1xDALI module after the CPU receives the response from the last CM command. If the CPU has not received the response, the "Write data record" instruction returns an error.

Receive CM command – data record 51

By reading data record number 51, the CPU gets the response from the last CM command.

When the CPU reads the data record and gets a CM response, the CM 1xDALI module clears the buffer. When the CPU reads the data record again, the "Read data record" instruction returns an error.

If the CPU does not read the response and sends another CM command to the CM 1xDALI module, the new CM response overwrites the last response.

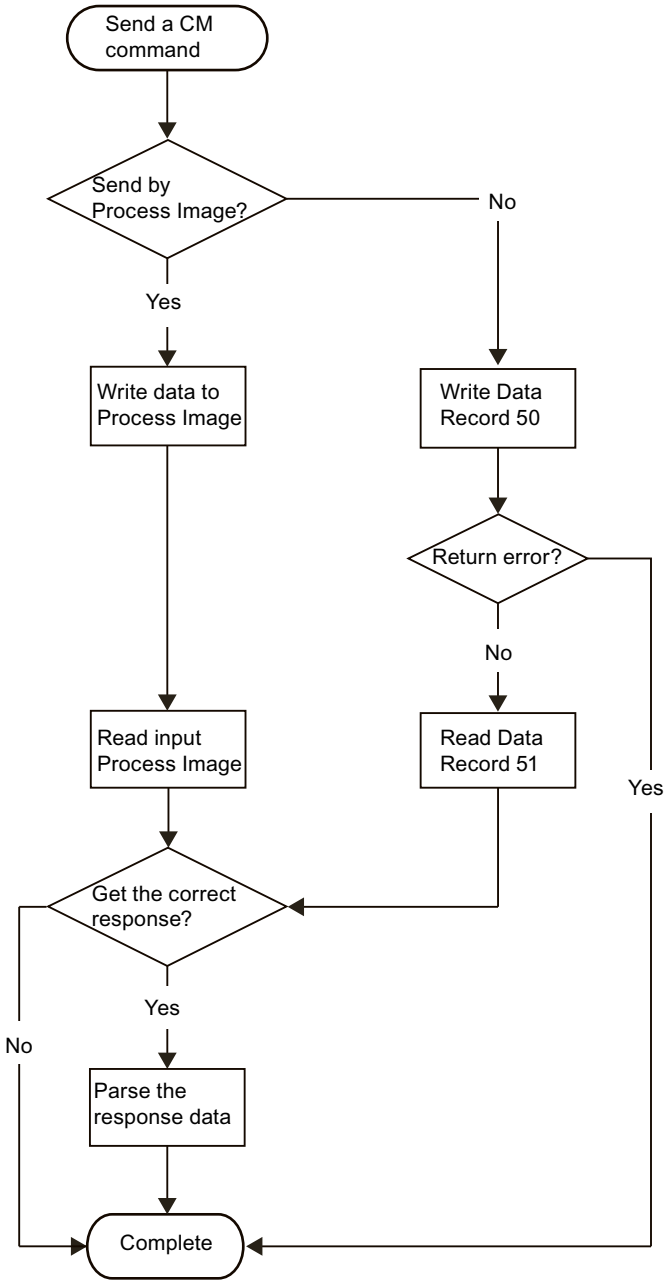

CM 1xDALI command list

3

Through the following commands, the CPUs can communicate with CM 1xDALI. Refer to chapter *5.1 CM 1xDALI data storage model* in the manual of ET 200SP Communication module CM 1xDALI (https://support.industry.siemens.com/cs/ww/en/view/109769428) to understand the storage model of CM 1xDALI.

You can send every command over a data record. The marked commands can be sent alternatively over process image.

Category	Command ID	Command Name	Over process image
System	0	Poll the status and event of CM 1xDAL (Page 17)I	√
	61	Send DALI command (Page 18)	√
	62	Reset module status (Page 19)	√
Dimming Control	1	Query level (Page 19)	√
	2	Set level (Page 19)	√
	3	Query control gear color (Page 20)	√
	4	Set control gear color (Page 20)	√
	5	Go to control gear scene (Page 21)	√
	6~10	Reserved	
Diagnostic	11	Query control gear status (Page 21)	√
	12	Check control gear status (Page 22)	
	13	Query control gear operating hours (Page 24)	√
	14	Set control gear operating hours (Page 25)	√
	15	Query input device status (Page 25)	
	16	Check input device status (Page 26)	
	17	Query instance input value of input device (Page 27)	√
	18	Query device GTIN (Page 27)	√
	19~20	Reserved	
Configuration	21	Add control gear (Page 28)	√
	22	Remove control gear (Page 28)	√
	23	Query control gear basic parameters (Page 29)	
	24	Set control gear basic parameters (Page 29)	
	25	Query control gear extended parameters (Page 30)	
	26	Set control gear extended parameters (Page 32)	

Configuration	27	Query control gear group (Page 32)	
	28	Add control gear to groups (Page 32)	
	29	Remove control gear from groups (Page 33)	
	30	Query control gear scene (Page 33)	
	31	Set control gear scene (Page 34)	
	32	Remove control gear scene (Page 34)	
	33	Start download control gear parameters (Page 35)	√
	34	Start upload control gear parameters (Page 35)	√
	35	Add input device (Page 35)	
	36	Remove input device (Page 36)	√
	37	Query input device parameters (Page 36)	
	38	Set input device parameters (Page 36)	
	39	Query instance parameters of input device (Page 37)	
	40	Set instance parameters of input device (Page 38)	
	41	Start download input device parameters (Page 39)	√
	42	Start upload input device parameters (Page 39)	√
	43	Reset device (Page 39)	√
	44~50	Reserved	
Addressing	51	Start scan and assign short address (Page 40)	√
	52	Start identify device (Page 40)	√
	53	Detect unaddressed device (Page 41)	√
	54	Query address status (Page 41)	
	55	Change short address (Page 42)	√
Progress	56	Query current command progress (Page 42)	√
	57	Cancel current command (Page 43)	√
	58~60	Reserved	

3.1 System

System commands are the basic CM command of the CM 1xDALI.

3.1.1 Poll the status and event of CM 1xDALI

Description	Use this CM command to send a heartbeat message to CM 1xDALI module to query its status and event message. In order to receive all the event messages in time, Siemens recommends sending this command every 100 milliseconds. If the CM 1xDALI does not receive this command for 10 seconds, it stops the background detection[1]. When the CM 1xDALI receives this command again, it starts an initialize process and the background detection. The event message value of 16#FFFFFF indicates there is no event message received.	
Command ID	0	
Input Parameters	Byte 0	• 0: CM 1xDALI only responds with its status. • 1: CM 1xDALI responds with its status and event message.
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1 to 4	This field shows the CM 1xDALI status. When this field is 0, the CM 1xDALI works normally. For the other values of the field, see the description below.
		Bit / **Description**
		0 / Initialization is not completed
		1 / Quiescent mode by DALI command
		2 / Inactive by DALI command
		3 / Application controller disabled
		4 / DALI bus over voltage
		5 / Missing voltage of module input
		6 / DALI bus short circuit
		7 / External DALI bus power failure
		8 / Too many error frames on DALI bus
		9 to 31 / Reserved
	Byte 5	Byte 0 of event message 1 [2]
	Byte 6	Byte 1 of event message 1 [2]
	Byte 7	Byte 2 of event message 1[2]
	Byte 8	Event message 2 [2]
	Byte 9	
	Byte 10	

1 CM 1xDALI periodically sends DALI commands to query the status of all the devices on the DALI bus and stores the information in the module. The query period can be set by module parameters. The program blocks of the CPU have a higher priority when accessing the DALI bus. If the program blocks of the CPU continuously access the DALI bus, the background detection might be blocked.

The background detection can detect the following results:

- Whether each DALI device has a short address
- For control gear: the information of basic status, control gear type and extended status
- For input device: the information of device status, number of instances and type of each instance

2 Event message is reported by an instance of the input device. It contains a change or a defined sequence of changes of its input value. Refer to IEC62386-103 chapter7.2.2 for the detailed frame format of event messages.

3.1.2 Send DALI command

Description	Use this CM command to send one DALI command to the DALI Bus.	
Command ID	61	
Input Parameters	Byte 0	DALI command in little-endian order For example, if the DALI command is 16#01FE30, Byte 0 to Byte 3 is set as below. • Byte 0: 16#30 • Byte 1: 16#FE • Byte 2: 16#01 • Byte 3: 16#00
	Byte 1	
	Byte 2	
	Byte 3	
	Byte 4	Bit length of the DALI command. Only 16#10 (16) or 16#18 (24) are valid.
	Byte 5	Flag for sending twice. • 0: command is sent once to the bus. • 1: command is sent twice to the bus.
	Byte 6	Flag for waiting for a response. • 0: CM 1xDALI does not wait for the response of command. • 1: CM 1xDALI waits for the response of command. You can get the response in Response Parameters.
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	• When the waiting response flag is 1, this byte shows the response of the DALI command. • When the waiting response flag is not 1, this byte shows 16#00.

3.1.3 Reset module status

Description	Use this CM command to reset the status of the CM 1xDALI module. It stops the quiescent mode, go to active mode (clear the bit 1 and bit 2 of status in Poll the status and event of CM 1xDALI (Page 17)).	
Command ID	61	
Input Parameters	None	
Response Parameters	Byte 0	Return code (Page 44)
Comment	As this command has no input parameters, the length of input parameters is 0.	

3.2 Control gear dimming

Use control gear dimming commands to query or set the level and color of the control gears.

3.2.1 Query level

Description	Use this CM command to query the actual arc power level of a control gear.	
Command ID	1	
Input Parameters	Byte 0	Short address of the control gear
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	Actual level

3.2.2 Set level

Description	Use this CM command to set the target arc power level of control gears.	
Command ID	2	
Input Parameters	Byte 0	• 0 (16#00) to 63 (16#3F): short address • 128 (16#80) to 143 (16#8F): group address • 253 (16#FD): unaddressed devices • 255 (16#FF): all the control gears

Input Parameters	Byte 1	Level actions • 16#00: OFF • 16#01: UP • 16#02: DOWN • 16#03: STEP UP • 16#04: STEP DOWN • 16#05: RECALL MAX LEVEL • 16#06: RECALL MIN LEVEL • 16#07: STEP DOWN AND OFF • 16#08: ON AND STEP UP • 16#0A: GOTO LAST ACTIVE LEVEL • 16#FF: Direct Arc Power Control (DAPC)
	Byte 2	• If Byte 1 is 16#FF (DAPC), Byte 2 is the target level to set. • If Byte 1 is not 16#FF, the CM 1xDALI ignores value of this byte.
Response Parameters	Byte 0	Return code (Page 44)

3.2.3 Query control gear color

Description	Use this CM command to query the current color of a type 8 control gear (color control device).	
Command ID	3	
Input Parameters	Byte 0	Short address
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	Shows the color type • 16#10: color xy-coordinate • 16#20: color temperature • Others value: color type is unknown. If the control gear type is not device type 8 (color control), this byte shows 0.
	Byte 2 to 3	Shows the value of the color type • Color coordinate-x (when Byte 1 is 16#10) • Color temperature (when Byte 1 is 16#20) • Unknow color type (when Byte 1 is 16#00)
	Byte 4 to 5	Shows the value of the color type • Color coordinate-y (When Byte 1 is 16#10) • Color type is not color-coordinate. (when Byte 1 is 16#00)

3.2.4 Set control gear color

Description	Use this CM command to set the color of type 8 control gears (color control device).	
Command ID	4	
Input Parameters	Byte 0	• 0 (16#00) to 63 (16#3F): short address • 128 (16#80) to 143 (16#8F): group number • 253 (16#FD): unaddressed devices • 255 (16#FF): all devices

Input Parameters	Byte 1	Sets the color type • 16#10: color coordinate-xy • 16#20: color-temperature • Others value: color-type is unknown. If the control gear type is not device type 8 (color control), this byte shows 0.
	Byte 2 to 3	Sets the value of color type • Color coordinate-x (when Byte 1 is 16#10) • Color temperature (when Byte 1 is 16#20)
	Byte 4 to 5	Sets the value of color type • Color coordinate-y (when Byte 1 is16#10.) • Color type is not color-coordinate. (When Byte 1 is 16#00)
Response Parameters	Byte 0	Return code (Page 44)

3.2.5 Go to control gear scene

Description	Use this CM command to go to the configure scene for control gears.	
Command ID	5	
Input Parameters	Byte 0	• 0 (16#00) to 63 (16#3F): short address of the control gear • 128 (16#80) to 143 (16#8F): group address • 253 (16#FD): unaddressed devices • 255 (16#FF): all devices
	Byte 1	Scene number
Response Parameters	Byte 0	Error code (Page 44)

3.3 Diagnostic

You use diagnostic commands to query the status information of the DALI devices.

3.3.1 Query control gear status

Description	Use this CM command to query the control gear status by sending DALI commands to the device. The response is the latest status and it updates the status stored in the CM 1xDALI.	
Command ID	11	
Input Parameters	Byte 0	Short address of the control gear
Response	Byte 0	Return code (Page 44)

Parameters	Byte 1	• Bit 0: configured flag: this Bit is 1 when the short address is configured by "Add control gear (Page 28)" or "Start upload control gear parameters (Page 35)". • Bit 1: short address changed flag – 0: if CM 1xDALI changed the short address of the device. – 1: if CM 1xDALI assigned the device a new short address after scanning. • Bit 2 to 7: Reserved
	Byte 2	Address status • 1: normal status • 2: no device with the short address • 3: The DALI device replies an error frame. This error can be caused by a short address conflict or a problem of DALI device. • 4: type mismatch: the configured type is not the same as the actual one.
	Byte 3	Basic control gear status. • Bit 0: control gear failure • Bit 1: lamp failure • Bit 2: lamp on • Bit 3: limit error • Bit 4: fade running • Bit 5: reset state • Bit 6: no short address • Bit 7: power cycle seen
	Byte 4	• Control gear type configured by user (when the configured flag is 1) • 16#FF (when the configured flag is 0)
	Byte 5	Actual type of the device
	Byte 6	Type-related failure status. Refer to Description of status (Page 45)
	Byte 7	Actual arc power level of the control gear.

3.3.2 Check control gears status

Description	Use this CM command to check the status of the control gears stored in the CM 1xDALI, compares them with the input status filters, and returns the matching results [1].	
Command ID	12	
Input Parameters	Byte 0	0: check basic control gear status [2]; 1: check type-related failure status [2].
	Byte 1 to 64	The status filters of all short addresses. For example, Byte 1 is for the device with address 0; byte 2 is for the device with address 1.
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1 to 8	Matched flag for all devices: If the bit set in device status matches the corresponding input status filter (the result of logical AND is not 0), the match flag is set. Each bit indicates the status of a device. For example, Bit 0 of Byte 1 indicates the device with address 0; Bit 1 of Byte 1 indicates the device with address 1; Bit 0 of Byte 2 indicates the device with address 8.

1 **Example**

For the control gear whose short address is 5, if you want to check whether the bit 1 of basic control gear status is set to 1, you should set the input parameters as:

16#00

16#00 16#00 16#00 16#00 16#00 16#02 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

If the bit 1 of basic control gear status is set to 1, you will get the response parameters as:

16#00

16#20 16#00 16#00 16#00 16#00 16#00 16#00 16#00

2 For the description about each bit of basic control gear and type-related failure status, refer to the following two tables.

Table 2-1824 Basic control gear status

Bit	Status	Explanation
Bit 0	Control gear failure	The control gear cannot be operated as intended.
Bit 1	Lamp failure	The lamp cannot operate as intended.
Bit 2	Lamp on	The lamp is on.
Bit 3	Limit error	The last requested target level is modified in accordance with limitations of "minimum level" or "maximum level".
Bit 4	Fade running	The fade timer is running.
Bit 5	Reset state	All the parameters of this device are at their reset value.
Bit 6	No short address	No short address is assigned to this device.
Bit 7	Power cycle seen	An external power cycle occurred.

Table 2-1825 Type-related failure status

Bit	Type 1 (emergency)	Type 2 (discharge)	Type 3 (halogen)	Type 4 (incandescent)	Type 5 (converter)	Type 6 (LED)	Type 7 (switch)	Type 8 (color control)
0	Circuit failure	Mains voltage too low	Short circuit	Load over-current shutdown	Output fault detected	Short circuit	Load error	XY-coordinate color point out of range
1	Battery duration failure	Mains voltage too high	Open circuit	Open circuit	Reserved	Open circuit	Error detection in hold off	Color temperature out of range
2	Battery failure	Converter thermal overload	Load decrease	Load decrease		Load decrease	Last threshold acted upon • '00' up switch-on • '01' up switch-off • '10' down switch on • '11' down switch off	Auto calibration running
3	Emergency lamp failure	Reserved	Load increase	Load increase		Load increase		Auto calibration successful
4	Function test max delay exceeded	Ignition time out	Current protector active	Reserved		Current protector active	Reserved	Color type XY-coordinate active
5	Duration test max delay exceeded	Reserved	Thermal shutdown	Thermal shutdown		Thermal shutdown		Color type color temperature active
6	Function test failed	Lamp voltage out of spec	Thermal overload	Thermal overload		Thermal overload		Color type primary N active
7	Duration test failed	Lamp cycling failure	Reference measurement failed	Reference measurement failed		Reference measurement failed	Reference measurement failed	Color type RGBWAF active

3.3.3 Query control gear operating hours

Description	Use this CM command to query the operating hours of a control gear. The operating hours accumulate when the control gear remains on for one hour. The operating hours are stored in the CM 1xDALI. If you change short addresses of two control gears, the operating hours of these two control gears are not be changed. With "Start upload control gear parameters (Page 35)", you can exchange the related operating hours of these two control gears. Before calling this command, configure the control gear using the "Add control gear (Page 28)" instruction or the "Start upload control gear parameters (Page 35)" instruction.	
Command ID	13	
Input Parameters	Byte 0	Short address
Response Parameters	Byte 0	Return code (Page 44) • 16#8D (if the control gear is not configured) • 16#8B (if the type of control gear is mismatched)

Response Parameters	Byte 1	Low byte of the operating hours.
	Byte 2	High byte of the operating hours.
Comment	When the actual level of the control gears is not 0, the operating hours accumulate. The CM 1xDALI checks the actual level every 10 minutes.	

3.3.4 Set control gear operating hours

Description	Use this CM command to set the operating hours of a control gear. The operating hours accumulate when the control gear remains on for one hour. The operating hours are stored in the CM 1xDALI. Before calling this function block, make sure that the control gear is configured by using the "Add control gear (Page 28)" instruction and the "Start upload control gear parameters (Page 35)" instruction. Reset the operating hours after exchanging the physical control gear device.	
Command ID	14	
Input Parameters	Byte 0	Short address
	Byte 1	Low byte of the operating hours.
	Byte 2	High byte of the operating hours.
Response Parameters	Byte 0	Return code (Page 44) When you set the operating hours of the control gears, the following occurs: • If the control gear is not configured, the error code in the response is 16#8D. • If the control gear is configured, but the type of control gear is mismatched, the error code in the response is 16#8B.

3.3.5 Query input device status

Description	Use this CM command to query the status of an input device and its instance by sending DALI commands to the device. CM 1xDALI updates the stored status with the latest response.	
Command ID	15	
Input Parameters	Byte 0	Short address of the input device
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	• Bit 0: configured flag: this bit is 1 when the "Add input device (Page 35)" instruction or the "Start upload input device parameters (Page 39)" instruction has configured the short address. • Bit 1: short address changed flag – This Bit is 0, if the CM 1xDALI changed the short address of the device. – This Bit shows 1, if the CM 1xDALI assigned the device a new short address after scanning. • Bit 2 to 7: Reserved
	Byte 2	Address status (Page 44)

Response Parameters	Byte 3	Device status of the input device. • Bit 0: input device error • Bit 1: quiescent mode • Bit 2: short address is 16#FF • Bit 3: application active • Bit 4: application controller error • Bit 5: power cycle seen • Bit 6: reset state • Bit 7: reserved
	Byte 4	Configured number of its instances
	Byte 5	Actual number of instances on the device
	Byte 6 to 9	Error bits of all the instances on the device: each bit indicates one instance. For example, Bit 0 of Byte 6 is for the instance number 0; bit 1 of Byte 6 is for the instance number 1; Bit 0 of Byte 7 is for instance number 8.
	Byte 10 to 13	Active bits of all the instances on the device: each bit indicates one instance. For example, Bit 0 of Byte 10 is for the instance number 0; bit 1 of Byte 10 is for the instance number 1; Bit 0 of Byte 11 is for instance number 8.
	Byte 14 to 45	Actual input device type of all the instances on the device: each byte indicates one instance. For example, Byte 14 is for instance number 0; Byte 15 is for instance number 1.
	Byte 46 to 77	Configured input device type of all the instances: each byte indicates one instance. For example, Byte 46 is for instance number 0; Byte 47 is for instance number 1.

3.3.6 Check input device status

Description	This command checks the input device status stored in the CM 1xDALI, compare them with the input status filters, and return the matching results [1].	
Command ID	16	
Input Parameters	Byte 0 to 63	Status filters for all short addresses: for example, Byte 0 is for the device with address 0; Byte 1 is for the device with address 1.
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1 to 8	Matched flag for all devices. If a logical AND of the input device status and the input status filter is not 0, this instruction sets the match flag. Each bit indicates the status for one device: for example, Bit 0 of Byte 1 indicates the device with address 0; Bit 1 of Byte 1 indicates the device with address 1; Bit 0 of Byte 2 indicates the device with address 8.

1 **Example**:

For the input device whose short address is 4, if you want to check whether bit 0 of the device status is set to 1, you should set the input parameters as:

16#00 16#00 16#00 16#00 16#01 16#00 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

16#00 16#00 16#00 16#00 16#00 16#00 16#00 16#00

If the bit 0 of the device status is set to 1, you will get the response parameters as:

16#00 16#10 16#00 16#00 16#00 16#00 16#00 16#00 16#00

3.3.7 Query instance input value of the input device

Description	Use this command to query the input value of a input device instance.	
Command ID	17	
Input Parameters	Byte 0	Short address of the input device
	Byte 1	Instance number
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	Resolution of the input device
	Byte 2 to 5	Input value in little-endian order

3.3.8 Query device GTIN

Description	Use this CM command to query the Global Trade Item Number (GTIN) of a DALI device.	
Command ID	18	
Input Parameters	Byte 0	Specifies the device type: 1: control gears 2: input devices
	Byte 1	Short address of the device
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1 to 6	GTIN of the device.
Comment	Some DALI devices do not support querying their GTIN. In this case, all the bytes of GTIN are set to 0.	

3.4 Configuration

You use configuration commands to configure the parameters of the DALI devices. These commands allow you to store configuration data in the CM 1xDALI module.

You can build up the configuration in the modules database by uploading the physical devices or by configuring the devices from the CPU. You can use these commands to query, modify and deploy a stored configuration.

3.4.1 Add control gear

Description	Use this CM command to add or modify a control gear in the module data base. • To add one configured control gear, you must set the device type of the control gear. • Adding a control gear does not send any DALI command to the device on the bus, but the configured flag of the device will be set. • After adding the device by this command, the parameters you set by command 24, 26, 28, and 29 are saved in the CM 1xDALI. • The device is marked as configured after the device type is set. • All of the setting parameters are saved in the CM 1xDALI until the device is deleted by the "Remove control gear (Page 28)" instruction or reset by the "Reset Device (Page 39)" instruction. • After the configure, parameters setting to this short address is allowed. • If the short address is added, the re-adding modifies the configured type. • If the short address already exists, the "Add control gear" instruction modifies the configuration type.	
Command ID	21	
Input Parameters	Byte 0	Short address of the control gear
	Byte 1	Configured control gear type
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	Address status (Page 44)after the configuration

3.4.2 Remove control gear

Description	Use this CM command to delete a configured control gear which is added by "Add control gear (Page 28)" and its data saved in the CM 1xDALI. Refer to chapter *5.1 CM 1xDALI data storage model* in the manual of ET 200SP Communication module CM 1xDALI (https://support.industry.siemens.com/cs/ww/en/view/109769428) to understand the storage model of CM 1xDALI. This CM command resets the saved configuration on the input short address. This CM command does not send any command to the DALI bus.	
Command ID	22	
Input Parameters	Byte 0	Short address of the control gear
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	Address status after the configuration

3.4.3 Query control gear basic parameters

Description	Use this CM command to query the general parameters of a control gear.	
Command ID	23	
Input Parameters	Byte 0	Short address of the control gear
	Byte 1	Query actual device flag: • 0: query the parameters saved in the CM 1xDALI. • 1: query the parameters on the device by DALI commands.
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	• 0: query the parameters saved in the CM 1xDALI. • 1: query the parameters on the device.
	Byte 2	Power on level: the level when the device is powered on.
	Byte 3	System failure level
	Byte 4	Minimum level
	Byte 5	Maximum level
	Byte 6	Fade rate $fade\ rate = \frac{506}{\sqrt{2^{FADE_RATE}}}\ step/s$
	Byte 7	Fade time $fade\ time = \begin{cases} use\ extended\ fade\ time, & FADE_TIME=0 \\ \frac{1}{2} \cdot \sqrt{2^{FADE_TIME}} \cdot 1\ s, & FADE_TIME > 0 \end{cases}$
	Byte 8	Extended fade time base
	Byte 9	Extended fade time multiplier
	Byte 10	Control gear type
	Byte 11	• Device version of the control gear (when byte 1 is 1) • 0 (when the byte 1 is 0)
	Byte 12	Physical minimum level: If queried parameters are saved in CM 1xDALI, the device version is 0.

3.4.4 Set control gear basic parameters

Description	Use this CM command to set the general parameters of a control gear. The command sets the parameters in the device and saves the parameters in CM 1xDALI.	
Command ID	24	
Input Parameters	Byte 0	Short address
	Byte 1	Power on level
	Byte 2	System failure level: level when the device is in system failure status.
	Byte 3	Minimum level
	Byte 4	Maximum level
	Byte 5	Fade rate $fade\ rate = \frac{506}{\sqrt{2^{FADE_RATE}}}\ step/s$

Input Parameters	Byte 6	Fade time $fade\ time = \begin{cases} use\ extended\ fade\ time, & FADE_TIME=0 \\ \frac{1}{2} \cdot \sqrt{2^{FADE_TIME}} \cdot 1\ s, & FADE_TIME > 0 \end{cases}$
	Byte 7	Extended fade time base
	Byte 8	Extended fade time multiplier
Response Parameters	Byte 0	Return code (Page 44)

3.4.5 Query control gear extended parameters

Description	Use this CM command to query the type-related parameters of a control gear. Only control gear types 1 to 8 have type-related parameters. Control gears of other type return a 16#87 (not supported) error in the response parameters.	
Command ID	25	
Input Parameters	Byte 0	Short address of the control gear
	Byte 1	Query actual device flag: • 0: query the parameters saved in the CM 1xDALI. • 1: query the parameters on the device by DALI commands.
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	• 0: query the parameters saved in CM 1xDALI. • 1: query the parameters on the device.
	Byte 2	Control gear type
	Byte 3 to 34	Type-related parameters (Page 30)

The following tables define the type-related parameters for control gear types.

Control gear type 1 (emergency)	
Byte 2	Emergency level
Byte 3	Prolong time
Byte 4 to 5	Function test delay (in little-endian order)
Byte 6 to 7	Duration test delay (in little-endian order)
Byte 8	Function test interval
Byte 9	Duration test interval
Byte 10	Test execute timeout
Byte 11 to 19	Reserved

Control gear type 4 (incandescent)	
Byte 2	Dimming curve
Byte 3 to 19	Reserved

Control gear type 5 (converter)	
Byte 2	Dimming curve
Byte 3	Output rage
Byte 4	Internal pull-up
Byte 5	Physical min level
Byte 6 to 19	Reserved

Control gear type 6 (LED)	
Byte 2	Dimming curve
Byte 3	Fast fade time
Byte 4 to 19	Reserved

Control Gear Type 7 (switch)	
Byte 2	Up switch-on threshold
Byte 3	Up switch-off threshold
Byte 4	Down switch-off threshold
Byte 5	Down switch-on threshold
Byte 6 to 19	Reserved

Control Gear Type 8 (color control)	
Byte 2	Power on color type
Byte 3 to 4	Power on color value 1, coordinate-x or color temperature.
Byte 5 to 6	Power on color value 2, coordinate-y.
Byte 7	System failure color type
Byte 8 to 9	Power on color value 1, coordinate-x or color temperature.
Byte 10 to 11	Power on color value 2, coordinate-y.
Byte 12 to 13	Color temperature physical coolest.
Byte 14 to 15	Color temperature physical warmest.
Byte 16 to 17	Color temperature coolest
Byte 18 to 19	Color temperature warmest

3.4.6 Set control gear extended parameters

Description	Use this CM command to set the type-related parameters of a control gear. Only control gear types 1 to 8 have type-related parameters. Control gears of other types return a 16#87 (not supported) error in the response parameter.	
Command ID	26	
Input Parameters	Byte 0	Short address
	Byte 1	Control gear type
	Byte 2 to 19	Type-related parameters (Page 30)
Response Parameters	Byte 0	Return code (Page 44)

3.4.7 Query control gear groups

Description	Use this CM command to query the group membership information of a control gear.	
Command ID	27	
Input Parameters	Byte 0	Short address of the control gear
	Byte 1	Query actual device flag. • 0: query the group membership information saved in CM 1xDALI. • 1: query the group membership information on the device.
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	• 0: queried group membership in CM 1xDALI. • 1: queried group membership on the device.
	Byte 2	Membership of group 0 to 7: Each bit indicates one group. For example, Bit 0 is for group 0, bit 1 is for group 1. • 1: control gear is added to this group. • 0: control gear is not in this group.
	Byte 3	Membership of group 8 to 15: Each bit indicates one group. For example, Bit 0 is for group 8, bit 1 is for group 9. • 1: control gear is added to this group. • 0: control gear is not in this group.

3.4.8 Add control gear to groups

Description	Use this CM command to add the control gear to some groups.	
Command ID	28	
Input Parameters	Byte 0	Short address of the control gear
	Byte 1	Add to group 0 to 7. Each bit indicates one group. For example, Bit 0 is for group 0; bit 1 is for group 1. • 1: add to this group • 0: no action

Input Parameters	Byte 2	Add to group 8 to15. Each bit indicates one group. For example, Bit 0 is for group 8; bit 1 is for group 9. • 1: add to this group • 0: no action
Response Parameters	Byte 0	Return code (Page 44)

3.4.9 Remove control gear from groups

Description	Use this CM command to remove the control gear from some groups.	
Command ID	29	
Input Parameters	Byte 0	Short address of the control gear
	Byte 1	Remove from group 0 to 7. Each bit indicates one group: for example, Bit 0 is for group 0; bit 1 is for group 1. • 1: remove from this group • 0: no action
	Byte 2	Remove from group 8 to15. Each bit indicates one group: for example, Bit 0 is for group 8; bit 1 is for group 9. • 1: remove from this group • 0: no action
Response Parameters	Byte 0	Return code (Page 44)

3.4.10 Query control gear scene

Description	Use this CM command to query the scene level and color of a control gear.	
Command ID	30	
Input Parameters	Byte 0	Short address of the control gear
	Byte 1	Scene number
	Byte 2	Query actual device flag. • 0: query the scene configuration saved in the CM 1xDALI. • 1: query the scene configuration on the device.
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	• 0: queried the scene membership in CM 1xDALI. • 1: queried the scene membership on the device.
	Byte 2	Scene level
	Byte 3	Show the scene color type. • 16#10: color xy-coordinate • 16#20: color temperature • 16#00: the control gear type is not type 8 (color control) • Other values: scene color type is unknown.

Response Parameters	Byte 4 to 5	Show the value of the color type. • Color coordinate-x (when the scene color type is color-coordinate (16#10).) • Color temperature (when the scene color type is color-temperature (16#20).) • 0 (when the scene color type is unknown.)
	Byte 6 to 7	Show the value of color type. • Color coordinate-y (when scene color type is color-coordinate (16#10).) • 16#00 (when the scene color type is unknown.)

3.4.11 Set control gear scene

Description	Use this CM command to set the scene level and color of a color-control control gear. If you can call this command with a scene level of 255 (16#FF), this command removes the scene from the addressed control gear. Note: This command has no effect on those control gears which are not color-control (type 8) control gears.	
Command ID	31	
Input Parameters	Byte 0	Short address
	Byte 1	Scene number
	Byte 2	Scene level
	Byte 3	Sets the scene color type • 16#10: color coordinate-xy. • 16#20: color-temperature.
	Byte 4 to 5	Sets the value of color type • Color coordinate-x (when Byte 1 is 16#10) • Color temperature (when Byte 1 is 16#20)
	Byte 6 to 7	Sets the value of color type • Color coordinate-y (when Byte 1 is 16#10) • Scene color type is not color coordinate-xy. (when Byte 1 is 16#00)
Response Parameters	Byte 0	Return code (Page 44)

3.4.12 Remove control gear scene

Description	Use this CM command to remove the scene configuration of a control gear. This command has the same behavior as calling "Set control gear scene (Page 34)" when scene level is 255 (16#FF).	
Command ID	32	
Input Parameters	Byte 0	Short address of the control gear
	Byte 1	Scene number
Response Parameters	Byte 0	Return code (Page 44)

3.4.13 Start download control gear parameters

Description	Use this CM command to send the parameters saved in the CM 1xDALI to the physical device. The CM 1xDALI provides a response to the CPU when the procedure is started. You can check the progress and result of the procedure by "querying the current command progress (Page 42)".	
Command ID	33	
Input Parameters	Byte 0	Short address of the device
Response Parameters	Byte 0	Return code (Page 44)

3.4.14 Start upload control gear parameters

Description	Use this CM command to query the parameters of the physical device, and save them in CM 1xDALI. The CM 1xDALI sends a response to the CPU when it starts the procedure. You can check the progress and result of the procedure by "querying the current command progress (Page 42)".	
Command ID	34	
Input Parameters	Byte 0	Short address
Response Parameters	Byte 0	Return code (Page 44)

3.4.15 Add input device

Description	Use this CM command to configure or modify an input device and its instances. • Adding an input device sets the configured flag of the device but does not send a DALI command to the device on the bus. • After the configuration, you can set parameters for this short address. • If the short address exists, this command overwrites the configured instance.	
Command ID	35	
Input Parameters	Byte 0	Short address of the input device
	Byte 1	Number of instances
	Byte 2 to 33	Types of the instances. Each byte indicates one instance. For example, Byte 2 is for instance 0; Byte 3 for instance 1.
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	Control status after the configuration

3.4.16 Remove input device

Description	Use this CM command to cancel the configuration of an input device and its instances. It also resets the saved configuration of this short address.	
Command ID	36	
Input Parameters	Byte 0	Short address of the input device
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	Control status after the configuration.

3.4.17 Query input device parameters

Description	Use this CM command to query the general parameters of a input device.	
Command ID	37	
Input Parameters	Byte 0	Short address of the input device
	Byte 1	Query actual device flag. • 0: query the parameters saved in CM 1xDALI. • 1: query the parameters of the device.
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	• 0: query the parameters saved in the CM 1xDALI. • 1: query the parameters of the device.
	Byte 2	Operating mode
	Byte 3	Power on cycle notification flag: If this flag is no set to 1, the input device can send a power cycle notification event when it powers on.
	Byte 4	Number of instances

3.4.18 Set input device parameters

Description	Use this CM command to set the input device parameters. The parameters are set to the input device and saved in the CM 1xDALI.	
Command ID	38	
Input Parameters	Byte 0	Short address of the input device
	Byte 1	Operating mode
	Byte 2	Power on cycle notification flag. If this flag is no set to 1, the input device can send a power cycle notification event when it powers on.
Response Parameters	Byte 0	Return code (Page 44)

3.4.19 Query instance parameters of input device

Description	Use this CM command to query the parameters of one instance in an input device. Note: Only input device types 1 to 4 have type-related parameters.	
Command ID	39	
Input Parameters	Byte 0	Short address of the input device
	Byte 1	Instance number Query actual device flag. • 0: query the parameters saved in the CM 1xDALI. • 1: query the parameters in the device by DALI commands.
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	• 0: query the parameters saved in the CM 1xDALI. • 1: query the parameters in the device.
	Byte 2	Input device type
	Byte 3	Instance active flag
	Byte 4	Event scheme
	Byte 5	Event filter
	Byte 6	Event priority
	Byte 7 to 13	Type-related parameters (Page 37)

3.4.20 Type-related parameters for input device

The following tables describe the type-related parameters for input devices:

Input device type 1 (push button)	
Byte 7	Short press time
Byte 8	Double click time
Byte 9	Repeat time
Byte 10	Stuck check time
Byte 11	Resolution
Byte 12	Minimum short press time
Byte 13	Minimum double click time

Input device type 2 (absolute input)	
Byte 7	Deadtime: if the deadtime timer is set, the instance does not send out an event until the deadtime timer has expired.
Byte 8	Report time: if the report timer is set, it triggers an event every T_{report} even if the “inputValue” is not changed.
Byte 9	Reserved
Byte 10	Reserved
Byte 11	Resolution
Byte 12	Reserved
Byte 13	Reserved

Input device type 3 (occupancy)	
Byte 7	Hold time
Byte 8	Report time
Byte 9	Deadtime
Byte 10	Reserved
Byte 11	Resolution
Byte 12	Reserved
Byte 13	Reserved

Input device type 4 (light sensor)	
Byte 7	Hysteresis band
Byte 8	Hysteresis minimum
Byte 9	Report time
Byte 10	Deadtime
Byte 11	Resolution
Byte 12	Reserved
Byte 13	Reserved

3.4.21 Set instance parameters of input device

Description	Use this CM command to set the type-related parameters of one instance in a input device. **Note**: Only input device types 1 to 4 have type-related parameters.	
Command ID	40	
Input Parameters	Byte 0	Short address of the input device
	Byte 1	Instance number
	Byte 2	Input device type
	Byte 3	Instance active flag
	Byte 4	Event scheme
	Byte 5	Event filter
	Byte 6	Event priority
	Byte 7 to 10	Type-related parameters (Page 37)
Response Parameters	Byte 0	Return code (Page 44)

3.4.22 Start download input device parameters

Description	Use this CM command to send the parameters saved in the CM 1xDALI to the physical input device. You can check the download progress by "querying the current command progress (Page 42)".	
Command ID	41	
Input Parameters	Byte 0	Short address of the input device
Response Parameters	Byte 0	Return code (Page 44)

3.4.23 Start upload input device parameters

Description	Use this CM command to query the parameters of the physical device, and save them in the CM 1xDALI. You can check the upload progress by "Query current command progress (Page 42)".	
Command ID	42	
Input Parameters	Byte 0	Short address of the input device
Response Parameters	Byte 0	Return code (Page 44)

3.4.24 Reset Device

Description	Use this CM command to reset the parameters of a DALI device, and clear the parameters saved in the CM 1xDALI. If this command executes without errors, it resets the physical device is reset and deletes the parameters saved in CM 1xDALI. The value of the configured flag in the query control gear status or input device status remains.	
Command ID	43	
Input Parameters	Byte 0	Specifies the device type • 1: control gears • 2: input devices
	Byte 1	Short address of the input device
	Byte 2	Delete short address flag: • 0: do not reset the short addresses • 1: reset the short addresses of the physical devices
Response Parameters	Byte 0	Return code (Page 44)

3.5 Addressing

You use addressing commands to manage the short address of the devices.

3.5.1 Start scan and assign short address

Description	Use this CM command to scan the physical devices on the DALI bus and assign random short addresses to the devices that have no short addresses or conflicted short addresses. This CM command changes the random address of devices: • If the device has a short address that is unique on the DALI bus, the device keeps its short address. • If the device does not have a short address or its short address is the same as another short address, CM 1xDALI assigns a new short address to it. If there are more than 64 devices of the same type on the DALI bus, you get the error "16#87 (not supported)" in the response parameters. This command returns 16#01(In progress) when it starts a progress of scanning. You can check the process of scanning by "querying the current command status (Page 42)" or stop scanning by "canceling the current command (Page 43)".	
Command ID	51	
Input Parameters	Byte 0	Specify the device type. • 1: control gears • 2: input devices
	Byte 1	Specify the short address to scan • 0 (16#00) to 63 (16#3F): short address • 253 (16#FD): only unaddressed • 255 (16#FF): all short addresses and unaddressed.
Response Parameters	Byte 0	Return code (Page 44)

3.5.2 Start identify device

Description	Use this CM command to start an identify process for a DALI device. The exact identify process is manufacturer-specific. You can check the process by "querying the current command status (Page 42)"or cancel the process by "canceling the current command (Page 43)".	
Command ID	52	
Input Parameters	Byte 0	Specify the device type. • 1: control gears; • 2: input devices.
	Byte 1	• 0 (16#00) to 63 (16#3F): short address; • 128 (16#80) to 143 (16#8F): group number; • 253 (16#FD): unaddressed devices; • 255 (16#FF): all devices.
Response Parameters	Byte 0	Return code (Page 44)

3.5.3 Detect unaddressed device

Description	Use this CM command to detect the existence of unaddressed devices.	
Command ID	53	
Input Parameters	Byte 0	Specifies the device type: • 1: control gears • 2: input devices
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	Existence of unaddressed device • 0: no unaddressed devices • 1: existing unaddressed devices

3.5.4 Query address status

Description	Use this CM command to query the status of all short addresses that are stored in the CM 1xDALI. CM 1xDALI updates the status by the background detection, so the response is not the latest status of the devices. You can set the period of background detection in module parameters.		
Command ID	54		
Input Parameters	Byte 0	Specify the device type. • 1: control gears • 2: input devices	
Response Parameters	Byte 0	Return code (Page 44)	
	Byte 1 to 64	This field shows the status of all the short addresses. Byte "n" indicates the status of the device with short address "n". For example, Byte 2 indicates the device with short address 2. For each byte, the bits have the following meanings:	
		Bit 7	Configured flag
		Bit 6	Address changed flag. If CM 1xDALI changed the short address after scan, this flag is set. The action changing short address or setting parameters clears this flag.
		Bit 5 to 0	Address status (Page 44) of the devices.
	Byte 65	Device number exceed flag. • 1: the number of the devices on the bus exceeds the maximum number of allowed devices (64) in a DALI system. • 0: the number of devices on the bus is within the allowed number.	
	Byte 66	Unaddressed device existed flag • 1: at least one unaddressed device exists on the bus. • 0: no unaddressed device exists on the bus.	

3.5.5 Change short address

Description	Use this CM command to change the short address of a device. If another device uses the new address, CM 1xDALI swaps the short addresses of these two devices. After changing the short address, the command clears auto-addressed flag of the device, and updates the address status.	
Command ID	55	
Input Parameters	Byte 0	Specifies the device type: • 1: control gears • 2: input devices
	Byte 1	Original short address
	Byte 2	New short address to be assigned
Response Parameters	Byte 0	Return code (Page 44)

3.6 Progress

You use progress commands to cancel or check the progress of a running procedure.

3.6.1 Query current command progress

Description	Use this CM command to query the progress of a running CM procedure.	
Command ID	56	
Input Parameters	Byte 0	The value is 0.
Response Parameters	Byte 0	Return code (Page 44)
	Byte 1	CM command ID
	Byte 2	Progress of the CM command. < 127 (16#7F): the command is in progress; = 127 (16#7F): the command has completed successfully; > 127 (16#7F): the command stopped with errors.

Comments

If no procedure has started, Byte 1 and Byte 2 of the response parameters are 255 (16#FF).

Progress Byte 2 of CM command 33 Start download control gear parameters": (Page 35)

Progress number	Device progress
16#01	Querying status of the control gear
16#02	Setting basic parameters
16#03	Setting type-related parameters
16#04	Setting group configuration
16#05	Setting scene configuration

Progress Byte 2 of CM command 34 Start upload control gear parameters: (Page 35)

Progress number	Device progress
16#01	Querying basic parameters
16#02	Querying extended parameters
16#03	Querying group configuration
16#04	Querying scene configuration
16#05	Saving all parameters

Progress Byte 2 of CM command 41 Start download input device parameters: (Page 39)

Progress number	Device progress
16#11	Querying status of the input device
16#12	Setting parameters of the input device
16#13~16#32	Setting parameters of the input device instances

Progress Byte 2 of CM command 42 Start upload input device parameters: (Page 35)

Progress number	Device progress
16#01	Querying input device parameters and saving
16#02~16#21	Querying input device instances parameters and saving

Progress Byte 2 of CM command 51 Start scan and assign short address: (Page 40)

Progress number	Device progress
16#01 to 16#40:	Scan in progress, increase by 1 for each device scanned.
16#41:	Assigning short address
16#42:	Querying device status

3.6.2 Cancel current command

Description	Use this CM command to stop current running CM command.	
Command ID	57	
Input Parameters	Byte 0	The value is 0.
Response Parameters	Byte 0	Return code (Page 44)

3.7 Return code and control status

3.7.1 Return code

Error code	Description
16#00	The command has completed successfully.
16#01	The procedure has started successfully. You can check the progress by the command Query current command progress (Page 42).
16#82	The CM 1xDALI is busy with the last command.
16#83	Timeout: the procedure did not complete within a limit time.
16#84	The procedure is canceled.
16#85	The CM 1xDALI received an error response frame after sending the query command. The error might be caused by a short address conflict or a DALI device failure. Note: Not every short address conflict can be detected. It can only be detected when the conflicted devices send the response frame at the same time.
16#87	Not supported: the action is not supported by the CM 1xDALI.
16#88	Invalid input parameters
16#89	No data: there is no data saved in CM 1xDALI or no response on the DALI bus.
16#8A	Status error: the CM 1xDALI is not in the normal state.
16#8B	Configuration mismatch. The physical device doesn't match the control gear or input device adding by the "Add control gear (Page 28)" instruction or "Add input device (Page 35)" instruction.
16#8C	The short address is not configured. No device with this short address exists on the DALI bus.
16#8D	No device is configured with this short address.
16#8E	No physical device with the specified short address is on the DALI bus.
16#8F	The scan procedure has stopped abnormally.
16#90	The CM 1xDALI cannot send commands to the DALI bus.
16#91	The device type of the control gear specified in the CM command "Set control gear extended parameters (Page 32)" or input device specified in the CM command "Set instance parameters of input device (Page 38)" does not match the physical device.

3.7.2 Address status

Error code	Description
16#00	Status is unknown. Query or scan the DALI bus.
16#01	If this short address is configured, the device with this short address is the same as configured. If this short address is not configured, a device with this address is present on the DALI bus.
16#02	No device with this short address is on the DALI bus.
16#03	More than one device with this short address is on the DALI bus.

Error code	Description
16#04	The configured type is not the type of the actual device on the DALI bus.
16#05	The configured number of instances does not correspond to the actual device. Only input devices have this status.
16#0F	This short address is assigned to DALI module itself.

3.7.3 Description of status

Control gear status

Bit	Description
0	Control gear failure
1	Lamp failure
2	Lamp on
3	Limit error
4	Fade running
5	Reset state
6	No short address
7	Power cycle seen

Control gear type related status

Bit	Type 1 (emergency)	Type 2 (discharge)	Type 3 (halogen)	type 4 (incandescent)
0	Circuit failure	Mains voltage too low	Short circuit	Load over-current shut-down
1	Battery duration failure	Mains voltage too high	Open circuit	Open circuit
2	Batter failure	Converter thermal overload	Load decrease	Load decrease
3	Emergency lamp failure	Reserved	Load increase	Load increase
4	Function test maximum delay exceeded	Ignition time out	Current protector active	Reserved
5	Duration test maximum delay exceeded	Reserved	Thermal shut down	Thermal shut down
6	Function test failed	Lamp voltage out of spec	Thermal overload	Thermal overload
7	Duration test failed	Lamp cycling failure	Reference measure-ment failed	Reference measure-ment failed

Bit	Type 5 (emergency)	Type 6 (discharge)	Type 7 (halogen)	type 8 (incandescent)
0	Output fault detected	Short circuit	Load error	XY-coordinate color point out of range
1	Reserved	Open circuit	Error detection in hold off	Color temperature out of range
2	Reserved	Load decrease	Last threshold acted upon ‘00’ up switch-on ‘01’ up switch-off ‘10’ down switch on ‘11’ down switch off	Auto calibration running
3	Reserved	Load increase		Auto calibration successful
4	Reserved	Current protector active	Reserved	Color type XY-coordinate active
5	Reserved	Thermal shut down	Reserved	Color type color temperature active
6	Reserved	Thermal overload	Reserved	Color type primary N active
7	Reserved	Reference measurement failed	Reference measurement failed	Color type RGBWAF active

Input device status

Bit	Description
0	Input device error
1	Quiescent mode
2	Short address is mask (0xFF).
3	Application active
4	Application controller error
5	Power cycle seen
6	Reset state
7	Reserved

SIEMENS

SIMATIC

ET 200SP Digital input module F-DI 8x24VDC HF (6ES7136-6BA01-0CA0)

Equipment Manual

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Introduction

1

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system. You can find functions that generally relate to the ET 200SP system in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

Conventions

Note the following identified notes:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you ought to pay special attention.

Important note for maintaining the operational safety of your plant

NOTE

Plants with safety-related features are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. For this reason, we inform you in personal notifications about product developments and features that are (or could be) relevant to the operation of plants from a safety perspective.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log onto Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/ww/en/ps/13751)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/ww/en/ps/13828)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/ww/en/ps/13683)
- Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/14667)

1.1 ET 200SP documentation guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet. (https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 S7 Failsafe Configuration Tool (S7-FCT)

SIMATIC S7-FCT

Failsafe Configuration Tool (FCT) enables you to GSD configure the following devices in third-party engineering systems:

- Selected, functionally fail-safe SIMATIC I/O devices
- Functionally fail-safe SIRIUS ACT PROFINET interfaces

The engineering system must meet the following requirements for this:

- Support of the CPD system integration acc. to "PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO"
- TCI implementation to Conformance Class C3

Additional information on S7-FCT can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
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You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

You can find general information and measures relating to industrial cybersecurity in the system manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

This section provides an overview of security-related information about your SIEMENS device.

NOTE

Security-related changes to software or devices are documented in the "New functions" section.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

3

3.1 Properties

Article number

6ES7136-6BA01-0CA0

View of the module

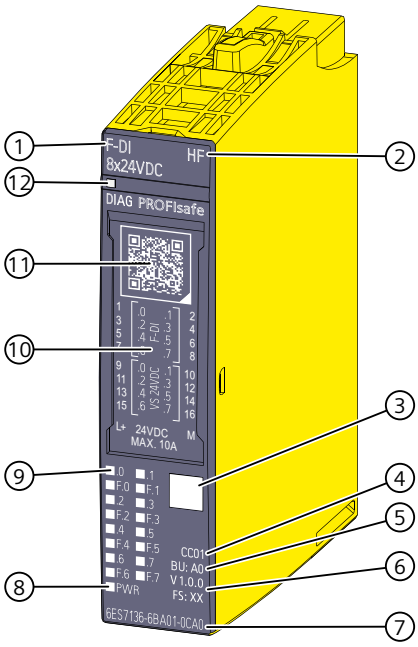

① Module type and name
② Function class
③ Color coding module type
④ Color code for selecting the color-coded labels
⑤ BU type
⑥ Firmware and function version
⑦ Article number
⑧ LED for supply voltage
⑨ LEDs for channel status
⑩ Wiring diagram
⑪ QR code for identification link
⑫ LED for diagnostics

Figure 2-1436 View of the F-DI 8×24VDC HF module

Properties

The module has the following technical properties:

- Fail-safe digital module
- PROFIsafe
- RIOforFA-Safety
- PROFIsafe address type 2
- 8 inputs (SIL3/Cat.3/PLd) or 4 inputs (SIL3/Cat.4/PLe)
- 8 outputs for sensor supply
- Use of various interconnection types (1oo1, 1oo2) is possible
- Suitable for the connection of 3-wire/4-wire sensors according to IEC 61131, Type 1
- Channel-specific assignable input delay 0.4 ms to 20 ms
- Internal short-circuit proof sensor supplies for each input
- External sensor supply possible
- Supply voltage L+
- Sink input (P-reading)
- Safety mat evaluation (firmware version V2.0.0 or higher)
- Suitable for the connection of 4-wire safety mats and pressure-sensitive protective devices (NO contact operating principle) according to ISO 13856-1, -2, -3
- Fail-safe counter (firmware version V3.0.0 or higher)
- Fail-safe standstill and overspeed monitoring (firmware version V3.0.0 or higher)
- Diagnostic display (DIAG red/green LED)
- Status display for each input (green LED)
- Error display for each input (red LED)
- Diagnostics
  - e.g., short-circuit, channel-specific
  - e.g., load voltage missing, module-specific
- Channel-based or module-based passivation

The module supports the following functions:

- Firmware update
- I&M identification data
- Service data

⚠ WARNING

If you have configured the digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) in a plant, but have inserted the digital input module F-DI 8x24VDC HF (6ES7136-6BA01-0CA0) instead, the information from the manual of the digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) still applies.

WARNING

The safety parameters in the technical data apply for a mission time of 20 years and a repair time of 100 hours. If repair is not possible within 100 hours, remove the respective module from the BaseUnit or switch off its supply voltage before the 100 hours have elapsed.

Proceed for the repair as described in the section Diagnostic messages.

Accessories

You can order the following accessories separately:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connection
- Electronic coding element as replacement part (part number 6ES7193-6EF00-1AA0)

For more information on accessories, refer to the system manual ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293).

3.2 Operating modes

The digital input module F-DI 8x24VDC HF can be operated in the following operating modes:

- "Digital inputs (Page 17)"operating mode
- "Counter (Page 54)" operating mode
- "Standstill and overspeed monitoring (Page 83)" operating mode

Digital inputs operating mode

4

4.1 Wiring

4.1.1 Pin assignment for "Digital inputs" operating mode

Pin assignment for "Digital inputs" operating mode

Table 2-1826 Pin assignment for "Digital inputs" operating mode

Pin assignment for "Digital inputs" operating mode						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • VS_n: Internal sensor supply, channel n	A0	 CC01 6ES7193-6CP01-2MA0
3	DI_2	**4**	DI_3			
5	DI_4	**6**	DI_5			
7	DI_6	**8**	DI_7			
9	VS_0	**10**	VS_1			
11	VS_2	**12**	VS_3			
13	VS_4	**14**	VS_5			
15	VS_6	**16**	VS_7			
L+	DC24V	**M**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System* system manual

NOTE

The first BaseUnit of a potential group must be a light-colored BaseUnit.

NOTE

Make sure that you only use digital modules with BaseUnit type A0 during commissioning.

4.1.2 Wiring and block diagram

This section includes the block diagram of the digital input module F-DI 8×24VDC HF with the pin assignment.

You can find more information about wiring the BaseUnit in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Block diagram

The following figure shows the pin assignment of the F-DI 8×24VDC HF digital input module on BaseUnit BU type A0.

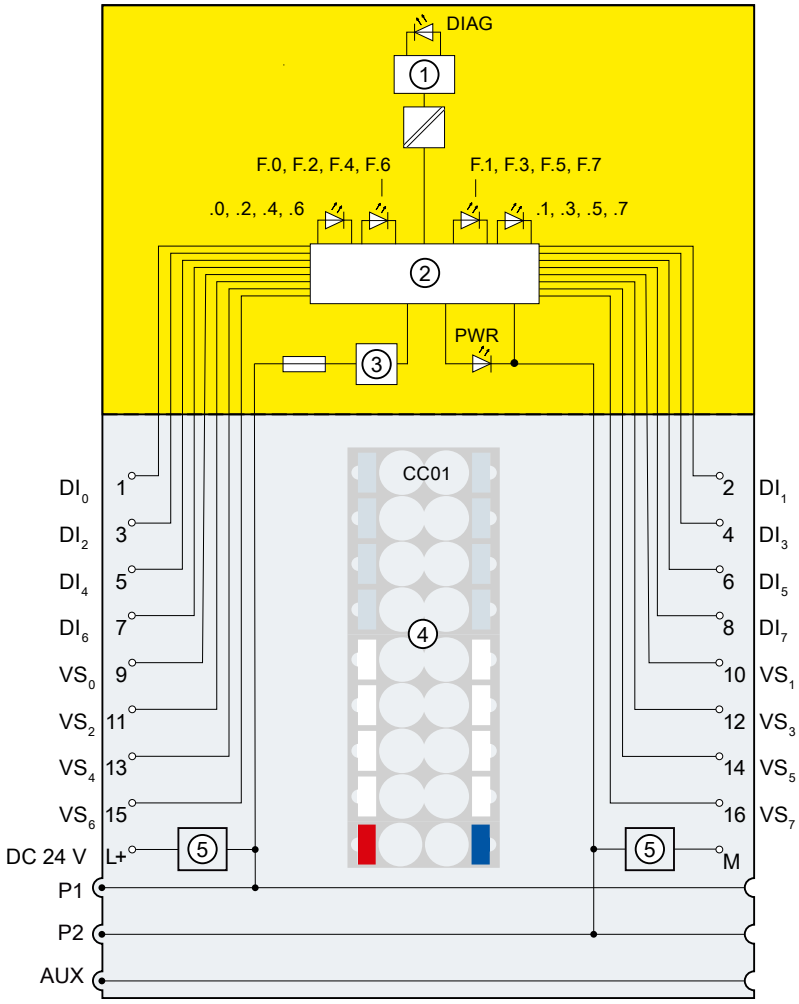

①	Backplane bus interface	VS_n	Internal sensor supply, channel n
②	Input electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Reverse polarity protection	DI_n	Input signal, channel n
④	Color identification label with color code CC01 (optional)	DIAG	Error or diagnostics LED (green, red)

⑤	Filter circuit supply voltage (available in light-colored BaseUnit only)	.0 to .7	Channel status LED (green)
L+	24 V DC (infeed only with light-colored BaseUnit)	F.0 to F.7	Channel fault LED (red)
M	Mass supply voltage	PWR	Power LED (green)

Figure 2-1437 Block diagram

4.2 Parameters/address space

"Digital inputs" operating mode is only effective if the operating mode selection is configured as "Digital inputs".

Parameters for the "Digital Inputs" operating mode

WARNING

You must enable or disable the diagnostic functions in accordance with the application; see section Application cases for inputs (Page 33).

The following parameters are possible:

Table 2-1827 Adjustable parameters

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
Module parameters:				
Operating mode	• Digital inputs • Counter • Standstill and Overspeed monitoring	Digital inputs	No	Module
F-parameters:				
Manual assignment of the F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Depends on the parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Is proposed by the F-system	No	Module
F-parameter signature (without address)	0 to 65535	Is calculated by the F-system	No	Module
Behavior after channel fault	• Passivate the entire module • Passivate channel	Passivate channel	No	Module

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	(S7-300/400) Adjustable (S7-1200/1500) All channels manually	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	Is proposed by the F-system	No	Module
F-I/O DB name	—	Is proposed by the F-system	No	Module
DI parameters:				
Sensor supply				
Sensor supply n				
Short-circuit test	• Disable • Enable	Enable	No	Channel
Time for short-circuit test	0.5 ms to 2 s	4.2 ms	No	Channel
Startup time of sensor after short-circuit test	0.5 ms to 2 s	4.2 ms	No	Channel
Channel parameters				
Channel n, n+4				
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation, equivalent • 1oo2 evaluation, non-equivalent • Safety mat evaluation	1oo2 evaluation, equivalent	No	Channel pair
Discrepancy behavior	• Supply value 0 • Supply last valid value	Supply value 0	No	Channel pair
Discrepancy time	5 ms to 30 s	5 ms	No	Channel pair
Reintegration after discrepancy error	• Test 0-Signal not necessary • Test 0-Signal necessary	Test 0-Signal not necessary	No	Channel pair
Channel n				
Activated	• Enable • Disable	Enable	No	Channel

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
Channel failure acknowledge	• Manual • Automatic The value range offered depends on the F-CPU used and the parameter assignment of the F-parameter "Reintegration after channel fault".	(S7-300/400) Parameter is not supported (S7-1200/1500) Manual	No	Channel
Sensor supply	• Sensor supply 0 to 7 • External sensor supply	Sensor supply n	No	Channel
Input delay	• 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 10.0 ms • 12.8 ms • 20 ms The provided value range depends on the parameter assignment of the employed sensor supply.	3.2 ms	No	Channel
Chatter monitoring	• Disable • Enable	Disable	No	Channel
Number of signal changes	2 to 31	5	No	Channel
Monitoring window	0 to 100 s (If 0 s is configured, the monitoring window is 0.5 s long.)	2 s	No	Channel

4.2.1 Explanation of parameters

4.2.1.1 Module parameters

Operating mode

This parameter is used to specify the desired operating mode.

The digital input module F-DI 8×24VDC HF can be operated in the following operating modes:

- "Digital inputs"
- “Counter"
- "Standstill and Overspeed monitoring"

4.2.1.2 F-parameters

F-parameters

You have to assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you start operation.

- You specify the F-source address with the "Central F-source address" parameter in the F-CPU.
- The F-destination address is assigned automatically for each F-module CPU-wide. You can change the specified F-destination address in the hardware configuration manually.

Information on the F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB can be found in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

See also

S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875)

Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use on S7-300/400 F-CPUs

This parameter is always set to "Adjustable" when you use the fail-safe module in S7-300/400 F-CPUs.

You make the required setting in the F-I/O DB of the fail-safe module.

Use on S7-1200/1500 F-CPUs

When using the F-module on F-CPUs S7-1200/1500, set this parameter in the STEP 7 dialog of the F-module:

- "Adjustable"
- "All channels automatically"
- "All channels manually"

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment "Adjustable". The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

4.2.1.3 Parameters of the sensor supply

Short-circuit test

Here you activate the short-circuit detection for the channels of the F-module for which an internal sensor supply is set.

The short-circuit test can always be performed when you use simple switches which do not have an own power supply. For switches with an own power supply, e.g. 3-/4-wire proximity switches or optical sensors with OSSD outputs (Output Signal Switching Device), you have to adjust the parameter "Startup time of sensor after short-circuit test" depending on the sensor used.

The short-circuit detection switches off the sensor supply briefly. The length of the deactivation period is equivalent to the configured "Time for short-circuit test".

If a short-circuit is detected, the F-module triggers a diagnostic interrupt and the input is passivated.

The following short-circuits are detected:

- Short-circuit of input to L+
- Short-circuit of the input with another channel, if this has a 1-signal
- Short-circuit between the input and sensor supply of another channel
- Short-circuit between the sensor supply and the sensor supply of another channel

If the short-circuit test is disabled, you must make your wiring short-circuit and cross-circuit proof or select a connection type (discrepancy, non-equivalent) which also detect the cross-circuits using discrepancy.

NOTE

During the execution time (Time for short-circuit test + Startup time of sensor after short-circuit test) of the short-circuit test, the last valid value of the input before the start of the short-circuit test is passed to the F-CPU. The activation of the short-circuit test thus affects the response time of the respective channel or channel pair.

NOTE

Safety mat evaluation

If you have configured "Safety mat evaluation" for a channel pair under "Sensor evaluation", short-circuit tests are performed on the internal sensor supplies that were assigned to this channel pair. These short-circuit tests are performed with a defined test pattern. The parameters "Time for short-circuit test" and "Startup time of sensor after short-circuit test" cannot be changed.

Time for short-circuit test

Function

When the short-circuit test is enabled, the corresponding sensor supply is switched off for the configured time. If the module does not detect a "0" signal at the input within the assigned time, a diagnostic message is generated.

Note the following during parameter assignment:

- If the channel is passivated, this may be due to too high capacitance between sensor supply and input. This consists of the capacitance per unit length of the cable and the capacitance of the employed sensor. If the connected capacitance does not discharge within the assigned time, you need to adjust the "Time for short-circuit test" parameter.
- The values available for the input delay depend on the "Startup time of sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

Requirement

The short-circuit test is activated.

NOTE

Safety mat evaluation

If you have configured "Safety mat evaluation" for a channel pair under "Sensor evaluation", short-circuit tests are performed on the internal sensor supplies that were assigned to this channel pair. These short-circuit tests are performed with a defined test pattern. The parameters "Time for short-circuit test" and "Startup time of sensor after short-circuit test" cannot be changed.

Startup time of sensor after short-circuit test

Function

Apart from the switch-off time ("Time for short-circuit test"), a startup time must also be specified for the execution of the short-circuit test. With this parameter you inform the module how long the used sensor requires for the startup after the sensor supply is switched on. This way you avoid an undefined input status due to transient responses in the sensor.

Note the following during parameter assignment:

- This parameter must be larger than the settling time of the sensor used.
- Since the parameterized time affects the response time of the module, we recommend setting this time as short as possible but large enough so that the sensor has stabilized.
- The values available for the input delay depend on the "Startup time of sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

Requirement

The short-circuit test is activated.

NOTE

Dependencies between the parameters "Startup time of sensor after short-circuit test" and "Time for short-circuit test"

The startup time of the sensor after the short-circuit test must amount to at least 1 % of the time for the short-circuit test.

NOTE

Safety mat evaluation

If you have configured "Safety mat evaluation" for a channel pair under "Sensor evaluation", short-circuit tests are performed on the internal sensor supplies that were assigned to this channel pair. These short-circuit tests are performed with a defined test pattern. The parameters "Time for short-circuit test" and "Startup time of sensor after short-circuit test" cannot be changed.

4.2.1.4 Parameters of the channel pairs

Sensor evaluation

Overview

Select the type of sensor evaluation with the "Sensor evaluation" parameter:

- 1oo1 evaluation
- 1oo2 evaluation, equivalent
- 1oo2 evaluation, non-equivalent
- Safety mat evaluation

1oo1 evaluation

The sensor uses only one input channel for the 1oo1 evaluation.

1oo2 evaluation, equivalent/non-equivalent

With a 1oo2 evaluation equivalent/non-equivalent, two input channels are occupied by:

- One two-channel sensor
- Two one-channel sensors
- One non-equivalent sensor

The input signals are compared internally for equivalence or non equivalence.

Note that in 1oo2 evaluation, two channels are combined into a channel pair. The number of available process signals of the F-module is reduced accordingly.

Discrepancy analysis

When using a two-channel sensor or two one-channel sensors which measure the same process variable, the sensors interact with a slight time delay due to the limited precision of their arrangement.

The discrepancy analysis for equivalence/non equivalence is used for fail-safe applications to prevent errors from time differences between two signals for the same function. The discrepancy analysis is initiated when different levels are detected in two associated input signals (when testing for non equivalence: the same levels). A check is made to determine whether the difference in levels (when testing for non equivalence: the same levels) has disappeared after an assignable time period, the so-called discrepancy time. If not, this means that a discrepancy error exists.

Safety mat evaluation

With safety mat evaluation, two input channels and two internal sensor supplies are occupied by a 4-wire safety mat (NO contact operating principle). If necessary, you can also connect several 4-wire safety mats connected in series.

Discrepancy behavior

Function

For the "Discrepancy behavior", you assign the value that is supplied to the safety program in the F-CPU during a discrepancy between two relevant input channels, which means while discrepancy time is running. You assign the discrepancy behavior as follows:

- "Supply last valid value"
- "Supply value 0"

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

"Supply last valid value"

The most recent valid value (old value) before the discrepancy occurred is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the signals of the two affected input channels. This value is supplied until the discrepancy disappears or the discrepancy time expires and a discrepancy error is detected. The sensor-actuator response time is correspondingly increased by this time.

This means the discrepancy time of connected sensors with 1oo2 evaluation must be adjusted to short response times. It makes no sense, for example, if connected sensors with a discrepancy time of 500 ms trigger a time-critical shutdown. In the worst possible case, the sensor-actuator response time is extended by the discrepancy time:

- For this reason, position the sensors in the process in such a way as to **minimize discrepancy**.
- Then select the **shortest possible** discrepancy time which is also sufficient to compensate for faulty triggering of discrepancy errors.

"Supply value 0"

As soon as a discrepancy between the signals of the two relevant input channels is detected, the value "0" is made available to the safety program in the F-CPU.

If you have set "Supply value 0", the sensor-actuator response time is not affected by the discrepancy time.

Discrepancy time

Function

You can set the discrepancy time for each channel pair.

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

In most cases, a discrepancy time is started, but does not fully expire because the signal differences are cleared within a short time.

Set the discrepancy time high enough that in the error-free case the difference between the two signals (when testing for non equivalence: the same levels) has always disappeared before the discrepancy time has expired.

Behavior while discrepancy time is running

While the programmed discrepancy time is running internally on the module, either the **last valid value** or **"0"** is returned to the safety program on the F-CPU by the input channels involved, depending on the parameter settings for the behavior at discrepancy.

Behavior after expiration of the discrepancy time

If no agreement (when checking for non equivalence: inequality) of the input signals exists once the assigned discrepancy time expires, for example, due to a break in a sensor wire, a discrepancy error is detected and the "Discrepancy error" diagnostic message containing information on which channels are faulty is generated.

NOTE
Dependencies between the parameters "Discrepancy time" und "Input delay"
The discrepancy time must be parameterized greater than the input delay.

Reintegration after discrepancy error

Function

This parameter specifies the criteria for when a discrepancy error is regarded as corrected, thus enabling reintegration of the relevant input channels. The following parameter assignment options are available:

- "Test 0-Signal necessary"
- "Test 0-Signal not necessary"

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

"Test 0-Signal necessary"

If you have assigned "Test 0-Signal necessary", a discrepancy error is not regarded as corrected until a 0-signal is present at both of the relevant input channels.

If you are using non equivalent sensors, which means you have set "Sensor evaluation" to "1oo2 evaluation, non-equivalent", the result of the channel pair must be "0" again.

"Test 0-Signal not necessary"

If you have assigned "Test 0-Signal not necessary", a discrepancy error is regarded as corrected when a discrepancy no longer exists at both of the relevant input channels.

4.2.1.5 Parameters of the channels

Activated

You hereby enable the corresponding channel for signal processing in the safety program.

Channel failure acknowledge

Use on S7-1200/1500 F-CPUs

The parameter is only relevant if the F-module is operated on an S7-1200/1500 F-CPU.

The parameter can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".

The value of this parameter specifies how the channel reacts after a channel fault:

- Manual: A channel failure is reintegrated after manual acknowledgment.
- Automatically: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

Use on S7-300/400 F-CPUs

The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. For S7-300/400 F-CPUs you set the corresponding property at the F-I/O DB by means of the ACK_NEC tag.

For detailed information about the F-I/O DB, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Sensor supply

You can select one of the internal sensor supplies VS_0 to VS_7 or an external sensor supply.

The selection of an internal sensor supply is required for using the short-circuit test.

With safety mat evaluation, the internal sensor supplies are assigned to the channel pair. For additional information, see the section Safety mat evaluation application (from firmware version V2.0.0) (Page 50).

⚠ WARNING
Sensor supply with safety mat evaluation With safety mat evaluation, the internal sensor supply assigned to the respective channel must be used. The internal sensor supply must not be used for any other channel. The use of a different internal sensor supply or an external sensor supply is prohibited.

See also

Time for short-circuit test (Page 24)

Input delay

Function

To suppress injected interference, you can set an input delay for a channel or a channel pair.

Interference pulses whose pulse time is less than the set input delay are suppressed. Suppressed interference pulse are not visible in the safety program.

A high input delay suppresses longer interference pulses, but results in a longer response time.

The set value for the input delay has to be smaller than the configured "Startup time of sensor after short-circuit test" and smaller than the configured "Time for short-circuit test".

With 1oo2 evaluation, the input delay of the lower-order channel (channel n) automatically applies to the higher-order channel (channel n+4).

NOTE

Input delay with Safety mat evaluation

If the Safety mat evaluation is set, you must configure an input delay of 1.6 ms.

NOTE

Due to the physical properties, there is a possibility of crosstalk between signals in the case of long, unshielded signal lines (see section "Electromagnetic compatibility" in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293)).

Adapt the input delay or use shielded signal lines in order to prevent possible passivation of the fail-safe digital inputs and switch-off of the sensor supply.

See also

Response times (Page 124)

Technical specifications (Page 120)

Chatter monitoring

Function

Chatter monitoring is a process control function for digital input signals. It detects and reports unusual signal sequences in the process with 1oo1 evaluation, for example, an input signal fluctuating between "0" and "1" too frequently. The occurrence of such signal characteristics is an indication of faulty sensors or process control instability.

Recognizing unusual signal patterns

An assigned monitoring window is available for each input channel. The monitoring window starts with the first signal change of the input signal. If the input signal changes within the monitoring window at least as often as the assigned "Number of signal changes", a chatter error is detected. If no chatter error is detected within the monitoring window, the next signal change restarts the monitoring window.

If a chatter error is detected, a diagnostic is signaled. If the chatter error does not occur for the monitoring window for three times the configured period, the diagnostic is reset.

Principle

The figure below shows the principle of chatter monitoring as a graphic.

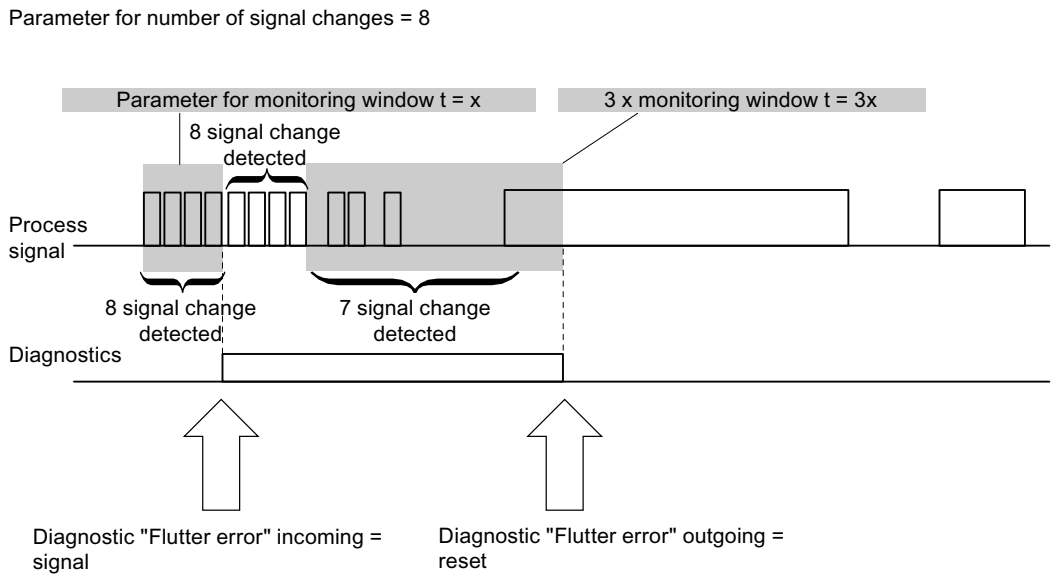

Figure 2-1438 Figure chatter monitoring

Number of signal changes

Defines the number of signal changes after whose sequence a chatter error is to be reported.

Monitoring window

Sets the time for the monitoring window of chatter monitoring.

You can set times of 1 s to 100 s in whole seconds for the monitoring window.

If you parameterize 0 s, the monitoring window is 0.5 s long.

4.2.2 Address space

Address assignment of the digital input module F-DI 8×24VDC HF in "Digital inputs" operating mode

The digital input module F-DI 8×24VDC HF occupies the following address areas in the F-CPU:

Table 2-1828 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In the input range**	**In the output range**
F-CPUs S7-300/400	IB x + 0 to x + 5	QB x + 0 to x + 3
F-CPUs S7-1200/1500	IB x + 0 to x + 6	QB x + 0 to x + 4

x = Module start address

Address assignment of the user data and the value status of digital input module F-DI 8×24VDC HF in "Digital inputs" operating mode

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital input module F-DI 8×24VDC HF:

Table 2-1829 User data address assignment in the input range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	DI_7	DI_6	DI_5	DI_4	DI_3	DI_2	DI_1	DI_0
IB x + 1	Value status for DI_7	Value status for DI_6	Value status for DI_5	Value status for DI_4	Value status for DI_3	Value status for DI_2	Value status for DI_1	Value status for DI_0

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

With safety mat evaluation and 1oo2 evaluation of the sensors, the two channels are combined, for example, DI_0 and DI_4. With safety mat evaluation and 1oo2 evaluation of the sensors, you may only access the low order channel in the safety program, for example, DI_0.

More information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

See also

S7 Distributed Safety - Configuring and Programming
(https://support.industry.siemens.com/cs/ww/en/view/22099875)

4.3 Applications for inputs

Selecting the application

The diagram below supports you in selecting the application that suits your fail-safe requirements. In the following sections, you will learn how to wire the F-module, the specific parameters you must assign in STEP 7 Safety and the errors that are detected.

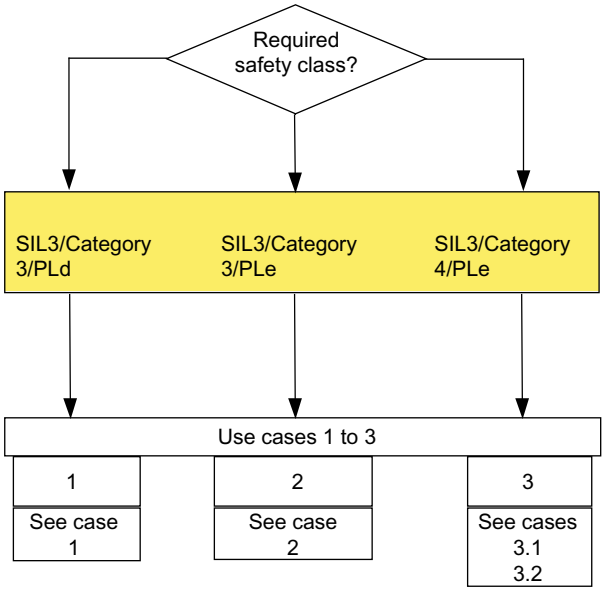

Figure 2-1439 Selecting the application – digital input module F-DI 8×24VDC HF

WARNING

The achievable safety class depends on the quality of the sensor and the duration of the proof-test interval in accordance with IEC 61508:2010. If the quality of the sensor is lower than the quality required by the safety class, redundant sensors connected via two channels must be used and evaluated.

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving at least the corresponding safety requirements.

Table 2-1830 Conditions for achieving SIL/Cat./PL

Application	Sensor evaluation	Sensor supply	Achievable SIL/Cat./PL
1	1oo1	Internal, with short-circuit test	3 / 3 / d
		Internal, without short-circuit test	
		External	
2	1oo2 equivalent	Internal, without short-circuit test	3 / 3 / e
		External	
3.1	1oo2 equivalent	Internal, with short-circuit test	3 / 4 / e
3.2	1oo2 non-equivalent	Internal, with short-circuit test	
		Internal, without short-circuit test	
		External	

NOTE

With a module you can realize the applications listed in Table 5-1 simultaneously on different inputs. You only have to interconnect the inputs and assign parameters as described in the following sections.

Sensor requirements

Information on the safety-oriented use of sensors can be found in the section Requirements for sensors and actuators for fail-safe modules and fail-safe motor starters in the system manual ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293).

4.3.1 Application 1: Safety mode SIL3/Cat.3/PLd

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

The sensor supply can be internal or external.

Wiring diagram – connecting one sensor via one channel

Per process signal, one sensor is connected via one channel (1oo1 evaluation).

You can assign any module sensor supply to each input, as well as an external sensor supply, via which the sensor is then supplied.

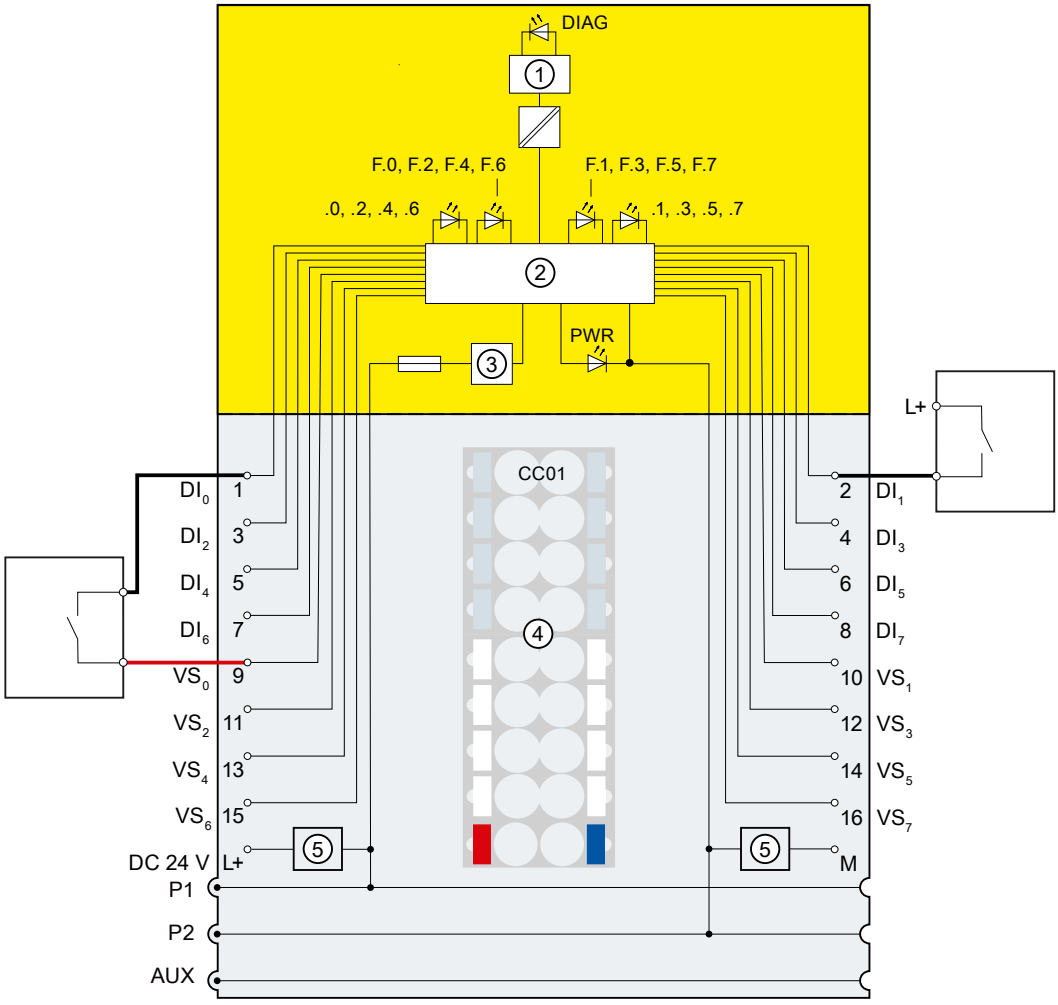

Figure 2-1440 One sensor connected via one channel, internal and external sensor supply

WARNING

To achieve SIL3/Cat.3/PLd using this wiring, you must use a qualified sensor.

WARNING

To achieve SIL3/Cat.3/PLd with this wiring, you have to route the cables cross-circuit proof and apply the positive opening operation principle for the sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 2-1831 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo1 evaluation	
Sensor supply	Sensor supply n	External sensor supply*
Short-circuit test	• Disable • Enable	Disable

*) Otherwise a diagnostic message will be generated when short-circuit test is activated.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 2-1832 Fault detection

Fault	Fault detection		
	Internal sensor supply and short-circuit test activated	Internal sensor supply and short-circuit test deactivated	External sensor supply
Short-circuit of the input with other channels or other sensor supplies (short-circuit with other channels is detected only if they use a different sensor supply)	Yes*	No	No
Short-circuit of the input with the associated sensor supply	No	No	No
Short-circuit with L+ to DI_n	Yes	No	No
Short-circuit with M to DI_n	Yes*	Yes*	No
Discrepancy error	—	—	—
Short-circuit with L+ to VS_n	Yes	No	—
Short-circuit with M to VS_n or defective	Yes	Yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

4.3.2 Application 2: Safety mode SIL3/Cat.3/PLe

Assigning inputs to each other

The digital input module F-DI 8×24VDC HF has 8 fail-safe inputs, DI_0 to DI_7 (SIL3). You can combine two of these inputs to one input.

You can combine the following inputs:

- DI_0 and DI_4
- DI_1 and DI_5
- DI_2 and DI_6
- DI_3 and DI_7

The process signals are provided by channels DI_0, DI_1, DI_2 and DI_3.

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

The sensor supply can be internal or external.

Wiring diagram - connecting a two-channel sensor equivalent via two channels

Per process signal, a two-channel sensor is connected equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

You can assign any module sensor supply to each input, as well as an external sensor supply, via which the sensor is then supplied.

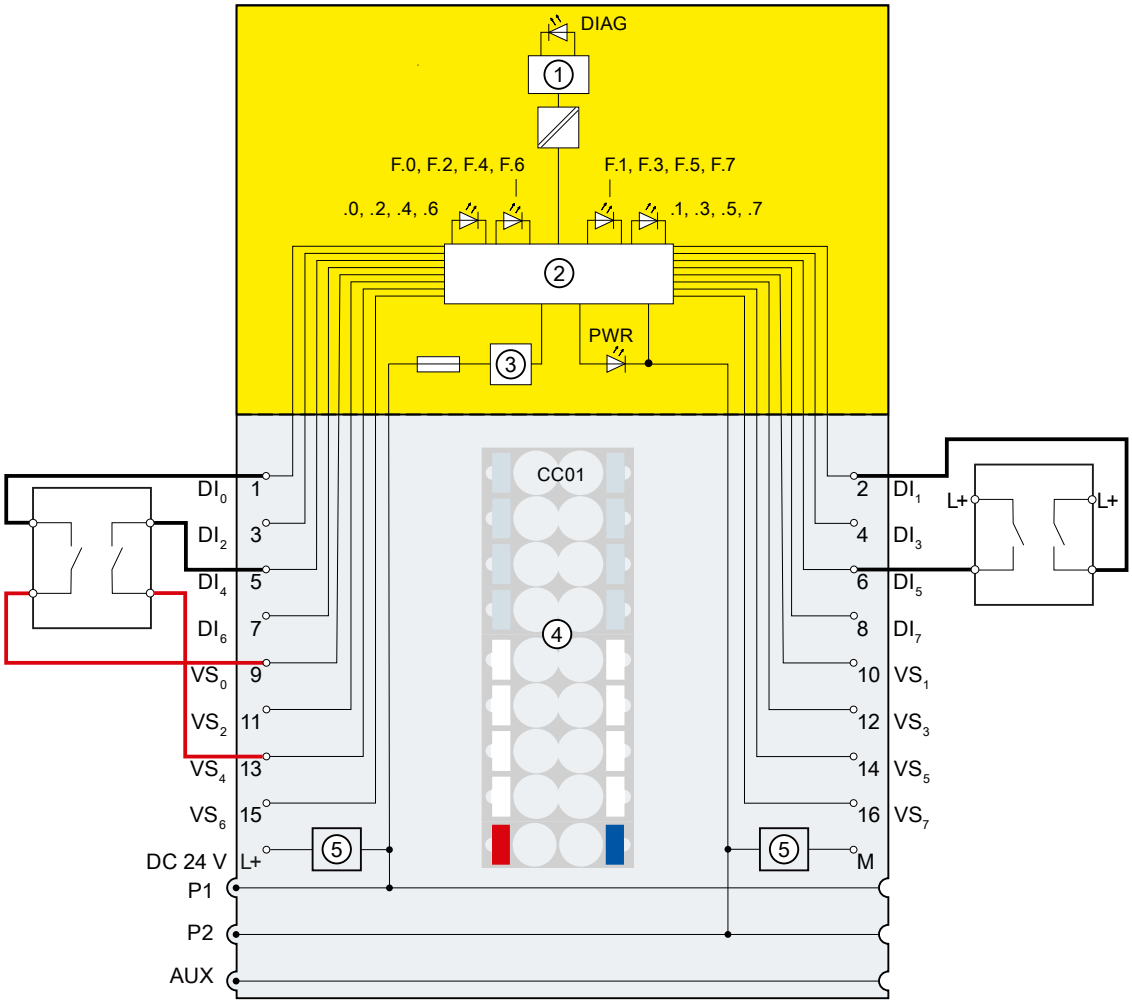

Figure 2-1441 A two-channel sensor connected via two channels, internal and external sensor supply

WARNING

To achieve SIL3/Cat.3/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram - connecting two one-channel sensors equivalent via two channels

Per process signal, two one-channel sensors, which record the same process value, are connected equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

You can assign any module sensor supply to each input, as well as an external sensor supply, via which the sensors are then supplied.

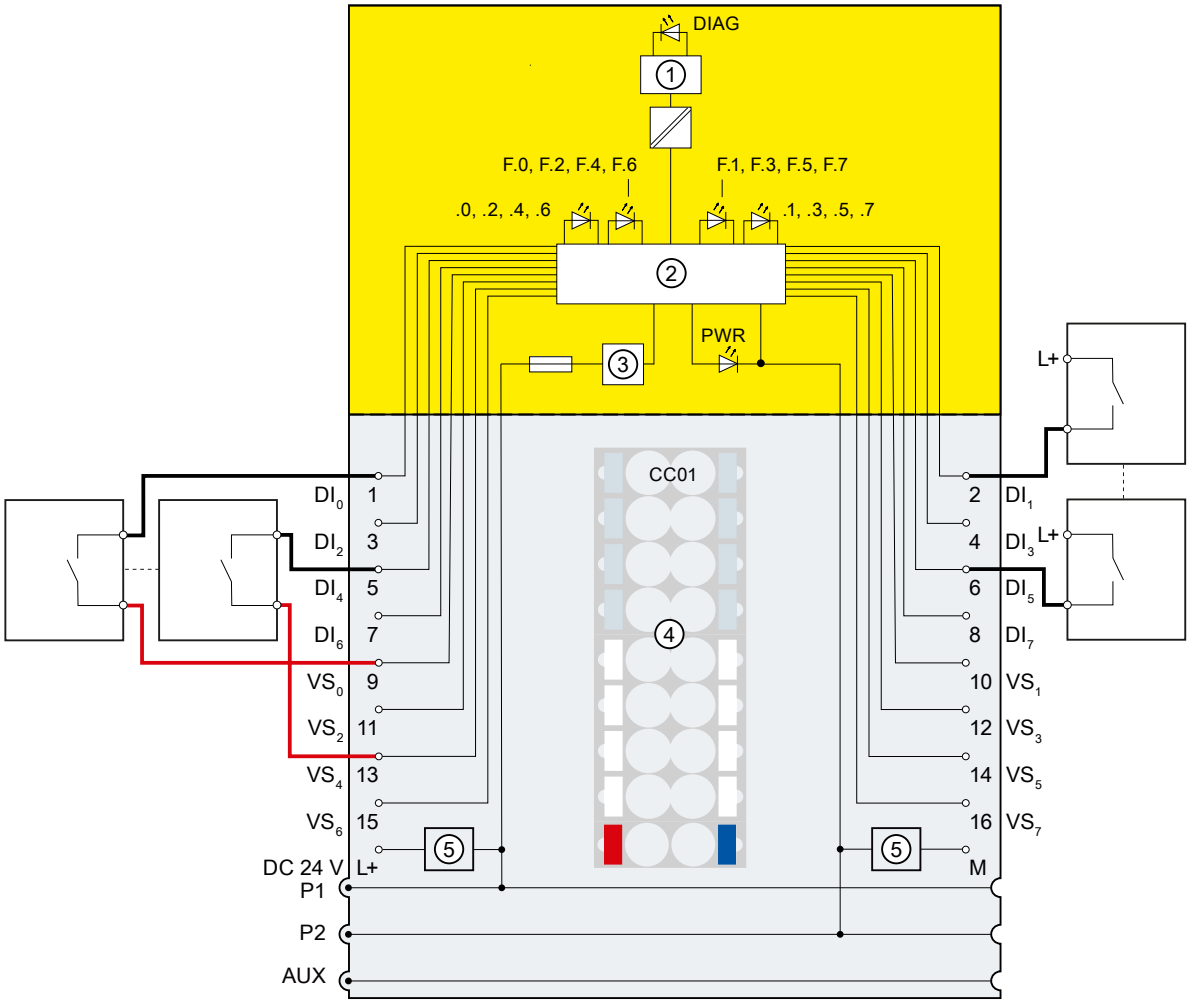

Figure 2-1442 Two one-channel sensors connected via two channels, internal and external sensor supply

WARNING

To achieve SIL3/Cat.3/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 2-1833 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, equivalent	
Sensor supply	Sensor supply n	External sensor supply*
Short-circuit test	• Disable • Enable	Disable

*) Otherwise a diagnostic message will be generated when short-circuit test is activated.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 2-1834 Fault detection

Fault	Fault detection	
	Internal sensor supply and short-circuit test deactivated	External sensor supply
Short-circuit within the channel pair	No	No
Short-circuit with other channels or other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to VS_n	No	—
Short-circuit with M to VS_n or defective	Yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

4.3.3 Application 3: Safety mode SIL3/Cat.4/PLe

Assigning inputs to each other

The digital input module F-DI 8×24VDC HF has 8 fail-safe inputs, DI_0 to DI_7 (SIL3). You can combine two of these inputs to one input.

You can combine the following inputs:

- DI_0 with DI_4
- DI_1 with DI_5
- DI_2 with DI_6
- DI_3 with DI_7

The process signals are provided by channels DI_0,DI_1,DI_2 and DI_3.

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

For application 3.1, the sensor supply must be set up for at least one channel internally with activated short-circuit test.

The sensor can be supplied internally or externally for application 3.2.

Requirements for applications in machinery protection with Cat.4

Both conditions must be met for applications in machine protection with Cat.4:

- The wiring between sensors and automation system and between automation system and actuators must be designed to state-of-the-art engineering and standards to prevent short-circuits.
- The actuators must be wired as seen in sections Application 3.1: Safety mode SIL3/Cat.4/PLe (Page 44) or Application 3.2: Safety mode SIL3/Cat.4/PLe (Page 47). You only need to detect **one** short-circuit because two faults are required to generate it. This means both signal cables in short-circuit have an isolation fault. A multiple short-circuit analysis is not required.

Procedures for locating all short-circuits are also permitted if single short-circuits are not located. One of the two conditions must be met for this purpose:

- Short-circuits may not corrupt the read signals compared to the sensor signals.
- Short-circuits cause a corruption of the read signals compared to sensor signals in the direction that ensures safety.

4.3.3.1 Application 3.1: Safety mode SIL3/Cat.4/PLe

Wiring diagram - connecting a two-channel sensor equivalent via two channels

Per process signal, a two-channel sensor is connected equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

Supply the sensor from two different internal sensor supplies or from an internal and an external sensor supply.

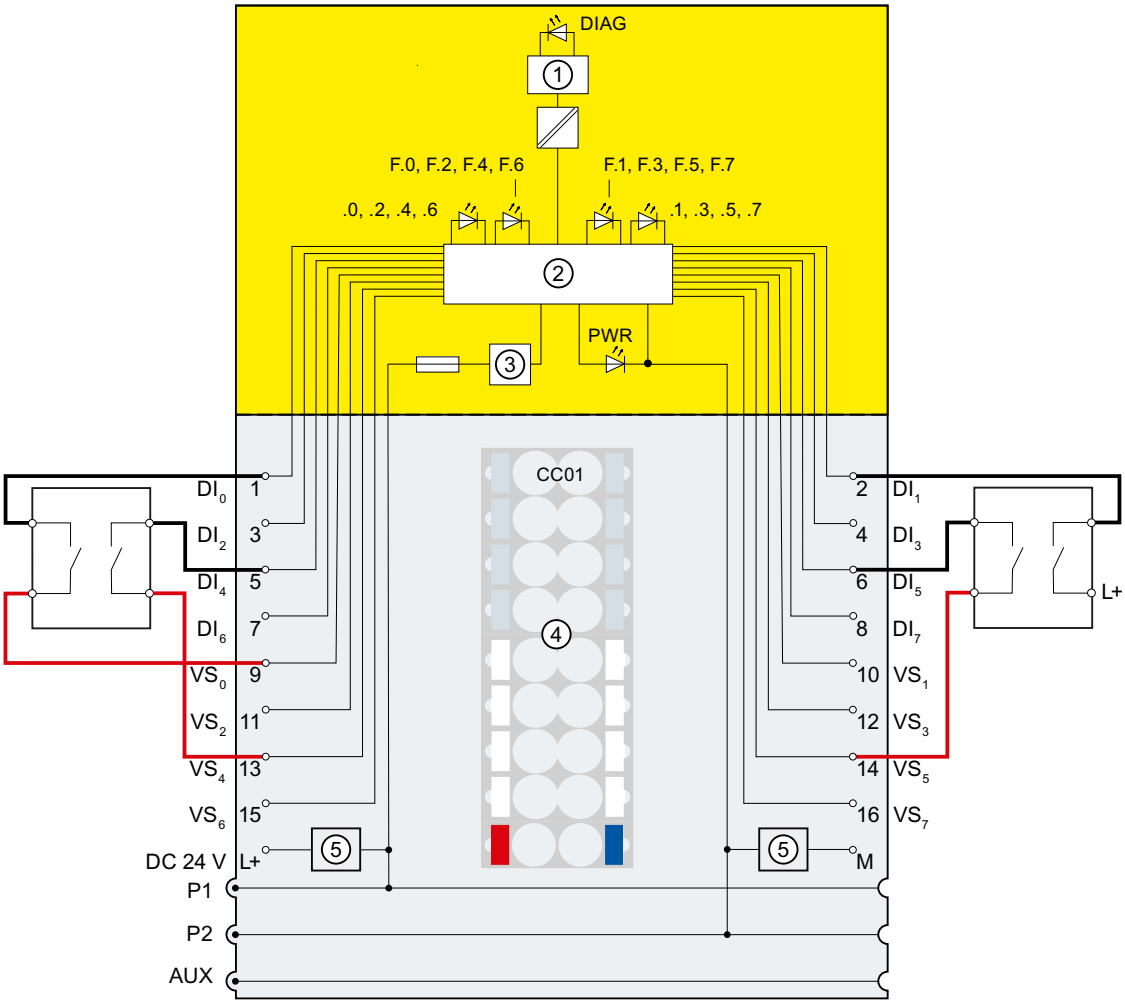

Figure 2-1443 A two-channel sensor connected via two channels, internal sensor supply and a two-channel sensor connected via two channels, internal and external sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a qualified sensor.

Wiring diagram - connecting two one-channel sensors equivalent via two channels

Per process signal, two one-channel sensors, which record the same process value, are connected equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

Supply the sensors from two different internal sensor supplies or from an internal and an external sensor supply.

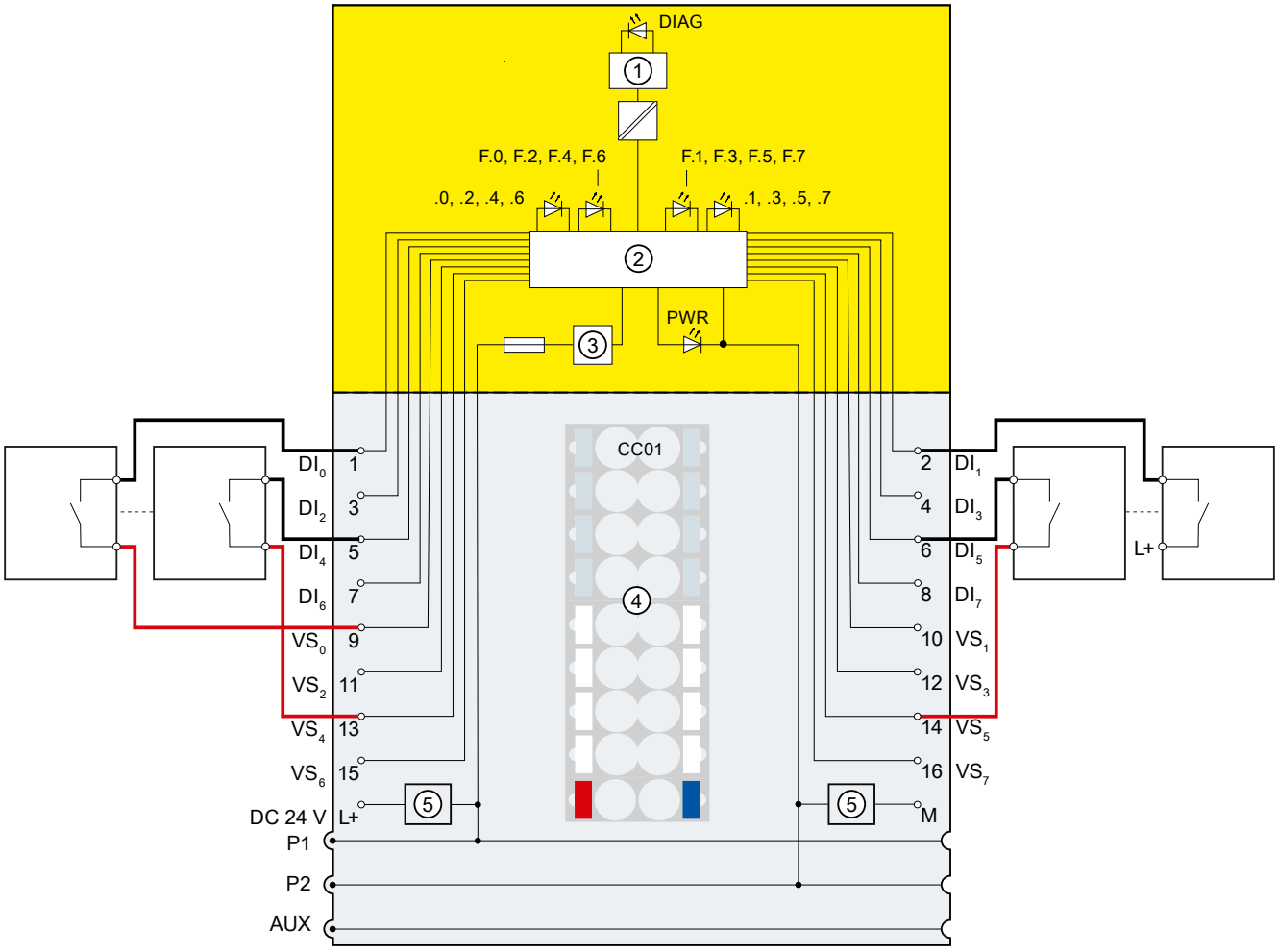

Figure 2-1444 Two one-channel sensors connected via two channels, internal sensor supply and two one-channel sensors connected via two channels, internal and external sensor supply.

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 2-1835 Parameter assignment

Parameter	Channel with internal sensor supply*	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, equivalent	
Sensor supply	Sensor supply n	External sensor supply**
Short-circuit test	Enable*	Disable

*) The sensor supply must be set up for at least one channel internally with activated short-circuit test.

**) Otherwise a diagnostic message is generated for an activated short-circuit test.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 2-1836 Fault detection

Fault	Fault detection	
	Internal sensor supply and short-circuit test activated	External sensor supply
Short-circuit within the channel pair	Yes*	Yes*
Short-circuit with other channels or other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to VS_n	Yes	-
Short-circuit with M to VS_n or defective	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

4.3.3.2 Application 3.2: Safety mode SIL3/Cat.4/PLe

Wiring diagram – connecting a non-equivalent sensor

Per process signal, a non-equivalent sensor is connected to two inputs of the F-module (1oo2 evaluation).

You can supply the sensor via an internal or external sensor supply.

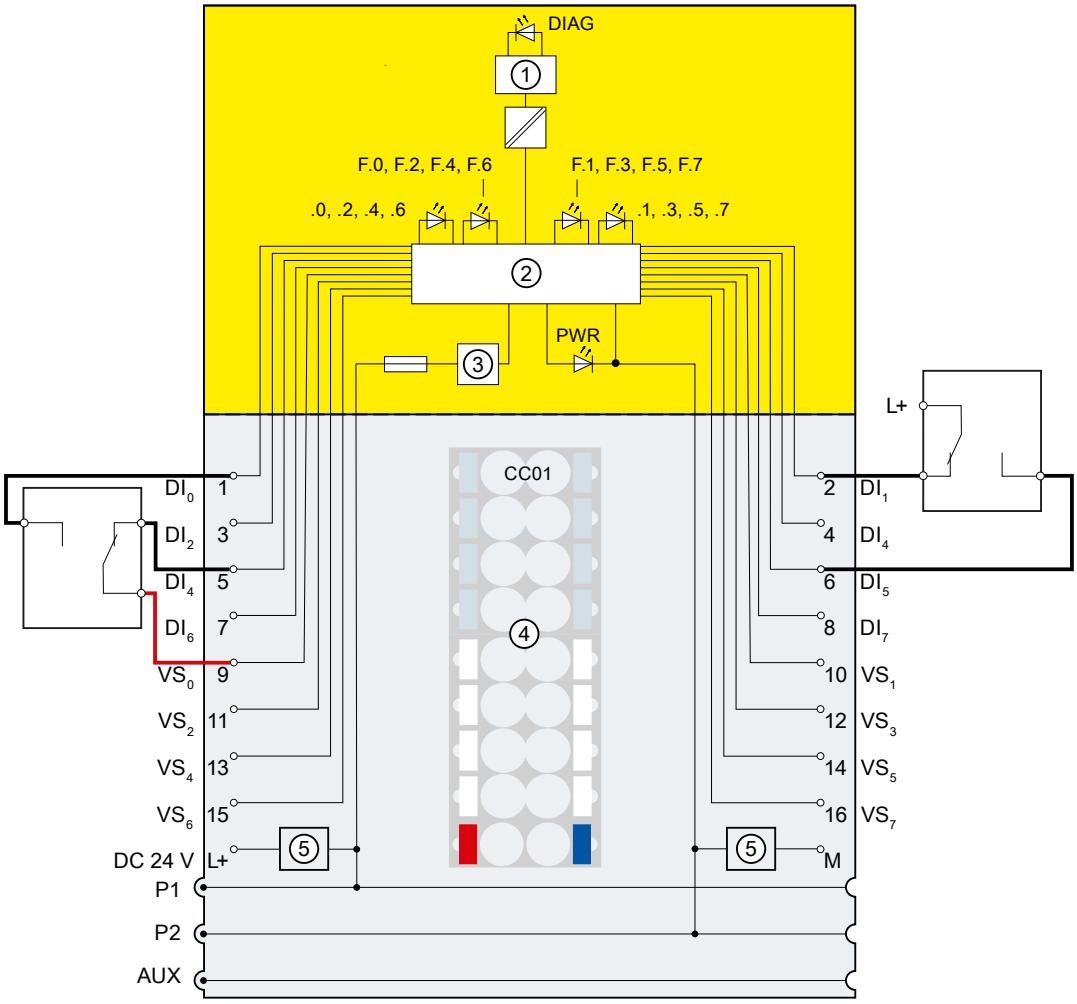

Figure 2-1445 One non-equivalent sensor connected, internal sensor supply and one non-equivalent sensor connected, external sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram - connecting two one-channel sensors non-equivalent via two channels

Per process signal, two one-channel sensors, which record the same process value, are connected non-equivalent via two channels to two inputs of the F-module (1oo2 evaluation).

You can assign any module sensor supply to each input, as well as an external sensor supply, via which the sensors are then supplied.

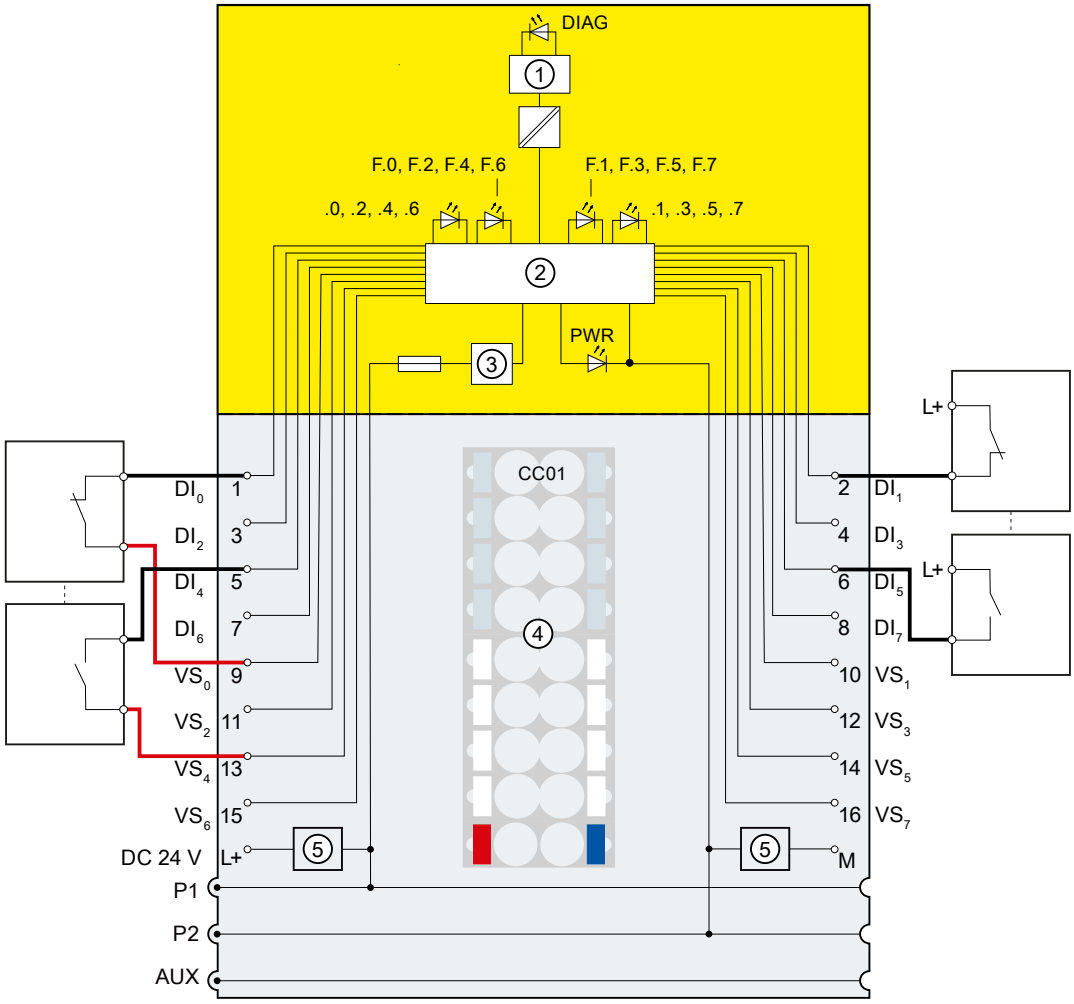

Figure 2-1446 Two one-channel sensors connected via two channels non-equivalent, internal sensor supply and two one-channel sensors connected via two channels non-equivalent, external sensor supply.

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 2-1837 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, non-equivalent	
Sensor supply	Sensor supply n	External sensor supply*
Short-circuit test	• Disable • Enable	Disable

*) Otherwise a diagnostic message will be generated when short-circuit test is activated.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short-circuit test:

Table 2-1838 Fault detection

Fault	Fault detection		
	Internal sensor supply and short-circuit test activated	Internal sensor supply and short-circuit test deactivated	External sensor supply
Short-circuit within the channel pair	Yes	Yes	Yes
Short-circuit with other channels or other sensor supplies	Yes*	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*	Yes*
Discrepancy error	Yes	Yes	Yes
Short-circuit with L+ to VS_n	Yes	No	-
Short-circuit with M to VS_n or defective	Yes	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

4.3.4 Safety mat evaluation application (from firmware version V2.0.0)

Assigning inputs to each other

The digital input module F-DI 8×24VDC HF has 8 fail-safe inputs, DI_0 to DI_7 (SIL3). You can combine two of these inputs to one input and use for the monitoring of safety mats.

You can combine the following inputs:

- DI_0 and DI_4
- DI_1 and DI_5
- DI_2 and DI_6
- DI_3 and DI_7

The process signals are provided by channels DI_0, DI_1, DI_2 and DI_3.

NOTE
Process signal
When a safety mat is activated, the process signal "0" is provided. When a safety mat is not activated, the process signal is "1".

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

The sensor supplies are operated in the "Safety mat evaluation" mode and must be assigned to the digital inputs as follows:

- VS_0 to DI_0 and VS_4 to DI_4
- VS_1 to DI_1 and VS_5 to DI_5
- VS_2 to DI_2 and VS_6 to DI_6
- VS_3 to DI_3 and VS_7 to DI_7

Wiring diagram – connecting multiple safety mats in series

For each process signal, you can connect multiple 4-wire safety mats in series to two inputs and two internal sensor supplies of the F-module.

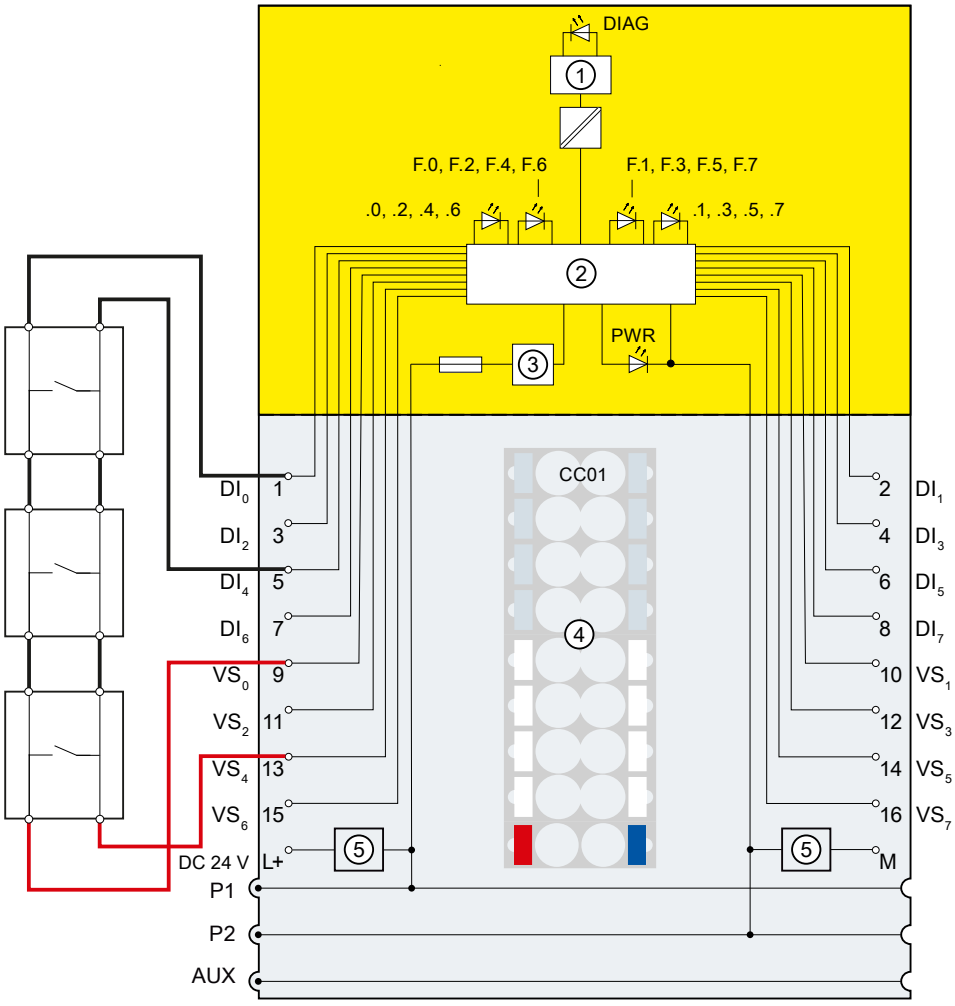

Figure 2-1447 Safety mats connected via two channels to two internal sensor supplies

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor. If a regular function test is required, observe the requirements in the application standard or in the manual of the sensor in use.

WARNING

You must ensure short-circuit-proof wiring. Cables intended for the connection of the safety mats must be laid separately from the cables for applications 1 to 3 (Page 33).

WARNING

You may only use 4-wire safety mats with a current-carrying capacity of at least 100 mA.

WARNING

If a short-circuit of the sensor supply to ground occurs, you must check after resolving the short-circuit whether the safety mat is functional by activating it. An excessive current load may damage the contact of the safety mat.

WARNING

When selecting the cables and safety mats, note that the ohmic resistance of the cables including an activated safety mat must not exceed 100 ohms.

Determining the ohmic resistance for connecting a safety mat

If you do not know the resistance of the cables including activated safety mat, you must determine the resistance through measurements.

Proceed as follows:

- Unplug the digital input module from the BaseUnit.
- Measure the resistance of the cables including activated safety mat between VS_n and DI_{n+4}.
- Measure the resistance of the cables including activated safety mat between VS_{n+4} and DI_n.

For the above-mentioned measurements, the resistance must not exceed 100 ohms.

You can use the measuring tap of the BaseUnit for the measurements. For more information, refer to the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 2-1839 Parameter assignment

Parameter	Channel with internal sensor supply
Sensor evaluation	Safety mat evaluation
Sensor supply	Sensor supply n
Short-circuit test	Enable
Time for short-circuit test	Default value 4.2 ms (not used)

Parameter	Channel with internal sensor supply
Startup time of sensor after short-circuit test	Default value 4.2 ms (not used)
Input delay	1.6 ms
Chatter monitoring	Disable

NOTE

With configured safety mat monitoring, the parameters "Short-circuit test", "Input delay" and "Chatter monitoring" cannot be adjusted since they are fixed with the listed values.

Fault detection

The following table presents fault detection:

Table 2-1840 Fault detection

Fault	Fault detection
Short-circuit within the channel pair of the safety mat evaluation	No (activation of the safety mat is detected)
Short-circuit with other channel pairs with configured safety mat evaluation	Yes
Short-circuit with other channels that are used for the applications 1 to 3	No
Short-circuit with L+ to DI_n or DI_{n+4}	Yes*
Short-circuit with M to DI_n or DI_{n+4}	Yes
Wire break	Yes
Short-circuit with L+ to VS_n or VS_{n+4}	Yes*
Short-circuit with M to VS_n or VS_{n+4}	Yes

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

NOTE

The fault detection diagnostics is not signaled as outgoing until the safety mat function is once again error-free after running self-tests. The safety mat must not be activated in this case.

Counter operating mode

5

5.1 Wiring

5.1.1 Pin assignment “Counter" operating mode

Pin assignment for “Counter" operating mode

Table 2-1841 Pin assignment for “Counter" operating mode

Pin assignment for “Counter" operating mode						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • VS_n: Internal sensor supply, channel n	A0	 CC01 6ES7193-6CP01-2MA0
3	DI_2	**4**	DI_3			
5	DI_4	**6**	DI_5			
7	DI_6	**8**	DI_7			
9	VS_0	**10**	VS_1			
11	VS_2	**12**	VS_3			
13	VS_4	**14**	VS_5			
15	VS_6	**16**	VS_7			
L+	DC24V	**M**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System* system manual

NOTE

The first BaseUnit of a potential group must be a light-colored BaseUnit.

NOTE

Make sure that you only use digital modules with BaseUnit type A0 during commissioning.

5.1.2 Wiring and block diagram

This section includes the block diagram of the digital input module F-DI 8×24VDC HF with the pin assignment.

You can find more information about wiring the BaseUnit in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Block diagram

The following figure shows the pin assignment of the F-DI 8×24VDC HF digital input module on BaseUnit BU type A0.

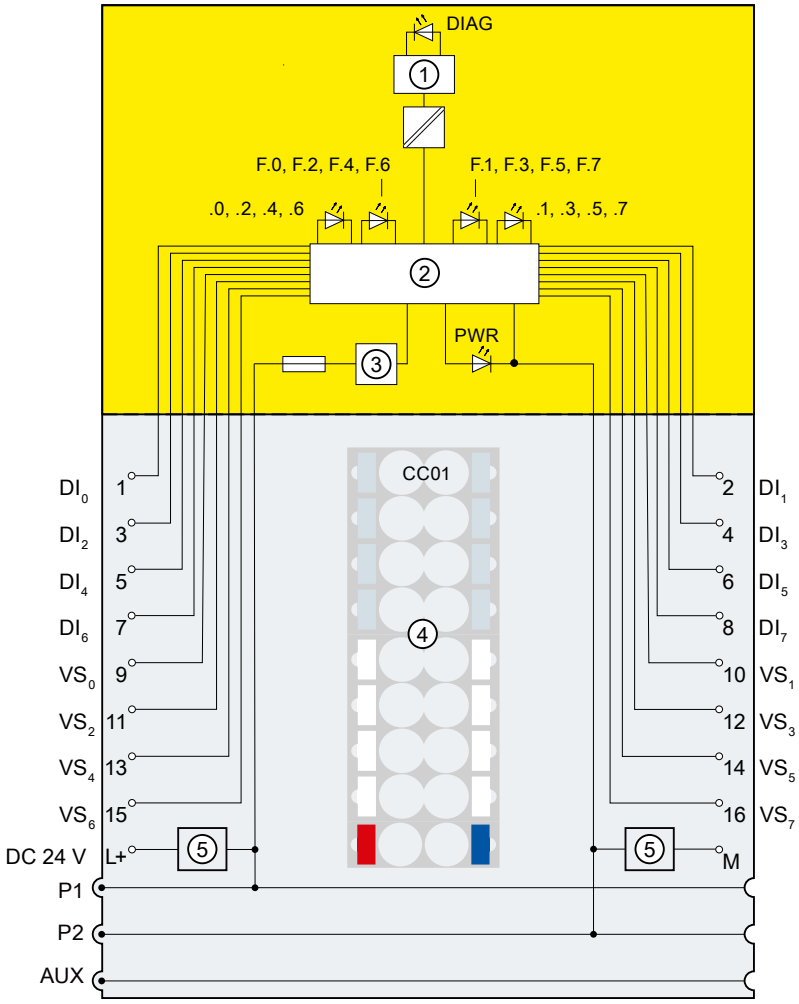

①	Backplane bus interface	VS_n	Internal sensor supply, channel n
②	Input electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Reverse polarity protection	DI_n	Input signal, channel n
④	Color identification label with color code CC01 (optional)	DIAG	Error or diagnostics LED (green, red)

⑤	Filter circuit supply voltage (available in light-colored BaseUnit only)	.0 to .7	Channel status LED (green)
L+	24 V DC (infeed only with light-colored BaseUnit)	F.0 to F.7	Channel fault LED (red)
M	Mass supply voltage	PWR	Power LED (green)

Figure 2-1448 Block diagram

5.2 Parameters/address space

5.2.1 Counter

Function

Counting is the detecting and adding up of events. The counter of the module detects sensor signals and pulses and evaluates them accordingly, e.g.:

- For counting piece goods up to a maximum limit
- For counting of continuous pulses

The counting process is performed by non-equivalent 1oo2 evaluation of the DI_0 and DI_4 inputs. You define the properties of the counter with the functions described below.

The counter matches relevant edges on DI_0 with relevant edges on DI_4.

The relevant edges are:

- Rising edges for DI_0
- Falling edges for DI_4

If a relevant edge is detected, the counter is incremented by the value 1 (when counting up) or decremented (when counting down).

In order for a rising or falling edge to be detected, a constant input signal must be present for the minimum pulse duration. See the figure below.

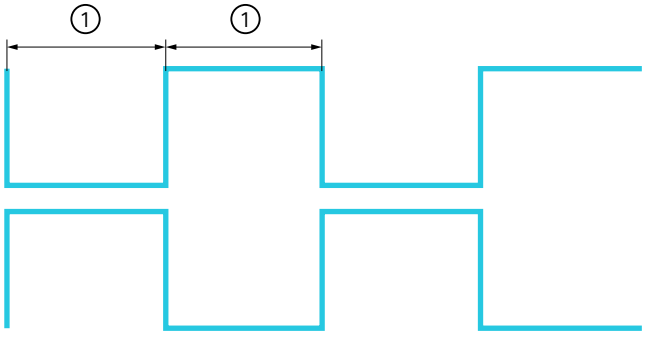

① Minimum pulse duration

Figure 2-1449 Minimum pulse duration

Table 2-1842 Numerical values

Input delay	Minimum pulse duration	Maximum frequency
0.4 ms	0.71 ms	500 Hz
0.8 ms	1.10 ms	400 Hz
3.2 ms	3.60 ms	130 Hz

NOTE

Maximum frequency exceeded

If the maximum frequency is exceeded, a diagnostic message (Frequency too high) may occur, even if the gate is closed.

WARNING

Input signals shorter than the minimum pulse duration may not be detected. This can lead to a falsification of the count value.

Counting limits

The counting limits define the range of the count value. You can only change the counting limits during parameter assignment. It is not possible to change the counting limits during runtime.

The following counting limits can be configured:

- **High counting limit**

The maximum configurable counting limit is 2000000000.

- **Low counting limit**

The minimum configurable counting limit is –2000000000.

You can continue or stop the counting processes when a counting limit is violated (Reaction to violation of a counting limit). In the event of an overflow or underflow of the count value, the respective event bit in the feedback interface is set to "1". See section Assignment of the counter feedback interface (Page 68).

Application examples for counter mode

Information on possible application examples can be found in the section Application examples for counter mode (Page 77).

Reset control

You have two options to reset the counter:

- Using the user program
- Via the digital inputs DI_2 and DI_6 or the user program

You can select one of these two options through parameter assignment. Resetting sets the counter value to the configured start value and clears all counter errors present on counter input channels DI_0 and DI_4. Counting errors can thus be eliminated and the passivated channel can be reintegrated.

In both cases, a rising edge on a control element (SW or HW) triggers the reset.

A reset is also necessary if errors have occurred on the other HW inputs.

After resetting, the counter starts counting automatically when the gate is at logic 1.

Gate control

The opening and closing of the hardware gate (HW gate) and software gate (SW gate) define the time window in which the counting signals are detected.

You have two options to control the gate:

- Via the user program (SW gate)
- Via the digital inputs DI_1 and DI_5 (HW gate)

You can select one of these two options through parameter assignment. The gate is closed when the control signal is at logic 0 and open when the control signal is at logic 1.

With the gate open, ensure that the two signals adopt unequal (antivalent) states ($DI_0 = 1$, $DI_4 = 0$ or $DI_0 = 0$, $DI_4 = 1$). If the signal on one channel changes, the other channel must change to the opposite state within the adjustable discrepancy time.

The gate control is active as long as no error is present. The gate control remains inactive even after a discrepancy error has been resolved and can only be reactivated by a reset. Only then will the error be reported as resolved and the outgoing error acknowledged.

When the gate is closed, the discrepancy evaluation of the digital inputs DI_0 and DI_4 is not active. However, exceeding the maximum possible frequency will continue to be monitored and will result in an error message even when the gate is closed.

After you have closed the gate, the two digital inputs of the counter must have adopted unequal (antivalent) states within the set "Discrepancy time limit" ($DI_0 = 1$, $DI_4 = 0$ or $DI_0 = 0$, $DI_4 = 1$). Otherwise, a diagnostic interrupt "Discrepancy error" can be triggered.

NOTE

Automatic closing of the gate

The gate is automatically closed in the following situations:

- If the CPU is in STOP mode
- CRC error in PROFIsafe communication
- In the event of a timeout of the PROFIsafe communication
- In the event of errors in the safety program that lead to a CPU STOP

WARNING

Reinitialization after parameter download

When you download the parameter assignment to the F-CPU, the internal module states are reinitialized. The internal module states thus correspond to the state on startup.

The reinitialization affects the following internal module states:

- Status and event bits in the process image are reset
- The count value is set to the start value

In addition to a user-command-controlled download of parameters from STEP 7 (TIA Portal), parameters are downloaded and the module is reinitialized in the following situations:

- Power cycling the F-CPU
- Pulling/plugging the module
- Power cycling the module supply voltage L+
- Power cycling the interface module in a distributed setup
- Pulling/plugging the PROFINET cable to the interface module in a distributed setup

Direction control

You have two options to control the counting direction:

- Using the user program
- Via the digital inputs DI_3 and DI_7

You can select one of these two options through parameter assignment. Changes in direction are only made when the gate is closed. The counting direction is up if the control signal is at logic 0 and down if the control signal is at logic 1.

Exceeding the counting limit

Exceeding the high or falling below the low counting limit is signaled by setting the corresponding event bit in the feedback interface.

You can acknowledge and clear these events via the user data interface (reset event) in the user program.

If a counting limit is exceeded twice without acknowledgment, the counter is deactivated and the "Channel passivated" diagnostics is generated.

5.2.2 Parameters

The "Counter" operating mode is only effective if the operating mode selection is configured as "Counter".

Parameters for "Counter" operating mode

The following parameters are possible:

Table 2-1843 Adjustable parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Module parameters:				
Operating mode	• Digital inputs • Counter • Standstill and Overspeed monitoring	Digital inputs	No	Module
F-parameters				
Manual assignment of the F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Depends on the parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Is proposed by the F-system	No	Module
F-parameter signature (without address)	0 to 65535	Is calculated by the F-system	No	Module
Behavior after channel fault	Passivate channel	Passivate channel (unchangeable)	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically	Adjustable	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	Is proposed by the F-system	No	Module
F-I/O DB name	—	Is proposed by the F-system	No	Module

Table 2-1844 Configurable counter parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Counter - Channel 0, 4				
Input delay	• 0.4 ms • 0.8 ms • 3.2 ms	3.2 ms	No	Channel pair

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Reset when counting limit is violated	• Start value • Opposite counting limit value	Start value	No	Channel pair
Reaction to violation of a counting limit	• Stop counting • Continue counting	Continue counting	No	Channel pair
Discrepancy limit [number of pulses]	1	1 (unchangeable)	No	Channel pair
Discrepancy time limit	5 ms to 30 s	5 ms	No	Channel pair
High counting limit	-2000000000 to 2000000000	2000000000	No	Channel pair
Low counting limit	-2000000000 to 2000000000	-2000000000	No	Channel pair
Start value	-2000000000 to 2000000000	0	No	Channel pair
Counting value change reported	When present on a single channel	When present on a single channel (unchangeable)	No	Channel pair
Channel failure acknowledge	• Manual • Automatic	Manual	No	Channel pair
Gate, reset, direction control				
Gate controlled by	• Software • Hardware	Software	No	Module
Reset controlled by	• Software • Software or Hardware	Software	No	Module
Direction controlled by	• Software • Hardware	Software	No	Module
Gate, reset, direction hardware control				
Sensor evaluation	1oo2 evaluation, non-equivalent	1oo2 evaluation, non-equivalent (unchangeable)	No	Channel pair
Discrepancy behavior	Supply last valid value	Supply last valid value (unchangeable)	No	Channel pair
Reintegration after discrepancy error	Test 0-Signal not necessary	Test 0-Signal not necessary (unchangeable)	No	Channel pair
Discrepancy time	5 ms to 30 s	5 ms	No	Channel pair
Channel failure acknowledge	Automatic	Automatic (unchangeable)	No	Channel pair
Input delay	• 0.4 ms • 0.8 ms • 3.2 ms	3.2 ms (3.2 ms is fixed and unchangeable for reset hardware control)	No	Channel pair

5.2.3 Explanation of parameters

5.2.3.1 Module parameters

Operating mode

This parameter is used to specify the desired operating mode.

The digital input module F-DI 8×24VDC HF can be operated in the following operating modes:

- "Digital inputs"
- “Counter"
- "Standstill and Overspeed monitoring"

5.2.3.2 F-parameters

F-parameters

You have to assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you start operation.

- You define the F-source address with the "Central F-source address" parameter in the F-CPU.
- The F-destination address is assigned automatically for each F-module CPU-wide. You can change the specified F-destination address in the hardware configuration manually.

Information on the F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB can be found in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults. In "Counter" mode, the parameter must be set to "Passivate channel".

Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use on S7-1200/1500 F-CPUs

When using the F-module on F-CPUs S7-1200/1500, set this parameter in the STEP 7 dialog of the F-module:

- "Adjustable"
- "All channels automatically"

The parameter "Behavior after channel fault" is set to "Passivate the channel". You allow the individual configuration of the reintegration type per channel using the "Adjustable" parameter assignment. The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

5.2.3.3 Counter parameters

Input delay

Input delay applied to the counting channels. See section Input delay (Page 30).

Reset when counting limit is violated

Determines whether the count value is to be set to the start value or to the opposite counting limit when the high or low counting limit is violated.

After a count overflow, the specified reset value is adjusted by one counting step to take the overflow pulse into account:

- When counting up: Reset value + 1
- When counting down: Reset value - 1

Reaction to violation of a counting limit

Determines the behavior when the high and low counting limit is violated. You can select whether counting continues or is stopped. If counting is to be stopped, you must close and reopen the gate to resume counting.

The following figure shows the reaction when a counting limit is violated and configured with "Continue counting":

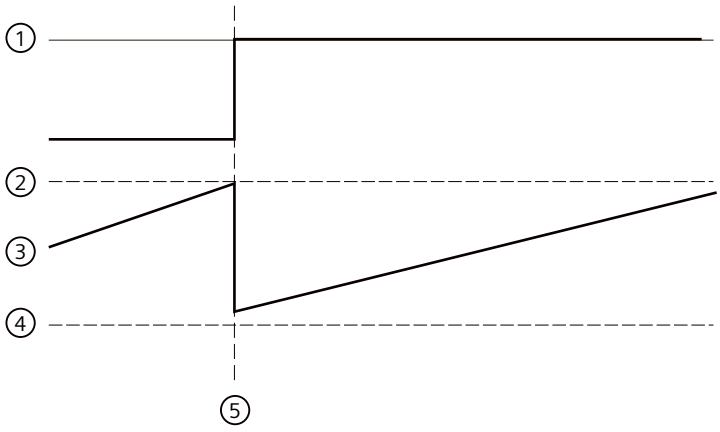

① Overflow status

② High counting limit

③ Evaluated count value

④ Start value/opposite counting limit

⑤ Count value exceeds the configured high counting limit, is reset to the initial value/opposite counting limit value +1 and counting continues.
The user program detects that the "Overflow status" bit changes to high, indicating that the upper counting limit has been exceeded. The user program detects an updated count value.

Discrepancy limit [number of pulses]

The discrepancy limit is the difference in the number of pulses between the two counting channels. The permissible discrepancy is fixed to one pulse. Because a pulse consists of two edges, the detection of a third unequal edge triggers a counting discrepancy error and the diagnostic message "Counter discrepancy limit exceeded" is generated for both channels.

Discrepancy time limit

The time limit for discrepancy is the maximum time within which, after a pulse edge is detected on one input signal (DI_0 or DI_4), a corresponding edge must be detected on the opposite input signal (DI_4 or DI_0). The discrepancy time is measured for each individual unequal edge.

If an edge does not match after the set discrepancy time has expired, e.g. due to a wire break in a sensor cable, a discrepancy error is detected and the diagnostic message "Discrepancy error" is generated for both channels.

High counting limit

You limit the counting range by specifying the high counting limit. When the current count value exceeds the high counting limit, an overflow event is triggered in the feedback interface. You can select if counting is stopped or continued after the high counting limit is exceeded. The current count value is then set to the start value +1 or the low counting limit +1, depending on the parameter assignment. The high counting limit must be greater than the start value. The permissible range is between -2000000000 and 2000000000. The default setting is 2000000000.

Low counting limit

You limit the counting range by specifying the low counting limit. If the current count value falls below the low counting limit, an underflow event is triggered in the feedback interface. You can select if counting is stopped or continued after the low counting limit is undershot. The current count value is then set to the start value -1 or the high counting limit -1, depending on the parameter assignment. The low counting limit must be lower than the start value. The permissible range is between -2000000000 and 2000000000. The default setting is -2000000000.

Start value

You determine the count value at the beginning of the counting by configuring the start value. The current count value is reset to the start value in the following situations:

- After startup
- After parameter download
- After reset
- When the counting limit is exceeded, if configured

The start value must be a value between the high and low counting limit. The permissible range is between -2000000000 and 2000000000. The default setting is 0.

Counting value change reported

Determines when the count value is updated. This parameter is always set to "When present on a single channel". This results in an update being triggered as soon as a "single" rising edge on the primary channel DI_0 or a "single" falling edge on the secondary channel DI_4 is detected. In this context, "single" means that it is not a matching edge. A matching edge is an edge that coincides with an opposite edge already detected on the other channel.

Channel failure acknowledge

Determines how faults on channels 0 and 4 are acknowledged.

You can select from the following options:

- Manual
- Automatic

5.2.3.4 Parameters for gate, reset and direction control

Gate, reset and direction control

Specifies the source for gate, reset, and direction control.

You can select the following options for the gate or direction control:

- "Software"
- "Hardware"

You can choose the following options for the reset control:

- "Software"
- "Software or Hardware"

The default setting is "Software".

NOTE

If you select the "Hardware" option, the respective internal sensor supply is automatically enabled. However, their use in the wiring is optional.

5.2.3.5 Parameters for gate, reset and direction hardware control

Sensor evaluation

If the hardware control option is selected, the setting is always "1oo2 evaluation, non-equivalent". For more information, see section Sensor evaluation (Page 25).

Discrepancy behavior

If the hardware control option is selected, the setting is always "Supply last valid value". For more information, see section Discrepancy behavior (Page 26).

Reintegration after discrepancy error

If the hardware control option is selected, the setting is always "Test 0-Signal not necessary". For more information, see section Reintegration after discrepancy error (Page 28).

Discrepancy time

For more information, see section Discrepancy time (Page 27).

Channel failure acknowledge

This setting is always "Automatic". For more information, see section Channel failure acknowledge (Page 29).

Input delay

For more information, see section Input delay (Page 30).

5.2.4 Address space

Address assignment of the digital input module F-DI 8×24VDC HF in "Counter" operating mode

The digital input module F-DI 8×24VDC HF occupies the following address areas in the F-CPU:

Table 2-1845 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In the input range**	**In the output range**
S7-1200/1500 F-CPUs*	IB x + 0 to x + 14	QB x + 0 to x + 5

*) The counter only works with F-CPUs that support PROFIsafe version 2.6.1

x = Module start address

Address assignment of the user data and the value status of digital input module F-DI 8×24VDC HF in "Counter" operating mode

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital input module F-DI 8×24VDC HF:

Table 2-1846 User data address assignment in the input range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Reserved				HW direction signal	HW reset signal	HW gate signal	Reserved
IB x + 1	Reserved		Underflow status	Overflow status	Direction status	Reset status	Gate status	Reserved

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
IB x + 2	Count value							
IB x + 3								
IB x + 4								
IB x + 5								
IB x + 6	Reserved				HW direction value status	HW reset value status	HW gate value status	Reserved
IB x + 7	Reserved		Value status of underflow status	Value status of overflow status	Value status of direction status	Value status of reset status	Value status of gate status	Reserved
IB x + 8	Reserved							Value status of count value
IB x + 9	Reserved			Event reset controlled by SW	Direction controlled by SW	Reset controlled by SW	Gate controlled by SW	Reserved

Table 2-1847 User data address assignment in the output range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
QB x + 0	Reserved			Event reset	SW direction control	SW reset control	SW gate control	Reserved

5.2.5 Assignment of the control interface counter

The safety program can influence the behavior of the module in "Counter" operating mode via the control interface.

Assignment of the control interface

The following table shows the assignment of the control interface:

Table 2-1848 Address assignment in the F-CPU

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
QB x + 0	Reserved			Event reset	SW direction control	SW reset control	SW gate control	Reserved

Explanations

Table 2-1849 Explanations

Byte	Bit	Control bit/value	Explanations
QB x + 0	1	SW gate control	Use this bit to control whether the software gate is open, and thus counting is activated. • 0: SW gate closed, counting stopped • 1: SW gate open, counting possible
QB x + 0	2	SW reset control	Use this bit to reset the current value to the configured start value. • 0: No action • 1: Resets the counter to the start value and clears all counter errors present on the channels. The "SW reset" action is always initiated when this bit transitions from 0 to 1. The counter is set to the "Start value" and any error status present on the channels of the counter is cleared.
QB x + 0	3	SW direction control	Use this bit to specify the counting direction. • 0: Counting direction up • 1: Counting direction down Changes in direction are only made when the gate is closed.
QB x + 0	4	Event reset	Use this bit to reset the following status bits in the feedback interface: • Underflow status • Overflow status As long as the "Reset event" bit is set to 1, the "Underflow status" and "Overflow status" bits are continuously reset.

5.2.6 Assignment of the feedback interface counter

In "Counter" operating mode, the safety program can receive actual values and status information via the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Table 2-1850 Assignment of the feedback interface

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Reserved				HW direction signal	HW reset signal	HW gate signal	Reserved
IB x + 1	Reserved		Underflow status	Overflow status	Direction status	Reset status	Gate status	Reserved
IB x + 2	Count value							
IB x + 3								
IB x + 4								
IB x + 5								

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
IB x + 6	Reserved				HW direction value status	HW reset value status	HW gate value status	Reserved
IB x + 7	Reserved		Value status of underflow status	Value status of overflow status	Value status of direction status	Value status of reset status	Value status of gate status	Reserved
IB x + 8	Reserved							Value status of count value
IB x + 9	Reserved			Event reset controlled by SW	Direction controlled by SW	Reset controlled by SW	Gate controlled by SW	Reserved

Explanations

Table 2-1851 Explanations

Byte	Bit	Feedback bit/value	Description
IB x + 0	1	HW gate signal	Only valid if the HW control is configured for the gate. The signal value is formed via a 1oo2 evaluation, non-equivalent of the digital inputs DI_1 and DI_5.
IB x + 0	2	HW reset signal	Only valid if the HW control is configured for the reset. The signal value is formed via a 1oo2 evaluation, non-equivalent of the digital inputs DI_2 and DI_6.
IB x + 0	3	HW direction signal	Only valid if the HW control is configured for the direction. The signal value is formed via a 1oo2 evaluation, non-equivalent of the digital inputs DI_3 and DI_7.
IB x + 1	1	Gate status	The "Gate status" bit indicates that the module has received the gate control from either the SW control interface or the HW control and has responded as follows: • If the gate control is set to 1, the "Gate status" bit is also set to 1. The module begins monitoring the counter channel pair. • If the gate control is set to 0, the "Gate status" bit is also set to 0. Changes to the counter channel pair are ignored.
IB x + 1	2	Reset status	The "Reset status" bit indicates that the module has received the "Reset" from the control interface and responded as follows: • If the reset control transitions from 0 to 1, the module sets the count value to the start value and clears the counter error states. The "Reset status" bit is set to 1. • If the reset control is set to 0, the "Reset status" bit is also set to 0. If both HW and SW control are used, both must be set to 0 to clear the status bit.
IB x + 1	3	Direction status	The "Direction status" bit indicates the counting direction. • 0: Counting direction is up • 1: Counting direction is down

Byte	Bit	Feedback bit/value	Description
IB x + 1	4	Overflow status	The "Overflow status" bit is always set when the current count value exceeds the configured "High counting limit". • 0: High counting limit not violated • 1: High counting limit was violated The overflow status bit remains set to 1 until the "Event reset" bit of the module is set to 1, and remains cleared as long as the “Event reset” bit is set to 1.
IB x + 1	5	Underflow status	The "Underflow status" bit is always set when the current count value falls below the configured "Low counting limit". • 0: Low counting limit not violated • 1: Low counting limit was violated The “Underflow status” bit remains set to 1 until the "Event reset" bit of the module is set to 1, and remains cleared as long as the "Event reset" bit is set to 1.
IB x + 2 **IB x + 3** **IB x + 4** **IB x + 5**	0-7	Count value	The count value is a 32-bit signed integer value with a high limit of 2 billion and a low limit of -2 billion.
IB x + 6	1	HW gate value status	Contains the value status of the hardware control inputs in the event that gate is controlled by the hardware.
IB x + 6	2	HW reset value status	Contains the value status of the hardware control inputs in the event that reset is controlled by the hardware.
IB x + 6	3	HW direction value status	Contains the value status of the hardware control inputs in the event that direction is controlled by the hardware.
IB x + 7	1	Value status of gate status	Contains the value status of gate status
IB x + 7	2	Value status of reset status	Contains the value status of reset status
IB x + 7	3	Value status of direction status	Contains the value status of direction status
IB x + 7	4	Value status of overflow status	Contains the value status of overflow status
IB x + 7	5	Value status of underflow status	Contains the value status of underflow status
IB x + 8	0	Value status of count value	Contains the value status of count value
IB x + 9	1	Gate controlled by SW	Contains bit that indicates whether gate is software-controlled.*
IB x + 9	2	Reset controlled by SW	Contains bit that indicates whether reset is software-controlled.*
IB x + 9	3	Direction controlled by SW	Contains bit indicating whether direction is software-controlled.*
IB x + 9	4	Event reset controlled by SW	Contains bit indicating whether reset event is software-controlled.*

*) This can only be changed by parameter assignment.

A detailed bit assignment of the bytes IB x + 6 to IB x + 9 can be found in the table "Address assignment by user data in the input range (Page 66)".

5.3 Use cases for Counter (as of firmware version V3.0.0)

WARNING

Make sure that the highest frequency occurring in the application does not exceed 500 Hz.

WARNING

Reinitialization after parameter download

When you download the parameter assignment to the F-CPU, the internal module states are reinitialized. The internal module states thus correspond to the state on startup.

The reinitialization affects the following internal module states:

- Status and event bits in the process image are reset
- The count value is set to the start value

In addition to a user-command-controlled download of parameters from STEP 7 (TIA Portal), parameters are downloaded and the module is reinitialized in the following situations:

- Power cycling the F-CPU
- Pulling/plugging the module
- Power cycling the module supply voltage L+
- Power cycling the interface module in a distributed setup
- Pulling/plugging the PROFINET cable to the interface module in a distributed setup

WARNING

In the time range $2*T_{cycle}$ before the gate opens, signal changes at the inputs DI_0 and DI_4 can be included in the count value.

In the time range $2*T_{cycle}$ before the gate closes, signal changes at the inputs DI_0 and DI_4 are not necessarily included in the count value.

Ensure that, in these time ranges, either no signal changes occur at DI_0 and DI_4, or the influence of signal changes occurring in these time ranges on the count value is tolerated by the application.

When using the software gate, the times described in the section "Monitoring and response times" in the programming and operating manual "Industrial Software SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126)" influence the gate control. These times can influence the count value and must be taken into account in the application.

Details on this can be found in the application examples (Page 77).

Inputs for counter

The digital input module F-DI 8x24VDC HF has 8 fail-safe inputs, DI_0 to DI_7.

The inputs are paired in a non-equivalent 1oo2 logic and are used as follows:

- DI_0 and DI_4 are used as counting channels.
- DI_1 and DI_5 are used optionally for HW gate control.
- DI_2 and DI_6 are used optionally for HW reset control.
- DI_3 and DI_7 are used optionally for HW direction control.

The process signals for the HW controls are provided by channels DI_1, DI_2 and DI_3.

The counter counts the number of relevant edges detected on both DI_0 and DI_4. The higher count value on relevant edges of both channels is output as the count value by the module.

Relevant edges are:

- Rising edges for DI_0
- Falling edges for DI_4

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

In “Counter” mode, the internal sensor supplies are permanently assigned to the inputs and cannot be changed.

- VS_0 to DI_0 and VS_4 to DI_4 (always activated)
- VS_1 to DI_1 and VS_5 to DI_5 (activated if the HW gate control is configured)
- VS_2 to DI_2 and VS_6 to DI_6 (activated if the HW reset control is configured)
- VS_3 to DI_3 and VS_7 to DI_7 (activated if the HW direction control is configured)
- The short-circuit tests of the sensor supplies are permanently deactivated.

NOTE

The use of the internal sensor supply in the wiring is optional.

NOTE

Avoidance of interference due to high-energy surge voltages

To avoid interference caused by high-energy surge voltages, you must observe the following restrictions when operating in "Counter" mode:

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 3.2 ms:

No restrictions

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.8 ms:

For the DI_0 and DI_4 inputs, you need to use either shielded cables with a maximum length according to the technical specifications (Page 120) or unshielded cables with a maximum length of 30 m. When unshielded cables are used, they can only be installed inside a building.

The following applications are not supported:

- Applications according to NAMUR recommendation NE 21
- Applications according to EN 298
- Shipbuilding applications

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.4 ms:

For the DI_0 and DI_4 inputs, you need to use either shielded cables with a maximum length according to the technical specifications (Page 120) or unshielded cables with a maximum length of 30 m. When unshielded cables are used, they can only be installed inside a building.

The following applications are not supported:

- Applications according to NAMUR recommendation NE 21
- Applications according to EN 298
- Shipbuilding applications

The length of the cable between the power supply unit and the F-module cannot be greater than 30 m. The cable can only be installed inside a building.

NOTE

Interruptions of the supply voltage according to IEC 61131-2 are not buffered by the F-module and thus influence the internal sensor supplies. This can lead to the occurrence of diagnostics and passivation of the F-module in "Counter" operating mode. To ensure problem-free functioning of the F-module and the sensors, we recommend the following:

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 3.2 ms:

No additional measures necessary.

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.8 ms or 0.4 ms:

For the power supply, use a separate power supply unit that only supplies voltage to digital input modules F-DI 8x24VDC HF in "Counter" operating mode and the associated sensors.

WARNING

When selecting the sensors, take into account that test pulses at the output of the sensor may influence the counter value.

Wiring diagram - Use case with external sensor supply

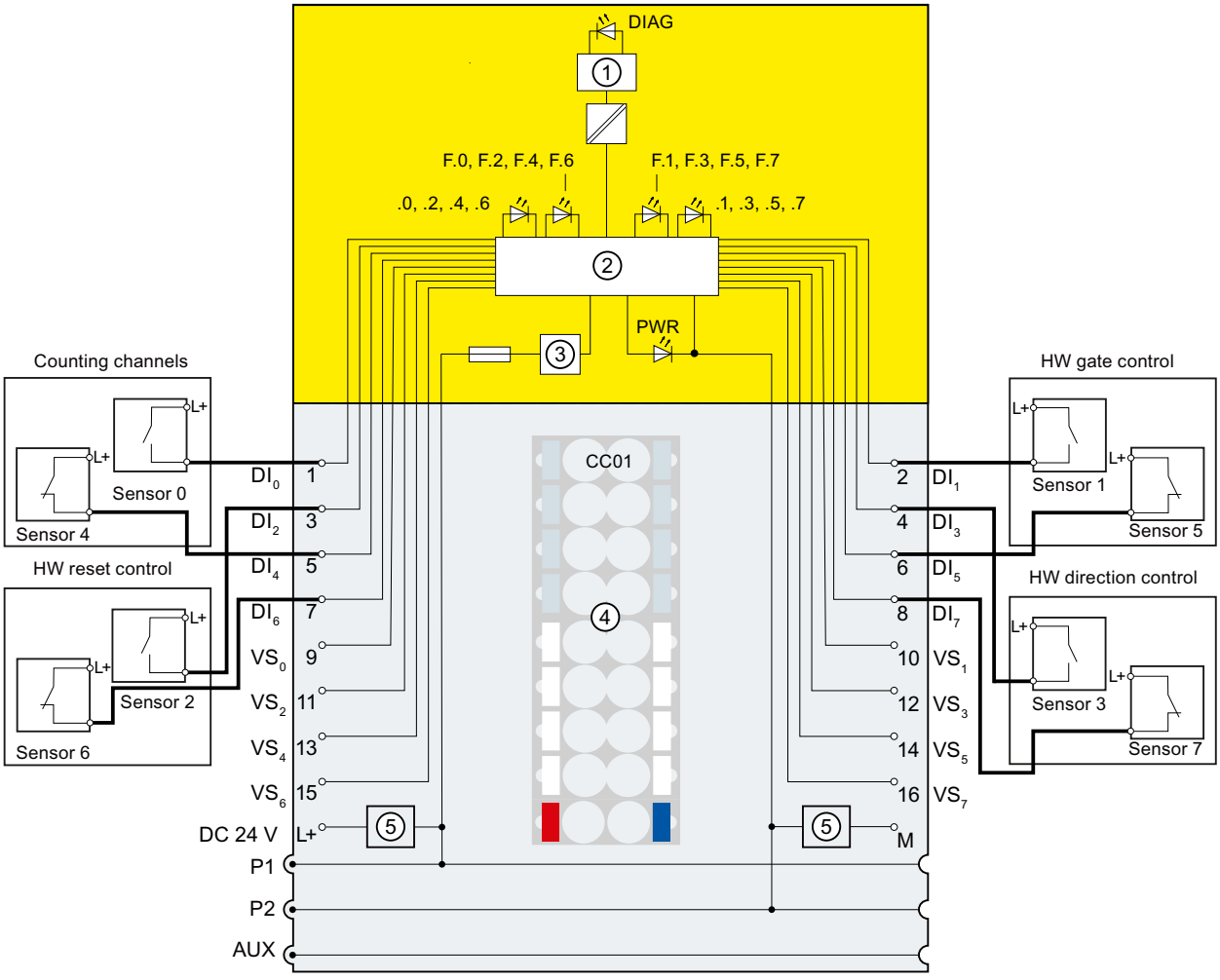

Figure 2-1450 Use case with external sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram - Use case with internal sensor supply

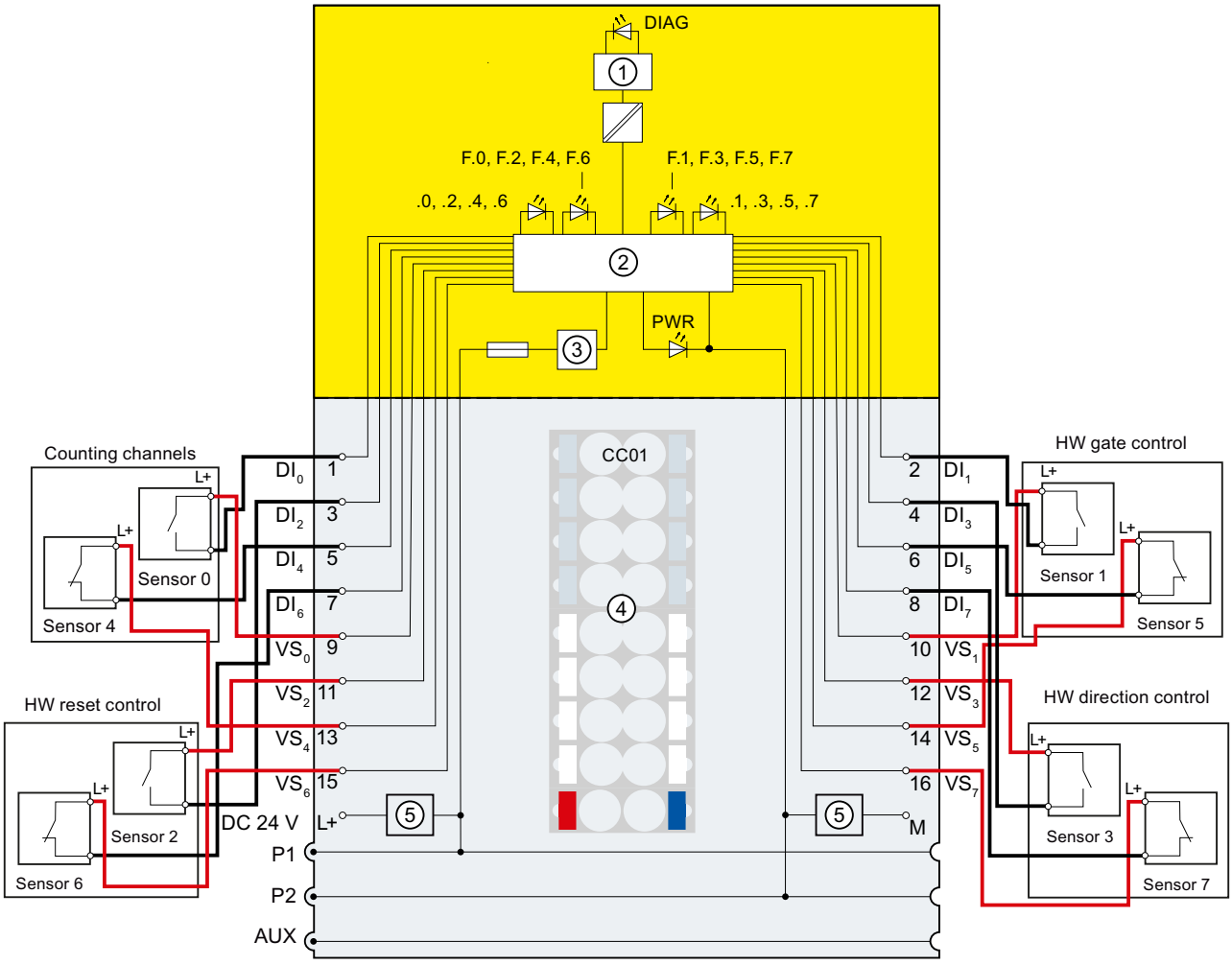

Figure 2-1451 Use case with internal sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Fault detection

The following tables show the fault detection depending on the sensor supply:

Table 2-1852 Error detection at counter inputs (DI_0 and DI_4)

Faults	Fault detection at counter inputs	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_0 or DI_4	Yes*	Yes*
Short-circuit with M to DI_0 or DI_4	Yes*	Yes*
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-
Discrepancy error	Yes	Yes
Counter discrepancy limit exceeded	Yes	Yes
Wire break	Yes*	Yes*

*) All these errors are detected based on the discrepancy. A discrepancy error is reported after the discrepancy time. Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption compared to the sensor signal, error detection is neither possible nor required from a safety standpoint.

Table 2-1853 Fault detection at HW inputs (DI_1, DI_2, DI_3, DI_5, DI_6 and DI_7)

Faults	Fault detection at HW control inputs	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption compared to the sensor signal, error detection is neither possible nor required from a safety standpoint.

5.4 Application examples for counter mode

The following are two possible application examples for counter mode:

- Piece count
- Counting of continuous pulses

Piece count

In the illustrated example, the number of items transported on a conveyor belt is counted. The counting is performed via two sensors connected to DI_0 and DI_4.

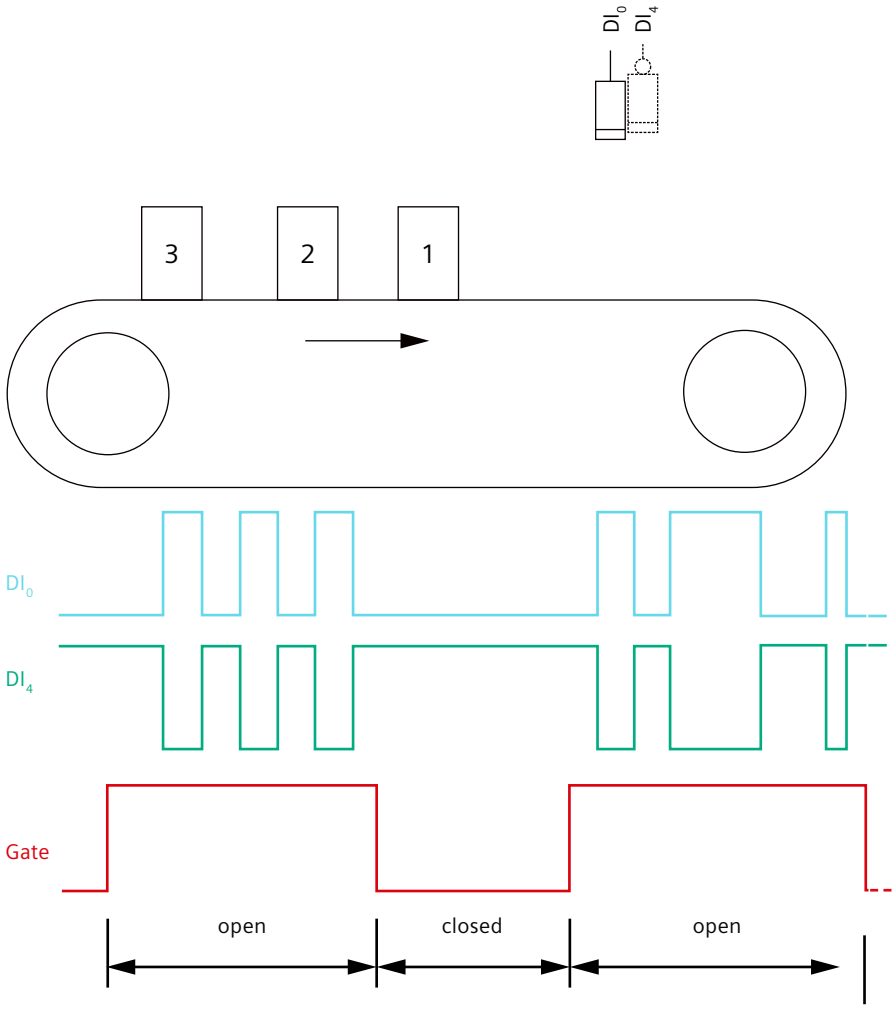

Figure 2-1452 Piece count

The piece count refers to cases where an exact number of events is to be counted.

The piece count is defined by the following main characteristics:

- The signal change at the inputs occurs at an unpredictable time.
- The cycle duration and width of the pulses are variable.
- If the gate of the counter is open, the signal changes at the inputs can be stopped, paused, or resumed.
- This application example allows for an exact count value. (For details, see Rules and restrictions)

Rules and restrictions:

WARNING

In the time range 2*T_{cycle} before the gate opens, signal changes at the inputs DI_0 and DI_4 can be included in the count value.

In the time range 2*T_{cycle} before the gate closes, signal changes at the inputs DI_0 and DI_4 are not necessarily included in the count value.

Ensure that, in these time ranges, either no signal changes occur at DI_0 and DI_4, or the influence of signal changes occurring in these time ranges on the count value is tolerated by the application.

When using the software gate, the times described in the section "Monitoring and response times" in the programming and operating manual "Industrial Software SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126)" influence the gate control. These times can influence the count value and must be taken into account in the application.

NOTE

After you have closed the gate, the two digital inputs of the counter must have adopted unequal (antivalent) states within the set "Discrepancy time limit" (DI_0 = 1, DI_4 = 0 or DI_0 = 0, DI_4 = 1). Otherwise, a diagnostic interrupt "Discrepancy error" can be triggered.

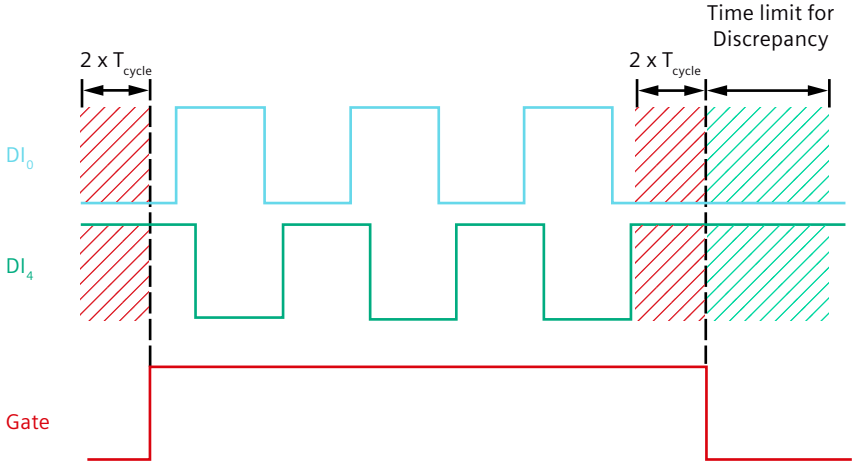

Figure 2-1453 Leader and trailer

Counting of continuous pulses

In the illustrated example, the length of the item transported on a conveyor belt is determined.

The object is detected and the gate is controlled via sensors at digital inputs DI_1 and DI_5.

A cam disk is placed on the drive shaft of the conveyor belt. This is detected by sensors connected to DI_0 and DI_4. The length of the object can be inferred from the pulses counted by the sensors.

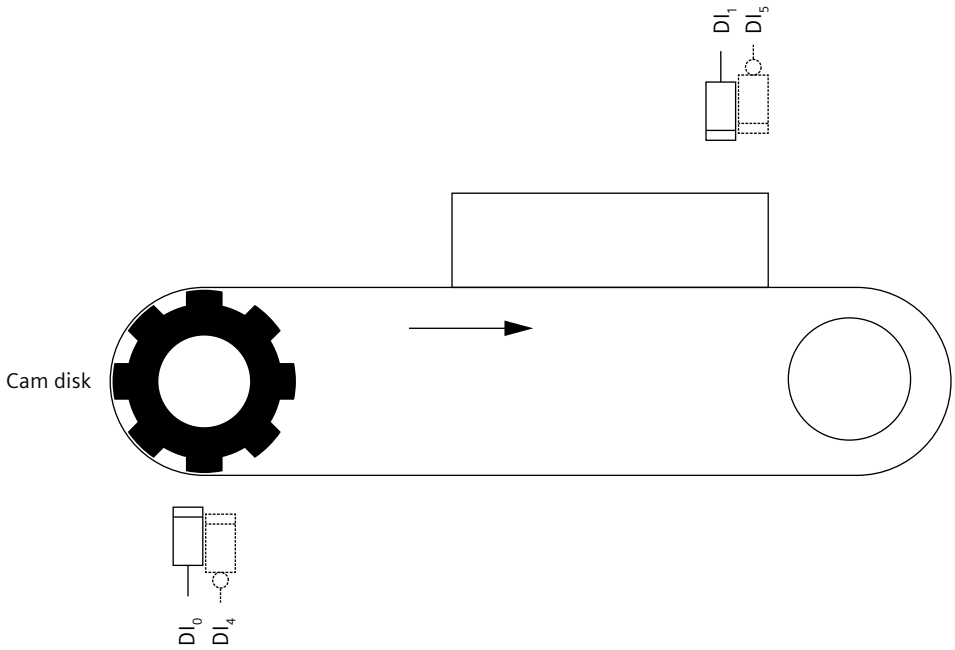

Counting continuous pulses refers to cases where recurring events are to be counted.

The counting of continuous pulses is defined by the following main characteristics:

- The signal change at the inputs occurs periodically.
- The maximum cycle duration of the pulses applied to the inputs depends on the "Discrepancy time limit" parameter.
- If the counter gate is open, the signal changes at the inputs **cannot** be stopped, paused, or resumed.
- This application example is suitable for applications that allow a tolerance-based count value. (For details, see Rules and restrictions)

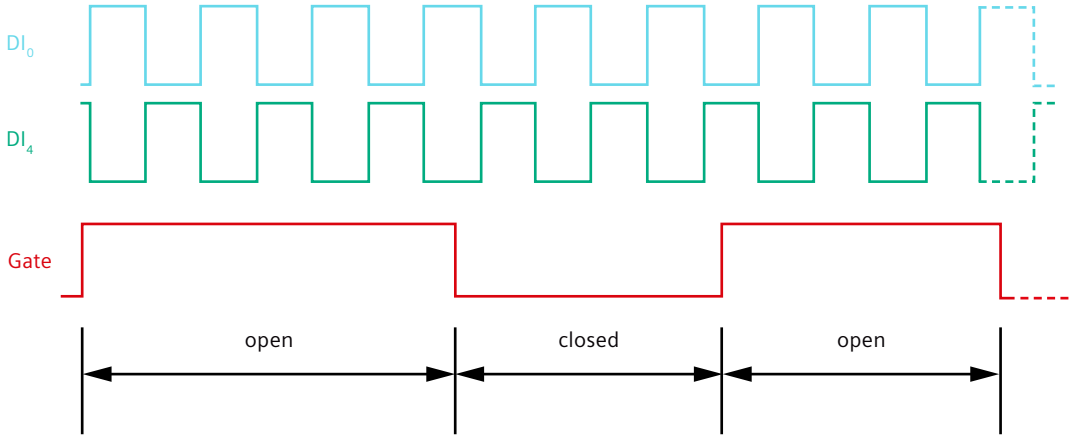

Figure 2-1454 Counting of continuous pulses

Rules and restrictions:

- Ensure that the time assigned in the "Discrepancy time limit" parameter is longer than the longest time that the counter inputs are expected to remain unchanged (the longest gap between 2 edges). The figure below shows a continuous pulse pattern that alternates between three cycle durations: P1, P2, P3. The time assigned in the "Discrepancy time limit" parameter must be greater than T1. T1 is the largest distance between 2 edges.

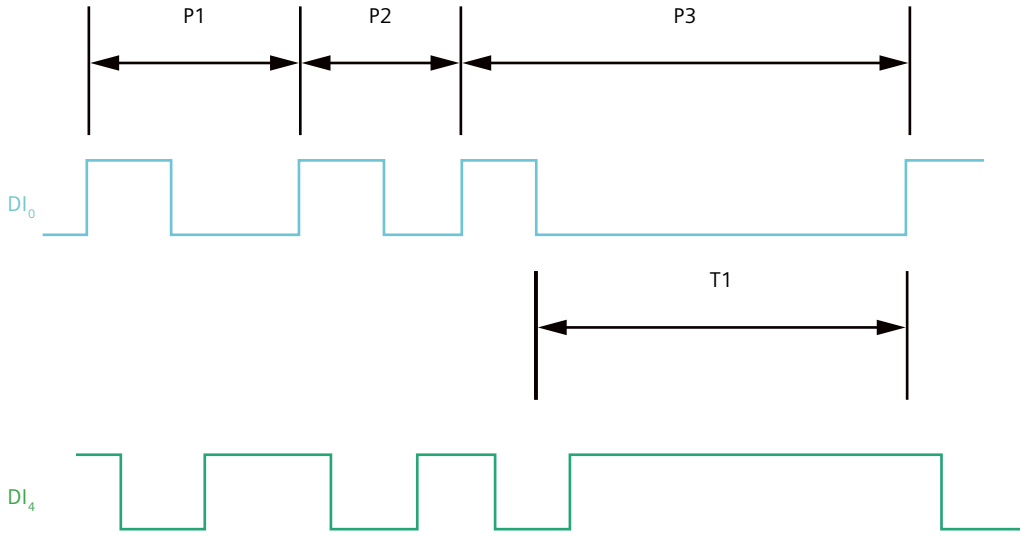

Figure 2-1455 Pulse pattern

WARNING

In the time range $2*T_{cycle}$ before the gate opens, signal changes at the inputs DI_0 and DI_4 can be included in the count value.

In the time range $2*T_{cycle}$ before the gate closes, signal changes at the inputs DI_0 and DI_4 are not necessarily included in the count value.

Ensure that, in these time ranges, either no signal changes occur at DI_0 and DI_4, or the influence of signal changes occurring in these time ranges on the count value is tolerated by the application.

When using the software gate, the times described in the section "Monitoring and response times" in the programming and operating manual "Industrial Software SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126)" influence the gate control. These times can influence the count value and must be taken into account in the application.

NOTE

Ensure that the continuous pulse pattern shown in the "Leader and trailer" figure is detected by inputs DI_0 and DI_4 for at least $2*T_{cycle}$ before the gate is opened. Otherwise, a diagnostic interrupt "Discrepancy error" can be triggered.

Ensure that, after the gate is closed, the continuous pulse pattern is detected by inputs DI_0 and DI_4 for at least the configured "Discrepancy time limit". Otherwise, a diagnostic interrupt "Discrepancy error" can be triggered.

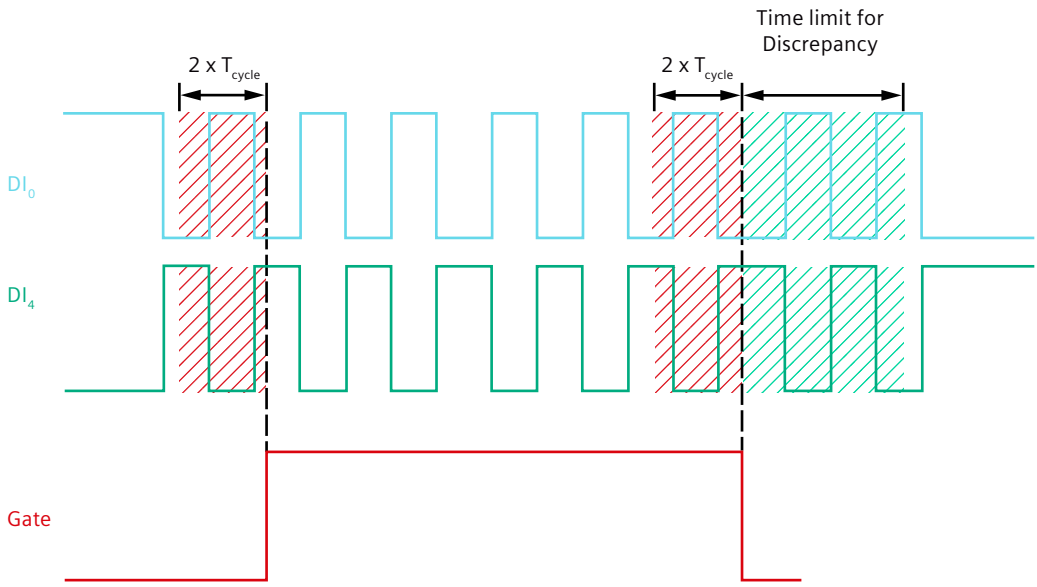

Figure 2-1456 Leader and trailer

Standstill and Overspeed monitoring operating mode

6

6.1 Wiring

6.1.1 Pin assignment "Standstill and Overspeed monitoring" operating mode

Pin assignment for the "Standstill and Overspeed monitoring" operating mode

Table 2-1854 Pin assignment for the "Standstill and Overspeed monitoring" operating mode

Pin assignment for the "Standstill and Overspeed monitoring" operating mode						
Terminal	**Assignment**	**Terminal**	**Assignment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • VS_n: Internal sensor supply, channel n	A0	 CC01 6ES7193-6CP01-2MA0
3	DI_2	**4**	DI_3			
5	DI_4	**6**	DI_5			
7	DI_6	**8**	DI_7			
9	VS_0	**10**	VS_1			
11	VS_2	**12**	VS_3			
13	VS_4	**14**	VS_5			
15	VS_6	**16**	VS_7			
L+	DC24V	**M**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System* system manual

NOTE

The first BaseUnit of a potential group must be a light-colored BaseUnit.

NOTE

Make sure that you only use digital modules with BaseUnit type A0 during commissioning.

6.1.2 Wiring and block diagram

This section includes the block diagram of the digital input module F-DI 8×24VDC HF with the pin assignment.

You can find more information about wiring the BaseUnit in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Block diagram

The following figure shows the pin assignment of the F-DI 8×24VDC HF digital input module on BaseUnit BU type A0.

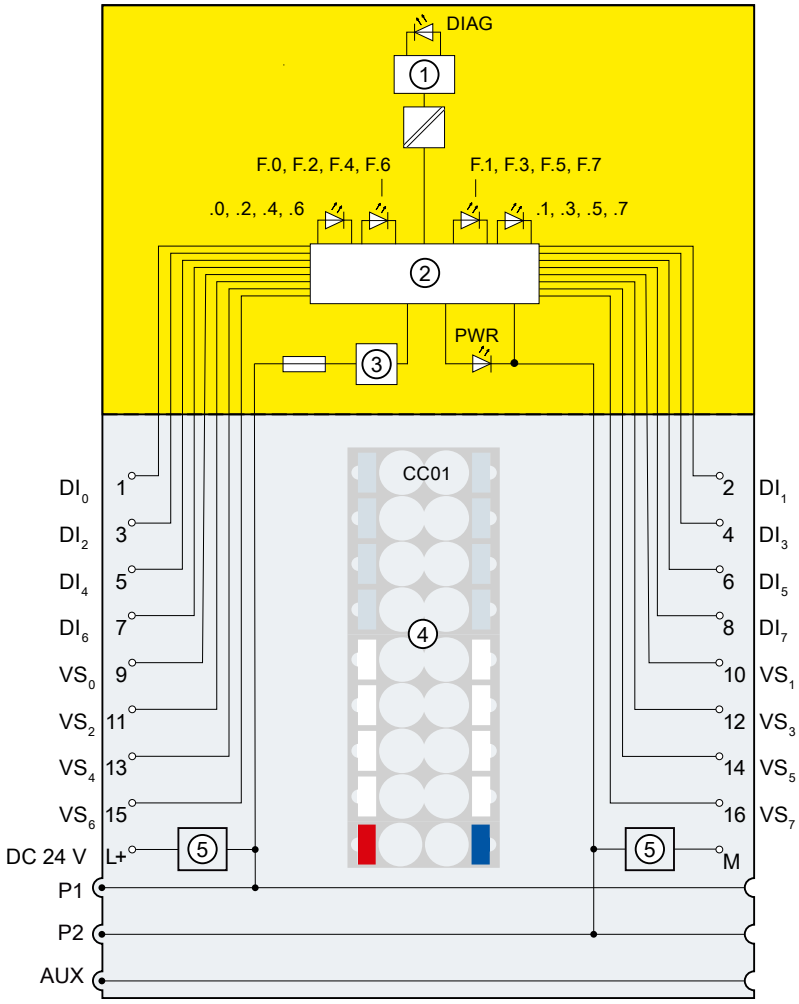

①	Backplane bus interface	VS_n	Internal sensor supply, channel n
②	Input electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Reverse polarity protection	DI_n	Input signal, channel n
④	Color identification label with color code CC01 (optional)	DIAG	Error or diagnostics LED (green, red)

⑤	Filter circuit supply voltage (available in light-colored BaseUnit only)	.0 to .7	Channel status LED (green)
L+	24 V DC (infeed only with light-colored BaseUnit)	F.0 to F.7	Channel fault LED (red)
M	Mass supply voltage	PWR	Power LED (green)

Figure 2-1457 Block diagram

6.2 Parameters/address space

6.2.1 Standstill and overspeed monitoring

Function

Standstill and overspeed monitoring means the detection of periodically occurring pulse events. The module determines the number of pulses occurring in a defined time window and evaluates them.

Possible applications include:

- Monitoring for excessively high speed during rotation
- Monitoring of the standstill or runout of a rotational movement to its maximum residual speed

The standstill and overspeed monitoring is carried out by means of 1oo2 evaluation of the inputs DI_0 and DI_4. The following figure shows the required pulse pattern.

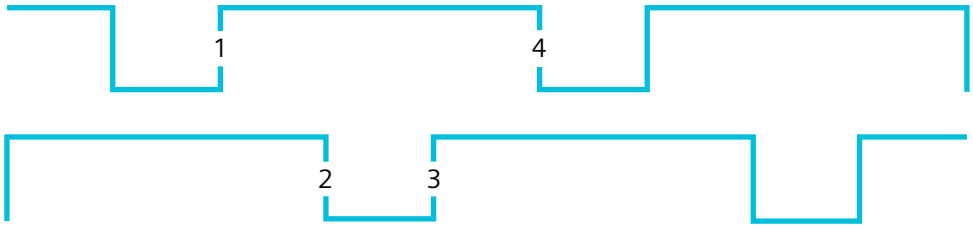

Figure 2-1458 Pulse pattern

Between a rising edge (1) and falling edge (4) on the first channel, there must always be a falling edge (2) and a rising edge (3) on the second channel.

In order for a rising or falling edge to be detected, a constant input signal must be present for the minimum pulse duration. See the figure below.

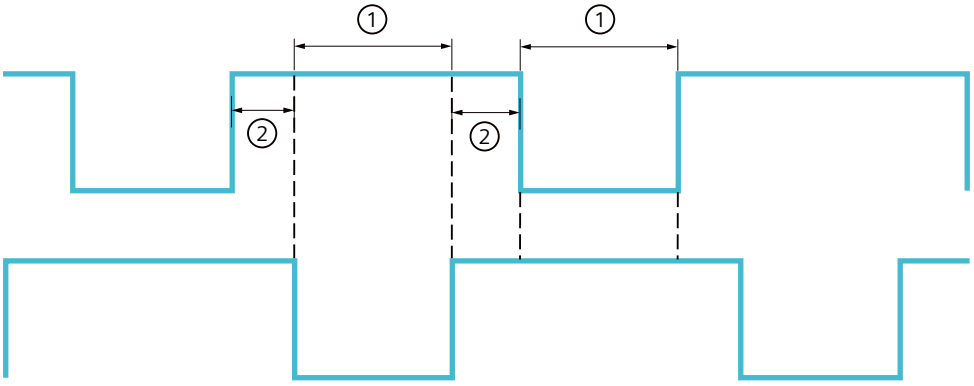

① Minimum pulse duration of the "0" signal

② Minimum duration between edge changes = 330 µs

Figure 2-1459 Minimum pulse length

Table 2-1855 Numerical values

Input delay	Minimum pulse duration of the "0" signal	Maximum frequency
0.4 ms	0.71 ms	480 Hz
0.8 ms	1.10 ms	350 Hz
3.2 ms	3.60 ms	120 Hz

NOTE

Maximum frequency exceeded

If the maximum frequency is exceeded, a diagnostic message (Frequency too high) may occur, even if the gate is closed.

⚠ WARNING

Input signals shorter than the minimum pulse duration may not be detected. This can lead to a falsification of the standstill and speed detection.

The pulse pattern requirements can be met with applications using a cam disk mounted on a motor shaft. For example, in the following figure in which the sensors are designed as normally open contacts:

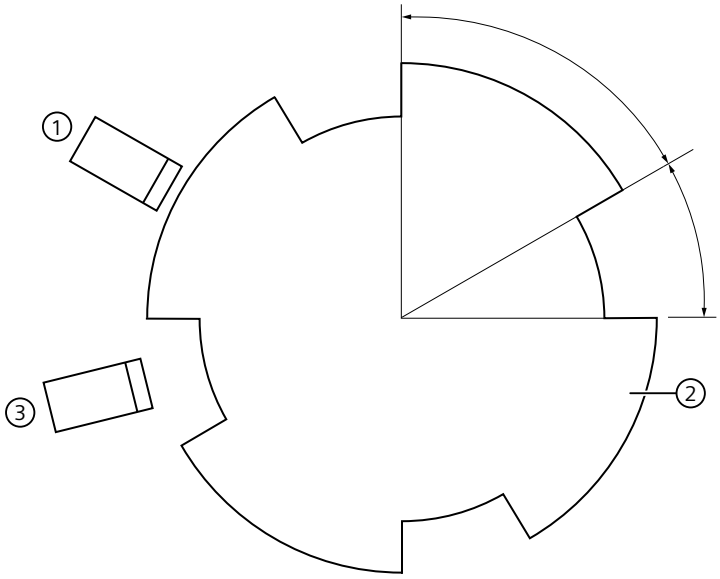

① Sensor 1
② Cam disk
③ Sensor 2

Figure 2-1460 Example of a pulse detection

With pulse detection, note the following:

- The segment that provides the "1" signal state is larger than the segment that represents the "0" signal state.
- You must position the sensors so that the signals on both sensors do not change at the same time and do not deliver the signal state "0" at the same time.
- After the logic of a sensor switches from 1 to 0, a minimum pulse duration of the "0" signal must be observed. During this entire duration, both sensors must constantly maintain their logic.

  Furthermore, a minimum duration of at least 330 µs must be between the edge changes. This period defines a phase in which both sensors must consistently keep logical 1 at the same time.
- After each logic change on either of the two sensors, a minimum pulse duration should elapse during which the logic on both sensors remains unchanged. See figure "Minimum pulse length" at the beginning of this section.

You define the properties of the standstill and overspeed monitoring with the functions described below.

Standstill monitoring counts the number of relevant edges.

Relevant edges are:

- Rising edges for DI_0
- Rising edges for DI_4 (valid only for tolerant discrepancy evaluation method during standstill)

The standstill monitoring reports the counted number of relevant edges in each monitoring window (at the end of the monitoring window):

- If the tolerant discrepancy evaluation method during standstill is configured, the highest counter reading of DI_0 and DI_4 is reported.
- If the tolerant discrepancy evaluation method during standstill is not configured, the counter reading of DI_0 is reported.

You can find additional information in the section "Use case standstill and overspeed monitoring (Page 101)".

Standstill monitoring

You set the standstill monitoring by selecting a standstill threshold and the duration of a monitoring window. The pulses per monitoring window are counted and compared to the standstill threshold at the end of each monitoring window. A standstill is reported if the number of pulses per monitoring window is less than or equal to the "Standstill threshold" parameter and remains less than or equal for the number of subsequent monitoring windows of "Standstill on-delay" + 1. The standstill is reported by the feedback interface by means of the "Standstill event status" bit. You can find more information under Feedback interface (Page 98).

If the number of input pulses per monitoring window exceeds the "Standstill threshold" parameter, the "Standstill event state" bit is set to "0".

Overspeed monitoring

You set the overspeed monitoring by selecting an overspeed threshold. The pulses per monitoring window are counted and compared to the overspeed threshold at the end of each monitoring window. Overspeed is detected as soon as the number of counted pulses is equal to or greater than the "Overspeed threshold". The overspeed is reported by the feedback interface using the "Overspeed event status" bit. You can find more information under Feedback interface (Page 98).

Reset control

The reset is triggered on the transition from logic 0 to logic 1. A reset clears all standstill and overspeed monitoring faults that are present on the channels. A reset is also necessary if a fault has occurred in the gate input channels. The reset function can only be executed if the standstill and overspeed monitoring is in fault status. If the reset is triggered with the gate open, counting begins immediately after the first monitoring window.

Gate control

Opening the hardware or software gate activates the standstill and overspeed monitoring.

You have two options to control the gate:

- Using the user program
- Via the digital inputs DI_1 and DI_5

You can select one of these two options through parameter assignment. The gate is closed when the control signal is at logic 0 and open when the control signal is at logic 1.

Make sure that a valid pulse pattern is present at digital inputs DI_0 and DI_4 when the gate is opened. See the "Pulse pattern" figure at the beginning of this section.

When the gate is closed, the signal evaluation of the digital inputs DI_0 and DI_4 is not active.

If the reset is triggered with the gate open, counting begins immediately after the first monitoring window. You can find more information under Feedback interface.

NOTE

Automatic closing of the gate

The gate is automatically closed in the following situations:

- If the CPU is in STOP mode
- CRC error in PROFIsafe communication
- In the event of a timeout of the PROFIsafe communication
- In the event of errors in the safety program that lead to a CPU STOP

Discrepancy evaluation method

Standstill and overspeed monitoring allows you to choose by parameter assignment between a strict discrepancy evaluation method and a tolerant discrepancy evaluation method during standstill.

The differences in the discrepancy evaluation method are only applied if the standstill and overspeed monitoring is in the standstill state. This occurs when the number of pulses per monitoring window is lower than the configured "Standstill threshold".

- **Strict discrepancy evaluation method during standstill**

Each detected edge that deviates from the pulse pattern results in a discrepancy error. Use this discrepancy evaluation method to achieve maximum SIL3/Cat.4/PLe.

The parameter "Tolerant discrepancy evaluation method during standstill" is not activated.

- **Tolerant discrepancy evaluation method during standstill**

During standstill, a discrepancy error is only detected if the input signals DI_0 and DI_4 are at logical 0 at the same time. This can help when filtering jitter. To achieve SIL3/Cat.4/PLe, you must use cross-circuit proof wiring. Without cross-circuit proof wiring, you will achieve a maximum of SIL2/ Cat.3/Pld.

The parameter "Tolerant discrepancy evaluation method during standstill" is activated.

6.2.2 Parameters

The "Standstill and Overspeed monitoring" operating mode is only effective if the operating mode selection is configured as "Standstill and Overspeed monitoring".

Parameters for the "Standstill and Overspeed monitoring" operating mode

The following parameters are possible:

Table 2-1856 Adjustable parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Module parameters:				
Operating mode	• Digital inputs • Counter • Standstill and Overspeed monitoring	Digital inputs	No	Module
F-parameters				
Manual assignment of the F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Depends on the parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Is proposed by the F-system	No	Module
F-parameter signature (without address)	0 to 65535	Is calculated by the F-system	No	Module
Behavior after channel fault	Passivate channel	Passivate channel (unchangeable)	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically	Adjustable	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	Is proposed by the F-system	No	Module
F-I/O DB name	—	Is proposed by the F-system	No	Module

Table 2-1857 Configurable standstill and overspeed monitoring parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Standstill and Overspeed monitoring - Channel 0, 4				
Input delay	• 0.4 ms • 0.8 ms • 3.2 ms	3.2 ms	No	Channel pair
Channel failure acknowledge	• Manual • Automatic	Manual	No	Channel pair

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Monitoring window duration	0.1 to 30 s	6 s	No	Channel pair
Overspeed threshold	2 to 14,400	7	No	Channel pair
Overspeed off-delay [number of monitoring windows]	1 to 127	1	No	Channel pair
Standstill threshold	0 to 14,398	2	No	Channel pair
Standstill on-delay [number of monitoring windows]	1 to 127	1	No	Channel pair
Tolerant discrepancy evaluation method during standstill	• Not activated • Activated	Not activated	No	Channel pair
Gate control				
Gate controlled by	• Software • Hardware	Software	No	Module
Gate hardware control - Channel 1, 5				
Sensor evaluation	1oo2 evaluation, non-equivalent	1oo2 evaluation, non-equivalent (unchangeable)	No	Channel pair
Discrepancy behavior	Supply last valid value	Supply last valid value (unchangeable)	No	Channel pair
Reintegration after discrepancy error	Test 0-Signal not necessary	Test 0-Signal not necessary (unchangeable)	No	Channel pair
Discrepancy time	5 ms to 30 s	5 ms	No	Channel pair
Channel failure acknowledge	Automatic	Automatic (unchangeable)	No	Channel pair
Input delay	• 0.4 ms • 0.8 ms • 3.2 ms	3.2 ms	No	Channel pair
Reset control				
Reset controlled by	Software	Software (unchangeable)	No	Module

See also

Standstill and overspeed monitoring use cases (as of firmware version V3.0.0) (Page 101)

6.2.3 Explanation of parameters

6.2.3.1 Module parameters

Operating mode

This parameter is used to specify the desired operating mode.

The digital input module F-DI 8×24VDC HF can be operated in the following operating modes:

- "Digital inputs"
- “Counter"
- "Standstill and Overspeed monitoring"

6.2.3.2 F-parameters

F-parameters

You have to assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you start operation.

- You specify the F-source address with the "Central F-source address" parameter in the F-CPU.
- The F-destination address is assigned automatically for each F-module CPU-wide. You can change the specified F-destination address in the hardware configuration manually.

Information on the F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB can be found in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults. In "Standstill and Overspeed monitoring" mode, the parameter must be set to "Passivate the channel".

Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use on S7-1200/1500 F-CPUs

When using the F-module on F-CPUs S7-1200/1500, set this parameter in the STEP 7 dialog of the F-module:

- "Adjustable"
- "All channels automatically"

The parameter "Behavior after channel fault" is set to "Passivate the channel". You allow the individual configuration of the reintegration type per channel using the "Adjustable" parameter assignment. The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

6.2.3.3 Standstill and overspeed monitoring parameters

Input delay

Input delay applied to the channels. See section Input delay (Page 30).

Channel failure acknowledge

Determines how faults on channels 0 and 4 are acknowledged.

You can select from the following options:

- "Manual"
- "Automatic"

Monitoring window duration

Specifies the monitoring window duration in 0.1 s increments. You can set a range of 0.1 to 30 s. The default setting is 6 s.

Overspeed threshold

Determines the limit for overspeed detection in pulses per monitoring window. You can set a range from 2 to 14,400 pulses. To take the limit into account for normal operation, the set value must be at least 2 greater than the standstill threshold. The default setting is 7.

WARNING

When configuring the overspeed threshold, you need to consider the monitoring window duration and the input delay.

If the overspeed threshold cannot be reached, speed monitoring will not be performed correctly.

With the following formula, you must determine the maximum reachable value for the overspeed threshold:

*Maximum overspeed threshold = maximum frequency * monitoring window duration*

The value for the maximum frequency can be found in the following "Numerical values" table.

Table 2-1858 Numerical values

Input delay	Minimum pulse duration of the "0" signal	Maximum frequency
0.4 ms	0.71 ms	480 Hz
0.8 ms	1.10 ms	350 Hz
3.2 ms	3.60 ms	120 Hz

Overspeed off-delay [number of monitoring windows]

Determines how many consecutive monitoring windows without overspeed must be registered before the "Overspeed event status" bit is reset from 0 to 1. You can set a range from 1 to 127. The default setting is 1. The delay corresponds to the parameterized value + 1 monitoring window.

Standstill threshold

Determines the limit for the standstill detection in pulses per monitoring window. You can set a range from 0 to 14,398 pulses. To take the limit into account for normal operation, the set value must be at least 2 lower than the overspeed limit. The default setting is 2.

WARNING

When configuring the standstill threshold, you need to consider the monitoring window duration and the input delay.

If the standstill threshold cannot be reached, standstill monitoring will not be performed correctly.

With the following formula, you must determine the maximum reachable value for the standstill threshold:

*Maximum standstill threshold = maximum frequency * monitoring window duration -2*

You must always set the value of the standstill threshold lower than the value of the overspeed threshold.

The value for the maximum frequency can be found in the following "Numerical values" table.

Table 2-1859 Numerical values

Input delay	Minimum pulse duration of the "0" signal	Maximum frequency
0.4 ms	0.71 ms	480 Hz
0.8 ms	1.10 ms	350 Hz
3.2 ms	3.60 ms	120 Hz

Standstill on-delay [number of monitoring windows]

Determines how many consecutive monitoring windows must detect a standstill before the standstill event status bit is set. You can set a range from 1 to 127. The default setting is 1. The delay corresponds to the parameterized value + 1 monitoring window.

Tolerant discrepancy evaluation method during standstill

If you select this option, a tolerant discrepancy evaluation method is applied during the standstill. This can help when filtering jitter.

To achieve SIL3/Cat.4/PLe, you must use cross-circuit proof wiring.

6.2.3.4 Parameters for gate and reset control

Gate and reset control

Specifies the source for gate and reset control.

You can choose the following options for the gate control:

- "Software"
- "Hardware"

NOTE

If you select the "Hardware" option, the respective internal sensor supply is automatically enabled. However, their use in the wiring is optional.

You can choose the following options for the reset control:

- "Software"

6.2.3.5 Parameters for gate hardware control

Sensor evaluation

If the hardware control option is selected, the setting is always "1oo2 evaluation, non-equivalent". For more information, see section Sensor evaluation (Page 25).

Discrepancy behavior

If the hardware control option is selected, the setting is always "Supply last valid value". For more information, see section Discrepancy behavior (Page 26).

Reintegration after discrepancy error

If the hardware control option is selected, the setting is always "Test 0-Signal not necessary". For more information, see section Reintegration after discrepancy error (Page 28).

Discrepancy time

For more information, see section Discrepancy time (Page 27).

Channel failure acknowledge

This setting is always "Automatic". For more information, see section Channel failure acknowledge (Page 29).

Input delay

For more information, see section Input delay (Page 30).

6.2.4 Address space

Address assignment of the digital input module F-DI 8×24VDC HF in "Standstill and Overspeed monitoring" operating mode

The digital input module F-DI 8×24VDC HF occupies the following address ranges in the F-CPU:

Table 2-1860 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In the input range**	**In the output range**
S7-1200/1500 F-CPUs*	IB x + 0 to x + 14	QB x + 0 to x + 5

*) The standstill and overspeed monitoring only works with F-CPUs that support PROFIsafe version 2.6.1

x = Module start address

Address assignment of the user data and the value status of digital input module F-DI 8×24VDC HF in "Standstill and Overspeed monitoring" operating mode

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital input module F-DI 8×24VDC HF:

Table 2-1861 User data address assignment in the input range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Reserved						HW gate signal	Reserved
IB x + 1	Standstill event status	Over-speed event status	Reserved			Reset status	Gate status	First mon-itoring window
IB x + 2	Number of pulses per monitoring window							
IB x + 3								
IB x + 4								
IB x + 5								
IB x + 6	Reserved						Value status of HW gate signal	Reserved

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
IB x + 7	Value status of standstill event status	Value status of overspeed event status	Reserved			Value status of reset status	Value status of gate status	Value status of first monitoring window
IB x + 8	Reserved							Value status of the number of pulses per monitoring window
IB x + 9	Reserved					Reset controlled by SW	Gate controlled by SW	Reserved

Table 2-1862 User data address assignment in the output range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
QB x + 0	Reserved					SW reset control	SW gate control	Reserved

6.2.5 Assignment of the standstill and overspeed monitoring control interface

The safety program can influence the behavior of the module in "Standstill and Overspeed monitoring" operating mode via the control interface.

Assignment of the control interface

The following table shows the assignment of the control interface:

Table 2-1863 Address assignment in the F-CPU

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
QB x + 0	Reserved					SW reset control	SW gate control	Reserved

Explanations

Table 2-1864 Explanations

Byte	Bit	Control bit/value	Explanations
QB x + 0	1	SW gate control	Use this bit to control when the software gate is opened and the standstill and overspeed monitoring is activated. • 0: The SW gate is closed and the standstill and overspeed monitoring is stopped. • 1: The SW gate is open and standstill and overspeed monitoring is enabled.
QB x + 0	2	SW reset control	Use this bit to clear all error statuses in the standstill and overspeed monitoring. • 0: No action • 1: Sets the number of pulses per monitoring window to 0 and clears all error states in the standstill monitoring that are present on the channels. The "SW reset" action is always initiated when this bit transitions from 0 to 1. The current number of pulses per monitoring window is set to 0 and any error status that is present on the channels of the standstill and overspeed monitoring is cleared.

6.2.6 Assignment of the standstill and overspeed monitoring feedback interface

The safety program can receive actual values and status information in "Standstill and Overspeed monitoring" operating mode via the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Table 2-1865 Assignment of the feedback interface

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Reserved						HW gate signal	Reserved
IB x + 1	Standstill event status	Overspeed event status	Reserved			Reset status	Gate status	First monitoring window
IB x + 2	Number of pulses per monitoring window							
IB x + 3								
IB x + 4								
IB x + 5								
IB x + 6	Reserved						Value status of HW gate signal	Reserved

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 7	Value status of standstill event status	Value status of over-speed event status	Reserved			Value status of reset status	Value status of gate status	Value status of first mon-itoring win-dow
IB x + 8	Reserved							Value status of the num-ber of pulses per monitor-ing window
IB x + 9	Reserved					Reset con-trolled by SW	Gate con-trolled by SW	Reserved

Explanations

Table 2-1866 Explanations

Byte	Bit	Feedback bit/value	Description
IB x + 0	1	HW gate signal	Only valid if the HW control is configured for the gate. The signal value is formed via a 1oo2 evaluation, non-equivalent of the digital inputs DI_1 and DI_5.
IB x + 1	0	First monitoring window	The "First monitoring window" bit indicates whether the current monitoring window is the first after a new gate open command was received. • 0: The current monitoring window is not the first after a gate open command. Therefore, normal measured data can be expected. This bit enables the control system to identify the first monitoring window after gate opening. In this first window, the data may not be valid yet. In this way, the control system can distinguish the first window with an error from the subsequent regular monitoring windows. This allows you to distinguish between an actual error and the expected initial state during the first monitoring window. The first monitoring window should be handled by the user program accordingly before the actual measured values can be received. • 1: The current monitoring window is the first after a new gate open command. In the sampling phase, the standstill value status during the first monitoring window is 0 because there is no valid measurement data available to report.
IB x + 1	1	Gate status	The "Gate status" bit indicates that the module has received and responded to the gate control from either the SW control interface or the HW control: • 1: Gate opened. Standstill and overspeed monitoring active. • 0: Gate closed Changes to the counting channel pair for standstill and overspeed monitoring are ignored.

Byte	Bit	Feedback bit/value	Description
IB x + 1	2	Reset status	The "Reset status" bit indicates that the module has received the "Reset" from the control interface and responded as follows: • If the reset control transitions from 0 to 1, the "Reset status" bit is set to 1 and the module deletes the error states for standstill and overspeed monitoring. • If the reset control is set to 0, the "Reset status" bit is also set to 0.
IB x + 1	6	Overspeed event status	The "Overspeed event status" bit indicates the status of an overspeed detection. • 0: Overspeed detected • 1: No overspeed The bit is set to "0" if the pulse count within a monitoring window is greater than or equal to the configured "Overspeed threshold". The bit is automatically reset to "1" when both of the following conditions are met: • The number of pulses is below the "Overspeed threshold". • This state is detected in the number of consecutive monitoring windows defined by the "Overspeed off-delay".
IB x + 1	7	Standstill event status	The "Standstill event status" bit indicates the status of a detected standstill. • 0: No standstill detected • 1: Standstill detected The bit is set to "1" if both of the following conditions are met: • The pulse count within a monitoring window is less than or equal to the configured "Standstill threshold". • This state is detected in the number of consecutive monitoring windows defined by the "Standstill on-delay". The bit is automatically reset to "0" as soon as the pulse count exceeds the defined "Standstill threshold".
IB x + 2 **IB x + 3** **IB x + 4** **IB x + 5**	0-7	Number of pulses per monitoring window	Contains the value status of the number of pulses per monitoring window
IB x + 6	1	Value status of HW gate signal	Contains the value status of the hardware control channel pair in the event that the gate is controlled by the hardware.
IB x + 7	0	Value status of first monitoring window	Contains the value status of first monitoring window
IB x + 7	1	Value status of gate status	Contains the value status of gate status
IB x + 7	2	Value status of reset status	Contains the value status of reset status
IB x + 7	6	Value status of overspeed event status	Contains the value status of overspeed event status
IB x + 7	7	Value status of standstill event status	Contains the value status of standstill event status
IB x + 8	0	Value status of the number of pulses per monitoring window	Contains the value status of the number of pulses per monitoring window
IB x + 9	1	Gate controlled by SW	Contains bit that indicates whether gate is software-controlled.*
IB x + 9	2	Reset controlled by SW	Contains bit that indicates whether reset is software-controlled.*

*) This can only be changed by parameter assignment.

A detailed bit assignment of the bytes IB x + 6 to IB x + 9 can be found in the above table "Assignment of the feedback interface".

6.3 Standstill and overspeed monitoring use cases (as of firmware version V3.0.0)

WARNING

When the "Tolerant discrepancy evaluation method during standstill" parameter is activated

To achieve SIL3/Cat.4/PLe when the parameter is activated, the cables used for standstill and overspeed monitoring must be installed in a cross-circuit proof manner.

WARNING

Make sure that the highest possible frequency does not exceed 480 Hz in the application.

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving at least the corresponding safety requirements.

Table 2-1867 Conditions for achieving SIL/Cat./PL

Discrepancy evaluation	Wiring requirements	Achievable SIL/Cat./PL
Standstill and overspeed monitoring (tolerant discrepancy evaluation method during standstill deactivated)	None	3 / 4 / e
	Cross-circuit proof wiring	3 / 4 / e
Standstill and overspeed monitoring (tolerant discrepancy evaluation method during standstill activated)	None	2 / 3 / d
	Cross-circuit proof wiring	3 / 4 / e

Inputs for standstill and overspeed monitoring

The digital input module F-DI 8x24VDC HF has 8 fail-safe inputs, DI_0 to DI_7.

The inputs are paired in 1oo2 equivalent logic for the standstill and overspeed monitoring counter channels and in 1oo2 non-equivalent logic for the hardware gate control channels:

- DI_0 and DI_4 are used as channels for the standstill and overspeed monitoring.
- DI_1 and DI_5 are used optionally for HW gate control.

The process signal for the hardware control is provided via channel DI_1.

Strict discrepancy evaluation method during standstill

If the strict discrepancy evaluation method is used during standstill, only input DI_0 counts.

If the speed or overspeed is detected, only input DI_0 counts.

Tolerant discrepancy evaluation method during standstill

If the tolerant discrepancy evaluation method during standstill is used, both DI_0 and DI_4 count, and the highest value of both (DI_0, DI_4) is used.

The tolerant discrepancy evaluation method for normal speed and overspeed is identical to the strict discrepancy evaluation method, which means that only DI_0 is counted.

Relevant edges are:

- Rising edges for DI_0
- Rising edges for DI_4 (valid only for tolerant discrepancy evaluation method during standstill)

The standstill monitoring reports the counted number of pulses in each monitoring window (at the end of the monitoring window).

Wiring

The wiring is performed on a suitable BaseUnit.

Sensor supply

In "Standstill and Overspeed monitoring" mode, the internal sensor supplies are permanently switched on, permanently assigned to the inputs, and cannot be changed.

- VS_0 to DI_0 and VS_4 to DI_4 (always activated)
- VS_1 to DI_1 and VS_5 to DI_5 (activated if the HW gate control is configured)
- The short-circuit tests of the sensor supplies are permanently deactivated.

NOTE

The use of the internal sensor supply in the wiring is optional.

NOTE

Avoidance of interference due to high-energy surge voltages

To avoid interference due to high-energy surge voltages, you need to consider the following restrictions in "Standstill and Overspeed monitoring" operating mode:

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 3.2 ms:

No additional restrictions apply.

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.8 ms:

For the DI_0 and DI_4 inputs, you need to use either shielded cables with a maximum length according to the technical specifications (Page 120) or unshielded cables with a maximum length of 30 m. When unshielded cables are used, they can only be installed inside a building.

The following applications are not supported:

- Applications according to NAMUR recommendation NE 21
- Applications according to EN 298
- Shipbuilding applications

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.4 ms:

For the DI_0 and DI_4 inputs, you need to use either shielded cables with a maximum length according to the technical specifications (Page 120) or unshielded cables with a maximum length of 30 m. When unshielded cables are used, they can only be installed inside a building.

The following applications are not supported:

- Applications according to NAMUR recommendation NE 21
- Applications according to EN 298
- Shipbuilding applications

The length of the cable between the power supply unit and the F-module cannot be greater than 30 m. The cable can only be installed inside a building.

NOTE

Interruptions of the supply voltage according to IEC 61131-2 are not buffered by the F-module and thus influence the internal sensor supplies. This can lead to the occurrence of diagnostics and passivation of the F-module in "Standstill and Overspeed monitoring" operating mode. To ensure problem-free functioning of the F-module and the sensors, we recommend the following:

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 3.2 ms:

No additional measures necessary.

With parameter assignment of the DI_0 and DI_4 inputs with an input delay of 0.8 ms or 0.4 ms:

For the power supply, use a separate power supply unit that only supplies voltage in "Standstill and Overspeed monitoring" operating mode to F-DI 8x24VDC HF digital input modules and their associated sensors.

WARNING

When selecting the sensors, take into account that test pulses at the output of the sensor may influence the number of pulses per monitoring window.

Wiring diagram - Use case with external sensor supply

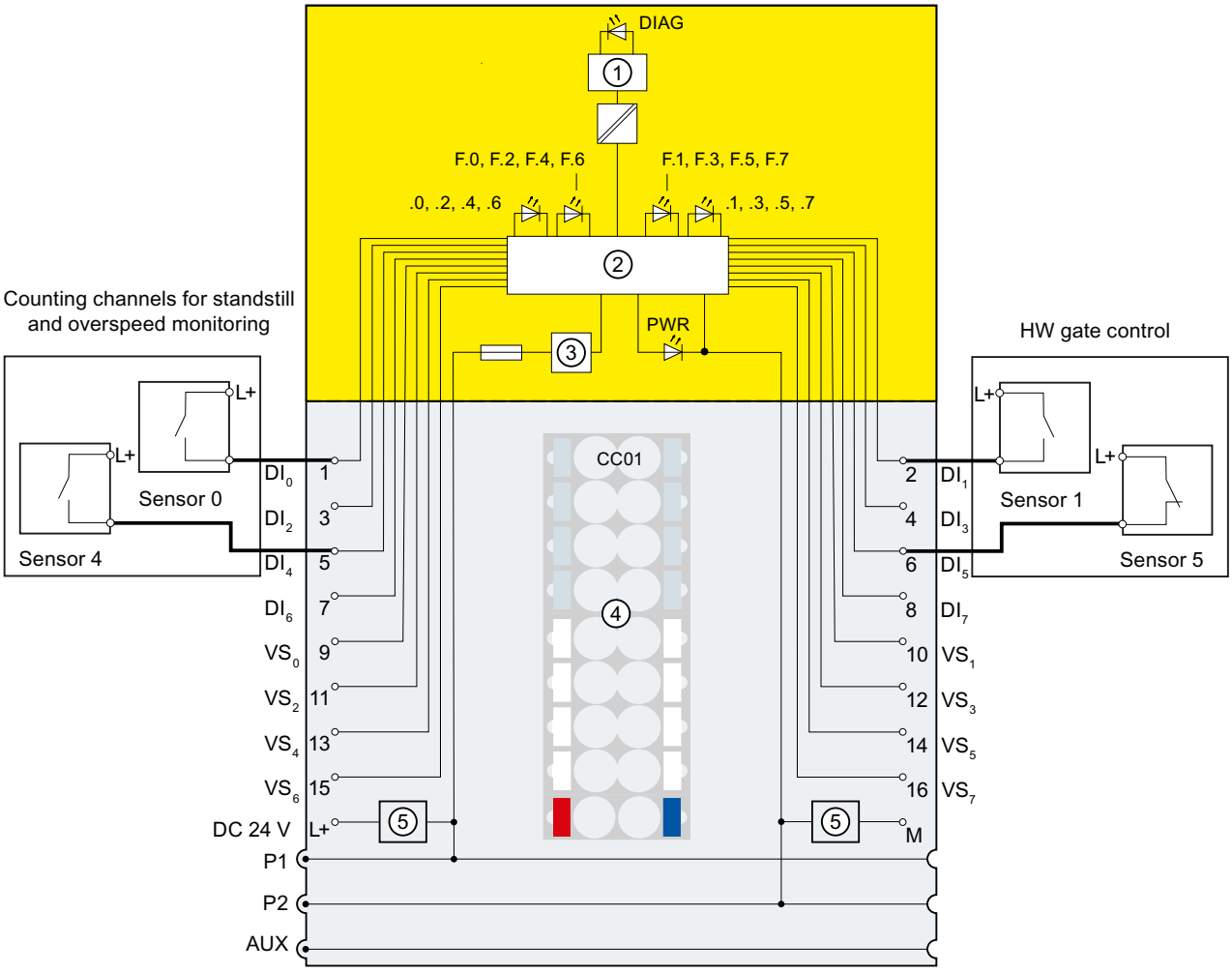

Figure 2-1461 Use case with external sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

WARNING

When the "Tolerant discrepancy evaluation method during standstill" parameter is activated

To achieve SIL3/Cat.4/PLe when the parameter is activated, the cables used for standstill and overspeed monitoring must be installed in a cross-circuit proof manner.

Wiring diagram - Use case with internal sensor supply

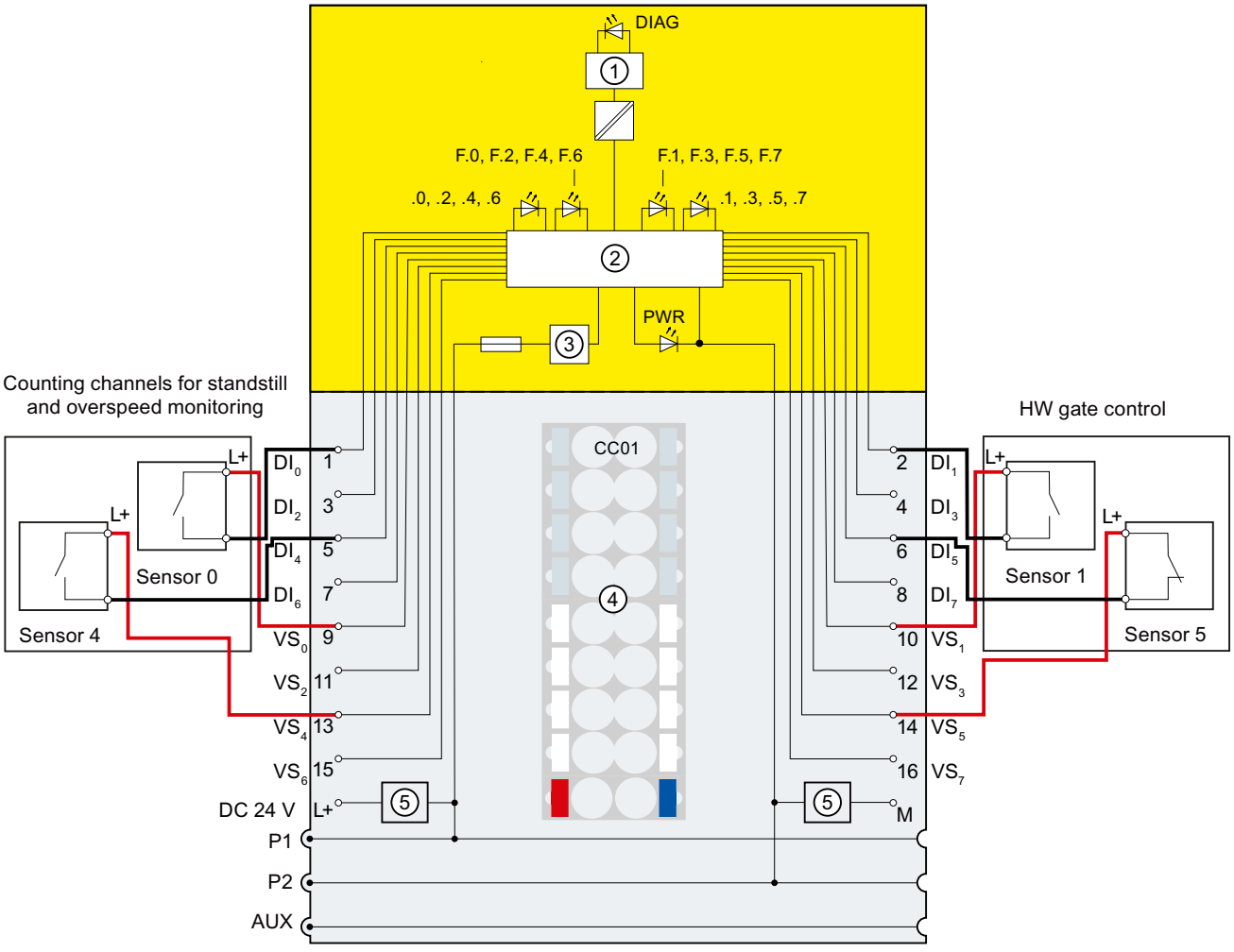

Figure 2-1462 Use case with internal sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

WARNING

When the "Tolerant discrepancy evaluation method during standstill" parameter is activated

To achieve SIL3/Cat.4/PLe when the parameter is activated, the cables used for standstill and overspeed monitoring must be installed in a cross-circuit proof manner.

Fault detection

The following tables show the fault detection depending on the sensor supply:

Table 2-1868 Fault detection at standstill and overspeed monitoring inputs (DI_0 and DI_4)

Tolerant discrepancy evaluation method during standstill disabled		
Faults	**Fault detection at standstill and overspeed monitoring inputs**	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_0 or DI_4	Yes*	Yes*
Short-circuit with M to DI_0 or DI_4	Yes*	Yes*
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-
Discrepancy error	Yes	Yes
Wire break	Yes**	Yes**

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

**) A single fault (wire break on one channel) may not be detected immediately, but only when the next pulse signals are generated during rotation. A double fault (wire break on both channels DI

Table 2-1869 Fault detection at HW control inputs (DI_1 and DI_5)

Tolerant discrepancy evaluation method during standstill disabled		
Faults	**Fault detection at HW control inputs**	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

Fault detection

Table 2-1870 Fault detection at standstill and overspeed monitoring inputs (DI_0 and DI_4)

Tolerant discrepancy evaluation method during standstill enabled		
Faults	**Fault detection at standstill and overspeed monitoring inputs**	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	No	No
Short-circuit with other channel pairs or with other sensor supplies	No	No
Short-circuit with L+ to DI_0 or DI_4	No	No
Short-circuit with M to DI_0 or DI_4	Yes*	Yes*
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-
Discrepancy error	Yes	Yes
Wire break	Yes**	Yes**

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

**) A single fault (wire break on one channel) may not be detected immediately, but only when the next pulse signals are generated during rotation. A double fault (wire break on both channels DI

Table 2-1871 Fault detection at HW control inputs (DI_1 and DI_5)

Tolerant discrepancy evaluation method during standstill enabled		
Faults	**Fault detection at HW control inputs**	
	Internal sensor supply	**External sensor supply**
Short-circuit within the channel pair	Yes	Yes
Short-circuit with other channel pairs or with other sensor supplies	Yes*	Yes*
Short-circuit with L+ to DI_n	Yes*	Yes*
Short-circuit with M to DI_n	Yes*	Yes*
Discrepancy error	Yes	Yes
Short-circuit with L+ to SV_n	No	-
Short-circuit with M to SV_n or defective	Yes	-

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

Interrupts/diagnostic messages

7

7.1 Status and error display

LED display

The following figure shows you the LED display of the F-DI 8x24VDC HF.

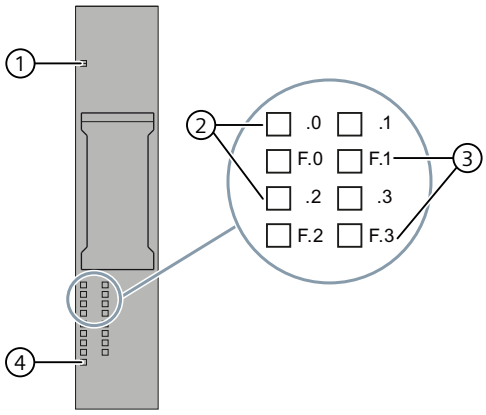

① DIAG (green/red)

② Channel status (green)

③ Channel error (red)

④ PWR (green)

Figure 2-1463 LED display

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic messages can be found in section Diagnostic messages (Page 113).

WARNING

The DIAG LED and the channel status and channel fault LEDs of the inputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

DIAG LED

Table 2-1872 DIAG LED fault display

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not okay
Flashing	Module parameters not configured
On	Module parameters configured and no module diagnostics
Flashing	• Module parameters configured and module diagnostics • Operation at F-CPUs S7-1200/1500: At least one channel waits for a user acknowledgement.
Flashing	• Operation at F-CPUs S7-1200/1500: After a module fault, the F-module waits for a user acknowledgement. • Operation at F-CPUs S7-300/400: The F-module waits for a user acknowledgement.

Channel status/channel fault LED

Table 2-1873 Status display of the LED channel status/channel fault

Channel status	Channel fault	Meaning
Off	Off	Process signal = 0 and no channel diagnostics
On	Off	Process signal = 1 and no channel diagnostics
Off	On	Process signal = 0 and channel diagnostics
/ Alternately flashing		At least one channel waits for a user acknowledgement.

Channel status/DIAG/channel fault LED

Table 2-1874 Status display of the LED channel status/DIAG/channel fault

Channel status	DIAG	Channel fault	Meaning
Off	Flashing	All On	The PROFIsafe address does not match the PROFIsafe address of the configuration or there is a module-wide error. See section Interrupts (Page 111)
Flashing	Flashing	Off	Identification of the F-module when assigning the PROFIsafe address

PWR LED

Table 2-1875 Status display of the PWR LED

PWR	Meaning
□ Off	Supply voltage L+ not present
■ On	Supply voltage L+ present

7.2 Interrupts

Introduction

The fail-safe digital input module F-DI 8×24VDC HF supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 113).

The following list provides you with an overview of the diagnostic interrupts of the F-module. The diagnostic interrupts are assigned either to one channel or the entire F-module.

⚠ WARNING

Before acknowledgment of a diagnostic message, eliminate the respective error and validate your safety function. Proceed as described in section Diagnostic messages (Page 113) to eliminate the error.

Module-wide diagnostic interrupts:

- Overtemperature
- Parameter error
- Supply voltage missing
- Communication fault
- Mismatch of safety destination address (F_Dest_Add)
- Safety destination address not valid (F_Dest_Add)
- Safety source address not valid (F_Source_Add)
- Safety watchdog time value is 0 ms (F_WD_Time)
- Parameter F_SIL exceeds SIL from specific device application
- Parameter F_CRC_Length does not match the generated values
- Version of F parameter set incorrect
- CRC1 fault

- Device-specific diagnostics information, see manual
- Inconsistent iParameter (iParCRC error)
- F_Block_ID not supported
- Transmission error: Inconsistent data (CRC error)
- Transmission error: Timeout (watchdog time 1 or 2 expired)
- Acknowledge required to enable channel(s) - as channel error(s) are remedied.
- Watchdog tripped
- Invalid/inconsistent firmware present
- Diagnostic queue overflow
- F-address memory not accessible
- No valid F-address available
- Undertemperature
- Supply voltage too high
- Supply voltage too low
- F-module error (0x032F)

Channel-wide diagnostic interrupts

- Wire break
- Discrepancy failure, channel status 0/0
- Discrepancy failure, channel status 0/1
- Discrepancy failure, channel status 1/0
- Discrepancy failure, channel status 1/1
- Input signal not recorded unique
- Internal sensor supply short-circuit to P
- Overload or internal sensor supply short-circuit to ground
- Sensor signal flutters
- Frequency too high
- Discrepancy error
- Input shorted to P
- Channel passivated
- Counter discrepancy limit exceeded

7.3 Diagnostic messages

Diagnostic messages

Module faults are indicated as diagnostics (module status).

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

NOTE

If you are using a GSDML file for configuring the F-module, other error codes will be supplied. In this case you must multiply the listed error numbers by 0x40 (e.g. 0x05 * 0x40 = 0x140). However, the text in the CPU diagnostic buffer corresponds to the text of the diagnostic interrupt as listed in the table below.

Table 2-1876 Diagnostic messages of the F-DI 8x24VDC HF

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_H	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range. (See Technical specifications (Page 120)) Once the fault has been eliminated, the F-module must be removed and inserted or the power switched OFF and ON
Wire break	6_H	Possible causes: • There is an interrupted cable between the module and sensor. • The channel is not connected (open).	Establish a cable connection.
Parameter error	10_H	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	• Correct the parameter assignment. • Check whether a coding element is available.
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check supply voltage L+ at the BaseUnit • Check BaseUnit type
Communication fault	13_H	Possible causes: • An impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and reacted to it in a safety-oriented manner.	• Correct the fault. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put into operation anymore, consider a replacement.
Mismatch of safety destination address (F_Dest_Add)	40_H	The PROFIsafe driver has detected a different F-destination address.	Check the parameter assignment of the PROFIsafe driver and the address setting of the F-module.
Safety destination address not valid (F_Dest_Add)	41_H	The PROFIsafe driver has detected an invalid F-destination address.	Check the parameter assignment of the PROFIsafe driver.

Diagnostic message	Fault code	Meaning	Remedy
Safety source address not valid (F_Source_Add)	42_H	The PROFIsafe driver has detected an invalid F-source address.	
Safety watchdog time value is 0 ms (F_WD_Time)	43_H	The PROFIsafe driver has detected an invalid watchdog time.	
Parameter F_SIL exceeds SIL from specific device application	44_H	The PROFIsafe driver has detected a discrepancy between the SIL setting of the communication and the application.	
Parameter F_CRC_Length does not match the generated values	45_H	The PROFIsafe driver has detected a discrepancy in the CRC length.	
Version of F parameter set incorrect	46_H	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.	
CRC1 fault	47_H	The PROFIsafe driver has detected inconsistent F-parameters.	
Device-specific diagnostics information, see manual	48_H	The PROFIsafe driver has received inconsistent fail-safe parameters.	
Inconsistent iParameter (iParCRC error)	$4B_H$	The PROFIsafe driver has detected inconsistent iParameters.	Check the parameter assignment of the PROFIsafe driver.
F_Block_ID not supported	$4C_H$	The PROFIsafe driver has detected an incorrect Block ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Inconsistent data (CRC error)	$4D_H$	The PROFIsafe driver has detected a CRC error. Possible causes: • The communication between F-CPU and F-module is interrupted. • Impermissibly high electromagnetic interference is present. • An error has occurred during the sign-of-life monitoring.	• Check the communication link between the F-module and the F-CPU. • Eliminate the cause of the electromagnetic interference.
Transmission error: Timeout (watchdog time 1 or 2 expired)	$4E_H$	The PROFIsafe driver has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Check the parameter assignment. • Make sure that your communication is operating correctly.
Acknowledge required to enable channel(s) - as channel error(s) are remedied.	$4F_H$	A channel fault was detected. A confirmation is required to enable the channel.	Confirm the channel fault.
Watchdog tripped	103_H	Possible causes: • An impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and reacted to it in a safety-oriented manner.	• Correct the fault. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put into operation anymore, consider a replacement.

Diagnostic message	Fault code	Meaning	Remedy
Invalid/inconsistent firmware present	$11B_H$	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Diagnostic queue overflow	$13E_H$	Overflow of the diagnostic memory. Not all pending diagnostics could be sent. This error can result in deactivation of the module up to switching on/off of the power supply.	Eliminate the previously reported error.
Discrepancy failure, channel status 0/0	300_H	The discrepancy time set for 1oo2 evaluation was exceeded. Possible causes: • The process signal is faulty. • The sensor is defective. • The configured discrepancy time is too low. • There is a short-circuit between an unconnected sensor cable and the sensor supply cable. • Wire break in connected sensor cable or the sensor supply cable • An error occurred during the discrepancy check.	• Check the process signal. • Replace the sensor. • Check the parameter assignment of the discrepancy time. • Check the process wiring. You must eliminate the occurred error within 100 hours if no short-circuit test has been configured for the corresponding sensor supply.
Discrepancy failure, channel status 0/1	301_H		
Discrepancy failure, channel status 1/0	302_H		
Discrepancy failure, channel status 1/1	303_H		
Input signal not recorded unique	305_H	An error occurred during the plausibility check of the input signal between the processors. Possible causes: • The input signal is faulty. For example, through an impermissibly high electromagnetic interference. • There is a high-frequency input signal. For example, through reciprocal interference of the sensors, or the signal lies above the sampling frequency of the input signal. • A momentary interruption/short-circuit of the sensor cable (loose contact) is present. • The sensor/switch bounces.	• Use shielded cables to reduce the EMC effects. • Reduce the input frequency. • Check the wiring of the sensor.
Internal sensor supply short-circuit to P	306_H	Possible causes: • There is a short-circuit of the internal sensor supply with L+. • There is a short-circuit of two sensor supplies. • The capacitance of the connected sensor for the configured test time is too high. • The sensor is defective.	• Eliminate the short-circuit in the process wiring. • Check the configured test time and the process wiring. • Replace the sensor.

Diagnostic message	Fault code	Meaning	Remedy
Overload or internal sensor supply short-circuit to ground	307_H	Possible causes: • The internal sensor supply is short-circuited to ground. • Impermissibly high electromagnetic interference is present.	• Eliminate the overload. • Eliminate the short-circuit in the process wiring. • Check the "Sensor supply" parameter. • Eliminate/reduce the electromagnetic interference.
F-address memory not accessible	$30D_H$	F-source address placed in the electronic coding element and F-destination address cannot be accessed.	Check whether the coding element is available. Replace the coding element, if necessary.
No valid F-address available	$30E_H$	No valid PROFIsafe address is stored in the retentive memory. Possible causes: • Initial commissioning • Deliberate parameter change of the PROFIsafe address • Deviation between setpoint and actual configuration of the plant	• Perform the assignment of the PROFIsafe address during initial commissioning or deliberate parameter changes. • Check the consistency between the setpoint and actual configuration.
Sensor signal flutters	310_H	Too many signal changes have occurred within the time configured with the "Monitoring window" parameter. • The "Monitoring window" parameter setting is too high. • The "Number of signal changes" parameter setting is too low. • A momentary interruption/short-circuit of the sensor cable (loose contact) is present. • Impermissibly high electromagnetic interference is present. • The sensor/switch is bouncing. • The sensor is defective.	• Check the "Monitoring window" parameter. • Check the "Number of signal changes" parameter. • Check the process wiring. • Eliminate/reduce the electromagnetic interference. • Replace the sensor.
Frequency too high	311_H	The switching frequency of the sensor is too high. For counter as well as standstill and overspeed monitoring: This error can be detected even when the gate signal is closed.	Reduce the switching frequency of the sensor.
Undertemperature	312_H	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range. (See Technical specifications (Page 120))
Discrepancy error	314_H	The discrepancy time set for 1oo2 evaluation was exceeded. The error message is output for channel n+4. Additional information: see error codes 300_H ... 303_H. For counter as well as standstill and overspeed monitoring:	Additional information: see error codes 300_H ... 303_H. For counter as well as standstill and overspeed monitoring: Determine and resolve the cause for the discrepancy error and then reset the counter or standstill and overspeed monitoring with the reset control.

Diagnostic message	Fault code	Meaning	Remedy
		This error indicates that the edges on the two channels do not match: • For counter, the edges were not matched within the configured discrepancy time. • For counter, a gate start was triggered while an unmatched edge was unresolved. • During standstill and overspeed monitoring, an out-of-sequence edge was detected using the strict discrepancy evaluation method during standstill. • During standstill and overspeed monitoring with either of the two discrepancy evaluation methods, both signals are logical 0 at the same time.	
Input shorted to P	$31C_H$	The input signal is short-circuited to L+.	Eliminate the short-circuit.
Supply voltage too high	321_H	The supply voltage is too high.	Check the supply voltage.
Supply voltage too low	322_H	Possible causes: • The supply voltage is too low. • Wrong BaseUnit	• Check the supply voltage. • Use a BaseUnit of the type A0.
Channel passivated	$32B_H$	Possible causes: • The high or low counting limit of the counter was violated twice without acknowledgment. • An error occurred on a hardware control channel pair.	Check the diagnostic buffer for errors that may have occurred in the hardware control channels. Resolve all existing errors and then reset the counter or the standstill monitoring with the reset control.
F-module error (0x032F)	$32F_H$	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• The internal diagnostics has detected an error. Removing and inserting the module or POWER OFF – POWER ON necessary. • If the F-module cannot be put into operation anymore, consider a replacement.
Counter discrepancy limit exceeded	334_H	The counter discrepancy limit between the two channels of the counter has exceeded the permissible limit of 1.	Determine and resolve the cause for the discrepancy error and then reset the counter with the reset control.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the module is passivated.

With subsequent voltage recovery (level must be within the specified value range for at least 1 minute (see Technical specifications (Page 120): Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Behavior in case of cross circuit/short-circuit to the sensor supply

When internal sensor supply is configured and short-circuit test is deactivated, short-circuits to ground at the sensor supplies are detected. Channels for which the relevant sensor supply is configured will be passivated.

When internal sensor supply is configured and short-circuit test is enabled, short-circuits to ground and potential at the sensor supply are detected. Channels for which the relevant sensor supply is configured will be passivated.

Behavior of the safety mat evaluation in case of cross circuit/short-circuit to the sensor supply or the digital input

With configured safety mat evaluation, short-circuits with L+, short-circuits with M and cross circuits to another channel are detected with configured safety mat evaluation. Both channels assigned to the affected safety mat evaluation are passivated.

To make it easier to determine the cause of the error, the red channel LED of the input affected by the short-circuit/cross circuit lights up.

Behavior of the safety mat evaluation after wire break of the sensor supply cable or the cable of the digital input

With configured safety mat evaluation, the wire break is detected on all cables used for the connection of the safety mat evaluation. Both channels assigned to the affected safety mat evaluation are passivated.

To make it easier to determine the cause of the error, the red channel LED of the input affected by the wire break lights up.

Special features for fault detection

The detection of certain faults (short-circuits or discrepancy errors, for example) depends on the application, the wiring, and the parameter assignment of the short-circuit test and the sensor power supply. For this reason, tables on fault detection for the applications are presented under:

Applications for inputs (Page 33)

Use cases for Counter (as of firmware version V3.0.0) (Page 71)

Standstill and overspeed monitoring use cases (as of firmware version V3.0.0) (Page 101)

Detection of a cross circuit is not ensured in mixed operation between a channel with safety mat and a channel with 1oo1 or 1oo2 configuration.

Generally applicable information on diagnostics

For information on diagnostics which apply to all F-modules (e.g. reading out the diagnostic functions, passivation of channels), refer to the SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

See also

S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875)

7.4 Value status

Properties

In addition to the diagnostic messages and the status and error display, the F-module makes available information about the validity of each input and output signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is additional binary information of a digital input or output signal. It is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the input or output signal.

The value status is influenced by all errors.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

Assignment of inputs and outputs for the value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in the following sections:

Address space (Page 32) of the "Digital inputs" operating mode

Address space (Page 66) of the "Counter" operating mode

Address space (Page 96) of the "Standstill and Overspeed monitoring" operating mode

Reference

A detailed description of the evaluation and processing of the value status can be found in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Technical specifications 8

Technical specifications of F-DI 8×24VDC HF

The following table lists the technical specifications as of the issue date. You can find a data sheet including updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7136-6BA01-0CA0/td?dl=en).

Article number	6ES7136-6BA01-0CA0
General information	
Product type designation	F-DI 8x24VDC HF
Firmware version	V3.0
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC01
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	SIMATIC Safety V20 or higher with HSP 0484
• STEP 7 configurable/integrated from version	as 6ES7136-6BA00-0CA0
• PROFINET from GSD version/GSD revision	GSDML V2.45
Operating mode	
• DI	Yes
• Counter	Yes; pulse counting, standstill and speed monitoring
CiR - Configuration in RUN	
Reparameterization possible in RUN	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
power supply according to NEC Class 2 required	No
Input current	
Current consumption, max.	40 mA; without load
Encoder supply	
Number of outputs	8

Article number	6ES7136-6BA01-0CA0
24 V encoder supply	
• 24 V	Yes; min. L+ (-1.5 V)
• Short-circuit protection	Yes; Electronic (response threshold 0.7 A to 1.8 A)
• Output current per channel, max.	300 mA
• Output current per module, max.	800 mA; Total current of all encoders
Power loss	
Power loss, typ.	2 W
Address area	
Address space per module	
• Inputs	7 byte; S7-300/400F CPU, 6 byte
• Outputs	5 byte; S7-300/400F CPU, 4 byte
Hardware configuration	
Automatic encoding	Yes
• Electronic coding element type F	Yes
Digital inputs	
Number of digital inputs	8
Digital inputs, parameterizable	Yes
Source/sink input	Yes; P-reading
Input characteristic curve in accordance with IEC 61131, type 1	Yes
Digital input functions, parameterizable	
• Counter	Yes
– Number, max.	1
– Counting frequency, max.	500 Hz
– Counting direction up/down	Yes
Input voltage	
• Rated value (DC)	24 V
• for signal "0"	-30 to +5 V
• for signal "1"	+15 to +30 V
Input current	
• for signal "1", typ.	3.7 mA
Input delay (for rated value of input voltage)	
for standard inputs	
– parameterizable	Yes
– at "0" to "1", min.	0.4 ms
– at "0" to "1", max.	20 ms
– at "1" to "0", min.	0.4 ms
– at "1" to "0", max.	20 ms

Article number	6ES7136-6BA01-0CA0
for technological functions	
– parameterizable	No
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	500 m
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	No
Diagnostics indication LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PLe
• Category according to ISO 13849-1	Cat. 4
• SIL acc. to IEC 61508	SIL 3
Probability of failure (for service life of 20 years and repair time of 100 hours)	
– Low demand mode: PFDavg in accordance with SIL3	< 2.00E-05
– High demand/continuous mode: PFH in accordance with SIL3	< 1.00E-09 1/h
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C

Article number	6ES7136-6BA01-0CA0
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	4 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	29 g

Dimension drawing

See the Equipment Manual ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521).

Response times

A

Introduction

The next section shows the response times of the digital input module F-DI 8×24VDC HF. The response times of the digital input module F-DI 8×24VDC HF are included in the calculation of the response time of the F-system. To do this, use the SIMATIC STEP7 response time table (https://support.industry.siemens.com/cs/ww/en/view/93839056).

WARNING

If you have configured the digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) in a plant, but have inserted the digital input module F-DI 8x24VDC HF (6ES7136-6BA01-0CA0) instead, the information from the manual of the digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) still applies.

Definition of response time for fail-safe digital inputs

The response time represents the interval between a signal change at the digital input and reliable availability of the safety frame on the backplane bus.

Times required for the calculation

- Maximum cycle time: T_{cycle} = 8.0 ms
- Max. acknowledgement time (device acknowledgement time): T_{DAT} = 16 ms

Maximum response time in an error-free scenario (worst case delay time, WCDT) for 1oo1 evaluation.

The following formula applies to a sensor supply without short-circuit test:

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay

The following formula applies to a sensor supply with short-circuit test:

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay + T1 + T2

T1 = Time for short-circuit test

T2 = Startup time of sensor after short-circuit test

Maximum response time in an error-free scenario (worst case delay time, WCDT) for 1oo2 evaluation.

The following formula applies to a sensor supply without short-circuit test:

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay+ Discrepancy time*

The following formula applies to a sensor supply with short-circuit test:

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay + max (T1p + T2p, T1s + T2s) + Discrepancy time*

*) Is omitted for discrepancy behavior "Supply value 0"

T1p = Time for short-circuit test (sensor 1)

T2p = Startup time of sensor after short-circuit test (sensor 1)

T1s = Time for short-circuit test (sensor 2)

T2s = Startup time of sensor after short-circuit test (sensor 2)

The discrepancy time is included in the calculation of the maximum response time (T_{WCDT}) and can therefore be set to 0 in the SIMATIC STEP7 response time table.

Maximum response time to external short-circuits (one fault delay time, OFDT)

Maximum response time (T_{OFDT}) = Input delay + T_{cycle} + (n * T_{cycle}) + Sum[x=0...7](Tsx)

Tsx summation term:

(T1x + T2x) < T_{cycle} → Tsx = T_{cycle}

(T1x + T2x) >= T_{cycle} → Tsx = max (T1x, T_{cycle}) + T2x

For deactivated sensor supplies or sensor supplies with deactivated short-circuit test, the value 0 has to be used in the formula for Tsx.

x = Sensor supply

T1x = Time for short-circuit test

T2x = Startup time of sensor after short-circuit test

n = Number of sensor supplies with activated short-circuit test

Below you will find two examples for calculating the maximum response time to external short-circuits on a F-DI 8×24VDC HF depending on the parameter assignment.

Channel	Input delay (ms)	Short-circuit test	T1 (ms)	T2 (ms)	T_{cycle} (ms)	T1 + T2 < T_{cycle}	Ts (ms)	Max. response time to external short-circuits (ms)
0	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
1	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
2	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8

Channel	Input delay (ms)	Short-circuit test	T1 (ms)	T2 (ms)	T_{cycle} (ms)	T1 + T2 < T_{cycle}	Ts (ms)	Max. response time to external short-circuits (ms)
3	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
4	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
5	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
6	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8
7	3.2	Enable	4.2	4.2	8.0	NO	12.2	172.8

Example calculation: (4.2 ms + 4.2 ms) >= 8.0 ms→ Ts = max (4.2 ms, 8.0 ms) + 4.2 ms = 12.2 ms

Channel	Input delay (ms)	Short-circuit test	T1 (ms)	T2 (ms)	T_{cycle} (ms)	T1 + T2 < T_{cycle}	Ts (ms)	Max. response time to external short-circuits (ms)
0	0.4	Enable	0.5	0.5	8.0	YES	8.0	5334.8
1	0.8	Enable	4.2	10	8.0	NO	18.0	5335.2
2	1.6	Enable	20	4.2	8.0	NO	24.2	5336.0
3	3.2	Enable	100	100	8.0	NO	200	5337.6
4	0.4	Disable	-	-	8.0	-	-	- *)
5	0.8	Enable	4.2	4.2	8.0	NO	12.2	5335.2
6	1.6	Enable	500	500	8.0	NO	1000	5336.0
7	3.2	Enable	2000	2000	8.0	NO	4000	5337.6

*) External short-circuits are not detected with a deactivated short-circuit test.

Example calculation channel 1: (4.2 ms +10 ms) >= 8.0 ms → Ts = max(4.2 ms, 8.0 ms) + 10 ms = 18.0 ms

Maximum response time for discrepancy error for 1oo2 evaluation (one fault delay time, OFDT)

Maximum response time (T_{OFDT}) = 2 * T_{cycle} + Input delay + 2 * max (T1p + T2p, T1s + T2s) + Discrepancy time

T1p = Time for short-circuit test (sensor 1)

T2p = Startup time of sensor after short-circuit test (sensor 1)

T1s = Time for short-circuit test (sensor 2)

T2s = Startup time of sensor after short-circuit test (sensor 2)

Maximum response time with no faults (Worst Case Delay Time, WCDT) for safety mat evaluation

When the safety mat is activated (the contact is closed), the maximum response time is 17.6 ms.

Maximum response time in the case of fault (One Fault Delay Time, OFDT) for safety mat evaluation

If a safety mat evaluation is only configured on one channel pair, the maximum response time in case of a fault is 25.6 ms.

If a safety mat evaluation is configured on 2 to 4 channel pairs, the maximum response time in case of a fault is 33.6 ms.

Maximum response time with no faults (Worst Case Delay Time, WCDT) for counter

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay

Maximum response time to discrepancy error for counter (One Fault Delay Time, OFDT)

Maximum response time (T_{OFDT}) = 3 * T_{cycle} + Input delay + T1w

T1w = Discrepancy time limit (maximum permissible value is 30,000 ms).

Maximum response time with no faults (Worst Case Delay Time, WCDT) for standstill and overspeed monitoring

Maximum response time (T_{WCDT}) = 2 * T_{cycle} + Input delay + T2w * 1.002

T2w = Monitoring window duration (maximum permissible value is 30,000 ms).

Maximum response time to discrepancy error for standstill and overspeed monitoring (One Fault Delay Time, OFDT)

To define the worst case failure response time for standstill and overspeed monitoring, the following assumptions need to be made:

- An event must occur that makes the failure noticeable. This implies a deviation from the expected pulse sequence. This event is defined as failure event.
- A type of motion must activate the sensor to trigger an event.

The failure reaction indicates the time between the occurrence of the failure event and the occurrence of a discrepancy on the backplane bus. To detect the discrepancy and pass it on to the backplane bus, 2 * T_{cycle} + Input delay are required.

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ET 200SP
Analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1)

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Preface

Purpose of the documentation

This manual supplements the system manual Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293).

Functions that affect the system in general are described in the system manual.

The information in this manual and the system/function manuals provide support when you commission the system.

A description of the F-system SIMATIC Safety can be found in the programming and operating manual SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).

Conventions

CPU: When the term "CPU" is used hereafter, it refers to both the CPUs of the S7-1200/1500 automation system and CPUs of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software " (STEP 7 TIA Portal)".

Note the following identified notes:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you ought to pay special attention.

Standards

You can find a dated reference to the respective standards in the certificate (https://support.industry.siemens.com/cs/ww/en/view/57141281) or in the EC Declaration of Conformity (https://support.industry.siemens.com/cs/ww/en/view/71764057) for the F-module.

Certified versions

You can find the certified product and firmware versions in annex 1 of the report on the TÜV certificate (https://support.industry.siemens.com/cs/ww/en/view/57141289).

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Important note for maintaining the operational safety of your system

WARNING

The operators of systems with safety-related characteristics must adhere to specific operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators in the form of personal notifications about product developments and properties which may be or become important issues in terms of operational safety.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log on to Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/products?pnid=13751&lc=en-WW)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/products?pnid=13828&lc=en-WW)
- SIMATIC WinAC RTX (F) (https://support.industry.siemens.com/cs/ww/en/ps/13915)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/products?pnid=13716&lc=en-WW)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/products?pnid=13683&lc=en-WW)
- Distributed I/O (https://support.industry.siemens.com/cs/products?pnid=14029&lc=en-WW)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/products?pnid=24471&lc=en-WW)

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (https://www.siemens.com/industrialsecurity).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

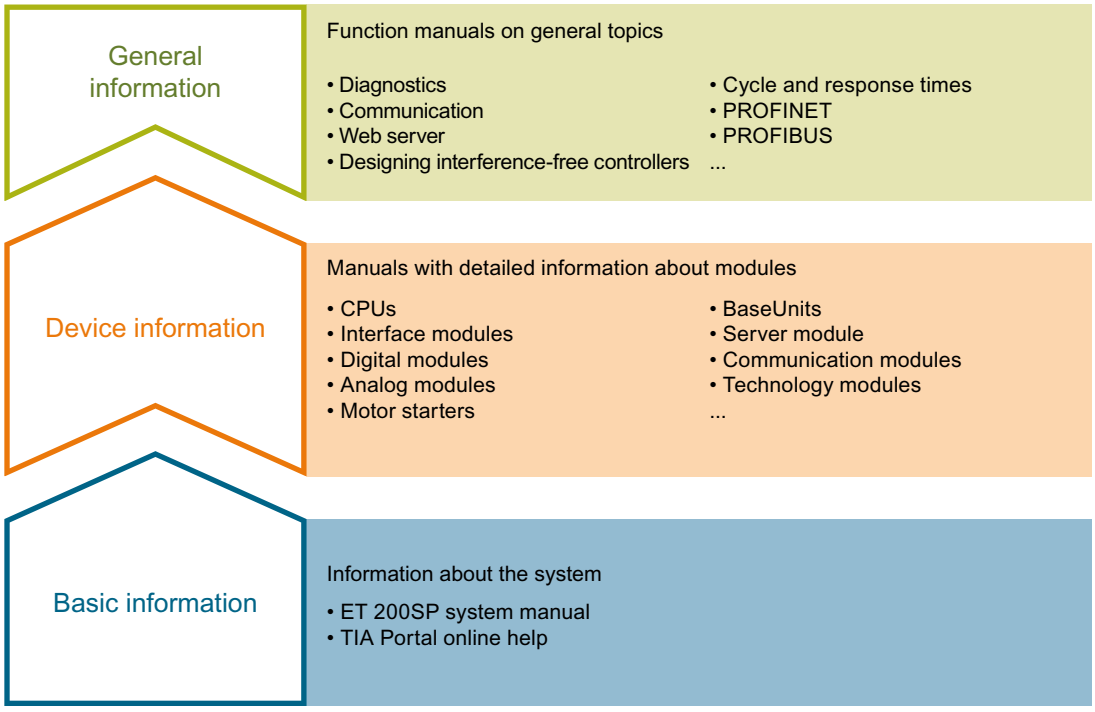

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP. distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" in the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual.
You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation in the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can have access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data in the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7136-6AA00-0CA1

View of the module

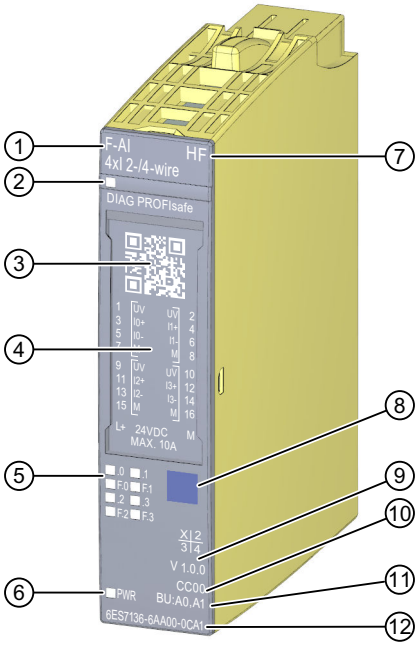

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-1464 View of the F-AI 4xI 0(4)..20mA 2-/4-wire HF module

Properties

The module has the following technical properties:

- Fail-safe module
- PROFIsafe
- Supports the "RIOforFA-Safety" profile on F-CPUs S7-1200/1500.
- PROFIsafe address type 2
- 4 analog inputs with electrical isolation between channels and the backplane bus (up to SIL3/Cat.4/PLd)
- Measuring ranges: 0..20 mA and 4..20 mA
- Resolution: 16 bits including sign
- Short circuit-proof power supply for 2-wire or 4-wire transmitter
- Supply voltage L+
- External sensor supply possible
- Assignable diagnostics
- Diagnostics display (DIAG, red/green LED)
- Status display for each input (green LED)
- Error display for each input (red LED)
- Diagnostics
  - e.g., short-circuit, channel-specific
  - e.g. supply voltage missing, module-specific
- Channel- and module-wide passivation

The module supports the following functions:

- Firmware update
- I&M identification data
- Value status

WARNING

The fail-safe performance characteristics in the technical specifications apply for a mission time life of 20 years and a repair time of 100 hours. If a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before 100 hours expires.

The module switches off independently after the 100 hours have expired.

Follow the repair procedure described in section Diagnostic messages (Page 49).

NOTE

Cyclic reading of I&M data

Cyclic reading of I&M data can affect the timing of the F-modules. You should therefore avoid short read cycles of less than 500 ms.

Accessories

You can order the following accessories separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector
- Electronic coding element as spare part (article number 6ES7193-6EF00-1AA0)

You can find additional information about accessories in the Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293) System Manual.

Connecting

3

3.1 Wiring and block diagram

This section provides the block diagram of the F-AI 4xI 0(4)..20mA 2-/4-wire HF analog input module with the terminal assignment.

You can find additional information about wiring BaseUnits in the Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293) System Manual.

Block diagram

The following figure shows the block diagram of the F-AI 4xI 0(4)..20mA 2-/4-wire HF analog input module on the BaseUnit BU type A0/A1.

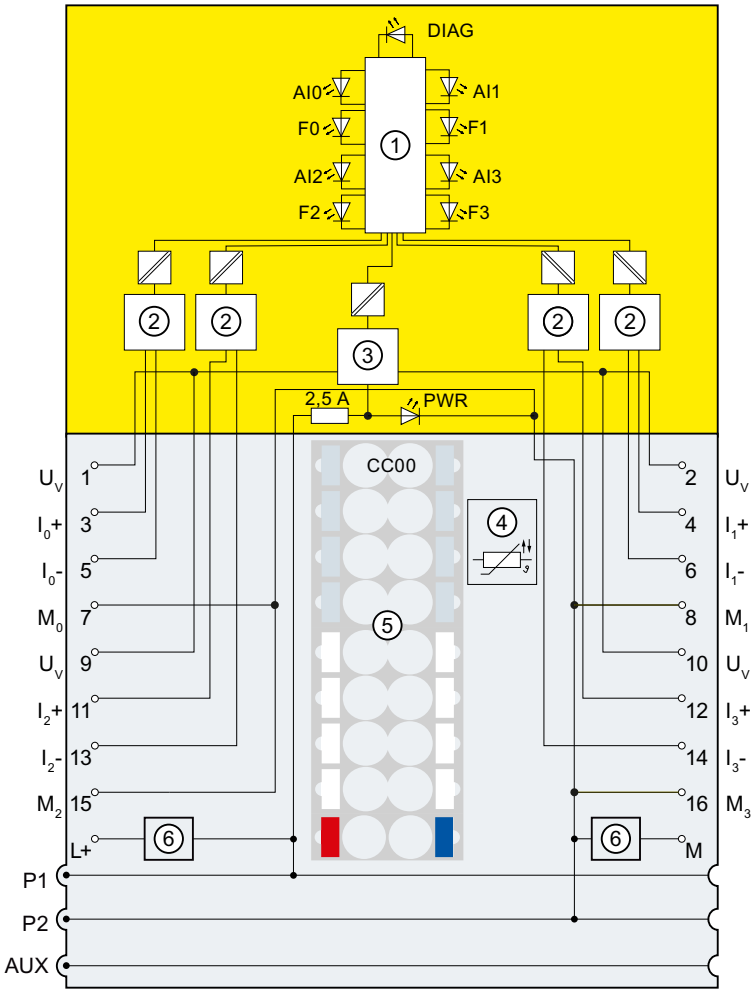

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground to channel n
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)
I_n+	Current input positive, channel n	AI0, AI1, AI2, AI3	Channel status LED (green)
I_n-	Current input negative, channel n	F0, F1, F2, F3	Channel fault LED (red)
		PWR	Power LED (green)

Figure 2-1465 Block diagram

Sensor supply

⚠ WARNING

Voltage dips and voltage fluctuations of the voltage supply are not buffered by the F-module and, thus, affect the sensor supply.

This can cause the measured value to be false and must be taken into account when determining the safety function.

To ensure that the sensor functions problem-free, we recommend one of the following options:

- You can avoid voltage dips by using a voltage supply according to the NAMUR recommendation NE 21.

or

- Use a transducer with an appropriate battery backup or diagnostics.

Recommendation: Internal sensor supply

You are strongly advised to use the short circuit-proof internal sensor supply of the F-module. This internal sensor supply is monitored and its status is indicated by the Fn LED. The input is also protected in the event of short-circuits in the wiring or at the sensor.

NOTE

The internal sensor supply is switched off in case of a short circuit to ground or during power-up in the event of short circuit to L+.

The sensor supply is also switched off at input currents > 35 mA.

A check is made approximately 1 minute later to determine if the error has gone.

NOTE

Behavior of process values and diagnostics evaluation

Sensor startup during module startup:

After the internal sensor supply is activated, the evaluation of wire break and underflow diagnostics is suppressed for 3 seconds. During this time, the module makes the secure process data 0 available at all channels. This suppresses a possible wire break or underflow diagnostics caused by the sensor startup. If the sensor startup is not yet complete after the 3 seconds have elapsed, it is possible that the module might detect wire break or underflow and passivate the affected channel. In this case, the channel fault must be acknowledged during startup.

Sensor startup during operation:

If a sensor startup takes place during operation, e.g. the sensor supply is reactivated after a short-circuit, all analog values are invalid and wire break or underflow diagnostics can occur on the sensors connected to the internal sensor supply.

External/internal sensor supply

The figures in section "Applications of the F-I/O module (Page 35)" show how you can supply power to the sensors via an external sensor supply (for example, from another module).

⚠ WARNING

If there is a short-circuit from L+ to Mn+, the input resistors could be destroyed, depending on the selected interconnection type.

You can avoid this problem through proper wiring and use of the internal sensor supply. When an external sensor supply is used, other suitable measures are necessary to protect the input resistors (e.g. external fast 50 mA fuse in the input circuit of the F-module).

WARNING

External sensor supply

If you use an external sensor supply, you need to take into consideration the voltage dips and voltage fluctuations when determining the safety function.

To ensure that the sensor functions problem-free, we recommend one of the following options:

- Use a transducer with an appropriate battery backup or diagnostics.

  or
- Use a **redundant** external sensor supply

  or
- **Monitor** the external sensor supply for undervoltage/overvoltage, including shutdown of the sensor supply in the event of a fault (single channel for SIL2; two-channel for SIL3).

Parameters/address space

4

4.1 Measurement types and measuring ranges

The following table shows the measurement types and the respective measuring range.

Table 2-1877 Measurement types and measuring ranges

Measurement type	Measuring range	Resolution
Current	0 to 20 mA (2-wire and 4-wire transducer) 4 to 20 mA (2-wire and 4-wire transducer)	16 bits including sign 16 bits including sign

You can find the tables of the measuring ranges as well as overflow, overrange, etc. in the Appendix Representation of analog values (Page 61).

4.2 Parameters

Parameters for F-AI 4xI 0(4)..20mA 2-/4-wire HF

WARNING

Diagnostics functions should be activated or deactivated in accordance with the application, see section Applications of the F-I/O module (Page 35).

The following parameters are possible:

Table 2-1878 Configurable parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
F-parameters:				
Manual assignment of the F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	depends on parameter assignment of F-CPU	No	Module
F-destination address	1 to 65534	suggested by F-system	No	Module
F-parameter signature (without address)	0 to 65535	calculated by F-system	No	Module
Behavior after channel faults	• Passivate entire module • Passivate channel	Passivate channel	No	Module

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	(S7-300/400) Adjustable (S7-1200/1500) All channels manually	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	suggested by F-system	No	Module
F-I/O DB name	—	suggested by F-system	No	Module
AI parameters				
Interference frequency suppression	• 50 Hz • 60 Hz	50 Hz	No	Module
Channel parameters:				
Channel n				
Sensor evaluation	• 1oo1 evaluation (max. SIL3/Cat.3/PLd) • 1oo2 evaluation (max. SIL3/Cat.4/PLe)	1oo1 evaluation (max. SIL3/Cat.3/PLd)	No	Channel
Standard value	• MIN • MAX	MIN	No	Channel
Discrepancy time *	100 to 30000 ms	100 ms	No	Channel
Tolerance window %, absolute	2.0 to 20.0%	5.0%	No	Channel
Tolerance window %, relative	2.0 to 20.0%	5.0%	No	Channel
Activated	• Disable • Enable	Enable	No	Channel
Channel fault acknowledgment	• Manual • Automatic The value range offered depends on the F-CPU in use and on the configuration of the F-parameter "Reintegration after channel fault".	(S7-300/400) Parameter is not supported (S7-1200/1500) Manual	No	Channel
Measuring range	• 0 to 20 mA • 4 to 20 mA	4 to 20 mA	No	Channel
Diagnostics: Wire break **	• Disable • Enable	Enable	No	Channel
Smoothing	• 1 • 2 • 4 • 8 • 16 • 32 • 64	1	No	Channel

* See formula under Parameter assignment of discrepancy analysis for 1oo2 evaluation (Page 23)

* Can only be set with 4 to 20 mA measuring range

4.3 Explanation of parameters

4.3.1 F-parameters

You must assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation.

- You define the F-source address using the "Base for PROFIsafe addresses" parameter in the F-CPU.
- An F-destination address unique throughout the CPU is automatically assigned for each F-module. You can manually change the F-destination addresses set in the hardware configuration.

You can find information on F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB in the manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).

4.3.2 Parameters of the channels

4.3.2.1 Interference frequency suppression

Here you set the interference frequency suppression for the line frequency:

- 50 Hz
- 60 Hz

You can find additional information on this in the Analog value processing function manual (https://support.industry.siemens.com/cs/ww/en/view/67989094).

4.3.2.2 Evaluation of the sensors

Overview

Here you select the type of sensor evaluation:

- "1oo1 evaluation (max. SIL3/Cat.3/PLd)"
- "1oo2 evaluation (max. SIL3/Cat.4/PLe)"

If you do not want to measure with a channel or channel pair, disable the channel or the channel pair.

1oo1 evaluation (max. SIL3/Cat.3/PLd)

With the 1oo1 evaluation, there is one sensor, and it is connected to the F-module via a single channel.

1oo2 evaluation (max. SIL3/Cat.4/PLe)

With the 1oo2 evaluation, two input channels are occupied by:

- Two single-channel sensors
- One two-channel sensor

Note that in 1oo2 evaluation, two channels are combined into a channel pair.

Achievable safety class

Depending on the selected sensor evaluation, you achieve the following safety classes with a sensor that is qualified accordingly:

- SIL3/Cat.3/PLd for "1oo1 evaluation" or
- SIL3/Cat.4/PLe for "1oo2 evaluation"

See also

Parameter assignment of discrepancy analysis for 1oo2 evaluation (Page 23)

4.3.2.3 Standard value

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can choose for each input channel pair which of the two F-CPU values is provided.

- "MIN": the lesser of the two values.
- "MAX": the greater of the two values.

During a discrepancy between the two input channels, the last valid standard value prior to the occurrence of the discrepancy is made available to the F-CPU.

4.3.2.4 Discrepancy time

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the discrepancy time for each channel pair here in milliseconds.

The discrepancy time does not start until the standard value is outside the assigned tolerance window (relative or absolute). If the two redundant input channels of the channel pair differ by more than the specified tolerance and for longer than the specified discrepancy time but no longer than the duration of the maximum response time, the F-module detects a discrepancy error and triggers a diagnostic interrupt. If the input channels fall below the specified tolerance prior to expiration of the discrepancy time (input channels are no longer discrepant), the discrepancy time is cleared and is restarted only when a new discrepancy is detected.

You can find additional information about configuring the discrepancy analysis under Parameter assignment of discrepancy analysis for 1oo2 evaluation (Page 23).

A discrepancy error is handled by the safety program in the same way as a channel fault. Additional information is available in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

4.3.2.5 Tolerance window %, absolute

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the size of a tolerance window for the discrepancy here for the channel pair. You specify the tolerance window as a percentage of the full-scale value. The reference value is the full-scale value, i.e. 20 mA. The entered value is rounded to one decimal place.

If two redundant input channels of the channel pair differ by more than the tolerance specified here and for longer than the specified discrepancy time, the F-module detects a discrepancy error and triggers a diagnostic interrupt.

For more information regarding setting the tolerance window, refer to Parameter assignment of discrepancy analysis for 1oo2 evaluation (Page 23).

Example

You have assigned the following:

- The "Tolerance window % absolute" 10%
- The measuring range 0..20 mA
- A discrepancy time of 100 ms

The input channels may differ from the configured discrepancy time (100 ms) up to the max. reaction time for a time window with a difference of more than 2 mA.

See also

Discrepancy time (Page 21)

4.3.2.6 Tolerance window %, relative

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the size of a tolerance window for the discrepancy here for each channel pair. You specify the tolerance window as a percentage of the assigned standard value. The entered value is rounded to one decimal place.

If two redundant input channels of the channel pair differ by more than the tolerance specified here and for longer than the specified discrepancy time, the F-module detects a discrepancy error and triggers a diagnostic interrupt.

The two parameters "Tolerance window % absolute" and "Tolerance window % relative" are combined. The "Tolerance window % absolute" parameter is decisive in case of low process values.

For more information regarding setting the tolerance window, refer to Parameter assignment of discrepancy analysis for 1oo2 evaluation (Page 23).

Example

You have assigned the following:

- The "tolerance window % relative" is set at 10%
- A measuring range of 0 to 20 mA
- A discrepancy time of 200 ms
- A unit value of 20 mA

The input channels may differ from the configured discrepancy time (200 ms) up to the max. reaction time for a time window with a difference of more than 2 mA.

See also

Discrepancy time (Page 21)

4.3.2.7 Parameter assignment of discrepancy analysis for 1oo2 evaluation

Operating principle of discrepancy analysis

A discrepancy analysis is performed with a configured 1oo2 evaluation. **Smoothed** process values are used for the discrepancy analysis.

An assignable tolerance window is formed around the process value that represents the instantaneous standard value (value that is signaled to the F-CPU).

The tolerance window is formed relative to the process value or as an absolute value relative to the measuring range end value. Relative and absolute tolerance windows are combined.

If the process value does not represent the standard value at an instant and is within the tolerance window, **no** discrepancy exists.

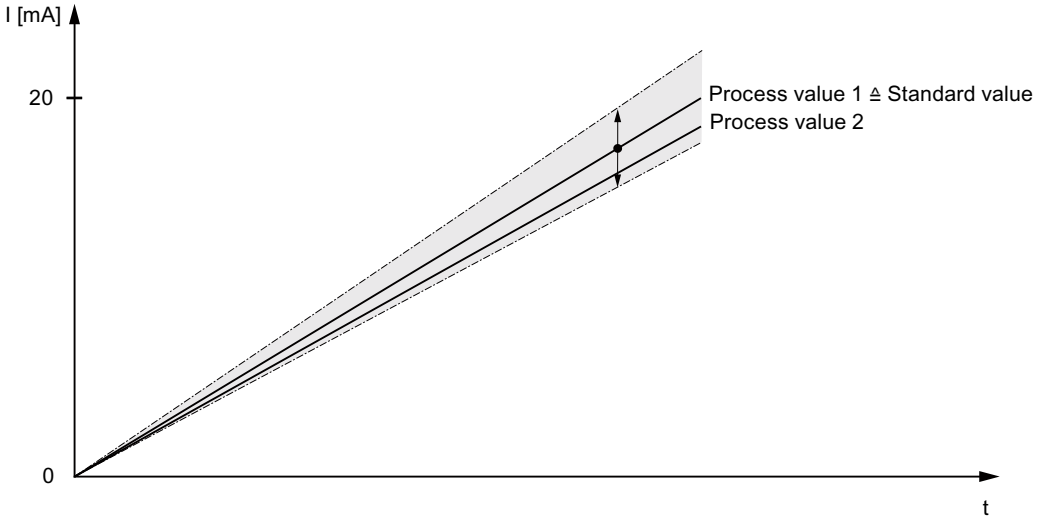

Figure 2-1466 Example of a relative tolerance window *without* discrepancy (parameter assignment: standard value = MAX)

If the process value does not represent the standard value at an instant but is outside the tolerance window, a discrepancy exists.

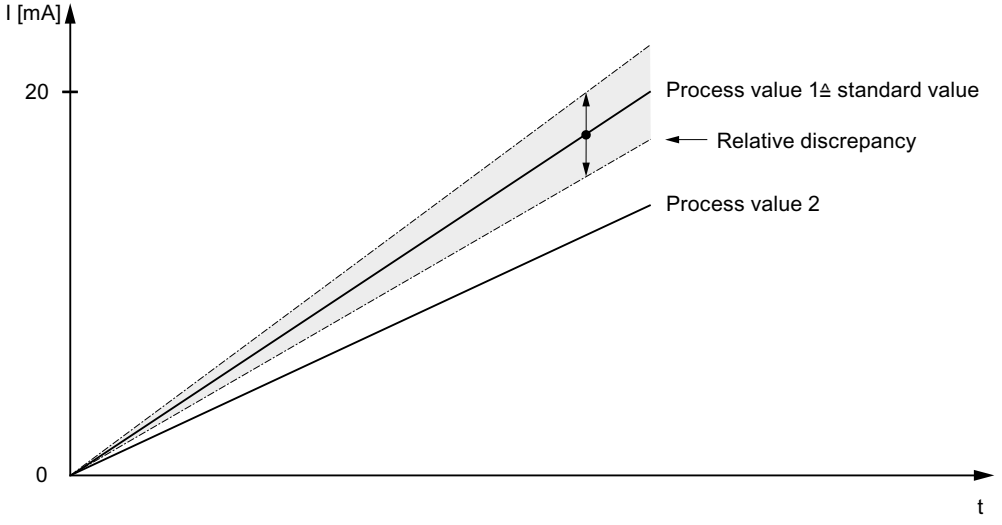

Figure 2-1467 Example of a relative tolerance window *with* discrepancy (parameter assignment: standard value = MAX)

The assigned discrepancy time starts as soon as a discrepancy is detected. The discrepancy time runs as long as the discrepancy exists.

- During a discrepancy between the two input channels, the last valid standard value prior to occurrence of the discrepancy is signaled to the F-CPU.

  If the input channels fall below the specified tolerance prior to expiration of the discrepancy time (input channels are no longer discrepant), the discrepancy time is cleared and is restarted only when a new discrepancy is detected.

- There is no valid old value after startup. If the discrepancy is detected during this time, $7FFF_H$ is output for S7-300/400 F-CPUs or 0 is output for S7-1200/1500 F-CPUs and the discrepancy time is started.

  If there is no longer a discrepancy between the input channels when the discrepancy time expires, the standard value is output.

If the discrepancy time has expired, an error is signaled and the process value is set to $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs. In the PII, the substitute value 0 is set for the safety program.

A discrepancy error is handled by the safety program in the same way as a channel fault. Additional information is available in the STEP 7 Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Configuring the discrepancy analysis parameters

The following four parameters for the discrepancy analysis are assigned for each channel pair:

- Discrepancy time
- Standard value
- Tolerance window %, absolute
- Tolerance window %, relative

"Discrepancy time" parameter

If the following is true, the F-module detects a discrepancy error:

- The process value that does not represent the standard value is outside the configured tolerance window.
- Lasts longer than the configured discrepancy time.
- Lasts at maximum the duration of the maximum response time.

In the case of a discrepancy error, the F-module triggers a diagnostic interrupt and sets the process value to $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs. The discrepancy time is reset if the standard value lies within the tolerance window again.

In the PII, the substitute value 0 is set for the safety program.

You calculate the maximum discrepancy time that is permitted in the respective application using the following formula:

Discrepancy time = Maximum response time (in case of discrepancy error) – 2 × Conversion cycle time × Smoothing – 2 × Conversion cycle time

NOTE

You calculate the discrepancy time by using the values from section Discrepancy time (Page 59) in the above equation.

You can assign the discrepancy time for each channel pair.

"Standard value" parameter

You can select which of the two values is to be signaled to the F-CPU for each input channel pair. During a discrepancy between the two input channels, the last valid standard value prior to occurrence of the discrepancy is signaled to the F-CPU.

- "MIN": The lower of the two values is signaled to the F-CPU as the standard value.
- "MAX": The higher of the two values is signaled to the F-CPU as the standard value.

"Tolerance window %, absolute" parameter

You can calculate the absolute tolerance window using the following formula:

$$T_{abs} = \frac{|\Delta I_{abs}|}{I_{ME} - I_{MA}} \times 100 \ [\%]$$

Calculate the maximum deviation of the current using the following formula:

$$\Delta I_{abs} = \pm \frac{(I_{ME} - I_{MA}) \times T_{abs}}{100} \ [mA]$$

With

- I_{ME} = 20 mA (full-scale value)
- I_{MA} = 0 mA for measuring range 0 ... 20 mA (start-of-scale value)
- I_{MA} = 4 mA for measuring range 4 ... 20 mA (start-of-scale value)
- T_{abs} = Tolerance in %
- ΔI_{abs} = Maximum deviation of current (+/-)

You can assign a value of 2.0 to 20.0% for the "Tolerance window %, absolute" parameter for each channel pair.

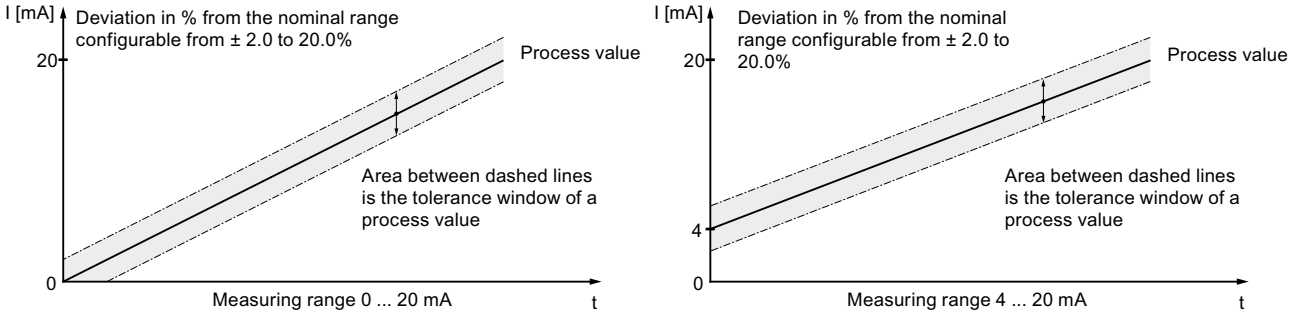

Figure 2-1468 Absolute deviation in % of the nominal range for measuring range 0 to 20 mA or 4 to 20 mA

"Tolerance window %, relative" parameter

The tolerance window is calculated as a percentage of the **smoothed** process value that represents the MIN or MAX value (depending on the parameter assignment of the standard value) in this instant.

You can calculate the relative tolerance window using the following formula:

$$T_{rel} = \frac{|\Delta I_{rel}|}{|I_{EW} - I_{MA}|} \times 100 \ [\%]$$

Calculate the maximum deviation of the current using the following formula:

$$\Delta I_{rel} = \pm \frac{|I_{EW} - I_{MA}| \times T_{rel}}{100} \ [mA]$$

With

- I_{EW} = Process standard value (min./max.)
- I_{MA} = 0 mA for measuring range 0 ... 20 mA
- I_{MA} = 4 mA for measuring range 4 ... 20 mA
- T_{rel} = Tolerance in %
- ΔI_{rel} = Maximum deviation of current (+/-)

You can assign a value of 2.0 to 20.0% for the "Tolerance window %, relative" parameter for each channel pair.

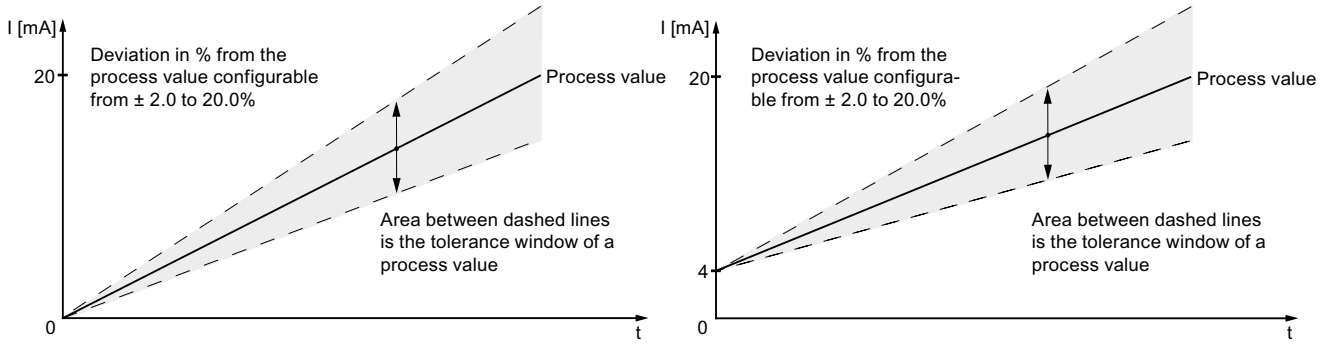

Figure 2-1469 Relative deviation in % of the nominal range for measuring range 0 to 20 mA or 4 to 20 mA

Combination of the "Tolerance window %, absolute" and "Tolerance window %, relative" parameters

You can combine the "Tolerance window %, absolute" and "Tolerance window %, relative" parameters as needed. The combined tolerance window (shown in gray in the figure below) is the maximum of T_{rel} and T_{abs}.

$T = MAX \{ T_{rel}, T_{abs} \}$

$\Delta I = MAX \{ \Delta I_{rel}, \Delta I_{abs} \}$

With

- T = Tolerance, in %
- ΔI = Maximum deviation of current (+/-)

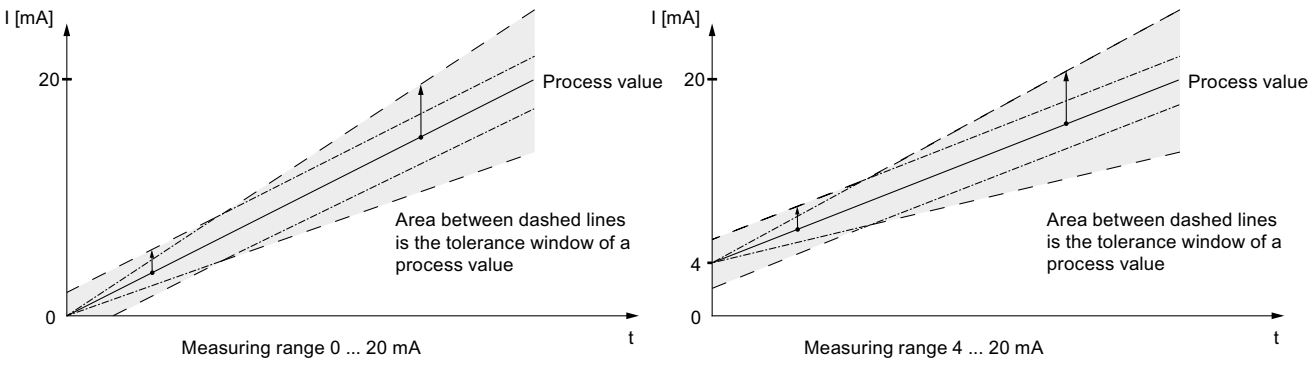

Example

The following diagrams show you the behavior of the discrepancy evaluation when standard value = MAX.

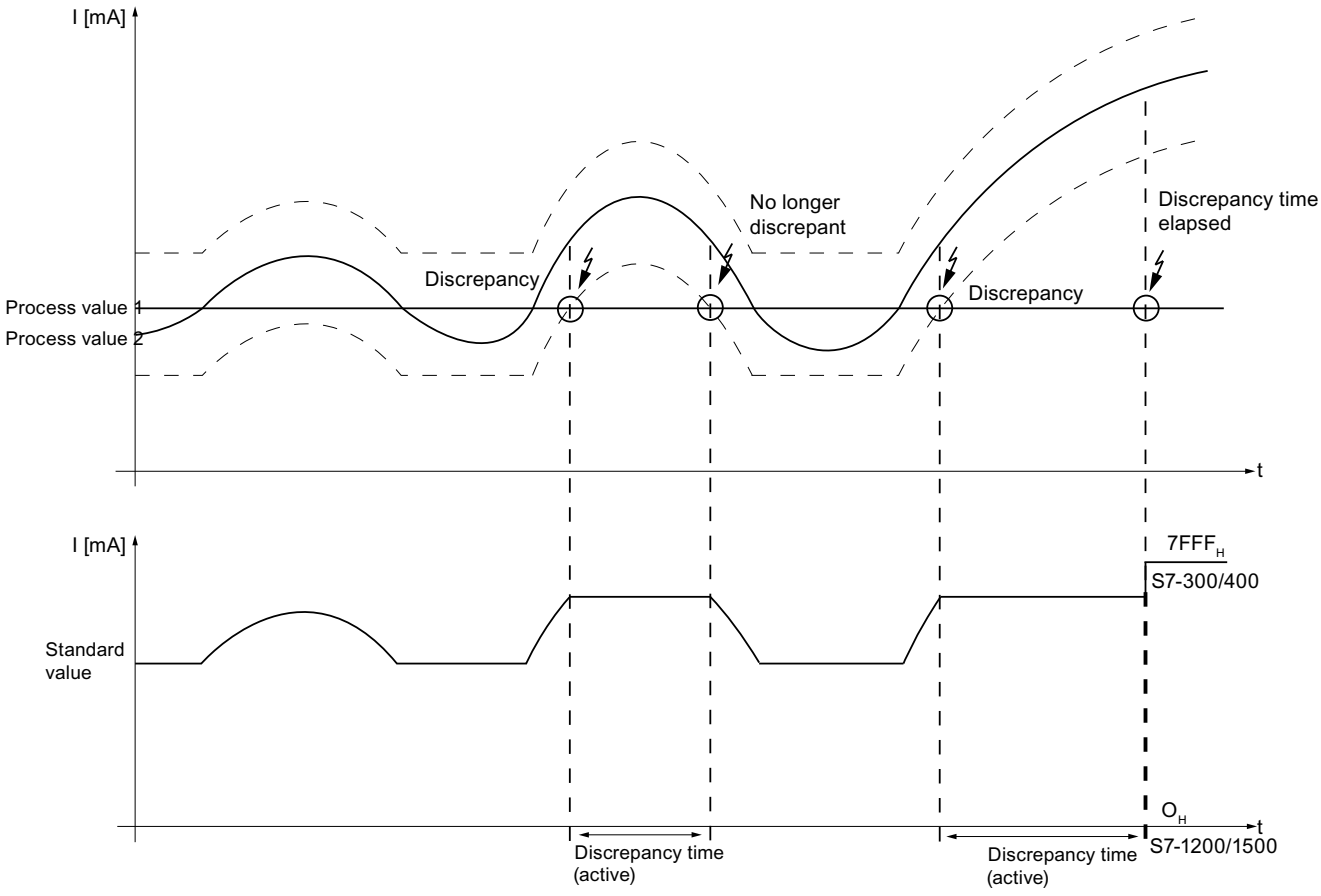

The upper of the two diagrams shows you the characteristic curve of the two process values. The dashed line represents the absolute tolerance range configured in this example.

The lower of the two diagrams shows you the standard value signaled to the F-CPU.

In this example, on the first occurrence of a discrepancy, process value 1 is **within** the tolerance range again **before** expiration of the discrepancy time. This means the discrepancy error is not signaled.

In this example, on the second occurrence of a discrepancy, process value 1 is **outside** the tolerance range when the discrepancy time expires. As a result, a discrepancy error is signaled with $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs after expiration of the discrepancy time. In the PII, the substitute value 0 is set for the safety program.

See also

Discrepancy time (Page 21)
Tolerance window %, absolute (Page 22)
Tolerance window %, relative (Page 22)

4.3.2.8 Activated

If you select this check box, the corresponding channel is enabled for signal processing.

You can deactivate an unused channel with this parameter.

If you deactivate unused channels, the response time of the F-module is reduced.

4.3.2.9 Channel failure acknowledge

Use on S7-1200/1500 F-CPUs

The parameter is only relevant if the F-module can be operated on an S7-1200/1500 F-CPU.

The parameter can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".

The value of this parameter specifies how the channel reacts after a channel fault:

- Manual: A channel failure is reintegrated after manual acknowledgment.
- Automatically: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

Use in S7-300/400 F-CPUs

The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. For S7-300/400 F-CPUs you set the corresponding property at the F-I/O DB by means of the ACK_NEC tag.

For detailed information about the F-I/O DB, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

4.3.2.10 Measuring range

You select the measuring range for the channel with this parameter:

- 0 to 20 mA
- 4 to 20 mA

4.3.2.11 Diagnostics: Wire break

Function

Here you activate wire break detection for a configured measuring range of 4 to 20 mA.

With an assigned measuring range of 4 to 20 mA:

- With assigned wire break diagnostics and currents < 3.6 mA, a wire break is detected and a diagnostic interrupt is triggered in the F-CPU.
- Without configured wire break and currents diagnostics < 0.4444 mA detects "underflow" and triggers a diagnostic interrupt in the F-CPU.

With an assigned measuring range of 0 to 20 mA, the wire break diagnostics is permanently set by default. With currents < 0.4442 mA, a wire break is detected and a diagnostic interrupt is triggered in the F-CPU.

If you do not need a channel, deactivate the channel. Then, a wire break is not detected.

4.3.2.12 Smoothing

Using smoothing

Smoothing of analog values provides a stabilized analog signal for further processing. Smoothed values are always used for discrepancy analysis.

⚠ WARNING

The smoothing takes place as a result of averaging over the selected number of most recently converted analog values of a channel, e.g. 64.

The mean value generation causes a discrepancy to be delayed with a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)". You can find an example below.

Smoothing principle

The measured values are smoothed by a digital filter. Smoothing is achieved by the F-module forming the mean of a number of converted (digitized) analog values determined by the "Smoothing" parameter.

You assign smoothing in 7 levels (1, 2, 4, 8, 16, 32, 64 conversion cycles). The level determines the number of analog signals that are averaged. If smoothing = 1 is configured, the smoothing is deactivated.

A higher smoothing provides a more stable analog value, and prolongs the time it takes to apply a smoothed analog signal following a unit step. You can find an example below.

NOTE

Smoothing is reset after startup, short circuit, wire break or another channel fault. If, for example, smoothing with 16 conversion cycles is assigned and all channels are active, it takes up to 2000 ms until the process value is signaled with a configured interference frequency suppression of 50 Hz.

Until the first valid process value, the F-module signals for the channel $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs.

If a discrepancy occurs, measuring and smoothing continues and is not restarted.

Example

The figure below shows the number of conversion cycles, depending on the smoothing setting, after which the analog value is completely smoothed and available in the case of a unit step. The figure applies to all signal changes at the analog input.

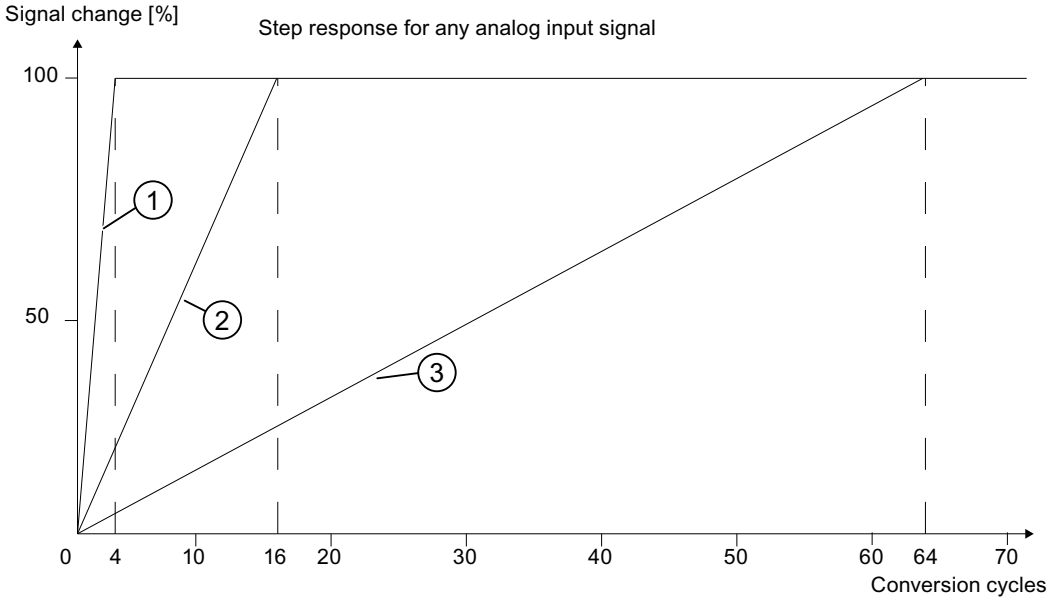

① Smoothing - 4 conversion cycles

② Smoothing - 16 conversion cycles

③ Smoothing - 64 conversion cycles

Example: Effect of smoothing on the maximum response time for a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)" in case of error

If an error (One Fault Delay Time, OFDT) occurred with a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you calculate the maximum response time according to the following formula:

Maximum response time (in case of discrepancy error) = 2 × Conversion cycle time × Smoothing + Discrepancy time + 2 × Conversion cycle time

Example: One channel pair connected and configured (activated), interference frequency 50 Hz, smoothing = 16 conversion cycles, discrepancy time = 2000 ms, conversion cycle time calculated with the formula from section Response times (Page 59):

Max. response time (in case of discrepancy error) = 2 × 70 ms × 16 + 2000 ms + 2 × 70 ms = 4380 ms

If a discrepancy exists between the two input channels, it can take 4380 ms until the F-module signals a discrepancy error to the F-CPU.

If the discrepancy time expires, an error is signaled and the process value is set to $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs. In the PII, the substitute value 0 is set for the safety program.

4.4 Address space

Address assignment for the analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF

The analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF occupies the following address areas in the F-CPU:

Table 2-1879 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In input range**	**In output range**
S7-300/400 F-CPUs	IB x + 0 to x + 12	QB x + 0 to x + 3
S7-1200/1500 F-CPUs	IB x + 0 to x + 13	QB x + 0 to x + 4

x = Module start address

Address assignment of the user data and the value status of the analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF

The user data occupy the following addresses in the analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF out of all the assigned addresses in the F-CPU:

Table 2-1880 User data address assignment in the input range

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
IB x + 0	Input value at channel 0 (Result of the 1oo2 evaluation channel 0/2)							
IB x + 1								
IB x + 2	Input value at channel 1 (Result of the 1oo2 evaluation channel 1/3)							
IB x + 3								
IB x + 4	Input value at channel 2							
IB x + 5								
IB x + 6	Input value at channel 3							
IB x + 7								
IB x + 8	—	—	—	—	Value status* for AI_3	Value status* for AI_2	Value status* for AI_1	Value status* for AI_0

* Only S7-1200/1500 F-CPUs

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

Additional information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Applications of the F-I/O module 5

You achieve SIL3/Cat.4/PLe with the following applications.

The wiring is performed on the suitable BaseUnit. Additional information is available in the Connecting section in the Distributed I/O System ET 200SP (http://support.automation.siemens.com/WW/view/en/58649293) System Manual.

5.1 Application 1: Safety mode SIL3/Cat.3/PLd with 2-wire transducer

Introduction

Below you will find the wiring scheme and the parameter assignment of the F-AI 4xI 0(4)..20mA 2-/4-wire HF for

- Application 1: Safety mode SIL3/Cat.3/PLd, 1oo1 (1v1) evaluation.

Possible diagnostic messages, the error causes and possible corrective measures are given in section "Diagnostic messages (Page 49)".

Current measurement 0/4 to 20 mA, 2-wire transducer

Four process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.

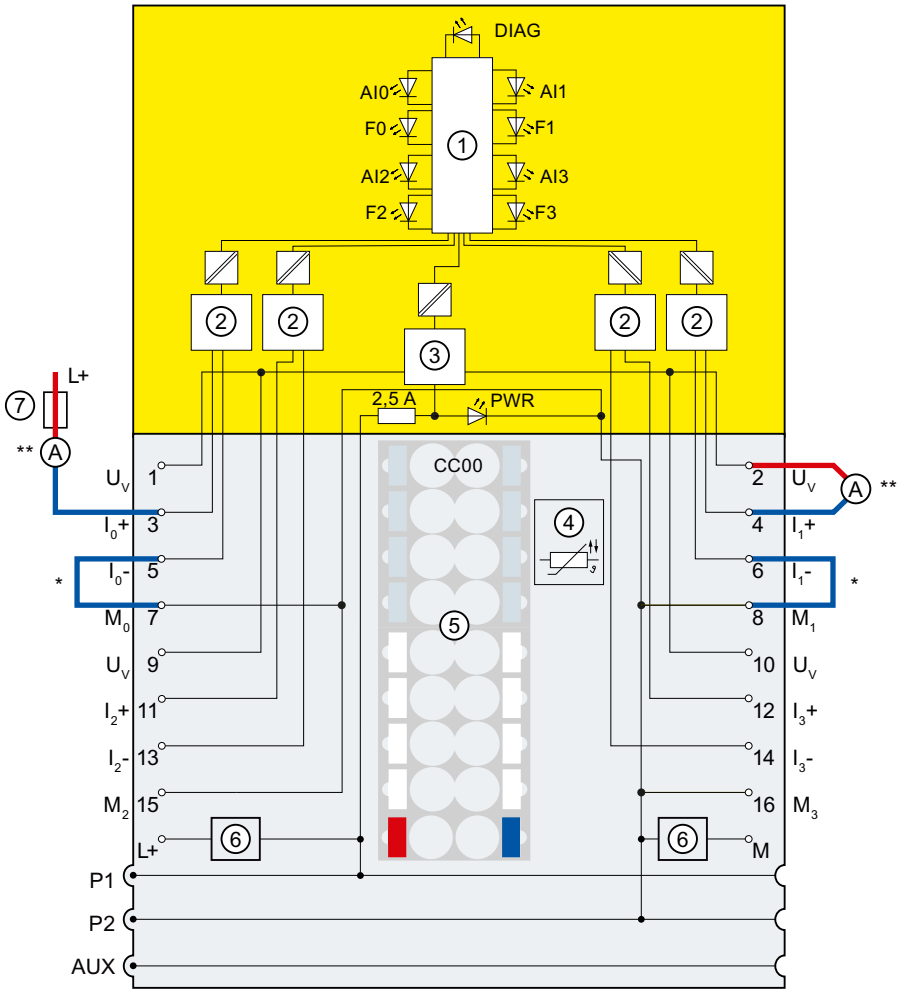

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground reference to U_V, channel n
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)
⑦	External fuse	AI0, AI1, AI2, AI3	Channel status LED (green)

I_n+	Current input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
I_n-	Current input negative, channel n	PWR	Power LED (green)
*	Create the bridge directly at the terminal connection.	**	Measuring transducer

Figure 2-1470 1oo1 evaluation

WARNING

To achieve SIL3/Cat.3/PLd using this wiring, you must use a suitably qualified sensor.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for application 1

Table 2-1881 Parameters for application 1 of F-AI 4xI 0(4)..20mA 2-/4-wire HF

Parameters	Range of values in safety mode
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo1 evaluation (max. SIL3/Cat.3/PLd)
Measuring range	• 0 ... 20 mA • 4 ... 20 mA
Diagnostics: Wire break	(in the measuring range 4 to 20 mA) • Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

5.2 Application 2: Safety mode SIL3/Cat.4/PLe with 2-wire transducer

Introduction

Below you will find the wiring scheme and the parameter assignment of the F-AI 4xI 0(4)..20mA 2-/4-wire HF for

- application 2: Safety mode SIL3/Cat.4/PLe, 1oo2 (2v2) evaluation.

Possible diagnostic messages, the error causes and possible corrective measures are given in section "Diagnostic messages (Page 49)".

Current measurement 0/4 to 20 mA, 2-wire transducer

Two process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.

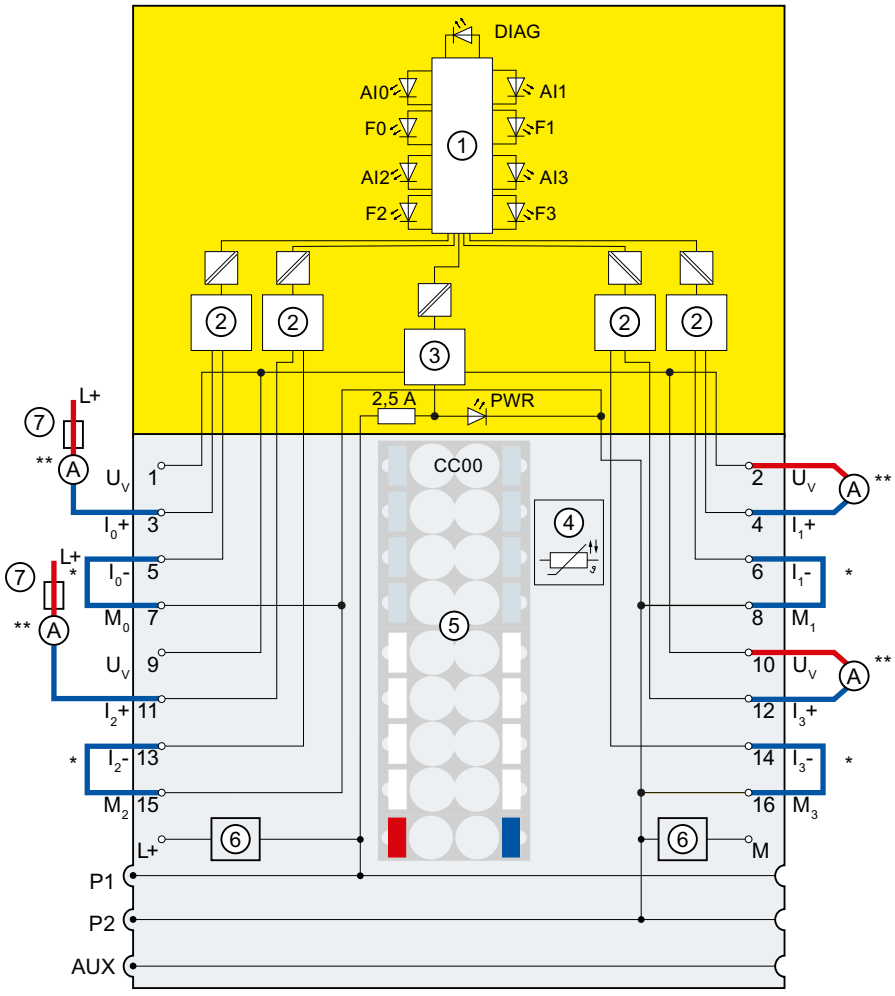

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground reference to U_V, channel n

④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)
⑦	External fuse	AI0, AI1, AI2, AI3	Channel status LED (green)
I_n+	Current input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
I_n-	Current input negative, channel n	PWR	Power LED (green)
*	Create the bridge directly at the terminal connection.	**	Measuring transducer

Figure 2-1471 1oo2 evaluation

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a qualified, two-channel sensor or two qualified single-channel sensors.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for application 2

Table 2-1882 Parameters for application 2 of F-AI 4xI 0(4)..20mA 2-/4-wire HF

Parameters	Range of values in safety mode
Standard value	• MIN • MAX
Discrepancy time	100 to 30000 ms
Tolerance window %, absolute	2.0 to 20.0%
Tolerance window %, relative	2.0 to 20.0%
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo2 evaluation (max. SIL3/Cat.4/PLe)

Parameters	Range of values in safety mode
Measuring range	• 0 to 20 mA • 4 to 20 mA
Diagnostics: Wire break	(in the measuring range 4 to 20 mA) • Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

5.3 Application 3: Safety mode SIL3/Cat.3/PLd with 4-wire transducer

Introduction

Below you will find the wiring scheme and the parameter assignment of the F-AI 4xI 0(4)..20mA 2-/4-wire HF for

- Application 3: Safety mode SIL3/Cat.3/PLd, 1oo1 (1v1) evaluation.

Possible diagnostic messages, the error causes and possible corrective measures are given in section "Diagnostic messages (Page 49)".

Current measurement 0/4 to 20 mA, 4-wire transducer

Four process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.

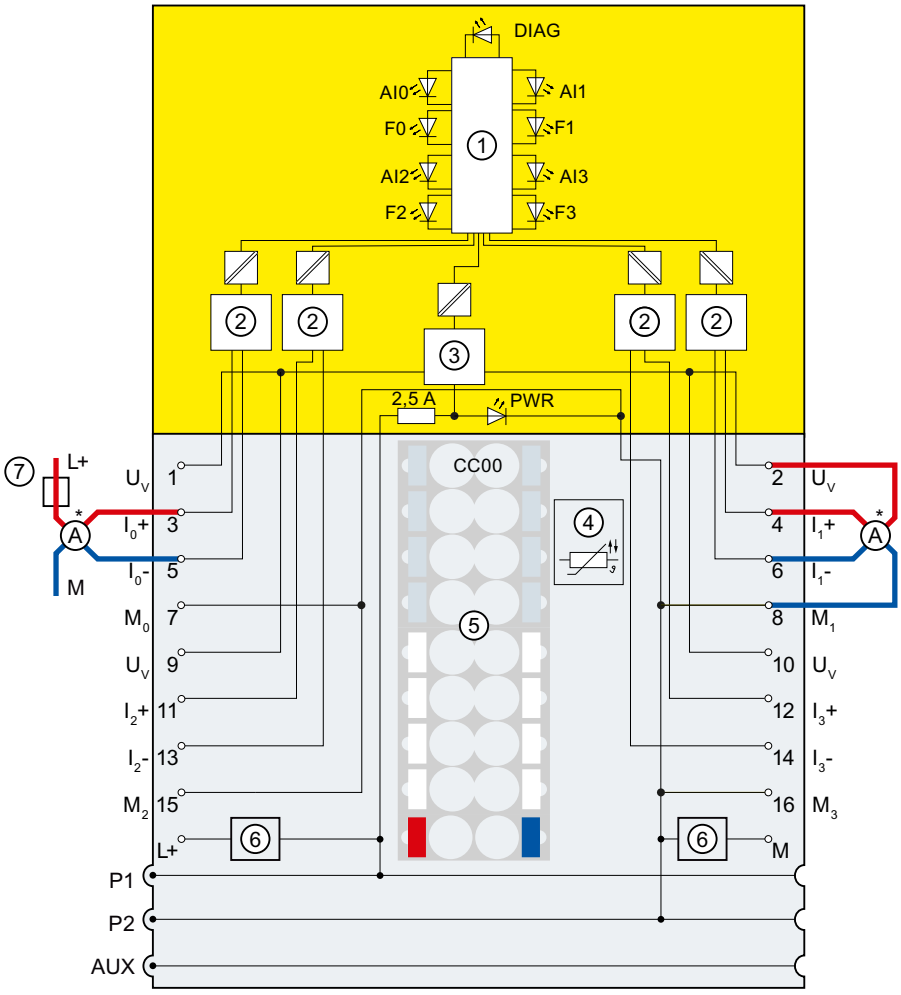

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground reference to U_V, channel n
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)
⑦	External fuse	AI0, AI1, AI2, AI3	Channel status LED (green)

I_n+	Current input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
I_n-	Current input negative, channel n	PWR	Power LED (green)
*	Measuring transducer		

Figure 2-1472 1oo1 evaluation

WARNING

To achieve SIL3/Cat.3/PLd using this wiring, you must use a suitably qualified sensor.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for application 3

Table 2-1883 Parameters for application 3 of F-AI 4xI 0(4)..20mA 2-/4-wire HF

Parameters	Range of values in safety mode
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo1 evaluation (max. SIL3/Cat.3/PLd)
Measuring range	• 0 to 20 mA • 4 to 20 mA
Diagnostics: Wire break	(in the measuring range 4 to 20 mA) • Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

5.4 Application 4: Safety mode SIL3/Cat.4/PLe with 4-wire transducer

Introduction

Below you will find the wiring scheme and the parameter assignment of the F-AI 4xI 0(4)..20mA 2-/4-wire for

- application 4: Safety mode SIL3/Cat.4/PLe, 1oo2 (2v2) evaluation.

Possible diagnostic messages, the error causes and possible corrective measures are given in section "Diagnostic messages (Page 49)".

Current measurement 0/4 to 20 mA, 4-wire transducer

Two process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.

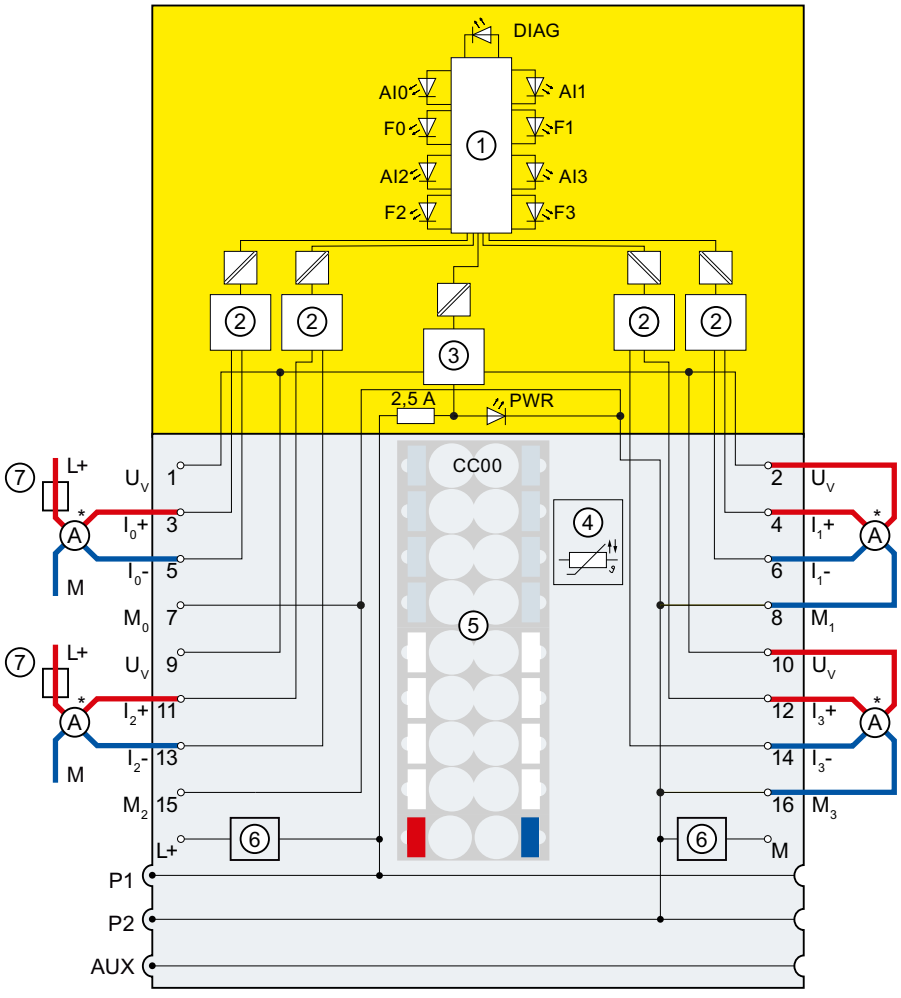

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground reference to U_V, channel n
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)
⑦	External fuse	AI0, AI1, AI2, AI3	Channel status LED (green)

I_n+	Current input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
I_n-	Current input negative, channel n	PWR	Power LED (green)
*	Measuring transducer		

Figure 2-1473 1oo2 evaluation

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use suitably qualified sensors.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for application 4

Table 2-1884 Parameters for application 4 of F-AI 4xI 0(4)..20mA 2-/4-wire HF

Parameters	Range of values in safety mode
Standard value	• MIN • MAX
Discrepancy time	100 to 30000 ms
Tolerance window %, absolute	2.0 to 20.0%
Tolerance window %, relative	2.0 to 20.0%
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo2 evaluation (max. SIL3/Cat.4/PLe)
Measuring range	• 0 to 20 mA • 4 to 20 mA
Diagnostics: Wire break	(in the measuring range 4 to 20 mA) • Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

Interrupts/diagnostic messages

6

6.1 Status and error display

LED display

The following figure shows the LED display of the F-AI 4xI 0(4)..20mA 2-/4-wire HF.

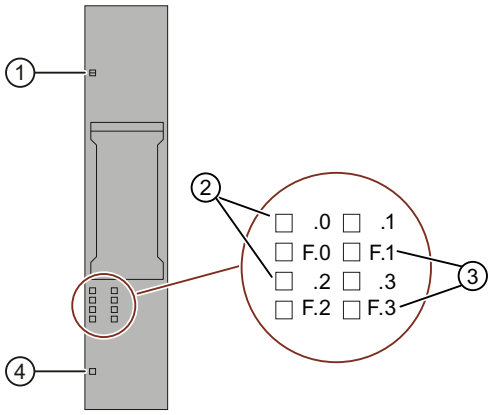

① DIAG (green/red)

② Channel status (green)

③ Channel fault (red)

④ PWR (green)

Figure 2-1474 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostic messages (Page 49).

WARNING

The DIAG LED and the channel status and channel fault LEDs of the outputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

DIAG LED

Table 2-1885 Error display of the LED DIAG

DIAG	Meaning
□ Off	Backplane bus supply of the ET 200SP not okay
☼ Flashing	Module parameters not configured
■ On	Module parameters configured and no module diagnostics
☼ Flashing	• Module parameters configured and module diagnostics • Operation in S7-1200/1500 F-CPUs: At least one channel is waiting for a user acknowledgment.
☼ Flashing	• Operation in S7-1200/1500 F-CPUs: The F-module is waiting for a user acknowledgment after a module fault. • Operation in S7-300/400 F-CPUs: The F-module is waiting for a user acknowledgment.

Channel status/channel fault LED

Table 2-1886 Status display of the LEDs channel status / channel error

Channel status	Channel fault	Meaning
□ Off	□ Off	Channel deactivated or supply voltage L+ missing.
■ On	□ Off	Channel activated and no channel diagnostics
□ Off	■ On	Channel activated and channel diagnostics
☼/☼ Alternately flashing		At least one channel is waiting for a user acknowledgment.

Channel status/DIAG/channel fault LED

Table 2-1887 Status display of the LEDs channel status / DIAG / channel error

Channel status	DIAG	Channel fault	Meaning
□ Off	☼ Flashing	■ All On	The PROFIsafe address does not match the configured PROFIsafe address.
☼ Flashing	☼ Flashing	□ Off	Identification of the F-module when assigning the PROFIsafe address.

PWR LED

Table 2-1888 Status display of LED PWR

PWR	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ available

6.2 Interrupts

Introduction

The fail-safe analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 49).

The list below provides an overview of the diagnostic interrupts of the F-module. The diagnostic interrupts are assigned either to one channel or the entire F-module.

⚠ WARNING

Before acknowledging the short circuit diagnostic message, remedy the respective fault and validate your safety function. Follow the fault remedying procedure described in section Diagnostic messages (Page 49)

Scope of diagnostic interrupt: F-module

- Overtemperature
- Parameter error
- Supply voltage missing
- Channel/component temporarily not available
- Mismatch of safety destination address (F_Dest_Add)
- Safety destination address not valid (F_Dest_Add)
- Safety source address not valid (F_Source_Add)
- Safety watchdog timer value is 0 ms (F_WD_Time)
- Parameter F_SIL exceeds SIL from specific device application
- Parameter F_CRC_Length does not match the generated values
- Version of F-parameter set incorrectly
- CRC1 fault

- Inconsistent iParameters (iParCRC error)
- F_Block_ID not supported
- Transmission error: Inconsistent data (CRC error)
- Transmission error: Timeout (monitoring time 1 or 2 expired)
- Module is defective
- Watchdog tripped
- Invalid/inconsistent firmware present
- Diagnostics memory overflow
- Channel failure acknowledgment
- F-address memory not accessible
- No valid F-address available
- Diagnostics memory overflow
- Undertemperature
- Supply voltage too high
- Supply voltage too low
- Channel/component not available

Scope of diagnostic interrupt: Channel

- Diagnostics: Wire break (can only be configured for measuring range 4..20mA)
- High limit exceeded
- Low limit violated
- Safety-related switch off
- Internal supply voltage of the module failed
- Common mode error
- Analog input signal not recorded unique
- Internal sensor supply short-circuit to P
- Overload or internal sensor supply short-circuit to M
- Discrepancy error
- Analog input signal not recorded unique
- Internal sensor supply short-circuit to P
- Overload or internal sensor supply short-circuit to M
- Read back failure
- ADC error
- Fault in test circuit

6.3 Diagnostic messages

Diagnostic messages

Module faults are indicated as diagnostics (module status).

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Table 2-1889 Diagnostic messages of the F-AI 4xI 0(4)..20mA 2-/4-wire HF

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_H	The F-module measured an excessively high temperature.	Operate the F-module within the specified temperature range (see Technical specifications (Page 54)) Once the temperature has been reduced and returns to the specified range, the F-module must be removed and inserted or the power switched OFF and ON.
Wire break	6_H	Possible causes: • A cable to the sensor is broken. • Fault at the external circuit • Defective sensor • Wrong sensor type set in the parameters • Input channel not used • Measurement resistance too high	Check the possible causes and eliminate the fault.
High limit exceeded	7_H	The measured value exceeds the measuring range.	Check the interaction between the module and the sensor.
Low limit violated	8_H	The measured input value is below a measuring range.	Check the interaction between the module and the sensor.
Parameter error	10_H	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check the supply voltage L+ on the BaseUnit. • Check the BaseUnit.
Safety-related switch off	19_H	For safety purposes, channel was switched off due to an error on another channel. Possible causes: • Short circuit is present.	• Correct the process wiring.
Channel/component temporarily not available	$1F_H$	Possible causes: • Internal fault in the F-module • Firmware update error	• Replace the F-module. • Repeat the firmware update.

Diagnostic message	Fault code	Meaning	Remedy
Mismatch of safety destination address (F_Dest_Add)	40_H	The F-module detected a different F-destination address.	• Check the parameter assignment of the PROFIsafe driver and the PROFIsafe address assigned to the F-module. • Assign the PROFIsafe address to the F-module (again).
Safety destination address not valid (F_Dest_Add)	41_H	The F-module detected an invalid F-destination address.	
Safety source address not valid (F_Source_Add)	42_H	The F-module detected a different F-source address.	
Safety watchdog timer value is 0 ms (F_WD_Time)	43_H	The F-module detected an invalid safety watchdog time.	
Parameter F_SIL exceeds SIL from specific device application	44_H	The F-module detected a discrepancy between the SIL setting of the communication and the application.	
Parameter F_CRC_Length does not match the generated values	45_H	The F-module detected a discrepancy in the CRC length.	
Version of F-parameter set incorrectly	46_H	The F-module detected an incorrect F_Par_Version or an invalid F_Block_ID.	
CRC1 fault	47_H	The F-module detected inconsistent F-parameters.	
Transmission error: Inconsistent data (CRC error)	$4D_H$	The F-module detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Electromagnetic interference has exceeded limits. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference.
Inconsistent iParameters (iParCRC error)	51_H	The firmware of the F-module has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	52_H	The F-module detected an incorrect block ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Timeout (monitoring time 1 or 2 expired)	54_H	The F-module detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Check the parameter assignment. • Ensure that communication is functioning correctly.
Module is defective	100_H	Possible causes: • Electromagnetic interference has exceeded limits. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.
Watchdog tripped	103_H	Possible causes: • Electromagnetic interference has exceeded limits. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.

Diagnostic message	Fault code	Meaning	Remedy
Internal supply voltage of the module failed	104_H	Internal voltage is too low.	Replace the F-module.
Common mode error	118_H	Voltage between two input channels is too high.	Correct the input wiring.
Invalid/inconsistent firmware present	$11B_H$	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for the F-module. Note any error messages. • Use only firmware versions released for this F-module.
Diagnostics memory overflow	$13E_H$	Overflow of the diagnostics memory. It was not possible to send all pending diagnostics. This error can lead to deactivation of the F-module and even to switch off/on of the supply voltage.	Remedy the cause of the diagnostics surge.
Analog input signal not recorded unique	304_H	Measured values from the sensor are not plausible. Possible causes: • Increased EMC • F-module defective	Check the interaction between the F-module and the sensor.
Internal sensor supply short-circuit to P	306_H	Possible causes: • Short-circuit of internal sensor supply to P	Check the process wiring.
Overload or internal sensor supply short-circuit to M	307_H	• The internal sensor supply is overloaded. • Missing or insufficient supply voltage L+.	• Eliminate the short-circuit in the process wiring. • Check the supply voltage L+ on the BaseUnit. • Check the BaseUnit.
Channel failure acknowledgment	$30B_H$	A channel fault was detected. Confirmation is required to enable the channel.	Confirm the channel fault.
No valid F-address available	$30D_H$	The F-source address and F-destination address stored in the electronic coding element cannot be accessed.	Verify that the coding element is present. Replace the coding element, if necessary.
F-address memory not accessible	$30E_H$	No valid PROFIsafe address is saved in the retentive memory. Possible causes: • Initial commissioning • Deliberate parameter change of the PROFIsafe address • Deviation between target and actual configuration of the plant.	• In the case of initial commissioning or deliberate parameter change, assign the PROFIsafe address. • Check the consistency of the target and actual configuration.
Undertemperature	312_H	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range (see Technical specifications (Page 54))
Discrepancy error	314_H	The discrepancy time set for 1oo2 operation has been exceeded. Possible causes of the discrepancy error: • Incorrect parameter assignment • Wire break in the sensor's supply cable	Check the discrepancy time, the sensors and the cabling.

Diagnostic message	Fault code	Meaning	Remedy
Read back failure	$31E_H$	The F-module detected an internal error in the test connection. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.
Auxiliary voltage too high	321_H	The supply voltage is too high.	Check the supply voltage and then test the safety application.
Auxiliary voltage too low	322_H	The supply voltage is too low.	Check the supply voltage and then test the safety application.
ADC error	331_H	Internal error during analog-digital conversion. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.
Fault in test connection	332_H	The F-module detected an internal error in the test connection. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the module is passivated.

When the voltage is then recovered (level must remain within the specified value for at least 1 minute (see Technical specifications (Page 54): Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Generally applicable information on diagnostics

Information on diagnostics that pertains to all fail-safe modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

6.4 Value status

Properties

In addition to the diagnostic messages and the status and fault display, the F-module provides information about the validity of each analog input signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is the binary additional information of an analog input signal. The value status is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the analog input signal.

The value status is affected by all faults.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

NOTE

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

1oo2 evaluation of the sensors combines the two channels. With 1oo2 evaluation of the sensors, you can only access the low order channel in the safety program, e.g. channel 0.

Assignment of the inputs and value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in section Address space (Page 33).

Reference

A detailed description of the evaluation and processing of the respective input signals can be found in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Technical specifications 7

7.1 Technical specifications

Technical specifications of the F-AI 4xI 0(4)..20mA 2-/4-wire HF

Article number	6ES7136-6AA00-0CA1
General information	
Product type designation	F-AI 4xI 0(4) ... 20 mA 2/4-wire HF
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V15 with HSP 203
CiR – Configuration in RUN	
Reparameterization possible in RUN	No
Calibration possible in RUN	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	0.38 A
Current consumption, max.	0.4 A
24 V encoder supply	
• 24 V	Yes; min. L+ (-1.5 V)
• Short-circuit protection	Yes
• Output current, max.	300 mA; total current of all encoders/channels
Power	
Power available from the backplane bus	70 mW
Power loss	
Power loss, typ.	2 W

Article number	6ES7136-6AA00-0CA1
Address area	
Address space per module	
• Inputs	14 byte; S7-300/400F CPU, 13 byte
• Outputs	5 byte; S7-300/400F CPU, 4 byte
Hardware configuration	
Automatic encoding	
• Electronic coding element type F	Yes
Analog inputs	
Number of analog inputs	4
• For current measurement	4
permissible input current for current input (destruction limit), max.	35 mA
Input ranges (rated values), currents	
• 0 to 20 mA	Yes
• Input resistance (0 to 20 mA)	125 Ω
• 4 mA to 20 mA	Yes
• Input resistance (4 mA to 20 mA)	125 Ω
Cable length	
• shielded, max.	1 000 m
Analog value generation for the inputs	
Measurement principle	Sigma Delta
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Integration time (ms)	20 / 16,667
• Interference voltage suppression for interference frequency f1 in Hz	50 / 60 Hz
Smoothing of measured values	
• Number of smoothing levels	7
• parameterizable	Yes
• Step: None	Yes; 1x conversion cycle time
• Step: low	Yes; 2x / 4x conversion cycle time
• Step: Medium	Yes; 8x / 16x conversion cycle time
• Step: High	Yes; 32x / 64x conversion cycle time

Article number	6ES7136-6AA00-0CA1
Encoder	
Connection of signal encoders	
• for current measurement as 2-wire transducer	Yes
– Burden of 2-wire transmitter, max.	650 Ω
• for current measurement as 4-wire transducer	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.1 %
Temperature error (relative to input range), (+/-)	0.023 %/K
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.1 %
Operational error limit in overall temperature range	
• Current, relative to input range, (+/-)	2 %
Basic error limit (operational limit at 25 °C)	
• Current, relative to input range, (+/-)	0.1 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	40 dB
• Common mode interference, min.	70 dB
Interrupts/diagnostics/status information	
Diagnostics function	Yes, "Alarms/diagnostic messages" section in the manual
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	Yes
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	Yes; Measuring range 4 to 20 mA only
• Short-circuit	Yes
Diagnostics indication LED	
• RUN LED	Yes; Green LED
• ERROR LED	Yes; Red LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	Yes; Red LED
• for module diagnostics	Yes; Green/red LED

Article number	6ES7136-6AA00-0CA1
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Permissible potential difference	
between the inputs (UCM)	10 Vpp
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PLe
• Category according to ISO 13849-1	Cat. 4
• SIL acc. to IEC 61508	SIL 3
Probability of failure (for service life of 20 years and repair time of 100 hours)	
– Low demand mode: PFDavg in accordance with SIL3	< 5.00E-05
– High demand/continuous mode: PFH in accordance with SIL3	< 1.00E-09 1/h
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	48 g

Operational limit in complete temperature range

WARNING

When designing the safety function, you must take into account the information "Operational limit in complete temperature range" for the entire mission time.

Temperature characteristic values

NOTE

When the ambient temperature exceeds 55 °C, you must only apply a maximum total current of 3 A to an adjacent F-DQ 4x24VDC/2A PM HF.

Dimension drawing

See ET 200SP BaseUnits manual

See also

ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300)

Response times

A

Introduction

You will find the response times of the F-AI 4xI 0(4)..20mA 2-/4-wire HF below. The response times are included in the calculation of the F-system response time.

Definition of response time for fail-safe analog inputs

The response time results from the number of channels/channel pairs, the response time per channel/channel pair, the basic response time and the configured smoothing.

Times required for the calculation

- Max. acknowledgment time (Device Acknowledgment Time): T_{DAT} = 20 ms
- Basic response time: 20 ms
- Response time per channel
  - At 50 Hz: 25 ms
  - At 60 Hz: 22 ms

Conversion cycle time = basic response time + (N × response time per channel)

(N = number of active channels)

The conversion cycle time is the time in which all activated channels are processed/converted once.

Typical response time

You can calculate the typical response time of F-AI 4xI 0(4)..20mA 2-/4-wire HF using the following formula:

Typical response time = Conversion cycle time × Smoothing

Max. response time (worst case delay time, WCDT)

You can calculate the maximum response time of F-AI 4xI 0(4)..20mA 2-/4-wire HF (worst case delay time, WCDT) using the following formula:

Max. response time = 2 × Conversion cycle time × Smoothing

Response time in the case of a fault (one fault delay time, OFDT)

You can calculate the response time of F-AI 4xI 0(4)..20mA 2-/4-wire HF (one fault delay time, OFDT) as follows:

- According to the following formula if a discrepancy error is present:

  Typical response time = Conversion cycle time × Smoothing + Discrepancy time + Conversion cycle time

  Maximum response time = 2 × Conversion cycle time × Smoothing + Discrepancy time + 2 × Conversion cycle time

- According to the following formula if a channel fault is present:

  Typical response time = Conversion cycle time

  Max. response time = 2 × Conversion cycle time

This means that, for OFDT, the time on occurrence of a discrepancy error should be taken with parameter assignment "1oo2 evaluation (max. SIL3/Kat.4/PLe)" and the time on occurrence of a channel fault should be taken with parameter assignment "1oo1 evaluation (max. SIL3/Kat.3/PLd)".

Representation of analog values

B

In this section we are presenting the analog values for all measuring ranges that you can use with the F-AI 4xI 0(4)..20mA 2-/4-wire HF analog input module.

Measured value resolution

The analog values are shown as fixed-point number in two's complement.

The resolutions shown here are 16 bits including sign.

Table 2-1890 Resolution of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of analog values

The following tables list the decimal and hexadecimal values (codes) of the possible current measuring ranges.

Table 2-1891 Current measuring range 0 to 20 mA

Values		Current measuring range	Range
Dec.	Hex.	0 to 20 mA	
32512	$7F00_H$	> 23.518 mA	Overflow[2]
32511 . . 27649	$7EFF_H$ . . $6C01_H$	23.518 mA . . 20.0007 mA	Overrange
27648 . . 614	$6C00_H$ . . 266_H	20 mA . . 0.4442 mA	Nominal range
613 . . 1 0	265_H . . 1_H 0_H	< 0.4442 mA . . 723.4 nA 0 mA	Wire break[1]

1 The F-module signals a wire break, $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs.

2 In *STEP 7 Safety*, the fail-safe value 0 is provided in place of $7FFF_H$ (for overflow) in the PII for the safety program.

Table 2-1892 Current measuring range 4 to 20 mA

Values		Current measuring range	Range	
Dec.	**Hex.**		**Diagnostics wire break: No**	**Diagnostics wire break: Yes**
32512	$7F00_H$	> 22.814 mA	Overflow[2]	Overflow[2]
32511 . . 27649	$7EFF_H$ . . $6C01_H$	22.814 mA . . 20.0006 mA	Overrange	Overrange
27648 . . 1 0	$6C00_H$ . . 1_H 0_H	20 mA . . 4 mA + 578.7 nA 4 mA	Nominal range	Nominal range
-1 . . -691	$FFFF_H$ . . $FD4D_H$	3.9994 mA . . 3.6 mA	Underrange	Underrange
-692 . . -6144	$FD4C_H$ . . $E800_H$	< 3.6 mA . . 0.4444 mA		Wire break[1]
-6145	$E7FF_H$	< 0.4444 mA	Underflow[2]	

1 The F-module signals a wire break, $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs.

2 In *STEP 7 Safety*, the substitute value 0 is provided in place of $7FFF_H$ (for overflow) or 8000_H (for underflow) in the PII for the safety program.

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SIMATIC

ET 200SP
Analog input module F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)

Equipment Manual

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Preface

Purpose of the documentation

This manual supplements the system manual Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that affect the system in general are described in the system manual.

The information in this manual and the system/function manuals provide support when you commission the system.

A description of the F-system SIMATIC Safety can be found in the programming and operating manual SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Conventions

CPU: When the term "CPU" is used hereafter, it refers to both the CPUs of the S7-1200/1500 automation system and CPUs of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software " (STEP 7 TIA Portal)".

PII: Process image inputs (analog value).

Analog value: Process value available to the customer in the user program (PII).

Analog signal: Sensor signal at the input terminal.

Measured value: Digital analog signal for internal processing / evaluation.

Note the following identified notes:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you ought to pay special attention.

Standards

You can find a dated reference to the respective standards in the certificate (https://support.industry.siemens.com/cs/ww/en/view/57141281) or in the EC Declaration of Conformity (https://support.industry.siemens.com/cs/ww/en/view/71764057) for the F-module.

Certified versions

You can find the certified product and firmware versions in annex 1 of the report on the TÜV certificate (https://support.industry.siemens.com/cs/ww/en/view/57141289).

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Important note for maintaining the operational safety of your system

WARNING

The operators of systems with safety-related characteristics must adhere to specific operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators in the form of personal notifications about product developments and properties which may be or become important issues in terms of operational safety.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log on to Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/ww/en/ps/13751)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/ww/en/ps/13828)
- SIMATIC WinAC RTX (F) (https://support.industry.siemens.com/cs/ww/en/ps/13915)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/ww/en/ps/13683)
- Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/24471)

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that can be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

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Documentation guide

1

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

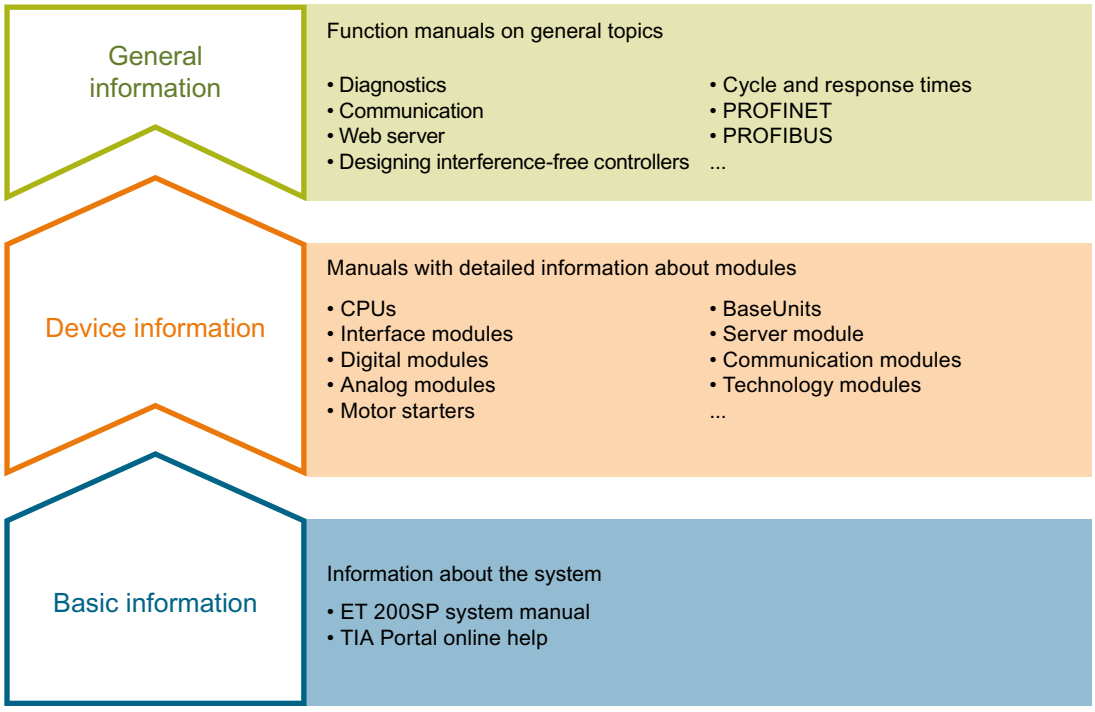

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system, e.g. diagnostics, communication, Web server, motion control and OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

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"mySupport" - Documentation

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You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (https://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules
- Support for the following processes of the fail-safe CPUs:
  - Program update
  - Restore from a backup file
  - Reset to factory settings
  - Memory reset

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a quick test of the wiring and the module configuration of a plant, including fail-safe digital inputs and outputs.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Product overview

2

2.1 Properties

Article number

6ES7136-6AB00-0CA1

View of the module

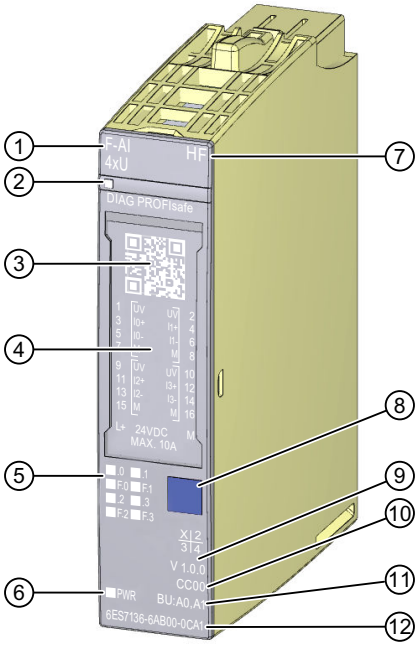

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color coding module type
③	2D matrix code	⑨	Function and firmware version
④	Wiring diagram	⑩	Color code for selecting the color identification labels
⑤	LEDs for channel status	⑪	BU type
⑥	LED for supply voltage	⑫	Article number

Figure 2-1475 View of the F-AI 4xU 0..10V HF module

Properties

The module has the following technical properties:

- Fail-safe analog input module
- PROFIsafe
- Supports the "RIOforFA-Safety" profile on F-CPUs S7-1200/1500.
- PROFIsafe address type 2
- 4 analog inputs with electrical isolation between channels and the backplane bus (up to SIL3/Cat.4/PLd)
- 1oo2 evaluation with configurable tolerance window and discrepancy
- Measuring range: 0 ... 10 V
- Resolution: 16 bits including sign
- Short-circuit-proof power supply
- Supply voltage L+
- External sensor supply possible
- Internal sensor supply U_V
- Configurable wire break diagnostics
- Diagnostics display (DIAG, red/green LED)
- Status display for each input (green LED)
- Error display for each input (red LED)
- Diagnostics
  - e.g. high limit exceeded, channel-specific
  - e.g. supply voltage missing, module-specific
- Channel- and module-wide passivation

The module supports the following functions:

- Firmware update
- I&M identification data
- Value status

WARNING

The fail-safe performance characteristics in the technical specifications apply for a mission time life of 20 years and a repair time of 100 hours. If a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before 100 hours expires.

The module switches off independently after the 100 hours have expired.

Follow the repair procedure described in section Diagnostic messages (Page 48).

NOTE

Cyclic reading of I&M data

Cyclic reading of I&M data can affect the timing of the F-modules. You should therefore avoid short read cycles of less than 500 ms.

Accessories

You can order the following accessories separately:

- Labeling strips
- Color identification labels
- Reference identification label
- Shield connector
- Electronic coding element type H as spare part (article number 6ES7193-6EH00-1AA0)

You can find additional information about accessories in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

NOTE

The following fail-safe modules need an electronic coding element type F (white):

- F-AI 4xI (0)4..20mA HF (6ES7136-6AA00-0CA1)
- F-DQ 8x24VDC/0.5A PP HF (6ES7136-6DC00-0CA0)
- F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0)
- F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)
- F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)

The following fail-safe modules need an electronic coding element type H (gray):

- F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)

Connecting

3

3.1 Wiring and block diagram

This section provides the block diagram of the F-AI 4xU 0..10V HF analog input module with the terminal assignment.

You can find additional information about wiring the BaseUnit in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Block diagram

The following figure shows the block diagram of the F-AI 4xU 0..10V HF analog input module on the BaseUnit BU type A0/A1.

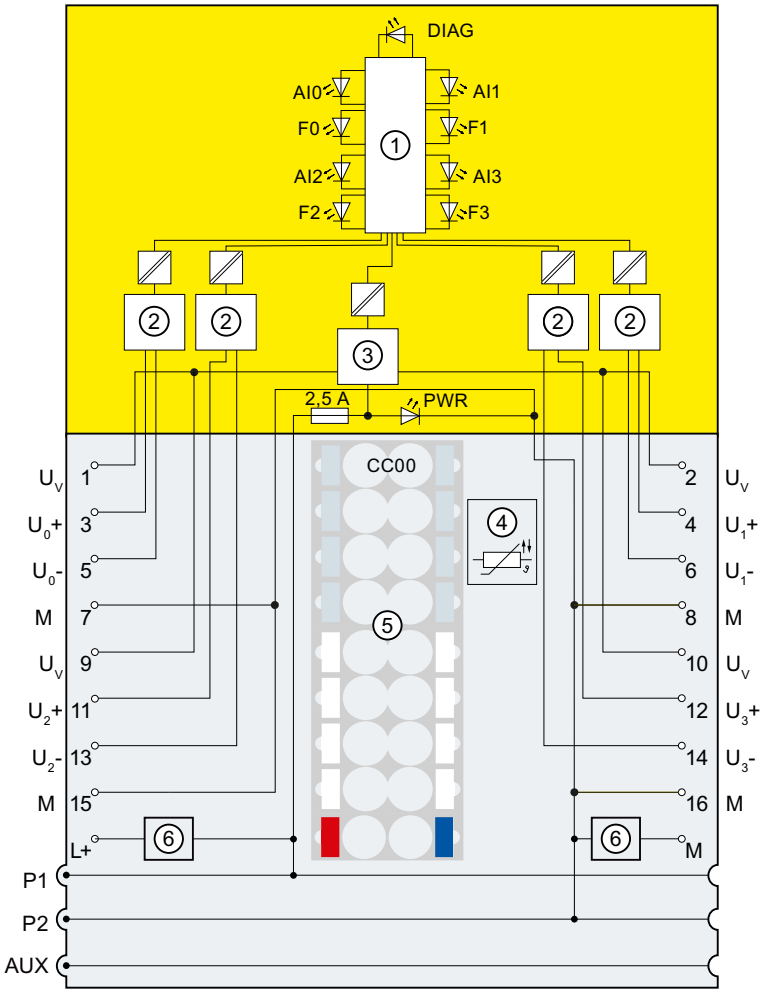

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 2-1476 Block diagram

Sensor supply

WARNING

Voltage dips and voltage fluctuations of the voltage supply are not buffered by the F-module and, thus, affect the sensor supply.

This can cause the measured value to be falsified and must be taken into account when determining the safety function.

To ensure that the sensor functions without problems, we recommend one of the following options:

- You can avoid voltage dips by using a voltage supply according to the NAMUR recommendation NE 21.

or

- Use a transducer with an appropriate battery backup or diagnostics.

Recommendation: Internal sensor supply

You are strongly advised to use the short-circuit-proof internal sensor supply of the F-module. This internal sensor supply is monitored and its status is indicated by the respective error LED. The input is also protected in the event of short-circuits in the wiring or at the sensor.

NOTE

The internal sensor supply is switched off in case of a short circuit to ground or during power-up in the event of short circuit to L+.

A check is made approximately 1 minute later to determine if the error has gone.

NOTE

Behavior of process values and diagnostics evaluation

Sensor startup during module startup:

After the internal sensor supply is activated, the "Wire break" and "Low limit violated" diagnostics is suppressed for 3 seconds to prevent passivation of the respective channel by the sensor startup. During this time, the module makes the secure process data 0 available at all channels. If the sensor startup is not completed in time, passivation will occur that must subsequently be acknowledged.

Sensor startup during operation:

If a sensor startup takes place during operation, e.g. the sensor supply is reactivated after a short-circuit, all analog values are invalid and wire break or underflow diagnostics can occur on the sensors connected to the internal sensor supply.

External/internal sensor supply

The figures in section "Applications of the F-I/O module (Page 34)" show how you can supply power to the sensors via an external sensor supply (for example, from another module).

WARNING

External sensor supply

If you use an external sensor supply, you need to take voltage dips and voltage fluctuations into consideration for the safety function.

To ensure that the sensor functions without problems, we recommend one of the following options:

- Use a transducer with an appropriate battery backup or diagnostics.

  or
- Use a **redundant** external sensor supply

  or
- **Monitor** the external sensor supply for undervoltage/overvoltage, including shutdown of the sensor supply in the event of a fault (single channel for SIL2; two-channel for SIL3).

Parameters/address space

4

4.1 Measurement types and measuring ranges

The following table shows the measurement types and the respective measuring range.

Table 2-1893 Measurement types and measuring ranges

Measurement type	Measuring range	Resolution
Voltage	0 ... 10 V	16 bits including sign

You can find the table of the measuring ranges as well as overflow, overrange, etc. in the Appendix Representation of analog values (Page 60).

4.2 Parameters

Parameters for F-AI 4xU 0..10V HF

WARNING

Diagnostics functions should be activated or deactivated in accordance with the application, see section Applications of the F-I/O module (Page 34).

The following parameters are possible:

Table 2-1894 Configurable parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
F-parameters:				
Manual assignment of F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 ... 65535 ms	150 ms	No	Module
F-source address	1 ... 65534	Depends on parameter assignment of F-CPU	No	Module
F-destination address	1 ... 65534	Suggested by F-system	No	Module
F-parameter signature (without addresses)	0 ... 65535	Calculated by F-system	No	Module
Behavior after channel faults	• Passivate entire module • Passivate channel	Passivate channel	No	Module

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	(S7-300/400) Adjustable (S7-1200/1500) All channels manually	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	Suggested by F-system	No	Module
F-I/O DB name	—	Suggested by F-system	No	Module
AI parameters				
Interference frequency suppression	• 50 Hz • 60 Hz	50 Hz	No	Module
Channel parameters:				
Channel n				
Sensor evaluation	• 1oo1 evaluation (max. SIL2/Cat.3/PLd) • 1oo2 evaluation (max. SIL3/Cat.4/PLe)	1oo1 evaluation (max. SIL2/Cat.3/PLd)	No	Channel
Standard value	• MIN • MAX	MIN	No	Channel
Discrepancy time *	100 ... 30000 ms	100 ms	No	Channel
Tolerance window %, absolute	2.0 ... 20.0%	5.0%	No	Channel
Tolerance window %, relative	2.0 ... 20.0%	5.0%	No	Channel
Activated	• Disable • Enable	Enable	No	Channel
Channel failure acknowledge	• Manual • Automatic The value range offered depends on the F-CPU in use and on the configuration of the F-parameter "Reintegration after channel fault".	(S7-300/400) Parameter is not supported (S7-1200/1500) Manual	No	Channel
Measuring range	0 ... 10 V	0 ... 10 V	No	Channel
Diagnostics: Wire break	• Disable • Enable	Enable	No	Channel
Smoothing	• 1 • 2 • 4 • 8 • 16 • 32 • 64	1	No	Channel

* See formula under Discrepancy analysis with 1oo2 evaluation (Page 22)

4.3 Explanation of parameters

4.3.1 F-parameters

You must assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation.

- You define the F-source address using the "Central F-source address" parameter in the F-CPU.
- An F-destination address unique throughout the CPU is automatically assigned for each F-module. You can manually change the F-destination addresses set in the hardware configuration.

You can find information on F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

4.3.2 Parameters of the channels

4.3.2.1 Interference frequency suppression

Here you set the interference frequency suppression for the line frequency:

- 50 Hz
- 60 Hz

For more information, refer to the Analog value processing Function Manual (https://support.industry.siemens.com/cs/ww/en/view/67989094).

4.3.2.2 Sensor evaluation

Overview

Here you select the type of sensor evaluation:

- "1oo1 evaluation (max. SIL2/Cat.3/PLd)"
- "1oo2 evaluation (max. SIL3/Cat.4/PLe)"

If you do not want to measure with a channel or channel pair, disable the channel or the channel pair. If you deactivate unused channels, the response time of the F-module is reduced.

1oo1 evaluation (max. SIL2/Cat.3/PLd)

With the 1oo1 evaluation, there is one sensor, and it is connected to the F-module via a single channel.

1oo2 evaluation (max. SIL3/Cat.4/PLe)

With the 1oo2 evaluation, two input channels are occupied by:

- Two single-channel sensors
- One two-channel sensor

Note that in 1oo2 evaluation, two channels are combined into a channel pair.

Achievable safety level

Depending on the selected sensor evaluation, you achieve the following safety classes with a sensor that is qualified accordingly:

- SIL2/Cat.3/PLd for "1oo1 evaluation"
- SIL3/Cat.4/PLe for "1oo2 evaluation"

See also

Discrepancy analysis with 1oo2 evaluation (Page 22)

4.3.2.3 Standard value

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", two channels are considered to be a channel pair. You can select from two measured values in this case, which is provided by the F-CPU as analog value:

- "MIN": the lesser of the two values.
- "MAX": the greater of the two values.

During a discrepancy between the two input channels, the last valid standard value prior to the occurrence of the discrepancy is made available to the F-CPU.

4.3.2.4 Discrepancy time

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the discrepancy time for each channel pair here in milliseconds.

The discrepancy time does not start until the standard value is outside the assigned tolerance window (relative or absolute). If the two redundant input channels of the channel pair differ by more than the specified tolerance and for longer than the specified discrepancy time but no longer than the duration of the maximum response time, the F-module detects a discrepancy error and triggers a diagnostic interrupt. If the input channels fall below the specified tolerance prior to expiration of the discrepancy time (input channels are no longer discrepant), the discrepancy time is restarted when a new discrepancy is detected.

You can find additional information about configuring the discrepancy analysis under Discrepancy analysis with 1oo2 evaluation (Page 22).

A discrepancy error is handled by the safety program in the same way as a channel fault. Additional information is available in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

4.3.2.5 Tolerance window %, absolute

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the size of a tolerance window for the discrepancy here for the channel pair. You specify the tolerance window as a percentage of the full-scale value. The reference value is the maximum full-scale value, i.e. 10 V. The entered value is rounded to one decimal place.

If the two redundant input channels of the channel pair differ by more than the tolerance specified here and for longer than the specified discrepancy time, the F-module detects a discrepancy error and triggers a diagnostic interrupt.

For more information regarding setting the tolerance window, refer to Discrepancy analysis with 1oo2 evaluation (Page 22).

Example

You have assigned the following:

- The "Tolerance window % absolute" at 10%
- The measuring range 0 V ... 10 V
- A discrepancy time of 100 ms

The input channels may differ from the configured discrepancy time (100 ms) up to the max. response time for a time window with a difference of more than 1 V.

See also

Discrepancy time (Page 20)

4.3.2.6 Tolerance window %, relative

Function

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you can enter the size of a tolerance window for the discrepancy here for each channel pair. You specify the tolerance window as a percentage of the assigned standard value. The entered value is rounded to one decimal place.

If the two redundant input channels of the channel pair differ by more than the tolerance specified here and for longer than the specified discrepancy time, the F-module detects a discrepancy error and triggers a diagnostic interrupt.

The two parameters "Tolerance window % absolute" and "Tolerance window % relative" are combined. The "Tolerance window % absolute" parameter is decisive in case of low process values.

For more information regarding setting the tolerance window, refer to Discrepancy analysis with 1oo2 evaluation (Page 22).

Example

You have assigned the following:

- The "tolerance window % relative" at 10%
- The measuring range 0 V ... 10 V
- A discrepancy time of 200 ms

The analog signals may differ for a time window of set discrepancy time (200 ms) up to the maximum reaction time. If your measured values are 9 V and 10 V, a difference in the measured values up to 1 V is tolerated for the MAX standard value. If you configure the MIN standard value, only a difference of up to 0.9 V is tolerated. If the tolerated difference is exceeded, the module signals a diagnostics.

See also

Discrepancy time (Page 20)

4.3.2.7 Discrepancy analysis with 1oo2 evaluation

Operating principle of discrepancy analysis

A discrepancy analysis is performed with a configured 1oo2 evaluation. **Smoothed** process values are used for the discrepancy analysis.

An assignable tolerance window is formed around the process value that represents the instantaneous standard value (value that is signaled to the F-CPU).

The tolerance window is formed relative to the process value as well as an absolute value relative to the full-scale value.

If the process value does not represent the standard value at an instant and is within the tolerance window, **no** discrepancy exists.

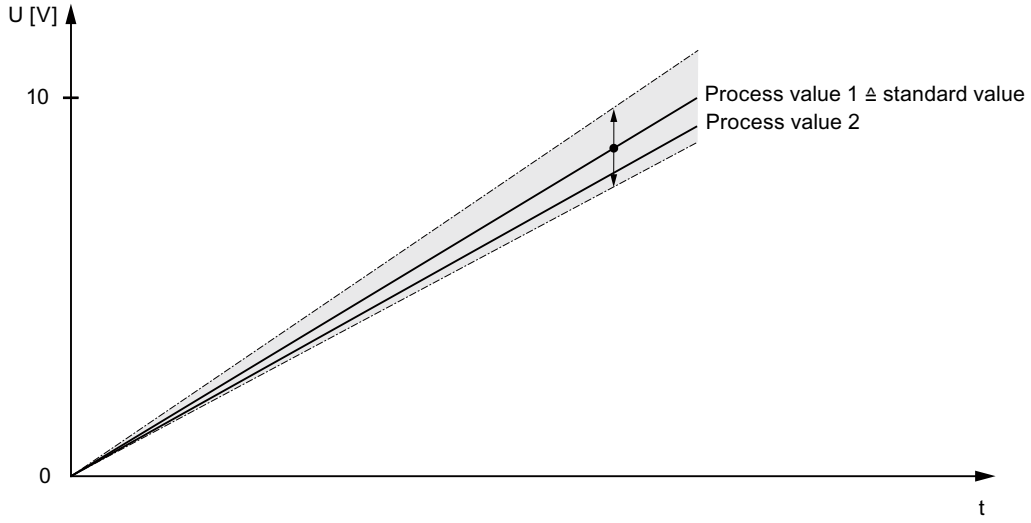

Figure 2-1477 Example of a relative tolerance window *without* discrepancy (parameter assignment: standard value = MAX)

If the process value does not represent the standard value at an instant but is outside the tolerance window, a discrepancy exists.

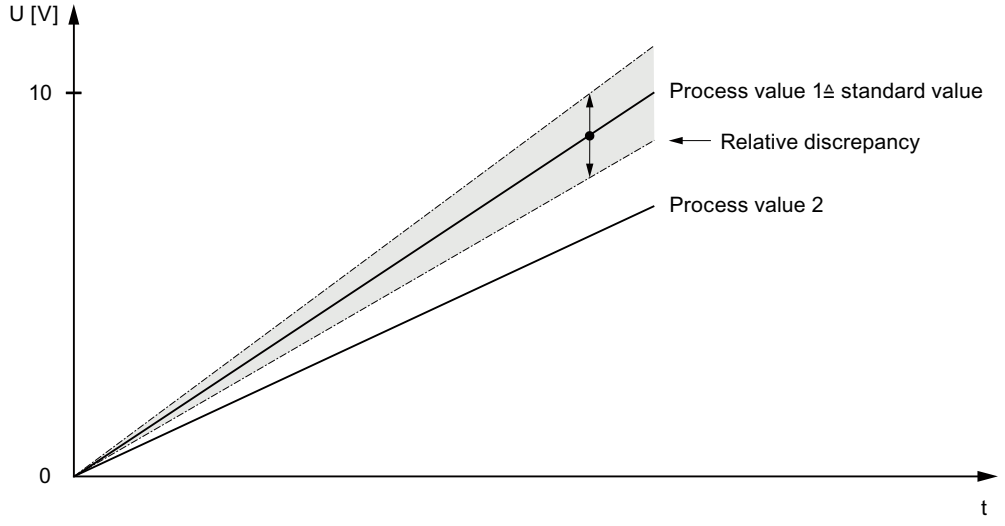

Figure 2-1478 Example of a relative tolerance window *with* discrepancy (parameter assignment: standard value = MAX)

The assigned discrepancy time starts as soon as a discrepancy is detected.

- During a discrepancy between the two input channels, the last valid standard value prior to occurrence of the discrepancy is signaled to the F-CPU.
- There is no valid old value after startup from an error or after Off/On of the power supply. During this time, the process value $7FFF_H$ is output for the S7-300/400 F-CPUs and the process value 0 for S7-1200/1500 F-CPUs until a smoothed process value is available once again (see section Smoothing (Page 20)). If a discrepancy of the smoothed process value is now determined, the configured discrepancy time starts running.
- If the input channels fall below the specified tolerance prior to expiration of the discrepancy time (input channels are no longer discrepant), the standard value is output. With a new discrepancy, the discrepancy time measurement starts again.

If the discrepancy time has expired with an existing discrepancy, a discrepancy error is signaled and the process value is set to $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs. In the PII, the substitute value 0 is set for the safety program.

A discrepancy error is handled by the safety program in the same way as a channel fault. Additional information is available in the STEP 7 Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Configuring the discrepancy analysis parameters

The following four parameters for the discrepancy analysis are assigned for each channel pair:

- Discrepancy time
- Standard value
- Tolerance window %, absolute
- Tolerance window %, relative

"Discrepancy time" parameter

When all criteria are met, the F-module triggers a discrepancy error:

- The process value that does not represent the standard value is outside the configured tolerance window.
- Lasts longer than the configured discrepancy time.
- Lasts at maximum the duration of the maximum response time.

In the case of a discrepancy error, the F-module triggers a diagnostic interrupt and sets the process value to $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs. The discrepancy time is reset if the standard value lies within the tolerance window again.

In the PII, the substitute value 0 is set for the safety program.

You calculate the maximum discrepancy time that is permitted in the respective application using the following formula:

Discrepancy time = Maximum response time (in case of discrepancy error) – 2 × Conversion cycle time × Smoothing – 2 × Conversion cycle time

NOTE

You calculate the discrepancy time by using the values from section Response times (Page 58) in the above equation.

You can assign the discrepancy time for each channel pair.

"Standard value" parameter

If you have selected "1oo2 evaluation (max. SIL3/Cat.4/PLe)", two channels are considered to be a channel pair. You can select from two measured values in this case, which is provided by the F-CPU as analog value:

- "MIN": The lower of the two values is signaled to the F-CPU as the standard value.
- "MAX": The higher of the two values is signaled to the F-CPU as the standard value.

"Tolerance window %, absolute" parameter

You can calculate the absolute tolerance window using the following formula:

$$T_{abs} = \frac{|\Delta U_{abs}|}{U_{ME} - U_{MA}} \times 100 \ [\%]$$

You can calculate the maximum absolute deviation of the voltage of the full-scale value using the following formula:

$$\Delta U_{abs} = \pm \frac{(U_{ME} - U_{MA}) \times T_{abs}}{100} \ [V]$$

With the following parameters:

- U_{ME} = 10 V (full-scale value)
- U_{MA} = 0 V for measuring range 0 V ... 10 V (start-of-scale value)
- T_{abs} = absolute tolerance in %
- ΔU_{abs} = Maximum absolute deviation of the voltage from the full-scale value (+/-)

You can assign a value of 2.0 to 20.0% for the "Tolerance window %, absolute" parameter for each channel pair.

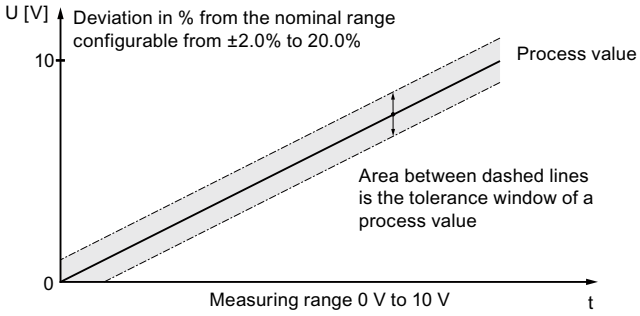

Figure 2-1479 Absolute deviation in % from the nominal range for measuring range of 0 V to 10 V

"Tolerance window %, relative" parameter

The tolerance window is calculated as a percentage of the **smoothed** process value that represents the MIN or MAX value (depending on the parameter assignment of the standard value).

You can calculate the relative tolerance window using the following formula:

$$T_{rel} = \frac{|\Delta U_{rel}|}{|U_{EW} - U_{MA}|} \times 100 \ [\%]$$

You can calculate the maximum relative deviation of the voltage of the measured value using the following formula:

$$\Delta U_{rel} = \pm \frac{|U_{EW} - U_{MA}| \times T_{rel}}{100} [V]$$

With the following parameters:

- U_{EW} = Process standard value (min./max.)
- U_{MA} = 0 V for measuring range 0 V ... 10 V (start-of-scale value)
- T_{rel} = Relative tolerance in %
- ΔU_{rel} = Maximum relative deviation of the voltage from the measured value (+/-)

You can assign a value of 2.0 to 20.0% for the "Tolerance window %, relative" parameter for each channel pair.

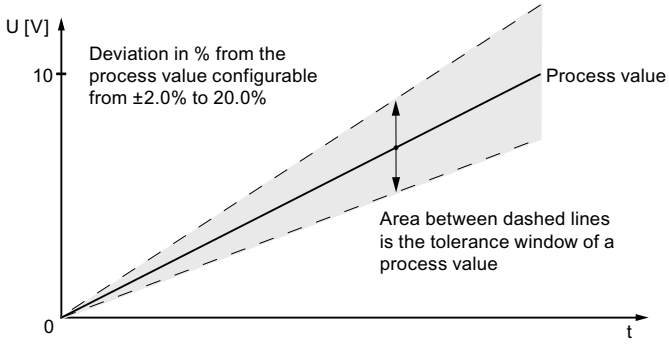

Figure 2-1480 Relative deviation in % from the nominal range for measuring range of 0 V to 10 V

Combination of the "Tolerance window %, absolute" and "Tolerance window %, relative" parameters

You can combine the "Tolerance window %, absolute" and "Tolerance window %, relative" parameters as needed. The combined tolerance window (shown in gray in the figure below) is the maximum of T_{rel} and T_{abs}.

$T = MAX \{ T_{rel}, T_{abs} \}$

$\Delta U = MAX \{ \Delta U_{rel}, \Delta U_{abs} \}$

With:

- T = Tolerance, in %
- ΔU = maximum deviation of the voltage (+/-)

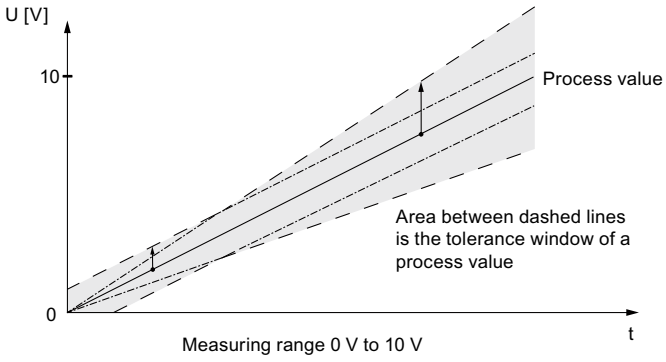

Example

The following diagrams show you the behavior of the discrepancy evaluation when standard value = MAX.

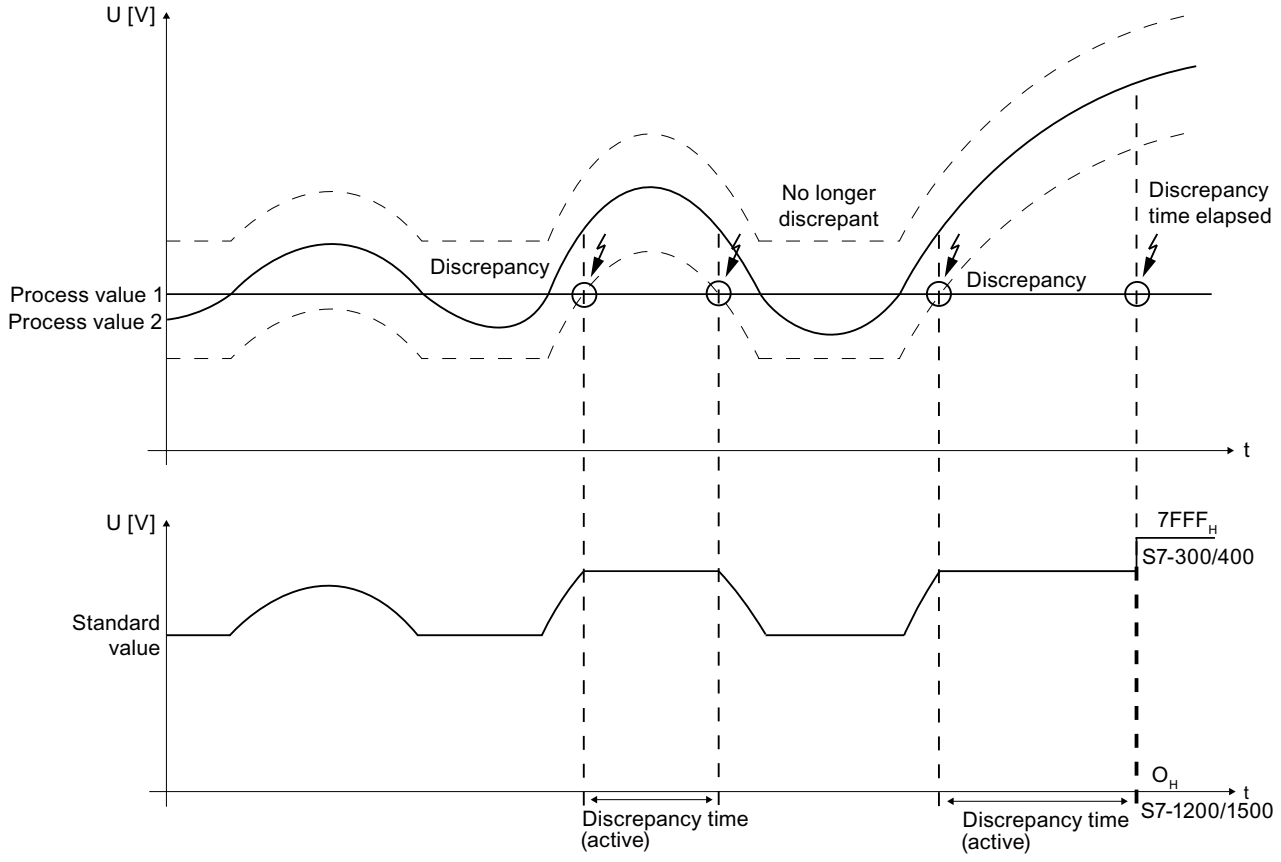

The upper of the two diagrams shows the characteristic curve of the two process values. The dashed line represents the absolute tolerance range configured in this example.

The lower of the two diagrams shows the standard value signaled to the F-CPU.

In this example, on the first occurrence of a discrepancy, process value 1 is **within** the tolerance range again **before** expiration of the discrepancy time. This means the discrepancy error is not signaled.

In this example, on the second occurrence of a discrepancy, process value 1 is **outside** the tolerance range when the discrepancy time expires. As a result, a discrepancy error is signaled with 7FFF$_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs after expiration of the discrepancy time. In the PII, the substitute value 0 is set for the safety program.

See also

Tolerance window %, absolute (Page 21)

Tolerance window %, relative (Page 21)

Smoothing (Page 30)

4.3.2.8 Activated

If you select this check box, the corresponding channel is enabled for signal processing.

You can deactivate an unused channel with this parameter.

If you deactivate unused channels, the response time of the F-module is reduced.

4.3.2.9 Channel failure acknowledge

Use on S7-1200/1500 F-CPUs

The parameter is only relevant if the F-module can be operated on an S7-1200/1500 F-CPU.

The parameter can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".

The value of this parameter specifies how the channel reacts after a channel fault:

- Manual: A channel failure is reintegrated after manual acknowledgment.
- Automatically: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

Use on S7-300/400 F-CPUs

The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. For S7-300/400 F-CPUs you set the corresponding property at the F-I/O DB by means of the ACK_NEC tag.

For detailed information about the F-I/O DB, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

4.3.2.10 Measuring range

The parameter shows the measuring range for the channel:

- 0 ... 10 V

4.3.2.11 Diagnostics: Wire break

Function

Here you activate the wire break detection. No smoothed measured values are used for the wire break diagnostics.

With a measuring range of 0 V to 10 V:

- With configured wire break diagnostics and voltages < 1 V, a wire break is detected and a diagnostic interrupt is triggered in the F-CPU.
- Without configured wire break diagnostics and voltages < 0.2962 V, an "underflow" is detected and a diagnostic interrupt is triggered in the F-CPU.

For performance reasons, an unused channel should be disabled. There is no wire break detection for a disabled channel.

4.3.2.12 Smoothing

Smoothing principle

The measured values are smoothed by a digital filter. Smoothing is achieved by the F-module forming the sliding mean of a number of converted (digitized) analog values determined by the "Smoothing" parameter.

You assign smoothing in 7 levels (1, 2, 4, 8, 16, 32, 64 conversion cycles). The level determines the number of analog signals converted last that are averaged. If smoothing = 1 is configured, the smoothing is deactivated.

The higher the smoothing you select, the more stable the smoothed analog value of the converted analog signal, and the longer the time it takes until the smoothed analog signal is available as analog value following a unit step. You can find an example below.

For more information on the analog value, refer to the Analog value processing Function Manual (https://support.industry.siemens.com/cs/ww/en/view/67989094).

NOTE

Smoothing is recalculated after startup, short circuit, wire break or any other channel fault. If, for example, smoothing is configured with 16 conversion cycles, all channels are activated and the configured frequency suppression is 50 Hz, it can take up to 2000 ms until the valid process value is signaled.

Until the first valid process value, the F-module signals $7FFF_H$ for the channel on S7-300/400 F-CPUs or 0 on S7-1200/1500 F-CPUs.

The calculation of the smoothing is not interrupted in case of a discrepancy.

Using smoothing

Smoothing of analog values provides a stabilized analog signal for further processing. Smoothed values are always used for discrepancy analysis.

⚠ WARNING

The smoothing takes place as a result of mean value generation over the selected number of most recently converted analog values of a channel, e.g. 64.

The mean value generation causes a discrepancy to be delayed with a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)". You can find an example below.

Example

The figure below shows the number of conversion cycles, depending on the set smoothing, after which the analog value is completely available following a unit step. The figure applies to all signal changes at the analog input.

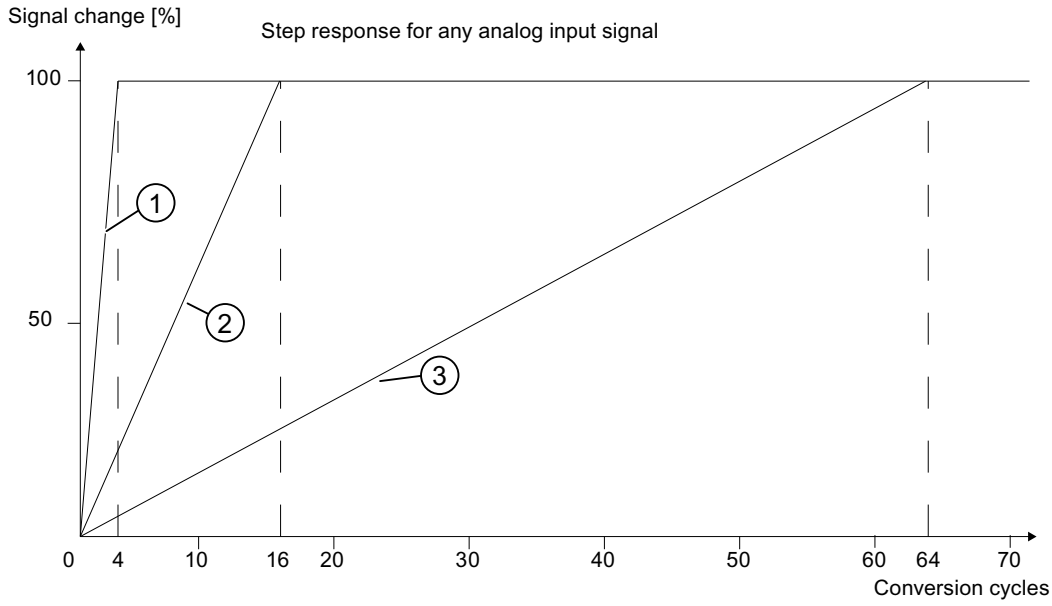

① Smoothing - 4 conversion cycles

② Smoothing - 16 conversion cycles

③ Smoothing - 64 conversion cycles

Example: Effect of smoothing on the maximum response time for a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)" in case of error

If an error (One Fault Delay Time, OFDT) occurred with a configured "1oo2 evaluation (max. SIL3/Cat.4/PLe)", you calculate the maximum response time according to the following formula:

Maximum response time (in case of discrepancy error) = 2 × Conversion cycle time × Smoothing + Discrepancy time + 2 × Conversion cycle time

In this example, one channel pair is connected and configured (activated), interference frequency 50 Hz, smoothing = 16 conversion cycles, discrepancy time = 2000 ms, conversion cycle time calculated with the formula from section Response times (Page 58):

Max. response time (in case of discrepancy error) = 2 × 70 ms × 16 + 2000 ms + 2 × 70 ms = 4380 ms

If a discrepancy exists between the two input channels, it can take 4380 ms until the F-module detects a discrepancy error. This error is then signaled to the F-CPU.

If the discrepancy time has expired, a discrepancy error is signaled and the process value is set to $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs. In the PII, the substitute value 0 is set for the safety program.

4.4 Address space

Address assignment of the F-AI 4xU 0..10V HF analog input module

The analog input module F-AI 4xU 0..10V HF occupies the following address ranges in the F-CPU:

Table 2-1895 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In input range**	**In output range**
S7-300/400 F-CPUs	IB x + 0 to x + 12	QB x + 0 to x + 3
S7-1200/1500 F-CPUs	IB x + 0 to x + 13	QB x + 0 to x + 4

x = Module start address

Address assignment of the user data and the value status of the F-AI 4xU 0..10V HF analog input module

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the F-AI 4xU 0..10V HF analog input module:

Table 2-1896 User data address assignment in the input range

Byte in the F-CPU	Occupied bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
IB x + 0	Input value at channel 0 (Result of the 1oo2 evaluation channel 0/2)							
IB x + 1								
IB x + 2	Input value at channel 1 (Result of the 1oo2 evaluation channel 1/3)							
IB x + 3								
IB x + 4	Input value at channel 2							
IB x + 5								
IB x + 6	Input value at channel 3							
IB x + 7								
IB x + 8	—	—	—	—	Value status* for AI_3	Value status* for AI_2	Value status* for AI_1	Value status* for AI_0

* Only S7-1200/1500 F-CPUs

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

Additional information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Applications of the F-I/O module

5

The wiring is performed on a suitable BaseUnit. Additional information is available in the Connecting section in the Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

5.1 Application 1: Safety mode SIL2/Cat.3/PLd with two-wire connection, 1oo1 evaluation

Voltage measurement from 0 V to 10 V

Four process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.

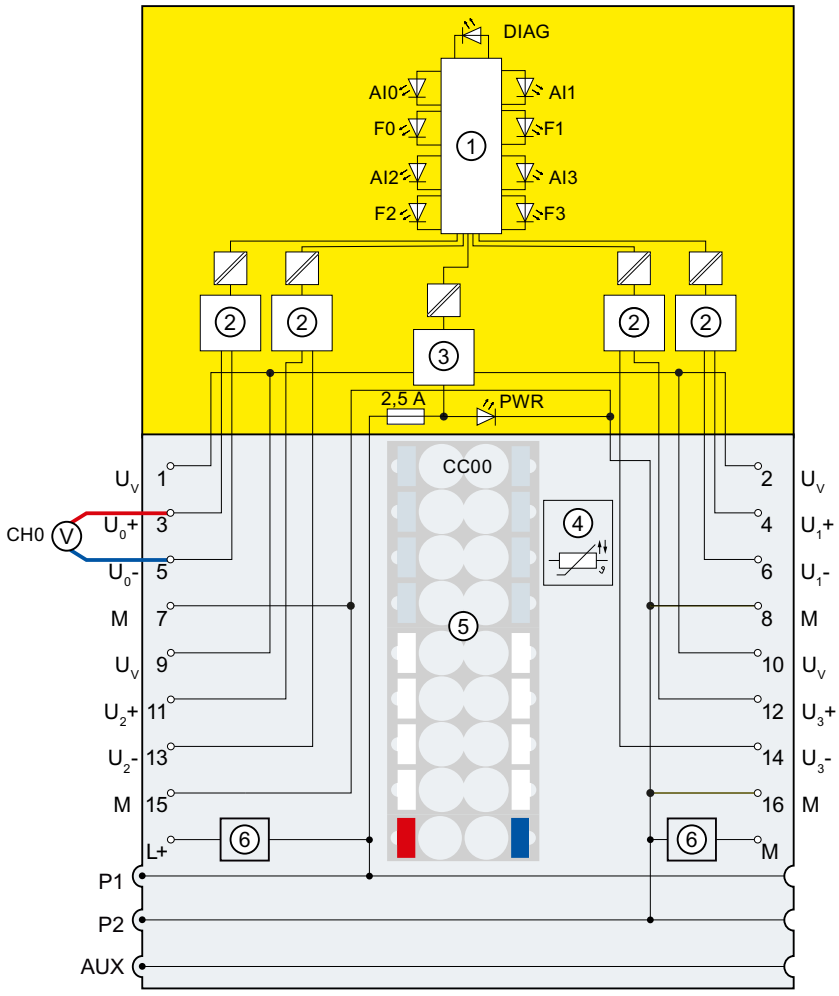

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 2-1481 1oo1 evaluation

WARNING

To achieve SIL2/Cat.3/PLd using this wiring, you must use a suitably qualified sensor.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

WARNING

For voltage inputs, changes in resistance along the transmission path (from sensor to module) can result in the measured value being falsified.

For correct measured value acquisition during the entire service life, you must take these changes in resistance into account when designing the safety functions and take appropriate measures.

Assignable parameters for application 1

Table 2-1897 Parameters for application 1 of the F-AI 4xU 0..10V HF

Parameters	Range of values in safety mode
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo1 evaluation (max. SIL2/Cat.3/PLd)
Measuring range	0 ... 10 V
Diagnostics: Wire break	• Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

See also

Diagnostic messages (Page 48)

5.2 Application 2: Safety mode SIL3/Cat.4/PLe with two-wire connection, 1oo2 evaluation

Voltage measurement 0 V to 10 V

Two process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.

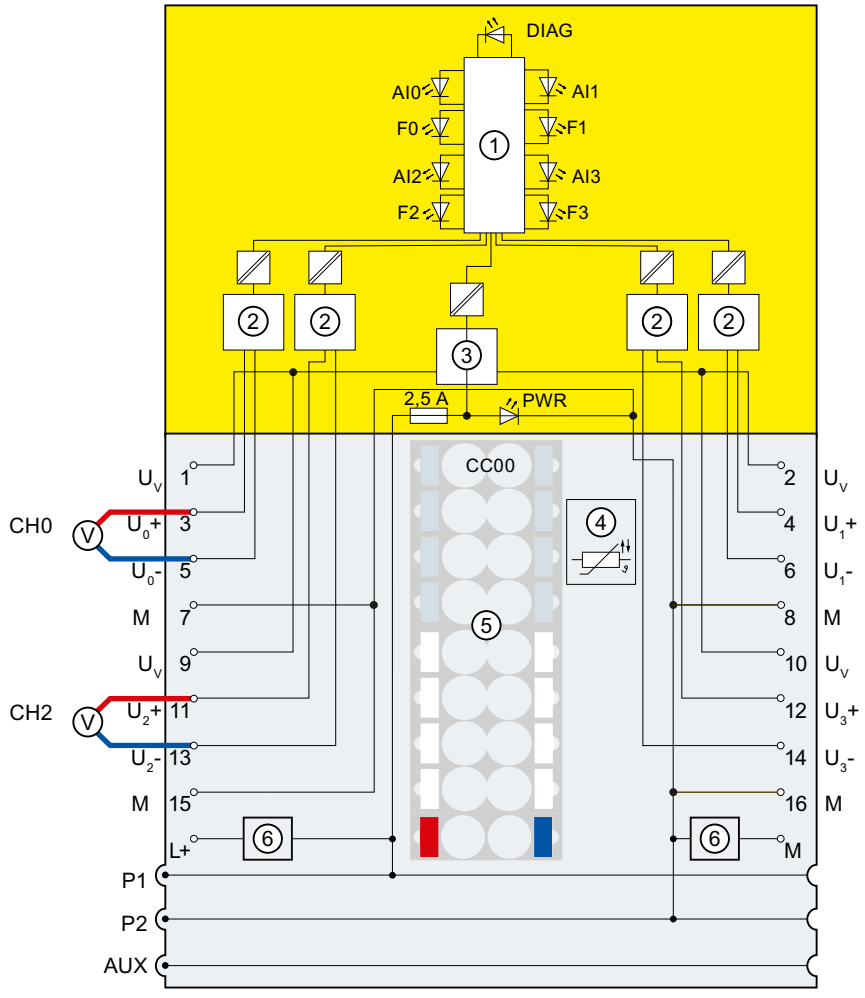

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)

⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 2-1482 1oo2 evaluation

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a qualified, two-channel sensor or two qualified single-channel sensors.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for application 2

Table 2-1898 Parameters for application 2 of the F-AI 4xU 0..10V HF

Parameters	Range of values in safety mode
Standard value	• MIN • MAX
Discrepancy time	100 ... 30000 ms
Tolerance window %, absolute	2.0 ... 20.0%
Tolerance window %, relative	2.0 ... 20.0%
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo2 evaluation (max. SIL3/Cat.4/PLe)
Measuring range	0 ... 10 V
Diagnostics: Wire break	• Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

See also

Diagnostic messages (Page 48)

5.3 Application 3: Safety mode SIL2/Cat.3/PLd with four-wire connection, 1oo1 evaluation

Voltage measurement 0 V to 10 V

Four process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.

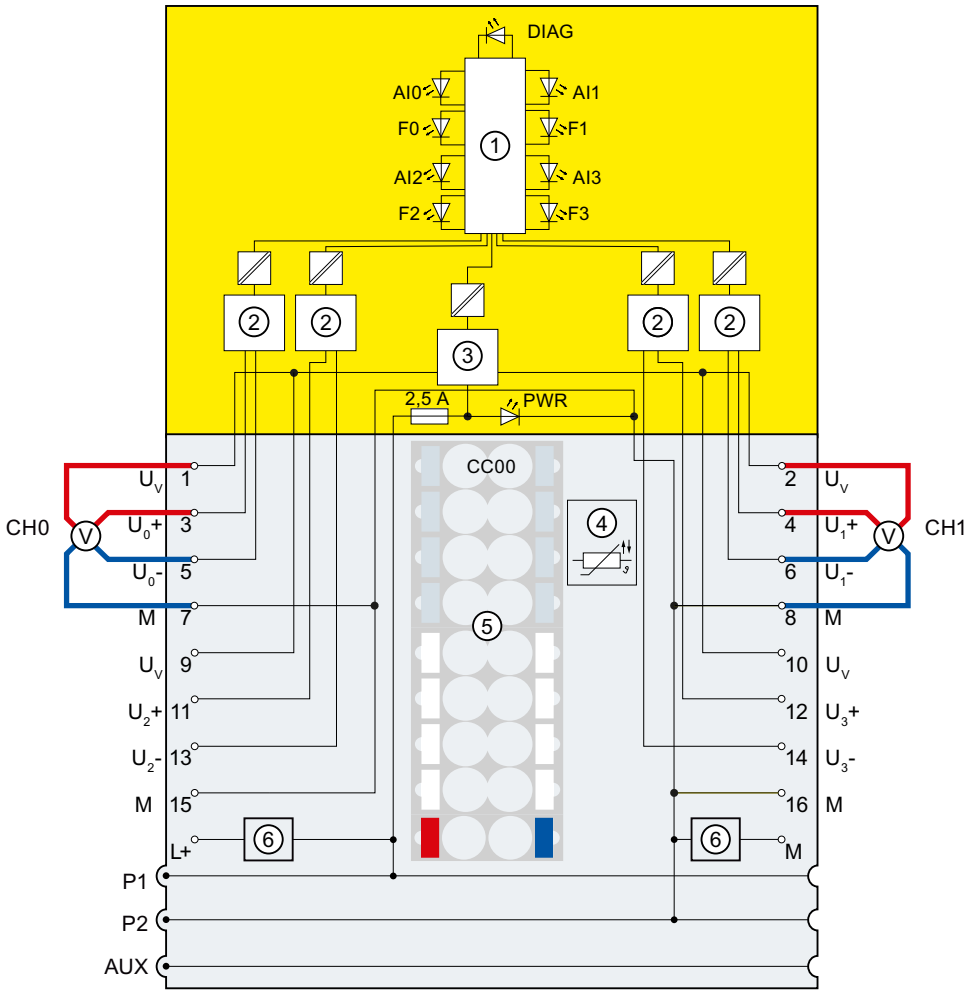

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)

④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 2-1483 1oo1 evaluation

WARNING

To achieve SIL2/Cat.3/PLd using this wiring, you must use a suitably qualified sensor.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

WARNING

For voltage inputs, changes in resistance along the transmission path (from sensor to module) can result in the measured value being falsified.

For correct measured value acquisition during the entire service life, you must take these changes in resistance into account when designing the safety functions and take appropriate measures.

Assignable parameters for application 3

Table 2-1899 Parameters for application 3 of the F-AI 4xU 0..10V HF

Parameters	Range of values in safety mode
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo1 evaluation (max. SIL2/Cat.3/PLd)

Parameters	Range of values in safety mode
Measuring range	0 ... 10 V
Diagnostics: Wire break	• Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

See also

Diagnostic messages (Page 48)

5.4 Application 4: Safety mode SIL3/Cat.4/PLe with four-wire connection, 1oo2 evaluation

Voltage measurement 0 V to 10 V

Two process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.

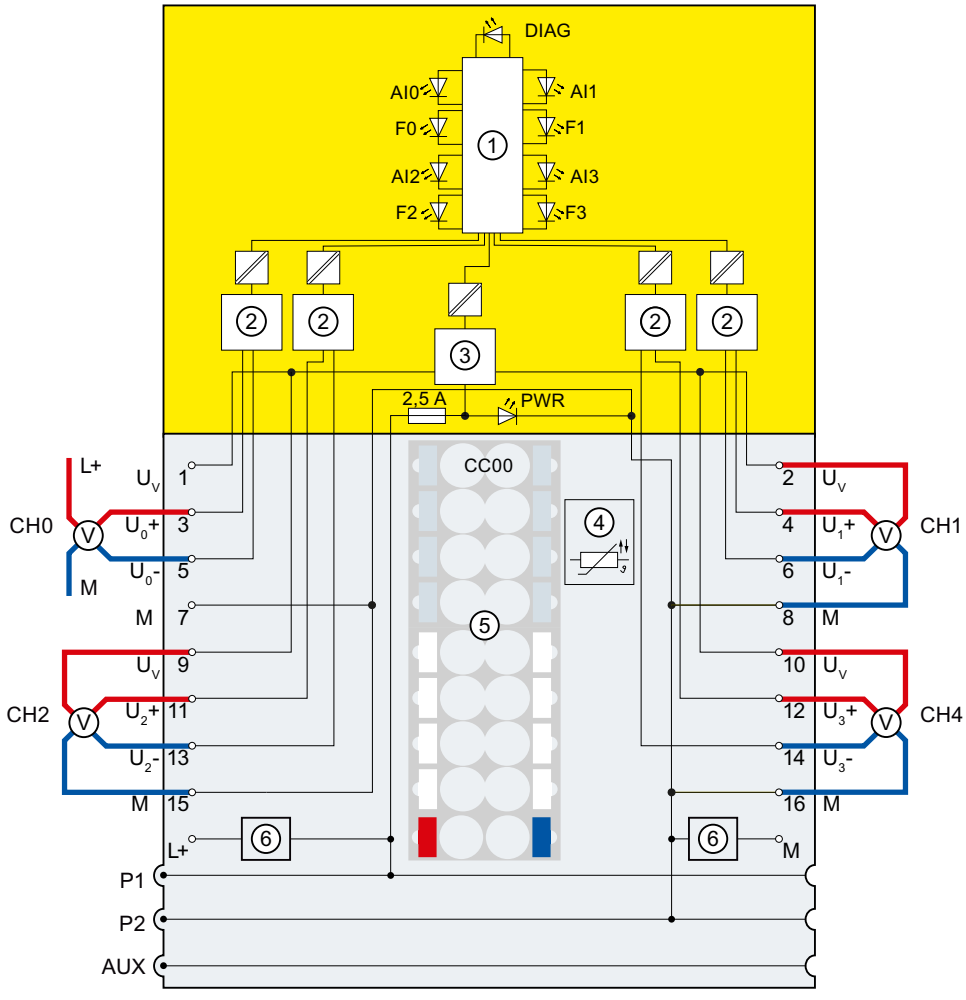

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)
⑥	Filter connection supply voltage (available with light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 2-1484 1oo2 evaluation

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use suitably qualified sensors.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for application 4

Table 2-1900 Parameters for application 4 of the F-AI 4xU 0..10V HF

Parameters	Range of values in safety mode
Standard value	• MIN • MAX
Discrepancy time	100 ... 30000 ms
Tolerance window %, absolute	2.0 ... 20.0%
Tolerance window %, relative	2.0 ... 20.0%
Behavior after channel faults	• Passivate the entire F-module • Passivate channel
Interference frequency suppression	• 50 Hz • 60 Hz
Sensor evaluation	1oo2 evaluation (max. SIL3/Cat.4/PLe)

Parameters	Range of values in safety mode
Measuring range	0 ... 10 V
Diagnostics: Wire break	• Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

See also

Diagnostic messages (Page 48)

Interrupts/diagnostic messages

6

6.1 Status and error display

LED display

The following figure shows the LED display of the F-AI 4xU 0..10V HF.

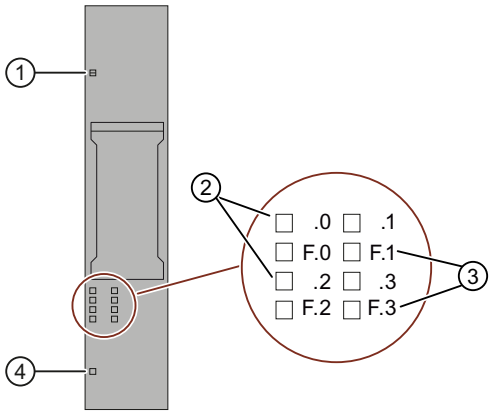

① DIAG (green/red)

② Channel status (green)

③ Channel fault (red)

④ PWR (green)

Figure 2-1485 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. Remedies for diagnostics alarms can be found in section Diagnostic messages (Page 48).

WARNING

The DIAG LED and the channel status and channel fault LEDs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

DIAG LED

Table 2-1901 Error display of the LED DIAG

DIAG	Meaning
□ Off	Backplane bus supply of the ET 200SP not okay
☼ Flashing	Module parameters not configured
■ On	Module parameters configured and no module diagnostics
☼ Flashing	• Module parameters configured and module diagnostics • Operation with S7-1200/1500 F-CPUs: At least one channel is waiting for a user acknowledgment.
☼ Flashing	• Operation with S7-1200/1500 F-CPUs: The F-module is waiting for a user acknowledgment after a module fault. • Operation with S7-300/400 F-CPUs: The F-module is waiting for a user acknowledgment.

Channel status/channel fault LED

Table 2-1902 Status display of the LEDs channel status / channel error

Channel status	Channel fault	Meaning
□ Off	□ Off	Channel deactivated or supply voltage L+ missing.
■ On	□ Off	Channel activated and no channel diagnostics
□ Off	■ On	Channel activated and channel diagnostics
☼/☼ Alternately flashing		At least one channel is waiting for a user acknowledgment.

Channel status/DIAG/channel fault LED

Table 2-1903 Status display of the LEDs channel status / DIAG / channel error

Channel status	DIAG	Channel fault	Meaning
□ Off	☼ Flashing	■ All On	The PROFIsafe address does not match the configured PROFIsafe address or there is a module-wide error. See section Alarms (Page 46).
☼ Flashing	☼ Flashing	□ Off	Identification of the F-module when assigning the PROFIsafe address.

PWR LED

Table 2-1904 Status display of LED PWR

PWR	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ available

6.2 Interrupts

Introduction

The fail-safe analog input module F-AI 4xU 0..10V HF supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 48).

The list below provides an overview of the diagnostic interrupts of the F-module. The diagnostic interrupts are assigned either to one channel or the entire F-module.

⚠ WARNING

Before acknowledging a diagnostic message, remedy the respective fault and check your safety function. Follow the fault remedying procedure described in section Diagnostic messages (Page 48)

Module-wide diagnostic interrupts:

- Overtemperature
- Undertemperature
- Parameter error
- Supply voltage missing
- Channel/component temporarily not available
- Mismatch of safety destination address (F_Dest_Add)
- Safety destination address not valid (F_Dest_Add)
- Safety source address not valid (F_Source_Add)
- Safety watchdog timer value is 0 ms (F_WD_Time)
- Parameter F_CRC_Length does not match the generated values
- Version of F-parameter set incorrectly
- CRC1 fault

- Inconsistent iParameters (iParCRC error)
- F_Block_ID not supported
- Transmission error: Inconsistent data (CRC error)
- Transmission error: Timeout (monitoring time 1 or 2 expired)
- Module is defective
- Watchdog tripped
- Invalid/inconsistent firmware present
- Diagnostics memory overflow
- Acknowledgement required to activate the channel as soon as the channel faults are remedied.
- F-address memory not accessible
- No valid F-address available
- Supply voltage too high
- Supply voltage too low
- Channel/component not available

Channel-wide diagnostic alarms

- Wire break
- High limit exceeded
- Low limit violated
- Safety-related switch off
- Internal supply voltage of the module failed
- Common mode error
- Analog input signal not recorded unique
- Internal sensor supply short-circuit to P
- Overload or internal sensor supply short-circuit to M
- Discrepancy error
- Read back failure
- ADC error
- Fault in test circuit

6.3 Diagnostic messages

Diagnostic messages

Module faults are indicated as diagnostics (module information).

Once the fault is eliminated, the F-module must be reintegrated in the safety program with manual acknowledgment. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Table 2-1905 Diagnostic alarms of the F-AI 4xU 0..10V HF

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_H	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range (see Technical specifications (Page 53)) Once the temperature has been reduced and returns to the specified range, the F-module must be removed and inserted or the power switched OFF and ON.
Wire break	6_H	Possible causes: • A cable to the sensor is broken. • Fault at the external circuit • Defective sensor • Wrong sensor type set in the parameters • Input channel not used	Check the possible causes and eliminate the fault.
High limit exceeded	7_H	The measured value exceeds the measuring range.	Check the interaction between the module and the sensor.
Low limit violated	8_H	The measured value is below the measuring range.	Check the interaction between the module and the sensor.
Parameter error	10_H	The parameter error can be: • The F-module cannot use the parameters (unknown, invalid combination, etc.).	Correct the parameter assignment.
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Check the supply voltage L+ on the BaseUnit. • Check the BaseUnit.
Safety-related switchoff	19_H	For safety purposes, the channel was switched off due to an error on another channel. Possible causes: • A short-circuit of the sensor supply to ground is present.	• Correct the process wiring.
Channel/component temporarily not available	$1F_H$	Possible causes: • Internal fault in the F-module • The firmware version of the F-module is inconsistent.	• Replace the F-module. • Repeat the firmware update.

Diagnostic message	Fault code	Meaning	Remedy
Mismatch of safety destination address (F_Dest_Add)	40_H	The F-module detected a different F-destination address.	• Check the parameter assignment of the F-parameters and the assigned PROFIsafe address of the F-module. • Assign the PROFIsafe address to the F-module (again).
Safety destination address not valid (F_Dest_Add)	41_H	The F-module detected an invalid F-destination address.	
Safety source address not valid (F_Source_Add)	42_H	The F-module detected a different F-source address.	
Safety watchdog time value is 0 ms (F_WD_Time)	43_H	The F-module detected an invalid safety watchdog time.	
Parameter F_CRC_Length does not match the generated values	45_H	The F-module detected a discrepancy in the CRC length.	
Version of F parameter set incorrect	46_H	The F-module detected an incorrect F_Par_Version or an invalid F_Block_ID.	
CRC1 fault	47_H	The F-module detected inconsistent F-parameters.	
Inconsistent iParameters (iParCRC error)	$4B_H$	The firmware of the F-module has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	$4C_H$	The F-module detected an incorrect block ID.	Check the parameter assignment of the PROFIsafe driver.
Transfer error: Inconsistent data (CRC error)	$4D_H$	The F-module detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Electromagnetic interference has exceeded limits. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference.
Transfer error: Timeout (monitoring time 1 or 2 expired)	$4E_H$	The F-module detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Check the parameter assignment. • Check the components that are involved in the communication.
Acknowledgement required to activate the channel as soon as the channel faults are remedied.	$4F_H$	A channel fault was detected. Confirmation is required to enable the channel.	Confirm the channel fault.
Module is defective	100_H	Possible causes: • Electromagnetic interference has exceeded limits. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.

Diagnostic message	Fault code	Meaning	Remedy
Watchdog tripped	103_H	Possible causes: • Electromagnetic interference has exceeded limits. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • If the F-module cannot be put back into operation, consider replacing it.
Internal supply voltage fault	104_H	Internal power supply of the module failed.	Replace the F-module.
Common mode error	118_H	Voltage between two input channels is too high.	Correct the input wiring.
Invalid/inconsistent firmware present	$11B_H$	The firmware is incomplete and/or firmware added to the F-module is incompatible. This results in the F-module not being ready for operation.	• Perform a firmware update for the F-module. Note any error messages. • Use only firmware versions released for this F-module.
Analog input signal not recorded unique	304_H	Measured values from the sensor are not plausible. Possible causes: • Increased EMC • F-module defective	Check the interaction between the F-module and the sensor.
Internal sensor supply short-circuit to P	306_H	Possible causes: • Short-circuit of internal sensor supply to P	Check the process wiring.
Overload or internal sensor supply short-circuit to M	307_H	• The internal sensor supply is overloaded. • Missing or insufficient supply voltage L+.	• Eliminate the short-circuit in the process wiring. • Check the supply voltage L+ on the BaseUnit. • Check the BaseUnit.
F-address memory not accessible	$30D_H$	The F-source address and F-destination address stored in the electronic coding element cannot be accessed.	Verify that the coding element is present. Replace the coding element, if necessary.
No valid F-address available	$30E_H$	No valid PROFIsafe address is saved in the retentive memory. Possible causes: • Initial commissioning • Deliberate parameter change of the PROFIsafe address • Deviation between target and actual configuration of the plant.	• In the case of initial commissioning or deliberate parameter change, assign the PROFIsafe address. • Check the consistency of the target and actual configuration.
Undertemperature	312_H	The F-module has fallen below its specified temperature range.	Operate the F-module within the specified temperature range (see Technical specifications (Page 53))
Discrepancy error	314_H	The discrepancy time set for 1oo2 operation has been exceeded. Possible causes of the discrepancy error: • Unsuitable parameter assignment • One of the two sensors is defective	Check the discrepancy time, the sensors and their cabling.

Diagnostic message	Fault code	Meaning	Remedy
Read back failure	$31E_H$	The F-module has detected an internal error through the test connection. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.
Supply voltage too high	321_H	The supply voltage L+ is too high.	Check the supply voltage L+ and then test the safety application.
Supply voltage too low	322_H	The supply voltage L+ is too low.	Check the supply voltage L+ and then test the safety application.
ADC error	331_H	Internal error during analog-digital conversion. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.
Fault in test connection	332_H	The F-module detected an internal error in the test connection. Possible causes: • Increased EMC • F-module defective	If the error persists, replace the F-module.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the module is passivated.

When the voltage is then recovered (level must remain within the specified value range for at least 1 minute (see Technical specifications (Page 53): Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Generally applicable information on diagnostics

Information on diagnostics that pertains to all fail-safe modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

6.4 Value status

Properties

In addition to the diagnostic messages and the status and fault display, the F-module provides information about the validity of each analog input signal – the value status. The value status is entered in the process image along with the input signal.

Value status for F-modules

The value status is a binary additional information of an input signal. The value status is entered in the process image inputs (PII) at the same time as the process signal. It provides information about the validity of the input signal.

The value status is affected by all faults.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

NOTE

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

1oo2 evaluation of the sensors combines the two channels. With 1oo2 evaluation of the sensors, you can only access the low order channel in the safety program, e.g. channel 0, channel pair 0/2.

Assignment of the inputs and value status in the PII

Each channel of the F-module is assigned a value status in the process image inputs. You can find the assignment in section Address space (Page 32).

Reference

A detailed description of the evaluation and processing of the respective input signals can be found in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Technical specifications 7

7.1 Technical specifications

Technical specifications of the F-AI 4xU 0..10V HF

Article number	6ES7136-6AB00-0CA1
General information	
Product type designation	F-AI 4XU 0..10V HF
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0, A1
Color code for module-specific color identification plate	CC00
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated as of version	V16 with HSP 308
Operating mode	
• cyclic measurement	Yes
• Oversampling	No
• MSI	No
CiR – Configuration in RUN	
Reparameterization possible in RUN	No
Calibration possible in RUN	No
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	0.38 A
Current consumption, max.	0.4 A
24 V encoder supply	
• 24 V	Yes; min. L+ (-1.5 V)
• Short-circuit protection	Yes
• Output current, max.	300 mA; total current of all encoders/channels

Article number	6ES7136-6AB00-0CA1
Power	
Power available from the backplane bus	70 mW
Power loss	
Power loss, typ.	2 W
Address area	
Address space per module	
• Inputs	14 byte; S7-300/400F CPU, 13 byte
• Outputs	5 byte; S7-300/400F CPU, 4 byte
Hardware configuration	
Automatic encoding	Yes
• Electronic coding element type H	Yes
Analog inputs	
Number of analog inputs	4
• For voltage measurement	4
permissible input voltage for voltage input (destruction limit), max.	35 V
Input ranges (rated values), voltages	
• 0 to +10 V	Yes
– Input resistance (0 to 10 V)	16 kΩ
Cable length	
• shielded, max.	200 m
Analog value generation for the inputs	
Measurement principle	Sigma Delta
Integration and conversion time/resolution per channel	
• Resolution with overrange (bit including sign), max.	16 bit
• Integration time, parameterizable	Yes
• Integration time (ms)	20 / 16,667
• Interference voltage suppression for interference frequency f1 in Hz	50 / 60 Hz
Smoothing of measured values	
• Number of smoothing levels	7
• parameterizable	Yes
• Step: None	Yes; 1x conversion cycle time
• Step: low	Yes; 2x / 4x conversion cycle time
• Step: Medium	Yes; 8x / 16x conversion cycle time
• Step: High	Yes; 32x / 64x conversion cycle time
• Average value filter	Yes

Article number	6ES7136-6AB00-0CA1
Encoder	
Connection of signal encoders	
• for voltage measurement	Yes
Errors/accuracies	
Linearity error (relative to input range), (+/-)	0.1 %
Temperature error (relative to input range), (+/-)	0.023 %/K
Repeat accuracy in steady state at 25 °C (relative to input range), (+/-)	0.1 %
Operational error limit in overall temperature range	
• Voltage, relative to input range, (+/-)	2 %
Basic error limit (operational limit at 25 °C)	
• Voltage, relative to input range, (+/-)	0.1 %
Interference voltage suppression for f = n x (f1 +/- 1 %), f1 = interference frequency	
• Series mode interference (peak value of interference < rated value of input range), min.	40 dB
• Common mode voltage, max.	10 V
• Common mode interference, min.	70 dB
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Alarms	
• Diagnostic alarm	Yes
• Limit value alarm	No
Diagnostic messages	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
Diagnostics indication LED	
• RUN LED	Yes; Green LED
• ERROR LED	Yes; red LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; Green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; Green/red LED

Article number	6ES7136-6AB00-0CA1
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	Yes
Permissible potential difference	
between the inputs (UCM)	10 Vpp
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PLe
• Category according to ISO 13849-1	Cat. 4
• SIL acc. to IEC 61508	SIL 3
Probability of failure (for service life of 20 years and repair time of 100 hours)	
– Low demand mode: PFDavg in accordance with SIL3	< 5.00E-05
– High demand/continuous mode: PFH in accordance with SIL3	< 1.00E-09 1/h
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	48 g

Operational limit in complete temperature range

WARNING

When designing the safety function, you must take into account the information "Operational limit in complete temperature range" for the entire mission time.

Temperature characteristic values

NOTE

When the ambient temperature exceeds 55 °C, you must only apply a maximum total current of 3 A to an adjacent F-DQ 4x24VDC/2A PM HF.

Dimension drawing

See ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) manual

Response times

A

Introduction

You will find the response times of the F-AI 4xU 0..10V HF below. The response times are included in the calculation of the F-system response time.

Definition of response time for fail-safe analog inputs

The response time results from the number of channels/channel pairs, the response time per channel/channel pair, the basic response time and the configured smoothing.

Times required for the calculation

- Max. acknowledgment time (Device Acknowledgment Time): T_{DAT} = 20 ms
- Basic response time: 20 ms
- Response time per channel
  - At 50 Hz: 25 ms
  - At 60 Hz: 22 ms

Conversion cycle time = basic response time + (N × response time per channel)

(N = number of active channels)

The conversion cycle time is the time in which all activated channels are processed/converted once.

Typical response time

You can calculate the typical response time of the F-AI 4xU 0..10V HF using the following formula:

Typical response time = Conversion cycle time × Smoothing

Maximum response time (worst case delay time, WCDT)

You can calculate the maximum response time of F-AI 4xU 0..10V HF (worst case delay time, WCDT) using the following formula:

Maximum response time = 2 × Conversion cycle time × Smoothing

Response time in the case of a fault (one fault delay time, OFDT)

You can calculate the response time of the F-AI 4xU 0..10V HF (one fault delay time, OFDT) as follows:

- According to the following formula if a discrepancy error is present:

  Typical response time = Conversion cycle time × Smoothing + Discrepancy time + Conversion cycle time

  Maximum response time = 2 × Conversion cycle time × Smoothing + Discrepancy time + 2 × Conversion cycle time

- According to the following formula if a channel fault is present:

  Typical response time = Conversion cycle time

  Max. response time = 2 × Conversion cycle time

This means that, for OFDT, the time on occurrence of a discrepancy error should be taken with parameter assignment "1oo2 evaluation (max. SIL3/Cat.4/PLe)" and the time on occurrence of a channel fault should be taken with parameter assignment "1oo1 evaluation (max. SIL2/Cat.3/PLd)".

Representation of analog values

B

In this section we are presenting the analog values for all measuring ranges that you can use with the F-AI 4xU 0..10V HF analog input module.

Measured value resolution

The analog values are shown as fixed-point number in two's complement.

The resolutions shown here are 16 bits including sign.

Table 2-1906 Resolution of the analog values

Resolution in bits	Values		Analog value	
	Decimal	Hexadecimal	High byte	Low byte
16	1	1_H	Sign 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1

B.1 Representation of analog values

The following tables list the decimal and hexadecimal values (codes) of the voltage measuring range 0 V to 10 V.

Table 2-1907 Voltage measuring range 0 V to 10 V

Values		Voltage measuring range	Range	
Dec.	Hex.		Diagnostics wire break: No	Diagnostics wire break: Yes
32512	$7F00_H$	> 11.759 V	Overflow[1]	Overflow[1]
32511 . . 27649	$7EFF_H$ . . $6C01_H$	11.759 V . . 10 V + 361.69 µV	Overrange	Overrange

1 The F-module signals a "Wire break" or "High limit violated", $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs.

2 The F-module signals a "Low limit violated", 8000_H for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs.

Values		Voltage measuring range	Range	
27648 . . 2765	$6C00_H$ . . 0ACD	10 V . . 1 V (1.0000723 V)	Nominal range	Nominal range
2764 . . 819	0ACC . . 0333	< 1 V (1.0000723 V) . . 0.2962240 V		Wire break[1]
818 . . 1 0	0332 . . 1 0	< 0.2962240 V . . 361.69 µV 0 V	Underflow[2]	

1 The F-module signals a "Wire break" or "High limit violated", $7FFF_H$ for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs.

2 The F-module signals a "Low limit violated", 8000_H for S7-300/400 F-CPUs or 0 for S7-1200/1500 F-CPUs.

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SIMATIC

ET 200SP
Digital Output Module F-DQ 4x24VDC/2A PM HF (6ES7136-6DB01-0CA0)

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Introduction 1

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system. You can find functions that generally relate to the ET 200SP system in the system manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

Conventions

Note the following identified notes:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you ought to pay special attention.

Important note for maintaining the operational safety of your plant

NOTE

Plants with safety-related features are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. For this reason, we inform you in personal notifications about product developments and features that are (or could be) relevant to the operation of plants from a safety perspective.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log onto Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/products?pnid=13751&lc=en-WW)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/products?pnid=13828&lc=en-WW)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/products?pnid=13716&lc=en-WW)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/products?pnid=13683&lc=en-WW)
- Distributed I/O (https://support.industry.siemens.com/cs/products?pnid=14029&lc=en-WW)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/products?pnid=14340&lc=en-WW)

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 S7 Failsafe Configuration Tool (S7-FCT)

SIMATIC S7-FCT

Failsafe Configuration Tool (FCT) enables you to GSD configure the following devices in third-party engineering systems:

- Selected, functionally fail-safe SIMATIC I/O devices
- Functionally fail-safe SIRIUS ACT PROFINET interfaces

The engineering system must meet the following requirements for this:

- Support of the CPD system integration acc. to "PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO"
- TCI implementation to Conformance Class C3

Additional information on S7-FCT can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

1.1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

You can find general information and measures relating to industrial cybersecurity in the system manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

This section provides an overview of security-related information about your SIEMENS device.

NOTE

Security-related changes to software or devices are documented in the "New functions" section.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Product overview

3

3.1 Properties

Article number

6ES7136-6DB01-0CA0

View of the module

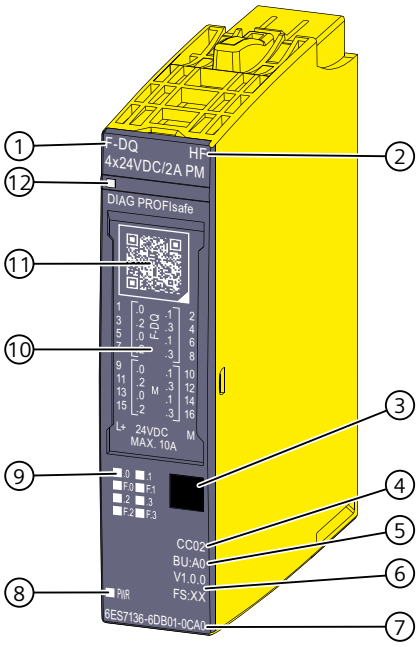

①	Module type and name	⑦	Article number
②	Function class	⑧	LED for supply voltage
③	Color coding module type	⑨	LEDs for channel status
④	Color code for selecting the color-coded labels	⑩	Wiring diagram
⑤	BU type	⑪	QR code for identification link
⑥	Firmware and function version	⑫	LED for diagnostics

Figure 2-1486 View of the F-DQ 4×24VDC/2A PM HF module

Properties

The module has the following technical properties:

- Fail-safe digital module
- PROFIsafe
- PROFIsafe address type 2
- 4 outputs, PM switching (SIL3/Cat.4/PLe)
- Supply voltage L+
- Output current per output 2 A
- Source output (PM switching)
- Suitable for solenoid valves, DC contactors, and indicator lights
- Diagnostic display (DIAG red/green LED)
- Status display for each output (green LED)
- Fault display for each output (red LED)
- Diagnostics e.g. short-circuit/wire break, channel by channel
- Channel-based or module-based passivation

The module supports the following functions:

- Firmware update
- I&M identification data
- Service data
- "Keep last valid value" parameter

WARNING

If you have configured the digital output module F-DQ 4×24VDC/2A PM HF (6ES7136-6DB00-0CA0) in a plant, but have inserted the digital output module F-DQ 4×24VDC/2A PM HF (6ES7136-6DB01-0CA0) instead, the information from the equipment manual of the digital output module F-DQ 4×24VDC/2A PM HF (6ES7136-6DB00-0CA0) continues to apply.

WARNING

The safety parameters in the technical specifications apply for a service life of 20 years and a repair time of 100 hours. If repair is not possible within 100 hours, remove the respective module from the BaseUnit or switch off its supply voltage before the 100 hours have elapsed. The module switches off independently after the 100 hours have expired.

Follow the repair procedure described in section Diagnostic messages (Page 48).

Accessories

The following accessories, which are not included in the product package of the F-module, can be used with the F-module:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connection
- Electronic coding element as replacement part (article number 6ES7193-6EF00-1AA0)

You can find more information on accessories in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

Passivation of fail-safe outputs over a long period of time

WARNING

Unintentional activation of F-I/O with fail-safe outputs

If an F-I/O with fail-safe outputs is passivated for a period longer than that specified in the safety parameters (> 100 hours) and the fault remains uncorrected, you need to exclude the possibility that the F-I/O can be activated unintentionally by a second fault, and thus place the F-system in a dangerous state.

Even though it is highly unlikely that such hardware faults occur, you must prevent the unintentional activation of F-I/O with fail-safe outputs by using circuit measures or organizational measures.

One possibility is the shutdown of the power supply of the passivated F-I/O within a time period of 100 hours, for example.

The required measures are standardized for plants with product standards.

For all other plants, the plant operator must create a concept for the required measures and have it approved by the inspector.

Property of the individual shutdown of F-modules with fail-safe outputs:

A channel-specific shutdown occurs when a fault is detected. It is also possible to react to critical process states staggered over time or to perform safety-related shutdown of individual outputs.

Use in safety mode with the "Keep last valid value" setting

With the "Keep last valid value" setting for the "Behavior at loss of communication" parameter, you can only use the F-DQ 4×24VDC/2A PM HF I/O module in compliance with the EN 54-2 standard.

NOTE

If the "Behavior at loss of communication" parameter is set to "Keep last valid value", it cannot be used in accordance with the standards for machine safety (IEC 61508, ISO 13849-1).

Connecting

4

4.1 Wiring and schematic circuit diagram

This section includes the schematic circuit diagram of the digital output module F-DQ 4×24VDC/2A PM HF with the terminal assignment.

You can find information on wiring the BaseUnit in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

General terminal assignment

Table 2-1908 Terminal assignment for F-DQ 4×24VDC/2A PM HF

Pin assignment for F-DQ 4×24VDC/2A PM HF (6ES7136-6DB01-0CA0)						
Terminal	**Assign-ment**	**Terminal**	**Assign-ment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DQ-P_0	**2**	DQ-P_1	• DQ-P_n: Output signal, channel n, P-switching • DQ-M_n: Chassis ground for output signal, channel n, M-switching	A0	 CC02 6ES7193-6CP02-2MA0
3	DQ-P_2	**4**	DQ-P_3			
5	DQ-P_0	**6**	DQ-P_1			
7	DQ-P_2	**8**	DQ-P_3			
9	DQ-M_0	**10**	DQ-M_1			
11	DQ-M_2	**12**	DQ-M_3			
13	DQ-M_0	**14**	DQ-M_1			
15	DQ-M_2	**16**	DQ-M_3			
L+	DC24V	**M**	M			

[1] Usable BaseUnit types, can be identified by the last two digits of the article number. See also *ET 200SP Distributed I/O System* system manual

NOTE

The first BaseUnit of a potential group must be a light-colored BaseUnit.

NOTE

The fuse integrated in the BaseUnit type A1 can be triggered for the digital output module, rendering the terminals unusable.

Make sure that you only use digital modules with the BaseUnit type A0 during commissioning.

Switching non-floating loads

If the following two conditions are met, a short-circuit is detected by the F-DQ 4×24VDC/2A PM HF:

- When loads are switched from the F-DQ 4×24VDC/2A PM HF that have a connection between chassis ground and ground. For example to improve the EMC properties.
- When chassis ground and ground are connected on the supplying power supply unit.

From the perspective of the F-module, the M-switch is bridged by the chassis-ground connection.

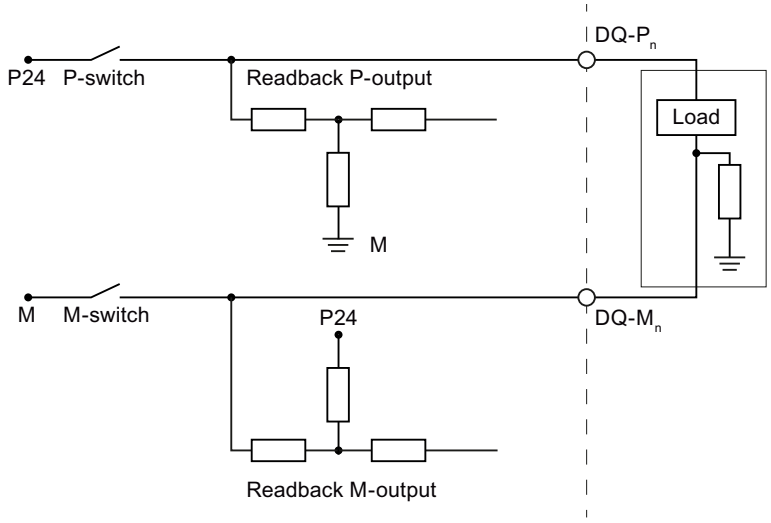

Figure 2-1487 Switching of grounded loads (resistance between chassis and ground)

Alternatively, you can use the following modules:

- F-DQ 8x24VDC/0.5A PP HF
- The F-PM-E 24VDC/8A PPM ST power module for which the output is configured as PP switching

Schematic circuit diagram

The following figure shows the pin assignment of the digital output module F-DQ 4×24VDC/2A PM HF on the BaseUnit BU type A0.

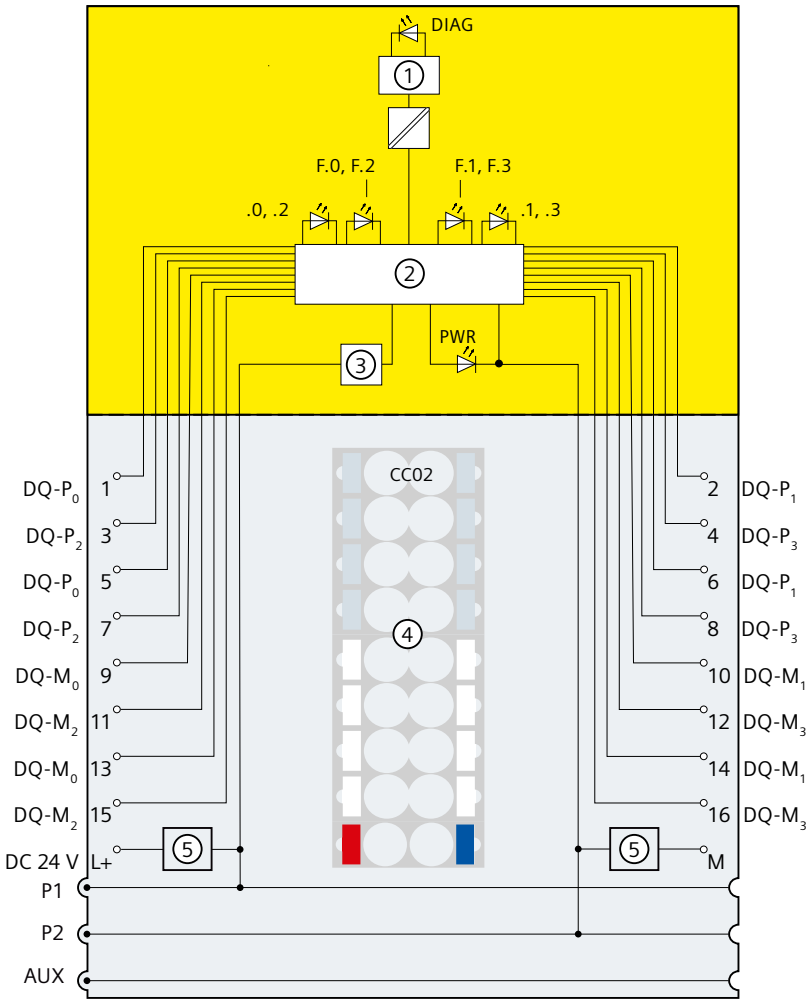

①	Backplane bus interface	$DQ\text{-}P_n$	Output signal, channel n, P-switching
②	Input electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Reverse polarity protection	$DQ\text{-}M_n$	Chassis ground for output signal, channel n, M-switching
④	Color-coded label with color code CC02 (optional)	DIAG	Error or diagnostics LED (green, red)

⑤	Filter connection supply voltage (only when light-colored BaseUnit is present)	0.0 to 0.3	Channel status LED (green)
L+	24 V DC (infeed only with light-colored BaseUnit)	F.0 to F.3	Channel fault LED (red)
M	Chassis ground supply voltage	PWR	Power LED (green)

Figure 2-1488 Schematic circuit diagram of the F-DQ 4×24VDC/2A PM HF

Parameters/address space 5

5.1 Parameters

Parameters for F-DQ 4×24VDC/2A PM HF

WARNING

Diagnostics functions should be activated or deactivated in accordance with the application, see section Applications of the F-I/O module (Page 38).

The following parameters are possible:

Table 2-1909 Adjustable parameters

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
F-parameters:				
Manual assignment of F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Depends on the parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Is proposed by the F-system	No	Module
F-parameter signature (with addresses)	0 to 65535	Is calculated by the F-system	No	Module
F-parameter signature (without address)	0 to 65535	Is calculated by the F-system	No	Module
Behavior after channel fault	• Passivate entire module • Passivate channel	Passivate channel	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	Adjustable	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB-number	—	Is proposed by the F-system	No	Module
F-I/O DB-name	—	Is proposed by the F-system	No	Module

*) When the "Enable Dynamic Read Back" parameter is enabled.

Parameter	Value range	Default	Parameter reassignment in RUN	Scope
DQ parameters:				
Maximum test period	• 100 s • 1000 s	1000 s	No	Module
Behavior at loss of communication	• Apply substitute value "0" • Keep last valid value	Apply substitute value "0"	No	Module
Disable Dark Test (max. SIL2, CAT3, PLd)	• Disable • Enable	Disable	No	Module
Disable Dark Test for 48 hours	• Disable • Enable	Disable	No	Module
Enable Dynamic Read Back	• Disable • Enable	Disable	No	Module
Channel parameters:				
Channel n				
Activated	• Disable • Enable	Enable	No	Channel
Max. readback time, dark test and switch-off test	• 0.6 to 400.0 ms • 0.6 to 20.0 ms *	1.0 ms	No	Channel
Max. readback time switch-on test	0.6 to 5.0 ms	0.6 ms	No	Channel
Channel failure acknowledge	• Manual • Automatic The value range offered depends on the F-CPU used and the parameter assignment of the F-parameter "Reintegration after channel fault".	Manual	No	Channel
Activated light test	• Disable • Enable	Disable	No	Channel
Diagnosis: Wire break	• Disable • Enable	Disable	No	Channel

*) When the "Enable Dynamic Read Back" parameter is enabled.

5.2 Explanation of parameters

5.2.1 F-parameters

5.2.1.1 PROFIsafe address

You have to assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you start operation.

- You specify the F-source address with the "Central F-source address" parameter in the F-CPU.
- The F-destination address is assigned automatically for each F-module CPU-wide. You can change the specified F-destination address in the hardware configuration manually.

Information on the F-parameters for the F-monitoring time, the PROFIsafe addressing (F-source address, F-destination address) and the F-I/O DB can be found in the manual SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

See also

S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875)

5.2.1.2 Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

5.2.1.3 Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use on S7-300/400 F-CPUs

This parameter is always set to "Adjustable" when you use the fail-safe module in S7-300/400 F-CPUs.

You make the required setting in the F-I/O DB of the fail-safe module.

Use on S7-1200/1500 F-CPUs

When using the F-module on F-CPUs S7-1200/1500, set this parameter in the STEP 7 dialog of the F-module:

- "Adjustable"
- "All channels automatically"
- "All channels manually"

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment

"Adjustable". The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

5.2.2 DQ parameters

5.2.2.1 Maximal test period

With this parameter, you specify the time within which the light, dark and switch on tests (complete bit pattern test) should be performed throughout the module. When this time expires, the tests are repeated. In case of a fault, the test time is reduced to 60 seconds.

- Use "1000 s", for example, to conserve your actuators.
- Use "100 s" to detect faults more quickly.

5.2.2.2 Behavior at loss of communication

Defines the reaction of the digital output in the event of CPU STOP or communication failure between the F-module and CPU.

- Apply substitute value "0"
- Keep last valid value

Behavior of the I/O module depending on the "Behavior at loss of communication" parameter.

With the "Keep last valid value" setting of the "Behavior at loss of communication" parameter, the I/O module is only compliant with EN 54-2.

Options:

- Safety mode (SIL3)
- Safety mode (EN 54)

You can find more information on the behavior of the I/O module depending on the "Behavior at loss of communication" parameter in the section "Reaction of the output module with the "Keep last valid value" setting (Page 26)".

5.2.2.3 Reaction of the output module with the "Keep last valid value" setting

Behavior of I/O module

Depending on the "Behavior at loss of communication" parameter, the digital output module complies with the following standards:

Table 2-1910 Conformity to standards

Setting of the "Behavior at loss of communication" parameter	
"Apply substitute value "0""	**"Keep last valid value"**
In conformance with all standards mentioned in the certificates. You will find the certificates on the Internet at: • Certificate for S7 F/FH Systems (https://support.industry.siemens.com/cs/ww/en/ps/14362/cert)	Only compliant with EN 54-2

NOTE

To provide the substitute value, it is necessary to supply the interface module with voltage.

Applications

Typical applications for safety mode with the "Keep last valid value" setting are:

- Ventilation systems
- Smoke flaps

Reactions to faults

NOTE

Observe the appropriate standards for the installation.

NOTE

With the "Keep last valid value" setting of the "Behavior at loss of communication" parameter, only the EN 54-2 standards are met.

The last valid value is supplied when the following communication failures/interruptions occur:

- STOP of the F-CPU (interruption of the PROFIsafe communication)
- Breakdown of PROFIsafe communication
  - Following CRC errors
  - Disconnection of the PROFINET connection
  - Monitoring time of data frames exceeded
- Error in the safety program of the F-CPU
- Error in the PROFIsafe protocol

After resumption of the PROFIsafe communication, the current process value is output again.

The safe state "0" is assumed at the output of the digital output module when the following faults occur:

- Channel fault
- Module fault

If a channel fault occurs in connection with S7 F/FH systems, the last valid value of all error-free channels is held after a STOP-RUN transition of the F-CPU until the channels are re-integrated in the safety program. If the parameter "Behavior after channel fault" is set to "Passivate entire module", you need to eliminate the channel fault before you can reintegrate the channels in the safety program.

5.2.2.4 Disable Dark Test (max. SIL2, CAT3, PLd)

To prevent an unwanted reaction of the actuator to a dark test, you can deactivate the dark test at the F-module output. An unwanted reaction can be for example, the brief de-energizing of a magnetic drive or a process value change of a digital input with very short input delay.

A capacitive load that does not correspond to the load curves (see section Switching capacitive loads (Page 58)) can lead to passivation of the output during a process value change, switch-on test or light test despite the dark test being disabled.

The "Enable Dynamic Read Back" and "Disable Dark Test for 48 hours" parameters must be disabled in conjunction with the "Disable Dark Test (max. SIL2, CAT3, PLd)" parameter.

They achieve max. SIL2/Cat.3/PLd with disabled dark test.

For disabled dark test:

WARNING

SIL2/Cat.3/PLd requires that there is a signal change from "1" to "0" at the corresponding output at least once a year. The "0" signal must have a duration of at least 2 seconds. It is not enough to simply turn off the supply voltage of the F-module and turn it on again.

WARNING

When you use the function "Disable Dark Test", cross-circuits between channels with "1" signal are not detected. If an error caused by short-circuits (cross-circuits) is detected when you request the safety function (shutdown of the output), not only is this output passivated, but all outputs are shut down and the F-module is passivated. Also take into consideration the respective requirements of your product standards regarding error detection time.

5.2.2.5 Disable Dark Test for 48 hours

This option allows you to suppress the dark test.

To suppress dark test pulses, you must ensure that all channels together carry the 0-signal once within the 48 hours. This suspends the dark test for a further 48 hours.

If this condition is not fulfilled, all dark test pulses will be applied anyway on all channels after expiration of this time. With 0-signal channels, the test pulses of light test continue to occur.

The "Enable Dynamic Read Back" and "Disable Dark Test for 48 hours" parameters must be disabled in conjunction with the "Disable Dark Test (max. SIL2, CAT3, PLd)" parameter.

If the following condition is met, the dark test is permanently suppressed:

- Before the 48 hours have elapsed, all channels together have a 0 signal.

WARNING

If a fault caused by short-circuits (cross-circuits) is detected when the safety function is requested (switching off of the output), not only is this output passivated but all outputs are switched off and the module is passivated. This is necessary because no complete bit pattern test is performed within 48 hours and therefore an undetected accumulation of errors cannot be ruled out.

Observe the respective requirements of your product standards with regard to the error discovery time.

If you enable the "Disable Dark Test for 48 hours" parameter, all channels use the values set for channel 0 for the "Max. readback time switch-on test/dark test" parameter.

5.2.2.6 Enable Dynamic Read Back

To avoid an undesired reaction of the actuator to a dark test, you have the option of dynamizing the dark test of the output of the F-module.

The dynamic readback function ends the dark test as soon as the readback signal of the dark test has been validly detected.

- The "Disable Dark Test (max. SIL2, CAT3, PLd)" and "Disable Dark Test for 48 hours" parameters must be disabled in conjunction with the "Enable Dynamic Read Back" parameter.
- The value range of the "Max. readback time, dark test and switch-off test" parameter is limited to a range between 0.6 and 20 ms.

WARNING

If the "Enable Dynamic Read Back" function is used, cross-circuits between 1-signal channels are not detected.

If an error caused by short-circuits (cross-circuits) is detected when you request the safety function (shutdown of the output), not only is this output passivated, but all outputs are shut down and the F-module is passivated.

Also take into consideration the respective requirements of your product standards regarding error detection time.

5.2.3 Parameters of the channels

5.2.3.1 Activated

If you select this check box, the corresponding channel is enabled for signal processing in the safety program.

You can deactivate an unused channel with this parameter.

5.2.3.2 Max. readback time, dark test and switch-off test

Function

Dark tests are switch-off tests with bit pattern test.

For "Disable dark test" mode, the parameter "Max. readback time, dark test and switch-off test" is only relevant for the process value change.

For a dark test, a test signal is switched to the output channel while the output channel is active (output signal "1"). This output channel is then briefly disabled (= "dark period") and read back. A sufficiently slow actuator does not respond to this and remains switched on.

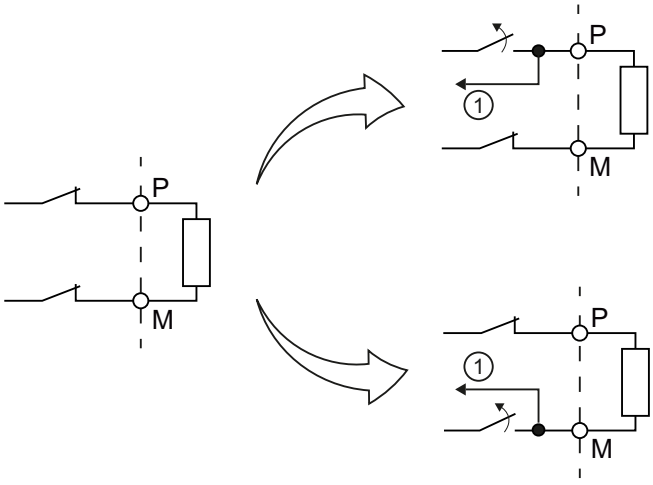

① Readback

Figure 2-1489 Functional principle of the dark test (PM switching)

This parameter allows you to set the time for the readback.

If the expected signals (P-readback and M-readback) could not be read back correctly after expiration of the max. readback time, dark test and switch-off test, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher max. readback time, dark test and switch-off test increases the response time of the F-module.

WARNING

Through the configured "Max. readback time, dark test and switch-off test", short circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured max. readback time, dark test and switch-off test) Hz cannot be detected (50:50 sampling ratio).

Short circuits (cross-circuits) to an output of the same module are recognized.

The parameter also has an effect on the short circuit detection (cross-circuit) with "1" signal when the output signal is changed from "1" to "0" with the safety program.

Setting the parameter "Max. readback time, dark test and switch-off test"

Because the fault response time is extended by the max. readback time, dark test and switch-off test, we recommend that you set the max. readback time, dark test and switch-off test by trial and error as low as possible, but high enough that the output channel is not passivated.

You determine the readback time required for your actuator with the diagram in the chapter Switching capacitive loads (Page 58).

If the capacity of the actuator is not known, it may be necessary for you to determine the value for the max. readback time, dark test and switch-off test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the "Max. readback time, dark test and switch-off test" so that the output channel can be read back correctly but your actuator does not respond yet.
- For verification, use the process value "1" with a minimum duration that corresponds to the "Maximum test time" parameter.
- If the output channel is passivated sporadically, set a higher value for the max. readback time, dark test and switch-off test.
- If the output channel is passivated, the max. readback time, dark test and switch-off test is too small for a connected capacitive load. The discharge cannot take place within the configured max. readback time, dark test and switch-off test. Increase the max. readback time, dark test and switch-off test.

If you have set the max. readback time, dark test and switch-off test to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

Test pulses of the dark test

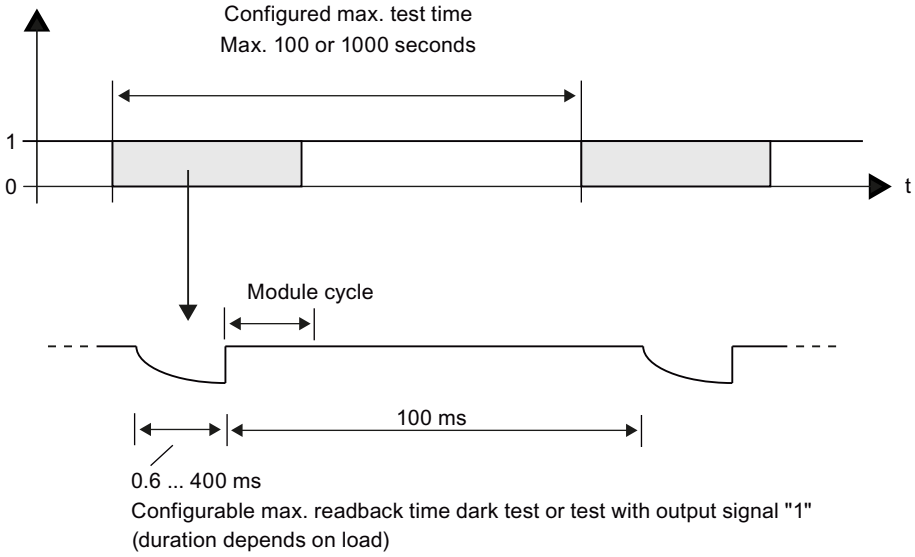

Figure 2-1490 Test pulses of the dark test

The interval between two test pulses amounts to at least 100 ms.

NOTE

Note that the test pulses can be T_{diff} longer than the set test time.
T_{diff} = max (150 µs, min (10% of the set test time, 300 µs))

5.2.3.3 Max. readback time switch on test

Function

The switch on test is part of the bit pattern test.

During the switch on test, the P-switch and M-switch of the output channel are alternately closed and read back when the output channel is inactive (output signal "0"). Contrary to the light test, no power flows through the connected load during the switch on test.

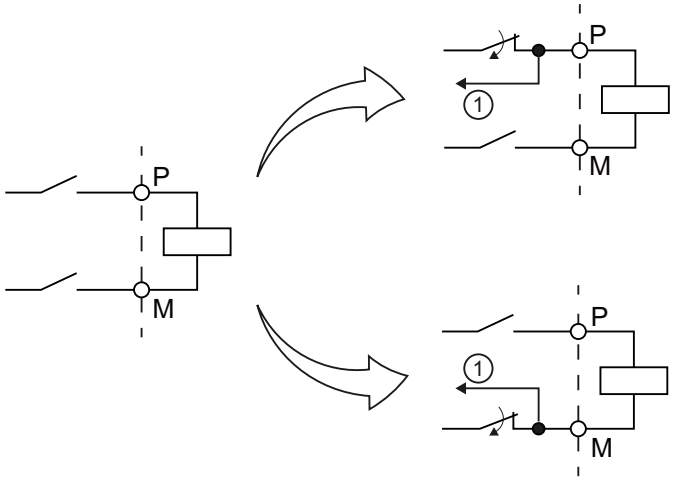

① Readback

Figure 2-1491 Functional principle of the switch on test (PM switching)

This parameter allows you to set the time for the readback. If the signal was not read back correctly once the time has expired, the output channel is passivated.

The switch on test detects the following faults:

- Short circuit to L+ with output signal "0"
- Short circuit to ground with output signal "0"

WARNING

Through the configured readback time, short circuits (cross-circuits) to an interfering signal with a frequency > 1 / (2 x configured readback time) Hz can be suppressed (50:50 sampling ratio).

Short circuits (cross-circuits) to an output of the same module are recognized.

Setting readback time

Because the fault reaction time is extended by the length of the set readback time, we recommend that you set the readback time by trial and error as low as possible but high enough that the output channel is not passivated.

To determine the readback time required for your actuator, refer to the diagram in the section Switching capacitive loads (Page 58).

If the capacitance of the actuator is not known, you may have to determine the required value for the readback time switch-on test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the readback time switch on test in such a way that the output channel can be read back correctly but your actuator does not respond yet.
- If the output channel is passivated sporadically, set a higher value for the maximum readback time switch on test.
- If the output channel is passivated, the readback time is too small for a connected capacitive load. The charge of the capacitive load cannot take place during the configured readback time. Increase the readback time.

If you have set the readback time to the maximum value of 5 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

To increase availability, we recommend that you maintain an interval to the determined limit for the times.

5.2.3.4 Channel failure acknowledge

Use on S7-1200/1500 F-CPUs

The parameter is only relevant if the F-module is operated on an S7-1200/1500 F-CPU.

The parameter can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".

The value of this parameter specifies how the channel reacts after a channel fault:

- Manual: A channel failure is reintegrated after manual acknowledgment.
- Automatic: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

Use on S7-300/400 F-CPUs

The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. For S7-300/400 F-CPUs you set the corresponding property at the F-I/O DB by means of the ACK_NEC tag.

For detailed information about the F-I/O DB, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

5.2.3.5 Activated light test

Function

Overload and wire break are detected with a 0 signal at the output. Wire break is only detected with a 0 signal at the output if the "Diagnosis: Wire break" parameter is activated in addition to the "Activated light test" parameter.

For a light test, a test signal is switched to the output channel while the output channel is inactive (output signal "0"). The output channel is switched on briefly during the light test (=

"light period") and read back. A sufficiently slow actuator does not respond to this and remains switched off.

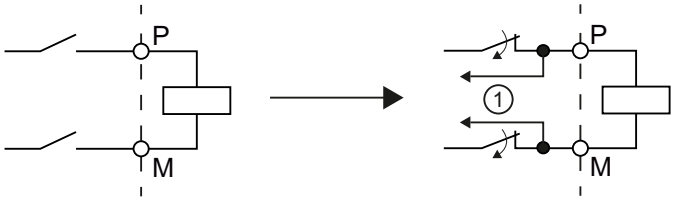

① Readback

Figure 2-1492 Functional principle of the light test (PM switching)

In contrast to the switch on test, the P-switch and the M-switch switch at the same time during the light test and power flows through the connected load.

With bad readback signals, the signal is always present at the output channel for the configured readback time.

If a wire break or overload is detected after the maximum readback time has elapsed, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time switch on test for the light test increases the response time of the F-module.

Test pulses of the light test

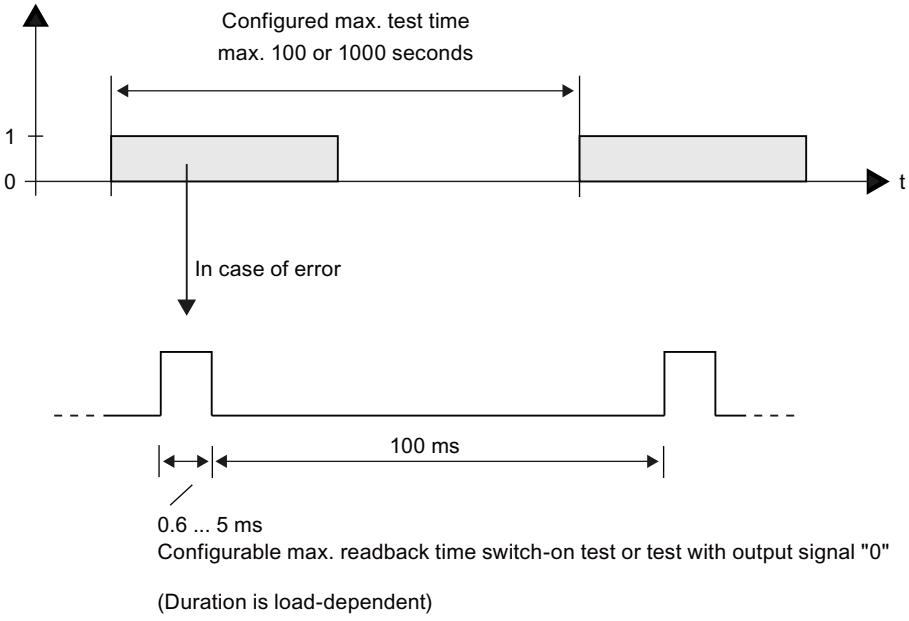

Figure 2-1493 Test pulses of the light test

A light pulse with the configured duration takes place within the configured maximum test time per output channel.

If a light pulse returns a fault, the same light pulse (which means the same bit pattern) is repeated once after 100 ms. If the fault is still present, the maximum test time is

automatically reduced to 60 seconds and a diagnostic message is generated. If the fault is no longer present, the output channel is reintegrated after the next fault-free test cycle.

5.2.3.6 Diagnosis: Wire break

You can use a wire break test to monitor the connection from the output channel to the actuator.

Selecting this check box enables the wire break monitoring for the relevant channel.

To detect a wire break with a "0" output signal, you must also enable the light test.

5.3 Address space

Address assignment of the digital output module F-DQ 4×24VDC/2A PM HF

The digital output module F-DQ 4×24VDC/2A PM HF occupies the following address areas in the F-CPU:

Table 2-1911 Address assignment in the F-CPU

	Occupied bytes in the F-CPU:	
F-CPU	**In input range**	**In output range**
F-CPUs S7-300/400	IB x + 0 to x + 4	QB x + 0 to x + 4
F-CPUs S7-1200/1500	IB x + 0 to x + 5	QB x + 0 to x + 5

x = Module start address

Address assignment of the user data and the value status of digital output module F-DQ 4×24VDC/2A PM HF

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital output module F-DQ 4×24VDC/2A PM HF:

Table 2-1912 Address assignment through user data

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
IB x + 0	—	—	—	—	Value status DQ_3	Value status DQ_2	Value status DQ_1	Value status DQ_0
QB x + 0	—	—	—	—	DQ_3	DQ_2	DQ_1	DQ_0

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

Additional information

You can find detailed information on F-I/O access in the SIMATIC Safety – Configuration and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual or S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875).

See also

Value status (Page 52)

Applications of the F-I/O module

6

6.1 Applications of the F-DQ 4x24VDC/2A PM HF

You achieve SIL3/Cat.4/PLe with the following applications.

The wiring is performed on a suitable BaseUnit (Page 18).

6.2 Application: Wiring a load to each digital output

Each of the four fail-safe digital output consists of a P-switch DQ-P_n and an M-switch DQ-M_n. You connect the load between the P-switch and the M-switch. The two switches are always activated so that voltage is applied to the load. This circuit achieves SIL3/Cat.4/PLe.

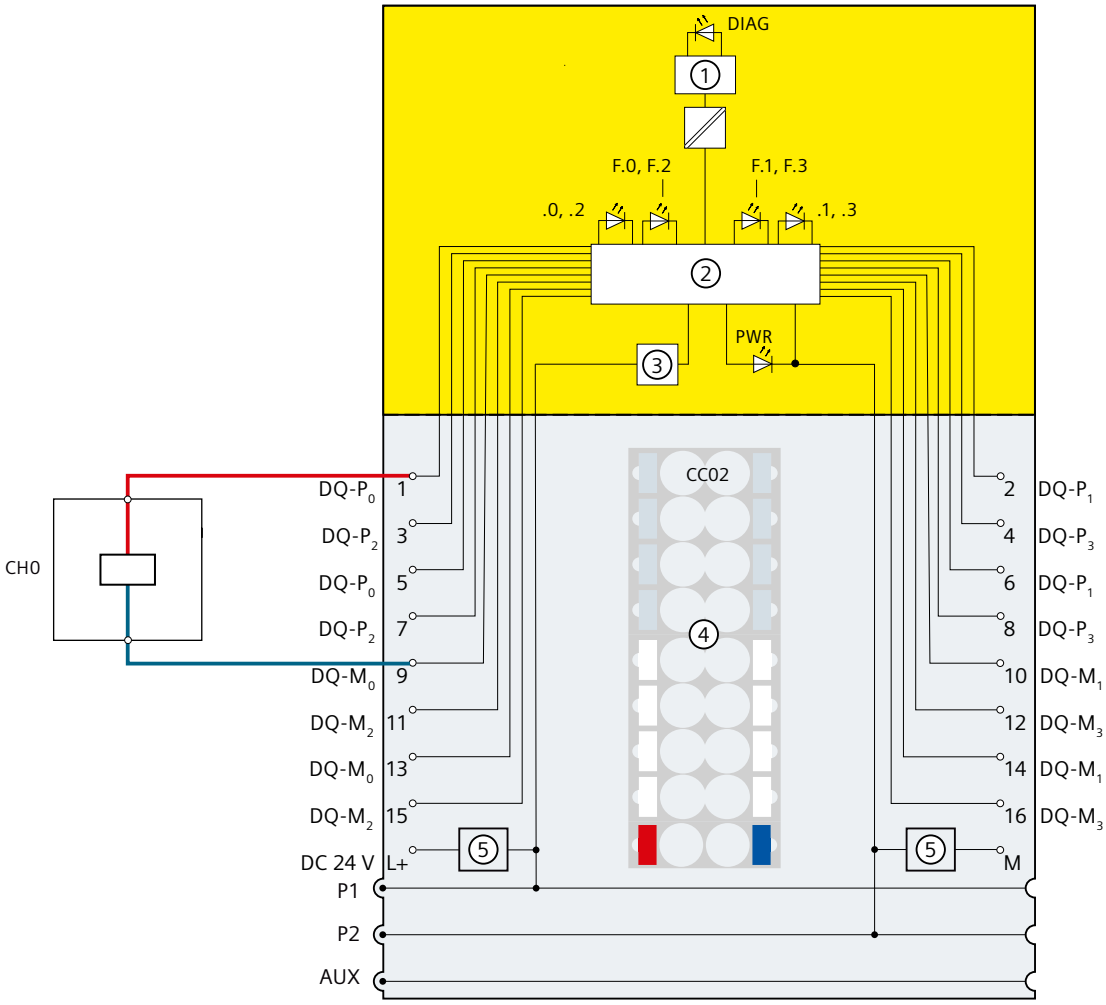

Figure 2-1494 Wiring diagram for 1 relay each at 1 F-DQ of the digital output module F-DQ 4×24VDC/2A PM HF

⚠ WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator, for example, in accordance with IEC 60947.

6.3 Application: Connection of loads to L+ and M at each digital output

You can connect two relays using one fail-safe digital output. The following conditions should be kept in mind:

- Same reference potential
- The normally open contacts of the two relays must be connected in series.

This configuration achieves SIL3/Cat.4/PLe (process status readback required).

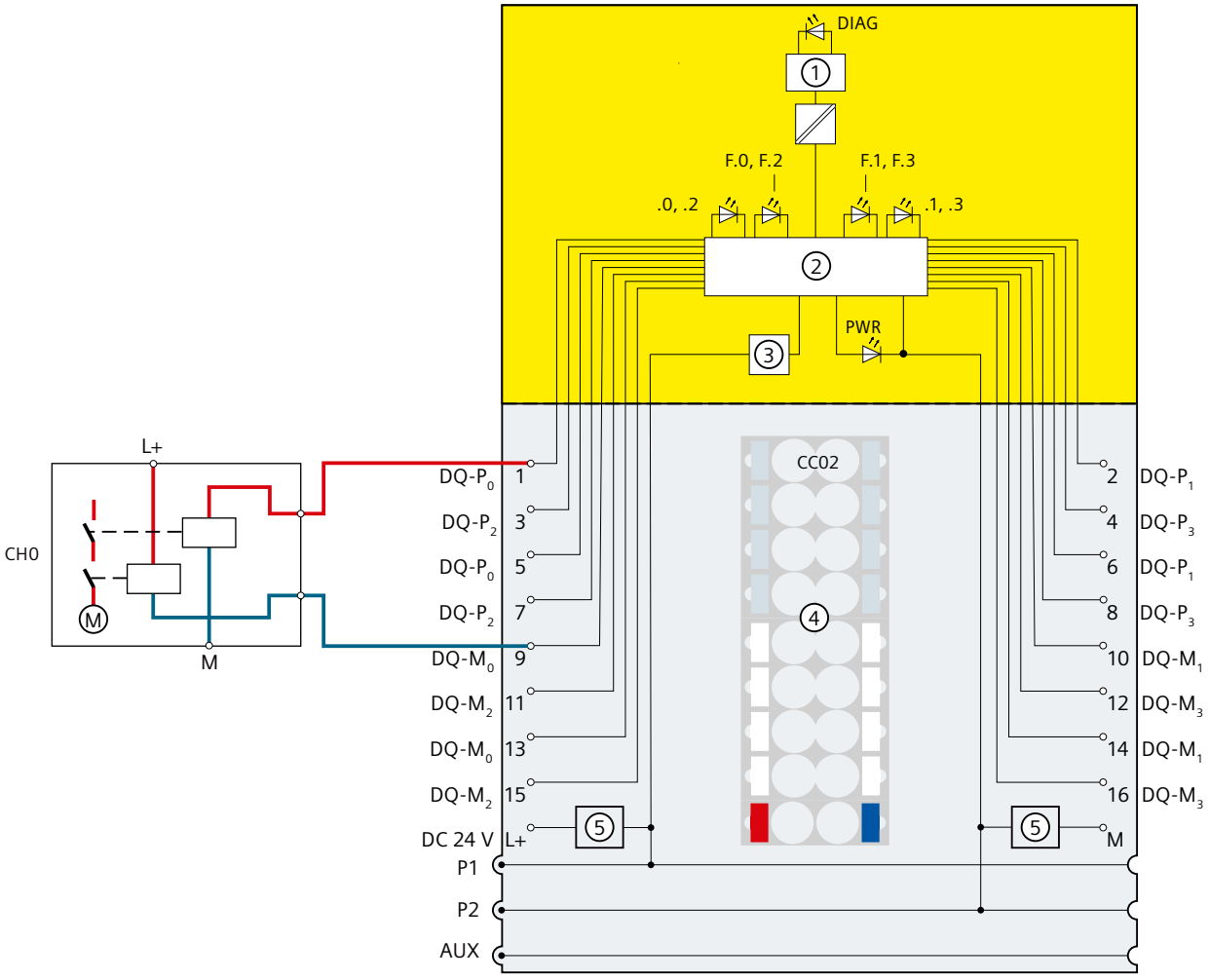

Figure 2-1495 Wiring diagram for connecting 2 relays each to 1 F-DQ of the digital output module F-DQ 4×24VDC/2A PM HF

WARNING

When two relays are connected to one digital output, as shown in the figure above, the "wire break" and "overload" faults are detected only at the P-switch of the output (not at the M-switch).

WARNING

With a cross circuit between P-switch and M-switch of the output, the module detects the fault and switches off the output. But the actuator is still supplied with power due to the external fault.

To avoid cross-circuits between P- and M-switches of a fail-safe digital output, you need to lay the cables for connecting the relays to the P- and M-switch in such a way that they are protected against cross-circuits, for example as separately sheathed cables or in separate cable ducts.

NOTE

The digital output module F-DQ 4×24VDC/2A PM HF performs a bit pattern test depending on the parameter assignment. For this, the module outputs up to 5 ms pulses depending on the parameter assignment. This test (switch-on test) is run with a time offset between the P-switch and M-switch to prevent the actuator from being activated. This pulse may cause the corresponding relay to operated, which may reduce its service life.

We therefore recommend adhering to the wiring scheme described below.

6.4 Application: Wiring two loads in parallel to each digital output

To protect against cross-circuits between P-switch and M-switch in fail-safe digital outputs, we recommend the following wiring scheme. This circuit achieves SIL3/Cat.4/PLe.

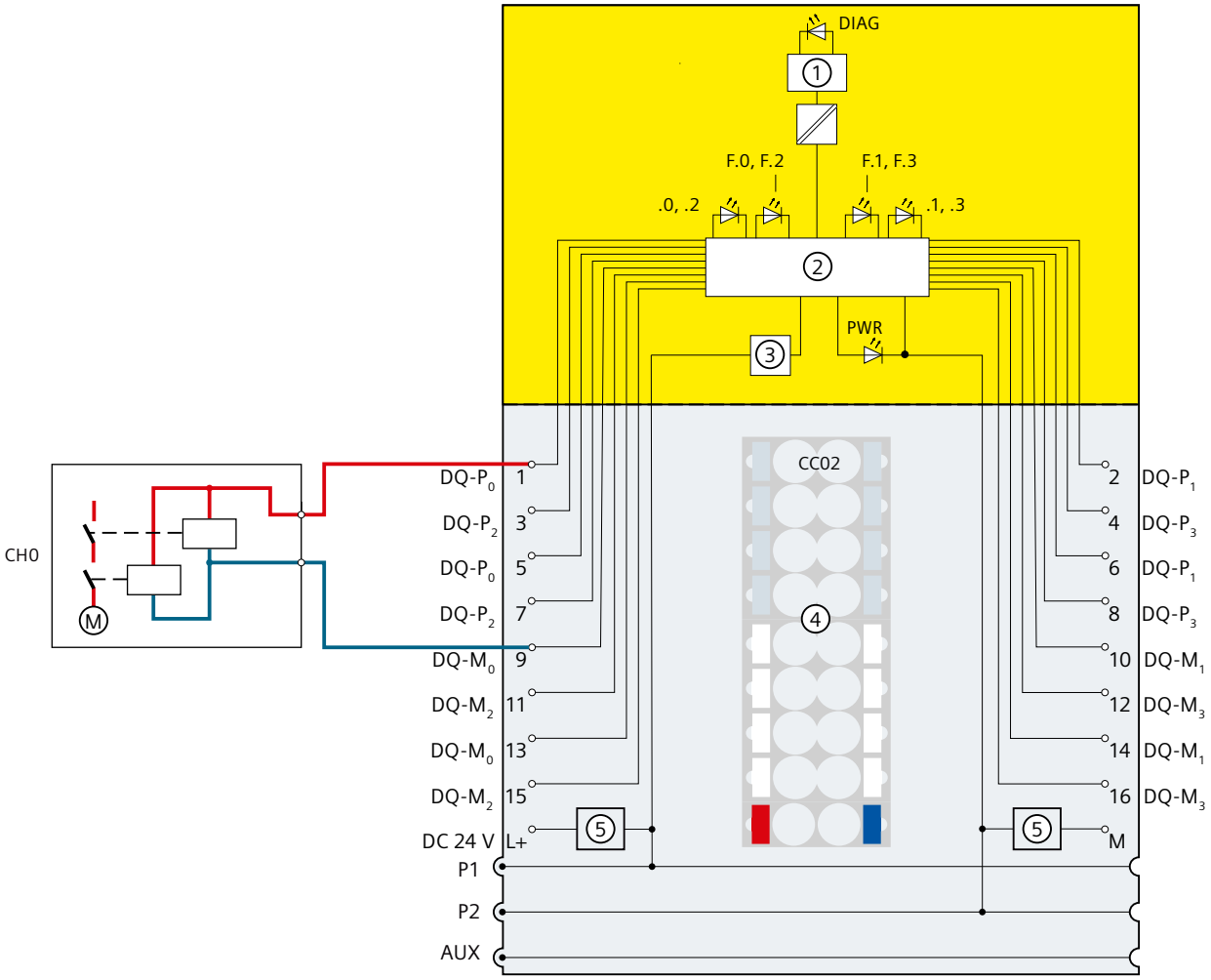

Figure 2-1496 Wiring diagram for 2 relays each parallel at 1 F-DQ of the digital output module F-DQ 4×24VDC/2A PM HF

NOTE

With a parallel connection of two relays on one digital output (as shown above) the "wire break" fault is only detected if the wire break disconnects both relays from P or M. This diagnostics is not safety-related.

Interrupts/diagnostic messages

7

7.1 Status and error display

LED display

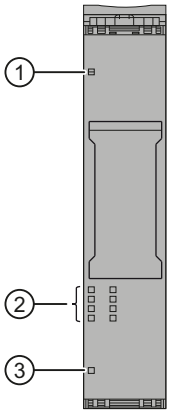

① DIAG (green/red)

② Channel status (green), channel fault (red)

③ PWR (green)

Figure 2-1497 LED display

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic messages can be found in section Diagnostic messages (Page 48).

⚠ WARNING

The DIAG LED and the channel status and channel fault LEDs of the outputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

PWR LED

Table 2-1913 Meaning of the PWR LED

PWR	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ available

DIAG LED

Table 2-1914 Meaning of the DIAG LED

DIAG	Meaning
□ Off	Backplane bus supply of the ET 200SP not okay
☼ Flashing	Module parameters not configured
■ On	Module parameters configured and no module diagnostics
☼ Flashing	Module parameters configured and module diagnostics
☼ Flashing	Module waits for user acknowledgment

Channel status/channel fault LED

Table 2-1915 Meaning of the channel status/channel fault LED

Channel status	Channel fault	Meaning
□ Off	□ Off	Process signal = 0 and no channel diagnostics
■ On	□ Off	Process signal = 1 and no channel diagnostics
□ Off	■ On	Process signal = 0 and channel diagnostics
☼/☼ Alternately flashing		Channel waiting for user acknowledgment

Channel status/DIAG/channel fault LED

Table 2-1916 Meaning of the channel status/DIAG/channel fault LED

Channel status	DIAG	Channel fault	Meaning
□ Off	☼ Flashing	■ All On	The PROFIsafe address does not match the configured PROFIsafe address
☼ Flashing	☼ Flashing	□ Off	Identification of the F-module when assigning the PROFIsafe address

7.2 Interrupts

Introduction

The F-DQ 4x24VDC/2A PM HF fail-safe digital output module supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 48).

The table below provides an overview of the diagnostic interrupts of the F-module . The diagnostic interrupts are assigned either to one channel or the entire F-module.

WARNING

Before acknowledging the short circuit diagnostic message, remedy the respective fault and validate your safety function. Proceed as described in section Diagnostic messages (Page 48) to eliminate the error.

Module-wide diagnostic interrupts:

- Overtemperature
- Parameter error
- Supply voltage missing
- Mismatch of safety destination address (F_Dest_Add)
- Safety destination address not valid (F_Dest_Add)
- Safety source address not valid (F_Source_Add)
- Safety watchdog time value is 0 ms (F_WD_Time)
- Parameter F_SIL exceeds SIL from specific device application
- Parameter F_CRC_Length does not match the generated values
- Version of F parameter set incorrect
- CRC1 fault
- Device-specific diagnostics information, see manual
- Inconsistent iParameters (iParCRC error)
- F_Block_ID not supported
- Transmission error: Inconsistent data (CRC error)
- Transmission error: Timeout (watchdog time 1 or 2 expired)
- Channel failure acknowledgment
- Watchdog tripped
- Invalid/inconsistent firmware present
- Diagnostic queue overflow

- F-address memory not accessible
- No valid F-address available
- Undertemperature
- Auxiliary voltage too high
- Auxiliary voltage too low
- F-module error (0x032F)

Channel-wide diagnostic interrupts

- Wire break
- Safety-related shutdown
- Short-circuit to L+
- Short-circuit to ground
- Frequency too high
- Output defective
- Readback failure
- Overload

7.3 Diagnostic messages

Diagnostic messages

Module faults are indicated as diagnostics (module status).

NOTE

You can connect multiple actuators per output

The diagnostics of the actuators influence each other in the case of multiple wiring.

This means:

- A wire break is only signaled if both actuators are affected.
- A single short-circuit affects both actuators.

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual or S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875).

Table 2-1917 Diagnostic messages of the F-DQ 4×24VDC/2A PM HF

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_H	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range. (See Technical specifications (Page 53)) Once the fault has been eliminated, the F-module must be removed and inserted or the power switched OFF and ON
Wire break	6_H	Possible causes: • There is an interrupted cable between the module and actuator. • The channel is not connected (open).	• Establish a cable connection. • Disable the wire break detection for the channel in the parameter assignment. • Eliminate the short circuit.
Parameter error	10_H	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Operate the F-module within the specified supply voltage range. • Check BaseUnit type
Safety-related shutdown	19_H	The channel was switched off for safety reasons due to an error on another channel. Possible causes: • There is a short-circuit. • The capacitive load is too high.	• Correct the process wiring. • Increase the test times (dark and light test).

Diagnostic message	Fault code	Meaning	Remedy
Mismatch of safety destination address (F_Dest_Add)	40_H	The PROFIsafe driver has detected a different F-destination address.	Check the parameter assignment of the PROFIsafe driver and the address setting of the F-module.
Safety destination address not valid (F_Dest_Add)	41_H	The PROFIsafe driver has detected an invalid F-destination address.	Check the parameter assignment of the PROFIsafe driver.
Safety source address not valid (F_Source_Add)	42_H	The PROFIsafe driver has detected an invalid F-source address.	
Safety watchdog time value is 0 ms (F_WD_Time)	43_H	The PROFIsafe driver has detected an invalid watchdog time.	
Parameter F_SIL exceeds SIL from specific device application	44_H	The PROFIsafe driver has detected a discrepancy between the SIL setting of the communication and the application.	
Parameter F_CRC_Length does not match the generated values	45_H	The PROFIsafe driver has detected a discrepancy in the CRC length.	
Version of F parameter set incorrect	46_H	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.	
CRC1 fault	47_H	The PROFIsafe driver has detected inconsistent F-parameters.	
Device-specific diagnostics information, see manual	48_H	The PROFIsafe driver has received inconsistent fail-safe parameters.	
Inconsistent iParameters (iParCRC error)	$4B_H$	The PROFIsafe driver has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	$4C_H$	The PROFIsafe driver has detected an incorrect Block ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Inconsistent data (CRC error)	$4D_H$	The firmware of the F-module has detected a CRC error. Possible causes: • The communication between F-CPU and F-module is interrupted. • Impermissibly high electromagnetic interference is present. • An error has occurred during the sign-of-life monitoring.	• Check the communication connection between the F-module and the F-CPU. • Eliminate the cause of the electromagnetic interference. • POWER OFF - ON of the station • Reassign the configuration and parameter assignments to the F-module (the station).
Transmission error: Timeout (watchdog time 1 or 2 expired)	$4E_H$	The firmware of the F-module has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	Check the parameter assignment. Make sure that your communication is operating correctly.
Channel failure acknowledgment	$4F_H$	A channel fault was detected. A confirmation is required to enable the channel.	Confirm the channel fault.

Diagnostic message	Fault code	Meaning	Remedy
Watchdog tripped	103_H	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and reacted to it in a safety-oriented manner.	• Correct the fault. The module must then be pulled and plugged, or the power switched OFF and ON • If the F-module cannot be put into operation anymore, consider a replacement.
Short-circuit to L+	105_H	Short circuit to L+ can mean: • The output cable is short-circuited to L+. • There is a short circuit between two output channels. • The capacitive load is too high.	• Correct the process wiring. • Increase the test times (dark, light, switch-on tests).
Short-circuit to ground	106_H	Short circuit to ground can mean: • The output cable is short-circuited to ground. • The output signal is short-circuited to ground. • There is a short circuit between two output channels. • The capacitive load is too high.	• Correct the process wiring. • Increase the test times (dark, light, switch-on tests).
Invalid/inconsistent firmware present	$11B_H$	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Diagnostic queue overflow	$13E_H$	Overflow of the diagnostics memory. Not all pending diagnostics could be sent. This error can result in deactivation of the module up to switching on/off of the supply voltage.	Eliminate the previously reported error.
F-address memory not accessible	$30D_H$	F-source address placed in the coding element and F-destination address cannot be accessed.	Check whether the coding element is available or replace it.
No valid F-address available	$30E_H$	No valid PROFIsafe address is stored in the retentive memory. Possible causes: • Initial commissioning • Deliberate parameter change of the PROFIsafe address • Deviation between setpoint and actual configuration of the plant.	• Perform the assignment of the PROFIsafe address during initial commissioning or deliberate parameter changes. • Check the consistency between the setpoint and actual configuration.
Frequency too high	311_H	The maximum switching frequency of the F-module has been exceeded.	Reduce the switching frequency (see Technical specifications (Page 53)).
Undertemperature	312_H	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range. (See Technical specifications (Page 53))

Diagnostic message	Fault code	Meaning	Remedy
Output defective	$31D_H$	The F-module has detected an internal error. Possible causes: • The capacitive load is too high. • Short circuit to L+ or M • The F-module is defective	• Increase the test times (dark, light, switch-on tests). • Check the wiring. • Replace the F-module.
Readback failure	$31E_H$	The F-module has detected an internal error. Possible causes: • Impermissibly high electromagnetic interference is present. • The capacitive load is too high. • The F-module is defective.	• Increase the test times (dark, light, switch-on tests). • If the error persists, replace the F-module.
Overload	320_H	The maximum permissible output current has been exceeded. The output stage has been switched off. Possible causes: • A short circuit exists. • The capacitive load is too high.	Check the process wiring.
Auxiliary voltage too high	321_H	The supply voltage is too high.	Check the supply voltage.
Auxiliary voltage too low	322_H	The supply voltage is too low.	Check the supply voltage.
F-module error (0x032F)	$32F_H$	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• The internal diagnostics has detected an error. Pulling and plugging the module or POWER OFF – POWER ON is necessary. • If the F-module cannot be put into operation anymore, consider a replacement.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the module is passivated.

When the voltage is then recovered (level must remain within the specified value for at least 1 minute (see Technical specifications (Page 53) Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Generally applicable information on diagnostics

For information on diagnostics which apply to all fail-safe modules (e.g. for reading out the diagnostic functions, passivation of channels), refer to the SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual or S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875).

7.4 Value status

Properties

In addition to the diagnostic messages and the status and error display, the F-module makes available information about the validity of each input and output signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is additional binary information of a digital input or output signal. It is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the input or output signal.

The value status is influenced by the wire break check, short-circuit, chatter monitoring, pulse extension, and plausibility check.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

Assignment of the inputs and value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in section Address space (Page 36).

Reference

A detailed description of the evaluation and processing of the respective input signals can be found in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Technical specifications

8

Technical specifications of F-DQ 4×24VDC/2A PM HF

The following table lists the technical specifications on the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7136-6DB01-0CA0/td?dl=en).

Article number	6ES7136-6DB01-0CA0
General information	
Product type designation	F-DQ 4x24VDC/2A PM HF
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC02
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V20 with HSP / V21
• PROFINET from GSD version/GSD revision	GSDML V2.45
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
power supply according to NEC Class 2 required	No
Input current	
Current consumption (rated value)	30 mA; without load
Current consumption, max.	21 mA; From the backplane bus
output voltage / header	
Rated value (DC)	24 V
Power	
Power available from the backplane bus	70 mW
Power loss	
Power loss, typ.	3 W

Article number	6ES7136-6DB01-0CA0
Address area	
Address space per module	
• Inputs	6 byte; S7-300/400F CPU, 5 byte
• Outputs	6 byte; S7-300/400F CPU, 5 byte
Hardware configuration	
Automatic encoding	Yes
• Electronic coding element type F	Yes
Digital outputs	
Type of digital output	Transistor
Number of digital outputs	4
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes
• Response threshold, typ.	> 3.3 A
Open-circuit detection	Yes
• Response threshold, typ.	8 mA
Overload protection	Yes
• Response threshold, typ.	3 A
Limitation of inductive shutdown voltage to	sourcing output: -39 V DC in relation to 2M, sinking output: +47 V DC in relation to 2M
Controlling a digital input	Yes; digital output, according to IEC 61131-2, type 2
Switching capacity of the outputs	
• with resistive load, max.	2 A
• on lamp load, max.	10 W
Load resistance range	
• lower limit	12 Ω
• upper limit	2 000 Ω
Output voltage	
• for signal "1", min.	24 V; L+ (-0.5 V)
Output current	
• for signal "1" rated value	2 A
• for signal "0" residual current, max.	0.5 mA
Switching frequency	
• with resistive load, max.	30 Hz; Symmetrical
• with inductive load, max.	0.1 Hz; according to IEC 60947-5-1, DC-13, symmetrical
• with capacitive load, max.	30 Hz; observe chapter "Switching of capacitive loads" in the manual
• on lamp load, max.	10 Hz; Symmetrical
Total current of the outputs	
• Current per channel, max.	2 A; note derating data in the manual

Article number	6ES7136-6DB01-0CA0
• Current per module, max.	6 A; note derating data in the manual
Cable length	
• shielded, max.	1 000 m
• unshielded, max.	500 m
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	No
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	No
Diagnostics indication LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PLe
• Category according to ISO 13849-1	Cat. 4
• SIL acc. to IEC 61508	SIL 3
Probability of failure (for service life of 20 years and repair time of 100 hours)	
– Low demand mode: PFDavg in accordance with SIL2	< 2.00E-04
– Low demand mode: PFDavg in accordance with SIL3	< 2.00E-05
– High demand/continuous mode: PFH in accordance with SIL2	< 1.00E-08 1/h

Article number	6ES7136-6DB01-0CA0
– High demand/continuous mode: PFH in accordance with SIL3	< 1.00E-09 1/h
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	4 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	30 g

Temperature characteristic values

Mounting position	Maximum temperature	Total current across all channels
Horizontal	40 °C	6 A
	50 °C	5 A
	60 °C	4 A
Vertical	50 °C	4 A

NOTE

Due to the small size of output modules with higher loads, pay attention to the heat development between adjacent modules. If overtemperature occurs in an output module exposed to an elevated load, shutdown may result and reduce the plant availability. If you fully load an output module, the average total current of the modules directly adjacent to it should not exceed 75% of the values listed in the technical specifications. If you load directly adjacent modules with their maximum total current, reduce the maximum total current of the output module by 1 A (e.g., for horizontal installation up to 60 °C → total current of 3 A across all channels).

Dimension drawing

See ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) manual

Response times

A

Introduction

The reaction time of the digital output module F-DQ 4×24VDC/2A PM HF is specified below. The reaction times of the digital output module F-DQ 4×24VDC/2A PM HF are included in the calculation of the reaction time of the F-system.

Definition of response time for fail-safe digital outputs

The response time represents the interval between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Times required for the calculation

- Maximum cycle time: T_{cycle} = 5 ms
- Max. acknowledgment time (device acknowledgment time): T_{DAT} = 31 ms

You configure the dark test time (Readback time, T_{rb}) and switch-on time (Readback time switch-on test, T_{rb_swon}) in STEP 7.

Definition of maximum reaction time in an error-free scenario (worst case delay time, WCDT)

The maximum reaction time (T_{WCDT}) for fail-safe digital outputs in the error-free case is as follows:

Max. reaction time (T_{WCDT}) = 2 × T_{cycle} + Maximum T_{rb} (dark test time), T_{rb_swon} (switch-on time)

Definition of maximum reaction time if there is a fault/error (one fault delay time, OFDT)

Max. reaction time (T_{OFDT}) = 2 × T_{cycle} + Maximum T_{rb} (dark test time), T_{rb_swon} (switch-on time)

Maximum reaction time when a channel fault is detected by bit pattern test

Max. reaction time (T_{WCDT}) = 2 ×T_{cycle} + Maximum T_{rb} (dark test time), T_{rb_swon} (switch-on time) + configured test time

Mode of operation: Disable Dark Test for 48 hours - enabled

It can take up to a process value change 0-1 on the corresponding channel before a channel fault is detected. Note the restrictions in the section Disable Dark Test for 48 hours (Page 28).

Switching of loads

B

B.1 Connecting capacitive loads

If a digital output module F-DQ 4×24VDC/2A PM HF is connected to loads that require little current and have a capacitance, a short-circuit or overload may be detected. Reason: The capacitance cannot be sufficiently discharged or charged during the configured readback time of the bit pattern test.

The typical trend shown in the diagram below represents the correlation between load impedance and maximum switched load capacitance at a supply voltage of 24 V DC.

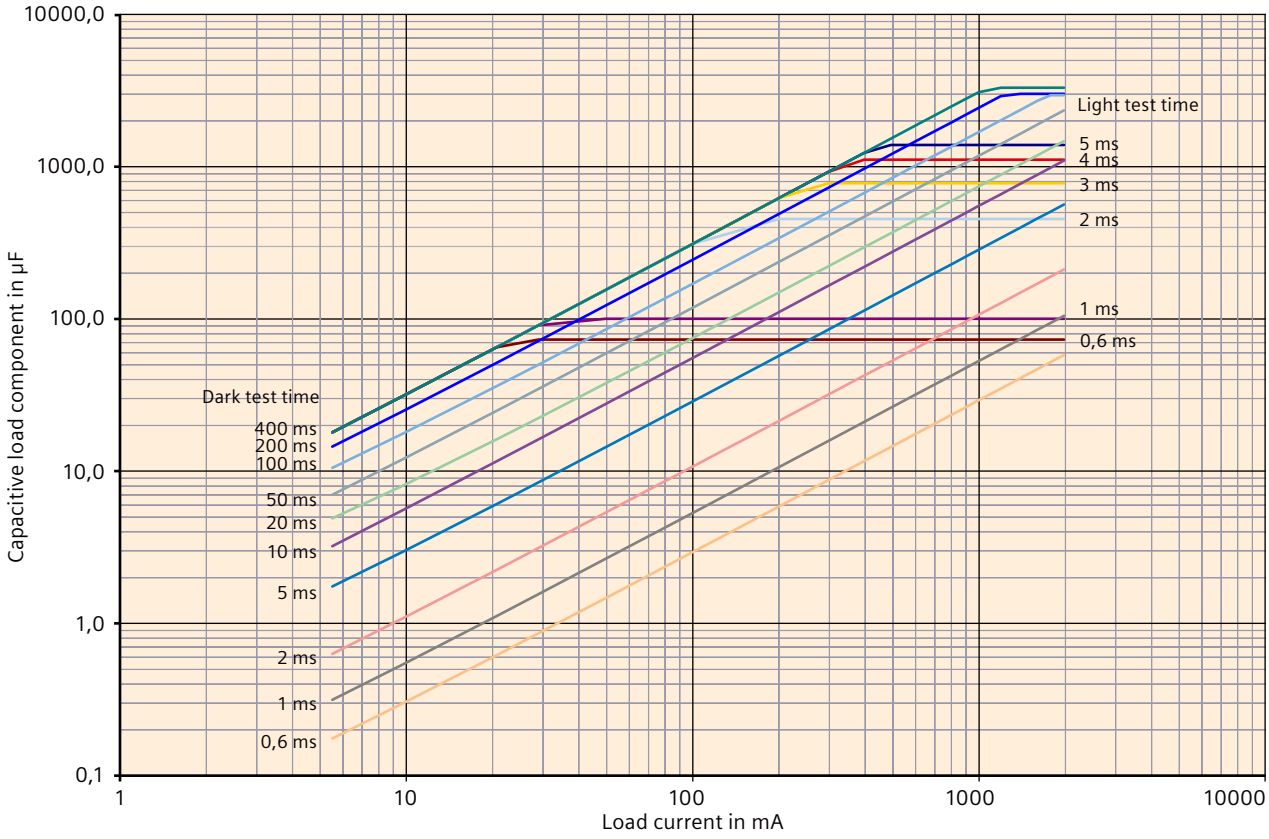

Figure 2-1498 Switching of capacitive loads for digital output module F-DQ 4×24VDC/2A PM HF depending on the configured dark and light test time

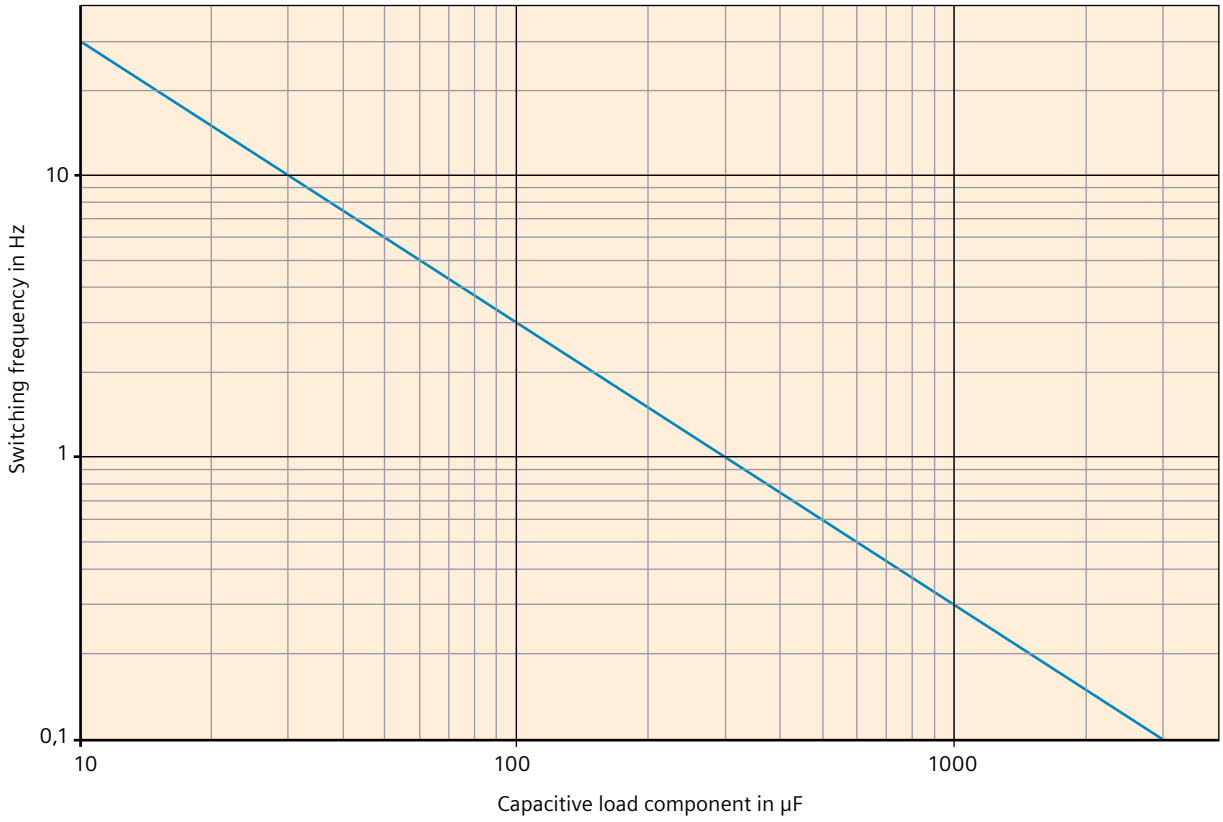

Figure 2-1499 Maximum switching frequency depending on the capacity of the load

Remedy for detecting a short circuit

1. Determine the load current and capacitance of the load.
2. Locate the operating point in the diagram above.
3. If the operating point is above the curve, you must increase the load current until the new operating point is below the curve by connecting a resistor in parallel.

B.2 Switching of inductive loads

Switching of inductive loads

The diagram below shows the maximum permitted inductive loads as a function of the load current and switching frequency.

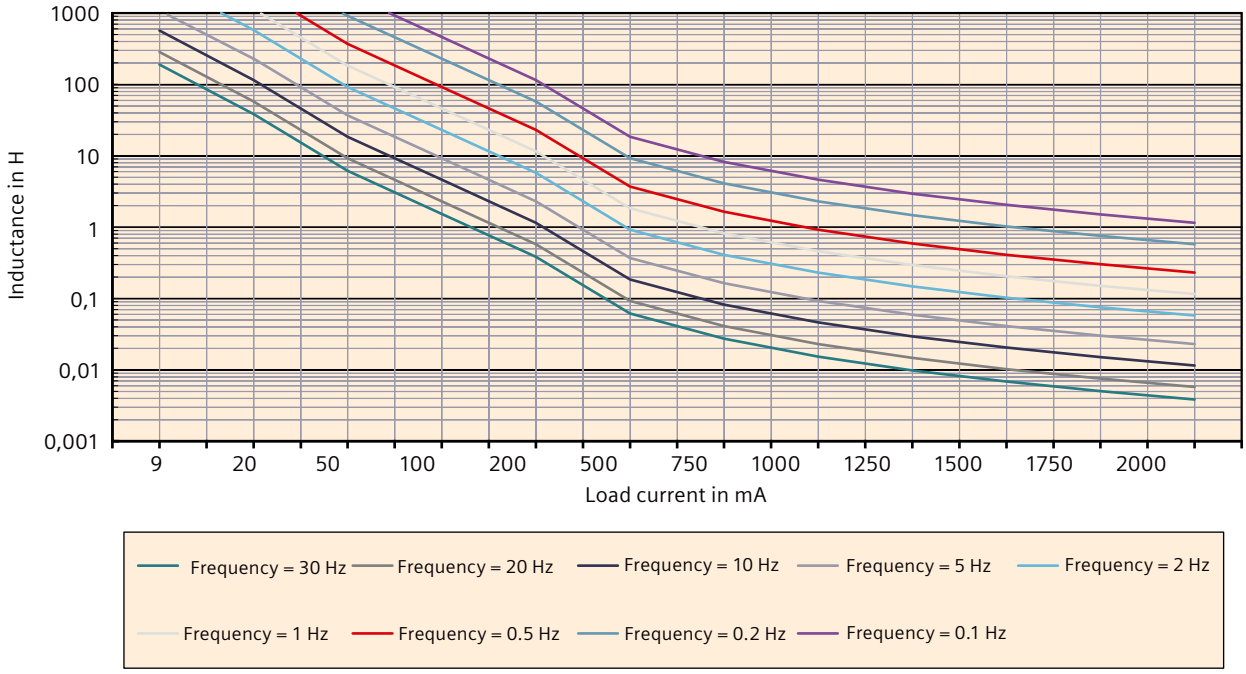

Figure 2-1500 Switching of inductive loads for the digital output module F-DQ 4x24VDC/2A PM HF depending on load current and switching frequency

SIEMENS

SIMATIC

ET 200SP
Digital output module F-DQ 8x24VDC/0.5A PP HF (6ES7136-6DC00-0CA0)

Equipment Manual

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Preface

Purpose of the documentation

This manual supplements the system manual Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that affect the system in general are described in this system manual.

The information in this manual and the system/function manuals provide support when you commission the system.

A description of the F-system SIMATIC Safety can be found in the programming and operating manual SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Conventions

CPU: When the term "CPU" is used below, it refers to the central processing units of the S7-1200/1500 automation system and the S7-300/S7-400 automation systems of the previous generation and to CPUs of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software " (STEP 7 TIA Portal)".

PII: Process image input.

Note the following identified notes:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you ought to pay special attention.

Standards

You can find a dated reference to the respective standards in the certificate (https://support.industry.siemens.com/cs/ww/en/view/57141281) or in the EC Declaration of Conformity (https://support.industry.siemens.com/cs/ww/en/view/71764057) for the F-module.

Certified versions

You can find the certified product and firmware versions in Annex 1 of the report to the TÜV certificate (https://support.industry.siemens.com/cs/ww/en/view/57141289).

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Important note for maintaining the operational safety of your system

⚠ WARNING

The operators of systems with safety-related characteristics must adhere to specific operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators in the form of personal notifications about product developments and properties which may be or become important issues in terms of operational safety.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log on to Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/ww/en/ps/13751)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/ww/en/ps/13828)
- S7-1500 Software Controller (https://support.industry.siemens.com/cs/us/en/ps/13912)
- SIMATIC S7-1500/SIMATIC S7-1500F (https://support.industry.siemens.com/cs/ww/en/ps/13716)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/ww/en/ps/13683)
- Distributed I/O (https://support.industry.siemens.com/cs/ww/en/ps/14029)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/ww/en/ps/24471)

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

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For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

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To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/cert).

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ET 200SP documentation guide

1

1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.3 S7 Failsafe Configuration Tool (S7-FCT)

SIMATIC S7-FCT

Failsafe Configuration Tool (FCT) enables you to GSD configure the following devices in third-party engineering systems:

- Selected, functionally fail-safe SIMATIC I/O devices
- Functionally fail-safe SIRIUS ACT PROFINET interfaces

The engineering system must meet the following requirements for this:

- Support of the CPD system integration acc. to "PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO"
- TCI implementation to Conformance Class C3

Additional information on S7-FCT can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

1.4 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

mySupport

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Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Product overview

2

2.1 Properties

Article number

6ES7136-6DC00-0CA0

View of the module

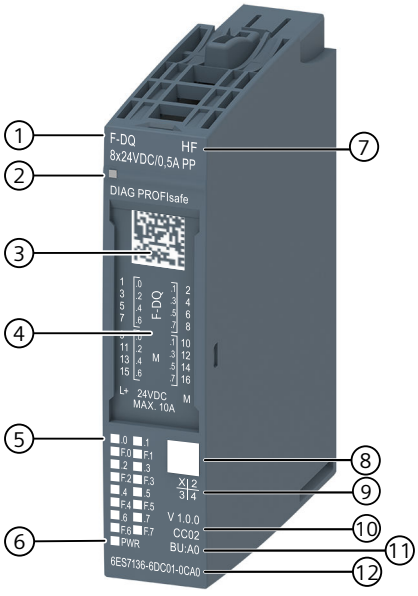

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Color identification module type
③	2D matrix code	⑨	Function and firmware version
④	Connection diagram	⑩	Color code to select the color identification labels
⑤	LEDs for channel status	⑪	Article number
⑥	LED for supply voltage		

Figure 2-1501 View of the module F-DQ 8x24VDC/0.5A PP HF

Properties

The module has the following technical characteristics:

- Fail-safe digital module
- PROFIsafe
- Supports the "RIOforFA-Safety" profile on F-CPUs S7-1200/1500.
- PROFIsafe address type 2
- 8 outputs, PP-switching (SIL3/Cat.4/PLe)
- Supply voltage L+
- Output current 0.5 A per output
- Sourcing output (PP-switching)
- Suitable for solenoid valves, DC contactors and signal lamps
- Direct interconnection to inputs of an F-DI possible
- Diagnostics display (DIAG red/green LED)
- Status display for each output (green LED)
- Fault display for each output (red LED)
- Diagnostics
  - e.g., short-circuit, channel-specific
  - e.g. supply voltage missing, module-specific
- Channel-specific or module-wide passivation

The module supports the following functions:

- Firmware update
- I&M identification data
- Service data (V1.0.1 and higher)

WARNING

The fail-safe performance characteristics in the technical specifications apply for a mission time of 20 years and a repair time of 100 hours. If a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before the 100 hours elapse. The module switches off independently after the 100 hours have expired.

Follow the repair procedure described in section Diagnostics alarms (Page 43).

NOTE

Cyclic reading of I&M data

Cyclic reading of I&M data can affect the timing of the F-modules. You should therefore avoid short read cycles of less than 500 ms.

Accessories

The following accessory must be ordered separately:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connection
- Electronic coding element as spare part (article number 6ES7193-6EF00-1AA0)

You can find additional information about accessories in the Distributed I/O System ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Passivation of fail-safe outputs over a long period of time

WARNING

Unintentional activation of F-I/O with fail-safe outputs

If an F-I/O with fail-safe outputs is passivated for a period longer than that specified in the safety parameters (> 100 hours) and the fault remains uncorrected, you need to exclude the possibility that the F-I/O can be activated unintentionally by a second fault, and thus put the F-system in a dangerous state.

Even though it is highly unlikely that such hardware faults occur, you must prevent the unintentional activation of F-I/O with fail-safe outputs by using circuit measures or organizational measures.

One possibility is the shutdown of the power supply of the passivated F-I/O within a time period of 100 hours, for example.

The required measures are standardized for plants with product standards.

For all other plants, the plant operator must create a concept for the required measures and have it approved by the inspector.

Property of the individual shutdown of F-modules with fail-safe outputs:

A channel-specific shutdown occurs when a fault is detected. It is also possible to react to critical process states staggered over time or to perform safety-related shutdown of individual outputs.

Connecting 3

3.1 Wiring and block diagram

This section provides the block diagram of the F-DQ 8×24VDC/0.5A PP HF F-module with the terminal assignment.

You can find information about the various connection options and their configuration in the section Applications of the F-I/O module (Page 27) or Parameters/address space (Page 18).

You can find more information about wiring the BaseUnit in the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual.

NOTE

The load group of the F-module must begin with a light-colored BaseUnit. Keep this in mind as well during configuration.

NOTE

Make sure that you only use the digital output module with BaseUnit type A0 during commissioning.

Block diagram

The following figure shows the terminal assignment of the F-DQ 8×24VDC/0.5A PP HF digital output module on BaseUnit BU type A0.

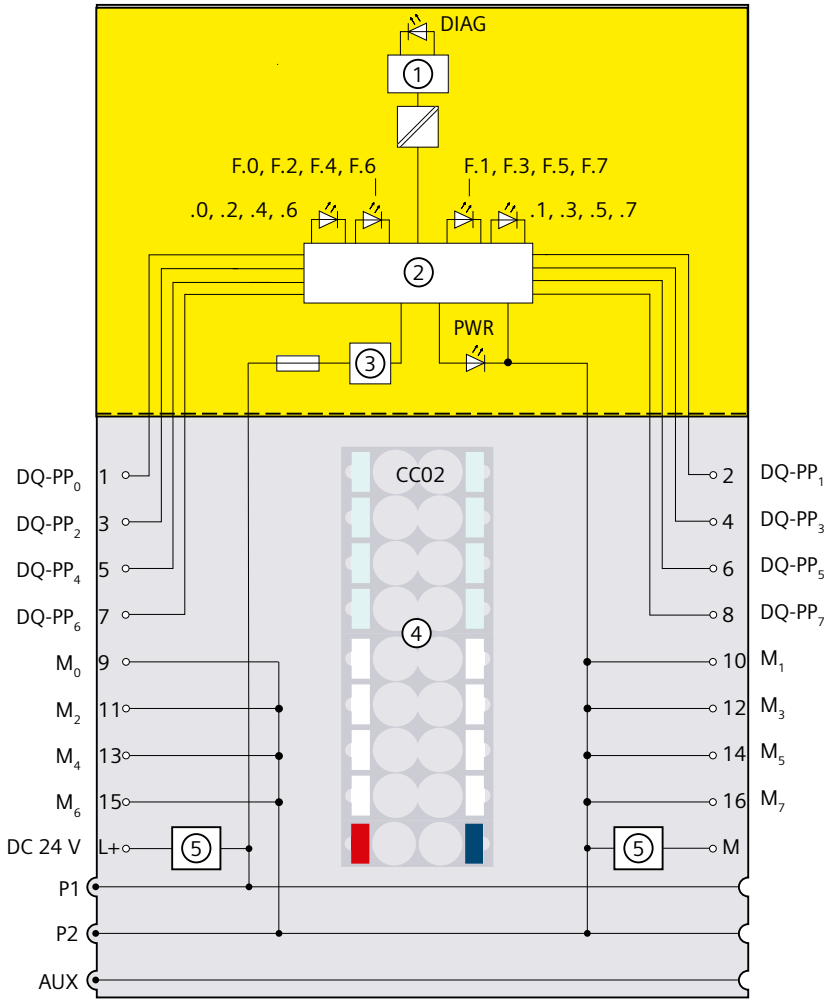

①	Backplane bus interface	M_n	Ground for connection of actuator of channel n.
②	Output electronics	P1, P2, AUX	Internal self-assembling voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
③	Reverse polarity protection	$DQ\text{-}PP_n$	Output bit n, channel n, PP-switching (sourcing output)
④	Color-coded label with color code CC02 (optional)	DIAG	LED error of diagnostics (green, red)
⑤	Filter circuit supply voltage (available in light-colored BaseUnit only)	.0 to .7	LED channel status (green)
24 VDC	Supply voltage L+ (feed for light-colored BaseUnit only)	F.0 to F.7	LED channel error (red)
M	Supply voltage ground	PWR	LED Power (green)

Figure 2-1502 Block diagram

Parameters/address space

4

4.1 Parameters

Parameters for F-DQ 8x24VDC/0.5A PP HF

WARNING

Diagnostics functions should be activated or deactivated in accordance with the application, see section Applications of the F-I/O module (Page 27).

The following parameters are possible:

Table 2-1918 Configurable parameters

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
F-parameters:				
Manual assignment of F-monitoring time	• Disable • Enable	Disable	No	Module
F-monitoring time	1 to 65535 ms	150 ms	No	Module
F-source address	1 to 65534	Dependent on parameter assignment of the F-CPU	No	Module
F-destination address	1 to 65534	Suggested by F-system	No	Module
F-parameter signature (without addresses)	0 to 65535	Calculated by F-system	No	Module
Behavior after channel faults	• Passivate the entire module • Passivate channel	Passivate channel	No	Module
Reintegration after channel fault	• Adjustable • All channels automatically • All channels manually	(S7-300/400) Adjustable (S7-1200/1500) All channels manually	No	Module
F-I/O DB manual number assignment	• Disable • Enable	Disable	No	Module
F-I/O DB number	—	Suggested by F-system	No	Module
F-I/O DB name	—	Suggested by F-system	No	Module
DQ parameters:				
Maximum test period	• 100 s • 1000 s	1000 s	No	Module

Parameters	Value range	Default	Parameter reassignment in RUN	Scope
Disable dark test for 48 hours	• Disable • Enable	Disable	No	Module
Channel parameters:				
Channel n				
Activated	• Enable	Enable	No	Channel
Max. readback time light test / dark test	• 0.8 / 1.0 ms • 3.0 / 5.0 ms	0.8 / 1.0 ms	No	Channel
Activated light test	• Enable	Enable	No	Channel
Channel failure acknowledge	• Manual • Automatic The value range offered depends on the F-CPU in use and on the configuration of the F-parameter "Reintegration after channel fault".	(S7-300/400) Parameter is not supported (S7-1200/1500) Manual	No	Channel

4.2 Explanation of parameters

4.2.1 F-parameters

4.2.1.1 F-parameters

You must assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation.

- You define the F-source address with the "Central F-source address" parameter in the F-CPU.
- An F-destination address unique throughout the CPU is automatically assigned for each F-module. You can manually change the F-destination addresses assigned in the hardware configuration.

You can find information on F-parameters for the F-monitoring time, the PROFIsafe address assignment (F-source address, F-destination address) and the F I/O DB in the manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

See also

S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875)

4.2.1.2 Behavior after channel fault

This parameter is used to specify whether the entire F-module is passivated or just the faulty channel(s) in the event of channel faults:

- "Passivate the entire module"
- "Passivate channel"

4.2.1.3 Reintegration after channel fault

Use this parameter to select how the channels of the fail-safe module are reintegrated after a fault.

Use in S7-300/400 F-CPUs

This parameter is always set to "Adjustable" when you use the fail-safe module in S7-300/400 F-CPUs.

You make the required setting in the F-I/O DB of the fail-safe module.

Use in S7-1500 F-CPUs

When using the fail-safe module in S7-1500 F-CPUs, you set this parameter in the STEP 7 dialog of the fail-safe module:

- "Adjustable"
- "All channels automatically"
- "All channels manually"

If you have set the "Behavior after channel fault" parameter to "Passivate channel", you enable individual setting of the reintegration type per channel with the parameter assignment "Adjustable". The reintegration type of the respective channel is specified with the "Channel failure acknowledge" channel parameter.

If you have set the "Behavior after channel fault" parameter to "Passivate the entire module", you can only select the same reintegration type for all channels.

4.2.2 Parameters of the channels

4.2.2.1 Maximum test period

With this parameter, you specify the time within which the light, dark tests (complete bit pattern test) should be performed throughout the module. When this time expires, the tests are repeated. In case of a fault, the test period is reduced to 60 seconds.

- Use "1000 s", for example, to conserve your actuators.
- Use "100 s" to detect faults more quickly.

4.2.2.2 Disable dark test for 48 hours

This option allows you to suppress the dark test.

To suppress dark test pulses, you must ensure that all channels together carry the 0-signal once within the 48 hours. If this condition is not fulfilled, all dark test pulses will be applied anyway on all channels after expiration of this time.

With 0-signal channels, the test pulses of light test continue to occur.

WARNING

When you use the function "Disable dark test for 48 hours", cross-circuits between channels with 1-signal are not detected.

If an error caused by short-circuits (cross-circuits) is detected when you request the safety function (shutdown of the output), not only is this output passivated, but all outputs are shut down and the F-module is passivated.

Also take into consideration the respective requirements of your product standards regarding error detection time.

When you activate the parameter "Disable dark test for 48 hours", all channels use the values set for channel 0 for the parameter "Max. readback time light test / dark test".

4.2.2.3 Activated

The channel is always activated for this F-module.

4.2.2.4 Max. readback time dark test

Function

Dark tests are shutdown tests with bit pattern test.

For a dark test, a test signal is switched to the output channel while the output channel has the 1-signal. This output channel is then briefly disabled (= "dark period") and read back. A sufficiently slow actuator does not respond to this and remains switched on.

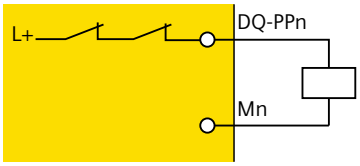

① Readback

Figure 2-1503 Functional principle of the dark test (PP switching)

This parameter allows you to set the time for the readback.

If the expected signals could not be read back correctly after expiration of the readback time dark test, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time for the dark test increases the reaction time of the F-module.

WARNING

Through the configured dark test time, short-circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured dark test time) Hz cannot be recognized (50:50 sampling ratio).

Short-circuits (cross-circuits) to an output of the same module are recognized.

The parameter also has an effect on the short-circuit detection (cross-circuit) with 1-signal when the output signal is changed from "1" to "0" with the safety program.

Setting readback time dark test

Because the fault reaction time is extended by the length of the readback time dark test, we recommend that you only use the large readback time dark test if the output channel would be passivated with the small readback time.

In case of the "Connecting a load per digital output" (Page 28) application, see the warnings and notes in the section describing the application.

To determine the readback time required for your actuator, refer to the diagram in the section Switching capacitive loads (Page 54).

Setting readback time dark test with unknown actuator capacity

If the capacity of the actuator is not known, it may be necessary for you to set the larger readback time. This may also be necessary due to component variation in the

actuator or external influences.

Proceed as follows:

- Set the readback time dark test so that the output channel can be read back correctly but your actuator does not respond yet.
- For verification use a 1-signal with a minimum duration that corresponds to the "Maximum test period".
- If the output channel is passivated sporadically, set a higher value for the maximum readback time dark test.
- If the output channel is passivated, the readback time dark test is too small for a connected capacitive load. The discharge cannot take place during the configured readback time dark test. Increase the readback time dark test.

If you have set the readback time dark test to the maximum value of 5 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

To increase availability, we recommend that you maintain an interval to the determined limit for the times.

Test pulses of the dark test

The interval between two test pulses is 500 ms.

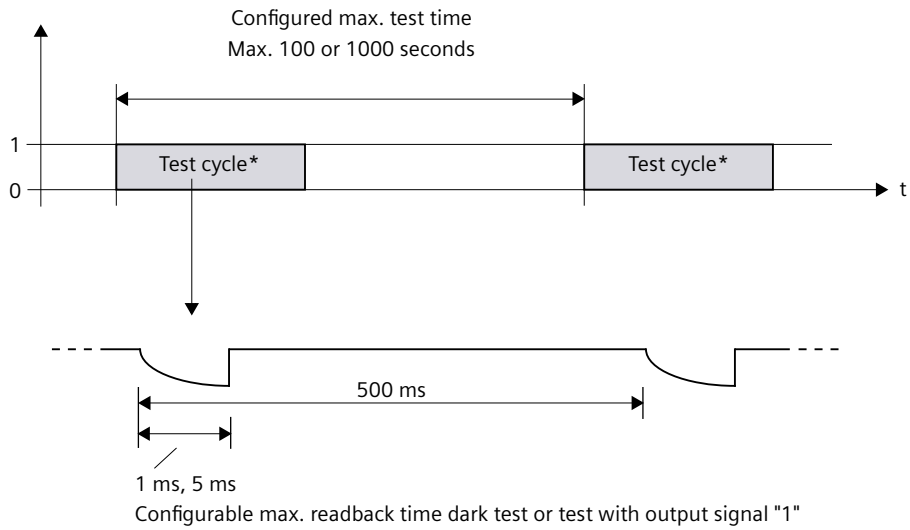

* Output of test pulses only during test cycle.

Figure 2-1504 Test pulses of the dark test

NOTE

If the dark test detects an error, the affected channel is switched off with the error message "Short circuit to L+", all the other channels with the error message "Safety-related shutoff".

4.2.2.5 Max. readback time light test

Function

Short-circuit is detected with a 0-signal at the output.

For a light test, a test signal is switched to the output channel while the output channel has the 0-signal. The output channel is switched on briefly during the light test (= "light period") and read back. A sufficiently slow actuator does not respond to this and remains switched off.

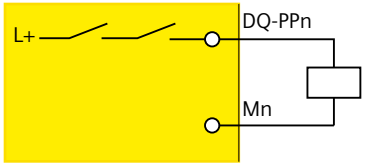

① Readback

Figure 2-1505 Functional principle of the light test

If the signal was not read back correctly once the maximum readback time light test has expired, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time light test for the light test increases the reaction time of the F-module.

Test pulses of the light test

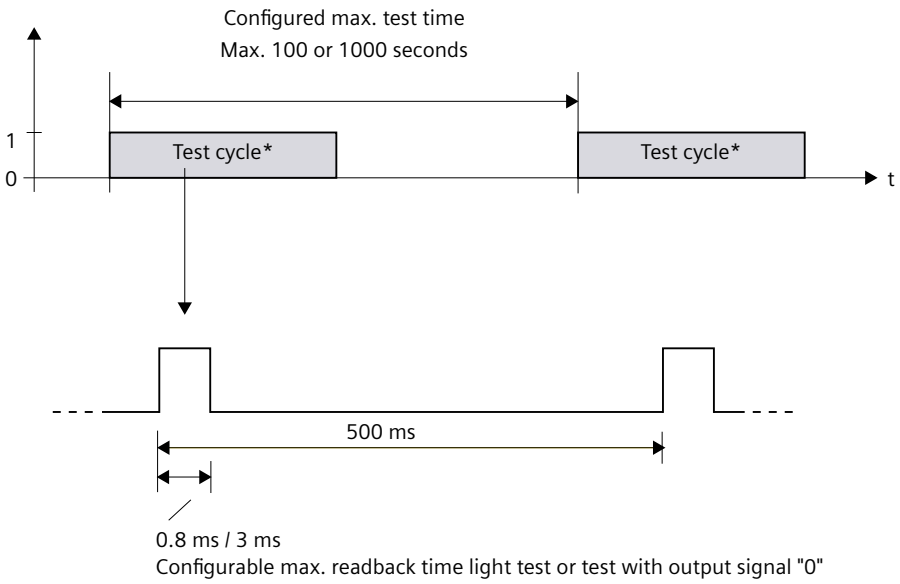

* Output of test pulses only during test cycle.

Figure 2-1506 Test pulses of the light test

A light pulse with the configured duration takes place within the configured maximum test period per output channel.

If a light pulse returns a fault, the same light pulse (which means the same bit pattern) is repeated once after 500 ms. If the fault is still present, the maximum test period is automatically reduced to 60 seconds and a diagnostics alarm is generated. If the fault is no longer present, the output channel is reintegrated after the next fault-free test cycle.

4.2.2.6 Activated light test

The light test is always enabled for this F-module.

4.2.2.7 Channel failure acknowledge

Use on S7-1200/1500 F-CPUs

This parameter is only relevant if the fail-safe module is operated on an S7-1500 F-CPU, and can only be set if the F-parameter "Behavior after channel fault" is set to "Passivate channel" and the F-parameter "Reintegration after channel fault" is set to "Adjustable".

The value of this parameter specifies how the channel should react to a channel fault:

- Manual: A channel failure is reintegrated after manual acknowledgment.
- Automatically: The channel is reintegrated automatically after a channel fault. Manual acknowledgment is not necessary.

Use in S7-300/400 F-CPUs

The value of this parameter is not relevant in the case of operation on S7-300/400 F-CPUs. There you set the corresponding property at the F-I/O DB by means of the ACK_NEC tag.

For detailed information about the F-I/O DB, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

4.3 Address space

Address assignment of the digital output module F-DQ 8x24VDC/0.5A PP HF

The digital output module F-DQ 8x24VDC/0.5A PP HF occupies the following address areas in the F-CPU:

Table 2-1919 Address assignment in the F-CPU

Occupied bytes in the F-CPU:		
F-CPU	**In input range**	**In output range**
S7-300/400 F-CPUs	IB x + 0 to x + 4	QB x + 0 to x + 4
S7-1200/1500 F-CPUs	IB x + 0 to x + 5	QB x + 0 to x + 5

x = Module start address

Address assignment of the user data and the value status of digital output module F-DQ 8x24VDC/0.5A PP HF

The user data occupy the following addresses in the F-CPU out of all the assigned addresses of the digital output module F-DQ 8x24VDC/0.5A PP HF:

Table 2-1920 Address assignment of user data **in the input range**

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
IB x + 0	Value status DQ_7	Value status DQ_6	Value status DQ_5	Value status DQ_4	Value status DQ_3	Value status DQ_2	Value status DQ_1	Value status DQ_0

x = Module start address

Table 2-1921 Address assignment of user data **in the output range**

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	6	5	4	3	2	1	0
QB x + 0	DQ_7	DQ_6	DQ_5	DQ_4	DQ_3	DQ_2	DQ_1	DQ_0

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

Additional information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

See also

S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875)

Applications of the F-I/O module

5

You achieve SIL3/Cat.4/PLe with the following applications.

You carry out the wiring on the appropriate BaseUnit. For more on this, see Connecting section in the system manual Distributed I/O System ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/58649293).

5.1 Installation of the ground line between the power supply and the BaseUnit

Interconnection	Achievable fail-safe performance characteristics	
	Single ground line	Redundant ground line
Connection of the load to the M_n terminal of the BaseUnit	SIL3/Cat.4/PLe	Not required
Connection of the load to the ground of the BaseUnit	SIL3/Cat.3/PLd	SIL3/Cat.4/PLe

In case of redundant installation of the ground line between the power supply and the BaseUnits, the ground connection to the BaseUnits must be installed as follows:

- When the fail-safe digital output module F-DQ 8x24VDC/0.5A PP HF is installed on a dark-colored BaseUnit, terminal M of this dark-colored BaseUnit must be additionally connected to the ground of the power supply.
- When the fail-safe digital output module F-DQ 8x24VDC/0.5A PP HF is installed on a light-colored BaseUnit, terminal M of the dark-colored BaseUnit installed to the right of the light-colored BaseUnit must be additionally connected to the ground of the power supply.

WARNING

When connecting the load to the ground of the power supply, you must run two ground lines between the power supply and the BaseUnits for safety reasons to achieve SIL3/Cat.4/PLe. Otherwise, the maximum residual current at signal "0" (specified in the technical specifications) cannot be maintained if a single ground line is interrupted.

See also

Connecting (Page 16)

5.2 Application: Wiring a load to each digital output

Each of the 8 fail-safe digital outputs consists of two P-switches, which form a PP-switch DQ-PP$_n$. You connect the load between the sourcing output DQ-PP$_n$ and ground. The ground may be the internal ground M$_n$ or an external ground. The two P-switches are always activated so that voltage is applied to the load. This circuit achieves SIL3/Cat.4/PLe.

To achieve SIL3/Cat.4/PLe see section Installation of the ground line between the power supply and the BaseUnit (Page 27).

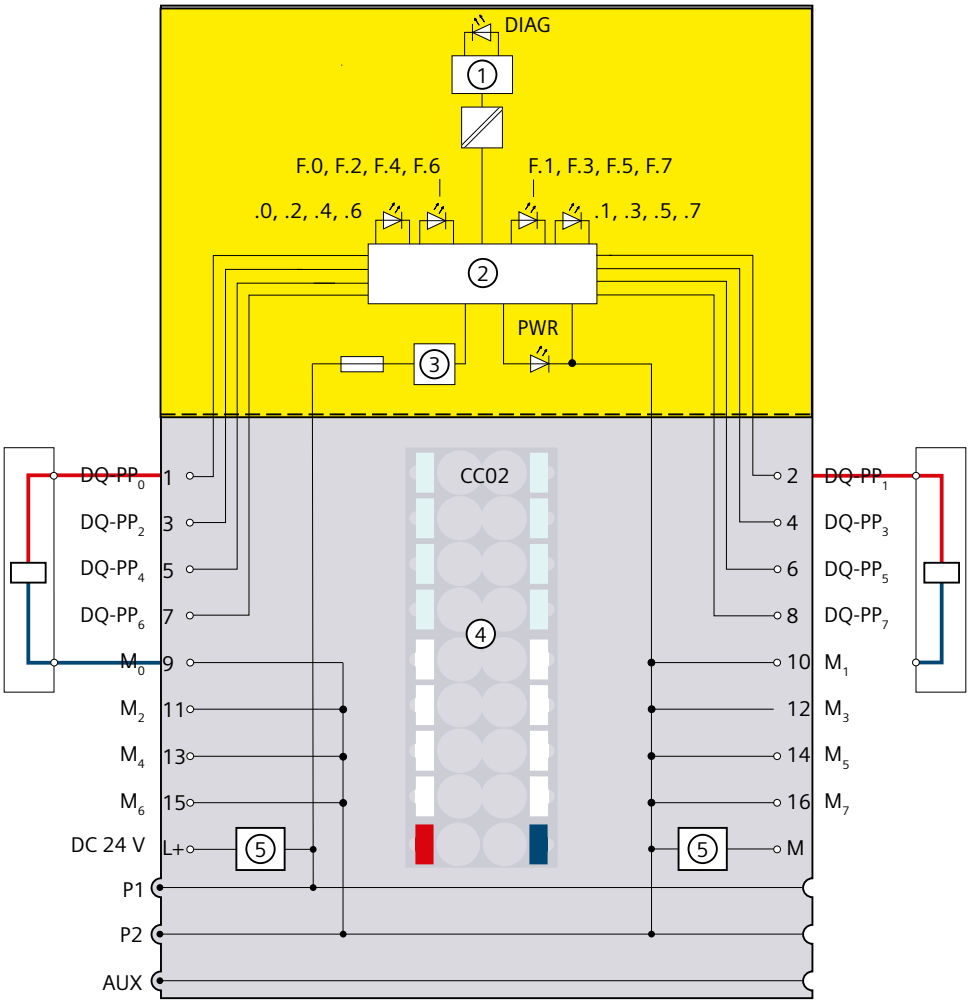

① Backplane bus interface

② Output electronics

③ Reverse polarity protection

④ Color-coded label with color code CC02 (optional)

⑤ Filter circuit supply voltage (available in light-colored BaseUnit only)

Figure 2-1507 Wiring diagram for one relay each to a F-DQ of the digital output module F-DQ 8x24VDC/0.5A PP HF

WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, a suitably-qualified actuator, e.g. in accordance with IEC 60947, is required.

WARNING

The actuator can no longer be shut down if a cross circuit has developed between positive potential (e.g. L+) and DQ-PP_n. To prevent cross-circuits between positive potential (e.g. L+) and DQ-PP_n, you must route the lines used to connect the actuators in a cross-circuit-proof manner (for example, as separate, sheathed cables or in separate cable ducts).

WARNING

If there is a cross-circuit to another output at a non-passivated, switched off output, a brief 1-signal can occur with a duration of 2x max. cycle time (T_{cycle}) + Max. readback time dark test (T_{rb}).

If there is a cross-circuit between two outputs, the test pulses of light tests of the respective other output are also visible. With a different setting of the "Max. readback time light test" parameter, this can cause cyclically occurring 1-signals that last as long as the longest configured "Max. readback time light test".

If the above mentioned 1-signals dangerously affect the plant when a cross-circuit occurs between outputs, you need to guard against the cross-circuits between the outputs with a cross-circuit-proof installation, for example, with separate sheathed cables or separate cable ducts.

5.3 Application: Wiring two loads in parallel to each digital output

The ground may be the internal ground M_n or an external ground. This circuit achieves SIL3/Cat.4/PLe.

To achieve SIL3/Cat.4/PLe see section Installation of the ground line between the power supply and the BaseUnit (Page 27).

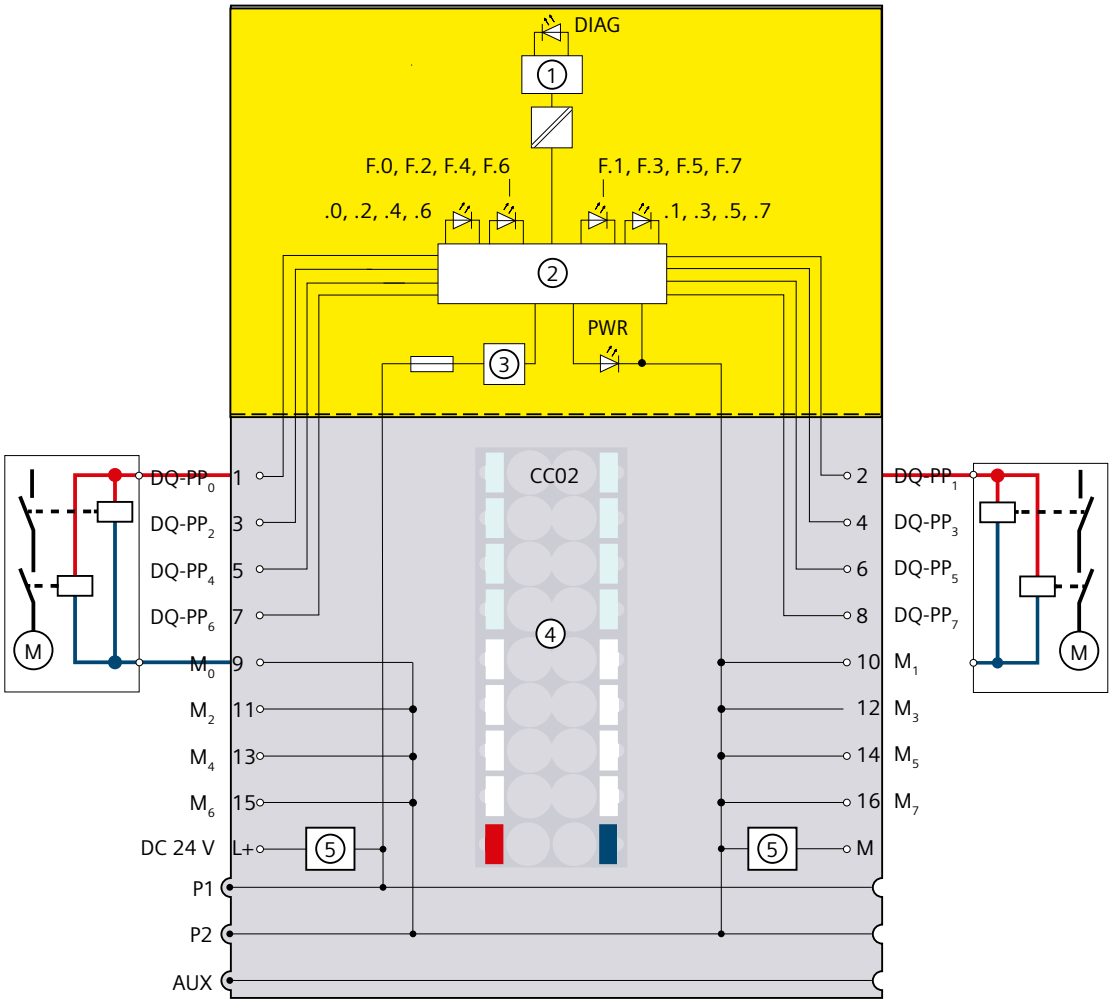

① Backplane bus interface

② Output electronics

③ Reverse polarity protection

④ Color-coded label with color code CC02 (optional)

⑤ Filter circuit supply voltage (available in light-colored BaseUnit only)

Figure 2-1508 Wiring diagram for two relays in parallel to a F-DQ of the digital output module F-DQ 8x24VDC/0.5A PP HF

WARNING

The actuator can no longer be shut down if a cross circuit has developed between positive potential (e.g. L+) and DQ-PP_n. To prevent cross-circuits between positive potential (e.g. L+) and DQ-PP_n, you must route the lines used to connect the actuators in a cross-circuit-proof manner (for example, as separate, sheathed cables or in separate cable ducts).

WARNING

If there is a cross-circuit to another output at a non-passivated, switched off output, a brief 1-signal can occur with a duration of 2x max. cycle time (T_{cycle}) + Max. readback time dark test (T_{rb}).

If there is a cross-circuit between two outputs, the test pulses of light tests of the respective other output are also visible. With a different setting of the "Max. readback time light test" parameter, this can cause cyclically occurring 1-signals that last as long as the longest configured "Max. readback time light test".

If the above mentioned 1-signals dangerously affect the plant when a cross-circuit occurs between outputs, you need to guard against the cross-circuits between the outputs with a cross-circuit-proof installation, for example, with separate sheathed cables or separate cable ducts.

5.4 Application: Two-channel actuator connection via 2 digital outputs

Electronic outputs

Safety-related electronic outputs are always implemented internally using two channels. As a result, each of these outputs can be used for applications up to SIL3 according to EN 62061 or Cat.4/PLe according to EN ISO 13849-1. The two outputs must have an identical configuration and be controlled simultaneously. Passivation must take place module-wide.

The ground may be the internal ground M_n or an external ground. This circuit achieves SIL3/Cat.4/PLe. To achieve SIL3/Cat.4/PLe, see section Installation of the ground line between the power supply and the BaseUnit (Page 27).

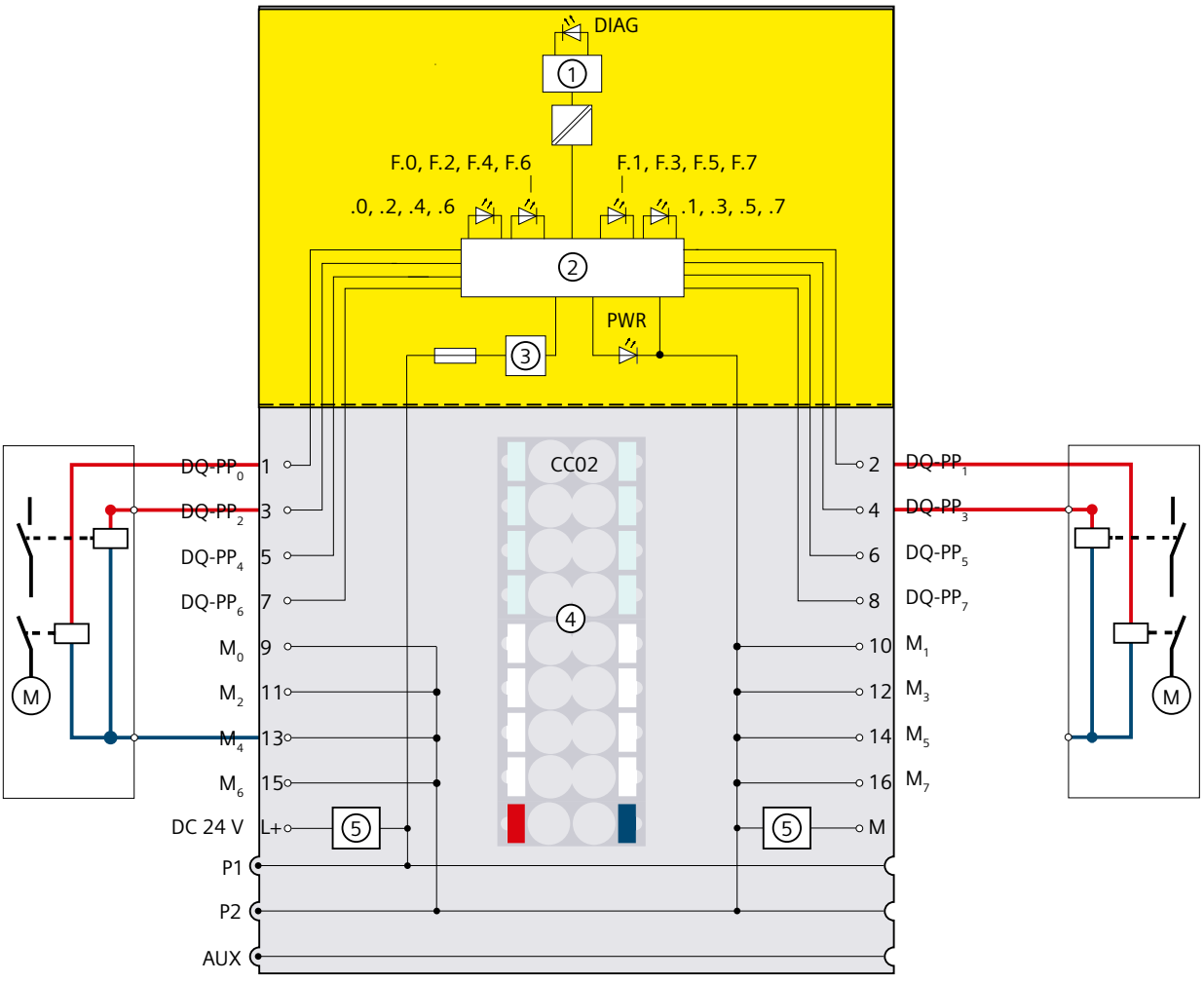

① Backplane bus interface

② Output electronics

③ Reverse polarity protection

④ Color-coded label with color code CC02 (optional)

⑤ Filter circuit supply voltage (available in light-colored BaseUnit only)

Figure 2-1509 Wiring diagram for two relays in parallel to two F-DQs of the digital output module F-DQ 8x24VDC/0.5A PP HF

WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, a suitably-qualified actuator, e.g. in accordance with IEC 60947, is required.

5.5 Application: Connection of a fail-safe digital input to each digital output

Each of the 8 fail-safe digital outputs can be connected to a fail-safe digital input of the type 1, 2 or 3 in accordance with IEC61131-2.

In this application, the input delay of the fail-safe digital input must be set so that the light test and the dark test of the fail-safe digital output do not impair the fail-safe digital input.

You can achieve SIL3/Cat.4/PLe with this circuit.

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified fail-safe digital input, e.g. ET 200SP F-DI 8x24VDC HF.

Input without ground return

To achieve SIL3/Cat.4/PLe see section Installation of the ground line between the power supply and the BaseUnit (Page 27).

If the fail-safe digital output module F-DQ 8x24VDC/0.5A PP HF and the fail-safe digital input module are supplied by different power supply units, the grounds of the two power supply units must be connected to each other.

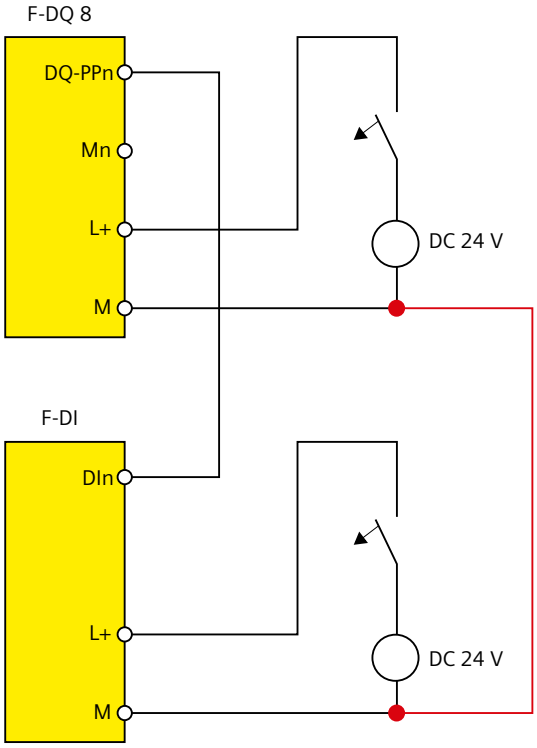

Figure 2-1510 Wiring diagram of an output of the digital output module F-DQ 8x24VDC/0.5A PP HF with an input of a fail-safe digital input module (without ground return).

WARNING

To avoid an impermissible process value at the fail-safe digital input, the wiring must be installed so that an interruption of the connection between the ground of the fail-safe digital output module and the ground of the fail-safe digital input module can be excluded (e.g. redundant lines).

WARNING

In case of a cross-circuit between a positive potential (e.g. L+) and DQ-PP_n, a 1-signal is permanently present at the fail-safe digital input. To prevent cross-circuits between positive potential (e.g. L+) and DQ-PP_n, you must route the lines used to connect the fail-safe digital inputs in a cross-circuit-proof manner, for example, as separate, sheathed cables or in separate cable ducts.

WARNING

If there is a cross-circuit to another output at a non-passivated, switched off output, a brief 1-signal can occur with a duration of 2x max. cycle time (T_{cycle}) + Max. readback time dark test (T_{rb}).

If there is a cross-circuit between two outputs, the test pulses of light tests of the respective other output are also visible. With a different setting of the "Max. readback time light test" parameter, this can cause cyclically occurring 1-signals that last as long as the longest configured "Max. readback time light test".

If the above mentioned 1-signals dangerously affect the plant when a cross-circuit occurs between outputs, you need to guard against the cross-circuits between the outputs with a cross-circuit-proof installation, for example, with separate sheathed cables or separate cable ducts.

Input with ground return

To achieve SIL3/Cat.4/PLe see section Installation of the ground line between the power supply and the BaseUnit (Page 27).

In this application for potential-free, fail-safe digital inputs, the connection DI_n- of the fail-safe digital input is returned to the internal ground M_n of the fail-safe digital output module.

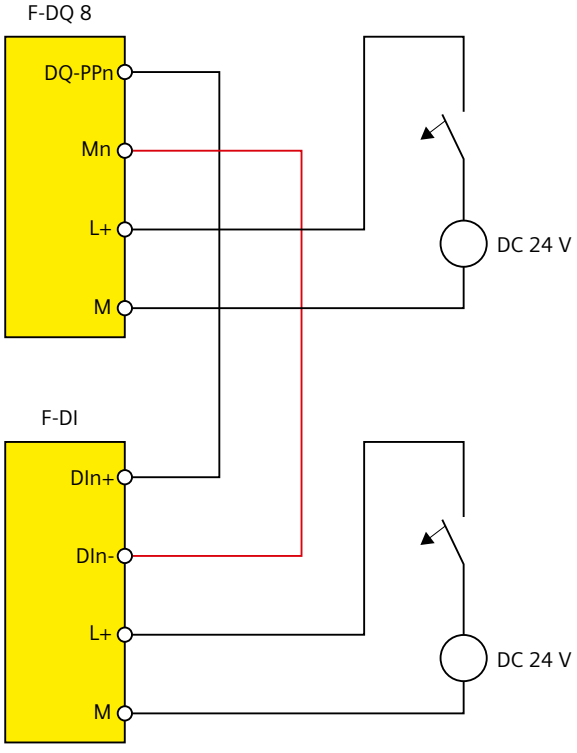

Figure 2-1511 Wiring diagram of an output of the digital output module F-DQ 8x24VDC/0.5A PP HF with an input of a fail-safe digital input module (with ground return).

WARNING

In case of a cross-circuit between a positive potential (e.g. L+) and DQ-PP_n, a 1-signal is permanently present at the fail-safe digital input. To prevent cross-circuits between positive potential (e.g. L+) and DQ-PP_n, you must route the lines used to connect the fail-safe digital inputs in a cross-circuit-proof manner, for example, as separate, sheathed cables or in separate cable ducts.

WARNING

If there is a cross-circuit to another output at a non-passivated, switched off output, a brief 1-signal can occur with a duration of 2x max. cycle time (T_{cycle}) + Max. readback time dark test (T_{rb}).

If there is a cross-circuit between two outputs, the test pulses of light tests of the respective other output are also visible. With a different setting of the "Max. readback time light test" parameter, this can cause cyclically occurring 1-signals that last as long as the longest configured "Max. readback time light test".

If the above mentioned 1-signals dangerously affect the plant when a cross-circuit occurs between outputs, you need to guard against the cross-circuits between the outputs with a cross-circuit-proof installation, for example, with separate sheathed cables or separate cable ducts.

5.6 Application: Connection of the ET 200SP digital output module F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)

You can use any of the 8 fail-safe digital outputs to actuate one or more digital output modules F-RQ 1x24VDC/24..230VAC/5A.

Pay attention to the permitted current for the corresponding output channel and the total current over all outputs at the corresponding ambient temperature.

To achieve SIL3/Cat.4/PLe see section Installation of the ground line between the power supply and the BaseUnit (Page 27).

For operation of the digital output module F-RQ 1x24VDC/24..230VAC/5A as of FS 04, use of the following readback times is required: Channel parameter Max. readback time light test/dark test with the default value "0.8 / 1.0 ms".

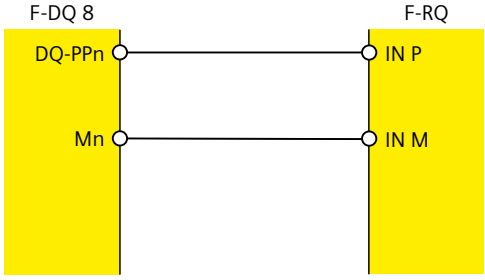

Figure 2-1512 Wiring diagram

NOTE

The output signals "OUT P, OUT M" of the digital output module F-RQ 1x24VDC/24..230VAC/5A are looped through from "IN P, IN M" and should therefore be considered like the output signals of the F-DQ 8x24VDC/0.5A PP HF "DQ-PP_n, M_n". For this reason, please observe the wiring rules for the F-DQ 8x24VDC/0.5A PP HF.

WARNING

The digital output module F-RQ 1x24VDC/24..230VAC/5A can no longer be shut down if a cross circuit has developed between positive potential (e.g. L+) and DQ-PP_n. To prevent cross-circuits between positive potential (e.g. L+) and DQ-PP_n, you must route the lines used to connect the digital output modules F-RQ 1x24VDC/24..230VAC/5A in a cross-circuit-proof manner, e.g. as separate, sheathed cables or in separate cable ducts.

WARNING

If there is a cross-circuit to another output at a non-passivated, switched off output, a brief 1-signal can occur with a duration of 2x max. cycle time (T_{cycle}) + Max. readback time dark test (T_{rb}).

If there is a cross-circuit between two outputs, the test pulses of light tests of the respective other output are also visible. With a different setting of the "Max. readback time light test" parameter, this can cause cyclically occurring 1-signals that last as long as the longest configured "Max. readback time light test".

If the above mentioned 1-signals dangerously affect the plant when a cross-circuit occurs between outputs, you need to guard against the cross-circuits between the outputs with a cross-circuit-proof installation, for example, with separate sheathed cables or separate cable ducts.

Interrupts/diagnostic messages

6

6.1 Status and error display

LED display

The following figure shows the LED display of the F-DQ 8x24VDC/0.5A PP HF.

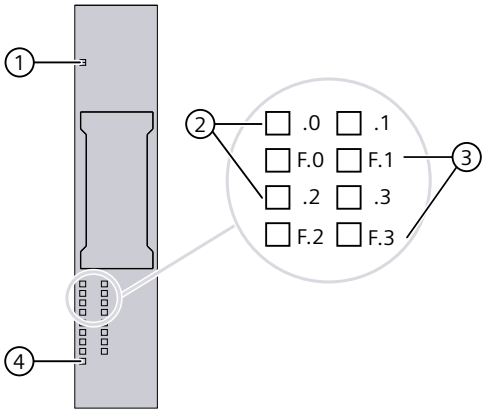

① DIAG (green/red)
② Channel status (green)
③ Channel fault (red)
④ PWR (green)

Figure 2-1513 LED display

Meaning of the LED displays

The following tables show the meaning of the status and error displays. You can find solutions for diagnostics alarms in section Diagnostics alarms (Page 43).

WARNING

The DIAG LED and the channel status and channel fault LEDs of the outputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

DIAG LED

Table 2-1922 Error display of the LED DIAG

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP not okay
Flashing	Module parameters not configured

DIAG	Meaning
On	Module parameters configured and no module diagnostics
Flashing	• Module parameters configured and module diagnostics • Operation in S7-1200/1500 F-CPUs: At least one channel is waiting for user acknowledgment.
Flashing	• Operation in S7-1200/1500 F-CPUs: The F-module expects user acknowledgment after a module error. • Operation in S7-300/400 F-CPUs: The F-module is waiting for user acknowledgment.

Channel status/channel fault LED

Table 2-1923 Status display of the LEDs channel status / channel error

Channel status	Channel fault	Meaning
Off	Off	Process signal = 0 and no channel diagnostics
On	Off	Process signal = 1 and no channel diagnostics
Off	On	Process signal = 0 and channel diagnostics
/ Alternately flashing		• Operation in S7-1200/1500 F-CPUs: At least one channel is waiting for user acknowledgment. • Operation in S7-300/400 F-CPUs: At least one channel is waiting for user acknowledgment.

Channel status/DIAG/channel fault LED

Table 2-1924 Status display of the LEDs channel status / DIAG / channel error

Channel status	DIAG	Channel fault	Meaning
Off	Flashing	All On	The PROFIsafe address does not match the configured PROFIsafe address or there is a module fault. See section Interrupts (Page 42).
Flashing	Flashing	Off	Identification of the F-module when assigning the PROFIsafe address

PWR LED

Table 2-1925 Status display of LED PWR

PWR	Meaning
Off	Supply voltage L+ missing
On	Supply voltage L+ available

6.2 Interrupts

Introduction

The fail-safe digital output module F-DQ 8x24VDC/0.5A PP HF supports diagnostic interrupts.

Diagnostic interrupts

The F-module generates a diagnostic interrupt for each diagnostics alarm described in section Diagnostics alarms (Page 43).

The list below provides an overview of the diagnostic interrupts of the F-module. The diagnostic interrupts are assigned either to one channel or the entire F-module.

WARNING

Before acknowledging the short circuit diagnostics message, correct the respective fault and validate your safety function. In this case, follow the steps described in section Diagnostics alarms (Page 43).

Module-wide diagnostic interrupts

- Overtemperature
- Error
- Parameter error
- Supply voltage missing
- Safety-related shutoff
- Channel/component temporarily unavailable
- Mismatch of safety destination address (F_Dest_Add)
- Safety destination address not valid (F_Dest_Add)
- Safety source address not valid (F_Source_Add)
- Safety watchdog time value is 0 ms (F_WD_Time)
- Parameter F_SIL exceeds SIL from specific device application
- Parameter F_CRC_Length does not match the generated values

- Version of F-parameter set incorrectly
- CRC1 fault
- Save iParameter watchdog time exceeded
- Restore iParameter watchdog time exceeded
- Inconsistent iParameters (iParCRC error)
- F_Block_ID not supported
- Transmission error: Inconsistent data (CRC error)
- Transmission error: Timeout (watchdog time 1 or 2 expired)
- Module is defective
- Watchdog tripped
- Invalid/inconsistent firmware present
- F-address memory not accessible
- Undertemperature
- Supply voltage too high
- Supply voltage too low

Channel-wide diagnostic interrupts

- Short-circuit to L+
- Short-circuit to ground
- Channel failure acknowledgment
- Frequency too high

6.3 Diagnostics alarms

Diagnostics alarms

A diagnostics alarm is generated for each diagnostics event and the F-module flashes the DIAG LED. You can read out the diagnostics alarm, for example, from the diagnostics buffer of the F-CPU. You can evaluate the error codes using the user program.

NOTE

You can connect several actuators per output.

If several actuators are connected to an output, the diagnostics of each actuator affects the other ones.

In other words, a single short-circuit affects multiple actuators.

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Table 2-1926 Diagnostics alarms, their meaning and possible remedies

Diagnostics alarm	Fault code	Meaning	Solution
Overtemperature	5_H	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range (see Technical specifications (Page 48)) Once the temperature has been reduced and returns to the specified range, the F-module must be removed and inserted or the power switched OFF and ON.
Parameter error	10_H	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Supply voltage missing	11_H	Missing or insufficient supply voltage L+	• Operate the F-module within the specified supply voltage range. • Check BaseUnit type
Safety-related shutoff	19_H	For safety purposes, channel was switched off due to an error on another channel. Possible causes: • A short-circuit exists. • The capacitive load is too high.	• Correct the process wiring. • Increase the test times (dark, light).
Channel/component temporarily unavailable	$1F_H$	The firmware version of the F-module is inconsistent.	Repeat the firmware update.
Mismatch of safety destination address (F_Dest_Add)	40_H	The firmware of the F-module has detected a different F-destination address.	• Check the parameter assignment of the PROFIsafe driver and the PROFIsafe address assigned to the F-module. • Assign the PROFIsafe address to the F-module (again).
Safety destination address not valid (F_Dest_Add)	41_H	The firmware of the F-module has detected an illegal different F-destination address.	Check the configuration/parameter assignment of the iPar server.
Safety source address not valid (F_Source_Add)	42_H	The firmware of the F-module has detected a different F-source address.	
Safety watchdog time value is 0 ms (F_WD_Time)	43_H	The firmware of the F-module has detected an invalid watchdog time.	
Parameter F_SIL exceeds SIL from specific device application	44_H	The firmware of the F-module has detected a discrepancy between the SIL setting of the communication and the application.	
Parameter F_CRC_Length does not match the generated values	45_H	The firmware of the F-module has detected a discrepancy in the CRC length.	
Version of F-parameter set incorrectly	46_H	The firmware of the F-module has detected an incorrect F_Par_Version or an invalid F_Block_ID.	

Diagnostics alarm	Fault code	Meaning	Solution
CRC1 fault	47_H	The firmware of the F-module has detected inconsistent F-parameters.	Check the configuration/parameter assignment of the iPar server.
Save iParameter watchdog time exceeded	49_H	iPar server does not respond to "save IPar" within 4.4 minutes.	
Restore iParameter watchdog time exceeded	$4A_H$	iPar server does not respond to "restore IPar" within 4.4 minutes.	Check the configuration/parameter assignment of the iPar server.
Inconsistent iParameters (iParCRC error)	$4B_H$	The firmware of the F-module has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	$4C_H$	The firmware of the F-module has detected an incorrect block ID.	Check the parameter assignment of the PROFIsafe driver.
Transmission error: Inconsistent data (CRC error)	$4D_H$	The firmware of the F-module has detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Impermissibly high electromagnetic interference is present. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference. • Power switched OFF and ON for station • Assign the configuration and parameter assignment to the F-module (of the station).
Transmission error: Timeout (watchdog time 1 or 2 expired)	$4E_H$	The firmware of the F-module has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Check the parameter assignment. • Ensure that communication is functioning correctly.
Module is defective	100_H	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner. • Wrong BaseUnit	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON • If the F-module cannot be put back into operation, consider replacing it. • Use a BaseUnit of the type A0.
Watchdog tripped	103_H	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON • If the F-module cannot be put back into operation, consider replacing it.

Diagnostics alarm	Fault code	Meaning	Solution
Short-circuit to L+	105_H	Short circuit to L+ can mean: • The output cable is short-circuited to L+. • The capacitive load between the channels is too high (for example, due to cable length or load current being too low). • There is a short circuit between two output channels. You must eliminate the error within 100 hours; otherwise, the F-module is permanently passivated and an acknowledgment is no longer possible.	• Correct the process wiring. • Increase the test times (dark, light). • Pay attention to the warnings in Applications of the F-I/O module (Page 27).
Short-circuit to ground	106_H	Short-circuit to ground can mean: • The output cable is short-circuited to ground. • The output signal is short-circuited to ground. • The capacitive load is too high. You must eliminate the error within 100 hours; otherwise, the F-module is permanently passivated and an acknowledgment is no longer possible.	• Correct the process wiring. • Increase the test times (dark, light). • Check the actuator.
Invalid/inconsistent firmware present	$11B_H$	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Channel failure acknowledgment	$30B_H$	A channel fault was detected. Confirmation is required to enable the channel.	Confirm the channel fault.
F-address memory not accessible	$30D_H$	The F-source address and F-destination address stored in the coding element cannot be accessed.	Verify that the coding element is present or replace the coding element.
Frequency too high	311_H	The maximum switching frequency of the F-module has been exceeded.	Reduce the switching frequency (see Technical specifications (Page 48))
Undertemperature	312_H	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range (see Technical specifications (Page 48)) Once the temperature has increased and returns to the specified range, the F-module must be removed and inserted or the power switched OFF and ON.
Supply voltage too high	321_H	The supply voltage is too high.	Check the supply voltage and then test the safety application.
Supply voltage too low	322_H	• The supply voltage is too low. • EMC, wrong BaseUnit	Check the supply voltage and then test the safety application.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the module is passivated.

A supply voltage that is too low is detected for voltages less than 17 V. A supply voltage that is too high is detected for voltages greater than 32 V.

When the voltage is then recovered (level must remain within the specified value range for at least 1 minute (see Technical specifications (Page 48): Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Generally applicable information on diagnostics

Information on diagnostics that pertains to all fail-safe modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

6.4 Value status

Properties

In addition to the diagnostics alarm and the status and error display, the F-module provides information about the validity of each input and output signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is additional binary information of a digital input or output signal. It is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the input or output signal.

The value status is affected by a short-circuit and the plausibility check.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

Assignment of the inputs and value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in section Address space (Page 25).

Reference

A detailed description of the evaluation and processing of the respective input signals can be found in the SIMATIC Safety – Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126) manual.

Technical specifications 7

Technical specifications of F-DQ 8x24VDC/0.5A PP HF

The table below shows the technical specifications as of 12/2022. A data sheet with technical specifications updated on a daily basis can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7136-6DC00-0CA0/td?dl=en).

Article number	6ES7136-6DC00-0CA0
General information	
Product type designation	F-DQ 8x24 V DC/0.5 A PP HF
Firmware version	
• FW update possible	Yes
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC02
Product function	
• I&M data	Yes; I&M0 to I&M3
Engineering with	
• STEP 7 TIA Portal configurable/integrated from version	V14 SP1 with HSP 202
• STEP 7 configurable/integrated from version	V5.5 SP4 HF5
• PROFINET from GSD version/GSD revision	V2.31
Supply voltage	
Rated value (DC)	24 V
permissible range, lower limit (DC)	19.2 V
permissible range, upper limit (DC)	28.8 V
Reverse polarity protection	Yes
power supply according to NEC Class 2 required	No
Input current	
Current consumption (rated value)	75 mA; without load
Current consumption, max.	21 mA; From the backplane bus
output voltage / header	
Rated value (DC)	24 V
Power	
Power available from the backplane bus	70 mW
Power loss	
Power loss, typ.	3 W

Article number	6ES7136-6DC00-0CA0
Address area	
Address space per module	
• Inputs	6 byte; 5 bytes non-RIOforFA; 6 bytes RIOforFA
• Outputs	6 byte; 5 bytes non-RIOforFA; 6 bytes RIOforFA
Hardware configuration	
Automatic encoding	Yes
• Electronic coding element type F	Yes
Digital outputs	
Type of digital output	Transistor
Number of digital outputs	8
Digital outputs, parameterizable	Yes
Short-circuit protection	Yes
• Response threshold, typ.	Min. 0.7 A
Open-circuit detection	No
Limitation of inductive shutdown voltage to	Typ. -39 V
Controlling a digital input	Yes
Switching capacity of the outputs	
• with resistive load, max.	0.5 A
• on lamp load, max.	2 W
Load resistance range	
• lower limit	48 Ω
• upper limit	12 000 Ω
Output voltage	
• for signal "1", min.	24 V; L+ (-0.5 V)
Output current	
• for signal "1" rated value	0.5 A
• for signal "0" residual current, max.	0.5 mA
Switching frequency	
• with resistive load, max.	30 Hz; Symmetrical
• with inductive load, max.	0.1 Hz; according to IEC 60947-5-1, DC-13, symmetrical
• with capacitive load, max.	2 Hz; Symmetrical
• on lamp load, max.	10 Hz; Symmetrical
Total current of the outputs	
• Current per channel, max.	0.5 A; note derating data in the manual
• Current per module, max.	3 A; note derating data in the manual
Total current of the outputs (per module)	
horizontal installation	
– up to 40 °C, max.	3 A
– up to 50 °C, max.	2.5 A

Article number	6ES7136-6DC00-0CA0
– up to 60 °C, max.	2 A
vertical installation	
– up to 50 °C, max.	2 A
Cable length	
• shielded, max.	100 m
• unshielded, max.	100 m
Interrupts/diagnostics/status information	
Diagnostics function	Yes
Substitute values connectable	No
Alarms	
• Diagnostic alarm	Yes
Diagnostics indication LED	
• RUN LED	Yes; green LED
• ERROR LED	Yes; red LED
• Monitoring of the supply voltage (PWR-LED)	Yes; green PWR LED
• Channel status display	Yes; green LED
• for channel diagnostics	Yes; red LED
• for module diagnostics	Yes; green/red DIAG LED
Potential separation	
Potential separation channels	
• between the channels	No
• between the channels and backplane bus	Yes
• between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Standards, approvals, certificates	
Suitable for safety functions	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	PLe
• Category according to ISO 13849-1	Cat. 4
• SIL acc. to IEC 61508	SIL 3
Probability of failure (for service life of 20 years and repair time of 100 hours)	
– Low demand mode: PFDavg in accordance with SIL3	< 6.00E-05
– High demand/continuous mode: PFH in accordance with SIL3	< 2.00E-09 1/h

Article number	6ES7136-6DC00-0CA0
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	0 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	0 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	4 000 m; with derating
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	48 g

Dimension drawing

See ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) manual

Response times

A

Introduction

You can find the reaction times of the F-DQ 8x24 V DC/0.5 A PP HF digital output module below. The reaction times of the F-DQ 8x24 V DC/0.5 A PP HF digital output module are included in the calculation of the F-system reaction time.

Use the SIMATIC STEP7 Reaction Time Table (https://support.industry.siemens.com/cs/ww/en/view/93839056) for this.

Definition of reaction time for fail-safe digital outputs

The reaction time represents the interval between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Times required for the calculation

- Max. cycle time: T_{cycle} = 8 ms
- Max. acknowledgment time (Device Acknowledgment Time): T_{DAT} = 16 ms

The maximum reaction time in the case of fault (One Fault Delay Time, OFDT) is equivalent to the maximum reaction time with no faults (Worst Case Delay Time, WCDT).

You assign the parameters for maximum readback time dark test (T_{rb}) and maximum readback time light test (T_{rb_lt}) in STEP 7 or the TIA Portal.

Operating mode: Disable dark test for 48 hours – disabled

Maximum reaction time with no faults (Worst Case Delay Time, WCDT)

$t <= 4 * T_{cycle}$

Maximum reaction time with detection of a channel fault by readback

$t <= 6 * T_{cycle} + T_{rb}$

Maximum reaction time with detection of a channel fault by bit pattern test

$t <= 2 * T_{cycle}$ + maximum test period

Operating mode: Disable dark test for 48 hours – enabled

Maximum reaction time with no faults (Worst Case Delay Time, WCDT)

$t <= 5 * T_{cycle} + T_{rb} + T_{rb_lt}$

Maximum reaction time with detection of a channel fault

A channel fault may not be detected until a 0-1 process value change takes place on the corresponding channel. Please note the restrictions detailed in section Disable dark test for 48 hours (Page 21)

Switching of loads

B

B.1 Connecting capacitive loads

If an F-DQ 8x24VDC/0.5A PP HF digital output module is interconnected with loads that have an excessive capacitance, this can lead to detection of a short-circuit. Reason: The capacitance cannot be sufficiently discharged or charged during the configured readback time of the bit pattern test.

The typical trend shown in the diagram below represents the correlation between load current and maximum switchable load capacitance at a supply voltage of 24 V DC.

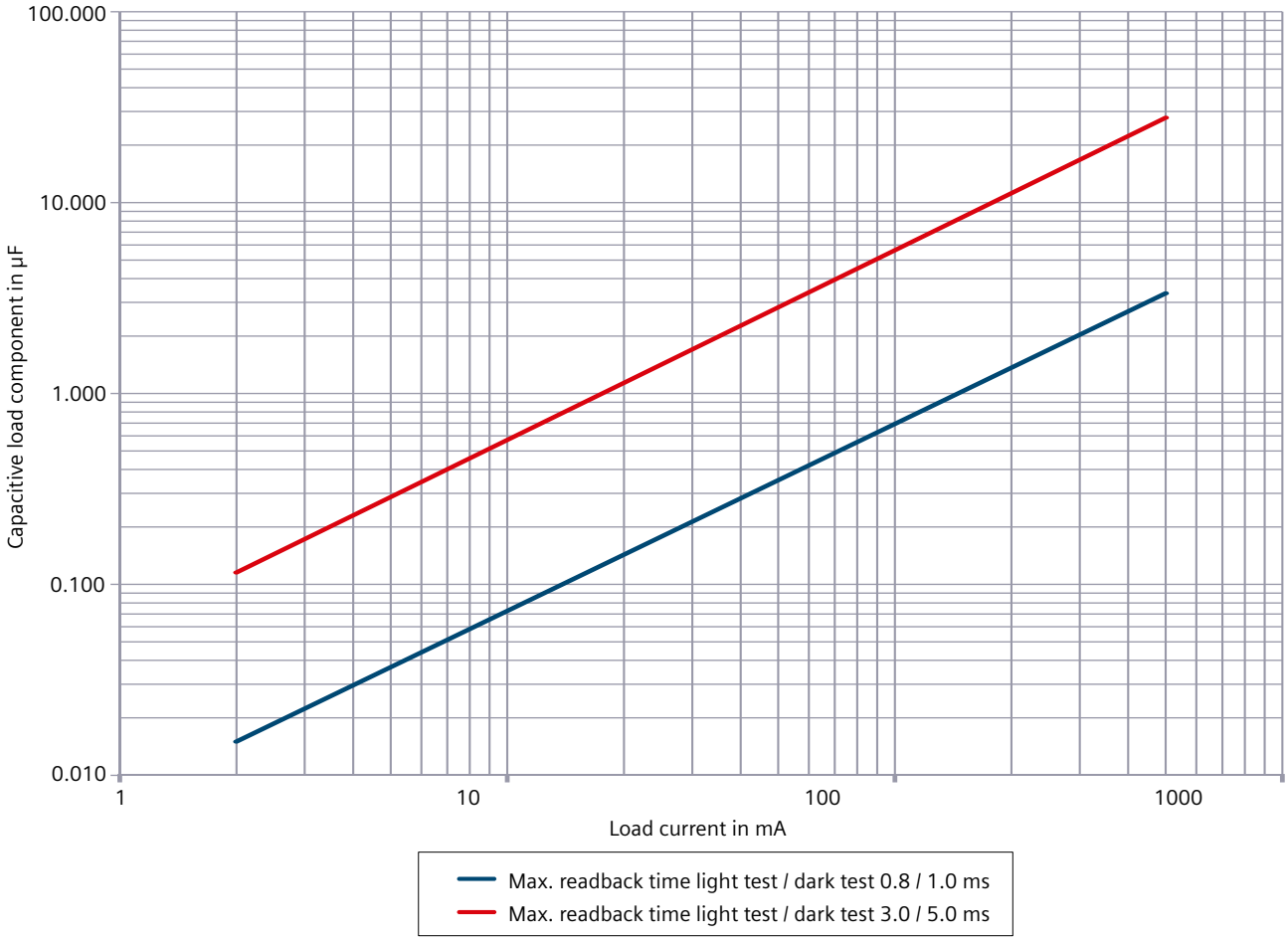

Figure 2-1514 Switching of capacitive loads for the F-DQ 8x24VDC/0.5A PP HF digital output module depending on the configured max. readback time light test / dark test.

Remedy for detecting a short circuit

1. Determine the load current and capacitance of the load.
2. Locate the operating point in the diagram above.
3. If the operating point is above the trend, select an actuator with higher current consumption so that the new operating point is below the curve.

Example

You have configured a maximum readback time light test/dark test of "0.8 / 1.0 ms". You have set the load current to 20 mA and the capacity to 0.2 µF. The operating point is thus outside the range defined by the trend (gray background).

Solution: Select an actuator with higher current consumption. In this example, 40 mA. Alternatively, you can configure the parameter "Max. readback time light test / dark test" with "3.0 / 5.0 ms".

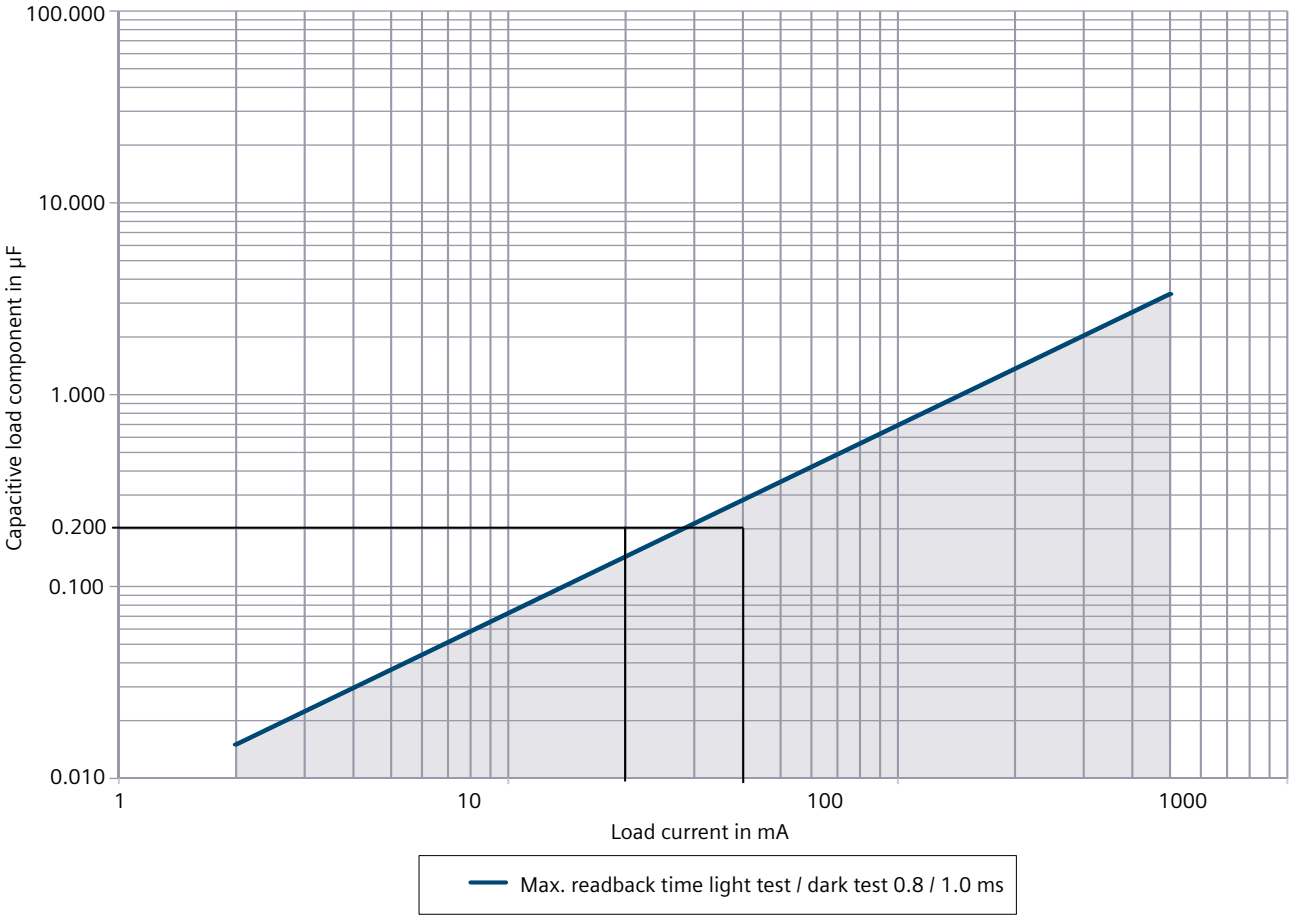

B.2 Switching of inductive loads

Switching of inductive loads

The diagram below shows the maximum permitted inductive loads as a function of the load current and switching frequency.

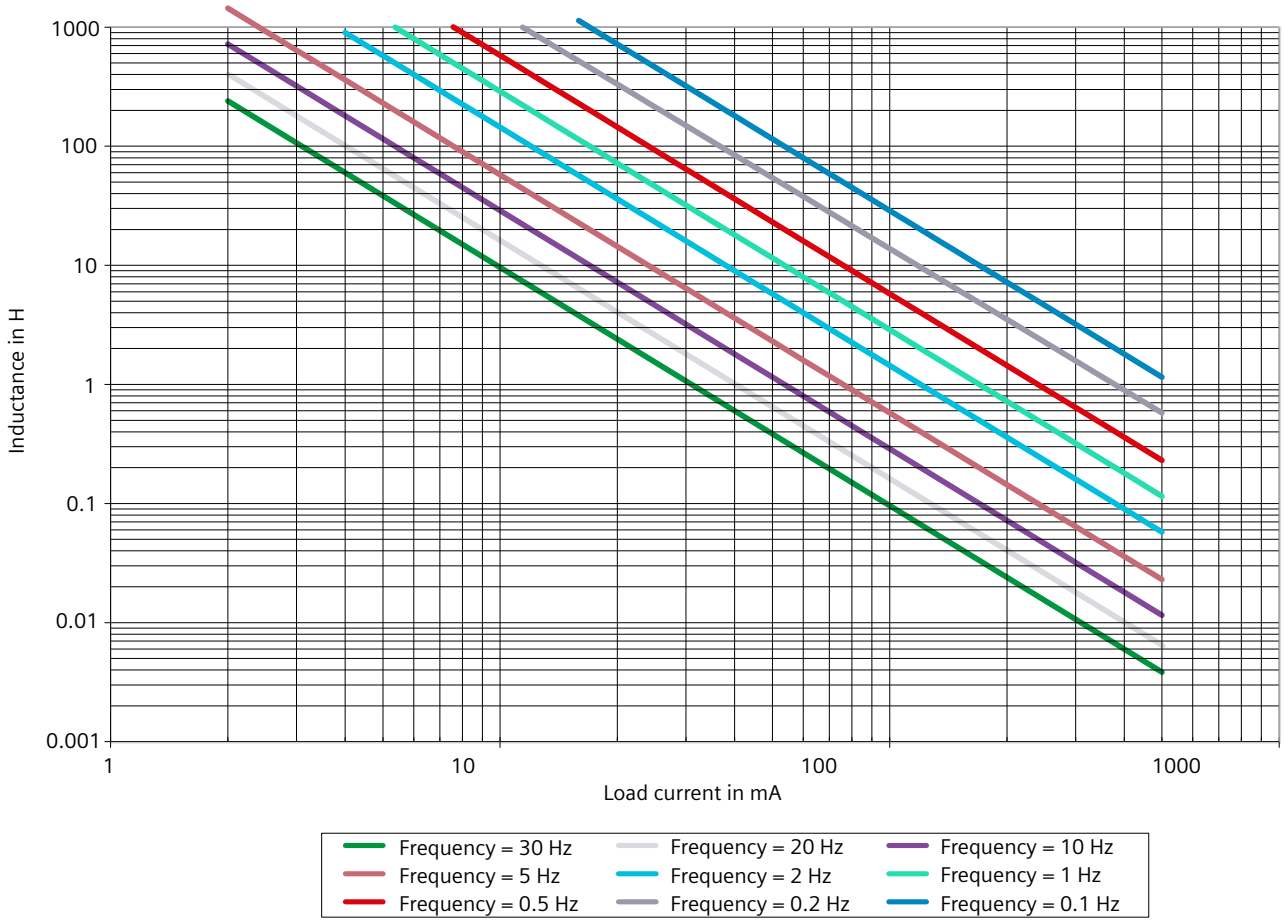

Figure 2-1515 Switching of inductive loads for the F-DQ 8x24VDC/0.5A PP HF digital output module depending on the load current and switching frequency

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SIMATIC

ET 200SP
Digital output module F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)

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03/2014
A5E33267029-AA

Preface

Purpose of this documentation

This manual complements the system manual ET 200SP distributed I/O system. General functions of the ET 200SP are described in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

The information in this manual and the system manual supports you when commissioning the ET 200SP system.

Conventions

Pay particular attention to notes highlighted as follows::

NOTE

A note contains important information on the product described in the documentation, on handling the product or on the part of the documentation to which you should pay special attention.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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1.1 Guide to the documentation for the digital output module F-RQ 1x24VDC/24..230VAC/5A

Introduction

The documentation of the SIMATIC products has a modular structure and includes topics relating to your automation system.

The complete documentation of the ET 200SP system consists of different modules made up of system manuals, function manuals and device manuals.

The STEP 7 (online help) information system supports you when configuring and programming your automation system.

Overview of the documentation for the fail-safe digital output module F-RQ 1x24VDC/24..230VAC/5A

The table below lists additional documents that complement this description of the fail-safe digital output module F-RQ 1x24VDC/24..230VAC/5A and that are available on the Internet.

Table 2-1927 Documentation for the fail-safe digital output module F-RQ 1x24VDC/24..230VAC/5A

Topic	Documentation	Most important contents
Description of the system	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting up • Commissioning • Approvals • TÜV certificates
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)	Technical specifications
Description of the SIMATIC Safety F-system	Programming and operating manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)	• Configuring • Programming • Approvals

SIMATIC manuals

The latest manuals for SIMATIC products are available on the Internet (http://www.siemens.com/automation/service&support) for free download.

Functional Safety Services

Siemens Functional Safety Services support you with a comprehensive package of services from risk assessment and verification right through to plant commissioning and modernization. We also offer consultation on the use of fail-safe and fault-tolerant SIMATIC S7 automation systems.

You will find more detailed information on the Internet (http://www.siemens.com/automation/service&support).

Please e-mail any queries you may have e-mail (mailto:safety-services.industry@siemens.com).

Product overview

2

2.1 Properties of the F-RQ 1x24VDC/24..230VAC/5A

Article number

6ES7136-6RA00-0BF0

View of the module

Figure 2-1516 View of the F-RQ 1x24VDC/24..230VAC/5A module

Properties

- Technical properties
  - Digital module with 1 relay output (2 isolated NO contacts)
  - Safety class SIL3/category 4/PLe can be achieved if the F-RQ module is controlled by a fail-safe output (for example F-module F-DQ 4x24VDC/2A PM HF)
  - Control voltage 24 VDC
  - Total current for both NO contacts 5 A max.
  - Isolated from control voltage
  - Suitable for solenoid valves, DC contactors and signal lamps

- Supported system functions
  - I&M identification data
  - Firmware update

WARNING

The fail-safe performance characteristics in the technical specifications apply for a service life of 20 years and a repair time of 100 hours. If a repair within 100 hours is not possible, remove the module in question from the BaseUnit or switch off its supply voltage before 100 hours are up.

Accessories

The following components can be used with the module:

- Labeling strips
- Color identification labels
- Reference identification labels

Connecting up

3

3.1 Terminal assignment

General terminal assignment

Table 2-1928 Terminal assignment for F-RQ 1x24VDC/24..230VAC/5A

Terminal assignment for F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)						
Terminal	**Assign-ment**	**Terminal**	**Assign-ment**	**Description**	**BaseUnit**	**Color identification label (terminals 1 to 16)**
1	RQ_{01}+ [13]	**2**	RQ_{01}- [14]	• RQ_n+, RQ_n-: Channel n • IN: Control input • OUT: Control input for loop-through	BU20-P8+A4-+0B	 CC42 6ES7193-6CP42-2MB0
3	RQ_{02}+ [23]	**4**	RQ_{02}- [24]			
5	—	**6**	—			
7	—	**8**	—			
9	IN P	**10**	OUT P			
11	IN M	**12**	OUT M			
13	AUX	**14**	AUX			
15	AUX	**16**	AUX			

3.2 Block diagram

Block diagram

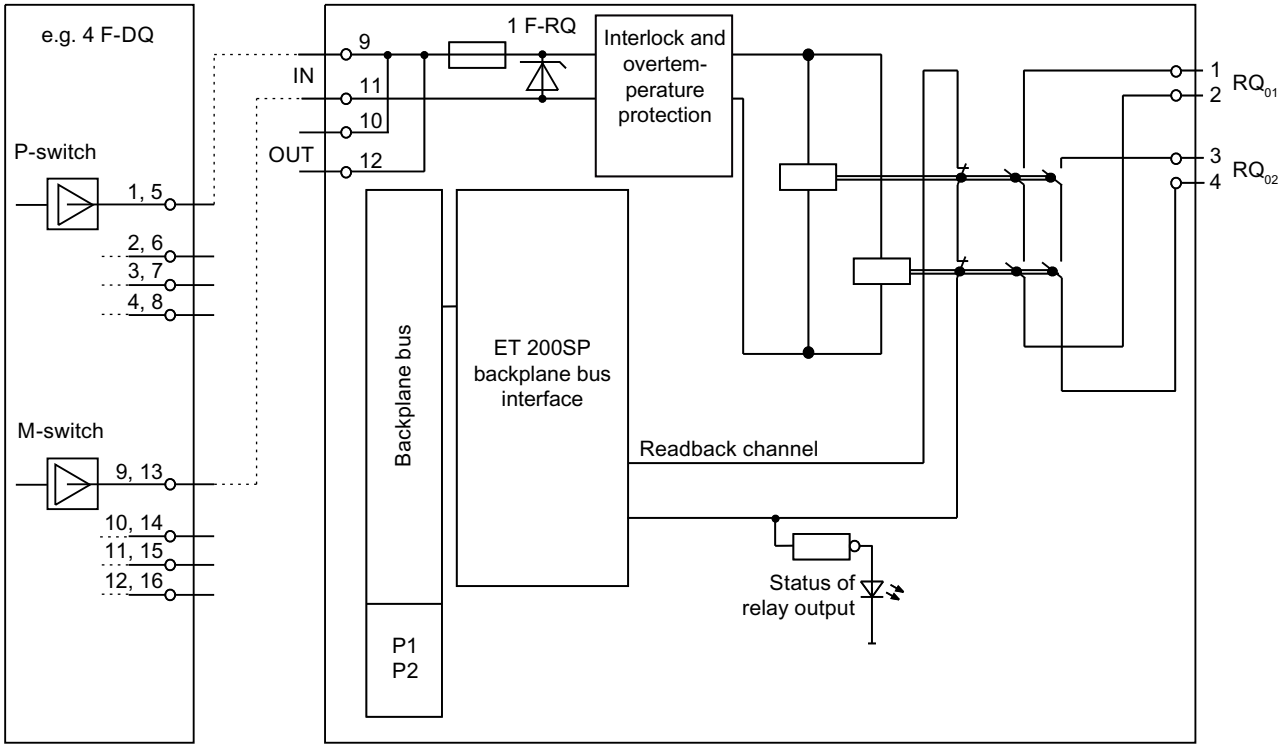

Figure 2-1517 Block diagram F-RQ 1x24VDC/24..230VAC/5A

Addressing

4

4.1 Address space

Address assignment of the digital output module F-RQ 1x24VDC/24..230VAC/5A

The digital output module F-RQ 1x24VDC/24..230VAC/5A occupies the following address ranges in the F-CPU:

Table 2-1929 Address assignment in the F-CPU

Occupied bytes in the F-CPU:	
in input range	**in output range**
x.0 and x.1	—

x = Module start address

Address assignment of the user data of the digital output module F-RQ 1x24VDC/24..230VAC/5A

Of the occupied addresses of the digital output module F-RQ 1x24VDC/24..230VAC/5A, the user data occupies the following addresses in the F-CPU:

Table 2-1930 User data address assignment in the input range

Byte in the F-CPU	**Assigned bits in F-CPU per F-RQ module:**							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
x + 0	—	—	—	—	—	—	RQ_1 Inverted readback channel (corresponds to process signal at IN)	RQ_0 Readback channel

x = Module start address

The user data is in the standard process image of the inputs and is not transferred to the F-CPU in safety-related communication. The readback channel in the user program is therefore displayed as a non-failsafe variable.

NOTE

With migration projects from the ET 200S product family, note the following:

The readback channel RQ_0 (bit 0) allows direct interconnection with the FDBACK instruction (F-block F_FDBACK) to its FEEDBACK input without additional inversion.

The readback channel RQ_1 (bit 1) is inverted.

Additional information

For detailed information about F-I/O access, refer to the SIMATIC Safety, Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Applications of the F-I/O module

5

5.1 Applications of the F-RQ 1x24VDC/24..230VAC/5A

You can achieve SIL3/category 4/PLe in the following applications if the activating F-module supports SIL3/category 4/PLe.

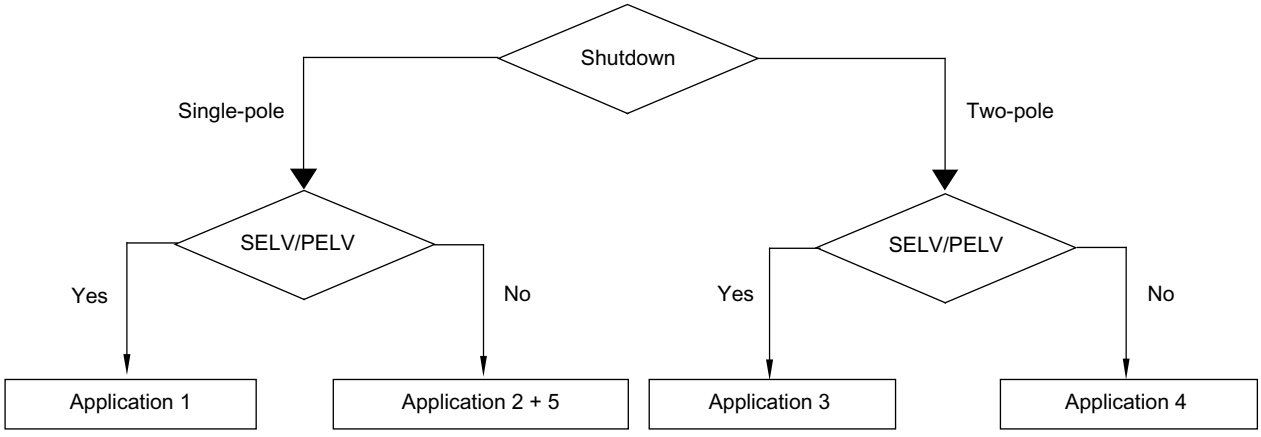

The wiring is carried out on the suitable BaseUnit (http://support.automation.siemens.com/WW/view/en/58532597/133300).

Wiring the 24 VDC power supply

Apply the 24 VDC control voltage to IN P (terminal 9) and IN M (terminal 11). The 24 VDC supply line is usually connected via a sourcing/sinking fail-safe output (e.g. digital output module F-DQ 4x24VDC/2A PM HF). Wire the P output (sourcing) of the F-DQ to the IN P of the F-RQ module and the M output (sinking)to the IN M of the F-RQ module.

As an alternative, you can also connect to a sourcing-sourcing fail-safe output. However, note that external short-circuits to P at the P input cannot be controlled. In this case, IN M would be connected directly to the control voltage ground.

NOTICE
Connecting the control voltage to the IN P and IN M inputs with the reverse polarity will destroy the F-module.

Wiring the load voltage and the load

The connectors of the relay output are electrically isolated NO contacts. This means that power must be supplied to these contacts from an external source. Connect the load supply (supply 1) and the load (load 1) in series to the RQ_{01} connectors (terminals 1;2). This ensures that the NO contacts of the relay interrupt the current flow of the power supply through the load. Due to the two relay contacts connected in series, the current flow can still be interrupted if one of the two relays has a fault..

The second circuit is independent of the first. They are logically interconnected by the common control. This means that the potential in the RQ_{02} (terminals 3;4), supply 2 and load 2 circuit may be different.

WARNING

If you connect a non-SELV/PELV power supply to one channel, you must not use the other channel.

Parameter assignment of the digital output module F-DQ 4x24VDC/2A PM HF

Assign the following parameters for the channel of the F-DQ 4x24VDC/2A PM HF digital output module to be activated:

Table 2-1931 Parameter assignment

Parameter	
Max. readback time dark test	1 ms
Max. readback time switch on test	1 ms

As the relays are highly inductive, you have the option of activating "Diagnostics: wire break" *or* "enable light test".

5.2 Application 1: 2 loads, single-pole switch-off

Wiring diagram

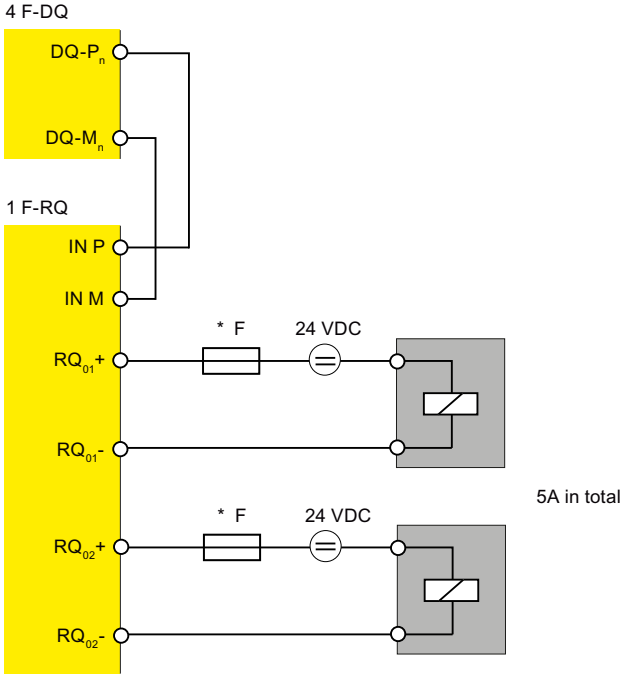

Figure 2-1518 Wiring diagram of the F-RQ 1x24VDC/24..230VAC/5A to an F-DQ module

In this application, you can use one F-RQ module for single-pole switching of two loads with a total of 5A and one/two SELV/PELV power supplies.

WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.

Note that for applications in accordance with EN 50156-1 the specified rated current of the overcurrent protective device must be multiplied by a safety factor of 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).

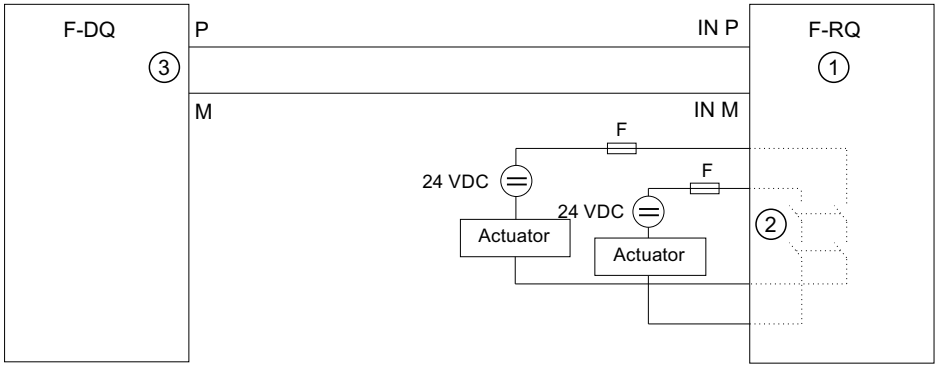

① F-RQ with integrated FEEDBACK input

② Relay contacts for switching the load

③ Output Q

Figure 2-1519 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

NOTE

SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.

SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.

If a fault is detected during this function test, replace the F-RQ module.

5.3 Application 2: 1 load, single-pole switch-off

Wiring diagram

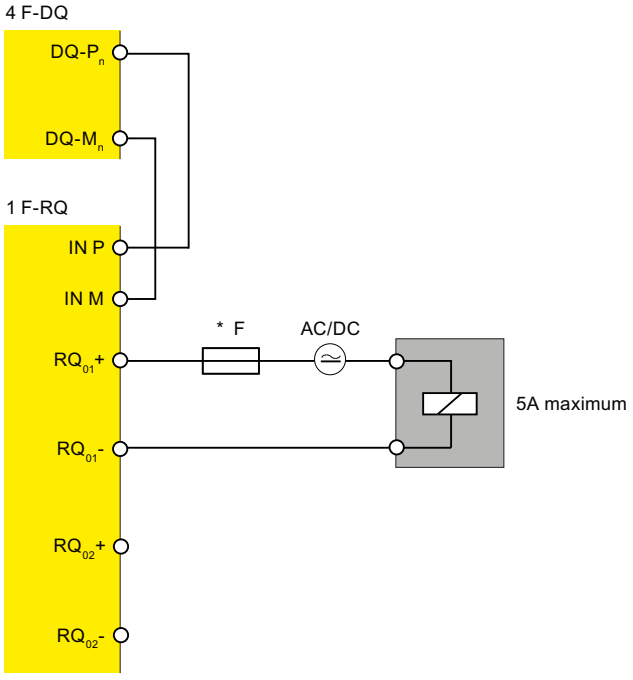

Figure 2-1520 Wiring diagram of the F-RQ 1x24VDC/24..230VAC/5A to an F-DQ module

This application allows single-pole switching of one load with a total of 5A with one F-RQ module.

WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.

Please note that for applications in accordance with EN 50156-1, the specified rated current of the overcurrent protective device must be multiplied by the safety factor 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).

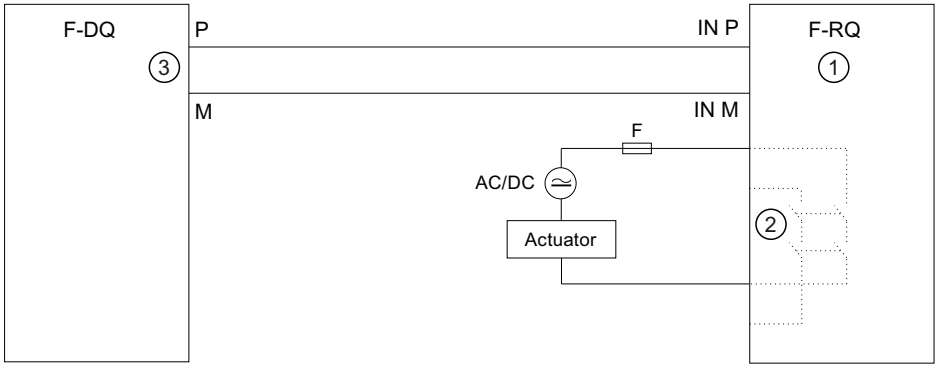

① F-RQ with integrated FEEDBACK input

② Relay contacts for switching the load

③ Output Q

Figure 2-1521 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

NOTE

SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.

SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.

If a fault is detected during this function test, replace the F-RQ module.

5.4 Application 3: 1 load, two-pole switch-off with 1 F-RQ module

Wiring diagram

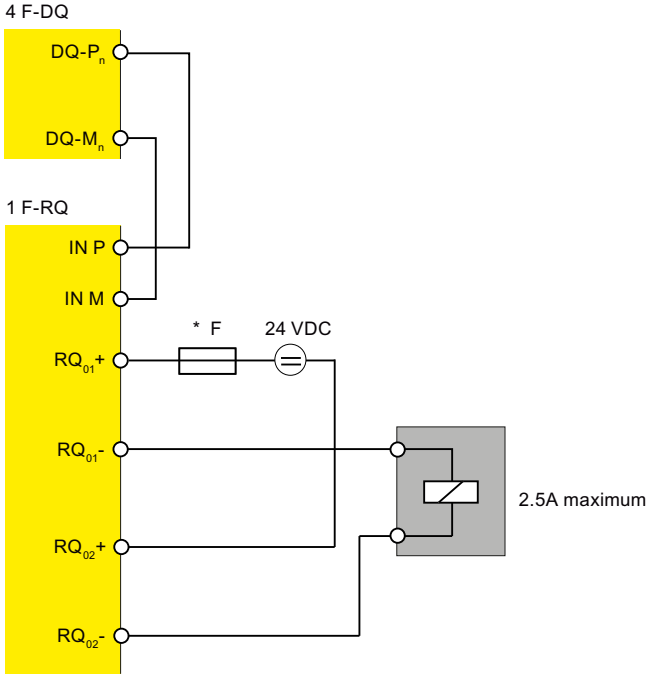

Figure 2-1522 Wiring diagram for two F-RQ 1x24VDC/24..230VAC/5A to one F-DQ module

This application allows two-pole switching with one F-RQ module of one load with a maximum of 2.5A and an SELV/PELV power supply.

⚠ WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.

Note that for applications in accordance with EN 50156-1 the specified rated current of the overcurrent protective device must be multiplied by a safety factor of 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).

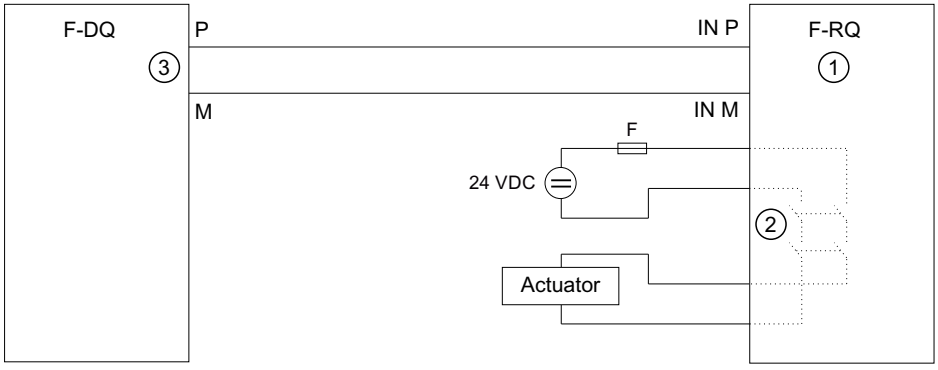

① F-RQ with integrated FEEDBACK input

② Relay contacts for switching the load

③ Output Q

Figure 2-1523 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

NOTE

SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.

SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.

If a fault is detected during this function test, replace the F-RQ module.

5.5 Application 4: 1 load, two-pole switch-off with 2 F-RQ modules

Wiring diagram

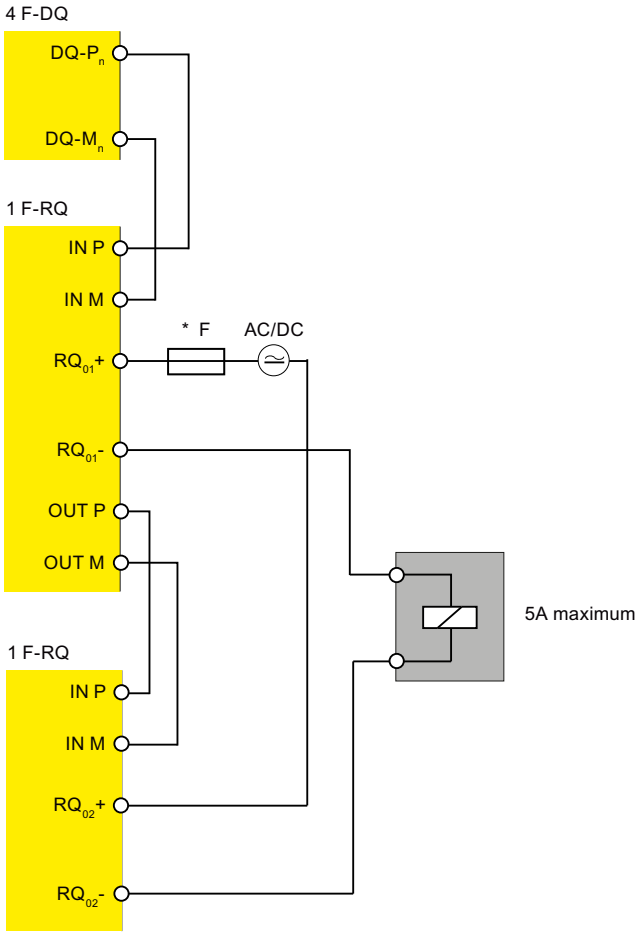

Figure 2-1524 Wiring diagram for two F-RQ 1x24VDC/24..230VAC/5A to one F-DQ module

This application allows two-pole switching of one load with a max. of 5A with two F-RQ modules.

WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.

Note that for applications in accordance with EN 50156-1 the specified rated current of the overcurrent protective device must be multiplied by a safety factor of 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).

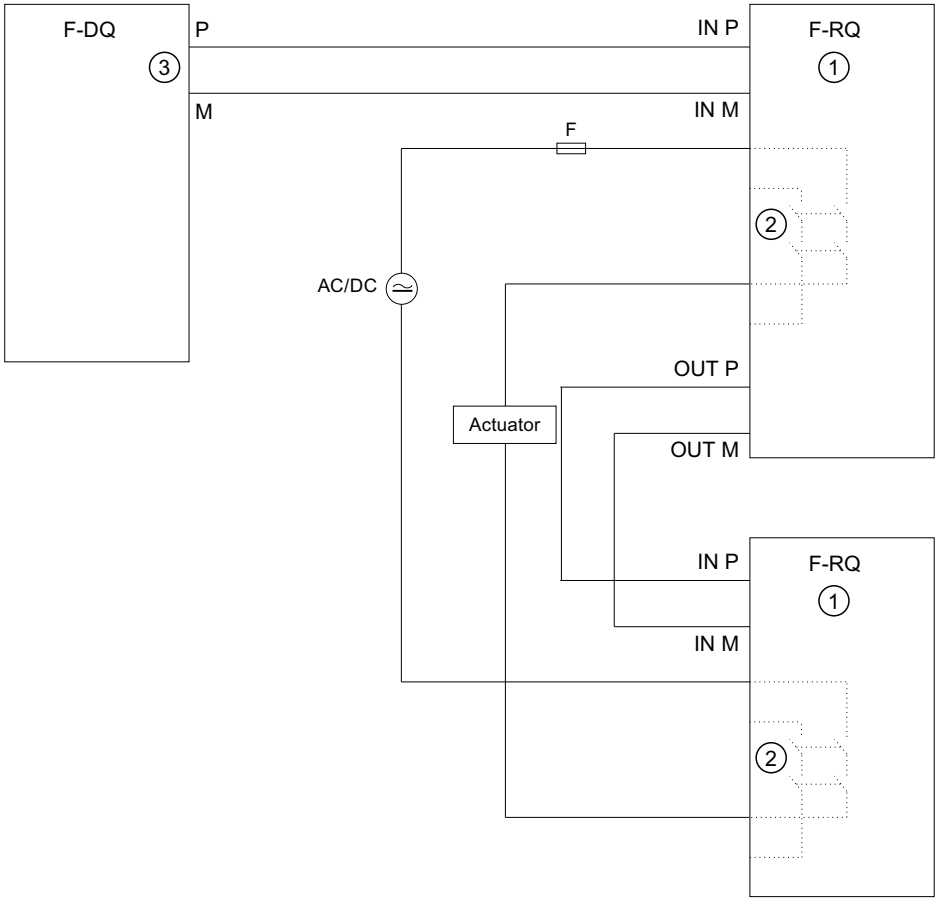

① F-RQ with integrated FEEDBACK input

② Relay contacts for switching the load

③ Output Q

Figure 2-1525 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

NOTE

SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.

SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.

If a fault is detected during this function test, replace the F-RQ module.

Program example

For this application, program an FDBACK instruction for each F-RQ module as follows:

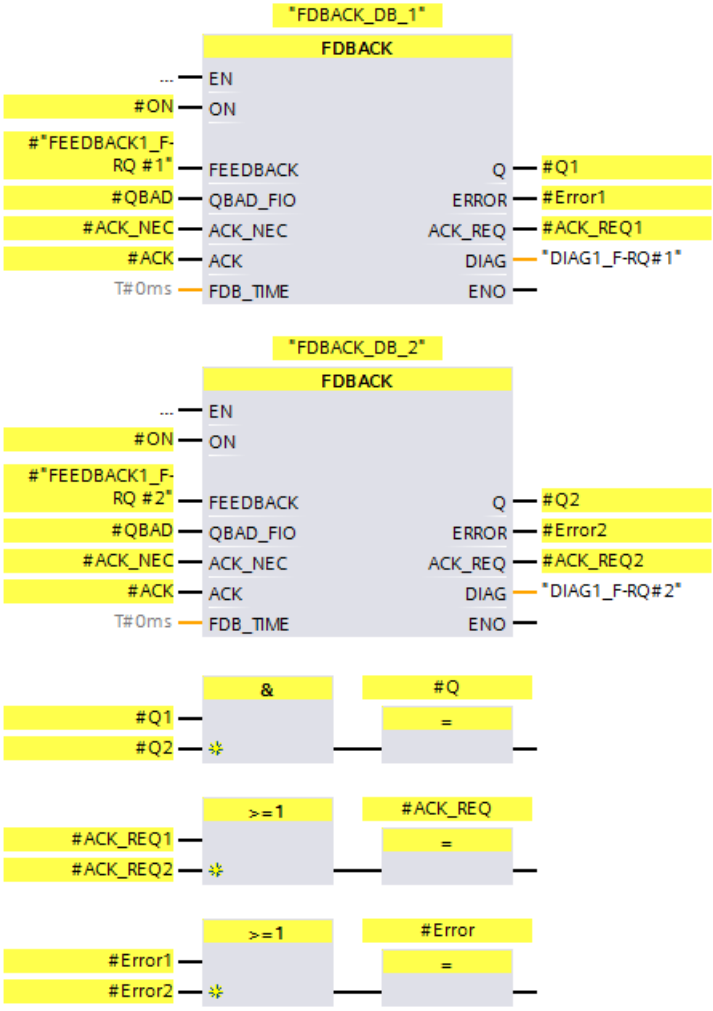

5.6 Application 5: 2 loads, single-pole switch-off with 2 F-RQ modules

Wiring diagram

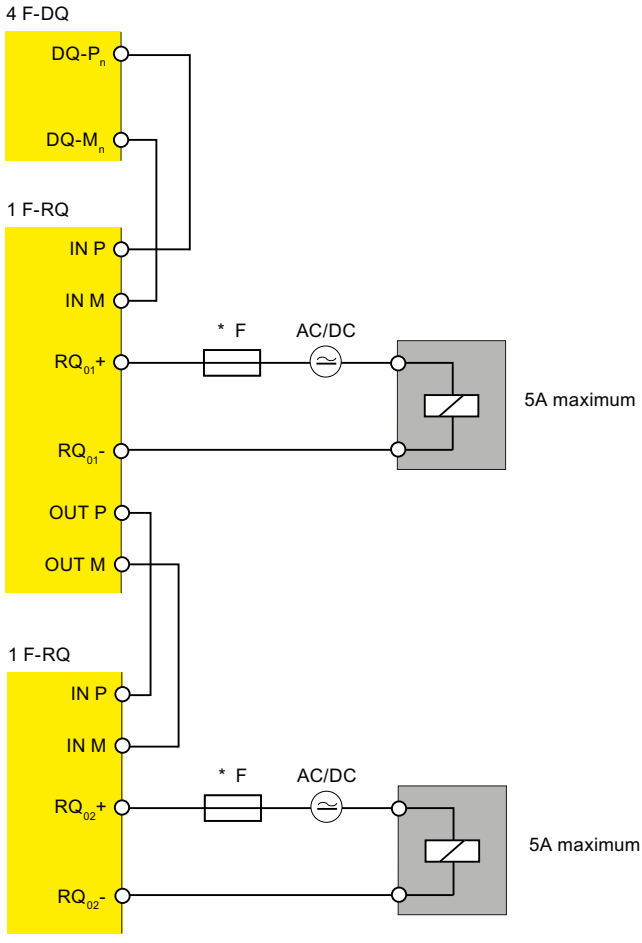

Figure 2-1526 Wiring diagram for two F-RQ 1x24VDC/24..230VAC/5A to one F-DQ module

This application allows the single-pole switching of two loads with 5A each with two F-RQ modules. One power supply is not SELV/PELV.

WARNING

* Always install an external fuse with the following properties to protect the relay contacts from overload and short-circuits: Fuse, 6 A, operating class gL/gG or C6A miniature circuit breaker, rated short-circuit current of 400 A.

Note that for applications in accordance with EN 50156-1 the specified rated current of the overcurrent protective device must be multiplied by a safety factor of 0.6 to rule out the error "non-opening of contact elements due to permanent contact welding".

Reading back the relay contacts

In the safety program, always compare the readback value returned by the F-RQ module with the control status. In *STEP 7 Safety Advanced*, you can use the instruction "FDBACK: Feedback circuit monitoring" in your safety program (see the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual).

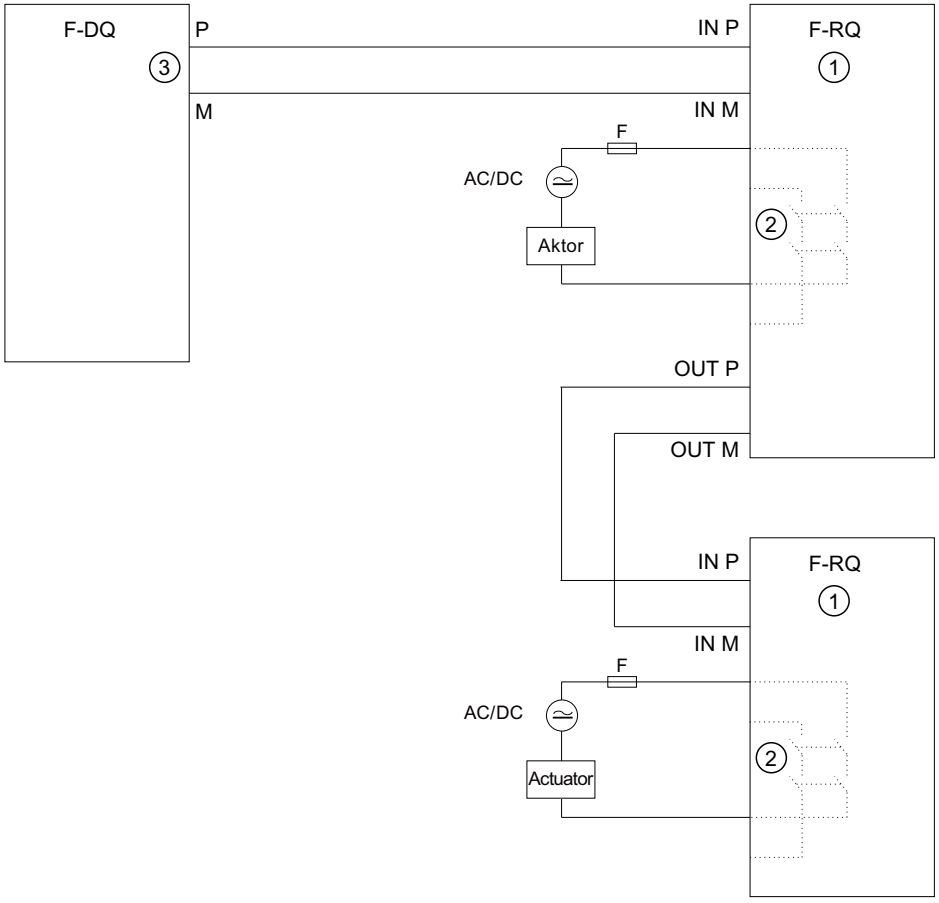

① F-RQ with integrated FEEDBACK input

② Relay contacts for switching the load

③ Output Q

Figure 2-1527 Wiring example for the FDBACK instruction

If the 24 VDC control voltage falls below the value required for relay pick-up or if the wire to the input connectors breaks, the relays are released and "1" is read back instead of "0". This fault is only detected if the F-DQ module output is switched on.

If one of the two load contacts connected in series fails to open, "0" is read back by the module. The fault is detected by comparing this readback value with the setpoint "1" in the safety program. This fault is only detected if the control voltage is switched off.

NOTE

SIL3/category 4/PLe requires that there is a signal change at least once a month and that the process status is read back.

SIL2/category 3/PLd requires that there is a signal change at least once a year and that the process status is read back.

If a fault is detected during this function test, replace the F-RQ module.

Program example

For this application, program an FDBACK instruction for each F-RQ module as follows:

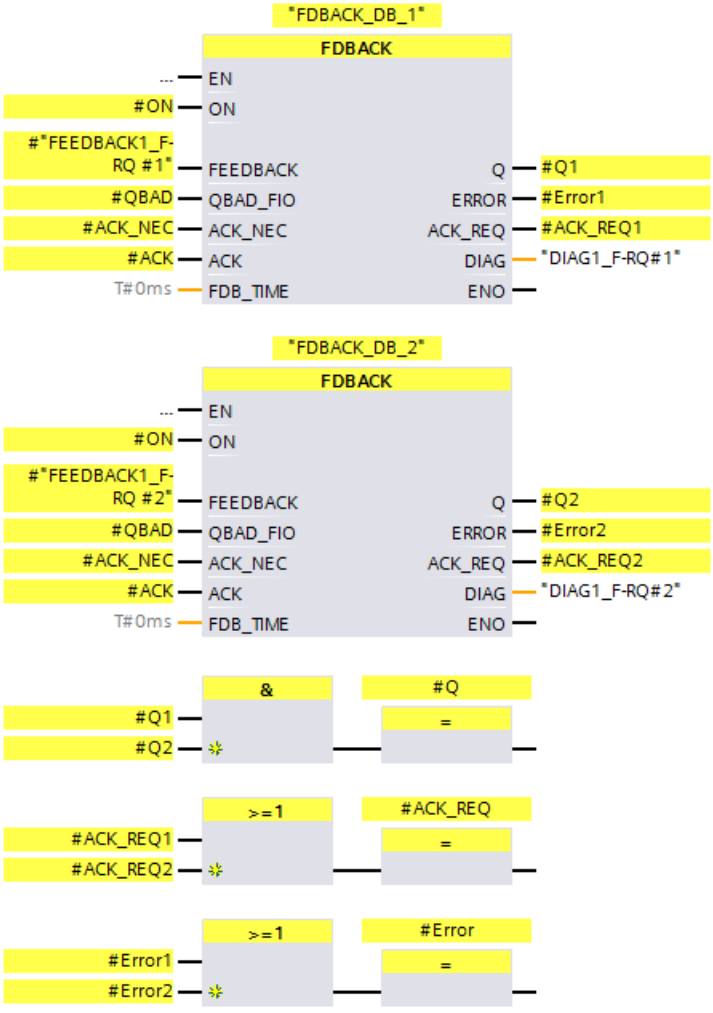

Status and error display

6

6.1 Status and error display

LED display

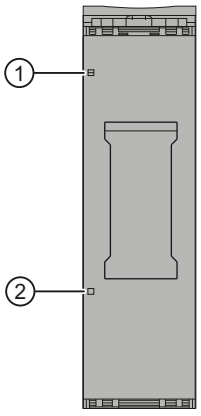

① DIAG (green/red)

② Channel status (green)

Figure 2-1528 LED display

Meaning of the LED displays

The following tables explain the meaning of the status and error displays.

WARNING

The DIAG LED and the channel status LED of the output are not designed as safety-related LEDs and therefore must not be evaluated for safety-related activities.

DIAG LED

Table 2-1932 Meaning of the DIAG LED

DIAG	Meaning
□ Off	Backplane bus supply of the ET 200SP not OK
☼ Flashing	Module parameters not set
■ On	Module parameters set and no module diagnostics

Channel status LED

Table 2-1933 Meaning of the channel status LED

Status	Meaning
□ Off	Process signal = 0
■ On	Process signal = 1

Technical specifications 7

7.1 Technical specifications

Technical specifications of F-RQ 1×24VDC/24...230VAC/5A

	6ES7136-6RA00-0BF0
Product type designation	F-RQ 1x24VDC/24 ... 230VAC/5A
General information	
Hardware product version	01
Firmware version	V1.0.0
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal configurable/integrated as of version	V13
STEP 7 configurable/integrated as of version	V5.5 SP4 and higher
Installation type/mounting	
Rail mounting possible	Yes; standard mounting rail
Supply voltage	
Type of supply voltage	24 VDC
Rated value (DC)	24 V; coil voltage
Low limit of permitted range (DC)	20.4 V
High limit of permitted range (DC)	28.8 V
Power	
Power consumption from the backplane bus	100 mW
Power loss	
Power loss, typ.	1 W
Address range	
Address space per module	
Input	1 byte
Digital outputs	
Number of outputs	1
Voltage induced on current interruption limited to	No
Control of a digital input	Yes
Switching capacity of outputs	
With resistive load, max.	5 A
With lamp load, max.	25 W
Switching frequency	

	6ES7136-6RA00-0BF0
With resistive load, max.	2 Hz
With inductive load, max.	0.1 Hz; see information in the manual
With inductive load (to IEC 60947-5-1, DC13), max.	0.1 Hz
With inductive load (to IEC 60947-5-1, AC15), max.	2 Hz
Total current of the outputs (per module)	
Horizontal installation	
Up to 40 ℃, max.	5 A; note derating information in the manual
Up to 50 ℃, max.	4 A; note derating information in the manual
Up to 60 ℃, max.	3 A; note derating information in the manual
Vertical installation	
Up to 50 ℃, max.	3 A; note derating information in the manual
Relay outputs	
Number of relay outputs	1; 2 NO contacts
Rated input voltage of relay coil L+ (DC)	24 V
Current consumption of relays (coil current of all relays), max.	70 mA
External fuse for relay outputs	Yes, 6 A, see information in the manual
Relay approved acc. to UL 508	Yes; Pilot Duty B300 R300
Switching capacity of contacts	
With inductive load, max.	See additional description in the manual
With resistive load, max.	See additional description in the manual
Thermal continuous current, max.	5 A
Contact rating, min.	1 mA
Contact rating after exceeding 300 mA, min.	10 mA
Contact rating after exceeding 300 mA, max.	5 A
Rated switching voltage (DC)	24 V
Rated switching voltage (AC)	230 V
Length of cable	
Cable length, shielded, max.	500 m; for load contacts
Cable length unshielded, max.	300 m; for load contacts
Control cable (input), max.	10 m
Interrupts/diagnostics/status information	
Diagnostics messages	
Diagnostics	Yes, firmware update
Diagnostics display LED	
RUN LED	Yes; green/red DIAG LED
Channel status display	Yes; green LED
Electrical isolation	
Electrical isolation, channels	
Between channels	Yes; only with SELV / PELV
Between the channels and the backplane bus	Yes

	6ES7136-6RA00-0BF0
Between the channels and the supply voltage of the electronics	Yes
Permitted potential difference	
Between channels and backplane bus/supply voltage	250 VAC (reinforced insulation)
Between backplane bus and supply voltage	60 VAC/75 VDC
Insulation	
Insulation test voltage	2545 VDC 2 s (routine test)
Overvoltage category	III
Tested with	
Between channels and backplane bus/supply voltage	2545 VDC 2s (routine test), surge voltage test 7200 VDC/5 positive and 5 negative pulses (type test)
Between backplane bus and supply voltage	707 VDC (type test)
Standards, approvals, certificates	
Suitable for safety functions	Yes
Maximum achievable safety class in safety mode	
Performance level according to EN ISO 13849-1:2008	PLe
Category according to ISO 13849-1:2008	4
SIL according to IEC 61508:2010	SIL 3
Low demand (PFD) acc. to SIL2	<1.00E-04, proof test interval 1 year
Low demand (PFD) acc. to SIL3	<1.00E-05, proof test interval 1 month
High demand (PFH) acc. to SIL2	<1.00E-08 1/h, proof test interval 1 year
High demand (PFH) acc. to SIL3	<6.00E-09 1/h, proof test interval 1 month
Dimensions	
Width	20 mm
Weights	
Weight, approx.	56 g

Supplement to the technical specifications

Technical specifications	
Relay outputs	
Current consumption of relays (coil current of all relays), min.	20 mA
Permitted potential difference	
• Between NO contacts	75 VDC / 60 VAC
Insulation tested	
• Between the NO contacts	707 VDC (type test)

Derating

NOTE

As the modules are small, you need to monitor the heat build-up between adjacent modules if output modules are subject to high loads. A temperature rise in an output module exposed to a high load can result in shutdown and reduce plant availability. If the operating voltage > 25 VDC, the average total current of the modules directly adjacent should not exceed 50% of the levels listed in the technical specifications, and the ambient temperature should not exceed 50 °C.

If the ambient temperature exceeds 50 °C, supply voltage L+ must not exceed 25 VDC.

Dimension drawing

See ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

7.2 Mechanical and climatic ambient conditions

In contrast to the specifications for mechanical environmental conditions and mechanical environmental conditions testing in the "Mechanical and climatic ambient conditions" section of the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual, the following applies to this F-module:

Mechanical ambient conditions

The following table shows the mechanical ambient conditions in the form of sinusoidal vibrations.

Table 2-1934 Mechanical ambient conditions

Frequency band	ET 200SP with BusAdapter BA 2×FC	ET 200SP with BusAdapter BA 2×RJ45/ BA 2xSCRJ
5 ≤ f ≤ 8.4 Hz	3.5 mm amplitude	
8.4 ≤ f ≤ 150 Hz	1 g constant acceleration	

Tests of mechanical ambient conditions

The following table provides important information about the type and scope of the tests for ambient mechanical conditions.

Table 2-1935 Tests of mechanical ambient conditions

Check for ...	Test standard	Comment
Vibration	Vibration test according to IEC 60068-2-6 (sinus)	Type of vibration: Frequency sweeps with a rate of change of 1 octave/minute. • 5 Hz ≤ f ≤ 8.4 Hz, 3.5 mm constant amplitude • 8.4 Hz ≤ f ≤ 150 Hz, 1 g constant acceleration Duration of vibration: 10 frequency sweeps per axis at each of three vertically aligned axes
Shock	Shock, tested according to IEC 60068-2-27	Type of shock: Half sine Shock intensity: 150 m/s^2 peak value, 11 ms duration Direction of shock: 3 shocks in each direction (+/-) at each of three vertically aligned axes

7.3 Switching capacity and service life of contacts

Switching capacity and service life of contacts

You can extend the service life beyond the value indicated in the tables below by installing an external protective circuit.

The tables below show the switching capacity and service life of the contacts.

Table 2-1936 Switching capacity and service life of contacts with resistive load

Voltage	Current	Duty cycles (typ.) NO contact
24 VDC	5.0 A	350000
	3.0 A	500000
	2.0 A	750000
	1.0 A	1800000
	0.5 A	4000000
230 VAC	5.0 A	100000
	3.0 A	150000
	2.0 A	200000
	1.0 A	400000
	0.5 A	800000

Table 2-1937 Switching capacity and service life of contacts **with inductive load according to IEC 947-5-1 DC 13/ AC15**

Voltage	Current	Duty cycles (typ.) NO contact
24 VDC	1.0 A	100000
	0.5 A	200000
230 VAC	1.0 A	200000
	0.5 A	350000

Table 2-1938 B10d values

AC	750000
DC	10000000

Response times

A

A.1 Response times

Introduction

The section below shows the response times of the digital output module F-RQ 1x24VDC/24..230VAC/5A. The response times of digital output module F-RQ 1x24VDC/24..230VAC/5A are included in the calculation of the F-system response time.

Definition of response time for fail-safe relay outputs

The response time defines the interval between controlling by means of a fail-safe digital output module until the signal change at the relay output.

Maximum response time without errors

The maximum response time for fail-safe relay outputs when there are no errors is equal to:

Max. response time = 16 ms

Readback response time

The readback response time for fail-safe relay outputs is equal to:

Readback response time = 30 ms

Maximum response time until error detection

Max. response time = cycle time of the safety program + max. readback time of the FDBACK instruction + max. response time of the F-DQ module + max. response time of the F-RQ module + 12.8 ms

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SIMATIC

ET 200SP
Fail-safe Module F-CM AS-i Safety ST (3RK7136-6SC00-0BC1)

Equipment Manual

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Preface

Purpose of the documentation

This manual complements the ET 200SP distributed I/O system system manual. General functions of the ET 200SP are listed in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

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Documentation guide

1

Introduction

The following paragraph gives you an overview of the additional documentation you need to use the F-CM AS-i Safety ST.

Documentation for the distributed I/O system ET 200SP with the F-CM AS-i Safety ST

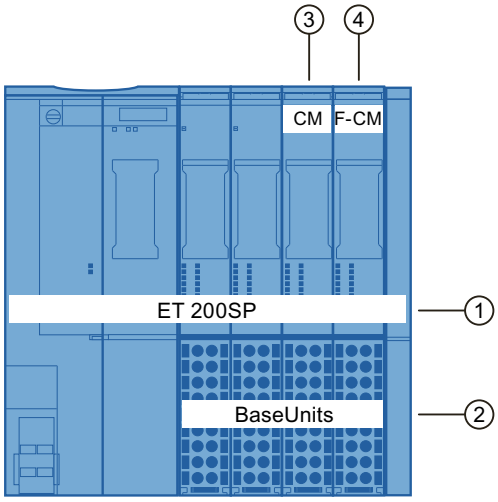

Figure 2-1529 Example of a system structure

Table 2-1939 Documentation for the distributed I/O system ET 200SP with the F-CM AS-i Safety ST

No.	Component	Documentation	Most important contents
1	System	Fail-safe modules: Product Information ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/78361093/0/en) ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en)	• Application planning • Installation • Connecting • Commissioning • Technical specifications
		Fail-safe system: Programming and Operating Manual S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en) Programming and Operating Manual SIMATIC Safety (http://support.automation.siemens.com/WW/view/en/54110126/0/en)	• Configuration • Programming

No.	Component	Documentation	Most important contents
②	BaseUnits	SIMATIC ET 200 SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521/0/en)	• Connecting • Technical specifications
③	CM AS-i Master ST	Manual CM AS-i Master ST for SIMATIC ET 200SP (http://support.automation.siemens.com/WW/view/en/71756485)	• Commissioning • Technical specifications
④	ET 200SP F-CM AS-i Safety ST fail-safe module	Device manual ET 200SP F-CM AS-i Safety ST fail-safe module (3RK7136-6SC00-0BC1)	• Installation • Connecting • Configuration

Safety instructions 2

Important safety instructions

WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

For operation in Pollution Degree 2 environment.

WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

When used in hazardous environments corresponding to Class I, Division 2 or Class I, Zone 2, the device must be installed in a cabinet or an enclosure. To comply with EU Directive 94/9 (ATEX 95), this enclosure must meet the requirements of at least IP54 according to EN 60529.

WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Wires must not be connected to the device or disconnected from the device within a flammable or combustible environment.

WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Do not disconnect live wires from the device if it cannot be ensured that an explosive atmosphere is not present in the environment.

WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Replacement of components may impair suitability for Class I, Division 2 or Zone 2.

WARNING

Explosion hazard; failure to observe this information may result in death, severe injury, and serious property damage.

Do not open the device when the supply voltage is switched on.

WARNING

Connection only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition

Connect the BaseUnit only to an AS-i power supply unit that meets the conditions indicated in the Section "Power supply units for AS-Interface". Connection to a higher voltage may result in death, severe injury, and serious property damage.

For this reason, you are only permitted to connect safety extra-low voltage (SELV) with limited power source (LPS) according to IEC 60950-1, EN 60950-1, VDE 0805-1 to the supply connections.

The supply of the device must comply with NEC Class 2, as described by the National Electrical Code (r) (ANSI / NFPA 70).

WARNING

Failure to observe this information may result in death, severe injury, and serious property damage.

Take measures to prevent transient overvoltages of more than 40% of the rated voltage. You can ensure this by using only AS-i power supply units that meet the requirements indicated in Section Terminal assignment (Page 21) in "Power supply units for AS-Interface". Transient overvoltages are not permitted to exceed 119 V under any circumstances. This will ensure compliance with an ATEX requirement.

CAUTION

Failure to observe this information may result in property damage and bodily injury

This device is only suitable for use in areas defined as Class I, Division 2, Groups A, B, C, and D and is not suitable for use in hazardous areas.

WARNING

To be operated by experienced users only

Improper operation may result in death, severe injury, and serious property damage. Users must be familiar with ASIsafe and the safety system used, e.g., SIMATIC, Distributed Safety, SIMATIC Safety Advanced.

Only an experienced user is permitted to teach the code sequences of safe AS-i slaves (organizational specification).

CAUTION

Failure to observe this information may result in property damage and bodily injury

This equipment is only suitable for use in areas defined as Class I, Zone 2, Group IIC and in non-hazardous areas.

NOTICE

Checking parameters

Check that all parameters are correctly set before final acceptance.

NOTICE

Reaction to faults in fail-safe modules

If you are using the module in safety-critical applications, the PROFIsafe mechanism of passivation and reintegration is enabled and must be used.

Observe the information concerning passivation and other fault reactions in the documentation for the ET 200SP Distributed I/O System, see Section Documentation guide (Page 5).

NOTICE

Single-channel use of safe AS-i input slaves

The values in the PROFIsafe process image input have Safety Integrity Level SIL 3.

If two-channel interconnection is not used for a safe AS-i input slave, the application has a maximum safety integrity level of SIL 2 or less. The configuration tool / STEP 7 cannot detect this.

You must ensure that the signals are correctly processed in the safety application.

NOTICE

Ensure that the plant is functioning correctly in productive operation

Carry out a function test before the system goes into productive operation.

Important note for maintaining the operational safety of the system

NOTE

Newsletter containing information on product development and product features

Owners of systems with safety-related characteristics must ensure compliance with special operational safety requirements. Suppliers are required to comply with special product monitoring measures. For this reason, Siemens publishes a special newsletter containing information on product developments and features that are (or could be) relevant to operation of systems from a safety perspective. A newsletter keeps you constantly up to date in this regard. A subscription to the newsletter is necessary so that you can make any needed changes to your system. To sign up for the newsletter, go to:

Internet (https://www.industry.siemens.com/newsletter)

Select "Service & Support" > "Industry Online Support" > "Automation Technology" > "AS-Interface". Select the "Update" entry type.

See also

References (Page 86)

Product overview

3

3.1 Properties of the F-CM AS-i Safety ST

Item number

3RK7136-6SC00-0BC1

View of the module

Figure 2-1530 View of the F-CM AS-i Safety ST module

Use of the module

The F-CM AS-i Safety ST module is a communication module for use in the SIMATIC ET 200SP Distributed I/O System.

The F-CM AS-i Safety ST module features a 20 mm wide ET 200SP module housing. A BaseUnit (BU) is required for use in the ET 200SP. The F-CM AS-i Safety ST module can be plugged in to:

- BaseUnit Type C0
- BaseUnit Type C1

The F-CM AS-i Safety ST fail-safe communication module expands a standard AS-Interface network to include safety-related communication.

The F-CM AS-i Safety ST module reads the input states of safety-related AS-Interface input modules and provides these states to a fail-safe F-CPU for further evaluation.

In the opposite direction, the F-CM AS-i Safety ST module receives safe output states of an F-CPU and outputs them for control of safety-related outputs on AS-Interface.

The F-CM AS-i Safety ST fail-safe module supports safety-related applications up to SIL 3 according to EN 62061 or safety category up to PL e according to EN 13849-1. The input and output values of the safety-related AS-i slaves are addressed using the safe cyclic process image. You need an F-CPU for safe processing.

The F-CM AS-i Safety ST module has no AS-i master functionality. For operation of the AS-i network, you need a CM AS-i Master ST module (3RK7137-6SA00-0BC1) or another AS-i master conforming to AS-i Specification V3.0.

You can plug several F-CM AS-i Safety ST modules into one SIMATIC ET 200SP station. An F-CM AS-i Safety ST occupies 16 input bytes and 8 output bytes in the I/O address space. The number of F-CM AS-i Safety ST modules that can be plugged in depends on:

- The maximum address space of the utilized interface module (IM) of the ET 200SP
- The amount of address space occupied by other modules

Up to five module combinations of CM AS-i Master ST (32 input bytes/32 output bytes) and F-CM AS-i Safety ST (16 input bytes/8 output bytes) can be plugged in to one SIMATIC ET 200SP station with standard interface module IM 155-6 PN ST having a maximum address space of 256 input bytes/256 output bytes. If other modules are present in the ET 200SP station, the available address space and the maximum number of AS-i modules are reduced.

In a SIMATIC ET 200SP station with High Feature Interface Module IM 155-6 PN HF and a maximum address space of 1 440 input bytes/1 440 output bytes, a correspondingly greater number of modules can be plugged in.

You can find additional information in ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293/0/en).

Properties

- Technical properties
  - Gateway between PROFIsafe and ASIsafe, without master functionality
  - Expands a standard AS-i network to include safety-related communication (ASIsafe)
  - Transfer of safety-related digital I/O values in the cyclic process image
  - Monitoring of up to 31 safety-related input slaves
  - Control of up to 16 safety-related AS-i output slaves or switch-off groups
  - Power supplied from the AS-i voltage
  - Use of various interconnection types (1oo1 and 1oo2) is possible
  - Input delay of 0 ms to 150 ms can be assigned for each channel
  - Startup test can be activated for each channel
  - Discrepancy monitoring can be configured for each channel
  - Sequence monitoring can be set for each channel
  - Channel-wise passivation
  - Test for 0 signal before reintegration
  - 8 LED displays for status and error diagnostics

- Supported functions
  - I&M identification data
  - PROFIsafe V2.4
  - Firmware update

NOTICE
Max. proof test interval When the proof test interval has expired, you must replace the device; see "Technical specifications (Page 78)".

- New properties as from FW V1.0.1
  As from product version 02, the module is shipped with FW V1.0.1 (or higher).
  - Extended functions (diagnostic texts)
  - New messages
  - New diagnostics data record 206

For more information, see Section "Parameterizing (Page 33)".

Accessories

The following components can be used with the module:

- Labeling strips
- Reference identification label

Ease of maintenance

The following features support maintenance:

- Code sequences are saved in the coding element. As a result, teaching of the code sequences does not have to be repeated after an F-CM AS-i Safety ST module is replaced.
- Use is automated to the greatest extent possible. This applies, in particular, to the teaching of the code sequences of safe AS-i slaves.
- An F-address that has already been assigned is stored in the coding element. This means that there is no need to repeat teaching-in after replacing the F-CM AS-i Safety ST module.
- The module/BaseUnit concept allows you to easily replace defective hardware. Remove the defective module from the rack and plug in the new module.

Further information can be found in the Section "Code sequences (Page 64)".

Certifications

More detailed information regarding certifications can be found in the ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293/0/en).

3.2 Operating modes of the F-CM AS-i Safety ST

3.2.1 Standard mode

Self test during device startup

After the AS-i voltage is switched on (PWR LED shows steady green light), the F-CM AS-i Safety ST module performs a comprehensive self-test. During this test, all LEDs are lit for approximately 3 seconds. Exception: the "DIAG" LED is controlled directly by the ET 200SP backplane bus and indicates the communication status for the ET 200SP system.

Checking of the F-address

After the self-test, the module checks the F-address. If no valid F-address is available, the "DIAG" and "PROFIsafe" LEDs flash red (the status LED flashes green). You must then assign the F-address, see Section "F-parameters (Page 35).

Downloading of the module parameters

The F-CM AS-i Safety ST then begins to read in code sequences of the safe AS-i slaves on the connected AS-i bus. At the same time, the module downloads the module parameters that were stored in the PLC CPU. The module parameters can only be downloaded when the operating voltage is applied to the interface module of the ET 200SP and the parameters have been made available by the PLC CPU during startup of the ET 200SP station.

The "Status" LED flashes green until the module parameters are completely downloaded or the PLC CPU is in STOP state, or the PLC communication is interrupted.

Cyclic data exchange of safe input/output data

When a valid set of module parameters has been downloaded and the PLC CPU is in "RUN" state, the safe input/output data is evaluated according the parameter assignment and exchanged with the PLC CPU.

The PROFIsafe protocol is used for the data exchange.

The "Status" LED is lit green during cyclic data exchange.

If the F-CM AS-i Safety ST module starts cyclic data exchange directly after startup, but communication cannot yet be established on the AS-i bus, the F-CM AS-i Safety ST module supplies the substitute value "0" in the input image. Passivation is delayed by a maximum of 30 s in this case. As a result, communication can start on the AS-i bus within this time window without passivation. After this time window, the input/output channels are passivated if there is no AS-i communication.

3.2.2 Error statuses

NOTE

Statuses not considered to be errors

The F-CM AS-i Safety ST module does not consider the following statuses to be errors, i.e. no alarm and no passivation is triggered:

- Waiting for start-up test
- Input/output with value = 0 in the process image without error condition, e.g. normal opening of the input contacts by pressing an emergency stop button or opening a protective door.

Diagnostic information can be read out in the user program using data records. For information, please refer to Section "Data records for diagnostics (Page 47)".

3.2.2.1 Serious device fault

Description

Examples of conditions that trigger a serious device fault are:

- Fault in the electronics
- Repeated synchronization error

You can read the following pattern on the LEDs:

Table 2-1940 LED display for a serious device fault

LED	Display
"Status"	☐ "Off"
"Error"	■ Red "On"
"CFG"	■ Red "On"
"PSF"	■ Red "On"

In the event of a serious device fault, communication with the F-CM AS-i Safety ST module, e.g., reading a data record, is not possible. The substitute value "0" is processed for inputs and outputs, and all channels are passivated.

1. Switch off the module.
2. Wait for the module to cool down, if necessary.
3. Switch on the device again.
4. If the error persists after the module is switched on, the module must be replaced.

3.2.2.2 Device fault

Description

Examples of conditions that trigger a device fault are:

- Device fault (e.g. sporadic synchronization error, see also DS92)
- Configuration error (e.g. problem with contact to backplane bus, coding plug missing, see also DS92)

You can read the following pattern on the LEDs:

Table 2-1941 LED display for device faults

LED	Display
"Status"	☐ "Off"
"Error"	✻ Red "flashes"
"CFG"	☐ "Off"
"PSF"	☐ "Off"

In the event of a device fault of this type, communication with the F-CM AS-i Safety ST module is only possible. e.g., for reading out additional diagnostic information via data records. The substitute value "0" is processed for inputs and outputs, and all channels are passivated.

- Make sure that the station is properly grounded.
- Check whether the coding element is present or replace it if necessary.
- Plug the module into the BaseUnit in an untwisted position.

Switch off the module. If the error persists after the module is switched on and no external error cause can be found, the module must be replaced.

3.2.2.3 Process signal error

Description

Examples of conditions that trigger a process signal error are:

- Discrepancy error at the inputs of a safe AS-i input slave
- Sequence error at the inputs of a safe AS-i input slave
- Sporadic code sequence error (from FW V1.0.1), e.g. fault caused by EMC in the input circuit
- Code sequence error at a safe AS-i input slave, e.g. due to cross-circuit at the inputs
- Failure of a safe AS-i input slave

You can read the following pattern on the LEDs:

Table 2-1942 LED display for discrepancy error or sequence error

LED	Display
"Status"	■ Green "On"
"Error"	□ "Off"
"CFG"	□ "Off"
"PSF"	✻ Red "flashes"

Table 2-1943 LED display for code sequence errors (e.g. due to cross-circuit) or for slave failure

LED	Display
"Status"	■ Green "On"
"Error"	□ "Off"
"CFG"	✻ Red "flashes"
"PSF"	✻ Flashes red if the CPU is in RUN "off" if the CPU is in STOP.

In the event of a process signal error, the F-CM AS-i Safety ST module remains in cyclic data exchange. Only at the safe input slave involved in each case is the substitute value "0" processed and the channel passivated. After the cause of the error has been eliminated, the channel can be reintegrated via the safety program.

The "PSF" LED goes out only after all channels have been reintegrated.

The "DIAG" LED switches from flashing red to green as soon as all errors that led to a passivation of the individual channels have been cleared.

Communication with the F-CM AS-i Safety ST module is possible, for example, for reading out additional diagnostic information via data records.

Response to code sequence errors

- **Sporadic code sequence error**
  Momentary interruption to code sequence, e.g. due to electromagnetic interference on the sensor cable.
  Behavior as from firmware V1.0.1:
  - Sporadic code sequence error leads to passivation of the channel, which must then be reintegrated.
  - Safety input bit of the channel is reset to substitute value 0 until the channel is reintegrated.
  - The resetting to the substitute value 0 takes place without any delay.

- Diagnostic alarm is triggered (after a short delay, in order to distinguish between sporadic code sequence errors and general code sequence errors).
- **Response to FW V1.0.0**
- No message as diagnostic alarm in FW V1.0.0 and no passivation of the channel.
- Safety input bit of the channel is reset to substitute value 0 without a delay and automatically switches to the process value 0 or 1 if there is no interference to the code sequence.

- **Code sequence error (general)**
  Permanent interruption to code sequence, e.g. due to electromagnetic interference on the sensor cable or code sequence corruption after replacement of the fail-safe input module.
  Behavior (identical for firmware V1.0.0 and V1.0.1 or higher):
  - Code sequence error leads to passivation of the channel, which must then be reintegrated.
  - Safety input bit of the channel is reset to substitute value 0 until the channel is reintegrated.
  - The reset to the substitute value 0 takes place without a delay, while the diagnostic alarm is triggered after a short delay (delay necessary in order to distinguish between sporadic code sequence errors and general code sequence errors).

3.2.2.4 Parameter assignment error

Description

In the event of invalid configuration data, the cyclic data exchange will not start.

You can read the following pattern on the LEDs:

Table 2-1944 LED display for parameter assignment errors

LED	Display
"Status"	✻ Green "flashing"
"Error"	☐ "Off"
"CFG"	☐ "Off"
"PSF"	✻ Red "flashes"

1. Check the hardware configuration in *STEP 7*.
2. Perform a compilation.
3. Download the configuration data to the PLC CPU.

3.3 Firmware update

Performing a firmware update

Information about updating the firmware can be found in the ET 200SP System Manual.

NOTE

Noting the firmware version

After a firmware update, mark the current firmware version on the housing of the F-CM AS-i Safety ST.

NOTE

Requirement for the firmware update

Always perform the firmware update of the F-CM AS-i Safety ST in a separate ET 200SP rack. Ensure that no other modules besides the interface module (IM), the F-CM AS-i Safety ST, and the terminating server module are located in the ET 200SP rack.

During the firmware update of the F-CM AS-i Safety ST module, the associated CPU must be in the STOP operating state. To do this, switch the CPU to the STOP state before starting the firmware update.

NOTE

If the FW V1.0.0 is replaced by another FW version, then an intermediate step is necessary. If you would like to replace a higher FW version with FW version V1.0.0, then this intermediate step is also necessary.

As an intermediate step, the Bootloader Version (B1.0.0) of the firmware must be loaded before the actual firmware V1.x.x.

NOTICE

Observe references to the download page for executing the firmware change Failure to do so can result in the destruction of the device.

The firmware versions are made available in the Online Support:
Online Support (https://support.industry.siemens.com/cs/ww/en/view/109743655)

NOTICE

Checking the firmware version for F-permission

Before using a new firmware version, check whether it is permitted for use in the respective module.

The permissible firmware version is specified in the appendices of the F-CM AS-i Safety ST Safety certificate.

See also:

Certificate for failsafe module F-CM AS-i Safety ST (3RK7136-6SC00-0BC1)
(https://support.industry.siemens.com/cs/ww/en/view/90477145)

Certificate for ET 200SP modules
(http://support.automation.siemens.com/WW/view/en/49368678/134200)

Handling of the F-address and the code sequences

NOTE

Saving of the F-address in the coding element

During a firmware update, the F-address that is saved in the coding element is retained. Observe the information in the description of the firmware version.

NOTE

Saving of the code sequences in the coding element

During a firmware update, the ASIsafe code sequences that are saved in the coding element are retained. Observe the information in the description of the firmware version.

LED behavior during a firmware update

During a firmware update, the LEDs exhibit the following behavior:

- "DIAG" LED flashes red.
- "ADDR" LED flashes green.
- "PWR" LED lights up green.
- The rest of the LEDs are Off.

NOTE

Supply voltage during a firmware update

The AS-i voltage and the supply voltage of the ET 200SP station must not be switched off during a firmware update.

On successful completion of a firmware update, the module performs a hot restart. It is not necessary to switch off the voltage.

After the restart, the LEDs indicate the status of the F-CM AS-i Safety ST same as after a device startup.

If the firmware update cannot be completed, switch the AS-i voltage off and back on again and repeat the firmware update.

See also

Error statuses (Page 15)

Connection

4

4.1 Terminal assignment

Requirement

For connecting, you require a BaseUnit:

- Type C1 (dark BaseUnit, e.g., item number 6ES7193-6BP20-0BC1)
- Type C0 (light BaseUnit, e.g., item number 6ES7193-6BP20-0DC0)

Note that, within a BaseUnit group for AS-i consisting of light and dark BaseUnits, only the AS-i modules CM AS-i Master ST and F-CM AS-i Safety ST may be combined. Other module types of the ET 200SP must always be separated from the BaseUnit group for AS-i using light BaseUnits.

WARNING

Connection of the BaseUnit only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition

Connect the BaseUnit only to AS-i power supply units that meet the requirements given in Section "Power supply units for AS-Interface". Connection to a higher voltage may result in death, severe injury, and serious property damage.

Variants

Use with light BaseUnit Type C0

If the F-CM AS-i Safety ST module is connected to an AS-i network whose AS-i master is located outside the ET 200SP station, use the light BaseUnit Type C0.

If the AS-i master is located within the ET 200SP station, you can also use the light BaseUnit. However, you must wire the AS-i network explicitly using the connecting terminals.

The light BaseUnit Type C0 has no internal connection to the module plugged in on the left.

Use with dark BaseUnit Type C1

If you are using a combination of CM AS-i Master ST and F-CM AS-i Safety ST on the same AS-i network, use the dark BaseUnit. In this case, plug the CM AS-i Master ST module into a light BaseUnit Type C0. Next to it on the right, plug the F-CM AS-i Safety ST module into a dark BaseUnit Type C1.

In this case, connect the AS-i network to the light BaseUnit. The dark BaseUnit does not have to be connected to the AS-i network because the connection is made automatically via the BaseUnit group.

In contrast to other BaseUnit types, for the BaseUnits Type C0 and Type C1, the P1 and P2 busbars of the BaseUnit are electrically isolated from the front panel connecting terminals

1L/2L (ASI+) and 1N/2N (ASI-). An electrical connection is made in each case via the plugged-in CM AS-i Master ST module or F-CM AS-i Safety ST module.

The AS-i voltage connected to the light BaseUnit Type C0 is applied through the plugged CM AS-i Master ST module to the busbars. The busbars of the BaseUnit group are connected-through. The F-CM AS-i Safety ST module is supplied with AS-i voltage via the busbars of the dark BaseUnit Type C1. It is not permitted to continue the AS-i voltage from the front panel connecting terminals 1L/2L (ASI+) and 1N/2N (ASI-) of the dark BaseUnit because this type of current draw can cause an overload in the modules.

If you want to maintain the voltage supply of the F-CM AS-i Safety ST module when the CM AS-i Master ST module is unplugged from the light BaseUnit, you can wire an external connection of the connecting terminals 1L/2L (ASI+) and 1N/2N (ASI-) between the light BaseUnit Type C0 and the dark BaseUnit Type C1.

Grouping of a light BaseUnit Type C0 with several dark BaseUnits Type C1

The use of a single F-CM AS-i Safety ST module on an AS-i network is generally sufficient. If several F-CM AS-i Safety ST modules are being used on an AS-i network by means of series connected dark BaseUnits Type C1, you must wire an external connection of the connecting terminals 1L/2L (ASI+) and 1N/2N (ASI-) between the light BaseUnit Type C0 and a dark BaseUnit Type C1. This will prevent an overload of the modules. A current draw from the dark BaseUnit is not allowed. Additional information about this can be found in "Use with dark BaseUnit Type C1".

General terminal assignment

Table 2-1945 Terminal assignment of the F-CM AS-i Safety ST

Terminal	Assignment	Description
1	TEACH1	Connection of the "TEACH" button (optional) See Section Code sequences (Page 64).
2	TEACH2	
3	RES	Reserved
4	RES	Reserved
5	RES	Reserved
6	RES	Reserved
1L, 2L[1)]	ASI+	Dark BaseUnit Type C1: optional connection of the AS-i cable, positive polarity Light BaseUnit Type C0: connection of the AS-i cable, positive polarity
1N, 2N [1)]	ASI-	Dark BaseUnit Type C1: optional connection of the AS-i cable, negative polarity Light BaseUnit Type C0: connection of the AS-i cable, negative polarity

1) The terminals are connected through in the BaseUnit.

Connecting an external "TEACH" button

You can connect a "TEACH" button to the "TEACH1" and "TEACH2" terminals of the F-CM AS-i Safety ST module. The "TEACH" button enables the transfer of code sequences of the connected safe AS-i input slaves. This function is activated by closing the button contact on the TEACH1 and TEACH2 terminals.

The maximum cable length between the terminal and "TEACH" button is 0.5 m.

Use two wires routed in parallel for connecting the button (not included in the scope of delivery).

Additional rules and instructions for operating the ET 200SP with fail-safe modules

Observe generally the information in Section "Connecting" in the following documentation:

- Manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en)
- Product Information ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/78361093/0/en)

The conditions for connecting sensors and actuators to the modules of the ET 200SP also apply generally to the connecting of sensors and actuators to the slaves and modules of the AS-i network.

In addition, the information in the documentation of the AS-i component applies.

Ensure that all components of the AS-i network are connected in such a way that the voltage applied to the safety-related AS-i modules is limited to a maximum of 40 V.

The ET 200SP modules CM AS-i Master ST and F-CM AS-i Safety ST have internal safe electrical isolation from the backplane bus of the ET 200SP.

Power supply units for AS-Interface

A connected power supply unit must have the following properties:

- Rated output voltage 30 V DC (AS-Interface Standard) or 24 V DC (AS-i Power24V)
- PELV/SELV (Protective/Safety Extra-Low Voltage) standard
- Residual ripple < 250 mVpp
- Limiting of output voltage to a maximum of 40 V in the event of a fault, including a second fault.

The Siemens power supply units for AS-Interface meet these requirements. For additional information, refer to the operating instructions of the power supply unit.

Use an AS-Interface power supply unit with integrated data decoupling or a combination of a power supply unit that meets the above-indicated requirements and an AS-i data decoupling unit.

In the following text, the expression "AS-i power supply unit" stands, unless described otherwise, for an AS-Interface power supply unit with integrated data decoupling or a combination of a power supply unit and an AS-i data decoupling unit.

When AS-i Power24V is used, there are limitations on the cable length (max. 50 m AS-i cable) and usability of AS-i components and connected sensors/actuators due to the reduced voltage.

Use a PELV / SELV power supply when operating the F-CM AS-i Safety ST module on PROFIsafe.

Additional notes:

- AS-Interface System Manual (http://support.automation.siemens.com/WW/view/en/26250840/0/en)
- FAQ "Compatibility for AS-i Power24V" (http://support.automation.siemens.com/WW/view/en/20025980/133000)

4.2 Schematic circuit diagram

Schematic circuit diagram

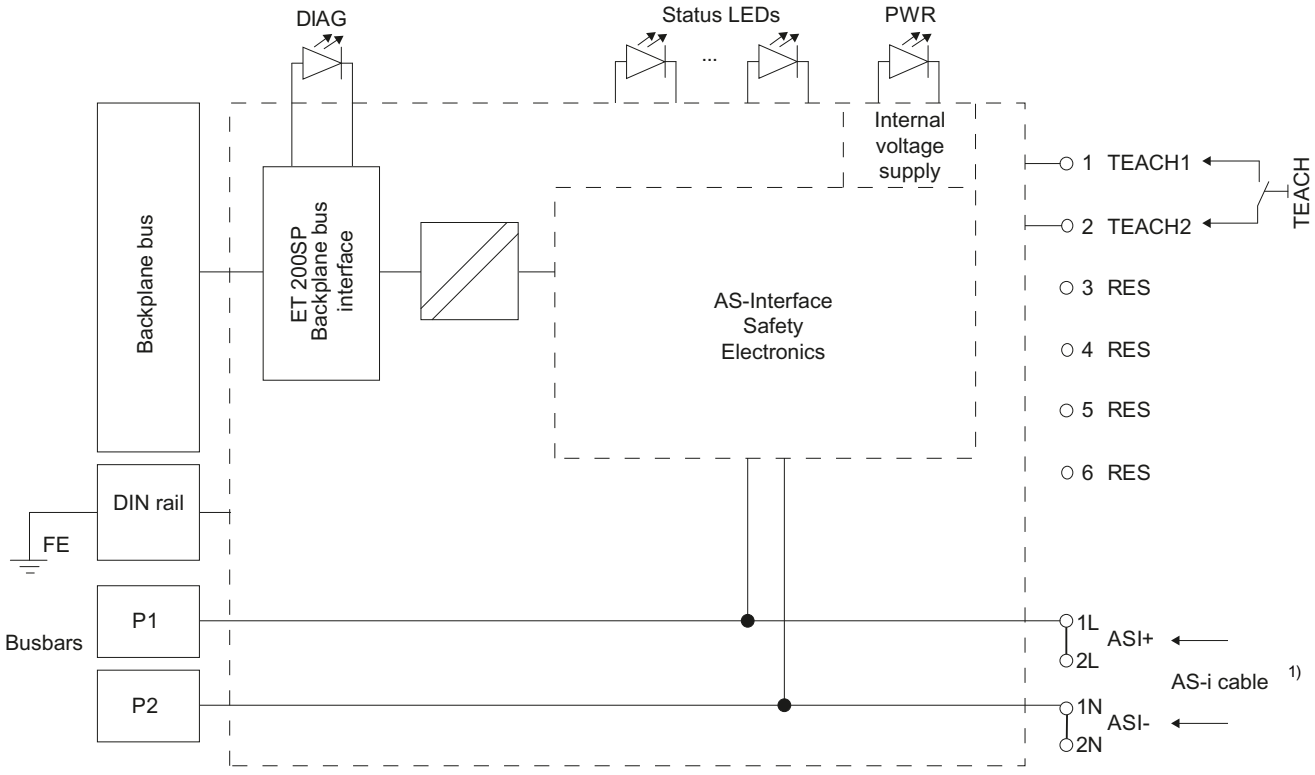

1) AS-i cable: Connection not applicable for dark BaseUnit

Figure 2-1531 Schematic diagram of F-CM AS-i Safety ST

Connection to busbars

Requirement:

- An AS-i power supply unit is connected to the light BaseUnit Type C0 of the BaseUnit group.
- A CM AS-i Master ST module is plugged into the light BaseUnit.

If you plug an F-CM AS-i Safety ST module into a dark BaseUnit Type C1, the F-CM AS-i Safety ST module will be automatically supplied with AS-i voltage via the busbars.

It is not permitted to continue the AS-i voltage from the front panel connecting terminals 1L, 2L (ASI+) and 1N, 2N (ASI-) of the dark BaseUnit because this type of current draw can cause an overload of the modules.

Note the additional explanations in Section Terminal assignment (Page 21).

Configuring 5

5.1 Configuring the F-CM AS-i Safety ST

Notes on configuration

You configure the ET 200SP station and its F-CM AS-i Safety ST module and assign their parameters with *STEP 7*.

There is currently no provision for configuration via a GSD file, because the GSD configuration procedure does not permit safety-related parameter assignment (according to PROFIsafe Specification V2.4).

NOTE

F-CM AS-i Safety ST in the hardware catalog of *STEP 7*

If the F-CM AS-i Safety ST module is not listed in the hardware catalog of *STEP 7* , you will need a "Hardware Support Package". This HSP can be obtained from the Internet using the corresponding function in *STEP 7*.

NOTE

Operation under S7 F systems is not approved.

NOTE

The data exchange with "F-DX-MOD" is not supported.

Software for configuration of the F-CM AS-i Safety ST

Configuration software	Requirements	Installation information
STEP 7 (classic) V5.5 SP3 HF4 or higher with Distributed Safety	Hardware Support Package HSP 2093[1)] Internet	Online Help for *STEP 7*
STEP 7 (classic) V5.5 SP4 or higher with Distributed Safety		
STEP 7 (TIA Portal) V13 or higher with Safety Advanced	Hardware Support Package HSP 70[1)] Internet (http://support.automation.siemens.com/WW/view/en/29156492/133100)	
STEP 7 (TIA Portal) V14 or higher with Safety Advanced / Basic		

[1)] Download optional, if not already contained in the hardware catalog

NOTE

Observe the online help on *STEP 7*.

The "S7 F-Configuration Pack" can be found on the Internet (http://support.automation.siemens.com/WW/view/en/15208817).

Procedure

1. Assign the parameters of the F-CM AS-i Safety ST module according to your safety application.
2. Configure the AS-i Master in such a way that it includes all AS-i slaves in the communication – including the control addresses for safe AS-i outputs that are activated in the F-CM AS-i Safety ST module.
3. Download the hardware configuration to the PLC-CPU.
4. Assign the associated F-address to the F-CM AS-i Safety ST module.
5. Start the teaching and transferring of the code sequences of the safe AS-i input slaves.
6. Create the safety program in the F-CPU.
7. Test your application.

Information concerning these steps can be found in the following sections and in the manuals of the utilized devices.

⚠ WARNING

Failure to observe this information may result in death, severe injury, and serious property damage
Observe instructions in the programming and operating manuals

Observe the instructions in the manuals.

- Programming and Operating Manual SIMATIC Safety - Programming and Configuring (http://support.automation.siemens.com/WW/view/en/54110126/0/en)
- Programming and Operating Manual S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)

See also

HSP WinCC "classic" (http://support.automation.siemens.com/WW/view/en/23183356)

5.2 Safety-related communication with AS-Interface

5.2.1 Operating principle of code sequences of safe AS-i slaves

For realization of safety-related communication, each safe AS-i input slave sends a code sequence over the AS-i bus. To prevent a mix-up of the AS-i input slaves on an AS-i bus, each AS-i input slave sends a different code sequence. The code sequences are permanently stored in the AS-i input slave.

The F-CM AS-i Safety ST module checks every code sequence for correct data content. Depending on the result of the evaluation, the module sets the the safe input image.

During initial commissioning, the F-CM AS-i Safety ST module must teach the code sequences of all safe AS-i input slaves present on the AS-i bus and transfer them to non-volatile memory. In so doing, the module detects both the slaves for which input monitoring is activated as well as the other safe input slaves.

After replacement of a safe AS-i input slave, the new code sequence must be taught and saved.

If the code sequence is not saved for a safe AS-i input slave, or if the code sequence does not correspond to the saved code sequence, the input channel will be passivated and assigned the substitute value "0".

As soon as the F-CM AS-i Safety ST module detects a new code sequence, the code sequences are automatically taught. Confirm the transfer of the code sequences into the memory to prevent unauthorized changes to the AS-i component.

You will find more information about teaching code sequences, and the LED behavior, in Section "Code sequences (Page 64)".

You can find a description of the individual parameters in the Section "Process signal errors (Page 16)".

5.2.2 Operating principle of the safe AS-i outputs

Safety-related communication for safe AS-i outputs also uses code sequences. However, they have a different data structure compared to the code sequences of safe AS-i input slaves. The code sequences for safe AS-i outputs do not have to be taught and transferred.

For the function of a safe AS-i output, you need the following components:

- A control unit
- An evaluation unit

Control unit

The control unit outputs safety-related IN or OUT control commands to the AS-i bus. The control unit is integrated in the F-CM AS-i Safety ST module. The control unit assumes an active position in the communication. It acts like an AS-i slave and has an AS-i address that must be called by the AS-i master. The values in the output data of the AS-i master are not relevant in this case. The F-CM AS-i Safety ST module inserts the safety-related control data into the communication data.

Besides controlling the OFF state according to specification, a control unit can control up to four different output switching states: F-OUT 1, F-OUT 2, F-OUT 3, and F-OUT 4. The F-CM AS-i Safety ST module, however, makes available only the output switching state F-OUT 1, i.e., The OFF and ON states are controlled.

In addition to the switching states, a control unit can send out two different auxiliary signals: AUX1 and AUX2. You can use these auxiliary signals for error acknowledgement in the evaluation unit. For technical reasons, the AUX1 and AUX2 signals are mapped in the safe process image output. The auxiliary signals are not safety-related signals, however. During control by the safety program, the F-CM AS-i Safety ST module sends a sequence from each auxiliary signal one after the other on the AS-i bus. Up to 16 different control units can be activated in the F-CM AS-i Safety ST module. The control units are managed in the F-CM AS-i Safety ST module as switching group 0 to switching group 15.

If you want to use more than 16 different control units, you can plug two F-CM AS-i Safety ST modules into the ET 200SP station.

Observe the information on the bus configuration in Section AS-i bus configuration with multiple F-CM AS-i Safety ST modules (Page 30).

NOTICE
Uniqueness of the AS-i address on the AS-i bus Carefully check the AS-i addresses for the control of the safe AS-i outputs. Ensure that the assigned AS-i address exists only once on the AS-i bus. This is particularly important when you are using multiple devices that can control safe AS-i outputs on the same AS-i bus. If this is not observed, reliable shutdown of a safe output module is not guaranteed.

Evaluation unit

The evaluation unit reads the safety-related control commands ON or OFF on the AS-i bus and passes corresponding switching commands, e.g., to switching contacts. In case of error, e.g., communication error on the AS-i bus, the evaluation unit switches off. The evaluation unit is integrated in the safe AS-i output module to which, for example, drive contactor coils are connected. The evaluation unit behaves as a passive unit in the AS-i communication. The master does not detect the evaluation unit and does not call it. The evaluation unit monitors the communication of the AS-i address of the control unit and reacts to its safety-related control signals.

You set the AS-i address (see Section "Control unit") the evaluation unit is to monitor.

You can set multiple evaluation units to the same address so that a control unit can control multiple safe output modules simultaneously.

NOTICE
Bus cycle time for safe AS-i outputs An evaluation unit requires a minimum AS-i bus cycle time. Ensure that at least 5 AS-i addresses are present on the AS-i bus. Otherwise, the control unit goes to error state. When A/B slaves are used, at least 5 different numerical AS-i addresses must be present. That is, a combination of slave addresses 1A and 1B count as 1 numerical address. The F-CM AS-i Safety ST module does not have a monitoring function for this configuration rule.

5.3 AS-i bus configuration with multiple F-CM AS-i Safety ST modules

The F-CM AS-i Safety ST module generates an additional physical bus load on the AS-i cable.

To avoid faults due to too low levels of the communication signals on the AS-i cable, the entire bus load on the AS-i cable must not exceed a maximum value.

The following rules apply to the determination of the physical bus load on the AS-i cable:

Device type	Bus load value
Slave with A/B address	0.5
Slave with standard address	1.0
F-CM AS-i Safety ST module	2.5
Maximum value as sum of all devices	35.0

Determine the total bus load by adding the bus load values of the components connected to the AS-i cable. You do not have to include the standard AS-i master and AS-i power supply unit system components when calculating the bus load.

To avoid disturbances, the maximum bus load must not exceed the value 35.

The bus load value of the F-CM AS-i Safety ST module remains unchanged if switching groups are activated in the F-CM AS-i Safety ST module for control of safe outputs. In other words, the internally generated AS-i addresses do not influence the bus load value.

If you connect additional components, e.g., an MSS 3RK3 modular safety system, to the AS-i cable, you must take into consideration the bus load values of these components. For more detailed information, refer to the relevant manual.

When a repeater is used, this yields multiple cable segments for which the bus load can be determined separately.

The following configuration examples result from the table:

- In a fully expanded AS-Interface network configuration (with 31 slaves with standard address), you can install 1 F-CM AS-i Safety ST module.
- In an AS-Interface network configuration with 30 slaves with standard address, you can install 2 F-CM AS-i Safety ST modules.

5.4 Configuring with STEP 7 (classic)

With *STEP 7* (classic) the F-CM AS-i Safety ST module is configured independently of the configuration of further ET 200SP modules, e.g. CM AS-i Master ST.

If a safe AS-i slave, which is not available on the connected AS-i network, is configured on the F-CM AS-i Safety ST module, then this configuration error is not recognized when compiling the configuration. The F-CM module does not report that the slave cannot be detected until operation is in progress or code sequences are being read.

5.5 Configuring with the TIA Portal

TIA Portal V13 SP1

With TIA Portal V13 SP1, an F-CM AS-i Safety module can only be configured in combination with an AS-i master, necessitating the configuration of the AS-i slaves in STEP 7.

The AS-i subnet of the AS-i master, including the configured AS-i slaves, must be linked to the configuration with the F-CM.

The safety parameters of the AS-i input slaves are set in the properties window of the AS-i slaves.

TIA Portal V14 or higher

From TIA Portal V14 onwards, an F-CM AS-i Safety module can be configured:

- In combination with an AS-i Master, necessitating the configuration of the AS-i slaves in STEP 7. The AS-i subnet of the AS-i master, including the configured AS-i slaves, must be linked to the configuration with the F-CM.
  The safety parameters of the AS-i input slaves are set in the properties window of the AS-i slaves.
- Regardless of an AS-i master, i.e. no configuration of the AS-i slaves in STEP 7 is required. In this case, the parameters of the AS-i input slaves are set in the properties window of the F-CM AS-i Safety ST module.

In the case of safe inputs/outputs, the "Configuration status" output field in the properties of the F-CM reports whether the configuration of the F-CM is compatible with the configuration of the connected AS-i subnet. If a safe AS-i slave, which is not available on the connected AS-i network, is configured on the F-CM module, then the compilation of the configuration is nevertheless still possible. During operation or when reading the code sequences, however, the F-CM module reports that the slave cannot be detected.

The affected input address is passivated.

Configuration of safe AS-i outputs

The F-CM module contains a control unit for the safe AS-i outputs, see Section "Functional principle of the safe AS-i outputs (Page 28)".

TIA Portal V13 SP1

When configuring with TIA Portal V13 SP1, this control unit is not visible in the network view on the AS-Interface subnet of the AS-i master. The configuration of the F-CM module, however, is always combined with the AS-i master.

TIA Portal V14 or higher

In TIA Portal V14 or higher, the control unit must additionally be configured as a virtual slave on the AS-i subnet of the master, in the event that the AS-i slaves are configured in STEP 7.

A virtual slave is inserted automatically if a safe AS-i output is activated in the properties of the F-CM module and the F-CM module is already linked with the AS-i subnet. If necessary, by using the "Add AS-i Slave to AS-i network" button, the virtual slave can be inserted in the properties of the F-CM module under "Safe outputs". If no AS-i subnet is connected to the F-CM when the "Add AS-i slave to AS-i network" button is actuated, a subnet is automatically inserted.
The virtual slave can be managed like any other slave on the subnet, which means that all AS-i slave addresses existing in the AS-i subnet are visible. The virtual slave can be deleted if the control of the safe AS-i output is no longer required.

If necessary, the virtual slave can also be inserted straight from the hardware catalog (3RK7136-6SC00-0BC1F-DQ) into the subnet of the master.

NOTE

The virtual slave 3RK7136-6SC00-0BC1F-DQ is not a hardware module that is connected to the AS-i cable, but only a tool for the configuration of the AS-i master. The AS-i address assigned to the virtual slave 3RK7136-6SC00-0BC1F-DQ is emulated in the F-CM AS-i Safety module as soon as the corresponding safe output is activated in the properties of the F-CM.

If the AS-i master is engineered without configuring the AS-i slaves in STEP 7, i.e. either configuration of the AS-i slaves via the "SET" button or via the control panel in the TIA Portal, then the secure outputs in the F-CM must be configured and must have been loaded into the station before the configuration of the AS-i slaves is read into the master by means of the "SET" button or via the control panel in the TIA Portal.

Assigning parameters / Setting the address space 6

6.1 Parameters

List of parameters

Table 2-1946 F-parameters

Parameter	Value range	Default setting	Parameter reassignment in RUN	Scope
F-monitoring time (ms)	1 ... 65534 ms	150 ms	No	F-CM AS-i Safety ST
F-source address	1 ... 65534	Assigned by the F-system	No	F-CM AS-i Safety ST
F-destination address	1 ... 65534	Is suggested by the F-system	No	F-CM AS-i Safety ST

For information on the F-parameters and the assignment of the F-address, refer to the Programming and Operating Manuals:

- SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126).
- S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)

Table 2-1947 Potential group / AS-i network

Parameter	Value	Default setting	Parameter reassignment in RUN	Scope
BaseUnit with AS-i voltage supply	Potential group: The AS-i network of the left module (dark BaseUnit) is used New potential group: New AS-i network (light BaseUnit)	The AS-i network of the left module (dark BaseUnit) is used	No	F-CM AS-i Safety ST

Table 2-1948 Module parameters: Behavior after channel faults

Parameter	Value	Default setting	Parameter reassignment in RUN	Scope
Behavior after channel faults	Passivate the channel (setting cannot be changed).	Passivate the channel	-	F-CM AS-i Safety ST

Safe inputs

Up to 31 safe AS-i input slaves are monitored. Open the settings for each required AS-i address. Activate the input monitoring and assign the parameters.

Table 2-1949 Module parameters: Safe inputs, AS-i address 1 to 31

Parameter	Value	Default setting	Parameter reassignment in RUN	Scope
Activate input monitoring	• Disable • Enable	Disable	No	If this parameter is not activated, none of the following settings are possible.
I address	Output field, value is calculated automatically	-	No	Channel / safe AS-i input slave
Input delay (ms)	0 ms, 50 ms ... 150 ms[1]	0 ms	No	Channel / safe AS-i input slave
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation, equivalent	1oo2 evaluation	No	Channel / safe AS-i input slave
Startup test	• Disable • Enable	Disable	No	Channel / safe AS-i input slave
Discrepancy monitoring	• Disable • Enable	• "Disable" if 1oo1 evaluation • "Enable" if 1oo2 evaluation	No	Channel / safe AS-i input slave
Discrepancy behavior	Supply "0" value[2]	Supply "0" value	-	Channel / safe AS-i input slave
Discrepancy time infinite	• Disable • Enable	Disable	No	Channel / safe AS-i input slave
Discrepancy time (ms)	0 ms ... 60 000 ms	500 ms	No	Channel / safe AS-i input slave
Sequence monitoring	• Deactivated • In ascending order (input 1 before input 2 at HIGH state) • In descending order (input 2 before input 1 at HIGH state)	Deactivated	No	Channel / safe AS-i input slave
Reintegration after discrepancy error	Test 0 signal necessary on both channels[2]	Test 0 signal necessary on both channels	-	F-CM AS-i Safety ST
Configuration status	-	-	-	(read-only)

[1] In increments of 10 ms

[2] The setting cannot be changed.

Safe outputs

You can activate up to 16 safe AS-i switching groups Open the settings for each required switching group. Activate the output control and set the associated AS-i address.

Table 2-1950 Safe outputs: Switching group 0 to 15

Parameter	Value	Default setting	Parameter reassignment in RUN	Scope
Activate output control	• Disable • Enable	Disable	No	If this parameter is not activated, none of the following settings are possible.
AS-i address	1 ... 31		No	Channel / safe AS-i output slave
AS-i address switching output	Output field, value is calculated automatically	-	No	Channel / safe AS-i output slave
AS-i address error acknowledgement	Output field, value is calculated automatically	-	No	Channel / safe AS-i output slave
Configuration status	-	-	-	(read-only)

You will find additional information in the Programming and Operating Manuals:

- SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)
- S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)

6.2 Explanation of the parameters

6.2.1 F-parameters

Specify F-destination address for F-I/O of the PROFIsafe address type 2

The F-destination address of F-I/O of the PROFIsafe address type 2 is automatically assigned for every F-CPU.

F-source address

With the parameter "Central F-source address" you specify the F-source address for the F-I/O of the PROFIsafe address type 2 assigned to this F-CPU. The F-source address must be unique throughout the network.

NOTE

A change to the parameter "Central F-source address" results in a modification to the safety program when it is recompiled. A new acceptance may therefore be required, as this centrally modifies the F-source address of all F-I/O devices of address type 2 retrospectively.

See also

S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)
SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126/0/en)

6.2.2 Potential group / AS-i network

Here, you set:

- The BaseUnit you are using.
- How the F-CM AS-i Safety ST I/O module is connected to the AS-i network.

The module can be connected to the AS-i cable by external wiring or automatically via the module plugged in on the left.

- Enable new AS-i network (light BaseUnit)
- Use AS-i network of the left module (dark BaseUnit)

BaseUnit with voltage supply

Enable new AS-i network (light BaseUnit)

Select this option if the module is plugged into a light BaseUnit.

Connect the module to the AS-i cable (ASI+ / ASI-) via the BaseUnit. The module is supplied with voltage from the AS-i cable. Connect the AS-i cable to an AS-i power supply unit or to a combination of a data decoupling unit and a suitable power supply unit.

There is no module-internal connection of the AS-i cable to the module plugged in on the left.

With TIA Portal or with STEP 7 (classic) the F-CM AS-i Safety module is configured independently of the configuration of the module inserted on the left (normally: CM AS-i Master ST).

⚠ WARNING

Connection of the BaseUnit only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition

Connect the BaseUnit only to AS-i power supply units that meet the requirements named in Section Terminal assignment (Page 21), "Power supply units for AS-Interface". Connection to higher voltage may result in death, severe injury, and serious property damage.

Use AS-i network of the left module (dark BaseUnit)

Select this option if the module is plugged into the dark BaseUnit.

The module inserted on the left must be a CM AS-i Master ST module (normal situation) or another F-CM AS-i Safety ST module (special case).

The module is connected to the AS-i cable of the module plugged in on the left and supplied with voltage via the module-internal connection.

The module-internal connection is designed only for supplying power to the F-CM AS-i Safety ST I/O module. If several dark BaseUnits are connected in series, a direct connection of the dark BaseUnits to the AS-i cable using external wiring is additionally recommended.

Supplying power to AS-i modules, e.g., AS-i slaves, via the terminals of the dark BaseUnit is not permitted.

With TIA Portal, the F-CM AS-i Safety ST module uses the same AS-Interface subnet as the module inserted on the left (normally: CM AS-i Master ST).

With STEP 7 (classic) the F-CM AS-i Safety module is configured independently of the configuration of the module inserted on the left (as a rule: CM AS-i Master ST).

WARNING

Connection of the BaseUnit only to safety extra-low voltage with limiting of output voltage to max. 40 V under fault condition

Connect the BaseUnit only to AS-i power supply units that meet the requirements named in Section Terminal assignment (Page 21), "Power supply units for AS-Interface". Connection to higher voltage may result in death, severe injury, and serious property damage.

6.2.3 Module parameters - General

Behavior after channel faults

This parameter is permanently set to "Passivate the channel".

After channel faults have occurred, only the faulty PROFIsafe channels are passivated. The PROFIsafe channel corresponds to the safe input and output address in the process image.

6.2.4 Module parameters - Safe inputs

Configuration status

A valid evaluation is only possible if a compatible safe AS-i slave is actively operating on the network.
Input monitoring where there is a missing safe input or a missing AS-i slave causes a passivation of the input address. If no configuration of the slaves is saved in the STEP 7 project, the settings of the AS-i master must ensure that the connected compatible safe AS-i slave is actively operating, for example, using the "SET" button of the master.

Input monitoring activated

With activation of the input monitoring, you activate the corresponding AS-i slave as an input channel for signal processing in the safety program. The AS-i address must be assigned to a safe AS-i input slave.

When the input monitoring is activated, the value of the input channel is calculated based on the input states of the assigned safe AS-i input slave and the evaluation conditions specified by the parameter assignment. If a fault occurs, the substitute value "0" is transferred and the channel is passivated.

If input monitoring is deactivated, the substitute value "0" is transferred. The channel is not passivated.

If required, the AS-i slave can be monitored by another evaluation module, e.g., by another F-CM AS-i Safety ST module, the 3RK3 Modular Safety System. This applies both when input monitoring is deactivated and when it is activated.

NOTE

Call of the AS-i slave

The AS-i slave must be called by the AS-i master. Set up the configuration of the AS-i master in such a way that the communication of the AS-i master with the AS-i address functions properly.

NOTE

Slave profile

A safe AS-i input slave has the slave profile (IO.ID) = 0.B or 7.B.

I address

The input bit address of the input channel for the signal processing in the safety program is indicated here. It is calculated automatically from the start of the inputs entered on the "Addresses" tab.

Input delay

To suppress coupled-in interference or brief switching pulses, you can set an input delay for each AS-i slave. This will suppress interference pulses whose pulse time is less than the set input delay, in ms. The input delay applies to both channels of the channel pair of the AS-i slave.

NOTE

Time of fault suppression shortened by up to 75 ms

It can take 15 AS-i cycles until the valid code sequence is detected. As a result, the time of the fault suppression is shortened by up to 75 ms compared to the set value.

A long input delay suppresses longer interference pulses but results in a longer response time.

Range of values:	0 to 150 ms
Default	0 ms

The values 0, 50 to 150 ms can be selected in 10 ms increments.

The input delay time acts in addition to the system response time. Suppressed interference pulses are not visible in the safety program.

Evaluation of the sensors

This parameter specifies how the connected sensors are to be evaluated.

1oo1 evaluation

In 1oo1 evaluation, the sensor exists once and is connected to the first input of the safe AS-i slave via a single channel. You jumper the second input of the AS-i slave. Instead of the jumper, you can also connect another single-channel sensor to the second input. Only when both inputs supply an ON signal does the F-CM AS-i Safety ST module transfer the "1" value to the safety program (the two inputs are ANDed).

The individual states of the two inputs of the AS-i slave are not visible in the safety program.

A discrepancy analysis is not performed in 1oo1 evaluation.

1oo2 evaluation, equivalent

In 1oo2 (2v2) evaluation, equivalent, both inputs of the safe AS-i slave are occupied by one two-channel sensor or by two single-channel sensors. The two single-channel sensors then belong together functionally as a pair.

The input signals are compared internally for equivalence. The two inputs of the AS-i slave are combined to form a channel pair.

A discrepancy analysis is possible in 1oo2 evaluation, equivalent.

Discrepancy analysis

If you are using a two-channel sensor or two single-channel sensors that acquire the same physical process variable, the sensors will, for example, respond with a delay due to the limited accuracy of their arrangement to each other. For fail-safe inputs, the discrepancy analysis for equivalence is used to infer errors from the time characteristic of two signals of the same functionality. For two associated input signals, if different levels are detected after the input delay time has expired, the discrepancy analysis is started. A check is made to determine if the difference has disappeared after expiration of an assignable time period, the so-called discrepancy time. If not, there is a discrepancy error.

Startup test

If the "Startup test" parameter is activated, after startup of the channel or after a cross-circuit error (code sequence error), the value transferred to the safety program is kept at the substitute value "0" until the connected sensor has been correctly actuated at least once. Afterwards, the value of the input channel is calculated according to the set functionality.

The actuation of the sensor is defined to mean that both inputs of the safe AS-i slave must supply an ON signal, e.g., both switching contacts of the sensor are closed. Then, they must supply an OFF signal, e.g., switching contacts open. Finally, an ON signal must be supplied again, e.g., switching contacts closed. During the sensor actuation phase, none of the following errors may occur:

- Discrepancy error
- Sequence error
- Cross-circuit error (code sequence error)

After reintegration is complete, you must perform a startup test. For this purpose, you actuate the sensor to be monitored once.

A discrepancy error or a sequence monitoring error does not trigger a new startup test.

Discrepancy monitoring

If the discrepancy monitoring is activated, a discrepancy analysis is performed. This is the normal setting for 1oo2 evaluation, equivalent, in order to achieve high error uncovering.

You can deactivate the discrepancy monitoring for special situations. This corresponds in principle to 1oo1 evaluation of sensors. Check whether the lower error uncovering is sufficient for the required safety level. You may possibly use a sensor with integrated error uncovering. If required, you can activate the sequence monitoring.

When 1oo2 evaluation of the sensors is set, discrepancies in signal states between input 1 and input 2 are monitored.

When discrepancy monitoring is activated, the discrepancy time starts to elapse as soon as a difference is detected between the signal on input 1 and the signal on input 2. If the set discrepancy time is exceeded and the difference continues to exist, a discrepancy error is triggered.

Before switch-on, the signal value 0 must be present at both inputs, even when a discrepancy error has not occurred or the discrepancy time has not been set to "infinite".

If the "Evaluation of the sensors" parameter has been assigned with 1oo1, discrepancy monitoring is not performed.

Discrepancy behavior

This parameter is permanently set to "Supply 0 value".

The discrepancy behavior determines the value that is made available to the safety program in the F-CPU during the discrepancy, i.e., while the discrepancy time is running.

After expiration of the set input delay time, once an "OFF" signal is detected at one of the two input channels of the channel pair involved, this parameter setting causes the value "0" to be provided to the safety program in the F-CPU. This setting does not affect the sensor-actuator response time as a result of the discrepancy time.

Discrepancy time infinite

If you activate "Discrepancy time infinite", the time period for the discrepancy analysis never expires. As a result, a time-related discrepancy error will not be detected.

Nevertheless, the following switch-on condition applies: After a channel has been switched off, a "0" signal must be read in simultaneously at both input channels of the relevant channel pair before the channel can be switched on again.

If this condition is not satisfied, especially in the event of a single-channel switch-off (i.e., signal OFF at only one of the two input channels of the relevant channel pair) followed by a change to signal ON at both input channels, a discrepancy error will be detected at the time of the change to signal ON (at both input channels) even though the time for the discrepancy

analysis has not expired. In data record 202, the bit 0.2 "= 1" is set in the status of the input monitoring of AS-i address n.

A discrepancy error is only detected if both input channels of the affected channel pair have not received the "0" signal simultaneously.

If "Discrepancy time infinite" is deactivated, the discrepancy analysis uses the value set for the "Discrepancy time" parameter.

Discrepancy time

You can specify the discrepancy time in the range of 0 to 60 000 ms for each channel pair.

The following settings are required:

- "Sensor evaluation": 1oo2 evaluation, equivalent
- "Discrepancy monitoring": Active
- "Discrepancy time infinite": Deactivated

In most cases, the discrepancy time is started but does not completely elapse, because the signal differences are evened out again after a short time.

Select a large enough discrepancy time so that in error-free cases, the difference between the two signals always disappears before the discrepancy time expires.

If the input signals do not match after expiration of the assigned discrepancy time, e.g., due to a mechanical defect of the sensor or sensor wire break, a discrepancy error is detected.

When discrepancy time is running, the switch-on condition also applies that after a channel has been switched off, a "0" signal must be read in simultaneously at both input channels of the relevant channel pair before the channel can be switched on again. If this condition is not satisfied, especially in the event of brief switch-off of a channel (due to signal OFF at only one of the two input channels) followed by a change to signal ON at both input channels, a discrepancy error will be detected at the time of the change to signal ON (at both input channels) if the time for the discrepancy analysis has not expired.

A detected discrepancy error indicates to the user that the switch-on condition is not satisfied.

Assign a discrepancy time that is greater than the input delay time.

Sequence monitoring

Overview

The sequence monitoring monitors the sequence of the signals of the channel pair when there is a signal change OFF >>> ON at the inputs of the safe AS-i slave.

The following settings are possible:

- Deactivated: The sequence is not a condition that has to be satisfied for switching on the function output.
- Ascending order: Input 1 before input 2 at "HIGH" state
- Descending order: Input 2 before input 1 at "HIGH" state

If the sequence is violated, the "Sequence condition violated" error is detected. The value transferred to the safety program is kept at "0" until the "OFF" signal is read in at both input

channels. Switch-on condition is, for example, both switching contacts of the sensor open. The inputs must be switched on one after the other in the assigned sequence and must not switch on simultaneously.

You can activate the sequence monitoring if 1oo2 evaluation, equivalent, is set for the sensor evaluation. In this case, the discrepancy monitoring can be activated or deactivated.

Deactivated

The sequence of the inputs is not monitored.

Ascending order: Input 1 before input 2 at "HIGH" state

For switch-on of the channel, input channel 1 must first read in and hold an "ON" signal followed by input channel 2.

When the channel is switched off, the sequence of the input channels is not monitored.

Descending order: Input 2 before input 1 at "HIGH" state

For switch-on of the channel, input channel 2 must first read in and hold an "ON" signal followed by input channel 1.

When the channel is switched off, the sequence of the input channels is not monitored.

Reintegration after discrepancy error

This parameter is permanently set to: "Test 0-signal necessary on both channels".

A discrepancy error is not considered to be rectified until an "OFF" signal is present again at both input channels. Reintegration of the PROFIsafe channel is then possible.

6.2.5 Module parameters - Safe outputs

Configuration status

For operation of the switching group the AS-i master must activate communication with the associated AS-i address of the control unit in the F-CM. For this reason the configuration of the AS-i network must include a virtual AS-i slave with the profile IO.ID.ID2 = 6.B.D and ID1 = 0. If the slaves are not configured, the AS-i master must be set such that the AS-i address of the control unit in the F-CM is actively operating, for example, using the "SET" button of the master while the F-CM module is being configured and connected to the AS-i master.

Activate output control

With this parameter, you activate the corresponding switching group and the associated AS-i address of the control unit in the F-CM AS-i Safety ST module.

You will find additional information in Section Operating principle of the safe AS-i outputs (Page 28), "Operating principle of the safe AS-i outputs."

When output control is activated, the control unit in the F-CM AS-i Safety ST module is switched on so that the F-CM AS-i Safety ST module generates an additional AS-i address on the AS-i Bus. The associated value is output from the safe process image via this AS-i address.

When output control is deactivated, the corresponding control unit in the F-CM AS-i Safety ST module is switched off, and an AS-i slave is not emulated on the AS-i bus.

AS-i address

Here, you set the AS-i address within the range of 1 to 31 that the F-CM AS-i Safety ST module is to use for control of a safe AS-i output.

WARNING

Uniqueness of the AS-i address on the AS-i bus

Carefully check the AS-i addresses for the control of the safe AS-i outputs. Ensure that the assigned AS-i address exists only once on the AS-i bus. This is particularly important when you are using multiple devices that can control safe AS-i outputs on the same AS-i bus. If this is not observed, reliable shutdown of a safe output module is not guaranteed.

NOTE

Communication of the AS-i master with the AS-i address

The AS-i address of the control unit must be called by the AS-i master. Set up the communication of the AS-i master in such a way that communication with the AS-i address of the control unit functions properly.

NOTE

Slave profile of the control unit in the F-CM AS-i Safety ST module (control of a safe AS-i output)

The AS-i address of the control unit corresponds to a slave with slave profile (IO.ID.ID2) = 6.B.D and ID1 = 0.

Q address switching output

The output bit address is displayed here. It determines the switching state of the safe output (control signal F-OUT 1). Interconnect the "Q address switching output" in your safety program according to the required safety logic.

The output bit address is calculated automatically from the start of the outputs entered on the "Addresses" tab.

Q address error acknowledgment

The output bit address that sends an acknowledgment signal to the safe output is displayed here.

The output bit address is calculated automatically from the start of the outputs entered on the "Addresses" tab.

A positive edge (0 >>> 1) triggers the F-CM AS-i Safety ST module to first send the AUX1 auxiliary signal to the safe output followed by the AUX2 auxiliary signal. Another positive edge is necessary for sending another sequence of auxiliary signals.

The auxiliary signals are used, in general, for acknowledging an error state at the safe output. Refer to the AS-Interface (http://support.automation.siemens.com/WW/view/en/26250840/0/en) System Manual and the Operating Instructions of the safe output module (http://support.automation.siemens.com/WW/view/en/43666143/0/en) used to find out which functions the auxiliary signals are used for.

NOTE

"Q address error acknowledgment"

The "Q address error acknowledgment" does not trigger an error acknowledgment in the F-CM AS-i Safety ST module. Rather, as described above, it sends an acknowledgement signal to the safe output module on the AS-i bus.

See also

ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en)

6.3 Address space

6.3.1 Address assignment for user data and value status of the F-CM AS-i Safety ST module

Input and output address assignment

Of the assigned addresses of the F-CM AS-i Safety ST module, the user data occupy the following addresses in the F-CPU:

Table 2-1951 Input address assignment in the F-CPU

Byte in the F-CPU	Assigned bits in the F-CPU per F-CM AS-i Safety ST module							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
x + 0	DI0.7 AS-i address 7	DI0.6 AS-i address 6	DI0.5 AS-i address 5	DI0.4 AS-i address 4	DI0.3 AS-i address 3	DI0.2 AS-i address 2	DI0.1 AS-i address 1	DI0.0 Reserved
x + 1	DI1.7 AS-i address 15	DI1.6 AS-i address 14	DI1.5 AS-i address 13	DI1.4 AS-i address 12	DI1.3 AS-i address 11	DI1.2 AS-i address 10	DI1.1 AS-i address 9	DI1.0 AS-i address 8
x + 2	DI2.7 AS-i address 23	DI2.6 AS-i address 22	DI2.5 AS-i address 21	DI2.4 AS-i address 20	DI2.3 AS-i address 19	DI2.2 AS-i address 18	DI2.1 AS-i address 17	DI2.0 AS-i address 16
x + 3	DI3.7 AS-i address 31	DI3.6 AS-i address 30	DI3.5 AS-i address 29	DI3.4 AS-i address 28	DI3.3 AS-i address 27	DI3.2 AS-i address 26	DI3.1 AS-i address 25	DI3.0 AS-i address 24
x + 4	Value status for DI0.7	Value status for DI0.6	Value status for DI0.5	Value status for DI0.4	Value status for DI0.3	Value status for DI0.2	Value status for DI0.1	Reserved
x + 5	Value status for DI1.7	Value status for DI1.6	Value status for DI1.5	Value status for DI1.4	Value status for DI1.3	Value status for DI1.2	Value status for DI1.1	Value status for DI1.0

X = Module start address

Byte in the F-CPU	Assigned bits in the F-CPU per F-CM AS-i Safety ST module							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
x + 6	Value status for DI2.7	Value status for DI2.6	Value status for DI2.5	Value status for DI2.4	Value status for DI2.3	Value status for DI2.2	Value status for DI2.1	Value status for DI2.0
x + 7	Value status for DI3.7	Value status for DI3.6	Value status for DI3.5	Value status for DI3.4	Value status for DI3.3	Value status for DI3.2	Value status for DI3.1	Value status for DI3.0
x + 8	Value status for DQ0.7	Value status for DQ0.6	Value status for DQ0.5	Value status for DQ0.4	Value status for DQ0.3	Value status for DQ0.2	Value status for DQ0.1	Value status for DQ0.0
x + 9	Value status for DQ1.7	Value status for DQ1.6	Value status for DQ1.5	Value status for DQ1.4	Value status for DQ1.3	Value status for DQ1.2	Value status for DQ1.1	Value status for DQ1.0
x + 10	Reserved							
...								
x + 15	Reserved							

X = Module start address

NOTICE

Process value "0" is transmitted as a non-safety related value

Based on the transfer principle of the code sequences, the process value "1" is transferred via AS-Interface as a safe value, so that the enable for switching on a machine can be issued in a safety-related manner. If an error occurs during transfer of the value "1", this error is detected and substitute value "0" is used.

The process value "0" is transferred via AS-interface as an unsafe value. That is, a faulty transmission of the "0" value cannot be detected. The "0" value must therefore not be used as safety-related information that initiates a dangerous action (e.g. feedback "0" of a switch position).

Table 2-1952 Output address assignment in the F-CPU

Byte in the F-CPU	Assigned bits in the F-CPU per F-CM AS-i Safety ST module							
	Bit 7	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
x + 0	DQ0.7 Switching group 7	DQ0.6 Switching group 6	DQ0.5 Switching group 5	DQ0.4 Switching group 4	DQ0.3 Switching group 3	DQ0.2 Switching group 2	DQ0.1 Switching group 1	DQ0.0 Switching group 0
x + 1	DQ1.7 Switching group 15	DQ1.6 Switching group 14	DQ1.5 Switching group 13	DQ1.4 Switching group 12	DQ1.3 Switching group 11	DQ1.2 Switching group 10	DQ1.1 Switching group 9	DQ1.0 Switching group 8
x + 2	Error acknowledg-ment for DQ0.7	Error acknowledg-ment for DQ0.6	Error acknowledg-ment for DQ0.5	Error acknowledg-ment for DQ0.4	Error acknowledg-ment for DQ0.3	Error acknowledg-ment for DQ0.2	Error acknowledg-ment for DQ0.1	Error acknowledg-ment for DQ0.0
x + 3	Error acknowledg-ment for DQ1.7	Error acknowledg-ment for DQ1.6	Error acknowledg-ment for D1.5	Error acknowledg-ment for DQ1.4	Error acknowledg-ment for DQ1.3	Error acknowledg-ment for DQ1.2	Error acknowledg-ment for DQ1.1	Error acknowledg-ment for DQ1.0

X = Module start address

The error acknowledgment bit initiates the AUX1 and AUX2 signals one after the other.

Byte in the F-CPU	Assigned bits in the F-CPU per F-CM AS-i Safety ST module							
	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
x + 4	Reserved							
...								
x + 7	Reserved							

X = Module start address

The error acknowledgment bit initiates the AUX1 and AUX2 signals one after the other.

NOTE

Use of the error acknowledgment bit of a safe AS-i output

The values in the PROFIsafe process output image have Safety Integrity Level SIL 3. In addition to the switching states, a control unit can send out two different auxiliary signals to a safe AS-i output: AUX1 and AUX2. These auxiliary signals are not safety-related signals. You can use the auxiliary signals for error acknowledgement in the evaluation unit. For technical reasons, these error acknowledgment bits are mapped in the safe process output image. If error acknowledgment bits are sent to a safe AS-i output, the *STEP 7* or SIMATIC Manager configuration tool is unable to detect that the error acknowledgment bits are not safe. This means: No warnings or faults will be output for it when the safety application is generated. The user is responsible for the correct processing of these signals in the safety application.

6.3.2 Value status

Properties

For each input signal and output signal, the F-CM AS-i Safety ST module provides information about the signal's validity, i.e., the "value status". Like the input signal, the value status is stored in the process image.

Value status for the digital input and output modules

The value status is binary supplementary information of a digital input or output signal. It is entered in the process input image simultaneously with the process signal. The value status provides information regarding the validity of the input or output signal.

The value status is influenced by the following:

- Code sequence errors, e.g, caused by a permanent fault on the AS-i bus, wiring error, etc.
- Missing safe AS-i input slaves
- Channel faults
- Replacement of a safe AS-i slave by a non-safe AS-i slave
- Discrepancy error
- Sequence error

Value status = 1: A valid process value is output for the channel.

Value status = 0: A substitute value is output for the channel or the channel is deactivated.

Assignment of the inputs and outputs to the value status in the process image

A value status is assigned to each channel of the F-CM AS-i Safety ST module in the process input image.

Additional information

A detailed description of the evaluation and processing of the value status can be found in the Programming and Operating Manual SIMATIC Safety - Programming and Configuring (http://support.automation.siemens.com/WW/view/en/54110126/0/en).

See also

Address assignment for user data and value status of the F-CM AS-i Safety ST module (Page 44)

6.4 Data records for diagnostics

For diagnostic purposes, you can read out the following data records via your user program. In firmware V1.0.1 or higher the diagnostics data record 206 is available. This data record contains a summary of the information that is relevant for a comprehensive diagnosis via your user program.

NOTE

Use of the DS 206 for diagnostic purposes is recommended (firmware V1.0.1 or higher).

The data records 92, 202 and 204 are required for the diagnosis via the user program for a module with firmware V1.0.0. For reasons of compatibility, these data records also remain available in firmware V1.0.1 or higher.

See also

Firmware update (Page 19)

6.4.1 DS 92 Device-specific diagnostics

Meaning

NOTE

Use of the data set 206 is recommended for diagnosis via the user program (firmware V1.0.1 or higher).

Data record 92 contains device-specific messages and information on the device function states of the F-CM AS-i Safety ST module.

For some events, the F-CM AS-i Safety ST module generates a diagnostic alarm.

The following applies for diagnostic alarms of the F-CM AS-i Safety ST module with firmware V1.0.0:

- The "Error code" column in the table below indicates which events are relevant here. If the associated bit changes in the data record, a diagnostic alarm with the indicated error code is generated (incoming alarm when bit changes to value "1" and outgoing alarm when bit changes to value "0").
- The text inside parentheses after the error code corresponds to the error text that is specified for the given error code according to the PROFIBUS Standard. Several error codes can be output. If no error code is specified ("-"), a diagnostic alarm is not generated.
- The diagnostic alarms in firmware V1.0.1 or higher are described in Section "DS 206 Diagnostic Data Record (Page 58)".

Table 2-1953 DS 92 device-specific diagnostics

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
0.0 ... 0.7	Reserved	-	-
1.0 ... 1.7	Reserved	-	-
2.0 ... 2.7	Reserved	-	-
3.0 ... 3.7	Reserved	-	-
4.0 ... 4.7	Reserved	-	-
5.0 ... 5.7	Reserved	-	-
6.0 ... 6.7	Reserved	-	-
7.0 ... 7.7	Reserved	-	-
8.0 ... 8.7	Reserved	-	-
9.0 ... 9.7	Reserved	-	-
10.0 ... 10.7	Reserved	-	-
11.0 ... 11.7	Reserved	-	-
12.0	Serious device fault	9 ("Error")	See Section Error statuses (Page 15)
12.1	Group error	24 ("Switch-off")	At least one error is present.
12.2	AS-i communication error	19 ("Communication error")	Failure of an AS-i slave configured in the F-CM AS-i Safety ST module or code sequence error
12.3	Group_Message_Device	-	At least one message about the device state is present, e.g., configuration missing.
12.4	Group_Message_Application	-	At least one message about the application state is present, e.g., startup test necessary, safety sensor tripped (Emergency Stop, protective door, etc.).
12.5 ... 12.7	Reserved	-	-
13.0	Reserved	-	-
13.1	Device fault	24 ("Switch-off") 27 ("Unclear error")	See Section Error statuses (Page 15)

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
13.2	Parameter assignment error	24 ("Switch-off") 16 ("Parameter assignment error")	Parameter not permitted in configuration.
13.3	Process signal error	24 ("Switch-off") 27 ("Unclear error")	See Section Error statuses (Page 15)
13.4	Code sequence error	24 ("Switch-off") 26 ("External error")	A code sequence error can occur, for example, in case of: • Cross-circuit at the inputs • EMC problem Bit 18.0 is additionally set.
13.5	Logic error	24 ("Switch-off") 25 ("Safety-related switch-off")	A logic error can occur, for example, in case of: • Discrepancy error • Sequence error Bit 18.0 is additionally set.
13.6 ... 13.7	Reserved	-	-
14.0	Downloading of module parameters is not yet complete	-	-
14.1	Reserved	-	-
14.2	Cyclic data exchange is active	-	-
14.3 ... 14.7	Reserved	-	-
15 ... 17	Reserved	-	-
18.0	Group error code sequence_Logic	24 ("Switch-off")	A code sequence error or logic error is present for at least one safe input. Bytes 90 ... 91 contain the AS-i address of the first safe input for which the error is present.
18.1	Reserved	-	-
18.2	Group_Message_Input_Triggered	-	At least one monitored safe input has value status "0". Possible cause: • Startup test necessary • Safety sensor triggered Bytes 94 ... 95 contain the AS-i address of the first safe input for which the value status "0" is present.
18.3 ... 18.7	Reserved	-	-
19 ... 21	Reserved	-	-
22.0 ... 22.1	Reserved	-	-
22.2	Timeout	24 ("Switch-off") 8 ("Lower limit undershot")	An internal data processing error has occurred. The F-CM AS-i Safety ST module signals a device fault. Bit 13.2 is additionally set.
22.3 ... 22.6	Reserved	-	-

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
22.7	AS-i slave failure	26 ("External error")	No communication is detected in the case of at least one monitored safe input slave or control unit for a safe AS-i output.
23.0 ... 23.7	Reserved	-	-
24 ... 25	Reserved	-	-
26.0 ... 26.3	Reserved	-	-
26.4	Coding element error	24 ("Switch-off") 27 ("Unclear error")	A data error occurred or coding element is missing when a coding element is accessed. The F-CM AS-i Safety ST module signals a device fault.
26.5 ... 26.7	Reserved	-	-
27 ... 28	Reserved	-	-
29.0 ... 29.7	Reserved	-	-
30 ... 33	Reserved	-	-
34 ... 35	Parameter assignment error object	-	Object number for which a parameter assignment error was detected. 0 = No error 1 ... 31 = The number corresponds to the AS-i address of a safe input. 32 ... 47 = A number 32 ... 47 corresponds to the number of the switching group 0 ... 15
36 ... 37	Reserved	-	-
38.0	AS-i bus error	26 ("External error")	The AS-i data communication is interrupted, substitute values in the interconnection logic
38.1	AS-i parameter assignment error	26 ("External error")	In addition, the AS-i address of the affected AS-i slave with the lowest address is entered in byte 55. If an AS-i address of an output switching group is not included by the AS-i master in the data communication, this bit is set. A substitute value will be used instead.
38.2	AS-i configuration error	-	In addition, the AS-i address of the affected AS-i slave with the lowest address is entered in byte 39. This bit is set when SET ≠ ACTUAL on the AS-i bus, when, for example, an AS-i slave is missing. A substitute value will be used instead.

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
38.3	AS-i voltage too low	-	If the AS-i voltage is too low during operation, a serious device fault results.
38.4	Reserved	-	-
38.5	AS-i communication okay	-	-
38.6 ... 38.7	Reserved	-	-
39	Incorrect AS-i address	-	AS-i address of the AS-i slave that the device has identified as faulty: 0 = No error 1 ... 31 = AS-i slave address
40 ... 47	Reserved	-	-
48.0	ASIsafe safe input active	-	As soon as safe AS-i slaves become monitored, this bit is set.
48.1	ASIsafe safe output active	-	If safe AS-i outputs are controlled, this bit is set.
48.2 ... 48.7	Reserved	-	-
49.0	ASIsafe code sequences missing	26 ("External error")	Safe input In addition, the AS-i address is entered in byte 50.
49.1	ASIsafe code sequences duplicated	24 ("Switch-off") 19 ("Communication error")	In addition, the AS-i address is entered in byte 50.
49.2	ASIsafe code sequences new	-	New code sequences are available for transfer. In addition, the AS-i address is entered in byte 50.
49.3	ASIsafe code sequences known	-	The code sequences are taught and saved in the coding element.
49.4	ASIsafe code sequence error	24 ("Switch-off") 19 ("Communication error")	In addition, the AS-i address is entered in byte 50.
49.5	ASIsafe code sequence teaching active	-	The code sequences are being collected. When the code sequences for all safe AS-i input slaves detected on the bus are taught, this bit is reset.
49.6 ... 49.7	Reserved	-	-
50	Code sequence error object	-	This bit contains the lowest AS-i address for which a code sequence problem has occurred. Code sequence problems are: • 49.0 ASIsafe code sequences missing (Prio 3) • 49.1 ASIsafe code sequences duplicated (Prio 1) • 49.2 ASIsafe code sequences new (Prio 4) • 49.4 ASIsafe code sequence error (Prio 2)

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark
51 ... 54	Reserved	-	-
55	Switching group error object	-	This byte contains the lowest AS-i address that is configured for an output switching group but is not addressed by the master. Correct the slave configuration of the master.
56 ... 61	Reserved	-	-
62.0	F_Dest_Adr does not match	24 ("Switch-off") 19 ("Communication error") 64 ("Different destination address")	-
62.1	F_Dest_Adr invalid	24 ("Switch-off") 19 ("Communication error") 65 ("Invalid destination address")	The coding element does not contain an F-address.
62.2	F_Source_Adr invalid	24 ("Switch-off") 19 ("Communication error") 66 ("Invalid source address")	-
62.3	F_WD-Time_0	24 ("Switch-off") 19 ("Communication error") 67 ("Watchdog time is 0 ms")	F_WD-Time value is 0 ms.
62.4	F_SIL value	24 ("Switch-off") 19 ("Communication error") 68 ("Parameter 'F_SIL' exceeds the appl. SIL")	F_SIL value exceeds SIL value of the specified device application
62.5	F_CRC_Length	24 ("Switch-off") 19 ("Communication error") 69 ("Parameter 'F_CRC_Length' does not match ...")	F_CRC_Length value does not match the actual CRC length.
62.6	F_Par_Version	24 ("Switch-off") 19 ("Communication error") 70 ("Incorrect F-parameter version or F_Block_ID")	F_Par_Version does not match the F-parameter set or F-Block_ID is invalid Block_ID
62.7	CRC1 error	24 ("Switch-off") 19 ("Communication error") 71 ("CRC1 error")	-
63.0 ... 63.2	Reserved	-	-
63.3	iPAR_CRC error	24 ("Switch-off") 19 ("Communication error") 75 ("Inconsistent I-parameters [iParCRC error]")	-
63.4	Operator acknowledge requested	-	Channel is ready for reintegration
63.5 ... 63.7	Reserved	-	-
64 ... 65	Reserved	-	-
70 ... 89	Reserved	-	-

Byte.Bit	Description	Only with firmware V1.0.0: Error code (decimal) in the diagnostic alarm	Remark		
90 ... 91	Object_Code_Sequence_Logic	-	AS-i address of the first safe AS-i slave for which a code sequence error or logic error is present. See also bit 18.0. 0 = No error		
			0	=	No error
			1 ... 31	=	AS-i slave address
			≥32	=	Internal error numbers
92 ... 93	Reserved	-	-		
94 ... 95	Object_input_triggered	-	AS-i address of the first safe AS-i slave for which the input_triggered message is present. See also bit 18.2.		
			0	=	No error
			1 ... 31	=	AS-i slave address
			≥32	=	Internal error numbers
96 ... 199	Reserved	-	-		

6.4.2 DS 202 Status safe inputs/outputs

Description

NOTE

Use of the data set 206 is recommended for diagnosis via the user program (firmware V1.0.1 or higher).

DS 202 contains non-safety-related status information for the safe input slaves and for the control of the safe output slaves.

The status information for the control of the safe output slaves relates either to the control units activated in the F-CM AS-i Safety ST module or to data of external control units for safe output slaves that is also read on the AS-i bus.

Table 2-1954 DS 202 Status safe inputs/safe outputs

Byte	Description
0 ... 1	Reserved
2 ... 5	Status input monitoring AS-i address 1
6 ... 9	Status input monitoring AS-i address 2
10 ... 13	Status input monitoring AS-i address 3
14 ... 17	Status input monitoring AS-i address 4
18 ... 21	Status input monitoring AS-i address 5
22 ... 25	Status input monitoring AS-i address 6
26 ... 29	Status input monitoring AS-i address 7

Byte	Description
30 ... 33	Status input monitoring AS-i address 8
34 ... 37	Status input monitoring AS-i address 9
38 ... 41	Status input monitoring AS-i address 10
42 ... 45	Status input monitoring AS-i address 11
46 ... 49	Status input monitoring AS-i address 12
50 ... 53	Status input monitoring AS-i address 13
54 ... 57	Status input monitoring AS-i address 14
58 ... 61	Status input monitoring AS-i address 15
62 ... 65	Status input monitoring AS-i address 16
66 ... 69	Status input monitoring AS-i address 17
70 ... 73	Status input monitoring AS-i address 18
74 ... 77	Status input monitoring AS-i address 19
78 ... 81	Status input monitoring AS-i address 20
82 ... 85	Status input monitoring AS-i address 21
86 ... 89	Status input monitoring AS-i address 22
90 ... 93	Status input monitoring AS-i address 23
94 ... 97	Status input monitoring AS-i address 24
98 ... 101	Status input monitoring AS-i address 25
102 ... 105	Status input monitoring AS-i address 26
106 ... 109	Status input monitoring AS-i address 27
110 ... 113	Status input monitoring AS-i address 28
114 ... 117	Status input monitoring AS-i address 29
118 ... 121	Status input monitoring AS-i address 30
122 ... 125	Status input monitoring AS-i address 31
126 ... 129	Status output control switching group 0
130 ... 133	Status output control switching group 1
134 ... 137	Status output control switching group 2
138 ... 141	Status output control switching group 3
142 ... 145	Status output control switching group 4
146 ... 149	Status output control switching group 5
150 ... 153	Status output control switching group 6
154 ... 157	Status output control switching group 7
158 ... 161	Status output control switching group 8
162 ... 165	Status output control switching group 9
166 ... 169	Status output control switching group 10
170 ... 173	Status output control switching group 11
174 ... 177	Status output control switching group 12
178 ... 181	Status output control switching group 13

Byte	Description
182 ... 185	Status output control switching group 14
186 ... 189	Status output control switching group 15
190 ... 199	Reserved

Table 2-1955 Input monitoring: Structure of the status information in DS 202

Byte.Bit	Message bit		Remark
0.0	Value = 1:	Startup test necessary	-
0.1	Value = 1:	Sequence condition violated	-
0.2	Value = 1:	Discrepancy condition violated	-
0.3	Value = 1:	Safety sensor triggered	-
0.4 ... 0.7	Reserved		-
1.0	Value = 1:	Code sequence error	Cross-circuit at input
1.1 ... 1.7	Reserved		-
2.0	Reserved		-
2.1	Value = 1:	Switch-on condition not met	-
2.2 ... 2.7	Reserved		-
3.0 ... 3.7	Reserved		

Table 2-1956 Output control: Structure of the status information in DS 202

Byte.Bit	Message bit	Remark
0.0	Output active	The control unit of the switching group sends the "F-OUT 1" control signal.
0.1 ... 0.7	Reserved	-
1.0 ... 1.3	Reserved	-
1.4	Auxiliary signal AUX1 sent	Auxiliary control signal AUX1 was transferred with value "1." If the error acknowledgment bit in the output process image has the value "0", the message is reset.
1.5	Auxiliary signal AUX2 sent	Auxiliary control signal AUX2 was transmitted with value "1." If the error acknowledgment bit in the output process image has the value "0", the message is reset.
1.6 ... 1.7	Reserved	-
2.0 ... 2.7	Reserved	-
3.0 ... 3.7	Reserved	-

6.4.3 DS 204 Status code sequences

Description

NOTE

Use of the data set 206 is recommended for diagnosis via the user program (firmware V1.0.1 or higher).

The DS 204 contains the statuses of all AS-i slaves that are known to the F-CM AS-i Safety ST module.

Table 2-1957 DS 204: Status code sequence for an AS-i address in DS 204

Byte	Description
0 ... 13	Reserved
14 ... 17	Status code sequence for AS-i address 1
18 ... 21	Status code sequence for AS-i address 2
22 ... 25	Status code sequence for AS-i address 3
26 ... 29	Status code sequence for AS-i address 4
30 ... 33	Status code sequence for AS-i address 5
34 ... 37	Status code sequence for AS-i address 6
38 ... 41	Status code sequence for AS-i address 7
42 ... 45	Status code sequence for AS-i address 8
46 ... 49	Status code sequence for AS-i address 9
50 ... 53	Status code sequence for AS-i address 10
54 ... 57	Status code sequence for AS-i address 11
58 ... 61	Status code sequence for AS-i address 12
62 ... 65	Status code sequence for AS-i address 13
66 ... 69	Status code sequence for AS-i address 14
70 ... 73	Status code sequence for AS-i address 15
74 ... 77	Status code sequence for AS-i address 16
78 ... 81	Status code sequence for AS-i address 17
82 ... 85	Status code sequence for AS-i address 18
86 ... 90	Status code sequence for AS-i address 19
90 ... 91	Status code sequence for AS-i address 20
94 ... 97	Status code sequence for AS-i address 21
98 ... 101	Status code sequence for AS-i address 22
102 ... 105	Status code sequence for AS-i address 23
106 ... 109	Status code sequence for AS-i address 24
110 ... 113	Status code sequence for AS-i address 25
114 ... 117	Status code sequence for AS-i address 26
118 ... 121	Status code sequence for AS-i address 27
122 ... 125	Status code sequence for AS-i address 28
126 ... 129	Status code sequence for AS-i address 29
130 ... 133	Status code sequence for AS-i address 30
134 ... 137	Status code sequence for AS-i address 31
138 ... 199	Reserved

Table 2-1958 Assignment of the bits of an AS-i address in the "Status code sequence" data structure

Byte	Bit	Description	Setting	Meaning of the setting
0	0 ... 2	Status of the slave	= 0	No slave present
			= 1	Standard slave (not safety-related)
			= 2	Safe slave, but the code sequence type safe input/safe output is not yet decoded.
			= 3	Code sequence type safe output
			= 4	Code sequence type safe input
			= 5 ... 7	Reserved
	3	-	Reserved	-
	4 ... 6	Status of parameter assignment	= 0	No safe AS-i output slave or AS-i input slave is configured.
			= 1	Reserved
			= 2	Safe AS-i slave is configured The detected slave corresponds to the activation.
			= 3	Safe AS-i slave is configured The detected slave does not correspond to the activation.
			= 4 ... 7	Reserved
	7	-	Reserved	-
1	0 ... 2	Status of the code sequence	= 0	Code sequence irrelevant: No activation or no slave is present.
			= 1	Code sequence missing: No code sequence is taught or transferred.
			= 2	Code sequence duplicated: At least one other slave has the same code sequence.
			= 3	Code sequence new: The taught code sequence does not correspond to the transferred code sequence.
			= 4	Code sequence known: The taught code sequence does not correspond to the transferred code sequence.
			= 5 ... 7	Reserved
	3	-	Reserved	-
	4 ... 5	Status of the safe input 1	= 0	The input is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Input signal = 0: The contact is open.
			= 3	Input signal = 1: The contact is closed.
	6 ... 7	Status of the safe input 2	= 0	The input is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Input signal = 0: The contact is open.
			= 3	Input signal = 1: The contact is closed.
2	0 ... 1	Status of the "F-OUT 1" control signal for safe output	= 0	The output is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Control signal for output = 0

Byte	Bit	Description	Setting	Meaning of the setting
2	0 ... 1	Status of the "F-OUT 1" control signal for safe output	= 3	Control signal for output = 1
	2 ... 3	Status of the "F-OUT 2" control signal for safe output	= 0	The output is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Control signal for output = 0
			= 3	Control signal for output = 1
	4 ... 5	Status of the "F-OUT 3" control signal for safe output	= 0	The output is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Control signal for output = 0
			= 3	Control signal for output = 1
	6 ... 7	Status of the "F-OUT 4" control signal for safe output	= 0	The output is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Control signal for output = 0
			= 3	Control signal for output = 1
3	0 ... 1	Status of the auxiliary signal 1	= 0	The signal is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Auxiliary signal = 0
			= 3	Auxiliary signal = 1
	2 ... 3	Status of the auxiliary signal 2	= 0	The signal is not present (or the code sequence type is not yet decoded).
			= 1	Error, e.g., code sequence error
			= 2	Auxiliary signal = 0
			= 3	Auxiliary signal = 1
	4 ... 7	-	Reserved = 0	-

6.4.4 DS 206 Diagnostic data record

Meaning

NOTE

Use of the data set 206 is recommended for diagnosis via the user program (firmware V1.0.1 or higher).

Data record 206 contains a summary of the information that is relevant for a comprehensive diagnosis of the F-CM AS-i Safety ST module via your user program.

For some events, the F-CM AS-i Safety ST module generates a diagnostic alarm.

The following applies for diagnostic alarms of the F-CM AS-i Safety ST module with firmware V1.0.1 or higher:

- The "Error code" column in the table below indicates which events are relevant here.
- If the associated bit changes in the data record, a diagnostic alarm with the indicated error code is generated (incoming alarm when bit changes to value "1" and outgoing alarm when bit changes to value "0").
- If no error code is specified ("-"), a diagnostic alarm is not generated.
- The diagnostic alarms for firmware V1.0.0 are described in Section "DS 92 Device-specific diagnosis (Page 47)".

Table 2-1959 DS 206 Diagnosis

Byte.Bit	Description In the case of binary values, the description declares the status "1"	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
0	Version High	-	-
1	Version Low	-	-
2.0	Overtemperature	1048	Maximum operating temperature exceeded
2.1	Undertemperature	786	Ambient temperature too low
2.2	Incorrect parameter value	16	Configuration data contains errors
2.3	Incorrect or inconsistent firmware	283	Firmware is faulty Firmware update necessary
2.4	Supply voltage too high	1038	AS-i voltage too high
2.5	Supply voltage too low	1039	AS-i voltage too low
2.6	Program cycle time exceeded	259	Internal cycle time exceeded
2.7	Device fault	1059	Self-test has determined a device fault. For details, see further error messages.
3.0	Serious device fault	9	Serious device fault. No communication possible
3.1	Teaching necessary	1055	New code tables are available for transfer.
3.2	Normal operation	-	Cyclic I/O data exchange active
3.3	Startup	-	Parameters are loaded No cyclic I/O data exchange
3.4	Serious device fault	-	Serious device fault. No communication possible
3.5	I/O device signal error	-	One or more channels are passivated
3.6	Code sequence cannot be read correctly	-	A code sequence is non-existent or incomplete
3.7	Reintegration necessary	-	Error is cleared, but at least one channel is still passivated
4.0	Access to device settings	-	Assignment of the F-address Acceptance of the code sequences Firmware update
4.1	ASIsafe code table teaching active	-	Teach LED flashes yellow; code sequences are collected. Is reset when the code tables for all safe AS-i input slaves detected on the bus have been taught.

Byte.Bit	Description In the case of binary values, the description declares the status "1"	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
4.2	Diagnostic memory overflow	33	Too many simultaneous error messages
4.3	Change of parameters not permissible	-	Modification of parameter data is rejected in normal mode
4.4 ... 4.7	Reserved	-	-
5.0	Status LED flashes green	-	-
5.1	Status LED lit green	-	-
5.2	Error LED flashes red	-	-
5.3	CFG LED flashes red	-	-
5.4	PSF LED flashes red	-	-
5.5	Teach LED flashes yellow	-	-
5.6	Teach LED lit yellow	-	-
5.7	ADDR LED flashes green	-	-
6.0	No access possible to the retentive storage of the F-address	781	The coding element (type H) in the BaseUnit is missing or there is an access error
6.1	Different destination address (F_Dest_Add)	64	The PROFIsafe driver has detected a different F-destination address.
6.2	Invalid target address (F_Dest_Add)	65	The PROFIsafe driver has detected an inadmissible F-destination address.
6.3	Invalid source address (F_Source_Add)	66	The PROFIsafe driver has detected an inadmissible F-source address.
6.4	Watchdog time is 0 ms (F_WD_Time or F_WD_Time2)	67	The PROFIsafe driver has detected an inadmissible watchdog time.
6.5	Parameter "F_SIL" exceeds the application-specific SIL	68	The PROFIsafe driver has detected a discrepancy between the communication SIL setting and the application SIL setting.
6.6	Parameter "F_CRC_Length" does not match the generation	69	The PROFIsafe driver has detected a discrepancy in the CRC length.
6.7	Incorrect F-parameter version or F_Block_ID	70	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.
7.0	CRC1 error	71	The PROFIsafe driver has detected inconsistent F-parameters.
7.1	Inconsistent i-parameters (iParCRC error)	75	The PROFIsafe driver has detected inconsistent i-parameters.
7.2	PROFIsafe communication error (timeout)	92	
7.3	PROFIsafe communication error (CRC)	F93	
7.4	PROFIsafe address assignment error	F94	Coding element contains inadmissible data
7.5 ... 7.7	Reserved	-	-
8	Configured AS-i address for output switching group 0	-	-

Byte.Bit	Description In the case of binary values, the description declares the status "1"	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
9	Configured AS-i address for output switching group 1	-	-
10	Configured AS-i address for output switching group 2	-	-
11	Configured AS-i address for output switching group 3	-	-
12	Configured AS-i address for output switching group 4	-	-
13	Configured AS-i address for output switching group 5	-	-
14	Configured AS-i address for output switching group 6	-	-
15	Configured AS-i address for output switching group 7	-	-
16	Configured AS-i address for output switching group 8	-	-
17	Configured AS-i address for output switching group 9	-	-
18	Configured AS-i address for output switching group 10	-	-
19	Configured AS-i address for output switching group 11	-	-
20	Configured AS-i address for output switching group 12	-	-
21	Configured AS-i address for output switching group 13	-	-
22	Configured AS-i address for output switching group 14	-	-
23	Configured AS-i address for output switching group 15	-	-
24 ... 27	Status AS-i address 1	-	-
28 ... 31	Status AS-i address 2	-	-
32 ... 35	Status AS-i address 3	-	-
36 ... 39	Status AS-i address 4	-	-
40 ... 43	Status AS-i address 5	-	-
44 ... 47	Status AS-i address 6	-	-
48 ... 51	Status AS-i address 7	-	-
52 ... 55	Status AS-i address 8	-	-
56 ... 59	Status AS-i address 9	-	-
60 ... 63	Status AS-i address 10	-	-
64 ... 67	Status AS-i address 11	-	-

Byte.Bit	Description In the case of binary values, the description declares the status "1"	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
68 ... 71	Status AS-i address 12	-	-
72 ... 75	Status AS-i address 13	-	-
76 ... 79	Status AS-i address 14	-	-
80 ... 83	Status AS-i address 15	-	-
84 ... 87	Status AS-i address 16	-	-
88 ... 91	Status AS-i address 17	-	-
92 ... 95	Status AS-i address 18	-	-
96 ... 99	Status AS-i address 19	-	-
100 ... 103	Status AS-i address 20	-	-
104 ... 107	Status AS-i address 21	-	-
108 ... 111	Status AS-i address 22	-	-
112 ... 115	Status AS-i address 23	-	-
116 ... 119	Status AS-i address 24	-	-
120 ... 123	Status AS-i address 25	-	-
124 ... 127	Status AS-i address 26	-	-
128 ... 131	Status AS-i address 27	-	-
132 ... 135	Status AS-i address 28	-	-
136 ... 139	Status AS-i address 29	-	-
140 ... 143	Status AS-i address 30	-	-
144 ... 147	Status AS-i address 31	-	-

Table 2-1960 Status AS-i addresses: Structure of the status information

Byte.Bit	Description	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
0.0	Reserved	-	-
0.1	Discrepancy error, channel status 0/1	1041	When the error occurs, the pair of channels at input 1 has the status "0" and at input 2 the status "1".
0.2	Discrepancy error, channel status 1/0	1042	When the error occurs, the pair of channels at input 1 has the status "1" and at input 2 the status "0".
0.3 ... 0.4	Reserved	-	-
0.5	Sequence error, channel status 0/1	1045	When the error occurs, the pair of channels at input 1 has the status "0" and at input 2 the status "1".
0.6	Sequence error, channel status 1/0	1046	When the error occurs, the pair of channels at input 1 has the status "1" and at input 2 the status "0".
0.7	Sequence error, channel status 1/1	1047	When the error occurs, the pair of channels at input 1 has the status "1" and at input 2 the status "1".

Byte.Bit	Description	FW V1.0.1 and higher: Error code (decimal) in the diagnostic alarm	Remark
1.0	Input slave missing or of the incorrect type	1050	-
1.1	Control unit of the output switching group not in cyclic data exchange	1051	The AS-i master does not address the configured AS-i address of the output switching group.
1.2	Code sequence error (systematic fault)	1054	Permanent interruption to code sequence, e.g. due to electromagnetic interference on the sensor cable or code sequence corruption after replacement of the safe input module.
1.3	Code sequence missing in the memory of the F-CM	1056	-
1.4	ASIsafe code sequences duplicated	1057	Identical code sequence occurs several times
1.5	Sporadic code sequence error	1058	Momentary interruption to code sequence, e.g. due to electromagnetic interference on the sensor cable.
1.6 ... 1.7	Reserved	-	-
2.0	Safety sensor triggered	-	-
2.1	Switch-on condition not met		The safe input value has been reset to the status "0"
2.2	Startup test necessary	-	Test of the input is necessary: Both inputs of the channel pair must assume the status "0".
2.3	Status of process image (user data)	-	-
2.4	Value status	-	Value status = 1: A valid process value is output for the channel. Value status = 0: A substitute value is output for the channel (error on channel or the channel is deactivated).
2.5... 2.7	Reserved	-	-
3.0	Safe AS-i input slave configured	-	-
3.1	Safe AS-i output slave configured	-	-
3.2	Unsafe slave detected	-	-
3.3	Safe slave detected, type unknown	-	-
3.4	Safe slave detected, type input slave	-	-
3.5	Safe slave detected, type output slave	-	-
3.6	Slave is located in cyclic data exchange	-	-
3.7	Reserved	-	-

Code sequences

7

The principle of the ASIsafe code sequences is briefly explained in Section Safety-related communication with AS-Interface (Page 28).

The F-CM AS-i Safety ST module manages the code sequences of the safe AS-i slaves in two steps. First, the F-CM AS-i Safety ST module reads all code sequences on the AS-i bus and checks whether the respective code sequence is plausible. This operation is referred to as "teaching the code sequences". The code sequences taught in this way are in volatile memory. The taught code sequences are transferred to the non-volatile memory after a request by the user.

Initial commissioning

During initial commissioning, the F-CM AS-i Safety ST module must teach the code sequences of all safe AS-i input slaves present on the AS-i bus and transfer them to non-volatile memory. In so doing, the module detects both the slaves for which input monitoring is activated as well as the other safe input slaves.

Replacement of a safe AS-i input slave

After replacement of a safe AS-i input slave, the new code sequence must be taught and saved.

If the code sequence is not saved for a safe AS-i input slave, or if the code sequence does not correspond to the saved code sequence, the input channel will be passivated and assigned the substitute value "0".

As soon as the F-CM AS-i Safety ST module detects a new code sequence, the code sequences are automatically taught. Confirm the transfer of the code sequences into the memory to prevent unauthorized changes to the AS-i component.

For the transfer of the code sequences to the non-volatile memory, you can open the "Teach ASIsafe" dialog by pressing the "Teach ..." button.

Alternatively, the transfer is also possible by pressing the optional "TEACH" button (at least 3 s).

Replacement of the F-CM AS-i Safety ST module

The non-volatile memory is located in the BaseUnit. The transferred code sequences are retained in this memory after replacement of the F-CM AS-i Safety ST module.

Below is a description of the options offered by the F-CM AS-i Safety ST module for transferring code sequences.

See also

Connection (Page 21)

7.1 Transferring code sequences via STEP 7 online access

When code sequence are managed via *STEP 7* online access, you have the option of monitoring the status of the existing code sequences in a graphic overview. In particular, the graphic overview offers advantages for initial commissioning. In addition, you can use the graphic overview for transferring the code sequences of replaced slaves during operation. You can open the graphic overview for diagnostic purposes without changing the saved code sequences. The transfer of taught code sequences is possible but not mandatory.

In order to open this dialog, there must be an online connection to the controller or to the F-CM AS-i Safety ST module. Load the hardware configuration into the modules of the controller before teaching the code sequences so that the online configuration of the F-CM AS-i Safety ST module matches the offline configuration.

7.1.1 "Teach ASIsafe code sequences" dialog

The "Teach ASIsafe code sequences" dialog contains an overview of the code sequences of the existing safety-related AS-i slaves. In this dialog, you start the transfer of the code sequences read in on the AS-i bus into the memory of the F-CM AS-i Safety ST module.

The "Teach ASIsafe code sequences" dialog does not make any changes to the module configuration. You can open the dialog for information purposes during operation. The information displayed in the dialog are obtained online from the F-CM AS-i Safety ST module. There is no comparison with the offline configuration in this case.

Within the "AS-i addresses 0...15" and "AS-i adresses 16...31", you see the following information for each AS-i address:

- Slave status
- Code sequence
- F-IN 1 ... 2
- F-OUT 1 ... 4

For the AS-i address 0, only information about the slave status can be displayed because a slave with the address 0 does not exchange cyclic input/output data.

Below this information you see:

- The "Transfer taught code sequences" button
- The "Progress of teaching operation" display

By double-clicking the "Close" button, you can exit the dialog at any time. If the button is actuated, the data will not be changed. If the code sequences have not been transferred or have only been partially transferred, a corresponding notice appears.

"Slave Status" column

The "Slave status" column shows the following information about the AS-i address via a color code:

Gray	The address does not exist on the AS-i bus. It is not needed in the configuration of the F-CM AS-i Safety ST module (input monitoring control / output monitoring control deactivated)
Green (without check mark)	The address belongs to a slave that exists on the AS-i bus. However, the slave is not needed in the configuration of the F-CM AS-i Safety ST module (input monitoring control / output monitoring control deactivated). The slave on the AS-i bus is a safe slave or a standard slave. It is available for use by the AS-i master or another module.
Green (with check mark)	The address is present on the AS-i bus and corresponds to the configuration of the F-CM AS-i Safety ST module (input monitoring or output monitoring is activated).
Yellow	An error has been detected: The address is present on the AS-i bus but does not correspond to the configuration of the F-CM AS-i Safety ST module (input monitoring control or output monitoring control is activated). Check the slave. Replace the slave with the required slave or change the configuration.
Red	An error has been detected: The address is not present on the AS-i bus but is needed in the configuration of the F-CM AS-i Safety ST module (input monitoring or output monitoring is activated). • Check whether the slave exists on the AS-i bus and has been included in the communication by the AS-i master. • Check whether the slave is contained in the configuration of the AS-i master. Correct the configuration of the AS-i bus, if required.

"Code sequence" column

The "Code sequence" column shows the following information about the AS-i address via a color code:

Gray	No code sequence is needed for the address.
Green (without check mark)	A code sequence was taught but not transferred to the memory. Start the transfer of the code sequence by double-clicking the "Transfer taught code sequences" button.
Green (with check mark)	The code sequence was transferred to the non-volatile memory. Note: This status is also displayed when the output control is activated for this address. The code sequences for safe outputs are automatically predefined in the F-CM AS-i Safety ST module. They are not transferred to the non-volatile memory of the code sequences.

Yellow	An error has been detected: A code sequence was taught that is already being used by another slave. The code sequence cannot be used. Replace the slave with a different slave.
Red	Warning or error: The address is sending an incomplete or invalid code sequence. Check whether both inputs of the safe input slave are assigned with the "ON" signal. If required, actuate the associated safety contacts. The contacts must be closed. • Check whether a cross-circuit exists at the inputs. If necessary, correct the wiring of the inputs.

"F-IN 1 ... 2" column

The "F-IN 1 ... 2" column shows the following information about the AS-i address via a color code:

The numbers 1 to 2 designate the number of the input channel.

Gray	The input channel is not present. A safe input slave was not detected at the address.
Green	The input channel shows the value 1 ("ON" status).
White	The input channel shows the value 0 ("OFF" status).
Yellow	The input channel shows the value 0 ("OFF" state) or is not present. Note: The status indication is unambiguous once the code sequence has been taught for a safe input slave (both inputs assigned with "ON" signal), or when an "ON" signal has been read in for an externally controlled safe output slave.
Red	An error was detected, e.g., a code sequence error: The status of the input channel cannot be read in. Substitute value 0 is used.

"F-OUT 1 ... 4" column

The "F-OUT 1 ... 4" column shows the following information about the AS-i address via a color code:

The numbers 1 to 4 designate the number of the output channel.

Gray	The output channel is not present. A safe output channel was not detected at the address.
Green	The output channel shows the value 1 ("ON" status).

White	The output channel shows the value 0 ("OFF" status).
Yellow	The output channel shows the value 0 ("OFF" state) or is not present. Note: The status indication is unambiguous once the code sequence has been taught for a safe input slave (both inputs assigned with "ON" signal), or when an "ON" signal has been read in for an externally controlled safe output slave.
Red	An error was detected, e.g., a code sequence error: The status of the output channel cannot be read in.

If the output control is activated for the address, the F-CM AS-i Safety ST module can control the status for F-OUT 1. The F-CM AS-i Safety ST module cannot control F-OUT 2 ... 4. The value 0 is output here.

If an external control unit uses the output address, the dialog shows the statuses for F-OUT 1 ... 4 read in on the AS-i bus.

7.1.2 Transferring taught code sequences

In order for the input data of a safe AS-i input slave to be evaluated and made available to the safety program, the taught code sequences must be transferred to the non-volatile memory.

To do so, click the "Transfer taught code sequences..." button.

A dialog opens prompting you whether the code sequences are to be transferred. With "Yes" you confirm that you are addressing the correct module. For checking purposes, the "ADDR" LED flashes green on the front of the F-CM AS-i Safety ST module The code sequences are transferred to the non-volatile memory. The input data of the safe AS-i input slaves are then evaluated. Reintegration in the safety program is enabled.

With "No" you cancel the prompt without transferring the code sequence.

⚠ WARNING

The switching on of plant components may result in death, severe injury, and serious property damage.

Depending on the safety program, the transfer of code sequences may cause plant components to be switched on. Before transferring the code sequences, ensure that no personal injury or property damage can occur. After transferring the code sequences, check the safety equipment for proper functioning.

The "Transfer taught code sequences" button is deactivated when all taught code sequences have already been transferred to the non-volatile memory.

7.1.3 "Progress of teaching operation" display

You can track the progress of the teaching operation.

Progress bar "Teaching in progress":

If at least one safe slave is detected on the AS-i bus whose code sequence has not yet been taught an active progress bar and the text "Teaching in progress" is displayed. Check the displays in the "Code sequences" column and ensure that the safe slaves send their code sequences.

For further information, refer to the "'Code sequence' column".

Taught slaves:

The "Taught slaves" output field shows the number of already transferred code sequences in relation to the number of code sequences that must still be transferred. You will additionally see the numerical ratio as a percentage. When 100% is indicated, all code sequences have been transferred to the non-volatile memory.

You will find additional information in the section "Accept taught code sequences".

7.2 Transferring code sequences with the "TEACH" button.

The use of the "TEACH" button provides an easy way of transferring taught code sequences.

The "TEACH" button can be used, for example, to transfer code sequences of replaced modules during operation. However, it is also suitable for initial commissioning.

To learn how to connect the button to the BaseUnit, refer to Section "Connecting". You can track the progress of the code sequence transfer via the LEDs.

Press the "TEACH" button for at least 3 s. This action causes all currently taught code sequences that are unique and consistent to be transferred to the non-volatile memory. The input data of the safe AS-i input slaves are then evaluated. Reintegration in the safety program is enabled.

⚠ WARNING

The switching on of plant components may result in death, severe injury, and serious property damage.

Depending on the safety program, the transfer of code sequences may cause plant components to be switched on. Before transferring the code sequences, ensure that no personal injury or property damage can occur. After transferring the code sequences, check the safety equipment for proper functioning.

When the transfer of the code sequences has been ended successfully, the "TEACH" LED goes out and you can release the "TEACH" button.

If you press the "TEACH" button before all code sequences are taught, the code sequences received up to then will be transferred.

7.3 Final steps

7.3.1 Reintegrating passivated input channels

The input channels of the F-CM AS-i Safety ST module for which no valid code sequences are saved supply the substitute value "0" and are passivated.

After the transfer of the code sequences, the passivated channels must be reintegrated so that the application can work with the real process values.

The procedure for this can be found in the following Programming and Operating Manuals:

- SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126/0/en)
- S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)

After transferring the code sequences, check the safety equipment for proper functioning.

Alarm, fault, and system events

8

8.1 Overview

Diagnostics options

The following diagnostics options are available for the F-CM AS-i Safety ST module:

- LEDs on the module
- Diagnostics in *STEP 7*:
  - Diagnostic buffer
- Alarm messages in user program

See also

Meaning of the LEDs (Page 73)

8.2 LED statuses

8.2.1 Arrangement of the LEDs on the F-CM AS-i Safety ST

Introduction

LEDs on the front plate of the respective module display module-internal and module-external faults. The LEDs and their evaluation are described in the manuals for the relevant modules of the SIMATIC devices.

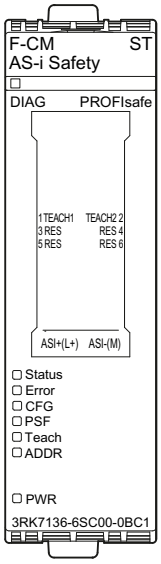

DIAG	Diagnosis
STATUS	Operating state of the module
Error	Operating state of the module
CFG	Fault on the AS-i bus
PSF	Process signal error, e.g.,channel fault on AS-i-F input slave
Teach	Teaching: Teaching of code sequences
ADDR	Addressing of the F-CM AS-i Safety ST module. F-addressing and teaching. The LED indicates whether the module is conducting safety-relevant communication with the software tool.
PWR	Supply voltage

Figure 2-1532 LEDs of F-CM AS-i Safety ST

8.2.2 Meaning of the LEDs

The "F-CM AS-i Safety ST" module has 8 LEDs on the front:

LED "DIAG"

The "DIAG" LED displays the general status of the ET 200SP module

Table 2-1961 Meaning of the "DIAG" LED

"DIAG"	Meaning
☐ Off	The voltage is not OK.
✳ Green flashes	The F-CM AS-i Safety ST module is not ready for operation. The module parameters are not assigned.
■ Green ON	The F-CM AS-i Safety ST module is parameterized and error-free. No diagnostic alarms of the F-CM AS-i Safety ST are active.
✳ Red flashes	The F-CM AS-i Safety ST module is parameterized and indicates a diagnostic fault, or a firmware update is in progress.
✳✳ The two-color LED alternately flashes red/green	The position (ping) is displayed for 3 seconds.

LED "Status"

The "Status" and "Error" LEDs indicate the operating state of the device.

Table 2-1962 Meaning of the "Status" LED

"Status"	Meaning
■ Green ON	• The F-CM AS-i Safety ST module is OK. • Cyclic I/O data exchange active
✳ Green flashes	• The system is powering up. • No cyclic I/O data exchange

LED "Error"

The "Status" and "Error" LEDs indicate the operating state of the device.

Table 2-1963 Meaning of the "Error" LED

"Error"	Meaning
■ Red ON	**Serious device fault, e.g.,** • Fault in the electronics • Overtemperature
✻ Red flashes	**Device fault, e.g.,** • Intermittent data processing error (EMC problem) • Contact problem with the backplane bus • Missing coding element in the BaseUnit • Missing firmware update
□ Off	No error

LED "CFG"

The "CFG" LED indicates errors on the AS-i bus.

Table 2-1964 Meaning of the "CFG" LED

"CFG"	Meaning
■ Red ON	The AS-i bus is OK, but a code sequence error exists.
✻ Red flashes	Fault on the AS-i bus: • A code sequence does not exist or it is incomplete.
□ "Off"	All code sequences are completely transferred.

LED "PSF"

The "PSF" LED indicates process signal errors at one or more channels of the module.

Table 2-1965 Meaning of the "PSF" LED

LED "PSF"	Meaning
■ Red ON	PROFIsafe channel fault for the complete F-CM AS-i Safety ST module, e.g. fault on F-CM AS-i input slave
✻ Red "flashes"	• Discrepancy error at the inputs of a safe AS-i input slave • Sequence error at the inputs of a safe AS-i input slave • Code sequence error at a safe AS-i input slave, e.g., due to cross-circuit at inputs or an EMC problem • Failure of a safe AS-i input slave The channel involved is passivated. The "PSF" LED goes out only after all channels have been reintegrated.

LED "PSF"	Meaning
☐ "Off"	No process signal error

LED "TEACH"

This LED indicates teaching of safe AS-i slaves. The "TEACH" LED indicates the progress of the teaching operation.

Table 2-1966 Meaning of the "TEACH" LED

LED "TEACH"	Meaning
■ Yellow ON	The code sequences have been successfully taught, but have not yet been accepted. Transfer the code sequences either via the STEP 7 online dialog or by pressing the optional "TEACH" button (for at least 3 s). For more information, see the Section "Code sequences (Page 64)".
✳ Yellow flashes	Teaching of code sequences in progress.
☐ "Off"	The code sequences are completely transferred.

LED "ADDR"

The "ADDR" LED indicates that the device is conducting safety-relevant communication with a software tool.

Table 2-1967 Meaning of the "ADDR" LED

LED "ADDR"	Meaning
✳ Green flashes	Feedback that the module is addressed: • For assignment of the F-address • For transfer of the code sequences • Firmware update in progress
☐ Off	Not relevant

LED "PWR"

The "PWR" LED indicates the status of the voltage supply.

Table 2-1968 Meaning of the "PWR" LED

LED "PWR"	Meaning
■ Green ON	AS-i voltage is applied.
☐ "Off"	Insufficient AS-i voltage is applied.

8.3 Diagnostic messages

The F-CM AS-i Safety ST module generates one or more alarms when various events occur.

NOTE

When replacing an F-CM AS-i Safety module with firmware V1.0.0, the following must be observed:

With firmware V1.0.1 or higher, the F-CM AS-i Safety ST module generates a modified range of alarm messages compared with V1.0.0.

If the user program evaluates the error numbers of the generated alarms directly, the user program may have to be adapted if the firmware version is changed (e.g. when changing a device). If necessary, the firmware version of a replacement device can be modified to the previously used firmware version (see Section "Firmware update (Page 19)").

It is expected that the upgrading of the firmware version from V1.0.0 to V1.0.1 will not usually have any influence on the user program. The safety functionality of the F-CM AS-i Safety ST module does not change when the firmware is replaced.

If, after the replacement of a device, an alarm message of the F-CM AS-i Safety module appears in the message system (e.g. on an HMI panel), which contains an error code instead of a message text, then the assigned message texts are not known to the message system. In order to update the message texts, the project must be re-compiled with a current version of the TIA Portal / STEP 7 and loaded into the controller or into the message system. The function of the message system can be checked by generating an alarm (e.g. by removing an assigned AS-i safety slave).

Diagnostic messages for firmware V1.0.0

The following applies for firmware V1.0.0: Which events lead to which alarm messages is indicated in the description of data record DS 92 "Device-specific diagnostics" (Page 47).

The alarms use the diagnostic codes 0 to 31 according to the PROFIBUS Standard.

Diagnostic messages as from firmware V1.0.1

The following applies as from firmware V1.0.1: Which events lead to which alarm messages is indicated in the description of data record DS 206 "Data record diagnostics" (Page 58).

The alarms use diagnostic codes in the extended range of values according to the PROFINET Standard. The alarms allow a meaningful system diagnosis to be made, specifying the type of error and the AS-i address affected.

8.4 Replacement of defective devices

8.4.1 Replacing a safe AS-i input slave

Replace a failed safe AS-i input slave with a new device of the same type and assign the correct AS-i address to the slave. This address assignment can be performed automatically by the AS-i master (see manual of the AS-i master) or manually, e.g., with the AS-i addressing device (1904-2AB02).

Close the contacts on the inputs of the safe AS-i input slave so that the slave sends the code sequences.

The F-CM AS-i Safety ST module detects a new code sequence automatically and teaches it. For reintegration, the taught code sequence must be transferred.

The transfer can be started from the STEP 7 online dialog or by pressing the optional "TEACH" button (at least 3 s). For more information, see Section Code sequences (Page 64).

Observe the "CFG" and "TEACH" LEDs, see Section Meaning of the LEDs (Page 73).

To exclude impermissible duplicate code sequences for two safe input slaves, code sequences from all safe input slaves present on the AS-i bus must be transferred, regardless of whether the monitoring is activated or deactivated.

8.4.2 Replacing the safe AS-i output module (evaluation unit)

After replacement of a safe AS-i output module (evaluation unit), no setting is necessary on the F-CM AS-i Safety ST module.

Observe the operating instructions of the AS-i output module, and set the correct F-address for the AS-i output module and the AS-i address of any integrated standard slave.

An error acknowledgment for the affected output switching group must be performed, if necessary. See Section 6.3 Address space.

Non-safety related AS-i slaves (standard slaves) are not evaluated by the F-CM AS-i Safety ST module. Observe the replacement instructions in the operating instructions of the AS-i master or the slave.

8.4.3 Replacing the F-CM AS-i Safety ST module

When the F-CM AS-i Safety ST module is replaced, the new device automatically receives all necessary settings from the head module (IM) of the ET 200SP and the coding element in the BaseUnit.

When replacing an F-CM AS-i Safety module with firmware V1.0.0, the instructions in Section "DS 206 Diagnostic data record (Page 58)" must be observed.

For more information, see Manual "ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293/0/en)

Technical specifications

9

9.1 Technical data in Siemens Industry Online Support

Technical data sheet

You can also find the technical data of the product at Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/15757/td).

1. Enter the full article number of the desired device in the "Product" field, and confirm with the Enter key.
2. Click the "Technical data link.

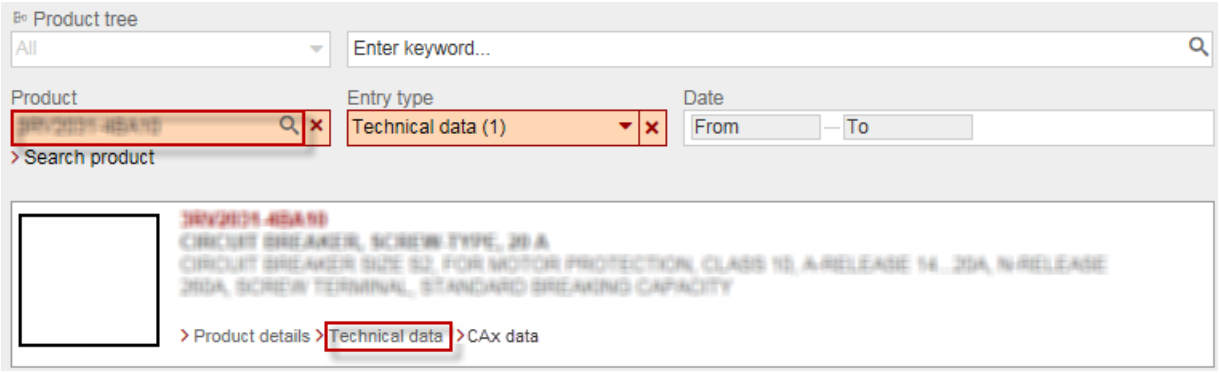

9.2 Configuration software

Information on the configuration software that you can use can be found in the Table "Software for configuration of the F-CM AS-i Safety ST" in Section Configuring the F-CM AS-i Safety ST (Page 26).

9.3 Safe technical specifications

Safety characteristics

Table 2-1969 Maximum achievable safety class in safety mode

Standard	Designation	Value
SIL according to IEC 61508	SIL	3
EN ISO 13849-1[1)]	PL	e
	Category	4

1) Performance Level

Table 2-1970 **Safety characteristics**

Characteristic	Designation	Value
High Demand according to SIL 3[1)] Total value for AS-i system with the F-CM AS-i Safety ST module[2)]	PFH_D	$1.00 \times 10^{-9} \times 1 / h$ $1.89 \times 10^{-9} \times 1 / h$
Individual value for F-CM AS-i Safety ST	PFH_D	$0.89 \times 10^{-9} \times 1 / h$
Individual value for AS-Interface transfer procedure	PFH_D	$1.00 \times 10^{-9} \times 1 / h$
Individual value for AS-Interface slave[2)]	PFH_D	0
Proof test interval	T1	20 years
Low Demand according to SIL 3[3)] Total value for AS-i system with the F-CM AS-i Safety ST module[2)]	PFD	2.00×10^{-5} 1.55×10^{-5}
Individual value for F-CM AS-i Safety ST	PFD	0.55×10^{-5}
Individual value for AS-Interface transfer procedure	PFD	1.00×10^{-5}
Individual value for AS-Interface slave[2)]	PFD	0
Mean Time To dangerous Failure	$MTTF_d$	≥100 years (37 000 years) High (according to EN ISO 13849-1)
Diagnostic Coverage level	DC	>99 %
Common Cause Failure	CCF	75 points (requirements met according to EN ISO 13849-1)

1) Probability of a dangerous failure in the case of an operating mode with high or continuous demand rate

2) Value "0" as an approximation for the individual value for AS-Interface slave applies only under the assumption that the PFH

3) Probability of a dangerous failure in the case of an operating mode with lower demand rate

9.4 Response times

The response times specified below represent worst case specifications. The response times relate to the switch-off operation (status change "1" → "0").

The response times for the switch-on operation (status change "0" → "1") can be longer but are not relevant for the given safety-related examination.

Maximum response time in the input direction

The maximum response time in the input direction results from the calculation of the response time from the safe AS-i input slave up to the head module (IM) of the ET 200SP:

max.	5 ms	AS-i bus cycle with maximum configuration
max.	5 ms	Disturbance in AS-i bus cycle with maximum configuration
max.	20 ms	Module-internal processing

max.	2 ms	Transfer ET 200SP backplane bus
max.	32 ms	Total response time in input direction (with 0 ms input delay)

WARNING

Increased response time

If an input delay time > 0 is assigned for a safe input, this input delay time must be added to the total response time.

In the total response time indicated above, external influencing variables are **not** included:

- Response time of the sensor
- Additional response time in the safe AS-i input slave (see operating instructions)
- Bus response time between the head module (IM) of the ET 200SP and the controller
- Response time of the controller
- Timeout time (F-monitoring time) of the controller in case of PROFIsafe failure

These influencing variables must be taken into consideration when calculating the system response time of the total system.

In the above-indicated total response time, it is taken into consideration that a maximum of 4 AS-i bus cycle times elapse between a safe input slave failure and detection of an error.

Maximum response time in the output direction

The maximum response time in the output direction results from the calculation of the response time from the head module (IM) of the ET 200SP to the safe AS-i input slave (evaluation unit).

max.	2 ms	Transfer ET 200SP backplane bus
max.	20 ms	Module-internal processing
max.	5 ms	AS-i bus cycle with maximum configuration
max.	5 ms	Disturbance in AS-i bus cycle with maximum configuration
max.	32 ms	Total response time in output direction (for disturbance-free PROFIsafe transmission)

WARNING

Increased response time

In case of PROFIsafe failure, the total response time in the output direction increases by the set timeout time of the F-CM AS-i Safety ST module (see F-parameters, F-monitoring time).

In the total response time indicated above, external influencing variables are **not** included:

- Response time of the controller
- Bus response time between the controller and the head module (IM) of the ET 200SP
- Response time in the safe AS-i output module (evaluation unit), see operating instructions
- For response time of the safe AS-i output module (evaluation unit) in case of AS-i failure, see operating instructions
- Response time of the actuator (e.g., contactor)

These influencing variables must be taken into consideration when calculating the system response time of the total system.

Additional information

Further information is provided in

System Manual SIMATIC Industrial Software Safety Engineering in SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/12490443/0/en)

For calculation of response times, the following aid is available on the Internet:

- For S7 Distributed Safety, the Excel file S7fcotia.xls (http://support.automation.siemens.com/WW/view/en/25412441)

9.5 Calculation of monitoring times and response times

The Excel file S7fcotia.xls for S7 Distributed Safety is available on the Internet to aid the approximate calculation of the runtime of the F-runtime group, the minimum F-monitoring time, and the maximum response time of the safety program:

S7fcotia (http://support.automation.siemens.com/WW/view/en/25412441)

Additional information is available in Manual "Safety Engineering in SIMATIC S7".

You can download this free of charge on the Internet at:

Safety Engineering in SIMATIC S7
(http://support.automation.siemens.com/WW/view/en/12490443/0/en)

Notes on completing the Excel file S7fcotia.xls (when used without IE/PB Link)

Tab "max. runtime F-run-time group"

Enter the number of modules (in the relevant F-runtime group) in the "F-CM AS-i Safety ST" row under "ET 200SP fail-safe modules".

Tab "min. F-Monitoring times"

In the "Configuring the PROFIsafe monitoring time" section, select one of the following variants depending on which head module (IM) of the ET 200SP is being used.

- Variant 3 (distributed F-I/O via PROFINET IO)

Use the values from the following table.

Table 2-1971 Values for calculating the minimum F-monitoring times

Description	Designation	Value
Max. acknowledgment time of the F-CM AS-i Safety ST	T_DAT	20 ms
F-I/O with inputs and outputs	-	Yes

Tab "max. response times"

In the "Input" section, select one of the following variants for the relevant signal flow of the safety function depending on which head module (IM) of the ET 200SP is being used:

- Variant 3 (distributed F-I/O via PROFINET IO)

Use the values from the following table.

Table 2-1972 Values for calculating the max. response times

Description	Designation	Value
Max. discrepancy time (Note: The safe value 0 is supplied while the discrepancy time is running)	T_DIS	0
Maximum response time in error-free operation	T_WCDT	20 ms
Maximum response time when an error is present	T_OFDT	20 ms

Description	Designation	Value
Max. acknowledgment time of the F-I/O	T_DAT	20 ms
Configured PROFIsafe monitoring time	T_PSTO, conf.	F_WD_TIME (see the setting on the PROFISAFE tab of the properties dialog)
Max. response time of sensor Note: For T_Sensor_DLY, the part of the system starting from the F-CM AS-i Safety ST module up to the sensor, including the AS-i bus, is considered.	T_Sensor_DLY	10 ms (signal flow of AS-i Bus) + Assigned input delay + Response time of the sensor + Additional response time in the safe AS-i input slave

List of abbreviations

A

A.1 List of abbreviations

Meaning of abbreviations

Abbreviation	Meaning
ADDR	Addressing
AS-i	AS-Interface
ATEX	Atmosphere Explosive
AUX	Auxiliary
BF	AS-i bus error
BU	BaseUnit
CFG	Configuration
CM	Communication Module
CPU	Central Processing Unit
CRC	Cyclic Redundancy Check
DI	Digital Input
DIAG	Diagnosis
DP	Distributed peripherals
DS	Data record/data set
I/O	Input/Output
EMC	Electromagnetic compatibility
EN	Europäische Norm (European standard)
F-	Fail-safe
GSD	Generic Station Description
GSDML	Generic Station Description Markup Language
HF	High Feature
HSP	Hardware support package
HW	Hardware
HW ID	Hardware identifier
I&M	Identification and Maintenance
ID	Identifier
IEC	International Electrotechnical Commission
IM	Interface module
IO	Input Output
IP	Ingress Protection (enclosure class)

Abbreviation	Meaning
ISO	International Organization for Standardization
LED	Light Emitting Diode
LPS	List of configured AS-i slaves (list of "projected" slaves)
NEC	National Electrical Code
NFPA	National Fire Protection Association
PIQ	Process Image Output
PII	Process image input
PELV	Protective extra low voltage
PF	Peripheral fault
PFD	Probability of dangerous failure on demand (from IEC 61508)
PFH_D	Probability of dangerous failure per hour (from IEC 61508)
PL	Performance Level
PSF	Process signal error
PWR	Power
SELV	Safety Extra Low Voltage
SIL	Safety Integrity Level
GF, CF	System fault
PLC	Programmable logic controller

References

B

B.1 References

Additional documentation

Further information is available in the following documents:

Document type	Internet link
System Manual	ET 200SP System Manual (http://support.automation.siemens.com/WW/view/en/58649293/0/en)
Manual	ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/59753521/0/en)
System Manual	ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293/0/en)
Product Information	Product Information ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/78361093/0/en)
Programming and Operating Manual	SIMATIC Safety - Programming and configuring (http://support.automation.siemens.com/WW/view/en/54110126/0/en)
Programming and Operating Manual	S7 Distributed Safety (http://support.automation.siemens.com/WW/view/en/22099875/0/en)
Manual	CM AS-i Master ST for SIMATIC ET 200SP (http://support.automation.siemens.com/WW/view/en/71756485)
System Manual	AS-Interface System Manual (http://support.automation.siemens.com/WW/view/en/26250840/0/en)
FAQ	FAQ "Compatibility for AS-i Power24V" (http://support.automation.siemens.com/WW/view/en/20025980/133000)
IEC 61508 standard	-
System Manual	SIMATIC Industrial Software Safety Engineering in SIMATIC S7 (http://support.automation.siemens.com/WW/view/en/12490443/0/en)

SIEMENS

SIMATIC

ET 200SP
ET 200SP F-TM Count 1x1Vpp sin/cos HF (6ES7136-6CB00-0CA0)

Equipment Manual

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V1.1, 05/2024
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Preface

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system. General functions of the ET 200SP are described in the *ET 200SP Distributed I/O System* system manual (http://support.automation.siemens.com/WW/view/en/58649293).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

The information in this manual and the system/function manuals provide support when you commission the system.

A description of the F-system SIMATIC Safety can be found in the *SIMATIC Safety – Configuring and Programming* programming and operating manual (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Conventions

CPU: When the term "CPU" is used hereafter, it refers to the fail-safe CPUs of the S7-1200/1500 automation system, prior generation S7-300/S7-400 automation systems, and ET 200 CPUs.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software STEP 7 (TIA Portal).

Please observe notes marked as follows:

NOTE

A note includes important information on the product described in the documentation, on handling the product, or on the part of the documentation to which you ought to pay special attention.

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Documentation guide

1

1.1 ET 200SP Documentation guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

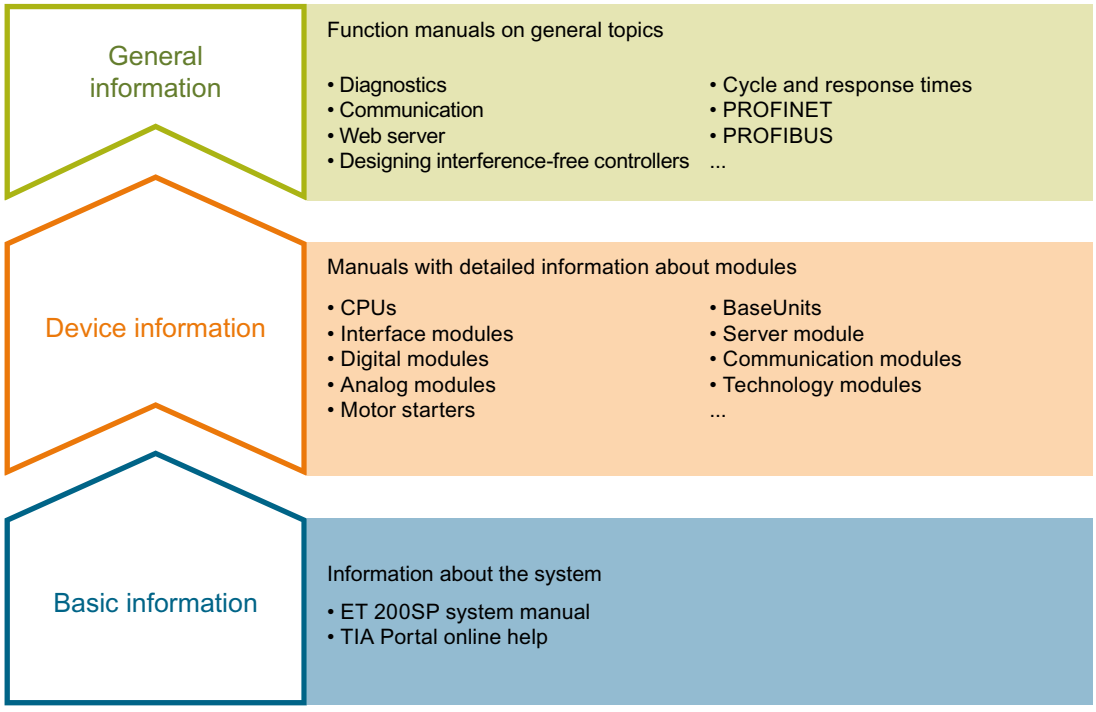

Basic information

The system manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics, and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC ET 200SP distributed I/O system (for example, diagnostics, communication, Web server, motion control, and OPC UA).

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/73021864).

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/ww/view/en/84133942).

"mySupport"

With "mySupport", your personal workspace, you make the most of your Industry Online Support.

In "mySupport" you can store filters, favorites and tags, request CAx data and put together your personal library in the Documentation area. Furthermore, your data is automatically filled into support requests and you always have an overview of your current requests.

You need to register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

In the Documentation area of "mySupport", you have the possibility to combine complete manuals or parts of them to make your own manual. You can export the manual in PDF format or in an editable format.

You can find "mySupport" - Documentation on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx Data

In the CAx Data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx Data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus in individual products.

You can find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure, and order devices for Totally Integrated Automation (TIA).

This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.

With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (https://support.industry.siemens.com/cs/us/en/view/109767888).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to run commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independently of the TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the data and the programming device/PC time converted to UTC time to the module
- Program download to CPU

- Operating mode switchover RUN/STOP
- Localization of the CPU by means of LED flashing
- Reading out CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Updating the firmware of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

With SIEMENS PRONETA (PROFINET network analysis), you analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview independently scans PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a system.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance include the following items:

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long-term and optimal exploitation of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Safety technology support

Siemens provides online comprehensive support for your use of safety technology. A Safety Evaluation Tool assists you in determining required safety levels, Functional Examples guide you in your safety applications, Siemens training (SITRAIN) classes offer training in safety standards and products, and you can calculate your maximum system response time using the SIMATIC STEP 7 Safety Advance F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times Excel file (RT_calculator) Excel file.

You can find the Safety Evaluation Tool on the Internet (http://www.siemens.com/safety-evaluation-tool).

You can find Functional Examples on the Internet (http://www.siemens.com/safety-functional-examples).

You can find SITRAIN classes on the Internet (http://www.siemens.com/sitrain-safetyintegrated).

You can find the RT_calculator on the Internet (https://support.industry.siemens.com/cs/ww/en/view/58856512).

Product overview

2

2.1 Properties

Article number

6ES7136-6CB00-0CA0

Firmware version

This manual describes the properties of the module with firmware version 1.00 or later.

View of the module

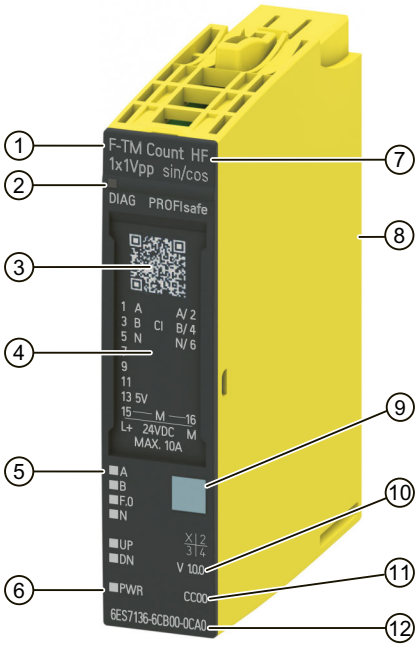

①	Module type and name	⑦	Function class
②	LED for diagnostics	⑧	Electronic coding element connector (not shown)
③	2D matrix code	⑨	Color coding module type
④	Wiring diagram	⑩	Function and firmware version
⑤	LEDs for channel status	⑪	Color code for selecting the color identification labels
⑥	LED for supply voltage	⑫	Article number

Figure 2-1533 View of the F-TM Count 1x1Vpp sin/cos HF module

Use of the module

The F-TM Count module reports events and statuses based on configured parameters and external movement operations in the SIMATIC ET 200SP distributed I/O system. It provides a SIN/COS encoder interface that can safely count up to a maximum speed of 200 kHz.

The F-TM Count module features a 15-mm wide, ET 200SP module housing. Refer to *Connecting* (Page 22) for a list of compatible BaseUnits (BUs).

The F-TM Count module supports safety-related applications up to SIL CL 3 according to EN 62061, or Cat. 4, PL e according to EN 13849-1. The input and output values of the safety-related F-TM Count module are addressed using the process image. You need an F-CPU for safety processing.

Properties

The F-TM Count module has the following technical properties:

- Failsafe module
- PROFIsafe (under supported system functions)
- 200 kHz counter input
- SIL 3, Cat. 4, PL e
  - Diagnostic display (DIAG red/green LED)
  - Status display for each input (green LED)
  - Error display for each input (red LED)
- Single configurable channel:
  - Interfaces:
    Sin/Cos differential encoder signals A, A/, B, B/, N and N/

    5 V DC encoder supply that is short-circuit proof

    Module supply voltage L+ (24V)
  - Count range: 32 bits
  - Monitoring of encoder signals for wire break, short-circuit and signal quality
  - Monitoring of supply voltage
- Supported encoder/signal types:
  - Sin/Cos differential encoder with and without N signal
- Supported system functions:
  - Module and channel diagnostics
  - Firmware update
  - Identification and maintenance data (I&M 0-3)

Accessories

You can use the following accessories with the F-module; however, the accessories are not included in the product package:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connector (article number 6ES7193-6SC00-1AM0)
- Cable (article number 6FX8008-1BD31-XXXX) sold by the meter or equivalent

Article numbers are provided for those items unique to the F-TM Count module. Additional information about accessories can be found in the *ET 200SP Distributed I/O System* system manual (http://support.automation.siemens.com/WW/view/en/58649293).

2.2 Functions

2.2.1 Safety

What are fail-safe automation systems?

Safety-related systems are primarily concerned with applications whose failure could have impact upon the safety of people and/or the environment. As a result, safety-related systems are used to mitigate hazards or failures that are likely to cause physical harm. Their intent is to achieve safety to an acceptable level of tolerable risk.

F-systems serve to control processes and ensure safe states upon detected failures. Failures are detected using very high levels of diagnostic coverage. Upon detection of failures, actions are taken to attempt to bring the respective application to a safe state.

F-systems provide improved fault detection and fault localization through detailed diagnostic identification and reporting. This is the primary difference between fail-safe systems and standard systems. Use of fail-safe systems should be considered for applications in which hazards are inherently present and may result in physical harm.

Supported safety monitoring functions

The F-TM Count module provides safety monitoring functions that may be used to monitor speed, position, and/or direction. These safety monitoring functions can be optionally enabled to report safety events if configured safety limits are exceeded. The safety monitoring functions include the following:

- Safe Direction (SDI) is used to monitor the direction of motion.
- Safety Limited Speed (SLS) is used to monitor that the motion does not exceed a preset speed limit.
- Safe Operating Stop (SOS) is used to monitor for unintentional movement.

WARNING

The F-TM Count module cannot take action that affects the safety functions.

The F-TM Count module reports when the parameter limits are exceeded to the F-CPU.

You must ensure code in your safety program does the following:

- Examines the safety-monitoring event data from the module
- Takes the necessary action to result in the appropriate outcome (for example, slowing down, or shutting down movement)

2.2.2 Detection of counting signals

The F-TM Count module monitors the encoder signals and evaluates them as quadrature encoded signals. The count direction is determined by the phase relationship of the encoder signals.

You can specify the counter characteristics using the functions described below.

Counting limits

You can configure the behavior of the counter at the counting limits. The counting limits define the counter value range used.

Start value

You can configure a start value within the counting limits.

2.2.3 Measured value determination

You can select one at a time from the following measured values reported:

- Frequency measurement with the unit of millihertz (-800000000 to +800000000 meaning -800000.000 to +800000.000 Hz)
- Period measurement with the unit of microseconds (-25000000 to +25000000 meaning -25.000000 to +25.000000 seconds)
- Velocity measurement is the calculated velocity * 1000 to include fractional portion of the calculation (-2147483648 to 2147483647 meaning -2147483.648 to +2147483.647 velocity unit)

All measured values are returned as scaled integers with the units noted above.

Negative values are reported when counting down, positive values are reported when counting up.

Update time

Calculated measured value accuracy is influenced by the duration of selected update times. You can configure the interval at which the technology module updates the measured values cyclically to the F-CPU. Setting a longer update time interval allows the module to collect more data to calculate a more accurate measured value, but reaction time increases.

The following figure illustrates the effect of update time on the approximate accuracy of measured value calculations:

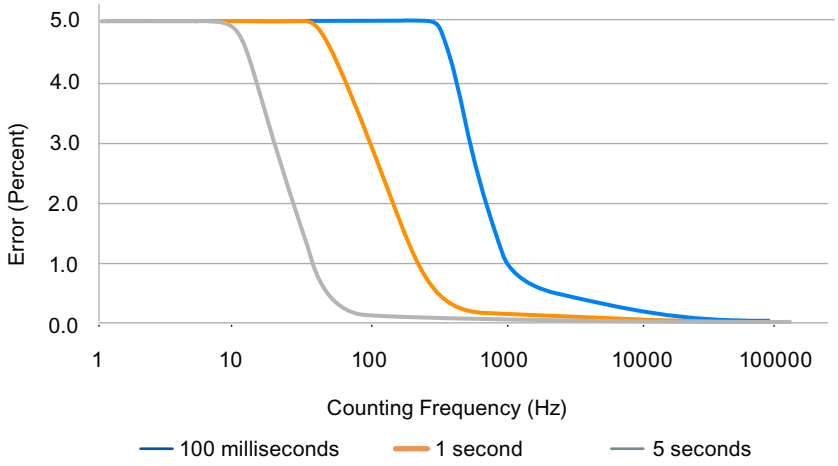

For example: the figure shows that at a frequency of 100 Hz, the percent error in the measured value is about 10 times greater at a 1 second update time as compared to a 5 second update time.

NOTE

The safety reaction time is influenced by the chosen update time when using measured values as part of your safety program (for example, at about 100 Hz, the relative error with a 1 second update time is approximately three times greater than a 5 second update time). For additional information, refer to Response times of the F-TM Count module (Page 80).

NOTE

The user should consider the measured value accuracy at the user's specified counting frequency range when determining the Safety Limited Speed "Speed limit" setting.

Gate control

Software (SW) gating is required to control when counting is permissible. When the SW gate is open, counting is enabled.

When the SW gate is closed the following occurs:

- Counting is disabled until the gate is opened again. Position is not maintained if movement occurs.
- Measured value calculations are still performed, but the last reported measured value is continually reported until the gate is opened again.
- Safety monitoring operations will still be performed. However, their progress is paused until the gate is again opened. Movement that violates specified limits will not be detected.

You can configure the reaction to the gate opening.

Examples of determining measured values

Use STEP 7 device configuration to set the values for the module in the following examples. For your velocity in meters per second, you set the "Time Base for Velocity Measurement" field to the value "1 second" and the "Counts per Unit for Velocity" to how many counts per meter the encoder will generate. The velocity value returned to your safety program will be the meters per second value * 1000. Multiplying the meters per second value by 1000 ensures the velocity value has sufficient resolution to show the fractional portion of the calculation.

Setting "Velocity" in meters per second

You set the parameter values as follows:

- "Measured value" to "Velocity"
- "Update Time" to 1000 milliseconds - Provides an updated velocity calculation to your safety program every second (1000 milliseconds)
- "Time Base for Velocity Measurement" value to "1 second"
- "Counts per Unit for Velocity" to 100 if your encoder generates 100 counts per meter

In this example, if you measured 452 counts during the one second update time and there are 100 counts per meter, the movement distance is 4.52 meters during the one second update time. Since the desired unit is meters per second, the velocity returns as a scaled value (velocity * 1000) and your safety program sees the velocity as 4520. You would then interpret the value as 4.520 meters per second.

Setting the "Update Time" to "100 milliseconds"

Use the same setup as the previous example, but set the "Update Time" to 100 milliseconds.

In this example, if you measure about 45 counts during the update time, convert this to meters per second. The result is a velocity measurement of 4500 which is 4.500 meters per second.

The module measured 4.5 meters per second, which is fewer than the previous measurement 4.52 meters per second. This results in you losing some resolution in the velocity measurement because of the shorter update time.

Setting the "Time Base for Velocity Measurement" to "100 milliseconds"

Use the same setup as the first example, but set the "Time Base for Velocity Measurement" to meters per 100 milliseconds.

In this example, if you measure 452 counts during the one second update time and there are 100 counts per meter, the movement distance is 4.52 meters during the one second update time. Since you want meters per 100 milliseconds, the velocity returns as a scaled value (velocity * 1000) and your safety program sees the velocity as 452. You would then interpret the value as 0.452 meters per 100 milliseconds.

2.2.4 Counter control and feedback

The safety-related counter input (feedback) and output (control) data are transferred to and from the F-CPU, via the PROFIsafe protocol to ensure the configured system operates safely.

Control

The following commands are set by your safety program and sent from the F-CPU to the F-TM Count module:

- Open SW Gate
- Reset Other Events
- Reset Safe Speed
- Reset Safe Stop
- Reset Safe Direction
- Set Start Value
- Enable Safe Speed
- Enable Safe Stop
- Enable Safe Direction
- Safe Direction

Feedback

The following feedback status and event data are sent from the F-TM Count module to the F-CPU:

- Direction Status
- Count Status
- Set Start Value Status

- Reset Other Events Status
- Reset Safe Speed Status
- SW Gate Status
- Reset Safe Stop Status
- Reset Safe Direction Status
- Value status (CQ HSC0)
- Zero Event
- Underflow Event
- Overflow Event
- Safe Speed Event
- Safe Stop Event
- Safe Direction Event
- HSC0 Current Value
- HSC0 Measured Value

See also

Refer to "Explanation of parameters (Page 35)" for additional information on the F-TM Count module control interface commands and feedback status and event data.

2.2.5 Counter input diagnostics

Counter discrepancy

The module uses multiple internal counters to monitor the single counter-module input. Discrepancy tests are performed to ensure respective internal counter values are compared for acceptable equivalency. If these evaluations do not provide expected results, a channel diagnostic event is generated.

After generating the diagnostic event, the module reinitializes its internal count to the last valid count before the discrepancy was detected. The module then continues monitoring the encoder and accumulating counts while the diagnostic is present.

A count value of zero and status values of zero (safe state values) are provided to your safety program while the diagnostic is present. When the error is resolved and the channel is reintegrated, the module will return the accumulated count and status values to your safety program.

WARNING

Discrepancy errors may result in a loss of counts due to the count being set back to the last known good values.

Your safety program must determine whether the reported count value remains representative of actual position.

If the position is lost, your safety program must do a homing operation and then reset the counter to its respective start value.

Maximum signal frequency

The F-TM Count module evaluates the input frequency. When encoder signal frequency reaches the maximum frequency rating (200 kHz), a reintegratable frequency error is generated.

WARNING

The count value can potentially be affected when exceeding the maximum supported signal frequency.

Your safety program must determine whether the reported count value remains representative of actual position. If position is lost, your safety program must do a homing operation and then reset the counter to its respective start value.

In situations where encoder signal frequency exceeds 250 kHz, the module generates a module is defective buffer diagnostic message. However, the module is not defective since the fatal error was caused by external events. The module must be power cycled to recover from the error.

N signal plausibility monitoring

This feature is only available when the encoder signal type is selected as an "A, B, N" signal and the "Pulses per revolution" is set to a non-zero value during module configuration in STEP 7. The test uses the "Pulses per revolution" parameter to determine the expected number of counts per revolution of the encoder. In situations where the N signal is not received at the configured "Pulses per revolution", a channel diagnostic event is generated.

The module continues monitoring the encoder and accumulating counts while the diagnostic is present. While the diagnostic is present, a count value of zero and status values of zero (safe state values) are provided to your safety program. When the error is resolved and the channel is reintegrated the module will return the accumulated count and status values to your safety program.

WARNING

It is possible for a channel fault to occur that is not readily detected by the module diagnostics if N signal plausibility monitoring is disabled.

Loss of the safety function can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.

If N signal plausibility monitoring is disabled, N signal or wire break errors detected are not reported and you might not achieve your required level of safety. You must provide your own safety measures if you disable these features.

A and B signal monitoring

Signal monitoring evaluates the quality of the A and B signals. The following A and B signal quality faults can cause a channel diagnostic event to be generated.

- Phase angle of A and B signal has shifted from 90°
- Signal amplitude (voltage) is too great or too small
- Wire break, shorted signals, or encoder failure

NOTE

A wire break might not be detected if the encoder is stopped. However, movement of the encoder position will result in detection of the break.

The module continues monitoring the encoder and accumulating counts while the diagnostic is present. While the diagnostic is present, a count value of zero and status values of zero (safe state values) are provided to your safety program. When the error is resolved and the channel is reintegrated the module will return the accumulated count and status values to your safety program.

WARNING

The count value can potentially be affected when a signal quality fault occurs.

Your safety program must determine whether the reported count value remains representative of actual position. If position is lost, your safety program must do a homing operation and then reset the counter to its respective start value.

WARNING

Signal monitoring allows the module to meet SIL, Cat., PL rating. It is possible for a channel fault to occur that is not readily detected by the module diagnostics if signal monitoring is disabled.

Disabling this feature reduces the safety rating to SIL 1, Cat. 2, PL c, which causes a loss of the safety function. Disabling this feature can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.

If signal monitoring is disabled, A and B signal or wire break errors detected are not reported and you might not achieve your required level of safety. You must provide your own safety measures if you disable these features.

Connecting

3

3.1 Wiring and block diagram

This section provides the block diagram of the F-TM Count 1x1Vpp sin/cos HF module with the terminal assignment.

Block diagram

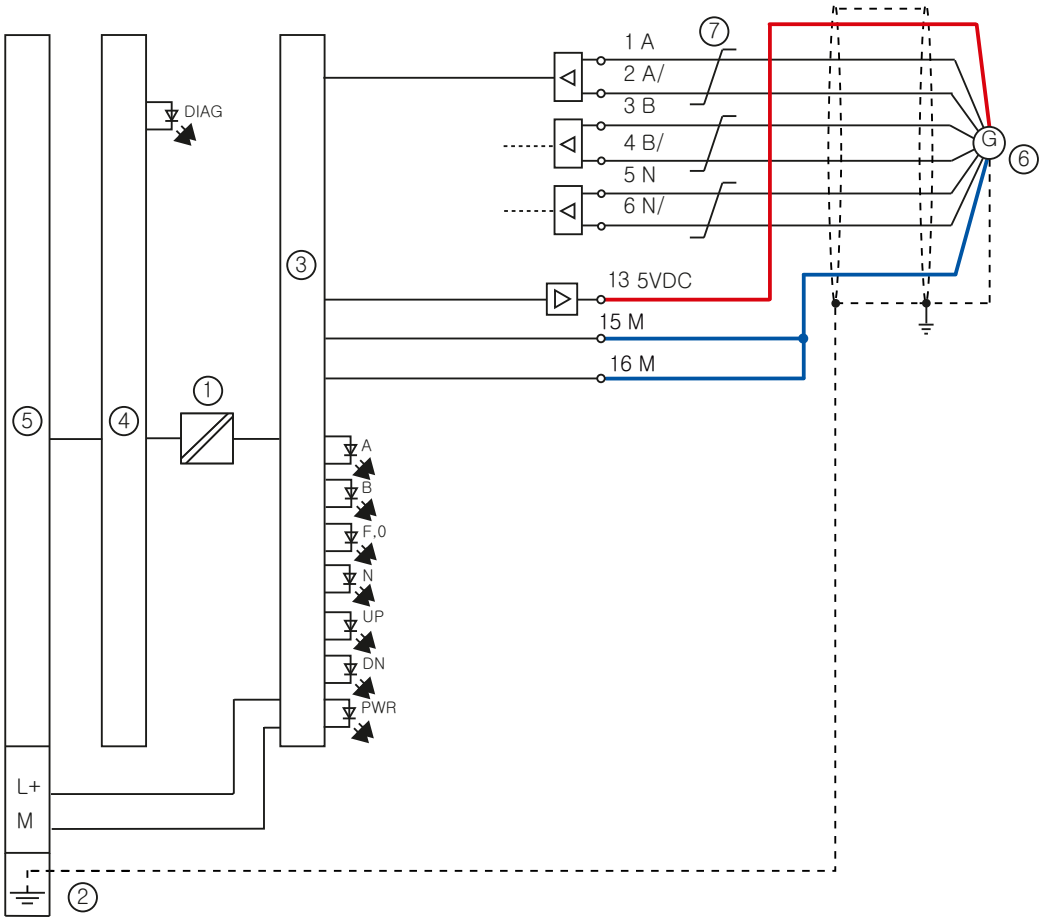

① Electrical isolation
② Shield connection on the BaseUnit
③ Technology
④ Backplane bus interface module of the F-TM Count module
⑤ Backplane bus
⑥ Sin/Cos encoder
⑦ Twisted in pairs

Figure 2-1534 Block diagram with sin/cos encoder

BaseUnit

The BaseUnit is not included with the delivery of the module.

You can find information on wiring the BaseUnit, connecting cable shields, etc. in the Connecting section of the *ET 200SP Distributed I/O System*, system manual (https://support.industry.siemens.com/cs/pl/en/view/58649293).

Pin assignment of the BaseUnit

Table 2-1973 Pin assignment of BaseUnit BU15-P16+A10+2B, BU type A0

Designation	Signal name		View	Signal name		Designation
SIN/COS differential encoder with or without signal N						
Encoder signal A	A	1	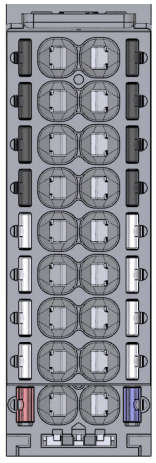	2	A/	Encoder signal A/
Encoder signal B	B	3		4	B/	Encoder signal B/
Encoder signal N	N	5		6	N/	Encoder signal N/
—	—	7		8	—	—
—	—	9		10	—	—
—	—	11		12	—	—
Encoder supply 5 V DC	5 VDC	13		14	—	—
Encoder supply ground	M	15		16	M	Encoder supply ground
Supply voltage 24 V DC	L+				M	Ground for supply voltage
Shield	—				—	Shield

Supply voltage L+/M

You connect the supply voltage to terminals L+ and M on a light BaseUnit. For a dark BaseUnit, the supply voltage of the module to the left is used. An internal protection circuit protects the F-TM Count module from reverse polarity of the supply voltage. The F-TM Count module monitors whether the supply voltage is connected.

CAUTION

Electrical noise risk

Electrical noise on the 24 V DC voltage supply lines can yield unexpected results. For example, inserting and removing modules into an I/O base that is powered on can generate electrical noise.

Avoid actions that have the possibility to generate electrical noise on the 24 V DC voltage supply lines. Electrical noise can occur when I/O connectors make and break contact between the base and module. This noise can become visible to all modules and sensors connected within the potential group. For F-TM Count applications, sensors include encoders, especially externally powered 24 V DC sensors. The electrical noise could result in unexpected influences, such as A and B signal failures. In this situation Siemens recommends a separate potential group for the F-TM Count module and encoder.

Encoder supply

The encoder supply from the F-TM Count module provides 5 V DC encoder sensor supply voltage. The encoder supply is only switched off during the following occurrences:

- There is a fatal error
- There is a firmware update in progress

NOTE

The F-TM Count module can only support 5 V DC encoders using the module's internal sensor supply. However, 10 to 30 V DC incremental encoders can be supported when externally powered.

3.2 Requirements for the Encoder

Encoder Characteristics

The selected incremental encoder must include the following capabilities:

- encoder generated signals at 1Vpp centered at 2.5V
- encoder generated A and B differential sinusoidal signals
- differential signals between A and A/, B and B/
- A and B signals are 90° phase-shifted
- N signal support is optional; the N terminals are unconnected when not used

Encoder signal names are defined by the encoder manufacturer and can differ from the signal names used in this manual. Signals herein are designated with the letters A, A/, B, B/, N and N/.

Due to anticipated safety application requirements when using the F-TM Count module, the connected encoder is evaluated in a safety-related manner. Encoder-generated faults, including correct A-to-B signal phase offsets, incorrect output signal voltages (1Vpp), wire breaks, parasitic oscillations, etc., are detected by the F-TM Count module. These faults are detected for any connected encoder, whether safety-rated or non-safety-rated.

To determine the achievable safety rating for the application, the encoder's functional safety failure characteristics must be determined--i.e., SIL, CAT, PL, $MTTF_d$, and $B10_d$. If such information cannot be found on the encoder manufacturer's data sheet, then the failure response data must be requested from the encoder manufacturer.

If encoders are used that specify no safety ratings, it is recommended that the failure response of the selected encoders causes the encoder signals to fall outside of the valid 1Vpp range. This allows the F-TM Count module to detect the encoder failure. Failure scenarios must be clarified with encoder manufacturers.

Siemens-specific encoder references may be found within the following SIOS entry:

SINAMICS S120 drive system for SINUMERIK Safety Integrated (https://support.industry.siemens.com/cs/de/en/view/33512621)

Immunity

WARNING

Failure to use properly shielded cable will result in degraded performance of the module because of lack of immunity.

To meet noise immunity standards, it is necessary to use cable (article number 6FX8008-1BD31-XXXX) sold by the meter for cable lengths greater than 1 meter or equivalent.

Wiring using the cable is shown in the following figure:

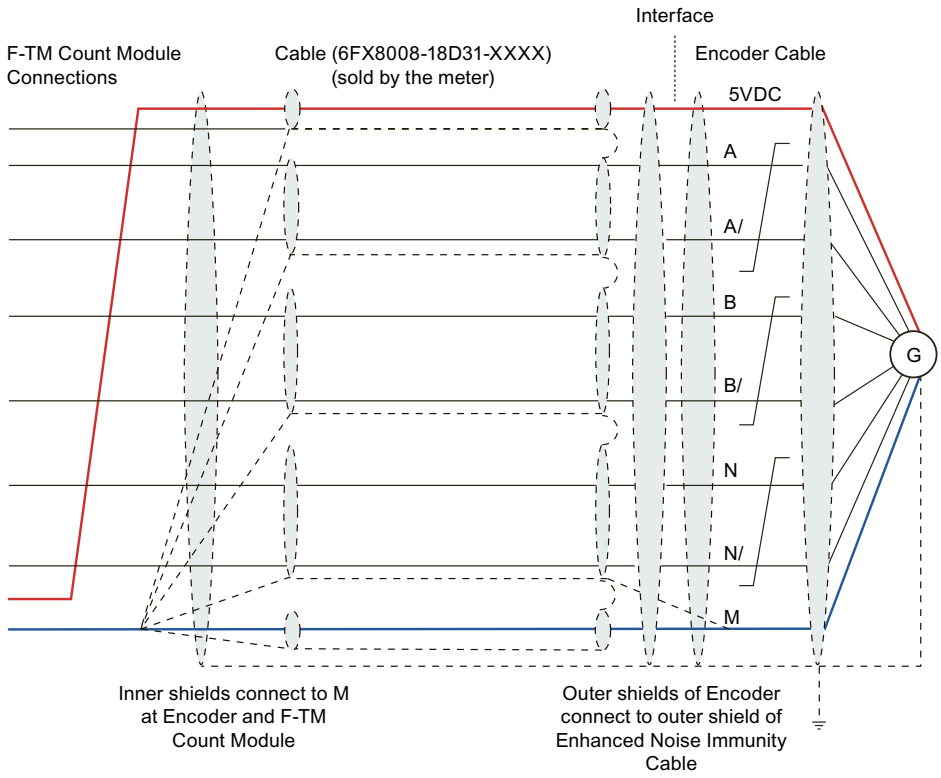

NOTICE
The right side of the F-TM Count module may exhibit some sensitivity to electrostatic discharge (ESD). Care should be taken to avoid exposure to ESD. If possible, it is recommended the F-TM Count module is not the last module on the right of the mounted configuration.

Radio frequency (RF) interference on encoder cables

Some encoders are sensitive to conducted RF on encoder cables. This can occur if the encoder cable is in a cable tray with other cables that can cause RF interference (for example, control cables).To prevent interference with the encoders, route control and encoder/sensor cables separately from each other. In the unlikely event that the encoder is still affected, you can place Type 28B ferrite clamp filters on the encoder cable at the encoder.

NOTE

For more information about the evaluation of differential signals, see "Quadrature evaluation of differential signal" (Page 47).

Parameters/address space

4

4.1 Configuring the F-TM Count module

All connected fail-safe I/O must have their operating properties configured by the STEP 7 Safety.

You have the responsibility to ensure that no unconfigured modules are connected in a fail-safe automation system.

Refer to the Configuring chapter of the *SIMATIC Safety - Configuring and Programming* manual (https://support.industry.siemens.com/cs/ww/en/view/54110126) for step-by-step instructions.

Fail-Safe CPUs

You can use any of the following F-CPUs with the F-TM Count module:

- S7-1200/1500 F
- S7-300/400 F
- ET 200SP F
- ET 200S F
- ET 200pro F

Hardware components for PROFINET fail-safe system

You can use the following fail-safe PROFINET hardware components in a fail-safe system:

- F-CPUs with built-in PROFINET interface
- F-CPUs with optional PROFINET communication module (CM) interface modules
- Fail-Safe inputs and outputs (F-I/O), such as:
  - ET 200SP fail-safe modules
  - Fail-Safe GSDML-based, PROFIsafe-capable I/O devices (for example, a light curtain or laser scanner)

Hardware components for PROFIBUS DP fail-safe system

You can use the following fail-safe PROFIBUS DP components in a fail-safe system:

- F-CPUs with built-in PROFIBUS interface (PROFIBUS DP master)
- F-CPUs with optional PROFIBUS DP CM interface modules
- Fail-Safe inputs and outputs (F-I/O), such as:
  - ET 200SP fail-safe modules
  - Fail-Safe GSD-based, PROFIsafe-capable DP slaves (for example, a light curtain or laser scanner)

4.1.1 Using STEP 7 (TIA Portal V17 or greater)

Assigning a PROFIsafe address

These are the three basic steps for assigning PROFIsafe addresses:

1. Configure the F-destination address and F-source address in the hardware configuration in STEP 7 Safety and download the hardware configuration.
2. Identify the F-TM Count modules to which you want to assign the configured F-destination and F-source addresses.
3. You must assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation as follows:
   - Right click on the F-TM Count module in the Device view in STEP 7.
   - Select "Assign PROFIsafe address" in the context menu.
   - Select the desired "Identification" method (LED flashing or serial number).
   - Select the check box on the left-hand side for the F-TM Count to assign an address to.
   - Click the "Identification" button.
   - Verify that the "Identification" method is correct (i.e. A and B channel LEDs flashing or serial number is correct).
   - Click the "Assign PROFIsafe addr..." button.
   - Click "Yes" in the prompt that follows.
   - If successful, the module is now operational.

NOTE

Refer to the *SIMATIC Safety - Configuring and Programming* manual (https://support.industry.siemens.com/cs/ww/en/view/54110126) for further information about PROFIsafe address identification and assignment.

Configuring F-TM Count module parameters

You specify the properties of the F-TM Count module in STEP 7 using various parameters. Depending on the settings, not all parameters are available.

You set the parameters of the module as follows:

1. Insert an ET 200SP CPU or an ET 200SP PROFINET or PROFIBUS interface module from the hardware catalog.
2. Insert the F-TM Count module from the hardware catalog under "Technology modules->Counting->F-TM Count".
3. Select the F-TM Count module (on the Device view or Device overview) and view the module's "Properties" tab.
4. In the "Properties" view, on the "General" tab, select the drop-down arrows for "Module parameters" and "TM-C parameters" to and see a subset of the properties of the "F-parameters" and "TM-C parameters".
5. Select "F-parameters" property or one of the "TM-C parameters" properties in the left-side property tree and then set values in the right-side property fields.
6. A successful compile and download of your hardware configuration to an F-CPU automatically configures your F-TM Count module.

4.1.2 Using STEP 7 (TIA Portal) with GSDML (versions of TIA Portal prior to V17)

Configuring F-modules with a GSDML file

If you need to configure F-modules with a GSDML file, you need the *S7-FCT* in order to calculate the F_iPar_CRC and assign the PROFIsafe addresses. Operating instructions and additional information for the *S7-FCT V2.0 - Fail-safe Configuration Tool* can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109763833).

You can find *S7-FCT* on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

Assigning a PROFIsafe address

These are the three basic steps for assigning PROFIsafe addresses:

1. Configure the F-destination address and F-source address in the hardware configuration in STEP 7 Safety and download the hardware configuration.
2. Identify the F-TM Count modules to which you want to assign the configured F-destination and F-source addresses. F-destination addresses are generally assigned with lower numbers (for example, less than 100) for GSDML configured devices, and should be within the range of the F-CPU F-destination address range for PROFIsafe address type 1 devices.
3. Use "Assigning the F-source address and F-destination addresses to the F-I/Os" section in the instructions for the *S7-FCT V2.0 - Fail-safe Configuration Tool* on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109763833) to assign the PROFIsafe address (F-destination address together with F-source address) to the F-module before you put it into operation.

NOTE

Refer to the *SIMATIC Safety - Configuring and Programming* manual (https://support.industry.siemens.com/cs/ww/en/view/54110126) for further information about PROFIsafe address identification and assignment.

Configuring F-TM Count module parameters

You specify the properties of the F-TM Count module in STEP 7 using various parameters. Depending on the settings, not all parameters are available.

You set the parameters of the module as follows:

1. Insert the IM 155-6 PN interface module from the hardware catalog under "Other field devices->PROFINET I/O->I/O->SIEMENS AG->ET 200SP->Interface modules".
2. Insert the F-TM Count module from the hardware catalog under "Module->TM->Counting->F-TM Count". Select PROFIsafe V2.4 if you are using an S7-300 or S7-400 F-CPU. Select PROFIsafe V2.6 version if you are using an S7-1200 or S7-1500 F-CPU.
3. Select the F-TM Count module (on the Device view or Device overview) and view the module's "Properties" tab.
4. In the "Properties" view, on the "General" tab, select the drop-down arrows for "Module parameters" and "TM-C parameters" to see a subset of the properties of the "F-parameters" and "TM-C parameters".
5. Select "F-parameters" property or one of the "TM-C parameters" properties in the left-side property tree and then set values in the right-side property fields.
6. Start the S7-FCT for the F-TM Count module and calculate the F_iParCRC.
7. Copy the F_iParCRC into the intended PROFIsafe parameter of the F-TM Count module.
8. A successful compile and download of your hardware configuration to an F-CPU automatically configures your F-TM Count module.

4.2 Reinitialize on parameterization download

Each time parameterization of the F-module occurs, reinitialization of internal module states is required. This means that internal module states are equivalent to power-up states. Reinitializing results in the following changes in the module:

- Process image status and event bits are reset
- Counter value is reinitialized to the start value
- Measured value calculations are reinitialized
- Process image command enables are reset
- Safety monitoring intermediate values are reset (for example, intermediate values associated with SOS, SDI, and SLS calculations)

In addition to a user commanded download of parameters from STEP 7 (TIA Portal), parameters will be downloaded, and the counter module will be reinitialized in the following circumstances:

- Power cycling of the F-CPU
- Pull/Plug of the module
- Power cycling the 24V user power to the module
- Power cycling of the IM on a remote rack
- Pull/Plug of the PROFInet cable to the IM remote rack

4.3 Reaction to CPU STOP

You set the response of the F-TM Count module to CPU STOP for the module in the device configuration.

Table 2-1974 Response of technology module to CPU STOP

Option	Meaning
Continue counting	The F-TM Count channel continues to count pulses while the F-CPU is in STOP mode or while PROFIsafe communication is lost.
Stop counting	The F-TM Count channel does not continue to count. This is equivalent to closing the SW gate.

WARNING

In situations where the F-CPU is in STOP mode, the count value can potentially be affected.

The count value can be affected by the following behaviors:

- Your safety program states that may result during the commanded transition to STOP mode.
- External channel-related errors that could occur while the F-CPU is in STOP mode.
- Power cycling of the module while the F-CPU is in STOP mode.
- Your safety program control of the software gate signal when transitioning again to RUN mode. Closing of the software gate results in the loss of counts during external movement.

Your safety program must determine whether the reported count value remains representative of actual position when the behaviors above occur. If the position is lost, your safety program must do a homing operation and then reset the counter to its respective start value.

4.4 Reactions to counting limit violation

A counting limit can be violated when the counter value exceeds the high or low counting limit. Reactions to violating a counting limit are as follows:

Table 2-1975 Response of technology module to counting limit violation

Option	Meaning
Continue counting	The F-TM Count channel continues to count pulses while the counting limit is violated after setting the count to either the opposite limit or to the start value.
Stop counting	The F-TM Count channel does not continue to count. This is equivalent to closing the SW gate.

4.5 Parameters of the F-TM Count

The following parameter settings are possible:

Table 2-1976 Settable parameters and their default setting

Parameter	Value range	Default setting	Parameter reassign-ment in RUN	Scope STEP 7 (TIA Portal); STEP 7; GSD file
F-parameters				
Manual assignment of F-monitoring time	Check box: • Enable • Disable	Disable	No	Module
F-monitoring time [1]	14 to 65535 ms in 1 ms steps	150 ms	No	Module
F-destination address	1 to 65534	Address supplied by F-CPU (Always enabled)	No	Module
TM-C parameters				
Signal Monitoring	• Disable • Enable	Enable	No	Channel
Encoder related parameters				
Signal type [2]	• Sin/Cos encoder (A, B, N) • Sin/Cos encoder (A, B)	Sin/Cos encoder (A, B, N)	No	Channel
Invert direction	• Disable • Enable	Disable	No	Channel
Pulses per revolution	0 to 32767	1024	No	Channel
Reaction to signal N	• No reaction to signal N • Synchronization at signal N	No reaction to signal N	No	Channel
Counter parameters				
High counting limit	-2147483647 to 2147483647	2147483647	No	Channel
Start value	-2147483648 to 2147483647	0	No	Channel
Low counting limit	-2147483648 to 2147483646	-2147483648	No	Channel
Reaction to violation of a counting limit	• Continue counting • Stop counting	Continue counting	No	Channel
Reset when counting lim-it is violated	• Start value • Opposite counting limit	Start value	No	Channel
Reaction to gate start	• Set to start value • Continue with current value	Set to start value	No	Channel
Safety monitoring				
Measured value	• Frequency • Velocity • Period duration	Frequency	No	Channel

1 STEP 7 uses this number to set the F-monitoring time in each F-TM Count module unless you select the check box for "Manual Assignment of F-monitoring time" in that module configuration and assign a different time.

2 If (A, B) is selected, then "Pulses per revolution" and "Reaction to N signal" are disabled.

3 Velocity must be selected to configure this parameter.

Parameter	Value range	Default setting	Parameter reassign-ment in RUN	Scope
				STEP 7 (TIA Portal); STEP 7; GSD file
Update time	0 ms to 25000 ms	100 ms	No	Channel
Time base for velocity measurement [3]	• 1 millisecond • 10 milliseconds • 100 milliseconds • 1 second • 60 seconds	1 second	No	Channel
Counts per unit for velo-city measurement [3]	1 to 65535	1	No	Channel
Safety Function - Safe Stop	• Enable • Disable	Disable	No	Channel
Standstill tolerance	0 to 65535 (counts)	0	No	Channel
Safety Function - Safe Dir-ection	• Enable • Disable	Disable	No	Channel
Monitoring tolerance	0 to 65535 (counts)	0	No	Channel
Safety Function - Limited Speed [2]	• Enable • Disable	Disable	No	Channel
Speed limit [3]	0 - 2147483647 (Velocity * 1000)	0	No	Channel
Reaction to CPU STOP				
Reaction to CPU STOP	• Continue counting operation • Discontinue counting operation	Continue counting operation	No	Channel

1 STEP 7 uses this number to set the F-monitoring time in each F-TM Count module unless you select the check box for "Manual Assignment of F-monitoring time" in that module configuration and assign a different time.

2 If (A, B) is selected, then "Pulses per revolution" and "Reaction to N signal" are disabled.

3 Velocity must be selected to configure this parameter.

4.6 Explanation of parameters

4.6.1 F-parameters

Manual assignment of F-monitoring time

This is a selection to enable the "Manual assignment of F-monitoring time".

F-monitoring time

The monitoring time of safety-related PROFIsafe communication occurring between the F-CPU and the F-I/O module.

F-source address

A unique network-wide address for the fail-safe CPU assigned to the F-CPU with the "Central F-source address" parameter.

F-destination address

A unique F-destination address for each fail-safe module.

F-parameter signature (with addresses)

A signature for all F-parameters including F-addresses; used to easily determine whether parameterization changes have occurred.

F-parameter signature (without addresses)

Signature for all F-parameters without F-addresses; used to easily determine whether parameterization changes have occurred.

Behavior after channel fault

Specifies a passivation response by the F-TM Count module to channel faults. (Always set to "Passivate channel" for the F-TM Count module since there is a single channel.)

Reintegration after channel fault

Specifies a switchover from fail-safe values to process data (reintegration) after channel faults are eliminated. (Always set to "All channels manually" for the F-TM Count module since RIOforFA is not supported.)

RIOforFA safety

Specifies whether the module supports the "RIOforFA-Safety" profile. (Always set to "No" for the F-TM Count module since RIOforFA is not supported.)

PROFIsafe mode

Specifies the PROFIsafe mode being used by the F-module.

PROFIsafe protocol version

Specifies the PROFIsafe protocol version being used by the F-module.

F-I/O DB manual number assignment

You must select the check box to manually set the DB number of the F-I/O DB. An F-I/O DB is automatically created during compilation for each configured F-I/O module.

F-I/O DB number

The number of the F-I/O DB that is created during compilation.

F-I/O DB name

Specifies the symbolic name of the F-I/O DB that is created during compilation.

See also

S7-FCT V2.0 - Fail-safe Configuration Tool Operating Instructions (https://support.industry.siemens.com/cs/ww/en/view/109763833)

SIMATIC Industrial Software SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126)

4.6.2 TM-C parameters

Selection of channel activation

Enables channel activation. The counter channel is always activated since there is only a single channel.

Selection of operating type: Counting/Position input

Enables whether to provide integer counter value. This selection is always enabled for the counter module and a counter value is always returned.

Selection of operating type: Measuring

Enables whether to provide an additional counter measured value. This selection is always enabled for the counter module and a measured value is always returned.

Signal monitoring

Allows you to enable or disable signal monitoring. Signal monitoring evaluates the quality of A and B signals for phase, voltage, and wire break. If signal monitoring is disabled, you must evaluate and provide safety measures suitable for your application. See "A and B signal monitoring" in "Counter input diagnostics (Page 18)" for the effects on safety and the precautions you must make if you disable signal monitoring.

WARNING

It is possible for a channel fault to occur that is not readily detected by the module diagnostics if signal monitoring is disabled.

Disabling this feature reduces the safety rating to SIL 1, Cat. 2, PL c, which causes a loss of the safety function. Disabling this feature can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.

If signal monitoring is disabled, A and B signal or wire break errors detected are not reported and you might not achieve your required level of safety. You must provide your own safety measures if you disable these features.

Signal Type

Specifies whether the encoder is providing A, B, or A, B, N signals. If (A, B) is selected, then Pulses per revolution and Reaction to N signal are disabled.

Invert direction

Specifies whether to reverse the counting direction.

Pulses per revolution

Specifies the total number of Sin/Cos pulses per revolution of the encoder. This is used for N signal plausibility monitoring. This field is only enabled when the "Signal type" selected is sin/cos encoder (A, B, N). Specifying a 0 value in this field disables N signal plausibility monitoring.

Signal evaluation

Specifies how many events per Sin/Cos pulse are counted. Only quadrature mode is supported. Quadrature mode evaluates all zero crossings of the sin/cos encoder signals, so that counts per revolution equal pulses per revolution times four.

Reaction to signal N

Specifies whether the reaction is to ignore the N signal or set the count to the start value. This field is only enabled when the "Signal type" selected is sin/cos encoder (A, B, N).

High counting limit

You limit the counting range by setting the high counting limit. An overflow event is triggered in the feedback interface when the current count exceeds the high counting limit. The current count will then be set to the start value or the low counting limit depending on parameterization. You can also select whether counting stops or continues after exceeding the high counting limit. The high counting limit must be greater than or equal to the start value and must be greater than the low counting limit. The allowed range is -2147483647 to 2147483647. The default setting is 2147483647.

Start value

You specify the initial count value when counting starts by configuring the start value. The current count will be set to the start value after power up, after downloading parameters, when explicitly set, and other situations depending on configuration. The start value must be a value between or equal to the counting limits. The allowed range is -2147483648 to 2147483647. The default setting is 0.

Low counting limit

You limit the counting range by setting the low counting limit. An underflow event is triggered in the feedback interface when the current count exceeds the low counting limit while counting down. The current count will then be set to the start value or the high counting limit depending on parameterization. The allowed range is -2147483648 to 2147483646. The default setting is -2147483648.

Reaction to violation of a counting limit

Specifies the reaction when either the high or low counting limit is exceeded. You can choose to either continue counting or to stop counting. If you choose to stop counting, you must close and reopen the software gate to resume counting.

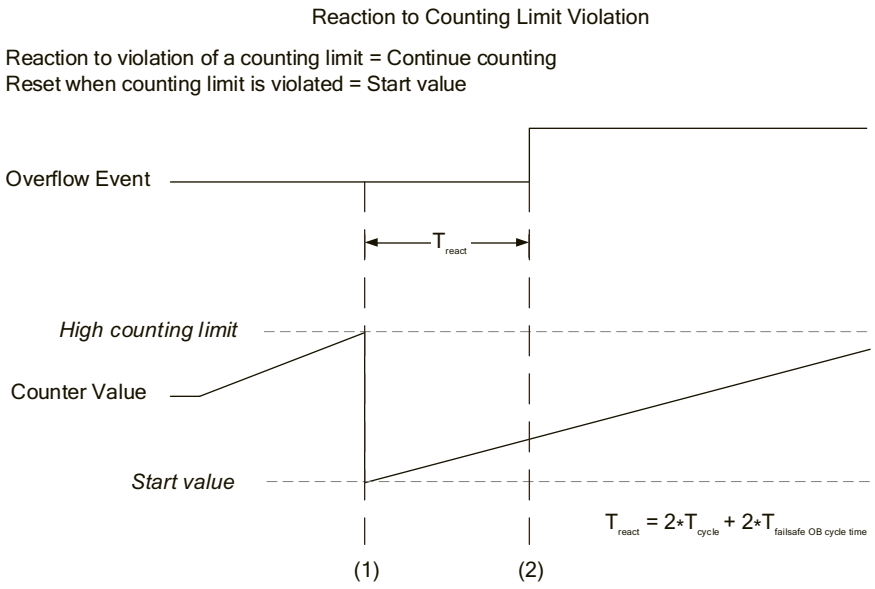

1 Counter value exceeds the configured high counting limit, is reset to the start value, and counting continues.

2 User program sees "Overflow Event" go high to indicate the high counting limit was exceeded and sees an updated counter value.

Reset when counting limit is violated

Specifies whether the count value is set to the start value or opposite counting limit when a counting limit is exceeded.

Reaction to gate start

Specifies whether the count value is set to the start value or continues with the current value when the SW gate is opened. This action occurs each time the SW gate changes from closed to open.

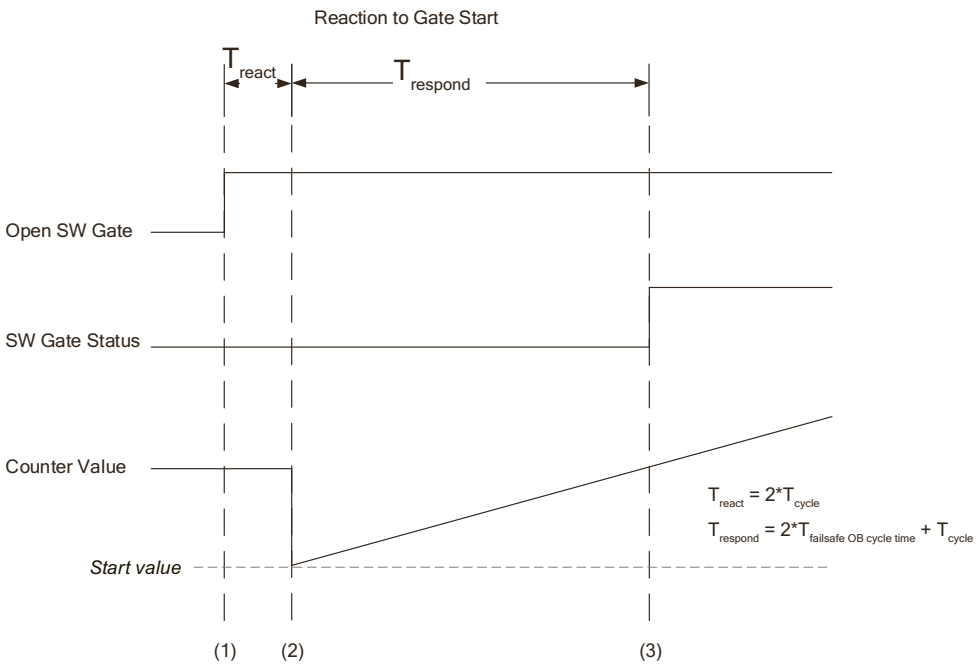

1 User program sets "Open SW Gate" high to open the software gate and enable counting.

2 Module sees the "Open SW Gate" command, opens the software gate, and sets the counter value to the start value.

3 User program sees "SW Gate Status" go high and an updated counter value.

Measured value

Specifies one of a possible three different engineering unit conversions as follows:

- **Frequency**: The average number of counts per second reported in millihertz (hertz * 1000)
- **Period duration**: The average period between two counts in microseconds (seconds * 1000000)
- **Velocity**: The speed of movement in a given direction. Velocity represents the units of measure per time base * 1000.

Negative values are reported when counting down, positive values are reported when counting up.

NOTE

Fields directly associated with velocity calculations are only enabled when velocity is selected.

Update time

Specifies the interval at which the F-TM Count module updates the measured values to the F-CPU. Setting a longer update time interval allows the module to collect more data to calculate a more accurate measured value, but increases the reaction time.

NOTE

The safety reaction time is influenced by the chosen update time when using measured values, and SLS as part of the safety application program.

Time base for velocity measurement

Specifies the time base unit for the velocity you want for the calculation output in increments of milliseconds or seconds.

Counts per unit of measure

Specifies the number of counts from the incremental encoder per relevant distance unit for the velocity measurement.

Safety Function - Safe Stop

Enables safe operating stop (SOS) monitoring.

Standstill tolerance

Specifies the acceptable standstill tolerance allowed for the SOS function measured in counts.

NOTE

The standstill tolerance selection is disabled if "Safety Function - Safe Stop" is disabled.

Safety Function - Safe Direction

Enables safe direction (SDI) monitoring.

Monitoring tolerance

Specifies the acceptable tolerance in the unsafe direction for the SDI function measured in counts.

NOTE

The monitoring tolerance selection is disabled if "Safety Function - Safe Direction" is disabled.

Safety Function - Limited Speed

Enables safety limited speed (SLS) monitoring only when "Velocity" is selected as the measured value.

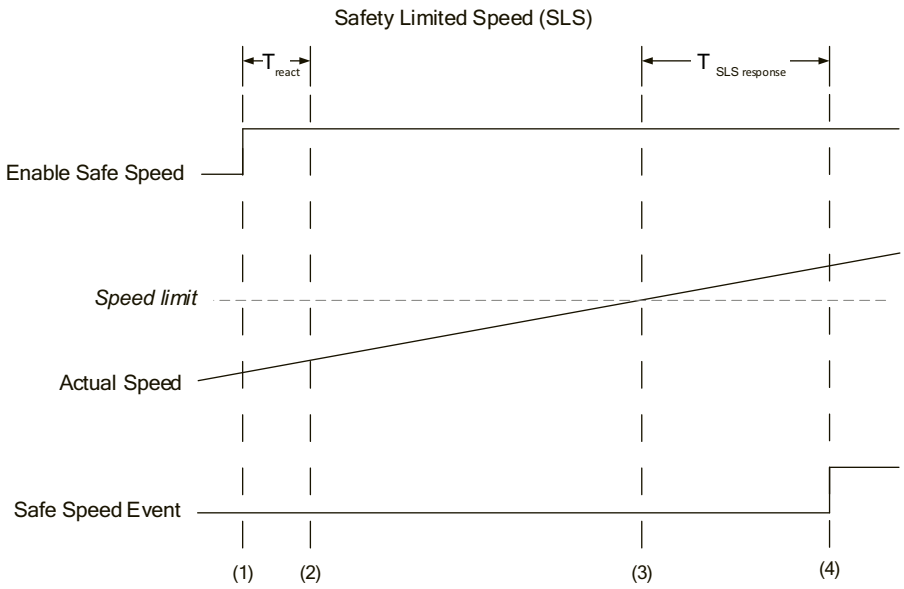

$T_{react} = 2*T_{cycle}$

$T_{SLS\ response} = 2*T_{failsafe\ OB\ cycle\ time} + T_{cycle} + T_{update}$

1 User program set "Enable Safe Speed" high to initiate SLS monitoring

2 Module process the "Enable Safe Speed" value and SLS monitoring is started.

3 Calculated speed exceeds the configured speed limit, "Safe Speed Event" set in the module.

4 User program sees "Safe Speed Event" go high to indicate an overflow occurred.

The calculated speed is updated once per configured update time and represents the average speed over the preceding interval. When determining what update time to use, it is important to consider the update time's effect on filtering of momentary speed limit violations and the overall response time of the SLS monitoring. Larger update time values result in more filtering of speed limit violations as well as an extended response time.

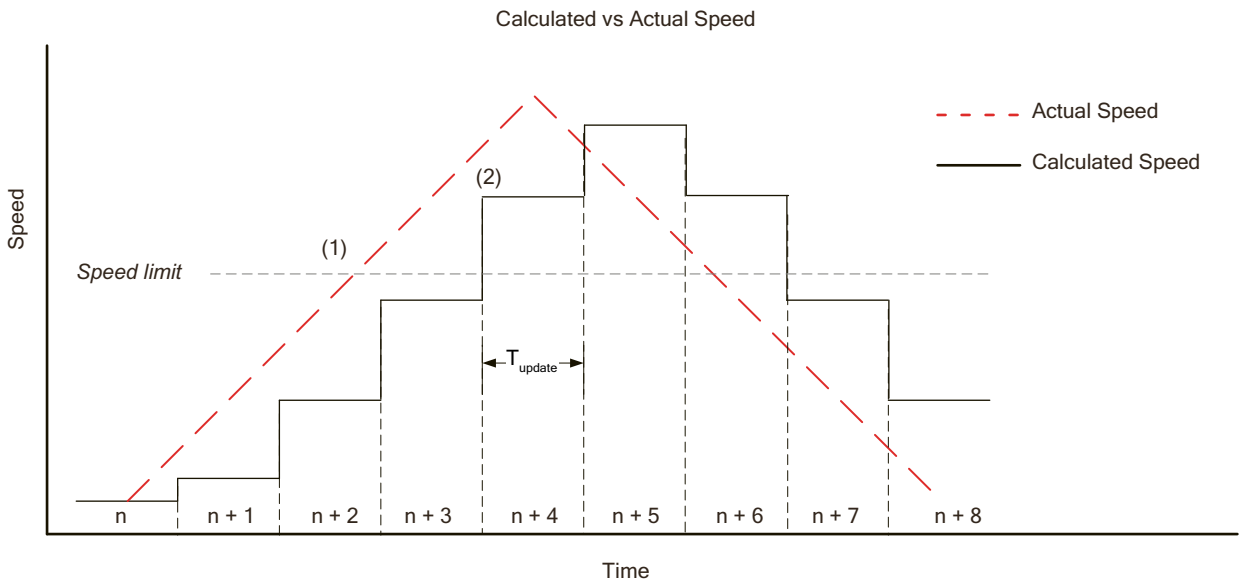

1 Actual speed exceeds the configured speed limit during the "n+2" update interval. Due to the averaging of the calculated speed, the measured value does not yet exceed the limit so no safe speed event is issued by the module now.

2 The calculated speed first exceeds the speed limit during the "n+4" update interval. A safe speed event will be issued by the module now.

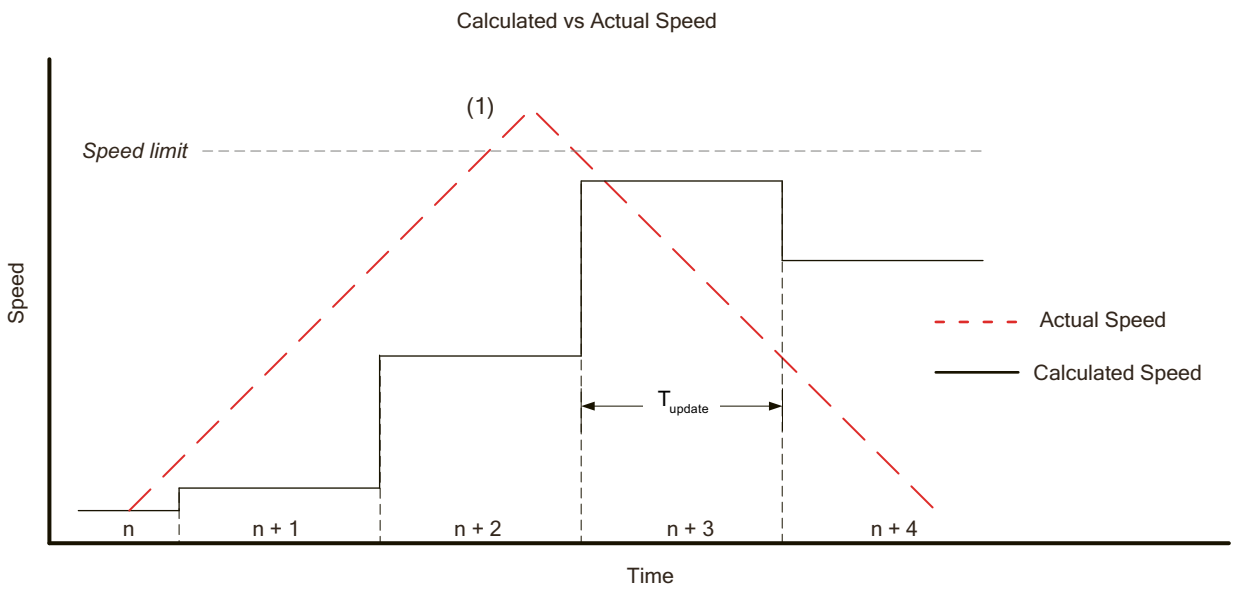

1 The actual speed exceeds the configured speed limit during the "n+2" update interval. Due to the averaging of the measured value, the calculated speed never exceeds the speed limit so no safe speed event is issued by the module. Larger update times effectively filter out short speed limit violations. Therefore, if the application needs to detect momentary speed limit violations, a shorter update time should be configured.

Speed limit

Specifies the maximum acceptable speed in velocity units for the SLS function only when velocity is selected.

NOTE

The speed limit selection is disabled if "Safety Function - Limited Speed" is disabled.

Reaction to CPU STOP

Specifies whether the channel continues to count pulses while the F-CPU is in STOP mode.

4.7 Behavior at the counting limits

"Reaction to violation of a counting limit" selections are defined as follows:

- **"Continue counting"**: After a violation of a counting limit, counting surpasses the limit and goes to either the start value or the opposite counting limit (depending upon configuration), and then continues.
- **"Stop counting"**: After a violation of a counting limit, counting surpasses the limit and goes to either the start value or the opposite counting limit (depending upon configuration), and then stops. To restart counting, the SW gate must be closed and reopened.

⚠ WARNING

The "Stop counting" selection may not allow the module to react at counting limits.

Configuring the "Reaction to violation of a counting limit" selection to stop counting may have a direct and detrimental influence upon configured safety monitoring and measured value.

You must ensure your safety program has provisions for the immediate stopping of counting and any potential influence upon configured safety monitoring functions and measured value.

Violation of a counting limit

The high counting limit is violated when the current counter value is equal to the high counting limit and another up-count is received. The low counting limit is violated when the current counter value is equal to the low counting limit and another down-count is received.

The appropriate status bit is set in the feedback interface in the event of limit violation:

Counting limit violated	Status bit
High counting limit	"Overflow Event" bit is set
Low counting limit	"Underflow Event" bit is set

You can reset the status bits with "Reset Other Events" bit.

Following a counting limit violation, you can configure whether counting is to continue and whether counting is continued at the start value or at the opposite counting limit.

NOTE

The high and low counting limits define the value range of the counter.

Examples

The figure below shows an example for terminating the counting process after an overflow and setting the counter to the start value:

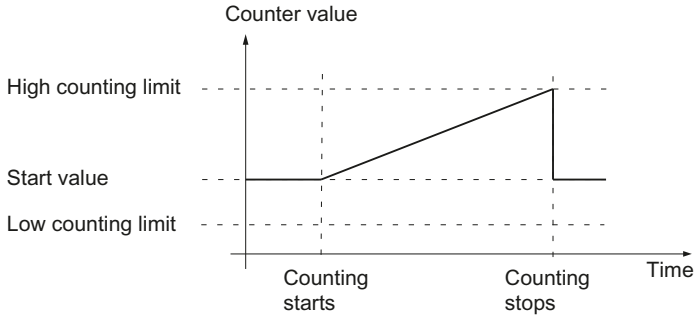

The figure below shows an example for continuing the counting process after an overflow and setting the counter to the start value:

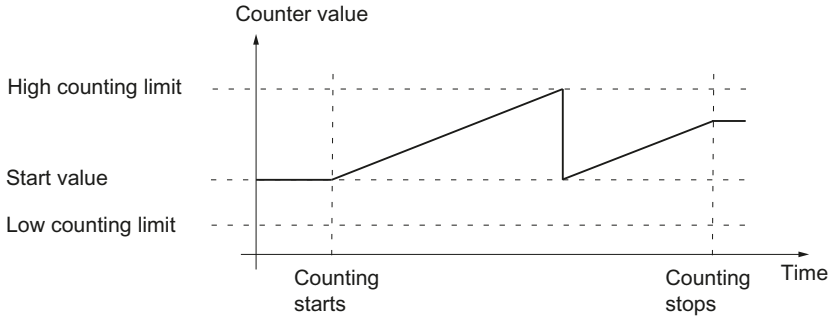

The figure below shows an example for terminating counting after an overflow and setting the counter to the opposite counting limit:

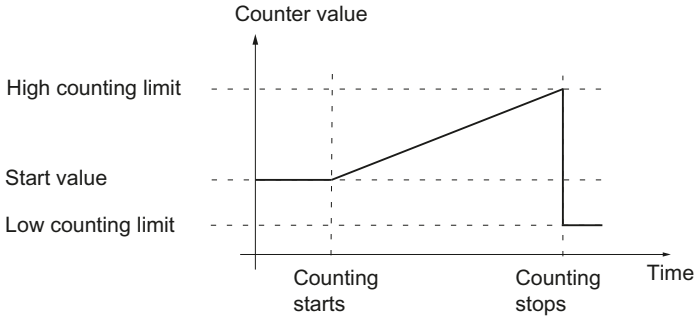

The figure below shows an example for continuing the counting process after an overflow and setting the counter to the opposite counting limit:

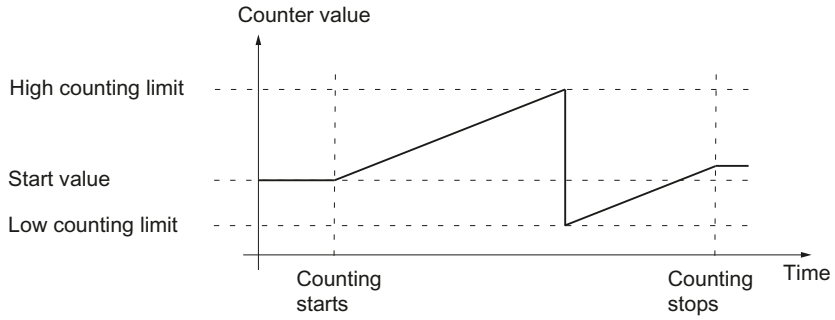

4.8 Quadrature evaluation of differential signals

With quadrature evaluation, the A and B signals are shifted by 90 degrees in relation to each other. When the A signal is leading, the movement is in the forward direction. When the B signal is leading, the movement is in the reverse direction.

Counting occurs at each "zero-crossing" of the A and B signals. As a result, each complete waveform has a total effect of 4 counts. For example, given a 200 kHz frequency, 800K counts per second can be achieved. These relationships are illustrated in the figure below:

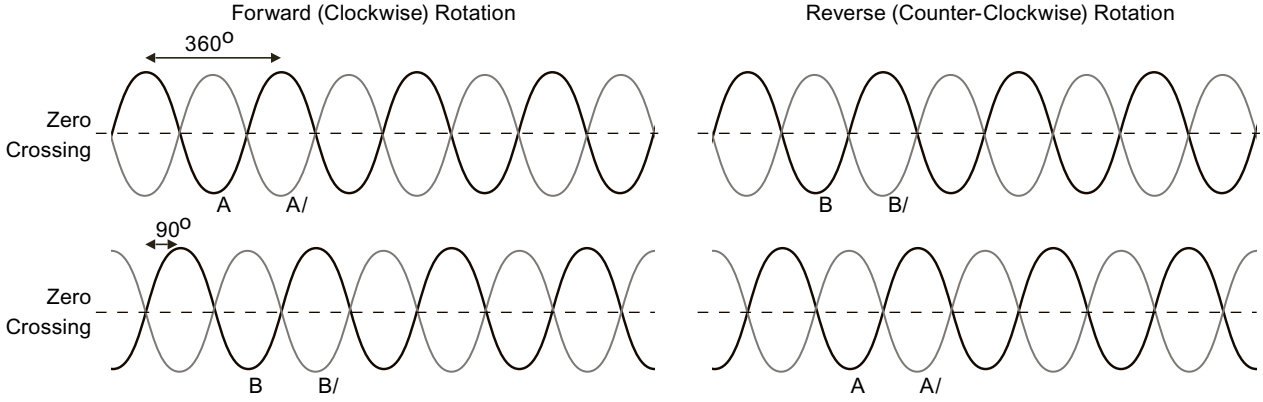

4.9 Safety functions

This provides a quick overview of the principle mode of operation of the F-TM Count module safety functions.

The description of the safety functions is based on the definition according to standard EN 61800-5-2 and some simple examples for using the function.

The description of the functions is simplified, as far as possible, to clearly show essential properties and configuration options.

4.9.1 Safe Operating Stop (SOS)

SOS monitoring

SOS monitoring is initiated whenever the "Enable Safe Stop" bit is set in the control interface and subsequently processed by the F-TM Count module. SOS monitoring terminates whenever the "Enable Safe Stop" bit is reset in the process output image and subsequently processed by the module.

Each time SOS monitoring is initiated, the current position is stored. A "Safe Stop Event" is set whenever any movement is detected in either direction that exceeds the configured "Standstill tolerance" as measured from the stored position.

Standstill tolerance is configured in counts.

Once set, the "Safe Stop Event" bit remains set and counting continues after the event is triggered. The "Safe Stop Event" remains set until the "Reset Safe Stop" bit is set to 1, until a power cycle, or until a new parameterization is loaded.

Configuring a value of 0 for the standstill tolerance results in the "Safe Stop Event" being set immediately after the first pulse in either direction.

⚠ WARNING

Safe stop monitoring continues when counting is suspended and SOS monitoring is enabled.

Since there is no active counting operation, this safety function becomes ineffective. This can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.

You must ensure steps outlined in safety standards applicable to your system are followed before the event bit is reset.

Using SOS monitoring

The safe stop position is stored when SOS monitoring is initiated by turning on the "Enable Safe Stop" bit and is used for the entire SOS monitoring session.

Your safety program examines the "Safe Stop Event" bit in the feedback interface and takes appropriate action during the SOS monitoring session.

Set the "Reset Safe Stop" bit to 1 to clear the "Safe Stop Event" bit in the feedback interface.

If you want to start a new SOS monitoring session, the "Enable Safe Stop" bit must be cleared in the module and then once again set in the module by separate executions of you safety program.

NOTE

The "Safe Stop Event" bit is also cleared by a power cycle, or when a new STEP 7 hardware configuration is downloaded.

If you reset the "Safe Stop Event" and the safe stop is still in violation, the "Safe Stop Event" bit will immediately set back to 1.

SOS suspension by external events

Suspension of counting operations can result from the following external events:

- SW gate closure
- Counting limit violation if module is configured to stop counting when the limit is violated. Refer to "Reactions to counting limit violation (Page 33)" for additional information.

NOTE

Counting operations that set the start value or exceed configured counting limits shall have no effect in determining whether a safe stop violation has occurred.

This means that regardless of how the "Reaction to violation of a counting limit" is configured and the current count is subsequently manipulated, the "Safe Stop Event" is only initiated upon violation of the specified "Standstill tolerance".

4.9.1.1 Function of SOS

The SOS function monitors the count value and notifies the user if the encoder/count deviates more than a defined amount from the stopped position.

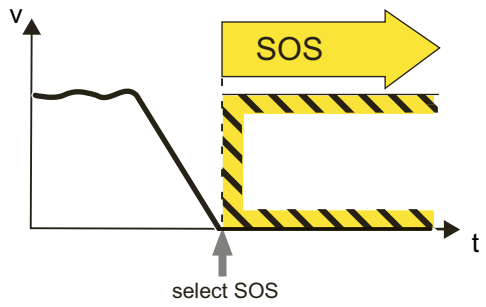

SOS Selection

Example of how the function can be used

Example	Possible solution
A protective door can only be opened if a machine is in the safe standstill state.	• Stop the movement of the hazard from your safety program. • Ensure no further movement as follows: – Engage/energize (brake/motor) – Engage the safety related actuator • Enable SOS monitoring in the counter module via the safety program in the F-CPU • Disable the door lock to permit access to the machine • Perform an appropriate safety reaction if the "Safe Stop Event" ever occurs

4.9.1.2 Example using SOS monitoring

The protected machine areas can be entered without having to shut down the machine as long as SOS is active.

Machine stopping is monitored using an SOS tolerance window. At the instant this function becomes enabled, the current position is stored as the comparison position until SOS is disabled again.

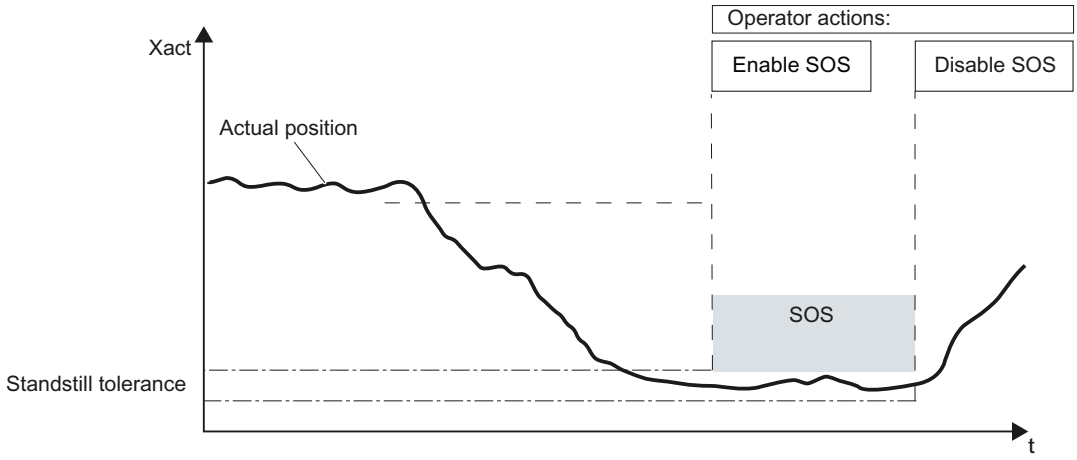

Figure 2-1535 Standstill tolerance

4.9.1.3 Configuring SOS

In STEP 7 do the following to configure SOS monitoring:

- Configure "Safety Function - Safe Stop"
- Configure the "Standstill tolerance" in counts
- Download this project to the F-CPU

4.9.1.4 Enabling SOS

In your safety program, set the "Enable Safe Stop" bit to 1 to begin SOS monitoring.

From that point, if the module ever detects a movement in either direction that exceeds the configured "Standstill tolerance", the "Safe Speed Event" bit is set to 1.

4.9.1.5 Responding to SOS

Your safety program examines the "Safe Stop Event" bit and takes appropriate action when the bit is seen as 1. Once set, the "Safe Stop Event" bit remains set to 1 until either of the following actions occur:

- Your safety program sets the "Reset Safe Stop" bit to 1
- A power cycle
- A new STEP 7 hardware configuration is downloaded

4.9.2 Safety Limited Speed (SLS)

Safe speed monitoring

SLS monitoring is initiated whenever the "Enable Safe Speed" bit is set in the control interface and subsequently processed by the F-TM Count module. SLS monitoring terminates whenever the "Enable Safe Speed" bit is reset in the process output image and subsequently processed by the module.

A "Safe Speed Event" is set whenever the calculated speed in either direction is greater than the configured "Speed limit". Once set, the "Safe Speed Event" bit remains set and counting continues after the event is triggered. The "Safe Speed Event" remains set until the "Reset Safe Speed" control bit to 1, until a power cycle, or until a new parameterization is loaded.

Configuring a "Speed limit" value of 0 results in the "Safe Speed Event" being set immediately after the first pulse in either direction.

NOTE

Triggering a "Safe Speed Event" is also dependent on the measured value, configured as "Velocity", that updates your safety program once every update time.

WARNING

Safe speed monitoring continues when counting is suspended and SLS monitoring is enabled.

Since there is no active counting operation when counting is suspended, this safety function becomes ineffective. This can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.

You must ensure steps outlined in safety standards applicable to your system are followed before the event bit is reset.

Using SLS monitoring

SLS monitoring is initiated by turning on the "Enable Safe Speed" bit.

Your safety program examines the "Safe Speed Event" bit in the feedback interface and takes appropriate action during the SLS monitoring session.

Set the "Reset Safe Speed" bit to 1 to clear the "Safe Speed Event" bit in the feedback interface.

If you want to start a new SLS monitoring session, clear and enable the "Enable Safe Speed" bit must be cleared in the module and then once again set in the module by separate executions of you safety program.

NOTE

Once set, the "Safe Speed Event" bit is also cleared by a power cycle, or when a new STEP 7 hardware configuration is downloaded. If you reset the "Safe Speed Event" and the safe speed is still in violation, the "Safe Speed Event" bit will immediately set back to 1.

SLS suspension by external events

SLS monitoring suspension can result from the following external events:

- SW gate closure
- Counting limit violation if module is configured to stop counting when the limit is violated. Refer to "Reactions to counting limit violation" for additional information.

NOTE

Counting operations that set the start value or exceed configured counting limits have no effect in determining whether a safe speed violation has occurred.

This means that regardless of how the "Reaction to violation of a counting limit" is configured and the current count is subsequently manipulated, the "Safe Speed Event" is only initiated upon actual violation of the specified "Speed limit".

4.9.2.1 Function of Safety Limited Speed (SLS)

The SLS function monitors the encoder and notifies the user if the calculated speed exceeds the specified speed limit in either direction.

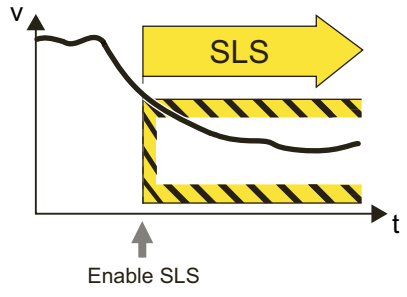

Examples of how the function can be used

Example	Possible solution
The machine operator must be able to enter the machine after the protective door has been opened and slowly move a horizontal conveyor with an acknowledgment button in the danger zone.	• Enable SLS in the counter via your safety program in the F-CPU. • The counter monitors the velocity of the horizontal conveyor.
A spindle drive, depending on the selection of the cutting tool, must not exceed a specific maximum speed.	• Enable SLS in the counter via your safety program in the F-CPU.

4.9.2.2 Configuring SLS

In STEP 7 do the following to configure SLS:

- Configure the "Measured Value" to be "Velocity" and specify the desired values for the following:
  - "Update time"
  - "Time base for velocity measurement"
  - "Counts per unit for velocity measurement"
- Configure "Safety Function - Limited Speed"
- Configure the "Speed limit"
- Download this project to the F-CPU

NOTE

SLS speed can only be configured if the measured value is set to velocity.

4.9.2.3 Enabling SLS

In your safety program, set the "Enable Safe Speed" bit to 1 to begin SLS monitoring.

From that point, if the module ever detects a speed in either direction that exceeds the configured "Speed limit", the "Safe Speed Event" bit is set to 1.

4.9.2.4 Responding to SLS

Your safety program examines the "Safe Speed Event" bit and takes appropriate action when the bit is seen as 1. Once set, the "Safe Speed Event" bit remains set until either of the following actions occur:

- Your safety program sets the "Reset Safe Speed" bit to 1
- A power cycle
- A new STEP 7 hardware configuration is downloaded

4.9.3 Safe Direction (SDI)

Safe direction (SDI) monitoring

SDI monitoring is initiated whenever the "Enable Safe Direction" bit is set in the control interface and subsequently processed by the F-TM Count module. SDI monitoring terminates whenever the "Enable Safe Direction" bit is reset in the process output image and subsequently processed by the module.

Each time safe direction monitoring is initiated, the current position and the specified safe direction are stored. The "Safe Direction Event" bit is set whenever a movement is detected in the unsafe direction and exceeds the configured "Monitoring tolerance". The "Monitoring tolerance" is measured from the farthest position achieved in the safe direction. As movement progresses in the safe direction, the tolerance of movement in the unsafe direction shall be measured from this farthest position.

Monitoring tolerance is configured in counts. The safe direction is specified in the process output image.

Once set, the "Safe Direction Event" bit remains set and counting continues after the event is triggered. The "Safe Direction Event" remains set until the "Reset Safe Direction" bit is set to 1, until a power cycle, or until a new parameterization is loaded.

Configuring a value of 0 for the monitoring tolerance results in the "Safe Direction Event" being set immediately after the first pulse in the unsafe direction.

⚠ WARNING

Safe direction monitoring continues when counting is suspended and SDI monitoring is enabled.

Since there is no active counting operation when counting is suspended, this safety function becomes ineffective. This can result in unexpected machine or process operation, which can cause death, severe personal injury, and/or property damage.

You must ensure steps outlined in safety standards applicable to your system are followed before the event bit is reset.

Using SDI monitoring

The safe direction is stored when SDI monitoring is initiated by enabling the "Enable Safe Direction" bit and is used for the entire SDI monitoring session. While the SDI monitoring session is in progress, subsequent changes to the "Safe Direction" bit are ignored.

Your safety program examines the "Safe Direction Event" bit in the feedback interface and takes appropriate action during the SDI monitoring session.

Set the "Reset Safe Direction" bit to 1 to clear the "Safe Direction Event" bit in the feedback interface.

If you want to start a new SDI monitoring session, clear and enable the "Enable Safe Direction" bit must be cleared in the module and then once again set in the module by separate executions of you safety program.

NOTE

Once set, the "Safe Direction Event" bit is also cleared by a power cycle, or when a new STEP 7 hardware configuration is downloaded. If you reset the "Safe Direction Event" and the safe direction is still in violation, the "Safe Direction Event" bit will immediately set back to 1.

SDI suspension by external events

SDI monitoring suspension can result from the following external events:

- Software gate closure
- Counting limit violation if module is configured to stop counting when the limit is violated. Refer to "Reactions to counting limit violation" for additional information.

NOTE

Counting operations that set the start value or exceed configured counting limits have no effect in determining whether a safe direction violation has occurred.

This means that regardless of how the "Reaction to violation of a counting limit" is configured and the current count is subsequently manipulated, the "Safe Direction Event" is only initiated upon actual violation of the specified "Monitoring tolerance".

4.9.3.1 Function of Safe Direction (SDI)

The SDI function monitors the encoder and notifies the user if the encoder/count moves more than a defined amount in the unintended direction.

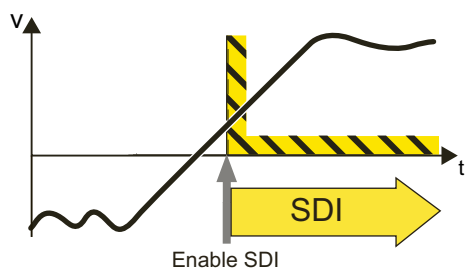

Examples of how the function can be used

Example	Possible solution
A protective door can only be opened if a conveyor belt moves in the safe direction (away from the operator).	• Specify the safe direction using the "Safe Direction" control bit in your safety program in the F-CPU. • Enable SDI in the counter via your safety program in the F-CPU. • Enable the locking mechanism of the protective doors via the PROFIsafe status bit of the counter.
When replacing the pressure cylinders of the plates, the conveyor can only move in the safe direction.	• Specify the safe direction using the "Safe Direction" control bit in your safety program in the F-CPU. • Enable SDI in the counter via your safety program in the F-CPU. • Inhibit the direction of motion that is not permitted in the counter.
Once the protection against jamming has been triggered, a roller shutter gate can only start moving in one direction.	
At an operational limit switch, the trolley of a crane can only start moving in the opposite direction.	

4.9.3.2 Configuring SDI

In STEP 7 do the following to configure SDI:

- Configure "Safety Function - Safe Direction"
- Configure the "Monitoring tolerance"
- Download this project to the F-CPU

4.9.3.3 Responding to SDI

Your safety program examines the "Safe Direction Event" bit and takes appropriate action when the bit is seen as 1. Once set, the "Safe Direction Event" bit remains set until either of the following actions occur:

- Your safety program sets the "Reset Safe Direction" bit to 1
- A power cycle
- A new STEP 7 hardware configuration is downloaded

4.10 Address space

Address space of the technology module

Table 2-1977 Size of input and output addresses of the F-TM Count for PROFIsafe version 2.4 (with S7-300/S7-400)

	Control (Outputs)	Feedback (Inputs)
Range for control and feedback interface	6 bytes	14 bytes

Table 2-1978 Size of input and output addresses of the F-TM Count for PROFIsafe version 2.6.1 (with S7-1200/S7-1500)

	Control (Outputs)	Feedback (Inputs)
Range for control and feedback interface	7 bytes	15 bytes

4.11 Control and feedback interface

4.11.1 Assignment of the control interface

Your safety program uses the control interface to influence the behavior of the F-TM Count module.

Control interface

The following table shows the assignment of the control interface:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reset Safe Direction	Reset Safe Stop	Reserved	Reset Safe Speed	Reserved	Reserved	Reset Other Events	Open SW Gate
1	Safe Direc-tion	Enable Safe Direction	Enable Safe Stop	Enable Safe Speed	Reserved	Set Start Value	Reserved	Reserved

Explanations

Byte	Bit	Control bit/value	Explanations
0	0	Open SW Gate	The "Open SW Gate" bit controls when the software gate is open and counting is enabled. • 0: SW gate is closed and counting is stopped • 1: SW gate is open and counting is allowed
0	1	Reset Other Events	The "Reset Other Events" bit is used to reset the following event bits in the feedback interface: • Zero Event • Underflow Event • Overflow Event As long as the "Reset Other Events" bit is set to 1, the "Zero Event", "Underflow Event", and "Overflow Event" bits are continually cleared.

Byte	Bit	Control bit/value	Explanations
0	4	Reset Safe Speed	The "Reset Safe Speed" bit is used to reset the "Safe Speed Event" bit in the feedback interface. • 0: No action • 1: Clear the "Safe Speed Event" bit As long as the "Reset Safe Speed" bit is set to 1, the "Safe Speed Event" bit is continually cleared.
0	6	Reset Safe Stop	The "Reset Safe Stop" bit is used to reset the "Safe Stop Event" bit in the feedback interface. • 0: No action • 1: Clear the "Safe Stop Event" bit As long as the "Reset Safe Stop" bit is set to 1, the "Safe Stop Event" bit is continually cleared.
0	7	Reset Safe Direction	The "Reset Safe Direction" bit is used to reset the "Safe Direction Event" bit in the feedback interface. • 0: No action • 1: Clear the "Safe Direction Event" bit As long as the "Reset Safe Direction" bit is set to 1, the "Safe Direction Event" bit is continually cleared.
1	2	Set Start Value	The "Set Start Value" bit sets the current count to the configured start value. • 0: No action • 1: Set the count to the start value The "Set Start Value" action is initiated whenever this bit is set. The current count value is continually set to the "Start Value" while the "Set Start Value" bit is set to 1.
1	4	Enable Safe Speed	The "Enable Safe Speed" bit enables the SLS monitoring function. The "Enable Safe Speed" is set in the control interface. • 0: Disabled • 1: Enabled SLS monitoring is initiated in the module whenever the "Enable Safe Speed" bit is set. SLS monitoring is active until the "Enable Safe Speed" bit is reset or a power cycle occurs. SLS monitoring is reinitialized when a new STEP 7 hardware configuration is downloaded.
1	5	Enable Safe Stop	The "Enable Safe Stop" bit enables the SOS monitoring function. The "Enable Safe Stop" is set in the control interface. • 0: Disabled • 1: Enabled SOS monitoring is initiated in the module whenever the "Enable Safe Stop" bit is set. SOS monitoring is active until the "Enable Safe Stop" bit is reset or a power cycle occurs. SOS monitoring is reinitialized when a new STEP 7 hardware configuration is downloaded.
1	6	Enable Safe Direction	The "Enable Safe Direction" bit enables the SDI monitoring function. The "Enable Safe Direction " is set in the control interface. • 0: Disabled • 1: Enabled SDI monitoring is initiated in the module whenever the "Enable Safe Direction" bit is set. SDI monitoring is active until the "Enable Safe Direction" bit is reset or a power cycle occurs. SDI monitoring is reinitialized when a new STEP 7 hardware configuration is downloaded.

Byte	Bit	Control bit/value	Explanations
1	7	Safe Direction	The "Safe Direction" bit in the control interface specifies the safe direction of movement for the safe direction monitoring function. • 0: Counting down is the safe direction • 1: Counting up is the safe direction Changing the safe direction requires you to reset the "Safe Direction Enable" bit. The safe direction must be set prior to setting the "Enable Safe Direction" bit.

4.11.2 Assignment of the feedback interface

Your safety program receives current values and status information from the F-TM Count module by means of the feedback interface.

Feedback interface

The following table shows the assignment of the feedback interface:

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Reset Safe Direction Status	Reset Safe Stop Status	SW Gate Status	Reset Safe Speed Status	Reset Other Events Status	Set Start Value Status	Count Status	Direction Status
1	Reserved	Safe Direc-tion Event	Safe Stop Event	Safe Speed Event	Overflow Event	Underflow Event	Zero Event	Value status (CQ HSC0)
2...5	High Speed Counter 0 - Current Value DINT: Current counter value Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
6...9	High Speed Counter 0 - Measured Value Measured Value as a scaled DINT							

Explanations

Byte	Bit	Feedback bit/value	Explanations
0	0	Direction Status	The "Direction Status" bit reflects the direction of the last movement. • 0: Last count was down • 1: Last count was up After power-up, the "Direction Status" bit resets to 0 and reinitializes to the actual state upon the next movement.
0	1	Count Status	The "Count Status" bit reflects the current counting status. • 0: No counts in the previous 500 ms • 1: At least one count received in the previous 500 ms
0	2	Set Start Value Status	The "Set Start Value Status" bit is used to acknowledge that the module has received and reacted to the "Set Start Value" bit from the control interface as follows: • When the "Set Start Value" bit is set to 1, the module sets the count value to the start value, then sets the "Set Start Value Status" bit to 1 • When the "Set Start Value" bit is set to 0, the "Set Start Value Status" bit is also set to 0

Byte	Bit	Feedback bit/value	Explanations
0	3	Reset Other Events Status	The "Reset Other Events Status" bit is used to acknowledge that the module has received and reacted to the "Reset Other Events" bit from the control interface as follows: • When the "Reset Other Events" bit is set to 1, the module resets the "Overflow Event", "Underflow Event", and "Zero Event" bits, then the "Reset Other Events Status" bit is set to 1 • When the "Reset Other Events" bit is set to 0, the "Reset Other Events Status" bit is set to 0
0	4	Reset Safe Speed Status	The "Reset Safe Speed Status" bit is used to acknowledge that the module has received and reacted to the "Reset Safe Speed" bit in the control interface as follows: • When the "Reset Safe Speed" bit is set to 1, the module resets the "Safe Speed Event" bit, then the "Reset Safe Speed Status" bit is set to 1 • When the "Reset Safe Speed" bit is set to 0, the "Reset Safe Speed Status" bit is set to 0
0	5	SW Gate Status	The "SW Gate Status" bit is used to acknowledge that the module has received and reacted to the "Open SW Gate" bit from the control interface as follows: • When the "Open SW Gate" bit is set to 1, the module performs the configured gate action, then the "SW Gate Status" bit is set to 1 • When the "Open SW Gate" bit is set to 0, the "SW Gate Status" bit is also set to 0
0	6	Reset Safe Stop Status	The "Reset Safe Stop Status" bit is used to acknowledge that the module has received and reacted to the "Reset Safe Stop" bit from the control interface as follows: • When the "Reset Safe Stop" bit is set to 1, the module resets the "Safe Stop Event" bit, then the "Reset Safe Stop Status" bit is set to 1 • When the "Reset Safe Stop" bit is set to 0, the "Reset Safe Stop Status" bit is set to 0
0	7	Reset Safe Direction Status	The "Reset Safe Direction Status" bit is used to acknowledge that the module has received and reacted to the "Reset Safe Direction" bit from the control interface as follows: • When the "Reset Safe Direction" bit is set to 1, the module resets the "Safe Direction Event" bit, then the "Reset Safe Direction Status" bit is set to 1 • When the "Reset Safe Direction" bit is set to 0, the "Reset Safe Direction Status" bit is set to 0
1	0	Value status (CQ HSC0)	The value status bit provides information on the validity operational quality of the corresponding channel. • 0: Fail-safe values (0 values) are provided for the channel • 1: Valid process values are provided for the channel
1	1	Zero Event	The "Zero Event" bit is set whenever the current count value transitions to 0. • 0: No event • 1: Count transitioned to 0 The "Zero Event" occurs when the count transitions to 0 from either direction. The "Zero Event" bit remains set until the module's "Reset Other Events" bit is set to 1 and remains cleared as long as the "Reset Other Events" bit is set to 1.

Byte	Bit	Feedback bit/value	Explanations
1	2	Underflow Event	The "Underflow Event" bit is set whenever the current count value exceeds the configured "Low Counting Limit". • 0: No violation of limit • 1: Low counting limit was exceeded The "Underflow Event" bit remains set until the module's "Reset Other Events" bit is set to 1 and remains cleared as long as the "Reset Other Events" bit is set to 1.
1	3	Overflow Event	The "Overflow Event" bit is set whenever the current count value exceeds the configured "High Counting Limit". • 0: No violation of the limit • 1: High counting limit was exceeded The "Overflow Event" bit remains set to 1 until the module's "Reset Other Events" bit is set to 1 and remains cleared as long as the "Reset Other Events" bit is set to 1.
1	4	Safe Speed Event	The "Safe Speed Event" bit informs the safety program that a safe speed violation has occurred. • 0: No violation • 1: The calculated speed, in either direction, was detected to be greater than the configured "Speed limit" The "Safe Speed Event" bit is cleared following an event when the "Reset Safe Speed" bit is set to 1 in the control interface.
1	5	Safe Stop Event	The "Safe Stop Event" bit informs the safety program that a safe stop violation has occurred. • 0: No violation • 1: A movement was detected in either direction that exceeded the configured "Standstill tolerance" as measured from the stored position The "Safe Stop Event" bit is cleared following an event when the "Reset Safe Stop" bit is set to 1 in the control interface.
1	6	Safe Direction Event	The "Safe Direction Event" bit informs the safety program that a safe direction violation has occurred. • 0: No violation • 1: A movement was detected in the unsafe direction that exceeded the configured "Monitoring tolerance" The "Safe Direction Event" bit is cleared following an event when the "Reset Safe Direction" bit is set to 1 in the control interface.
2...5	31...0	High Speed Counter 0 - Current Value	This signed double integer (DINT) value shows the current count. The position corresponds to the sign and the count value (process value). The count value assumes values between -2147483648 and 2147483647 unless restricted by the high and low counting limits.
6...9	31...0	High Speed Counter 0 - Measured Value	The measured value is returned as a scaled integer (DINT) value shown as one of the following, depending upon configuration: • Frequency is in millihertz (hertz * 1000) • Period is in microseconds (seconds * 1000000) • Velocity is units of measure per time base you select (velocity * 1000) Note that negative values are reported when counting down, positive values are reported when counting up.

Applications of the F-I/O module

5

5.1 Application mode 1: A/B with N

Application mode 1: A/B with N

The F-TM Count module supports the following application mode:

- A, B differential encoder signals
- N pulse per revolution differential encoder signal

The figure below is an example of the A/B with N application mode:

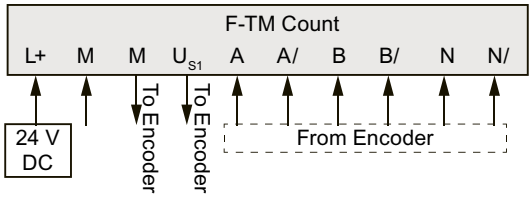

NOTE

The encoder may also be powered from an external source. If an external source is used, only the M supply voltage "To Encoder" must be connected to the encoder's ground/external power source ground.

WARNING

An external source of power for the encoder must be at the same ground potential as the power source for the F-TM Count module.

Ensure that ground potential for the external power source for the encoder and the F-TM Count module power source are the same. Any potential differences in the two power sources will cause current to flow through the modules that can cause damage to F-TM Count module, power supplies and the encoder.

5.2 Application mode 2: A/B without N

Application mode 2: A/B without N

The F-TM Count module supports the following application mode:

- A, B differential encoder signals

The figure below is an example of the A/B without N application mode:

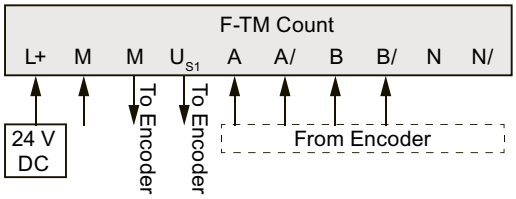

NOTE

The encoder may also be powered from an external source. If an external source is used, only the M supply voltage "To Encoder" must be connected to the encoder's ground/external power source ground.

WARNING

An external source of power for the encoder must be at the same ground potential as the power source for the F-TM Count module.

Ensure that ground potential for the external power source for the encoder and the F-TM Count module power source are the same. Any potential differences in the two power sources will cause current to flow through the modules that can cause damage to F-TM Count module, power supplies and the encoder.

Interrupts/diagnostic messages 6

6.1 Reactions to faults

Reactions to startup of the fail-safe system and to faults

The fail-safe concept depends on the identification of a safe state for all process variables.

The safety function requires that safe state values be applied to the fail-safe channel instead of process values (passivation of the fail-safe module or channel) in the following situations:

- When the fail-safe system is started up
- If module faults are detected, such as RAM or processor failures
- If errors are detected during safety-related communication between the fail-safe CPU and the fail-safe module through the PROFIsafe safety protocol (communication error)
- If module channel faults occur (for example, N signal plausibility monitoring or discrepancy errors)

The fail-safe CPU enters detected system faults into the diagnostic buffer.

Automatic safety measures and the PROFIsafe protocol ensure that the safe state is set if the system detects a fault.

Fail-safe modules do not remember errors upon power cycle. When the system is powered down and then restarted, the modules detect any faults that still exist.

Fail-Safe value for fail-safe modules

If the F-TM Count module input channel is passivated, the fail-safe system always provides "0" values for the count value, measured value, and event and status bits.

Timeout of the PROFIsafe message (F-monitoring time exceeded) passivates the module.

Response to faults in the fail-safe system

You should prepare maintenance procedures for your system to assure that returning to operation after a detected fault is controlled and documented.

The following steps must be performed:

1. Diagnosis and repair of the fault
2. Revalidation of the safety function
3. Recording in the service report

Reintegration of a fail-safe module

A channel or module can be reintegrated after successful diagnostics determine that a fault has cleared. The F-TM Count module requires that counting faults such as N-signal, discrepancy, frequency, and A and B signal monitoring must be cleared for at least 10 seconds before allowing reintegration. High and low voltage diagnostics require that the input voltage returns to the allowed range for 60 seconds before reintegration is possible.

The channel to be manually reintegrated must also be acknowledged in your safety program after the fault has cleared. The bits you use for this acknowledgement are referenced in the F-I/O data blocks (under the system blocks).

The "ACK_REQ" bit for that module goes true to indicate that reintegration is possible. After the "ACK_REQ" bit is true, your program can set the "ACK_REI" bit to allow the reintegration of all channels in that module that are ready to be reintegrated.

You can also acknowledge all faults in an F-runtime group using the "ACK_REI_GLOB" input of the "ACK_GL" instruction.

Fatal diagnostic errors require a power cycle with successful diagnostics.

Reintegration after high stress events

High temperature, high voltage, and excessive current stress can damage electronics, reducing the reliability while components continue to work apparently as expected. Passivation does not remove the potentially damaging effects of high ambient temperature or high applied voltage. Solid state switch outputs can be damaged by high currents prior to protective device activations. The reliability calculations assume the fail-safe module is operated within its specified operating parameters. When a module has passivated due to a high stress event, even though it apparently works correctly and passes all diagnostics, the probability of a future failure may be increased.

⚠ WARNING

It is possible to reintegrate a channel or module while some fault is still present that is not readily detected by the module diagnostics.

Reintegration of a faulty system can result in unexpected machine or process operation, which may cause death or serious injury to personnel, and/or damage to equipment.

After any reported fault, the steps outlined in this chapter and in safety standards applicable to your system should be followed to assure that the fault is completely understood and corrected before reintegration.

For an exact list of faults for the module, refer to the Diagnostic messages (Page 71) section.

At reintegration, the following occurs:

- Updated count value, measured value, and the event and status bits are provided to your safety program.
- Control outputs from your safety program are again transferred to the counter module.

Safety repair time

WARNING

The fail-safe performance characteristics in the technical specifications apply for a mission time life of 20 years and a repair time of 100 hours.

If a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before 100 hours expires. The module switches off independently after the 100 hours have expired.

Follow the repair procedure described in section Diagnostic messages (Page 71).

The repair time used for probability of dangerous failure per hour (PFH) and probability of dangerous failure on demand (PFD) calculations is 100 hours.

Passivation is designed to provide the safe state of the safety function in the event of a single fault. While a channel is passivated and energy is still available to the channel, there is a possibility that additional faults can cause a dangerous failure of the safety function. You should respond to passivations by repairing the fault or taking the passivated channel out of service in less than 100 hours to preserve the safety integrity level of your system.

If module or channel passivation persists for 100 hours, the module is taken to a fatal error state and the module's defective buffer diagnostic message is issued. The module is recovered through a power cycle.

If a repair within 100 hours is not possible, passivated fail-safe outputs should be taken out of service by physically disconnecting or opening circuits so that faults in the fail-safe module cannot apply energy to the load. To remove input channels from service in an operating PLC system, references to any passivated fail-safe inputs must be removed from any operating F-CPU Safety program logic that can result in activation of a safety function output.

Do not depend on channel or module passivation to maintain safe state for more than 100 hours.

Additional information on passivation and reintegration

For further information about fail-safe module access, refer to the *SIMATIC Safety - Configuring and Programming* manual (https://support.industry.siemens.com/cs/ww/en/view/54110126).

6.2 Status and error display

LEDs

The following figure shows you the LED displays (status and error displays) of F-TM Count module:

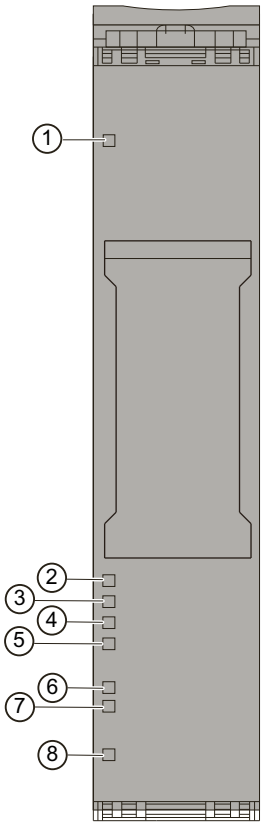

①	DIAG (green/red)	⑤	N (green)
②	A (green)	⑥	UP (green)
③	B (green)	⑦	DN (green)
④	F.0 (red)	⑧	PWR (green)

Figure 2-1536 LED displays of the F-TM Count

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedial measures for diagnostic alarms can be found in section Diagnostic messages (Page 71).

DIAG LED

The DIAG LED indicates system and module faults.

Table 2-1979 Meaning of the DIAG LED

DIAG	Meaning
Off	Backplane bus supply of the ET 200SP is not OK
Flashes	Module reintegratable diagnostic event has been resolved and the module or channel is awaiting reintegration. This can include the following events: • Reintegratable over-voltage error • Reintegratable under-voltage error • Module detected PROFIsafe CRC error • Module detected PROFIsafe timeout error • Reintegratable channel errors
Flashes	Module parameters are set, and module has active diagnostics (at least one error is present)
Flashes	Module parameters are not configured
On	Module parameters are configured, and module has no active diagnostics

Channel status/channel fault LEDs

The A and B LEDs indicate the current level of the associated input signals. At low counting speeds the A and B LEDs show the actual state of the signals. At higher counting speeds, the A and B LEDs will change at a limited rate to show activity. A and B LEDs flash when setting the profisafe address.

Table 2-1980 Meaning of the channel status/channel fault LEDs

A/B Channel	F.0	Meaning
Off	Off	Counter input signal is at 0 level and no active channel diagnostics
On	Off	Counter input signal is at 1 level and no active channel diagnostics
Off	On	Active channel diagnostics
Flashes		Prior diagnostic event has been resolved and the channel is awaiting reintegration

N LED

The N LED indicates the current level of the counter N pulse signal from the encoder. The N LED will show the state of the N signal only when the encoder is configured as A/B with N. The N LED will be in the ON state if the N signal is disconnected (but configured).

Table 2-1981 Meaning of the N LED

N	Meaning
□ Off	Counter N signal is at 0 level
■ On	Counter N signal is at 1 level

UP/DN LEDs

The UP and DN LEDs indicate the logical counting direction.

Table 2-1982 Meaning of the UP and DN LEDs

UP	DN	Meaning
□ Off	□ Off	No count has been detected within the last 0.5 s.
■ On	□ Off	The last count has incremented the counter and took place no more than 0.5 s ago.
□ Off	■ On	The last count has decremented the counter and took place no more than 0.5 s ago.

PWR LED

Table 2-1983 Meaning of the PWR LED

PWR	Meaning
□ Off	Supply voltage missing
■ On	Supply voltage is present and OK

6.3 Interrupts

Diagnostic interrupts

The F-module generates a diagnostic interrupt for each diagnostics alarm described in *Diagnostic messages* (Page 71).

The table below provides an overview of the diagnostic interrupts of the F-module. The diagnostic interrupts are assigned either to one channel or the entire F-module:

Table 2-1984 Diagnostic interrupts of the F-TM Count module

Diagnostic interrupt	Fault code	Scope of diagnostics interrupt	Configurable
Overtemperature	16#0005	F-module	No
Parameter failure (invalid parameters)	16#0010		
Supply voltage missing	16#0011		
Mismatch of safety destination address (F_Dest_Add)	16#0040		
Safety destination address not valid (F_Dest_Add)	16#0041		
Safety source address not valid (F_Source_Add)	16#0042		
CRC1 fault	16#0047		
Inconsistent iParameters (iParCRC error)	16#004B		
Transmission error: data inconsistent (CRC error)	16#004D		
Transmission error: timeout (watchdog time 1 or 2 elapsed)	16#004E		
Module is defective	16#0100		
Watchdog tripped	16#0103		
Invalid/inconsistent firmware present	16#011B		
Diagnostic queue overflow	16#013E		
F-address memory not accessible	16#030D		
No valid F-address available	16#030E		
Undertemperature	16#0312		
Supply voltage too high	16#0321		
Supply voltage too low	16#0322		
Load voltage too low	16#0324		
No pulses detected	16#030A	Channel	Yes
Sensor signal flutters	16#0310		No
Failure in the input circuit	16#0313		
Internal discrepancy failure	16#0315		
Illegal A/B signal ratio	16#0500		Yes
Frequency outside specification	16#0501		No

6.4 Diagnostic messages

Diagnostic alarms

The display of diagnostics is in plain text in STEP 7 in the online and diagnostics view. You can evaluate the error codes with your safety program.

NOTE

If you use a GSDML file for configuration, the diagnostic alarm text is only available in the project that installed the GSDML. The fault codes may be different, but the CPU diagnostic buffer will match the diagnostic alarm text in the table below.

NOTE

Some solutions below suggest pulling (removing) and plugging (reinserting) the module. For technology modules such as this one, L+ power must be switched off prior to pulling and plugging the module.

The following diagnostics can be signaled:

Table 2-1985 Diagnostics alarms, their meaning and possible remedies

Diagnostics alarm	Fault code	Meaning	Solution
Overtemperature	16#0005	An excessively high temperature was measured in the F-module.	• Operate the F-module within the specified temperature range (see Technical specifications). • Once the temperature has been reduced and returns to the specified range, the F-module must be removed and reinserted or the power switched OFF and ON.
Parameter failure (invalid parameters)	16#0010	On detection of invalid parameters, the module remains present in the system but goes to an unparameterized state and the module LEDs give an immediate indication of the fault. The module is included in STEP 7 (TIA Portal V17 or later), which includes detailed dependency checks. However, configuration may also be accomplished using the GSDML, which contains limited dependency checking. This error is seen when using the GSDML to configure the module since there is limited dependency checking performed by the GSDML. Possible causes: • i-Parameter CRC error • Invalid i-parameters (for example, invalid selection, parameter out-of-range, unsupported feature selected, and wrong value of reserved field) • Any PROFIsafe parameterization problem detected by the PROFIsafe driver	Check the i-Parameter CRC, i-parameter, and PROFIsafe parameter assigned to the F-module in the GSDML configuration.

Diagnostics alarm	Fault code	Meaning	Solution
Supply voltage missing	16#0011	Missing or insufficient supply voltage L+ Possible causes: • Operating the F-module outside the specified supply voltage range • Critical overvoltage range exceeded	• Operate the F-module within the specified supply voltage range. • After a critical over-voltage event, once the voltage returns to the specified range, the F-module must be removed and reinserted or the power switched OFF and ON.
Mismatch of safety destination address (F_Dest_Add)	16#0040	The PROFIsafe driver has detected a different F-destination address. Checked after new parameters received.	• Check the parameter assignment of the PROFIsafe address assigned to the F-module. • Reassign or reinitialize the PROFIsafe F-addresses using STEP 7.
Safety destination address not valid (F_Dest_Add)	16#0041	The PROFIsafe driver has detected an invalid destination address. Checked after new parameters received.	
Safety source address not valid (F_Source_Add)	16#0042	The PROFIsafe driver has detected a source address mismatch or an invalid source address. Checked after new parameters received.	
CRC1 fault	16#0047	The firmware of the F-module has detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Impermissibly high electromagnetic interference is present.	• Check PROFINET or PROFIBUS communications between the F-module and F-CPU. • Eliminate the electromagnetic interference. • Power switched OFF and ON for station. • Reassign or reinitialize the PROFIsafe F-addresses using STEP 7.
Inconsistent iParameters (iParCRC error)	16#004B		
Transmission error: data inconsistent (CRC error)	16#004D		
Transmission error: timeout (watchdog time 1 or 2 elapsed)	16#004E	The firmware of the F-module has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • A bus fault is present.	• Adjust F-monitoring time. • Adjust the F-runtime group cycle time. • Ensure that communication is functioning correctly.
Invalid/inconsistent firmware present	16#011B	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module. • Power cycle to restore the module to the firmware versions prior to getting the error.
Diagnostic queue overflow	16#013E	Overflow of the diagnostics memory. It was not possible to send all pending diagnostics. This error can lead to deactivation of the F-module.	Remedy the cause of the diagnostics surge.

Diagnostics alarm	Fault code	Meaning	Solution
No pulses detected	16#030A	The expected number of pulses was not received within a given revolution, where the revolution is determined by the module receiving an active N signal event. Possible causes: • There is a faulty N signal. • The "Pulses per revolution" configuration does not match the encoder's pulses per revolution. • The module is configured to use the N signal, but the encoder does not use an N signal or there is a wire break. • There is noise on the N signal line.	• Check the N signal process wiring. • Check the parameter is set to match the sinusoidal cycles per revolution.
F-address memory not accessible	16#030D	The F-source address and F-destination address stored in the coding element cannot be accessed.	Verify that the coding element is present or replace the coding element.
No valid F-address available	16#030E	The electronic coding element contains an invalid F-address.	Assign a PROFIsafe address to the F-module.
Module is defective	16#0100	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner. • Encoder frequencies received above 250kHz. In this situation, the module is not defective.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • Ensure encoder frequencies below 200kHz and reapply power to the module. • Replace defective F-module.
Watchdog tripped	16#0103	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module has detected an internal error and has reacted in a safety-related manner.	
Sensor signal flutters	16#0310	An internal diagnostic has been triggered due to instability of the encoder signals. Possible causes: • Consistent presence of external electrical noise • Placing encoder signal wires in the same tray with AC power wiring or high-energy, rapidly-switching DC wiring • Using unshielded encoder cables or improper shielded encoder cables	• Ensure that you are using proper shielded cables between the encoder and the module to meet noise immunity standards. • Reduce or eliminate the electrical noise influencing the encoder. • Avoid placing encoder signal wires in the same tray with AC power wiring and high-energy, rapidly-switched DC wiring.
Undertemperature	16#0312	The minimum permissible temperature limit has been violated.	• Operate the F-module within the specified temperature range (see Technical Specifications). • Once the temperature has increased and returns to the specified range, the F-module must be removed and reinserted or the power switched OFF and ON.

Diagnostics alarm	Fault code	Meaning	Solution
Failure in the input circuit	16#0313	The F-module has detected an internal error in the input circuits. Possible cause: • F-module is defective	• Replace defective F-module.
Internal discrepancy failure	16#0315	The internal counters of the F-module have resulted in divergent count values. Possible causes: • Impermissibly high electromagnetic interference is present • Encoder failure • Excessive frequency • F-module is defective	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON. • Replace encoder. • Operate within specified frequency range. • Replace defective F-module.
Supply voltage too high	16#0321	The supply voltage is too high.	• Operate the F-module within the specified voltage range (see Technical Specifications). • After a critical over-voltage event, once the voltage returns to the specified range, the F-module must be removed and reinserted or the power switched OFF and ON.
Supply voltage too low	16#0322	The supply voltage is too low.	
Load voltage too low	16#0324	The encoder supply voltage is out of the allowed range. This could be because of an internal module problem or a problem external to the module.	Disconnect the encoder and power cycle the module. • If the error goes away, there could be a problem with the encoder that causes the encoder supply to be out of range. • If the error is still present after a power cycle with no encoder attached, replace defective F-module.
Illegal A/B signal ratio	16#0500	The encoder's A and B signals are outside the allowed phase shift tolerance, or the amplitude (voltage) tolerance. Possible causes: • Encoder faulty • Process wiring faulty • Wire break • F-module is defective	• Check process wiring. • Check encoder. • Replace defective F-module.
Frequency outside specification	16#0501	The maximum frequency for the F-module has been exceeded.	Reduce the frequency of the application (see Technical Specifications).

6.5 Value status (CQ HSC0)

Properties

In addition to the diagnostic messages and the status and error display, the F-module makes available information about the validity of the count and status values in the feedback interface. The value status is available in the process image along with the count and status values for the channel.

Value status for the F-TM Count module

The value status is additional binary information provided in the feedback interface. It is provided in the process image of the inputs (PII) at the same time as the process values. It provides information about the validity of the process inputs.

The value status is influenced by channel and module wide diagnostic results.

- 1_B: Valid process values are provided for the channel.
- 0_B: Fail-safe process values are provided for the channel.

If the F-TM Count module input channel is passivated, the fail-safe system always provides ("0") for the count value, measured value, and event and status bits.

Assignment of inputs for the value status in the PII

The input channel of the F-module is assigned a value status (CQ HSC0) in the process image of the inputs. You can find the assignment in section Address space (Page 57).

Reference

A detailed description of the evaluation and processing of the value status can be found in the *SIMATIC Safety – Configuring and Programming* manual (https://support.industry.siemens.com/cs/ww/en/view/54110126).

Technical specifications 7

7.1 Specifications

	6ES7136-6CB00-0CA0
General information	
Product type designation	F-TM Count, 1x1Vpp sin/cos HF
Firmware version	V1.0
FW update possible	Yes
Product version	V1.0
usable BaseUnits	BU type A0
Color code for module-specific color identification plate	CC01
Product function	
I&M data	Yes; I&M0 to I&M3
Engineering with	
STEP 7 TIA Portal configurable/integrated as of version	Step 7 V17 or higher: use GSDML for prior versions
Supply voltage	
Load voltage L+	
Rated value (DC)	24 V
permissible range, lower limit (DC)	20,4 V
permissible range, upper limit (DC)	28,8 V
Reverse polarity protection	Yes
Input current	
Current consumption, max.	50 mA; Without load, 150 mA with 300 mA Encoder load
Encoder supply	
5 V	Yes; 5.1 V ±3.5 %
Short-circuit protection	Yes; Electronic overload protection; no protection on applying a normal or counter voltage.
Output current, max.	300 mA
Power loss	
Power loss, typ.	1,25 W
Address area	
Address space per module	
Inputs	14 byte; S7-300/400F CPU, 13 byte
Outputs	5 byte; S7-300/400F CPU, 4 byte
Digital inputs	
Number of digital inputs	1; (Counter Input)

	6ES7136-6CB00-0CA0
Digital inputs, parameterizable	Yes
Digital input functions, parameterizable	
Gate start/stop	Yes
Counter for incremental encoder	Yes
Number, max.	1
Input voltage	
Type of input voltage	sin/cos 1 Vpp; monitored to +/- 20% resolution
Input delay (for rated value of input voltage)	
Minimum pulse width for program reactions	2.5 µs for parameterization "none"
for technological functions	
parameterizable	Yes
Cable length	
shielded, max.	150 m
Encoder	
Connectable encoders	
Incremental encoder (symmetrical)	Yes; up to 200 kHz depending on cable type and length
Encoder signals, incremental encoder (symmetrical)	
Input voltage	1 Vpp, centered at 2.5 V offset
Input frequency, max.	200 kHz
Counting frequency, max.	800 kHz; with quadruple evaluation
Cable length, shielded, max.	150 m
Incremental encoder with A/B tracks, 90° phase offset	Yes; sin/cos
Incremental encoder with A/B tracks, 90° phase offset and zero track	Yes; sin/cos/zero
Interrupts/diagnostics/status information	
Diagnostics function	Yes; see chapter "Diagnostic Messages" in the manual
Alarms	
Diagnostic alarm	Yes
Hardware interrupt	No
Diagnoses	
Monitoring the supply voltage	Yes
Wire-break	Yes
Short-circuit	Yes
A/B transition error at incremental encoder	Yes
Diagnostics indication LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of the supply voltage (PWR-LED)	Yes; green LED
Channel status display	Yes; green LED
for channel diagnostics	Yes; red LED

	6ES7136-6CB00-0CA0
for module diagnostics	Yes; green/red DIAG LED
Integrated Functions	
Number of counters	1
Counting frequency (counter) max.	800 kHz; with quadruple evaluation
Safety monitoring functions	
Safe Operating Stop (SOS)	Yes
Safely-Limited Speed (SLS)	Yes
Safe Direction (SDI)	Yes
Safe Speed Monitor (SSM)	Yes
Counting functions	
Continuous counting	Yes
Counter response parameterizable	Yes
Software gate	Yes
Counting range, parameterizable	Yes
Measuring functions	
Measuring range	
Frequency measurement, min.	Hz
Frequency measurement, max.	800 kHz
Cycle duration measurement, min.	1 µs
Cycle duration measurement, max.	25 s
Velocity measurement, min.	0; (user defined units)
Velocity measurement, max.	2147483; +/- (user defined units)
Accuracy	
Frequency measurement	Up to 100 ppm; depending on measuring interval and signal evaluation. At low frequency external noise may have an effect on accuracy (reference the graph in 2.2.3)
Cycle duration measurement	Up to 100 ppm; depending on measuring interval and signal evaluation. At low frequency external noise may have an effect on accuracy (reference the graph in 2.2.3)
Velocity measurement	Up to 100 ppm; depending on measuring interval and signal evaluation. At low frequency external noise may have an effect on accuracy (reference the graph in 2.2.3)
Potential separation	
Potential separation channels	
between the channels	No; Only one channel is available
between the channels and backplane bus	Yes
Between the channels and load voltage L+	No
between the channels and the power supply of the electronics	No
Isolation	
Isolation tested with	707 V DC (type test)
Degree and class of protection	

	6ES7136-6CB00-0CA0
IP degree of protection	IP20
Standards, approvals, certificates	
Suitable for safety functions	Yes
Highest safety class achievable in safety mode	
Performance level according to ISO 13849-1	Cat. 4, PL e
SIL acc. to IEC 61508	SIL 3
Probability of failure (for service life of 20 years and repair time of 100 hours)	
Low demand mode: PFDavg in accordance with SIL 1	2.00E-03 signal monitoring disabled
Low demand mode: PFDavg in accordance with SIL 3	< 3.00E-05
High demand/continuous mode: PFH in accordance with SIL 1	< 3.00E-08 1/h signal monitoring disabled
High demand/continuous mode: PFH in accordance with SIL 3	< 1.00E-09 1/h
Ambient conditions	
Ambient temperature during operation	
horizontal installation, min.	0 °C
horizontal installation, max.	60 °C
vertical installation, min.	0 °C
vertical installation, max.	50 °C
Altitude during operation relating to sea level	
Ambient air temperature-barometric pressure-altitude	On request: Ambient temperatures lower than 0 °C (without condensation) and/or installation altitudes greater than 2 000 m
Dimensions	
Width	15 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	42 g

Response times

A

A.1 Maximum response time of the system

Calculating the maximum response time of the system

You can calculate your maximum system response time using the "SIMATIC STEP 7 Safety Advanced: F-Execution Times, F-Runtimes, F-Monitoring and Reaction Times (https://support.industry.siemens.com/cs/ww/en/view/58856512)" Excel file (RT_calculator). Use your configured individual fail-safe module timing parameters and the module characteristic parameters found in this appendix to determine the maximum response time of your system.

Data transport delays included

The T_{cycle} parameter value in the following paragraph includes an allowance for the fail-safe module to acquire and deliver PROFIsafe messages in transactions with the PLC I/O bus. The execution time of the Safety FB in the fail-safe CPU includes the physical transport delay time for PROFIsafe messages moving between the fail-safe module location and the fail-safe CPU. There are no separate transport delay parameters that you must include in your calculations.

A.2 Response times of the F-TM Count module

Maximum response time of the F-module input values

$T_{WCDT_i} = T_{cycle} * 2$

Where:

T_{cycle} 6 ms	Internal cycle time of the fail-safe module
T_{WCDT_i}	Worst Case Delay Time: Maximum response time from a signal transition at the fail-safe module's counter input to the reliable availability of the safety message frame available for the fail-safe CPU request

Count, status, and event values are reported during each T_{cycle}. In situations where an individual count of a movement is slower than T_{cycle}, the same value can be reported across one or more T_{cycles}.

The response time for counts, status, and event values is essentially a single T_{cycle}. For output image register commands, the response time behavior T_{cycle} * 2 applies. The maximum response time is defined as twice the cycle time for simplicity.

Maximum fault response time of the F-module input

$T_{WCDT_i} = (T_{cycle} * 2) + T_{signal}$ (when moving)

$T_{OFDT_i} = (T_{cycle} * 2) + T_{diagrep}$ (when not moving or moving slower than a single count per second)

Where:

T_{cycle} 6 ms	Internal cycle time of the fail-safe module
$T_{diagrep}$ 250 ms	Internal diagnostic repetition rate
T_{OFDT_i}	One Fault Delay Time: Maximum response time for the fail-safe module to report a channel as passivated
T_{signal} 20 ms	Maximum transition time of the signal monitoring error output
T_{WCDT_i}	Worst Case Delay Time: Maximum response time from a signal transition at the fail-safe module's counter input to the reliable availability of the safety message frame available for the fail-safe CPU request

Response times that use measured value

Measured values are calculated and updated by the module to the F-CPU at the rate specified by the configured "Update time". Safety reaction times that use measured values in your safety program (for example, SLS) are therefore dependent on the configured update time. Refer to Measured value determination (Page 15) to calculate measure values.

Parameter data record

B

B.1 Parameter defaults and dependencies when configuring with GSD file

When configuring the module with a GSD file, remember that the setting of some parameters are dependent on each other.

F-TM Count module and encoder

The following are F-TM Count module default parameters:

Channel activation	Count/Pos input	Measuring	Signal monitoring
Enabled	Enabled	Enabled	Enabled

The following are encoder default parameters:

Signal type	Invert direction	Pulses per revolution	Signal evaluation	Reaction to N signal
Sin/Cos	Disabled	1024	Quadruple	No reaction

The following are F-TM Count default parameters using STEP 7 or GSD:

	High limit	Start value	Low limit	Counting violation	Reset upon violation	Reaction to Gate start
STEP 7	2147483647	0	-2147483648	Continue	Start value	Set to start
GSD	2147483647 [1]	0 [1]	0 [1],[2]	Continue	Start value	Set to start

[1] Parameter errors result whenever "Low Limit" >= "High Limit", "High Limit" < "Start Value", or "Start Value" < "Low Limit".

[2] Signed values are not supported using FCT V2.0. Negative values must be entered as their equivalent two's compliment values (for example, 2147483648 = - 2147483648 and 4294967295 = -1).

Measured value

The following are measured value default parameters:

Measured value	Update time	Time base (velocity)	Counts/Unit (velocity)
Frequency	100	0	1
Period	100	0	1
Velocity	100	0	1

Safety monitoring

The following are safety monitoring default parameters:

SOS enable	SDI enable	SLS enable
Disabled	Disabled	Disabled [1]

SOS tolerance	SDI tolerance	SLS speed
0	0	0

[1] When SLS is enabled, a measured value other than velocity will result in a parameter error.

PLC data types

C

C.1 PLC data types for F-TM Count

PLC data types for F-TM Count

Fail-Safe compliant PLC user-defined data types (UDTs) for the F-TM-C module are available from SIOS. These PLC data types define and represent the F-TM-C input image register and the F-TM-C output image register. You can import these PLC data types into your TIA Portal project using "External source files" in the project tree.

See also

SIOS (https://support.industry.siemens.com/cs/ww/en/view/109792746)

SIEMENS

SIMATIC

ET 200SP
F-TM ServoDrive ST 1x24V..48V

Equipment Manual

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Introduction 1

1.1 About SIMATIC Micro-Drive

SIMATIC MICRO-DRIVE

SIMATIC MICRO-DRIVE is the drive system for safety extra-low voltages of 24 V to 48 V. Comprising SIMATIC MICRO-DRIVE, versatile motors and connecting cables from selected product partners, it extends the SIEMENS portfolio in the safety extra-low voltage area.

Suitable controllers from the SIMATIC range round out the motion control functionalities.

SIMATIC MICRO-DRIVE TM Drives

TM Drives is a technology module for SIMATIC ET 200SP. It can be controlled by a SIMATIC S7-1500/1200, including via technology objects (TO). TM Drives can be used in combination with a Distributed Controller or the SIMATIC ET 200SP Open Controller in decentralized system concepts.

1.2 About this information for use

1.2.1 Contents

To illustrate possible application areas for our products, typical use cases are listed in this product documentation and in the online help. These are purely exemplary and do not constitute a statement on the suitability of the respective product for applications in specific individual cases. Unless explicitly contractually agreed, Siemens assumes no liability for such suitability. Suitability for a particular application in specific individual cases must be assessed by the user, taking into account all technical, legal, and other requirements on a case-by-case basis. Always observe the descriptions of the technical properties and the relevant constraints of the respective product contained in the product documentation.

Purpose of the documentation

This Equipment Manual supplements the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that generally relate to the system are described in the System Manual.

The information provided in this Equipment Manual and in the System/Function Manuals supports you in commissioning the system.

Firmware versions

This manual is valid for firmware version FW 2.1 and current HSP versions from V18 and for the corresponding GSDML version.

NOTE

The current firmware versions can be found in Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/109781459).

Conventions

CPU: When the term "CPU" is used in the following, it applies to the central modules of the S7-1500 automation system, the S7-1200 automation system, as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

This documentation should be kept in a location where it can be easily accessed and made available to the personnel responsible.

Information regarding third-party products

NOTE

Recommendation relating to third-party products

This document contains recommendations relating to third-party products. Siemens accepts the fundamental suitability of these third-party products.

You can use equivalent products from other manufacturers.

Siemens does not accept any warranty for the properties of third-party products.

1.2.2 Target group

The Equipment Manual is intended for:

- Assemblers
- Commissioning engineers
- Operators
- Service personnel
- Project engineers

1.2.3 Standard scope

The functions of the system as delivered can only be found in the order documents.

Further functions may be executable in the system, which are not explained in this documentation. However, there is no entitlement to these functions in the case of a new delivery or service.

This documentation does not contain all detailed information on all types of the product. Furthermore, this documentation cannot take into consideration every conceivable type of installation, operation and service/maintenance.

The machine manufacturer must document any additions or modifications they make to the product themselves.

1.2.4 Use of third-party products in this documentation

This documentation contains recommendations relating to third-party products. Siemens accepts the fundamental suitability of these third-party products. You can use equivalent products from other manufacturers.

Siemens does not accept any warranty for the use of third-party products.

1.2.5 Websites of third-party companies

This document may contain hyperlinks to third-party websites. Siemens is not responsible for and shall not be liable for these websites and their content. Siemens has no control over the information which appears on these websites and is not responsible for the content and information provided there. The user bears the risk for their use.

1.3 SIMATIC documentation

1.3.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Figure 2-1537 Icon for device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/ww/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.automation.siemens.com/WW/view/en/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.3.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.4 Service & Support

1.4.1 FAQ

You will find FAQs on TM Drive on the Internet
(https://support.industry.siemens.com/cs/ww/en/ps/26085/faq).

1.4.2 ID link and Siemens Online Support

You can find additional information about the product:

- via ID link
- using the Siemens Industry Online Support
  - Website: SIOS
  - App Industry Online Support (for Apple iOS and Android)

Product-specific information via ID link

The QR code on your product and on the product packaging contains the ID link.

ID link is a globally unique identifier according to IEC 61406-1.

You can use the ID link to access product data, manuals, Declarations of Conformity, certificates and other information about your product.

Figure 2-1538 QR code with ID link included

The ID link is characterized by a frame with a black corner at the bottom right.

Content of Siemens Online Support

- Product support
- Global forum for information and best practice sharing between users and specialists
- Local contact persons via the contact person database (→ Contact)
- Product information
- FAQs (frequently asked questions)
- Application examples
- Manuals
- Downloads
- Compatibility tool
- Newsletter with product selection
- Catalogs/brochures
- Certificates

See also

SIOS (https://support.industry.siemens.com/cs/ww/en/)

1.4.3 Spare parts services

The online spare part service "Spares on Web (https://www.sow.siemens.com)" offers spare parts for the product.

1.5 Important product information

1.5.1 Intended use

This equipment is used for the open-loop and closed-loop control of EC motors for safety extra-low voltages up to 48 V DC.

⚠ WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Intended use of hardware products

This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens.

Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults.

EU note: Start-up/commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed fulfills the regulations/specifications of Directive 2006/42/EC.

1.6 Safety Evaluation Tool (SET)

You can quickly and easily evaluate the safety functions of your machine using the Safety Evaluation Tool (SET) for the IEC 62061 and ISO 13849-1 standards. You receive the results as a standard-compliant report that can be integrated in the machine documentation as proof of safety.

The free Safety Evaluation Tool is available on the Internet (https://new.siemens.com/global/en/products/automation/topic-areas/safety-integrated/factory-automation/support/safety-evaluation-tool.html).

Fundamental safety instructions 2

2.1 General safety instructions

WARNING

Electric shock and danger to life due to other energy sources

Touching live components can result in death or severe injury.

- Only work on electrical devices when you are qualified for this job.
- Always observe the country-specific safety rules.

Generally, the following steps apply when establishing safety:

1. Prepare for disconnection. Notify all those who will be affected by the procedure.
2. Isolate the drive system from the power supply and take measures to prevent it being switched back on again.
3. Wait until the discharge time specified on the warning labels has elapsed.
4. Check that there is no voltage between any of the power connections, and between any of the power connections and the protective conductor connection.
5. Check whether the existing auxiliary supply circuits are de-energized.
6. Ensure that the motors cannot move.
7. Identify all other dangerous energy sources, e.g. compressed air, hydraulic systems, or water. Switch the energy sources to a safe state.
8. Check that the correct drive system is completely locked.

After you have completed the work, restore the operational readiness in the inverse sequence.

WARNING

Risk of electric shock and fire from supply networks with an excessively high impedance

Excessively low short-circuit currents can lead to the protective devices not tripping or tripping too late, and thus causing electric shock or a fire.

- In the case of a conductor-conductor or conductor-ground short-circuit, ensure that the short-circuit current at the point where the converter is connected to the line supply at least meets the minimum requirements for the response of the protective device used.
- You must use an additional residual-current device (RCD) if a conductor-ground short circuit does not reach the short-circuit current required for the protective device to respond. The required short-circuit current can be too low, especially for TT supply systems.

WARNING

Risk of electric shock and fire from supply networks with an excessively low impedance

Excessively high short-circuit currents can lead to the protective devices not being able to interrupt these short-circuit currents and being destroyed, and thus causing electric shock or a fire.

- Ensure that the prospective short-circuit current at the line terminal of the converter does not exceed the breaking capacity (SCCR or Icc) of the protective device used.

WARNING

Electric shock if there is no ground connection

For missing or incorrectly implemented protective conductor connection for devices with protection class I, high voltages can be present at open, exposed parts, which when touched, can result in death or severe injury.

- Ground the device in compliance with the applicable regulations.

WARNING

Electric shock due to connection to an unsuitable power supply

When equipment is connected to an unsuitable power supply, exposed components may carry a hazardous voltage. Contact with hazardous voltage can result in severe injury or death.

- Only use power supplies that provide SELV (Safety Extra Low Voltage) or PELV- (Protective Extra Low Voltage) output voltages for all connections and terminals of the electronics modules.

WARNING

Electric shock due to equipment damage

Improper handling may cause damage to equipment. For damaged devices, hazardous voltages can be present at the enclosure or at exposed components; if touched, this can result in death or severe injury.

- Ensure compliance with the limit values specified in the technical data during transport, storage and operation.
- Do not use any damaged devices.

WARNING

Electric shock due to unconnected cable shield

Hazardous touch voltages can occur through capacitive cross-coupling due to unconnected cable shields.

- As a minimum, connect cable shields and the conductors of power cables that are not used (e.g. brake cores) at one end at the grounded housing potential.

WARNING

Arcing when a plug connection is opened during operation

Opening a plug connection when a system is in operation can result in arcing that may cause serious injury or death.

- Only open plug connections when the equipment is in a voltage-free state, unless it has been explicitly stated that they can be opened in operation.

NOTICE

Material damage caused by an incorrect power connection

An incorrect power connection can result in damage due to fire, device defects or malfunctions.

- Check all power connections at regular intervals, particularly after equipment has been transported.

WARNING

Electromagnetic interference due to inadequate shield support

A lack of adequate shield support for the power cables can cause malfunctions and impermissibly high levels of interference.

- Use the shield connection plates supplied or recommended.
- Use the shield connection clips recommended.

WARNING

Active implant malfunctions due to electromagnetic fields

Converters generate electromagnetic fields (EMF) in operation. Electromagnetic fields may interfere with active implants, e.g. pacemakers. People with active implants in the immediate vicinity of an converter are at risk.

- As the operator of an EMF-emitting installation, assess the individual risks of persons with active implants.
- Observe the data on EMF emission provided in the product documentation.

CAUTION

Symptomatic respiratory and skin reaction to chemicals

A newly purchased product might contain traces of substances that are identified as sensitizers.

Sensitizers are substances which can cause sensitization in the lungs and skin after exposure to them.

Once sensitized, individuals can have severe reactions to further exposure, even in small amounts. In the most extreme cases, individuals might develop asthma or dermatitis respectively.

- If the product has a strong smell, keep it in a well-ventilated area for 14 days.

WARNING

Unexpected machine movement caused by radio devices or cellphones

Using radio devices, cellphones, or mobile WLAN devices in the immediate vicinity of the components can result in equipment malfunction or faults and damage to the devices. Malfunctions may impair the functional safety of machines and can therefore put people in danger or lead to property damage.

- Avoid operating radio devices, cellphones and mobile WLAN devices in the direct vicinity of converters and operating units.
- Scan the machine readable code, e.g. a QR code, from a greater distance or switch off the converter power supply before scanning.
- Only operate built-in devices with the control cabinet doors closed.
- When control cabinet doors are open, only qualified electrical personnel are allowed to carry out service and maintenance work.

CAUTION

Radio frequency interference in residential areas

When you operate EMC category C2 devices in residential areas, the devices can cause radio frequency interference.

When you operate EMC category C3 or C4 devices in residential areas, it is to be expected that the devices will cause radio frequency interference.

- Do not operate EMC category C2 devices in residential areas.
- Do not operate EMC category C3 or C4 devices in public low-voltage networks supplying residential buildings.

NOTE

It cannot be guaranteed that EMC emission limits are complied with if the products are connected to an isolated line supply, a line supply grounded through a high ohmic connection or a line supply with a grounded line conductor.

- Draw-up an EMC plan to comply with the EMC requirements of the planned application.

⚠ WARNING

Fire due to inadequate ventilation clearances

Inadequate ventilation clearances can cause overheating of components with subsequent fire and smoke. This can cause severe injury or even death. This can also result in increased downtime and reduced service lives for devices/systems.

- Ensure compliance with the specified minimum clearance as ventilation clearance for the respective component.

NOTICE

Overheating due to inadmissible mounting position

The device may overheat and therefore be damaged if mounted in an inadmissible position.

- Only operate the device in admissible mounting positions.

NOTICE

Device damage caused by incorrect insulation resistance tests

High test voltages can damage the device.

- Measure the insulation resistance of low voltage circuits of machines or systems only with ≤ 500 V DC.
- Measure the insulation resistance of SELV circuits of machines or systems only with ≤ 250 V DC.

NOTICE

Device damage caused by incorrect voltage tests

High test voltages can damage the device. Capacitive leakage currents can distort the test results.

- Disconnect the components before carrying out a voltage test on the machine. [1)]

[1)] The components are voltage tested in accordance with the IEC 61800-5-1 product standard and must be disconnected during testing in accordance with IEC 60204-1:2021 Section 18.4.

WARNING

Unexpected movement of machines caused by inactive safety functions

Inactive or non-adapted safety functions can trigger unexpected machine movements that may result in serious injury or death.

- Observe the information in the appropriate product documentation before commissioning.
- Carry out a safety inspection for functions relevant to safety on the entire system, including all safety-related components.
- Ensure that the safety functions used in your drives and automation tasks are adjusted and activated through appropriate parameterizing.
- Perform a function test.
- Only put your plant into live operation once you have guaranteed that the functions relevant to safety are running correctly.

WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings

As a result of incorrect or changed parameterization, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameterization against unauthorized access.
- Handle possible malfunctions by taking suitable measures, e.g. emergency stop or emergency off.

2.2 Equipment damage due to electric fields or electrostatic discharge

Electrostatic sensitive devices (ESD) are individual components, integrated circuits, modules or devices that may be damaged by either electric fields or electrostatic discharge.

NOTICE

Equipment damage due to electric fields or electrostatic discharge

Electric fields or electrostatic discharge can cause malfunctions through damaged individual components, integrated circuits, modules or devices.

- Only pack, store, transport and send electronic components, modules or devices in their original packaging or in other suitable materials, e.g conductive foam rubber of aluminum foil.
- Only touch components, modules and devices when you are grounded by one of the following methods:
  - Wearing an ESD wrist strap
  - Wearing ESD shoes or ESD grounding straps in ESD areas with conductive flooring
- Only place electronic components, modules or devices on conductive surfaces (table with ESD surface, conductive ESD foam, ESD packaging, ESD transport container).

2.3 Warranty and liability for application examples

Application examples are not binding and do not claim to be complete regarding configuration, equipment, or any eventuality which may arise. Application examples do not represent customer-specific solutions, but merely serve to provide assistance with typical tasks.

As the user you yourself are responsible for ensuring that the products described are operated correctly. Application examples do not relieve you of your responsibility for safe handling when using, installing, operating and maintaining the equipment.

2.4 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Further information is provided on the Internet:
Configuration Manual Industrial Cybersecurity
(https://support.industry.siemens.com/cs/ww/en/view/109975311)

WARNING

Unsafe operating states resulting from software manipulation

Software manipulations, e.g. viruses, Trojans, or worms, can cause unsafe operating states in your system that may lead to death, serious injury, and property damage.

- Keep the software up to date.
- Incorporate the automation and drive components into a state-of-the-art, integrated industrial cybersecurity concept for the installation or machine.
- Make sure that you include all installed products in the integrated industrial cybersecurity concept.
- Protect files stored on exchangeable storage media from malicious software by with suitable protection measures, e.g. virus scanners.
- Carefully check all cybersecurity-related settings once commissioning has been completed.

2.5 Residual risks of power drive systems

When assessing the machine or system-related risk in accordance with the respective local regulations (e.g. EC Machinery Directive), the machine manufacturer or system integrator must take into account the following residual risks emanating from the control and drive components of a drive system:

1. Unintentional movements of driven machine or system components during commissioning, operation, maintenance, and repairs caused by, for example,
   - Hardware faults and/or software errors in the sensors, control system, actuators, and connections
   - Response times of the control system and of the drive
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - Parameterization, programming, cabling, and installation errors
   - Use of wireless devices/mobile phones in the immediate vicinity of electronic components
   - External influences/damage
   - X-ray, ionizing radiation and cosmic radiation

2. Unusually high temperatures inside and outside the components, including open flames, as well as emissions of light, noise, particles, gases, etc. due to fault conditions, e.g.:
   - Component failure
   - Software errors
   - Operation and/or environmental conditions outside the specification
   - External influences/damage
   - Short circuits or ground faults in the intermediate DC circuit of the converter
3. Hazardous shock voltages caused by, for example:
   - Component failure
   - Influence during electrostatic charging
   - Induction of voltages in moving motors
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - External influences/damage
4. Electrical, magnetic and electromagnetic fields generated in operation that can pose a risk to people with a pacemaker, implants or metal replacement joints, etc., if they are too close
5. Release of environmental pollutants or emissions as a result of improper operation of the system and/or failure to dispose of components safely and correctly
6. Influence of network-connected and wireless communications systems, e.g. ripple-control transmitters or data communication via the network or mobile radio, WLAN or Bluetooth.
7. Motors for use in potentially explosive areas:

   When moving components such as bearings become worn, this can cause enclosure components to exhibit unexpectedly high temperatures during operation, creating a hazard in areas with a potentially explosive atmosphere.

For more information about the residual risks of the drive system components, see the relevant sections in the technical user documentation.

Product overview

3

3.1 Area of application

Broad range of control applications

The SIMATIC ET 200SP distributed I/O system offers the necessary flexibility and performance for a wide range of control applications.

The F-TM ServoDrive ST is a product from the TM Drive range of modules in the ET 200SP network. The term TM Drive is synonymous with the F-TM ServoDrive ST in this manual.

The F-TM ServoDrive ST technology module offers you the following application possibilities:

- Variable speed control
- Positioning tasks in combination with higher-level controller
- In the area of safety extra-low voltage ≤ 60 V DC with integrated hardware Safety function Safe Torque Off (STO)

Areas of application

The F-TM ServoDrive has proven to be an ideal and compact drive in many applications.

Examples of applications:

- Packaging machines
- Automatic assembly machines
- Electronics and battery production
- Printing and labeling machines
- Winders/unwinders, e.g. in the textile, packing and printing and solar industries
- Driving of shuttles for storage and retrieval machines and storage rack systems
- Automated guided vehicle systems
- Battery-powered applications

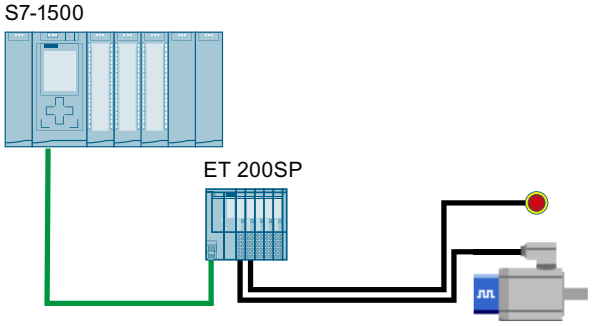

Figure 2-1539 Overview of standard variant with standard CPU

3.2 Properties

Article number

6BK1136-6AB00-0BU0

View of the module

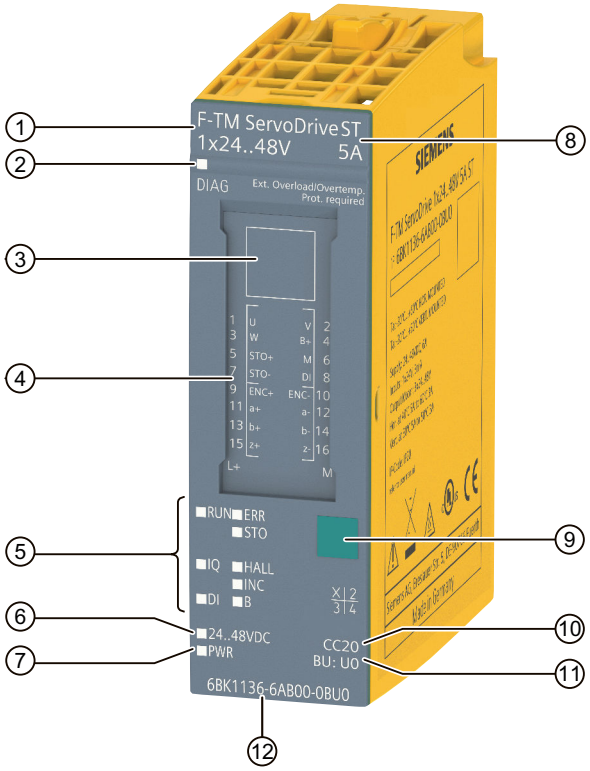

①	Module type and designation	⑧	Function class
②	LED for diagnostics	⑨	Color coding of module type
③	2D matrix code	⑩	Color code for selection of the color-coded labels
④	Wiring diagram	⑪	BU type
⑤	LEDs for motor control	⑫	Article number
⑥	LED for supply voltage		
⑦	LED for power		

Figure 2-1540 View of the F-TM ServoDrive module

Properties

The F-TM ServoDrive has the following properties:

- Operation on ET 200SP PROFINET IMs as of V4.0
- Operation on CPU 151x as of V2.0, S7-1200, OpenController and CPU 151xSP
- Speed-controlled single-axis drive with PROFIdrive profile
- Rated voltage of the drive module: 24 to 48 V DC (safety extra-low voltage)
- Support of IQ encoder technology
- Support of incremental encoders with (A, B, Z track)
- 24 V digital input
- Support of individually configurable motors (permanent-magnet synchronous motors (PMSM))
- Controller parameter determination possible using HSP
- Thermal monitoring of the motor and the power end stage
- Braking chopper, external braking resistor
- Cyclic overload capability
- Safety function STO hardwired
- Motor holding brake external via the process image
- Integrated engineering in STEP 7 (TIA Portal) via Hardware Support Package HSP0311 as of V16

Accessories

The following accessories that are not included in the module's scope of delivery can be used with the module:

Designation	Article number
Feed BaseUnit (light)*	6ES7193-6BP00-0DU0
Expansion BaseUnit (dark)*	6ES7193-6BP00-0BU0
MCB, B, 6 A	5SY6106-6
MCB, B, 10 A	5SY6110-6
MCB, B, 6 A for UL markets	5SJ4106-6HG40
MCB, B, 10 A for UL markets	5SJ4110-6HG40
Shield connection	6ES7193-6SC00-1AM0

* A BaseUnit of the type U0 (6ES7193-6BP00-0DU0 or 6ES7193-6BP00-0BU0) is needed for operation of the TM Drive. You can find an overview of the BaseUnits that you can use with the technology module in the Equipment Manual SIMATIC ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/109751716).

For additional information on accessories such as:

- Labeling strips
- Color-coded labels
- Reference identification labels

refer to the System Manual SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

NOTE
Unsuitable electronic fuses
Electronic fuses that disconnect the output voltage briefly in case of an overload and are not capable of power feedback (e.g. SITOP SEL1200) are not suitable for fuse protection.

3.3 Supported functions

System functions

F-TM ServoDrive supports the following PROFINET IO functions:

- Firmware update via PROFINET IO

F-TM ServoDrive supports the function:

- Identification data I&M 0 to 3

PROFIdrive communication types

The TM Drive supports the following communication types:

- Cyclic data exchange via a cyclic data channel

  Motion control systems require cyclically updated data during operation for open-loop and closed-loop control. This data must be sent as setpoints to the drive devices or read as actual values from the drive devices via the communication system. The transfer of this data is normally time-critical.
- Acyclic data exchange via an acyclic data channel

  An acyclic parameter channel for exchange of parameters between the CPU or supervisor and the drive devices is additionally available. Access to this data is not time-critical.
- Alarm channel

  Alarms are output event-triggered and indicate incoming and outgoing error states.

PROFIdrive application classes

The TM Drive supports Application Classes 1 and 4 of the PROFIdrive profile as of V4.2.

- Class 1 (AC1)

  The drive is controlled via a speed setpoint using PROFINET.

  The closed-loop speed control takes place entirely in the drive.

  Typical applications are, for example, simple frequency converters for pump and fan control.

- Class 4 (AC4)

  This PROFIdrive application class defines a speed setpoint interface with the closed-loop speed control taking place in the drive and the closed-loop position control taking place in the CPU, as is required for robot and machine tool applications with coordinated motion sequences on multiple drives.

Wiring

4

4.1 Pin assignment

Specific application

Observe the safety and accident prevention regulations applicable for specific applications, e.g. "Safety of Machinery EN ISO 13849-1".

During wiring and maintenance work, the TM Drive must be disconnected from the power supply.

EMERGENCY OFF equipment

EMERGENCY OFF devices according to IEC 60204 (corresponds to DIN VDE 0113) must remain in effect in all operating modes of the plant or system.

The drive-integrated safety function STO of the TM Drive does not replace the EMERGENCY OFF mechanism of the plant.

Excluding hazardous plant states

Hazardous operating states must not occur when

- The plant restarts up after a voltage dip or voltage failure
- Bus communication resumes after a fault

If necessary, the EMERGENCY OFF must be forced!

An uncontrolled or undefined startup must not occur after the EMERGENCY OFF is unlocked.

You can find a description on how to prevent uncontrolled startup in the section Safety Integrated functions (Page 44).

Potential group

Up to a continuous input current of max. 10 A for each potential group, up to 3 TM Drives can be connected together to form a drive line-up.

No other ET 200SP components may be located within a potential group consisting of one or more TM Drive.

A TM Drive potential group can be supplied as follows:

- With a separate power supply unit
- With a common power supply that also supplies other components. In this case, use a DC line filter (e.g. TDK Electronics 2-wire filter B84113C series) before the TM Drive potential group.

- If you are using a power supply unit with a rated current of more than 10 A or batteries/rechargeable batteries, it is imperative to connect a circuit breaker of characteristic B with max. 10 A rated current, approved for direct current and the corresponding SELV / PELV voltage, upstream of the TM Drive potential group. For a potential group with only one TM Drive, we recommend using an appropriate miniature circuit breaker with 6 A nominal current and characteristic B.
- You must not use voltage sources with low impedance such as supercaps without adequate current-limiting protective measures.

Short circuits

The power outputs of the TM Drive are short-circuit proof. If the module detects a short-circuit, it is still imperative to rectify the fault before switching it on again. Otherwise, the module can be damaged.

Disturbance of radio communication services due to radio-frequency interferences in residential environments

The TM Drive can cause radio frequency interference which requires measures for interference suppression. This system is not designed for liberal use in the first environment (residential area) and must not be used there without appropriate radio interference suppression measures. Have the installation and commissioning performed with appropriate radio interference suppression measures by experts.

Protection from external electrical effects

You can find information on interference-proof design in the function manual Designing interference-free controllers (https://support.industry.siemens.com/cs/ww/en/view/59193566).

Overload

The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

With automatic overload limiting, the output current is automatically reduced on reaching the rated load of the power end stage to effectively prevent an overload of the power unit.

SCCR (short circuit current rating)

Suitable For Use On A Circuit Capable Of Delivering Not More Than 5kA DC Symmetrical Amperes, 48 Volts DC Maximum.

4.2 Block diagram

WARNING

Fuse for the load circuit

In general, use a suitable overcurrent protection device to protect the F-TM ServoDrive.

Schematic circuit diagram

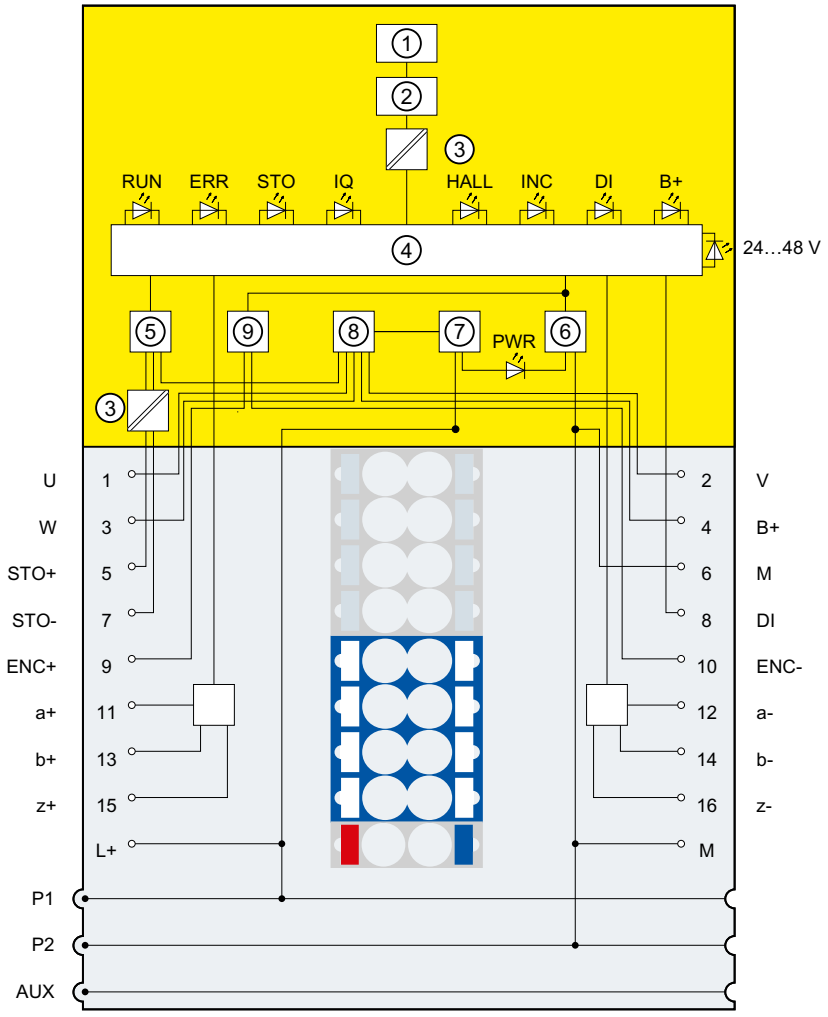

①	Backplane bus	**PMSM**	
②	Backplane bus interface module of the technology controller	U	Phase U
③	Electrical isolation	V	Phase V
④	Technology controller	W	Phase W
⑤	Safe Torque Off circuitry	B+	Connection of braking resistor
		Encoder supply	

⑥	Digital input circuit
⑦	Power supply/Preparation
⑧	Reverse polarity protection
⑨	Power electronics
⑩	Encoder power supply
Power supply	
L+	Power supply 24 - 48 V
M	Power supply GND
Inputs	
STO+	STO+ input (24 V)
M	Negative connection, e.g. for braking resistor
STO-	Negative STO input
DI	Digital input

ENC+	Power supply encoder 5 V
ENC-	Power supply encoder, negative connection
Incremental / IQ encoder	
a+	Differential encoder signal a+
a-	Differential encoder signal a-
b+	Differential encoder signal b+
b-	Differential encoder signal b-
z+	Differential encoder signal z+
z-	Differential encoder signal z-

Figure 2-1541 Schematic circuit diagram

Cable lengths and cable types

If you do not use an "all-in-one" plug-in cable, the following cable lengths and cable types are permitted for the interfaces:

Table 2-1986 Wiring rules for the interfaces

Connector	Function	Maximum cable length	Cable type
ENC+/ENC-	Incremental encoder signals and supply	10 m	Shielded For differential wiring, one twisted pair per signal pair
U/V/W	Motor phases	10 m	Shielded
DI, M	Input	10 m	≥ 2 m shielded
	Ground	10 m	-
L+/M	Power supply, power unit	10 m	-
B+	Connection of external braking resistor	2 m	≥ 0.5 m shielded
a, b, z	Encoder connectors	10 m	Shielded For differential wiring, one twisted pair per signal pair
STO	Safe Torque Off	10 m	-

* American Wire Gauge

CABLE SPEC.	Note that connected mains lines must be designed according to the expected minimum and maximum ambient temperature.

NOTE

In addition to the shield connection on the ET 200SP, the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor/encoder side.

4.3 Wiring of multiple F-TM ServoDrive

In a potential group

You can connect multiple TM Drives to form a potential group (drive line-up). The following figure shows you the TM Drive with different motors.

Wiring of multiple TM Drives to form a drive line-up

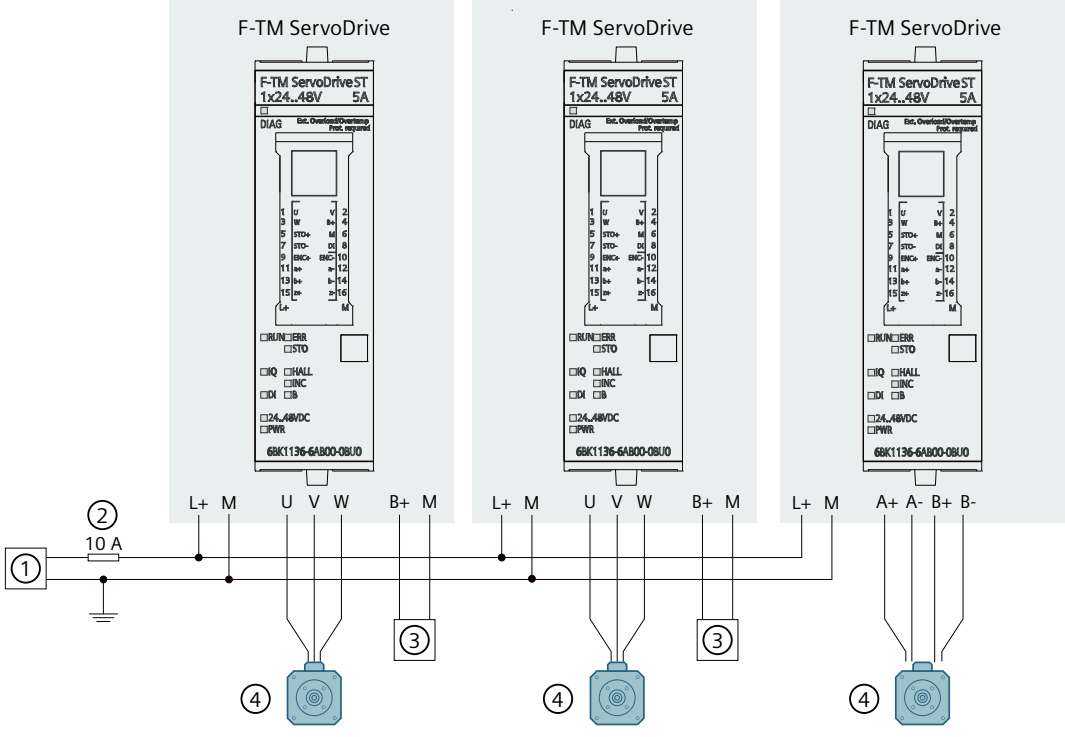

① Power supply unit
② Protective device
③ Braking resistor
④ Motor

Figure 2-1542 Wiring of multiple TM Drives to form a drive line-up

See also

Pin assignment (Page 29)

4.4 Connecting the motor

Overview

The F-TM ServoDrive supports permanent-magnet synchronous motors (PMSM).

Connecting the motor phases (PMSM)

The following figure shows the connection of the motor phases to the BaseUnit:

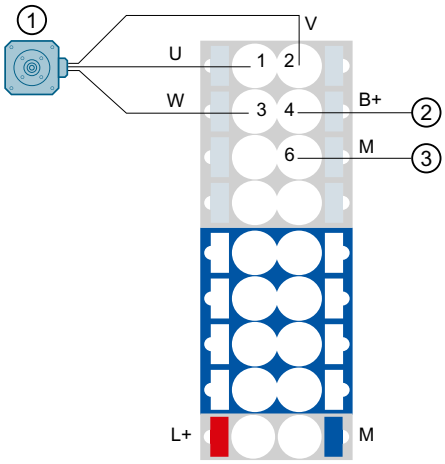

①	PMSM	②	Braking resistor
U, V, W	Motor phases	③	Negative connection for braking resistor

Figure 2-1543 Connecting the motor

NOTE

In addition to the shield connection on the ET 200SP, the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor side.

Pin assignment

Pin	Designation	Function
1	U	Motor phase U
2	V	Motor phase V
3	W	Motor phase W
4	B+	Braking resistor
6	M	Negative connection, e.g. for braking resistor

4.5 Connecting an encoder

4.5.1 Connecting an incremental encoders

You can connect motors with a 3-channel incremental encoder to the TM Drive. The A and B tracks and a reference track Z are required for evaluation. You connect all signals as "single-ended" or "differential".

The following figure shows the connection of an incremental encoder to the BaseUnit.

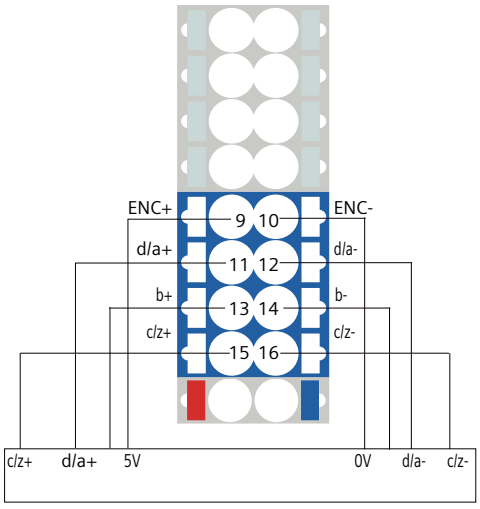

Figure 2-1544 Connection of incremental encoder with differential signals

Pin assignment of incremental encoder

Pin	Designation	Function
9	ENC+	Power supply encoder 5 V
10	ENC-	Power supply encoder, negative connection
11	a+	Differential encoder signal a+
12	a-	Differential encoder signal a-
13	b+	Differential encoder signal b+

Pin	Designation	Function
14	b-	Differential encoder signal b-
15	z+	Differential encoder signal z+
16	z-	Differential encoder signal z-

Table 2-1987 Power supply and signal processing conditions of the incremental encoder

Encoder property	Range/Value
TTL bipolar 5 V or differential	High 2 V .. 5.5 V
	Low -5.5 V ... -2 V
TTL unipolar 5 V	High 4 V .. 5.5 V
	Low 0 V .. 1 V
Encoder supply voltage	5 V ... 5.3 V
Maximum current consumption of the encoder	150 mA
Encoder output	Push Pull
Maximum signal frequency that can be processed (per signal A and B)*	500 kHz

*The quadrature interface results in a maximum step resolution of 2000 kHz.

NOTE

In addition to the shield connection on the ET 200SP, the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the encoder side.

4.5.2 Connecting IQ-Encoders

Motors from the SIMATIC MICRO-DRIVE Product Partner Program have an IQ encoder.

The following figure shows the connection of IQ encoders to the BaseUnit.

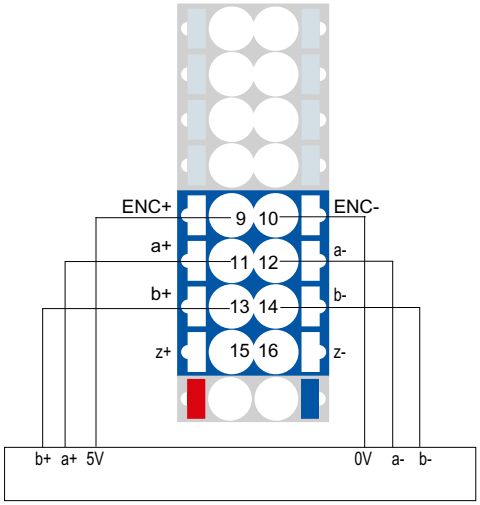

Figure 2-1545 IQ encoder connection with differential signals

Pin assignment of IQ encoder

Pin	Designation	Function
9	ENC+	Power supply encoder 5 V
10	ENC-	Power supply encoder, negative connection
11	a+	Differential encoder signal a+
12	a-	Differential encoder signal a-
13	b+	Differential encoder signal b+
14	b-	Differential encoder signal b-
15	z+	-
16	z-	-

Specifying the encoder interface

You connect the IQ encoder to the incremental encoder inputs like a two-channel standard incremental encoder. The polar wheel angle information is also transmitted via the interface (see Technical specifications (Page 140)).

NOTE

In addition to the shield connection on the ET 200SP, the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the encoder side.

4.5.3 Connecting safe torque off (Hardware STO)

Safe Torque Off (STO)

The safety function Hardware STO is activated via an exclusive safe input (STO+ and STO-). The TM Drive safely switches off the control of the motor. As long as Hardware STO is active, the motor does not generate any torque.

The safe state "Safe Torque Off" corresponds to the de-energized state at STO+/STO- (closed-circuit current principle).

The Hardware STO function meets the specification of a digital input according to EN 61131-2 Type 1 without limitation. In addition, this input has an increased leakage current resistance of 5 mA. That is, at leakage currents below 5 mA, the safe state is always selected.

WARNING

Danger to life due to coasting down of the drive with STO

The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

Wiring the Hardware STO

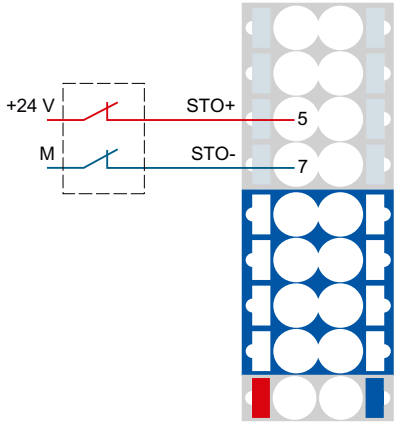

STO+ STO input 24 V

STO- STO input, negative connection

Figure 2-1546 Connection of Hardware STO

NOTE

Use different voltage supplies for the STO inputs and for the power supply.

Table 2-1988 Pin assignment

Pin	Designation	Function
5	STO+	STO input 24 V
7	STO-	STO input, negative connection

Route the hardware STO (STO+/STO-) cables separately from other cables, especially power cables.

Minimize the risk of crushing and short-circuits in ground connections by using appropriate routing.

Exclude premature aging of the cables due to continuous UV radiation.

4.5.4 Connecting the 24 V digital input

Connecting a 24 V digital input

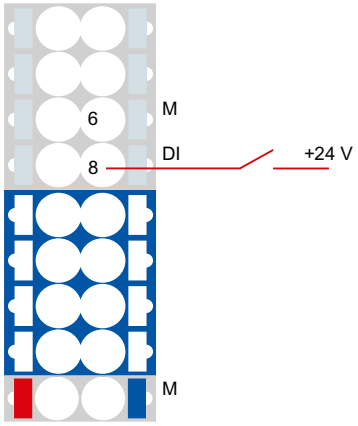

DI 24 V digital input

M Ground

Figure 2-1547 24 V digital input connection

Table 2-1989 Pin assignment

Pin	Designation	Function
6	M	Ground, internally connected to ground of 24 - 48 V power supply
8	DI	24 V digital input

4.6 Connecting an external braking resistor

External braking resistor

To ensure high dynamics of the drive due to fast acceleration and braking ramps, you need to connect a braking resistor to the TM Drive.

Recommendation: Use a braking resistor for power supplies with low intrinsic capacitance or an unregulated six-pulse bridge circuit (B6U).

A connected external braking resistor must be activated in the configuration software.

⚠ CAUTION

Risk of burns due to high surface temperature of the braking resistor

The braking resistor can become very hot. Touching the surface can cause severe burns.

- Mount the braking resistor so that it cannot be touched. In situations in which this is not possible, attach a clearly visible and understandable warning notice in areas at risk.

Wiring a non-Siemens external braking resistor

⚠ WARNING

Damage to braking resistor – Risk of fire!

If you use a non-Siemens external braking resistor, connect an overtemperature detection device to a digital input (e.g. a bimetallic switch that opens when the temperature is too high).

Implement fire prevention measures for the external braking resistor (e.g. fire protection housing, temperature fuse). The resistance of the externally connectable braking resistor must be ≥ 5 ohms.

Design the required power as a function of the braking energy to be converted.

Connection for external braking resistor

Table 2-1990 Connection of external braking resistor

Function	Maximum cable length	Cable type	Cable cross-section
Connection of external braking resistor	2 m	≥ 0.5 m shielded	Solid and stranded supply cable: AWG: 18 to 14 or 1.0 mm^2 to 2.5 mm^2

Wiring an external braking resistor

The figure below shows the connection of an external braking resistor as an example:

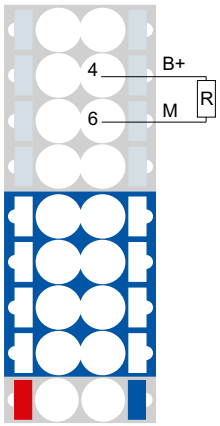

B+ Positive terminal of braking resistor

M Negative terminal of braking resistor

Figure 2-1548 Connection of external braking resistor

Pin assignment

Table 2-1991 Pin assignment: Wiring an external braking resistor

Pin	Designation	Function
4	B+	Connection of external braking resistor
6	M	

External braking resistor for potential group with multiple TM Drives

If you have connected multiple TM Drives to form a potential group, it may be sufficient to equip only one module with an external braking resistor.

Safety functions integrated in the drive 5

5.1 Basic safety information

5.1.1 General safety information

WARNING

Danger to life if the safety instructions and residual risks are not taken into consideration

The non-observance of the safety instructions and residual risks stated in the associated F-TM ServoDrive documentation can result in accidents causing severe injuries or death.

- Observe the safety instructions given in the F-TM ServoDrive documentation.
- Consider the residual risks for the risk evaluation.

WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings

As a result of incorrect or changed parameter settings, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameter assignment against unauthorized access.
- Respond to possible malfunctions by implementing suitable measures (e.g. EMERGENCY STOP or EMERGENCY OFF).

WARNING

Validity of safety features

The safety features of the product are guaranteed only for intended use within the intended ambient conditions (see section Technical specifications (Page 140)).

The safety features only apply when operating with a BaseUnit of the U0 type (6ES7193-6BP00-0DU0 or 6ES7193-6BP00-0BU0).

5.1.2 Warranty and liability for application examples

Application examples are non-binding and do not claim to be complete regarding configuration and equipment as well as all eventualities. Application examples do not represent customer-specific solutions. They are only intended to provide support for typical tasks.

As user, you are responsible for ensuring that the products described are used correctly. Application examples do not relieve you of the responsibility to use safe practices in application, installation, operation and maintenance.

5.1.3 Fundamental safety instructions for Safety Integrated

Additional safety instructions and residual risks are provided outside of this section at the relevant points of this system manual.

⚠ DANGER

Risk minimization through Safety Integrated

Safety Integrated can be used to minimize the risk associated with machines and plants. However, safe operation of the machine or system with Safety Integrated is only possible if the machine manufacturer:

- Knows and complies with this technical user documentation, including the documented constraints, safety instructions and residual risks
- Carefully constructs and configures the machine/plant and verifies it through a carefully implemented and documented acceptance test by qualified personnel
- Implements and validates all the measures required in accordance with the system/machine risk analysis by means of the programmed and configured Safety Integrated functions or by other means

The use of Safety Integrated does not replace the machine/plant risk assessment carried out by the machine manufacturer as required by the CE Machinery Directive.
In addition to using Safety Integrated functions, further risk reduction measures must be implemented.

⚠ WARNING

Danger to life as a result of undesirable motor movement when automatically restarting

An emergency stop must be performed according to Stop Category 0 (STO) (EN 60204-1). The emergency stop must be ensured by external measures.
It is not permissible that the motor automatically restarts after an Emergency Stop, as this represents danger to life as a result of the associated undesirable motor motion.
If individual safety functions are deactivated, an automatic restart is permitted under certain circumstances depending on the risk analysis (except when Emergency Stop is reset). An automatic start is possible when a protective door is closed, for example.

- Ensure that no automatic restart takes place in the indicated cases.

WARNING

Danger to life as a result of undesirable motor motion when the system powers up and the drives are activated after hardware and/or software is changed or replaced

After hardware and/or software components have been modified or replaced, or after drive parameters are changed or parameter backups are loaded, it is only permissible for the system to run up and the drives to be activated with the protective devices closed. Personnel shall not be present within the danger zone during this time.

- It may be necessary to carry out a partial or complete acceptance test or a simplified functional test after making certain changes or replacements.
- Before personnel may re-enter the hazardous area, all of the drives should be tested to ensure that they exhibit stable control behavior by briefly moving them in both the plus and minus directions (+/-).

5.1.4 Safety Integrated functions

This section gives you a quick insight into the functioning of the safety functions.

The description of the safety functions starts in each case with the definition in IEC/EN 61800-5-2 and simple examples of the use of the function.

The description of the functions is simplified as far as possible so that the essential properties and setting options are made clear.

Response time

You can find additional information on the response time of the listed safety functions in section Response times (Page 146).

Examples of safety devices and 3 F-TM ServoDrive

NOTE

The supply voltage for the STO inputs must be different from that of the power supply.

The following figure shows various safety devices that are connected to 3 F-TM ServoDrive.

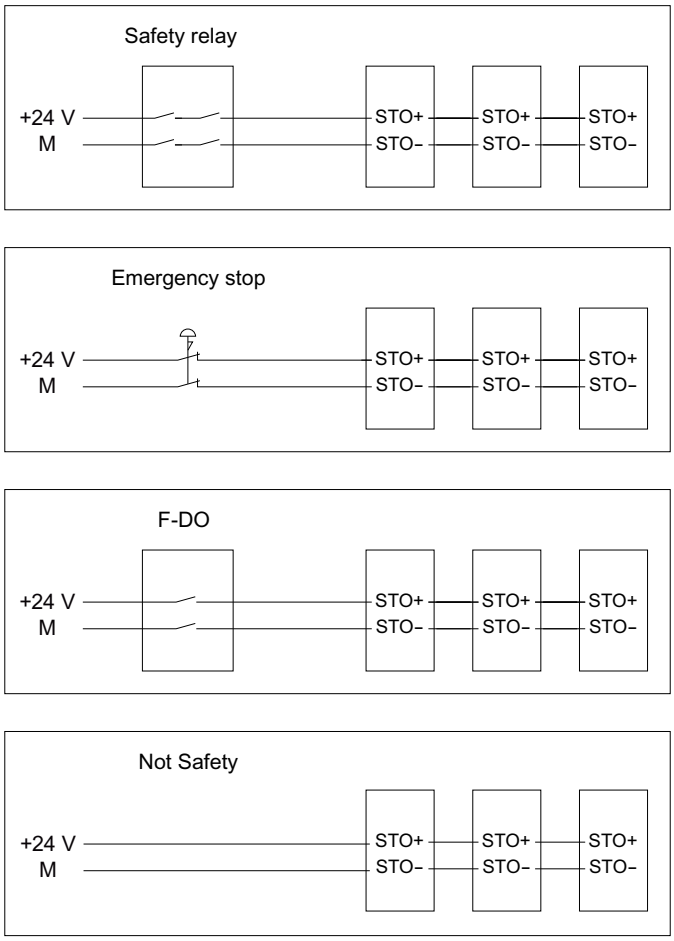

Figure 2-1549 Safety devices and 3 F-TM ServoDrive

NOTE

The F-TM ServoDrive does not support startup protection.

Measure:

Startup protection via additional safety relay or in higher-level controller, depending on the safety requirements.

Operating voltage range

Operate input STO+ as intended with 19.2 to 28.8 V DC for the active enable or lower 5 V DC for the disable.

Connect the input STO- for enabling or disabling the connection to ground.

5.1.4.1 Safe Torque Off (STO)

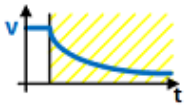

Safe Torque Off (STO) is a safety function that directly stops torque- or force-producing energy from being supplied to the motor. This function corresponds to Stop Category 0 according to EN 60204-1.

The F-TM ServoDrive complies with the definition of the STO function in IEC/EN 61800-5-2: "The STO function prevents torque-producing energy from being supplied to the motor."

If the motor is still rotating when STO is selected, the motor will coast to a standstill.

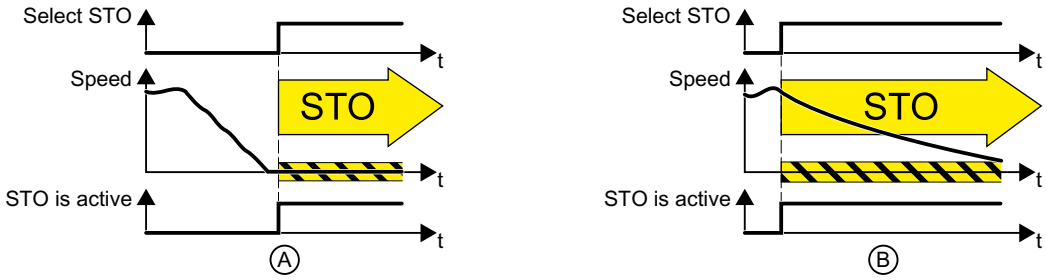

Figure 2-1550 Functioning of STO (A) when motor is at stopped and (B) when motor is rotating

Functional characteristics

WARNING

Danger to life due to coasting down of the drive with STO

The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

STO is a drive-specific function and must be wired individually for each drive.

The following applies when the "Safe Torque Off" function is selected:

- An unwanted startup of the motor cannot take place.
- The torque-producing energy supply to the motor is safely interrupted.
- An electrical isolation between the power unit and motor does not occur.

The stop function category 0 (selection of STO according to Safety Integrated) is only active when selected at the STO terminals. In order to meet the requirements of an EMERGENCY STOP in accordance with EN 60204-1, you need to ensure that the STO function at the STO terminals in the system can only be deselected by means of conscious manual operation. This prevents electrically driven machine components from restarting unintentionally.

Selection

The STO safety function is always enabled and cannot be disabled via parameter assignment.

You can select the STO function via the fail-safe digital input at STO+ and STO- terminals. The selection of the STO function is enabled directly as a response to safety messages (e.g. when a defect is detected in a monitoring channel).

Range of application

You can use the STO safety function without restrictions for a PMSM. A special encoder concept suitable for safety is not required.

Applications

Application areas are all machines or systems with moving axes (e.g. conveyor systems, handling systems).

The STO function can be used when the motor is already at a standstill. If the motor is in operation, the STO function causes the drive to coast down.

The STO function enables safe working when the protective door is open. A conventional Emergency Stop with electromechanical unlocking is not required. The converter remains connected to the supply system and has full diagnostics capability.

NOTE

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant. The STO function is suitable for implementing an EMERGENCY STOP, but not an EMERGENCY OFF.

Hardware STO

The F-TM ServoDrive internally monitors the fail-safe digital input at the STO+ and STO- terminals for discrepancies.

Discrepancy monitoring

Due to the design of the Hardware STO circuit, a discrepancy cannot occur at STO+ and STO- terminals. As long as the STO terminal is de-energized, STO is selected. The Hardware STO signal is read in internally via two channels.

To comply with the requirements for timely error detection from EN 61800-5-2, the switch-off signal paths of the end stage in both monitoring channels are also cyclically tested. Errors when testing the shutdown paths trigger STO. A manual forced checking procedure (test stop) for testing the shutdown paths of the F-TM ServoDrive is therefore not needed.

WARNING

Forced checking procedure

You should nevertheless examine its necessity for diagnosing the utilized sensors or for performing a test stop in the context of the overall system.

5.1.5 Overview of the Safety Integrated functions

Compared to standard drive functions, safety functions have an especially low error rate. Performance Level (PL) and Safety Integrity Level (SIL) of the corresponding standards are a measure of the error rate.

For this reason, safety functions are suitable for use and for risk reduction in safety-related applications. An application is safety-related when the risk analysis of the machine or plant has identified a particular risk potential in the application.

Safety Integrated means that the safety functions are integrated in the drive and can be executed without additional external components.

Conformity of Safety Integrated functions

The Safety Integrated functions comply with:

- Safety Integrity Level (SIL) 2 according to IEC 61508 Part 1-3
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

The standard IEC 61800-5-2, in which the Safety Integrated functions are defined, applies for the functional safety of variable-speed drives.

Function groups

The safety functions are divided into the following function groups for the F-TM ServoDrive:

- Safety Integrated stop function (hardware STO)

5.1.6 Supported safety functions

The supported safety functions are included in the standard scope of the F-TM ServoDrive and can be used without an additional license.

Stop functions

The stop functions do not pose any special requirements on the utilized encoder and do not need actual value acquisition. The stop functions include the following Safety Integrated functions:

- Safe Torque Off (STO)

  Safe Torque Off is a safety function for prevention of unexpected startup according to EN 60204-1. STO prevents torque-producing energy from being supplied to the motor and corresponds to Stop Category 0.

5.1.7 Examples of using the safety functions

Table 2-1992 Examples of using the safety functions

Safety function	Application examples	Possible solution
Safe Torque Off (STO)	It is only permissible to open a protective door if the motor torque has been switched off.	Activate STO in the F-TM ServoDrive via the STO inputs. The pulses are suppressed and the motor coasts to a standstill.
	A central Emergency Stop button ensures that multiple drives cannot start unintentionally.	Evaluate the emergency stop button in a central controller. Use a two-channel connection to the STO inputs on the F-TM ServoDrive.

5.1.8 Safety concept

The safety concept of the drive controller is based on a 2-channel system structure. Each channel has the possibility of bringing about the safe state, and the two channels monitor each other through a corresponding cross-comparison and cyclic diagnostics.

Safe state

The safe state of the system exists when the motor bridge is **de-energized**.

The safe state is reached in the following cases:

- Switch-off or failure of the external power supply to L+/M
- Missing enable signal at STO+ and STO-
- Detection of an internal HW fault

Safe state of Safety Integrated functions

The safe state of the STO input terminal is reached when at least one of the two STO supply terminals is disconnected from the energy supply.

NOTE

The safe state means the absence of torque in the sense of functional safety, but not necessarily the absence of voltage in the sense of electrical safety.

5.2 Acceptance of the safety functions

Responsibilities

The machine manufacturer is responsible for the performance and documentation of the acceptance test. In this section, you will find a recommendation for how to perform and document the acceptance tests for the individual safety functions.

NOTE

The performance and documentation of the acceptance tests are plant-specific and must be adapted appropriately and performed.

5.2.1 General information on acceptance

Why is acceptance required?

The EC Machinery Directive and ISO 13849-1 stipulate:

- You must test safety-relevant functions and machine parts after commissioning.

  See "Acceptance test" below in this section.

  For the F-TM ServoDrive Safety Integrated functions (SI functions), this means:
  The acceptance test is used to check the functionality of the safety functions used in the drive. Correct implementation of the defined safety functions is examined for this.
- You must create an "acceptance report" that describes the test results.

  See "Documentation" further on in this section.

NOTE

Purpose of the acceptance test

The measured values (e.g. speed, time) and the system behavior identified (e.g. initiation of a specific stop) serve to check the plausibility of the configured safety functions. The objective of an acceptance test is to identify potential configuration errors and/or to document the correct function of the configuration. The measured values are typical values (not worst case values). They represent the behavior of the machine at the time of measurement. These measurements cannot serve as the basis for deriving real values (e.g. maximum values for over-travel distances).

Requirements

The requirements for an acceptance test (configuration test) for safety functions of electric drives come from EN 61800-5-2, section 7.1, paragraph f). The acceptance test is called "configuration test" in this standard.

- Description of the application including an image
- Description of the safety-related components (including software versions) that are used in the application
- List of the utilized safety functions of the PDS(SR) [Power Drive System(Safety Related)]
- Results of all tests of these safety functions using the specified test procedure

Necessity of an acceptance test

An acceptance test is required (again) when the Safety Integrated functionality of a machine is commissioned or changed. The acceptance tests must be performed for each individual drive. Safety-related function extensions, transfer of commissioning to other series machines, hardware changes, software upgrades and the like may allow a partial performance test to be performed.

The conditions determining the necessity and recommendations for the test depth required in each case are summarized below.

Requirements for the acceptance test

- The machine is correctly wired.
- All safety equipment (e.g. protective door monitoring devices, light barriers, emergency limit switches) are connected and ready for operation.
- The commissioning of open-loop and closed-loop control must be complete; otherwise, the over-travel distance may be changed due to a changed dynamic response of the drive control, for example. This includes:
  - Settings of the setpoint channel
  - Position control in the higher-level CPU
  - Drive control

Acceptance test

The acceptance test comprises two parts:

- You test whether the safety functions are set correctly in the drive:
  - Does the configured safety function sufficiently reduce the residual risk at the machine/plant?
  - Do the set interfaces, timers and monitoring functions match the configuration of the machine?
- You test whether the safety-relevant functions in the machine or system function correctly.

  This part of the acceptance test goes beyond the acceptance test of the drive:
  - Is all safety equipment, such as protective door monitoring, light barriers and emergency limit switches, connected and ready for operation?
  - Do the drive settings match the configured safety-relevant function in the machine?

Documentation

The documentation consists of the following parts:

- Description of safety-relevant components and functions of the machine or system, including the program versions.
- Report of the acceptance test results.
- Report of the safety function wiring.
- The documentation must be signed off by the person who performed the acceptance test.

Authorized persons

Persons authorized by the **machine manufacturer** who, on account of their technical training and knowledge of the safety-relevant functions, can carry out the acceptance in an appropriate manner are entitled to perform the acceptance.

⚠ WARNING

Unwanted movement due to faulty wiring

Incorrect wiring for Safety Integrated functions can cause unwanted motion resulting in severe injury or death.

- For Safety Integrated functions, always carry out an acceptance test for the affected function after changing the wiring.
- Record the results of the acceptance test in an acceptance report.

WARNING

Unsafe operating states due to manipulation of the hardware configuration after the acceptance test

Changes to the wiring of the Safety Integrated functions after an acceptance test can cause unwanted motion resulting in severe injury or death.

- To prevent access to your machines and systems by unauthorized persons, implement access restrictions and take the precautions described in the security instructions in the preface.
- To prevent improper wiring of the Safety Integrated functions, take the precautions described in this manual.
- Review the safety change tracking of the drive at regular intervals. Make certain that no changes have been made to the wiring after the last successfully completed acceptance test.
- If intentional changes have been made, repeat the acceptance test for the Safety Integrated functions affected. The purpose of the acceptance test is to ensure and document safe operation of the system. Correct any unintentional changes back to the original values and repeat the acceptance test.

5.2.2 Content of an acceptance test

Documentation

Documentation of the machine including safety functions

- Machine description (with overview image)
- Information on controller (if available)
- Function table:
  - Active monitoring functions depending on operating mode and protective door
  - Additional sensors with protection functions
  - The table is an object or result of the configuration work.
- SI functions for each drive
- Information on the safety equipment

Function test of diagnostic/safety functions

Value-based function check of the SI functions used. You can use trace records of individual parameters, for example, to do this.

- Acceptance test for Safe Torque Off (STO)

Report completion

Reporting of the tested state of commissioning and countersignatures

- Control of the STO function as enable signal of the STO+ and STO- terminals
- Enable to control the motor is removed as soon as a connection (STO+ or STO-) is not connected
- Counter signature

5.2.3 Documentation of acceptance

Machine or system description

Describe your machine or plant using the following table. Insert a diagram of the plant, for example.

Table 2-1993 Machine description and overview image

Designation	
Type	
Serial number	
Manufacturer	
End customer	
Overview image of the machine	

Drive data

In the following table, enter information on the drive components used and add additional components as required.

Table 2-1994 Hardware components

Component	Designation	Article number	Hardware version	Type
Drive controller				
Motor				
Encoders				
Brake module				
Gearbox				

Utilized Safety Integrated functions

In the following table, describe the use of the Safety Integrated drive functions in relation to your plant or machine.

Table 2-1995 Utilized SI functions of the drive

SI function	Status/Description
Safe Torque Off (STO)	

5.2.4 Acceptance test for Safe Torque Off (STO)

Procedure

Test each configured activation of the STO function.

This test consists of the following steps:

Table 2-1996 Acceptance test for "Safe Torque Off" (STO) function

No.	Description	Status
1.	**Drive is ready for operation**	
	• No faults	
	• The enable signal is present (STO is deselected).	

No.	Description		Status
2.	**Switch on motor**		
	2.1	Set speed setpoint ≠ 0	
	2.2	Switch on motor (ON command)	
	2.3	Check that the intended motor is rotating	
3.	**Select STO**		
	3.1	Selecting STO means interrupting the wire, supplying the STO from STO+ and short-circuiting STO- (if the source is current-limited)	
	3.2	Check the following points:	
		• Motor coasts down to a standstill	
		Message is implemented, but is not safety-relevant	
4.	**Deselect STO**		
	4.1	Deselection of STO (HW STO terminal)	
	4.2	Check the following points:	
		• Enable is active, motor must allow switch-on	

5.2.5 Report completion

SI change tracking (Safety logbook)

Ensure that changes to the safety function (wiring) can be traced.

Countersignatures

Commissioning engineer

Professional execution of the above-stated tests and checks is confirmed.

Table 2-1997 Report completion - Countersignature of commissioning engineer

Date	Name	Company/Department	Signature

Machine manufacturer

The correctness of the parameter assignment documented above is confirmed.

Table 2-1998 Report completion - Countersignature of machine manufacturer

Date	Name	Company/Department	Signature

5.3 System features

5.3.1 Current information

Important note for maintaining the operational safety of your system:

NOTICE
Operational safety risk from unwanted motions Systems with safety-oriented variants are subject to special operational safety requirements on the part of the operator. If information becomes known in the course of product monitoring indicating insufficient product safety, this information will be disclosed in various ways. For this reason, our website provides information on product developments and features that are (or could be) relevant to operation of systems from a safety perspective.

5.3.2 Certifications

The safety functions of the F-TM ServoDrive drive system meet the following requirements:

- Safety Integrity Level SIL 2 according to IEC 61508 Part 1-3 and IEC 61800-5-2
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

In addition, the safety functions of the drive are generally certified by independent institutes. A list of the components that are currently already certified in each case is available on request from your Siemens branch.

5.3.3 Failure probability of the safety functions

The probability of failure of safety functions must be specified in the form of a PFH value (Probability of Failure per Hour) according to DIN EN 61800-5-2 and ISO 13849-1. The PFH value of a safety function depends on the safety concept of the drive device, its hardware configuration and the PFH values of the other components used for the safety function. For the F-TM ServoDrive drive system, PFH values are provided as a function of the hardware configuration.

NOTE

PFH values

The PFH value of the integrated safety function STO is 30 FIT (10^{-9}/h) and refers to a service life of 20 years.

The underlying assumption for the calculation is an average operating temperature of 40°C, an average repair time of 8 hours and an average time to recovery of 8 hours. A proof test is not necessary.

5.3.4 Response times

The response time is the time between the detection of an input signal and the change of a linked output signal. Below you will find information on the response times of the F-TM ServoDrive drive system.

NOTE

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

The drive system is the component that provides the safety functions. The description "error-free drive system" means that the component providing the safety functions itself has no defect:

- Maximum response time in error-free drive system

  When the enable is removed at the STO+ or STO- terminals, the maximum response time in an error-free drive system is guaranteed.

Stop function (via terminals)

The following table specifies the response times for the indicated stop functions from the time of activation until occurrence of the response.

Function	Maximum response time
STOP_STO	Max. 20 ms

5.4 Safety Integrated

Important notes on the Safety Integrated system are provided in this section.

Diagnostics hardware fault

If an internally diagnosed hardware fault occurs, you can only reset the module by restarting it. Nevertheless, the replacement of the F-TM ServoDrive is strongly recommended. Unwanted activation of the safety function can be an indication of a hardware fault.

Wiring the F-TM ServoDrive

For information on how to perform the electrical wiring for the F-TM ServoDrive, refer to section Wiring (Page 29)

STO inputs

The STO inputs are described in the section Connecting safe torque off (Hardware STO) (Page 38).

5.5 EMERGENCY OFF and EMERGENCY STOP

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant.

EMERGENCY OFF Risk of electric shock 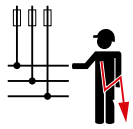	**EMERGENCY STOP** Risk of unexpected movement 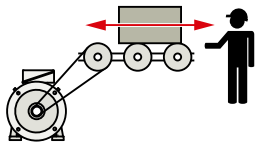

Table 2-1999 Measures and solutions

Command	EMERGENCY OFF	EMERGENCY STOP
Measure to minimize risk	**Safe switch off** Switching off the electric power supply for the installation, either completely or partially.	**Safely stop and safely prevent restarting** Stopping or preventing the dangerous movement
Classic solution	Switch off the power supply. 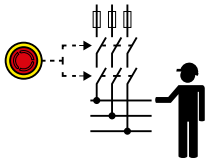	Switch off the drive power supply. 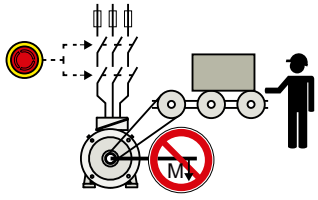
Solution with the STO safety function integrated in the drive	STO is not suitable for safely switching off a voltage.	Select STO. 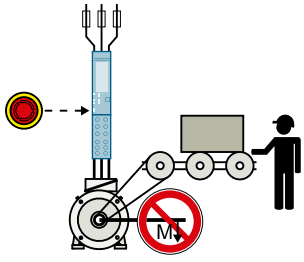 You may also switch off the power supply of the drive controller. However, switching off the voltage is not required as a risk-reduction measure.

Configuring 6

Configuration and parameter assignment

STEP 7 (TIA Portal) is available for configuring an ET 200SP TM Drive.

You can perform the following tasks, for example, with STEP 7 (TIA Portal):

- You configure the TM Drive (insert into the project and configure input addresses)
- You specify the desired hardware parameters for operation of the TM Drive.

Requirements

Hardware

- Supported interface modules: See Properties (Page 25)
- You have completed installation and wiring of the hardware. Take the potential group into account, see section Pin assignment (Page 29).
- You have connected the PG/PC via the PROFINET interface of the CPU.

Software

- You have installed the HSP0311. You can find the support packages for the hardware catalog in the TIA Portal (HSP) on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).
- You have installed the HSP0311.

As soon as the configuration and hardware parameter assignment have been successfully completed, you can create your user program and commission the drive.

⚠ WARNING

Safety Integrated

As soon as a safety program has been created, you must perform a complete function test based on your automation task.

For acceptance of the system, you must use the safety summary created according to the above manual.

Configuring a TM Drive (minimum configuration)

To configure a TM Drive, follow these steps:

1. Create a new project.
2. Add a CPU S7-1200 or S7-1500 as a new device.
3. Add a PROFINET interface module to the project under "Devices & networks" from the ET200SP system, e.g. IM 155-6PN ST.

4. Assign the inserted IO device to the configured IO controller.
5. Switch to the device view of the interface module.
6. Add the TM Drive module from the hardware catalog to the IO device.
7. Add a server module.

6.1 Communication telegrams

Selection of a communication telegram

The selection of a communication telegram determines the process data of the drive that will be transmitted between the drive and CPU.

The following table shows the supported telegram types for the drive and sensor assignment.

Table 2-2000 Supported communication telegrams

Supported PROFIdrive telegrams	Brief description	User data
Standard telegram 1 PZD-2/2	Speed setpoint 16 bits, without sensor	• Control word STW1, status word ZSW1 • Speed setpoint 16 bits (NSET), actual speed value 16 bits (NACT)
Standard telegram 2 PZD-4/4	Speed setpoint 32 bits, without position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT)
Standard telegram 3 PZD-9/5	Speed setpoint, 32 bits with one position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT) • Encoder control word 1 (Gx_STW), encoder status word 1 (Gx_ZSW) • Actual encoder position value 1 (Gx_XIST1, Gx_XIST2)
Siemens telegram 102 PZD-10/6	Speed setpoint 32 bits with one position encoder and torque reduction	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT) • Dynamic torque reduction (MOMRED) • Encoder control word 1 (Gx_STW), encoder status word 1 (Gx_ZSW) • Actual encoder position value 1 (Gx_XIST1, Gx_XIST2)
Extension word	Status bits of the inputs	• Bit 0: DI • Bit 1: STO

A PZD (process data word) corresponds to a 16-bit word.

Selecting a telegram in STEP 7

To select the telegram for the TM Drive in STEP 7, follow these steps:

1. Select the TM Drive in the device view.
2. Navigate to the properties of the module in the "General" tab under "TM Drive" > "Basic parameters".
3. Under "Telegram" in the drop-down list, select the desired telegram, e.g. "Standard telegram 3 (PZD length 9/5 words).
4. If needed, activate the extension word by selecting the "Telegram extension active" check box.

6.2 Structure of the encoder position actual value

Starting with standard telegram 3, the encoder position actual value is transmitted as a 32-bit value via the user data Gx_XIST1 and Gx_XIST2. These values provide the current **incremental and, for absolute encoders, also the absolute actual position** of the measuring system and are read cyclically by the "Positioning axis" technology object, for example, and processed accordingly (see also section 8.3 (Page 128)). The layout of the encoder position actual value mainly depends on the following factors:

- Type of the encoder
- Resolution of the encoder

Regardless of the type of encoder, the position actual value is structured as follows:

- G1_XIST1 is aligned right
- After it is switched on, a 32-bit counter is loaded with the current position value. Depending on the direction of rotation, this value is then only incremented or decremented. After reaching the max. position value, it starts again at 0.
- Shift factor for G1_XIST1 and G1_XIST2 is 2

NOTE

Dependence on the configured encoder resolution

The single-turn value ("increments / revolution") in Gx_XIST1 is directly dependent on the configured encoder resolution (p408).

6.2.1 Incremental encoder

If you are using a motor with an incremental encoder and you have configured this for the type of motor encoder (p404), then the structure of the encoder position actual value is as follows:

Table 2-2001 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution (p408). You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 137).
	Bits in Gx_XIST1 "Offset factor"	2
	Encoder type	Rotary incremental

Example of an incremental encoder with 4096 "steps per revolution", this corresponds to 1024 "increments per revolution" with a fine resolution of 2:

Table 2-2002 Structure G1_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Singleturn value (singleturn "steps per revolution")

F: Fine resolution

Table 2-2003 Structure G1_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

6.2.2 IQ encoder

If you are using a motor from the Siemens Product Partner Program with IQ encoder (incremental encoder) and have configured this accordingly for the type of motor encoder (p404), then the structure of the encoder position actual value is as follows:

Table 2-2004 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Default: 100 Depends on the parameter assignment of the encoder resolution (p408). You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 137).

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Bits in Gx_XIST1 "Offset factor"	2
	Encoder type	Rotary incremental

Table 2-2005 Structure G1_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Single-turn value (single-turn "steps per revolution")
F: Fine resolution

Table 2-2006 Structure G1_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

Commissioning the 7

The engineering of the TM Drive drive controller is integrated in STEP 7 (TIA Portal). You install it with the Hardware Support Package HSP0311. The graphic user interface supports you in the configuration, parameter assignment and commissioning of the drive functions of the TM Drive.

Parameter assignment is also possible via data sets (see appendix Data sets (Page 149)).

In this section you will find information on various topics including:

- Check before powering on for the first time
- Commissioning a TM Drive

CAUTION

Failure to comply with the instructions for Safety Integrated poses a risk of injury

Failure to comply with the instructions may result in serious injuries. Carefully read through the safety instructions in section Safety functions integrated in the drive (Page 42) before commissioning and before operation.

WARNING

Personal injury and property damage from the collapse of a suspended axis

If the drive system is used as suspended axis, the axis will fall down if the positive and negative poles of the power supply are interchanged during connection. An unexpected collapse of a suspended axis can result in personal injury and property damage.

Before commissioning, you need to ensure that a cross brace is fitted to hold the suspended axis in place and prevent it from collapsing unexpectedly. Also ensure that the power supply is connected properly.

WARNING

Personal injury and property damage from the collapse of a suspended axis

An unexpected collapse of a suspended axis can result in personal injury and property damage.

- When using the STO function in conjunction with suspended axes, the axis may fall down unexpectedly and cause property damage and personal injury.

NOTE

Performing tests

You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant.

Also allow for any possible foreseeable errors in the tests. This avoids endangering persons or equipment during operation.

7.1 Basics

7.1.1 Engineering

You perform parameter assignment as well as diagnostics of a TM Drive with a PG/PC or notebook (commissioning device) using the TIA Portal (Hardware Support Package HSP0311 needed).

The settings can be found in STEP 7 in the device navigation under "Ungrouped devices" > "<Name of the interface module>" > "<Name of the TM Drive>".

Overview

This drive engineering is divided into the following areas:

- Online & diagnostics
- Parameters
- Device configuration

"Device configuration" area

Contents in the "Device configuration" area of the TM Drive engineering.

- Potential group
- Basic parameters
  Define telegram, activate telegram extension
- I/O addresses

"Online & diagnostics" area

Contents in the "Online & diagnostics" area of the TM Drive engineering.

Diagnostics

- General (module information):

  Order number, firmware and hardware version, I&M data
- Diagnostic status (display of status information)
- Active messages:

  Pending faults and alarms
- Drive diagnostics
  Status bits, operating values, encoders, temperatures, inputs

Functions

- Firmware update

"Parameters" area

Contents in the "Parameters" area of the TM Drive TM Engineering.

- Drive:

  Drive data set, General settings, Motor, Motor gear, Thermal model, DC link voltage, Brake module
- Setpoint channel:

  Reference values, application limits, ramp-function generator
- Open-loop/closed-loop control:

  Control type, controller settings, speed controller, current controller
- Messages/monitoring

  Motor (thermal motor type), power output stage (utilization)

NOTE

The F-TM ServoDrive is not able to provide a holding torque for locking the drive.

In the application, especially note that abrupt movement of the axis can occur when lifting and lowering loads.

"Commissioning" area

Contents in the "Commissioning" area of the TM Drive TM Engineering.

- Configuration:

  Link to the parameter dialog
- Identification:

  Identification mode

  Encoder and pole position identification

  Encoder values
- Tuning:

  Calculate speed/current controller values

  Tuning the speed controller

  Transfer controller values to drive parameters

See also

PMSM drive parameters (Page 78)

7.1.2 Drive parameters

Parameter tooltips

In STEP 7 engineering of the TM Drive, all displayed drive parameters are linked with tooltips. You will find detailed information on the parameter in the tooltips, e.g. parameter name, properties, factory setting, value range, descriptions, notes and dependencies.

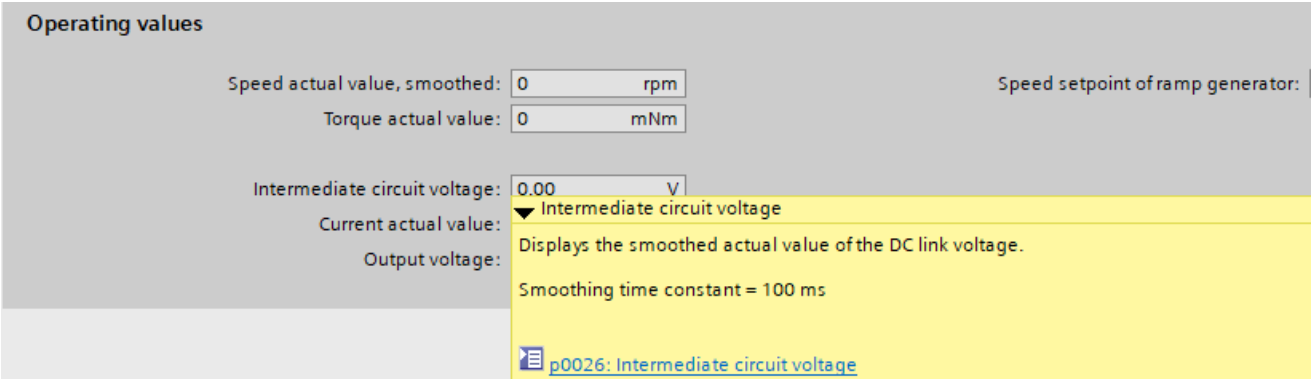

Figure 2-1551 DC link voltage tooltip

Changing a parameter

You can directly change the values of the writable adjustable parameters (p-parameters) in STEP 7.

You have the following options for this:

- You overwrite the current parameter value with the new value.

  Or

- You select a value via the drop-down list.

Invalid values are rejected.

NOTE

P-parameters cannot be changed online while the drive is in operation. In this case, the corresponding entry field is automatically disabled.

The following overview shows the display of an entry field, depending on the context and the properties of the drive parameter:

1,0000 Nm	Project (offline)	Parameter value can be changed and stored in the project.
48,0 V	Project (offline)	The parameter value is write-protected.
24,0 V	Project (online)	Parameter value is write-protected or disabled due to the drive status.

Parameter symbols and operator controls

The following overview explains additional symbols and operator controls in the engineering of the TM Drive:

	Drive value (online) could not be determined
	Bit parameter active (1-signal)
	Bit parameter inactive (0-signal)
	Binding values to be set by the commissioning engineer

Automatic check of the configured drive parameters

The configured parameters are checked both in STEP 7 and in the drive in order to detect incorrect parameter assignments and possible functional restrictions even before commissioning.

Both warning and error messages are output. In STEP 7, you obtain additional information and corrective measures about the respective message.

The causes of errors in the drive parameterization that prevent the drive from operating are listed below.

Parameter group	Possible causes of error
Motor	Electrical time constants of the connected motor are too low
	Torque constant is not consistent with other motor parameters
Encoders	Motor/encoder combination is not permitted
Speed/current controller	Controller parameters have not yet been set or are not permissible
DC link voltage	DC link volage limits are prohibited
Brake module	Brake chopper settings are not permitted

Loading drive parameters

You can synchronize all p-parameter values of your project (offline) using the "Download to device" function.

Constraints

- When you load parameters into the device, a rotating drive automatically stops.
- After the parameters are loaded, the drive does not restart automatically. You must activate the drive once again using a new drive command.
- If you send an invalid parameter to the TM Drive, the module remains in parameter assignment mode. The drive cannot be activated until valid parameters are loaded.

"Download to device" function for drive parameters

You can use the "Download to device" function to transfer parameter values from your project (offline) to the drive (online).

Procedure

1. Select the drive in the project tree.
2. Click on "Download to device" in the menu bar.

Or

1. Select "Download to device" > "Software" in the shortcut menu.

You have transferred the current parameter values of your project to the drive.

Loading drive parameters

You can synchronize all p-parameter values of your project (offline) using the "Download to device" function.

Conditions

- When you load parameters into the device, a rotating drive automatically stops.
- After the parameters are loaded, the drive does not restart automatically. You need to activate the drive via a new drive command.
- If you send an invalid parameter to the F-TM ServoDrive, the module remains in parameter assignment mode. The drive cannot be activated until valid parameters are loaded.

"Download to device" function for drive parameters

You can use the "Download to device" function to transfer parameter values from your project (offline) to the drive (online).

Procedure

1. Select the drive in the project tree.
2. Click on "Download to device" in the menu bar.

Or

1. Select "Download to device" > "Software" in the shortcut menu.

You have transferred the current parameter values of your project to the drive.

7.1.3 Calling help information

To obtain information on parameters and alarms (messages) of the drive, open the information system via "Help" > "Show help" and search for the article number of the product.

You can also directly open the information system for a parameter or a message. To do so, click the online help link in the tooltip of a parameter or message .

7.2 Requirements for the commissioning

Requirements

- The TM Drive was installed according to the information in the following sections:
  - Wiring (Page 29)
  - Configuring (Page 60)
- The motor is installed in the drive train to be operated in accordance with the plant/device construction planning.

NOTE

Additional information concerning the requirements

You can find additional information relating to technology objects and motion control in the online help of STEP 7 under "Using technology functions" > "Motion Control".

Before powering on for the first time

Before the first power-on, check the installation and the wiring of the TM Drive.

Questions for the check

The following questions provide guidance for checking your TM Drive in the form of a checklist.

Racks

- Is the mounting rail securely mounted to the wall, in the frame or in the cabinet?
- Are the cable ducts correctly installed?
- Have the minimum clearances been observed?

Grounding and chassis concept

- Is the mounting rail connected to the protective conductor?
- Is the connection between the ground reference and ground properly established for the mounting rail?
- Are the required equipotential bonding cables connected with low impedance to the affected plant units?

Module installation and wiring

- Is the TM Drive plugged in / installed and firmly connected or screwed in according to the assembly plan and the configuration with STEP 7?
- Are all connectors wired according to the circuit diagram?
- Is the PROFINET connection to the CPU and the engineering system of the STEP 7 (TIA Portal) connected?
- Is the input for Hardware STO (STO+/STO-) connected?
- Are the cables (motor connection cable, encoder cable) properly connected between the F-TM ServoDrive and the motor?
- Is the digital input connected?
- Was an external braking resistor optionally connected to the F-TM ServoDrive?
- Are the cables from the hardware STO (STO+/STO-) separated from the other cables, in particular from power cables?
- Have you minimized crushing hazards and short-circuits against ground connections by appropriate routing?
- Are the cables fully protected against premature aging due to continuous UV radiation?

Power supply

- Are all power supplies switched off?
- Is the power cable connector correctly wired?
- Has the connection to line voltage been made?

7.3 Procedure for commissioning the ET 200SP TM Drive

Procedure for commissioning with STEP 7

Commissioning is performed according to the steps listed below. The individual commissioning steps are optional and are to be performed as required. We recommend the following procedure for the first commissioning of a TM Drive.

Table 2-2007 Commissioning procedure

Step	Procedure	Comments	See section ...
1	Configure drive data set	Use one of the following options in the "Import drive data set" dialog under "Parameters > Drive": • Select pre-configured drive data set from list • Import drive data from file system	Drive data sets (Page 73)
2	Define setpoint channel	Under "Setpoint channel" you configure the following: • Reference values • Application limits • Ramp-function generator	Setpoint channel (Page 88)

Step	Procedure	Comments	See section ...
3	Set control/closed-loop control	Have the controller parameters automatically calculated using the "Speed/current controller settings" comfort function.	Speed control (cascade) (Page 94)
4	Configure DC link voltage monitoring and optionally the brake module	• Define limits for the DC link voltage • Brake chopper settings • Motor holding brake settings	DC link voltage monitoring (Page 106)
5	Configure messages/monitoring	• Define warning thresholds for thermal monitoring	Messages/monitoring (Page 112)
6	Optional: Depending on motor type and encoder, determine commutation angle offset and encoder values	• Perform automatic encoder identification in commissioning under "Encoder identification".	Setting the commutation angle offset and pole position identification (Page 82)
7	Optional: Perform automatic controlled system detection	• Automatic controlled system detection can be performed for setting the current and speed controller in the commissioning under "Controlled system detection".	Automatic controlled system detection
8	Optional: Perform online optimization	• Tuning the speed controller	Section Manual controller tuning Speed controller (cascade)

7.4 Drive data sets

Introduction

So that you can optimally handle the requirements of drive technology, the TM Drive drive system is compatible with motors (Dunkermotoren, ebm-papst) and connecting cables (Harting, KnorrTec) of proven product partners of Siemens. This allows you to optimally combine suitable products from proven product partners for your individual application.

You can find more information about the Siemens Product Partner Program in the Internet (https://new.siemens.com/global/en/products/drives/sinamics/servo-drive-system-simatic-micro-drive.html).

It is possible to connect motors from third-party motor manufacturers, provided that they meet the required conditions regarding motor, encoder system, connection system, electrical safety, EMC, etc., as described in this manual.

Drive data record

The motor or drive configuration of the TM Drive drive system is configured using a drive data set (DDS). A drive data record contains the settings and information for the following drive components:

- Motor
- Motor gear
- Thermal motor model

NOTE

The description "drive" means the combination of motor, encoder and additional built-on accessories such as a gearbox and holding brake.

Motor

You can find the settings for the motor in the "Parameters" > "Drive" > "Motor" area.

The TM Drive system supports PMSM. You specify important basic data and reference data of the motor.

Observe the information and notes in the help or in the tooltips of the individual parameters.

You can also find detailed information and descriptions for the drive parameters in the product information Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

Motor encoder

The motor encoder is used for the closed-loop speed control of the drive. The encoder values are transferred to the CPU in the PROFIdrive telegram of the TM Drive, independent of the encoder type.

The motor encoder (p0404) can be selected based on the motor type (p0300). The following combinations are available:

Motor type: PMSM motor

- (1) Incremental encoder (A, B, Z track)
- (5) IQ encoder (A, B track)

(1) Incremental encoder (A, B, Z track)

When selecting encoder type (1) incremental encoder, a 3-channel encoder with Z-track (often also called I-track) can be connected as an index track to identify the pole position.

(5) IQ encoder

If you are using a motor with IQ encoder, you must select the encoder type IQ encoder.

Thermal model

The motor can be protected from thermal overload. Take section Messages/monitoring (Page 112) into consideration for this.

You define the thermal properties of the motor in the "Parameters" > "Drive" > "Thermal model" area.

7.4.1 Using the drive data set

To configure a drive, you have the following options:

- Download preconfigured drive data sets as a file for selected motors from Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/25460).
- Create a user-defined drive data record and configure your motor manually.

NOTE

In TM Drive engineering, the drive parameters can only be edited in the "Parameters" > "Drive" area if you are using a user-defined drive data record.

NOTICE

After a change of the drive data record, you must adapt or optimize the parameters for the current and speed controllers, if necessary.

See section Speed control (cascade) (Page 94).

7.4.2 Using preconfigured drive data sets

You have the option of using preconfigured drive data sets for configuring your motor. You can obtain preconfigured drive data sets for selected motors from Siemens Industry Online Support or product partners.

Installing the drive data record

Pre-configured drive data sets are provided as a file (tms *.mpk) and must be installed in STEP 7 engineering. A drive data record file can contain the configuration of one or more motors.

Expand the list of drives by installing new drive data sets from the file system:

1. Open "Parameters" > "Drive" in the context of the drive.
2. Start the configuration wizard with the "Configure drive data record..." button in the "Drive data record" area.
3. Select the "Select drive from list" option.

4. Click "Install the drive data record" and select one or more drive data record files that you want to install.
5. Confirm the disclaimer by clicking on "I agree".
   If you do not agree to the disclaimer, close the dialog with "Cancel". In this case, no drive data record file will be installed.

You have installed a drive data record and can now use it.

NOTE

An installed drive data record is installed locally on the PG/PC only for the current STEP 7 version. To open the local installation folder, click the "Locally installed drives" link in the "Configure drive data record" wizard.

Using a preconfigured drive data record

You can search for the desired drive in the list of all locally installed drives.

1. Open "Parameters" > "Drive" in the context of the drive.
2. Start the configuration wizard with the "Configure drive data record..." button in the "Drive data record" area.
3. Select the "Select drive from list" option.
4. Select the desired drive from the list under "Search here for drive or enter filter".
5. The selected drive data record is displayed in the report area and you can check the data.
6. Accept the configuration with "Yes".

You have selected and set up a preconfigured drive data record.

NOTE

You can pass on a saved engineering project with preconfigured drive data record or use it on a different PG/PC on which the utilized drive is not installed. In this case, no optional additional information on the drive is displayed, e.g. manufacturer or order number. This is displayed as soon as you have installed the utilized drive.

7.4.3 Drive data export / import

In addition to the pre-defined drive data sets, custom drive data sets can also be exported and imported.

The standard CSV format with ',' (comma) as column separator including a line header is used.

The data is stored according to the file header and also read in again on the basis of this line.

The formatting of decimal numbers is region-independent using a '.' (dot) as the decimal separator.

For negative values, the value must be preceded by a '-' (minus).

UTF-8 is defined as the character coding.

The header line is defined as follows:

##PNU(mandatory)##,##name##,##value(mandatory)##,##unit##,##dataType##,
##group##,##ECLASS number##

- Motor
- Motor gear
- Encoders
- Thermal model
- Motor holding brake

All parameters contained in the CSV file are included in an import. The CSV file can be customized and, for example, unused parameters can be removed. For example, only one parameter can be imported.

The parameters are assigned via the PNU, where the value must be present. Name, unit, data type and ECLASS number are used for better readability and are ignored during import.

Quotation marks and spaces are hidden during import, which is why no further commas are supported except for column separation.

Export drive data

The existing drive parameter assignments can be exported and saved as a file (*.csv) from STEP 7 Engineering.

1. Open "Parameters" > "Drive".
2. Start the export via the "Export drive data set..." button in the "Drive data set" area.
3. In the "Save" dialog, select a folder and the file name and confirm with "Save".

Import drive data

The drive parameter assignment can be imported as a file (*.csv) in STEP 7 Engineering. A drive data set may contain all or part of the parameters supported by the TM Drive used.

NOTE

Importing the drive parameter assignments overwrites all parameters with the values contained in the csv file.
Parameters not contained in the drive data set are not changed and retain their value.
The "Undo" function is not possible for the "Import drive data set" function.
Save your parameter assignments before importing a drive data set.

1. Open "Parameters" > "Drive".
2. Start the configuration wizard via the "Import drive data set..." button in the "Drive data set" area.
3. Select the "Import drive data set from file system" option.
4. Select the drive data set (*.csv) via the file folder button.
5. The drive data set is displayed in the log area and you can check the data.
6. Apply the configuration with "Yes".

Status messages about the import are displayed in the Inspector window in the General tab.

7.4.4 Using a user-defined drive data set

Create a user-defined drive data set and configure your motor manually.

You can freely configure the current drive data at any time, even if it was imported via a pre-defined drive data set or a parameter table.

WARNING

Avoiding incorrect parameter assignments

Note that incorrect or modified parameter assignments can result in drive malfunctions and damage to the drive.

See also

Motor (Page 113)
PI DS ServoDrive (https://support.industry.siemens.com/cs/ww/en/view/109773204)

7.4.5 PMSM drive parameters

Parameter number	Name	Description	Unit
Motor			
p0300	Motor type	Selection of the motor type	
p0304	Nominal voltage	Refer to the motor data sheet for the nominal voltage of the motor. The nominal data of the motor are based on this voltage.	V
p0305	Nominal current	The nominal motor current is the current value at which the motor delivers its nominal power and nominal torque under nominal conditions. The nominal current value refers to the ambient conditions specified by the motor manufacturer. If, for example, the motor ambient temperature differs from that of the motor manufacturer, the nominal current must be adjusted according to the manufacturer's specifications.	A
p0311	Nominal speed	Nominal motor speed is the speed at which the nominal values of the motor are valid.	rpm
p0312	Nominal torque	Nominal torque is the torque at the nominal operating point of the machine.	Nm

p0322	Maximum speed	Maximum speed is the mechanically permissible speed of the machine. If the speed is exceeded, the motor may be damaged.	rpm
p0323	Maximum current	The maximum current is the maximum motor current permitted for a short time. The motor can be operated briefly up to this current without resulting in damage, but continuous operation is only permissible up to the maximum nominal current. The maximum current can flow until the limitation of the thermal model intervenes. Specifications such as permissible motor peak currents, e.g: for the duration of 1 s, are not to be entered here.	A
p0316	Torque constant	The torque constant of the motor is the proportionality factor between the RMS current of the q current and the internal torque of the motor. The motor torque is calculated from this constant.	mNm/A
p0314	Number of pole pairs	Number of pole pairs of the motor. For example, an 8-pole motor has 4 pole pairs	-
p0372	Connection resistance (= internal resistance)	Connection resistance of the motor between two motor phases.	Ohm
p0376	Connection inductance q component (=winding inductance q)	Connection inductance between two motor phases in the q axis. When only the value of the rotating field inductance is specified, this value can be used for d and q inductance.	mH
p0377	Motor connection inductance d component (=winding inductance d)	Connection inductance between two motor phases in the d axis. If only the value of the rotating field inductance is specified, this value can be used for d and q inductance.	mH
p0341	Rotor moment of inertia	The rotor moment of inertia is the mass moment of inertia of the rotor with the connecting shaft.	kgcm²
p0318	Standstill current (= holding current)	The standstill current of the motor corresponds to the current value with which the motor can be permanently loaded at standstill under the ambient conditions specified by the motor manufacturer.	A
Motor gear			
p2725	Motor gear moment of inertia	Sets the motor gear moment of inertia in relation to the motor axis.	kgcm²

Thermal model			
p0611[1]	Time constant winding - environment	Setting of the thermal time constant between the winding and the environment. In nominal operation (nominal load and the ambient temperatures and installation elevation specified by the manufacturer) the limit temperature of the motor is reached after five times the time constant. Note: If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. See 7.7.1 Thermal motor monitoring	s
Motor connection			
p0352	Motor cable line resistance	Input of the motor cable resistance value for outgoing and return conductor.	Ohm
p0353	Motor series inductance (=motor cable inductance)	Input of the line inductance of the outgoing and return conductor. The value can be neglected for motor connection cables < 10 m. If a series reactor is also connected between the motor and the inverter, you need to enter the inductance value as an additive to the line inductance.	mH

7.4.6 Motor encoder

7.4.6.1 Motor encoder

Under Encoder type configuration, select the appropriate encoder type for the motor.

Parameter number	Name	Description	Unit
Encoder type configuration			
p0404	Motor encoder selection	Selection of the motor encoder	-

Depending on the motor type, you can select the following encoders:

Motor type: PMSM motor

- (1) Incremental encoder (A, B, Z track)
- (5) IQ encoder (A, B track)

7.4.6.2 Encoder parameters incremental encoder and IQ encoder

The encoder types incremental encoder and IQ encoder use the same settings.

Parameter number	Name	Description	Unit
p0408	Increments per revolution	Setting of the increments per revolution or the pulses per revolution (PPR) of the motor encoder.	-
p0409	Steps per revolution	Display of the steps per revolution or counts per revolution (CPR) of the encoder. The value cannot be edited, results from the quadrature interface and is four times the value of increments per revolution (p0408).	-

Incremental encoder, IQ encoder

The increments per revolution must be set for the incremental encoder and the IQ encoder. The increments can be independently detected at the incremental encoder by the automatic encoder detection of the TM Drive.

7.4.6.3 Assign encoder counting direction parameters

For encoder type (1) incremental encoder, it may be necessary to invert the counting direction of the encoder by setting parameter p0410, Invert encoder counting direction. With incremental encoders, this may be necessary, for example, if the A and B tracks were swapped when the encoder was connected.

The following is defined as the positive direction of rotation of the encoder.

Incremental encoder:

The positive direction of rotation for an incremental encoder is defined as follows.

If the positive A edge comes before the positive B edge in terms of time, the motor with a view of the motor shaft rotates clockwise in the positive direction of rotation.

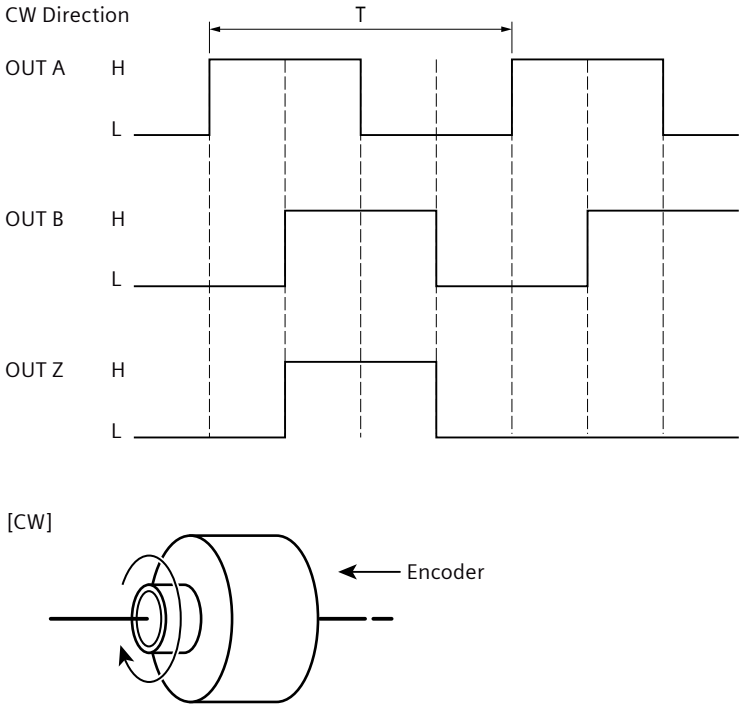

Figure 2-1552 Direction of rotation for the incremental encoder

Definition:

A positive speed in TM Drive is defined as follows:

The motor rotates clockwise looking down on the motor shaft. The encoder value increments during this process.

Table 2-2008 **Additional encoder values**

Parameter number	Name	Description	Unit
p0410	Reverse encoder counting direction	This setting negates the counting direction of the encoder.	-

7.4.6.4 Setting the commutation angle offset and pole position identification

For the commutation of a PMSM with the encoder type

- [1] Incremental encoder (A, B, Z track)

it is necessary to know the commutation angle offset or to determine it.

The commutation angle offset is the angle offset between a reference (Z-track for incremental encoders and the rotor / pole position).

Encoder calibration at each start (p1990)

If the parameter (p1990) "Encoder calibration at each start" is set, the determination of the commutation offset angle is repeated, for example, by voltage interruption at each restart or after each configuration of the drive.

If the parameter (p1990) is not selected, the value entered in the commutation angle offset (p0431) is used for commutation. If the offset angle is known, this can either be entered or automatically determined by TM Drive (see section Automatic encoder / pole position identification (Page 86)).

NOTE

Incremental encoder

After a new configuration or after switching off the power supply, the pole position is unknown when using an incremental encoder. If the parameter (p1990) "Encoder calibration at each start" is not set, the motor control is speed controlled with a fixed motor (running) current depending on the motor current parameters until there is synchronization of the pole position.

If synchronization with the Z-track is not possible, the control is aborted.

If the rotor position has not yet been synchronized, the drive may be twisted by an external load. If you want to prevent the drive from rotating directly after drive activation, you can use the Additional torque parameter (p1511) to ensure that a corresponding hold torque is applied to the motor (see section Speed control (cascade) (Page 94)).

NOTE

Motor replacement

When replacing the motor, remember that the motor encoder in a motor series is not always calibrated in the same way.

If the encoder calibration is selected at every start, no further action is required.

If this is not the case, the commutation angle offset must be determined again in the encoder / pole position identification (see section Automatic encoder / pole position identification (Page 86)).

⚠ WARNING

Incorrectly set commutation offset angle

It must always be ensured that the commutation offset angle is set correctly.

Otherwise, there will be insufficient control of the drive and it will not achieve its full performance or it will proceed in an uncontrolled manner.

Table 2-2009 Additional encoder values

Parameter number	Name	Description	Unit
p1990	Encoder calibration at each start	If this option is selected, the commutation angle offset is determined again at every restart (new configuration or switching off the supply voltage). It is recommended to determine the commutation angle offset once during commissioning. Calibration is then no longer necessary, except when replacing the motor.	-
p0431	Commutation angle offset	Setting of the commutation angle offset. The commutation angle offset is the angle between the rotor pole position and the 0° degree pulse of the encoder.	-

Parameter number	Name	Description	Unit
		If the angle offset is not known, it can be determined by the module during commissioning. The offset angle is defined as follows. Incremental encoder: 0° offset is present if the Z pulse is applied at least at one alignment point (depending on number of pole pairs) when the phase U is positive and V, W are negative. Absolute encoder: 0° offset is present if the angle value is 0 at least at one alignment point (depending on number of pole pairs) when the phase U is positive and V, W are negative. **Warning:** **An incorrectly set commutation angle offset can lead to uncontrolled behavior of the drive!**	

7.4.6.5 Calibration process of the commutation angle offset

When selecting parameter p1990 "Encoder calibration at each start", the TM Drive restarts the calibration process of the motor pole angle after:

- Every initial enable of the drive
- Every time the power supply is switched on again
- After re-configuration
- If certain malfunctions of the module occur

After that, the TM Drive references with the determined offset angle over the Z-track.

The motor is energized for the calibration process and thereby generates torque.

The motor current is limited by:

- Prospective locked rotor current (p0318)
- Equivalent current from the nominal torque of the motor (p0312)
- The equivalent current from the torque limitation (p1520)
- The maximum converter current

The smaller limitation in each case takes effect.

A possibly existing motor holding brake must be opened, so that a rotation of the motor is possible. If the motor holding brake is configured via the TM Drive and connected accordingly, the task of opening the holding brake is assumed by the TM Drive.

NOTE

If you have selected (p1990) "Encoder calibration at each start", the drive must retrain itself at initial commissioning and each time the power supply is switched back on or a new project download is performed. This process can take between 1 - 4 seconds. The motor can move by a maximum of 180° / number of pole pairs. Such movement must be possible in the application.

The following constraints must be observed:

- The motor must be able to rotate freely in both directions of rotation and the axis must not be loaded with a static load.
- With suspended loads, the option (p1900) "Encoder calibration at every start" must not be used.
- It is recommended to use a TM Drive with absolute encoder function and corresponding motor especially for suspended loads.
- The calibration process cannot be performed when the axis is rotating, or the speed must be below the standstill detection p1226.

NOTICE

Open motor holding brake

The motor holding brake is opened during calibration of the commutation angle offset. Especially with suspended axes, it is therefore important to ensure that it is possible to open the motor holding brake.

An unexpected collapse of a suspended axis can result in personal injury and property damage.

Before commissioning, you must ensure that a cross brace is fitted to hold the suspended axis in position and prevent it from collapsing unexpectedly. Also ensure that the power supply is connected properly.

WARNING

Motor movement by measurement on unbraked motors

The measurement can be used to trigger a rotation or movement of the motor via the specified current on unbraked motors. The magnitude of the movement depends on the specified current as well as on the moment of inertia of motor and load.

7.4.6.6 Automatic encoder / pole position identification

Automatic encoder pole position identification is found in the Commissioning submenu of the configured TM Drive. This function is only possible with the PMSM motor type. Incremental encoders can be detected. Depending on the encoder type, the following encoder / motor parameters are automatically detected:

Incremental encoder (1)

- Commutation angle offset (p0431)
- Number of pole pairs (p0314)
- Increments per revolution (p0408)
- Invert encoder counting direction (p0410)

For automatic encoder / pole position identification please proceed as follows:

Preconditions

- Motor type PMSM
- The motor parameters are known and the calculation of the controller parameters under open-loop/closed-loop control has been performed and transferred to the drive.
- The device is in RUN state and the drive is at standstill.
- The drive is not enabled in any other way (e.g. by a technology object or a user program).
- The motor can rotate freely in both directions of rotation and is not loaded with a static load (example: suspended load)

NOTE

If the motor is loaded with a static load during encoder detection, the commutation offset angle may not be correctly detected. The motor can then only deliver a reduced torque.

Step 1:

Go online and enable commissioning mode under Commissioning, Identification with the 'Start' button and select the encoder / pole position identifier.

NOTE

In this operating mode, the drive can only be controlled by the TM Drive. A control of the drive by the S7 control via PROFIdrive is not possible in this mode and is locked. This is also signaled by resetting ZSW1 bit 9.

Step 2:

The configured motor type and motor encoder is displayed under Commissioning encoder / Pole position identification. Insert the identification current allowed for the test. This is always automatically set to the rated motor current. However, it can be adjusted if required.

NOTE

If the motor is already installed in an application, you may need to increase the identification current in steps. The motor maximum current p0323 must not be exceeded. If necessary, observe idle times between the identification cycles to avoid overheating the motor.

Especially for motors with an increased cogging torque, it may be necessary to increase the identification current so that the encoder and pole position information can be accurately detected.

Step 3:

Start the encoder / pole position identification with the selection button "Start encoder detection".

A configured motor holding brake is opened during encoder / pole position identification. This is signaled via ZSW1 bit 12 both in the process image and in data set 209.

NOTICE

Open motor holding brake

The motor holding brake is opened during encoder / pole position identification. Especially with suspended axes, you must ensure that it is possible to open the motor holding brake.

An unexpected collapse of a suspended axis can result in personal injury and property damage.

Step 4:

If the drive is still in operation, execution of the identification commands is rejected. Stop the operation of the drive before the encoder / pole position identification. Then continue with step 3.

When all conditions are fulfilled, the TM Drive starts the identification after the confirmation of the safety prompt. It is necessary that the drive can be turned safely in both directions.

Step 5:

If the encoder / pole position identification is successfully executed, the determined values are displayed.

NOTE

Before you apply the determined values, you need to check them for plausibility.

Step 6:

You can now select which of the determined values you want to transfer to the offline project. By clicking the "Transfer determined values to offline project" button, the selected values are transferred to the offline project.

NOTE

The determined settings are stored only temporarily on the module. They are replaced by the permanently stored parameters on the next restart.

If you want to store the settings permanently on the module, change the drive parameters offline and download them again with "Download to device".

Step 7:

When you have transferred the parameters to the offline project, disable commissioning mode under Commissioning, Identification with the 'Exit' button. You must then load the parameters onto the module using "Download to device".

Encoder / pole position identification is completed. The option "Encoder calibration at each start" (p1990) is no longer required and should be deselected.

7.5 Setpoint channel

Overview

Setpoints from the respective setpoint source are prepared for the motor control in the setpoint channel of the drive.

You specify the setpoints via the drive telegrams to PROFIdrive.

You can find the settings for the setpoint channel in the context of the drive under "Parameters" > "Setpoint channel".

Under "Setpoint channel" you configure the following:

- Reference values (Page 89)
- Application limits (Page 90)
- Ramp-function generator and speed setpoint filter (Page 92)

The figure below shows the processing of the speed setpoint in the drive controller.

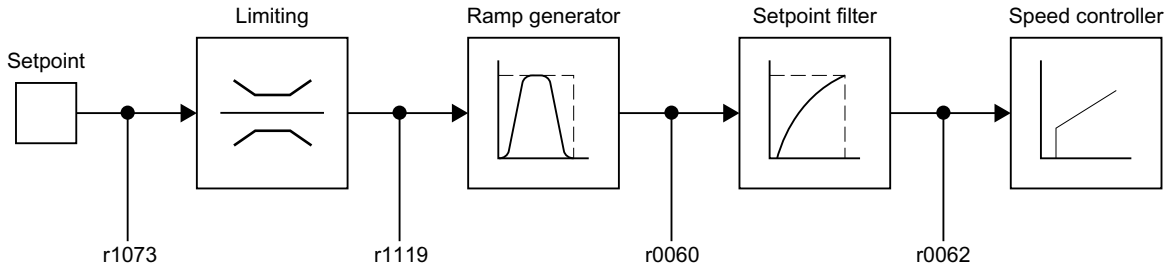

Figure 2-1553 Setpoint channel

The speed setpoint from the drive telegram is limited in the setpoint channel according to the specified values, see section Reference values (Page 89).

The limited speed setpoint is fed to the ramp generator as an input signal, see section Application limits (Page 90).

The output of the ramp generator is fed to the speed controller via the speed setpoint filter, see section Ramp-function generator and speed setpoint filter (Page 92).

7.5.1 Reference values

The physical variable speed is transmitted in the drive telegrams as a reference values.

- Speeds are normalized to the reference speed (p2000) in the drive telegram.
- Torques are normalized to the reference torque (p2003) in the drive telegram.

Parameters p2000 and p2003 are definitive as reference values (telegram content = 4000 hex or 4000 0000 hex for double words, if the input value has the value p2000 or p2003).

Example of the normalization of the speed:

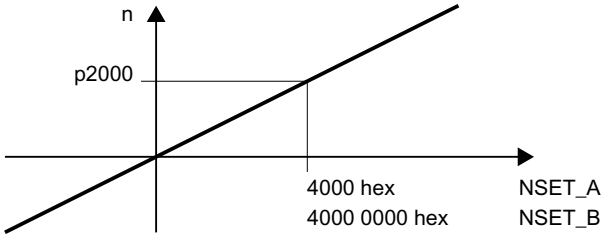

Figure 2-1554 Example of normalization of the speed

NOTE

The speed and torque are specified in the drive telegram as a percentage of the reference speed in the range -200% to 200%.

Therefore, set the reference variables in such a way that the desired maximum value falls within the value range of the control from -200% to +200%.

Procedure

1. Configure the reference value in the context of the drive under:

   "Parameters" > "Setpoint channel" > "Reference values".

WARNING

Uncontrolled drive behavior

Note that the specification of reference values in the CPU and the drive must always match. Otherwise, uncontrolled drive behavior and rotating of the motor might occur. We therefore recommend that commissioning of the drive and thus specification of the references values be completed first before you commission the CPU and, for example, a technology object.

7.5.2 Application limits

In the "Parameters" > "Setpoint channel" > "Application values" area, you can configure limitations for the speed and torque of the drive if required and adapt them to the requirements of your mechanical system.

Speed limiting

If you need a direction-dependent limiting of the speed p1083 and p1086, you can define speed limits for each direction.

Torque limiting

You can specify the torque limitation p1520 as an absolute value. The limiting acts both when motoring as well as generating.

WARNING

Accuracy of torque limitation

The function of the torque limitation is not safe torque limiting in the sense of functional safety. The torque limitation refers to the calculated internal (air gap) torque of the motor.

The internal torque is a calculated value from the internal motor constant and motor current. The torque output at the shaft is the internal torque minus friction and iron losses.

Due to the following influencing factors, the deviation of the torque calculation can be in the two-digit percentage range:

- Internal motor constant p0316
- Current measurement accuracy
- Temperature dependence
- Speed and load dependence on friction, iron and additional losses

WARNING

Danger to life due to uncontrolled movement of the drive as a result of incorrect parameter assignment

Incorrect parameterization of the torque limiting can result in uncontrolled movement of the drives if there is no counter-torque, and cause death or serious injury.

Ensure the correct parameterization.

Zero speed detection

Set the speed threshold for the motor standstill detection (p1226). For braking with OFF1 or OFF3, the zero speed is detected when this threshold is fallen below.

NOTE

A zero point calibration is only started if the speed falls below the speed threshold for standstill detection (p1226).

NOTE

A switch-on process of the drive via STW1 is always delayed until the speed has fallen below the speed threshold for standstill detection (p1226).

As long as the speed is still above this speed threshold, warning 2007 is issued. This can be the case, for example, if the motor shaft is driven externally.

If the switch-on command is still set despite this warning, the drive is switched on and the specified setpoint speed is adopted

as soon as the it falls below the speed threshold for the standstill detection.

Speed threshold values for message

Also specify the speed threshold values for the following messages of the drive status word:

- "Speed threshold 1" (p2141)

  If the speed exceeds the threshold value, bit 10 is set as feedback in ZSW 1
- "Speed threshold 4" (p2163)

  As long as the speed deviation lies within the tolerance range, bit 8 in ZSW1 is set as feedback
- "On delay time" (p2167)

  Setting the switch-on delay time for the message "Speed setpoint/actual deviation within tolerance" (see also p2163)

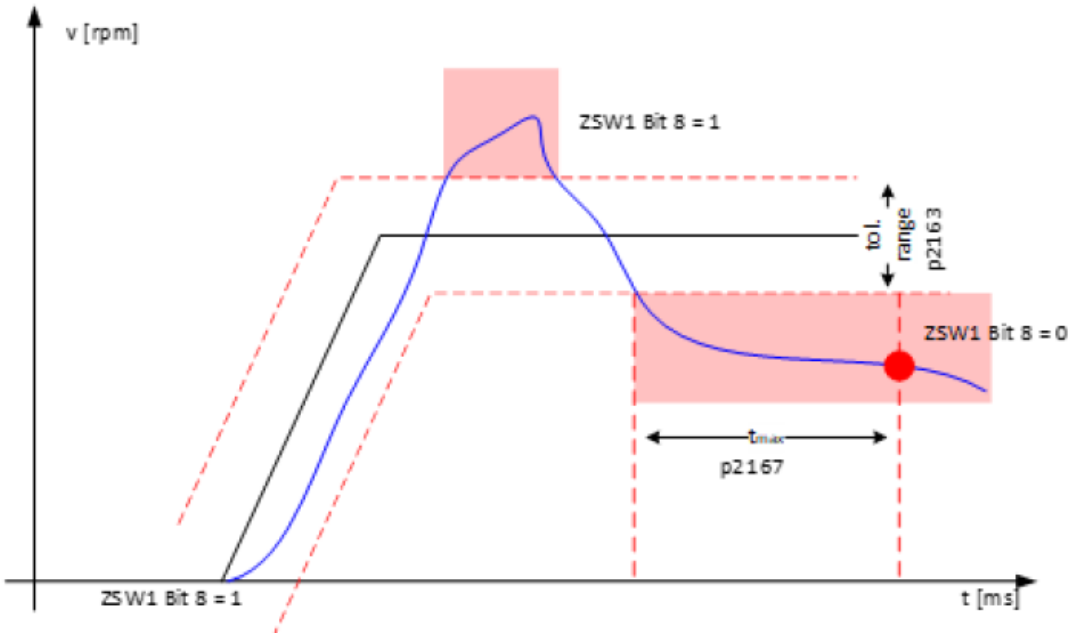

Figure 2-1555 Speed setpoint - actual value deviation within tolerance

7.5.3 Ramp-function generator and speed setpoint filter

Speed ramp-function generator

The TM Drive uses the speed ramp-function generator type "Basic ramp-function generator" p1115[0].

The ramp-function generator can be switched off with the setting "No ramp-function generator".

The speed ramp-function generator is used to limit the acceleration at sudden setpoint changes and helps to prevent drive train shock loads.

An acceleration ramp and a deceleration ramp can be set independently with the ramp-up time and ramp-down time. This enables a controlled transition at setpoint changes.

NOTE

On principle, the ramp-up and ramp-down times of the ramp-function generator in the setpoint channel of the drive should be set only so fast that, in case of accelerations and decelerations, the motor speed can track the setpoint without damaging the machine. This ensures optimal functioning of the speed controller precontrol.

Procedure

You enter the settings for the speed ramp-function generator under "Parameters" > "Parameters" > "Ramp-function generator":

- Rampup time
- Ramp-down time
- Speed

NOTE

The TM Drive uses the three values entered to form the values relative to 10,000 rpm "Speed ramp-function generator ramp-up time" (p1120) and "Speed ramp-function generator ramp-down time" (p1121).

When using the GSD file, directly enter the values relative to 10,000 rpm.

Speed setpoint filter

The drive has a first-order time-delay element (low pass PT1) as a speed setpoint filter. The filter time constant can be set with p1416.

The speed setpoint filter is able to attenuate harmonic components of the setpoint and thus to prevent any overshooting of the higher-level controller.

The speed setpoint filter has no effect on the stability of the speed controller because it is in the setpoint channel before the control loop. The dynamics of the response to setpoint changes is reduced by smoothing.

As a rule, set the speed setpoint filter to a low value, since the upstream ramp-function generator ensures sufficient limitation of the setpoint signal.

7.6 Controller settings

7.6.1 Controller settings

Under "Parameters" > "Open-loop/closed-loop control", you specify the type of control, the general controller settings and the settings for speed and current controllers.

Control type

The open-loop / closed-loop control type can be selected depending on the motor type. The following combinations are available:

Motor type: PMSM motor

- [100] Closed-loop speed control (cascade)

7.6.2 Speed control (cascade)

In Speed controller (cascade) mode, the speed difference between the actual and the nominal speed is detected using an encoder and the speed deviation is controlled accordingly. Since the speed controller is followed by a current controller, this speed control method is referred to as cascade control.

General controller settings

Speed and current controllers can be optimally tuned if the properties of the load mechanics of your machine and the electrical properties of the drive are specified as correctly as possible.

Enter the general controller settings under "Parameters" > "Control/closed-loop control" > "Controller settings".

- Moment of inertia load p1398
- Precontrol p1496
- Viscous friction p1399
- Additional torque p1511
- Speed actual value filter p1441

Speed stability can be improved using the actual speed filter, depending on the encoder resolution.

Constant loads can be compensated using additional torque p1511. This reduces compensation processes when the drive is switched on using motor holding brakes.

Additional important settings

The values for speed and current controllers can be determined in the best possible way if, in addition to the properties of the electric motor, you also specify the properties of the gearbox and the connecting cable.

- Motor cable line resistance p0352
- Motor cable/series inductance p0353
- Motor gear moment of inertia p2725

Precontrol p1496

Using the precontrol (p1496), the precontrol of the moments of inertia, consisting of Motor (p0341), Motor gear (p2725) and Moment of inertia load (p1496), can be specified as a percentage value. The precontrol allows the drive to be moved more dynamically. The precontrol is switched off with a preset of 0%. The precontrol is preset by the automatic controlled system detection (see section Automatic controlled system detection (Page 97)) depending on the controller dynamics.

To use this function, the setpoint speed must be preset by a ramp. For this, you can either use the internal ramp-function generator (see section Ramp-function generator and speed setpoint filter) or corresponding acceleration/deceleration functions in technology objects.

Viscous friction p1399

The friction of the system is precontrolled using Viscous friction (p1399). This is specified as a linear friction torque as a function of the speed and is detected during automatic controlled system detection.

Additional torque p1511

Constant loads can be compensated using additional torque (p1511). This reduces compensation processes when the drive is switched on using motor holding brakes.

Speed actual value filter p1441

The drive has a first-order time-delay element (low pass PT1) as a speed actual value filter. The filter time constant can be set via (p1441).

The parameter is preset depending on the parameter "Increments per revolution" p0408 in the HSP. If you configure the device using a GSDML, you can use the following table as a guide.

Table 2-2010 Actual speed filter times as a function of the encoder resolution

Encoder resolution (Steps per revolution p0409 or [2]Single-turn resolution p0423)	**Speed actual value filter p1441 in ms**
400	11
512	10
1024	8
2048	6
4096	4
6000	2
10000	1
16000	0

Speed controller and current controller

You can either have the speed and current controller parameters calculated via the controller settings of STEP 7 or you can perform the automatic controlled system detection (7.6.2). It is also possible to set the controller settings manually.

Having controller settings calculated

To have the controller settings of STEP 7 calculated, proceed as follows:

1. Click the "Calculate speed number/current controller settings" button in the area for the controller settings.
   The "Controller calculation" window opens. The window displays the appropriate controller parameters.
2. If needed, you can re-adjust the controller settings via the "Controller behavior" and "Load fluctuation" sliders.
   – "Controller behavior": If the value is increased, the controllers react more strongly to controller differences. At the same time, the controller tends to overshoot.
     The default setting here is 70%.
   – "Load fluctuation": A larger value allows more oscillation in the stable state. The speed deviations are greater during a load step.
     The default setting here is 30%.

   NOTE

   There is no guarantee that readjustment of the controller calculation will always result in a stable system.

   Change the settings for "Controller behavior" and "Load fluctuation" incrementally. Always check the settings with low speed and load profiles.

3. Apply the controller settings by clicking the "Apply" button.

You can then continue to change the calculated controller settings manually.

Setting the controller settings manually

Enter the settings for the speed controller under "Parameters" > "Control/closed-loop control" > "Speed controller".

- Prop. gain
- Integral action time
- Speed setpoint filter
- Speed actual value filter

Enter the settings for the current controller under "Parameters" > "Control/closed-loop control" > "Current controller".

- Iq proportional gain
- Iq integral action time
- Id proportional gain
- Id integral action time

NOTE

If you manually set the controller parameters to inappropriate values, the drive system can be damaged.

Make changes to the controller settings in small steps. Keep checking the behavior of the drive system until you have found a satisfactory setting.

7.6.3 Automatic controlled system detection

You can find the automatic controlled system detection in the Commissioning submenu of the configured TM Drive. This function is only possible with the cascade control mode (p1300).

During the measurement run, the system is measured using test signals. The drive is moved in the process. Configured torque (p1520) and speed limits (p1083 and p1086) are taken into account and can also be used to protect the drive or the application.

The drive accelerates to the test setpoint speed, stops and executes the same travel profile in the reverse direction of rotation. The motor is thereby approximately at the starting position again after the measurement run.

The "Reversal of direction of rotation" checkbox can be used to specify the direction of rotation for the measurement run. If the check box is selected, the motor rotates counterclockwise when viewing the motor shaft, otherwise the motor shaft rotates clockwise. By specifying the number of motor revolutions, it is possible to limit the maximum rotation of the drive. The input of the number of revolutions limits the test setpoint speed if necessary.

The following parameters are automatically determined during controlled system detection:

- Motor connection resistance including motor cable line resistance
- Current control parameters
  - Iq proportional gain p1715
  - Iq integral action time p1717
  - Id proportional gain p1735
  - Id integral action time p1736
- Speed controller parameters
  - Prop.gain p1460
  - Integral action time p1462
- Moment of inertia load p1398

- Precontrol p1496
- Viscous friction p1399

The controlled system detection function automatically provides you with the controller parameters specific to your application and motor.

The controlled system detection function can be adapted to different system requirements.

The connection resistance of the system is detected during the controlled system detection. The determined resistance is divided between the connection resistance (p0372) and the resistance of the motor supply line (p0352).

- If the measured resistance is greater than the connection resistance (p0372), the additional portion is allocated to the motor cable line resistance (p0352).
- If the measured resistance is less than the connection resistance (p0372), this is adjusted and the portion of the motor cable line resistance (p0352) is set to 0.

WARNING

Unplanned movement of the motor during speed controller tuning

Speed controller tuning causes movement of the drive which can result in death, serious injury or material damage.

- Ensure that nobody is present in the hazardous zone and that the mechanical system can move freely.

NOTE

Directions of rotation and permissible motor rotation range

In the application, the motor must be able to move at least in the specified motor rotation range (p8991). The machine may be damaged if the traversing range is not accordingly limited.

If this is not permissible due to your plant conditions, it is prohibited to perform controlled system detection.

Before commissioning, ensure that the motor and application parameters are correct.

Procedure

Preconditions

- Cascade control mode
- The motor and application parameters are known and transferred to the drive.
- Speed and torque limitation are configured and transferred to the drive.
- The device is in RUN mode and the drive is at standstill

- The drive is not enabled in any other way (e.g. by a technology object or a user program).
- The motor can rotate freely in both directions of rotation and is not loaded with a static load (example: suspended load)

NOTE

If the motor is loaded with a static load during the controlled system detection, this may result in the speed and current controller parameters not being detected correctly.

Step 1:

Go online and enable commissioning mode under Commissioning, Identification with the 'Start' button and select the controlled system detection.

You can abort controlled system detection at any time by pressing the "Exit" button. The drive coasts to a stop and the motor holding brake closes. The drive may have to be returned to its start position before a new measurement run.

NOTE

In this operating mode, the drive can only be controlled by the TM Drive. A control of the drive by the S7 control via PROFIdrive is not possible in this mode and is locked. This is also signaled by resetting ZSW1 bit 9.

Step 2:

Make the settings for controlled system detection.

- Measurement run dynamics p8990

  The acceleration gradient of the rotating measurement run can be influenced using the measurement run dynamics factor.

  A high value is suitable for torsionally stiff systems and low mass inertias and a low value for elastic systems or systems with high mass moment of inertia.

  Generally, a high measurement run dynamic factor provides better results for the rotating controlled system detection. However, too high a measurement run dynamics factor can possibly lead to twisting, bending or other damage to the machine.

Recommendation: Start with a low measurement run dynamics factor and, if necessary, repeat the controlled system detection with an increased measurement run dynamics factor.

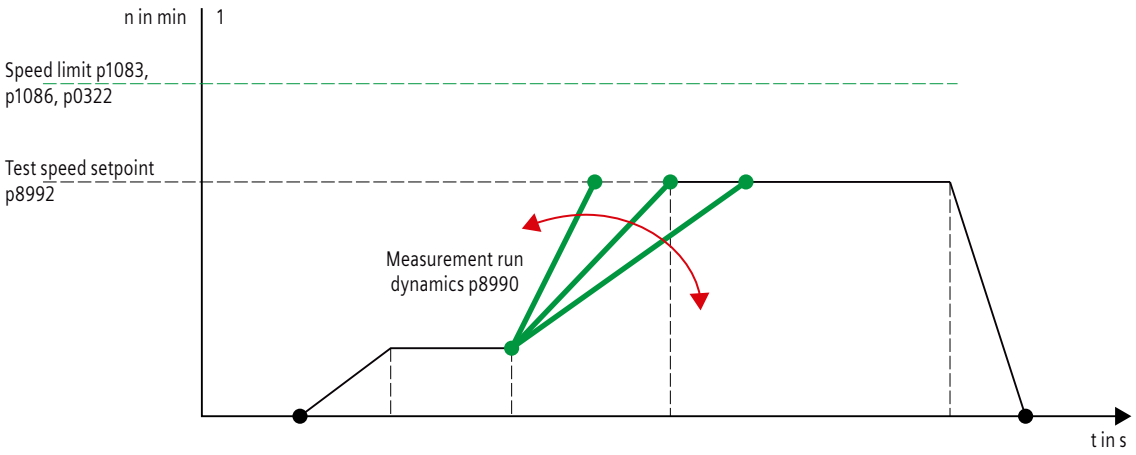

Figure 2-1556 Measurement run dynamics

- Max. number of motor revolutions p8991

  Specifies how many revolutions the motor may cover during the measurement. Ensure that a rotation with the configured number of motor revolutions is possible in the direction in which the motor is moved (specified via the "Reversal of direction of rotation" check box).

- Test speed setpoint p8992

  If possible, enter a typical speed value for the test speed setpoint at which the drive is to be operated later.

  If the measurement run is not possible due to the entry from max. number of motor revolutions (p8991) in combination with the test speed setpoint (p8992), this is displayed and a maximum possible test speed setpoint (p8992) is suggested in the text box.

- Torque limitation p1520

  The torque limitation is displayed as a parameter (read only). The setting must be made in the "Application limits" mask and the parameter must be loaded into the module.

- Controller dynamic factor

  Using the controller dynamic factor, you can set how the speed controller should be set up.

  – Conservative: Slow control – low mechanical load. (60% precontrol)
  – Default: Optimum between fast speed control and load of the mechanics. (80% precontrol)
  – Dynamic: Fast speed control – high mechanical load. (100% precontrol)

  A parameter check is performed automatically. This ensures that the drive can perform the measurement run with the configured dynamics within the configured max. number of revolutions. If the measurement run with the configured values is not possible, a warning is displayed and a reduced value for the test speed setpoint is entered.

Step 3:

Start the controlled system detection with the "Start controlled system detection" selection button.

A configured motor holding brake is opened during controlled system detection. This is signaled via ZSW1 bit 12.

NOTICE
Open motor holding brake The motor holding brake is opened during controlled system detection. Especially with suspended axes, you must ensure that it is possible to open the motor holding brake. An unexpected collapse of a hanging axis can result in personal injury and property damage.

Step 4:

If the drive is still in operation, execution of the controlled system detection is rejected. Stop the operation of the drive before the controlled system detection. Then continue with step 3.

When all conditions are fulfilled, the TM Drive starts the controlled system detection after the confirmation of the safety prompt. The drive is moved several revolutions for this.

Step 5:

After successful controlled system detection, the system variables and suitable controller values determined are displayed.

Depending on the application, it may be advantageous to perform the controlled system detection several times in succession and, if needed, to adjust the measurement run dynamics p8900.

NOTE

Before you apply the determined values, you need to check them for plausibility. If necessary, the control can be tested for stable behavior by traveling briefly in both directions (+/-).

Step 6:

You can now select which of the determined values you want to transfer to the offline project. The selected values are transferred to the offline project using the "Transfer determined values to offline project" button.

Step 7:

Once you have transferred the parameters to the offline project, disable commissioning mode under Commissioning, Identification with the 'Exit' button. You must then load the parameters onto the module using "Download to device". Otherwise, the parameters will be lost after switching the module off and on.

Automatic controller tuning is now complete.

Check the settings automatically found using a measurement run with your application. For additional optimization of the controller settings, you can use manual controller tuning from the section Manual controller tuning Speed controller (cascade).

NOTE

If the automatic controlled system detection could not determine any controller parameters, a new measurement run can be initiated by entering a higher moment of inertia of the load under control/closed-loop control parameters and repeating the controlled system detection. The controller parameters can thus be adapted for the machine. The measurement run is thus set to the increased inertia of the load.

You can save the measurement run to a csv file using the "Export measurement data" button.

Faults during controlled system detection

Faults during controlled system detection are displayed directly in the commissioning screen and can be acknowledged.

Table 2-2011 Causes of faults and errors

Fault number	Description	Cause / Solution
1055	Motor resistance detection could not be performed	If the motor phases are not connected correctly or insufficiently contacted, or if there is an asymmetry between the individual winding resistors, the error "Unable to successfully perform motor resistance detection" is set. Check the motor connections or the motor for defects and breaks.
1056	Following error during controlled system detection	If the drive is not able to follow the setpoint travel curve, this error is displayed. In this case, it is likely that the Measurement run dynamics p8990 was selected too large. Reduce the Measurement run dynamics p8990 and repeat the controlled system detection. It is also possible that the drive is blocked or the motor holding brake has not been configured or connected correctly.
1057	Position error during controlled system detection	If the maximum number of revolutions is exceeded, e.g. by an external load acting on the drive, this error is set and the drive is switched off. Either the controlled system detection is not possible in the application or reduce the external force on the drive train.

7.6.4 Manual controller tuning Speed controller (cascade)

You can find the manual controller tuning in STEP 7 under Commissioning. Here, you can optimize the control parameters according to your application and thereby fine-tune the drive.

Procedure

You can find the manual controller tuning in STEP 7 under Commissioning. Here, you can optimize the control parameters according to your application and thereby fine-tune the drive.

Procedure

For manual controller tuning, proceed as follows:

Step 1:

Go online to the module with TIA Portal by clicking on the "Connect online" selection button.

Step 2:

If you have not already calculated the controller parameters under Control/closed-loop control, you can do this again here. First, enter the mass moment of inertia of the load.

Use the "Calculate" selection button to calculate the controller parameters.

Step 3:

The calculated controller values are displayed. The online values, i.e. the currently active values, are also displayed on the module.

Step 4:

With the selection "Apply online" button, the new controller values are directly transferred and take effective.

NOTE

When the axis is in operation, the enable is automatically canceled and the new parameters are applied.

Step 5:

You can now put the drive into operation with a speed or positioning TO, for example, and evaluate the control behavior using a trace recording.

If the control behavior is satisfactory, continue with step 7.

Step 6:

If additional optimization is required, there are 2 options to better adjust the control parameters.

1. You can calculate the controller parameters again as described in step 2 and readjust the parameters accordingly using the sliders. (See section Control/closed-loop control under Speed controller and current controller)
2. You set the controller parameters manually. You can orientate yourself on the old values and change the proportional gain and/or the integral action time as well as the precontrol step-by-step.

Perform the steps starting with step 4 again.

Step 7:

After you have performed the optimization, you still need to transfer the detected controller parameters to the drive parameters using the selection button "Apply controller values".

Now you must disconnect the online connection ("Go offline" selection button) and then reload the project onto the module using "Download to device". This ensures that the parameters are still active in the project and on the module after a restart.

Controller tuning is now completed.

7.7 OFF responses

OFF1 (Switch off)

By resetting bit 0 in STW1 (On), you activate OFF1 and the drive is braked to 0 in a speed-controlled manner according to the ramp-function generator ramp-down (p1120, p1121).

If the actual speed falls below the value of the "Standstill detection" parameter (p1226) or a timeout is detected, the pulses are inhibited after the motor brake closing time p1217 has elapsed. "Switching on inhibited" is activated.

Timeout

With OFF1, the time is calculated in which the drive should normally stop from twice the reference speed. If the drive does not stop within 2 times of this time, the drive is de-energized and it coasts down.

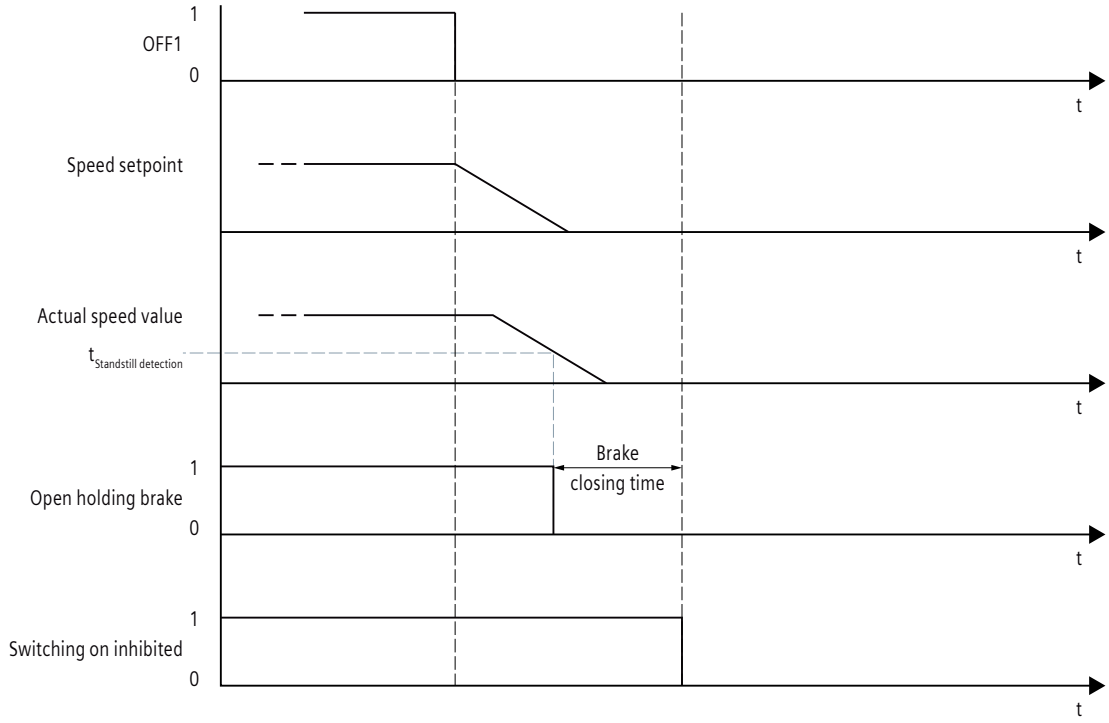

Figure 2-1557 OFF1 sequence diagram when standstill detection is reached p1226

OFF2 (Coast down)

You activate OFF2 by resetting bit 1 in STW1 (NoCoastStop). Immediate pulse cancellation occurs, any configured motor holding brake is closed. The drive coasts to a stop without a motor holding brake. "Switching on inhibited" is activated.

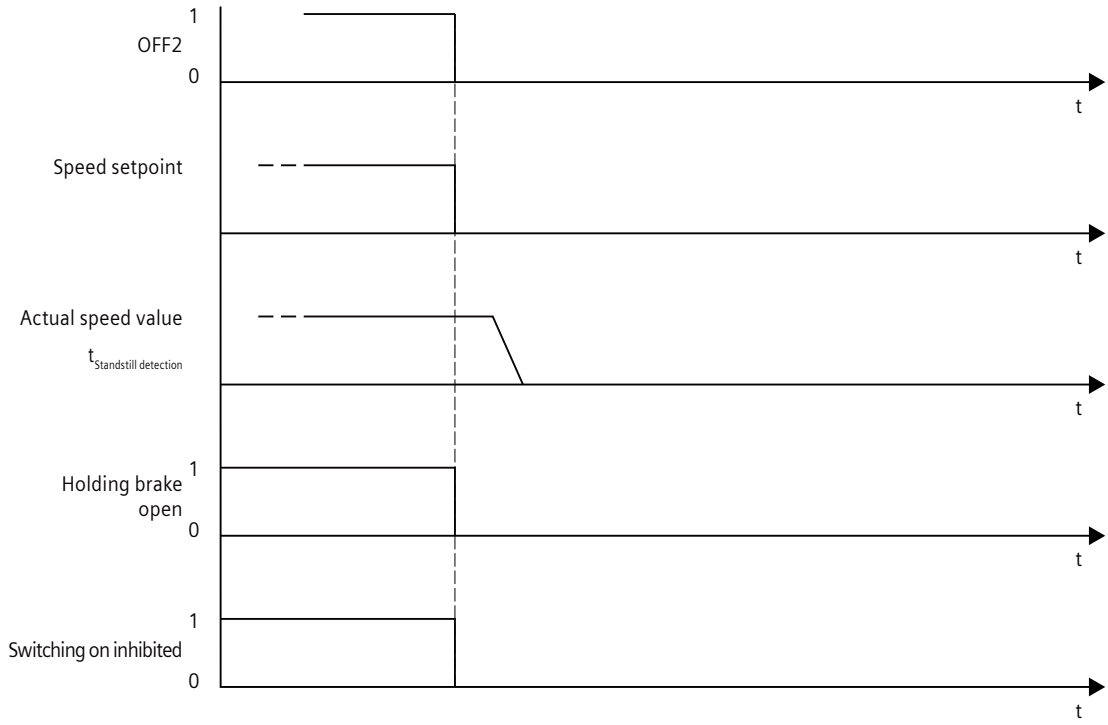

Figure 2-1558 OFF2 sequence diagram

OFF3 (QuickStop)

You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp-function generator"). After the standstill is detected or the monitoring time has elapsed, any configured motor holding brake is closed and the pulses are deleted after the motor holding brake closing time p1217 has expired. "Switching on inhibited" is activated.

NOTE

NOTE on rapid stop (OFF3)

You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp-function generator").

Timeout

The rapid stop is monitored for time and causes the motor to be energized after 6 seconds at the latest.

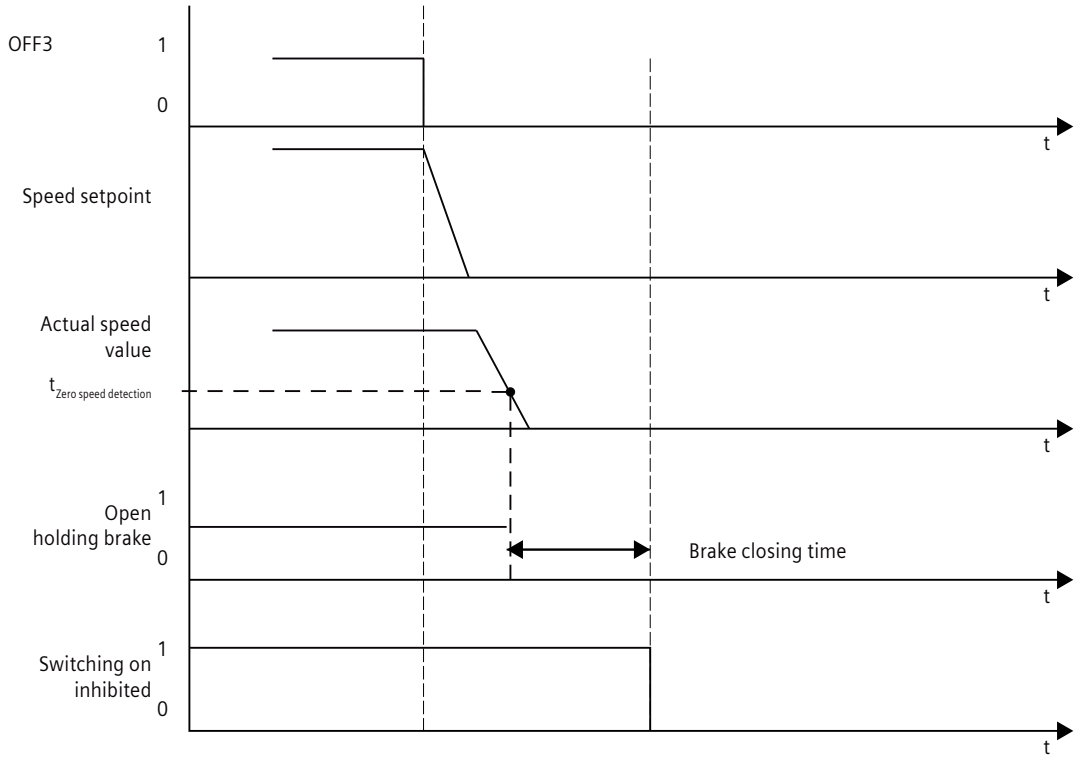

Figure 2-1559 OFF3 sequence diagram

Prioritization

The OFF responses are prioritized as follows:

- OFF2 (coast down) > OFF1 (switch off)
- OFF3 (QuickStop) > OFF1 (Switch off)
- OFF2 (coast down) > OFF3 (quick stop)

7.8 DC-link voltage

The TM Drive system cyclically monitors the DC link voltage. The limits can be set under "Drive/Monitoring".

The regenerative feedback into the DC power supply cannot be suppressed. This has several advantages.

When the drive is braked and the brake chopper is not connected and configured, energy is fed back, which results in an increase in the DC link voltage. For this reason, the DC link voltage is monitored by the module.

You can freely set the DC link voltage monitoring limits within the permissible range.

If the limits are exceeded, the module switches off. Before the module switches off, it issues a warning (limit ∓ 5%) stating that the limit is almost exceeded.

Procedure

1. Open the "DC link voltage" area in the context of the drive under "Parameters" > "Drive/monitoring".
2. Configure:
   - Minimum value of the DC link voltage p0390
   - Maximum value of the DC link voltage p0391

⚠ WARNING

Operation above the voltage setting range

Under the given application conditions, ensure that the motor is not operated above the voltage setting range by selecting the appropriate motor and motor gear. Otherwise, the DC link voltage may increase when the control is inactive via 60 V DC.

7.9 Brake module

7.9.1 Brake module

The TM Drive system has a brake chopper for connection of an external brake resistor and can control a motor holding brake externally via the process image using a DQ or relay module. These functions can be activated individually or in parallel.

You can select the following options for the PMSM motor type under "Brake module":

- [0] No function
- [2] Brake chopper
- [3] Brake chopper and motor holding brake external via the process image
- [4] Motor holding brake externally via the process image

7.9.2 Brake chopper

If the brake chopper function is enabled, you need to configure the following parameters in the "Parameters" > "Drive" > "Brake module" area.

Set the following values for the brake chopper:

- Chopper switch-on voltage
- Chopper switch-off voltage
- Thermal resistance of the braking resistor
- Time constant of the brake resistor
- Maximum temperature
- Ambient temperature
- Response to max. temperature

The switch-on and switch-off voltage of the brake chopper must be set correctly according to the DC voltage supply. The chopper switch-off voltage p6011 must be higher than the supply voltage (example UDC = 48 V à p6011 = 50 V; chopper switch-on voltage p6010 = 52 V).

The voltage thresholds of the brake chopper should be adjusted accordingly with the parameters of the DC link voltage monitoring (7.7).

The TM Drive is not designed to be operated permanently as a brake axis. The circuit of the brake chopper monitors itself and protects itself against overload by switching off.

NOTICE
Risk of fire The switch-off voltage must not be lower than the DC supply voltage, otherwise the brake chopper will not switch off after activation and it may lead to an overload of the brake resistor and/or the module.

Capacity of the braking chopper output

The TM Drive is not designed to be operated permanently as a brake axis. The circuit of the brake chopper monitors itself and protects itself against overload by switching off.

You can find information about power calculation and resistor design in the appendix Braking resistor and brake chopper power (Page 147).

Monitoring of the braking resistor

The specific values of the braking resistor, such as heat resistance and time constant, can be obtained from the manufacturer of the braking resistor (data sheet). Typical values are stored as default values in the TIA Portal. The default values must be checked and adjusted if necessary.

- The thermal resistance describes how large the temperature difference between the resistor and the environment must be in order for a heat flow (power) of one watt to be emitted.
- The time constant indicates the time after which the resistance, at constant power input, has approached approx. 63% of its thermal equilibrium. After five times the time constant, the resistor is in its thermal steady state.

You use the maximum temperature to define the switch-off temperature for the resistor. The switch-off temperature is calculated in a thermal model based on the ambient temperature.

You use "Response to max. temperature" to define the behavior that is triggered when the maximum temperature is reached.

- Shutdown when temperature is exceeded Brake chopper operation is stopped and a warning is generated.
- No shutdown when temperature is exceeded Brake chopper operation is still possible.
- The thermal resistance describes how large the temperature difference between the resistor and the environment must be in order for a heat flow (power) of one watt to be emitted.
- The time constant indicates the time after which the resistance, at constant power input, has approached approx. 63% of its thermal equilibrium. After five times the time constant, the resistor is in its thermal steady state.

NOTICE

Risk of fire

If braking chopper operation continues despite reaching the maximum operating temperature, this can result in a sharp increase in the temperature at the braking resistor. This can damage surrounding components or even result in fires in the worst case.

In addition, always ensure that the minimum distances between the braking resistor and other modules are maintained.

⚠ CAUTION

Risk of burns due to hot surfaces

The braking resistor heats up during operation. Touching the hot braking resistor can result in personal injury and burns.

Avoid contact with the hot braking resistor.

7.9.3 External motor holding brake

The motor holding brake can be used when the drive system is disabled (e.g. when the power supply to the drive system is switched off) to prevent unwanted movements of the motor shaft (e.g. falling due to gravity). The motor can move by its own weight or an external force even if the motor power supply is interrupted.

NOTE

- Use this brake only for "holding", which means to maintain the standstill. Do not use it for "braking", which means to stop the moving load. Use the holding brake only to hold a motor at a standstill.
- The holding brake is enabled when the motor is switched off.

If the motor holding brake function is enabled, you must configure the following settings in the "Parameters" > "Drive" > "Brake module" area.

Adjust the opening and closing times of the motor holding brake:

- Motor holding brake opening time (p1216)
- Motor holding brake closing time (p1217)

For the closing and opening times, delay times of relays may have to be taken into account and added to the times of the motor holding brake.

p1216 = motor brake opening time + relay opening time

p1217 = motor brake closing time + relay closing time

If the motor holding brake is configured, the drive takes the delay times into account and accordingly sets bit 12 in the process image ZSW1. This bit can be used to control a motor holding brake, for example, with a DQ module or relay module.

NOTE

When selecting the additional module, make sure that the current carrying capacity is suitable. This must be dimensionless depending on the current consumption of the motor holding brake.

RC circuit of a TM Drive with DQ module and motor holding brake

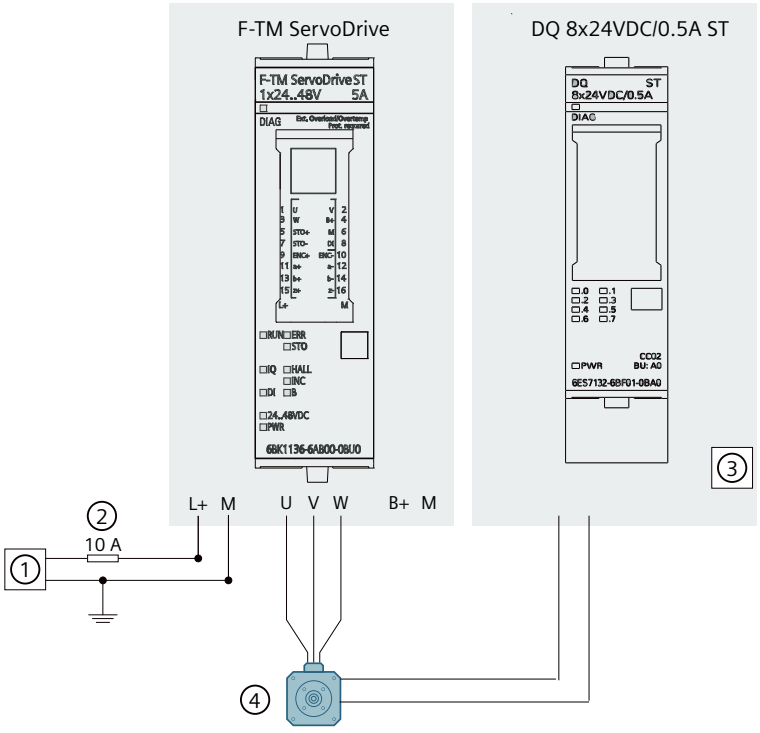

Figure 2-1560 RC circuit of a TM Drive with DQ module and motor holding brake

Suspended axes

The additional torque p1511 is used to set an additional load torque.

To prevent a suspended axis without mechanical weight compensation from sagging after the holding brake is released, you can set up an electronic weight compensation via a supplementary torque p1511, section 7.8.1.

This reduces the compensation action after the release of a holding brake and specifies the holding torque directly after switch-on of the motor.

The option (p1900) "Encoder calibration at every start" must not be used with suspended loads.

NOTE

Suspended load with incremental encoder

For motors with incremental encoders where the commutation offset angle has not yet been synchronized, the axis may drop. This can be counteracted using the additional torque p1511, although a slight movement of the axis cannot be ruled out even then.

- It is recommended to use an absolute encoder especially for suspended loads.

Braking sequence

The sequence diagram shows an example of the behavior of the drive with OFF1.

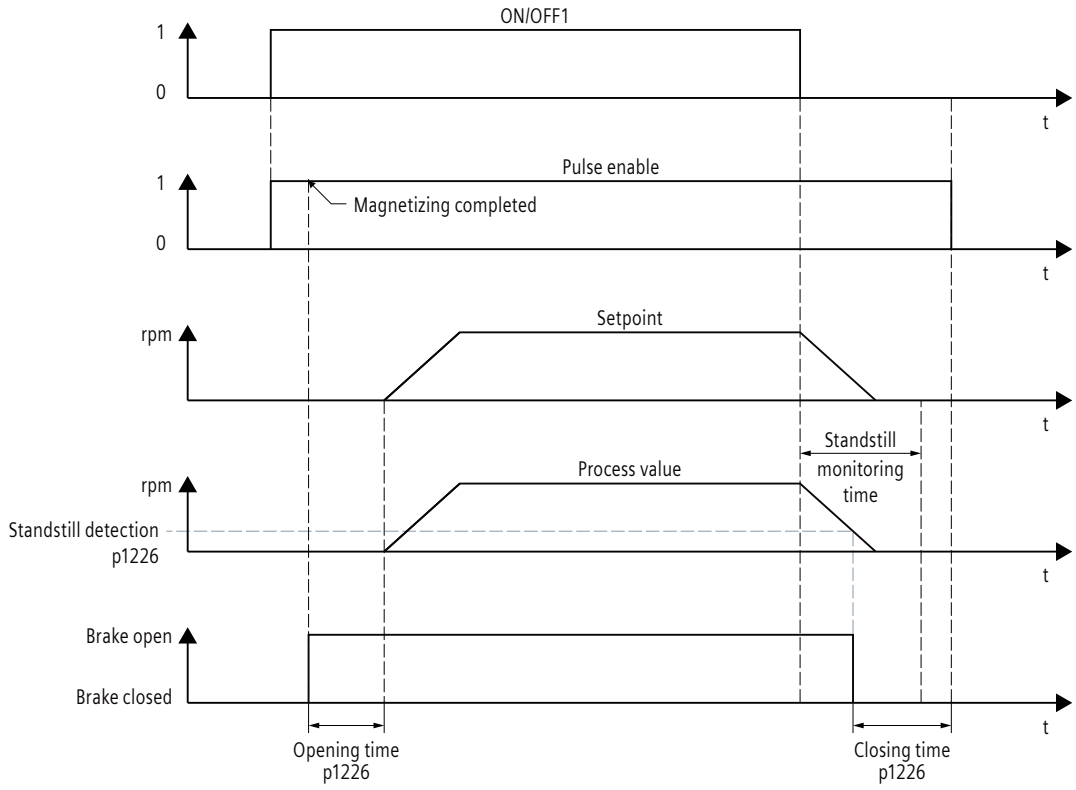

Figure 2-1561 Braking sequence

The magnetizing time is calculated automatically depending on the motor parameters.

The influence of the motor holding brake on the OFF reactions is described in section 7.6.4 OFF reaction.

NOTICE
Improper use Improper use of the motor brake will shorten its service life. The motor brake is only intended for holding purposes. Frequent emergency stops with the motor brake shorten its service life. Unless absolutely necessary, do not use the motor brake as emergency stop.

7.10 Messages/monitoring

Thermal monitoring

The purpose of thermal monitoring is to detect critical states. Parameterizable warning thresholds are available that allow further operation of the drive (e.g. with reduced power) and prevent an immediate shutdown. However, the parameter assignment options are only interventions below the shutdown thresholds.

The following thermal monitoring options are available:

- Motor
  - Motor I^2t model
- Braking resistor
  - Temperature model
- Power end stage
  - Overload protection
  - Temperature sensor

When an overload is detected by one of these monitoring functions, a warning is output first. The respective warning thresholds (p0291) are parameterizable. The current status of the monitoring functions is displayed. If an alarm or fault limit is exceeded, the "Temperature monitoring" message is sent.

NOTE

All alarm and fault limits are provided with a corresponding hysteresis. The corresponding alarm or fault messages therefore remain until the threshold including hysteresis has been fallen below.

NOTE

Motor and brake resistance values

The thermal motor and braking resistor utilization are calculated quantities. The values are not saved.

After a power reset, the values only match again after a sufficiently long cooling time.

Operating temperature

Note that the specified ambient temperature range for the drive must always be adhered to, see section Technical specifications (Page 140).

7.10.1 Motor

Thermal motor monitoring

The thermal motor monitoring is performed using a configurable I^2t temperature model.

WARNING

Thermal motor utilization cannot be immediately determined after initialization

The thermal model is reinitialized after changing the drive data set and when switching on the device.

After initialization, the thermal motor utilization cannot be immediately determined as the model must first settle. As a consequence, an initial utilization of 50 % is used as basis. The settling phase duration depends on the given thermal time constants; the accuracy depends on to what extent the specific installation situation deviates from the model.

During the settling time it is possible that the set alarm and/or fault threshold is reached with some delay. For the installation situation simulated in the model, a comparatively unfavorable installation was selected so that generally deviations occur on the safe side.

You can define the warning threshold under Parameters > Messages/monitoring > Motor relative to the respective shutdown threshold.

Procedure

1. Open the "Motor" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Motor I^2t model

The I2t monitoring operates with the relative motor power loss, and in addition to the nominal motor current (p0305) as reference value, only requires the thermal time constant winding - environment (p0611[0]) to calculate the limiting integral. The 100 % shutdown threshold corresponds to the maximum continuous power loss of the motor, i.e. to the square of the nominal motor current (p0305).

Motor type PMSM

If the PMSM reaches the 100% threshold, the motor current is limited to the rated motor current to prevent overheating.

WARNING

Compliance with the ambient conditions specified by the motor manufacturer

The motor may only be operated in ambient conditions such as ambient temperature, installation elevation, etc. as specified by the manufacturer.

If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. The derating behavior and the resulting lower motor performance data must be obtained from the motor manufacturer and adjusted accordingly in the motor parameters of the TM Drive.

If the motor is used outside its specification, the thermal model does not provide sufficient protection.

7.10.2 Braking resistor

Thermal monitoring of braking resistor

The braking resistor is monitored by a temperature model. You can specify the warning threshold (p0291[2]) relative to the shutdown threshold "Braking resistance maximum temperature" (p6023).

Procedure

1. Open the "Braking resistor" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[2].

WARNING

Thermal braking resistance load cannot be determined immediately after initialization

The thermal model is reinitialized after changing the drive data record and when switching on the device.

The thermal braking resistance load cannot be determined immediately after initialization because the model must settle. As a consequence, an initial utilization of 50 % is used as basis. The settling phase duration depends on the given thermal parameters; the accuracy depends on to what extent the specific installation situation deviates from the model. During the settling time it is possible that the set alarm and/or fault threshold is reached with some delay.

The installation situation should be taken into account for the thermal parameters of the braking resistor and, if necessary, less favorable parameters should be selected, for example, for the heat transfer resistance, so that deviations will generally occur towards the safe side.

7.10.3 Power end stage

Thermal monitoring of power end stage

The power end stage is monitored with a temperature sensor. You can specify the warning threshold (p0291[1]) relative to the shutdown threshold "System maximum temperature power end stage".

Procedure

1. Open the "Power end stage" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Besides the temperature monitoring, the current load is also monitored. The current load of the power unit is decisive for the temperature rise. The relative load of the power end stage is calculated based on the square of the output current according to the I^2t method.

Automatic overload limiting

The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

The maximum overload time $t_{overload}$ is calculated depending on the temperature of the power end stage TPU. When operating with cyclic overload, the rated power is not exceeded by the time-averaged power (rms).

PMSM

With a PMSM, a double overload of the rated current In cyclic for a duration of $t_{overload}$ = 3 s and a subsequent recovery time of 17 s at T_{PU} = 20 °C is possible. At T_{PU} = 80 °C, the overload time $t_{overload}$ ≈ 0.75 s.

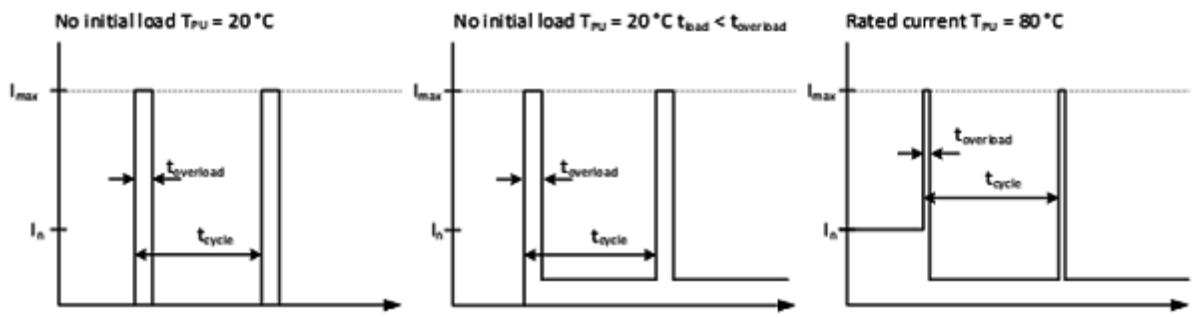

Figure 2-1562 Overload behavior of TM Drive

Observe the information on derating depending on the ambient conditions (e.g. temperature, mounting position) in the section Derating of the F-TM ServoDrive ST (Page 144)

NOTE

Overload capability of the power unit

Operation with a peak current of 10 A is possible temporarily if the average RMS value of the output current does not exceed the rated current of the power unit up to 5 A.

7.11 Dynamic torque reduction

If dynamic torque reduction is required, this can be realized using the MOMRED signal via drive telegram 102. The torque limit currently in effect in the drive is reduced via this setpoint. MOMRED is used to specify the percentage by which the torque limit is to be reduced.

$$M_{limit.actual} = M_{reference} \cdot \left(1 - \frac{MOMRED}{16384}\right)$$

NOTE

The MOMRED signal is normalized to 4000 hex (16384 dec). The value 4000 hex (16384 dec) in the MOMRED control word corresponds to a 100% reduction of the configured reference torque p2003.

The dynamic torque limit is set to the respective minimum of the configured torque limitation (p1520), the limitation via MOMRED or the limitation by the max. permissible torque-forming current value.

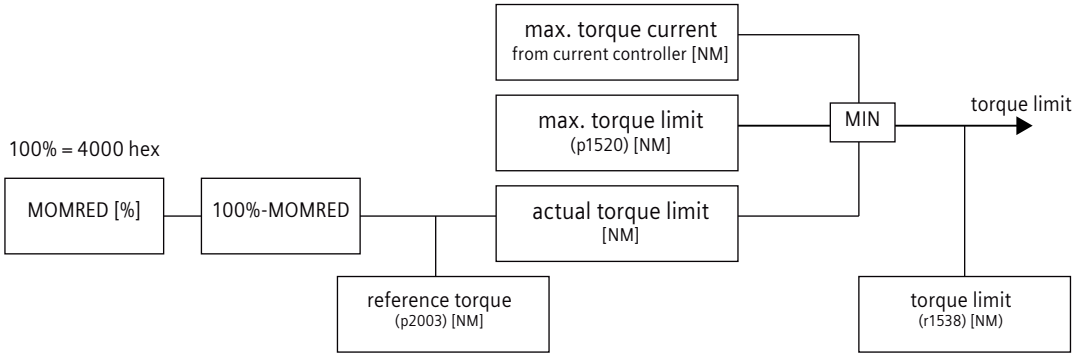

Figure 2-1563 Dynamic torque limitation (MOMRED)

The torque values that are output by the drive and the torque limitation currently in effect can be viewed under "Online & Diagnostics" > "Diagnostics" > "Drive Diagnostics" > "Operating Values" if an online connection to the drive is established.

The following actual values are available:

- Torque setpoint (at the output of the speed controller) (r0079)
- Torque actual value (r0080)
- Torque limit (r1538)

Programming 8

The TM Drive does not have its own control panel. A user program is required to control the motion sequences.

You have the following options for controlling the motion sequences in the user program:

- Control via the process image (Page 117)
- Control via the SINA_SPEED (Page 128) instruction
- Control with a technology object (Page 128)

8.1 Controlling TM Drive via the process image

Structure of the I/O addresses

The structure of the input addresses of the TM Drive depends on the configured communication telegram and the telegram extension.

The telegrams can be set in the "Properties" area under "General" and further via "Basic parameters". Set the Telegram extension active option to make the status available via the digital input and the status of the STO input via the process image.

NOTE

The telegram extension option is not available for telegram 102.

The structure of the output addresses of the TM Drive depends on the configured communication telegram.

Frame	**1**		**2**		**3**		**102**	
PZD1	STW1	ZSW1	STW1	ZSW1	STW1	ZSW1	STW1	ZSW1
PZD2	NSET_A	NACT_A	NSET_B	NACT_B	NSET_B	NACT_B	NSET_B	NACT_B
PZD3								
PZD4			STW2	ZSW2	STW2	ZSW2	STW2	ZSW2
PZD5					G1_STW	G1_ZSW	MOMRED	MELDW
PZD6						G1_XIST1	G1_STW	G1_ZSW
PZD7								G1_XIST1
PZD8						G1_XIST2		
PZD9								G1_XIST2
PZD10								

Standard telegram 1 Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Structure**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_MotorHoldingBrakeOpen	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_A	**Word**	**2.0**
Telegram extension word (only with telegram extension)	**Structure**	**4.0**
Reserved	Byte	4.0
Telegram extension STO_Status	Bool	5.0
Telegram extension DI_Status	Bool	5.1

Outputs

Element	Data type	Offset
Control word STW1	**Structure**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0

Element	Data type	Offset
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_A	**Word**	**2.0**

Standard telegram 2 Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word ZSW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5

Element	Data type	Offset
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Telegram extension word (only with telegram extension)	**Struct**	**8.0**
Reserved	Byte	8.0
Telegram extension STO_Status	Bool	9.0
Telegram extension DI_Status	Bool	9.1

Outputs

Element	Data type	Offset
Control word STW1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word STW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1

Element	Data type	Offset
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7

Standard telegram 3 Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_MotorHoldingBrakeOpen	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchON	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word ZSW2	**Struct**	**6.0**

Element	Data type	Offset
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder status word 1	**Struct**	**8.0**
Bit08_Probe1Deflected	Bool	8.0
Bit09_Probe2Deflected	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_EncoderFaultAcknowlegdeActive	Bool	8.3
Bit12_HomePositionExecuted	Bool	8.4
Bit13_AbsoluteValueCyclicallyExecuted	Bool	8.5
Bit14_ReservedParkingSensorExecuted	Bool	8.6
Bit15_ParkingSensorExecuted	Bool	8.7
Bit00_Function1Active	Bool	9.0
Bit01_Function2Active	Bool	9.1
Bit02_Function3Active	Bool	9.2
Bit03_Function4Active	Bool	9.3
Bit04_Value1Available	Bool	9.4
Bit05_Value2Available	Bool	9.5
Bit06_Value3Available	Bool	9.6
Bit07_Value4Available	Bool	9.7
Encoder position actual value 1 G1_XIST1	**DWord**	**10.0**
Encoder position actual value 2 G1_XIST2	**DWord**	**14.0**
Telegram extension word (only with telegram extension)	**Struct**	**18.0**

Element	Data type	Offset
Reserved	Byte	18.0
Telegram extension STO_Status	Bool	19.0
Telegram extension DI_Status	Bool	19.1

Outputs

Element	Data type	Offset
Control word STW1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word STW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5

Element	Data type	Offset
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder control word G1_STW	**Struct**	**8.0**
Bit08_Reserved	Bool	8.0
Bit09_Reserved	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_Reserved	Bool	8.3
Bit12_Reserved	Bool	8.4
Bit13_AbsoluteValueCyclically	Bool	8.5
Bit14_RequestParkingEncoder	Bool	8.6
Bit15_AcknowlegdeError	Bool	8.7
Bit00_Function1Request	Bool	9.0
Bit01_Function2Request	Bool	9.1
Bit02_Function3Request	Bool	9.2
Bit03_Function4Request	Bool	9.3
Bit04_Command0Request	Bool	9.4
Bit05_Command1Request	Bool	9.5
Bit06_Command2Request	Bool	9.6
Bit07_Mode	Bool	9.7

Siemens telegram 102: Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_MotorHoldingBrakeOpen	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchON	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4

Element	Data type	Offset
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word ZSW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Message word MELDW	**Word**	**8.0**
Encoder status word G1_ZSW	**Struct**	**10.0**
Bit08_Probe1Deflected	Bool	10.0
Bit09_Probe2Deflected	Bool	10.1
Bit10_Reserved	Bool	10.2
Bit11_EncoderFaultAcknowlegdeActive	Bool	10.3
Bit12_HomePositionExecuted	Bool	10.4
Bit13_AbsoluteValueCyclicallyExecuted	Bool	10.5
Bit14_ReservedParkingSensorExecuted	Bool	10.6
Bit15_ParkingSensorExecuted	Bool	10.7
Bit00_Function1Active	Bool	10.0
Bit01_Function2Active	Bool	11.1
Bit02_Function3Active	Bool	11.2
Bit03_Function4Active	Bool	11.3
Bit04_Value1Available	Bool	11.4
Bit05_Value2Available	Bool	11.5
Bit06_Value3Available	Bool	11.6

Element	Data type	Offset
Bit07_Value4Available	Bool	11.7
Encoder position actual value 1 G1_XIST1	**DWord**	**12.0**
Encoder position actual value 2 G1_XIST2	**DWord**	**16.0**

Outputs

Element	Data type	Offset
Control word STW1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word STW2	**Struct**	**4.0**
Bit08_Reserved	Bool	4.0
Bit09_Reserved	Bool	4.1
Bit10_Reserved	Bool	4.2
Bit11_Reserved	Bool	4.3
Bit12_Reserved	Bool	4.4
Bit13_Reserved	Bool	4.5
Bit14_Reserved	Bool	4.6
Bit15_Reserved	Bool	4.7
Bit00_Reserved	Bool	5.0
Bit01_Reserved	Bool	5.1
Bit02_Reserved	Bool	5.2
Bit03_Reserved	Bool	5.3
Bit04_Reserved	Bool	5.4
Bit05_Reserved	Bool	5.5

Element	Data type	Offset
Bit06_Reserved	Bool	5.6
Bit07_Reserved	Bool	5.7
Torque reduction MOMRED	**Word**	**6.0**
Encoder control word G1_STW	**Struct**	**8.0**
Bit08_Reserved	Bool	8.0
Bit09_Reserved	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_Reserved	Bool	8.3
Bit12_Reserved	Bool	8.4
Bit13_AbsoluteValueCyclically	Bool	8.5
Bit14_RequestParkingEncoder	Bool	8.6
Bit15_AcknowlegdeError	Bool	8.7
Bit00_Function1Request	Bool	9.0
Bit01_Function2Request	Bool	9.1
Bit02_Function3Request	Bool	9.2
Bit03_Function4Request	Bool	9.3
Bit04_Command0Request	Bool	9.4
Bit05_Command1Request	Bool	9.5
Bit06_Command2Request	Bool	9.6
Bit07_Mode	Bool	9.7

Basic procedure in STEP 7

1. In the project tree, create PLC data types in the CPU 2 with the appropriate structure for your configuration:
   - PLC data type for the structure of the input data (depending on PROFIdrive telegram type and telegram extension)
   - PLC data type for the structure of the output data (depending on PROFIdrive telegram type and telegram extension)
2. Create a tag from each type of the PLC data type in a tag table.
3. Assign the addresses for the tag according to the configured I/O addresses of the F-TM ServoDrive.
4. Control the F-TM ServoDrive by setting outputs bit-by-bit. You can find a description on how to set the outputs to control the F-TM ServoDrive in the PROFIdrive standard. You can find the current PROFIdrive specification under (https://www.profibus.com/).

8.2 Controlling a TM Drive via the instruction SINA_SPEED

Control with the SINA_SPEED instruction

For controlling the F-TM ServoDrive, you can also use the SINA-SPEED instruction from the "DriveLib" block library.

The SINA_SPEED block only works with the standard telegram 1. The telegram extension may have to be disabled. See Communication telegrams (Page 61).

The "DriveLib" block library can be downloaded from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109475044).

8.3 Controlling TM Drive with a technology object

Control with a technology object

You can also use a technology object, for example "Speed-controlled axis" or "Positioning axis", to control the TM Drive.

Note that the TM Drive itself does not have integrated positioning functionality and only supports speed operation.

Procedure

1. Create, for example, a "Speed axis" technology object in the CPU in the project tree in STEP 7.
2. Open the technology object.
3. Select the "TM Drive" under "Configuration" > "Hardware interface" > "Drive".
4. Reference the technology object in the user program using the Motion Control technology instructions, e.g. "MC-Power".

NOTE

We do not recommend using the "Encoder calibration at every startup" option in conjunction with positioning technology objects (positioning axis). The calibration process can lead to undesired behavior of the drive axis.

Additional information

You can find more information about the technology objects and technology instructions in the online help of STEP 7.

Maintenance 9

9.1 Firmware update

Firmware update

A firmware update is possible via PROFINET.

See SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

9.2 Stop responses

Overview of the stop responses

Faults with safety functions and violation of limits can trigger the following stop responses:

- "Hardware STO"

  "Safe Torque Off" (STO) corresponds to Stop Category 0 in accordance with EN 60204-1. With "Safe Torque Off" (STO), the motor is switched directly to zero torque. A motor at standstill cannot be started again accidentally. A moving motor coasts to standstill.

Table 2-2012 Overview of stop responses

Stop response	Triggered ...	Action	Effect
STO	At least one signal STO+/STO- is interrupted.	Motor controllers interrupted	Drive coasts down

After the drive has been stopped, restart it with PROFIdrive.

The faults and warnings are described in the appendix Active messages (Page 135).

Interrupts, error messages and diagnostics and system alarms

10

10.1 Status and error displays

LED display

The figure below shows the LEDs on the F-TM ServoDrive.

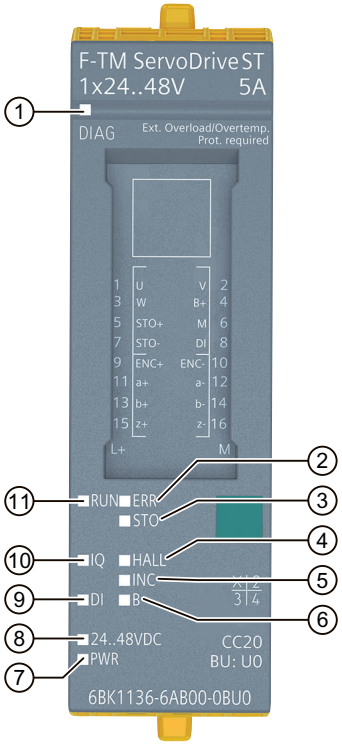

①	DIAG (red/green)	⑦	PWR (green)
②	ERR (red)	⑧	24..48V (green)
③	STO (yellow) Display not safety-related	⑨	DI (green)
④	HALL (green)	⑩	IQ (green)
⑤	INC (green)	⑪	RUN (green)
⑥	B (green)		

Figure 2-1564 LED display on F-TM ServoDrive

Meaning of the LED displays

The following tables contain the meanings of the status and error displays.

DIAG LED

Table 2-2013 DIAG status and error display

DIAG LED	Meaning	
□ Off	Backplane bus supply of the ET 200SP not OK	
☼ Flashing	Module parameters not assigned	
■ On	Module parameters assigned and no module diagnostics	
☼ Flashing	0.5 Hz (slow)	Module parameters assigned and module diagnostics There is a fault. You can find detailed information via "Online & Diagnostics" > "Diagnostics" > "Active messages" or in the section Active messages (Page 135).
	1 Hz (normal)	
	2 Hz (fast)	

RUN LED

Table 2-2014 RUN status and error display

RUN LED	Meaning	
□ Off	Device is not yet ready for operation	
■ On	Device is ready for operation and error-free	
☼ Flashing	0.5 Hz (slow)	Device is performing self-test during power-up
	1 Hz (normal)	Device performs a firmware update
	2 Hz (fast)	Device has detected a parameterization error

ERR LED

Table 2-2015 ERR status and error display

ERR LED	Meaning
□ Off	No fault
■ On	Device has a fault and needs to be restarted. This corresponds to a critical device fault.

DI LED

Table 2-2016 DI status and error display

DI LED	Meaning
□ Off	Input is faulty/inactive
■ On	Input is error-free/active

B LED

Table 2-2017 B status and error display

B LED	Meaning
■ On	The motor holding brake is open / information about the process image was set

STO LED

Table 2-2018 STO status and error display

STO LED	Meaning
■ On	Safety sensor is connected and has not tripped
☼ flashes (0.5 Hz)	Safety sensor has tripped (motor is disconnected from power)

IQ LED

Table 2-2019 Status and error display IQ (encoder)

IQ LED	Meaning
■ On	IQ speed encoder was assigned parameters/activated
☼ Flashes (2 Hz)	IQ speed encoder could not be initialized IQ speed encoder has a connection problem (A/B track not connected)

Hall LED

Table 2-2020 Status and error display Hall (encoder)

Hall LED	Meaning
■ On	Hall speed encoder was assigned parameters/activated

INC LED

Table 2-2021 Status and error display INC (encoder)

INC LED	Meaning
■ On	Incremental speed encoder was assigned parameters/activated
☼ Flashes (2 Hz)	Incremental speed encoder has a connection problem (A/B and/or Z track not connected)

24..48V LED

Table 2-2022 24..48V status and error display

24..48V LED	Meaning
□ Off	DC link voltage outside the configured limits
■ On	DC link voltage within the configured limits (is OK)
☼ flashes (0.5 Hz)	DC link voltage shortly before the interference threshold

PWR LED

Table 2-2023 PWR status and error display

PWR LED	Meaning
□ Off	Logic component supply of the converter is missing
■ On	Logic component supply of the converter is OK

10.2 Diagnostics

10.2.1 Diagnostics overview of the F-TM ServoDrive

Diagnostic view of the CPU and its associated I/O

If you go online to the CPU and establish an online connection via the CPU to the TM Drive, this occurs within the project context.

Procedure

To display the diagnostic information for the TM Drive, follow these steps.

1. Select the TM Drive in the project tree, for example under "Ungrouped devices".
2. Double-click "Online & diagnostics".
   The "Diagnostics - General" window appears.
3. Navigate to the required information.

The diagnostic window is divided into the following diagnostic groups:

- **General**

  The general diagnostic information is displayed for:

  – Module
  – Module information
  – Manufacturer information

- **Diagnostics status**

  "Diagnostics status" shows the current diagnostics status of the TM Drive.

- **Active messages**

  "Active messages" displays the currently pending alarms and faults in the TM Drive module.

- **Drive diagnostics**

  The current diagnostic information of the drive is displayed for:

  – Status bits
  – Operating values
  – Encoders
  – Temperatures
  – Inputs

10.2.2 Active messages

Pending faults and alarms

"Active messages" shows the currently pending faults and alarms in the TM Drive. Faults must be acknowledged after the cause has been corrected.

Procedure

To display the active messages, follow these steps:

1. Select the TM Drive in the project tree and go to "Online & diagnostics".
2. In the "Diagnostics" folder, select the "Active messages" area.

Faults and alarms

NOTE

In open-loop control operation, no diagnostics of the encoder signals is performed (see fault numbers 1045 and 1046)

The TM Drive supports the following faults.

Fault number	Description	S7 diagnostics alarm
1000	Overvoltage in the DC link	Undervoltage
1001	Undervoltage in the DC link	Overvoltage
1003	Shutdown due to overcurrent switch-off of a phase	Overload
1006	Braking resistor short-circuit	Overload
1019	External braking resistor/motor holding brake of the 4th phase interrupted	Wire break
1032	Temperature measured values implausible	Error
1035	Permitted temperature at the motor end stage exceeded	Overtemperature
1036	Permitted temperature at the motor winding exceeded	Overtemperature
1037	Permissible temperature of the braking resistor exceeded	Overtemperature
1039	Connection to IQ encoder interrupted	Wire break
1042	Fail-safe shutdown path (STO) defective	Safety-related shutdown
1043	Permissible temperature of the control electronics exceeded	Overtemperature
1044	Permissible temperature of the braking resistor exceeded The drive is switched off.	Overtemperature
1045	The connection to the A/B track of the incremental speed encoder is interrupted.	Wire break

Fault number	Description	S7 diagnostics alarm
1046	The connection to the Z track of the incremental speed encoder is interrupted.	Wire break
1047	An unsupported PROFIdrive speed encoder function was requested.	-
1049	Zero point calibration could not be performed. The rotor may be blocked. The motor holding brake may not be open.	External error
1050	A ramp/quick stop (OFF1/OFF3) could not be performed due to a timeout.	External error
1051	Zero point calibration could not be performed due to a timeout. The system may be oscillating too much.	External error
1053	Overload of the brake chopper control	Overload
1054	Permissible temperature at the motor winding when stepper motor exceeded	Overload
1055	Motor resistance detection could not be performed	Wire break
1056	Following error during controlled system detection	Overload
1057	Position error during controlled system detection	Overload
1200	CRC checksum error in absolute encoder	Error in actuator/sensor
1201	Internal encoder error in the absolute encoder	Error in actuator/sensor
1202	No communication with absolute encoder possible or communication establishment failed.	Wire break
1203	Internal error in encoder interface	Error
1300	There is an error in the parameter assignment of the motor type.	Parameterization error
1301	Electrical time constant of the q axis is too low.	Parameterization error
1302	Electrical time constant of the d axis is too low.	Parameterization error
1303	Torque constant inconsistent	Parameterization error
1340	There is an error in the parameter assignment of the encoder.	Parameterization error
1360	There is an error in the parameter assignment of the controller.	Parameterization error
1380	There is an error in the parameter assignment of the braking function.	Parameterization error
1999	General error	Error

Acknowledge faults

To acknowledge all active faults, click the "Acknowledge faults" button.

Alarms

Column	Description
Alarm number	Number of the warning
Description	Description of the warning

The F-TM ServoDrive supports the following warnings.

Alarm number	Description
2000	Voltage in the DC link shortly before shutdown
2001	STO shutdown active
2002	Warning threshold when motor end stage temperature is exceeded
2003	Warning threshold when motor winding temperature is exceeded
2004	Thermal overload of the motor end stage
2005	Thermal overload of the braking resistor
2007	Switch-on delay because axis is still rotating.

10.2.3 Drive diagnostics

You can find online information on important current drive diagnostics data and drive service data in the "Drive diagnostics" area under "Online & diagnostics" in the context of the drive.

NOTE

All drive diagnostics are only available online. They are automatically updated in the user interface.

You will find diagnostic information on the following points in the "Drive diagnostics" area:

- Status bits
- Operating values
- Encoders
- Temperatures
- Inputs

Properties of drive diagnostics

Drive diagnostics

- Show the current values of various parameters
- Are cyclically updated
- Are read-only.

Drive diagnostics: Status bits

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Status bits"

Table 2-2024 Drive diagnostics - status bits

Number	Parameter	Display/unit
Status word		
r0899	Status bits **Note**: Signal corresponds to status word 1 PROFIdrive (r0968).	• Ready for switching on • Ready for operation • Operation • Fault active • Coasting active • Rapid stop active • Switching on inhibited active • Alarm active • Speed setpoint - actual value deviation • Control by controller • n comparison value reached • Control of the motor holding brake is active **Note:** • Status word 1 is sent cyclically by the drive to the higher-level controller.

Drive diagnostics: Operating values

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Operating values"

Table 2-2025 Drive diagnostics - operating values

Number	Parameter	Display/unit
r0063	Speed actual value smoothed	rpm
r1045	Speed setpoint in front of the ramp-function generator	rpm
r0080	Torque actual value	Nm
r0079	Torque setpoint	Nm
r1538	Torque limit	Nm
r0026	DC link voltage	V
r0027	Current actual value	A_{eff}
r0072	Output voltage	V

Drive diagnostics: Encoders

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Encoder"

Table 2-2026 Drive diagnostics - encoder

Number	Parameter	Display/unit
r7811	Position	°
r7810[0]	Steps	-
p979[2]	Increments per revolution	-
P979[5]	Number of revolutions	-
p979[3]	Fine resolution bits in actual value Gx_XIST1	Bits
P979[4]	Fine resolution bits in actual value Gx_XIST2	Bits

Drive diagnostics: Temperatures

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Temperatures"

Table 2-2027 Drive diagnostics -temperatures

Number	Parameter	Display/unit
r0037[0]	Current microcontroller	°C
r0037[1]	Microcontroller max.	
r0037[4]	Power end stage	
r0037[5]	Power end stage max.	

Drive diagnostics: Inputs

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Inputs"

Table 2-2028 Drive diagnostics - inputs

Number	Parameter	Display/unit
-	Inputs	• Digital input • STO active

Reference

All displayed parameters have a tooltip that provides you with information and descriptions relating to the parameter as well as access to the online help.

You can find additional information on the parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

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11.1 Technical specifications

Technical specifications of the TM Drive

Article number	6BK1136-6AB00-0BU0
General information	
Product type designation	F-TM ServoDrive ST
HW functional status	V1.0
Firmware version	V1.3
• FW update possible	Yes
Product description	Control of EC motors
usable BaseUnits	BU type U0
Product function	
• I&M data	Yes
• Isochronous mode	No
• Four-quadrant operation	Yes
• Speed control with encoder	Yes
• Speed control without encoder	No
• Safety Functions	Yes; Drive controller with hardwired STO
Protection function	
• Undervoltage protection	Yes
• Overvoltage protection	Yes
• Overload protection	Yes
• Ground-fault protection	No
• Short-circuit protection	Yes
Installation type/mounting	
Type of ventilation	Convection cooling
Supply voltage	
Design of the power supply	24 ... 48 V DC, SELV / PELV
permissible range, lower limit (DC)	16.8 V
permissible range, upper limit (DC)	57.6 V

Article number	6BK1136-6AB00-0BU0
Input current	
Current consumption (rated value)	6 A
Current consumption, max.	10 A
Current consumption for the electronics, max.	0.1 A
Inrush current, max.	25 A; at 24 V
output voltage / header	
Rated value, min.	24 V
Rated value, max.	48 V
Output current	
Current output (rated value)	5 A
Output current, max.	10 A
Output frequency	599 Hz
Encoder supply	
Number of outputs	1
5 V encoder supply	
• 5 V	Yes
• Short-circuit protection	Yes
• Output current, max.	150 mA
Power	
DC power consumption	300 W; At 50 V
Power loss	
Power loss, typ.	3.5 W
Digital inputs	
Number of digital inputs	1; input for message signal
Number of safety inputs	1; For STO, antivalent (2-pin) - 24 V DC
Encoder	
Connectable encoders	
• Incremental encoder (symmetrical)	Yes; up to 500 Hz per channel
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	No
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• Group error	Yes
Diagnostics indication LED	
• RUN LED	Yes
• ERROR LED	Yes

Article number	6BK1136-6AB00-0BU0
Integrated Functions	
Position detection	
• Incremental acquisition	Yes
• Absolute acquisition	No
• Suitable for S7-1500 Motion Control	Yes
Potential separation	
Potential separation channels	
• between the channels and backplane bus	Yes
Isolation	
Isolation tested with	DC 850 V, type test (between backplane bus, DC input and functional grounding)
Overvoltage category	III
Degree of pollution	2 according to EN 61800-5-1
Degree and class of protection	
IP degree of protection	IP20
Standards, approvals, certificates	
CE mark	Yes
UKCA mark	Yes
cULus	Yes
RCM (formerly C-TICK)	Yes
KC approval	Yes
EAC (formerly Gost-R)	Yes
RoHS conformity	Yes
China RoHS compliance	Yes
Standard for EMC according to EN 61800-3	Yes
Standard for drive acc. to EN 61800-5-1	Yes
Standard for drive acc. to EN 61800-5-2	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	Category 3, performance level d, according to EN ISO 13849-1:2015
• SIL acc. to IEC 61508	2
• SIL according to DIN EN 61800-5-2	2
Ambient conditions	
Pollution degree during storage and transport	2
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted.
• horizontal installation, max.	60 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
• vertical installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted.

Article number	6BK1136-6AB00-0BU0
• vertical installation, max.	50 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
Ambient temperature during storage/transportation	
• Storage, min.	-30 °C
• Storage, max.	70 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3 000 m
Cables	
Cable length for motor, shielded, max.	10 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	55 g
Other	
Brake design	holding brake control via the process image
Braking chopper	Yes

Technical specifications of the IQ encoder

Type	IQ encoder
Output signals	2 square wave signals (A, B), 2 square wave signals inverse (nA, nB) Output differential or single ended TTL compatible, phase shifted
Number of pulses per revolution	100 (default)
Limit frequency	5 kHz
Supply voltage	+ 5 V (+/- 10 %)
Current consumption	Typ. 40 mA max. 100 mA
Permissible output current	Max. 20 mA
Permissible deviation of the pulse width from electrical 180°	+/- 90 °
Phase shift of channel A and B	Typ. 90 ° (+/- 30 °)
Output voltage (low level)	Typ. 0.25 V, max. 0.8 V (I = 20 mA at 5 V)
Output voltage (high level)	Typ. 4.25 V, max. 3.8 V (I = 20 mA at 5 V)
Permissible ambient temperature range (TU)	-25 °C ... +105 °C
Reverse polarity protection	Occurs due to a short-circuit of the supply voltage via a protective diode, max. 200 mA continuous current permissible

Climatic and mechanical environmental conditions

You can find the climatic and mechanical ambient conditions here SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

If there are discrepancies between the statements in this document and the system manual, the statements in the this document take priority.

Biological environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, IEC 60721-3-3: Edition 3.0, with the classes 1B1, 2B1 and 3B1 apply for the biological environmental conditions during operation, long-term storage and transport.

Conductive dust and sand

The TM Drive must not be exposed to conductive dust or sand during operation, long-term storage and transport.

Chemical environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, DIN EN 60721-3-3:1995, with the classes 1C2, 2C2 and 3C2 apply for the chemical environmental conditions during operation, long-term storage and transport.

11.2 Derating of the ET 200SP TM Drive

Maximum permitted output current as a function of installation altitude and ambient temperature

You must take into account the dependency on the ambient temperature and installation altitude.

Derating of the TM Drive depends on the installation elevation

For all permissible mounting types, starting from an installation altitude of 1000 m, a derating of 10% current per additional 1000 m elevation gain applies. The motor current and the output current of the outputs must be reduced.

All other functions do not have to be reduced up to the maximum installation altitude.

The figure below shows the maximum permitted output current as a function of the ambient air temperature for the derating.

Derating of the TM Drive depends on the ambient temperature (horizontal/vertical mounting position)

When installed horizontally (DIN rail horizontal), the TM Drive can be operated up to the maximum ambient temperature (60 °C). Note the derating curve.

With vertical mounting (vertical mounting rail), the TM Drive may be operated up to a maximum of 50 °C. Note the derating curve.

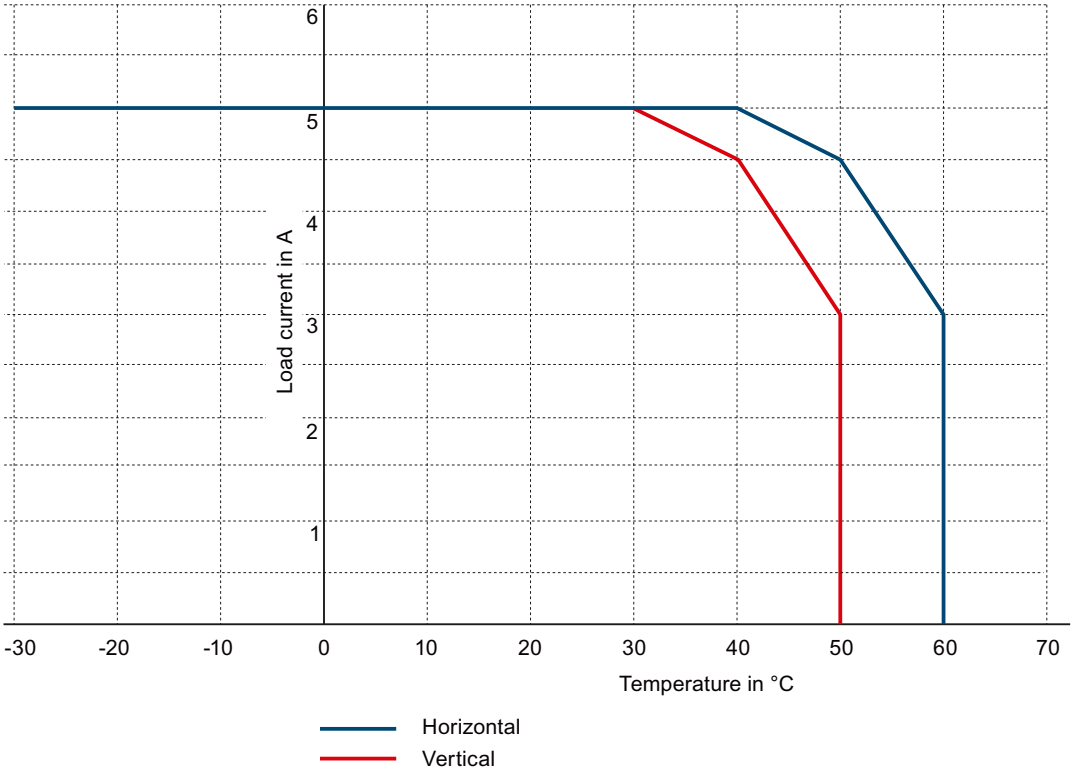

Figure 2-1565 Derating of the TM Drive

Test signal suppression

The STO inputs can be dark tested. The dark test time is up to 1 ms.

Appendix A

A.1 Response times

Introduction

Below you can find the response time of the TM Drive in STEP 7. The response times of the TM Drive are included in the calculation of the response time of the F-system.

The drive system is the component that provides the safety functions.

Definition of response time

The response time is the time between the detection of an input signal and the change of a linked output signal.

Definition of process safety time of a process

The process safety time of a process is the time between the occurrence of an error within which a process can be left unattended without risk to life and limb of the operating personnel or damage to the environment and the time of the completed reaction.

Any type of F-system control is tolerated within this process safety time, i.e. the F-system can control its processes incorrectly or even not at all. The process safety time of a process depends on the type of process and must be determined on a case-by-case basis.

Check that the process safety time of the process is not exceeded. You may need to reduce the specific monitoring times of the F-system.

Fluctuation width

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

Definition of maximum response time in an error-free scenario (worst case delay time, WCDT)

In the event of errors outside the drive system (e.g. incorrect setpoint setting by a controller, limit violations due to behavior of the motor, closed-loop control, load, etc.), the "maximum response time in an error-free scenario" is guaranteed.

Definition of maximum response time when an error is present (one fault delay time, OFDT)

In the event of a single error within the drive system (e.g. defect in a shutdown path of the power unit), the "maximum reaction time in the event of error" is guaranteed.

Times required for the calculation

Function	Maximum response time
STOP_STO via terminal	20 ms

STOP_STO:
With a STOP_STO, the drive safely switches off the torque of the connected motor immediately.

A.2 Braking resistor and brake chopper power

The maximum continuous current of the brake chopper end stage is 5 A. The end stage can be overloaded, so that higher currents / powers are possible for a short time.

The average braking current of 5 A is monitored using an I2t model. Once the end stage has fully cooled down, a braking current of 10 A is possible for approx. 15 s, for example.

Related to 60 s, this results in a load cycle of 25%. For other current values, the load cycle can be estimated using the following figure.

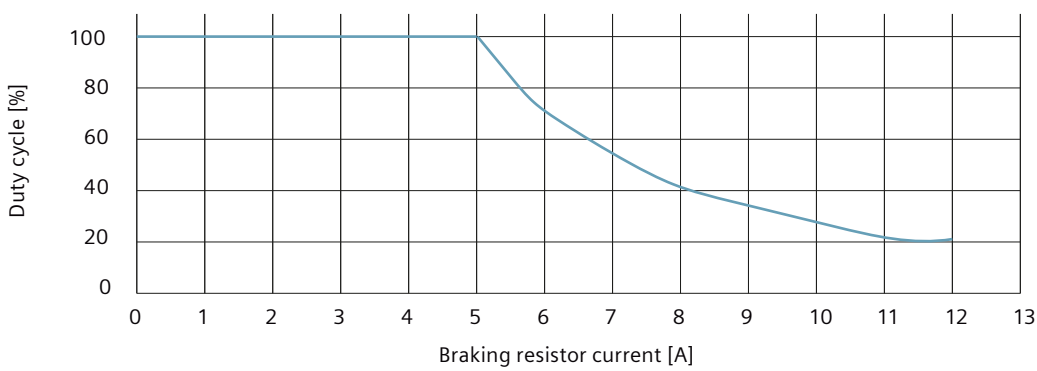

Figure 2-1566 Load cycle as a function of the braking resistor current

NOTE

The resistance of the externally connectable braking resistor must be ≥ 5 ohms.

Calculation of the continuous braking power of the end stage

The continuous power of the end stage can be estimated using the following formula.

$$P_{chopper_{rated}} = 0.5 \cdot (U_{on} + U_{off}) \cdot 5A$$

Table 2-2029 Examples of continuous power of the end stage

Average DC link voltage	Continuous power
26 V	130 W
50 V	250 W

Calculation of the continuous braking power as a function of the braking resistor

The average braking power of the braking resistor depends on the braking resistance value and the DC link voltage or the switch-on and switch-off values of the brake chopper (U_{on} p6010 and U_{off} p6011). It can be estimated with the following formula.

$$P_{brake\ resistor} = \frac{(0.5 \bullet (U_{on} + U_{off}))^2}{R_{brake\ resistor}}$$

Table 2-2030 Examples for braking resistor line

Average DC link voltage	Braking resistor value	Braking resistor power
26 V	5 Ω	135.2 W
	10 Ω	67.6 W
50 V	5 Ω	500 W
	10 Ω	250 W

Determination of the braking resistor peak power

In order to calculate the short-time peak power of the resistor, the configured switch-on voltage U_{on} p6010 of the brake chopper must be used.

$$P_{brake\ resistor_{max\ peak}} = \frac{U_{on}^{2}}{R_{brake\ resistor}}$$

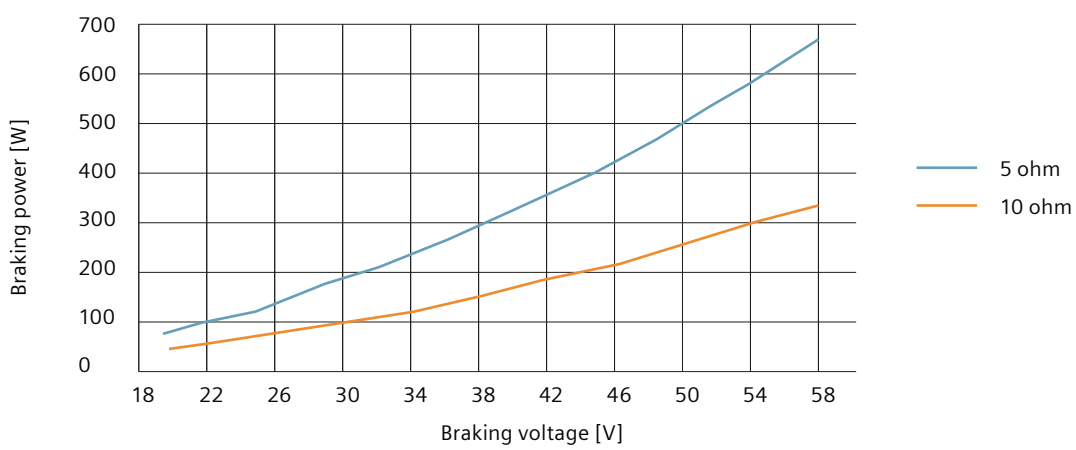

Figure 2-1567 Maximum peak power of the braking resistor

It must be checked whether the braking resistor can absorb the peak power and, if needed, the continuous power expected.

A.3 Data sets

You can find an overview of the data sets for the TM Drive and the structure of the data sets in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

A.4 Device disposal

Recycling and disposal

For environmentally-friendly recycling and disposal of your old device, please contact a company certified for the disposal of waste electrical and electronic equipment, and dispose of the old device as prescribed in the respective country of use.

NOTE

The device does not have its own memory. Neither personal data nor project-specific data are stored on it. It is not necessary to reset the memory for data security reasons.

A.5 Directives and standards

Directives and standards that are complied with

TM Drive complies with the requirements of the following directives and standards:

European Machinery Directive

TM Drive meets the requirements of the Machinery Directive, 2006/42/EU through compliance with EN 61800-5-2, insofar as the equipment is used within the area of application of this directive.

TM Drive has been fully evaluated for compliance with the material provisions relating to health and safety in the directive when used in a typical machine application.

European EMC Directive

The compliance of TM Drive with the regulations of Directive 2014/30/EU has been verified through full compliance with EN 61800-3.

Safety Integrated

TM Drive complies with the requirements for functional safety/machine safety.

RoHS

TM Drive complies with Directive 2011/65/EU on the restriction of the use of certain hazardous substances.

Underwriters Laboratories (North American market)
TM Drive equipment bearing any of the test symbols shown to the left complies with the requirements for the North American market as a component of drive applications and is listed accordingly.

- UL file number for DC mains connection: E229808

Eurasian conformity
TM Drive complies with the requirements of the Eurasian Customs Union (EAC).

Australia and New Zealand (RCM formerly C-Tick)
TM Drive equipment bearing the symbol shown complies with the EMC requirements for Australia and New Zealand.

EMC requirements for South Korea
TM Drive equipment bearing the KC symbol on the rating plate complies with the EMC requirements for South Korea.

Certificates for download

- EC declaration of conformity:
- Certificates for the relevant directives, prototype test certificates, manufacturers declarations and test certificates for functions relating to functional safety ("Safety Integrated"): (https://support.industry.siemens.com/cs/ww/en/ps/26085/cert)
- Certificates of products that were certified by UL: (https://iq.ulprospector.com)

Standards that are not relevant

China Compulsory Certification
TM Drive does not fall within the scope of China Compulsory Certification (CCC).

UKCA - United Kingdom Conformity Assessed

The TM Drive series complies with the conformity requirements for England, Scotland and Wales.

China RoHS

The TM Drive drive series complies with the China RoHS.

You will find more information at:
China RoHS (https://support.industry.siemens.com/cs/ww/en/ps/26085/cert)

SIEMENS

SIMATIC

ET 200SP
F-TM ServoDrive HF 1x24..48V 5A

Equipment Manual

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Introduction 1

1.1 About SIMATIC Micro-Drive

SIMATIC MICRO-DRIVE

SIMATIC MICRO-DRIVE is the drive system for safety extra-low voltages of 24 V to 48 V. Comprising SIMATIC MICRO-DRIVE, versatile motors and connecting cables from selected product partners, it extends the SIEMENS portfolio in the safety extra-low voltage area.

Suitable controllers from the SIMATIC range round out the motion control functionalities.

SIMATIC MICRO-DRIVE TM Drives

TM Drives is a technology module for SIMATIC ET 200SP. It can be controlled by a SIMATIC S7-1500/1200, including via technology objects (TO). TM Drives can be used in combination with a Distributed Controller or the SIMATIC ET 200SP Open Controller in decentralized system concepts.

1.2 About this information for use

1.2.1 Contents

To illustrate possible application areas for our products, typical use cases are listed in this product documentation and in the online help. These are purely exemplary and do not constitute a statement on the suitability of the respective product for applications in specific individual cases. Unless explicitly contractually agreed, Siemens assumes no liability for such suitability. Suitability for a particular application in specific individual cases must be assessed by the user, taking into account all technical, legal, and other requirements on a case-by-case basis. Always observe the descriptions of the technical properties and the relevant constraints of the respective product contained in the product documentation.

Content of the Equipment Manual

This Equipment Manual supplements the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that generally relate to the system are described in the System Manual.

The information provided in this Equipment Manual and in the System/Function Manuals supports you in commissioning the system.

Firmware versions

This manual is valid for firmware version FW 2.1 and current HSP versions from V18 and for the corresponding GSDML version.

NOTE

The current firmware versions can be found in Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/109801314).

Conventions

CPU: When the term "CPU" is used in the following, it applies to the central modules of the S7-1500 automation system, the S7-1200 automation system, as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

This documentation should be kept in a location where it can be easily accessed and made available to the personnel responsible.

Information regarding third-party products

NOTE

Recommendation relating to third-party products

This document contains recommendations relating to third-party products. Siemens accepts the fundamental suitability of these third-party products.

You can use equivalent products from other manufacturers.

Siemens does not accept any warranty for the properties of third-party products.

1.2.2 Target group

The Equipment Manual is intended for:

- Assemblers
- Commissioning engineers
- Operators
- Service personnel
- Project engineers

1.2.3 Standard scope

The functions of the system as delivered can only be found in the order documents.

Further functions may be executable in the system, which are not explained in this documentation. However, there is no entitlement to these functions in the case of a new delivery or service.

This documentation does not contain all detailed information on all types of the product. Furthermore, this documentation cannot take into consideration every conceivable type of installation, operation and service/maintenance.

The machine manufacturer must document any additions or modifications they make to the product themselves.

1.2.4 Use of third-party products in this documentation

This documentation contains recommendations relating to third-party products. Siemens accepts the fundamental suitability of these third-party products. You can use equivalent products from other manufacturers.

Siemens does not accept any warranty for the use of third-party products.

1.2.5 Websites of third-party companies

This document may contain hyperlinks to third-party websites. Siemens is not responsible for and shall not be liable for these websites and their content. Siemens has no control over the information which appears on these websites and is not responsible for the content and information provided there. The user bears the risk for their use.

1.3 SIMATIC documentation

1.3.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Figure 2-1568 Icon for device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/ww/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.automation.siemens.com/WW/view/en/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.3.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.4 Service & Support

1.4.1 ID link and Siemens Online Support

You can find additional information about the product:

- via ID link
- using the Siemens Industry Online Support
  - Website: SIOS
  - App Industry Online Support (for Apple iOS and Android)

Product-specific information via ID link

The QR code on your product and on the product packaging contains the ID link.

ID link is a globally unique identifier according to IEC 61406-1.

You can use the ID link to access product data, manuals, Declarations of Conformity, certificates and other information about your product.

Figure 2-1569 QR code with ID link included

The ID link is characterized by a frame with a black corner at the bottom right.

Content of Siemens Online Support

- Product support
- Global forum for information and best practice sharing between users and specialists
- Local contact persons via the contact person database (→ Contact)
- Product information
- FAQs (frequently asked questions)
- Application examples
- Manuals

- Downloads
- Compatibility tool
- Newsletter with product selection
- Catalogs/brochures
- Certificates

See also

SIOS (https://support.industry.siemens.com/cs/ww/en/)

1.4.2 Spare parts services

The online spare part service "Spares on Web (https://www.sow.siemens.com)" offers spare parts for the product.

1.4.3 FAQ

You will find FAQs on TM Drive on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/26085/faq).

1.5 Important product information

1.5.1 Intended use

This equipment is used for the open-loop and closed-loop control of EC and stepper motors for safety extra-low voltages up to 48 V DC.

⚠ WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Intended use of hardware products

This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens.

Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults.

EU note: Start-up/commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed fulfills the regulations/specifications of Directive 2006/42/EC.

1.6 Safety Evaluation Tool (SET)

You can quickly and easily evaluate the safety functions of your machine using the Safety Evaluation Tool (SET) for the IEC 62061 and ISO 13849-1 standards. You receive the results as a standard-compliant report that can be integrated in the machine documentation as proof of safety.

The free Safety Evaluation Tool is available on the Internet (https://new.siemens.com/global/en/products/automation/topic-areas/safety-integrated/factory-automation/support/safety-evaluation-tool.html).

Fundamental safety instructions 2

2.1 General safety instructions

WARNING

Electric shock and danger to life due to other energy sources

Touching live components can result in death or severe injury.

- Only work on electrical devices when you are qualified for this job.
- Always observe the country-specific safety rules.

Generally, the following steps apply when establishing safety:

1. Prepare for disconnection. Notify all those who will be affected by the procedure.
2. Isolate the drive system from the power supply and take measures to prevent it being switched back on again.
3. Wait until the discharge time specified on the warning labels has elapsed.
4. Check that there is no voltage between any of the power connections, and between any of the power connections and the protective conductor connection.
5. Check whether the existing auxiliary supply circuits are de-energized.
6. Ensure that the motors cannot move.
7. Identify all other dangerous energy sources, e.g. compressed air, hydraulic systems, or water. Switch the energy sources to a safe state.
8. Check that the correct drive system is completely locked.

After you have completed the work, restore the operational readiness in the inverse sequence.

WARNING

Risk of electric shock and fire from supply networks with an excessively high impedance

Excessively low short-circuit currents can lead to the protective devices not tripping or tripping too late, and thus causing electric shock or a fire.

- In the case of a conductor-conductor or conductor-ground short-circuit, ensure that the short-circuit current at the point where the converter is connected to the line supply at least meets the minimum requirements for the response of the protective device used.
- You must use an additional residual-current device (RCD) if a conductor-ground short circuit does not reach the short-circuit current required for the protective device to respond. The required short-circuit current can be too low, especially for TT supply systems.

WARNING

Risk of electric shock and fire from supply networks with an excessively low impedance

Excessively high short-circuit currents can lead to the protective devices not being able to interrupt these short-circuit currents and being destroyed, and thus causing electric shock or a fire.

- Ensure that the prospective short-circuit current at the line terminal of the converter does not exceed the breaking capacity (SCCR or Icc) of the protective device used.

WARNING

Electric shock if there is no ground connection

For missing or incorrectly implemented protective conductor connection for devices with protection class I, high voltages can be present at open, exposed parts, which when touched, can result in death or severe injury.

- Ground the device in compliance with the applicable regulations.

WARNING

Electric shock due to connection to an unsuitable power supply

When equipment is connected to an unsuitable power supply, exposed components may carry a hazardous voltage. Contact with hazardous voltage can result in severe injury or death.

- Only use power supplies that provide SELV (Safety Extra Low Voltage) or PELV- (Protective Extra Low Voltage) output voltages for all connections and terminals of the electronics modules.

WARNING

Electric shock due to equipment damage

Improper handling may cause damage to equipment. For damaged devices, hazardous voltages can be present at the enclosure or at exposed components; if touched, this can result in death or severe injury.

- Ensure compliance with the limit values specified in the technical data during transport, storage and operation.
- Do not use any damaged devices.

WARNING

Electric shock due to unconnected cable shield

Hazardous touch voltages can occur through capacitive cross-coupling due to unconnected cable shields.

- As a minimum, connect cable shields and the conductors of power cables that are not used (e.g. brake cores) at one end at the grounded housing potential.

WARNING

Arcing when a plug connection is opened during operation

Opening a plug connection when a system is in operation can result in arcing that may cause serious injury or death.

- Only open plug connections when the equipment is in a voltage-free state, unless it has been explicitly stated that they can be opened in operation.

NOTICE

Material damage caused by an incorrect power connection

An incorrect power connection can result in damage due to fire, device defects or malfunctions.

- Check all power connections at regular intervals, particularly after equipment has been transported.

WARNING

Electromagnetic interference due to inadequate shield support

A lack of adequate shield support for the power cables can cause malfunctions and impermissibly high levels of interference.

- Use the shield connection plates supplied or recommended.
- Use the shield connection clips recommended.

WARNING

Active implant malfunctions due to electromagnetic fields

Converters generate electromagnetic fields (EMF) in operation. Electromagnetic fields may interfere with active implants, e.g. pacemakers. People with active implants in the immediate vicinity of an converter are at risk.

- As the operator of an EMF-emitting installation, assess the individual risks of persons with active implants.
- Observe the data on EMF emission provided in the product documentation.

⚠ CAUTION

Symptomatic respiratory and skin reaction to chemicals

A newly purchased product might contain traces of substances that are identified as sensitizers.

Sensitizers are substances which can cause sensitization in the lungs and skin after exposure to them.

Once sensitized, individuals can have severe reactions to further exposure, even in small amounts. In the most extreme cases, individuals might develop asthma or dermatitis respectively.

- If the product has a strong smell, keep it in a well-ventilated area for 14 days.

⚠ WARNING

Unexpected machine movement caused by radio devices or cellphones

Using radio devices, cellphones, or mobile WLAN devices in the immediate vicinity of the components can result in equipment malfunction or faults and damage to the devices. Malfunctions may impair the functional safety of machines and can therefore put people in danger or lead to property damage.

- Avoid operating radio devices, cellphones and mobile WLAN devices in the direct vicinity of converters and operating units.
- Scan the machine readable code, e.g. a QR code, from a greater distance or switch off the converter power supply before scanning.
- Only operate built-in devices with the control cabinet doors closed.
- When control cabinet doors are open, only qualified electrical personnel are allowed to carry out service and maintenance work.

⚠ CAUTION

Radio frequency interference in residential areas

When you operate EMC category C2 devices in residential areas, the devices can cause radio frequency interference.

When you operate EMC category C3 or C4 devices in residential areas, it is to be expected that the devices will cause radio frequency interference.

- Do not operate EMC category C2 devices in residential areas.
- Do not operate EMC category C3 or C4 devices in public low-voltage networks supplying residential buildings.

NOTE

It cannot be guaranteed that EMC emission limits are complied with if the products are connected to an isolated line supply, a line supply grounded through a high ohmic connection or a line supply with a grounded line conductor.

- Draw-up an EMC plan to comply with the EMC requirements of the planned application.

⚠ WARNING

Fire due to inadequate ventilation clearances

Inadequate ventilation clearances can cause overheating of components with subsequent fire and smoke. This can cause severe injury or even death. This can also result in increased downtime and reduced service lives for devices/systems.

- Ensure compliance with the specified minimum clearance as ventilation clearance for the respective component.

NOTICE

Overheating due to inadmissible mounting position

The device may overheat and therefore be damaged if mounted in an inadmissible position.

- Only operate the device in admissible mounting positions.

NOTICE

Device damage caused by incorrect insulation resistance tests

High test voltages can damage the device.

- Measure the insulation resistance of low voltage circuits of machines or systems only with ≤ 500 V DC.
- Measure the insulation resistance of SELV circuits of machines or systems only with ≤ 250 V DC.

NOTICE

Device damage caused by incorrect voltage tests

High test voltages can damage the device. Capacitive leakage currents can distort the test results.

- Disconnect the components before carrying out a voltage test on the machine. [1)]

[1)] The components are voltage tested in accordance with the IEC 61800-5-1 product standard and must be disconnected during testing in accordance with IEC 60204-1:2021 Section 18.4.

WARNING

Unexpected movement of machines caused by inactive safety functions

Inactive or non-adapted safety functions can trigger unexpected machine movements that may result in serious injury or death.

- Observe the information in the appropriate product documentation before commissioning.
- Carry out a safety inspection for functions relevant to safety on the entire system, including all safety-related components.
- Ensure that the safety functions used in your drives and automation tasks are adjusted and activated through appropriate parameterizing.
- Perform a function test.
- Only put your plant into live operation once you have guaranteed that the functions relevant to safety are running correctly.

WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings

As a result of incorrect or changed parameterization, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameterization against unauthorized access.
- Handle possible malfunctions by taking suitable measures, e.g. emergency stop or emergency off.

2.2 Equipment damage due to electric fields or electrostatic discharge

Electrostatic sensitive devices (ESD) are individual components, integrated circuits, modules or devices that may be damaged by either electric fields or electrostatic discharge.

NOTICE

Equipment damage due to electric fields or electrostatic discharge

Electric fields or electrostatic discharge can cause malfunctions through damaged individual components, integrated circuits, modules or devices.

- Only pack, store, transport and send electronic components, modules or devices in their original packaging or in other suitable materials, e.g conductive foam rubber of aluminum foil.
- Only touch components, modules and devices when you are grounded by one of the following methods:
  - Wearing an ESD wrist strap
  - Wearing ESD shoes or ESD grounding straps in ESD areas with conductive flooring
- Only place electronic components, modules or devices on conductive surfaces (table with ESD surface, conductive ESD foam, ESD packaging, ESD transport container).

2.3 Warranty and liability for application examples

Application examples are not binding and do not claim to be complete regarding configuration, equipment, or any eventuality which may arise. Application examples do not represent customer-specific solutions, but merely serve to provide assistance with typical tasks.

As the user you yourself are responsible for ensuring that the products described are operated correctly. Application examples do not relieve you of your responsibility for safe handling when using, installing, operating and maintaining the equipment.

2.4 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Further information is provided on the Internet:
Configuration Manual Industrial Cybersecurity
(https://support.industry.siemens.com/cs/ww/en/view/109975311)

WARNING

Unsafe operating states resulting from software manipulation

Software manipulations, e.g. viruses, Trojans, or worms, can cause unsafe operating states in your system that may lead to death, serious injury, and property damage.

- Keep the software up to date.
- Incorporate the automation and drive components into a state-of-the-art, integrated industrial cybersecurity concept for the installation or machine.
- Make sure that you include all installed products in the integrated industrial cybersecurity concept.
- Protect files stored on exchangeable storage media from malicious software by with suitable protection measures, e.g. virus scanners.
- Carefully check all cybersecurity-related settings once commissioning has been completed.

2.5 Residual risks of power drive systems

When assessing the machine or system-related risk in accordance with the respective local regulations (e.g. EC Machinery Directive), the machine manufacturer or system integrator must take into account the following residual risks emanating from the control and drive components of a drive system:

1. Unintentional movements of driven machine or system components during commissioning, operation, maintenance, and repairs caused by, for example,
   - Hardware faults and/or software errors in the sensors, control system, actuators, and connections
   - Response times of the control system and of the drive
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - Parameterization, programming, cabling, and installation errors
   - Use of wireless devices/mobile phones in the immediate vicinity of electronic components
   - External influences/damage
   - X-ray, ionizing radiation and cosmic radiation

2. Unusually high temperatures inside and outside the components, including open flames, as well as emissions of light, noise, particles, gases, etc. due to fault conditions, e.g.:
   - Component failure
   - Software errors
   - Operation and/or environmental conditions outside the specification
   - External influences/damage
   - Short circuits or ground faults in the intermediate DC circuit of the converter
3. Hazardous shock voltages caused by, for example:
   - Component failure
   - Influence during electrostatic charging
   - Induction of voltages in moving motors
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - External influences/damage
4. Electrical, magnetic and electromagnetic fields generated in operation that can pose a risk to people with a pacemaker, implants or metal replacement joints, etc., if they are too close
5. Release of environmental pollutants or emissions as a result of improper operation of the system and/or failure to dispose of components safely and correctly
6. Influence of network-connected and wireless communications systems, e.g. ripple-control transmitters or data communication via the network or mobile radio, WLAN or Bluetooth.
7. Motors for use in potentially explosive areas:

   When moving components such as bearings become worn, this can cause enclosure components to exhibit unexpectedly high temperatures during operation, creating a hazard in areas with a potentially explosive atmosphere.

For more information about the residual risks of the drive system components, see the relevant sections in the technical user documentation.

Product overview

3

3.1 Area of application

Broad range of control applications

The SIMATIC ET 200SP distributed I/O system offers the necessary flexibility and performance for a wide range of control applications.

The F-TM ServoDrive HF is a product from the TM Drive range of modules in the ET 200SP network. The term TM Drive is synonymous with the F-TM ServoDrive HF in this manual.

The F-TM ServoDrive HF technology module offers you the following application possibilities:

- Variable speed control
- Positioning tasks in combination with higher-level controller
- In the area of safety extra-low voltage ≤ 60 V DC with integrated hardware Safety function Safe Torque Off (STO)

Areas of application

TM Drives have proven to be an ideal and compact drive in many applications.

Examples of applications:

- Packaging machines
- Automatic assembly machines
- Electronics and battery production
- Printing and labeling machines
- Winders/unwinders, e.g. in the textile, packing and printing and solar industries
- Driving of shuttles for storage and retrieval machines and storage rack systems
- Automated guided vehicle systems
- Battery-powered applications

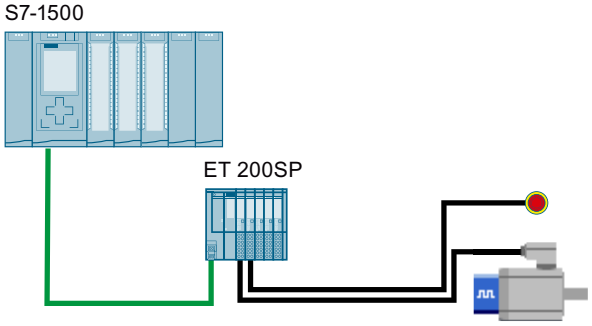

Figure 2-1570 Overview of standard variant with standard CPU

3.2 Properties

Article number

6BK1136-6AB00-0CU0

View of the module

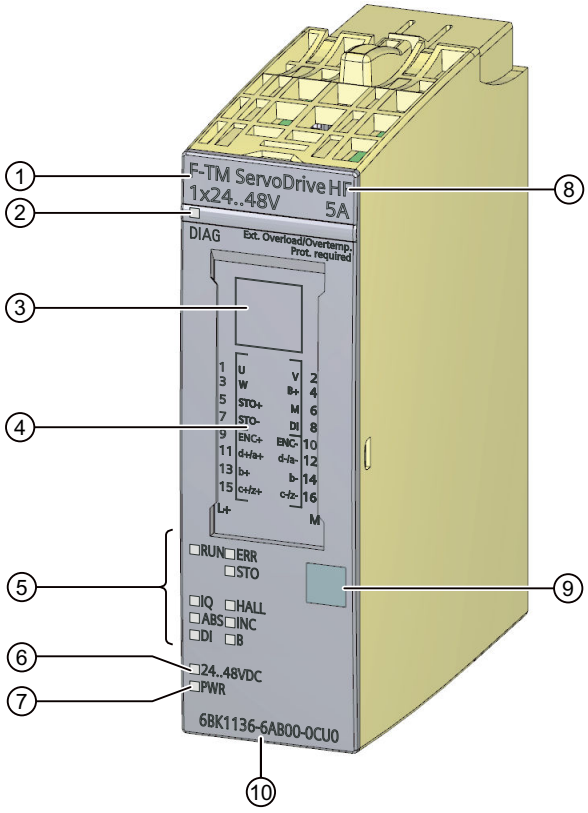

①	Module type and designation	⑧	Function class
②	LED for diagnostics	⑨	Color coding of module type
③	2D matrix code	⑩	Article number
④	Wiring diagram		
⑤	LEDs for motor control		
⑥	LED for supply voltage		
⑦	LED for power		

Figure 2-1571 View of the F-TM ServoDrive HF module

Properties

The F-TM ServoDrive HF has the following properties:

- Operation on ET 200SP PROFINET IMs as of V4.0
- Operation on CPU 151x as of V2.0, S7-1200, OpenController and CPU 151xSP
- Speed-controlled single-axis drive with PROFIdrive profile
- Rated voltage of the drive module: 24 to 48 V DC (safety extra-low voltage)
- Support of IQ encoder technology
- Support of incremental encoders with (A, B, Z track)
- Support of BiSS-C absolute encoders
- 24 V digital input
- Support of individually configurable motors (permanent-magnet synchronous motor (PMSM) and bipolar stepper motors)
- Controller parameter determination possible using HSP
- Thermal monitoring of the motor and the power end stage
- Braking chopper, external braking resistor
- Thermal monitoring of the braking resistor
- Cyclic overload capability
- Safety function STO hardwired
- Motor holding brake external via the process image
- Integrated engineering in STEP 7 (TIA Portal) via Hardware Support Package HSP0311 as of V16

Accessories

The following accessories that are not included in the module's scope of delivery can be used with the module:

Designation	Article number
Feed BaseUnit (light)*	6ES7193-6BP00-0DU0
Expansion BaseUnit (dark)*	6ES7193-6BP00-0BU0
MCB, B, 6 A	5SY6106-6
MCB, B, 10 A	5SY6110-6
MCB, B, 6 A for UL markets	5SJ4106-6HG40
MCB, B, 10 A for UL markets	5SJ4110-6HG40
Shield connection	6ES7193-6SC00-1AM0

* A BaseUnit of the type U0 (6ES7193-6BP00-0DU0 or 6ES7193-6BP00-0BU0) is needed for operation of the TM Drive. You can find an overview of the BaseUnits that you can use with the technology module in the Equipment Manual SIMATIC ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/109751716).

For additional information on accessories such as:

- Labeling strips
- Color-coded labels
- Reference identification labels

refer to the System Manual SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

NOTE
Unsuitable electronic fuses
Electronic fuses that disconnect the output voltage briefly in case of an overload and are not capable of power feedback (e.g. SITOP SEL1200) are not suitable for fuse protection.

3.3 Supported functions

System functions

The TM Drive supports the following PROFINET IO functions:

- Firmware update via PROFINET IO

The TM Drive supports the function:

- Identification data I&M 0 to 3

PROFIdrive communication types

TheTM Drive supports the following types of communication:

- Cyclic data exchange via a cyclic data channel

  Motion control systems require cyclically updated data during operation for open-loop and closed-loop control. This data must be sent as setpoints to the drive devices or read as actual values from the drive devices via the communication system. The transfer of this data is normally time-critical.
- Acyclic data exchange via an acyclic data channel

  An acyclic parameter channel for exchange of parameters between the CPU or supervisor and the drive devices is additionally available. Access to this data is not time-critical.
- Alarm channel

  Alarms are output event-triggered and indicate incoming and outgoing error states.

PROFIdrive application classes

The TM Drive supports Application Classes 1 and 4 of the PROFIdrive profile as of V4.2.

- Class 1 (AC1)

  The drive is controlled via a speed setpoint using PROFINET.

  The closed-loop speed control takes place entirely in the drive.

  Typical applications are, for example, simple frequency converters for pump and fan control.

- Class 4 (AC4)

  This PROFIdrive application class defines a speed setpoint interface with the closed-loop speed control taking place in the drive and the closed-loop position control taking place in the CPU, as is required for robot and machine tool applications with coordinated motion sequences on multiple drives.

Wiring

4

4.1 Pin assignment

Specific application

Observe the safety and accident prevention regulations applicable for specific applications, e.g. "Safety of Machinery EN ISO 13849-1".

During wiring and maintenance work, the TM Drive must be disconnected from the power supply.

EMERGENCY OFF equipment

EMERGENCY OFF devices according to IEC 60204 (corresponds to DIN VDE 0113) must remain in effect in all operating modes of the plant or system.

The drive-integrated safety function STO of the TM Drive does not replace the EMERGENCY OFF mechanism of the plant.

Excluding hazardous plant states

Hazardous operating states must not occur when

- The plant restarts up after a voltage dip or voltage failure
- Bus communication resumes after a fault

If necessary, the EMERGENCY OFF must be forced!

An uncontrolled or undefined startup must not occur after the EMERGENCY OFF is unlocked.

You can find a description on how to prevent uncontrolled startup in the section Safety Integrated functions (Page 47).

Potential group

Up to a continuous input current of max. 10 A for each potential group, up to 3 TM Drives can be connected together to form a drive line-up.

No other ET 200SP components may be located within a potential group consisting of one or more TM Drive.

A TM Drive potential group can be supplied as follows:

- With a separate power supply unit
- With a common power supply that also supplies other components. In this case, use a DC line filter (e.g. TDK Electronics 2-wire filter B84113C series) before the TM Drive potential group.

- If you are using a power supply unit with a rated current of more than 10 A or batteries/rechargeable batteries, it is imperative to connect a circuit breaker of characteristic B with max. 10 A rated current, approved for direct current and the corresponding SELV / PELV voltage, upstream of the TM Drive potential group. For a potential group with only one TM Drive, we recommend using an appropriate miniature circuit breaker with 6 A nominal current and characteristic B.
- You must not use voltage sources with low impedance such as supercaps without adequate current-limiting protective measures.

Short circuits

The power outputs of the TM Drive are short-circuit proof. If the module detects a short-circuit, it is still imperative to rectify the fault before switching it on again. Otherwise the module can be damaged.

Disturbance of radio communication services due to radio-frequency interferences in residential environments

The TM Drive can cause radio frequency interference which requires measures for interference suppression. This system is not designed for liberal use in the first environment (residential area) and must not be used there without appropriate radio interference suppression measures. Have the installation and commissioning performed with appropriate radio interference suppression measures by experts.

Protection from external electrical effects

You can find information on interference-proof design in the function manual Designing interference-free controllers (https://support.industry.siemens.com/cs/ww/en/view/59193566).

Overload

The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

With automatic overload limiting, the output current is automatically reduced on reaching the rated load of the power end stage to effectively prevent an overload of the power unit.

SCCR (short circuit current rating)

Suitable For Use On A Circuit Capable Of Delivering Not More Than 5kA DC Symmetrical Amperes, 48 Volts DC Maximum.

4.2 Block diagram

WARNING

Fuse for the load circuit

In general, use a suitable overcurrent protection device to protect the TM Drive.

Schematic circuit diagram

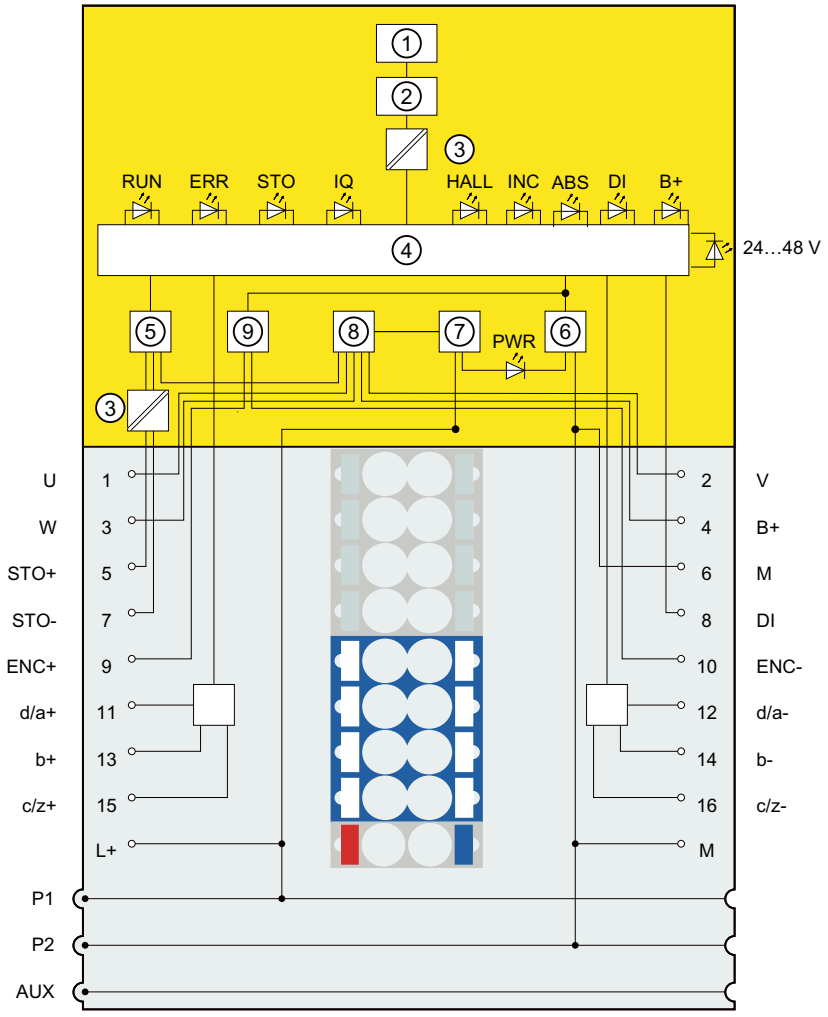

①	Backplane bus	**PMSM**	
②	Backplane bus interface module of the technology controller	U	Phase U
③	Electrical isolation	V	Phase V
④	Technology controller	W	Phase W
⑤	Safe Torque Off circuitry	B+	Connection of braking resistor
		Stepper motor	

⑥	Digital input circuit	U	Phase A-
⑦	Power supply/Preparation	V	Phase A+
⑧	Reverse polarity protection	W	Phase B-
⑨	Power electronics	B+	Phase B+
		Encoder supply	
⑩	Encoder power supply	ENC+	Power supply encoder 5 V
Power supply		ENC-	Power supply encoder, negative connection
L+	Power supply 24 - 48 V	**Incremental / IQ encoder**	
M	Power supply GND	d/a+	Differential encoder signal a+
Inputs		d/a-	Differential encoder signal a-
STO+	STO+ input (24 V)	b+	Differential encoder signal b+
M	Negative connection, e.g. for braking resistor	b-	Differential encoder signal b-
STO-	Negative STO input	c/z+	Differential encoder signal z+
DI	Digital input	c/z-	Differential encoder signal z-
		BiSS-C	
		d/a+	Dat+
		d/a-	Dat-
		c/z+	Clk+
		c/z-	Clk-

Figure 2-1572 Schematic circuit diagram

Cable lengths and cable types

If you do not use an "all-in-one" plug-in cable, the following cable lengths and cable types are permitted for the interfaces:

Table 2-2031 Wiring rules for the interfaces

Pins	Function	Maximum cable length	Cable type
ENC+/ENC-	Incremental encoder signals and supply	10 m	Shielded For differential wiring, one twisted pair per signal pair
U/V/W or A+/A-/B+/B-	Motor phases	10 m	Shielded
DI, M	Input	10 m	≥ 2 m shielded
	Ground	10 m	-
L+/M	Power supply, power unit	10 m	-

Pins	Function	Maximum cable length	Cable type
B+	Connection of external braking resistor	2 m	≥ 0.5 m shielded
d/a, b, c/z	Encoder connectors	10 m	Shielded For differential wiring, one twisted pair per signal pair In order to achieve higher transmission frequencies, it is recommended to shield the clock and data signal lines separately for a BiSS-C encoder.
STO	Safe Torque Off	10 m	-

Permissible cable cross-sections depend on the BaseUnit used. See ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/59753521) equipment manual.

CABLE SPEC.	Note that the electrical connections must be designed according to the expected current value at maximum ambient temperature and installation type in accordance with applicable standards.

NOTE

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor/encoder side.

4.3 Wiring of multiple TM Drive

In a potential group

You can connect multiple TM Drives to form a potential group (drive line-up). The following figure shows you the TM Drive with different motors.

Wiring of multiple TM Drive to form a drive line-up

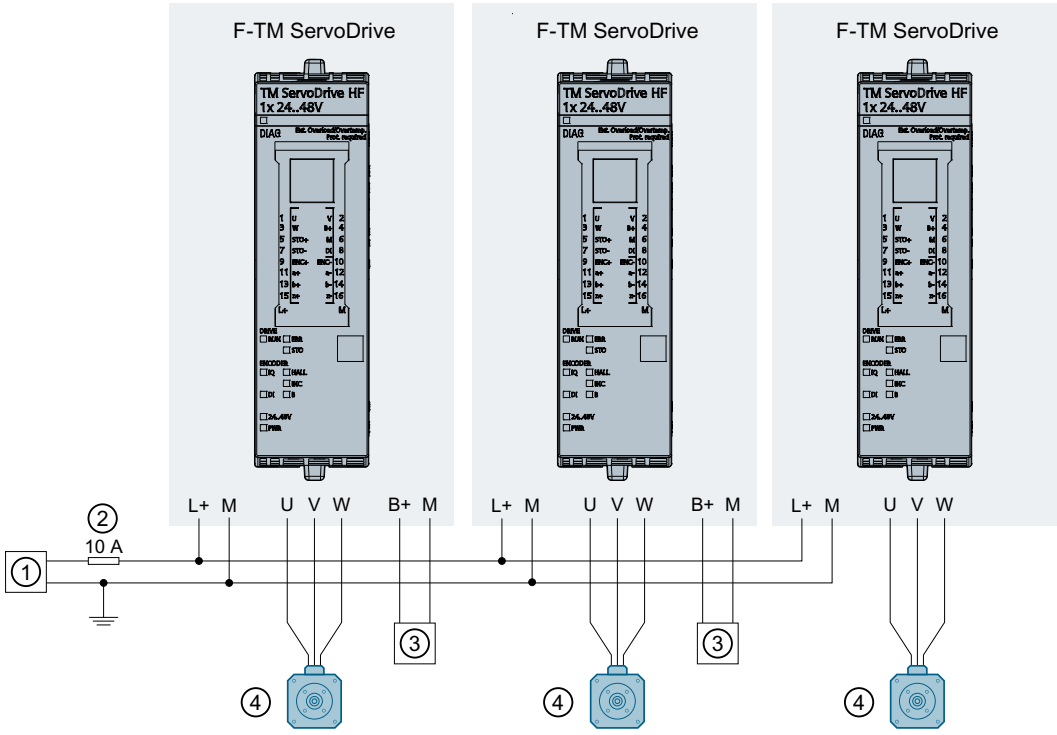

① Power supply unit

② Protective device

③ Braking resistor

④ Motor

Figure 2-1573 Wiring of multiple TM Drive to form a drive line-up

See also

Pin assignment (Page 29)

4.4 Connecting the motor

Overview

F-TM ServoDrive supports permanent magnet synchronous motors (PMSM) with suitable encoders and bipolar interconnected stepper motors.

4.4.1 Connecting the motor phases (PMSM)

The following figure shows the connection of the motor phases to the BaseUnit:

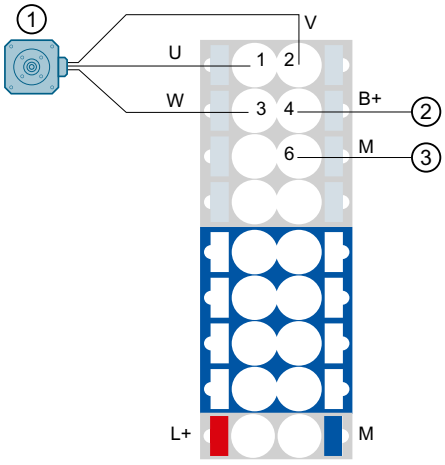

①	PMSM	②	Braking resistor
U, V, W	Motor phases	③	Negative connection for braking resistor

Figure 2-1574 Connecting the motor

NOTE

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor side.

Pin assignment

Pin	Designation	Function
1	U	Motor phase U
2	V	Motor phase V
3	W	Motor phase W
4	B+	Braking resistor
6	M	Negative connection, e.g. for braking resistor

4.4.2 Wiring the motor phases (stepper motor)

The following figure shows the connection of the motor phases to the BaseUnit:

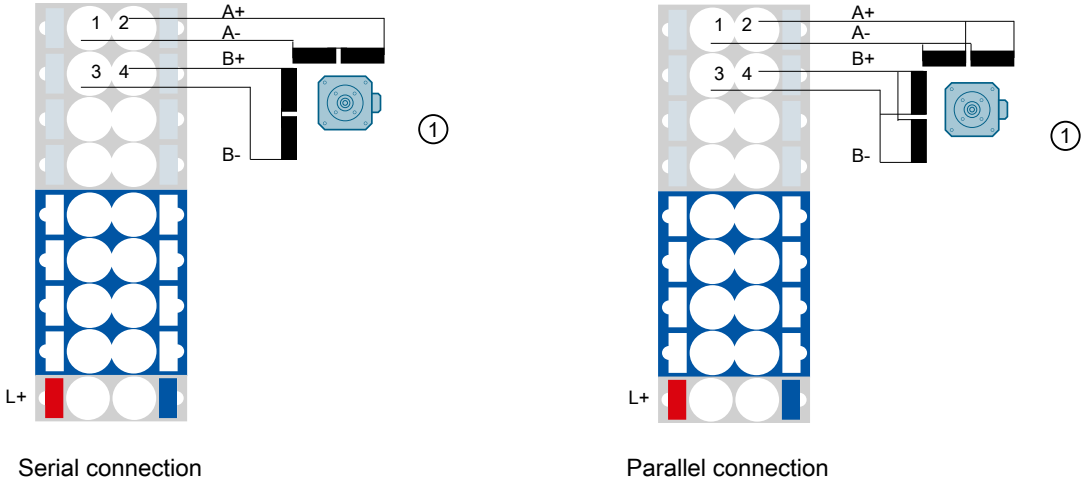

①	Stepper motor
A+, A-, B+, B-	Motor phases

Figure 2-1575 Connecting the motor

NOTE

In addition to the shield connection on the ET 200SP, the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor side.

Pin assignment

Pin	Designation	Function
1	A-	Motor phase A-
2	A+	Motor phase A+
3	B-	Motor phase B-
4	B+	Motor phase B+

4.5 Connecting an encoder

4.5.1 Connecting an incremental encoders

You can connect motors with a 3-channel incremental encoder to the TM Drive. The A and B tracks and a reference track Z are required for evaluation. You connect all signals as "single-ended" or "differential".

The following figure shows the connection of an incremental encoder to the BaseUnit.

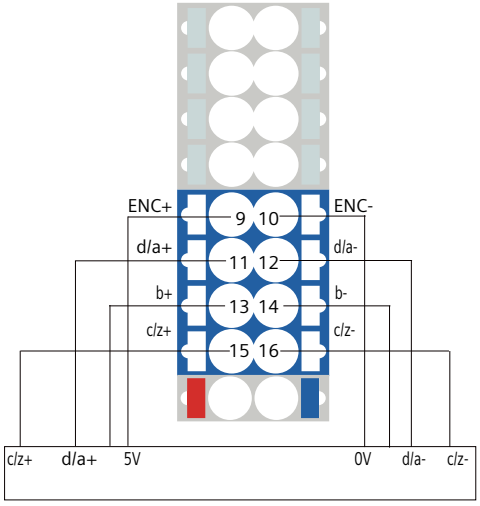

Figure 2-1576 Connection of incremental encoder with differential signals

Pin assignment of incremental encoder

Pin	Designation	Function
9	ENC+	Power supply encoder 5 V
10	ENC-	Power supply encoder, negative connection
11	a+	Differential encoder signal a+
12	a-	Differential encoder signal a-
13	b+	Differential encoder signal b+
14	b-	Differential encoder signal b-
15	z+	Differential encoder signal z+
16	z-	Differential encoder signal z-

Table 2-2032 Power supply and signal processing conditions of the incremental encoder

Encoder property	Range/Value
TTL bipolar 5 V or differential	High 2 V .. 5.5 V
	Low -5.5 V ... -2 V
TTL unipolar 5 V	High 4 V .. 5.5 V

*The quadrature interface results in a maximum step resolution of 2000 kHz.

Encoder property	Range/Value
TTL unipolar 5 V	Low 0 V .. 1 V
Encoder supply voltage	5 V ... 5.3 V
Maximum current consumption of the encoder	150 mA
Encoder output	Push Pull
Maximum signal frequency that can be processed (per signal A and B)*	500 kHz

*The quadrature interface results in a maximum step resolution of 2000 kHz.

NOTE

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the encoder side.

4.5.2 Connecting IQ-Encoders

Motors from the SIMATIC MICRO-DRIVE Product Partner Program have an IQ encoder.

The following figure shows the connection of IQ encoders to the BaseUnit.

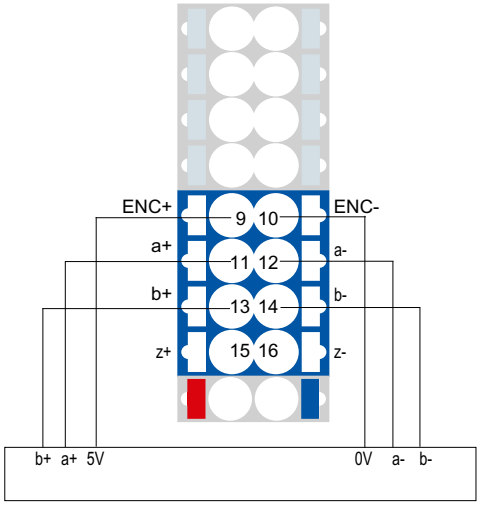

Figure 2-1577 IQ encoder connection with differential signals

Pin assignment of IQ encoder

Pin	Designation	Function
9	ENC+	Power supply encoder 5 V
10	ENC-	Power supply encoder, negative connection
11	a+	Differential encoder signal a+
12	a-	Differential encoder signal a-
13	b+	Differential encoder signal b+
14	b-	Differential encoder signal b-
15	z+	-
16	z-	-

Specifying the encoder interface

You connect the IQ encoder to the incremental encoder inputs like a two-channel standard incremental encoder. The polar wheel angle information is also transmitted via the interface (see Technical specifications (Page 152)).

NOTE

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the encoder side.

4.5.3 Connecting a BiSS-C encoder

You can connect motors with a BiSS-C interface to the TM Drive .

The following figure shows the connection of a BiSS encoder to the BaseUnit.

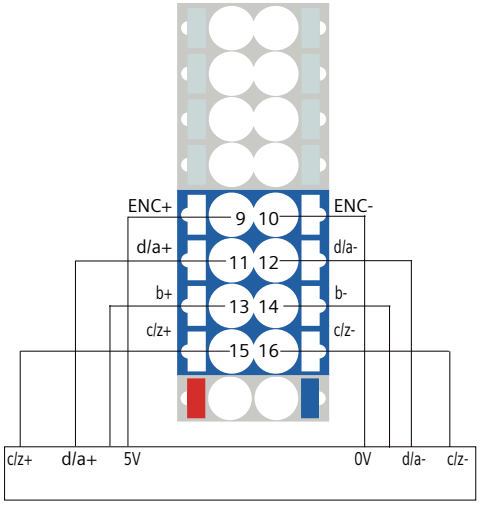

Figure 2-1578 Absolute encoder connection

Pin assignment of BiSS encoder

Pin	Designation	Function
9	ENC+	Power supply encoder 5 V
10	ENC-	Power supply encoder, negative connection
11	d/a+	Dat+
12	d/a-	Dat-
15	c/z+	Clk+
16	c/z-	Clk-

Table 2-2033 Power supply and signal processing conditions of the absolute encoder

Encoder property	Range/Value
Encoder supply voltage	5 V ... 5.3 V
Maximum current consumption of the encoder	150 mA
Maximum transmission frequency	2.8 MHz
CRC (Cyclic Redundancy Check)	43 hex

NOTE

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example, with a metal clip on the control cabinet rear panel. The cable shield must be applied on the encoder side.

Requirement of the BiSS-C interface

In addition to the electrical specification from Table 4-3, the BiSS-C interface must meet the following requirements:

- Unidirectional communication according to BiSS-C standard
- Transfer code: Dual
- CRC (Cyclic Redundancy Check) polynomial 43 hex
- Evaluation of the warning / alarm bits
- Sum of single-turn, multiturn and number of bits before position value <= 56
- See Table 4-1 for the cable and shielding requirements.

4.5.4 Connecting safe torque off (Hardware STO)

Safe Torque Off (STO)

The safety function Hardware STO is activated via an exclusive safe input (STO+ and STO-). The TM Drive safely switches off the control of the motor. As long as Hardware STO is active, the motor does not generate any torque.

The safe state "Safe Torque Off" corresponds to the de-energized state at STO+/STO- (closed-circuit current principle).

The Hardware STO function meets the specification of a digital input according to EN 61131-2 Type 1 without limitation. In addition, this input has an increased leakage current resistance of 5 mA. That is, at leakage currents below 5 mA, the safe state is always selected.

WARNING

Danger to life due to coasting down of the drive with STO

The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

Wiring the Hardware STO

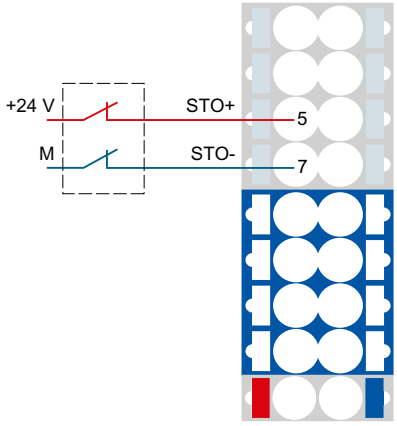

STO+ STO input 24 V

STO- STO input, negative connection

Figure 2-1579 Connection of Hardware STO

NOTE

Use different voltage supplies for the STO inputs and for the power supply.

Table 2-2034 Pin assignment

Pin	Designation	Function
5	STO+	STO input 24 V
7	STO-	STO input, negative connection

Route the hardware STO (STO+/STO-) cables separately from other cables, especially power cables.

Minimize the risk of crushing and short-circuits in ground connections by using appropriate routing.

Exclude premature aging of the cables due to continuous UV radiation.

4.5.5 Connecting the 24 V digital input

Connecting a 24 V digital input

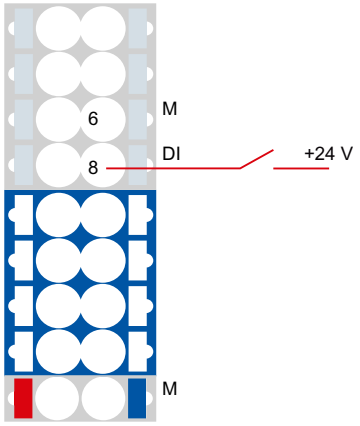

DI 24 V digital input

M Ground

Figure 2-1580 24 V digital input connection

Table 2-2035 Pin assignment

Pin	Designation	Function
6	M	Ground, internally connected to ground of 24 - 48 V power supply
8	DI	24 V digital input

4.6 Connecting an external braking resistor

External braking resistor

To ensure high dynamics of the drive due to fast acceleration and braking ramps, you need to connect a braking resistor to the TM Drive.

Recommendation: Use a braking resistor for power supplies with low intrinsic capacitance or an unregulated six-pulse bridge circuit (B6U).

A connected external braking resistor must be activated in the configuration software.

⚠ CAUTION

Risk of burns due to high surface temperature of the braking resistor

The braking resistor can become very hot. Touching the surface can cause severe burns.

- Mount the braking resistor so that it cannot be touched. In situations in which this is not possible, attach a clearly visible and understandable warning notice in areas at risk.

Wiring a non-Siemens external braking resistor

⚠ WARNING

Damage to braking resistor – Risk of fire!

If you use a non-Siemens external braking resistor, connect an overtemperature detection device to a digital input (e.g. a bimetallic switch that opens when the temperature is too high).

Implement fire prevention measures for the external braking resistor (e.g. fire protection housing, temperature fuse). The resistance of the externally connectable braking resistor must be ≥ 5 ohms.

Design the required power as a function of the braking energy to be converted.

Wiring an external braking resistor

The figure below shows the connection of an external braking resistor as an example:

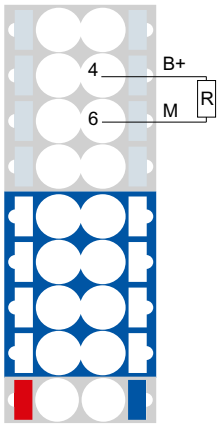

B+ Positive terminal of braking resistor

M Negative terminal of braking resistor

Figure 2-1581 Connection of external braking resistor

Pin assignment

Table 2-2036 Pin assignment: Wiring an external braking resistor

Pin	Designation	Function
4	B+	Connection of external braking resistor
6	M	

External braking resistor for potential group with several TM Drive

If you have connected multiple TM Drive to form a potential group, it may be sufficient to equip only one module with an external braking resistor.

Safety functions integrated in the drive 5

5.1 Basic safety information

5.1.1 General safety information

WARNING

Danger to life if the safety instructions and residual risks are not taken into consideration

The non-observance of the safety instructions and residual risks stated in the associated F-TM ServoDrive documentation can result in accidents causing severe injuries or death.

- Observe the safety instructions given in the F-TM ServoDrive documentation.
- Consider the residual risks for the risk evaluation.

WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings

As a result of incorrect or changed parameter settings, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameter assignment against unauthorized access.
- Respond to possible malfunctions by implementing suitable measures (e.g. EMERGENCY STOP or EMERGENCY OFF).

WARNING

Validity of safety features

The safety features of the product are guaranteed only for intended use within the intended ambient conditions (see section Technical specifications (Page 152)).

The safety features only apply when operating with a BaseUnit of the U0 type (6ES7193-6BP00-0DU0 or 6ES7193-6BP00-0BU0).

5.1.2 Warranty and liability for application examples

Application examples are non-binding and do not claim to be complete regarding configuration and equipment as well as all eventualities. Application examples do not represent customer-specific solutions. They are only intended to provide support for typical tasks.

As user, you are responsible for ensuring that the products described are used correctly. Application examples do not relieve you of the responsibility to use safe practices in application, installation, operation and maintenance.

5.1.3 Fundamental safety instructions for Safety Integrated

Additional safety instructions and residual risks are provided outside of this section at the relevant points of this system manual.

⚠ DANGER

Risk minimization through Safety Integrated

Safety Integrated can be used to minimize the risk associated with machines and plants. However, safe operation of the machine or system with Safety Integrated is only possible if the machine manufacturer:

- Knows and complies with this technical user documentation, including the documented constraints, safety instructions and residual risks
- Carefully constructs and configures the machine/plant and verifies it through a carefully implemented and documented acceptance test by qualified personnel
- Implements and validates all the measures required in accordance with the system/machine risk analysis by means of the programmed and configured Safety Integrated functions or by other means

The use of Safety Integrated does not replace the machine/plant risk assessment carried out by the machine manufacturer as required by the CE Machinery Directive.
In addition to using Safety Integrated functions, further risk reduction measures must be implemented.

⚠ WARNING

Danger to life as a result of undesirable motor movement when automatically restarting

An emergency stop must be performed according to Stop Category 0 (STO) (EN 60204-1). The emergency stop must be ensured by external measures.
It is not permissible that the motor automatically restarts after an Emergency Stop, as this represents danger to life as a result of the associated undesirable motor motion.
If individual safety functions are deactivated, an automatic restart is permitted under certain circumstances depending on the risk analysis (except when Emergency Stop is reset). An automatic start is possible when a protective door is closed, for example.

- Ensure that no automatic restart takes place in the indicated cases.

WARNING

Danger to life as a result of undesirable motor motion when the system powers up and the drives are activated after hardware and/or software is changed or replaced

After hardware and/or software components have been modified or replaced, or after drive parameters are changed or parameter backups are loaded, it is only permissible for the system to run up and the drives to be activated with the protective devices closed. Personnel shall not be present within the danger zone during this time.

- It may be necessary to carry out a partial or complete acceptance test or a simplified functional test after making certain changes or replacements.
- Before personnel may re-enter the hazardous area, all of the drives should be tested to ensure that they exhibit stable control behavior by briefly moving them in both the plus and minus directions (+/-).

5.1.4 Safety Integrated functions

This section gives you a quick insight into the functioning of the safety functions.

The description of the safety functions starts in each case with the definition in IEC/EN 61800-5-2 and simple examples of the use of the function.

The description of the functions is simplified as far as possible so that the essential properties and setting options are made clear.

Response time

You can find additional information on the response time of the listed safety functions in section Response times (Page 158).

Examples of safety devices and 3 F-TM ServoDrive

NOTE

Use different voltage supplies for the STO inputs and for the power supply.

The following figure shows various safety devices that are connected to 3 F-TM ServoDrive.

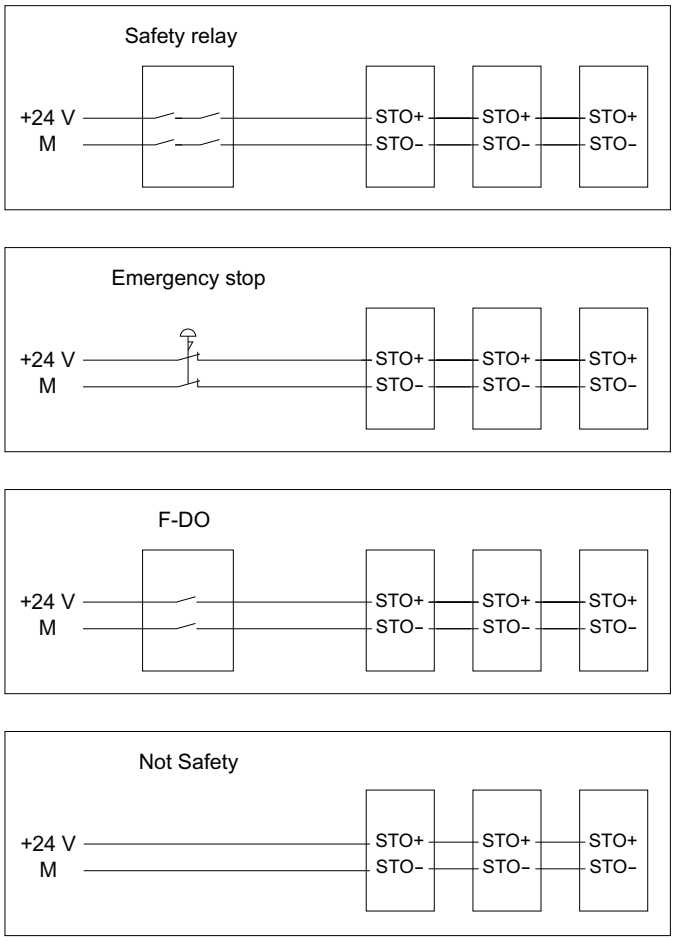

Figure 2-1582 Safety devices and 3 F-TM ServoDrive

NOTE

The F-TM ServoDrive does not support startup protection.

Measure:

Configure startup protection with an additional safety relay or in the higher-level controller, depending on the safety requirements.

Operating voltage range

Operate input STO+ as intended with 19.2 to 28.8 V DC for the active enable or lower 5 V DC for the disable.

Connect the input STO- for enabling or disabling the connection to ground.

Switching on again after power off

An On delay of more than 2 s must be observed between tripping and restarting the module, for example switching the power supply off and on. Otherwise the module can register an internal STO error and the module switches off in a safety-oriented manner.

5.1.4.1 Safe Torque Off (STO)

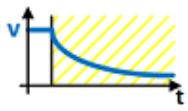

Safe Torque Off (STO) is a safety function that directly stops torque- or force-producing energy from being supplied to the motor. This function corresponds to Stop Category 0 according to EN 60204-1.

The F-TM ServoDrive complies with the definition of the STO function in IEC/EN 61800-5-2: "The STO function prevents torque-producing energy from being supplied to the motor."

If the motor is still rotating when STO is selected, the motor will coast to a standstill.

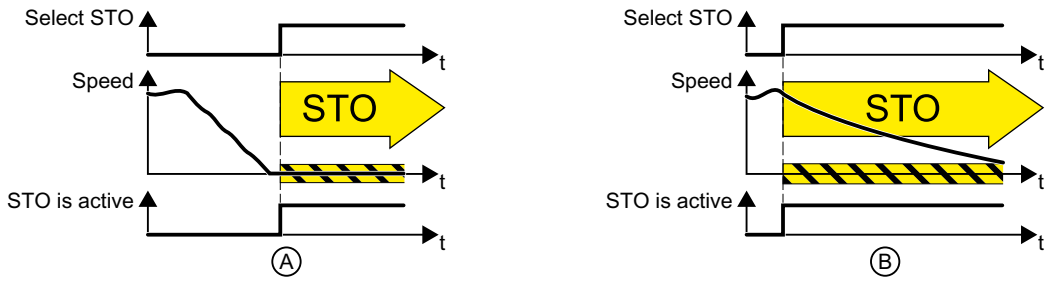

Figure 2-1583 Functioning of STO (A) when motor is at stopped and (B) when motor is rotating

Functional characteristics

⚠ WARNING

Danger to life due to coasting down of the drive with STO

The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

STO is a drive-specific function and must be wired individually for each drive.

The following applies when the "Safe Torque Off" function is selected:

- An unwanted startup of the motor cannot take place.
- The torque-producing energy supply to the motor is safely interrupted.
- An electrical isolation between the power unit and motor does not occur.

The stop function category 0 (selection of STO according to Safety Integrated) is only active when selected at the STO terminals. In order to meet the requirements of an EMERGENCY STOP in accordance with EN 60204-1, you need to ensure that the STO function at the STO terminals in the system can only be deselected by means of conscious manual operation. This prevents electrically driven machine components from restarting unintentionally.

Selection

The STO safety function is always enabled and cannot be disabled via parameter assignment.

You can select the STO function via the fail-safe digital input at STO+ and STO- terminals. The selection of the STO function is enabled directly as a response to safety messages (e.g. when a defect is detected in a monitoring channel).

Range of application

You can use the STO safety function without restrictions for a PMSM or bipolar connected two-phase stepper motor. A special encoder concept suitable for safety is not required.

Applications

Application areas are all machines or systems with moving axes (e.g. conveyor systems, handling systems).

The STO function can be used when the motor is already at a standstill. If the motor is in operation, the STO function causes the drive to coast down.

The STO function enables safe working when the protective door is open. A conventional Emergency Stop with electromechanical unlocking is not required. The converter remains connected to the supply system and has full diagnostics capability.

NOTE

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant. The STO function is suitable for implementing an EMERGENCY STOP, but not an EMERGENCY OFF.

Hardware STO

The F-TM ServoDrive internally monitors the fail-safe digital input at STO+ and STO- terminals for discrepancies.

Discrepancy monitoring

Due to the design of the Hardware STO circuit, a discrepancy cannot occur at STO+ and STO- terminals. As long as the STO terminal is de-energized, STO is selected. The Hardware STO signal is read in internally via two channels.

To comply with the requirements for timely error detection from EN 61800-5-2, the switch-off signal paths of the end stage in both monitoring channels are also cyclically tested. Errors when testing the shutdown paths trigger STO. A manual forced checking procedure (test stop) for testing the shutdown paths of the F-TM ServoDrive is therefore not needed.

⚠ WARNING
Forced checking procedure You should nevertheless examine its necessity for diagnosing the utilized sensors or for performing a test stop in the context of the overall system.

5.1.5 Overview of the Safety Integrated functions

Compared to standard drive functions, safety functions have an especially low error rate. Performance Level (PL) and Safety Integrity Level (SIL) as defined in the corresponding standards are a measure for the error rate.

For this reason, safety functions are suitable for use and for risk reduction in safety-related applications. An application is safety-related when the risk analysis of the machine or plant has identified a particular risk potential in the application.

Safety Integrated means that the safety functions are integrated in the drive and can be executed without additional external components.

Conformity of Safety Integrated functions

The Safety Integrated functions comply with:

- Safety Integrity Level (SIL) 3 according to IEC 61508 Part 1-3
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

For functional safety of variable-speed drives, the standard IEC 61800-5-2, in which the Safety Integrated functions are defined, applies.

Function groups

The safety functions are divided into the following function groups for the F-TM ServoDrive:

- Safety Integrated stop function (hardware STO)

5.1.6 Supported safety functions

The supported safety functions are included in the standard scope of the F-TM ServoDrive and can be used without an additional license.

Stop functions

The stop functions do not pose any special requirements on the utilized encoder and do not need actual value acquisition. The stop functions include the following Safety Integrated functions:

- Safe Torque Off (STO)

  Safe Torque Off is a safety function for prevention of unexpected startup according to EN 60204-1. STO prevents torque-producing energy from being supplied to the motor and corresponds to Stop Category 0.

5.1.7 Examples of using the safety functions

Table 2-2037 Examples of using the safety functions

Safety function	Application examples	Possible solution
Safe Torque Off (STO)	It is only permissible to open a protective door if the motor torque has been switched off.	Activate STO in the F-TM ServoDrive via the STO inputs. The pulses are suppressed and the motor coasts to a standstill.
	A central Emergency Stop button ensures that multiple drives cannot start unintentionally.	Evaluate the emergency stop button in a central controller. Use a two-channel connection to the STO inputs on the F-TM ServoDrive.

5.1.8 Safety concept

The safety concept of the drive controller is based on a 2-channel system structure. Each channel has the possibility of bringing about the safe state, and the two channels monitor each other through a corresponding cross-comparison and cyclic diagnostics.

Safe state

The safe state of the system exists when the motor bridge is **de-energized**.

The safe state is reached in the following cases:

- Switch-off or failure of the external power supply to L+/M
- Missing enable signal at STO+ and STO-
- Detection of an internal hardware fault

Safe state of Safety Integrated functions

The safe state of the STO input terminal is reached when at least one of the two STO supply terminals is disconnected from the energy supply.

NOTE

The safe state means the absence of torque in the sense of functional safety, but not necessarily the absence of voltage in the sense of electrical safety.

5.2 Acceptance of the safety functions

Responsibilities

The machine manufacturer is responsible for the performance and documentation of the acceptance test. In this section, you will find a recommendation for how to perform and document the acceptance tests for the individual safety functions.

NOTE

The performance and documentation of the acceptance tests are plant-specific and must be adapted appropriately and performed.

5.2.1 General information on acceptance

Why is acceptance required?

The EU machinery directive and ISO 13849-1 stipulate:

- You must test safety-relevant functions and machine parts after commissioning.

  See "Acceptance test" below in this section.

  For the F-TM ServoDrive Safety Integrated functions (SI functions), this means:
  The acceptance test is used to check the functionality of the safety functions used in the drive. Correct implementation of the defined safety functions is examined for this.
- You must create an "acceptance report" that describes the test results.

  See "Documentation" further on in this section.

NOTE

Purpose of the acceptance test

The measured values (e.g. speed, time) and the system behavior identified (e.g. initiation of a specific stop) serve to check the plausibility of the configured safety functions. The objective of an acceptance test is to identify potential configuration errors and/or to document the correct function of the configuration. The measured values are typical values (not worst case values). They represent the behavior of the machine at the time of measurement. These measurements cannot serve as the basis for deriving real values (e.g. maximum values for over-travel distances).

Requirements

The requirements for an acceptance test (configuration test) for safety functions of electric drives come from EN 61800-5-2, section 7.1, paragraph f). The acceptance test is called "configuration test" in this standard.

- Description of the application including an image
- Description of the safety-related components (including software versions) that are used in the application
- List of the utilized safety functions of the PDS(SR) [Power Drive System(Safety Related)]
- Results of all tests of these safety functions using the specified test procedure

Necessity of an acceptance test

An acceptance test is required (again) when the Safety Integrated functionality of a machine is commissioned or changed. The acceptance tests must be performed for each individual drive. Safety-related function extensions, transfer of commissioning to other series machines, hardware changes, software upgrades and the like may allow a partial performance test to be performed.

The conditions determining the necessity and recommendations for the test depth required in each case are summarized below.

Requirements for the acceptance test

- The machine is correctly wired.
- All safety equipment (e.g. protective door monitoring devices, light barriers, emergency limit switches) are connected and ready for operation.
- The commissioning of open-loop and closed-loop control must be complete; otherwise, the over-travel distance may be changed due to a changed dynamic response of the drive control, for example. This includes:
  - Settings of the setpoint channel
  - Position control in the higher-level CPU
  - Drive control

Acceptance test

The acceptance test comprises two parts:

- You test whether the safety functions are set correctly in the drive:
  - Does the configured safety function sufficiently reduce the residual risk at the machine/plant?
  - Do the set interfaces, timers and monitoring functions match the configuration of the machine?
- You test whether the safety-relevant functions in the machine or system function correctly.

  This part of the acceptance test goes beyond the acceptance test of the drive:
  - Is all safety equipment, such as protective door monitoring, light barriers and emergency limit switches, connected and ready for operation?
  - Do the drive settings match the configured safety-relevant function in the machine?

Documentation

The documentation consists of the following parts:

- Description of safety-relevant components and functions of the machine or system, including the program versions.
- Report of the acceptance test results.
- Report of the safety function wiring.
- The documentation must be signed off by the person who performed the acceptance test.

Authorized persons

Persons authorized by the **machine manufacturer** who, on account of their technical training and knowledge of the safety-relevant functions, can carry out the acceptance in an appropriate manner are entitled to perform the acceptance.

⚠ WARNING

Unwanted movement due to faulty wiring

Incorrect wiring for Safety Integrated functions can cause unwanted motion resulting in severe injury or death.

- For Safety Integrated functions, always carry out an acceptance test for the affected function after changing the wiring.
- Record the results of the acceptance test in an acceptance report.

WARNING

Unsafe operating states due to manipulation of the hardware configuration after the acceptance test

Changes to the wiring of the Safety Integrated functions after an acceptance test can cause unwanted motion resulting in severe injury or death.

- To prevent access to your machines and systems by unauthorized persons, implement access restrictions and take the precautions described in the security instructions in the preface.
- To prevent improper wiring of the Safety Integrated functions, take the precautions described in this manual.
- Review the safety change tracking of the drive at regular intervals. Make certain that no changes have been made to the wiring after the last successfully completed acceptance test.
- If intentional changes have been made, repeat the acceptance test for the Safety Integrated functions affected. The purpose of the acceptance test is to ensure and document safe operation of the system. Correct any unintentional changes back to the original values and repeat the acceptance test.

5.2.2 Content of an acceptance test

Documentation

Documentation of the machine including safety functions

- Machine description (with overview image)
- Information on controller (if available)
- Function table:
  - Active monitoring functions depending on operating mode and protective door
  - Additional sensors with protection functions
  - The table is an object or result of the configuration work.
- SI functions for each drive
- Information on the safety equipment

Function test of diagnostic/safety functions

Value-based function check of the SI functions used. You can use trace records of individual parameters, for example, to do this.

- Acceptance test for Safe Torque Off (STO)

Report completion

Reporting of the tested state of commissioning and countersignatures

- Control of the STO function as enable signal of the STO+ and STO- terminals
- Enable to control the motor is removed as soon as a connection (STO+ or STO-) is not connected
- Counter signature

5.2.3 Documentation of acceptance

Machine or system description

Describe your machine or plant using the following table. Insert a diagram of the plant, for example.

Table 2-2038 Machine description and overview image

Designation	
Type	
Serial number	
Manufacturer	
End customer	
Overview image of the machine	

Drive data

In the following table, enter information on the drive components used and add additional components as required.

Table 2-2039 Hardware components

Component	Designation	Article number	Hardware version	Type
Drive controller				
Motor				
Encoders				
Brake module				
Gearbox				

Utilized Safety Integrated functions

In the following table, describe the use of the Safety Integrated drive functions in relation to your plant or machine.

Table 2-2040 Utilized SI functions of the drive

SI function	Status/Description
Safe Torque Off (STO)	

5.2.4 Acceptance test for Safe Torque Off (STO)

Procedure

Test each configured activation of the STO function.

This test consists of the following steps:

Table 2-2041 Acceptance test for "Safe Torque Off" (STO) function

No.	Description	Status
1.	**Drive is ready for operation**	
	• No faults	
	• The enable signal is present (STO is deselected).	

No.	Description		Status
2.	**Switch on motor**		
	2.1	Set speed setpoint ≠ 0	
	2.2	Switch on motor (ON command)	
	2.3	Check that the intended motor is rotating	
3.	**Select STO**		
	3.1	Selecting STO means interrupting the wire, supplying the STO from STO+ and short-circuiting STO- (if the source is current-limited)	
	3.2	Check the following points:	
		• Motor coasts down to a standstill	
		Message is implemented, but is not safety-relevant	
4.	**Deselect STO**		
	4.1	Deselection of STO (HW STO terminal)	
	4.2	Check the following points:	
		• Enable is active, motor must allow switch-on	

5.2.5 Report completion

SI change tracking (Safety logbook)

Ensure that changes to the safety function (wiring) can be traced.

Countersignatures

Commissioning engineer

Professional execution of the above-stated tests and checks is confirmed.

Table 2-2042 Report completion - Countersignature of commissioning engineer

Date	Name	Company/Department	Signature

Machine manufacturer

The correctness of the parameter assignment documented above is confirmed.

Table 2-2043 Report completion - Countersignature of machine manufacturer

Date	Name	Company/Department	Signature

5.3 System features

5.3.1 Current information

Important note for maintaining the operational safety of your system:

NOTICE
Operational safety risk from unwanted motions Systems with safety-oriented variants are subject to special operational safety requirements on the part of the operator. If information becomes known in the course of product monitoring indicating insufficient product safety, this information will be disclosed in various ways. For this reason, our website provides information on product developments and features that are (or could be) relevant to operation of systems from a safety perspective.

5.3.2 Certifications

The safety functions of the F-TM ServoDrive drive system meet the following requirements:

- Safety integrity level SIL3 according to IEC 61508 Part 1-3 and IEC 61800-5-2
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

In addition, the safety functions of the drive are generally certified by independent institutes. A list of the components that are currently already certified in each case is available on request from your Siemens branch.

5.3.3 Failure probability of the safety functions

The probability of failure of safety functions must be specified in the form of a PFH value (Probability of Failure per Hour) according to DIN EN 61800-5-2 and ISO 13849-1. The PFH value of a safety function depends on the safety concept of the drive device, its hardware configuration and the PFH values of the other components used for the safety function. For the F-TM ServoDrive drive system, PFH values are provided as a function of the hardware configuration.

NOTE

PFH values

The PFH value of the integrated safety function STO is 30 FIT (10^{-9}/h) and refers to a service life of 20 years.

The underlying assumption for the calculation is an average operating temperature of 40°C, an average repair time of 8 hours and an average time to recovery of 8 hours. A proof test is not necessary.

5.3.4 Response times

The response time is the time between the detection of an input signal and the change of a linked output signal. Below you will find information on the response times of the F-TM ServoDrive drive system.

NOTE

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

The drive system is the component that provides the safety functions. The description "error-free drive system" means that the component providing the safety functions itself has no defect:

- Maximum response time in error-free drive system

  When the enable is removed at the STO+ or STO- terminals, the maximum response time in an error-free drive system is guaranteed.

Stop function (via terminals)

The following table specifies the response times for the indicated stop functions from the time of activation until occurrence of the response.

Function	Maximum response time
STOP_STO	Max. 20 ms

5.4 Safety Integrated

Important notes on the Safety Integrated system are provided in this section.

Diagnostics hardware fault

If an internally diagnosed hardware fault occurs, you can only reset the module by restarting it. Nevertheless, the replacement of the F-TM ServoDrive is strongly recommended. Unwanted activation of the safety function can be an indication of a hardware fault.

Wiring the F-TM ServoDrive

For information on how to perform the electrical wiring for the F-TM ServoDrive, refer to section Wiring (Page 29)

STO inputs

The STO inputs are described in the section Connecting safe torque off (Hardware STO) (Page 41).

5.5 EMERGENCY OFF and EMERGENCY STOP

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant.

EMERGENCY OFF Risk of electric shock 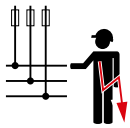	**EMERGENCY STOP** Risk of unexpected movement 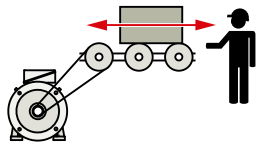

Table 2-2044 Measures and solutions

Command	EMERGENCY OFF	EMERGENCY STOP
Measure to minimize risk	**Safe switch off** Switching off the electric power supply for the installation, either completely or partially.	**Safely stop and safely prevent restarting** Stopping or preventing the dangerous movement
Classic solution	Switch off the power supply. 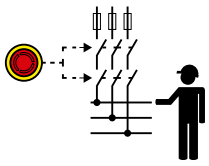	Switch off the drive power supply. 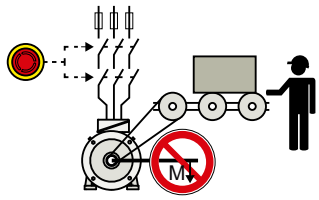
Solution with the STO safety function integrated in the drive	STO is not suitable for safely switching off a voltage.	Select STO. 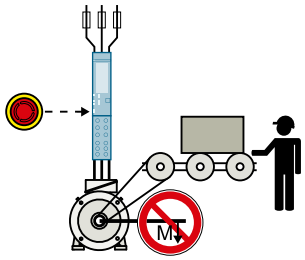 You may also switch off the power supply of the drive controller. However, switching off the voltage is not required as a risk-reduction measure.

Configuring 6

Configuration and parameter assignment

STEP 7 (TIA Portal) is available for configuring a ET 200SP TM Drive.

You perform the following tasks with STEP 7 (TIA Portal), for example:

- You configure the TM Drive (insertion into the project and setting the input addresses).
- You specify the desired hardware parameters for operation of the TM Drive.

Requirements

Hardware

- Supported interface modules: See Properties (Page 25)
- You have completed installation and wiring of the hardware. Take the potential group into account, see section Pin assignment (Page 29).
- You have connected the PG/PC via the PROFINET interface of the CPU.

Software

- You have installed the HSP0311. You can find the support packages for the hardware catalog in the TIA Portal (HSP) on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).
- You have installed the HSP0311.

As soon as the configuration and hardware parameter assignment have been successfully completed, you can create your user program and commission the drive.

⚠ WARNING

Safety Integrated

As soon as a safety program has been created, you must perform a complete function test based on your automation task.

To accept the plant, you must use the safety summary created in accordance with this manual.

Configuring a TM Drive (minimal configuration)

To configure a TM Drive , follow these steps:

1. Create a new project.
2. Add a CPU S7-1200 or S7-1500 as a new device.
3. Add a PROFINET interface module to the project under "Devices & networks" from the ET200SP system, e.g. IM 155-6PN ST.

4. Assign the inserted IO device to the configured IO controller.
5. Switch to the device view of the interface module.
6. Add the TM Drive module from the hardware catalog to the IO device.
7. Add a server module.

6.1 Communication telegrams

Selection of a communication telegram

The selection of a communication telegram determines the process data of the drive that will be transmitted between the drive and CPU.

The following table shows the supported telegram types for the drive and sensor assignment.

Table 2-2045 Supported communication telegrams

Supported PROFIdrive telegrams	Brief description	User data
Standard telegram 1 PZD-2/2	Speed setpoint 16 bits, without sensor	• Control word STW1, status word ZSW1 • Speed setpoint 16 bits (NSET), actual speed value 16 bits (NACT)
Standard telegram 2 PZD-4/4	Speed setpoint 32 bits, without position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT)
Standard telegram 3 PZD-9/5	Speed setpoint, 32 bits with one position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT) • Encoder control word 1 (Gx_STW), encoder status word 1 (Gx_ZSW) • Actual encoder position value 1 (Gx_XIST1, Gx_XIST2)
Siemens telegram 102 PZD-10/6	Speed setpoint 32 bits with one position encoder and torque reduction	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT) • Dynamic torque reduction (MOMRED) • Encoder control word 1 (Gx_STW), encoder status word 1 (Gx_ZSW) • Actual encoder position value 1 (Gx_XIST1, Gx_XIST2)
Extension word	Status bits of the inputs	• Bit 0: DI • Bit 1: STO

A PZD (process data word) corresponds to a 16-bit word.

Selecting a telegram in STEP 7

To select the telegram for the TM Drive in STEP 7, follow these steps:

1. Select the TM Drive module in the device view.
2. Navigate to the properties of the module in the "General" tab under "TM Drive" > "Basic parameters".
3. Under "Telegram" in the drop-down list, select the desired telegram, e.g. "Standard telegram 3 (PZD length 9/5 words).
4. If needed, activate the extension word by selecting the "Telegram extension active" check box.

6.2 Structure of the encoder position actual value

Starting with standard telegram 3, the encoder position actual value is transmitted as a 32-bit value via the user data Gx_XIST1 and Gx_XIST2. These values provide the current **incremental and, for absolute encoders, also the absolute actual position** of the measuring system and are read cyclically by the "Positioning axis" technology object, for example, and processed accordingly (see also section 8.3 (Page 140)). The layout of the encoder position actual value mainly depends on the following factors:

- Type of the encoder
- Resolution of the encoder

Regardless of the type of encoder, the position actual value is structured as follows:

- Gx_XIST1 and Gx_XIST2 are right-aligned
- After it is switched on, a 32-bit counter is loaded with the current position value. Depending on the direction of rotation, this value is then only incremented or decremented. After reaching the max. position value, it starts again at 0.

NOTE

Dependence on the configured encoder resolution

The single-turn value ("increments / revolution") in Gx_XIST1 is directly dependent on the configured encoder resolution (p408).

6.2.1 Incremental encoder

If you are using a motor with an incremental encoder and you have configured this for the type of motor encoder (p404), then the structure of the encoder position actual value is as follows:

Table 2-2046 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution (p408). You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 149).
	Bits in Gx_XIST1 "Offset factor"	2
	Encoder type	Rotary incremental

Example of an incremental encoder with 4096 "steps per revolution", this corresponds to 1024 "steps per revolution" with a fine resolution of 2:

Table 2-2047 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Singleturn value (singleturn "steps per revolution")

F: Fine resolution

Table 2-2048 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

6.2.2 IQ encoder

If you are using a motor from the Siemens Product Partner Program with IQ encoder (incremental encoder) and have configured this accordingly for the type of motor encoder (p404), then the structure of the encoder position actual value is as follows:

Table 2-2049 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Default: 100 Depends on the parameter assignment of the encoder resolution (p408). You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 149).

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Bits in Gx_XIST1 "Offset factor"	2
	Encoder type	Rotary incremental

Table 2-2050 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Single-turn value (single-turn "steps per revolution")
F: Fine resolution

Table 2-2051 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

6.2.3 Encoderless / calculated

If you have set encoder (0) encoderless / calculated as encoder type, the encoder position actual value is calculated. Actual encoder position value is structured as follows.

Table 2-2052 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution. You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 149).
	Bits in Gx_XIST1 "Offset factor"	2
	Encoder type	Rotary incremental

Example of a "simulated encoder" with 4096 "steps per revolution", this corresponds to 1024 "increments per revolution" with a offset factor of 2:

Table 2-2053 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Single-turn value (single-turn "steps per revolution")
F: Fine resolution

Table 2-2054 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

6.2.4 Absolute encoder BiSS

If you are using a motor with an BiSS encoder and you have configured this for the type of motor encoder (p404), the structure of the encoder position actual value is as follows:

Table 2-2055 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution. You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 149).
	Number of revolutions	
	Bits in Gx_XIST1 "Offset factor"	S* <= 16: Gx_XIST1 = 0 S* > 16: Bits in Gx_XIST1 = S - 16
Encoder position actual value 2 (Gx_XIST2)	Increments per revolution	Depends on the parameter assignment of the encoder resolution. You can read them back under "Drive diagnostics encoder" in the section Drive diagnostics (Page 149).
	Number of revolutions	
	Bits in Gx_XIST2 "Offset factor"	S* <= 16: Bit in Gx_XIST2 = 0 S* + M* <= 32 and S > 16: Bit in Gx_XIST2 = S - 16 S* + M* > 32 and S > 16: Bits in Gx_XIST2 = 16 - M; Minimum 0.
	Encoder type	Absolute

*S = Bits_Singleturn_resolution, M = Bits_Multiturn_resolution

For some absolute encoders, the total length of single-turn and multiturn bits can be greater than 32 bits (e.g. encoders with 17-bit single-turn resolution and 16-bit multiturn resolution). However, since only 32 bits are available in the actual position value Gx_XISTx, the following strategy is then used:

- For the actual position value in G1_XIST1, all single-turn bits are included if possible and higher-order bits of the multiturn value are truncated.
- For the actual position value in G1_XIST2, all multiturn bits are included if possible and lower-order bits of the single-turn value are truncated.

The values calculated automatically by the device are displayed in the Drive Diagnostics 10.2.3 in online mode and can be transferred directly from there to the configuration of the technology object or you can also take the offset factors from the following tables.

	Bits_Singleturn																		
Offset factor Gx_XIST1	1	...	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
	0	...	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Offset factor Gx_XIST2		**Bits_Singleturn**																		
		1	**...**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
Bits_Multi-turn	**0**	0	...	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	1	0	...	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	15
	2	0	...	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	14	14
	3	0	...	0	1	2	3	4	5	6	7	8	9	10	11	12	13	13	13	13
	4	0	...	0	1	2	3	4	5	6	7	8	9	10	11	12	12	12	12	12
	5	0	...	0	1	2	3	4	5	6	7	8	9	10	11	11	11	11	11	11
	6	0	...	0	1	2	3	4	5	6	7	8	9	10	10	10	10	10	10	10
	7	0	...	0	1	2	3	4	5	6	7	8	9	9	9	9	9	9	9	9
	8	0	...	0	1	2	3	4	5	6	7	8	8	8	8	8	8	8	8	8
	9	0	...	0	1	2	3	4	5	6	7	7	7	7	7	7	7	7	7	7
	10	0	...	0	1	2	3	4	5	6	6	6	6	6	6	6	6	6	6	6
	11	0	...	0	1	2	3	4	5	5	5	5	5	5	5	5	5	5	5	5
	12	0	...	0	1	2	3	4	4	4	4	4	4	4	4	4	4	4	4	4
	13	0	...	0	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	14	0	...	0	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	15	0	...	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	16	0	...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	32	0	...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Example of an absolute encoder with a resolution of 13 bits (8192 "increments per revolution") single-turn S and 12 bits (4096 "distinguishable revolutions") multiturn M.

Table 2-2056 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	S	S	S

M: Multiturn value (number of distinguishable revolutions)
S: Singleturn value (singleturn "steps per revolution")

Table 2-2057 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
							M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	S	S	S

M: Multiturn value (number of distinguishable revolutions)
S: Single-turn value (single-turn "steps per revolution")

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

Commissioning the 7

The engineering of the TM Drive drive controller is integrated in STEP 7 (TIA Portal). You install it with the Hardware Support Package HSP0311. The graphic user interface supports you in the configuration, parameter assignment and commissioning of the drive functions of the TM Drive.

Parameter assignment is also possible via data sets (see appendix Data sets).

In this section you will find information on various topics including:

- Check before powering on for the first time
- Commissioning an TM Drive drive

CAUTION

Failure to comply with the instructions for Safety Integrated poses a risk of injury

Failure to comply with the instructions may result in serious injuries. Carefully read through the safety instructions in section Safety functions integrated in the drive (Page 45) before commissioning and before operation.

WARNING

Personal injury and property damage from the falling down of a suspended axis

If the drive system is used as suspended axis, the axis will fall down if the positive and negative poles of the power supply are interchanged during connection. An unexpected falling down of a hanging axis can result in personal injury and property damage.

Before commissioning, you need to ensure that a cross brace is fitted to hold the suspended axis in place and prevent it from collapsing unexpectedly. Also ensure that the power supply is connected properly.

WARNING

Personal injury and property damage from the collapse of a suspended axis

An unexpected collapse of a suspended axis can result in personal injury and property damage

.

- When using the STO function in conjunction with suspended axes, the axis may fall down unexpectedly and cause property damage and personal injury.

NOTE
Performing tests
You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant.
Also allow for any possible foreseeable errors in the tests. This avoids endangering persons or equipment during operation.

7.1 Basics

7.1.1 Engineering

You perform configuration as well as diagnostics of a TM Drive with a PG/PC or notebook (commissioning device) using the TIA Portal (Hardware Support Package HSP0311 needed).

The settings can be found in STEP 7 in the device navigation under "Ungrouped devices" > "<Name of the interface module>" > "<Name of the TM Drive>".

Overview

This drive engineering is divided into the following areas:

- Online & diagnostics
- Parameters
- Device configuration

"Device configuration" area

Contents in the "Device configuration" area of the TM Drive engineering.

- Potential group
- Basic parameters
  Set telegram, activate telegram extension
- I/O addresses

"Online & diagnostics" area

Contents in the "Online & diagnostics" area of the TM Drive engineering.

Diagnostics

- General (module information):

  Order number, firmware and hardware version, I&M data
- Diagnostic status (display of status information)
- Active messages:

  Pending faults and alarms
- Drive diagnostics
  Status bits, operating values, encoders, temperatures, inputs

Functions

- Firmware update

"Parameters" area

Contents in the "Parameters" area of the TM Drive TM engineering.

- Drive:

  Drive data set, General settings, Motor, Motor gear, Thermal model, Intermediate circuit voltage, Brake module
- Setpoint channel:

  Reference values, application limits, speed-ramp sensor
- Open-loop/closed-loop control:

  Control type, controller settings, speed controller, current controller
- Messages/monitoring:

  Motor (thermal motor type), power output stage (utilization)

"Commissioning" area

Contents in the "Commissioning" area of the TM Drive TM Engineering.

- Configuration:

  Link to the parameter dialog
- Identification:

  Identification mode

  Encoder and pole position identification

  Encoder values
- Tuning:

  Calculate speed/current controller values

  Tuning the speed controller

  Transfer controller values to drive parameters

See also

PMSM drive parameters (Page 84)
Drive parameters stepper motor (Page 85)

7.1.2 Drive parameters

Parameter tooltips

In STEP 7 engineering of the TM Drive, all displayed drive parameters are linked with tooltips. You will find detailed information on the parameter in the tooltips, e.g. parameter name, properties, factory setting, value range, descriptions, notes and dependencies.

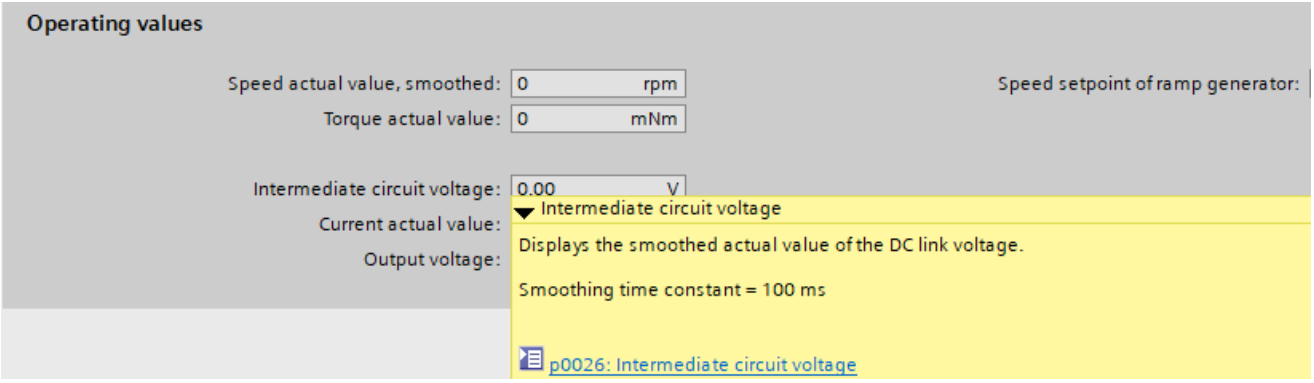

Figure 2-1584 Intermediate circuit voltage tooltip

Changing a parameter

You can directly change the values of the writable adjustable parameters (p-parameters) in STEP 7.

You have the following options for this:

- You overwrite the current parameter value with the new value.

  Or

- You select a value via the drop-down list.

Invalid values are rejected.

NOTE

P-parameters cannot be changed online while the drive is in operation. In this case, the corresponding entry field is automatically disabled.

The following overview shows the display of an entry field, depending on the context and the properties of the drive parameter:

1,0000 Nm	Project (offline)	Parameter value can be changed and stored in the project.
48,0 V	Project (offline)	The parameter value is write-protected.
24,0 V	Project (online)	Parameter value is write-protected or disabled due to the drive status.

Parameter symbols and operator controls

The following overview explains additional symbols and operator controls in the TM Drive engineering:

0,00 1/min	Drive value (online) could not be determined
	Bit parameter active (1-signal)
	Bit parameter inactive (0-signal)
	Binding values to be set by the commissioning engineer

Automatic check of the configured drive parameters

The configured parameters are checked both in STEP 7 and in the drive in order to detect incorrect parameter assignments and possible functional restrictions even before commissioning.

Both warning and error messages are output. In STEP 7, you obtain additional information and corrective measures about the respective message.

The causes of errors in the drive parameter assignments that prevent the drive from operating are listed below.

Parameter group	Possible causes of error
Motor	Electrical time constants of the connected motor are too low
	Torque constant is not consistent with other motor parameters
Encoders	Motor/encoder combination is not permitted
Speed/current controller	Controller parameters have not yet been set or are not permissible
Intermediate circuit voltage	Intermediate circuit limits are prohibited
Brake module	Brake chopper settings are not permitted

Loading drive parameters

You can synchronize all p-parameter values of your project (offline) using the "Download to device" function.

Constraints

- When you load parameters into the device, a rotating drive automatically stops.
- After the parameters are loaded, the drive does not restart automatically. You must activate the drive once again using a new drive command.
- If you send an invalid parameter to the TM Drive, the module remains in parameter assignment mode. The drive cannot be activated until valid parameters are loaded.

"Download to device" function for drive parameters

You can use the "Download to device" function to transfer parameter values from your project (offline) to the drive (online).

Procedure

1. Select the drive in the project tree.
2. Click on "Download to device" in the menu bar.

Or

1. Select "Download to device" > "Software" in the shortcut menu.

You have transferred the current parameter values of your project to the drive.

7.1.3 Calling help information

To obtain information on parameters and alarms (messages) of the drive, open the information system via "Help" > "Show help" and search for the article number of the product.

You can also directly open the information system for a parameter or a message. To do so, click the online help link in the tooltip of a parameter or message .

7.2 Requirements for the commissioning

Requirements

- The TM Drive was installed according to the information in the following sections:
  - Wiring (Page 29)
  - Configuring (Page 63)
- The motor is installed in the drive train to be operated in accordance with the plant/device construction planning.

NOTE

Additional information concerning the requirements

You can find additional information relating to technology objects and motion control in the online help of STEP 7 under "Using technology functions" > "Motion Control".

Before powering on for the first time

Before the first power-on, check the installation and the wiring of the TM Drive.

Questions for the check

The following questions provide guidance for checking your TM Drive in the form of a checklist.

Racks

- Is the mounting rail securely mounted to the wall, in the frame or in the cabinet?
- Are the cable ducts correctly installed?
- Have the minimum clearances been observed?

Grounding and chassis concept

- Is the mounting rail connected to the protective conductor?
- Is the connection between the ground reference and ground properly established for the mounting rail?
- Has the shielding of the motor/encoder cable been applied over a large area on the device and on the motor/encoder?
- Are the required equipotential bonding cables connected with low impedance to the affected plant units?
- Are the grounding terminals correctly attached and is the motor/encoder cable correctly connected?

Module installation and wiring

- Is the TM ServDrive plugged in / installed and firmly connected or screwed according to the assembly plan and configuration with STEP 7?
- Are all connectors wired according to the circuit diagram?
- Is the PROFINET connection to the CPU and the engineering system of the STEP 7 (TIA Portal) connected?
- Is the input for Hardware STO (STO+/STO-) connected?
- Are the cables (motor connection cable, encoder cable) properly connected between the TM Drive and the motor and installed according to the guidelines?
- Is the digital input connected?
- Was an external braking resistor optionally connected to the TM Drive?
- Are the cables from the hardware STO (STO+/STO-) separated from the other cables, in particular from power cables?
- Have you minimized crushing hazards and short-circuits against ground connections by appropriate routing?
- Are the cables fully protected against premature aging due to continuous UV radiation?

Power supply

- Are all power supplies switched off?
- Is the power cable connector correctly wired?
- Has the connection to line voltage been made?

7.3 Procedure for commissioning the ET 200SP TM Drive

Procedure for commissioning with STEP 7

Commissioning is performed according to the steps listed below. The individual commissioning steps are optional and are to be performed as required. We recommend the following procedure for the first commissioning of a TM Drive .

Table 2-2058 Commissioning procedure

Step	Procedure	Comments	See section ...
1	Configure drive data set	Use one of the following options in the "Import drive data set" dialog under "Parameters > Drive": • Select pre-configured drive data set from list • Import drive data from file system	Drive data sets (Page 79)
2	Define setpoint channel	Under "Setpoint channel" you configure the following: • Reference values • Application limits • Ramp generator	Setpoint channel (Page 96)
3	Set control/closed-loop control	Have the controller parameters automatically calculated using the "Speed/current controller settings" comfort function.	Speed control (cascade) (Page 102)
4	Configure intermediate circuit voltage monitoring and optionally the brake control module	• Define limits for intermediate circuit voltage • Brake chopper settings • Motor holding brake settings	Intermediate circuit voltage
5	Configure messages/monitoring	• Define warning thresholds for thermal monitoring	Messages/monitoring (Page 124)
6	Optional: Depending on motor type and encoder, determine commutation angle offset and encoder values	• Perform automatic encoder identification in commissioning under "Encoder identification".	Setting the commutation angle offset and pole position identification (Page 90)
7	Optional: Perform automatic controlled system detection	• Automatic controlled system detection can be performed for setting the current and speed controller in the commissioning under "Controlled system detection".	Automatic controlled system detection (Page 106)
8	Optional: Perform online optimization	• Tuning the speed controller	Section Manual controller tuning Speed controller (cascade) (Page 112)

7.4 Drive data sets

Introduction

So that you can optimally handle the requirements of drive technology, the TM Drive drive system is compatible with motors (Dunkermotoren, ebm-papst) and connecting cables (Harting, KnorrTec) of proven product partners of Siemens. This allows you to optimally combine suitable products from proven product partners for your individual application.

You can find more information about the Siemens Product Partner Program in theInternet (https://new.siemens.com/global/en/products/drives/sinamics/servo-drive-system-simatic-micro-drive.html).

It is possible to connect motors from third-party motor manufacturers, provided that they meet the required conditions regarding motor, encoder system, connection system, electrical safety, EMC, etc., as described in this manual.

For the F-TM ServoDrive HF this also includes stepper motors which can be connected bipolar, and which meet the constraints explained in this manual.

Drive data set

The motor or drive of the TM Drive drive system is configured using a drive data set (DDS). A drive data set contains the settings and information for the following drive components:

- Motor
- Gearbox
- Thermal motor model

NOTE

The description "drive" means the combination of motor, encoder and additional built-on accessories such as a gearbox and holding brake.

Motor

You can find the settings for the motor in the "Parameters" > "Drive" > "Motor" area.

The TM Drive drive system supports PMSM and stepper motors. You specify important basic data and reference data of the motor.

Observe the information and notes in the help or in the tooltips of the individual parameters.

You can also find detailed information and descriptions for the drive parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

Motor encoder

The motor encoder is used for the closed-loop speed control of the drive. The encoder values are transferred to the CPU in the PROFIdrive telegram of the TM Drive, independent of the encoder type.

The motor encoder (p0404) can be selected based on the motor type (p0300). The following combinations are available:

Motor type: Stepper motor

- (0) No encoder / calculated
- (1) Incremental encoder (A, B, Z track)

Motor type: PMSM motor

- (1) Incremental encoder (A, B, Z track)
- (5) IQ encoder (A, B track)
- (6) Absolute encoder BiSS-C

(0) No encoder / calculated

The setting (0) encoderless / calculated is only supported in connection with a stepper motor. In this case, the rotor position is calculated and transferred to the control depending on the increments per revolution (p0408) or the steps per revolution (p0409).

(1) Incremental encoder (A, B, Z track)

When selecting encoder type (1) incremental encoder, a 3-channel encoder with Z-track (often also called I-track) can be connected as an index track to identify the pole position.

(5) IQ encoder

If you are using a motor with IQ encoder, you must select the encoder type IQ encoder.

(6) Absolute encoder BiSS-C

A BiSS-C encoder transmits encoder value digitally and checks the data for transmission errors. Absolute encoders with multiturn and single-turn values as well as pure single-turn encoders with dual coding can be used.

Thermal model

The motor can be protected from thermal overload. Take section Messages/monitoring (Page 124) into consideration for this.

You define the thermal properties of the motor in the "Parameters" > "Drive" > "Thermal model" area.

7.4.1 Using the drive data set

To configure a drive, you have the following options:

- Download preconfigured drive data sets as a file for selected motors from Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/25460).
- Create a user-defined drive data set and configure your motor manually.

NOTICE
After a change of the drive data set, you must adapt or optimize the parameters for the current and speed controllers, if necessary. See section Speed control (cascade) (Page 102).

7.4.2 Drive data export / import

In addition to the pre-defined drive data sets, custom drive data sets can also be exported and imported.

The standard CSV format with ',' (comma) as column separator including a line header is used.

The data is stored according to the file header and also read in again on the basis of this line.

The formatting of decimal numbers is region-independent using a '.' (dot) as the decimal separator.

For negative values, the value must be preceded by a '-' (minus).

UTF-8 is defined as the character coding.

The header line is defined as follows:

##PNU(mandatory)##,##name##,##value(mandatory)##,##unit##,##dataType##, ##group##,##ECLASS number##

- Motor
- Motor gear
- Encoders
- Thermal model
- Motor holding brake

All parameters contained in the CSV file are included in an import. The CSV file can be customized and, for example, unused parameters can be removed. For example, only one parameter can be imported.

The parameters are assigned via the PNU, where the value must be present. Name, unit, data type and ECLASS number are used for better readability and are ignored during import.

Quotation marks and spaces are hidden during import, which is why no further commas are supported except for column separation.

Export drive data

The existing drive parameter assignments can be exported and saved as a file (*.csv) from STEP 7 Engineering.

1. Open "Parameters" > "Drive".
2. Start the export via the "Export drive data set..." button in the "Drive data set" area.
3. In the "Save" dialog, select a folder and the file name and confirm with "Save".

Import drive data

The drive parameter assignment can be imported as a file (*.csv) in STEP 7 Engineering. A drive data set may contain all or part of the parameters supported by the TM Drive used.

NOTE

Importing the drive parameter assignments overwrites all parameters with the values contained in the csv file.
Parameters not contained in the drive data set are not changed and retain their value.
The "Undo" function is not possible for the "Import drive data set" function.
Save your parameter assignments before importing a drive data set.

1. Open "Parameters" > "Drive".
2. Start the configuration wizard via the "Import drive data set..." button in the "Drive data set" area.
3. Select the "Import drive data set from file system" option.
4. Select the drive data set (*.csv) via the file folder button.
5. The drive data set is displayed in the log area and you can check the data.
6. Apply the configuration with "Yes".

Status messages about the import are displayed in the Inspector window in the General tab.

7.4.3 Using preconfigured drive data sets

You have the option of using preconfigured drive data sets for configuring your motor. You can obtain preconfigured drive data sets for selected motors from Siemens Industry Online Support (https://support.industry.siemens.com/cs/ww/en/ps/25460) or product partners.

Installing the drive data record

Pre-configured drive data sets are provided as a file (tms *.mpk) and must be installed in STEP 7 engineering. A drive data record file can contain the configuration of one or more motors.

Expand the list of drives by installing new drive data sets from the file system:

1. Open "Parameters" > "Drive" in the context of the drive.
2. Start the configuration wizard with the "Configure drive data record..." button in the "Drive data record" area.

3. Select the "Select drive from list" option.
4. Click "Install the drive data record" and select one or more drive data record files that you want to install.
5. Confirm the disclaimer by clicking on "I agree".
   If you do not agree to the disclaimer, close the dialog with "Cancel". In this case, no drive data record file will be installed.

You have installed a drive data record and can now use it.

NOTE

An installed drive data record is installed locally on the PG/PC only for the current STEP 7 version. To open the local installation folder, click the "Locally installed drives" link in the "Configure drive data record" wizard.

Using a preconfigured drive data record

You can search for the desired drive in the list of all locally installed drives.

1. Open "Parameters" > "Drive" in the context of the drive.
2. Start the configuration wizard with the "Configure drive data record..." button in the "Drive data record" area.
3. Select the "Select drive from list" option.
4. Select the desired drive from the list under "Search here for drive or enter filter".
5. The selected drive data record is displayed in the report area and you can check the data.
6. Accept the configuration with "Yes".

You have selected and set up a preconfigured drive data record.

NOTE

You can pass on a saved engineering project with preconfigured drive data record or use it on a different PG/PC on which the utilized drive is not installed. In this case, no optional additional information on the drive is displayed, e.g. manufacturer or order number. This is displayed as soon as you have installed the utilized drive.

7.4.4 Using a user-defined drive data set

Create a user-defined drive data set and configure your motor manually.

You can freely configure the current drive data at any time, even if it was imported via a pre-defined drive data set or a parameter table.

⚠ WARNING

Avoiding incorrect parameter assignments

Note that incorrect or modified parameter assignments can result in drive malfunctions and damage to the drive.

7.4.5 PMSM drive parameters

Parameter number	Name	Description	Unit
Motor			
p0300	Motor type	Selection of the motor type	
p0304	Nominal voltage	Refer to the motor data sheet for the nominal voltage of the motor. The nominal data of the motor are based on this voltage.	V
p0305	Nominal current	The nominal motor current is the current value at which the motor delivers its nominal power and nominal torque under nominal conditions. The nominal current value refers to the ambient conditions specified by the motor manufacturer. If, for example, the motor ambient temperature differs from that of the motor manufacturer, the nominal current must be adjusted according to the manufacturer's specifications.	A
p0311	Nominal speed	Nominal motor speed is the speed at which the nominal values of the motor are valid.	rpm
p0312	Nominal torque	Nominal torque is the torque at the nominal operating point of the machine.	Nm
p0322	Maximum speed	Maximum speed is the mechanically permissible speed of the machine. If the speed is exceeded, the motor may be damaged.	rpm
p0323	Maximum current	The maximum current is the maximum motor current permitted for a short time. The motor can be operated briefly up to this current without resulting in damage, but continuous operation is only permissible up to the maximum nominal current. The maximum current can flow until the limitation of the thermal model intervenes. Specifications such as permissible motor peak currents, e.g: for the duration of 1 s, are not to be entered here.	A
p0316	Torque constant	The torque constant of the motor is the proportionality factor between the RMS current of the q current and the internal torque of the motor. The motor torque is calculated from this constant.	mNm/A
p0314	Number of pole pairs	Number of pole pairs of the motor. For example, an 8-pole motor has 4 pole pairs	-
p0372	Connection resistance (= internal resistance)	Connection resistance of the motor between two motor phases.	Ohm
p0376	Connection inductance q component (=winding inductance q)	Connection inductance between two motor phases in the q axis. When only the value of the rotating field inductance is specified, this value can be used for d and q inductance.	mH

Parameter number	Name	Description	Unit
p0377	Motor connection inductance d component (=winding inductance d)	Connection inductance between two motor phases in the d axis. If only the value of the rotating field inductance is specified, this value can be used for d and q inductance.	mH
p0341	Rotor moment of inertia	The rotor moment of inertia is the mass moment of inertia of the rotor with the connecting shaft.	kgcm²
p0318	Standstill current (= holding current)	The standstill current of the motor corresponds to the current value with which the motor can be permanently loaded at standstill under the ambient conditions specified by the motor manufacturer.	A
Motor gear			
p2725	Motor gear moment of inertia	Sets the motor gear moment of inertia in relation to the motor axis.	kgcm²
Thermal model			
p0611[1]	Time constant winding - environment	Setting of the thermal time constant between the winding and the environment. In nominal operation (nominal load and the ambient temperatures and installation elevation specified by the manufacturer) the limit temperature of the motor is reached after five times the time constant. Note: If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. See 7.7.1 Thermal motor monitoring	s
Motor connection			
p0352	Motor cable line resistance	Input of the motor cable resistance value for outgoing and return conductor.	Ohm
p0353	Motor series inductance (=motor cable inductance)	Input of the line inductance of the outgoing and return conductor. The value can be neglected for motor connection cables < 10 m. If a series reactor is also connected between the motor and the inverter, you need to enter the inductance value as an additive to the line inductance.	mH

7.4.6 Drive parameters stepper motor

Parameter number	Name	Description	Unit
Motor			
p0300	Motor type	Selection of the motor type	
p0305	Nominal current	Nominal current per coil in full step mode.	A
p0312	Hold torque	Hold torque of the stepper motor in full step mode and nominal current.	Nm

Parameter number	Name	Description	Unit
p0322	Maximum speed	Maximum speed is the mechanically permissible speed of the machine. If the speed is exceeded, the motor may be damaged.	rpm
p0372	Connection resistance	Connection resistance of a phase	Ohm
p0376	Connection inductance	Connection inductance one phase	mH
p0341	Rotor moment of inertia	The rotor moment of inertia is the mass moment of inertia of the rotor with the connecting shaft.	kgcm²
p30000	Step angle	Step angle of the stepper motor in full step mode.	°
p30001	Number of steps	The number of steps indicates the number of steps per mechanical revolution in full step mode. The value cannot be edited and is calculated from the step angle. Number of steps = 360° / step angle	-
p0014	Number of pole pairs	The number of pole pairs indicates the number of pole pairs in the motor. The value cannot be edited and is calculated from the step angle. Number of pole pairs = step angle / 4.	-
Motor gear			
p2725	Motor gear moment of inertia	Sets the motor gear moment of inertia in relation to the motor axis.	kgcm²
Thermal model			
p0611[1]	Time constant winding - environment	Setting of the thermal time constant between the winding and the environment. In nominal operation (nominal load and the ambient temperatures and installation elevation specified by the manufacturer) the limit temperature of the motor is reached after five times the time constant. Note: If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. See 7.7.1 Thermal motor monitoring	s
Motor connection			
p0352	Motor cable line resistance	Input of the motor cable resistance value for outgoing and return conductor.	Ohm
p0353	Motor series inductance (=motor cable inductance)	Input of the line inductance of the outgoing and return conductor. The value can be neglected for motor connection cables < 10 m. If a series reactor is also connected between the motor and the inverter, you need to enter the inductance value as an additive to the line inductance.	mH

7.4.7 Motor encoder

Under Encoder type configuration, select the appropriate encoder type for the motor.

Parameter number	Name	Description	Unit
Encoder type configuration			
p0404	Motor encoder selec-tion	Selection of the motor encoder	-

Depending on the motor type, you can select the following encoders:

Motor type: PMSM motor

- (1) Incremental encoder (A, B, Z track)
- (5) IQ encoder (A, B track)
- (6) Absolute encoder BiSS-C

Motor type: Stepper motor

- (0) No encoder / calculated
- (1) Incremental encoder (A, B, Z track)

7.4.7.1 Encoder parameters, incremental encoder, IQ encoder and encoderless/calculated

The encoder types incremental encoder, IQ encoder and encoderless/calculated use the same settings.

Parameter number	Name	Description	Unit
p0408	Increments per revolution	Setting of the increments per revolution or the pulses per revolution (PPR) of the motor encoder.	-
p0409	Steps per revolution	Display of the steps per revolution or counts per revolution (CPR) of the encoder. The value cannot be edited, results from the quadrature interface and is four times the value of increments per revolution (p0408).	-

Incremental encoder, IQ encoder

The increments per revolution must be set for the incremental encoder and the IQ encoder. The increments can be independently detected at the incremental encoder by the automatic encoder detection of the TM Drive.

Encoderless / calculated with stepper motor

With the setting encoderless / calculated, the motor moves at low speeds in the set encoder resolution steps p0408 or p0409. The encoder resolution (increments per revolution (p0408)) must be at least 4 times or a multiple of the number of pole pairs of the motor. If the values are too high, the positioning accuracy can fluctuate depending on the motor quality (ripple).

It is recommended to set every integer multiple of the motor full step angle (p30001); a step division into partial steps (1/2, 1/4, 1/8, etc.) is not necessary but can improve the positioning accuracy, especially with multi-pole stepper motors. The following table shows how the corresponding step subdivisions are determined for this.

Step resolution	**Steps per revolution (p0409)**	**Increments per revolution (p0408)**	**Example: Step angle = 1.8°; Number of steps = 200; Number of pole pairs = 50**	
			Steps per revolution (p0409)	**Increments per revolution (p0408)**
Full step	1 x number of steps (p30001)	1/4 x number of steps (p30001)	200	50
1/2 half step	2 x number of steps (p30001)	2/4 x number of steps (p30001)	400	100
1/4 fourth step	4 x number of steps (p30001)	4/4 x number of steps (p30001)	800	200
1/8 eighth step	8 x number of steps (p30001)	8/4 x number of steps (p30001)	1600	400
.	.	.	.	.
1/64 sixty-fourth of a step	64 x number of steps (p30001)	64/4 x number of steps (p30001)	12800	3200

7.4.7.2 Encoder parameters for absolute encoder BiSS-C

A BiSS-C encoder transmits absolute encoder position as single-turn and optionally as multiturn values. The transmission occurs according to the specified BiSS-C protocol. The following figure shows the structure of the protocol. Using the BiSS-C protocol, in addition to the encoder position values single-turn (ST) and multiturn values (MT), an encoder-side alarm bit and a warning bit can also be transmitted. Transmission errors are detected using a CRC (Cyclic Redundancy Check).

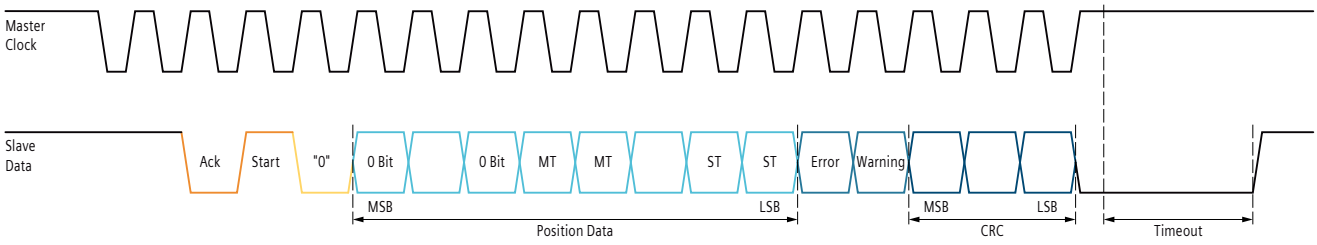

Figure 2-1585 BiSS-C protocol

Table 2-2059 **Encoder values**

Additional absolute encoder BiSS-C			
Parameter number	**Name**	**Description**	**Unit**
p0423	Single-turn resolution	Number of bits of the single-turn resolution The resolution of the single-turn value (ST) is calculated as follows 2^(p0423[0]). The sum of single-turn, multiturn and number of bits before position value must be <= 56.	Bits

Additional absolute encoder BiSS-C			
p0421	Multiturn resolution	Number of bits of the multiturn resolution The resolution of the multiturn value (MT) is calculated as follows 2^(p0421[1]). The sum of single-turn, multiturn and number of bits before position value must be <= 56.	Bits
p0449	Number of bits before position value	Number of bits before the position value In some telegrams, so-called empty bits (0-bit) are inserted before the position bits. The sum of single-turn, multiturn and number of bits before position value must be <= 56.	Bits
p0429:0..1	Transfer code	Selection of the transmission code Valid values: [1] Dual	-
p0427	Transmission frequency	Selection of the transmission frequency between the module and the encoder. The following values can be set: [0] 350 kHz [1] 700 kHz [2] 1.4 MHz [3] 2.8 MHz The maximum transmission speed depends on the cable length and its shielding as well as the technical specifications of the absolute encoder.	kHz
p0429:2	Encoder diagnostics	Selection whether the encoder diagnostic bits are to be evaluated or ignored. If diagnostics are not selected, warnings and errors of the encoder are ignored.	-
p0450	CRC polynomial	Input of the polynomial length of the cyclic redundancy check (CRC). Note: Only the recommended CRC value for BiSS-C encoders with 43 hex is supported.	-

7.4.7.3 Assign encoder counting direction parameters

For encoder type (1) incremental encoder, it may be necessary to invert the counting direction of the encoder by setting parameter p0410, Invert encoder counting direction. With incremental encoders, this may be necessary, for example, if the A and B tracks were swapped when the encoder was connected.

The following is defined as the positive direction of rotation of the encoder.

Incremental encoder:

The positive direction of rotation for an incremental encoder is defined as follows.

If the positive A edge comes before the positive B edge in terms of time, the motor with a view of the motor shaft rotates clockwise in the positive direction of rotation.

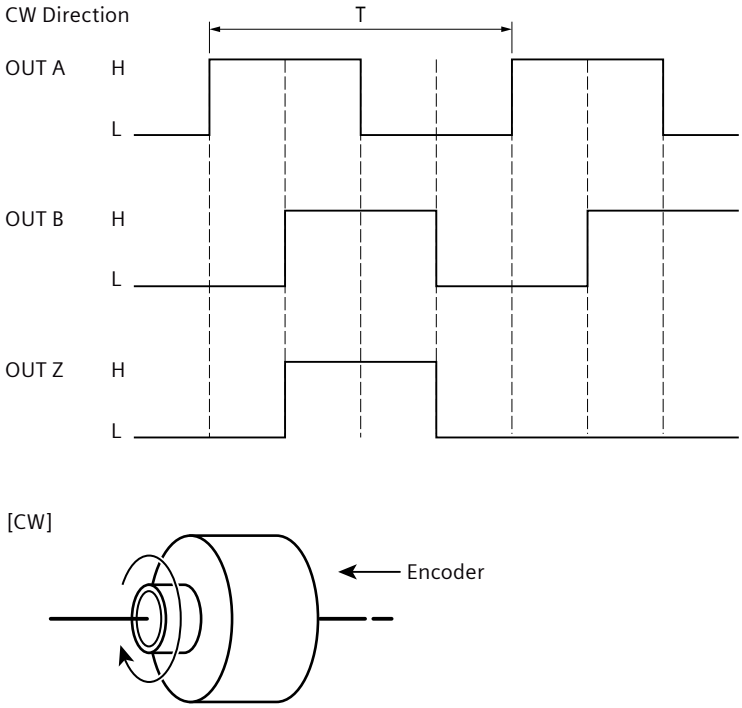

Figure 2-1586 Direction of rotation for the incremental encoder

Definition:

A positive speed in TM Drive is defined as follows:

The motor rotates clockwise looking down on the motor shaft. The encoder value increments during this process.

Table 2-2060 **Encoder values**

Parameter number	Name	Description	Unit
p0410	Reverse encoder counting direction	This setting negates the counting direction of the encoder.	-

7.4.7.4 Setting the commutation angle offset and pole position identification

For the commutation of a PMSM with the encoder type

- [1] Incremental encoder (A, B, Z track)
- [6] Absolute encoder BiSS-C

it is necessary to know the commutation angle offset or to determine it.

The commutation angle offset is the angle offset between a reference (Z-track for incremental encoders or the (single-turn) value "0" for absolute encoders) and the rotor / pole position.

Encoder calibration at each start (p1990)

If the parameter (p1990) "Encoder calibration at each start" is set, the determination of the commutation offset angle is repeated, for example, by voltage interruption at each restart or after each configuration of the drive.

If the parameter (p1990) is not selected, the value entered in the commutation angle offset (p0431) is used for commutation. If the offset angle is known, this can either be entered or automatically determined by TM Drive (see section Automatic encoder / pole position identification (Page 94)).

NOTE

Incremental encoder

After a new configuration or after switching off the power supply, the pole position is unknown when using an incremental encoder. If the parameter (p1990) "Encoder calibration at each start" is not set, the motor control is speed controlled with a fixed motor (running) current depending on the motor current parameters until there is synchronization of the pole position.

If synchronization with the Z-track is not possible, the control is aborted.

If the rotor position has not yet been synchronized, the drive may be twisted by an external load. If you want to prevent the drive from rotating directly after drive activation, you can use the Additional torque parameter (p1511) to ensure that a corresponding hold torque is applied to the motor (see section Speed control (cascade) (Page 102)).

NOTE

Motor replacement

When replacing the motor, remember that the motor encoder in a motor series is not always calibrated in the same way.

If the encoder calibration is selected at every start, no further action is required.

If this is not the case, the commutation angle offset must be determined again in the encoder / pole position identification (see section Automatic encoder / pole position identification (Page 94)).

⚠ WARNING

Incorrectly set commutation offset angle

It must always be ensured that the commutation offset angle is set correctly.

Otherwise, there will be insufficient control of the drive and it will not achieve its full performance or it will proceed in an uncontrolled manner.

Table 2-2061 Encoder values

Parameter number	Name	Description	Unit
p1990	Encoder calibration at each start	If this option is selected, the commutation angle offset is determined again at every restart (new configuration or switching off the supply voltage). It is recommended to determine the commutation angle offset once during commissioning. Calibration is then no longer necessary, except when replacing the motor.	-
p0431	Commutation angle offset	Setting the commutation angle offset The commutation angle offset is the angle between the rotor pole position and the 0° degree pulse of the encoder. If the angle offset is not known, it can be determined by the module during commissioning. The offset angle is defined as follows. Incremental encoder: 0° offset is present if the Z pulse is applied at least at one alignment point (depending on number of pole pairs) when the phase U is positive and V, W are negative. Absolute encoder: 0° offset is present if the angle value is 0 at least at one alignment point (depending on number of pole pairs) when the phase U is positive and V, W are negative. **Warning:** **An incorrectly set commutation angle offset can lead to uncontrolled behavior of the drive!**	-

7.4.7.5 Calibration process of the commutation angle offset

When selecting parameter p1990 "Encoder calibration at each start", the TM Drive restarts the calibration process of the motor pole angle after:

- Every initial enable of the drive
- Every time the power supply is switched on again
- After re-configuration
- If certain malfunctions of the module occur

After that, the TM Drive references with the determined offset angle over the Z-track or the encoder steps of the absolute encoder.

The motor is energized for the calibration process and thereby generates torque.

The motor current is limited by the:

- Prospective locked rotor current (p0318)
- Equivalent current from the nominal torque of the motor (p0312)
- The equivalent current from the torque limitation (p1520)
- The maximum converter current

The smaller limitation in each case takes effect.

A possibly existing motor holding brake must be opened, so that a rotation of the motor is possible. If the motor holding brake is configured via the TM Drive and connected accordingly, the task of opening the holding brake is assumed by the TM Drive.

NOTE

If you have selected (p1990) "Encoder calibration at each start", the drive must retrain itself at initial commissioning and each time the power supply is switched back on or a new project download is performed. This process can take between 1 - 4 seconds. The motor can move by a maximum of 180° / number of pole pairs. Such movement must be possible in the application.

The following constraints must be observed:

- The motor must be able to rotate freely in both directions of rotation and the axis must not be loaded with a static load.
- With suspended loads, the option (p1900) "Encoder calibration at every start" must not be used.
- It is recommended to use an absolute encoder especially for suspended loads.
- The calibration process cannot be performed when the axis is rotating, or the speed must be below the standstill detection p1226.

NOTICE

Open motor holding brake

The motor holding brake is opened during calibration of the commutation angle offset. Especially with suspended axes, it is therefore important to ensure that it is possible to open the motor holding brake.

An unexpected collapse of a hanging axis can result in personal injury and property damage.

Before commissioning, you must ensure that a cross brace is fitted to hold the suspended axis in position and prevent it from collapsing unexpectedly. Also ensure that the power supply is connected properly.

WARNING

Motor movement by measurement on unbraked motors

The measurement can be used to trigger a rotation or movement of the motor via the specified current on unbraked motors. The magnitude of the movement depends on the specified current as well as on the moment of inertia of motor and load.

7.4.7.6 Automatic encoder / pole position identification

Automatic encoder pole position identification is found in the Commissioning submenu of the configured TM Drive. This function is only possible with the PMSM motor type. Incremental encoders and absolute encoders can be detected. Depending on the encoder type, the following encoder / motor parameters are automatically detected:

Incremental encoder (1) and absolute encoder (6)

- Commutation angle offset (p0431)
- Number of pole pairs (p0314)

Incremental encoder only (1)

- Increments per revolution (p0408)
- Invert encoder counting direction (p0410)

For automatic encoder / pole position identification please proceed as follows:

Preconditions

- Motor type PMSM
- The motor parameters are known and the calculation of the controller parameters under open-loop/closed-loop control has been performed and transferred to the drive.
- The device is in RUN state and the drive is at standstill.
- The drive is not enabled in any other way (e.g. by a technology object or a user program).
- The motor can rotate freely in both directions of rotation and is not loaded with a static load (example: suspended load)

NOTE

If the motor is loaded with a static load during encoder detection, the commutation offset angle may not be correctly detected. The motor can then only deliver a reduced torque.

Step 1:

Go online and enable commissioning mode under Commissioning, Identification with the 'Start' button and select the encoder / pole position identifier.

NOTE

In this operating mode, the drive can only be controlled by the TM Drive. A control of the drive by the S7 control via PROFIdrive is not possible in this mode and is locked. This is also signaled by resetting ZSW1 bit 9.

Step 2:

The configured motor type and motor encoder is displayed under Commissioning encoder / Pole position identification. Insert the identification current allowed for the test. This is always automatically set to the rated motor current. However, it can be adjusted if required.

NOTE

If the motor is already installed in an application, you may need to increase the identification current in steps. The motor maximum current p0323 must not be exceeded. If necessary, observe idle times between the identification cycles to avoid overheating the motor.

Especially for motors with an increased cogging torque, it may be necessary to increase the identification current so that the encoder and pole position information can be accurately detected.

Step 3:

Start the encoder / pole position identification with the selection button "Start encoder detection".

A configured motor holding brake is opened during encoder / pole position identification. This is signaled via ZSW1 bit 12.

NOTICE

Open motor holding brake

The motor holding brake is opened during encoder / pole position identification. Especially with suspended axes, you must ensure that it is possible to open the motor holding brake.

An unexpected collapse of a suspended axis can result in personal injury and property damage.

Step 4:

If the drive is still in operation, execution of the identification commands is rejected. Stop the operation of the drive before the encoder / pole position identification. Then continue with step 3.

When all conditions are fulfilled, the TM Drive starts the identification after the confirmation of the safety prompt. It is necessary that the drive can be turned safely in both directions.

Step 5:

If the encoder / pole position identification is successfully executed, the determined values are displayed.

NOTE

Before you apply the determined values, you need to check them for plausibility.

Step 6:

You can now select which of the determined values you want to transfer to the offline project. By clicking the "Transfer determined values to offline project" button, the selected values are transferred to the offline project.

NOTE

The determined settings are stored only temporarily on the module. They are replaced by the permanently stored parameters on the next restart.

If you want to store the settings permanently on the module, change the drive parameters offline and download them again with "Download to device".

Step 7:

When you have transferred the parameters to the offline project, disable commissioning mode under Commissioning, Identification with the 'Exit' button. You must then load the parameters onto the module using "Download to device".

Encoder / pole position identification is completed. The option "Encoder calibration at each start" (p1990) is no longer required and should be deselected.

7.5 Setpoint channel

Overview

Setpoints from the respective setpoint source are prepared for the motor control in the setpoint channel of the drive.

You specify the setpoints via the drive telegrams to PROFIdrive.

You can find the settings for the setpoint channel in the context of the drive under "Parameters" > "Setpoint channel".

Under "Setpoint channel" you configure the following:

- Reference values (Page 97)
- Application limits (Page 98)
- Ramp generator and speed setpoint filter (Page 100)

The figure below shows the processing of the speed setpoint in the drive controller.

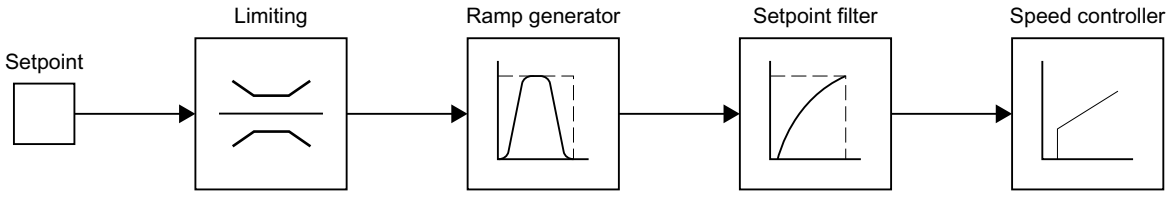

Figure 2-1587 Setpoint channel

The speed setpoint from the drive telegram is limited in the setpoint channel according to the specified values, see section Reference values (Page 97).

The limited speed setpoint is fed to the ramp generator as an input signal, see section Application limits (Page 98).

The output of the ramp generator is fed to the speed controller via the speed setpoint filter, see section Ramp generator and speed setpoint filter (Page 100).

7.5.1 Reference values

The physical variable speed is transmitted in the drive telegrams as a reference values.

- Speeds are normalized to the reference speed (p2000) in the drive telegram.
- Torques are normalized to the reference torque (p2003) in the drive telegram.

Parameters p2000 and p2003 are definitive as reference values (telegram content = 4000 hex or 4000 0000 hex for double words, if the input value has the value p2000 or p2003).

Example of the normalization of the speed:

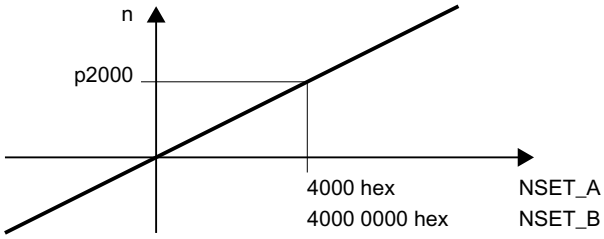

Figure 2-1588 Example of normalization of the speed

NOTE

The speed and torque are specified in the drive telegram as a percentage of the reference speed in the range -200% to 200%.

Therefore, set the reference variables in such a way that the desired maximum value falls within the value range of the control from -200% to +200%.

Procedure

1. Configure the reference value in the context of the drive under:

   "Parameters" > "Setpoint channel" > "Reference values".

WARNING

Uncontrolled drive behavior

Note that the specification of reference values in the CPU and the drive must always match. Otherwise, uncontrolled drive behavior and rotating of the motor might occur.

Recommendation: First, complete the commissioning of the drive and thereby the definition of the reference values before you start up the CPU and a technology object, for example.

7.5.2 Application limits

In the "Parameters" > "Setpoint channel" > "Application values" area, you can configure limitations for the speed and torque of the drive if required and adapt them to the requirements of your mechanical system.

Speed limiting

If you need a direction-dependent limiting of the speed p1083 and p1086, you can define speed limits for each direction.

Torque limiting

You can specify the torque limitation p1520 as an absolute value. The limiting acts both when motoring as well as generating.

WARNING

Accuracy of torque limitation

The function of the torque limitation is not safe torque limiting in the sense of functional safety. The torque limitation refers to the calculated internal (air gap) torque of the motor.

The internal torque is a calculated value from the internal motor constant and motor current. The torque output at the shaft is the internal torque minus friction and iron losses.

Due to the following influencing factors, the deviation of the torque calculation can be in the two-digit percentage range:

- Internal motor constant p0316
- Current measurement accuracy
- Temperature dependence
- Speed and load dependence on friction, iron and additional losses of the motor

WARNING

Danger to life due to uncontrolled movement of the drive as a result of incorrect parameter assignment

Incorrect parameterization of the torque limiting can result in uncontrolled movement of the drives if there is no counter-torque, and cause death or serious injury.

Ensure the correct parameterization.

Zero speed detection

Set the speed threshold for the motor standstill detection (p1226). For braking with OFF1 or OFF3, the zero speed is detected when this threshold is fallen below.

NOTE

A zero point calibration is only started if the speed falls below the speed threshold for standstill detection (p1226).

NOTE

A switch-on process of the drive via STW1 is always delayed until the speed has fallen below the speed threshold for standstill detection (p1226).

As long as the speed is still above this speed threshold, warning 2007 is issued. This can be the case, for example, if the motor shaft is driven externally.

If the switch-on command is still set despite this warning, the drive is switched on and the specified setpoint speed is adopted as soon as the speed threshold for standstill detection has been undershot.

Speed threshold values for message

Also specify the speed threshold values for the following messages of the drive status word:

- "Speed threshold 1" (p2141)

  If the speed exceeds the threshold value, bit 10 is set as feedback in ZSW 1
- "Speed threshold 4" (p2163)

  As long as the speed deviation lies within the tolerance range, bit 8 in ZSW1 is set as feedback

- "On delay time" (p2167)

  Setting the switch-on delay time for the message "Speed setpoint/actual deviation within tolerance" (see also p2163)

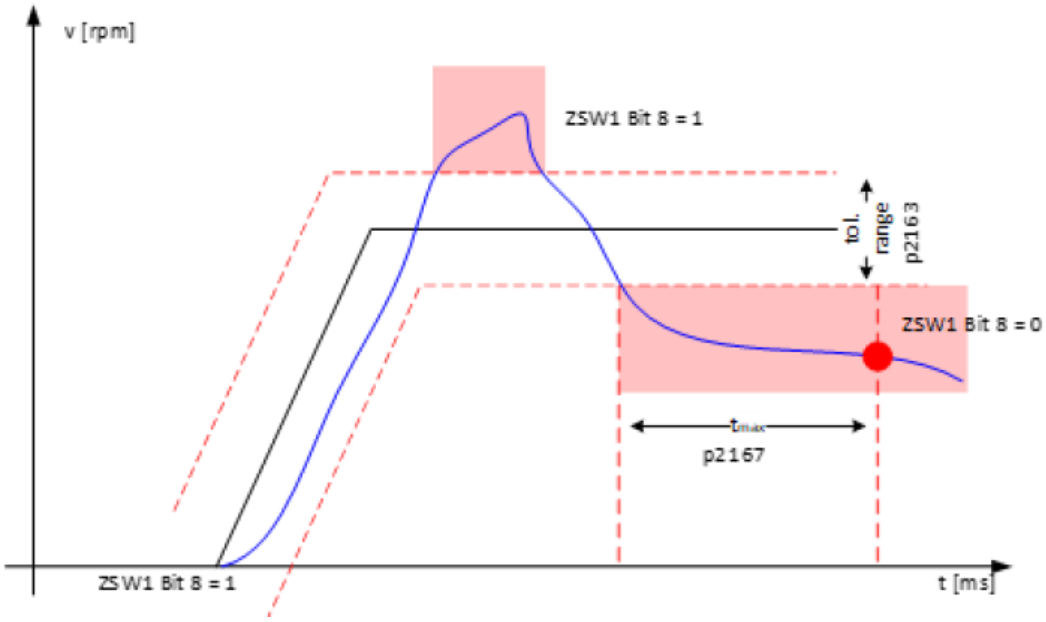

Figure 2-1589 Sets the ON-delay time (p2167) and the speed threshold value 4 (p2163)

End stop detection and step loss detection with the stepper motor

When an incremental encoder and the control type [103] controlled (I = const.) are used with a stepper motor, end stop detection or step loss detection can be implemented using bit 8 in the ZSW1. The parameters "speed threshold value 4" (p2163) and "On delay" (p2167) can be used to set the detection tolerance range.

7.5.3 Ramp generator and speed setpoint filter

Speed ramp generator

The TM Drive uses the speed ramp generator type "Basic ramp-function generator" p1115[0].

The ramp generator can be switched off with the setting "No ramp generator".

The speed ramp generator is used to limit the acceleration at sudden setpoint changes and helps to prevent drive train shock loads.

An acceleration ramp and a deceleration ramp can be set independently with the ramp-up time and ramp-down time. This enables a controlled transition at setpoint changes.

NOTE

On principle, the ramp-up and ramp-down times of the ramp generator in the setpoint channel of the drive should be set only so fast that, in case of accelerations and decelerations, the motor speed can track the setpoint without damaging the machine. This ensures optimal functioning of the speed controller precontrol.

Especially with the control type [103] controlled (I = const.), the ramp-up and ramp-down times must not be set too steep, as otherwise the rotor cannot follow the controlled rotating field.

Procedure

You enter the settings for the speed ramp generator under "Parameters" > "Parameters" > "Ramp generator":

- Rampup time
- Ramp-down time
- Speed

NOTE

The TM Drive uses the three values entered to form the values relative to 10,000 rpm "Speed ramp generator ramp-up time" (p1120) and "Speed ramp generator ramp-down time" (p1121).

When using the GSD file, directly enter the values relative to 10,000 rpm.

Speed setpoint filter

The drive has a first-order time-delay element (low pass PT1) as a speed setpoint filter. The filter time constant can be set with p1416.

The speed setpoint filter is able to attenuate harmonic components of the setpoint and thus to prevent any overshooting of the higher-level controller.

The speed setpoint filter has no effect on the stability of the speed controller because it is in the setpoint channel before the control loop. The dynamics of the response to setpoint changes is reduced by smoothing.

As a rule, set the speed setpoint filter to a low value, since the upstream ramp generator ensures sufficient limitation of the setpoint signal.

7.6 Controller settings

Under "Parameters" > "Open-loop/closed-loop control", you specify the type of control, the general controller settings and the settings for speed and current controllers.

Control type

The open-loop / closed-loop control type can be selected depending on the motor type. The following combinations are available:

Motor type: PMSM motor

- [100] Closed-loop speed control (cascade)

Motor type: Stepper motor

- [103] Controlled (I = constant)

7.6.1 Speed control (cascade)

In Speed controller (cascade) mode, the speed difference between the actual and the nominal speed is detected using an encoder and the speed deviation is controlled accordingly. Since the speed controller is followed by a current controller, this speed control method is referred to as cascade control.

General controller settings

Speed and current controllers can be optimally tuned if the properties of the load mechanics of your machine and the electrical properties of the drive are specified as correctly as possible.

Enter the general controller settings under "Parameters" > "Control/closed-loop control" > "Controller settings".

- Moment of inertia load p1398
- Precontrol p1496
- Viscous friction p1399
- Additional torque p1511
- Speed actual value filter p1441

Speed stability can be improved using the actual speed filter, depending on the encoder resolution.

Constant loads can be compensated using additional torque p1511. This reduces compensation processes when the drive is switched on using motor holding brakes.

Additional important settings

The values for speed and current controllers can be determined in the best possible way if, in addition to the properties of the electric motor, you also specify the properties of the gearbox and the connecting cable.

- Motor cable line resistance p0352
- Motor cable/series inductance p0353
- Motor gear moment of inertia p2725

Precontrol p1496

Using the precontrol (p1496), the precontrol of the moments of inertia, consisting of Motor (p0341), Motor gear (p2725) and Moment of inertia load (p1496), can be specified as a percentage value. The precontrol allows the drive to be moved more dynamically. The precontrol is switched off with a preset of 0%. The precontrol is preset by the automatic controlled system detection (see section Automatic controlled system detection (Page 106)) depending on the controller dynamics.

To use this function, the setpoint speed must be preset by a ramp. For this, you can either use the internal ramp generator (see section Ramp generator and speed setpoint filter (Page 100)) or corresponding acceleration/deceleration functions in technology objects.

Viscous friction p1399

The friction of the system is precontrolled using Viscous friction (p1399). This is specified as a linear friction torque as a function of the speed and is detected during automatic controlled system detection.

Additional torque p1511

Constant loads can be compensated using additional torque (p1511). This reduces compensation processes when the drive is switched on using motor holding brakes.

Speed actual value filter p1441

The drive has a first-order time-delay element (low pass PT1) as a speed actual value filter. The filter time constant can be set via (p1441).

The parameter is preset depending on the parameter "Increments per revolution" p0408 in the HSP. If you configure the device using a GSDML, you can use the following table as a guide.

Table 2-2062 Actual speed filter times as a function of the encoder resolution

Encoder resolution (Steps per revolution p0409 or [2]Single-turn resolution p0423)	**Speed actual value filter p1441 in ms**
400	11
512	10
1024	8
2048	6
4096	4
6000	2
10000	1
16000	0

Speed controller and current controller

You can either have the speed and current controller parameters calculated via the controller settings of STEP 7 or you can perform the automatic controlled system detection (7.6.2). It is also possible to set the controller settings manually.

Having controller settings calculated

To have the controller settings of STEP 7 calculated, proceed as follows:

1. Click the "Calculate speed number/current controller settings" button in the area for the controller settings.
   The "Controller calculation" window opens. The window displays the appropriate controller parameters.
2. If needed, you can re-adjust the controller settings via the "Controller behavior" and "Load fluctuation" sliders.
   – "Controller behavior": If the value is increased, the controllers react more strongly to controller differences. At the same time, the controller tends to overshoot.
     The default setting here is 70%.
   – "Load fluctuation": A larger value allows more oscillation in the stable state. The speed deviations are greater during a load step.
     The default setting here is 30%.

   NOTE

   There is no guarantee that readjustment of the controller calculation will always result in a stable system.

   Change the settings for "Controller behavior" and "Load fluctuation" incrementally. Always check the settings with low speed and load profiles.

3. Apply the controller settings by clicking the "Apply" button.

You can then continue to change the calculated controller settings manually.

Setting the controller settings manually

Enter the settings for the speed controller under "Parameters" > "Control/closed-loop control" > "Speed controller".

- Prop. gain
- Integral action time
- Speed actual value filter

Enter the settings for the current controller under "Parameters" > "Control/closed-loop control" > "Current controller".

- Iq proportional gain
- Iq integral action time
- Id proportional gain
- Id integral action time

NOTE

If you manually set the controller parameters to inappropriate values, the drive system can be damaged.

Make changes to the controller settings in small steps. Keep checking the behavior of the drive system until you have found a satisfactory setting.

7.6.2 Automatic controlled system detection

You can find the automatic controlled system detection in the Commissioning submenu of the configured TM Drive. This function is only possible with the cascade control mode (p1300).

During the measurement run, the system is measured using test signals. The drive is moved in the process. Configured torque (p1520) and speed limits (p1083 and p1086) are taken into account and can also be used to protect the drive or the application.

The drive accelerates to the test setpoint speed, stops and executes the same travel profile in the reverse direction of rotation. The motor is thereby approximately at the starting position again after the measurement run.

The "Reversal of direction of rotation" checkbox can be used to specify the direction of rotation for the measurement run. If the check box is selected, the motor rotates counterclockwise when viewing the motor shaft, otherwise the motor shaft rotates clockwise. By specifying the number of motor revolutions, it is possible to limit the maximum rotation of the drive. The input of the number of revolutions limits the test setpoint speed if necessary.

The following parameters are automatically determined during controlled system detection:

- Motor connection resistance including motor cable line resistance
- Current control parameters
  - Iq proportional gain p1715
  - Iq integral action time p1717
  - Id proportional gain p1735
  - Id integral action time p1736
- Speed controller parameters
  - Prop.gain p1460
  - Integral action time p1462
- Moment of inertia load p1398

- Precontrol p1496
- Viscous friction p1399

The controlled system detection function automatically provides you with the controller parameters specific to your application and motor.

The controlled system detection function can be adapted to different system requirements.

The connection resistance of the system is detected during the controlled system detection. The determined resistance is divided between the connection resistance (p0372) and the resistance of the motor supply line (p0352).

- If the measured resistance is greater than the connection resistance (p0372), the additional portion is allocated to the motor cable line resistance (p0352).
- If the measured resistance is less than the connection resistance (p0372), this is adjusted and the portion of the motor cable line resistance (p0352) is set to 0.

WARNING

Unplanned movement of the motor during speed controller tuning

Speed controller tuning causes movement of the drive which can result in death, serious injury or material damage.

- Ensure that nobody is present in the hazardous zone and that the mechanical system can move freely.

NOTE

Directions of rotation and permissible motor rotation range

In the application, the motor must be able to move at least in the specified motor rotation range (p8991). The machine may be damaged if the traversing range is not accordingly limited.

If this is not permissible due to your plant conditions, it is prohibited to perform controlled system detection.

Before commissioning, ensure that the motor and application parameters are correct.

Procedure

Preconditions

- Cascade control mode
- The motor and application parameters are known and transferred to the drive.
- Speed and torque limitation are configured and transferred to the drive.
- The device is in RUN mode and the drive is at standstill

- The drive is not enabled in any other way (e.g. by a technology object or a user program).
- The motor can rotate freely in both directions of rotation and is not loaded with a static load (example: suspended load)

NOTE

If the motor is loaded with a static load during the controlled system detection, this may result in the speed and current controller parameters not being detected correctly.

Step 1:

Go online and enable commissioning mode under Commissioning, Identification with the 'Start' button and select the controlled system detection.

You can abort controlled system detection at any time by pressing the "Exit" button. The drive coasts to a stop and the motor holding brake closes. The drive may have to be returned to its start position before a new measurement run.

NOTE

In this operating mode, the drive can only be controlled by the TM Drive. A control of the drive by the S7 control via PROFIdrive is not possible in this mode and is locked. This is also signaled by resetting ZSW1 bit 9.

Step 2:

Make the settings for controlled system detection.

- Measurement run dynamics p8990

  The acceleration gradient of the rotating measurement run can be influenced using the measurement run dynamics factor.

  A high value is suitable for torsionally stiff systems and low mass inertias and a low value for elastic systems or systems with high mass moment of inertia.

  Generally, a high measurement run dynamic factor provides better results for the rotating controlled system detection. However, too high a measurement run dynamics factor can possibly lead to twisting, bending or other damage to the machine.

Recommendation: Start with a low measurement run dynamics factor and, if necessary, repeat the controlled system detection with an increased measurement run dynamics factor.

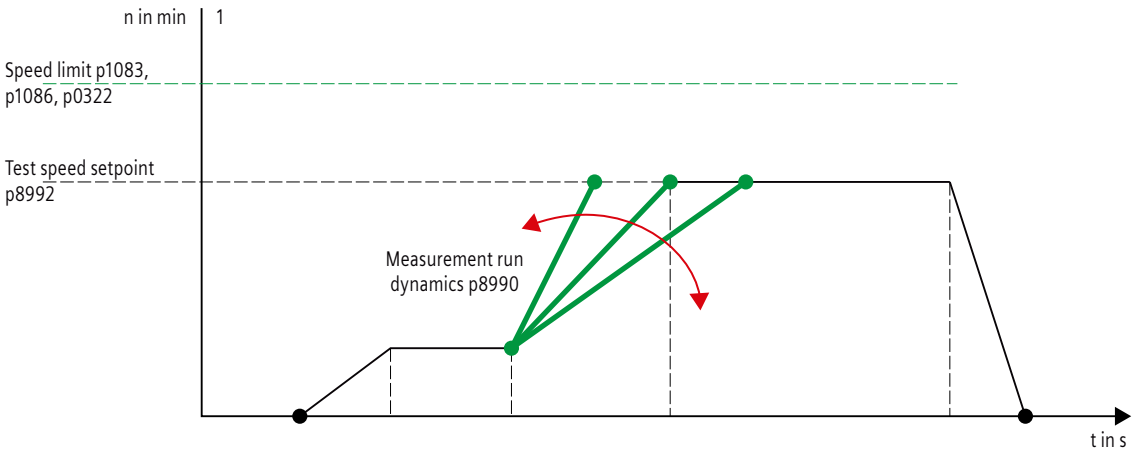

Figure 2-1590 Measurement run dynamics

- Max. number of motor revolutions p8991

  Specifies how many revolutions the motor may cover during the measurement. Ensure that a rotation with the configured number of motor revolutions is possible in the direction in which the motor is moved (specified via the "Reversal of direction of rotation" check box).

- Test speed setpoint p8992

  If possible, enter a typical speed value for the test speed setpoint at which the drive is to be operated later.

  If the measurement run is not possible due to the entry from max. number of motor revolutions (p8991) in combination with the test speed setpoint (p8992), this is displayed and a maximum possible test speed setpoint (p8992) is suggested in the text box.

- Torque limitation p1520

  The torque limitation is displayed as a parameter (read only). The setting must be made in the "Application limits" mask and the parameter must be loaded into the module.

- Controller dynamic factor

  Using the controller dynamic factor, you can set how the speed controller should be set up.

  – Conservative: Slow control – low mechanical load. (60% precontrol)
  – Default: Optimum between fast speed control and load of the mechanics. (80% precontrol)
  – Dynamic: Fast speed control – high mechanical load. (100% precontrol)

  A parameter check is performed automatically. This ensures that the drive can perform the measurement run with the configured dynamics within the configured max. number of revolutions. If the measurement run with the configured values is not possible, a warning is displayed and a reduced value for the test speed setpoint is entered.

Step 3:

Start the controlled system detection with the "Start controlled system detection" selection button.

A configured motor holding brake is opened during controlled system detection. This is signaled via ZSW1 bit 12.

NOTICE
Open motor holding brake The motor holding brake is opened during controlled system detection. Especially with suspended axes, you must ensure that it is possible to open the motor holding brake. An unexpected collapse of a hanging axis can result in personal injury and property damage.

Step 4:

If the drive is still in operation, execution of the controlled system detection is rejected. Stop the operation of the drive before the controlled system detection. Then continue with step 3.

When all conditions are fulfilled, the TM Drive starts the controlled system detection after the confirmation of the safety prompt. The drive is moved several revolutions for this.

Step 5:

After successful controlled system detection, the system variables and suitable controller values determined are displayed.

Depending on the application, it may be advantageous to perform the controlled system detection several times in succession and, if needed, to adjust the measurement run dynamics p8900.

NOTE

Before you apply the determined values, you need to check them for plausibility. If necessary, the control can be tested for stable behavior by traveling briefly in both directions (+/-).

Step 6:

You can now select which of the determined values you want to transfer to the offline project. The selected values are transferred to the offline project using the "Transfer determined values to offline project" button.

Step 7:

Once you have transferred the parameters to the offline project, disable commissioning mode under Commissioning, Identification with the 'Exit' button. You must then load the parameters onto the module using "Download to device". Otherwise, the parameters will be lost after switching the module off and on.

Automatic controller tuning is now complete.

Check the settings automatically found using a measurement run with your application. For additional optimization of the controller settings, you can use manual controller tuning from the section Manual controller tuning Speed controller (cascade) (Page 112).

NOTE

If the automatic controlled system detection could not determine any controller parameters, a new measurement run can be initiated by entering a higher moment of inertia of the load under control/closed-loop control parameters and repeating the controlled system detection. The controller parameters can thus be adapted for the machine. The measurement run is thus set to the increased inertia of the load.

You can save the measurement run to a csv file using the "Export measurement data" button.

Faults during controlled system detection

Faults during controlled system detection are displayed directly in the commissioning screen and can be acknowledged.

Table 2-2063 Causes of faults and errors

Fault number	Description	Cause / Solution
1055	Motor resistance detection could not be performed	If the motor phases are not connected correctly or insufficiently contacted, or if there is an asymmetry between the individual winding resistors, the error "Unable to successfully perform motor resistance detection" is set. Check the motor connections or the motor for defects and breaks.
1056	Following error during controlled system detection	If the drive is not able to follow the setpoint travel curve, this error is displayed. In this case, it is likely that the Measurement run dynamics p8990 was selected too large. Reduce the Measurement run dynamics p8990 and repeat the controlled system detection. It is also possible that the drive is blocked or the motor holding brake has not been configured or connected correctly.
1057	Position error during controlled system detection	If the maximum number of revolutions is exceeded, e.g. by an external load acting on the drive, this error is set and the drive is switched off. Either the controlled system detection is not possible in the application or reduce the external force on the drive train.

7.6.3 Manual controller tuning Speed controller (cascade)

You can find the manual controller tuning in STEP 7 under Commissioning. Here, you can optimize the control parameters according to your application and thereby fine-tune the drive.

Procedure

For manual controller tuning, proceed as follows:

Step 1:
Go online to the module with TIA Portal by clicking on the "Connect online" selection button.

Step 2:
If you have not already calculated the controller parameters under Control/closed-loop control, you can do this again here. First, enter the mass moment of inertia of the load.

Use the "Calculate" selection button to calculate the controller parameters.

Step 3:
The calculated controller values are displayed. The online values, i.e. the currently active values, are also displayed on the module.

Step 4:
With the selection "Apply online" button, the new controller values are directly transferred and take effect.

NOTE

When the axis is in operation, the enable is automatically canceled and the new parameters are applied.

Step 5:
You can now put the drive into operation with a speed or positioning TO, for example, and evaluate the control behavior using a trace recording.

If the control behavior is satisfactory, continue with step 7.

Step 6:
If additional tuning is required, there are 2 options to better adjust the control parameters.

1. You can calculate the controller parameters again as described in step 2 and readjust the parameters accordingly using the sliders. (See section Control/closed-loop control (Page 102) under Speed controller and current controller)
2. You set the controller parameters manually. You can orientate yourself on the old values and change the proportional gain and/or the integral action time as well as the precontrol step-by-step.

Perform the steps starting with step 4 again.

Step 7:
Once you have performed the tuning, you need to transfer the detected controller parameters to the drive parameters using the selection button "Apply controller values".

Terminate the online connection ("Go offline" selection button) and then reload the project onto the module using "Download to device". This ensures that the parameters are still active in the project and on the module after a restart.

Controller tuning is now completed.

7.6.4 Controlled (I = const.)

General controller settings

In the controlled control mode (I = const.), the speed is controlled by an angle adjuster. Depending on the respective speed, the control angle of the motor is switched faster or slower in quantified steps in the desired direction of rotation.

Speed controller

Recommendation: Specify speed changes along an acceleration and deceleration ramp, otherwise it is not possible for the drive to follow the speed specification.

The internal ramp-function generator (section 7.5.3) can be used as speed ramp.

Current controller

With the control mode controlled (I = const.), the current controller applies a constant current value to the motor. The motor current is specified using two current values for travel mode (p1738 run current) and standstill mode (p1739 stop current). The current values are effective values.

- Run current p1738
- Stop current p1739

The stop current is impressed on the motor while it is at a standstill and ensures a corresponding holding torque. If a speed not equal to 0 1/min is specified, the current setpoint is switched from stop current to run current. If the motor comes to a standstill from a movement, the setpoint current is switched from run current to stop current after 1 s.

In many applications, the stop current can be reduced during standstill. As a result, energy can be saved during the stop phases and the motor is subjected to less thermal stress.

For reasons of protection, the run and stop current may not be greater than 1.5 times the rated motor current (p0305).

Enter the general controller settings under "Parameters" > "Control/closed-loop control" > "Controller settings".

- Moment of inertia load p1398

Additional important settings

The speed and current controllers can be determined in the best possible way if, in addition to the properties of the electric motor, you also specify the properties of the gearbox and the connecting cable.

- Motor cable line resistance p0352
- Motor cable/series inductance p0353
- Motor gear moment of inertia p2725

Current controller

You can either set the current controller manually or have the controller settings calculated by STEP 7.

Having controller settings calculated

To have the controller settings of STEP 7 calculated, proceed as follows:

1. Click on the "Calculate current controller settings" button in the Controller settings area. The "Controller calculation" window opens. The window displays the appropriate controller parameters.
2. Apply the controller settings by clicking the "Apply" button.

You can then continue to change the calculated controller settings manually.

Setting the controller settings manually

Enter the settings for the current controller under "Parameters" > "Control/closed-loop control" > "Current controller".

- I proportional gain
- I integral action time

NOTE

If you manually set the controller parameters to inappropriate values, the drive system can be damaged.

Make changes to the controller settings in small steps. Keep checking the behavior of the drive system until you have found a satisfactory setting.

7.7 OFF responses

OFF1 (Switch off)

By resetting bit 0 in STW1 (On), you activate OFF1 and the drive is braked to 0 in a speed-controlled manner according to the ramp generator ramp-down (p1120, p1121).

If the actual speed falls below the value of the "Standstill detection" parameter (p1226) or a timeout is detected, the pulses are inhibited after the motor brake closing time p1217 has elapsed. "Switching on inhibited" is activated.

Timeout

With OFF1, the time is calculated in which the drive should normally stop from twice the reference speed. If the drive does not stop within twice this time, the drive is deenergized and coasts to a stop.

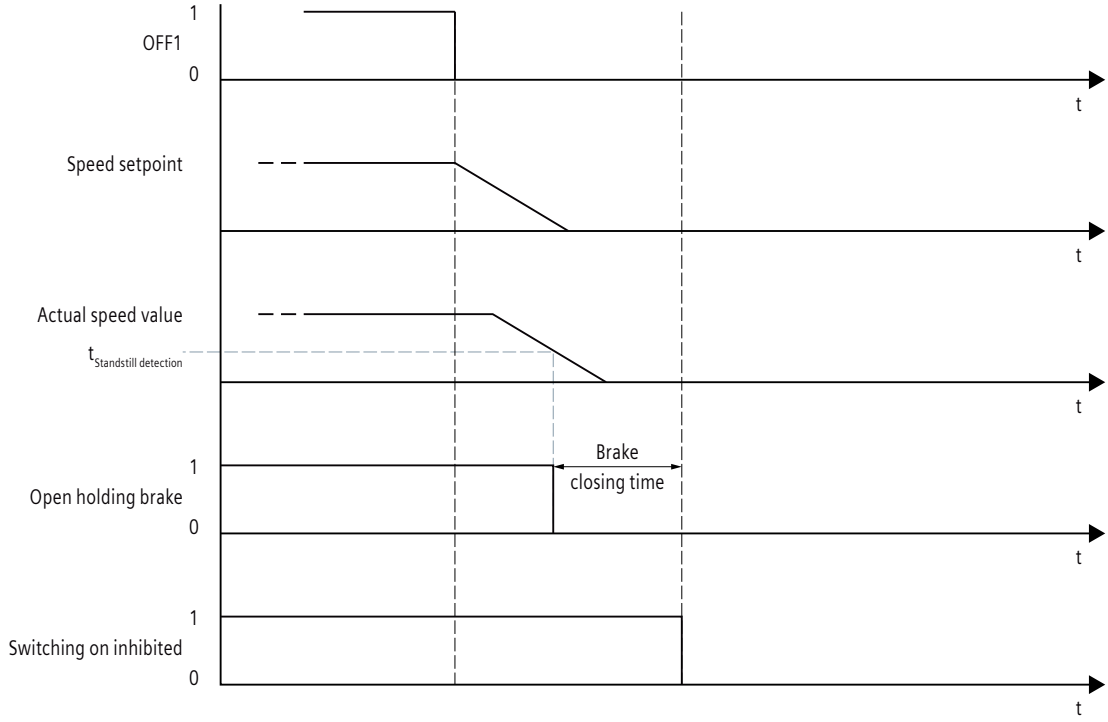

Figure 2-1591 OFF1 sequence diagram when standstill detection is reached p1226

OFF2 (Coast down)

You activate OFF2 by resetting bit 1 in STW1 (NoCoastStop). Immediate pulse cancellation occurs, any configured motor holding brake is closed. The drive coasts to a stop without a motor holding brake. "Switching on inhibited" is activated.

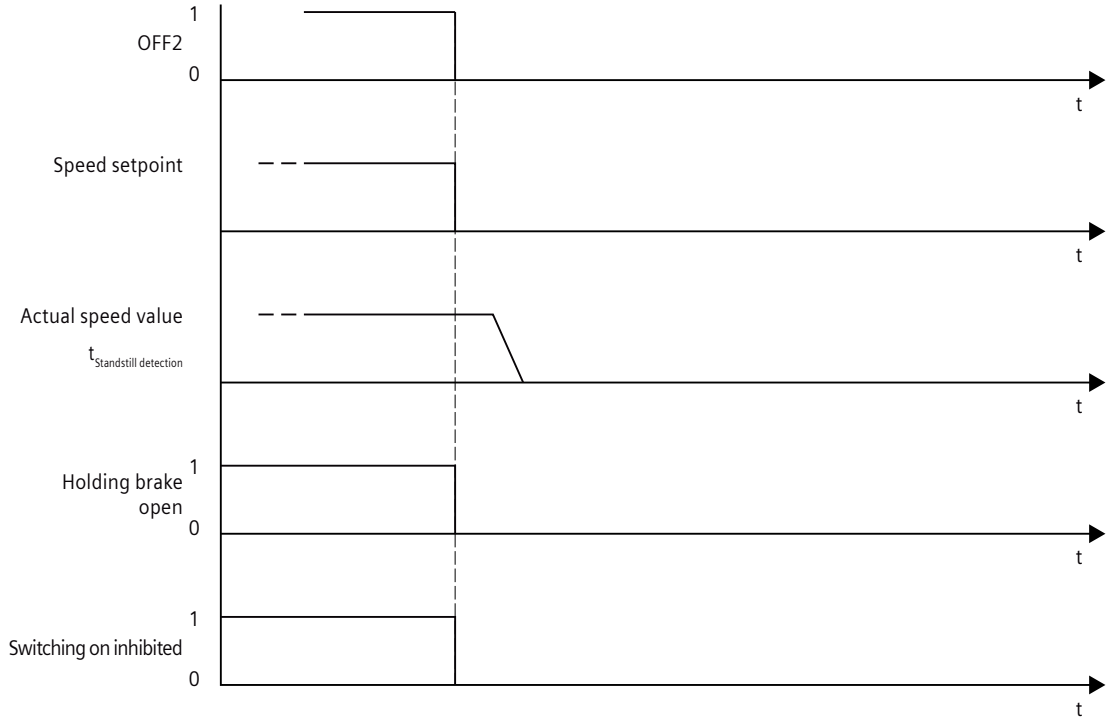

Figure 2-1592 OFF2 sequence diagram

OFF3 (QuickStop)

You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp generator"). After the standstill is detected or the monitoring time has elapsed, any configured motor holding brake is closed and the pulses are deleted after the motor holding brake closing time p1217 has expired. "Switching on inhibited" is activated.

NOTE

NOTE on rapid stop (OFF3)

You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp generator").

Timeout

The rapid stop is monitored for time and causes the motor to be energized after 6 seconds at the latest.

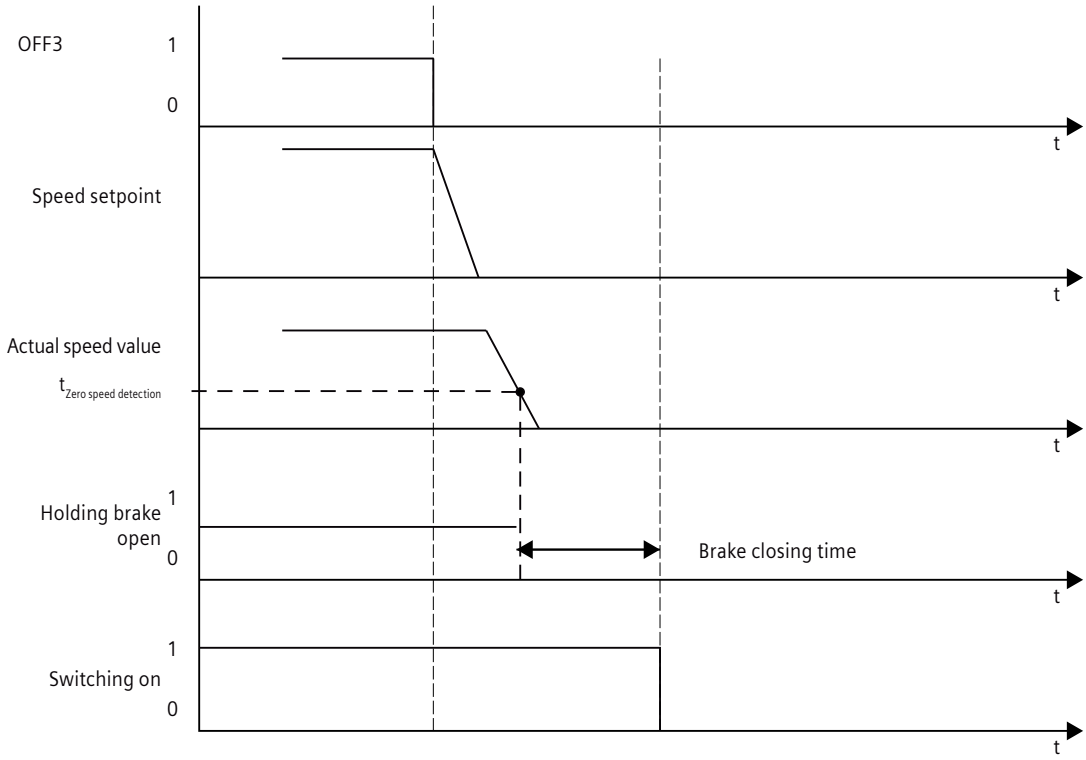

Figure 2-1593 OFF3 sequence diagram

Prioritization

The OFF responses are prioritized as follows:

- OFF2 (coast down) > OFF1 (switch off)
- OFF3 (QuickStop) > OFF1 (Switch off)
- OFF2 (coast down) > OFF3 (quick stop)

7.8 DC-link voltage

The TM Drive system cyclically monitors the intermediate circuit voltage. The limits can be set under "Drive/Monitoring".

The regenerative feedback into the DC power supply cannot be suppressed. This has several advantages.

When the drive is braked and the brake chopper is not connected and configured, energy is fed back, which results in an increase in the interemeidate circuit voltage. For this reason the intermediate circuit voltage is monitored by the module.

You can freely set the intermediate circuit voltage monitoring limits within the permissible range.

If the limits are exceeded, the module switches off. Before the module switches off, it issues a warning (limit ∓ 5%) stating that the limit is almost exceeded.

Procedure

1. Open the "Intermediate circuit voltage" area in the context of the drive under "Parameters" > "Drive/monitoring".
2. Configure:
   - Minimum value of the intermediate circuit voltage p0390
   - Maximum value of the intermediate circuit voltage p0391

WARNING

Operation above the voltage setting range

Under the given application conditions, ensure that the motor is not operated above the voltage setting range by selecting the appropriate motor and motor gear. Otherwise, the intermediate circuit voltage may increase when the control is inactive via 60 V DC.

7.9 Brake module

The TM Drive system has a brake chopper for connection of an external brake resistor and can control a motor holding brake externally via the process image using a DQ or relay module. These functions can be activated individually or in parallel.

You can select the following options for the PMSM motor type under "Brake module":

- [0] No function
- [2] Brake chopper
- [3] Brake chopper and motor holding brake external via the process image
- [4] Motor holding brake externally via the process image

You can select the following options for the stepper motor type under "Brake module":

- [0] No function
- [4] Motor holding brake externally via the process image

If stepper motors are selected, the brake chopper function cannot be used. If a brake chopper is required nevertheless, you can install another TM Drive module (except StepDrive) in the same potential group, connect the brake resistor there and configure the brake chopper as well. If no motor is connected to this module select a motor type (p0300) "[0] no motor".

7.9.1 Brake chopper

If the brake chopper function is enabled, you need to configure the following parameters in the "Parameters" > "Drive" > "Brake module" area.

Set the following values for the brake chopper:

- Chopper switch-on voltage
- Chopper switch-off voltage
- Thermal resistance of the braking resistor
- Time constant of the brake resistor
- Maximum temperature
- Ambient temperature
- Response to max. temperature

The switch-on and switch-off voltage of the brake chopper must be set correctly according to the DC voltage supply. The chopper switch-off voltage p6011 must be higher than the supply voltage (example U_{DC} = 48 V à p6011 = 50 V; chopper switch-on voltage p6010 = 52 V).

The voltage thresholds of the brake chopper should be adjusted accordingly with the parameters of the intermediate circuit voltage monitoring (7.7).

The TM Drive is not designed to be operated permanently as a brake axis. The circuit of the brake chopper monitors itself and protects itself against overload by switching off.

NOTICE
Risk of fire The switch-off voltage must not be lower than the DC supply voltage, otherwise the brake chopper will not switch off after activation and it may lead to an overload of the brake resistor and/or the module.

Capacity of the braking chopper output

The TM Drive is not designed to be operated permanently as a brake axis. The circuit of the brake chopper monitors itself and protects itself against overload by switching off.

You can find information about power calculation and resistor design in the appendix Braking resistor and brake chopper power (Page 159).

Monitoring of the braking resistor

The specific values of the braking resistor, such as heat resistance and time constant, can be obtained from the manufacturer of the braking resistor (data sheet). Typical values are stored as default values in the TIA Portal. The default values must be checked and adjusted if necessary.

- The thermal resistance describes how large the temperature difference between the resistor and the environment must be in order for a heat flow (power) of one watt to be emitted.
- The time constant indicates the time after which the resistance, at constant power input, has approached approx. 63% of its thermal equilibrium. After five times the time constant, the resistor is in its thermal steady state.

You use the maximum temperature to define the switch-off temperature for the resistor. The switch-off temperature is calculated in a thermal model based on the ambient temperature.

You use "Response to max. temperature" to define the behavior that is triggered when the maximum temperature is reached.

- Shutdown when temperature is exceeded Brake chopper operation is stopped and a warning is generated.
- No shutdown when temperature is exceeded Brake chopper operation is still possible.
- The thermal resistance describes how large the temperature difference between the resistor and the environment must be in order for a heat flow (power) of one watt to be emitted.
- The time constant indicates the time after which the resistance, at constant power input, has approached approx. 63% of its thermal equilibrium. After five times the time constant, the resistor is in its thermal steady state.

NOTICE

Risk of fire

If braking chopper operation continues despite reaching the maximum operating temperature, this can result in a sharp increase in the temperature at the braking resistor. This can damage surrounding components or even result in fires in the worst case.

In addition, always ensure that the minimum distances between the braking resistor and other modules are maintained.

⚠ CAUTION

Risk of burns due to hot surfaces

The braking resistor heats up during operation. Touching the hot braking resistor can result in personal injury and burns.

Avoid contact with the hot braking resistor.

NOTE

Brake chopper operation with STO selected

When STO is selected, the brake chopper of the respective module is inactive. This means that when STO is active, no braking energy of either the own or other axes can be dissipated by the braking resistor.

If the brake chopper function is mandatory despite STO release, you can install another TM Drive module (except F-TM StepDrive) into the same potential group, connect the brake resistor there and configure the brake chopper as well. If no motor is connected to this module, select the "[0] no motor" for motor type (p0300).

7.9.2 External motor holding brake

The motor holding brake can be used when the drive system is disabled (e.g. when the power supply to the drive system is switched off) to prevent unwanted movements of the motor shaft (e.g. falling due to gravity). The motor can move by its own weight or an external force even if the motor power supply is interrupted.

NOTE

- Use this brake only for "holding", which means to maintain the standstill. Do not use it for "braking", which means to stop the moving load. Use the holding brake only to hold a motor at a standstill.
- The holding brake is enabled when the motor is switched off.

If the motor holding brake function is enabled, you must configure the following settings in the "Parameters" > "Drive" > "Brake module" area.

Adjust the opening and closing times of the motor holding brake:

- Motor holding brake opening time (p1216)
- Motor holding brake closing time (p1217)

For the closing and opening times, delay times of relays may have to be taken into account and added to the times of the motor holding brake.

p1216 = motor brake opening time + relay opening time

p1217 = motor brake closing time + relay closing time

If the motor holding brake is configured, the drive takes the delay times into account and accordingly sets bit 12 in the process image ZSW1. This bit can be used to control a motor holding brake, for example, with a DQ module or relay module.

NOTE

When selecting the additional module, make sure that the current carrying capacity is suitable. This must be dimensionless depending on the current consumption of the motor holding brake.

RC circuit of a TM Drive with DQ module and motor holding brake

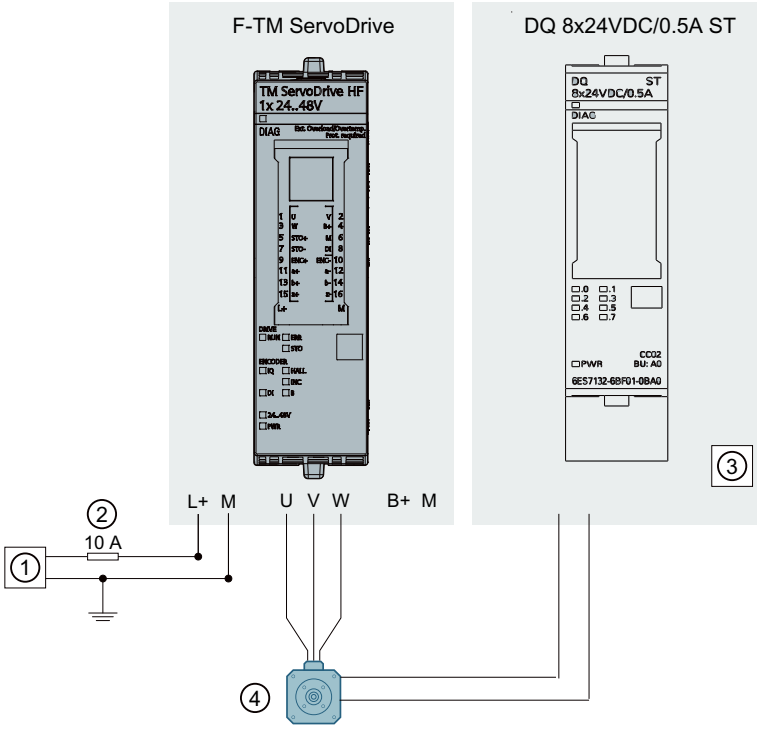

① Power supply unit

② Protective device

③ DQ module

④ Motor with holding brake

Figure 2-1594 RC circuit of a TM Drive with DQ module and motor holding brake

Suspended axes

The additional torque p1511 is used to set an additional load torque.

To prevent the axis from sagging after the holding brake has been released, you can set an electronic counterweight via an additional torque p1511, section 7.8.1, for a suspended axis without mechanical weight compensation.

This reduces the compensation action after the release of a holding brake and specifies the holding torque directly after switch-on of the motor.

The option (p1900) "Encoder calibration at every start" must not be used with suspended loads.

NOTE

Suspended load with incremental encoder

For motors with incremental encoders where the commutation offset angle has not yet been synchronized, the axis may drop. This can be counteracted using the additional torque p1511, although a slight movement of the axis cannot be ruled out even then.

- It is recommended to use an absolute encoder especially for suspended loads.

Braking sequence

The sequence diagram shows an example of the behavior of the drive with OFF1.

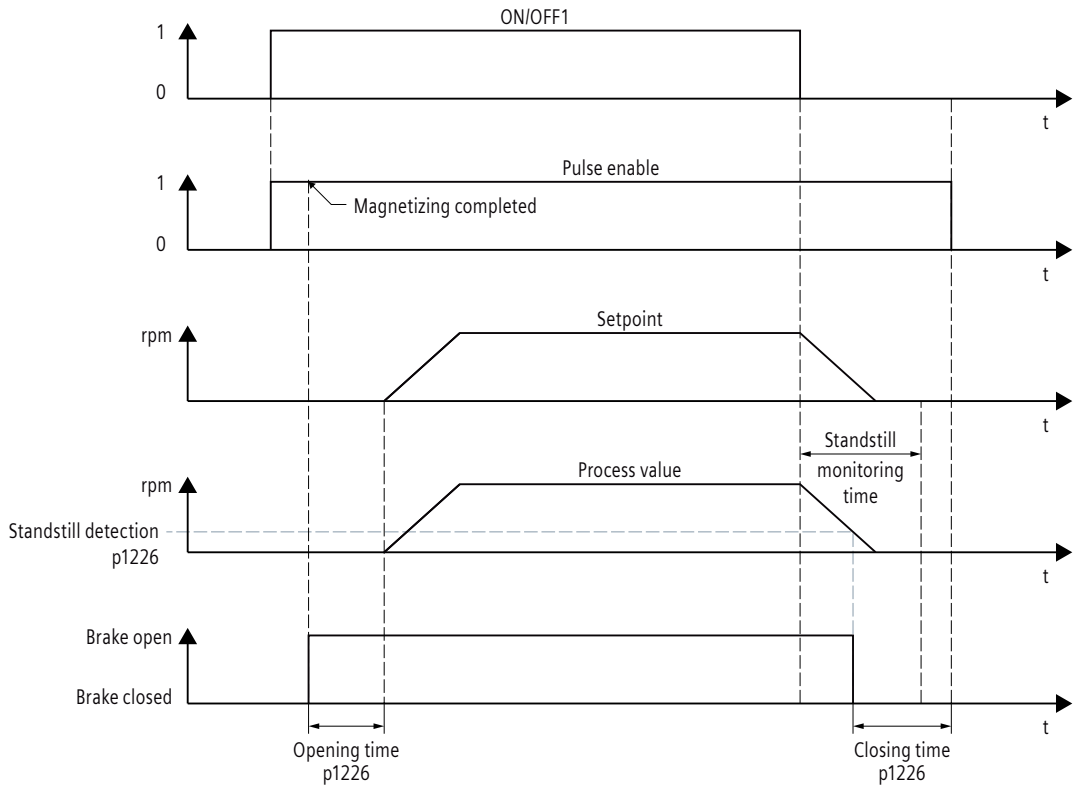

Figure 2-1595 Braking sequence

The magnetizing time is calculated automatically depending on the motor parameters.

The influence of the motor holding brake on the OFF reactions is described in section 7.6.4 (Page 114) OFF reaction.

NOTICE
Improper use Improper use of the motor brake will shorten its service life. The motor brake is only intended for holding purposes. Frequent emergency stops with the motor brake shorten its service life. Unless absolutely necessary, do not use the motor brake as emergency stop.

7.10 Messages/monitoring

Thermal monitoring

The purpose of thermal monitoring is to detect critical states. Parameterizable warning thresholds are available that allow further operation of the drive (e.g. with reduced power) and prevent an immediate shutdown. However, the parameter assignment options are only interventions below the shutdown thresholds.

The following thermal monitoring options are available:

- Motor
  - Motor I^2t model
- Braking resistor
  - Temperature model
- Power end stage
  - Overload protection
  - Temperature sensor

When an overload is detected by one of these monitoring functions, a warning is output first. The respective warning thresholds (p0291) are parameterizable. The current status of the monitoring functions is displayed. If an alarm or fault limit is exceeded, the "Temperature monitoring" message is sent.

NOTE

All alarm and fault limits are provided with a corresponding hysteresis. The corresponding alarm or fault messages therefore remain until the threshold including hysteresis has been fallen below.

NOTE

Motor and brake resistance values

The thermal motor and braking resistor utilization are calculated quantities. The values are not saved.

After a power reset, the values only match again after a sufficiently long cooling time.

Operating temperature

Note that the specified ambient temperature range for the drive must always be adhered to, see section Technical specifications (Page 152).

7.10.1 Motor

Thermal motor monitoring

The thermal motor monitoring is performed using a configurable I^2t temperature model.

⚠ WARNING

Thermal motor utilization cannot be immediately determined after initialization

The thermal model is reinitialized after changing the drive data set and when switching on the device.

After initialization, the thermal motor utilization cannot be immediately determined as the model must first settle. As a consequence, an initial utilization of 50 % is used as basis. The settling phase duration depends on the given thermal time constants; the accuracy depends on to what extent the specific installation situation deviates from the model.

During the settling time it is possible that the set alarm and/or fault threshold is reached with some delay. For the installation situation simulated in the model, a comparatively unfavorable installation was selected so that generally deviations occur on the safe side.

You can define the warning threshold under Parameters > Messages/monitoring > Motor relative to the respective shutdown threshold.

Procedure

1. Open the "Motor" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Motor I^2t model

The I^2t monitoring operates with the relative motor power loss, and in addition to the nominal motor current (p0305) as reference value, only requires the thermal time constant winding - environment (p0611[0]) to calculate the limiting integral. The 100 % shutdown threshold corresponds to the maximum continuous power loss of the motor, i.e. to the square of the nominal motor current (p0305).

Motor type PMSM

If the PMSM reaches the 100% threshold, the motor current is limited to the rated motor current to prevent overheating.

Motor type stepper motor

When the stepper motor reaches the 100% utilization threshold, the drive is switched off and an error is set.

WARNING

Compliance with the ambient conditions specified by the motor manufacturer

The motor may only be operated in ambient conditions such as ambient temperature, installation elevation, etc. as specified by the manufacturer.

If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. The derating behavior and the resulting lower motor performance data must be obtained from the motor manufacturer and adjusted accordingly in the motor parameters of the TM Drive.

If the motor is used outside its specification, the thermal model does not provide sufficient protection.

7.10.2 Braking resistor

Thermal monitoring of braking resistor

The braking resistor is monitored by a temperature model. You can specify the warning threshold (p0291[2]) relative to the shutdown threshold "Braking resistance maximum temperature" (p6023).

Procedure

1. Open the "Braking resistor" area in the context of the drive under "Parameters"" > "Messages/monitoring".
2. Configure the warning threshold p0291[2].

WARNING

Thermal braking resistance load cannot be determined immediately after initialization

The thermal model is reinitialized after changing the drive data record and when switching on the device.

The thermal braking resistance load cannot be determined immediately after initialization because the model must settle. As a consequence, an initial utilization of 50 % is used as basis. The settling phase duration depends on the given thermal parameters; the accuracy depends on to what extent the specific installation situation deviates from the model. During the settling time it is possible that the set alarm and/or fault threshold is reached with some delay.

The installation situation should be taken into account for the thermal parameters of the braking resistor and, if necessary, less favorable parameters should be selected, for example, for the heat transfer resistance, so that deviations will generally occur towards the safe side.

7.10.3 Power end stage

Thermal monitoring of power end stage

The power end stage is monitored with a temperature sensor. You can specify the warning threshold (p0291[1]) relative to the shutdown threshold "System maximum temperature power end stage".

Procedure

1. Open the "Power end stage" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Besides the temperature monitoring, the current load is also monitored. The current load of the power unit is decisive for the temperature rise. The relative load of the power end stage is calculated based on the square of the output current according to the I^2t method.

Automatic overload limiting

The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

The maximum overload time $t_{overload}$ is calculated depending on the temperature of the power end stage T_{PU}. When operating with cyclic overload, the rated power is not exceeded the by the time-averaged power (rms).

PMSM

With a PMSM, a 3-fold overload of the rated current I_n is possible cyclically for a duration of $t_{overload}$ = 1.5 s and a subsequent recovery time of 12.5 s at T_{PU} = 20 °C. At T_{PU} = 80 °C, the overload time $t_{overload}$ ≈ 0.35 s.

Stepper motor

With a stepper motor, a double overload of the rated current I_{-n} cyclic for a duration of $t_{overload}$ = 3 s with a subsequent recovery time of 17 s at T_{PU} = 20 °C is possible. At T_{PU} = 80 °C, the overload time $t_{overload}$ ≈ 0.75 s.

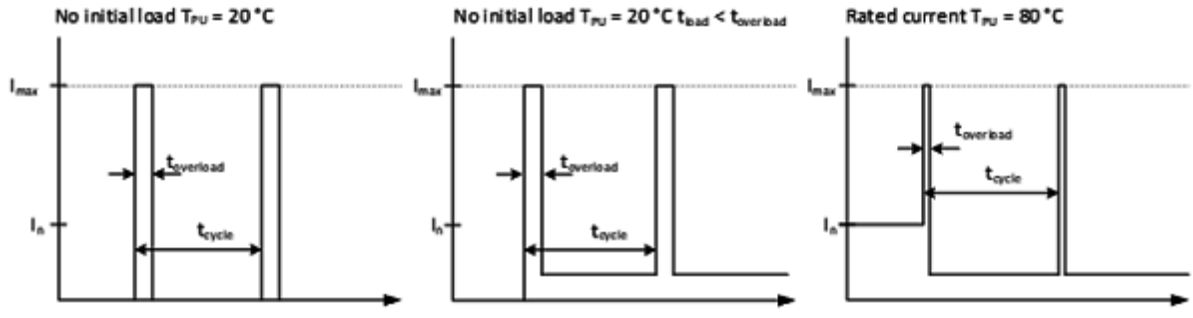

Figure 2-1596 Overload behavior of TM Drive

Observe the information on derating depending on the ambient conditions (e.g. temperature, mounting position) in the section Derating of the F-TM ServoDrive HF (Page 156).

NOTE

Overload capability of the power unit

Operation with a peak current of 15 A is possible temporarily if the average RMS value of the output current does not exceed the rated current of the power unit up to 5 A.

7.11 Dynamic torque reduction

If dynamic torque reduction is required, this can be realized using the MOMRED signal via drive telegram 102. The torque limit currently in effect in the drive is reduced via this setpoint. MOMRED is used to specify the percentage by which the torque limit is to be reduced.

$$M_{limit.actual} = M_{reference} \cdot \left(1 - \frac{MOMRED}{16384}\right)$$

NOTE

The MOMRED signal is normalized to 4000 hex (16384 dec). The value 4000 hex (16384 dec) in the MOMRED control word corresponds to a 100% reduction of the configured reference torque p2003.

The dynamic torque limit is set to the respective minimum of the configured torque limitation (p1520), the limitation via MOMRED or the limitation by the max. permissible torque-forming current value.

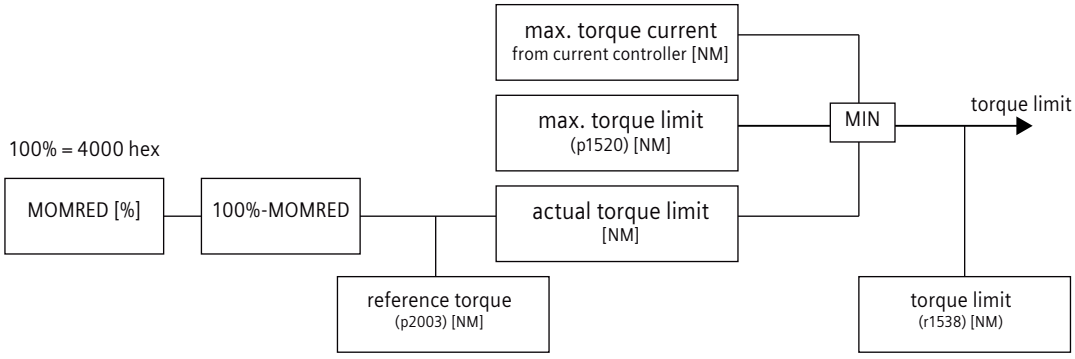

Figure 2-1597 Dynamic torque limitation (MOMRED)

The torque values that are output by the drive and the torque limitation currently in effect can be viewed under "Online & Diagnostics" > "Diagnostics" > "Drive Diagnostics" > "Operating Values" if an online connection to the drive is established.

The following actual values are available:

- Torque setpoint (at the output of the speed controller) (r0079)
- Torque actual value (r0080)
- Torque limit (r1538)

Programming

8

TM Drive does not have its own control panel. A user program is required to control the motion sequences.

You have the following options for controlling the motion sequences in the user program:

- Control via the process image (Page 129)
- Control via the SINA_SPEED (Page 140) instruction
- Control with a technology object (Page 140)

8.1 Controlling TM Drive via the process image

Structure of the I/O addresses

The structure of the input addresses of the TM Drive depends on the configured communication telegram and the telegram extension.

The telegrams can be set in the "Properties" area under "General" and further via "Basic parameters". Set the Telegram extension active option to make the status available via the digital input and the status of the STO input via the process image.

NOTE

The telegram extension option is not available for telegram 102.

The structure of the output addresses of the TM Drive depends on the configured communication telegram.

Frame	**1**		**2**		**3**		**102**	
PZD1	STW1	ZSW1	STW1	ZSW1	STW1	ZSW1	STW1	ZSW1
PZD2	NSET_A	NACT_A	NSET_B	NACT_B	NSET_B	NACT_B	NSET_B	NACT_B
PZD3								
PZD4			STW2	ZSW2	STW2	ZSW2	STW2	ZSW2
PZD5					G1_STW	G1_ZSW	MOMRED	MELDW
PZD6						G1_XIST1	G1_STW	G1_ZSW
PZD7								G1_XIST1
PZD8						G1_XIST2		
PZD9								G1_XIST2
PZD10								

Standard telegram 1 Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Structure**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_MotorHoldingBrakeOpen	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_A	**Word**	**2.0**
Telegram extension word (only with telegram extension)	**Structure**	**4.0**
Reserved	Byte	4.0
Telegram extension STO_Status	Bool	5.0
Telegram extension DI_Status	Bool	5.1

Outputs

Element	Data type	Offset
Control word STW1	**Structure**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0

Element	Data type	Offset
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_A	**Word**	**2.0**

Standard telegram 2 Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word ZSW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5

Element	Data type	Offset
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Telegram extension word (only with telegram extension)	**Struct**	**8.0**
Reserved	Byte	8.0
Telegram extension STO_Status	Bool	9.0
Telegram extension DI_Status	Bool	9.1

Outputs

Element	Data type	Offset
Control word STW1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word STW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1

Element	Data type	Offset
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7

Standard telegram 3 Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_MotorHoldingBrakeOpen	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchON	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word ZSW2	**Struct**	**6.0**

Element	Data type	Offset
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder status word 1	**Struct**	**8.0**
Bit08_Probe1Deflected	Bool	8.0
Bit09_Probe2Deflected	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_EncoderFaultAcknowlegdeActive	Bool	8.3
Bit12_HomePositionExecuted	Bool	8.4
Bit13_AbsoluteValueCyclicallyExecuted	Bool	8.5
Bit14_ReservedParkingSensorExecuted	Bool	8.6
Bit15_ParkingSensorExecuted	Bool	8.7
Bit00_Function1Active	Bool	9.0
Bit01_Function2Active	Bool	9.1
Bit02_Function3Active	Bool	9.2
Bit03_Function4Active	Bool	9.3
Bit04_Value1Available	Bool	9.4
Bit05_Value2Available	Bool	9.5
Bit06_Value3Available	Bool	9.6
Bit07_Value4Available	Bool	9.7
Encoder position actual value 1 G1_XIST1	**DWord**	**10.0**
Encoder position actual value 2 G1_XIST2	**DWord**	**14.0**
Telegram extension word (only with telegram extension)	**Struct**	**18.0**

Element	Data type	Offset
Reserved	Byte	18.0
Telegram extension STO_Status	Bool	19.0
Telegram extension DI_Status	Bool	19.1

Outputs

Element	Data type	Offset
Control word STW1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word STW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5

Element	Data type	Offset
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder control word G1_STW	**Struct**	**8.0**
Bit08_Reserved	Bool	8.0
Bit09_Reserved	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_Reserved	Bool	8.3
Bit12_Reserved	Bool	8.4
Bit13_AbsoluteValueCyclically	Bool	8.5
Bit14_RequestParkingEncoder	Bool	8.6
Bit15_AcknowlegdeError	Bool	8.7
Bit00_Function1Request	Bool	9.0
Bit01_Function2Request	Bool	9.1
Bit02_Function3Request	Bool	9.2
Bit03_Function4Request	Bool	9.3
Bit04_Command0Request	Bool	9.4
Bit05_Command1Request	Bool	9.5
Bit06_Command2Request	Bool	9.6
Bit07_Mode	Bool	9.7

Siemens telegram 102: Structure I/O addresses

Inputs

Element	Data type	Offset
Status word ZSW1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_MotorHoldingBrakeOpen	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchON	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4

Element	Data type	Offset
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word ZSW2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Message word MELDW	**Word**	**8.0**
Encoder status word G1_ZSW	**Struct**	**10.0**
Bit08_Probe1Deflected	Bool	10.0
Bit09_Probe2Deflected	Bool	10.1
Bit10_Reserved	Bool	10.2
Bit11_EncoderFaultAcknowlegdeActive	Bool	10.3
Bit12_HomePositionExecuted	Bool	10.4
Bit13_AbsoluteValueCyclicallyExecuted	Bool	10.5
Bit14_ReservedParkingSensorExecuted	Bool	10.6
Bit15_ParkingSensorExecuted	Bool	10.7
Bit00_Function1Active	Bool	10.0
Bit01_Function2Active	Bool	11.1
Bit02_Function3Active	Bool	11.2
Bit03_Function4Active	Bool	11.3
Bit04_Value1Available	Bool	11.4
Bit05_Value2Available	Bool	11.5
Bit06_Value3Available	Bool	11.6

Element	Data type	Offset
Bit07_Value4Available	Bool	11.7
Encoder position actual value 1 G1_XIST1	**DWord**	**12.0**
Encoder position actual value 2 G1_XIST2	**DWord**	**16.0**

Outputs

Element	Data type	Offset
Control word STW1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit09_Reserved	Bool	0.1
Bit10_ControlByPlc	Bool	0.2
Bit11_Reserved	Bool	0.3
Bit12_Reserved	Bool	0.4
Bit13_Reserved	Bool	0.5
Bit14_Reserved	Bool	0.6
Bit15_Reserved	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word STW2	**Struct**	**4.0**
Bit08_Reserved	Bool	4.0
Bit09_Reserved	Bool	4.1
Bit10_Reserved	Bool	4.2
Bit11_Reserved	Bool	4.3
Bit12_Reserved	Bool	4.4
Bit13_Reserved	Bool	4.5
Bit14_Reserved	Bool	4.6
Bit15_Reserved	Bool	4.7
Bit00_Reserved	Bool	5.0
Bit01_Reserved	Bool	5.1
Bit02_Reserved	Bool	5.2
Bit03_Reserved	Bool	5.3
Bit04_Reserved	Bool	5.4
Bit05_Reserved	Bool	5.5

Element	Data type	Offset
Bit06_Reserved	Bool	5.6
Bit07_Reserved	Bool	5.7
Torque reduction MOMRED	**Word**	**6.0**
Encoder control word G1_STW	**Struct**	**8.0**
Bit08_Reserved	Bool	8.0
Bit09_Reserved	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_Reserved	Bool	8.3
Bit12_Reserved	Bool	8.4
Bit13_AbsoluteValueCyclically	Bool	8.5
Bit14_RequestParkingEncoder	Bool	8.6
Bit15_AcknowlegdeError	Bool	8.7
Bit00_Function1Request	Bool	9.0
Bit01_Function2Request	Bool	9.1
Bit02_Function3Request	Bool	9.2
Bit03_Function4Request	Bool	9.3
Bit04_Command0Request	Bool	9.4
Bit05_Command1Request	Bool	9.5
Bit06_Command2Request	Bool	9.6
Bit07_Mode	Bool	9.7

Basic procedure in STEP 7

1. In the project tree, create PLC data types in the CPU 2 with the appropriate structure for your configuration:
   - PLC data type for the structure of the input data (depending on PROFIdrive telegram type and telegram extension)
   - PLC data type for the structure of the output data (depending on PROFIdrive telegram type and telegram extension)
2. Create a tag from each type of the PLC data type in a tag table.
3. Assign the addresses for the tag according to the configured I/O addresses of the TM Drive.
4. Control the TM Drive by setting outputs bit-by-bit. A description of how to set the outputs to control the TM Drive can be found in the PROFIdrive standard.
   You can find the current PROFIdrive specification under (https://www.profibus.com/).

8.2 Controlling a TM Drive via the instruction SINA_SPEED

Control with the SINA_SPEED instruction

For controlling the TM Drive, you can also use the SINA-SPEED instruction from the "DriveLib" block library.

The SINA_SPEED block only works with the standard telegram 1. The telegram extension may have to be disabled. See Communication telegrams (Page 64).

The "DriveLib" block library can be downloaded from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109475044).

8.3 Controlling TM Drive with a technology object

Control with a technology object

You can also use a technology object, for example "Speed-controlled axis" or "Positioning axis", to control the TM Drive.

Note that the TM Drive does not have an integrated positioning functionality and only supports speed operation.

Procedure

1. Create, for example, a "Speed axis" technology object in the CPU in the project tree in STEP 7.
2. Open the technology object.
3. Select "TM Drive" under "Configuration" > "Hardware interface" > "Drive".
4. Reference the technology object in the user program using the Motion Control technology instructions, e.g. "MC-Power".

NOTE

We do not recommend using the "Encoder calibration at every startup" option in conjunction with positioning technology objects (positioning axis). The calibration process can lead to undesired behavior of the drive axis.

Additional information

You can find more information about the technology objects and technology instructions in the online help of STEP 7.

Maintenance 9

9.1 Firmware update

Firmware update

A firmware update is possible via PROFINET.

See SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

9.2 Stop responses

Overview of the stop responses

Faults with safety functions and violation of limits can trigger the following stop responses:

- "Hardware STO"

  "Safe Torque Off" (STO) corresponds to Stop Category 0 in accordance with EN 60204-1. With "Safe Torque Off" (STO), the motor is switched directly to zero torque. A motor at standstill cannot be started again accidentally. A moving motor coasts to standstill.

Table 2-2064 Overview of stop responses

Stop response	Triggered ...	Action	Effect
STO	At least one signal STO+/STO- is interrupted.	Motor controllers interrupted	Drive coasts down

After the drive has been stopped, restart it with PROFIdrive.

The faults and warnings are described in the appendix Active messages (Page 147).

Interrupts, error messages and diagnostics and system alarms

10

10.1 Status and error displays

LED display

The figure below shows the LEDs on the TM Drive.

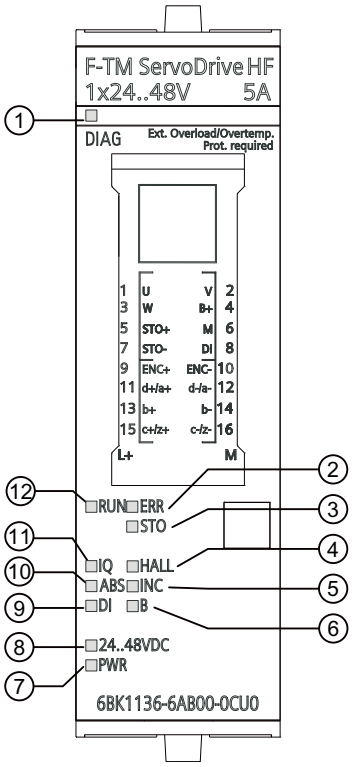

①	DIAG (red/green)	⑦	PWR (green)
②	ERR (red)	⑧	24..48V (green)
③	STO (yellow) Display not safety-related	⑨	DI (green)
④	HALL (green)	⑩	ABS (green)
⑤	INC (green)	⑪	IQ (green)
⑥	B (green)	⑫	RUN (green)

Figure 2-1598 LED display on F-TM ServoDrive

Meaning of the LED displays

The following tables contain the meanings of the status and error displays.

DIAG LED

Table 2-2065 DIAG status and error display

DIAG LED	Meaning	
□ Off	Backplane bus supply of the ET 200SP not OK	
☼ Flashing	Module parameters not assigned	
■ On	Module parameters assigned and no module diagnostics	
☼ Flashing	0.5 Hz (slow)	Module parameters assigned and module diagnostics There is a fault. You can find detailed information via "Online & Diagnostics" > "Diagnostics" > "Active messages" or in the section Active messages (Page 147).
	1 Hz (normal)	
	2 Hz (fast)	

RUN LED

Table 2-2066 RUN status and error display

RUN LED	Meaning	
□ Off	Device is not yet ready for operation	
■ On	Device is ready for operation and error-free	
☼ Flashing	0.5 Hz (slow)	Device is performing self-test during power-up
	1 Hz (normal)	Device performs a firmware update
	2 Hz (fast)	Device has detected a parameterization error

ERR LED

Table 2-2067 ERR status and error display

ERR LED	Meaning
□ Off	No fault
■ On	Device has a fault and needs to be restarted. This corresponds to a serious device error or the loaded firmware cannot be operated on these device versions.

DI LED

Table 2-2068 DI status and error display

DI LED	Meaning
□ Off	Input is inactive
■ On	Input is active

B LED

Table 2-2069 B status and error display

B LED	Meaning
■ On	The motor holding brake is open / information about the process image was set

STO LED

Table 2-2070 STO status and error display

STO LED	Meaning
■ On	Drive ready, switch connected correctly and STO not requested
☼ flashes (0.5 Hz)	STO requested (motor is disconnected from power)

IQ LED

Table 2-2071 Status and error display IQ (encoder)

IQ LED	Meaning
■ On	IQ speed encoder was assigned parameters/activated
☼ Flashes (2 Hz)	IQ speed encoder could not be initialized IQ speed encoder has a connection problem (A/B track not connected)

Hall LED

Table 2-2072 Status and error display Hall (encoder)

Hall LED	Meaning
■ On	IQ speed encoder was assigned parameters/activated

INC LED

Table 2-2073 Status and error display INC (encoder)

INC LED	Meaning
■ On	Incremental speed encoder was assigned parameters/activated
☼ Flashes (2 Hz)	Incremental speed encoder has a connection problem (A/B and/or Z track not connected)

LED ABS

Table 2-2074 Status and error display ABS (encoder)

24..48V LED	Meaning
■ On	An absolute encoder has been configured/activated
☼ Flashes (2 Hz)	The absolute encoder has a connection problem

24..48V LED

Table 2-2075 24..48V status and error display

24..48V LED	Meaning
□ Off	DC link voltage outside the configured limits
■ On	DC link voltage within the configured limits (is OK)
☼ flashes (0.5 Hz)	DC link voltage shortly before the interference threshold

PWR LEDs

Table 2-2076 PWR status and error display

PWR LED	Meaning
□ Off	Logic component supply of the converter is missing
■ On	Logic component supply of the converter is OK

10.2 Diagnostics

10.2.1 Diagnostics overview of the TM Drive

Diagnostic view of the CPU and its associated I/O

If you go online to the CPU and establish an online connection via the CPU to the TM Drive, this occurs within the project context.

Procedure

To display the diagnostic information for the TM Drive, follow these steps.

1. Select the TM Drive in the project tree, for example under "Ungrouped devices".
2. Double-click "Online & diagnostics".
   The "Diagnostics - General" window appears.
3. Navigate to the required information.

The diagnostic window is divided into the following diagnostic groups:

- **General**

  The general diagnostic information is displayed for:

  – Module
  – Module information
  – Manufacturer information

- **Diagnostics status**

  "Diagnostics status" shows the current diagnostics status of the TM Drive.

- **Active messages**

  "Active messages" displays the currently pending alarms and faults in the TM Drive module.

- **Drive diagnostics**

  The current diagnostic information of the drive is displayed for:

  – Status bits
  – Operating values
  – Encoders
  – Temperatures
  – Inputs

10.2.2 Active messages

Pending faults and alarms

"Active messages" shows the currently pending faults and alarms in the TM Drive. Faults must be acknowledged after the cause has been corrected.

Procedure

To display the active messages, follow these steps:

1. Select the TM Drive in the project tree and go to "Online & diagnostics".
2. In the "Diagnostics" folder, select the "Active messages" area.

Faults and alarms

NOTE

In open-loop control operation, no diagnostics of the encoder signals is performed (see fault numbers 1045 and 1046)

The TM Drive supports the following faults.

Fault number	Description	S7 diagnostics alarm
1000	Overvoltage in the DC link	Undervoltage
1001	Undervoltage in the DC link	Overvoltage
1003	Shutdown due to overcurrent switch-off of a phase	Overload
1006	Braking resistor short-circuit	Overload
1019	External braking resistor/motor holding brake of the 4th phase interrupted	Wire break
1032	Temperature measured values implausible	Error
1035	Permitted temperature at the motor end stage exceeded	Overtemperature
1036	Permitted temperature at the motor winding exceeded	Overtemperature
1037	Permissible temperature of the braking resistor exceeded	Overtemperature
1039	Connection to IQ encoder interrupted	Wire break
1042	Fail-safe shutdown path (STO) defective	Safety-related shutdown
1043	Permissible temperature of the control electronics exceeded	Overtemperature
1044	Permissible temperature of the braking resistor exceeded The drive is switched off.	Overtemperature
1045	The connection to the A/B track of the incremental speed encoder is interrupted.	Wire break
1046	The connection to the Z track of the incremental speed encoder is interrupted.	Wire break

Fault number	Description	S7 diagnostics alarm
1047	An unsupported PROFIdrive speed encoder function was requested.	-
1049	Zero point calibration could not be performed. The rotor may be blocked. The motor holding brake may not be open.	External error
1050	A ramp/quick stop (OFF1/OFF3) could not be performed due to a timeout.	External error
1051	Zero point calibration could not be performed due to a timeout. The system may be oscillating too much.	External error
1053	Overload of the brake chopper control	Overload
1054	Permissible temperature at the motor winding when stepper motor exceeded	Overload
1055	Motor resistance detection could not be performed	Wire break
1056	Following error during controlled system detection	Overload
1057	Position error during controlled system detection	Overload
1200	CRC checksum error in absolute encoder	Error in actuator/sensor
1201	Internal encoder error in the absolute encoder	Error in actuator/sensor
1202	No communication with absolute encoder possible or communication establishment failed.	Wire break
1203	Internal error in encoder interface	Error
1300	There is an error in the parameter assignment of the motor type.	Parameterization error
1301	Electrical time constant of the q axis is too low.	Parameterization error
1302	Electrical time constant of the d axis is too low.	Parameterization error
1303	Torque constant inconsistent	Parameterization error
1340	There is an error in the parameter assignment of the encoder.	Parameterization error
1360	There is an error in the parameter assignment of the controller.	Parameterization error
1380	There is an error in the parameter assignment of the braking function.	Parameterization error
1999	General error	Error

Acknowledge faults

To acknowledge all active faults, click the "Acknowledge faults" button.

Alarms

Column	Description
Alarm number	Number of the warning
Description	Description of the warning

The TM Drive supports the following warnings.

Alarm number	Description
2000	Voltage in the DC link shortly before shutdown
2001	STO shutdown active
2002	Warning threshold when motor end stage temperature is exceeded
2003	Warning threshold when motor winding temperature is exceeded
2004	Thermal overload of the motor end stage
2005	Thermal overload of the braking resistor
2007	Switch-on delay because axis is still rotating.
2200	Encoder warning in the encoder error

10.2.3 Drive diagnostics

You can find online information on important current drive diagnostics data and drive service data in the "Drive diagnostics" area under "Online & diagnostics" in the context of the drive.

NOTE

All drive diagnostics are only available online. They are automatically updated in the user interface.

You will find diagnostic information on the following points in the "Drive diagnostics" area:

- Status bits
- Operating values
- Encoders
- Temperatures
- Inputs

Properties of drive diagnostics

Drive diagnostics

- Show the current values of various parameters
- Are cyclically updated
- Are read-only.

Drive diagnostics: Status bits

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Status bits"

Table 2-2077 Drive diagnostics - status bits

Number	Parameter	Display/unit
Status word		
r0899	Status bits **Note**: Signal corresponds to status word 1 PROFIdrive (r0968).	• Ready for switching on • Ready for operation • Operation • Fault active • Coasting active • Rapid stop active • Switching on inhibited active • Alarm active • Speed setpoint - actual value deviation • Control by controller • n comparison value reached • Control of the motor holding brake is active **Note:** • Status word 1 is sent cyclically by the drive to the higher-level controller.

Drive diagnostics: Operating values

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Operating values"

Table 2-2078 Drive diagnostics - operating values

Number	Parameter	Display/unit
r0063	Speed actual value smoothed	rpm
r1045	Speed setpoint of ramp generator	rpm
r0080	Torque actual value	Nm
r0079	Torque setpoint	Nm
r1538	Torque limit	Nm
r0026	Intermediate circuit voltage	V
r0027	Current actual value	A_{eff}
r0072	Output voltage	V

Drive diagnostics: Encoders

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Encoder"

Table 2-2079 Drive diagnostics - encoder

Number	Parameter	Display/unit
r7811	Position	°
r7810[0]	Steps	-
p979[2]	Increments per revolution	-
P979[5]	Number of revolutions	-
p979[3]	Fine resolution bits in actual value Gx_XIST1	Bits
P979[4]	Fine resolution bits in actual value Gx_XIST2	Bits

Drive diagnostics: Temperatures

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Temperatures"

Table 2-2080 Drive diagnostics -temperatures

Number	Parameter	Display/unit
r0037[0]	Current microcontroller	°C
r0037[1]	Microcontroller max.	
r0037[4]	Power end stage	
r0037[5]	Power end stage max.	

Drive diagnostics: Inputs

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Inputs"

Table 2-2081 Drive diagnostics - inputs

Number	Parameter	Display/unit
-	Inputs	• Digital input • STO active

Reference

All displayed parameters have a tooltip that provides you with information and descriptions relating to the parameter as well as access to the online help.

You can find additional information on the parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

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11.1 Technical specifications

Technical specifications of the IQ encoder

Article number	6BK1136-6AB00-0CU0
General information	
Product type designation	F-TM ServoDrive HF
HW functional status	V1.0
Firmware version	V1.1
• FW update possible	Yes
Product description	control of EC and stepper motors
usable BaseUnits	BU type U0
Product function	
• I&M data	Yes
• Isochronous mode	No
• Four-quadrant operation	Yes
• Speed control with encoder	Yes
• Speed control without encoder	No
• Safety Functions	Yes; Drive controller with hardwired STO
Protection function	
• Undervoltage protection	Yes
• Overvoltage protection	Yes
• Overload protection	Yes
• Ground-fault protection	No
• Short-circuit protection	Yes
Installation type/mounting	
Type of ventilation	Convection cooling
Supply voltage	
Design of the power supply	24 ... 48 V DC, SELV / PELV
permissible range, lower limit (DC)	16.8 V
permissible range, upper limit (DC)	57.6 V

Article number	6BK1136-6AB00-0CU0
Input current	
Current consumption (rated value)	6 A
Current consumption, max.	10 A
Current consumption for the electronics, max.	0.1 A
Inrush current, max.	25 A; at 24 V
output voltage / header	
Rated value, min.	24 V
Rated value, max.	48 V
Output current	
Current output (rated value)	5 A
Output current, max.	15 A
Output frequency	599 Hz
Encoder supply	
Number of outputs	1
5 V encoder supply	
• 5 V	Yes
• Short-circuit protection	Yes
• Output current, max.	150 mA
Power	
DC power consumption	300 W; At 50 V
Power loss	
Power loss, typ.	3.5 W
Digital inputs	
Number of digital inputs	1; input for message signal
Number of safety inputs	1; For STO, antivalent (2-pin) - 24 V DC
Encoder	
Connectable encoders	
• Incremental encoder (symmetrical)	Yes; up to 500 Hz per channel
• Absolute encoder (SSI)	Yes; BiSS-C
• BiSS-C encoder	Yes
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	No
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• Telegram error at SSI encoder	Yes; BiSS-C
• Group error	Yes

Article number	6BK1136-6AB00-0CU0
Diagnostics indication LED	
• RUN LED	Yes
• ERROR LED	Yes
Integrated Functions	
Position detection	
• Incremental acquisition	Yes
• Absolute acquisition	Yes
• Suitable for S7-1500 Motion Control	Yes
Potential separation	
Potential separation channels	
• between the channels and backplane bus	Yes
Isolation	
Isolation tested with	DC 850 V, type test (between backplane bus, DC input and functional grounding)
Overvoltage category	III
Degree of pollution	2 according to EN 61800-5-1
Degree and class of protection	
IP degree of protection	IP20
Standards, approvals, certificates	
CE mark	Yes
UKCA mark	Yes
cULus	Yes
RCM (formerly C-TICK)	Yes
KC approval	Yes
EAC (formerly Gost-R)	Yes
RoHS conformity	Yes
China RoHS compliance	Yes
Standard for EMC according to EN 61800-3	Yes
Standard for drive acc. to EN 61800-5-1	Yes
Standard for drive acc. to EN 61800-5-2	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	Category 3, performance level d, according to EN ISO 13849-1:2015
• SIL acc. to IEC 61508	3
• SIL according to DIN EN 61800-5-2	3
Ambient conditions	
Pollution degree during storage and transport	2
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted.

Article number	6BK1136-6AB00-0CU0
• horizontal installation, max.	60 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
• vertical installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted.
• vertical installation, max.	50 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
Ambient temperature during storage/transportation	
• Storage, min.	-30 °C
• Storage, max.	70 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3 000 m
Cables	
Cable length for motor, shielded, max.	10 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	55 g
Other	
Brake design	holding brake control via the process image
Braking chopper	Yes

Type	IQ encoder
Output signals	2 square wave signals (A, B), 2 square wave signals inverse (nA, nB) Output differential or single ended TTL compatible, phase shifted
Number of pulses per revolution	100 (default)
Limit frequency	5 kHz
Supply voltage	+ 5 V (+/- 10 %)
Current consumption	Typ. 40 mA max. 100 mA
Permissible output current	Max. 20 mA
Permissible deviation of the pulse width from electrical 180°	+/- 90 °
Phase shift of channel A and B	Typ. 90 ° (+/- 30 °)
Output voltage (low level)	Typ. 0.25 V, max. 0.8 V (I = 20 mA at 5 V)

Type	IQ encoder
Output voltage (high level)	Typ. 4.25 V, max. 3.8 V (I = 20 mA at 5 V)
Permissible ambient temperature range (T_U)	-25 °C ... +105 °C
Reverse polarity protection	Occurs due to a short-circuit of the supply voltage via a protective diode, max. 200 mA continuous current permissible

Climatic and mechanical environmental conditions

You can find the climatic and mechanical ambient conditions here SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

If there are discrepancies between the statements in this document and the system manual, the statements in the this document take priority.

Biological environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, IEC 60721-3-3: Edition 3.0, with the classes 1B1, 2B1 and 3B1 apply for the biological environmental conditions during operation, long-term storage and transport.

Conductive dust and sand

The TM Drive must not be exposed to conductive dust or sand during operation, long-term storage and transport.

Chemical environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, DIN EN 60721-3-3:1995, with the classes 1C2, 2C2 and 3C2 apply for the chemical environmental conditions during operation, long-term storage and transport.

11.2 Derating of the ET 200SP TM Drive

Maximum permitted output current as a function of installation altitude and ambient temperature

You must take into account the dependency on the ambient temperature and installation altitude.

Derating of the TM Drive depends on the installation elevation

For all permissible mounting types, starting from an installation altitude of 1000 m, a derating of 10% current per additional 1000 m elevation gain applies. The motor current and the output current of the outputs must be reduced.

All other functions do not have to be reduced up to the maximum installation altitude.

The figure below shows the maximum permitted output current as a function of the ambient air temperature for the derating.

Derating of the TM Drive depends on the ambient temperature (horizontal/vertical mounting position)

When installed horizontally (DIN rail horizontal), the TM Drive can be operated up to the maximum ambient temperature (60 °C). Note the derating curve.

With vertical mounting (vertical mounting rail), the TM Drive may be operated up to a maximum of 50 °C. Note the derating curve.

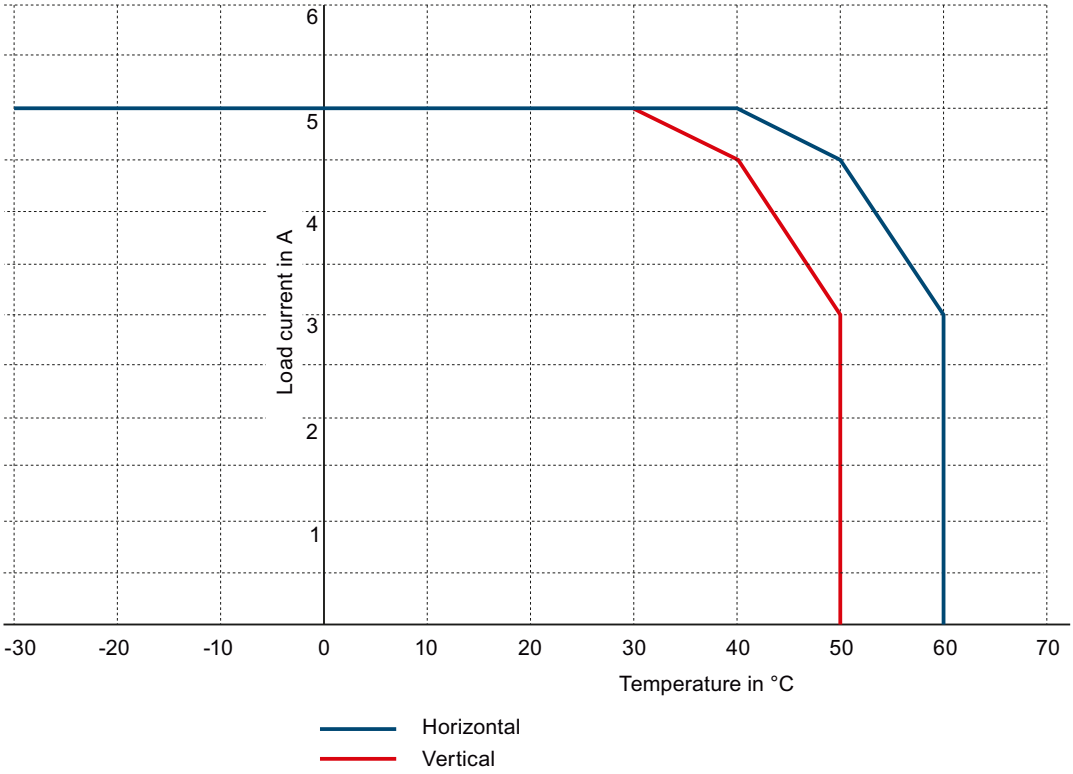

Figure 2-1599 Derating of the TM Drive

Test signal suppression

The STO inputs can be dark tested. The dark test time is up to 1 ms.

Appendix A

A.1 Response times

Introduction

Below you can find the response time of the TM Drive in STEP7. The response times of the TM Drive are included in the calculation of the response time of the F-system.

The drive system is the component that provides the safety functions.

Definition of response time

The response time is the time between the detection of an input signal and the change of a linked output signal.

Definition of process safety time of a process

The process safety time of a process is the time between the occurrence of an error within which a process can be left unattended without risk to life and limb of the operating personnel or damage to the environment and the time of the completed reaction.

Any type of F-system control is tolerated within this process safety time, i.e. the F-system can control its processes incorrectly or even not at all. The process safety time of a process depends on the type of process and must be determined on a case-by-case basis.

Check that the process safety time of the process is not exceeded. You may need to reduce the specific monitoring times of the F-system.

Fluctuation width

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

Definition of maximum response time in an error-free scenario (worst case delay time, WCDT)

In the event of errors outside the drive system (e.g. incorrect setpoint setting by a controller, limit violations due to behavior of the motor, closed-loop control, load, etc.), the "maximum response time in an error-free scenario" is guaranteed.

Definition of maximum response time when an error is present (one fault delay time, OFDT)

In the event of a single error within the drive system (e.g. defect in a shutdown path of the power unit), the "maximum reaction time in the event of error" is guaranteed.

Times required for the calculation

Function	Maximum response time
STOP_STO via terminal	20 ms

STOP_STO:
With a STOP_STO, the drive safely switches off the torque of the connected motor immediately.

A.2 Braking resistor and brake chopper power

The maximum continuous current of the brake chopper end stage is 5 A. The end stage can be overloaded, so that higher currents / powers are possible for a short time.

The average braking current of 5 A is monitored using an I2t model. Once the end stage has fully cooled down, a braking current of 10 A is possible for approx. 15 s, for example.

Related to 60 s, this results in a load cycle of 25%. For other current values, the load cycle can be estimated using the following figure.

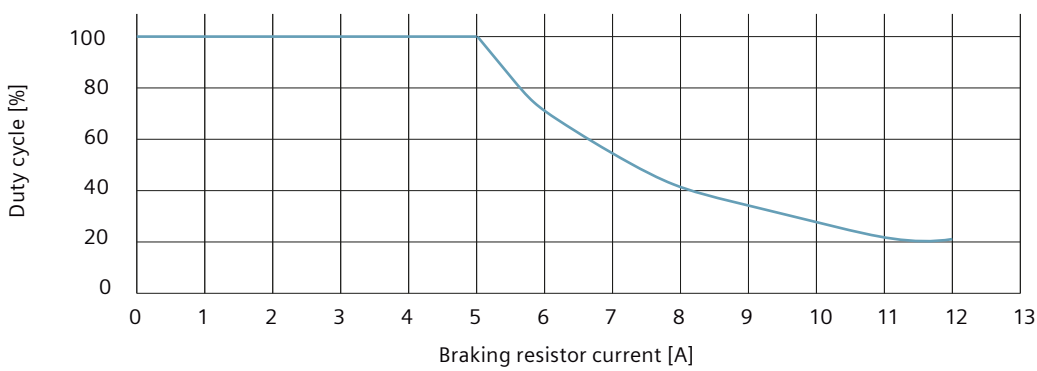

Figure 2-1600 Load cycle as a function of the braking resistor current

NOTE

The resistance of the externally connectable braking resistor must be ≥ 5 ohms.

Calculation of the continuous braking power of the end stage

The continuous power of the end stage can be estimated using the following formula.

$$P_{chopper_{rated}} = 0.5 \cdot (U_{on} + U_{off}) \cdot 5A$$

Table 2-2082 Examples of continuous power of the end stage

Medium intermediate circuit voltage	Continuous power
26 V	130 W
50 V	250 W

Calculation of the continuous braking power as a function of the braking resistor

The average braking power of the braking resistor depends on the braking resistance value and the intermediate circuit voltage or the switch-on and switch-off values of the brake chopper (U_{on} p6010 and U_{off} p6011). It can be estimated with the following formula.

$$P_{brake\ resistor} = \frac{(0.5 \bullet (U_{on} + U_{off}))^2}{R_{brake\ resistor}}$$

Table 2-2083 Examples for braking resistor line

Medium intermediate circuit voltage	Braking resistor value	Braking resistor power
26 V	5 Ω	135.2 W
	10 Ω	67.6 W
50 V	5 Ω	500 W
	10 Ω	250 W

Determination of the braking resistor peak power

In order to calculate the short-time peak power of the resistor, the configured switch-on voltage U_{on} p6010 of the brake chopper must be used.

$$P_{brake\ resistor_{max\ peak}} = \frac{U_{on}^2}{R_{brake\ resistor}}$$

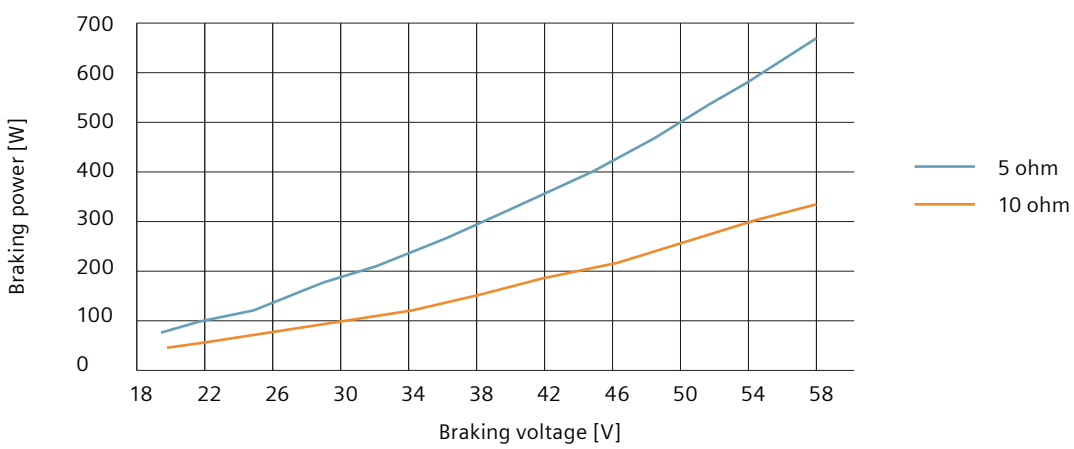

It must be checked whether the braking resistor can absorb the peak power and, if needed, the continuous power expected.

A.3 Data sets

You can find an overview of the data sets for the TM Drive and the structure of the data sets in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

A.4 Device disposal

Recycling and disposal

For environmentally-friendly recycling and disposal of your old device, please contact a company certified for the disposal of waste electrical and electronic equipment, and dispose of the old device as prescribed in the respective country of use.

NOTE

The device does not have its own memory. Neither personal data nor project-specific data are stored on it. It is not necessary to reset the memory for data security reasons.

A.5 Directives and standards

SIEMENS

SIMATIC

ET 200SP
F-TM StepDrive ST 1x24..48V 5A

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A5E50747356-AC

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Introduction 1

1.1 About SIMATIC Micro-Drive

SIMATIC MICRO-DRIVE

SIMATIC MICRO-DRIVE is the drive system for safety extra-low voltages of 24 V to 48 V. Comprising SIMATIC MICRO-DRIVE, versatile motors and connecting cables from selected product partners, it extends the SIEMENS portfolio in the safety extra-low voltage area.

Suitable controllers from the SIMATIC range round out the motion control functionalities.

SIMATIC MICRO-DRIVE TM Drives

TM Drives is a technology module for SIMATIC ET 200SP. It can be controlled by a SIMATIC S7-1500/1200, including via technology objects (TO). TM Drives can be used in combination with a Distributed Controller or the SIMATIC ET 200SP Open Controller in decentralized system concepts.

1.2 About this information for use

1.2.1 Contents

To illustrate possible application areas for our products, typical use cases are listed in this product documentation and in the online help. These are purely exemplary and do not constitute a statement on the suitability of the respective product for applications in specific individual cases. Unless explicitly contractually agreed, Siemens assumes no liability for such suitability. Suitability for a particular application in specific individual cases must be assessed by the user, taking into account all technical, legal, and other requirements on a case-by-case basis. Always observe the descriptions of the technical properties and the relevant constraints of the respective product contained in the product documentation.

Purpose of the documentation

This Equipment Manual supplements the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that generally relate to the system are described in the System Manual.

The information provided in this Equipment Manual and in the System/Function Manuals supports you in commissioning the system.

Firmware versions

This manual is valid for firmware version FW 2.1 and current HSP versions from V18 and for the corresponding GSDML version.

NOTE

The current firmware versions can be found in Industry Online Support (https://support.industry.siemens.com/cs/ww/en/view/109807362).

Conventions

CPU: When the term "CPU" is used in the following, it applies to the central modules of the S7-1500 automation system, the S7-1200 automation system, as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

This documentation should be kept in a location where it can be easily accessed and made available to the personnel responsible.

Information regarding third-party products

NOTE

Recommendation relating to third-party products

This document contains recommendations relating to third-party products. Siemens accepts the fundamental suitability of these third-party products.

You can use equivalent products from other manufacturers.

Siemens does not accept any warranty for the properties of third-party products.

1.2.2 Target group

The Equipment Manual is intended for:

- Assemblers
- Commissioning engineers
- Operators
- Service personnel
- Project engineers

1.2.3 What's new?

Equipment Manual revision level	Change/new functions
03/2023	Regulated operation of stepper motors

1.2.4 Standard scope

The functions of the system as delivered can only be found in the order documents.

Further functions may be executable in the system, which are not explained in this documentation. However, there is no entitlement to these functions in the case of a new delivery or service.

This documentation does not contain all detailed information on all types of the product. Furthermore, this documentation cannot take into consideration every conceivable type of installation, operation and service/maintenance.

The machine manufacturer must document any additions or modifications they make to the product themselves.

1.2.5 Use of third-party products in this documentation

This documentation contains recommendations relating to third-party products. Siemens accepts the fundamental suitability of these third-party products. You can use equivalent products from other manufacturers.

Siemens does not accept any warranty for the use of third-party products.

1.2.6 Websites of third-party companies

This document may contain hyperlinks to third-party websites. Siemens is not responsible for and shall not be liable for these websites and their content. Siemens has no control over the information which appears on these websites and is not responsible for the content and information provided there. The user bears the risk for their use.

1.3 SIMATIC documentation

1.3.1 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Figure 2-1601 Icon for device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/ww/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.automation.siemens.com/WW/view/en/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.3.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.4 Service & Support

1.4.1 FAQ

You will find FAQs on TM Drive on the Internet
(https://support.industry.siemens.com/cs/ww/en/ps/26085/faq).

1.4.2 ID link and Siemens Online Support

You can find additional information about the product:

- via ID link
- using the Siemens Industry Online Support
  - Website: SIOS
  - App Industry Online Support (for Apple iOS and Android)

Product-specific information via ID link

The QR code on your product and on the product packaging contains the ID link.

ID link is a globally unique identifier according to IEC 61406-1.

You can use the ID link to access product data, manuals, Declarations of Conformity, certificates and other information about your product.

Figure 2-1602 QR code with ID link included

The ID link is characterized by a frame with a black corner at the bottom right.

Content of Siemens Online Support

- Product support
- Global forum for information and best practice sharing between users and specialists
- Local contact persons via the contact person database (→ Contact)
- Product information
- FAQs (frequently asked questions)
- Application examples
- Manuals
- Downloads
- Compatibility tool
- Newsletter with product selection
- Catalogs/brochures
- Certificates

See also

SIOS (https://support.industry.siemens.com/cs/ww/en/)

1.4.3 Spare parts services

The online spare part service "Spares on Web (https://www.sow.siemens.com)" offers spare parts for the product.

1.5 Important product information

1.5.1 Intended use

This equipment is used for the open-loop and closed-loop control of EC and stepper motors for safety extra-low voltages up to 48 V DC.

⚠ WARNING

Hazardous Voltage
Can Cause Death, Serious Injury, or Property Damage.

Intended use of hardware products

This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens.

Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults.

EU note: Start-up/commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed fulfills the regulations/specifications of Directive 2006/42/EC.

1.6 Safety Evaluation Tool (SET)

You can quickly and easily evaluate the safety functions of your machine using the Safety Evaluation Tool (SET) for the IEC 62061 and ISO 13849-1 standards. You receive the results as a standard-compliant report that can be integrated in the machine documentation as proof of safety.

The free Safety Evaluation Tool is available on the Internet (https://new.siemens.com/global/en/products/automation/topic-areas/safety-integrated/factory-automation/support/safety-evaluation-tool.html).

Fundamental safety instructions 2

2.1 General safety instructions

WARNING

Electric shock and danger to life due to other energy sources

Touching live components can result in death or severe injury.

- Only work on electrical devices when you are qualified for this job.
- Always observe the country-specific safety rules.

Generally, the following steps apply when establishing safety:

1. Prepare for disconnection. Notify all those who will be affected by the procedure.
2. Isolate the drive system from the power supply and take measures to prevent it being switched back on again.
3. Wait until the discharge time specified on the warning labels has elapsed.
4. Check that there is no voltage between any of the power connections, and between any of the power connections and the protective conductor connection.
5. Check whether the existing auxiliary supply circuits are de-energized.
6. Ensure that the motors cannot move.
7. Identify all other dangerous energy sources, e.g. compressed air, hydraulic systems, or water. Switch the energy sources to a safe state.
8. Check that the correct drive system is completely locked.

After you have completed the work, restore the operational readiness in the inverse sequence.

WARNING

Risk of electric shock and fire from supply networks with an excessively high impedance

Excessively low short-circuit currents can lead to the protective devices not tripping or tripping too late, and thus causing electric shock or a fire.

- In the case of a conductor-conductor or conductor-ground short-circuit, ensure that the short-circuit current at the point where the converter is connected to the line supply at least meets the minimum requirements for the response of the protective device used.
- You must use an additional residual-current device (RCD) if a conductor-ground short circuit does not reach the short-circuit current required for the protective device to respond. The required short-circuit current can be too low, especially for TT supply systems.

WARNING

Risk of electric shock and fire from supply networks with an excessively low impedance

Excessively high short-circuit currents can lead to the protective devices not being able to interrupt these short-circuit currents and being destroyed, and thus causing electric shock or a fire.

- Ensure that the prospective short-circuit current at the line terminal of the converter does not exceed the breaking capacity (SCCR or Icc) of the protective device used.

WARNING

Electric shock if there is no ground connection

For missing or incorrectly implemented protective conductor connection for devices with protection class I, high voltages can be present at open, exposed parts, which when touched, can result in death or severe injury.

- Ground the device in compliance with the applicable regulations.

WARNING

Electric shock due to connection to an unsuitable power supply

When equipment is connected to an unsuitable power supply, exposed components may carry a hazardous voltage. Contact with hazardous voltage can result in severe injury or death.

- Only use power supplies that provide SELV (Safety Extra Low Voltage) or PELV- (Protective Extra Low Voltage) output voltages for all connections and terminals of the electronics modules.

WARNING

Electric shock due to equipment damage

Improper handling may cause damage to equipment. For damaged devices, hazardous voltages can be present at the enclosure or at exposed components; if touched, this can result in death or severe injury.

- Ensure compliance with the limit values specified in the technical data during transport, storage and operation.
- Do not use any damaged devices.

WARNING

Electric shock due to unconnected cable shield

Hazardous touch voltages can occur through capacitive cross-coupling due to unconnected cable shields.

- As a minimum, connect cable shields and the conductors of power cables that are not used (e.g. brake cores) at one end at the grounded housing potential.

WARNING

Arcing when a plug connection is opened during operation

Opening a plug connection when a system is in operation can result in arcing that may cause serious injury or death.

- Only open plug connections when the equipment is in a voltage-free state, unless it has been explicitly stated that they can be opened in operation.

NOTICE

Material damage caused by an incorrect power connection

An incorrect power connection can result in damage due to fire, device defects or malfunctions.

- Check all power connections at regular intervals, particularly after equipment has been transported.

WARNING

Electromagnetic interference due to inadequate shield support

A lack of adequate shield support for the power cables can cause malfunctions and impermissibly high levels of interference.

- Use the shield connection plates supplied or recommended.
- Use the shield connection clips recommended.

WARNING

Active implant malfunctions due to electromagnetic fields

Converters generate electromagnetic fields (EMF) in operation. Electromagnetic fields may interfere with active implants, e.g. pacemakers. People with active implants in the immediate vicinity of an converter are at risk.

- As the operator of an EMF-emitting installation, assess the individual risks of persons with active implants.
- Observe the data on EMF emission provided in the product documentation.

⚠ CAUTION

Symptomatic respiratory and skin reaction to chemicals

A newly purchased product might contain traces of substances that are identified as sensitizers.

Sensitizers are substances which can cause sensitization in the lungs and skin after exposure to them.

Once sensitized, individuals can have severe reactions to further exposure, even in small amounts. In the most extreme cases, individuals might develop asthma or dermatitis respectively.

- If the product has a strong smell, keep it in a well-ventilated area for 14 days.

⚠ WARNING

Unexpected machine movement caused by radio devices or cellphones

Using radio devices, cellphones, or mobile WLAN devices in the immediate vicinity of the components can result in equipment malfunction or faults and damage to the devices. Malfunctions may impair the functional safety of machines and can therefore put people in danger or lead to property damage.

- Avoid operating radio devices, cellphones and mobile WLAN devices in the direct vicinity of converters and operating units.
- Scan the machine readable code, e.g. a QR code, from a greater distance or switch off the converter power supply before scanning.
- Only operate built-in devices with the control cabinet doors closed.
- When control cabinet doors are open, only qualified electrical personnel are allowed to carry out service and maintenance work.

⚠ CAUTION

Radio frequency interference in residential areas

When you operate EMC category C2 devices in residential areas, the devices can cause radio frequency interference.

When you operate EMC category C3 or C4 devices in residential areas, it is to be expected that the devices will cause radio frequency interference.

- Do not operate EMC category C2 devices in residential areas.
- Do not operate EMC category C3 or C4 devices in public low-voltage networks supplying residential buildings.

NOTE

It cannot be guaranteed that EMC emission limits are complied with if the products are connected to an isolated line supply, a line supply grounded through a high ohmic connection or a line supply with a grounded line conductor.

- Draw-up an EMC plan to comply with the EMC requirements of the planned application.

⚠ WARNING

Fire due to inadequate ventilation clearances

Inadequate ventilation clearances can cause overheating of components with subsequent fire and smoke. This can cause severe injury or even death. This can also result in increased downtime and reduced service lives for devices/systems.

- Ensure compliance with the specified minimum clearance as ventilation clearance for the respective component.

NOTICE

Overheating due to inadmissible mounting position

The device may overheat and therefore be damaged if mounted in an inadmissible position.

- Only operate the device in admissible mounting positions.

NOTICE

Device damage caused by incorrect insulation resistance tests

High test voltages can damage the device.

- Measure the insulation resistance of low voltage circuits of machines or systems only with ≤ 500 V DC.
- Measure the insulation resistance of SELV circuits of machines or systems only with ≤ 250 V DC.

NOTICE

Device damage caused by incorrect voltage tests

High test voltages can damage the device. Capacitive leakage currents can distort the test results.

- Disconnect the components before carrying out a voltage test on the machine. [1)]

[1)] The components are voltage tested in accordance with the IEC 61800-5-1 product standard and must be disconnected during testing in accordance with IEC 60204-1:2021 Section 18.4.

WARNING

Unexpected movement of machines caused by inactive safety functions

Inactive or non-adapted safety functions can trigger unexpected machine movements that may result in serious injury or death.

- Observe the information in the appropriate product documentation before commissioning.
- Carry out a safety inspection for functions relevant to safety on the entire system, including all safety-related components.
- Ensure that the safety functions used in your drives and automation tasks are adjusted and activated through appropriate parameterizing.
- Perform a function test.
- Only put your plant into live operation once you have guaranteed that the functions relevant to safety are running correctly.

WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings

As a result of incorrect or changed parameterization, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameterization against unauthorized access.
- Handle possible malfunctions by taking suitable measures, e.g. emergency stop or emergency off.

2.2 Equipment damage due to electric fields or electrostatic discharge

Electrostatic sensitive devices (ESD) are individual components, integrated circuits, modules or devices that may be damaged by either electric fields or electrostatic discharge.

NOTICE

Equipment damage due to electric fields or electrostatic discharge

Electric fields or electrostatic discharge can cause malfunctions through damaged individual components, integrated circuits, modules or devices.

- Only pack, store, transport and send electronic components, modules or devices in their original packaging or in other suitable materials, e.g conductive foam rubber of aluminum foil.
- Only touch components, modules and devices when you are grounded by one of the following methods:
  - Wearing an ESD wrist strap
  - Wearing ESD shoes or ESD grounding straps in ESD areas with conductive flooring
- Only place electronic components, modules or devices on conductive surfaces (table with ESD surface, conductive ESD foam, ESD packaging, ESD transport container).

2.3 Warranty and liability for application examples

Application examples are not binding and do not claim to be complete regarding configuration, equipment, or any eventuality which may arise. Application examples do not represent customer-specific solutions, but merely serve to provide assistance with typical tasks.

As the user you yourself are responsible for ensuring that the products described are operated correctly. Application examples do not relieve you of your responsibility for safe handling when using, installing, operating and maintaining the equipment.

2.4 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Further information is provided on the Internet:
Configuration Manual Industrial Cybersecurity
(https://support.industry.siemens.com/cs/ww/en/view/109975311)

WARNING

Unsafe operating states resulting from software manipulation

Software manipulations, e.g. viruses, Trojans, or worms, can cause unsafe operating states in your system that may lead to death, serious injury, and property damage.

- Keep the software up to date.
- Incorporate the automation and drive components into a state-of-the-art, integrated industrial cybersecurity concept for the installation or machine.
- Make sure that you include all installed products in the integrated industrial cybersecurity concept.
- Protect files stored on exchangeable storage media from malicious software by with suitable protection measures, e.g. virus scanners.
- Carefully check all cybersecurity-related settings once commissioning has been completed.

2.5 Residual risks of power drive systems

When assessing the machine or system-related risk in accordance with the respective local regulations (e.g. EC Machinery Directive), the machine manufacturer or system integrator must take into account the following residual risks emanating from the control and drive components of a drive system:

1. Unintentional movements of driven machine or system components during commissioning, operation, maintenance, and repairs caused by, for example,
   - Hardware faults and/or software errors in the sensors, control system, actuators, and connections
   - Response times of the control system and of the drive
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - Parameterization, programming, cabling, and installation errors
   - Use of wireless devices/mobile phones in the immediate vicinity of electronic components
   - External influences/damage
   - X-ray, ionizing radiation and cosmic radiation

2. Unusually high temperatures inside and outside the components, including open flames, as well as emissions of light, noise, particles, gases, etc. due to fault conditions, e.g.:
   - Component failure
   - Software errors
   - Operation and/or environmental conditions outside the specification
   - External influences/damage
   - Short circuits or ground faults in the intermediate DC circuit of the converter
3. Hazardous shock voltages caused by, for example:
   - Component failure
   - Influence during electrostatic charging
   - Induction of voltages in moving motors
   - Operation and/or environmental conditions outside the specification
   - Condensation/conductive contamination
   - External influences/damage
4. Electrical, magnetic and electromagnetic fields generated in operation that can pose a risk to people with a pacemaker, implants or metal replacement joints, etc., if they are too close
5. Release of environmental pollutants or emissions as a result of improper operation of the system and/or failure to dispose of components safely and correctly
6. Influence of network-connected and wireless communications systems, e.g. ripple-control transmitters or data communication via the network or mobile radio, WLAN or Bluetooth.
7. Motors for use in potentially explosive areas:

   When moving components such as bearings become worn, this can cause enclosure components to exhibit unexpectedly high temperatures during operation, creating a hazard in areas with a potentially explosive atmosphere.

For more information about the residual risks of the drive system components, see the relevant sections in the technical user documentation.

Product overview

3

3.1 Area of application

Broad range of control applications

The SIMATIC ET 200SP distributed I/O system provides the flexibility and power required for a wide range of control applications.

The F-TM StepDrive ST is a product from the range of TM Drive modules in the ET 200SP network. In this manual, the term TM Drive is used as a synonym for F-TM StepDrive ST.

The F-TM StepDrive technology module offers you the following possible applications:

- Variable speed control
- Positioning tasks in combination with higher-level controller
- In the area of safety extra-low voltage ≤ 60 V DC with integrated hardware Safety function Safe Torque Off (STO)

Areas of application

The TM Drives have proven to be an ideal and compact drive in many applications.

Examples of applications:

- Packaging machines
- Automatic assembly machines
- Electronics and battery production
- Printing and labeling machines
- Winders/unwinders, e.g. in the textile, packing and printing and solar industries
- Driving of shuttles for storage and retrieval machines and storage rack systems
- Automated guided vehicle systems
- Battery-powered applications

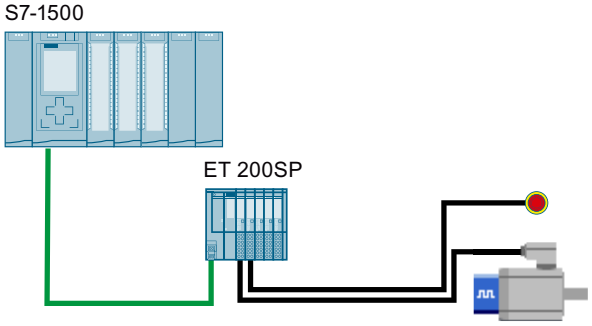

Figure 2-1603 Overview of standard variant with standard CPU

3.2 Properties

Article number

6BK1136-6SB00-0BU0

View of the module

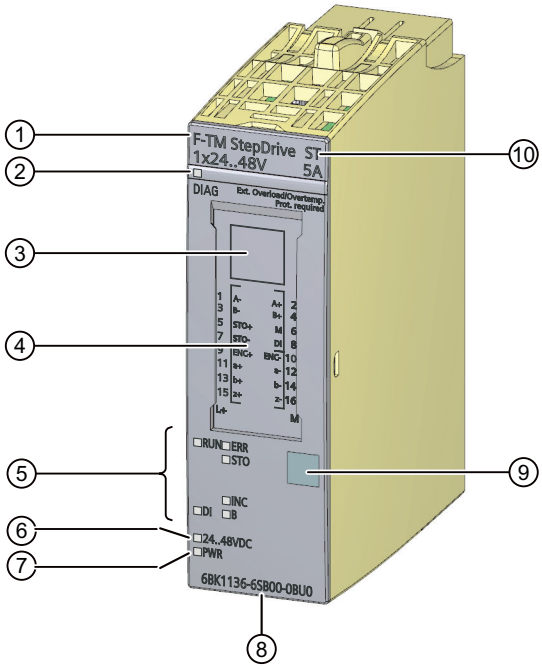

①	Module type and designation	⑥	LED for supply voltage
②	LED for diagnostics	⑦	LED for power
③	2D matrix code	⑧	Article number
④	Wiring diagram	⑨	Color coding of module type
⑤	LEDs for motor control	⑩	Function class

Figure 2-1604 View of the F-TM StepDrive ST module

Properties

The F-TM StepDrive ST has the following properties:

- Operation on ET 200SP PROFINET IMs as of V4.0
- Operation on CPU 151x as of V2.0, S7-1200, OpenController and CPU 151xSP
- Speed-controlled single-axis drive with PROFIdrive profile

- Rated voltage of the drive module: 24 to 48 V DC (safety extra-low voltage)
- Support of incremental encoders (with A, B, Z track)
- 24 V digital input
- Support of individually configurable bipolar stepper motors
- Controller parameter determination possible using HSP
- Thermal monitoring of the motor and the power end stage
- Cyclic overload capability
- Safety function STO hardwired
- Motor holding brake external via the process image
- Integrated engineering in STEP 7 (TIA Portal) via Hardware Support Package HSP0311 V16 or higher

Accessories

The following accessories, which are not included in the scope of delivery of this module, can be used with the module:

- Labeling strips
- Color-coded labels
- Reference identification labels
- Shield connection

A BaseUnit of the type U0 (6ES7193-6BP00-0DU0 oder 6ES7193-6BP00-0BU0) is needed for operation of the TM Drive. You can find an overview of the BaseUnits that you can use with the technology module in the Equipment Manual SIMATIC ET 200SP BaseUnits (https://support.industry.siemens.com/cs/ww/en/view/109751716).

For more information on accessories, refer to the system manual SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

NOTE

Unsuitable electronic fuses

Electronic fuses that disconnect the output voltage briefly in case of an overload and are not capable of power feedback (e.g. SITOP SEL1200) are not suitable for fuse protection.

3.3 Supported functions

System functions

The TM Drive supports the following PROFINET IO functions:

- Firmware update via PROFINET IO

The TM Drive supports the function:

- Identification data I&M 0 to 3

PROFIdrive communication types

TheTM Drive supports the following types of communication:

- Cyclic data exchange via a cyclic data channel

  Motion control systems require cyclically updated data during operation for open-loop and closed-loop control. This data must be sent as setpoints to the drive devices or read as actual values from the drive devices via the communication system. The transfer of this data is normally time-critical.

- Acyclic data exchange via an acyclic data channel

  An acyclic parameter channel for exchange of parameters between the CPU or supervisor and the drive devices is additionally available. Access to this data is not time-critical.

- Alarm channel

  Alarms are output event-triggered and indicate incoming and outgoing error states.

PROFIdrive application classes

The TM Drive supports Application Classes 1 and 4 of the PROFIdrive profile as of V4.2.

- Class 1 (AC1)

  The drive is controlled via a speed setpoint using PROFINET.

  The closed-loop speed control takes place entirely in the drive.

  Typical applications are, for example, simple frequency converters for pump and fan control.

- Class 4 (AC4)

  This PROFIdrive application class defines a speed setpoint interface with the closed-loop speed control taking place in the drive and the closed-loop position control taking place in the CPU, as is required for robot and machine tool applications with coordinated motion sequences on multiple drives.

Wiring

4

4.1 Pin assignment

Specific application

Observe the safety and accident prevention regulations applicable for specific applications, e.g. "Safety of Machinery EN ISO 13849-1".

During wiring and maintenance work, the TM Drive must be disconnected from the power supply.

EMERGENCY OFF equipment

EMERGENCY OFF devices according to IEC 60204 (corresponds to DIN VDE 0113) must remain in effect in all operating modes of the plant or system.

The drive-integrated safety function STO of the TM Drive does not replace the EMERGENCY OFF mechanism of the plant.

Excluding hazardous plant states

Hazardous operating states must not occur when

- The plant restarts up after a voltage dip or voltage failure
- Bus communication resumes after a fault

If necessary, the EMERGENCY OFF must be forced!

An uncontrolled or undefined startup must not occur after the EMERGENCY OFF is unlocked.

You can find a description on how to prevent uncontrolled startup in the section Safety Integrated functions (Page 41).

Potential group

Up to a continuous input current of up to max. 10 A for each potential group, up to 3 TM Drive can be connected together to form a drive group.

No other ET 200SP components may be located within a potential group consisting of one or more TM Drive.

A TM Drive potential group can be supplied as follows:

- With a separate power supply unit
- With a common power supply that also supplies other components. In this case, use a DC line filter (TDK Electronics 2-wire filter series B84113C) before the TM Drive potential group.

- If you are using a power supply unit with a rated current of more than 10 A or batteries/rechargeable batteries, then it is imperative to connect a circuit breaker of characteristic B with max. 10 A rated current, approved for direct current and the corresponding SELV / PELV voltage, upstream of the TM Drive potential group.
  For a potential group with only one TM Drive we recommend using an appropriate miniature circuit breaker with 6 A fuse and characteristic B.
- You must not use voltage sources with low impedances (such as supercaps) without adequate current-limiting protective measures.

Short circuits

The power outputs of the TM Drive are short-circuit proof. If the module detects a short circuit, it is still imperative to rectify the fault before switching it on again. Otherwise the module can be damaged.

Disturbance of radio communication services due to radio-frequency interferences in residential environments

The TM Drive can cause radio frequency interference which requires measures for interference suppression. This system is not designed for liberal use in the first environment (residential area) and must not be used there without appropriate radio interference suppression measures. Have the installation and commissioning performed with appropriate radio interference suppression measures by experts.

Protection from external electrical effects

You can find information on interference-proof design in the function manual Designing interference-free controllers (https://support.industry.siemens.com/cs/ww/en/view/59193566).

Overload

The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

With automatic overload limiting, the output current is automatically reduced on reaching the rated load of the power end stage to effectively prevent an overload of the power unit.

SCCR (short circuit current rating)

Suitable For Use On A Circuit Capable Of Delivering Not More Than 5kA DC Symmetrical Amperes, 48 Volts DC Maximum.

4.2 Block diagram

WARNING

Fuse for the load circuit
In general, use a suitable overcurrent protection device to protect the TM Drive.

Schematic circuit diagram

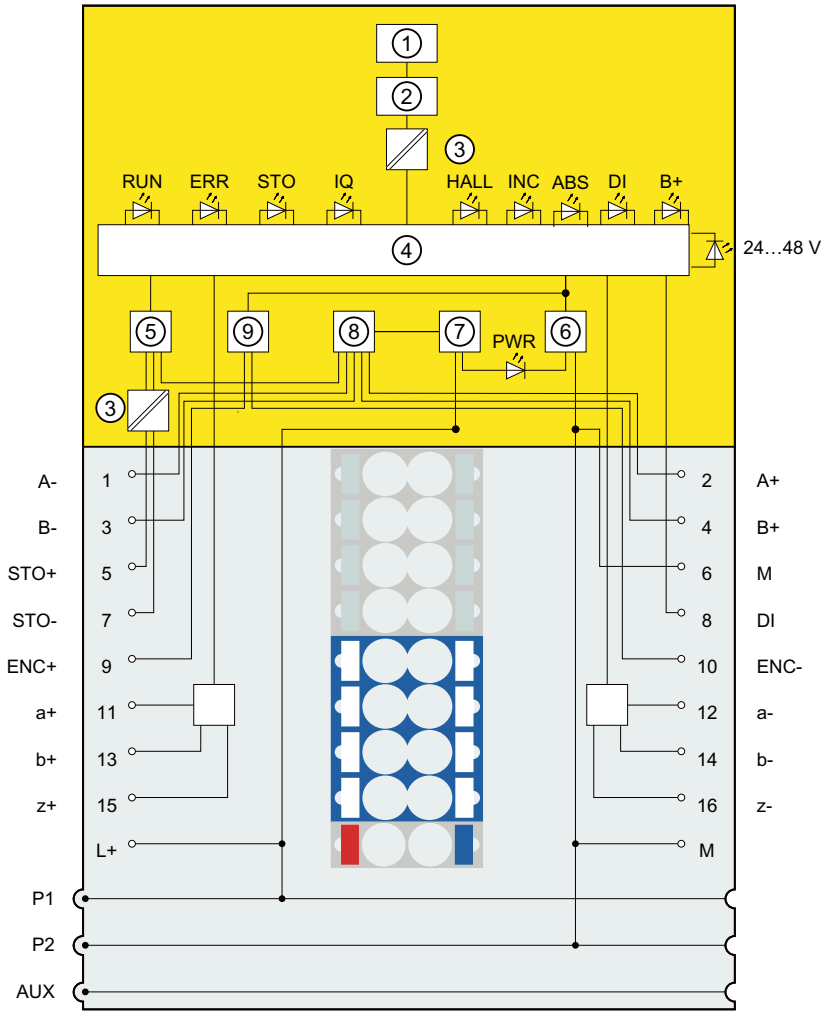

①	Backplane bus	**Stepper motor**
②	Backplane bus interface module of the technology controller	A-
③	Galvanic isolation	A+
④	Technology controller	B-
⑤	Safe Torque Off circuitry	B+
		Encoder supply

⑥ Digital input circuit

⑦ Power supply/Preparation

⑧ Reverse polarity protection

⑨ Power electronics

⑩ Encoder power supply

Power supply

L+ Power supply 24 - 48 V

M Power supply GND

Inputs

STO+ STO+ input (24 V)

M Negative terminal

STO- Negative STO input

DI Digital input

ENC+ Power supply encoder 5 V

ENC- Power supply encoder, negative connection

Incremental encoder

a+ Differential encoder signal a+

a- Differential encoder signal a-

b+ Differential encoder signal b+

b- Differential encoder signal b-

z+ Differential encoder signal z+

z- Differential encoder signal z-

Figure 2-1605 Schematic circuit diagram

Cable lengths and cable types

If you do not use an "all-in-one" plug-in cable, the following cable lengths and cable types are permitted for the interfaces:

Table 2-2084 Wiring rules for the interfaces

Pins	Function	Maximum cable length	Cable type
ENC+/ENC-	Incremental encoder signals and supply	10 m	Shielded For differential wiring, one twisted pair per signal pair
A+/A-/B+/B-	Motor phases	10 m	Shielded
DI, M	Input	10 m	≥ 2 m shielded
	Ground	10 m	-
L+/M	Power supply, power unit	10 m	-
a, b, z	Encoder connectors	10 m	Shielded For differential wiring, one twisted pair per signal pair
STO	Safe Torque Off	10 m	-

Permissible cable cross-sections depend on the BaseUnit used. See ET 200SP BaseUnits Equipment Manual (https://support.industry.siemens.com/cs/ww/en/view/59753521)

CABLE SPEC.	Note that connected power lines must be designed according to the expected current value at maximum ambient temperature and installation type in accordance with applicable standards.

NOTE

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor/encoder side.

4.3 Wiring of multiple TM Drive

In a potential group

You can connect multiple TM Drive to form a potential group (drive line-up). The following figure shows you the TM Drive with different motors.

Wiring of multiple TM Drive to form a drive line-up

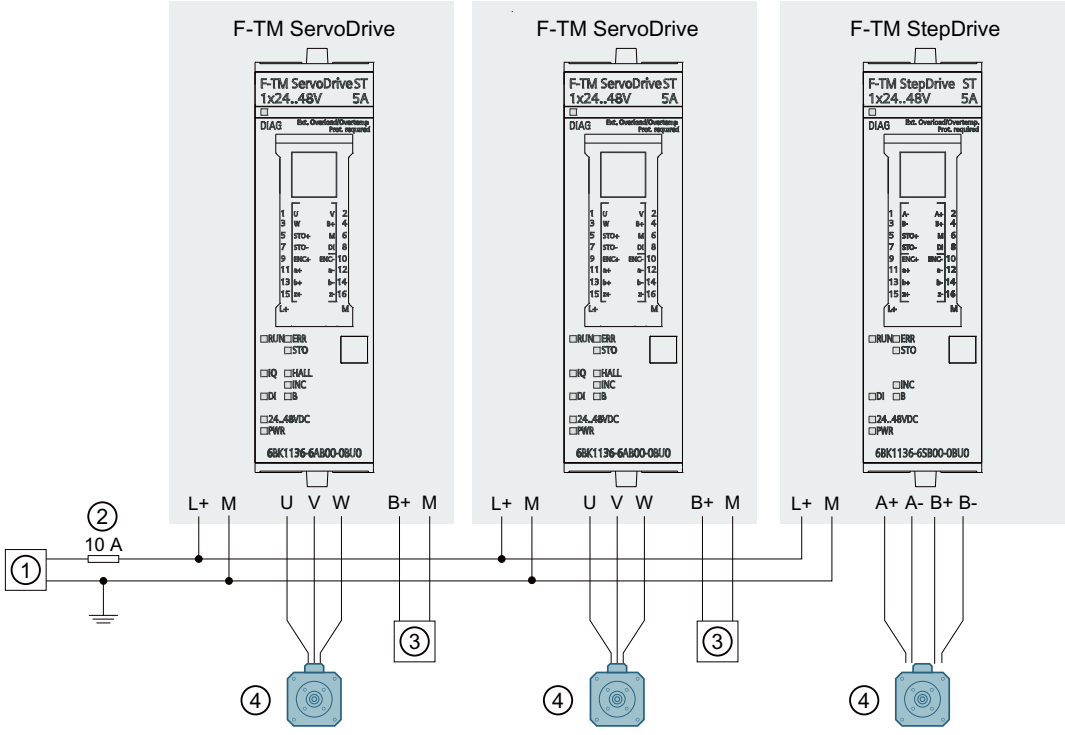

① Power supply unit

② Protective device

③ Braking resistor

④ Motor

Figure 2-1606 Wiring of multiple TM Drive to form a drive line-up

4.4 Connecting the motor

Overview

The F-TM StepDrive supports bipolar interconnected stepper motors.

4.4.1 Wiring the motor phases (stepper motor)

The following figure shows the connection of the motor phases to the BaseUnit:

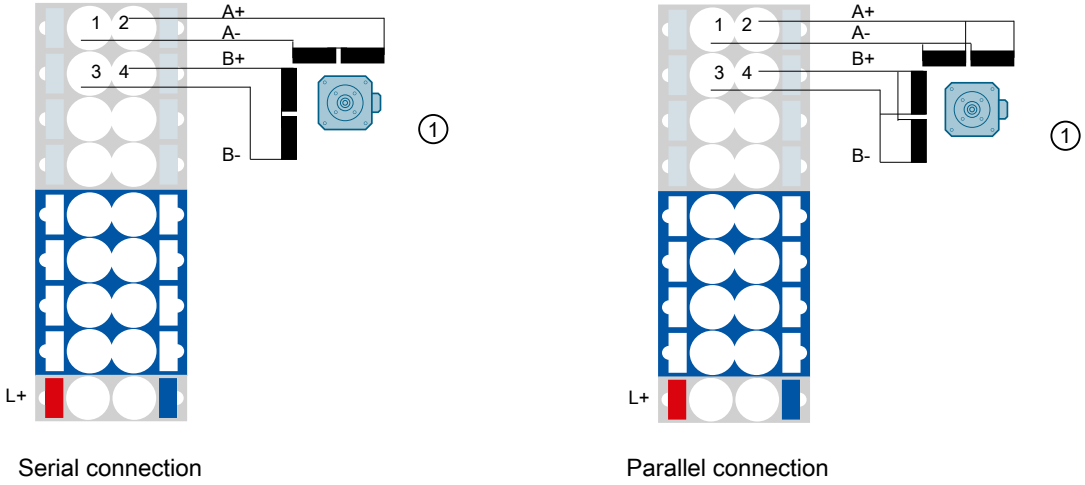

①	Stepper motor
A+, A-, B+, B-	Motor phases

Figure 2-1607 Connecting the motor

NOTE

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the motor side.

Pin assignment

Pin	Designation	Function
1	A+	Motor phase A+
2	A-	Motor phase A-
3	B+	Motor phase B+
4	B-	Motor phase B-

4.5 Connecting an encoder

4.5.1 Connecting an incremental encoders

You can connect motors with a 3-channel incremental encoder to the TM Drive. The A and B tracks and a reference track Z are required for evaluation. You connect all signals as "single-ended" or "differential".

The following figure shows the connection of an incremental encoder to the BaseUnit.

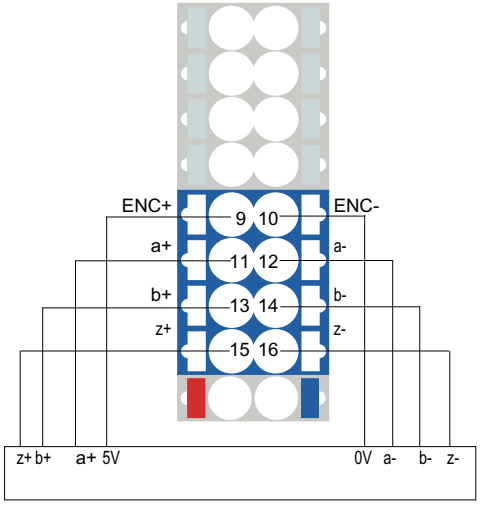

Figure 2-1608 Connection of incremental encoder with differential signals

Pin assignment of incremental encoder

Pin	Designation	Function
9	ENC+	Power supply encoder 5 V
10	ENC-	Power supply encoder, negative connection
11	a+	Differential encoder signal a+
12	a-	Differential encoder signal a-
13	b+	Differential encoder signal b+
14	b-	Differential encoder signal b-
15	z+	Differential encoder signal z+
16	z-	Differential encoder signal z-

Table 2-2085 Power supply and signal processing conditions of the incremental encoder

Encoder circuit	Range
TTL bipolar 5 V or differential	High 2 V .. 5.5 V
	Low -5.5 V ... -2 V
TTL unipolar 5 V	High 4 V .. 5.5 V

*The quadrature interface results in a maximum step resolution of 2000 kHz

Encoder circuit	Range
TTL unipolar 5 V	Low 0 V .. 1 V
Encoder supply voltage	5 V ... 5.3 V
Maximum current consumption of the encoder	150 mA
Maximum signal frequency that can be processed (per signal A and B)*	500 kHz

*The quadrature interface results in a maximum step resolution of 2000 kHz

NOTE

In addition to the shield connection on the ET 200SP the cable shield must also be grounded with a suitable fastening, for example with a metal clip on the control cabinet rear panel. The cable shield must be applied on the encoder side.

4.5.2 Connecting safe torque off (Hardware STO)

Safe Torque Off (STO)

The safety function Hardware STO is activated via an exclusive safe input (STO+ and STO-). The TM Drive safely switches off the control of the motor. As long as Hardware STO is active, the motor does not generate any torque.

The safe state "Safe Torque Off" corresponds to the de-energized state at STO+/STO- (closed-circuit current principle).

The Hardware STO function meets the specification of a digital input according to EN 61131-2 Type 1 without limitation. In addition, this input has an increased leakage current resistance of 5 mA. That is, at leakage currents below 5 mA, the safe state is always selected.

WARNING

Danger to life due to coasting down of the drive with STO

The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

Wiring the Hardware STO

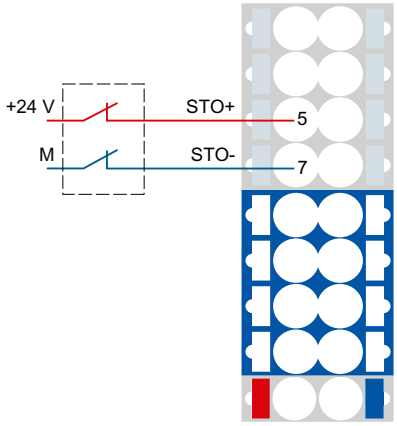

STO+ STO input 24 V

STO- STO input, negative connection

Figure 2-1609 Connection of Hardware STO

NOTE

The supply voltage for the STO inputs must be different from that of the power supply.

Table 2-2086 Pin assignment

Pin	Designation	Function
5	STO+	STO input 24 V
7	STO-	STO input, negative connection

The cables of the hardware STO (STO+/STO-) must be routed separately from other cables, especially power cables.

The risk of crushing and short-circuits against earth connections must be minimized by appropriate routing.

Premature aging of the cables due to continuous UV radiation must be ruled out.

4.5.3 Connecting the 24 V digital input

Connecting a 24 V digital input

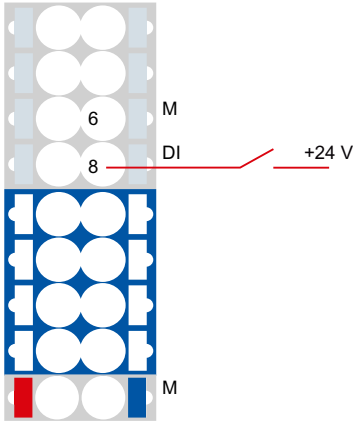

DI 24 V digital input

M Ground

Figure 2-1610 24 V digital input connection

Table 2-2087 Pin assignment

Pin	Designation	Function
6	M	Ground, internally connected to ground of 24 - 48 V power supply
8	DI	24 V digital input

Safety functions integrated in the drive 5

5.1 Basic safety information

5.1.1 General safety information

WARNING

Danger to life if the safety instructions and residual risks are not taken into consideration

The non-observance of the safety instructions and residual risks stated in the associated F-TM StepDrive documentation can result in accidents causing severe injuries or death.

- Observe the safety instructions given in the F-TM StepDrive documentation.
- Consider the residual risks for the risk evaluation.

WARNING

Malfunctions of the machine as a result of incorrect or changed parameter settings

As a result of incorrect or changed parameter settings, machines can malfunction, which in turn can lead to injuries or death.

- Protect the parameter assignment against unauthorized access.
- Respond to possible malfunctions by implementing suitable measures (e.g. EMERGENCY STOP or EMERGENCY OFF).

WARNING

Validity of safety features

The safety features of the product are guaranteed only for intended use within the intended ambient conditions (see section Technical specifications (Page 110)).

The safety features only apply when operating with a BaseUnit of the U0 type (6ES7193-6BP00-0DU0 or 6ES7193-6BP00-0BU0).

5.1.2 Warranty and liability for application examples

Application examples are non-binding and do not claim to be complete regarding configuration and equipment as well as all eventualities. Application examples do not represent customer-specific solutions. They are only intended to provide support for typical tasks.

As user, you are responsible for ensuring that the products described are used correctly. Application examples do not relieve you of the responsibility to use safe practices in application, installation, operation and maintenance.

5.1.3 Fundamental safety instructions for Safety Integrated

Additional safety instructions and residual risks are provided outside of this section at the relevant points of this system manual.

⚠ DANGER

Risk minimization through Safety Integrated

Safety Integrated can be used to minimize the risk associated with machines and plants. However, safe operation of the machine or system with Safety Integrated is only possible if the machine manufacturer:

- Knows and complies with this technical user documentation, including the documented constraints, safety instructions and residual risks
- Carefully constructs and configures the machine/plant and verifies it through a carefully implemented and documented acceptance test by qualified personnel
- Implements and validates all the measures required in accordance with the system/machine risk analysis by means of the programmed and configured Safety Integrated functions or by other means

The use of Safety Integrated does not replace the machine/plant risk assessment carried out by the machine manufacturer as required by the CE Machinery Directive.
In addition to using Safety Integrated functions, further risk reduction measures must be implemented.

⚠ WARNING

Danger to life as a result of undesirable motor movement when automatically restarting

An emergency stop must be performed according to Stop Category 0 (STO) (EN 60204-1). The emergency stop must be ensured by external measures.
It is not permissible that the motor automatically restarts after an Emergency Stop, as this represents danger to life as a result of the associated undesirable motor motion.
If individual safety functions are deactivated, an automatic restart is permitted under certain circumstances depending on the risk analysis (except when Emergency Stop is reset). An automatic start is possible when a protective door is closed, for example.

- Ensure that no automatic restart takes place in the indicated cases.

WARNING

Danger to life as a result of undesirable motor motion when the system powers up and the drives are activated after hardware and/or software is changed or replaced

After hardware and/or software components have been modified or replaced, or after drive parameters are changed or parameter backups are loaded, it is only permissible for the system to run up and the drives to be activated with the protective devices closed. Personnel shall not be present within the danger zone during this time.

- It may be necessary to carry out a partial or complete acceptance test or a simplified functional test after making certain changes or replacements.
- Before personnel may re-enter the hazardous area, all of the drives should be tested to ensure that they exhibit stable control behavior by briefly moving them in both the plus and minus directions (+/-).

5.1.4 Safety Integrated functions

This section gives you a quick insight into the functioning of the safety functions.

The description of the safety functions starts in each case with the definition in IEC/EN 61800-5-2 and simple examples of the use of the function.

The description of the functions is simplified as far as possible so that the essential properties and setting options are made clear.

Response time

You can find additional information on the response time of the listed safety functions in section Response times (Page 116).

Examples of safety devices and 3 F-TM StepDrive

NOTE

The supply voltage for the STO inputs must be different from that of the power supply.

The following figure shows various safety devices that are connected to 3 F-TM StepDrive.

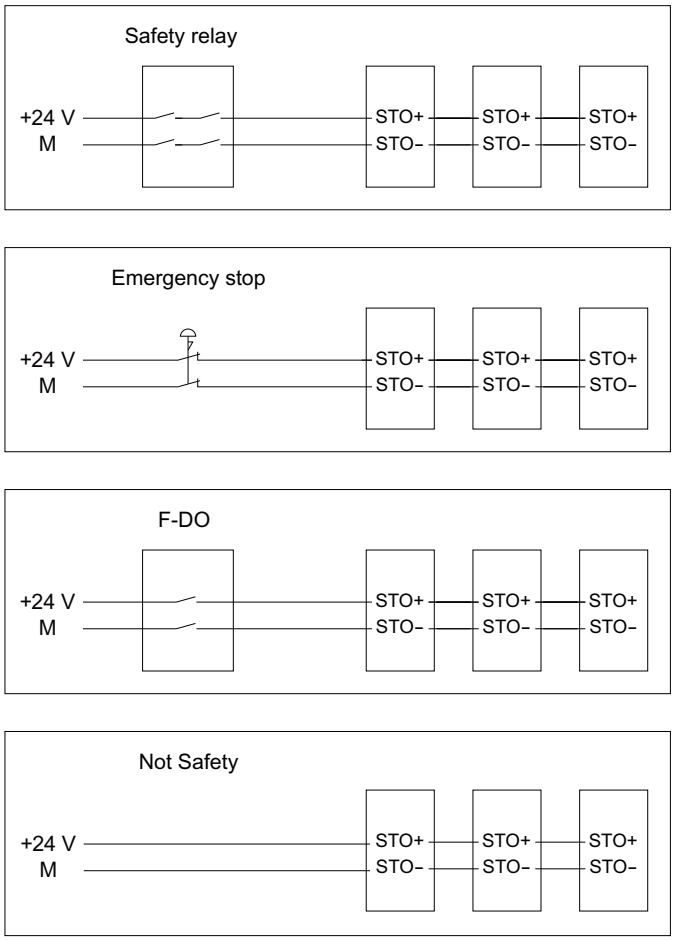

Figure 2-1611 Safety devices and 3 F-TM StepDrive

NOTE

The F-TM StepDrive does not support startup protection.

Measure:

Startup protection via additional safety relay or in higher-level controller, depending on the safety requirements.

Operating voltage range

Operate input STO+ as intended with 19.2 to 28.8 V DC for the active enable or lower 5 V DC for the disable.

Connect the input STO- for enabling or disabling the connection to ground.

Switching on again after power off

An On delay of more than 2 s must be observed between tripping and restarting the module, for example switching the power supply off and on. Otherwise the module can register an internal STO error and the module switches off in a safety-oriented manner.

5.1.4.1 Safe Torque Off (STO)

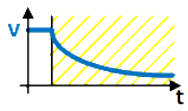

Safe Torque Off (STO) is a safety function that directly stops torque- or force-producing energy from being supplied to the motor. This function corresponds to Stop Category 0 according to EN 60204-1.

The F-TM StepDrive complies with the definition of the STO function in IEC/EN 61800-5-2: "The STO function prevents torque-producing energy from being supplied to the motor."

If the motor is still rotating when STO is selected, the motor will coast to a standstill.

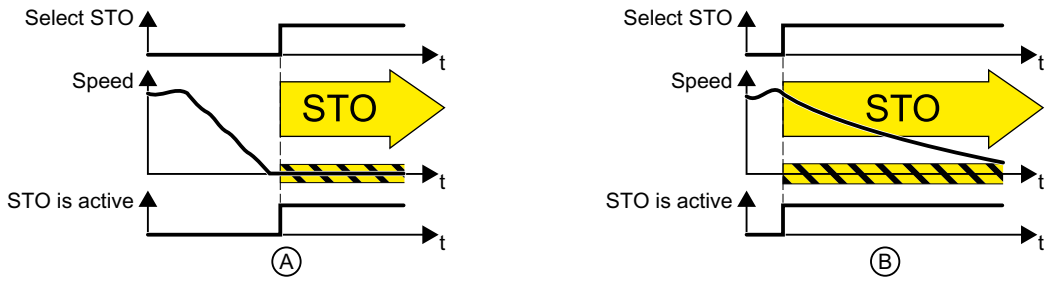

Figure 2-1612 Functioning of STO (A) when motor is at stopped and (B) when motor is rotating

Functional characteristics

WARNING

Danger to life due to coasting down of the drive with STO

The Category 0 stop function according to EN 60204-1 (STO according to Safety Integrated) means that the drives are not braked but instead coast down for an amount of time corresponding to the kinetic energy.

- You must take this behavior into account, for example, in the logic for the protective door interlock.

STO is a drive-specific function and must be wired individually for each drive.

The following applies when the "Safe Torque Off" function is selected:

- An unwanted startup of the motor cannot take place.
- The torque-producing energy supply to the motor is safely interrupted.
- An electrical isolation between the power unit and motor does not occur.

The stop function category 0 (selection of STO according to Safety Integrated) is only active when selected at the STO terminals. In order to meet the requirements of an EMERGENCY STOP in accordance with EN 60204-1, you need to ensure that the STO function at the STO terminals in the system can only be deselected by means of conscious manual operation. This prevents electrically driven machine components from restarting unintentionally.

Selection

The STO safety function is always enabled and cannot be disabled via parameter assignment.

You can select the STO function via the fail-safe digital input at STO+ and STO- terminals. The selection of the STO function is enabled directly as a response to safety messages (e.g. when a defect is detected in a monitoring channel).

Range of application

You can use the STO safety function without restrictions for a bipolar connected two-phase stepper motor. A special encoder concept suitable for safety is not required.

Applications

Application areas are all machines or systems with moving axes (e.g. conveyor systems, handling systems).

STO can be used in which the motor is already at a standstill or comes to a standstill safely due to friction in a short time.

STO allows safe working while a protective door is open. A conventional Emergency Stop with electromechanical unlocking is not required. The converter remains connected to the supply system and has full diagnostics capability.

NOTE

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant. The STO function is suitable for implementing an EMERGENCY STOP, but not an EMERGENCY OFF.

Hardware STO

The F-TM StepDrive internally monitors the fail-safe digital input at STO+ and STO- terminals for discrepancies.

Discrepancy monitoring

Due to the design of the Hardware STO circuit, a discrepancy cannot occur at STO+ and STO- terminals. As long as the STO terminal is de-energized, STO is selected. The Hardware STO signal is read in internally via two channels.

To comply with the requirements for timely error detection from EN 61800-5-2, the switch-off signal paths of the end stage in both monitoring channels are also cyclically tested. Errors when testing the shutdown paths trigger STO. A manual forced checking procedure (test stop) for testing the shutdown paths of the F-TM StepDrive is therefore not needed.

⚠ WARNING
Forced checking procedure You should nevertheless examine its necessity for diagnosing the utilized sensors or for performing a test stop in the context of the overall system.

5.1.5 Overview of the Safety Integrated functions

Compared to standard drive functions, safety functions have an especially low error rate. Performance Level (PL) and Safety Integrity Level (SIL) as defined in the corresponding standards are a measure for the error rate.

For this reason, safety functions are suitable for use and for risk reduction in safety-related applications. An application is safety-related when the risk analysis of the machine or plant has identified a particular risk potential in the application.

Safety Integrated means that the safety functions are integrated in the drive and can be executed without additional external components.

Conformity of Safety Integrated functions

The Safety Integrated functions comply with:

- Safety Integrity Level (SIL) 3 according to IEC 61508 Part 1-3
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

For functional safety of variable-speed drives, the standard IEC 61800-5-2, in which the Safety Integrated functions are defined, applies.

Function groups

The safety functions are divided into the following function groups for the F-TM StepDrive:

- Safety Integrated stop function (hardware STO)

5.1.6 Supported safety functions

The supported safety functions are included in the standard scope of the F-TM StepDrive and can be used without an additional license.

Stop functions

The stop functions do not pose any special requirements on the utilized encoder and do not need actual value acquisition. The stop functions include the following Safety Integrated functions:

- Safe Torque Off (STO)

  Safe Torque Off is a safety function for prevention of unexpected startup according to EN 60204-1. STO prevents torque-producing energy from being supplied to the motor and corresponds to Stop Category 0.

5.1.7 Examples of using the safety functions

Table 2-2088 Examples of using the safety functions

Safety function	Application examples	Possible solution
Safe Torque Off (STO)	It is only permissible to open a protective door if the motor torque has been switched off.	Activate STO in the F-TM StepDrive via the STO inputs. The pulses are suppressed and the motor coasts to a standstill.
	A central Emergency Stop button ensures that multiple drives cannot start unintentionally.	Evaluate the emergency stop button in a central controller. Use a two-channel connection to the STO inputs on the F-TM StepDrive.

5.1.8 Safety concept

The safety concept of the drive controller is based on a 2-channel system structure. Each channel has the possibility of bringing about the safe state, and the two channels monitor each other through a corresponding cross-comparison and cyclic diagnostics.

Safe state

The safe state of the system exists when the motor bridge is **de-energized**.

The safe state is reached in the following cases:

- Switch-off or failure of the external power supply to L+/M
- Missing enable signal at STO+ and STO-
- Detection of an internal HW fault

Safe state of Safety Integrated functions

The safe state of the STO input terminal is reached when at least one of the two STO supply terminals is disconnected from the energy supply.

NOTE

The safe state means the absence of torque in the sense of functional safety, but not necessarily the absence of voltage in the sense of electrical safety.

5.2 Acceptance of the safety functions

Responsibilities

The machine manufacturer is responsible for the performance and documentation of the acceptance test. In this section, you will find a recommendation for how to perform and document the acceptance tests for the individual safety functions.

NOTE

The performance and documentation of the acceptance tests are plant-specific and must be adapted appropriately and performed.

5.2.1 General information on acceptance

Why is acceptance required?

The EU machinery directive and ISO 13849-1 stipulate:

- You must test safety-relevant functions and machine parts after commissioning.

  See "Acceptance test" below in this section.

  For the F-TM StepDrive Safety Integrated functions (SI functions), this means:
  The acceptance test is used to check the functionality of the safety functions used in the drive. Correct implementation of the defined safety functions is examined for this.
- You must create an "acceptance report" that describes the test results.

  See "Documentation" further on in this section.

NOTE

Purpose of the acceptance test

The measured values (e.g. speed, time) and the system behavior identified (e.g. initiation of a specific stop) serve to check the plausibility of the configured safety functions. The objective of an acceptance test is to identify potential configuration errors and/or to document the correct function of the configuration. The measured values are typical values (not worst case values). They represent the behavior of the machine at the time of measurement. These measurements cannot serve as the basis for deriving real values (e.g. maximum values for over-travel distances).

Requirements

The requirements for an acceptance test (configuration test) for safety functions of electric drives come from EN 61800-5-2, section 7.1, paragraph f). The acceptance test is called "configuration test" in this standard.

- Description of the application including an image
- Description of the safety-related components (including software versions) that are used in the application
- List of the utilized safety functions of the PDS(SR) [Power Drive System(Safety Related)]
- Results of all tests of these safety functions using the specified test procedure

Necessity of an acceptance test

An acceptance test is required (again) when the Safety Integrated functionality of a machine is commissioned or changed. The acceptance tests must be performed for each individual drive. Safety-related function extensions, transfer of commissioning to other series machines, hardware changes, software upgrades and the like may allow a partial performance test to be performed.

The conditions determining the necessity and recommendations for the test depth required in each case are summarized below.

Requirements for the acceptance test

- The machine is correctly wired.
- All safety equipment (e.g. protective door monitoring devices, light barriers, emergency limit switches) are connected and ready for operation.
- The commissioning of open-loop and closed-loop control must be complete; otherwise, the over-travel distance may be changed due to a changed dynamic response of the drive control, for example. This includes:
  - Settings of the setpoint channel
  - Position control in the higher-level CPU
  - Drive control

Acceptance test

The acceptance test comprises two parts:

- You test whether the safety functions are set correctly in the drive:
  - Does the configured safety function sufficiently reduce the residual risk at the machine/plant?
  - Do the set interfaces, timers and monitoring functions match the configuration of the machine?
- You test whether the safety-relevant functions in the machine or system function correctly.

  This part of the acceptance test goes beyond the acceptance test of the drive:
  - Is all safety equipment, such as protective door monitoring, light barriers and emergency limit switches, connected and ready for operation?
  - Do the drive settings match the configured safety-relevant function in the machine?

Documentation

The documentation consists of the following parts:

- Description of safety-relevant components and functions of the machine or system, including the program versions.
- Report of the acceptance test results.
- Report of the safety function wiring.
- The documentation must be signed off by the person who performed the acceptance test.

Authorized persons

Persons authorized by the **machine manufacturer** who, on account of their technical training and knowledge of the safety-relevant functions, can carry out the acceptance in an appropriate manner are entitled to perform the acceptance.

⚠ WARNING

Unwanted movement due to faulty wiring

Incorrect wiring for Safety Integrated functions can cause unwanted motion resulting in severe injury or death.

- For Safety Integrated functions, always carry out an acceptance test for the affected function after changing the wiring.
- Record the results of the acceptance test in an acceptance report.

WARNING

Unsafe operating states due to manipulation of the hardware configuration after the acceptance test

Changes to the wiring of the Safety Integrated functions after an acceptance test can cause unwanted motion resulting in severe injury or death.

- To prevent access to your machines and systems by unauthorized persons, implement access restrictions and take the precautions described in the security instructions in the preface.
- To prevent improper wiring of the Safety Integrated functions, take the precautions described in this manual.
- Review the safety change tracking of the drive at regular intervals. Make certain that no changes have been made to the wiring after the last successfully completed acceptance test.
- If intentional changes have been made, repeat the acceptance test for the Safety Integrated functions affected. The purpose of the acceptance test is to ensure and document safe operation of the system. Correct any unintentional changes back to the original values and repeat the acceptance test.

5.2.2 Content of an acceptance test

Documentation

Documentation of the machine including safety functions

- Machine description (with overview image)
- Information on controller (if available)
- Function table:
  - Active monitoring functions depending on operating mode and protective door
  - Additional sensors with protection functions
  - The table is an object or result of the configuration work.
- SI functions for each drive
- Information on the safety equipment

Function test of diagnostic/safety functions

Value-based function check of the SI functions used. You can use trace records of individual parameters, for example, to do this.

- Acceptance test for Safe Torque Off (STO)

Report completion

Reporting of the tested state of commissioning and countersignatures

- Control of the STO function as enable signal of the STO+ and STO- terminals
- Enable to control the motor is removed as soon as a connection (STO+ or STO-) is not connected
- Counter signature

5.2.3 Documentation of acceptance

Machine or system description

Describe your machine or plant using the following table. Insert a diagram of the plant, for example.

Table 2-2089 Machine description and overview image

Designation	
Type	
Serial number	
Manufacturer	
End customer	
Overview image of the machine	

Drive data

In the following table, enter information on the drive components used and add additional components as required.

Table 2-2090 Hardware components

Component	Designation	Article number	Hardware version	Type
Drive controller				
Motor				
Encoders				
Brake module				
Gearbox				

Utilized Safety Integrated functions

In the following table, describe the use of the Safety Integrated drive functions in relation to your plant or machine.

Table 2-2091 Utilized SI functions of the drive

SI function	Status/Description
Safe Torque Off (STO)	

5.2.4 Acceptance test for Safe Torque Off (STO)

Procedure

Test each configured activation of the STO function.

This test consists of the following steps:

Table 2-2092 Acceptance test for "Safe Torque Off" (STO) function

No.	Description	Status
1.	**Drive is ready for operation**	
	• No faults	
	• The enable signal is present (STO is deselected).	

No.	Description		Status
2.	**Switch on motor**		
	2.1	Set speed setpoint ≠ 0	
	2.2	Switch on motor (ON command)	
	2.3	Check that the intended motor is rotating	
3.	**Select STO**		
	3.1	Selecting STO means interrupting the wire, supplying the STO from STO+ and short-circuiting STO- (if the source is current-limited)	
	3.2	Check the following points:	
		• Motor coasts down to a standstill	
		Message is implemented, but is not safety-relevant	
4.	**Deselect STO**		
	4.1	Deselection of STO (HW STO terminal)	
	4.2	Check the following points:	
		• Enable is active, motor must allow switch-on	

5.2.5 Report completion

SI change tracking (Safety logbook)

Ensure that changes to the safety function (wiring) can be traced.

Countersignatures

Commissioning engineer

Professional execution of the above-stated tests and checks is confirmed.

Table 2-2093 Report completion - Countersignature of commissioning engineer

Date	Name	Company/Department	Signature

Machine manufacturer

The correctness of the parameter assignment documented above is confirmed.

Table 2-2094 Report completion - Countersignature of machine manufacturer

Date	Name	Company/Department	Signature

5.3 System features

5.3.1 Current information

Important note for maintaining the operational safety of your system:

NOTICE
Operational safety risk from unwanted motions Systems with safety-oriented variants are subject to special operational safety requirements on the part of the operator. If information becomes known in the course of product monitoring indicating insufficient product safety, this information will be disclosed in various ways. For this reason, our website provides information on product developments and features that are (or could be) relevant to operation of systems from a safety perspective.

5.3.2 Certifications

The safety functions of the F-TM StepDrive drive system meet the following requirements:

- Safety Integrity Level (SIL) 3 according to IEC 61508 Part 1-3 and IEC 61800-5-2
- Category 3 according to ISO 13849-1
- Performance Level (PL) d according to ISO 13849-1

In addition, the safety functions of the drive are generally certified by independent institutes. A list of the components that are currently already certified in each case is available on request from your Siemens branch.

5.3.3 Failure probability of the safety functions

The probability of failure of safety functions must be specified in the form of a PFH value (Probability of Failure per Hour) according to DIN EN 61800-5-2 and ISO 13849-1. The PFH value of a safety function depends on the safety concept of the drive device, its hardware configuration and the PFH values of the other components used for the safety function. For the F-TM StepDrive drive system, PFH values are provided as a function of the hardware configuration.

NOTE

PFH values

The PFH value of the integrated safety function STO is 30 FIT (10^{-9}/h) and refers to a service life of 20 years.

The underlying assumption for the calculation is an average operating temperature of 40°C, an average repair time of 8 hours and an average time to recovery of 8 hours. A proof test is not necessary.

5.3.4 Response times

The response time is the time between the detection of an input signal and the change of a linked output signal. Below you will find information on the response times of the F-TM StepDrive drive system.

NOTE

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

The drive system is the component that provides the safety functions. The description "error-free drive system" means that the component providing the safety functions itself has no defect:

- Maximum response time in error-free drive system

  When the enable is removed at the STO+ or STO- terminals, the maximum response time in an error-free drive system is guaranteed.

Stop function (via terminals)

The following table specifies the response times for the indicated stop functions from the time of activation until occurrence of the response.

Function	Maximum response time
STOP_STO	Max. 20 ms

5.4 Safety Integrated

Important notes on the Safety Integrated system are provided in this section.

Diagnostics hardware fault

If an internally diagnosed hardware fault occurs, you can only reset the module by restarting it. Nevertheless, the replacement of the F-TM StepDrive is strongly recommended. Unwanted activation of the safety function can be an indication of a hardware fault.

Wiring the F-TM StepDrive

For information on how to perform the electrical wiring for the F-TM StepDrive, refer to section Wiring (Page 28)

STO inputs

The STO inputs are described in the section Connecting safe torque off (Hardware STO) (Page 36).

5.5 EMERGENCY OFF and EMERGENCY STOP

Difference between EMERGENCY OFF and EMERGENCY STOP

EMERGENCY OFF and EMERGENCY STOP are commands that mitigate different risks in the machine or plant.

EMERGENCY OFF Risk of electric shock 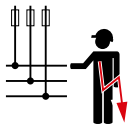	**EMERGENCY STOP** Risk of unexpected movement 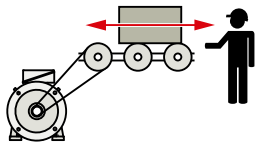

Table 2-2095 Measures and solutions

Command	EMERGENCY OFF	EMERGENCY STOP
Measure to minimize risk	**Safe switch off** Switching off the electric power supply for the installation, either completely or partially.	**Safely stop and safely prevent restarting** Stopping or preventing the dangerous movement
Classic solution	Switch off the power supply. 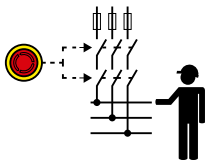	Switch off the drive power supply. 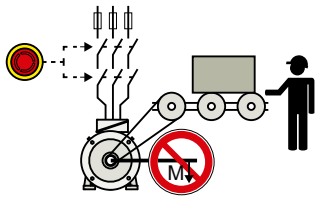
Solution with the STO safety function integrated in the drive	STO is not suitable for safely switching off a voltage.	Select STO. 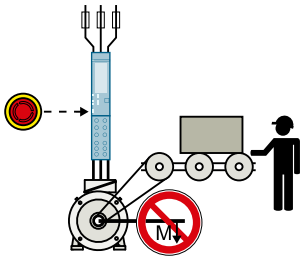 You may also switch off the power supply of the drive controller. However, switching off the voltage is not required as a risk-reduction measure.

Configuring

6

Configuration and parameter assignment

STEP 7 (TIA Portal) is available for configuring a ET 200SP TM Drive.

You perform the following tasks with STEP 7 (TIA Portal), for example:

- You configure the TM Drive (insertion into the project and setting the input addresses).
- You specify the desired hardware parameters for operation of the TM Drive.

Requirements

Hardware

- Supported interface modules: See Properties (Page 25)
- You have completed installation and wiring of the hardware. Take the potential group into account, see section Pin assignment (Page 28).
- You have connected the PG/PC via the PROFINET interface of the CPU.

Software

- You have installed the HSP0311. You can find the support packages for the hardware catalog in the TIA Portal (HSP) on the Internet (https://support.industry.siemens.com/cs/ww/en/view/72341852).

As soon as the configuration and hardware parameter assignment have been successfully completed, you can create your user program and commission the drive.

⚠ WARNING

Safety Integrated

As soon as a safety program has been created, you must perform a complete function test based on your automation task.

To accept the plant, you must use the safety summary created in accordance with this manual.

Configuring a TM Drive (minimal configuration)

To configure a TM Drive , follow these steps:

1. Create a new project.
2. Add a CPU S7-1200 or S7-1500 as a new device.
3. Add a PROFINET interface module to the project under "Devices & networks" from the ET200SP system, e.g. IM 155-6PN ST.
4. Assign the inserted IO device to the configured IO controller.

5. Switch to the device view of the interface module.
6. Add the TM Drive module from the hardware catalog to the IO device.
7. Add a server module.

6.1 Communication telegrams

Selection of a communication telegram

The selection of a communication telegram determines the process data of the drive that will be transmitted between the drive and CPU.

The following table shows the supported telegram types for the drive and sensor assignment.

Table 2-2096 Supported communication telegrams

Supported PROFIdrive telegrams	Brief description	User data
Standard telegram 1 PZD-2/2	Speed setpoint 16 bits, without sensor	• Control word STW1, status word ZSW1 • Speed setpoint 16 bits (NSET), actual speed value 16 bits (NACT)
Standard telegram 2 PZD-4/4	Speed setpoint 32 bits, without position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT)
Standard telegram 3 PZD-9/5	Speed setpoint, 32 bits with one position encoder	• Control words STW1 and STW2, status words ZSW1 and ZSW2 • Speed setpoint 32 bits (NSET), actual speed value 32 bits (NACT) • Encoder control word 1 (Gx_STW), encoder status word 1 (Gx_ZSW) • Actual encoder position value 1 (Gx_XIST1, Gx_XIST2)
Extension word	Status bits of the inputs	• Bit 0: DI • Bit 1: STO

A PZD (process data word) corresponds to a 16-bit word.

Selecting a telegram in STEP 7

To select the telegram for the TM Drive in STEP 7, follow these steps:

1. Select the TM Drive module in the device view.
2. Navigate to the properties of the module in the "General" tab under "TM Drive" > "Basic parameters".
3. Under "Telegram" in the drop-down list, select the desired telegram, e.g. "Standard telegram 3 (PZD length 9/5 words).
4. If needed, activate the extension word by selecting the "Telegram extension active" check box.

6.2 Structure of the encoder position actual value

Starting with standard telegram 3, the encoder position actual value is transmitted as a 32-bit value via the user data Gx_XIST1 and Gx_XIST2. These value provide the current **actual incremental position** of the encoder system and are read cyclically, for example by the "Positioning axis" technology object and further processed accordingly (see also section 8.3 (Page 98)). The layout of the encoder position actual value mainly depends on the following factors:

- Type of the encoder
- Resolution of the encoder

Regardless of the type of encoder, the actual position value is structured as follows:

- G1_XIST1 and Gx_XIST2 are right-aligned
- After it is switched on, a 32-bit counter is loaded with the current position value. Depending on the direction of rotation, this value is then only incremented or decremented. After reaching the max. position value, it starts again at 0.

NOTE

Dependence on the configured encoder resolution

The singleturn value ("increments / revolution") in G1_XIST1 is directly dependent on the configured encoder resolution (p408).

6.2.1 Incremental encoder

If you are using a motor with an incremental encoder and you have configured this for the type of motor encoder (p404), then the structure of the encoder position actual value is as follows:

Table 2-2097 Structure of the encoder position actual value

User data	Contents	
Actual encoder position value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution. You can read this back under "Drive diagnostics section 10.2.3 Encoders (Page 107)".
	Bits in Gx_XIST1 "Shift factor"	2
	Encoder type	Rotary incremental

Example of an incremental encoder with 4096 "steps per revolution", this corresponds to 1024 "steps per revolution" with a fine resolution of 2:

Table 2-2098 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Singleturn value (singleturn "steps per revolution")
F: Fine resolution

Table 2-2099 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

6.2.2 Encoderless / calculated

If you have set encoder (0) encoderless / calculated as encoder type, the encoder position actual value is calculated. Actual encoder position value is structured as follows.

Table 2-2100 Structure of the encoder position actual value

User data	Contents	
Encoder position actual value 1 (Gx_XIST1)	Increments per revolution	Depends on the parameter assignment of the encoder resolution. You can read this back under "Drive diagnostics section 10.2.3 Encoders (Page 107)".
	Bits in Gx_XIST1 "Shift factor"	2
	Encoder type	Rotary incremental

Example of a "simulated encoder" with 4096 "steps per revolution", this corresponds to 1024 "steps per revolution" with a shift factor of 2:

Table 2-2101 Structure Gx_XIST1

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	S	S	S	S	S	S	S	S	S	S	F	F

M: Multiturn value (number of distinguishable revolutions)
S: Singleturn value (singleturn "steps per revolution")
F: Fine resolution

Table 2-2102 Structure Gx_XIST2

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																											error				

Error code: See PROFIdrive specification
(https://mall.industry.siemens.com/mall/en/WW/Catalog/Products/10293158)

Commissioning the 7

The engineering of the TM Drive drive controller is integrated in STEP 7 (TIA Portal). You install it with the Hardware Support Package HSP0311. The graphic user interface supports you in the configuration, parameter assignment and commissioning of the drive functions of the TM Drive.

In this section you will find information on various topics including:

- Check before powering on for the first time
- Commissioning an TM Drive drive

⚠ CAUTION

Failure to comply with the instructions for Safety Integrated poses a risk of injury

Failure to comply with the instructions may result in serious injuries. Carefully read through the safety instructions in section Safety functions integrated in the drive (Page 39) before commissioning and before operation.

⚠ WARNING

Personal injury and property damage from the falling down of a suspended axis

If the drive system is used as suspended axis, the axis will fall down if the positive and negative poles of the power supply are interchanged during connection. An unexpected falling down of a hanging axis can result in personal injury and property damage.

Before commissioning, it must be ensured that a cross brace is fitted to hold the suspended axis in place and prevent it from falling down unexpectedly. Also ensure that the power supply is connected properly.

⚠ WARNING

Personal injury and property damage from the falling down of a suspended axis

An unexpected falling down of a hanging axis can result in personal injury and property damage

.

- When using the STO function in conjunction with suspended axes, the axis may fall down unexpectedly and cause property damage and personal injury.

NOTE

Performing tests

You must ensure the safety of your plant. You therefore need to perform a complete functional test and the necessary safety checks before the final commissioning of a plant.

Also allow for any possible foreseeable errors in the tests. This avoids endangering persons or equipment during operation.

7.1 Basics

7.1.1 Engineering

You perform configuration as well as diagnostics of a TM Drive with a PG/PC or notebook (commissioning device) using the TIA Portal (Hardware Support Package HSP0311 needed).

The settings can be found in STEP 7 in the device navigation under "Ungrouped devices" > "<Name of the interface module>" > "<Name of the TM Drive>".

Overview

This drive engineering is divided into the following areas:

- Device configuration
- Online & diagnostics
- Parameters

"Device configuration" area

Contents in the "Device configuration" area of the TM Drive engineering.

- Potential group
- Basic parameters
  Define telegram, activate telegram extension
- I/O addresses

"Online & diagnostics" area

Contents in the "Online & diagnostics" area of the TM Drive engineering.

Diagnostics

- General (module information):

  Order number, firmware and hardware version, I&M data
- Diagnostic status (display of status information)
- Active messages:

  Pending faults and alarms
- Drive diagnostics
  Status bits, operating values, encoders, temperatures, inputs

Functions

- Firmware update

"Parameters" area

Contents in the "Parameters" area of the TM Drive TM engineering.

- Drive:

  Drive data record, general settings, motor, gearbox, thermal model, brake module
- Setpoint channel:

  Reference values, application limits, speed-ramp sensor
- Open-loop/closed-loop control:

  Control type, controller settings, speed controller, current controller
- Messages/monitoring

  Motor (thermal motor model), intermediate circuit voltage, braking resistor (load), power end stage (load)

7.1.2 Drive parameters

Parameter tooltips

In STEP 7 engineering of the TM Drive, all displayed drive parameters are linked with tooltips. You will find detailed information on the parameter in the tooltips, e.g. parameter name, properties, factory setting, value range, descriptions, notes and dependencies.

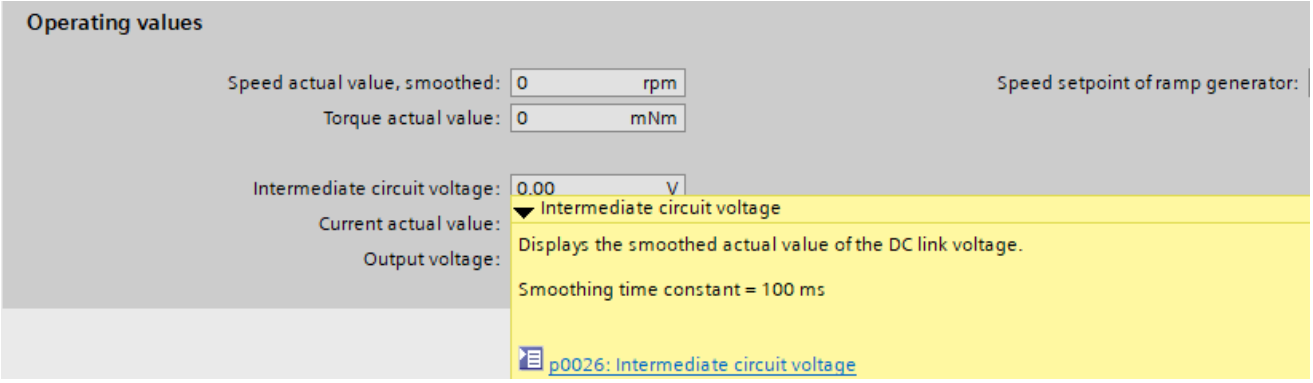

Figure 2-1613 Intermediate circuit voltage tooltip

Changing a parameter

You can directly change the values of the writable adjustable parameters (p-parameters) in STEP 7.

You have the following options for this:

- You overwrite the current parameter value with the new value.

  Or
- You select a value via the drop-down list.

Invalid values are rejected.

NOTE

P-parameters cannot be changed online while the drive is in operation. In this case, the corresponding entry field is automatically disabled.

The following overview shows the display of an entry field, depending on the context and the properties of the drive parameter:

1,0000 Nm	Project (offline)	Parameter value can be changed and stored in the project.
48,0 V	Project (offline)	The parameter value is write-protected.
24,0 V	Project (online)	Parameter value is write-protected or disabled due to the drive status.

Parameter symbols and operator controls

The following overview explains additional symbols and operator controls in the TM Drive engineering:

0,00 1/min	Drive value (online) could not be determined
	Bit parameter active (1-signal)
	Bit parameter inactive (0-signal)

Loading drive parameters

You can synchronize all p-parameter values of your project (offline) using the "Download to device" function.

Conditions

- When you load parameters into the device, a rotating drive automatically stops.
- After the parameters are loaded, the drive does not restart automatically. You must activate the drive once again using a new drive command.
- If you send an invalid parameter to the TM Drive, the module remains in parameter assignment mode. The drive cannot be activated until valid parameters are loaded.

"Download to device" function for drive parameters

You can use the "Download to device" function to transfer parameter values from your project (offline) to the drive (online).

Procedure

1. Select the drive in the project tree.
2. Click on "Download to device" in the menu bar.

Or

1. Select "Download to device" > "Software" in the shortcut menu.

You have transferred the current parameter values of your project to the drive.

7.1.3 Calling help information

To obtain information on parameters and alarms (messages) of the drive, open the information system via "Help" > "Show help" and search for the article number of the product.

You can also directly open the information system for a parameter or a message. To do so, click the online help link in the tooltip of a parameter or message.

7.2 Requirements for the commissioning

Requirements

- The TM Drive was installed according to the information in the following sections:
  - Wiring (Page 28)
  - Configuring (Page 57)
- The motor is installed in the drive train to be operated in accordance with the plant/device construction planning.

NOTE

Additional information concerning the requirements

You can find additional information relating to technology objects and motion control in the online help of STEP 7 under "Using technology functions" > "Motion Control".

Before powering on for the first time

Before the first power-on, check the installation and the wiring of the TM Drive.

Questions for the check

The following questions provide guidance for checking your TM Drive in the form of a checklist.

Racks

- Is the mounting rail securely mounted to the wall, in the frame or in the cabinet?
- Are the cable ducts correctly installed?
- Have the minimum clearances been observed?

Grounding and chassis concept

- Is the mounting rail connected to the protective conductor?
- Is the connection between the ground reference and ground properly established for the mounting rail?
- Has the shielding of the motor/encoder cable been applied over a large area on the device and on the motor/encoder?
- Are the required equipotential bonding cables connected with low impedance to the affected plant units?
- Are the grounding terminals correctly attached and is the motor/encoder cable correctly connected?

Module installation and wiring

- Is the TM StepDrive plugged in / installed and firmly connected or screwed according to the assembly plan and configuration with STEP 7?
- Are all connectors wired according to the circuit diagram?
- Is the PROFINET connection to the CPU and the engineering system of the STEP 7 (TIA Portal) connected?
- Is the input for Hardware STO (STO+/STO-) connected?
- Are the cables (motor connection cable, encoder cable) properly connected between the TM Drive and the motor and installed according to the guidelines?
- Is the optional digital input connected?
- Are the cables from the hardware STO (STO+/STO-) separated from the other cables, in particular from power cables?
- Have you minimized crushing hazards and short-circuits against ground connections by appropriate routing?
- Are the cables fully protected against premature aging due to continuous UV radiation?

Power supply

- Are all power supplies switched off?
- Is the power cable connector correctly wired?
- Has the connection to line voltage been made?

7.3 Procedure for commissioning the ET 200SP TM Drive

Procedure for commissioning with STEP 7

Commissioning is performed according to the steps listed below. The individual commissioning steps are optional and are to be performed as required. We recommend the following procedure for the first commissioning of a TM Drive .

Table 2-2103 Commissioning procedure

Step	Procedure	Comments	See section ...
1	Configure drive data record	Use one of the following options in the "Configure drive data record" dialog under "Parameters > Drive": • Select pre-configured drive data record from list • Custom edit drive data record	Drive data sets (Page 67)
2	Define setpoint channel	Under "Setpoint channel" you configure the following: • Reference values • Application limits • Ramp generator	Setpoint channel (Page 74)
3	Set control/closed-loop control	Have the controller parameters automatically calculated using the "Speed/current controller settings" comfort function.	Controller settings (Page 79)
4	Configure intermediate circuit voltage monitoring and optionally the brake control module	• Define limits for the intermediate circuit voltage • Motor holding brake settings	Intermediate circuit voltage
5	Configure messages/monitoring	• Define warning thresholds for thermal monitoring	Messages/monitoring (Page 87)

See also

Intermediate circuit voltage (Page 83)

7.4 Drive data sets

Introduction

It is possible to connect motors from third-party motor manufacturers, provided that they meet the required conditions regarding motor, encoder system, connection technology, electrical safety, EMC etc., as described in this manual.

With the F-TM StepDrive ST, this also includes stepper motors which can be connected in a bipolar manner and which meet the boundary conditions explained in this manual.

Drive data record

The motor or drive of the TM Drive drive system is configured using a drive data set (DDS). A drive data record contains the settings and information for the following drive components:

- Motor
- Motor gear
- Thermal motor model

NOTE

The description "drive" means the combination of motor, encoder and additional built-on accessories such as a gearbox and holding brake.

Motor

You can find the settings for the motor in the "Parameters" > "Drive" > "Motor" area.

The TM Drive drive system supports stepper motors. You specify important basic data and reference data of the motor.

Observe the information and notes in the help or in the tooltips of the individual parameters.

You can also find detailed information and descriptions for the drive parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

Motor encoder

The motor encoder is used for the closed-loop speed control of the drive. The encoder values are transferred to the CPU in the PROFIdrive telegram of the TM Drive, independent of the encoder type.

The following combinations are available:

Motor type: Stepper motor

- (0) No encoder / calculated
- (1) Incremental encoder (A, B, Z track)

(0) No encoder / calculated

The setting (0) encoderless / calculated is only supported in connection with a stepper motor. In this case, the rotor position is calculated and transferred to the control depending on the steps per revolution (p0408) or the steps per revolution (p0409).

(1) Incremental encoder (A, B, Z track)

When selecting the encoder type (1) incremental encoder, a 3-channel encoder with Z-track (often also referred to as I-track) can be connected.

Thermal model

The motor can be protected from thermal overload. Take section Messages/monitoring (Page 87) into consideration for this.

You define the thermal properties of the motor in the "Parameters" > "Drive" > "Thermal model" area.

7.4.1 Using the drive data set

To configure a drive, you have the following options:

- Create a user-defined drive data record and configure your motor manually.

NOTE

In the TM Drive engineering, the drive parameters can only be edited in the "Parameters" > "Drive" area if you are using a user-defined drive data set.

NOTICE

After a change of the drive data record, you must adapt or optimize the parameters for the current and speed controllers, if necessary.

See section Controller settings (Page 79).

7.4.2 Using a user-defined drive data set

Create a user-defined drive data record and configure your motor manually.

You can also use this function to edit an existing drive data record.

⚠ WARNING

Avoiding incorrect parameter assignments

Note that incorrect or modified parameter assignments can result in drive malfunctions and damage to the drive.

Procedure

To freely configure the current drive data, follow these steps:

1. Open "Parameters" > "Drive" in the context of the drive.
2. Start the configuration wizard with the "Configure drive data record..." button in the "Drive data record" area.
3. Select the "Edit drive data record by user" option.
4. Accept the configuration with "Yes".

5. Confirm that you are changing the drive data record.
6. Adjust the motor settings for your drive.

   Observe the information and notes in the help or in the tooltips of the individual parameters.

   You can also find detailed information and descriptions for the drive parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

You have selected user-defined editing of the drive and adapted the settings.

See also

Motor (Page 88)

7.4.3 Drive parameters stepper motor

Parameter number	Name	Description	Unit
Motor			
p0300	Motor type	Selection of the motor type	
p0305	Nominal current	Nominal current per coil in full step mode.	A
p0312	Hold torque	Hold torque of the stepper motor in full step mode and nominal current.	Nm
p0322	Maximum speed	Maximum speed is the mechanically permissible speed of the machine. If the speed is exceeded, the motor may be damaged.	rpm
p0372	Connection resistance	Connection resistance of a phase	Ohm
p0376	Connection inductance	Connection inductance one phase	mH
p0341	Rotor moment of inertia	The rotor moment of inertia is the mass moment of inertia of the rotor with the connecting shaft.	kgcm²
P30000	Step angle	Step angle of the stepper motor in full step mode.	-
P30001	Number of steps	The number of steps indicates the number of steps per mechanical revolution in full step mode. The value cannot be edited and is calculated from the step angle. Number of steps = 360° / step angle	-
P30014	Number of pole pairs	The number of pole pairs indicates the number of pole pairs in the motor. The value cannot be edited and is calculated from the step angle. Number of pole pairs = step angle / 4.	-
Motor gear			
P2725	Motor gear moment of inertia	Sets the motor gear moment of inertia in relation to the motor axis.	kgcm²
Thermal model			
p0611[1]	Time constant wind-	Setting of the thermal time constant between	s

Parameter number	Name	Description	Unit
	ing - environment	the winding and the environment. In nominal operation (nominal load and the ambient temperatures and installation elevation specified by the manufacturer) the limit temperature of the motor is reached after five times the time constant. Note: If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. See 7.7.1 Thermal motor monitoring	
Motor connection			
p0352	Motor cable line resistance	Input of the motor cable resistance value for outgoing and return conductor.	Ohm
p0353	Motor series inductance (=motor cable inductance)	Input of the line inductance of the outgoing and return conductor. The value can be neglected for motor connection cables < 10 m. If a series reactor is also connected between the motor and the inverter, you need to enter the inductance value as an additive to the line inductance.	mH

7.4.4 Motor encoder

Under Encoder type configuration, select the appropriate encoder type for the motor.

Encoder type configuration			
p0404	Motor encoder selection	Selection of the motor encoder	-

7.4.4.1 Encoder parameters incremental encoder and encoderless / calculated

The encoder types incremental encoder and encoderless / calculated use the same settings.

Parameter number	Name	Description	Unit
p0408	Increments per revolution	Setting of the increments per revolution or the pulses per revolution (PPR) of the motor encoder.	-
p0409	Steps per revolution	Display of the steps per revolution or counts per revolution (CPR) of the encoder. The value cannot be edited, results from the quadrature interface and is four times the value of increments per revolution (p0408).	-

Incremental encoder

With the incremental encoder, the increments per revolution must be set.

Encoderless / calculated

With the setting encoderless / calculated, the motor is moved at low speeds in the set encoder resolution steps p0408 or p0409. The encoder resolution must be at least 4 times or a multiple of the number of pole pairs of the motor. If the values are too high, the positioning accuracy can fluctuate depending on the motor quality (ripple).

Encoderless / calculated with stepper motor

With the setting encoderless / calculated with stepper motor, the motor moves at low speeds in the set encoder resolution steps p0408 or p0409. The encoder resolution (increments per revolution (p0408)) must be at least 4 times or a multiple of the number of pole pairs of the motor. If the values are too high, the positioning accuracy can fluctuate depending on the motor quality (ripple).

It is recommended to set every integer multiple of the motor full step angle (p30001); a step division into partial steps (1/2, ¼, 1/8 ...) is not necessary but can improve the positioning accuracy, especially with multi-pole stepper motors. The following table shows how the corresponding step subdivisions are determined for this.

Table 2-2104 Determination of the step subdivisions

Step resolution	**Steps per revolution (p0409)**	**Increments per revolution (p0408)**	**Example: Step angle = 1.8 °; Number of steps = 200; Number of pole pairs = 50**	
			Steps per revolution (p0409)	**Increments per revolution (p0408)**
Full step	1 x number of steps (p30001)	1/4 x number of steps (p30001)	200	50
½ Half step	2 x number of steps (p30001)	2/4 x number of steps (p30001)	400	100
¼ quarter step	4 x number of steps (p30001)	4/4 x number of steps (p30001)	800	200
1/8 eighth step	8 x number of steps (p30001)	8/4 x number of steps (p30001)	1600	400
.	.	.	.	.
1/64 sixty-fourth of a step	64 x number of steps (p30001)	64/4 x number of steps (p30001)	12800	3200

7.4.4.2 Assign encoder counting direction parameters

With encoder type (1) incremental encoder, it may be necessary to invert the counting direction of the encoder by setting the Swap encoder counting direction parameter p0410. With incremental encoders, this may be necessary, for example, if the A and B tracks were swapped when the encoder was connected.

The following is defined as the positive direction of rotation of the encoder.

Incremental encoder:

The positive direction of rotation for an incremental encoder is defined as follows:

If the positive A edge comes before the positive B edge in terms of time, the motor with a view of the motor shaft rotates clockwise in the positive direction of rotation.

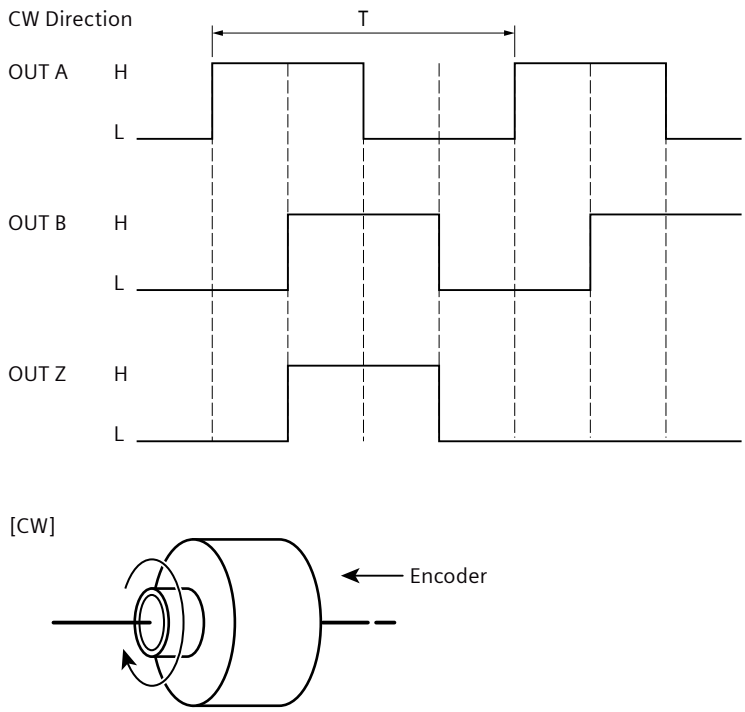

Figure 2-1614 Direction of rotation for the incremental encoder

Table 2-2105 **Encoder values**

Parameter number	Name	Description	Unit
p0410	Swap encoder counting direction	This setting negates the counting direction of the encoder.	-

7.5 Setpoint channel

Overview

Setpoints from the respective setpoint source are prepared for the motor control in the setpoint channel of the drive.

You specify the setpoints via the drive telegrams to PROFIdrive.

You can find the settings for the setpoint channel in the context of the drive under "Parameters" > "Setpoint channel".

Under "Setpoint channel" you configure the following:

- Reference values (Page 75)
- Application limits (Page 75)
- Ramp generator (Page 78)

The figure below shows the processing of the speed setpoint in the drive controller.

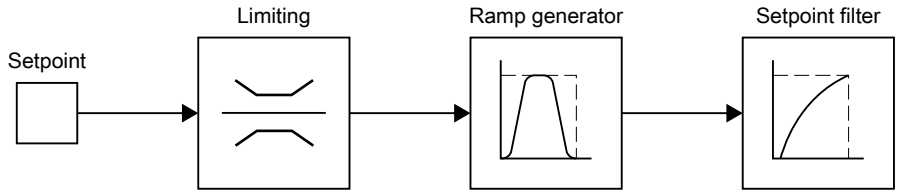

Figure 2-1615 Setpoint channel

The speed setpoint from the drive telegram is limited in the setpoint channel according to the specified values, see section Reference values (Page 75).

The limited speed setpoint is fed to the ramp generator as an input signal, see section Application limits (Page 75).

The output of the ramp generator is fed to the speed controller via the speed setpoint filter, see section Ramp generator (Page 78).

7.5.1 Reference values

The physical variable speed is transmitted in the drive telegrams as a reference values.

- Speeds are normalized to the reference speed (p2000) in the drive telegram.

Here, p2000 is decisive as the reference value (telegram content = 4000 hex or 4000 0000 hex for double words if the input variable has the value p2000).

Example of the normalization of the speed:

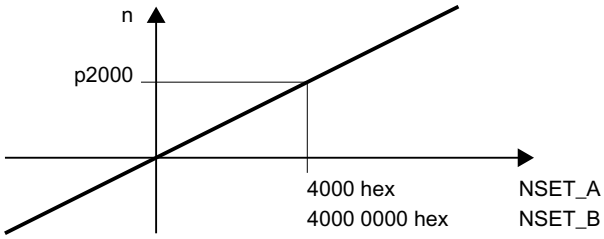

Figure 2-1616 Example of normalization of the speed

NOTE

The speed and torque are specified in the drive telegram as a percentage of the reference speed in the range -200% to 200%.

Therefore, set the reference variables in such a way that the desired maximum value falls within the value range of the control from -200% to +200%.

Procedure

1. Configure the reference value in the context of the drive under:

   "Parameters" > "Setpoint channel" > "Reference values".

WARNING

Uncontrolled drive behavior

Note that the specification of reference values in the CPU and the drive must always match. Otherwise, uncontrolled drive behavior and rotating of the motor might occur. We therefore recommend that commissioning of the drive and thus specification of the references values be completed first before you commission the CPU and, for example, a technology object.

7.5.2 Application limits

In the "Parameters" > "Setpoint channel" > "Application values" area, you can configure limitations for the speed and torque of the drive if required and adapt them to the requirements of your mechanical system.

Speed limiting

If you need a direction-dependent speed limiting, you can define speed limits for each direction.

Torque limiting

You can specify the torque limiting as an absolute value. The limiting acts both when motoring as well as generating.

WARNING

Accuracy of torque limitation

The function of the torque limitation is not safe torque limiting in the sense of functional safety. The torque limitation refers to the calculated internal (air gap) torque of the motor.

The internal torque is a calculated value from the internal motor constant and motor current. The torque output at the shaft is the internal torque minus friction and iron losses.

Due to the following influencing factors, the deviation of the torque calculation can be in the two-digit percentage range:

- Motor parameters
- Current measurement accuracy
- Temperature dependence
- Speed and load dependence on friction, iron and additional losses of the motor

WARNING

Danger to life due to uncontrolled movement of the drive as a result of incorrect parameter assignment

Incorrect parameterization of the torque limiting can result in uncontrolled movement of the drives if there is no counter-torque, and cause death or serious injury.

Ensure the correct parameterization.

Standstill detection

Set the speed threshold for the motor standstill detection (p1226). For braking with OFF1 or OFF3, the zero speed is detected when this threshold is fallen below.

NOTE

A zero point calibration is only started if the speed falls below the speed threshold for standstill detection (p1226).

NOTE

A switch-on process of the drive via STW1 is always delayed until the speed has fallen below the speed threshold for standstill detection (p1226).

As long as the speed is still above this speed threshold, warning 2007 is issued. This can be the case, for example, if the motor shaft is driven externally.

If the switch-on command is still set despite this warning, the drive is switched on and the specified setpoint speed is adopted as soon as the speed threshold for standstill detection has been undershot.

Speed threshold values for message

Also specify the speed threshold values for the following messages of the drive status word:

- "Speed threshold 1" (p2141)

  If the speed exceeds the threshold value, bit 10 is set as feedback in ZSW 1
- "Speed threshold 4" (p2163)

  As long as the speed deviation lies within the tolerance range, bit 8 in ZSW1 is set as feedback
- "On delay time" (p2167)

  Setting the switch-on delay time for the message "Speed setpoint/actual deviation within tolerance" (see also p2163)

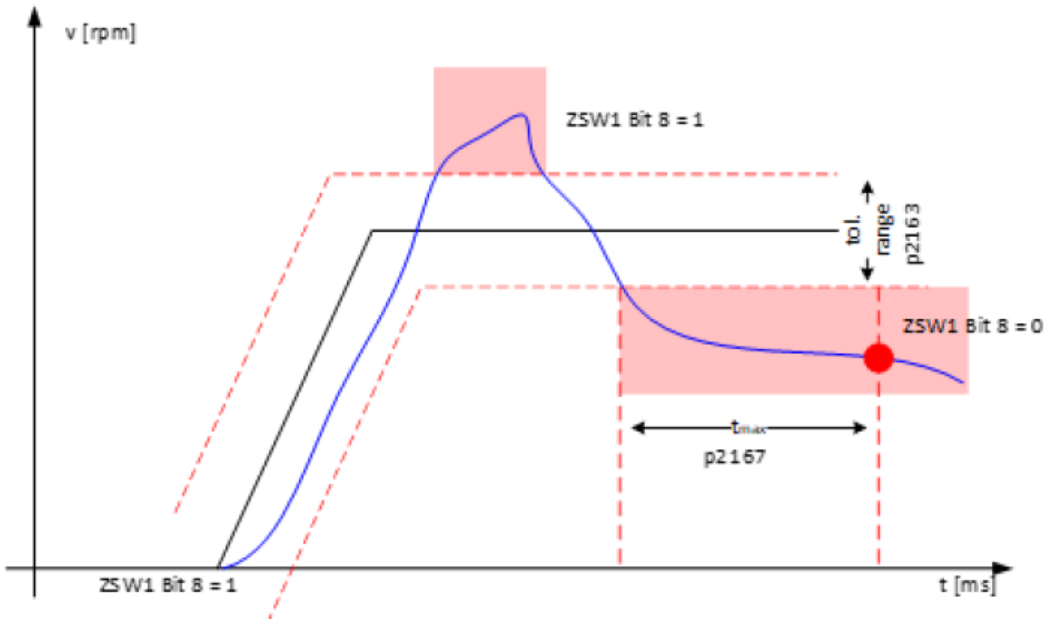

Figure 2-1617 Sets the ON-delay time (p2167) and the speed threshold value 4 (p2163)

End stop detection and step loss detection with the stepper motor

If an incremental encoder and the control type [103] controlled (I = const.) are used with a stepper motor, end stop detection or step loss detection can be implemented using bit 8 in the ZSW1. The "speed threshold value 4" parameters (p2163) and the "On delay" (p2167) can be used to set the detection tolerance range.

7.5.3 Ramp generator

The TM Drive uses the speed ramp generator type "Basic ramp-function generator" p1115[0].

Speed ramp generator

The speed ramp generator is used to limit the acceleration at sudden setpoint changes and helps to prevent drive train shock loads.

An acceleration ramp and a deceleration ramp can be set independently with the ramp-up time and ramp-down time. This enables a controlled transition at setpoint changes.

The reference value for calculating the ramps from the ramp-up and ramp-down times of the speed ramp generator is the speed specified in the "Speed" dialog box.

NOTE

On principle, the ramp-up and ramp-down times of the ramp generator in the setpoint channel of the drive should be set only so fast that, in case of accelerations and decelerations, the motor speed can track the setpoint without damaging the machine. This ensures optimal functioning of the speed controller precontrol.

Especially with the control type [103] controlled (I = const.), the ramp-up and ramp-down times must not be set too steep, as otherwise the rotor cannot follow the controlled rotating field.

Procedure

You enter the settings for the speed ramp generator under "Parameters" > "Parameters" > "Ramp generator":

- Rampup time
- Ramp-down time
- Speed

NOTE

The TM Drive uses the three values entered to form the values relative to 10,000 rpm "Speed ramp generator ramp-up time" (p1120) and "Speed ramp generator ramp-down time" (p1121).

When using the GSD file, directly enter the values relative to 10,000 rpm.

7.6 Controller settings

Under "Parameters" > "Open-loop/closed-loop control", you specify the type of control, the general controller settings and the settings for speed and current controllers.

Control type

The open-loop / closed-loop control type can be selected depending on the motor type.

Motor type: Stepper motor

- [103] Controlled (I = constant)

7.6.1 Controlled (I = const.)

General controller settings

In the controlled control mode (I = const.), the speed is controlled by an angle adjuster. Depending on the respective speed, the control angle of the motor is switched faster or slower in quantified steps in the desired direction of rotation.

Speed controller

It is advisable to specify speed changes along an up and down ramp, as otherwise the drive is not able to follow the specified speed.

The internal ramp-function generator (section 7.5.3) can be used as speed ramp.

Current controller

With the control mode controlled (I = const.), the current controller applies a constant current value to the motor. The motor current is specified using two current values for travel mode (p1738 run current) and standstill mode (p1739 stop current). The current values are effective values.

- Run current p1738
- Stop current p1739

The stop current is impressed on the motor while it is at a standstill and ensures a corresponding holding torque. If a speed not equal to 0 1/min is specified, the current setpoint is switched from stop current to run current. If the motor comes to a standstill from a movement, the setpoint current is switched from run current to stop current after 1 s.

In many applications, the stop current can be reduced during standstill. As a result, energy can be saved during the stop phases and the motor is subjected to less thermal stress.

For reasons of protection, the run and stop current may not be greater than 1.5 times the rated motor current (p0305).

NOTE

With the closed-loop control mode (I = const.), no distinction is made between the magnetic longitudinal inductance (for Id) and transverse inductance (for Iq) of the motor. There are therefore only current controller values for the total current.

Enter the general controller settings under "Parameters" > "Control/closed-loop control" > "Controller settings".

- Moment of inertia load p1398
- Speed setpoint filter p1416

Additional important settings

The speed and current controllers can be determined in the best possible way if, in addition to the properties of the electric motor, you also specify the properties of the gearbox and the connecting cable.

- Motor cable line resistance p0352
- Motor cable/series inductance p0353
- Motor gear moment of inertia p2725

Current controller

You can either set the current controller manually or have the controller settings calculated by STEP 7.

Having controller settings calculated

To have the controller settings of STEP 7 calculated, proceed as follows:

1. Click on the "Calculate current controller settings" button in the Controller settings area. The "Controller calculation" window opens. The window displays the appropriate controller parameters.
2. Apply the controller settings by clicking the "Apply" button.

You can then continue to change the calculated controller settings manually.

Setting the controller settings manually

Enter the settings for the current controller under "Parameters" > "Control/closed-loop control" > "Current controller".

- Proportional gain
- Integral action time

NOTE

If you manually set the controller parameters to inappropriate values, the drive system can be damaged.

Make changes to the controller settings in small steps. Keep checking the behavior of the drive system until you have found a satisfactory setting.

7.6.2 OFF responses

OFF1 (Switch off)

By resetting bit 0 in STW1 (On), you activate OFF1 and the drive is braked to 0 in a speed-controlled manner according to the ramp generator ramp-down (p1120, p1121). If the actual speed falls below the value of the "Standstill detection" parameter (p1226) or if a timeout is detected, the pulses are blocked after the motor brake closing time p1217 has expired. "Switching on inhibited" is activated.

Timeout

With OFF1, the time is calculated in which the drive should normally stop from twice the reference speed. If the drive does not stop within 2 times of this time, the drive is de-energized and it coasts down.

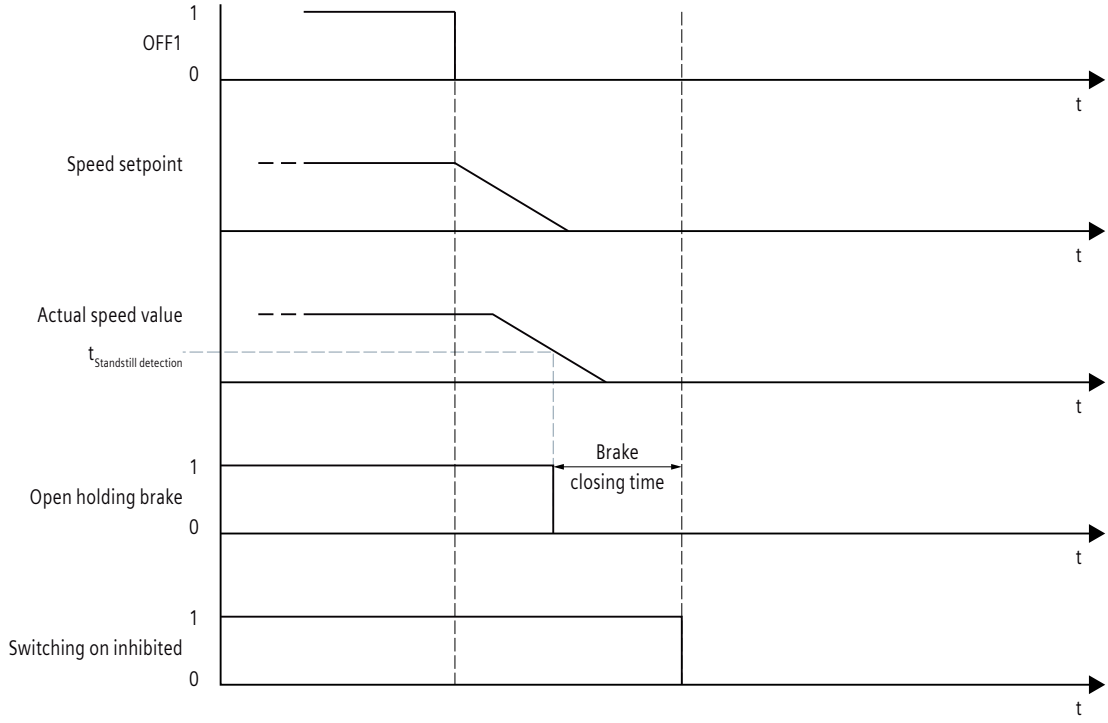

Figure 2-1618 OFF1 sequence diagram

OFF2 (Coast down)

You activate OFF2 by resetting bit 1 in STW1 (NoCoastStop). The pulses are immediately canceled, any parameterized motor holding brake is applied and the drive coasts down. "Switching on inhibited" is activated.

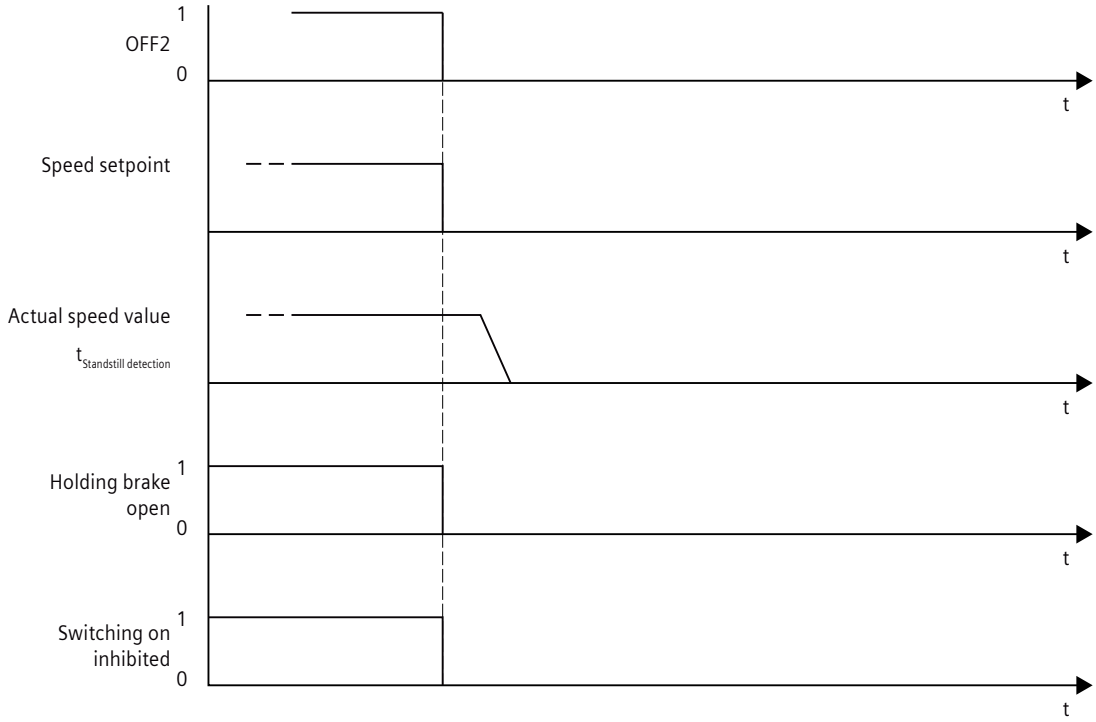

Figure 2-1619 OFF2 sequence diagram

OFF3 (QuickStop)

You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp generator"). After the standstill is detected or the monitoring time has elapsed, any configured motor holding brake is closed and the pulses are deleted after the motor holding brake closing time p1217 has expired. "Switching on inhibited" is activated.

NOTE

NOTE on rapid stop (OFF3)

You trigger a quick stop (OFF3) by resetting bit 2 in STW1 (NoQuickStop). The rapid stop takes into account the ramp-down time configured in the HSP ("Parameter" > "Setpoint channel" > "Speed – Ramp generator"). The rapid stop is monitored for time and causes the motor to be energized after 6 seconds at the latest.

Timeout

The rapid stop is monitored for time and causes the motor to be energized after 6 seconds at the latest.

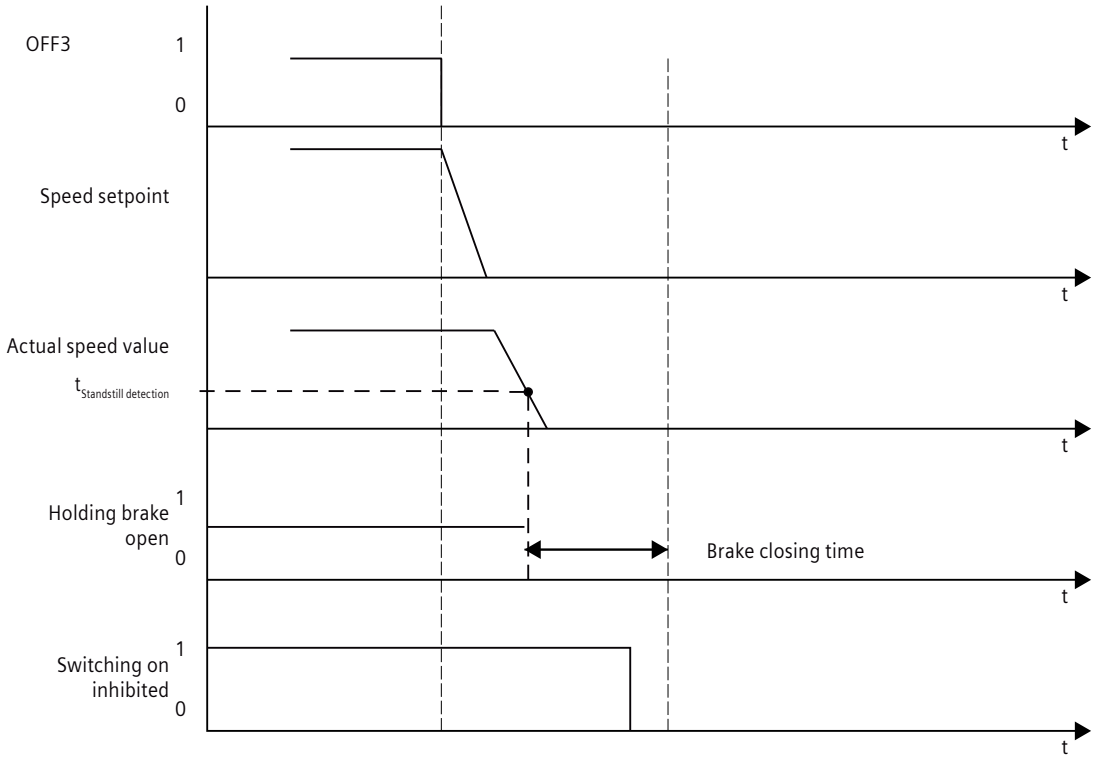

Figure 2-1620 OFF3 sequence diagram

Prioritization

The OFF responses are prioritized as follows:

- OFF2 (coast down) > OFF1 (switch off)
- OFF3 (QuickStop) > OFF1 (Switch off)

7.7 Intermediate circuit voltage

The TM Drive system cyclically monitors the intermediate circuit voltage. The limit values can be set under "Alarms/Monitoring".

The following options can be selected under "Intermediate circuit voltage":

- Minimum value of the intermediate circuit voltage (p0390)
- Maximum value of the intermediate circuit voltage (p0391)

If the limit values are exceeded or not reached, the motor control is switched off. If a intermediate circuit voltage close to the limit values is detected, a corresponding warning is issued.

7.8 Brake module

The drive system TM Drive can externally control a motor holding brake via the process image using a DQ or relay module.

The following options for the stepper motor type can be selected under "Brake module":

- [0] No function
- [4] Motor holding brake externally via the process image

If stepper motors are selected, the brake chopper function cannot be used. Should a brake chopper nevertheless be required, you can install another TM Drive module with brake chopper functionality in the same potential group and connect the brake resistor there and parameterize the brake chopper.

7.8.1 External motor holding brake

The motor holding brake can be used when the drive system is disabled (e.g. when the power supply to the drive system is switched off) to prevent unwanted movements of the suspended load (e.g. falling due to gravity). The motor can move by its own weight or an external force even if the motor power supply is interrupted.

NOTE

- Use this brake only for "holding", which means to maintain the standstill. Do not use it for "braking", which means to stop the moving load. Use the holding brake only to hold a motor at a standstill.
- The holding brake is enabled when the motor is switched off.

If the motor holding brake function is enabled, you must configure the following settings in the area "Parameters" > "Drive" > "Brake module".

Adjust the opening and closing times of the motor holding brake:

- Motor holding brake opening time (p1216)
- Motor holding brake closing time (p1217)

For the closing and opening times, delay times of relays may have to be taken into account and added to the times of the motor holding brake.

p1216 = motor brake opening time + relay opening time

p1217 = motor brake closing time + relay closing time

If the motor holding brake is parameterized, the drive takes the delay times into account and accordingly sets bit 12 in the process image ZSW1. This bit can be used to control a motor holding brake, for example with a DQ module or relay module.

RC circuit of a TM Drive with DQ module and motor holding brake

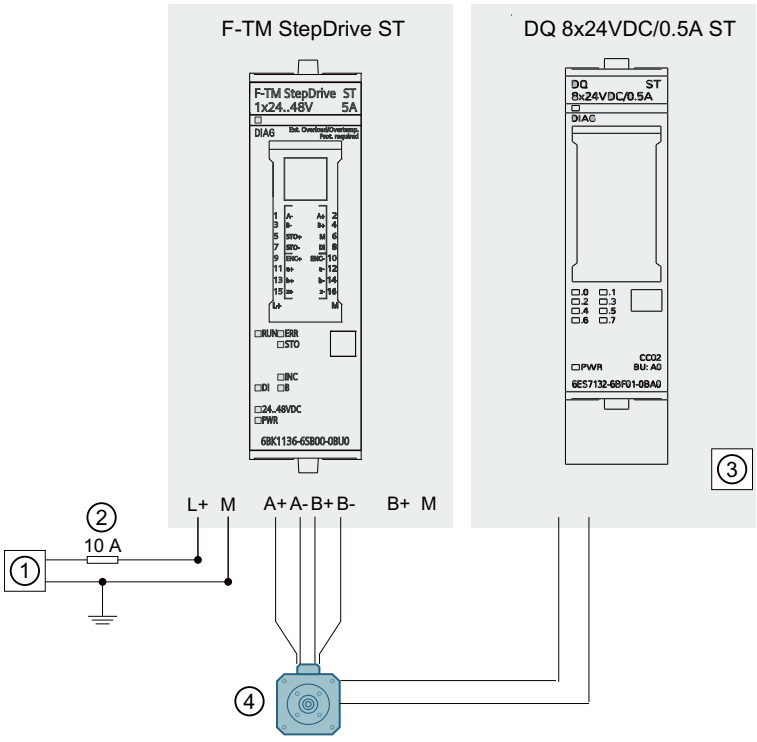

① Power supply unit

② Protective device

③ DQ module

④ Motor with holding brake

Figure 2-1621 RC circuit of a TM Drive with DQ module and motor holding brake

Braking sequence

The sequence diagram shows an example of the behavior of the drive with OFF1.

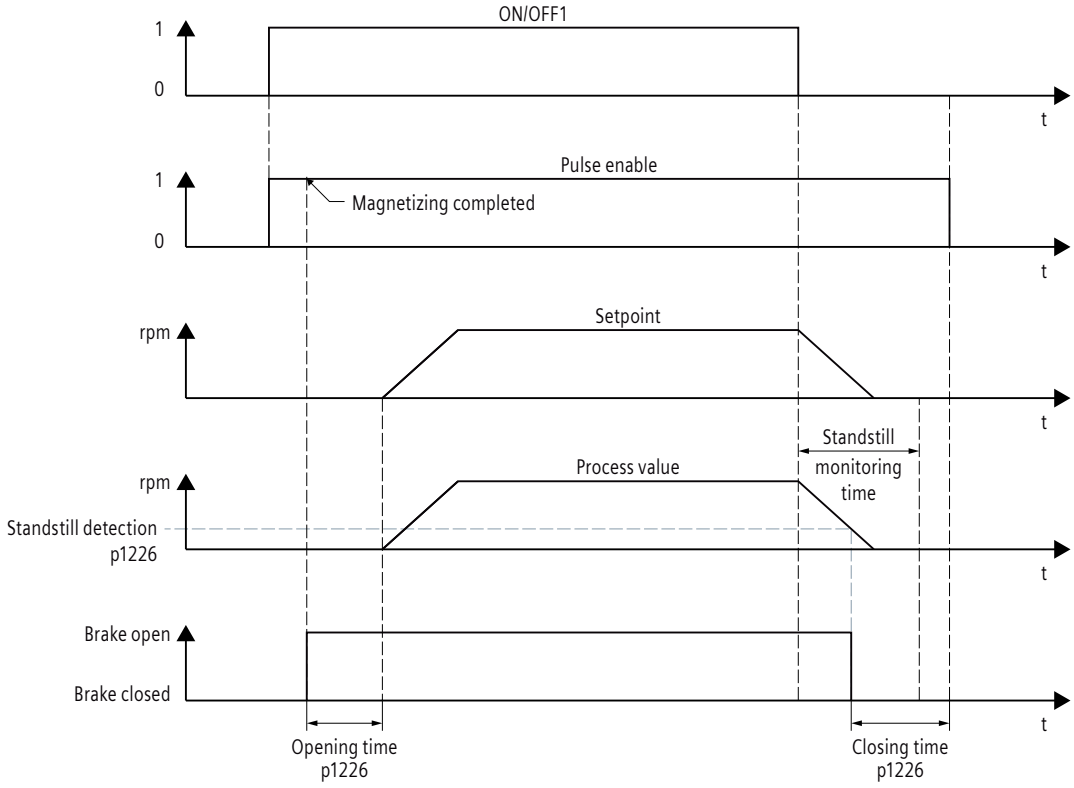

Figure 2-1622 Braking sequence

The magnetizing time is calculated automatically depending on the motor parameters.

The influence of the motor holding brake on the OFF reactions is described in section 7.6.4 (Page 81) OFF reaction.

NOTICE
Improper use Improper use of the motor brake will shorten its service life. The motor brake is only intended for holding purposes. Frequent emergency stops with the motor brake shorten its service life. Unless absolutely necessary, do not use the motor brake as emergency stop.

7.9 Messages/monitoring

Thermal monitoring

The purpose of thermal monitoring is to detect critical states. Parameterizable warning thresholds are available that allow further operation of the drive (e.g. with reduced power) and prevent an immediate shutdown. However, the parameter assignment options are only interventions below the shutdown thresholds.

The following thermal monitoring options are available:

- Motor
  - Motor I^2t model
- Power end stage
  - Overload protection
  - Temperature sensor

When an overload is detected by one of these monitoring functions, a warning is output first. The respective warning thresholds (p0291) are parameterizable. The current status of the monitoring functions is displayed. If an alarm or fault limit is exceeded, the "Temperature monitoring" message is sent.

NOTE

All alarm and fault limits are provided with a corresponding hysteresis. The corresponding alarm or fault messages therefore remain until the threshold including hysteresis has been fallen below.

NOTE

Motor monitoring

The thermal motor resistance utilization is a calculated value. The values are not saved.

After a power reset, the values only match again after a sufficiently long cooling time.

Operating temperature

Note that the specified ambient temperature range for the drive must always be adhered to, see section Technical specifications (Page 110).

7.9.1 Motor

Thermal motor monitoring

The thermal motor monitoring is performed using a configurable I^2t temperature model.

WARNING

Thermal motor utilization cannot be immediately determined after initialization

The thermal model is reinitialized after changing the drive data record and when switching on the device.

After initialization, the thermal motor utilization cannot be immediately determined as the model must first settle. As a consequence, an initial utilization of 50 % is used as basis. The settling phase duration depends on the given thermal time constants; the accuracy depends on to what extent the specific installation situation deviates from the model.

During the settling time it is possible that the set alarm and/or fault threshold is reached with some delay. For the installation situation simulated in the model, a comparatively unfavorable installation was selected so that generally deviations occur on the safe side.

You can define the warning threshold under Parameters > Messages/monitoring > Motor relative to the respective shutdown threshold.

Procedure

1. Open the "Motor" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Motor I^2t model

The I^2t monitoring operates with the relative motor power loss, and in addition to the nominal motor current (p0305) as reference value, only requires the thermal time constant winding - environment (p0611[0]) to calculate the limiting integral. The 100 % shutdown threshold corresponds to the maximum continuous power loss of the motor, i.e. to the square of the nominal motor current (p0305).

WARNING

Compliance with the ambient conditions specified by the motor manufacturer

The motor may only be operated in ambient conditions such as ambient temperature, installation elevation, etc. as specified by the manufacturer.

If the ambient conditions of the motor do not correspond to the values specified by the manufacturer, the motor must be derated. The derating behavior and the resulting lower motor performance data must be obtained from the motor manufacturer and adjusted accordingly in the motor parameters of the TM Drive.

If the motor is used outside its specification, the thermal model does not provide sufficient protection.

7.9.2 Power end stage

Thermal monitoring of power end stage

The power end stage is monitored with a temperature sensor. You can specify the warning threshold (p0291[1]) relative to the shutdown threshold "System maximum temperature power end stage".

Procedure

1. Open the "Power end stage" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the warning threshold p0291[1].

Besides the temperature monitoring, the current load is also monitored. The current load of the power unit is decisive for the temperature rise. The relative load of the power end stage is calculated based on the square of the output current according to the I^2t method.

Automatic overload limiting

The TM Drive is overload-capable. The load of the power end stage is automatically limited by the drive.

The maximum overload time $t_{overload}$ is calculated depending on the temperature of the power end stage T_{PU}. When operating with cyclic overload, the rated power is not exceeded the by the time-averaged power (rms).

Stepper motor

With a stepper motor, a double overload of the rated current I_{-n} cyclic for a duration of $t_{overload}$ = 3 s with a subsequent recovery time of 17 s at T_{PU} = 20 °C is possible. At T_{PU} = 80 °C, the overload time $t_{overload}$ ≈ 0.75 s.

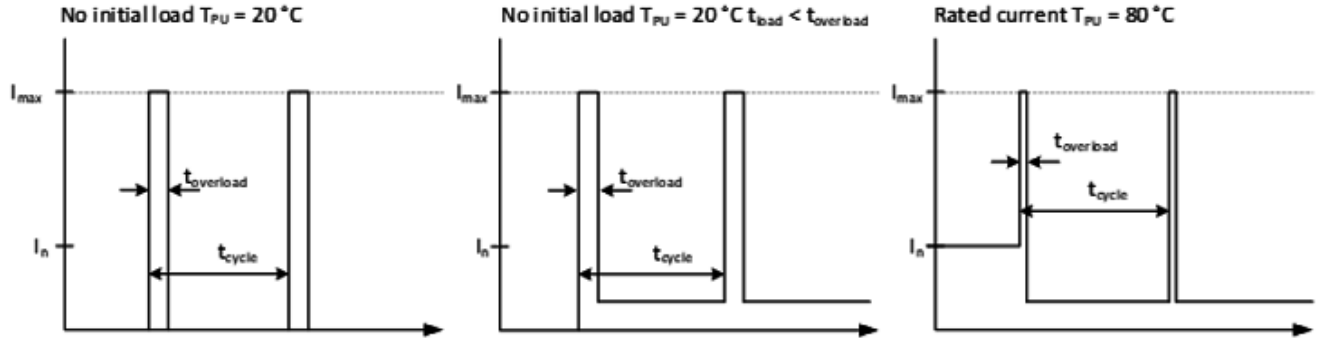

Figure 2-1623 Overload behavior of TM Drive

Note the information on derating as a function of environmental conditions (e.g. temperature, mounting position) in section Derating of the ET 200SP TM Drive (Page 114).

NOTE

Overload capability of the power unit

Operation with a peak current of 10 A is possible temporarily if the average RMS value of the output current does not exceed the rated current of the power unit up to 5 A.

7.9.3 Intermediate circuit voltage

Monitoring of the intermediate circuit voltage

The energy recovery in the power supply cannot be suppressed. Energy is fed back when the drive brakes and the braking chopper is not connected and configured. The energy recovery results in an increase of the intermediate circuit voltage.

You can set the limits for the intermediate circuit voltage within the permissible values.

If the limits are exceeded, the module switches off. Before the module is switched off, a warning (limit - 5%) indicates that the limit has almost been exceeded. The user is responsible for ensuring compliance with the permissible voltage limits.

Procedure

1. Open the "Intermediate circuit voltage" area in the context of the drive under "Parameters" > "Messages/monitoring".
2. Configure the minimum value (p0390) and the maximum value (p0391).

⚠ WARNING

Operation above the voltage setting range

Under the given application conditions, ensure that the motor is not operated above the voltage setting range by selecting the appropriate motor and gear unit. Otherwise, the intermediate voltage may increase when the control is inactive via 60 V DC.

Programming

8

TM Drive does not have its own control panel. A user program is required to control the motion sequences.

You have the following options for controlling the motion sequences in the user program:

- Control via the process image (Page 91)
- Control via the SINA_SPEED (Page 98) instruction
- Control with a technology object (Page 98)

8.1 Controlling TM Drive via the process image

Structure of the I/O addresses

The structure of the input addresses of the TM Drive depends on the configured communication telegram and the telegram extension.

The structure of the output addresses of the TM Drive depends on the configured communication telegram.

Standard telegram 1 Structure I/O addresses

Inputs

Bool	Data type	Offset
Status word 1	**Structure**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5

Bool	Data type	Offset
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_A	**Word**	**2.0**
Telegram extension word (only with telegram extension)	**Structure**	**4.0**
Reserved	Byte	4.0
Telegram extension STO_Status	Bool	5.0
Telegram extension DI_Status	Bool	5.1

Outputs

Element	Data type	Offset
Control word 1	**Structure**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_A	**Word**	**2.0**

Standard telegram 2 Structure I/O addresses

Inputs

Bool	Data type	Offset
Status word 1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2

Bool	Data type	Offset
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchOn	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word 2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Telegram extension word (only with telegram extension)	**Struct**	**8.0**
Reserved	Byte	8.0
Telegram extension STO_Status	Bool	9.0
Telegram extension DI_Status	Bool	9.1

Outputs

Element	Data type	Offset
Control word 1	**Struct**	**0.0**
Bit08_Reserved	Bool	0.0
Bit08_NoSpeedDeviation	Bool	0.1
Bit09_ControlRequested	Bool	0.2
Bit10_SpeedComparisonValueReachedExeed	Bool	0.3
Bit11_TorqueLimitNotReached	Bool	0.4
Bit12_OpenHoldingBrake	Bool	0.5
Bit13_NoMotorOvertemperature	Bool	0.6
Bit14_ActualSpeedPositive	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word 2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7

Standard telegram 3 Structure I/O addresses

Inputs

Bool	Data type	Offset
Status word 1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_ReadyToSwitchON	Bool	1.0
Bit01_ReadyToOperate	Bool	1.1
Bit02_OperationEnabled	Bool	1.2
Bit03_FaultPresent	Bool	1.3
Bit04_NoCoastStopActivation	Bool	1.4
Bit05_NoQuickStopActivated	Bool	1.5
Bit06_SwitchingOnInhibited	Bool	1.6
Bit07_AlarmPresent	Bool	1.7
Speed setpoint NACT_B	**DWord**	**2.0**
Status word 2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder status word 1	**Struct**	**8.0**

Bool	Data type	Offset
Bit08_Probe1Deflected	Bool	8.0
Bit09_Probe2Deflected	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_EncoderFaultAcknowlegdeActive	Bool	8.3
Bit12_HomePositionExecuted	Bool	8.4
Bit13_AbsoluteValueCyclicallyExecuted	Bool	8.5
Bit14_ReservedParkingSensorExecuted	Bool	8.6
Bit15_ParkingSensorExecuted	Bool	8.7
Bit00_Function1Active	Bool	9.0
Bit01_Function2Active	Bool	9.1
Bit02_Function3Active	Bool	9.2
Bit03_Function4Active	Bool	9.3
Bit04_Value1Available	Bool	9.4
Bit05_Value2Available	Bool	9.5
Bit06_Value3Available	Bool	9.6
Bit07_Value4Available	Bool	9.7
Actual encoder position value 1 (Gx_XIST1)	**DWord**	**10.0**
Actual encoder position value 2 (Gx_XIST2)	**DWord**	**14.0**
Telegram extension word (only with telegram extension)	**Struct**	**18.0**
Reserved	Byte	18.0
Telegram extension STO_Status	Bool	19.0
Telegram extension DI_Status	Bool	19.1

Outputs

Element	Data type	Offset
Control word 1	**Struct**	**0.0**
Bit08_NoSpeedDeviation	Bool	0.0
Bit09_ControlRequested	Bool	0.1
Bit10_SpeedComparisonValueReachedExeed	Bool	0.2
Bit11_TorqueLimitNotReached	Bool	0.3
Bit12_OpenHoldingBrake	Bool	0.4
Bit13_NoMotorOvertemperature	Bool	0.5
Bit14_ActualSpeedPositive	Bool	0.6
Bit15_NoPowerUnitOvertemperature	Bool	0.7
Bit00_On	Bool	1.0
Bit01_NoCoastStop	Bool	1.1
Bit02_NoQuickStop	Bool	1.2
Bit03_EnableOperation	Bool	1.3

Element	Data type	Offset
Bit04_EnableRampGenerator	Bool	1.4
Bit05_UnfreezeRampGenerator	Bool	1.5
Bit06_EnableSetpoint	Bool	1.6
Bit07_FaultAcknocklegde	Bool	1.7
Speed setpoint NSET_B	**DWord**	**2.0**
Control word 2	**Struct**	**6.0**
Bit08_Reserved	Bool	6.0
Bit09_Reserved	Bool	6.1
Bit10_Reserved	Bool	6.2
Bit11_Reserved	Bool	6.3
Bit12_Reserved	Bool	6.4
Bit13_Reserved	Bool	6.5
Bit14_Reserved	Bool	6.6
Bit15_Reserved	Bool	6.7
Bit00_Reserved	Bool	7.0
Bit01_Reserved	Bool	7.1
Bit02_Reserved	Bool	7.2
Bit03_Reserved	Bool	7.3
Bit04_Reserved	Bool	7.4
Bit05_Reserved	Bool	7.5
Bit06_Reserved	Bool	7.6
Bit07_Reserved	Bool	7.7
Encoder control word 1	**Struct**	**8.0**
Bit08_Reserved	Bool	8.0
Bit09_Reserved	Bool	8.1
Bit10_Reserved	Bool	8.2
Bit11_Reserved	Bool	8.3
Bit12_Reserved	Bool	8.4
Bit13_AbsoluteValueCyclically	Bool	8.5
Bit14_RequestParkingEncoder	Bool	8.6
Bit15_AcknowlegdeError	Bool	8.7
Bit00_Function1Request	Bool	9.0
Bit01_Function2Request	Bool	9.1
Bit02_Function3Request	Bool	9.2
Bit03_Function4Request	Bool	9.3
Bit04_Command0Request	Bool	9.4
Bit05_Command1Request	Bool	9.5
Bit06_Command2Request	Bool	9.6
Bit07_Mode	Bool	9.7

Basic procedure in STEP 7

1. In the project tree, create PLC data types in the CPU 2 with the appropriate structure for your configuration:
   - PLC data type for the structure of the input data (depending on PROFIdrive telegram type and telegram extension)
   - PLC data type for the structure of the output data (depending on PROFIdrive telegram type and telegram extension)
2. Create a tag from each type of the PLC data type in a tag table.
3. Assign the addresses for the tag according to the configured I/O addresses of the TM Drive.
4. Control the TM Drive by setting outputs bit-by-bit. A description of how to set the outputs to control the TM Drive can be found in the PROFIdrive standard.
   You can find the current PROFIdrive specification under (https://www.profibus.com/).

8.2 Controlling a TM Drive via the instruction SINA_SPEED

Control with the SINA_SPEED instruction

For controlling the TM Drive, you can also use the SINA-SPEED instruction from the "DriveLib" block library.

The SINA_SPEED block only works with the standard telegram 1. The telegram extension may have to be disabled. See Communication telegrams.

The "DriveLib" block library can be downloaded from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109475044).

See also

Communication telegrams (Page 58)

8.3 Controlling TM Drive with a technology object

Control with a technology object

You can also use a technology object, for example "Speed-controlled axis" or "Positioning axis", to control the TM Drive.

Note that the TM Drive does not have an integrated positioning functionality and only supports speed operation.

Procedure

1. Create, for example, a "Speed axis" technology object in the CPU in the project tree in STEP 7.
2. Open the technology object.
3. Select "TM Drive" under "Configuration" > "Hardware interface" > "Drive".
4. Reference the technology object in the user program using the Motion Control technology instructions, e.g. "MC-Power".

NOTE

We do not recommend using the "Encoder calibration at every startup" option in conjunction with positioning technology objects (positioning axis). The calibration process can lead to undesired behavior of the drive axis.

Additional information

You can find more information about the technology objects and technology instructions in the online help of STEP 7.

Maintenance 9

9.1 Firmware update

Firmware update

A firmware update is possible via PROFINET.

See SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

9.2 Stop responses

Overview of the stop responses

Faults with safety functions and violation of limits can trigger the following stop responses:

- "Hardware STO"

  "Safe Torque Off" (STO) corresponds to Stop Category 0 in accordance with EN 60204-1. With "Safe Torque Off" (STO), the motor is switched directly to zero torque. A motor at standstill cannot be started again accidentally. A moving motor coasts to standstill.

Table 2-2106 Overview of stop responses

Stop response	Triggered ...	Action	Effect
STO	At least one signal STO+/STO- is interrupted.	Motor controllers interrupted	Drive coasts down

After the drive has been stopped, restart it with PROFIdrive.

The faults and warnings are described in the appendix Active messages (Page 105).

Interrupts, error messages and diagnostics and system alarms

10

10.1 Status and error displays

LED display

The figure below shows the LEDs on the TM Drive.

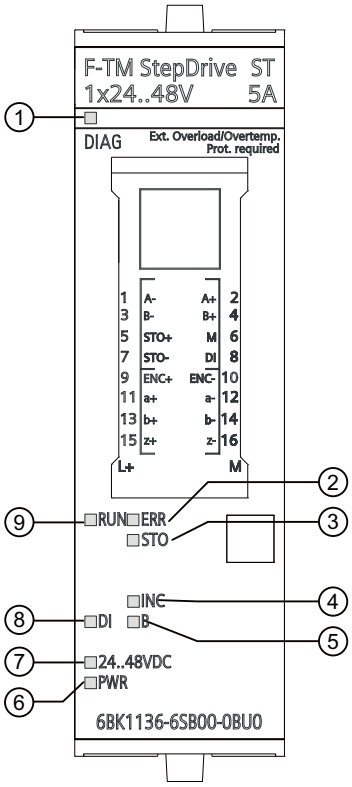

①	DIAG (red/green)	⑦	24..48V (green)
②	ERR (red)	⑧	DI (green)
③	STO (yellow) Display not safety-related	⑨	RUN (green)
④	INC (green)		
⑤	B (green)		
⑥	PWR (green)		

Figure 2-1624 LED display on F-TM StepDrive

Meaning of the LED displays

The following tables contain the meanings of the status and error displays.

DIAG LED

Table 2-2107 DIAG status and error display

DIAG LED	Meaning	
□ Off	Backplane bus supply of the ET 200SP not OK	
☼ Flashing	Module parameters not assigned	
■ On	Module parameters assigned and no module diagnostics	
☼ Flashing	0.5 Hz (slow)	Module parameters assigned and module diagnostics There is a fault. You can find detailed information via "Online & Diagnostics" > "Diagnostics" > "Active messages" or in the section Active messages (Page 105).
	1 Hz (normal)	
	2 Hz (fast)	

RUN LED

Table 2-2108 RUN status and error display

RUN LED	Meaning	
□ Off	Device is not yet ready for operation	
■ On	Device is ready for operation and error-free	
☼ Flashing	0.5 Hz (slow)	Device is performing self-test during power-up
	1 Hz (normal)	Device performs a firmware update
	2 Hz (fast)	Device has detected a parameterization error

ERR LED

Table 2-2109 ERR status and error display

ERR LED	Meaning
□ Off	No fault
■ On	Device has a fault and needs to be restarted. This corresponds to a serious device error or the loaded firmware cannot be operated on this device version.

DI LED

Table 2-2110 DI status and error display

DI LED	Meaning
□ Off	Input is inactive
■ On	Input is active

B LED

Table 2-2111 B status and error display

B LED	Meaning
■ On	The motor holding brake is open / information about the process image was set

STO LED

Table 2-2112 STO status and error display

STO LED	Meaning
■ On	Drive ready, switch connected correctly and STO not requested
☼ flashes (0.5 Hz)	STO requested (motor is disconnected from power)

INC LED

Table 2-2113 Status and error display INC (encoder)

INC LED	Meaning
■ On	Incremental speed encoder was assigned parameters/activated
☼ Flashes (2 Hz)	Incremental speed encoder has a connection problem (A/B and/or Z track not connected)

24..48V LED

Table 2-2114 24..48V status and error display

24..48V LED	Meaning
□ Off	DC link voltage outside the configured limits
■ On	DC link voltage within the configured limits (is OK)
☼ flashes (0.5 Hz)	DC link voltage shortly before the interference threshold

PWR LEDs

Table 2-2115 PWR status and error display

PWR LED	Meaning
□ Off	Logic component supply of the converter is missing
■ On	Logic component supply of the converter is OK

10.2 Diagnostics

10.2.1 Diagnostics overview of the TM Drive

Diagnostic view of the CPU and its associated I/O

If you go online to the CPU and establish an online connection via the CPU to the TM Drive, this occurs within the project context.

Procedure

To display the diagnostic information for the TM Drive, follow these steps.

1. Select the TM Drive in the project tree, for example under "Ungrouped devices".
2. Double-click "Online & diagnostics".
   The "Diagnostics - General" window appears.
3. Navigate to the required information.

The diagnostic window is divided into the following diagnostic groups:

- **General**

  The general diagnostic information is displayed for:

  – Module
  – Module information
  – Manufacturer information

- **Diagnostics status**

  "Diagnostics status" shows the current diagnostics status of the TM Drive.

- **Active messages**

  "Active messages" displays the currently pending alarms and faults in the TM Drive module.

- **Drive diagnostics**

  The current diagnostic information of the drive is displayed for:

  – Status bits
  – Operating values
  – Encoders
  – Temperatures
  – Inputs

10.2.2 Active messages

Pending faults and alarms

"Active messages" shows the currently pending faults and alarms in the TM Drive. Faults must be acknowledged after the cause has been corrected.

Procedure

To display the active messages, follow these steps:

1. Select the TM Drive in the project tree and go to "Online & diagnostics".
2. In the "Diagnostics" folder, select the "Active messages" area.

Faults and alarms

NOTE

In open-loop control operation, no diagnostics of the encoder signals is performed (see fault numbers 1045 and 1046)

The TM Drive supports the following faults.

Fault number	Description	S7 diagnostics alarm
1000	Overvoltage in the DC link	Undervoltage
1001	Undervoltage in the DC link	Overvoltage
1003	Shutdown due to overcurrent switch-off of a phase	Overload
1032	Temperature measured values implausible	Error
1035	Permitted temperature at the motor end stage exceeded	Overtemperature
1036	Permitted temperature at the motor winding exceeded	Overtemperature
1042	Fail-safe shutdown path (STO) defective	Safety-related shutdown
1043	Permissible temperature of the motor electronics exceeded	Overtemperature
1045	The connection to the A/B track of the incremental speed encoder is interrupted.	Wire break
1046	The connection to the Z track of the incremental speed encoder is interrupted.	Wire break
1047	An unsupported PROFIdrive speed encoder function was requested.	-
1050	A ramp/quick stop (OFF1/OFF3) could not be performed due to a timeout.	External error
1054	Permissible temperature at the motor winding when stepper motor exceeded	Overload
1300	There is an error in the parameter assignment of the motor type.	Parameterization error
1340	There is an error in the parameter assignment of the encoder.	Parameterization error
1360	There is an error in the parameter assignment of the controller.	Parameterization error
1380	There is an error in the parameter assignment of the braking function.	Parameterization error

Acknowledge faults

To acknowledge all active faults, click the "Acknowledge faults" button.

Alarms

Column	Description
Alarm number	Number of the warning
Description	Description of the warning

The TM Drive supports the following warnings.

Alarm number	Description
2000	Voltage in the DC link shortly before shutdown
2001	STO shutdown active
2002	Warning threshold when motor end stage temperature is exceeded
2003	Warning threshold when motor winding temperature is exceeded
2004	Thermal overload of the motor end stage
2200	Encoder warning in the encoder error

10.2.3 Drive diagnostics

You can find online information on important current drive diagnostics data and drive service data in the "Drive diagnostics" area under "Online & diagnostics" in the context of the drive.

NOTE

All drive diagnostics are only available online. They are automatically updated in the user interface.

You will find diagnostic information on the following points in the "Drive diagnostics" area:

- Status bits
- Operating values
- Encoders
- Temperatures
- Inputs

Properties of drive diagnostics

Drive diagnostics

- Show the current values of various parameters
- Are cyclically updated
- Are read-only.

Drive diagnostics: Status bits

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Status bits"

Table 2-2116 Drive diagnostics - status bits

Number	Parameter	Display/unit
Status word		
r0899	Status bits **Note**:	• Ready for switching on • Ready for operation

Number	Parameter	Display/unit
	Signal corresponds to status word 1 PROFIdrive (r0968).	• Operation • Fault active • Coasting active • Rapid stop active • Switching on inhibited active • Alarm active • Speed setpoint - actual value deviation • Control by controller • n comparison value reached • Control of the motor holding brake is active **Note:** • Status word 1 is sent cyclically by the drive to the higher-level controller.

Drive diagnostics: Operating values

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Operating values"

Table 2-2117 Drive diagnostics - operating values

Number	Parameter	Display/unit
r0063	Speed actual value smoothed	rpm
r0080	Torque actual value	Nm
r1045	Speed setpoint in front of the ramp generator	rpm
r0026	DC link voltage	V
r0027	Current actual value	A_{eff}
r0072	Output voltage	V

NOTE

With a stepper motor and the "controlled (I = const.)" control type, the actual torque value corresponds to the current hold torque.

Drive diagnostics: Encoders

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Encoder"

Table 2-2118 Drive diagnostics - encoder

Number	Parameter	Display/unit
r7811	Position	°
r7810[0]	Single-turn steps	-
p979[2]	Increments per revolution	-
p979[3]	Fine resolution bits in actual value Gx_XIST1	Bits

Drive diagnostics: Temperatures

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Temperatures"

Table 2-2119 Drive diagnostics -temperatures

Number	Parameter	Display/unit
r0037[0]	Current microcontroller	°C
r0037[1]	Microcontroller max.	
r0037[4]	Power end stage	
r0037[5]	Power end stage max.	

Drive diagnostics: Inputs

"Online & diagnostics" > "Diagnostics" > "Drive diagnostics" > "Inputs"

Table 2-2120 Drive diagnostics - inputs

Number	Parameter	Display/unit
-	Inputs	• Digital input • STO active

Reference

All displayed parameters have a tooltip that provides you with information and descriptions relating to the parameter as well as access to the online help.

You can find additional information on the parameters in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

Technical specifications 11

11.1 Technical specifications

Technical specifications of TM Drive

Article number	6BK1136-6SB00-0BU0
General information	
Product type designation	F-TM StepDrive ST
HW functional status	V1.0
Firmware version	V1.0
• FW update possible	Yes
Product description	control of stepper motors
usable BaseUnits	BU type U0
Product function	
• I&M data	Yes
• Isochronous mode	No
• Four-quadrant operation	Yes
• Speed control with encoder	No
• Speed control without encoder	No
• Safety Functions	Yes; Drive controller with hardwired STO
Protection function	
• Undervoltage protection	Yes
• Overvoltage protection	Yes
• Overload protection	Yes
• Ground-fault protection	No
• Short-circuit protection	Yes
Installation type/mounting	
Type of ventilation	Convection cooling
Supply voltage	
Design of the power supply	24 ... 48 V DC, SELV / PELV
permissible range, lower limit (DC)	16.8 V
permissible range, upper limit (DC)	57.6 V

Article number	6BK1136-6SB00-0BU0
Input current	
Current consumption (rated value)	6 A
Current consumption, max.	10 A
Current consumption for the electronics, max.	0.1 A; at 24 V
Inrush current, max.	25 A; at 24 V
output voltage / header	
Rated value, min.	24 V
Rated value, max.	48 V
Output current	
Current output (rated value)	5 A
Output current, max.	10 A
Output frequency	1 000 Hz
Encoder supply	
Number of outputs	1
5 V encoder supply	
• 5 V	Yes
• Short-circuit protection	Yes
• Output current, max.	150 mA
Power	
DC power consumption	300 W; At 50 V
Power loss	
Power loss, typ.	3.5 W
Digital inputs	
Number of digital inputs	1; input for message signal
Number of safety inputs	1; For STO, antivalent (2-pin) - 24 V DC
Encoder	
Connectable encoders	
• Incremental encoder (symmetrical)	Yes; up to 500 Hz per channel
Interrupts/diagnostics/status information	
Alarms	
• Diagnostic alarm	Yes
• Hardware interrupt	No
Diagnoses	
• Monitoring the supply voltage	Yes
• Wire-break	Yes
• Short-circuit	Yes
• Group error	Yes
Diagnostics indication LED	
• RUN LED	Yes
• ERROR LED	Yes

Article number	6BK1136-6SB00-0BU0
Integrated Functions	
Position detection	
• Incremental acquisition	Yes
• Absolute acquisition	No
• Suitable for S7-1500 Motion Control	Yes
Potential separation	
Potential separation channels	
• between the channels and backplane bus	Yes
Isolation	
Isolation tested with	DC 850 V, type test (between backplane bus, DC input and functional grounding)
Overvoltage category	III
Degree of pollution	2 according to EN 61800-5-1
Degree and class of protection	
IP degree of protection	IP20
Standards, approvals, certificates	
CE mark	Yes
UKCA mark	Yes
cULus	Yes
RCM (formerly C-TICK)	Yes
KC approval	Yes
EAC (formerly Gost-R)	Yes
RoHS conformity	Yes
China RoHS compliance	Yes
Standard for EMC according to EN 61800-3	Yes
Standard for drive acc. to EN 61800-5-1	Yes
Standard for drive acc. to EN 61800-5-2	Yes
Highest safety class achievable in safety mode	
• Performance level according to ISO 13849-1	Category 3, performance level d, according to EN ISO 13849-1:2015
• SIL acc. to IEC 61508	3
• SIL according to DIN EN 61800-5-2	3
Ambient conditions	
Pollution degree during storage and transport	2
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted.
• horizontal installation, max.	60 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
• vertical installation, min.	-30 °C; No condensation, splash water, icing, salt spray or oil mist permitted.

Article number	6BK1136-6SB00-0BU0
• vertical installation, max.	50 °C; No condensation, splash water, icing, salt spray or oil mist permitted. Note the derating data!
Ambient temperature during storage/transportation	
• Storage, min.	-30 °C
• Storage, max.	70 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3 000 m
Cables	
Cable length for motor, shielded, max.	10 m
Dimensions	
Width	20 mm
Height	73 mm
Depth	58 mm
Weights	
Weight, approx.	55 g
Other	
Brake design	holding brake control via the process image
Braking chopper	No

Climatic and mechanical environmental conditions

You can find the climatic and mechanical ambient conditions here SIMATIC ET200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

If there are discrepancies between the statements in this document and the system manual, the statements in the this document take priority.

Biological environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, IEC 60721-3-3: Edition 3.0, with the classes 1B1, 2B1 and 3B1 apply for the biological environmental conditions during operation, long-term storage and transport.

Conductive dust and sand

The TM Drive must not be exposed to conductive dust or sand during operation, long-term storage and transport.

Chemical environmental conditions

The standards DIN EN IEC 60721-3-1:2018, DIN EN IEC 60721-3-2:2018, DIN EN 60721-3-3:1995, with the classes 1C2, 2C2 and 3C2 apply for the chemical environmental conditions during operation, long-term storage and transport.

11.2 Derating of the ET 200SP TM Drive

Maximum permitted output current as a function of installation altitude and ambient temperature

You must take into account the dependency on the ambient temperature and installation altitude.

Derating of the TM Drive depends on the installation elevation

For all permissible mounting types, starting from an installation altitude of 1000 m, a derating of 10% current per additional 1000 m elevation gain applies. In this case, the motor current and the output current of the digital outputs must be reduced.

All other functions do not have to be reduced up to the maximum installation altitude.

The figure below shows the maximum permitted output current as a function of the ambient air temperature for the derating.

Derating of the TM Drive depends on the ambient temperature (horizontal/vertical mounting position)

When installed horizontally (DIN rail horizontal), the TM Drive can be operated up to the maximum ambient temperature (60 °C). Note the derating curve.

With vertical mounting (vertical mounting rail), the TM Drive may be operated up to a maximum of 50 °C. Note the derating curve.

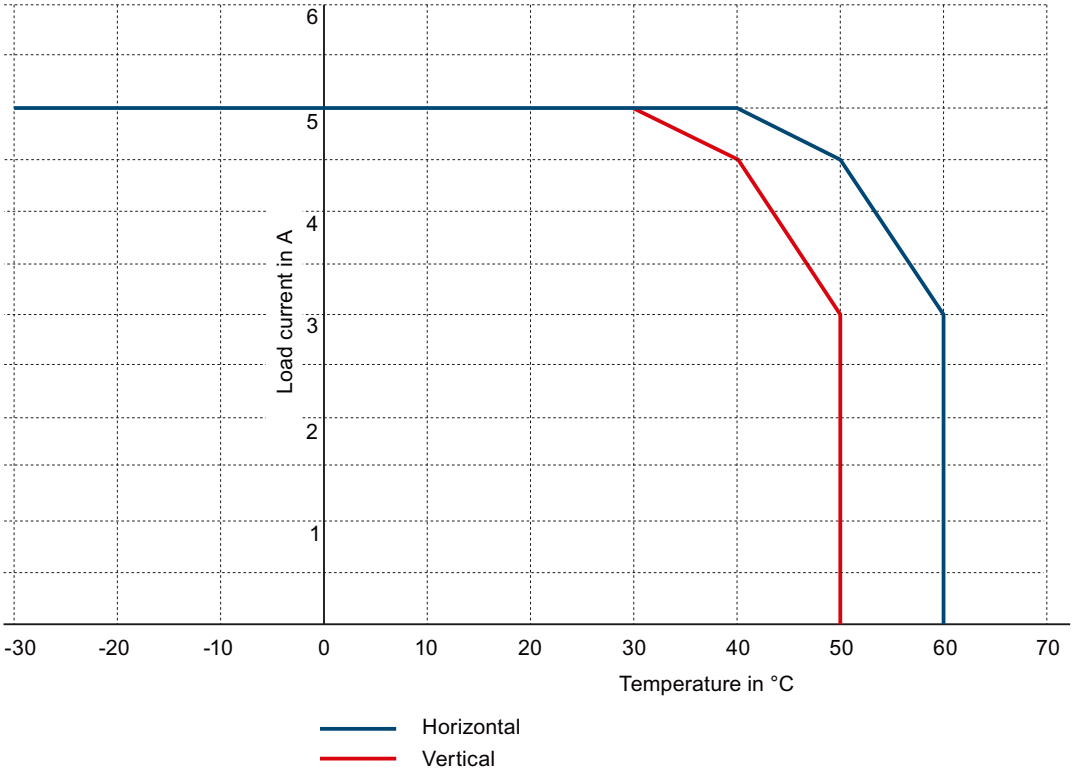

Figure 2-1625 Derating the TM Drive with a stepper motor

Test signal suppression

The STO inputs can be dark tested. The dark test time is up to 1 ms.

Appendix A

A.1 Response times

Introduction

Below you can find the response time of the TM Drive in STEP7. The response times of the TM Drive are included in the calculation of the response time of the F-system.

The drive system is the component that provides the safety functions.

Definition of response time

The response time is the time between the detection of an input signal and the change of a linked output signal.

Definition of process safety time of a process

The process safety time of a process is the time between the occurrence of an error within which a process can be left unattended without risk to life and limb of the operating personnel or damage to the environment and the time of the completed reaction.

Any type of F-system control is tolerated within this process safety time, i.e. the F-system can control its processes incorrectly or even not at all. The process safety time of a process depends on the type of process and must be determined on a case-by-case basis.

Check that the process safety time of the process is not exceeded. You may need to reduce the specific monitoring times of the F-system.

Fluctuation width

The actual response time falls between a minimum and maximum response time. You must always assume the maximum response time when configuring your system.

Definition of maximum response time in an error-free scenario (worst case delay time, WCDT)

In the event of errors outside the drive system (e.g. incorrect setpoint setting by a controller, limit violations due to behavior of the motor, closed-loop control, load, etc.), the "maximum response time in an error-free scenario" is guaranteed.

Definition of maximum response time when an error is present (one fault delay time, OFDT)

In the event of a single error within the drive system (e.g. defect in a shutdown path of the power unit), the "maximum reaction time in the event of error" is guaranteed.

Times required for the calculation

Function	Maximum response time
STOP_STO via terminal	20 ms

STOP_STO:
With a STOP_STO, the drive safely switches off the torque of the connected motor immediately.

You can find an overview of the data sets for the TM Drive and the structure of the data sets in the Product Information (https://support.industry.siemens.com/cs/ww/en/view/109773204).

A.2 Device disposal

Recycling and disposal

For environmentally-friendly recycling and disposal of your old device, please contact a company certified for the disposal of waste electrical and electronic equipment, and dispose of the old device as prescribed in the respective country of use.

NOTE

The device does not have its own memory. Neither personal data nor project-specific data are stored on it. It is not necessary to reset the memory for data security reasons.

A.3 Directives and standards

SIEMENS

SIMATIC

ET 200SP
Power Module F-PM-E 24VDC/8A
PPM ST (6ES7136-6PA00-0BC0)

Equipment Manual

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07/2013
A5E03857933-01

Preface

Purpose of the documentation

This device manual complements the system manual ET 200SP distributed I/O system. General functions of the ET 200SP are described in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293).

The information provided in this device manual and the system manual enables you to commission the ET 200SP distributed I/O system.

Conventions

Note the following identified notes:

NOTE

A note includes important information on the product described in the documentation, on handling the product or on the part of the documentation to which you should pay special attention.

Security information

Siemens provides automation and drive products with industrial security functions that support the secure operation of plants or machines. They are an important component in a holistic industrial security concept. With this in mind, our products undergo continuous development. We therefore recommend that you keep yourself informed with respect to our product updates. Please find further information and newsletters on this subject at: (http://support.automation.siemens.com)

To ensure the secure operation of a plant or machine it is also necessary to take suitable preventive action (e.g. cell protection concept) and to integrate the automation and drive components into a state-of-the-art holistic industrial security concept for the entire plant or machine. Any third-party products that may be in use must also be taken into account. Please find further information at: (http://www.siemens.com/industrialsecurity)

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Documentation guide

1

1.1 Documentation Guide for Power Module F-PM-E 24VDC/8A PPM ST

Introduction

The documentation of the SIMATIC products has a modular design and includes topics concerning your automation system.

The complete documentation of the ET 200SP system consists of different modules divided into system manuals, function manuals and manuals.

The STEP 7 (online help) information system supports you in configuring and programming your automation system.

Overview of documentation for the F-PM-E 24VDC/8A PPM ST fail-safe power module

The table below lists additional documents that complement this description of the F-PM-E 24VDC/8A PPM ST fail-safe power module and are available on the Internet.

Table 2-2121 Documentation for the F-PM-E 24VDC/8A PPM ST fail-safe power module

Topic	Documentation	Most important contents
Description of the system	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	• Application planning • Installation • Connecting • Commissioning • Approvals • TÜV certificate
BaseUnits	Manual ET 200SP BaseUnits (http://support.automation.siemens.com/WW/view/en/58532597/133300)	Technical specifications
Description of the SIMATIC Safety F-system	Programming and operating manual SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126)	• Configuring • Programming • Approvals

SIMATIC manuals

The latest manuals for SIMATIC products are available on the Internet (http://www.siemens.com/automation/service&support) for free download.

Functional Safety Services

Siemens Functional Safety Services support you with a comprehensive package of services from risk assessment to verification all the way to plant commissioning and modernization. We also offer consultation on the use of fail-safe and fault-tolerant SIMATIC S7 automation systems.

You will find more detailed information on the Internet (http://www.siemens.com/safety-services).

Please send your questions to us by e-mail (mailto:safety-services.industry@siemens.com).

Product overview

2

2.1 Properties of the F-PM-E 24VDC/8A PPM ST

Order number

6ES7136-6PA00-0BC0

View of the module

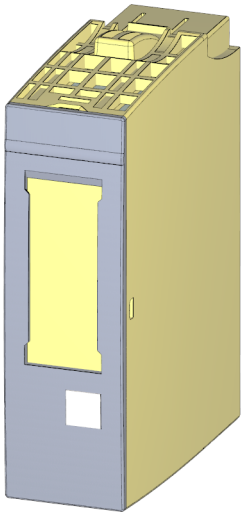

Figure 2-1626 View of the F-PM-E 24VDC/8A PPM ST module

Properties

- Technical properties
  - Fail-safe digital module
  - 2 inputs (SIL3/Cat.4/PLe)
  - 1 output PM-switching or PP-switching, output current 8 A (SIL3/Cat.4/PLe)
  - 2 outputs for sensor supply
  - Sink input (P-reading)
  - Source output (PM/PP-switching)
  - Supply voltage L+
  - Suitable for connection of 2-wire sensors to IEC 61131, type 1
  - Channel-specific assignable input delay 0.4 ms to 20 ms

  - Diagnostic display (DIAG red/green LED)
  - Status display for each input or output (green LED)
  - Fault display for each input or output (red LED)
  - Diagnostics, e.g., short circuit/wire break, channel-specific
  - Diagnostics, e.g., load voltage missing, module-specific
  - Channel-specific or passivation throughout the module
- Supported functions
  - Firmware update
  - I&M identification data
  - PROFIsafe

WARNING

The fail-safe performance characteristics in the technical specifications apply to a proof-test interval of 20 years and a mean time to repair of 100 hours. If a repair within 100 hours is not possible, remove the respective module from the BaseUnit or switch off its supply voltage before 100 hours expires. The module switches off independently after the 100 hours have expired.

Follow the repair procedure described in section Diagnostic messages (Page 58).

Accessories

The following accessories, which are not included in the product package of the F-module, can be used with the F-module:

- Labeling strips
- Color identification labels
- Reference identification labels
- Shield connection

Additional information on accessories can be found in the ET 200SP Distributed I/O System System Manual (http://support.automation.siemens.com/WW/view/en/58649293).

Safety-related shutdown of standard DQ modules by the F-PM-E 24VDC/8A PPM ST

This cost-effective solution allows for full and simultaneous shutdown of all affected outputs of the standard DQ modules when a fault is detected in the process or on the F-PM-E 24VDC/8A PPM ST power module.

You achieve SIL2/Cat.3/PLd with safety-related shutdown of standard DQ modules.

You can use the F-PM-E 24VDC/8A PPM ST power module with all standard DQ modules within a potential group. Additional information is available in Applications for safety-related shutdown of standard modules (Page 49).

Passivation of fail-safe outputs over a long period of time

WARNING

Unintentional activation of F-I/O with fail-safe outputs

If an F-I/O with fail-safe outputs is passivated for a period longer than that specified in the safety parameters (> 100 hours) and the fault remains uncorrected, you need to exclude the possibility that the F-I/O can be activated unintentionally by a second fault, and thus place the F-system in a dangerous state.

Even though it is highly unlikely that such hardware faults occur, you must prevent the unintentional activation of F-I/O with fail-safe outputs by using circuit measures or organizational measures.

One possibility is the shutdown of the power supply of the passivated F-I/O within a time period of 100 hours, for example.

The required measures are standardized for plants with product standards.

For all other plants, the plant operator must create a concept for the required measures and have it approved by the inspector.

Connecting

3

3.1 Terminal assignment

General terminal assignment

Table 2-2122 Terminal assignment for F-PM-E 24VDC/8A PPM ST

Terminal assignment for F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)						
Terminal	**Assign-ment**	**Terminal**	**Assign-ment**	**Description**	**BaseUnit**[1]	**Color identification label (terminals 1 to 16)**
1	DI_0	**2**	DI_1	• DI_n: Input signal, channel n • VS_n: Internal sensor supply, channel n • $DQ\text{-}P_0$: Output signal, channel 0, P-switching • $DQ\text{-}M_0$: Ground for output signal, channel 0, M-switching • AUX: Protective conductor connection or voltage bus for SELV/PELV circuits	C0	 CC52 6ES7193-6CP52-2MC0
3	VS_0	**4**	VS_1			
5	$DQ\text{-}P_0$	**6**	$DQ\text{-}M_0$			
7	AUX	**8**	AUX			
L+	DC24V	**N**	M			
L+	DC24V	**N**	M			

[1] Usable BaseUnit types can be identified by the last two digits of their order number. See also *ET 200SP Distributed I/O System* system manual

NOTE

Make sure that you only use the power module with BaseUnit type C0 during commissioning.

Digital output

The digital output switches the voltage L+ and M using two electronic switches (see Block diagram (Page 13)). The switched voltage and chassis are conducted to the internal voltage buses P1 and P2. The switched voltage and chassis is also available at the BaseUnit at DQ-P_0 and DQ-M_0.

This results in two connection options that can be used at the same time, if desired:

- One load can be wired directly to the BaseUnit (see Applications for the output DQ/P1 and P2 (Page 34)).
- The standard modules can be supplied and switched off safety-related by means of the internal voltage buses P1 and P2. You can, in turn, connect loads to the standard modules (see Applications for safety-related shutdown of standard modules (Page 49)).

WARNING

It is no longer possible to shut down an actuator if a cross circuit has developed between L+ and DQ. To prevent cross circuits between L+ and DQ, you must route the cables used to connect the actuators in a cross-circuit proof manner (for example, as separate, sheathed cables or in separate cable ducts).

Redundant ground conductor required

WARNING

The ground conductor to the BaseUnit for F-PM-E 24VDC/8A PPM ST must be installed twice for safety reasons. Any interruption of a single ground conductor would prevent the safety-related shutdown of voltage bus P2.

Property of the individual shutdown of F-modules with fail-safe outputs

A channel-specific shutdown occurs when a fault is detected. It is also possible to react to critical process states staggered over time or to perform safety-related shutdown of individual outputs.

Switching of loads with ground if the F-module is configured PM-switching

If the following two conditions are met, F-PM-E 24VDC/8A PPM ST detects a short circuit:

- If loads that have a connection between chassis and ground are switched by the F-PM-E 24VDC/8A PPM ST , for example, to improve the EMC properties.
- If chassis and ground are connected at the power supply unit.

From the perspective of the F-module, the M-switch is bridged by the chassis-ground connection (refer to the diagram below as an example for an F-PM-E 24VDC/8A PPM ST).

Remedy:

- Use the F-PM-E 24VDC/8A PPM ST configured as a PP-switching module.
- Increase the value of the resistance between chassis and ground at the load end to more than 100 kΩ.
- Reduce the capacitance value between chassis and ground at the load end to less than 2 µF.

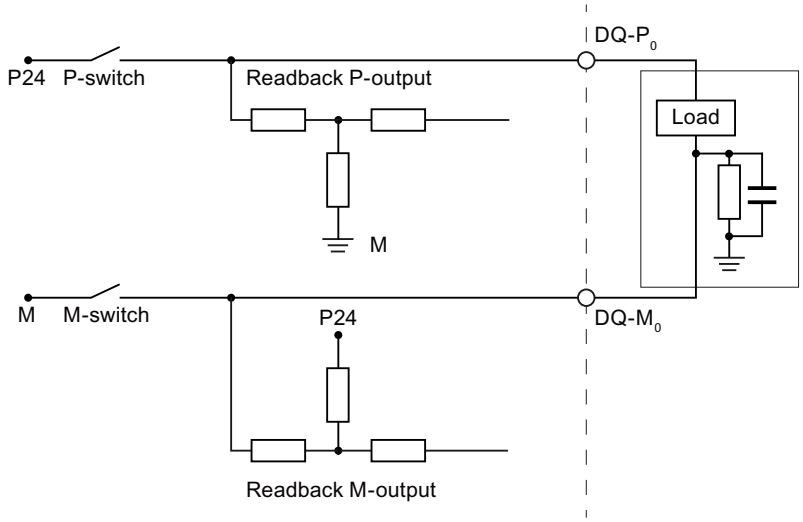

Figure 2-1627 Switching of grounded loads (resistance between chassis and ground)

WARNING

During startup, the F-PM-E 24VDC/8A PPM ST carries out a switch-on test of approximately 3 ms. The capacitance between chassis and ground at the load end is charged by way of the load resistance. This low charging current may briefly trigger sensitive load circuits.

See also

ET 200SP distributed I/O system
(http://support.automation.siemens.com/WW/view/en/58649293)

3.2 Block diagram

Block diagram

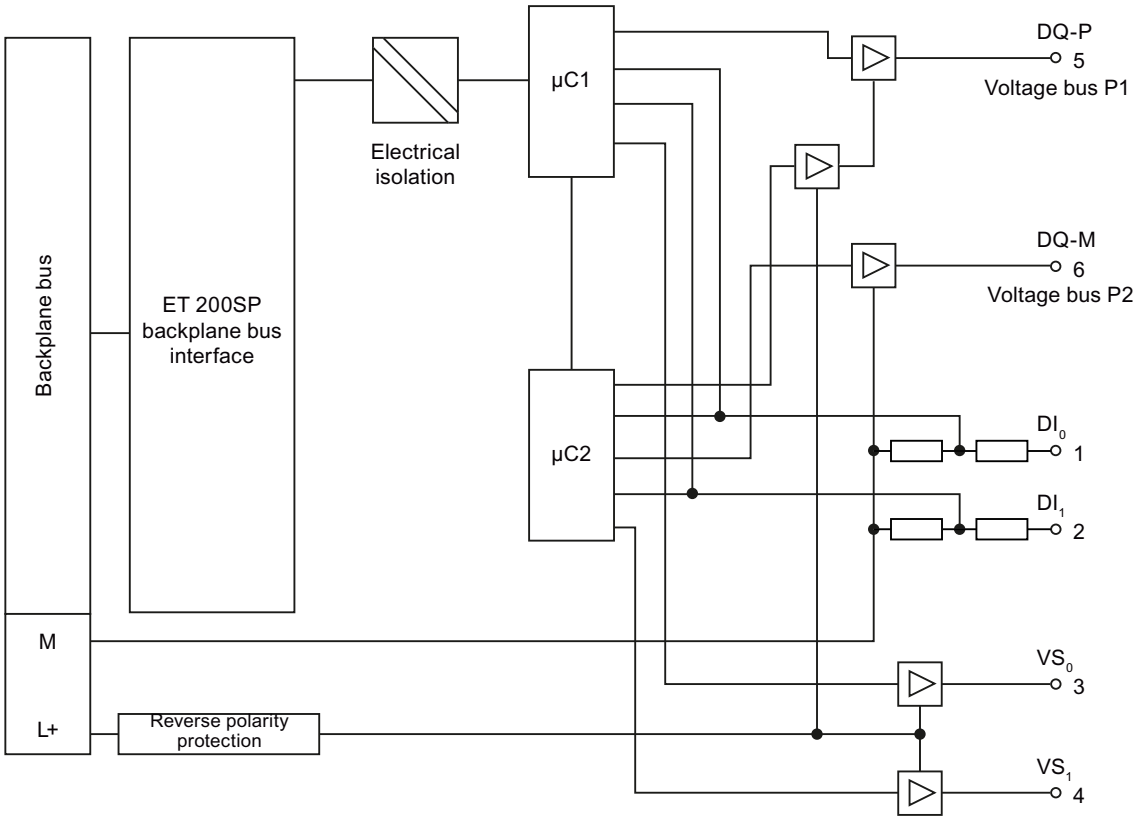

Figure 2-1628 Block diagram F-PM-E 24VDC/8A PPM ST

Parameters/address space

4

4.1 Parameters

Parameters

WARNING

Diagnostic functions should be activated or deactivated in accordance with the application.

Table 2-2123 Parameters for power module

Parameter	Value range	Parameter reassignment in RUN	Scope
F-parameters:			
Manual assignment of the F-monitoring time	• disable • enable	no	Module
F-monitoring time	1 to 65535 ms	no	Module
F-source address	1 to 65534	no	Module
F-destination address	1 to 65534	no	Module
F-parameter signature (without address)	0 to 65535	no	Module
Behavior after channel faults	• Passivate entire module • Passivate channel	no	Module
F-I/O DB manual number assignment	• disable • enable	no	Module
F-I/O DB number	—	no	Module
F-I/O DB name	—	no	Module
PM-parameters:			
Maximum test period	• 100 s • 1000 s	no	Module
Sensor supply:			
Short circuit test	• disable • enable	no	Channel
Time for short circuit test	0.5 ms to 2 s	no	Channel
Startup time of the sensors after short circuit test	0.5 ms to 2 s	no	Channel

Parameter	Value range	Parameter reassignment in RUN	Scope
Inputs:			
Sensor evaluation	• 1oo1 evaluation • 1oo2 evaluation, equivalent • 1oo2 evaluation, non-equivalent	no	Channel pair
Discrepancy behavior	• Supply last valid value • Supply 0 value	no	Channel pair
Discrepancy time	5 ms to 30 s	no	Channel pair
Reintegration after discrepancy error	• Test 0-signal necessary • Test 0-signal not necessary	no	Channel pair
Activated	• disable • enable	no	Channel
Sensor supply	• Sensor supply 0 • Sensor supply 1 • External sensor supply	no	Channel
Input delay	• 0.4 ms • 0.8 ms • 1.6 ms • 3.2 ms • 6.4 ms • 10.0 ms • 12.8 ms • 20 ms The provided value range depends on the parameter assignment of the employed sensor supply.	no	Channel
Pulse extension	• — • 0.5 s • 1 s • 2 s	no	Channel
Chatter monitoring activated	• disable • enable	no	Channel
Number of signal changes	2 to 31	no	Channel
Monitoring window	0 to 100 s (If 0 s is configured, the monitoring window is 0.5 s long.)	no	Channel
Output:			
Activated	• disable • enable	no	Channel
Control of the output	• F-CPU • F-CPU and onboard F-DI	no	Module
Output type	• PM switching • PP switching	no	Channel
Max. readback time dark test	0.8 to 400.0 ms	no	Channel

Parameter	Value range	Parameter reassignment in RUN	Scope
Disable dark test for 48 hours	• disable • enable	no	Channel
Max. readback time switch on test	0.8 to 5.0 ms	no	Channel
Activated light test	• disable • enable	no	Channel
Diagnosis: Wire break	• disable • enable	no	Channel

4.2 Explanation of parameters

4.2.1 F-parameters

F-parameters

Information on F-parameters is available in the SIMATIC Safety - Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

4.2.2 PM-parameters

4.2.2.1 Maximum test period

Here you specify the time within which the light and dark tests (in all combinations) should be performed throughout the module. When this time expires, the tests are repeated.

The "Maximum test period" parameter is a module parameter, which means the test cycle for the entire fail-safe output module is performed within the configured maximum test time. If the bit pattern test is not performed within the configured time (or the shortened test time of 60 seconds in case of an error), the module goes into the error state.

4.2.3 Parameters of the sensor supply

4.2.3.1 Short circuit test

Here you enable the short-circuit detection for the channels of the F-module for which "Internal sensor supply" is set.

The short-circuit test is only useful if you are using simple switches that do not have their own power supply. For switches with power supply, for example, 3/4-wire proximity switches, a short-circuit test is not possible.

The short-circuit detection switches off the sensor supply briefly. The length of the deactivation period is equivalent to the configured "Time for sensor test".

If a short-circuit is detected, the F-module triggers a diagnostic interrupt and the input is passivated.

The following short-circuits are detected:

- Short-circuit of input to L+
- Short-circuit of the input of another channel when it has a 1 signal
- Short-circuit between the input and sensor supply of another channel
- Short-circuit between the sensor supply and the sensor supply of another channel

If the short-circuit test is disabled, you must make your wiring short-circuit and cross-circuit proof or select a connection type (discrepancy, non-equivalent) which also detect the cross-circuits using discrepancy.

During the execution time (Time for sensor test + Startup time of sensor after sensor test) of the short circuit test, the last valid value of the input before the start of the short circuit test is passed to the F-CPU. The activation of the short-circuit test thus affects the response time of the respective channel or channel pair.

4.2.3.2 Time for short circuit test

Function

When the short-circuit test is enabled, the corresponding sensor supply is switched off for the configured time. If the module does not detect a "0" signal at the input within the assigned time, a diagnostic message is generated.

When assigning parameters, note that

- If the channel is passivated, this may be due to too high capacitance between sensor supply and input. This consists of the capacitance per unit length of the cable and the capacitance of the employed sensor. If the connected capacitance does not discharge within the assigned time, you need to adjust the "Time for sensor test" parameter.
- The values available for the input delay depend on the "Ramp-up time of the sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

4.2.3.3 Startup time of sensors after short circuit test

Function

In addition to the off time ("Time for sensor test"), a startup time must be specified for performing the short circuit test. You use this parameter to notify the module how long the utilized sensor needs to start up after connecting the sensor supply. This prevents an undefined input state due to transient reactions in the sensor.

When assigning parameters, note that

- This parameter must be greater than the transient recovery time of the employed sensor.
- Because the assigned time affects the response time of the module, we recommend that you set the time as short as possible but long enough so that your sensor can settle safely.
- The values available for the input delay depend on the "Ramp-up time of the sensor after short-circuit test" and the "Time for short-circuit test" of the configured sensor supply.

Requirement

The short circuit test is enabled.

4.2.4 Parameters of the inputs

4.2.4.1 Sensor evaluation

Overview

Select the type of sensor evaluation with the "Sensor evaluation" parameter:

- 1oo2 evaluation, equivalent
- 1oo2 evaluation, non-equivalent

1oo2 evaluation equivalent/non-equivalent

With a 1oo2 evaluation equivalent/non-equivalent, two input channels are occupied by:

- One single-channel sensor
- One non-equivalent sensor
- One two-channel sensor
- Two single-channel sensors

The input signals are compared internally for equivalence or non equivalence.

Note that in 1oo2 evaluation, two channels are combined into a channel pair. The number of available process signals of the F-module is reduced accordingly.

Discrepancy analysis

When using a two-channel sensor or two single-channel sensors which measure the same process variable, the sensors interact with a slight time delay due to the limited precision of their arrangement.

The discrepancy analysis for equivalence/non-equivalence is used for fail-safe applications to prevent errors from time differences between two signals for the same function. The discrepancy analysis is initiated when different levels are detected in two associated input signals (when testing for non-equivalence: the same levels). A check is made to determine whether the difference in levels (when testing for non equivalence: the same levels) has disappeared after an assignable time period, the so-called discrepancy time. If not, this means that a discrepancy error exists.

Achievable safety class

The following safety class can be achieved depending on the selected sensor evaluation:

- SIL3/Cat.4/PLe with "1oo2 evaluation equivalent/non-equivalent"

4.2.4.2 Discrepancy behavior

Function

For the "Discrepancy behavior", you assign the value that is supplied to the safety program in the F-CPU during a discrepancy between two relevant input channels, which means while discrepancy time is running. You assign the discrepancy behavior as follows:

- "Supply last valid value"
- "Supply value 0"

Requirements

You have assigned the following:

- "Evaluation of the sensors": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

"Supply last valid value"

The most recent valid value (old value) before the discrepancy occurred is made available to the safety program in the F-CPU as soon as a discrepancy is detected between the signals of the two affected input channels. This value is supplied until the discrepancy disappears or the discrepancy time expires and a discrepancy error is detected. The sensor-actuator response time is correspondingly increased by this time.

This means the discrepancy time of connected sensors with 1oo2 evaluation must be adjusted to fast response times. It makes no sense, for example, if connected sensors with a discrepancy time of 500 ms trigger a time-critical shutdown.. In the worst-case scenario, the sensor-actuator response time is extended by an amount approximately equal to the discrepancy time:

- For this reason, position the sensors in the process in such a way as to **minimize discrepancy**.
- Then select the **shortest possible** discrepancy time which is also sufficient to compensate for faulty triggering of discrepancy errors.

"Supply value 0"

As soon as a discrepancy between the signals of the two relevant input channels is detected, the value "0" is made available to the safety program in the F-CPU.

If you have set "Supply value 0", the sensor-actuator response time is not affected by the discrepancy time.

4.2.4.3 Discrepancy time

Function

You can set the discrepancy time for each channel pair.

Requirements

You have assigned the following:

- "Evaluation of the sensors": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non-equivalent"

In most cases, a discrepancy time is started, but does not fully expire because the signal differences are cleared within a short time.

Set the discrepancy time high enough that in the error-free case the difference between the two signals (when testing for non equivalence: the same levels) has always disappeared before the discrepancy time has expired.

Behavior while discrepancy time is running

While the programmed discrepancy time is running internally on the module, either the **last valid value** or **"0"** is returned to the safety program on the F-CPU by the input channels involved, depending on the parameter settings for the behavior at discrepancy.

Behavior after expiration of the discrepancy time

If no agreement (when checking for non equivalence: inequality) of the input signals exists once the assigned discrepancy time expires, for example, due to a break in a sensor wire, a discrepancy error is detected and the "Discrepancy error" diagnostic message containing information on which channels are faulty is generated.

4.2.4.4 Reintegration after discrepancy error

Function

This parameter specifies the criteria for when a discrepancy error is regarded as corrected, thus enabling reintegration of the relevant input channels. The following parameter assignment options are available:

- "Test 0-signal necessary"
- "Test 0-signal not necessary"

Requirements

You have assigned the following:

- "Sensor evaluation": "1oo2 evaluation, equivalent" or "1oo2 evaluation, non equivalent"

"Test 0-signal necessary"

If you have assigned "Test 0-signal necessary", a discrepancy error is not regarded as corrected until a 0-signal is present at both of the relevant input channels.

If you are using non equivalent sensors, which means you have set "Sensor evaluation" to "1oo2 evaluation, non equivalent", a 0-signal must be present again at the low order channel of the channel pair.

"Test 0-signal not necessary"

If you have assigned "Test 0-Signal not necessary", a discrepancy error is regarded as corrected when a discrepancy no longer exists at both of the relevant input channels.

4.2.4.5 Activated

You hereby enable the corresponding channel for signal processing in the safety program.

4.2.4.6 Sensor supply

Here you select one of the internal sensor supplies VS_0 to VS_n or an external sensor supply.

The selection of an internal sensor supply is required for using the short circuit test.

See also

Time for short circuit test (Page 17)

4.2.4.7 Input delay

Function

To suppress stray interference, you can set an input delay for the entire channel or channel pair.

Interference pulses whose pulse time is less than the set input delay (in ms) are suppressed. Suppressed interference pulses are invisible in the PII.

A high input delay suppresses longer interference pulses, but results in a longer response time.

The values available for the input delay depend on the "Startup time of sensors after short circuit test" and the "Time for short circuit test" of the configured sensor supply.

NOTE

Due to the physical properties, there is a possibility of crosstalk between signals in the case of long, unshielded signal lines (see section "Electromagnetic compatibility" in the system manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)).

Adapt the input delay or use shielded signal lines in order to prevent possible passivation of the fail-safe digital inputs and switch-off of the sensor supply.

See also

Technical specifications (Page 64)

4.2.4.8 Pulse extension

Function

Pulse extension is a function to change a digital input signal. A pulse on a digital input is extended to at least the assigned length. If the input pulse is already longer than the assigned length, the pulse is not changed.

The fail-safe electronic module only lengthens pulses with the value "0" because the basis of the safety concept is that there is a safe state for all process variables. For digital F-I/O, this is the value "0", which applies to sensors as well as to actuators.

With 1oo2 evaluation, the result of the evaluation of both sensors is used for the pulse extension.

4.2.4.9 Chatter monitoring

Function

Chatter monitoring is a process control function for digital input signals. It detects and reports unusual signal sequences in the process with 1oo1 evaluation, for example, an input signal fluctuating between "0" and "1" too frequently. The occurrence of such signal characteristics is an indication of faulty sensors or process control instability.

Recognizing unusual signal patterns

An assigned monitoring window is available for each input channel. The monitoring window starts with the first signal change of the input signal. If the input signal changes within the monitoring window at least as often as the assigned "Number of signal changes", a chatter error is detected. If no chatter error is detected within the monitoring window, the next signal change restarts the monitoring window.

If a chatter error is detected, a diagnostic is signaled. If the chatter error does not occur for the monitoring window for three times the configured period, the diagnostic is reset.

Principle

The figure below shows the principle of chatter monitoring as a graphic.

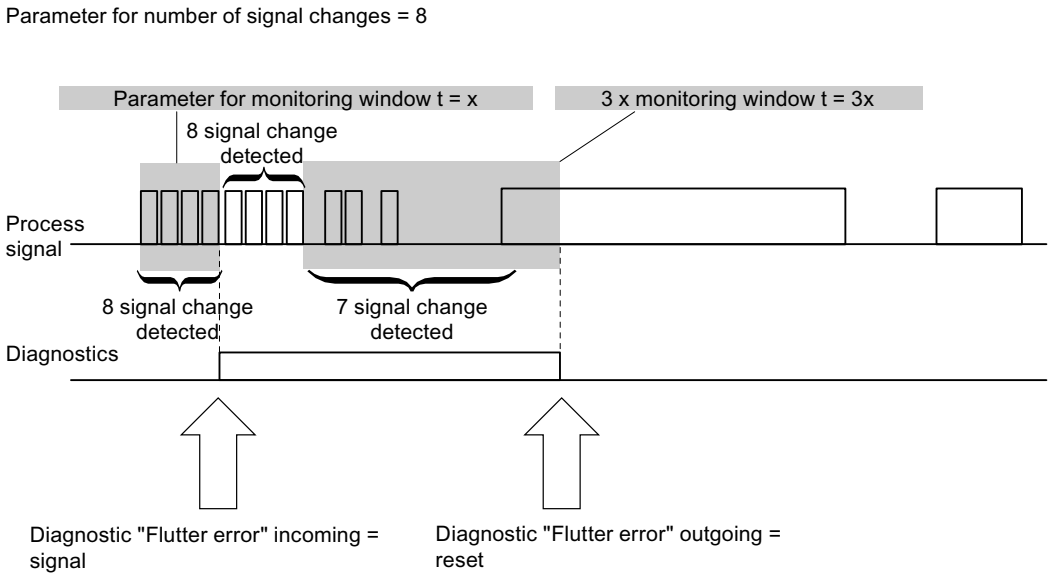

Figure 2-1629 Figure chatter monitoring

Number of signal changes

Sets the number of signal changes after which a chatter error should be reported.

4.2.4.10 Monitoring window

Sets the time for the monitoring window of flutter monitoring.

You can set times of 1 s to 100 s in whole seconds for the monitoring window.

You can configure a monitoring window of 0.5 s when you set 0 s.

4.2.5 Parameters of the output

4.2.5.1 Activated

If you select this check box, the corresponding channel is enabled for signal processing in the safety program.

You can deactivate an unused channel with this parameter.

4.2.5.2 Controlling the output

Activates the internal evaluation.

Additional information on internal evaluation is available in the chapter "Application for internal evaluation" (Page 47).

4.2.5.3 Output type

The parameter specifies if the output switches PM or PP.

4.2.5.4 Max. readback time dark test

Function

Dark tests are shutdown tests with bit pattern test.

For a dark test, a test signal is switched to the output channel while the output channel is active (output signal "1"). This output channel is then briefly disabled (= "dark period") and read back. A sufficiently slow actuator does not respond to this and remains switched on.

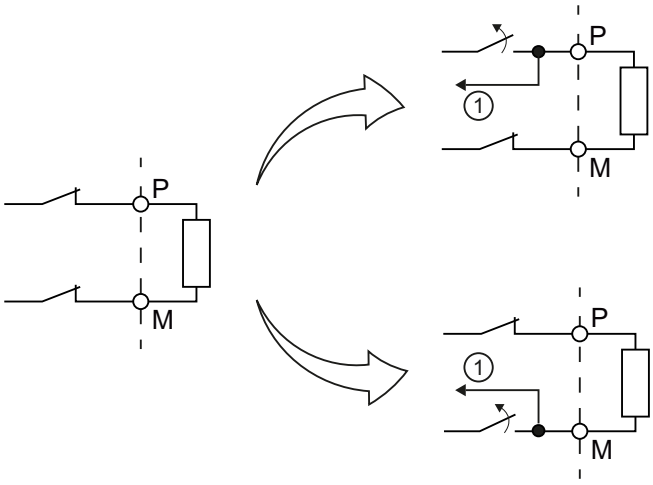

① Readback

Figure 2-1630 Functional principle of the dark test (PM switching)

This parameter allows you to set the time for the readback.

If the expected signals (P-readback and M-readback) could not be read back correctly after expiration of the readback time dark test, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time for the dark test increases the response time of the F-module.

WARNING

Through the configured readback time dark test, short circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured readback time dark test) Hz cannot be recognized (50:50 sampling ratio).

Short circuits (cross-circuits) to an output of the same module are recognized.

The parameter also has an effect on the short circuit detection (cross-circuit) with "1" signal when the output signal is changed from "1" to "0" with the safety program.

Setting readback time dark test

Because the fault reaction time is extended by the length of the readback time dark test, we recommend that you set the readback time dark test by trial and error as low as possible, but high enough that the output channel is not passivated.

You determine the readback time required for your actuator with the diagram in the chapter Switching capacitive loads (Page 72).

If the capacity of the actuator is not known, it may be necessary for you to determine the value for the readback time light test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the readback time dark test so that the output channel can be read back correctly but your actuator does not respond yet.
- If the output channel is passivated sporadically, set a higher value for the maximum readback time dark test.
- If the output channel is passivated, the readback time dark test is too small for a connected capacitive load. The discharge cannot take place during the configured readback time dark test. Increase the readback time dark test.

If you have set the readback time dark test to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

Test pulses of the dark test

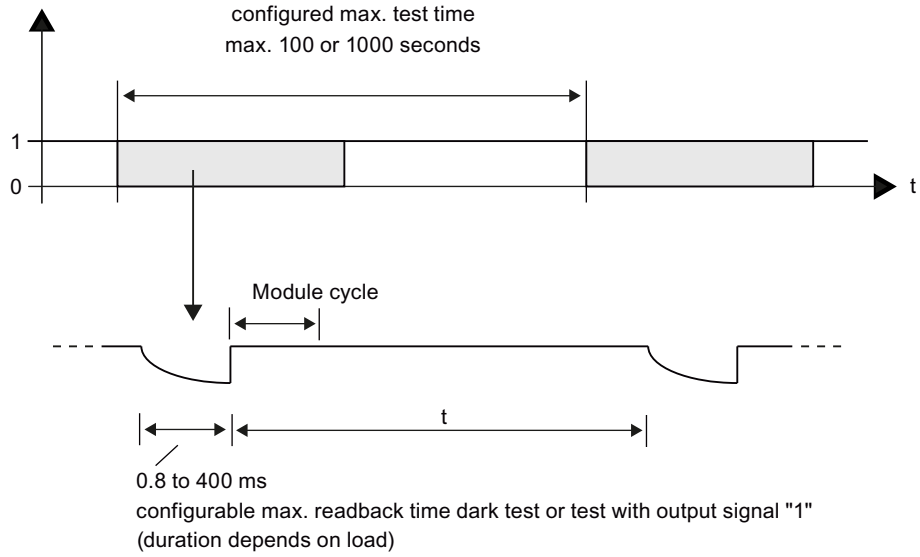

Figure 2-1631 Test pulses of the dark test

The distance between two test pulses (t) depends on the parameter assignment. Additional information is available in Minimum distance of test pulses (Page 71).

4.2.5.5 Disable dark test for 48 hours

This option allows you to suppress the dark test.

If the channel is permanently active (1) for 48 hours, 2 dark test pulses (PP switching) or 3 dark test pulses (PM switching) are directed to this channel once the time has expired.

You must provide the signal change from 1 to 0 at the channel yourself within 48 hours to prevent the dark test pulse. The dark test is suspended for another 48 hours after the signal change from 0 to 1.

The dark test is permanently suppressed if the following condition is met:

- A signal change from 1 to 0 takes place before the 48 hours have expired.

WARNING

The output is passivated if an error caused by a short-circuit is recognized when the safety-function is executed (output turned off). This is necessary because a complete bit pattern test is not performed within 48 hours, which means an undetected error burst may not be ruled out.

If the channel can retain signal 0 for 48 hours and longer, the function "Disable dark test for 48 hours" must not be used.

Consult the respective requirements of your product standards regarding error detection time.

4.2.5.6 Max. readback time switch on test

Function

The switch on test is part of the bit pattern test.

During the switch on test, the P-switch and M-switch of the output channel are alternately closed and read back when the output channel is inactive (output signal "0"). Contrary to the light test, no power flows through the connected load during the switch on test.

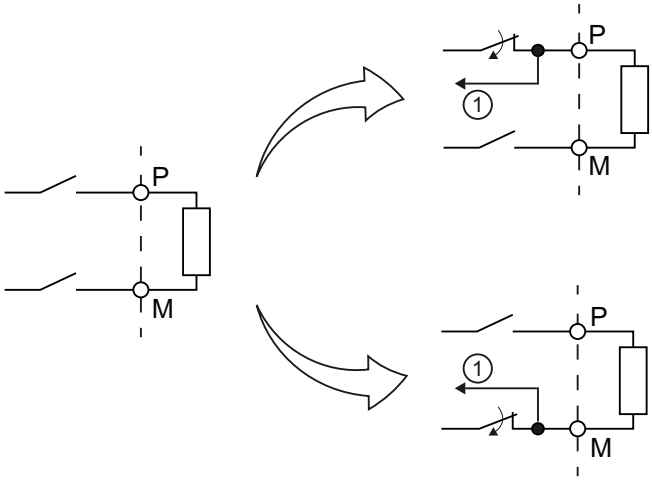

① Readback

Figure 2-1632 Functional principle of the switch on test (PM switching)

This parameter allows you to set the time for the readback. If the signal was not read back correctly once the time has expired, the output channel is passivated.

The switch on test detects the following faults:

- Short circuit to L+ with output signal "0"
- Short circuit to ground with output signal "0"

⚠ WARNING

Through the configured readback time, short circuits (cross-circuits) to an interfering signal with a frequency > 1 / (2 x configured readback time) Hz can be suppressed (50:50 sampling ratio).

Short circuits (cross-circuits) to an output of the same module are recognized.

Setting readback time

Because the fault reaction time is extended by the length of the set readback time, we recommend that you set the readback time by trial and error as low as possible but high enough that the output channel is not passivated.

To determine the readback time required for your actuator, refer to the diagram in the chapter Switching capacitive loads (Page 72).

If the capacity of the actuator is not known, it may be necessary for you to determine the required value for the readback time by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the readback time switch on test in such a way that the output channel can be read back correctly but your actuator does not respond yet.
- If the output channel is passivated sporadically, set a higher value for the maximum readback time switch on test.
- If the output channel is passivated, the readback time switch on test is too small for a connected capacitive load. The charge of the capacitive load cannot take place within the configured readback time switch on test. Increase the readback time.

If you have set the readback time to the maximum value of 5 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

4.2.5.7 Activated light test

Function

Overload and wire break are detected with a 0 signal at the output.

For a light test, several test signals are switched to the output channel while the output channel is inactive (output signal "0"). The output channel is switched on briefly during the light test (= "light period") and read back. A sufficiently slow actuator does not respond to this and remains switched off.

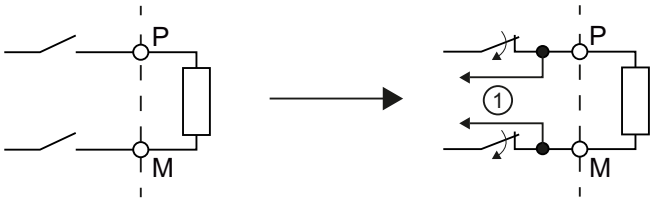

① Readback

Figure 2-1633 Functional principle of the light test (PM switching)

In contrast to the switch on test, the P-switch and the M-switch switch at the same time during the light test and power flows through the connected load.

If the readback signals are incorrect, the signal is present for the configured readback time at the output channel before the fault causes passivation of the output channel.

If the signal was not read back correctly once the maximum readback time switch on test has expired, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time switch on test for the light test increases the response time of the F-module.

Test pulses of the light test

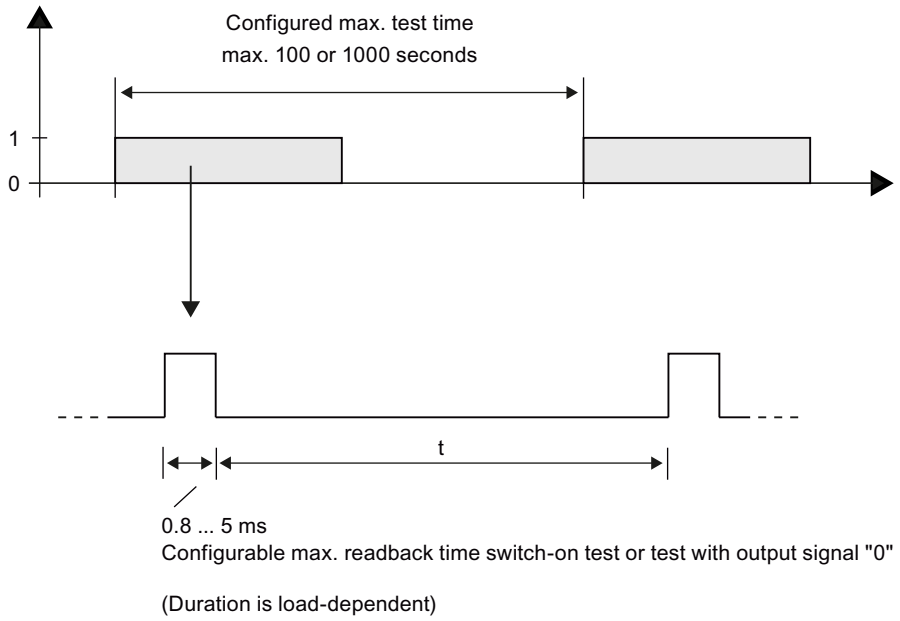

Figure 2-1634 Test pulses of the light test

The distance between two test pulses (t) depends on the parameter assignment. Additional information is available in Minimum distance of test pulses (Page 71).

If a light pulse returns a fault, the same light pulse (which means the same bit pattern) is repeated once after t. If the fault is still present, the maximum test time is automatically reduced to 60 seconds and a diagnostic message is generated. If the fault is no longer present, the output channel is reintegrated after the next fault-free test cycle.

4.2.5.8 Diagnosis: Wire break

You can use a wire break test to monitor the connection from the output channel to the actuator.

Selecting this check box enables the wire break monitoring for the relevant channel.

Wire break is signaled when the following conditions are met:

- Wiring to the actuator is interrupted.
- A module that is disabled in fail-safe mode by the F-PM module has been removed.

You also have to activate the light test to detect a wire break with an output signal "0".

4.3 Address space

Address assignment of power module F-PM-E 24VDC/8A PPM ST

The F-PM-E 24VDC/8A PPM ST power module occupies the following address areas in the F-CPU:

Table 2-2124 Address assignment in the F-CPU

Occupied bytes in the F-CPU:	
In input range	**In output range**
x + 0 to x + 6	x + 0 to x + 4

x = Module start address

Address assignment of the user data and value status of power module F-PM-E 24VDC/8A PPM ST

Of the assigned addresses of power module F-PM E 24VDC/8A PPM ST, the user data occupy the following addresses in the F-CPU:

Table 2-2125 Address assignment of user data **in the input range**

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
x + 0	—	—	—	—	—	—	DI_1	DI_0
x + 1	—	—	—	—	—	—	Value status for DI_1	Value status for DI_0
x + 2	—	—	—	—	—	—	—	Value status DQ_0

x = Module start address

Table 2-2126 Address assignment of user data **in the output range**

Byte in the F-CPU	Assigned bits in F-CPU per F-module:							
	7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
x + 0	—	—	—	—	—	—	—	DQ_0

x = Module start address

NOTE

You may only access the addresses occupied by user data and value status.

The other address areas occupied by the F-modules are assigned for functions including safety-related communication between the F-modules and F-CPU in accordance with PROFIsafe.

1oo2 evaluation of the sensors combines the two channels. With 1oo2 evaluation of the sensors you may only access the low order channel in the safety program.

Additional information

For detailed information about F-I/O access, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

See also

Value status (Page 63)

Applications of the F-I/O module 5

5.1 Applications for the output DQ/P1 and P2

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving the various safety categories.

Table 2-2127 Conditions for achieving SIL/Cat./PL

F-PM-E 24VDC/8A PPM ST		Achievable safety class
Digital output DQ	Without standard DQ modules	SIL3/Cat.4/PLe
	With standard DQ modules	SIL2/Cat.3/PLd

5.1.1 Applications: Safety mode up to SIL3/Cat.4/PLe

Wiring

The wiring is carried out on the matching BaseUnit (Page 10).

5.1.1.1 Application: Wiring a load to the digital output, PM switching

The fail-safe digital output consists of two P-switches for DQ-P_0 and one M-switch for DQ-M_0. They connect the load between the P-switches DQ-P_0 and the M-switch DQ-M_0. The two P-switches and the M-switch are always activated so that voltage is applied to the load. This circuit achieves SIL3/Cat.4/PLe.

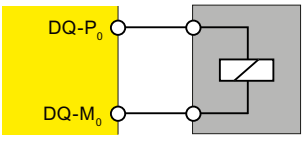

Figure 2-1635 Wiring diagram of power module F-PM-E 24VDC/8A PPM ST

WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator, for example, in accordance with IEC 60947.

Parameter assignment

Assign the following parameter for the corresponding channel:

Table 2-2128 Parameters

Parameter	
Output type	PM switching

5.1.1.2 Application: Wiring a load to the digital output, PP switching

The fail-safe digital output consists of two P-switches for DQ-P_0 and one M-switch for DQ-M_0. You connect the load between the P-switch DQ-P_0 and chassis in this case. The two P-switches are always activated so that voltage is applied to the load. This circuit achieves SIL3/Cat.4/PLe.

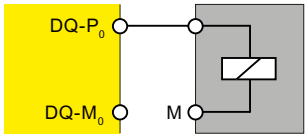

Figure 2-1636 Wiring diagram of power module F-PM-E 24VDC/8A PPM ST

⚠ WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator, for example, in accordance with IEC 60947.

Parameter assignment

Assign the following parameter for the corresponding channel:

Table 2-2129 Parameters

Parameter	
Output type	PP switching

5.1.1.3 Application: Wiring two loads in parallel to the digital output, PM switching

You achieve SIL3/Cat.4/PLe with the following wiring variant.

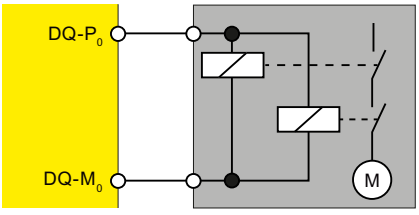

Figure 2-1637 Wiring diagram for connecting two relays each in parallel to F-DQ of power module F-PM-E 24VDC/8A PPM ST

NOTE

When two relays are connected in parallel to one digital output (as shown above), a wire break is only detected if the wire break disconnects both relays from P or M. The diagnostics generated in the process is not safety-related.

Parameter assignment

Assign the following parameter for the corresponding channel:

Table 2-2130 Parameters

Parameter	
Output type	PM switching

5.1.1.4 Application: Wiring two loads in parallel to the digital output, PP switching

You achieve SIL3/Cat.4/PLe with the following wiring variant.

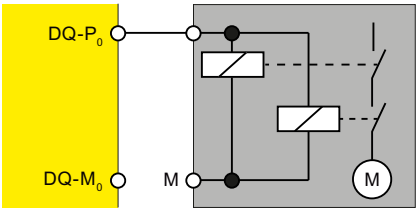

Figure 2-1638 Wiring diagram for connecting two relays each in parallel to F-DQ of power module F-PM-E 24VDC/8A PPM ST

NOTE

When two relays are connected in parallel to one digital output (as shown above), a wire break is only detected if the wire break disconnects both relays from P or M. The diagnostics generated in the process is not safety-related.

Parameter assignment

Assign the following parameter for the corresponding channel:

Table 2-2131 Parameters

Parameter	
Output type	PP switching

5.2 Applications for inputs

5.2.1 Applications of the electronic module

Selecting the application

The diagram below supports you in selecting the application that suits your fail-safe requirements. In the following sections, you will learn how to wire the F-module, the specific parameters you must assign in STEP 7 Safety and the errors that are detected.

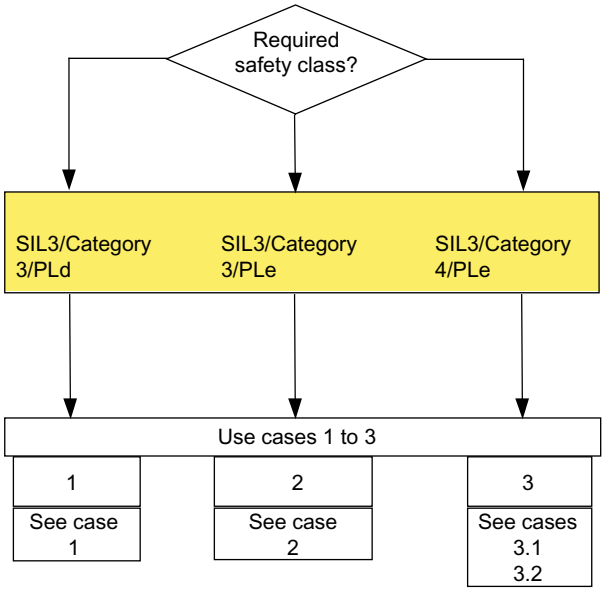

Figure 2-1639 Selecting the application – digital inputs of the F-PM-E 24VDC/8A PPM ST

WARNING

The achievable safety class depends on the quality of the sensor and the duration of the proof-test interval in accordance with IEC 61508:2010. If the quality of the sensor is lower than the quality required by the safety class, redundant sensors connected via two channels must be used and evaluated.

Conditions for achieving SIL/Cat./PL

The table below lists the conditions which have to be met for achieving at least the corresponding safety requirements.

Table 2-2132 Conditions for achieving SIL/Cat./PL

Application	Sensor evaluation	Sensor supply	Achievable SIL/Cat./PL
1	1oo1	Any	3 / 3 / d
2	1oo2 equivalent	Internal, without short circuit test	3 / 3 / e
		External	
3.1	1oo2 equivalent	Internal, with short circuit test	3 / 4 / e
3.2	1oo2 non-equivalent	External/internal, with short circuit test	

Sensor requirements

Information on safety-related use of sensors is available in the section Requirements for sensors and actuators for fail-safe modules in the ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

5.2.2 Application 1: Safety mode SIL3/Cat.3/PLd

Wiring

The wiring is carried out on the matching BaseUnit (Page 10).

Sensor supply

The sensor supply can be powered internally or externally.

Wiring diagram – connecting one sensor via one channel

One sensor is connected via one channel (1oo1 evaluation) for each process signal. Any sensor supply of the module can be assigned to each input.

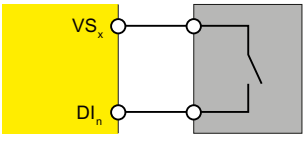

Figure 2-1640 One sensor connected via one channel, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

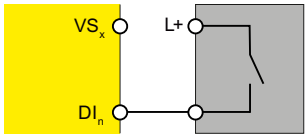

Figure 2-1641 One sensor connected via one channel, external sensor supply

WARNING

To achieve SIL3/Cat.3/PLd using this wiring, you must use a qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 2-2133 Parameter assignment

Parameters	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo1 evaluation	
Short circuit test	• disable • enable	disable
Sensor supply	• Sensor supply n	External sensor supply*

*) Otherwise a diagnostic message will be generated when short circuit test is activated.

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 2-2134 Fault detection

Fault	Fault detection		
	Internal sensor supply and short circuit test activated	Internal sensor supply and short circuit test deactivated	External sensor supply
Short circuit with other channels or other sensor supplies (short circuit with other channels is detected only if they use a different sensor supply)	yes*	no	no
Short circuit with L+ to DI_n	yes	no	no
Short circuit with M to DI_n	yes*	yes*	no
Discrepancy error	—	—	—
Short circuit with L+ to VS_n	yes	no	—
Short circuit with M to VS_n or defective	yes	yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal. If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

WARNING

If the short circuit test is not activated or the sensor supply to digital inputs is set to "External sensor supply", the wiring between the sensor and the input channel must be short circuit proof.

5.2.3 Application 2: Safety mode SIL3/Cat.3/PLe

Assigning inputs to each other

The F-PM-E 24VDC/8A PPM ST power module has two fail-safe inputs, DI_0 and DI_1 (SIL3). You can combine the two inputs into one input.

The process signal is supplied by channel DI_0.

Wiring

The wiring is carried out on the matching BaseUnit (Page 10).

Sensor supply

The sensor supply can be powered internally or externally.

Wiring diagram – connecting a two-channel sensor via two channels

A two-channel sensor is connected equivalent to two inputs of the F-module for each process signal (1oo2 evaluation).

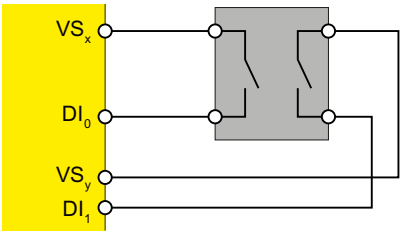

Figure 2-1642 One two-channel sensor connected via two channels, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

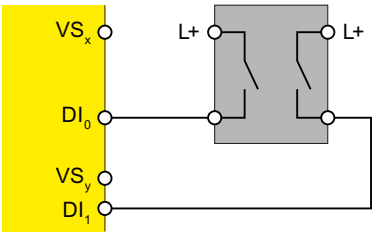

Figure 2-1643 One two-channel sensor connected via two channels, external sensor supply

Wiring diagram – connecting two single-channel sensors via two channels

Two single-channel sensors that capture the same process value are connected to two inputs of the F-module for each process signal (1oo2 evaluation).

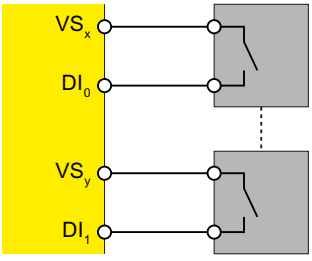

Figure 2-1644 Two single-channel sensors connected via two channels, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

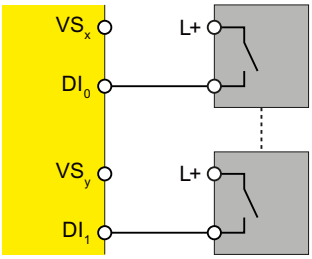

Figure 2-1645 Two single-channel sensors connected via two channels, external sensor supply

WARNING

To achieve SIL3/Cat.3/PLe using this wiring, you must use a qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 2-2135 Parameter assignment

Parameter	Channel with internal sensor supply	Channel with external sensor supply
Sensor evaluation	1oo2 evaluation, equivalent	
Short circuit test	• disable • enable	disable

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 2-2136 Fault detection

Fault	Fault detection	
	Internal sensor supply and short circuit test deactivated	External sensor supply
Short circuit within the channel pair, with other channels or other sensor supplies	no	no
Short circuit with L+ to DI_n	yes*	yes*
Short circuit with M to DI_n	yes*	yes*

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

Fault	Fault detection	
	Internal sensor supply and short circuit test deactivated	External sensor supply
Discrepancy error	yes	yes
Short circuit with L+ to VS_n	no	no
Short circuit with M to VS_n or defective	yes	—

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

5.2.4 Application 3: Safety mode SIL3/Cat.4/PLe

Assigning inputs to each other

The F-PM-E 24VDC/8A PPM ST power module has two fail-safe inputs, DI_0 and DI_1 (SIL3). You can combine the two inputs into one input.

The process signal is supplied by channel DI_0.

Wiring

The wiring is carried out on the matching BaseUnit (Page 10).

Sensor supply

The sensor must be supplied **internally** for application 3.1 (Page 44).

The sensor can be supplied internally or externally for application 3.2 (Page 45).

Requirements for applications in machine protection with Cat.4

Both conditions must be met for applications in machine protection with Cat.4:

- The wiring between sensors and automation system and between automation system and actuators must be designed to state-of-the-art engineering and standards to prevent short circuits.
- All short circuits listed in Fault detection and Fault detection must be detected. You only need to detect **one** short circuit because two faults are required to generate it. This means both signal cables in short circuit have an isolation fault. A multiple short circuit analysis is not required.

Procedures for locating all short circuits are also permitted if single short circuits are not located. One of the two conditions must be met for this purpose:

- Short circuits may not corrupt the read signals compared to the sensor signals.
- Short circuits cause a corruption of the read signals compared to sensor signals in the direction that ensures safety.

5.2.4.1 Application 3.1 (SIL3/Cat.4/PLe)

Wiring diagram – connecting a two-channel sensor via two channels

A two-channel sensor is connected to both inputs of the power module for each process signal (1oo2 evaluation).

Supply the sensors from two different sensor supplies.

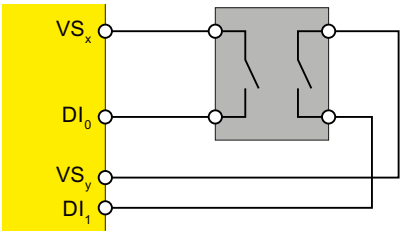

Figure 2-1646 One two-channel sensor connected via two channels, internal sensor supply

You can also connect two single-channel sensors via two channels. In this case, the same process variable is acquired with two mechanically separate sensors.

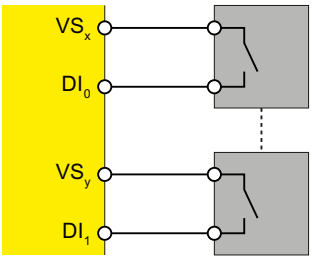

Figure 2-1647 Two single-channel sensors connected via two channels, internal sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 2-2137 Parameter assignment

Parameter	Channel with internal sensor supply
Sensor evaluation	1oo2 evaluation, equivalent
Short circuit test	enable
Sensor supply	• Sensor supply n • External sensor supply

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 2-2138 Fault detection

Fault	Fault detection
Short circuit within the channel pair, with other channels or other sensor supplies	yes*
Short circuit with L+ to DI_n	yes* / yes (for channel whose short circuit test is activated)
Short circuit with M to DI_n	yes*
Discrepancy error	yes
Short circuit with L+ to VS_n	yes
Short circuit with M to VS_n or defective	yes

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

5.2.4.2 Application 3.2 (SIL3/Cat.4/PLe)

Wiring diagram – connecting a nonequivalent sensor nonequivalent via two channels

A nonequivalent sensor is connected nonequivalent via 2 channels to both inputs of the power module for each process signal (1oo2 evaluation, nonequivalent).

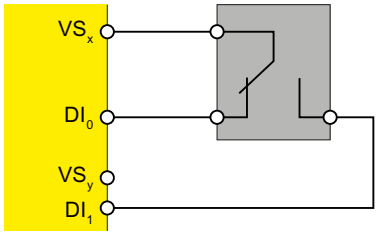

Figure 2-1648 Nonequivalent sensor connected, internal sensor supply

You can also supply the sensor by means of an external sensor supply.

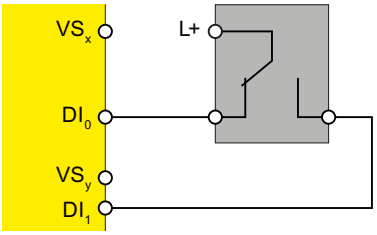

Figure 2-1649 Nonequivalent sensor connected, external sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Wiring diagram – connecting two single-channel sensors nonequivalent via two channels

Two single-channel sensors are connected nonequivalent to both inputs of the power module for each process signal (1oo2 evaluation).

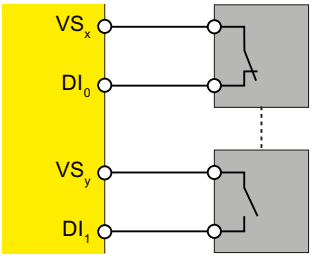

Figure 2-1650 Two single-channel sensors connected nonequivalent, internal sensor supply

You can also supply the sensors by means of an external sensor supply.

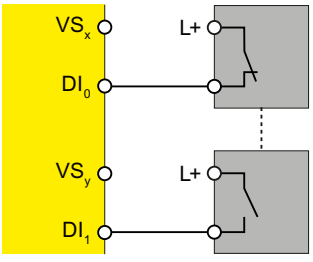

Figure 2-1651 Two single-channel sensors connected nonequivalent, external sensor supply

WARNING

To achieve SIL3/Cat.4/PLe using this wiring, you must use a suitably qualified sensor.

Parameter assignment

Assign the following parameters for the corresponding channel:

Table 2-2139 Parameter assignment

Parameters	
Sensor evaluation	1oo2 evaluation, non equivalent
Short circuit test	• disable • enable
Sensor supply	• Sensor supply n • External sensor supply

Fault detection

The following table presents fault detection according to the sensor supply and the parameter assignment for the short circuit test:

Table 2-2140 Fault detection

Fault	Fault detection
Short circuit within the channel pair, with other channels or other sensor supplies	yes
Short circuit with L+ to DI_n	yes* / yes (for channel whose short circuit test is activated)
Short circuit with M to DI_n	yes*
Discrepancy error	yes
Short circuit with L+ to VS_n	yes, if used
Short circuit with M to VS_n or defective	yes, if sensor supply is activated

*) Fault detection only if signals are corrupted. That is, the read signal differs from the sensor signal (discrepancy error). If there is no signal corruption with respect to the sensor signal, fault detection is not possible and is not required from a safety standpoint.

5.3 Application for internal evaluation

Function

The evaluation of the safety function takes place internally in the F-module.

You can choose between 1oo1 evaluation or nonequivalent/equivalent 1oo2 evaluation of the sensors.

- With 1oo1 evaluation, the activated inputs are logically ANDed with the process image of output DQ_0.
- With 1oo2 evaluation, the result of the inputs is logically ANDed with the process image of output DQ_0.

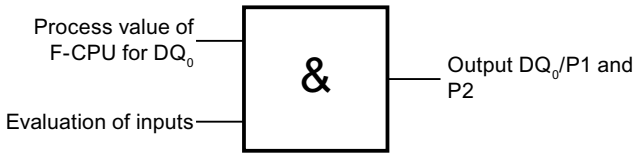

The acknowledgment in case of an error takes place by the safety program in the F-CPU.

Use the wiring diagrams Applications for the output DQ/P1 and P2 (Page 34) and Applications for inputs (Page 37).

You achieve SIL3/Cat.4/PLe.

WARNING

In order to achieve SIL3/Cat.4/PLe with this wiring, you must install a qualified actuator and sensor, for example, in accordance with IEC 60947.

NOTE

If an error occurs at the inputs in this application, the F-module also outputs the error message "Safety-related shutdown" or "Safety event" for the output. Following elimination of the error at the inputs, a reintegration of the output is only possible after the bit pattern test (within the test time shortened to 60 s) has been performed.

Interconnection example

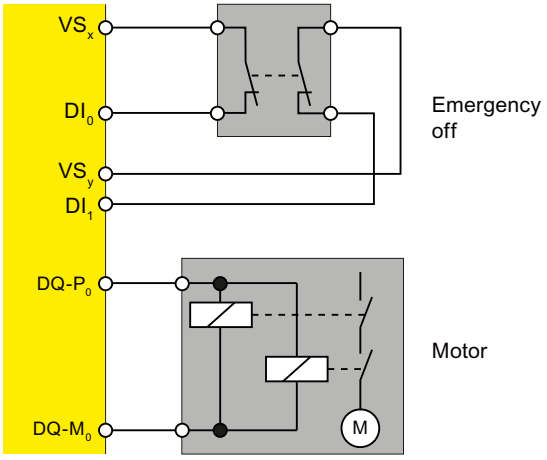

Figure 2-1652 Emergency Off shutdown of a motor with equivalent 1oo2 evaluation

Parameter assignment

Assign the following parameters for the F-module:

Parameter	
Control of the output	F-CPU and onboard F-DI
Type of sensor interconnection	• 1-channel • 2-channel equivalent • 2-channel, non equivalent
Sensor supply	Sensor supply 0, Sensor supply 1, or External sensor supply

5.4 Applications for safety-related shutdown of standard modules

5.4.1 Safety-related shutdown of standard output modules, PM-switching

The F-PM-E 24VDC/8A PPM ST power module opens, together with the matching BaseUnit, a new potential group . Standard DQ modules that you use in the potential group can undergo a safety-related shutdown by the F-PM-E 24VDC/8A PPM ST power module. For this, the F-PM-E 24VDC/8A PPM ST power module performs a safety-related shutdown of voltage buses P1 and P2.

Configure the power module parameters as described in section Terminal assignment (Page 10).

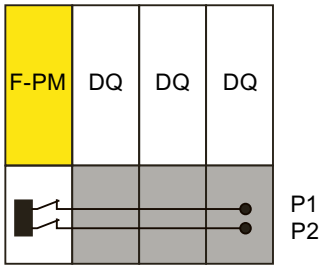

Figure 2-1653 Safety-related shutdown of standard output modules

You achieve SIL2/Cat.3/PLd with safety-related shutdown of standard DQ modules.

WARNING

Safety-related activation of standard DQ module outputs is not possible; only safety-related **shutdown** is possible. You must therefore take the following possible effects into consideration:

In the worst case scenario, you must consider all possible faults of the standard DQ modules and the program controlling them for which there is no direct fault detection. For example, the F-PM-E 24VDC/8A PPM ST and F-DQ 4×24VDC/2A PM HF do not detect external short circuits to L+ at the standard DQ module outputs. All faults of the standard DQ modules act on the process via final controlling elements. The process must be made known to the F-CPU by way of sensors and a corresponding safety program.

Because safety-critical faults in the standard DQ modules cannot be detected by self-tests within the module, the "diagnostics" must be performed indirectly via the controlled process. As long as the incorrectly controlled process does not pose a hazard, the safety-related control does not intervene It only performs a shutdown if the process exhibits unwanted or potentially dangerous behavior.

It therefore follows that the reaction times for faults within standard DQ modules are not based on the specified short fault detection times of S7 but rather depend on the controlled process and the evaluation of feedback from the process.

Safety-related process values must be

- safely
- read in by way of fail-safe inputs or fail-safe input modules (e.g., F-DI)
- the safety function must be evaluated locally in the power module F-PM-E 24VDC/8A PPM ST or processed by the fail-safe CPU to form output commands and
- output by the fail-safe output module for shutdown of the corresponding safety relay or
- output by the F-PM-E 24VDC/8A PPM ST fail-safe power module.

If the expectations at the process end are not met (due to a process malfunction or faulty standard DO modules), the standard DQ modules must be brought to a safe state by way of the higher-level safety circuit.

The process safety time is of particular importance here. During this process safety time, no hazard is posed by an incorrectly controlled process.

The safety program must react in a safety-related and logical manner to unwanted or potentially dangerous states in the process via the F-PM-E 24VDC/8A PPM ST, F-DQ 4×24VDC/2A PM HF and fail-safe output modules.

If you want to avoid the problems described above completely, we recommend that you use the PM-switching F-DQ 4×24VDC/2A PM HF module instead of standard DQ modules.

WARNING

Always connect the 24 V DC supply for the standard ET 200SP modules to the F-PM-E 24VDC/8A PPM ST. Otherwise, the outputs of DQ modules may exhibit safety-critical behavior.

WARNING

When supplying standard DQ modules, always use the BaseUnits of these modules to supply the actuators (actuator feedback on the DQ module).

See also Terminal assignment (Page 10).

WARNING

Note the following for the "Safety-related shutdown of standard modules" application:

If standard modules behind a F-PM-E 24VDC/8A PPM ST power module are exposed to surge conditions, immunity according to failure criterion B is achieved (according to EN 298 and IEC 61326-3-2), i.e., the standard modules may fail in the event of surge conditions.

5.4.2 Safety-related shutdown of standard output modules, PP-switching

The F-PM-E 24VDC/8A PPM ST power module opens, together with the matching BaseUnit, a new potential group . Standard DQ modules that you use in the potential group can undergo a safety-related shutdown by the F-PM-E 24VDC/8A PPM ST power module. For this, the F-PM-E 24VDC/8A PPM ST power module performs a safety-related shutdown of voltage bus P1.

Configure the power module parameters as described in section Terminal assignment (Page 10).

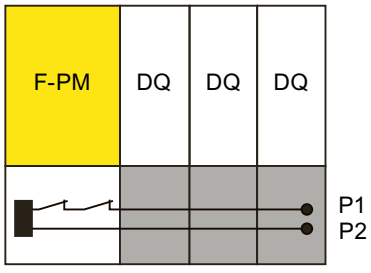

Figure 2-1654 Safety-related shutdown of standard output modules

You achieve SIL2/Cat.3/PLd with safety-related shutdown of standard DQ modules.

WARNING

Safety-related activation of standard DQ module outputs is not possible; only safety-related **shutdown** is possible. You must therefore take the following possible effects into consideration:

In the worst case scenario, you must consider all possible faults of the standard DQ modules and the program controlling them for which there is no direct fault detection. For example, the F-PM-E 24VDC/8A PPM ST and F-DQ 4×24VDC/2A PM HF do not detect external short circuits to L+ at the standard DQ module outputs. All faults of the standard DQ modules act on the process via final controlling elements. The process must be made known to the F-CPU by way of sensors and a corresponding safety program.

Because safety-critical faults in the standard DQ modules cannot be detected by self-tests within the module, the "diagnostics" must be performed indirectly via the controlled process. As long as the incorrectly controlled process does not pose a hazard, the safety-related control does not intervene It only performs a shutdown if the process exhibits unwanted or potentially dangerous behavior.

It therefore follows that the reaction times for faults within standard DQ modules are not based on the specified short fault detection times of S7 but rather depend on the controlled process and the evaluation of feedback from the process.

Safety-related process values must be

- safely
- read in by way of fail-safe inputs or fail-safe input modules (e.g., F-DI)
- the safety function must be evaluated locally in the power module F-PM-E 24VDC/8A PPM ST or processed by the fail-safe CPU to form output commands and
- output by the fail-safe output module for shutdown of the corresponding safety relay or
- output by the F-PM-E 24VDC/8A PPM ST fail-safe power module.

If the expectations at the process end are not met (due to a process malfunction or faulty standard DO modules), the standard DQ modules must be brought to a safe state by way of the higher-level safety circuit.

The process safety time is of particular importance here. During this process safety time, no hazard is posed by an incorrectly controlled process.

The safety program must react in a safety-related and logical manner to unwanted or potentially dangerous states in the process via the F-PM-E 24VDC/8A PPM ST, F-DQ 4×24VDC/2A PM HF and fail-safe output modules.

If you want to avoid the problems described above completely, we recommend that you use the PM-switching F-DQ 4×24VDC/2A PM HF module instead of standard DQ modules.

WARNING

Always connect the 24 V DC supply for the standard ET 200SP modules to the F-PM-E 24VDC/8A PPM ST. Otherwise, the outputs of DQ modules may exhibit safety-critical behavior.

WARNING

When supplying standard DQ modules, always use the BaseUnits of these modules to supply the actuators (actuator feedback on the DQ module).

See also Terminal assignment (Page 10).

WARNING

Note the following for the "Safety-related shutdown of standard modules" application:

If standard modules behind a F-PM-E 24VDC/8A PPM ST power module are exposed to surge conditions, immunity according to failure criterion B is achieved (according to EN 298 and IEC 61326-3-2), i.e., the standard modules may fail in the event of surge conditions.

Interrupts/diagnostic messages

6

6.1 Status and error display

LED display

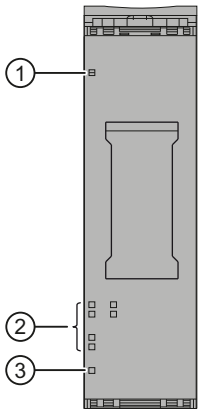

① DIAG (green/red)

② Channel status (green), channel fault (red)

③ PWR (green)

Figure 2-1655 LED display

Meaning of the LED displays

The following tables explain the meaning of the status and error displays. Remedies for diagnostic messages can be found in section Diagnostic messages (Page 58).

WARNING

The DIAG LED and the channel status and channel fault LEDs of the inputs and outputs are not designed as safety-related LEDs and therefore may not be evaluated for safety-related activities.

PWR LED

Table 2-2141 Meaning of the PWR LED

PWR	Meaning
□ Off	Supply voltage L+ missing
■ On	Supply voltage L+ available

DIAG LED

Table 2-2142 Meaning of the DIAG LED

DIAG	Meaning
□ Off	Backplane bus supply of the ET 200SP not okay
☼ Flashing	Module parameters not configured
■ On	Module parameters configured and no module diagnostics
☼ Flashing	Module parameters configured and module diagnostics

Channel status/channel fault LED

Table 2-2143 Meaning of the channel status/channel fault LED

Channel status	Channel fault	Meaning
□ Off	□ Off	Process signal = 0 and no channel diagnostics
■ On	□ Off	Process signal = 1 and no channel diagnostics
□ Off	■ On	Process signal = 0 and channel diagnostics
/ Alternately flashing		Channel waiting for user acknowledgment

Channel status/DIAG/channel fault LED

Table 2-2144 Meaning of the channel status/DIAG/channel fault LED

Channel status	DIAG	Channel fault	Meaning
Off	Flashing	All On	The PROFIsafe address does not match the configured PROFIsafe address
Flashing	Flashing	Off	Identification of the F-module when assigning the PROFIsafe address

6.2 Interrupts

Introduction

The F-PM-E 24VDC/8A PPM ST fail-safe power module supports diagnostic interrupts.

Diagnostic interrupt

The F-module generates a diagnostic interrupt for each diagnostic message described in section Diagnostic messages (Page 58).

The table below provides an overview of the diagnostic interrupts of the F-module . The diagnostic interrupts are assigned either to one channel or the entire F-module.

WARNING

Before acknowledging the short circuit diagnostic message, remedy the respective fault and validate your safety function. Follow the fault remedying procedure described in section Diagnostic messages (Page 58).

Table 2-2145 Diagnostic interrupts of the F-PM-E 24VDC/8A PPM ST

Diagnostic interrupt	Fault code	Signaled in application	Scope of diagnostic interrupt	Configurable
Overtemperature	5_D	—	F-module	No
Parameter assignment error	16_D			
Load voltage missing	17_D			
Access to retentive storage of F-address not possible	30_D			
Different destination address (F_Dest_Add)	64_D			
Invalid destination address (F_Dest_Add)	65_D			
Invalid source address (F_Source_Add)	66_D			
Watchdog time is 0 ms (F_WD_Time or F_WD_Time2)	67_D			
"F_SIL" parameter exceeds the application-specific SIL	68_D			
"F_CRC_Length" parameter does not match the generated CRC	69_D			

Diagnostic interrupt	Fault code	Signaled in application	Scope of diagnostic interrupt	Configurable
Incorrect F-parameter version or F_Block_ID	70_D	—	F-module	No
CRC1 error	71_D			
Inconsistent iParameters (iParCRC error)	75_D			
F_Block_ID not supported	76_D			
Internal error	256_D			
Time monitoring activated	259_D			
Internal supply voltage of the module failed	260_D			
Output short-circuited to L+	261_D		Channel	Yes
Output short-circuited to ground	262_D			
Wire break	265_D			
Incorrect/inconsistent firmware present. Firmware update required	283_D			No
Discrepancy error, channel status 0/0	768_D	2, 3		
Discrepancy error, channel status 0/1	769_D			
Discrepancy error, channel status 1/0	770_D			
Discrepancy error, channel status 1/1	771_D			
Input signal could not be clearly detected	773_D	1, 2, 3		
Short circuit of internal sensor supply to L+	774_D			Yes
Overload or short circuit of internal sensor supply to ground	775_D			
No pulse detected	778_D	1		
Sensor signal chatters	784_D			
Switching frequency too high	785_D	1,2,3		No
Undertemperature	786_D		F-module	
Fault in input circuit	787_D			
PROFIsafe communication error (timeout)	792_D			
PROFIsafe communication error (CRC)	793_D			
PROFIsafe address assignment error	794_D			
Input short-circuited to L+	796_D		Channel	Yes
Output defective	797_D	—		No
Readback error	798_D			
Overload	800_D			
Supply voltage too high	802_D	1, 2, 3	F-module	
Supply voltage too low	803_D			

6.3 Diagnostic messages

Digital module error types

Module faults are indicated as diagnostics (module status).

Once the fault is eliminated, the F-module must be reintegrated in the safety program. For additional information on passivation and reintegration of F-I/O, refer to the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Table 2-2146 Diagnostic messages of the F-PM-E 24VDC/8A PPM ST

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_D	An excessively high temperature was measured in the F-module.	Operate the F-module within the specified temperature range. (see Technical specifications (Page 64)) Once the fault has been eliminated, the F-module must be removed and inserted or the power switched OFF and ON
Wire break	6_D	Possible causes: • There is an interrupted cable between the module and actuator. • The channel is not connected (open). • There is a short circuit between channels with different signals.	• Establish a cable connection. • Disable the wire break detection for the channel in the parameter assignment. • Eliminate the short circuit.
Parameter assignment error	16_D	Parameter assignment errors include: • The F-module cannot use the parameters (unknown, invalid combination, etc.). • The F-module parameters have not been configured.	Correct the parameter assignment.
Load voltage missing	17_D	Missing or insufficient supply voltage L+	• Check supply voltage L+ at BaseUnit • Check BaseUnit type
Access to retentive storage of F-address not possible	30_D	The F-destination address stored in the coding element cannot be accessed.	Verify that the coding element is present or replace the coding element.
Different destination address (F_Dest_Add)	64_D	The PROFIsafe driver has detected a different F-destination address.	Check the parameter assignment of the PROFIsafe driver and the address setting of the F-module.
Invalid destination address (F_Dest_Add)	65_D	The PROFIsafe driver has detected an invalid F-destination address.	Check the parameter assignment of the PROFIsafe driver.
Invalid source address (F_Source_Add)	66_D	The PROFIsafe driver has detected an invalid F-source address.	
Watchdog time is 0 ms (F_WD_Time or F_WD_Time2)	67_D	The PROFIsafe driver has detected an invalid watchdog time.	
"F_SIL" parameter exceeds the application-specific SIL	68_D	The PROFIsafe driver has detected a discrepancy between the SIL setting of the communication and the application.	
"F_CRC_Length" parameter does not match the generated CRC	69_D	The PROFIsafe driver has detected a discrepancy in the CRC length.	

Diagnostic message	Fault code	Meaning	Remedy
Incorrect F-parameter version or F_Block_ID	70_D	The PROFIsafe driver has detected an incorrect version of the F-parameters or an invalid F_Block_ID.	Check the parameter assignment of the PROFIsafe driver.
CRC1 error	71_D	The PROFIsafe driver has detected inconsistent F-parameters.	
Inconsistent iParameters (iParCRC error)	75_D	The PROFIsafe driver has detected inconsistent iParameters.	Check the parameter assignment.
F_Block_ID not supported	76_D	The PROFIsafe driver has detected an incorrect Block ID.	Check the parameter assignment of the PROFIsafe driver.
Internal error	256_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate the interference. The module must then be pulled and plugged, or the power switched OFF and ON • Replace the F-module.
Internal supply voltage of the module failed	260_D	Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate the electromagnetic interference. The module must then be pulled and plugged, or the power switched OFF and ON • Replace the F-module.
Output short-circuited to L+	261_D	Short circuit to L+ can mean: • The sensor cable is short-circuited to L+. • The output cable is short-circuited to L+.	Correct the process wiring.
Output short-circuited to ground	262_D	Short circuit to ground can mean: • The sensor cable is short-circuited to ground. • The output cable is short-circuited to ground. • The output signal is short-circuited to ground.	Correct the process wiring.
Incorrect/inconsistent firmware present. Firmware update required	283_D	The firmware is incomplete and/or firmware added to the F-module is incompatible. This leads to errors or functional limitations when operating the F-module.	• Perform a firmware update for all parts of the F-module and note any error messages. • Use only firmware versions released for this F-module.
Discrepancy error, channel status 0/0	768_D	Possible causes: • The process signal is faulty. • The sensor is defective. • The configured discrepancy time is too low. • There is a short circuit between an unconnected sensor cable and the sensor supply cable. • Wire break in connected sensor cable or the sensor supply cable • An error occurred during the discrepancy check.	• Check the process signal. • Replace the sensor. • Check the parameter assignment of the discrepancy time. • Check the process wiring.
Discrepancy error, channel status 0/1	769_D		
Discrepancy error, channel status 1/0	770_D		
Discrepancy error, channel status 1/1	771_D		

Diagnostic message	Fault code	Meaning	Remedy
Input signal could not be clearly detected	773_D	An error occurred in the plausibility check of the input signal between the processors. You must eliminate the error within 100 hours. If you do not eliminate the error within 100 hours, the F-module will become inoperative. Possible causes: • The input signal is faulty, e.g., as a result of impermissibly high electromagnetic interference. • A high-frequency input signal is present, e.g., due to mutual interference of sensors or the signal being above the sampling frequency of the input signal. • A momentary interruption/short circuit of the sensor cable (loose contact) is present. • The sensor/switch is bouncing.	• Use shielded cables to reduce the EMC effects. • Reduce the input frequency. • Check the wiring of the sensor.
Short circuit of internal sensor supply to L+	774_D	Possible causes: • There is a short circuit of the internal sensor supply with L+. • There is a short circuit of two sensor supplies. • The capacitance of the connected sensor for the configured test time is too high. • The sensor is defective.	• Eliminate the short circuit in the process wiring. • Check the configured test time and the process wiring. • Replace the sensor.
Overload or short circuit of internal sensor supply to ground	775_D	Possible causes: • The internal sensor supply is short-circuited to ground. • Impermissibly high electromagnetic interference is present.	• Eliminate the overload. • Eliminate the short circuit in the process wiring. • Check the "Sensor supply" parameter. • Eliminate/reduce the electromagnetic interference.
No pulse detected	778_D	A pulse with a length greater than or equal to "Minimum pulse time" has not occurred within the time configured with the "Pulse monitoring window" parameter. Possible causes: • The "Pulse monitoring window" parameter setting is too low. • The "Minimum pulse time" parameter setting is too high. • There is a wire break in the process wiring.	• Check the "Pulse monitoring window" parameter. • Check the "Minimum pulse time" parameter. • Check the process wiring.

Diagnostic message	Fault code	Meaning	Remedy
Sensor signal chatters	784_D	Too many signal changes have occurred within the time configured with the "Monitoring window" parameter. • The "Monitoring window" parameter setting is too high. • The "Number of signal changes" parameter setting is too low. • A momentary interruption/short circuit of the sensor cable (loose contact) is present. • Impermissibly high electromagnetic interference is present. • The sensor is bouncing. • The sensor is defective.	• Check the "Monitoring window" parameter. • Check the "Number of signal changes" parameter. • Check the process wiring. • Eliminate/reduce the electromagnetic interference. • Replace the sensor.
Switching frequency too high	785_D	The maximum switching frequency of the F-module has been exceeded.	Reduce the switching frequency. (see Technical specifications (Page 64))
Undertemperature	786_D	The minimum permissible temperature limit has been violated.	Operate the F-module within the specified temperature range. (see Technical specifications (Page 64))
Fault in input circuit	787_D	The F-module has detected an internal error. Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	• Eliminate/reduce the electromagnetic interference. • Replace the F-module.
PROFIsafe communication error (timeout)	792_D	The PROFIsafe driver has detected a timeout. Possible causes: • The F-monitoring time is set incorrectly. • Bus faults are present.	• Check the parameter assignment. • Ensure that communication is functioning correctly.
PROFIsafe communication error (CRC)	793_D	The PROFIsafe driver has detected a CRC error. Possible causes: • The communication between the F-CPU and F-module is disturbed. • Impermissibly high electromagnetic interference is present. • An error occurred in the sign-of-life monitoring.	• Check the communication connection between the F-module and F-CPU. • Eliminate the electromagnetic interference.
PROFIsafe address assignment error	794_D	An error occurred during the automatic PROFIsafe address assignment.	Check the configuration.
Input short-circuited to L+	796_D	The input signal is short-circuited to L+.	Eliminate the short circuit.
Output defective	797_D	The F-module has detected an internal error. Possible causes: • Short circuit to L+ or M • The F-module is defective.	• Check the wiring. • Replace the F-module.

Diagnostic message	Fault code	Meaning	Remedy
Readback error	798_D	The F-module has detected an internal error. Possible causes: • Impermissibly high electromagnetic interference is present. • The F-module is defective.	If the error persists, replace the F-module.
Overload	800_D	The maximum permissible output current has been exceeded. The output stage has been switched off. Possible causes: • A short circuit exists.	Check the process wiring.
Supply voltage too high	802_D	The supply voltage is too high.	Check the supply voltage.
Supply voltage too low	803_D	The supply voltage is too low.	Check the supply voltage.

Supply voltage outside the nominal range

In the case of a voltage dip in the supply voltage L+, the DIAG LED flashes and the module is passivated.

When the voltage has recovered (level must remain above the specified value for at least 1 minute (see Technical specifications (Page 64): Voltages, Currents, Potentials)), the DIAG LED stops flashing. The module remains passivated.

Behavior in case of cross circuit/short circuit to the sensor supply

When internal sensor supply is specified and short circuit test is disabled, short circuits to ground at the sensor supplies are detected. Channels for which the relevant sensor supply is configured will be passivated.

When internal sensor supply is specified and short circuit test is enabled, short circuits to ground and potential at the sensor supply are detected. Channels for which the relevant sensor supply is configured will be passivated.

Special features for fault detection

The detection of certain faults (short-circuits or discrepancy errors, for example) depends on the application, the wiring, and the parameter assignment of the short circuit test and the sensor power supply. The corresponding tables for fault detection for the applications are available under Applications of the F-I/O module (Page 34).

Generally applicable information on diagnostics

Information on diagnostics that pertains to all fail-safe modules (for example, readout of diagnostics functions or passivation of channels) is available in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

6.4 Value status

Properties

In addition to the diagnostic messages and the status and error display, the F-module makes available information about the validity of each input and output signal – the value status. The value status is entered in the process image along with the input signal.

Value status for digital input and output modules

The value status is additional binary information of a digital input or output signal. It is entered in the process image of the inputs (PII) at the same time as the process signal. It provides information about the validity of the input or output signal.

The value status is influenced by the wire break check, short-circuit, chatter monitoring, pulse extension, and plausibility check.

- 1_B: A valid process value is output for the channel.
- 0_B: A fail-safe value is output for the channel, or the channel is deactivated.

Assignment of the inputs and value status in the PII

Each channel of the F-module is assigned a value status in the process image of the inputs. You can find the assignment in section Address space (Page 32).

Reference

A detailed description of the evaluation and processing of the respective input signals can be found in the SIMATIC Safety – Configuring and Programming (http://support.automation.siemens.com/WW/view/en/54110126) manual.

Technical specifications 7

Technical specifications of F-PM-E 24VDC/8A PPM ST

	6ES7136-6PA00-0BC0
Product type designation	F-PM-E PPM 24VDC
General information	
Hardware product version	01
Firmware version	V1.0.0
Product function	
I&M data	Yes; IM0 to IM3
Engineering with	
STEP 7 TIA Portal configurable/integrated as of version	V12.0
STEP 7 configurable/integrated as of version	as of V5.5 SP3 / -
PROFIBUS as of GSD version/GSD revision	V2.3
PROFINET as of GSD version/GSD revision	V2.31
Operating mode	
Multi-output	No
Installation type/mounting	
Rack mounting possible	No
Front installation possible	No
Rail mounting possible	Yes; standard DIN rail
Wall mounting/direct mounting possible	No
Supply voltage	
Type of supply voltage	24 V DC
Rated value (DC)	24 V
Low limit of permissible range (DC)	20.4 V
High limit of permissible range (DC)	28.8 V
Reverse polarity protection	Yes
Input current	
Current consumption (rated value)	75 mA; without load
Current consumption, max.	21 mA; from backplane bus
Output voltage	
Rated value (DC)	24 V
Sensor supply	
Number of outputs	2
Output current	
Up to 60 °C, max.	0.3 A
Short circuit protection	Yes; electronic (response threshold 0.7 A to 2.1 A)

	6ES7136-6PA00-0BC0
24 V sensor supply	
24 V	Yes; min. L+ (-1.5 V)
Short circuit protection	Yes
Output current, max.	600 mA; total current of all sensors
Power	
Power consumption from the backplane bus	70 mW
Power loss	
Power loss, typ.	5 W
Address space	
Address space per module	
Input	7 bytes
Output	5 bytes
Digital inputs	
Number of inputs	2
m/p-reading	Yes; p-reading
Input characteristic curve according to IEC 61131, Type 1	Yes
Input voltage	
Type of input voltage	DC
Rated value, DC	24 V
For "0" signal	-30 to +5 V
For "1" signal	+15 to +30 V
Input current	
For "1" signal, typ.	3.7 mA
Input delay (for rated value of input voltage)	
For standard inputs	
Assignable	Yes
For "0" to "1", min.	0.4 ms
For "0" to "1", max.	20 ms
For "1" to "0", min.	0.4 ms
For "1" to "0", max.	20 ms
For counter/technological functions	
Assignable	No
Length of cable	
Cable length, shielded, max.	1000 m
Cable length unshielded, max.	500 m
Digital outputs	
Number of outputs	1
Digital outputs, configurable	Yes
Short circuit protection	Yes
Response threshold, typ.	> 14.8 A
Wire break detection	Yes
Response threshold, typ.	8 mA

	6ES7136-6PA00-0BC0
Overload protection	Yes
Response threshold, typ.	8.8 A
Voltage induced on current interruption limited to	max 1.5 V
Switching capacity of outputs	
With resistive load, max.	8 A
With lamp load, max.	100 W
Load resistance range	
Low limit	3 Ω
High limit	2000 Ω
Output voltage	
Type of output voltage	DC
For "1" signal, min.	24 V; L+ (-0.5 V)
Output current	
For "1" signal, rated value	8 A
For "0" signal, residual current, max.	1.5 mA; PP-switching: Max. 1.5 mA; PM-switching: Max. 1 mA
Switching frequency	
With resistive load, max.	10 Hz; symmetrical
With inductive load, max.	0.1 Hz; acc. to IEC 947-5-1, DC13, symmetrical
With lamp load, max.	4 Hz; symmetrical
Total current of outputs	
Max. current per channel	8 A; (note derating data in the manual)
Max. current per module	8 A; (note derating data in the manual)
Length of cable	
Cable length, shielded, max.	1000 m
Cable length unshielded, max.	500 m
Interrupts/diagnostics/status information	
Fail-safe values can be switched to	No
Interrupts	
Diagnostic interrupt	Yes
Hardware interrupt	No
Diagnostic messages	
Diagnostics	Yes, see section "Interrupts/diagnostic messages" in the manual
Diagnostics display LED	
RUN LED	Yes; green LED
ERROR LED	Yes; red LED
Monitoring of supply voltage	Yes; green PWR LED
Channel status display	Yes; green LED
For channel diagnostics	Yes; red LED
For module diagnostics	Yes; green/red DIAG LED
Electrical isolation	
Electrical isolation channels	

	6ES7136-6PA00-0BC0
Between channels	No
Between the channels and the backplane bus	Yes
Between the channels and the supply voltage of the electronics	No
Permitted potential difference	
Between different circuits	60 V DC / 75 V AC
Isolation	
Isolation test voltage	707 V DC (type test)
Standards, approvals, certificates	
SIL acc. to IEC 61508	SIL 3
Suitable for safety functions	Yes
Maximum achievable safety class in safety mode	
Performance level according to EN ISO 13849-1	PLe
Low demand (PFD) acc. to SIL3	< 2.00E-05 1/h
High demand (PFH) acc. to SIL3	< 1.00E-09 1/h
Environmental conditions	
Operating temperature	
Min.	0 °C
Max.	60 °C
Horizontal installation, min.	0 °C
Horizontal installation, max.	60 °C
Vertical installation, min.	0 °C
Vertical installation, max.	50 °C
Storage/transport temperature	
Min.	-40 °C
Max.	70 °C
Dimensions	
Width	20 mm
Height	72 mm
Depth	55 mm
Weights	
Weight, approx.	70 g

Temperature characteristic values (derating)

Mounting position	Maximum temperature	Maximum output current
Horizontal	40 °C	8 A
	50 °C	6 A
	60 °C	4 A
Vertical	50 °C	4 A

Dimension drawing

See ET 200SP BaseUnits
(http://support.automation.siemens.com/WW/view/en/58532597/133300) manual

Response times

A

A.1 Response times

Introduction

The next section shows the response times of power module F-PM-E 24VDC/8A PPM ST. The response times of the fail-safe modules are included in the calculation of the F-system response time.

Times required for the calculation

Maximum internal processing time: $T_{max.}$ = 29 ms

Maximum cycle time: T_{cycle} = 14 ms

Short circuit test time for the sensor supply configured for the channel = "Time for short circuit test" + "Startup time after short circuit test"

The input delay, short circuit test times, dark test time, switch-on time, discrepancy time, and test time are configured in STEP 7.

Definition of response time for fail-safe digital inputs

The response time represents the interval between a signal change at the digital input and reliable availability of the safety frame on the backplane bus.

Definition of response time for internal evaluation: Cycle time + Input delay + Short circuit test time + Maximum(readback time, switch-on time, light test time)

Maximum response time in the error-free case with 1oo1 evaluation

Maximum response time = T_{max} + Input delay + Short circuit test time for the sensor supply configured for the channel

Maximum response time in the error-free case with 1oo2 evaluation

Maximum response time = T_{max} + Input delay + Maximum (short circuit test time for the sensor supply configured for channel 0, short circuit test time for the sensor supply configured for channel n1)

Maximum response time with external short circuits

Maximum response time = Input delay + (n × T_{cycle}) + Sum(all short circuit test times + all startup times of sensors with activated short circuit test)

n = Number of sensor supplies with activated short circuit test

Maximum response time with discrepancy error and 1oo2 evaluation

Maximum response time = T_{max} + Input delay + Discrepancy time + 2 × Maximum (short circuit test time for the sensor supply configured for channel 0, short circuit test time for the sensor supply configured for channel 1)

Maximum response time with error and change of user data

Maximum response time = 3 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time with detection by bit pattern test

Maximum response time = T_{cycle} + Maximum(dark test time, switch-on time) + configured test time

Definition of response time for fail-safe digital outputs

The response time represents the interval between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Maximum response time for fail-safe digital outputs

The maximum response time for fail-safe digital outputs in the error-free case is equal to:

Maximum response time = 2 × T_{cycle} + Maximum(dark test time, switch-on time)

The maximum response time for fail-safe digital outputs in the presence of an error is equal to:

Maximum response time = T_{cycle} + 2 × Maximum(dark test time, switch-on time) + interval between test pulses

A.2 Minimum distance of test pulses

The minimum interval between two test pulses depends on the activation of the light test, the configured maximum test time, and whether the output has been specified as a PM-switching or PP-switching output.

You can find the dependencies in the table below:

Assigned maximum test time	PM switching, light test not active	PM switching, light test active	PP switching, light test not active	PP switching, light test active
1000 s	62.080 s	45.147 s	82.913 s	38.137 s
100 s	5.830 s	4.238 s	7.913 s	3.521 s

Switching of loads

B

B.1 Connecting capacitive loads

If the output of power module F-PM-E 24VDC/8A PPM ST is interconnected with loads that require little current and have capacitance, this can lead to detection of a short circuit or overload. Reason: The capacitance cannot be sufficiently discharged or charged during the configured readback time of the bit pattern test.

The figure below shows typical curves for the assignable readback times representing the correlation between load resistance and switchable load capacitance at a supply voltage of 24 V DC.

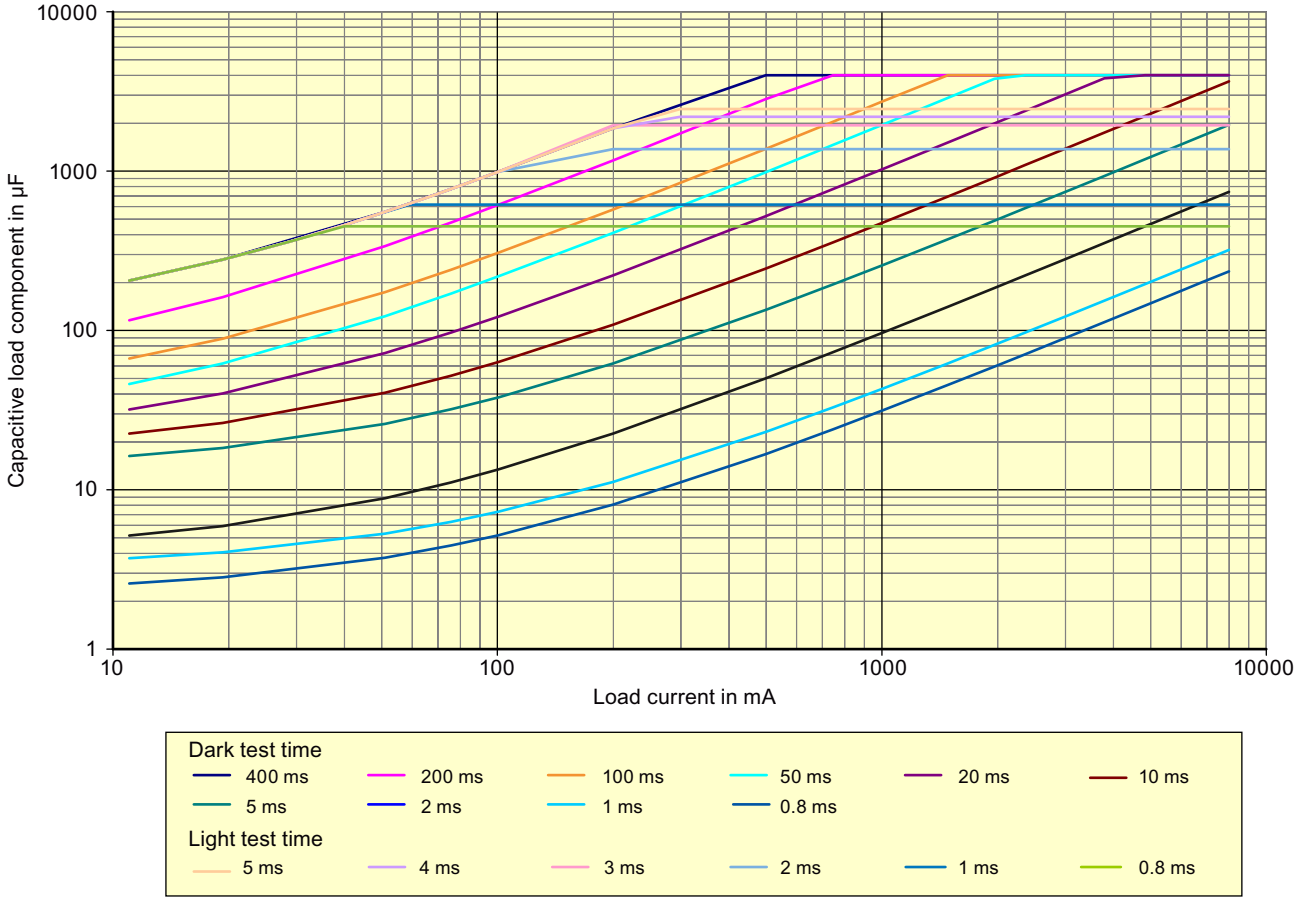

Figure 2-1656 Switching of capacitive loads for the F-PM-E 24VDC/8A PPM ST power module depending on the configured dark and light test times

The curves shown were plotted using a SIMATIC PS 307 10A power supply unit with a cable length of 25 m (cable cross-section of 1.5 mm^2) between the output of the F-PM-E 24VDC/8A PPM ST power module and the load.

Remedy for detecting a short circuit

1. Determine the load current and capacitance of the load.
2. Locate the operating point in the diagram above.
3. If the operating point is above the curve, you must increase the load current until the new operating point is below the curve by connecting a resistor in parallel.

B.2 Switching of inductive loads

Switching of inductive loads

The diagram below shows the maximum permitted inductive loads as a function of the load current and switching frequency.

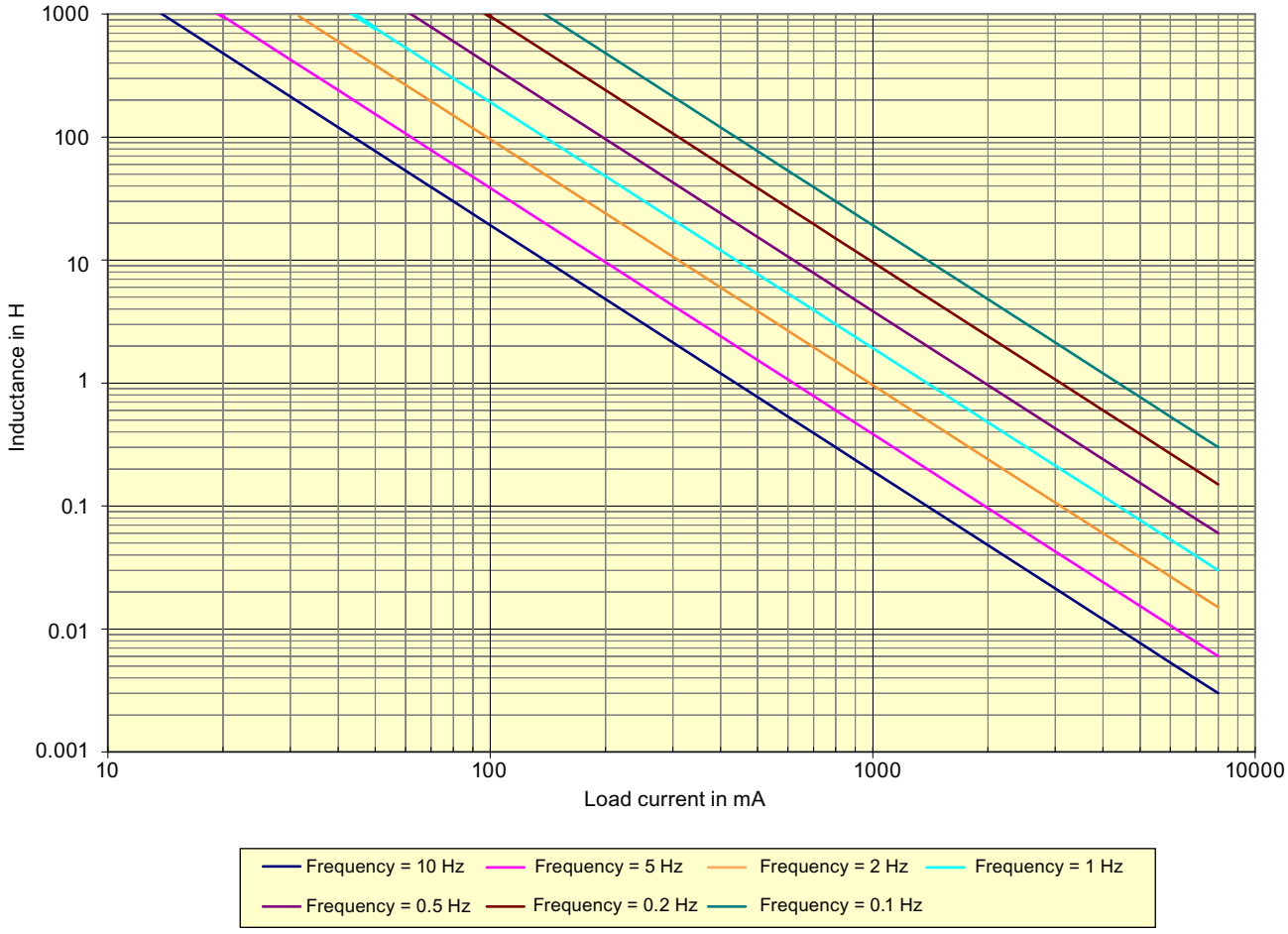

Figure 2-1657 Switching of inductive loads for the F-PM-E 24VDC/8A PPM ST power module depending on the load current and switching frequency

SIEMENS

Product Information for ET 200SP F-TM Count 1x1Vpp sin/cos HF (6ES7136-6CB00-0CA0)

Product Information

Introduction

Scope of the product information

This product information includes amendments and corrections to the documentation of the *ET 200SP Distributed I/O System, System Manual*. This product information also includes the addition of the ET 200SP F-TM Count 1x1Vpp sin/cos HF module (F-TM Count). The statements provided herein should be considered to be more up-to-date than other documentation if uncertainties arise.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/cert).

Incorrect counter value

Description

1. An issue has been identified which may cause the count value to be reported incorrectly or the module to enter a fatal error state. Either situation may occur when all three of the following selections are enabled:

- The encoder Signal type is set to "Sin/Cos encoder (A, B, N)".
- The "Invert direction" option is selected.
- The Reaction to signal N parameter is set to "Synchronization at signal N".

While a solution is under development, the following steps constitute a suitable workaround:

1. Swap the wiring of the SIN and COS signals on the terminal block.
2. Unselect the "Invert direction" configuration in TIA Portal.

2. An additional issue has been identified which may cause the count value to be incorrect if the N signal synchronization occurs at frequencies greater than 4 KHz. The error in the count value is proportional to the counting frequency when the N

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signal is processed by the counter module. The error in the count value will be most visible when the movement stops. The count error does not accumulate over multiple revolutions, but is reset each time the counter module processes an N signal.

The issue occurs when the following selections are enabled:

- The encoder Signal type is set to "Sin/Cos encoder (A, B, N)".
- The Reaction to signal N parameter is set to "Synchronization at signal N".

While a solution is under development, a workaround is to decelerate prior to stopping. This will minimize the error in the count value.

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Product Information for the documentation on Power Module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)
Product Information

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions only form one element of such a concept.

Customer is responsible to prevent unauthorized access to its plants, systems, machines and networks. Systems, machines and components should only be connected to the enterprise network or the internet if and to the extent necessary and with appropriate security measures (e.g. use of firewalls and network segmentation) in place.

Additionally, Siemens' guidance on appropriate security measures should be taken into account. For more information about industrial security, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends to apply product updates as soon as available and to always use the latest product versions. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

General amendments to the documentation

Content

This Product Information contains additional information and corrections relating to the documentation on Power Module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0) up to and including hardware version (FS) 04.

The Product Information is part of the product supplied. The information in it should be considered more up-to-date if uncertainties arise.

Technical specifications of the F-PM-E 24VDC/8A PPM ST up to and including hardware version (FS) 04.

	6ES7136-6PA00-0BC0
Output current	
For "0" signal, residual current max.	6 mA; PP switching: typ. 1.5 mA, max. 6 mA PM switching: max. 1 mA

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SIMATIC
ET 200SP

Product Information for the documentation on Power Module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0) as of firmware version V2.0.0

Product Information

Security information

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For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

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General amendments to the documentation

Content

This Product Information contains additional information and corrections relating to the documentation on power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0) firmware version V2.0.0 and higher.

The Product Information is part of the product supplied. The statements provided in it should be considered more up-to-date than other documentation if uncertainties arise.

You can use the power module F-PM-E 24VDC/8A PPM ST with the standard modules listed under entry ID: 83203124 (https://support.industry.siemens.com/cs/ww/es/view/83203124) within a potential group.

Parameters

Table 1 **Parameters for power module**

Parameters	Value range	Parameter reassignment in RUN	Scope
Output:			
Activated	• disable • enable	no	Channel

* Firmware V2.0.0 and higher

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Parameters	Value range	Parameter reassignment in RUN	Scope
Control of the output	• F-CPU • F-CPU and onboard F-DI	no	Module
Output type	• PM switching • PP switching	no	Channel
Max. readback time, dark test and shutdown test	0.8 to 400.0 ms	no	Channel
Max. readback time switch on test	0.8 to 5.0 ms	no	Channel
Activated light test	• disable • enable	no	Channel
Diagnosis: Wire break	• disable • enable	no	Channel
Deactivation dark test (max. SIL2, Cat. 3, PLd) *	• disable • enable	no	Channel

* Firmware V2.0.0 and higher

Addendum to section "Max. readback time, dark test and shutdown test" of the "Power Module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)" manual

Function

Dark tests are switch-off tests with bit pattern test.

For "Deactivation dark test" mode, the parameter "Max. readback time, dark test and switch-off test" is only relevant for the process value change.

For a dark test, a test signal is switched to the output channel while the output channel is active (output signal "1"). This output channel is then briefly disabled (= "dark period") and read back. A sufficiently slow actuator does not respond to this and remains switched on.

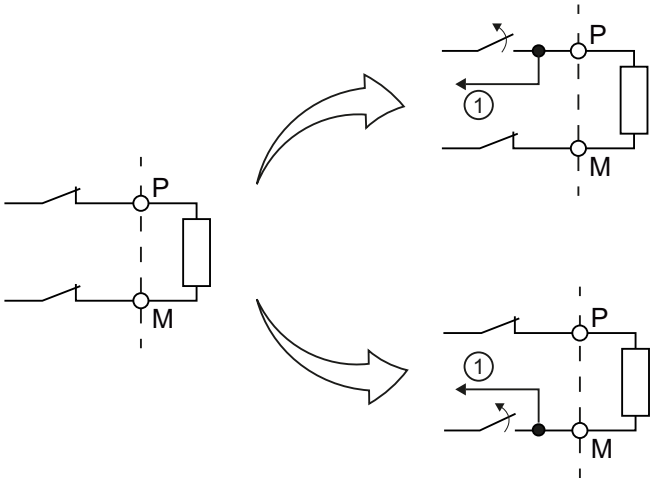

① Readback

Figure 1 Functional principle of the dark test (PM switching)

This parameter allows you to set the time for the readback.

If the expected signals (P-readback and M-readback) could not be read back correctly after expiration of the readback time dark test, the output channel is passivated.
No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher maximum readback time for the dark test increases the response time of the F-module.

WARNING

Through the configured "Max. readback time, dark test and switch-off test", short circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured readback time dark test) Hz cannot be recognized (50:50 sampling ratio).

Short circuits (cross-circuits) to an output of the same module are recognized.

The parameter also has an effect on the short circuit detection (cross-circuit) with "1" signal when the output signal is changed from "1" to "0" with the safety program.

Setting the parameter "Max. readback time, dark test and switch-off test"

Because the fault reaction time is extended by the length of the readback time dark test, we recommend that you set the readback time dark test by trial and error as low as possible, but high enough that the output channel is not passivated.

You determine the readback time required for your actuator with the diagram in the chapter Switching capacitive loads.

If the capacity of the actuator is not known, it may be necessary for you to determine the value for the readback time light test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the "Max. readback time, dark test and switch-off test" so that the output channel can be read back correctly but your actuator does not respond yet.
- For verification use the process value "0" with a minimum duration that corresponds to the "maximum test time" parameter. Execute a process value change from "1" to "0".
- If the output channel is passivated sporadically, set a higher value for the maximum readback time dark test.
- If the output channel is passivated, the readback time dark test is too small for a connected capacitive load. The discharge cannot take place during the configured readback time dark test. Increase the readback time dark test.

If you have set the readback time dark test to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

Test pulses of the dark test

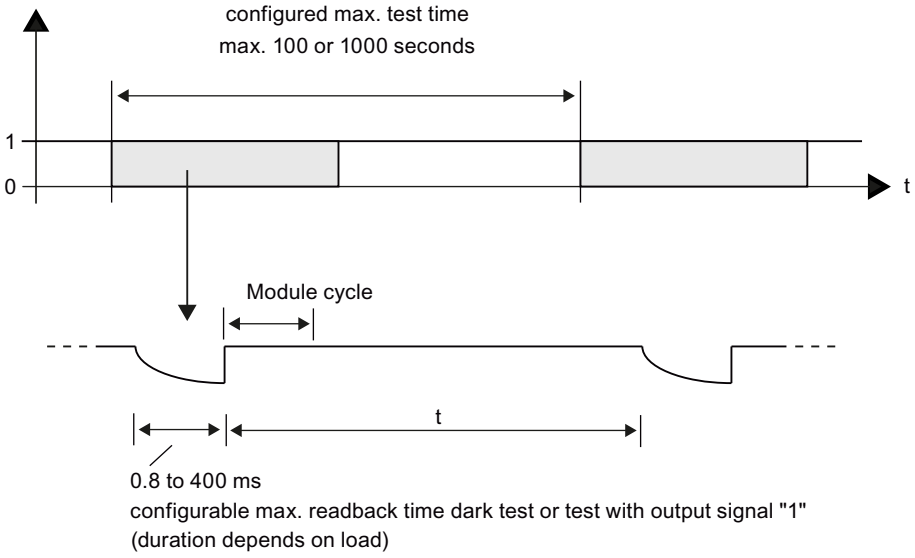

Figure 2 Test pulses of the dark test

The distance between two test pulses (t) depends on the parameter assignment. Additional information is available in Minimum distance between test pulses.

Deactivation dark test (max. SIL2, Cat. 3, PLd)

To prevent an unwanted reaction of the actuator to a dark test, you can deactivate the dark test at the F-module output. This undesirable reaction can be, for example, a brief failure of a magnetic drive or a process value change of a digital input with very short input delay.
A capacitive load that does not meet the load curve (see section Switching capacitive loads) can result in a passivation of the output in case of a process value change, switch on test or light test, even if the dark test is deactivated.
You can reach SIL2/Cat.3/PLd with deactivated dark test.
For deactivated dark test:

WARNING

SIL2/category 3/PLd requires that there is a signal change from 1 to 0 at output DQ/P1 and P2 at least once a year. It is not enough to simply turn off the supply voltage of the F-module and turn it on again.

You achieve the following technical specifications with deactivated dark test:

XE TDB_S	6ES7136-6PA00-0BC0
Maximum achievable safety class in safety mode XE U1:1	
Performance Level to EN ISO 13849-1:2015 XE T:2	PLd
SIL according to IEC 61508 XE T:2	SIL 2
Low demand mode: PFDavg according to SIL2 XE N:2	< 2.00E-04
High demand/continuous mode: PFH according to SIL2 XE N:2	1/h; < 1.00E-08

Addendum to section 5.1 "*Applications for the output DQ/P1 and P2*"

You can reach SIL2/Cat.3/PLd with deactivated dark test.

Addendum to section 5.3 "*Application for internal evaluation*"

NOTE

If an error occurs at the inputs in this application, the F-module also outputs the error message "Safety-related shutdown" or "Safety event" for the output. Following elimination of the error at the inputs, a reintegration of the output is only possible after the bit pattern test (within the test time shortened to max. 120 seconds) has been performed.

Minimum distance of test pulses

The minimum interval between two test pulses depends on the activation of the light test, the configured maximum test time, and whether the output has been specified as a PM-switching or PP-switching output.

The minimum interval between two test pulses at a maximum test time of 100 s is at least 2 seconds, and with a maximum test time of 1000 s at least 20 seconds.

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Product information on the ET 200SP fail-safe modules
Product Information

Affected modules

ET 200SP F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)

ET 200SP F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)

Modules with firmware versions V1.0.1 and V1.0.3
(Production period up to and including 2015 with the serial numbers: S C-D..., S C-E..., S C-F1... to S C-F9..., S C-FO... and S C-FN...)

Security information

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For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

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Important note for maintaining the operational safety of your system - Upgrade to firmware version >= V1.0.5

This product information contains important details on maintaining the operational safety of your system. The product information is part of the product supplied. The statements provided in it should be considered more up-to-date than other documentation if uncertainties arise.

Measures for maintaining operational safety in the event of undervoltage/overvoltage events

To maintain the operational safety, you must install a firmware version >= V1.0.5.

Reason:

Within the scope of internal quality assurance measures and continuous market observations, output characteristics of 24 V DC switched-mode power supplies on the market have been detected which significantly differ in their quality from the voltage curves for the supply of programmable controllers specified by IEC/EN 61131-2.

Switched-mode power supplies can maintain the output voltage at less than 50% of the nominal output voltage when an overload or short-circuit occurs and then return to the rated value.

The fail-safe modules ET 200SP F-DI 8x24VDC HF (6ES7136-6BA00-0CA0) and ET 200SP F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0) passivate themselves in the event of undervoltage and thereby guarantee safety in the machine/system. Once the fault is eliminated and the supply voltage returns to the nominal voltage range for at least 1 minute, the modules can be acknowledged, depassivated and reintegrated into the system.

In rare cases, due to the above-mentioned characteristics of switched-mode power supplies, the modules may erroneously indicate correct operation. Correct operation can be restored with an OFF/ON of the 24 V DC supply voltage or pulling/plugging the modules.

In order to ensure that the modules are acknowledged or depassivated and normal operation is resumed, install a firmware version >= V1.0.5 for the affected output versions of the two modules.

In general, we recommend that you always observe the following warning and implement the described measures:

⚠ WARNING

When an undervoltage or overvoltage event is detected (supply voltage too high/low – outside nominal range), it must be assumed that components may not execute their correct function properly after the supply voltage has returned to the nominal operating range. You can identify these components using a function check.

Therefore, we recommend that you always perform a full function check of the machine/plant or in any case a check of the safety functions directly after an undervoltage or overvoltage event and before re-commissioning.

See also

Firmware update for ET 200SP F-DI 8x24VDC HF (https://support.industry.siemens.com/cs/ww/en/view/99086745)
Firmware update for ET200SP F-PM-E PPM DC24V (https://support.industry.siemens.com/cs/ww/en/view/109479266)

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Product Information for the Documentation of ET 200SP Fail-safe Modules
Product Information

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For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

General amendments to the documentation

This Product Information contains amendments and corrections to the documentation of the ET 200SP fail-safe modules. The Product Information is part of the product supplied. The statements provided in it should be considered more up-to-date than other documentation if uncertainties arise.

Validity of the Product Information

The following information supplements the equipment manual of the ET 200SP fail-safe module:

- ET 200SP Digital Output Module F-DQ 8x24VDC/0.5A PP HF (https://support.industry.siemens.com/cs/ww/en/view/109747998)

Section 5.5 "Application: Connection of the ET 200SP digital output module F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)"

For the operation of the digital output module F-RQ 1x24VDC/24..230VAC/5A from FS 04 on, the use of the following readback times is required: Channel parameter "Max. readback time light test / dark test" with the default value "0.8 / 1.0 ms".

Validity of the Product Information

The following information supplements the equipment manuals of the ET 200SP fail-safe modules:

- ET 200SP Digital input module F-DI 8x24VDC HF (https://support.industry.siemens.com/cs/us/en/view/78589499)
- ET 200SP Digital output module F-DQ 4x24VDC/2A PM HF (https://support.industry.siemens.com/cs/us/en/view/78645789)
- ET 200SP Power module F-PM-E 24VDC/8A PPM ST (https://support.industry.siemens.com/cs/us/en/view/78645796)

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Section 6.3 "Interrupts/diagnostic alarms" – Table 6-6

Diagnostic alarm	Error code	Meaning	Remedy
Supply voltage too high	801_D	The supply voltage is too high.	Check the supply voltage and then test the safety application.
Supply voltage too low	802_D	The supply voltage is too low.	Check the supply voltage and then test the safety application.

Supply voltage outside the nominal range

If the supply voltage L+ is outside the specified value range, the DIAG LED flashes and the F-module is passivated.

When the voltage has recovered (level must remain within the specified value range for at least 1 minute (see section 7 "Technical specifications", subsection "Voltages, currents, potentials)), the DIAG LED stops flashing. The F-module remains passivated.

NOTICE

When an undervoltage or overvoltage event is detected (supply voltage too high/low – outside nominal range), it must be assumed that components may not execute their correct function properly after the supply voltage has returned to the nominal operating range. You can identify these components using a function check.

Therefore, we recommend that you always perform a full function check of the machine/plant or in any case a check of the safety functions directly after an undervoltage or overvoltage event before re-commissioning.

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PFDavg and PFH values according to IEC 61508:2010 for components with use in SIMATIC Safety, Distributed Safety, PCS neo Safety and S7 F/FH Systems

Product Information

Cybersecurity information

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PFDavg and PFH values according to IEC 61508:2010 for components with use in SIMATIC Safety, Distributed Safety, PCS neo Safety and S7 F/FH Systems

This product information contains **important information on the F-systems SIMATIC Safety, Distributed Safety, PCS neo Safety and S7 F/FH Systems**. The Product Information is part of the product supplied. The statements provided in it should be considered more up-to-date than other documentation if uncertainties arise.

PFD_{avg} and PFH values

The following tables contain the PFD_{avg} and PFH values for individual components with use in SIMATIC Safety (S), Distributed Safety (D), PCS neo Safety (N) and S7 F/FH Systems (F) with a repair time of 100 hours, an operational altitude of up to 2 000 m above sea level and, unless marked otherwise, an ambient temperature of 60 °C.

S7-1200/1500 F-CPUs	**Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand**	**High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]**	**With a mission time of**	**S**	**D**	**N**	**F**
For all **S7-1200/1500 F-CPUs**	< 2E-05	< 1E-09 up to an operational altitude[1] of 3 000 m or < 2E-09 at an operational altitude[1] greater than 3 000 m up to 5 000 m	20 years	x	-	-	-

[1] Information on which F-CPU supports an operational altitude > 2 000 m can be found in the F-CPU Product Information (https://support.industry.siemens.com/cs/ww/en/view/109478599).

S7-300/400 F-CPUs	**Article number**	**Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand**	**High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]**	**With a mission time of**	**S**	**D**	**N**	**F**
IM 151-7 F-CPU	6ES7151-7FA21-0-AB0	< 1.5E-05 < 3E-05	< 3.5E-10 < 3.5E-10	10 years 20 years	x	x	-	-
IM 151-8F PN/DP CPU	6ES7151-8FB01-0-AB0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
IM 154-8F PN/DP CPU	6ES7154-8FB01-0-AB0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
IM 154-8FX PN/DP CPU	6ES7154-8FX00-0-AB0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
CPU 315F-2 DP	6ES7315-6FF04-0-AB0	< 2E-05 < 4E-05	< 5E-10 < 5E-10	10 years 20 years	x	x	-	-

1 With use in an extended temperature range up to max. 70 °C.

2 With use up to max. 40 °C.

S7-300/400 F-CPUs	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
CPU 315F-2 PN/DP	6ES7315-2FJ14-0A-B0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
CPU 317F-2 DP	6ES7317-6FF04-0-AB0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
CPU 317F-2 PN/DP	6ES7317-2FK14-0-AB0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
CPU 317TF-3 PN/DP	6ES7317-7UL10-0-AB0	< 4E-05 < 8E-05	< 1E-09 < 1E-09	10 years 20 years	-	x	-	-
CPU 319F-3 PN/DP	6ES7318-3FL01-0-AB0	< 1E-04 < 2E-04	< 3E-09 < 3E-09	10 years 20 years	x	x	-	-
CPU 414F-3 PN/DP	6ES7414-3FM06-0-AB0	< 4.5E-05 < 9E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
	6ES7414-3FM07-0-AB0	< 4.5E-05 < 9E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
CPU 416F-2	6ES7416-2FN05-0-AB0	< 4.76E-05 < 9.52E-05	< 1.09E-09 < 1.09E-09	10 years 20 years	x	x	-	-
	6ES7416-2FP07-0-AB0	< 4.5E-05 < 9E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
CPU 416F-3 PN/DP	6ES7416-3FS06-0-AB0	< 4.5E-05 < 9E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
	6ES7416-3FS07-0-AB0	< 4.5E-05 < 9E-05	< 1E-09 < 1E-09	10 years 20 years	x	x	-	-
CPU 410-5H	6ES7410-5HX08-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	x	x
		< 2.8E-04[1] < 5.6E-04[1]	< 6.3E-09[1] < 6.3E-09[1]	10 years 20 years	-	-	x	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	x	x
CPU 410E	6ES7410-5HM08-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	-	x
		< 2.8E-04[1] < 5.6E-04[1]	< 6.3E-09[1] < 6.3E-09[1]	10 years 20 years	-	-	-	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	-	x
CPU 410SIS	6ES7410-5FM08-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	-	x

1 With use in an extended temperature range up to max. 70 °C.

2 With use up to max. 40 °C.

S7-300/400 F-CPUs	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
CPU 410SIS	6ES7410-5FM08-0-AB0	< 2.8E-04[1] < 5.6E-04[1]	< 6.3E-09[1] < 6.3E-09[1]	10 years 20 years	-	-	-	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	-	x
CPU 412-5H PN/DP	6ES7412-5HK06-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	-	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	-	x
CPU 414-5H PN/DP	6ES7414-5HM06-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	-	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	-	x
CPU 416-5H PN/DP	6ES7416-5HS06-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	-	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	-	x
CPU 417-5H PN/DP	6ES7417-5HT06-0-AB0	< 1.9E-04 < 3.8E-04	< 4.3E-09 < 4.3E-09	10 years 20 years	-	-	-	x
		< 1.0E-04[2] < 2.0E-04[2]	< 2.2E-09[2] < 2.2E-09[2]	10 years 20 years	-	-	-	x
WinAC RTX F based controller		< 1E-04	< 3E-09	10 years	x	x	-	-

1 With use in an extended temperature range up to max. 70 °C.

2 With use up to max. 40 °C.

S7-300 F-CPUs	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
For all F-CPUs	< 2E-04	< 3E-09 at an operational altitude[1] greater than 2 000 m up to 5 000 m	20 years	x	-	-	-

[1] Information on which F-CPU supports an operational altitude > 2 000 m can be found in the S7-300 Product Information: Use of (F-)CPUs at altitudes > 2,000 m (https://support.industry.siemens.com/cs/ww/en/view/109763261).

Safety-related communication	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
	< 1E-05[1]	< 1E-09[1]	20 years	x	x	x	x

[1] **Note on S7-300/400 F-CPUs:**

The PFD_{avg} value is valid under the assumption that a maximum of 25 F-modules are involved in a safety function. If more than 25 F-modules are used, you need to add 3.5E-7 per F-modules for this safety function.

The PFH value is valid under the assumption that a maximum of 100 F-modules are involved in a safety function. If more than 100 F-modules are used, you need to add a 4E-12 1/h for each F-modules for this safety function.

S7-1200 F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
SM 1226 F-DI 16 x 24 VDC	6ES7226-6BA32-0-XB0	SIL 2: < 5E-04 SIL 3: < 1E-05	SIL 2: < 1E-08 SIL 3: < 1E-10	20 years	x	-	-	-
SM 1226 F-DQ 4 x 24 VDC	6ES7226-6DA32-0-XB0	SIL 3: < 1E-05	SIL 3: < 4E-09	20 years	x	-	-	-
SM 1226 F-DQ 2 x Relay	6ES7226-6RA32-0-XB0	SIL 3: < 1E-05	SIL 3: < 4E-09	20 years	x	-	-	-

ET 200SP F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
F-AI 4xI 0(4)..20mA 2-/4-wire HF	6ES7136-6AA00-0-CA1	SIL 3: < 5E-05	SIL 3: < 1E-09	20 years	x	-	-	x[1]
F-AI 4xU 0..10V HF	6ES7136-6AB00-0-CA1	SIL 3: < 5E-05	SIL 3: < 1E-09	20 years	x	-	-	-
F-DI 8x24VDC HF	6ES7136-6BA00-0-CA0	SIL 3: < 2E-05	SIL 3: < 1E-09	20 years	x	x	-	x[1]
F-DI 8x24VDC HF	6ES7136-6BA01-0-CA0	SIL 3: < 2E-05	SIL 3: < 1E-09	20 years	x	x[4]	-	x[4]
F-DQ 4x24VDC/2A PM HF	6ES7136-6DB00-0-CA0	SIL 2: < 2E-04[3] SIL 3: < 2E-05	SIL 2: < 1E-08[3] SIL 3: < 1E-09	20 years	x	x[2]	-	x[1]
F-DQ 4x24VDC/2A PM HF	6ES7136-6DB01-0-CA0	SIL 2: < 2E-04[5] SIL 3: < 2E-05	SIL 2: < 1E-08[5] SIL 3: < 1E-09	20 years	x	x[6]	-	x[6]
F-DQ 8x24VDC/0.5A PP HF	6ES7136-6DC00-0-CA0	SIL 3: < 6E-05	SIL 3: < 2E-09	20 years	x	x	-	x[1]
F-PM-E 24VDC/8A PPM ST	6ES7136-6PA00-0-BC0	SIL 2: < 2E-04[3] SIL 3: < 2E-05	SIL 2: < 1E-08[3] SIL 3: < 1E-09	20 years	x	x[2]	-	x[1]
F-RQ 1x24VDC/24..230VAC/5A	6ES7136-6RA00-0-BF0	SIL 2: < 1E-04 With function test 1x per year	SIL 2: < 1E-08 With function test 1x per year	20 years	x	x	-	x[1]
		SIL 3: < 1E-05 With function test 1x per month	SIL 3: < 6E-09 With function test 1x per month	20 years	x	x	-	x[1]
F-TM Count 1x1Vpp sin/cos HF	6ES7136-6CB00-0-CA0	SIL 1: < 2E-03 Signal monitoring deactivated SIL 3: < 3E-05	SIL 1: < 3E-08 Signal monitoring deactivated SIL 3: < 1E-09	20 years	x	-	-	-

1 Supports S2 redundancy with S7-400 H-CPUs

2 As of firmware version V2.0.0 can be used with GSD and S7-FCT

3 With deactivated dark test as of firmware version V2.0.0. A signal change is necessary at least once a year.

4 As spare part for 6ES7136-6BA00-0CA0

5 With deactivated dark test. A signal change is necessary at least once a year.

6 As a replacement part for 6ES7136-6DB00-0CA0

ET 200SP HA F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
F-DI 16x24VDC HA	6DL1136-6BA00-0-PH1	SIL 3: < 3E-05[1] SIL 3: < 2E-05[2]	SIL 3: < 2E-09[1] SIL 3: < 1E-09[2]	20 years	-	-	x	x
F-DQ 10x24VDC/2A PP HA	6DL1136-6DA00-0-PH1	SIL 3: < 7E-05[1] SIL 3: < 5E-05[2]	SIL 3: < 2E-09[1] SIL 3: < 1E-09[2]	20 years	-	-	x	x
F-AI 8xI 2-/4-wire HART HA	6DL1136-6AA00-0-PH1	SIL 3: < 2.7E-04 (< 9E-05 for 1oo2 voting in the F-CPU)[1] SIL 3: < 9E-05 (< 3E-05 for 1oo2 voting in the F-CPU)[2]	SIL 3: < 4E-09 (< 1E-09 for 1oo2 voting in the F-CPU)[1] SIL 3: < 1E-09 (< 1E-09 for 1oo2 voting in the F-CPU)[2]	20 years	-	-	x	x
F-DI 16xNAMUR HA	6DL1136-6TH00-0-PH1	SIL 3: < 4.00E-05[1] SIL 3: < 2.00E-05[2]	SIL 3: < 1.00E-09[1] SIL 3: < 1.00E-09[2]	20 years	-	-	-	x

1 With use up to max. 70 °C.

2 With use up to max. 40 °C.

ET 200MP F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
F-DI 16x24VDC	6ES7526-1BH00-0-AB0	SIL 3: < 5E-05	SIL 3: < 1E-09	20 years	x	-	-	-
F-DQ 8x24VDC/2A PPM	6ES7526-2BF00-0-AB0	SIL 3: < 6E-05	SIL 3: < 2E-09	20 years	x	-	-	-
F-AI 8xI 0(4)..20 mA	6ES7536-1MF00-0-AB0	SIL 3: < 4E-05	SIL 3: < 1E-09	20 years	x	-	-	-

ET 200eco PN F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A PM, 3xM12	6ES7146-6FF00-0-AB0	1-channel input: SIL 2: < 6E-04 2-channel input: SIL 3: < 1E-05 Output channel: SIL 3: < 2E-05	1-channel input: SIL 2: < 1E-08 2-channel input: SIL 3: < 2E-10 Output channel: SIL 3: < 7E-09	20 years	x	x[1]	-	x[1]
4x F-DI + 2x F-DQ + 4x DIQ + CM IO-Link M12L	6ES7146-6FF00-0-BB0[2]	F-DI SIL 2: < 8E-05 SIL 3: < 7E-05 F-DQ SIL 2< 3E-04 SIL 3< 8E-05	F-DI SIL 2: < 1E-09 SIL 3: < 6E-10 F-DQ SIL 2: < 5E-09 SIL 3: < 4E-09	20 years	x	x	-	x

1 Can be used with GSD and S7-FCT

2 Can be used up to 5 000 m above sea level

ET 200AL F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
ET 200AL F-DI 4+F-DQ 2x24VDC/2A , 4xM12	6ES7146-5FF00-0-BA0	1-channel input: SIL 2: < 1E-03 2-channel input: SIL 3: < 1E-05 Output channel: SIL 2: < 1E-03[1] SIL 3: < 2E-05	1-channel input: SIL 2: < 1E-08 2-channel input: SIL 3: < 1E-09 Output channel: SIL 2: < 1E-07[1] SIL 3: < 1E-08	20 years	x	-	-	-

[1] With deactivated dark test

S7-300/ET 200M F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
SM 326; DI 24 x DC24V	6ES7326-1BK02-0-AB0	SIL 2: < 8E-04 (alternative: SIL 2: < 1E-05 + 3.5E-05 per input) SIL 3: < 2E-05	SIL 2: < 1E-08 SIL 3: < 1E-09	20 years	x	x	-	x
SM 326; DI 8 x NAMUR	6ES7326-1RF01-0-AB0	SIL 2: < 1E-03 (alternative: SIL 2: < 2E-05 + 1.3E-04 per input) SIL 3: < 3E-05	SIL 2: < 2E-08 SIL 3: < 1E-09	20 years	x	x	-	x
SM 326; F-DO 10 x DC 24V/2A PP	6ES7326-2BF10-0-AB0	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	-	x
SM 326; DO 8 x DC 24V/2A PM	6ES7326-2BF41-0-AB0	SIL 3: < 1E-05	SIL 3: < 3E-09	20 years	x	x	-	x
SM 336; F-AI 6 x 0/4...20mA HART	6ES7336-4GE00-0-AB0	1-channel: SIL 3: < 1E-04 2-channel: SIL 3: < 1E-05	1-channel: SIL 3: < 1E-08 2-channel: SIL 3: < 1E-09	20 years	x	x	-	x

Fail-safe I/O S7-300/ET 200M F-MTA	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
6-Channel F Analog Input HART MTA	6ES7650-1AH62-5-XX0	Channel: SIL 3: 6.17E-05	Channel: SIL 3: 1.90E-09	10 years	x	x	-	x
		Channel: SIL 3: 1.45E-04		20 years				
12/24-Channel, 24 VDC F Discrete Input MTA	6ES7650-1AK11-7-XX0	Channel: SIL 2: 0 SIL 3: 0	Channel: SIL 2: 0 SIL 3: 0	20 years	x	x	-	x
10-Channel, 24 VDC F Discrete Output MTA	6ES7650-1AL11-6-XX0	Channel: SIL 3: 0	Channel: SIL 3: 0	20 years	x	x	-	x
Failsafe 10-Channel, 24-150 VDC/120-230VAC Relay Output MTA	6ES7650-1AM31-6-XX0	Channel: SIL 2: 2.53E-02	Channel: SIL 2: 5.77E-07	10 years	x	x	-	x
		Channel: SIL 2: 5.06E-02		20 years				

ET 200S F-I/O	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
4/8 F-DI DC24V PROFIsafe	6ES7138-4FA05-0-AB0	SIL 2: < 1E-03 SIL 3: < 1E-05	SIL 2: < 1E-08 SIL 3: < 1E-09	20 years	x	x	-	x
4 F-DO DC24V/2A PROFIsafe	6ES7138-4FB04-0-AB0	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	-	x
4 F-DI/3 F-DO DC24V PROFIsafe	6ES7138-4FC01-0-AB0	SIL 2: < 1E-03	SIL 2: < 1E-08	20 years	x	x	-	x
PM-E F pm DC24V PROFIsafe	6ES7138-4CF03-0-AB0	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	-	x
PM-E F pp DC24V PROFIsafe	6ES7138-4CF42-0-AB0	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	-	x
PM-D F DC24V PROFIsafe	3RK1903-3BA02	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	-	x

With a mission time of 20 years, the following values apply to the 1 F-RO DC24V/AC24..230V/5A 6ES7138-4FR00-0AA0:

Load according to IEC 60947-5-1 DC13/AC1-5	Current	Average max. permitted switching cycles	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	S	D	N	F
DC13	I <= 5 A	1 time per day	< 4E-05	< 1E-09	x	x	-	x
		3 times per day	< 1.2E-04	< 2E-09	x	x	-	x
	I <= 2.5 A	1 time per day	< 3E-05	< 1E-09	x	x	-	x
		3 times per day	< 8E-05	< 1E-09	x	x	-	x
	I <= 1.25 A	1 time per day	< 2E-05	< 1E-09	x	x	-	x
		3 times per day	< 5E-05	< 1E-09	x	x	-	x
		1 time per hour	—	< 8E-09	x	x	-	x
AC15	I <= 3 A	1 time per day	< 2E-05	< 1E-09	x	x	-	x
		3 times per day	< 5E-05	< 1E-09	x	x	-	x
		1 time per hour	—	< 7E-09	x	x	-	x
	I <= 1.5 A	1 time per day	< 1E-05	< 1E-09	x	x	-	x
		3 times per day	< 3E-05	< 1E-09	x	x	-	x
		1 time per hour	—	< 4E-09	x	x	-	x

Within the range of validity of the machinery directive or IEC 62061:2021, SIL3/Cat.4/PLe requires the readback of process states and at least monthly signal change.

F-I/O ET 200pro	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
8/16 F-DI DC24V PROFIsafe	6ES7148-4FA00-0-AB0	SIL 2: < 1E-03 SIL 3: < 2E-05	SIL 2: < 2E-08 SIL 3: < 1E-09	20 years	x	x	-	x
4/8 F-DI/4 F-DO DC24V/2A PROFIsafe	6ES7148-4FC00-0-AB0	SIL 2: < 1E-03 SIL 3: < 2E-05	SIL 2: < 1E-08 SIL 3: < 1E-09	20 years	x	x	-	x
F-Switch PROFIsafe	6ES7148-4FS00-0-AB0	SIL 2: < 1E-03 SIL 3: < 1E-05	SIL 2: < 1E-08 SIL 3: < 1E-09	20 years	x	x	-	x

F-I/O ET 200eco	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
4/8 F-DI DC24V PROFIsafe	6ES7148-3FA00-0-XB0	SIL 2: < 8E-04 SIL 3: < 1E-05	SIL 2: < 1E-08 SIL 3: < 1E-09	20 years	x	x	-	x

F-I/O ET 200iSP	Article number	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
EM138 8 F-DI Ex NAMUR	6ES7138-7FN00-0-AB0	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	x	x
EM138 4 F-DO Ex 17,4V/40mA	6ES7138-7FD00-0-AB0	SIL 3: < 1E-05	SIL 3: < 1E-09	20 years	x	x	x	x
EM138 4 F-AI Ex HART	6ES7138-7FA00-0-AB0	1-channel: SIL 3: < 1E-04 2-channel: SIL 3: < 1E-05	1-channel: SIL 3: < 1E-08 2-channel: SIL 3: < 1E-09	20 years	x	x	x	x

Fail-safe GSD based DP standard slaves Fail-safe GSD based IO devices Fail-safe PA field devices Fail-safe HMI devices	Low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]	With a mission time of	S	D	N	F
Fail-safe GSD based DP standard slaves: See technical specifications for fail-safe GSD based DP standard slave							
Fail-safe GSD based IO devices: See technical specifications for fail-safe GSD based IO device							
Fail-safe PA field devices: See technical specifications for fail-safe PA field device							
Fail-safe HMI devices: See technical specifications on the fail-safe HMI device							
Other fail-safe devices: See technical specifications on the fail-safe device							

Determine the contribution of the F-system to the PFD_{avg} and PFH values

The contribution of the fail-safe system to the PFD_{avg} and PFH values of a safety function is determined by adding the PFD_{avg}- and PFH values of the F-CPUs and F-I/Os involved.

The contribution of the safety-oriented communication is added to this. Note that several F-systems can be involved in a safety function.

You determine the PFD_{avg} and PFH values of a safety function by adding the contribution of the fail-safe system to the contribution of the encoders and actuators involved in the safety function.

Calculation example

A safety function is implemented with a SIMATIC Safety F-system. The F-CPU and fail-safe modules listed in the following table are involved in the safety function.

20 years was selected as the mission time. The fail-safe modules are in safety mode for SIL3/Cat.4/PLe. Operation is in high demand mode:

F-CPU, F-modules and safety-related communication involved in the safety function	Quantity	High demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure per hour [h^{-1}]
F-CPU S7-1500	1	1E-09
F-DQ 8x24VDC/2A PPM 6ES7526-2BF00-0AB0	1	2E-09
F-DI 16x24VDC 6ES7526-1BH00-0AB0	2	2 x 1E-09
Safety-related communication		1E-09
Total		**6E-09**

SIEMENS

SIMATIC
ET 200SP
Product Information on documentation for the digital output module F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0) as of firmware version V2.0.0

Product Information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

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Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

General amendments to the documentation

Content

Product Information contains supplements and corrections on the documentation for the digital output module F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0) as of firmware version V2.0.0

The Product Information is part of the product supplied. The statements provided in it should be considered more up-to-date than other documentation if uncertainties arise.

Parameters

Table 1 Parameters for F-DQ 4×24VDC/2A PM HF

Parameters	Value range	Parameter reassignment in RUN	Scope
DQ parameters:			
Maximum test period	• 100 s • 1000 s	no	Module
Disable Dark Test (max. SIL2, CAT3, PLd) *	• disable • enable	no	Module

* Firmware V2.0.0 and higher

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Parameters	Value range	Parameter reassignment in RUN	Scope
Channel parameters:			
Channel n			
Activated	• disable • enable	no	Channel
Max. readback time, dark test and switch-off test *	0.6 ms to 400.0 ms	no	Channel
Max. readback time switch-on test	0.6 ms to 5.0 ms	no	Channel
Activated light test	• disable • enable	no	Channel
Diagnostics: Wire break	• disable • enable	no	Channel

* Firmware V2.0.0 and higher

Disable Dark Test (max. SIL2, CAT3, PLd)

To prevent an unwanted reaction of the actuator to a dark test, you can deactivate the dark test at the F-module output. An unwanted reaction can be for example, the brief de-energizing of a magnetic drive or a process value change of a digital input with very short input delay.

A capacitive load that does not meet the load curve (see section Switching capacitive loads) can result in a passivation of the output in case of a process value change, switch-on test or light test, even if the dark test is deactivated.

You can reach up to SIL2/Cat.3/PLd with disabled dark test.

For disabled dark test:

WARNING

SIL2/Cat.3/PLd requires that there is a signal change from "1" to "0" at the corresponding output at least once a year. The "0" signal must have a duration of at least 2 seconds. It is not enough to simply turn off the supply voltage of the F-module and turn it on again.

WARNING

When you use the function "Disable dark test", cross-circuits between channels with "1" signal are not detected. If an error caused by short-circuits (cross-circuits) is detected when you request the safety function (shutdown of the output), not only is this output passivated, but all outputs are shut down and the F-module is passivated. Also take into consideration the respective requirements of your product standards regarding error detection time.

Max. readback time, dark test and switch-off test

Function

Dark tests are switch-off tests with bit pattern test.

For "Disable dark test" mode, the parameter "Max. readback time, dark test and switch-off test" is only relevant for the process value change.

For a dark test, a test signal is switched to the output channel while the output channel is active (output signal "1"). This output channel is then briefly disabled (= "dark period") and read back. A sufficiently slow actuator does not respond to this and remains switched on.

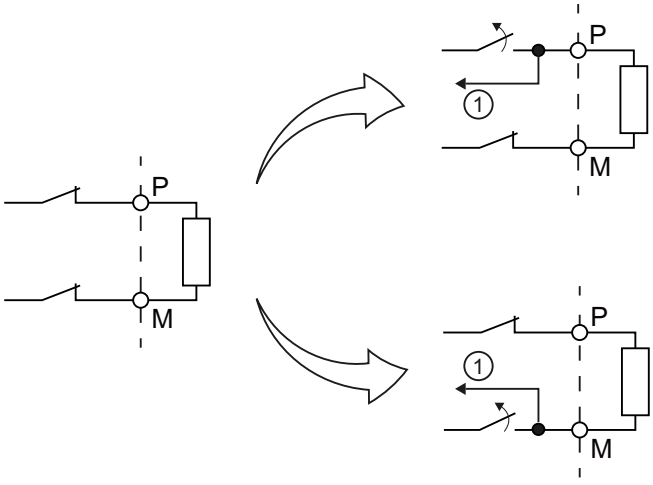

① Readback

Figure 1 Functional principle of the dark test (PM switching)

This parameter allows you to set the time for the readback.

If the expected signals (P-readback and M-readback) could not be read back correctly after expiration of the max. readback time, dark test and switch-off test, the output channel is passivated.

No new process values are switched to the output channels while a bit pattern is still active (switch test is carried out). This means that a higher max. readback time, dark test and switch-off test increases the response time of the F-module.

⚠ WARNING

Through the configured "Max. readback time, dark test and switch-off test", short circuits (cross-circuits) to a signal with a frequency greater than 1/(2 x configured max. readback time, dark test and switch-off test) Hz cannot be detected (50:50 sampling ratio).

Short circuits (cross-circuits) to an output of the same module are recognized.

The parameter also has an effect on the short circuit detection (cross-circuit) with "1" signal when the output signal is changed from "1" to "0" with the safety program.

Setting the parameter "Max. readback time, dark test and switch-off test"

Because the fault response time is extended by the max. readback time, dark test and switch-off test, we recommend that you set the max. readback time, dark test and switch-off test by trial and error as low as possible, but high enough that the output channel is not passivated.

You determine the readback time required for your actuator with the diagram in the chapter Switching capacitive loads.

If the capacity of the actuator is not known, it may be necessary for you to determine the value for the max. readback time, dark test and switch-off test by trial and error. This may also be necessary due to the part variances in the actuator or external influences.

Proceed as follows:

- Set the "Max. readback time, dark test and switch-off test" so that the output channel can be read back correctly but your actuator does not respond yet.
- For verification use the process value "0" with a minimum duration that corresponds to the "maximum test time" parameter. Execute a process value change from "1" to "0".
- If the output channel is passivated sporadically, set a higher value for the max. readback time, dark test and switch-off test.
- If the output channel is passivated, the max. readback time, dark test and switch-off test is too small for a connected capacitive load. The discharge cannot take place within the configured max. readback time, dark test and switch-off test. Increase the max. readback time, dark test and switch-off test.

If you have set the max. readback time, dark test and switch-off test to the maximum value of 400 ms and there is still a passivation of the output channel, there is either an external fault or the connected capacity is outside the permitted range.

Test pulses of the dark test

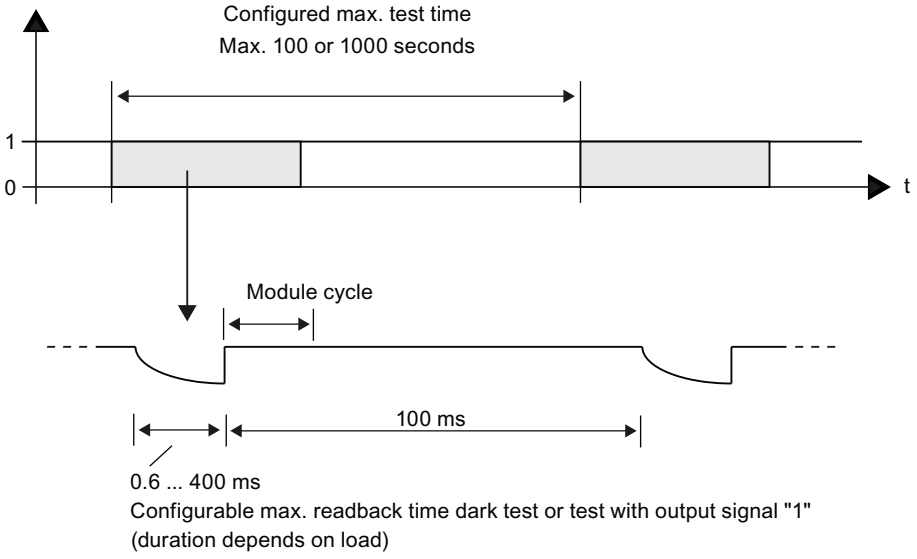

Figure 2 Test pulses of the dark test

The interval between two test pulses amounts to at least 100 ms.

Applications of the F-I/O module

Supplement to section 5 "Applications of the F-I/O module"

You can reach up to SIL2/Cat.3/PLd with disabled dark test.

Technical specifications

Technical specifications of the F-DQ 4×24VDC/2A PM HF

You achieve the following technical specifications with disabled dark test:

XE TDB_S	6ES7136-6DB00-0CA0
Maximum achievable safety class in safety mode XE U1:1	
Performance level according to EN ISO 13849-1:2015 XE T:2	PLd

XE TDB_S	6ES7136-6DB00-0CA0
Category according to EN ISO 13849-1:2015 XE T:2	Cat.3
SIL according to IEC 61508 XE T:2	SIL 2
Low demand mode: PFDavg according to SIL2 XE N:2	< 2.00E-04
High demand/continuous mode: PFH according to SIL2 XE N:2	< 1.00E-08 1/h

Response times

Introduction

The next section shows the response times of the digital output module F-DQ 4×24VDC HF. The response times of the F-DQ 4×24VDC HF digital output module are included in the calculation of the F-system response time.

Definition of response time for fail-safe digital outputs

The response time represents the interval between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Times required for the calculation

Maximum cycle time: T_{cycle} = 15.5 ms
You assign the dark test time and switch-on time in STEP 7.

The following applies to the enabling of the dark test:

Maximum response time with no faults

The maximum response time for fail-safe digital outputs in the error-free case is equal to:
Max. response time = 2 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time with error and change of user data

Max. response time = 3 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time with detection by bit pattern test

Maximum response time = T_{cycle} + Maximum(dark test time, switch-on time) + configured test time

The following applies to the disabling of the dark test:

Maximum response time with no faults

The maximum response time for fail-safe digital outputs in the error-free case is equal to:
Max. response time = 2 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time with error and change of user data

Max. response time = 3 × T_{cycle} + Maximum(dark test time, switch-on time)
A channel fault might not be detected until a process value change "1" to "0" takes place on the corresponding output.

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Dependencies during configuration with GSD files for ET 200SP fail-safe modules

Product Information

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under https://new.siemens.com/cert.

Introduction

Note the following dependencies for PROFINET IO during configuration of ET 200SP fail-safe modules per with GSD file.

NOTE

When using ET 200SP fail-safe modules with the GSD file on F-CPUs, note that the warnings, information and references contained in the F-module manuals are still valid for other manuals.

Also observe the specifications of the F-CPU.

An F-CPU is an F-capable IO controller that supports PROFIsafe.

Requirement

ET 200SP fail-safe modules can be used with the GSD file on the following interface modules:

- IM 155-6 PN ST as of V3.1
- IM 155-6 PN HF as of V3.1
- IM 155-6 PN/2 HF as of V4.2
- IM 155-6 PN/3 HF as of V4.2
- IM 155-6 PN HS as of V4.0
- IM 155-6 MF HF as of V5.0

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An S7-FCT is required to calculate the F_iParCRC and address the F-I/O.

NOTE

If the identification during the assignment of the PROFIsafe address does not succeed, e.g. the F module flashes continuously, the following corrective measures are possible:

- Pull/plug the F module.
- Repeat the assignment of the PROFIsafe address after approx. 2 minutes.
- Increase the PROFINET update time of the F-CPU and IM for the duration of the F-address assignment.

S7-FCT allows you to configure selected F-I/Os from SIEMENS in an engineering system from another manufacturer.
You can find S7-FCT on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).
Observe the minimum requirements for the installation of the F-system to be used.

Table 1 Configuration software and requirements

Configuration software	Requirements	Information on installation
STEP 7 (TIA Portal) as of V15	S7-FCT as of V2.0	STEP 7 online help
STEP 7 as of V5.5 SP4 HF19		
STEP 7 as of V5.6 HF5 or higher		
STEP 7 as of V5.6 SP1 HF5		
Software of another manufacturer		Documentation of the manufacturer

We recommend that you use the latest HF.

NOTE

Observe the module-specific restrictions.

Dependencies F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0) as of firmware version V2.0.0

Reintegration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU. The F module supports configuration per GSD file PROFIsafe V2.4.
When configuring with GSD file, only module-wide passivation is possible.
In TIA Portal, the "IO Tags" tab displays more tags than supported by the F module.

F-DQ 4x24VDC/2A PM HF (6ES7136-6DB01-0CA0) dependencies as of firmware version V1.0.0

The same dependencies apply to this F-module as to F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0).
In addition, channel-by-channel passivation is also possible due to the support of PROFIsafe V2.6MU1.
With the "Keep last valid value" setting of the "Behavior at loss of communication" parameter, the I/O module is only compliant with EN 54-2.

Dependencies for "Disable Dark Test (max. SIL2, CAT3, PLd)"

If you have enabled "Disable Dark Test (max. SIL2, CAT3, PLd)", "Disable Dark Test for 48 hours" and "Enable Dynamic Read Back" cannot be set.

Dependencies for "Disable Dark Test for 48 hours"

If you have enabled "Disable Dark Test for 48 hours", you must configure the "Max. readback time light test / dark test" parameter the same for all channels.

"Disable Dark Test (max. SIL2, CAT3, PLd)" and "Enable Dynamic Read Back" cannot be set.

Dependencies for "Enable Dynamic Read Back"

If you have enabled "Enable Dynamic Read Back", then "Disable Dark Test (max. SIL2, CAT3, PLd)" and "Disable Dark Test for 48 hours" cannot be set.

Limit the range of values of the "Max. readback time, dark test and switch-off test" parameter to between 0.6 ms and 20 ms.

Dependencies F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)

General dependencies

The following applies to the "Input delay" parameter, depending on the sensor supply and activation of the short-circuit test: "Input delay" < MIN ("Startup time of the sensor after a short-circuit test", "Time for the short-circuit test").

The "Startup time of the sensor after a short circuit test" must be configured to be at least 1% of the "Time for the short circuit test".

If a sensor supply is selected for a channel, this sensor supply must also be activated. You also need to disable unused encoder supplies.

Reintegration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU. The F module supports configuration per GSD file PROFIsafe V2.4.

When configuring with GSD file, only module-wide passivation is possible.

Dependencies for 1oo2 evaluation

Both channels must be activated.

The "Input delay" parameter must be identical for each pair. The "Input delay" parameter for the channel pair is determined as follows:

"Input delay" < MIN("Input delay" for channel n, "Input delay" for channel n+4).

The configured discrepancy time must be greater than the configured input delay.

Disable chatter monitoring for both channels.

Dependencies F-DI 8x24VDC HF (6ES7136-6BA01-0CA0)

The same dependencies apply to this F-module as for F-DI 8x24VDC HF (6ES7136-6BA00-0CA0).

In addition, channel-by-channel passivation is also possible due to the support of PROFIsafe V2.6MU1.

Dependencies for safety mat evaluation (as of firmware version V2.0.0)

If you have configured a channel group as a safety mat evaluation, you must assign the sensor supplies to the digital inputs as follows:

- VS_0 to DI_0 and VS_4 to DI_4
- VS_1 to DI_1 and VS_5 to DI_5
- VS_2 to DI_2 and VS_6 to DI_6
- VS_3 to DI_3 and VS_7 to DI_7

The short-circuit test must be activated on both sensor supplies.

You must set the parameters "Time for short-circuit test" and "Startup time of sensor after short-circuit test" to 4.2 ms.

Both channels must be activated.

You must set the parameter "Input delay" to the fixed value 1.6 ms for each channel of the channel pair.

Disable chatter monitoring for both channels.

The parameter "Channel failure acknowledge" must have the same value for both channels of the channel pair.

Dependencies for the "Counter" operating mode (as of firmware version V3.0.0)

Ensure that the value of the "High counting limit" parameter is higher than the value of the "Start value" parameter.

Ensure that the value of the "Start value" parameter is higher than the value of the "Low counting limit" parameter.

Configure the "Input delay" parameter for "Gate hardware control - Channel 1, 5" so that it is equal to the "Input delay" parameter of "Counter - Channel 0, 4".

Configure the "Input delay" parameter for "Direction hardware control - Channel 3, 7" so that it is equal to the "Input delay" parameter of "Counter - Channel 0, 4".

Dependencies for the "Standstill and overspeed monitoring" operating mode (as of firmware version V3.0.0)

Ensure that the value of the "Overspeed threshold" parameter is at least 2 greater than the value of the "Standstill threshold" parameter.

Configure the "Input delay" parameter for "Gate hardware control - Channel 1, 5" so that it is equal to the "Input delay" parameter of "Standstill and overspeed monitoring - Channel 0, 4".

NOTE

Note that the following parameters are connected to each other and influence each other:

- Overspeed threshold
- Standstill threshold
- Input delay
- Monitoring window duration [100 ms]

If one of these parameters is changed, you have to ensure by means of the following formula that the Overspeed threshold and Standstill threshold can be reached:

$$\text{Maximum reachable value} = \text{maximum frequency} * \frac{\text{Monitoring window duration [100 ms]}}{10}$$

The "Maximum reachable value" is the highest possible value that can be reached in a monitoring window.

The value of the "Overspeed threshold" parameter must be less than or equal to "Maximum reachable value" to ensure that the limit is reachable.

The value of the "Standstill threshold" parameter must be less than or equal to "Maximum reachable value" - 2.

The "Maximum frequency" tag is determined by the "Input delay" parameter:

- If the "Input delay" is 0.4 ms, the maximum frequency is 480 Hz.
- If the "Input delay" is 0.8 ms, the maximum frequency is 350 Hz.
- If the "Input delay" is 3.2 ms, the maximum frequency is 120 Hz.

The value of the "Monitoring window duration" parameter is set as a multiple of 100 ms.

Dependencies F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0) as of firmware version V2.0.0

The same dependencies apply to this F-module as for the two F-modules with article numbers 6ES7136-6DB00-0CA0 and 6ES7136-6BA00-0CA0 described above.

In TIA Portal, the "IO Tags" tab displays more tags than supported by the F module.

Dependencies F-DQ 8x24VDC/0.5A PP HF (6ES7136-6DC00-0CA0)

If you have enabled "Disable Dark Test for 48 hours", you must configure the "Max. readback time light test / dark test" parameter the same for all channels.
Reintegration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU. The F module supports configuration per GSD file PROFIsafe V2.4.
When configuring with GSD file, only module-wide passivation is possible.

Dependencies F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)

The F module has no F_iPar_CRC and no PROFIsafe address. You do not need to assign a PROFIsafe address to the F module.
If you nevertheless assign a PROFIsafe address to the F module with S7-FCT, an error message is displayed.

Dependencies of F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1) as of firmware version V1.0.2

NOTE

If the F-module is not visible in the module selection after the installation of the GSDML, check whether your configuration software supports the GSDML specification V2.35 or higher.

Reintegration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU.
In the module parameters, you can set the reintegration method a channel at a time. Manual or automatic reintegration is possible. When configuring with GSD file, only module-wide passivation is possible.
With configuration by GSD file, the F-module supports PROFIsafe V2.6MU1. An F-CPU is required which also supports a PROFIsafe V2.6MU1 or higher.

With "Evaluation of the sensors" with the setting "1oo1 evaluation (max. SIL3/Cat.3/PLd)"

The following parameters do not have any influence on the measured values and can be ignored.

- Standard value
- Discrepancy time
- Tolerance window % absolute
- Tolerance window % relative

With "Evaluation of the sensors" with the setting "1oo2 evaluation (max. SIL3/Cat.4/PLe)"

When switching from 1oo1 evaluation to 1oo2 evaluation, you have to activate the two corresponding channels.
The following parameters must have the same settings for the primary and secondary channel:

- Channel failure acknowledge
- Measuring range
- Diagnosis: Wire break
- Smoothing

NOTE

For the measuring range 0...20 mA, you have to activate the parameter "Diagnosis: Wire break".

NOTE

Ignore the following error message. This is a representation problem in the GSDML configuration. When you access the process data in your application, the IO variables are available.

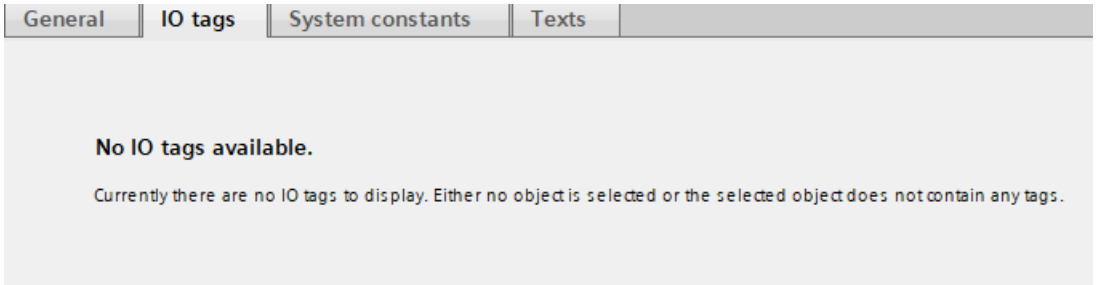

Dependencies of F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)

NOTE

If the F-module is not visible in the module selection after the installation of the GSDML, check whether your configuration software supports the GSDML specification V2.35 or higher.

Reintegration after a channel fault depends on the F-CPU used. You can find information on this in the documentation of the F-CPU.

In the module parameters, you can set the reintegration method a channel at a time. Manual or automatic reintegration is possible. When configuring with GSD file, only module-wide passivation is possible.

With configuration by GSD file, the F-module supports PROFIsafe V2.6MU1. An F-CPU is required which also supports a PROFIsafe V2.6MU1 or higher.

With "Evaluation of the sensors" with the setting "1oo1 evaluation (max. SIL2/Cat.3/PLd)"

The following parameters do not have any influence on the measured values and can be ignored:

- Standard value
- Discrepancy time
- Tolerance window % absolute
- Tolerance window % relative

With "Evaluation of the sensors" with the setting "1oo2 evaluation (max. SIL3/Cat.4/PLe)"

When switching from 1oo1 evaluation to 1oo2 evaluation, you have to activate the two corresponding channels.

The following parameters must have the same settings for the primary and secondary channel:

- Channel failure acknowledge
- Diagnosis: Wire break
- Smoothing

NOTE

If the above-mentioned condition is not met, a parameter assignment error occurs or the parameter assignment is refused.

NOTE

Ignore the following error message. This is a representation problem in the GSDML configuration. When you access the process data in your application, the IO variables are available.

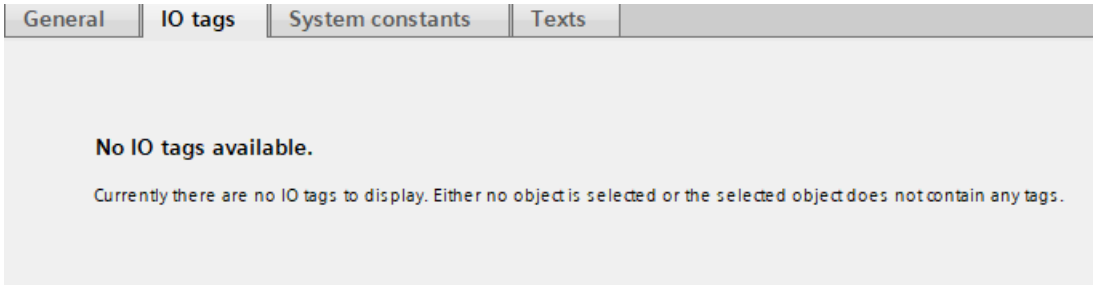

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Product information for the ET 200SP fail-safe modules: Use at altitudes > 2000 m above sea level
Product Information

Introduction

This document contains important product information on the F-modules specified in the section "Validity". The product information is part of the product supplied. This product information should be considered more up-to-date than other documentation if uncertainties arise.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

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Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

Validity

The statements in this product information apply to the F-modules listed below for operating altitudes > 2000 m above sea level:

Table 1 Validity

Designation	Article number	Version	Max. operating altitude
ET 200SP F-DI 8x24VDC HF	6ES7136-6BA00-0CA0	FS04 or higher	4000 m above sea level
ET 200SP F-DQ 4x24VDC/2A PM HF	6ES7136-6DB00-0CA0	FS04 or higher	
ET 200SP F-DQ 8x24VDC/0.5A PP HF	6ES7136-6DC00-0CA0	FS01 or higher	
F-PM-E 24VDC/8A PPM ST	6ES7136-6PA00-0BC0	FS05 or higher	
F-AI 4xI 0(4)..20mA 2-/4-wire HF	6ES7136-6AA00-0CA1	FS01 or higher	
F-AI 4xU 0..10V HF	6ES7136-6AB00-0CA1	FS01 or higher	

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Effects on the availability of modules

The higher cosmic radiation present during operation at altitudes over 2000 m above sea level will also start to have an effect on the failure rate of electronic components (the so-called soft error rate). In rare cases this can result in a transition of the module into the safe state, especially for safety modules. However, the functional safety of the module is fully retained.

Currently valid markings and approvals

NOTE

Information on the components of the ET 200SP automation system:

The markings and approvals printed on the components of the ET 200SP automation system are currently based on an operating altitude of up to 2000 m above sea level. The fail-safe modules are certified for use in safety mode up to the maximum operating altitude listed in Table 1 (according to IEC 61508:2010, EN ISO 13849-1:2015 and IEC 62061:2005/A2:2015).

F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)

Shipping and storage conditions

The following information applies to the fail-safe module F-DI 8x24VDC HF.

Table 2 Shipping and storage conditions for modules

Type of condition	Permissible range
Barometric pressure	From 1140 hPa to 616 hPa (corresponds to an altitude of -1000 m to 4000 m above sea level)

Climatic environmental conditions

The following information applies to the fail-safe module F-DI 8x24VDC HF.

Table 3 Climatic environmental conditions

Ambient conditions	Permissible range	Comments
Barometric pressure	From 1140 hPa to 616 hPa	Corresponds to an altitude of -1000 m to 4000 m above sea level

Table 4 Permissible ambient temperature depending on installation location

Mounting position	Installation location above sea level		
	- 1000 m to 2000 m	from 2000 m to 3000 m	from 3000 m to 4000 m
	Maximum ambient temperature		
Horizontal	60 °C	54 °C	48 °C
Vertical	50 °C	45 °C	40 °C

The normative basis for the derating is IEC 61131-2:2017.

Comments

Linear interpolation between altitudes is permissible.
The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.

NOTE

Ensure that the power supply units used are also suitable for altitudes > 2000 m above sea level.

Safety characteristics values

The safety characteristic values (PFD_{avg}, PFH values) given in the manual already include the influence of stronger cosmic radiation (soft error rate) for an application up to 4000 m above sea level.

F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0)

Shipping and storage conditions

The following information applies to the fail-safe module F-DQ 4x24VDC/2A PM HF.

Table 5 Shipping and storage conditions for modules

Type of condition	Permissible range
Barometric pressure	From 1140 hPa to 616 hPa (corresponds to an altitude of -1000 m to 4000 m above sea level)

Climatic environmental conditions

The following information applies to the fail-safe module F-DQ 4x24VDC/2A PM HF.

Table 6 Climatic environmental conditions

Ambient conditions	Permissible range	Comments
Barometric pressure	From 1140 hPa to 616 hPa	Corresponds to an altitude of -1000 m to 4000 m above sea level

Table 7 Permissible ambient temperature depending on installation location

Mounting position	Installation location above sea level			Total current of the outputs per module
	- 1000 m to 2000 m	from 2000 m to 3000 m	from 3000 m to 4000 m	
	Maximum ambient temperature			
Horizontal	40 °C	36 °C	32 °C	6 A
	50 °C	45 °C	40 °C	5 A
	60 °C	54 °C	48 °C	4 A
Vertical	50 °C	45 °C	40 °C	4 A

The normative basis for the derating is IEC 61131-2:2017.

Comments

Linear interpolation between altitudes is permissible.
The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.

NOTE

Ensure that the power supply units used are also suitable for altitudes > 2000 m above sea level.

Safety characteristics values

The safety characteristic values (PFD_{avg}, PFH values) given in the manual already include the influence of stronger cosmic radiation (soft error rate) for an application up to 4000 m above sea level.

F-DQ 8x24VDC/0.5A PP HF (6ES7136-6DC00-0CA0)

Shipping and storage conditions

The following information applies to the fail-safe module F-DQ 8x24VDC/0.5A PP HF.

Table 8 Shipping and storage conditions for modules

Type of condition	Permissible range
Barometric pressure	From 1140 hPa to 616 hPa (corresponds to an altitude of -1000 m to 4000 m above sea level)

Climatic environmental conditions

The following information applies to the fail-safe module F-DQ 8x24VDC/0.5A PP HF.

Table 9 Climatic environmental conditions

Ambient conditions	Permissible range	Comments
Barometric pressure	From 1140 hPa to 616 hPa	Corresponds to an altitude of -1000 m to 4000 m above sea level

Table 10 Permissible ambient temperature depending on installation location

Mounting position	Installation location above sea level			Total current of the outputs per module
	- 1000 m to 2000 m	from 2000 m to 3000 m	from 3000 m to 4000 m	
	Maximum ambient temperature			
Horizontal	40 °C	36 °C	32 °C	3 A
	50 °C	45 °C	40 °C	2.5 A
	60 °C	54 °C	48 °C	2 A
Vertical	50 °C	45 °C	40 °C	2 A

The normative basis for the derating is IEC 61131-2:2017.

Comments

Linear interpolation between altitudes is permissible.
The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.

NOTE

Ensure that the power supply units used are also suitable for altitudes > 2000 m above sea level.

Safety characteristics values

The safety characteristic values (PFD_{avg}, PFH values) given in the manual already include the influence of stronger cosmic radiation (soft error rate) for an application up to 4000 m above sea level.

F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)

Shipping and storage conditions

The following information applies to the fail-safe module F-PM-E 24VDC/8A PPM ST.

Table 11 Shipping and storage conditions for modules

Type of condition	Permissible range
Barometric pressure	From 1140 hPa to 616 hPa (corresponds to an altitude of -1000 m to 4000 m above sea level)

Climatic environmental conditions

The following information applies to the fail-safe module F-PM-E 24VDC/8A PPM ST.

Table 12 Climatic environmental conditions

Ambient conditions	Permissible range	Comments
Barometric pressure	From 1140 hPa to 616 hPa	Corresponds to an altitude of -1000 m to 4000 m above sea level

Table 13 Permissible ambient temperature depending on installation location

Mounting position	Installation location above sea level			Total current of the outputs per module
	- 1000 m to 2000 m	from 2000 m to 3000 m	from 3000 m to 4000 m	
	Maximum ambient temperature			
Horizontal	40 °C	36 °C	32 °C	8 A
	50 °C	45 °C	40 °C	6 A
	60 °C	54 °C	48 °C	4 A
Vertical	50 °C	45 °C	40 °C	4 A

The normative basis for the derating is IEC 61131-2:2017.

Comments

Linear interpolation between altitudes is permissible.
The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.

NOTE

Ensure that the power supply units used are also suitable for altitudes > 2000 m above sea level.

Safety characteristics values

The safety characteristic values (PFD_{avg}, PFH values) given in the manual already include the influence of stronger cosmic radiation (soft error rate) for an application up to 4000 m above sea level.

F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1) and F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)

Shipping and storage conditions

The following specifications apply to the fail-safe modules F-AI 4xI 0(4)..20mA 2-/4-wire HF and F-AI 4xU 0..10V HF.

Table 14 Shipping and storage conditions for modules

Type of condition	Permissible range
Barometric pressure	From 1140 hPa to 616 hPa (corresponds to an altitude of -1000 m to 4000 m above sea level)

Climatic environmental conditions

The following specifications apply to the fail-safe modules F-AI 4xI 0(4)..20mA 2-/4-wire HF and F-AI 4xU 0..10V HF.

Table 15 Climatic environmental conditions

Ambient conditions	Permissible range	Comments
Barometric pressure	From 1140 hPa to 616 hPa	Corresponds to an altitude of -1000 m to 4000 m above sea level

Table 16 Permissible ambient temperature depending on installation location

Mounting position	Installation location above sea level		
	- 1000 m to 2000 m	from 2000 m to 3000 m	from 3000 m to 4000 m
	Maximum ambient temperature		
Horizontal	60 °C	54 °C	48 °C
Vertical	50 °C	45 °C	40 °C

The normative basis for the derating is IEC 61131-2:2017.

Comments

Linear interpolation between altitudes is permissible.
The derating factors compensate for the decreasing cooling effect of air at higher altitudes due to lower density.

NOTE

Ensure that the power supply units used are also suitable for altitudes > 2000 m above sea level.

Safety characteristics values

The safety characteristic values (PFD_{avg}, PFH values) given in the manual already include the influence of stronger cosmic radiation (soft error rate) for an application up to 4000 m above sea level.

SIEMENS
SIMATIC
ET 200SP
Product Information for the Documentation of ET 200SP Fail-safe Modules
Product Information

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

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To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

General amendments to the documentation

This Product Information contains amendments and corrections to the documentation of the following ET 200SP fail-safe modules.

- Digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)
- Digital input module F-DI 8x24VDC HF (6ES7136-6BA01-0CA0)
- Digital output module F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0)
- Digital output module F-DQ 8x24VDC/0.5A PP HF (6ES7136-6DC00-0CA0)
- Power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)
- Digital output module F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)
- Analog input module F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)
- Analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1)
- Counter module F-TM Count 1x1Vpp sin/cos HF (6ES7136-6CB00-0CA0)

The Product Information is part of the product supplied. The statements provided in it should be considered more up-to-date than other documentation if uncertainties arise.

You can use the Power Module F-PM-E 24VDC/8A PPM ST with the standard modules listed under entry ID: 83203124 (https://support.industry.siemens.com/cs/ww/en/view/83203124) **within a potential group.**

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Supplement to the section "Response times" of the Equipment Manual "Digital input module F-DI 8x24VDC HF (6ES7136-6BA01-0CA0)"

The discrepancy time is included in the calculation of the maximum response time (T_{WCDT}) and can therefore be set to 0 in the SIMATIC STEP 7 response-time table.

Amendment to chapter 5.1.1.2 "*Application: Wiring a load to the digital output, PP switching*", 5.1.1.4 "*Application: Wiring of two parallel loads to the digital output, PP switching*" and 5.4.2 "*Safety-related shutdown of standard output modules, PP switching*" of the manual "Power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)"

WARNING

The light test must be activated if the output channel can permanently carry the "0" signal for 100 hours or more. Consult the respective requirements of your product standards regarding error detection time.

Addendum to section 5.1 "*Applications for the output DQ/P1 and P2*" and 5.4 "*Applications for the safety-related shutdown of standard modules*" of the manual "Power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)"

WARNING

A defective F-module can result in cyclic "1" signals with the duration of the "Max. readback time switch on test" at the output DQ/P1 and P2.

Correction of section 3.1 "*Terminal assignment*" of the manual "Power Module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)"

The warning in the section "Redundant ground conductor required" is being omitted, and being replaced by the new warning in section 5.1.1.2 "*Application: Wiring a load to the digital output, PP switching*", section 5.1.1.4 "*Application: Wiring two loads in parallel to the digital output, PP switching*" and section 5.4.2 "*Safety-related shutdown of standard output modules, PP switching*".

Amendment to chapter 5.1.1.2 "*Application: Wiring a load to the digital output, PP switching*", section 5.1.1.4 "*Application: Wiring two loads in parallel to the digital output, PP switching*" and section 5.4.2 "*Safety-related shutdown of standard output modules, PP switching*" of the manual "Power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)"

WARNING

In this application, you have to connect two ground cables to the BaseUnit for safety reasons. Otherwise, the maximum residual current at signal "0" (specified in the technical specifications) cannot be maintained if a single ground cable is interrupted.

Amendment to chapter 5.2 "*Application 1: Safety mode SIL3/Cat.3/PLd*" of the Equipment Manual "Digital input module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)" and section 5.2.2 "Application 1: Safety mode SIL3/Cat.3/PLd" of the manual "Power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)"

NOTE

SIL3/Cat.3/PLd can be achieved through cross-circuit proof wiring and for the sensor, through application of the principle of positive opening operation.

Unsupported parameters

The "Pulse stretching" and "Disable dark test for 48 hours" parameters are not supported.

Dependencies between the "Discrepancy time" and "Input delay" parameters

The configured discrepancy time must be greater than the configured input delay.

Dependencies between the "Startup time of the sensors after short circuit test" and "Time for short circuit test" parameters

The startup time of the sensor after a short-circuit test must amount to at least 1% of the time for the short-circuit test.

Switching on the supply voltage L+ for the ET 200SP F-modules and IM

Make sure that the F-module as well as the IM were de-energized at the same time before you switch on the supply voltage L+ for an F-module. You do not have to observe a switch-on sequence.

Cyclic reading of I&M data

Cyclic reading of I&M data can affect the timing of the F-modules. You should therefore avoid short read cycles of less than 500 ms.

Wire break detection for F-DQ 4x24VDC/2A PM HF fail-safe module up to and including hardware revision level 02

The response threshold of the wire break detection is < 15 mA.

T_{DAT} acknowledgment time

F-Module	T_{DAT} acknowledgment time
Digital input module F-DI 8x24VDC HF	23 ms
Digital output module F-DQ 4x24VDC/2A PM HF	31 ms
Power module F-PM-E 24VDC/8A PPM ST	30 ms

Technical specifications

The information on "Permitted potential difference between different circuits" is no longer part of the technical specifications.

Technical specifications, digital output module F-DQ 4x24VDC/2A PM HF (6ES7136-6DB00-0CA0)

Voltage induced on current interruption limited to	-2*47 V, typical

Technical specifications, power module F-PM-E 24VDC/8A PPM ST (6ES7136-6PA00-0BC0)

Voltage induced on current interruption limited to	max. -1.5 V

Block diagram F-RQ 1x24VDC/24..230VAC/5A (6ES7136-6RA00-0BF0)

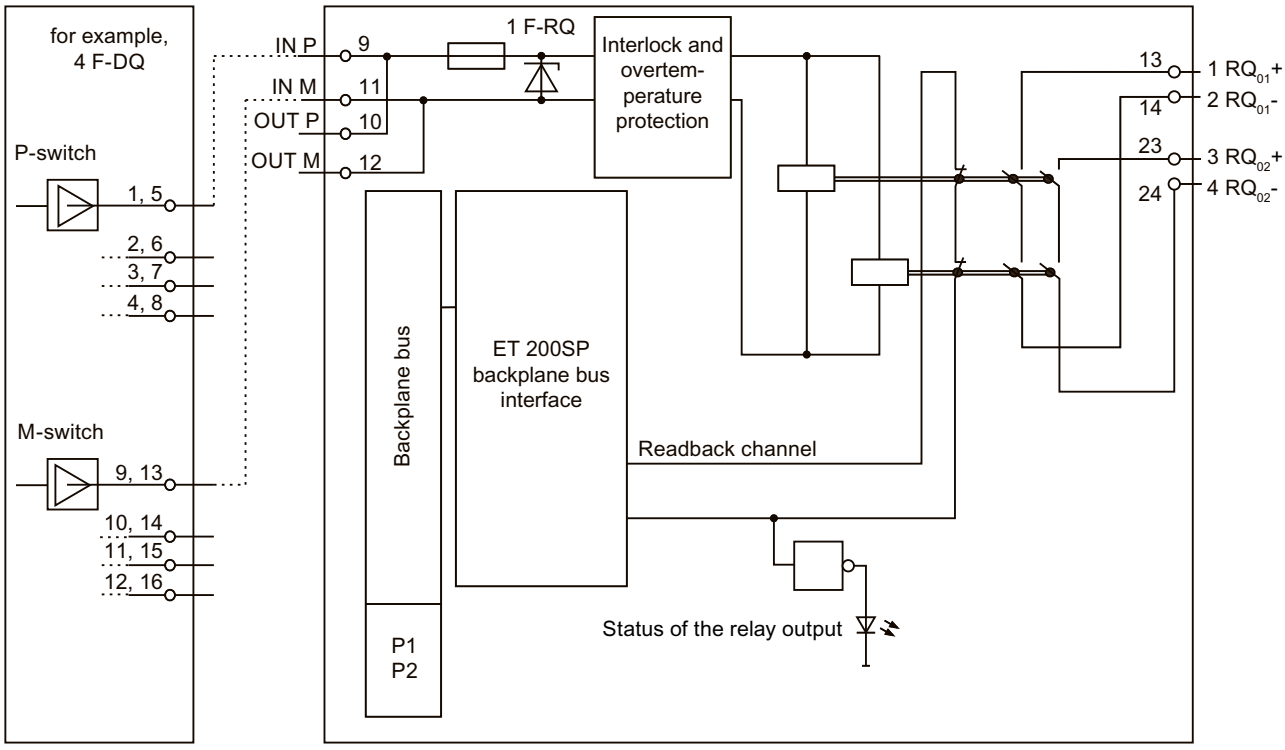

Figure 1 Block diagram F-RQ 1x24VDC/24..230VAC/5A

Amendment to section 5.1 "Application 1: Safety mode SIL2/Cat.3/PLd with two-wire connection, 1oo1 evaluation" of the Equipment Manual "Analog input module F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)"

⚠ WARNING

In the case of 1oo1 evaluation, faults with the sensor or wiring of the F-AI module are not detected.

Amendment to section 5.3 "Application 3: Safety mode SIL2/Cat.3/PLd with four-wire connection, 1oo1 evaluation" of the Equipment Manual "Analog input module F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)"

⚠ WARNING

In the case of 1oo1 evaluation, faults with the sensor or wiring of the F-AI module are not detected.

New section 5.5 "Application 5: Safety mode SIL2/Cat.3/PLd with 3-wire connection, 1oo1 evaluation" in the Equipment Manual "Analog input module F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)"

Voltage measurement 0 V to 10 V

Four process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.

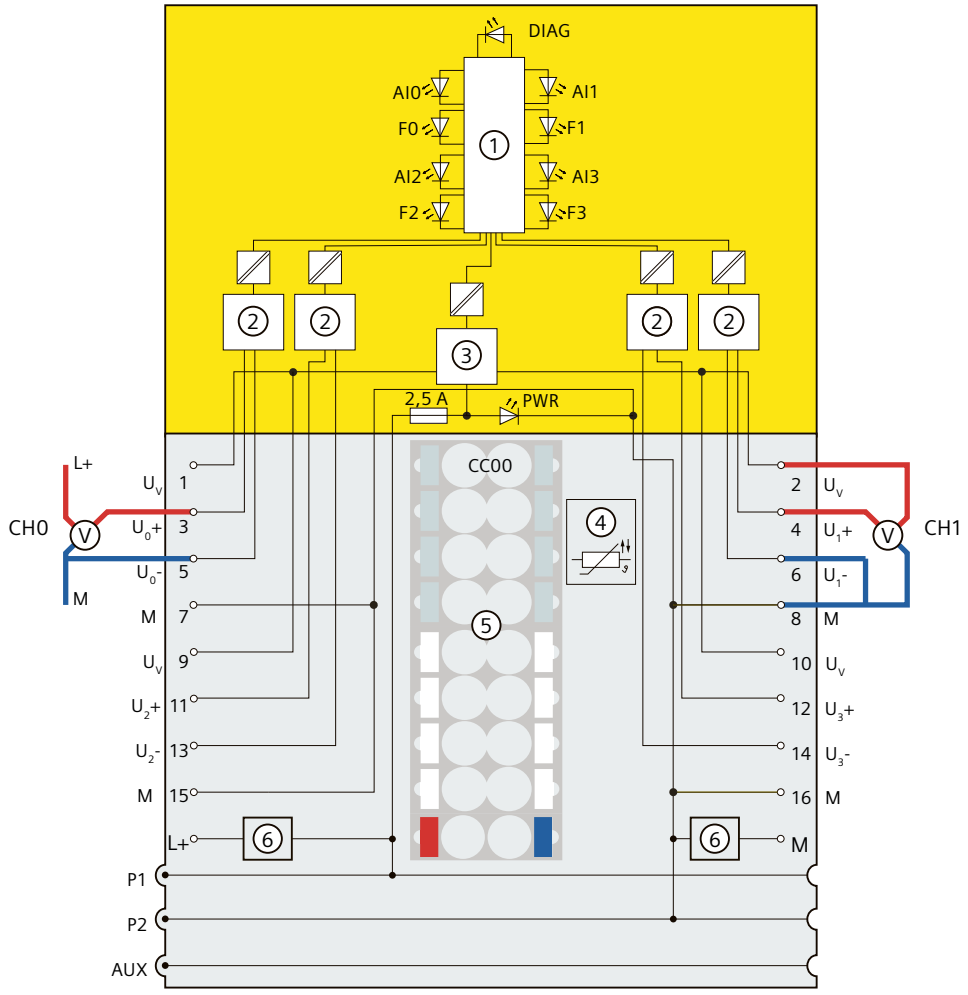

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-establishing voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)
⑥	Filter circuit supply voltage (available in light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 2 1oo1 evaluation

WARNING

To achieve SIL2/Cat.3/PLd when using this wiring, you must use a suitably qualified sensor.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

WARNING

For voltage inputs, changes in resistance along the transmission path (from sensor to module) can result in the measured value being falsified.

For correct measured value acquisition during the entire service life, you must take these changes in resistance into account when designing the safety functions and take appropriate measures.

WARNING

In the case of 1oo1 evaluation, faults with the sensor or wiring of the F-AI module are not detected.

Assignable parameters for Application 5

Table 1 Parameters for Application 5 of the F-AI 4xU 0..10V HF

Parameter	Value range in safety mode
Behavior after channel faults	• Passivation of the entire F-module • Passivation of the channel
Interference frequency suppression	• 50 Hz • 60 Hz

Parameter	Value range in safety mode
Evaluation of the sensors	1oo1 evaluation (max. SIL2/Cat.3/PLd)
Measuring range	0 to 10 V
Diagnostics: Wire break	• Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

New section "5.6 Application 6: Safety mode SIL3/Cat.4/PLe with 3-wire connection, 1oo2 evaluation" in the Equipment Manual "Analog input module F-AI 4xU 0..10V HF (6ES7136-6AB00-0CA1)"

Voltage measurement 0 V to 10 V

Two process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.

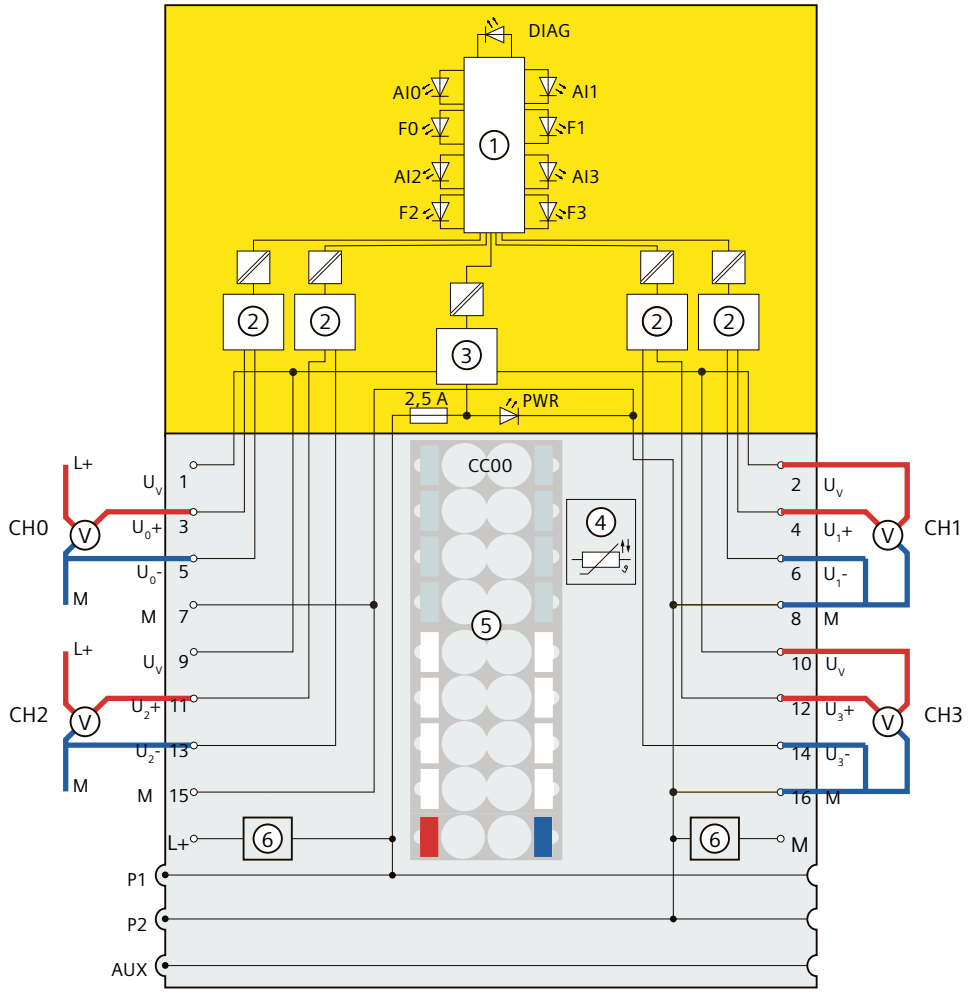

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Chassis ground
③	Sensor supply/reverse polarity protection	L+	24 V DC (infeed only with light-colored BaseUnit)

④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	P1, P2, AUX	Internal self-establishing voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	DIAG	Diagnostics LED (green, red)
⑥	Filter circuit supply voltage (available in light-colored BaseUnit only)	AI0, AI1, AI2, AI3	Channel status LED (green)
U_n+	Voltage input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
U_n-	Voltage input negative, channel n	PWR	Power LED (green)

Figure 3 1oo2 evaluation

WARNING

To achieve SIL3/Cat.4/PLe with this wiring, you must use suitably qualified sensors.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for Application 6

Table 2 Parameters for Application 6 of the F-AI 4xU 0..10V HF

Parameter	Value range in safety mode
Standard value	• MIN • MAX
Discrepancy time	100 to 30000 ms
Tolerance window %, absolute	2.0 to 20.0%
Tolerance window %, relative	2.0 to 20.0%
Behavior after channel faults	• Passivation of the entire F-module • Passivation of the channel
Interference frequency suppression	• 50 Hz • 60 Hz
Evaluation of the sensors	1oo2 evaluation (max. SIL3/Cat.4/PLe)
Measuring range	0 to 10 V
Diagnostics: Wire break	• Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

Amendment to section 5.1 "Application 1: Safety mode SIL3/Cat.3/PLd with 2-wire transducer" of the Equipment Manual "Analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1)"

⚠ WARNING

In the case of 1oo1 evaluation, faults with the sensor or wiring of the F-AI module are not detected.

Amendment to section 5.3 "Application 3: Safety mode SIL3/Cat.3/PLd with 4-wire transducer" of the Equipment Manual "Analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1)"

⚠ WARNING

In the case of 1oo1 evaluation, faults with the sensor or wiring of the F-AI module are not detected.

New section 5.5 "Application 5: Safety mode SIL3/Cat.3/PLd with 3-wire measuring transducer" in the Equipment Manual "Analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1)"

Introduction

The following section describes the wiring scheme and the parameter assignment of the F-AI 4xI 0(4)..20mA 2-/4-wire HF for

- Application 5: Safety mode SIL3/Cat.3/PLd, 1oo1 evaluation with 3-wire measuring transducer.

Possible diagnostic messages, the error causes and possible corrective measures are specified in the section "Diagnostic messages".

Current measurement 0/4 to 20 mA, 3-wire measuring transducer

Four process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.

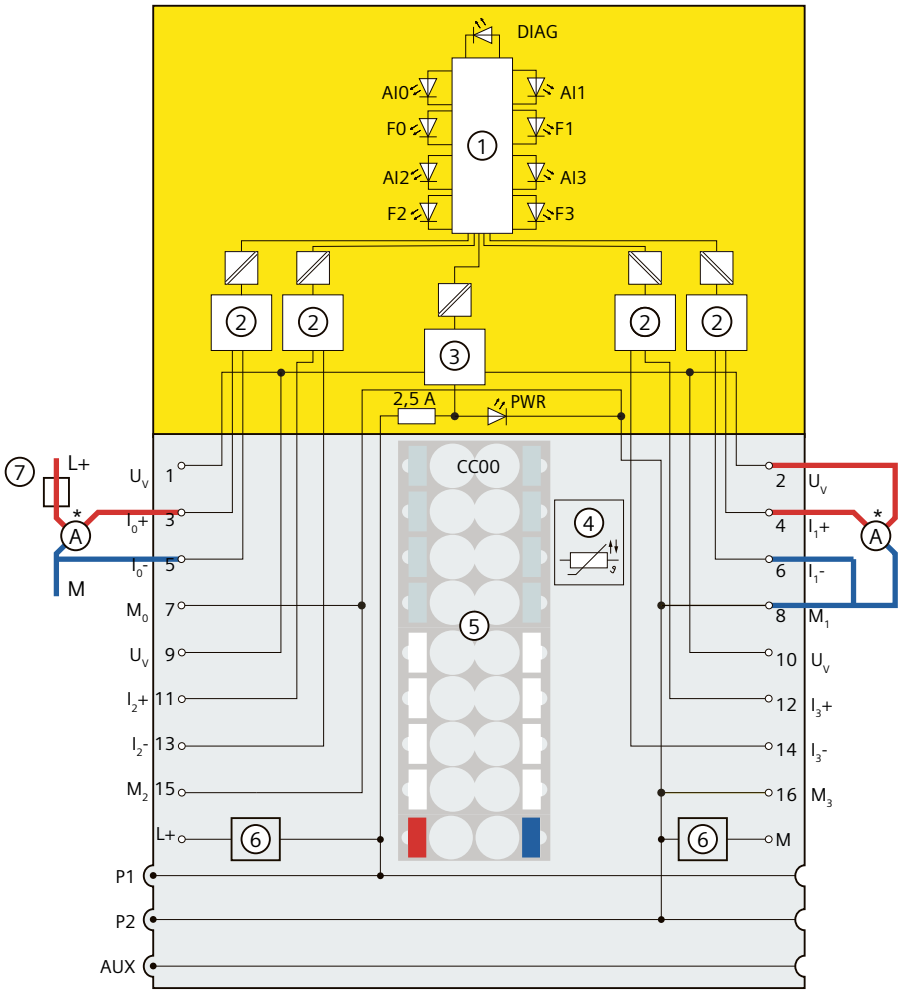

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground reference to U_V, channel n
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-establishing voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter circuit supply voltage (available in light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)
⑦	External fuse	AI0, AI1, AI2, AI3	Channel status LED (green)
I_n+	Current input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
I_n-	Current input negative, channel n	PWR	Power LED (green)
*	Measuring transducer		

Figure 4 1oo1 evaluation

WARNING

To achieve SIL3/Cat.3/PLd with this wiring, you must use a suitably qualified sensor.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

WARNING

In the case of 1oo1 evaluation, faults with the sensor or wiring of the F-AI module are not detected.

Assignable parameters for Application 5

Table 3 Parameters for Application 5 of F-AI 4xI 0(4)..20mA 2-/4-wire HF

Parameter	Value range in safety mode
Behavior after channel faults	• Passivation of the entire F-module • Passivation of the channel
Interference frequency suppression	• 50 Hz • 60 Hz
Evaluation of the sensors	1oo1 evaluation (max. SIL3/Cat.3/PLd)
Measuring range	• 0 to 20 mA • 4 to 20 mA
Diagnostics: Wire break	(in the measuring range 4 to 20 mA) • Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

New section 5.6 "Application 6: Safety mode SIL3/Cat.4/PLe with 3-wire measuring transducer" in the Equipment Manual "Analog input module F-AI 4xI 0(4)..20mA 2-/4-wire HF (6ES7136-6AA00-0CA1)"

Introduction

The following section contains the wiring scheme and the parameter assignment of the F-AI 4xI 0(4)..20mA 2-/4-wire for

- Application 6: Safety mode SIL3/Cat.4/PLe, 1oo2 evaluation with 3-wire measuring transducer

Possible diagnostic messages, their error causes and possible corrective measures are specified in the section "Diagnostic message".

Current measurement 0/4 to 20 mA, 3-wire measuring transducer

Two process signals can be connected to the F-module in this interconnection variant. Sensor supply U_V is provided by the F-module for 4 channels. You can also supply the sensors by means of an external sensor supply.

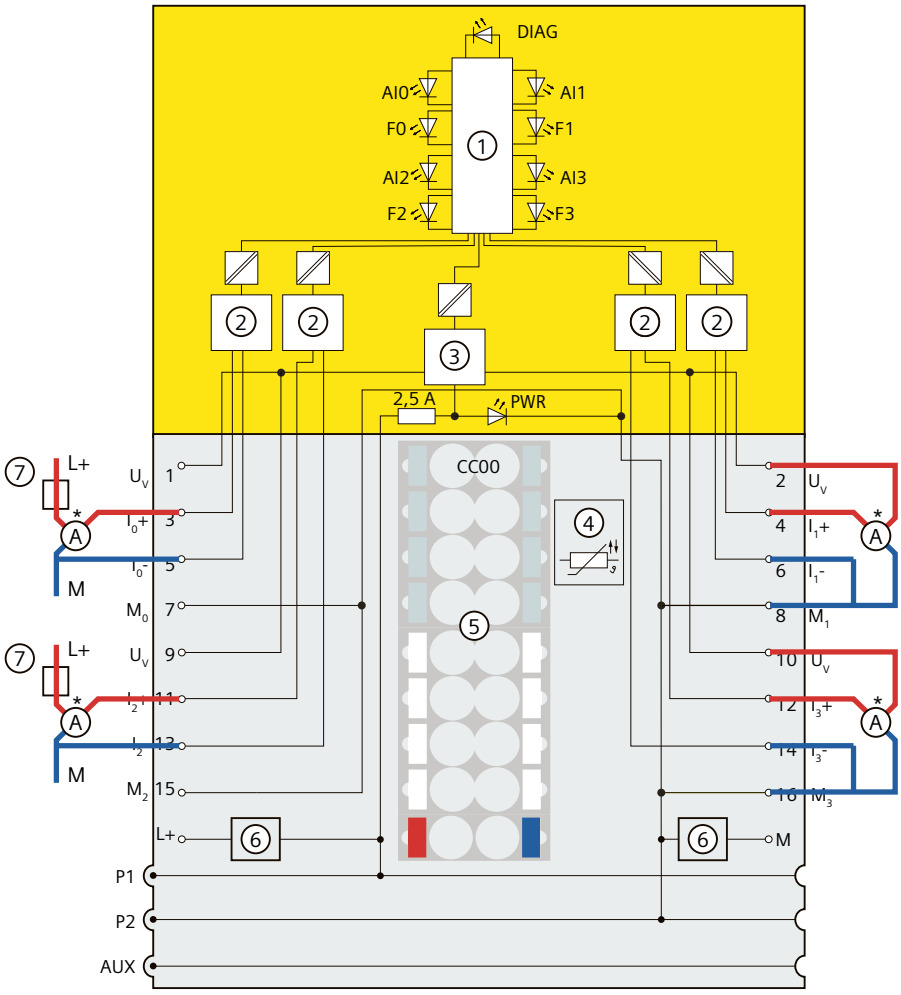

①	Backplane bus interface	U_V	Sensor supply
②	Analog-to-digital converter (ADC)	M	Supply voltage ground
③	Sensor supply/reverse polarity protection	M_n	Ground reference to U_V, channel n
④	Temperature measurement for BU type A1 only (the function cannot be used for this module.)	L+	24 V DC (infeed only with light-colored BaseUnit)
⑤	Color-coded label with color code CC00 (optional)	P1, P2, AUX	Internal self-establishing voltage buses Connection to left (dark-colored BaseUnit) Connection to left interrupted (light-colored BaseUnit)
⑥	Filter circuit supply voltage (available in light-colored BaseUnit only)	DIAG	Diagnostics LED (green, red)
⑦	External fuse	AI0, AI1, AI2, AI3	Channel status LED (green)
I_n+	Current input positive, channel n	F0, F1, F2, F3	LED channel fault (red)
I_n-	Current input negative, channel n	PWR	Power LED (green)
*	Measuring transducer		

Figure 5 1oo2 evaluation

WARNING

To achieve SIL3/Cat.4/PLe with this wiring, you must use suitably qualified sensors.

WARNING

All cables need to be laid in such a way that they are resistant to interference voltage. Use shielded cables.

Assignable parameters for Application 6

Table 4 Parameters for Application 6 of F-AI 4xI 0(4)..20mA 2-/4-wire HF

Parameter	Value range in safety mode
Standard value	• MIN • MAX
Discrepancy time	100 to 30000 ms
Tolerance window %, absolute	2.0 to 20.0%
Tolerance window %, relative	2.0 to 20.0%
Behavior after channel faults	• Passivation of the entire F-module • Passivation of the channel
Interference frequency suppression	• 50 Hz • 60 Hz
Evaluation of the sensors	1oo2 evaluation (max. SIL3/Cat.4/PLe)
Measuring range	• 0 to 20 mA • 4 to 20 mA
Diagnostics: Wire break	(in the measuring range 4 to 20 mA) • Disable • Enable
Smoothing	1 / 2 / 4 / 8 / 16 / 32 / 64 conversion cycles

Use of radio devices and cell phones

WARNING

Unexpected malfunctions of machines caused by radio devices/cell phones

Malfunctions are possible when radio devices or cell phones are used in the direct proximity of F-I/O. This can result in death, serious injury or property damage.

If you scan the 2D matrix code/ID Link or use the "SIEMENS Industry Support App" with a powered-on F-I/O, then deactivate all radio connections of the radio device/cell phone beforehand. Alternatively, power off the F-I/O before scanning.

Power off radio devices in the immediate proximity of the F-I/O.

Supplement to the Attachment "Reaction times" of the Manuals "Power Module F-PM-E 24VDC/8A PPM ST

(6ES7136-6PA00-0BC0)" and "Digital Input Module F-DI 8x24VDC HF (6ES7136-6BA00-0CA0)"

Digital output of the Power Module F-PM-E 24VDC/8A PPM ST

Definition of response time for fail-safe digital outputs

The response time represents the interval between an incoming safety message frame from the backplane bus and the signal change at the digital output.

Following applies to activation of the dark test:

Maximum response time with no faults

The maximum response time for fail-safe digital outputs in the error-free case is equal to:

Max. response time = 2 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time in case of error with detection by readback (change of user data)

Max. response time = 3 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time in case of error with detection by bit pattern test

Max. response time = Configured test period

The following applies to deactivation of the dark test:

Maximum response time with no faults

The maximum response time for fail-safe digital outputs in the error-free case is equal to:

Max. response time = 2 × T_{cycle} + Maximum(dark test time, switch-on time)

Maximum response time in case of error with detection by readback (change of user data)

Max. response time = 3 × T_{cycle} + Maximum(dark test time, switch-on time)

A channel fault may not be detected until process value change 1 to 0 takes place at the output DQ/P1 and P2.

Digital inputs of Power Module F-PM-E 24VDC/8A PPM ST and fail-safe module F-DI 8x24VDC HF

Definition of the response time for fail-safe digital inputs

The response time represents the interval between a signal change at the digital input and reliable availability of the safety frame on the backplane bus.

Maximum response time with external short-circuits

F-PM-E 24VDC/8A PPM ST:

Max. response time = T1 + T_{cycle} + (n * T_{cycle}) + Sum[x=0...1](Tsx) + MAX(T_{cycle}, T2)

F-DI 8x24VDC HF:

Max. response time = T1 + T_{cycle} + (n * T_{cycle}) + Sum[x=0...7](Tsx) + MAX(T_{cycle}, T2)

Tsx sum term:

(T2x + T3x) < T_{cycle} → Tsx = T_{cycle}

(T2x + T3x) >= T_{cycle} → Tsx = MAX(T2x, T_{cycle}) + T3x

For deactivated sensor supplies or sensor supplies with deactivated short-circuit test, enter the value of 0 in the formula for Tsx.

T1 = Input delay for the considered channel

T2 = Short-circuit test time for the considered channel

x = activated sensor supply
T2x = Time for the short-circuit test
T3x = Startup time of sensors after the short-circuit test
n = Number of sensor supplies with activated short-circuit test

Examples

The following section contains an example for the calculation of the maximum response time with external short-circuits at an F-DI 8x24VDC HF with a maximum cycle time T_{cycle} of 11.5 ms with the default parameter assignment.

Channel	T1 [ms]	Short-circuit test	T2 [ms]	T3 [ms]	T_{cycle} [ms]	T2 + T3 < T_{cycle}	Ts [ms]	MAX(T_{cycle}, T2) [ms]	Max. response time with external short-circuits [ms]
0	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
1	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
2	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
3	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
4	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
5	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
6	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2
7	3.2	Enable	4.2	4.2	11.5	YES	11.5	11.5	210.2

Sample calculation: Sum term Ts = (4.2 ms + 4.2 ms) < 11.5 ms → Tsx = T_{cycle}

The following section shows an example for the calculation of the maximum response time with external short-circuits at an F-DI 8x24VDC HF with a maximum cycle time T_{cycle} of 11.5 ms depending on the parameter assignment.

Channel	T1 [ms]	Short-circuit test	T2 [ms]	T3 [ms]	T_{cycle} [ms]	T2 + T3 < T_{cycle}	Ts [ms]	MAX(T_{cycle}, T2) [ms]	Max. response time with external short-circuits [ms]
0	0.4	Enable	0.5	0.5	11.5	YES	11.5	11.5	5465.3
1	0.8	Enable	4.2	10	11.5	NO	21.5	11.5	5465.7
2	1.6	Enable	20	4.2	11.5	NO	24.2	20	5475.0
3	3.2	Enable	100	100	11.5	NO	200	100	5556.6
4	0.4	Disable	-	-	11.5	-	0	11.5	- *)
5	0.8	Enable	100	4.2	11.5	NO	104.2	100	5554.2
6	1.6	Enable	500	500	11.5	NO	1000	500	5955.0
7	3.2	Enable	2000	2000	11.5	NO	4000	2000	7456.6

*) With short-circuit test deactivated, external short-circuits are not detected.

Sample calculation: Sum term Ts = (4.2 ms +10 ms) >= 11.5 ms → Tsx = MAX(4.2 ms, 11.5 ms) + 10 ms

Diagnostic messages

Table 5 Diagnostic messages of the F-PM-E 24VDC/8A PPM ST

Diagnostic message	Fault code	Meaning	Remedy
Overtemperature	5_D	• An excessively high temperature was measured in the F-module. • The PWM function of a load causes interference signals in the supply voltage of the F-module.	• Operate the F-module within the specified temperature range (see Technical specifications) Once the fault has been eliminated, the F-module must then be pulled and plugged, or the power switched OFF and ON. • Decouple the supply voltages of the load using the PWM function and the F-module.

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Product Information on fail-safe modules with GSD configuration

Product Information

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/cert).

Introduction

Observe the following notes and explanations for PROFINET IO during parameterization of fail-safe modules with GSD file in the PROFIsafe profile 2.4 (BP mode).

NOTE

When using fail-safe modules with the GSD file on an F-host, note that the warnings, information and references to other manuals contained in the F-module equipment manuals are still valid.

Please also observe the F-host specifications.

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Implementation of the Device_Fault bit in BP (Basic Protocol) mode of the fail-safe modules

PROFIsafe 2.4 with automatic reintegration:

In this mode, the F-host is responsible for module-wide passivation in the event of a channel fault. This means that if an individual channel reports a fault, the F-host performs passivation of all channels within an F-module. Notification of the F-CPU about faults and the consequent reaction of the F-CPU takes place via PROFIsafe status and control bits.

Reintegration of an F-module with faults in this mode takes place automatically after all channel faults have been completely eliminated.

After all pending faults have been corrected, the F-module returns to the normal state and process values are updated cyclically again.

PROFIsafe 2.4 with operator acknowledgment for reintegration:

This is the same mode as before, but the reintegration can only be completed after a pending operator acknowledgment signal is released by the F-host (i.e. operator acknowledgment is handled by the F-host).

From the operator's perspective, waiting for the operator acknowledgment signal is indicated by specific LED flashing (red-green). This means that, after pending faults of an affected channel have been eliminated, the value status is set to "good" and the LED flashing will show optically that the channel is ready to finish reintegration.

After all channel faults have been eliminated, the F-module checks whether operator acknowledgment from the F-host is pending by evaluating the PROFIsafe control bit **OA_Req**. As long as this control bit is set to "true", the channel shows "Waiting for reintegration" through flashing LEDs. In this state, note that the value status bits for the channels have already been set to "good" and the F-module is ready to function normally. For this reason, the received operator acknowledgment only affects the LED flashing.

Summary of failure and reintegration from the perspective of the F-module

1. Fault occurs and is detected.
2. Device_Fault is sent to the F-host.

   NOTE

   This can be viewed as an implicit request for an operator acknowledgment.

3. Channel fault is corrected, Device_Fault=0 is sent to the F-host and the F-module is reintegrated
4. Operator acknowledgment via the PROFIsafe control bit OA_Req is received by the F-host and the alternating flashing of the LEDs is switched off.

Restart

After all channel faults have been corrected (all I/O self-tests are completed successfully), the process values are automatically output or supplied again.

⚠ WARNING

Manual reintegration must be realized on the F-host side

You can find a description of suitable measures in the technical specification PROFISafe Version 2.6, Annex C, subsection *"C.1.4.2 Prevent unintentional restart by application measures"*.

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ET 200SP BaseUnits (6ES7193-6BP... /3RK1908-0AP00...)

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Introduction

1

Purpose of the documentation

This Equipment Manual supplements the System Manual ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Functions that generally relate to the system are described in this System Manual.

The information provided in this Equipment Manual and in the System/Function Manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used hereinafter, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally sustainable recycling and disposal of your old device, contact a certified disposal service for electronic scrap and dispose of the device in accordance with the regulations in your country.

1.1 ET 200SP Documentation Guide

1.1.1 Information classes ET 200SP

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/cn/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109806400)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Industrial cybersecurity 2

2.1 Introduction to industrial cybersecurity

Digitalization and the increasing networking of machines and industrial plants are also increasing the risk of cyberattacks. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O System System Manual.

This section provides an overview of security-relevant information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

New properties

3

What's new in Edition 06/2025 of the BaseUnits Equipment Manual compared with Edition 06/2023?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	BaseCarrier	Reduced wiring work and error prevention	Section BaseCarrier (Page 28)

What's new in Edition 06/2023 of the BaseUnits Equipment Manual compared with Edition 11/2022?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	BU type A1, light-colored version, without add-on terminals BU type A1, dark-colored version, with add-on terminals	New extract from the technical specifications	Section Technical specifications of the BU type A1, light-colored version, without add-on terminals (Page 63) Section Technical specifications of the BU type A1, dark-colored version, with add-on terminals (Page 68)

What's new in Edition 11/2022 of the BaseUnits Equipment Manual compared with Edition 04/2022?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	BaseUnit BU type M0	The BaseUnit BU type M0 connects the IM 155-6 PN R1 interface modules to the backplane bus and provides the supply voltage for the IM 155-6 PN R1 interface modules.	Section BU type M0 (Page 24)

What's new in Edition 04/2022 of the BaseUnits Equipment Manual compared with Edition 09/2019?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	New shield terminal for connecting cable shields	The new stacked shield terminal provides extended space for clamping thanks to two clamping positions. In addition, a supporting element absorbs torsional and bending forces.	Section Dimension drawings of I/O modules (Page 183)

What's new in Edition 09/2019 of the BaseUnits Equipment Manual, compared with Edition 02/2018?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	BaseUnits BU30-MS7, BU30-MS8, BU30-MS9 and BU30-MS10 for fail-safe motor starters	A simple, wire-saving group shutdown for fail-safe motor starters. In contrast to the earlier solution (BU30-MS5 and BU30-MS6), the fail-safe signal only has to be wired to the first motor starter. The fail-safe signal is internally routed via the BaseUnits.	Section BU30-MS7 BaseUnit with F-DI and 500 V AC infeed (Page 137) Section BU30-MS8 BaseUnit with 500 V AC infeed and F-DI routing (Page 141) Section BU30-MS9 BaseUnit with F-DI routing (Page 145) Section BU30-MS10 BaseUnit with F-DI infeed (Page 149)

What's new in Edition 02/2018 of the BaseUnits Equipment Manual compared with Edition 12/2016?

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Potential distributor modules	A system-integrated potential distribution can be implemented via the PotDis modules. One application is, for example, the design of digital input modules with 16 channels and three-wire connection. You use the potential distributor modules to reserve the unused signal cables of antivalent sensors. Another application is the supply of potentials for supply of external components.	Section Potential distributor modules (Page 153)
	BaseUnit type U0 Can be used for all I/O modules whose article number ends in U0	Light-colored version: BU20-P16+A0+2D Per slot, up to 16 process terminals to the module are supplied with max. 230 V per terminal. • 2 supply terminals on integrated self-assembling voltage buses P1/P2, max. 230 V AC/10 A • Separation of voltage buses P1/P2 and AUX from the adjacent module on the left	Section BU20-P16+A0+2D (Page 102)

What's new?		What are the customer benefits?	Where can I find the information?
New contents	BaseUnit type U0 Can be used for all I/O modules whose article number ends in U0	Dark-colored version: BU20-P16+A0+2B Per slot, up to 16 process terminals to the module are supplied with max. 230 V per terminal. • 2 terminals for external supply/forwarding from integrated self-assembling voltage buses P1/P2 • Bridging voltage buses P1/P2 and AUX to the adjacent module on the left	Section BU20-P16+A0+2B (Page 106)

Terminal labeling of the PotDis-TB

New specification offers the following advantages:

- Unique terminal numbering per slot, even if the same reference identifier is used for the PotDis-BU and the PotDis-TB of a slot.
- Best possible readability
- Shortest possible designation to keep the work for conductor labeling as low as possible
- Compliant with ECAD rules
- Consistent with the previous ET 200SP logic
- You can continue using the color-coded label CC00

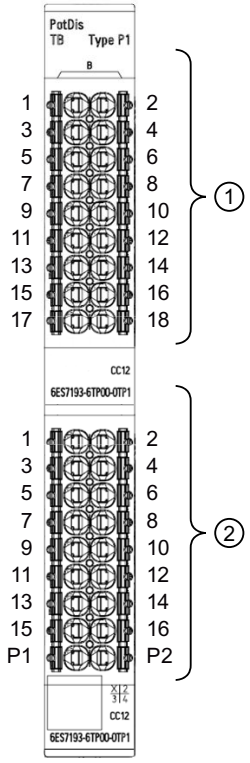

①	**Terminal labeling of the PotDis-TB**	B1 to B18. To save space, the preceding character "B" is printed once at the top and must not be covered by the color-coded labels.
②	**Terminal labeling of the PotDis-BU**	1 to 16, the infeed terminals P1 and P2.

Product overview

4

General properties of the BaseUnits

The ET 200SP distributed I/O system includes various BaseUnits. You use the BaseUnit to specify the following, for example:

- Process connection
- Plug-in I/O module/motor starter
- Infeed of supply voltage specified

You can recognize the properties of the BaseUnits from their short description:

Table 2-2171 Properties of the BaseUnits

Short description BU15-P16+A10+2D/T (example)			**BaseUnit properties**
Name/module width	BU	15	BaseUnit with width of 15 mm
		20	BaseUnit with width of 20 mm
		30	BaseUnit with width of 30 mm
Process connection	P	4	• Connection method: Push-in terminal • Number of terminals to the I/O module: 4
		8	• Connection method: Push-in terminal • Number of terminals to the I/O module: 8
		16	• Connection method: Push-in terminal • Number of terminals to the I/O module: 16
Connection to the AUX busbar	A	0	No connection to the AUX busbar
		10	n = number of AUX terminals, e.g. 10
Self-assembling voltage buses	2		2 push-in terminals for supplying or tapping the supply voltage via the self-assembling voltage buses P1, P2 (see D, B)
	12		• 2 push-in terminals for supplying or tapping the supply voltage via the self-assembling voltage buses P1, P2 (see D, B) • 2×5 push-in additional terminals (1 B to 5 B, 1 C to 5 C). For connecting further potential up to a maximum supply current of 24 V DC/10 A
	0		No terminals with access to the self-assembling voltage buses P1, P2

Short description BU15-P16+A10+2D/T (example)			BaseUnit properties
Self-assembling voltage buses		B	• Looping through the potential group • Tapping the supply voltage for external components or looping through with a maximum total current of 10 A per potential group
		D	• Opening a new potential group • Feeding in of supply voltage up to a maximum supply current of 10 A
Additional functions	T		Integrated temperature sensor to compensate the reference junction temperature for thermocouples

Properties of the BaseUnits for motor starters

The following table lists the properties of the individual BaseUnits for motor starters:

BaseUnit	Properties
BU30-MS1	• Push-in terminals for opening a new potential group (24 V DC). • Feeding in of supply voltage up to a maximum supply current of 7 A DC. • Opening a new supply voltage potential group (500 V AC) • Feeding in of supply voltage up to a maximum supply current of 32 A AC.
BU30-MS2	• Further conduction of the potential group (24 V DC) • Push-in terminals for opening a new supply voltage potential group (500 V AC) • Infeed of supply voltage up to a maximum supply current up to 32 A AC.
BU30-MS3	• Push-in terminals for opening a new potential group (24 V DC) • Infeed of the supply voltage L+ up to an infeed current of 7 A DC • Further conduction of the supply voltage potential group (500 V AC)
BU30-MS4	• Further conduction of the supply voltage potential group (500 V AC) • Further conduction of the potential group (24 V DC)
BU30-MS5	• Further conduction of the potential group (24 V DC) • Push-in terminals for opening a new supply voltage potential group (500 V AC) • Infeed of supply voltage up to a maximum supply current of 32 A AC • A fail-safe digital input
BU30-MS6	• Further conduction of the potential group (24 V DC) • Further conduction of the supply voltage potential group (500 V AC) • A fail-safe digital input
BU30-MS7	• Further conduction of the potential group (24 V DC) • Infeed F-DI busbar • Push-in terminals for opening a new supply voltage potential group (500 V AC) • Infeed of supply voltage up to a maximum supply current of up to AC 32 A.

BaseUnit	Properties
BU30-MS8	• Further conduction of the potential group (24 V DC) • Further conduction of the F-DI busbar • Push-in terminals for opening a new supply voltage potential group (500 V AC) • Infeed of supply voltage up to a maximum supply current up to 32 A AC.
BU30-MS9	• Further conduction of the potential group (24 V DC) • Further conduction of the F-DI busbar • Further conduction of the supply voltage potential group (500 V AC)
BU30-MS10	• Further conduction of the potential group (24 V DC) • Infeed F-DI busbar • Further conduction of the supply voltage potential group (500 V AC)

Properties of the potential distributor modules

The following table shows the properties of the individual potential distributor modules:

Table 2-2172 PotDis-BaseUnits properties

Short description PotDis-BU-P1/D-R (example)			PotDis-BaseUnit properties
Designation	PotDis-BU		PotDis-BaseUnit
Process connection (24 V DC / 10 A)	P1		Terminals for supplying or tapping the supply voltage with connection to the voltage bus P1 (see D, B)
	P2		Terminals for supplying or tapping the supply voltage with connection to the voltage bus P2 (see D, B)
Self-assembling voltage buses		D	• Opening a new PotDis potential group • Feeding in of supply voltage up to a maximum supply current up to 10 A • Tapping the supply voltage for external components or looping with a maximum total current of 10 A per potential group
		B	• Further conduction of the potential group • Tapping the supply voltage for external components or looping with a maximum total current of 10 A per potential group
Color coding of the spring releases	R		Connection to the internal voltage bus P1 Red spring release
	B		Connection to the internal voltage bus P2 Blue spring release

Properties of the terminal blocks PotDis-TB

The following table shows the properties of the individual terminal blocks:

Table 2-2173 Properties of the PotDis-Terminalblocks

Short description PotDis-TB-P1-R (example)		PotDis-Terminalblock properties
Designation	PotDis-TB	PotDis terminal block
Process connection (24 V DC / 10 A)	P1	• Connection to the voltage bus P1 • Terminals for picking off the rated supply voltage 24 V DC with max. 10 A of the same voltage level
	P2	• Connection to the voltage bus P2 • Terminals for picking off the rated supply voltage 24 V DC with max. 10 A of the same voltage level
	n.c.	• No connection to the P1, P2 or AUX bus • Terminals can be used freely up to 230 V AC with max. 10 A
	BR	• No connection to the P1, P2 or AUX bus • Terminals for protective conductor connection or voltage bus (internal connected) freely usable up to 230 V AC with max. 10 A
Color coding of the spring releases	R	Red spring release
	B	Blue spring release
	W	White spring release
	G	Gray spring release

Selecting, installing and connecting BaseUnits

You can find additional information in the system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

WARNING

Personal injury or damage to equipment is possible.

Connecting a rated supply voltage to the BaseUnit higher than the one given in the technical specifications may lead to dangerous situations in your plant or cause defects in ET 200SP components.

Therefore, only connect the rated supply voltage given in the technical specifications to the BaseUnit.

The connected rated supply voltage must correspond to the rated supply voltage of the I/O modules in the potential group.

When mains voltage is connected to the BaseUnit, ensure that all other supply voltages on this BaseUnit use the same phase as the mains.

The Totally Integrated Automation Selection Tool (TIA Selection Tool) (http://w3.siemens.com/mcms/topics/de/simatic/tia-selection-tool) supports you in selecting, configuring and ordering the ET 200SP modules. The free TIA Selection Tool is available on the Internet (http://support.automation.siemens.com/WW/view/en/58649293).

WARNING

Hazardous Voltage (when using ET 200SP motor starters)
Can Cause Death, Serious Injury, or Property Damage.

Proper use of hardware products

This equipment is only allowed to be used for the applications described in the catalog and in the technical description, and only in conjunction with non-Siemens equipment and components recommended by Siemens.

Correct transport, storage, installation and assembly, as well as careful operation and maintenance, are required to ensure that the product operates safely and without faults.

EU note: Start-up/commissioning is absolutely prohibited until it has been ensured that the machine in which the component described here is to be installed fulfills the regulations/specifications of Machinery Directive 2006/42/EC.

WARNING

Hazardous Voltage (when using ET 200SP motor starters)
Can Cause Death, Serious Injury, or Property Damage.

Please take note of our latest information.

Systems with safety-related characteristics are subject to special operational safety requirements on the part of the operator. The supplier is also obliged to comply with special product monitoring measures. For this reason, we publish a special newsletter containing information on product developments and features that are (or could be) relevant to operation of safety-related systems. You need to subscribe to the corresponding newsletter to ensure that you always remain up-to-date and are able to make any necessary changes to your plant regarding operational safety should the need arise.

Siemens Newsletter (http://www.industry.siemens.com/newsletter)

Sign on to the following newsletter under "Products & Solutions":

- Control Components and System Engineering News
- Safety Integrated Newsletter

BaseUnits for interface modules

5

5.1 BU type M0

5.1.1 Introduction

The BaseUnit M0, together with the IM 155-6 PN R1, forms the interface of the ET 200SP R1.

You can find more information on using the BaseUnits in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

5.1.2 Product overview

Delivery options (packing unit PU)

6ES7193-6BR00-0HM0 (PU: 1 unit)

View

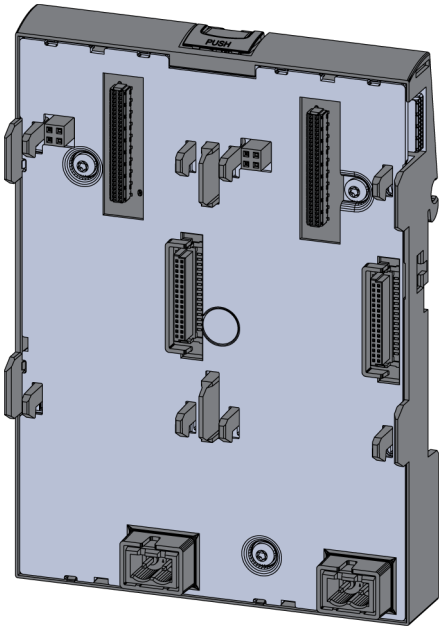

Figure 2-1667 BU type M0

Properties

- The BaseUnit BU type M0 connects two IM 155-6 PN R1 interface modules to the backplane bus. The IM 155-6 PN R1 interface modules enable the data exchange with the I/O modules. The BaseUnit BU type M0 provides the supply voltage for the IM 155-6 PN R1 interface modules.
- BaseUnit suitable for all IM 155-6 PN R1 interface modules.
- The BaseUnit BU type M0 may only be operated on the SIMATIC system bus.

Short designation

Short designation: BU type M0

5.1.3 Connecting

Pin assignment

Pin assignment for BaseUnit BU type M0	
Terminal	**Explanations**
L+/M	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram

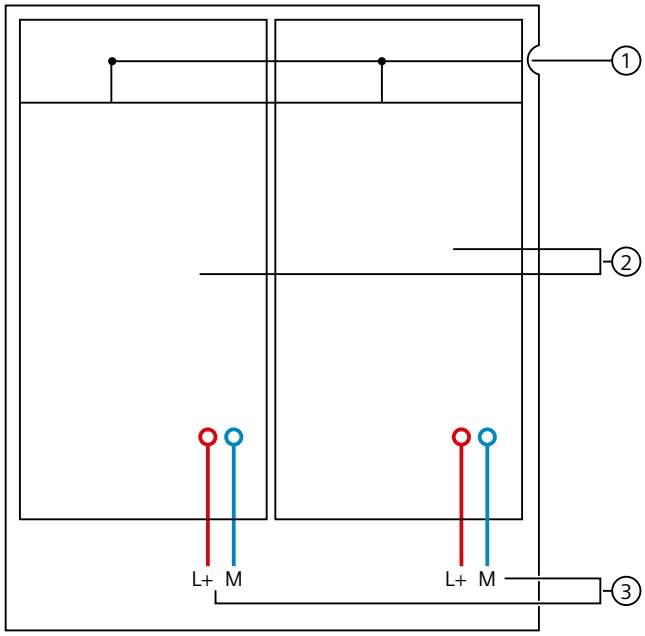

① Backplane bus
② IM 155-6 PN R1 interface module
③ Terminals for 24 V DC rated supply voltage and ground

Figure 2-1668 Block diagram of BU type M0

5.1.4 Technical specifications

Technical specifications of BU type M0

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7193-6BR00-0HM0/td?dl=en).

Article number	6ES7193-6BR00-0HM0
General information	
Product type designation	BU type M0
Supply voltage	
Rated value (DC)	24 V
Hardware configuration	
Slots	
• Number of slots	2
Potential separation	
between backplane bus and supply voltage	Yes
Isolation	
Isolation tested with	707 V DC (type test)

Article number	6ES7193-6BR00-0HM0
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	100 mm
Height	141 mm
Depth	29 mm
Weights	
Weight, approx.	142 g

BaseCarrier

6

6.1 BC type A0, light-colored version

6.1.1 Short designation

Short designation

Short designation: BC type A0

6.1.2 Product overview

Delivery options (packing unit PU)

6ES7193-6MT15-2DA0 (PU: 10 units)

Article number 6ES7193-6MT15-2DA0 contains the following components:

- BaseCarrier type A0, light-colored version (6ES7193-6MT15-0DA0)

View

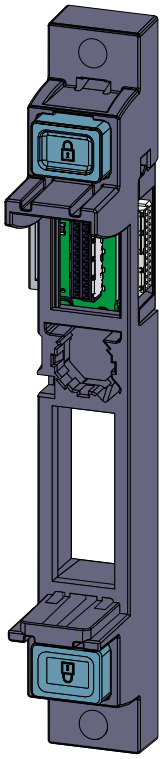

Figure 2-1669 BaseCarrier type A0, light-colored version

Properties

BaseCarrier suitable for all I/O modules of the BaseCarrier type "A0/A1"

BaseCarrier BC type A0 opens up a new potential group.

6.1.3 Connecting

Information on wiring the BaseCarrier is available in the design guideline of the BaseCarrier system.

6.1.4 Technical specifications

Technical specifications of the BC type A0, light-colored version

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7193-6MT15-2DA0/td?dl=en).

Article number	6ES7193-6MT15-2DA0
General information	
Product type designation	BU type A0
HW functional status	from FS01
Installation type/mounting	
PCB installation	Yes
Hardware configuration	
Formation of potential groups	
• New potential group	Yes
• Potential group continued from the left	No
Slots	
• Number of slots	1; Type A0
• Plug-in modules, analog I/O	Yes
• Plug-in modules, digital I/O	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	15 mm
Height	117 mm
Depth	32 mm
Weights	
Weight, approx.	5 g

6.2 BC type A0, dark-colored version

6.2.1 Short designation

Short designation

Short designation: BC type A0

6.2.2 Product overview

Delivery options (packing unit PU)

6ES7193-6MT15-2BA0 (PU: 10 units)

Article number 6ES7193-6MT15-2BA0 contains the following components:

- BaseCarrier type A0, dark-colored version (6ES7193-6MT15-0BA0)

View

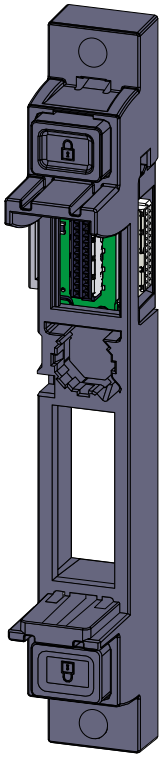

Figure 2-1670 BaseCarrier type A0, dark-colored version

Properties

BaseCarrier suitable for all I/O modules of the BaseCarrier type "A0/A1"

BaseCarrier BC type A0 forwards a new potential group.

6.2.3 Connecting

Information on wiring the BaseUnit is available in the design guideline of the BaseCarrier system.

6.2.4 Technical specifications

Technical specifications of the BC type A0, dark-colored version

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7193-6MT15-2BA0/td?dl=en).

Article number	6ES7193-6MT15-2BA0
General information	
Product type designation	BU type A0
HW functional status	from FS01
Installation type/mounting	
PCB installation	Yes
Hardware configuration	
Formation of potential groups	
• New potential group	No
• Potential group continued from the left	Yes
Slots	
• Number of slots	1; Type A0
• Plug-in modules, analog I/O	Yes
• Plug-in modules, digital I/O	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual

Article number	6ES7193-6MT15-2BA0
Dimensions	
Width	15 mm
Height	117 mm
Depth	32 mm
Weights	
Weight, approx.	5 g

6.3 BC type V0, BaseCarrier for server module

6.3.1 Short designation

Short designation

Short designation: BC type V0

6.3.2 Product overview

Delivery options (packing unit PU)

6ES7193-6MT15-0SV0 (PU: 1 unit)

View

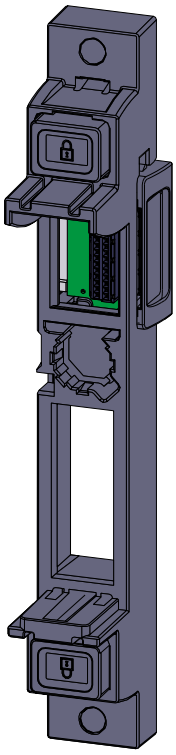

Figure 2-1671 BaseCarrier type V0, BaseCarrier for server module

Properties

BaseCarrier type V0 suitable for BaseCarrier server module

6.3.3 Connecting

Information on wiring the BaseUnit is available in the design guideline of the BaseCarrier system.

6.3.4 Technical specifications

Technical specifications of the BC type V0, BaseCarrier for server module

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7193-6MT15-0SV0/td?dl=en).

Article number	6ES7193-6MT15-0SV0
General information	
Product type designation	BU type V0
HW functional status	from FS01
Installation type/mounting	
PCB installation	Yes
Hardware configuration	
Formation of potential groups	
• New potential group	No
• Potential group continued from the left	Yes
Slots	
• Number of slots	1; type V0
• Plug-in modules, analog I/O	No
• Plug-in modules, digital I/O	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Dimensions	
Width	18 mm
Height	117 mm
Depth	32 mm
Weights	
Weight, approx.	5 g

6.4 IO adapter

6.4.1 Short designation

Short designation

Short designation: IO adapter

6.4.2 Product overview

Delivery options (packing unit PU)

6ES7193-6CM00-0AA0 (PU: 1 unit)

View

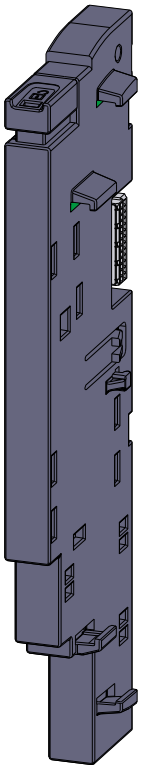

Figure 2-1672 IO adapter

Properties

The IO adapter connects the head module with the first BaseCarrier and is thus used for the creation of the BaseCarrier system.

The IO adapter is located before the first BaseCarrier.

6.4.3 Connecting

Information on wiring the IO adapter is available in the design guideline of the BaseCarrier system.

6.4.4 Technical specifications

Technical specifications of the IO adapter

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/ww/en/pv/6ES7193-6CM00-0AA0/td?dl=en).

Article number	6ES7193-6CM00-0AA0
General information	
Product type designation	IO Adapter
HW functional status	from FS01
Installation type/mounting	
Mounting	PCB installation
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	7.5 mm
Height	117 mm
Depth	36.6 mm
Weights	
Weight, approx.	19 g

BaseUnits for I/O modules 7

7.1 Product description

7.1.1 Introduction

Properties of the BaseUnits

The ET 200SP distributed I/O system offers you a rugged and service-friendly design with permanent wiring over the BaseUnits (BU).

The BaseUnits provide the electrical and mechanical connection of the ET 200SP modules. A wide range of BaseUnits is available to suit individual requirements.

You can place BaseUnits at any location with the ET 200SP distributed I/O system. Take into account the specific properties of the respective BaseUnit. Thanks to the push-in connection system, you can wire the terminals without tools.

You can find additional information on using the BaseUnit in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

NOTE

All BaseUnits placed in a potential group have to match the infeed potential of the corresponding light-colored BaseUnit.

NOTE

The following BaseUnits with functional version < 04 can only be used in potential groups with rated voltages ≤ 48 V DC or 24 V AC:

- BaseUnit BU20-P12+A0+4B (6ES7193-6BP20-0BB1).
- BaseUnit BU20-P12+A0+0B (6ES7193-6BP00-0BD0).

7.2 BU type A0, light-colored version, with AUX terminals

Short designation

Short designation: BU15-P16+A10+2D

7.2.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP20-0DA0 (PU: 1 unit)
6ES7193-6BP20-2DA0 (PU: 10 units)

View

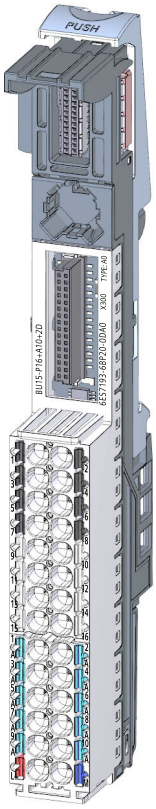

Figure 2-1673 BU type A0, light-colored version, with AUX terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "A0/A1". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Supply voltage (L+ terminal, ground): Max. 24 V DC/10 A
  - Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit opens up a new potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are interrupted to the left-hand neighboring module (BaseUnit, interface module).
- Access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- 10 AUX terminals for connecting a protective conductor or potential. The AUX busbar is not connected to the I/O module. Max. 24 V DC/10 A
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Maximum configuration per potential group

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated according to item 1. and item 2. must not exceed 10 A.

7.2.2 Connecting

Pin assignment

Pin assignment for BaseUnit BU type A0, light-colored version with AUX terminals	
Terminal	**Explanations**
1 to 16	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.
1 A, 2 A, 3 A, 4 A, 5 A, 6 A, 7 A, 8 A, 9 A, 10 A	Protective conductor connection or voltage bus freely usable up to 24 V DC with max. 10 A
L+/M	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram

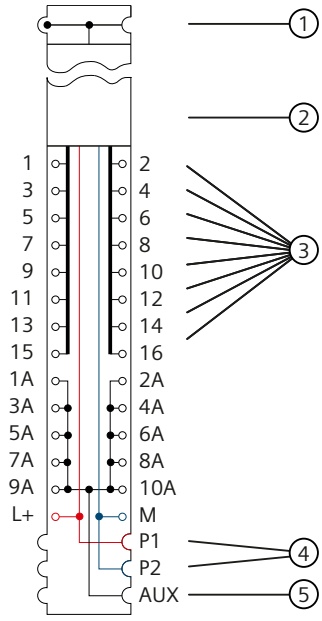

① Backplane bus

② I/O module

③ Terminals with connection to the I/O module

④ System-integrated, self-assembling voltage buses P1, P2 with connection to the infeed terminals, interrupted to the adjacent module on the left, form a new potential group

⑤ System-integrated, self-assembling AUX voltage bus with connection to the 10 AUX terminals, interrupted to the adjacent module on the left forms a new potential group

Figure 2-1674 Block diagram of the BU type A0, light-colored version with AUX terminals

7.2.3 Technical specifications

Technical specifications of the BU type A0, light-colored version with AUX terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP20-2DA0/td?dl=de).

Article number	6ES7193-6BP20-2DA0
General information	
Product type designation	BU type A0
HW functional status	From FS07
Supply voltage	
Rated value (DC)	24 V
external protection for power supply lines	Yes; 24 V DC/10 A miniature circuit breaker with type B or C tripping characteristic

Article number	6ES7193-6BP20-2DA0
Current carrying capacity	
For P1 and P2 bus, max.	10 A
For AUX bus, max.	10 A
For process terminals, max.	2 A
Hardware configuration	
Formation of potential groups	
• New potential group	Yes
• Potential group continued from the left	No
Potential separation	
between the potential groups	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC00 to CC09
• for AUX terminals	CC71 to CC73
• for add-on terminals	does not exist
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²; AWG 26
• Conductor cross-section, max.	2.5 mm²; AWG 14
• Number of process terminals to I/O module	16
• Number of terminals to AUX bus	10
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	2

Article number	6ES7193-6BP20-2DA0
Dimensions	
Width	15 mm
Height	141 mm
Depth	35 mm
Weights	
Weight, approx.	50 g

7.3 BU type A0, light-colored version, without AUX terminals

Short designation

Short designation: BU15-P16+A0+2D

7.3.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP00-0DA0 (PU: 1 unit)
6ES7193-6BP00-2DA0 (PU: 10 units)

View

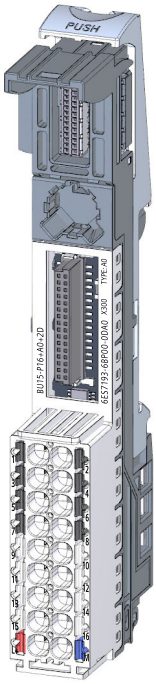

Figure 2-1675 BU type A0, light-colored version, without AUX terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "A0/A1". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Supply voltage (L+ terminal, ground): Max. 24 V DC/10 A
  - Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit opens up a new potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are interrupted to the left-hand neighboring module (BaseUnit, interface module).
- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Maximum configuration per potential group

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated according to item 1. and item 2. must not exceed 10 A.

7.3.2 Connecting

Pin assignment

Pin assignment for BaseUnit BU type A0, light-colored version, without AUX terminals	
Terminal	**Explanations**
1 to 16	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.
(AUX)	No access to the AUX busbar via terminals
L+ / M	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram

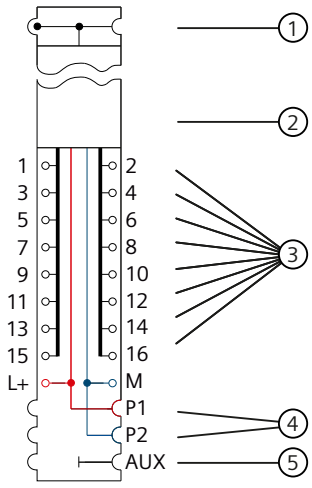

① Backplane bus

② I/O module

③ Terminals with connection to the I/O module

④ System-integrated, self-assembling voltage buses P1, P2 with connection to the infeed terminals, interrupted to the adjacent module on the left, form a new potential group

⑤ System-integrated, self-assembling AUX voltage bus without connection to the AUX terminals, interrupted to the adjacent module on the left, forms a new potential group

Figure 2-1676 Block diagram of the BU type A0, light-colored version, without AUX terminals

7.3.3 Technical specifications

Technical specifications of the BaseUnit BU type A0, light-colored version, without AUX terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP00-2DA0/td?dl=de).

Article number	6ES7193-6BP00-2DA0
General information	
Product type designation	BU type A0
HW functional status	From FS06
Supply voltage	
Rated value (DC)	24 V
external protection for power supply lines	Yes; 24 V DC/10 A miniature circuit breaker with type B or C tripping characteristic
Mains filter	
• integrated	Yes

Article number	6ES7193-6BP00-2DA0
Current carrying capacity	
For P1 and P2 bus, max.	10 A
For process terminals, max.	2 A
Hardware configuration	
Formation of potential groups	
• New potential group	Yes
• Potential group continued from the left	No
Slots	
• Number of slots	1; Type A0
• Plug-in modules, analog I/O	Yes
• Plug-in modules, digital I/O	Yes
Potential separation	
between the potential groups	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC00 to CC09
• for AUX terminals	does not exist
• for add-on terminals	does not exist
connection method / header	
Terminals	
• Terminal type	Push-in terminal
• system-integrated shield connection	Yes; Optional
• Conductor cross-section, min.	0.14 mm^2; AWG 26
• Conductor cross-section, max.	2.5 mm^2; AWG 14
• Number of process terminals to I/O module	16
• Number of terminals to AUX bus	0
• Number of add-on terminals	0

Article number	6ES7193-6BP00-2DA0
• Number of terminals with connection to P1 and P2 bus	2
Dimensions	
Width	15 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	40 g

7.4 BU type A0, dark-colored version, with AUX terminals

Short designation

Short designation: BU15-P16+A10+2B

7.4.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP20-0BA0 (PU: 1 unit)
6ES7193-6BP20-2BA0 (PU: 10 units)

View

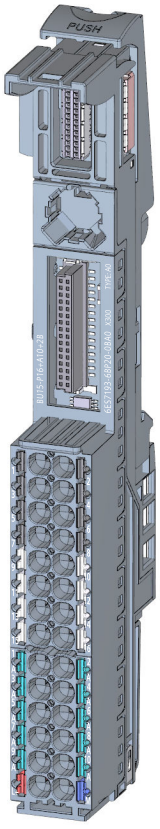

Figure 2-1677 BU type A0, dark-colored version, with AUX terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "A0/A1". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit further conducts the potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- Access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- 10 AUX terminals for connecting a protective conductor or potential. The AUX busbar is not connected to the I/O module. Max. 24 V DC/10 A
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

7.4.2 Connecting

Pin assignment

Pin assignment for BU type A0, dark-colored version, with AUX terminals	
Terminal	**Explanations**
1 to 16	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.
1 A, 2 A, 3 A, 4 A, 5 A, 6 A, 7 A, 8 A, 9 A, 10 A, AUX	Protective conductor connection or voltage bus freely usable up to 24 V DC with max. 10 A
L+ / M	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram

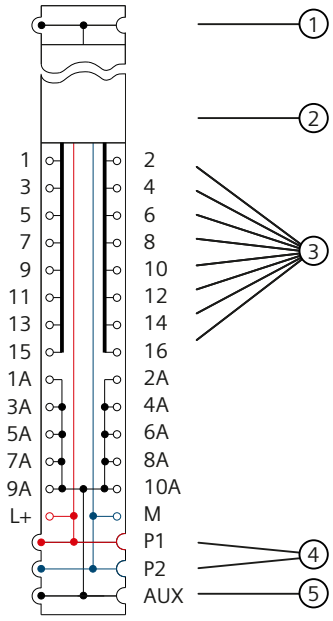

① Backplane bus

② I/O module

③ Terminals with connection to the I/O module

④ System-integrated, self-assembling voltage buses P1, P2 with connection to the infeed terminals, connected to the adjacent module on the left

⑤ System-integrated, self-assembling AUX voltage bus with connection to the 10 AUX terminals, connected to the adjacent module on the left

Figure 2-1678 Block diagram BU type A0, dark-colored version, with AUX terminals

7.4.3 Technical specifications

Technical specifications of the BU type A0, dark-colored version, with AUX terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP20-0BA0/td?dl=de).

Article number	6ES7193-6BP20-0BA0
General information	
Product type designation	BU type A0
HW functional status	From FS06
Supply voltage	
Rated value (DC)	24 V
external protection for power supply lines	Yes; 24 V DC/10 A miniature circuit breaker with type B or C tripping characteristic

Article number	6ES7193-6BP20-0BA0
Current carrying capacity	
For P1 and P2 bus, max.	10 A
For AUX bus, max.	10 A
For process terminals, max.	2 A
Hardware configuration	
Formation of potential groups	
• New potential group	No
• Potential group continued from the left	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC00 to CC09
• for AUX terminals	CC71 to CC73
• for add-on terminals	does not exist
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm^2; AWG 26
• Conductor cross-section, max.	2.5 mm^2; AWG 14
• Number of process terminals to I/O module	16
• Number of terminals to AUX bus	10
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	2
Dimensions	
Width	15 mm
Height	141 mm
Depth	35 mm
Weights	
Weight, approx.	50 g

7.5 BU type A0, dark-colored version, without AUX terminals

Short designation

Short designation: BU15-P16+A0+2B

7.5.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP00-0BA0 (PU: 1 unit)

6ES7193-6BP00-2BA0 (PU: 10 units)

View

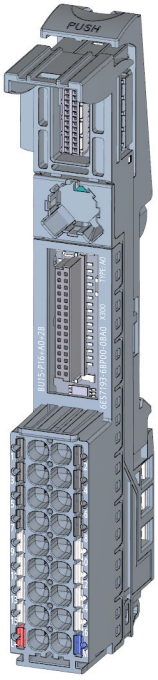

Figure 2-1679 BU type A0, dark-colored version without AUX terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "A0/A1". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit further conducts the potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).

- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

7.5.2 Connecting

Pin assignment

Pin assignment for BU type A0, dark-colored version, without AUX terminals	
Terminal	**Explanations**
1 to 16	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.
(AUX)	No access to the AUX busbar via terminals
L+ / M	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram

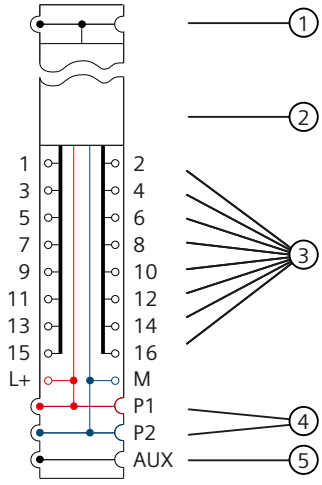

① Backplane bus

② I/O module

③ Terminals with connection to the I/O module

④ System-integrated, self-assembling voltage buses P1, P2 with connection to the infeed terminals, connected to the adjacent module on the left

⑤ System-integrated, self-assembling AUX voltage bus without connection to the AUX terminals, connected to the adjacent module on the left

Figure 2-1680 Block diagram of the BU type A0, dark-colored version, without AUX terminals

7.5.3 Technical specifications

Technical specifications of the BU type A0, dark-colored version, without AUX terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP00-0BA0/td?dl=de).

Article number	6ES7193-6BP00-0BA0
General information	
Product type designation	BU type A0
HW functional status	From FS06
Supply voltage	
Rated value (DC)	24 V
external protection for power supply lines	Yes; 24 V DC/10 A miniature circuit breaker with type B or C tripping characteristic
Mains filter	
• integrated	No

Article number	6ES7193-6BP00-0BA0
Current carrying capacity	
For P1 and P2 bus, max.	10 A
For process terminals, max.	2 A
Hardware configuration	
Automatic encoding	Yes
Formation of potential groups	
• New potential group	No
• Potential group continued from the left	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC00 to CC09
• for AUX terminals	does not exist
• for add-on terminals	does not exist
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm^2; AWG 26
• Conductor cross-section, max.	2.5 mm^2; AWG 14
• Number of process terminals to I/O module	16; Pro slot
• Number of terminals to AUX bus	0
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	2; Pro slot
Dimensions	
Width	15 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	40 g

7.6 BU type A1, light-colored version, with add-on terminals

Short designation

Short designation: BU15-P16+A0+12D/T

7.6.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP40-0DA1 (PU: 1 unit)

View

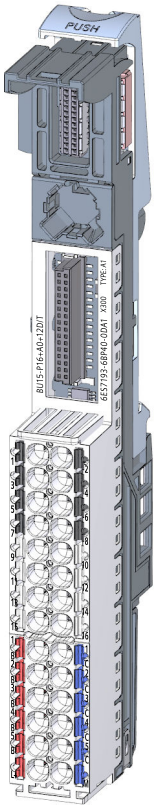

Figure 2-1681 BU type A1, light-colored version, with add-on terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "A1". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.

  NOTE

  Using another I/O module can trigger an internal, non-exchangeable fuse. You then have to exchange the terminal box.

  – Supply voltage (L+ terminal, ground): Max. 24 V DC/10 A
  – Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit opens up a new potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are interrupted to the left-hand neighboring module (BaseUnit, interface module).
- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- 2x5 add-on terminals for supplying a supply voltage up to 24 V DC/ 10 A. The add-on terminals are not connected to the I/O module.
- Recording of the terminal temperature for internal temperature compensation at connected thermocouples
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Maximum configuration per potential group

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated according to item 1. and item 2. must not exceed 10 A.

7.6.2 Connecting

Pin assignment

Pin assignment for BU type A1, light-colored version, with add-on terminals	
Terminal	**Explanations**
1 to 16	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.

Pin assignment for BU type A1, light-colored version, with add-on terminals	
1 B, 2 B, 3 B, 4 B, 5 B / 1 C, 2 C, 3 C, 4 C, 5 C	2 x 5 add-on terminals for the infeed of a supply voltage up to 24 V DC with max. 10 A
(AUX)	No access to the AUX busbar via terminals
L+ / M	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram

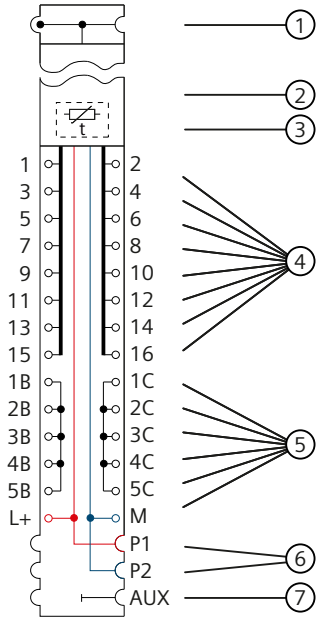

① Backplane bus

② I/O module

③ Internal reference junction for temperature compensation

④ Terminals with connection to the I/O module

⑤ Add-on terminals for feeding an add-on supply voltage

⑥ System-integrated, self-assembling voltage buses P1, P2 with connection to the infeed terminals, interrupted to the adjacent module on the left, form a new potential group

⑦ System-integrated, self-assembling AUX voltage bus without connection to the AUX terminals, interrupted to the adjacent module on the left, forms a new potential group

Figure 2-1682 Block diagram BU type A1, light-colored version, with add-on terminals

7.6.3 Technical specifications

Technical specifications of the BU type A1, light-colored version with add-on terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP40-0DA1/td?dl=de).

Article number	6ES7193-6BP40-0DA1
General information	
Product type designation	BU type A1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	24 V
external protection for power supply lines	Yes; 24 V DC/10 A miniature circuit breaker with type B or C tripping characteristic
Current carrying capacity	
For P1 and P2 bus, max.	10 A
For process terminals, max.	2 A
Hardware configuration	
Additional terminals	Yes
Temperature sensor	Yes
Formation of potential groups	
• New potential group	Yes
• Potential group continued from the left	No
Potential separation	
between the potential groups	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC00 to CC09
• for AUX terminals	does not exist
• for add-on terminals	CC74

Article number	6ES7193-6BP40-0DA1
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm^2; AWG 26
• Conductor cross-section, max.	2.5 mm^2; AWG 14
• Number of process terminals to I/O module	16
• Number of terminals to AUX bus	0
• Number of add-on terminals	2x5
• Number of terminals with connection to P1 and P2 bus	2
Dimensions	
Width	15 mm
Height	141 mm
Depth	35 mm
Weights	
Weight, approx.	50 g

7.7 BU type A1, light-colored version, without add-on terminals

Short designation

Short designation: BU15-P16+A0+2D/T

7.7.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP00-0DA1 (PU: 1 unit)

View

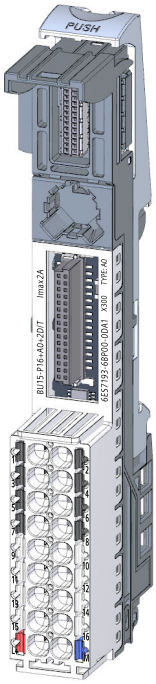

Figure 2-1683 BU type A1, light-colored version, without add-on terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "A1". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.

NOTE

Using another I/O module can trigger an internal, non-exchangeable fuse. You then have to exchange the terminal box.

  - Supply voltage (L+ terminal, ground): Max. 24 V DC/10 A
  - Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit opens up a new potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are interrupted to the left-hand neighboring module (BaseUnit, interface module).
- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- Recording of the terminal temperature for internal temperature compensation at connected thermocouples
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Maximum configuration per potential group

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated according to item 1. and item 2. must not exceed 10 A.

7.7.2 Connecting

Pin assignment

Pin assignment for BU type A1, light-colored version, without add-on terminals	
Terminal	**Explanations**
1 to 16	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.
(AUX)	No access to the AUX busbar via terminals
L+, P1 / M, P2	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram

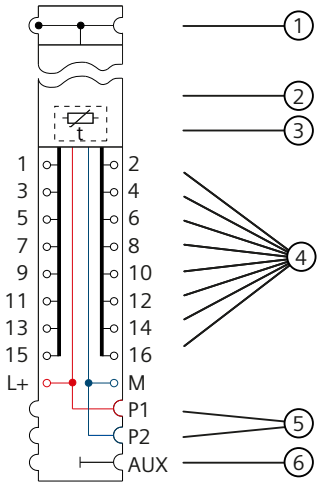

① Backplane bus

② I/O module

③ Internal reference junction for temperature compensation

④ Terminals with connection to the I/O module

⑤ System-integrated, self-assembling voltage buses P1, P2 with connection to the infeed terminals, interrupted to the adjacent module on the left, form a new potential group

⑥ System-integrated, self-assembling AUX voltage bus without connection to the AUX terminals, interrupted to the adjacent module on the left, forms a new potential group

Figure 2-1684 Block diagram BU type A1, light-colored version, without add-on terminals

7.7.3 Technical specifications

Technical specifications of the BU type A1, light-colored version, without add-on terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP00-0DA1/td?dl=de).

Article number	6ES7193-6BP00-0DA1
General information	
Product type designation	BU type A1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	24 V
external protection for power supply lines	Yes; 24 V DC/10 A miniature circuit breaker with type B or C tripping characteristic
Current carrying capacity	
For P1 and P2 bus, max.	10 A
For process terminals, max.	2 A

Article number	6ES7193-6BP00-0DA1
Hardware configuration	
Temperature sensor	Yes
Formation of potential groups	
• New potential group	Yes
• Potential group continued from the left	No
Slots	
• Number of slots	1; Type A1
• Plug-in modules, analog I/O	Yes
• Plug-in modules, digital I/O	No
Potential separation	
between the potential groups	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC00 to CC09
• for AUX terminals	does not exist
• for add-on terminals	does not exist
connection method / header	
Terminals	
• Terminal type	Push-in terminal
• system-integrated shield connection	Yes; Optional
• Conductor cross-section, min.	0.14 mm²; AWG 26
• Conductor cross-section, max.	2.5 mm²; AWG 14
• Number of process terminals to I/O module	16
• Number of terminals to AUX bus	0
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	2

Article number	6ES7193-6BP00-0DA1
Dimensions	
Width	15 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	40 g

7.8 BU type A1, dark-colored version, with add-on terminals

Short designation

Short designation: BU15-P16+A0+12B/T

7.8.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP40-0BA1 (PU: 1 unit)

View

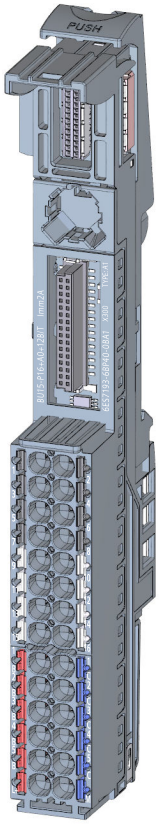

Figure 2-1685 BU type A1, dark-colored version, with add-on terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "A1". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.

  NOTE

  Using another I/O module can trigger an internal, non-exchangeable fuse. You then have to exchange the terminal box.

  – Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit further conducts the potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- 2x5 add-on terminals for supplying a supply voltage up to 24 V DC/ 10 A. The add-on terminals are not connected to the I/O module.
- Recording of the terminal temperature for internal temperature compensation at connected thermocouples
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

7.8.2 Connecting

Pin assignment

Pin assignment for BU type A1, dark-colored version, with add-on terminals	
Terminal	**Explanations**
1 to 16	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.
1 B, 2 B, 3 B, 4 B, 5 B / 1 C, 2 C, 3 C, 4 C, 5 C	2 x 5 add-on terminals for the infeed of a supply voltage up to 24 V DC with max. 10 A
(AUX)	No access to the AUX busbar via terminals
L+, P1 / M, P2	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram

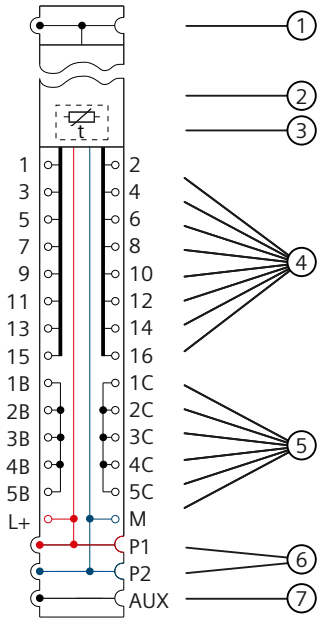

① Backplane bus

② I/O module

③ Internal reference junction for temperature compensation

④ Terminals with connection to the I/O module

⑤ Add-on terminals for feeding an add-on supply voltage

⑥ System-integrated, self-assembling voltage buses P1, P2 with connection to the infeed terminals, connected to the adjacent module on the left

⑦ System-integrated, self-assembling AUX voltage bus without connection to the AUX terminals, connected to the adjacent module on the left

Figure 2-1686 Block diagram BU type A1, dark-colored version, with add-on terminals

7.8.3 Technical specifications

Technical specifications of the BU type A1, dark-colored version, with add-on terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP40-0BA1/td?dl=de).

Article number	6ES7193-6BP40-0BA1
General information	
Product type designation	BU type A1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	24 V
external protection for power supply lines	Yes; 24 V DC/10 A miniature circuit breaker with type B or C tripping characteristic

Article number	6ES7193-6BP40-0BA1
Current carrying capacity	
For P1 and P2 bus, max.	10 A
For process terminals, max.	2 A
Hardware configuration	
Additional terminals	Yes
Temperature sensor	Yes
Formation of potential groups	
• New potential group	No
• Potential group continued from the left	Yes
Slots	
• Number of slots	1; Type A1
• Plug-in modules, analog I/O	Yes
• Plug-in modules, digital I/O	No
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC00 to CC09
• for AUX terminals	does not exist
• for add-on terminals	CC74
connection method / header	
Terminals	
• Terminal type	Push-in terminal
• system-integrated shield connection	Yes; Optional
• Conductor cross-section, min.	0.14 mm²; AWG 26
• Conductor cross-section, max.	2.5 mm²; AWG 14
• Number of process terminals to I/O module	16
• Number of terminals to AUX bus	0
• Number of add-on terminals	2x5
• Number of terminals with connection to P1 and P2 bus	2

Article number	6ES7193-6BP40-0BA1
Dimensions	
Width	15 mm
Height	141 mm
Depth	35 mm
Weights	
Weight, approx.	50 g

7.9 BU type A1, dark-colored version, without add-on terminals

Short designation

Short designation: BU15-P16+A0+2B/T

7.9.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP00-0BA1 (PU: 1 unit)

View

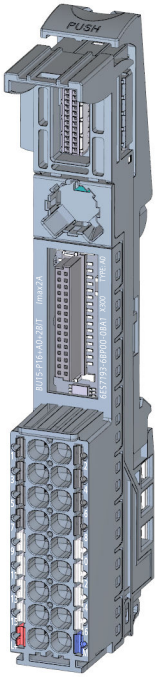

Figure 2-1687 BU type A1, dark-colored version, without add-on terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "A1". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.

  NOTE

  Using another I/O module can trigger an internal, non-exchangeable fuse. You then have to exchange the terminal box.

  – Current-carrying capacity per process terminal (terminal 1 to 16): Max. 2 A
- The BaseUnit further conducts the potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- Recording of the terminal temperature for internal temperature compensation at connected thermocouples
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

7.9.2 Connecting

Pin assignment

Pin assignment for BU type A1, dark-colored version, without add-on terminals	
Terminal	**Explanations**
1 to 16	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.
(AUX)	No access to the AUX busbar via terminals
L+, P1 / M, P2	L+: Rated supply voltage 24 V DC with max. 10 A M: Ground

Block diagram

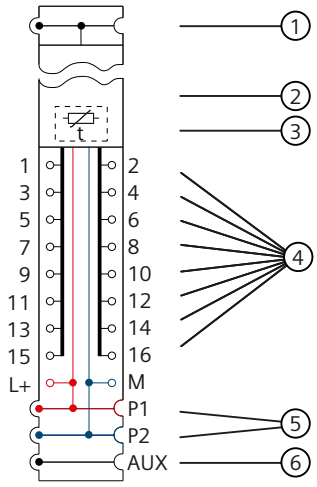

① Backplane bus

② I/O module

③ Internal reference junction for temperature compensation

④ Terminals with connection to the I/O module

⑤ System-integrated, self-assembling voltage buses P1, P2 with connection to the infeed terminals, connected to the adjacent module on the left

⑥ System-integrated, self-assembling AUX voltage bus without connection to the AUX terminals, connected to the adjacent module on the left

Figure 2-1688 Block diagram BU type A1, dark-colored version, without add-on terminals

7.9.3 Technical specifications

Technical specifications of the BU type A1, dark-colored version, without add-on terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP00-0BA1/td?dl=de).

Article number	6ES7193-6BP00-0BA1
General information	
Product type designation	BU type A1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	24 V
external protection for power supply lines	Yes; 24 V DC/10 A miniature circuit breaker with type B or C tripping characteristic
Current carrying capacity	
For P1 and P2 bus, max.	10 A
For process terminals, max.	2 A

Article number	6ES7193-6BP00-0BA1
Hardware configuration	
Temperature sensor	Yes
Formation of potential groups	
• New potential group	No
• Potential group continued from the left	Yes
Isolation	
Isolation tested with	707 V DC (type test)
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC00 to CC09
• for AUX terminals	does not exist
• for add-on terminals	does not exist
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm^2; AWG 26
• Conductor cross-section, max.	2.5 mm^2; AWG 14
• Number of process terminals to I/O module	16
• Number of terminals to AUX bus	0
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	2
Dimensions	
Width	15 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	40 g

7.10 BU type B0, dark-colored version, with AUX terminals, supply over P1, P2 busbar

Short designation

Short designation: BU20-P12+A4+0B

7.10.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP20-0BB0 (PU: 1 unit)

6ES7193-6BP20-2BB0 (PU: 10 units)

View

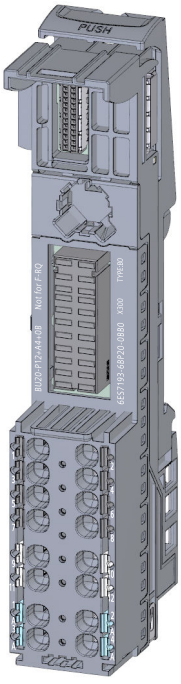

Figure 2-1689 BU type B0, dark-colored version, with AUX terminals, supply over P1, P2 busbar

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "B0/B1". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 12): Max. 5 A
- The BaseUnit further conducts the potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- Access to the AUX busbar via terminals
- 12 terminals to the process (assignment with the I/O module)
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

7.10.2 Connecting

Pin assignment

Pin assignment for BU type B0, dark-colored version, with AUX terminals, supply over P1, P2 busbar	
Terminal	**Explanations**
1 to 12	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.
1 A, 2 A, 3 A, 4 A, AUX	Protective conductor connection or voltage bus. Freely usable up to 230 V AC/DC with max. 10 A. If you connect a voltage, this voltage must belong to the same potential group as the rated supply voltage.

Block diagram

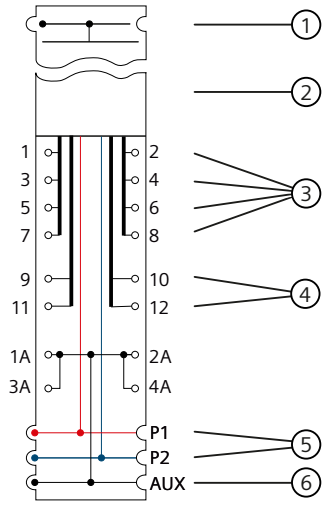

① Backplane bus

② I/O module

③ Process terminals 1 to 8 with connection to the I/O module

④ Process terminals 9 to 12 with connection to the I/O module

⑤ System-integrated, self-assembling voltage buses P1, P2 with connection to the infeed terminals, connected to the adjacent module on the left

⑥ System-integrated, self-assembling AUX voltage bus with connection to the 4 AUX terminals, connected to the adjacent module on the left

Figure 2-1690 Block diagram of the BU type B0, dark-colored version, with AUX terminals, supply over P1, P2 busbar

7.10.3 Technical specifications

Technical specifications of the BU type B0, dark-colored version, with AUX terminals, supply over P1, P2 busbar

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP20-0BB0/td?dl=de).

Article number	6ES7193-6BP20-0BB0
General information	
Product type designation	ET 200SP, BaseUnit BU-Typ B0, PU 1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	See manual
• For P1 and P2 bus	24 V
• For AUX bus	24 V; Equal potential group to P1/P2 bus or PE
• for process terminals	24 V

Article number	6ES7193-6BP20-0BB0
Rated value (AC)	See manual
• For P1 and P2 bus	230 V
• For AUX bus	230 V; Equal potential group to P1/P2 bus or PE
• for process terminals	230 V
Mains filter	
• integrated	No
Current carrying capacity	
up to 60 °C, max.	10 A
For P1 and P2 bus, max.	10 A
For AUX bus, max.	10 A
For process terminals, max.	5 A
Hardware configuration	
Automatic encoding	Yes
Potential separation	
between backplane bus and supply voltage	Yes
between process terminals and supply voltage	Yes
between power bus and supply voltage	No
Isolation	
Isolation tested with	3 100 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Accessories	
Color coding labels	
• for AUX terminals	CC81 to CC83
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²; AWG 26
• Conductor cross-section, max.	2.5 mm²; AWG 14
• Number of process terminals to I/O module	12; Pro slot
• Number of terminals to AUX bus	0
• Number of add-on terminals	0

Article number	6ES7193-6BP20-0BB0
• Number of terminals with connection to P1 and P2 bus	0; Pro slot
Dimensions	
Width	20 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	48 g

7.11 BU type B1, dark-colored version, without AUX terminals, supply over supply terminals

Short designation

Short designation: BU20-P12+A0+4B

7.11.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP20-0BB1 (PU: 1 unit)

6ES7193-6BP20-2BB1 (PU: 10 units)

View

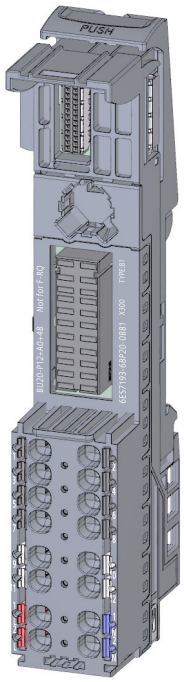

Figure 2-1691 BU type B1, dark-colored version, without AUX terminals, supply over supply terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "B1". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 12): Max. 5 A
- The BaseUnit further conducts the potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- No access to the power and AUX busbars via terminals
- Not suitable for the shield connection terminals.
- 12 terminals to the process (assignment with the I/O module)
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

7.11.2 Connecting

Pin assignment

Pin assignment for BU type B1, dark-colored version, without AUX terminals, supply over supply terminals	
Terminal	**Explanations**
1 to 12	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/de/55679691/133300) manual.
P1, P2, AUX	No access to the P1, P2, AUX bus via terminals
1 L, 2 L / 1 N, 2 N	1 L, 2 L: Rated supply voltage up to 230 V AC with max. 10 A 1 N, 2 N: Neutral/Ground

Block diagram

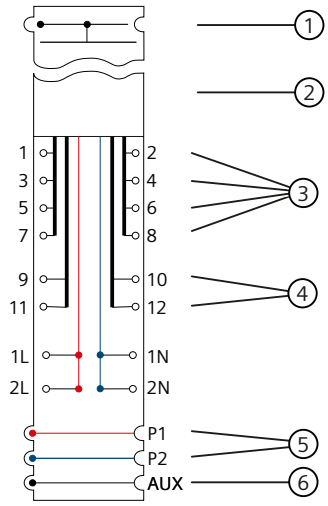

① Backplane bus

② I/O module

③ Process terminals 1 to 8 with connection to the I/O module

④ Process terminals 9 to 12 with connection to the I/O module

⑤ System-integrated, self-assembling voltage buses P1, P2 without connection to the terminals, connected to the adjacent module on the left

⑥ System-integrated, self-assembling AUX voltage bus without connection to the AUX terminals, connected to the adjacent module on the left

Figure 2-1692 Block diagram of the BU type B1, dark-colored version, without AUX terminals, supply over supply terminals

7.11.3 Technical specifications

Technical specifications of the BU type B1, dark-colored version, without AUX terminals, supply over infeed terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP20-0BB1/td?dl=de).

Article number	6ES7193-6BP20-0BB1
General information	
Product type designation	Type B1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	See manual
• For P1 and P2 bus	24 V
• For AUX bus	24 V; Equal potential group to P1/P2 bus or PE
• for process terminals	24 V

Article number	6ES7193-6BP20-0BB1
Rated value (AC)	See manual
• For P1 and P2 bus	230 V
• For AUX bus	230 V; Equal potential group to P1/P2 bus or PE
• for process terminals	230 V
external protection for power supply lines	Yes
Mains filter	
• integrated	No
Current carrying capacity	
up to 60 °C, max.	10 A
For P1 and P2 bus, max.	10 A
For AUX bus, max.	10 A
For process terminals, max.	5 A
Hardware configuration	
Automatic encoding	Yes
Potential separation	
between backplane bus and supply voltage	Yes
between process terminals and supply voltage	Yes; Not applicable for process terminals 9 to 12
between power bus and supply voltage	Yes
Isolation	
Isolation tested with	3 100 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²; AWG 26
• Conductor cross-section, max.	2.5 mm²; AWG 14
• Number of process terminals to I/O module	12; Pro slot
• Number of terminals to AUX bus	0
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	0; Pro slot

Article number	6ES7193-6BP20-0BB1
Dimensions	
Width	20 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	48 g

7.12 BU type C0, light-colored version, with AUX terminals, supply over supply terminals

Short designation

Short designation: BU20-P6+A2+4D

7.12.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP20-0DC0 (PU: 1 unit)

View

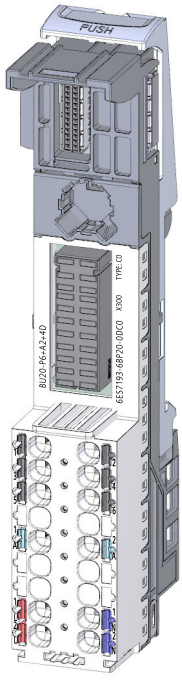

Figure 2-1693 BU type C0, light-colored version, with AUX terminals, supply over supply terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "C0/C1". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Supply voltage (terminal 1 L, 2 L / 1 N, 2 N): Max. 230 V AC/10 A
  - Current-carrying capacity per process terminal (terminal 1 to 4): Max. 5 A
  - Current carrying capacity per process terminal (terminal 5 and 6): Max. 10 A
- The BaseUnit opens up a new potential group by means of the inserted I/O module. The self-assembling voltage buses P1 and P2, and the AUX busbar are interrupted to the left-hand neighboring module (BaseUnit, interface module).
- Access to the AUX busbar via terminals
- 6 terminals to the process (assignment with the I/O module)
- Two AUX terminals for connecting a PE terminal or potential. The AUX busbar is not connected to the I/O module. Max. 24 V DC/10 A
- Connection system in the form of push-in terminals You can find more information in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Maximum configuration per potential group

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated according to item 1. and item 2. must not exceed 10 A.

7.12.2 Connecting

Pin assignment

Pin assignment for BU type C0, light-colored version, with AUX terminals, supply over supply terminals	
Terminal	**Explanations**
1 to 6	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.
1 A, 2 A, AUX	Protective conductor connection or voltage bus, freely usable up to 230 V AC/DC with max. 10 A. If you connect a voltage, this voltage must belong to the same potential group as the rated supply voltage.
1 L, 2 L, (P1) / 1 N, 2 N, (P2)	1 L, 2 L: Rated supply voltage up to 230 V AC with max. 10 A 1 N, 2 N: Neutral/Ground

Block diagram

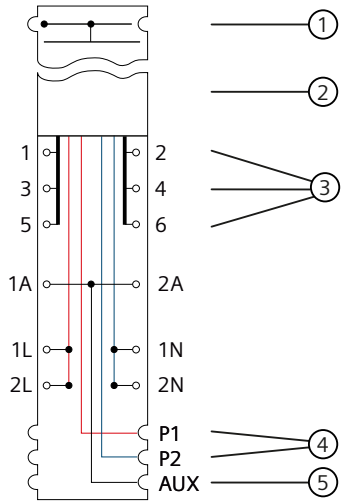

① Backplane bus

② I/O module

③ Terminals with connection to the I/O module

④ System-integrated, self-assembling voltage buses P1, P2 with connection to the infeed terminals (through the inserted I/O module). Interrupted to the adjacent module on the left, forms a new potential group

⑤ System-integrated, self-assembling AUX voltage bus with connection to the AUX terminals, interrupted to the adjacent module on the left, forms a new potential group

Figure 2-1694 Block diagram of the BU type C0, light-colored version, with AUX terminals, supply over supply terminals

7.12.3 Technical specifications

Technical specifications of the BU type C0, light-colored version, with AUX terminals, supply over infeed terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP20-0DC0/td?dl=de).

Article number	6ES7193-6BP20-0DC0
General information	
Product type designation	ET 200SP, BaseUnit BU type C0, PU 1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	See manual
• For P1 and P2 bus	24 V
• For AUX bus	24 V; Equal potential group to P1/P2 bus or PE
• for process terminals	24 V

Article number	6ES7193-6BP20-0DC0
Rated value (AC)	See manual
• For P1 and P2 bus	230 V
• For AUX bus	230 V; Equal potential group to P1/P2 bus or PE
• for process terminals	230 V
external protection for power supply lines	Yes; 10 A miniature circuit breaker with type B or C tripping characteristic for the respective rated supply voltage
Mains filter	
• integrated	No
Current carrying capacity	
up to 60 °C, max.	10 A
For P1 and P2 bus, max.	10 A
For AUX bus, max.	10 A
For process terminals, max.	5 A; 10 A for process terminals 5 and 6
Hardware configuration	
Automatic encoding	Yes
Potential separation	
between backplane bus and supply voltage	Yes
between process terminals and supply voltage	Yes
between power bus and supply voltage	No
Isolation	
Isolation tested with	3 100 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Accessories	
Color coding labels	
• for process terminals	CC51, CC52
• for AUX terminals	CC84 to CC86
• for add-on terminals	does not exist
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²; AWG 26
• Conductor cross-section, max.	2.5 mm²; AWG 14

Article number	6ES7193-6BP20-0DC0
• Number of process terminals to I/O module	12; Pro slot
• Number of terminals to AUX bus	0
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	0; Pro slot
Dimensions	
Width	20 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	47 g

7.13 BU type C1, dark-colored version, with AUX terminals, supply over P1, P2 busbar

Short designation

Short designation: BU20-P6+A2+4B

7.13.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP20-0BC1 (PU: 1 unit)

View

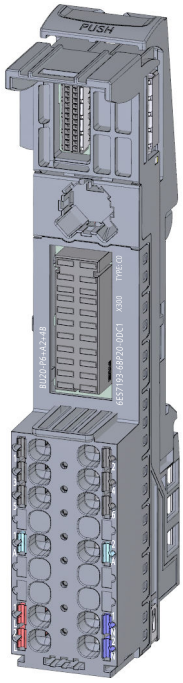

Figure 2-1695 BU type C1, dark-colored version, with AUX terminals, supply over P1, P2 busbar

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "C0/C1". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 4): Max. 5 A
  - Current carrying capacity per process terminal (terminal 5 and 6): Max. 10 A
- The BaseUnit further conducts the potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- Access to the AUX busbar via terminals
- 6 terminals to the process (assignment with the I/O module)
- Two AUX terminals for connecting a PE terminal or potential. The AUX busbar is not connected to the I/O module. Max. 24 V DC/10 A
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

7.13.2 Connecting

Pin assignment

Pin assignment for BU type C1, dark-colored version, with AUX terminals, supply over P1, P2 busbar	
Terminal	**Explanations**
1 to 6	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.
1 A, 2 A, AUX	Protective conductor connection or voltage bus, freely usable up to 230 V AC/DC with max. 10 A. If you connect a voltage, this voltage must belong to the same potential group as the rated supply voltage.
1 L, 2 L, (P1) / 1 N, 2 N, (P2)	1 L, 2 L: Rated supply voltage up to 230 V AC with max. 10 A 1 N, 2 N: Neutral/Ground

Block diagram

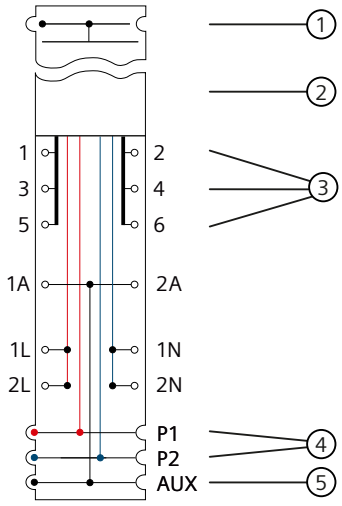

① Backplane bus

② Power module

③ Terminals with connection to the I/O module

④ System-integrated, self-assembling voltage buses P1, P2 with connection to the infeed terminals (through the inserted I/O module). Connected to the adjacent module on the left

⑤ System-integrated, self-assembling AUX voltage bus with connection to the AUX terminals, connected to the adjacent module on the left

Figure 2-1696 Block diagram of the BU type C1, dark-colored version, with AUX terminals, supply over P1, P2 busbar

7.13.3 Technical specifications

Technical specifications of the BU type C1, dark-colored version, with AUX terminals, supply over P1, P2 busbar

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP20-0BC1/td?dl=de).

Article number	6ES7193-6BP20-0BC1
General information	
Product type designation	Type C1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	See manual
• For P1 and P2 bus	24 V
• For AUX bus	24 V; Equal potential group to P1/P2 bus or PE
• for process terminals	24 V

Article number	6ES7193-6BP20-0BC1
Rated value (AC)	See manual
• For P1 and P2 bus	230 V
• For AUX bus	230 V; Equal potential group to P1/P2 bus or PE
• for process terminals	230 V
Mains filter	
• integrated	No
Current carrying capacity	
up to 60 °C, max.	10 A
For P1 and P2 bus, max.	10 A
For AUX bus, max.	10 A
For process terminals, max.	5 A; 10 A for process terminals 5 and 6
Hardware configuration	
Automatic encoding	Yes
Potential separation	
between backplane bus and supply voltage	Yes
between process terminals and supply voltage	Yes
between power bus and supply voltage	No
Isolation	
Isolation tested with	3 100 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Accessories	
Color coding labels	
• for process terminals	CC51
• for AUX terminals	CC84 to CC86
• for add-on terminals	does not exist
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm^2; AWG 26
• Conductor cross-section, max.	2.5 mm^2; AWG 14
• Number of process terminals to I/O module	16; Pro slot
• Number of terminals to AUX bus	0

Article number	6ES7193-6BP20-0BC1
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	2; Pro slot
Dimensions	
Width	20 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	47 g

7.14 BU type D0, dark-colored version, without AUX terminals, supply over supply terminals

Short designation

Short designation: BU20-P12+A0+0B

7.14.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP00-0BD0 (PU: 1 unit)

View

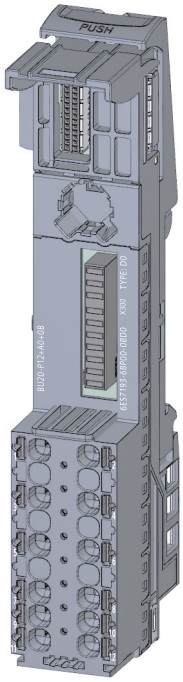

Figure 2-1697 BU type D0, dark-colored version, without AUX terminals, supply over supply terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "D0". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 12): Max. 5 A
- The BaseUnit further conducts the potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).

- No access to the power and AUX busbars via terminals
- 12 terminals to the process (assignment with the I/O module)
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

NOTE

The shield connection (shield support and shield terminal) is not intended for BaseUnit BU20-P12+A0+0B and must not be installed.

7.14.2 Connecting

Pin assignment

Pin assignment for BU type D0, dark-colored version, without AUX terminals, supply over supply terminals	
Terminal	**Explanations**
1 to 12	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.
(AUX)	No access to the AUX busbar via terminals

Block diagram

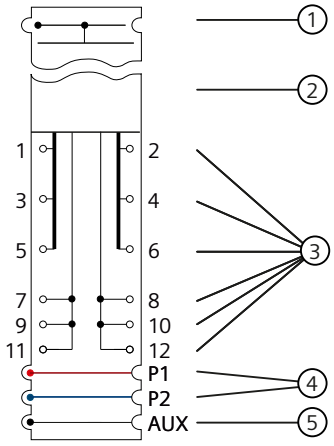

① Backplane bus

② I/O module

③ Terminals with connection to the I/O module

④ System-integrated, self-assembling voltage buses P1, P2 without connection to the terminals, connected to the adjacent module on the left

⑤ System-integrated, self-assembling AUX voltage bus without connection to the AUX terminals, connected to the adjacent module on the left

Figure 2-1698 Block diagram of the BU type D0, dark-colored version, without AUX terminals, supply over supply terminals

7.14.3 Technical specifications

Technical specifications of the BU type D0, dark-colored version, without AUX terminals, supply over infeed terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP00-0BD0/td?dl=de).

Article number	6ES7193-6BP00-0BD0
General information	
Product type designation	ET 200SP, BaseUnit BU type D0, PU 1
HW functional status	FS10 and higher
Supply voltage	
Rated value (AC)	See manual
• For P1 and P2 bus	277 V
• For AUX bus	277 V; Equal potential group to P1/P2 bus or PE
• for process terminals	277 V; 480 V (L1 - L2 - L3); 277 V (L, N)
Mains filter	
• integrated	Yes; Between N and FE

Article number	6ES7193-6BP00-0BD0
Current carrying capacity	
up to 60 °C, max.	5 A
For P1 and P2 bus, max.	10 A
For AUX bus, max.	10 A
For process terminals, max.	5 A
Hardware configuration	
Automatic encoding	Yes
Formation of potential groups	
• New potential group	No
• Potential group continued from the left	Yes
Potential separation	
between backplane bus and supply voltage	Yes
between power bus and supply voltage	Yes
Isolation	
Isolation tested with	3 100 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Accessories	
Color coding labels	
• for process terminals	does not exist
• for AUX terminals	does not exist
• for add-on terminals	does not exist
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²; AWG 26
• Conductor cross-section, max.	2.5 mm²; AWG 14
• Number of process terminals to I/O module	12; Pro slot
• Number of terminals to AUX bus	0
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	0; Pro slot

Article number	6ES7193-6BP00-0BD0
Dimensions	
Width	20 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	47 g

7.15 BU type F0, dark-colored version, with AUX terminals, supply over supply terminals

Short designation

Short designation: BU20-P8+A4+0B

7.15.1 Product overview

When you use the AUX terminals as a PE busbar:

NOTICE
When AUX is used as PE, AUX must be identified as green-yellow (e.g., gn/ye color-coded labels). These identifications must be removed if the terminals are no longer used as PE.

Delivery options (packing unit PU)

6ES7193-6BP20-0BF0 (PU: 1 unit)

View

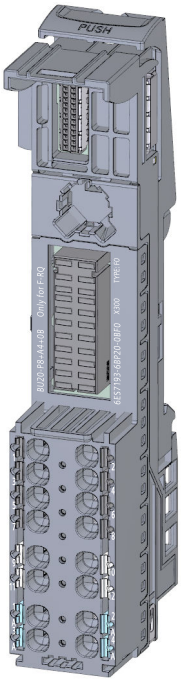

Figure 2-1699 BU type F0, dark-colored version, with AUX terminals, supply over supply terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "F0". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Current carrying capacity per process terminal (terminals 1 to 4 and 9 to 12): Max. 5 A
- The BaseUnit loops the potential group through with the self-assembling voltage buses P1, P2 and the AUX bus of the left-hand neighboring module (BaseUnit).
- Access to the AUX busbar via terminals 1 A to 4 A max. 24 V DC/10 A
- 8 terminals to the process (occupied by the I/O module)
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

7.15.2 Connecting

Pin assignment

Pin assignment for BU type F0, dark-colored version, with AUX terminals, supply over supply terminals		
Terminals of a potential group	**Fail-safe module Overvoltage category 3**	**Non-fail-safe module Overvoltage category 2**
1 to 4	Up to 230 V AC/DC (AC only one phase) Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.	
9 to 12	Safe extra low voltage SELV/PELV Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/en/55679691/133300) manual.	
P1, P2, AUX (1 A to 4 A)	SELV/PELV (max. 10 A)	SELV/PELV or up to 230 V AC/DC (AC only one phase) (max. 10 A)

Use the AUX terminals only with an identical voltage or PE associated with the supply voltage.

Block diagram

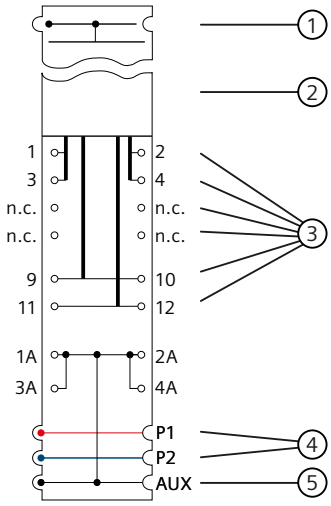

① Backplane bus

② I/O module

③ Terminals with connection to the I/O module

④ System-integrated, self-assembling voltage buses P1, P2 without connection to the terminals, connected to the adjacent module on the left

⑤ System-integrated, self-assembling AUX voltage bus with connection to the AUX terminals, connected to the adjacent module on the left

Figure 2-1700 Block diagram of the BU type F0, dark-colored version, with AUX terminals, supply over supply terminals

7.15.3 Technical specifications

Technical specifications of the BU type F0, dark-colored version, with AUX terminals, supply over infeed terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP20-0BF0/td?dl=de).

Article number	6ES7193-6BP20-0BF0
General information	
Product type designation	ET 200SP, BaseUnit BU type F0, BU20-P8+A4+0B, PU 1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	See manual
Rated value (AC)	See manual
Mains filter	
• integrated	No

Article number	6ES7193-6BP20-0BF0
Current carrying capacity	
up to 60 °C, max.	10 A
For P1 and P2 bus, max.	10 A
For AUX bus, max.	10 A
For process terminals, max.	5 A
Hardware configuration	
Automatic encoding	Yes
Potential separation	
between backplane bus and supply voltage	Yes
between process terminals and supply voltage	Yes
between power bus and supply voltage	Yes
Isolation	
Isolation tested with	3 100 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	2 000 m; On request: Installation altitudes greater than 2 000 m
Dimensions	
Width	20 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	48 g

7.16 BU type U0, light-colored version without AUX terminals

Short designation

Short designation: BU20-P16+A0+2D

7.16.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP00-0DU0 (PU: 1 unit)
6ES7193-6BP00-2DU0 (PU: 10 units)

View

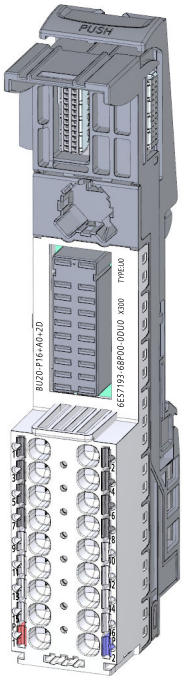

Figure 2-1701 BU type U0, light-colored version without AUX terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "U0". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 16): Max. 10 A
- The BaseUnit opens up a new potential group. The self-assembling voltage buses P1, P2 and the AUX busbar are disconnected from the adjacent module on the left (BaseUnit, interface module, CPU).

- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Maximum configuration per potential group

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated according to item 1. and item 2. must not exceed 10 A.

NOTE

A potential group opened with light-colored BaseUnit of type U0 must not contain a dark-colored BaseUnit of type A0 or A1.

7.16.2 Connecting

Pin assignment

Pin assignment for BU type U0, light-colored version, without AUX terminals	
Terminal	**Explanations**
1 to 16	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/de/55679691/133300) manual.
(AUX)	No access to the AUX busbar via terminals
P1 / P2	P1: Rated supply voltage up to 230 V AC with max. 10 A P2: Neutral/Ground

Block diagram

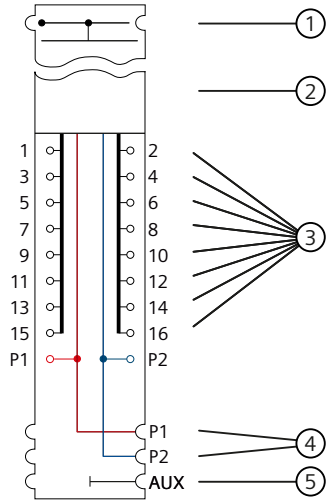

① Backplane bus

② I/O module

③ Terminals with connection to the I/O module

④ System-integrated, self-assembling voltage buses P1, P2 with connection to the infeed terminals, interrupted to the adjacent module on the left, form a new potential group

⑤ System-integrated, self-assembling AUX voltage bus without connection to the AUX terminals, interrupted to the adjacent module on the left, forms a new potential group

Figure 2-1702 Block diagram of the BU type U0, light-colored version, without AUX terminals

7.16.3 Technical specifications

Technical specifications of the BU type U0, light-colored version, without AUX terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP00-0DU0/td?dl=de).

Article number	6ES7193-6BP00-0DU0
General information	
Product type designation	BU type U0
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	See manual
• For P1 and P2 bus	120 V
• For AUX bus	120 V; Equal potential group to P1/P2 bus or PE
• for process terminals	120 V
Rated value (AC)	See manual
• For P1 and P2 bus	277 V
• For AUX bus	277 V; Equal potential group to P1/P2 bus or PE

Article number	6ES7193-6BP00-0DU0
• for process terminals	277 V
external protection for power supply lines	Yes
Mains filter	
• integrated	No
Current carrying capacity	
up to 60 °C, max.	10 A
For P1 and P2 bus, max.	10 A
For AUX bus, max.	10 A
For process terminals, max.	10 A; Point of contact, derating depends on the module
Hardware configuration	
Automatic encoding	Yes
Formation of potential groups	
• New potential group	Yes
• Potential group continued from the left	No
Potential separation	
between backplane bus and supply voltage	Yes
between process terminals and supply voltage	Yes; Not applicable for process terminals 15 and 16
between power bus and supply voltage	No
Isolation	
Isolation tested with	3 100 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3 000 m
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²; 0.2 mm² without wire end ferrule
• Conductor cross-section, max.	2.5 mm²; 1.5 mm² with wire end ferrule
• Number of process terminals to I/O module	16
• Number of terminals to AUX bus	0
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	2

Article number	6ES7193-6BP00-0DU0
Dimensions	
Width	20 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	50 g

7.17 BU type U0, dark-colored version, without AUX terminals

Short designation

Short designation: BU20-P16+A0+2B

7.17.1 Product overview

Delivery options (packing unit PU)

6ES7193-6BP00-0BU0 (PU: 1 unit)

6ES7193-6BP00-2BU0 (PU: 10 units)

View

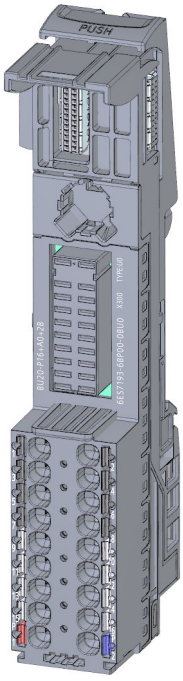

Figure 2-1703 BU type U0, dark-colored version, without AUX terminals

Properties

- BaseUnit suitable for all I/O modules of the BaseUnit type "U0". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Current-carrying capacity per process terminal (terminal 1 to 16): Max. 10 A
- The BaseUnit further conducts the potential group. The self-assembling voltage buses P1 and P2, and the AUX busbar are connected to the left-hand neighboring module (BaseUnit).
- No access to the AUX busbar via terminals
- 16 terminals to the process (assignment through the I/O module)
- Connection system in the form of push-in terminals Connection cross-sections are available in the ET 200SP System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

7.17.2 Connecting

Pin assignment

Pin assignment for BU type U0, dark-colored version, without AUX terminals	
Terminal	**Explanations**
1 to 16	Assignment is determined by the I/O module. You can find additional information in the I/O Module (http://support.automation.siemens.com/WW/view/de/55679691/133300) manual.
(AUX)	No access to the AUX busbar via terminals
P1 / P2	P1: Rated supply voltage up to 230 V AC with max. 10 A P2: Neutral/Ground

Block diagram

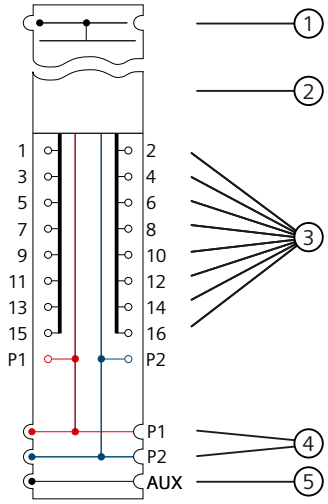

① Backplane bus

② I/O module

③ Terminals with connection to the I/O module

④ System-integrated, self-assembling voltage buses P1, P2 with connection to the infeed terminals, connected to the adjacent module on the left

④ System-integrated, self-assembling AUX voltage bus without connection to the AUX terminals, connected to the adjacent module on the left

Figure 2-1704 Block diagram of the BU type U0, dark-colored version, without AUX terminals

7.17.3 Technical specifications

Technical specifications of the BU type U0, dark-colored version, without AUX terminals

The following table lists the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6BP00-0BU0/td?dl=de).

Article number	6ES7193-6BP00-0BU0
General information	
Product type designation	BU type U0
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	See manual
• For P1 and P2 bus	120 V
• For AUX bus	120 V; Equal potential group to P1/P2 bus or PE
• for process terminals	120 V
Rated value (AC)	See manual
• For P1 and P2 bus	277 V
• For AUX bus	277 V; Equal potential group to P1/P2 bus or PE

Article number	6ES7193-6BP00-0BU0
• for process terminals	277 V
Mains filter	
• integrated	No
Current carrying capacity	
up to 60 °C, max.	10 A
For P1 and P2 bus, max.	10 A
For AUX bus, max.	10 A
For process terminals, max.	10 A; Point of contact, derating depends on the module
Hardware configuration	
Automatic encoding	Yes
Formation of potential groups	
• New potential group	No
• Potential group continued from the left	Yes
Potential separation	
between backplane bus and supply voltage	Yes
between process terminals and supply voltage	Yes; Not applicable for process terminals 15 and 16
between power bus and supply voltage	No
Isolation	
Isolation tested with	3 100 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	3 000 m
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²; 0.2 mm² without wire end ferrule
• Conductor cross-section, max.	2.5 mm²; 1.5 mm² with wire end ferrule
• Number of process terminals to I/O module	16
• Number of terminals to AUX bus	0
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	2

Article number	6ES7193-6BP00-0BU0
Dimensions	
Width	20 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	50 g

BaseUnits for motor starters 8

8.1 Introduction

Properties of the infeed bus

- The infeed bus is set up by connecting the BaseUnits, and wiring takes place automatically
- The infeed bus distributes the energy to the SIMATIC ET 200SP motor starters within one load group
- The max. current carrying capacity is up to 32 A (3-phase)
  - With infeed (for one load group) and motor connection
  - Infeed bus: 3-pole + PE
  - The voltage range for power infeed is 48 V AC to 500 V AC

You must observe the deratings depending on the configuration.

Properties of the self-assembling voltage bus (power bus)

- Maximum current: 7 A
- Rated voltage: 24 V DC

You must observe the deratings depending on the configuration.

AUX1 bus

For BaseUnits BU30-MS7 to BU30-MS10, the AUX1 bus is used for routing the F-DI signal.

This enables a group shutdown via the F-DI bus.

You can find assembly rules of the BaseUnits for the SIMATIC ET 200SP motor starter in the System Manual SIMATIC ET 200SP motor starters.

8.2 Safety-related shutdown

Single shutdown

With BaseUnits BU30-MS5 to BU30-MS6, an single shutdown can be implemented using the F-DI. The single shutdown in SIL3 Cat. 4 PLe is possible with fail-safe PP-switching or PM-switching control modules.

For single use of the BU30-MS7 and BU30-MS10, a fail-safe PP-switching control module must always be used.

Group shutdown

With BaseUnits BU30-MS7 to BU30-MS10, a group shutdown can be implemented using the F-DI.

The group shutdown in SIL3 Cat. 4 PLe is only possible with fail-safe PP-switching control modules. A group shutdown is also possible by a fail-safe shutdown of the supply voltage with all motor starter BaseUnits.

WARNING

Safety-related shutdown using the F-DI

Depending on the I/O used, the shutdown takes place via one or two output channels (terminals):

- PM-switching: The shutdown takes place via two output channels.
- PP-switching: The shutdown takes place via one output channel.

Shutdown via only one output channel (PP-switching) achieves SILCL 3 according to EN 62061, PL e / Cat. 4 according to EN ISO 13849-1, if it is ensured that the cabling is installed in a cross-circuit-proof/P-short-circuit-proof manner.

8.3 BU30-MS1 - BaseUnit with 24 V DC and 500 V AC infeed

8.3.1 Product overview

Article number

3RK1908-0AP00-0AP0

View

Figure 2-1705 BaseUnit with 24 V DC and 500 V AC infeed

Properties

- BaseUnit suitable for all fail-safe and non-fail-safe SIMATIC ET 200SP High Feature motor starters
- The BaseUnit opens a new potential group (24 V DC). The potential group (24 V DC) is interrupted to the adjacent module on the left (BaseUnit, interface module/CPU).
- The BaseUnit opens a new potential group (500 V AC). The infeed bus L1 (L), L2 (N), L3, PE is interrupted to the left-hand BaseUnit of the ET 200SP motor starter.
- Connection system in the form of push-in terminals
- The touch protection cover for the infeed bus (3RK1908-1DA00-2BP0) is included in the scope of delivery.

- The F-DI of the fail-safe motor starter is connected internally to the potential group (24 V DC). When the supply voltage (24 V DC) is applied, the motor starter is ready for operation.
- Version for HA system available: 3RK1908-0AP00-0AH0

Maximum configuration per voltage group (24 V DC)

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated according to item 1. and item 2. must not exceed 7 A.

Maximum configuration of the infeed bus (500 V AC)

The number of motor starters that can be used per infeed group depends on the following factors:

1. Total current requirement of all motor starters operated on this infeed group.
2. Ambient temperature and installation type in which the motor starters are operated. You can find further information in the derating table in the Manual SIMATIC ET 200SP Motor Starter (https://support.industry.siemens.com/cs/ww/en/view/109479973).

8.3.2 Connecting

Pin assignment

Pin assignment for BaseUnit with 24 V DC and 500 V AC infeed	
Terminal	**Explanations**
L1(L), L2(N), L3, PE	Power supply Assignment is determined by the motor starter. You can find more information in the ET 200SP Motor Starter (https://support.industry.siemens.com/cs/ww/en/view/109479973) manual.
T1, T2, T3, PE	Motor feeder
24 V DC, M	24 V DC: Supply voltage 24 V DC with max. 7 A M: Ground

Block diagram

The figure below shows the block diagram of the BaseUnit with 24 V DC and 500 V AC infeed.

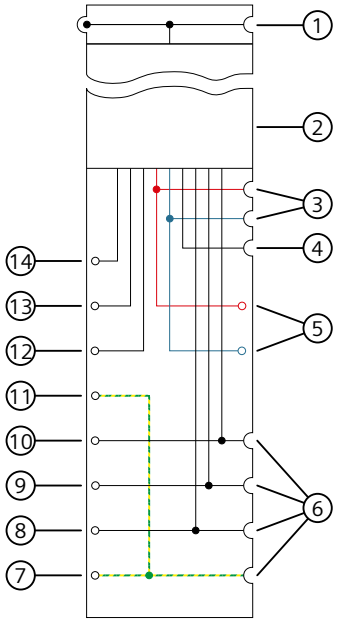

① Backplane bus
② Motor starter module
③ Interrupted busbars 24 V DC, M
④ Interrupted AUX bus
⑤ Terminals for 24 V DC and ground M
⑥ Interrupted busbars for the infeed system L1(L), L2(N), L3, PE
⑦ Infeed terminal for protective ground PE
⑧ Infeed terminal L3
⑨ Infeed terminal L2(N)
⑩ Infeed terminal L1(L)
⑪ Terminal for protective ground PE
⑫ Terminal T3
⑬ Terminal T2
⑭ Terminal T1

Figure 2-1706 Block diagram BaseUnit with 24 V DC and 500 V AC infeed

8.3.3 Technical specifications

Technical specifications of the BaseUnit with 24 V DC and 500 V AC infeed

	3RK1908-0AP00-0AP0
Product type designation	BU30-MS1
Galvanic isolation	

	3RK1908-0AP00-0AP0
Galvanic isolation between backplane bus and supply voltage	Yes
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating[1)])
Rated insulation voltage in accordance with IEC 60947-1	500 V
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 V AC to 500 V AC
Max. current-carrying capacity	32 A (observe derating[1)])
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weights	
Weight, approx.	164 g

[1)] Derating table in SIMATIC ET 200SP Motor Starter manual (https://support.industry.siemens.com/cs/ww/en/view/109479973)

8.4 BU30-MS2 - BaseUnit with 500 V AC infeed

8.4.1 Product overview

Article number

3RK1908-0AP00-0CP0

View

Figure 2-1707 BaseUnit with 500 V AC infeed

Properties

- BaseUnit suitable for all fail-safe and non-fail-safe SIMATIC ET 200SP High Feature motor starters
- The BaseUnit takes over the potential group (24 V DC) from the adjacent module on the left and loops this through.
- The BaseUnit opens a new potential group (500 V AC). The infeed bus L1 (L), L2 (N), L3, PE is interrupted to the left-hand BaseUnit of the ET 200SP motor starter.
- Connection system in the form of push-in terminals
- The touch protection cover for the infeed bus (3RK1908-1DA00-2BP0) is included in the scope of delivery.

- The F-DI of the fail-safe motor starter is connected internally to the potential group (24 V DC). When the supply voltage (24 V DC) is applied, the motor starter is ready for operation.
- Version for HA system available: 3RK1908-0AP00-0CH0

Maximum configuration of the infeed bus (500 V AC)

The number of motor starters that can be used per infeed group depends on the following factors:

1. Total current requirement of all motor starters operated on this infeed group.
2. Ambient temperature and installation type in which the motor starters are operated. You can find further information in the derating table in the Manual SIMATIC ET 200SP Motor Starter (https://support.industry.siemens.com/cs/ww/en/view/109479973).

8.4.2 Connecting

Pin assignment

Pin assignment for BaseUnit with 500 V AC infeed	
Terminal	**Explanations**
L1(L), L2(N), L3, PE	Power supply Assignment is determined by the motor starter. See Manual ET 200SP motor starters (https://support.industry.siemens.com/cs/ww/en/view/109479973).
T1, T2, T3, PE	Motor feeder

Block diagram

The figure below shows the block diagram of the BaseUnit with 500 V AC infeed.

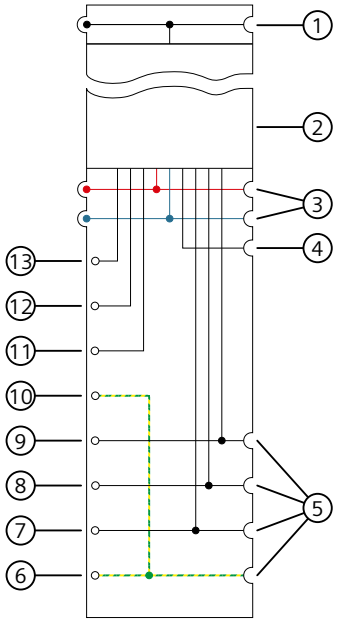

① Backplane bus
② Motor starter module
③ Connected busbars 24 V DC, M
④ Interrupted AUX bus
⑤ Interrupted busbars for the infeed system L1(L), L2(N), L3, PE
⑥ Infeed terminal for protective ground PE
⑦ Infeed terminal L3
⑧ Infeed terminal L2(N)
⑨ Infeed terminal L1(L)
⑩ Terminal for protective ground PE
⑪ Terminal T3
⑫ Terminal T2
⑬ Terminal T1

Figure 2-1708 Block diagram of BaseUnit with 500 V AC infeed

8.4.3 Technical specifications

Technical specifications of the BaseUnit with 500 V AC infeed

		3RK1908-0AP00-0CP0
Product type designation	BU30-MS2	
Galvanic isolation		
Galvanic isolation between backplane bus and supply voltage	Yes	

	3RK1908-0AP00-0CP0
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating[1])
Rated insulation voltage in accordance with IEC 60947-1	500 V
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 V AC to 500 V AC
Max. current-carrying capacity	32 A (observe derating[1])
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weight, approx.	160 g

[1] Derating table in SIMATIC ET 200SP Motor Starter manual (https://support.industry.siemens.com/cs/ww/en/view/109479973)

8.5 BU30-MS3 - BaseUnit with 24 V DC infeed

8.5.1 Product overview

Article number

3RK1908-0AP00-0BP0

View

Figure 2-1709 BaseUnit with 24 V DC infeed

Properties

- BaseUnit suitable for all fail-safe and non-fail-safe SIMATIC ET 200SP High Feature motor starters
- The BaseUnit opens a new potential group (24 V DC). The potential group (24 V DC) is interrupted to the adjacent module on the left (BaseUnit, interface module/CPU).
- This BaseUnit takes over the infeed bus (500 V AC) of the left-hand BaseUnit and loops it through.
- Connection system in the form of push-in terminals
- The touch protection cover for the infeed bus (3RK1908-1DA00-2BP0) is not included in the scope of delivery.

- The F-DI of the fail-safe motor starter is connected internally to the potential group (24 V DC). When the supply voltage (24 V DC) is applied, the motor starter is ready for operation.
- Version for HA system available: 3RK1908-0AP00-0BH0

Maximum configuration per voltage group (24 V DC)

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated according to item 1. and item 2. must not exceed 7 A.

8.5.2 Connecting

Pin assignment

Pin assignment for BaseUnit with 24 V DC infeed	
Terminal	**Explanations**
T1, T2, T3, PE	Motor feeder
24 V DC, M	24 V DC: Rated supply voltage 24 V DC with max. 7 A M: Ground

Block diagram

The figure below shows the three-phase connection with 24 V infeed and mains infeed.

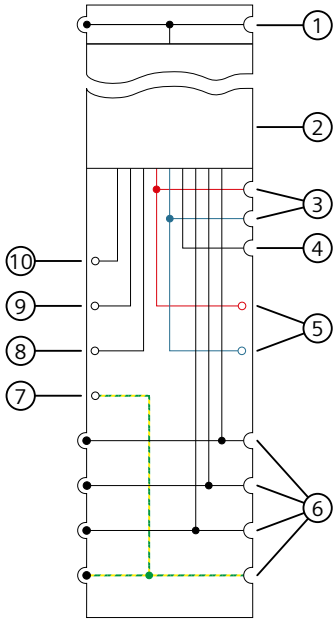

① Backplane bus
② Motor starter module
③ Interrupted busbars 24 V DC, M
④ Interrupted AUX bus
⑤ Terminal for 24 V DC and ground M
⑥ Connected busbars for the infeed system L1(L), L2(N), L3, PE
⑦ Terminal for protective ground PE
⑧ Terminal T3
⑨ Terminal T2
⑩ Terminal T1

Figure 2-1710 Block diagram BaseUnit with 24 V DC infeed

8.5.3 Technical specifications

Technical specifications of the BaseUnit with 24 V DC infeed

	3RK1908-0AP00-0BP0
Product type designation	BU30-MS3
Galvanic isolation	
Galvanic isolation between backplane bus and supply voltage	Yes
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating[1)])

	3RK1908-0AP00-0BP0
Rated insulation voltage in accordance with IEC 60947-1	500 V
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 V AC to 500 V AC
Max. current-carrying capacity	32 A (observe derating[1)])
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weight, approx.	152 g

[1)] Derating table in SIMATIC ET 200SP Motor Starter manual (https://support.industry.siemens.com/cs/ww/en/view/109479973)

8.6 BU30-MS4 - BaseUnit without infeed

8.6.1 Product overview

Article number

3RK1908-0AP00-0DP0

View

Figure 2-1711 BaseUnit without infeed

Properties

- BaseUnit suitable for all fail-safe and non-fail-safe SIMATIC ET 200SP High Feature motor starters
- No new potential groups are opened with this BaseUnit.
- The BaseUnit takes over the potential group (24 V DC) from the adjacent module on the left and loops it through.
- This BaseUnit takes over the infeed bus (500 V AC) of the left-hand BaseUnit and loops it through.
- Connection method using push-in terminals

- The touch protection cover for the infeed bus (3RK1908-1DA00-2BP0) is not included in the scope of delivery.
- The F-DI of the fail-safe motor starter is connected internally to the potential group (24 V DC). When the supply voltage (24 V DC) is applied, the motor starter is ready for operation.
- Version for HA system available: 3RK1908-0AP00-0DH0

8.6.2 Connecting

Pin assignment

Pin assignment for BaseUnit without infeed	
Terminal	**Explanations**
T1, T2, T3, PE	Motor feeder

Block diagram

The figure below shows the block diagram of the BaseUnit without infeed.

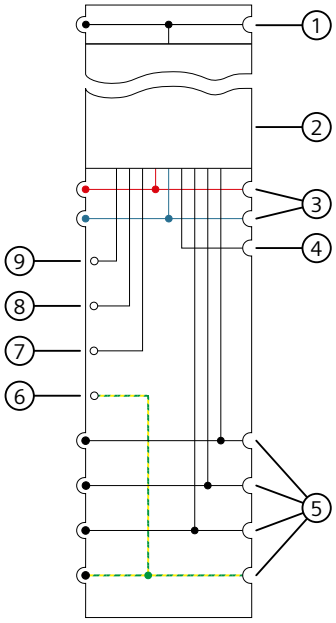

① Backplane bus
② Motor starter module
③ Connected busbars 24 V DC, M
④ Interrupted AUX bus
⑤ Connected busbars for the infeed system L1(L), L2(N), L3, PE
⑥ Terminal for protective ground PE
⑦ Terminal T3
⑧ Terminal T2
⑨ Terminal T1

Figure 2-1712 Block diagram BaseUnit without infeed

8.6.3 Technical specifications

Technical specifications of BaseUnit without infeed

	3RK1908-0AP00-0DP0
Product type designation	BU30-MS4
Galvanic isolation	
Galvanic isolation between backplane bus and supply voltage	Yes
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating[1)])

	3RK1908-0AP00-0DP0
Rated insulation voltage in accordance with IEC 60947-1	500 V
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 V AC to 500 V AC
Max. current-carrying capacity	32 A (observe derating[1)])
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weight, approx.	150 g

[1)] Derating table in SIMATIC ET 200SP Motor Starter manual (https://support.industry.siemens.com/cs/ww/en/view/109479973)

8.7 BU30-MS5 BaseUnit with 500 V AC infeed and single F-DI

8.7.1 Product overview

Article number

3RK1908-0AP00-0EP0

View

Figure 2-1713 BaseUnit with 500 V AC and F-DI

Properties

- BaseUnit suitable for all fail-safe SIMATIC ET 200SP High Feature motor starters
- The BaseUnit takes over the potential group (24 V DC) from the adjacent module on the left and loops it through.
- The BaseUnit opens a new potential group (500 V AC). The infeed bus L1 (L), L2 (N), L3, PE is interrupted to the left-hand BaseUnit of the ET 200SP motor starter.
- Connection system in the form of push-in terminals

- The touch protection cover for the infeed bus (3RK1908-1DA00-2BP0) is included in the scope of delivery.
- The BaseUnit has an F-DI input terminal for fail-safe control signals of the motor starter. This signal is not routed to neighboring motor starters.

Maximum configuration of the supply bus

The number of I/O modules that can be used per potential group depends on the following factors:

1. Total power requirement of all I/O modules operated on this potential group
2. Total power requirement of all loads connected externally to this potential group

The total current calculated according to item 1. and item 2. must not exceed 7 A.

Properties of the F-DI

The fail-safe digital input "F-DI" has the following properties:

- Use of interconnection type 1oo1
- Sink input (P-reading)
- Input delay 10 ms
- Status display of the F-DI on the motor starter module (green LED)

8.7.2 Connecting

Pin assignment

Pin assignment for BaseUnit with 500 V AC infeed and F-DI	
Terminal	**Explanations**
T1, T2, T3, PE	Motor feeder
F-DI, M	F-DI: Connection of fail-safe signal M: Reference potential of fail-safe signal
L1(L), L2(N), L3, PE	Power supply Assignment is determined by the motor starter. You can find more information in the ET 200SP Motor Starter (https://support.industry.siemens.com/cs/ww/en/view/109479973) manual.

Block diagram

The figure below shows the two-phase connection with 500 V AC infeed and F-DI:

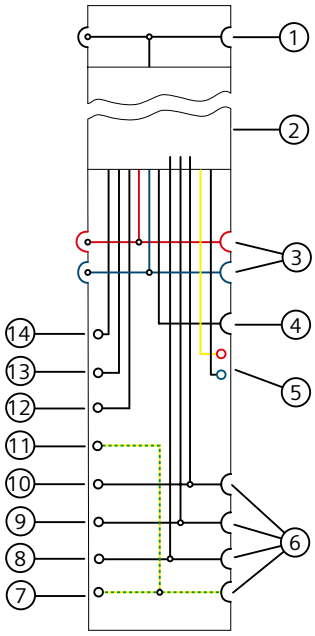

① Backplane bus
② Motor starter module
③ Connected busbars 24 V DC, M
④ Interrupted AUX bus
⑤ F-DI (P24/M)
⑥ Interrupted busbars for the infeed system L1(L), L2(N), L3, PE
⑦ Infeed terminal for protective ground PE
⑧ Infeed terminal L3
⑨ Infeed terminal L2(N)
⑩ Infeed terminal L1(L)
⑪ Terminal for protective ground PE
⑫ Terminal T3
⑬ Terminal T2
⑭ Terminal T1

Figure 2-1714 Block diagram of BaseUnit with 500 V AC infeed and fail-safe input

8.7.3 Technical specifications

Technical specifications of the BaseUnit with 500 V AC infeed and F-DI

	3RK1908-0AP00-0EP0
Product type designation	BU30-MS5
Galvanic isolation	

	3RK1908-0AP00-0EP0
Galvanic isolation between backplane bus and supply voltage	Yes
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating[1)])
Galvanic isolation between fail-safe digital input and supply voltage	Yes
F-DI	Type 1 according to DIN EN 61131-2
Input current F-DI for signal "1", typ.	5 mA
Rated insulation voltage in accordance with IEC 60947-1	500 V
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 V AC to 500 V AC
Max. current-carrying capacity	32 A (observe derating[1)])
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weight, approx.	152 g

[1)] Derating table in SIMATIC ET 200SP Motor Starter manual (https://support.industry.siemens.com/cs/ww/en/view/109479973)

8.8 BU30-MS6 Base Unit without infeed and with single F-DI

8.8.1 Product overview

Article number

3RK1908-0AP00-0FP0

View

Figure 2-1715 BaseUnit without 500 V AC infeed, with F-DI

Properties

- BaseUnit suitable for all fail-safe SIMATIC ET 200SP High Feature motor starters
- No new potential groups are opened with this BaseUnit.
- The BaseUnit takes over the potential group (24 V DC) from the adjacent module on the left and loops it through.
- This BaseUnit takes over the infeed bus (500 V AC) of the left-hand BaseUnit and loops it through.
- Connection system in the form of push-in terminals

- The touch protection cover for the infeed bus (3RK1908-1DA00-2BP0) is not included in the scope of delivery.
- The BaseUnit has an F-DI input terminal for fail-safe control signals of the motor starter. This signal is not routed to neighboring motor starters.

Properties of the F-DI

The fail-safe digital input "F-DI" has the following properties:

- Use of interconnection type 1oo1
- Sink input (P-reading)
- Input delay 10 ms
- Status display of the F-DI on the motor starter module (green LED)

8.8.2 Connecting

Pin assignment

Pin assignment for BaseUnit with 24 V DC infeed	
Terminal	**Explanations**
T1, T2, T3, PE	Motor feeder
F-DI, M	F-DI: Connection of fail-safe signal M: Reference potential of fail-safe signal

Block diagram

The following figure shows the block diagram for the BaseUnit without infeed, but with fail-safe input:

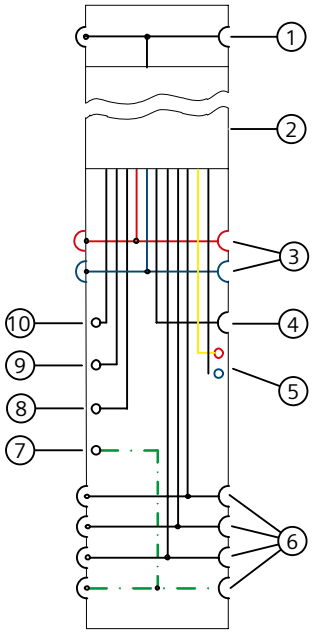

① Backplane bus
② Motor starter module
③ Connected busbars 24 V DC, M
④ Interrupted AUX bus
⑤ F-DI (P24/M)
⑥ Connected busbars infeed system L1, L2, L3, PE
⑦ Terminal for protective ground PE
⑧ Terminal T3
⑨ Terminal T2
⑩ Terminal T1

Figure 2-1716 Block diagram of BaseUnit without infeed, with fail-safe input

8.8.3 Technical specifications

Technical specifications of BaseUnit without infeed, with F-DI

	3RK1908-0AP00-0FP0
Product type designation	BU30-MS6
Galvanic isolation	
Galvanic isolation between backplane bus and supply voltage	Yes
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC

	3RK1908-0AP00-0FP0
Max. operating current	7 A (observe derating[1])
Rated insulation voltage in accordance with IEC 60947-1	500 V
Galvanic isolation between fail-safe digital input and supply voltage	Yes
F-DI	Type 1 according to DIN EN 61131-2
Input current F-DI for signal "1", typ.	5 mA
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 V AC to 500 V AC
Max. current-carrying capacity	32 A (observe derating[1])
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weight, approx.	152 g

[1] Derating table in SIMATIC ET 200SP Motor Starter manual (https://support.industry.siemens.com/cs/ww/en/view/109479973)

8.9 BU30-MS7 BaseUnit with F-DI and 500 V AC infeed

8.9.1 Product overview

Article number

3RK1908-0AP00-0GP0

View

Figure 2-1717 BaseUnit with F-DI and 500 V AC infeed

Properties

- BaseUnit suitable for all fail-safe SIMATIC ET 200SP High Feature motor starters
- The BaseUnit takes over the potential group (24 V DC) from the adjacent module on the left and loops it through.
- The BaseUnit opens a new potential group (500 V AC). The infeed bus L1 (L), L2 (N), L3, PE is interrupted to the left-hand BaseUnit of the ET 200SP motor starter.
- Connection method using push-in terminals

- The touch protection cover (3RK1908-1DA00-2BP0) for the infeed bus is included in the scope of delivery.
- The BaseUnit has an F-DI input terminal for fail-safe control signals of the motor starter. These signals are routed to the adjacent motor starter on the right if a BU30-MS8 or BU30-MS9 is being used on the right side.

Maximum configuration of the infeed bus (500 V AC)

The number of motor starters that can be used per infeed group depends on the following factors:

1. Total current requirement of all motor starters operated on this infeed group.
2. Ambient temperature and installation type in which the motor starters are operated. You can find further information in the derating table in the Manual SIMATIC ET 200SP Motor Starter (https://support.industry.siemens.com/cs/ww/en/view/109479973).

Properties of the F-DI

The fail-safe digital input "F-DI" has the following properties:

- Use of interconnection type 1oo1
- Sink input (P-reading)
- Input delay 10 ms
- Status display of the F-DI on the motor starter module (green LED)

Maximum configuration of F-DI routing

The number of BaseUnits for F-DI routing is possible for a system configuration up to 1 m.

8.9.2 Connecting

Pin assignment

Pin assignment for BaseUnit with F-DI and 500 V AC infeed	
Terminal	**Explanations**
L1(L), L2(N), L3, PE	Power supply Assignment is determined by the motor starter. You can find more information in the ET 200SP Motor Starter (https://support.industry.siemens.com/cs/ww/en/view/109479973) manual.
T1, T2, T3, PE	Motor feeder
F-DI, M	F-DI: Connection of fail-safe signal M: Reference potential of fail-safe signal

Block diagram

The figure below shows the block diagram of the BaseUnit with F-DI and 500 V AC infeed.

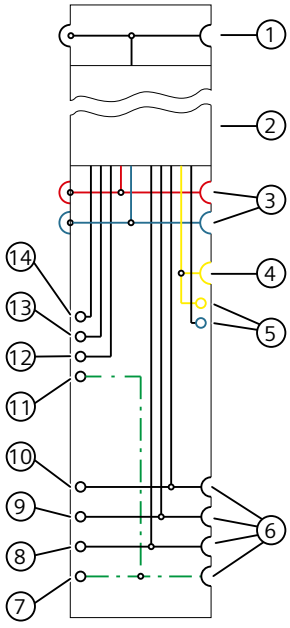

① Backplane bus
② Motor starter module
③ Connected busbar 24 V DC, M
④ F-DI infeed on AUX bus
⑤ F-DI, M
⑥ Connected busbars for infeed system L1, L2, L3, PE
⑦ Infeed terminal for protective ground PE
⑧ Infeed terminal for L3
⑨ Infeed terminal for L2 (N)
⑩ Infeed terminal for L1 (L)
⑪ Terminal for protective ground PE
⑫ Terminal for T3
⑬ Terminal for T2
⑭ Terminal for T1

Figure 2-1718 Block diagram of BaseUnit with F-DI and 500 V AC infeed

8.9.3 Technical specifications

Technical specifications of BaseUnit with F-DI and 500 V AC infeed

		3RK1908-0AP00-0GP0
Product type designation	BU30-MS7	
Galvanic isolation		

	3RK1908-0AP00-0GP0
Galvanic isolation between backplane bus and supply voltage	Yes
F-DI	Type 1 according to DIN EN 61131-2 5 mA
Input current F-DI for signal "1", typ.	5 mA
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating[1)])
Rated insulation voltage in accordance with IEC 60947-1	500 V
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 V AC to 500 V AC
Max. current-carrying capacity	32 A (observe derating[1)])
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weights	
Weight, approx.	164 g

[1)] Derating table in SIMATIC ET 200SP Motor Starter manual (https://support.industry.siemens.com/cs/ww/en/view/109479973)

8.10 BU30-MS8 BaseUnit with 500 V AC infeed and F-DI routing

8.10.1 Product overview

Article number

3RK1908-0AP00-0HP0

View

Figure 2-1719 BaseUnit with 500 V AC infeed and F-DI routing

Properties

- BaseUnit suitable for all fail-safe SIMATIC ET 200SP High Feature motor starters
- The BaseUnit takes over the potential group (24 V DC) from the adjacent module on the left and loops it through.
- The BaseUnit opens a new potential group (500 V AC). The infeed bus L1 (L), L2 (N), L3, PE is interrupted to the left-hand BaseUnit of the ET 200SP motor starter.
- Connection system in the form of push-in terminals

- The touch protection cover for the infeed bus (3RK1908-1DA00-2BP0) is included in the scope of delivery.
- The BaseUnit takes over the fail-safe control signals from the adjacent BU30-MS7 or BU30-MS10 BaseUnit on the left. This signal is routed to the adjacent motor starter on the right if a BU30-MS8 or BU30-MS9 is being used on the right side.

Maximum configuration of the infeed bus (500 V AC)

The number of motor starters that can be used per infeed group depends on the following factors:

1. Total current requirement of all motor starters operated on this infeed group.
2. Ambient temperature and installation type in which the motor starters are operated. You can find further information in the derating table in the Manual SIMATIC ET 200SP Motor Starter (https://support.industry.siemens.com/cs/ww/en/view/109479973).

Maximum configuration of F-DI routing

The number of BaseUnits for F-DI routing is possible for a system configuration up to 1 m.

8.10.2 Connecting

Pin assignment

Pin assignment for BaseUnit with 500 V AC infeed and F-DI routing	
Terminal	**Explanations**
L1(L), L2(N), L3, PE	Power supply Assignment is determined by the motor starter. See Manual ET 200SP motor starters (https://support.industry.siemens.com/cs/ww/en/view/109479973).
T1, T2, T3, PE	Motor feeder

Block diagram

The figure below shows the block diagram of the BaseUnit with 500 V AC infeed.

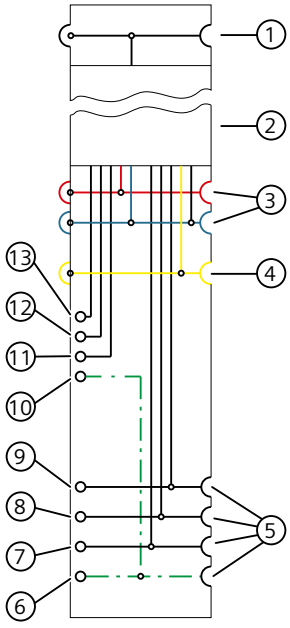

① Backplane bus
② Motor starter module
③ Connected busbars P24, M
④ Interrupted F-DI AUX bus
⑤ Connected busbars for infeed system L1, L2, L3, PE
⑥ Infeed terminal for protective ground PE
⑦ Infeed terminal for L3
⑧ Infeed terminal for L2 (N)
⑨ Infeed terminal for L1 (L)
⑩ Terminal for protective ground PE
⑪ Terminal for T3
⑫ Terminal for T2
⑬ Terminal for T1

Figure 2-1720 Block diagram of BaseUnit with 500 V AC infeed

8.10.3 Technical specifications

Technical specifications of BaseUnit with 500 V AC infeed and F-DI routing

	3RK1908-0AP00-0HP0
Product type designation	BU30-MS8
Galvanic isolation	
Galvanic isolation between backplane bus and supply voltage	Yes

	3RK1908-0AP00-0HP0
F-DI	Type 1 according to DIN EN 61131-2 Input current F-DI for signal "1", typ. 5 mA
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating[1)])
Rated insulation voltage in accordance with IEC 60947-1	500 V
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 V AC to 500 V AC
Max. current-carrying capacity	32 A (observe derating[1)])
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weight, approx.	160 g

[1)] Derating table in SIMATIC ET 200SP Motor Starter manual (https://support.industry.siemens.com/cs/ww/en/view/109479973)

8.11 BU30-MS9 BaseUnit with F-DI routing

8.11.1 Product overview

Article number

3RK1908-0AP00-0JP0

View

Figure 2-1721 BaseUnit with F-DI routing

Properties

- BaseUnit suitable for all fail-safe SIMATIC ET 200SP High Feature motor starters
- No new potential groups are opened with this BaseUnit .
- The BaseUnit takes over the potential group (24 V DC) from the adjacent module on the left and loops this through.
- This BaseUnit takes over the infeed bus (500 V AC) of the left-hand BaseUnit and loops it through.
- Connection system in the form of push-in terminals

- The touch protection cover for the infeed bus (3RK1908-1DA00-2BP0) is not included in the scope of delivery.
- The BaseUnit takes over the fail-safe control signals from the adjacent BU30-MS7 or BU30-MS10 BaseUnit on the left. This signal is routed to the adjacent motor starter on the right if a BU30-MS8 or BU30-MS9 is being used on the right side.

Maximum configuration of F-DI routing

The number of BaseUnits for F-DI routing is possible for a system configuration up to 1 m.

8.11.2 Connecting

Pin assignment

Pin assignment for BaseUnit with 24 V DC infeed	
Terminal	**Explanations**
T1, T2, T3, PE	Motor feeder

Block diagram

The figure below shows the three-phase connection with 24 V infeed and mains infeed.

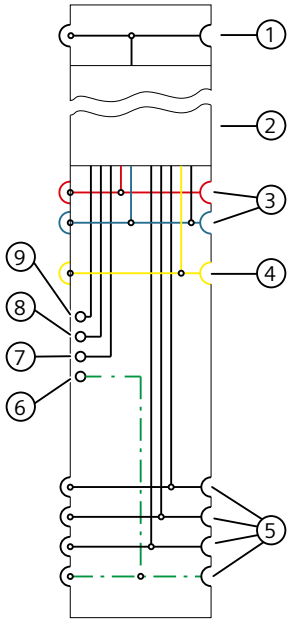

① Backplane bus
② Motor starter module
③ Connected busbars P24, M
④ Connected F-DI on AUX bus
⑤ Connected busbars for infeed system L1, L2, L3, PE
⑥ Terminal for protective ground
⑦ Terminal for T3
⑧ Terminal for T2
⑨ Terminal for T1

Figure 2-1722 Block diagram of BaseUnit with F-DI routing

8.11.3 Technical specifications

Technical specifications of BaseUnit with F-DI routing

	3RK1908-0AP00-0JP0
Product type designation	BU30-MS9
Galvanic isolation	
Galvanic isolation between backplane bus and supply voltage	Yes
F-DI	Type 1 according to DIN EN 61131-2 5 mA
Input current F-DI for signal "1", typ.	5 mA
Insulation tested with	2500 V AC
Rated operating voltage	24 V DC

	3RK1908-0AP00-0JP0
Max. operating current	7 A (observe derating[1])
Rated insulation voltage in accordance with IEC 60947-1	500 V
Galvanic isolation between fail-safe digital input and supply voltage	Yes
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 V AC to 500 V AC
Max. current-carrying capacity	32 A (observe derating[1])
Isolating function between the infeed terminals L1(L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weight, approx.	152 g

[1] Derating table in SIMATIC ET 200SP Motor Starter manual (https://support.industry.siemens.com/cs/ww/en/view/109479973)

8.12 BU30-MS10 BaseUnit with F-DI infeed

8.12.1 Product overview

Article number

3RK1908-0AP00-0KP0

View

Figure 2-1723 BU30-MS10 BaseUnit with F-DI infeed

Properties

- BaseUnit suitable for all fail-safe SIMATIC ET 200SP High Feature motor starters
- No new potential groups are opened with this BaseUnit .
- The BaseUnit takes over the potential group (24 V DC) from the adjacent module on the left and loops it through.
- This BaseUnit takes over the infeed bus (500 V AC) of the left-hand BaseUnit and loops it through.
- Connection system in the form of push-in terminals

- The touch protection cover for the infeed bus (3RK1908-1DA00-2BP0) is not included in the scope of delivery.
- The BaseUnit has an F-DI input terminal for fail-safe control signals of the motor starter. These signals are routed to the adjacent motor starter on the right if a BU30-MS8 or BU30-MS9 is being used on the right side.

Properties of the F-DI

The fail-safe digital input "F-DI" has the following properties:

- Use of interconnection type 1oo1
- Sink input (P-reading)
- Input delay 10 ms
- Status display of the F-DI on the motor starter module (green LED)

Maximum configuration of F-DI routing

The number of BaseUnits for F-DI routing is possible for a system configuration up to 1 m.

8.12.2 Connecting

Pin assignment

Pin assignment for BaseUnit with infeed	
Terminal	**Explanations**
T1, T2, T3, PE	Motor feeder
F-DI, M	F-DI: Connection of fail-safe signal M: Reference potential of fail-safe signal

Block diagram

The figure below shows the block diagram of the BaseUnit with F-DI infeed.

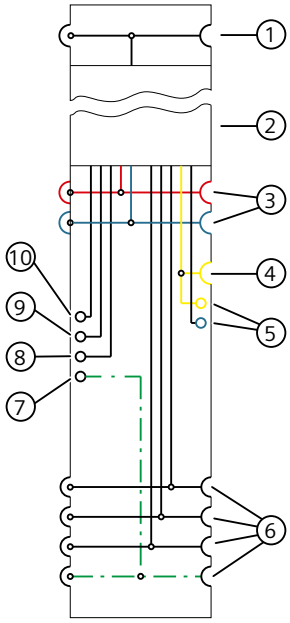

① Backplane bus
② Motor starter module
③ Connected busbars P24, M
④ F-DI infeed on AUX bus
⑤ F-DI, M
⑥ Connected busbars for infeed system L1, L2, L3, PE
⑦ Terminal for protective ground PE
⑧ Terminal for T3
⑨ Terminal for T2
⑩ Terminal for T1

Figure 2-1724 Block diagram of BaseUnit with F-DI infeed

8.12.3 Technical specifications

Technical specifications of BaseUnit with F-DI infeed

	3RK1908-0AP00-0KP0
Product type designation	BU30-MS10
Galvanic isolation	
Galvanic isolation between backplane bus and supply voltage	Yes
F-DI	Type 1 according to DIN EN 61131-2 5 mA
Input current F-DI for signal "1", typ.	5 mA
Insulation tested with	2500 V AC

	3RK1908-0AP00-0KP0
Rated operating voltage	24 V DC
Max. operating current	7 A (observe derating[1)])
Rated insulation voltage in accordance with IEC 60947-1	500 V
Impulse withstand voltage/rated value U_{imp} according to IEC 60947-1	6 kV
Operating voltage range	48 V AC to 500 V AC
Max. current-carrying capacity	32 A (observe derating[1)])
Isolating function between the infeed terminals L1 (L), L2 (N), L3 and motor feeder terminals T1, T2, T3 for motor starters in parking position, or removed motor starters: Impulse withstand voltage/rated value Uimp according to IEC 60947-1	6 kV
Wiring	
Push-in	Required tools for releasing: Standard screwdriver size 1 (SZF1 - 0.6x3.5)
Dimensions	
Width	30 mm
Height	215 mm
Weight, approx.	150 g

[1)] Derating table in SIMATIC ET 200SP Motor Starter manual (https://support.industry.siemens.com/cs/ww/en/view/109479973)

Potential distributor modules 9

9.1 Introduction

Properties of potential distributor modules

A potential distributor module (PotDis module) consists of a potential distributor BaseUnit (PotDis-BU) and a potential distributor terminal block (PotDis-TB) installed on top of it.

A system-integrated potential distribution is possible with the various PotDis-BUs and PotDis-TBs.

You can place potential distributor modules at any location with the ET 200SP distributed I/O system. In doing so, you must observe the same design rules that apply to the design of a potential group from the BaseUnits for I/O modules. The following information is particularly important:

- The potential groups opened with a light-colored PotDis-BU must contain no I/O modules. You can integrate any dark-colored PotDis-BUs into I/O module potential groups provided these are based on SELV/PELV supply.
- If you do not need the additional terminals of the PotDis-TB in a potential distributor module, replace the PotDis-TB with a BU-Cover.
- You may only connect one potential group within a combination of PotDis-BU and PotDis-TB.
- Only SELV/PELV potentials are permitted on PotDis-BUs. Separate different SELV/PELV potential groups using light-colored PotDis-BUs.
- With potential distributor modules you may only connect to the PotDis-TB versions BR-W and n.c.-G potential, which exceed the voltage level of SELV/PELV.
- PotDis terminals are not directly configurable as PotDis via GSD/GSDML. When configuring with GSD, always use an empty module; with GSDML, integrate a free space.

Potential distributor modules are configurable with STEP 7/STEP 7 TIA Portal. Individual versions are listed in the following table:

Engineering with	version/HSP
STEP 7 TIA Portal	
• Configurable as of version • Configurable as of version • Configurable as of version • Configurable as of version	HSP0241 up to V13 SP1 Update 8 HSP0241 up to V14 HSP0241 up to V14 SP1 Update 5 HSP0241 up to V15 Update 1
STEP 7	
• Configurable as of version	HSP0293 up to V5.5 SP4

You can find additional information on the use of the potential distributor modules in the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

9.2 PotDis-BU type P1, light-colored version

9.2.1 Short designation

Short designation

Light-colored version with 16 terminals to P1 + 2 supply terminals P1/P2.

Short designation: PotDis-BU-P1/D-R.

D stands for a new potential group, meaning P1, P2, AUX separated to the left, R stands for a red spring release.

9.2.2 Product overview

Delivery options (packing unit VPE)

6ES7193-6UP00-0DP1 (VPE: 1 unit)

View

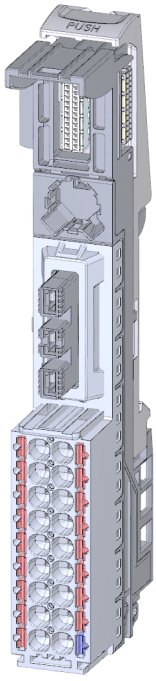

Figure 2-1725 PotDis-BU type P1, light-colored version

Properties

- BaseUnit suitable for all PotDis terminal blocks of the type "P1/P2/N0/P0". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Supply voltage (terminal P1, P2) up to DC 48 V/10 A
  - Current carrying capacity per terminal: Max. 10 A
- BaseUnit opens up a new PotDis potential group. The self-assembling voltage buses P1, P2 and the AUX busbar are disconnected from the adjacent module on the left (BaseUnit, CPU, interface module).

NOTICE
Opening a potential group for I/O modules is not permitted with the BaseUnit PotDis-BU-P1/D-R. The BaseUnit PotDis-BU-P1/D-R opens a new potential group only for the potential distributor modules. Opening a potential group for I/O modules is not permitted with the BaseUnit PotDis-BU-P1/D-R.

- 18 terminals
  - 17 red terminals (P1)
  - 1 blue terminal (P2)
- 36 terminals (with PotDis-TB)
- Connection system in the form of push-in terminals

9.2.3 Connecting

Pin assignment

Pin assignment for BaseUnit PotDis-BU type P1, light-colored version	
Terminal	**Explanations**
P1	Rated supply voltage up to 48 V DC with max. 10 A (17 terminals)
P2	Ground (1 terminal)

Block diagram

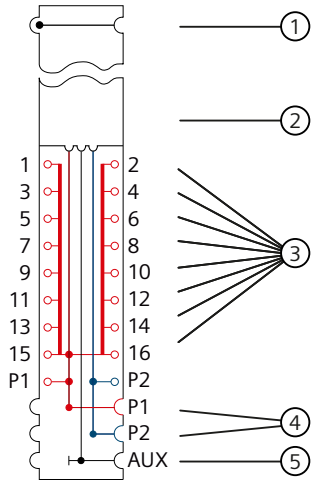

① Backplane bus
② PotDis-TB terminal block
③ Terminals with connection to the supply voltage P1
④ Disconnected voltage buses with connection to the terminals for supply
⑤ Interrupted AUX bus

Figure 2-1726 Block diagram of the PotDis-BU type P1, light-colored version

9.2.4 Technical specifications

Technical specifications of the BaseUnit PotDis-BU type P1, light-colored version

Article number	6ES7193-6UP00-0DP1
General information	
Product type designation	PotDis BU type P1, light version, PU 1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	
• For P1 and P2 bus	48 V; max.
• for process terminals	48 V; max.
external protection for power supply lines	Yes; 10 A miniature circuit breaker with type B or C tripping characteristic for the respective rated supply voltage
Current carrying capacity	
For P1 and P2 bus, max.	10 A
For process terminals, max.	10 A

Article number	6ES7193-6UP00-0DP1
Hardware configuration	
Formation of potential groups	
• New potential group	Yes
• Potential group continued from the left	No
Potential separation	
between backplane bus and supply voltage	Yes
Isolation	
Isolation tested with	3 250 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC62
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²
• Conductor cross-section, max.	2.5 mm²
• Number of terminals with connection to P1 and P2 bus	17 terminals to P1, 1 terminal to P2
Dimensions	
Width	15 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	40 g

9.3 PotDis-BU type P1, dark-colored version

Short designation

Dark-colored version with 16 terminals to P1 + 2 supply terminals P1/P2.

Short designation: PotDis-BU-P1/B-R.

B stands for a jumpered potential group, meaning P1, P2, AUX jumpered to the left, R stands for a red spring release.

9.3.1 Product overview

Delivery options (packing unit VPE)

6ES7193-6UP00-0BP1 (VPE: 1 unit)

View

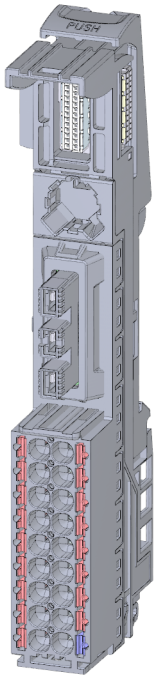

Figure 2-1727 PotDis-BU type P1, dark-colored version

Properties

- BaseUnit suitable for all PotDis terminal blocks of the type "P1/P2/N0/P0". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Current carrying capacity per terminal: Max. 10 A
- BaseUnit further conducts the potential group. The self-assembling voltage buses P1, P2 and the AUX busbar are connected to the adjacent module on the left (BaseUnit).
- 18 terminals
  - 17 red terminals (P1)
  - 1 blue terminal (P2)
- 36 terminals (with PotDis-TB)
- Connection system in the form of push-in terminals

9.3.2 Connecting

Pin assignment

Pin assignment for BaseUnit PotDis-BU type P1, dark-colored version	
Terminal	**Explanations**
P1	Rated supply voltage up to 48 V DC with max. 10 A (17 terminals)
P2	Ground (1 terminal)

Block diagram

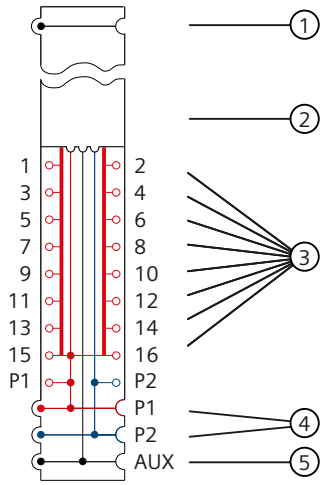

① Backplane bus
② PotDis-TB terminal block
③ Terminals with connection to the supply voltage P1
④ Connected voltage buses with connection to the terminals
⑤ Connected AUX bus

Figure 2-1728 Block diagram of the PotDis-BU type P1, dark-colored version

9.3.3 Technical specifications

Technical specifications of the BaseUnit PotDis-BU type P1, dark-colored version

Article number	6ES7193-6UP00-0BP1
General information	
Product type designation	PotDis BU type P1, dark version, PU 1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	
• For P1 and P2 bus	48 V; max.
• for process terminals	48 V; max.
external protection for power supply lines	Yes; 10 A miniature circuit breaker with type B or C tripping characteristic for the respective rated supply voltage
Current carrying capacity	
For P1 and P2 bus, max.	10 A
For process terminals, max.	10 A

Article number	6ES7193-6UP00-0BP1
Hardware configuration	
Formation of potential groups	
• New potential group	No
• Potential group continued from the left	Yes
Potential separation	
between backplane bus and supply voltage	Yes
Isolation	
Isolation tested with	3 250 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC62
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²
• Conductor cross-section, max.	2.5 mm²
• Number of terminals with connection to P1 and P2 bus	17 terminals to P1, 1 terminal to P2
Dimensions	
Width	15 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	40 g

9.4 PotDis-BU type P2, light-colored version

9.4.1 Short designation

Short designation

Light-colored version with 16 terminals to P2 + 2 supply terminals P1/P2.

Short designation: PotDis-BU-P2/D-B.

D stands for a new potential group, meaning P1, P2, AUX separated to the left, B stands for a blue spring release.

9.4.2 Product overview

Delivery options (packing unit VPE)

6ES7193-6UP00-0DP2 (VPE: 1 unit)

View

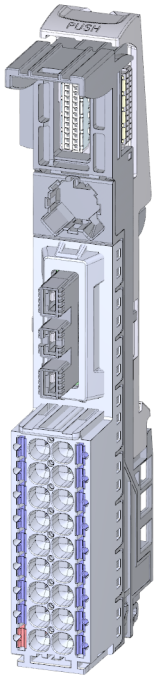

Figure 2-1729 PotDis-BU type P2, light-colored version

Properties

- BaseUnit suitable for all PotDis terminal blocks of the type "P1/P2/N0/P0". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Supply voltage (terminal P1, P2) up to DC 48 V/10 A
  - Current carrying capacity per terminal: Max. 10 A
- BaseUnit opens up a new PotDis potential group. The self-assembling voltage buses P1, P2 and the AUX busbar are disconnected from the adjacent module on the left (BaseUnit, CPU, interface module).

NOTICE
Opening a potential group for I/O modules is not permitted with the BaseUnit PotDis-BU-P2/D-B. The BaseUnit PotDis-BU-P2/D-B opens a new potential group only for the potential distributor modules. Opening a potential group for I/O modules is not permitted with the BaseUnit PotDis-BU-P2/D-B.

- 18 terminals
  - 1 red terminal (P1)
  - 17 blue terminals (P2)
- 36 terminals (with PotDis-TB)
- Connection system in the form of push-in terminals

9.4.3 Connecting

Pin assignment

Pin assignment for PotDis-BU type P2, light-colored version	
Terminal	**Explanations**
P1	Rated supply voltage up to 48 V DC with max. 10 A (1 terminal)
P2	Ground (17 terminals)

Block diagram

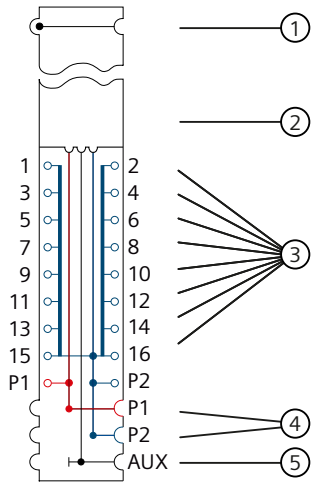

① Backplane bus
② PotDis-TB terminal block
③ Terminals with connection to ground P2
④ Disconnected voltage buses with connection to the terminals for supply
⑤ Interrupted AUX bus

Figure 2-1730 Block diagram of the PotDis-BU type P2, light-colored version

9.4.4 Technical specifications

Technical specifications of the BaseUnit PotDis-BU type P2, light-colored version

Article number	6ES7193-6UP00-0DP2
General information	
Product type designation	PotDis BU type P2, light version, PU 1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	
• For P1 and P2 bus	48 V; max.
• for process terminals	48 V; max.
external protection for power supply lines	Yes; 10 A miniature circuit breaker with type B or C tripping characteristic for the respective rated supply voltage
Current carrying capacity	
For P1 and P2 bus, max.	10 A
For process terminals, max.	10 A

Article number	6ES7193-6UP00-0DP2
Hardware configuration	
Formation of potential groups	
• New potential group	No
• Potential group continued from the left	Yes
Potential separation	
between backplane bus and supply voltage	Yes
Isolation	
Isolation tested with	3 250 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC63
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²
• Conductor cross-section, max.	2.5 mm²
• Number of terminals with connection to P1 and P2 bus	18; 17 terminals to P2, 1 terminal to P1
Dimensions	
Width	15 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	40 g

9.5 PotDis-BU type P2, dark-colored version

9.5.1 Short designation

Short designation

Dark-colored version with 16 terminals to P2 + 2 supply terminals P1/P2.

Short designation: PotDis-BU-P2/B-B.

B stands for a jumpered potential group, this means P1, P2, AUX jumpered to the left, B stands for blue spring release.

9.5.2 Product overview

Delivery options (packing unit VPE)

6ES7193-6UP00-0BP2 (VPE: 1 unit)

View

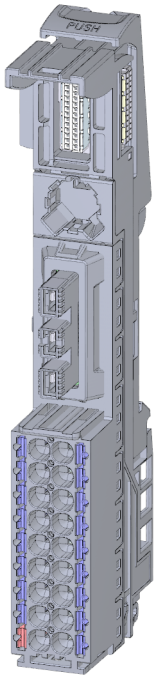

Figure 2-1731 PotDis-BU type P2, dark-colored version

Properties

- BaseUnit suitable for all PotDis terminal blocks of the type "P1/P2/N0/P0". Can be recognized by the laser inscription on the front and/or the last two digits of the article number.
  - Current carrying capacity per terminal: Max. 10 A
- BaseUnit further conducts the potential group. The self-assembling voltage buses P1, P2 and the AUX busbar are connected to the adjacent module on the left (BaseUnit).
- 18 terminals
  - 1 red terminal (P1)
  - 17 blue terminals (P2)
- 36 terminals (with PotDis-TB)
- Connection system in the form of push-in terminals

9.5.3 Connecting

Pin assignment

Pin assignment for PotDis-BU type P2, dark-colored version	
Terminal	**Explanations**
P1	Rated supply voltage up to 48 V DC with max. 10 A (1 terminal)
P2	Ground (17 terminals)

Block diagram

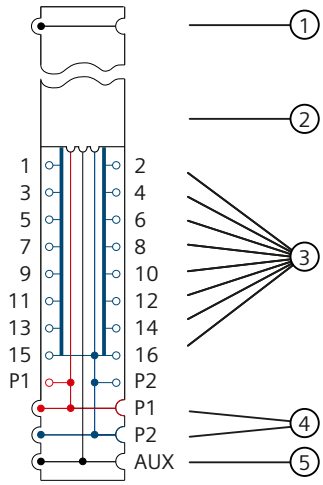

① Backplane bus
② PotDis-TB terminal block
③ Terminals with connection to ground P2
④ Connected voltage buses with connection to the terminals
⑤ Connected AUX bus

Figure 2-1732 Block diagram of the PotDis-BU type P2, dark-colored version

9.5.4 Technical specifications

Technical specifications of the BaseUnit PotDis-BU type P2, dark-colored version

Article number	6ES7193-6UP00-0BP2
General information	
Product type designation	PotDis BU type P2, dark version, PU 1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	
• For P1 and P2 bus	48 V; max.
• for process terminals	48 V; max.
external protection for power supply lines	Yes; 10 A miniature circuit breaker with type B or C tripping characteristic for the respective rated supply voltage
Current carrying capacity	
For P1 and P2 bus, max.	10 A
For process terminals, max.	10 A

Article number	6ES7193-6UP00-0BP2
Hardware configuration	
Formation of potential groups	
• New potential group	No
• Potential group continued from the left	Yes
Potential separation	
between backplane bus and supply voltage	Yes
Isolation	
Isolation tested with	3 250 V DC
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC63
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²
• Conductor cross-section, max.	2.5 mm²
• Number of terminals with connection to P1 and P2 bus	18; 17 terminals to P2, 1 terminal to P1
Dimensions	
Width	15 mm
Height	117 mm
Depth	35 mm
Weights	
Weight, approx.	40 g

9.6 PotDis-TB

9.6.1 Product overview

Article number

- PotDis-TB-P1-R terminal block: 6ES7193-6TP00-0TP1
- PotDis-TB-P2-B terminal block: 6ES7193-6TP00-0TP2
- PotDis-TB-n.c.-G terminal block: 6ES7193-6TP00-0TN0
- PotDis-TB-BR-W terminal block: 6ES7193-6TP00-0TP0

View

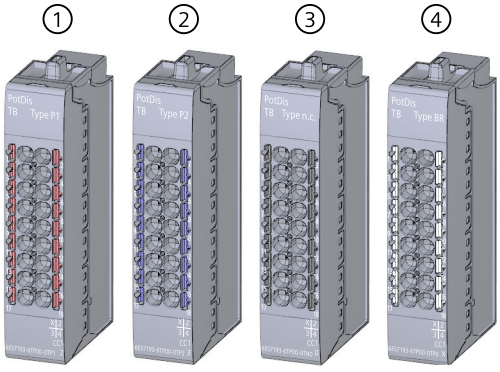

① PotDis-TB-P1-R
② PotDis-TB-P2-B
③ PotDis-TB-n.c.-G
④ PotDis-TB-BR-W

Figure 2-1733 PotDis terminal blocks

Properties

- Terminal blocks matching all BaseUnits PotDis-BU
  - Current carrying capacity per terminal: Max. 10 A
- 18 terminals
  - PotDis-TB-P1-R terminal block: Red terminals with connection to the supply voltage P1 of the BaseUnit PotDis-BU
  - PotDis-TB-P2-B terminal block: Blue terminals with connection to ground P2 of the BaseUnit PotDis-BU

– PotDis-TB-n.c.-G terminal block: Gray (internal not connected) terminals without connection to the BaseUnit PotDis-BU

NOTICE
Mixed connection of direct current or alternating current (DC/AC) is not permitted on the PotDis-TB-n.c-G Connect direct currents up to 48 V or alternating currents up to 230 V to the terminals of the PotDis-TB-n.c.-G. A mixed connection of both types of voltages (DC/AC) is not permitted at the terminals of the PotDis-TB-n.c.-G.

– PotDis-TB-BR-W terminal block: White (internal not connected) terminals without connection to the BaseUnit-BU

NOTICE
Only PotDis-TB-BR may be used for protective conductors. Check all protective conductors. Check the required conductor cross-section for the respective plant unit before commissioning of the plant (especially for motor starters).

- Connection system in the form of push-in terminals
- You can find the assignment of color-coded labels in the ET 200SP System Manual under Accessories.

NOTICE
Use of color-coded labels Before commissioning the system, check that the color-coded labels attached correspond to the wired potential.

NOTICE
Voltages greater than SELV/PELV Voltages greater than SELV/PELV are only permitted for the PO PotDis-TBs BR (bridged) and NC (not connected). This applies equally to protective conductors. No voltages greater than SELV/PELV are present on the terminals of the PotDis module with connection to the P1/P2 rails.

9.6.2 Connecting

Pin assignment

Pin assignment for PotDis-TB terminal block		
Terminal block	**Terminal**	**Explanations**
PotDis-TB-P1-R	P1	Rated supply voltage up to 48 V DC with max. 10 A (18 red terminals)
PotDis-TB-P2-B	P2	Ground (18 blue terminals)
PotDis-TB-n.c.-G	n c. (not connected)	Terminals can be used freely up to 230 V AC with max. 10 A (18 gray terminals). If you connect voltage, it must belong to the same potential group.
PotDis-TB-BR-W	BR (bridged)	Terminals for protective conductor connection or voltage bus freely usable up to 230 V AC with max. 10 A (18 white terminals)

Block diagram

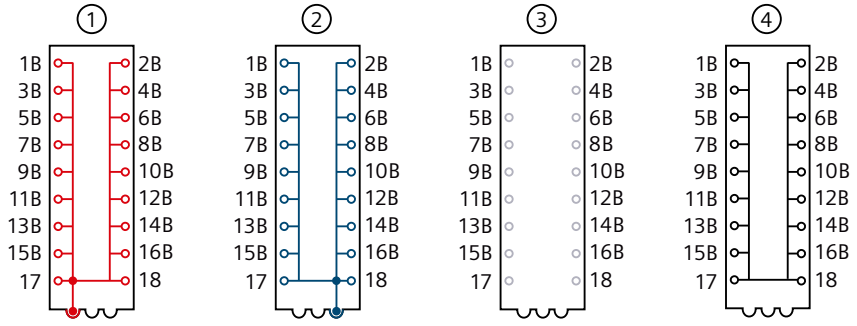

① PotDis-TB-P1-R
② PotDis-TB-P2-B
③ PotDis-TB-n.c.-G
④ PotDis-TB-BR-W

Figure 2-1734 PotDis-TB block diagram

9.6.3 Technical specifications

Technical specifications of the PotDis-TB-P1_R terminal block

Article number	6ES7193-6TP00-0TP1
General information	
Product type designation	PotDis TB P1-R, PU 1
HW functional status	FS10 and higher

Article number	6ES7193-6TP00-0TP1
Supply voltage	
Rated value (DC)	
• For P1 and P2 bus	48 V; max.
• for process terminals	48 V; max.
external protection for power supply lines	Yes; 10 A miniature circuit breaker with type B or C tripping characteristic for the respective rated supply voltage
Current carrying capacity	
up to 60 °C, max.	10 A
For P1 and P2 bus, max.	10 A
For process terminals, max.	10 A
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC10, CC12
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²; 0.2 mm² without wire end ferrule
• Conductor cross-section, max.	2.5 mm²; 1.5 mm² with wire end ferrule
• Number of process terminals to I/O module	16
• Number of terminals to AUX bus	0
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	2
Dimensions	
Width	15 mm
Height	74 mm
Depth	34 mm
Weights	
Weight, approx.	24 g

Technical specifications of the PotDis-TB-P2-B terminal block

Article number	6ES7193-6TP00-0TP2
General information	
Product type designation	PotDis TB P2-B, PU 1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	
• For P1 and P2 bus	48 V; max.
• for process terminals	48 V; max.
external protection for power supply lines	Yes; 10 A miniature circuit breaker with type B or C tripping characteristic for the respective rated supply voltage
Current carrying capacity	
up to 60 °C, max.	10 A
For P1 and P2 bus, max.	10 A
For process terminals, max.	10 A
Potential separation	
between process terminals and supply voltage	No
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC10, CC13
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²; 0.2 mm² without wire end ferrule
• Conductor cross-section, max.	2.5 mm²; 1.5 mm² with wire end ferrule
• Number of process terminals to I/O module	16
• Number of terminals to AUX bus	0
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	2

Article number	6ES7193-6TP00-0TP2
Dimensions	
Width	15 mm
Height	74 mm
Depth	34 mm
Weights	
Weight, approx.	24 g

Technical specifications of the PotDis-TB-n.c.-G

Article number	6ES7193-6TP00-0TN0
General information	
Product type designation	PotDis TB n.c. G, PU 1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	
• for process terminals	48 V; max.
Rated value (AC)	
• for process terminals	240 V; max.
external protection for power supply lines	Yes; 10 A miniature circuit breaker with type B or C tripping characteristic for the respective rated supply voltage
Current carrying capacity	
up to 60 °C, max.	10 A
For P1 and P2 bus, max.	10 A
Potential separation	
between process terminals and supply voltage	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC10
Connection method	
Terminals	
• Terminal type	Push-in terminal

Article number	6ES7193-6TP00-0TN0
• Conductor cross-section, min.	0.14 mm²; 0.2 mm² without wire end ferrule
• Conductor cross-section, max.	2.5 mm²; 1.5 mm² with wire end ferrule
• Number of process terminals to I/O module	16
• Number of terminals to AUX bus	0
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	2
Dimensions	
Width	15 mm
Height	74 mm
Depth	34 mm
Weights	
Weight, approx.	24 g

Technical specifications of the PotDis-TB-BR-W terminal block

Article number	6ES7193-6TP00-0TP0
General information	
Product type designation	PotDis TB BR-W, PU 1
HW functional status	FS10 and higher
Supply voltage	
Rated value (DC)	
• for process terminals	48 V; max.
Rated value (AC)	
• for process terminals	240 V; max.
external protection for power supply lines	Yes; 10 A miniature circuit breaker with type B or C tripping characteristic for the respective rated supply voltage
Current carrying capacity	
up to 60 °C, max.	10 A
For P1 and P2 bus, max.	10 A
For process terminals, max.	10 A
Potential separation	
between process terminals and supply voltage	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C

Article number	6ES7193-6TP00-0TP0
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; Restrictions for installation altitudes > 2 000 m, see manual
Accessories	
Color coding labels	
• for process terminals	CC10, CC11, CC12, CC13
Connection method	
Terminals	
• Terminal type	Push-in terminal
• Conductor cross-section, min.	0.14 mm²; 0.2 mm² without wire end ferrule
• Conductor cross-section, max.	2.5 mm²; 1.5 mm² with wire end ferrule
• Number of process terminals to I/O module	16
• Number of terminals to AUX bus	0
• Number of add-on terminals	0
• Number of terminals with connection to P1 and P2 bus	2
Dimensions	
Width	15 mm
Height	74 mm
Depth	34 mm
Weights	
Weight, approx.	24 g

Dimension drawings of interface modules

A

Dimension drawing of BU type M0

The figure below shows the dimension drawing of the BU type M0 with plugged-in interface module.

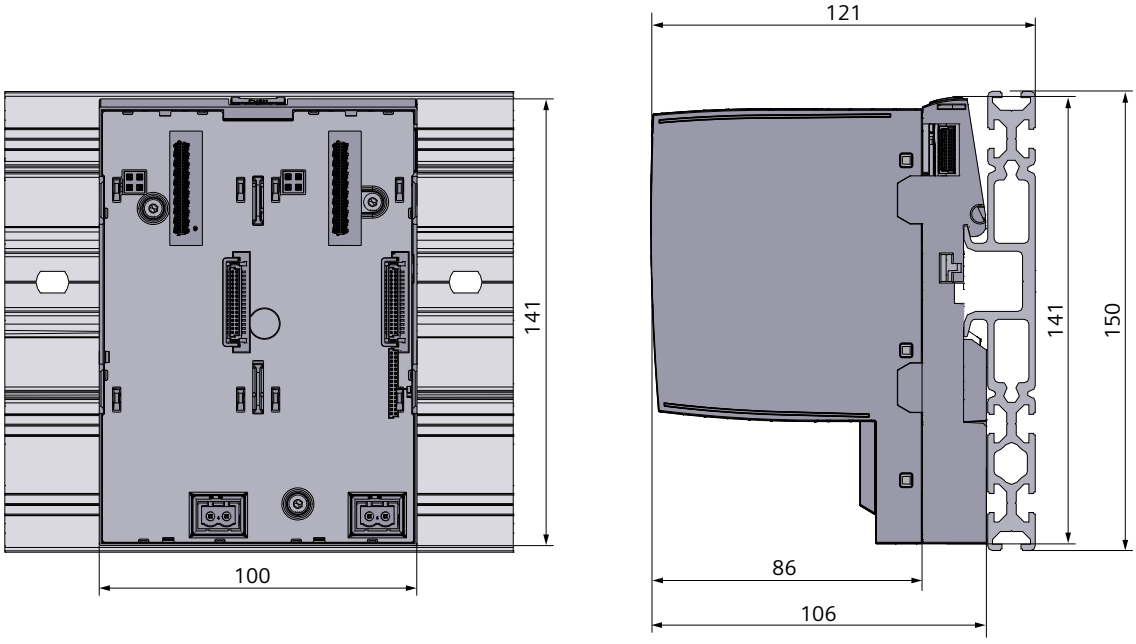

Figure 2-1735 Dimension drawing of BU type M0

BaseCarrier dimension drawings

B

Dimension drawing BC type A0, light-colored version

The figure below shows the dimension drawing of the BC type A0, light-colored version with plugged-in I/O module as an example.

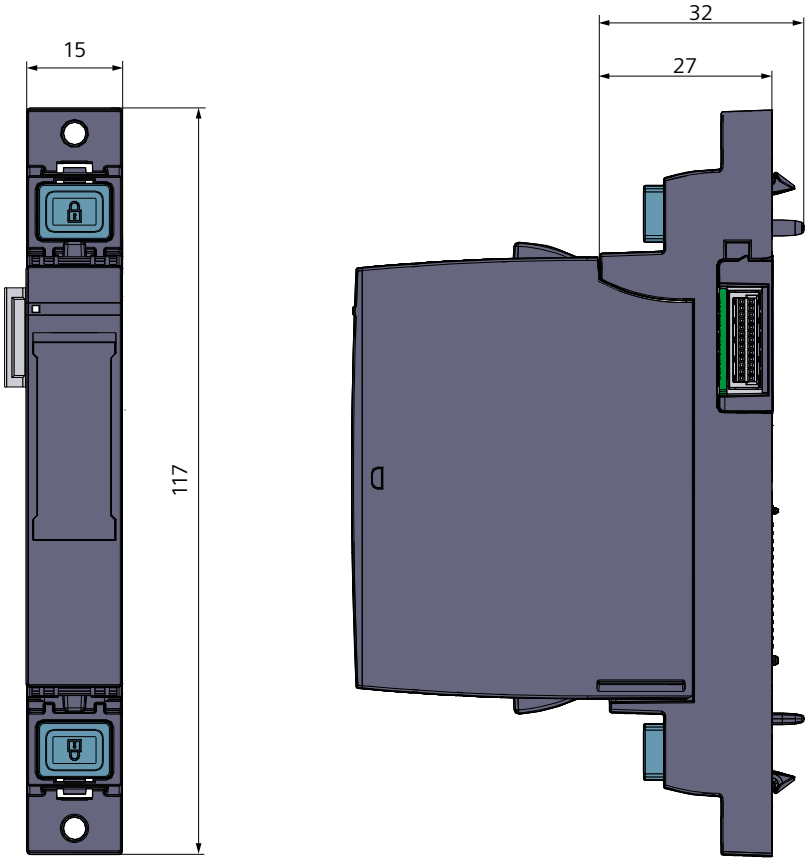

Figure 2-1736 Dimension drawing BC type A0, light-colored version

Dimension drawing BC type A0, dark-colored version

The figure below shows the dimension drawing of the BC type A0, dark-colored version with plugged-in I/O module as an example.

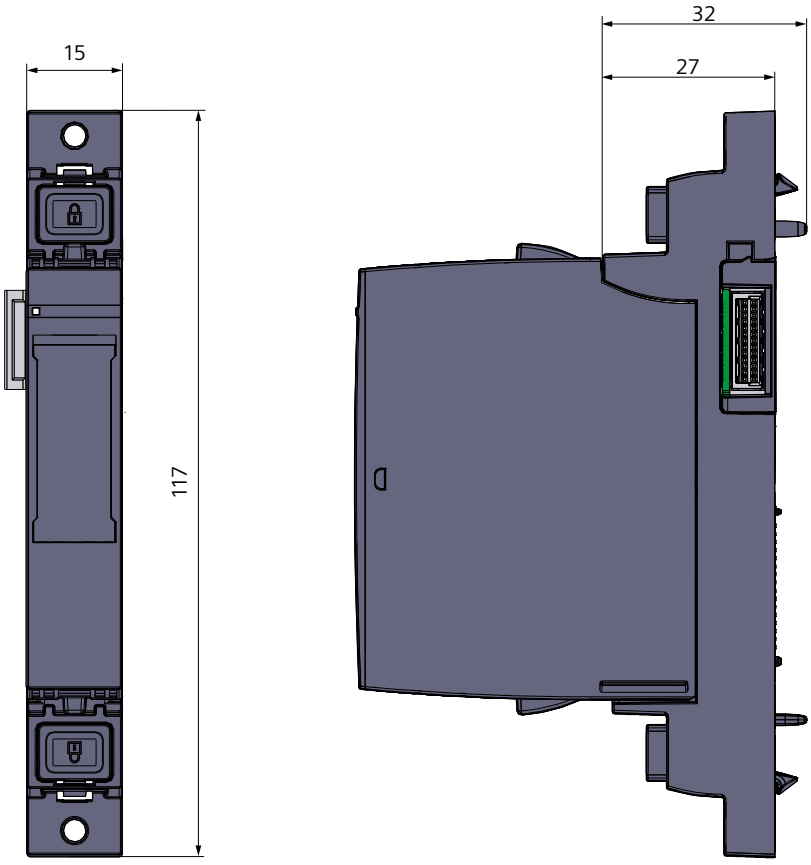

Figure 2-1737 Dimension drawing BC type A0, dark-colored version

Dimension drawing BC type A0, BaseCarrier for server module

The figure below shows the dimension drawing of the BC type A0 with plugged-in server module as an example.

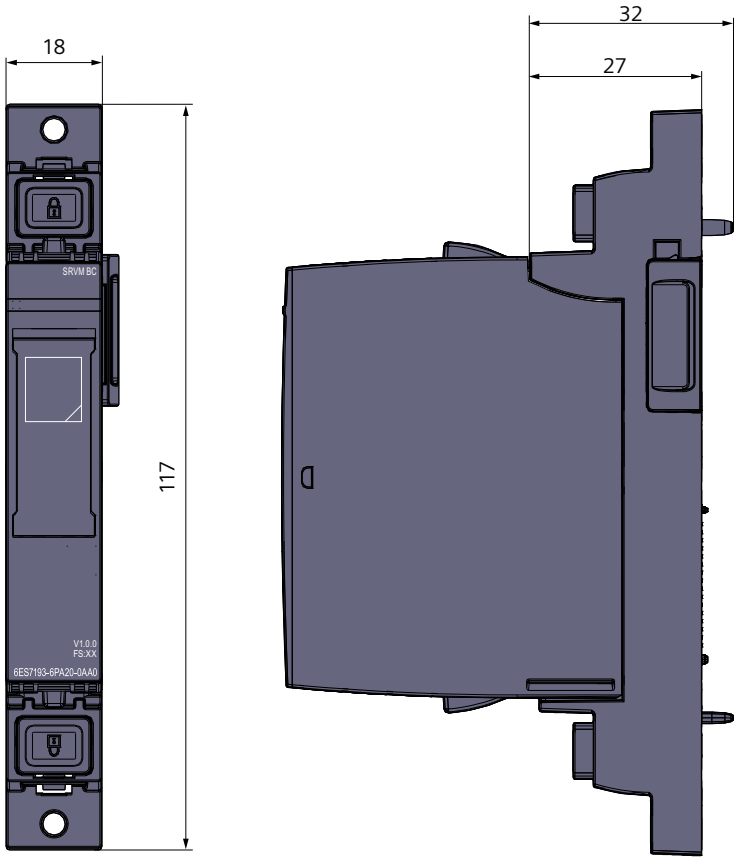

Figure 2-1738 Dimension drawing BC type A0, BaseCarrier for server module

Dimension drawing IO adapter

The figure below shows the dimension drawing of the IO adapter as an example.

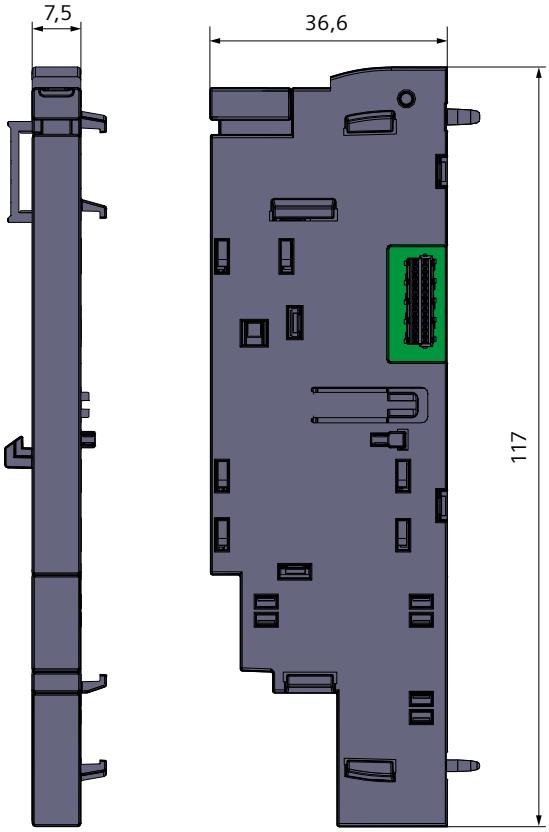

Figure 2-1739 Dimension drawing IO adapter

Dimension drawings of I/O modules

C

Dimension drawing BU15-P16+A10+2D, BU15-P16+A10+2B, BU15-P16+A0+12D/T, BU15-P16+A0+12B/T

The figure below shows the dimension drawing of the BU15-P16+A10+2D with plugged-in I/O module as an example.

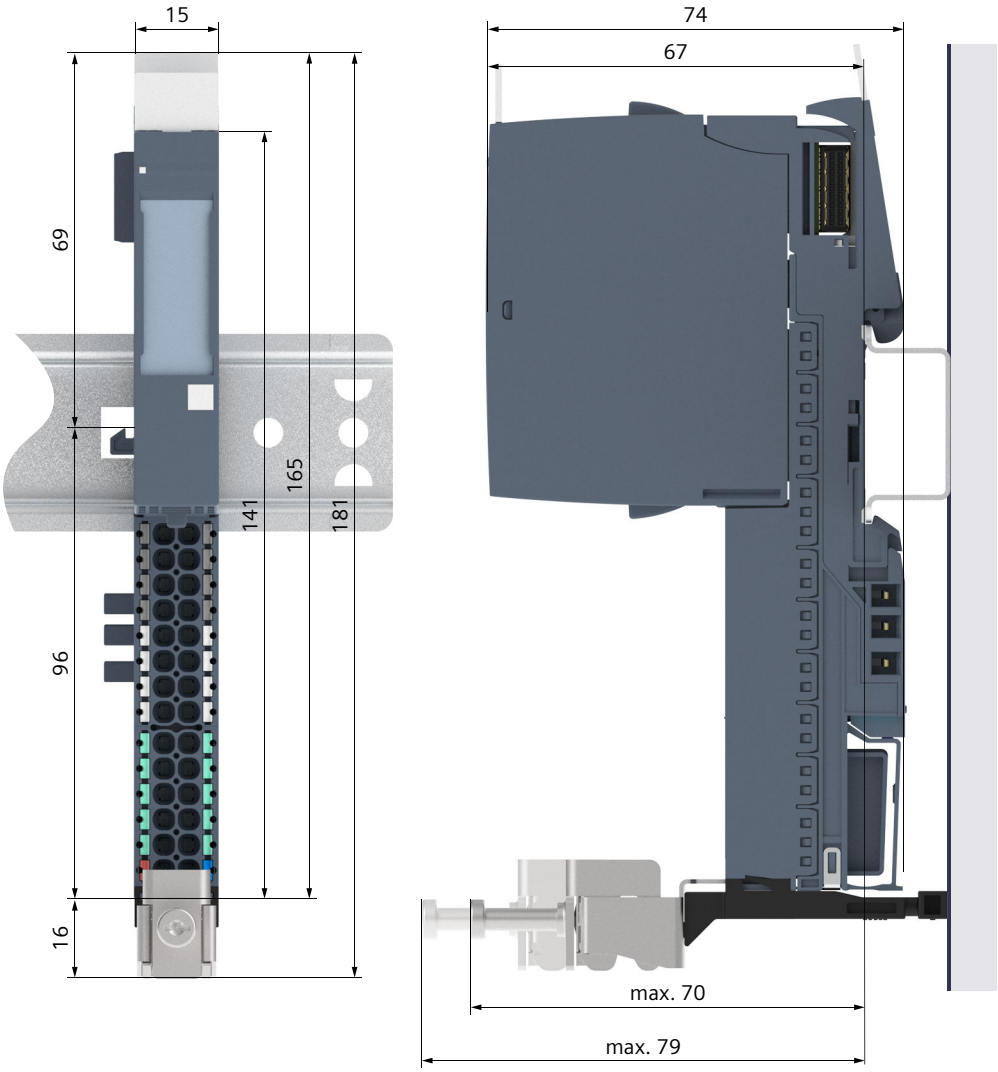

Figure 2-1740 Dimension drawing BU15-P16+A10+2D

Dimension drawing BU15-P16+A0+2D, BU15-P16+A0+2B, BU15-P16+A0+2D/T, BU15-P16+A0+2B/T

The figure below shows the dimension drawing of the BU15-P16+A0+2D with plugged-in I/O module as an example.

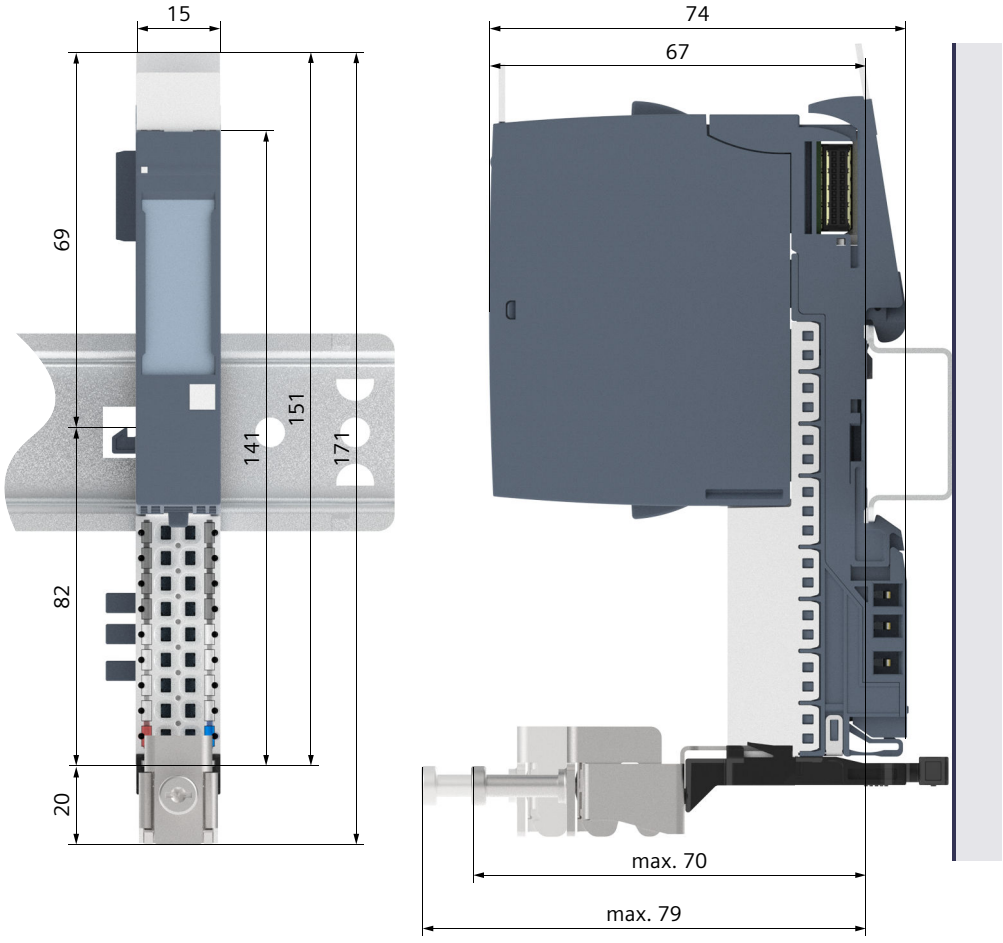

Figure 2-1741 Dimension drawing BU15-P16+A0+2D

Dimension drawing BU20-P6+A2+4D, BU20-P6+A2+4B, BU20-P12+A4+0B, BU20-P12+A0+0B, BU20-P12+A0+4B, BU20-P8+A4+0B

The figure below shows the dimension drawing of the BU20-P12+A4+0B with plugged-in I/O module as an example.

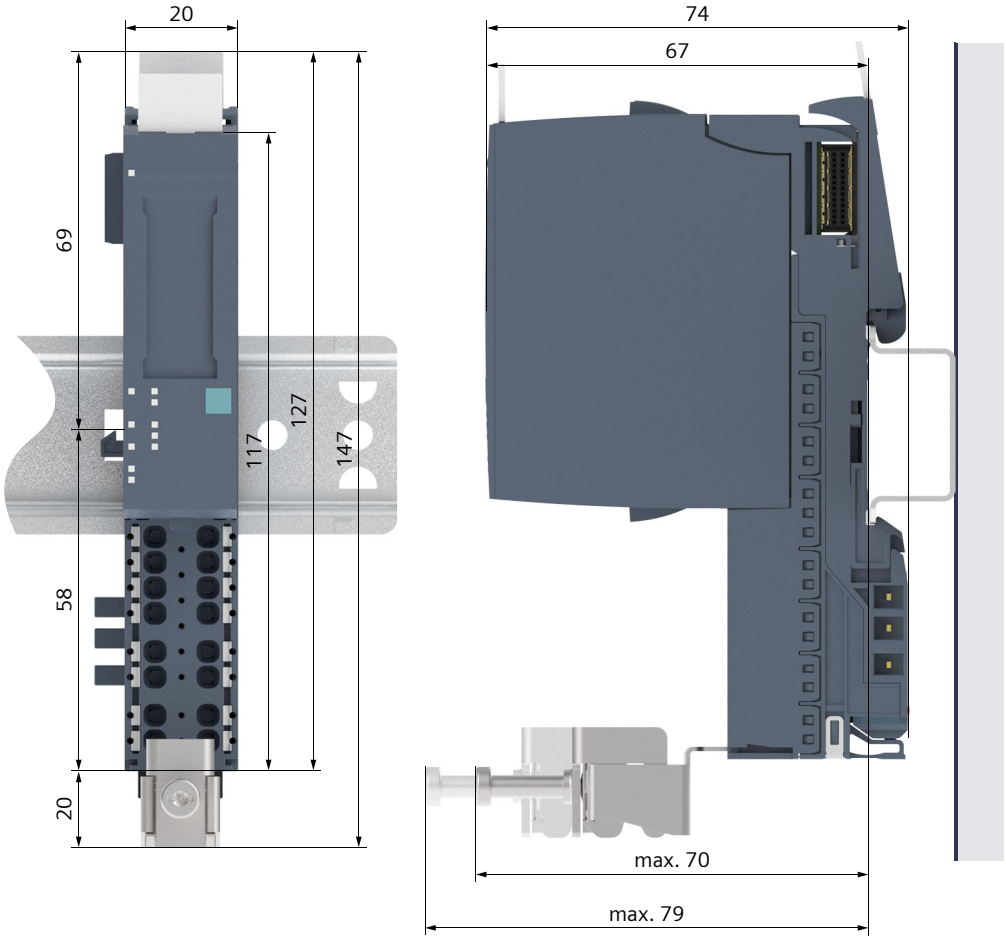

Figure 2-1742 Dimension drawing BU20-P12+A4+0B

Dimension drawing test probe for measurement tap

The figure below shows the dimension drawing of a suitable test probe for measurement tap at the BaseUnit.

Figure 2-1743 Dimension drawing test probe

Dimension drawings of motor starters

D

Dimension drawing BU30-MS1, BU30-MS2, BU30-MS3, BU30-MS4, BU30-MS5, BU30-MS6, BU30-MS7, BU30-MS8, BU30-MS9, BU30-MS10

The figure below shows the dimension drawing of the BU30-MS-1 with plugged-in motor starter module as an example.

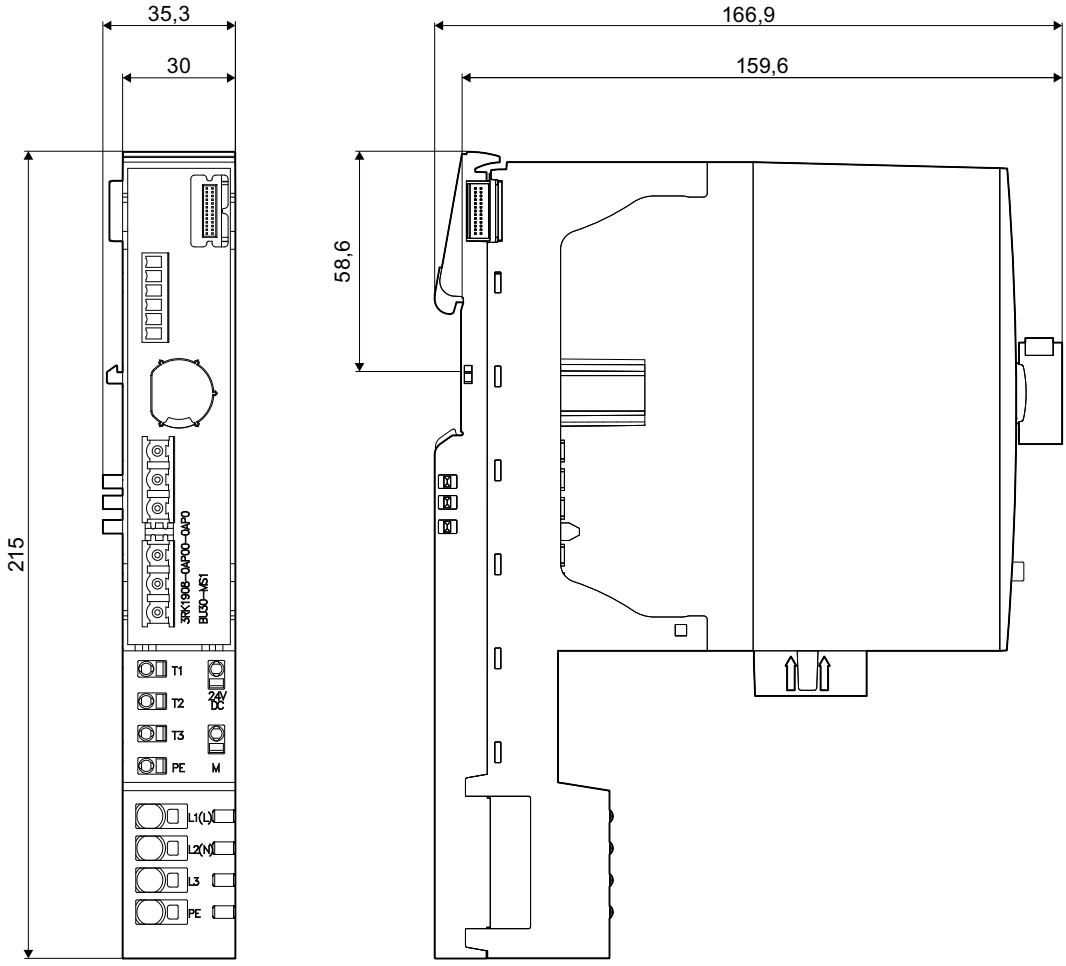

Figure 2-1744 Dimension drawing BU30-MS1

Dimension drawings of the potential distributor modules

E

Dimension drawing

The figure below shows the dimension drawing of the PotDis-BU-P1/B-R with plugged-in PotDis-TB-P1-R terminal block.

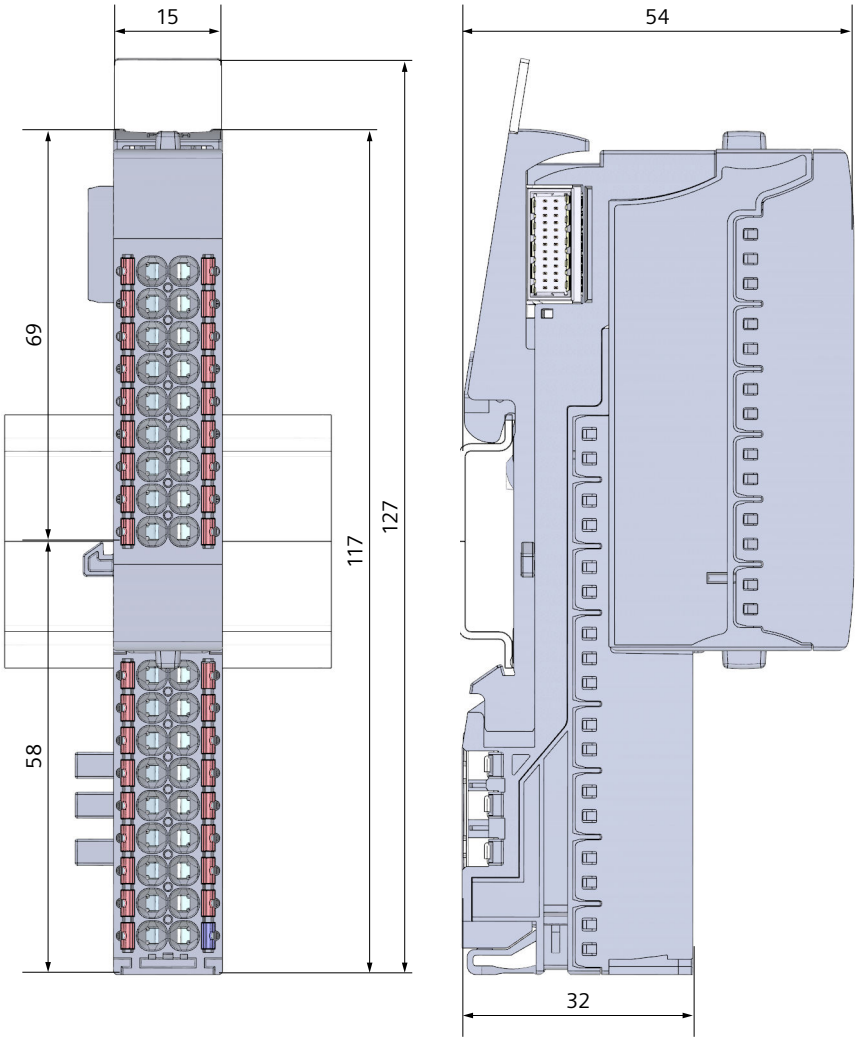

Figure 2-1745 Dimension drawing of PotDis BU-P1/B-R with plugged-in terminal block

SIEMENS

SIMATIC

BusAdapter

Equipment Manual

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Introduction 1

1.1 Introduction

Purpose of the documentation

This equipment manual supplements the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

Functions that generally relate to the system are described in the system manual.

The information provided in this manual and in the system/function manuals supports you in commissioning the system.

Conventions

CPU: When the term "CPU" is used hereinafter, it applies to the CPUs of the S7-1500 automation system as well as to the CPUs/interface modules of the ET 200SP distributed I/O system.

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

1.2 ET 200SP Documentation Guide

The documentation for the SIMATIC ET 200SP distributed I/O system is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742709).

Basic information

The System Manual describes in detail the configuration, installation, wiring and commissioning of the SIMATIC ET 200SP distributed I/O system.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- ET 200SP System Manual
- System Manual ET 200SP HA/ET 200SP modules for devices used in a hazardous area
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment Manuals CPUs
- Equipment Manuals Interface Modules
- Equipment Manuals Digital Modules
- Equipment Manuals Analog Modules
- Equipment Manuals Motor Starter
- BaseUnits Equipment Manuals
- Equipment Manual Server Module
- Equipment Manuals Communications Modules
- Equipment Manuals Technology Modules

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC ET 200SP distributed I/O system.

Examples:

- Function Manual ET 200AL/ET 200SP Mixed Configuration
- Function Manual Diagnostics
- Function Manual Communication
- PROFINET Function Manual
- PROFIBUS Function Manual
- Function Manual Designing Interference-free Controllers
- MultiFieldbus Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You can find the latest Product Information on the ET 200SP distributed I/O system on the Internet. (https://support.industry.siemens.com/cs/de/en/view/73021864)

Manual Collection ET 200SP

The Manual Collection contains the complete documentation on the SIMATIC ET 200SP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/84133942)

Manual Collection fail-safe modules

The Manual Collection contains the complete documentation on the fail-safe SIMATIC modules, gathered together in one file.

You can find the Manual Collection on the Internet.

1.2.1 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

AI-powered online support chat

The "AskSUPport" function is an advanced AI-controlled platform that gives you access to the powerful knowledge base of the Siemens Support Portal (https://sieportal.siemens.com/en-de/support). You do not just receive mechanical answers to your questions, but precise, interactive informational material. This allows you to effectively speed up your research and decision processes.

The following link (https://support.industry.siemens.com/cs/ww/en/view/109974274) provides current information on the availability of AskSUPport:

You can also access the entry by means of the "AI powered Online Support Chat" command in the "Help" menu in TIA Portal.

1.2.2 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.3 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109773881)

Industrial Cybersecurity 2

2.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

You can find more general information and measures on the subject of industrial cybersecurity in the ET 200SP Distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) System Manual.

This section provides an overview of security-related information pertaining to your SIEMENS device.

2.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

2.3 Cybersecurity-relevant information

Observe all cybersecurity-relevant information.

Topics with cybersecurity-relevant information	Reference
Operational application environment and security assumptions	
Requirements for the operational application environment of the system and security assumptions	You can find this section in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Security properties of the product	
Access protection	Note the information on access protection in the Protection chapter of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Data integrity	The topic of data integrity is described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Signed firmware update	The topic of signed firmware updates is described in the "Industrial cybersecurity" section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
PROFINET Security Class 1 • The device supports PROFINET Security Class 1. • With the introduction of PROFINET Security Class 1, additional security settings have been integrated into the PROFINET communication.	Detailed information about PROFINET Security Class 1 and the additional security settings can be found in the PROFINET with STEP 7 Function Manual (https://support.automation.siemens.com/WW/view/en/49948856)
Supported Ethernet services	You can find information on supported services in the Technical specifications section. You can find detailed information about supported Ethernet services in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
Interfaces, ports, protocols and services	
Information on the following is security-relevant: • Communication layer and communication role • Default states • Enabling/disabling of ports and services	You can find detailed information on these topics in the Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).
Secure operation	
Recommendations for safe operation	You can find cross-system information on the safe operation of interface modules in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Corrective measures for known risks	Corrective measures for known risks are announced on the Siemens ProductCERT and Siemens CERT (https://siemens.com/productcert) web page. You can find more information on SIEMENS ProductCERT in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).

Topics with cybersecurity-relevant information	Reference
Security checks	You can find descriptions of specific security measures, such as cyclic checks of the configuration via checksums, in the Industrial cybersecurity section of the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293).
Secure decommissioning Products that contain security-relevant data must be securely decommissioned before disposal or resale.	You can find information on secure decommissioning in the System Manual (https://support.industry.siemens.com/cs/ww/en/view/58649293), Secure operation of the system section

Product overview

3

Introduction

The SIMATIC BusAdapters connect Industrial Ethernet to your ET 200SP system. Select the necessary connection technology and connection method for your process from the different versions of the SIMATIC BusAdapter.

Supported PROFINET devices

The SIMATIC BusAdapter can be used, for example, for:

- ET 200SP interface module and central processing unit (CPU and Open Controller)
- PN/PN Couplers
- PN/MF Coupler
- Switches
- Network transitions (IE/PB Link)
- Communication for SIMATIC ET 200SP (CP1542, CP1543)

NOTE

Compatibility

You can find the compatibility to SIMATIC BusAdapters in the technical specifications of the respective PROFINET device.

Overview

The SIMATIC BusAdapters can be ordered in the following versions:

Interface	Variant	Article number	Properties of the BusAdapter
RJ45	BA 2xRJ45	6ES7193-6AR00-0AA0	PROFINET BusAdapter with standard Ethernet socket for standard RJ45 connector
	BA LC/RJ45	6ES7193-6AG20-0AA0	
	BA SCRJ/RJ45	6ES7193-6AP20-0AA0	
	BA LC-LD/RJ45	6ES7193-6AG60-0AA0	
FC	BA 2xFC	6ES7193-6AF00-0AA0	PROFINET BusAdapter with FastConnect Ethernet connection for direct connection of the bus cable for applications with increased EMC and vibration/shock load
	BA SCRJ/FC	6ES7193-6AP40-0AA0	
	BA LC/FC	6ES7193-6AG40-0AA0	
	BA-Send 1xFC	6ES7193-6AS00-0AA0	
M12	BA 2xM12	6ES7193-6AM00-0AA0	PROFINET BusAdapter with standard M12 plug (D-coded) or as a pluggable push-pull version with increased mechanical load rating
	BA LC-LD/M12	6ES7193-6AG70-0AA0	

Interface	Variant	Article number	Properties of the BusAdapter
SCRJ	BA 2xSCRJ	6ES7193-6AP00-0AA0	PROFINET BusAdapter with fiber-optic cable connection POF/PCF for SCRJ connector for applications with increased EMC and vibration/shock load as well as electrical potential differences between two stations
	BA SCRJ/RJ45	6ES7193-6AP20-0AA0	
	BA SCRJ/FC	6ES7193-6AP40-0AA0	
LC	BA 2xLC	6ES7193-6AG00-0AA0	PROFINET BusAdapter with glass fiber-optic cable connection for LC connector for applications with increased EMC and vibration/shock load as well as electric potential differences between two stations. Media type multimode. Multimode phaser only
	BA LC/RJ45	6ES7193-6AG20-0AA0	
	BA LC/FC	6ES7193-6AG40-0AA0	
LC-LD	BA 2xLC-LD	6ES7193-6AG50-0AA0	PROFINET BusAdapter with glass fiber-optic cable connection for LC connector for applications with increased EMC and vibration/shock load as well as electric potential differences between two stations. Media type single mode
	BA LC-LD/RJ45	6ES7193-6AG60-0AA0	
	BA LC-LD/M12	6ES7193-6AG70-0AA0	

See also

Strain relief (Page 99)

BusAdapter BA 2xRJ45

4

4.1 Product overview

Article number

6ES7193-6AR00-0AA0

View

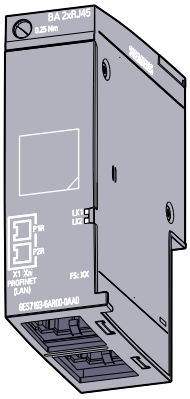

Figure 2-1746 BusAdapter BA 2×RJ45

Properties

- Direct connection of the Industrial Ethernet/ PROFINET cable
- Two standard Ethernet sockets for standard RJ45 connector

4.2 Connecting

Tools required

3 to 3.5 mm screwdriver, alternatively TX10 (torx).

Accessories required

- Connector:
  - IE FC RJ45 plug 180 2X2 (6GK1901-1BB10-2A)
  - IE FC RJ45 plug 180 4X2 (6GK1901-1BB12-2A)
- Cables:
  - IE FC TP standard cable (6XV1840-2A)
  - IE FC TP trailing cable (6XV1840-3AH10)
  - IE FC TP Marine Cable (6XV1840-4AH10)
  - IE FC TP robust cable (6XV1841-2)
  - IE TP torsion cable (6XV1870-2F)
- Read the information in the system manual Industrial Ethernet/PROFINET (https://support.industry.siemens.com/cs/ww/en/view/84922825), section "Installing network components in cabinets".

Pin assignment

The following table shows the signal name and description of the pin assignment of the BusAdapter BA 2×RJ45.

Table 2-2174 Industrial Ethernet/PROFINET pin assignment with BusAdapter BA 2×RJ45

View	Signal name		Description
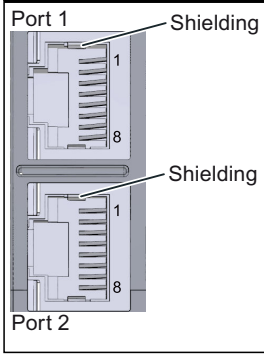	1	TD	Transmit Data +
	2	TD_N	Transmit Data –
	3	RD	Receive Data +
	4	TERM1	Termination Network 1
	5	TERM1	Termination Network 1
	6	RD_N	Receive Data –
	7	TERM2	Termination Network 2
	8	TERM2	Termination Network 1

Procedure

Watch video sequence of "Connecting BusAdapter BA 2xRJ45 to the ET 200SP interface module" (https://support.industry.siemens.com/cs/ww/de/view/95886218)

To connect Industrial Ethernet/PROFINET to the PROFINET device via the BusAdapter BA 2xRJ45, follow these steps:

1. Plug the BusAdapter BA 2×RJ45 into the PROFINET device.
2. Screw the BusAdapter BA 2×RJ45 to the PROFINET device (1 screw with 0.25 Nm tightening torque).
3. Insert the RJ45 bus connector into the Industrial Ethernet/PROFINET port on the BusAdapter BA 2×RJ45.

You can also swap steps 2 and 3.

BusAdapter BA 2×RJ45 installed

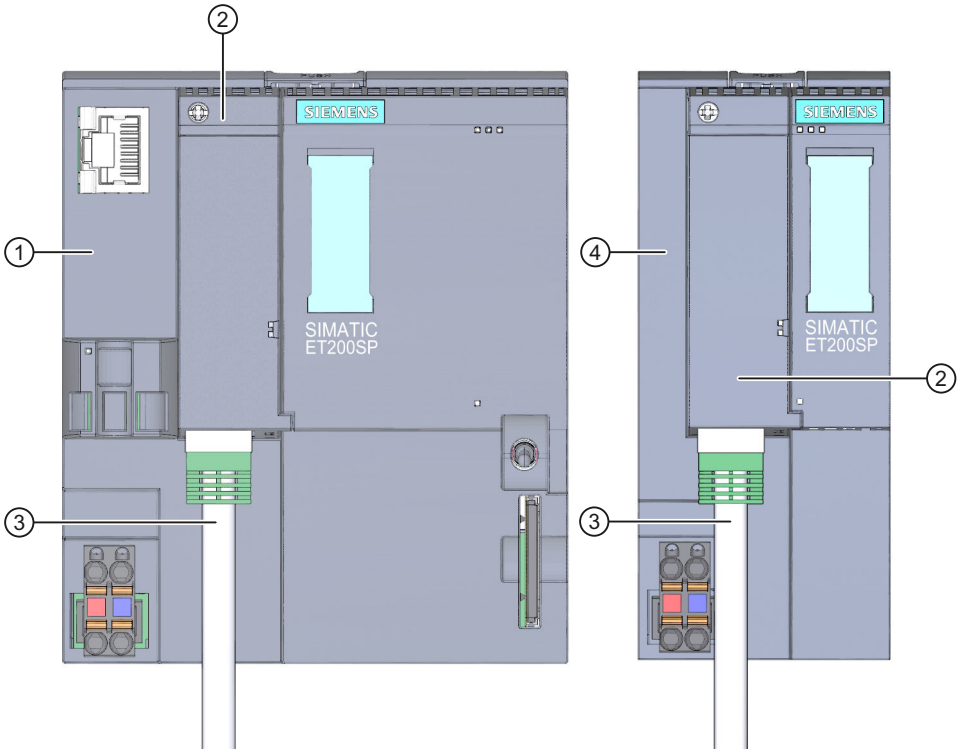

① CPU

② BusAdapter BA 2×RJ45

③ Industrial Ethernet/PROFINET connecting cable

④ Interface module

Figure 2-1747 BusAdapter BA 2×RJ45 installed (using an ET 200SP CPU/interface module as an example)

NOTE

Installation guidelines for modules with Industrial Ethernet/ PROFINET interfaces

Ensure that all devices are connected to the SELV/PELV power supply (or equivalent). Only then are you permitted to operate the modules with Industrial Ethernet/ PROFINET interfaces in LAN networks (Local Area Networks).

A data transfer point that guarantees this degree of safety is prescribed for connection to the WAN (Wide Area Network).

4.3 Diagnostics

LEDs

The figure below shows the LEDs on the BusAdapter BA 2xRJ45:

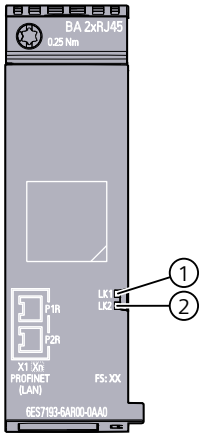

① LK1 (green)

② LK2 (green)

Figure 2-1748 LEDs on the BusAdapter BA 2xRJ45

LK1/LK2 LEDs on the BusAdapter

Table 2-2175 Status and error displays

LED LK1/LK2	Meaning	Remedy
□ off	There is no Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	Check whether the bus cable to the switch or IO controller is disconnected.
■ on	There is an Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	-
☼ flashes	The "Node flash test" is running. The RN/ER/MT LEDs are also flashing.	-

4.4 Technical specifications

Technical specifications of BusAdapter BA 2×RJ45

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6AR00-0AA0/td?dl=de).

Article number	6ES7193-6AR00-0AA0
General information	
Product type designation	BA 2x RJ45
Interfaces	
Number of PROFINET interfaces	1
Supports protocol for PROFINET IO	
• Number of RJ45 ports	2
• Number of SCRJ ports	0
• Number of LC ports	0
Cable length	
– Cu conductors	100 m
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	46 g

BusAdapter BA 2xFC

5

5.1 Product overview

Article number

6ES7193-6AF00-0AA0

View

Figure 2-1749 BusAdapter BA 2xFC

Properties

- Direct connection of the Industrial Ethernet/ PROFINET cable
- High mechanical load capacity
- High immunity against electromagnetic interference
- Two PROFINET IO ports

5.2 Connecting

Tools required

3 to 3.5 mm screwdriver, alternatively TX10 (torx).

Accessories required

- If you use Fast Connect Cable, we recommend the Industrial Ethernet Fast Connect Stripping Tool (6GK1901-1GA00) with green knife cassette (6GK1901-1B). This guarantees fast and safe stripping.
- Fast Connect Cable (recommended types):
- Fast Connect Cable (recommended types):
  - IE FC TP Standard Cable GP 2x2 (6XV1840-2AH10)
  - IE FC TP Trailing Cable 2x2 (6XV1840-3AH10)
  - IE FC TP Marine Cable (6XV1840-4AH10)
  - IE FC TP Flexible Cable GP 2x2 (6XV1870-2B)
  - IE FC TP Trailing Cable 2x2 (6XV1870-2D)
  - IE TP Torsion Cable 2x2 (6XV1870-2F)
  - IE FC TP Food Cable GP 2x2 (6XV1871-2L)
  - IE FC TP Festoon Cable 2x2 (6XV1871-2S)
- Read the information in the system manual Industrial Ethernet/PROFINET (https://support.industry.siemens.com/cs/ww/en/view/84922825), section "Installing network components in cabinets".

Pin assignment

The following table shows the signal name and description of the pin assignment of the BusAdapter BA 2×FC:

Table 2-2176 Industrial Ethernet/PROFINET pin assignment with BusAdapter BA 2×FC

View	Signal name		Description
	4	RD_N	Receive Data -
	3	TD_N	Transmit Data -

View	Signal name		Description
Port 1 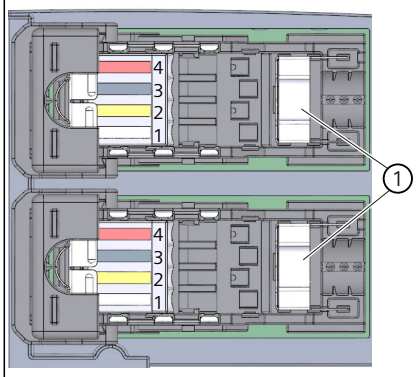 Port 2 BusAdapter BA 2xFC	2	RD	Receive Data +
	1	TD	Transmit Data +
	①		Shielding

Procedure

Watch video sequence of "Connecting the BusAdapter BA 2xFC to the interface module" (https://support.industry.siemens.com/cs/ww/de/view/95886218)

To connect PROFINET IO to the PROFINET device via the BusAdapter BA 2xFC, follow these steps:

1. Strip insulation from the sheath of the PROFINET connecting cable as follows:

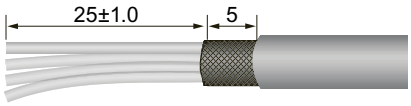

Figure 2-1750 PROFINET connecting cable

2. Pull back the locking slide and fold up the cover of the connection element.

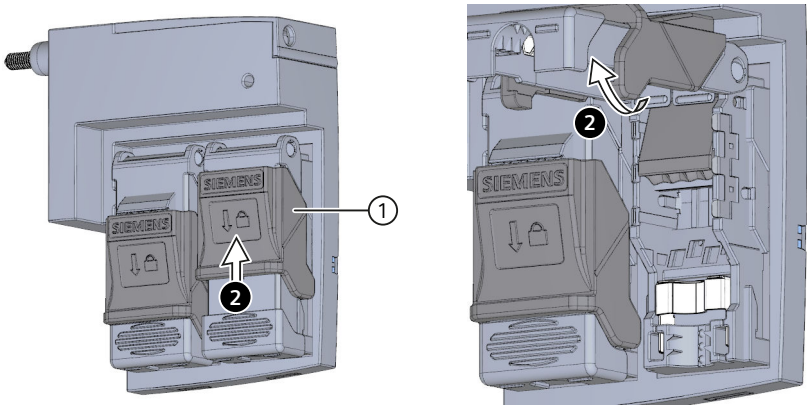

① Locking slide

3. Pull up the wire guide as far as it will go.

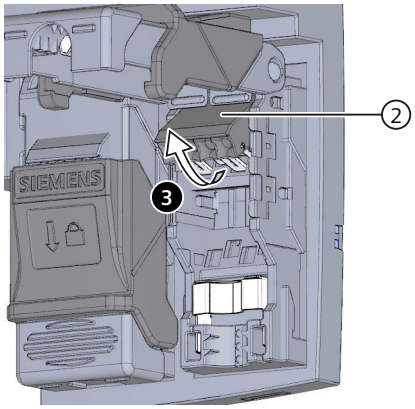

② Wire guide

4. Insert the unstripped single cores of the PROFINET connecting cable (4b) into the cable routing as far as it will go (4a). **Firmly** press down the wire guide as far as it will go (4c). Please refer to the color coding.

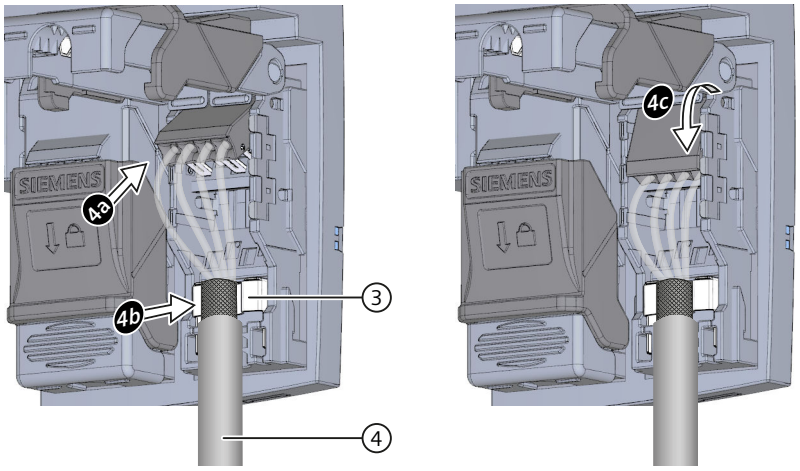

③ Shield contact

④ Connecting cable

5. Close the cover of the connection element (5a). Then push the locking slide forwards as far as it will go (5b).

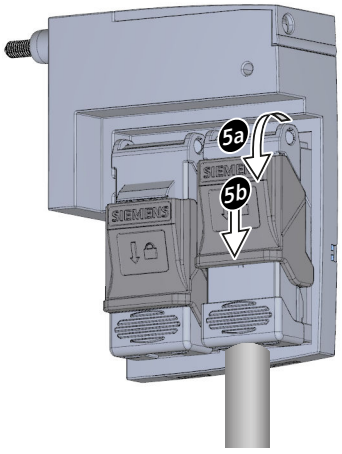

6. Screw the BusAdapter BA 2×FC to the PROFINET device (1 screw with 0.25 Nm tightening torque). To do this, use a screwdriver with a 3 to 3.5 mm blade, alternatively TX10.

BusAdapter BA 2xFC installed

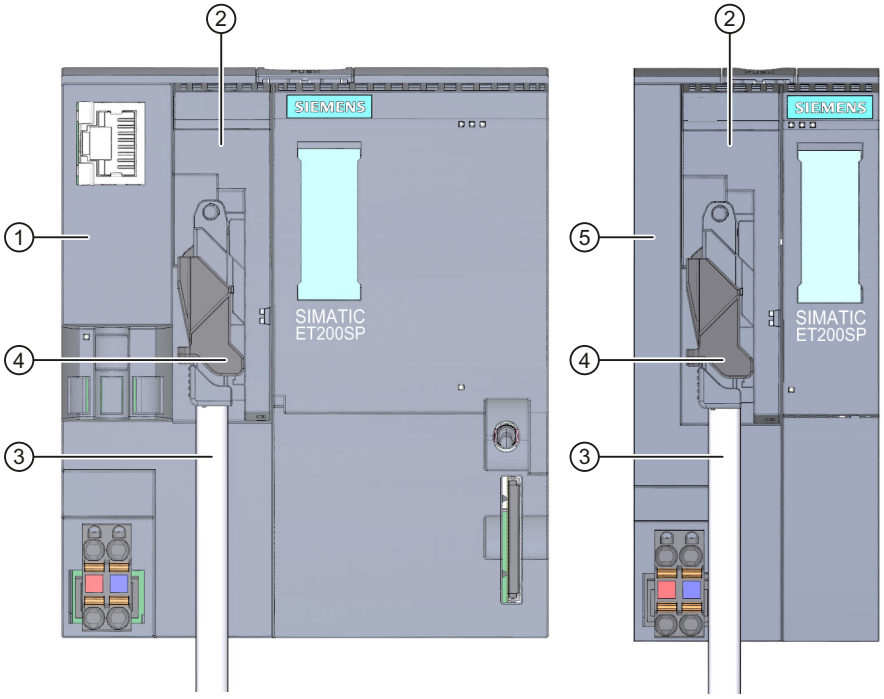

① CPU

② BusAdapter BA 2xFC

③ Industrial Ethernet/PROFINET connecting cable

④ Connection element

Figure 2-1751 BusAdapter BA 2xFC installed (using an ET 200SP CPU/interface module as an example)

NOTE

Installation guidelines for modules with Industrial Ethernet/ PROFINET interfaces

Ensure that all devices are connected to the SELV/PELV power supply (or equivalent). Only then are you permitted to operate the modules with Industrial Ethernet/ PROFINET interfaces in LAN networks (Local Area Networks).

A data transfer point that guarantees this degree of safety (SELV/PELV) is prescribed for connection to the WAN (Wide Area Network).

5.3 Diagnostics

LEDs

The figure below shows the LEDs on the BusAdapter BA 2xFC:

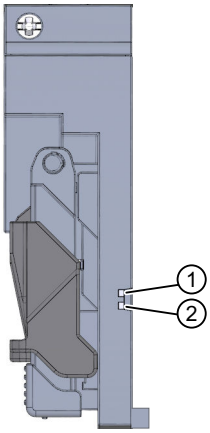

① LK1 (green)

② LK2 (green)

Figure 2-1752 LEDs on the BusAdapter BA 2xFC

LK1/LK2 LEDs on the BusAdapter

Table 2-2177 Status and error displays

LED LK1/LK2	Meaning	Remedy
□ off	There is no Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	Check whether the bus cable to the switch or IO controller is disconnected.
■ on	There is an Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	-
☼ flashes	The "Node flash test" is running. The RN/ER/MT LEDs are also flashing.	-

5.4 Technical specifications

Technical specifications of the BusAdapters BA 2×FC

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6AF00-0AA0/td?dl=de).

Article number	6ES7193-6AF00-0AA0
General information	
Product type designation	BA 2xFC
Interfaces	
Number of PROFINET interfaces	1
Supports protocol for PROFINET IO	
• Number of FC (FastConnect) connections	2
Cable length	
– Cu conductors	100 m
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	53 g

BusAdapter BA 2xM12

6

6.1 Product overview

Article number

6ES7193-6AM00-0AA0

View

Figure 2-1753 View BA 2xM12

Properties

- Two M12 push-pull sockets according to IEC 61076-2-012
- Connection option of the Industrial Ethernet/PROFINET cable using two connector versions:
  - Pluggable push-pull version (see the section "Accessories required")
  - Standard M12 connector (D-coded) with screw-type terminal
- Increased mechanical load capacity
- High immunity against electromagnetic interference

6.2 Connecting

Installing the bus connector

NOTE
Push-pull connector
For simplifying installation (only plugging in instead of screwing with a defined torque), we recommend using the push-pull plug for the PROFINET connection.

Tools required

3 to 3.5 mm screwdriver, alternatively TX10 (torx).

Accessories required

- Push-pull version:
  - Unlatching straps (6ES7193-6DL00-2AA0)
- M12 connecting cables with push-pull connection system:
  - M12 connecting cable 0.5 m (6XV1 871-8AE50)
  - M12 connecting cable 1.0 m (6XV1 871-8AH10)
  - M12 connecting cable 1.5 m (6XV1 871-8AH15)
  - M12 connecting cable 2.0 m (6XV1 871-8AH20)
  - M12 connecting cable 3.0 m (6XV1 871-8AH30)
  - M12 connecting cable 5.0 m (6XV1 871-8AH50)
  - M12 connecting cable 10.0 m (6XV1 871-8AN10)
  - M12 connecting cable 15.0 m (6XV1 871-8AN15)
- Siemens pre-assembled connector/cable M12 D-coded without push/pull up to a maximum length of **15 m**:
  - IE Connecting Cable M12-180/M12-180 0.3M (6XV1870-8A E30)
  - IE Connecting Cable M12-180/M12-180 0.5M (6XV1870-8A E50)
  - IE Connecting Cable M12-180/M12-180 1M (6XV1870-8A H10)
  - IE Connecting Cable M12-180/M12-180 1.5M (6XV1870-8A H20)
  - IE Connecting Cable M12-180/M12-180 2M (6XV1870-8A H30)
  - IE Connecting Cable M12-180/M12-180 3M (6XV1870-8A H30)
  - IE Connecting Cable M12-180/M12-180 5M (6XV1870-8A H50)
  - IE Connecting Cable M12-180/M12-180 10M (6XV1870-8A N10)
  - IE Connecting Cable M12-180/M12-180 15M (6XV1870-8A N15)

- Siemens pre-assembled connector/cable M12 D-coded without push/pull up to a maximum length of **100 m**:
  - Currently only available as a custom made solution. Mr. Hertlein (Tel.: +49 (172) 3172810, juergen.hertlein@siemens.com) is the main contact person for passive components that are not available as standard equipment in the catalog. He implements all custom-made solutions.

Read the information in the system manual Industrial Ethernet/PROFINET (https://support.industry.siemens.com/cs/ww/en/view/84922825), section "Installing network components in cabinets".

Pin assignment

The following table shows the signal name and description of the pin assignment of the BusAdapter BA 2×M12.

Table 2-2178 Industrial Ethernet/PROFINET pin assignment with BusAdapter BA 2×M12

View	Signal name		Description
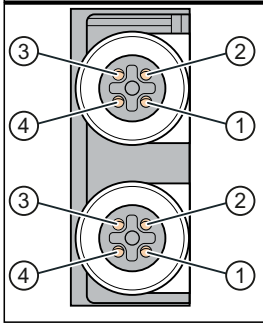	1	TD+	Transmit Data +
	2	RD+	Receive Data +
	3	TD-	Transmit Data -
	4	RD-	Receive Data –

Procedure for standard M12 connector

To connect PROFINET IO to the PROFINET device via the BusAdapter BA 2xM12, follow these steps:

1. Plug the BusAdapter BA 2×M12 into the PROFINET device.
2. Screw the BusAdapter BA 2×M12 to the PROFINET device (1 screw with 0.25 Nm tightening torque).
3. Plug the M12 bus connector into the PROFINET port on the BusAdapter BA 2×M12.

Tightening torque for the M12 screw connector is 0.4 - 0.5 Nm.

Procedure for push-pull connectors

Insert the connector axially into the socket till the connection clicks into place.

You can detach the connector with an axial pull on the outer unlocking sleeve. To do so, you need to first disassemble the BusAdapter.

NOTE

Simple unlocking of the push-pull connector without previous disassembly of the BusAdapter

With push-pull connectors, if necessary, pull the unlatching strap over the connector.

The unlatching strap allows detaching of the connector without previous disassembly of the BusAdapter

---

BusAdapter BA 2xM12 installed

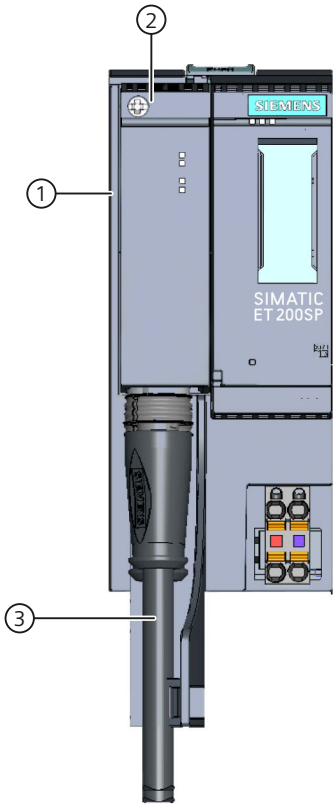

① Interface module

② BusAdapter BA 2xM12

③ Industrial Ethernet/PROFINET connecting cable with M12 plug

Figure 2-1754 Connecting the BusAdapter BA 2xM12 to the interface module

NOTE

Installation guidelines for modules with Industrial Ethernet/ PROFINET interfaces

Ensure that all devices are connected to the SELV/PELV power supply (or equivalent). Only then are you permitted to operate the modules with Industrial Ethernet/ PROFINET interfaces in LAN networks (Local Area Networks).

A data transfer point that guarantees this degree of safety is prescribed for connection to the WAN (Wide Area Network).

Using accessories

- Use the strain relief (Page 99) for vibration and shock loads exceeding 1g.
- For easier removal of push-pull connectors, fit the unlatching straps, 6ES7193-6DL00-2AA0 (under development).

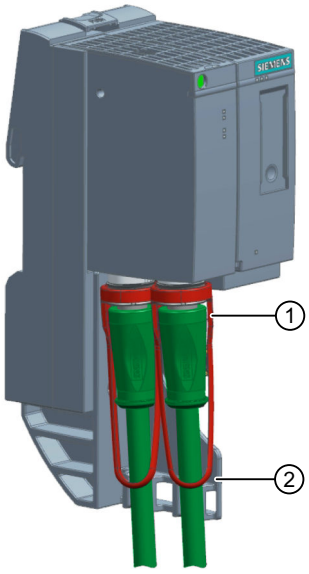

① Unlatching straps

② Strain relief

Figure 2-1755 Using accessories

Compatibility of the M12 sockets used

The M12 sockets used conform to IEC 61076-2-012 and can thus be used with the M12 push-pull connectors as well as with conventional D-coded M12 connectors with screwed connections.

6.3 Diagnostics

LEDs

The figure below shows the LEDs on the BusAdapter BA 2xM12:

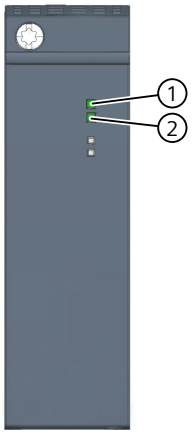

① LK1 (green)

② LK2 (green)

Figure 2-1756 LEDs on the BusAdapter BA 2xM12

LK1/LK2 LEDs on the BusAdapter

Table 2-2179 Status and error displays

LED LK1/LK2	Meaning	Remedy
☐ off	There is no Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	Check whether the bus cable to the switch or IO controller is disconnected.
■ on	There is an Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	-
☼ flashes	The "Node flash test" is running. The RN/ER/MT LEDs are also flashing.	-

6.4 Technical specifications

Technical specifications of BusAdapter BA 2xM12

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6AM00-0AA0/td?dl=de).

Article number	6ES7193-6AM00-0AA0
General information	
Product type designation	BA 2x M12 BusAdapter
Interfaces	
Number of PROFINET interfaces	1
Supports protocol for PROFINET IO	
• Number of M12 ports	2
Cable length	
– Cu conductors	100 m
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C; No condensation
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C; No condensation
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	20 mm
Height	73.5 mm
Depth	59 mm
Weights	
Weight, approx.	59 g

BusAdapter BA 2xSCRJ

7

7.1 Product overview

Article number

6ES7193-6AP00-0AA0

View

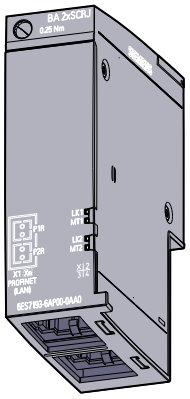

Figure 2-1757 BusAdapter BA 2xSCRJ

Properties

- Two FOC connections POF/PCF for SCRJ plug connector
- Applications with increased EMC and vibration/shock load
- Applications with potential differences between two stations

7.2 Connecting

Tools required

3 to 3.5 mm screwdriver, alternatively TX10 (torx).

Accessories required

- Connector for PROFINET connection: IE SCRJ POF Plug
- Fiber-optic cable:
  - IE POF standard cable (6XV1874-2A)
  - IE POF trailing cable (6XV1874-2B)
  - IE PCF standard cable (6XV1861-2A)
  - IE PCF trailing cable (6XV1861-2C)

Requirements

- Prepare the IE POF cables with the connectors IE SCRJ POF Plug or IE SC RJ PCF Plug.

  You will find more Instructions in the installation instructions:
  - POF fiber-optic cables with IE SCRJ POF plugs (A5E00351141).
  - PCF fiber-optic cables with IE SCRJ PCF plugs (A5E00835119).
- When installing the fiber-optic cable, make sure the bending radius is not less than permitted:
  - IE POF/PCF standard cable: 150 mm
  - IE POF/PCF trailing cable: 60 mm
- The maximum lengths of the fiber-optic cables are as follows:
  - IE POF standard cable: 50 m
  - IE POF trailing cable: 50 m
  - IE PCF standard cable: 100 m
  - IE PCF trailing cable: 100 m
- When the PROFINET device is the last device of the fiber-optic cable network, the unoccupied fiber-optic cable interface must be closed with a blanking plug. When the modules ship, the blanking plugs are inserted in the PROFINET sockets of the BusAdapter.

Pin assignment

The following table shows the signal name and description of the pin assignment of the BusAdapter BA 2×SCRJ.

Table 2-2180 Industrial Ethernet/PROFINET pin assignment with BusAdapter BA 2×SCRJ

View	Signal name	Description
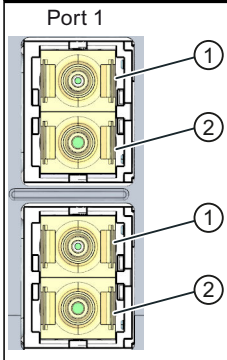	1	Receive Data
	2	Transmit Data

Procedure

1. Plug the BusAdapter BA 2×SCRJ into the PROFINET device.
2. Screw the BusAdapter BA 2×SCRJ to the PROFINET device (1 screw with 0.25 Nm tightening torque). To do this, use a screwdriver with a 3 to 3.5 mm blade, alternatively TX10.
3. Remove the blanking plugs from the PROFINET sockets.
4. Hold the prepared connector by the housing. Insert it into the PROFINET socket on the BusAdapter BA 2xSCRJ until you hear it click into place. The coding of the connectors ensures a safe connection.

> **⚠ CAUTION**
>
> **The BusAdapter/synchronization module contains a laser system and is classified as a "CLASS 1 LASER PRODUCT" in accordance with IEC 60825-1.**
>
> Can cause personal injury.
>
> Avoid direct eye contact with the laser beam. Do not open the housing. Read the information in the system manual (https://support.industry.siemens.com/cs/ww/en/view/84133942) carefully.

You can swap steps 3 and 4.

BusAdapter BA 2×SCRJ installed

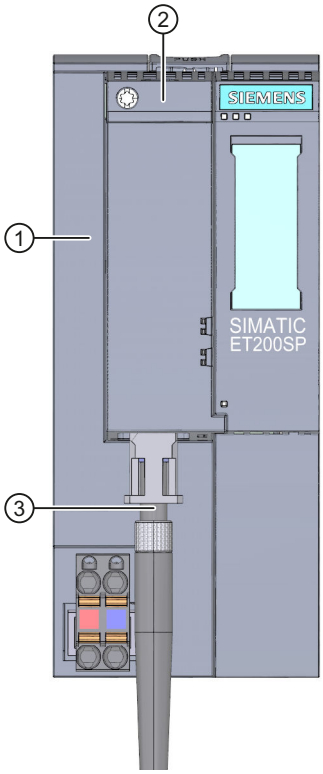

① Interface module

② BusAdapter BA 2xSCRJ

③ Industrial Ethernet/PROFINET connecting cable (FOC)

Figure 2-1758 BusAdapter BA 2×SCRJ connected to interface module (using ET 200SP interface module as an example)

Reusing used fiber-optic cables

NOTE

Shorten both fiber-optic cores by the damaged lengths and reassemble the connectors. This will prevent any attenuation losses due to the heavily stressed portions of the fiber-optic cores.

Reference

For more information on the installation guidelines for fiber-optic cables, refer to the SIMATIC NET PROFIBUS Network Manual (https://support.industry.siemens.com/cs/de/de/view/1172302).

7.3 Diagnostics

LEDs

The figure below shows the LED display on the BusAdapter BA 2xSCRJ:

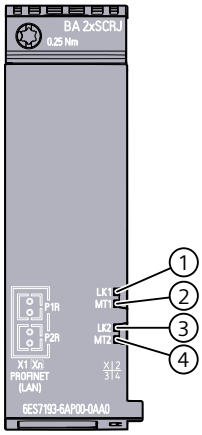

① LK1 (green)

② MT1 (yellow)

③ LK2 (green)

④ MT2 (yellow)

Figure 2-1759 LEDs on the BusAdapter BA 2xSCRJ

LK1/LK2 and MT1/MT2 LEDs on the BusAdapter

Table 2-2181 Status and error displays

LED		Meaning	Remedy
LK1/LK2	MT1/MT2		
□ off	Not relevant	There is no Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	Check whether the bus cable to the switch or IO controller is disconnected.
■ on	Not relevant	There is an Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	-
☼ flashes	Not relevant	The "Node flash test" is running. The RN/ER/MT LEDs are also flashing.	-
Not relevant	□ off	No error	-

LED		Meaning	Remedy
LK1/LK2	MT1/MT2		
Not relevant	■ on	• Fiber-optic error • Maintenance demanded: attenuation through the fiber-optic cable is already so high that operation will soon no longer be possible.	Causes and measures for the transmission route: • Replace the fiber-optic cable if damaged or aged. • Ensure correct installation of the PROFINET plugs or PROFINET connectors. • Adhere to maximum length of 50 m for POF cable or 100 m for PCF cable. • Ensure that the FOC connectors fit securely.

7.4 Technical specifications

Technical specifications of BusAdapter BA 2×SCRJ

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6AP00-0AA0/td?dl=de).

Article number	6ES7193-6AP00-0AA0
General information	
Product type designation	BA 2xSCRJ
HW functional status	from FS04
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch) SCRJ FO
Supports protocol for PROFINET IO	
• Number of SCRJ ports	2
• Number of LC ports	0
Cable length	
– PCF	100 m
– Plastic FOC (POF)	50 m
– PCF-GI	250 m
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-25 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-25 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual

Article number	6ES7193-6AP00-0AA0
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

BusAdapter BA 2xLC

8

8.1 Product overview

Article number

6ES7193-6AG00-0AA0

View

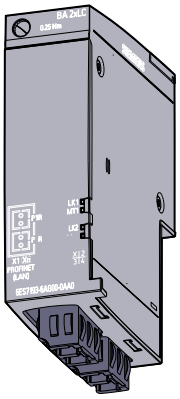

Figure 2-1760 BusAdapter BA 2xLC

Properties

- BusAdapter BA 2×LC is designed for multimode fiber-optic cables with a maximum length of 3 km.
- Applications with increased EMC and vibration/shock load
- Applications with potential differences between two stations

8.2 Connecting

Tools required

3 to 3.5 mm screwdriver, alternatively TX10 (torx).

Accessories required

- If you prepare the FC FO cables with the IE FC FO LC plug, we recommend the FC FO Termination Kit (LC) (6GK1900-0RL00-0AA0). You can cleave the glass fiber precisely using the FC FO Termination Kit (LC).

⚠ CAUTION
Cleaving the fiber-optic cable – Wear protective glasses during the cleaving process. – Dispose of the remaining fibers in a suitable waste container.

- Connector for PROFINET fiber-optic cable connection: IE FC FO LC Plug (10 duplex plugs: 6GK1900-1RB00-2AB0)
- Fiber-optic cable:
  - IE FC FO Standard Cable GP (62.5/200/230) (6XV1847-2A)
  - IE FC FO Trailing Cable (62.5/200/230) (6XV1847-2C)
- Pre-assembled FO cables with LC connection plug in various lengths:
  - IE FO Robust Cable (6XV1873-5Rxx)
  - IE FO Standard Cable (6XV1873-5Axx)
  - IE FO Trailing Cable (6XV1873-5Cxx)
- FO patch cables/adapter cables with LC connection plug
  - MM Cord SC/LC (6XV1843-5EH10-0CA0)
  - MM Cord BFOC/LC (6XV1843-5EH10-0AB0)
  - MM Cord LC/LC (6XV1843-5EH10-0AA0), 1 m
  - MM Cord LC/LC (6XV1843-5EH20-0AA0), 2 m
  - MM Cord LC/LC (6XV1843-5EH30-0AA0), 3 m

See also Cabling technology in SIOS (https://support.industry.siemens.com/cs/attachments/109766358/IE_cabling-technology_EN_Web.pdf).

Pin assignment

The following table shows the signal name and description of the pin assignment of the BusAdapter BA 2×LC:

Table 2-2182 Industrial Ethernet/PROFINET pin assignment with BusAdapter BA 2xLC

View	Signal name	Description
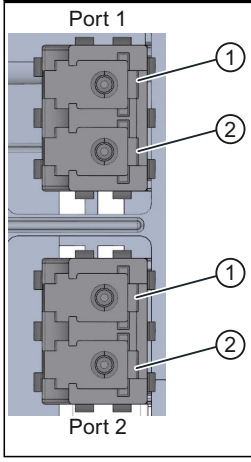	1	Receive Data
	2	Transmit Data

NOTE

The metal part of the LC-LD transceiver is non-grounded and must not be grounded.

Requirements

- Prepare the IE FC FO cable with the IE FC FO LC plug connectors. For detailed instructions, refer to the assembly instructions Preparing IE FC FO Cable with the plug-in connector IE FC FO LC Plug (A5E36312721).
- When installing the fiber-optic cable, make sure the bending radius is not less than permitted:
  - IE FC FO Standard Cable GP (62.5/200/230): 70 mm
  - IE FC FO Trailing Cable (62.5/200/230) (6XV1847-2C): 88 mm
- The maximum lengths of the fiber-optic cables are as follows:
  - IE FC FO Standard Cable GP (62.5/200/230): 2 km
  - IE FC FO Trailing Cable (62.5/200/230): 2 km
- When the interface module is the last device of the fiber-optic cable network, the unoccupied fiber-optic cable interface must be closed with a blanking plug. When the modules ship, the blanking plugs are inserted in the PROFINET sockets of the BusAdapter.

Procedure

To connect PROFINET IO to the PROFINET device via the BusAdapter BA 2xLC, follow these steps:

1. Plug the BusAdapter BA 2xLC into the PROFINET device.
2. Screw the BusAdapter BA 2xLC to the PROFINET device (1 screw with 0.25 Nm tightening torque). To do this, use a screwdriver with a 3 to 3.5 mm blade, alternatively TX10.
3. Remove the blanking plugs from the PROFINET sockets.
4. Hold the prepared connector by the housing. Insert it into the PROFINET socket on the BusAdapter BA 2xLC until you hear it click into place. The coding of the connectors ensures a safe connection.

⚠ CAUTION

The BusAdapter/synchronization module contains a laser system and is classified as a "CLASS 1 LASER PRODUCT" in accordance with IEC 60825-1.

Can cause personal injury.

Avoid direct eye contact with the laser beam. Do not open the housing. Read the information in the system manual (https://support.industry.siemens.com/cs/ww/en/view/84133942) carefully.

BusAdapter BA 2xLC installed

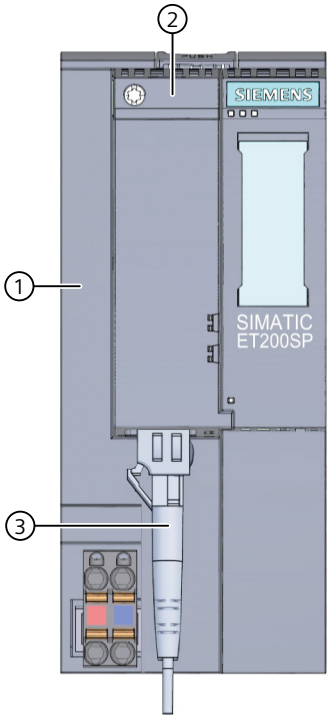

① Interface module

② BusAdapter BA 2xLC

③ Industrial Ethernet/PROFINET fiber-optic connection cable

Figure 2-1761 Connecting the BusAdapter BA 2xLC to the interface module

Reusing used fiber-optic cables

NOTE

Shorten both fiber-optic cores by the damaged lengths and reassemble the connectors. This will prevent any attenuation losses due to the heavily stressed portions of the fiber-optic cores.

Fiber type and shape of the fiber end

NOTE

When setting up an optical connection, note the following:

- Use the multimode fiber type
- Use appropriate shape of the fiber end:
  - PC (Physical Contact): Flat, rounded, polished fiber end
  - UPC (Ultra Physical Contact): Flat, rounded, highly polished fiber end

Reference

For more information on the installation guidelines for fiber-optic cables, refer to the SIMATIC NET PROFIBUS Network Manual (https://support.industry.siemens.com/cs/de/de/view/1172302).

8.3 Diagnostics

LEDs

The figure below shows the LEDs on the BusAdapter BA 2xLC:

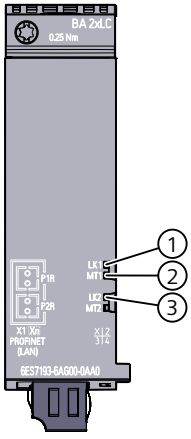

① LK1 (green)

② MT (yellow)

③ LK2 (green)

Figure 2-1762 BA front LED_LK1_LK2

LK1/LK2 LEDs on the BusAdapter

Table 2-2183 Status and error displays

LED LK1/LK2	Meaning	Remedy
off	There is no Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	Check whether the bus cable to the switch or IO controller is disconnected.
on	There is an Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	-
flashes	The "Node flash test" is running. The RN/ER/MT LEDs are also flashing.	-

8.4 Technical specifications

Technical specifications of BusAdapter BA 2xLC

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6AG00-0AA0/td?dl=de).

Article number	6ES7193-6AG00-0AA0
General information	
Product type designation	BA 2xLC
HW functional status	from FS04
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch) LC Multimode Glass Fibre
Supports protocol for PROFINET IO	
• Number of SCRJ ports	0
• Number of LC ports	2; Wavelength of 1 270 ... 1 380 nm, corresponds to 100BASE-FX
Cable length	
– Multimode graded-index fiber 50/125 µm	3 km
– Multimode graded-index fiber 62.5/125 µm	3 km
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C

Article number	6ES7193-6AG00-0AA0
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	40 g

BusAdapter BA 2xLC-LD

9

9.1 Product overview

Article number

6ES7193-6AG50-0AA0

View

Figure 2-1763 BA 2xLC-LD

Properties

- BusAdapter BA 2×LC-LD (Long Distance) is designed for single-mode fiber-optic cables with a maximum length of 20 km
- Applications with increased EMC and vibration/shock load
- Applications with potential differences between two stations

9.2 Connecting

Tools required

3 to 3.5 mm screwdriver, alternatively TX10 (torx).

Accessories required

CAUTION

Cleaving the fiber-optic cable

- Wear protective glasses during the cleaving process.
- Dispose of the remaining fibers in a suitable waste container.

- Connector for PROFINET fiber-optic cable connection: IE FC FO LC Plug
- Fiber-optic cable:
  - Single-mode fiber 9/125/300 OS1 and OS2
- Tested cables:
  - IE FC FO Robust cable GP (6XV1843-2R)
  - SM Cord LC/LC (6XV1843-5FH10-0AA0)

Additional information on cables and connection technology can be found on our FastConnect (http://www.siemens.com/fastconnect) homepage and in SIOS (https://support.industry.siemens.com/cs/attachments/109766358/IE_cabling-technology_EN_Web.pdf).

Pin assignment

The following table shows the signal name and description of the pin assignment of the BusAdapter BA 2×LC-LD:

Table 2-2184 Industrial Ethernet/PROFINET pin assignment with BusAdapter BA 2xLC-LD

View	Signal name	Description
	1	Receive Data

View	Signal name	Description
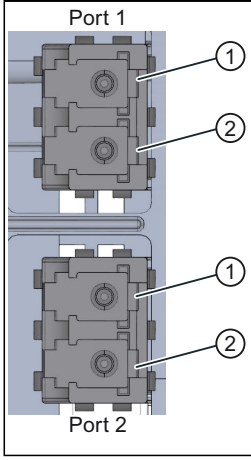	2	Transmit Data

NOTE

The metal part of the LC-LD transceiver is non-grounded and must not be grounded.

Requirements

- When installing the fiber-optic cable, make sure the bending radius is not less than permitted:
  - IE FC FO Robust cable GP (6XV1843-2R): 90 mm (single), 135 mm (multi)
  - SM Cord LC/LC (6XV1843-5FH10-0AA0): 42 mm
- The maximum lengths of the fiber-optic cables are as follows:
  - IE FC FO Robust cable GP (6XV1843-2R): 20 km
  - SM Cord LC/LC (6XV1843-5FH10-0AA0): 1 m
  - SM Cord LC/LC (6XV1843-5FH20-0AA0): 2 m
  - SM Cord LC/LC (6XV1843-5FH30-0AA0): 3 m
- When the interface module is the last device of the fiber-optic cable network, the unoccupied fiber-optic cable interface must be closed with a blanking plug. When the modules ship, the blanking plugs are inserted in the PROFINET sockets of the BusAdapter.

Procedure

To connect PROFINET IO to the PROFINET device via the BusAdapter BA 2xLC-LD, follow these steps:

1. Plug the BusAdapter BA 2xLC-LD into the PROFINET device.
2. Screw the BusAdapter BA 2xLC-LD to the PROFINET device (1 screw with 0.25 Nm tightening torque). To do this, use a screwdriver with a 3 to 3.5 mm blade, alternatively TX10.
3. Remove the blanking plugs from the PROFINET sockets.

4. Hold the prepared connector by the housing. Insert it into the PROFINET socket on the BusAdapter BA 2xLC-LD until you hear it click into place. The coding of the connectors ensures a safe connection.

CAUTION

The BusAdapter/synchronization module contains a laser system and is classified as a "CLASS 1 LASER PRODUCT" in accordance with IEC 60825-1.

Can cause personal injury.

Avoid direct eye contact with the laser beam. Do not open the housing. Read the information in the system manual (https://support.industry.siemens.com/cs/ww/en/view/84133942) carefully.

BusAdapter BA 2xLC-LD installed

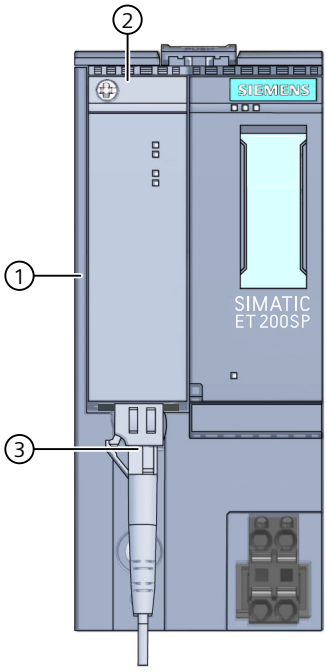

① Interface module

② BusAdapter BA 2xLC-LD

③ Industrial Ethernet/PROFINET fiber-optic connection cable

Figure 2-1764 Connecting the BusAdapter BA 2xLC-LD to the interface module

Reusing used fiber-optic cables

NOTE

Shorten both fiber-optic cores by the damaged lengths and reassemble the connectors. This will prevent any attenuation losses due to the heavily stressed portions of the fiber-optic cores.

Fiber type and shape of the fiber end

NOTE

When setting up an optical connection, note the following:

- Use the single-mode fiber type
- Use appropriate shape of the fiber end:
  - PC (Physical Contact): Flat, rounded, polished fiber end
  - UPC (Ultra Physical Contact): Flat, rounded, highly polished fiber end

Reference

For more information on the installation guidelines for fiber-optic cables, refer to the SIMATIC NET PROFIBUS Network Manual (https://support.industry.siemens.com/cs/de/de/view/1172302).

9.3 Diagnostics

LEDs

The figure below shows the LEDs on the BusAdapter BA 2xLC-LD:

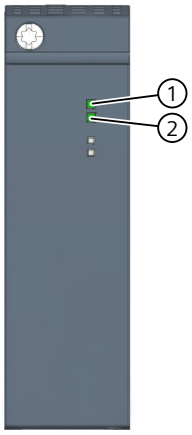

① LK1 (green)

② LK2 (green)

Figure 2-1765 LED displays on the BusAdapter BA 2xLC-LD

LK1/LK2 LEDs on the BusAdapter

Table 2-2185 Status and error displays

LED LK1/LK2	Meaning	Remedy
□ off	There is no Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	Check whether the bus cable to the switch or IO controller is disconnected.
■ on	There is an Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	-
☼ flashes	The "Node flash test" is running. The RN/ER/MT LEDs are also flashing.	-

9.4 Technical specifications

Technical specifications of BusAdapter 2x LC-LD

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6AG50-0AA0/td?dl=de).

Article number	6ES7193-6AG50-0AA0
General information	
Product type designation	BA 2 x LC-LD
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch) LC-LD single-mode fiber-optic cable
Supports protocol for PROFINET IO	
• Number of LC ports	2; wavelength of 1 270 ... 1 380 nm, corresponds to 100BASE-LX
Cable length	
– single-mode fiber-optic cable 9/125 µm	20 km; 10 km for topology or IRT configuration; max. attenuation 13 dB
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	40 g

BusAdapter BA SCRJ/RJ45

10

10.1 Product overview

Article number

6ES7193-6AP20-0AA0

View

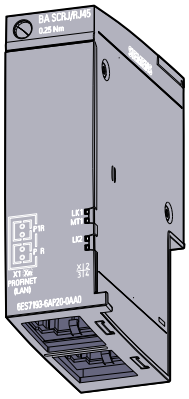

Figure 2-1766 BusAdapter BA SCRJ/RJ45

Properties

You connect Industrial Ethernet/PROFINET connection cables to the PROFINET device via the BusAdapter BA SCRJ/RJ45:

- Optically with fiber-optic cables (FOC) with an SCRJ connector to port 1
- Electrically with a standard RJ45 connector to port 2

To do this, screw the BusAdapter BA SCRJ/RJ45 to the PROFINET device and plug in the SCRJ connector or the RJ45 connector.

You loop through the Industrial Ethernet/PROFINET via the integrated 2-port switch. You can use any port of the BusAdapter for feeding or for looping through. The integrated media converter converts the signals automatically.

10.2 Connecting

Connecting the SCRJ connector

You can find more information about the required tools, accessories, requirements and procedures in the section Connecting BusAdapter BA 2×SCRJ (Page 40).

Connecting the RJ45 connector

You can find more information about the required tools, accessories and procedures in the section Connecting BusAdapter BA 2×RJ45 (Page 19).

Pin assignment

The following table shows the signal names and description of the pin assignment for the BusAdapter BA SCRJ/RJ45:

Table 2-2186 Industrial Ethernet/PROFINET pin assignment with BusAdapter BA SCRJ/RJ45

View	Signal name		Description
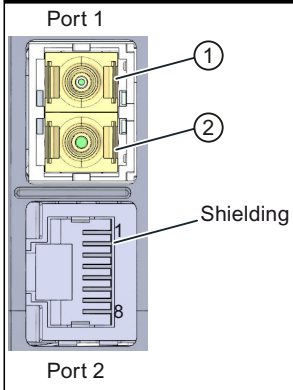	1		Receive Data
	2		Transmit Data
	1	TD	Transmit Data +
	2	TD_N	Transmit Data -
	3	RD	Receive Data +
	4	TERM1	Termination Network 1
	5	TERM1	Termination Network 1
	6	RD_N	Receive Data -
	7	TERM2	Termination Network 2
	8	TERM2	Termination Network 2

BusAdapter BA SCRJ/RJ45 installed

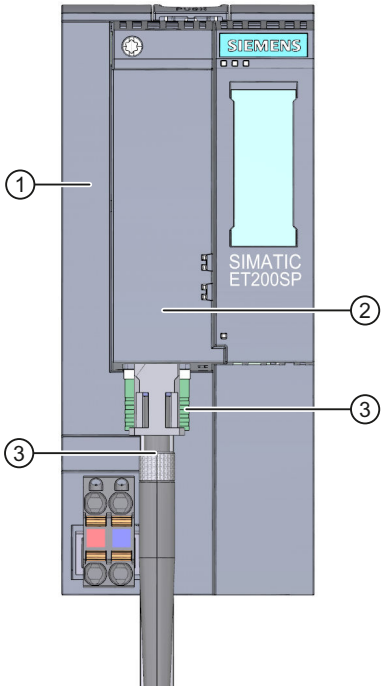

① Interface module

② BusAdapter BA SCRJ/RJ45

③ Industrial Ethernet/PROFINET connecting cable

Figure 2-1767 Connecting the BusAdapter BA SCRJ/RJ45 to the interface module

NOTE

Installation guidelines for modules with Industrial Ethernet/ PROFINET interfaces

Ensure that all devices are connected to the SELV/PELV power supply (or equivalent). Only then are you permitted to operate the modules with Industrial Ethernet/ PROFINET interfaces in LAN networks (Local Area Networks).

A data transfer point that guarantees this degree of safety is prescribed for connection to the WAN (Wide Area Network).

10.3 Diagnostics

LEDs

The figure below shows the LEDs on the BusAdapter BA SCRJ/RJ45:

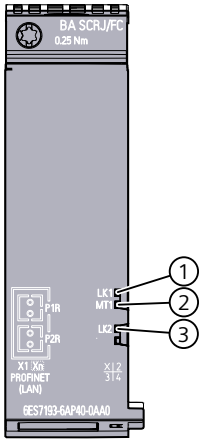

① LK1 (green)

② MT (yellow)

③ LK2 (green)

Figure 2-1768 LED displays on the BusAdapter BA SCRJ/RJ45

LK1/LK2 and MT LEDs on the BusAdapter

Table 2-2187 Status and error displays

LED		Meaning	Remedy
LK1/LK2	MT		
off	Not relevant	There is no Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	Check whether the bus cable to the switch or IO controller is disconnected.
on	Not relevant	There is an Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	-
flashes	Not relevant	The "Node flash test" is running. The RN/ER/MT LEDs are also flashing.	-
Not relevant	off	No error	-

LED		Meaning	Remedy
LK1/LK2	MT		
Not relevant	■ on	• Fiber-optic error • Maintenance demanded: attenuation through the fiber-optic cable is already so high that operation will soon no longer be possible.	Causes and measures for the transmission route: • Replace the fiber-optic cable if damaged or aged. • Ensure correct installation of the PROFINET plugs or PROFINET connectors. • Adhere to maximum length of 50 m for POF cable or 100 m for PCF cable. • Ensure that the FOC connectors fit securely.

10.4 Technical specifications

Technical specifications of BusAdapter BA SCRJ/RJ45

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6AP20-0AA0/td?dl=de).

Article number	6ES7193-6AP20-0AA0
General information	
Product type designation	BA SCRJ/RJ45
HW functional status	from FS04
Interfaces	
Number of PROFINET interfaces	1; 2 ports (SCRJ + RJ45)
Supports protocol for PROFINET IO	
• Number of RJ45 ports	1
• Number of SCRJ ports	1
• Number of LC ports	0
Cable length	
– PCF	100 m
– Plastic FOC (POF)	50 m
– PCF-GI	250 m
– Cu conductors	100 m
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-25 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-25 °C
• vertical installation, max.	50 °C

Article number	6ES7193-6AP20-0AA0
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	20 mm
Weights	
Weight, approx.	50 g

BusAdapter BA SCRJ/FC

11

11.1 Product overview

Article number

6ES7193-6AP40-0AA0

View

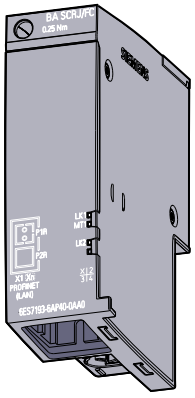

Figure 2-1769 BusAdapter BA SCRJ/FC

Properties

- You connect Industrial Ethernet/PROFINET to the PROFINET device via the BusAdapter BA SCRJ/FC .
- The BusAdapter BA SCRJ/FC has one port for connection of a copper cable and one port for connection of a fiber-optic cable.

Screw the BusAdapter BA SCRJ/FC with the attached Fast Connect bus cable onto the interface module and plug in the SCRJ connector.

You loop through the Industrial Ethernet/PROFINET via the integrated 2-port switch. You can use any port of the BusAdapter for feeding or for looping through. The integrated media converter converts the signals automatically.

11.2 Connecting

Connecting the SCRJ connector

You can find more information about the required tools, accessories, requirements and procedures in the section Connecting BusAdapter BA 2×SCRJ (Page 40).

Connecting FC plug-in connectors

You can find more information about the required tools, accessories and procedures in the section Connecting BusAdapter BA 2×FC (Page 25).

Pin assignment

The following table shows the signal name and description of the pin assignment of the BusAdapter BA SCRJ/FC.

Table 2-2188 Industrial Ethernet/PROFINET pin assignment with BusAdapter BA SCRJ/FC

View	Signal name		Description
Port 1 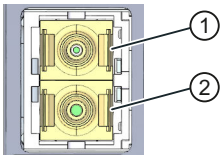	1		Receive Data
	2		Transmit Data
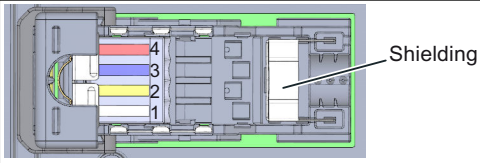 Port 2	1	RD_N	Receive Data –
	2	TD_N	Transmit Data -
	3	RD	Receive Data +
	4	TD	Transmit Data +

Procedure

To connect PROFINET IO to the PROFINET device via the BusAdapter BA SCRJ/FC, follow these steps:

1. Plug the BusAdapter BA SCRJ/FC into the PROFINET device.
2. Screw the BusAdapter BA SCRJ/FC to the PROFINET device (1 screw with 0.25 Nm tightening torque). To do this, use a screwdriver with a 3 to 3.5 mm blade, alternatively TX10.
3. Plug the RJ45 bus connector into the PROFINET port on the BusAdapter BA SCRJ/FC.

BusAdapter BA SCRJ/FC installed

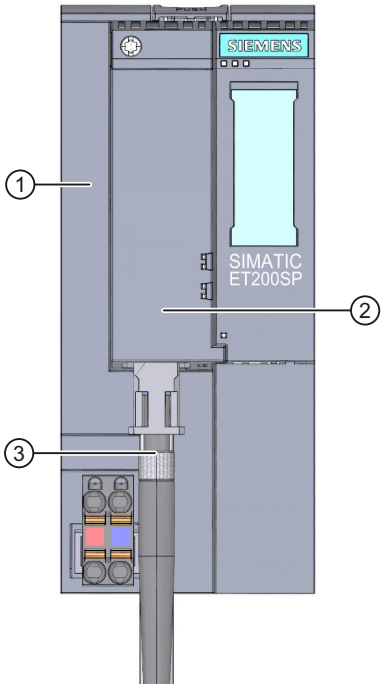

① Interface module

② BusAdapter BA SCRJ/FC

③ Industrial Ethernet/PROFINET connecting cable

Figure 2-1770 BusAdapter BA SCRJ/FC installed (using an ET 200SP interface module as an example)

NOTE

Installation guidelines for modules with Industrial Ethernet/ PROFINET interfaces

Ensure that all devices are connected to the SELV/PELV power supply (or equivalent). Only then are you permitted to operate the modules with Industrial Ethernet/ PROFINET interfaces in LAN networks (Local Area Networks).

A data transfer point that guarantees this degree of safety is prescribed for connection to the WAN (Wide Area Network).

11.3 Diagnostics

LEDs

The figure below shows the LEDs on the BusAdapter BA SCRJ/FC:

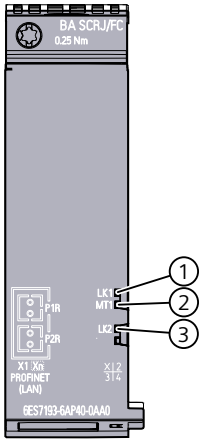

① LK1 (green)

② MT (yellow)

③ LK2 (green)

Figure 2-1771 LEDs on the BusAdapter BA SCRJ/FC

LK1/LK2 and MT LEDs on the BusAdapter

Table 2-2189 Status and error displays

LED		Meaning	Remedy
LK1/LK2	MT		
off	Not relevant	There is no Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	Check whether the bus cable to the switch or IO controller is disconnected.
on	Not relevant	There is an Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	-
flashes	Not relevant	The "Node flash test" is running. The RN/ER/MT LEDs are also flashing.	-
Not relevant	off	No error	-

LED		Meaning	Remedy
LK1/LK2	MT		
Not relevant	■ on	• Fiber-optic error • Maintenance demanded: attenuation through the fiber-optic cable is already so high that operation will soon no longer be possible.	Causes and measures for the transmission route: • Replace the fiber-optic cable if damaged or aged. • Ensure correct installation of the PROFINET plugs or PROFINET connectors. • Adhere to maximum length of 50 m for POF cable or 100 m for PCF cable. • Ensure that the FOC connectors fit securely.

11.4 Technical specifications

Technical specifications of BusAdapter BA SCRJ/FC

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6AP40-0AA0/td?dl=de).

Article number	6ES7193-6AP40-0AA0
General information	
Product type designation	BA SCRJ/FC
HW functional status	from FS04
Interfaces	
Number of PROFINET interfaces	1; 2 ports (SCRJ + FC)
Supports protocol for PROFINET IO	
• Number of FC (FastConnect) connections	1
• Number of SCRJ ports	1
• Number of LC ports	0
Cable length	
– PCF	100 m
– Plastic FOC (POF)	50 m
– PCF-GI	250 m
– Cu conductors	100 m
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-25 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-25 °C
• vertical installation, max.	50 °C

Article number	6ES7193-6AP40-0AA0
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

BusAdapter BA LC/RJ45

12

12.1 Product overview

Article number

6ES7193-6AG20-0AA0

View

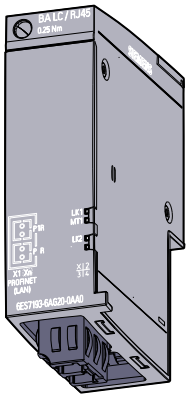

Figure 2-1772 BusAdapter BA LC/RJ45

Properties

You connect Industrial Ethernet/PROFINET connection cables to the PROFINET device via the BusAdapter BA LC/RJ45:

- Optically with glass fiber-optic cables with an LC connector to port 1
- Electrically with a standard RJ45 connector to port 2

To do this, screw the BusAdapter BA LC/RJ45 to the PROFINET device and plug in the LC connector or the RJ45 connector.

You loop through the Industrial Ethernet/PROFINET via the integrated 2-port switch. You can use any port of the BusAdapter for feeding or for looping through. The integrated media converter converts the signals automatically.

12.2 Connecting

Attaching LC connectors

You can find more information about the required tools, accessories, requirements and procedures in the section Connecting BusAdapter BA 2×LC (Page 47).

Connecting the RJ45 connector

You can find more information about the required tools, accessories and procedures in the section Connecting BusAdapter BA 2×RJ45 (Page 19).

Pin assignment

The following table shows the signal name and description of the pin assignment of the BusAdapter BA LC/RJ45:

Table 2-2190 Industrial Ethernet/PROFINET pin assignment with BusAdapter BA LC/RJ45

View	Signal name		Description
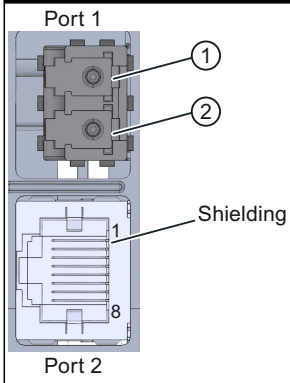	①		Receive Data
	②		Transmit Data
	1	TD	Transmit Data +
	2	TD_N	Transmit Data -
	3	RD	Receive Data +
	4	TERM1	Termination Network 1
	5	TERM1	Termination Network 1
	6	RD_N	Receive Data -
	7	TERM2	Termination Network 2
	8	TERM2	Termination Network 2

NOTE

The metal part of the LC-LD transceiver is non-grounded and must not be grounded.

⚠ CAUTION

The BusAdapter/synchronization module contains a laser system and is classified as a "CLASS 1 LASER PRODUCT" in accordance with IEC 60825-1.

Can cause personal injury.

Avoid direct eye contact with the laser beam. Do not open the housing. Read the information in the system manual (https://support.industry.siemens.com/cs/ww/en/view/84133942) carefully.

BusAdapter BA LC/RJ45 installed

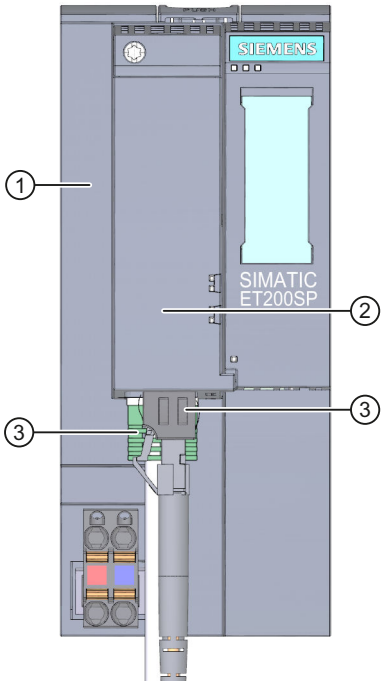

① Interface module

② BusAdapter BA LC/RJ45

③ Industrial Ethernet/PROFINET connecting cable

Figure 2-1773 BusAdapter BA LC/RJ45 installed (using an ET 200SP interface module as an example)

NOTE

Installation guidelines for modules with Industrial Ethernet/ PROFINET interfaces

Ensure that all devices are connected to the SELV/PELV power supply (or equivalent). Only then are you permitted to operate the modules with Industrial Ethernet/ PROFINET interfaces in LAN networks (Local Area Networks).

A data transfer point that guarantees this degree of safety is prescribed for connection to the WAN (Wide Area Network).

12.3 Diagnostics

LEDs

The figure below shows the LEDs on the BusAdapter BA LC/RJ45:

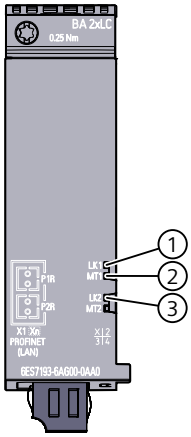

① LK1 (green)

② MT (yellow)

③ LK2 (green)

Figure 2-1774 BA front LED_LK1_LK2

LEDs LK1/LK2 on the BusAdapter

Table 2-2191 Status and error displays

LED LK1/LK2	Meaning	Remedy
☐ off	There is no Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	Check whether the bus cable to the switch or IO controller is disconnected.
■ on	There is an Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	-
☼ flashes	The "Node flash test" is running. The RN/ER/MT LEDs are also flashing.	-

12.4 Technical specifications

Technical specifications of the BusAdapters BA LC/RJ45

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6AG20-0AA0/td?dl=de).

Article number	6ES7193-6AG20-0AA0
General information	
Product type designation	BA LC/RJ45
HW functional status	from FS04
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch) LC / RJ45
Supports protocol for PROFINET IO	
• Number of RJ45 ports	1
• Number of SCRJ ports	0
• Number of LC ports	1; Wavelength of 1 270 ... 1 380 nm, corresponds to 100BASE-FX
Cable length	
– Cu conductors	100 m
– Multimode graded-index fiber 50/125 µm	3 km
– Multimode graded-index fiber 62.5/125 µm	3 km
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	32 g

BusAdapter BA LC/FC

13

13.1 Product overview

Article number

6ES7193-6AG40-0AA0

View

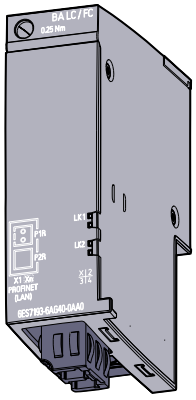

Figure 2-1775 BusAdapter BA LC/FC

Properties

You connect Industrial Ethernet/PROFINET connection cables to the PROFINET device via the BusAdapter BA LC/FC:

- Optically with glass fiber-optic cables with an LC connector to port 1
- Electrically with direct connection of the Fast Connect bus cable to port 2

Screw the BusAdapter BA LC/FC with the attached Fast Connect bus cable onto the PROFINET device and plug in the LC connector.

You loop through the Industrial Ethernet/PROFINET via the integrated 2-port switch. You can use any port of the BusAdapter for feeding or for looping through. The integrated media converter converts the signals automatically.

13.2 Connecting

Attaching LC connectors

You can find more information about the required tools, accessories, requirements and procedures in the section Connecting BusAdapter BA 2×LC (Page 47).

Connecting FastConnect bus cable

You can find more information about the required tools, accessories and procedures in the section Connecting BusAdapter BA 2×FC (Page 25).

Pin assignment

The following table shows the signal name and description of the pin assignment of the BusAdapter BA LC/FC:

Table 2-2192 Industrial Ethernet/PROFINET pin assignment with BusAdapter BA LC/FC

View	Signal name		Description
Port 1 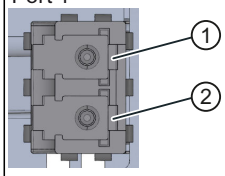	1		Receive Data
	2		Transmit Data
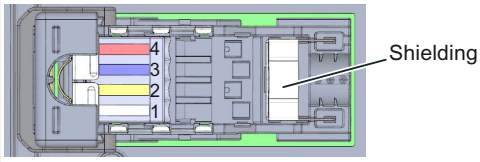 Port 2	1	RD_N	Receive Data –
	2	TD_N	Transmit Data -
	3	RD	Receive Data +
	4	TD	Transmit Data +

NOTE

The metal part of the LC-LD transceiver is non-grounded and must not be grounded.

⚠ CAUTION

The BusAdapter/synchronization module contains a laser system and is classified as a "CLASS 1 LASER PRODUCT" in accordance with IEC 60825-1.

Can cause personal injury.

Avoid direct eye contact with the laser beam. Do not open the housing. Read the information in the system manual (https://support.industry.siemens.com/cs/ww/en/view/84133942) carefully.

BusAdapter BA LC/FC installed

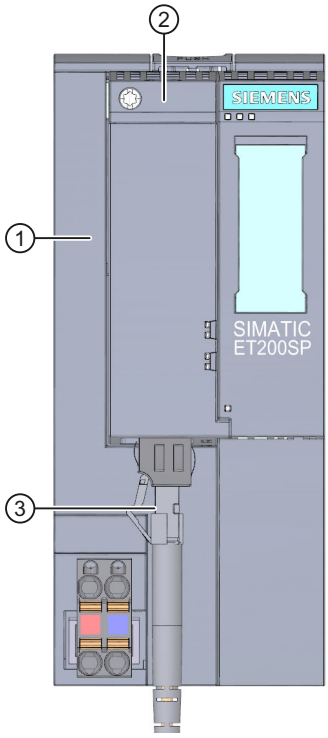

① Interface module

② BusAdapter BA LC/FC

③ Industrial Ethernet/PROFINET connecting cable

Figure 2-1776 Connecting the BusAdapter BA LC/FC to the interface module

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NOTE

Installation guidelines for modules with Industrial Ethernet/ PROFINET interfaces

Ensure that all devices are connected to the SELV/PELV power supply (or equivalent). Only then are you permitted to operate the modules with Industrial Ethernet/ PROFINET interfaces in LAN networks (Local Area Networks).

A data transfer point that guarantees this degree of safety is prescribed for connection to the WAN (Wide Area Network).

13.3 Diagnostics

LEDs

The figure below shows the LEDs on the BusAdapter BA LC/FC:

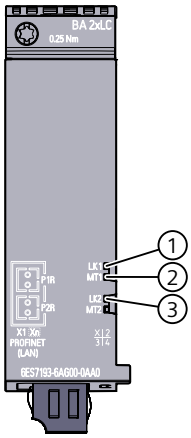

① LK1 (green)

② MT (yellow)

③ LK2 (green)

Figure 2-1777 BA front LED_LK1_LK2

LK1/LK2 LEDs on the BusAdapter

Table 2-2193 Status and error displays

LED LK1/LK2	Meaning	Remedy
☐ off	There is no Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	Check whether the bus cable to the switch or IO controller is disconnected.
■ on	There is an Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	-
☼ flashes	The "Node flash test" is running. The RN/ER/MT LEDs are also flashing.	-

13.4 Technical specifications

Technical specifications of the BusAdapters BA LC/FC

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6AG40-0AA0/td?dl=de).

Article number	6ES7193-6AG40-0AA0
General information	
Product type designation	BA LC/FC
HW functional status	from FS04
Interfaces	
Number of PROFINET interfaces	1
Supports protocol for PROFINET IO	
• Number of FC (FastConnect) connections	1
• Number of SCRJ ports	0
• Number of LC ports	1; Wavelength of 1 270 ... 1 380 nm, corresponds to 100BASE-FX
Cable length	
– Cu conductors	100 m
– Multimode graded-index fiber 50/125 µm	3 km
– Multimode graded-index fiber 62.5/125 µm	3 km
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	50 g

BusAdapter BA LC-LD/RJ45

14

14.1 Product overview

Article number

6ES7193-6AG60-0AA0

View

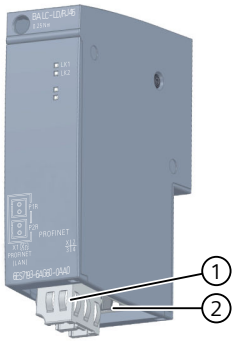

① Glass fiber-optic cable LC

② RJ45

Figure 2-1778 BusAdapter BA LC-LD/RJ45

Properties

You connect Industrial Ethernet/PROFINET connection cables to the PROFINET device via the BusAdapter BA LC-LD/RJ45:

- Optically with glass fiber-optic cables with an LC connector to port 1
- Electrically with a standard RJ45 connector to port 2.

To do this, screw the BusAdapter BA LC-LD/RJ45 to the PROFINET device and plug in the LC connector or the RJ45 connector.

You loop through the Industrial Ethernet/PROFINET via the integrated 2-port switch. You can use any port of the BusAdapter for feeding or for looping through. The integrated media converter converts the signals automatically.

14.2 Connecting

Attaching LC connectors

You can find more information about the required tools, accessories, requirements and procedures in the section Connecting BusAdapter BA 2xLC-LD (Page 55).

Connecting the RJ45 connector

You can find more information about the required tools, accessories and procedures in the section Connecting BusAdapter BA 2×RJ45 (Page 19).

Pin assignment

The following table shows the signal name and description of the pin assignment of the BusAdapter BA LC-LD/RJ45:

Table 2-2194 Industrial Ethernet/PROFINET pin assignment with BusAdapter BA LC-LD/RJ45

View	Signal name		Description
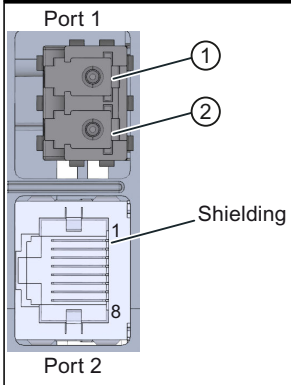	①		Receive Data
	②		Transmit Data
	1	TD	Transmit Data +
	2	TD_N	Transmit Data -
	3	RD	Receive Data +
	4	TERM1	Termination Network 1
	5	TERM1	Termination Network 1
	6	RD_N	Receive Data -
	7	TERM2	Termination Network 2
	8	TERM2	Termination Network 2

NOTE

The metal part of the LC-LD transceiver is non-grounded and must not be grounded.

⚠ CAUTION

The BusAdapter/synchronization module contains a laser system and is classified as a "CLASS 1 LASER PRODUCT" in accordance with IEC 60825-1.

Can cause personal injury.

Avoid direct eye contact with the laser beam. Do not open the housing. Read the information in the system manual (https://support.industry.siemens.com/cs/ww/en/view/84133942) carefully.

BusAdapter BA LC-LD/RJ45 installed

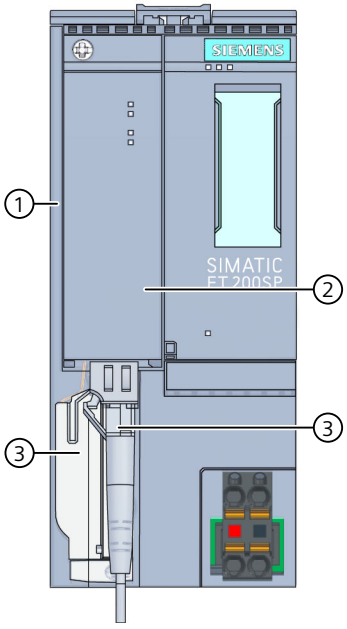

① Interface module

② BusAdapter BA LC-LD/RJ45

③ Industrial Ethernet/PROFINET connecting cable

Figure 2-1779 BusAdapter BA LC-LD/RJ45 installed (using an ET 200SP interface module as an example)

NOTE

Installation guidelines for modules with Industrial Ethernet/ PROFINET interfaces

Ensure that all devices are connected to the SELV/PELV power supply (or equivalent). Only then are you permitted to operate the modules with Industrial Ethernet/ PROFINET interfaces in LAN networks (Local Area Networks).

A data transfer point that guarantees this degree of safety is prescribed for connection to the WAN (Wide Area Network).

14.3 Diagnostics

LEDs

The figure below shows the LEDs on the BusAdapter BA LC-LD/RJ45:

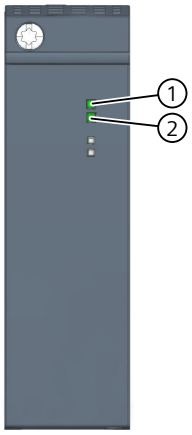

① LK1 (green)

② LK2 (green)

Figure 2-1780 LED displays on the BusAdapter BA LC-LD/RJ45

LEDs LK1/LK2 on the BusAdapter

Table 2-2195 Status and error displays

LED LK1/LK2	Meaning	Remedy
□ off	There is no Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	Check whether the bus cable to the switch or IO controller is disconnected.
■ on	There is an Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	-
☼ flashes	The "Node flash test" is running. The RN/ER/MT LEDs are also flashing.	-

14.4 Technical specifications

Technical specifications of the BusAdapters BA LC-LD/RJ45

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6AG60-0AA0/td?dl=de).

Article number	6ES7193-6AG60-0AA0
General information	
Product type designation	BA LC-LD / RJ45
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch) 1x LC-LD single-mode + 1x RJ45
Supports protocol for PROFINET IO	
• Number of RJ45 ports	1
• Number of LC ports	1; wavelength of 1 270 ... 1 380 nm, corresponds to 100BASE-LX
Cable length	
– Cu conductors	100 m
– single-mode fiber-optic cable 9/125 µm	20 km; 10 km for topology or IRT configuration; max. attenuation 13 dB
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	32 g

BusAdapter BA LC-LD/M12

15

15.1 Product overview

Article number

6ES7193-6AG70-0AA0

View

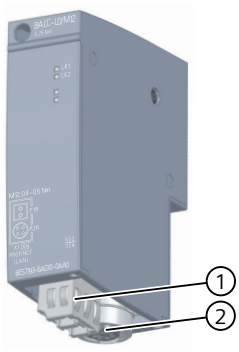

① Glass fiber-optic cable LC

② M12

Figure 2-1781 BusAdapter BA LC-LD/M12

Properties

You connect Industrial Ethernet/PROFINET connection cables to the PROFINET device via the BusAdapter BA LC-LD/M12:

- Optically with glass fiber-optic cables with an LC connector to port 1
- Electrically with a standard 12-pin connector to port 2.

To do this, screw the BusAdapter BA LC-LD/M12 to the PROFINET device and plug in the LC connector or the M12 plug.

You loop through the Industrial Ethernet/PROFINET via the integrated 2-port switch. You can use any port of the BusAdapter for feeding or for looping through. The integrated media converter converts the signals automatically.

15.2 Connecting

Attaching LC connectors

You can find more information about the required tools, accessories, requirements and procedures in the section Connecting BusAdapter BA 2xLC-LD (Page 55).

Connecting M12 plugs

You can find more information about the required tools, accessories and procedures in the section Connecting BusAdapter BA 2×M12 (Page 33).

Pin assignment

The following table shows the signal name and description of the pin assignment of the BusAdapter BA LC-LD/M12:

Table 2-2196 Industrial Ethernet/PROFINET pin assignment with BusAdapter BA LC-LD/M12

View	Signal name		Description
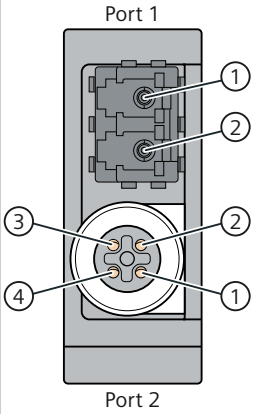	1		Receive Data
	2		Transmit Data
	1	TD+	Transmit Data +
	2	RD+	Receive Data +
	3	TD-	Transmit Data -
	4	RD-	Receive Data -

NOTE

The metal part of the LC-LD transceiver is non-grounded and must not be grounded.

⚠ CAUTION

The BusAdapter/synchronization module contains a laser system and is classified as a "CLASS 1 LASER PRODUCT" in accordance with IEC 60825-1.

Can cause personal injury.

Avoid direct eye contact with the laser beam. Do not open the housing. Read the information in the system manual (https://support.industry.siemens.com/cs/ww/en/view/84133942) carefully.

BusAdapter BA LC-LD/M12 installed

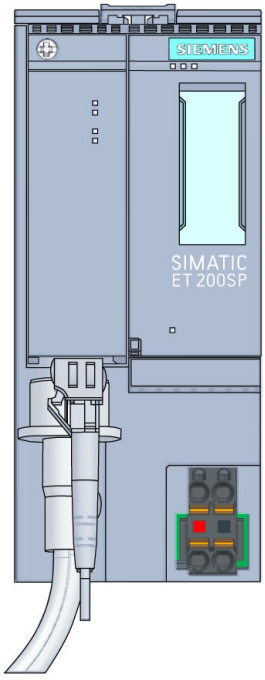

① Interface module

② BusAdapter BA LC-LD/M12

③ Industrial Ethernet/PROFINET connecting cable

Figure 2-1782 BusAdapter BA LC-LD/M12 installed (using an ET 200SP interface module as an example)

NOTE

Installation guidelines for modules with Industrial Ethernet/ PROFINET interfaces

Ensure that all devices are connected to the SELV/PELV power supply (or equivalent). Only then are you permitted to operate the modules with Industrial Ethernet/ PROFINET interfaces in LAN networks (Local Area Networks).

A data transfer point that guarantees this degree of safety is prescribed for connection to the WAN (Wide Area Network).

15.3 Diagnostics

LEDs

The figure below shows the LEDs on the BusAdapter BA LC-LD/M12:

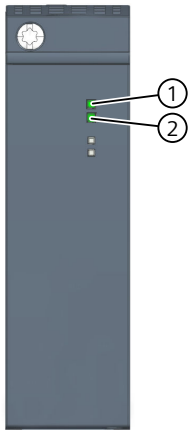

① LK1 (green)

② LK2 (green)

Figure 2-1783 LED displays on the BusAdapter BA LC-LD/M12

LEDs LK1/LK2 on the BusAdapter

Table 2-2197 Status and error displays

LED LK1/LK2	Meaning	Remedy
☐ off	There is no Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	Check whether the bus cable to the switch or IO controller is disconnected.
■ on	There is an Ethernet connection between the Industrial Ethernet/PROFINET interface of your PROFINET device and a communication partner, e.g. IO controller.	-
☼ flashes	The "Node flash test" is running. The RN/ER/MT LEDs are also flashing.	-

15.4 Technical specifications

Technical specifications of the BusAdapters BA LC-LD/M12

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6AG70-0AA0/td?dl=de).

Article number	6ES7193-6AG70-0AA0
General information	
Product type designation	BA LC-LD / M12
Interfaces	
Number of PROFINET interfaces	1; 2 ports (switch) 1x LC-LD single-mode + 1x M12
Supports protocol for PROFINET IO	
• Number of LC ports	1; wavelength of 1 270 ... 1 380 nm, corresponds to 100BASE-LX
• Number of M12 ports	1
Cable length	
– Cu conductors	100 m
– single-mode fiber-optic cable 9/125 µm	20 km; 10 km for topology or IRT configuration; max. attenuation 13 dB
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	20 mm
Height	69.5 mm
Depth	59 mm
Weights	
Weight, approx.	45 g

BusAdapter BA-Send 1xFC

16

16.1 Product overview

Article number

6ES7193-6AS00-0AA0

View

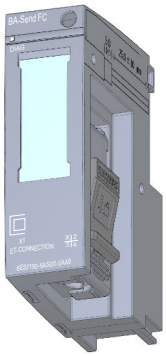

Figure 2-1784 View of the BusAdapter BA-Send 1xFC

Properties

The module has the following technical properties:

- BusAdapter for the direct connection of ET-Connection
- Connects the interface module via ET-Connection with the ET 200AL I/O modules
- Supports all ET 200AL I/O modules

The module supports the following functions:

- Identification data I&M 0 to 3. See system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

Maximum configuration

- 16 ET 200AL I/O modules
- 15 m bus cable between BusAdapter BA Send and the first ET 200AL I/O module and between two ET 200AL I/O modules.
- Supported functions:

Function	Mixed configuration		
	ET 200SP		ET 200AL I/O modules on ET-Connection
	IM	CPU	
Isochronous mode	●	--	--
Configuration control	●	●	●
Shared device	●	●	●
PROFIenergy	●	--	●
System redundancy S2	●[1]	--	●[1]

1) With IM 155-6 PN/3 HF and IM 155-6 PN/2 HF V4.2 or higher

Accessories

The following components must be ordered separately:

- Labeling strips
- Reference identification label
- Stripping tool for ET-Connection
- Bus cables for ET-Connection

See also

You will find additional information on accessories and the other components in the system manuals ET 200AL Distributed I/O System (http://support.automation.siemens.com/WW/view/en/89254965) and the Accessories/Spare parts section of the ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) system manual.

16.2 Connecting

ET-Connection with BusAdapter BA-Send 1xFC

The following table shows the signal names and the designations for the pin assignment of the BusAdapter BA-Send 1xFC.

Table 2-2198 ET connection pin assignment with BusAdapter BA-Send 1xFC

View	Signal name		Description
Port 1 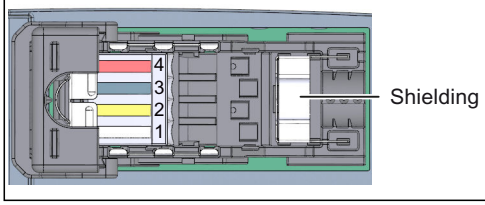	1	TD	Transmit Data +
	2	RD	Receive Data +
	3	TD_N	Transmit Data –
	4	RD_N	Receive Data -

Block diagram

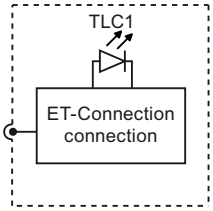

Figure 2-1785 Schematic circuit diagram for BusAdapter BA-Send 1xFC

16.3 Diagnostics

LED display

The figure below shows the LED display (status and fault display) of the BusAdapter BA-Send 1xFC.

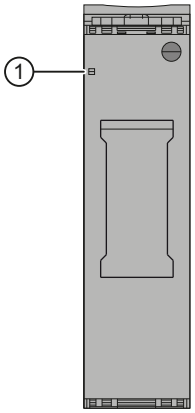

① DIAG (green/red)

Figure 2-1786 LED display

Meaning of the LED display

The table below explains the meaning of the status and fault display.

DIAG LED

Table 2-2199 Status and fault display DIAG

DIAG LED	Meaning	Remedy
□ Off	There is no connection between the ET-Connection interface of the BusAdapter BA-Send 1xFC and the ET 200AL.	Check whether the bus cable is interrupted.
	The CPU/interface module does not support the BA-Send 1xFC.	Run a firmware update.
■ On	There is a connection between the ET-Connection interface of the BusAdapter BA-Send 1xFC and the ET 200AL.	---
☼ Flashes	There is (at least) one diagnostics alarm of an ET-Connection device. Group error for all ET-Connection bus nodes.	Check the ET-Connection device.
	Set configuration does not match the actual configuration on the ET-Connection.	Check the configuration of the ET-Connection to see whether a module is missing or defective, or whether a non-configured module is wired.

16.4 Technical specifications

Technical specifications of the BusAdapter BA-Send 1xFC

The following table shows the technical specifications as of the issue date. You can find a data sheet including daily updated technical specifications on the Internet (https://support.industry.siemens.com/cs/de/en/pv/6ES7193-6AS00-0AA0/td?dl=en).

Article number	6ES7193-6AS00-0AA0
General information	
Product type designation	BA-Send 1xFC
HW functional status	From FS05
Interfaces	
Supports protocol for PROFINET IO	
Cable length	
– Cu conductors	15 m; from IM firmware V3.3: between BA-send and the first ET-CONNECTION bus node and between all other bus nodes
ET-Connection	
• Number of interfaces ET connection	1
• FC (FastConnect)	Yes
Ambient conditions	
Ambient temperature during operation	
• horizontal installation, min.	-30 °C
• horizontal installation, max.	60 °C
• vertical installation, min.	-30 °C
• vertical installation, max.	50 °C
Altitude during operation relating to sea level	
• Installation altitude above sea level, max.	5 000 m; restrictions for installation altitudes > 2 000 m, see ET 200SP system manual
Dimensions	
Width	20 mm
Weights	
Weight, approx.	44 g

Strain relief

17

17.1 Product overview

Article number

6ES7193-6RA00-1AN0 (VPE: 5 strain relief units incl. screws)

View

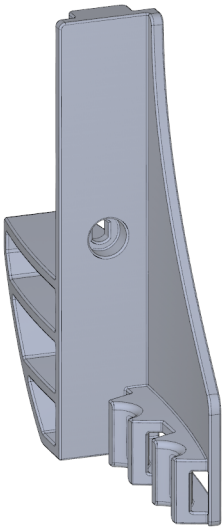

Figure 2-1787 Strain relief

Properties

- The strain relief is a mechanical protective device for the electrical Industrial Ethernet/PROFINET cables on the BusAdapter
- The strain relief is suitable for all electrical Industrial Ethernet/PROFINET cables of the BusAdapter
- The strain relief is an optional accessory.
- Cable ties are not included in the delivery. We recommend cable ties with a width of 4.8 mm. The maximum width is 7.0 mm. The length of the cable tie is min. 60 mm.

17.2 Installing

Requirement

- The Industrial Ethernet/PROFINET cables are not inserted on the BusAdapter. Inserted Industrial Ethernet/PROFINET cables impede mounting of the strain relief.
- BusAdapter and strain relief can be mounted separately.

Tools required

Screwdriver TX10 (torx).

Procedure

To install the strain relief, follow these steps:

1. Press the strain relief below the BusAdapter seat of the PROFINET device.

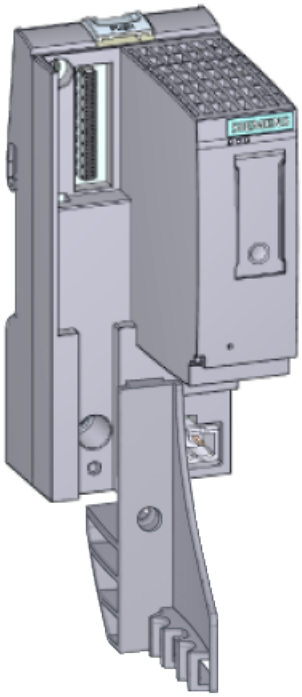

Figure 2-1788 Strain relief before mounting

2. Fasten the strain relief (1 screw with 0.7 to 0.8 Nm tightening torque).
3. Plug the BusAdapter into the PROFINET device.
4. Screw the BusAdapter to the PROFINET device (1 screw with 0.25 Nm tightening torque).

5. Fasten each Industrial Ethernet/PROFINET cable individually to the strain relief with the cable ties.

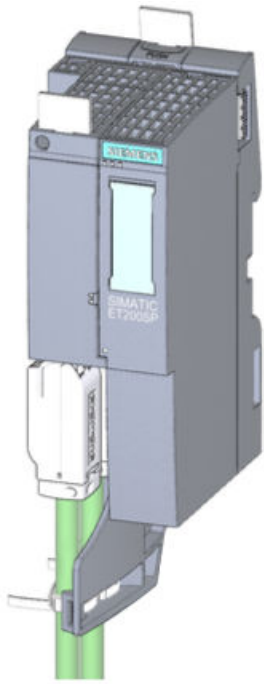

Figure 2-1789 Strain relief installed

Dimension drawings

A

A.1 BusAdapter dimension drawings

The figure below shows the dimension drawing of the BusAdapter BA 2xRJ45 as an example.

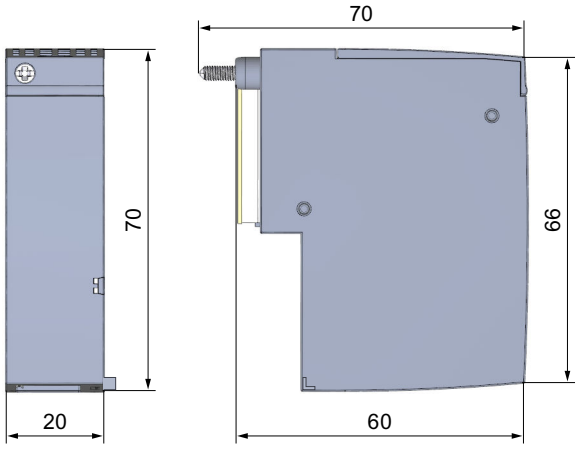

Figure 2-1790 Dimensional drawing of BusAdapter BA 2xRJ45

A.2 Strain relief dimension drawings

The figure below shows the dimension drawing of the strain relief.

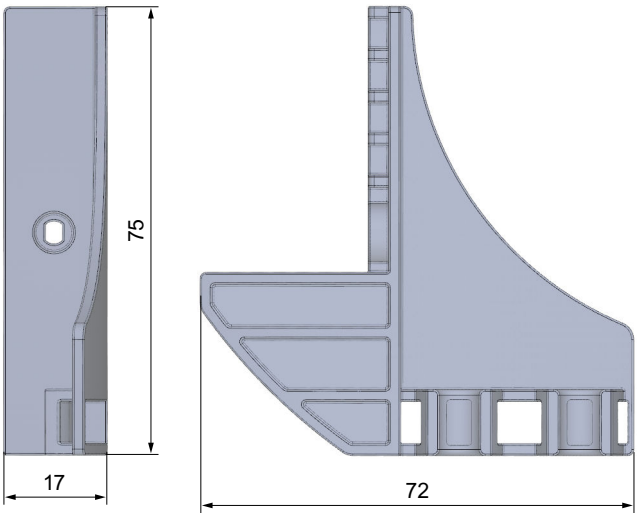

Figure 2-1791 Strain relief dimension drawing

Accessories

B

B.1 Accessories

Additional accessories are available for the SIMATIC BusAdapters:

Accessories	Article number	Property	Figure
Strain relief	6ES7193-6RA00-1AN0	The strain relief is a mechanical protective device for the electrical Industrial Ethernet/PROFINET cables on the BusAdapter. The strain relief can be ordered as optional accessory. You install the strain relief on the PROFINET device (e.g.: interface module) before you install the BusAdapter. You can find additional information in section Strain relief (Page 99).	
Reference identification label (10 mats with 16 labels each)	6ES7193-6LF30-0AW0	The labels enable the reference identification labeling of the BusAdapter. The labels can be ordered on a mat for thermal transfer and inkjet printers as optional accessories. You insert the reference identification label into the opening on the top of the BusAdapter.	

Cables and connectors

You can find the recommended cables and connectors with the respective BusAdapters.

Assembly tools

Tool	MLFB	Description
Industrial Ethernet FastConnect Stripping Tool	6GK1901-1GA00	Stripping tool for the fast stripping of IE FastConnect cables with green blade cassette
Termination Kit FC LC Plug	6GK1900-0RL00-0AA0	Assembly case for on-site assembly of FC LC connectors to FC FOC cables
Termination Kit SC RJ POF Plug	6GK1900-0ML00-0AA0	Assembly case for on-site assembly of SC RJ connectors consisting of stripping tool, Kevlar scissors, polishing set

Compatibility

C

Overview of the introduction of the BusAdapter in the engineering tools

The table shows with which STEP 7 version or HSP version you can use the BusAdapters.

	STEP 7 Classic		STEP 7 TIA Portal
	In STEP 7 Release available from	HSP version installable from	
BA 2xRJ45	V5.5.4.0	HSP0250, V1.0 V5.5.3.0	V13
BA 2xFC	V5.5.4.0	HSP0250, V1.0 V5.5.3.0	V13
BA 2xSCRJ	V5.5.4.0	HSP0250, V1.0 V5.5.3.0	V13 SP1
BA SCRJ/R45	V5.6.0.0	HSP0250, V3.0 V5.5.4.0	V13 SP1 (HSP0129)
BA SCRJ/FC	V5.6.0.0	HSP0250, V3.0 V5.5.4.0	V13 SP1 (HSP0129)
BA 2xLC	V5.6.0.0	HSP0250, V4.0 V5.5.4.0	V13 SP1 Upd6 (HSP0158)
BA LC/RJ45	V5.6.0.0	HSP0250, V4.0 V5.5.4.0	V13 SP1 Upd6 (HSP0158)
BA LC/FC	V5.6.0.0	HSP0250, V4.0 V5.5.4.0	V13 SP1 Upd6 (HSP0158)
BA 2xM12	-	HSP0250, V5.0 V5.5.4.0	V16 (HSP0302)
BA 2xLC-LD	-	-	V18
BA LC-LD/RJ45	-	-	V18
BA LC-LD/M12	-	-	V18

SIEMENS

SIMATIC

S7-1500, S7-1500R/H, ET 200SP, ET 200pro
Cycle and response times

Function Manual

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11/2024
A5E03461504-AJ

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Introduction 1

Purpose of the documentation

The controller offers various options for program execution with different run priorities. Cyclic-driven and time-driven program execution have the largest share. The response times of a controller are therefore significantly determined by the processing cycles.

There is also the possibility of event-driven program execution. The event-driven program execution is normally limited to a few selected events.

This manual provides information on the following topics:

- Types of program execution
- Run priorities
- Cycle and response times, and the influences to which they are subject
- Configuration options for the optimization of your user program

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the SIMATIC industrial automation system
- Knowledge of the use of Windows-based computers
- Knowledge of working with STEP 7

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Scope of the documentation

This documentation mainly covers the description of the CPU components of the cycle and response times of the following systems:

- SIMATIC S7-1500 automation system
- SIMATIC S7-1500R/H redundant system
- The CPUs of the ET 200SP distributed I/O system
- The CPUs of the ET 200pro distributed I/O system based on SIMATIC S7-1500

You can find links to more information on the ET 200MP, ET 200SP and ET 200pro distributed I/O systems at the corresponding points in this manual.

NOTE

F-specific monitoring and response times are not covered by the Cycle and Response Times function manual.

For F-specific monitoring and response times, refer to the programming and operating manual SIMATIC Safety - Configuration and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

What's new in edition 11/2024 compared to edition 11/2023?

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Cycle and response times	Updating of the specified cycle and response times in the Function Manual.	Starting from section Program execution
	Performance increase	You can specify the ambient conditions at the operating site in the hardware configuration and thus optimize the program processing of the CPU. Valid for: • CPU 1518-3 PN (6ES7518-3AT10-0AB0) • CPU 1518F-3 PN (6ES7518-3FT10-0AB0) • CPU 1518T-3 PN (6ES7518-3TT10-0AB0) • CPU 1518TF-3 PN (6ES7518-3UT10-0AB0)	Performance increase (Page 41) section

What's new in edition 11/2023 compared to edition 11/2022?

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Cycle and response times	Update of the specified cycle and response times in the Function Manual for the following CPUs: • CPU 1511C-1 PN (6ES7511-1CL03-0AB0) • CPU 1512C-1 PN (6ES7512-1CM03-0AB0) • CPU 1513pro-2 PN (6ES7513-2PM03-0AB0) • CPU 1513pro F-2 PN (6ES513-2GM03-0AB0) • CPU 1516pro-2 PN (6ES7516-2PP03-0AB0) • CPU 1516pro F-2 PN (6ES7516-2GP03-0AB0)	Starting from section Program execution (Page 16)

What's new in edition 11/2022 compared to edition 02/2021?

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Cycle and response times	Updating of the specified cycle and response times in the Function Manual.	Starting from section Program execution (Page 16)
	Extension of the scope of the Function Manual to include the CPU 1514SP(F)-2 PN of the ET 200SP distributed I/O system	The CPU 1514SP-2 PN extends the ET 200SP portfolio. The CPU provides the following advantages, among others: • Suitable for applications with medium requirements with regard to the program scope and the processing speed. • Integrated Motion Control functionalities for activation of speed and positioning axes, support of external encoders, cams/cam tracks and measuring probes • 2 interfaces PROFINET IO X1 and X2 The CPU 1514SP F-2 PN can additionally be used for safety functions according to IEC 61508 up to SIL 3, and ISO 13849 up to PLe for safety applications.	Starting from section Program execution (Page 16)
	Extension of the scope of validity of the Function Manual to include the CPU 1514SP T(F)-2 PN of the ET 200SP distributed I/O system	The CPU 1514SP T-2 PN extends the ET 200SP portfolio. In contrast to the CPU 1514SP-2 PN, the CPU 1514SP T-2 PN features high-performance, extended Motion Control functions, for example: • Synchronous operation • Cyclic cams Important technical specifications: • Code work memory: 900 KB • Data work memory: 3.5 MB • Motion Control resources: 2400 • Extended Motion Control resources: 120	Starting from section Program execution (Page 16)

What's new?		What are the customer benefits?	Where can I find information?
		The CPU 1514SP TF-2 PN can additionally be used for safety functions according to IEC 61508 up to SIL 3, and ISO 13849 up to PLe for safety applications.	

What's new in edition 02/2021 compared to edition 11/2019?

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Scope of the function manual expanded to include CPU 1518HF-4 PN of the S7-1500R/H redundant system	The CPU 1518HF-4 PN extends the R/H CPU portfolio by an HF CPU. The CPU offers the following advantages: • High-performance H-CPU with integrated F-functionality • The CPU can also be used for safety functions according to IEC 61508 up to SIL 3 and ISO 13849 up to PLe for safety applications. • 3 PROFINET interfaces	Starting from section Program execution (Page 16)
	Scope of the function manual expanded to include CPU 1518T-4 PN/DP of the S7-1500 automation system	CPU 1518T-4 PN/DP offers a very large program and data memory for demanding applications in applications that contain distributed I/O in addition to central automation structures. CPU 1518T-4 PN/DP features high-performance, extended Motion Control functions, for example: • Synchronous operation • Cyclic cams Important technical specifications: • Code work memory: 9 MB • Data work memory: 60 MB • Motion Control resources: 15360 • Extended Motion Control resources: 512	Starting from section Program execution (Page 16)
	Scope of the function manual expanded to include CPU 1518TF-4 PN/DP of the S7-1500 automation system	CPU 1518TF-4 PN/DP offers a very large program and data memory for demanding applications in applications that contain distributed I/O in addition to central automation structures. The CPU can also be used for safety functions according to IEC 61508 up to SIL 3 and ISO 13849 up to PLe for safety applications. CPU 1518TF-4 PN/DP features high-performance, extended Motion Control functions, for example: • Synchronous operation • Cyclic cams Important technical specifications: • Code work memory: 9 MB • Data work memory: 60 MB • Motion Control resources: 15360 • Extended Motion Control resources: 512	Starting from section Program execution (Page 16)

What's new in edition 11/2019 as compared to edition 10/2018?

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Improved visualization of the communication load in the web server	The visualization of the current communication load and its effects on the cycle time helps you to find suitable values for the parameterization of the communication load.	• In section Extension of cycle time due to communication load (Page 41) • In the Web Server (https://support.industry.siemens.com/cs/ww/en/view/591935-60) function manual

What's new in edition 10/2018 as compared to edition 09/2016?

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Scope of the function manual expanded to include CPUs of the S7-1500R/H redundant system	The determination of the cycle and response times of the S7-1500R/H redundant system follows the same principle as for the CPUs of the S7-1500 automation system.	Section Cycle and response times of the S7-1500R/H redundant system (Page 68)

What's new in the 09/2016 edition compared to the 02/2014 edition?

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Scope of the function manual expanded to include the CPUs of the ET 200SP distributed I/O system and CPU 1516pro-2 PN of the ET 200pro distributed I/O system	Functions that you will be familiar with from the SIMATIC S7-1500 CPUs are implemented in CPUs in other designs (ET 200SP) and in the CPU 1516pro-2 PN (degree of protection IP 65, IP 66 and IP 67).	Starting from section Program execution (Page 16)

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

1.1 Function Manuals documentation guide

1.1.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Program execution 3

3.1 Principle of operation

Introduction

You often program your user program with a program cycle organization block (OB), usually in OB 1. With complex applications, it is often necessary to comply with short response times required by the application. You can often meet the response time requirements by splitting the user program up into several parts with different response time requirements. The CPU offers a number of different OB types for this purpose, the properties (priority, frequency, etc.) of which can be adapted to meet your requirements.

Program organization

You can choose from the following types of program execution for running your user program:

Program execution in the cyclic program of the CPU:

The CPU executes the user program cyclically. When the execution has reached the end of a cycle, the program execution starts again in the next cycle. In the simplest case, you execute the entire user program in the cyclic program of the CPU. All tasks in the user program are then processed with equal rank. This also results in the same response times for all tasks.

In addition to program execution in the cyclic program, there is time-driven and event-driven program execution.

Time-driven execution:

In a complex user program, there are frequently portions with different response time requirements. You can optimize the response times by taking advantage of these differences in the requirements. To do so, you can break down the program parts with higher response time requirements into higher-priority OBs with shorter cycles, for example cyclic interrupt OBs.

The execution of these parts can thus occur at different frequencies and with different priorities.

Event-driven execution:

Depending on the I/O modules used, you can configure hardware interrupts for specific process events (such as an edge change of a digital input) that result in the call of the assigned hardware interrupt OB. The hardware interrupts have a higher priority and interrupt the cyclic program of the CPU. You can achieve very short response times in the CPU with hardware interrupts by directly triggering program execution.

Keep in mind that the time characteristics of your application becomes less predictable with intense use of hardware interrupts. The reason for this is that the time at which the triggering events occur can result in drastically different response times.

Tip: Use hardware interrupts only for a few selected events.

Special consideration for hardware interrupts: If you have assigned an OB to an event (hardware interrupt), the OB then has the priority of the event.

Using process image partitions

If you have distributed a program over various OBs, for example, due to different response time requirements, it is advisable and often necessary to assign the update of the used I/O data directly to these OBs. You can use process image partitions for this purpose.

You group the input and output data in a process image partition according to their use in the program and assign the data to the OB.

A process image partition of the inputs (PIPI) permits the associated input data for an OB program to be updated immediately before the OB program starts.

A process image partition of the outputs (PIPQ) permits the output data associated with an OB program to become effective on the outputs immediately after the OB program runs.

You have 32 (0 ... 31) process image partitions at your disposal. The I/O is assigned to the process image partition 0 by default (setting: "Automatic update"). Process image partition 0 is permanently assigned to cyclic execution.

You have to configure the "system-side update of process image partitions". You can find additional information on configuration of process image partitions in the online help for STEP 7 under the keyword "Assign process image/process image partition".

Interruptibility of program execution

Each organization block is processed according to the priority it has been assigned. You can adapt the priority according to the response time requirements for most organization blocks.

All program cycle OBs always have the lowest priority of 1. The highest priority is 26.

Communication tasks always have priority 15. If necessary, you can change the priority of your blocks and select a higher priority than the communication.

Organization blocks or system activities with higher priority interrupt organization blocks or system activities with lower priority. Organization blocks or system activities with higher priority interrupt thus extend the runtime of the interrupted organization blocks or system activities. If two pending tasks have the same priority, these tasks are processed in the order in which the relevant start events occurred.

NOTE

Higher priority OBs

Communication functionality is strongly influenced by too many and/or runtime-intensive OBs with a priority > 15.

When using OBs with a priority ≥ 15, you should therefore consider the runtime load that they cause.

Reference

You can find additional information on the subject of "priorities" in the "Events and OBs" section of the following manuals:

- S7-1500 automation system (https://support.industry.siemens.com/cs/ww/en/view/59191792) system manual
- S7-1500R/H redundant system (https://support.industry.siemens.com/cs/ww/en/view/109754833) system manual
- ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293) system manual
- Operating instructions CPU 1513pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109769507) and CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482416)

You can find additional information on organization blocks and their priorities for Motion Control on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109751049).

3.2 Overload behavior

CPU overload behavior

An occurring event triggers the execution of the associated OB. Depending on the OB priority and the current processor load, a time delay may occur before the OB is executed when there is an overload. The same event can therefore occur once or several times before the user program processes the OB belonging to the preceding event. The CPU handles such a situation as follows: The operating system queues the events in the queue associated with their priority in the order of their occurrence. The CPU then takes the oldest event for the highest priority and processes the associated OB. After the OB has been processed, the CPU processes the OB for the next event.

To control temporary overload situations, you can limit the number of queued events that originate from the same source. The next event is discarded as soon as the maximum number of pending triggers of a specific cyclic interrupt OB, for example, is reached.

Overload occurs when similar events occur faster than the CPU can process these events. Similar events are events from a single source, such as start events for a specific cyclic interrupt OB.

Configuration of the overload response

In the properties of an organization block in which an overload can occur, you can select the response to overload under "Attributes" and "Event queuing".

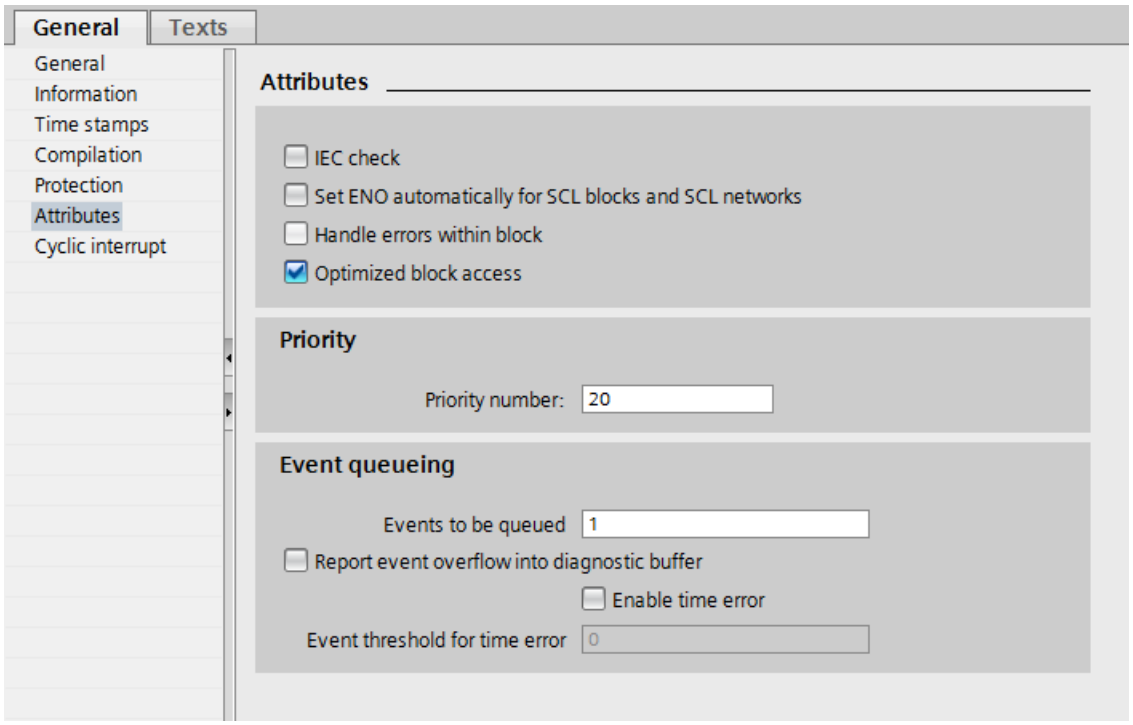

Figure 3-1 Configuration of the overload response in the block properties

Events to be queued

The OB parameter "Events to be queued" is used to specify how many similar events the operating system places in the associated queue and therefore post-processes. If this parameter has the value 1, for example, exactly one event is stored temporarily.

If the maximum number of similar start events is reached in the queue, each additional start event is only counted and subsequently discarded. During the next scheduled processing of the event, the CPU provides the number of discarded start events in the "Event_Count" input parameter (in the start information). You can then react appropriately to the overload situation. The CPU then resets the counter for lost events to zero.

NOTE

Post-processing of cyclic events is often not desirable, as this can lead to an overload with OBs of the same or lower priority. Therefore, it is generally advantageous to discard similar events and to react to the overload situation during the next scheduled OB processing. A low value of the "Events to be queued" parameter mitigates an overload situation.

To ensure that the CPU processes the OB of at least one queued event, the minimum number of events to be queued is "1". The maximum number of events that can be queued is "12".

Report event overflow into diagnostic buffer

If the CPU first discards a start event of a cyclic interrupt OB, for example, its further behavior depends on the OB parameter "Report event overflow into diagnostic buffer". If you have selected the check box, the CPU enters the event in the diagnostic buffer for the overload

situation at this event source. If an overload situation occurs again (overflow counter changes from 0 to 1), another diagnostic buffer entry is made at the next OB end.

Enable time error

The cyclic interrupt OB parameter "Enable time error" is used to specify whether the CPU is to call a time error OB when a specific overload level is reached for similar events. You use the OB parameter "Enable time error" to program a reaction to an overload before the limit for similar events is reached. The reaction occurs before the CPU discards similar events.

By default, the "Enable time error" parameter is not set.

Event threshold for time error

Select the "Enable time error" check box to enable the "Event threshold for time error" OB parameter. You use the "Event threshold for time error" OB parameter to specify how many similar events in the queue are permitted before the CPU calls a time error OB.

The following value range applies to the "Event threshold for time error" parameter:

1 ≤ "Event threshold for time error" ≤ "Events to be queued".

Example 1

The following example shows the response of the CPU when multiple similar events occur faster than the CPU can process the associated OBs. In example 1, the user selected the following parameter assignment:

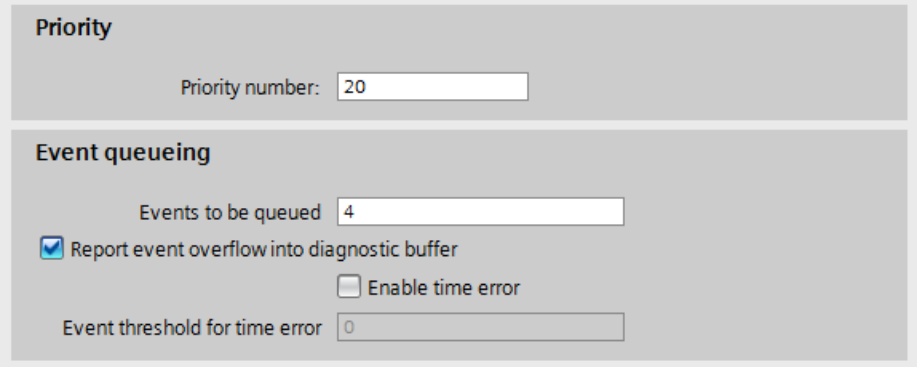

Figure 3-2 Example of parameter assignment for the overload behavior

The figure below shows the processing sequence as soon as an event calls an associated OB.

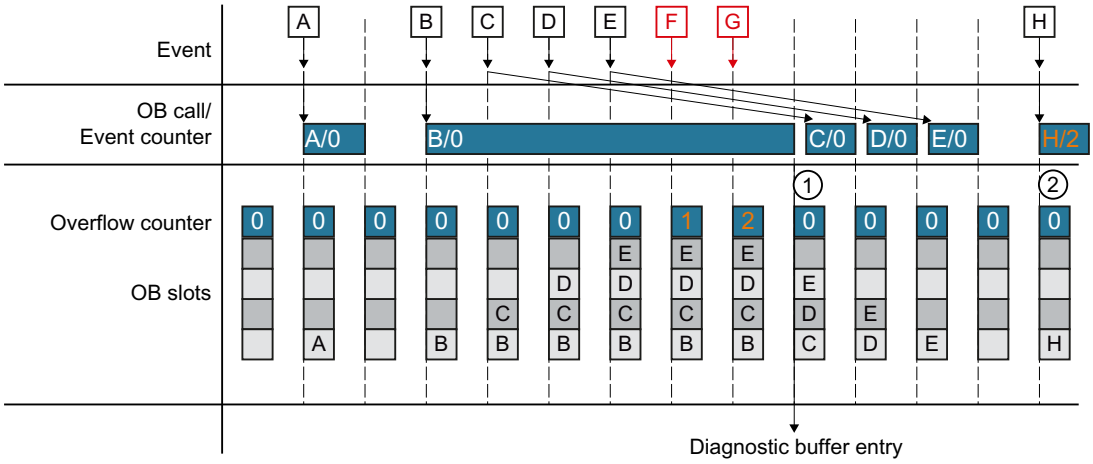

Figure 3-3 Example 1

As soon as an occurring event calls an OB, the event occupies a slot of the OB. The occupied slot is free again as soon as the CPU has processed the event. If the CPU has not completed processing the OB of an occurring event, additional occurring events each occupy an additional slot of the OB during this time. As soon as this number exceeds the configured number of events to be queued, these events are discarded and counted by the overflow counter. When an OB which takes a long time to run is completed, the CPU creates an entry in the diagnostic buffer and sets the overflow counter to zero (①). After the CPU has processed this long-running OB, the CPU then processes the OBs of the events that are queued one after the other. At the next new occurring event, the CPU writes the previous value of the reset overflow counter to the start information of the OB. The CPU then processes the OB (②).

Example 2

In example 2, the user has selected the following parameter assignment:

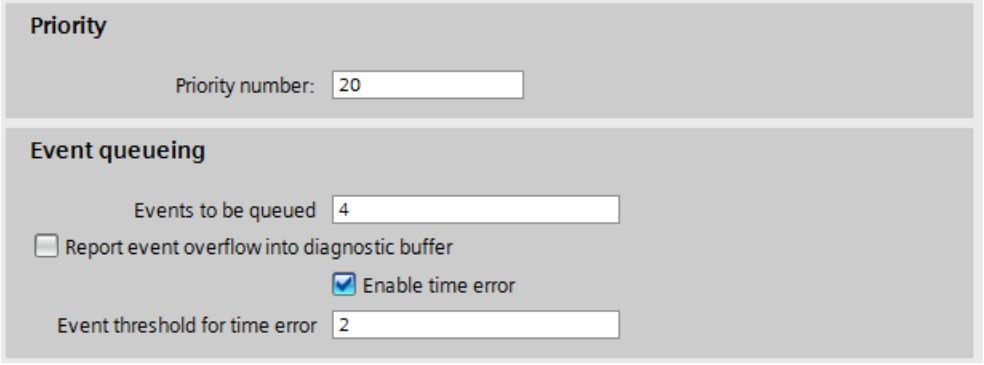

Figure 3-4 Example of parameter assignment for the overload behavior

Contrary to example 1, the CPU in example 2 requests a time error as soon as the configured event threshold has been exceeded. An additional time error can then only occur if all slots of the OB have been free once in the meantime.

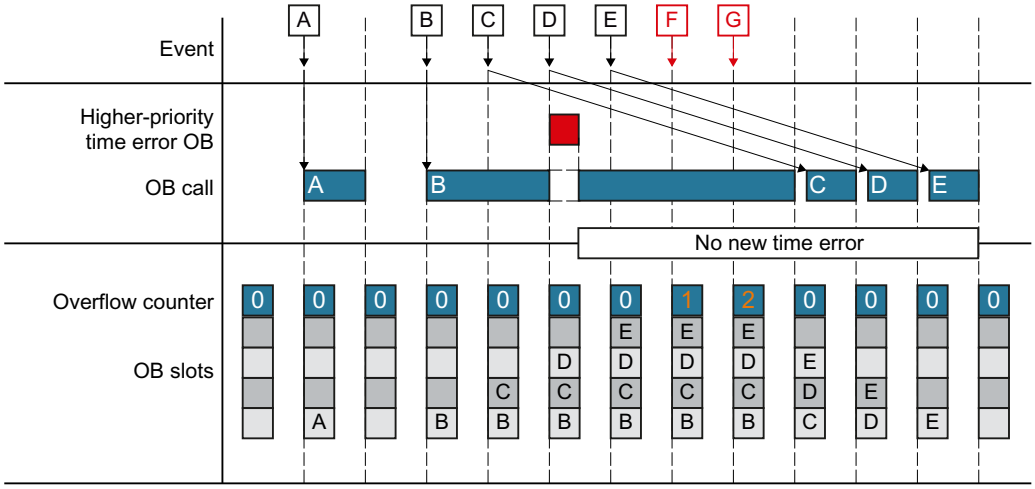

Figure 3-5 Example 2

Cyclic program execution

4

Validity

The statements of the section "Cyclic program execution" apply to the CPU components of the following systems:

- S7-1500 automation system
- ET 200MP and ET 200SP distributed I/O systems
- The CPUs of the ET 200pro distributed I/O system based on SIMATIC S7-1500
- S7-1500R/H redundant system (in RUN-Solo system state)
  In RUN-Redundant system state, the statements of section "Cycle and response times of the S7-1500R/H redundant system (Page 68)" apply.

Restrictions

With the S7-1500R/H redundant system, there are restrictions compared to the S7-1500 automation system. The S7-1500R/H redundant system does not support all hardware properties and firmware functions of the S7-1500 automation system.

The restrictions are described in the S7-1500R/H redundant system (https://support.industry.siemens.com/cs/ww/en/view/109754833) system manual.

4.1 Cycle

Definition of cycle

A cycle includes the following sections:

- Automatic update of process image partition 0 of the outputs (PIPQ 0)
- Automatic update of process image partition 0 of the inputs (PIPI 0)
- Execution of the cyclic program

The process image partition 0 is automatically updated in the cycle. You assign the I/O addresses to these process image partitions (PIPI 0/PIPQ 0) when you configure the I/O modules via the "Automatic update" setting (default).

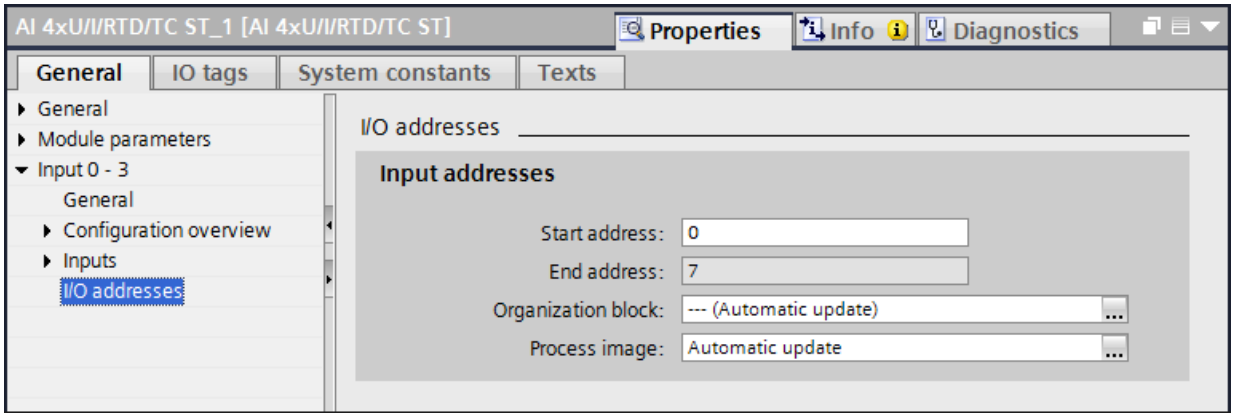

Figure 3-6 Assigning I/O addresses to process image partitions

The figure below illustrates the phases that are passed through during a cycle. In the example below the user has configured a minimum cycle time. Updating of the process image partitions and processing of the cyclic program is completed before the end of the configured minimum cycle time. Therefore, the CPU waits until the configured minimum cycle time has expired before the next program cycle starts.

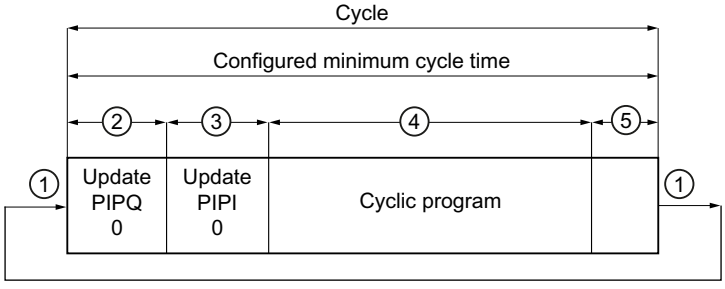

① Cycle control point at which the operating system starts measurement of the cycle time.

② The CPU writes the states from the process image output to the output modules.

③ The CPU reads the status of the inputs at the input modules and writes the input data to the process image input.

④ The CPU processes the user program and executes the instructions specified in the program.

⑤ Wait phase until end of configured minimum cycle time

Figure 3-7 Cycle

Cycle control point

When the cycle control point is reached, the CPU has completed the cycle program and is no longer executing OBs. All user data are consistent at this time. The requirement is that no communication that modifies user data (such as HMI communication or PUT/GET communication) is active.

The cycle control point marks:

- The end of a cycle and its cycle time statistics
- The start of the next cycle and its cycle time statistics
- The restart of the monitoring of the configured maximum cycle time (time-out counter is reset)

The cycle control point is reached depending on which of the following events occurred last:

- End of the last program cycle OB
- Expiry of the minimum cycle time (if configured)

After the cycle control point has been reached, the CPU executes the following steps:

1. Writes the process image outputs to the output modules
2. Reads in the status of the inputs from the input modules into the process image input
3. Executes the first program cycle OB

4.2 Cycle time

Definition of cycle time

The cycle time is the time the CPU needs for:

- Updating the process image inputs/outputs
- Executing the cyclic program
- All program parts and system activities interrupting this cycle
- Waiting for the minimum cycle time (if it is parameterized and is longer than the program execution time)

4.2.1 Different cycle times

Introduction

The cycle time (T_{cyc}) is not the same in each cycle because the processing times may vary. Causes of this include:

- For example, different program runtimes:
  - Program loops
  - Conditional commands
  - Conditional block calls
  - Different program paths
- Lengthening due to interruptions, for example:
  - Time-driven interrupt processing
  - Event-driven interrupt processing
  - Communication

Causes of different cycle times

The figure below shows the different cycle times T_{cyc1} and T_{cyc2} using an example.

Because the cyclic program is interrupted by a cyclic interrupt OB in this example (for example: OB 30), the cycle time T_{cyc2} is greater than T_{cyc1}. The cyclic interrupt OB in turn is interrupted by Motion Control functions and communication.

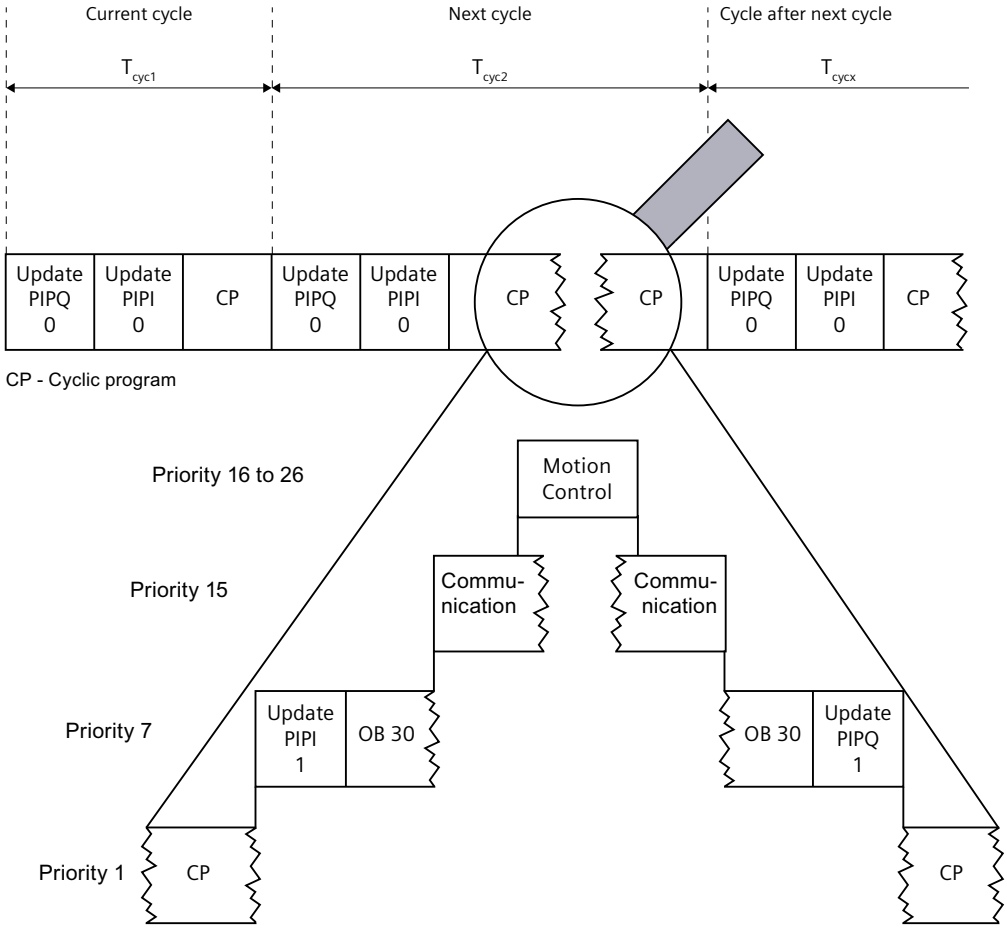

Figure 3-8 Possible causes of differing cycle times

Minimum cycle time

In STEP 7, you can set a minimum cycle time for a CPU. The default setting for the minimum cycle time of the non-redundant CPUs is one millisecond. It is advisable to increase this setting in the following cases:

- To reduce the cycle time's fluctuation range.
- To make remaining computing time available for communication tasks. The CPU then processes these communication tasks until the minimum cycle time has expired. Making the remaining computing time available to communication tasks offers the following advantages:
  - Longer minimum cycle times prevent that process images are updated unnecessarily often and thus lead to less load on the backplane bus.
  - Longer minimum cycle times result in an increase in communication performance.

Maximum cycle time

The maximum cycle time is a configurable upper limit of the cyclic program runtime. The task of the maximum cycle time is to monitor the response time required for the respective process.

The maximum cycle time of non-redundant CPUs is set to 150 ms by default. You can set this value from 1 ms to 6000 ms when assigning parameters to the CPU. When the time of the cycle currently being processed is longer than the maximum cycle time, the time error OB (OB 80) is called. You specify how the CPU responds to the time error with the user program in OB 80.

The following table shows the response of the CPU to the cycle time being exceeded with and without a configured OB 80:

Table 3-1 Response of the CPU to cycle time being exceeded

Number of times cycle time is exceeded ⇒	Operating mode
First time cycle time is exceeded[1)] without OB 80 ⇒	STOP
First time cycle time is exceeded with OB 80 ⇒	RUN
Second time cycle time is exceeded with OB 80 ⇒	STOP

1) Within the current cycle

For the behavior of the R/H CPUs in the event of cycle time overruns, refer to the section Maximum cycle time and time errors (Page 68).

Cycle time statistics

You can read the cycle time statistics either directly from STEP 7 ("Online tools" task card) or with the "RT_INFO" instruction.

You can use the "RT_INFO" instruction to generate statistics in STEP 7 on the runtime of specific organization blocks for communication or for the user program. For example, this includes

- The shortest and longest cycle time
- The portions of runtime used for communication and the user program

---

NOTE

Showing the cycle time statistics on the display and Web server

With the S7-1500 CPUs, you also have the option of calling the cycle time statistics via the display of the CPU. As of firmware version 2.0 of the CPUs, the cycle time statistics are also displayed in the Web server.

To view the cycle time statistics directly in STEP 7, follow these steps:

1. Establish an online connection to the CPU with STEP 7.
2. Select the "Online tools" task card.

Result: The diagram of the cycle time statistics is displayed in the cycle time section.

The following figure shows an extract from STEP 7 with the cycle time statistics. In this example, the cycle time fluctuates between 7 ms and 12 ms. The current cycle time is 10 ms. The maximum cycle time in this example is set to 40 ms.

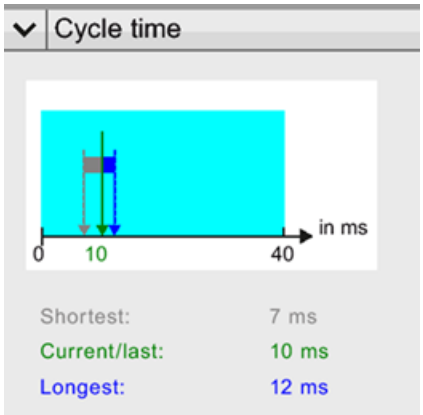

Figure 3-9 Cycle time statistics

You can find additional information on the runtime characteristics of the CPU with the "RT_INFO" instruction in the user program. The instruction includes information about:

- The utilization of the CPU by the user program and communication in percentage
- The runtimes of the individual OBs

With the "RT_INFO" instruction, you can reset the cycle time statistics and thus start a new measurement of the shortest and longest cycle time.

Reference

Additional information on the "RT_INFO" instruction is available in the STEP 7 online help.

4.2.2 Influences on the cycle time

4.2.2.1 Update time for process image partitions

Estimating update time for process image partitions

The update time of the process image partitions depends on the volume of assigned central and distributed I/O module data.

You can estimate the update time using the following formula:

Base load for process image update
+ Number of words in the process image x copy time for central I/O
+ Number of words in the process image via DP x copy time for PROFIBUS I/O

+ Number of words in the process image via PROFINET x copy time for PROFINET I/O

= **Update time of the process image partition**

Update times of the process image partitions

The following table contains the times for estimating the typical update times of the process image partitions.

Update time of the process image partitions for the S7-1500 CPUs

Table 3-2 Data for estimating the typical update time of the process image partitions for the S7-1500 CPUs

Components	**Update times of the S7-1500 CPUs**			
	Article numbers xxxxxxx-xxx00-xxxx, xxxxxxx-xxx01-xxxx, xxxxxxx-xxx02-xxxx			
	1511(T)(F)-1 PN 1511C-1 PN 1512C-1 PN 1513(F)-1 PN	**1515(T)(F)-2 PN 1516(T)(F)-3 PN/DP**	**1517(T)(F)-3 P-N/DP**	**1518(T)(F)-4 P-N/DP 1518(F)-4 PN/D-P MFP**
Basic load for updating process image partitions	35 µs	30 µs	7 µs	5 µs
Copy time for central I/O	9 µs/word	8 µs/word	5 µs/word	4 µs/word
Copy time for distributed I/O via PROFIBUS	0.5 µs/word	0.5 µs/word	0.4 µs/word	0.3 µs/word
Copy time for distributed I/O via PROFINET	0.5 µs/word	0.5 µs/word	0.4 µs/word	0.3 µs/word

Components	Update times of the S7-1500 CPUs			
	Article number xxxxxxx-xxx03-xxxx	**Article number xxxxxxx-xxx10-xxxx**		
	1511(T)(F)-1 PN 1511C-1 PN 1512C-1 PN 1513(F)-1 PN 1515(T)(F)-2 PN 1516(F)-3 PN/DP	**1516T(F)-3 PN**	**1517(T)(F)-3 PN**	**1518(T)(F)-3 PN**
Basic load for updating process image partitions	30 µs	30 µs	7 µs	5 µs
Copy time for central I/O	8 µs/word	8 µs/word	5 µs/word	4 µs/word
Copy time for distributed I/O via PROFIBUS	0.5 µs/word	0.5 µs/word	0.4 µs/word	0.3 µs/word
Copy time for distributed I/O via PROFINET	0.5 µs/word	0.5 µs/word	0.4 µs/word	0.3 µs/word

Update time of the process image partitions for the ET 200SP CPUs

Table 3-3 Data for estimating the typical update time of the process image partitions for the ET200SP CPUs

Components	Update time of the ET 200SP CPUs
	Article numbers xxxxxxx-xxx00-xxxx, xxxxxxx-xxx01-xxxx
	1510SP(F)-1 PN 1512SP(F)-1 PN
Basic load for updating process image partitions	60 µs
Copy time for central I/O	0.5 µs/word
Copy time for distributed I/O via PROFIBUS	0.5 µs/word
Copy time for distributed I/O via PROFINET	0.5 µs/word

Components	Update time of the ET 200SP CPUs	
	Article number xxxxxxx-xxx03-xxxx	**All article numbers**
	1510SP(F)-1 PN **1512SP(F)-1 PN** **1514SP(T)(F)-2 PN**	**1515SP(F)-PC**
Basic load for updating process image partitions	60 µs	30 µs
Copy time for central I/O	0.5 µs/word	0.5 µs/word
Copy time for distributed I/O via PROFIBUS	0.5 µs/word	0.5 µs/word
Copy time for distributed I/O via PROFINET	0.5 µs/word	0.5 µs/word

NOTE

Update time of the backplane bus for ET 200SP CPUs

For the update time of the ET 200SP CPUs, observe also the information in table "Update time of the ET 200SP CPUs" of the section Response time for cyclic and time-driven program execution (Page 57).

Update time of the process image partitions for the ET 200pro CPUs

Table 3-4 Data for estimating the typical update time of the process image partitions for the ET200pro CPUs

Components	Update time of the ET 200pro CPUs	
	Article number xxxxxxx-xxx00-xxxx	**Article numbers xxxxxxx-xxx00-xxxx, xxxxxxx-xxx03-xxxx**
	1513pro(F)-2 PN	**1513pro(F)-2 PN** **1516pro(F)-2 PN**
Basic load for updating process image partitions	35 µs	30 µs
Copy time for central I/O	140 µs/word	120 µs/word
Copy time for distributed I/O via PROFIBUS	0.5 µs/word	0.5 µs/word
Copy time for distributed I/O via PROFINET	0.5 µs/word	0.5 µs/word

4.2.2.2 User program execution time

Introduction

Organization blocks or system activities with higher priority interrupt organization blocks or system activities with lower priority, and thus extend their runtime.

Program execution time without interruptions

The user program has a certain runtime without interruptions. The runtime depends on the number of operations that are executed in the user program.

The following table contains the typical durations of operations.

Duration of an operation for the S7-1500 CPUs

Table 3-5 Duration of an operation for the S7-1500 CPUs

	S7-1500						
	Article numbers xxxxxxx-xxx00-xxxx, xxxxxxx-xxx01-xxxx, xxxxxxx-xxx02-xxxx						
	1511(T)(F)-1 PN 1511C-1 PN	**1512C-1 PN**	**1513(F)-1 PN**	**1515(T)(F)-2 PN**	**1516(T)(F)-3 PN/DP**	**1517(T)(F)--3 PN/DP**	**1518(T)(F)--4 PN/DP 1518(F)-4 PN/DP MFP**
Bit operations, typ.	60 ns	48 ns	40 ns	30 ns	10 ns	2 ns	1 ns
Word operations, typ.	72 ns	58 ns	48 ns	36 ns	12 ns	3 ns	2 ns
Fixed-point arithmetic, typ.	96 ns	77 ns	64 ns	48 ns	16 ns	3 ns	2 ns
Floating-point arithmetic, typ.	384 ns	307 ns	256 ns	192 ns	64 ns	12 ns	6 ns

	S7-1500			
	Article number xxxxxxx-xxx03-xxxx	**Article number xxxxxxx-xxx10-xxxx**		
	1511(T)(F)-1 PN 1511C-1 PN 1512C-1 PN 1513(F)-1 PN 1515(T)(F)-2 PN 1516(F)-3 PN/DP	**1516T(F)-3 PN**	**1517(T)(F)-3 PN**	**1518(T)(F)-3 PN**
Bit operations, typ.	6 ns	1.2 ns	0.6 ns	0.3 ns
Word operations, typ.	7 ns	2.6 ns	1.3 ns	0.8 ns
Fixed-point arithmetic, typ.	9 ns	2.6 ns	1.3 ns	0.8 ns
Floating-point arithmetic, typ.	37 ns	7.6 ns	3.8 ns	2.5 ns

Duration of an operation for the S7-1500R/H CPUs

Table 3-6 Duration of an operation for the S7-1500R/H CPUs

	S7-1500R* in RUN-Solo system state		
	Article number xxxxxxx-xxx00-xxxx		
	1513R-1 PN	1515R-2 PN	1517H-3 PN 1518HF-4 PN
Bit operations, typ.	40 ns	30 ns	2 ns
Word operations, typ.	48 ns	36 ns	3 ns
Fixed-point arithmetic, typ.	64 ns	48 ns	3 ns
Floating-point arithmetic, typ.	256 ns	192 ns	12 ns

	S7-1500R/H* in RUN-Solo system state	
	Article number xxxxxxx-xxx03-xxxx	Article number xxxxxxx-xxx10-xxxx
	1513R-1 PN 1515R-2 PN	1517H-4 PN 1518HF-4 PN
Bit operations, typ.	12 ns	0.6 ns
Word operations, typ.	15 ns	1.3 ns
Fixed-point arithmetic, typ.	20 ns	1.3 ns
Floating-point arithmetic, typ.	78 ns	3.8 ns

* Additional information about cycle and response times of R/H CPUs is available in the section "Cycle and response times of the S7-1500R/H redundant system"

Duration of an operation for the ET 200SP CPUs

Table 3-7 Duration of an operation for the ET 200SP CPUs

	ET 200SP	
	Article numbers xxxxxxx-xxx00-xxxx, xxxxxxx-xxx01-xxxx	
	1510SP(F)-1 PN	1512SP(F)-1 PN
Bit operations, typ.	72 ns	48 ns
Word operations, typ.	86 ns	58 ns
Fixed-point arithmetic, typ.	115 ns	77 ns
Floating-point arithmetic, typ.	461 ns	307 ns

	ET 200SP	
	Article number xxxxxxx-xxx03-xxxx	**All article numbers**
	1510SP(F)-1 PN **1512SP(F)-1 PN** **1514SP(T)(F)-2 PN**	**1515SP(F)-PC**
Bit operations, typ.	6 ns	30 ns
Word operations, typ.	7 ns	36 ns
Fixed-point arithmetic, typ.	9 ns	48 ns
Floating-point arithmetic, typ.	37 ns	192 ns

Duration of an operation for the ET 200pro CPUs

Table 3-8 Duration of an operation for the ET 200pro CPUs

	ET 200pro	
	Article number xxxxxxx-xxx00-xxxx	
	1513pro(F)-2 PN	**1516pro(F)-2 PN**
Bit operations, typ.	40 ns	10 ns
Word operations, typ.	48 ns	12 ns
Fixed-point arithmetic, typ.	64 ns	16 ns
Floating-point arithmetic, typ.	256 ns	64 ns

	ET 200pro
	Article number xxxxxxx-xxx03-xxxx
	1513pro(F)-2 PN **1516pro(F)-2 PN**
Bit operations, typ.	6 ns
Word operations, typ.	7 ns
Fixed-point arithmetic, typ.	9 ns
Floating-point arithmetic, typ.	37 ns

NOTE

Instruction "RUNTIME"

Please note that the times specified in the tables are typical values. There can therefore be user programs that deviate from the specified typical values.

Make sure to check the runtime of critical program sequences beforehand with the "RUNTIME" instruction.

Extension due to nesting of higher-priority OBs and/or interrupts

The interruption of a user program by a higher-priority OB causes a certain basic time expenditure. Take account of this basic time expenditure in addition to the update time of the assigned process image partitions and the execution time of the contained user program. The following tables contain the typical times for the various interrupts and error events.

Basic time expenditure for an interrupt for the S7-1500 CPUs

Table 3-9 Basic time expenditure for an interrupt for the S7-1500 CPUs

	S7-1500	
	Article numbers xxxxxxx-xxx00-xxxx, xxxxxxx-xxx01-xxxx, xxxxxxx-xxx02-xxxx	
	1511(T)(F)-1 PN 1511C-1 PN 1512C-1 PN 1513(F)-1 PN	**1515(T)(F)-2 PN 1516(T)(F)-3 PN/DP**
Hardware interrupt	90 µs	80 µs
Time-of-day interrupt	90 µs	80 µs
Time-delay interrupt	90 µs	80 µs
Cyclic interrupt	90 µs	80 µs

	S7-1500		
	Article number xxxxxxx-xxx03-xxxx	**All article numbers**	
	1511(T)(F)-1 PN 1511C-1 PN 1512C-1 PN 1513(F)-1 PN 1515(T)(F)-2 PN 1516(F)-3 PN/DP	**1517(T)(F)-3 PN 1517(T)(F)-3 PN/DP**	**1518(T)(F)-3 PN 1518(T)(F)-4 PN/DP 1518(F)-4 PN/DP MFP**
Hardware interrupt	80 µs	20 µs	12 µs
Time-of-day interrupt	80 µs	20 µs	12 µs
Time-delay interrupt	80 µs	20 µs	12 µs
Cyclic interrupt	80 µs	20 µs	12 µs

Basic time expenditure for an interrupt for the S7-1500R/H CPUs

Table 3-10 Basic time expenditure for an interrupt for the S7-1500R/H CPUs

	S7-1500R* in RUN-Solo system state	
	Article number xxxxxxx-xxx00-xxxx	
	1513R-1 PN	**1515R-2 PN**
Hardware interrupt	170 µs	140 µs
Time-of-day interrupt	170 µs	140 µs
Time-delay interrupt	170 µs	140 µs
Cyclic interrupt	170 µs	140 µs

	S7-1500R/H* in RUN-Solo system state	
	Article number xxxxxxx-xxx03-xxxx	**All article numbers**
	1513R-1 PN **1515R-2 PN**	**1517H-3 PN** **1517H-4 PN** **1518HF-4 PN**
Hardware interrupt	90 µs	20 µs
Time-of-day interrupt	90 µs	20 µs
Time-delay interrupt	90 µs	20 µs
Cyclic interrupt	90 µs	20 µs

* Additional information about cycle and response times of R/H CPUs is available in the section "Cycle and response times of the S7-1500R/H redundant system"

Basic time expenditure for an interrupt for the ET 200SP CPUs

Table 3-11 Basic time expenditure for an interrupt for the ET 200SP CPUs

	ET 200SP
	Article numbers xxxxxxx-xxx00-xxxx, xxxxxxx-xxx01-xxxx
	1510SP(F)-1 PN **1512SP(F)-1 PN**
Hardware interrupt	90 µs
Time-of-day interrupt	90 µs
Time-delay interrupt	90 µs
Cyclic interrupt	90 µs

	ET 200SP	
	Article number xxxxxxx-xxx03-xxxx	**All article numbers**
	1510SP(F)-1 PN **1512SP(F)-1 PN** **1514SP(T)(F)-2 PN**	**1515SP(F)-PC**
Hardware interrupt	80 µs	80 µs
Time-of-day interrupt	80 µs	80 µs
Time-delay interrupt	80 µs	80 µs
Cyclic interrupt	80 µs	80 µs

Basic time expenditure for an interrupt for the ET 200pro CPUs

Table 3-12 Basic time expenditure for an interrupt for the ET 200pro CPUs

	ET 200pro	
	Article number xxxxxxx-xxx00-xxxx	
	1513pro(F)-2 PN	**1516pro(F)-2 PN**
Hardware interrupt	90 µs	80 µs
Time-of-day interrupt	90 µs	80 µs
Time-delay interrupt	90 µs	80 µs
Cyclic interrupt	90 µs	80 µs

	ET 200pro
	Article number xxxxxxx-xxx03-xxxx
	1513pro(F)-2 PN 1516pro(F)-2 PN
Hardware interrupt	80 µs
Time-of-day interrupt	80 µs
Time-delay interrupt	80 µs
Cyclic interrupt	80 µs

Basic time expenditure for an error OB for the S7-1500 CPUs

Table 3-13 Basic time expenditure for an error OB for the S7-1500 CPUs

	S7-1500	
	Article numbers xxxxxxx-xxx00-xxxx, xxxxxxx-xxx01-xxxx, xxxxxxx-xxx02-xxxx	
	1511(T)(F)-1 PN 1511C-1 PN 1512C-1 PN 1513(F)-1 PN	1515(T)(F)-2 PN 1516(T)(F)-3 PN/DP
Programming error	90 µs	80 µs
I/O access error	90 µs	80 µs
Time error	90 µs	80 µs
Diagnostic interrupt	90 µs	80 µs
Module failure/recovery	90 µs	80 µs
Station failure/recovery	90 µs	80 µs

	S7-1500		
	Article number xxxxxxx-xxx03-xxxx	All article numbers	
	1511(T)(F)-1 PN 1511C-1 PN 1512C-1 PN 1513(F)-1 PN 1515(T)(F)-2 PN 1516(F)-3 PN/DP	1517(T)(F)-3 PN 1517(T)(F)-3 PN/DP	1518(T)(F)-3 PN 1518(T)(F)-4 PN/DP 1518(F)-4 PN/DP MFP
Programming error	80 µs	20 µs	12 µs
I/O access error	80 µs	20 µs	12 µs
Time error	80 µs	20 µs	12 µs
Diagnostic interrupt	80 µs	20 µs	12 µs
Module failure/recovery	80 µs	20 µs	12 µs
Station failure/recovery	80 µs	20 µs	12 µs

Basic time expenditure for an error OB for the S7-1500R/H CPUs

Table 3-14 Basic time expenditure for an error OB for the S7-1500R/H CPUs

	S7-1500R* in RUN-Solo system state	
	Article number xxxxxxx-xxx00-xxxx	
	1513R-1 PN	**1515R-2 PN**
Programming error	170 µs	140 µs
I/O access error	170 µs	140 µs
Time error	170 µs	140 µs
Diagnostic interrupt	170 µs	140 µs
Module failure/recovery	170 µs	140 µs
Station failure/recovery	170 µs	140 µs

	S7-1500R/H* in RUN-Solo system state	
	Article number xxxxxxx-xxx03-xxxx	**All article numbers**
	1513R-1 PN **1515R-2 PN**	**1517H-3 PN** **1517H-4 PN** **1518HF-4 PN**
Programming error	90 µs	20 µs
I/O access error	90 µs	20 µs
Time error	90 µs	20 µs
Diagnostic interrupt	90 µs	20 µs
Module failure/recovery	90 µs	20 µs
Station failure/recovery	90 µs	20 µs

* Additional information about cycle and response times of R/H CPUs is available in the section "Cycle and response times of the S7-1500R/H redundant system"

Basic time expenditure for an error OB for the ET 200SP CPUs

Table 3-15 Basic time expenditure for an error OB for the ET 200SP CPUs

	ET 200SP
	Article numbers xxxxxxx-xxx00-xxxx, xxxxxxx-xxx01-xxxx
	1510SP(F)-1 PN **1512SP(F)-1 PN**
Programming error	90 µs
I/O access error	90 µs
Time error	90 µs
Diagnostic interrupt	90 µs
Module failure/recovery	90 µs
Station failure/recovery	90 µs

	ET 200SP	
	Article number xxxxxxx-xxx03-xxxx	**All article numbers**
	1510SP(F)-1 PN 1512SP(F)-1 PN 1514SP(T)(F)-2 PN	**1515SP(F)-PC**
Programming error	80 µs	80 µs
I/O access error	80 µs	80 µs
Time error	80 µs	80 µs
Diagnostic interrupt	80 µs	80 µs
Module failure/recovery	80 µs	80 µs
Station failure/recovery	80 µs	80 µs

Basic time expenditure for an error OB for the ET 200pro CPUs

Table 3-16 Basic time expenditure for an error OB for the ET 200pro CPUs

CPU	**ET 200pro**	
	Article number xxxxxxx-xxx00-xxxx	
	1513pro(F)-2 PN	**1516pro(F)-2 PN**
Programming error	90 µs	80 µs
I/O access error	90 µs	80 µs
Time error	90 µs	80 µs
Diagnostic interrupt	90 µs	80 µs
Module failure/recovery	90 µs	80 µs
Station failure/recovery	90 µs	80 µs

CPU	**ET 200pro**
	Article number xxxxxxx-xxx03-xxxx
	1513pro(F)-2 PN 1516pro(F)-2 PN
Programming error	80 µs
I/O access error	80 µs
Time error	80 µs
Diagnostic interrupt	80 µs
Module failure/recovery	80 µs
Station failure/recovery	80 µs

Reference

You can find additional information on the topic of error handling in the Events and OBs section of the

- S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792) system manual
- S7-1500R/H redundant system (https://support.industry.siemens.com/cs/ww/en/view/109754833) system manual
- ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) system manual
- In the CPU 1513pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109769507) and CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482416) operating instructions, each in the Events and OBs chapter

You can find additional information on the topic of the complete cycle time of a program in an FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/87668055).

4.2.2.3 Performance increase

The configuration of more restrictive ambient conditions than given in the technical specifications allows the power consumption of the CPU 1518(T)(F)-3 PN to be adjusted. In this way, you can increase the speed of program processing.

If the set ambient temperature is exceeded, the power consumption is reduced to protect the device. This significantly increases the cycle time and can result in a STOP of the CPU due to the cycle time being exceeded. A mode change is required to leave this state.

Table 3-17 Program processing speed depending on the set maximum ambient temperature

	S7-1500 6ES751x-xxx10-0AB0		
	1516T(F)-3 PN 1517(T)(F)-3 PN	**1518(T)(F)-3 PN**	**1517H-4 PN 1518HF-4 PN**
Standard performance	100%	100%	100%
Horizontal mounting position, max. 50 °C	---	Approx. 125%	---
Overtemperature [1]	Approx. 50%	Approx. 50%	Approx. 50%

[1] If the set maximum ambient temperature is exceeded, the performance is reduced to the specified value.

4.2.2.4 Extension of cycle time due to communication load

Impact of communication on the cycle time

In the sequence model of the CPU, communication tasks are processed with priority 15. All program parts with priority > 15 (e.g. for Motion Control functions) are unaffected by communication.

Configured communication load

The CPU operating system provides the maximum specified percentage of total CPU processing power for communication tasks. The communication load can be set in STEP 7 for the CPUs of the S7 series. The default value when creating a CPU depends on the type and version of CPU used. If the processing power is not needed for communication, then the processing power is available to the operating system and the user program.

Communication is allocated the requisite computing time in 1 ms increments, with priority 15. At 50% communication load, 500 µs of each 1 millisecond are used for communication.

The following formula may be used to estimate the extension of the cycle time by communication.

$$\text{Actual cycle time} = \text{Cycle time without communication} \times \frac{100}{100 - \text{"configured communication load in \%"}}$$

Figure 3-10 Formula: Impact of communication load

With a complete use of the communication load of 50% (default), the following value results:

$$\text{Actual cycle time} = \text{Cycle time without communication} \times 2$$

Figure 3-11 Extension of cycle time due to communication load

The actual cycle time is up to twice as long as the cycle time without communication when you use the default communication load.

Dependency of maximum cycle time on the configured communication load

The chart shows the nonlinear relationship between maximum cycle time and configured communication load with a cycle time without communication of 10 ms. In the example, there are no OBs with a priority > 1.

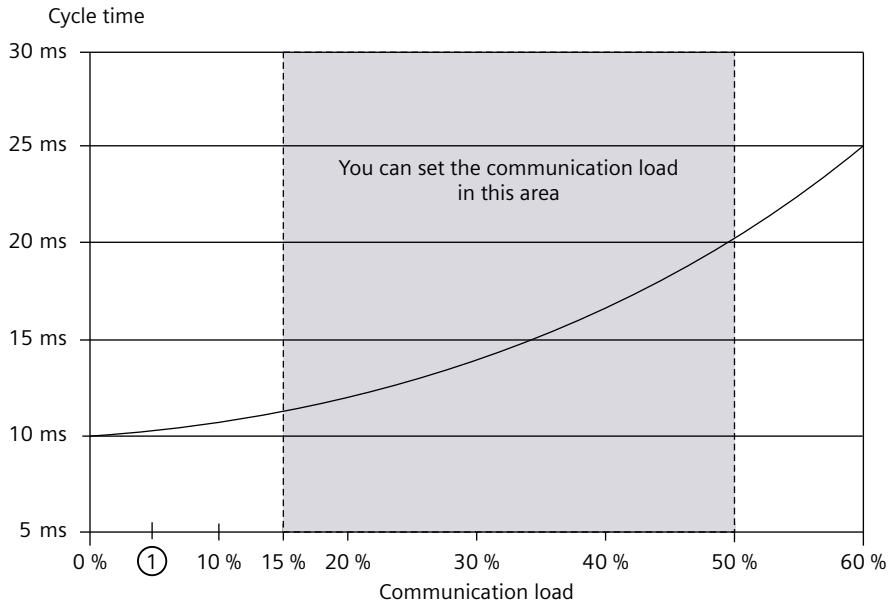

① CPUs 1516T(F)-3 PN/DP, 1517(F)-3 PN/DP, CPU 1517T(F)-3 PN/DP, CPU 1518(F)-4 PN/DP, 1518(F)-4 PN/DP MFP: The (minimum) communication load that can be set is 5%.

Figure 3-12 Maximum cycle time depending on the configured communication load

Reducing the cycle time with a lower communication load

You can reduce the setting for the communication load in the hardware configuration. If you set a communication load of 20% instead of 50%, for example, the cycle time extension due to the communication is reduced from a factor of 2 to 1.25.

Effect on the actual cycle time

Communication is only one cause of extension of the cycle time. All configured events that extend the cycle time (e.g. hardware interrupts) mean that more asynchronous events can occur within a cycle. These asynchronous events further extend the cyclic program. The extension depends on the number of events that occur and are processed in the cycle.

NOTE

Checking parameter changes

- Check the effects of a value change on the "Cycle load due to communication" parameter during system operation. You can use the "RT_INFO" instruction to determine which portions of runtime are used for communication and the user program.
- Take the communication load into consideration when setting the maximum cycle time to prevent time errors (for example, exceeding the cycle time within a cycle) from occurring.

Effect of load on the actual cycle time

The following examples show how the cycle time increases depending on the load.

Example 1

Example 1 shows an OB 1 with a runtime of 100 ms. The runtime of OB 1 is neither interrupted by communication load nor by higher-priority OBs.

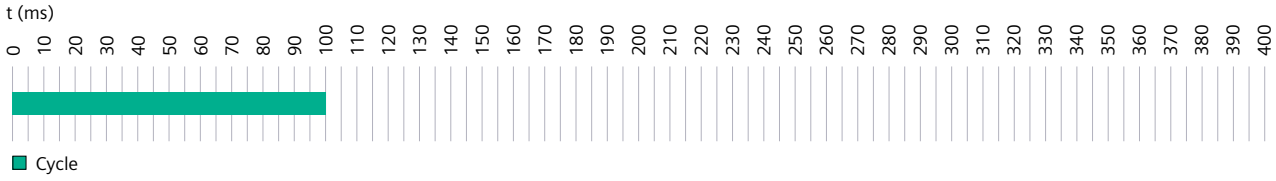

Figure 3-13 Cycle time without interruptions

Example 2

Example 2 shows that the runtime of OB 1 increases by a factor of 2 to 200 ms with a communication load of 50%.

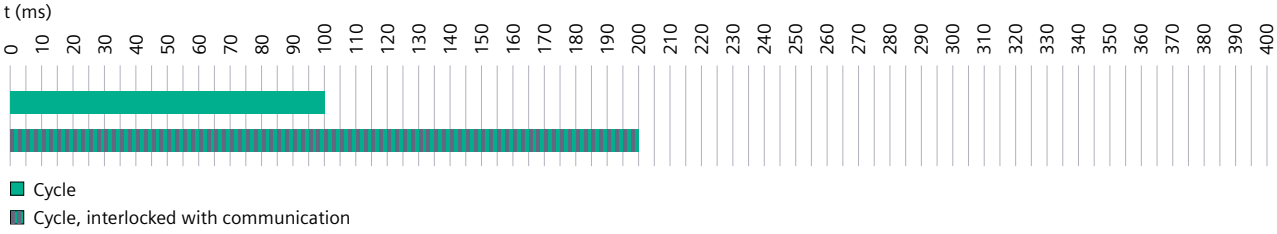

Figure 3-14 Cycle time with communication

Example 3

In example 3, OB 1 is interrupted every 20 ms by a cyclic higher-priority OB 30 (orange) with a runtime of 5 ms. The cycle time is extended to 135 ms by the higher-priority OB.

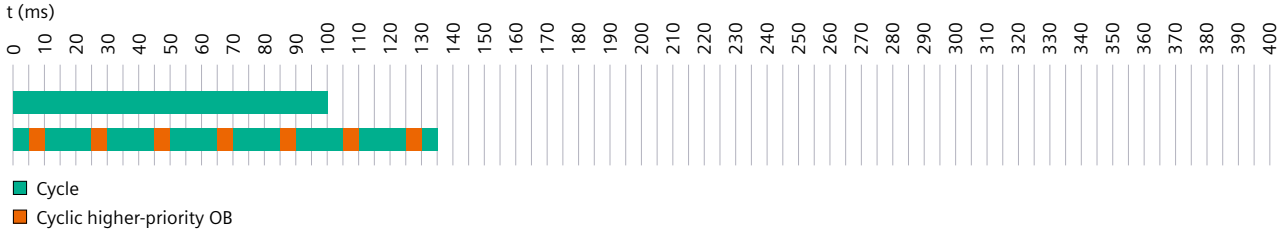

Figure 3-15 Cycle time with higher-priority OB

Example 4

In example 4, OB 1 is also interrupted by an OB 30 with priority 13. In addition, OB 1 and OB 30 are interrupted by communication tasks (priority 15). The cycle time increases to 400 ms.

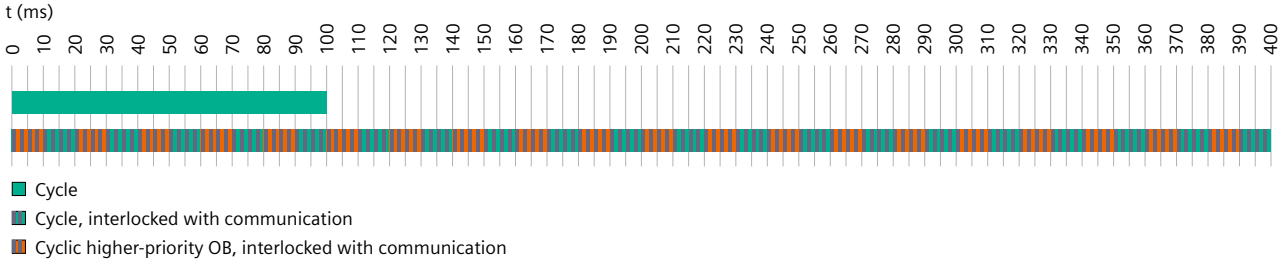

Figure 3-16 Cycle time with higher-priority OB and communication load

Example 5

In example 5, OB 1 is also interrupted by an OB 30 with priority 17. In addition, OB 1 is interrupted by communication tasks. Because the priority of OB 30 (priority 17) is higher than the priority of the communication tasks (priority 15), the interrupt points differ from example 4. The communication tasks suppressed by OB 30 are made up for within specific limits. Communication therefore completely suppresses the cyclic program within this time, 5 ms in the example. The cycle time increases to 400 ms, just like in example 4.

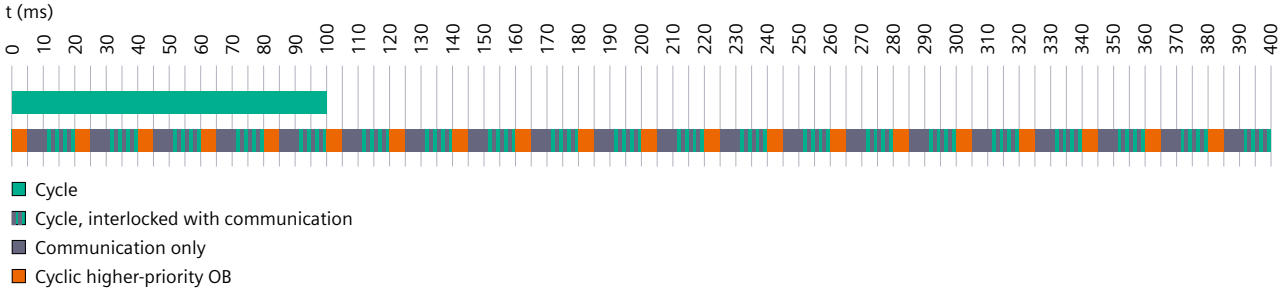

Figure 3-17 Cycle time with higher-priority OB and communication load

Cycle time curve for low and high loads

The y-axis of the following diagram indicates the cycle time in %. The value 100% stands for a cycle time of the CPU without higher-priority OBs and without communication. The x-axis indicates the load in % which is caused by higher priority OBs.

The blue curve ① of the diagram shows the course of the cycle time without communication load. The red curve ② shows the course of the cycle time with maximum communication and a parameterized communication load of 50%.

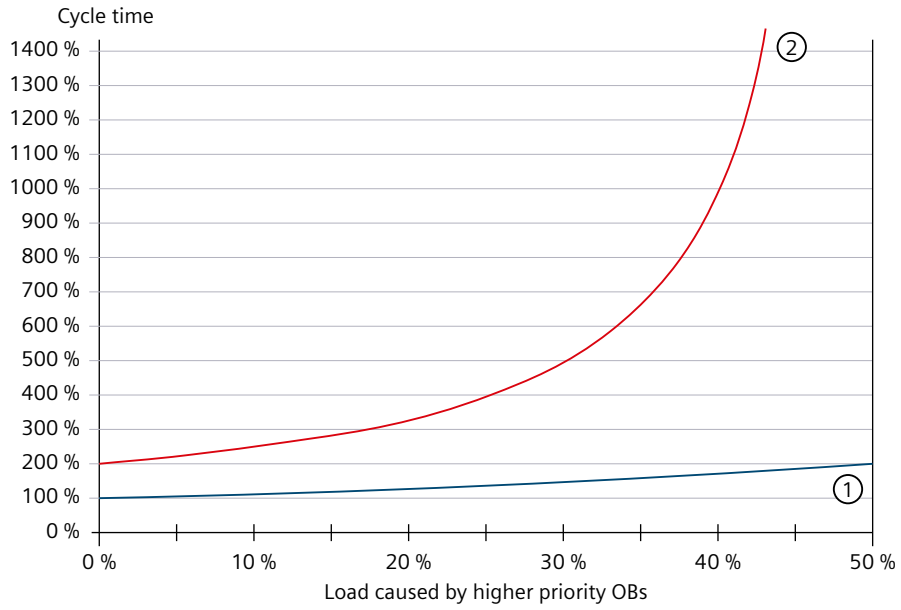

① Cycle time without communication load

② Cycle time with maximum communication

Figure 3-18 Cycle time for low and high loads

The course of the two curves shows the extent to which the communication load and the load from the higher-priority OBs influence the cycle time.

The longer the cycle time, the more the interruptions of OB 1 caused by higher-priority OBs and communication increase.

If both the base load and the communication load are at 50%, no computing capacity remains for the cyclic program and a time error occurs.

NOTE

Parameter assignment of the communication load

When the load in higher-priority OBs is high, reduce the configurable communication load.

NOTE

Parameter assignment of the communication load for the S7-1500R/H redundant system

Due to the synchronization of data between primary CPU and backup CPU, the S7-1500R/H redundant system is subject to an additional synchronization load. Therefore, choose a lower value for the communication load than for a non-redundant system.

Additional information on the particular features of the CPUs of the S7-1500R/H redundant system is available in the section Cycle and response times of the S7-1500R/H redundant system (Page 68).

Display of program and communication load (not supported for R/H CPUs)

In the web server, you can find information on the current program/communication load and cycle time of your user program on the "Diagnostics > Runtime Information" web page.

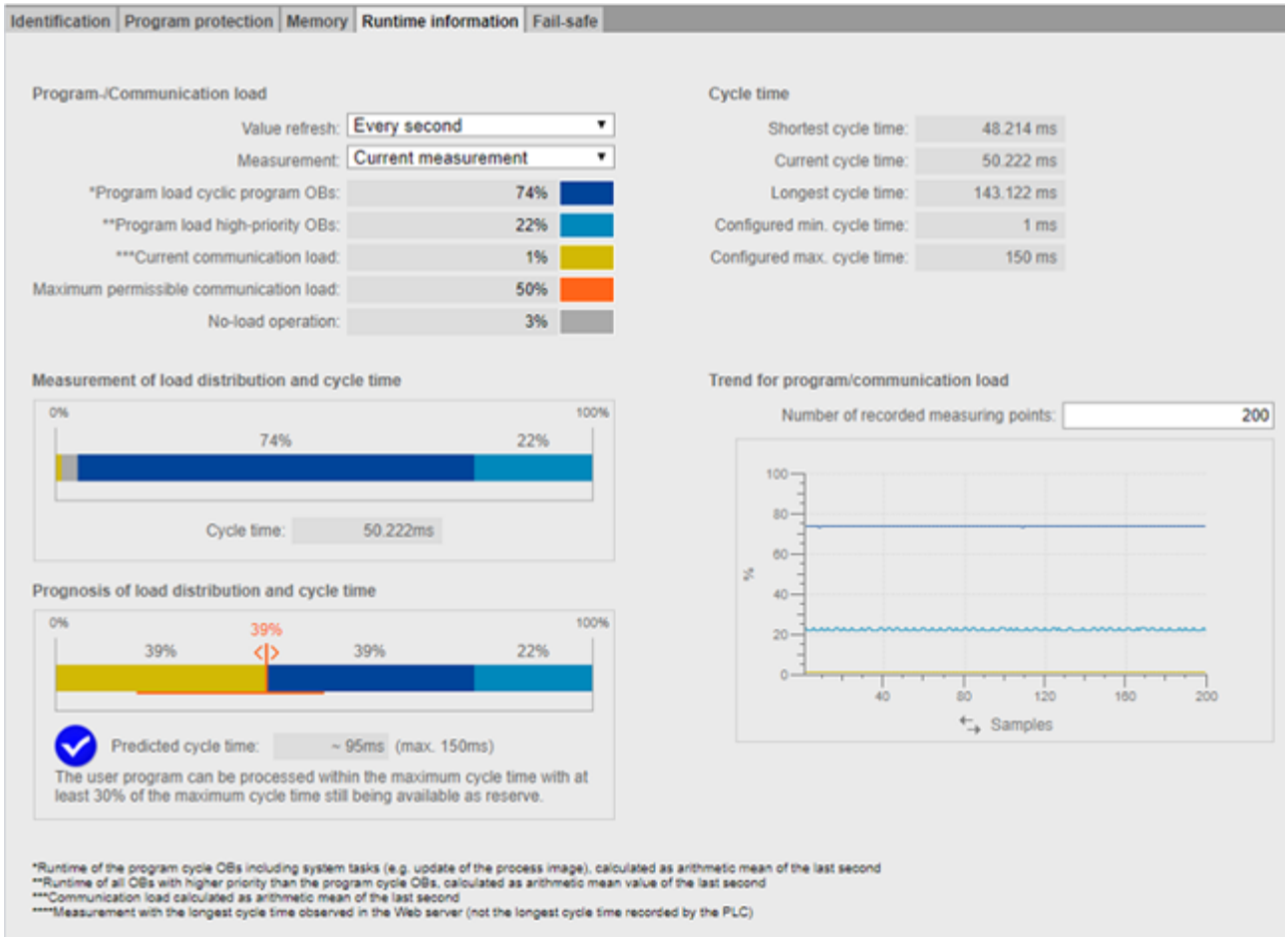

Figure 3-19 Graphical display of program and communication load

Program/communication load

With the "Value refresh" function, you update the data displayed in the bar charts:

- At intervals of 1 second
- Automatic (as configured in STEP 7)

With the "Measurement" function, you can decide which measurement the bar charts display. You can choose between:

- The current measurement
- The measurement of the longest cycle time

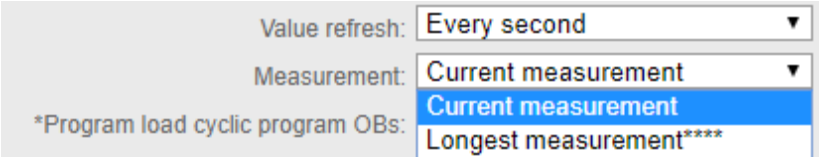

Figure 3-20 Program/communication load

The legend of the program/communication load shows information on the following values, highlighted in color:

- "Program load cyclic program OBs"

  Required calculation time in percent within a cycle for program cycle OBs
- "Program load high-priority OBs"

  Required calculation time in percent within a cycle for higher-priority OBs
- "Current communication load"

  Required calculation time in percent for current communication tasks within a cycle
- "Maximum permissible communication load"

  The configured maximum communication load as a percentage
- "No-load operation"

  There is no program/communication load

NOTE

When you have configured a minimum cycle time, it can happen that no-load operation displays a high percentage value, although the value of the cycle time is also high.

The reason for this is that the loads are recorded as mathematical average of the last second, but the cycle time relates to the last cycle.

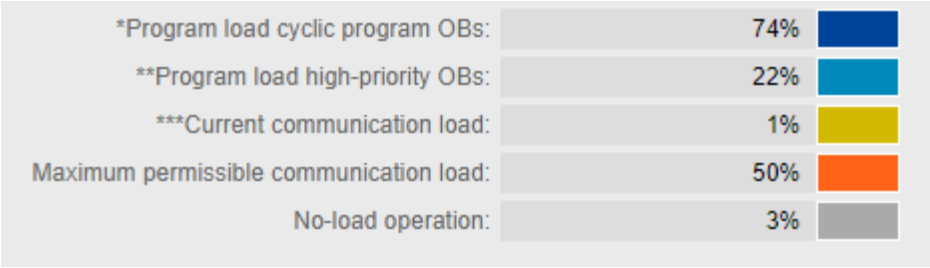

Figure 3-21 Color legend

If you click on a specific color, the selected color is highlighted in the chart. If you click on a highlighted color, you remove the highlighting.

Measurement of load distribution and cycle time

The "Measurement of load distribution and cycle time" bar chart shows the percentage of the calculation time within a cycle for the following values:

- "Program load cyclic program OBs"
- "Program load high-priority OBs"
- "Current communication load"
- "No-load operation"

Prognosis of load distribution and cycle time

The "Prognosis of load distribution and cycle time" bar chart predicts whether the CPU can process the user program with maximum communication load within the maximum cycle time.

Example 1:

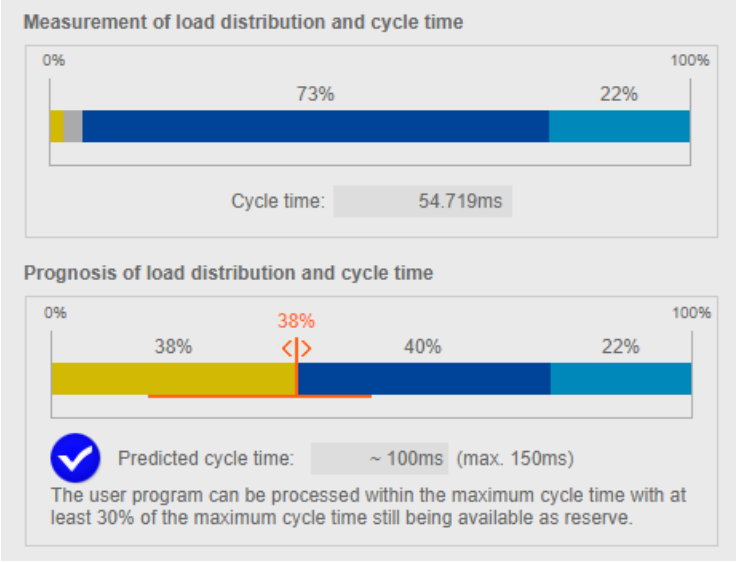

Figure 3-22 Cycle time < 70% of the maximum cycle time

Example 1 shows that the CPU can process the user program within the maximum cycle time of 150 ms when the maximum communication load of 38% is reached. The predicted cycle time is < 70% of the configured maximum cycle time.

Example 2:

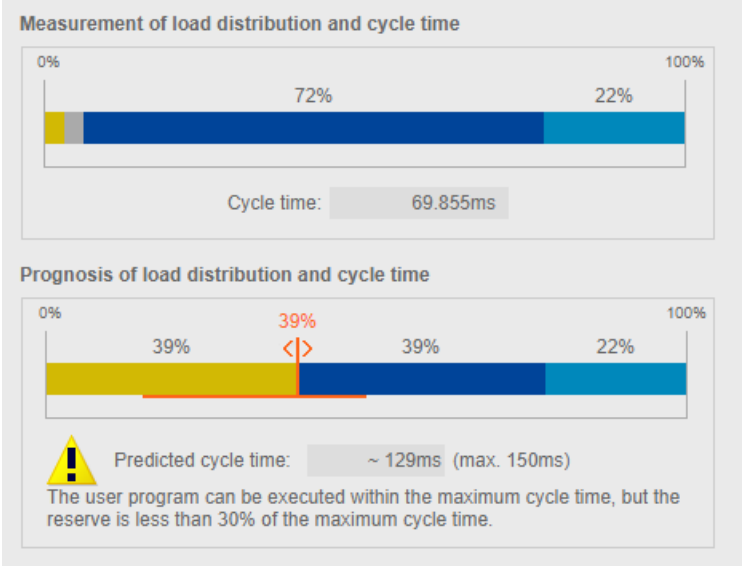

Figure 3-23 Cycle time ≥ 70% of the maximum cycle time

In example 2, the CPU can also process the user program with maximum communication load within the maximum cycle time. However, the predicted cycle time is already at 129 ms. If the predicted cycle time is ≥ 70% of the maximum cycle time, the chart outputs a warning.

Example 3:

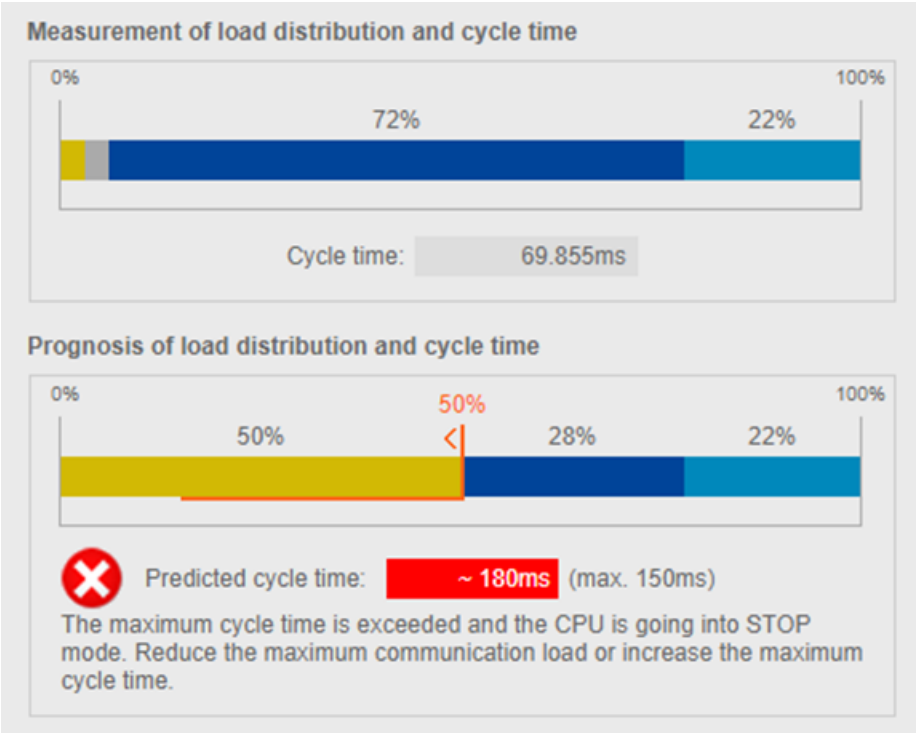

Figure 3-24 Cycle time longer than maximum cycle time

Example 3 shows that the CPU can no longer process the user program within the maximum cycle time when the maximum communication load is reached. If the predicted cycle time is longer than the maximum cycle time, the chart outputs an error message.

If it is predicted that the maximum cycle time will be exceeded, use the following controller in order to reduce the maximum communication load.

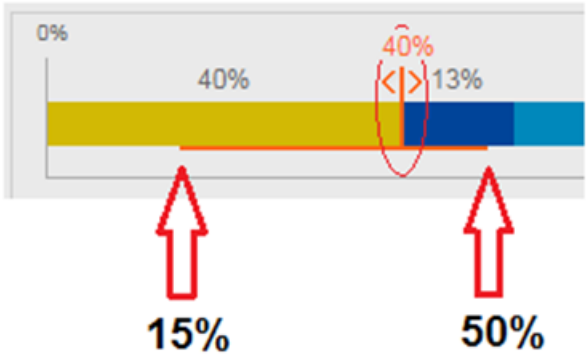

Figure 3-25 Controller for setting the maximum communication load

NOTE

Setting the communication load

The controller predicts the effects of the changed communication load on the cycle time. You configure the maximum communication load in STEP 7.

NOTE

For non-measurable fluctuations in the user program, e.g. for future changes in the user program, plan a sufficiently low value for the maximum communication load.

NOTE

Due to the different acquisition base of cycle time and load, a settled system state is required to display reliable measured values.

Progression of program/communication load

If your browser supports the display of SVG (Scalable Vector Graphics), the display in the "Runtime information" tab is expanded to show the progression of the program/communication load.

With the line charts in the "Trend for program/communication load" area, you can track the progression of the following values:

- "Program load cyclic program OBs"
- "Program load high-priority OBs"
- "Current communication load"

With the "Number of recorded measuring points" option, you can choose between the last 20 to 1 000 measured values for the display of the measured values.

For the trend on the x-axis, you can choose between "Time" (CPU time) and "Measuring points" by clicking on the desired unit.

NOTE

If you have selected the "Time" unit on the x-axis, all measured values that are more than 24 hours old are deleted automatically.

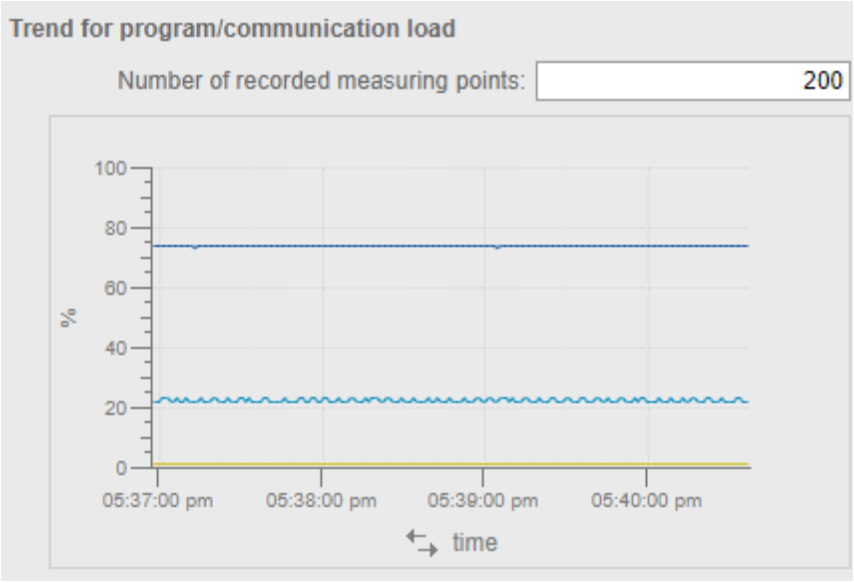

Figure 3-26 Line chart

4.2.2.5 Special consideration when PROFINET IO communication is configured on the 2nd PROFINET interface (X2)

The following special feature does not apply to CPUs as of article number 6ES751x-xxx03-0AB0.

If you configure the PROFINET IO communication at the 2nd PROFINET interface (X2) on the following CPUs as of firmware version 2.0, an additional system load occurs:

- CPU 1515(F)-2 PN
- CPU 1515T(F)-2 PN
- CPU 1516(F)-3 PN/DP
- CPU 1516T(F)-3 PN/DP
- CPU 1513(F)pro-2 PN (as of firmware version V2.8)
- CPU 1516(F)pro-2 PN

This additional system load has a higher priority than the user program (>26) and extends its run time. The execution of synchronous cycle interrupts or hardware interrupts, for example, can be delayed as a result.

The additional system load depends on:

- Communication traffic at the 2nd PROFINET interface (X2)
  The communication traffic at the interface in frames per second causes communication load as well as system load. You cannot limit the communication traffic using the "Communication load" parameter.
- Number of IO devices which the CPU at the 2nd PROFINET interface (X2) updates within a millisecond

You determine the additional system load with the "RT_INFO" (read RUNTIME statistics) instruction at the Mode parameter with mode 10 or mode 20.

Reducing additional system load

You reduce the communication load at the 2nd PROFINET interface, e.g. with:

- Fewer connected HMI devices or slower update cycles on the HMI devices
- Less or slower communication with other CPUs

Increase the update times in STEP 7 for all IO devices that are assigned to the 2nd PROFINET interface (X2):

1. Select the "IO Communication" in the "Network view" of STEP 7.
2. Set the "Update mode" parameter to "Adjustable".
3. Select a higher value for the "Update time [ms]" parameter in the drop-down list.
4. Repeat this setting for the other IO devices.

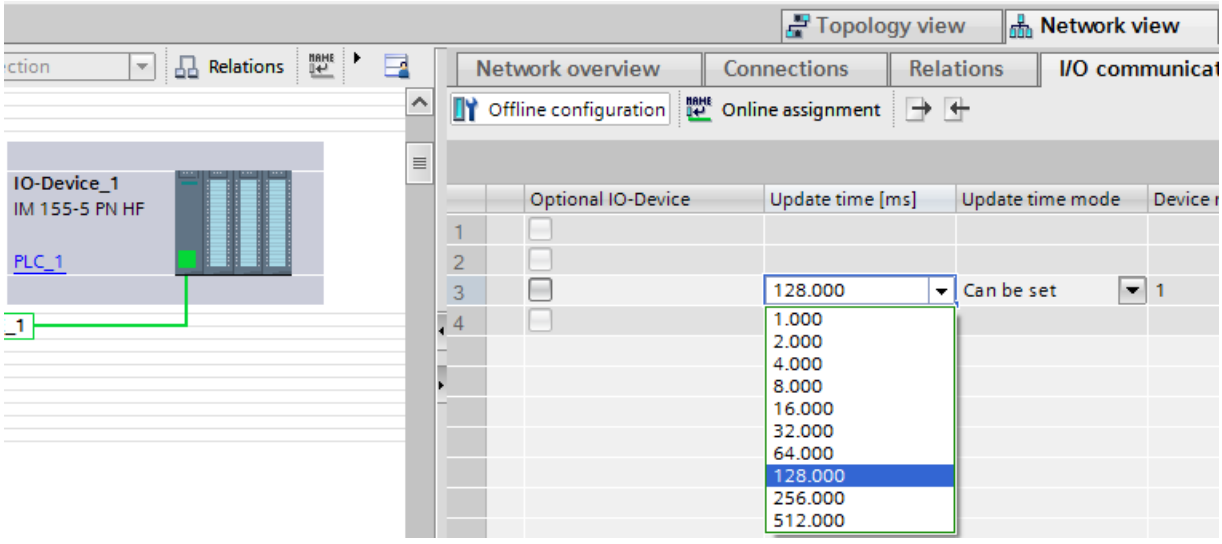

Figure 3-27 Increasing update times

4.3 Time-driven program execution in cyclic interrupts

With a cyclic interrupt you have the option of having a specific OB processed in a time interval. The time interval is independent of the execution time of the cyclic program. A priority from 2 to 24 can be selected for the cyclic interrupt. This makes the priority of cyclic interrupts higher than the priority of the cyclic program. A cyclic interrupt increases the execution time of the cyclic program.

In STEP 7 the organization blocks OB 30 to OB 38 are intended for processing cyclic interrupts. You can create additional cyclic interrupts starting with organization block OB 123. The number of available organization blocks depends on the CPU used.

Cyclic interrupt

A cyclic interrupt is an interrupt initiated according to a defined cycle that causes a cyclic interrupt OB to be processed. A cyclic interrupt OB is assigned to the "Cyclic interrupt" event class.

Cycle of a cyclic interrupt

The cycle of a cyclic interrupt is defined as the time between the occurrence of two consecutive events that each call the associated cyclic interrupt OB.

The following figure shows an example of the cycle of a cyclic interrupt.

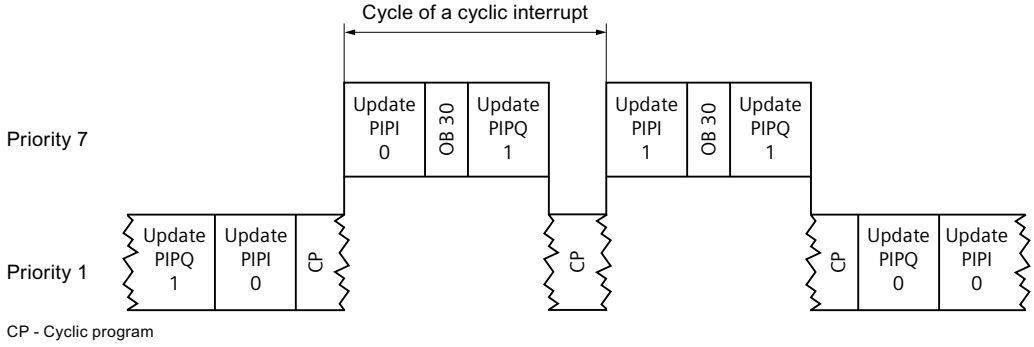

Figure 3-28 Call interval of a cyclic interrupt

Accuracy of a cyclic interrupt

Even if a cyclic interrupt is not delayed by a higher-priority OB or communication activities, the accuracy with which it is started is nevertheless subject to system-dependent fluctuations.

The following tables show the accuracy with which a cyclic interrupt is triggered:

Accuracy of cyclic interrupts for the S7-1500 CPUs

Table 3-18 Accuracy of cyclic interrupts for the S7-1500 CPUs

	S7-1500	
	Article numbers xxxxxxx-xxx00-xxxx, xxxxxxx-xxx01-xxxx, xxxxxxx-xxx02-xxxx	
	1511(T)(F)-1 PN 1511C-1 PN 1512C-1 PN 1513(F)-1 PN	**1515(T)(F)-2 PN 1516(T)(F)-3 PN/DP**
Cyclic interrupt	±90 µs	±80 µs

	S7-1500			
	Article number xxxxxxx-xxx03-xxx-x	**All article numbers**		
	1511(T)(F)-1 PN 1511C-1 PN 1512C-1 PN 1513(F)-1 PN 1515(T)(F)-2 PN 1516(F)-3 PN/DP	**1516T(F)-3 PN**	**1517(T)(F)-3 PN/-DP 1517(T)(F)-3 PN**	**1518(T)(F)-4 PN/DP 1518(T)(F)-3 PN 1518(F)-4 PN/DP MFP**
Cyclic interrupt	±80 µs	±80 µs	±30 µs	±25 µs

Accuracy of cyclic interrupts for the S7-1500R/H CPUs

Table 3-19 Accuracy of cyclic interrupts for the S7-1500R/H CPUs

	S7-1500R* in RUN-Solo system state	
	Article number xxxxxxx-xxx00-xxxx	
	1513R-1 PN	**1515R-2 PN**
Cyclic interrupt	±390 µs	±300 µs

	S7-1500R/H* in RUN-Solo system state	
	Article number xxxxxxx-xxx03-xxxx	**All article numbers**
	1513R-1 PN 1515R-2 PN	**1517H-3 PN 1517H-4 PN 1518HF-4 PN**
Cyclic interrupt	±200 µs	±90 µs

* Additional information about cycle and response times of R/H CPUs is available in the section "Cycle and response times of the S7-1500R/H redundant system"

Accuracy of cyclic interrupts for the ET 200SP CPUs

Table 3-20 Accuracy of cyclic interrupts for the ET 200SP CPUs

	ET 200SP
	Article numbers xxxxxxx-xxx00-xxxx, xxxxxxx-xxx01-xxxx
	1510SP(F)-1 PN **1512SP(F)-1 PN**
Cyclic interrupt	±90 µs

	ET 200SP	
	Article number xxxxxxx-xxx03-xxxx	**All article numbers**
	1510SP(F)-1 PN **1512SP(F)-1 PN** **1514SP(T)(F)-2 PN**	**1515SP(F)-PC**
Cyclic interrupt	±80 µs	±80 µs

Accuracy of cyclic interrupts for the ET 200pro CPUs

Table 3-21 Accuracy of cyclic interrupts for the ET 200pro CPUs

	ET 200pro	
	Article number xxxxxxx-xxx00-xxxx	
	1513pro(F)-2 PN	**1516pro(F)-2 PN**
Cyclic interrupt	±90 µs	±80 µs

	ET 200pro
	Article number xxxxxxx-xxx03-xxxx
	1513pro(F)-2 PN **1516pro(F)-2 PN**
Cyclic interrupt	±80 µs

NOTE

Scope of validity

Please note that the accuracy data for the cyclic interrupt also applies to all other higher-priority execution levels/OBs.

Processing sequence of cyclic interrupts

NOTE

With several cyclic interrupt OBs with identical parameterization, the processing sequence of the cyclic interrupt OBs cannot be predicted.

If you want to ensure a defined execution sequence of cyclic interrupt OBs with the same cycle time and priority, configure a different phase offset in each case.

Effects of parameter changes of a cyclic interrupt in RUN operating state

You can also change the values for the time interval or the phase offset in RUN mode, for example, by loading in RUN mode or by calling the "SET_CINT" instruction.

Please note that the operating system of the CPU always calculates the start events of a cyclic interrupt OB relative to the time when the CPU is switched on (POWER ON). Depending on the point in time at which the parameter change takes place, the new time interval can therefore once have a different value than the newly specified value:

- Two successive start events of the cyclic interrupt OB can have a shorter interval than the old time interval, and a shorter interval than the new time interval (in extreme cases, a significantly shorter interval).
- Two successive start events of the cyclic interrupt OB can be further apart than the old and the new time interval (the distance can be as large as the sum of the old and the new time interval).

For more information on the parameters and on how to assign parameters for cyclic interrupt OBs, refer to the STEP 7 online help.

4.4 Response time for cyclic and time-driven program execution

Introduction

In this section you learn:

- How the response time is composed
- How to calculate the response time

Definition

The response time in the case of cyclic or time-controlled program execution is the time between the detection of an input signal and the change of a connected output signal.

Fluctuation in the response time of the CPU

The actual response time of the CPU fluctuates between one and two cycles for cyclic program execution and between one and two cyclic interrupt cycles for time-controlled program execution.

You should always assume the longest response time when configuring your system.

The following figure shows the shortest and longest response times of the CPU to an event.

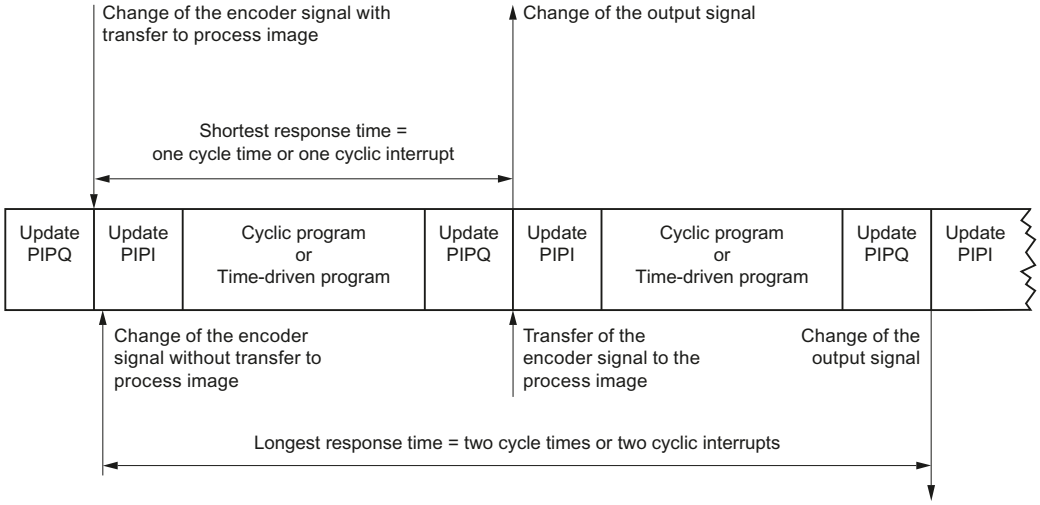

Figure 3-29 Shortest and longest response times of the CPU

Factors

To determine the process response time, you must take account of the following factors in addition to the CPU response time described above:

- Delay of the inputs and outputs at the I/O module
- Switching times of the sensors and actuators used
- Update times for PROFINET IO or DP cycle times on PROFIBUS DP; update time of the backplane bus for ET 200SP CPUs

NOTE
Backplane bus of the S7-1500 CPUs
The update time of the backplane bus of the S7-1500 CPUs can be ignored here.

Delay at the inputs and outputs of the modules

The delay and cycle times can be found in the technical specifications of the I/O modules.

Update times for PROFINET IO and DP cycle times on PROFIBUS DP

When distributed I/O is used, the maximum response time is additionally extended by the bus transmission times of PROFIBUS or PROFINET. These bus transmission times occur during both the reading and output of the process image partitions. The bus transmission times correspond to the bus update cycle of the distributed device.

PROFINET IO

If you use STEP 7 to configure your PROFINET IO system, STEP 7 calculates the update time. To display the update time, follow these steps:

- Select the PROFINET interface of the I/O module.
- In the General tab, select "Advanced options > Real time settings > IO cycle".

The update time is displayed in the "Update time" field and can be set for each IO device.

PROFIBUS DP

If you use STEP 7 to configure your PROFIBUS DP master system, STEP 7 calculates the DP cycle time. To display the DP cycle time, follow these steps:

- Select the PROFIBUS subnet in the network view.
- In the General tab of the Inspector window, navigate to the Bus parameters.

The DP cycle time is displayed in the "Parameters" field at "Typical Ttr".

The following figure illustrates the additional bus runtimes using distributed I/O.

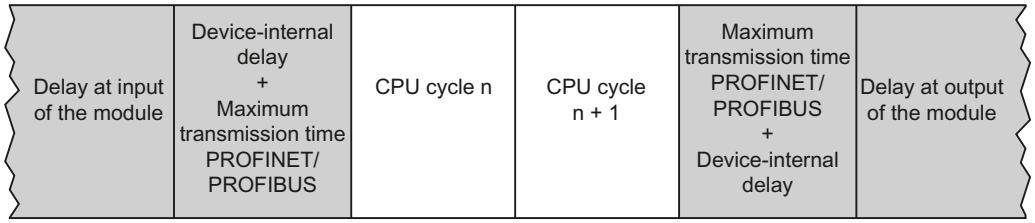

Figure 3-30 Additional bus runtimes with distributed I/O

A further optimization of the response times is achieved by using isochronous mode.

Update time of the backplane bus for ET 200SP CPUs

The following table shows the central (typical) update times of the backplane bus for the ET 200SP CPUs.

Table 3-22 Update time of the ET 200SP CPUs

	Update time of the CPU
	ET 200SP
	1510SP(F)-1 PN **1512SP(F)-1 PN** **1514SP(T)(F)-2 PN** **1515SP(F)-PC**
Update time for central I/O	250 µs to 1 ms, depending on number and type of central I/O modules[1]

[1] The duration of the update time depends on the number of the I/O modules and their type (ST, HF, HS). The update time is set at 1 ms for a max. central I/O configuration with standard I/O modules. You can reduce the update time down to 250 µs, for example, by using HF I/O modules and by reducing the number of modules.

The table below is an orientation guide. It shows the approximate relationship between the number of ET 200SP I/O modules and the bus cycle that is used. As an example, 8 bytes of I/O data per I/O module are assumed in the table.

Number of ET 200SP I/O modules	Input data (bytes)	Output data (bytes)	Used bus cycle (µs)
8	64	64	250
16	128	128	250
24	192	192	281.25
32	256	256	312.5
40	320	320	343.75
48	384	384	375
56	448	448	406.25
64	512	512	437.5

For I/O modules with more than 32 bytes of I/O data, the bus cycle is calculated with an I/O module of 32 bytes. In this case the I/O module requires multiple bus cycles to update its I/O data.

Reference

The following links provide additional information:

- Application example for determining the response time for PROFINET (https://support.industry.siemens.com/cs/ww/en/view/21869080)
- Transmission times and isochronous mode in the Function Manual PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856); see also the section "Tips on assembly"
- Transmission times and isochronous mode in the Function Manual PROFIBUS with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/59193579); see also the section "Network settings"
- Delays at the input or output of the modules can be found in the manual for the respective device.
- Information on device-internal delays can be found in the manuals for the ET 200MP and ET 200SP distributed I/O systems.

4.5 Summary of response time with cyclic and time-controlled program execution

Estimation of the shortest and longest response time

The following formulas may be used to estimate the shortest and longest response time:

Estimation of the shortest response time

The shortest response time is the sum of:

1 x delay of the input/output module for inputs
+ 1 x (update PROFINET IO or PROFIBUS DP)*; (update time of the backplane bus for the ET 200SP CPUs)
+ 1 x transfer time of the process image input
+ 1 x execution of the user program
+ 1 x transfer time of the process image output
+ 1 x (update PROFINET IO or PROFIBUS DP)*; (update time of the backplane bus for the ET 200SP CPUs)
+ 1 x delay of the input/output module for outputs

= **Shortest response time**

* Time is dependent on the configuration and the extent of the network.

The shortest response time is equivalent to the sum of the cycle time plus the input and output delay times.

Estimation of the longest response time

The longest response time is the sum of:

1 x delay of the input/output module for inputs
+ 2 x (update PROFINET IO or PROFIBUS DP)*; (update time of the backplane bus for the ET 200SP CPUs)
+ 2 x transfer time of the process image input
+ 2 x execution of the user program
+ 2 x transfer time of the process image output
+ 2 x (update PROFINET IO or PROFIBUS DP)*; (update time of the backplane bus for the ET 200SP CPUs)
+ 1 x delay of the input/output module for outputs

= **Longest response time**

* Time is dependent on the configuration and the extent of the network.

The longest response time is equivalent to the sum of twice the cycle time plus the delay times of the inputs and outputs. Twice the update time for PROFINET IO or twice the DP cycle time on PROFIBUS DP is added to the longest response time.

Event-driven program execution 5

5.1 Response time of the CPUs when program execution is event-controlled

Introduction

Hardware interrupts are used to detect events in the process in the user program and to react to them with an appropriate program. In STEP 7, the organization blocks OB 40 to OB 47 are intended for processing hardware alarms. You can create additional hardware interrupts starting with organization block OB 123. The number of available organization blocks depends on the CPU used.

Hardware interrupt

A hardware interrupt is an interrupt that occurs during the running program execution, due to an interrupt-triggering process event. The operating system calls the assigned interrupt OB; as a result, the execution of the program cycle or of lower priority program parts is interrupted. A hardware interrupt OB is assigned to the "Hardware interrupt" event class.

Interrupt response times of the CPUs for hardware interrupts

The interrupt response time starts with the occurrence of a hardware interrupt event in the CPU. The interrupt response time ends with the start of processing of the assigned hardware interrupt OB.

This time is subject to system-inherent fluctuations, and this is expressed using a minimum and maximum interrupt response time.

The following tables contain the length of the typical response times of the CPUs for hardware interrupts.

Response times of the CPUs for hardware interrupts for the S7-1500 CPUs

Table 3-23 Response times of the CPUs for hardware interrupts for the S7-1500 CPUs

		S7-1500	
		Article numbers xxxxxxx-xxx00-xxxx, xxxxxxx-xxx01-xxxx, xxxxxxx-xxx02-xxxx	
		1511(T)(F)-1 PN 1511C-1 PN 1512C-1 PN 1513(F)-1 PN	**1515(T)(F)-2 PN 1516(T)(F)-3 PN/DP**
Interrupt response times	Min.	100 µs	90 µs
	Max.	400 µs	360 µs

		S7-1500			
		Article number xxxxxxx-xxx03-xxxx	**All article numbers**		
		1511(T)(F)-1 PN 1511C-1 PN 1512C-1 PN 1513(F)-1 PN 1515(T)(F)-2 PN 1516(F)-3 PN/DP	**1516T(F)-3 PN**	**1517(T)(F)-3 PN 1517(T)(F)-3 PN-/DP**	**1518(T)(F)-3 PN 1518(T)(F)-4 PN/DP 1518(F)-4 PN/DP MFP**
Interrupt response times	Min.	90 µs	90 µs	30 µs	20 µs
	Max.	360 µs	360 µs	120 µs	90 µs

Response times of the CPUs for hardware interrupts for the S7-1500R/H-CPUs

Table 3-24 Response times of the CPUs for hardware interrupts for the S7-1500R/H-CPUs

		S7-1500R* in RUN-Solo system state		
		Article number xxxxxxx-xxx00-xxxx		
		1513R-1 PN	**1515R-2 PN**	**1517H-3 PN 1518HF-4 PN**
Interrupt response times	Min.	100 µs	90 µs	30 µs
	Max.	400 µs	360 µs	120 µs

		S7-1500R/H* in RUN-Solo system state	
		Article number xxxxxxx-xxx03-xxxx	**Article number xxxxxxx-xxx10-xxxx**
		1513R-1 PN 1515R-2 PN	**1517H-4 PN 1518HF-4 PN**
Interrupt response times	Min.	90 µs	30 µs
	Max.	360 µs	120 µs

* Additional information about cycle and response times of R/H CPUs is available in the section "Cycle and response times of the S7-1500R/H redundant system"

Response times of the CPUs for hardware interrupts for the ET 200SP CPUs

Table 3-25 Response times of the CPUs for hardware interrupts for the ET 200SP CPUs

		ET 200SP
		Article numbers xxxxxxx-xxx00-xxxx, xxxxxxx-xxx01-xxxx
		1510SP(F)-1 PN 1512SP(F)-1 PN
Interrupt response times	Min.	100 µs
	Max.	400 µs

		ET 200SP	
		Article number xxxxxxx-xxx03-xxxx	**All article numbers**
		1510SP(F)-1 PN 1512SP(F)-1 PN 1514SP(T)(F)-2 PN	**1515SP(F)-PC**
Interrupt response times	Min.	90 µs	90 µs
	Max.	360 µs	360 µs

Response times of the CPUs for hardware interrupts for the ET 200pro CPUs

Table 3-26 Response times of the CPUs for hardware interrupts for the ET 200pro CPUs

		ET 200pro	
		Article number xxxxxxx-xxx00-xxxx	
		1513pro(F)-2 PN	**1516pro(F)-2 PN**
Interrupt response times	Min.	100 µs	90 µs
	Max.	400 µs	360 µs

		ET 200pro
		Article number xxxxxxx-xxx03-xxxx
		1513pro(F)-2 PN 1516pro(F)-2 PN
Interrupt response times	Min.	90 µs
	Max.	360 µs

The specified times are extended:

- If higher-priority interrupts are queued for execution
- If the hardware interrupt OB is assigned to a process image partition

You can find these times in the tables in the section "Extension due to nesting of higher-priority OBs and/or interrupts" in the chapter User program execution time (Page 33).

If you need fast interrupt response times, do not assign a process image partition to the hardware interrupt OB and use direct access in the hardware interrupt OB instead.

You can find additional information on determining response times for PROFINET in the application example with the entry ID 21869080 on the Service&Support (https://support.industry.siemens.com/cs/ww/en/view/21869080) Internet page.

Influence of input modules on the interrupt response times of hardware interrupts

Digital input modules:

Interrupt response time of hardware interrupts = internal interrupt processing time + input delay (see section Technical specifications in the relevant manual)

Analog input modules:

Interrupt response time of hardware interrupts = internal interrupt processing time + conversion time (see section Technical specifications in the relevant manual)

Impact of communication on interrupts

Communication tasks are always processed by the CPU with priority 15. If you do not want the interrupt execution to be delayed or interrupted by communication, configure the interrupt execution with priority > 15. The default setting for interrupt execution is priority 16.

Special consideration when PROFINET IO communication is configured on the 2nd PROFINET interface (X2)

Additional information on this is available in section Special consideration when PROFINET IO communication is configured on the 2nd PROFINET interface (X2) (Page 52).

5.2 Process response time when program execution is event-driven

When program execution is event-driven, the process response time is determined by the following:

- Delay times of the input and output modules used
- Update times for PROFIBUS/PROFINET for distributed modules; update time of the backplane bus for ET 200SP CPUs
- Interrupt response time of CPU
- Runtimes of the interrupt OB including update of the process image partition

The following figure shows the individual execution steps for event-driven program execution.

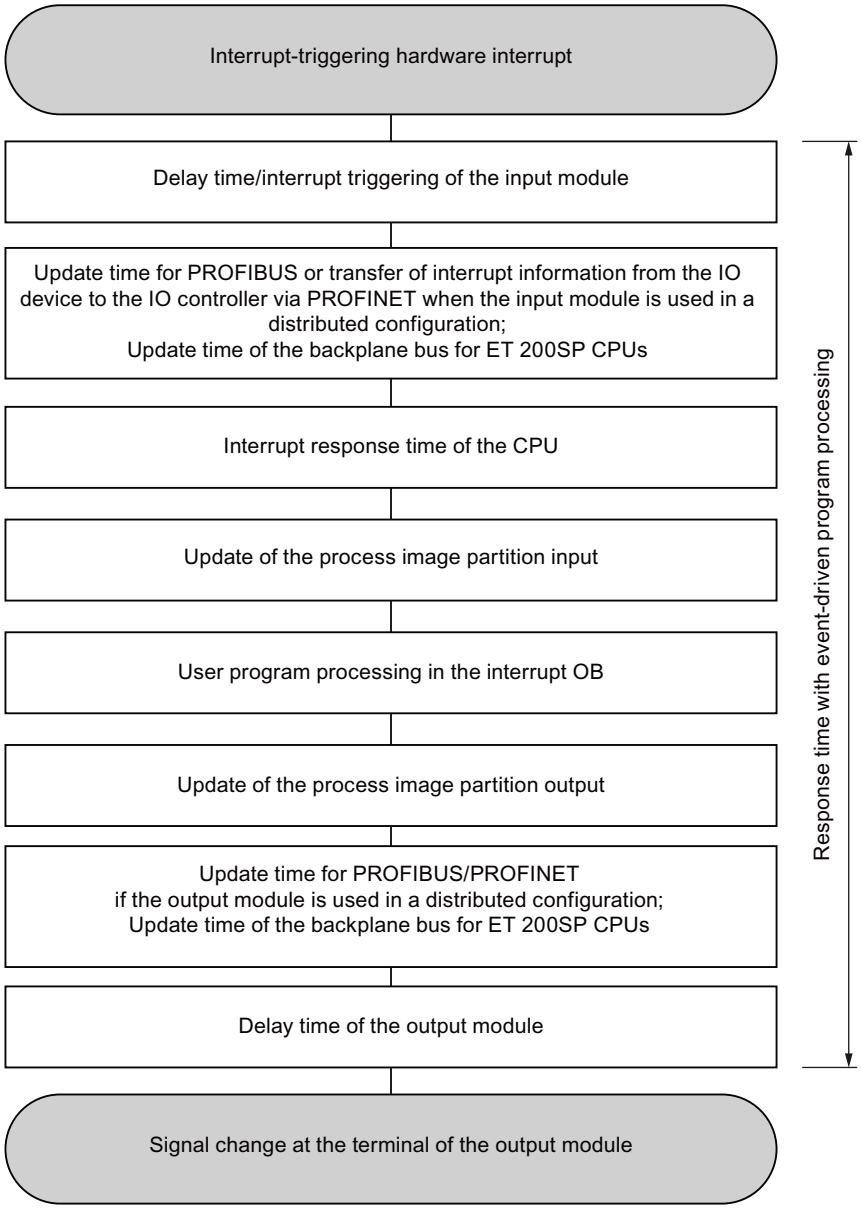

Figure 3-31 Schematic representation of event-driven program execution

Cycle and response times of the S7-1500R/H redundant system

6

6.1 Introduction

CPUs of the S7-1500R/H redundant system are designed as being redundant. The goal of the redundant configuration is to avoid production downtimes. When a CPU fails, the other CPU maintains control over the process.

Compared to non-redundant CPUs, the CPUs of the S7-1500R/H redundant system have the following special features:

- Longer cycle and response times
- Specific operating and system states
- Additional load and delays through synchronization

Contents of this section

This section describes the effects of the mode of operation of the S7-1500R/H redundant system on the cycle and response times.

It also describes how to estimate and control the cycle and response times of the CPUs. This prevents excessive cycle times.

NOTE

Classification of this chapter

The statements in the previous chapters describe the response of an individual CPU.

The section "Cycle and response times of the S7-1500R/H redundant system" supplements the information of the previous sections with information on the S7-1500R/H redundant system.

6.2 Maximum cycle time and time errors

Maximum cycle time

As with non-redundant CPUs, you can parameterize an upper limit of the cyclic program by setting the maximum cycle time.

The cycle time of redundant CPUs is usually longer compared to non-redundant CPUs (especially in the RUN-Redundant and SYNCUP system states).

The factor by which the cycle time for redundant CPUs is higher than that for non-redundant CPUs depends very strongly on your specific automation task.

NOTE

Maximum cycle time in SYNCUP system state

The length of the parameterized maximum cycle time also affects the SYNCUP system state.

If the following condition is fulfilled during the SYNCUP, the system initiates a transition to RUN-Redundant:
The actual cycle time is ≤ 80% of the maximum cycle time over several cycles.

More information on this is available in section Influences on the cycle time in SYNCUP system state (Page 71).

Maximum cycle time in RUN-Redundant system state

On the failure of one of the two CPUs, the cycle time also contains a dead time of up to 300 ms for R-CPUs and up to 50 ms for the H-CPU. You must schedule this time as cycle time reserve in case of failure of one of the two CPUs. Therefore, ensure that the longest cycle time plus this dead time is < 60% of the configured maximum cycle time in RUN-Redundant system state. By doing so, you prevent the parameterized maximum cycle time from being exceeded in case of load fluctuations and delays due to synchronization.

Time error

As with non-redundant CPUs, you can specify the response to a time error for the CPUs of the S7-1500R/H redundant system. In RUN-Solo system state, the redundant CPUs behave like non-redundant CPUs when the maximum cycle time is exceeded (see section Cycle time (Page 25)).

In the SYNCUP and RUN-Redundant system states the redundant CPUs behave as follows:

Table 3-27 Response of the S7-1500R/H redundant system when cycle time is exceeded, without OB 80

Initial situation			1st time cycle time is exceeded			2nd time cycle time is exceeded		
System	**Primary CPU**	**Backup CPU**	**System**	**Primary CPU**	**Backup CPU**	**System**	**Primary CPU**	**Backup CPU**
RUN-Solo	RUN	STOP	**STOP**	STOP	STOP	**---**	---	---
SYNCUP[1)]	RUN-Syncup	SYNCUP	**STOP**	STOP	STOP	---	---	---
SYNCUP[2)]	RUN-Syncup	SYNCUP	**RUN-Solo**	RUN	STOP	**STOP**	STOP	STOP
RUN-Redundant	RUN-Redundant	RUN-Redundant	**RUN-Solo**	RUN	STOP	**STOP**	STOP	STOP

1) SYNCUP up to snapshot of the work memory contents

2) SYNCUP after snapshot of the work memory contents

Table 3-28 Response of S7-1500R/H redundant system when cycle time is exceeded with OB 80

Initial situation			1st time cycle time is exceeded			2nd time cycle time is exceeded			3rd time cycle time is exceeded		
System	**Primary CPU**	**Backup CPU**	**System**	**Primary CPU**	**Backup CPU**	**System**	**Primary CPU**	**Backup CPU**	**System**	**Primary CPU**	**Backup CPU**
RUN-Solo	RUN	STOP	**RUN-Solo**	RUN + OB 80	STOP	**STOP**	STOP	STOP	**---**	---	---
SYNCUP [1]	RUN-Syncup	SYNCUP	**SYNCUP**	RUN-Syncup + OB 80	SYNCUP	**STOP**	STOP	STOP	---	---	---
SYNCUP [2]	RUN-Syncup	SYNCUP	**SYNCUP**	RUN-Syncup + OB 80	SYNCUP + OB 80	**RUN-Solo**	RUN + OB 80	STOP	**STOP**	STOP	STOP
RUN-Redundant	RUN-Redundant	RUN-Redundant	**RUN-Redundant**	RUN-Redundant + OB 80	RUN-Redundant + OB 80	**RUN-Solo**	RUN + OB 80	STOP	**STOP**	STOP	STOP

[1] SYNCUP up to snapshot of the work memory contents

[2] SYNCUP after snapshot of the work memory contents

NOTE

System state change after STOP with OB 80

The primary CPU also switches to STOP after the maximum cycle time has been exceeded three times in the same cycle.

Switchover of the backup CPU to STOP operating state when the maximum cycle time is exceeded

A switchover of the backup CPU to STOP operating state reduces the synchronization load and relieves the load on the primary CPU.

6.3 Influences on the cycle time of the S7-1500R/H redundant system

6.3.1 Influences on the cycle time in RUN-Solo system state

RUN-Solo system state

In RUN-Solo system state, the primary CPU is in RUN operating state. The primary CPU executes the cyclic, time- and interrupt-controlled program execution on its own. The backup CPU is in STOP operating state, is switched off or defective.

Influence on the cycle time

In RUN-Solo system state, the primary CPU behaves exactly the same as a standard CPU (non-redundant CPU) with regard to cycle time monitoring. Additional information on this is available in section "Cycle time (Page 25)".

6.3.2 Influences on the cycle time in SYNCUP system state

SYNCUP system state

In SYNCUP system state, the primary CPU is in RUN-Syncup operating state. The backup CPU is in SYNCUP operating state. The task of the SYNCUP system state is to synchronize the data of both CPUs so that the CPUs can subsequently work redundantly.

Influence on the cycle time

The figure below shows the chronological behavior of primary CPU and backup CPU during the SYNCUP system state.

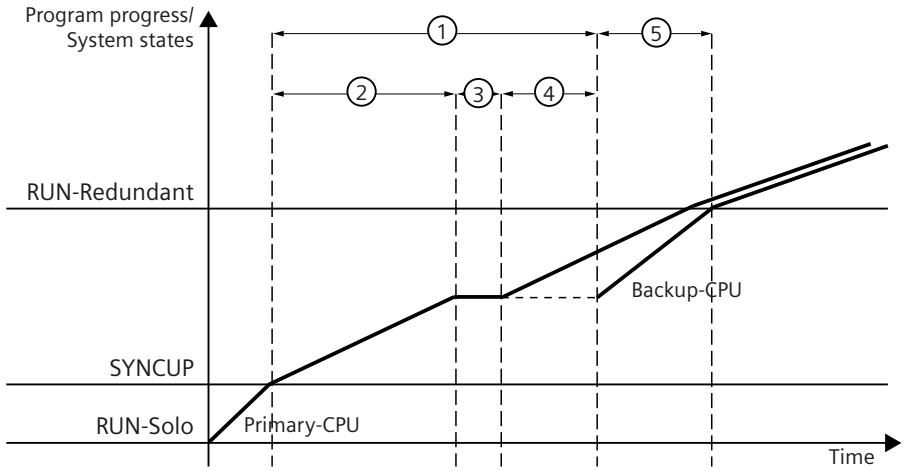

① Synchronization of data from the primary CPU to the backup CPU

② Copying the load memory and terminating the asynchronous instructions

③ Snapshot of the work memory contents

④ Transfer of the work memory contents to the backup CPU

⑤ Backup CPU makes up the time lag to the primary CPU caused by the synchronization of data

Figure 3-32 Effects of the SYNCUP on the cycle times of the CPUs

In SYNCUP system state, all relevant data is synchronized from the primary CPU to the backup CPU. At the end of SYNCUP, the backup CPU makes up the time lag to the primary CPU caused by the synchronization.

⚠ CAUTION

SYNCUP system state

- The synchronization of data, in particular the snapshot of the work memory contents, extends the cycle time. In addition, most test and commissioning functions cannot be executed during SYNCUP.
- During SYNCUP, diagnostic interrupts are processed with a significant delay.
- The cycle time increases greatly during the transition from SYNCUP system state to RUN-Redundant.

Therefore, only execute the SYNCUP during uncritical process states.

① Synchronization of data from the primary CPU to the backup CPU

During this phase all relevant contents of the load memory, work memory, and system memory of the primary CPU are synchronized to the backup CPU.

② Copying the load memory and terminating the asynchronous instructions

The primary CPU copies parts of its load memory from its SIMATIC memory card to the SIMATIC memory card of the backup CPU. The backup CPU restarts and automatically switches to SYNCUP operating state. The backup CPU copies the transferred load memory contents to its work memory. Data blocks, the process image, etc. are immediately overwritten with current data from the primary CPU.
Subsequently, asynchronous instructions that are already running are overwritten and newly started asynchronous instructions are delayed until synchronous operation has been realized.

③ Snapshot of the work memory contents

The primary CPU saves a consistent snapshot of its work memory contents at the next cycle control point.

When creating the snapshot of the work memory contents, the execution of the user program (on the primary CPU) is delayed during the SYNCUP by the following times:

Table 3-29 Delay times when creating the snapshot of memory contents during SYNCUP

R/H CPUs Article number xxxxxxx-xxx00-xxxx	**Duration of the snapshot of work memory contents in the SYNCUP [ms] (typical values)**		**Max. data work memory [MB]**
	With allocation of data work memory: 0%	**With allocation of data work memory: 100%**	
CPU 1513R-1 PN	105	145	1.5
CPU 1515R-2 PN	225	290	3
CPU 1517H-3 PN	18	23	8
CPU 1518HF-4 PN	25	47	60

R-CPUs Article number xxxxxxx-xxx03-xxxx	**Duration of the snapshot of work memory contents in the SYNCUP [ms] (typical values)**		**Max. data work memory [MB]**
	With allocation of data work memory: 0%	**With allocation of data work memory: 100%**	
CPU 1513R-1 PN	25	30	2.5
CPU 1515R-2 PN	34	42	4.5

H-CPUs Article number xxxxxxx-xxx10-xxxx	**Duration of the snapshot of work memory contents in the SYNCUP [ms] (typical values)**		**Max. data work memory [MB]**
	With allocation of data work memory: 0%	**With allocation of data work memory: 100%**	
CPU 1517H-4 PN	6	15	50
CPU 1518HF-4 PN	8	35	150

④ Transfer of work memory contents to the backup CPU

During this phase the consistent snapshot is transferred from the primary CPU to the backup CPU. The transfer of the work memory contents extends the cycle time. The time required for

the transfer of the work memory contents depends on the performance capability of the CPU and the amount of work memory data.

⑤ Backup CPU makes up the time lag to the primary CPU

During this phase the backup CPU makes up the time lag in program execution to the primary CPU. As in redundant mode, events are already synchronized during this phase as needed.

NOTE

No switchover possible during SYNCUP

If a fault occurs in the primary CPU during SYNCUP, no switchover to the backup CPU is possible. The SYNCUP is canceled and the backup CPU returns to STOP operating state.

Switchover from SYNCUP to RUN-Redundant

The system checks continuously which cycle time would result from a change to the RUN-Redundant system state. If this cycle time would be ≤ 80% of the maximum cycle time over multiple cycles, the transition is initiated. You can find more information in the system manual S7-1500R/H Redundant System (https://support.industry.siemens.com/cs/ww/en/view/109754833).

NOTE

Determination of the cycle time during the SYNCUP

You can track the progress of the SYNCUP on the display of the primary CPU and backup CPU. At each cycle control point the backup CPU sends a status message on its program progress to the primary CPU. The display of the primary CPU indicates the duration of the time lag of the backup CPU.

In addition to viewing the progress in the displays, the progress of the SYNCUP can also be read out using the "RT_INFO" instruction.

Reasons for cancellation of the SYNCUP

Possible causes for the cancellation of the SYNCUP are:

- The load of the user program or the load on the redundancy connections between primary and backup CPU is too high
- The maximum cycle time of the primary CPU was exceeded

An overview of all reasons for the cancellation of the SYNCUP and remedial measures is available in the system manual S7-1500R/H redundant system (https://support.industry.siemens.com/cs/ww/en/view/109754833).

Disable SYNCUP

To avoid the described effects of the SYNCUP on the cycle times during critical process states, use the instruction "RH_CTRL".

The "RH_CTRL" instruction can be used to disable the SYNCUP system state for the S7-1500R/H redundant system. If the disable is no longer required, the "RH_CTRL" instruction can be used to enable the SYNCUP system state once again.

More information on the "RH_CTRL" instruction is available in the system manual S7-1500R/H redundant system (https://support.industry.siemens.com/cs/ww/en/view/109754833).

Minimum cycle time

It is often necessary to set a longer minimum cycle time for the CPUs of the S7-1500R/H redundant system than for those of the non-redundant CPUs.

Recommendation: Select the minimum cycle time so that the cyclic program does not have to be executed more frequently than your process requires. A longer minimum cycle time that has been adapted to your process optimizes the entire system. The computing power that is available per cycle by extending the minimum cycle time is then available for system tasks such as communication.

The selected minimum cycle time should at least correspond to the measured cycle time in redundant mode of the user program (where the minimum cycle time is has yet to have an effect). A minimum cycle time that is significantly lower is only effective in solo mode of the system. It burdens and prolongs the SYNCUP system state and increases the probability of sporadic aborts of the SYNCUP.

NOTE

Too low cycle times

Cycle times that are too low can result in an excessive synchronization load and thus terminate the SYNCUP.

Parameter assignment of the communication load

NOTE

An increased synchronization load occurs in the SYNCUP system state. Because this synchronization load places a load on the cycle in addition to the communication, it is recommended to reduce the communication load to ≤ 30%.

6.3.3 Influences on the cycle time in RUN-Redundant system state

RUN-Redundant system state

In RUN-Redundant system state, the primary CPU controls the process. The primary CPU continuously synchronizes itself with the backup CPU. In the event of a failure of the primary CPU, the backup CPU adopts its role and thus control over the process.

Cycle time without interruption of the cyclic program

In RUN-Redundant system state, the backup CPU has a time lag compared to the primary CPU. This time lag results from the time required for event-controlled synchronization of data from the primary CPU to the backup CPU.

The following figure shows the phases which the CPUs run through without an interruption of the cyclic program.

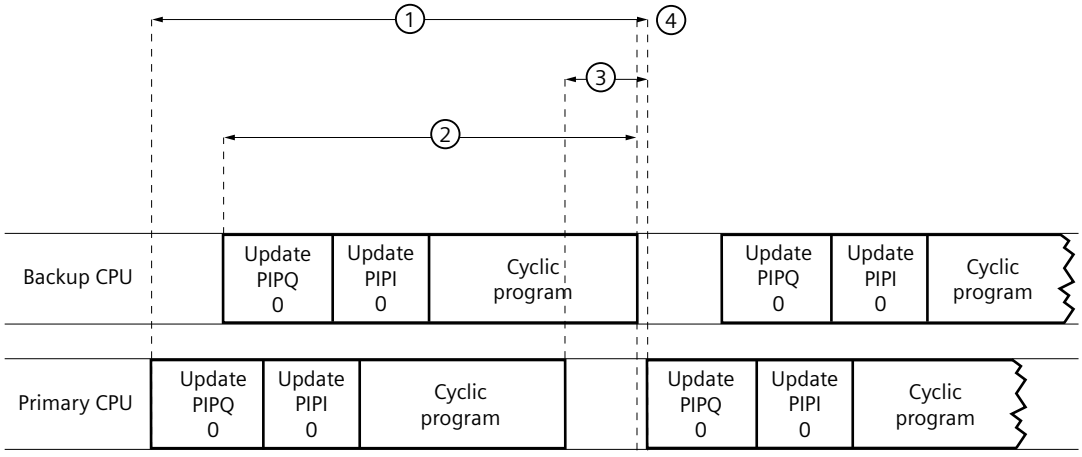

① Cycle time

② Cycle of the backup CPU

③ Time lag

④ Cycle end and start of the next cycle (cycle control point)

Figure 3-33 Cycle time without interruption of the cyclic program

The cycle time ① includes the cycle of the backup CPU ② and the time lag ③ of the backup CPU compared to the primary CPU. The time lag results from the time required for the synchronization of the data between primary CPU and backup CPU. The synchronization between primary CPU and backup CPU occurs automatically if required. The more data has to be synchronized between the CPUs during a cycle, the greater the time lag. The program cycle ends as soon as the backup CPU has reached the end of its cyclic program. The primary CPU starts the next cycle as soon as the backup CPU reports the cycle end to the primary CPU ④.

Extension of the cycle

As with non-redundant CPUs, an occurring event and the associated OB can extend the cycle. Events can occur both during the execution of the cyclic program and during the time lag.

In the following example the CPU must process a higher-priority OB (OB 30 with priority 7), while the primary CPU waits for the end of the cycle of the backup CPU. The figure below shows the phases which the CPUs run through in such a case.

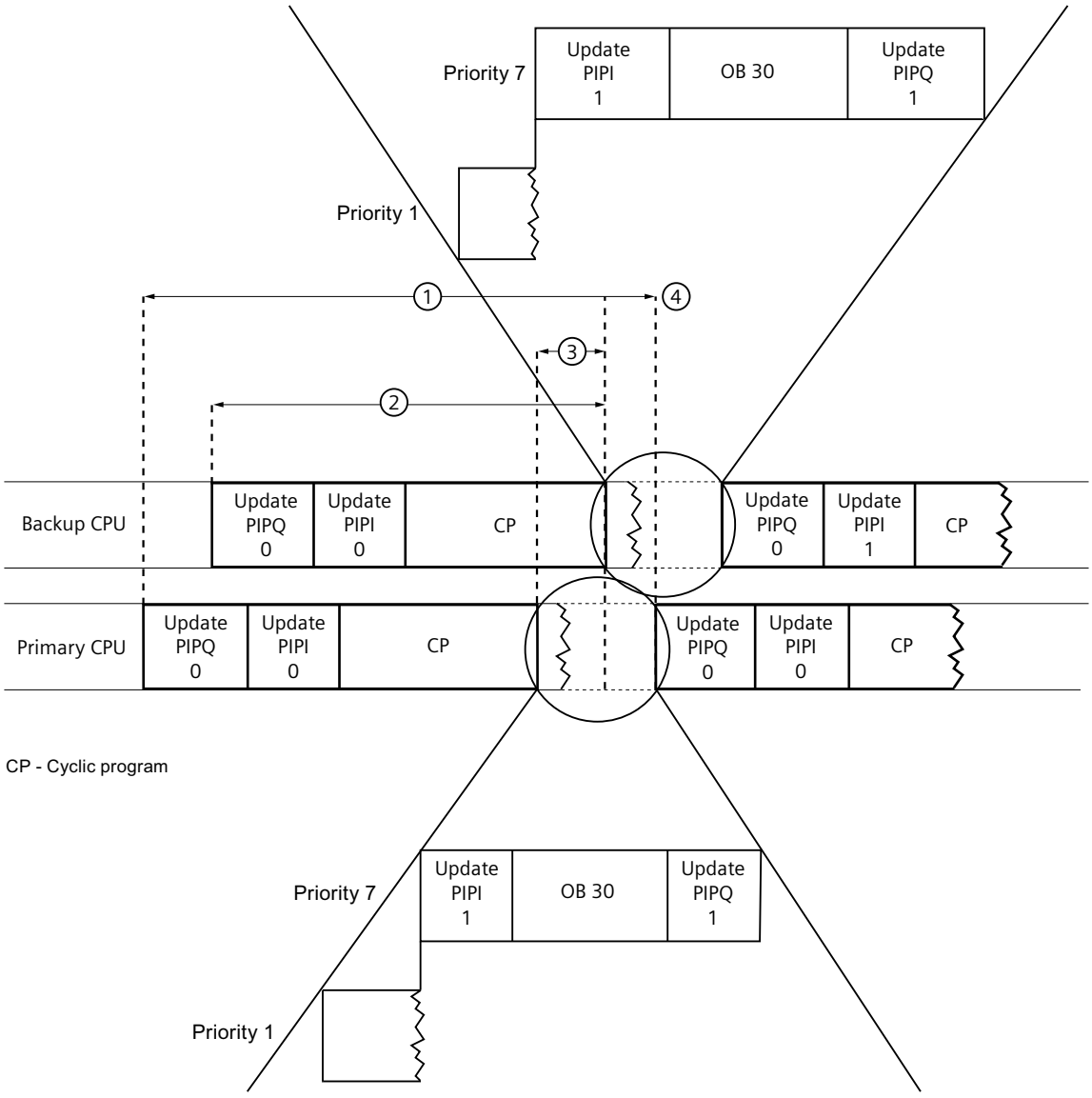

① Cycle time

② Cycle of the backup CPU

③ Time lag

④ Cycle end and start of the next cycle (cycle control point)

Figure 3-34 Processing of a higher-priority OB

Execution of the cyclic program (CP with priority 1) is complete. While the primary CPU waits for the end of the cycle of the backup CPU, a higher priority OB (OB 30 with priority 7) starts. The primary CPU starts the next cycle as soon as the following conditions have been fulfilled:

- The primary CPU has received the message from the backup CPU that the backup CPU has finished processing the cyclic program.
- The primary CPU has processed OB 30 and updated PIPQ1.

NOTE

Due to the change of the run level and the synchronization, interruptions of the program cycle by higher-priority OBs result in a higher load. Interruptions of the program cycle extend the cycle time.

Differences between the synchronization times

The available bandwidth has a significant impact on the synchronization time.

With the R-CPUs both the synchronization of data and the synchronization of communication tasks operate over the PROFINET ring. 25% of the bandwidth is reserved for the synchronization.

With the H-CPU, synchronization works independently of the PROFINET ring/PROFINET network over fiber optic cables.

The table below provides an overview of performance features of R-CPUs and H-CPU.

Table 3-30 Performance features of S7-1500R and S7-1500H

	S7-1500R		**S7-1500H**	
	CPU 1513R-1 PN (6ES7513-1RM03-0AB0)	**CPU 1515R-2 PN (6ES7515-2RN03-0AB0)**	**CPU 1517H-4 PN (6ES7517-4HQ10-0AB0)**	**CPU 1518HF-4 PN (6ES7518-4JT10-0AB0)**
Performance	• Data transfer rate of 100 Mbps (for synchronization and communication)		• Significantly greater performance than S7-1500R due to – Separate redundancy connections over fiber-optic cables – Greater computing power – Transmission rate of 1 Gbps (for the synchronization)	
	• Data work memory: max. 2.5 MB • Code work memory: max. 600 KB	• Data work memory: max. 4.5 MB • Code work memory: max. 1 MB		
			• Data work memory: max. 50 MB • Code work memory: max. 4 MB	• Data work memory: max. 150 MB • Code work memory: max. 18 MB
Hardware	• The CPUs are identical in design with the respective S7-1500 standard versions. • The synchronization of the CPUs takes place over the PROFINET ring. • The H-Sync-Forwarding function is recommended for all devices in the PROFINET ring. • Part of the bandwidth on the PROFINET cable is used to synchronize the CPUs. Less bandwidth is therefore available for PROFINET IO communication.		• The CPUs each have two optical interfaces. • The synchronization of the CPUs works independently from the PROFINET network via optical fiber. • The bandwidth for PROFINET IO communication is not affected by the synchronization of the H-system.	

Technical specifications

More information about the technical specifications is available in the manuals of the specific CPUs.

6.3.4 Influences on the cycle time when a CPU fails

If one of the two CPUs fails during redundant operation, the other CPU controls the process alone. The system state then changes from RUN-Redundant to RUN-Solo. The CPU continues executing the user program in RUN operating state.

NOTE

Dead time in case of a CPU failure

On the failure of a CPU, the cycle time also contains a dead time of up to 300 ms for R-CPUs and up to 50 ms for the H-CPU. You must schedule this time as cycle time reserve for a CPU failure.

To avoid exceeding the maximum cycle time after a CPU failure, further increase the maximum cycle time by this value.

NOTE

Change of the system state from RUN-Redundant to Run-Solo by the user

If you deliberately trigger a change of the system state by switching the backup CPU to STOP via the display or with the "RH_CTRL" instruction (mode 9), for example, this will also extend the cycle time. However, the cycle time will not increase to the same extent as with switchover of the CPUs in the event of an error (failure of one of the CPUs).

Information on the causes for the failure of a CPU is available in the S7-1500R/H redundant system (https://support.industry.siemens.com/cs/ww/en/view/109754833) system manual.

Failure of the primary CPU

The figure below shows the impact of the failure of the primary CPU on the cycle time.

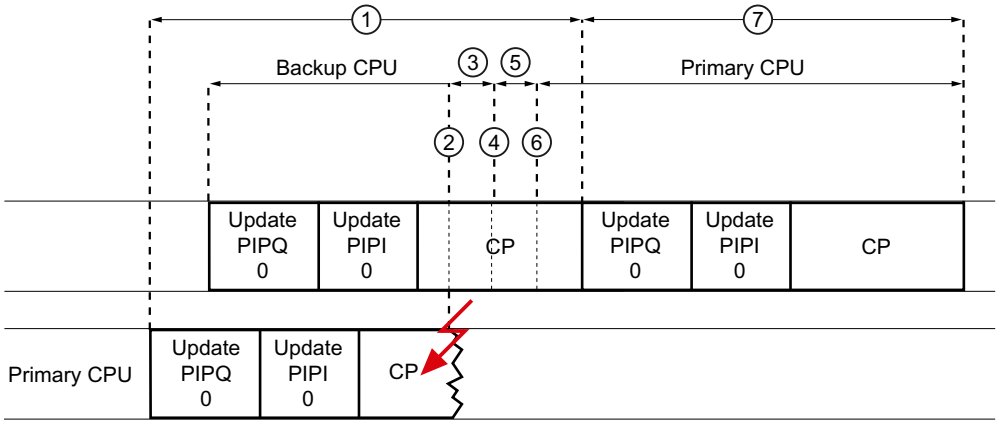

CP - Cyclic program

① Cycle time
② Failure of the primary CPU
③ Backup CPU continues processing the program
④ Backup CPU no longer receives synchronization telegrams
⑤ Backup CPU waits for the monitoring time to expire
⑥ End of the monitoring time, switchover time and system state transition
⑦ Cycle time of the new primary CPU in RUN operating state

Figure 3-35 Impact of the failure of the primary CPU on the cycle time

The example shows the failure of the primary CPU ② while it is processing the cyclic program. The primary CPU no longer sends any synchronization telegrams to the backup CPU. During the period ③, the backup CPU continues operating only on the basis of the synchronization data transferred before the failure of the primary CPU. At ④, the backup CPU has reached the point in the program where the primary CPU stopped sending synchronization telegrams. During the phase ⑤, the backup CPU waits to see whether data will again be sent from the primary CPU after all. Because no synchronization data is transferred until the monitoring time has expired, the backup CPU becomes the new primary CPU at point ⑥. The redundant system switches from RUN-Redundant system state to RUN-Solo system state.

The cycle time ① extends from the time processing of the cyclic program is started in RUN-Redundant to the time when processing of the cyclic program ends in RUN-Solo.

Because no more data is synchronized in the RUN-Solo system state, the cycle time ⑦ is shorter than the cycle time ①.

NOTE
Monitoring time
The monitoring time is an internal time with fixed duration. You cannot assign parameters for the internal time. The monitoring time starts as soon as synchronization data arrives on the respective CPU. If no synchronization data is received from the primary CPU, the system automatically performs a system state change (from RUN-Redundant to RUN-Solo) after the monitoring time has expired.

Failure of the backup CPU

The figure below shows the impact of the failure of the backup CPU on the cycle time.

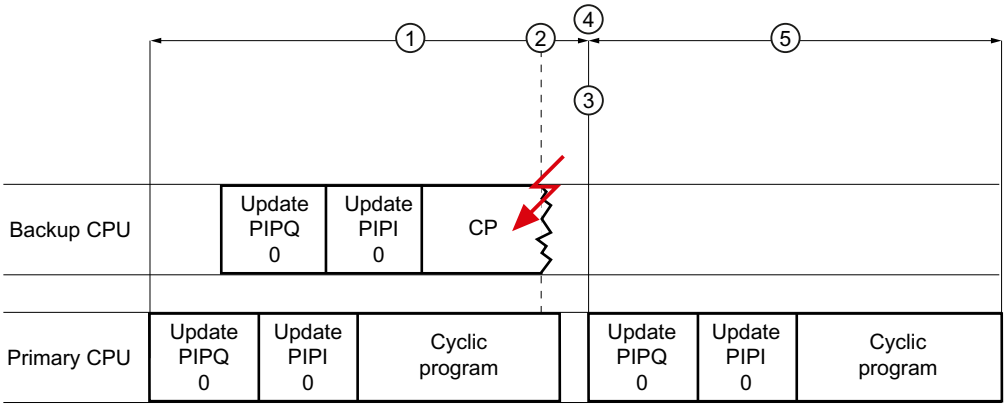

CP = Cyclic program

① Cycle time
② Failure of the backup CPU
③ Expiration of the monitoring time
④ System status transition
⑤ Cycle time of the primary CPU in RUN-Solo operating state

Figure 3-36 Impact of the failure of the backup CPU on the cycle time

The backup CPU fails before processing of the cyclic program has ended ②. The primary CPU detects the failure of the backup CPU because no synchronization data has been received until the monitoring time ③ has expired. The primary CPU terminates the synchronization with the backup CPU. The redundant system switches from RUN-Redundant system state to RUN-Solo system state ④.

Because no more data is synchronized in RUN operating state, the cycle time ⑤ is shorter than the cycle time ①.

6.4 Response time of R/H CPUs

Relationship between the cycle time and response time

The cycle time of the system also forms the basis for its response time. The response time depends, among other things, on the cycle time of the individual program cycles.

Fluctuation of the response time

The actual response time fluctuates between one and two cycles during cyclic program execution. The actual response time fluctuates between one and two cyclic interrupt cycles for time-controlled program execution.

You should always assume the longest response time when configuring your system.

In the figure below the process image is updated immediately after the change of the encoder signal. The output can therefore respond to the signal change after a cycle has ended.

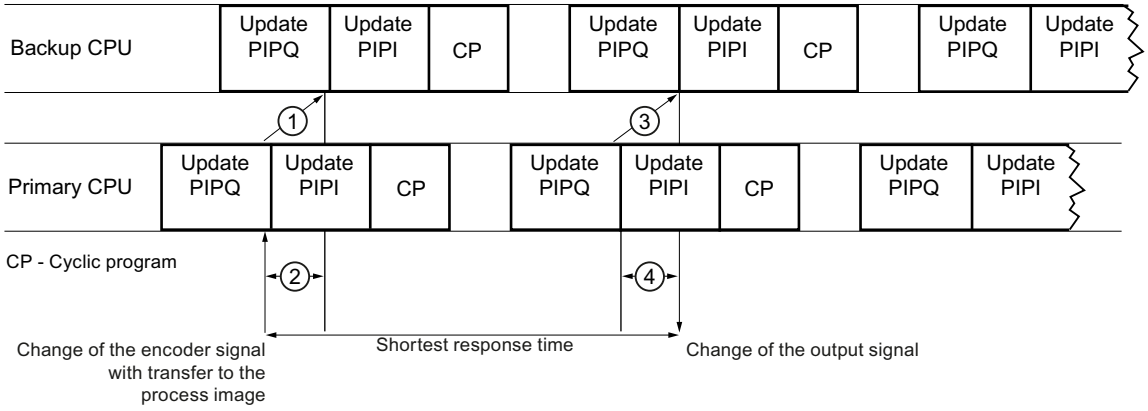

① Synchronization of the encoder signal change in the backup CPU

② Time lag of the backup CPU to the primary CPU

③ Synchronization of the output signal change in the backup CPU

④ Time lag of the backup CPU to the primary CPU until actual output of the signal change to the IO devices in the PROFINET ring/PROFINET network

Figure 3-37 Shortest response time

In the figure below, the process image has already been updated by the time of the signal change. It therefore takes one cycle until the system detects the change and sets the input in the process image. The output signal is changed after an additional cycle.

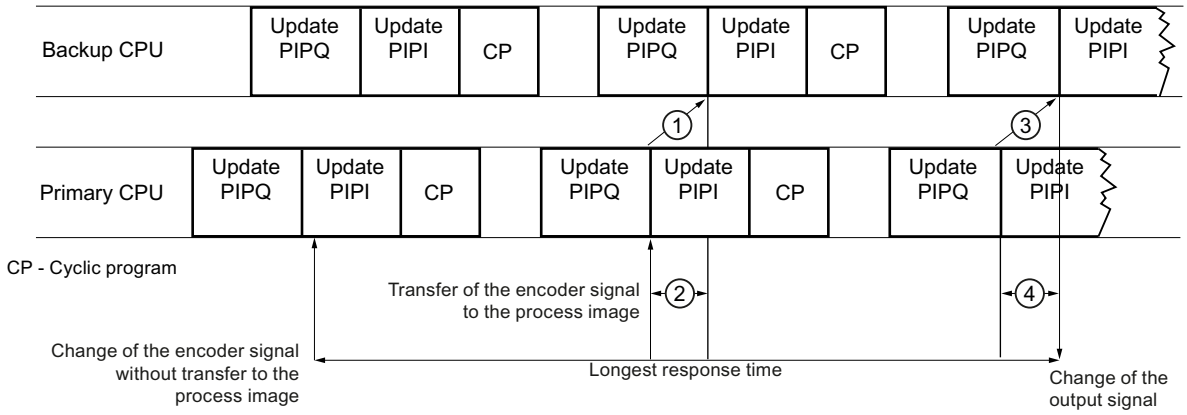

① Synchronization of the encoder signal change in the backup CPU

② Time lag of the backup CPU to the primary CPU

③ Synchronization of the output signal change in the backup CPU

④ Time lag of the backup CPU to the primary CPU until actual output of the signal change to the IO devices in the PROFINET ring/PROFINET network

Figure 3-38 Longest response time

The cycle times include the time lag. The time lag of the backup CPU to the primary CPU depends on the synchronization load. The synchronization load results from the data to be synchronized in the user program and in the communication.

NOTE

Effect of the time lag

The synchronization and transfer of the changes requires computing time. The time lag therefore affects both CPUs (from the primary CPU to the backup CPU and from the backup CPU to the primary CPU). The slower the CPU and the slower and longer the synchronization connection, the greater the time lag.

NOTE

Response time when downloading a modified user program into the R/H CPUs in the RUN-Redundant system state

During the download process in the RUN-Redundant system state, the response time of the system is restricted compared with the normal redundant mode. The more changes the user program contains, the higher the impact on the response time.

NOTE

Improving the response time of the R/H system

- Reduce the load on the redundancy connections between primary and backup CPU:
  - Avoid excessive usage of instructions which increase the synchronization load: Direct accesses, time accesses (for example, instructions RD_SYS_T, WR_SYS_T, RD_LOC_T).
  - Reduce the open user communication with many connections, high communication load with large packages.
- If possible, distribute the comprehensively planned program changes in smaller units with multiple loading processes.
  Multiple loading processes of small units can result in total in a lower load of the response time.

NOTE

Response time of the R/H system for an AR switchover

The smaller you set the PROFINET update times of an IO device, the faster current input data of this IO device is available again after an AR switchover (backup AR becomes primary AR), which can occur in the case of redundancy scenarios.
Result: The smaller you set the PROFINET update times of an IO device, the smaller - generally speaking - the response time of the R/H system.

Also observe the notes in the System Manuals of the I/O systems (e. g. ET 200SP).

Determination of cycle and response times

At the end of the cyclic program, the primary CPU waits until the backup CPU too has acknowledged the end of the cyclic program. The cycle time of the primary CPU therefore also includes the time lag of the backup CPU. The cycle is extended by the time lag.

Advantages

The fact that the cycle time includes the time lag of the backup CPU to the primary CPU offers the following advantages:

- By monitoring the cycle time in STEP 7, in the HMI or in the user program after SYNCUP, it is possible to determine the cycle time in the event of a failure of the primary CPU.
- During commissioning it is not necessary to perform complicated tests to determine whether the required response time can still be complied with if a CPU fails.
- During commissioning and ongoing operation you can estimate whether your automation task can meet the response times required for the process.

The same functions as those for the non-redundant CPUs are available for determining the cycle and response times:

Table 3-31 Functions for determining the cycle and response times

Function	Additional information
Defining the minimum cycle time and the maximum cycle time in STEP 7	Section Cycle time (Page 25)
Defining the desired response of the user program if the maximum cycle time has been exceeded	

Function	Additional information
Reading out the cycle time statistics via STEP 7 and the display of the CPU	Section Cycle time (Page 25)
Reading out the cycle time and reading out the progress in the SYNCUP system state with the instruction "RT_INFO"	• Section Different cycle times (Page 26) • STEP 7 online help
Display of measurements (traces) which record special time-critical signal characteristics	Function manual Using the trace and logic analyzer functions (https://support.industry.siemens.com/cs/ww/en/view/64897128)
Reading out the progress of the SYNCUP system state using the display of the CPU	S7-1500R/H redundant system (https://support.industry.siemens.com/cs/ww/en/view/109754833) system manual

6.5 Timetables for the RUN-Redundant system state

The following section describes the typical times of the CPUs of the S7-1500R/H redundant system in the RUN-Redundant system state.

Update times of the process image partitions

The following table contains the times for estimating the typical update times of the process image partitions.

Table 3-32 Data for estimating the typical update time of the process image partitions

	Update times of the CPUs in the RUN-Redundant system state		
	Article number xxxxxxx-xxx00-xxxx		
	CPU 1513R-1 PN	**CPU 1515R-2 PN**	**CPU 1517H-3 PN CPU 1518HF-4 PN**
Basic load for updating process image partitions	63 µs	57 µs	13 µs
Copy time for distributed I/O via PROFINET	6.5 µs/word	6.5 µs/word	2.6 µs/word

	Update times of the CPUs in the RUN-Redundant system state	
	Article number xxxxxxx-xxx03-xxxx	**Article number xxxxxxx-xxx10-xxxx**
	CPU 1513R-1 PN CPU 1515R-2 PN	**CPU 1517H-4 PN CPU 1518HF-4 PN**
Basic load for updating process image partitions	57 µs	13 µs
Copy time for distributed I/O via PROFINET	6.5 µs/word	2.6 µs/word

Program execution time without interruptions

The user program has a certain runtime without interruptions. The runtime depends on the number of operations that are executed in the user program.

The following table contains the typical durations of operations.

Table 3-33 Duration of an operation

	Program execution times of the CPUs in RUN-Redundant system state		
	Article number xxxxxxx-xxx00-xxxx		
	CPU 1513R-1 PN	**CPU 1515R-2 PN**	**CPU 1517H-3 PN CPU 1518HF-4 PN**
Bit operations, typ.	80 ns	60 ns	4 ns
Word operations, typ.	96 ns	72 ns	6 ns
Fixed-point arithmetic, typ.	128 ns	96 ns	6 ns
Floating-point arithmetic, typ.	512 ns	384 ns	24 ns

	Program execution times of the CPUs in RUN-Redundant system state	
	Article number xxxxxxx-xxx03-xxxx	**Article number xxxxxxx-xxx10-xxxx**
	CPU 1513R-1 PN CPU 1515R-2 PN	**CPU 1517H-4 PN CPU 1518HF-4 PN**
Bit operations, typ.	20 ns	1 ns
Word operations, typ.	24 ns	2 ns
Fixed-point arithmetic, typ.	32 ns	2 ns
Floating-point arithmetic, typ.	128 ns	8 ns

A table of the program execution times of the CPUs in the RUN-Solo system state is available in section User program execution time (Page 33).

Extension due to nesting of higher-priority OBs and/or interrupts

The interruption of a user program at the end of an instruction by a higher-priority OB causes a certain basic time expenditure. Take account of this basic time expenditure in addition to the update time of the assigned process image partitions and the execution time of the contained user program. The following tables contain the typical times for the various interrupts and error events.

Table 3-34 Basic time expenditure for an interrupt

	Basic time expenditure of the CPUs for an interrupt in the RUN-Redundant system state	
	Article number xxxxxxx-xxx00-xxxx	
	CPU 1513R-1 PN	**CPU 1515R-2 PN**
Hardware interrupt	560 µs	430 µs
Time-of-day interrupt	560 µs	430 µs
Time-delay interrupt	560 µs	430 µs
Cyclic interrupt	560 µs	430 µs

	Basic time expenditure of the CPUs for an interrupt in the RUN-Redundant system state	
	Article number xxxxxxx-xxx03-xxxx	**All article numbers**
	CPU 1513R-1 PN **CPU 1515R-2 PN**	**CPU 1517H-3 PN** **CPU 1517H-4 PN** **CPU 1518HF-4 PN**
Hardware interrupt	240 µs	70 µs
Time-of-day interrupt	240 µs	70 µs
Time-delay interrupt	240 µs	70 µs
Cyclic interrupt	240 µs	70 µs

A table of the time expenditure of the CPUs for an interrupt in the RUN-Solo system state is available in section User program execution time (Page 33).

Table 3-35 Basic time expenditure for an error OB

	Basic time expenditure of the CPUs for an error OB in the RUN-Redundant system state	
	Article number xxxxxxx-xxx00-xxxx	
	CPU 1513R-1 PN	**CPU 1515R-2 PN**
Programming error	560 µs	430 µs
I/O access error	560 µs	430 µs
Time error	560 µs	430 µs
Diagnostic interrupt	560 µs	430 µs
Module failure/recovery	560 µs	430 µs
Station failure/recovery	560 µs	430 µs

	Basic time expenditure of the CPUs for an error OB in the RUN-Redundant system state	
	Article number xxxxxxx-xxx03-xxxx	**All article numbers**
	CPU 1513R-1 PN CPU 1515R-2 PN	**CPU 1517H-3 PN CPU 1517H-4 PN CPU 1518HF-4 PN**
Programming error	240 µs	70 µs
I/O access error	240 µs	70 µs
Time error	240 µs	70 µs
Diagnostic interrupt	240 µs	70 µs
Module failure/recovery	240 µs	70 µs
Station failure/recovery	240 µs	70 µs

A table with the basic time expenditure of the CPUs for an error OB in the RUN-Solo system state is available in section User program execution time (Page 33).

Accuracy of a cyclic interrupt

Even if a cyclic interrupt is not delayed by a higher-priority OB or communication activities, the accuracy with which it is started is nevertheless subject to system-dependent fluctuations.

The following table shows the accuracy with which a cyclic interrupt is triggered:

Table 3-36 Accuracy of cyclic interrupts

	Accuracy of cyclic interrupts of the CPUs in the RUN-Redundant system state	
	Article number xxxxxxx-xxx00-xxxx	
	CPU 1513R-1 PN	**CPU 1515R-2 PN**
Cyclic interrupt	±5.8 ms	±3.2 ms

	Accuracy of cyclic interrupts of the CPUs in the RUN-Redundant system state	
	Article number xxxxxxx-xxx03-xxxx	**All article numbers**
	CPU 1513R-1 PN CPU 1515R-2 PN	**CPU 1517H-3 PN CPU 1517H-4 PN CPU 1518HF-4 PN**
Cyclic interrupt	±2.4 ms	±1.6 ms

A table with the accuracy of cyclic interrupts of the CPUs in the RUN-Solo system state is available in section Time-driven program execution in cyclic interrupts (Page 54).

NOTE

Scope of validity

Please note that the accuracy data for the cyclic interrupt also applies to all other higher-priority execution levels/OBs.

Interrupt response times for hardware interrupts

The interrupt response times of the CPUs start with the occurrence of a hardware interrupt event in the CPU and end with the start of the assigned hardware interrupt OB.

This time is subject to system-inherent fluctuations, and this is expressed using a minimum and maximum interrupt response time.

The following table contains the length of the typical response times of the CPUs for hardware interrupts.

Table 3-37 Interrupt response times for hardware interrupts

		Interrupt response times of the CPUs for hardware interrupts in the RUN-Redundant system state	
		Article number xxxxxxx-xxx00-xxxx	
		CPU 1513R-1 PN	**CPU 1515R-2 PN**
Interrupt response times	Min.	180 µs	150 µs
	Max.	1420 µs	1360 µs

		Interrupt response times of the CPUs for hardware interrupts in the RUN-Redundant system state	
		Article number xxxxxxx-xxx03-xxxx	**All article numbers**
		CPU 1513R-1 PN **CPU 1515R-2 PN**	**CPU 1517H-3 PN** **CPU 1517H-4 PN** **CPU 1518HF-4 PN**
Interrupt response times	Min.	150 µs	40 µs
	Max.	1360 µs	470 µs

A table of the interrupt response times of the CPUs in the RUN-Solo system state is available in section Response time of the CPUs when program execution is event-controlled (Page 63).

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SIMATIC

S7-1500, S7-1500R/H, SIMATIC Drive Controller, ET 200SP, ET 200pro
Structure and Use of the CPU Memory

Function Manual

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Safety instructions 2

Memory areas and retentive memory 3

Memory usage and application examples 4

SIMATIC memory card 5

11/2023
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Introduction

1

Purpose of the documentation

This documentation describes the various memory areas of the following systems:

- SIMATIC S7-1500 automation system
- SIMATIC S7-1500R/H redundant system
- SIMATIC Drive Controller
- The CPUs of the ET 200SP distributed I/O system
- The CPUs of the ET 200pro distributed I/O system based on SIMATIC S7-1500

The book also shows:

- How to make the best use of the memory areas
- How to reduce work memory utilization by:
  - Using recipes and data logs
  - Saving data blocks on the SIMATIC memory card

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the SIMATIC industrial automation system
- Knowledge about the use of computers
- Proficiency with STEP 7

Conventions

STEP 7: in this documentation, "STEP 7" is used as a synonym for all versions of the "STEP 7 (TIA Portal)" configuring and programming software.

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Scope of the documentation

This documentation is valid for the central modules of the SIMATIC S7-1500, SIMATIC Drive Controller and ET 200SP systems and for ET 200pro.

The CPUs of the redundant system S7-1500R/H do not support all the memory objects described in this function manual. The limitations of the redundant S7-1500R/H system are pointed out where appropriate in the manual. You can find a list of the unsupported functions in the Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833) system manual.

What's new in edition 11/2023 as compared to edition 11/2019?

What's new?		What are the customer benefits?	Where can I find the information?
Changed contents	Content update	The function manual has been updated for new functions of the S7-1500R/H redundant system.	• In the corresponding sections of this manual • S7-1500R/H redundant system (https://support.industry.siemens.com/cs/ww/en/view/109754833) system manual

What's new in edition 11/2019 as compared to edition 10/2018?

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Scope of the function manual expanded to include the CPUs of the SIMATIC Drive Controller	SIMATIC Drive Controller and SINAMICS Integrated support the memory structure familiar from the S7-1500 automation system. Information on the special features of the SIMATIC Drive Controller is explained at the relevant points in the manual.	• In the corresponding sections of the manual • SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766665) system manual

What's new in Edition 10/2018 compared to Edition 09/2016

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Scope of the function manual expanded to include the CPUs of the redundant system S7-1500R/H.	The CPUs of the redundant system S7-1500R/H support the memory structure familiar from the S7-1500 automation system. Information on the particularities of the redundant S7-1500R/H system is provided where appropriate in the manual.	• In the corresponding sections of the manual • System manual Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833)

What's new in Edition 09/2016 compared to Edition 01/2013

What's new?		What are the customer benefits?	Where can I find information?
New contents	Analyzing memory requirements and memory usage	You have various options for analyzing the memory requirements and the memory usage of the CPU: • With STEP 7 • With the display of the CPU • With the web server of the CPU	Section Memory requirements and memory usage (Page 17)
	Memory requirements in load memory for downloading software changes	When loading software changes to the SIMATIC memory card, the files in question are only deleted after creation of the new files. For this reason, the CPU requires adequate free memory space on the SIMATIC memory card. You have various options for creating memory space; these will be explained.	Section Memory requirements for downloading software changes (Page 28)
	Service life of SIMATIC memory cards	Using calculation examples of the service life of a SIMATIC memory card, you can estimate which SIMATIC memory card is required for your automation task.	Section Service life of the SIMATIC memory card (Page 59)
Changed contents	Scope of the function manual expanded to include the CPUs of the ET 200SP distributed I/O system and the CPU 1516pro-2 PN	Functions that you will be familiar with from the SIMATIC S7-1500 CPUs are implemented in CPUs in other designs (ET 200SP) and in the CPU 1516pro-2 PN (degree of protection IP65, IP66 and IP67).	• Manual CPU 1510SP-1 PN (https://support.industry.siemens.com/cs/ww/en/view/901571-30) • Manual CPU 1512SP-1 PN (https://support.industry.siemens.com/cs/ww/en/view/901570-13) • Operating instructions CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482-416)

Recycling and disposal

For environmentally friendly recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Industry Mall

The Industry Mall is the catalog and ordering system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive technology products on the internet (https://mall.industry.siemens.com).

See also

Memory usage for data logging (Page 36)

1.1 Function Manuals documentation guide

1.1.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

Memory areas and retentive memory

3

3.1 Memory areas

The automation data is located in the automation system in different memory areas.

The offline data of the project created in STEP 7 is located on the hard disk of the programming device. The online data of the project is located in the load memory on the SIMATIC memory card. In addition, the work memory, retentive memory and other memory areas are located on the CPU.

The following figure shows an overview of the memory areas of the CPUs:

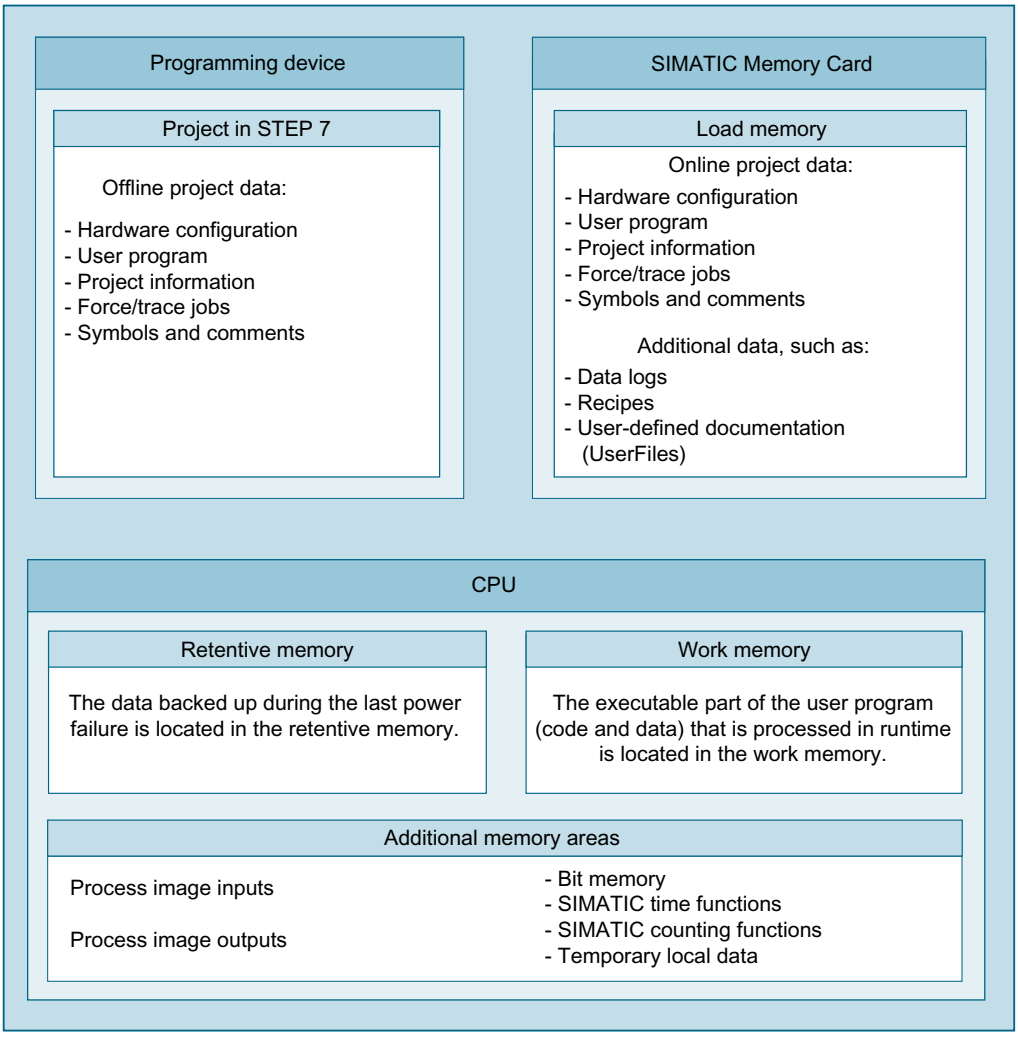

Figure 3-39 Memory areas

Load memory

Load memory is non-volatile memory for code blocks, data blocks, technology objects and the hardware configuration. This load memory is located on the SIMATIC memory card. STEP 7 transfers the project data from the programming device to the load memory.

You can copy additional data (for example HMI backups and other files) to the SIMATIC memory card using the web server or Explorer. This data can then be found in the load memory on the SIMATIC memory card.

NOTE

An inserted SIMATIC memory card is required to operate the CPU.

Load memory: CPU 1518-4 PN/DP MFP and CPU 1518F-4 PN/DP MFP

On these CPUs additional memory space is used in the load memory by:

- Linux runtime, which runs in parallel with the CPU runtime
- C/C++ runtime applications
- Files that are needed for C/C++ runtime applications
- CPU function libraries

NOTE

CPU runtime

In the context of the CPU 1518-4 PN/DP MFP and the CPU 1518F-4 PN/DP MFP as well as the Open Development Kit (ODK), the term "CPU runtime" has the following meaning:

The CPU runtime is the runtime environment in which a CPU runtime application can be executed. CPU 1518-4 PN/DP MFP and CPU 1518F-4 PN/DP MFP run a Linux runtime in parallel with the CPU runtime. The Linux runtime is the runtime environment for applications that are executable in Linux, e.g. C/C++ runtime applications.

For additional information on the CPUs, refer to the CPU 1518-4 PN/DP MFP (https://support.industry.siemens.com/cs/ww/en/view/109749061) manual and the CPU 1518(F)-4 PN/DP MFP (https://support.industry.siemens.com/cs/ww/en/view/109756478) product information. You can find information on creating C/C++ runtime applications in the SIMATIC S7-1500 ODK 1500S (https://support.industry.siemens.com/cs/ww/en/ps/13914/man) manual.

Work memory

The work memory is volatile memory that contains the code and data blocks. The work memory is integrated into the CPU and cannot be extended. The work memory is only used in operation of the CPU.

In the CPUs, the work memory is divided into two areas:

- Code work memory: The code work memory contains runtime-relevant parts of the program code.

- Data work memory: The data work memory contains the runtime-relevant parts of the data blocks and technology objects.
  Tags of global data blocks, instance data blocks and technology objects are initialized with their start values at the operating states changes below. Retentive tags receive their actual values saved in the retentive memory.
  - STOP → STARTUP
  - POWER ON → STARTUP
  - POWER ON → STOP

Work memory of CPU 1518-4 PN/DP MFP and CPU 1518F-4 PN/DP MFP

Additional work memory is needed for use of the CPU function libraries and C/C++ runtime applications.

Retentive memory

The retentive memory is non-volatile memory for saving a limited amount of data in the event of power failure.

The following actions delete certain memory objects of the retentive memory:

- Memory reset
- Reset to factory settings

You can find an overview of the retentive behavior of the individual memory objects in section Retentive behavior of the memory objects (Page 25).

You can find additional information on the memory reset and reset to factory settings functions in the following manuals:

- System manual S7-1500, ET 200MP Automation System (http://support.automation.siemens.com/WW/view/en/59191792)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766665) system manual
- System manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)
- Operating instructions ET 200pro CPU 1513pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109769507) and ET 200pro CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482416)

Additional memory areas

Besides the memory areas that have been described for the user program and data, the CPU has additional memory areas available.

The additional memory areas include the following:

- Process images
- Temporary local data

The CPU-specific sizes can be found in the technical specifications for the respective CPU.

3.1.1 Specifics of the CPUs of the redundant system S7-1500R/H

The redundant system S7-1500R/H consists of two CPUs. There must be a SIMATIC memory card in each of the CPUs. We recommend the same memory size for each SIMATIC memory card. During redundant operation, both CPUs execute the user program in parallel. In so doing, one CPU takes the role of the leading CPU (Primary CPU) and one CPU takes the role of the following CPU (Backup CPU). If one CPU fails, the second CPU maintains control over the process.

Memory areas

The two CPUs of the redundant system S7-1500R/H have the same memory areas as the CPUs of non-redundant systems.

You create the hardware configuration of the offline project data only once in STEP 7 STEP 7 loads the offline project data into the current primary CPU. The system synchronizes all data required for redundant operation from the primary CPU to the backup CPU.

Both CPUs receive identical online project data. The online project data contains the hardware configuration of the H-system.

Particularities of the retentive memory

Like for non-redundant CPUs, the retentive memory is a non-volatile memory. The retentive memory saves a limited amount of data in the event of power failure.

Each of the CPUs of the redundant system S7-1500R/H has its own retentive memory. If one of the CPUs changes to POWER OFF and the second CPU is still in RUN, the retentive data of the CPU in RUN continues to be updated. If the remaining CPU also goes from RUN to POWER OFF, the retentive memory of this CPU contains the more up-to-date retentive data. Note the following for when you switch the CPUs back to RUN afterwards.

NOTE

Characteristics of retentive data after a STOP or POWER OFF of both CPUs

After a STOP or POWER OFF of both CPUs, switch the CPU with the more up-to-date data to RUN first. The more up-to-date data is located in the CPU that controlled the process before STOP or POWER OFF. This procedure gives you certainty that you are using the more up-to-date retentive data. The precondition for this is that you did not change any data using STEP 7 or the HMI while the CPUs were in STOP.

Redundancy ID

Unlike in a non-redundant CPU, an additional memory object is contained in the retentive memory of the respective redundant CPU. Each CPU saves its respective redundancy ID in this memory object. The redundancy IDs can assume the values 1 and 2. Different redundancy IDs are required for redundant operation in order to clearly identify the CPUs and assign the project data to the respective CPUs. For additional information on redundancy IDs of the CPUs, refer to the Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833) system manual.

You can find an overview of the retentive behavior of the individual memory objects in section Retentive behavior of the memory objects (Page 25).

3.2 Memory requirements and memory usage

You can access information regarding the memory areas of the CPUs in the following ways depending on product family used:

Product family	Information regarding the memory areas of the CPU is accessible via:		
	STEP 7	Web server	Display
S7-1500	✓	✓	✓
S7-1500R/H	✓	✓[1]	✓
SIMATIC Drive Controller	✓	✓	--
ET 200SP	✓	✓	--
ET 200pro CPU 151xpro-2 PN	✓	✓	--

[1] Web API of the web server only

Memory requirements of the program in the offline project

During creation or modification of a project, the display of memory utilization in STEP 7 shows you the size of the project in the following memories:

- Load memory
- Work memory
- Retentive memory

You can find this information for the CPU under "Program info" in the project tree, "Resources" tab.

- Total size of the memory areas of the respective CPU project (in the figure below line "Total:")
- Memory requirements of the program elements (blocks, data types, objects for motion technology and PLC tags)
- Memory amounts in the respective memory area of the offline project (in figure below, line "Used:")
- Used inputs and outputs

The following figure shows an overview of the utilization of the various memory areas of the "Resources" tab:

Resources of PLC_1

	Objects	Load memory	Code work-memory	Data work-memory	Retain memory
1		?%	0 %	0 %	0 %
2					
3	Total:	not specified	1048576 bytes	5242880 bytes	484000 bytes
4	Used:	not specified	164 bytes	0 bytes	0 bytes
5	Details				
6	OB		>164 bytes		
7	FC		-		
8	FB		?		
9	DB			-	0 bytes
10	Objects for Motion Technology	?		-	0 bytes
11	Data types	43941 bytes			
12	PLC tags	1426 bytes			0 bytes

not specified
2 MB
4 MB
12 MB
24 MB
256 MB
2 GB
32 GB

Figure 3-40 Display of the utilization of the various memory areas

For a CPU, you can select the total size of the load memory in a drop-down list. Select the size of the load memory in accordance with the size of the SIMATIC memory card you are using. The percentage shown in the Load memory column depends on the selected size of the load memory. As soon as the memory size exceeds the size of the load memory of the memory card you are using, the sizes indicated turn red.

NOTE

Determination of the memory utilization

Note that the SIMATIC memory card also contains data other than the user program that you cannot determine using "Resources". This data includes:

- Hardware configuration
- Recipes, data logs and user files
- HMI backups (not supported for S7-1500R/H)
- Data blocks that were dynamically created/deleted using the CREATE_DB/DELETE DB instructions

Therefore, the drop-down list with the size of your SIMATIC memory card only serves as a visual orientation aid.

Also refer to the FAQ "How do you estimate the memory requirements of your project in the load memory of a SIMATIC S7-1500" on the Internet (https://support.industry.siemens.com/cs/ww/en/view/97553417).

NOTE

Display of the memory utilization under "Program info"

The display of the memory utilization in the program information is an offline display in STEP 7 and only shows the memory requirements of the program in the project. The program on the memory card of the CPU may differ, however, for example if the program:

- is more up to date
- contains blocks generated by other projects
- contains blocks generated on the CPU

Data on the SIMATIC memory card

In addition to the program and the associated program elements (blocks, data types, objects for motion technology and PLC tags), the following data is also stored on the memory card:

- Hardware configuration
- Project information
- Force jobs
- Trace recordings (not supported for S7-1500R/H)
- Symbols and comments

The following further data may also be found on the memory card:

- Recipes, data logs and user files
- HMI backups (not supported for S7-1500R/H)
- Data blocks that were dynamically created/deleted using the CREATE_DB/DELETE DB instructions

Display of the memory utilization in STEP 7

In online mode, the online function "Memory" provides you with the following up-to-date memory information:

- Size of the total free and already allocated load memory on the SIMATIC memory card.
- Size of the total free and already allocated work memory, separated by code and data.
- Size of the total free and already allocated retain memory.

The online function "Memory" can be found in Online & Diagnostics under "Diagnostics > Memory". You can access the functions under Online & Diagnostics in various ways:

- In the project tree under each configured CPU.
- In the project tree under Online access > Accessible devices, in order to display the memory utilization of CPUs that were not configured in the project.
- In all views of the device configuration (topology view, network view, device view) by selecting a CPU with the right mouse button.

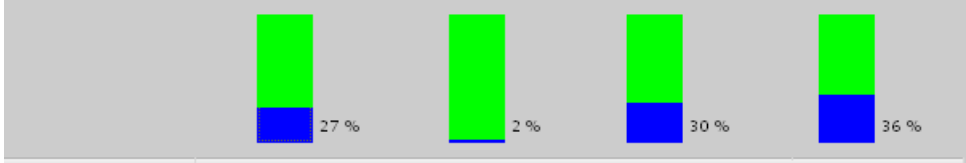

Sizes in bytes	Load memory	Code work-memory	Data work-memory	Retain memory
Free:	6291456	1048576	5242880	524288
In use:	2316997	17355	2299642	301234
Total:	8608453	1065931	7542522	825522

Figure 3-41 "Memory" online function

NOTE

Fill levels of the CPUs of the redundant system S7-1500R/H

The CPUs of the redundant system S7-1500R/H can have CPU-specific fill levels in non-redundant operation.

The fill levels of the load memory of the CPUs can differ in redundant operation and non-redundant operation (e.g. due to stored PDF files or SIMATIC memory cards of different sizes).

You can have the memory utilization of both CPU 1 and CPU 2 displayed in STEP 7.

Alternatively to the "Memory" online function, you will also find a display of the current memory functions on the "Online tools" task card in the "Memory" section.

Display of the memory utilization on the display of the CPU

To obtain information about the available memory via the display, proceed as follows:

- Select the "Diagnostics" menu on the display with the help of the arrow keys.
- Select the "Used memory" command from the "Diagnostics" menu.

Under the "Used memory" menu item, you can find information about the utilization of the various memory areas (see following figure). Note that the memory usage is a snapshot of the memory used at the time of the request and is not continuously updated.

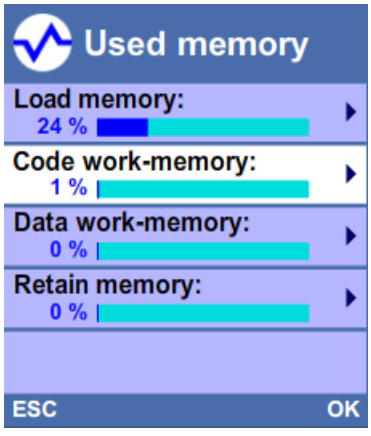

To find out details about the respective memory areas (e.g. code work memory), select the required memory area with the help of the arrow keys (see following figure).

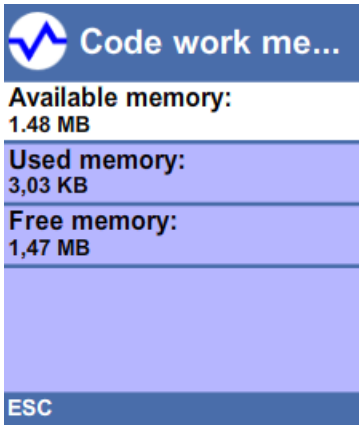

In the detail view, e.g. of the code work memory, the display provides you with the following information:

- Memory space which is still available in the code work memory.
- Memory space which is already allocated in the code work memory.
- Total available memory space in the code work memory.

Display of the memory usage in the Web server

On the Web server, you can find information about the current usage of the individual memory areas on the Web page "Diagnostics" in the "Memory" tab.

Detailed information about the use of the Web server can be found in the S7-1500 Web server (https://support.industry.siemens.com/cs/ww/en/view/59193560) function manual.

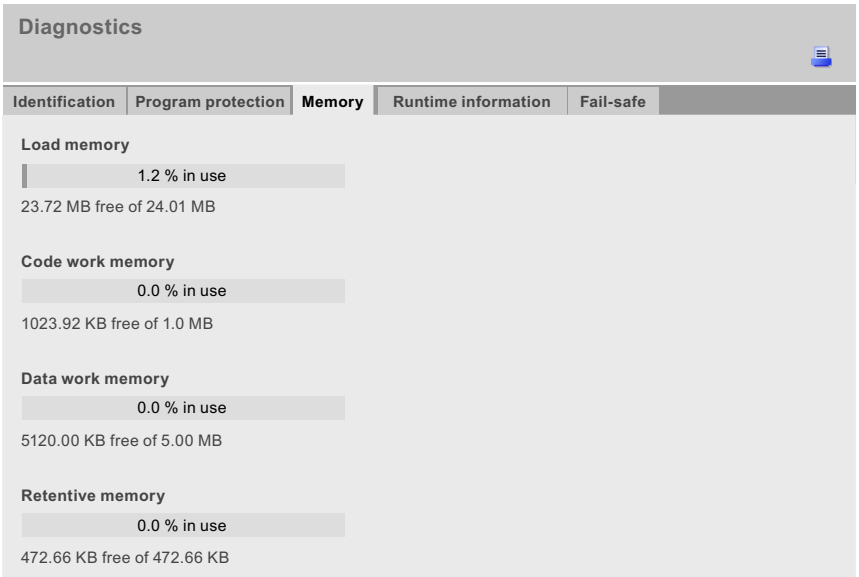

Figure 3-42 Display of the memory usage in the Web server

NOTE
Redundant system S7-1500R/H
The redundant system S7-1500R/H only supports the Web API of the web server.

3.3 Retentive memory areas

Introduction

The CPUs have a memory for storing retentive data at POWER OFF. You can find the size of the retentive memory in the technical specifications of the respective CPU.

You can find the utilization of the retentive memory of the configured CPU in STEP 7 offline under "Program info > Resources" or online under Online & diagnostics with "Diagnostics > Memory".

If you define data as retentive, its content is retained for the startup of a program after STOP or a power failure.

You can define the following data and objects as retentive:

- Tags of global data blocks
- Tags of instance data blocks of a function block
- Bit memories, timers and counters

Tags of a global data block

In a global data block, you can define either individual tags from a block or all of its tags collectively as retentive, depending on the setting for the "Optimized block access" attribute:

- "Optimized block access" activated: In the declaration table of the data block, you can define individual tags as retentive.

		Name	Data type	Start value	Retain	Visible in HMI	Comment
1		Static			☐	☐	
2		var1	Bool	false	☑	☑	
3		var2	Bool	false	☐	☑	
4		var3	Bool	false	☑	☑	
5		var4	Bool	false	☐	☑	
6		var5	Bool	false	☑	☑	

Figure 3-43 Retentivity setting "Optimized block access" activated

- "Optimized block access" not activated: In the declaration table of the data block, you can only define the retentivity of all tags collectively.

		Name	Data type	Offset	Start value	Retain	Visible in HMI	Comment
1		Static				☐	☐	
2		var6	Bool	...	false	☑	☑	
3		var7	Bool	...	false	☑	☑	
4		var8	Bool	...	false	☑	☑	
5		var9	Bool	...	false	☑	☑	
6		var10	Bool	...	false	☑	☑	

Figure 3-44 Retentivity setting "Optimized block access" not activated

You can find additional information on optimized and non-optimized data blocks in the Programming guideline for S7-1200/S7-1500 (https://support.industry.siemens.com/cs/de/de/view/90885040/en).

Tags of an instance data block of a function block

You can define the tags of the instance data block of a function block as retentive in STEP 7. Depending on the setting for the "Optimized block access" attribute, you can define retentivity either for individual tags from a block or for all of its tags collectively:

- "Optimized block access" activated: In the interface of the function block, you can define individual tags as retentive.
- "Optimized block access" not activated: In the instance data block, you can only define the retentivity of all tags collectively.

Creation of a data block in the user program

The instruction "CREATE_DB" is used to create a new data block in the load and/or work memory. For data blocks which you create in the load memory, depending on the selection for the ATTRIB parameter, the generated data block either has the property "retentive" or the property "non-retentive". Setting the retentivity for individual tags is not possible here. The "Optimized block access" attribute is disabled.

If you create a data block in the user program, then the write protection of the SIMATIC memory card must not be activated. You can find additional information on the "CREATE_DB" instruction in the STEP 7 online help under "Programming a PLC > Instructions > Extended instructions > Data block control > CREATE_DB: Create data block".

NOTE

Redundant system S7-1500R/H

The redundant system S7-1500R/H only supports the modes "Only in load memory" or "Work and load memory" in the "CREATE_DB" instruction. Creation of the data block in the "Only in work memory" mode is not supported.

Tags of technology objects

Tags of technology objects are retentive, e.g. calibration values of absolute encoders. STEP 7 manages the retentivity of the technology object tags automatically. Hence, you do not have to configure retentivity.

The retentive tags of technology objects are unaffected by a memory reset. They can be deleted only by a reset to factory settings.

If you have backed up adjustment values of absolute encoders to the SIMATIC Memory Card with the "MC_SaveAbsoluteEncoderData" instruction, these become valid after the reset to factory settings with the SIMATIC Memory Card inserted in the CPU.

NOTE

Redundant S7-1500R/H system

Technology objects are not supported by the CPUs of the redundant system S7-1500R/H.

Bit memories, timers and counters

You can define the number of retentive bit memories, timers and counters in STEP 7 in the PLC tag table using the "Retain" button.

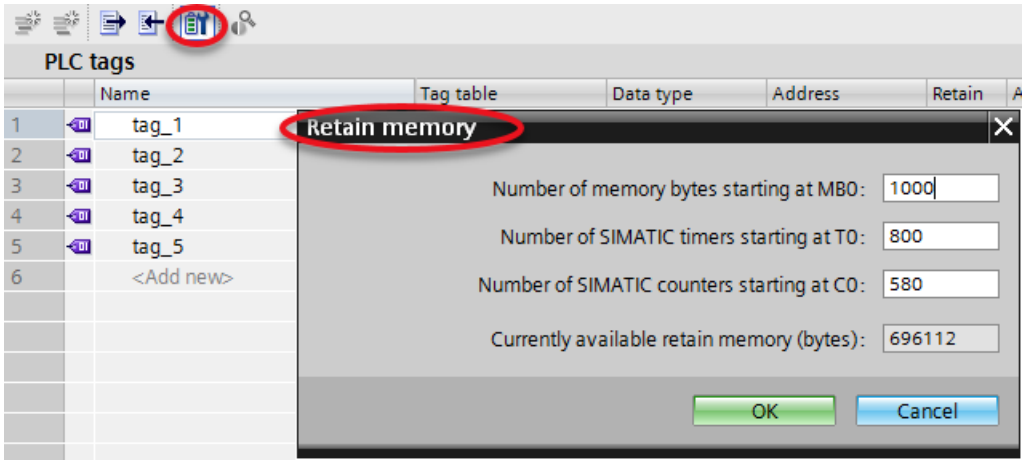

Figure 3-45 Definition of the number of retentive bit memories, timers and counters (beginning at 0, continuing without gaps) using the "Retain" button

Reference

You can find additional information on setting the retentivity in the STEP 7 online help.

3.4 Summary of retentive behavior

3.4.1 Retentive behavior of the memory objects

This section gives an overview of the retentive behavior of the memory objects of the CPUs.

In addition to the retentive memory areas described, there are other objects with retentive characteristics, for example, the diagnostics buffer. These objects do not occupy any storage space in the retentive memory.

The following table shows the retentive behavior of the memory objects in the case of the following:

- STOP → STARTUP
- POWER ON → STARTUP
- POWER ON → STOP
- "Memory reset"
- "Reset to factory settings"

Table 3-38 Retentive behavior of the memory objects

Memory object	STOP → STARTUP POWER ON → STARTUP POWER ON → STOP	Memory reset	Reset to factory settings
Actual values of the data blocks, instance data blocks	Can be set in the properties of the DB in STEP 7 [1]	-	-
Bit memories, timers and counters - configured as retentive	x	-	-
Bit memories, timers and counters - configured as non-retentive	-	-	-
Retentive tags of technology objects (e.g. calibration values of absolute encoders) [2]	x	x	-
Diagnostics buffer entries	x	x	-
Operating hours counter	x	x	-
Clock time	x	x	-
Redundancy ID [3]	x	x	-
x = content is retained – = object is initialized			

[1] For DBs with optimized access the retentive behavior is configurable for specific tags.

[2] Not for the CPUs of the redundant system S7-1500R/H

[3] Only for the CPUs of the redundant system S7-1500R/H

Diagnostics buffer

The 500 most recent entries in the diagnostics buffer are retained after power failure and are not affected by a memory reset. The diagnostics buffer can be cleared only by a reset to factory settings. The entries in the diagnostics buffer do not occupy any memory space in the retentive memory.

Operating hours counter

The operating hours counters of the CPUs are retentive and are not affected by a memory reset. By resetting to factory settings, the operating hours counters are set to zero.

Clock time

The clock time of the CPUs is retentive and is not affected by a memory reset. A reset to factory settings resets the system time to 01.01.2012 00:00:00.

3.5 Memory behavior when loading software changes

Introduction

You can download software changes in STOP and RUN without affecting the actual values of previously loaded tags.

You load changes to the software in STEP 7 (in the project tree and with selected PLC station) under "Download to device > Software (only changes)".

Impact of software changes on PLC tags

You can load the following software changes without affecting the actual values of PLC tags that have already been loaded:

- Name change
- Comment change
- Addition of new tags
- Deletion of tags
- Change of retentivity settings for Retentive memory areas (Page 22)

The actual values are affected by loading the following software changes:

- Data type change
- Change to addresses

Memory reserve of global DBs and instance DBs

Each function block or data block with the "Optimized block access" attribute activated contains, by default, a memory reserve which you can use for subsequent interface changes. The memory reserve is initially not used. When you have compiled and loaded the block, and then observe that you want to reload interface changes, activate the memory reserve. All tags that you subsequently declare will be placed in the memory reserve. During the next load, the new tags are then initialized to their start values. Tags which have already been loaded are not reinitialized.

The setting of the memory reserve can be found in STEP 7 under the data block properties in the "Download without reinitialization" category.

Impacts of software changes on data blocks without memory reserve

If you are not using memory reserve, you can load the following software changes without this reinitializing the actual values of DB tags that have already been loaded:

- Start value change
- Comment change

Impacts of software changes on data blocks with memory reserve

If you are using the memory reserve for data blocks ("Optimized block access" attribute and "Enable download without reinitialization for retentive tags" button selected), you can load the following software changes. The actual values of previously downloaded DB tags are not reinitialized by this.

- Start value change
- Comment change
- Addition of new tags

If the button "Enable download without reinitialization for retentive tags" is deactivated, then all actual values of the data block are reinitialized on the next loading of the following software changes:

- Name change
- Data type change
- Retentivity change
- Deletion of tags
- Changes to the memory reserve settings
- Addition of new tags

Reference

You can find additional information on setting and activating the memory reserve and on downloading block changes in the STEP 7 online help under "Programming a PLC > Compiling and downloading PLC programs > Downloading blocks for S7-1200/1500 > Loading block extensions without reinitialization".

3.6 Memory requirements for downloading software changes

Memory requirements in RUN state

For the consistent and atomic execution of the complete download operation, the CPU requires adequate free memory space in the work memory and on the SIMATIC memory card. The files affected by loading the software changes to the CPU are only deleted after the new files have been created. This SIMATIC memory card therefore requires free memory space corresponding approximately to the space required for all program objects to be loaded on the memory card.

If this amount of memory is not available on your SIMATIC memory card, the following message is displayed in STEP 7 during the download operation to the CPU: "There is insufficient memory on the memory card for this amount of data."

In order to still enable the loading of changes to the CPU in such a case, we recommend one or more of the following options:

- Download in RUN state
  - Delete any files no longer required (e.g. CSV files, panel backups, etc.) on the memory card using the Web server.
  - Preferably, you should download extensive changes in RUN state in multiple steps or perform the download after each change step.

  NOTE

  Loading in the RUN-Redundant system state into the CPUs of the redundant system S7-1500R/H: Check for sufficient free space before a write function

  Before a write function is performed, the system checks whether there is enough free space on the SIMATIC memory cards of the CPUs for the function. Write functions are online functions with the PG/PC, for example, test functions, loading a modified user program in the RUN-Redundant system state.

  If there is not enough space on a SIMATIC memory card or on both SIMATIC memory cards, the write function is aborted and the redundant system continues operation with the original configuration. The redundant system will remain in the RUN-Redundant system state.

- Download in STOP state
  - If downloading in several steps is not possible, load extensive changes in STOP state.
- Use a larger memory card
  - In order to perform extensive downloads in RUN state of the CPU in the future, use a larger memory card. A description of how to change the memory card can be found in the section "Changing the memory card without loss of retentive data".

Impact of minor program changes on the load procedure

Under the objects of a program, there are dependencies, e.g.

- Of code blocks to called code blocks
- Of code blocks to data blocks
- Of data blocks to data types (PLC data types, FB types)

This means that the load procedure for a minor change may be very time-consuming if the change affects a large number of dependent objects.

Example:

A STEP 7 program contains an organization block (OB), 20 functions (FC) and a data block (DB). The OB calls the 20 FCs. All the FCs access the DB. If you change the program code in one of the FCs, the following load procedure only contains the changed FC. If you change the data type of a tag in the DB, however, the following load procedure then contains all the FCs and the DB.

The following figure shows the objects in the load procedure in a preview.

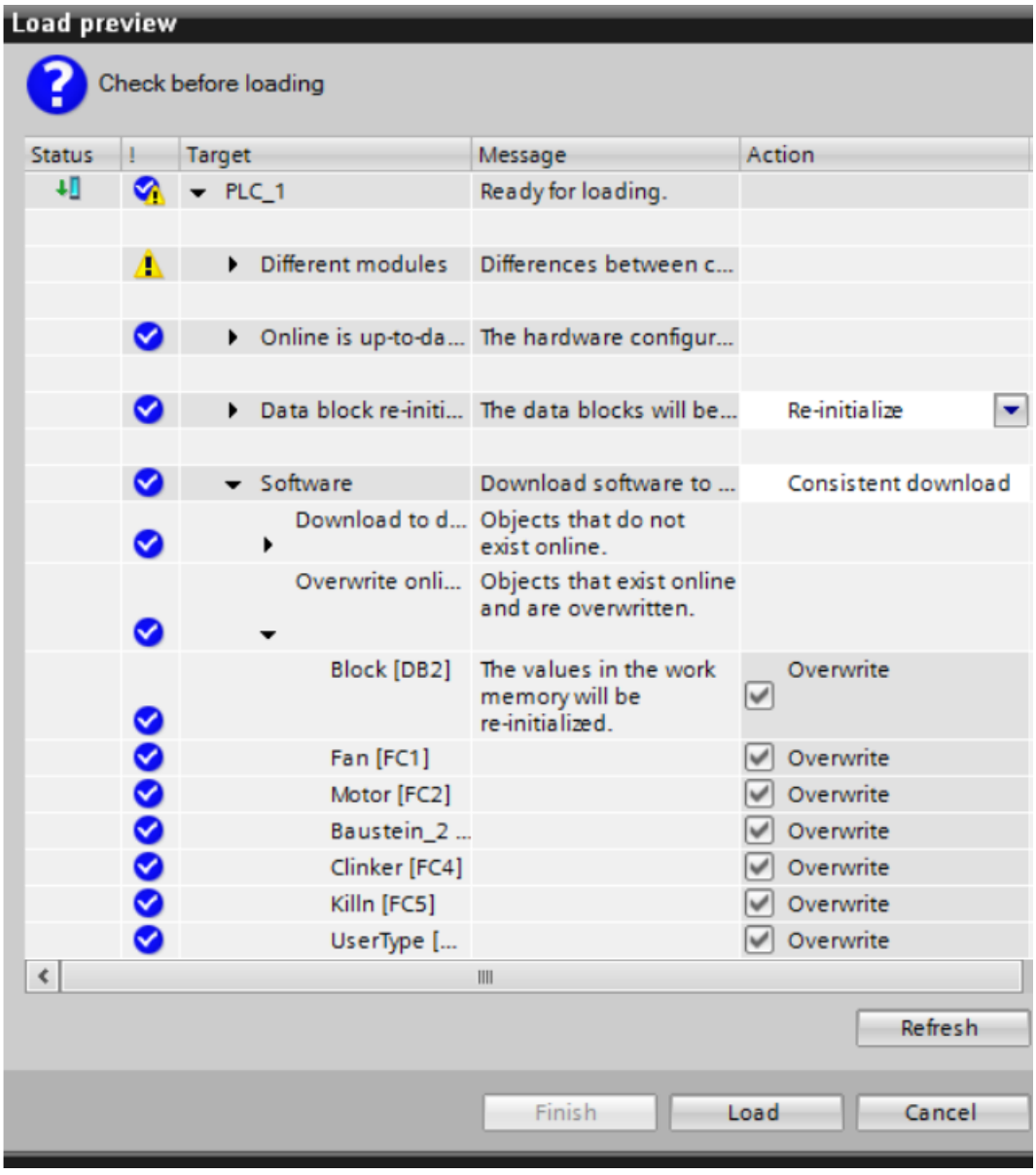

Figure 3-46 Preview for loading

To find the interdependencies of the individual objects, double-click "Program info" in the project tree. Change to the "Dependency structure" tab in the "Program info" dialog.

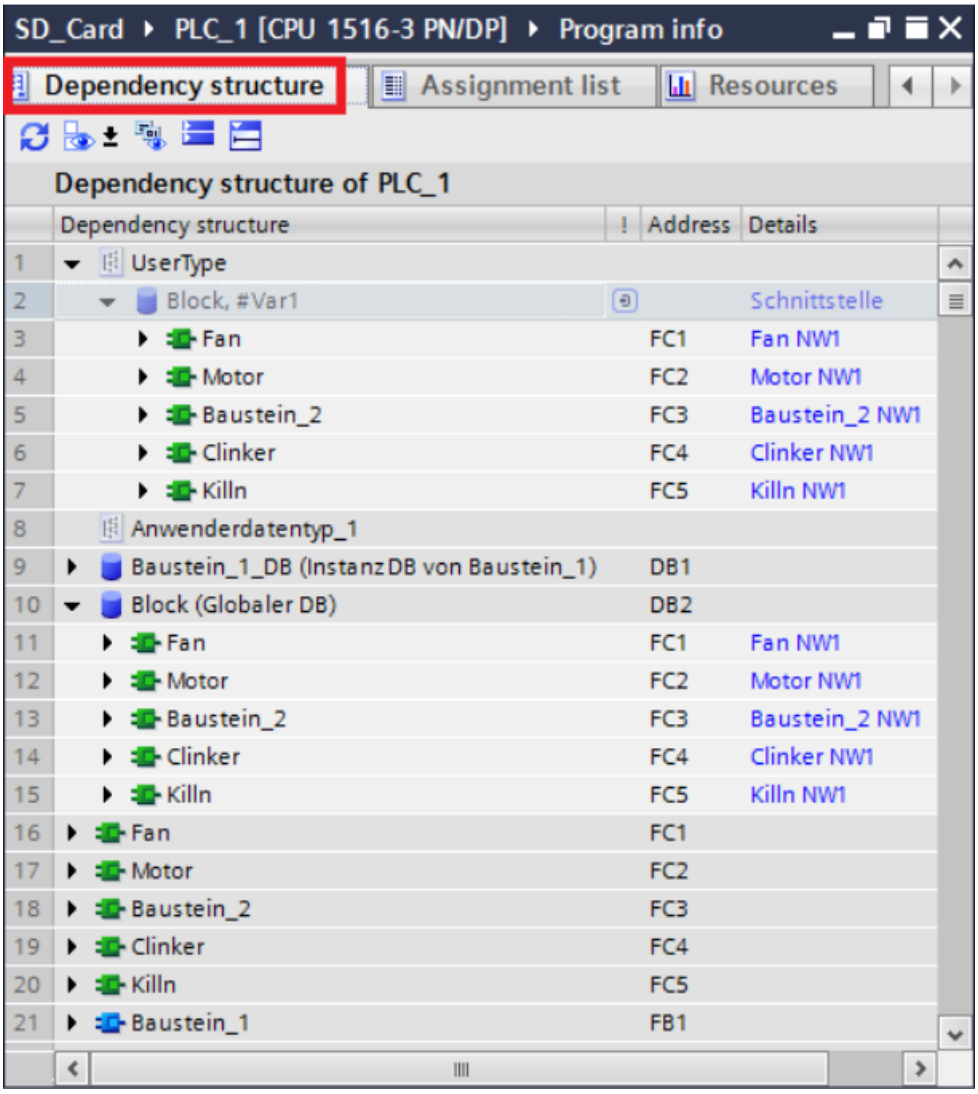

Figure 3-47 Dependency structure

Memory requirements in STOP state

Even when downloading in STOP state, a certain amount of reserve memory is required, because your CPU needs sufficient free memory on the memory card for consistent downloading of individual data blocks. The files affected by loading the data blocks are only deleted after the new files have been created. Therefore, for the modifications you must have available at least the memory requirement of the largest data block.

If insufficient reserve memory is available on your SIMATIC memory card when loading in STOP state, the following message is displayed in STEP 7 during the download to the CPU: "There is insufficient memory on the memory card for this amount of data."

In order to still enable the loading of changes to the CPU in such a case, we recommend one or more of the following options:

- Delete any files no longer required (e.g. CSV files, panel backups, etc.) from the memory card using the Web server.
- Use a larger memory card. A description of how to change the memory card can be found in the section "Changing the memory card without loss of retentive data".

NOTE

Please note that retentive data and possibly also project data is lost with the following three options. Therefore only use the following options described if the two options described previously did not lead to the desired result.

- In STEP 7, download your program to the CPU with menu command "Online > Download and reset PLC program".
- Remove the memory card from the slot of the CPU. Delete the content that is longer needed from the memory card with your programming device.
- Delete the entire contents, e.g. by formatting the memory card. A description of how to format the memory card can be found in the section "Formatting a SIMATIC memory card".

Note also the following FAQs:

- "When downloading to the S7-1500 CPU, why is the message "There is insufficient memory on the memory card for this amount of data" displayed although there is still enough memory available?" on the Internet (https://support.industry.siemens.com/cs/ww/en/view/107108015).
- **"**Why can you not load the project data into the load memory of the S7-1500 CPU when the number of alarms and messages is too large?**"** on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109751485).

Memory usage and application examples 4

4.1 Memory usage for data blocks

Processing sequence

- **Storing data records in the load memory**

  STEP 7 stores individual data records in a non-runtime-relevant DB and downloads the DB to the CPU. In order to configure a non-runtime-relevant DB, you must enable the "Only store in load memory" block attribute. The data records then only use memory space in the load memory and not in the work memory.

- **Working with data record data in the user program**

  You use the "READ_DBL" instruction to copy a data record from the DB in the load memory to a runtime-relevant DB in the work memory. As a result, the work memory only has to accommodate the data for the data record currently required. The user program can now access the data of the current data record.

- **Saving back changed recipe data records**

  The "WRIT_DBL" instruction writes new or changed data records from the user program back to the load memory. The data written to the load memory is portable and not affected by a memory reset. To back up changed data records, you need to upload the data blocks and back them up on the PG/PC.
  You can find information on uploading data blocks in the STEP 7 online help under "Programming a PLC>Compiling and downloading blocks>Downloading blocks for S7-1200/1500>Uploading blocks from a memory card".

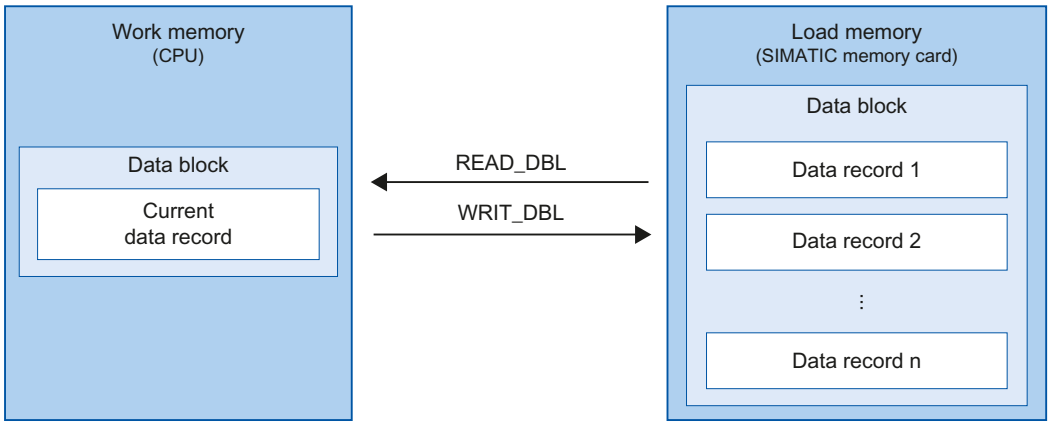

Figure 3-48 Processing sequence with "READ_DBL" and "WRIT_DBL"

Please also note the FAQ "How do you configure data blocks with the "Only store in load memory" attribute for the S7-1200/S7-1500?" on the Internet (https://support.industry.siemens.com/cs/ww/en/view/53034113).

NOTE

Instructions that access the SIMATIC memory card have a lower performance than instructions that access the work memory. The associated blocks (e.g. READ_DBL and WRIT_DBL) are therefore asynchronous. Their execution extends if necessary over several cycles.

NOTICE

Service life of the SIMATIC memory card

Only a limited number of delete and write operations are possible on the SIMATIC memory card. After expiration of the service life, there is a risk that the card can no longer be used.

You can find additional information on the service life of the SIMATIC memory card in Service life of the SIMATIC memory card (Page 59).

NOTE

Memory size of the SIMATIC memory card

Use a SIMATIC memory card with sufficient memory for your particular purposes.

4.2 Memory usage for recipes

Introduction

A recipe is a collection of parameter sets with the same structure. These recipe data records are located in a data block in the load memory, and do not occupy any storage space in the work memory. You have the option of reading individual recipe data records to a data block in the work memory and accessing the data in the user program. You can write a recipe data record that has been changed in the user program back to the recipe data block.

Recipes contain, for example, the related data of a particular batch in production. You can export recipe data records of a recipe DB as a csv file. A web browser can read data via the web server of the CPU, even when the CPU is in STOP state. You can also directly access the data of the SIMATIC memory card using a card reader on the programming device.

Import and export of recipe data

You have the option of exporting recipe data records of a recipe DB as a CSV file, and importing them from a CSV file into a DB. The CSV file is located in the "\recipes" directory on the SIMATIC memory card. You can open and process this file further with a spreadsheet program such as Microsoft Excel.

You can easily work with CSV files on the SIMATIC memory card via the web server of the CPU (e.g. rename, save to hard disk, delete, etc.). To avoid undesired manipulation, set access rights for the web server in STEP 7. You can find additional information on the Web server in the Web Server (http://support.automation.siemens.com/WW/view/en/59193560) function manual.

- **Export of recipe data**

  The "RecipeExport" instruction exports all the recipe data records of a recipe DB from the load memory to a CSV file on the SIMATIC memory card. The CSV file has the same name as the recipe of the DB. The CSV file is stored in the "\recipes" directory on the SIMATIC memory card.

  The "RecipeExport" instruction only exports valid and unencrypted recipe data records.

- **Import of recipe data**

  The "RecipeImport" instruction imports all recipe data records from the CSV file into the recipe DB in the load memory. The name of the CSV file must match the name of the recipe DB.

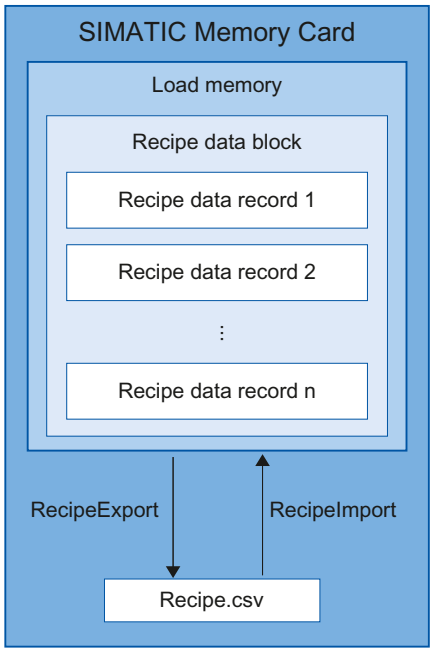

Figure 3-49 Import and export of recipe data

NOTE

Asynchronous instructions

Please note that the "RecipeExport" and "RecipeImport" instructions are asynchronous instructions.

In contrast to synchronous instructions, this means the execution of an asynchronous instruction can extend over multiple calls before execution is completed. The CPU processes asynchronous instructions in parallel with the cyclic user program.

A CPU can process several asynchronous instruction jobs in parallel. The CPU can process a maximum of 10 jobs of the instructions listed in parallel.

You can find additional information about asynchronous instructions in the following manuals:

- System manual S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792)
- System manual Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766665) system manual
- System manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)
- Operating instructions ET 200pro CPU 1513pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109769507) and ET 200pro CPU 1516pro-2 PRezepte (https://support.industry.siemens.com/cs/ww/en/view/109482416)

NOTE

Recipes for the redundant system S7-1500R/H

For the redundant system S7-1500R/H, for recipes, keep in mind the special features during the SYNCUP system state. You can find more information in the system manual Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833).

Additional information

You can find additional information on the instructions for recipes in the STEP 7 online help under "Programming a PLC > Instructions > Instructions (S7-1200, S7-1500) > Extended instructions > Recipes and data logging > Recipe functions".

Note also the application example "Using recipe functions for persistent data with SIMATIC S7-1200 and S7 1500" on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109479727).

4.3 Memory usage for data logging

4.3.1 Overview of data logging

With data logging, you save selected process values from the user program in a file, the data log. The data logs are saved on the SIMATIC memory card in csv format and stored in the "\datalogs" directory. A web browser can read data via the web server of the CPU, even when the CPU is in STOP state. You can also directly access the data of the SIMATIC memory card using a card reader on the programming device.

NOTICE

Service life of the SIMATIC memory card

Only a limited number of delete and write operations are possible on the SIMATIC memory card. Cyclic write operations to the SIMATIC memory card by the user program reduce the service life of the SIMATIC memory card. After expiration of the service life, there is a risk that the card can no longer be used. Therefore, use a SIMATIC memory card with sufficient memory for your particular purposes.

Information on the service life of the SIMATIC memory card can be found in the section Service life of the SIMATIC memory card (Page 59).

NOTE

Memory size of the SIMATIC memory card

Use a SIMATIC memory card with sufficient memory for your particular purposes.

The "data logging" instructions can be used in your program to create, open, write, close or delete data logs. You decide which tags are logged by creating a data block that defines a single data log data record. Your data block is used as temporary storage for a new data log data record. New current values for the tags must be transferred into the data block during runtime by means of user program instructions. If all tag values have been updated, you can execute the "DataLogWrite" instruction, in order to transfer data from the data block into the data log.

You manage your data logs with the integrated web server. The integrated web server allows you to view, download, and delete data logs. After you have transferred a data log to your PC, you can analyze the data using popular spreadsheet programs, e.g. Microsoft Excel.

The following figure shows the basic sequence for creating a data log:

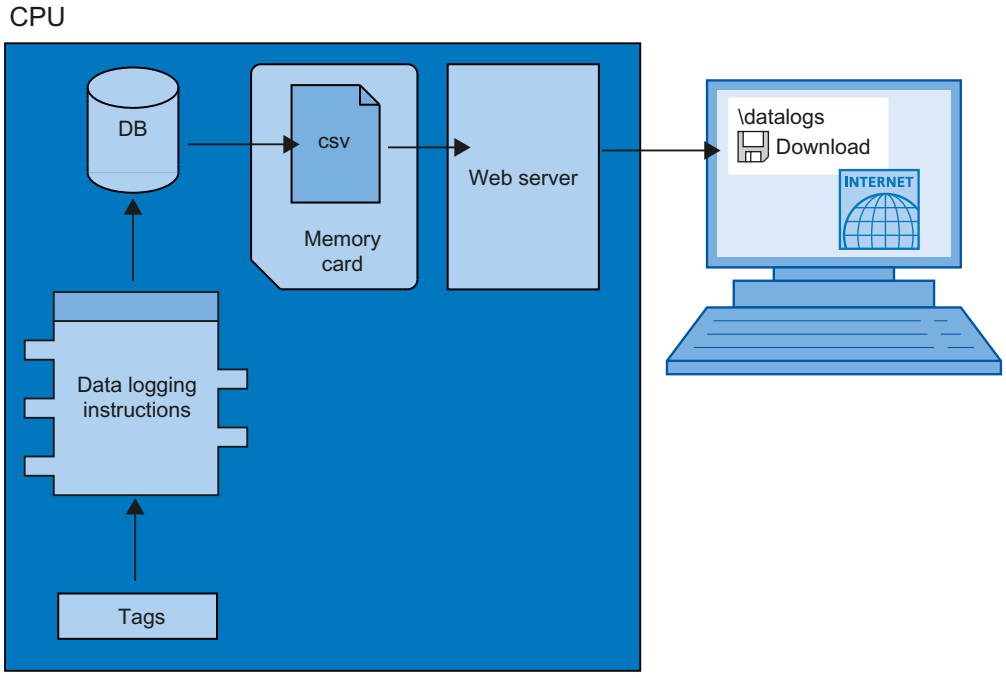

Figure 3-50 Basic sequence during the creation of a data log

NOTE

Data logging for the redundant system S7-1500R/H

For the redundant system S7-1500R/H, for data logging, note the special features during the SYNCUP system state. You can find more information in the system manual Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833).

4.3.2 Data structure of the data logs

Introduction

You use the "DataLogCreate" instruction to create a data log in STEP 7. The NAME parameter assigns the data log a name. The DATA and HEADER parameters specify the data type of all data elements in a data log data record, and the header line of the data log. The RECORDS parameter indicates the maximum number of records in the data log.

NAME parameter for the "DataLogCreate" instruction

You use the NAME parameter to assign a name for the data log. This is the name under which the data log is saved in the "\datalogs" directory of the SIMATIC memory card.

DATA parameter for the "DataLogCreate" instruction

The DATA block parameter specifies the structure of the data log's records. The columns and data types of a data record in the data log are determined by the elements of the structure declaration or array declaration of this data buffer. Each element of a structure or array corresponds to a column in a row in the data log.

HEADER parameter for the "DataLogCreate" instruction

Using the HEADER block parameter, you can assign a heading in the header row to each column in the data log.

RECORDS parameter for the "DataLogCreate" instruction

The RECORDS parameter specifies the maximum number of records that can be stored in a data log. When the specified maximum number of data records in a data log is reached, the next write operation overwrites the oldest data record.

4.3.3 Instructions for data logging

Overview

The following table gives an overview of the instructions for data logging. You will find the data logging instructions in "STEP 7" in the "Instructions" task card, under "Extended instructions > Recipe and data logging > Data Logging".

Table 3-39 Overview of the data logging instructions

Name of the instruction	Description
"DataLogCreate": Create data log	With the "DataLogCreate" instruction you create a data log. The data log is saved on the SIMATIC memory card in the "\datalogs" directory. You can use the data logging instructions to save process data. The amount of data in a data log depends on the available memory space on the SIMATIC memory card.
"DataLogOpen": Open data log	With the "DataLogOpen" instruction, you open an existing data log on the SIMATIC memory card. A data log must be open before you can write new data records to it. The data log opens automatically when the "DataLogCreate" and "DataLogNewFile" instructions are executed. A maximum of 10 data logs can be open at any one time. The data log to be opened can be selected using the ID or name of the data log. The maximum file size of data logs is 2 GB. A maximum number of 1000 data log files is possible with firmware version V2.0.
"DataLogWrite": Write data log	With the "DataLogWrite" instruction you write a data record into an existing data log. Use the ID parameter to select the data log to which the data record is to be written. To write a new data record, the data log must be open.
"DataLogClose": Close data log	With the "DataLogClose" instruction, you close an open data log. You select the data log using the ID parameter. When the CPU changes to STOP state, all open data logs are closed.
"DataLogNewFile": Data log in new file	With the "DataLogNewFile" instruction you create a new data log. The new data log has the same properties as an already existing data log. By creating a new data log, you prevent cyclic overwriting of existing data records.

Name of the instruction	Description
	When the instruction is called it creates a new data log on the SIMATIC memory card using the name defined in the NAME parameter. You use the ID parameter to specify the ID of the old data log whose properties you want to apply to the new data log. The ID parameter then outputs the ID of the new data log.
"DataLogClear": Empty data log	The "DataLogClear" instruction deletes all data records in an existing data log. The header of the data log is not deleted (see description of parameter Data structure of the data logs (Page 37)).
"DataLogDelete": Delete data log	The "DataLogDelete" instruction is used to delete a data log from the SIMATIC memory card. Select the data log to be deleted using the NAME and ID parameters.

NOTE

Asynchronous instructions

Note that the instructions in the table are asynchronous instructions.

In contrast to synchronous instructions, this means the execution of an asynchronous instruction can extend over multiple calls before execution is completed. The CPU processes asynchronous instructions in parallel with the cyclic user program.

A CPU can process several asynchronous instruction jobs in parallel. The CPU can process a maximum of 10 jobs of the instructions listed in the table in parallel.

You can find additional information about asynchronous instructions in the following manuals:

- System manual S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792)
- System manual Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833)
- System manual ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/109482416)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766665) system manual
- Operating instructions ET 200pro CPU 1513pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109769507) and ET 200pro CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482416)

4.3.4 Example program for data logging

This example program shows the storing of process values for counter content, temperature, and pressure in a data log.

The example shows the basic functioning of the instructions for data logs. The complete program logic is not shown.

NOTE

General use of data logs

- Data logs are automatically opened after execution of the "DataLogCreate" and "DataLogNewFile" instructions.
- Data logs are automatically closed at a change of the CPU from RUN to STOP or a restart of the CPU.
- A data log must be open so that data can be written to the data log with the "DataLogWrite" instruction.
- A maximum of 10 data logs can be open at any one time, even when more than 10 data logs exist.

Tags of the data block

The following figure shows the tags of the "My_Datalog_Vars" data block. These tags are used by the "Data logging" instructions "DataLogCreate" and "DataLogNewFile". The "MyDataLogName" and "MyNEWDataLogName" tags are called in the NAME block parameter, and give the data logs a name. The "MyData" structure is called in the DATA block parameter and specifies the structure of the csv file. The three MyData tags temporarily store new values. The tag values at these DB addresses are transferred to a data log using the "DataLogWrite" instruction. The "MyDataLogHeaders" tag is called in the HEADER block parameter and specifies a header for the data log.

My_Datalog_Vars

	Name	Data type	Start value
1	Static		
2	MyNEWDataLogName	String	'MyNEWDataLog'
3	MyDataLogName	String	'MyDataLog'
4	MyDataLogID	DWord	0
5	MyDataLogHeaders	String	'Count,Temperature,Pressure'
6	MyData	Struct	
7	MyCount	Int	0
8	MyTemperature	Real	0.0
9	MyPressure	Real	0.0

Figure 3-51 Declaration table with the data block's tags

Network 1

A rising edge at REQ starts the creation of the data log.

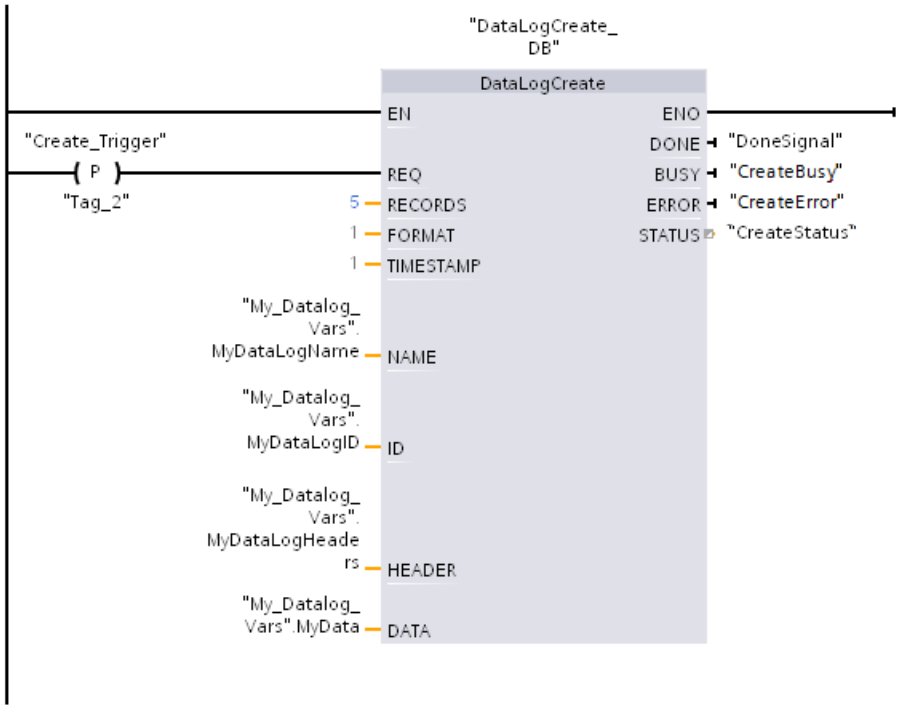

Figure 3-52 Network 1

Network 2

Detect the output DONE of "DataLogCreate", because after the execution of "DataLogCreate" it is only set to 1 for one cycle.

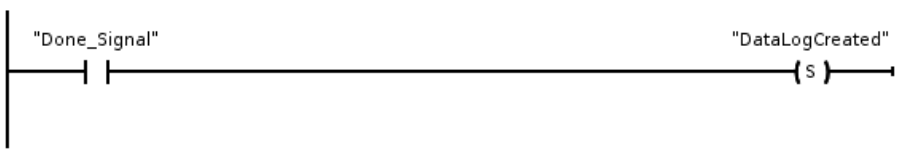

Figure 3-53 Network 2

Network 3

A rising edge triggers the point in time at which new process values are stored in the MyData structure.

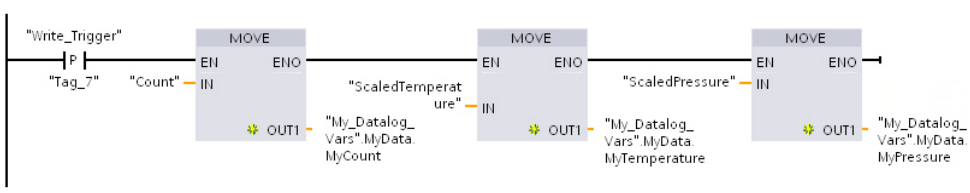

Figure 3-54 Network 3

Network 4

The state of the input EN is based on the point in time at which the execution of "DataLogCreate" was completed. One execution of "DataLogCreate" extends over multiple

cycles, and must be completed before a write operation is executed. The rising edge at input REQ is the event that triggers an activated write operation.

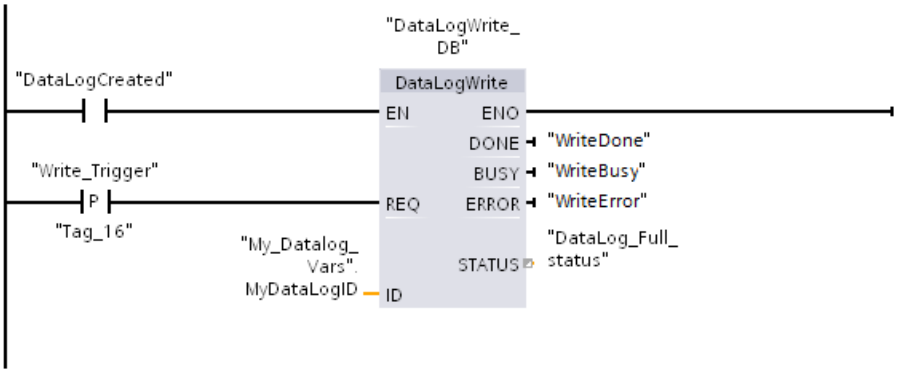

Figure 3-55 Network 4

Network 5

Close the data log after the last data record has been written. After execution of the "DataLogWrite" instruction, which writes the last data record, the STATUS output is set to "1".

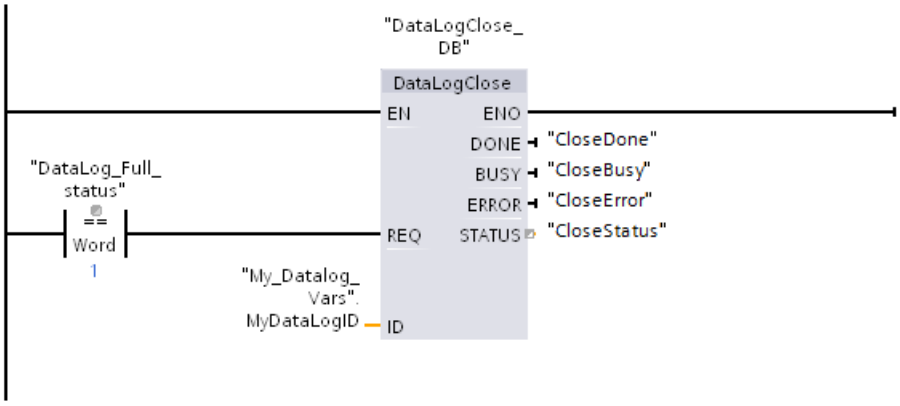

Figure 3-56 Network 5

Network 6

A rising edge at the input REQ of the instruction "DataLogOpen" simulates that the user presses a button on an HMI device, which opens a data log. If you open a data log in which all records are occupied by process data, then the next execution of the "DataLogWrite" instruction overwrites the oldest data record. You can however also preserve the old data log, and create a new data log instead. This is shown in network 7.

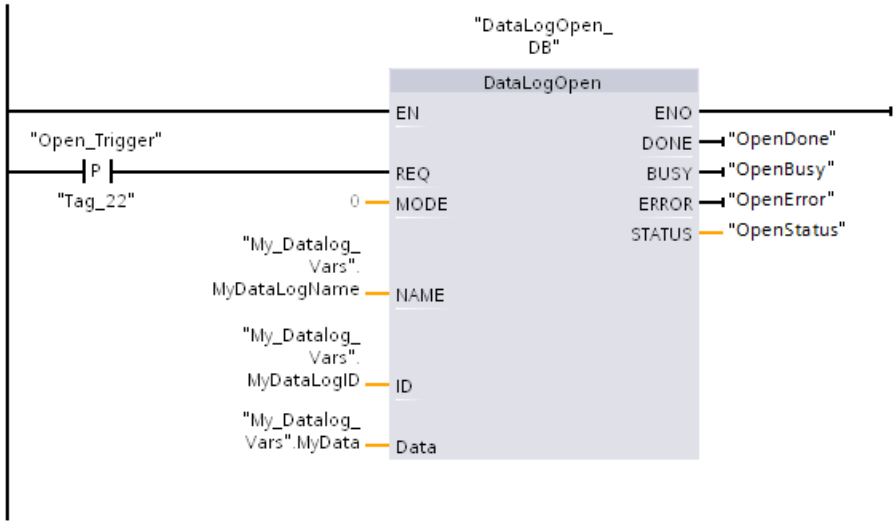

Figure 3-57 Network 6

Network 7

The ID parameter is an IN/OUT type. First you indicate the ID value of the existing data log whose structure you want to copy. After the "DataLogNewFile" instruction has been executed, a new and unique ID value for the new data log is written back into the address of the ID reference. The required detection DONE bit = TRUE is not shown. An example for the logic of the DONE bit can be found in networks 1, 2 and 4.

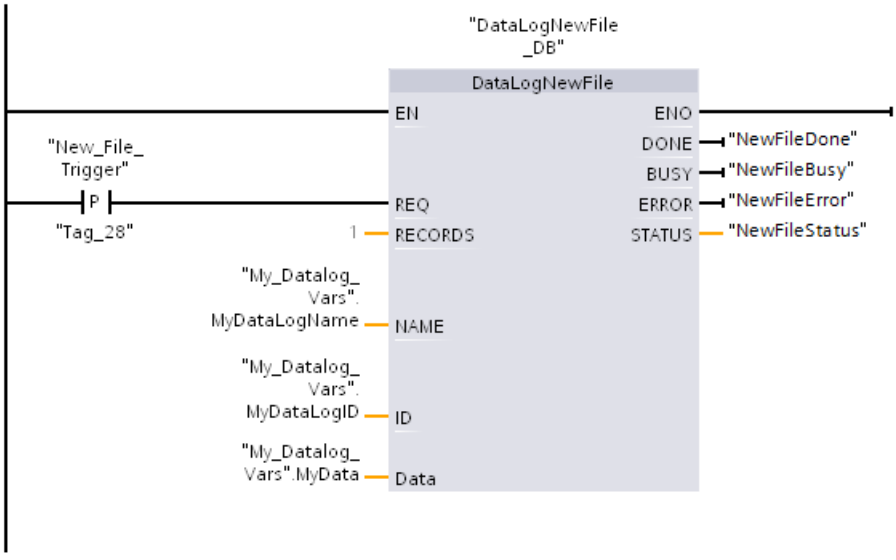

Figure 3-58 Network 7

The data logs created in the example program can be found on the CPU Web server's standard "File browser" Web page in the "\datalogs" folder.

The following figure shows the standard Web page of the Web server using the example of the CPU 1516-3 PN/DP.

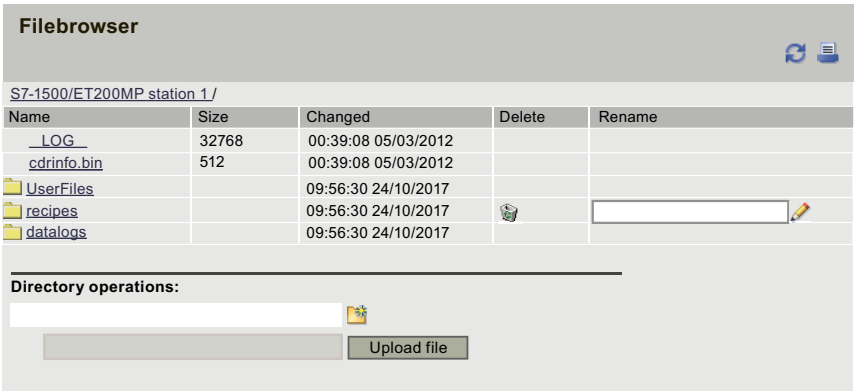

Figure 3-59 Standard "File browser" web page of the Web server

In the file browser, you can download the data logs created in the example program. It is not possible to delete or rename the data logs in the Web server. To delete a data log you either use the "DataLogDelete" instruction or you format the SIMATIC memory card.

On the DataLogs web page, you can have all the data logs that you created displayed. You can call and empty the relevant data log file by clicking the icon .

NOTE

Manipulation of the data logs using a card reader

Do not delete or change the data logs using a card reader on the PG/PC. You can copy the data logs on the SIMATIC memory card, however, using a card reader on the PG/PC.

The recommended medium for viewing, downloading (copying) and deleting data logs is the file browser of the web server, however. Direct file access via Windows Explorer brings with it the risk of inadvertent deletion of modification of data logs or system files. This can cause the files to be damaged or the SIMATIC memory card to become unusable.

Figure 3-60 Example - Data logs in the folder "\datalogs" of the file browser

Table 3-40 Downloaded examples of data logs displayed in Microsoft Excel

Two data records written in a data log which contains a maximum of five data records.	

	A	B	C	D	E	F
1	Record	Date	Time	Count	Temperature	Pressure
2	1	1/3/2012	10:16:47	5	5,00E+00	5,00E+00
3	2	1/3/2012	10:16:48	5	5,00E+00	5,00E+00
4	//END					
5						

Five data records written in a data log which contains a maximum of five data records.

	A	B	C	D	E	F
1	Record	Date	Time	Count	Temperature	Pressure
2	1	1/3/2012	10:08:23	1	9,86E+01	3,52E+01
3	2	1/3/2012	10:08:39	2	1,00E+02	3,73E+01
4	3	1/3/2012	10:08:54	3	9,99E+01	3,68E+01
5	4	1/3/2012	10:09:11	4	9,95E+01	3,64E+01
6	5	1/3/2012	10:09:28	5	9,92E+01	3,74E+01
7						

After another data record has been written, the 6th write operation overwrites the oldest data record (record 1) with data record 6. Another write operation overwrites data record 2 with data record 7, etc.

	A	B	C	D	E	F
1	Record	Date	Time	Count	Temperature	Pressure
2	6	1/3/2012	10:09:42	6	9,87E+01	3,58E+01
3	2	1/3/2012	10:08:39	2	1,00E+02	3,73E+01
4	3	1/3/2012	10:08:54	3	9,99E+01	3,68E+01
5	4	1/3/2012	10:09:11	4	9,95E+01	3,64E+01
6	5	1/3/2012	10:09:28	5	9,92E+01	3,74E+01
7						

4.3.5 Calculation of the data log size

The maximum memory size is allocated when you create the data log. Besides ensuring enough memory space for all the data records, you must take into account the memory space of the following elements for the memory allocation:

- Data log header (if used)
- Time stamp header (if used)
- Data record index header
- Minimum block size

The formula below represents a method to help you determine the estimated size of your data log. Make sure that you observe the rule for the maximum size.

Data bytes of the data log = ((data bytes in a data record + time stamp bytes + 12 bytes) * number of data records)

Header

Header bytes of the data log = header character bytes + 2 bytes

Header character bytes

- No data header and no time stamp = 7 bytes
- No data header and time stamp (with time stamp header) = 21 bytes
- Data header and no time stamp = Number of character bytes in all column headers including separating commas
- Data header and time stamp (with time stamp header) = Number of character bytes in all column headers including separating commas + 21 bytes

Data

Data bytes of the data log = ((data bytes in a data record + time stamp bytes + 12 bytes) * number of data records)

Data bytes in a data record

The DATA parameter of the "DataLogCreate" instruction points to a structure. The structure assigns the number of data fields and the data type of each data field for a data log data record.

Multiply the number of the respective data type with the number of bytes required for this data type. Repeat this step for each data type in a data record. Add all the data bytes to obtain the sum of all the data elements in a data record.

Size of the individual data types

The data in data logs is saved as character bytes in csv format (comma separated values). The table below shows the number of bytes that are required to save each data type.

Data type	Bytes
Any	10
Bool	1
Byte	4
Char	1
Date	10
DInt	12
DTL	31
DWORD	11
Int	7
LDT	31
LReal	25
Real	16
Sint	5
String	**Example 1:** MyString String[10] The maximum character string size is specified with 10 characters. • Text character + automatic filling with spaces = 10 bytes • Quotation marks at the start and end + comma character = 3 bytes 10 + 3 = 13 bytes total **Example 2:** Mystring2 String If no size is specified in square brackets, 254 bytes are assigned by default. • Text character + automatic filling with spaces = 254 bytes • Quotation marks at the start and end + comma character = 3 bytes 254 + 3 = 257 bytes total
Time	14
Tod	12
UDInt	12
UInt	7

Data type	Bytes
USInt	5
WChar	1
Word	6

Number of data records in a data log

The RECORDS parameter of the "DataLogCreate" instruction specifies the maximum number of data records that can be stored in a data log.

Time stamp bytes in a data record

- No time stamp = 0 bytes
- Time stamp = 22 bytes

Example for size of a CSV file

The figure "Open CSV file" shows a CSV file opened in a spreadsheet program with five written data records in one data log.

The figure "Size of the header and the data records" shows the size of the header used in the CSV file and the size of the individual data records on the SIMATIC memory card.

The figure "Column size" shows the size of the respective columns depending on the data type used.

Open CSV file

	A	B	C	D	E	F
1						
2	Record	Date	UTC Time	Count	Temperature	Pressure
3	1	9/30/2010	20:26:56	1	9.86E+01	3.52E+01
4	2	9/30/2010	20:28:43	2	1.00E+02	3.73E+01
5	3	9/30/2010	20:29:03	3	9.99E+01	3.68E+01
6	4	9/30/2010	20:29:21	4	9.95E+01	3.64E+01
7	5	9/30/2010	20:30:19	5	9.92E+01	3.74E+01
8						

Size of the header and the data records

	G
	49 (42 characters + 5 commas + 2 line ending)
	79 (72 + 5 commas + 2 line ending)
	79 (72 + 5 commas + 2 line ending)
	79 (72 + 5 commas + 2 line ending)
	79 (72 + 5 commas + 2 line ending)
	77 (72 + 5 commas)
	Total = 442

Column size

9	Size of each column:					
10	index	Date	Time	int	real	real
11	11	10	12	7	16	16

Each data record also has a separator comma. Therefore, the calculation of the total size per column also includes 1 byte for each separator comma.

Note that the calculation of the size of the header, the data records and the columns is not an integral component of the open CSV file. The size information was added manually to illustrate the elements that make up the size of a data log. You can have the total size of a data log you have created as CSV file displayed in the web server on the "DataLogs" page.

SIMATIC memory card

5

5.1 SIMATIC memory card - Overview

Introduction

The automation system uses a SIMATIC memory card as the program memory. The SIMATIC memory card is a preformatted memory card compatible with the Windows file system. The memory card is available in different memory sizes and can be used for the following purposes:

- Transportable data carrier
- Program card
- Firmware update card
- Service data card

When you transfer the user program to the CPU via an online connection, it is written to the SIMATIC memory card. The SIMATIC memory card must be in the card slot of the CPU for this.

You can also write the SIMATIC memory card in the programming device or PC. A commercially available SD card reader is needed to read or write the SIMATIC memory card with the programming device or PC. You use this, for example, to copy files directly to the SIMATIC memory card with Windows Explorer.

NOTE

The SIMATIC memory card is mandatory for operation of the CPU.

NOTE

SIMATIC memory cards of the redundant system S7-1500R/H

For the redundant system S7-1500R/H you need a SIMATIC memory card for each of the two CPUs. During redundant operation, both CPUs access the memory cards.

There must be a SIMATIC memory card in each of the CPUs. We recommend the same memory size for each SIMATIC memory card. Both memory cards must have enough memory reserve.

NOTE

SIMATIC memory card of the SIMATIC Drive Controller

In addition to the CPU data of the SIMATIC Drive Controller, you also store the configuration of the SINAMICS Integrated on the SIMATIC memory card.

A description of how to store the online and offline data can be found in the SIMATIC memory card section of the SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766665) system manual.

Labeling of the SIMATIC memory card

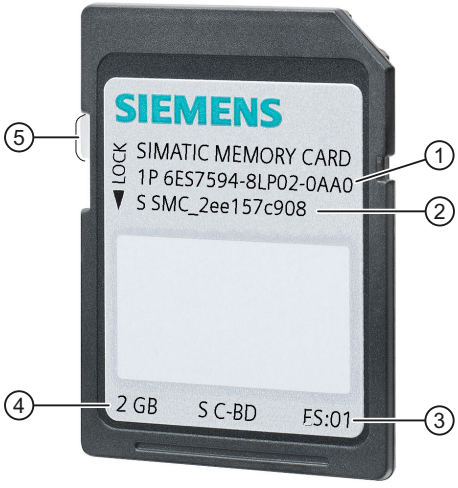

① Article number

② Serial number

③ Production version

④ Memory size

⑤ Slider for setting the write protection:
- Slider up: not write-protected
- Slider down: write-protected

Figure 3-61 Labeling of the SIMATIC memory card

Folders and files on the SIMATIC memory card

The following folders and files can be found on the SIMATIC memory card:

Table 3-41 Folder structure

Folder	Description
FWUPDATE.S7S	Firmware update files for CPU, I/O modules or SINAMICS Integrated**
SIMATIC.S7S	User program, i.e. all blocks (OBs, FCs, FBs, DBs) and system blocks, project data of the CPU
SINAMICS.S7S**	SINAMICS Integrated project data The folder structure below the SINAMICS.S7S folder is based on the structure of a SINAMICS S120 memory card.
SIMATIC.HMI	HMI-relevant data
DataLogs*	DataLog files
Recipes*	Recipe files
UserFiles*	You have to manually create the folder named "UserFiles" on the memory card for your user data. Only files in this folder (*.pdf, *.txt, *.csv, etc) are also loaded into the STEP 7 project with the "Upload device as new station" function.
Backups	Files for backing up and restoring via the display
DUMP.S7S	Service data files

* The content of these folders is also loaded into the STEP 7 project with the "Upload device as new station" function.

** Only with SIMATIC Drive Controllers

Table 3-42 File structure

File type	Description
S7_JOB.S7S	Job file
SIMATIC.HMI\Backup*.psb	Panel backup files
SIMATICHMI_Backups_DMS.bin	Protected file (necessary for use of panel backup files in STEP 7)
__LOG__	Protected system file (necessary for use of card)
crdinfo.bin	Protected system file (necessary for use of card)
*.pdf, *.txt, *.csv, etc.	Additional file with different formats that you can also store in folders of the SIMATIC memory card If you store the files in the "UserFiles" folder, the files are stored in the STEP 7 project with "Upload device as new station" and can be used, for example, for restoring files in the event of a defective SIMATIC memory card.

NOTE

Supported file/directory names and hierarchy levels on the SIMATIC memory card

The following rules apply to file names, directory names and hierarchy levels on the SIMATIC memory card:

- Do not use any umlauts (ö, ä, ü, Ö, Ä, Ü) in file and/or directory names.
- Use a maximum of 60 characters for file and/or directory names.
- Use a maximum of 6 hierarchy levels for the directory structure of the SIMATIC memory card (for example: /mountpoint/1/2/3/4/5/6/file.txt).
  The operating system of the CPU supports directories of no more than 8 levels, where one level is reserved for the mount point and one for the actual file.

Additional folders and files: CPU 1518-4 PN/DP MFP and CPU 1518F-4 PN/DP MFP

The SIMATIC memory card of the CPU 1518-4 PN/DP MFP and CPU 1518F-4 PN/DP MFP also contain the following folders and files:

- The following C/C++ runtime containers are located in the "/CppEnv1.MFP" directory on the SIMATIC memory card and are mounted in the file system in Linux:
  - System.img → Mount point: "/etc/mfp" (system files)
  - User.img → Mount point: "/home" (home directories of users, for C/C++ runtime application, for example)
  - Data.img → Mount point: "/var/userdata" (e.g. log data)
- RAM-Disk → Mount point: "/var/volatile"

NOTE

First-time startup of CPU 1518-4 PN/DP MFP and CPU 1518F-4 PN/DP MFP with empty SIMATIC memory card

When the CPU starts up for the first time with an empty SIMATIC memory card, the card is prepared for use with C/C++ runtime. This process takes up to three minutes. Do not turn off the CPU during this phase; the STOP LED flashes.

NOTE

Impact on performance of the CPU 1518-4 PN/DP MFP and CPU 1518F-4 PN/DP MFP

Depending on the type of programming, C/C++ runtime applications, such as mass storage accesses to the SIMATIC memory card, can affect the performance of the CPU.

You can find additional information on these CPUs in the CPU 1518-4 PN/DP MFP (https://support.industry.siemens.com/cs/ww/en/view/109749061) manual and the CPU 1518(F)-4 PN/DP MFP (https://support.industry.siemens.com/cs/ww/en/view/109756478) product information.

You can find information on creating C/C++ runtime applications in the SIMATIC S7-1500 ODK 1500S (https://support.industry.siemens.com/cs/ww/en/ps/13914/man) manual.

SIMATIC Memory Card S7-1500 Motion Control KinPlus

The Motion Control package "S7-1500T Motion Control KinPlus" must be copied to a SIMATIC Memory Card of type "S7-1500T Motion Control KinPlus". The function extensions are loaded from this card at runtime.

You can find additional information on "S7-1500 Motion Control KinPlus" in the function manual S7-1500T Kinematics Functions (https://support.industry.siemens.com/cs/ww/en/view/109781850).

Using the serial number for copy protection

You can set up copy protection for CPUs that binds execution of the block to a specific SIMATIC memory card. You can then only execute the block if it is on the SIMATIC memory card with the specified serial number.

You can find additional information about copy protection in the following manuals:

- System manual S7-1500, ET 200MP Automation System (http://support.automation.siemens.com/WW/view/en/59191792)Hotspot text (https://support.industry.siemens.com/cs/ww/en/view/109754833)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766665) system manual and SINAMICS S120 Drive Functions (https://support.industry.siemens.com/cs/ww/en/view/109763287) function manual
- System manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)
- Operating instructions ET 200pro CPU 1513pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109769507) and ET 200pro CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482416)

NOTE

Redundant system S7-1500R/H

The CPUs of the S7-1500R/H redundant system do not support the copy protection function.

Removing a SIMATIC memory card from the CPU

NOTE

Do not remove the SIMATIC memory card while a write operation is in progress.

If you remove the memory card from the CPU during a write operation, the contents of the memory card may become invalid. The retentivity of the memory areas can then be lost. It may be necessary to delete the memory card from the PG and reload the program.

To remove the memory card, follow these steps:

- Turn off the line voltage.

NOTE

If there are no write accesses via the PG, you can even remove the memory card when the power is on and the operating state is STOP. In this case, first disconnect all communication connections as a precaution.

Inserting the SIMATIC memory card in the CPU in STOP state triggers a re-evaluation of the SIMATIC memory card. The CPU compares the content of the configuration on the SIMATIC memory card with the backed-up retentive data. If the backed-up retentive data matches the data of the configuration on the SIMATIC memory card, the retentive data is retained. If the data differs, the CPU automatically performs a memory reset. A memory reset deletes the retentive data on the CPU. After the memory reset, the CPU goes to STOP.

With regard to removal of the SIMATIC memory card, note also the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/59457183).

NOTE

Using the SIMATIC memory card as a firmware update card

If you use the SIMATIC memory card as a firmware update card, removing and inserting the card will not result in the loss of retentive data.

Removing a SIMATIC memory card from Windows computers

If you are using the card in a commercially available card reader under Windows, use the "Eject" function before you remove the card from the card reader. If you remove the card without using the "Eject" function, you may lose data.

Deleting contents of the SIMATIC memory card

You have the following options for deleting the content of the SIMATIC memory card:

- Delete files with Windows Explorer
- Format with STEP 7

NOTE

Deletion of files and folders is permitted, with the exception of the "__LOG__" and "crdinfo.bin" system files. The CPU needs these system files. When you delete the files, you will no longer be able to use the SIMATIC memory card with the CPU.

If you have deleted the "__LOG__" and "crdinfo.bin" system files, format the SIMATIC memory card as described in the following section.

Formatting a SIMATIC memory card

NOTICE
Formatting the SIMATIC memory card Do **not** format the memory card with Windows tools. Formatting with Windows renders the memory card unusable by a CPU initially. You can find information on how to repair an inconsistent or incorrectly formatted card in the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/69063974).

To free up memory space on your SIMATIC memory card, you have the option of formatting the SIMATIC memory card. During formatting, the entire content of the memory card is deleted.

The SIMATIC memory card may only be formatted in the CPU. With a SIMATIC memory card inserted, follow these steps:

Formatting with STEP 7:

- Establish an online connection.
- Open the online and diagnostics view of the CPU (either from the project context or via "Accessible devices").
- In the dialog window select "Functions > Format memory card" and then select the "Format" button.

Formatting via the display of the CPU

- In the display of the CPU, select the menu "Settings" > "Card functions" > "Format card" and confirm with OK.

Changing the memory card without loss of retentive data

You can change the memory card or use a larger SIMATIC memory card without losing the retentive data. When you switch off the CPU, the retentive data is backed up in the retentive memory of the CPU. While the CPU is switched off, you can remove the memory card and copy its content to a larger memory card. After switching on the CPU, the data backed up in the CPU when the CPU was switched off is restored.

5.2 Setting the card type

Introduction

You can use the SIMATIC memory card as a program card or as a firmware update card.

Procedure using STEP 7

1. To set the card type, insert the SIMATIC memory card into the card reader of the programming device.
2. Select the "SIMATIC Card Reader" folder in the project tree.
3. In the properties of the selected SIMATIC memory card, specify the card type:

- **Program card**

  You use a program card as an external load memory for the CPU. It contains the complete user program for the CPU. The CPU transfers the user program from the load memory to the work memory. The user program runs in the work memory.

  The following folders are created on the SIMATIC memory card:

  – SIMATIC.S7
  – SINAMICS.S7S (only with SIMATIC Drive Controller)

- **Firmware update card**

  You can save firmware for a CPU and for I/O modules on a SIMATIC memory card. This enables you to perform a firmware update with the help of a specially prepared SIMATIC memory card.

  The following folder is created on the SIMATIC memory card: FWUPDATE.S7S

Reference

You can find additional information in the STEP 7 online help.

Procedure using the job file

You can also set whether the SIMATIC memory card works as a program card or a firmware update card via the job file S7_JOB.S7S on the SIMATIC memory card.

Entry in the job file:

- PROGRAM: The SIMATIC memory card is used as a program card
- FWUPDATE: The SIMATIC memory card is used as a firmware update card

Proceed as follows:

1. Open the job file S7_JOB.S7S with an editor.
2. Overwrite the PROGRAM entry with FWUPDATE using the editor (or vice versa).

   Do not use spaces, line breaks, or quotation marks.
3. Save the file under the existing file name.

Program card incl. firmware update files

If, for example, you want to deliver your project with a firmware that you have validated, you can store program data and firmware update files together on the memory card. Your customers then have the opportunity to upgrade the CPU to exactly this firmware version.

NOTE

Note that depending on the tool used (e.g. STEP 7, Display, Web server), the firmware update files are also deleted when the "Program card" is reset.

5.3 Data transfer with SIMATIC memory cards

Saving objects from the project to the SIMATIC memory card

When the SIMATIC memory card is inserted in the programming device or in the external card reader, you can save the following objects from the project tree (STEP 7) to the SIMATIC memory card:

- Individual blocks (multiple selection possible)

  In this case, the transfer is consistent, i.e. the function takes dependencies between blocks due to block calls into account.
- CPU folder

  In this case, all the runtime-relevant objects, such as blocks and the hardware configuration, are saved to the SIMATIC memory card, just as with downloading.
- Service data
  In this case, the service data saved beforehand is saved to the SIMATIC memory card. You will find additional information on the service data in the following manuals:
  - System manual S7-1500, ET 200MP Automation System (http://support.automation.siemens.com/WW/view/en/59191792)
  - System manual Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833)
  - SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766665) system manual
  - System manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)
  - Operating instructions ET 200pro CPU 1513pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109769507) and ET 200pro CPU 1516pro-2 PN (http://support.automation.siemens.com/WW/view/en/58649293).

You have the following options for performing the save operation:

- Save the objects using drag-and-drop.
- Use the "Card Reader/USB memory > Write to memory card" command in the "Project" menu.

Saving trace recordings to the SIMATIC memory card

The "Save measurements on device (memory card)" function allows you to save trace recordings on your SIMATIC memory card.

NOTE

Redundant system S7-1500R/H

The CPUs of the redundant system S7-1500R/H do not support the saving of measurements on the SIMATIC memory card.

To access the corresponding dialog, proceed as follows:

1. In the project tree, select the "Traces" > "Trace".
2. In the work area, select "Configuration" > "Recording conditions" > "Measurements in the device (memory card)"

Response when number reached

"Deactivate recording" repeats the measurements until the configured "Number of measurements" is reached.

"Overwrite oldest recording" replaces the oldest measurement with the latest measurement when the configured "Number of measurements" is reached. Note, however, that continuously writing data to the SIMATIC memory card shortens its service life.

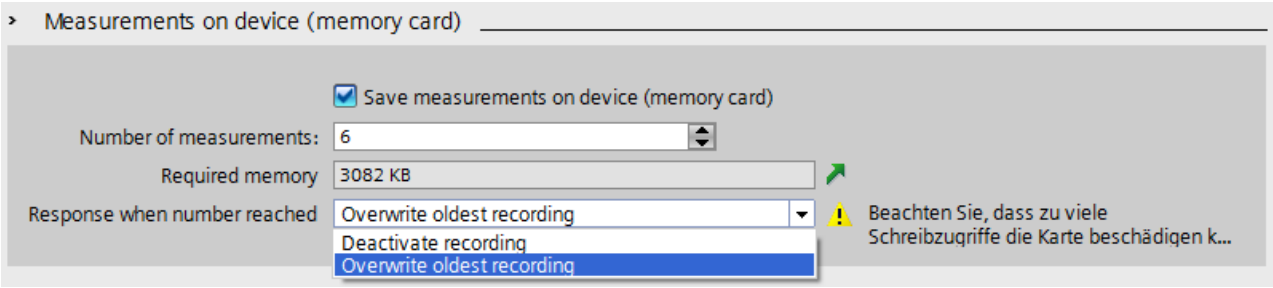

Figure 3-62 Dialog of settings for saving measurements on the memory card in STEP 7

Number of measurements

The CPU supports a maximum of 999 measurements. The CPU writes the trace recordings to the load memory of the memory card. Meanwhile, the CPU pauses the checking of trigger conditions for the trace job. Once the CPU finishes saving the trace recordings, the CPU continues checking the trigger conditions.

NOTICE
Memory required on the SIMATIC memory card When the trace function "Measurements on device (memory card)" requires more memory than is available on the SIMATIC memory card, undesired effects may result. Ensure there is always sufficient free memory space to use the "Measurements on device (memory card)" function. In addition to the "Measurements on device (memory card)" trace function, other functions such as storing data logs use memory space on the SIMATIC memory card. Ensure there is always sufficient memory space available for all functions that use memory.

You can find additional information about trace measurements and trace recordings in the following:

- Function manual Using the Trace and Logic Analyzer Function (http://support.automation.siemens.com/WW/view/en/64897128)
- Function manual Web Server (http://support.automation.siemens.com/WW/view/en/59193560)
- STEP 7 online help

Firmware update using SIMATIC memory card

You can find information on how to perform a firmware update in the following:

- System manual S7-1500, ET 200MP Automation System (http://support.automation.siemens.com/WW/view/en/59191792)
- System manual Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833)
- In the SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766665) system manual
- System manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)
- Operating instructions ET 200pro CPU 1513pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109769507) and ET 200pro CPU 1516pro-2 PN (http://support.automation.siemens.com/WW/view/en/58649293)

Reference

You can find additional information about the SIMATIC memory card in the STEP 7 online help.

5.4 Service life of the SIMATIC memory card

Calculation of the theoretical service life of a SIMATIC memory card serves as a decision-making aid for selecting which card you need for your automation task. The following examples only return a guide value, however. A precise calculation of the service life is not possible due to the fact that the description cannot cover all the theoretically possible scenarios.

Influences on the service life

You can influence the service life of SIMATIC memory cards by the following factors:

- Card size and number of guaranteed write operations
- Number of actual write operations

  The number of physical write operations to the memory blocks of the card results from the number of write operations from the application.

Structure of a SIMATIC memory card

The internal flash memory of the SIMATIC memory card is organized in memory blocks. A memory block is a memory area of a fixed size. A write operation always addresses entire memory blocks on the SIMATIC memory card. When a memory block has been written once it must be deleted before it can be written again. The number of delete/write operations per memory block is limited. The service life of the SIMATIC memory card is measured by the maximum number of supported delete or write operations per memory block.

In contrast to delete or write operations, read operations have a negligible impact on the service life. Therefore, the impact of the read operations on the service life is not included in this calculation. A very high number of read operations can, however, influence the service life to a small extent.

Maximum number of write/delete operations

The internal controller of the memory card ensures that the available memory blocks are evenly used. In this way, a maximum number of write operations is possible on the SIMATIC memory card. Internal algorithms distribute the write accesses to the same logical memory area over changing physical memory areas in order to use the memory blocks evenly.

The following table shows the maximum possible number of write/delete operations as a function of the SIMATIC memory card used. The number of maximum write/delete operations of the respective SIMATIC memory card is also available online in the technical specifications of the respective SIMATIC memory card.

Memory size of the SIMATIC memory card *	Article number	Max. number of write/delete operations per memory block
4 MB	6ES7954-8LCxx-0AA0	500 000
12 MB	6ES7954-8LExx-0AA0	500 000

* The memory size figures named in the table are theoretical values. The actual existing memory size in practice is below the theoretical value. The reason for this is that the internal controller of the card and the file system reserve part of the existing memory for internal memory management.

Memory size of the SIMATIC memory card *	Article number	Max. number of write/delete operations per memory block
24 MB	6ES7954-8LFxx-0AA0	500 000
256 MB	6ES7954-8LL03-0AA0	200 000
2 GB	6ES7954-8LP01-0AA0	100 000
2 GB	6ES7954-8LP02-0AA0	60 000
32 GB	6ES7954-8LT03-0AA0	100 000

* The memory size figures named in the table are theoretical values. The actual existing memory size in practice is below the theoretical value. The reason for this is that the internal controller of the card and the file system reserve part of the existing memory for internal memory management.

NOTE

Write or delete operations

Write or delete operations, particularly repeated (cyclic) write/delete operations by the user program on the SIMATIC memory card reduces its service life.

Cyclic execution of the following instructions reduces the service life of the memory card depending on the number of write operations and data:

- "CREATE_DB" (with ATTRIB "Create DB in load memory")
- "DataLogWrite"
- "RecipeExport"
- "RecipeImport" (if target DB in load memory)
- "WRIT_DBL"
- "SET_TIMEZONE"
- "FileWriteC"
- "FileDelete"

Note also that, in addition to the cyclic write/delete operations, the writing or deleting of very large amounts of data also adversely affects the service life of the SIMATIC memory card.

Guaranteed data retention time

If you do not use your SIMATIC memory card for an extended period of time, there is the risk that data contained on the memory card may no longer be readable after a certain amount of time.

The guaranteed data retention time of a SIMATIC memory card is 10 years on delivery and with proper storage. With a number of ≤ 10% of the maximum write/delete operations, the data stored on the card has a retention time of 10 years.

Please note that increasing numbers of write/delete operations to the card reduces its data retention time. If 90% of the maximum write/delete operations is reached, the guaranteed data retention time is reduced to 1 year. If 100% of the maximum write/delete operations is reached, the retention time of the saved data can no longer be guaranteed.

Determining the current usage level of a SIMATIC memory card in STEP 7

When you activate the "Aging of the SIMATIC memory card" option, you enter a threshold value as a percentage in the text box below. As soon as the service life of the SIMATIC memory card has reached the specified threshold value (e.g.: 80 %), the CPU outputs a diagnostics alarm and the MAINT LED lights up in yellow.

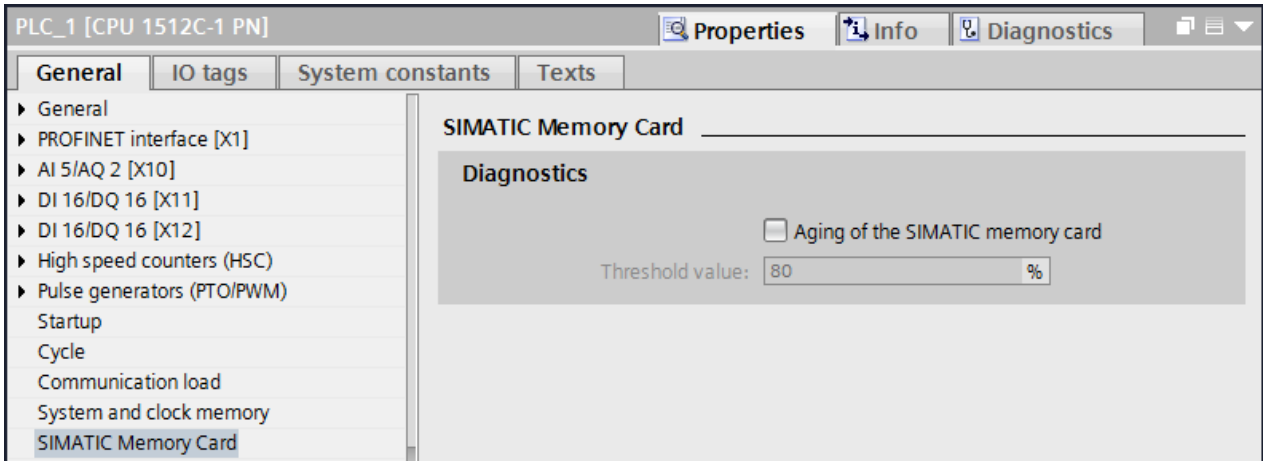

Figure 3-63 Enabled option "Aging of the SIMATIC memory card"

Calculation of the theoretical service life of a SIMATIC memory card

We will use the following example as a basis for calculation:

The user is using a new **256** MB memory card. In accordance with the table, this memory card type supports **200 000** write operations. After parameter changes, the user would like to write **200** DBs of **5** KB each to the SIMATIC memory card at a frequency of **50** times per day with the "RecipeExport" instruction.

Step 1: Calculating the write operations

First use the following formula to calculate the service life of the SIMATIC memory card:

$$\text{Write operations} = \frac{\text{Size of the memory card} \ * \ \text{Maximum number of write operations}}{\text{Number of written bytes}}$$

We first use the sizes from the example in the formula "Write operations" as a basis for calculating the service life:

- Size of the memory card: **256** MB = **268 435 456** bytes
- Maximum number of write operations: **200 000**
- Number of written bytes: **1024 000** bytes (**200** x **5** KB)

If we use the sizes from the example in the formula, we obtain the following result:

$$\text{Write operations} = \frac{268\,435\,456 \text{ byte} \ * \ 200\,000}{1\,024\,000 \text{ byte}} = 52\,428\,800 \text{ write operations}$$

Step 2: Calculating the service life

Use the following formula to calculate the service life in years:

$$\text{Service life} = \frac{\frac{\text{Write operations}}{\text{Write operations per day}}}{365\ \text{days}} : \text{Net-gross factor} = \text{years}$$

NOTE

Net-gross factor

Internal data (metadata) are also written to the SIMATIC memory card with each write operation. Due to this additional data, include the net-gross factor **100** when calculating the service life.

If we use the sizes from the example in the formula, we obtain the following result:

$$\text{Service life} = \frac{\frac{52\,428\,800}{50}}{365\ \text{days}} : 100 = 28.7\ \text{years}$$

Calculation with more frequent write accesses and a higher number of bytes written

If the frequency of write accesses and the number of bytes written per day increases, the service life of the SIMATIC memory card is reduced.

The following table shows, based on empirical values, how the service life of a SIMATIC memory card with a size of 256 MB is reduced

Write accesses per day	Number of bytes written per instruction	Service life of the SIMATIC memory card in years
50	1 024 000	28.7
100	1 024 000	14.3
400	1 024 000	3.6
400	2 048 000	1.8
400	4 096 000	0.9

The following table shows how the same values impact the service life of a SIMATIC memory card with a size of 2 GB (6ES7954-8LP01-0AA0).

Write accesses per day	Number of bytes written per instruction	Service life of the SIMATIC memory card in years
50	1 024 000	114.9
100	1 024 000	57.5
400	1 024 000	14.4
400	2 048 000	7.2
400	4 096 000	3.6

The result shows that a high number of write accesses together with a high number of written bytes significantly shortens the service life of the SIMATIC memory card.

Reference

You can find an alternative method for calculating the service life of a SIMATIC memory card in an FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109482591).

GetSMCinfo instruction

When the SIMATIC memory card inserted, you can read out the following information in STEP 7 (TIA Portal) using the GetSMCinfo instruction:

- Memory size in (1 KB = 1 024 bytes)
- Memory space occupied in (1 KB = 1 024 bytes)
- Maintenance information: Previously used up portion of the service life in %
- Configured percentage of service life after which the CPU creates a diagnostics buffer entry.

You can find additional information on the GetSMCinfo instruction in the STEP 7 online help.

5.5 Expanding the load memory of the CPUs of the redundant system S7-1500R/H

Memory requirements

If the memory space on one of the two SIMATIC memory cards is not sufficient, you can replace this card during operation of the redundant system S7-1500R/H.

NOTE

To avoid errors on the SIMATIC memory card due to insufficient memory, use memory cards with enough memory space.

Expanding the load memory during operation

To expand the load memory of the CPUs of the redundant system S7-1500R/H during operation, follow these steps:

Action		System response
1.	Switch the first CPU to STOP while in redundant operation.	The system changes to system state RUN-Solo.
2.	Remove the existing SIMATIC memory card from the CPU that is in STOP. Insert a larger SIMATIC memory card.	The CPU performs a memory reset.
3.	After the memory reset switch the CPU back to RUN.	The CPU performs a SYNCUP.
4.	Wait until the SYNCUP of the CPU is complete and then switch the second CPU to STOP.	The system changes to system state RUN-Solo again.

Action		System response
5.	Remove the existing SIMATIC memory card from the CPU that is in STOP. Insert a larger SIMATIC memory card.	The CPU performs a memory reset.
6.	After the memory reset, switch the CPU back to RUN.	The CPU performs a SYNCUP.
7.	Wait until the SyncUp of the CPU is complete.	The CPUs now have a larger load memory and are in system state RUN-Redundant again.

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S7-1500, SIMATIC Drive Controller, ET 200SP, ET 200pro Web server

Function Manual

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Introduction 1

Purpose of the documentation

This documentation supports you in the operation of the Web server.

The Web server offers, among other things, web page access to diagnostic data and to process data of the CPU.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge in the field of automation technology
- Knowledge of the SIMATIC industrial automation system
- Experience of working with Windows-based computers
- Knowledge about how to use STEP 7 (TIA Portal)

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuring and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Scope of the documentation

This documentation is valid for CPUs as of firmware version V2.5 and contains illustrations of the Web server user interface. The illustrations used can be transferred to the following CPUs:

- The CPUs of the SIMATIC S7-1500 automation system
- The CPUs of the S7-1500 Software Controller for the Windows and Industrial OS operating systems
- The CPUs of the SIMATIC Drive controller
- The CPUs of the ET 200SP distributed I/O system
- The CPUs 1516pro-2 PN and 1513pro-2 PN of the ET 200pro distributed I/O system

The displayed illustrations can differ from the interface of the Web server in some details, e.g. depending on the web browser used.

What's new in the Web Server Function Manual, Version 11/2023 compared to Version 10/2022

What's new?		What are the customer benefits?	Where can I find information?
New contents	New Web API methods	Many new API methods extend your access options to the CPU via the Web API.	You can find an overview of all Web API methods in the section Supported clients (Page 159).
	Introduction of the local user management for CPUs with firmware version ≥ V3.1	You define and manage the users of CPUs in a TIA Portal project. You assign roles and rights to the users. The user accounts are valid project-wide.	Section Configuring the Web server (Page 24)
Changed contents	Scope of this function manual expanded to include the R/H-CPU of the redundant system S7-1500R/H	You can apply Web API methods on the R/H-CPUs.	Section API (Application Programming Interface) (Page 159)

What's new in the Web Server Function Manual, Version 10/2022 compared to Version 05/2021

What's new?		What are the customer benefits?	Where can I find information?
New contents	New Web API methods	Many new API methods extend your access options to the CPU via the Web API.	Section API (Application Programming Interface) (Page 159)
	Management of certificates in runtime	In addition to loading Web server certificates via the TIA Portal, this option makes it possible to provide such certificates from a certificate management server at runtime. This allows you, for example, to update expiring certificates in time without interrupting the process.	Section Managing certificates in runtime (Page 31)
	Motion Control Diagnostics (T CPUs)	Display of the diagnostics of the axis status for the "Encoder homed" signal of the encoders of all 4 possible axes.	Section Motion Control Diagnostics (Page 64) Function manuals for S7-1500/1500T Motion Control on the Internet (https://support.industry.siemens.com/cs/ww/de/view/109751049)
Changed contents	Extension of the scope of this function manual to the CPU 1514SP-2 PN and the CPU 1514SPT-2 PN of the ET 200SP distributed I/O system.	Web server functions can now also be used on these CPUs.	• Equipment Manual CPU 1514SP-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109813-105) • Equipment Manual CPU 1514SPT-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109813-106)

What's new in the Web Server Function Manual, Version 05/2021 compared to Version 11/2019

What's new?		What are the customer benefits?	Where can I find information?
New contents	New Web API methods: • Plc.ReadOperatingMode • Plc.RequestChangeOperatingMode	Reading and changing CPU operating mode via Web API	Section Reading and changing the operating mode (Page 212)
	Ticket mechanism and ticket methods for handling the tickets: • Api.BrowseTickets • Api.CloseTicket	With the Web server as of firmware version V2.9, you can use the ticket mechanism of the Web API. You can use the ticket mechanism to transfer large amounts of data outside of the JSON-RPC protocol. The ticket mechanism is the basis for all file-based methods, such as file upload/download of resources.	Section Ticket mechanism (Page 170)
	Web applications of the Web API that can be loaded by the user: Web applications that can be loaded by the user provide you with an additional set of methods to manage web applications via Web API. You can use all available Web API methods within the web application.	Web applications that can be loaded by the user offer you the following major advantages as of firmware version V2.9 compared to the older method that provided the user-defined pages via the system function SFC 99 in STEP 7: Only the TIA Portal project in the SIMATIC.S7S directory on the SIMATIC Memory Card changes. Your TIA Portal project is extended by the option of saving resources (e.g. HTML, CSS, JavaScript, etc.) in the project but outside of the data blocks of the user program. The resources are saved in the associated web application. Via the Web API you can download the resources to your PC, edit them and upload them back to the CPU. This procedure results in significantly reduced development times of user-defined pages. You can access resources independent of the CPU operating mode (e.g. RUN, STOP) and update these. Web applications are also available in the STOP mode of the CPU.	Section Web applications that can be loaded by the user (Page 256)
	Creating user-defined pages with TIA Portal WinCC Unified as of Version V17	Compared to creating user-defined pages with a random HTML editor, creating and loading user-defined pages with WinCC Unified for SIMATIC S7-1500 CPUs offers the following advantages: • No HTML code expertise required • You can make changes to the user-defined pages while the CPU is in the RUN mode.	Section User-defined pages (Page 128) WinCC Unified online help

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Diagnostics	The display in the "Memory" tab is extended by information on the data type memory so that the user program can be changed accordingly when the available memory is not sufficient.	Section Diagnostics (Page 52)
	Motion Control Diagnostics	Comprehensive diagnostic options for Motion Control applications: • Diagnostics information is available for all technology objects • Improved display and grouping of the tags	Section Motion Control Diagnostics (Page 64)
	Communication	Extension of the "Parameter" tab to assign the network configuration via a DHCP server and display the DNS settings	Section Communication (Page 80)

What's new in the Web Server Function Manual, Version 11/2019 compared to Version 12/2017

What's new?		What are the customer benefits?	Where can I find information?
New contents	The CPU has a web-based API (Application Programming Interface) as an interface for: • Reading and writing CPU data • Executing functions (e.g. backing up and restoring the CPU configuration, changing the operating mode) The Web API supports all common browsers and command line programs, such as cURL and Wget.	• Established standard mechanisms for creating web pages: Automation Web Programming commands (AWP commands) are no longer required for output of CPU data • No dependency between custom Web pages and CPU program: No synchronization between user program and Web server required by the SFC 99 instruction • Lower communication load: A smaller data packet (JSON instead of HTML) of the custom web page generated by the CPU is transferred between the server and the client. This improves the communication performance. The CPU needs less runtime to generate the information and make it available. • Secure data traffic: the Web API only supports the transmission protocol "HTTPS"	Section API (Application Programming Interface) (Page 159)
Changed contents	Extension of the scope of this function manual to the CPUs of the SIMATIC Drive Controller	Webserver functions which you are familiar with from the CPUs of the SIMATIC S7-1500 can now also be used on the CPUs of the SIMATIC Drive Controller.	• System Manual SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766-665) • Equipment Manual SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766-666)

What's new in the Web Server Function Manual, Version 12/2017 compared to Version 09/2016

What's new?		What are the customer benefits?	Where can I find information?
New contents	New web page "User files"	You can download ASCII files (files in binary format) from the SIMATIC Memory Card, directory UserFiles\ to the web page and delete them.	Section User files (Page 126)
	Time display as Coordinated Universal Time (UTC) or as PLC local time	The display of the UTC allows you to use a uniform time for the web pages. You can set the format of the time display to Coordinated Universal Time (UTC) or PLC local time (default setting).	Section Start page with general CPU information (Page 45)
	Automated downloading, reading out and archiving of DataLogs	You can, for example, read out and archive DataLogs daily from one or more CPUs at a specific time via the Web server. Automatic downloading of DataLogs is realized either by the execution of scripts in, for example, Bash or via JavaScript on your HTML user-defined page.	Section Automated reading out of DataLogs (Page 124)
	The "Permit access only with HTTPS" check box is activated in the default setting of a configured CPU.	The web pages are transmitted by default via a secure connection and are protected from attacks by third parties.	Section Configuring the Web server (Page 24)
Changed contents	Web page "Module information": New column Device number	You can read the assignment of the device number to the device name.	Section Module information (Page 70)
	Web page "Topology": Selection of the available PROFINET interfaces, for example X1, X2, CM 1542-1	You can select the topology display for the PROFINET interfaces X1, X2 and for connected PROFINET communication modules.	Section Topology (Page 86)
	Web page "DataLogs": New column for deleting DataLog files	You can delete DataLog files via the Web server.	Section DataLogs (Page 123)
	Web page "Record": Changes in the display of Trace recordings	You can evaluate the Trace recordings in more detail through the extension of the display.	Section Record (Page 104)
	Web page "Record": New arithmetic functions	In the case of completed measurements you can combine the measured signals mathematically with each other and this generate signals that were not recorded. You can, for example, form the difference of two signals in order to better display the deviation of the current pressure of a boiler from the set setpoint value.	

What's new in the Web Server Function Manual, Version 09/2016 compared to Version 12/2014

What's new?		What are the customer benefits?	Where can I find information?
New contents	Handling of certificate modified	You protect the Web server connection against tapping or distortion of the communication through access via the secure transmission protocol "HTTPS" including a special Web server certificate.	Section Configuring the Web server (Page 24)
	Four additional languages for the Web server interface	You can set the Web server interface to the following languages: • Korean • Russian • Turkish • Portuguese (Brazil)	Section Start page with general CPU information (Page 45)
	Assignment of different project languages extended	You can assign up to three different project languages for comments, alarm texts and diagnostics information to the user interface languages of the Web server.	Section Language settings (Page 35)
	"Start page" web page extended	The display of the TIA project name immediately indicates whether the desired project is selected.	Section Start page with general CPU information (Page 45)
	"Diagnostics" web page extended by one tab: • "Program protection" • "Runtime information" • "Fail-safe" (with an F-CPU)	Here you can find information about: • Know-how protection or copy protection of the PLC program • Program/communication load and cycle time • F-collective signatures, cycle times and runtimes of the F-runtime group(s)	Section Diagnostics (Page 52)
	"Alarms" web page extended	You can acknowledge alarms of the CPU via the Web server.	Section Alarms (Page 78)
	"Tag status" and "Watch tables" web pages extended	You can change the value of tags and write them to the CPU, also using the absolute address.	• Section Tag status (Page 95) • Section Watch tables (Page 98)
	New web page "Online backup"	You can back up and restore the CPU configuration to/from the SIMATIC Memory Card via the Web server.	Section Online backup (Page 100)
	New "Motion Control Diagnostics" web page	You can monitor statuses, errors, technology alarms and the current values of configured technology objects (TOs) with the Web server without STEP 7.	Section Motion Control diagnostics (Page 64)
	New "Record" web page	You can read, view and save trace recordings via the Web server and thus obtain plant and project information for diagnostics and maintenance without STEP 7.	Section Record (Page 104)

What's new?		What are the customer benefits?	Where can I find information?
Changed contents	Extension of the scope of this function manual to the CPUs of the ET 200SP distributed I/O system and the CPU 1516pro-2 PN	Functions that you will be familiar with from the SIMATIC S7-1500 CPUs are implemented in CPUs in other designs (ET 200SP) and in the CPU 1516pro-2 PN (degree of protection IP65, IP66 and IP67).	• Equipment Manual CPU 1510SP-1 PN (https://support.industry.siemens.com/cs/ww/en/view/901571-30) • Equipment Manual CPU 1512SP-1 PN (https://support.industry.siemens.com/cs/ww/en/view/901570-13) • Operating instructions CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482-416)
	Web page "Watch tables": Note added on the maximum configuration limits.		Section Watch tables (Page 98)
	Web page "User-defined pages": Note added on the maximum size of the HTML pages.		Section User pages (Page 128)

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal service and dispose of the equipment according to the applicable regulations in your country.

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all Automation and Drives products on the Internet (https://mall.industry.siemens.com).

1.1 Function manuals documentation guide

1.1.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety and security instructions 2

2.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on protective industrial cybersecurity measures for implementation, please visit (https://www.siemens.com/global/en/products/automation/topic-areas/industrial-cybersecurity.html).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates at all times, subscribe to the Siemens Industrial Cybersecurity RSS Feed under (https://new.siemens.com/global/en/products/services/cert.html).

General information 3

3.1 Properties of the Web server

Benefits of the web server

The web server enables monitoring and administering of the CPU by authorized users over a network. Evaluations, diagnostics, and modifications are thus possible over long distances. Monitoring and evaluation is possible without STEP 7, only a web browser is required. Note that you must take appropriate measures to protect the CPU from compromise (such as restricting network access, using firewalls).

Activating the web server

The web server is deactivated in the delivery state of the CPU. This means that you must load a project in which the web server is activated to enable access using the web browser.

Security functions

The web server provides the following safety functions:

- Access via the secure transmission protocol "HTTPS" using the CA-signed web server certificate
- User authorizations you can configure by means of user list
- Activation for specific interfaces

Web browser

You need a web browser to access the HTML pages of the CPU.

The web browsers listed below have been tested for communication with the CPU. Other web browsers may also work, especially newer versions. However, if problems occur with web browsers not mentioned here that cannot be rectified, use one of the following tested web browsers:

- Microsoft Edge (Version 116.0)
- Google Chrome (Version 116.0)
- Mozilla Firefox (Version 116.0.3)
- Opera (Version 102.0)
- Mobile Safari and Chrome (iOS 12.5.1, 16.5)
- Android browser (7.x, 8.x and 10.x, 11.x, 12.x)

- Chrome for Android (7.x, 8.x and 10.x, 11.x, 12.x)
- HMI Panels:
  - Basic Panel
  - Comfort Panel

NOTE

If you are using Internet Explorer, deactivate "Compatibility view" in the settings ("Options" menu).

NOTE

For access to display devices with low screen resolution, we recommend the use of basic web pages, see section Basic websites (Page 156).

NOTE

Older versions of the web browsers named above, which previously supported access to the HTML pages of the CPU, continue to allow this. However, these older versions do not support the new functions and HTML pages described in this edition.

NOTE

Two reserved communication connections are available to the web server for communication with the CPU.

Depending on the web browser used, different numbers of connections to the CPU are established. If more connections are available, more communication connections will be established.

If no more connections are available, display or functional problems may occur. This is because the web server will reject all other communication connections apart from the two that are reserved.
For this reason, the web pages may not load fully.

NOTE

If you access the web server of the CPU using a communications processor (CP), ensure that the cache (temporary Internet files) is activated in your web browser. Choose the "Automatically" option in the cache settings of your web browser.

If the cache is deactivated or if a setting other than "Automatically" is made in the cache settings of your web browser, this may result in slow access times and incomplete display.

NOTE

After a firmware update of the CPU, incorrect display of web pages can occur in various web browsers. This is caused by problems of the new CPU firmware with the cache of the web browser.

Solution: Press F5 or clear the web browser cache.

NOTE

Web browser behavior can be different if a certificate is not valid yet or is no longer valid. Siemens has no influence on this behavior. This means we cannot guarantee the reliable functionality of the web server with invalid certificates.

Reading out data

With the web server, you can read out the following data from the CPU and, in some cases, modify and write back the data to the CPU.

- Start page with general CPU information (Page 45)
- Information on Diagnostics (Page 52)
  - Identification
  - Program protection
  - Memory
  - Runtime information
  - Fail-safe (with an F CPU)
- Contents of the diagnostics buffer (Page 63)
- Module information (Page 70)
- Firmware update (Page 76)
- Alarms (Page 78)
- Information on Communication (Page 80)
  - Important interface parameters
  - Port statistics
  - Display of the communication resources
  - Display of the communication connections
- PROFINET-Topology (Page 86)
  - Graphical view (set and actual topology)
  - Table view (actual topology)
  - Status overview
- Tag status (Page 95)
- Watch tables (Page 98)

- User pages (Page 128)
- Filebrowser (Page 155)
- DataLogs (Page 123)
- User files (Page 126)
- Online backup and restoration of the configuration (Page 100)
- Diagnostics information for technology objects (Page 64)
- Evaluation of trace recordings (Page 104)
- Reading out service data (Page 156)
- Basic websites (Page 156)

The HTML pages are described in more detail on the following pages.

NOTE

Max. characters at data type WSTRING

Note that the data type WSTRING is limited to 254 characters for the display in the web server. If the 254 characters are exceeded, the web server does not display the superfluous characters.

Web access to the CPU via PG/PC, HMI devices and mobile end devices

Proceed as follows to access the web server:

1. Use STEP 7 to download a project in which the web server is activated to the CPU.
2. Connect the display device (PG/PC, HMI, mobile terminal device) with the CPU or a communications module using a PROFINET interface.
   If you are working with WLAN, activate the WLAN on the display device and establish a connection to the access point (e.g. SCALANCE W788-1RR or SCALANCE W784-1), which is in turn connected to the CPU.
3. Open the web browser on the display device.
4. Enter the IP address of the interface of the CPU which is connected to the client in the "Address" field of the web browser in the following format: https://a.b.c.d (entry example: https://192.168.3.141).
   The introduction page of the CPU opens. From the intro page you can navigate to more information.

More information on access using the secure transmission protocol "HTTPS" is available in the section Configuring the Web server (Page 24).

More information

Using a smartphone, you can access the web server of the CPU either via WLAN or access to the CPU via the SIMATIC S7 app (using web server functionality). You can find additional information in the FAQ entry ID 103473392 on the Service&Support (https://support.industry.siemens.com/cs/ww/en/view/103473392) Internet page.

Note: The web server must also be activated for access to the CPU via the SIMATIC S7 app.

The SIMATIC S7 app offers you additional functions. You can find a detailed application example with further documentation and example projects on the Service&Support (https://support.industry.siemens.com/cs/ww/en/view/84133612) Internet page.

3.2 Configuring the Web server

To use the full functionality of the Web server, the following settings in STEP 7 are necessary.

Activate Web server on this module

The Web server is deactivated in the default setting of a configured CPU. Proceed as follows to activate the Web server:

1. Open the "Devices & Networks" view by double-clicking in the project tree in STEP 7.
2. Select the desired CPU in the device, network or topology view.
3. Navigate to the "Web server" area in the inspector window properties, "General" tab.
4. Select the "Activate Web server on this module" check box.
   The following note is output:

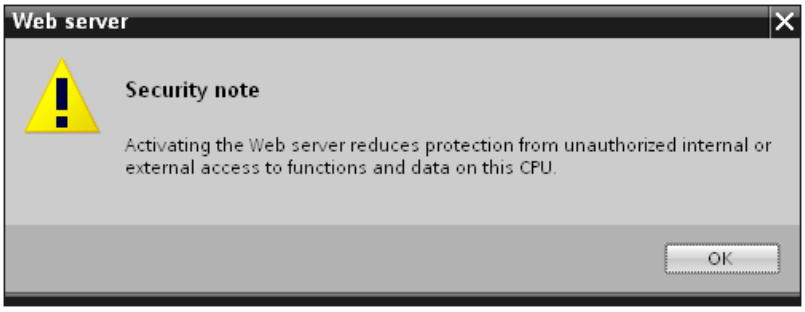

Figure 3-64 Security note upon activation of the Web server in STEP 7

NOTE

When projects from deliveries are applied in which the Web server was already activated and configured on the module, this security note is not shown.

NOTE

Activating Web server for R/H-CPUs

For R/H-CPUs you can only activate the Web server for both R/H-CPUs and the identical settings. In addition to the Web server properties, this also applies to the "Overview of the interfaces", for the certificates and the user management.

You can use the IP addresses of both CPUs to use the Web server.

Depending on the CPU used, you can make your own settings or the settings are fixed.

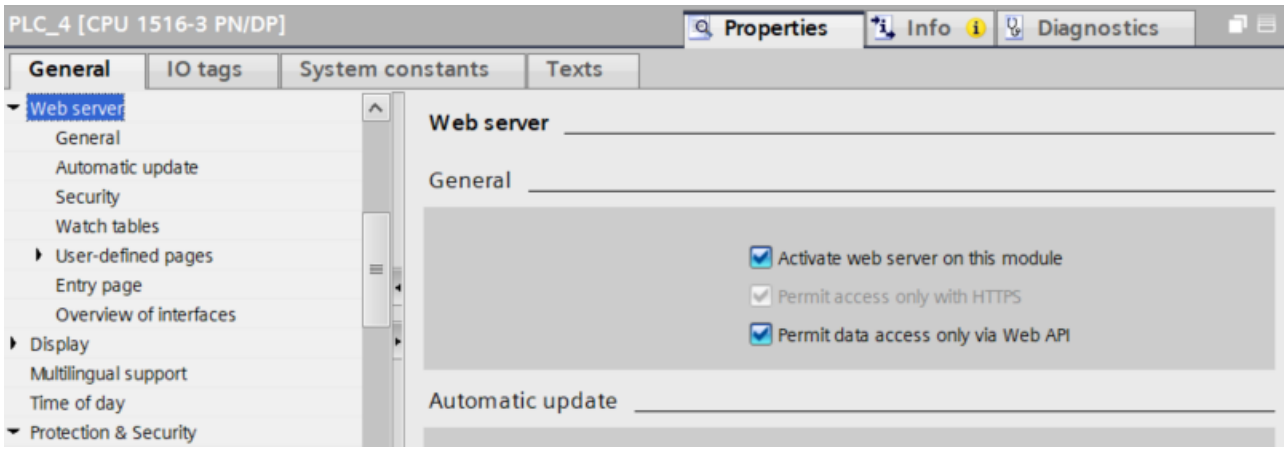

Figure 3-65 Web server settings in STEP 7

Permit access only with HTTPS

Note: A valid Web server certificate is required in the CPU to operate the Web server using the secure transfer protocol "HTTPS". You can find information on how to create and assign Web server certificates in the section Managing certificates via TIA Portal (Page 29).

To ensure secure access to the Web server the "Permit access only with HTTPS" check box is activated in the basic setting of a configured CPU.

The web pages are transmitted by default via a secure connection and are protected from attacks by third parties. Note that in this case the URL of the CPU starts with "https://".

The requirements for error-free HTTPS access to the CPU are as follows:

- The current date/time must be set in the CPU.

  NOTE

  When using secure communication (e.g. HTTPS), make sure that the corresponding modules have the current time of day and the current date. Otherwise the modules cannot check the validity period or evaluate the certificates used as invalid. Therefore, a secure connection cannot be established.

- The IP address of the CPU must be assigned.

- A valid Web server certificate offered by the CPU is installed in the web browser.

NOTICE
Safety-related functions only possible with CA-signed Web server certificate The safety-related functions backup and restoring the CPU configuration, see section Online backup (Page 100), are only possible with a CA-signed Web server certificate. A valid CA-signed Web server certificate in the CPU is also required: – User management with password-protected users – Saving and downloading diagnostics information in csv files To use the full functionality of the Web server, we therefore recommend that you use the Certificate Manager to create a CA-signed server certificate in the global security settings and assign it to the CPU.

If no CA-signed Web server certificate is installed, a warning is output recommending that you do not use the page. To view the page, you may need to "Add an exception", depending on the web browser used.

A valid CA certificate is available for download from the "Intro" web page under "Download certificate".

You can find instructions for installing the certificate in the help system of your web browser and in the FAQ with the entry ID 103528224 at the Service&Support (https://support.industry.siemens.com/cs/ww/en/view/103528224) website.

NOTE

To protect against manipulation from the outside, download the certificate only in an environment that is guaranteed not to be compromised. Installation of the CA certificate has to be carried out once for each display device you wish to use.

Permit data access only via Web API

If you select the "Permit data access only via Web API" check box, only Web API-based functions are available, including:

- JSON-RPC interface
- Ticketing and web applications

Functions on the Web server via the unencrypted HTTP protocol and AWP commands are no longer accessible.

If you select the "Permit data access only via Web API" check box, the "Allow access only via HTTPS" check box is automatically selected and cannot be changed.

For R/H-CPUs, data access is only possible via Web API and is therefore preset and cannot be changed.

Access protection and user management

The encrypted connection created with the help of the certificate prevents eavesdropping or falsification of communication, but does not provide access protection. This means you have to protect your CPU from unauthorized access with the corresponding configuration in the user management.

The procedure for setting up the user management with password-protected users for the Web server is based on the configured firmware version of your project. You can find more information in the User management (Page 37) section.

You can find more information on access protection on the CPU in the STEP 7 online help, keyword: "Protection".

Activate automatic update

Automatic updating is activated in the default setting of a configured CPU.

The following web pages are updated automatically:

- Start page
- Diagnostics (memory, runtime information, fail-safe)
- Diagnostics buffer
- Motion Control Diagnostics
- Module information
- Alarms
- Communication
- Topology
- Tag status
- Watch tables
- Record
- DataLogs
- User files
- User-defined pages
- File browser

NOTE

The default activation interval is 10 seconds.
Larger data volumes or multiple HTTP/HTTPS-connections increase the update time.

Setting the language for the Web

In total, you can assign up to three different project languages to the user interface languages of the Web server.

In STEP 7, activate the project languages that you want to use and then assign one of the activated project languages to each of the Web server interface languages.

You can find more information about the language settings and a description of how to assign a project language to the interface languages in the section Language settings (Page 35).

User-defined pages

In the "User-defined pages" area, you can download your own web pages to the CPU and make your own web applications available via the web browser.

You can find more information in section User pages (Page 128).

Activation of the Web server for specific interfaces

In the "Overview of interfaces" area, you have the option to enable access to the Web server.

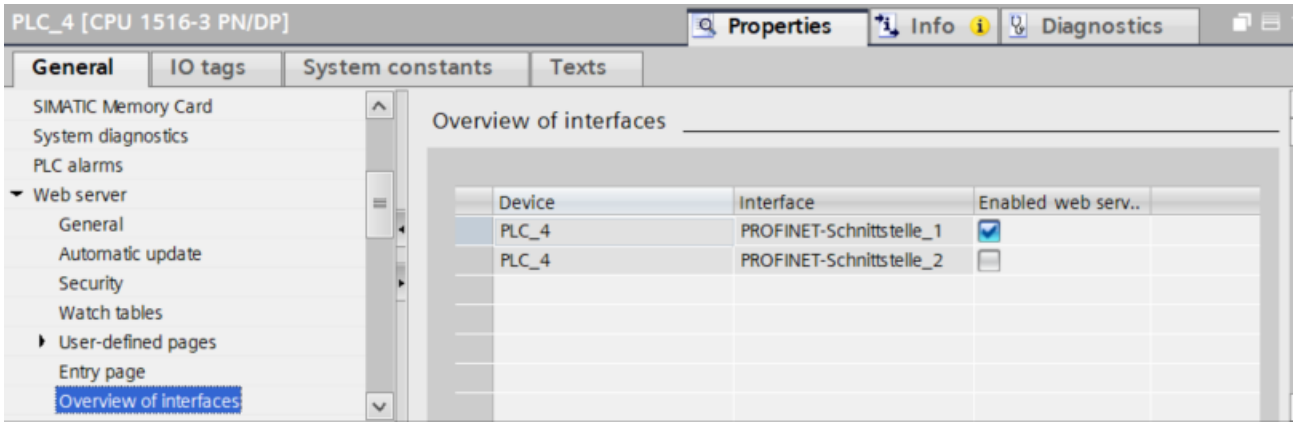

Figure 3-66 Enabling access to the Web server via the interfaces

3.3 Certificate

3.3.1 Web server certificates

To secure the data exchange with a partner, different applications and communication functions of the CPU use device certificates that are managed specific to the application. In the case of the device certificate for the Web server, this involves a Web server certificate.

3.3.2 Managing certificates via TIA Portal

Creating and assigning a Web server certificate

Operation of the Web server using the secure transfer protocol "HTTPS" requires a valid Web server certificate.

For SIMATIC S7 1500 CPUs with firmware V2.0 and higher, you have to create the Web server certificate of the CPU yourself using STEP 7 and assign it to the Web server in the properties of the CPU. This certificate is also downloaded to the CPU automatically when the hardware configuration is downloaded.

NOTE

If you update the firmware of a SIMATIC S7 1500 CPU or ET 200SP CPU with a firmware version < V2.0 to a firmware version ≥ V2.0, a valid Web server certificate is automatically generated and used. The same applies to the replacement parts scenario in which a newer CPU replaces a CPU with firmware version < V2.0.

If you update or replace an already configured CPU, a valid Web server certificate is automatically generated and used for CPUs with a firmware version ≤ V1.8.

You can create different Web server certificates:

- If you use the global security settings for the certificate manager, the certification authority of the project (CA certificate) signs the device certificate of the Web server. During loading, the CA certificate of the project is automatically loaded as well.
- If you do not use the certificate manager in the global security settings, STEP 7 generates the device certificate as a self-signed certificate.

NOTICE

Utilizing the full functionality of the Web server

A valid CA-signed Web server certificate in the CPU is a requirement for the following functions:

- User management with password-protected users
- Saving and downloading diagnostic information in csv files
- Backup and restore of security-related functions such as the configuration of the CPU

To use the full functionality of the Web server, we therefore recommend you activate the global security settings of the certificate manager, create a CA-signed Web server certificate and assign it to the CPU.

Creating a self-signed Web server certificate

To create a self-signed Web server certificate with TIA Portal, follow these steps:

1. In the Inspector window Properties of the CPU, "General" tab, navigate to the "Web server > Security" area.
2. Click the "Add" button in the drop-down list to select a certificate.
   The "Create a new certificate" dialog opens.
3. Select the "Self-signed" check box in the follow-up dialog.

4. Enter the parameters for the new certificate or confirm the default settings.
   - Select "Web server" in the "Usage" box.
   - Enter the IP address(es) of the interface(s) or the domain name of the configured CPU in the "Subject Alternative Name" field.
5. Click "OK" to confirm.
6. Compile and load the configuration into the CPU.
   The device certificate of the Web server is a component of the configuration.

Creating and assigning a CA-signed Web server certificate

To create a CA-signed Web server certificate with TIA Portal, follow these steps:

1. Protect your project with the security settings "Protect this project".

   The "Security functions" appear in the project tree.
2. In the "General" tab of the Properties of the CPU Inspector window, navigate to the "Protection & Security > Certificate Manager" area and select the "Use global security settings for certificate manager" option.

   NOTE

   For managing certificates with the global security settings, you require the "Configure security" configuration permission.

3. Log in as a user in the project tree in the "Security settings" section. The "Administrator" role is the default for the first logon for a new project.
4. In the Inspector window Properties of the CPU, "General" tab, navigate to the "Web server > Security" area.
5. Click the "Add" button in the drop-down list to select a certificate.
   The "Create certificate" dialog opens.
6. In the follow-up dialog, select the "Signed by certificate authority" check box and select the certificate authority from the drop-down list.
7. Enter the parameters for the new certificate or confirm the default settings.
   - Select "Web server" in the "Usage" box.
   - Enter the IP address(es) of the interface(s) or the domain name of the configured CPU in the "Subject Alternative Name" field.
8. Click "OK" to confirm.
9. Compile and load the configuration in the CPU.
   The device certificate of the Web server and the CA certificate are components of the configuration.

NOTICE
Addressing the Web server of the CPU via domain names If you enter the IP address(es) of the interface(s) of the configured CPU in the "Subject Alternative Name" field, the generated certificate may not be accepted by all Internet browsers. In addition, you must generate and load a new Web server certificate (end entity certificate) with each change of the IP address of an Ethernet interface of the CPU, since the identity of the CPU changes with the IP address. You can avoid this problem by addressing the Web server of the CPU using domain names instead of IP address(es), e.g. "myconveyer-cpu.room13.myfactory.com". For this purpose, you have to manage the domain names of your CPU via a DNS server. Addressing via domain names is recommended especially for a configuration with reception of the IP address from a DHCP server, as in this case the assigned IP address is not known beforehand.

More information

For detailed information on local self-signed and global CA-signed certificates, on the "Public Key Infrastructure" (PKI) and on certificate management, refer to the Communications Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925) and to the STEP 7 online help, keyword "Secure Communication".

The application example "The use of certificates with the TIA Portal (https://support.industry.siemens.com/cs/de/en/view/109769068)" includes detailed instructions on how to create a secure connection to the Web server of a SIMATIC S7-1500 CPU.

3.3.3 Managing certificates in runtime

If you manage certificates via the TIA Portal, load a certificate together with the hardware configuration into the CPU. To do this, the CPU must be in STOP mode. You cannot load a new certificate or renew an existing certificate without a RUN-STOP-RUN transition.

If you manage certificates at runtime of the CPU, loading or updating a certificate is also possible in RUN mode.

Managing the web server certificate during the CPU runtime

As of firmware version V3.0, it is also possible to transfer web server certificates to the CPU during runtime via the GDS server using OPC UA methods. The GDS server is part of the OPC UA server in the CPU. Through GDS push management functions, you can automatically update OPC UA certificates for the OPC UA server of the S7-1500 CPU.

You can find detailed information about the concept of automated certificate management with GDS (Global Discovery Services) in the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) Function Manual.

Setting the type of certificate management

In the "Protection & Security" > "Certificate manager" category on the "General" tab of the "Properties" Inspector window, select how you want to handle certificates.

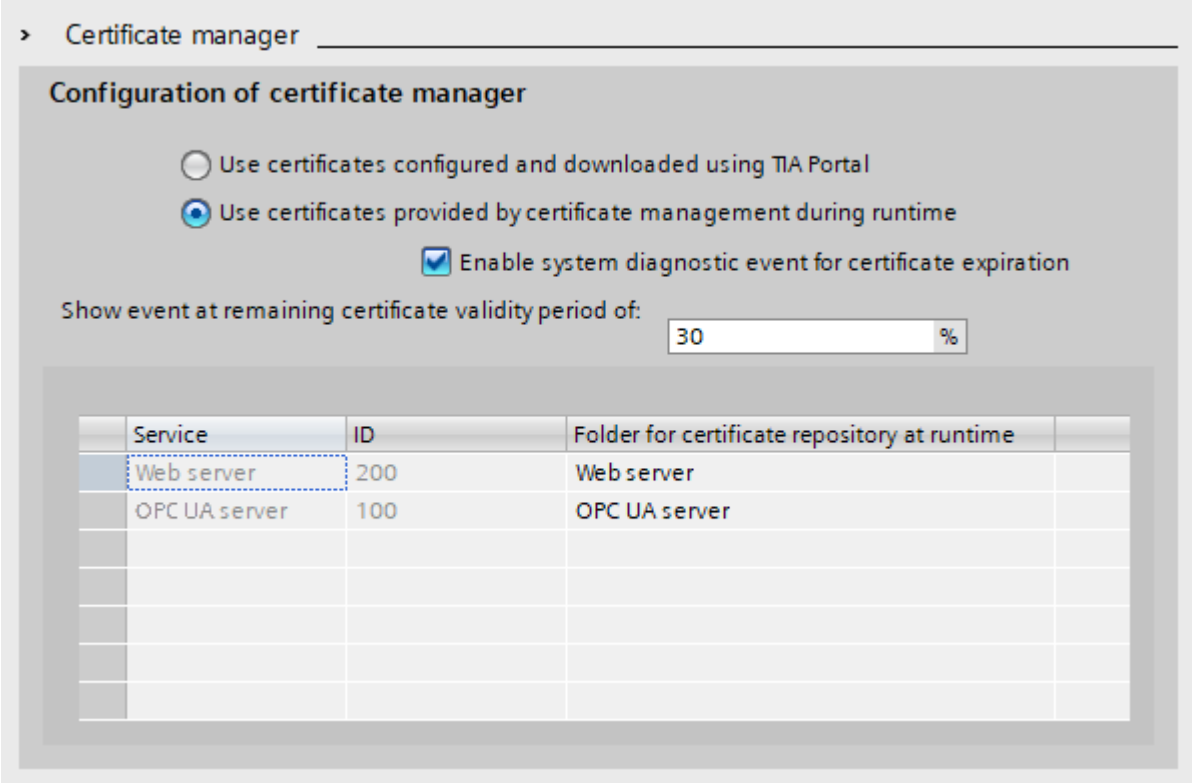

Figure 3-67 Configuration of the certificate manager

If you want to submit certificates via GDS at runtime, click the "Use certificates provided by the certificate management during runtime" option.

By selecting the "Enable system diagnostics event for certificate expiration" button, you specify that you want to be notified when a certificate expires. In the input field "Show event at remaining certificate validity period of:" enter a percent value. At the time this value is reached, the CPU triggers a system alarm with a maintenance request.

Example:
The certificate transferred via GDS on 01/06/2022 has a validity from 01/06/2022 to 30/06/2022 (30 days). You have input a percent value of 10 for the diagnostics event. On 27/06/2022, after 90% of the validity period has expired, the system diagnostics alarm reports that the transmitted certificate will expire on 30/06/2022.

Regardless of the configured percentage value, a message appears in any case when the validity period of a certificate expires.

NOTE

Time settings in the CPU

In order for the CPU to detect the expiration of a certificate, you must set the system time to Coordinated Universal Time (UTC). An incorrect system time can lead to incorrect messages regarding the expiration of certificates.

In the lower area of the "Certificate manager" category in the table, you can find a list of all CPU applications with certificates you may transfer to the CPU at runtime. In the list, the CPU applications are assigned an ID. Under the "Folder for certificate repository at runtime" column, you can find the changeable name of the certificate group.

Handling of existing certificates during loading

Before you load a project into the CPU, you may determine in the "Load preview" dialog window what should happen with the certificates of the CPU received at runtime.

As of firmware version V3.0, you can use the "Delete selected" option to delete certificates of selected CPU applications.

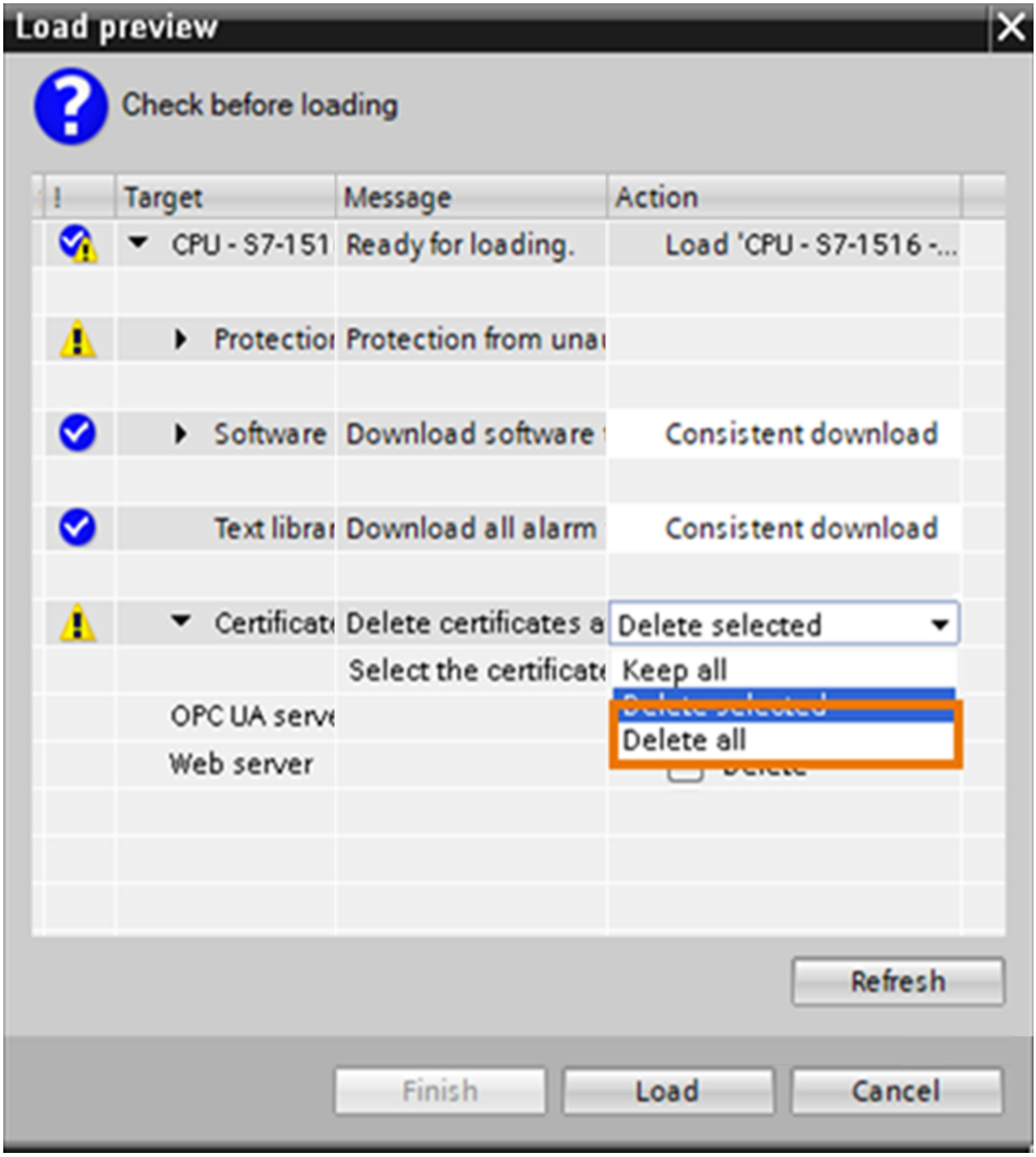

Figure 3-68 Deleting certificates

3.4 Language settings

Introduction

The Web server provides the user interface in the following languages:

- German (Germany)
- English (USA)
- French (France)
- Italian (Italy)
- Spanish (traditional sort)
- Japanese
- Chinese (Simplified)
- Korean
- Russian
- Turkish
- Portuguese (Brazil)

Requirements for the availability of East Asian languages

The following requirements must be met for East Asian languages:

- The appropriate package for support of East Asian languages is installed on the display device (such as PC).
  For more information on installing files for East Asian languages, refer to your Windows documentation.
- STEP 7 for East Asian languages is installed on the programming device for configuring the CPU.

NOTE

SIMATIC HMI devices with the Windows CE operating system do not support East Asian languages.

Requirement for multilingual output of texts

In order for the Web server to correctly display messages, comments, and diagnostics information in the different project languages, you must assign a project language to each of the desired user interface languages of the Web server in STEP 7.

NOTE

The project languages of the STEP 7 project that you want to assign must be activated and the corresponding texts (translations) must be available in the project. You can find a list of available project languages in the project tree under "Languages & resources".

Configuring a project language for the Web server

Once you have activated the Web server on your module, assign a STEP 7 project language to each of the user interface languages of the Web server. This assignment affects the display of pages with project language-dependent texts, such as the diagnostics buffer.

1. Navigate to the "Multilingual support" area in the "General" tab of the CPU properties in the inspector window.
2. Assign a project language from the drop-down list to each user interface language of the Web server.

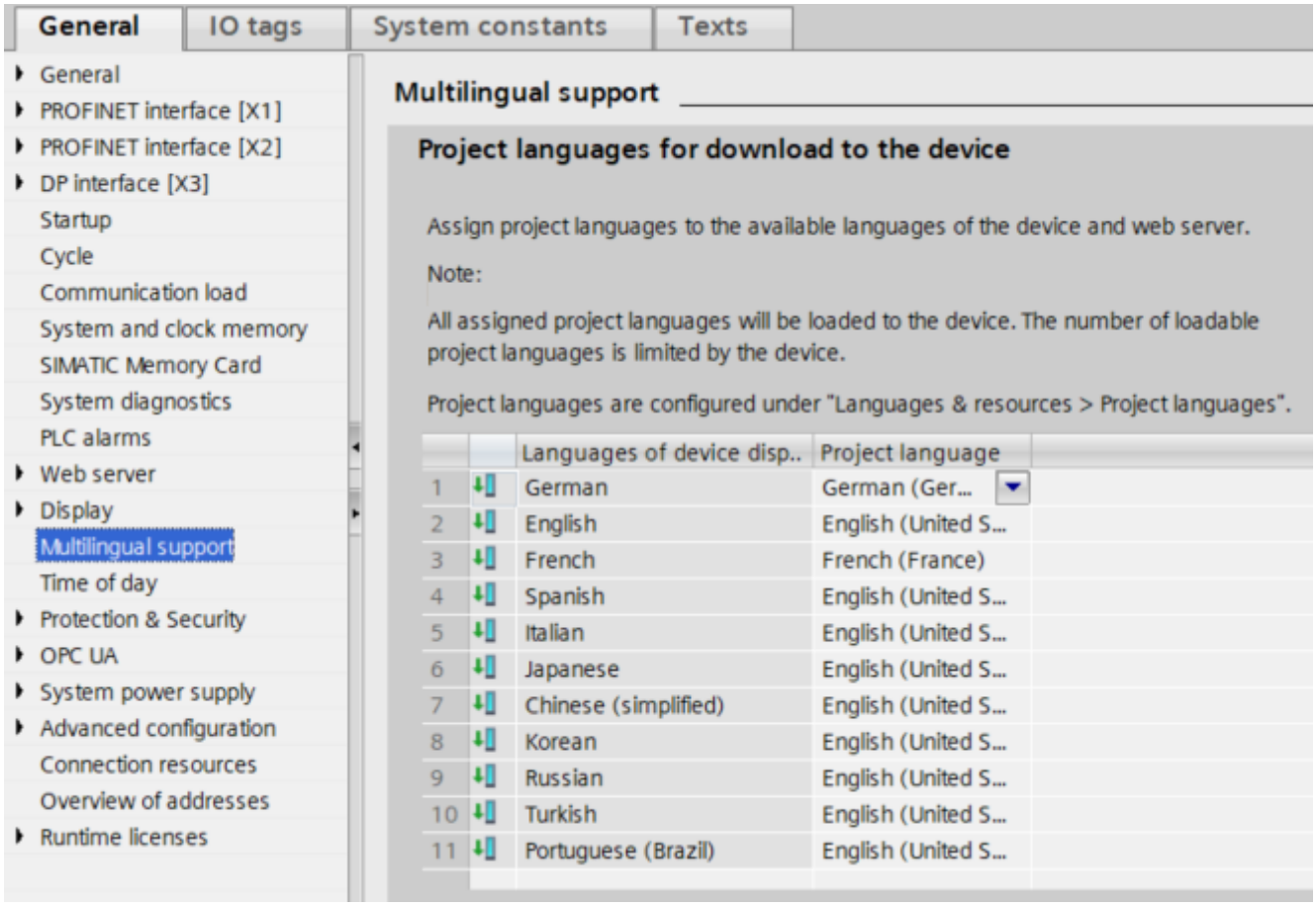

Figure 3-69 Language settings for the Web server in STEP 7

You can also assign user interface languages the same project language, for example:

- ① Project language German for user interface language German, English (USA) for English, French for French.
- ② Project language English (USA) for all other available user interface languages of the Web server.

In total, you can assign up to three different project languages of the STEP 7 project to the user interface languages of the Web server.

Reference

You can find more information on how to set the project language in STEP 7 in the STEP 7 online help, keyword: "Selecting project languages".

3.5 User management

User authentication on the Web server always takes place via secure HTTPS communication.

Setting up user management

You set up the user management in the TIA Portal depending on the configured firmware version of your CPU in the project.

- The static (old) user management applies to CPUs with firmware version ≤ V3.0
- CPUs with configured firmware version ≥ V3.1 support both the static (old) user management and the local (new) user management, depending on whether an old or new project was loaded.

Static user management for CPUs with configured firmware version ≤ V3.0

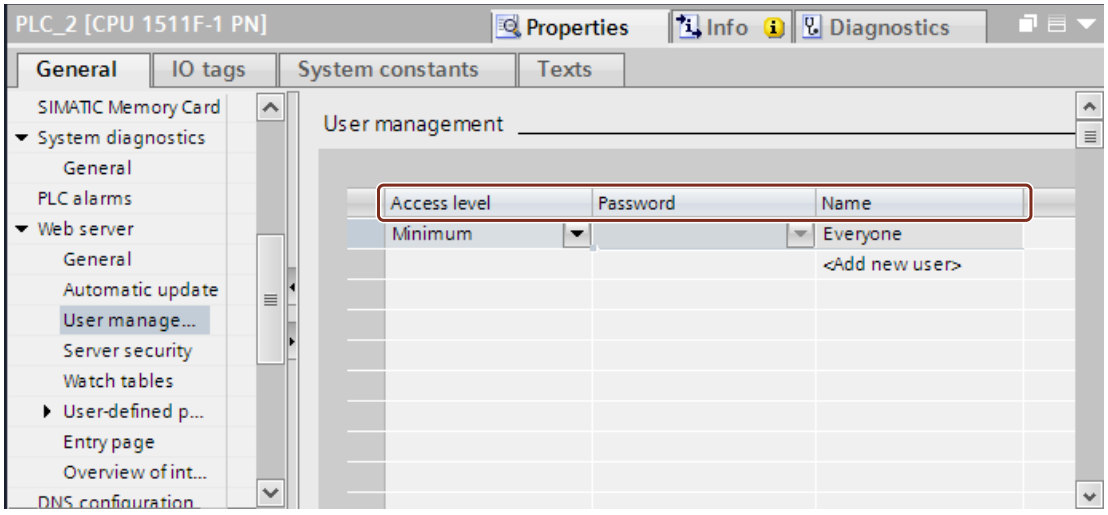

Figure 3-70 User management in TIA Portal for CPUs with configured firmware version ≤ V3.0

In the TIA Portal you can manage the user list in the "Web server > User management" area.

The user list provides the following options:

- Create users
- Specify access permissions
- Assign passwords

Users only have access to the options that are permanently linked to the access rights.

You can assign different user rights depending on the CPU and firmware used.

The available user rights can be available for selection in TIA Portal as follows:

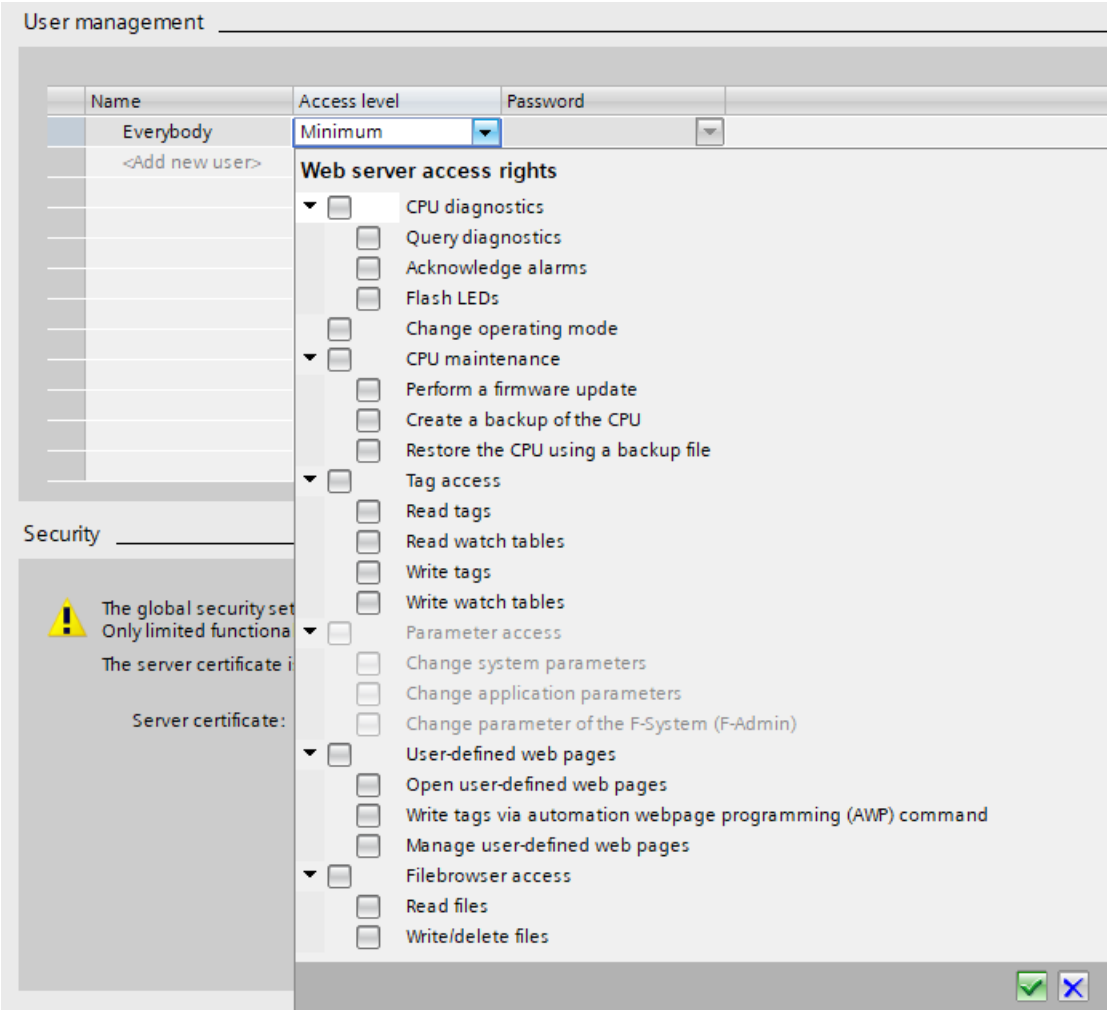

Figure 3-71 Assignment of user rights in TIA Portal for CPUs with configured firmware version ≤ V3.0

Local user management for CPUs with configured firmware version ≥ V3.1

As of TIA Portal version V19 and CPU firmware version V3.1, S7-1500 CPUs feature improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC). Software Controller as of version V30.1 also have this function. You manage all project users along with their rights (for example, access rights) for all CPUs in the project in the editor for users and roles of the project in the TIA Portal:

- Navigate to the "Security Settings > Users and roles" area in the project tree to manage users with their rights, for example, to control access rights.

The TIA Portal saves the assignment of the function rights of a CPU to user-defined roles and the assignment of these roles to users for each CPU. There are no system-defined roles with predefined function rights for CPUs. After loading the configuration, the user management

becomes effective in the respective CPUs. After loading, every CPU "knows" who may access which service and execute specific functions.

The following settings can be made for a local project user:

- User name: Name of the local project user which must be used to log on to the project.
- Password: The password assigned by the administrator with which the project user can log on to the CPU. The project user can change the password later.
- Authentication method: For CPUs only possible via the password.
- Runtime timeout: Time span of inactivity after which a user is logged out from a device. You can use this timeout for your own web applications to have the application exit after a user-defined period of inactivity.
- Comment: Comment on the respective project user.
- Use the check box to the left of the user name to specify whether or not the project user should be downloaded to the CPU.

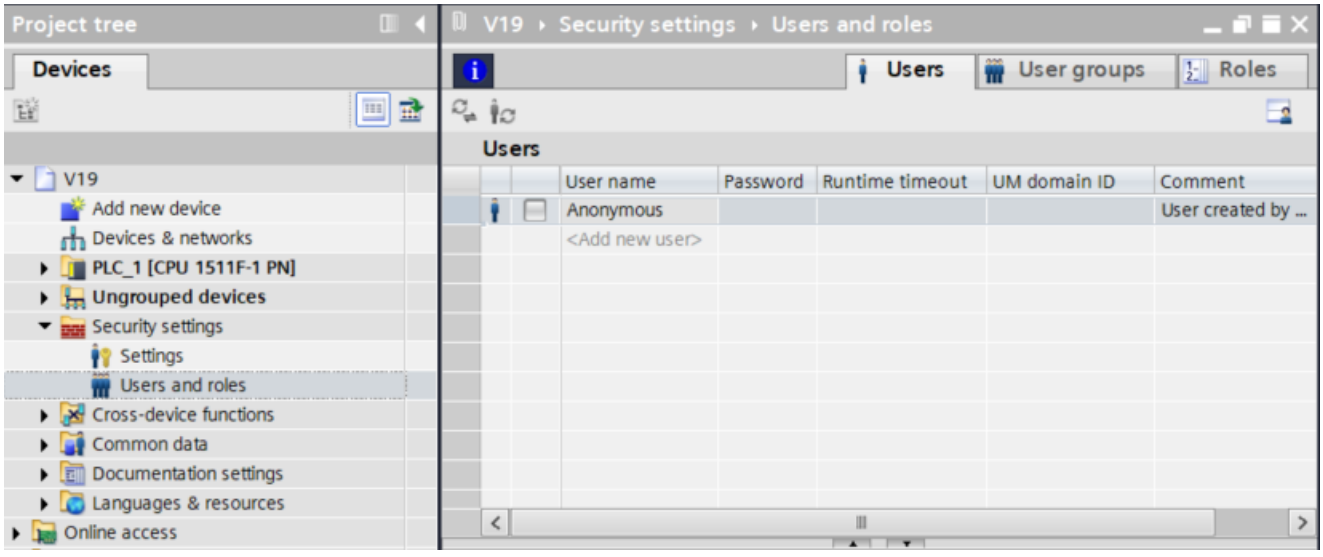

Figure 3-72 User management: Users and roles

You assign the roles and rights to the user.

Requirement:

CPU parameter assignment: To be able to set up users, roles and function rights for a CPU, the "Enable access control" option in the "Protection & Security > Access control" tab must be selected (which is the default).

Procedure:

In the following example, you assign the "admin" role to the user "User_1" with all rights for the Web server:

1. Create a new local user in the "User" tab, in the example "User_1", and assign a password.

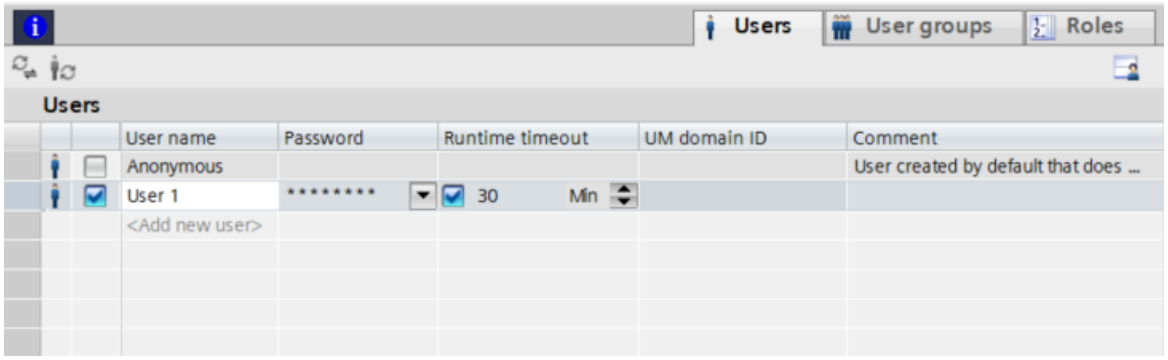

Figure 3-73 User management: Creating a local user

2. Define one or more roles in the "Roles" tab, the role "admin" in the example.

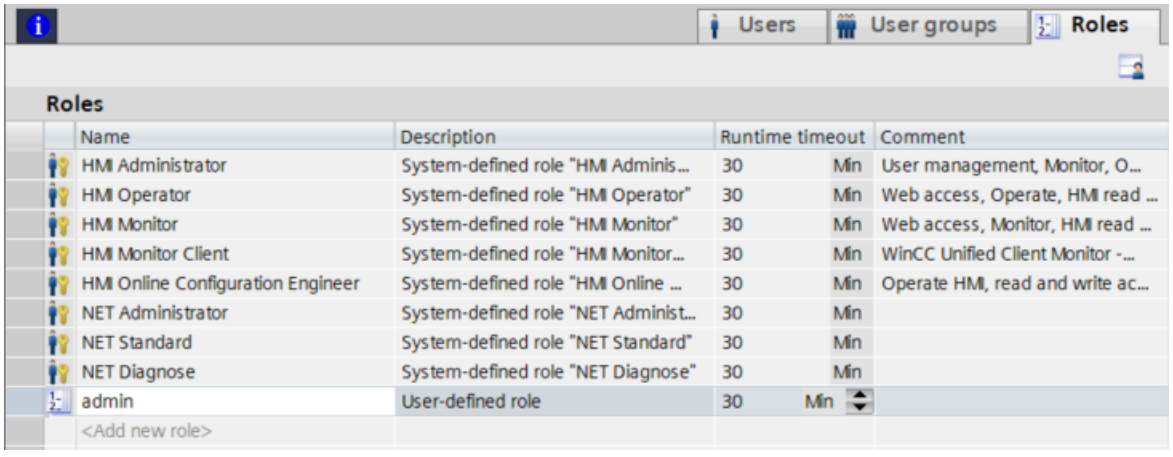

Figure 3-74 User management: Defining a role

3. Assign function rights for the Web server to the "admin" role. To do this, switch to the "Runtime rights" tab and select all function rights for the Web server for the example.

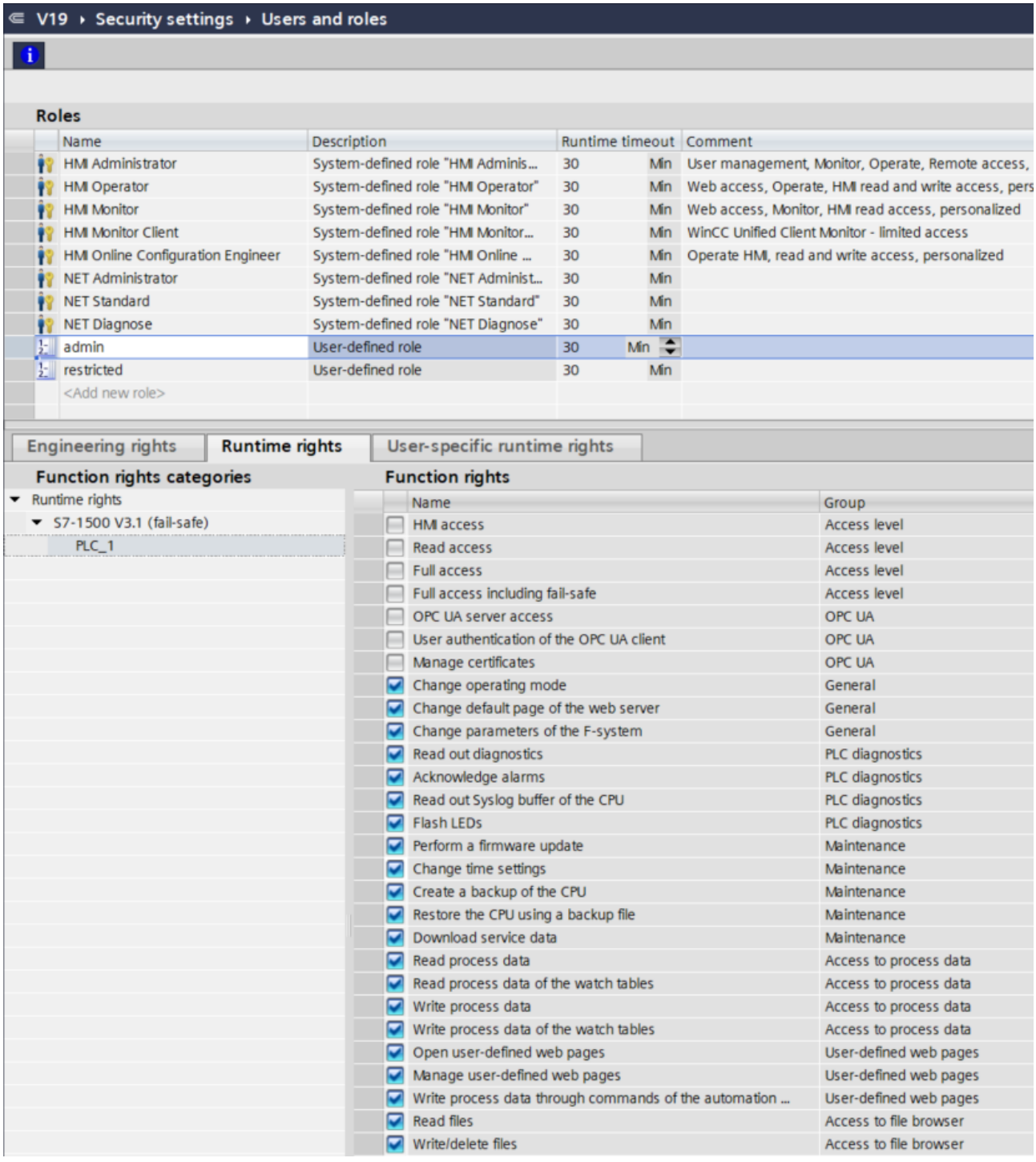

Figure 3-75 User management: Assigning rights to a role

4. Assign one or more roles to the user "User_1" in the tab "Assigned roles". In the example, you assign the "admin" role to the user "User_1". The roles and rights assigned to a user can be found in the corresponding tabs.

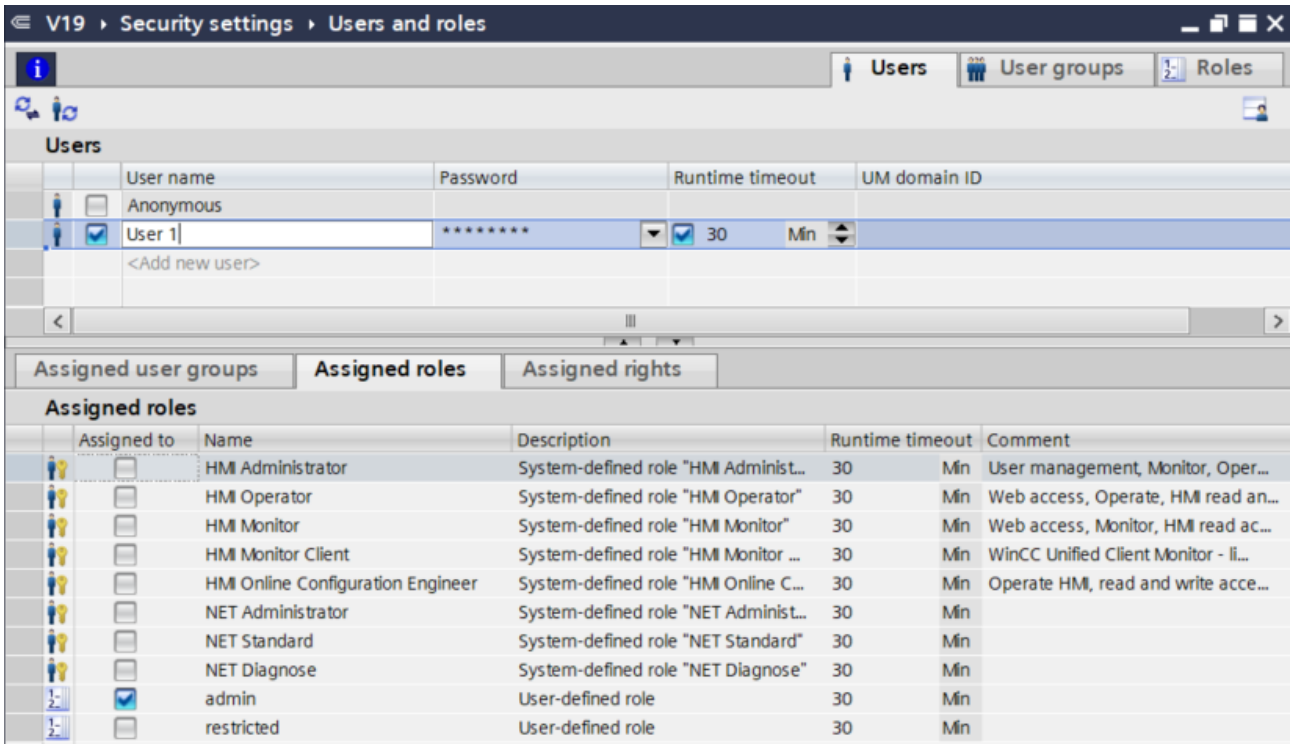

Figure 3-76 User management: Assigned role

5. Download the configuration to the CPU.

You can find more information on roles and rights in the online help for TIA Portal, keyword "Basics on user management in TIA Portal".

Deactivating the user management

For CPUs with configured firmware version ≥ V3.1, you can disable access control in the hardware configuration in the CPU properties under "Protection & Security" > "Access control".

There is no user management in the project with deactivated access control. Users who are defined under "Users and roles" are not considered and authentication is not possible. The CPU itself creates an "Anonymous" user that has full access rights to the functions of the Web server and the CPU.

User name "Everybody"/"Anonymous"

As a non-logged-in user, you always access web pages as "Everybody" or "Anonymous" by default. It does not matter in this case whether you have configured additional users. The user name depends on the configured firmware version of the CPU:

- For CPUs with configured firmware version ≤ V3.0: Static user management with the user "Everybody"
- For CPUs with configured firmware version ≥ V3.1: Local user management with the user "Anonymous"

The user "Everybody" or "Anonymous" has minimum access authorizations. These are read-only access to the intro page and start page. The user "Everybody"/"Anonymous" is defined without assigning a password, but you can assign all access authorizations available in TIA Portal to it.

Number of users:

- Static user management: Minimum 1 "Everybody" user and maximum 20 users can be created
- Local user management: Minimum 1 "Anonymous" user and maximum 100 users can be created

If the "Anonymous" user has not been activated under "Users and roles", an anonymous user without authorizations is available automatically on the CPU.

Because the user "Everybody"/"Anonymous" is defined in TIA Portal without assignment of a password, be careful of the access authorizations that you assign to this user.
Certain authorizations, such as the possibility of changing the operating mode, could represent a security risk.
For the assignment of security-relevant authorizations, we recommend that you create a user with password protection in TIA Portal.

WARNING

For an F-CPU, do **not** assign the access authorization "Perform changes as F-Admin" to the user "Everybody"/"Anonymous".

Make sure that you observe the warnings relating to this in the section "Restoring a backup of the safety program to an S7-300/1500 F-CPU" in the manual SIMATIC Safety - Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126).

Passwords should always be more than 8 characters in length and contain uppercase and lowercase characters as well as special characters and numbers (?!+%$1234...). Computer keyboard character strings and words from the dictionary are unsuitable. Change the password regularly.

You can read the password policies of the CPU as of firmware version V3.1 with the Api.GetPasswordPolicy method. In the TIA Portal you can read the policies and change these in the project tree via "Security settings" > "Settings" > "Password policies". You can find more information in the online help for the TIA Portal.

NOTE

When assigning rights, note that read and write access to tags of the "Watch tables (Page 98)" and "Tag status (Page 95)" web pages is retained, even if you have deactivated the attribute "Accessible from HMI/OPC UA/Web API" in the PLC tag table when configuring the data block in STEP 7.

3.6 Updating and saving information

Updating the screen content

Automatic updating is activated in the default setting. The preset update time is 10 s.

You update the web pages manually via the function key <F5>.

Disabling automatic updating for an individual web page

Click Off to temporarily deactivate automatic updating for a web page.
Note that the deactivation affects only the currently visited web page. Automatic updating is activated again when you change to a different web page.

You reactivate automatic updating by clicking On.

NOTE

If the load on the CPU is very high during operation, for example, due to a large number of PROFINET interrupts or extensive communication jobs, the updating of web pages may be significantly delayed for the duration of this high CPU load.

Printing web pages

The Web server offers you a print preview on most web pages. Click the symbol to open it.

Created printouts always contain the current information in the CPU. This means that it is possible that the information in the print preview is more up-to-date than the information in the standard view.

Web pages

4

4.1 Start page with general CPU information

Connecting to the Web server

Establish a connection to the Web server by entering the IP address of the interface of the configured CPU which is connected to the client in the address bar of the web browser, for example, https://192.168.3.141. The connection is set up and the "Intro" page opens.

NOTE

Web pages for R/H-CPUs

Note that the web pages are not available for R/H-CPUs. If you enter the IP address in the address bar of the browser, the error message "404 NOT FOUND" appears.

The examples in the next section provide information about the different web pages.

Intro

The figure below shows the first page (Intro) called by the Web server.

Figure 3-77 Introduction page of the Web server of the CPU 1516-3 PN/DP

Click the NEXT link to go to the Web server pages.

NOTE

Select the "Skip Intro" check box in order to skip the intro. The Web server will then take you directly to its start page in future. This setting is saved in the user profile of the current PC user.

You can undo the setting "Skip Intro" by clicking the "Intro" link in the left-hand navigation bar of a web page.

Setting the user interface language

You can change the language for the Web server interface, e.g., from English to German, in the upper right corner. This option is available to you on all web pages of the Web server.

Switching the time display

You can set the format of the time display to Coordinated Universal Time (UTC) or PLC local time (default setting) on the left next to the language setting.

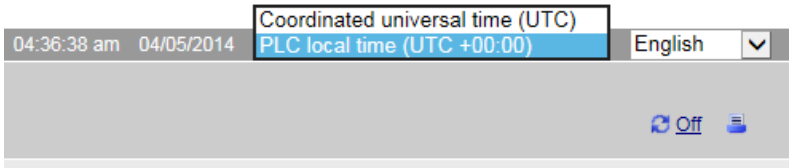

Figure 3-78 Switching the time display

You can switch the time display on all the Web pages that provide this drop-down list.

The displayed PLC local time comes from the time zone set in the CPU properties without consideration of the daylight saving / standard time setting.

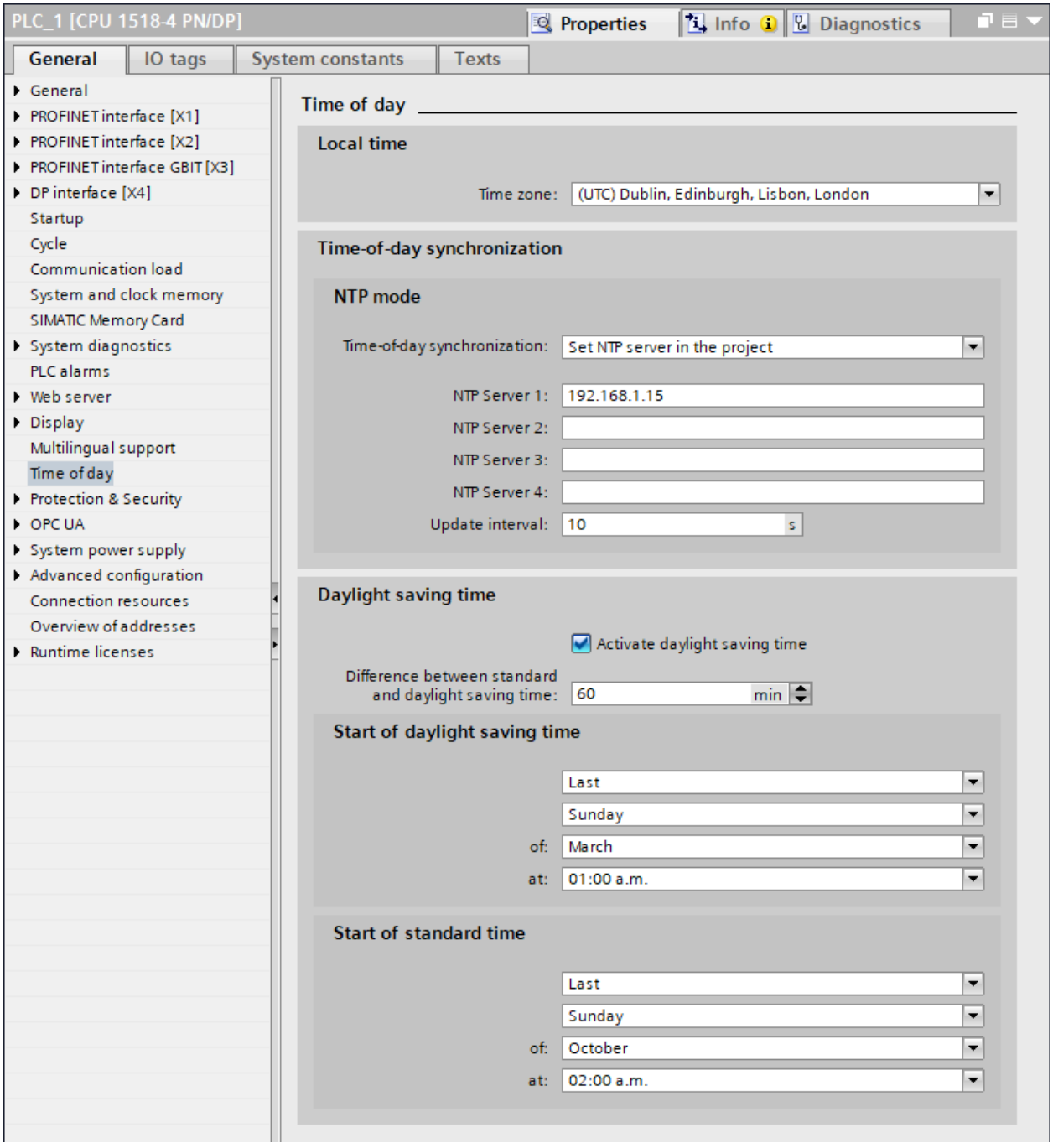

Figure 3-79 Setting the time in the CPU properties

The switchover has an effect on the following Web pages:

Table 3-43 Switching the time display: Display on Web pages

Web pages	Display as Coordinated Universal Time (UTC) or as PLC local time
Start page	Last F-change
Diagnostics buffer	Date and time of the diagnostic buffer entry
Alarms	Date and time of the alarms
Online backup	Backup file with date and time of the backup
DataLogs	Date of change and time of change
File browser	Date of change and time of change
User files	Date of change and time of change
Save service data	File with time stamp of the storage

Start page

The start page before login offers information as shown in the figure below. The image of the CPU with LEDs shows its current status at the time of the data request.

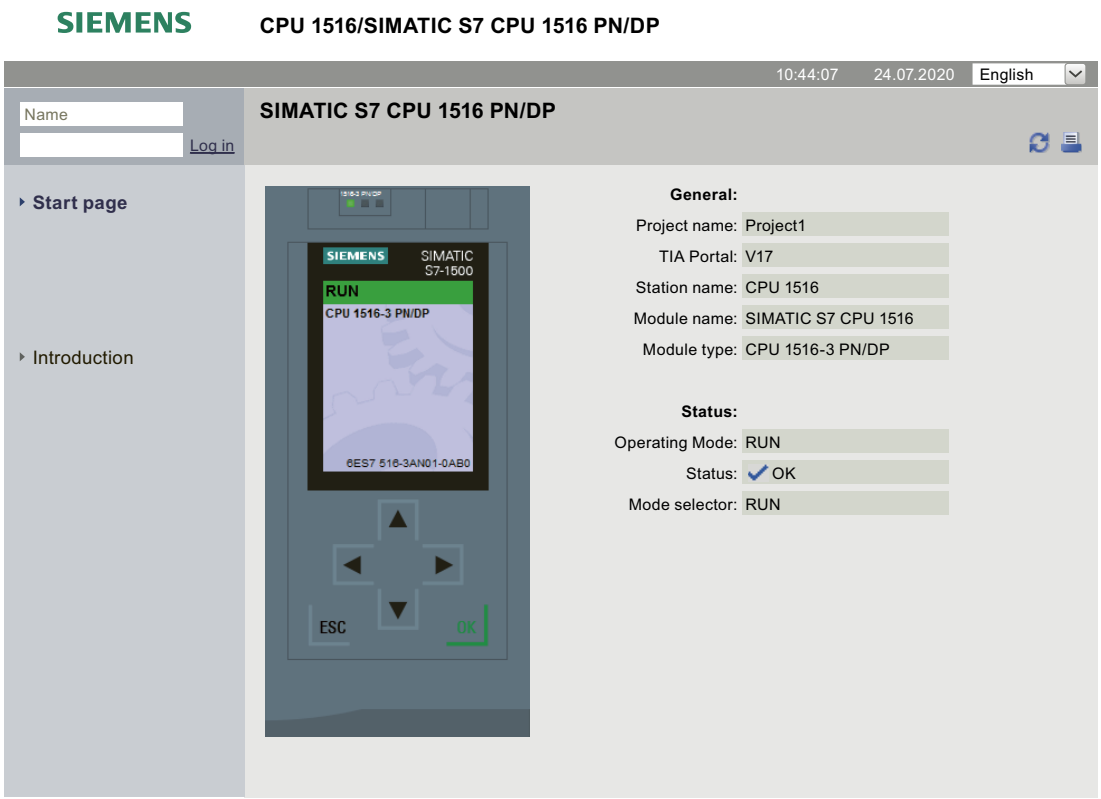

Figure 3-80 General information before login

Log in

To use the full functionality of the web pages, you must be logged in. Log in with a user name and password specified in the Web configuration in STEP 7. You now have corresponding permissions to access the web pages released for this user. If you have not configured a user, read-only access is granted to intro and start pages by default.

NOTE

After carrying out your required actions, log out explicitly from the Web server by clicking "Logout" in order to minimize the risk of unauthorized external access.

NOTE

Session timeout

The timeout for each started session is 30 minutes. After each update/automatic update, the session is automatically extended by another 30 minutes.

Figure 3-81 Start page after login

① "General"

"General" contains information about the CPU whose Web server you are currently connected to, as well as the project name and the version of the TIA Portal with which the CPU was configured. The displayed TIA Portal version is at least required to load or edit the entire project.

② "Status"

"Status" contains information about the CPU status at the time of the query.

③ "CPU operator panel"

In the area "CPU operator panel" you have the possibility to change the operating mode of the CPU ("RUN"/"STOP" buttons) or to have the LEDs blink ("LED blink" button) with corresponding access rights.

Additional information for F-CPUs

Figure 3-82 Start page after login to an F-CPU

④ "Fail-safe"

"Fail-safe" contains additional information on the F-CPU. Further information about the specification is available in the Programming and Operating Manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/de/de/view/54110126/en?dl=en).

Reference

You can find additional information in the section Configuring the Web server (Page 24).

4.2 Diagnostics

Overview

The "Diagnostics" web page provides more information about the tabs:

- Identification
- Program protection
- Memory
- Runtime information
- Fail-safe (with an F CPU)

"Identification" tab

The CPU characteristics are available in the "Identification" tab.

Figure 3-83 "Identification" tab

"Identification"

The "Identification" info box contains the plant and location designation and the serial number. Plant and location designations can be configured in STEP 7 in the properties dialog of the CPU in the "General" tab.

"Order number"

The "Order number" info box contains the order number for the hardware.

"Version"

You can find the information on hardware version, firmware version on the CPU and bootloader version in the "Version" info box.

"Drive Controller Info"

If you are using a SIMATIC drive controller, you will find information about the hardware update version of the drive controller, the firmware version of SINAMICS Integrated, and a link to the readable information of SINAMICS Integrated.

You can find more information in the SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766665) System Manual.

"Motion control package information"

Display of the name and version of the Motion Control technology package used (Technology Package Standard Motion Control or Technology Package Motion Control KinPlus).

For more information, refer to the SIMATIC S7-1500 S7-1500T Kinematics Functions (https://support.industry.siemens.com/cs/ww/en/view/109781850) manual.

"Program protection" tab

The "Program protection" tab provides information on whether the PLC program contains know-how protection or copy protection.

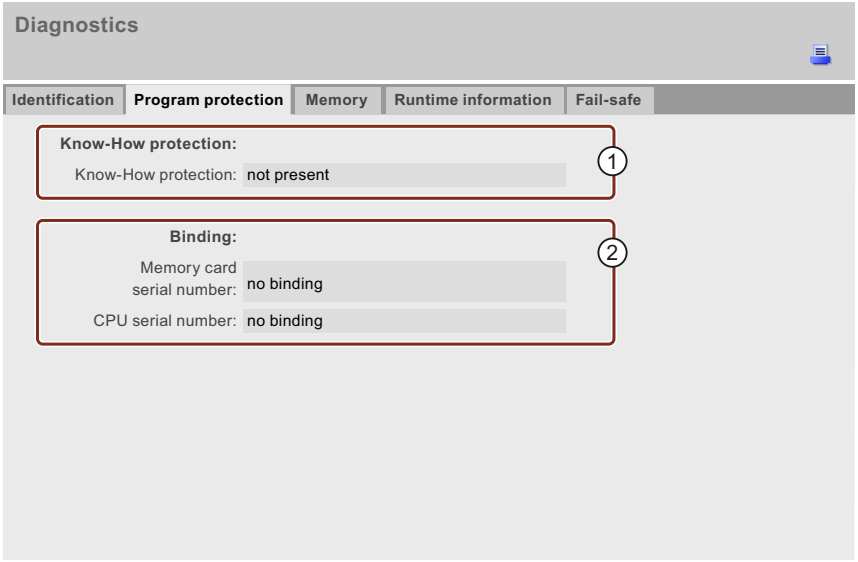

Figure 3-84 "Program protection" tab

① "Know-how protection"

Information on whether the PLC program contains at least one block with know-how protection or not can be found in the info field "Know-how protection".

②"Binding"

In the info field "Binding" you can find information on whether copy protection has been activated by binding at least one program block of the PLC program to the serial number of the CPU or memory card.

- "Binding"
- "No binding"
- "Binding mismatch": At least one block is bound to a different serial number (load process is rejected)

"Memory" tab

The "Memory" tab contains current values on the memory currently in use.

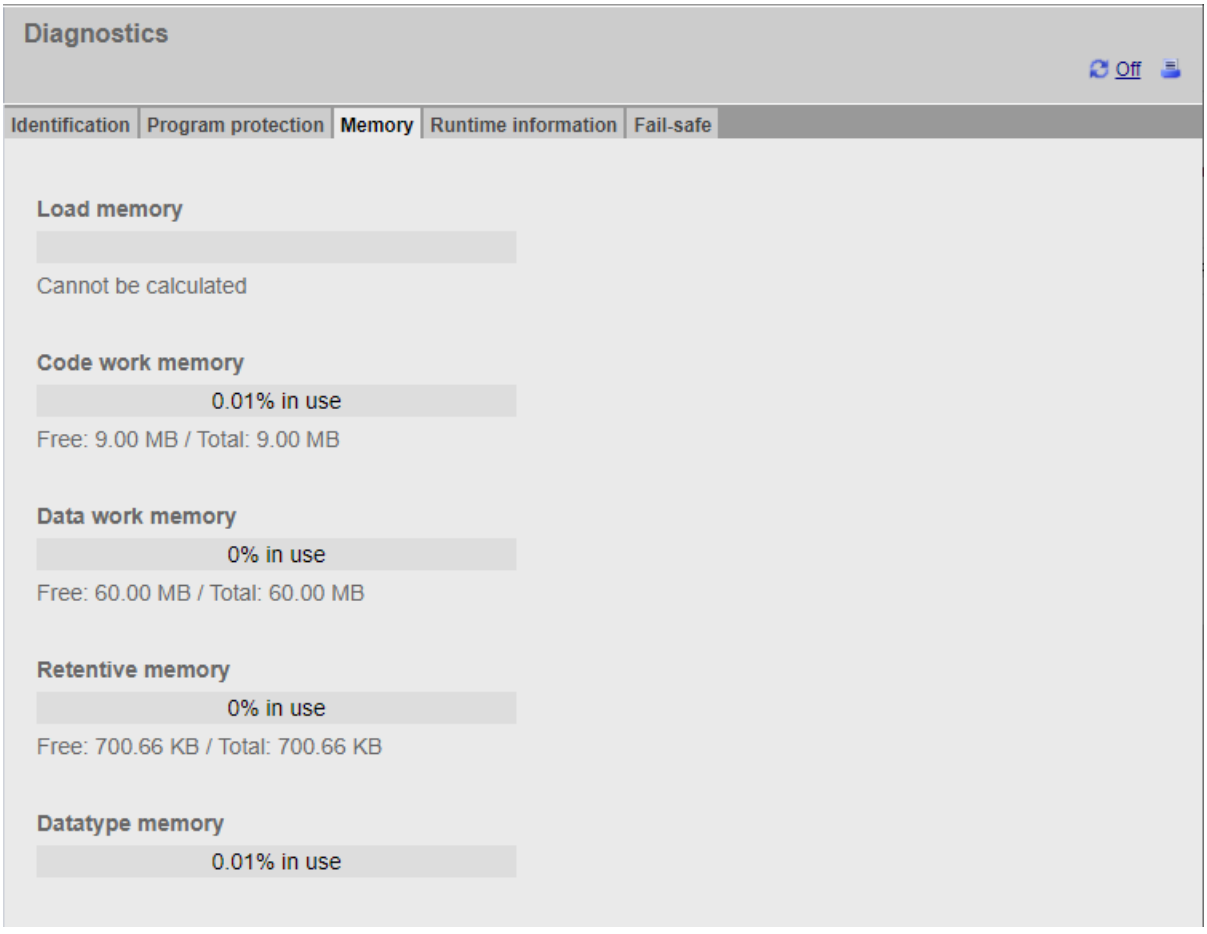

Figure 3-85 "Memory" tab

"Runtime information" tab

Current information on program/communication load and cycle time can be found in the "Runtime information" tab. This enables you to see whether there may be runtime problems during execution of your user program.

Figure 3-86 "Runtime information" tab

Program-/Communication load

With the "Value refresh" function, you update the data displayed in the bar charts:

- At intervals of 1 second
- Automatic (as configured in STEP 7)

With the "Measurement" function, you can decide which measurement the bar charts display. You can choose between:

- The current measurement
- The measurement of the longest cycle time

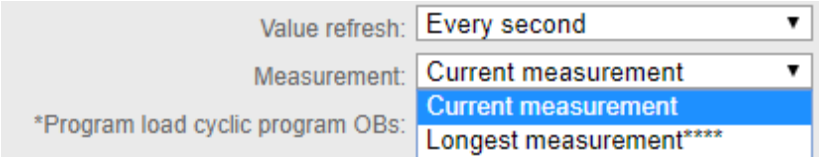

Figure 3-87 Program-/Communication load

The legend of the program-/communication load shows information on the following values, highlighted in color:

- "Program load cyclic program OBs"

  required computing time in percent within a cycle for cyclic program OBs
- "Program load high-priority OBs"

  Required calculation time in percent within a cycle for higher-priority OBs (priority ≥ 15)
- "Current communications load"

  Required calculation time in percent for current communications tasks within a cycle
- "Maximum permissible communication load"

  The configured maximum communication load as a percentage
- "No-load operation"

  There is no program-/communication load

NOTE

When you have configured a minimum cycle time, it can happen that no-load operation displays a high percentage value, although the value of the cycle time is also high.

The reason for this is that the loads are recorded as mathematical average of the last second, but the cycle time relates to the last cycle.

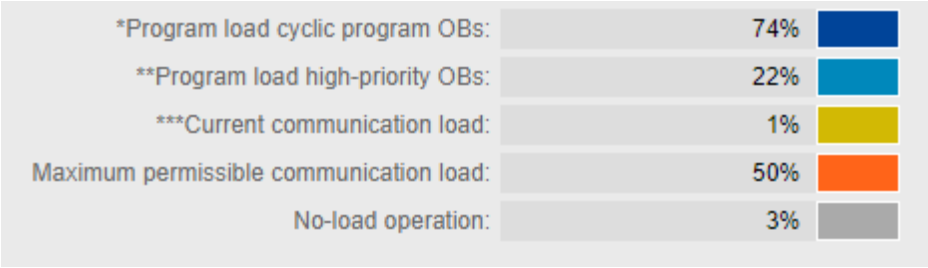

Figure 3-88 Color legend

If you click on a specific color, the selected color is highlighted in the chart. If you click on a highlighted color, you remove the highlighting.

Measurement of load distribution and cycle time

The "Measurement of load distribution and cycle time" bar chart shows the percentage of the calculation time within a cycle for the following values:

- "Program load cyclic program OBs"
- "Program load high-priority OBs"
- "Current communications load"
- "No-load operation"

Prognosis of load distribution and cycle time

The "Prognosis of load distribution and cycle time" bar chart predicts whether the CPU can process the user program with maximum communication load within the maximum cycle time.

Example 1:

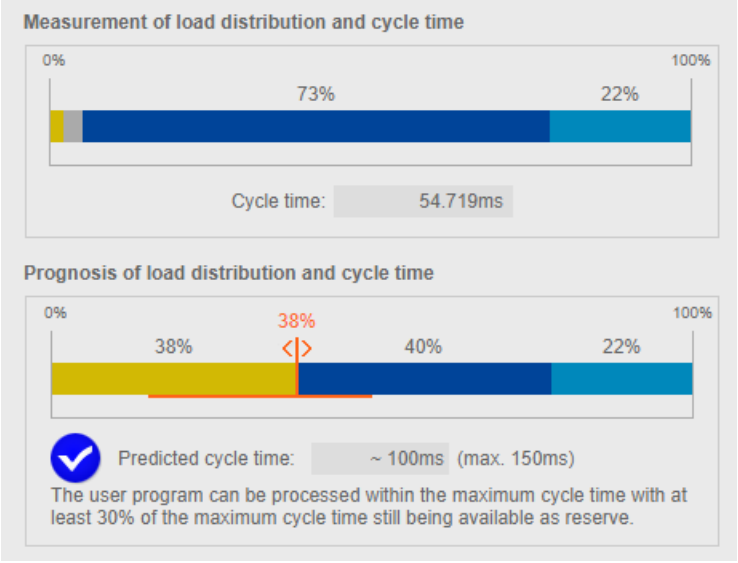

Figure 3-89 Cycle time < 70% of the maximum cycle time

Example 1 shows that the CPU can process the user program within the maximum cycle time of 150 ms when the maximum communication load of 38% is reached. The predicted cycle time is < 70% of the configured maximum cycle time.

Example 2:

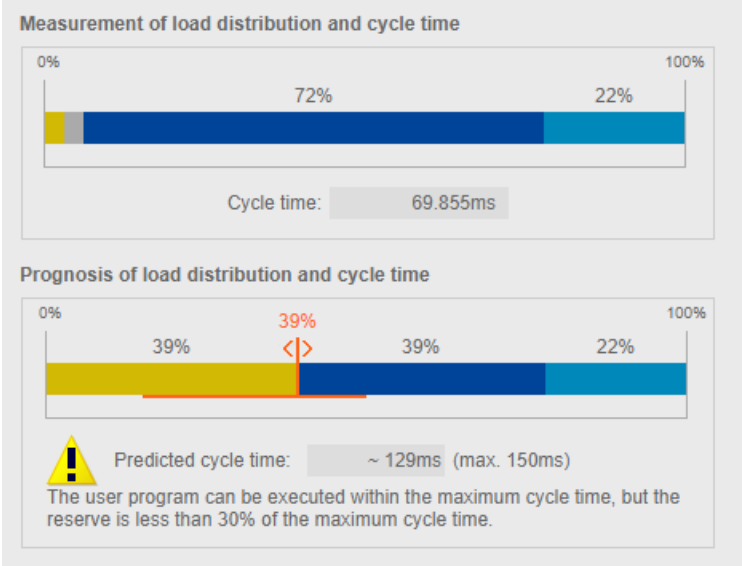

Figure 3-90 Cycle time ≥ 70% of the maximum cycle time

In example 2, the CPU can also process the user program with maximum communication load within the maximum cycle time. However, the predicted cycle time is already at 129 ms. As soon as the predicted cycle time is ≥ 70% of the maximum cycle time, the chart outputs a warning.

Example 3:

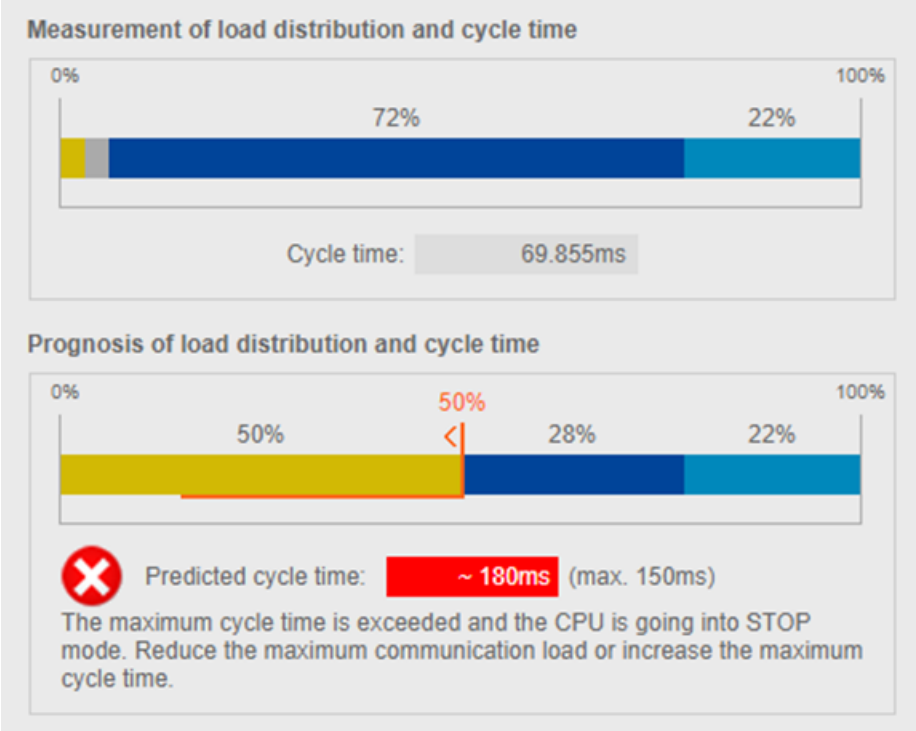

Figure 3-91 Cycle time longer than maximum cycle time

Example 3 shows that the CPU can no longer process the user program within the maximum cycle time when the maximum communication load is reached. If the predicted cycle time is longer than the maximum cycle time, the chart outputs an error message.

If it is predicted that the maximum cycle time will be exceeded, use the following controller in order to reduce the maximum communication load.

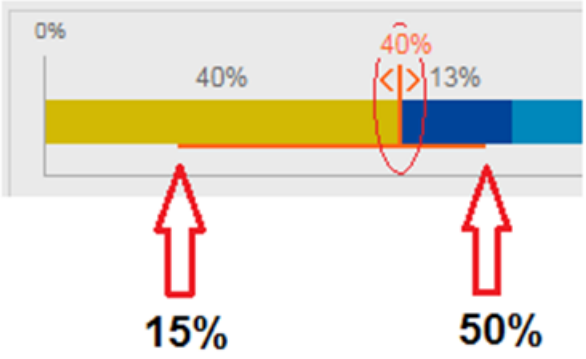

Figure 3-92 Controller for setting the maximum communication load

NOTE

Setting the communication load

The controller predicts the effects of the changed communication load on the cycle time. You configure the maximum communication load in STEP 7.

NOTE

For non-measurable fluctuations in the user program, e.g. for future changes in the user program, plan a sufficiently low value for the maximum communication load.

NOTE

Due to the different acquisition bases of cycle time and load, a settled system state is required to display reliable measured values.

You can find more information about the influence of the communication load on the cycle time in the Cycle and Response Times Function Manual (https://support.industry.siemens.com/cs/us/en/view/59193558).

Trend for program/communication load

If your web browser supports the display of SVG (Scalable Vector Graphics), the display in the "Runtime information" tab is expanded to show the trend for program/communication load.

With the line charts in the "Trend for program/communication load" area, you can track the progression of the following values:

- "Program load of the cyclic program OBs"
- "Program load high-priority OBs"
- "Current communications load"

With the "Number of recorded measuring points" option, you can choose between the last 20 to 1 000 measured values for the display of the measured values.

For the trend on the x-axis, you can choose between "Time" (CPU time) and "Samples" by clicking on the desired unit.

NOTE

If you have selected the "Time" unit on the x-axis, all measured values that are more than 24 hours old are deleted automatically.

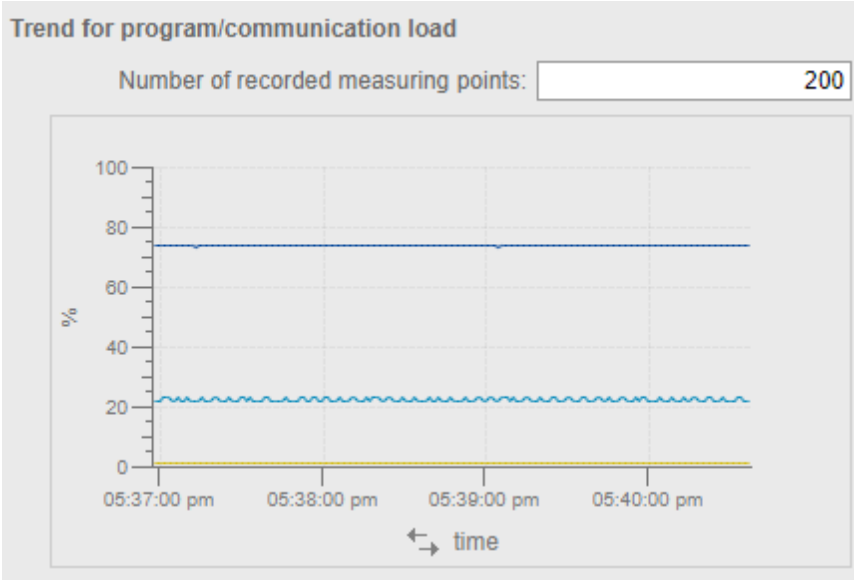

Figure 3-93 Line chart

"Fail-safe" tab (with an F-CPU)

The safety program of an F-CPU consists of one or two F-runtime groups. You can find their F-runtime group signature, cycle times (F-monitoring time) and runtimes in the "Fail-safe" tab.

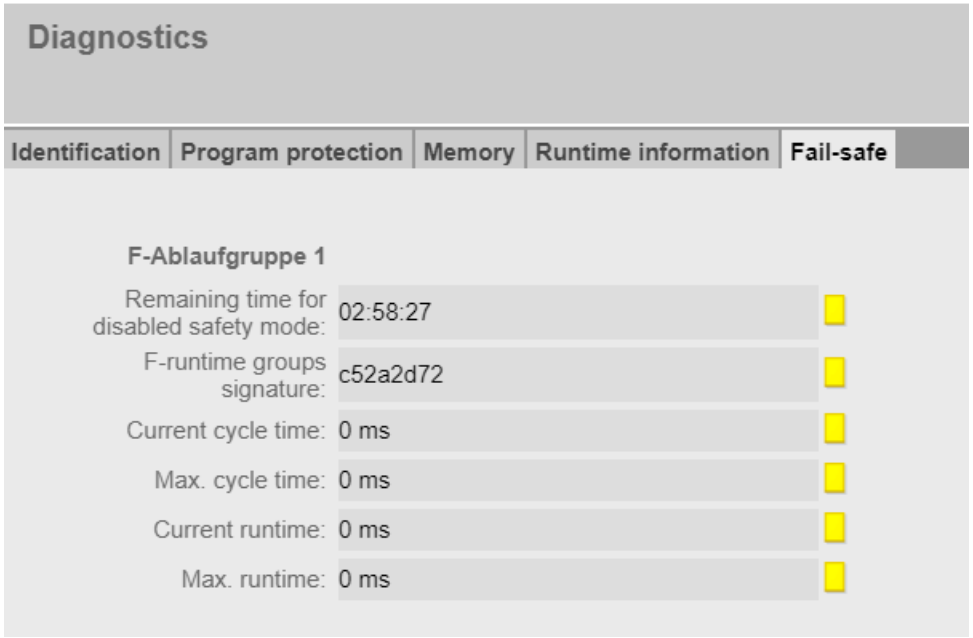

Figure 3-94 "Fail-safe" tab

4.3 Diagnostics buffer

Requirements

The web server is activated, languages are set, the text libraries are loaded and the project has been compiled and downloaded with STEP 7.

Diagnostics buffer

The content of the diagnostic buffer is displayed by the browser on the web page "Diagnostics buffer".

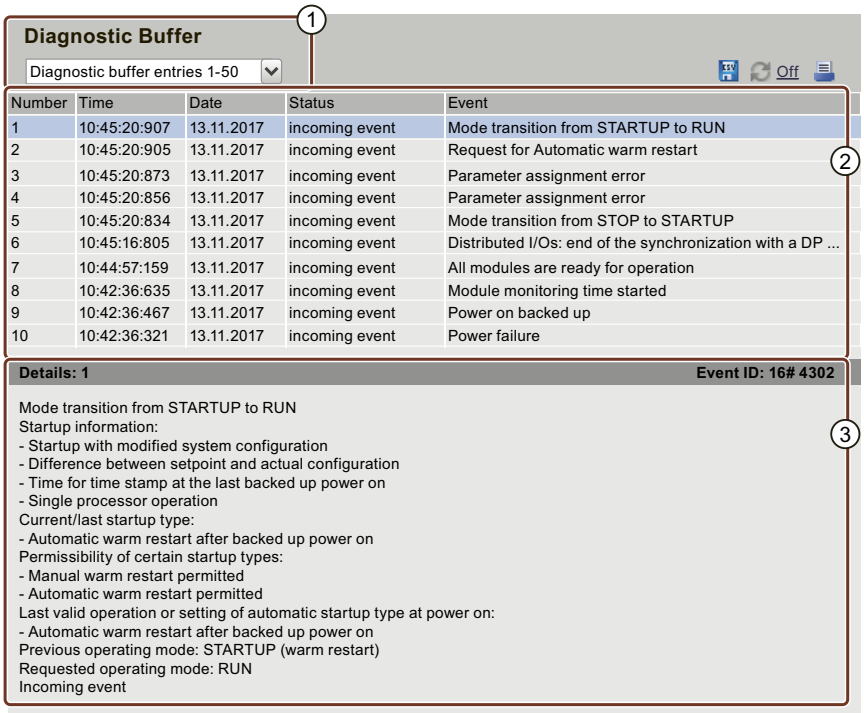

Number	Time	Date	Status	Event
1	10:45:20:907	13.11.2017	incoming event	Mode transition from STARTUP to RUN
2	10:45:20:905	13.11.2017	incoming event	Request for Automatic warm restart
3	10:45:20:873	13.11.2017	incoming event	Parameter assignment error
4	10:45:20:856	13.11.2017	incoming event	Parameter assignment error
5	10:45:20:834	13.11.2017	incoming event	Mode transition from STOP to STARTUP
6	10:45:16:805	13.11.2017	incoming event	Distributed I/Os: end of the synchronization with a DP ...
7	10:44:57:159	13.11.2017	incoming event	All modules are ready for operation
8	10:42:36:635	13.11.2017	incoming event	Module monitoring time started
9	10:42:36:467	13.11.2017	incoming event	Power on backed up
10	10:42:36:321	13.11.2017	incoming event	Power failure

Figure 3-95 Diagnostics buffer

① "Diagnostics buffer entries 1-50"

The diagnostics buffer can accommodate different numbers of alarms depending on the CPU used.
For information on the maximum number of diagnostics buffer entries, refer to the technical specifications of the CPU used.

Select an interval for the entries from the drop-down list. Each interval comprises 50 entries.

② "Event"

The "Event" info box contains the diagnostics interrupts with date and time.

Note that the diagnostic events are displayed in the project language of the STEP 7 project that is assigned to the current web server interface language. You can find out how to assign project languages to interface languages in section Language settings (Page 35).

③ "Details"

This field outputs detailed information about a selected event. Select the corresponding event from the ② "Event" info field.

Saving diagnostics buffer entries

You can save diagnostics buffer entries to a csv file for further processing in a spreadsheet program or database program.
Save the data by clicking the icon.

A dialog opens in which you can specify the file name and target directory.

4.4 Motion Control diagnostics

Overview

On the "Motion Control Diagnostics" web page, you will find the status, error, and warning bits as well as the latest values for the configured technology objects (TO).

The Web server supports the following technology objects:

- Speed-controlled axis (TO_SpeedAxis)
- Positioning axis (TO_PositioningAxis)
- Synchronous axis (TO_SynchronousAxis)
- External encoder (TO_ExternalEncoder)
- Measuring input (TO_MeasuringInput)
- Output cam (TO_OutputCam)
- Cam track (TO_CamTrack)
- Cam disk (TO_Cam, TO_Cam_10k) (S7-1500T)
- Leading axis proxy (TO_LeadingAxisProxy) (S7-1500T)
- Kinematics (TO_Kinematics) (S7-1500T)
- Interpreter (TO_Interpreter) (S7-1500T)

The web page is subdivided into the tabs:

- Diagnostics
- Service overview

"Diagnostics" tab

In the "Diagnostics" view you will see:

- ① A list of the configured technology objects
- ② The status and error bits of a selected technology object
- ③ Specific diagnostic information for the technology objects

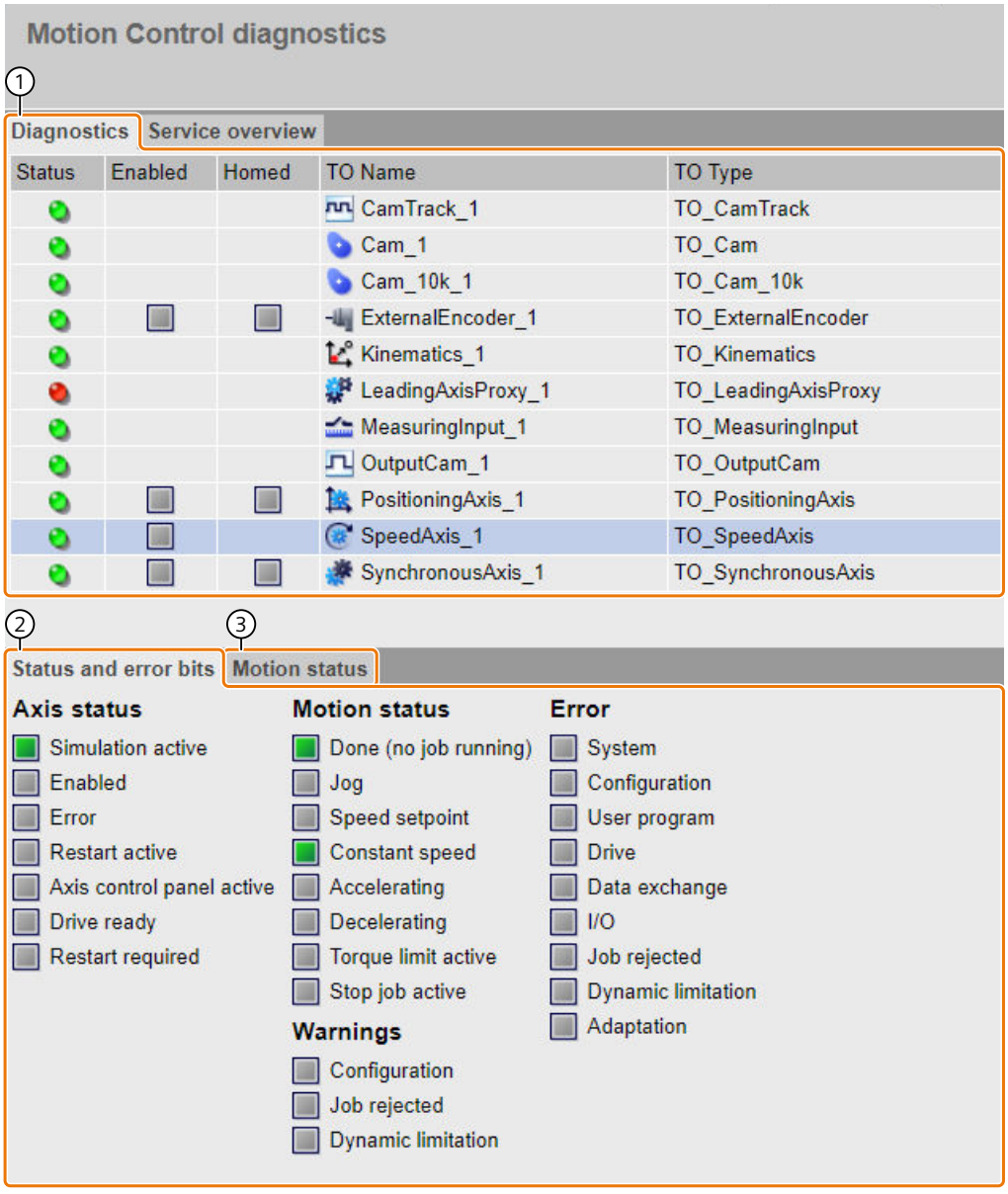

Figure 3-96 Diagnostics - Speed axis status and error bits

① List of the configured technology objects

Check the following diagnostic information in the list of technology objects:

- Status (green = no warning, no alarm; yellow = warning is pending; red = error is pending)
- Enabled
- Homed

Click on a technology object in the list to display the current status and error bits ② as well as specific diagnostic information ③ for this technology object.

② Status and error bits

The displayed status and error bits correspond to the diagnostics of the technology object in STEP 7.

③ **Specific diagnostic information for the technology objects**

Depending on the type of technology object, you will receive additional diagnostic information, for example, the status of a speed axis. The displayed diagnostic information corresponds to the diagnostics of the technology object in STEP 7.

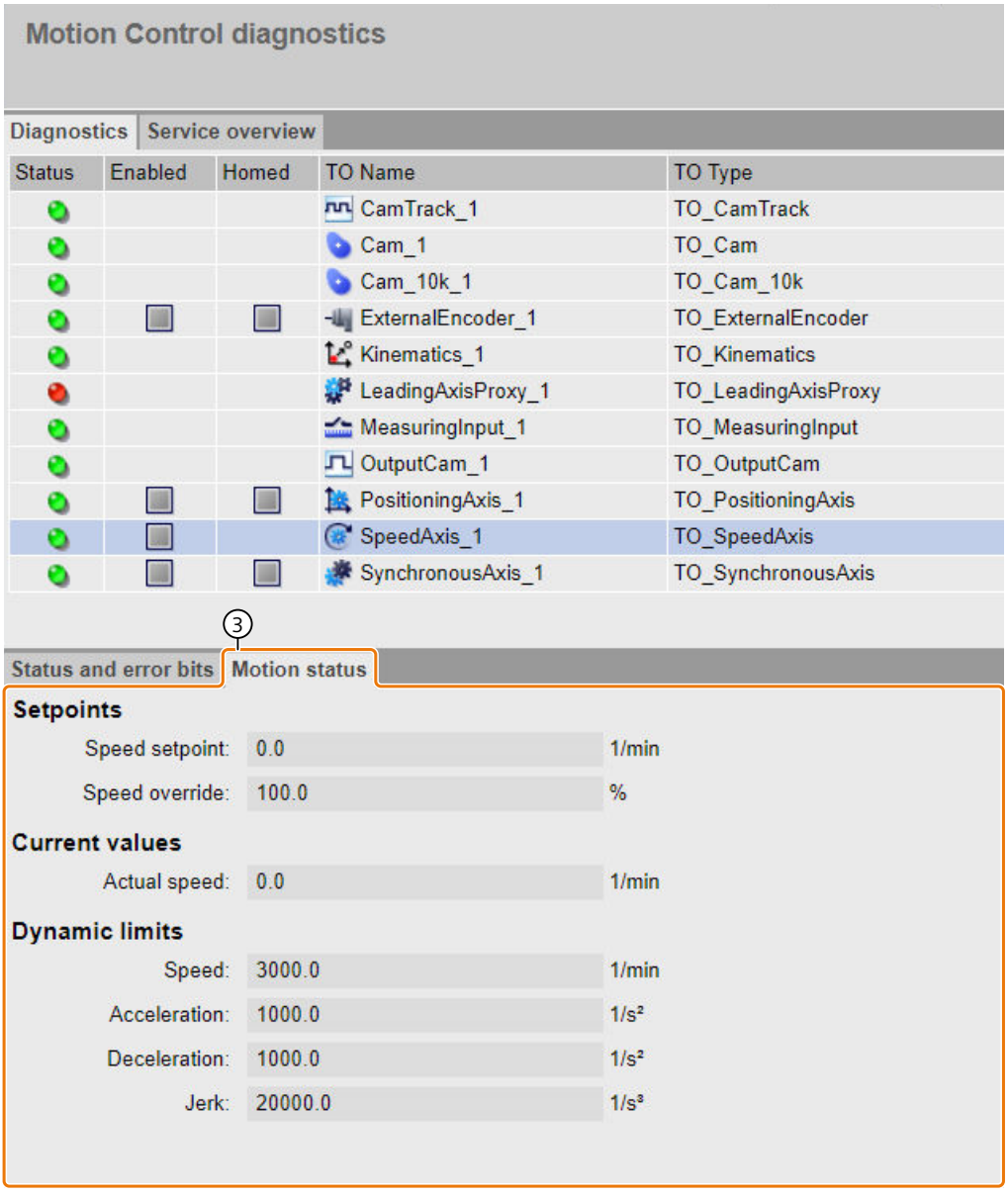

Figure 3-97 Diagnostics - Speed axis motion status

"Service overview" tab

In the "Service overview" tab, you observe selected signals of multiple technology objects at the same time, for example, the actual position of multiple axes.

The "Service overview" is subdivided into the areas:

- ① Select technology objects
- ② Signal table

① Select technology objects

In this area, you select which technology objects you want to observe in the signal table.

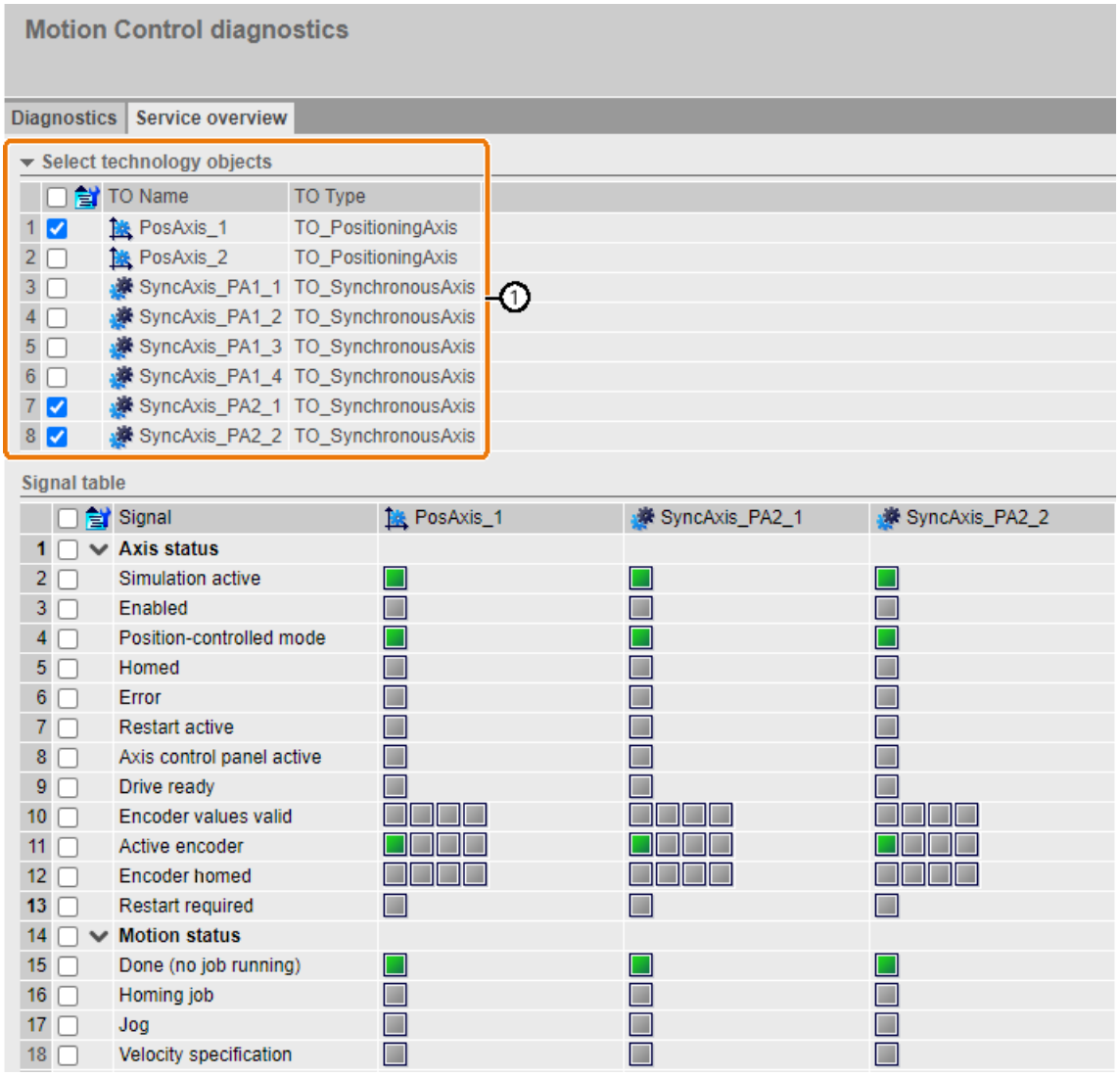

Figure 3-98 Service overview - Select technology objects

1. To sort the list of technology objects, click on the column header "TO Name" or "TO Type".
2. To observe a technology object in the signal table, select the check box in front of the technology object.

   A column is only displayed for the selected technology objects in the signal table. Signals that do not exist for the selected technology objects are hidden.
3. Click the icon.

   Only the selected technology objects are displayed in the "Select technology objects" area.
4. Click the icon again.

   All technology objects are displayed once again in the "Select technology objects" area.

② **Signal table**

In this area, you select which signals of the selected technology objects you want to observe. The signals are grouped.

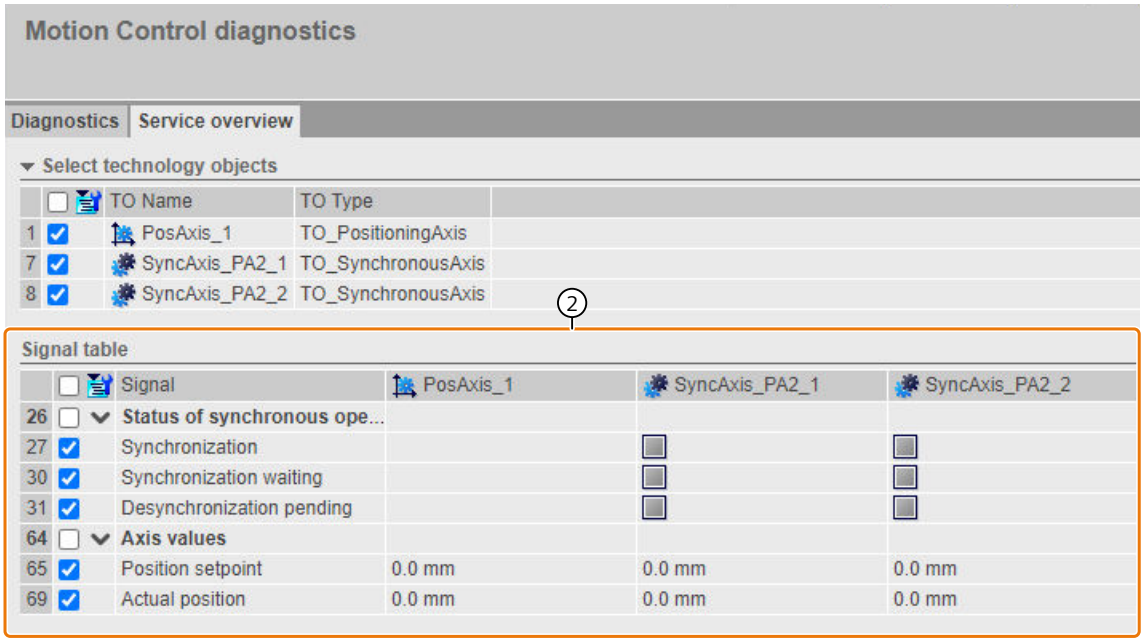

Figure 3-99 Service overview - Signal table

1. To expand or collapse a scaling group, click the arrow in front of the scaling group.
2. To only observe selected scaling groups or signals, select the check box in front of the scaling group or signal.
3. Click the icon.

   Only the selected signal groups or signals are displayed.
4. Click the icon again.

   All signal groups and signals are displayed.

Displaying and acknowledging technology alarms

On the "Alarms (Page 78)" web page you will find an overview of the pending technology alarms with error numbers.

You can acknowledge the pending technology alarms on the "Alarms" web page.

More information

You can find explanations for the diagnostics functions of the individual technology objects in the STEP 7 online help or the S7-1500/1500T Motion Control function manuals on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109751049).

4.5 Module information

Module information

The status of a device is indicated by means of symbols and comments on the "Module information" web page.

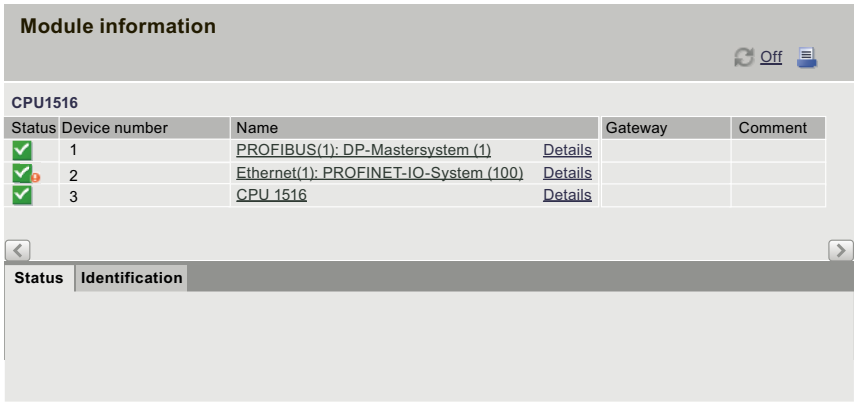

Figure 3-100 Module information

Meaning of the symbols in the "Status" column

Table 3-44 Meaning of symbols

Symbol	Symbol color	Meaning
	green	Component is OK
	gray	Deactivated PROFIBUS or PROFINET devices.

Symbol	Symbol color	Meaning
	gray	State cannot be determined • "State cannot be determined" is displayed during system diagnostics for all configured I/O modules and I/O systems after restart of the CPU. • However, this state can also be displayed temporarily during operation if a diagnostics interrupt burst occurs for all modules. • It is not possible to determine the status of modules on a subsystem that is connected to a CP.
	red	Component "not reachable" "Not reachable" is displayed when a module has been removed or a module has been configured but does not exist.
	black	No input or output data available. Input or output channels of the (sub)module are disabled.
	green	Maintenance required (Maintenance Required)
	yellow	Maintenance demanded (Maintenance Demanded)
	red	Error - component faulty or not available due to an incorrect type
	red	A module in a lower module level does not have the status "Component OK"

Navigation to further module levels

The status of individual components/modules/submodules is displayed when you navigate to the further module levels:

- To the next higher module level using the links in the display of the module levels
- To the next lower module level using the links in the "Name" column

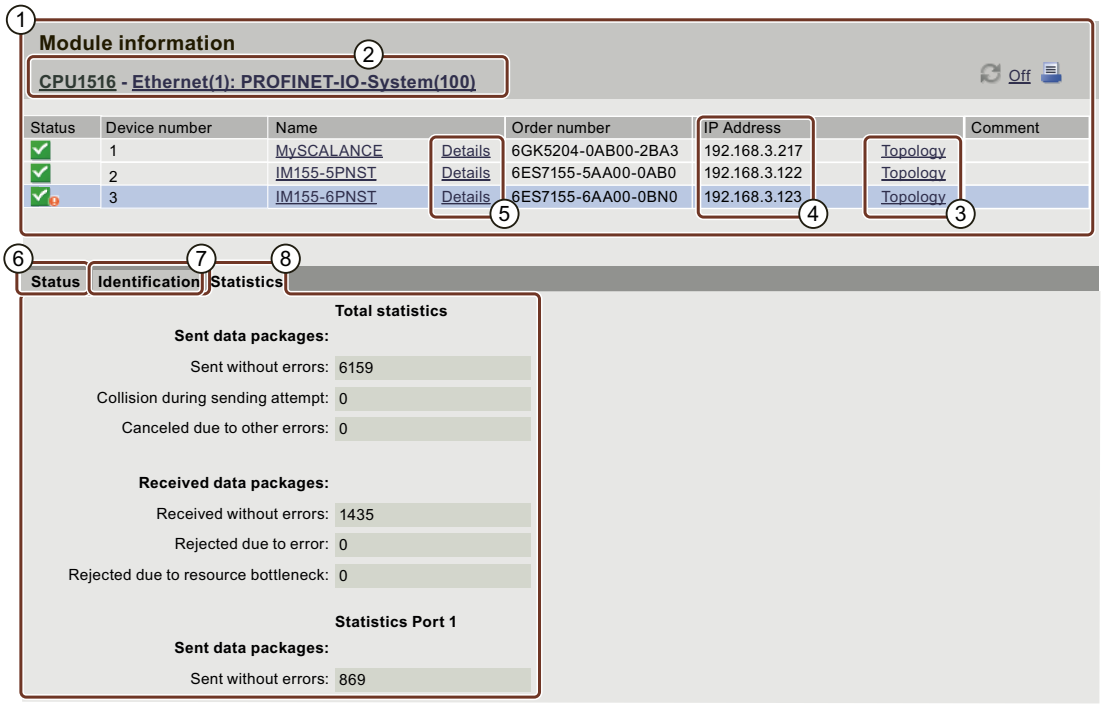

Figure 3-101 Navigation to further module levels

① "Module information"

Depending on the selected level, the table contains information on the rack, the DP master system, the PROFINET IO master system, the stations, the individual modules or the modules or submodules of the station.

② "Display of the module levels"

The links are used to access the "Module information" of the higher module levels.

③ "Topology"

The two web pages, "Topology" and "Module information", are linked. A click on "Topology" of the selected module automatically takes you to this module in the graphic view of the set topology on the "Topology" web page. The module is displayed in the visible area of the "Topology" web page. The device header of the selected module flashes for a few seconds.

④ "IP address"

If a link is available, you can use it to access the Web server of the configured device you selected.

⑤ "Details"

More information about the selected module is provided in the "Status" and "Identification" tabs via the "Details" link.

⑥ "Status" tab

The tab contains information about the status of the selected module when a fault or alarm exists.

⑦ "Identification" tab

The tab contains data on the identification of the selected module.

NOTE

This tab displays only the data configured offline of the module.

⑧ "Statistics" tab

The tab is only displayed for PROFINET IO devices and contains the following information on the communication statistics of the selected IO device:

- "Total statistics - Sent data packages"

  You can assess the data transmission on the transmit line based on the key data in this info box.
- "Total statistics - Received data packages"

  You can assess the data transmission on the receive line based on the key data in this info box.
- "Statistics port x - Sent data packages"

  You can assess the data transmission on the transmit line for each port based on the key data in this info box.

- "Statistics port x - Received data packages"

  You can assess the data transmission on the receive line for each port based on the key data in this info box.

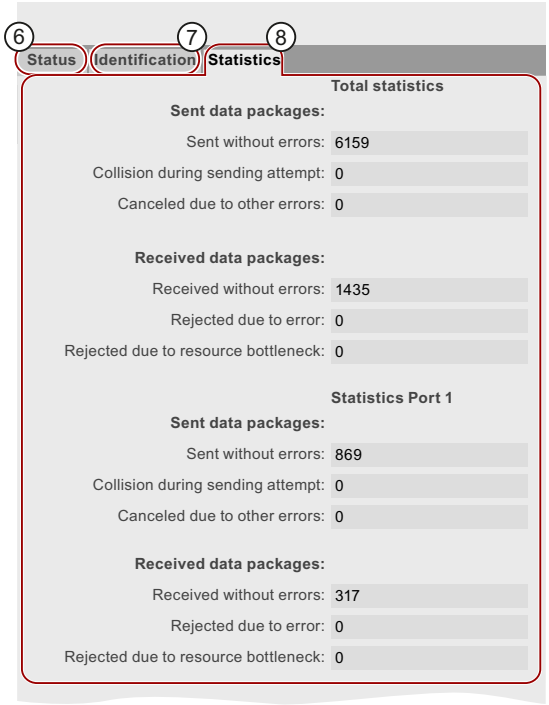

Figure 3-102 "Statistics" tab

Reference

You can find more information in the "Statistics" tab in the section Communication (Page 80).

"Safety" tab for fail-safe I/O

The tab is only displayed for fail-safe I/O and contains the following parameters:

- F-Par_CRC (with addresses)
- F-monitoring time
- F-source address
- F-destination address

Reference

You can find more information about the F-parameters in the Programming and Operating Manual SIMATIC Safety - Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126).

Example: Module information - module

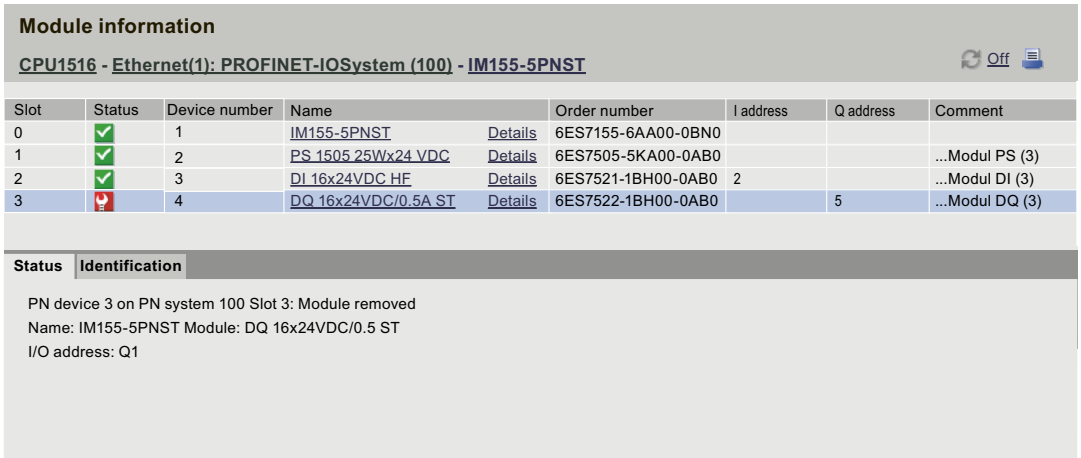

Figure 3-103 Example: Module information - module

NOTE

If you are using the function Configuration control (option handling) in the central configuration of your plant, the information text in the headings area of the web page informs you that the status of the I/O modules may be displayed inconsistently. No corresponding text is displayed for the distributed I/O.

Example: Module information - submodule

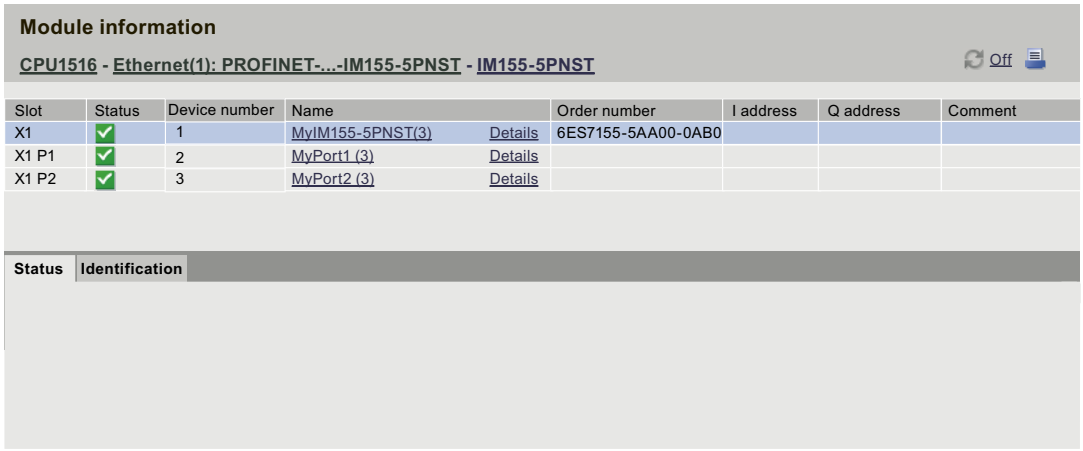

Figure 3-104 Example: Module information - submodule

Reference

You can find more information on the "Module information" in the STEP 7 online help, keyword: "Module information".

4.6 Firmware update

Introduction

You can update the firmware as a user with the corresponding access rights on the "Module information" web page at the module level. You can find information on user management in section Configuring the Web server (Page 24) under "Amending user management".
With the help of an update file, you can update the firmware of the CPU, the display of the CPU, or individual centralized and distributed modules. Note that all modules you want to update must be compatible with the TIA Portal as of V12.0.

NOTE

A firmware update is not possible if access is via a mobile terminal device with the "iOS" operating system.

Procedure

The following steps are required to perform a firmware update:

- Click on "Browse" in the Firmware Loader area.
- Select the file you would like to use for the firmware update. You can find the available firmware updates on the Service&Support page on the Internet (https://support.automation.siemens.com).

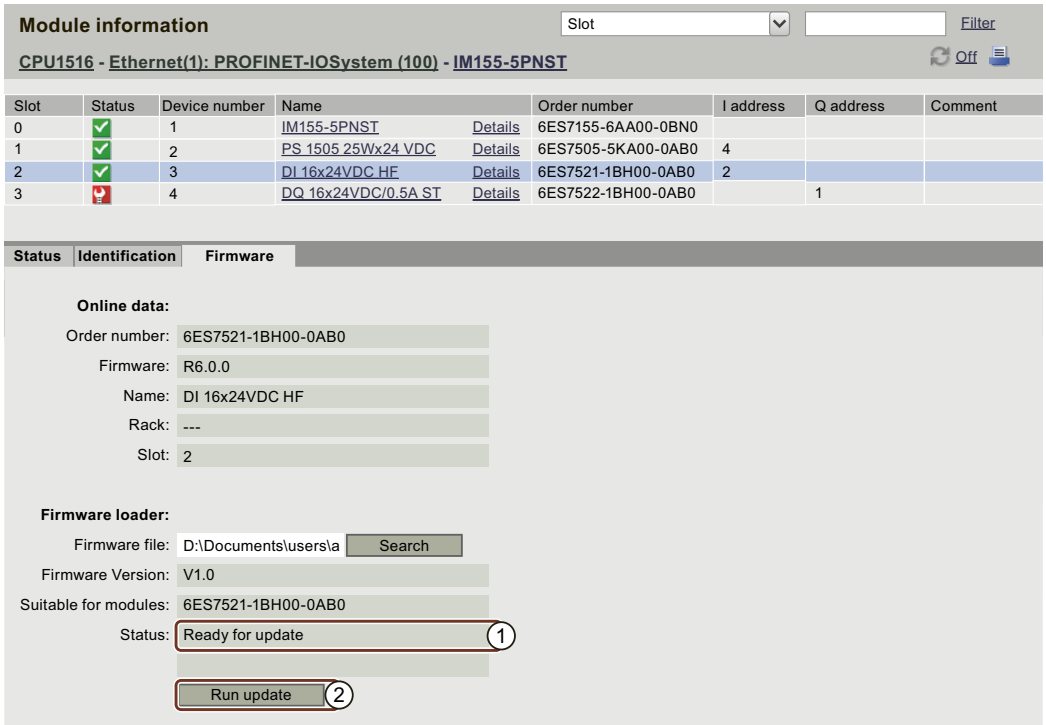

① Status of the selected firmware file

② Button to execute the update

Figure 3-105 Module information, "Firmware" tab, "Ready for update" status

- If the status is "Ready for update", click "Run update". If the CPU is in RUN mode during the update, the following alarm is output:

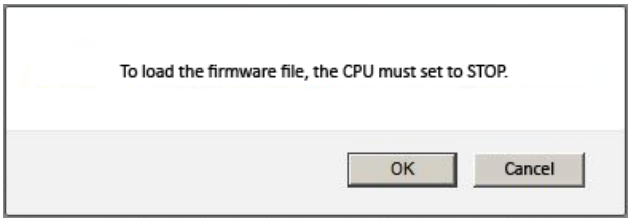

Figure 3-106 Alarm after clicking "Run update"

Acknowledge the alarm output by clicking "OK". The CPU is set to STOP mode and the firmware update is executed.
If you click "Cancel", the CPU remains in the current operating mode and the firmware update is canceled.

- A alarm informs you about the order number and version ID of the updated firmware once the update is complete.
  The CPU is automatically placed in RUN mode when the mode selector of the CPU is in RUN and when you acknowledge the alarm with "OK". This may take a few minutes; there is no progress indicator.
  If you click "Cancel", the CPU remains in STOP mode and you can run additional updates.

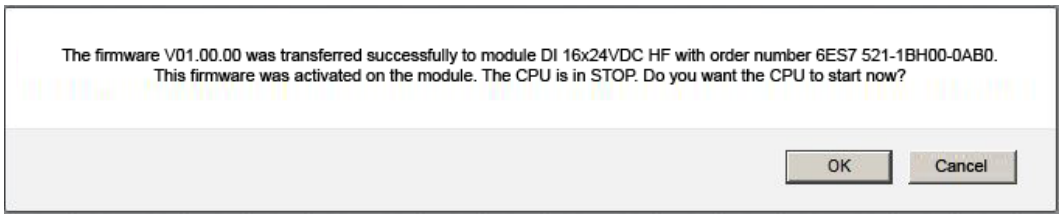

Figure 3-107 Alarm: Firmware successfully transferred

Reference

For more information on the topic of firmware update, refer to the STEP 7 online help and the following FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67190848).

4.7 Alarms

Requirements

The alarm texts were configured in the user-specific languages. You can find information about the configuration of alarm texts in STEP 7.

Alarms

To receive compact information on fault analysis, we recommend that you always first read out the content of the alarm buffer. This is the most effective method to get an overview of the pending faults.

The browser displays the content of the alarm buffer on the "Alarms" web page.

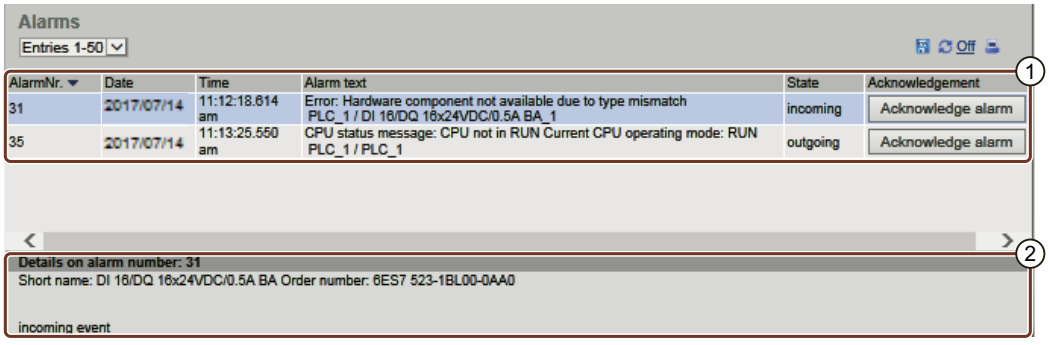

Figure 3-108 Alarms

① "Alarms"

Alarms of the CPU are displayed in descending chronological order with **date** and **time** in info box ①.

The **alarm text** parameter is an entry which contains the alarm texts configured for the corresponding fault definitions.

Note that the message texts are displayed in the project language of the STEP 7 project that is assigned to the current Web server interface language. You can find out how to assign project languages to interface languages in section Language settings (Page 35).

Sorting

You also have the option to display the individual parameters of the currently displayed web page (max. 50 entries) sorted in ascending or descending order. For this purpose, click on one of the parameters in the column header:

- Alarm number
- Date
- Time (of the CPU)
- Alarm text
- Status
- Acknowledgment

The alarms are returned in chronological order when you click the "Date" entry. Incoming and outgoing events are output at the **Status** parameter.

If you have the appropriate user rights (see section Configuring the Web server (Page 24)), for alarms which can be acknowledged, a button is available to you in the "Acknowledgment" column with which you can acknowledge the alarm.

② "Details on alarm number"

You can view detailed alarm information in this info box. Select the corresponding alarm from the info field ②.

Saving alarms

You can save alarms to a csv file for further processing in a spreadsheet program or database program.
Save the data by clicking the icon.

A dialog opens in which you can specify the file name and target directory.

4.8 Communication

Overview

The "Communication" web page provides detailed information about the following tabs:

- Parameters
- Statistics
- Resources
- Connections

① "Parameter" tab

A summary of the information on the PROFINET and Ethernet interfaces of the selected CPU is available in the "Parameter" tab.

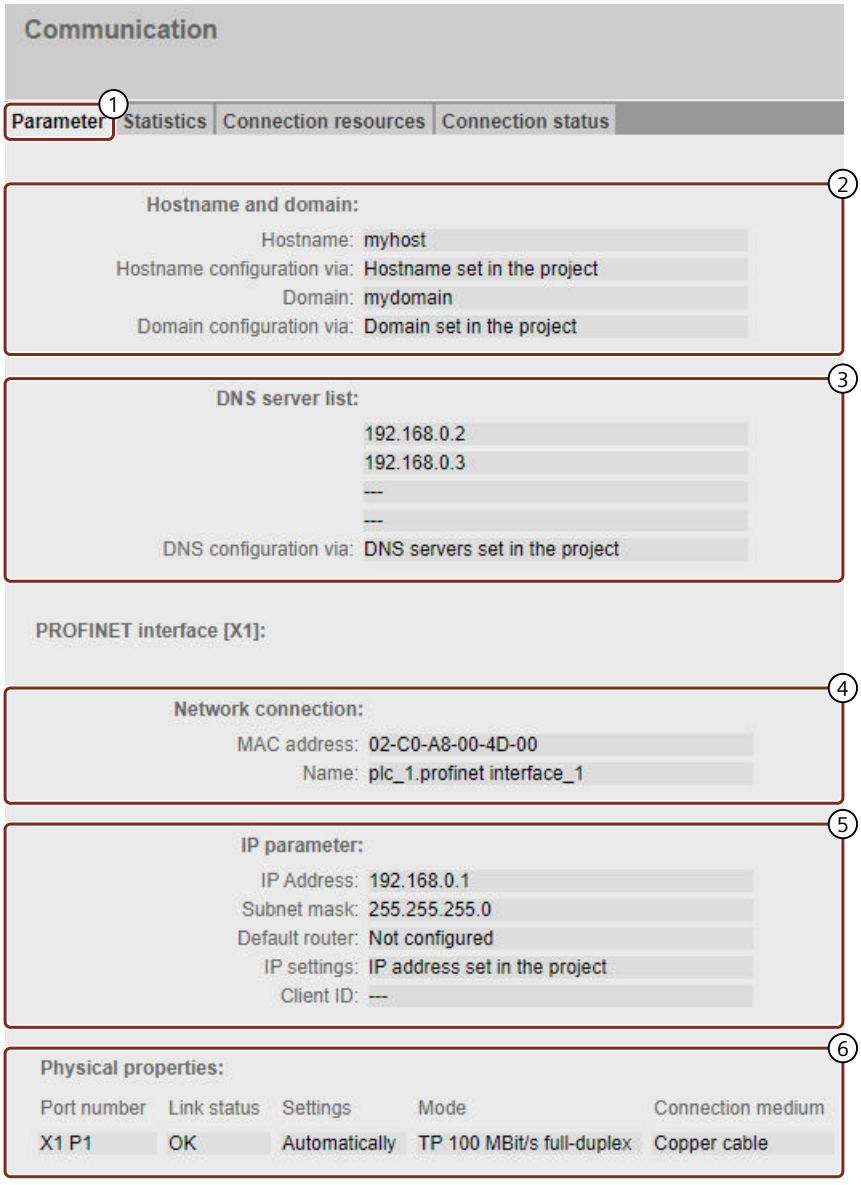

Figure 3-109 "Parameter" tab for communication via PROFINET

② "Host name and domain"

The CPU can use the DHCP communication protocol to assign the network configuration via a DHCP server. The CPU can make its host name and the domain available to the DHCP server.

Here, you will receive information on the host name and the domain of the CPU and where the configuration was specified, for example, remotely via DHCP, in the project or the user program.

③ "DNS server list"

Here, you will receive information on which DNS servers can communicate with the CPU and where the DNS configuration was specified, for example, remotely via DHCP, in the project or in the user program.

④ "Network connection"

Under "Network connection", you will find information for identification of the integrated PROFINET and Ethernet interfaces of the corresponding CPU. The MAC address is located on the CPU above the respective PROFINET or Ethernet interface.

⑤ "IP parameter"

This parameter includes information on the configured IP address and number of the subnet in which the corresponding CPU is located. If a client ID for DHCP was configured for the CPU, it is displayed here.

⑥ "Physical properties"

The following information on the interface hardware is available in the "Physical properties" field:

- Port number
- Link status
- Settings
- Mode
- Connection medium

① "Statistics" tab

Information on the data transmission can be found on the "Statistics" tab.

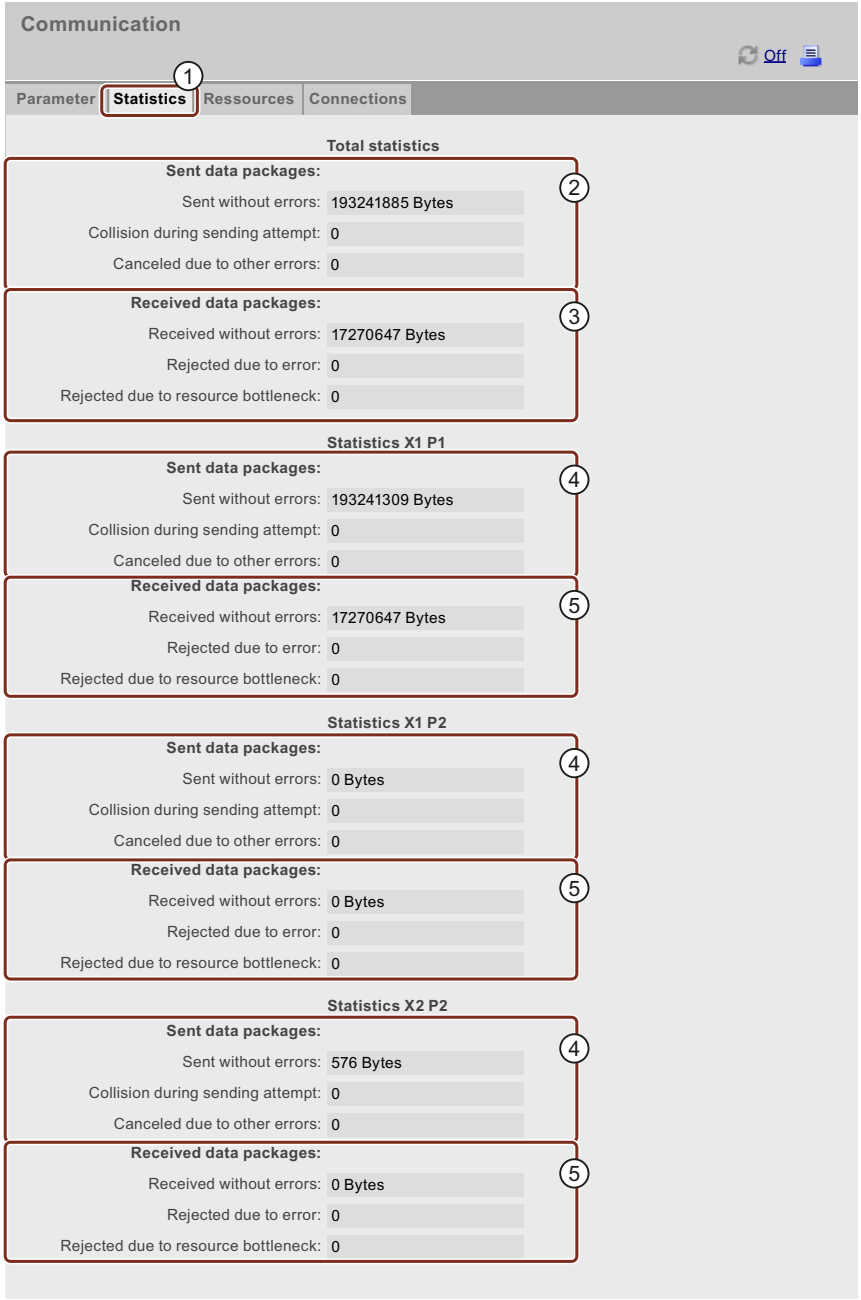

Figure 3-110 "Statistics" tab with key data on data transmission

② "Total statistics - Sent data packages"

You can assess the data transmission on the transmit line based on the key data in this info box.

③ "Total statistics - Received data packages"

You can assess the data transmission on the receive line based on the key data in this info box.

④ "Statistics Port x - Sent data packages"

You can assess the data transmission on the transmit line for each port based on the key data in this info box.

⑤ "Statistics port x - Received data packages"

You can assess the data transmission on the receive line for each port based on the key data in this info box.

① The "Resources" tab

For information about the resource consumption of the connections, refer to the "Resources" tab.

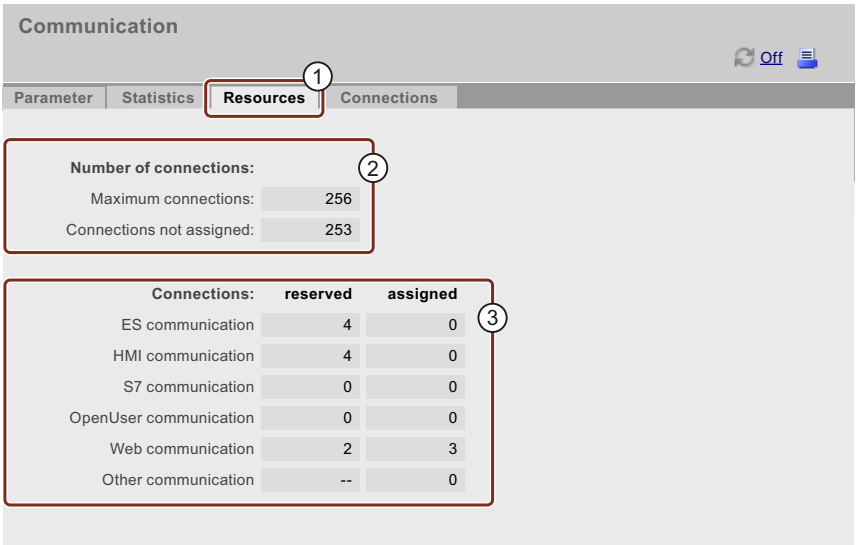

Figure 3-111 "Resources" tab

② Number of connections

Under "Number of connections", you will find information on the maximum number of connections and the number of connections not assigned.

③ Connections

The item "Connections" provides information on the number of connections reserved or used for ES, HMI, S7, OpenUser, web communication and other communication functions.

① "Connections" tab

The "Connections" tab contains information on the status of the communication connections.

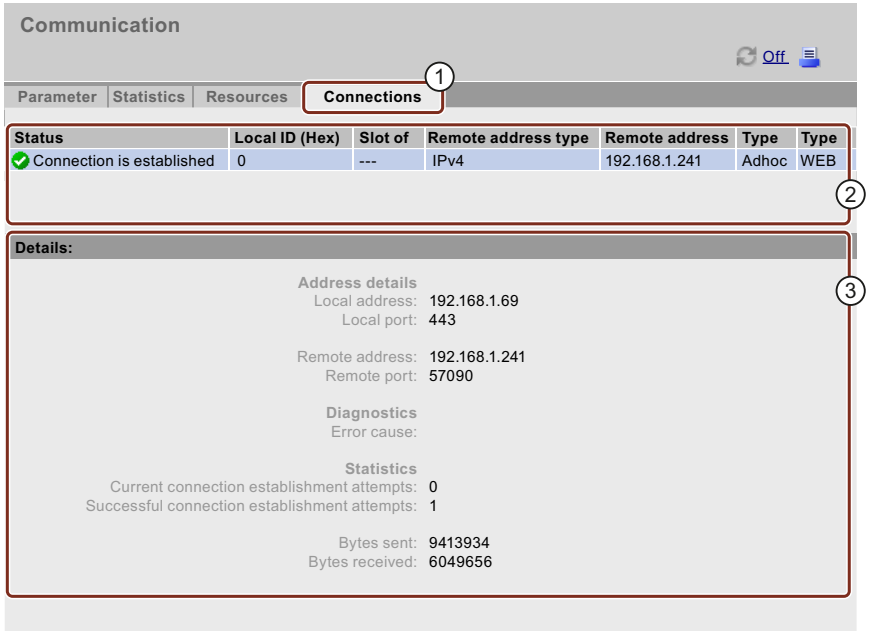

Figure 3-112 "Connections" tab

② Status

Under "Status", you will find an overview of the communication connections being established and the already established communication connections.

For each of these connections, the table contains information about the connection status, the local ID, the slot of the gateway, the remote address (IP address), the corresponding remote address type, and the connection types.

③ Details

Under "Details", you will find detailed information about the selected connection.

Reference

For an explanation of the error message displayed when a connection is interrupted or an attempt to establish a connection fails, refer to the STEP 7 online help.

4.9 Topology

4.9.1 Introduction

Topology of the PROFINET devices

The "Topology" web page provides information on the topological configuration and status of the PROFINET devices on your PROFINET IO system.

There are three tabs for the following views:

- Graphical view (set and actual topology)
- Table view (actual topology only)
- Status overview (excluding topological correlations)

You can print the table view and status overview. Before printing, use the print preview of your browser and, if necessary, correct the format.

Set topology

The set topology is displayed if you have topologically interconnected the connections in the configuration with STEP 7.

This view identifies the topological assignment of PROFINET devices that have failed, the differences between the set and actual topology, and interchanged ports.

NOTE

The configured set topology is always displayed by default in the following scenarios:

- When the "Topology" web page is called via the navigation bar
- When you change from the overview of PROFINET IO devices on the "Module information" web page to the "Topology" web page by means of the "Topology" link.

If a setpoint topology was not configured, the actual topology is displayed.

Actual topology

Displays the current topological structure of the "configured" PROFINET devices of a PROFINET IO system and the directly adjacent, non-configured PROFINET devices (display of the neighbor relationships, provided these can be determined; but the status of these adjacent PROFINET devices is not displayed).

4.9.2 Graphical view

Requirements

For error-free operation of the topology, the following conditions must be met:

- You have made the Language settings (Page 35).
- In the Topology Editor of STEP 7, you configured the topological interconnection of ports (requirement for display of the set topology and the corresponding topological target connections).
- The project has been compiled in STEP 7.
- The project is completely loaded.

Set and actual topology - graphical view

You can select the interface with the topology you want to display (X1, X2, X3 or PROFINET communication modules such as CM 1542-1) at the top left of the "Topology" Web page.

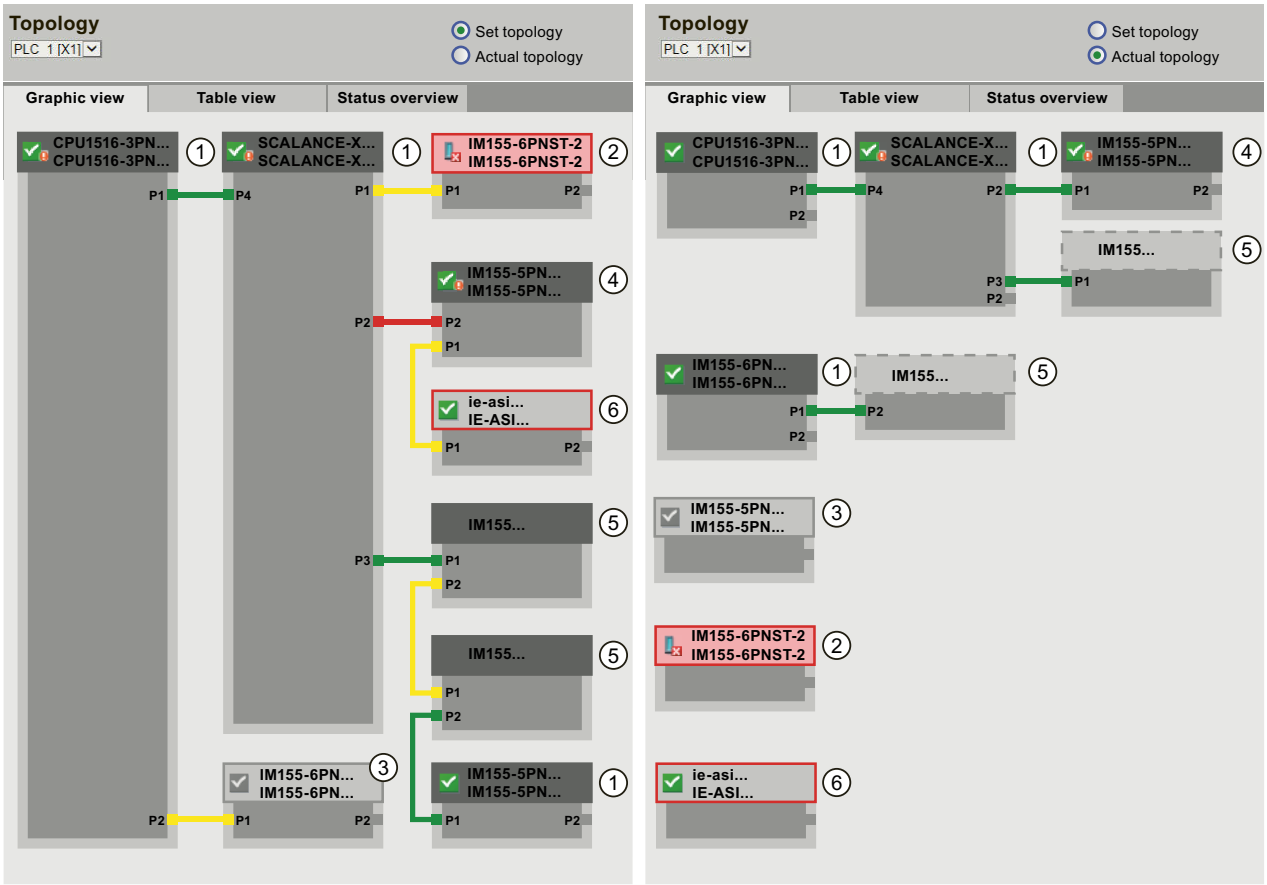

Figure 3-113 Graphical view - Set and actual topology

Meaning of the colored connections in the set/actual topology:

Table 3-45 Meaning of the colored connections in the set/actual topology

Connection	Meaning	
	Set topology	**Actual topology**
Green	The current actual connection matches the configured target connection.	Connections detected
Red	Mismatch between the current actual connection and the configured target connection (e.g., port interchanged).	-
Yellow	Connection diagnostics not possible. Causes: • Malfunction of communication with a device (e.g., cable was removed) • Connection to a passive component (e.g., switches or cables) • Connection to devices/PROFINET devices on a different IO controller or IO subsystem.	-

① Configured and accessible PROFINET devices

Configured and accessible PROFINET devices are displayed in dark gray. Connections indicate the ports used to connect the PROFINET devices of a station.

② Configured but inaccessible PROFINET devices

Configured but inaccessible PROFINET devices are indicated in pink with red frame (e.g., device failure, cable disconnected).

③ Deactivated devices

All deactivated, configured PROFINET devices are displayed in light gray.

④ Interchanged ports

Interchanged ports are highlighted in red in the set topology view. The actual topology view indicates the actually connected ports, while the set topology view displays the configured target connections.

⑤ PROFINET devices of a different PROFINET IO subsystem

- In the set topology:

  A PROFINET device of a different PROFINET IO subsystem is indicated by means of a green link (or red link for interchanged ports) if it is available on the bus and directly adjacent to an accessible configured PROFINET device ①. If the PROFINET device of a different

PROFINET IO subsystem is inaccessible, it is identified by means of a yellow connecting line.
The connection between two PROFINET devices which both belong to a different PROFINET IO subsystem cannot be identified and is always indicated in yellow color.

- In the actual topology:

  The PROFINET device of a different PROFINET IO subsystem is not displayed unless it is directly adjacent to a configured PROFINET device. The PROFINET device is shown in light gray with a dashed line around the device header.

The status of PROFINET devices of a different PROFINET IO subsystem is **not** displayed in the device header.

⑥ Displaying faulty neighbor relationships

Devices from which the relation data could not be read completely or with error are highlighted in light gray with a red frame.

NOTE

Displaying faulty neighbor relationships

If a device does not have the matching firmware, the relationships cannot be displayed correctly. This means a firmware update of the respective device is required in case a faulty neighbor relationship is displayed.

Views after changes to the configuration

- If a device fails, it remains at the same position in the "Set topology" view. This error state is indicated with a red border around the device header and the icon .
- If a device fails, it is displayed in the "Actual topology" view. This error state is indicated separately in the bottom area with a red border around the device header and the icon .

Link between the "Topology" and "Module information" web pages

The two web pages, "Topology" and "Module information", are linked. A click on the header of a selected module in the topology view automatically takes you to this module on the "Module information" web page.

You can find additional information on this in the section Module information (Page 70).

Reference

Additional examples for graphical topology view are available in the section Examples for graphical topology views (Page 93).

4.9.3 Tabular view

Topology - tabular view

The "Tabular view" always shows the "Actual topology".

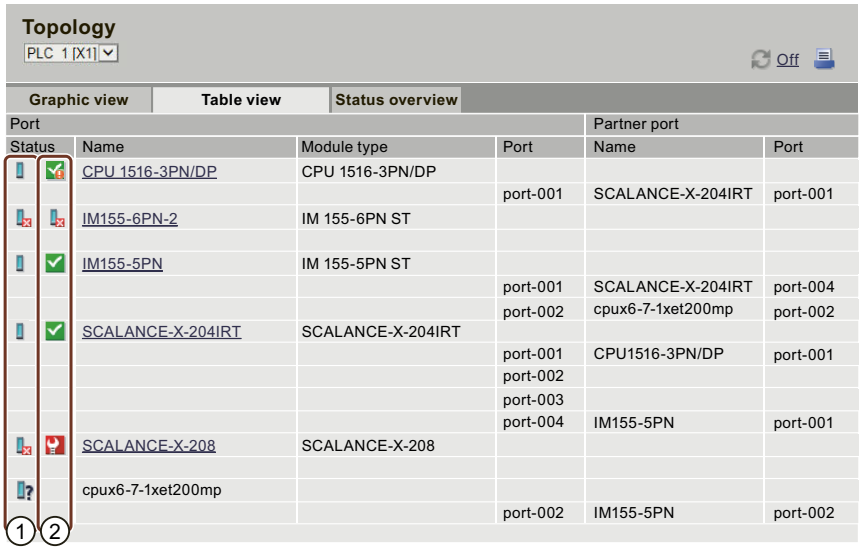

Figure 3-114 Topology - tabular view

① Meaning of the symbols relating to the status of the PROFINET devices

Table 3-46 Meaning of the symbols relating to the status of the PROFINET devices

Symbol	Meaning
	Configured and accessible PROFINET devices
?	Unconfigured and accessible PROFINET devices
	Configured but inaccessible PROFINET devices
!	Devices for which neighbor relations cannot be determined, or for which the neighbor relationship could not be read out completely, or only with errors

② Meaning of the symbols relating to the module status of the PROFINET devices

Table 3-47 Meaning of the symbols relating to the module status of the PROFINET devices

Symbol	Color	Meaning
	green	Component is OK.
	gray	Deactivated PROFIBUS or PROFINET devices.
	black	State cannot be determined • For example, "Status cannot be determined" is always displayed while the CPU is in STOP mode, or during startup evaluation of "Report system error" for all configured I/O modules and I/O systems after a CPU restart. • However, this status can also be displayed temporarily during operation if a diagnostics interrupt burst occurs at all modules. • It is not possible to determine the status of modules on a subsystem that is connected to a CP.
	red	Component failed or is not reachable • "Not reachable" is displayed for e.g. a module that has been removed or a module that has been configured but does not exist.
	green	Maintenance required (Maintenance Required)
	yellow	Maintenance demanded (Maintenance Demanded)
	red	Error - component faulty or not available due to an incorrect type.
	-	A module in a lower module level does not have the status "Component OK".

Reference

For additional information on the "Report System Error" function, refer to the STEP 7 online help, keyword: "System diagnostics".

4.9.4 Status overview

Topology - status overview

The "Status overview" provides a clear presentation of all PROFINET IO devices/PROFINET devices (without connection relations) on one page. A quick error diagnostics is possible based on the symbols that show the module statuses.

The overview also provides a link of the modules to the Web page Module information (Page 70).

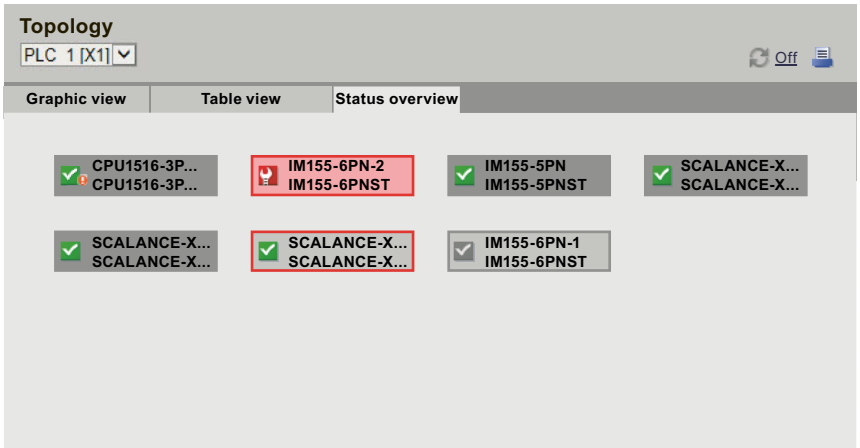

Figure 3-115 Topology - status overview

4.9.5 Examples for graphical topology views

The following section shows, as an example, some displays of the different topology views for a simple project.

"Set topology" is OK

Here you see the connections as they are configured in the topology editor by STEP 7. The configuration and wiring match.

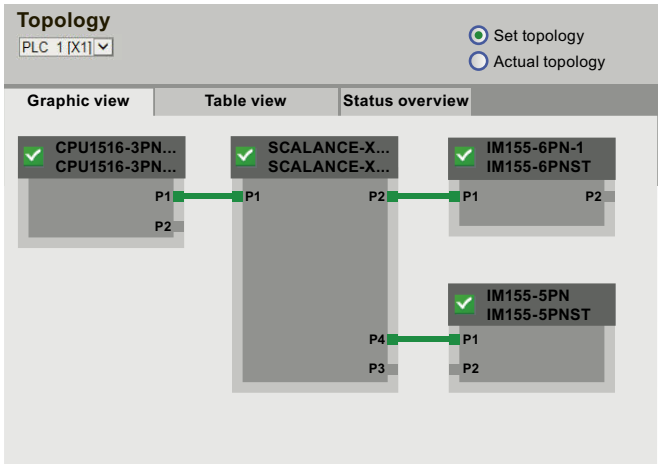

Figure 3-116 "Set topology" is OK

"Actual topology" is OK

Shows the actual layout of all configured devices that can be reached topologically.

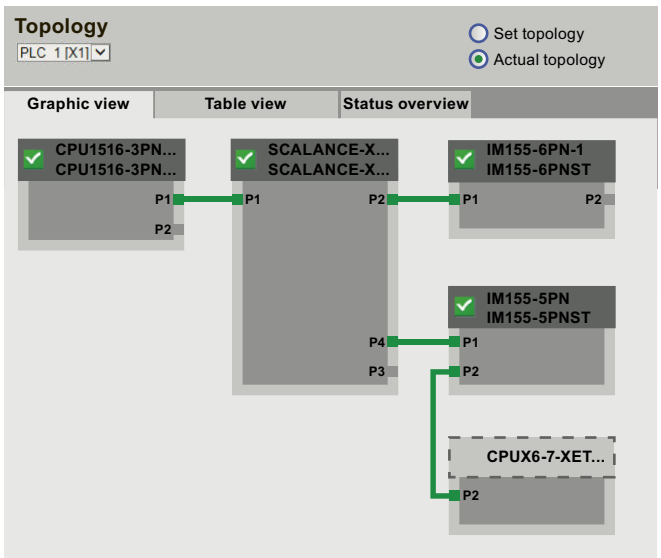

Figure 3-117 "Actual topology" is OK

"Set topology" with failed device

If a device has failed in the meantime, this device remains in the same place in the "Set topology" view. The failed device is displayed with a red border around the device header and the icon.

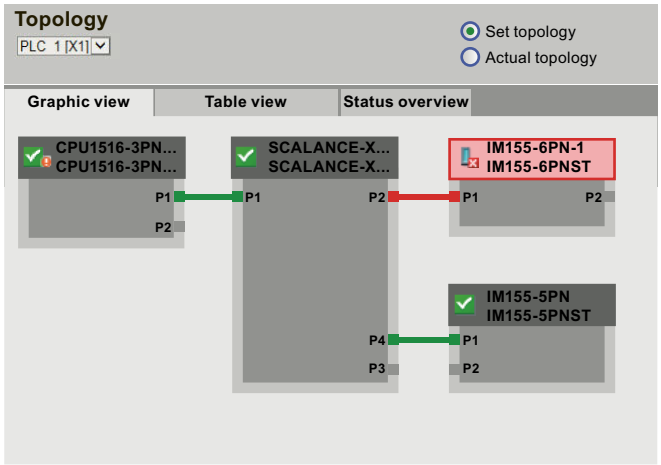

Figure 3-118 "Set topology" with failed device

"Actual topology" with failed device

In the "Actual topology" view, the device that has failed in the meantime is displayed separately in the bottom area of the view. The failed device is displayed with a red border around the device header and the icon.

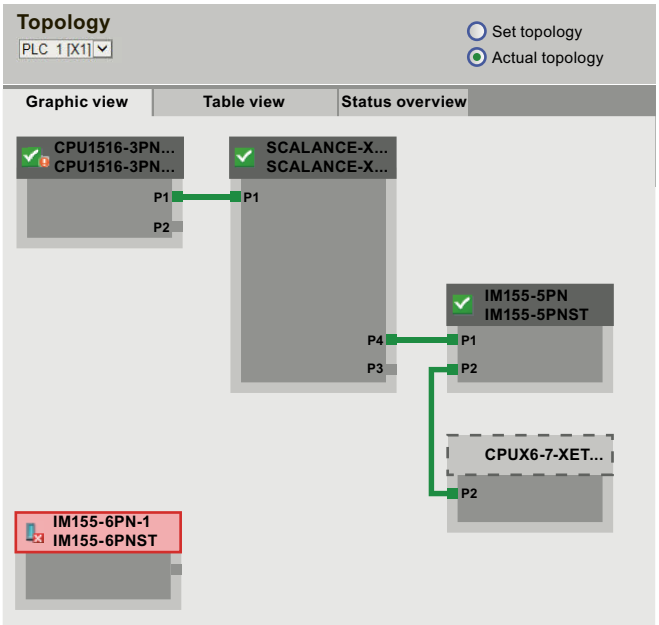

Figure 3-119 "Actual topology" with failed device

"Set topology" with interchanged ports

If a port was interchanged for a configured, directly adjacent PROFINET device, this device remains in the same place in the "Set topology" view. The interchanged connection is indicated by a red line.

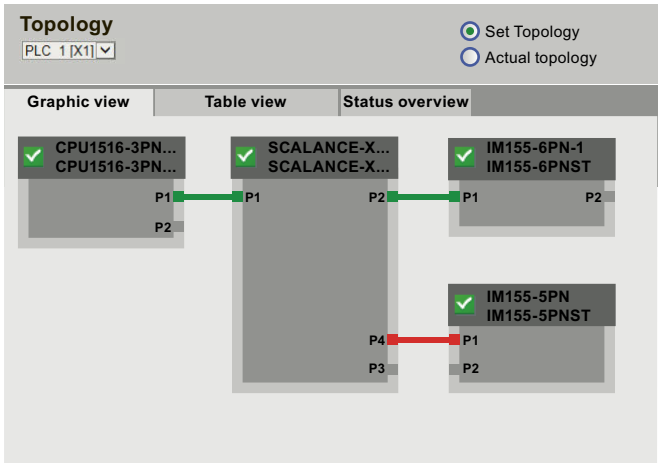

Figure 3-120 "Set topology" with interchanged ports

4.10 Tag status

Tag status

The web browser outputs the tag status on the web page of the same name.

NOTE

Saving the tag status as a bookmark

When the page is exited, the entries made on it are not saved. If you want to monitor the same entered tags again later on, then create a bookmark in your web browser for the "Tag status" page. Otherwise, you will have to enter the tags again when the page is reopened.

NOTE

Selected tag addresses are copied to the URL

The maximum number of characters for the URL of the tag status page is 2083. You can see the URL which corresponds to your current tag status page in the address bar of your web browser.

To monitor several tags, we recommend the use of the watch tables (Page 98).

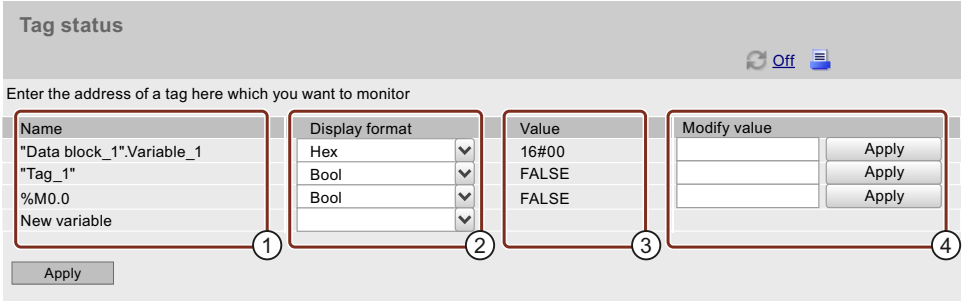

Figure 3-121 Tag status

① "Name"

In the "Name" text box, enter the address of the tag whose behavior you want to monitor. This may be a symbolic or absolute address.

- PLC tags (inputs and outputs, bit memories, times and counters) and DB tags in blocks with standard access have an absolute and a symbolic address.
- DB tags in blocks with optimized access have a symbolic address and no absolute address.

Example for access to the absolute address of a data block with standard access:
The absolute address consists of the preceding address ID %, the number of the data block and the absolute address of the tags in the data block, separated by a period: `%DB1.DBX1.0` = absolute addressing of the tags "DBX1.0" in the global data block "DB1".

Invalid entries are displayed in red font.

② "Display format"

Using the drop-down list box, select the desired display format for the tag. If the tag cannot be displayed in the desired format, it will be displayed in hexadecimal format.

③ "Value"

Under "Value", the value of the corresponding operand is displayed in the selected format.

④ "Modify value"

You can change the value of tags and write them to the CPU in this column. To transfer several changed values in one operation, click the "Apply" button below the table.

To be able to read values and write values to the CPU, you need to have configured a user with the appropriate access rights in STEP 7.

If the value you entered is not valid (e.g. binary value in a BOOL field), the entry is not applied and the corresponding input field remains empty. A specific message relating to this is not output.

You can change the values of the following data types:

- Bool, Byte
- DWord, LWord, Word
- Int, DInt, LInt, SInt, UDInt, UInt, ULInt, USInt
- Real, LReal
- LDT
- Counter, Date
- Time, LTime, Time_Of_Day, LTime_Of_Day, Timer
- S5Time
- Char, WChar, String

NOTE

The following generally applies: To be able to write data, the "Referrer" transfer must be activated in your web browser (this is the default in all common browsers).

Special considerations when changing languages

You can change the language, e.g., from German to English, in the upper right corner. Note that the German mnemonics differ from those of the other languages.

For monitoring available data types

Basically, you can monitor all data types of PLC tags via the web Server, which you can also monitor in STEP 7.

Note that structured data types such as ARRAY, STRUCT and DTL are not available as data types for PLC tags due to their data volume.

Reference

You can find additional information on the available data types in the STEP 7 online help, keyword: "Overview of the valid data types".

4.11 Watch tables

Watch tables

The browser displays the content of the configured, web-enabled watch tables on the web page of the same name.

NOTE

Please note that you can observe a maximum of 50 of the watch tables configured in STEP 7 in the Web server.

Each of these tables is displayed in the Web server with a maximum of 200 entries.

If you are monitoring many large watch tables in the Web server, the update time may increase due to the large data volumes.

The number of watch tables that you can monitor download into the CPU also depends on the size of the SIMATIC memory card used.

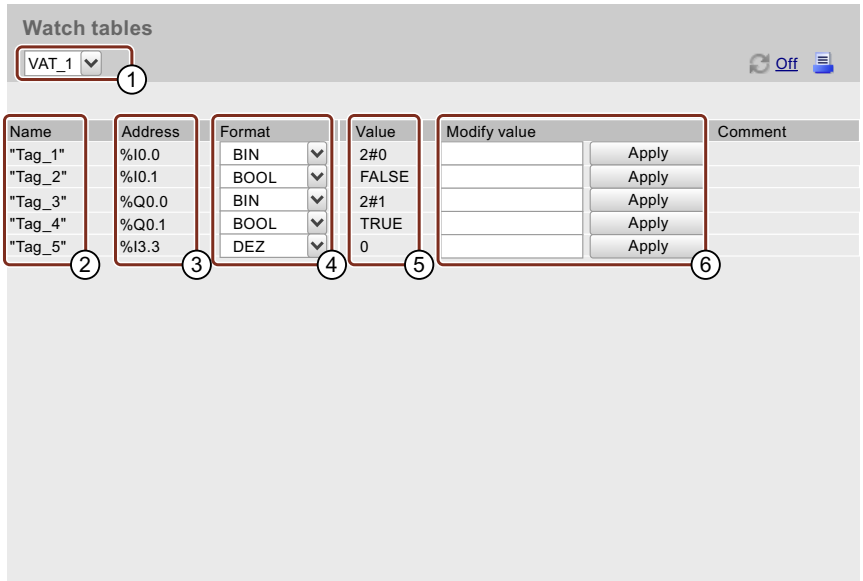

Figure 3-122 Watch tables

① Selection

Select one of the configured watch tables from the drop-down list.

② "Name"

The symbolic name of the tag is shown in this info box.

③ "Address"

The absolute address of the tags is displayed within this info field (if present, e.g. for inputs or outputs; DB tags in blocks with optimized access have no absolute address).

③ "Format"

Select the display format of the respective tag from the drop-down list.

⑤ "Value"

This column shows the values in the corresponding display format.

⑥ "Modify value"

You can change the value of tags and write them to the CPU in this column.

To be able to read values and write values to the CPU, you need to have configured a user with the appropriate access rights in STEP 7.

If the value you entered is not valid (e.g. binary value in a BOOL field), the entry is not applied and the corresponding input field remains empty. A specific message relating to this is not output.

NOTE

The following generally applies: To be able to write data, the "Referrer" transfer must be activated in your Web browser (this is the default in all common browsers).

Note that the comments are displayed in the project language of the STEP 7 project that is assigned to the current user interface language of the Web server. You can find out how to assign project languages to interface languages in section Language settings (Page 35).

Reference

You can find additional information on the available data types in the STEP 7 online help, keyword: "Overview of the valid data types".

4.12 Online backup

Backing up and restoring the CPU configuration

You can back up a CPU configuration using the Web server with the corresponding access rights. If necessary, you can also restore this configuration at a later time using the Web server.

You can create as many backups as you want and store a variety of configurations for a CPU.

NOTICE

Prior to every restoration of the CPU configuration, always first perform an online backup of the current CPU configuration and save this backup file to a local directory of your PC.

This ensures that you can undo a restoration which failed (e.g. due to a damaged backup file) or which does not show the desired result.

NOTE

You can also perform online backup and restoration of the CPU configuration in STEP 7 (see STEP 7 online help, keyword: "Creating a backup of an S7 CPU").

When backing up using STEP 7, the backup file is saved within the STEP 7 project. With a backup using the Web server, the backup file is saved to a local directory of your PG/PC (e.g. "Downloads" directory). Web server backup files cannot be restored via STEP 7, nor can STEP 7 backup files be restored directly using the web server.

To restore a STEP 7 backup file using the web server, first save the STEP 7 backup file to a local directory of your programming device/PC (e.g. "Downloads" directory). From there, you can restore the backup with the Web server.

NOTE

The "Online backup" function is not available if you access the web server via:

- a virtual IP address
- a communication module (CM)
- a communication processor (CP)

Requirements

- You access the CPU via the secure transmission protocol "HTTPS".
- A valid CA-signed certificate is installed in the Web browser; see section Configuring the Web server (Page 24).

Online backup

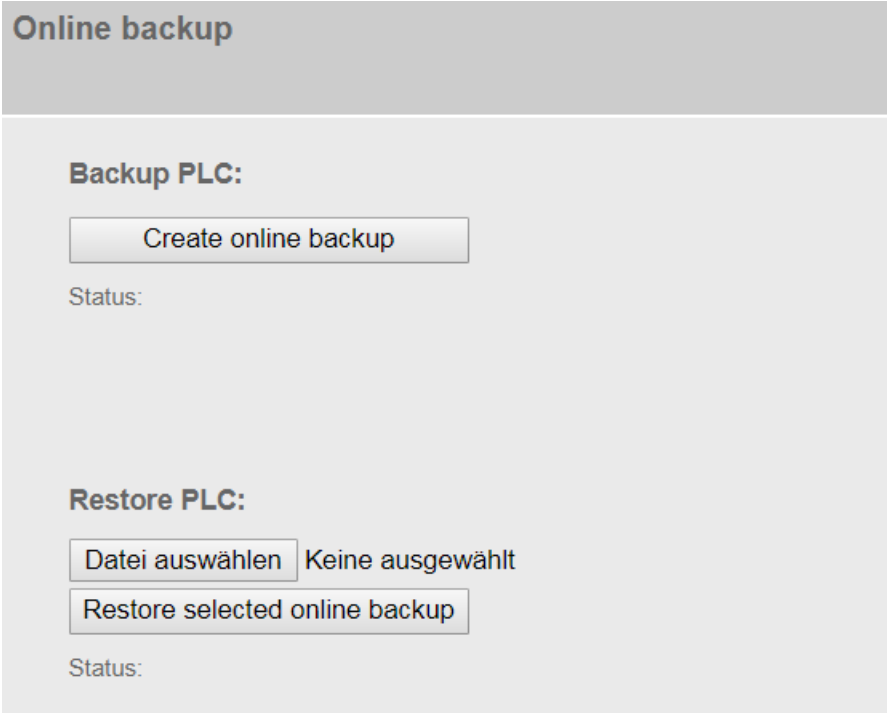

Figure 3-123 Online backup

Perform online backup of the configuration

To perform an online backup of the CPU configuration, proceed as follows:

1. Click the "Create online backup" button in the "PLC backup" area.
2. If the CPU is in RUN mode, the following alarm is output:
   "Creation of an online backup requires PLC STOP. Do you want to set the PLC to STOP mode?"

   Acknowledge the alarm output by clicking "OK". The CPU is set to STOP mode and online backup is performed. (If you click "Cancel", the CPU remains in the current mode and the online backup is canceled.)
3. Save the backup file to a local directory of your PC.
4. Set the CPU back to RUN mode ("RUN" button in the "CPU operator panel" area of the start page).

NOTE

During the execution of the online backup, some data is not available in the web page view of the web server.

Scope of the backup

The backup includes all data needed to restore a particular state of a CPU, i.e. the specific combination of the configuration of the CPU with the current values of the user-related retentive data.

The following data of the configuration of the CPU is backed up:

- The contents of the SIMATIC memory card, e.g. configuration, program code, recipes and archives, DataLogs

The following user-relevant retentive data is backed up:

- Retentive memory areas of data blocks, bit memories, counters and timers
- Front-panel settings, dynamic IP configuration data, operating hours counters, retentive motion control sensor data

Note:

- Entries in the diagnostics buffer are not included in the backup.
- With a SIMATIC S7-1500 CPU, the current time is not saved.
- The complete content of the SIMATIC memory card is saved, i.e. also any data stored on the card (e.g. PDF files, GSD files).
- The backup file is assigned the name of the CPU and the project with the time and date of the backup, e.g. "2015-09-10_11-01_03_online backup_PLC69_machineControl.s7pbkp".
- The backup file of an F-CPU also contains the collective signature of the safety program in the file name. Check whether it is the expected F-collective signature.
- You can rename the backup, but you cannot make any changes to the contents of the backup.
- For the motion control technology objects positioning axis, synchronous axis and external encoder with absolute encoder, the position actual value does not match the actual mechanical axis position after the configuration is restored. Reference the technology object once again using absolute adjustment.

Restoring the configuration

To restore the CPU configuration, follow these steps:

1. Enter the password of the currently logged-in user in the "Restore PLC" area.
2. Click the "Select file" button and select the backup file of the configuration that you want to restore.
3. Click "Restore selected online backup".
4. If the CPU is in RUN mode, the following alarm is output:
   "Download online backup to device. The CPU is set to STOP and the contents of the CPU will be overwritten. Do you want to continue?"

   If the CPU is already in STOP mode, the following alarm is output:
   "Download online backup to device. The contents of the CPU will be overwritten. Do you want to continue?"

   Acknowledge the alarm output by clicking "OK". The CPU is set to "STOP" mode if required, and the online backup is downloaded. (If you click "Cancel", the CPU remains in the current mode and downloading is canceled.)

5. An alarm informs you that you must not leave the web page during the "restore procedure". Acknowledge the alarm output by clicking "OK".

   The restoration of the CPU configuration starts and you will be continuously informed of the current status:

   – "Download of online backup has been started."
   – "Checking backup file."
   – "Formatting memory card and resetting CPU."

6. If you have started the restoration procedure with a user name and password defined in the Web server configuration, you will be asked to enter these again after restoration of the CPU. Enter the required information and click "Login".

   If you have started the restoration procedure as the user "Everybody"/"Anonymous" without a password (but with appropriate access rights), this prompt is not displayed.

NOTE

To restore the configuration of an F-CPU whose security program and/or password has been changed for the F-CPU in the meantime, you also need the access authorization "Perform changes as F-Admin"; see "Amending user management" in the section Configuring the Web server (Page 24).

WARNING

The authorization "Perform changes as F-Admin" on the Web server without password protection (User "Everybody" or "Anonymous") is only for test purposes, commissioning, etc. In other words, only when the system is not in productive operation. In this case, you have to ensure the security of the plant through other organizational measures, e.g. through spatial protection.

Before the transition to productive operation, you must remove the right "Perform changes as F-Admin" from the user "Everybody" or "Anonymous".

The password of the user of the web server with the right "Perform changes as F-Admin" must only be accessible to authorized persons.

   The restoration of the CPU configuration starts and you will be continuously informed of the current status:

   – "Loading configuration."
   – "Resetting CPU."

   This may take a few minutes.

7. When the procedure is complete, you will be logged out and the "Reload page..." button will be displayed.

   If you did not receive an error message during the restoration procedure, the restoration of the CPU configuration was successfully completed and you will receive a corresponding message.

   Click the "Reload page..." button and log on to the newly downloaded CPU configuration with your user name and password.

You will receive the following error message if:

- the newly downloaded CPU configuration does not contain the same IP address as the former one
- the Web server is deactivated in the newly downloaded CPU configuration
- the browser does not receive a response from the CPU after 3 minutes

Error message: "The CPU is not reachable anymore. Please check the IP address and the Web server configuration. The result of the restore can be checked in the ASLog."

4.13 Record

Trace and logic analyzer function

You record device tags and evaluate the recordings with the trace and logic analyzer function. Tags are, for example, drive parameters or system and user tags of a CPU.

The recordings are saved on the device and can be read out by users with appropriate access rights via the Web server and saved. The trace and logic analyzer function is therefore suitable for monitoring highly dynamic processes in the Web server.

Requirements

- A trace configuration has been created, i.e. you have defined the recording and trigger conditions and selected the signals to be recorded.
  - Note: You can only display measurements stored on the SIMATIC Memory Card on the "Record" web page.

    In order for the CPU to save the measurements on the SIMATIC Memory Card, you must make the following settings in the trace configuration in STEP 7:

    1. Set the "Trigger mode" to "Trigger on tag".
    2. Select the "Save measurements on device (memory card)" check box.
- You have transferred the trace configuration to the device and activated it there.
- You have been assigned the access right "The user is authorized to..." > "...query diagnostics" in the user administration of the Web server; see section Configuring the Web server (Page 24).

Space requirements for storing trace recordings

The "Save measurements on device (memory card)" function in STEP 7 saves Trace recordings on your SIMATIC Memory Card.

Response when number reached

The "Deactivate recording" parameter repeats the measurements until the configured "Number of measurements" is reached.

The "Overwrite oldest recording" parameter replaces the oldest measurement with the latest measurement when the configured "Number of measurements" is reached. Please note, however, that continuously writing data to the SIMATIC Memory Card shortens its service life.

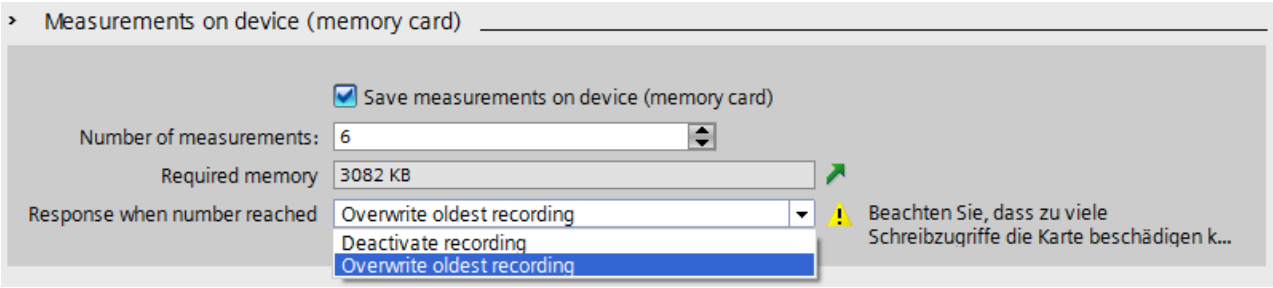

Figure 3-124 Dialog of the settings for saving measurements to the Memory Card in STEP 7

Number of measurements

The CPU supports a maximum of 999 measurements. While the CPU writes the trace recordings to the load memory of the memory card, it pauses monitoring of the trigger conditions for the trace job. After the CPU has terminated the storing of Trace recordings, the CPU continues checking of the trigger conditions.

NOTICE
Memory required on the SIMATIC Memory Card When the trace function "Measurements on device (memory card)" requires more memory than is available on the SIMATIC Memory Card, undesired effects may result. Ensure there is always sufficient free storage space to use the "Measurements on device (memory card)" function. In addition to the "Measurements on device (memory card)" Trace function, other functions, such as storing DataLogs, use storage space on the SIMATIC Memory Card. Make sure that enough memory space is available for all functions that occupy memory.

You can view the current values on the currently used storage space in the load memory in the "Memory" tab on the "Diagnostics" web page.

More information

The user interface of the "Trace" web page is largely the same as that of the trace function in STEP 7. See the Using the trace and logic analyzer Function Manual (https://support.industry.siemens.com/cs/ww/en/view/64897128) and the online help for STEP 7 for more details.

Displaying the trace recordings

The web page of the trace and logic analyzer function consists of several areas. The example in the figure below shows how the Web server user interface is divided when the "Trace" web page is first called.

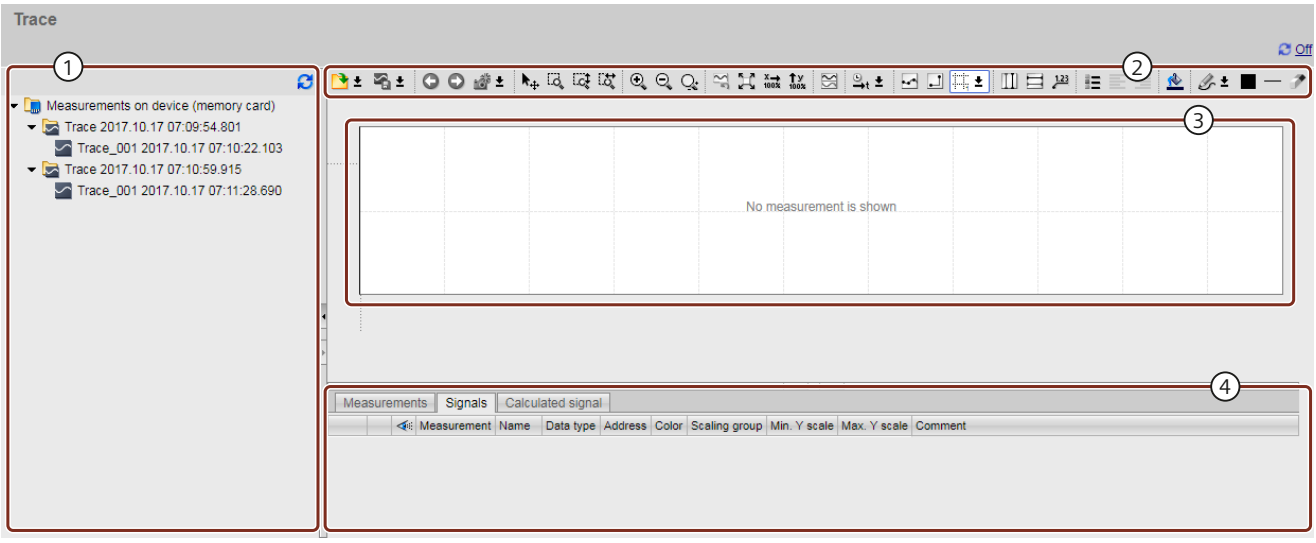

① Trace recordings

② Toolbar of the trend diagram

③ Trend diagram and bit trace

④ Signal tables

Figure 3-125 Trace start page without measurement

Opening measurements

To open a measurement, right-click on a measurement to select it from the "Trace recordings" area. Then select the command "Show in chart" in the shortcut menu.

The measurement is displayed in the "Trend diagram and bit trace" area.

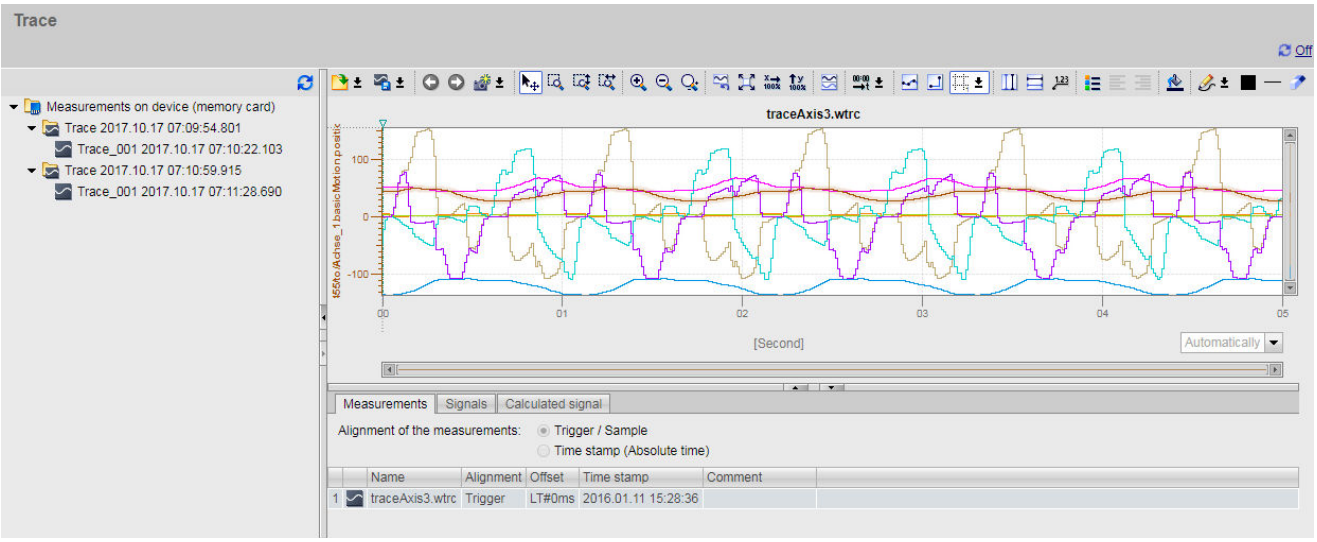

Figure 3-126 Displaying an individual measurement

To display multiple measurements at once, right-click on a measurement to select it from the "Trace recordings" area. Then select the command "Add to table" in the shortcut menu.

The measurements are displayed in the "Trend diagram and bit trace" area.

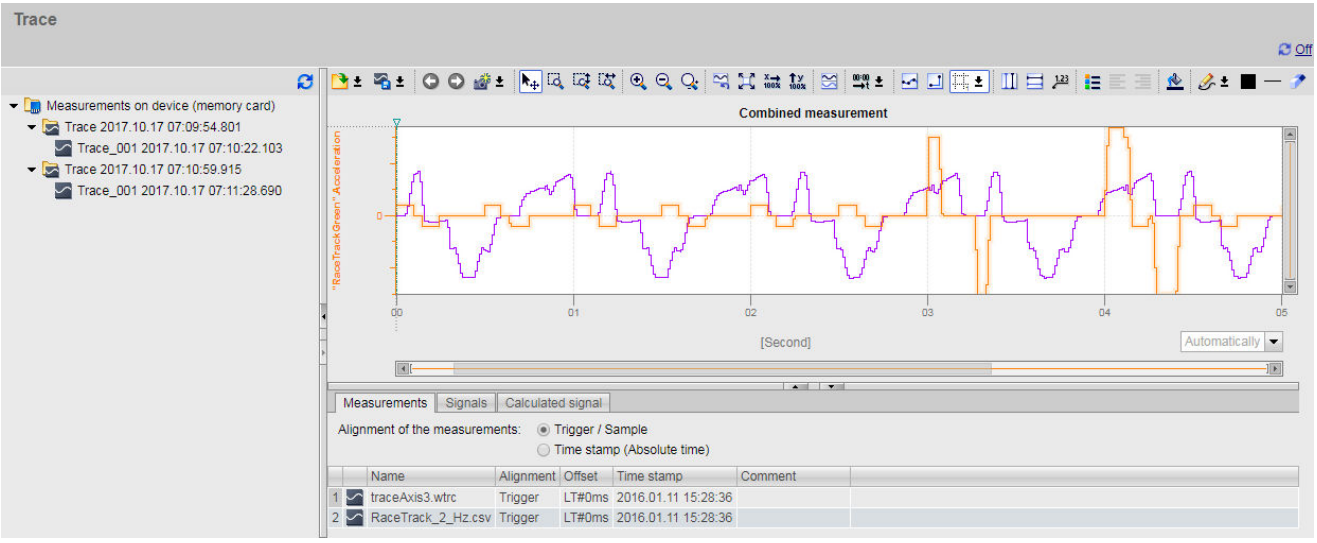

Figure 3-127 Displaying several measurements

Trace recordings

The "Trace recordings" area shows a list of all existing measurements, sorted by date and time of the trace recordings. A measurement always consists of a trace configuration with an associated recording.

The following table shows the special Web server shortcut menu commands in the Trace recordings area:

Table 3-48 Web server shortcut menu commands in the trace recordings area

Shortcut menu command	Description
"Delete"	Deletes the selected measurement on the memory card of the CPU. A confirmation dialog opens. After deletion, the display in the trend diagram is not automatically overwritten.
"Save as"	Saves the selected measurement.
"Show in chart"	Loads the selected measurement to the display area of the Web server.
"Add in table"	Inserts the selected measurement into the table in the "Measurements" tab.

Some data types offer the display of individual bit traces. Activate the individual bit traces of the signal opened in the signal table using the icon.

You can adjust the display of the signals in the signal table and with the aid of the toolbar of the trend diagram.

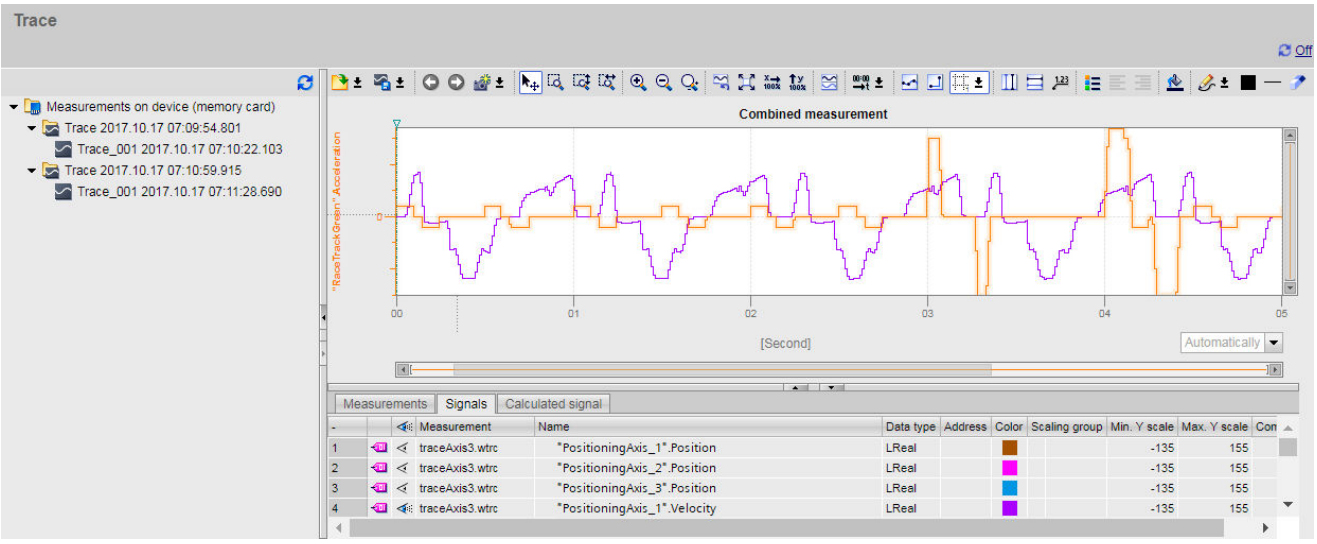

Figure 3-128 Trace measurement - All areas visible

Toolbar of the trend diagram

As in STEP 7, the buttons in the toolbar of the trend diagram provide you with tools for adjusting the display.

The following table shows the Web server buttons in the trend diagram toolbar:

Table 3-49 Buttons of the trend diagram toolbar

Symbol	Function	Description
	Open / add measurement	Opens measurements or adds measurement to an existing measurement.
	Save as	Saves measurement(s) as a file with the extension .csv, .wtrc (SIMOTION format for saving Trace data) or .ttrecx (TIA Portal format for saving Trace data). In addition to the measured data the command also saves the diagram, snapshots, marking and calculated signals. Condition for saving in the .wtrc format: • Only one measurement in the .wtrc format was loaded to the "Trace recordings" area. Condition for saving in the .ttrecx format: • Only one measurement in the .ttrecx format was loaded to the "Trace recordings" area. In all other cases, you can only save the measurements in the .csv format.
	Undo move / zoom	Undoes the move / zoom function executed last. If you have carried out several move / zoom functions, you can undo these step-by-step.
	Repeat move / zoom	Redoes the last undone move / zoom function. If you have undone several move / zoom functions, you can redo these step-by-step.
	Snapshot	Saves the current view as a snapshot (see the section "Settings and displays of the Snapshot symbol").
	Move view	Moves the display with a pressed mouse button - corresponds to the button in STEP 7.
	Zoom selection	Selection of an arbitrary range with the mouse button pressed. The button scales the display to the range selection.
	Vertical zoom selection	Selection of a vertical range with the mouse button pressed. The button scales the display to the range selection.
	Horizontal zoom selection	Selection of a horizontal range with the mouse button pressed. The button scales the display to the range selection.
	Zoom in	Enlargement of the display. The ranges of the X axis and Y axis are reduced every time the button is clicked. The curves are displayed larger.
	Zoom out	Reduction of the display. The ranges of the X axis and Y axis are reduced every time the button is clicked. The curves are displayed smaller.
	Scaling	Scales all the signals or also just signal / signal group vertically and horizontally.
	Restore standard view	The button undoes scaling and move commands. The view is reset to the status at the time of loading of the measurement. Hidden signals are also reset but remain deactivated.
	Display all	The button moves all the signals completely into the display area without changing the relative positions of the signals to each other.

Symbol	Function	Description
	Scale X automatically	Automatic scaling of all visible signals on the horizontal X area.
	Scale Y automatically	Automatic scaling of all visible signals on the vertical Y area.
	Arrange in tracks	Activate or deactivate the trace arrangement. When the trace arrangement is activated the signals are arranged among themselves with the relevant value axes. Signal groups are displayed in the same trace. This setting does not affect the display for the bit traces.
	Unit switching of the time axis	Switching the unit of the time axis You can enter the following information: • Measuring points • Time (relative time related to the trigger time) • Time stamp of the measurement points
	Display measurement points	The button displays the measurement point as small circles on the curves.
/	Interpolation on/off	The buttons activate / deactivate the interpolation of the data of the trend diagram.
	Grid	The button activates / deactivates the grid of the trend diagram and regulates its brightness in the Levels 1 to 9.
	Vertical measurement cursor	Display of vertical measurement cursor. The vertical position of the two measurement cursors can be moved with the mouse. The values of the signals and the difference between two measuring points are displayed in the signal table for all displayed signals and also in the trend diagram for the selected signal. The measuring point or the relative/absolute time to the measurement cursors is displayed depending on the set unit of the time axis (X axis) in the movable pop-up window "Measuring points/Time values".
	Horizontal measurement cursor	Display of the horizontal measurement cursors. The horizontal position of the two measurement cursors can be moved with the mouse. The Y values of the measurement cursor for the selected signal are displayed in the movable pop-up window "Y values".
1.23	Difference of the measurement cursor	Display of the difference of the horizontal and vertical measurement cursors and the Y values at the intersections with the vertical measurement cursors.
	Show legend	Showing or hiding of the legend in the trend diagram and the bit trace labels.
	Align the chart legend to the left	Display of the legend and the bit trace labels on the left side of the trend diagram.
	Align the chart legend to the right	Display of the legend and the bit trace labels on the right side of the trend diagram.
	Change background color	Changeover between various background colors.
	Identification	The following table provides an overview of marked signal areas. Note that selections are possible only for analog and real signals (no calculated signals).

All icons in the toolbar are equipped with tooltips.

Trend diagram

The trend diagram displays the selected signals of a recording. Bits are shown in the lower diagram as a bit trace.

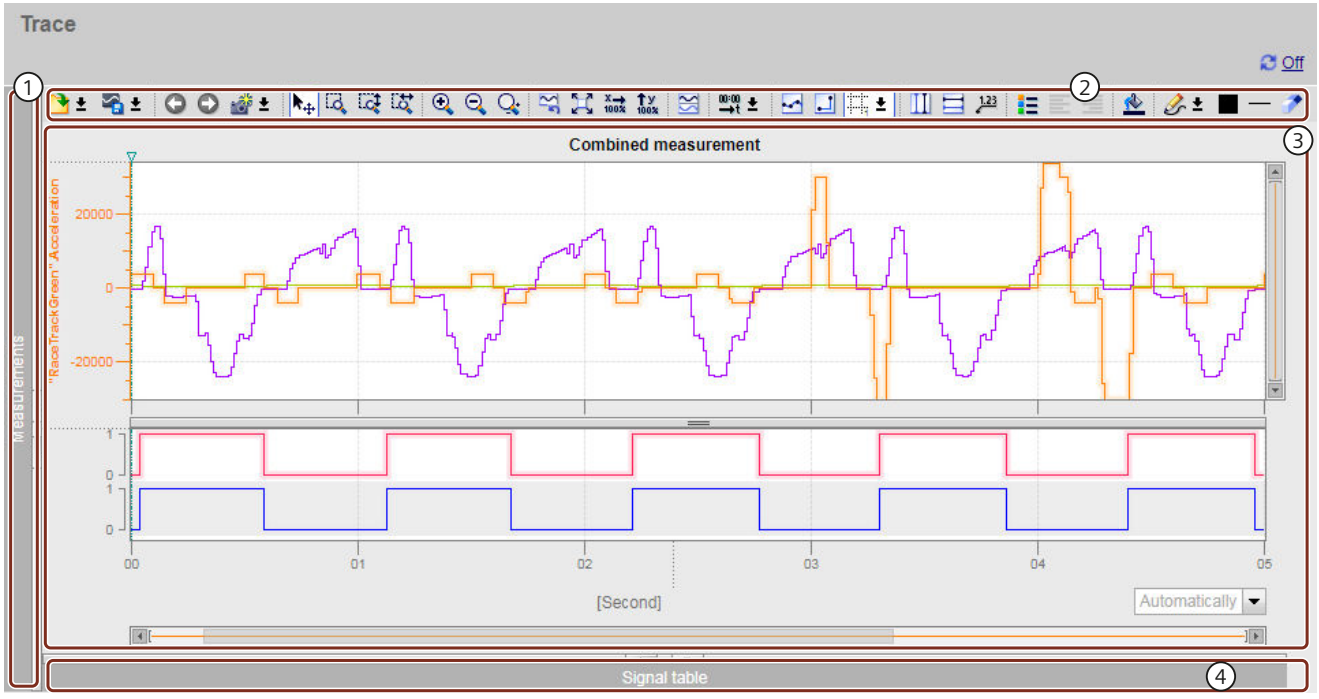

① Trace recordings (minimized)

② Toolbar of the trend diagram

③ Trend diagram and bit trace

④ Signal table (minimized)

Figure 3-129 Trace measurement - only trend diagram visible

The following table shows the special Web server shortcut menu commands of a selected signal in the trend diagram:

Table 3-50 Web server shortcut menu commands in the trend diagram area

Shortcut menu command	Description
"Scale Y automatically"	Automatic scaling of the selected signal in the Y direction.
"Hide signal"	Hides the selected signal in the trend diagram.

Use of the trend diagram

You can zoom the display area as you like. Measurement cursors (see "② Toolbar of the trend diagram") can be used to select individual values for display in the signal table.

The following image shows how you can change the display area of the trend diagram as required with rulers and scroll bars.

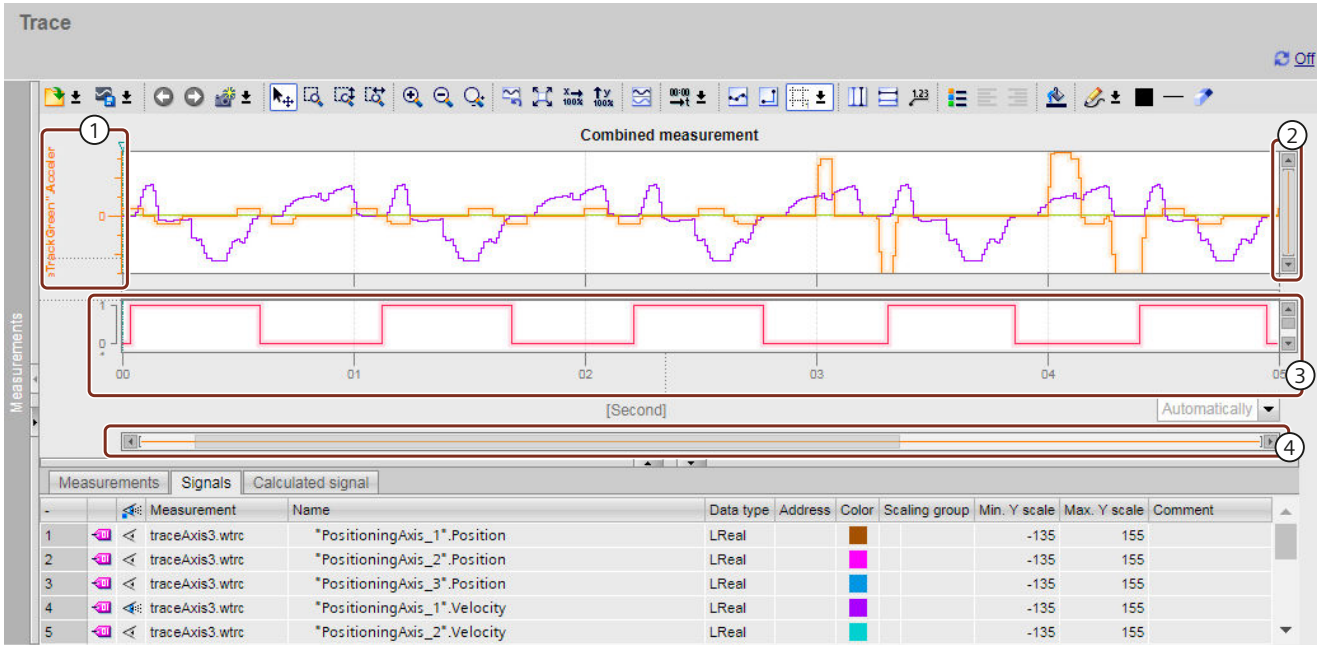

① Vertical ruler

② Vertical scroll bar

③ Horizontal ruler

④ Horizontal scroll bar

Figure 3-130 Trace measurement - rulers and scroll bars

Using the vertical ruler

- If you click the vertical ruler at the top or the bottom, you increase the size of the display at the top or bottom.
- If you click the vertical ruler at the top or the bottom while keeping the shift key pressed, you scale both ends.
- If you click the vertical ruler at the top or the bottom while keeping the Ctrl key pressed, you move the display up or down.

Using the horizontal ruler

- If you click the horizontal ruler on the left or the right, you increase the size of the display on the left or right.
- If you click the horizontal ruler on the left or right while keeping the shift key pressed, you scale both ends.
- If you click the horizontal ruler on the left or the right while keeping the Ctrl key pressed, you move the display to the left or right.

Using the mouse wheel

- If you activate the mouse wheel in the display, you move the display up or down.
- If you activate the mouse wheel in the display while keeping the shift key pressed, you move the display to the left or right.
- If you activate the mouse wheel in the display while keeping the Ctrl key pressed, you increase/reduce the size of the display at the position of the mouse pointer.

Signal tables

The signal tables list the signals of the selected measurement and provides setting options for some properties. The area of the signal tables is divided into the tabs "Measurements", "Signals" and "Calculated signal".

Settings and displays in the "Signals" tab

The following figure shows the signal table of the "Signals" tab.

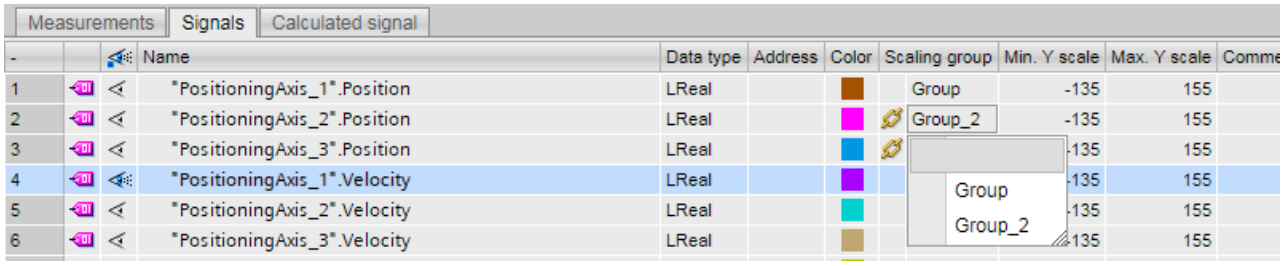

Figure 3-131 Display in the "Signals" tab

The following table shows the settings and displays of the recorded signals of the "Signals" tab:

Column	Description
Signal or error symbol	
	Signal symbol
	Symbol for calculated signals (formulas)
	Selection for the display in the trend diagram
	The point indicates that at least one bit has been selected for display as bit trace for the signal in the bit selection.
Signal number	Automatically generated number of the signal The signal can be accessed via the signal number in the formulas.
Name	Display of the signal name A click on the name of a displayed signal updates the scale in the trend diagram.

Column	Description
▸	Open bit selection Individual bits can also be selected for the following data types for display as a bit trace in the lower trend diagram: • Byte, Word, DWord, LWord • SInt, USInt, Int, UInt, DInt, UDInt, LInt, ULInt Example of an opened bit selection for the DWORD data type: 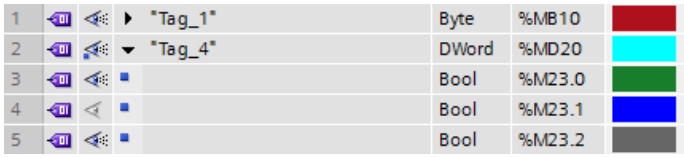 Select or deselect the relevant bit for display by clicking the icon.
Data type	Display of the data type
Address	Display of the address of the signal The field remains empty with optimized / type correct tags.
Color	Display and setting option for the color of the signal
Signal group	Display or input of the signal group name for one signal group. The Y-scales are scaled identically for all signals of one signal group. Enter an identical signal group name for those signals that you want to scale identically. To remove signals from a signal group: • Delete the signal group name. • Click the empty entry in the shortcut menu of the signal group. Note that you cannot group binary signals.
Gray field for the chain icon of the signal group	To add or delete the signal from a signal group, move the mouse pointer over the grey field or the chain icon (or), Clicking the chain icon adds the signal to a signal group or creates a new signal group. Clicking the chain icon removes the signal from the signal group. For a selected signal with signal group, the chain icon displays all signals of the same signal group.
Input field of the signal group	The input field displays the signal group name. As an alternative to the chain icon, you can assign or delete a group name via text input in this field.
Min. Y-scale	Display or input of the minimum value for the scaling of the signal.
Max. Y-scale	Display or input of the maximum value for the scaling of the signal.
Comment	Display and input option for a comment about the signal
Y(t1)	Display of the value at the position of the first measuring cursor
Y(t2)	Display of the value at the position of the second measuring cursor
ΔY	Display of the value difference between the first and the second measuring cursor

The following table shows the possible Web server shortcut menu commands of the "Signals" tab:

Table 3-51 Web server shortcut menu commands of the "Signals" tab

Shortcut menu command	Description
"Scale Y automatically"	Automatic scaling of the selected signal in the Y direction.
"Show signal"	Shows the signal in the trend diagram
"Hide signal"	Hides the signal in the trend diagram
"Show all bits"	Shows all the bits of a signal
"Hide all bits"	Hides all the bits of a signal

Shortcut menu command	Description
"Use for determined signal"	Calculates a new signal based on the selected real signal
"Process calculated signal"	Switches the selected calculated signal to the editing mode.
"Delete calculated signal"	Deletes the selected calculated signal

Settings and displays in the "Measurements" tab

The following figure shows the display of the "Measurements" tab and the shortcut menu of the "Alignment" column of a selected measurement.

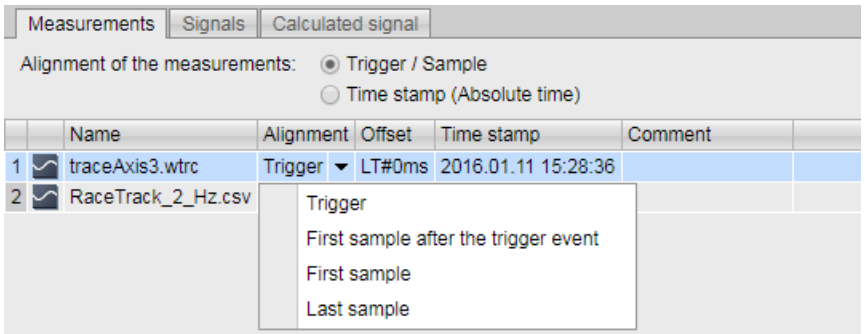

Figure 3-132 Tab "Measurements" with shortcut menu

The following table shows the settings and displays for the measurements:

Column	Description
Alignment of the measurements	
Trigger/Sample	Alignment of the measurements in accordance with the trigger or measurement point. The individual zero point for the measurement is predefined in the table under the "Alignment" column.
Time stamp (absolute time)	Alignment of the measurements in accordance with their time stamp. The signals are aligned in accordance with the time from the absolute time stamp.
Table columns	
	Static display of the measurement icon
Name	Display and change options for the name Note that the name must be unique.
Alignment	Alignment of the measurement (only adjustable with the "Trigger/Sample" check box selected). Determines the individual zero point for a measurement. All signals for the measurement are displayed in relation to this zero point. The following settings are possible: • Trigger • First sample after the trigger event • First sample • Last sampling
Offset	Offset related to the time axis Moves the measurement left or right by the offset stated on the time axis. If you enter solely a numerical value without a unit of measurement, the system automatically assigns the unit "ms" (for example 0=0ms, 100=100ms, 1000=1s, -1001=-1s 1ms , LT#2000ms=2s, LT#-3605000ms=-1h 5s , LT#-1h5s=-1h 5s)

Column	Description
Time stamp	Display of the trigger time
Comment	Display and input option for a comment about the signal
Shortcut menu commands	
"Save as WTRC"	Saves the measurement(s) as a file with the extension .csv, .wtrc (SIMOTION format for saving Trace data) or .ttrecx (TIA Portal format for saving Trace data).
"Save as CSV"	Exports a measurement as a file with the file extension .´csv. Note that the command only saves the measured data. The command does not save the diagram, snapshots, markings and calculated signals.
"Edit name"	Switches the name in editing mode
"Edit offset"	Switches the offset in editing mode
"Edit comment"	Switches the comment in editing mode
"Delete measurement"	Deletes the measurement

Settings and displays in the "Calculated signal" tab

You can use this function to calculate new signals based on real signals. The system calculates the Y-values of the signal points in the process.

To parameterize the signals to be calculated, open the "Calculated signal" tab.

In the "General" section specify the name, the data type and color of a signal to be calculated. Note that the name of the signal to be calculated must differ from the name of a real signal.

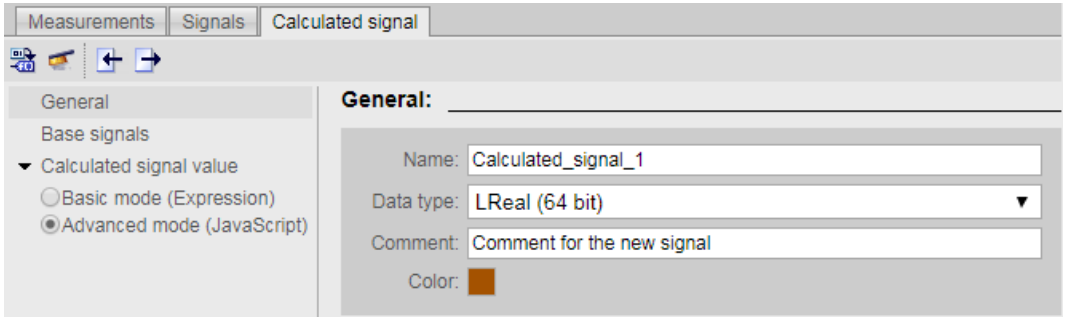

Figure 3-133 "General" section of the "Calculated signal" tab

Add the basic signals in the "Basic signals" section. The basic signals form the basis for calculating the new signal. You can change the default name of the variable in the "Name" column. You select real signals for the specification of the number of signal points to be calculated in the "Signal" column.

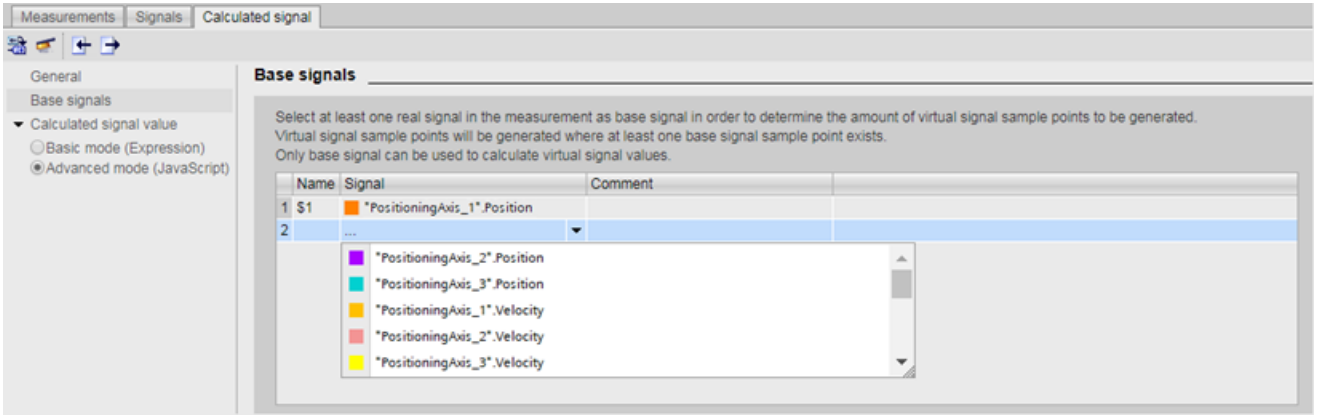

Figure 3-134 "Basic signals" section of the "Calculated signal" tab

Enter the code for the calculation of the Y values of the signal points in the "Calculated signal value" section. The section is divided into:

- Basic mode (expression)
- Advanced mode (JavaScript)

Use the JavaScript syntax to enter the code for both modes. Take into account, however, that not the full JavaScript functionality is supported.

Basic mode (expression)

In this mode you use the following to create your code:

- Standardized JavaScript expressions and operators (for example +, -, /, *, %, ~, &, |, ?, !)
- Standardized math libraries
- The tag names specified under "Basic signals"
  (the system writes the Y-value directly to the tag name)

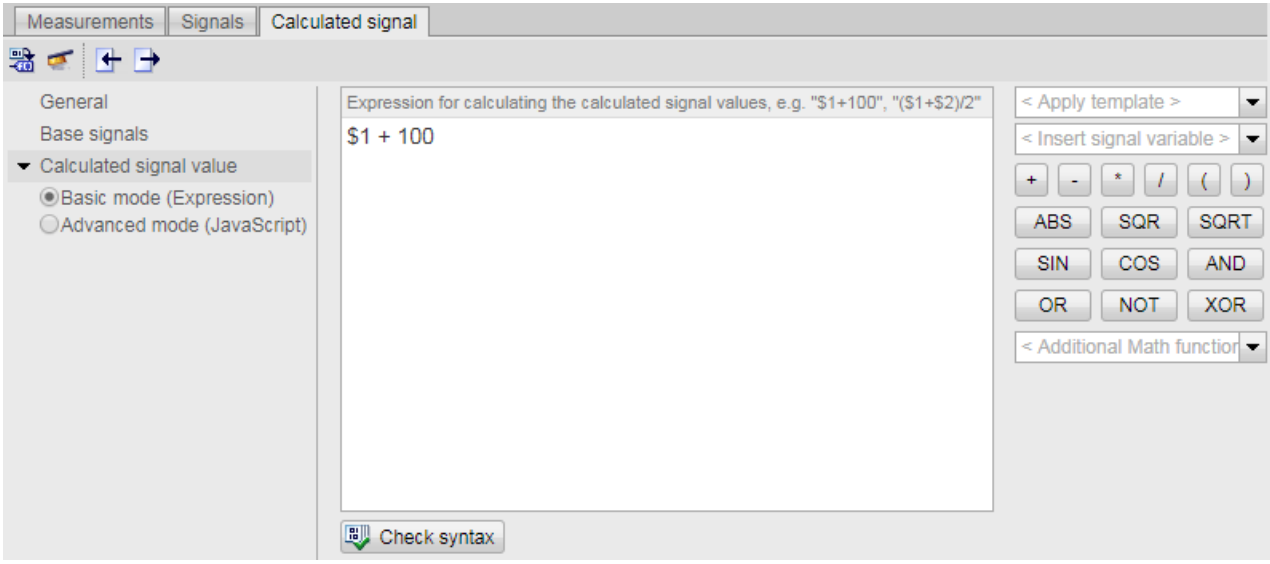

Figure 3-135 Basic mode (expression)

Advanced mode (JavaScript)

This mode offers you an advanced functional scope for the calculation of the Y value by means of a complex JavaScript code. You can, for example, specify own static tags for the iteration of code sections:

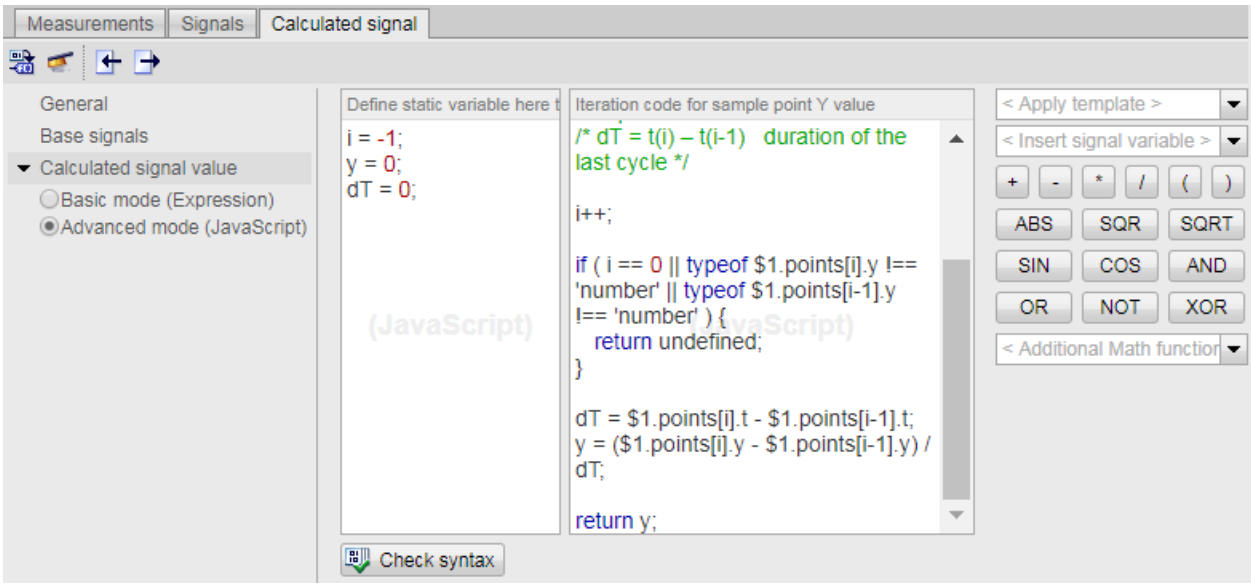

Figure 3-136 Advanced mode (JavaScript)

The following table shows all the elements that you can use for your code:

Reserved words (case-sensitive)						
if	var	Math	Array	catch	typeof	unescape
encodeURI	in	for	else	break	escape	delete
Infinity	decodeURI	do	Date	case	false	String

Object	continue	parseFloat	new	case	true	while
return	Number	parseInt	try	null	isNaN	throw
switch	default	undefined				
Operators						
%	-	*=	!=	<=	|=	&&
!==	+	--	/	>	=	||
^	===	++	-=	/=	>=	==
&	~	+=	*	!	<	|
&=	?					
Delimiters						
(	)	{	}	[	]	.
,	:	;				
Comments						
/*	*/					

Every signal point consists of the following attributes:

1. x (measuring point)
2. t (relative ^time in milliseconds)
3. y (Y value)
4. points (number of signal points that are available for the calculation of a new signal)

In "Advanced Mode (JavaScript)" you can access all four attributes (e.g. "$1.y", "$1.t", "$1.x", $1.points[i].y, ...).

The following function tables support you in writing expressions or complex code in JavaScript. The function table contains the functions used most often:

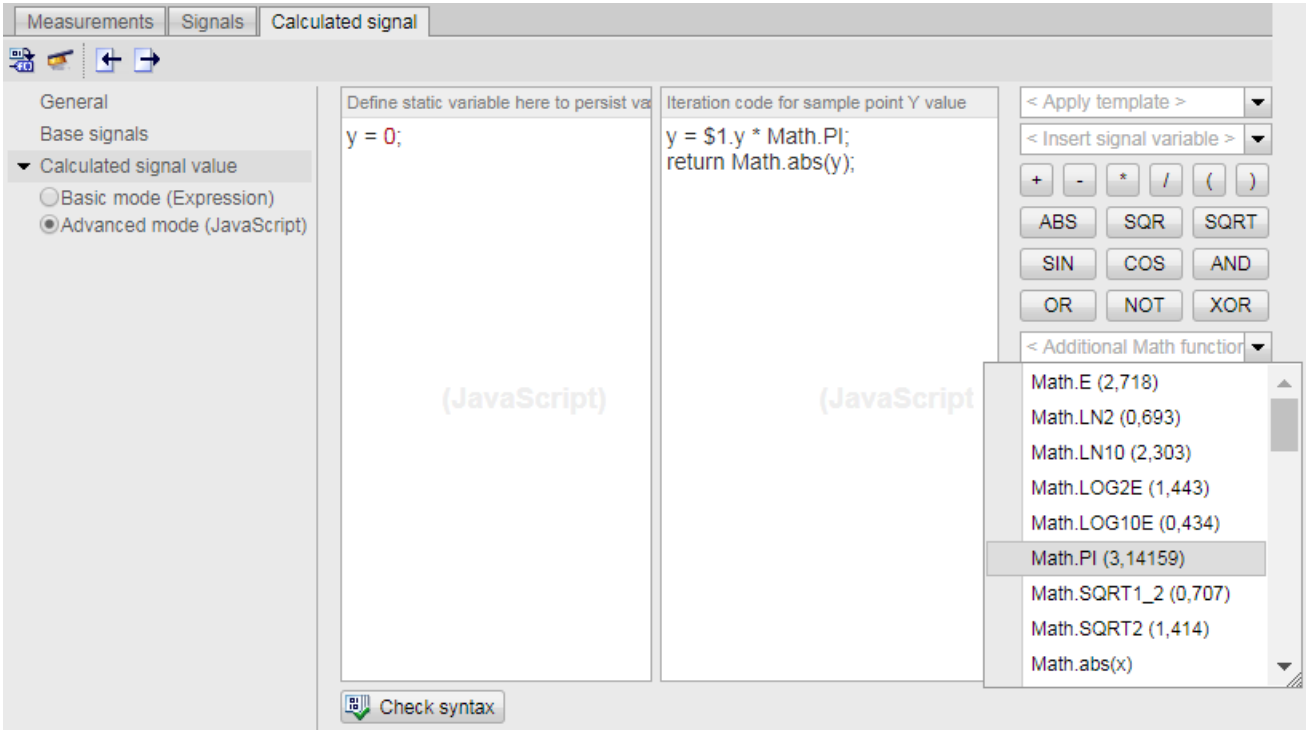

Figure 3-137 "Calculated signal" tab with function table

You can also generate the JavaScript code of a real signal from the "Signals" tab. Alternatively, you can also select one of predefined templates of the function table, change the code and generate a calculated signal.

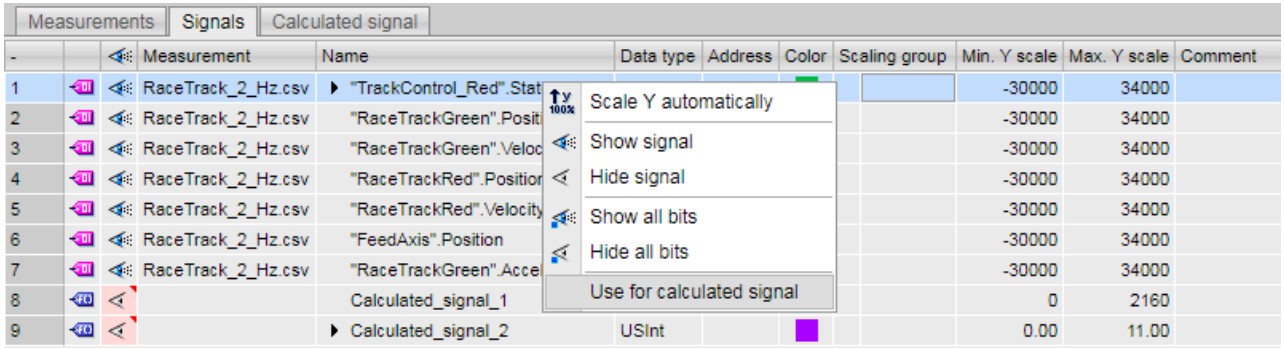

Figure 3-138 Real signals of the "Signals" tab

The following templates are available in the function table:

- Numerical differentiation
- Numerical integration
- Arithmetic mean

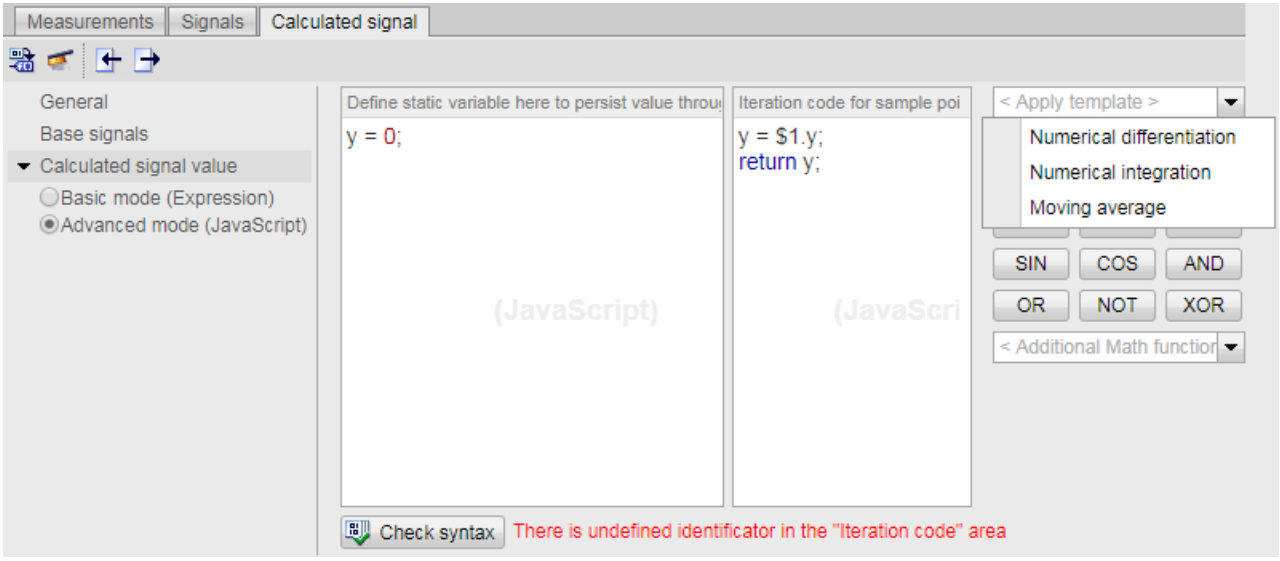

Figure 3-139 Templates

To check the syntax, click the symbol "Check syntax" or generate the signal by clicking the icon in the toolbar. If the code has any errors, these are displayed to the right of the "Check syntax" icon in red lettering. If the code does not have any errors, the "Syntax check successful" message is displayed.

How does the system calculate a new signal?

The system checks:

- Whether you have selected a basic signal for the calculation of a new signal
- The name of the signal to be calculated
- The syntax of your JavaScript code

Subsequently, the system defines the counting of the measuring points and executes the code for each measuring point to be calculated. In each iteration the system stores the measuring points of the new signal on the basis of the following four attributes:

- Measuring point
- Relative time
- Calculated Y value
- Signal point with x-, t, y-values

The course is displayed after calculation has been completed.

Example for calculating on the basis of a basic signal

You use a single basic signal to calculate the new signal. The basic signal consists of 1000 measuring points.

In this case, the system carries out your written code a thousand times. The calculated signal then consists of 1000 calculated signal points with the same x- and t-values, but with own y-values.

Import/export settings

You can import/export certain parameters (formulas, calculation method, signal type and signal name. To import parameters, click the icon in the toolbar of the "Calculated signal" tab. To export parameters, click the icon in the toolbar of the "Calculated signal" tab.

Settings and displays of the Snapshot icon

With the "Snapshot" icon in the toolbar of the trend diagram, you save the current signal course in the form of a snapshot.

To create a snapshot of the signal course click the icon. To manage the created snapshots, click the arrow on the left next to the "Snapshot" icon and select the entry "Manage snapshots".

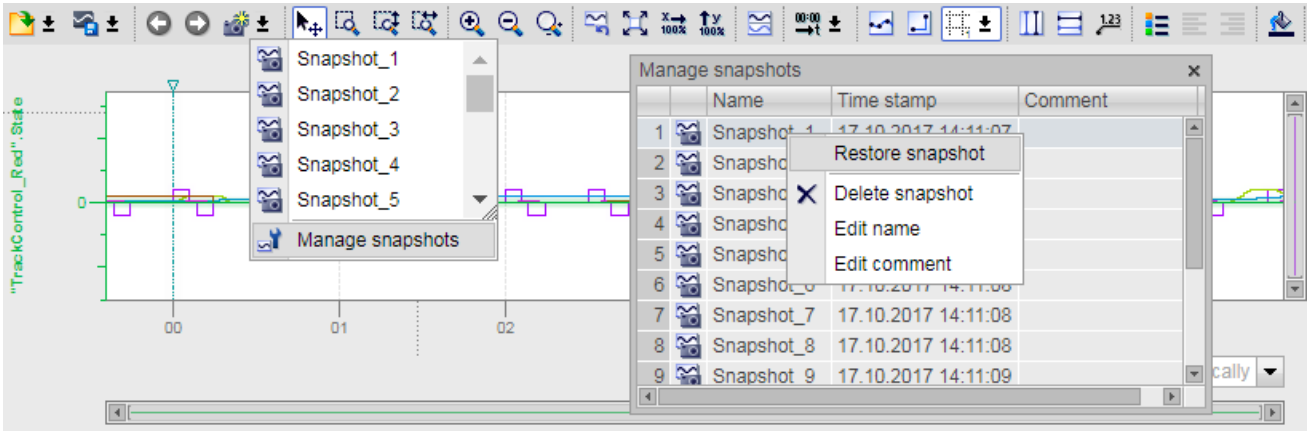

Figure 3-140 Managing snapshots

The following table shows the settings and displays of the "Managing snapshots" window.

Column	Description
	Static display of the snapshot icon
Name	Display and change options for the name
Time stamp	Display of the creation time of the snapshot
Comment	Display and input option for a comment

The following table shows the possible shortcut menu commands:

Shortcut menu command	Description
"Restore snapshot"	Shows the measurement with the saved view in the "Diagram" tab.
"Remove snapshot"	Deletes the snapshot.
"Edit name"	Switches the name in editing mode
"Edit comment"	Switches the comment in editing mode

NOTE

Delete measurement

If you delete a measurement of a calculated signal, all the associated snapshots are also deleted.

4.14 DataLogs

DataLogs

On the DataLogs web page, you can view all the DataLogs that you have created.

You can sort the DataLogs according to individual parameters in ascending or descending order.
For this purpose, click on one of the parameters in the column header:

- Name
- Size
- Changed

You can download the relevant DataLog file by clicking the file name.

The "Active" column shows whether the respective DataLog file is used (is active) or not.

When the DataLog file is active, you can call (download) and empty the relevant DataLog file by clicking the icon . The file must be closed. The empty DataLog file is still maintained in the list of DataLogs.

You delete the DataLog file by clicking the icon in the "Delete" column. The file must be closed.

You close an opened DataLog file in STEP 7 by using the "DataLogClose" instruction.

Figure 3-141 DataLogs

4.14.1 Automated reading out of DataLogs

In addition to the downloading of individual DataLogs via the user interface of the Web server, you can download, read out and archive DataLogs. Automatic downloading of DataLogs is realized either by the execution of scripts in, for example, Bash or on your HTML customer page via JavaScript.

A typical application for this functionality is the daily reading out and archiving of DataLogs from one or more CPUs at a specific time.

Calling up of the DataLogs from the SIMATIC memory card

The CPU makes a URL in the following format available so that you can download DataLogs automatically from the SIMATIC memory card of your CPU:

```
https://[ip]/DataLogs?Action=List
```

Enter the correct IP address of the interface of your CPU at this URL and use the appropriate transfer protocol (HTTP or HTTPS), for example `https://192.168.2.132/DataLogs?Action=LIST`. Subsequently call up the URL in your browser or command line interpreter.

The URL returns a list of the DataLogs on the SIMATIC memory card. Each entry returns the URL by which you download the corresponding DataLog.

For simple syntax analysis of the list by command line interpreters (such as Bash) or web-based programming languages (such as JavaScript) the individual URLs are separated by a line break `<CR><LF>`. The following example shows the syntax of two URLs that access the DataLog files `Test.txt` and `Test2.txt`:

```
/DataLogs?Path=/DataLogs/Test.txt&Action=DOWNLOAD&E=1<CR><LF>
/DataLogs?Path=/DataLogs/Test2.txt&Action=DOWNLOAD&E=1<CR><LF>
<CR><LF>
```

When the URLs are called successfully, the CPU returns the status code `200 OK`. The CPU also returns this status code if no DataLogs exist on the SIMATIC memory card.

NOTE

Access authorization to the CPU for the reading out of data

In order to download DataLogs from the CPU, the user has to dispose of reading rights on the CPU. If the user does not have the required rights, the CPU returns the status code `403 FORBIDDEN` in the HTTP Response.

Downloading of the DataLogs via Bash scripts

The following example shows how you can download DataLogs automatically from the CPU by using a Bash script. Replace the URL of the example by the correct IP address of the interface of your CPU at this URL and use the appropriate transfer protocol (HTTP or HTTPS).

```
wget --content-disposition -i
"https://192.168.2.132/DataLogs?Action=LIST"
```

Downloading of the DataLogs via JavaScript

The following example shows how you can download DataLogs automatically by using JavaScript. Replace the URL of the example by the correct IP address of the interface of your CPU at this URL and use the appropriate transfer protocol (HTTP or HTTPS).

```
<html>
 <head>
  <title>DataLog JavaScript Test</title>
  <script type="text/javascript"
src="jquery-1.12.4.min.js"></script>
 </head>
 <body>
  <h1>DataLog JavaScript Test</h1>
  <div><button id="load">Load DataLogs</button></div>
  <div><ul id="list"></ul></div>
  <script type="text/javascript">
   $('#load').click(function(){
    $.get('https://192.168.2.132/DataLogs', {'Action': 'LIST'},
     function(data){
      $('#list').empty();
      $.each(data.split(/\r\n/), function(){
       if (this.length == 0) continue;
       $('#list').append('<li><a href="https://192.168.2.132' +
        this + '">' + this + '</a></li>');
      });
     });
    });
  </script>
 </body>
</html>
```

4.15 User files

Introduction

You read and write with the instructions "FileReadC" (Compact Read Data of a File) or "FileWriteC" (Compact Write Data to a File) in STEP 7 ASCII files (files in binary format).

Requirements

You need to save the UserFiles in the "UserFiles" directory on the SIMATIC memory card. You specify the storage location in the path of the "FileReadC" or "FileWriteC" instruction.

Path and file name for UserFiles have to fulfill the following rules:

- The file name must not be longer than 55 characters.
- The following characters are permitted for the directory and file name: 0 to 9, a to z in upper- and lower-case, "-" and "_"
- The path name must not start with "/", "\" or "."
- The path name must not contain ".."

Examples:

- UserFiles\Lift16_DataBase.txt
- UserFiles\2017-04-13_ErrorLog.bin

"User files" Web page

The browser displays the content of the SIMATIC memory card, directory UserFiles\ on the "User files" Web page.

You can sort the UserFiles according to the individual parameters in ascending or descending order.
To do this, click on one of the parameters in the column header:

- Name
- Size
- Changed

You can download, delete, and upload files.

You download the UserFile by clicking the file name.

By clicking on the ✕ icon, you can delete the UserFile. The file must be closed.

Figure 3-142 User files view

NOTICE
Size UserFiles When you open a large UserFile through this Web page, the processing times of the instructions that process this file can increase notably.

4.15.1 Automatically read or upload user files

In addition to the Web server's user interface, you can automatically list, delete, download and upload UserFiles. Use JavaScript or Bash for this, for example.

Opening UserFiles from the SIMATIC memory card

The CPU makes a URL in the following format available so that you can list UserFiles automatically from the SIMATIC memory card of your CPU:

`https://[ip]/UserFiles?Action=List`

Enter the correct IP address of the interface of your CPU at this URL and use the appropriate transfer protocol (HTTP or HTTPS), e.g. `https://192.168.2.132/UserFiles?Action=LIST`. Subsequently call up the URL in your browser or command line interpreter.

The URL returns a list of the UserFiles on the SIMATIC memory card. Each entry returns the URL by which you download or delete the corresponding UserFile from the CPU. The actions to be performed are separated by a vertical line "|".

For simple syntax analysis of the list by web-based programming languages (such as JavaScript), the individual URLs are separated by a line break `<CR><LF>`. The following example shows the syntax of two URLs that access the UserFiles `File1.csv` and `File2.csv`:

```
File1.csv|/UserFiles?Name=File1.csv&Action=DOWNLOAD&E=1|/UserFiles?N-
ame=File1.csv&Action=DELETE&E=1<CR><LF>
File2.csv|/UserFiles?Name=File2.csv&Action=DOWNLOAD&E=1|/UserFiles?N-
ame=File2.csv&Action=DELETE&E=1<CR><LF>
<CR><LF>
```

When the URLs are called successfully, the CPU returns the status code `200 OK`. The CPU also returns this status code if there are no UserFiles on the SIMATIC memory card.

NOTE

Access authorization to the CPU for the reading out of data

In order to download UserFiles from the CPU, the user must have reading rights for the CPU. If the user does not have the required rights, the CPU returns the status code `403 FORBIDDEN` in the HTTP Response.

Downloading UserFiles via Bash scripts

The following example shows how you can download UserFiles automatically from the CPU using a Bash script. Replace the URL of the example by the correct IP address of the interface of your CPU at this URL and use the appropriate transfer protocol (HTTP or HTTPS).

```
wget --content-disposition -i
"https://192.168.2.132/UserFiles?Action=LIST"
```

4.16 User pages

User-defined pages

In the "User-defined pages" area of the Web server you can upload HTML pages you have created yourself for reading out data of the target system.

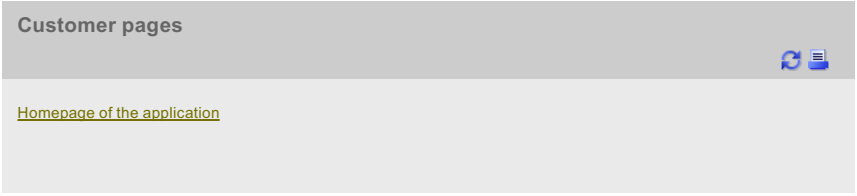

Figure 3-143 User-defined pages

You create the pages with an HTML editor of your choice from which you generate data blocks (Web control DB and Fragment DBs) in STEP 7 and download them to the CPU. The "WWW" instruction synchronizes the user program with the Web server on the CPU and initializes the Web server. With the first call of the "WWW" instruction, the link to the user page is displayed on the web page of the CPU. A click on the link opens the user page in a new window.

NOTE

Write access to user-defined pages allows the process parameters and, thus, the operation of the CPU to be influenced.
To prevent external manipulation, always assign a password for users with write access to user pages in the user management. You can find information on user management in section Configuring the Web server (Page 24) under "Amending user management".

Creating user-defined pages

To create your own user page(s), you can use TIA Portal WinCC Unified as of version V17 or any HTML editor.

Creating user-defined pages with WinCC Unified in the TIA Portal (as of version V17)

With "View of Things" (VoT), you use WinCC Unified Engineering in the TIA Portal to create web pages for a SIMATIC S7-1500 CPU, ET 200SP CPU or CPU 1513/1516pro and to map the process.

You connect to the Web server of the CPU via a web browser. You can operate the objects that you have created with WinCC Unified on the "ViewOfThings" web page.

Compared to a random HTML editor, creating and loading with WinCC Unified offers you the following advantages:

- No HTML code expertise required; the web pages can be created as screen in the WinCC Unified editor and then downloaded to the CPU.
- You can make changes to the user-defined pages while the CPU is in the RUN mode.

More information on creating, loading and operating user-defined pages with VoT as well as special features in the hardware configuration, is available in the WinCC Unified online help under the keyword "View of Things".

Requirements for creating user-defined pages with an HTML editor

- You have assigned symbolic names to the tags you want to use on your web page in STEP 7 .
- In the Inspector window under "Properties > General > Web server", you have at least:
  - Activated the Web server
  - Assigned read-only or read and write permissions to the users for user-defined pages (see section Configuring the Web server (Page 24))
- You have completed all necessary communication settings (IP address parameter, subnet mask, etc.).
- You have downloaded the configuration.
- You have created your user page in an HTML editor of your choice.

Creating user-defined pages with an HTML editor

To create your user page(s) with any HTML editor, make sure that your HTML code complies with the standards of the W3C (World Wide Web Consortium), because STEP 7 does not check the HTML syntax in any way. In addition to the simple HTML code, you can also use JavaScript commands in your user-defined pages.

Proceed as follows:

1. Create the HTML file for your user page with an HTML editor.
   To allow data from the CPU to be output on your web page, integrate the AWP commands as HTML comments (see section AWP commands (Page 131)).
2. Store the HTML file and all associated source files (e.g., *.gif, *.jpg, *.js, etc.) in a directory on your PG/PC and note the storage path.
3. Call the "WWW" instruction in STEP 7 and program it (see section Programming the WWW instruction (Page 145)).
4. Configure the user page in STEP 7 (see section Configuring user pages (Page 144)). In this way, you compile the contents of your HTML files, among other things, into data blocks.
5. Download the configuration and the user program to the CPU.
6. Open your user page with your display device by means of a web browser in the Web server of the CPU.

NOTE

Extensive HTML pages, especially those with a lot of images, take up a lot of space in the load memory. Make sure you select a SIMATIC memory card with enough storage space to provide sufficient load memory.

If the **sum of the HTML pages** > 1 MB, performance losses may occur as only 1 MB data is saved in the cache.

We recommend that you create **each individual file of an HTML page** with a size not exceeding 512 KB; otherwise, problems can occur when sending the file from the Web server to the web browser. You can view the size of the respective file in the file explorer of the directory.

Updating user-defined pages

User-defined pages are not updated automatically in the web browser. You can program the HTML code so that the pages are updated automatically.

Pages which read out data from the controller are always up-to-date due to regular updates.

NOTE

If the HTML page contains form fields for data input, automatic update can impair the correct data input by the user.

To update the entire page automatically, you can add the following instruction to the <head> area of your HTML page, whereby the number "10" stands for the update interval in seconds:

```
<meta http-equiv="refresh" content="10">
```

References

The description of a user page is available in the section Example of a user page (Page 149).

Additional help for visualization with user-defined pages is available in the application examples on the Internet:

- Creating and using your own web pages for S7-1200 (https://support.automation.siemens.com/WW/view/en/58862931)
- Creating and using your own web pages for S7-1200 / S7-1500 (https://support.industry.siemens.com/cs/de/en/view/68011496)
- Visualizing with user-defined web pages on SIMATIC CPUs with PROFINET interface (https://support.automation.siemens.com/WW/view/en/44212999)
- How do you integrate the string contents in your user-defined web page of the S7-1500 CPU as of Firmware V1.6? (https://support.industry.siemens.com/cs/ww/en/view/98754370)

You will find more information on JavaScript commands in the ECMAScript specification on the Internet (https://www.ecma-international.org/ecma-262/5.1/).

For more information about how to automatically update web pages and how to incorporate user-defined pages with relative path names, refer to the FAQ with entry ID 62543256 on the Service&Support (https://support.industry.siemens.com/cs/ww/en/view/62543256) Internet page.

4.16.1 AWP commands

Overview

Automation Web Programming (AWP) commands are a special command syntax for exchanging data between the CPU and the customer page (HTML file).

AWP commands are entered as HTML comments and offer you the following options for your customer pages:

- Reading PLC tags
- Writing PLC tags
- Reading special tags
- Writing special tags
- Defining enum types
- Assigning enum types to tags
- Defining data block fragments
- Importing data block fragments
- Accessing the values of an array
- Accessing the values of a PLC tag of the data type STRUCT

General syntax

All AWP commands, except for the command for reading a PLC tag, have this structure:

```
<!-- AWP_< command name and parameter> -->
```

Files including AWP commands:

- must be UTF-8 encoded.
  To define UTF-8 as the character set of the page, include the following line in your HTML code:
  ```
  <meta http-equiv="content-type" content="text/html; charset utf-8">
  ```

  NOTE
  Saving the HTML page
  Make sure that you save the file in the editor in UTF 8 character encoding as well.

- may not include the following sequence:]]>
- may not include the following sequence outside "read tag areas" (:="<Varname>":):
- depending on the use, must identify special characters in tag names or data block names with character escape sequences or quotation marks
- are case-sensitive
- should be additionally enclosed by JavaScript comments ("/*...*/") in JavaScript files
- must not exceed a file size of 64 KB

  To reduce the size of a file, you can subdivide the file into individual fragments (dynamic files). The maximum size of each individual fragment within the file (AWP command) is 64 KB.

Overview of AWP commands

Table 3-52 AWP commands

Function	Representation
Reading PLC tags	:=<Varname>:
Writing PLC tags	<!-- AWP_In_Variable Name='<Varname1>' -->
Reading special tags	<!-- AWP_Out_Variable Name='<Typ>:<Name>' -->
Writing special tags	<!-- AWP_In_Variable Name='<Typ>:<Name>' -->
Defining enum types	<!-- AWP_Enum_Def Name='<Name Enum-Typ>' Values='0: "<Text_1>",1:"<Text_2>",...,x:"<Text_y>"' -->
Assigning enum types to tags	<!-- AWP_Enum_Ref Name='<Varname>' Enum='<Name Enum-Typ>' -->
Defining data block fragments	<!-- AWP_Start_Fragment Name='<Name>'[Type=<Typ>] [ID=<Id>] -->
Importing data block fragments	<!-- AWP_Import_Fragment Name='<Name>' -->
Accessing the values of an array	<!-- AWP_Start_Array Name='"<DB name>".<array name>' --> ... <!-- AWP_End_Array -->
Accessing the values of a PLC tag of the data type STRUCT	<!-- AWP_Start_Struct Name='"<DB name>".<struct name>' --> ... <!-- AWP_End_Struct -->

4.16.1.1 PLC tags

Introduction to PLC tags

User pages can read PLC tags from the CPU and write data to the CPU.

To do so, PLC tags must:

- be enclosed by double quotation marks ("...").
- also be enclosed by single quotation marks ('" ... "') or with quotation marks masked with a backslash ("\" ... "\").
- be specified by a PLC tag name.
- if the PLC tag name includes the characters \ (backslash) or ', identify these characters with the escape sequence \\ or \' as normal characters of the PLC tag name.
- be enclosed with single quotation marks ('...'), if an absolute address (input, output, bit memory) is used in the AWP command.

Reading PLC tags

These out-tags (output direction as seen from the controller) are inserted at any place in the HTML text with the syntax described below.

Syntax

```
:=<Varname>:
```

<Varname> corresponds to the tag to be read from your STEP 7 project and can be a simple shared tag or a complete tag path to a structural element. Make sure that you use the name of the data block and not its number when you use data blocks.

Examples

```
:="Conveying speed":
:="My_datablock".bitmemory1:
:=%MW100:
```

Reading tags of the String and Character type

Below, these types of quotation marks are used in the explanation: single quotation marks ('), double quotation marks (").

As of firmware V1.6, with the "Read PLC tags" function, the CPU outputs tags of the String or Character type enclosed in single quotation marks to the browser.
For example:

- "Varname".MyString = ABC string tag
- You read the tag in HTML using the function :="Varname".MyString:
- The Web server outputs the character string 'ABC' to the browser

Using String or Character tags in expressions

On your HTML page, you use an expression in which the character string for reading a tag is enclosed in quotation marks, for example in forms.

Possible HTML code used:

```
<input type="text" name="appfield" value="myvalue">
```

If you read the displayed value for the "value" attribute from a PLC tag in this expression, the HTML code appears as follows:

```
<input type="text" name="appfield" value=":="Varname".MyString:">
```

By reading the PLC tag, the Web server outputs the value 'ABC'. In HTML, the code is then represented as follows:

```
<input type="text" name="appfield" value=" 'ABC' ">
```

If you have used single quotes instead of double quotes in your HTML code to enclose the attributes, the web server passes on the content of the tag enclosed in two single quotes to the browser. As a result of this, the browser does not output the content of the String or Character tag, since two consecutive single quotation marks each form a closed sequence. The values to be read are located between these sequences and are not output by the browser.

In this context, note in particular that the character string with double quotation marks is not identical to two single quotation marks even if they appear to be identical.

NOTE

The code is not adapted automatically during an update to firmware as of V1.6.
Adapt your HTML code if you have used single quotation marks to enclose attributes for the "Read PLC tags" function.

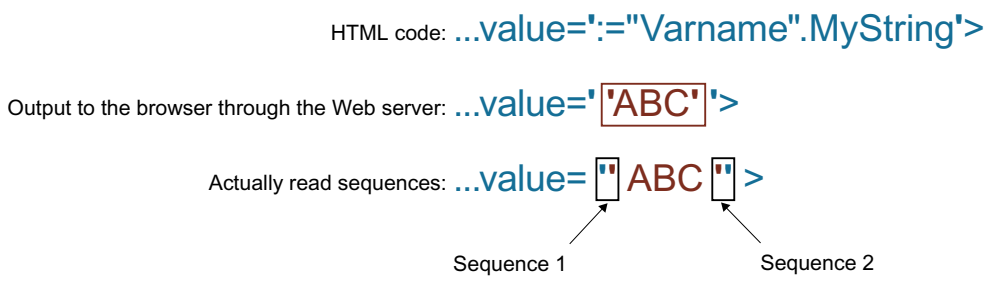

Figure 3-144 Example of HTML code with attribute in single quotation marks

Writing PLC tags

These in-tags (input direction as seen from the controller) are set on the browser page. This can take place in a form on your HTML page, for example, with text input or list selection boxes that correspond to the tags that can be written.

The tags are either set in the HTTP header (by cookie or POST method) or in the URL (GET method) by the browser in the HTTP request and are then written by the web server into the respective PLC tag.

NOTE

Write access during operation

In order for data to be written to the CPU from a user page, a user with corresponding write rights must be set up and the user must be logged in as this user. This applies to all write accesses of web pages to the CPU.

Syntax

```
<!-- AWP_In_Variable Name='"<Varname1>"' Name='"<Varname2>"'
Name='"<Varname3>"' -->
```

If the name of the tag that you are using for the web application is not identical with the name of the PLC tag, you can assign it to a PLC tag with the "Use" parameter.

```
<!-- AWP_In_Variable Name='<Varname_Webapp>' Use='<PLC_Varname>' -->
```

Examples with HTML input fields

```
<!-- AWP_In_Variable Name='"Target_Level"' -->
<form method="post">
<p>Input Target Level: <input name='"Target_Level"'
type="text"><input type="submit" value="Write to PLC"> </p>
</form>

<!-- AWP_In_Variable Name='"Data_block_1".Braking' -->
<form method="post">
<p>Braking: <input name='"Data_block_1".Braking' type="text"> <input
type="submit" value="Write to PLC"></p>
</form>
```

Example with HTML selection list

```
<!-- AWP_In_Variable Name='"Data_block_1".ManualOverrideEnable' -->
<form method="post">
<select name='"Data_block_1".ManualOverrideEnable'>
<option value=1>Yes</option>
<option value=0>No</option>
</select><input type="submit" value="submit setting"> </form>
```

4.16.1.2 Special tags

Special tags

The special tags are mainly the so-called HTTP tags that are defined in the definitions of the World Wide Web Consortium (W3C). Special tags are also used for cookies and server tags.

Reading special tags

The Web server can read PLC tags and pass them to special tags in the HTTP response header. You can, for example, read out a path name from a PLC tag to redirect the URL to another storage location with the special tag "HEADER:Storage location".

Syntax

```
<!-- AWP_Out_Varible Name='<Type>:<Name>' Use='<Varname>' -->
```

<Type> corresponds to the type of the special tag.
Options are:

- HEADER
- COOKIE_VALUE
- COOKIE_EXPIRES

<Name> corresponds to the name of the HEADER tag or the cookie:

- HEADER tags:
  - Status: HTTP status code (if no other value is set, status code 302 is returned).
  - Location: Path for redirection to another page. Status code 302 must be set.
  - Retry-After: Time for which the service is most likely not available. Status code 503 must be set.
- COOKIE_VALUE:name: Value of the named cookies.
- COOKIE_EXPIRES:name: Delay time of the named cookie in seconds.

Examples

The HTTP HEADER tag is written to the PLC tag of the same name:

```
<!-- AWP_Out_Variable Name='"HEADER:Status"' -->
```

If the name of the special tag is not identical with the name of the PLC tag, you can assign it to a PLC tag with the "Use" parameter:

```
<!-- AWP_Out_Variable Name='"HEADER:Status"' Use='"Status"' -->
```

Writing special tags

The Web server allows you to write values of special tags written in the HTTP header to the CPU. In STEP 7, for example, you can store information on the cookie of a user-defined page, or on the user accessing a page.

Syntax

```
<!-- AWP_In_Variable Name='<Type>:<Name>' Use='Varname' -->
```

<Type> corresponds to the type of the special tag.
Options are:

- HEADER
- SERVER
- COOKIE_VALUE

<Name> corresponds to the name of the HEADER tag or the cookie:

- HEADER tags:
  - Accept-Language: Accepted or preferred language
  - User-Agent: Browser information
  - Authorization: Credentials for a requested resource
- SERVER tags:
  - current_user_id: Indicates whether a user is logged in:
    current_user_id=0: No user is logged on / user "Everybody" or "Anonymous" has access.
    current_user_id=1: At least one user is logged on.
  - current_user_name: User name of the logged-on user
- COOKIE_VALUE:name: Value of the named cookies.

Examples

The HTTP SERVER tag is written to the PLC tag of the same name:

```
<!-- AWP_In_Variable Name='"SERVER:current_user_id"' -->
```

The HTTP SERVER tag is written to the PLC tag "My_User ID":

```
<!-- AWP_In_Variable Name='"SERVER:current_user_id"'
Use='"My_User-ID"' -->
```

4.16.1.3 Enum types

Enumeration types (enum types)

Enum types convert numerical values from the PLC program into texts or vice versa. The numerical values may also be assigned for use with several languages.

Define enum types

You can define enum types in your user pages and assign the values in an AWP command.

Syntax

```
<!-- AWP_Enum_Def Name='<Name Enum-Typ>' Values='0:"<Text_1>",
1:"<Text_2>",...,x:"<Text_y>"' -->
```

Examples

To store German values as HTML file in the "de" folder of the HTML directory:

```
<!-- AWP_Enum_Def Name="Enum1" Values='0:"an", 1:"aus", 2:"Störung"'
-->
```

To store English values as HTML file in the "en" folder of the HTML directory:

```
<!-- AWP_Enum_Def Name="Enum1" Values='0:"on", 1:"off", 2:"error"'
-->
```

Assigning enum types to tags

The assignment of tags from the user program to the individual enum types takes place by means of a separate AWP command. The used tag can be used at a different location of the user pages in a read operation or in a write operation.

During a read operation, the web server replaces the value read from the CPU with the correspondingly defined enum text value. During a write operation, the web server replaces the defined enum text value with the corresponding integer value of the enumeration before the value is written to the CPU.

Syntax

```
<!-- AWP_Enum_Ref Name='<Varname>' Enum="<Enum-Type>" -->
```

<Varname> is the symbolic tag name from the user program, <Enum-Type> of the previously defined name of the enum type.

Example for a declaration

```
<!-- AWP_Enum_Ref Name='"Alarm"' Enum="AlarmEnum" -->
```

Example of how to use when reading a tag

```
<!-- AWP_Enum_Def Name='AlarmEnum' Values='0:"No Alarm", 1:"Vessel
is full", 2:"Vessel is empty"' -->
<!-- AWP_Enum_Ref Name='"Alarm"' Enum="AlarmEnum" -->
...
<p> The current value of "Alarm" is :="Alarm": </p>
```

If the value of "Alarm" in the CPU is 2, the HTML page shows 'The current value of "Alarm" is container is empty' because the definition of the enum type assigns the numerical value 2 to the character sequence "Container is empty".

Example of how to use when writing a tag

```
<!-- AWP_Enum_Def Name='AlarmEnum' Values='0:"No Alarm", 1:"Vessel
is full", 2:"Vessel is empty"' -->
<!-- AWP_In_Variable Name='"Alarm"' -->
<!-- AWP_Enum_Ref Name='"Alarm"' Enum="AlarmEnum" -->
...
<form method="post">
<p><input type="hidden" name ='"Alarm"' value='Vessel is full'
/></p>
<p><input type="submit" value='Set vessel is full' /></p>
</form>
```

The value 1 is written to the PLC tag "Alarm" because the definition of the enum type assigns the numerical value 1 the text "Container is full".

Note that the name specified in "AWP_In_Variable" must be exactly the same as the name specified in "AWP_Enum_Ref".

4.16.1.4 Fragments

Fragments

Fragments are "logical sections" of a web page to be processed by the CPU individually.

Fragments are usually entire pages, but they can be individual elements, such as files (e.g. images) or documents.

NOTE

In each fragment in which enum texts are referenced by a PLC tag, this PLC tag must be assigned to the enum type name with the appropriate AWP command.

Defining fragments

A fragment extends to the beginning of the next fragment or to the end of the file.

Syntax

```
<!-- AWP_Start_Fragment Name='<Name>' [Type="<Typ>"] [ID="<Id>"]
[Mode="<Mode>"] -->
```

This command specifies the start of a fragment.

- <Name> Specifies the name of the fragment. The name must start with a letter [a-zA-Z] or an underscore (_). This first character can be followed by letters, underscores or numbers [0-9].
- <Type> Specifies the type of the fragment.
  - "automatic": The page is edited automatically (default)
  - "manual": Do not use this fragment type. Use the preset fragment type "automatic".
- <Id> You can specify a numerical ID for the fragment. If no ID is assigned, the fragment is automatically assigned an ID. For manual pages (<Type>=manual), the fragment can be addressed with this ID in the user program of the CPU.

  NOTE
  ID assignment
  Set the ID as low as possible because the highest ID influences the size of the Web control DB.

- <Mode>
  - "visible": The contents of the fragment are displayed on the user page (default).
  - "hidden": The contents of the fragment are **not** displayed on the user page.

Importing fragments

You can specify a fragment in an HTML page and import this fragment into other websites.

NOTE

Ensure that no AWP command for importing fragments is positioned between an enum assignment and enum usage, because this import can result in the enum assignment being located in a different fragment than the enum usage.

Example

A company logo is to be displayed on all websites of a web application.

The HTML code for the fragment that displays the company logo exists only once. You can import the fragment as many times and into as many HTML files as required.

Syntax

```
<!-- AWP_Import_Fragment Name='<Name>' -->
```

<Name> corresponds to the name of the fragment to be imported.

Example

HTML code within a web page that creates a fragment for displaying an image:

```
<!-- AWP_Start_Fragment Name='Mein_Firmenlogo' -->
<p><img src="CompanyLogo.jpg"></p>
```

HTML code that imports the created fragment into another web page:

```
<!-- AWP_Import_Fragment Name='My_Company_Logo' -->
```

4.16.1.5 Arrays

Arrays

The Web server provides the user program commands AWP_Start_Array and AWP_End_Array for accessing all values of an array.

Only one-dimensional arrays are supported.

Multidimensional arrays of the form array[x][y] are not supported.

Syntax

```
<!-- AWP_Start_Array Name='"<DB name>".<array name>' -->
... Content of the array, utilized keywords: ArrayIndex and value..
<!-- AWP_End_Array -->
```

Parameter

- <Name> defines the name of the array with the elements you want to access.
  - You require the DB name and the name of the array corresponding to the data block structure defined in STEP 7.
  - The name must be within single or double quotation marks.
  - The DB name is within double quotation marks.
- <ArrayIndex> Index of an array element
- <value> Value of an array element

Example

The example reads all elements of the "MyArray" structure in the "DB_Name" data block of the CPU and displays the index and the values of the tags on the user-defined web page.

DB_Name

		Name	Data type	Start value
1		Static		
2		myArray	Array [0..2] of Int	
3		myArray[0]	Int	42
4		myArray[1]	Int	43
5		myArray[2]	Int	44

```
<!-- AWP_Start_Array Name='"DB_Name".MyArray' -->
Index: :=ArrayIndex: Value: :=value:
<!-- AWP_End_Array -->
```

The code indicated above generates the following display:

Index: 1 Value: 42

Index: 2 Value: 43

Index: 3 Value: 44

Representation of arrays of the BOOL data type

The output of arrays of the BOOL type is always filled to the next full 8 bits. This particular feature only occurs with BOOL arrays.

Example:

```
"DB_1".bitArray is a BOOL array with 5 elements.
<!-- AWP_Start_Array Name='"DB_1".bitArray' -->
:=ArrayIndex: -> :=value:
<!-- AWP_End_Array -->
```

Edition:

0 -> Value from "DB_1".bitArray[0]

1 -> Value from "DB_1".bitArray[1]

2 -> Value from "DB_1".bitArray[2]

3 -> Value from "DB_1".bitArray[3]

4 -> Value from "DB_1".bitArray[4]

5 -> 0

6 -> 0

7 -> 0

4.16.1.6 Structures

Structures

The web server provides AWP commands for accessing structures in order to access the values of a PLC tag of the data type STRUCT.

Syntax

```
<!-- AWP_Start_Struct Name='"<DB name>".<struct name>' -->
... Content of structure ...
<!-- AWP_End_Struct -->
```

Parameter

- <Name> defines the name of the structure with the elements you want to access.
  - You require the DB name and the name of the structure corresponding to the data block structure defined in STEP 7.
  - The name must be within single or double quotation marks.
  - The DB name is within double quotation marks.

Example

The example reads elements of the "MyStruct" structure in the "DB_Name" data blocks of the CPU and displays the value of the tag on the user-defined web page.

DB_Name1

	Name	Data type	Start value
1	Static		
2	myStruct	Struct	
3	A	Int	0
4	B	Word	16#0
5	C	Bool	false

```
<!-- AWP_Start_Struct Name='"DB_Name".MyStruct' -->
:=A:
:=B:
:=C:
<!-- AWP_End_Struct -->
```

The code indicated above corresponds to the following commands:

```
:="DB_Name".MyStruct.A:
:="DB_Name".MyStruct.B:
:="DB_Name".MyStruct.C:
```

4.16.2 Configuring user pages

Configuring customer pages

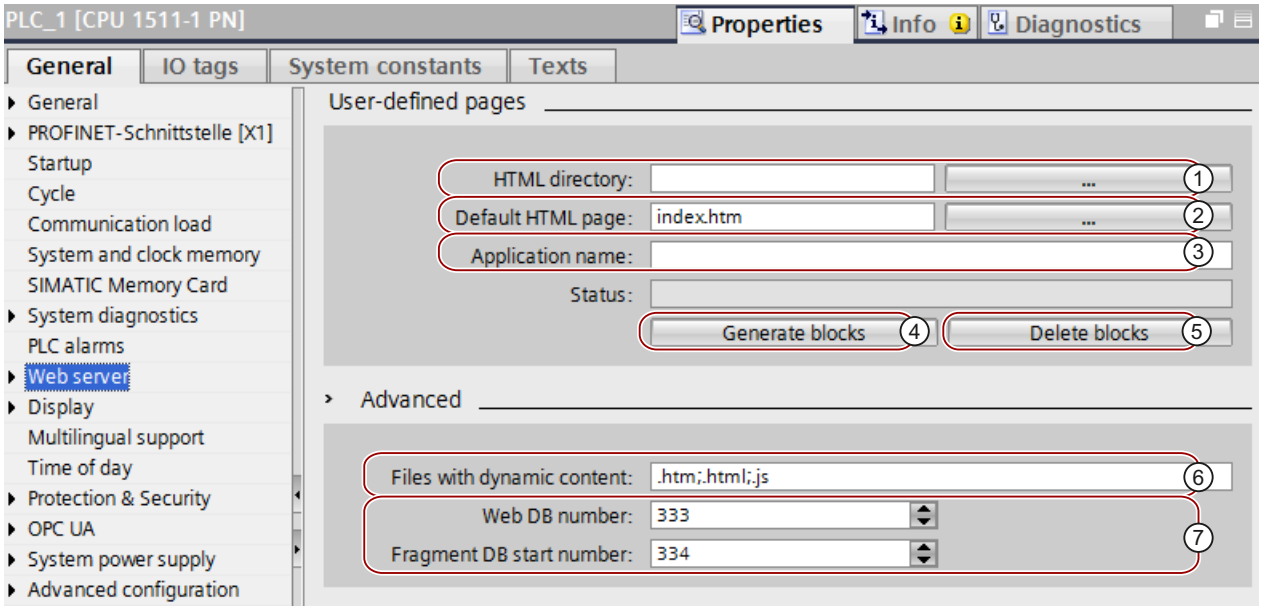

Figure 3-145 Configuring customer pages in STEP 7

To configure the customer pages in STEP 7, follow these steps:

1. Select the CPU in the device configuration.
2. Open the settings in the Inspector window of the CPU under "Properties > General > Web server".
3. Select the folder on your display device in which you have saved your HTML page in the "Customer pages" area under ① "HTML directory".
4. Enter the name of the HTML page under ② "Default HTML page" that is to open when you start the application.
5. You can also specify a name for your application under ③ "Application name". This name is used to further divide or group the webpages. If an application name already exists, the URL is displayed in the following format: https://a.b.c.d/awp/<Application name>/<Page name>.html
6. In the "Extended" area, enter the file extensions that have to be checked for AWP commands in input box ⑥ "Files with dynamic contents". By default, STEP 7 analyses files with the extensions "htm" and "html". Here you can enter other file extensions that you have used when creating your customer page.
7. You can accept the number for the Web DB ⑦ and the fragment DB start number ⑦ or you can assign a new number of your choice that is not assigned.

8. Click the button ④ "Create blocks" to create data blocks from the source files. The generated data blocks are stored in the STEP 7 project tree in the folder "System blocks > Web server". These data blocks consist of a control data block (Web control DB) that controls the display of the webpages and one or several data block fragments (fragment DBs) with the compiled webpages.
9. In the network view, select the CPU to be loaded and then select the "Download to device" command in the "Online" menu to download the blocks. The compilation of the blocks is implicitly triggered before the download. If errors are signaled during this process, they must be remedied before you can download the configuration.

Deleting data blocks

Click the "Delete blocks" button ⑤ to delete previously generated data blocks. STEP 7 deletes the Web Control DB and all fragment DBs from the project in which your customer pages are located.

4.16.3 Programming the WWW instruction

The WWW instruction

The instruction WWW initializes the Web server of the CPU or synchronizes the user-defined pages with the user program in the CPU. The Web Control DB is the input parameter for the WWW instruction and specifies the content of the pages as they are displayed in the fragment DBs, as well as the status and control information. STEP 7 creates the Web-Control DB when you click on the "Generate blocks" button.

NOTE

DB number of the web control DB.

If you change the DB number of the DB 333, the user pages in the Web server can no longer be reached at renewed downloading into the CPU. Error code W#16#007F is output at the parameter RET_VAL. Therefore observe the default setting DB 333 for the Web Control DB.

If you want to change the DB number nevertheless, you have to switch the CPU POWER-OFF → POWER ON, so that the user pages in the Web server can be reached.

NOTE

Calling the WWW instruction

You have created your user page in an HTML editor of your choice.

- Use automatic HTML pages if you want to **deactivate** control of the page layout by means of the user program (requires at least one call of SFC 99) Operating mode changes from RUN to STOP do not affect the call of the user-defined pages.
- Use manual HTML pages if you want to **enable** control of the page layout by means of the user program (cyclic call of SFC 99 required).

Programming the WWW instruction

The user program must execute the WWW instruction in order that the user-defined pages can be called in the Web server.

Table 3-53 WWW instruction

LAD/FBD	SCL	Description
	ret_val :=WWW(ctrl_db:=uint_in_);	Access to user pages by means of the Web server

Parameters

The following table shows the parameters of the WWW instruction.

Table 3-54 Parameters

Parameters	Declaration	Data type	Description
CTRL_DB	Input	DB_WWW	Data block that describes the user pages (Web control DB)
RET_VAL	Output	INT	Error information

RET_VAL parameter

Table 3-55 RET_VAL

Error code (W#16#...)	Explanation
0000	No error has occurred. There are no pending website requests that must be released by the user program.
00xy	x: Indicates whether an error occurred during initialization of the Web Control DB (CTRL_DB): x=0: No errors occurred. x=1: Error(s) occurred. The error is encoded in the byte "CTRL_DB.last_error" of the Web Control DB. y: Number of the pending request. Several requests are possible (e.g., request "0" and "1" are pending: y="3"). y="1": Request "0" y="2": Request "1" y="4": Request "2" y="8": Request "3"
803A	The specified Web Control DB does not exist on the CPU.
8081	Incorrect version or incorrect format of the Web Control DB.
80C1	There are no resources available to initialize the web application.

4.16.4 Defining the user page as start page

Defining the customer page as start page

In addition to the default introduction page, you can also define the start page of your customer pages as the start page of the Web server.

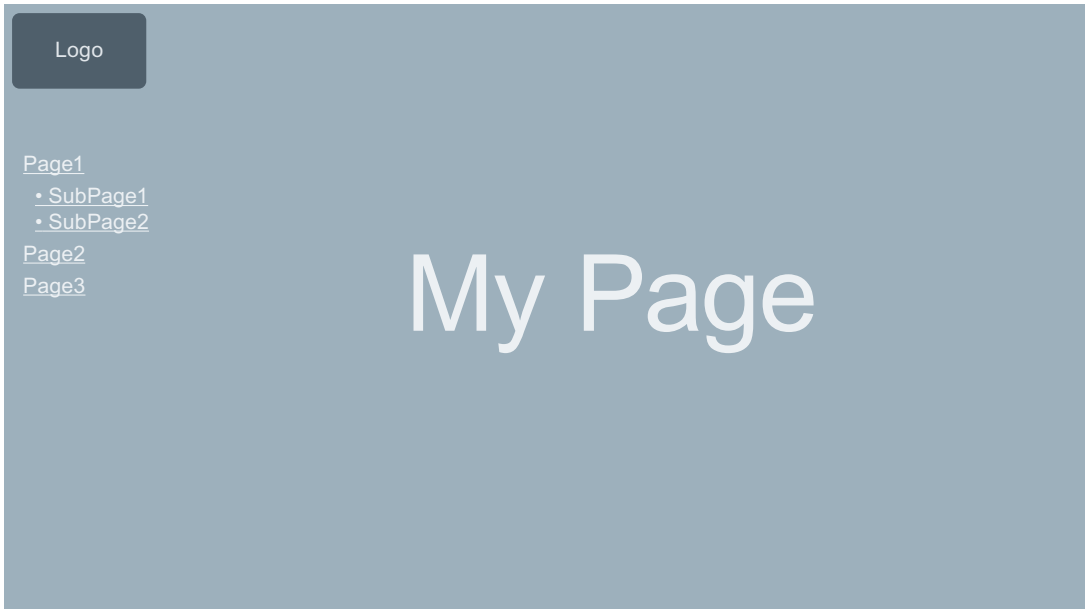

Figure 3-146 Example of customer page as start page of the Web server

Requirements

The following requirements must be met before the customer page is displayed as the start page of the Web server:

- You have configured the customer page as the start page.
- You have configured a user in STEP 7 whom you have assigned at least the authorization "... open customer web pages".
- The CPU is in RUN mode.

Procedure

To define the customer pages in STEP 7 as the start page of the Web server, proceed as follows:

1. Select the CPU in the device configuration.
2. Open the settings in the Inspector window of the CPU under "Properties > General > Web server".

3. Select the entry "AWP1" in the area "Entry page" under "Select entry page".

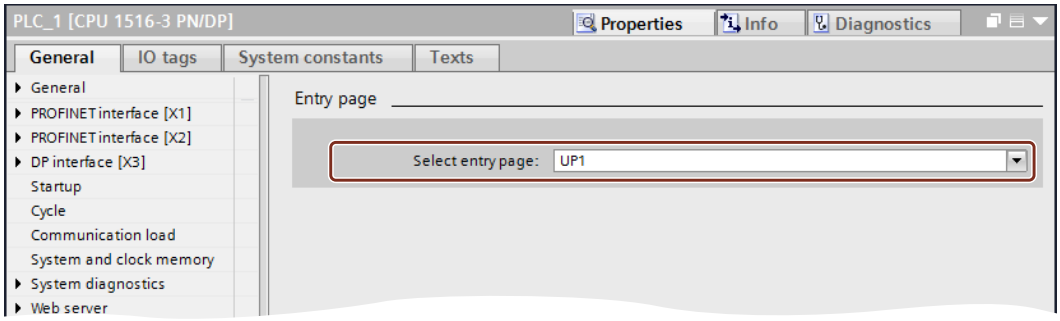

Figure 3-147 Set customer page as start page in STEP 7

4. Download the configuration to the CPU.

If you now enter the IP address of the CPU in the browser, a connection is automatically established to your customer pages.

If you want to access the web pages of the CPU again, link the web pages from your customer pages, e.g. via the URL "https://a.b.c.d./Portal/Portal.mwsl?PriNav=Start" or "https://a.b.c.d/Portal/Portal.mwsl?PriNav=Start". The specification "a.b.c.d" is an example of the IP address of the configured CPU.

Example of link in HTML:

```
<a href="/Portal/Portal.mwsl?PriNav=Start">SIMATIC web pages</a>
```

Reading out service data

If you define your customer page as start page of the Web server, all direct access to the web pages for reading out the service data is also disabled.
If you want to continue to read out service data via the Web server when servicing is required, here is how you can link the service data page directly to your customer page.
Just as for the web pages of the CPU, link the service data page, e.g. via the URL "https://a.b.c.d/save_service_data" or "https://a.b.c.d/save_service_data", the "a.b.c.d" here is an example of the IP address of the configured CPU.

Example of link in HTML:

```
<a href="/save_service_data">Service data</a>
```

Reference

You can find additional information on the topic of customer page as start page in the FAQ with entry ID 67184104 on the Service&Support (https://support.industry.siemens.com/cs/ww/en/view/67184104) Internet page.

4.16.5 Example of a user page

4.16.5.1 Website for monitoring and controlling a wind turbine

Example of a user page

Here you see a user page for monitoring and controlling a wind turbine:

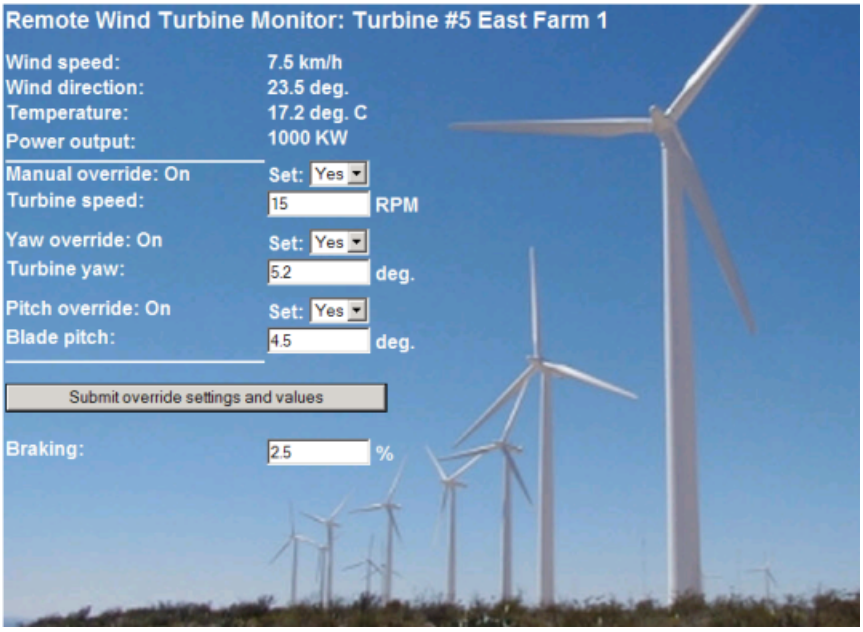

Figure 3-148 Overview of user page wind turbine

The user page was created in English in this example, but you can select any language you wish when you create your own user page.

In this application, each wind turbine of the wind farm in STEP 7 has a data block with specific data for the respective location and respective turbine.

The user page gives you the option to access the turbine remotely with a display device. Users can call the standard web pages of a CPU of a specific wind turbine and switch to the user page "Remote Wind Turbine Monitor", where they can view the turbine data. A user with the corresponding access permissions can also set the turbine into the manually controlled mode and thus control the tags for speed, orientation and angle of attack of the turbine by means of the website. The user can also specify a brake value regardless of manual or automatic control of the turbine.

STEP 7 checks the Boolean values for override of the automatic control and, if set, uses the values for speed, orientation and angle of attack of the turbine as defined by the user.

Files used

Three files are used in the application example:

- Wind_turbine.html: The user page in the figure shown above. The control data is accessed by AWP commands.
- Wind_turbine.css: The Cascading Style Sheet which includes the formatting specifications of the user page. The use is optional but can simplify the design of the user page.
- Wind_turbine.jpg: The background image displayed on the user page. The use of images is optional, user pages with lots of images require a lot more memory in the load memory.

These files are not part of your installation but they are described as an example below.

Implementation

The user page uses AWP commands to read out values from the CPU as well as writing values to it. The user page also uses AWP commands for the definition of enum types, such as the assignment of tags to enum types for handling the ON/OFF settings.

The user page is structured as follows:

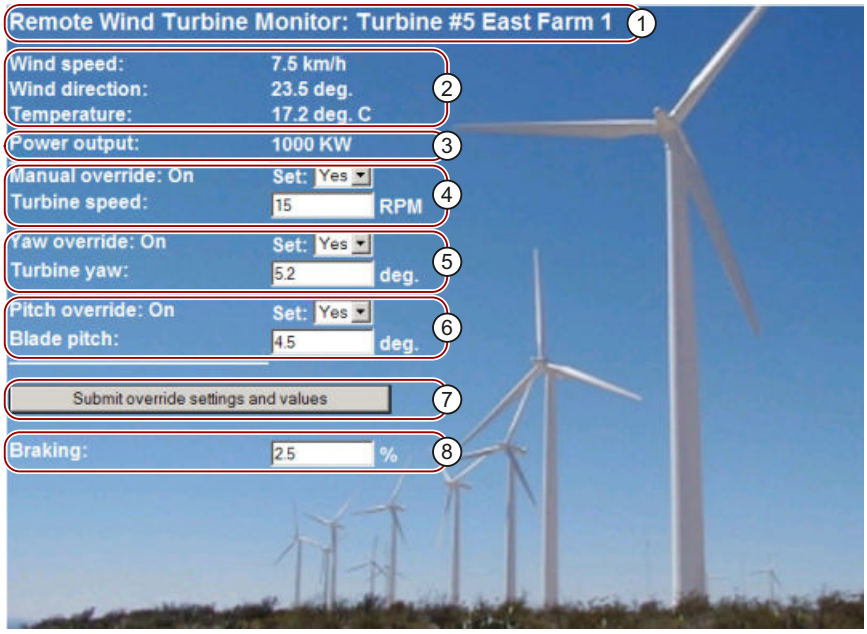

① Header of the website with number and location of the wind turbine.

② Atmospheric conditions at the turbine, wind speed, wind direction and current temperature are displayed.

③ Read-out power output.

④ Manual override: Activates manual override of the turbine. To make manual settings for speed, orientation and angle of attack, the STEP 7 user program requires that manual override has been activated.

⑤ Override of the orientation: Activates manual override of the turbine orientation.

⑥ Override of the angle of attack: Activates manual override of the angle of attack of the rotor blades.

⑦ By clicking this button, you transfer the override settings to the CPU.

⑧ Manual setting of a percentage value for braking. The setting "Manual override" is not required to enter a brake value.

Figure 3-149 Overview of user page wind turbine

In addition, the user page uses an AWP command that writes the special tag to the tag table. The tag table contains the ID of the user who is currently accessing the page.

4.16.5.2 Reading and displaying data from the CPU

Example of HTML code for reading and displaying data from the CPU

This part of the HTML code is used to display the power output on the user page.

On the left-hand side the "Power Output": text is displayed, on the right-hand side, the value of the tags for the power output including the unit ("KW").

The AWP command `:="Data_block_1".PowerOutput` executes the read operation. The data block is referenced here by its symbolic name and not by its number ("Data_block_1" instead of "DB1").

The code used in the example is:

```
<tr style="height:2%;">
<td>
<p>Power output:</p>
</td>
<td>
<p style="margin-bottom:5px;"> :="Data_block_1".PowerOutput: KW</p>
</td>
</tr>
```

4.16.5.3 Using enum types

Definition of enum types

The described user page uses enum types in three locations. "On" or "Off" is displayed for a Boolean value at these locations.

The enum type for "On" results in a value of 1, the enum type for "Off" results in a value of 0. The following statements from the HTML code of the user page show the declaration of an enum type with the name "OverrideStatus" and the values "0" and "1" for "Off" or "On" as well as the definition of an enum type reference from "OverrideStatus" to the tag "ManualOverrideEnable" in the data block "Data_block_1".

NOTE

Assignment of enum types

If the user page writes into a tag by using an enum type, there has to be a declaration "AWP_In_Variable" for each "AWP_Enum_Ref" declaration.

The code used in the example is:

```
<!-- AWP_In_Variable Name='"Data_block_1".ManualOverrideEnable' -->
<!-- AWP_Enum_Def Name="OverrideStatus" Values='0:"Off",1:"On"' -->
<!-- AWP_Enum_Ref Name='"Data_block_1".ManualOverrideEnable'
Enum="OverrideStatus" -->
```

The following code describes a display box for displaying the current status of "ManualOverrideEnable". A normal read command for tags is used but because of the declared and referenced enum type, the website displays the values "On" and "Off" instead of "1" and "0".

```
<td style="width:24%; border-top-style: Solid; border-top-width:
2px; border-top-color: #ffffff;">
<p>Manual override: :="Data_block_1".ManualOverrideEnable:</p>
</td>
```

The following code describes a drop-down list for changing "ManualOverrideEnable" by the user. The drop-down list consists of the "Yes" and "No" options that are assigned to the "On" or "Off" values by means of the enum type reference. If you make no selection, the status remains the same.

```
<select name='"Data_block_1".ManualOverrideEnable'>
<option value=':"Data_block_1".ManualOverrideEnable:'> </option>
<option value="On">Yes</option>
<option selected value="Off">No</option>
</select>
```

The drop-down list is included in the form on the website. The form is uploaded, when the user clicks on the "Submit override settings and values" button. If the user has selected "Yes", the value "1" is written in the tag "ManualOverrideEnable" in the "Data_block_1" data block; if the user has selected "No", the value "0" is written.

4.16.5.4 Writing user inputs into the controller

Setting options

The user page "Remote Wind Turbine Monitor" includes different AWP commands for writing data into the controller. A user with the corresponding access permissions can control the wind turbine manually, activate the override for the turbine speed and the turbine orientation as well as the angle of attack of the rotor blades with the declaration of different "AWP_In_Variable" write commands. The user can also specify floating-point numbers for turbine speed, orientation angle of attack and percentage of braking. The user page uses an HTTP command in the format "POST" to write the tags into the controller.

The code used in the example for setting the brake value is:

```
<!-- AWP_In_Variable Name='"Data_block_1"' -->
...
<tr sytle="vertical-align: top; height: 2%;">
<td style="width: 22%;"><p>Braking:</p></td>
<td>
<form method="POST">
<p><input name='"Data_block_1".Braking' size="10" type ="text">
%</p>
</form>
</td>
</tr>
```

This excerpt from the HTML code first defines a "AWP_In_Variable" for the "Data_block_1" data block which enables the user page to write any number of tags into the data block. The text "Braking:" is displayed on the left-hand side; on the right-hand side is a box in which the user can make entries for the "Braking" tag in the data block.

The user page reads out the actual braking value from the controller and displays it in the text box. A user with the corresponding access permissions can then write a brake value that controls the braking process into the data block of the CPU.

NOTE

Declaration of data blocks

If you declare an entire data block by means of a "AWP_In_Variable", each tag in the data block can be written by means of the user page. If only certain tags in the data block are to be writable, you declare this specifically using `<!-- AWP_In_Variable Name='"Data_block_1".Braking' -->`, for example.

4.16.5.5 Writing special tags

Using special tags

The user page "Remote Wind Turbine Monitor" writes the special tag "Server:current_user_id" into a tag of the CPU. The tag value contains the value "1" if a user is logged on and "0" if a user is not logged on. In this example, a user is logged on, so the tag value is set to "1". The special tag is written into the CPU by the user page and does not need a user interface.

The code used in the example is:

```
<!-- AWP_in_variable Name="SERVER:current_user_id" Use="User_ID" -->
```

4.16.5.6 HTML code of the user page "Remote Wind Turbine Monitor"

Example

You can find the complete HTML code of the sample customer page "Remote Wind Turbine Monitor" as well as the used Cascading Style Sheet (CSS) on the Internet (https://support.industry.siemens.com/cs/ww/en/view/107623221/71849346059).

4.17 Filebrowser

Requirements

Access rights must be assigned for the user in the user management.

Filebrowser

The contents of the SIMATIC memory card are displayed by the browser on the "Filebrowser" web page. This means, for example, that you can read and edit the log files generated by the CPU without having to use STEP 7.

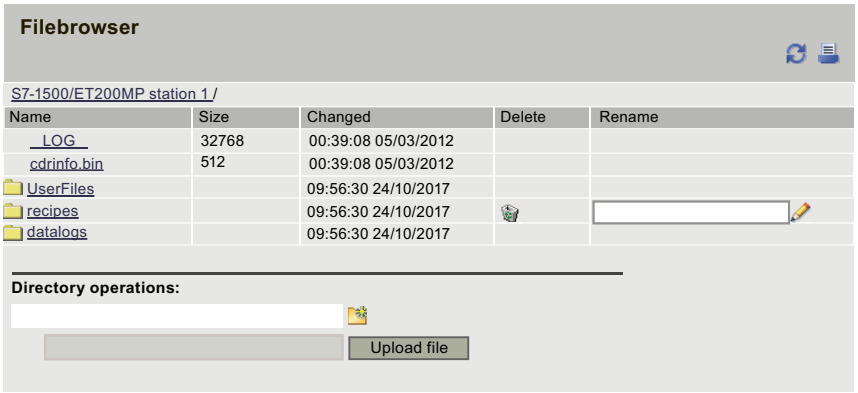

Figure 3-150 Filebrowser view

The file browser lists all existing files and directories located on the SIMATIC memory card. You can download, delete, rename and upload the files. You can create, delete and rename the directories.

NOTE

The Filebrowser only grants you read access to the “DataLogs”, "Backups" and “UserFiles” directories.

Exception system files

The system files include the job file and all special directories including their contents to which the job file refers. System files are not displayed, and cannot be changed or deleted.

4.18 Reading out service data

The Web server gives you the option to save service data. In addition to the content of the diagnostics buffer, they include more information on the internal status of the CPU. If you should encounter a problem with the CPU that cannot be resolved otherwise, you therefore have the option to submit the service data to the Service&Support team.

Procedure

1. Enter the following address in the address bar of your web browser:
   "https://<CPU IP address>/save_service_data", e.g.
   "https://192.168.3.141/save_service_data"
2. Your screen displays the service data page with a button for saving the service data.

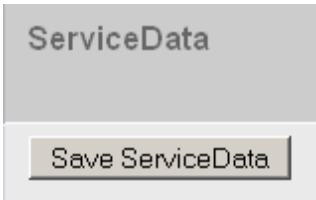

3. Save the service data locally on your display device by clicking on "Save ServiceData".

Result

The data is stored in a .dmp file with the following naming convention: "<MLFB><Serial number><Time stamp>.dmp." The user can change the file name at a later time.

NOTE

If you have defined your customer page as the start page, observe the note on reading out service data in section Defining the user page as start page (Page 147).

4.19 Basic websites

Web pages with reduced contents

Basic websites are offered for display devices with smaller screens, for example HMI, on the Web server.
Basic websites are web pages with reduced content that are adapted to the requirements of small screens with low resolution.
These sites do not support JavaScript for the sake of fast access. This means that not all standard websites are available as basic websites. The basic website can also have fewer functions than the standard website.

The switch to basic websites takes place automatically for HMI devices.
You access basic websites from other end devices by entering the IP address of the configured CPU and the extension "/basic" in the address bar of the Web browser, for example, https://192.168.3.141/basic.

The following standard websites are also available as basic websites:

- Start page (in Basic: "Status")
- Diagnostics (without the "Program protection", "Runtime information" and "Fail-safe" tabs)
- Diagnostics buffer
- Memory usage
- Module information
- Alarms (without acknowledgment option)
- Communication
- Tag status
- Watch tables
- Customer pages
- Filebrowser (read access only)
- DataLogs
- Intro

The basic websites are displayed as follows:

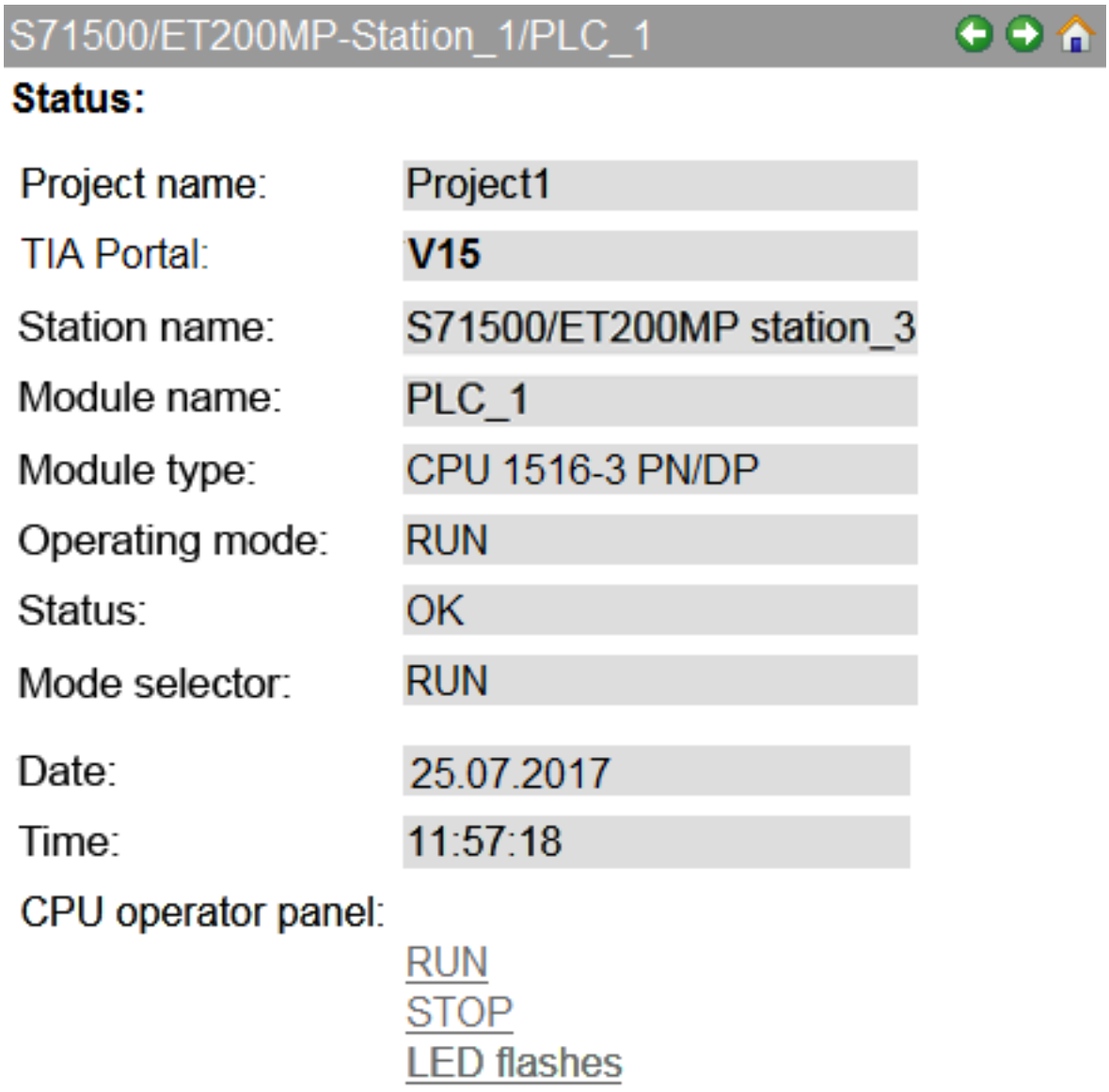

Figure 3-151 Example basic websites, "Status" web page

API (Application Programming Interface) 5

Web API

The CPU offers you a Web-based API (Web API) as an interface for reading and writing CPU data.

The Web API enables you to:

- Implement web applications at the latest state-of-the-art technology
- Communicate with the Web server of the CPU via script and programming languages
- Create web applications that connect to multiple CPUs at the same time, for example, to create dashboards that visualize the status of multiple CPUs

Connection established between CPU, Web API and terminal device.

The following graphic shows an example of the Web API between CPU and terminal device.

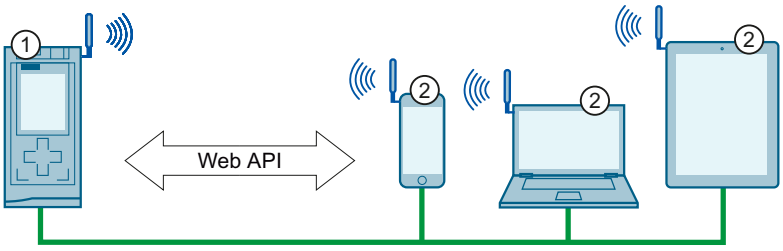

① CPU

② Terminal devices

Figure 3-152 Web API

Communication between the CPU and the terminal device takes place via PROFINET or WLAN integration.

NOTE

Security information

Please note that the following graphic only shows the role of the Web API between CPU and terminal device.

For the correct setup of a secure WLAN connection, observe the Security Information in the preface of this manual.

Requirements

The Web API can only be used for CPUs as of firmware version from V2.8 for the following systems:

- The standard F and T-CPUs of the automation system S7-1500
- The CPUs 1504D TF and 1507D TF of the SIMATIC Drive Controller
- The CPUs of the ET 200pro distributed I/O system
- The standard F and T-CPUs of the distributed I/O system ET 200SP
- The standard F and T-CPUs of the S7-1500 software controller
- As of firmware version V3.1, the R/H-CPUs of the automation system S7-1500

The following requirements must be met before you can use the Web API.

- You have assigned the correct firmware version (≥ V2.8) in the Hardware catalog of STEP 7.
- You have created and configured a project and downloaded it to the CPU.
- You have ensured that the following check box is selected in STEP 7:
  - Activate Web server on this module

Overview of the Web API methods depending on the firmware version of the CPU

The Web API is being continuously extended. The following table shows the mechanisms and methods you can use with a specific firmware version of the CPU:

Method	Standard/T-CPU as of firmware version	F-CPUs as of firmware version	R/H-CPUs as of firmware version
Basic functions			
Api.Login (Page 177)	V2.8	V2.8	V3.1
Api.GetPermissions (Page 181)	V2.8	V2.8	V3.1
Api.Browse (Page 183)	V2.8	V2.8	V3.1
Api.Version (Page 184)	V2.8	V2.8	V3.1
Api.Ping (Page 184)	V2.8	V2.8	-
Api.GetCertificateUrl (Page 185)	V2.8	V2.8	-
Api.Logout (Page 185)	V2.8	V2.8	V3.1
Api.GetQuantityStructures (Page 185)	V3.1	V3.1	V3.1
Api.ChangePassword (Page 186)	V3.1	V3.1	V3.1
Api.GetPasswordPolicy (Page 187)	V3.1	V3.1	V3.1
Api.GetAuthenticationMode (Page 189)	V3.1	V3.1	V3.1

Method	Standard/T-CPU as of firmware version	F-CPUs as of firmware version	R/H-CPUs as of firmware version
Setting the Web server default page			
WebServer.SetDefaultPage (Page 190)	V3.1	V3.1	-
WebServer.ReadDefaultPage (Page 191)	V3.1	V3.1	-

Method	Standard/T-CPU as of firmware version	F-CPUs as of firmware version	R/H-CPUs as of firmware version
Ticket mechanism (Page 170)			
Api.BrowseTickets (Page 174)	V2.9	V2.9	V3.1
Api.CloseTicket (Page 176)	V2.9	V2.9	V3.1

Method	Standard/T-CPU as of firmware version	F-CPUs as of firmware version	R/H-CPUs as of firmware version
Reading and writing process data			
PlcProgram.Read (Page 196)	V2.8	V2.8	-
PlcProgram.Write (Page 198)	V2.8	V2.8	-
PlcProgram.DownloadProfilingData (Page 200)	V3.1	V3.1	-
PlcProgram.Browse (Page 206)	V2.8	V2.8	-

Method	Standard/T-CPU as of firmware version	F-CPUs as of firmware version	R/H-CPUs as of firmware version
Reading and changing the operating mode			
Plc.ReadOperatingMode (Page 212)	V2.9	V2.9	-
Plc.RequestChangeOperatingMode (Page 212)	V2.9	V2.9	-
Plc.ReadModeSelectorState (Page 213)	V3.1	V3.1	-

Method	Standard/T-CPU as of firmware version	F-CPUs as of firmware version	R/H-CPUs as of firmware version
Performing time settings via Web API			
Plc.ReadSystemTime (Page 214)	V3.0	V3.0	-

Method	Standard/T-CPU as of firmware version	F-CPUs as of firmware version	R/H-CPUs as of firmware version
Plc.SetSystemTime (Page 215)	V3.1	V3.1	-
Plc.ReadTimeSettings (Page 216)	V3.0	V3.0	-
Plc.SetTimeSettings (Page 218)	V3.1	V3.1	-

Method	Standard/T-CPU as of firmware version	F-CPUs as of firmware version	R/H-CPUs as of firmware version
Reading diagnostics and service data			
Alarms.Browse (Page 222)	V3.1	V3.1	-
Alarms.Acknowledge (Page 227)	V3.1	V3.1	-
Syslog.Browse (Page 228)	V3.1	V3.1	V3.1
DiagnosticBuffer.Browse (Page 231)	V3.1	V3.1	-
Modules.DownloadServiceData (Page 233)	V3.1	V3.1	-
Project.ReadLanguages (Page 221)	V3.1	V3.1	-

Method	Standard/T-CPU as of firmware version	F-CPUs as of firmware version	R/H-CPUs as of firmware version
Backing up and restoring the configuration			
Plc.CreateBackup (Page 235)	V3.0	V3.0	-
Plc.RestoreBackup (Page 236)	V3.0	V3.0	-

Method	Standard/T-CPU as of firmware version	F-CPUs as of firmware version	R/H-CPUs as of firmware version
Accessing the contents of the SIMATIC Memory Card			
Files.Browse (Page 240)	V3.0	V3.0	V3.1
Files.Download (Page 242)	V3.0	V3.0	V3.1
Files.Create (Page 244)	V3.0	V3.0	V3.1
Files.Rename (Page 245)	V3.0	V3.0	V3.1
Files.Delete (Page 247)	V3.0	V3.0	V3.1
Files.CreateDirectory (Page 248)	V3.0	V3.0	V3.1
Files.DeleteDirectory (Page 249)	V3.0	V3.0	-
DataLogs.DownloadAndClear (Page 251)	V3.0	V3.0	V3.1

Method	Standard/T-CPU as of firmware version	F-CPUs as of firmware version	R/H-CPUs as of firmware version
Reading information from SIMATIC Safety			
Failsafe.ReadRuntimeGroups (Page 252)	-	V3.1	-
Failsafe.ReadParameters (Page 254)	-	V3.1	-

Table 3-56 Overview of web applications that can be loaded by the user

Web applications that can be loaded by the user (Page 256)	Standard/T-CPU as of firmware version	F-CPUs as of firmware version	R/H-CPUs as of firmware version
WebApp.Create (Page 260)	V2.9	V2.9	-
WebApp.Delete (Page 261)	V2.9	V2.9	-
WebApp.Rename (Page 262)	V2.9	V2.9	-
WebApp.Browse (Page 263)	V2.9	V2.9	-
WebApp.SetState (Page 265)	V2.9	V2.9	-
WebApp.SetDefaultPage (Page 266)	V2.9	V2.9	-
WebApp.SetNotFoundPage (Page 267)	V2.9	V2.9	-
WebApp.SetNotAuthorizedPage (Page 268)	V2.9	V2.9	-
WebApp.BrowseResources (Page 270)	V2.9	V2.9	-
WebApp.CreateResource (Page 272)	V2.9	V2.9	-
WebApp.DeleteResource (Page 273)	V2.9	V2.9	-
WebApp.RenameResource (Page 274)	V2.9	V2.9	-
WebApp.DownloadResource (Page 276)	V2.9	V2.9	-
WebApp.SetResourceVisibility (Page 277)	V2.9	V2.9	-
WebApp.SetResourceETag (Page 279)	V2.9	V2.9	-
WebApp.SetResourceMediaType (Page 280)	V2.9	V2.9	-
WebApp.SetResourceModificationTime (Page 281)	V2.9	V2.9	-

API endpoint

As an RPC protocol, JSON-RPC V2.0 is based on HTTP. The Web API can be reached via POST Requests to the following URL:

```
https://[ip]/api/jsonrpc
```

The Web API supports bulk operations as defined in JSON-RPC 2.0. While bulk operations are not explicitly limited by a fixed number of method calls, there is a limit for the HTTP request body. The limit differs depending on the firmware version of the CPU:

- Limit of 64 KB for CPUs with firmware version ≤ V3.0
- Limit of 128 KB for CPUs as of firmware version ≥ V3.1

As of firmware version V3.1, you can use the API method Api.GetQuantityStructures to read the limit.

An example of the required structure of an HTTP Request and HTTP Response for successfully making a Web API request can be found in the chapter Web API integration (Page 165).

Compatibility with regard to future extensions of the Web API

The order of attributes within a JSON object does not affect API clients.

Web server responses to requests via the API may be extended with new JSON attributes in future firmware versions, e.g. to enrich results with more details.

Error codes of possible API error messages based on JSON-RPC may change in future firmware versions, if applicable, and existing error messages may be made more precise.

NOTE

To check if your API request was successful, first check if the request was successful in general. You can evaluate the JSON-RPC error codes for detailed information.

Textual error information only provides information. If you want to implement error evaluation in a way specific to an application, use the corresponding numeric error codes of the error message.

The precision of floating point values may differ in the display from other clients, such as the TIA Portal.

Bulk requests are always processed in descending order, whereby the individual requests are contained in the HTTP request body in descending order.

If an API method includes time stamps, these time stamps are always returned based on UTC time. Examples of this are the time stamps of the Files.Browse and Api.BrowseTickets methods. With the API methods Plc.ReadSystemTime and Plc.ReadTimeSettings, you can read out the system time and determine the PLC local time.

Supported clients

The products and versions listed in the following table were tested for the Web API. The column "As of Version" lists the tested version as of which the clients are supported:

Product *	As of Version	Supported functions
Chrome-based Desktop web browser (e.g. Google Chrome) (https://chromium.woolyss.com/)	75.x (Windows and Android)	Web API access with JavaScript for asynchronous requests
Mozilla Firefox (https://www.mozilla.org/en-US/firefox/)	64.x (long-term support)	
Microsoft Internet Explorer	11.x (Windows 7, Windows 10)	

* Not included in the scope of delivery of the product described here

Product *	As of Version	Supported functions
Microsoft Edge	44.x Windows 10	Web API access with JavaScript for asynchronous requests
Apple Safari	12.x iOS	
Opera	58.x	
SIMATIC HMI Panels	2	
Microsoft C# (https://docs.microsoft.com/en-us/dotnet/api/system.net.webrequest?view=netframework-4.7.2) with WebRequest class and Json.Net library (https://www.newtonsoft.com/json)	.Net Framework 4.7	Web API access for pure HTTP requests and Json.Net for generating and parsing content
GNU Wget (https://www.gnu.org/software/wget/)	1.20 Windows	Web API access for pure HTTP requests, e.g. for automatic archiving of DataLogs.
cURL (https://curl.haxx.se/)	7.63.x Windows	
Python (https://www.python.org/downloads/)	3.10	
Microsoft PowerShell	5.0	Web API access for pure HTTP Requests with Invoke WebRequest and ConvertTo-Json/ConvertFrom-Json for generating and parsing content
WebserverApi Client Library for .NET (https://github.com/siemens/simatic-s7-webserver-api)	1.0.1	Web API access for pure HTTP requests in C#. The library is also available as a NuGet package at the following address (https://www.nuget.org/packages/Siemens.Simatic.S7.Webserver.API).

* Not included in the scope of delivery of the product described here

Github

You can also find examples of using API methods in practice on Github at the following repository (https://github.com/siemens/simatic-s7-webserver-api).

5.1 Web API integration

In the following section you will find examples of how to integrate the Web API into your application.

Structure of an HTTP Request and HTTP Response

The following section shows the example of the required structure of an HTTP Request and HTTP Response for successfully making a Web API request.

```
POST /api/jsonrpc HTTP/1.1
Host: 192.168.3.14
```

```
Content type: application/json
Content length: 92

[{"jsonrpc":"2.0","method":"Api.Login","params":{"user":"User1","pa-
ssword":"SecurePassword"},"id":999}]

HTTP/1.1 200 OK
Content type: application/json
Cache-Control: no-cache
Pragma: no-cache
Expires: 0
Access-Control-Allow Origin: *
Access-Control-Allow Headers: Content-Type,X-Auth Token
Access-Control-Allow Methods: POST,OPTIONS
transfer-encoding: chunked
date: Tue, 23 Apr 2019 17:50:31 GMT

[{"jsonrpc":"2.0","id":999,"result":{"token":"Sy8pe3VNv86rTMldzFBsY-
zmw12Lg"}}]
```

Web API examples

The following section contains related examples of how you can use the described methods in the Web API.

The examples use HTML, JSON and JQuery library for asynchronous requests.

NOTE

Information used in the examples

Note that the names of the methods, parameters and the JavaScript code are specified without liability and can deviate from the current API methods.

Example 1

Example 1 shows a code section that wants to maintain a session with JavaScript. For this purpose, a one-time ping request is sent using the Api.Ping method. If the intervals at which the ping request is sent are less than the timeout of 2 minutes, the user remains permanently logged in.

A maintained session lends itself to scenarios such as operating and monitoring tasks.

```
$.post({
url:"https://192.168.2.132/api/jsonrpc",
headers:{
 'X-Auth-Token':"Sy8pe3VNv86rTMldzFBsYzmw12Lg"
```

```
},
data:JSON.stringify({"jsonrpc":"2.0", method:"Api.Ping", "id":1}),
success:function(data){ console.log(data); }
dataType:"text",
contentType:"application/json"
});
```

NOTE

X-Auth-Token

To extend the session, you must send the token (X-Auth-Token) as an HTTP header to the CPU.

When you call the Api.Ping method without a token, the session is not extended because the CPU cannot assign a token to the user.

Example 3 shows an example of a token in the HTTP request.

In the example, the selected user has the necessary authorizations. The methods after the login request were successfully carried out, as the following result shows.

```
{"jsonrpc":"2.0","id":1,"result":"ZWlmbnJwZmplb3Nwd2l1Y3N3dWE="}
```

Example 2

Example 2 shows a client that wants to log in to the CPU with JavaScript and calls several methods within an HTTP request using a bulk request.

```
$.post({
  url:"https://192.168.2.132/api/jsonrpc",
  data:JSON.stringify([
    {"jsonrpc":"2.0", "id":1, method:"Api.Login",
      params:{user:"Admin",password:"12345"} },
    {"jsonrpc":"2.0", "id":2, method:"Api.GetPermissions" },
    {"jsonrpc":"2.0", "id":3, method:"Api.Browse" }]),
  success: function(data){ console.log(data); },
  dataType: "text",
  contentType: "application/json"});
```

The following section shows an example of a bulk request response. The selected user has the necessary authorizations. The methods after the login request were successfully carried out with the authorizations of the authenticated user.

```
[
"jsonrpc": "2.0", "id": 2, "result":[
{ "name": "Api.Browse" },
{ "name": "Api.Login" },
```

```
{ "name": "Api.Logout" },
{ "name": "Api.GetPermissions" },
{ "name": "PlcProgram.Read" },
{ "name": "PlcProgram.Write" }
]
```

Example 3

Example 3 shows a bulk request for read and write access to a stack of tags in a single HTTP request. This procedure is recommended for bulk requests, as it is more efficient than a series of single accesses and therefore places less load on the CPU.

```
$.post({
  url:"https://192.168.2.132/api/jsonrpc",
  data:JSON.stringify([
    {"jsonrpc":"2.0", "id":1, method:"PlcProgram.Read"},
    {"jsonrpc":"2.0", "id":2, method:"PlcProgram.Read",
      params:{"var":"\"MyDB\".InvalidField"}},
    {"jsonrpc":"2.0", "id":3, method:"PlcProgram.Read",
      params:{"var":"MyDB.MyDate"} },
    {"jsonrpc":"2.0", "id":4, method:"PlcProgram.Write",
      params:{"var":"\"BoilerControl\".TempSetPoint", value:9001}
}]),
  success: function(data){ console.log(data); },
  dataType: "text",
  contentType: "application/json",
  headers: {
    "X-Auth-Token":"d29kamV3cGxtdm5keHNhcXd1aXJ0empkZXN3cQ==""}});
```

The bulk request contains an invalid tag with an error message providing information about this. All other methods were successfully carried out, as the following result shows.

```
[
{"jsonrpc":"2.0","id":1,"result":{"value":42}},
{"jsonrpc":"2.0","id":2,"error":{"code":201,"message":"Invalid
 address"}},
{"jsonrpc":"2.0","id":3,"result":{"value":"1990-01-01"}},
{"jsonrpc":"2.0","id":4,"result":true}
]
```

5.2 Web API sessions

Timeout for Web API sessions

NOTE

If a Web API call is not made within a session before 120 seconds have elapsed, the CPU terminates the session with a logout event. A timeout reset is initiated by every successful action of the user in which a toke is supplied.

Call the Api.GetPermission or Api.Ping method cyclically within the timeout grid to ensure that:

- Your session remains active
- Your authorizations for the call of other methods remain active

Limitations for Web API sessions

The CPU limits the number of active sessions. The following table shows the limitations based on the memory platform used.

CPUs	Limitation
1510 to 1513	50
1514, 1515, 1516 and 1504D TF	100
1517, 1518 and 1507D TF	200

Limitation of the active Web API sessions

If you request another authentication token and none are available, then the request is rejected.

Changes to CPU user administration

The following applies to configured CPUs with firmware version ≤ V3.0: If the configuration of the CPU user management changes (by downloading the HW configuration in the TIA Portal), e.g. password changed or user removed, the CPU terminates all sessions with a logout event.

The following applies to configured CPUs with firmware version ≥ V3.1: If a user has been authenticated and the project is subsequently loaded into the CPU, deleted or deactivated users are logged out. If only the password or role of the user changes, the user remains authenticated.

Security events

The following applies to configured CPUs with firmware version ≤ V3.0: The CPU generates a security event for successful and failed logins. The CPU enters this security event in the diagnostics buffer.

For configured CPUs with firmware version ≥ V3.1, security events are logged in the CPU's internal syslog buffer. You can read out the entries with the Syslog.Browse (Page 228) method.

You can find more information about syslog messages in the Communication function manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

5.3 Ticket mechanism

With the web server as of firmware version V2.9, you can use the ticket mechanism of the Web API . The ticket mechanism is the basis for all file-based methods, such as the download of resources from the CPU.

The ticket mechanism enables you to:

- Transfer large amounts of data outside of the JSON-RPC protocol.
- Call status information, for example, to implement progress indicators in your application and respond conveniently to mode changes

---

NOTE

4 tickets per session

The ticket mechanism enables you to use up 4 tickets simultaneously per session.

The number of tickets that can be created per type is additionally limited. For more information, see the API methods that create a ticket:

- WebApp.CreateResource (Page 272)
- WebApp.DownloadResource (Page 276)
- Plc.CreateBackup (Page 235)
- Files.Download (Page 242)
- Files.Create (Page 244)
- PlcProgram.DownloadProfilingData (Page 200)

Principle of the ticket mechanism

Data transfers outside the JSON-RPC protocol are initiated by Web API methods, such as WebApp.DownloadResource. This method returns a specific identifier, a so-called "ticket". The ticket can be redeemed by a subsequent request to another HTTP end point. In the request, the data are exchanged with standard HTTP mechanisms.

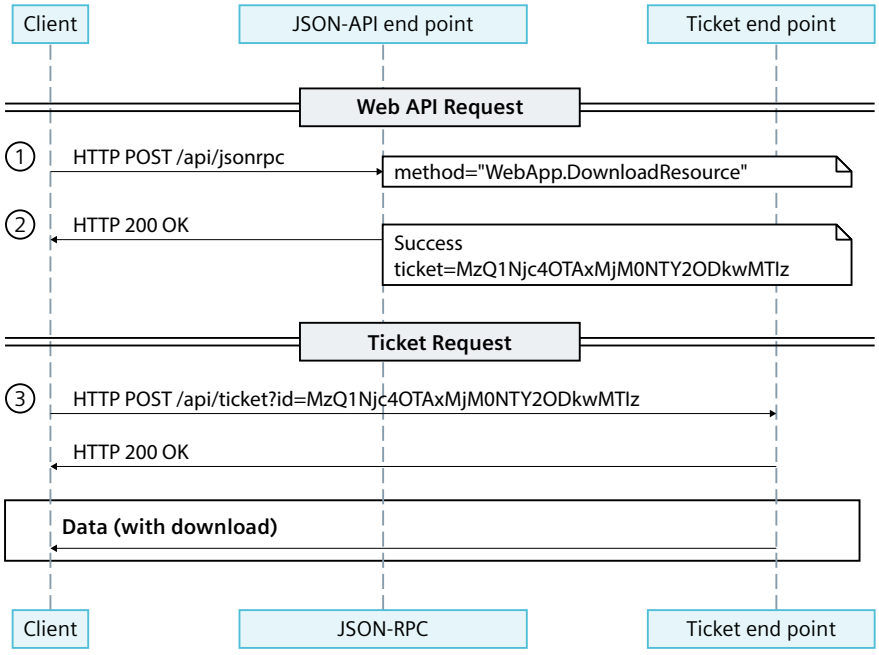

Figure 3-153 Ticket mechanism

① To request the upload or download of a resource from/to the CPU, a client sends a request to the JSON-RPC.

② After successful authorization and resource check, the client receives a valid ticket ID.

③ The client sends a request to the ticket end point with the valid ticket ID and an X-Auth-Token. The data is included here during upload to the CPU. The request is confirmed to the client with "HTTP 200 OK" or "204 No Content". The data is returned in a download from the CPU.

Ticket IDs are one-time tokens that may not be reused by the client or by the CPU after being redeemed.

NOTE

Changes in firmware version V3.0

As of firmware version V3.0, no X-Auth-Token is required for the ticket end point.

Do not share the token with third parties, because the owner of the token gets control over a ticket.

As of firmware version V3.0, GET requests for downloads are possible in addition to POST requests. For GET requests, a content disposition header is returned with the HTTP response. It contains a default file name for storage in the web browser. The browser uses the file name as the storage location. However, you can also evaluate the file name programmatically using a programming language (for example, via C#).

Ticket end point

The ticket end point is accessible via GET (for downloads only), POST and OPTIONS requests to the following URL:

```
https://[ip]/api/ticket?id=<ticket-id>
```

The ticket mechanism alone is not enough to execute a file action. To do this, you must call a specific method. In the web server of the firmware version V2.9, you use the ticket mechanism for the following methods:

- WebApp.CreateResource (Page 272)
- WebApp.DownloadResource (Page 276)

Procedure to execute a file action

To create a resource or download one from the CPU, follow these steps:

1. Call the corresponding method with the necessary method parameters, for example, WebApp.DownloadResource. The method returns a character string that includes a valid ticket ID.
2. Call the ticket end point via POST request with the returned ticket ID. The method will then execute the download, for example.

For more information, see the paragraph "Principle of the ticket mechanism".

NOTE

In some cases, programming languages perform preprocessing of text files before the upload. For example, a UTF-8 BOM-encoded (Byte Order Mark) file in Javascript is converted to a UTF8 file in advance.

Examples

Below you will find two examples for further processing of the tickets. The examples use HTML, Json and JQuery library.

WebApp.CreateResource (upload a resource):

```
<td><input id="fileForticketCustomerExampleUpload" type="file"
onchange="fReadFile()" /></td>
var fileReader = new FileReader();
function fReadFile() {
   fileReader = new FileReader();
   fileReader.readAsText(this.files[0]);
}
$("#ApiUploadticketCustomerExample").click(function () {
     var ticketId = $("#iApiUploadticketIdCustomerExample").val();
     var content = fileReader.result; // e.g. <!DOCTYPE
html><html><head>...
     $.post({
```

```
        url: "https://" + window.location.hostname +
"/api/ticket?id=" + ticketId,
        headers: { "X-Auth-Token": token, "Content-Type":
"application/octet-stream" },
        contentType: "application/json",
        data: content,
        // ticketing: status = 204: No content (=> no data) upload
has finished successfully:
        success: function (data, textStatus, jqXHR) { if
(jqXHR.status == 204) {
$("#ApiUploadticketCustomerExampleRes").text("true"); } },
//print error to the document
        error: function (jqXHR, textStatus, errorThrown) {
$("#ApiUploadticketCustomerExampleRes").html("<tr><td>code:
</td><td>" + jqXHR + "</td></tr><tr><td>textStatus:</td><td>" +
textStatus + "</td></tr><tr><td>error:</td><td>" + errorThrown +
"</td></tr>"); }
      });
    });
```

WebApp.DownloadResource (download a resource):

```
// Function to save data in a file - will be stored in the default
download folder
function saveDataInFile(data, filename, type) {
   var file = new Blob([data], { type: type });
   if (window.navigator.msSaveOrOpenBlob) // IE10+
     window.navigator.msSaveOrOpenBlob(file, filename);
   else { // Others
     var a = document.createElement("a"),
       url = URL.createObjectURL(file);
     a.href = url;
     a.download = filename;
     document.body.appendChild(a);
     a.click();
     setTimeout(function () {
       document.body.removeChild(a);
       window.URL.revokeObjectURL(url);
     }, 0);
   }
}
 $("#ApiDownloadTicketCustomerExample").click(function () {
     var ticketId = $("#iApiDownloadTicketIdCustomerExample").val();
     var filename =
$("#iApiDownloadTicketCustomerExampleFileName").val();  //e.g. index
     var type =
$("#iApiDownloadTicketCustomerExampleFileType").val();    //e.g.
text/html
     $.post({
```

```
        url: "https://" + window.location.hostname +
"/api/ticket?id=" + ticketId,
        headers: { "X-Auth-Token": token, "Content-Type":
"application/octet-stream" },
        contentType: "application/json",
        // ticketing: status = 200: download has finished
successfully:
        success: function (data, textStatus, jqXHR) { if
(jqXHR.status == 200) { download(data, filename, type); } },
//print error to document
        error: function (jqXHR, textStatus, errorThrown) {
$("#ApiDownloadTicketCustomerExampleRes").html("<tr><td>code:
</td><td>" + jqXHR + "</td></tr><tr><td>textStatus:</td><td>" +
textStatus + "</td></tr><tr><td>error:</td><td>" + errorThrown +
"</td></tr>"); }
      });
    });
```

Ticket methods

Two methods are available for handling your tickets as an authenticated user:

- You can use the Api.BrowseTickets (Page 174) method to find out which tickets are currently active for you and read out the status for the active tickets in each case.
- After the action, you can delete your ticket with the Api.CloseTicket (Page 176) method to clean the application with regard to active tickets.

5.3.1 Api.BrowseTickets

The Api.BrowseTickets method calls the status of all active tickets of a logged-in user. Alternatively, the status of a specific ticket can be called. This will provide information on the ticket status. You can also call this method during an active file action to retrieve the current status. Depending on the file action, additional information is provided by Api.BrowseTickets.

To call the Api.CloseTicket method, you do not need an authorization but you do need a valid session token. You can find information on the session token in the section Api.Login (Page 177).

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-57 Api_BrowseTickets_Request (object)

Name	Required	Data type	Description
id	No	string	The ticket ID that was returned by an API method for use by the ticket system. If the parameter is not specified, then the response structure returns all valid tickets of the user.

Example

In the following example, a ticket ID is transferred as parameter.

```
{
  "id": "U2VyaW91c2x5LCBTdG9wIGl0ISE6"
}
```

Response structure

The following table shows you the structure of the server response to a successful request.

Table 3-58 Api_BrowseTickets_Response (object)

Name	Required	Data type	Description
max_tickets	yes	number	Maximum number of tickets for one session (4)
tickets	Yes	array of Api_ BrowseTickets_ Ticket_ Response	Ticket ID
id	yes	string	Ticket ID
date_created	yes	string	ISO8601 time stamp as string. Time of the ticket creation based on the CPU time
provider	yes	string	Name of the method that has created the ticket, for example, WebApp.DownloadResource
state	yes	string	Current ticket status. The following alternatives are possible: "created", "active", "", "completed" or "failed"
data	No	object	Additional ticket data: Some ticket-based methods offer users additional information. This additional information is provided via "data" and described in the sections of the respective API methods.

Example

A response is shown in the following example.

```
{
 "max_tickets": 4,
 "tickets":
 [
  {
   "id": "U2VyaW91c2x5LCBTdG9wIGl0ISE6",
   "date_created": "2021-01-15T08:00:00-05:00",
   "provider": "WebApp.DownloadResource",
   "state": "active"
  }
 ]
```

```
}
```

NOTE
Additional ticket data (as of version V18)
As of version V18, each ticket is extended by the entry "bytes_processed" as part of the "data" object. This entry specifies how many bytes have been transferred when downloading or uploading a ticket until the Api.BrowseTicket method is called.

Possible error messages

The following table shows the possible error messages of the Api.BrowseTickets method.

Error code	Error message	Meaning
400	Not Found	The returned ticket ID does not exist in the ticket list of the user or does not match the assigned session token.

5.3.2 Api.CloseTicket

You use the Api.DeleteTicket method to delete a ticket provided by the system that is assigned to the current user session.

To call the Api.CloseTicket method, you do not need an authorization but a valid session token. You can find information on the session token in the section Api.Login (Page 177).

Structure of the request

The following table informs you about the necessary parameters for the request.

Table 3-59 Api_CloseTicket_Request (object)

Name	Required	Data type	Description
id	yes	string	The ticket ID that was returned by an API method for use by the ticket system.

Example

In the following example, a ticket ID is transferred as parameter.

```
{
  "id": "U2VyaW91c2x5LCBTdG9wIGl0ISE6"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the Api.GetTicketStatus method.

Error code	Error message	Meaning
400	Not Found	The returned ticket ID does not exist in the ticket list of the user. The returned ticket ID or does not match the assigned session token.

5.4 Web API basic functions

The following section gives an overview of all Web API basic functions with extracts from the corresponding HTML code.

NOTE

Files which contain Web API methods must be encoded and stored in the UTF-8 character encoding.

For detailed examples of an integration of the Web API into your web application, refer to the section Web API integration (Page 165).

5.4.1 Api.Login

The Api.Login method checks the login data of the user and on successful verification opens a new Web API session. The method requests the name and the password of the user in plain text as proof of authorization. The user name and the password are encrypted before they are transferred to the server.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-60 Api_Login_Request (object)

Name	Required	Data type	Description
user	Yes	string	The user name
password	Yes	string	The current password in plain text
include_web_application_cookie	No	bool	As of CPU firmware version V2.9, Web Server supports the optional parameter "include_web_application_cookie". This parameter specifies: • Whether a "web_application_cookie" cookie was generated for access to protected web applications • Whether you want to return the cookie with the response to the successful login

Examples

The following examples show the parameters that are required or optional for calling the Api.Login method.

```
{
  "user": "User1",
  "password": "1234"
}
```

Parameter "include_web_application_cookie":

```
{
  "user": "User1",
  "password": "SecurePassword",
  "include_web_application_cookie": true
}
```

After successful authentication the user receives a token. The token identifies the user as successfully authenticated.

In addition to the token, the Api.Login method optionally returns a cookie that is required to access web applications:

```
{
   "token": "eG9mcHdhaGR0dWVsdm5teGFxcGw=",
   "web_application_cookie": "Cb5xdhgiokr0dWVsdm5teGCncFb="
}
```

The "web_application_cookie" cookie is set with a value from the HTTP response of the login as "siemens_web_secure" cookie.

Token

The token comprises a 28-byte string. The token is transferred in encrypted form.

For every additional request which requires authentication, you have to specify the assigned token in the HTTP request header. If further communication no longer takes place in the meantime, the token becomes invalid after maximum 2.5 minutes. Each new request within a session extends the validity of the token by another 2 to 2.5 minutes, calculated from the completion of the request processing by the server.

The token is not required for methods that do not require authentication. However, you can still enter the token. If the token is passed when a method is called, the timeout of the corresponding session is reset.

When you call the Api.Ping method without a token, for example, the session is not extended because the CPU cannot assign a token to the user.

The following methods work with and without tokens:

- Api.Browse
- Api.Ping
- Api.GetPermissions

Receiving a token for a passwordless user account without password

If a user wants to use a user account without password to access the Web API, they must authenticate with the API method Api.Login using the user name "Everybody"/"Anonymous" and an empty password ("). The name of the specific user depends on the firmware version of the CPU:

- For projects with a firmware version ≤ V3.0: Static user management with the user "Everybody"
- For projects with a firmware version ≥ V3.1: Local user management with the user "Anonymous"

The "Anonymous" user can be deactivated in STEP 7 and is then not available on the CPU. Unverified users are not downloaded to the CPU. This means that a call of the API method Api.Login with the user name "Anonymous" fails if the user was deactivated in STEP 7.

NOTE

User "Everybody"/"Anonymous"

Note that, unlike TIA Portal, the API only accepts the English notation "Everybody" or "Anonymous".

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-61 Api_Login_Response (object)

Name	Required	Data type	Description
token	Yes	string	The token indicates that its holder has successfully authenticated themselves at the Web API. The returned token must be passed via the HTTP request header "X-Auth-Token" in subsequent Web API requests.
web_application-_cookie	No	string	Only present if "include_web_application_cookie" is "true". The holder of the token has successfully authenticated themselves with the Web API and has authorization to access protected web applications.
password_expiration	No	object of type Api_Login_PasswordExpiration_Response	This object contains information on the expiration of the password, if: • The "local" authentication mode is used for the CPU and • The password policy is activated on the CPU
runtime_timeout	No	string	If the "local" authentication mode is used for the CPU: ISO 8601 time span as string Time span of inactivity in seconds after which a client application is to perform a logout using the API method Api.Logout.

Table 3-62 Api_Login_PasswordExpiration_Response (object)

Name	Required	Data type	Description
timestamp	Yes	string	ISO8601 time stamp as a string in Coordinated Universal Time (UTC) Indicates when the user password expires. The accuracy must be specified in seconds.
warning	Yes	bool	This parameter specifies whether the warning threshold was reached before the password expired.

Examples

Successful login for a user without expiration of the password (either static user management or password expiration deactivated):

```
{
  "token": "TXlMdWdnYWdlSGFzVGhlU2FtZSE="
}
```

Successful login for a user with password expiration:

```
{
  "token": "TXlMdWdnYWdlSGFzVGhlU2FtZSE=",
  "password_expiration":
  [
     "timestamp": "2023-11-05T18:25:43Z",
     "warning": true
  }
}
```

Successful login for a user with expiration of the password and runtime_timeout of 30 minutes:

```
{
  "token": "TXlMdWdnYWdlSGFzVGhlU2FtZSE=",
  "runtime_timeout": "PT30M",
  "password_expiration":
  [
     "timestamp": "2023-11-05T18:25:43Z",
     "warning": true
  }
}
```

Possible error messages

The following table shows the possible error messages of the Api.Login method.

Error code	Error message	Meaning
4	No resources	The system does not have the required resources to carry out this request. Perform the request again as soon as enough resources are available again.
100	Login failed	The user name and/or password are not permissible. Assign a permissible user name and a permissible password. Another reason why the login failed may be an active brute force attack.
101	Already authenticated	The current X-Auth-Token is already authenticated. Use Api.Logout before you authenticate yourself again.
102	Login Failed - Password expired	The password of the user account has expired. The user must change the password in order to be able to successfully authenticate again.

Example

You can find an example with further processing of the cookie "web_application_cookie" in section Example: Web page for monitoring and controlling a wind turbine.

5.4.2 Api.GetPermissions

After the successful login, the Api.GetPermissions returns a list of actions for whose execution the user is authorized.

Response structure

The following table shows the structure of server responses to successful requests:

Table 3-63 Api_GetPermissions_Response (array of objects)

Name	Required	Data type	Description
Name	Yes	string	Name of authorization

Example

The following example shows the actions for which the user is authorized.

```
[
  { "name": "read_value" },
  { "name": "change_operating_mode" }
]
```

Checkable authorizations

You can use the Web API to check the authorizations for the following functions.

Action	User authorization	As of the firmware version of the CPU
flash_leds	Identify device	V2.8
acknowledge_alarms	Acknowledge alarms	V2.8
read_diagnostics	Query diagnostics data from the CPU without being permitted to change data.	V2.8
read_value	Read process data from the CPU.	V2.8
write_value	Write process data to the CPU.	V2.8
open_user_pages	Call user-defined pages on the CPU.	V2.8
manage_user_pages	Change user-defined pages on the CPU.	V2.9
read_file*	Read the contents of files on the CPU.	V2.8
write_file*	Change the contents of files and folders on the CPU.	V2.8
change_operating_mode	Change the operating mode.	V2.8
backup_plc	Back up the CPU configuration.	V2.8
restore_plc	Restore configuration of the CPU.	V2.8
failsafe_admin	Make fail-safe changes on the CPU.	V2.8
update_firmware	Perform firmware update	V3.0
read_watch_table_value	Read value of a tag in watch table	V3.1
write_watch_table_value	Write value of a tag in watch table	V3.1
read_syslog*	Read the SysLog buffers of the CPU	V3.1
change_time_settings	Change the system time settings of the CPU	V3.1
change_webserver_default_page	Change the default page of the Web server	V3.1
download_service_data	Load the service data of the CPU	V3.1

* Also available for the R/H-CPU of the redundant S7-1500R/H system (as of firmware version V3.1).

For projects with firmware version ≤ V3.0, the Web API checks the authorization based on the rights and passwords assigned in STEP 7 in the Inspector window in the "Web server > User management" area.

For projects with firmware version ≥ V3.1, the Web API checks the authorization based on the rights and passwords assigned in STEP 7 in the project tree in the "Security settings > Users and roles" area.

A description of the user management can be found in section "Configuring the Web server (Page 24)".

5.4.3 Api.Browse

The Api.Browse method gives you a list of all methods that you can call via the Web API with the current firmware. This provides you with an overview of all the methods supported by the CPU.

No authorization is required for calling the Api.Browse method.

Example

The following example shows the HTTP request and a possible response to the request for the Api.Browse method.

```
POST /api/jsonrpc HTTP/1.1
Host: 192.168.3.14
Content type: application/json
Content length: 48

[{"jsonrpc":"2.0","method":"Api.Browse","id":1}]
```

Response of the server:

```
[
 { "name": "Api.Browse" },
 { "name": "Api.GetCertificateUrl" },
 { "name": "Api.GetPermissions" },
 { "name": "Api.Login" },
 { "name": "Api.Logout" },
 { "name": "Api.Ping" },
 { "name": "Api.Version" },
 { "name": "PlcProgram.Browse" },
 { "name": "PlcProgram.Read" },
 { "name": "PlcProgram.Write" }
]
```

NOTE

Checking authorizations

The Api.Browse method does not filter the list of the available methods by the individual authorizations of users.

The list of available methods may therefore contain methods which the user may not execute without authorization.

Possible error messages

The following table shows the possible error messages of the Api.Browse method.

Error code	Error message	Meaning
4	No resources	The system does not have the necessary resources to execute the Web API request. Perform the request again as soon as enough resources are available again.

5.4.4 Api.Version

Use the Api.Version method to request the current version number of the Web API. You can draw conclusions from the version number:

- The functions supported by the CPU version
- The hardware functional status of the CPU

This information lets you implement applications that dynamically adapt to the scope of functions offered by the contacted CPU. An application can support multiple CPU versions.

No authorization is required for calling the Api.Version method.

Example

The following example shows a possible result of calling the Api.Version method.

```
3.28
```

The version number is displayed as a floating-point number and is incremented with every release and every change of the Web API.

5.4.5 Api.Ping

The Api.Ping method outputs a unique ID for the CPU used. You can use it to determine whether the CPU can be reached. The CPU ID comprises a 28-byte string. The system assigns a new, unique CPU ID after each restart (POWER ON - POWER OFF) or warm start of the CPU. By comparing this with previously output IDs, you can also determine whether the CPU was restarted in the meantime.

No authorization is required for calling the Api.Ping method.

Example

The following example shows the output of a CPU ID:

```
"ZWlmbnJwZmplb3Nwd2l1Y3N3dWE="
```

5.4.6 Api.GetCertificateUrl

The Api.GetCertificateUrl method returns a relative URL (https://<IP>) with which you can retrieve the SSL certificate of the Web server.

Example

The following example shows the result of the Api.GetCertificateUrl method call.

```
"/MiniWebCA_Cer.crt"
```

The method outputs a string with a relative URL to the root directory of the CPU Web server (https://[ip-address]).

If the Web server has not been configured with a CA certificate generated via the global security settings, the method outputs an empty string.

5.4.7 Api.Logout

The Api.Logout method removes the token from the list of active Web API sessions and ends the session.

The Api.Logout method returns the status of whether the logout was successful or not. For security reasons, however, the method always returns the Boolean value "true" even if the token is invalid.

5.4.8 Api.GetQuantityStructures

The Api.GetQuantityStructures method returns different structure information of the Web server.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-64 Api_GetQuantityStructures_Response (object)

Name	Required	Data type	Description
webapi_max_http_request_body_size	Yes	number	Maximum size of the HTTP request body of a Web API request in bytes
webapi_max_parallel_requests	Yes	number	Maximum number of parallel requests at the API end point
webapi_max_parallel_user_sessions	Yes	number	Maximum number of parallel user sessions that use the API end point

Example

The following example shows the response with the read parameters of a CPU.

```
{
  "webapi_http_request_body_size": 131072,
  "webapi_parallel_requests": 4,
  "webapi_parallel_user_sessions": 200
}
```

5.4.9 Api.ChangePassword

You can change the password for a user account with the Api.ChangePassword method.

Recommendation: Before changing a password, read the password policy from the CPU using the Api.GetPasswordPolicy API method. If the new password does not conform to the password policy of the CPU, a corresponding error message is returned.

No prior authorizations are required to call the Api.ChangePassword method, but you must enter the current password for this call.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-65 Api_ChangePassword_Request (object)

Name	Required	Data type	Description
username	Yes	string	The user name for which the password was changed.
password	Yes	string	The current password of the specified user.
new_password	Yes	string	The new password.

Example

In the following example, the password is changed for the user account "HappyUser".

```
{
  "username": "HappyUser",
  "password": "mycurrentpassword",
  "new_password": "mynewpassword"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows possible error messages with the Api.ChangePassword method.

Error code	Error message	Meaning
5	System is read-only	The memory card is write-protected. Therefore, the password cannot be changed.
6	Not accepted	The password change is not performed because a CPU was configured with firmware version < V3.1. The method can only be used with CPUs as of firmware version V3.1.
100	Login failed	The user name and password combination is invalid. Assign a permissible user name and a permissible password. Another reason why the login failed may be an active brute force attack.
103	New password does not follow password policy	The provided new password does not match with the required password policy. Assign a password conforming to the password policy. The Api.GetPasswordPolicy method provides you with the password policy of the CPU, if the CPU is in "local" authentication mode.
104	New password matches former password	The new password is identical with the previous password. Assign a different password. Note that the CPU does not store a password history. The comparison is therefore only performed between the new and previous password.

5.4.10 Api.GetPasswordPolicy

Passwords must fulfill specific criteria to be secure. The Api.GetPasswordPolicy method provides you with the password policy of the CPU. The password policy is a global setting in the STEP 7 project and applies for all users of the Web server. The method does not contain any information on the expiration of the password. Any user, including unauthenticated users ("Anonymous"), can call this API method.

No authorization is required for calling the Api.GetPasswordPolicy method.

Response structure

The following table shows you the structure of server responses to successful requests.

Table 3-66 Api_GetPasswordPolicy_Response (object)

Name	Required	Data type	Description
password_policy	Yes	object	The object represents the current password policy of the CPU.
min_password_length	Yes	number	The minimum length of the password in UTF-8 character encoding. Value range: 8 to 255
max_password_length	Yes	number	The maximum length of the password in UTF-8 character encoding.
min_digits	Yes	number	The minimum number of numerals (0 to 9) within the password. Value range: 0 to 255
min_special_characters	Yes	number	The minimum number of special characters within the password. Special characters are: !#$%&()*+,-./:;<=>?@[\]_{|}~^ Value range: 0 to 255
requires_uppercase_characters	Yes	bool	The password contains at least one uppercase character A to Z. Values: true or false
requires_lowercase_characters	Yes	bool	The password contains at least one lowercase character a to z. Values: true or false

Example

CPU project with a password policy

```
{
 "password_policy":
  {
"min_password_length": 8,
"max_password_length ": 120,
"min_digits": 2,
   "min_special_characters": 1,
   "requires_uppercase_characters": true,
   "requires_lowercase_characters": true
  }
}
```

Possible error messages

The following table shows possible error messages with the Api.GetPasswordPolicy method.

Error code	Error message	Meaning
6	Not accepted	The password policy cannot be read because a CPU is configured with a firmware version < V3.1. The method can only be used with CPUs as of firmware version V3.1.

5.4.11 Api.GetAuthenticationMode

You can read the current authentication mode of the CPU with the Api.GetAuthenticationMode method.

No authorization is required for calling the Api.GetAuthenticationMode method.

Possible authentication modes

The following authentication modes are available to you with the Web server.

Table 3-67 Authentication modes

Mode	String	Meaning	Supported from configured FW version of the CPU
Static user management	`static`	In this mode, changes are only possible by downloading the hardware configuration from the CPU. Passwords cannot be changed during runtime of the user program.	V2.8 to V3.0
Access control deactivated	`disabled`	No user management and authentication is possible in this mode. Only the "Anonymous" user is available. This specific user has full access/rights to the CPU and Web server functionality. As with every other user the Api.Login API method must be called. The returned X-Auth Token allows the full access right to all API functionalities.	V3.1
Local user management	`local`	In this mode, the authorizations and user roles continue to be configured as part of the STEP 7 project and a password change is possible via the Web API.	V3.1

Response structure

The following table shows you the structure of server responses to successful requests.

Table 3-68 Api_GetAuthenticationMode_Response (object)

Name	Required	Data type	Description
authentication_mode	Yes	array of strings	The parameter describes the current authentication mode supported by the CPU.

Example

In the following example, the authentication mode "local" (local user management) is read by the CPU.

```
{
  "authentication_modes": ["local"]
}
```

5.5 Setting the Web server default page

The Web server of the CPU will use the default page if you do not specify a path along with the requested IP address, the domain and the host name in the web browser. You no longer have to configure the default page using the TIA Portal. This also eliminates the need to download the hardware configuration when changes are made.

5.5.1 WebServer.SetDefaultPage

Use the API method WebServer.SetDefaultPage to configure a web application as the default page of the Web server.

You can only configure web applications as the start page, but not web pages or user-defined pages of the CPU's Web server.

To call this method, you need "change_webserver_default_page" authorization.

Structure of the request

The following table contains information about the parameters of the request:

Table 3-69 Webserver_SetDefaultPage_Request (object)

Name	Required	Data type	Description
default_page	Yes	string	The name of the default page you want to use.

Examples

In the following example, the default page named "index.html" for the web application "webapp1" is used:

```
{
  "default_page": "/~webapp1/index.html"
}
```

In the following example, the default page is set to "webapp1": In this case, you need to configure the web application to reference the specific default page of the web application.

```
{
  "default_page": "/~webapp1/"
}
```

In the following example, the value for the default page name is empty. In this case, the system falls back to the default page as defined in the hardware configuration in the TIA Portal.

```
{
  "default_page": ""
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read only	The system is currently in a write-protected state. Changes are not currently permitted.
1300	Invalid default page	The default page provided is invalid. Make sure that you have used the default page name correctly.

5.5.2 WebServer.ReadDefaultPage

You use the API method WebServer.ReadDefaultPage to read the default page set with WebServer.SetDefaultPage.

Response structure

If successful, the response returns the following structure:

Table 3-70 Webserver_ReadDefaultPage_Response

Name	Required	Data type	Description
default_page	Yes	string	The default page currently configured during runtime. The returned value does not take into account the configuration of the hardware configuration start page in the TIA Portal.

5.6 Reading and writing process data

5.6.1 Supported data types

Binary representation

The Web API presents the values of primitive data types as pure binary data ("raw"). The binary data is formatted as a JSON array. Each element within an array represents a single data byte.

Simple display ("simple")

The Web API formats primitive data types into a readable form while preserving the ability to process the data using a program. The following section describes how primitive data types are represented as JSON data type.

Supported data types

The following table shows:

- The data types supported by the Web API for reading and writing process values
- The representation in the Web API
- The respective match of the data type in the TIA Portal

Name of the data type in the TIA Portal	Name of the data type in Web API	Representation in the Web API
Bool	bool	Boolean JSON value: **true** or **false**
Byte	Byte	JSON unsigned integer in a range from 0 to 255
USInt	usint	
Word	word	JSON unsigned integer in a range from 0 to 65 535
UInt	uint	
HW_ANY	hw_any	
HW_IOSYSTEM	hw_iosystem	
HW_DPMASTER	hw_dpmaster	
HW_DEVICE	hw_device	
HW_DPSLAVE	hw_dpslave	
HW_IO	hw_io	
HW_MODULE	hw_module	
HW_SUBMODULE	hw_submodule	
HW_HSC	hw_hsc	
HW_PWM	hw_pwm	
HW_PTO	hw_pto	
HW_INTERFACE	hw_interface	
HW_IEPORT	hw_ieport	
CONN_ANY	conn_any	
CONN_PRG	conn_prg	
CONN_OUC	conn_ouc	
PORT	port	
RTM	rtm_id	
PIP	pip	
DB_ANY	db_any	
DB_WWW	db_www	
DB_DYN	db_dyn	
DWord	dword	JSON unsigned integer in a range from 0 to 4 294 967 295
UDInt	udint	
AOM_IDENT	aom_ident	
EVENT_ANY	event_any	
EVENT_ATT	event_att	
EVENT_HWINT	event_hwint	

Name of the data type in the TIA Portal	Name of the data type in Web API	Representation in the Web API
CONN_R_ID	conn_r_id	JSON unsigned integer in a range from 0 to 4 294 967 295
LWord	lword	JSON string with a numerical representation of an unsigned integer based on the number 10 in a range from 0 to 18 446 744 073 709 551 615
ULInt	ulint	
SInt	sint	JSON signed integer in a range from -128 to 127
Int	int	JSON signed integer in a range from -32 768 to 32 767
OB_ANY	ob_any	
OB_DELAY	ob_delay	
OB_TOD	ob_tod	
OB_CYCLIC	ob_cyclic	
OB_ATT	ob_att	
OB_PCYCLE	ob_pcycle	
OB_HWINT	ob_hwint	
OB_DIAG	ob_diag	
OB_TIMEERROR	ob_timeerror	
OB_STARTUP	ob_startup	
DInt	dint	JSON signed integer in a range from -2 147 483 648 to 2 147 483 647.
LInt	lint	JSON string with a numerical representation of an unsigned integer based on the number 10 in a range from -9 223 372 036 854 775, 808 to 9 223 372 036 854 775 807
Real	real	JSON floating-point number If the floating-point number is infinite or NaN (not-a-number), the Web API returns the value **null** when reading a tag of this type.
LReal	lreal	
Character	char	JSON string with a single ASCII character in a valid range from 0 to 127 If a tag of this type is read with a value outside the valid range, the Web API outputs the value **null**.
WChar	wchar	JSON string with a UTF-8 string that represents a single UCS-2 character in a valid range from 0 to 55 295. If a tag of this type is read with a value outside the valid range, the Web API returns the value **null**.
String	string	JSON string with a UTF-8 string If a tag of this type is read with a value outside the valid UTF-8 string (max. length 254 characters), the Web API returns the value **null**.
WString	wstring	JSON string with a UTF-8 string that represents a USC-2 string in a valid range from 0 to 55 295. If a tag of this type is read with a value outside the valid range (max. length 254 characters), the Web API outputs the value **null**.
Date	date	JSON unsigned integer in a range from 0 to 65 535 This value represents the number of days since 01.01.1990.
Time_Of_Day	time_of_day	JSON unsigned integer in a range from 0 to 4 294 967 295 This value represents the number of milliseconds since the beginning of the day.
LTime_Of_Day	ltime_of_day	JSON string with a numerical representation of an unsigned integer based on the number 10 in a range from 0 to 18 446 744 073 709 551 615 This value represents the number of nanoseconds since the beginning of the day.

Name of the data type in the TIA Portal	Name of the data type in Web API	Representation in the Web API
Time	time	JSON signed integer in a range from -2 147 483 648 to 2 147 483 647) This value represents the number of milliseconds since a user-defined point in time.
LTime	ltime	JSON string with a numerical representation of an unsigned integer based on the number 10 in a range from -9 223 372 036 854 775 808 to 9 223 372 036 854 775 807 This value represents the number of nanoseconds since a user-defined point in time.
S5Time	s5time	JSON object with the keys **basis** and **value**: • The **basis** value is a JSON Unsigned Integer with a value of either 10, 100, 1000, or 10 000. The value **basis** represents the millisecond multiplier of the value **value**. • The value **value** is a JSON unsigned integer in the range from 0 to 999. The value **basis** multiplied by the value **value** gives the timer interval in milliseconds.
Date_And_Time	date_and_time	JSON object with the keys **year**, **month**, **date**, **hour**, **minute**, **second**, and **day_of_week**: • **year** is a JSON unsigned integer with a value in the range from 1 990 to 2 089 • **month** is a JSON unsigned integer with a value in the range 1 to 12 • **day** is a JSON unsigned integer with a value in the range 1 to 31 • **hour** is a JSON unsigned integer with a value in the range 0 to 23 • **minute** is a JSON unsigned integer with a value in the range 0 to 59 • **second** is a JSON floating point number with a value in the range 0 to 60 • **day_of_week** is a JSON string with a value of either **sun**, **mon**, **tue**, **wed**, **thu**, **fri**, or **sat**
LDT	ldt	JSON string with a numerical representation of an unsigned integer based on the number 10 in a range from 0 to 18 446 744 073 709 551 615 This value represents the number of nanoseconds since 01.01.1970 midnight (12:00:00.0 am).
Struct	struct	Structured data type whose data structure can be determined using the PlcProgram.Browse method.
IEC_COUNTER	iec_counter	
IEC_TIMER	iec_timer	
DTL	dtl	
IEC_LTIMER	iec_ltimer	
IEC_SCOUNTER	iec_scounter	
IEC_DCOUNTER	iec_dcounter	
IEC_LCOUNTER	iec_lcounter	
IEC_UCOUNTER	iec_ucounter	
IEC_USCOUNTER	iec_uscounter	
IEC_UDCOUNTER	iec_udcounter	
IEC_ULCOUNTER	iec_ulcounter	
ERROR_STRUCT	error_struct	
NREF	nref	
CREF	cref	

Arrays

Arrays are displayed as JSON objects. The key is a string with a numeric representation of the index.

The following example shows the representation in the TIA Portal:

User data type_2

	Name	Data type	Default value	Accessible from HMI/OPC UA
1	ExampleArray	Array[0..1, 10..12] of Byte		☑
2	ExampleArray[0,10]	Byte	1	☑
3	ExampleArray[0,11]	Byte	2	☑
4	ExampleArray[0,12]	Byte	3	☑
5	ExampleArray[1,10]	Byte	4	☑
6	ExampleArray[1,11]	Byte	5	☑
7	ExampleArray[1,12]	Byte	6	☑

Figure 3-154 Representation in the TIA Portal

Addressing the user data

The Web API supports the following addressing formats:

- Symbolic addressing of a tag in the tag table, e.g. Tag_1
- Symbolic addressing of a tag in a data block, e. g. "MyDB".Static_1

5.6.2 Parameter assignment of the block properties

Configuring access to the Web API in the TIA Portal

To restrict the read and write access to data blocks of your project, you can define the desired parameters in the attributes of the respective block.

To allow the Web API to access the data block, select the check box "DB accessible from Webserver".

NOTE

F-blocks

Note that fail-safe blocks allow read access only. It is not possible to write tags into fail-safe blocks.

Parameter assignment for access to the Web API in tag tables

For read and write access of Web API to tags, the options "Accessible from HMI/OPC UA/Web API" and "Writable from HMI/OPC UA/Web API" must be enabled:

Tag table_1

	Name	Data type	Address	Retain	Accessible from HMI/OPC UA	Writable from HMI/OPC UA
1	Lint	LInt	%M99.0	☐	☑	☑
2	word	Word	%MW100	☐	☑	☑
3	MyTimer1	Timer	%T15	☐	☑	☑
4	MyCounter1	Counter	%C16	☐	☑	☑
5	MyTimer2	S5Time	%MW1000	☐	☑	☑
6	<Add new>			☐	☑	☑

Figure 3-155 Tag table in the TIA Portal

5.6.3 PlcProgram.Read

Use the PlcProgram.Read method to read a single variable from a CPU.

To call the PlcProgram.Read method, you need the "read_value" authorization.

Structure of the request

The following table informs you about the properties of the tag to be read.

Table 3-71 PlcProgram_Read_Request (object)

Name	Required	Data type	Description
var	yes	string	Name of the tag to be read.
mode	no, default is "simple"	string	Enumeration that determines the response format for this method: • "simple": Returns tag values according to the "simple" representation (see section Supported data types (Page 191)). • "raw": Returns tag values according to the "raw" representation (see section Supported data types (Page 191)).

Examples

In the following example, the user requests a global tag in the "simple" representation.

```
{
  "var": "\"MotorSpeed\""
}
```

In the following example, the user requests a data block tag in the "raw" representation.

```
{
  "var": "\"MyDB\".MyVariable",
```

```
  "mode": "raw"
}
```

Response structure

If the request to the server was successful, the server returns JSON data values.

Examples

The following example shows the result of reading in a tag of type "int" in the "simple" representation.

```
-42
```

The following example shows the result of reading in a tag of type "dword" in the "raw" representation.

```
[ 1, 47, 233, 0 ]
```

Possible error messages

The following table shows the possible error messages of the PlcProgram.Read method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
4	No resources	The system does not have the necessary resources to read the requested address. Carry out the request again as soon as sufficient resources are available.
200	Address does not exist	The requested address does not exist or the Web server cannot access it.
201	Invalid address	The name structure of the symbolic address is not correct.
203	Invalid array index	The dimensions and limits of the array indexes do not correspond to the type information of the CPU.
204	Unsupported address	The data type of the address cannot be read.

NOTE

Tag access with the methods PlcProgram.Read, PlcProgram.Write, and PlcProgram.Browse

With these methods it is not yet possible to access all tags in firmware version V3.0.

There are selective restrictions when reading tags of technology objects. If access to specific tags is not possible, the API returns the message "unsupported".

5.6.4 PlcProgram.Write

Use the PlcProgram.Write method to write a single process tag to the CPU.

To call the PlcProgram.Write method, you need the "write_value" authorization.

Structure of the request

The following table informs you about the properties of the tag to be written.

Table 3-72 PlcProgram_Write_Request (object)

Name	Required	Data type	Description
var	yes	string	Name of the tag to be written.
value	yes	variant	of the value to be written; The value depends on the operating mode.
mode	no, default is "simple"	string	Enumeration that specifies the format of "value": • "simple": The user must specify the values according to the "simple" representation (see section Supported data types (Page 191)) • "raw": The user must specify the values according to the "raw" representation (see section Supported data types (Page 191))

Examples

In the following example, the user writes a global tag in the "simple" display.

```
{
  "var": "\"MotorSpeed\"",
  "value": 9001
}
```

In the following example, the user writes a tag to a data block in the "raw" representation.

```
{
  "var": "\"MyDB\".MyVariable",
  "value": [ 255, 77, 1, 99 ],
  "mode": "raw"
}
```

In the following example, the user writes a string tag consisting of 10 characters to the "simple" representation:

```
{
  "var": "\"MyDB\".MyString",
  "value": "Short Str",
  "mode": "simple"
}
```

In the following example, the user writes a string tag consisting of 10 characters with the text "Short Str" in the "raw" representation:

```
{
  "var": "\"MyDB\".MyString",
  "value": [ 10, 9, 83, 104, 111, 114, 116, 32, 83, 116, 114, 0 ],
  "mode": "raw"
}
```

In the following example, the user writes a Wstring tag consisting of 6 characters in the "simple" representation:

```
{
  "var": "\"MyDB\".MyWString",
  "value": "Hello",
  "mode": "simple"
}
```

In the following example, the user writes a string tag consisting of 6 characters with the text "Hello" in the representation "raw":

```
{
  "var": "\"MyDB\".MyWString",
  "value": [ 0, 6, 0, 5, 0, 72, 0, 101, 0, 108, 0, 108, 0, 111, 0, 0
],
  "mode": "raw"
}
```

Response structure

If the write operation was successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the PlcProgram.Read method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
4	No resources	The system does not have the necessary resources to write the requested address. Carry out the request again as soon as sufficient resources are available.

Error code	Error message	Meaning
200	Address does not exist	The requested address does not exist or the Web server cannot access the requested address.
201	Invalid address	The name structure of the symbolic address is not correct.
203	Invalid array index	The dimensions and limits of the array indexes do not correspond to the type information of the CPU.
204	Unsupported address	The data type of the address cannot be written.

NOTE

Tag access with the methods PlcProgram.Read, PlcProgram.Write, and PlcProgram.Browse

With these methods it is not yet possible to access all tags in firmware version V3.0.

There are selective restrictions when reading tags of technology objects. If access to specific tags is not possible, the API returns the message "unsupported".

5.6.5 PlcProgram.DownloadProfilingData

The PlcProgram.DownloadProfilingData method supplies you with detailed runtime data for the user program in the CPU. The API method returns a ticket that you use to download the runtime data from the CPU. You can evaluate and graphically display the information later in order to analyze the program flow.

This information assists you in the following tasks:

- Runtime optimization of the user program
- Error diagnostics
- Evaluating the power reserve of the automation system
- Quality assurance of the application

To call the API method PlcProgram.DownloadProfilingData, you need "read_value" authorization.

Response structure

If successful, the method returns a string with a ticket ID. You can use this ticket ID to download the runtime data from the CPU.

You can find more information about the ticket mechanism in the section Ticket mechanism (Page 170).

Example

The following example shows a generated ticket ID for downloading the runtime data.

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

File name

The file name for downloading the runtime data to a web browser is structured as follows:
`[project_name]_[module_name]_YYYY-MM-DD_HH-mm-ss_profiling.bin`
Example: `[1500_example01]_[plc_1]_2023-11-03_12-20-05_profiling.bin`
The file name is returned as an HTTP Content-Disposition header in the server response.

Structure and contents of the file

The file contains a list of entries in which the byte sequence of each entry is based on a specific entry type. The first byte of an entry in each case contains the entry type.

Table 3-73 Block events

Byte	0	1	2	3
0	Entry type	Block type	Block number	
4	Number of OB currently being executed in the program		Call hierarchy of the OB	Priority of the OB
8	Time stamp in 10^{-12} seconds			
12				

The entry types of the following table are supported.

Table 3-74 Entry type

Value	Entry type
0x00	Invalid
0x01	Block event: Start of a block
0x02	Block event: End of a block
0x10	Read process image partition
0x11	Write process image partition
0x20	Direct read access
0x21	Direct write access
0x30	Error ID
0x31	Communication load and cycle time

Entry type: Block events

The file is structured as follows:

The following table explains the meaning of the possible block types:

Table 3-75 Block type

Value	Block type
0x00	Invalid
0x01	Organization block (OB)
0x02	Function (FC)
0x03	Function block (FB)
0x11	System function (SFC)
0x12	System function block (SFB)

The following table provides an example for block events:

Table 3-76 Example for block events

Byte	0	1	2	3
0	0x01	0x02	0x12	0x00
4	0x01	0x00	0x01	0x01
8	0x08	0x07	0x06	0x05
12	0x04	0x03	0x02	0x01

0x01: Start of a block
0x02: Block type = FC
0x0012: Block number = 18
0x0001: OB number = 1
0x01: Call hierarchy of the OB = 1
0x01: Priority of the OB = 1
0x0102030405060708: Time stamp

Entry type: Read/write process image partition

The file is structured as follows:

Table 3-77 Read/write process image partition

Byte	0	1	2	3
0	Entry type	-	Process image partition number	
4	-	-	-	Priority of the OB
8	Time stamp in 10^{-12} seconds			
12				

The following table provides an example for read process image partition:

Table 3-78 Example for read/write process image partition

Byte	0	1	2	3
0	0x10	-	0x01	0x00
4	-	-	-	0x01
8	0x08	0x07	0x06	0x05
12	0x04	0x03	0x02	0x01

0x10 Read process image partition
0x0001: Process image partition number = 1
0x01: Priority of the OB = 1
0x0102030405060708: Time stamp

Entry type: Direct read/write access

The file is structured as follows:

Table 3-79 Direct read/write access

Byte	0	1	2	3
0	Entry type	Event type	DB number	
4	-			Priority of the OB
8	Time stamp in 10^{-12} seconds			
12				

The following table explains the meaning of the possible entry types for direct I/O access:

Table 3-80 Event type

Value	Event type
0x00	Invalid
0x01	I/O
0x02	Motion Control
0x03	Diagnostics

The following table provides an example for direct reading:

Table 3-81 Example for direct reading

Byte	0	1	2	3
0	0x20	0x02	0x12	0x00
4	-	-	-	0x01
8	0x08	0x07	0x06	0x05
12	0x04	0x03	0x02	0x01

0x20: Direct reading
0x02: Motion Control = 2
0x0012: DB number = 18
0x01: Priority of the OB = 1
0x0102030405060708: Time stamp

Entry type: Error ID

The file is structured as follows:

Table 3-82 Entry in the diagnostics buffer

Byte	0	1	2	3
0	Entry type	-	Error type	
4	-	-	-	-
8	Time stamp in 10^{-12} seconds			
12				

The following table provides an example for a diagnostics buffer entry:

Table 3-83 Example for diagnostics buffer entry

Byte	0	1	2	3
0	0x30	-	0x42	0x29
4	-	-	-	-
8	0x08	0x07	0x06	0x05
12	0x04	0x03	0x02	0x01

0x30: Entry in the diagnostics buffer
0x2942: Error type = I/O read access error
0x0102030405060708: Time stamp

Entry type: Communication load and cycle time

The file is structured as follows:

Table 3-84 Entry in the diagnostics buffer

Byte	0	1	2	3
0	Entry type	-	Communication load in %	
4	Last cycle time in µs			
8	Time stamp in 10^{-12} seconds			
12				

The following table provides an example for the communication load:

Table 3-85 Example for communication load

Byte	0	1	2	3
0	0x31	-	0x12	0x00
4	0x03	0x02	0x01	0x00
8	0x08	0x07	0x06	0x05
12	0x04	0x03	0x02	0x01

0x31: Communication load and cycle time
0x0012: Communication load = 18%
0x00010203: Last cycle time = 66051µs
0x0102030405060708: Time stamp

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
4	No resources	You have exhausted all tickets in this user session. Close existing tickets to free up resources. Then call the method again.

Further processing of runtime data

With the "SIMATIC S7-1500 Profiling" library (https://support.industry.siemens.com/cs/at/de/view/109750245/en), Siemens offers a comprehensive analysis tool for analyzing the runtime behavior of your user programs. All relevant information is displayed graphically using a web-based visualization. For further analysis purposes, you can output the recorded data as a CSV file and evaluate it in a spreadsheet.

You can also find examples of using API methods in practice on Github under the following repository (https://github.com/siemens/simatic-s7-webserver-api).

5.6.6 PlcProgram.Browse

The PlcProgram.Browse method allows you to search for tags and the corresponding metadata according to your individual requirements.

To call the PlcProgram.Browse method, you need the "read_value" authorization.

Structure of the request

The following table informs you about the properties of the tag to be searched.

Table 3-86 PlcProgram_Browse_Request (object)

Name	Required	Data type	Description
var	Yes/no, see "Description" column	string	Name of the tag to be searched. If this attribute is present, it cannot be an empty string. • If "mode" = "var", then this attribute is required. The Browse method searches for the provided tag to retrieve the metadata of the tag. • If "mode" = "children", this attribute is optional. The Browse method searches for the tag and returns a list of child tags and metadata.
mode	Yes	string	Enumeration that determines the behavior of this method: • "var": Displays information about the specified tag. • "children": Outputs information about the immediate descendants (children) of the specified tags.
type	No	array of string	Possible array entries are: • "code_blocks": Reads all code blocks • "data_blocks": Reads all data blocks • "tags": Removes all tags If no "type" parameter is selected for compatibility reasons, only DBs and tags are returned.

Example 1

In the following example the user searches the root node ("root") of the CPU.

```
{
  "mode": "children"
}
```

The following example shows a possible response from the server.

```
[
  {
    "name": "TestDB",
    "has_children": true,
    "db_number": 2,
    "datatype": "datablock"
  },
  {
    "name": "GenUsrMsg_Ret",
```

```
    "address": "%MW43",
    "area": "M",
    "datatype": "int"
  }
]
```

Example 2

In the following example, the user searches the descendants (children) of a data block.

```
{
  "var": "\"MyDB\"",
  "mode": "children"
}
```

The following example shows a possible response from the server.

```
[
  {
    "name": "Static_1",
    "db_number": 1,
    "datatype": "int"
  },
  {
    "name": "Static_2",
    "db_number": 1,
    "datatype": "int"
  }
]
```

Example 3

In the following example, the user requests information about a specific tag.

```
{
  "var": "\"MyDB\".MyStruct.MyField",
  "mode": "var"
}
```

The following example shows a possible response from the server.

```
[
  {
```

```
    "name": "MyDateTimeValue",
    "db_number": 2,
    "datatype": "date_and_time",
    "array_dimensions": [
      {
        "start_index": 0,
        "count": 3
      }
    ]
  }
]
```

Example 4

In the following example, the user searches code blocks of a CPU.

```
{
   "mode": "children",
   "type": ["code_blocks"]
}
```

The following example shows a possible response from the server.

```
[
   {

    "name": "MainOB",

    "block_number": 1,

    "block_type": "ob"

},
{
"name": "MotorControlConveyor",
"block_number": 23,
"block_type": "fb"
}
{
"name": "CREATE_DB",
"block_number": 86,
"block_type": "sfc",

}
{
…
```

```
}
]
```

Example 5

In the following example, the user searches the data blocks of a CPU.

```
{
   "mode": "children",
   "type": ["data_blocks"]
}
```

The following example shows a possible response from the server.

```
[
  {
    "name": "TestDB",
    "block_number": 2,
    "datatype": "datablock"
  },
  {
    "name": "MotorControlConveyorDB",
    "block_number": 23,
    "datatype": "datablock"
  }
]
```

Example 6

The following example shows the result of searching the root node "root" of the CPU when the "type" parameter and all 3 possible array entries "data_blocks", "code_blocks" and "tags" are selected:

```
{
   "mode": "children",
   "type": ["data_blocks, "code_blocks", "tags"]
}
```

The following example shows a possible response from the server.

```
[
  {
   "name": "TestDB",
```

```
    "has_children": true,
    "db_number": 2,
    "datatype": "datablock"
   },
   {
    "name": "GenUsrMsg_Ret",
    "address": "%MW43",
    "area": "M",
    "datatype": "int",
   }
   {
    "name": "MainOB",
    "block_number": 1,
    "block_type": "ob"
   }
]
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-87 PlcProgram_Browse_Response (array of objects)

Name	Required	Data type	Description
name	Yes	string	Tag name; can be used as a string identifier for the field.
address	No	string	Address of the tag in STEP 7; only applicable for the tags in the ranges M, I, Q, timer and counter and tags in non-optimized data blocks. The representation corresponds to the addresses in the watch tables in the TIA Portal.
read_only	No	bool	Query whether the tag is read-only. The only valid value is "true". If the tag is to be written, this attribute does not appear.
has_children	No	bool	Query whether the tag is a structured tag with child tags. The only valid value is "true". If the tags are an unstructured data type, this attribute is not displayed.
db_number	No	number	Numerical data block identifier; appears when "datatype" = "datablock" and for each child element of a data block (with corresponding data block number).
area	No	string	Letter which defines the range (M/I/Q/timer/counter) of the tag. If the tag is not in one of these ranges, the attribute does not appear.
datatype	Yes	string	Data type of the tag For data blocks, this is the "datablock" data type; for tags, see the table in the section Supported data types (Page 191). If the data type is not supported, the data type is "unsupported".
max_length	No	number	If the data type is a "string" or "wstring", this value is the maximum number of characters allowed in the tag.

Name	Required	Data type	Description
array_dimensions	No	PlcProgram_Browse_Response_ArrayData	Object arrays arranged from the most significant to the least significant array dimension. The attribute is only displayed if the tag is an array.
block_number	No	number	Number of the logic block
block_type	No	string	The type of the logic block: • "ob" • "fc" • "fb" • "sfc" • "sfb"

Table 3-88 PlcProgram_Browse_Response_ArrayData (array of objects)

Name	Required	Data type	Description
start_index	Yes	integer	Start index for this array dimension, as specified in the TIA Portal project.
count	Yes	integer	Number of elements in this array dimension

Possible error messages

The following table shows possible error messages of the PlcProgram.Browse method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
3	System is busy	The desired operation cannot be performed because the system is currently performing a different request. Restart the query as soon as the current operation is complete.
4	No resources	The system does not have the required resources to retrieve the type information. Perform the request again as soon as enough resources are available again.
200	Address does not exist	The requested address does not exist or the Web server cannot access the requested address.
201	Invalid address	The name structure of the symbolic address is not correct.
202	Variable is not a structure	It is not possible to search the specific address because the tag is not a structured data type.
203	Invalid array index	The dimensions and limits of the array indexes do not correspond to the type information of the CPU.

NOTE

Tag access with the methods PlcProgram.Read, PlcProgram.Write, and PlcProgram.Browse

It is not yet possible to access all tags with these methods in firmware version ≥ V3.0.

There are selective restrictions when reading tags of technology objects. If access to specific tags is not possible, the API returns the message "unsupported".

5.7 Reading and changing the operating mode

5.7.1 Plc.ReadOperatingMode

With the Plc.ReadOperatingMode method you can read the operating mode of the CPU.

To call the Plc.ReadOperatingMode method, you need the "read_diagnostics" authorization.

Response structure

If the request to the server was successful, the server returns the operating mode as a string. The following strings are possible for operating modes:

String	Operating mode
`stop`	STOP
`startup`	STARTUP
`run`	RUN
`hold`	HOLD
`unknown`	-

Possible error messages

The following table shows the possible error messages of the Plc.ReadOperatingMode method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.

5.7.2 Plc.RequestChangeOperatingMode

With the Plc.RequestChangeOperatingMode method, you request a new operating mode for the CPU.

Note that this is only a request for an operating mode. The conditions for an operating mode change must be given at the CPU, e.g. by the corresponding position of the mode selector. You can use the Plc.ReadOperatingMode (Page 212) method to check whether the operating mode change on the CPU was successful.

To call the Plc.RequestChangeOperatingMode method, you need the "change_operating_mode" authorization.

Structure of the request

The following table informs you about the necessary parameters for the request.

Table 3-89 Plc_RequestChangeOperatingMode_Request (object)

Name	Required	Data type	Description
mode	yes	string	Requested operating mode: "stop" STOP mode "run" RUN mode

Example

In the following example, the RUN mode is requested.

```
{
  "mode": "run"
}
```

Response structure

If the request to the server was successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the Plc.RequestChangeOperatingMode method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.

5.7.3 Plc.ReadModeSelectorState

The Plc.ReadModeSelectorState method reads the current position of the mode switch to the CPU.

To call the Plc.ReadModeSelectorState method, you need "read_diagnostics" authorization.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-90 Plc_ReadModeSelectorState_Response (object)

Name	Required	Data type	Description
redundancy_id	Yes for R/H-CPUs No for all other CPUs	number	The parameter redundancy ID must be available if the request is performed on an R/H-CPU. The redundancy ID has the value 1 or 2. For all other CPUs, the parameter does not have to be part of the request.

Name	Required	Data type	Description
mode_selector	Yes	string	Possible values: • "run" • "stop" • "no_switch" • "unknown"

Example

In the following example, RUN mode is read.

```
{
  "mode_selector": "run"
}
```

Possible error messages

The following table shows possible error messages with the Plc.ReadModeSelectorState method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.

5.8 Change time settings via Web API

5.8.1 Plc.ReadSystemTime

This API method provides the system time of the CPU. If you have synchronized the system time of the CPU, for example via the TIA Portal function "Online & diagnostics", the system time corresponds to Coordinated Universal Time (UCT).

Response structure

The following table shows you the structure of server responses to successful requests.

Table 3-91 Plc_ReadSystemTime_Response (object)

Name	Required	Data type	Description
timestamp	Yes	string	ISO8601 time stamp as string in nanoseconds

Example

The following example shows the structure of the time stamp.

```
{
 "timestamp": "2012-04-23T18:25:43.123456789Z"
}
```

5.8.2 Plc.SetSystemTime

Use this API method to set the system time of the CPU (PLC local time).

To call the Plc.SetSystemTime method, you need the "change_time_settings" permission.

Structure of the request

The following table contains information about the parameters of the request:

Table 3-92 Plc_SetSystemTime_Request (object)

Name	Required	Data type	Description
timestamp	Yes	string	ISO 8601 timestamp as a string in nanoseconds; represents the time stamp of the system time to be set

Example

The following example shows the structure of the time stamp.

```
{
  "timestamp": "2023-11-05T18:25:43.515154511Z"
}
```

Response structure

The server always returns the Boolean value "true" for successful requests.

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
900	Invalid timestamp	The time stamp used does not match the required time-stamp format (ISO time-stamp defaults).
901	Time not within allowed time range	The time stamp is not within the allowed period for time stamps. The end of the possible timespan is 2200-12-31T23:59:59.999999999Z

5.8.3 Plc.ReadTimeSettings

This API method returns the currently active time, the deviation of the time zone from Coordinated Universal Time (UCT), and any daylight saving time rules.

Structure of the request

The following tables contain information about the individual parameters of the request.

Table 3-93 Plc_ReadTimeSettings_Response (object)

Name	Required	Data type	Description
current_offset	Yes	string the time range, shown in accordance with ISO 8601	The currently active deviation of the PLC local time from the coordinated universal time (UTC) configured on the CPU in minutes, e.g. "PT1H30M" for a deviation of 1 hour and 30 minutes.
utc_offset	Yes	string the time range, shown in accordance with ISO 8601	The deviation of the time zone from the coordinated universal time (UTC) in minutes without consideration of the daylight saving time rules.
rule	No	object of type Plc_ ReadTimeSettings_ Rule_Response	Displays the daylight saving time settings. If no settings are active, daylight saving time is not set and only the "utc_offset" value is used to calculate the PLC local time.

Table 3-94 Plc_ReadTimeSettings_Rule_ Response (object)

Name	Required	Data type	Description
std	Yes	object of type Plc_ ReadTimeSettings_ StdRule_Response	Stands for the zone time setting.
dst	Yes	object type Plc_ ReadTimeSettings_ DstRule_Response	Stands for the daylight saving time settings

Table 3-95 Plc_ReadTimeSettings_StdRule_Response (object)

Name	Required	Data type	Description
start	Yes	object of type Plc_ ReadTimeSettings_ Start_Response	Stands for the start time of the zone time.

Table 3-96 Plc_ReadTimeSettings_DstRule_Response (object)

Name	Required	Data type	Description
start	Yes	object of type Plc_ ReadTimeSettings_ Start_Response	Stands for the start time of daylight saving time.
offset	Yes	string the time range, shown in accordance with ISO 8601	Stands for the deviation of daylight saving time from the zone time in minutes (only used in the dst object).

Table 3-97 Plc_ReadTimeSettings_Start_Response (object)

Name	Required	Data type	Description
month	Yes	number	Used in the "dst.start/std.start" objects. Stands for the month in which the time starts.
week	Yes	number	Used in the "dst.start/std.start" objects. Stands for the week in which the time change is performed. Value 1: First occurrence of the day of the week in the month Value 5: Last occurrence of the day of the week in the month
day_of_week	Yes	string	Used in the "dst.start/std.start" objects. Describes the day of the week on which the time change is performed as a string with 3 characters. The following values are possible: • sun • mon • tue • wed • thu • fri • sat
hour	Yes	number	Used in the "dst.start/std.start" objects. Describes the hour in which the time change is performed.
minute	Yes	number	Used in the "dst.start/std.start" objects. Describes the minute in which the time change is performed.

Example 1

A daylight saving time rule is configured in the following example.

```
{
 "current_offset": "PT1H",
 "utc_offset": "PT2H",
 "rule":
 {
  "dst":
  {
   "offset": "PT1H",
   "start":
   {
    "month": 4,
    "week": 4,
    "day_of_week": "sun",
    "hour": 3,
    "minute": 0
  }
 },
 "std":
  {
```

```
    "start":
    {
     "month": 10,
     "week": 5,
     "day_of_week": "sun",
     "hour": 2,
     "minute": 0
    }
   }
  }
 }
```

Example 2

In the following example, no daylight saving time rule has been configured and a time offset of 1 hour exists.

```
{
 "current_offset": "PT1H",
 "utc_offset": "PT2H",
}
```

5.8.4 Plc.SetTimeSettings

With this API method you can set the time settings of the CPU.

To call the Plc.SetTimeSettings method, you need the "change_time_settings" permission.

Structure of the request

The following tables contain information about the individual parameters of the request.

Table 3-98 Plc_SetTimeSettings_Response (object)

Name	Required	Data type	Description
utc_offset	Yes	string	ISO 8601 timespan as a string; the deviation of the time zone from the coordinated universal time (UTC) without consideration of the daylight saving time rules.
rule	No	object of type Plc_SetTimeSettings_Rule_Response	Displays the daylight saving time settings. If no settings are active, daylight saving time is not set and only the "utc_offset" value is used to calculate the local time.

Table 3-99 Plc_SetTimeSettings_Rule_Response (object)

Name	Required	Data type	Description
std	Yes	object of type Plc_SetTimeSettings_StdRule_Response	Stands for the zone time setting.
dst	Yes	object of type Plc_SetTimeSettings_DstRule_Response	Stands for the daylight saving time settings

Table 3-100 Plc_SetTimeSettings_StdRule_Response (object)

Name	Required	Data type	Description
start	Yes	object of type Plc_SetTimeSettings_Start_Response	Stands for the start time of the zone time.

Table 3-101 Plc_SetTimeSettings_DstRule_Response (object)

Name	Required	Data type	Description
start	Yes	object of type Plc_SetTimeSettings_Start_Response	Stands for the start time of daylight saving time.
offset	Yes	string	ISO 8601 timespan as a string; the deviation of daylight saving time from the zone time in minutes (only used in the dst object).

Table 3-102 Plc_SetTimeSettings_Start_Response (object)

Name	Required	Data type	Description
month	Yes	number	Used in the "dst.start/std.start" objects. Stands for the month in which the time starts.
week	Yes	number	Used in the "dst.start/std.start" objects. Stands for the week in which the time change is performed Value 1: First occurrence of the day of the week in the month Value 5: Last occurrence of the day of the week in the month
day_of_week	Yes	string	Used in the "dst.start/std.start" objects. Describes the day of the week on which the time change is performed as a string with 3 characters. The following values are possible: • sun • mon • tue • wed • thu • fri • sat
hour	Yes	number	Used in the "dst.start/std.start" objects. Describes the hour in which the time change is performed.
minute	Yes	number	Used in the "dst.start/std.start" objects. Describes the minute in which the time change is performed.

Example 1

The following example shows how to set a rule with daylight saving time parameters.

```
{
 "utc_offset": "PT2H",
 "rule":
 {
  "dst":
  {
   "offset": "PT1H",
   "start":
   {
    "month": 4,
    "week": 4,
    "day_of_week": "wed",
    "hour": 3,
    "minute": 0
   }
  },
  "std":
  {
   "start":
   {
    "month": 10,
    "week": 5,
    "day_of_week": "wed",
    "hour": 2,
    "minute": 0
   }
  }
 }
}
```

Example 2

The following example shows the setting of a rule without daylight saving time parameters.

```
{
 "utc_offset": "PT6H",
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
5	System is read-only	The system cannot be written to (SIMATIC Memory Card is read-only). Changes are currently not permitted.
902	Invalid time rule	The rule provided is invalid. Check that the time settings are correct.
903	Invalid UTC offset	The Coordinated Universal Time (UTC) deviation provided is invalid. Check that the time settings are correct.

5.9 Reading diagnostics and service data

5.9.1 Project.ReadLanguages

This API method returns a list with the project languages available on the CPU.

You can then use the "Alarms.Browse" or "DiagnosticBuffer.Browse" API methods in one of the available languages to get alarm messages or diagnostic messages in the available languages.

To call the Project.ReadLanguages method, you need the "read_diagnostics" permission.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-103 Project_ReadLanguages_Response (Array of objects)

Name	Required	Data type	Description
languages	Yes	array of Project_ReadLanguages_Entry_Response	Object array, where each object represents a project language.

Table 3-104 Project_ReadLanguages_Entry_Response (object)

Name	Required	Data type	Description
language	Yes	string	String with the project language.

Example

The following example shows the output of a project language as a string.

```
{
  "languages":
  [
    {
      "language": "en-US"
    }
  ]
```

```
}
```

NOTE
No project language configured
If no project language was configured, the object array is empty.

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

5.9.2 Alarms.Browse

With this method you can determine which alarms are currently active on the CPU, and when the last change occurred within the diagnostics buffer.

To call the Alarms.Browse method, you need the "read_diagnostics" permission.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-105 Alarms_Browse_Request (object)

Name	Required	Data type	Description
language	Yes	string	The desired language in which the text is returned in RFC 4647 format, e.g. "en-US"
count	No	number	The maximum number of alarm entries that are returned. The default value is 50. If you want to determine the current status of the diagnostics buffer, enter 0 as "count".
alarm_id	No	string	The alarm ID of the CPU for which you are requesting data. If the Alarm ID is included, only the "count" parameter can be offered as a filter.
filters	No	object of type Alarms_Browse_Filters_Request	Optional object containing parameters for filtering the response

Table 3-106 Alarms_Browse_Filters_Request (object)

Name	Required	Data type	Description
mode	Yes	string	The mode that determines whether attributes are to be included or excluded in the response. The following modes are available: • include • exclude

Name	Required	Data type	Description
filters.attributes	Yes	array of strings	Possible array entries are: • "alarm_text" • "info_text" • "status" • "timestamp" • "acknowledgement" • "alarm_number" • "producer"

Examples

The following example shows a request for reading a single alarm with all alarm areas in the English language:

```
{
 "language": "en-US",
 "alarm_id": "1231231231"
}
```

The following example shows the request for reading a single alarm without the alarm areas excluded under "exclude":

```
{
 "language": "en-US",
 "alarm_id": "1231231231",
 "filters":
 {
  "mode": "exclude",
  "attributes": ["alarm_text", "info_text"],
 }
}
```

The following example shows the request for reading 50 alarms with the alarm ranges included in "include".

```
{
 "language": "en-US",
 "count": 50,
 "filters":
 {
  "mode": "include",
  "attributes": ["status", "acknowledgement"]
 }
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-107 Alarms_Browse_Response (object)

Name	Required	Data type	Description
language	No, optional and only available when entries are returned; not relevant if, for example, count = 0 is requested	string	The language of the response in which the message text is output. If no valid language was requested, the server outputs the message "invalid".
last_modified	Yes	string	ISO 8601 time stamp in UTC as string; The time stamp with the last change of the alarm system since you made the last read request. The time stamp allows you to see when the last alarm change occurred in the system without having to check individual alarms in detail.
count_current	Yes	number	The number of active alarms.
count_max	Yes	number	The maximum number of active alarms.
entries	No	array of objects of Alarm_Browse_Entry_response	The list of pending alarms, where each alarm entry is represented as an object.

Table 3-108 Alarms_Browse_Entry_Response (object)

Name	Required	Data type	Description
id	Yes	string	Alarm ID.
alarm_number	Yes, if not excluded by user	number	Alarm number.
status	Yes, if not excluded by user	string	Alarm status; is either "incoming" or "outgoing".
timestamp	Yes, if not excluded by user	string	ISO 8601 time stamp as a string; Time stamp in Coordinated Universal Time (UTC) of the time at which the alarm assumed the status "incoming" or "outgoing".
producer	Yes, if not excluded by user	string	Possible alarm trigger: • "program_alarm" • "system_diagnostics" • "motion" • "security" • "sinumerik" • "graph7" • "prodiag" • "other"
hwid	No	number	Contains the hardware ID if the alarm producer is "system_diagnostics".
acknowledgement	No	object	Appears when an alarm needs to be acknowledged.

Name	Required	Data type	Description
acknowledge-ment.state	Yes	string	String in readable form, which provides information about the status of the acknowledgement: • "not_acknowledged" • "acknowledged"
acknowledge-ment.timestamp	Yes	string	ISO 8601 time stamp as a string; If the current status ("incoming" or "outgoing") has been acknow-ledged, the time stamp provides information about the time of acknowledgement.
alarm_text	Yes, if not excluded by user	string	Alarm text in the selected language.
info_text	Yes, if not excluded by user	string	Info text in the selected language.
text_inconsistent	No	boolean	If the alarm text or info text is inconsistent, this flag returns "true".

Examples

The following example shows the response to a request with a non-acknowledged alarm and all attributes (no filters set).


```
{
 "entries":
 [
  {
   "id": "121651651651",
   "timestamp": "2023-11-05T18:25:43.511987654Z",
   "status": "incoming",
   "alarm_number": 37,
   "producer": "system_diagnostics",
   "hwid": 49,
   "acknowledgement":
   {
    "state": "not_acknowledged"
   },
   "alarm_text": "CPU maintenance demanded: Emergency IP suite
parameter for IE interface activated PLC_1516 / Current CPU
operating mode: STOP",
   "info_text": "Short name: CPU general Order number: 6ES7
516-3AP03-0AB0",
   "text_inconsistent": false
  }
 ],
 "last_modified": "2023-11-05T18:25:43.511546151Z",
 "count_current": 1,
 "count_max": 5000,
 "language": "en-US"
```

```
}
```

The following example shows the response to a request with an acknowledged alarm and all attributes (no filters set):


```
{
 "entries":
 [
  {
   "id": "121651651651",
   "timestamp": "2023-11-05T18:25:43.511987654Z",
   "status": "incoming",
   "alarm_number": 35,
   "producer": "system_diagnostics",
   "hwid": 49,
   "acknowledgement":
   {
    "state": "acknowledged",
    "timestamp": "2023-11-05T18:25:50.123456789Z"
   },
   "alarm_text": "CPU status message: CPU not in RUN Current CPU
operating mode: STOP",
   "info_text": "Short name: CPU general Order number: 6ES7
516-3AP03-0AB0",
   "text_inconsistent": false
  }
 ],
 "last_modified": "2023-11-05T18:25:43.511546151Z",
 "count_current": 1,
 "count_max": 5000,
 "language": "en-US"
}
```


The following example shows the filtered response to a query with only alarm IDs:


```
{
 "entries":
 [
  {
   "id": "121651651651",
   "producer": "system_diagnostics"
  }
  {
   "id": "121651651652"
   "producer": "system_diagnostics",
  }
```

```
    {
     "id": "121651651653"
     "producer": "program_alarm",
    }
   ],
   "last_modified": "2023-11-05T18:25:43.511546151Z",
   "count_current": 3,
   "count_max": 5000,
   "language": "en-US"
  }
```


Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
800	Invalid alarm ID	The alarm ID provided is invalid.
801	Invalid parameters	The request is invalid because provided parameters are invalid (e.g. the parameters "count" and "id" are present at the same time).

5.9.3 Alarms.Acknowledge

Use this method to acknowledge individual alarms.

To call the Alarms.Acknowledge method, you need the "acknowledge_alarms" permission.

Structure of the request

The following table contains information about the parameters of the request:

Table 3-109 Alarms_Acknowledge_Request (object)

Name	Required	Data type	Description
id	Yes	string	The acknowledgement ID of the alarm to be acknowledged. The acknowledgement ID can be found in the alarm object returned by the Alarm.Read method.

Examples

The following example shows the ID of an alarm to be acknowledged:


```
{
 "id": "9979413824317259784"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

5.9.4 Syslog.Browse

The Syslog.Browse method reads the entries of the CPU's internal syslog buffer.

To call the Syslog.Browse method, you need "read_syslog" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-110 Plc_ReadModeSelectorState_Request (object)

Name	Required	Data type	Description
redundancy_id	Yes for R/H-CPUs No for all other CPUs	number	The parameter redundancy ID must be available if the request is performed on an R/H-CPU. The redundancy ID has the value 1 or 2. For all other CPUs, the parameter does not have to be part of the request.
count	No	number	The maximum number of syslog entries is requested. The default and maximum value is 20. If the value is 0, all syslog entries are omitted from the response. Only the attributes last_modified, count_total and count_lost are returned.
first	No	number	"first" specifies the latest entry to be read. When count > 1 is set, the values are read backward. For example, if you request the value 42 with count 3, the entries 42, 41 and 40 are returned. When the value 0 is set, the latest <count> elements are read.

Example 1

In the following example, the user requests up to 20 syslog entries, beginning with the latest entries.

```
{
  "count": 20
}
```

Example 2

In the following example, the user requests up to 20 syslog entries, beginning with entry 853.

```
{
  "count": 20,
  "first": 853
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-111 Syslog_Browse_Response (object)

Name	Required	Data type	Description
entries	Yes	array of Syslog_Browse_ Entry_Request	Contains an array of objects where each object is a single syslog entry of the CPU's internal syslog buffer.
count_total	Yes	number	This attribute contains the overall number of the entries in the syslog buffer since startup of the CPU.
count_lost	Yes	number	This attribute contains the number of entries of the syslog buffer which were lost. This is the number of the entries which were not overwritten through new entries and not stored on the syslog server.

Table 3-112 Syslog_Browse_Entry_Response (object)

Name	Required	Data type	Description
raw	Yes	string	An unformatted syslog entry according to RFC 3164.

Example 1

In the following example, an individual syslog entry is returned.

```
{
"entries":
 [
  {
   "<35>1 2023-08-24T22:22:50.468Z 192.168.0.1 Webserver - ID6
[device@4329.6.100.1.1500 devVendor="Siemens" devProduct="CPU1500
(PLCSIM)"
FWVersion="T31.16.20"][session@4329.6.100.1.1500 protocolType="HTTP-
S" userName="Anonymous" src="192.168.0.99"
sessionID="1"][function@4329.6.100.1.1500 fct="login"
result="success"] SE_DEFAULT_USER_AUTHENTICATION_USED"
  }
 ],
 "count_total": 546875456,
 "count_lost": 0
```

```
}
```

Example 2

In the following example, an empty syslog response is returned, if previously no syslog message was available in the syslog buffer.

```
{
  "entries": [],
  "count_total": 0,
  "count_lost": 0
}
```

Example 3

In the following example, an empty syslog response is returned, if count = 0 is requested. This query can be used to request the ID of the last syslog entry without data to detect if new entries are available.

```
{
  "entries": [],
  "count_total": 546875456,
  "count_lost": 0
}
```

Possible error messages

The following table shows possible error messages with the Plc.ReadModeSelectorState method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
4	No resources	The system does not have the resources required to read the requested address. Perform the request again as soon as enough resources are available again.
7	Partner not accessible	The data of a partner CPU of an R/H system is not available. This can be the case when the CPU is not in RUN-Redundant system state.

5.9.5 DiagnosticBuffer.Browse

With this method you read out entries from the diagnostics buffer of the CPU.

To call the DiagnosticBuffer.Browse method, you need the "read_diagnostics" permission.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-113 DiagnosticBuffer_Browse_Request (object)

Name	Required	Data type	Description
language	Yes	string	The desired language in which the text is returned in RFC 4647 format, e.g. "en-US"
count	No	number	The maximum number of alarm entries that are returned. The default value is 50. If you want to determine the current status of the diagnostics buffer, enter 0 as "count".
filters	No	object of type DiagnosticBuffer_ Browse_Filters_ Request	The object that represents the different filtering options.

Table 3-114 DiagnosticBuffer_Browse_Filters_Request (object)

Name	Required	Data type	Description
attributes	Yes	array of strings	The following attributes are possible for the diagnostics buffer entries: • short_text • long_text • help_text
mode	Yes	string	The mode that determines whether attributes are to be included or excluded in the request. The following modes are available: • include • exclude

Example

The following example shows a request of the diagnostic entries as LCID value 1033 (dec value), which stands for "English – United States".

```
{
 "language": "en-US",
 "count": 50,
 "entries":
 {
  "mode": "include",
  "attributes": ["short_text", "long_text", "help_text"]
 }
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-115 DiagnosticBuffer_Browse_Response (object)

Name	Required	Data type	Description
entries	No	array of objects of DiagnosticBuffer_Browse_Entry_Response	Array of diagnostics buffer entries, where each object represents one diagnostics buffer entry.
last_modified	Yes	string	ISO 8601 time stamp as a string; time stamp of the last change in the diagnostics buffer.
count_current	Yes	number	Number of available diagnostics buffer entries.
count_max	Yes	number	Maximum number of possible diagnostics buffer entries
language	No, optional and only available when entries are returned; not relevant if, for example, count = 0 is requested	string	The language in which the response is output.

Table 3-116 DiagnosticBuffer_Browse_Entry_Response (object)

Name	Required	Data type	Description
timestamp	Yes	string	ISO 8601 time stamp as a string; The attribute is provided in Coordinated Universal Time (UTC) and not in PLC local time.
status	Yes	string	The status parameter for events is either "incoming" (incoming events) or "outgoing" (outgoing events).
event	Yes	object	Contains the event ID of the diagnostics buffer which consists of the text list ID and the text ID of the event
event.textlist_id	Yes	number	Text list ID of the event
event.text_id	Yes	number	Text ID of the event
long_text	Yes, if not excluded by the user	string	Diagnostics buffer entries in the long form
short_text	Yes, if not excluded by the user	string	Diagnostics buffer entries in the short form
help_text	Yes, if not excluded by the user	string	Help text for an incoming event.

Example

The following example shows the representation of a single entry in the diagnostics buffer (system diagnostics message).

```
{
```

```
 "entries":
 [
  {
   "timestamp": "2023-11-05T18:25:43.511854547Z",
   "status": "outgoing",
   "long_text": "CPU info: Boot up
memory card type: Program card (external load memory)
CPU changes from OFF to STOP (initialization) mode

PLC_2 / PLC_2",
   "short_text": "Boot up - CPU changes from OFF to STOP
(initialization) mode",
   "help_text": "",
   "event"
   {
    "textlist_id": 2,
    "text_id": 16385
   }
  }
 ],
 "last_modified": "2023-11-05T18:25:43.514678521Z",
 "count_current": 1234,
 "count_max": 3200,
 "language": "en-US"
}
```


Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.

5.9.6 Modules.DownloadServiceData

The API method Modules.DownloadServiceData returns a ticket that you use to download service data from the CPU. You can then forward the service data to Customer Support, for example for an analysis of your production data in the event of an error.

To call the API method Modules.DownloadServiceData, you need "download_service_data" authorization.

You can find more information about the ticket mechanism in the section Ticket mechanism (Page 170).

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-117 Modules_DownloadServiceData_Request (object)

Name	Required	Data type	Description
hwid	Yes	number	Hardware ID of the module whose service data you want to read out.

Response structure

If successful, the method returns a string with a ticket ID. Use this ticket ID to download the service data.

NOTE

A maximum of only one Modules.DownloadServiceData ticket can be created for all users. A new ticket can be created for this method only after this ticket has been closed.

Example

The following example shows a generated ticket ID for service data download.

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
4	No resources	You have exhausted all tickets in this user session. Close existing tickets to free up resources. Then call the method again.
7	Partner not accessible	The data of the CPU of an R/H system is not available. This can be the case when the system is in SYNCUP operating state or RUN-Redundant system state or when the service data of the partner CPU is queried.
600	No service data resources	Only one ticket resource for service data is available for all users at the same time.
1100	Invalid hardware identifier	The specified hardware ID is not valid for the current request. Make sure that you have used the correct hardware ID.

5.10 Backing up and restoring the configuration

5.10.1 Plc.CreateBackup

With this API method, you request a ticket to create a backup file of the CPU configuration.

To call the Plc.CreateBackup method, you need the "backup_plc" permission.

Response structure

The method returns a string with a ticket ID for creating a backup file.

Example

The following example shows a generated ticket ID for creating a backup file.

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

An example of further processing of the ticket ID can be found in the Ticket mechanism (Page 170) section.

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
4	No resources	You have exhausted all tickets in this user session. Close existing tickets to free up resources. Then call the method again.
1000	Backup creation in progress	The creation of a backup file is in progress.
1001	Backup restoration in progress	The restoration of a saved configuration is currently being carried out. It is not possible to perform both operations at the same time.
1004	PLC not in STOP	A backup file can only be created when the CPU is in STOP mode. Set the CPU to STOP mode and execute the request again.

Overview of creating a backup file

Perform the steps below to create a backup file:

1. Authenticate yourself with the API method Api.Login.
2. Request a ticket for creating a backup file using the Plc.CreateBackup method.

   If you are authorized to call this method and the CPU is in STOP, the CPU creates a ticket. Once a ticket has been created for the creation of a backup file, it is no longer possible to switch to the RUN operating state. This ensures the consistency of the backup file.

3. Use the ticket end point to start downloading the backup file.

   The CPU informs you about the current status of the generation in the additional ticket information. Additional information is available using the Api.BrowseTickets(id) method.
4. After the download has been completed successfully, the CPU sets the ticket to the "completed" status.
5. Close the ticket using the Api.CloseTicket(id) method.
6. Now you can set the CPU back to RUN mode.

Format of the backup file name

The default file name of the backup file, which is returned by the HTTP content disposition header, contains the following information:

- Time stamp in Coordinated Universal Time (UTC)
- Module name
- Name of the TIA Portal project
- F-collective signature (for F-CPUs)

5.10.2 Plc.RestoreBackup

Use this API method to request a ticket that restores the configuration of a CPU via a backup file.

To call the Plc.RestoreBackup method, you need the "restore_plc" permission.

Structure of the request

The following table contains information about the parameters of the request:

Table 3-118 Plc_RestoreBackup_Request (object)

Name	Required	Data type	Description
password	Yes	string	The required password for the logged on user An empty password string is transferred for the "Everybody" or "Anonymous" user. The "passwort" attribute is therefore always required. The password must be the password of the user who previously authenticated via Api.Login and whose session token was used to call the Plc.RestoreBackup method.

Example

The following example shows how to enter a password.

```
{
 "password": "SecurePassword"
}
```

Response structure

The method returns a string. The string contains a ticket ID that you can use to restore the configuration on a backup file.

Example

The following example shows a generated ticket ID for restoring the configuration of a CPU.

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

An example of further processing of the ticket ID can be found in the Ticket mechanism (Page 170) section.

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method.
4	No resources	You have exhausted all tickets in this user session. Close existing tickets to free up resources. Then call the method again.
5	System is read-only	The system cannot be written to (SIMATIC Memory Card is read-only). Changes are currently not permitted.
1000	Backup creation in progress	The creation of a backup file is in progress.
1001	Backup restoration in progress	The restoration of a saved configuration is currently being carried out. It is not possible to perform both operations at the same time.
1003	Restore not possible through this interface	Calling the method via CM/CP modules, via IP the address or via a virtual CP is not allowed. Perform the recovery via the IP address of one of the network interfaces of a CPU.
1004	PLC not in STOP	A backup file can only be created when the CPU is in STOP mode. Set the CPU to STOP mode and execute the request again.
1005	Legitimation failed	The user legitimation was not successful. Reasons for this can be the entry of password for the "Everybody" or "Anonymous" user, or the entry of an invalid password.

Overview of the recovery of the CPU configuration

The following section shows you all steps that are required to restore the CPU configuration.

NOTE

Tracking the recovery process via Api.BrowseTickets

The Api.BrowseTickets method provides information about the current status of the recovery.

Use this method to found out the recovery process phase, and whether the recovery process was successful.

1. Authenticate yourself with the API method Api.Login.
2. Request a ticket for restoring a CPU configuration using the Plc.RestoreBackup method.
3. Use the ticket end point to start the upload of the backup file.

   The CPU receives the file header and checks whether it is valid. After a successful check, the CPU restarts after 3 seconds. If the file header is invalid, the CPU aborts the restoration process and the ticket changes to the `failed` status.

   When checking the restoration process, the following states may occur. These states can be read out via the API method Api.BrowseTickets.

Status	Description
`waiting`	The waiting state is active until the upload of the backup file is started.
`ongoing`	As soon as the upload of the backup file has started, the state changes to `ongoing`.
`rebooting_format`	The CPU is restarting. The reason for the restart is the formatting of the SIMATIC Memory Card.
`rebooting`	The CPU is restarting. The reason for the restart is the activation of the restored project.
`failed`	An error occurred during the upload of the backup file. You can abort the upload when an error occurs.
`failed_failsafe`	An error occurred during the execution of the fail-safe function. Ensure that the password passed to the Plc.RestoreBackup method is correct and the user has the F-Admin function right.
`failed_wrong_interface`	You have started the upload of the backup file to the CPU via a CM or CP interface.

NOTE

Loss of the configuration during the restoration process

Note that the CPU loses the configuration during the restoration process.

4. Before restarting the CPU, it is possible to read the status with the Api.BrowseTickets(id) method. The additional information informs you about restarting the CPU and formatting the SIMATIC Memory Card as next steps.

   To be informed about the process and all messages, we recommend that you read the information of the Api.BrowseTickets method cyclically, e.g. every second.
5. The CPU then restarts and formats the SIMATIC Memory Card.

   During the restart you can use the Api.Ping method to determine when the CPU is available again.

   During the restart, the Api.BrowseTickets and Api.Ping methods do not respond.

6. The CPU puts the web server into a state with reduced functionality. Only a limited number of API methods is available to you during this time.

NOTE

If you want to restore the CPU to its normal state during the restoration process, perform a download via the TIA Portal. After the download, the CPU and the web server are again in normal operation and all functions are available for use.

7. Use the Api.Login method to log on with the logon data that were also valid at the beginning of the restoration process.
8. Request a ticket for the restore using the Plc.RestoreBackup method.
9. Upload the backup file via the ticket end point.

   After successful upload, the CPU restarts after 3 seconds.
10. Before restarting the CPU, it is possible to read the status with the Api.BrowseTickets(id) method. The additional information informs you about the restart and about the successful upload.

    The restart is required to activate the new project.
11. During the restart you can use the Api.Ping method to determine when the CPU is available again.
12. As soon as the CPU is available again, the restoration process is completed and the recovered project is loaded into the CPU.

You can now log in with the credentials of a user of the project loaded into the CPU, if desired.

Further work in the API requires a new login with the Api.Login method.

5.11 Accessing the contents of the SIMATIC Memory Card

The methods described in this section allow you to access the files in the file system on the SIMATIC Memory Card. You can access standard files as well as your own user files (UserFiles), DataLogs, and recipes.

NOTE

Access to the file system for R/H-CPUs

The file API only offers limited access to the SIMATIC Memory Card. Access is restricted to the "UserFiles", "DataLogs", and "Recipes" folders. Other content on the SIMATIC Smart Card is not accessible via the API.

5.11.1 Files.Browse

This method returns a list of the contents of subdirectories and attributes of specific directories or files which are located on the SIMATIC Memory Card of a CPU.

To call the Files.Browse method, you need the "read_file" permission.

NOTE

For R/H-CPUs, only a maximum of three folders – Recipes, UserFiles and DataLogs – are returned in the root directory of the SIMATIC memory card. No other folders are returned.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-119 Files_Browse_Request (object)

Name	Required	Data type	Description
resource	No	string	Path to the directory or file from the root node. For the root node, the use of a "/" is necessary. You can optionally use a "/" for the root node. If the attribute "resource" is missing or empty, the system interprets it as "/".

Example

The following example shows a request specifying the desired path to a txt file:

```
{
 "resource": "/myfolder/file.txt"
}
```

The following example shows a request specifying the desired path to a csv file (datalog).

```
{
 "resource": "/Datalogs/datalog1.csv"
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-120 Communication_ReadStatistics_Response (object)

Name	Required	Data type	Description
resources	yes	array of files_Browse_Entry_Response	Resource list.

Table 3-121 Files_Browse_Entry_Response (object)

Name	Required	Data type	Description
name	yes	string	Name of the entry.
type	yes	string	Type of entry, either "file" or "dir".
size	No	number	Size of the file in bytes (if type is "file").
last_modified	yes	string	ISO8601 time stamp as string; time stamp of the last change.
state	No	string	Attribute reserved for active or inactive DataLogs in the "DataLogs" folder

Example

The following example shows the response to a request with a file and a folder:

```
{
 "resources":
 [
  {
   "name": "my_dir",
   "type": "dir",
   "last_modified": "2012-04-23T18:25:43Z"
  },
  {
   "name": "my_file.txt",
   "type": "file",
   "size": 87654567,
   "last_modified": "2012-04-23T18:25:43Z"
  }
 ]
}
```

The following example shows the response to a query with an active csv file:

```
{
 "resources":
 [
  {
   "name": "datalog1.csv",
   "type": "file",
   "size": 87654567,
   "last_modified": "2012-04-23T18:25:43Z",
   "state": "active"
  }
 ]
}
```

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method.
4	No resources	The system does not have the required resources to carry out this request.
300	Path contains an illegal sequence	The parameter specified under "resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" is subject to access restrictions.
302	Entity does not exist	The file or path to be accessed by the "resource" parameter does not exist.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.

5.11.2 Files.Download

This method creates a ticket that you can use to download a file from the CPU.

To call the Files.Download method, you need the "read_file" permission.

For more information about the ticket mechanism, see the Ticket mechanism (Page 170) section.

Structure of the request

The following table contains information about the individual parameters of the request:

Table 3-122 Files_Download_Request (object)

Name	Required	Data type	Description
resource	yes	string	Path to the file from the root node of the SIMATIC Memory Card

Examples

The following example shows a request specifying the path to a txt file:

```
{
 "resource": "/myfolder/file.txt"
}
```

The following example shows a request specifying the path to a csv file (datalog):

```
{
 "resource": "/Datalogs/datalog1.csv"
}
```

Response structure

If successful, the method returns a string with a ticket ID.

Example

The following example shows a generated ticket ID for downloading the file:

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

NOTE
Ticket-based file downloads
For all ticket-based file downloads, the ticket returns a file name in the HTTP content disposition header. You can use this file name as the default file name, or as the name used by the web browser as the default name.

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The user does not have read permissions.
4	No resources	The system does not have the required resources to carry out this request.
300	Path contains an illegal sequence	The parameter specified under "resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" is subject to access restrictions.
302	Entity does not exist	The file or path to be accessed by the "resource" parameter does not exist.
303	Entity in use	The file or path to be accessed by the "resource" parameter is locked because of another operation (e.g. because of a write access).
305	Entity not a directory	The directory or subdirectory specified under "resource" is attempting to access a file.
306	Entity not a file	The file name specified under "resource" is attempting to access a directory.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.

5.11.3 Files.Create

This method creates a ticket that you use to upload a file to the CPU.

To call the Files.Create method, you need the "write_file" permission.

For more information about the ticket mechanism, see the Ticket mechanism (Page 170) section.

NOTE
Uploading a file on R/H-CPUs
If a file is uploaded during SYNCUP, the R/H system aborts the upload of this file. During SYNCUP, the R/H does not wait until the file has uploaded.

NOTE
Storage location of files on R/H-CPUs
Files can only be created in the Recipes and UserFiles folders and not in the root directory or outside these two folders.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-123 Files_Create_Request (object)

Name	Required	Data type	Description
resource	yes	string	Path to the file from the root node of the SIMATIC Memory Card

Example

The following example shows a request specifying the path to the desired file:

```
{
 "resource": "/mydir/file.txt"
}
```

Response structure

If successful, the method returns a string with a ticket ID.

Example

The following example shows a generated ticket ID for uploading the file:

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The user does not have read permissions.
4	No resources	The system does not have the required resources to carry out this request.
5	System is read-only	The system cannot be written to at present. File changes are not possible because the SIMATIC Memory Card is read-only.
300	Path contains an illegal sequence	The parameter specified under "resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" is subject to access restrictions.
302	Entity does not exist	The directory or subdirectory to be accessed by the "resource" parameter does not exist.
304	Entity already exists	The parameter specified under "resource" is attempting to create a file that already exists.
305	Entity not a direct-ory	The directory or subdirectory specified under "resource" is attempting to access a file.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.

5.11.4 Files.Rename

This method changes the name of a file or directory. You can also use this method to move files from one directory to another.

To call the Files.Rename method, you need the "write_file" permission.

NOTE

Note that you cannot use this method for the "DataLogs" folder.

Structure of the request

The following table contains information about the individual parameters of the request:

Table 3-124 Files_Rename_Request (object)

Name	Required	Data type	Description
resource	yes	string	Current file path or directory path.
new_resource	yes	string	New file path or directory path.

Example

The following example shows a change of the file name.

```
{
 "resource": "/folder/old_file_name.txt",
 "new_resource": "/folder/new_file_name.txt"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The user does not have write permission for the file.
4	No resources	The system does not have the required resources to carry out this request.
5	System is read-only	The system cannot be written to (SIMATIC Memory Card is read-only). Changes are currently not permitted.
300	Path contains an illegal sequence	The parameter specified under "resource" and/or "new_resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" and/or under "new_resource" is subject to access restrictions.
302	Entity does not exist	The file or path to be accessed by the parameter "resource" and/or under "new_resource" does not exist.
303	Entity in use	The parameter specified under "resource" is accessing a file or directory that is already locked by another operation (e.g. read or write).
304	Entity already exists	The parameter specified in "new_resource" is attempting to create a file or directory that already exists.
305	Entity not a directory	The parameter specified under "resource" and/or "new_resource" is attempting to access a file.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.
308	Directories cannot be moved	The parameter specified under "resource" and/or "new_resource" is attempting to move a directory structure. Moving a directory structure is not allowed.

5.11.5 Files.Delete

This method deletes files from the CPU.

To call the Files.Delete method, you need the "write_file" permission.

NOTE
Deleting DataLog files
You can also delete DataLog files with this method, but only if the file is not currently in use. If the DataLog file is currently in use, error message 303 appears: Entity in use.

NOTE
Deleting inactive DataLog files
If you have created a ticket for DataLogs.DownloadAndClear or Files.Download on an inactive DataLog file, you can still use the Files.Delete method to delete this file.
As a result, a download that has already been started or will be started in the future will fail with these tickets.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-125 Files_Delete_Request (object)

Name	Required	Data type	Description
resource	Yes	string	Path to the file from the root node of the SIMATIC Memory Card

Example

The following example shows a request specifying the path to a txt file:

```
{
 "resource": "/myfolder/file.txt"
}
```

The following example shows a request specifying the path to a csv file (datalog).

```
{
 "resource": "/Datalogs/datalog1.csv"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The user does not have write permission for the file.
4	No resources	The system does not have the required resources to carry out this request.
5	System is read-only	The system cannot be written to at present. File changes are not possible because the SIMATIC Memory Card is read-only.
300	Path contains an illegal sequence	The parameter specified under "resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" is subject to access restrictions.
302	Entity does not exist	The directory or subdirectory to be accessed by the "resource" parameter does not exist.
303	Entity in use	The parameter specified under "resource" is accessing a file or directory that is already locked by another operation (e.g. read or write).
305	Entity not a direct-ory	The directory or subdirectory specified under "resource" is attempting to access a file.
306	Entity not a file	The file name specified under "resource" is attempting to access a directory.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.

5.11.6 Files.CreateDirectory

This method creates a new directory on the CPU.

To call the Files.CreateDirectory method, you need the "write_file" permission.

NOTE

Available folders for R/H-CPUs

You can only create the DataLogs, Recipes and UserFiles folders. The folders are created on the system with the corresponding spelling UserFiles, Recipes, DataLogs, regardless of whether you specify resource="/datalogs", for example.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-126 Files_CreateDirectory_Request (object)

Name	Required	Data type	Description
resource	yes	string	Path to the file from the root node of the SIMATIC Memory Card

Example

The following example shows a request specifying the path to the desired directory:

```
{
 "resource": "/SPH_Storage/OPCUA"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The user does not have write permissions.
4	No resources	The system does not have the required resources to carry out this request.
5	System is read-only	The system cannot be written to at present. Changes are not possible because the SIMATIC Memory Card is read-only.
300	Path contains an illegal sequence	The parameter specified under "resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" is subject to access restrictions.
302	Entity does not exist	The directory to be accessed by the "resource" parameter does not exist.
304	Entity already exists	The parameter specified under "resource" is attempting to create a directory that already exists.
305	Entity not a directory	The parameter specified under "resource" is attempting to access a file.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.

5.11.7 Files.DeleteDirectory

This method deletes an existing directory from the CPU.

To call the Files.DeleteDirectory method, you need the "write_file" permission.

NOTE

Recursive deletion

Note that recursive deletion is not possible, and that the directory must be empty before you can delete it.

Structure of the request

The following table contains information about the individual parameters of the request:

Table 3-127 Files_DeleteDirectory_Request (object)

Name	Required	Data type	Description
resource	yes	string	Path of the directory to be deleted.

Example

The following example shows a request specifying the path to the desired directory:

```
{
 "resource": "/SPH_Storage"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The user does not have write permissions.
4	No resources	The system does not have the required resources to carry out this request.
5	System is read-only	The system cannot be written to at present. Changes are not possible because the SIMATIC Memory Card is read-only.
300	Path contains an illegal sequence	The parameter specified under "resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" is subject to access restrictions.
302	Entity does not exist	The directory to be accessed by the "resource" parameter does not exist.
303	Entity in use	The parameter specified under "resource" is accessing a directory that is already locked by another operation (e.g. read or write).
305	Entity not a direct-ory	The parameter specified under "resource" is attempting to access a file.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.

5.11.8 DataLogs.DownloadAndClear

The DataLogs.DownloadAndClear method creates a ticket to download DataLogs from the CPU and delete them after processing.

NOTE

If you do not want to delete the contents of DataLogs after downloading, use the Files.Download method instead.

For more information about this method, see the Files.Download (Page 242) section.

NOTE

You can apply the DataLogs.DownloadAndClear method only if the DataLog is not currently in use. If the DataLog is currently in use, the error message 303: Entity in use appears.

To call the Files.DownloadAndClear method, you need the write_file permission.

Structure of the request

The following table contains information about the individual parameters of the request:

Table 3-128 DataLogs_DownloadAndClear_Request (object)

Name	Required	Data type	Description
resource	yes	string	The name of the DataLog you want to download. Alternatively, you can use a path starting with /datalogs/ (see examples below).

Examples

The following example shows a request specifying the name of the desired DataLog.

```
{
 "resource": "datalog1"
}
```

The following example shows a request with specification of the path to the desired DataLog:

```
{
 "resource": "/datalogs/datalog1"
}
```

Response structure

If successful, the method returns a string with a ticket ID.

Example

The following example shows a generated ticket ID for downloading and deleting the DataLog:

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The user does not have write permissions.
4	No resources	The system does not have the required resources to carry out this request.
5	System is read-only	The system cannot be written to at present. Changes to the log file are not possible because the SIMATIC Memory Card is write-protected.
303	Entity in use	The file or path to be accessed by the "resource" parameter is locked because of another operation (e.g. the user program is currently accessing the DataLog).
309	Entity is not a valid data log	The parameter specified under "resource" is attempting to access an unlinked DataLog. An unlinked DataLog cannot be deleted.

5.12 Reading information from SIMATIC Safety

5.12.1 Failsafe.ReadRuntimeGroups

This method outputs a list with all available F-runtime groups.

To call the Failsafe.ReadRuntimeGroups method, you need the "read_diagnostics" permission.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-129 Failsafe_ReadRuntimeGroups_Response (object)

Name	Required	Data type	Description
groups	Yes	array of Failsafe_ReadRuntimeGroups_Entry_Response	Object array in which each object represents one F-runtime group.

Table 3-130 Failsafe_ReadRuntimeGroups_Entry_Response (object)

Name	Required	Data type	Description
name	Yes	string	Name of F-runtime group
signature	Yes	string	Signature of F-runtime group as array of decimal numbers Each number represents one byte of the signature.
cycle_time_current	Yes	string	ISO 8601 time span as string; Current cycle time in milliseconds.
cycle_time_max	Yes	string	ISO 8601 time span as string; Maximum cycle time in milliseconds.
runtime_current	Yes	string	ISO 8601 time span as string; Current runtime in milliseconds.
runtime_max	Yes	string	ISO 8601 time span as string; Maximum runtime in milliseconds.

Examples

The following example shows the parameters of the response to a query with an F-runtime group with remaining time "remaining_time".

```
{
  "groups":
  [
    {
      "name": "RTG_1",
      "signature": "FD62F235",
      "cycle_time_current": "PT0.110S",
      "cycle_time_max": "PT0.200S",
      "runtime_current": "PT0.050S",
      "runtime_max": "PT0.080S"
    }
  ]
}
```

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.

5.12.2 Failsafe.ReadParameters

With this method, you can read out fail-safe parameters of a fail-safe CPU or a fail-safe module via the hardware ID of the module.

To call the Failsafe.ReadParameters method, you need the "read_diagnostics" permission.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-131 Failsafe_ReadModuleParameters_Request (object)

Name	Required	Data type	Description
hwid	Yes	number	Hardware ID of the module whose parameters you want to read out.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-132 Failsafe_ReadParameters_Response (object)

Name	Required	Data type	Description
safety_mode	No	string	Status message indicating whether safety mode is active ("enabled") or not ("disabled"). Note that this status message only applies to the CPU and not to other modules.
type	Yes	string	Defines whether the required hardware ID is the fail-safe module or represents a different fail-safe module.
parameters	No	object	Indicates whether the required hardware ID is the fail-safe module with safety program or represents a different fail-safe module. The returned object is alternatively of type: • Failsafe_ReadParameters_Cpu_Response • Failsafe_ReadParameters_Module_Response

Table 3-133 Failsafe_ReadParameters_Cpu_Response (object)

Name	Required	Data type	Description
last_f_program_modification	Yes	string	ISO 8601 time stamp in UTC as string; time stamp of the last change in the safety program.
collective_signature	Yes	string	Collective F signature as byte array with 4 numbers for representing a 32-bit signature.
remaining_time	No	string	ISO 8601 time span as string; Remaining time in milliseconds (as of firmware version V2.9).

Table 3-134 Failsafe_ReadParameters_Module_Response (object)

Name	Required	Data type	Description
f_monitoring_time	Yes	number	ISO 8601 time stamp in UTC as string; F-monitoring time in milliseconds
f_source_address	Yes	number	F-source address
f_destination_address	Yes	number	F-destination address
f_par_crc	Yes	array of number	CRC signature of the F parameters as a byte array with 4 numbers for representing a 32-bit signature.

Examples

The following example shows the parameters of a fail-safe CPU in active safety mode.

```
{
 "safety_mode": "enabled",
 "type": "cpu",
 "parameters":
 {
  "last_f_program_modification": "2023-11-05T18:25:43.510Z",
  "collective_signature": "C572BC16"
 }
}
```

The following example shows the parameters of a fail-safe module in active safety mode.

```
{
 "type": "module",
 "parameters":
 {
  "f_monitoring_time": "PT0.123S",
  "f_source_address": 123,
  "f_destination_address": 123,
  "f_par_crc": "F062F235"
 }
}
```

Possible error messages

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
1100	Invalid hardware identifier	The specified hardware ID is not valid for the current request. Make sure that you have used the correct hardware ID.

5.13 Web applications that can be loaded by the user

With the Web server as of firmware version V2.9, you can use web applications that can be loaded by the user (user-defined). In the following, we will refer to "web applications" for short.

Web applications offer you a set of methods to manage web applications via Web API. You can use all available Web API methods within a web application.

NOTE

HTTP-Range-Requests

For access to web application resources, the web Server provides you with a limited support for HTTP range requests. These requests allow you to read individual areas of a resource.

Advantages

Web applications offer you advantages compared to the older method that provided customer pages via the system function SFC 99 in STEP 7:

- The resources are saved in the associated web application. Via the Web API, you can download the resources to your PC, edit them and upload them back to the CPU. This procedure results in significantly reduced development times of customer pages.
- Unlike the previous customer pages, you can test the web application during implementation without having to load it onto the CPU.
- You can access resources independent of the CPU mode (e.g. RUN, STOP) and update these.
- Web applications are also available in the STOP mode of the CPU.
- No synchronization between the user program and Web server required by the SFC 99 instruction.
- You can access multiple CPUs within a web application using the Web API .
- The CPU supports saving multiple web applications that you can access simultaneously via the HTTP end point.
- Access to the resources of a web application via the HTTP end point can be activated or deactivated for each application. In so doing, an administrator can deactivate access to a web application, for example, to update the resources consistently.
- You can specify a standard entry page for each application. When you visit the basic URL of a web application, such as https://[ip]/~[application_name], you are automatically being forwarded to the configured home page.

- You can specify an individual media type (MIME type) for each resource.
- You can specify a visibility flag for each resource:
  - Public resource: Access without user authentication
  - Protected resource: Access limited to authenticated users with access right "open_user_pages"
- You can specify for each resource:
  - The time stamp of the resource change
  - The value for the HTTP header ETag

  In so doing, you reduce the communication load on the CPU. This enables the caching of resource files by the web browser.

NOTE

When you use the Web API for managing web applications, the TIA Portal project in the SIMATIC.S7S directory on the SIMATIC Memory Card changes. Your TIA Portal project is extended by the option of saving resources (e.g. HTML, CSS, JavaScript, etc.) in the project but outside of the data blocks of the user program.

As with the previous customer pages, the web applications must not contain any instructions in the STEP 7 user program and are thus purely static files without dynamic content.

Methods for managing web applications

The following methods are available to manage web applications using Web API:

Table 3-135 Methods for managing web applications

Method	Explanation
WebApp.Create (Page 260)	Enables users to create a new web application.
WebApp.Delete (Page 261)	Enables users to delete an existing web application.
WebApp.Rename (Page 262)	Enables users to change the name of an existing web application.
WebApp.Browse (Page 263)	Enables users to display a list of web applications with the associated properties.
WebApp.SetState (Page 265)	Enables users to activate /deactivate a web application for access from the HTTP end point.
WebApp.SetDefaultPage (Page 266)	Enables users to define a default page for the web application.
WebApp.SetNotFoundPage (Page 267)	Enables users to define a page that is loaded when a requested resource does not exist in the web application.
WebApp.SetNotAuthorizedPage (Page 268)	Enables users to define a page that is loaded when a requested resource is not public (protected) in the web application.

Methods for managing resources

The following methods are available to manage the resources of a web application using Web API:

Table 3-136 Web applications: Methods for managing resources

Method	Explanation
WebApp.BrowseResources (Page 270)	Enables users to display all resources with their properties that are assigned to a web application.
WebApp.CreateResource (Page 272)	Enables users to create a new resource in a web application.
WebApp.DeleteResource (Page 273)	Enables users to delete an existing resource in a web application.
WebApp.RenameResource (Page 274)	Enables users to change the name of an existing resource in a web application.
WebApp.DownloadResource (Page 276)	Allows the user to download a resource from a web application from the CPU.
WebApp.SetResourceVisibility (Page 277)	Enables users to change the visibility of a resource in a web application.
WebApp.SetResourceETag (Page 279)	Enables users to change or delete the ETag value of a resource in a web application.
WebApp.SetResourceMediaType (Page 280)	Enables users to change the media type of a resource in a web application.
WebApp.SetResourceModificationTime (Page 281)	Enables users to set the modification time of a resource in a web application.

End point for web applications

Web applications are only accessible via secure HTTPS communication. This increases security when accessing the resources of the CPU. When the Web server was configured for HTTP access, requests via HTTP are automatically rerouted to an HTTPS connection.

A web application is accessible via the following URL, provided that the default page (default_page) or the substitute page of an application (not_found_page) is configured:

```
https://[ip]/~[application_name]
```

A resource of a web application can be reached via the following URL:

```
https://[ip]/~[application_name]/[resource_name]
```

NOTE

The tilde symbol "~" is important in the path and must always exist for web applications.

Procedure to access resources of a protected web application

If resources of a web application are protected and you want to access/modify data of this web application, then you have to authenticate yourself first, for example on a public page.

For example, perform the following step on the default page:

- From JavaScript, call the Api.Login method using the "include_web_application_cookie" parameter.

  Result: If authentication is successful, the Api.Login method returns the session token and a cookie for accessing the protected files of a web application (see also section Api.Login (Page 177)).

  JavaScript is used to set the cookie "web_application_cookie" with a value from the HTTP response of the login as cookie "siemens_web_secure".

NOTE

To ensure that the API token is not lost after the web page is called up again, you can save the API token in a cookie or in the LoadStorage of the web browser, for example, using JavaScript.

The behavior after timeout for protected web applications is the same as the behavior after timeout for web API sessions: After a timeout, the cookie becomes invalid for access to the protected web applications. Reloading a resource file of a web application does not extend the session. Use appropriate methods of the Web API to stay logged in (see section Web API Sessions (Page 169)).

Rules for a valid application name

The application name may be max. 100 letters/characters long. The following letters and characters are permitted for the application name:

`A-Z, a-z, 0-9, -_.+"`

Rules for a valid resource name

The resource name can be max. 200 letters/characters in length. The following letters and characters are permitted for the resource name:

`A-Z, a-z, 0-9, -_.+()/|,*!'"`

Rules for a valid name for the media type

The web browser needs a media type to display a file correctly or to open it. The format of the media type is standardized. Valid media types are, for example, "text/html" or "image/jpeg". You can use all valid media types.

More information can be found on the Internet by entering "MIME type" or "media type".

5.13.1 WebApp.Create

With the WebApp.Create method, you can create a new web application in the CPU.

To call the WebApp.Create method, you need the "manage_user_pages" authorization.

Structure of the request

The following table informs you about the necessary parameters for the request.

Table 3-137 WebApp_Create_Request (object)

Name	Required	Data type	Description
name	yes	string	The name of the user-defined web application.
state	no, default is "enabled"	string	The status of the application is: • "disabled": Pages cannot be reached via HTTP end point • "enabled": Pages can be reached via HTTP end point

Example

In the following example, the user creates an application with the name "application_1".

```
{
  "name": "application_1",
  "state": "enabled"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the WebApp.Create method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
500	Application name already exists	An application with the name already exists. Assign a name that does not exist yet.
502	Application limit reached	The maximum number of web applications has been reached. Delete applications that you do not need to free up resources for new applications.
503	Invalid application name	The name of the application is invalid. Assign an application name that meets the rules for a valid application name (see section Web applications that can be loaded by the user (Page 256)).

5.13.2 WebApp.Delete

With the WebApp.Delete method, you delete an existing web application that was loaded by the user with all its web page resources.

To call the WebApp.Delete method, you need the "manage_user_pages" authorization.

Structure of the request

The following table informs you about the necessary parameters for the request.

Table 3-138 WebApp_Delete_Request (object)

Name	Required	Data type	Description
name	yes	string	The name of the web application that is deleted

Example

In the following example, the user deletes an application with the name "application1".

```
{
  "name": "application1"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the WebApp.Delete method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
3	System is busy	The desired operation cannot be performed because the system is currently performing a different request. Restart the query as soon as the current operation is complete.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
501	Application does not exist	An application with this name does not exist.

5.13.3 WebApp.Rename

With the WebApp.Rename method, you change the name of the web application to a new name.

To call the WebApp.Rename method, you need the "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-139 WebApp_Rename_Request (object)

Name	Required	Data type	Description
name	yes	string	The current name of the web application.
new_name	yes	string	The new name of the web application.

Example

In the following example, the user changes the name of the application from "application1" to "application_new".

```
{
  "name": "application1"
  "new_name": "application_new"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the WebApp.Rename method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
500	Application name already exists	An application with the name already exists. Assign a name that does not exist yet.
501	Application does not exist	An application with this name does not exist.
503	Invalid application name	The name of the application is invalid. Assign an application name that meets the rules for a valid application name (see section Web applications that can be loaded by the user (Page 256)).

5.13.4 WebApp.Browse

The WebApp.Browse method returns alternatively:

- A list of all web applications with the associated properties.
- The properties for a specific web application

No authorization is required for calling the WebApp.Browse method.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-140 WebApp_Browse_Request (object)

Name	Required	Data type	Description
name	No, default is an empty string	string	If this parameter does not exist, all applications will be returned by the method. If the parameter is available, the list will contain only the application whose name matches this parameter. If you have not specified a name, the list may also be empty, depending on whether applications are present or not.

Example

In the following example, the user specifies the name of the "application1" for the list.

```
{
  "name": "application1"
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-141 WebApp_Browse_Request (object)

Name	Required	Data type	Description
max_applications	yes	number	Maximum number of applications supported by the CPU
applications	yes	array of WebApp_Browse_Application_Respon-se	List of the applications in the CPU

Table 3-142 WebApp_Browse_Application_Response (object)

Name	Required	Data type	Description
name	yes	string	The name of the application
state	yes	string	The status of the application: • "disabled": Pages cannot be reached via HTTP end point • "enabled": Pages can be reached via HTTP end point

Name	Required	Data type	Description
type	yes	string	The type of application: • "user": created by the user
default_page	No	string	Default page of the application when no resource name was specified when accessing the web application
not_found_page	No	string	Substitute page in an application when the requested resource does not exist
not_authorized_page	No	string	If the user has tried to access a protected resource to which the user does not have access. This page can, for example, be implemented as a login page.

Example

In the following example, the user requests responses from the server.

```
{
 "max_applications": 4,
 "applications": [
  {
   "name": "application1",
   "state": "enabled",
   "type": "user",
   "default_page": "index.html"
  },
  {
   "name": "vottheapp",
   "state": "enabled",
   "type": "vot"
  }
 ]
}
```

Possible error messages

The following table shows the possible error messages of the WebApp.Browse method.

Error code	Error message	Meaning
501	Application does not exist	An application with this name does not exist.

5.13.5 WebApp.SetState

With the WebApp.SetState method, you can activate or deactivate a web application that was loaded by the user. A web application that was loaded by the user and is deactivated cannot be called by the HTTP end point.

To call the WebApp.SetState method, you need the "manage_user_pages" authorization.

Structure of the request

The following table informs you about the necessary parameters for the request.

Table 3-143 WebApp_SetState_Request (object)

Name	Required	Data type	Description
name	yes	string	Name of the web application whose status is changed
state	yes	string	The status of the application is: • disabled; pages cannot be reached via HTTP end point • enabled; pages can be reached via HTTP end point

Example

In the following example, the user deactivates the application with the name "webapp":

```
{
  "name": "webapp",
  "state": "disabled"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the WebApp.SetState method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
501	Application does not exist	An application with this name does not exist.

5.13.6 WebApp.SetDefaultPage

With the WebApp.SetDefaultPage method, you set a default page for a user-defined web application. This page is loaded if you have not assigned a resource name when accessing the web application.

To call the WebApp.SetDefaultPage method, you need the "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-144 WebApp_SetDefaultPage_Request (object)

Name	Required	Data type	Description
name	yes	string	The name of the web application for which the default page is to be configured
resource_name	yes	string	The name of the resource in the web application that was loaded by the user An empty character string indicates that the default page is to be deleted.

Example

In the following example, the page "index.html" is used as a resource in the web application "application_1".

```
{
  "name": "application_1",
  "resource_name": "index.html"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the WebApp.SetDefaultPage method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.

Error code	Error message	Meaning
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	The requested resource does not exist in the application. When calling this method, select a resource in the application.
505	Resource visibility is not public	The requested resource is not marked as "public". You should change the resource to "public" or select another resource that is already "public".

5.13.7 WebApp.SetNotFoundPage

With the WebApp.SetNotFoundPage method, you set a page for a user-defined web application. This page is loaded if you have used a resource name that does not exist when accessing the web application.

To call the WebApp.SetNotFoundPage method, you need the "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-145 WebApp_SetNotFoundPage_Request (object)

Name	Required	Data type	Description
name	yes	string	The name of the web application whose page must be changed
resource_name	yes	string	The name of the resource in the web application that was loaded by the user An empty character string indicates that the PageNotFound page should no longer be set.

Example

In the following example, the page "404.html" is used as a resource in the "application_1" web application.

```
{
  "name": "application_1",
  "resource_name": "404.html"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the WebApp.SetNotFoundPage method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	The requested resource does not exist in the application. When calling this method, select a resource in the application.
505	Resource visibility is not public	The requested resource is not marked as "public". You should change the resource to "public" or select another resource that is already "public".

5.13.8 WebApp.SetNotAuthorizedPage

With the WebApp.SetNotAuthorizedPage method, you set a publicly visible page for a user-defined web application. This page is loaded if you have used a resource name that cannot be accessed publicly (protected) when accessing the web application, thus accessing the web application without a valid cookie.

You can get a valid cookie using the Api.Login (Page 177) method with the "include_web_application_cookie" parameter.

To call the WebApp.SetNotAuthorizedPage method, you need the "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-146 WebApp_SetDefaultPage_Request (object)

Name	Required	Data type	Description
name	yes	string	The name of the web application whose public page must be changed
resource_name	yes	string	The name of the resource in the web application that was loaded by the user An empty character string indicates that the non-public page is to be deleted.

Example

In the following example, the page "login.html" is used as a resource in the "application_1" web application.

```
{
  "name": "application_1",
  "resource_name": "login.html"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the WebApp.SetNotAuthorizedPage method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	The requested resource does not exist in the application. When calling this method, select a resource in the application.
505	Resource visibility is not public	The requested resource is not marked as "public". You should change the resource to "public" or select another resource that is already "public". An example with a set cookie "web_application_cookie" for access to protected web applications can be found in section Example: Web page for monitoring and controlling a wind turbine.

5.13.9 WebApp.BrowseResources

The WebApp.BrowseResources method provides a list of all resources with their properties that are assigned to a web application.

To call the WebApp.BrowseResources method, you need the "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-147 WebApp_BrowseResources_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application whose list is provided
name	No, default is an empty string	string	If this parameter does not exist, all resources must be returned. Otherwise, the list of returned resources only contains one resource whose name matches this parameter. If no such resource is found, then: • The return list must be empty • It is not an error

Example

In the following example, the user specifies the name of the "application1" application for the list.

```
{
  "app_name": "application_1"
}
```

Response structure

The following tables show the structure of the server response to a successful request.

Table 3-148 WebApp_BrowseResources_Response (object)

Name	Required	Data type	Description
max_resources	yes	number	Maximum number of resources supported by the CPU.
resources	yes	array of WebApp_BrowseResources_Resource_Response	List of the resources in the specific application.

Table 3-149 WebApp_BrowseResources_Resource_Response (object)

Name	Required	Data type	Description
name	yes	string	The name of the resource.
size	yes	integer	The size of the resource in bytes.
media_type	yes	string	The media type of the resource.

Name	Required	Data type	Description
etag	No	string	The ETag value of the resource.
visibility	yes	string	The visibility of the resource.
last_modified	yes	string	ISO8601 time stamp as string. The time stamp of the last modification.

Example

In the following example, the user requests responses from the server.

```
{
 "max_resources": 200,
 "resources": [
  {
    "name": "index.html",
    "size": 24387,
    "media_type": "text/html",
    "etag": "896a9s8df0897g098a",
    "visibility": "public",
    "last_modified": "2020-08-24T07:08:06Z"
  },
  {
    "file_name": "secret.js",
    "size": 97826348,
    "media_type": "application/javascript",
    "visibility": "protected",
    "last_modified": "2020-08-24T07:08:06Z"
  }
 ]
}
```

Possible error messages

The following table shows the possible error messages of the WebApp.BrowseResources method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. When calling this method, select a resource in the application.

5.13.10 WebApp.CreateResource

With the WebApp.CreateResource method, you create a new resource in a web application that was loaded by the user on the CPU.

To call the WebApp.CreateResource method, you need the "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-150 WebApp_CreateResource_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application (Page 256) for which a resource must be created
name	yes	string	The name of the resource (Page 256) that is uploaded
media_type	yes	string	The media type of the resource (Page 256).
visibility	no; the default value is "public"	string	The visibility of the resource (Page 277).
etag	no; the default value is an empty character string	string	The ETag value of the resource (Page 279).
last_modified	yes	string	ISO8601 time stamp as string. The time stamp of the last modification.

Example

In the following example, the user creates a new resource "index.html" of the application "application_1" with the media type "text/html".

```
{
  "app_name": "application_1",
  "name": "index.html",
  "media_type": "text/html",
  "last_modified": "2020-08-24T07:08:06Z"
}
```

Response structure

This method returns a character string that includes a valid ticket ID. The user uses this ticket to upload the content of the resource to the CPU using the ticket end point.

NOTE

A maximum of only one WebApp.CreateResource ticket can be created. A new ticket can be created for this method only after this ticket has been closed.

Example of ticket ID:

`"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"`

An example of further processing of the ticket ID can be found in the Ticket mechanism (Page 170) section.

Possible error messages

The following table shows the possible error messages of the WebApp.CreateResource method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
4	No resources	You have exhausted all tickets in this user session or already have a ticket for WebApp.CreateResource that has not yet been closed. Close existing tickets to free up resources. Then call the method again.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
507	Resource alredy exists	A resource with the specified name already exists for this application. Select a new resource name or delete/rename the resource before you call this method.
508	Invalid resource name	The resource name is invalid. Correct the resource name (Page 256) before you call this method.
509	Resource limit reached	The maximum number of resources has been exhausted for this application. Delete some resources before you call this method.
511	Invalid modification time	The planned modification time is not within the permissible time window of the modification time. Reduce the modification time accordingly before you call this method.
512	Invalid media type	The media type is invalid. Correct the media type (Page 256) before you call this method.
513	Invalid ETag	The ETag value is invalid. Correct the ETag value (Page 279) before you call this method.

5.13.11 WebApp.DeleteResource

With the WebApp.Delete method, you can delete a resource from a specific web application.

To call the WebApp.DeleteResource method, you need the "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-151 WebApp_DeleteResource_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the user-defined web application from which the resource is to be deleted
name	yes	string	The name of the resource that is to be deleted

Example

In the following example, the user deletes the resource "img/wrong.png" of the application "application_1".

```
{
  "app_name": "application1",
  "name": "img/wrong.png"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the WebApp.DeleteResource method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with the specified name does not exist. When calling this method, select a resource in the application.

5.13.12 WebApp.RenameResource

With the WebApp.RenameResource method, you change the name of a resource in a specific web application.

To call the WebApp.RenameResource method, you need the "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-152 WebApp_RenameResource_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the user-defined web application in which the name of the resource is changed
name	yes	string	The name of the resource that is changed
new_name	yes	string	The new name of the resource.

Example

In the following example, the user changes the name of the resource to "corrspelled.png" in the "application1" application.

```
{
  "app_name": "application1",
  "name": "msspelled.png",
  "new_name": "corrspelled.png"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the WebApp.RenameResource method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. When calling this method, select a resource in the application.
507	Resource already exists	A resource with the new name already exists for this application. Select a new resource name or delete/rename the resource before you call this method.
508	Invalid resource name	The new resource name is invalid. Correct the resource name (Page 256) before you call this method.

5.13.13 WebApp.DownloadResource

With the WebApp.DownloadResource method, you can load a resource to a web application that was loaded by the user from the CPU.

To call the WebApp.DownloadResource method, you need the "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-153 WebApp_DownloadResource_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application that contains the resource
name	yes	string	The name of the resource that is downloaded

Example

In the following example, the user downloads the resource "secrets.pdf" of the application "application_1".

```
{
  "app_name": "application_1",
  "name": "secrets.pdf"
}
```

Response structure

This method returns a character string that includes a valid ticket ID. The user uses this ticket to download the content of the resource from the CPU using the ticket end point.

NOTE

A maximum of 1 WebApp.DownloadResource ticket can be created at the same time.

Example of ticket ID:

`"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"`

An example of further processing of the ticket ID can be found in the Ticket mechanism (Page 170) section.

Possible error messages

The following table shows the possible error messages of the WebApp.DownloadResource method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
4	No resources	You have exhausted all tickets in this user session or already have a ticket for WebApp.DownloadResource that has not yet been closed. Close existing tickets to free up resources. Then call the method again.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. Select a resource name that exists in the application before you call the method.
514	Resource content has been corrupted	The file content has been damaged as a result of file manipulations on the SIMATIC Memory Card. You can rectify the damage by deleting and recreating the resource file via the API.
504	Resource content is not ready	The content of the resource is not yet ready because it is currently being uploaded. Wait until the upload has finished.

5.13.14 WebApp.SetResourceVisibility

With the WebApp.SetResourceVisibility method, you change the visibility of a resource, public or protected, in a web application that was loaded by the user. A protected resource cannot be called by the HTTP end point without authentication.

To call the WebApp.SetResourceVisibility method, you need the "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-154 WebApp_SetResourceVisibility_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application that contains the resource
name	yes	string	The name of the resource that is changed
visibility	yes	string	The visibility of the resource. public: public protected: only for authorized users An example with a set cookie "web_application_cookie" for access to protected web applications can be found in section Example: Web page for monitoring and controlling a wind turbine.

Example

In the following example, the user sets the "secrets.html" resource of the "myapp" application to "protected":

```
{
  "app_name": "myapp",
  "name": "secrets.html",
  "visibility": "protected"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the WebApp.SetResourceVisibility method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. Select a resource name that exists in the application before you call the method.
505	Resource visibility must be public	The respective resource is referenced: • as default page, • as unauthorized page or • as page not found You cannot mark the resource as protected. You must set the visibility in the application to "public" before calling this method.

5.13.15 WebApp.SetResourceETag

With the WebApp.SetResourceETag method, you change or delete the ETag attribute that is returned when accessing the resource via the HTTP header. ETag (Entity Tag) is an HTTP header field. It only serves to determine changes at the requested resource and is used to avoid redundant data transfers.

To call the WebApp.SetResourceETag method, you need the "manage_user_pages" authorization.

Rules for a valid ETag value

You can use any character string as ETag value as seen in the example below. The length is limited to a maximum of 128 characters.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-155 WebApp_SetResourceETag_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application that contains the resource
name	yes	string	The name of the resource that is to be changed.
etag	yes	string	The ETag value of the resource. An empty character string indicates that the value is to be deleted.

Example

In the following example, the user sets the ETag value to "09as7df09h8j23r" for the "secrets.html" resource in the "myapp" application.

```
{
  "app_name": "myapp",
  "name": "secrets.html",
  "etag": "09as7df09h8j23r"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the WebApp.SetResourceETag method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. Select a resource name that exists in the application before you call the method.
513	Invalid ETag	The ETag value is invalid. Correct the value before you call this method.

5.13.16 WebApp.SetResourceMediaType

With the WebApp.SetResourceMediaType method, you change the media type of a resource in a web application that was loaded by the user.

To call the WebApp.SetResourceMediaType method, you need the "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-156 WebApp_SetResourceMediaType_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application that contains the resource
name	yes	string	The name of the resource that is changed
media_type	yes	string	The media type of the resource (Page 256).

Example

In the following example, the user sets the media type to "image/jpeg" for the "secrets.jpg" resource in the "myapp" application.

```
{
  "app_name": "myapp",
  "name": "secrets.jpg",
  "media_type": "image/jpeg"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the WebApp.SetResourceMediaType method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. Select a resource name that exists in the application before you call the method.
512	Invalid media type	The media type is invalid. Correct the media type (Page 256) before you call this method.

5.13.17 WebApp.SetResourceModificationTime

With the WebApp.SetResourceModificationTime method, you set the modification time of a resource in a web application that was loaded by the user.

To call the WebApp.SetResourceModificationTime method, you need the "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-157 WebApp_SetResourceModificationTime_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application that contains the resource
name	yes	string	The name of the resource that is changed
last_modified	yes	string	ISO8601 time stamp as a string; the time stamp of the last change

Example

In the following example, the user sets the modification time to "24.08.2020 07:08:06" for the "secrets.html" resource in the "myapp" application:

```
{
  "app_name": "myapp",
  "name": "secrets.html",
  "last_modified": "2020-08-24T07:08:06Z"
}
```

Response structure

If successful, the server returns the Boolean value "true".

Possible error messages

The following table shows the possible error messages of the WebApp.SetResourceModificationTime method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log on with a user account that has sufficient privileges to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. Select a resource name that exists in the application before you call the method.
511	Invalid modification time	The planned modification time is not within the permissible time window of the modification time. Reduce the modification time accordingly before you call this method.

SIEMENS

SIMATIC

S7-1500, S7-1200 G2, ET 200SP, ET 200pro Web server

Function Manual

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Introduction 1

1.1 Introduction

Purpose of the documentation

The web server of SIMATIC S7-1500 CPUs supports three types of web applications:

- System web pages: Default web pages provided for visualization and access to process data of the CPU
- VoT web pages: Customer-specific web pages developed in the TIA Portal using the View of Things environment
- User-defined web pages: Users can develop their own web pages using JSON APIs

This documentation supports you in setting up and using the web server for system web pages and JSON API for the creation of user-defined web pages.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge in the field of automation technology
- Knowledge of the SIMATIC industrial automation system
- Experience of working with Windows-based computers
- Knowledge about how to use STEP 7 (TIA Portal)
- Knowledge about the use of web servers and web browsers.

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuring and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

Scope of the documentation

This document is valid for the CPUs:

- SIMATIC S7-1500, ET 200SP and ET 200pro as of firmware version V4.1
- SIMATIC S7-1500 Software Controller as of firmware version V41.0
- SIMATIC S7-1500 Virtual Controller as of firmware version V4.1
- SIMATIC S7-1200 G2 CPU 1216/1217 as of firmware version V4.0
- SIMATIC S7-1200 G2 CPU 1212/1214 as of firmware version V4.1

The documentation contains images of the user interface of the web pages and STEP 7 configuration for a SIMATIC S7-1500 CPU. The images apply as an example for all CPUs.

The images can differ from the interface of the web server in some details, for example depending on the browser used.

NOTE

Web server Function Manual, Edition 11/2023 continues to be valid

With the CPU firmware versions specified above, new "system web pages" have been introduced in contrast to the "previous web pages". The web pages of previous firmware versions remain valid.

You will find the description of the previous web pages in the Web server Function Manual, Edition 11/2023 (https://support.industry.siemens.com/cs/ww/en/view/59193560), in the "Web pages" chapter.

What's new in the Web Server Function Manual, Version 11/2024 compared to Version 11/2023

What's new?		What are the customer benefits?	Where can I find information?
New contents	Introduction of system web pages with new design and functionality for: • Overview • Diagnostics • User program • Messages and DataLogs • Maintenance	• Modern design of the user interface • Intuitive and convenient operation • Flexible change management • Interaction with user-defined web applications with reference to Web API sessions	Section System web pages (Page 49)
	New Web API methods	Many new API methods extend your access options to the CPU via the Web API.	An overview of the Web API methods depending on the firmware version of the CPU is available in the section Supported clients (Page 97).
	Introduction of the central user management System-wide, central management of users and user groups outside the TIA Portal via UMC server	User management for extensive automation solutions with several projects, users and user groups Users and user groups can work in all projects in which they are activated and for the appropriate rights have been assigned to them. During operation, users can be added to or removed from a group or their passwords	Section User management (Page 41)

What's new?		What are the customer benefits?	Where can I find information?
		can be changed, all without the CPU configuration having to be changed or loaded.	
Changed contents	Extension of the scope of this Function Manual to the S7-1500 Virtual Controller	You can apply Web API methods to the CPUs.	An overview of all Web API methods is available in the section Supported clients (Page 97).

What's new in the Web server Function Manual, Edition 11/2025 compared to Edition 11/2024

What's new?		What are the customer benefits?	Where can I find information?
New contents	Introduction of system web pages with new design and functionality for: • Hardware status • Redundancy • Motion Control • Service data • Safety	• Modern design of the user interface • Intuitive and convenient operation • Flexible change management • Interaction with user-defined web applications with reference to Web API sessions	Section System web pages (Page 49)
	System web pages also on redundant CPUs	The information is also available in the system web pages for the R/H CPUs	• System web pages: Section Redundancy (Page 75) • API methods: Section Reading information from a redundant system (Page 299)
	Implementation of web server for the S7-1200 G2 devices	You can also use the functions of the web server with the S7-1200 G2 devices.	
	New Web API methods	Many new API methods extend your access options to the CPU via the Web API.	An overview of the Web API methods depending on the firmware version of the CPU is available in the section Supported clients (Page 97).
Changed contents	The system web pages have been revised or extended.	• Display of more information • Clearer representation	Section System web pages (Page 49)

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal service and dispose of the equipment according to the applicable regulations in your country.

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive technology products on the Internet (https://mall.industry.siemens.com).

1.2 Function Manuals documentation guide

1.2.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.2.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.2.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 General security information

Note the security-relevant information provided in the corresponding system manual.

You can find information relevant to cybersecurity in the section Industrial cybersecurity (Page 16).

Industrial cybersecurity 3

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the System Manual and in the Security guideline for SIMATIC HMI operator devices and SIMATIC WinCC Unified (https://support.industry.siemens.com/cs/ww/de/view/109481300/en) for general information and measures regarding industrial cybersecurity.

This section provides an overview of security-related information pertaining to the communication of your SIMATIC system.

NOTE

Security-relevant changes to software or devices are documented in the section Introduction (Page 6).

3.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

3.2 Cybersecurity-relevant information in this manual

Observe all security-relevant notes on topics in this Function Manual.

Security-relevant notes on ...	Section
Activation of the Web server for specific interfaces	Configuring the web server (Page 21)
Secure communication: Secure data traffic through access via secure "HTTPS" transfer protocol Usage of CA-signed or self-signed web server certificates	Configuring the web server (Page 21) Certificates (Page 30)
Setting up local or central user management	User management (Page 41)
Changing a password in runtime via Web API	Api.ChangePassword (Page 116)

Setting up and calling a web server

4

4.1 Properties of the Web server

Using the web server

The web server enables monitoring and administering of the CPU by authorized users over a network. Evaluations, diagnostics, and modifications are thus possible over long distances. Monitoring and evaluation is possible without STEP 7; only a web browser is required. Make sure that you take appropriate measures (such as limiting network access, using firewalls) to protect the CPU from being compromised.

Activating the web server

The web server is deactivated in the delivery state of the CPU. This means that you must load a project in which the web server is activated to enable access.

Security functions

The web server provides the following safety functions:

- Access via the secure "HTTPS" transfer protocol using the CA-signed or self-signed web server certificate
- Authentication via local or central user management
- Activation for specific interfaces
- Changing the password of local users in runtime via Web API

Web browser

You require a web browser to access the web pages of the CPU. You can use the web browsers listed below to access the web server. The web pages are fundamentally based on new functions that are supported by current versions of the web browsers.

Table 3-158 Supported web browsers

Web browser*	Operating system
Microsoft Edge	Windows 11
Mozilla Firefox	Windows 11
Google Chrome	Windows 11

* Not included in the scope of delivery of the product described here

Web browser*	Operating system
Chrome Mobile	Android
Safari Mobile	iOS
HMI BrowserControl	HMI Unified Comfort Panels

* Not included in the scope of delivery of the product described here

Always keep the operating system and web browser up-to-date and protect your computer on the basis of the latest recommendations for IT security.

NOTE

Two reserved communication connections are available to the web server for communication with the CPU.

Depending on the web browser used, a different number of connections to the CPU are established. If more connections are available, more communication connections will be established.

If no further connections are available, display or functional problems may occur. This is because the web server can reject all further communication connections apart from the two that are reserved if resources problems arise. For this reason, the web pages may not load fully.

For more details about connections and connection resources, refer to the S7-1500/ET 200 Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) Function Manual.

NOTE

After a firmware update of the CPU, incorrect display of web pages can occur in various web browsers.

Solution: Press F5 or clear the web browser cache.

NOTE

Web browser behavior can be different if a certificate is not valid yet or is no longer valid. Siemens has no influence on this behavior. Usage of self-signed certificates can also cause problems.

This means we cannot guarantee the reliable functionality of the web server with self-signed and invalid certificates.

System web pages

Some of the web pages are available in a new, modern design. This makes solutions on the basis of modern web technologies possible.

The new web pages are supplied by default with the firmware of the CPU and are called "system web pages".

The system web pages can be used as of the following configured firmware version of the CPUs:

- CPUs S7-1500, ET 200SP or ET 200pro as of firmware version V4.0
- S7-1500 R/H CPUs as of firmware version V4.1
- CPUs S7-1500 Software Controller as of firmware version V40.0
- CPUs S7-1500 Virtual Controller as of firmware version V4.0
- CPUs S7-1200 G2 1216/1217 as of firmware version V4.0
- CPUs S7-1200 G2 1212/1214 as of firmware version V4.1

More information

The system web pages are described in the section System web pages (Page 49).

For information on calling up the system web pages and previous web pages, refer to the section System web pages and previous web pages (Page 25).

Access to the CPU via PG/PC, HMI devices and mobile end devices

Proceed as follows to access the web server:

1. Use STEP 7 to download a project in which the web server is activated to the CPU.
2. Connect the display device (PG/PC, HMI, mobile terminal device) with the CPU or a communications module using a PROFINET interface.
   If you are working with WLAN, activate the WLAN on the display device and establish a connection to the access point (e.g. SCALANCE W788-1RR or SCALANCE W784-1), which is in turn connected to the CPU.
3. Open the web browser on the display device.
4. Enter the IP address of the interface of the CPU which is connected to the client in the "Address" field of the web browser in the following format: https://a.b.c.d (example entry: https://192.168.3.141). You get to the login page, if it is configured as default web page.

Access to the CPU via smartphone

You can access the web server of the CPU via WLAN with the smartphone. You can find information on how to do this in the document entry ID 103473392 (https://support.industry.siemens.com/cs/ww/en/view/103473392) on the Internet.

4.2 Configuring the Web server

To use the full functionality of the Web server, the following settings in STEP 7 are necessary.

Activate Web server on this module

The Web server is deactivated in the default setting of a configured CPU. Proceed as follows to activate the Web server:

1. Open the "Devices & Networks" view by double-clicking in the project tree in STEP 7.
2. Select the desired CPU in the device, network or topology view.
3. Navigate to the "Web server" area in the inspector window properties, "General" tab.
4. Activate the "Activate web server on this module" check box.
   In the process the following message is output:

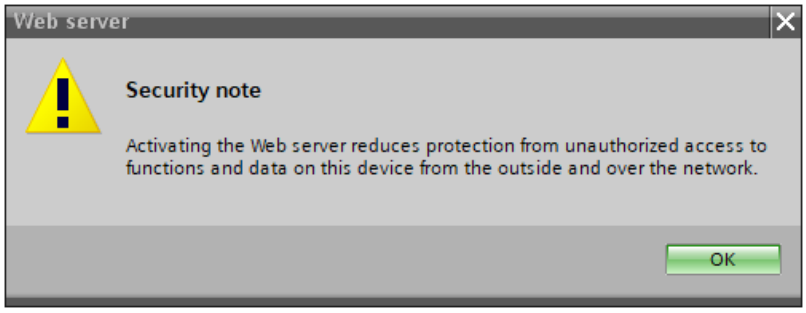

Figure 3-156 Security note upon activation of the Web server in STEP 7

NOTE

When projects from deliveries are applied in which the Web server was already activated and configured on the module, this security note is not shown.

NOTE

Activating Web server for R/H-CPUs

In the case of R/H-CPUs you can only activate the Web server for both R/H-CPUs and with the identical settings. In addition to the Web server properties, this also applies to the "Overview of the interfaces", for the certificates and the user management.

When both CPUs have loaded the project, you can use the IP addresses of both CPUs to use the Web server.

As of firmware version V4.1, access via system IP address can be selected in addition for access to the web server of an R/H CPU. You can find more information in the S7-1500/ET 200 Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) Function Manual.

Depending on the CPU used, you can make your own settings or the settings are fixed.

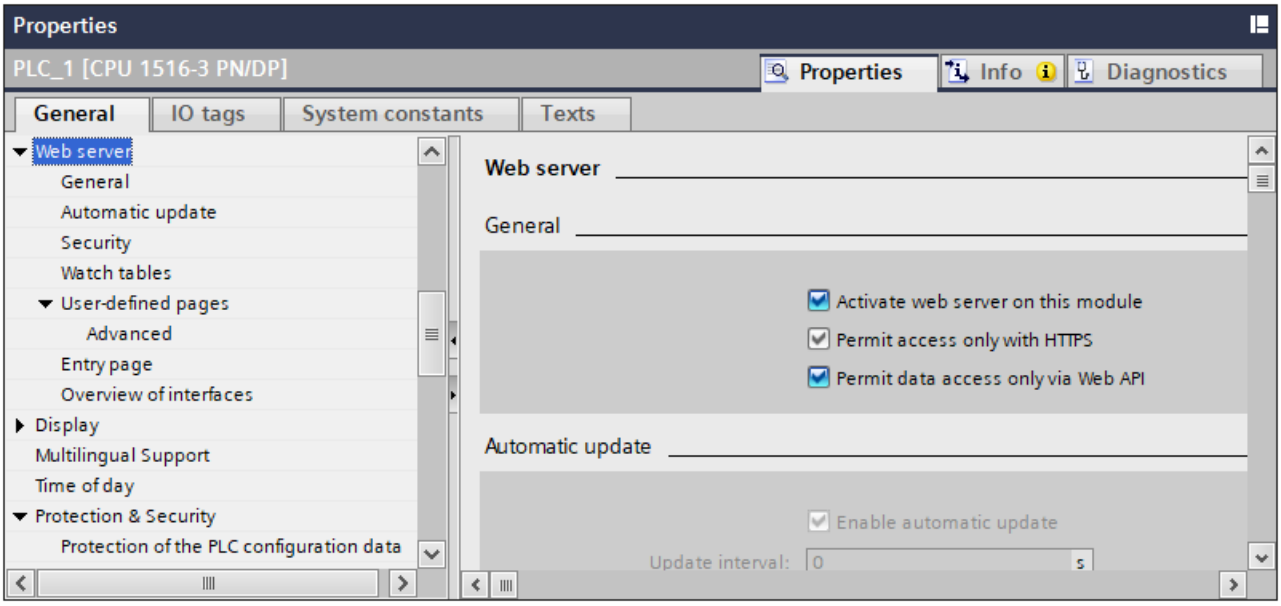

Figure 3-157 Web server settings in STEP 7

Permit access only with HTTPS

The secure transfer protocol "HTTPS" is always activated in the web server (via Port 443) and cannot be deactivated. Prerequisite for operating the web server with HTTPS is a valid web server certificate. You can find information on how to create and assign web server certificates in the section Managing certificates via TIA Portal (Page 30).

To ensure secure access to the Web server the "Permit access only with HTTPS" check box is activated in the basic setting of a configured CPU. In the case of R/H-CPUs, data access is only possible via HTTPS and is therefore preset and cannot be changed.

By default, data exchange between client and web server takes place via a secure connection and is therefore protected against attacks by third parties. Note that the URL of the CPU starts with "https://" in this case.

The requirements for error-free HTTPS access to the CPU are as follows:

- The current date/time must be set in the CPU.

  NOTE

  When using secure communication (e.g. HTTPS), make sure that the corresponding modules have the current time of day and the current date.

- The IP addresses of the CPU must be assigned.
- A valid certificate from a certificate authority is installed in the web browser, on which the web server certificate in the CPU is based.

For some CPUs, data access is only possible via HTTPS and is therefore preset and cannot be changed.

Permit data access only via Web API

If you select the "Permit data access only via Web API" check box, only Web API-based functions are available, including:

- JSON-RPC interface
- Ticketing and web applications including system web pages

Functions on the Web server via the unencrypted HTTP protocol and AWP commands are no longer accessible.

If you select the "Permit data access only via Web API" check box, the "Permit access only with HTTPS" check box is automatically selected and cannot be changed.

For some R/H CPUs, data access is only possible via Web API and is therefore preset and cannot be changed.

The setting of the "Permit data access only via Web API" check box influences whether you can access the previous web pages. You can find more information in section System web pages and previous web pages (Page 25).

Security: Certificates, access protection and user management

STEP 7 automatically generates and uses a self-signed web server certificate for the CPUs.

The certificate establishes an encrypted connection that prevents tapping or distortion of the communication but does not provide access protection. This means you have to protect your CPU from unauthorized access with the corresponding configuration in the user management.

NOTICE
Self-signed certificates and browser caching The web server supplies resources with HTTP headers that enable browser caching and thus reduce the communication load on the CPU. When self-signed certificates are used, browsers such as Chrome restrict or disable caching. Resources are thus reloaded every time the page is called. Recommendation: To make full use of the caching function, use trusted certificates for productive systems.

You can find information on how to create and manage certificates in the section Certificates (Page 30).

The procedure for setting up the user management with password-protected users for the web server is based on the configured firmware version of your project. You can find more information in section User management (Page 41).

You can find more information on access protection on the CPU in the STEP 7 online help, keyword: "Protection".

Entry page

The setting in the "Entry page" section is only relevant if you use the previous web pages and the previous user program for the CPUs. In this case, you can select a start page for the web server in the "Entry page" section. You can find more information on calling the previous web pages in the section System web pages and previous web pages (Page 25).

Activation of the Web server for specific interfaces

In the "Overview of interfaces" area, you have the option to enable access to the Web server.

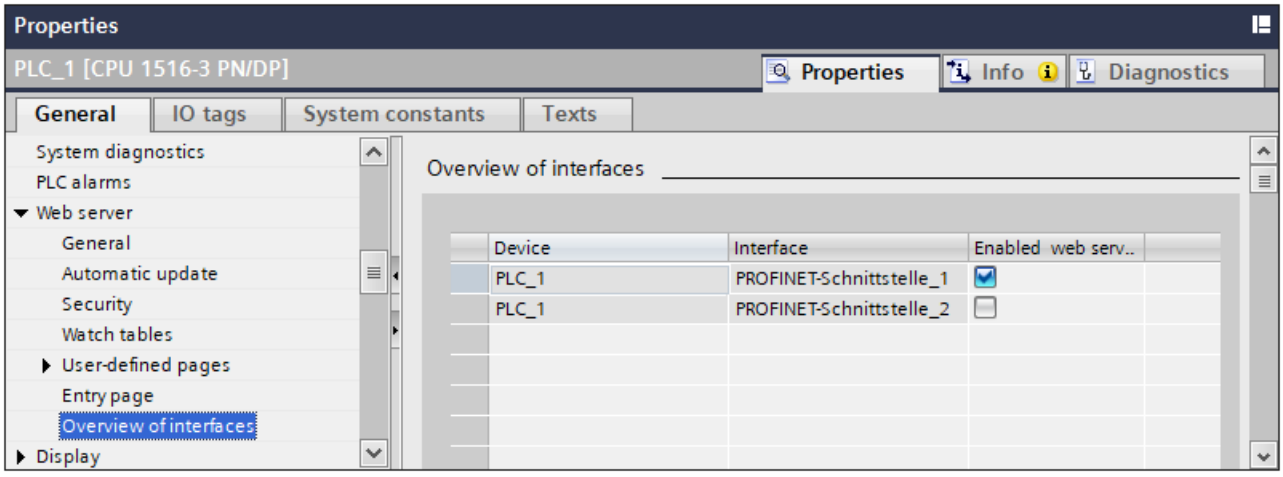

Figure 3-158 Enabling access to the Web server via the interfaces

Setting the project languages for the Web server

In total, you can assign up to three different project languages to the user interface languages of the web pages.

In STEP 7, activate the project languages that you want to use and then assign one of the activated project languages to each of the Web server interface languages.

You can find more information about the language settings and a description of how to assign a project language to the interface languages in the section Language settings (Page 39).

NOTE

The language can only be changed in STOP mode. Subsequently a download is carried out.

4.3 System web pages and previous web pages

With firmware version V4.1/41.0 of the CPUs, some of the web pages are available in a new, modern design. This makes solutions on the basis of modern web technologies possible. The new web pages are characterized by their intuitive and convenient operation.

The new web pages are supplied by default with the firmware of the CPU and are called "system web pages". Through the system web pages, interaction with user-defined web applications in the Web API sessions becomes possible.

The existing web pages in CPUs with firmware version < V4.0/V40.0 are called "previous web pages".

Overview: Displaying system web pages and previous web pages

The web pages that are displayed depend on the configured firmware version of the CPU and on the setting in STEP 7 for "Permit data access only via Web API" (see section Configuring the Web server (Page 21)).

Table 3-159 Web page display and firmware version of the CPU

Configured firmware version of the CPU				Available web pages	Default web pages of the Web server	Where can I find information?
S7-1500/ ET 200SP/ ET 200pro	Software control-ler	S7-1500V	S7-1200 G2			
≤ V3.1[1]	≤ V30.1	V3.1		Previous web pages	Previous web pages	Web server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193560), Edition 11/2023
≥ V4.0[2]	≥ V40.0	≥ V4.0		With "Permit data access only via Web API" check box selected: System web pages	System web pages	Web server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/109977246), Edition 11/2024
				With "Permit data access only via Web API" check box cleared: Previous and system web pages in parallel[3]	Previous web pages[3] You can configure the system web pages as default web pages via the project tree.	Web server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/109977246), Edition 11/2024
≥ V4.1	≥ V41.0	≥ V4.0	≥ V4.0[4] ≥ V4.1[5]	With "Permit data access only via Web API" check box selected: System web pages	System web pages	Present section
				With "Permit data access only via Web API" check box cleared: Previous and system web pages in parallel[3]	Previous web pages[3] You can configure the system web pages as default web pages via the project tree.	Present section

1 S7-1500R/H CPUs do not support the previous web pages, i.e. the web server only functions via the Web API.

2 S7-1500R/H CPUs only support system web pages as of firmware version 4.1.

3 S7-1500V CPUs and S7-1500R/H CPUs support only the system web pages, so these are displayed.

4 Firmware version 4.0 or higher for S7-1200 G2 1216/1217.

5 Firmware version 4.1 or higher for S7-1200 G2 1212/1214.

Configuring system web pages in STEP 7

If you have set "Permit data access only via Web API" in the hardware configuration of the CPU, only the system web pages and the Web API are available.

You use STEP 7 for the following tasks:

- To deactivate/activate the system web pages
- To configure any URL of a web application as the default web page of the web server

The system web pages are a special type of a web application. In the project tree in STEP 7, you select the "General settings" menu under the CPU in the "Web applications" folder.

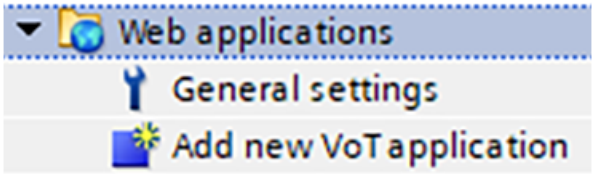

Figure 3-159 Project tree web applications

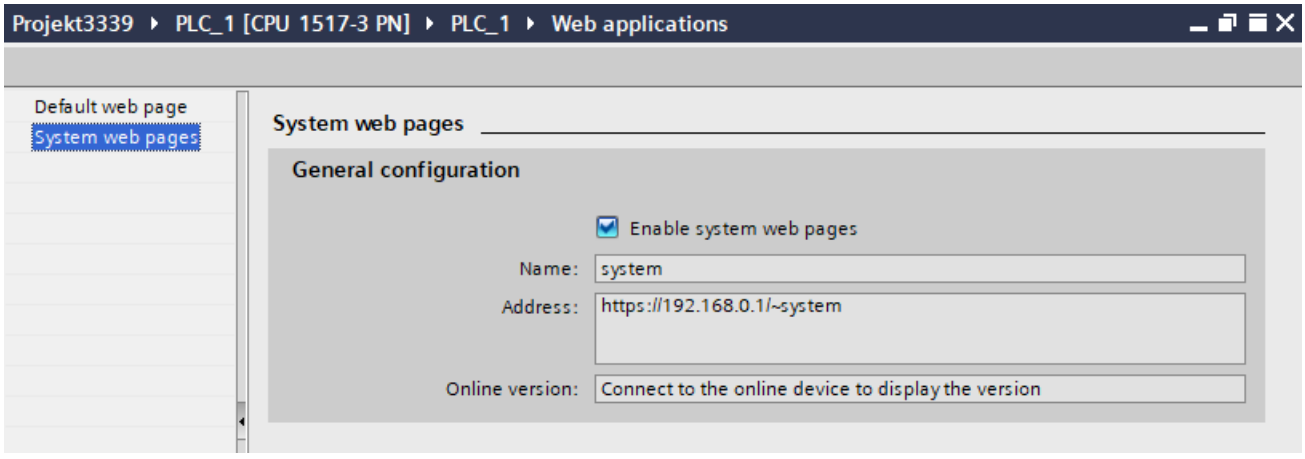

Figure 3-160 Project tree general settings web server

For a configured CPU as of firmware version V4.0/V40.0/V2.0, you can deactivate the system web pages here or activate them again. You can change the setting later via the Web API method WebServer.SetDefaultPage (Page 140), independently of the operating mode of the CPU.

System web pages with S7-1500 R/H CPUs

S7-1200 G2 CPUs only support system web pages as of firmware version 4.1.

Access to the web server is possible with the following addresses:

- IP address of PROFINET interface X1/X2/X3 (if available) of the primary CPU
- IP address of PROFINET interface X1/X2/X3 (if available) of the backup CPU
- System IP address of PROFINET interface X1/X2/X3 (if available)

NOTE

If you use the system IP address function, you can also use it for access to the web server and the system web pages. If the system IP address is set on the primary CPU, you can continuously access the web pages, even in the event of a failure.

The system web pages provide a view of the overall system for the R/H system. You can connect to the web server with both the primary and the backup CPU and receive the same system web page.

You can find detailed information on the S7-1500R/H redundant system in the SIMATIC S7-1500 S7-1500R/H Redundant System (https://support.industry.siemens.com/cs/ww/de/view/109754833) System Manual.

System web pages with S7-1200 G2 CPUs

S7-1200 G2 CPUs only support system web pages as of firmware version 4.1.

Extended functionality of the web server

The following additional functions and settings are possible:

- The existing web application end point makes the contents of the system web pages available.
- You activate or deactivate the system web pages in STEP 7.
- You specify a system or previous web page as the web server default web page in STEP 7.

You set these options in the TIA Portal under Web applications.

Configuring the web server default web page in STEP 7

You can configure the default web page of the web server in the "General settings" menu.

1. Select "Default web page".
2. Select the web application whose overview you want to configure as the default web page:
   - The system web pages
   - The web server entry page specified in the hardware configuration (only available if the previous web pages are available)
   - A VoT application

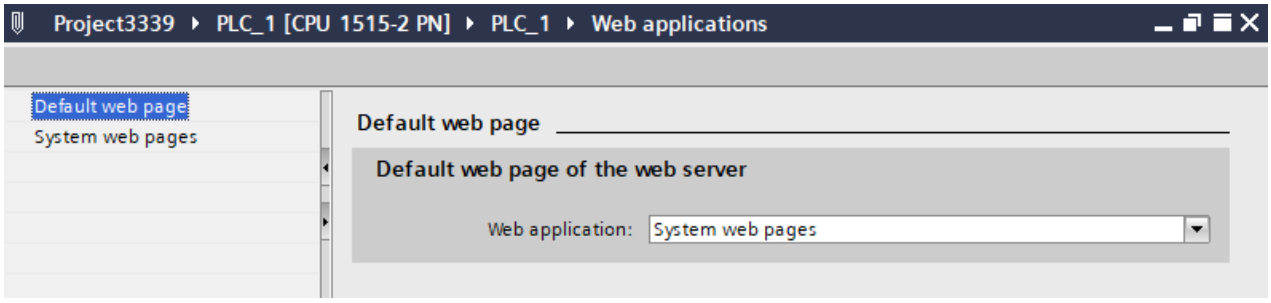

Figure 3-161 Project tree default web page

Connecting to the Web server

You establish a connection to the Web server by entering the IP address of the interface of the configured CPU which is connected to the client in the address bar of the web browser.

The URL address differs depending on whether you want to call up the system web pages or the previous web pages:

- System web pages, for example via: https://192.168.3.141/~system
- Previous web pages, for example via: https://192.168.3.141/Portal/Portal.mwsl?PriNav=Start

The connection is established and the login page or overview of the system web pages (intro page of the web server in previous pages) is opened.

More information

The section System web pages (Page 49) contains the structure and describes the contents of the system web pages.

The description of the previous web pages is contained in section 4 of the Web server Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193560), Edition 11/2023

4.4 Certificates

4.4.1 Web server certificates

To secure the data exchange with a partner against interception of the communication, different applications and communication functions of the CPU use device certificates that are managed application-specifically. In the case of the device certificate for the web server, this involves a web server certificate.

The new system web pages, user pages on the basis of the web applications as well as the Web API are only available via HTTPS. Operation of the Web server using the secure transfer protocol HTTPS requires a valid Web server certificate.

The previous web pages and user-defined pages can also use the unencrypted transfer protocol.

You manage certificates in a number of ways.

4.4.2 Managing certificates via TIA Portal

Creating and assigning a Web server certificate

The secure transfer protocol "HTTPS" is always activated in the web server (via Port 443) and cannot be deactivated. Prerequisite for operating the web server with "HTTPS" is a valid web server certificate.

The previous web pages also allow the unencrypted transfer protocol "HTTP". The new system web pages support only "HTTPS".

Configuring the web server for individual protocols is described in the section Configuring the Web server (Page 21).

You create the web server certificate of the CPU using STEP 7 and assign it to the web server in the properties of the CPU. This certificate is also downloaded to the CPU automatically when the hardware configuration is downloaded.

You can create different Web server certificates:

- If you use the global security settings for the certificate manager, the certification authority of the project (CA certificate) signs the device certificate of the Web server. During loading, the **CA certificate** of the project is automatically loaded as well.
- If you do not use the certificate manager in the global security settings, STEP 7 generates the device certificate as a **self-signed certificate**.

NOTICE
Self-signed certificates and browser caching The web server supplies resources with HTTP headers that enable browser caching and thus reduce the communication load on the CPU. When self-signed certificates are used, browsers such as Chrome restrict or disable caching. Resources are thus reloaded every time the page is called. Recommendation: To make full use of the caching function, use trusted certificates for productive systems.

If no certificate is set up in the web browser, a warning appears recommending that you do not use the page. To view the page, you may need to "Add an exception", depending on the web browser used.

You can find instructions for installing the certificate in the help system of your web browser and in the document with the entry ID 103528224 (https://support.industry.siemens.com/cs/ww/en/view/103528224) on the Service&Support web page.

NOTE

To protect against manipulation from the outside, download the certificate only in an environment that is guaranteed not to be compromised. Installation of the certificate has to be carried out once for each display device you wish to use.

Advantages and disadvantages of self-signed certificates

The self-signed certificates offer the following advantages:

- No fees for the creation of the signature
- Rapid installation. You do not require a response from the certificate authority

The self-signed certificates have the following disadvantages:

- Threat to personal user data
- Permanent warning "Unknown publisher" in the web browser
- Data security is not ensured
- Lack of user trust because a signature of the certificate authority is missing
- Performance disadvantages when accessing the web pages due to restrictions in browser caching

The self-signed certificates are subject to the following restrictions:

- Self-signed certificates are not embedded in a "Public Key Infrastructure" (PKI) and cannot sign other certificates.
- The certificate only applies to the configured CPU and is not available throughout the project.
- Private keys of the certificate cannot be exported.

NOTE

Recommendation: Use the CA-signed web server certificates to use the functions of the CPU optimally.

Creating and assigning a CA-signed Web server certificate

To create a CA-signed Web server certificate with TIA Portal, follow these steps:

1. In the project tree, navigate to "Security settings > Settings".
2. Click in the "Project protection" section on the "Protect this project" button and assign a user name and password for the project administrator. A new "Certificate manager" entry is displayed under "Security functions" in the project tree.

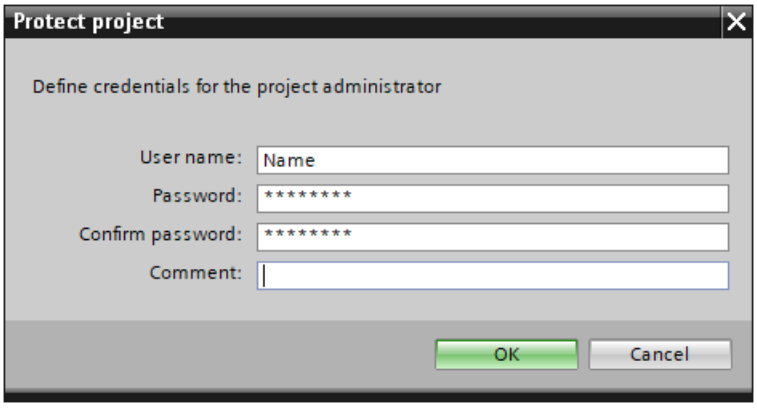

Figure 3-162 Protecting a project

3. In the "General" tab of the "Properties" Inspector window, navigate to the "Protection & Security > Certificate Manager" area and select the "Use global security settings for certificate manager" option.

NOTE

For managing certificates with the global security settings, you require the "Configure security" configuration permission.

4. Log in as a user in the project tree in the "Security settings" section. For a new project, the "Administrator" role is intended for the first login.
5. Navigate to the "Web server > Security" area in the "Properties" Inspector window, "General" tab.
6. Click the "..." button in the drop-down list to select a certificate.
   The dialog for selecting and creating a new certificate opens.

7. Click the "Create" button in the drop-down list to select a certificate.
   The "Create certificate" dialog opens.

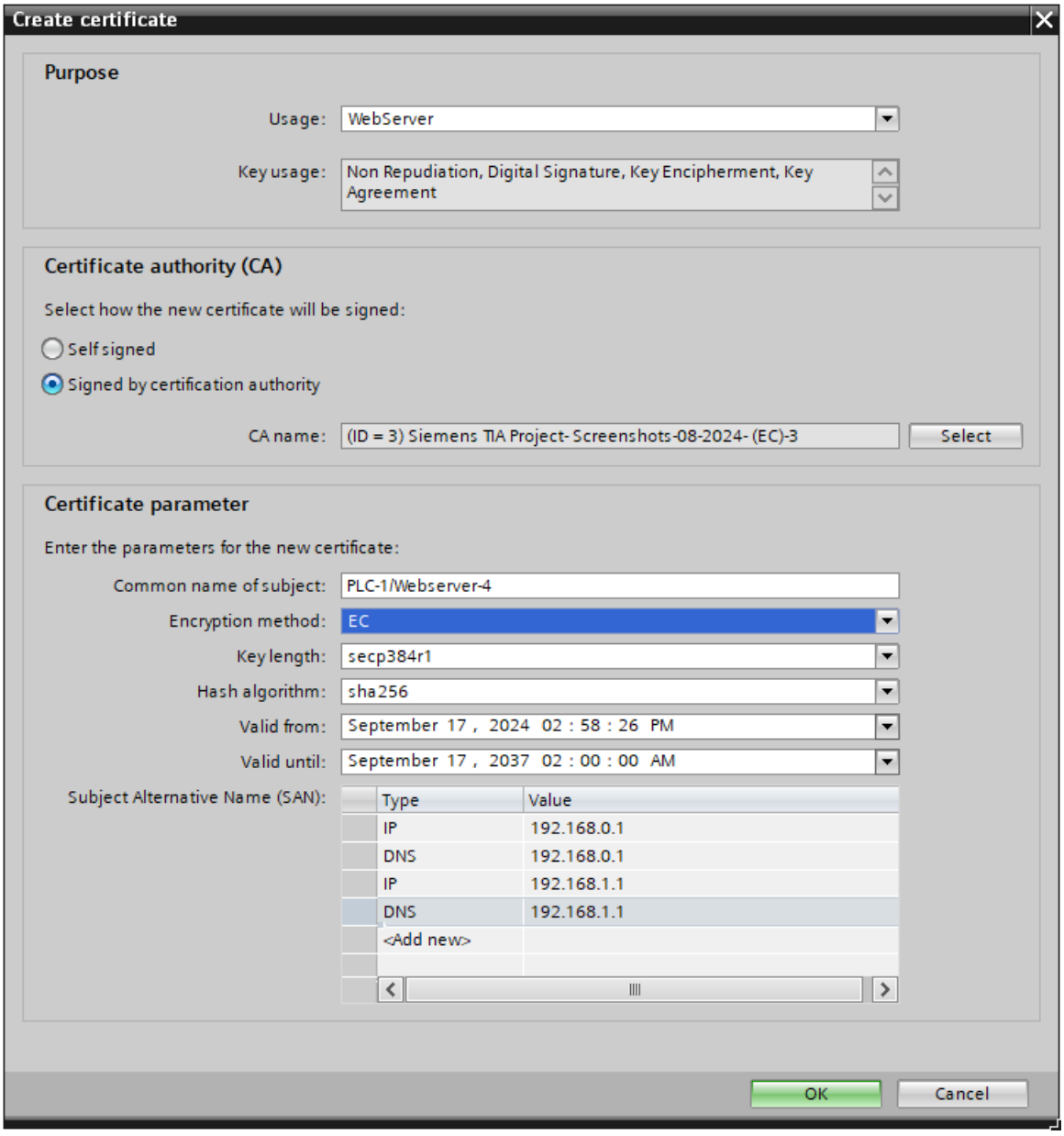

Figure 3-163 Creating a CA certificate

8. In the follow-up dialog box, select the "Signed by certificate authority" check box and select the certificate authority from the drop-down list.

9. Enter the parameters for the new certificate or confirm the default settings.
   - Select "Web server" in the "Usage" box.
   - RSA as well as EC certificates are supported by the web server. The advantage of the EC certificates is the higher performance provided.
   - Enter the IP address(es) of the interface(s) or the domain name of the configured CPU in the "Subject Alternative Name" field.
10. Click "OK" to confirm.
11. Compile and load the configuration in the CPU.
    The device certificate of the Web server and the CA certificate are components of the configuration.

NOTICE
Addressing the Web server of the CPU via domain names If you enter the IP address(es) of the interface(s) of the configured CPU in the "Subject Alternative Name" field, the generated certificate may not be accepted by all Internet browsers. In addition, you must generate and load a new Web server certificate (end entity certificate) with each change of the IP address of an Ethernet interface of the CPU, since the identity of the CPU changes with the IP address. You can avoid this problem by addressing the Web server of the CPU using domain names instead of IP address(es), e.g. "myconveyer-cpu.room13.myfactory.com". For this purpose, you have to manage the domain names of your CPU via a DNS server. Addressing via domain names is recommended especially for a configuration with reception of the IP address from a DHCP server, as in this case the assigned IP address is not known beforehand.

Creating a self-signed Web server certificate

To create a self-signed Web server certificate with TIA Portal, follow these steps:

1. Navigate to the "Web server > Security" area in the "Properties" Inspector window, "General" tab.
2. Click the "..." button in the drop-down list to select a certificate.
   The dialog for selecting and creating a new certificate opens.
3. To select an existing certificate, double-click a certificate of the list.

4. To create a new certificate, click the "Create" button.
   The "Create certificate" dialog opens.

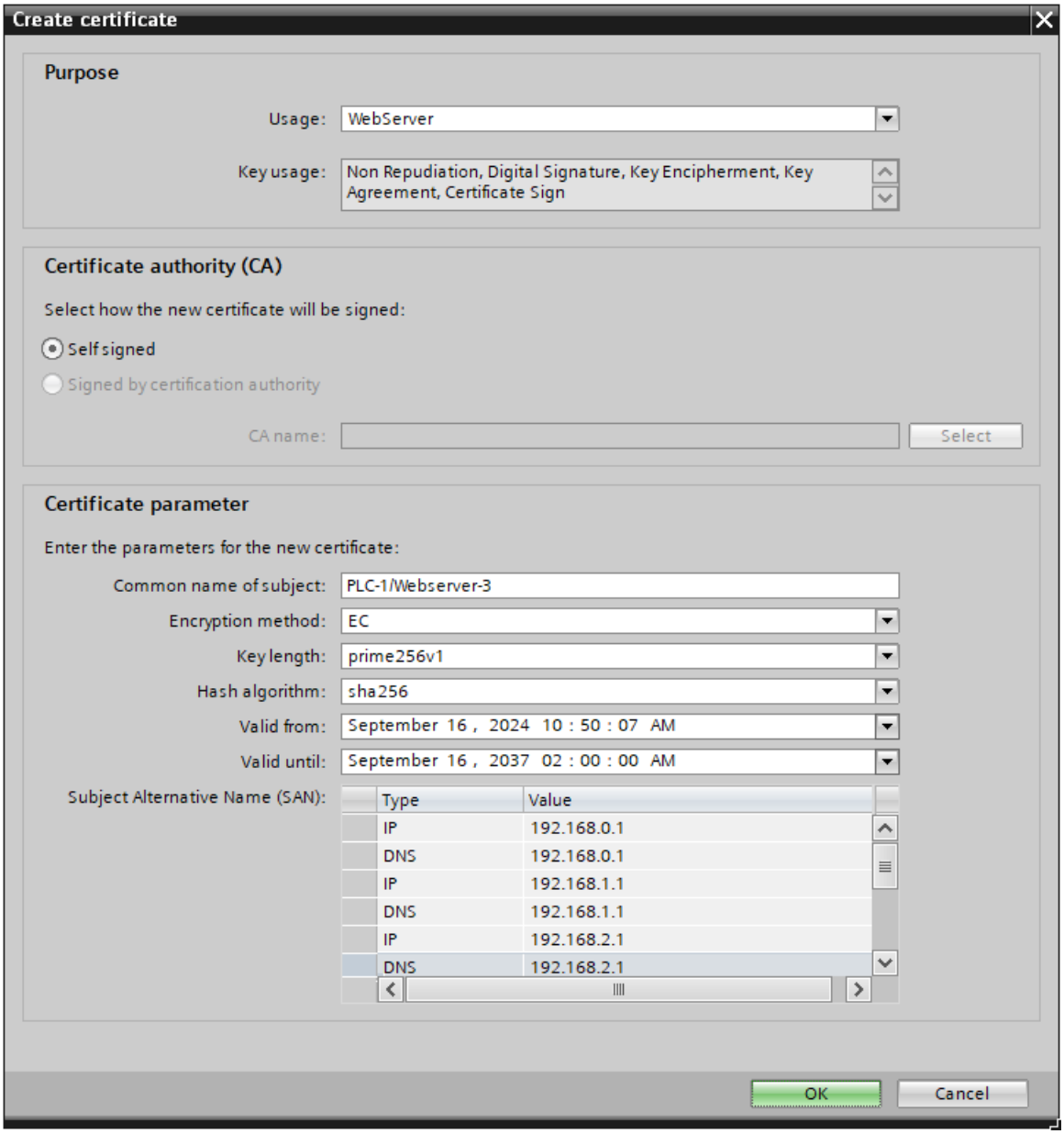

Figure 3-164 Creating a self-signed certificate

5. Select the "Self-signed" check box.
6. Enter the parameters for the new certificate or confirm the default settings.
   - Select "Web server" in the "Usage" box.
   - RSA as well as EC certificates are supported by the web server. The advantage of the EC certificates is the higher performance provided.
   - Enter the IP address(es) of the interface(s) or the domain name of the configured CPU in the "Subject Alternative Name" field.

7. Click "OK" to confirm.
8. Compile and load the configuration into the CPU.
   The device certificate of the Web server is a component of the configuration.

More information

For detailed information on local self-signed and global CA-signed certificates, on the "Public Key Infrastructure" (PKI) and on certificate management, refer to the S7-1500/ET 200 Communication Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925) and to the STEP 7 online help, keyword "Secure communication".

The application example "Using certificates with TIA Portal (https://support.industry.siemens.com/cs/ww/en/view/109769068)" includes detailed instructions on how to create a secure connection to the web server of a SIMATIC S7-1500 CPU.

4.4.3 Managing certificates in runtime

If you manage certificates via the TIA Portal, load a certificate together with the hardware configuration into the CPU. To do this, the CPU must be in STOP mode. You cannot load a new certificate or renew an existing certificate without a RUN-STOP-RUN transition. To this purpose the global certificate management must be used and a certificate renewed.

If you manage certificates at runtime of the CPU, loading or updating a certificate is also possible in RUN mode.

Managing the web server certificate during the CPU runtime

As of firmware version V3.0, it is also possible to transfer web server certificates to the CPU during runtime via the GDS server using OPC UA methods. The GDS server is part of the OPC UA server in the CPU. Through GDS push management functions, you can automatically update OPC UA certificates for the OPC UA server of the S7-1500 CPU.

As of firmware version 3.1, the certificate can be exchanged during runtime. No system STOP is required - the system continues to run.

You can find detailed information about the concept of automated certificate management with GDS (Global Discovery Services) in the S7-1500/ET 200 Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) Function Manual, section "Certificate management via Global Discovery Server (GDS)".

Setting the type of certificate management

In the "Protection & Security" > "Certificate manager" category on the "General" tab of the "Properties" Inspector window, select how you want to handle certificates.

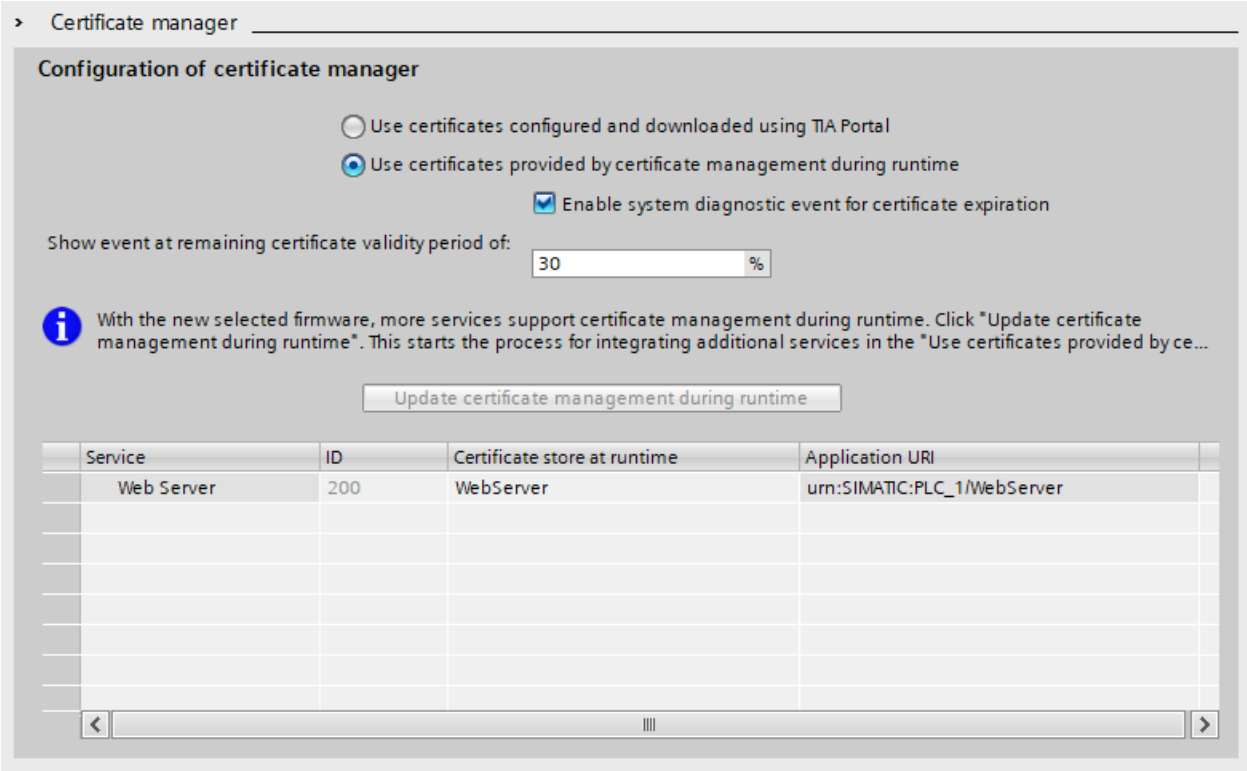

Figure 3-165 Configuration of the certificate manager

If you want to submit certificates via GDS at runtime, click the "Use certificates provided by certificate management during runtime" option.

By selecting the "Enable system diagnostic event for certificate expiration" button, you specify that you want to be notified when a certificate expires. In the input field "Show event at remaining certificate validity period of:" enter a percent value. At the time this value is reached, the CPU triggers a system alarm with a maintenance request.

Example:

The certificate transferred via GDS on 2024-06-01 is valid from 2024-06-01 to 2024-06-30 (30 days). You have input a percent value of 10 for the diagnostics event. On 2024-06-27, after 90% of the validity period has expired, the system diagnostics alarm reports that the transmitted certificate will expire on 2024-06-30.

Regardless of the configured percentage value, a message appears in any case when the validity period of a certificate expires.

In the lower area of the "Certificate manager" category in the table, you can find a list of all CPU applications with certificates you may transfer to the CPU at runtime. In the list, the CPU applications are assigned an ID. Under the "Folder for certificate repository at runtime" column, you can find the changeable name of the certificate group.

Handling of existing certificates during loading

Before you load a project into the CPU, you can determine in the "Load preview" dialog window what should happen with the certificates of the CPU received during runtime.

As of firmware version V3.0, you can use the "Delete selected" option to delete certificates of selected CPU applications.

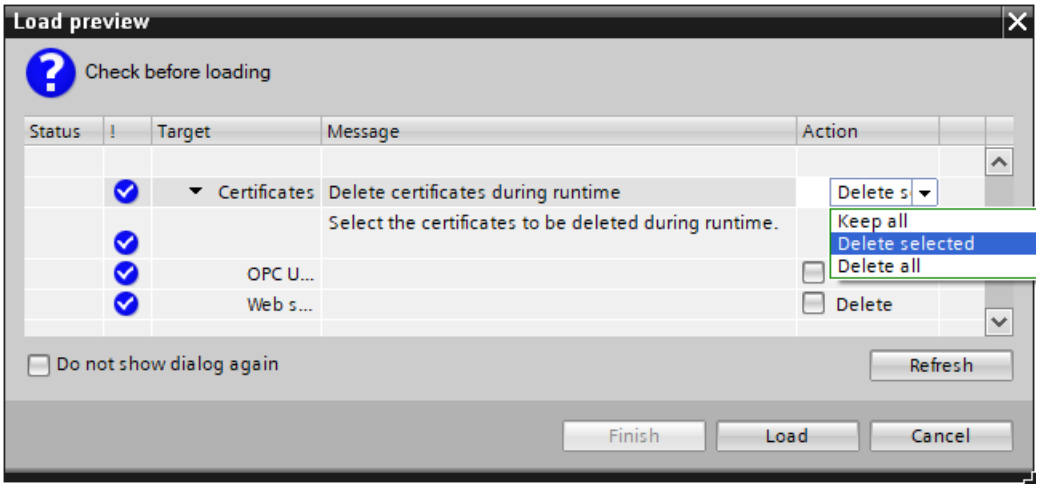

Figure 3-166 Deleting certificates

4.4.4 Installing certificates for the web browser

In order to use the web browsers for HTTPS pages, you have to install the correct certificates in the web browser. The installation is described below for the web browsers "Firefox", "Chrome", and "MS Edge":

Installing certificates in Firefox

1. Ensure that the certificate that you want to import into Firefox is stored on your computer.
2. Start "Firefox" and then click at the top right on the button to open the menu.
3. Select the "Settings" entry.
4. Then change to the left to the "Data protection & security" menu and scroll completely downwards on this page.
5. The "Certificates" section is located here. Click the "Display certificates" button.
6. Click at the bottom on "Import..." and navigate to your certificate file.
7. Click "OK".

The entry is included subsequently in Firefox. Should there be any problems, ensure that the most recent version of Firefox is installed.

Installing certificates in Chrome or MS Edge

1. Ensure that the certificate that you want to import into "Chrome" or "MS Edge" is stored on your computer.
2. Open the settings or go to chrome://settings.
3. Click "Data protection and security" on the left.
4. Click "Security".
5. Scroll to "Advanced".
6. Click "Manage certificates".
7. Click "Import".
8. Click "Next" and navigate to the storage location of the downloaded certificate. Select it and click "Open".
9. Click "Next".
10. Click "Store all certificates in the following memory".
    - If you want to use the certificate generated by the server, select "Trusted root certification authorities".
    - If you want to use a certificate from a different source, select "Intermediate certification authorities".
11. Click "Next" and then "Finish".
12. Click "OK".

Installing certificates in Safari

A detailed description is available in the respective documentation for iOS- or Android-based products.

4.5 Language settings

Introduction

The Web server provides the user interface in the following languages: The defaults is English (USA):

- German
- English (USA)
- French
- Italian
- Spanish
- Japanese
- Chinese (Simplified)

- Korean
- Russian
- Turkish
- Portuguese (Brazil)

You can set the user interface language in the header of the overview of the new system web pages, see section Overview (Page 61).

Requirement for multilingual output of texts

In order for the web server to correctly display alarms, comments, and diagnostics information in the different project languages, you must assign a project language to each of the desired user interface languages of the web server in STEP 7.

NOTE

The project languages of the STEP 7 project that you want to assign must be activated and the corresponding texts (translations) must be available in the project. You can find a list of available project languages in the project tree under "Languages & resources".

Configuring a project language for the Web server

Once you have activated the Web server on your module, assign an active project language from the drop-down list to each interface language. This assignment affects the display of pages with project language-dependent texts, such as the diagnostics buffer.

1. Navigate to the "Multilingual support" area in the "General" tab of the CPU properties in the inspector window.
2. Assign an active project language from the drop-down list to each interface language.

Overall, you can assign up to three different project languages to the user interface languages of the web server.

NOTE

A project language can only be added in STOP mode. Subsequently a download is carried out.

Reference

You can find more information on how to set the project language in STEP 7 in the STEP 7 online help, keyword: "Selecting project languages".

4.6 User management

User authentication on the Web server always takes place via secure HTTPS communication. You can authenticate yourself via the system web pages or using the Web API.

The CPU supports various possibilities for the user management.

Possibilities - setting up user management

You set up the user management in TIA Portal depending on the configured and loaded firmware version of the CPU.

Table 3-160 User management and firmware version of the CPU

Configured firmware version of the CPU				User management			Where can I find information?
S7-1500/ ET 200SP/ ET 200pro	Software controller	S7-1500V	S7-1200 G2	Static	Local	Central	
≤ V3.0	≤ V30.0	-	-	x	-	-	Web server Function Manual, Edition 11/2023 (https://support.industry.siemens.com/cs/ww/en/view/59193560)
V3.1	V30.1	V3.1	-	-	x	-	Web server Function Manual, Edition 11/2024 (https://support.industry.siemens.com/cs/ww/en/view/1099772-46)
V4.0	V40.0	V4.0	-	-	x	x	Web server Function Manual, Edition 11/2024 (https://support.industry.siemens.com/cs/ww/en/view/1099772-46)
≥ V4.1	≥ V41.0	≥ V4.1	≥ V1.0[1] ≥ V4.0[2] ≥ V4.1[3]	-	x	x[2, 3]	This section, S7-1500, ET 200MP System Manual (https://support.industry.siemens.com/cs/ww/en/view/59191792)

[1] As of firmware version 1.0 for S7-1200 G2 1212/1214, only local user management.

[2] As of firmware version 4.0 for S7-1200 G2 1216/1217, local and central user management.

[3] As of firmware version 4.1 for S7-1200 G2 1212/1214, local and central user management.

Static user management: You can create users, define access rights and assign passwords via the user list. You only have access to the options that are permanently linked to the access rights.

Local user management: You manage all project users along with their rights (for example, function rights) for all CPUs in the project in the editor for users and roles of the project in TIA Portal.

Central user management: The central user management allows system-wide, central management of users outside TIA Portal. The users and user groups can work in all projects in which they are activated and for the appropriate rights have been assigned to them.

Local user management

As of TIA Portal version V19 and CPU firmware version V3.1/V30.1/V1.0, the CPUs dispose of an improved management of users, roles, and CPU function rights (User Management & Access Control, UMAC).

You manage all project users along with their rights (for example, access rights) for all CPUs in the project in the editor for users and roles of the project in the TIA Portal:

- Navigate to the "Security Settings > Users and roles" area in the project tree to manage users with their rights, for example, to control function rights.

The TIA Portal saves the assignment of the function rights of a CPU to user-defined roles and the assignment of these roles to users for each CPU. There are no system-defined roles with predefined function rights for CPUs. After loading the configuration, the user management becomes effective in the respective CPUs. After loading, every CPU "knows" who may access which service and execute specific functions.

The following settings can be made for a local project user:

- User name: Name of the local project user which must be used to log on to the project.
- Password: The password assigned by the administrator with which the project user can log on to the CPU. The project user can change the password later.
- Authentication method: For CPUs only possible via the password.
- Runtime timeout: Time span of inactivity after which a user is logged out from a device. You can use this timeout for your own web applications to have the application exit after a user-defined period of inactivity.
- Comment: Comment on the respective project user.
- Use the check box to the left of the user name to specify whether or not the project user should be downloaded to the CPU.

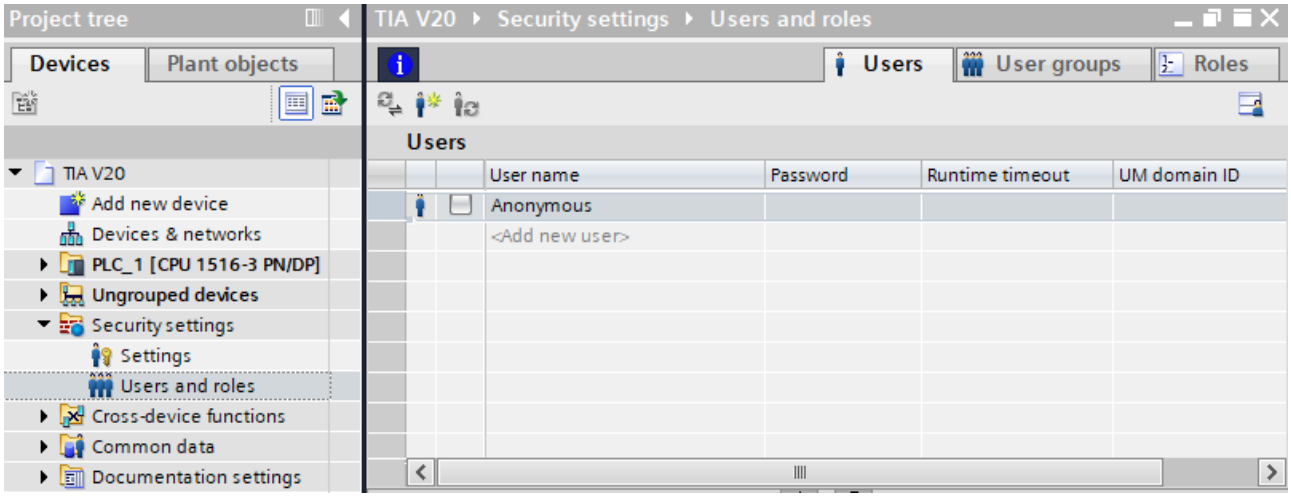

Figure 3-167 User management: Users and roles

You assign the roles and rights to the user.

Requirements:

CPU parameter assignment: To be able to set up users, roles and function rights for a CPU, the "Enable access control" option in the "Protection & Security > Access control" tab must be selected (which is the default). In addition, usage of the local user management must be activated in the "User management configuration".

Procedure:

In the following example, you assign the "admin" role to the user "User_1" with all rights for the web server:

1. Create a new local user in the "Users" tab, in the example "User_1", and assign a password.

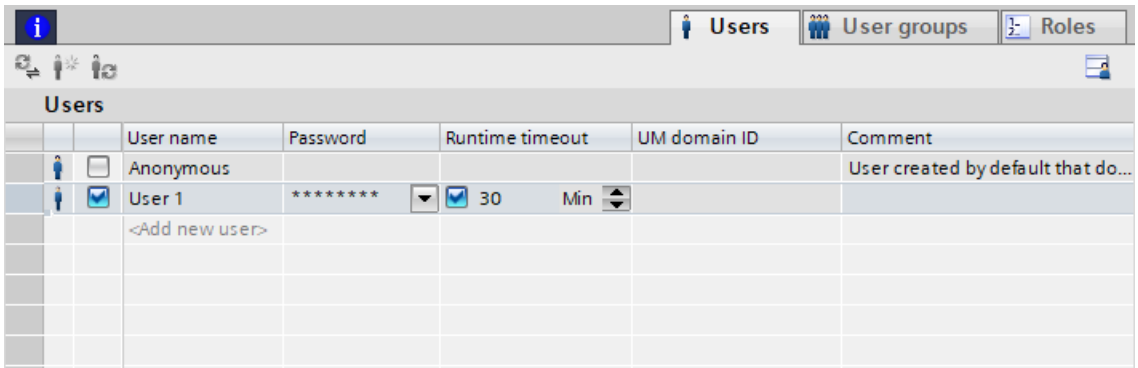

Figure 3-168 User management: Creating a local user

2. Define one or more roles in the "Roles" tab, the role "admin" in the example.

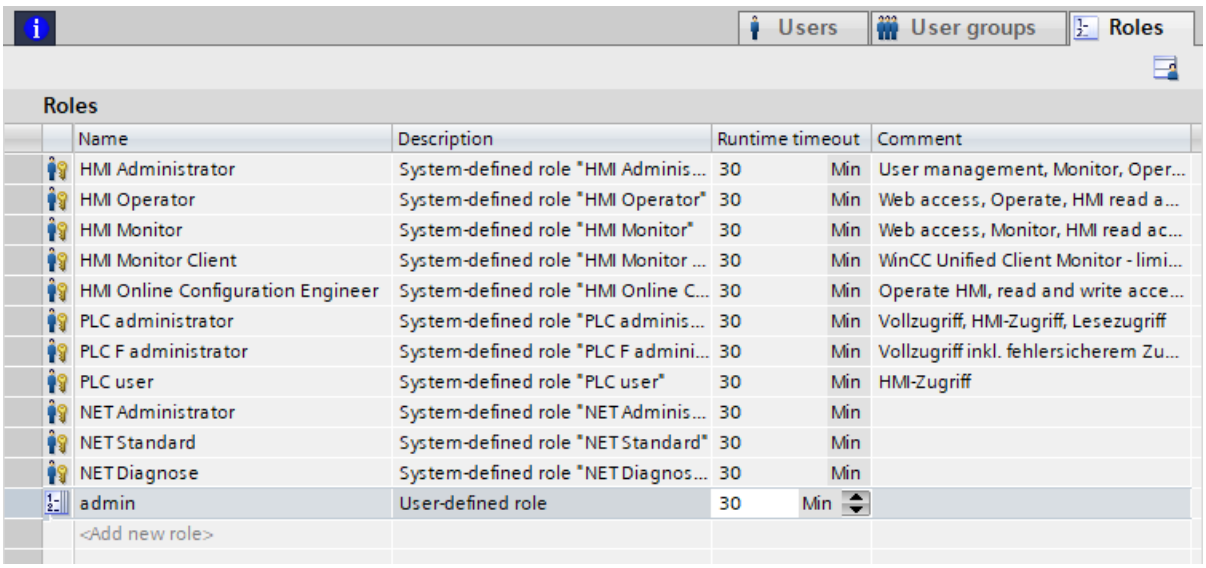

Figure 3-169 User management: Defining a role

3. Assign function rights for the Web server to the "admin" role. To do this, switch to the "Runtime rights" tab and select all function rights for the Web server for the example.

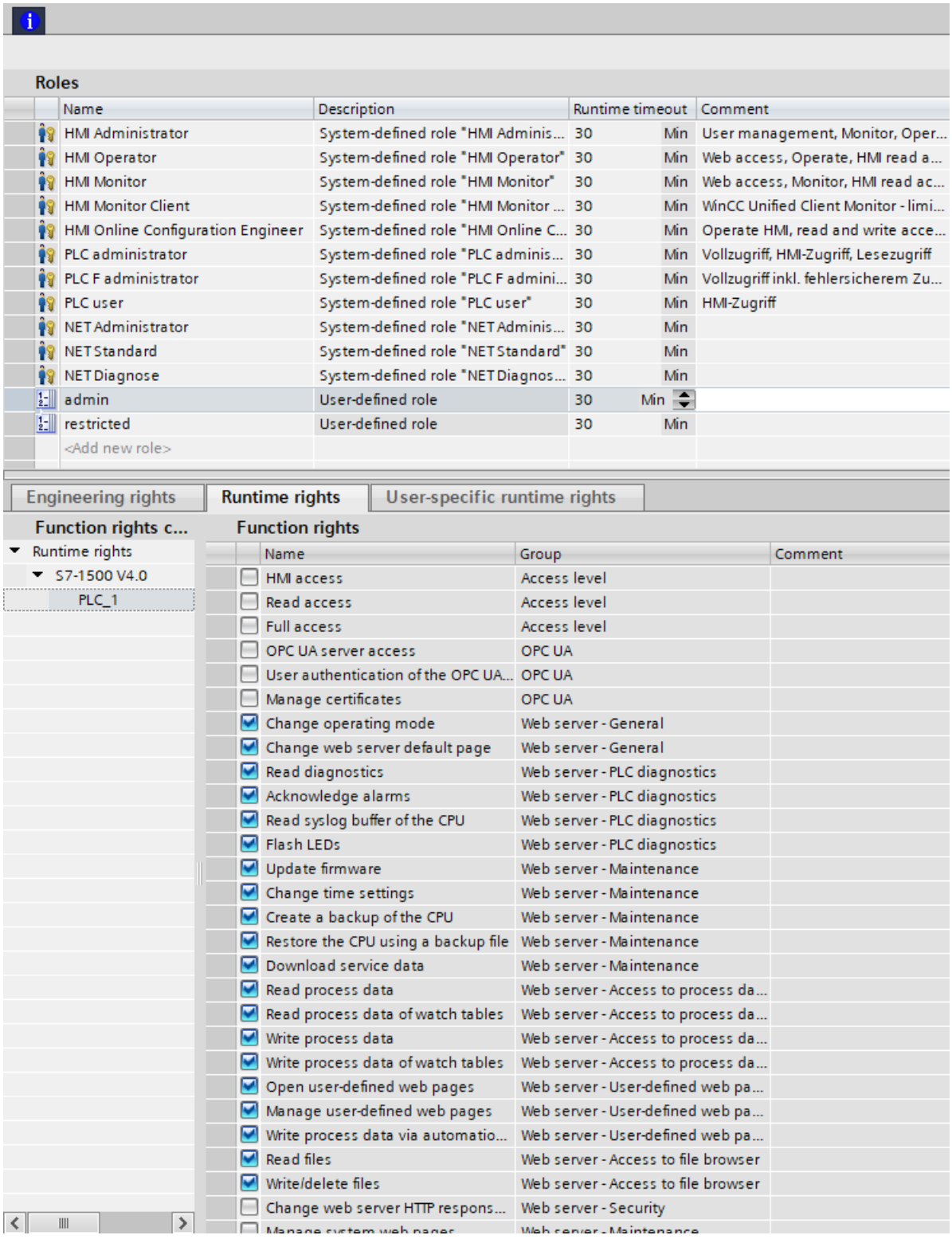

Figure 3-170 User management: Assigning rights to a role

4. At least one user must have full access to the CPU. Otherwise, the configuration cannot be compiled. Assign the "Full access" function right to the "admin" role.

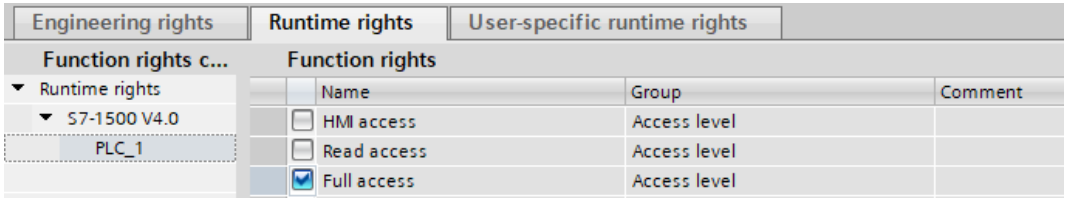

Figure 3-171 Setting up the full access access level

5. Assign one or more roles to the user "User_1" in the "Assigned roles" tab. In the example, you assign the "admin" role to the user "User_1". The roles and rights assigned to a user can be found in the corresponding tabs.

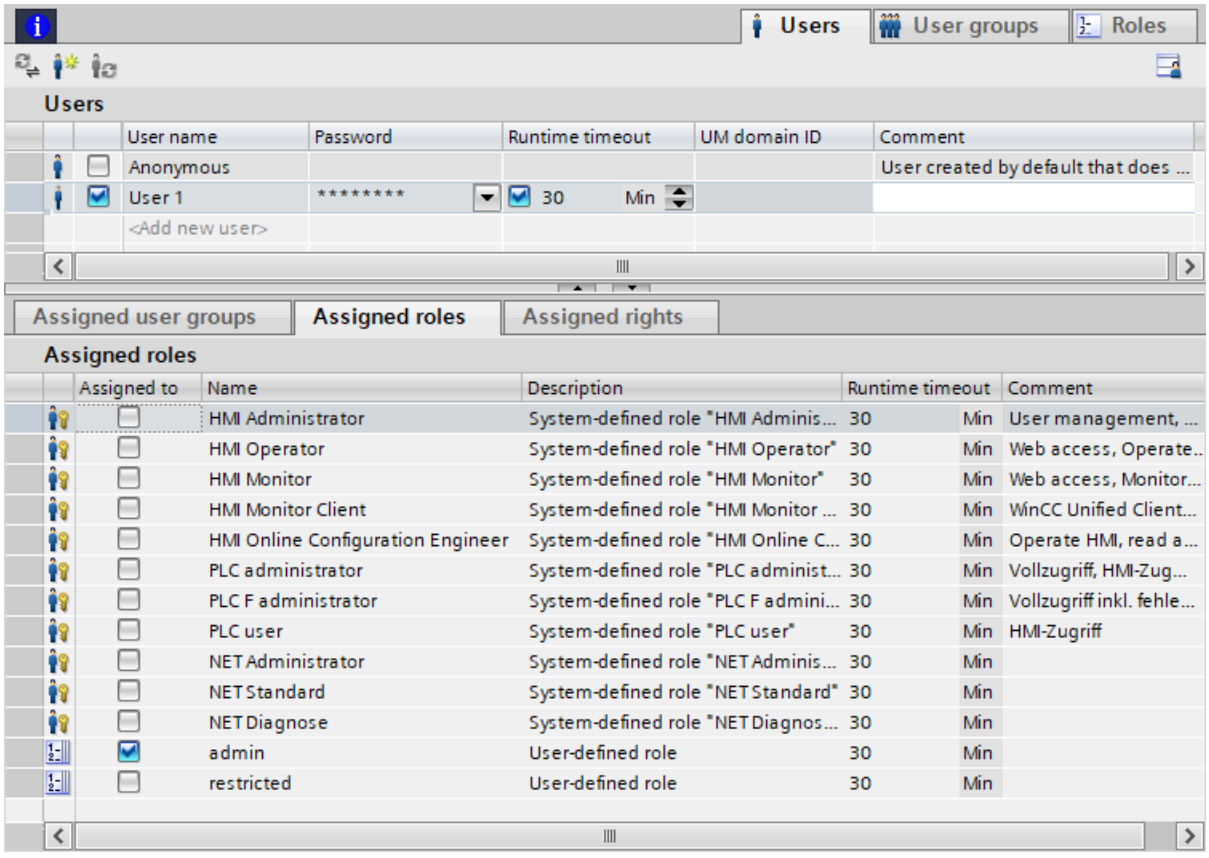

Figure 3-172 User management: Assigned role

6. Download the configuration to the CPU.

You can find more information on roles and rights in the online help for TIA Portal, keyword "Basics of user management in the TIA Portal".

If you delete a user in TIA Portal, their active user sessions are terminated.

Central user management

As of TIA Portal Version V20 and CPU firmware version V4.0/V40.0/V2.0, the CPUs support the central user management UMC (User Management Component).

The central user management allows system-wide, central management of users with an optional connection to Microsoft Active Directory.

With the software package UMC (User Management Component) you define and manage users and user groups on connected servers, across different software programs and devices. The authentication is implemented using UMC. UMC offers, among other things, a user management for CPU-specific function rights, such as for functions of the web server.

You set up linking between user/user group and assigned roles in the "Users and roles" editor in TIA Portal - as with the local user management.

During operation, users can be added to a group or removed from a group on the UMC server or their passwords can be changed without the CPU configurations having to be changed and loaded.

If you delete a user, their active user sessions are terminated.

Required information for the authorization via UMC

A CPU that has to authenticate the users for queries to the web server requires the following information to access the authentication service:

- The UMC server address

  Example: https://central.umc.testnet:443/ra

  (443 = Port for https, ra = Remote Authentication)
- A server ID (fingerprint of the server certificate).

Configure and apply central user management of the function rights for the web server of the CPU

You can find all the information on configuring and applying the central user management for CPUs in the section "Central user management" of the S7-1500, ET 200MP System Manual (https://support.industry.siemens.com/cs/ww/en/view/59191792).

Information on setting up (installing, configuring) a UMC server as well as on creating central users and groups is available in this application example (https://support.industry.siemens.com/cs/at/de/view/109780337/en).

Deactivating the user management

For CPUs with configured firmware version ≥ V3.1/V30.1/V1.0, you can disable access control in the hardware configuration in the CPU properties under "Protection & Security" > "Access control".

There is no user management in the project with deactivated access control. Users who are defined under "Users and roles" are not considered and authentication is not possible. The CPU itself creates an "Anonymous" user that has full access rights to the functions of the web server and the CPU.

If you deactivate local or central user management respectively, all the user sessions logged in locally or centrally are terminated.

NOTE

Take into account that deactivation of the access control is a security risk and can therefore not be recommended.

"Anonymous" user

As a non-logged-in user, you access web pages or the Web API as an "Anonymous" user. It does not matter in this case whether you have configured additional users. You activate the "Anonymous" user in the "Users" tab of the editor "Security settings > Users and roles".

The "Anonymous" user does not use any access authorizations by default and is specified without assignment of a password. However, you can assign all the function rights available in TIA Portal to it.

When the system web pages are called, these attempt to log into the system with the "Anonymous" user by default. The overview of the system web pages is opened automatically if one of the following conditions applies:

- An "Anonymous" user has been activated in TIA Portal.
- Function rights for the web server have been assigned to the "Anonymous" user.

The login page cannot be exited without successful authentication with a different user.

Number of users:

- Local user management: Minimum of 1 user and maximum of 100 users
- Central user management: Minimum of 1 user and maximum of 256 users or 50 user groups

NOTE

Because the "Anonymous" user is specified with assignment of a password in TIA Portal, pay close attention to the access rights you assign to this user.

The authorization on the web server as an "Anonymous" user is only foreseen for test purposes, commissioning, etc. In other words, when the system is not in productive operation. In this case, you have to ensure the security of the plant through other organizational measures, e.g. spatial protection.

Individual authorizations, such as the option to change the operating mode, may pose a safety risk.

Recommendation: When assigning security-relevant authorizations, create a user with password protection in TIA Portal.

WARNING

"Anonymous"user at an F-CPU

For an F-CPU, do **not** assign the access authorization "Perform changes as F-Admin" to the "Anonymous" user.

Make sure that you observe the warnings relating to this in the section "Restoring a backup of the safety program to an F-CPU" in the manual SIMATIC Safety - Configuring and Programming (https://support.automation.siemens.com/WW/view/en/54110126).

Selecting a user for a session

Always assign a user who has only the required authorizations for a session.

Example:

A user wants to display the new system web pages on an HMI panel. If the panel is used only for write-protected information, the user should not authenticate an administrator user who disposes of more function rights than are required.

A device that remains authenticated at the web server could be unsupervised so that an attacker could possibly carry out an unintended operation.

Rules for passwords

Passwords should always be more than 8 characters in length and contain uppercase and lowercase characters as well as special characters and numbers (?!+%$1234...). Computer keyboard character strings and words from the dictionary are unsuitable. Change the password regularly.

You can read the password policies of the CPU as of firmware version V3.1 with the Api.GetPasswordPolicy method. In the TIA Portal, you can read the policies and change these in the project tree via "Security settings" > "Settings" > "Password policies". You can find more information in the online help for the TIA Portal.

More information

More information on the user administration:

- with TIA Portal is available in the online help for the TIA Portal.
- for SIMATIC S7-1500 is available in the System Manual S7-1500, ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/59191792), in the Protection section

System web pages

5

5.1 Working with system web pages

5.1.1 Getting started

Connecting to the Web server

To access the system web pages, follow these steps. This description is also valid for other variants, e.g. S7-1200 G2. However, there are differences depending on the CPU variant.

1. Use STEP 7 to download a project in which the web server is activated to the CPU.
2. Optional: In the project tree in STEP 7, verify the "General settings" menu under the CPU in the "Web applications" folder and configure the system web pages optionally as default web pages of the web server.
3. Connect a display device (PG/PC, HMI, mobile terminal device) with the CPU or a communication module using a PROFINET interface.
   If you are working with WLAN, activate WLAN on the display device and establish a connection to the access point (e.g. SCALANCE W788-1RR or SCALANCE W784-1), which is in turn connected to the CPU.
4. Enter the IP address of the interface of the configured CPU which is connected to the client in the address bar of the web browser, for example:
   - https://192.168.3.141
   - If you have not configured the system web pages as default web pages: https://192.168.3.141/~system

Result: The connection is established. The site to which you are directed depends on the access/function rights of the user.

You can find more information in the section "Setting up and calling a web server (Page 18)."

The following section provides information about the different web pages using an S7-1500 CPU as an example.

Login page

The following figure shows the login page displayed in the web browser, if authentication is required.

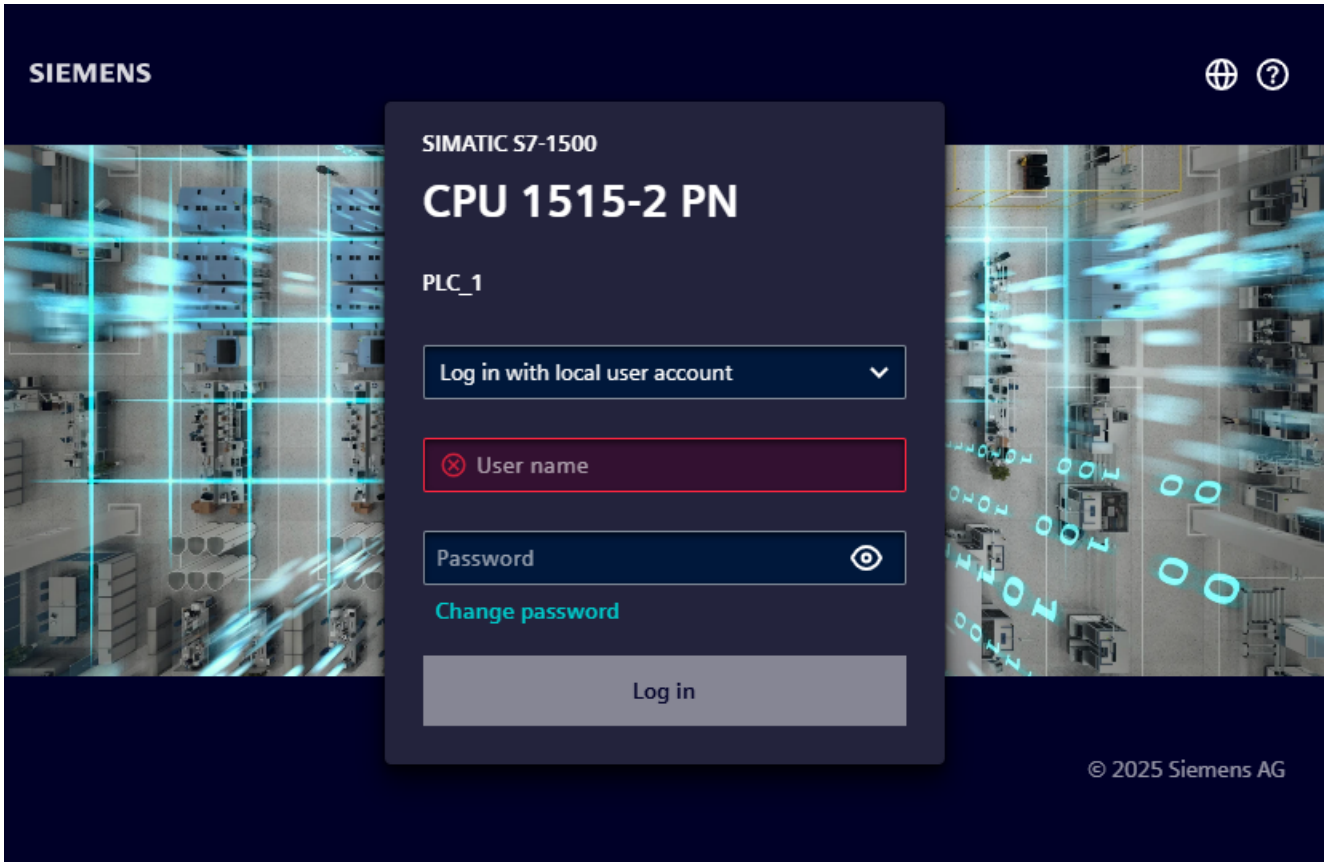

Figure 3-173 Login page

To access other functions of the system web pages, log in. The entire procedure is described in the section Authentication (Page 56).

Overview of system web pages

Once you have logged in successfully or if no authentication is required, the start page (overview) of the system web pages appears.

All system web pages are arranged as follows on the screen:

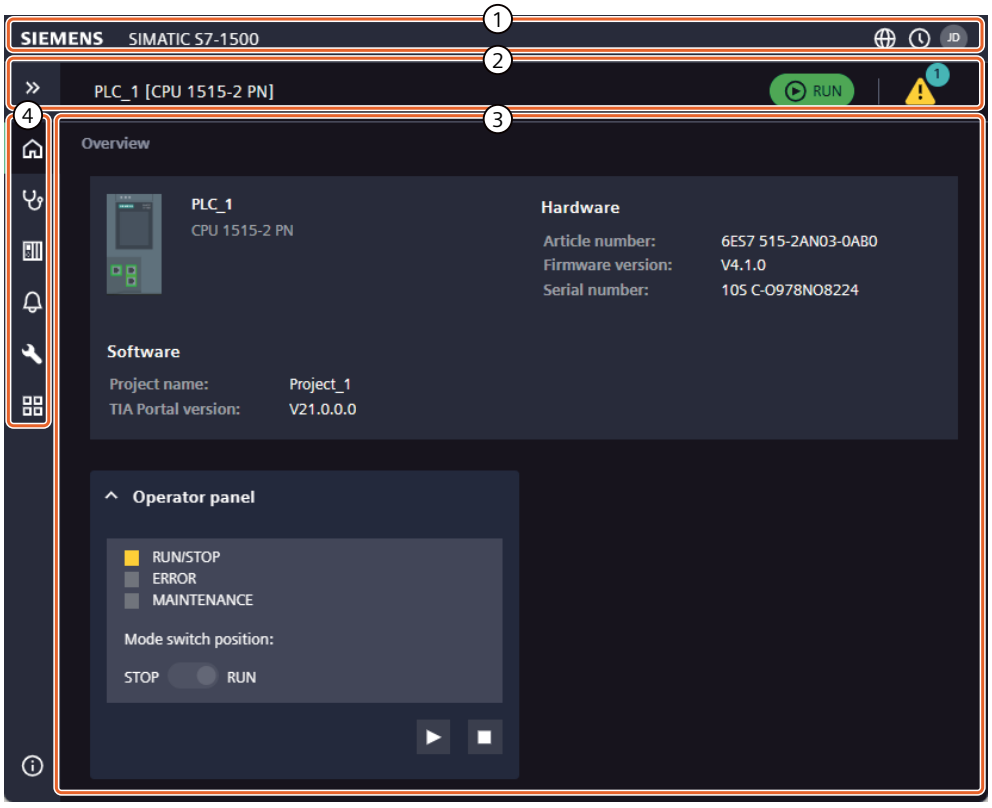

① Header with product family and information on the time and language settings and the currently logged-in user

② Secondary header with information on the selected CPU type: Module name, station name (with R/H CPUs), product name, operating mode and possibly alarms

③ Area for the contents of the selected system web page

④ Main menu

Figure 3-174 Layout of a system web page

Main menu

You expand the main menu of the web server with the » button at the top left of the screen. Here, you have the option of navigating to the system web pages:

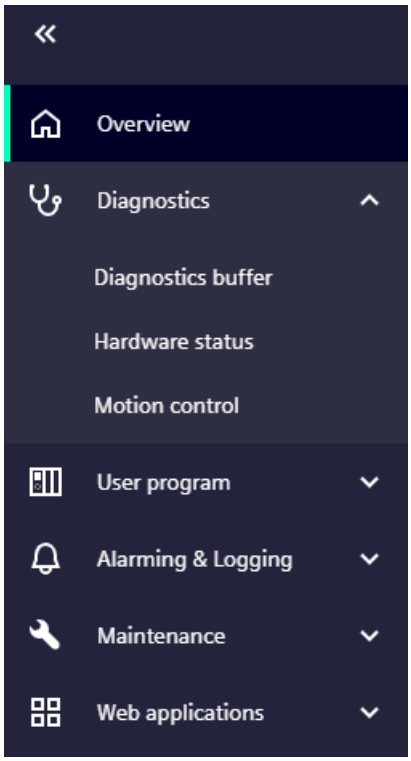

Figure 3-175 Expanded main menu

Operating mode

If you click on the colored operating mode icon in the secondary header, an extended view opens:

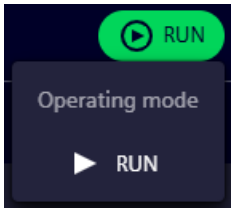

Figure 3-176 Extended view of the operating mode

RUN	RUN
STOP	STOP
HOLD	HOLD

STARTUP	STARTUP
Unknown	Unknown
No connection	Connection lost

NOTE
R/H CPUs
For the R/H CPUs, the system state of both CPUs is displayed instead of the operating mode. The display of the system state is described below.

System state, roles of CPUs and pairing status (for R/H CPUs)

If you click on the colored system state icon in the secondary header, an extended view opens.

This extended view shows the system state, the roles of the CPUs and information on pairing:

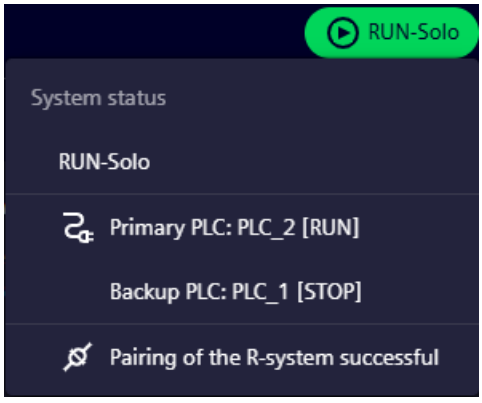

Figure 3-177 System state, roles of CPUs and pairing status

System state

The following system states are possible:

RUN-Redundant	RUN-Redundant
RUN-Solo	RUN-Solo
STOP	STOP
SYNCUP	SYNCUP
STARTUP	STARTUP
Unknown	Unknown
No connection	Connection lost

Roles of the CPUs

The following roles are possible:

- Primary
- Backup
- Unknown

Pairing status

The following pairing statuses are possible:

- Pairing successful
- Single pairing successful
- No pairing
- No pairing: Different firmware
- No pairing: Different article numbers
- No pairing: Too many partners

You will find more information on R/H CPUs in the S7-1500R/H redundant system (https://support.industry.siemens.com/cs/ww/en/view/109754833) System Manual.

Language and time settings

Language setting

You can change the language of the user interface with the globe icon in the header. You can find more information in the section Language settings (Page 39).

Time

Click the clock icon in the header. A window with time zones opens. All time stamps are displayed by default based on the PLC local time.

You can select your desired time zone here:

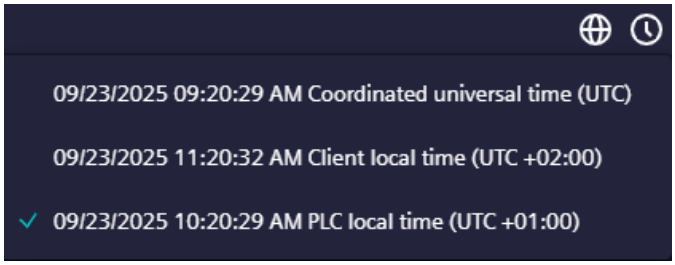

Figure 3-178 Available time zones of system web pages

System web pages of the CPUs as of firmware version V4.1/V41.0

The web server contains the following system web pages as of FW version V4.1/V41.0:

Table 3-161 System web pages of CPUs

Web page	Submenus/Contents
Overview	• Overview (Page 61)
Diagnostics	• Diagnostics buffer (Page 66) • Hardware status (Page 68) • Redundancy (Page 75) • Motion Control (Page 77)
User program	• Recipes (Page 82) • User files (Page 83)
Alarming & Logging	• Alarms (Page 84) • Data logs (Page 85)
Maintenance	• File browser (Page 89) • Service data (Page 93)
Safety	• Safety administration (Page 94)
Web applications*	• System web pages and previous web pages (Page 25)

* With this menu item, you open user-defined web applications and View-of-Things, if you have configured them.

The contents of the individual system web pages are described in the following sections.

Display of the user interface light/dark

The following designs are available for the display of the web pages:

- Light: Dark print on a light background
- Dark: Light print on a dark background:

The design that is used depends on the web browser or operating system on which the system web pages are shown.

Alternatively, you can also override the setting, e.g. with user-defined web applications. You can find more information on the display of the user interface (key siemens_web_ui_theme) in the section Interaction between web applications (Page 147).

5.1.2 Authentication

To use the full range of functions offered by the web server, you require a user with corresponding function rights. Log in with a user name and password specified in the user management in TIA Portal. You now have corresponding permissions to access the web pages released for this user.

You can find more information in the section "User management (Page 41)."

NOTE

After carrying out the actions planned by you, log out explicitly from the web server by clicking "Logout" in order to minimize the risk of unauthorized access.

NOTE

If your password has expired, you are informed when logging in that your password must be changed. As soon as you have changed your password, you can log into the web server again.

If your password expires soon, you are informed when logging in that your password must be changed soon.

Logging in to the web server

When the system web pages are called, the login page for the web server is opened on which you can log in. If the "Anonymous" user has at least one function right for the web server, the Overview (Page 61) of the web server is opened automatically.

NOTE

Logging in at the web server is required under the following conditions:

- No "Anonymous" user is activated in TIA Portal.
- No function rights for the web server have been assigned to the "Anonymous" user.

Proceed as follows to log into the web server:

1. Open the web browser on your display device.
2. Enter the IP address of the interface of the CPU which is connected to the client in the "Address" field of the web browser in the following format: https://a.b.c.d (example entry: https://192.168.3.141)
3. Enter your user name and your password in the login mask of the login page.

   In addition, you can choose between two login methods:

   – Logging in with a local user account
   – Logging in with a central user account

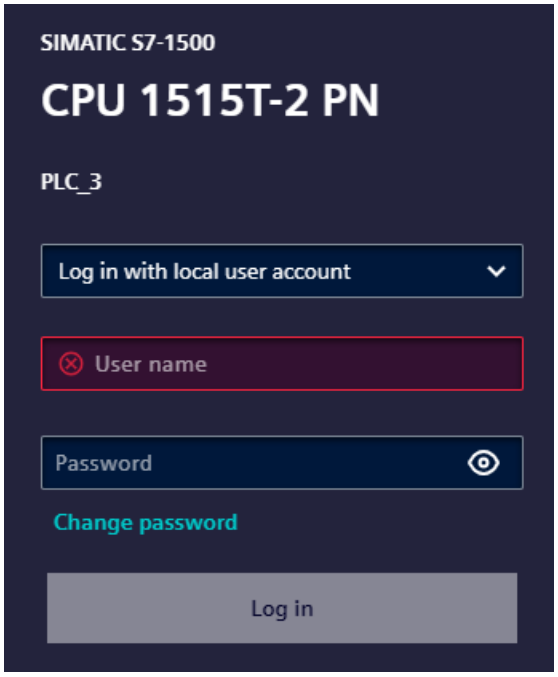

Figure 3-179 Logging in to the web server

4. Click "Login".

Result: You are in the web server overview; see section Overview (Page 61). The user currently logged in is displayed in the header.

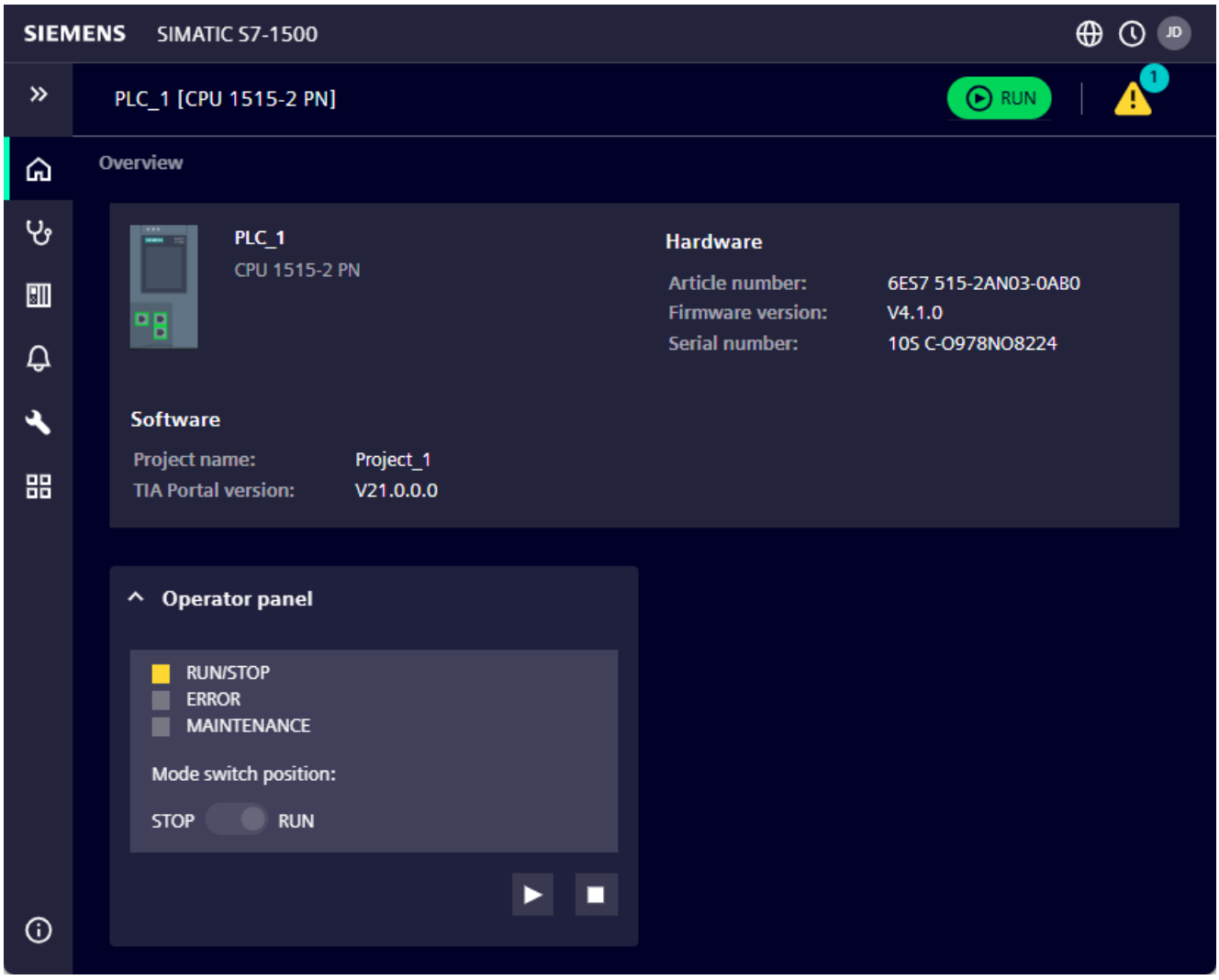

Figure 3-180 Overview of the web server

NOTE

Users are always shown the information for which they have authorizations. All further information is hidden.

Logging out from the web server

Proceed as follows to log out of the web server:

1. While you are logged in, click on your user name in the header of the web server.
2. Click "Logout".

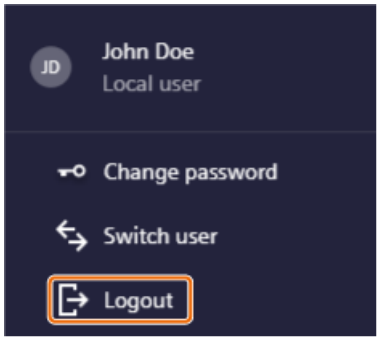

Figure 3-181 Logging out from the web server

Result: You have been logged out of the web server successfully and are on the login page.

Changing the user

Proceed as follows to change the user logged in at the web server:

1. While you are logged in, click on your user name in the header of the web server.
2. Click "Switch user".

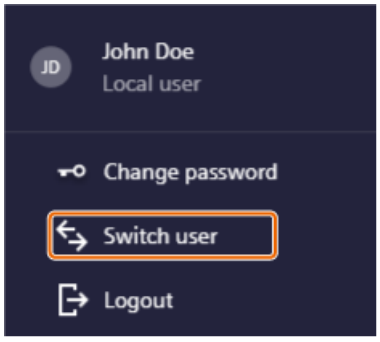

Figure 3-182 Changing the user

3. Enter a different user name and the corresponding password in the login mask in the popup window.
4. Click "Switch user".

Result: The logged-in user currently logged in is displayed in the header.

Change the password

NOTE

Central user accounts

The password can only be changed for local user accounts. With the central user accounts, you navigate to the web pages of the UMC server and change the password there.

You can find all the information on configuring and applying the central user management for CPUs in the section "Central user management" of the SIMATIC S7-1500/ET 200MP Automation system (https://support.industry.siemens.com/cs/ww/en/view/59191792) System Manual.

The password can be changed on the login page before logging in as well as in the overview of the web server after logging in.

Changing the password on the login page

Proceed as follows to change the password on the login page:

1. Click "Change password".

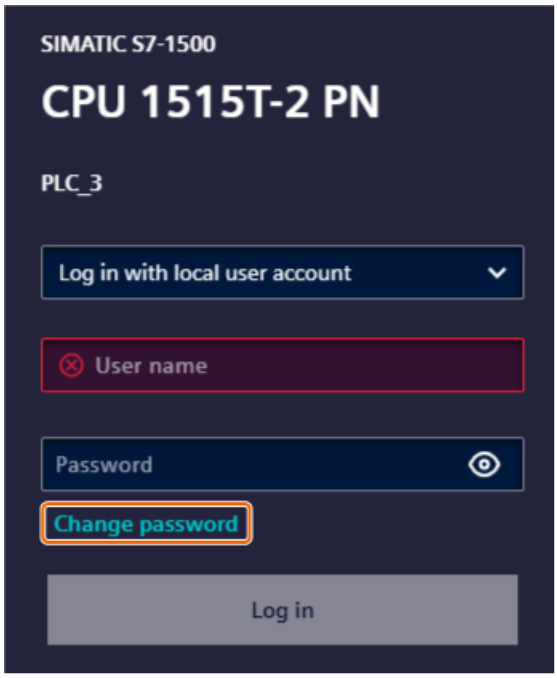

Figure 3-183 Changing the password on the login page

2. Enter your user name in the following window.
3. Click "Next".
4. In the following window enter your old password once as well as your new password twice in the corresponding input fields.
5. Click "Confirm".

NOTE

The password specifications, for example length and permitted characters, are displayed below the entry field and are confirmed with a green check mark when used correctly.

Result: The password has been changed and you are in the web server overview The user currently logged in is displayed in the header.

Changing the password in the logged-in state

Proceed as follows to change the password in the web server overview:

1. While you are logged in, click on your user name in the header of the web server.
2. Click "Change password".

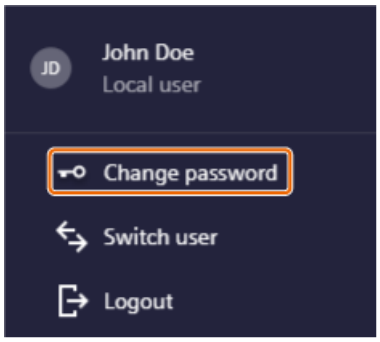

Figure 3-184 Changing the password in the overview

3. In the popup window, enter your old password once as well as your new password twice in the corresponding input fields.
4. Click "Confirm".

NOTE

The password specifications, for example length and permitted characters, are displayed below the entry field and are confirmed with a green check mark when used correctly.

The password specifications are configurable under "Users and roles" in TIA Portal. You can find more information in section User management (Page 41).

Result: The password has been changed and you are in the web server overview The user currently logged in is displayed in the header.

5.2 Overview

This system web page shows general information, for example configured module name and module type.

The overview is displayed if you have logged on with a user (see section "Authentication (Page 56)") or the Anonymous user has web server rights.

To display the information on this system web page, you require the "Read diagnostics" authorization. To be able to change the operating modes, you require the "Change operating mode" authorization.

The following contents and information is provided in the overview:

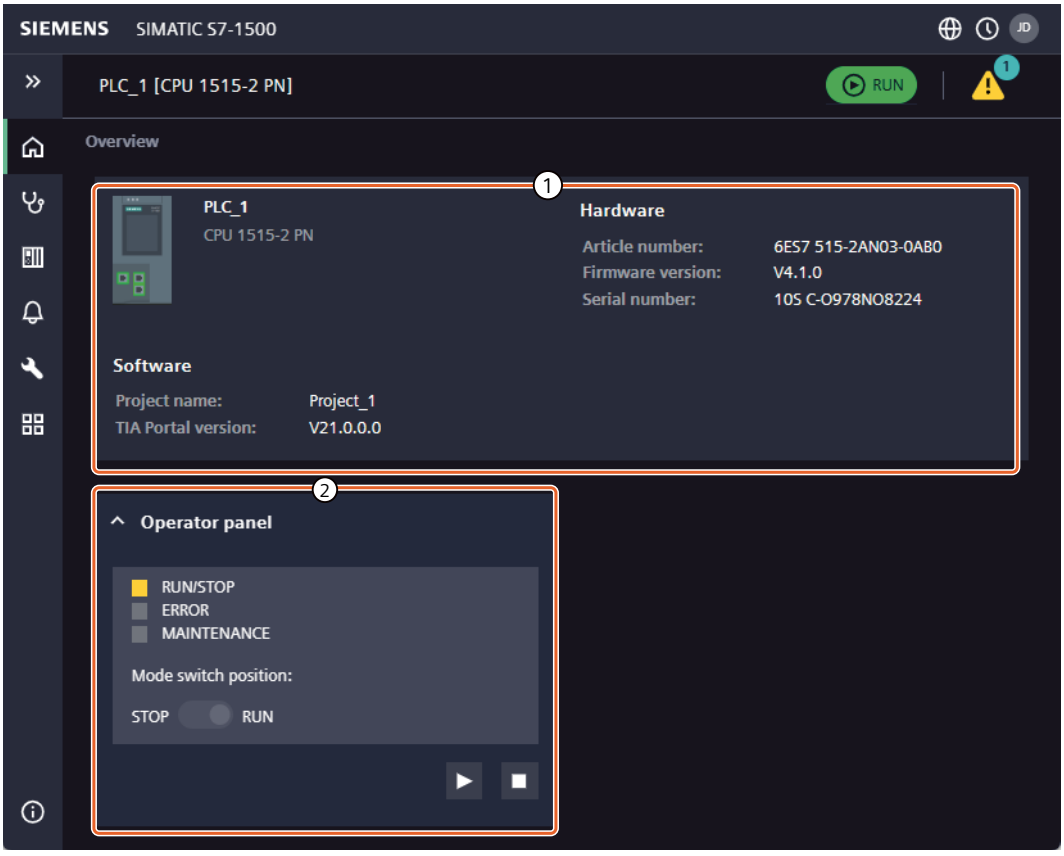

① Information on the hardware and software used

② Operator panel

Figure 3-185 Overview

The information and options offered in the overview depend on the hardware used and the available function rights. The following information is always available to the user:

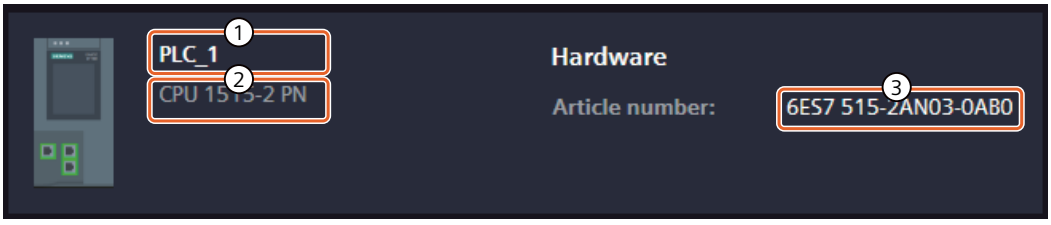

① Module name

② Product name

③ Article number

Figure 3-186 Basic information in the overview

To display additional information, you require the "Read diagnostics" authorization. Without this authorization, this information is hidden.

NOTE

Simulation with S7-PLCSIM Advanced

If an unspecific CPU is simulated, the display of the overview page is adapted accordingly. In this way, the user can easily identify that a CPU with maximum configuration limits, and not the specific CPU, is being simulated.

S7-1500 R/H-CPUs

You can operate the R/H CPUs in normal operation or standalone operation; see System Manual SIMATIC S7-1500 S7-1500R/H redundant system (https://support.industry.siemens.com/cs/ww/de/view/109754833).

For an R/H CPU, you see the following information:

Figure 3-187 R/H CPU in normal operation

In normal operation of the R/H CPU, the station name is specified together with the serial numbers of both CPUs. The remaining information that is displayed corresponds to the standard CPUs.

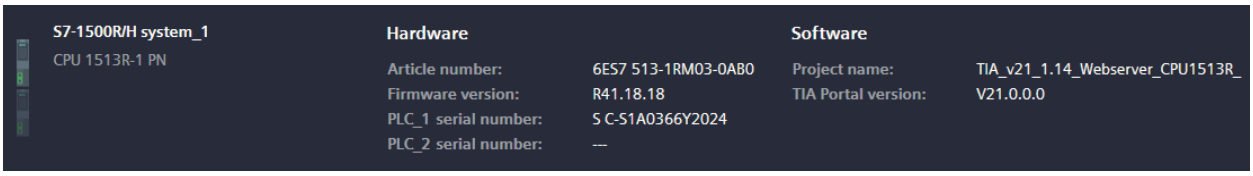

Figure 3-188 R/H CPU in standalone mode

In standalone mode of the R/H CPU, the module name is specified. The remaining information that is displayed corresponds to the standard CPUs.

You can find more information in section Redundancy (Page 75).

Fail-safe CPUs

You can operate the fail-safe CPU as standard CPU or fail-safe CPU.

You see additional information for a fail-safe CPU:

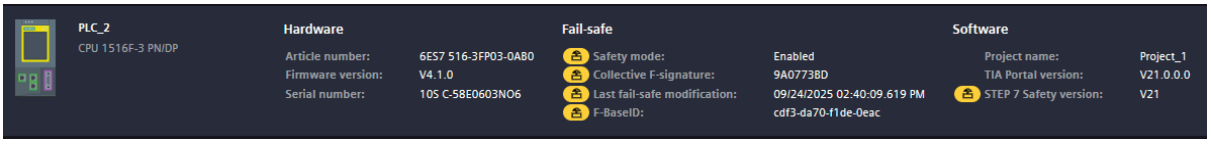

Figure 3-189 Fail-safe CPU in safety mode

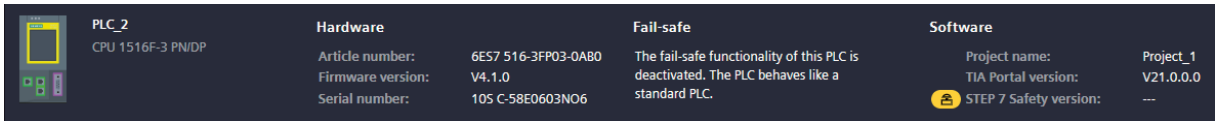

Figure 3-190 Operating a fail-safe CPU as standard CPU

You can find more information in section Safety (Page 94).

Operator panel

The operator panel is only displayed if the logged-in user has the "Read diagnostics" authorization. The LEDs on the screen show their states on the CPU.

If you also have the "Change operating mode" authorization, you can change the operating mode of the CPU in the operator panel with the ▶ and ■ buttons in addition.

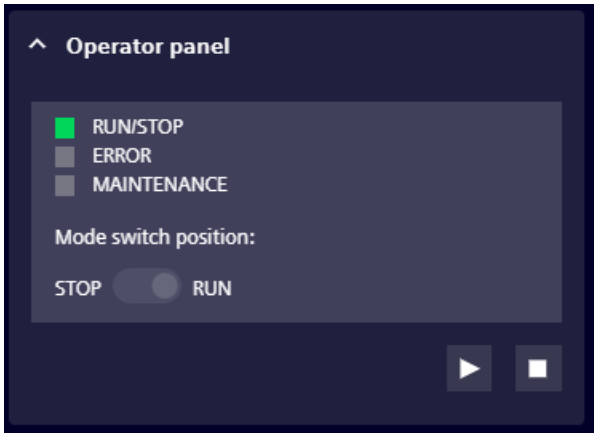

Figure 3-191 Operator panel of a standard CPU

NOTE

S7-1200 G2 CPU

The S7-1200 G2 CPUs do not have a mode switch. The mode switch is not displayed in the operator panel.

Operator panel of an R/H CPU

Three fields are displayed for the R/H CPU in normal operation: One system operator panel and two individual operator panels for the two CPUs of the R/H system:

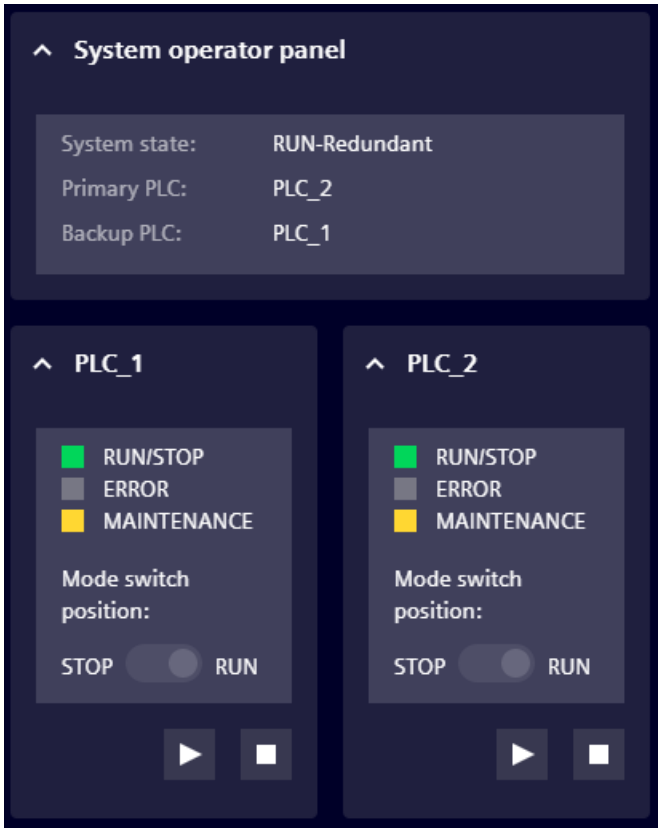

Figure 3-192 Operator panel of an R/H CPU

You can change the operating mode of both CPUs. In standalone mode, the view changes.

5.3 Diagnostics

Overview

The following web pages and information are available under the "Diagnostics" menu item:

- Diagnostics buffer (Page 66)
- Hardware status (Page 68)
- Redundancy (Page 75)
- Motion Control (Page 77)

5.3.1 Diagnostics buffer

Overview

With "Diagnostics" > "Diagnostics buffer", you open the diagnostics buffer of the CPU and load the diagnostics buffer into the web server.

To call this system web page, you require the "Read diagnostics" authorization.

Figure 3-193 "Diagnostics buffer" overview

It is possible that not all diagnostics buffer entries are displayed. With the button at the top right of the screen, you can reload either the last 250 or all entries:

- Reload last 250 entries
- Reload complete buffer

NOTE

Load strategy for diagnostics buffer entries

Adjust the load strategy to the available performance. At best, all diagnostics buffer entries are displayed.

You can change the order of the rows based on values in a column by clicking the column header.

You can change the width of a column with the mouse.

Note that the diagnostic events are displayed in the project language of the STEP 7 project that is assigned to the current web server interface language. You can find out how to assign project languages to interface languages in the section "Language settings (Page 39)".

Opening details of a diagnostics buffer entry

Click the icon to the left of the diagnostics buffer entry whose details you want to view. The icon changes to . A detailed view of the diagnostics buffer entry is shown.

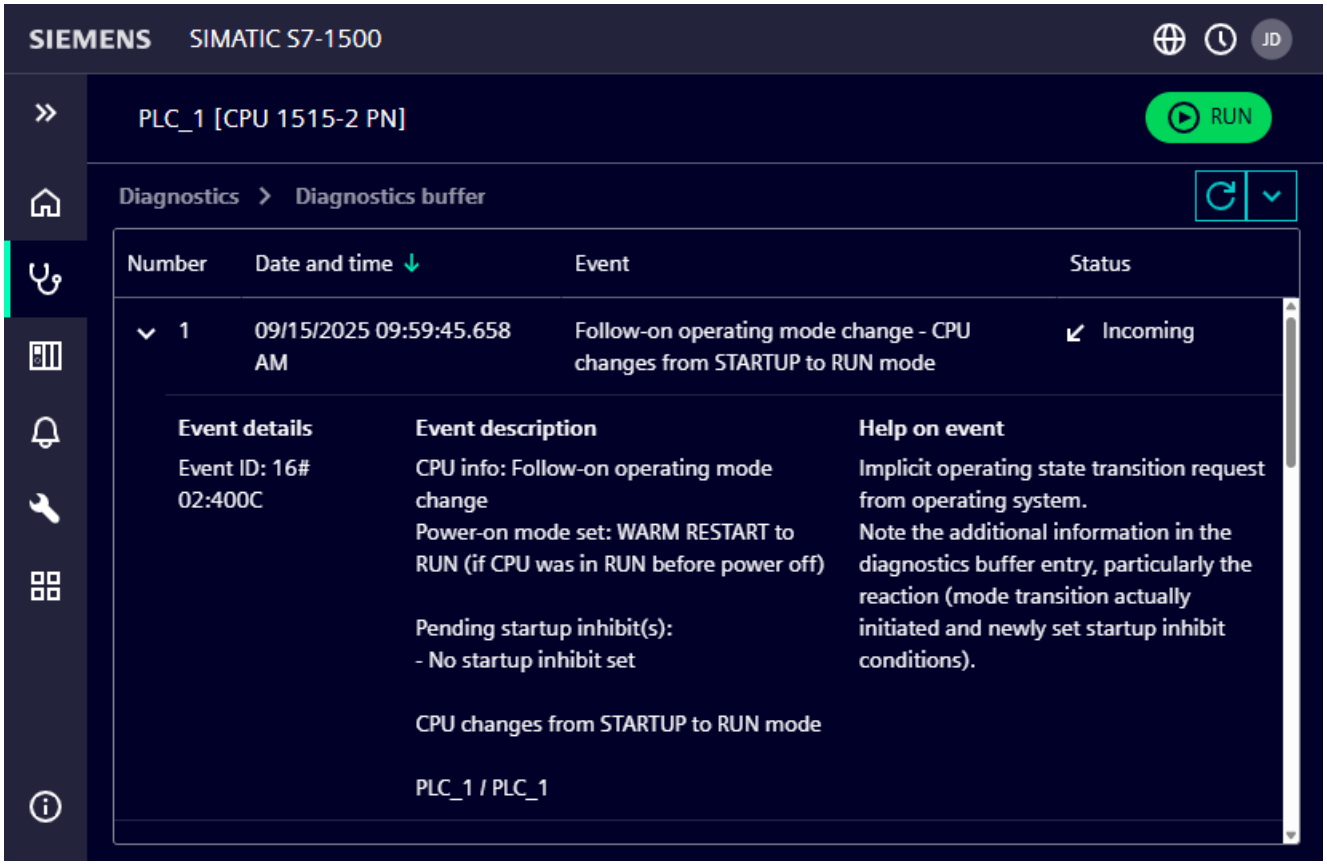

Figure 3-194 Details of a diagnostics buffer entry

Updating the diagnostics buffer

The display is not updated automatically.

With the "Refresh" button , you reload the latest 250 entries of the diagnostics buffer.

With the "Refresh" button, you update the entire diagnostics buffer and load new incoming diagnostics buffer entries.

Notifications

If a new diagnostics buffer entry comes in, an asterisk is displayed to the top right of the "Refresh" button . Position the cursor above the button to see when the new diagnostics buffer entry came in. Update the display manually.

NOTE

The asterisk above the "Refresh" button is displayed with a delay after a new diagnostics buffer entry has come in.

NOTE

The diagnostics buffer is not updated automatically when new diagnostics buffer entries come in

5.3.2 Hardware status

The hardware status shows the current state of the configured hardware components of an automation system.

To call this system web page, you require the "Read diagnostics" authorization.

NOTE

R/H CPUs

This function is not supported with the R/H CPUs.

Table view

By default, a list of I/O systems and the CPU (for standard CPUs) is shown.

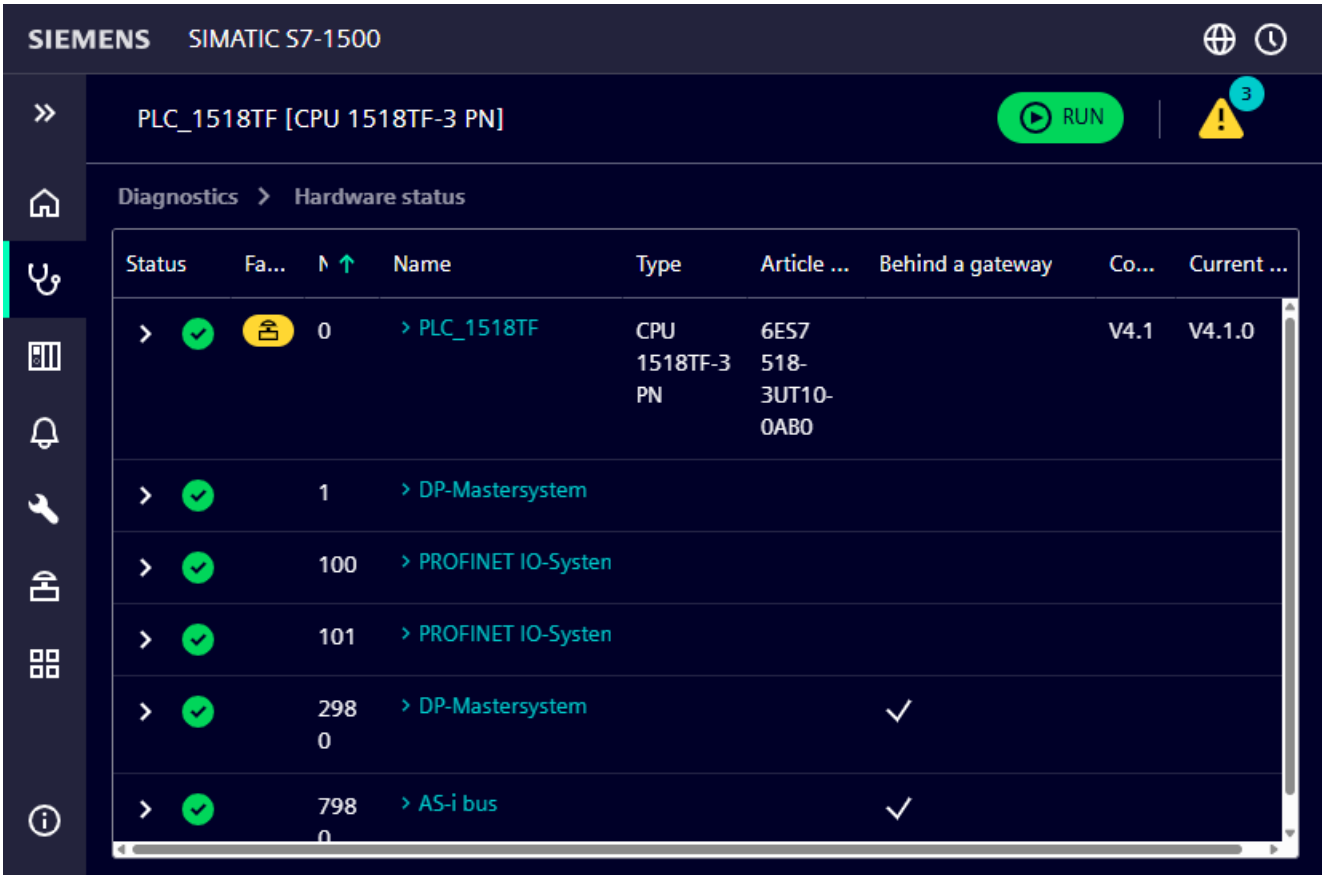

Figure 3-195 Table view of a hardware status: One CPU with multiple IO systems

By default, the rows are shown in descending order of the value in the Number column. You can change the order of the rows based on values in a column by clicking the column header.

When you click on the name of a node, you get to a list of lower-level nodes.

The individual columns contain the following information:

Column	Displayed	Meaning
Status	Yes	Status of the component. The meaning of this field is described in the next table.
Fail-safe	Yes	For F-modules: Yellow symbol. For non-F-modules, the field remains empty.
Current number	Depending on the configuration control	The current number refers to the slot number of a module.
Number	Depending on the configuration control	Depending on the context, the number refers to a submodule, module, device or I/O system.
Name	Yes	Node name
Type	Yes	Hardware type of the node

Column	Displayed	Meaning
Article number	Yes	Article number of the module. If the current article number differs from the configured article number, both article numbers are specified.
Downstream from a gateway	Yes	A symbol is displayed for the `gateway` subtype.
I-address	Only if there is at least one module with input or output addresses	The input address. The start address and end address are specified.
Q-address	Only if there is at least one module with input or output addresses	The output address. The start address and end address are specified.
F-Par_CRC	Only with the `failsafe` attribute	CRC signature of the F parameters as a byte array with 4 numbers for representing a 32-bit signature.
F-monitoring time	Only with the `failsafe` attribute	ISO 8601 time stamp in UTC as string; F-monitoring time in milliseconds
F-source address	Only with the `failsafe` attribute	
F-destination address	Only with the `failsafe` attribute	
Configured FW version	For modules and devices	The configured firmware version
Current FW version	For modules and devices	Current firmware version
Comment	If a comment was entered for one of the displayed entries	

The columns that do not contain information for the displayed devices are hidden by default.

Meaning of the symbols in the "Status" column

Table 3-162 Meaning of symbols

Symbol (dark)	Symbol (light)	Meaning
		Component is OK
		Maintenance required
		Maintenance demanded
		Error. Component faulty or not available due to an incorrect type.

Symbol (dark)	Symbol (light)	Meaning
		Component "not reachable" "Not reachable" is displayed when a module has been removed or a module has been configured but does not exist.
		No input or output data available. Input or output channels of the (sub)module are disabled. An incorrect module without inputs or outputs was probably inserted.
		Disabled components
		State cannot be determined • "State cannot be determined" is displayed during system diagnostics for all configured I/O modules and I/O systems after restart of the CPU. • However, this status can also be displayed temporarily during operation if a diagnostics interrupt burst occurs for all modules. • It is not possible to determine the status of modules on a subsystem that is connected to a CP.
		The cause of the problem is in a lower-level component. For this purpose, navigate to the corresponding component to show its lower-level components.

Extended view

Click the icon to the left of the entry whose extended view you want to display. The icon changes to .

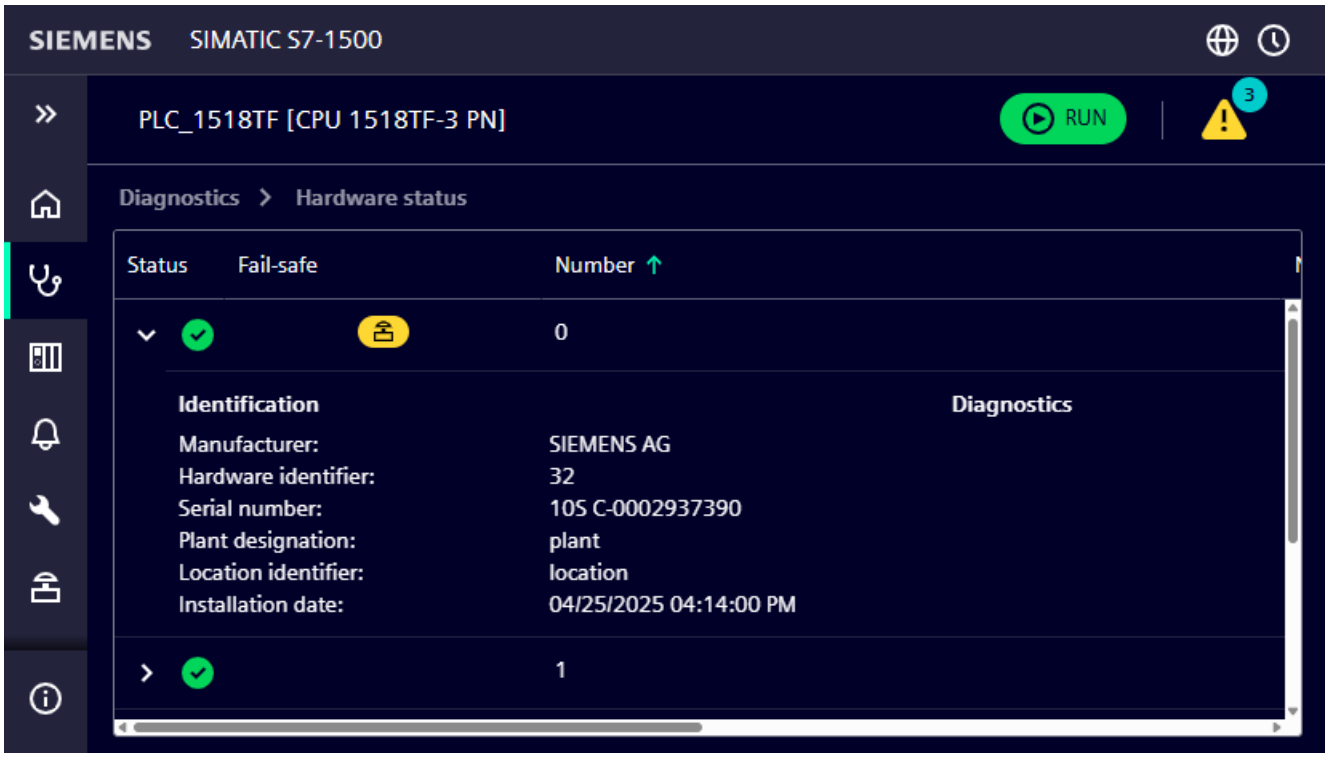

Figure 3-196 Example of an identification

The extended view shows information that exceeds the size of the table view. It is divided into two areas:

Identification

The identification in the left part of the screen shows common attributes of the extended view. The following values can be displayed if they contain valid values:

- Manufacturer
- Bootloader version
- Hardware identifier
- Serial number
- Plant designation
- Location identifier
- Installation date
- Description

Diagnostic information

Diagnostics information in the selected project language is shown in the right-hand area of the screen.

Configuration control

Configuration control can be helpful if you are developing an automation solution to be used with variations in different setups. The hardware status is extended in the case of configuration control to support you in the correct interpretation of the hardware configuration.

You can find more information on configuration control in the SIMATIC S7-1200 Automation system (https://support.industry.siemens.com/cs/ww/en/view/109759862) System Manual.

Note

When configuration control is enabled for a selected device, a note is displayed:

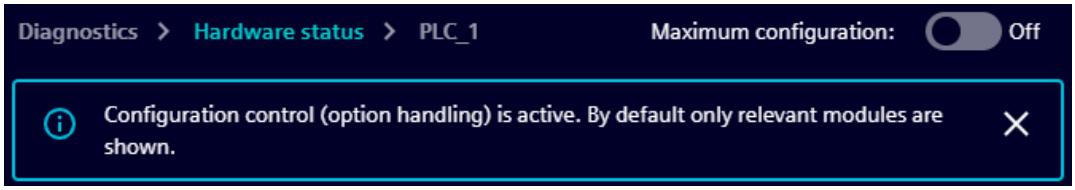

Figure 3-197 Configuration control: Note

Displaying the complete configuration

You can select whether you want to display the complete hardware configuration (maximum configuration) or only relevant modules that were enabled in the option control.

Figure 3-198 Configuration control: Shift key

Table view

The default setting of the Shift key is switched off (Off). The table is shown with the actual configuration. You see the slot numbers according to the configuration of the option control.

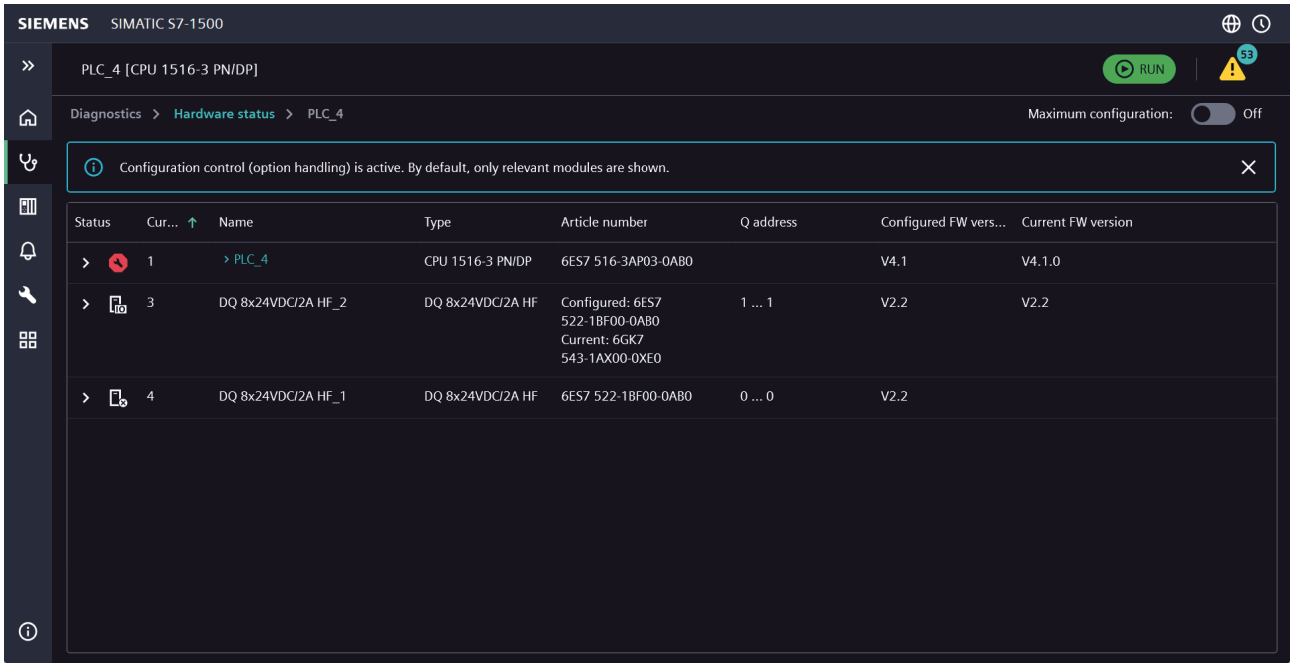

Figure 3-199 Configuration control: Table view with actual configuration

The maximum configuration is only displayed when you explicitly activate the Shift key (On). Then the additional "Number" column is shown, which specifies the slot numbers configured in the maximum configuration.

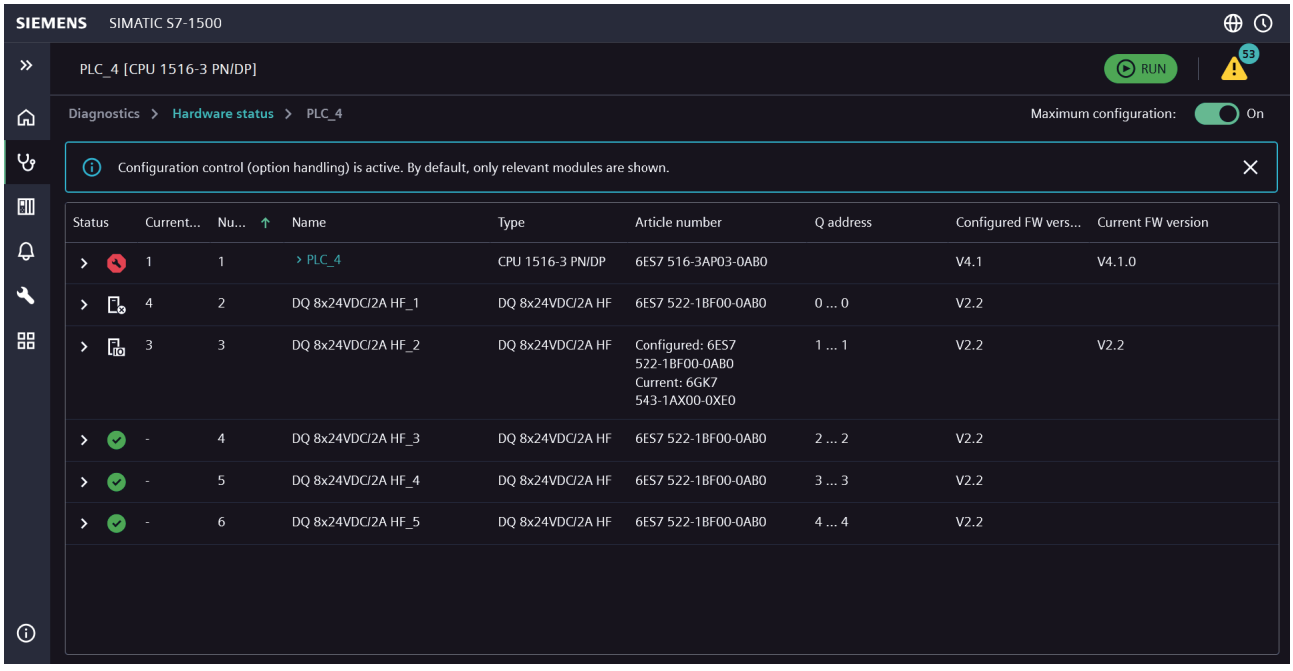

Figure 3-200 Configuration control: Table view with maximum configuration

5.3.3 Redundancy

This web page shows specific information for the R/H CPUs, e.g. the current configuration of the R/H system, the system state and the operating modes of the primary and backup CPUs. The layout of the web page depends on the configuration of the S7-1500R/H system.

To call this system web page, you require the "Read diagnostics" authorization.

Redundantly operated R/H CPUs

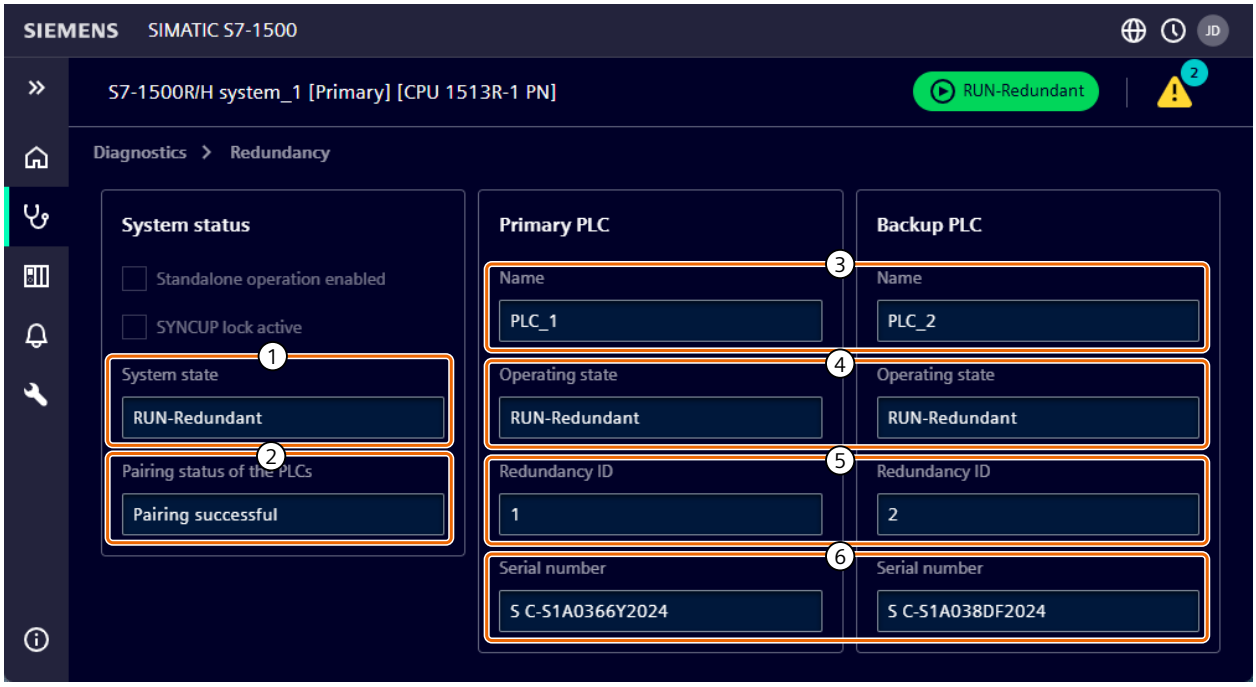

① System state, e.g. "RUN-Redundant"
② Pairing status of the CPUs: "Pairing successful"
③ Name of the two CPUs
④ Operating mode of the two CPUs
⑤ Redundancy ID of the two CPUs
⑥ Serial number of the two CPUs

Figure 3-201 Redundantly operated R/H CPUs

R/H CPU in standalone mode

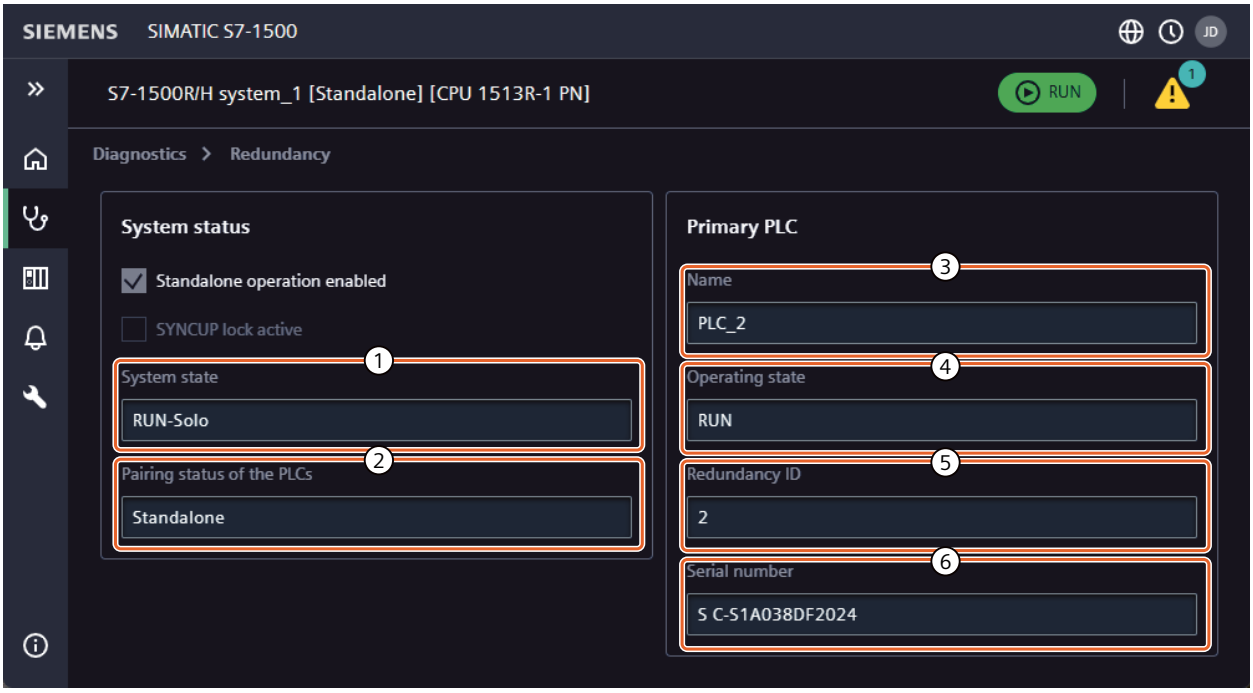

① System state, e.g. "RUN-Solo"
② Pairing status of the CPUs: "Standalone mode"
③ Name of the CPU
④ CPU operating mode
⑤ Redundancy ID of the CPU
⑥ Serial number of the CPU

Figure 3-202 R/H CPU in standalone mode

System state, roles of CPUs and pairing status

You can show the roles of the two CPUs and information about pairing when you click on the colored icon for the system state. You can find a description of the individual values in section Getting started (Page 49).

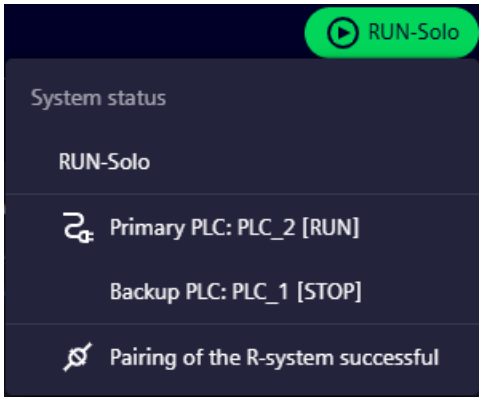

Figure 3-203 System state, roles of CPUs and pairing status

More information

You can find more information in the System Manual S7-1500R/H redundant system (https://support.industry.siemens.com/cs/ww/en/view/109754833).

5.3.4 Motion Control

Diagnostics information on technology objects is shown on this system web page.

To call this system web page, you require the "Read diagnostics" authorization.

NOTE

Select the "Data block accessible via Web server" check box in the properties of the data block in the TIA Portal. Otherwise, the technology objects will not be shown in the web page or their attributes will not be visible.

NOTE

If attributes are marked accordingly as not accessible via "HMI/OPCUA/WebAPI", TOs may not be shown.

Introduction

When you call the Motion Control menu item, an entry screen is shown first:

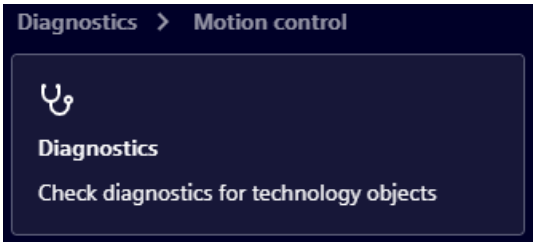

Figure 3-204 Entry screen for Motion Control

Here, click the entry "Check diagnostics for technology objects". You are forwarded to the overview.

Overview

The "Motion Control Diagnostics" web page is divided into two areas:

- You will find a list of configured technology objects in the left half of the screen.
- The right half shows detailed information on the technology object selected in the list. It is arranged in tabs.

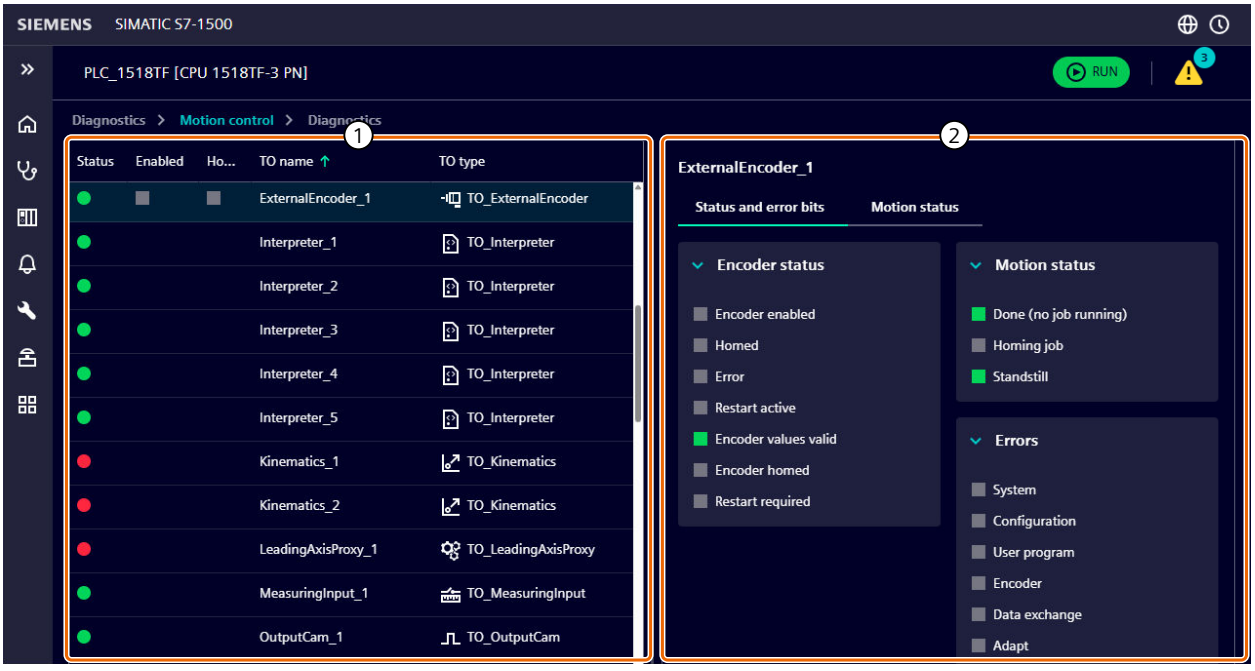

① List of technology objects

② Tabs for the selected technology object

Figure 3-205 Motion Control: Overview

List of configured technology objects

Check the following diagnostics information in the list of configured technology objects:

- Status:
  - (green) = no warning, no alarm
  - (yellow) = warning present
  - (red) = error present
- Enabled
- Homed

The entries can be sorted according to individual parameters in ascending or descending order. You change the order of the entries based on values in a column by clicking the column header.

To display the current status and error bits as well as technology object-specific diagnostic information of a technology object in tabs, select the technology object in the list.

The web server supports the display of information for the following technology objects:

- Speed axis (TO_SpeedAxis)
- Positioning axis (TO_PositioningAxis)
- Synchronous axis (TO_SynchronousAxis)
- External encoder (TO_ExternalEncoder)
- Measuring input (TO_MeasuringInput)
- Output cam (TO_OutputCam)
- Cam track (TO_CamTrack)
- Cyclic cam (TO_Cam, TO_Cam_10k, To_Cam_600Seg, To_Cam_6kSeg) (S7-1500T, S7-1200 G2)
- Kinematics (TO_Kinematics) (S7-1500T, S7-1200 G2)
- Leading axis proxy (TO_LeadingAxisProxy) (S7-1500T)
- Interpreter (TO_Interpreter) (S7-1500T)

Tabs

Status and error bits

This tab shows status and error bits of the selected technology object, based on the example of an external encoder. The display differs depending on the selected TO type.

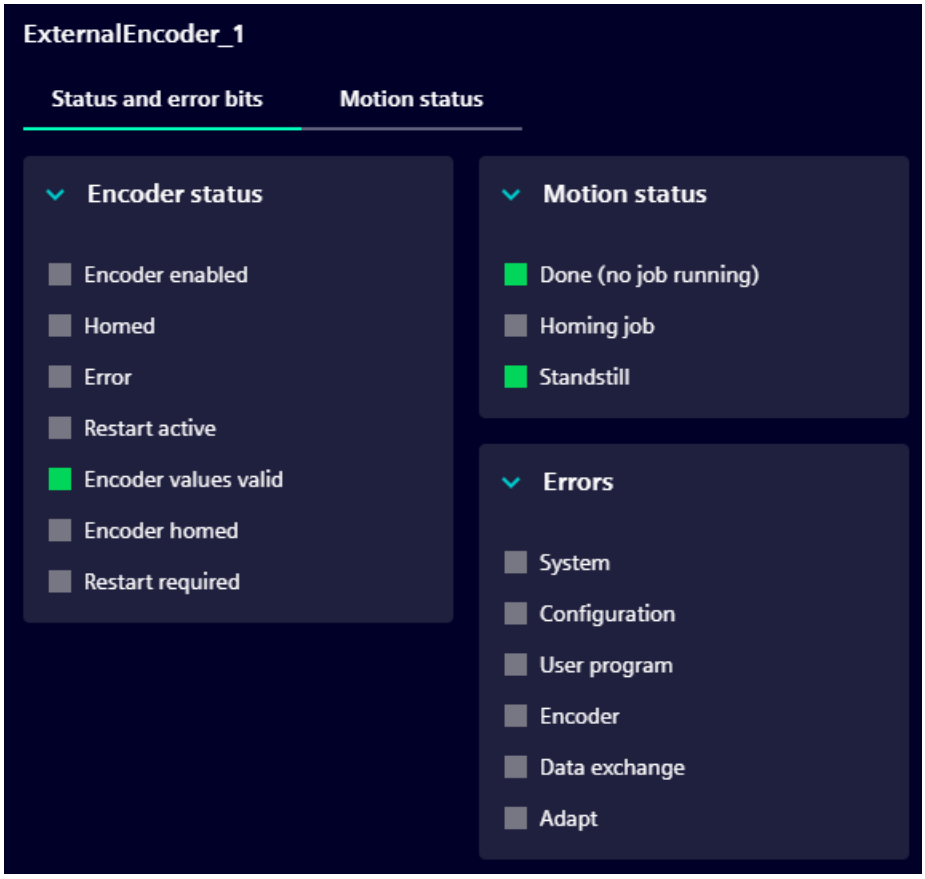

Figure 3-206 Status and error bits tab

Technology object-specific diagnostics information

Depending on the type of technology object, you will receive additional diagnostic information, for example, the status of a speed axis. The displayed diagnostic information corresponds to the diagnostics of the technology object in STEP 7.

This information is arranged into technology object-specific tabs, e.g. Motion status, Range scaling or Cam track status.

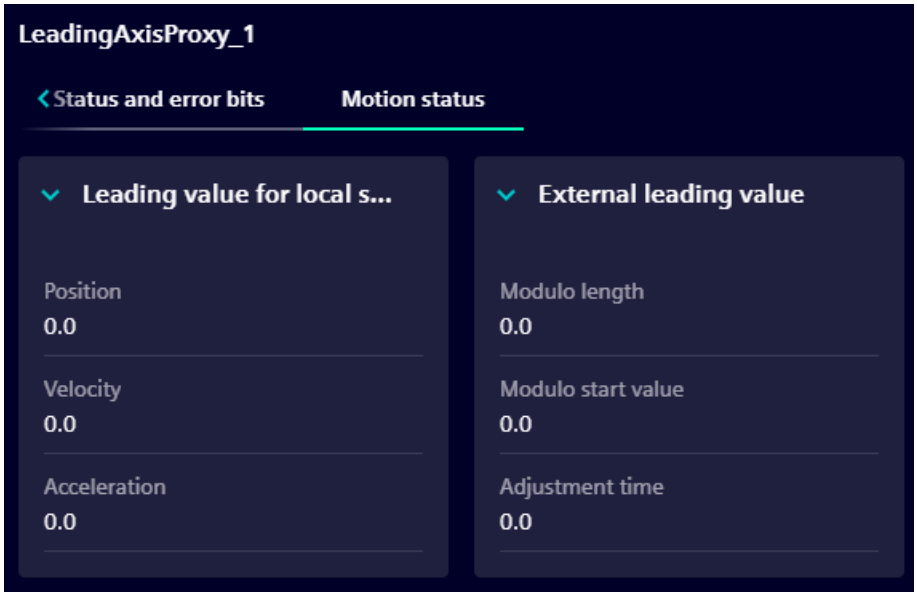

Figure 3-207 Technology object-specific tab Motion status

NOTE

Limiting access to technology objects

You can limit access to technology objects. You can find more information in the section Parameter assignment of the block properties (Page 238).

Technology objects for which "Data block accessible via Web server" has been disabled do not appear in the list of configured technology objects in the system web pages.

Displaying and acknowledging technology alarms

On the "Alarms (Page 84)" web page, you will find an overview of the pending technology alarms with error numbers. You can acknowledge the pending technology alarms.

More information

You can find explanations for the diagnostics functions of the individual technology objects in the STEP 7 online help or in the S7-1500/1500T Motion Control Overview (https://support.industry.siemens.com/cs/ww/en/view/109974347) Function Manual.

5.4 User program

Overview

The following web pages and information are available under the "User program" menu item:

- Recipes (Page 82)
- User files (Page 83)

5.4.1 Recipes

The recipe contains a group of tags (e.g. temperature, velocity, time) that, together, represent a specific configuration or setting for a production process. These values can be saved, loaded, changes and transferred between controller and HMI device. You can find more in the SIMATIC S7 S7-1200 Automation System (https://support.industry.siemens.com/cs/ww/en/view/109759862) System Manual.

To call this system web page, you require the "Read diagnostics" authorization.

Creating a folder for recipes

Proceed as follows to create a folder for recipes:

1. Navigate to "User program" > "Recipes".

   If no folder has been created for recipes yet, the view displays the "Create folder" message.

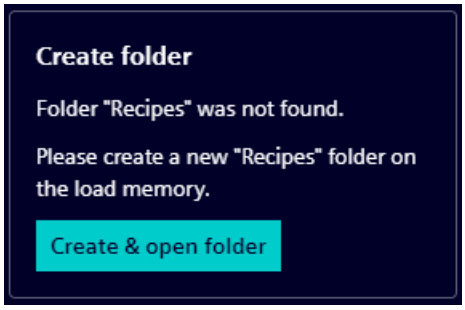

Figure 3-208 "Create folder" message

   If you do not have the required authorizations to create a folder in the SIMATIC load memory, the view shows "Folder "Recipes" was not found".

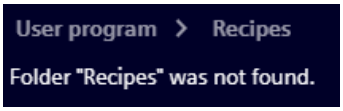

Figure 3-209 "Folder "Recipes" was not found" message

   Set the authorizations in the TIA project or contact your administrator.

2. Click the "Create & open folder" button.

Result: You are forwarded to "Maintenance" > "File browser" > "Load memory" > "Recipes" and the created folder is opened.

You can find a more detailed description of the file browser in the section File browser (Page 89).

5.4.2 User files

User files are files that are created, managed or integrated in the project by the user to provide additional functions or data. They are not part of the standard project, but are used for expansion or individualization.

To call this system web page, you require the "Read diagnostics" authorization.

Creating a folder for user files

Proceed as follows to create a folder for user files:

1. Navigate to "User program" > "User files".

   If no folder has been created for user files yet, the view displays the "Create folder" message.

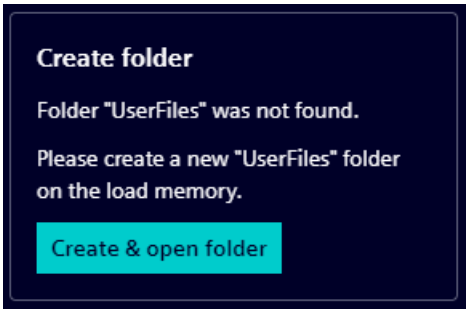

   Figure 3-210 "Create folder" message

   If you do not have the required authorizations to create a folder in the SIMATIC load memory, the view shows "Folder "UserFiles" was not found".

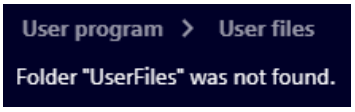

   Figure 3-211 "Folder "UserFiles" was not found" message

   Set the authorizations in the TIA project or contact your administrator.

2. Click the "Create & open folder" button.

Result: You are forwarded to "Maintenance" > "File browser" > "Load memory" > "UserFiles" and the created folder is opened.

You can find a more detailed description of the file browser in the section File browser (Page 89).

5.5 Alarming & Logging

Overview

The following web pages and information are available under the "Alarming & Logging" menu item:

- Alarms (Page 84)
- Data logs (Page 85)

5.5.1 Alarms

Alarms are structured information that show the operator or maintenance personnel what is happening in the automation system, particularly in the case of errors, warnings or important state changes.

To call this system web page, you require the "Read diagnostics" authorization. To be able to acknowledge the alarms, you require the "Acknowledge alarms" authorization.

Overview

Read out the message buffer to obtain compact information for fault analysis. This is the most effective method to get an overview of the pending faults.

The "Alarms" web page contains the alarm buffer of events with time specification, alarm text and status as well as the following possibilities to acknowledge the event:

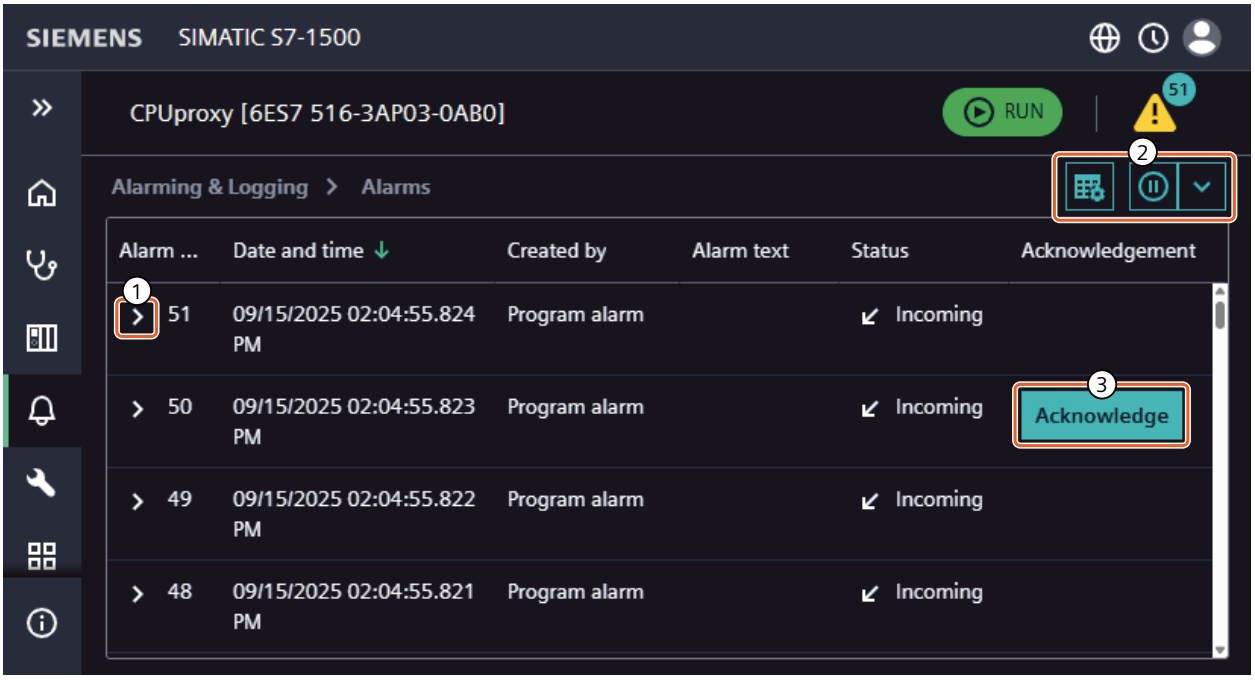

① Viewing of details of an alarm via drop-down function

② Controls keys for displaying alarms

③ Button to acknowledge an alarm

Figure 3-212 "Alarms" overview

By default, alarms are displayed in descending chronological order with date and time. However, they can be sorted according to individual parameters in ascending or descending order. You define the order of the alarms based on values in a column by clicking the column header.

The "Alarm text" column contains the entry of configured alarm texts of the respective error definitions.

The alarm texts are displayed in the project language of the STEP 7 project that is assigned to the current interface language of the web server. You can find out how to assign project languages to interface languages in the section "Language settings (Page 39)".

With the button on the top right on the screen, you can select the range to be displayed:

- Last 250 alarms
- All alarms

Column selection

Click the button on the top right of the screen to select the displayed columns.

Detailed view of events

Click the icon to the left of the entry whose details you want to view. The icon changes to .

Alarm details and infotext of the selected entry are shown.

Acknowledging events

Click the "Acknowledge" button of all desired alarms to acknowledge these.

Freezing of the message buffer

Proceed as follows to freeze the message buffer:

1. Open the "Alarms" view.
2. Click the "Pause" button at the top right.

Result: As long as the alarm buffer is frozen, the list of alarms is not updated. Only the alarms already available are displayed.

If new alarms are available at a frozen alarm buffer, the number of new alarms is displayed above the "Play" button . When you click the button, all the active and new alarms are displayed in the list again.

5.5.2 Data logs

A data log consists of a collection of measured values or states that can be recorded at regular intervals or event-controlled. This data can be, for example:

- Temperatures
- Pressures
- Meter readings
- Machine states
- Recipe parameters

To call this system web page, you require the "Read files" authorization.

Creating a folder for data logs

Proceed as follows to create a folder for data logs:

1. Navigate to "User program" > "User files".

   If no folder has been created for user files yet, the view displays the "Create folder" message.

   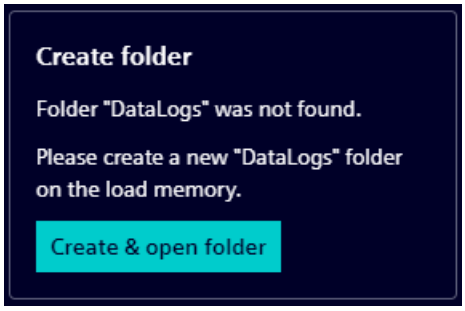

   Figure 3-213 "Create folder" message

   If you do not have the required authorizations to create a folder in the SIMATIC load memory, the view shows "Folder "Data logs" was not found".

   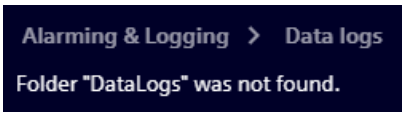

   Figure 3-214 "Folder "Data logs" was not found" message

   Set the authorizations in the TIA project or contact your administrator.

2. Click the "Create & open folder" button.

Result: You are forwarded to "Maintenance" > "File browser" > "Load memory" > "DataLogs" and the created folder is opened.

You can find a more detailed description of the file browser in the section File browser (Page 89).

Overview

All the created data logs can be viewed on the "Data logs" web page.

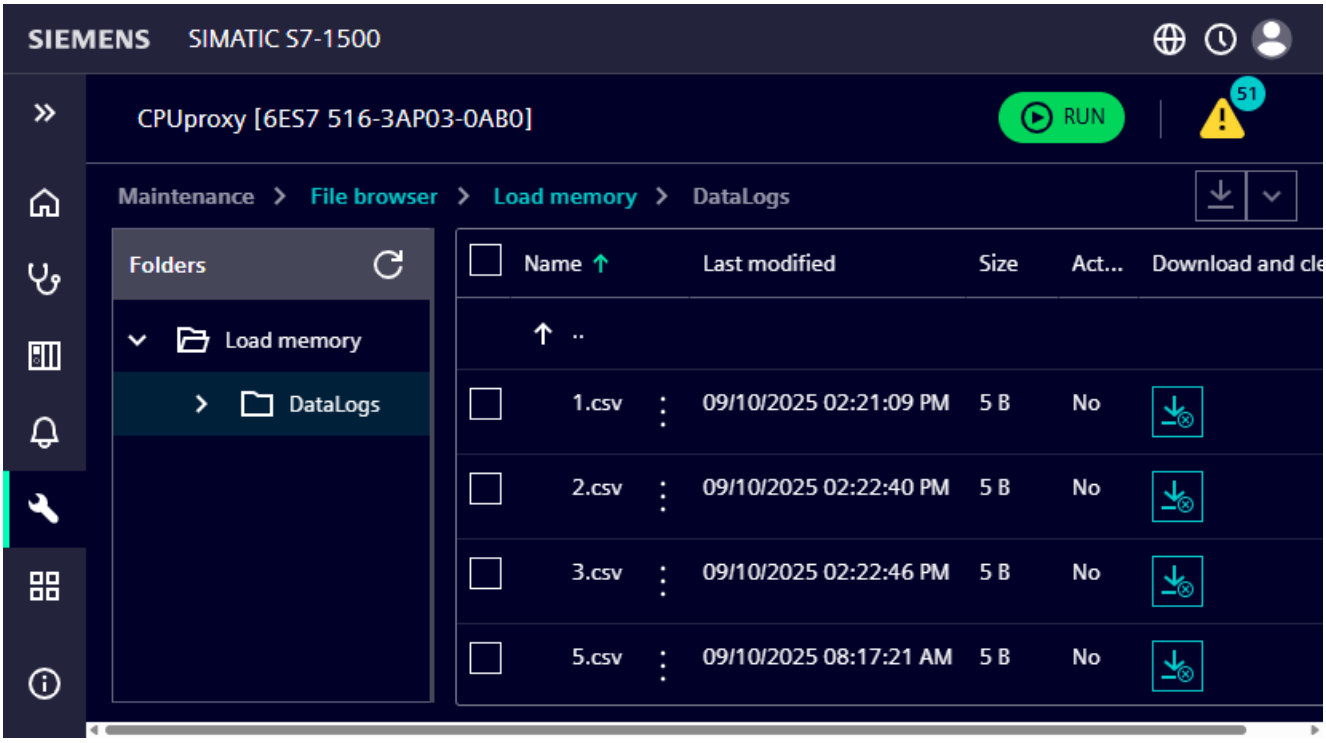

Figure 3-215 Data logs overview

The data logs can be sorted according to individual parameters in ascending or descending order. You define the order of the data logs based on values in a column by clicking the column header.

The "Active" column shows whether the respective data log file is used (is active) or not in the user program.

You close an opened (active) data log file in STEP 7 by using the "DataLogClose" instruction.

You can manually refresh the web page display with the button.

Downloading, clearing and deleting files in the folder for data logs

You have the following options for these operations in the folder for data logs:

Downloading of an individual file

An active file cannot be downloaded.

1. Right-click on the icon to the right of the file name and select "Download from PLC".

Result: The file is downloaded. A popup window is displayed with feedback about successful or failed downloading of the file.

Downloading and emptying an individual file

An active file cannot be downloaded and emptied.

1. In the row of the desired file, click the "Download and empty" button.

Result: The file is downloaded and emptied in a second step. The empty data log file is still included in the list of data logs. A popup window is displayed with feedback about successful or failed downloading of the file.

Deleting a single file

An active file cannot be deleted.

1. In the row of the desired file, click the "Delete" button.

Result: The file is deleted. A popup window is displayed with feedback about successful or failed deletion of the file.

Downloading multiple files

Active files cannot be downloaded.

1. In the current folder, click next to the desired files on the associated check boxes to select these. The number of selected files is displayed above the "Expand" button.
2. Click the "Download from PLC" button . If this button is not displayed in the top line, click on the "Expand" button and select the "Download from PLC" function in the drop-down menu.

Result: The files are downloaded one after the other. A popup window is displayed with feedback about successful or failed downloading of the files.

Downloading and emptying several files

Active files cannot be downloaded and emptied.

1. In the current folder, click next to the desired files on the associated check boxes to select these. The number of selected files is displayed above the "Expand" button.
2. Click the "Download and empty" button . If this button is not displayed in the top line, click on the "Expand" button and select the "Download and empty" function in the drop-down menu.

Result: The files are downloaded one after the other and emptied in the second step. The empty data log files are still included in the list of data logs. A popup window is displayed with feedback about successful or failed downloading of the files.

Deleting multiple files

Active files cannot be deleted.

1. In the current folder, click next to the desired files on the associated check boxes to select these. The number of selected files is displayed above the "Expand" button.
2. Click the "Delete" button. If this button is not displayed in the top line, click on the "Expand" button and select the "Delete" function in the drop-down menu.

Result: The files are deleted. A popup window is displayed with feedback about successful or failed deletion of the files.

5.6 Maintenance

Overview

The following web pages and information are available under the "Maintenance" menu item:

- File browser (Page 89)
- Service data (Page 93)

5.6.1 File browser

Introduction

The web browser displays the content of the SIMATIC load memory on the web page "Maintenance" > "File browser" > "Load memory". This means, for example, that you can read and edit the log files generated by the CPU without having to use STEP 7.

The file browser lists all the existing files and folders that are located in the SIMATIC load memory.

You can download, delete, rename and upload the files as well as create, delete and rename the directories.

To call this system web page, you require the "Read diagnostics" authorization. To be able to modify the file system, you require the "Write/delete files" authorization.

NOTE

There are restrictions for accessing the Recipes, Data logs, and User files folders. For example, you cannot create subfolders.

NOTE

Exception system files

The system files include the job file and all special folders including their contents to which the job file refers. System files are not displayed, and cannot be changed or deleted.

Overview

On the "Maintenance" > "File browser" > "Load memory" web page, you can edit and manage files and folders and find the following information:

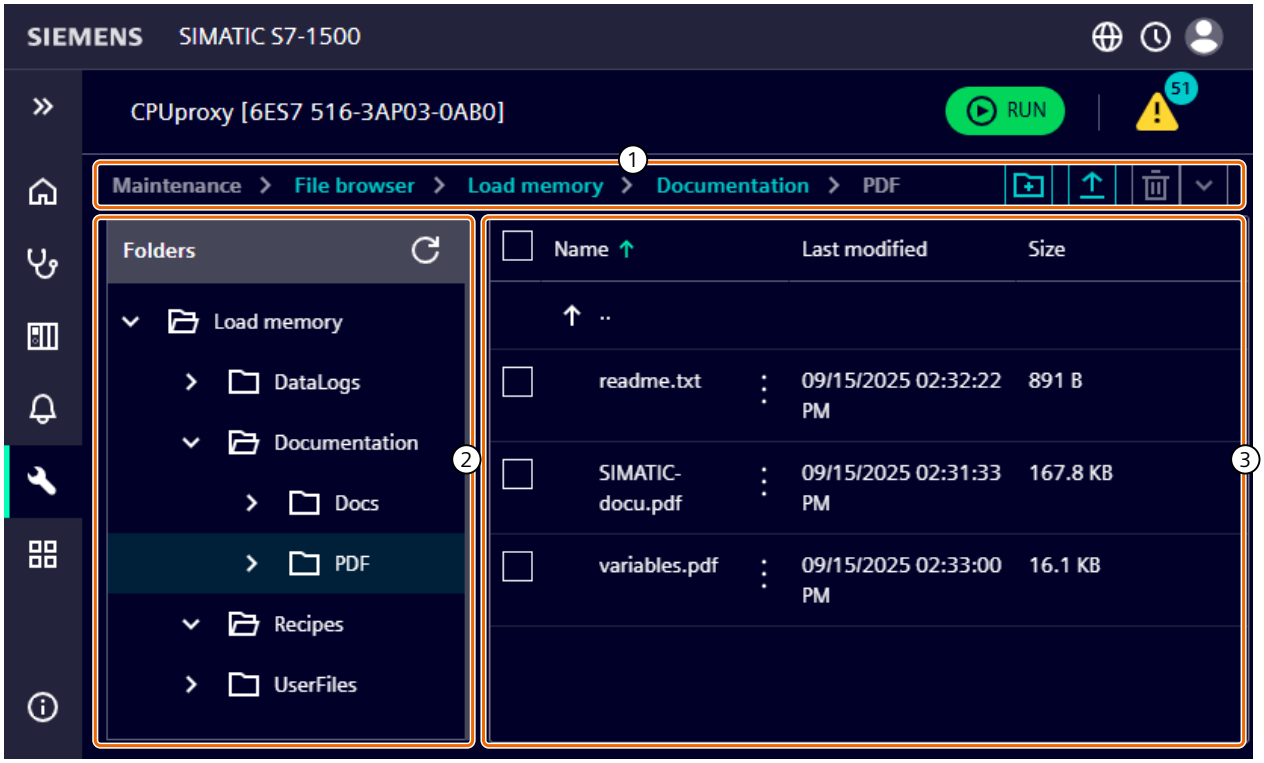

① Path to the current folder
② Structure of folders
③ Files in the current folder

Figure 3-216 "File browser" overview

Uploading a file

Proceed as follows to upload a file:

1. In the file structure select the folder into which you want to upload the file.
2. Click the "Upload" button in the top right of the screen.
3. A browser-specific dialog box opens. Select the desired file.

Result: After uploading the current folder shows the uploaded file. A popup window is displayed with feedback about successful or failed uploading of the file.

Moving a file

Proceed as follows to move a file:

1. In the current folder, click the button next to the desired file.
2. A context menu opens. Click "Move to".
3. A dialog box opens. Navigate to the desired folder and confirm with "Move".

Result: The current folder no longer shows the moved file. A popup window is displayed with feedback about successful or failed moving of the file.

Moving several files

Proceed as follows to move several files:

1. In the current folder, click next to the desired files on the associated check boxes. The number of selected files is displayed above the "Expand" button.
2. Click on the "Expand" button and click on "Move to".
3. A dialog box opens. Navigate to the desired folder and confirm with "Move".

Result: The current folder no longer shows the moved files. A popup window is displayed with feedback about successful or failed moving of the file.

Renaming a file

Proceed as follows to rename a file:

1. In the current folder, click the button next to the desired file.
2. A context menu opens. Click "Rename".
3. A dialog box opens. Enter the required file name and confirm with "Rename".

NOTE
Invalid character
If you use an invalid character, you are informed of this by means of a text box under the "File name" text field, and you cannot confirm with "Rename". Delete invalid characters in order to continue.

Result: The current folder shows the new file name. A popup window is displayed with feedback about successful or failed renaming of the file.

Creating a folder

Proceed as follows to create a folder:

1. In the file structure, select the folder in which you want to create a new folder.
2. Click the button.
3. A dialog box opens. Enter the required folder name and confirm with "Create".

Result: The current folder shows the new folder. A popup window is displayed with feedback about successful or failed creation of the folder.

Deleting a file or folder

Proceed as follows to delete a file or folder:

1. In the current folder, click the button next to the desired file or the desired folder.
2. A context menu opens. Click "Delete" .

NOTE

Only empty folders can be deleted. If you want to delete a folder with contents, first delete all the files and folders in it.

3. A dialog box opens. Click the "Delete" button.

Result: The current folder no longer shows the file or folder. A popup window is displayed with feedback about successful or failed deletion.

Deleting multiple files or folders

To delete multiple files or folders, follow these steps:

1. In the current folder, click next to the desired files or folders on the associated check boxes. The number of selected files is displayed above the "Expand" button.
2. Click the "Delete" button. If this button is not displayed in the top line, click on the "Expand" button and select the "Delete" function in the drop-down menu.

NOTE

Only empty folders can be deleted. If you want to delete a folder with contents, first delete all the files and folders in it.

3. A dialog box opens. Click the "Delete" button.

Result: The current folder no longer shows the deleted files and folders. A popup window is displayed with feedback about successful or failed deletion of files and folders.

5.6.2 Service data

The web server gives you the option to save service data. If you should encounter a problem with the CPU that cannot be resolved otherwise, you therefore have the option to submit the service data to the Service&Support team. Service data contains various information about the state of the CPU for advanced problem analysis.

To call this system web page, you require the "Download service data" authorization.

Figure 3-217 Service data to download

Procedure

1. Open the system web page "Service data".
2. Download the service data of the device with the button, which is shown in the right-hand column of the row.

The file is downloaded. A popup window is displayed with feedback about successful or failed downloading of the file.

Result

The data is stored in a .dmp file with the following naming convention: "<MLFB><Serial number><Time stamp>.dmp." You can change the file name retroactively.

More information

You can find more information on service data in the S7-1500/ET 200MP Automation system (https://support.industry.siemens.com/cs/ww/en/view/59191792) System Manual.

5.7 Safety

Overview

The following web pages and information are available under the "Safety" menu item:

- Safety administration (Page 94)

5.7.1 Safety administration

This web page shows an overview of safety information for the fail-safe CPUs.

To call this system web page, you require the "Read diagnostics" authorization.

The layout of the web page depends on the safety mode:

Fail-safe mode

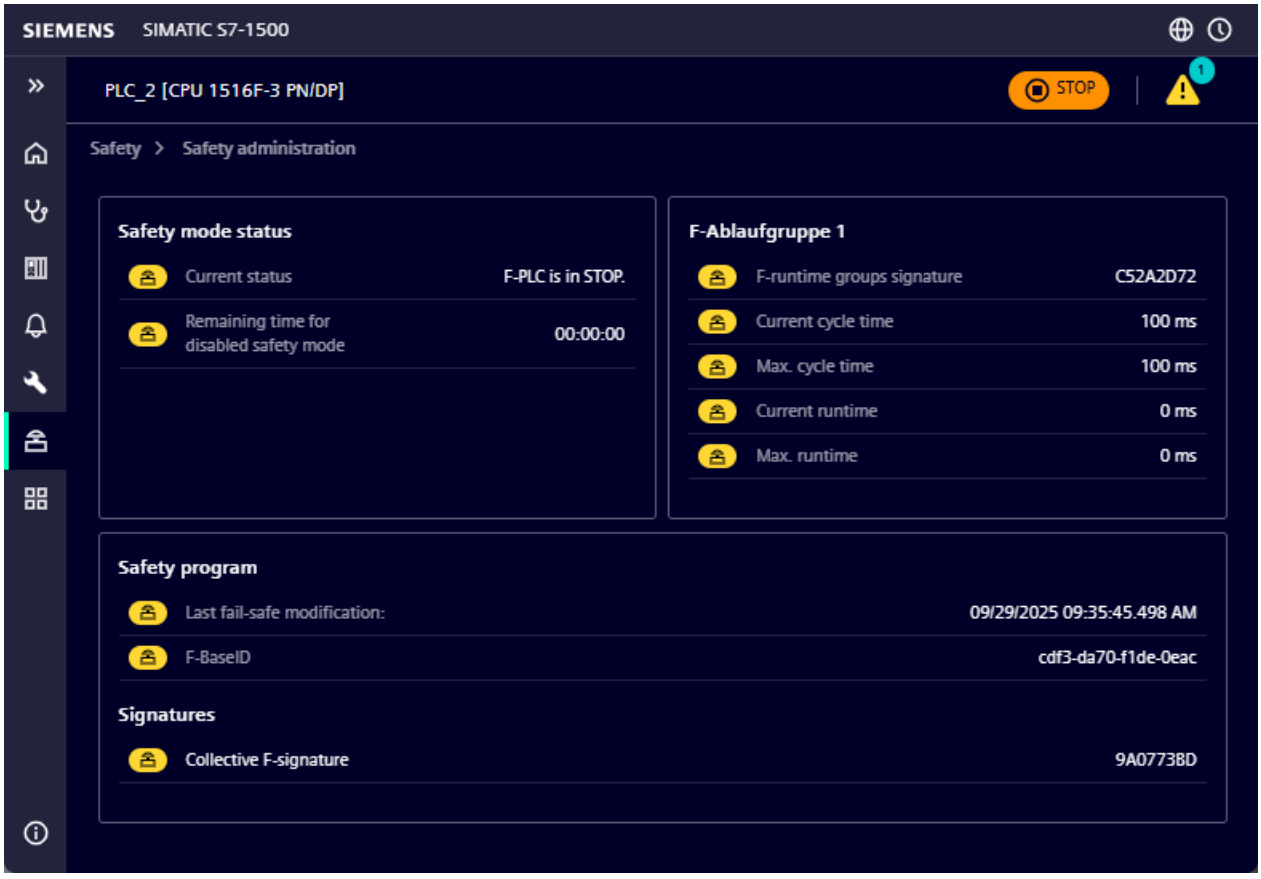

Figure 3-218 CPU in fail-safe mode

Various information about safety functions is output in fail-safe mode of the CPU.

Standard mode

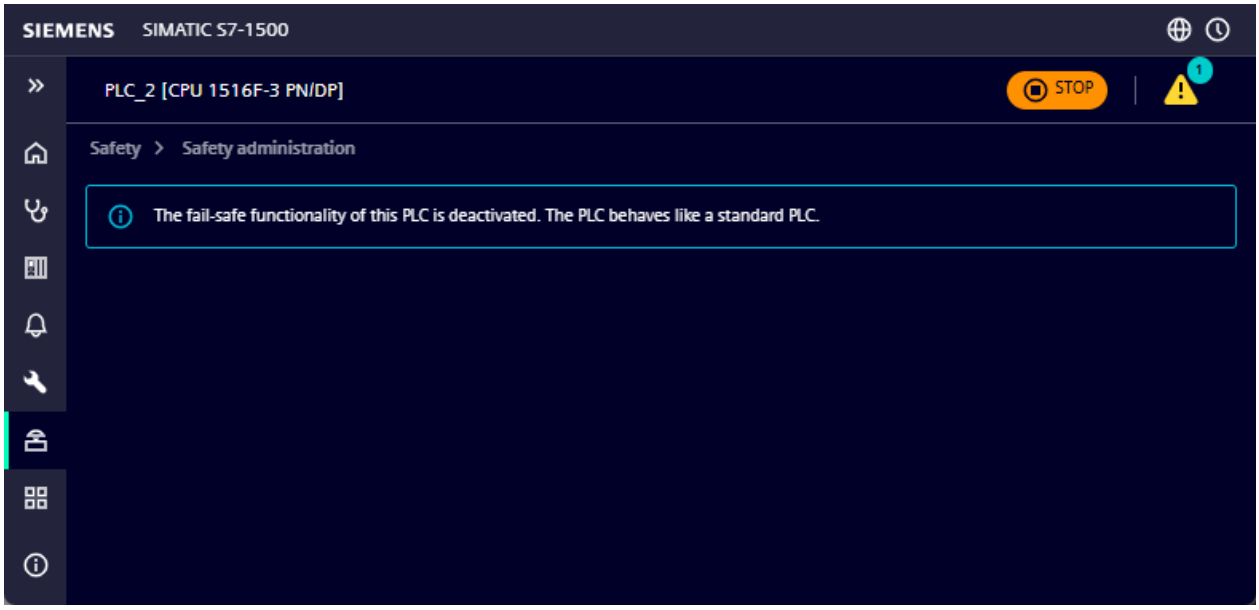

Figure 3-219 CPU in standard mode

A message indicating that safety mode of the fail-safe CPU is switched off is output in standard mode. The CPU behaves like a standard CPU.

More information

You can find more information on safety functions in the Programming and Operating Manual SIMATIC Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/54110126).

API (Application Programming Interface) 6

Web API

The CPU offers you a web-based API (Web API) as an interface for reading and writing CPU data.

The Web API enables you to:

- Communicate with the Web server of the CPU via script and programming languages
- Implement web applications at the latest state-of-the-art technology
- Create web applications that connect to multiple CPUs at the same time, for example, to create dashboards that visualize the status of multiple CPUs
- Loading web applications on to the web server of the CPU and making them available to the user. See section User-defined web applications (Page 142).

Relation between CPU, Web API and end devices

The following image shows an example of the Web API between CPU and end device.

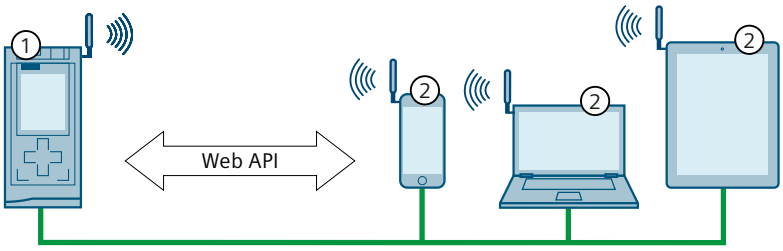

① CPU

② Terminal devices

Figure 3-220 Web API

Communication between the CPU and the terminal device takes place via PROFINET or WLAN integration.

NOTE

Security information

Note that the graphic only shows the role of the Web API between CPU and end device.

For the correct setup of a secure WLAN connection, observe the security information in the section Safety instructions (Page 15).

6.1 Supported clients

Requirements

The Web API can only be used for CPUs as of firmware version V2.8 for the following systems:

- Standard and F-CPUs of the S7-1200 G2 automation system
- Standard CPUs, F-CPUs and T-CPUs of the S7-1500 automation system
- CPUs of the ET 200pro distributed I/O system
- Standard CPUs, F-CPUs and T-CPUs of the distributed I/O system ET 200SP
- Standard CPUs, F-CPUs and T-CPUs of the S7-1500 Software Controller
- As of firmware version V3.1, the R/H-CPUs of the S7-1500 automation system
- As of firmware version V3.1, the S7-1500 Virtual Controller

The following requirements must be fulfilled before you can use the Web API:

- You have assigned the correct firmware version to the CPU used in the hardware catalog of STEP 7.
- You have created and configured a project and downloaded it to the CPU.
- You have ensured that the following check box is selected in STEP 7:
  - Activate Web server on this module

Overview of the Web API methods depending on the firmware version of the CPU

The Web API is being continuously extended. The following table shows which mechanisms and methods you can use on which CPU as of which firmware version:

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Basic functions				
Api.Login (Page 110)	V2.8	V3.1	V3.1	V1.0
Api.Logout (Page 114)	V2.8	V3.1	V3.1	V1.0
Api.GetPermissions (Page 114)	V2.8	V3.1	V3.1	V1.0
Api.ChangePassword (Page 116)	V3.1	V3.1	V3.1	V1.0
Api.GetPasswordPolicy (Page 117)	V3.1	V3.1	V3.1	V1.0
Api.GetAuthenticationMode (Page 119)	V3.1	V3.1	V3.1	V1.0
Api.GetSessionInfo (Page 120)	V4.0	V4.0	V4.0	V4.1
Api.Browse (Page 122)	V2.8	V3.1	V3.1	V1.0
Api.Version (Page 123)	V2.8	V3.1	V3.1	V1.0
Api.Ping (Page 124)	V2.8	V3.1	V4.1	V1.0
Api.GetCertificateUrl (Page 124)	V2.8	V3.1	-	V1.0
Api.GetQuantityStructures (Page 125)	V3.1	V3.1	V3.1	V1.0

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Ticket mechanism				
Api.BrowseTickets (Page 131)	V2.9	V3.1	V3.1	V1.0
Api.CloseTicket (Page 133)	V2.9	V3.1	V3.1	V1.0

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Reading and writing user-configurable HTTP response headers				
WebServer.ReadResponseHeaders (Page 137)	V4.0	V4.0	V4.1	V4.1
WebServer.ChangeResponseHeaders (Page 138)	V4.0	V4.0	V4.1	V4.1

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Setting the web server default page				
WebServer.SetDefaultPage (Page 140)	V3.1	V3.1	V4.1	V1.0
WebServer.ReadDefaultPage (Page 141)	V3.1	V3.1	V4.1	V1.0

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
User-defined web applications				
WebApp.Create (Page 150)	V2.9	V3.1	-	V1.0
WebApp.Delete (Page 151)	V2.9	V3.1	-	V1.0
WebApp.Rename (Page 152)	V2.9	V3.1	-	V1.0
WebApp.Browse (Page 153)	V2.9	V3.1	V4.1	V1.0
WebApp.SetState (Page 156)	V2.9	V3.1	V4.1	V1.0
WebApp.SetDefaultPage (Page 157)	V2.9	V3.1	-	V1.0
WebApp.SetNotFoundPage (Page 158)	V2.9	V3.1	-	V1.0
WebApp.SetNotAuthorizedPage (Page 160)	V2.9	V3.1	-	V1.0
WebApp.BrowseResources (Page 161)	V2.9	V3.1	-	V1.0
WebApp.CreateResource (Page 163)	V2.9	V3.1	-	V1.0
WebApp.DeleteResource (Page 165)	V2.9	V3.1	-	V1.0
WebApp.RenameResource (Page 166)	V2.9	V3.1	-	V1.0
WebApp.DownloadResource (Page 167)	V2.9	V3.1	-	V1.0
WebApp.SetResourceVisibility (Page 169)	V2.9	V3.1	-	V1.0
WebApp.SetResourceETag (Page 170)	V2.9	V3.1	-	V1.0
WebApp.SetResourceMediaType (Page 172)	V2.9	V3.1	-	V1.0

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
WebApp.SetResourceModificationTime (Page 173)	V2.9	V3.1	-	V1.0
WebApp.SetVersion (Page 174)	V4.0	V4.0	-	V4.1
WebApp.SetUrlRedirectMode (Page 175)	V4.0	V4.0	-	V4.1

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Reading and writing process data				
PlcProgram.Read (Page 182)	V2.8	V3.1	V3.1	V1.0
PlcProgram.Write (Page 184)	V2.8	V3.1	V3.1	V1.0
PlcProgram.DownloadProfilingData (Page 187)	V3.1	V3.1	V3.1	V1.0
PlcProgram.Browse (Page 192)	V2.8	V3.1	V3.1	V1.0
Plc.ReadMemoryInformation (Page 199)	V4.1	V4.1	V4.1	V4.1
Project.ReadInformation (Page 200)	V4.1	V4.1	V4.1	V4.1

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Reading and changing the operating mode				
Plc.ReadOperatingMode (Page 202)	V2.9	V3.1	V4.0	V1.0
Plc.RequestChangeOperatingMode (Page 203)	V2.9	V3.1	V4.0	V1.0
Plc.ReadModeSelectorState (Page 205)	V3.1	V3.1	V4.0	V1.0
Plc.ReadRuntimeInformation (Page 206)	V4.1	V4.1	V4.1	V4.1

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Entering time settings via Web API				
Plc.ReadSystemTime (Page 209)	V3.0	V3.1	V4.1	V1.0
Plc.SetSystemTime (Page 210)	V3.1	V3.1	-	V1.0
Plc.ReadTimeSettings (Page 211)	V3.0	V3.1	V4.1	V1.0
Plc.SetTimeSettings (Page 214)	V3.1	V3.1	-	V1.0

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Reading diagnostics and service data				
Project.ReadLanguages (Page 217)	V3.1	V3.1	V4.1	V1.0
Alarms.Browse (Page 219)	V3.1	V3.1	V4.1	V1.0

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Alarms.Acknowledge (Page 226)	V3.1	V3.1	V4.1	V1.0
Syslog.Browse (Page 227)	V3.1	V3.1	V3.1	V1.0
DiagnosticBuffer.Browse (Page 230)	V3.1	V3.1	V4.1	V1.0
Modules.DownloadServiceData (Page 235)	V3.1	V3.1	-	V1.0
Communication.ReadProtocolResources (Page 236)	V4.1	V4.1	V4.1	V4.1

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Technology/Motion Control				
Technology.BrowseObjects (Page 239)	V4.0	V4.0	-	V4.1
Technology.Read (Page 241)	V4.0	V4.0	-	V4.1

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Backing up and restoring the configuration				
Plc.CreateBackup (Page 242)	V3.0	-	-	V4.1*
Plc.RestoreBackup (Page 244)	V3.0	-	-	V4.1*

* Only available for S7-1200 G2 1212/1214 CPUs, but not for 1216/1217.

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Accessing contents of the SIMATIC load memory				
Files.Browse (Page 247)	V3.0	V3.1	V3.1	V1.0
Files.Download (Page 250)	V3.0	V3.1	V3.1	V1.0
Files.Create (Page 252)	V3.0	V3.1	V3.1	V1.0
Files.Rename (Page 253)	V3.0	V3.1	V3.1	V1.0
Files.Delete (Page 255)	V3.0	V3.1	V3.1	V1.0
Files.CreateDirectory (Page 256)	V3.0	V3.1	V3.1	V1.0
Files.DeleteDirectory (Page 257)	V3.0	V3.1	-	V1.0
DataLogs.DownloadAndClear (Page 259)	V3.0	V3.1	V3.1	V1.0

Method	S7-1500 F-CPUs	S7-1500V F-CPUs	S7-1500 R/H-CPUs (F-CPUs)	S7-1200 G2 F-CPUs
Reading information from SIMATIC Safety				
Failsafe.ReadRuntimeGroups (Page 260)	V3.1	V3.1	V4.0	V1.0
Failsafe.ReadParameters (Page 261)	V3.1	V3.1	V4.0	V1.0

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Reading CPU information				
Plc.ReadCpuType (Page 264)	V4.0	V4.0	V4.0	V4.1
Plc.ReadStationName (Page 264)	V4.0	V4.0	V4.0	V4.1
Plc.ReadModuleName (Page 265)	V4.0	V4.0	V4.0	V4.1
Plc.ReadLoadMemoryInformation (Page 266)	V4.1	V4.1	-	V4.1

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Reading information about device configuration				
Modules.Browse (Page 268)	V4.1	V4.1	-	V4.1
Modules.ReadParameters (Page 277)	V4.1	V4.1	-	V4.1
Modules.ReadIdentificationMaintenance (Page 287)	V4.1	V4.1	-	V4.1
Modules.ReadStatus (Page 291)	V4.1	V4.1	-	V4.1
Modules.FlashLeds (Page 295)	V4.1	V4.1	V4.1	V4.1
Modules.ReadLeds (Page 296)	V4.1	V4.1	V4.1	V4.1

Method	S7-1500 Standard/T/F-CPUs	S7-1500V Standard/F-CPUs	S7-1500 R/H-CPUs (Standard/F-CPUs)	S7-1200 G2 Standard/F-CPUs
Reading information from a redundant system				
Redundancy.ReadSystemInformation (Page 299)	-	-	V4.0	-
Redundancy.ReadSystemState (Page 302)	-	-	V4.0	-
Redundancy.RequestChangeSystemState (Page 303)	-	-	V4.0	-
Redundancy.ReadSyncupProgress (Page 304)	-	-	V4.0	-

API endpoint

As an RPC protocol, JSON-RPC V2.0 is based on HTTP. You can find the current version of the JSON-RPC V2.0 specification (https://www.jsonrpc.org/specification) on the Internet.

The Web API can be reached via POST requests to the following URL:

```
https://[ip]/api/jsonrpc
```

The Web API supports bulk operations as defined in JSON-RPC 2.0. While bulk operations are not explicitly limited by a fixed number of method calls, there is a limit for the HTTP request body. The limit differs depending on the firmware version of the CPU:

- Limit of 64 KB for CPUs with firmware version ≤ V3.0
- Limit of 128 KB for CPUs as of firmware version ≥ V3.1

As of firmware version V3.1 you can use the API method Api.GetQuantityStructures (Page 125) to read out the limit.

An example of the required structure of an HTTP request and HTTP response for successfully making an API request can be found in the section Web API integration (Page 104).

NOTE

The API method responses described in this manual only describe the "`result`" and "`error`" attributes. The examples only refer to these two attributes. Other attributes such as "`jsonrpc`" or "`id`" are not described in the individual methods.

Behavior of the API methods depending on the request attribute "`id`"

Two types of API methods are available:

- Query methods that only perform read access (for example Alarms.Browse)
- Command methods that modify data or execute functions (for example Alarms.Acknowledge)

Depending on the presence of the parameter "`id`" in a request, the following behavior applies based on the classification of the API methods:

ID	API command method	API query method
JSON-RPC request (with ID)	1. Parameters are validated 2. Business logic is executed 3. Response is generated	
JSON-RPC response (without ID)	1. Parameters are validated 2. Business logic is executed	No action is performed

Compatibility with regard to future extensions of the Web API

The order of attributes within a JSON object does not affect API clients.

Web server responses to requests via the Web API may be extended with new JSON attributes in future firmware versions, e.g. to enrich results with more details.

Error codes of possible API error messages based on JSON-RPC may change in future firmware versions, if applicable, and existing error messages may be made more precise.

NOTE

To check if your API request was successful, first check if the request was successful in general. You can evaluate the JSON-RPC error codes for detailed information.

Textual error information only provides information. If you want to implement error evaluation in a way specific to an application, use the corresponding numeric error codes of the error message.

The precision of floating point values may differ in the display from other clients, such as the TIA Portal.

Bulk requests are always processed in descending order, whereby the individual requests are contained in the HTTP request body in descending order.

If an API method includes time stamps, these time stamps are always returned based on UTC time. Examples of this are the time stamps of the Files.Browse and Api.BrowseTickets

methods. With the API methods Plc.ReadSystemTime and Plc.ReadTimeSettings, you can read out the system time and determine the CPU local time.

Supported clients

The products and versions listed in the following table were tested for the Web API. The column "As of Version" lists the tested version as of which the clients are supported:

Product *	As of Version	Supported functions
Chrome-based Desktop web browser (e.g. Google Chrome) (https://chromium.woolyss.com/)	75.x (Windows and Android)	Web API access with JavaScript for asynchronous requests
Mozilla Firefox (https://www.mozilla.org/en-US/firefox/)	64.x (long-term support)	
Microsoft Internet Explorer	11.x (Windows 7, Windows 10)	
Microsoft Edge	44.x Windows 10	
Apple Safari	12.x iOS	
Opera	58.x	
SIMATIC HMI Panels	2	
Microsoft C# (https://docs.microsoft.com/en-us/dotnet/api/system.net.webrequest?view=netframework-4.7.2) with WebRequest class and Json.Net library (https://www.newtonsoft.com/json)	.Net Framework 4.7	Web API access for pure HTTP requests and Json.Net for generating and parsing content
GNU Wget (https://www.gnu.org/software/wget/)	1.20 Windows	Web API access for pure HTTP requests, e.g. for automatic archiving of data logs.
cURL (https://curl.haxx.se/)	7.63.x Windows	
Python (https://www.python.org/downloads/)	3.10	
Python scripts for Web API (https://github.com/siemens/python-simatic-s7-webserver-api)		
Microsoft PowerShell	5.0	Web API access for pure HTTP requests with Invoke WebRequest and ConvertTo-Json/ConvertFrom-Json for generating and parsing content
WebserverApi Client Library for .NET (https://github.com/siemens/simatic-s7-webserver-api)	1.0.1	Web API access for pure HTTP requests in C#. The library is also available as a NuGet package at the following address (https://www.nuget.org/packages/Siemens.Simatic.S7.Webserver.API).

* Not included in the scope of delivery of the product described here

Github

You can also find examples of using API methods in practice on Github at the following repository (https://github.com/siemens/simatic-s7-webserver-api).

6.2 Web API integration

In the following section you will find examples of how to integrate the Web API into your application.

Structure of an HTTP request and HTTP response

The following section shows the required structure of an HTTP request and HTTP response for successfully making a Web API request.

```
POST /api/jsonrpc HTTP/1.1
Host: 192.168.3.14
Content type: application/json
Content length: 92

[{"jsonrpc":"2.0","method":"Api.Login","params":{"user":"User1","pa-
ssword":"SecurePassword"},"id":999}]

HTTP/1.1 200 OK
Content type: application/json
Cache-Control: no-cache
Pragma: no-cache
Expires: 0
Access-Control-Allow Origin: *
Access-Control-Allow Headers: Content-Type,X-Auth Token
Access-Control-Allow Methods: POST,OPTIONS
transfer-encoding: chunked
date: Tue, 23 Apr 2019 17:50:31 GMT

[{"jsonrpc":"2.0","id":999,"result":{"token":"Sy8pe3VNv86rTMldzFBsY-
zmw12Lg"}}]
```

Web API examples

The following section contains examples of how you can use the described methods in the Web API.

The examples use HTML, JSON and JQuery library for asynchronous requests.

NOTE

Information used in the examples

Note that the names of the methods, parameters and the JavaScript code are specified without liability and can deviate from the current API methods.

Example 1

Example 1 shows a code section with which a session can be maintained. For this purpose, a one-time ping request is sent using the Api.Ping method. If the intervals at which the ping request is sent are less than the timeout of 2 minutes, the user remains permanently logged in.

A maintained session lends itself to scenarios such as monitoring and control tasks.

```
$.post({
url:"https://192.168.2.132/api/jsonrpc",
headers:{
 'X-Auth-Token':"Sy8pe3VNv86rTMldzFBsYzmw12Lg"
},
data:JSON.stringify({"jsonrpc":"2.0", method:"Api.Ping", "id":1}),
success:function(data){ console.log(data); }
dataType:"text",
contentType:"application/json"
});
```

NOTE

Authentication token

To extend the session, you must send the authentication token (X-Auth-Token) as an HTTP header to the CPU.

When you call the Api.Ping method without a token, the session is not extended because the CPU cannot assign a token to the user.

Example 3 shows an example of a token in the HTTP request.

In the example, the selected user has the necessary authorizations. The methods after the login request were successfully carried out, as the following result shows.


```
{"jsonrpc":"2.0","id":1,"result":"ZWlmbnJwZmplb3Nwd2l1Y3N3dWE="}
```

Example 2

Example 2 shows a client that wants to log in to the CPU with JavaScript and calls several methods within an HTTP request using a bulk request.

```
$.post({
  url:"https://192.168.2.132/api/jsonrpc",
  data:JSON.stringify([
    {"jsonrpc":"2.0", "id":1, method:"Api.Login",
      params:{user:"Admin",password:"12345"} },
    {"jsonrpc":"2.0", "id":2, method:"Api.GetPermissions" },
    {"jsonrpc":"2.0", "id":3, method:"Api.Browse" }]),
  success: function(data){ console.log(data); },
  dataType: "text",
  contentType: "application/json"});
```

The following section shows an example of a bulk request response. The selected user has the necessary authorizations. The methods after the login request were successfully carried out with the authorizations of the authenticated user.

```
[
"jsonrpc": "2.0", "id": 2, "result":[
{ "name": "Api.Browse" },
{ "name": "Api.Login" },
{ "name": "Api.Logout" },
{ "name": "Api.GetPermissions" },
{ "name": "PlcProgram.Read" },
{ "name": "PlcProgram.Write" }
]
```

Example 3

Example 3 shows a bulk request for read and write access to a stack of tags in a single HTTP request. This procedure is recommended for bulk requests, as it is more efficient than a series of single accesses and therefore places less load on the CPU.

```
$.post({
  url:"https://192.168.2.132/api/jsonrpc",
  data:JSON.stringify([
    {"jsonrpc":"2.0", "id":1, method:"PlcProgram.Read"},
    {"jsonrpc":"2.0", "id":2, method:"PlcProgram.Read",
      params:{"var":"\"MyDB\".InvalidField"}},
    {"jsonrpc":"2.0", "id":3, method:"PlcProgram.Read",
      params:{"var":"MyDB.MyDate"} },
    {"jsonrpc":"2.0", "id":4, method:"PlcProgram.Write",
```

```
      params:{"var":"\"BoilerControl\".TempSetPoint", value:9001}
}]),
  success: function(data){ console.log(data); },
  dataType: "text",
  contentType: "application/json",
  headers: {
    "X-Auth-Token":"d29kamV3cGxtdm5keHNhcXd1aXJ0empkZXN3cQ==""}});
```

The bulk request contains an invalid tag with an error message providing information about this. All other methods were successfully carried out, as the following result shows.

```
[
{"jsonrpc":"2.0","id":1,"result":{"value":42}},
{"jsonrpc":"2.0","id":2,"error":{"code":201,"message":"Invalid
 address"}},
{"jsonrpc":"2.0","id":3,"result":{"value":"1990-01-01"}},
{"jsonrpc":"2.0","id":4,"result":true}
]
```

Framework for simple provision of web pages

The application example "Provision of a framework for web page upload (https://support.industry.siemens.com/cs/ww/en/view/109814059)" provides an instruction for simple provision of web pages on the basis of the Web API directly onto the CPU. The application example provides you with a simple possibility to use the functionalities of the Web API without having to take HTTP requests into account.

6.3 Web API sessions

Timeout for Web API sessions

NOTE

If a Web API call is not made within a session before 120 seconds have elapsed, the CPU terminates the session with a logout event. A timeout reset is initiated by every successful action of the user in which a toke is supplied.

Call the Api.GetPermission or Api.Ping method cyclically within the timeout grid to ensure that:

- Your session remains active
- Your authorizations for the call of other methods remain active

Limitations for Web API sessions

The CPU limits the number of active sessions. The following table shows the limitations, meaning the available resources depending on the CPU used.

CPUs	Limitation
1510 to 1513	50
1514, 1515, 1516 and 1504D TF	100
1517, 1518, 1516T and 1507D TF	200

Limitation of the active Web API sessions

If you request another authentication token and none are available, the request is rejected.

Each call of Api.Login means a new authentication token. This applies for every user, also for activated "Anonymous" user.

Change as of firmware version V4.0: In contrast to users with password, only one resource is still occupied for the "Anonymous" user in the CPU, instead of <n> resources, if "Anonymous" authenticates themselves <n> times in parallel. This means that Anonymous users no longer occupy the maximum session resources of the CPU.

NOTE

The authorization on the web server as an "Anonymous" user is only foreseen for test purposes, commissioning, etc. In other words, when the system is not in productive operation. In this case, you have to ensure the security of the plant through other organizational measures, e.g. spatial protection. This user is described in more details in the section User management (Page 41).

Changes to CPU user administration

The following applies to configured CPUs with firmware version ≤ V3.0: If the configuration of the CPU user management changes (by downloading the HW configuration in the TIA Portal), e.g. password changed or user removed, the CPU terminates all sessions with a logout event.

The following applies to configured CPUs with firmware version ≥ V3.1: If a user has been authenticated and the project is subsequently loaded into the CPU, deleted or deactivated users are logged out. If only the password or role of the user changes, the user remains authenticated.

Security events

The following applies to configured CPUs with firmware version ≤ V3.0: The CPU generates a security event for successful and failed logins. The CPU enters this security event in the diagnostics buffer.

For configured CPUs with firmware version ≥ V3.1, security events are logged in the CPU's internal syslog buffer.

For more information on Syslog messages, refer to the S7-1500, ET 200MP System Manual (https://support.industry.siemens.com/cs/ww/en/view/59191792).

Authentication token

You must be able to limit the access to the functions of the CPU in order to ensure both the security as well as the protection of your process. This functionality was realized in the previous web server by specifying user accounts and authorizations. No authorization or several authorizations can be assigned to each user. When the user executes functions on the CPU, the CPU checks whether the user disposes of the corresponding authorizations before the requested action is carried out.

The authentication token is the result of a successful login using the Api.Login method.

This token must be transferred to the Web API at all the subsequent API requests after a successful login as an HTTP header "X-Auth-Token".

In the following example, the X-Auth-Token is passed on as an HTTP header to the request:

```
$.post({
  url:"https://192.168.2.132/api/jsonrpc",
  data:JSON.stringify({jsonrpc:"2.0",id:1,
    method:"RequestChangeOperatingMode",params:{mode:"run"}}),
  success: function(data){ console.log(data); },
  dataType: "text",
  contentType: "application/json",
  headers: {
    "X-Auth-Token":"VGhpc0lzU2hvcnRUb1ByZXZlbnRXcmFwcGluZw==""}});
```

You can find a description of the method in the section Api.Login (Page 110).

6.4 Web API basic functions

The following section gives an overview of all Web API basic functions with extracts from the corresponding HTML code.

NOTE

Files which contain Web API methods must be encoded and stored in the UTF-8 character encoding.

For detailed examples of an integration of the Web API into your web application, refer to the section Web API integration (Page 104).

6.4.1 Api.Login

This method checks the login data of the user and on successful verification opens a new Web API session. The method requests the name and the password of the user in plain text as proof of authorization. The user name and the password are encrypted before they are transferred to the server.

No authorization is required to call the Api.Login method.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-163 Api_Login_Request (object)

Name	Required	Data type	Description
mode	No	string	Login mode. You can use all the modes supported by the Api.GetAuthenticationMode method, see Api.GetAuthenticationMode (Page 119). If no parameter is used, the query is assumed to be "local".
user	Yes	string	The user name. The parameter must be specified in the following modes: "static", "disabled", "local" and "umc".
password	Yes	string	The current password in plain text, without encryption. The parameter must be specified in the following modes: "static", "disabled", "local" and "umc".
include_web_application_cookie	No	bool	This parameter specifies: • Whether a "web_application_cookie" cookie was generated for access to protected web applications • Whether you want to return the cookie with the response to the successful login

Example 1

The following example shows the parameters required to call an Anonymous user.

```
{
  "user": "Anonymous",
  "password": ""
}
```

Example 2

The following example shows the parameters required to call a regular user.

```
{
  "user": "user_1",
  "password": "1234"
}
```

Example 3

The following example shows the parameters required to call an Anonymous user with local user management.

```
{
  "mode": "local",
  "user": "user_1",
  "password": "1234"
}
```

Example 4

The following example shows the parameters required to call an Anonymous user with central user management.

```
{
  "mode": "umc",
  "user": "user_1",
  "password": "1234"
}
```

Token

The token comprises a 28-byte string. The token is transferred in encrypted form.

For every additional request which requires authentication, you have to specify the assigned token in the HTTP request header. If further communication no longer takes place in the meantime, the token becomes invalid after maximum 2.5 minutes. Each new request within a session extends the validity of the token by another 2 to 2.5 minutes, calculated from the completion of the request processing by the server.

The token is not required for methods that do not require authentication. However, you can still enter the token. If the token is passed when a method is called, the timeout of the corresponding session is reset.

When you call, for example, the Api.Ping method without a token, the session is not extended because the CPU cannot assign a token to the user.

The following methods, amongst others, work with and without tokens:

- Api.Browse
- Api.Ping
- Api.GetPermissions

Receiving a token for a passwordless user account without password

If a user wants to use a user account without password to access the Web API, they must authenticate with the API method Api.Login using the user name "Everybody"/"Anonymous" and an empty password ("").

Even if only the central user management was activated, an Anonymous user can be present on the CPU, in as far as it was activated. In this case the GetAuthenticationMode method only

returns "umc", but not "local". Nevertheless, a login with mode=local or without mode parameter is possible.

The name of the specific user depends on the firmware version of the CPU:

- For projects with a firmware version ≤ V3.0: Static user management with the user "Everybody"
- For projects with a firmware version ≥ V3.1: Local user management with "Anonymous" user
- For projects with a firmware version ≥ V4.0: Local or central user management with "Anonymous" user

The "Anonymous" user can be deactivated in STEP 7 and is then not available on the CPU. Non-activated users are not downloaded to the CPU. This means that a call of the API method Api.Login with the user name "Anonymous" fails if the user was deactivated in STEP 7.

NOTE

User "Everybody"/"Anonymous"

Note that, unlike TIA Portal, the Web API only accepts the English notation "Everybody" or "Anonymous".

NOTE

The session token is security-relevant. You are not permitted to forward it or pass it on.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-164 Api_Login_Response (object)

Name	Required	Data type	Description
token	Yes	string	The token indicates that its holder has successfully authenticated themselves at the Web API. The returned token must be passed via the HTTP request header "X-Auth-Token" in subsequent Web API requirements.
web_application-_cookie	No	string	Only present if "include_web_application_cookie" is "true". The holder of the token has successfully authenticated themselves with the Web API and has authorization to access protected web applications.
password_expiration	No	object of type `Api_Login_PasswordExpiration_Response`	This object contains information on the expiration of the password, if: • The "local" or "umc" authentication mode is used for the CPU and • The password policy is activated on the CPU
runtime_timeout	No	string	ISO 8601 time span as string Time span of inactivity in seconds after which a client application is to perform a logout using the API method Api.Logout.
has_no_permissions	No	bool	If the user does not have authorization to access the web server, true is returned.

Table 3-165 Api_Login_PasswordExpiration_Response (object)

Name	Required	Data type	Description
timestamp	Yes	string	ISO8601 time stamp as a string in Coordinated Universal Time (UTC) Indicates when the user password expires. The accuracy must be specified in seconds.
warning	Yes	bool	This parameter specifies whether the warning threshold was reached before the password expired.

Example 1

The example below shows a successful login for a user without expiration of the password (either static user management or password expiration deactivated):

```
{
  "token": "TXlMdWdnYWdlSGFzVGhlU2FtZSE="
}
```

Example 2

The following example shows a successful login for a user with password expiration:

```
{
  "token": "TXlMdWdnYWdlSGFzVGhlU2FtZSE=",
  "password_expiration":
  {
     "timestamp": "2023-11-05T18:25:43Z",
     "warning": true
  }
}
```

Example 3

The following example shows a successful login for a user with password expiration and runtime_timeout of 30 minutes:

```
{
  "token": "TXlMdWdnYWdlSGFzVGhlU2FtZSE=",
  "runtime_timeout": "PT30M",
  "password_expiration":
  {
     "timestamp": "2023-11-05T18:25:43Z",
     "warning": true
  }
}
```

Possible error messages

The following table shows possible error messages of the Api.Login method.

Error code	Error message	Meaning
4	No resources	The system does not have the required resources to carry out this request. Perform the request once more as soon as enough resources are available again.
6	Not accepted	The authentication cannot be performed because the mode is not supported by the CPU.
100	Login failed	The user name and/or password are not permissible. Assign a permissible user name and a permissible password. Another reason why the login failed may be an active brute force attack.
101	Already authenticated	The current authentication token is already authenticated. Use `Api.Logout` before you authenticate yourself again.
102	Login Failed - Password expired	The password of the user account has expired. The user must change the password in order to be able to successfully authenticate again.
105	Login Failed - Infrastructure Error	The authentication was not successful, for example because the server cannot be reached.

6.4.2 Api.Logout

The Api.Logout method removes the token from the list of active Web API sessions and ends the session.

No authorization is required to call the Api.Logout method.

The Api.Logout method returns the status of whether the logout was successful or not. For security reasons, however, the method always returns the Boolean value "true" even if the token is invalid.

6.4.3 Api.GetPermissions

After a successful login, this method returns a list of actions for whose execution the user is authorized.

No authorization is required to call the Api.GetPermissions method.

Response structure

The following table shows you the structure of server responses to successful requests:

Table 3-166 Api_GetPermissions_Response (array of objects)

Name	Required	Data type	Description
name	Yes	string	Name of authorization

Example

The following example shows the actions for which the user is authorized.

```
[
  { "name": "read_value" },
  { "name": "change_operating_mode" }
]
```

Checkable authorizations

You can use the Web API to check the authorizations for the following functions.

Action	User authorization	As of the firmware version of the CPU
flash_leds	Identify device	V2.8
acknowledge_alarms	Acknowledge alarms	V2.8
read_value*	Read process data from the CPU.	V2.8
write_value	Write process data to the CPU.	V2.8
read_diagnostics*	Query diagnostics data from the CPU without being permitted to change data.	V2.8
change_operating_mode*	Change the operating mode.	V2.8
read_file*	Read the contents of files on the CPU.	V2.8
write_file*	Change the contents of files and folders on the CPU.	V2.8
backup_plc	Back up the CPU configuration.	V2.8
restore_plc	Restore configuration of the CPU.	V2.8
failsafe_admin	Make fail-safe changes on the CPU.	V2.8
open_user_pages	Call user-defined pages on the CPU.	V2.8
manage_user_pages	Change user-defined pages on the CPU.	V2.9
update_firmware	Perform firmware update	V3.0
read_watch_table_value	Read the value of a tag in the watch table	V3.1
write_watch_table_value	Write the value of a tag in the watch table	V3.1
read_syslog*	Read the SysLog buffers of the CPU	V3.1
change_time_settings	Change the system time settings of the CPU	V3.1
change_webserver_default_page	Changing the default web page of the web server	V3.1
download_service_data	Load the service data of the CPU	V3.1
change_webserver_response_headers	Change the response header of the Web server	V4.0
manage_system_pages	Update or configure system pages of the web server	V4.0

* Not every CPU variant supports the same functionality. An adapted subset of the function rights is therefore also available.

For projects with firmware version ≤ V3.0, the Web API checks the authorization based on the rights and passwords assigned in STEP 7 in the Inspector window in the "Web server > User management" area.

For projects with firmware version ≥ V3.1, the Web API checks the authorization based on the rights and passwords assigned in STEP 7 in the project tree in the "Security settings > Users and roles" area.

A description of the user management can be found in section "Configuring the Web server (Page 21)".

6.4.4 Api.ChangePassword

You can change the password for a user account with this method.

Recommendation: Before changing a password, read the password policy from the CPU using the Api.GetPasswordPolicy API method. If the new password does not conform to the password policy of the CPU, a corresponding error message is returned.

No prior authorizations are required to call the Api.ChangePassword method, but you must enter the current password for this call.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-167 Api_ChangePassword_Request (object)

Name	Required	Data type	Description
mode	No	string	Password change mode. Possible values: • local The values are described in the Api.GetAuthenticationMode method. If no parameter is entered, "local" is used.
username	Yes	string	The user name for which the password is changed
password	Yes	string	The current password of the specified user
new_password	Yes	string	The new password. Select a secure password in order to exclude negative effects on the CPU.

Example

In the following example, the password is changed for the user account "HappyUser".

```
{
  "username": "HappyUser",
  "password": "mycurrentpassword",
  "new_password": "mynewpassword"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows possible error messages of the Api.ChangePassword method.

Error code	Error message	Meaning
4	No resources	No resources for the password. Only a parallel resource is available for the password change.
5	System is read-only	The memory card is write-protected. Therefore, the password cannot be changed.
6	Not accepted	The password change is not performed because a CPU was configured a with firmware version < V3.1 or the selected mode does not support the function. The method can only be used with CPUs as of firmware version V3.1.
100	Login failed	The user name and password combination is invalid. Assign a permissible user name and a permissible password. Another reason why the login failed may be an active brute force attack.
103	New password does not follow password policy	The provided new password does not match with the required password policy. Assign a password conforming to the password policy. The Api.GetPasswordPolicy method provides you with the password policy of the CPU, if the CPU is in "local" authentication mode.
104	New password matches former password	The new password is identical with the previous password. Assign a different password. Note that the CPU does not store a password history. The comparison is therefore only performed between the new and previous password.

6.4.5 Api.GetPasswordPolicy

This method provides you with the password expiry policy of the CPU when the CPU is in the authentication mode "local" or "umc".

Passwords must fulfill specific criteria to be secure. The Api.GetPasswordPolicy method provides you with the password policy of the CPU. The password policy is a global setting in the STEP 7 project and applies for all users of the Web server. The method does not contain any information on the expiration of the password. Any user, including unauthenticated users ("AnonymousAnonymous"), can call this API method.

No authorization is required to call the Api.GetPasswordPolicy method.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-168 Api_GetPasswordPolicy_Request (object)

Name	Required	Data type	Description
mode	No	string	Password change mode. Possible values: • local The values are described in the Api.GetAuthenticationMode (Page 119) method. If no parameter is entered, "local" is used.

Response structure

The following table shows you the structure of server responses to successful requests.

Table 3-169 Api_GetPasswordPolicy_Response (object)

Name	Required	Data type	Description
password_policy	Yes	object	The object represents the current password policy of the CPU.
min_password_length	Yes	number	The minimum length of the password in UTF-8 character encoding. Value range: 8 to 255
max_password_length	Yes	number	The maximum length of the password in UTF-8 character encoding.
min_digits	Yes	number	The minimum number of numerals (0 to 9) within the password. Value range: 0 to 255
min_special_characters	Yes	number	The minimum number of special characters within the password. Special characters are: !#$%&()*+,-./:;<=>?@[\]_{|}~^ Value range: 0 to 255
requires_uppercase_characte-rs	Yes	bool	The password contains at least one uppercase character A to Z. Values: true or false
requires_lowercase_character-s	Yes	bool	The password contains at least one lowercase character a to z. Values: true or false

Example

The following example shows a CPU project with a password policy.

```
{
  "password_policy":
  {
    "min_password_length": 8,
    "max_password_length ": 120,
    "min_digits": 2,
    "min_special_characters": 1,
    "requires_uppercase_characters": true,
    "requires_lowercase_characters": true
  }
}
```

Possible error messages

The following table shows possible error messages of the Api.GetPasswordPolicy method.

Error code	Error message	Meaning
6	Not accepted	The password change is not performed because a CPU was configured a with firmware version < V3.1 or the selected mode does not support the function. The method can only be used with CPUs as of firmware version V3.1.

6.4.6 Api.GetAuthenticationMode

You can read the current authentication mode of the CPU with this method.

No authorization is required to call the Api.GetAuthenticationMode method.

Possible authentication modes

The following authentication modes are available to you with the Web server.

Table 3-170 Authentication modes

Mode	String	Meaning	Supported as of the configured FW version of the CPU
Static user management	`static`	In this mode, changes are only possible by downloading the hardware configuration from the CPU. Passwords cannot be changed during runtime of the user program.	V2.8 to V3.0
Access control deactivated	`disabled`	No user management and authentication is possible in this mode. Only the "Anonymous" user is available. This specific user has full access/rights to the CPU and Web server functionality. As with every other user the Api.Login method must be called. The returned X-Auth Token allows the full access right to all API functionalities.	V3.1
Local user management	`local`	In this mode, the authorizations and user roles continue to be configured as part of the STEP 7 project and a password change is possible via the Web API.	V3.1
Central user management (via user name and password)	`umc`	In this mode the user management is controlled by the central server (UMC server). The user roles are stored in the CPU: Changing the password is not possible via the Web API. In this mode the CPU checks the login data against the UMC server.	V4.0

Response structure

The following table shows you the structure of server responses to successful requests.

Table 3-171 Api_GetAuthenticationMode_Response (object)

Name	Required	Data type	Description
authentication_modes	Yes	array of string	The parameter describes the current authentication mode supported by the CPU.

Example 1

In the following example, the authentication mode "local" (local user management) is read by the CPU.

```
{
  "authentication_modes": ["local"]
}
```

Example 2

In the following example, the authentication mode "local" (local user management) and umc (central user management) is read by the CPU.

```
{
  "authentication_modes": ["local", "umc"]
}
```

6.4.7 Api.GetSessionInfo

This method is used to read the information about the current API session.

No authorization is required to call the Api.GetSessionInfo method.

You can find more information on the authentication token in Web API sessions (Page 107).

Response structure

The following table shows you the structure of server responses to successful requests.

Table 3-172 Api_GetSessionInfo_Response (object)

Name	Required	Data type	Description
authentication_mode	No	string	The parameter describes the authentication mode used when the user session is opened: • Static user management ("static") • Local user management ("local") • Central user management (via user name and password; "umc") No authentication mode is returned for the users "Anonymous"/"Everybody".
username	Yes	string	The parameter contains the user name of the session.
password_expiration	No	Object of type `Api_GetSessionInfo_PasswordExpiration_Response`	This object contains information on the expiration of the password, if: • The "local" or "umc" authentication mode is used for the CPU and • The password policy is activated on the CPU
runtime_timeout	No	string	ISO 8601 time span as string Time span of inactivity after which a client application is to perform a logout using the API method Api.Logout.

Table 3-173 Api_GetSessionInfo_PasswordExpiration_Response (object)

Name	Required	Data type	Description
timestamp	Yes	string	ISO8601 time stamp as a string in Coordinated Universal Time (UTC) Indicates when the user password expires. The accuracy must be specified in seconds.
warning	Yes	bool	This parameter specifies whether the warning threshold was reached before the password expired.

Example 1

The following example describes a session opened with static user management.

```
{
  "authentication_mode": "static",
  "username": "MyUser"
}
```

Example 2

The following example describes a session opened through deactivated access control. Only the "Anonymous" user is available.

```
{
  "username": "Anonymous"
}
```

Example 3

The following example describes a session opened with central user management for the user with timeout and expiry of the password.

```
{
  "authentication_mode": "umc",
  "username": "MyUser",
  "runtime_timeout": "PT30M",
  "password_expiration":
  [
     "timestamp": "2012-04-23T18:25:43Z",
     "warning": true
  }
}
```

Example 4

The following example describes a session opened with local user management for the user with timeout and expiry of the password.

```
{
  "authentication_mode": "local",
  "username": "MyUser",
  "runtime_timeout": "PT30M",
  "password_expiration":
  {
     "timestamp": "2012-04-23T18:25:43Z",
     "warning": true
  }
}
```

Example 5

The following example describes a session opened with local user management for the user without expiry of the password.

```
{
  "authentication_mode": "local",
  "username": "MyUser",
  "runtime_timeout": "PT30M"
}
```

Possible error messages

The following table shows possible error messages of the Api.GetSessionInfo method.

Error code	Error message	Meaning
6	Not accepted	The method cannot be carried out due to an authentication token.

6.4.8 Api.Browse

This method gives you a list of all methods that you can call via the Web API with the current firmware. This provides you with an overview of all the methods supported by the CPU.

No authorization is required to call the Api.Browse method.

Response structure

The following table shows you the structure of server responses to successful requests.

Table 3-174 Api_Browse_Response (array of objects)

Name	Required	Data type	Description
name	Yes	string	The name of the method.

Example

The following example below shows the supported methods of the CPU.

```
[
 { "name": "Api.Browse" },
 { "name": "Api.Login" },
 { "name": "Api.Logout" },
 { "name": "Api.GetPermissions" },
 { "name": "PlcProgram.Read" },
 { "name": "PlcProgram.Write" }
]
```

NOTE

Checking authorizations

The Api.Browse method does not filter the list of the available methods by the individual authorizations of users.

The list of available methods may therefore contain methods which the user may not execute without authorization.

Possible error messages

The following table shows possible error messages of the Api.Browse method.

Error code	Error message	Meaning
4	No resources	The system does not have the necessary resources to execute the Web API request. Perform the request once more as soon as enough resources are available again.

6.4.9 Api.Version

With this method you request the current version number of the Web API. You can draw conclusions from the version number:

- The functions supported by the CPU version
- The hardware functional status of the CPU

This information lets you implement applications that dynamically adapt to the scope of functions offered by the contacted CPU. An application can support multiple CPU versions.

No authorization is required to call the Api.Version method.

Response structure

The version number is displayed as a floating-point number and is incremented with every release and every change of the Web API.

Example

The following example shows a possible result of calling the Api.Version method.

```
5.2801020
```

6.4.10 Api.Ping

This method outputs a unique ID for the CPU used. You can use it to determine whether the CPU can be reached. The CPU ID comprises a 28-byte string. The system assigns a new, unique CPU ID after each restart (POWER ON - POWER OFF) or warm start of the CPU. By comparing this with previously output IDs, you can also determine whether the CPU was restarted in the meantime.

NOTE

Notes for redundant operation

- In redundant operation, the two CPUs return the same value.
- In the event of a failover, i.e. if a CPU fails, the CPU that is still running continues to return the same value.
- If you switch the CPUs to non-redundant mode, both CPUs return the same value.

No authorization is required to call the Api.Ping method.

Response structure

The method issues a string that contains 20 bytes of "random" data generated by the CPU. Encrypted with Base64 it represents a total of 28 bytes.

Example

The following example shows the output of a CPU ID:

```
"QXJlWW91UmVhbGx5U2VyaW91cz8="
```

6.4.11 Api.GetCertificateUrl

This method outputs a relative URL (`https://<IP>`) with which you can call the SSL certificate of the web server.

No authorization is required to call the Api.GetCertificateUrl method.

Response structure

The method outputs a string with a relative URL to the root directory of the CPU Web server (`https://[ip-address]`).

If the Web server has not been configured with a CA certificate generated via the global security settings, the method outputs an empty string.

Example

The following example shows the result of the Api.GetCertificateUrl method call.

```
"/MiniWebCA_Cer.crt"
```

6.4.12 Api.GetQuantityStructures

This method returns various units of structure information of the web server.

No authorization is required to call the Api.GetQuantityStructures method.

Response structure

The following table shows you the structure of server responses to successful requests.

Table 3-175 Api_GetQuantityStructures_Response (object)

Name	Required	Data type	Description
webapi_max_http_request_body_size	Yes	number	The maximum size of the HTTP request body of a Web API request in bytes
webapi_max_parallel_requests	Yes	number	The maximum number of parallel requests at the web application end point
webapi_max_parallel_user_sessions	Yes	number	The maximum number of parallel user sessions that use the web application end point

Example

The following example shows the response with the read parameters of a CPU.

```
{
  "webapi_http_request_body_size": 131072,
  "webapi_parallel_requests": 4,
  "webapi_parallel_user_sessions": 200
}
```

6.5 Ticket mechanism

With the web server as of firmware version V2.9, you can use the ticket mechanism of the Web API. The ticket mechanism is the basis for all file-based methods, such as the download of resources from the CPU.

The ticket mechanism enables you to:

- Transfer large amounts of data outside of the JSON-RPC protocol.
- Call status information, for example, to implement progress indicators in your application and respond conveniently to mode changes

---

NOTE

4 tickets per session

The ticket mechanism enables you to use a maximum of 4 tickets simultaneously per session.

The number of tickets that can be created per type is additionally limited. For more information, see the API methods that create a ticket:

- WebApp.CreateResource (Page 163)
- WebApp.DownloadResource (Page 167)
- Plc.CreateBackup (Page 242)
- Files.Download (Page 250)
- Files.Create (Page 252)
- PlcProgram.DownloadProfilingData (Page 187)

Principle of the ticket mechanism

Data transfers outside the JSON-RPC protocol are initiated by Web API methods, such as WebApp.DownloadResource. This method returns a specific identifier, a so-called "ticket". The ticket can be redeemed by a subsequent request to another HTTP end point. In the request, the data are exchanged with standard HTTP mechanisms.

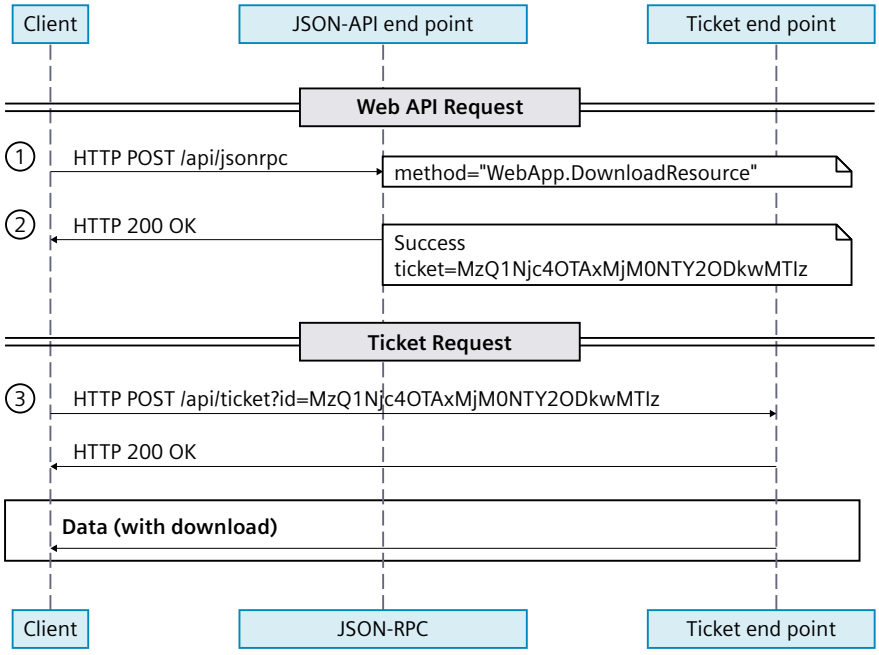

Figure 3-221 Ticket mechanism

① To request the upload or download of a resource from/to the CPU, a client sends a request to the JSON-RPC.

② After successful authorization and resource check, the client receives a valid ticket ID.

③ The client sends a request to the ticket end point with the valid ticket ID and an X-Auth-Token. The data is included here during upload to the CPU. The request is confirmed to the client with "HTTP 200 OK" or "204 NO CONTENT". The data is returned in a download from the CPU.

Ticket IDs are one-time tokens that may not be reused by the client or by the CPU after being redeemed.

NOTE

Changes in firmware version V3.0

As of firmware version V3.0, no X-Auth-Token is required for the ticket end point.

Do not share the token with third parties, because the owner of the token gets control over a ticket.

As of firmware version V3.0, GET requests for downloads are possible in addition to POST requests. For GET requests, a content disposition header is returned with the HTTP response. It contains a default file name for storage in the web browser. The browser uses the file name as the storage location. However, you can also evaluate the file name programmatically using a programming language (for example, via C#).

NOTE

Changes in firmware version V4.0

As of firmware version V4.0 file names with special characters are supported if the `filename*` attribute of the content disposition header is used.

File names for CPUs as of firmware version V4.0

As of firmware version V4.0 file names with special characters are supported if the `filename*` attribute of the content disposition header is used. In addition to the `filename` attribute, the header also contains the `filename*` attribute that is used implicitly and is interpreted in accordance with the encryption process. In the older web browsers `filename*` is not implemented. `filename` is therefore used.

Example of an HTTP content disposition header

```
Content disposition: attachment;
filename*=UTF-8''%e9%a1%b9%e7%9b%ae1.zap19;
filename="e9a1b9e79bae1.zap19"
```

Ticket end point

The ticket end point is accessible via GET (for downloads only), POST and OPTIONS requests to the following URL:

```
https://[ip]/api/ticket?id=<ticket-id>
```

The ticket mechanism alone is not enough to execute a file action. To do this, you must call a specific method. In the web server of the firmware version V2.9, you use the ticket mechanism for the following methods:

- WebApp.CreateResource (Page 163)
- WebApp.DownloadResource (Page 167)

Procedure to execute a file action

To create a resource or download one from the CPU, follow these steps:

1. Call the corresponding method with the necessary method parameters, for example, WebApp.DownloadResource. The method returns a character string that includes a valid ticket ID.
2. Call the ticket end point via POST request with the returned ticket ID. The method will then execute the download, for example.

For more information, see the paragraph "Principle of the ticket mechanism".

NOTE

In some cases, programming languages perform preprocessing of text files before the upload. For example, a UTF-8 BOM-encoded (Byte Order Mark) file in Javascript is converted to a UTF8 file in advance.

Examples

Below you will find two examples for further processing of the tickets. The examples use HTML, Json and JQuery library.

WebApp.CreateResource (upload a resource):

```
<td><input id="fileForticketCustomerExampleUpload" type="file"
onchange="fReadFile()" /></td>
var fileReader = new FileReader();
function fReadFile() {
   fileReader = new FileReader();
   fileReader.readAsText(this.files[0]);
}
$("#ApiUploadticketCustomerExample").click(function () {
     var ticketId = $("#iApiUploadticketIdCustomerExample").val();
     var content = fileReader.result; // e.g. <!DOCTYPE
html><html><head>...
     $.post({
       url: "https://" + window.location.hostname +
"/api/ticket?id=" + ticketId,
       headers: { "X-Auth-Token": token, "Content-Type":
"application/octet-stream" },
       contentType: "application/json",
       data: content,
       // ticketing: status = 204: No content (=> no data) upload
has finished successfully:
       success: function (data, textStatus, jqXHR) { if
(jqXHR.status == 204) {
$("#ApiUploadticketCustomerExampleRes").text("true"); } },
//print error to the document
       error: function (jqXHR, textStatus, errorThrown) {
$("#ApiUploadticketCustomerExampleRes").html("<tr><td>code:
</td><td>" + jqXHR + "</td></tr><tr><td>textStatus:</td><td>" +
textStatus + "</td></tr><tr><td>error:</td><td>" + errorThrown +
"</td></tr>"); }
     });
   });
```

WebApp.DownloadResource (download a resource):

```
// Function to save data in a file - will be stored in the default
download folder
function saveDataInFile(data, filename, type) {
   var file = new Blob([data], { type: type });
   if (window.navigator.msSaveOrOpenBlob) // IE10+
     window.navigator.msSaveOrOpenBlob(file, filename);
   else { // Others
     var a = document.createElement("a"),
       url = URL.createObjectURL(file);
     a.href = url;
     a.download = filename;
```

```
      document.body.appendChild(a);
      a.click();
      setTimeout(function () {
        document.body.removeChild(a);
        window.URL.revokeObjectURL(url);
      }, 0);
    }
}
 $("#ApiDownloadTicketCustomerExample").click(function () {
      var ticketId = $("#iApiDownloadTicketIdCustomerExample").val();
      var filename =
$("#iApiDownloadTicketCustomerExampleFileName").val();  //e.g. index
      var type =
$("#iApiDownloadTicketCustomerExampleFileType").val();    //e.g.
text/html
      $.post({
        url: "https://" + window.location.hostname +
"/api/ticket?id=" + ticketId,
        headers: { "X-Auth-Token": token, "Content-Type":
"application/octet-stream" },
        contentType: "application/json",
        // ticketing: status = 200: download has finished
successfully:
        success: function (data, textStatus, jqXHR) { if
(jqXHR.status == 200) { download(data, filename, type); } },
//print error to document
        error: function (jqXHR, textStatus, errorThrown) {
$("#ApiDownloadTicketCustomerExampleRes").html("<tr><td>code:
</td><td>" + jqXHR + "</td></tr><tr><td>textStatus:</td><td>" +
textStatus + "</td></tr><tr><td>error:</td><td>" + errorThrown +
"</td></tr>"); }
      });
    });
```

Ticket methods

Two methods are available for handling your tickets as an authenticated user:

- You can use the Api.BrowseTickets (Page 131) method to find out which tickets are currently active for you and read out the status for the active tickets in each case.
- After the action, you can delete your ticket with the Api.CloseTicket (Page 133) method to clean the application with regard to active tickets.

6.5.1 Api.BrowseTickets

This method calls the status of all active tickets of a logged-in user. Alternatively, the status of a specific ticket can be called. This will provide information on the ticket status. You can also call this method during an active file action to retrieve the current status. Depending on the file action, additional information is provided via Api.BrowseTickets.

No authorization is required to call the Api.BrowseTickets method, but a valid session token. You can find information on the session token in the section Api.Login (Page 110).

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-176 Api_BrowseTickets_Request (object)

Name	Required	Data type	Description
id	No	string	The ticket ID that was returned by an API method for use by the ticket system. If the parameter is not specified, then the response structure returns all valid tickets of the user.

Example

In the following example, a ticket ID is transferred as parameter.

```
{
  "id": "U2VyaW91c2x5LCBTdG9wIGl0ISE6"
}
```

Response structure

The following table shows you the structure of the server response to a successful request.

Table 3-177 Api_BrowseTickets_Response (object)

Name	Required	Data type	Description
max_tickets	yes	number	Maximum number of tickets for one session (4)
tickets	Yes	array of Api_ BrowseTickets_ Ticket_ Response	Ticket ID
id	yes	string	Ticket ID
date_created	yes	string	ISO8601 time stamp as string. Time of the ticket creation based on the CPU time

Name	Required	Data type	Description
provider	yes	string	Name of the method that has created the ticket, for example, WebApp.DownloadResource
state	yes	string	Current ticket status. The following alternatives are possible: "created", "active", "", "completed" or "failed"
data	No	object	Additional ticket data: Some ticket-based methods offer users additional information. This additional information is provided via "data" and described in the sections of the respective API methods.

Example

The following example shows a response of the CPU.

```
{
  "max_tickets": 4,
  "tickets":
  [
    {
      "id": "U2VyaW91c2x5LCBTdG9wIGl0ISE6",
      "date_created": "2021-01-15T08:00:00-05:00",
      "provider": "WebApp.DownloadResource",
      "state": "active"
    }
  ]
}
```

NOTE

Additional ticket data (as of TIA Portal V18)

As of TIA Portal V18, each ticket is extended by the entry "bytes_processed" as part of the "data" object. This entry specifies how many bytes have been transferred when downloading or uploading a ticket until the Api.BrowseTicket method is called.

Possible error messages

The following table shows possible error messages of the Api.BrowseTickets method.

Error code	Error message	Meaning
400	Not Found	The returned ticket ID does not exist in the ticket list of the user or does not match the assigned session token.

6.5.2 Api.CloseTicket

You use this method to delete a ticket provided by the system that is assigned to the current user session.

No authorization is required to call the Api.CloseTicket method, but a valid session token. You can find information on the session token in the section Api.Login (Page 110).

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-178 Api_CloseTicket_Request (object)

Name	Required	Data type	Description
id	yes	string	The ticket ID that was returned by an API method for use by the ticket system.

Example

In the following example, a ticket ID is transferred as parameter.

```
{
  "id": "U2VyaW91c2x5LCBTdG9wIGl0ISE6"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the Api.CloseTicket method.

Error code	Error message	Meaning
400	Not Found	The returned ticket ID does not exist in the ticket list of the user. The returned ticket ID or does not match the assigned session token.

6.6 User-configurable HTTP response headers

6.6.1 Reading and writing user-configurable HTTP response headers

User-configurable HTTP response headers

With the introduction of the SIMATIC HMI Unified Comfort Panels, the HMI Panels are also based on the web technology. It is now possible to access the contents of a Unified Comfort Panels via a web browser. The BrowserControl of an HMI-Panel loads web pages into an HTML frame.

To prevent clickjacking, Siemens products by default block the loading of web pages or applications in HTML frames. The option `sameorigin` prevents the loading of the web page in a frame. This also applies to the SIMATIC HMI Unified Comfort Panels.

The current configuration and return of the `frame-ancestors` response header by the CPU web server informs a web browser of the frame into which the web page can be loaded. You can configure a list of trusted addresses in which the web pages can be embedded.

For CPUs as of firmware version V4.0, you can configure headers for web applications that are returned as part of an HTTP response. You can use the response headers for different application cases, for example to increase the security of web pages, for information purposes and for debugging. You can configure these headers via the API.

The headers are applied to the web application end point and thus to all available web applications, including the system web pages. The previous web pages are not included.

NOTE

When configuring the header for frame-ancestors, only enter the domain without the path (for example https://myfriend.site.com instead of https://myfriend.site.com/ABC). Specifying a path in web browsers may result in the configuration not being applied as desired.

Example

You have configured the CPU web server on the address 192.168.0.1 and one on the address 192.168.0.2.

Trusted clients are not configured.

If you now want to embed the web pages of 192.168.0.2 in a frame on the web pages of 192.168.0.1, this will not work automatically because the web pages of 192.168.0.2 are defined as `X-frame options: sameorigin` and therefore cannot be loaded into external frames.

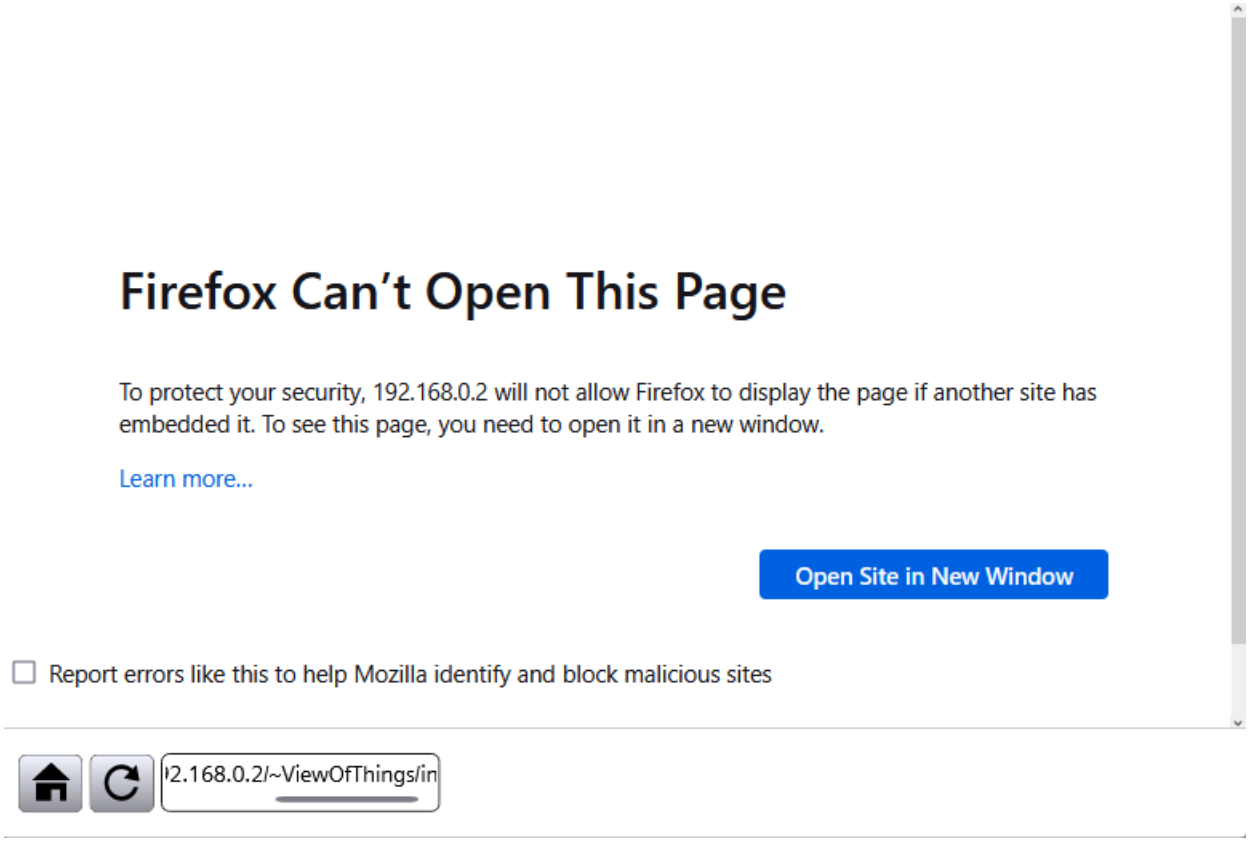

Figure 3-222 The web page cannot be loaded into the frame.

If you now configure a header `Content-Security-Policy: frame-ancestors` on the web server at the address 192.168.0.2 as follows, 192.168.0.1 is marked as trustworthy.

```
{
  "jsonrpc": "2.0",
  "id": 6,
  "result": {
    "configured_headers": [
      {
        "pattern": "~**/*",
        "header": "Content-Security-Policy: frame-ancestors 'self'
https://192.168.0.1"
      }
    ]
```

```
      "allowed_headers": [
        {
          "pattern": "~**/*",
          "key": "Content-Security-Policy"
        }
      ]
    }
  }
```

After you have performed a refresh, the web page of 192.168.0.2 can be called in the frame of the web pages of 192.168.0.1. The configured headers are used on the web application end point.

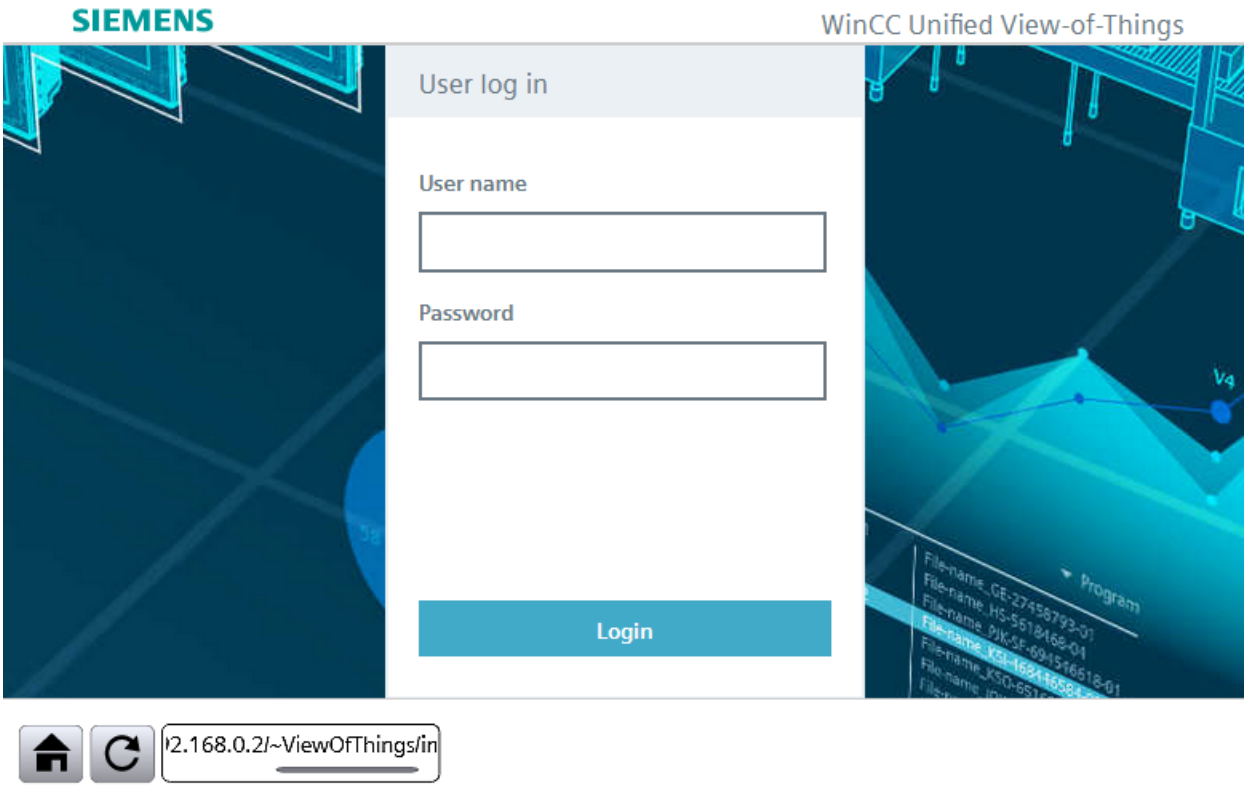

Figure 3-223 The web page can be loaded into the frame.

6.6.2 WebServer.ReadResponseHeaders

With this method, you read the list of configured HTTP response headers, as well as the list of HTTP response headers which you can configure.

To call the WebServer.ReadResponseHeaders method, you require the "change_webserver_response_headers" authorization.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-179 WebServer_ReadResponseHeaders_Response (object)

Name	Required	Data type	Description
configured_headers	Yes	array of data type `WebServer_ReadResponseHeaders_Configured_Response`	An array of objects. Each object represents an HTTP header that you have configured.
allowed_headers	Yes	array of data type `WebServer_ReadResponseHeaders_Allowed_Response`	An array of objects. Each object represents an HTTP header that you can configure.

Table 3-180 WebServer_ReadResponseHeaders_Configured_Response (object)

Name	Required	Data type	Description
pattern	Yes	string	The sample describes for which URLs this HTTP response header is returned. The parameter must always contain the value "/~**/*". This means that this header can be applied to all URLs, which begin with "~".
header	Yes	string	The HTTP response header that is added to the HTTP response

Table 3-181 WebServer_ReadResponseHeaders_Allowed_Response (object)

Name	Required	Data type	Description
pattern	Yes	string	The sample for which the header can be used.
key	Yes	string	A predefined or user-defined key. Only the following value is possible: • "Content-Security-Policy"

Example 1

The following example shows a response header with permitted list.

```
{
  "configured_headers": [
  {
      "pattern": "~**/*",
      "header": "Content-Security-Policy: frame-ancestors
*.somesite.com;"
    }
  ],
```

```
  "allowed_headers": [
  {
      "pattern": "~**/*",
      "key": "Content-Security-Policy"
    }
  ]
}
```

Example 2

The following example shows a non-configured response header.

```
{
  "configured_headers": [],
  "allowed_headers": [
  {
    "pattern": "~**/*",
    "key": "Content-Security-Policy"
  }
}
```

Possible error messages

The following table shows possible error messages of the WebServer.ReadResponseHeaders method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.6.3 WebServer.ChangeResponseHeaders

With this method, you can overwrite and configure a set of user-defined HTTP response headers. To ensure the correct sequence of the HTTP headers and simplify the use, all HTTP response headers configured by you are specified in a API call.

Currently only headers with the key "Content-Security-Policy" are supported.

To call the WebServer.ChangeResponseHeaders method, you require "change_webserver_response_headers" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-182 WebServer_ChangeResponseHeaders_Request (object)

Name	Required	Data type	Description
pattern	Yes	string	The sample for which the header must be output. The parameter must always have the value "/~**/*". Other values are not permitted.
header	Yes	string	The HTTP response header which matches the sample.

Example 1

The following example shows how you can create a user-defined HTTP header.

```
{
  "headers": [
    {
      "pattern": "~**/*",
      "header": "Content-Security-Policy: frame-ancestors 'self'
*.somesite.com https://myfriend.site.com;"
    }
  ]
}
```

Example 2

The following example shows how you can reset a user-defined HTTP header.

```
{
  "headers": []
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows possible error messages of the WebServer.ChangeResponseHeaders method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read-only	The memory card is write-protected. Therefore, the file cannot be changed.

Error code	Error message	Meaning
1301	Invalid pattern	The sample is included in the supported list. Select an approved sample.
1302	HTTP header not allowed	An HTTP header is not contained in the supported list. Select an approved HTTP header.
1303	HTTP header invalid	The HTTP header contains invalid or non-supported characters. Check the HTTP header.
1304	Too many HTTP headers	Too many user-defined HTTP headers. Restrict the number to 1.
1305	Request too large	The entirety of the HTTP header which you want to configure exceeds the maximum permissible size. Reduce the length of the HTTP header.

6.7 Setting the web server default page

The web server of the CPU will use the default web page if you do not specify a path along with the requested IP address, the domain and the host name in the web browser. You no longer have to configure the default web page using TIA Portal. This also eliminates the need to download the hardware configuration when changes are made. You can configure any existing web application as a default web page.

6.7.1 WebServer.SetDefaultPage

With this method, you set the default web page of the web server.

To call the WebServer.SetDefaultPage method, you require "change_webserver_default_page" authorization.

Structure of the request

The following table contains information about the parameters of the request:

Table 3-183 Webserver_SetDefaultPage_Request (object)

Name	Required	Data type	Description
default_page	Yes	string	The default web page that you want to set. An empty string undoes the changes and activates the hardware configuration.

Example 1

In the following example, the default web page named "index.html" is set for the web application "webapp1".

```
{
  "default_page": "/~webapp1/index.html"
}
```

Example 2

In the following example, the default web page is set for the web application "webapp1".

```
{
  "default_page": "/~webapp1/"
}
```

Example 3

In the following example, the default web page of the hardware configuration is used.

```
{
  "default_page": ""
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows possible error messages of the WebServer.SetDefaultPage method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read-only	The system is currently in a write-protected state. Changes are not currently permitted.
1300	Invalid default page	The default page entered is invalid. Check the entered parameter.

6.7.2 WebServer.ReadDefaultPage

This method is used to read the default web page specified with WebServer.SetDefaultPage.

No authorization is required to call the WebServer.ReadDefaultPage method.

Response structure

The following table shows you the structure of server responses to successful requests.

Table 3-184 Webserver_ReadDefaultPage_Response

Name	Required	Data type	Description
default_page	Yes	string	The default web page currently configured during runtime. The returned value does not take into account the configuration of the hardware configuration overview in TIA Portal.

6.8 User-defined web applications

With the web server as of firmware version V2.9, you can use user-defined web applications. In the following, we will refer to "web applications" for short.

Web applications offer you a set of methods to manage web applications via the Web API. You can use all available Web API methods within a web application.

NOTE

The contents of the web applications are stored on the memory card as plain text. They are not encrypted.

NOTE

HTTP range requests

For access to web application resources, the web Server provides you with a limited support for HTTP range requests. These requests allow you to read individual areas of a resource.

Advantages

Web applications offer you various advantages compared to the previous method that provided customer pages via the system function SFC 99 in STEP 7. They represent a higher-performance successor to UP:

- The resources are saved in the associated web application. Via the Web API you can download the resources to your PC, edit them and upload them back to the CPU. This procedure results in significantly reduced development times of customer pages.
- Unlike the previous customer pages, you can test the web application during implementation without having to load it onto the CPU.
- You can access resources independent of the CPU mode (e.g. RUN, STOP) and update these.
- Web applications are also available in the STOP mode of the CPU.
- No synchronization between the user program and Web server required by the SFC 99 instruction.
- You can access multiple CPUs within a web application using the Web API.
- The CPU supports saving multiple web applications that you can access simultaneously via the HTTP end point.
- Access to the resources of a web application via the HTTP end point can be activated or deactivated per each application. In so doing, an administrator can deactivate access to a web application, for example, to update the resources consistently.
- You can specify a default entry page for each application. When you visit the basic URL of a web application, such as https://[ip]/~[application_name], you are automatically being forwarded to the configured home page.
- You can specify an individual media type (MIME type) for each resource.

- You can specify a visibility flag for each resource:
  - Public resource: Access without user authentication
  - Protected resource: Access limited to authenticated users with access right "open_user_pages"
- You can specify for each resource:
  - The time stamp of the resource change
  - The value for the HTTP header ETag

  This enables the caching of resource files by the web browser. This reduces the communication load on the CPU and reduces the loading time of your web application.

NOTE

When you use the Web API for managing web applications, the TIA Portal project in the `SIMATIC.S7S` folder on the SIMATIC load memory changes. Your TIA Portal project is extended by the option of saving resources (e.g. HTML, CSS, JavaScript, etc.) in the project but outside of the data blocks of the user program. Resources are stored securely in the `s7p.web.apps` folder. Include this folder in the backup as well.

As with the previous customer pages, the web applications must not contain any instructions in the STEP 7 user program and are thus purely static files without dynamic content.

Backing up web applications

Ensure that you always have a backup copy of the user-defined web application you have created, especially for security-relevant applications. The web applications can be loaded onto the CPU independently of the TIA Portal project, or the CPU optionally offers an alternative communication channel for specific functionalities of the web application. A backup copy allows you to quickly restore the functionality of the web application.

An alternative communication channel allows you to perform certain actions even if the web pages are down or not functioning. This includes, for example, TIA Portal Online & Diagnostics or OPC UA.

Methods for managing web applications

The following methods are available to manage web applications using Web API:

Table 3-185 Methods for managing web applications

Method	Explanation
WebApp.Create (Page 150)	Enables the user to create a new web application
WebApp.Delete (Page 151)	Enables the user to delete an existing web application
WebApp.Rename (Page 152)	Enables the user to change the name of an existing web application
WebApp.Browse (Page 153)	Enables the user to display a list of web applications with the associated properties
WebApp.SetState (Page 156)	Enables the user to activate/deactivate a web application for access from the HTTP end point

Method	Explanation
WebApp.SetDefaultPage (Page 157)	Enables the user to specify a default web page for the web application
WebApp.SetNotFoundPage (Page 158)	Enables the user to define a page that is loaded when a requested resource does not exist in the web application
WebApp.SetNotAuthorizedPage (Page 160)	Enables the user to define a page that is loaded when a requested resource is not public (protected) in the web application

Methods for managing resources

The following methods are available to manage the resources of a web application using Web API:

Table 3-186 Web applications: Methods for managing resources

Method	Explanation
WebApp.BrowseResources (Page 161)	Enables the user to display all resources with their properties that are assigned to a web application
WebApp.CreateResource (Page 163)	Enables the user to create a new resource in a web application
WebApp.DeleteResource (Page 165)	Enables the user to delete an existing resource in a web application
WebApp.RenameResource (Page 166)	Enables the user to change the name of an existing resource in a web application
WebApp.DownloadResource (Page 167)	Enables the user to download a resource from a web application from the CPU
WebApp.SetResourceVisibility (Page 169)	Enables the user to change the visibility of a resource in a web application
WebApp.SetResourceETag (Page 170)	Enables the user to change or delete the ETag value of a resource in a web application
WebApp.SetResourceMediaType (Page 172)	Enables the user to change the media type of a resource in a web application
WebApp.SetResourceModificationTime (Page 173)	Enables the user to set the modification time of a resource in a web application
WebApp.SetVersion (Page 174)	Enables the user to assign a version of the user-defined web application as string
WebApp.SetUrlRedirectMode (Page 175)	Enables the user to set the redirect mode for a default web page, non-authorized page and non-found page

End point for web applications

Web applications are only accessible via secure HTTPS communication. This increases security when accessing the resources of the CPU. When the Web server was configured for HTTP access, requests via HTTP are automatically rerouted to an HTTPS connection.

A web application is accessible via the following URL, in as far as the default web page (default_page) or the substitute page of an application (not_found_page) is configured:

```
https://[ip]/~[application_name]
```

A resource of a web application can be reached via the following URL:

```
https://[ip]/~[application_name]/[resource_name]
```

NOTE

The tilde symbol "~" is important in the path and must always exist for web applications.

NOTE

If a web application is disabled, the web server returns the following error code.

```
503 SERVICE UNAVAILABLE
```

Rules for a valid application name

The application name may be max. 100 letters/characters long. The following letters and characters are permitted for the application name:

```
A-Z, a-z, 0-9, -_.+"
```

Rules for a valid resource name

The resource name can be max. 200 letters/characters in length. The following letters and characters are permitted for the resource name:

```
A-Z, a-z, 0-9, -_.+()/|,*!'"
```

Rules for a valid name for the media type

The web browser needs a media type to display a file correctly or to open it. The format of the media type is standardized. For example, "text/html" or "image/jpeg" are valid media types. You can use all valid media types.

More information can be found on the Internet by entering "MIME type" or "media type".

Rules for a valid version number

The version number name can be a max. of 100 letters/characters long. The following letters and characters are permitted for the version number:

```
A-Z, a-z, 0-9, -_.+"
```

Examples:

- V1
- 1.0.0
- 20.0.0.0_0.0.0.0
- WebApp_Test_V1.0

Modes for implementing web applications

Various options are available to implement a web application. Web applications may have special requirements for endpoint behavior regarding the loading of default resources (default web page, unauthorized page, non-found page).

If the user, for example, requests a resource which does not exist on the server, the HTTP protocol offers two modes for treating HTTP requests:

- Forward mode: Forwarding of requests
- Redirect mode: Redirecting of requests

Forward mode

If the web server determines that default treatment is required, the web server searches the target file and immediately returns its content instead of the content of the resource requested originally by the user. The web server returns the `HTTP-Statuscode 200 OK`, `401 UNAUTHORIZED` or `404 NOT FOUND`.

The web server does not know that another source file was loaded, the original URL remains intact.

If the web browser reloads the resulting page, the original request with the original URL is repeated.

NOTE

This mode is supported as of firmware version V4.0.

Because modern web applications as a rule rewrite the web browser URL, the web server offers the option to treat these requests accordingly as forwarding. An example: The user opens the URL https://s7-1500-webserver/~system/overview in the web browser. No resource with the specified name is available on the server. Therefore the server returns the content of the configured default web page (e.g. index.html). The web browser application then takes care of the corresponding processing of the request.

Redirect mode

A redirect is a two-step process. As response to the first request the web server returns the `HTTP-Statuscode 307 TEMPORARY REDIRECT` which also contains the new URL. With this response, the web server instructs the web browser to call a second URL which is different from the original URL.

When a web browser loads the second URL again, the original request is not repeated, rather the second URL is requested.

Redirects are slightly slower than forwards because they require two HTTP requests, not just one.

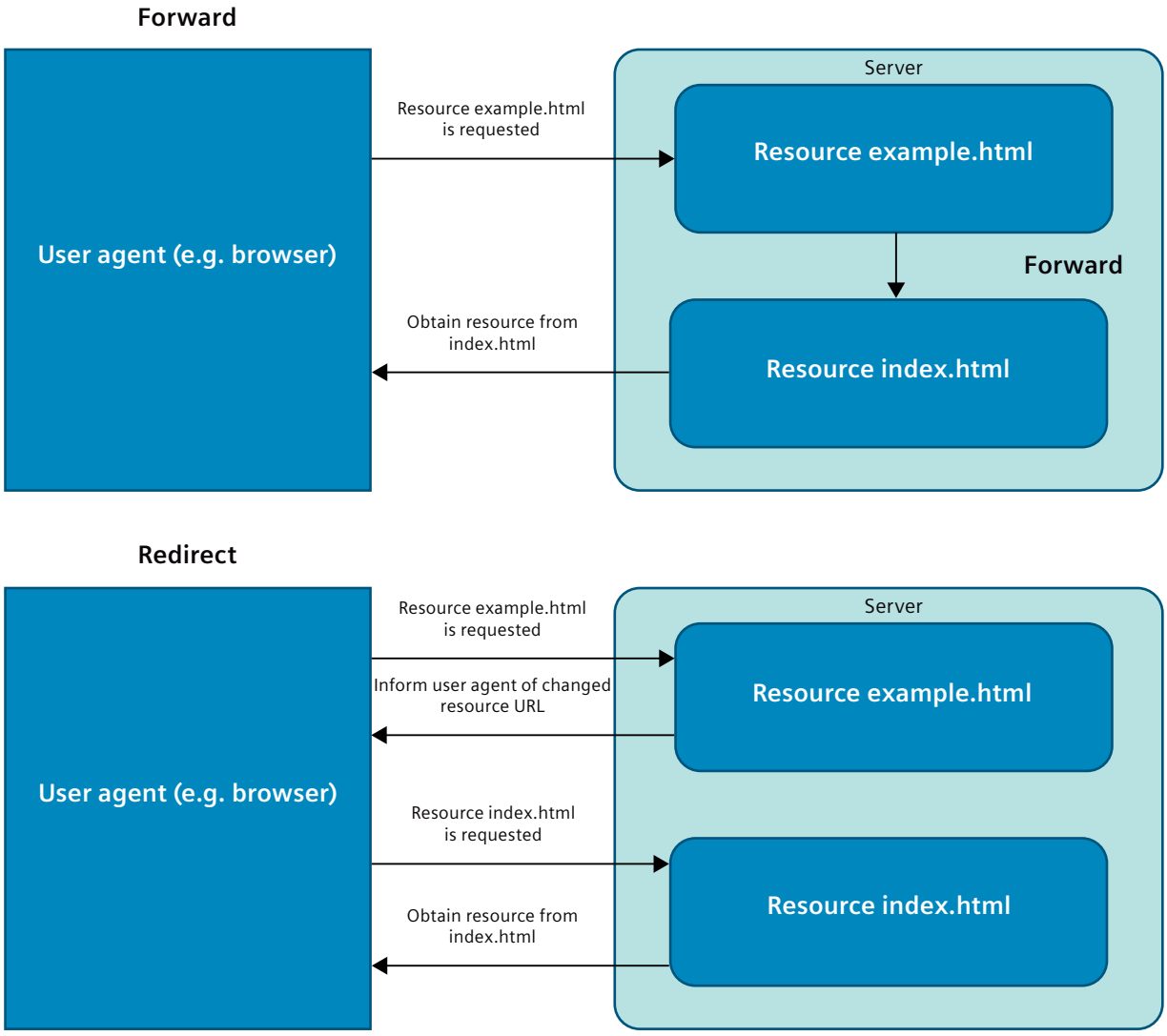

Figure 3-224 Redirect mode

6.8.1 Interaction between web applications

The system web pages, user-defined web applications and VoT (View of Things) applications are based on the Web API technology. You can use these web applications with each other without having to authenticate yourself for each application. Other settings, such as language, light/dark user interface mode and time settings, can also be used across the board.

A session cookie is required for the session. The session cookie must be passed to the web server as an X-AUTH token HTTP response header.

Some keys in the local memory are used together with other web applications on the web server. When different web applications are used together, you can either change settings or respond to changes via the keys.

Keys for the interaction between web applications

The following keys are supported for the interaction with other web applications:

Session cookie: Web API token

Name of the key: siemens_web_api_token

The response of the API method Api.Login contains a Web API token. The Web API token is required for each subsequent request to the Web API that depends on an API token. After a log-off the session cookie is removed.

The following example shows the required settings for the parameters SameSite and Secure. This allows you to also use the same API token from other web applications.

```
siemens_web_api_token="E+ty89DBnYhJ6NBxA0a0mkefG2PZ"; SameSite=None;
Secure
```

Session cookie: Access to web applications

Name of the key: siemens_web_secure

This session cookie allows you to access the contents of the non-public (protected) web application.

If resources of a web application are protected and you want to access data of this web application, then you have to authenticate yourself first, for example on a public page.

For example, perform the following step on the default web page:

- From JavaScript, call the Api.Login method using the "include_web_application_cookie" parameter.

Result: If authentication is successful, the Api.Login method returns the session token and a cookie for accessing the protected resources of a web application (see also section Api.Login (Page 110)).

JavaScript is used to set the cookie "web_application_cookie" with a value from the HTTP response of the login as cookie "siemens_web_secure".

NOTE

To ensure that the API token is not lost after the web page is called up again, you can save the API token by means of JavaScript in a cookie or in the local storage of the web browser.

The behavior after timeout for protected web applications corresponds to the behavior after timeout for Web API sessions. After a timeout, the cookie becomes invalid for access to the protected web applications. Reloading a resource file of a web application does not extend the session. Use appropriate methods of the Web API to stay logged in (see section Web API sessions (Page 107)).

The following example shows the required settings for the parameters SameSite and Secure.

```
siemens_web_secure=TXlMdWdnYWdlSGFzVGhlU2FtZSE=; SameSite=None;
Secure
```

Local storage: Display of the user interface

Name of the key: siemens_web_ui_theme

With this setting, you change the default setting of the web browser. You can ensure the optimal legibility under all light conditions by switching over from the light representation to a dark representation. You can store and use the selected representation of the user interface in the local storage of the web browser.

Table 3-187 Modes for the display of the user interface

Modes for the display of the user interface	Description
auto	The web application uses the display preferred by the web browser.
dark	The web application uses the dark display, irrespective of the configuration of the web browser. This mode uses bright text and bright symbols and graphical operator controls on a dark background.
light	The web application uses the light display, irrespective of the configuration of the web browser. This mode uses dark text and bright symbols and graphical operator controls on a dark background.

Local storage: Language of the user interface

Name of the key: siemens_web_ui_language

If you want to change the language of the user interface, change the language by means of this key. You can store and use the selected language of the user interface in the local storage of the web browser.

Table 3-188 Supported languages of the user interface

Possible settings	Language
de-DE	German
en-US	English (USA)
fr-FR	French
it-IT	Italian
es-ES	Spanish
ja-JP	Japanese
zh-CN	Chinese (Simplified)
ko-KR	Korean
ru-RU	Russian
tr-TR	Turkish
pt-BR	Portuguese (Brazil)

6.8.2 WebApp.Create

With this method, you can create a new web application in the CPU.

To call the WebApp.Create method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-189 WebApp_Create_Request (object)

Name	Required	Data type	Description
name	yes	string	The name of the user-defined web application.
state	no, default is "enabled"	string	The status of the application is: • "disabled": Pages cannot be reached via HTTP end point • "enabled": Pages can be reached via HTTP end point

Example

In the following example, the user creates an application with the name "application_1".

```
{
  "name": "application_1",
  "state": "enabled"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.Create method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.

Error code	Error message	Meaning
500	Application name already exists	An application with the name already exists. Assign a name that does not exist yet.
502	Application limit reached	The maximum number of web applications has been reached. Delete applications that you do not need to free up resources for new applications.
503	Invalid application name	The name of the application is invalid. Assign an application name that meets the rules for a valid application name (see User-defined web applications (Page 142)).

6.8.3 WebApp.Delete

With this method, you delete an existing user-defined web application with all its web page resources.

To call the WebApp.Delete method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-190 WebApp_Delete_Request (object)

Name	Required	Data type	Description
name	yes	string	The name of the web application that is deleted

Example

In the following example, the user deletes an application with the name "application1"

```
{
  "name": "application1"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.Delete method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
3	System is busy	The desired operation cannot be performed because the system is currently performing a different request. Restart the query as soon as the current operation is complete.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
501	Application does not exist	An application with this name does not exist.

6.8.4 WebApp.Rename

With this method, you change the name of the web application to a new name.

To call the WebApp.Rename method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-191 WebApp_Rename_Request (object)

Name	Required	Data type	Description
name	yes	string	The current name of the web application.
new_name	yes	string	The new name of the web application.

Example

In the following example, the user changes the name of the application from "application1" to "swac".

```
{
  "name": "application1"
  "new_name": "swac"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.Rename method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
500	Application name already exists	An application with the name already exists. Assign a name that does not exist yet.
501	Application does not exist	An application with this name does not exist.
503	Invalid application name	The name of the application is invalid. Assign an application name that meets the rules for a valid application name (see User-defined web applications (Page 142)).

6.8.5 WebApp.Browse

This method delivers a list of all web applications with the associated properties.

No authorization is required to call the WebApp.Browse method.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-192 WebApp_Browse_Request (object)

Name	Required	Data type	Description
name	No, default is an empty string	string	If this parameter does not exist, all applications will be returned by the method. If the parameter is available, the list will contain only the application whose name matches this parameter. If you have not specified a name, the list may also be empty, depending on whether applications are present or not.

Example

In the following example, the user specifies the name of the "application1" application for the list.

```
{
  "name": "application1"
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-193 WebApp_Browse_Request (object)

Name	Required	Data type	Description
max_applications	Yes	number	Maximum number of applications supported by the CPU
applications	Yes	array of `WebApp_Browse_Application_Response`	List of the applications in the CPU

Table 3-194 WebApp_Browse_Application_Response (object)

Name	Required	Data type	Description
name	Yes	string	The name of the application
state	Yes	string	The status of the application The following values are possible: • "disabled": Pages cannot be reached via HTTP end point • "enabled": Pages can be reached via HTTP end point
type	Yes	string	The type of application The following values are possible: • "user": User-defined • "vot": View of Things (VoT) web application • "system_builtin": Installed system web sites
version	No	string	The version of the application
redirect_mode	Yes	string	Redirect mode The following values are possible: • "redirect" • "forward" You can find more information on the redirect mode User-defined web applications (Page 142).
default_page	No	string	Default web page of the application when no resource name was specified when accessing the web application.
not_found_page	No	string	Substitute page in an application when the requested resource does not exist.
not_authorized_-page	No	string	If the user has tried to access a protected resource to which the user does not have access. This page can be implemented as a login page, for example.

Example 1

In the following example, the user requests responses from the server, for no configured version and for an old loaded project.

```
{
  "max_applications": 4,
  "applications": [
    {
      "name": "application1",
      "state": "enabled",
```

```
      "type": "user",
      "default_page": "index.html",
      "redirect_mode": "redirect"
    },
    {
      "name": "ViewOfThings",
      "state": "enabled",
      "type": "vot",
      "redirect_mode": "redirect"
    }
  ]
}
```

Example 2

In the following example, the user requests responses from the server, for a configured version and for a new project.

```
{
  "max_applications": 4,
  "applications": [
    {
      "name": "application1",
      "state": "enabled",
      "type": "user",
      "version": "V1.23",
      "redirect_mode": "forward",
      "default_page": "index.html"
    },
    {
      "name": "system",
      "state": "enabled",
      "type": "system_builtin",
      "version": "V1.0.0",
      "redirect_mode": "forward"
      "default_page": "index.html",
      "not_found_page": "index.html",
      "not_authorized_page": "index.html"
    }
  ]
}
```

Possible error messages

The following table shows possible error messages of the WebApp.Browse method.

Error code	Error message	Meaning
501	Application does not exist	An application with this name does not exist.

6.8.6 WebApp.SetState

With this method, you activate or deactivate a user-defined web application or a system web page. A deactivated user-defined web application or system web page cannot be called by the HTTP end point.

To call the WebApp.SetState method, you require "manage_user_pages" or "manage_system_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-195 WebApp_SetState_Request (object)

Name	Required	Data type	Description
name	yes	string	Name of the web application whose status is changed
state	yes	string	The status of the application is: • disabled; pages cannot be reached via HTTP end point • enabled; pages can be reached via HTTP end point

Example

In the following example, the user deactivates the application with the name "webapp":

```
{
  "name": "webapp",
  "state": "disabled"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.SetState method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
501	Application does not exist	An application with this name does not exist.

6.8.7 WebApp.SetDefaultPage

With this method, you set a default web page for a user-defined web application. This page is loaded if you have not assigned a resource name when accessing the web application.

To call the WebApp.SetDefaultPage method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-196 WebApp_SetDefaultPage_Request (object)

Name	Required	Data type	Description
name	yes	string	The name of the web application for which the default web page is to be configured
resource_name	yes	string	The name of the resource in the user-defined web application An empty character string indicates that the default web page is to be deleted.

Example

In the following example, the "index.html" page is used as a resource in the "application_1" web application.

```
{
  "name": "application_1",
  "resource_name": "index.html"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.SetDefaultPage method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	The requested resource does not exist in the application. When calling this method, select a resource in the application.
505	Resource visibility must be public	The requested resource is not marked as "public". You should change the resource to "public" or select another resource that is already "public".

6.8.8 WebApp.SetNotFoundPage

With this method, you set a page for a user-defined web application. This page is loaded if you have used a resource name that does not exist when accessing the web application.

To call the WebApp.SetNotFoundPage method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-197 WebApp_SetNotFoundPage_Request (object)

Name	Required	Data type	Description
name	yes	string	The name of the web application whose page must be changed
resource_name	yes	string	The name of the resource in the user-defined web application An empty character string specifies that the PageNotFound page should no longer be set.

Example

In the following example, the "404.html" page is used as a resource in the "application_1" web application.

```
{
  "name": "application_1",
  "resource_name": "404.html"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.SetNotFoundPage method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application. Most methods are only allowed for applications of the type "user", however, not for "vot" or "system_builtin".
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	The requested resource does not exist in the application. When calling this method, select a resource in the application.
505	Resource visibility is not public	The requested resource is not marked as "public". You should change the resource to "public" or select another resource that is already "public".

6.8.9 WebApp.SetNotAuthorizedPage

With this method, you set a publicly visible page for a user-defined web application. This page is loaded if you have used a resource name that cannot be accessed publicly (protected) when accessing the web application, thus accessing the web application without a valid cookie.

You can get a valid cookie using the Api.Login (Page 110) method with the "include_web_application_cookie" parameter.

To call the WebApp.SetNotAuthorizedPage method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-198 WebApp_SetNotAuthorizedPage_Request (object)

Name	Required	Data type	Description
name	yes	string	The name of the web application whose public page must be changed
resource_name	yes	string	The name of the resource in the user-defined web application An empty character string indicates that the non-public page is to be deleted.

Example

In the following example, the "login.html" page is used as a resource in the "application_1" web application.

```
{
  "name": "application_1",
  "resource_name": "login.html"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.SetNotAuthorizedPage method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	The requested resource does not exist in the application. When calling this method, select a resource in the application.
505	Resource visibility must be public	The requested resource is not marked as "public". You should change the resource to "public" or select another resource that is already "public".

6.8.10 WebApp.BrowseResources

This method provides a list of all resources with their properties that are assigned to a web application.

To call the WebApp.BrowseResources method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-199 WebApp_BrowseResources_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application whose list is provided
name	No, default is an empty string	string	If this parameter does not exist, all resources must be returned. Otherwise, the list of returned resources only contains one resource whose name matches this parameter. If no such resource is found, then: • The return list must be empty • It is not an error

Example

In the following example, the user specifies the name of the "application1" application for the list.

```
{
  "app_name": "application_1"
}
```

Response structure

The following tables show the structure of the server response to a successful request.

Table 3-200 WebApp_BrowseResources_Response (object)

Name	Required	Data type	Description
max_resources	yes	number	Maximum number of resources supported by the CPU.
resources	yes	array of WebApp_BrowseResources_Resource_Response	List of the resources in the specific application.

Table 3-201 WebApp_BrowseResources_Resource_Response (object)

Name	Required	Data type	Description
name	yes	string	The name of the resource.
size	yes	integer	The size of the resource in bytes.
media_type	yes	string	The media type of the resource.
etag	No	string	The ETag value of the resource.
visibility	yes	string	The visibility of the resource.
last_modified	yes	string	ISO8601 time stamp as string. The time stamp of the last modification.

Example

In the following example, the user requests responses from the server.

```
{
  "max_resources": 300,
  "resources":
  [
    {
      "name": "index.html",
      "size": 24387,
      "media_type": "text/html",
      "etag": "896a9s8df0897g098a",
      "visibility": "public",
      "last_modified": "2020-08-24T07:08:06Z"
    },
    {
      "name": "secret.js",
      "size": 97826348,
      "media_type": "application/javascript",
      "visibility": "protected",
      "last_modified": "2020-08-24T07:08:06Z"
    }
  ]
```

```
}
```

NOTE

For the CPUs up to firmware version V3.1, the limit of resources is (`max_resources`) 200.

As of firmware version V4.0 the limit is set to 300, in as far as the loaded project is based on V4.0 or higher.

Possible error messages

The following table shows possible error messages of the WebApp.BrowseResources method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. When calling this method, select a resource in the application.

6.8.11 WebApp.CreateResource

With this method, you create a new resource in a user-defined web application on the CPU.

To call the WebApp.CreateResource method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-202 WebApp_CreateResource_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application (Page 142) for which a resource must be created
name	yes	string	The name of the resource (Page 142) that is uploaded
media_type	yes	string	The media type of the resource (Page 142).
visibility	No; the default value is "`public`"	string	The visibility of the resource (Page 169).
etag	no; the default value is an empty character string	string	The ETag value of the resource (Page 170).
last_modified	yes	string	ISO8601 time stamp as string The time stamp of the last modification.

Example

In the following example, the user creates a new resource "index.html" of the application "application_1" with the media type "text/html".

```
{
  "app_name": "application_1",
  "name": "index.html",
  "media_type": "text/html",
  "last_modified": "2020-08-24T07:08:06Z"
}
```

Response structure

This method returns a character string that includes a valid ticket ID. The user uses this ticket to upload the content of the resource to the CPU using the ticket end point.

NOTE

You can create a maximum of one WebApp.CreateResource ticket. You can create a new ticket for this method only after this ticket has been closed.

Example

The following example shows a response for ticket ID.

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

An example of further processing of the ticket ID can be found in the Ticket mechanism (Page 126) section.

Possible error messages

The following table shows possible error messages of the WebApp.CreateResource method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
4	No resources	You have exhausted all tickets in this user session or already have a ticket for WebApp.CreateResource that has not yet been closed. Close existing tickets to free up resources. Then call the method again.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
507	Resource alredy exists	A resource with the specified name already exists for this application. Select a new resource name or delete/rename the resource before you call this method.

Error code	Error message	Meaning
508	Invalid resource name	The resource name is invalid. Correct the resource name (Page 142) before you call this method.
509	Resource limit reached	The maximum number of resources has been exhausted for this application. Delete some resources before you call this method.
511	Invalid modification time	The planned modification time is not within the permissible time window of the modification time. Reduce the modification time accordingly before you call this method.
512	Invalid media type	The media type is invalid. Correct the media type (Page 142) before you call this method.
513	Invalid ETag	The ETag value is invalid. Correct the ETag value (Page 170) before you call this method.

6.8.12 WebApp.DeleteResource

With this method, you can delete a resource from a specific web application.

To call the WebApp.DeleteResource method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-203 WebApp_DeleteResource_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the user-defined web application from which the resource is to be deleted
name	yes	string	The name of the resource that is to be deleted

Example

In the following example, the user deletes the resource "img/wrong.png" of the application "application1".

```
{
  "app_name": "application1",
  "name": "img/wrong.png"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.DeleteResource method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
3	System is busy	The desired operation cannot be performed because the system is currently performing a different request. Restart the query as soon as the current operation is complete.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with the specified name does not exist. When calling this method, select a resource in the application.

6.8.13 WebApp.RenameResource

With this method, you change the name of a resource in a specific web application.

To call the WebApp.RenameResource method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-204 WebApp_RenameResource_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the user-defined web application in which the name of the resource is changed
name	yes	string	The name of the resource that is changed
new_name	yes	string	The new name of the resource.

Example

In the following example, the user changes the name of the resource to "corrspelled.gif" in the "application1" application.

```
{
  "app_name": "application1",
  "name": "msspelled.png",
  "new_name": "corrspelled.gif"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.RenameResource method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. When calling this method, select a resource in the application.
507	Resource already exists	A resource with the new name already exists for this application. Select a new resource name or delete/rename the resource before you call this method.
508	Invalid resource name	The new resource name is invalid. Correct the resource name (Page 142) before you call this method.

6.8.14 WebApp.DownloadResource

With this method, you can load a resource to a user-defined web application from the CPU.

To call the WebApp.DownloadResource method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-205 WebApp_DownloadResource_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application that contains the resource
name	yes	string	The name of the resource that is downloaded

Example

In the following example, the user downloads the resource "secrets.pdf" of the application "application_1".

```
{
  "app_name": "application_1",
  "name": "secrets.pdf"
}
```

Response structure

This method returns a character string that includes a valid ticket ID. The user uses this ticket to download the content of the resource from the CPU using the ticket end point.

NOTE

You can create a maximum of one WebApp.DownloadResource ticket at the same time.

Example

The following example shows a response for ticket ID.

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

An example of further processing of the ticket ID can be found in the Ticket mechanism (Page 126) section.

Possible error messages

The following table shows possible error messages of the WebApp.DownloadResource method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
4	No resources	You have exhausted all tickets in this user session or already have a ticket for WebApp.DownloadResource that has not yet been closed. Close existing tickets to free up resources. Then call the method again.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. Select a resource name that exists in the application before you call the method.
514	Resource content has been corrupted	The file content has been damaged as a result of file manipulations in the SIMATIC load memory. You can rectify the damage by deleting and recreating the resource file via the API.
504	Resource content is not ready	The content of the resource is not yet ready because it is currently being uploaded. Wait until the upload has finished.

6.8.15 WebApp.SetResourceVisibility

With this method, you change the visibility of a resource, public or protected, in a user-defined web application. A protected resource cannot be called by the HTTP end point without authentication.

To call the WebApp.SetResourceVisibility method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-206 WebApp_SetResourceVisibility_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application that contains the resource
name	yes	string	The name of the resource that is changed
visibility	yes	string	The visibility of the resource. The following values are possible: public: public protected: only for authorized users An example with a set cookie "web_application_cookie" for access to protected web applications can be found in section Example: Web page for monitoring and controlling a wind turbine (https://support.industry.siemens.com/cs/ww/en/view/107623221/71849212939).

Example

In the following example, the user sets the "secrets.html" resource of the "myapp" application to "protected":

```
{
  "app_name": "myapp",
  "name": "secrets.html",
  "visibility": "protected"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.SetResourceVisibility method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. Select a resource name that exists in the application before you call the method.
505	Resource visibility must be public	The respective resource is referenced: • as default web page • as a non-authorized page or • as page not found You cannot mark the resource as protected. You must set the visibility in the application to "public" before calling this method.

6.8.16 WebApp.SetResourceETag

With this method, you change or delete the ETag attribute that is returned when accessing the resource via the HTTP header. ETag (Entity Tag) is an HTTP header field. It only serves to determine changes at the requested resource and is used to avoid redundant data transfers.

To call the WebApp.SetResourceETag method, you require "manage_user_pages" authorization.

Rules for a valid ETag value

You can use any character string as an ETag value as seen in the example below. The length is limited to a maximum of 128 characters.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-207 WebApp_SetResourceETag_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application that contains the resource
name	yes	string	The name of the resource that is to be changed.
etag	yes	string	The ETag value of the resource. An empty character string indicates that the value is to be deleted.

Example

In the following example, the user sets the ETag value to "09as7df09h8j23r" for the "secrets.html" resource in the "myapp" application.

```
{
  "app_name": "myapp",
  "name": "secrets.html",
  "etag": "09as7df09h8j23r"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.SetResourceETag method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. Select a resource name that exists in the application before you call the method.
513	Invalid ETag	The ETag value is invalid. Correct the value before you call this method.

6.8.17 WebApp.SetResourceMediaType

With this method, you change the media type of a resource in a user-defined web application.

To call the WebApp.SetResourceMediaType method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-208 WebApp_SetResourceMediaType_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application that contains the resource
name	yes	string	The name of the resource that is changed
media_type	yes	string	The media type of the resource (Page 142).

Example

In the following example, the user sets the media type to "image/jpeg" for the "secrets.jpg" resource in the "myapp" application.

```
{
  "app_name": "myapp",
  "name": "secrets.jpg",
  "media_type": "image/jpeg"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.SetResourceMediaType method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.

Error code	Error message	Meaning
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. Select a resource name that exists in the application before you call the method.
512	Invalid media type	The media type is invalid. Correct the media type (Page 142) before you call this method.

6.8.18 WebApp.SetResourceModificationTime

With this method, you set the modification time of a resource in a user-defined web application.

To call the WebApp.SetResourceModificationTime method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-209 WebApp_SetResourceModificationTime_Request (object)

Name	Required	Data type	Description
app_name	yes	string	The name of the web application that contains the resource
name	yes	string	The name of the resource that is changed
last_modified	yes	string	ISO8601 time stamp as a string; the time stamp of the last change

Example

In the following example, the user sets the modification time to "24.08.2020 07:08:06" for the "secrets.html" resource in the "myapp" application:

```
{
  "app_name": "myapp",
  "name": "secrets.html",
  "last_modified": "2020-08-24T07:08:06Z"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.SetResourceModificationTime method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because it is not supported for this application.
501	Application does not exist	An application with this name does not exist.
506	Resource does not exist	A resource with this name does not exist. Select a resource name that exists in the application before you call the method.
511	Invalid modification time	The planned modification time is not within the permissible time window of the modification time. Reduce the modification time accordingly before you call this method.

6.8.19 WebApp.SetVersion

With this method, you assign a version of the user-defined web application as a string.

To call the WebApp.SetVersion method, you require "manage_user_pages" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-210 WebApp_SetVersion_Request (object)

Name	Required	Data type	Description
name	yes	string	The name of the web application in which the resource is located.
version	yes	string	The version of the resource in the user-defined web application. An empty character string specifies that the version is to be reset. See section User-defined web applications (Page 142) for rules for a valid version number.

Example

In the following example, the user assigns the version "V1.2" to the application with the name "myapp".

```
{
  "name": "myapp",
  "version": "V1.2"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.SetVersion method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read only	The system is currently in a write-protected state. Changes to web applications are currently not permitted.
6	Not accepted	The method cannot be executed because this method of the application is not supported either for this application type or for the loaded project version.
501	Application does not exist	An application with this name does not exist.
510	Invalid version string	The version string entered by the user does not fulfill the criteria for valid version strings.

6.8.20 WebApp.SetUrlRedirectMode

With this method, you can set the Redirect mode for default web page, non-authorized page and non-found page.

To call the WebApp.SetUrlRedirectMode method, you require the "manage_user_pages" authorization.

You can find more information on the Redirect mode in the section User-defined web applications (Page 142).

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-211 WebApp_SetUrlRedirectMode_Request (object)

Name	Required	Data type	Description
name	Yes	string	The application where you change the Redirect mode.
redirect_mode	Yes	string	Redirect mode of the application.

Example

The following example shows a changed Redirect mode.

```
{
  "name": "myapp",
  "redirect_mode": "redirect"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Example

The following example shows a response of the CPU.

```
true
```

Possible error messages

The following table shows possible error messages of the WebApp.SetUrlRedirectMode method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read-only	The memory card is write-protected. Therefore, the file cannot be changed.
6	Not accepted	The method cannot be executed because this method of the application is not supported either for this application type or for the loaded project version.
501	Application does not exist	An application with this name does not exist.

6.9 Reading and writing process data

6.9.1 Supported data types

Binary representation

The Web API represents the values of simple data types as pure binary data ("raw"). The binary data is formatted as a JSON array. Each element within an array represents a single data byte.

Simple display ("simple")

The Web API formats simple data types into a readable form while retaining the ability to process the data using a program. The following section describes how simple data types are represented as JSON data type.

Supported data types

The following table shows:

- The data types supported by the Web API for reading and writing process values
- The visualization in the Web API
- The respective match of the data type in the TIA Portal

Name of the data type in the TIA Portal	Name of the data type in the Web API	Visualization in Web API
Bool	bool	Boolean JSON value: **true** or **false**
Byte	Byte	JSON unsigned integer in a range from 0 to 255
USInt	usint	
Word	word	JSON unsigned integer in a range from 0 to 65 535
UInt	uint	
HW_ANY	hw_any	
HW_IOSYSTEM	hw_iosystem	
HW_DPMASTER	hw_dpmaster	
HW_DEVICE	hw_device	
HW_DPSLAVE	hw_dpslave	
HW_IO	hw_io	
HW_MODULE	hw_module	
HW_SUBMODULE	hw_submodule	
HW_HSC	hw_hsc	
HW_PWM	hw_pwm	
HW_PTO	hw_pto	
HW_INTERFACE	hw_interface	
HW_IEPORT	hw_ieport	
CONN_ANY	conn_any	
CONN_PRG	conn_prg	
CONN_OUC	conn_ouc	
PORT	port	
RTM	rtm_id	
PIP	pip	
DB_ANY	db_any	
DB_WWW	db_www	
DB_DYN	db_dyn	
DWord	dword	JSON unsigned integer in a range from 0 to

Name of the data type in the TIA Portal	Name of the data type in the Web API	Visualization in Web API
UDInt	udint	4 294 967 295
AOM_IDENT	aom_ident	
EVENT_ANY	event_any	
EVENT_ATT	event_att	
EVENT_HWINT	event_hwint	
CONN_R_ID	conn_r_id	
LWord	lword	JSON string with a numerical representation of an unsigned integer based on the number 10 in a range from 0 to 18 446 744 073 709 551 615
ULInt	ulint	
SInt	sint	JSON signed integer in a range from -128 to 127
Int	int	JSON signed integer in a range from -32 768 to 32 767
OB_ANY	ob_any	
OB_DELAY	ob_delay	
OB_TOD	ob_tod	
OB_CYCLIC	ob_cyclic	
OB_ATT	ob_att	
OB_PCYCLE	ob_pcycle	
OB_HWINT	ob_hwint	
OB_DIAG	ob_diag	
OB_TIMEERROR	ob_timeerror	
OB_STARTUP	ob_startup	
OPC_UA_LocalizedTextEncoding-Mask	opc_ua_localizedtextencodingm-ask	JSON unsigned integer in a range from 0 to 255
OPC_UA_ByteStringActualLength	opc_ua_bytestringactuallength	JSON unsigned integer in a range from 0 to 4 294 967 295
DInt	dint	JSON signed integer in a range from -2 147 483 648 to 2 147 483 647.
LInt	lint	JSON string with a numerical representation of an unsigned integer based on the number 10 in a range from -9 223 372 036 854 775, 808 to 9 223 372 036 854 775 807
Real	real	JSON floating-point number If the floating-point number is infinite or NaN (not-a-number), the Web API returns the value **null** when reading a tag of this type.
LReal	lreal	
Char	char	JSON string with a single ASCII character in a valid range from 0 to 127 If a tag of this type is read with a value outside the valid range, the Web API returns the value **null**.
WChar	wchar	JSON string with a UTF-8 string that represents a single UCS-2 character in a valid range from 0 to 55 295. If a tag of this type is read with a value outside the valid range, the Web API returns the value **null**.

Name of the data type in the TIA Portal	Name of the data type in the Web API	Visualization in Web API
String	string	JSON string with a UTF-8 string If a tag of this type is read with a value outside the valid UTF-8 string (max. length 254 characters), the Web API returns the value **null**.
WString	wstring	JSON string with a UTF-8 string that represents a USC-2 string in a valid range from 0 to 55 295. If a tag of this type is read with a value outside the valid range (max. length 254 characters), the Web API outputs the value **null**.
Date	date	JSON unsigned integer in a range from 0 to 65 535 This value represents the number of days since 01.01.1990.
Time_Of_Day	time_of_day	JSON unsigned integer in a range from 0 to 4 294 967 295 This value represents the number of milliseconds since the beginning of the day.
LTime_Of_Day	ltime_of_day	JSON string with a numerical representation of an unsigned integer based on the number 10 in a range from 0 to 18 446 744 073 709 551 615 This value represents the number of nanoseconds since the beginning of the day.
Time	time	JSON signed integer in a range from -2 147 483 648 to 2 147 483 647) This value represents the number of milliseconds since a user-defined point in time.
LTime	ltime	JSON string with a numerical representation of an unsigned integer based on the number 10 in a range from -9 223 372 036 854 775 808 to 9 223 372 036 854 775 807 This value represents the number of nanoseconds since a user-defined point in time.
S5Time	s5time	JSON object with the keys **basis** and **value**: • The **basis** value is a JSON Unsigned Integer with a value of either 10, 100, 1000, or 10 000. The value **basis** represents the millisecond multiplier of the value **value**. • The value **value** is a JSON unsigned integer in the range from 0 to 999. The value **basis** multiplied by the value **value** gives the timer interval in milliseconds.

Name of the data type in the TIA Portal	Name of the data type in the Web API	Visualization in Web API
Date_And_Time	date_and_time	JSON object with the keys **year**, **month**, **date**, **hour**, **minute**, **second**, and **day_of_week**: • **year** is a JSON unsigned integer with a value in the range from 1 990 to 2 089 • **month** is a JSON unsigned integer with a value in the range 1 to 12 • **day** is a JSON unsigned integer with a value in the range 1 to 31 • **hour** is a JSON unsigned integer with a value in the range 0 to 23 • **minute** is a JSON unsigned integer with a value in the range 0 to 59 • **second** is a JSON floating point number with a value in the range 0 to 60 • **day_of_week** is a JSON string with a value of either **sun**, **mon**, **tue**, **wed**, **thu**, **fri**, or **sat**
LDT	ldt	JSON string with a numerical representation of an unsigned integer based on the number 10 in a range from 0 to 18 446 744 073 709 551 615 This value represents the number of nanoseconds since 01.01.1970 midnight (12:00:00.0 am).
Struct	struct	Structured data type whose data structure can be determined using the PlcProgram.Browse method.
IEC_COUNTER	iec_counter	
IEC_TIMER	iec_timer	
DTL	dtl	
IEC_LTIMER	iec_ltimer	
IEC_SCOUNTER	iec_scounter	
IEC_DCOUNTER	iec_dcounter	
IEC_LCOUNTER	iec_lcounter	
IEC_UCOUNTER	iec_ucounter	
IEC_USCOUNTER	iec_uscounter	
IEC_UDCOUNTER	iec_udcounter	
IEC_ULCOUNTER	iec_ulcounter	
ERROR_STRUCT	error_struct	
NREF	nref	
CREF	cref	

Arrays

Arrays are displayed as JSON objects. The key is a string with a numeric representation of the index.

The following example shows the representation in the TIA Portal:

User data type_2

	Name	Data type	Default value	Accessible from HMI/OPC UA
1	ExampleArray	Array[0..1, 10..12] of Byte		☑
2	ExampleArray[0,10]	Byte	1	☑
3	ExampleArray[0,11]	Byte	2	☑
4	ExampleArray[0,12]	Byte	3	☑
5	ExampleArray[1,10]	Byte	4	☑
6	ExampleArray[1,11]	Byte	5	☑
7	ExampleArray[1,12]	Byte	6	☑

Figure 3-225 Display in the TIA Portal

Addressing the user data

The Web API supports the following addressing formats:

- Symbolic addressing of a tag in the tag table, e.g. Tag_1
- Symbolic addressing of a tag in a data block, e. g. "MyDB".Static_1

6.9.2 Parameter assignment of the block properties

Configuring access to the Web API in the TIA Portal

To restrict the read and write access to data blocks of your project, you can define the desired parameters in the attributes of the respective block.

To allow the Web API to access the data block, select the "Data block accessible from web server" check box.

NOTE

F-blocks

Note that fail-safe blocks allow read access only. It is not possible to write tags into fail-safe blocks.

Parameter assignment for access to the Web API in tag tables

For read and write access of Web API to tags, the options "Accessible from HMI/OPC UA/Web API" and "Writable from HMI/OPC UA/Web API" must be activated:

Tag table_1

	Name	Data type	Address	Retain	Accessible from HMI/OPC UA	Writable from HMI/OPC UA
1	Lint	LInt	%M99.0	☐	☑	☑
2	word	Word	%MW100	☐	☑	☑
3	MyTimer1	Timer	%T15	☐	☑	☑
4	MyCounter1	Counter	%C16	☐	☑	☑
5	MyTimer2	S5Time	%MW1000	☐	☑	☑
6	<Add new>			☐	☑	☑

Figure 3-226 Tag table in the TIA Portal

6.9.3 PlcProgram.Read

Use this method to read a single tag from a CPU.

To call the PlcProgram.Read method, you require the "read_value" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-212 PlcProgram_Read_Request (object)

Name	Required	Data type	Description
var	Yes	string	Name of the tag to be read. The name must not be empty.
mode	no, default is "simple"	string	Enumeration that determines the response format for this method: • "simple"*: Returns tag values according to the "simple" representation (see section Supported data types (Page 176)) • "raw": Returns tag values according to the "raw" representation (see section Supported data types (Page 176))
* The values of the data type Real or LReal are returned as a floating-point number in mode = "simple" with the highest accuracy in each case. If you want to apply the values, use mode = "raw" instead.			

Example 1

In the following example, the user requests a global tag in the "simple" representation.

```
{
  "var": "\"MotorSpeed\""
}
```

Example 2

In the following example, the user requests a data block tag in the "raw" representation.

```
{
  "var": "\"MyDB\".MyVariable",
  "mode": "raw"
}
```

Response structure

If the request to the server was successful, the server returns JSON data values.

Example 1

The following example shows the result of reading in a tag of type "int" in the "simple" representation.

```
-42
```

Example 2

The following example shows the result of reading in a printable tag of the type "char" in the "simple" representation.

```
m
```

Example 3

The following example shows the result of reading in a non-printable tag of the type "char" in the "simple" representation.

```
u0001
```

Example 4

The following example shows the result of reading in a tag of type "dword" in the "raw" representation.

```
[ 1, 47, 233, 0 ]
```

Possible error messages

The following table shows the possible error messages of the PlcProgram.Read method.

Error code	Error message	Meaning
1	Internal error	An internal error in the desired operation
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

Error code	Error message	Meaning
4	No resources	The system does not have the necessary resources to read the requested address. Perform the request once more as soon as enough resources are available again.
200	Address does not exist	The requested address does not exist or the Web server cannot access it.
201	Invalid address	The name structure of the symbolic address is not correct.
203	Invalid array index	The dimensions and limits of the array indexes do not correspond to the type information of the CPU.
204	Unsupported address	The data type of the address cannot be read.

NOTE

Tag access with the methods PlcProgram.Read, PlcProgram.Write, and PlcProgram.Browse

With these methods it is not yet possible to access all tags in firmware version V3.0.

There are selective restrictions when reading tags of technology objects. If access to specific tags is not possible, the API returns the message "unsupported".

6.9.4 PlcProgram.Write

This method is used to write a single process tag to the CPU.

To call the PlcProgram.Write method, you require "write_value" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-213 PlcProgram_Write_Request (object)

Name	Required	Data type	Description
var	yes	string	Name of the tag to be written.
value	yes	variant	The value to be written. The value depends on the operating mode.
mode	no, default is "simple"	string	Enumeration that specifies the format of "value": • "simple": The user must specify the values according to the "simple" representation (see section Supported data types (Page 176)) • "raw": The user must specify the values according to the "raw" representation (see section Supported data types (Page 176))

Example 1

In the following example, the user writes a global tag in the "simple" display.

```
{
  "var": "\"MotorSpeed\"",
  "value": 9001
}
```

Example 2

In the following example, the user writes a tag to a data block in the "raw" representation.

```
{
  "var": "\"MyDB\".MyVariable",
  "value": [ 255, 77, 1, 99 ],
  "mode": "raw"
}
```

Example 3

In the following example, the user writes a string tag consisting of 10 characters to the "simple" representation.

```
{
  "var": "\"MyDB\".MyString",
  "value": "Short Str",
  "mode": "simple"
}
```

Example 4

In the following example, the user writes a string tag consisting of 10 characters with the text "Short Str" in the "raw" representation.

```
{
  "var": "\"MyDB\".MyString",
  "value": [ 10, 9, 83, 104, 111, 114, 116, 32, 83, 116, 114, 0 ],
  "mode": "raw"
}
```

Example 5

In the following example, the user writes a Wstring tag consisting of 6 characters in the "simple" representation.

```
{
  "var": "\"MyDB\".MyWString",
  "value": "Hello",
  "mode": "simple"
}
```

Example 6

In the following example, the user writes a string tag consisting of 6 characters with the text "Hello" in the representation "raw".

```
{
  "var": "\"MyDB\".MyWString",
  "value": [ 0, 6, 0, 5, 0, 72, 0, 101, 0, 108, 0, 108, 0, 111, 0, 0
],
  "mode": "raw"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows possible error messages of the PlcProgram.Write method.

Error code	Error message	Meaning
1	Internal error	An internal error in the desired operation
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
4	No resources	The system does not have the necessary resources to write the requested address. Perform the request again as soon as enough resources are available again.
200	Address does not exist	The requested address does not exist or the Web server cannot access the requested address.
201	Invalid address	The name structure of the symbolic address is not correct.
203	Invalid array index	The dimensions and limits of the array indexes do not correspond to the type information of the CPU.
204	Unsupported address	The data type of the address cannot be written.

NOTE

Tag access with the methods PlcProgram.Read, PlcProgram.Write, and PlcProgram.Browse

With these methods it is not yet possible to access all tags in firmware version V3.0.

There are selective restrictions when reading tags of technology objects. If access to specific tags is not possible, the API returns the message "unsupported".

6.9.5 PlcProgram.DownloadProfilingData

S7-1500 CPUs as of firmware version V3.1 support profiling. The PlcProgram.DownloadProfilingData method supplies you with detailed runtime data for the user program in the CPU. The API method returns a ticket that you use to download the runtime data from the CPU. You can evaluate and graphically display the information later in order to analyze the program flow.

This information assists you in the following tasks:

- Runtime optimization of the user program
- Error diagnostics
- Evaluating the power reserve of the automation system
- Quality assurance of the application

To call the PlcProgram.DownloadProfilingData API method, you require the "read_value" authorization.

For more information about the ticket mechanism, see the Ticket mechanism (Page 126) section.

Response structure

If successful, the method returns a string with a ticket ID. You can use this ticket ID to download the runtime data from the CPU.

Example

The following example shows a generated ticket ID for downloading the runtime data.

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

File name

The file name for downloading the runtime data to a web browser is structured as follows:

`[project_name]_[module_name]_YYYY-MM-DD_HH-mm-ss_profiling.bin`

Example: `[1500_example01]_[plc_1]_2023-11-03_12-20-05_profiling.bin`

The file name is returned as an HTTP Content-Disposition header in the server response.

Structure and contents of the file

The file contains a list of entries in which the byte sequence of each entry is based on a specific entry type. The first byte of an entry in each case contains the entry type.

Table 3-214 Block events

Byte	0	1	2	3
0	Entry type	Block type	Block number	
4	Number of OB currently being executed in the program		Call hierarchy of the OB	Priority of the OB
8	Time stamp in 10^{-12} seconds			
12				

The entry types of the following table are supported.

Table 3-215 Entry type

Value	Entry type
0x00	Invalid
0x01	Block event: Start of a block
0x02	Block event: End of a block
0x10	Read process image partition
0x11	Write process image partition
0x20	Direct read access
0x21	Direct write access
0x30	Error ID
0x31	Communication load and cycle time

Entry type: Block events

The file is structured as follows:

The following table explains the meaning of the possible block types:

Table 3-216 Block type

Value	Block type
0x00	Invalid
0x01	Organization block (OB)
0x02	Function (FC)
0x03	Function block (FB)
0x11	System function (SFC)
0x12	System function block (SFB)

The following table provides an example for block events:

Table 3-217 Example for block events

Byte	0	1	2	3
0	0x01	0x02	0x12	0x00
4	0x01	0x00	0x01	0x01
8	0x08	0x07	0x06	0x05
12	0x04	0x03	0x02	0x01

0x01: Start of a block
0x02: Block type = FC
0x0012: Block number = 18
0x0001: OB number = 1
0x01: Call hierarchy of the OB = 1
0x01: Priority of the OB = 1
0x0102030405060708: Time stamp

Entry type: Read/write process image partition

The file is structured as follows:

Table 3-218 Read/write process image partition

Byte	0	1	2	3
0	Entry type	-	Process image partition number	
4	-	-	-	Priority of the OB
8	Time stamp in 10^{-12} seconds			
12				

The following table provides an example for read process image partition:

Table 3-219 Example for read/write process image partition

Byte	0	1	2	3
0	0x10	-	0x01	0x00
4	-	-	-	0x01
8	0x08	0x07	0x06	0x05
12	0x04	0x03	0x02	0x01

0x10: Read process image partition
0x0001: Process image partition number = 1
0x01: Priority of the OB = 1
0x0102030405060708: Time stamp

Entry type: Direct read/write access

The file is structured as follows:

Table 3-220 Direct read/write access

Byte	0	1	2	3
0	Entry type	Event type	DB number	
4	-			Priority of the OB
8	Time stamp in 10^{-12} seconds			
12				

The following table explains the meaning of the possible entry types for direct I/O access:

Table 3-221 Event type

Value	Event type
0x00	Invalid
0x01	I/O
0x02	Motion Control
0x03	Diagnostics

The following table provides an example for direct reading:

Table 3-222 Example for direct reading

Byte	0	1	2	3
0	0x20	0x02	0x12	0x00
4	-	-	-	0x01
8	0x08	0x07	0x06	0x05
12	0x04	0x03	0x02	0x01

0x20: Direct reading
0x02: Motion Control = 2
0x0012: DB number = 18
0x01: Priority of the OB = 1
0x0102030405060708: Time stamp

Entry type: Error ID

The file is structured as follows:

Table 3-223 Entry in the diagnostics buffer

Byte	0	1	2	3
0	Entry type	-	Error type	
4	-	-	-	-
8	Time stamp in 10^{-12} seconds			
12				

The following table provides an example for a diagnostics buffer entry:

Table 3-224 Example for diagnostics buffer entry

Byte	0	1	2	3
0	0x30	-	0x42	0x29
4	-	-	-	-
8	0x08	0x07	0x06	0x05
12	0x04	0x03	0x02	0x01

0x30: Entry in the diagnostics buffer
0x2942: Error type = I/O read access error
0x0102030405060708: Time stamp

Entry type: Communication load and cycle time

The file is structured as follows:

Table 3-225 Entry in the diagnostics buffer

Byte	0	1	2	3
0	Entry type	-	Communication load in %	
4	Last cycle time in µs			
8	Time stamp in 10^{-12} seconds			
12				

The following table provides an example for the communication load:

Table 3-226 Example for communication load

Byte	0	1	2	3
0	0x31	-	0x12	0x00
4	0x03	0x02	0x01	0x00
8	0x08	0x07	0x06	0x05
12	0x04	0x03	0x02	0x01

0x31: Communication load and cycle time
0x0012: Communication load = 18%
0x00010203: Last cycle time = 66051µs
0x0102030405060708: Time stamp

Possible error messages

The following table shows possible error messages of the PlcProgram.DownloadProfilingData method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
4	No resources	You have exhausted all tickets in this user session. Close existing tickets to free up resources. Then call the method again.
1401	Motion functionality is currently active	It is not possible to download profiling data because the motion functions are used.

Further processing of runtime data

"SIMATIC Controller Profiling (https://support.industry.siemens.com/cs/ww/en/view/109750245)" allows you to analyze and evaluate the runtime behavior of your user program of a CPU as of firmware version V3.1. You can display and analyze all relevant information graphically with Google Chrome.

NOTE

R/H-CPUs

Profiling is available at the R/H-CPUs as of V4.0.

You read out the data from the CPU with "SIMATIC Controller Profiling" and generate a compressed trace file in JSON format for analysis with the Chrome web browser.

You can also find examples of using API methods in practice on Github under the following repository (https://github.com/siemens/simatic-s7-webserver-api).

6.9.6 PlcProgram.Browse

This method allows you to search for tags and the corresponding metadata according to your individual requirements.

To call the PlcProgram.Browse method, you require the "read_value" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-227 PlcProgram_Browse_Request (object)

Name	Required	Data type	Description
var	Yes/no, see "Description" column	string	Name of the tag to be searched. If this attribute is present, it cannot be an empty string. • If "mode" = "var", then this attribute is required. The Browse method searches for the provided tag to retrieve the metadata of the tag. • If "mode" = "children", this attribute is optional. The Browse method searches for the tag and returns a list of child tags and metadata.

Name	Required	Data type	Description
mode	Yes	string	Enumeration that determines the behavior of this method: • "var": Displays information about the specified tag. • "children": Outputs information about the immediate descendants (children) of the specified tags.
type	No	array of string	Possible array entries are: • "code_blocks": Reads out all code blocks • "data_blocks": Reads out all data blocks • "tags": Reads out all tags If no "type" parameter is selected for compatibility reasons, only DBs and tags are returned.

Example 1

In the following example, the user searches the root node ("root") of the CPU.

```
{
  "mode": "children"
}
```

Example 2

In the following example, the user searches the descendants (children) of a data block.

```
{
  "var": "\"MyDB\"",
  "mode": "children"
}
```

Example 3

In the following example, the user requests information about a specific tag.

```
{
  "var": "\"MyDB\".MyStruct.MyField",
  "mode": "var"
}
```

Example 4

In the following example, the user searches code blocks of a CPU.

```
{
  "mode": "children",
  "type": ["code_blocks"]
}
```

Example 5

In the following example, the user searches the data blocks of a CPU.

```
{
  "mode": "children",
  "type": ["data_blocks"]
}
```

Example 6

In the following example, the user searches the data blocks, code blocks, and tags of a CPU.

```
{
  "mode": "children",
  "type": ["data_blocks, "code_blocks", "tags"]
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-228 PlcProgram_Browse_Response (array of objects)

Name	Required	Data type	Description
name	Yes	string	Tag name; can be used as a string identifier for the field.
address	No	string	Address of the tag in STEP 7; only applicable for the tags in the ranges M, I, Q, timer and counter and tags in non-optimized data blocks. The representation corresponds to the addresses in the watch tables in the TIA Portal.
read_only	No	bool	Query whether the tag is read-only. The only valid value is "true". If the tag is to be written, this attribute does not appear.
has_children	No	bool	Query whether the tag is a structured tag with child tags. The only valid value is "true". If the tags are an unstructured data type, this attribute is not displayed.
db_number	No	number	Numerical data block identifier Appears when "datatype" = "datablock" and for each child element of a data block (with corresponding data block number).
area	No	string	Letter which defines the range (M/I/Q/timer/counter) of the tag. If the tag is not in one of these ranges, the attribute does not appear.
datatype	Yes	string	Data type of the tag For data blocks, this is the "datablock" data type; for tags, see the table in the section Supported data types (Page 176). If the data type is not supported, the data type is "unsupported".
max_length	No	number	If the data type is a "string" or "wstring", this value is the maximum number of characters allowed in the tag.

Name	Required	Data type	Description
array_dimensions	No	array of data type `PlcProgram_Browse_Response_ArrayData`	Object array, arranged from the most significant to the least significant array dimension. The attribute is only displayed if the tag is an array.
block_number	No	number	Number of the logic block
block_type	No	string	The type of the logic block: • "ob" • "fc" • "fb" • "sfc" • "sfb"

Table 3-229 PlcProgram_Browse_Response_ArrayData (array of objects)

Name	Required	Data type	Description
start_index	Yes	integer	Start index for this array dimension, as specified in the TIA Portal project.
count	Yes	integer	Number of elements in this array dimension

Example 1

The following example shows the result of searching the root node "root" of the CPU without code blocks. If the "type" parameter does not exist, only data blocks and tags are output.

```
[
  {
    "name": "TestDB",
    "has_children": true,
    "db_number": 2,
    "datatype": "datablock"
  },
  {
    "name": "GenUsrMsg_Ret",
    "address": "%MW43",
    "area": "M",
    "datatype": "int"
  }
]
```

Example 2

The following example shows the result of searching the descendants (children) of the data block "`MyDB`" with `db_number` = 1.

```
[
  {
    "name": "Static_1",
    "db_number": 1,
```

```
    "datatype": "int"
  },
  {
    "name": "Static_2",
    "db_number": 1,
    "datatype": "int"
  }
]
```

Example 3

The following example shows the result of querying information via a specific tag.

```
[
  {
    "name": "MyDateTimeValue",
    "db_number": 2,
    "datatype": "date_and_time",
    "array_dimensions": [
      {
        "start_index": 0,
        "count": 3
      }
    ]
  }
]
```

Example 4

The following example shows the result of searching the data blocks at the CPU.

```
[
  {
    "name": "TestDB",
    "block_number": 2,
  },
  {
    "name": "MotorControlConveyorDB",
    "block_number": 23,
  }
]
```

Example 5

The following example shows the result of searching the code blocks at the CPU.

```
[
  {
    "name": "MainOB",
    "block_number": 1,
    "block_type": "ob"
  },
  {
    "name": "MotorControlConveyor",
    "block_number": 23,
    "block_type": "fb"
  }
  {
    "name": "CREATE_DB",
    "block_number": 86,
    "block_type": "sfc",
  }
  {
    ...
  }
]
```

Example 6

The example below shows the result of searching the root node "root" of the CPU with data blocks, code blocks and tags, when the parameter "type" and all 3 possible array entries "data_blocks", "code_blocks" and "tags" are selected.

```
[
  {
    "name": "TestDB",
    "has_children": true,
    "db_number": 2,
    "datatype": "datablock"
  },
  {
    "name": "GenUsrMsg_Ret",
    "address": "%MW43",
    "area": "M",
    "datatype": "int",
  }
  {
    "name": "MainOB",
    "block_number": 1,
    "block_type": "ob"
```

```
    }
]
```

Possible error messages

The following table shows possible error messages of the PlcProgram.Browse method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
3	System is busy	The desired operation cannot be performed because the system is currently performing a different request. Restart the query as soon as the current operation is complete.
4	No resources	The system does not have the required resources to retrieve the type information. Perform the request once more as soon as enough resources are available again.
200	Address does not exist	The requested address does not exist or the Web server cannot access the requested address.
201	Invalid address	The name structure of the symbolic address is not correct.
202	Variable is not a structure	It is not possible to search the specific address because the tag is not a structured data type.
203	Invalid array index	The dimensions and limits of the array indexes do not correspond to the type information of the CPU.

NOTE

Tag access with the methods PlcProgram.Read, PlcProgram.Write, and PlcProgram.Browse

It is not yet possible to access all tags with these methods in firmware version ≥ V3.0.

There are selective restrictions when reading tags of technology objects. If access to specific tags is not possible, the API returns the message "unsupported".

6.9.7 Plc.ReadMemoryInformation

This method provides information on the memory consumption of a CPU program.

To call the Plc.ReadMemoryInformation method, you require the "read_diagnostics" authorization.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-230 Plc_ReadMemoryInformation_Response (object)

Name	Required	Data type	Description
code_work_memory	Yes	object of type `Plc_ReadMemoryInformation_Absolute_Response`	Size of the code memory in bytes.
data_work_memory	Yes	object of type `Plc_ReadMemoryInformation_Absolute_Response`	Size of the work memory in bytes.
retentive_memory	Yes	object of type `Plc_ReadMemoryInformation_Absolute_Response`	Size of the retentive memory in bytes.
datatype_memory	Yes	object of type `Plc_ReadMemoryInformation_Percentage_Response`	Percentage size of the data memory.

Table 3-231 Plc_ReadMemoryInformation_Absolute_Response (object)

Name	Required	Data type	Description
free_bytes	Yes	number	Free size of the specified memory in bytes.
total_bytes	Yes	number	Total size of the specified memory in bytes.

Table 3-232 Plc_ReadMemoryInformation_Percentage_Response (object)

Name	Required	Data type	Description
free_percentage	Yes	floating-point number	Percentage value between 0 and 100 for the free memory.

Example

The following example shows the statistics of a CPU.

```
{
  "code_work_memory":
  {
    "free_bytes": 11213,
    "total_bytes": 9437184
  },
```

```
    "data_work_memory":
    {
      "free_bytes": 214531,
      "total_bytes": 62914560
    },
    "retentive_memory":
    {
      "free_bytes": 717470,
      "total_bytes": 717476
    },
    "datatype_memory":
    {
      "free_percentage": 95.01
    }
  }
```

Possible error messages

The following table shows possible error messages of the Plc.ReadMemoryInformation method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.9.8 Project.ReadInformation

This method provides information about the TIA Portal project.

To call the Project.ReadInformation method, you require the "read_diagnostics" authorization.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-233 Project_ReadInformation_Response (object)

Name	Required	Data type	Description
project_name	No	string	Name of the project, for example "Project1_V18"
versions	Yes	array of object of type `Project_ReadInformation_Versions_Response`	Information about components that you have used to create and download this project to the CPU.

Table 3-234 Project_ReadInformation_Versions_Response (object)

Name	Required	Data type	Description
source	Yes	string	Source to which the version number refers. The following values are possible: • `tia_portal` • `step_7_safety`
version	Yes	string	Version of the component, for example "V18 SP1"

Example 1

The following example shows project information for a standard CPU.

```
{
  "project_name": "Project1_V18",
  "versions":
  [
    {
      "source": "tia_portal",
      "version": "V18 SP1"
    }
  ]
}
```

Example 2

The following example shows project information for an F-CPU.

```
{
  "project_name": "Project1_V21",
  "versions":
  [
    {
      "source": "tia_portal",
      "version": "V21.0.0.0"
    },
    {
      "source": "step_7_safety",
      "version": "V21"
    }
  ]
}
```

Possible error messages

The following table shows possible error messages of the Project.ReadInformation method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.10 Reading and changing the operating mode

6.10.1 Plc.ReadOperatingMode

With this method you read the operating mode of the CPU.

To call the Plc.ReadOperatingMode method, you require "read_diagnostics" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-235 Plc_ReadOperatingMode_Request (object)

Name	Required	Data type	Description
redundancy_id	Yes, for R/H-CPUs; No for all other CPUs	number	The parameter redundancy ID must be available if the request is performed on an R/H-CPU. The redundancy ID has the value 1 or 2. With all other CPUs, the parameter must not be part of the request. You can find more information on the system state SYNCUP at the R/H-CPUs in the System Manual Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833).

Response structure

If the request to the server was successful, the server returns the operating mode as a string. The following strings are possible for operating modes:

Operating mode	String	Only for R/H-CPU?
STOPSELFINITIALIZATION	stop_self_init	No
STOP	`stop`	No
STARTUP	`startup`	No
RUN	`run`	No
RUNREDUNDANT	run_redundant	Yes
HALT	`hold`	No
SYNCUP	syncup	Yes

Operating mode	String	Only for R/H-CPU?
RUNSYNCUP	run_syncup	Yes
REMOTEUNKNOWN	remote_unknown	Yes
ERRORSEARCH	`unknown`	Yes

Example

```
"stop"
```

Possible error messages

The following table shows possible error messages of the Plc.ReadOperatingMode method.

Error code	Error message	Meaning
-32602	Invalid params	Invalid parameters of the method. This error occurs when the parameter redundancy_id is specified at a non-R/H-CPU or, respectively, when the parameter is invalid at an R/H-CPU.
1	Internal error	An internal error in the desired operation
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.10.2 Plc.RequestChangeOperatingMode

With this method, you request a new operating mode for the CPU.

Note that this is only a request for an operating mode. The conditions for an operating mode change must be given at the CPU, e.g. by the corresponding position of the mode selector. You can use the Plc.ReadOperatingMode (Page 202) method to check whether the operating mode change on the CPU was successful.

To call the Plc.RequestChangeOperatingMode method, you require "change_operating_mode" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-236 Plc_RequestChangeOperatingMode_Request (object)

Name	Required	Data type	Description
mode	yes	string	Requested operating mode: "stop" STOP mode "run" RUN mode
redundancy_id	Yes, for R/H-CPUs; No for all other CPUs	number	The parameter redundancy ID must be available if the request is performed on an R/H-CPU. The redundancy ID has the value 1 or 2. With all other CPUs, the parameter must not be part of the request. You can find more information on the system state SYNCUP at the R/H-CPUs in the System Manual Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833).

Example 1

In the following example, the RUN operating state is requested at a non-R/H-CPU.

```
{
  "mode": "run"
}
```

Example 2

In the following example, the RUN operating state is requested at an R/H-CPU.

```
{
  "mode": "run",
  "redundancy_id": 1
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows possible error messages of the Plc.RequestChangeOperatingMode method.

Error code	Error message	Meaning
-32602	Invalid params	Invalid parameters of the method. This error occurs when the parameter redundancy_id is specified at a non-R/H-CPU or, respectively, when the parameter is invalid at an R/H-CPU.
1	Internal error	An internal error in the desired operation
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.10.3 Plc.ReadModeSelectorState

This method reads the current position of the mode switch at the CPU.

To call the Plc.ReadModeSelectorState method, you require "read_diagnostics" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-237 Plc_ReadModeSelectorState_Request (object)

Name	Required	Data type	Description
redundancy_id	Yes, for R/H-CPUs; No for all other CPUs	number	The parameter redundancy ID must be available if the request is performed on an R/H-CPU. The redundancy ID has the value 1 or 2. With all other CPUs, the parameter must not be part of the request. You can find more information on the system state SYNCUP at the R/H-CPUs in the System Manual Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833).

Response structure

The following table shows you the structure of server responses to successful requests.

Table 3-238 Plc_ReadModeSelectorState_Response (object)

Name	Required	Data type	Description
mode_selector	Yes	string	Possible values: • "run" • "stop" • "no_switch" • "unknown"

Example

In the following example, the RUN operating mode.

```
{
  "mode_selector": "run"
}
```

Possible error messages

The following table shows possible error messages of the Plc.ReadModeSelectorState method.

Error code	Error message	Meaning
-32602	Invalid params	Invalid parameters of the method. This error occurs when the parameter redundancy_id is specified at a non-R/H-CPU or, respectively, when the parameter is invalid at an R/H-CPU.
1	Internal error	An internal error in the desired operation
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.10.4 Plc.ReadRuntimeInformation

Use this method to determine the cycle time and runtime information of the system.

To call the Plc.ReadRuntimeInformation method, you require the "read_diagnostics" authorization.

More information

You can find more information on cycle times in the S7-1500, S7-1500R/H, ET 200SP, ET 200pro Cycle and response times Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59193558), section 4.2 "Cycle time".

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-239 Plc_ReadRuntimeInformation_Response (object)

Name	Required	Data type	Description
load	Yes	object of type `Plc_ReadRuntimeInformation_Load_Response`	Contains the current and configured values of the program and communication load.
cycle_time	Yes	object of type `Plc_ReadRuntimeInformation_CycleTime_Response`	Contains the current and configured cycle time values.

Table 3-240 Plc_ReadRuntimeInformation_Load_Response (object)

Name	Required	Data type	Description
actual	Yes	object of type `Plc_ReadRuntimeInformation_Load_Actual_Response`	Contains the current values of the program and communication load.
configured	Yes	object of type `Plc_ReadRuntimeInformation_Load_Configured_Response`	Contains the configured values of the program and communication load.

Table 3-241 Plc_ReadRuntimeInformation_CycleTime_Response (object)

Name	Required	Data type	Description
actual	Yes	object of type `Plc_ReadRuntimeInformation_CycleTime_Actual_Response`	Contains the current values of the cycle time.
configured	Yes	object of type `Plc_ReadRuntimeInformation_Cycletime_Configured_Response`	Contains the configured values for the cycle time.

Table 3-242 Plc_ReadRuntimeInformation_Load_Actual_Response (object)

Name	Required	Data type	Description
program_load_cyclic_program_obs_percentage	Yes	number	Program load of cyclic program OBs in percent
program_load_high_priority_obs_percentage	Yes	number	Program load of higher priority OBs in percent
current_communication_load_percentage	Yes	number	Current communication load of the system in percent

Table 3-243 Plc_ReadRuntimeInformation_Load_Configured_Response (object)

Name	Required	Data type	Description
max_communication_load_percentage	Yes	number	The configured maximum communication load as a percentage

Table 3-244 Plc_ReadRuntimeInformation_CycleTime_Actual_Response (object)

Name	Required	Data type	Description
shortest	Yes	string of the time range, shown in accordance with ISO 8601	Duration of the shortest cycle
current	Yes	string of the time range, shown in accordance with ISO 8601	Duration of the last cycle
longest	Yes	string of the time range, shown in accordance with ISO 8601	Duration of the longest cycle

Table 3-245 Plc_ReadRuntimeInformation_CycleTime_Configured_Response (object)

Name	Required	Data type	Description
min	Yes	string of the time range, shown in accordance with ISO 8601	Minimum configured duration of a cycle
max	Yes	string of the time range, shown in accordance with ISO 8601	Maximum configured duration of a cycle

Example

The following example shows the information of a CPU.

```
{
  "load":
  {
    "actual":
    {
      "program_load_cyclic_program_obs_percentage": 33,
      "program_load_high_priority_obs_percentage": 40,
      "current_communication_load_percentage": 27
    },
    "configured":
    {
      "max_communication_load_percentage": 50
    }
  },
  "cycle_time":
  {
    "actual":
    {
      "shortest": "PT1.370123S",
```

```
        "current": "PT1.420123S",
        "longest": "PT3.370123S"
      },
      "configured":
      {
        "min": "PT0.001S",
        "max": "PT0.150S"
      }
    }
  }
```

Possible error messages

The following table shows possible error messages of the Plc.ReadRuntimeInformation method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.11 Changing time settings via Web API

6.11.1 Plc.ReadSystemTime

This method returns the system time of the CPU. If you have synchronized the system time of the CPU, for example via the TIA Portal function "Online & diagnostics", the system time corresponds to Coordinated Universal Time (UCT).

No authorization is required to call the Plc.ReadSystemTime method.

Response structure

The following table provides information about the individual parameters of the request.

Table 3-246 Plc_ReadSystemTime_Response (object)

Name	Required	Data type	Description
timestamp	Yes	string	ISO8601 time stamp as string in nanoseconds

Example

The following example shows the structure of the time stamp.

```
{
 "timestamp": "2012-04-23T18:25:43.123456789Z"
}
```

6.11.2 Plc.SetSystemTime

Use this method to set the system time of the CPU (CPU local time).

To call the Plc.SetSystemTime method, you require "change_time_settings" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-247 Plc_SetSystemTime_Request (object)

Name	Required	Data type	Description
timestamp	Yes	string	ISO 8601 timestamp as a string in nanoseconds; represents the time stamp of the system time to be set

Example

The following example shows the structure of the time stamp.

```
{
  "timestamp": "2023-11-05T18:25:43.515154511Z"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows possible error messages of the Plc.SetSystemTime method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
900	Invalid timestamp	The time stamp used does not match the required time-stamp format (ISO time-stamp defaults).
901	Time not within allowed time range	The time stamp is not within the allowed period for time stamps. The end of the possible timespan is 2200-12-31T23:59:59.999999999Z

6.11.3 Plc.ReadTimeSettings

This method returns the currently active time, the deviation of the time zone from Coordinated Universal Time (UCT), and any daylight saving time rules.

No authorization is required to call the Plc.ReadTimeSettings method.

Structure of the request

The following tables contain information about the individual parameters of the request.

Table 3-248 Plc_ReadTimeSettings_Response (object)

Name	Required	Data type	Description
current_offset	Yes	string the time range, shown in accordance with ISO 8601	The currently active deviation of the CPU local time from the coordinated universal time (UTC) configured on the CPU in minutes, e.g. "PT1H30M" for a deviation of 1 hour and 30 minutes.
utc_offset	Yes	string the time range, shown in accordance with ISO 8601	The deviation of the time zone from the coordinated universal time (UTC) in minutes without consideration of the daylight saving time rules.
rule	No	object of type Plc_ ReadTimeSettings_ Rule_Response	Displays the daylight saving time settings. If no settings are active, daylight saving time is not set and only the "utc_offset" value is used to calculate the CPU local time.

Table 3-249 Plc_ReadTimeSettings_Rule_ Response (object)

Name	Required	Data type	Description
std	Yes	object of type Plc_ ReadTimeSettings_ StdRule_Response	Stands for the zone time setting.
dst	Yes	object type Plc_ ReadTimeSettings_ DstRule_Response	Stands for the daylight saving time settings

Table 3-250 Plc_ReadTimeSettings_StdRule_Response (object)

Name	Required	Data type	Description
start	Yes	object of type Plc_ ReadTimeSettings_ Start_Response	Stands for the start time of the zone time.

Table 3-251 Plc_ReadTimeSettings_DstRule_Response (object)

Name	Required	Data type	Description
start	Yes	object of type Plc_ ReadTimeSettings_ Start_Response	Stands for the start time of daylight saving time.
offset	Yes	string the time range, shown in accordance with ISO 8601	Stands for the deviation of daylight saving time from the zone time in minutes (only used in the dst object).

Table 3-252 Plc_ReadTimeSettings_Start_Response (object)

Name	Required	Data type	Description
month	Yes	number	Used in the "dst.start/std.start" objects. Stands for the month in which the time starts.
week	Yes	number	Used in the "dst.start/std.start" objects. Stands for the week in which the time change is performed. Value 1: First occurrence of the day of the week in the month Value 5: Last occurrence of the day of the week in the month
day_of_week	Yes	string	Used in the "dst.start/std.start" objects. Describes the day of the week on which the time change is performed as a string with 3 characters. The following values are possible: • sun • mon • tue • wed • thu • fri • sat
hour	Yes	number	Used in the "dst.start/std.start" objects. Describes the hour in which the time change is performed.
minute	Yes	number	Used in the "dst.start/std.start" objects. Describes the minute in which the time change is performed.

Example 1

A daylight saving time rule is configured in the following example.

```
{
 "current_offset": "PT1H",
 "utc_offset": "PT2H",
 "rule":
 {
  "dst":
  {
   "offset": "PT1H",
   "start":
   {
    "month": 4,
    "week": 4,
    "day_of_week": "sun",
    "hour": 3,
    "minute": 0
  }
 },
 "std":
  {
   "start":
```

```
    {
     "month": 10,
     "week": 5,
     "day_of_week": "sun",
     "hour": 2,
     "minute": 0
    }
   }
  }
}
```

Example 2

In the following example, no daylight saving time rule has been configured and a time offset of 1 hour exists.

```
{
 "current_offset": "PT1H",
 "utc_offset": "PT2H",
}
```

Example 3

In the following example, no daylight saving time rule has been configured and a time offset of minus 1 hour and 30 minutes exists.

```
{
  "current_offset": "-PT1H30M",
  "utc_offset": "-PT30M"
}
```

Example 4

In the following example, no daylight saving time rule has been configured and no time offset exists.

```
{
  "current_offset": "PT0M",
  "utc_offset": "PT0M"
}
```

6.11.4 Plc.SetTimeSettings

With this method you can set the time settings of the CPU.

To call the Plc.SetTimeSettings method, you require "change_time_settings" authorization.

Structure of the request

The following tables contain information about the individual parameters of the request.

Table 3-253 Plc_SetTimeSettings_Response (object)

Name	Required	Data type	Description
utc_offset	Yes	string	ISO 8601 timespan as a string; the deviation of the time zone from the coordinated universal time (UTC) without consideration of the daylight saving time rules.
rule	No	object of type Plc_SetTimeSettings_Rule_Response	Displays the daylight saving time settings. If no settings are active, daylight saving time is not set and only the "utc_offset" value is used to calculate the local time.

Table 3-254 Plc_SetTimeSettings_Rule_Response (object)

Name	Required	Data type	Description
std	Yes	object of type Plc_SetTimeSettings_StdRule_Response	Stands for the zone time setting.
dst	Yes	object of type Plc_SetTimeSettings_DstRule_Response	Stands for the daylight saving time settings

Table 3-255 Plc_SetTimeSettings_StdRule_Response (object)

Name	Required	Data type	Description
start	Yes	object of type Plc_SetTimeSettings_Start_Response	Stands for the start time of the zone time.

Table 3-256 Plc_SetTimeSettings_DstRule_Response (object)

Name	Required	Data type	Description
start	Yes	object of type Plc_SetTimeSettings_Start_Response	Stands for the start time of daylight saving time.
offset	Yes	string	ISO 8601 timespan as a string; the deviation of daylight saving time from the zone time in minutes (only used in the dst object).

Table 3-257 Plc_SetTimeSettings_Start_Response (object)

Name	Required	Data type	Description
month	Yes	number	Is used in the "dst.start/std.start" objects. Stands for the month in which the time starts.
week	Yes	number	Is used in the "dst.start/std.start" objects. Stands for the week in which the time change is performed Value 1: First occurrence of the day of the week in the month Value 5: Last occurrence of the day of the week in the month

Name	Required	Data type	Description
day_of_week	Yes	string	Is used in the "dst.start/std.start" objects. Describes the day of the week on which the time change is performed as a string with 3 characters. The following values are possible: • sun • mon • tue • wed • thu • fri • sat
hour	Yes	number	Is used in the "dst.start/std.start" objects. Describes the hour in which the time change is performed.
minute	Yes	number	Is used in the "dst.start /std.start" objects. Describes the minute in which the time change is performed.

Example 1

The following example shows how to set a rule with daylight saving time parameters.

```
{
 "utc_offset": "PT2H",
 "rule":
 {
  "dst":
  {
   "offset": "PT1H",
   "start":
   {
    "month": 4,
    "week": 4,
    "day_of_week": "wed",
    "hour": 3,
    "minute": 0
   }
  },
  "std":
  {
   "start":
   {
    "month": 10,
    "week": 5,
    "day_of_week": "wed",
    "hour": 2,
    "minute": 0
   }
```

```
    }
  }
}
```

Example 2

The following example shows the setting of a rule without daylight saving time parameters.

```
{
 "utc_offset": "PT6H",
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows possible error messages of the Plc.SetTimeSettings method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
5	System is read-only	The system cannot be written to (SIMATIC load memory is write-protected). Changes are currently not permitted.
902	Invalid time rule	The rule provided is invalid. Check that the time settings are correct.
903	Invalid UTC offset	The Coordinated Universal Time (UTC) deviation provided is invalid. Check that the time settings are correct.

6.12 Reading diagnostics and service data

6.12.1 Project.ReadLanguages

This method returns a list with the project languages available on the CPU.

You can then use the "Alarms.Browse" or "DiagnosticBuffer.Browse" methods in one of the available languages to get alarm messages or diagnostic messages in the available languages.

To call the Project.ReadLanguages method, you require "read_diagnostics" authorization.

Available languages

The available languages are interpreted with the language codes to RFC4647. The following languages can be available for the CPUs:

Language code to RFC4647	Language
de	German (Germany)
en	English (US)
fr	French (France)
es	Spanish (Spain)
it	Italian (Italy)
ja	Japanese (Japan)
zh	Chinese (China)
ko	Korean (Korea)
ru	Russian (Russia)
tr	Turkish (Türkiye)
pt	Portuguese (Portugal)

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-258 Project_ReadLanguages_Request (object)

Name	Required	Data type	Description
mode	No	string	This parameter specifies the languages that can be returned: • "all" (all languages are listed) • "active" (only active languages are listed)

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-259 Project_ReadLanguages_Response (Array of objects)

Name	Required	Data type	Description
languages	Yes	array of Project_ReadLanguages_Entry_Response	Object array, where each object represents a project language.

Table 3-260 Project_ReadLanguages_Entry_Response (object)

Name	Required	Data type	Description
language	Yes	string	String with the project language as a language code to RFC4647
active	Yes	bool	This parameter specifies whether the project language is available for API methods, for example Alarms.Browse (Page 219).
user_interface_languages	Yes	array of string	String array, with each string representing an interface language for which the project language is to be used as the default. An application can overrule this information.

Example 1

The following example shows the output of a project language as a string for a firmware version <= 3.1.

```
{
  "languages":
  [
    {
      "language": "en-US"
    }
  ]
}
```

NOTE
No project language configured
If no project language was configured, the array is empty.

Example 2

The example below shows several languages with different status for a firmware version >= 4.0.

```
{
  "languages":
  [
    {
```

```
        "language": "en-US",
        "active": true,
        "user_interface_languages": [
          "de-DE",
          "en-US"
        ]
      },
      {
        "language": "en-US",
        "active": false,
        "user_interface_languages": []
      }
    ]
  }
```

Possible error messages

The following table shows possible error messages of the Project.ReadLanguages method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.12.2 Alarms.Browse

With this method you can determine which alarms are currently active on the CPU, and when the last change occurred within the diagnostics buffer.

To call the Alarms.Browse method, you require the "read_diagnostics" authorization.

Structure of the request

The following tables contain information about the individual parameters of the request.

Table 3-261 Alarms_Browse_Request (object)

Name	Required	Data type	Description
language	Yes	string	The desired project language in which the text is returned in RFC 4647 format, for example "en-US". You can read out the available project languages using the Project.ReadLanguages (Page 217) method.
count	No	number	The maximum number of alarm entries that are returned. The default value is 50. If you want to determine the current status of the diagnostics buffer, enter 0 as "count".
alarm_id	No	string	The alarm ID of the CPU for which you are requesting data. If the alarm ID is included, only the "count" parameter can be offered as a filter.
filters	No	object of type `Alarms_Browse_Filters_Request`	Optional object containing parameters for filtering the response.

Table 3-262 Alarms_Browse_Filters_Request (object)

Name	Required	Data type	Description
mode	Yes	string	The mode that determines whether attributes are to be included or excluded in the response. The following modes are available: • "include" • "exclude"
attributes	Yes	array of string	Possible array entries are: • "alarm_text" • "info_text" • "status" • "timestamp" • "acknowledgement" • "alarm_number" • "producer"

Example 1

The following example shows a request for reading a single alarm with all alarm areas in the English language:

```
{
  "language": "en-US",
  "alarm_id": "1231231231"
}
```

Example 2

The following example shows the request for reading a single alarm without the alarm areas excluded under "exclude":

```
{
  "language": "en-US",
  "alarm_id": "1231231231",
  "filters":
  {
    "mode": "exclude",
    "attributes": ["alarm_text", "info_text"],
  }
}
```

Example 3

The following example shows the request for reading 50 alarms with the alarm ranges included in "include".

```
{
  "language": "en-US",
  "count": 50,
  "filters":
  {
    "mode": "include",
    "attributes": ["status", "acknowledgement"]
  }
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-263 Alarms_Browse_Response (object)

Name	Required	Data type	Description
language	No, optional and only available if entries are returned; not relevant if, for example, count = 0 is requested	string	The language of the response in which the message text is output. If no valid language was requested, the server outputs the message "invalid".
last_modified	Yes	string	ISO 8601 time stamp in UTC as string. The time stamp with the last change of the alarm system since you made the last read request. The time stamp allows you to see when the last alarm change occurred in the system without having to check individual alarms in detail.
count_current	Yes	number	The number of active alarms.
count_max	Yes	number	The maximum number of active alarms.
entries	No	array of data type `Alarm_Browse_Entry_response`	The list of pending alarms, where each alarm entry is represented as an object.

Table 3-264 Alarms_Browse_Entry_Response (object)

Name	Required	Data type	Description
id	Yes	string	Alarm ID.
alarm_number	Yes, if not excluded by user	number	Alarm number.
status	Yes, if not excluded by user	string	Alarm status; is either "incoming" or "outgoing".
timestamp	Yes, if not excluded by user	string	ISO 8601 time stamp as a string. Time stamp in Coordinated Universal Time (UTC) of the time at which the alarm assumed the status "incoming" or "outgoing".

Name	Required	Data type	Description
producer	Yes, if not excluded by user	string	Possible alarm trigger: • "program_alarm" • "system_diagnostics" • "motion" • "security" • "sinumerik" • "graph7" • "prodiag" • "other"
hwid	No	number	Contains the hardware ID if the trigger for the alarm is "system_diagnostics".
acknowledge-ment	No	object	Appears when the alarm needs to be acknowledged.
acknowledge-ment.state	Yes	string	String in readable form, which provides information about the status of the acknowledgement: • "not_acknowledged" • "acknowledged"
acknowledge-ment.timestamp	Yes	string	ISO 8601 time stamp as a string. If the current status ("incoming" or "outgoing") has been acknow-ledged, the time stamp provides information about the time of acknowledgement.
alarm_text	Yes, if not excluded by user	string	Alarm text in the selected language.
info_text	Yes, if not excluded by user	string	Info text in the selected language.
text_inconsistent	No	bool	If the alarm text or info text is inconsistent, this flag returns "true".

Example 1

The following example shows the response to a query with a number = 0:

```
{
  "last_modified": "2012-04-23T18:25:43.511546151Z",
  "count_current": 1,
  "count_max": 5000
}
```

Example 2

The following example shows the response to a request with a non-acknowledged alarm and with all attributes (no filters set).

```
{
  "entries":
  [
    {
      "id": "121651651651",
```

```
      "timestamp": "2012-04-23T18:25:43.511987654Z",
      "status": "incoming",
      "alarm_number": 37,
      "producer": "system_diagnostics",
      "hwid": 49,
      "acknowledgement":
      {
        "state": "not_acknowledged"
      },
      "alarm_text": "CPU maintenance demanded: Emergency IP suite
parameter for IE interface activated PLC_1516 / Current CPU
operating mode: STOP",
      "info_text": "Short name: CPU general Order number: 6ES7
516-3AP03-0AB0",
      "text_inconsistent": false
    }
  ],
  "last_modified": "2012-04-23T18:25:43.511546151Z",
  "count_current": 1,
  "count_max": 5000,
  "language": "en-US"
}
```


Example 3

The following example shows the response to a request with an acknowledged alarm and with all attributes (no filters set):


```
{
  "entries":
  [
    {
      "id": "121651651651",
      "timestamp": "2012-04-23T18:25:43.511980000Z",
      "status": "incoming",
      "alarm_number": 35,
      "producer": "system_diagnostics",
      "hwid": 49,
      "acknowledgement":
      {
        "state": "acknowledged",
        "timestamp": "2012-04-23T18:25:50.123456789Z"
      },
      "alarm_text": "CPU status message: CPU not in RUN Current CPU
operating mode: STOP",
      "info_text": "Short name: CPU general Order number: 6ES7
516-3AP03-0AB0",
```

```
      "text_inconsistent": false
    }
  ],
  "last_modified": "2012-04-23T18:25:43.511546151Z",
  "count_current": 1,
  "count_max": 5000,
  "language": "en-US"
}
```


Example 4

The following example shows the response to a request with a non-acknowledged alarm and with all attributes (no filters set) and with a valid language.


```
{
  "entries":
  [
    {
      "id": "121651651651",
      "timestamp": "2012-04-23T18:25:43.511987654Z",
      "status": "incoming",
      "alarm_number": 37,
      "producer": "program_alarm",
      "alarm_text": "My alarm text created by Program_Alarm",
      "info_text": "My info text created by Program_Alarm",
      "text_inconsistent": false
    }
  ],
  "last_modified": "2012-04-23T18:25:43.511546151Z",
  "count_current": 1,
  "count_max": 5000,
  "language": "en-US"
}
```


Example 5

The following example shows the response to a request with a non-acknowledged alarm and with all attributes (no filters set) and with an invalid language.


```
{
  "entries":
  [
    {
      "id": "121651651651",
      "timestamp": "2012-04-23T18:25:43.511987654Z",
      "status": "incoming",
      "alarm_number": 37,
```

```
      "producer": "program_alarm",
      "alarm_text": "#273, 1",
      "info_text": "#273, 0",
      "text_inconsistent": true
    }
  ],
  "last_modified": "2012-04-23T18:25:43.511546151Z",
  "count_current": 1,
  "count_max": 5000,
  "language": "invalid"
}
```


Example 6

The following example shows the filtered response to a query with only alarm text and info text, partially empty (empty text configured in project).


```
{
  "entries":
  [
    {
      "id": "121651651651",
      "alarm_text": "my alarm text",
      "info_text": ""
    },
    {
      "id": "121651651652",
      "alarm_text": "",
      "info_text": "my info text"
    }
  ],
  "last_modified": "2012-04-23T18:25:43.511546151Z",
  "count_current": 2,
  "count_max": 5000,
  "language": "en-US"
}
```


Example 7

The following example shows the filtered response to a query with only alarm IDs:


```
{
  "entries":
  [
    {
      "id": "121651651651",
      "producer": "system_diagnostics"
```

```
      },
      {
        "id": "121651651652",
        "producer": "system_diagnostics"
      },
      {
        "id": "121651651653",
        "producer": "program_alarm"
      }
    ],
    "last_modified": "2012-04-23T18:25:43.511546151Z",
    "count_current": 3,
    "count_max": 5000,
    "language": "en-US"
  }
```


Possible error messages

The following table shows possible error messages of the Alarms.Browse method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
800	Invalid alarm ID	The alarm ID provided is invalid.
801	Invalid parameters	The request is invalid because provided parameters are invalid (e.g. the parameters "count" and "id" are present at the same time).

6.12.3 Alarms.Acknowledge

Use this method to acknowledge individual alarms.

To call the Alarms.Acknowledge method, you require "acknowledge_alarms" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-265 Alarms_Acknowledge_Request (object)

Name	Required	Data type	Description
id	Yes	string	The acknowledgement ID of the alarm to be acknowledged. The acknowledgement ID can be found in the alarm object returned by the Alarm.Read method.

Example

The following example shows the ID of an alarm to be acknowledged:

```
{
 "id": "1213515461"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows possible error messages of the Alarms.Acknowledge method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.12.4 Syslog.Browse

This method reads the entries of the CPU's internal syslog buffer.

To call the Syslog.Browse method, you require the "read_syslog" authorization.

Structure of the request

The following table provides information about the required parameters for the request.

Table 3-266 Plc_ReadModeSelectorState_Request (object)

Name	Required	Data type	Description
redundancy_id	Yes for R/H-CPUs No for all other CPUs	number	The parameter redundancy ID must be available if the request is performed on an R/H-CPU. The redundancy ID has the value 1 or 2. With all other CPUs, the parameter must not be part of the request.
count	No	number	The maximum number of syslog entries is requested. The default and maximum value is 20. When the value is 0, all syslog entries are omitted from the response. Only the attributes last_modified, count_total and count_lost are returned.
first	No	number	"first" specifies the latest entry to be read. With the setting count > 1, the values are read backwards. If, for example, you request the value 42 with count = 3, the entries 42, 41 and 40 are returned. If the value is 0, the most recent <count> elements are read.

Example 1

In the following example, the user requests up to 100 syslog entries, beginning with the latest entries.

```
{
  "count": 100
}
```

Example 2

In the following example, the user requests up to 100 syslog entries, beginning with entry 853.

```
{
  "count": 100,
  "first": 853
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-267 Syslog_Browse_Response (object)

Name	Required	Data type	Description
entries	Yes	array of `Syslog_Browse_Entry_Request`	Contains an array of objects where each object is a single syslog entry of the CPU's internal syslog buffer.
count_total	Yes	number	This attribute contains the overall number of the entries in the syslog buffer since startup of the CPU.
count_lost	Yes	number	This attribute contains the number of entries of the syslog buffer which were lost. This is the number of entries that were not overwritten through new entries and not stored on the syslog server.

Table 3-268 Syslog_Browse_Entry_Response (object)

Name	Required	Data type	Description
raw	Yes	string	An unformatted syslog entry according to RFC 3164.

Example 1

In the following example, an individual syslog entry is returned.

```
{
  "entries":
  [
    {
      "<35>1 2023-08-24T22:22:50.468Z 192.168.0.1 Webserver - ID6
[device@4329.6.100.1.1500 devVendor="Siemens" devProduct="CPU1500
```

```
(PLCSIM)"
FWVersion="T31.16.20"][session@4329.6.100.1.1500 protocolType="HTTP-
S" userName="Anonymous" src="192.168.0.99"
sessionID="1"][function@4329.6.100.1.1500 fct="login"
result="success"] SE_DEFAULT_USER_AUTHENTICATION_USED"
    }
  ],
  "count_total": 546875456,
  "count_lost": 0
}
```


Example 2

In the following example, an empty syslog response is returned, if previously no syslog message was available in the syslog buffer.


```
{
  "entries": [],
  "count_total": 0,
  "count_lost": 0
}
```


Example 3

In the following example, an empty syslog response is returned, if count = 0 is requested. This query can be used to request the ID of the last syslog entry without data to detect if new entries are available.


```
{
  "entries": [],
  "count_total": 546875456,
  "count_lost": 0
}
```


Possible error messages

The following table shows possible error messages of the Syslog.Browse method.

Error code	Error message	Meaning
-32602	Invalid params	Invalid parameters of the method. This error occurs when the parameter redundancy_id is specified at a non-R/H-CPU or, respectively, when the parameter is invalid at an R/H-CPU.
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
4	No resources	The system does not have the necessary resources to read the requested address. Perform the request once more as soon as enough resources are available again.
7	Partner not access-ible	The data of a partner CPU of an R/H system is not available. This can be the case when the CPU is not in RUN-Redundant system state.

6.12.5 DiagnosticBuffer.Browse

With this method you read out entries from the diagnostics buffer of the CPU.

To call the DiagnosticBuffer.Browse method, you require the "read_diagnostics" authorization.

Structure of the request

The following tables provide information about the required parameters for the request.

Table 3-269 DiagnosticBuffer_Browse_Request (object)

Name	Required	Data type	Description
language	Yes	string	The desired project language in which the text is returned in RFC 4647 format, for example "en-US". You can read out the available project languages using the Project.ReadLanguages (Page 217) method.
count	No	number	The maximum number of alarm entries that are returned. The default value is 50. If you want to determine the current status of the diagnostics buffer, enter 0 as "count".
filters	No	object of type `DiagnosticBuffer_Browse_Filters_Request`	The object that represents the different filtering options.

Table 3-270 DiagnosticBuffer_Browse_Filters_Request (object)

Name	Required	Data type	Description
attributes	Yes	array of string	The following attributes are possible for the diagnostics buffer entries: • short_text • long_text • help_text
mode	Yes	string	The mode that determines whether attributes are to be included or excluded in the request. The following modes are available: • include • exclude

Example

The following example shows a request of the diagnostic entries as LCID value 1033 (dec value), which stands for "English – United States".

```
{
  "language": "en-US",
  "count": 50,
  "filters":
  {
    "mode": "include",
    "attributes": ["short_text", "long_text", "help_text"]
  }
```

```
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-271 DiagnosticBuffer_Browse_Response (object)

Name	Required	Data type	Description
entries	No	array of data type `DiagnosticBuffer_Browse_Entry_Response`	Array of diagnostics buffer entries, where each object represents one diagnostics buffer entry.
last_modified	Yes	string	ISO 8601 time stamp as a string; time stamp of the last change in the diagnostics buffer.
count_current	Yes	number	Number of available diagnostics buffer entries.
count_max	Yes	number	Maximum number of possible diagnostics buffer entries
language	No, optional and only available when entries are returned; not relevant if, for example, count = 0 is requested	string	The language in which the response is output.

Table 3-272 DiagnosticBuffer_Browse_Entry_Response (object)

Name	Required	Data type	Description
timestamp	Yes	string	ISO 8601 time stamp as a string; The attribute is provided in Coordinated Universal Time (UTC) and not in CPU local time.
status	Yes	string	The status parameter for events is either "incoming" (incoming events) or "outgoing" (outgoing events).
event	Yes	object	Contains the event ID of the diagnostics buffer which consists of the text list ID and the text ID of the event
long_text	Yes, if not excluded by the user	string	Diagnostics buffer entries in the long form
short_text	Yes, if not excluded by the user	string	Diagnostics buffer entries in the short form
help_text	Yes, if not excluded by the user	string	Help text for an incoming event.

Table 3-273 DiagnosticBuffer_Browse_Entry_Event_Response (object)

Name	Required	Data type	Description
event.textlist_id	Yes	number	Text list ID of the event
event.text_id	Yes	number	Text ID of the event

Example 1

The following example shows the representation of an entry for display = 0.

```
{
  "last_modified": "2012-04-23T18:25:43.514678521Z",
  "count_current": 1234,
  "count_max": 3200
}
```

Example 2

The following example shows the representation of a multiline entry in the diagnostics buffer (system diagnostics message).

```
{
  "entries":
  [
    {
      "timestamp": "2012-04-23T18:25:43.511854547Z",
      "status": "outgoing",
      "long_text": "CPU info: Boot up

memory card type: Program card (external load memory)
CPU changes from OFF to STOP (initialization) mode

PLC_2 / PLC_2",
      "short_text": "Boot up - CPU changes from OFF to STOP
(initialization) mode",
      "help_text": "",
      "event":
      {
        "textlist_id": 2,
        "text_id": 16385
      }
    }
  ],
  "last_modified": "2012-04-23T18:25:43.514678521Z",
  "count_current": 1234,
  "count_max": 3200,
  "language": "en-US"
}
```

Example 3

The following example shows the representation of a multiline entry in the diagnostics buffer (system diagnostics message).


```
{
  "entries":
  [
    {
      "timestamp": "2012-04-23T18:25:43.511854547Z",
      "status": "incoming",
      "long_text": "My long text created with Gen_UsrMsg!",
      "short_text": "My short text created with Gen_UsrMsg!",
      "help_text": "",
      "event":
      {
        "textlist_id": 512,
        "text_id": 42
      }
    }
  ],
  "last_modified": "2012-04-23T18:25:43.514678521Z",
  "count_current": 1234,
  "count_max": 3200,
  "language": "en-US"
}
```


Example 4

The following example shows the representation for a valid language but with an invalid text list ID / text ID.


```
{
  "entries":
  [
    {
      "timestamp": "2012-04-23T18:25:43.511854547Z",
      "status": "incoming",
      "long_text": "#254, 128",
      "short_text": "#253, 128",
      "help_text": "",
      "event":
      {
        "textlist_id": 0,
        "text_id": 42
      }
    }
  ],
```

```
  "last_modified": "2012-04-23T18:25:43.514678521Z",
  "count_current": 1234,
  "count_max": 3200,
  "language": "en-US"
}
```


Example 5

The following example shows the display for a valid language but with an invalid text list ID / text ID in the text.


```
{
  "entries":
  [
    {
      "timestamp": "2012-04-23T18:25:43.511854547Z",
      "status": "incoming",
      "long_text": "The status of the sensor is: #513, 0",
      "short_text": "The status of the sensor is: #513, 0",
      "help_text": "",
      "event":
      {
        "textlist_id": 512,
        "text_id": 1
      }
    }
  ],
  "last_modified": "2012-04-23T18:25:43.514678521Z",
  "count_current": 1234,
  "count_max": 3200,
  "language": "en-US"
}
```


Example 6

The following example shows the representation for an invalid language.


```
{
  "entries":
  [
    {
      "timestamp": "2012-04-23T18:25:43.511854547Z",
      "status": "incoming",
      "long_text": "#254, 17",
      "short_text": "#253, 17",
      "help_text": "#32770, 4416",
      "event":
```

```
        {
          "textlist_id": 2,
          "text_id": 4416
        }
      }
    ],
    "last_modified": "2012-04-23T18:25:43.514678521Z",
    "count_current": 1234,
    "count_max": 3200,
    "language": "invalid"
  }
```

Possible error messages

The following table shows possible error messages of the DiagnosticBuffer.Browse method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.12.6 Modules.DownloadServiceData

This method returns a ticket that you use to download service data from the CPU. You can then forward the service data to Customer Support, for example for an analysis of your production data in the event of an error.

To call the Modules.DownloadServiceData method, you require "download_service_data" authorization.

You can find more information about the ticket mechanism in the section Ticket mechanism (Page 126).

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-274 Modules_DownloadServiceData_Request (object)

Name	Required	Data type	Description
hwid	Yes	number	Hardware ID of the module whose service data you want to read out.

Example

The following example shows a request of the method.

```
{
  "hwid": 49
}
```

Response structure

If successful, the method returns a string with a ticket ID. Use this ticket ID to download the service data.

NOTE

You can create a maximum of one Modules.DownloadServiceData ticket for all users. You can create a new ticket for this method only after this ticket has been closed.

Example

The following example shows a generated ticket ID for service data download.

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

Possible error messages

The following table shows possible error messages of the Modules.DownloadServiceData method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
4	No resources	You have exhausted all tickets in this user session. Close existing tickets to free up resources. Then call the method again.
7	Partner not accessible	The data of the CPU of an R/H system is not available. This can be the case when the system is in SYNCUP operating state or RUN-Redundant system state or when the service data of the partner CPU is queried.
600	No service data resources	Only one ticket resource for service data is available for all users at the same time.
1100	Invalid hardware identifier	The specified hardware ID is not valid for the current request. Make sure that you have used the correct hardware ID.

6.12.7 Communication.ReadProtocolResources

You can use this method to read out detailed information on communication protocols.

To call the Communication.ReadProtocolResources method, you require the "read_diagnostics" authorization.

More information

You can find more information on cycle times in the S7-1500, S7-1500R/H, ET 200SP, ET 200pro Cycle and response times Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59192925), section 4.2 "Cycle time".

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-275 Communication_ReadProtocolResources_Response (object)

Name	Required	Data type	Description
protocols	Yes	object of type `Communication_ReadProtocolResources_Content_Response`	The object contains information about various protocols. The following values are possible: • "hmi"

Table 3-276 Communication_ReadProtocolResources_Content_Response (object)

Name	Required	Data type	Description
hmi	Yes	object of type `Communication_ReadProtocolResources_Content_Hmi_Response`	The object contains information about HMI communication resources.

Table 3-277 Communication_ReadProtocolResources_Content_Hmi_Response (object)

Name	Required	Data type	Description
subscriptions	Yes	object of type `Communication_ReadProtocolResources_Elements_Response`	Number of free and maximum HMI connection resources in the CPU.
subscription_attributes	Yes	object of type `Communication_ReadProtocolResources_Elements_Response`	Number of free and maximum attributes in the HMI connection resources in the CPU.
subscription_memory	Yes	object of type `Communication_ReadProtocolResources_Memory_Response`	Free and maximum size of the memory available for HMI connection resources in the CPU.

Table 3-278 Communication_ReadProtocolResources_Elements_Response (object)

Name	Required	Data type	Description
free	No	number	Number of free elements.
max	Yes	number	Total number of elements.

Table 3-279 Communication_ReadProtocolResources_Memory_Response (object)

Name	Required	Data type	Description
free_bytes	No	number	Number of free bytes of the selected memory area.
total_bytes	Yes	number	Total number of bytes of the selected memory area.

Example

The following example shows a response with various items of information.

```
{
  "protocols":
  {
```

```
    "hmi":
{
      "subscriptions":
      {
        "free": 497,
        "max": 500
      }
      "subscription_attributes":
      {
        "free": 4518,
        "max": 8000
      }
      "subscription_memory":
      {
        "free_bytes": 1046528,
        "total_bytes": 1048576
      }
    }
  }
}
```


Possible error messages

The following table shows possible error messages of the Communication.ReadProtocolResources method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.13 Motion Control

6.13.1 Parameter assignment of the block properties

Configuring access to the Web API in the TIA Portal

To restrict the read and write access to data blocks of your project, you can define the desired parameters in the attributes of the respective block.

Web API access to the data block is permitted by default for technology objects. If you want to restrict access, clear the "Data block accessible from web server" check box.

Parameter assignment for access to the Web API in tag tables

For read and write access of Web API to tags, the options "Accessible from HMI/OPC UA/Web API" and "Writable from HMI/OPC UA/Web API" must be activated:

Tag table_1

	Name	Data type	Address	Retain	Accessible from HMI/OPC UA	Writable from HMI/OPC UA
1	Lint	LInt	%M99.0	☐	☑	☑
2	word	Word	%MW100	☐	☑	☑
3	MyTimer1	Timer	%T15	☐	☑	☑
4	MyCounter1	Counter	%C16	☐	☑	☑
5	MyTimer2	S5Time	%MW1000	☐	☑	☑
6	<Add new>			☐	☑	☑

Figure 3-227 Tag table in the TIA Portal

6.13.2 Technology.BrowseObjects

This method returns a list of all technology objects that were configured for the CPU. You can use this method, for example, to create a diagnostics overview for Motion Control.

To call the Technology.BrowseObjects method, you require the "read_diagnostics" authorization.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-280 Technology_BrowseObjects_Response (object)

Name	Required	Data type	Description
type	Yes	string	Type of CPU. The following values are possible: • "1500t": The CPU is an S7-1500 Technology CPU • "1500": The CPU is an S7-1500 CPU • "1200": The CPU is an S7-1200 (G2) CPU
objects	Yes	array of data type `Technology_BrowseObjects_Entry_Response`	The array contains a list of all technology objects whereby each element is represented as an object with detail information. If no technology object is configured, an empty list is returned.

Table 3-281 Technology_BrowseObjects_Response (array of objects)

Name	Required	Data type	Description
number	Yes	number	The number of the technology object
name	Yes	string	The name of the technology object
type	Yes	string	The type of the technology object The following values are possible: • "to_speedaxis" • "to_positioningaxis" • "to_positioningaxis_pto" • "to_synchronousaxis" • "to_externalencoder" • "to_measuringinput" • "to_outputcam"

Name	Required	Data type	Description
			• "to_camtrack" • "to_cam" • "to_kinematics" • "to_leadingaxisproxy" • "to_cam_10k" • "to_interpreter" • "to_interpretermapping" • "to_interpreterprogram" • "to_cam_600seg" • "to_cam_6kseg" • "unknown"
version	Yes	floating-point number	The version number of the technology object

Example

The following example shows the output of the properties of a configured technology object.

```
{
  "objects":
  [
    {
      "number": 2,
      "name": "Kinematics_1",
      "type": "to_kinematics",
      "version": 6
    }
  ]
}
```

Possible error messages

The following table shows possible error messages of the Technology.BrowseObjects method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.13.3 Technology.Read

This method returns the value of a process tag of the technology object. You use this method for Motion Control diagnostics.

To call the Technology.Read method, you require the "read_diagnostics" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-282 Technology_Read_Request (object)

Name	Required	Data type	Description
var	Yes	string	Name of the tag to be read. The name must not be empty.
mode	no, default is "simple"	string	Enumeration that determines the response format for this method: • "simple"*: Returns tag values according to the "simple" representation (see section Supported data types (Page 176)) • "raw": Returns tag values according to the "raw" representation (see section Supported data types (Page 176))
* The values of the data type Real or LReal are returned as a floating-point number in mode = "simple" with the highest accuracy in each case. If you want to apply the values, you can use mode = "raw" instead.			

NOTE

Format of the request

The format of the request and the response is the same as for the PlcProgram.Read (Page 182) method, but with the constraint that you can only read technology object tags.

Example

In the following example, the user requests a data block tag in the "raw" representation.

```
{
  "var": "\"MyTO_Axis\".StatusWord",
  "mode": "raw"
}
```

Response structure

If the request to the server was successful, the server returns JSON data values.

Example 1

The following example shows the result of reading in a tag of type "int" in the "simple" representation.

```
-42
```

Example 2

The following example shows the result of reading in a tag of type "dword" in the "raw" representation.

```
[ 1, 47, 233, 0 ]
```

Possible error messages

The following table shows possible error messages of the Technology.Read method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
4	No resources	The system does not have the necessary resources to read the requested address. Perform the request once more as soon as enough resources are available again.
200	Address does not exist	The requested address does not exist or the Web server cannot access it.
201	Invalid address	The name structure of the symbolic address is not correct.
203	Invalid array index	The dimensions and limits of the array indexes do not correspond to the type information of the CPU.
204	Unsupported address	The data type of the address cannot be read.
1400	Not a technology object	The tag is not a technology object tag. Therefore, the tag cannot be read.

6.14 Backing up and restoring the configuration

6.14.1 Plc.CreateBackup

With this method, you request a ticket to create a backup file of the CPU configuration.

To call the Plc.CreateBackup method, you require "backup_plc" authorization.

Response structure

The method returns a string with a ticket ID for creating a backup file.

Example

The following example shows a generated ticket ID for creating a backup file.

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

An example of further processing of the ticket ID can be found in the Ticket mechanism (Page 126) section.

Possible error messages

The following table shows possible error messages of the Plc.CreateBackup method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
4	No resources	You have exhausted all tickets in this user session. Close existing tickets to free up resources. Then call the method again.
1000	Backup creation in progress	The creation of a backup file is in progress.
1001	Backup restoration in progress	The restoration of a saved configuration is currently being carried out. It is not possible to perform both operations at the same time.
1004	PLC not in STOP	A backup file can only be created when the CPU is in STOP mode. Set the CPU to STOP mode and execute the request again.

Overview of creating a backup file

Perform the steps below to create a backup file:

1. Authenticate yourself with the API method Api.Login.
2. Request a ticket for creating a backup file using the Plc.CreateBackup method.

   If you are authorized to call this method and the CPU is in STOP, the CPU creates a ticket. Once a ticket has been created for the creation of a backup file, it is no longer possible to switch to the RUN. This ensures the consistency of the backup file.
3. Use the ticket end point to start downloading the backup file.

   The CPU informs you about the current status of the generation in the additional ticket information. Additional information is available using the Api.BrowseTickets(id) method.
4. After the download has been completed successfully, the CPU sets the ticket to the "completed" status.
5. Close the ticket using the Api.CloseTicket(id) method.
6. Now you can set the CPU back to RUN

Format of the backup file name

The default file name of the backup file, which is returned by the HTTP content disposition header, contains the following information:

- Time stamp in Coordinated Universal Time (UTC)
- Module name
- Name of the TIA Portal project
- F-collective signature (for F-CPUs)

6.14.2 Plc.RestoreBackup

Use this method to request a ticket that restores the configuration of a CPU via a backup file.

To call the Plc.RestoreBackup method, you require "restore_plc" authorization.

Structure of the request

The following table contains information about the parameters of the request:

Table 3-283 Plc_RestoreBackup_Request (object)

Name	Required	Data type	Description
password	Yes	string	The required password for the logged on user An empty password string is transferred for the "Everybody" or "Anonymous" user. The "password" attribute is therefore always required. The password must be the password of the user who previously authenticated via Api.Login and whose session token was used to call the Plc.RestoreBackup method.

Example

The following example shows how to enter a password.

```
{
 "password": "SecurePassword"
}
```

Response structure

The method returns a string. The string contains a ticket ID that you can use to restore the configuration on a backup file.

Example

The following example shows a generated ticket ID for restoring the configuration of a CPU.

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

An example of further processing of the ticket ID can be found in the Ticket mechanism (Page 126) section.

Possible error messages

The following table shows possible error messages of the Plc.RestoreBackup method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method.
4	No resources	You have exhausted all tickets in this user session. Close existing tickets to free up resources. Then call the method again.

Error code	Error message	Meaning
5	System is read-only	The system cannot be written to (SIMATIC load memory is write-protected). Changes are currently not permitted.
1000	Backup creation in progress	The creation of a backup file is in progress.
1001	Backup restoration in progress	The restoration of a saved configuration is currently being carried out. It is not possible to perform both operations at the same time.
1003	Restore not possible through this interface	Calling the method via CM/CP modules, via IP the address or via a virtual CP is not allowed. Perform the recovery via the IP address of one of the network interfaces of a CPU.
1004	PLC not in STOP	A backup file can only be created when the CPU is in STOP mode. Set the CPU to STOP mode and execute the request again.
1005	Legitimation failed	The user legitimation was not successful. Reasons for this can be the entry of password for the "Everybody" or "Anonymous" user, or the entry of an invalid password.

Overview of the recovery of the CPU configuration

The following section shows you all steps that are required to restore the CPU configuration.

NOTE

Tracking the recovery process via Api.BrowseTickets

The Api.BrowseTickets (Page 131) method provides information about the current status of the recovery.

Use this method to found out the recovery process phase, and whether the recovery process was successful.

1. Authenticate yourself with the API method Api.Login (Page 110).
2. Request a ticket for restoring a CPU configuration using the Plc.RestoreBackup method.
3. Use the ticket end point to start the upload of the backup file.

   The CPU receives the file header and checks whether it is valid. After a successful check, the CPU restarts after 3 seconds. If the file header is invalid, the CPU aborts the restoration process and the ticket changes to the `failed` status.

   When checking the restoration process, the following states may occur. These states can be read out via the API method Api.BrowseTickets.

Status	Description
`waiting`	The waiting state is active until the upload of the backup file is started.
`ongoing`	As soon as the upload of the backup file has started, the state changes to `ongoing`.
`rebooting_format`	The CPU is restarting. The reason for the restart is the formatting of the SIMATIC load memory.

Status	Description
`rebooting`	The CPU is restarting. The reason for the restart is the activation of the restored project.
`failed`	An error occurred during the upload of the backup file. You can abort the upload when an error occurs.
`failed_failsafe`	An error occurred during the execution of the fail-safe function. Ensure that the password passed to the Plc.RestoreBackup method is correct and the user has the F-Admin function right.
`failed_wrong_interface`	You have started the upload of the backup file to the CPU via a CM or CP interface.

NOTE

Loss of the configuration during the restoration process

Note that the CPU loses the configuration during the restoration process.

4. Before restarting the CPU, it is possible to read the status with the Api.BrowseTickets (Page 131) method, "id" parameter. The additional information informs you about restarting the CPU and formatting the SIMATIC load memory as next steps.

   To be informed about the process and all alarms, we recommend that you read the information of the Api.BrowseTickets method cyclically, e.g. every second.

5. The CPU then restarts and formats the SIMATIC load memory.

   After the restart, you can use the Api.Ping (Page 124) method to determine when the CPU is available again.

   During the restart, the Api.BrowseTickets and Api.Ping methods do not respond.

6. The CPU puts the web server into a state with reduced functionality. Only a limited number of API methods is available to you during this time.

NOTE

If you want to restore the CPU to its normal state during the restoration process, perform a download via the TIA Portal. After the download, the CPU and the web server are again in normal operation and all functions are available for use.

7. Use the Api.Login method to log on with the logon data that were also valid at the beginning of the restoration process.

NOTE

In this state of the CPU only a local authentication is possible. If the restore was started with a central user (parameter "mode" was specified with "umc"), this user is available locally in this mode. Always use the restore mode "mode=local" or leave the parameter out completely.

8. Request a ticket for the restore using the Plc.RestoreBackup method.
9. Upload the backup file via the ticket end point.

   After successful upload, the CPU restarts after 3 seconds.

10. Before restarting the CPU, it is possible to read the status with the Api.BrowseTickets method, "id" parameter. The additional information informs you about the restart and about the successful upload.

    The restart is required to activate the new project.
11. During the restart you can use the Api.Ping method to determine when the CPU is available again.
12. As soon as the CPU is available again, the restoration process is completed and the recovered project is loaded into the CPU.

You can now log in with the credentials of a user of the project loaded into the CPU, if desired.

Further work in the API requires a new login with the Api.Login method.

6.15 Accessing contents of the SIMATIC load memory

The methods described in this section allow you to access the files in the file system in the SIMATIC load memory. You can access standard files as well as your own user files, data logs, and recipes.

NOTE

Access to the file system for R/H-CPUs

The file API only offers limited access to the SIMATIC load memory. Access is restricted to the "UserFiles", "DataLogs" and "Recipes" folders. Other content in the SIMATIC load memory is not accessible via the API.

6.15.1 Files.Browse

This method returns a list of the contents of subfolders and attributes of a specific folder or a file which are located on the SIMATIC load memory of a CPU.

To call the Files.Browse method, you require the "read_file" authorization.

NOTE

For R/H-CPUs, only a maximum of 3 folders – Recipes, UserFiles and DataLogs – are returned in the root folder of the SIMATIC load memory. No other folders are returned.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-284 Files_Browse_Request (object)

Name	Required	Data type	Description
resource	No	string	Path to the folder or file from the root node. For the root node, the use of a "/" is necessary. You can optionally use a "/" for the root node. If the attribute "resource" is missing or empty, the system interprets it as "/".

Example 1

The following example shows a request specifying the desired path to a txt file:

```
{
  "resource": "/myfolder/file.txt"
}
```

Example 2

The following example shows a request specifying the desired path to a csv file (DataLog).

```
{
  "resource": "/Datalogs/datalog1.csv"
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-285 Files_Browse_Response (object)

Name	Required	Data type	Description
resources	Yes	array of files_Browse_Entry_Response	Resource list.

Table 3-286 Files_Browse_Entry_Response (object)

Name	Required	Data type	Description
name	Yes	string	Name of the entry.
type	Yes	string	Type of entry, either "file" or "dir".
size	No	number	Size of the file in bytes (if type is "file").
last_modified	Yes	string	ISO8601 time stamp as string; time stamp of the last change.
state	No	string	Attribute reserved for active or inactive DataLogs in the "DataLogs" folder

Example 1

The following example shows the response to a request with a file and a folder:

```
{
  "resources":
  [
    {
      "name": "my_dir",
      "type": "dir",
      "last_modified": "2012-04-23T18:25:43Z"
    },
    {
      "name": "my_file.txt",
```

```
      "type": "file",
      "size": 87654567,
      "last_modified": "2012-04-23T18:25:43Z"
    }
  ]
}
```

Example 2

The following example shows the response to a query to the test.txt file. Note that the entry is case-sensitive.

```
{
  "resources":
  [
    {
      "name": "Test.txt",
      "type": "file",
      "size": 87654567,
      "last_modified": "2012-04-23T18:25:43Z"
    }
  ]
}
```

Example 3

The following example shows the response to a query with an active csv file:

```
{
  "resources":
  [
    {
      "name": "datalog1.csv",
      "type": "file",
      "size": 87654567,
      "last_modified": "2012-04-23T18:25:43Z",
      "state": "active"
    }
  ]
}
```

Possible error messages

The following table shows possible error messages of the Files.Browse method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method.
4	No resources	The system does not have the required resources to carry out this request.
300	Path contains an illegal sequence	The parameter specified under "resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" is subject to access restrictions.
302	Entity does not exist	The file or path to be accessed by the "resource" parameter does not exist.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.
310	Entity access denied	The parameter specified under "resource" was rejected.

6.15.2 Files.Download

This method creates a ticket that you can use to download a file from the CPU.

To call the Files.Download method, you require "read_file" authorization.

For more information about the ticket mechanism, see the Ticket mechanism (Page 126) section.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-287 Files_Download_Request (object)

Name	Required	Data type	Description
resource	yes	string	Path to the file from the root node of the SIMATIC load memory

Example 1

The following example shows a request specifying the desired path to a txt file:

```
{
  "resource": "/myfolder/file.txt"
}
```

Example 2

The following example shows a request specifying the desired path to a csv file (DataLog).

```
{
  "resource": "/Datalogs/datalog1.csv"
}
```

Response structure

If successful, the method returns a string with a ticket ID.

Example

The following example shows a generated ticket ID for downloading the file:

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

NOTE

Ticket-based file downloads

For all ticket-based file downloads, the ticket returns a file name in the HTTP content disposition header. You can use this file name as the default file name, or as the name used by the web browser as the default name.

Possible error messages

The following table shows possible error messages of the Files.Download method.

Error code	Error message	Meaning
2	Permission denied	The user does not have read permissions.
4	No resources	The system does not have the required resources to carry out this request.
300	Path contains an illegal sequence	The parameter specified under "resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" is subject to access restrictions.
302	Entity does not exist	The file or path to be accessed by the "resource" parameter does not exist.
303	Entity in use	The file or path to be accessed by the "resource" parameter is locked because of another operation (e.g. because of a write access).
306	Entity not a file	The file name specified under "resource" is attempting to access a folder.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.
310	Entity access denied	The parameter specified under "resource" was rejected.

6.15.3 Files.Create

This method creates a ticket that you use to upload a file to the CPU.

To call the Files.Create method, you require "write_file" authorization.

For more information about the ticket mechanism, see the Ticket mechanism (Page 126) section.

NOTE
Uploading a file on R/H-CPUs
If a file is uploaded during SYNCUP, the R/H system aborts the upload of this file. During SYNCUP, the R/H does not wait until the file has uploaded.

NOTE
Storage location of files on R/H-CPUs
Files can only be created in the Recipes and UserFiles folders and not in the root folder or outside these two folders.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-288 Files_Create_Request (object)

Name	Required	Data type	Description
resource	yes	string	Path to the file from the root node of the SIMATIC load memory

Example

The following example shows a request specifying the path to the desired file:

```
{
  "resource": "/mydir/file.txt"
}
```

Response structure

If successful, the method returns a string with a ticket ID.

Example

The following example shows a generated ticket ID for uploading the file:

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

Possible error messages

The following table shows possible error messages of the Files.Create method.

Error code	Error message	Meaning
2	Permission denied	The user does not have read permissions.
4	No resources	The system does not have the required resources to carry out this request.
5	System is read-only	The system cannot be written to at present. File changes are not possible because the SIMATIC load memory is read-only.
300	Path contains an illegal sequence	The parameter specified under "resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" is subject to access restrictions.
302	Entity does not exist	The folder or subfolder to be accessed by the "resource" parameter does not exist.
304	Entity already exists	The parameter specified under "resource" is attempting to create a file that already exists.
305	Entity not a direct-ory	The folder or subfolder specified under "resource" is attempting to access a file.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.
310	Entity access denied	The parameter specified under "resource" was rejected.

6.15.4 Files.Rename

This method changes the name of a file or folder. You can also use this method to move files from one folder to another folder.

To call the Files.Rename method, you require "write_file" authorization.

NOTE

Note that you cannot use this method for the "DataLogs" folder.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-289 Files_Rename_Request (object)

Name	Required	Data type	Description
resource	yes	string	Current file path or folder path
new_resource	yes	string	New file path or folder path

Example

The following example shows a change of the file name.

```
{
  "resource": "/folder/old_file_name.txt",
  "new_resource": "/folder/new_file_name.txt"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows possible error messages of the Files.Rename method.

Error code	Error message	Meaning
2	Permission denied	The user does not have write permission for the file.
4	No resources	The system does not have the required resources to carry out this request.
5	System is read-only	The system cannot be written to (SIMATIC load memory is write-protected). Changes are currently not permitted.
300	Path contains an illegal sequence	The parameter specified under "resource" and/or under "new_resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" and/or under "new_resource" is subject to access restrictions.
302	Entity does not exist	The file or path to be accessed by the parameter "resource" and/or under "new_resource" does not exist.
303	Entity in use	The parameter specified under "resource" is accessing a file or folder that is already locked by another operation (e.g. read or write).
304	Entity already exists	The parameter specified in "new_resource" is attempting to create a file or folder that already exists.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.
308	Directories cannot be moved	The parameter specified under "resource" and/or "new_resource" is attempting to move a folder. Moving a folder structure is not allowed.
310	Entity access denied	The parameter specified under "resource" was rejected.

6.15.5 Files.Delete

This method deletes files from the CPU.

To call the Files.Delete method, you require "write_file" authorization.

NOTE
Deleting DataLog files
You can also delete DataLog files with this method, but only if the file is not currently in use. If the DataLog file is currently in use, error message 303 appears: Entity in use.

NOTE
Deleting inactive DataLog files
If you have created a ticket for DataLogs.DownloadAndClear or Files.Download on an inactive DataLog file, you can still use the Files.Delete method to delete this file.

As a result, a download that has already been started or will be started in the future will fail with these tickets.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-290 Files_Delete_Request (object)

Name	Required	Data type	Description
resource	Yes	string	Path to the file from the root node of the SIMATIC load memory

Example 1

The following example shows a request specifying the desired path to a txt file:

```
{
  "resource": "/myfolder/file.txt"
}
```

Example 2

The following example shows a request specifying the desired path to a csv file (DataLog).

```
{
  "resource": "/Datalogs/datalog1.csv"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows possible error messages of the Files.Delete method.

Error code	Error message	Meaning
2	Permission denied	The user does not have write permission for the file.
4	No resources	The system does not have the required resources to carry out this request.
5	System is read-only	The system cannot be written to at present. File changes are not possible because the SIMATIC load memory is read-only.
300	Path contains an illegal sequence	The parameter specified under "resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" is subject to access restrictions.
302	Entity does not exist	The folder or subfolder to be accessed by the "resource" parameter does not exist.
303	Entity in use	The parameter specified under "resource" is accessing a file or folder that is already locked by another operation (e.g. read or write).
306	Entity not a file	The file name specified under "resource" is attempting to access a folder.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.
310	Entity access denied	The parameter specified under "resource" was rejected.

6.15.6 Files.CreateDirectory

This method creates a new folder.

To call the Files.CreateDirectory method, you require the "write_file" authorization.

NOTE

Available folders for R/H-CPUs

You can only create the DataLogs, Recipes and UserFiles folders. The folders are created on the system with the corresponding spelling UserFiles, Recipes, DataLogs, regardless of whether you specify `resource="/datalogs"`, for example. You cannot create subfolders.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-291 Files_CreateDirectory_Request (object)

Name	Required	Data type	Description
resource	Yes	string	Path to the file from the root node of the SIMATIC load memory

Example

The following example shows a request specifying the path to the desired folder.

```
{
  "resource": "/SPH_Storage/OPCUA"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows possible error messages of the Files.CreateDirectory method.

Error code	Error message	Meaning
2	Permission denied	The user does not have write permissions.
4	No resources	The system does not have the required resources to carry out this request.
5	System is read-only	The system cannot be written to at present. Changes are not possible because the SIMATIC load memory is write-protected.
300	Path contains an illegal sequence	The parameter specified under "resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" is subject to access restrictions.
302	Entity does not exist	The folder to be accessed by the "resource" parameter does not exist.
304	Entity already exists	The parameter specified under "resource" is attempting to create a folder that already exists.
305	Entity not a direct-ory	The parameter specified under "resource" is attempting to access a file.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.
310	Entity access denied	The parameter specified under "resource" was rejected.

6.15.7 Files.DeleteDirectory

This method deletes an existing folder from the CPU.

To call the Files.DeleteDirectory method, you require "write_file" authorization.

NOTE

Recursive deletion

Note that recursive deletion is not possible, and that the folder must be empty before you can delete it.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-292 Files_DeleteDirectory_Request (object)

Name	Required	Data type	Description
resource	yes	string	Path of the folder to be deleted

Example

The following example shows a request specifying the path to the desired folder.

```
{
  "resource": "/SPH_Storage"
}
```

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows possible error messages of the Files.DeleteDirectory method.

Error code	Error message	Meaning
2	Permission denied	The user does not have write permissions.
4	No resources	The system does not have the required resources to carry out this request.
5	System is read-only	The system cannot be written to at present. Changes are not possible because the SIMATIC load memory is write-protected.
300	Path contains an illegal sequence	The parameter specified under "resource" violates the naming convention (e.g. contains invalid characters).
301	Entity access is restricted	The parameter specified under "resource" is subject to access restrictions.
302	Entity does not exist	The folder to be accessed by the "resource" parameter does not exist.
303	Entity in use	The parameter specified under "resource" is accessing a folder that is already locked by another operation (e.g. read or write).
305	Entity not a direct-ory	The parameter specified under "resource" is attempting to access a file.
307	Maximum path depth exceeded	The parameter specified under "resource" exceeds the maximum path length.
310	Entity access denied	The parameter specified under "resource" was rejected.

6.15.8 DataLogs.DownloadAndClear

This method creates a ticket to download a DataLog from the CPU and to empty the contents after downloading.

NOTE

Use the DataLogs.DownloadAndClear method before using the Files.Browse (Page 247) method. Use the Files.Browse method to determine whether a DataLog is active or not.

You can apply the DataLogs.DownloadAndClear method only if the DataLog is not currently in use. If the DataLog is currently in use, the error message 303: Entity in use appears.

NOTE

If you do not want to delete the contents of DataLogs after downloading, use the Files.Download (Page 250) method instead.

To call the DataLogs.DownloadAndClear method, you require the "write_file" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-293 DataLogs_DownloadAndClear_Request (object)

Name	Required	Data type	Description
resource	Yes	string	The name of the DataLog you want to download. Alternatively, you can use a path starting with /datalogs/ (see examples below).

Example

The following example shows a request specifying the desired path to a csv file (DataLog).

```
{
  "resource": "/DataLogs/datalog1.csv"
}
```

Response structure

If successful, the method returns a string with a ticket ID.

Example

The following example shows a generated ticket ID for downloading and deleting the DataLog:

```
"NDU2Nzg5MDEyMzQ1Njc4OTAxMjM0"
```

Possible error messages

The following table shows possible error messages of the DataLogs.DownloadAndClear method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
4	No resources	The system does not have the required resources to carry out this request.
5	System is read-only	The system cannot be written to at present. Changes to the log file are not possible because the SIMATIC load memory is write-protected.
303	Entity in use	The file or path to be accessed by the "resource" parameter is locked because of another operation (e.g. the user program is currently accessing the DataLog).
309	Entity is not a valid data log	The parameter specified under "resource" is attempting to access an unlinked DataLog. An unlinked DataLog cannot be deleted.

6.16 Reading information from SIMATIC Safety

6.16.1 Failsafe.ReadRuntimeGroups

This method outputs a list with all available F-runtime groups.

To call the Failsafe.ReadRuntimeGroups method, you require "read_diagnostics" authorization.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-294 Failsafe_ReadRuntimeGroups_Response (object)

Name	Required	Data type	Description
groups	Yes	array of Failsafe_ReadRuntimeGroups_Entry_Response	Object array in which each object represents one F-runtime group.

Table 3-295 Failsafe_ReadRuntimeGroups_Entry_Response (object)

Name	Required	Data type	Description
name	Yes	string	Name of F-runtime group
signature	Yes	string	Signature of F-runtime group as array of decimal numbers Each number represents one byte of the signature.
cycle_time_current	Yes	string	ISO 8601 time span as string Current cycle time in milliseconds.
cycle_time_max	Yes	string	ISO 8601 time span as string Maximum cycle time in milliseconds.
runtime_current	Yes	string	ISO 8601 time span as string Current runtime in milliseconds.
runtime_max	Yes	string	ISO 8601 time span as string Maximum runtime in milliseconds.

Example

The following example shows the parameters of the response to a query with an F-runtime group with remaining time "remaining_time".

```
{
  "groups":
  [
    {
      "name": "RTG_1",
      "signature": "FD62F235",
      "cycle_time_current": "PT0.110S",
      "cycle_time_max": "PT0.200S",
      "runtime_current": "PT0.050S",
      "runtime_max": "PT0.080S"
    }
  ]
}
```

Possible error messages

The following table shows possible error messages of the Failsafe.ReadRuntimeGroups method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.16.2 Failsafe.ReadParameters

With this method, you can read out fail-safe parameters of a fail-safe CPU or a fail-safe module via the hardware ID of the module.

To call the Failsafe.ReadParameters method, you require the "read_diagnostics" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-296 Failsafe_ReadModuleParameters_Request (object)

Name	Required	Data type	Description
hwid	Yes	number	Hardware ID of the module whose parameters you want to read out.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-297 Failsafe_ReadParameters_Response (object)

Name	Required	Data type	Description
safety_mode	No	string	Status message indicating whether safety mode is active ("enabled") or not ("disabled"). Note that this status message only applies to the CPU and not to other modules.
type	Yes	string	Defines whether the required hardware ID is the fail-safe module or represents a different fail-safe module.
parameters	No	object	Indicates whether the required hardware ID is the fail-safe module with safety program or represents a different fail-safe module. The returned object is alternatively of type: • Failsafe_ReadParameters_Cpu_Response • Failsafe_ReadParameters_Module_Response

Table 3-298 Failsafe_ReadParameters_Cpu_Response (object)

Name	Required	Data type	Description
last_f_program_modification	Yes	string	ISO 8601 time stamp in UTC as string; time stamp of the last change in the safety program.
collective_signature	Yes	string	Collective F signature as byte array with 4 numbers for representing a 32-bit signature.
remaining_time	No	string	ISO 8601 time span as string; Remaining time in milliseconds (as of firmware version V2.9).
base_id	No	string	BaseID as hexadecimal representation

Table 3-299 Failsafe_ReadParameters_Module_Response (object)

Name	Required	Data type	Description
f_monitoring_time	Yes	string	ISO 8601 time stamp in UTC as string; F-monitoring time in milliseconds
f_source_address	Yes	number	F-source address
f_destination_address	Yes	number	F-destination address
f_par_crc	Yes	string	CRC signature of the F parameters as a byte array with 4 numbers for representing a 32-bit signature.

Example 1

The following example shows the parameters of a fail-safe CPU without safety mode.

```
{
  "type": "f_cpu"
}
```

Example 2

The following example shows the parameters of a fail-safe CPU in active safety mode.

```
{
  "type": "f_cpu",
  "safety_mode": "enabled",
  "parameters":
  {
    "last_f_program_modification": "2012-04-23T18:25:43.510Z",
    "collective_signature": "C572BC16",
    "remaining_time": "PT5D2H33M5.123S"
  }
}
```

Example 3

The following example shows the parameters of a fail-safe module in active safety mode.

```
{
  "type": "f_module",
  "parameters":
  {
    "f_monitoring_time": "PT0.123S",
    "f_source_address": 123,
    "f_destination_address": 123,
    "f_par_crc": "F062F235"
  }
}
```

Possible error messages

The following table shows possible error messages of the Failsafe.ReadParameters method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
1100	Invalid hardware identifier	The specified hardware ID is not valid for the current request. Make sure that you have used the correct hardware ID.

6.17 Reading CPU information

6.17.1 Plc.ReadCpuType

With this method, you can read the product names and the article number of the CPU. Thus you have the possibility to find out before the authentication with which CPU you are communicating.

No authorization is required to call the Plc.ReadCpuType method.

Response structure

The following table shows you the structure of the server response to a successful request.

Table 3-300 Plc_ReadCpuType_Response (object)

Name	Required	Data type	Description
product_name	Yes	string	The product name of the CPU or a CPU of the R/H system
order_number	Yes	string	The article number of the CPU or a CPU of the R/H system

Example

The following example shows the product name and the order number of the device.

```
{
  "product_name": "CPU 1516-3 PN/DP",
  "order_number": "6ES7 516-3AP03-0AB0"
}
```

6.17.2 Plc.ReadStationName

With this method you obtain the station name of the CPU.

No authorization is required to call the Plc.ReadStationName method.

Response structure

The following table shows you the structure of server responses to successful requests:

Table 3-301 Plc_ReadStationName_Response (object)

Name	Required	Data type	Description
station_name	Yes	string	The station name of the CPU

Example

In the following example, the user obtains the station name of the CPU.

```
{
  "station_name": "S71500/ET200MP station_1"
}
```

6.17.3 Plc.ReadModuleName

With this method you obtain the name of the CPU.

No authorization is required to call the Plc.ReadModuleName method.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-302 Plc_ReadModuleName_Request (object)

Name	Required	Data type	Description
redundancy_id	Yes, for R/H-CPUs; No for all other CPUs	number	The parameter "redundancy ID" must be available if the request is performed on an R/H-CPU. The "redundancy ID" has the value 1 or 2. This allows you to read out the name of both CPUs of an R/H system individually. With all other CPUs, the parameter must not be part of the request.

Response structure

The following table shows you the structure of server responses to successful requests:

Table 3-303 Plc_ReadModuleName_Response (object)

Name	Required	Data type	Description
module_name	Yes	string	The name of the CPU

Example

In the following example, the user obtains the article number of the CPU.

```
{
  "module_name": "PLC_1"
}
```

Possible error messages

The following table shows possible error messages of the Plc.ReadModuleName method.

Error code	Error message	Meaning
-32602	Invalid params	Invalid parameters of the method. This error occurs when the parameter redundancy_id is specified at a non-R/H-CPU or, respectively, when the parameter is invalid at an R/H-CPU.

6.17.4 Plc.ReadLoadMemoryInformation

This method returns information on the memory usage of the load memory.

To call the Plc.ReadLoadMemoryInformation method, you require the "read_diagnostics" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-304 Plc_ReadLoadMemoryInformation_Request (object)

Name	Required	Data type	Description
redundancy_id	Yes for R/H-CPUs; No for all other CPUs	number	The parameter "redundancy ID" must be available if the request is performed on an R/H-CPU. The "redundancy ID" has the value 1 or 2. With all other CPUs, the parameter must not be part of the request.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-305 Plc_ReadLoadMemoryInformation_Response (object)

Name	Required	Data type	Description
load_memory	No	object of type `Plc_ReadLoadMemory-Information_Response`	Load memory information. If you are using PLCSIM Advanced, this attribute is not included in the response.

Table 3-306 **Plc_ReadLoadMemoryInformation_Response (object)**

Name	Required	Data type	Description
free_bytes	No	number	Free size of the specified memory in bytes. If the R/H system is not in redundant status, this value is not available.
total_bytes	Yes	number	Total size of the specified memory in bytes.
aging	Yes	object of type `Plc_ReadLoad-MemoryInforma-tion_Aging_Res-ponse`	Age information of the memory card.

Table 3-307 **Plc_ReadLoadMemoryInformation_Aging_Response (object)**

Name	Required	Data type	Description
service_life_used-_percentage	No	number	Percentage between 0 and 100 indicates how much of the service life of the memory card has already expired. If no valid value is read in internally, this attribute is not included in the response.
treshold_configu-red_percentage	No	number	Number between 0 and 100 indicates the configured percentage at which a diagnostics event is triggered. If no valid value is read in internally, this attribute is not included in the response.

Example 1

The following example shows statistics for a CPU 1516 with age information.

```
{
  "load_memory":
  {
    "free_bytes": 50000,
"total_bytes": 25165824
"aging":
{
      "service_life_used_percentage": 2,
      "threshold_percentage": 80
    }
  }
}
```

Example 2

The following example shows statistics for a CPU 1516 without a threshold value.

```
{
  "load_memory":
  {
    "free_bytes": 50000,
    "total_bytes": 25165824
    "aging":
    {
      "service_life_used_percentage": 7
    }
  }
}
```

Example 3

The following example shows the statistics of a partner CPU 1516 of an R/H system in non-redundant status.

```
{
  "load_memory":
  {
    "total_bytes": 25165824
  }
}
```

Example 4

The following example shows PLCSIM Advanced without load memory / CPU 1516 without SIMATIC Memory Card / an inaccessible CPU of an R/H system.

```
{
}
```

Possible error messages

The following table shows possible error messages of the Plc.ReadLoadMemoryInformation method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
7	Partner not accessible	The data of the CPU of an R/H system is not available. This can be the case when the system is in SYNCUP operating state or RUN-Redundant system state or when the service data of the partner CPU is queried.

6.18 Reading information about device configuration

You can use the following methods to read out various information about the device configuration and status information.

The term "node" in the following sections includes the following elements:

- PROFINET IO system
- IO device
- Module
- Submodule

6.18.1 Modules.Browse

Use this method to read information about the hardware configuration.

To call the Modules.Browse method, you require the "read_diagnostics" authorization.

More information

For more information on the configuration control, refer to the S7-1500 System Manual (https://support.industry.siemens.com/cs/ww/en/view/59191792), "Configuration control (option handling)" section.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-308 Modules_Browse_Request (object)

Name	Required	Data type	Description
hwid	No	number	The hardware ID of the node you want to query. If the request does not contain a `hwid` parameter, Root is queried and all available central devices and distributed I/O systems of the CPU are output.
mode	No	string	Defines what is returned in the response. Possible values are: • "node": Only information on the specified `hwid` is output. • "children": Information on the specified `hwid` and its subordinate elements is output.

Example 1

In this example, the hardware ID is queried with mode = node.

```
{
  "hwid": 49,
  "mode": "node"
}
```

Example 2

In this example, the hardware ID is queried with mode = children.

```
{
  "hwid": 49,
  "mode": "children"
}
```

Example 3

In this example, the hardware ID is queried with mode = children (default).

```
{
  "hwid": 49
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-309 **Modules_Browse_Response (object)**

Name	Required	Data type	Description
nodes	Yes	array of `Modules_Browse_Entry_Response`	Array of addressed nodes

Table 3-310 **Modules_Browse_Entry_Response (object)**

Name	Required	Data type	Description
hwid	Yes	number	Hardware ID of the node
class	No	string	Hardware type of the node, for example "`CPU 1516-3 PN/DP`"
type	Yes	string	Basic type of the node. The following values are possible: • "iosystem": PROFINET IO system • "device": IO device • "module": Module • "submodule": Submodule
subtype	No	string	Subtype of the node. The following values are possible: • "profinet_interface" • "profinet_interface_virtual" • "profinet_port" • "profibus_interface" • "cpu" • "central_iosystem" • "central_device" • "profinet_iosystem" • "profibus_iosystem" • "gateway" If no subtype is defined for the node, the value indicates `none`.
name	Yes	string	Name of the node that you have configured in the TIA Portal.
attributes	No	array of string	The attribute contains identifiers for each criterion that corresponds to the node. The following values are possible: • "firmware_update": Module supports firmware update. • "failsafe": F-module. • "configuration_control": Option handling is activated for this device in the hardware configuration. • "configured_topology": The topology is configured in the hardware configuration. • "service_data": Module supports downloading service data.
has_children	No	bool	Information on whether there are any child nodes under the node. This value is only output if `mode = node`.
children	No	array of data type `Modules_Browse_Children_Entry_Response`	Array of objects where each object represents a node that is a child node of the specified node. This value is only output if `mode = children`.
parent	No	array of number	This value indicates the `hwid` of the parent node to the specified `hwid`. If you query Root, this parameter is not included in the response. For R/H-CPUs, several parent nodes are listed for a device; for other CPUs, only one parent node.

Table 3-311 Modules_Browse_Children_Entry_Response (object)

Name	Required	Data type	Description
hwid	Yes	number	Hardware ID of the node
class	No	string	Hardware type of the node
type	Yes	string	Basic type of the node. The following values are possible: • "iosystem": PROFINET IO system • "device": IO device • "module": Module • "submodule": Submodule
subtype	No	string	Subtype of the node. The following values are possible: • "profinet_interface" • "profinet_interface_virtual" • "profinet_port" • "profibus_interface" • "cpu" • "central_iosystem" • "central_device" • "profinet_iosystem" • "profibus_iosystem" • "gateway"
name	Yes	string	Name of the node that you have configured in the TIA Portal.
attributes	No	array of string	The attribute contains identifiers for each criterion that corresponds to the node. The following values are possible: • "firmware_update": Module supports firmware update. • "failsafe": F-module. • "configuration_control": Option handling is activated for this device in the hardware configuration. • "configured_topology": The topology is configured in the hardware configuration. • "service_data": Module supports downloading service data.
has_children	Yes	bool	The attribute contains Information on whether there are other child nodes under the node.

Example 1

In this example, Root is queried: No hwid, configuration control from central device permitted. The response contains one central device and two distributed IO systems.

```
{
  "nodes":
  [
    {
      "hwid": 32,
      "name": "S7-1500/ET200MP-station_1",
      "class": "CPU 1516F-3 PN/DP",
      "type": "device",
      "subtype": "central_device",
      "attributes": ["configuration_control"]
    },
```

```
    {
      "hwid": 265,
      "name": "PROFINET IO-System_1",
      "type": "iosystem",
      "subtype": "profinet_iosytem"
    },
    {
      "hwid": 257,
      "name": "PROFINET IO-System_2",
      "type": "iosystem",
      "subtype": "profinet_iosytem"
    }
  ]
}
```


Example 2

In this example, Root is queried: No hwid, mode = children as default value. The response contains a central device and a distributed IO system with its direct child nodes.


```
{
  "nodes":
  [
    {
      "hwid": 32,
      "name": "S7-1500/ET200MP-station_1",
      "class": "CPU 1516-3 PN/DP",
      "type": "device",
      "subtype": "central_device",
      "children":
      [
        {
          "hwid": 49,
          "name": "PLC_1",
          "class": "CPU 1516-3 PN/DP",
          "type": "module",
          "subtype": "cpu"
          "attributes": ["firmware_update", "service_data"],
          "has_children": true
        },
        {
          "hwid": 284,
          "name": "CP_1543-1",
          "class": "CP 1543-1",
          "type": "module",
          "attributes": ["firmware_update"],
```

```
            "has_children": false
          }
        ]
      },
      {
        "hwid": 265,
        "name": "PROFINET IO-System_1",
        "type": "iosystem",
        "children":
        [
          {
            "hwid": 266,
            "name": "iodevice_1",
            "class": "IM 155-6 PN BA",
            "type": "device",
            "has_children": true
          }
        ]
      }
    ]
}
```


Example 3

In this example, a device (hwid = 32, central device) is queried: mode = children. The response contains the central device with its child nodes. hwid is a root node and therefore has no parents. The parent attribute is not included in the response.


```
{
  "nodes":
  [
    {
      "hwid": 32,
      "name": "S7-1500/ET200MP-station_1",
      "class": "CPU 1516-3 PN/DP",
      "type": "device",
      "subtype": "central_device",
      "children":
      [
        {
          "hwid": 49,
          "name": "PLC_1",
          "class": "CPU 1516-3 PN/DP",
          "type": "module",
          "subtype": "cpu",
          "attributes": ["firmware_update", "service_data"],
```

```
            "has_children": true
          },
          {
            "hwid": 284,
            "name": "CP_1545-1",
            "type": "module",
            "attributes": ["firmware_update"],
            "has_children": true
          }
        ]
      }
    ]
}
```


Example 4

In this example, a submodule is queried: Subtype = profinet_interface, mode = children. The response contains the PROFINET interface with its child nodes (2 ports and a linked distributed IO system).


```
{
  "nodes":
  [
    {
      "hwid": 64,
      "name": "PROFINET-Interface_1",
      "class": "PROFINET interface",
      "type": "submodule",
      "subtype": "profinet_interface",
      "parent": [49],
      "children":
      [
        {
          "hwid": 65,
          "name": "Port_1",
          "class": "Port",
          "type": "submodule",
          "subtype": "profinet_port",
          "has_children": true
        },
        {
          "hwid": 66,
          "name": "Port_2",
          "class": "Port",
          "type": "submodule",
          "subtype": "profinet_port",
```

```
            "has_children": true
          },
          {
            "hwid": 257,
            "name": "PROFINET IO system",
            "type": "iosystem",
            "subtype": "profinet_iosystem",
            "has_children": true
          }
        ]
      }
    ]
  }
```


Example 5

In this example, a submodule is queried: Subtype = profinet_port, mode = children. The response contains the port node. There are no linked child nodes. The childern attribute must be present but empty.


```
{
  "nodes":
  [
    {
      "hwid": 65,
      "name": "Port_1",
      "class": "Port",
      "type": "submodule",
      "subtype": "profinet_port",
      "parent": 64,
      "children": []
    }
  ]
}
```


Example 6

In this example, a module is queried. The response contains the CPU 1516F module with further specific parameters and its child nodes.


```
{
  "nodes":
  [
    {
      "hwid": 49,
      "name": "PROFINET-Interface_1",
      "class": "CPU 1516-3 PN/DP",
```

```
            "type": "module",
            "subtype": "cpu",
            "attributes": ["failsafe", "firmware_update", "service_data"]
            "parent": [32],
            "children":
            [
              {
                "hwid": 64,
                "name": "PROFINET-Interface_1",
                "class": "PROFINET interface",
                "type": "submodule",
                "subtype": "profinet_interface",
                "has_children": true
              },
              {
                "hwid": 72,
                "name": "PROFINET-Interface_2",
                "class": "PROFINET interface",
                "type": "submodule",
                "subtype": "profinet_interface",
                "has_children": false
              },
              {
                "hwid": 60,
                "name": "DP-Interface_1",
                "class": "DP interface",
                "type": "submodule",
                "subtype": "profibus_interface",
                "has_children": false
              },
              {
                "hwid": 135,
                "name": "Virtual communication interface_1",
                "class": "Virtual communication interface",
                "type": "submodule",
                "subtype": "profinet_interface_virtual",
                "has_children": false
              }
            ]
          }
        ]
      }
```

Possible error messages

The following table shows possible error messages of the Modules.Browse method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
1100	Invalid hardware identifier	The specified hardware ID is not valid for the current request. Make sure that you have used the correct hardware ID.

6.18.2 Modules.ReadParameters

This method provides detailed information on the node with the given hardware ID.

To call the Modules.ReadParameters method, you require the "read_diagnostics" authorization.

More information

For more information on the configuration control, refer to the S7-1500 System Manual (https://support.industry.siemens.com/cs/ww/en/view/59191792), "Configuration control (option handling)" section.

Structure of the request

The following tables contain information about the individual parameters of the request.

Table 3-312 Modules_ReadParameters_Request (object)

Name	Required	Data type	Description
hwid	Yes	number	Hardware ID of the node whose service data you want to read out.
filters	No	object of type `Modules_Read-Paramet-ers_Filters_Re-quest`	Optional object containing parameters for filtering the response.

Table 3-313 Modules_ReadParameters_Filters_Request (object)

Name	Required	Data type	Description
mode	Yes	string	The mode with which you specify whether you want to include or exclude attributes in the response. The following modes are available: • "include" • "exclude"
attributes	Yes	array of string	Possible array entries are: • "comment" • "parameters" • "geo_address"

Example

This example shows a request.

```
{
  "hwid": 49,
  "filters":
  {
    "mode": "include",
    "attributes": ["comment", "parameters", "geo_address"]
  }
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-314 Modules_ReadParameters_Response (object)

Name	Required	Data type	Description
language	Yes	string	Project language of the comment. If there is no text in the CPU, the response shows `invalid` and the comment is empty. You can read out the available project languages using the Project.ReadLanguages (Page 217) method.
general	Yes	object of data type `Modules_ReadParameters_Common_Response`	General information about the node
comment	Yes, if not excluded by the user	object of data type `Modules_ReadParameters_Common_Response`	Comment about the node. This is loaded onto the CPU in the project language that was set as the current language in TIA.
geo_address	Yes, if not excluded by the user	object of data type `Modules_ReadParameters_GeoAddress_Response`	Geographical address of the node
parameters	Yes, if not excluded by the user	object of data type `Modules_ReadParameters_Parameters_Response`	Parameters of the node

Table 3-315 Modules_ReadParameters_General_Response (object)

Name	Required	Data type	Description
name	Yes	string	Node name
class	Yes	string	Hardware type of the node, for example "`CPU 1516-3 PN/DP`"
type	Yes	string	Basic type of the node. The following values are possible: • "iosystem": PROFINET IO system • "device": IO device • "module": Module • "submodule": Submodule

Name	Required	Data type	Description
subtype	No	string	Subtype of the node. The following values are possible: • "profinet_interface" • "profinet_interface_virtual" • "profinet_port" • "profibus_interface" • "cpu" • "central_iosystem" • "central_device" • "profinet_iosystem" • "profibus_iosystem" • "gateway"
attributes	No	array of string	The attribute contains identifiers for each criterion that corresponds to the node. The following values are possible: • "firmware_update": Module supports firmware update. • "failsafe": F-module. • "configuration_control": Option handling is activated for this device in the hardware configuration. • "configured_topology": The topology is configured in the hardware configuration. • "service_data": Module supports downloading service data.

Table 3-316 Modules_ReadParameters_Comment_Response (object)

Name	Required	Data type	Description
text	Yes	string	Comment about the node

Table 3-317 Modules_ReadParameters_GeoAddress_Response (object)

Name	Required	Data type	Description
actual	No	object of data type `Modules_ReadParameters_GeoAddres_Actual_Response`	The current geographical address of the node
configured	Yes	object of data type `Modules_ReadParameters_GeoAddres_Configured_Response`	The configured geographical address of the node

Table 3-318 Modules_ReadParameters_GeoAddress_Actual_Response (object)

Name	Required	Data type	Description
iosystem	No	number	I/O system number of the node. Is not output if the removed_by_configuration_control parameter has the value `true`.
device	No	number	Device number of the node. For the PROFIBUS device, it corresponds to the PROFIBUS address of the station. Is not output if the removed_by_configuration_control parameter has the value `true`.
slot	No	number	Slot number of the node. Is not output if the removed_by_configuration_control parameter has the value `true`.

Name	Required	Data type	Description
subslot	No	number	Subslot number of the node. Is not output if the removed_by_configuration_control parameter has the value `true`.
rack	No	number	Rack number of the node. Is not output if the removed_by_configuration_control parameter has the value `true`.
removed_by_configuration_control	Yes	bool	If the configuration control has removed the configured node from the current configuration, this value is `true`; otherwise, the value is `false`.

Table 3-319 Modules_ReadParameters_GeoAddress_Configured_Response (object)

Name	Required	Data type	Description
iosystem	Yes	number	I/O system number of the node
device	Yes	number	Device number of the node. For the PROFIBUS device, it corresponds to the PROFIBUS address of the station.
slot	Yes	number	Slot number of the node
subslot	Yes	number	Subslot number of the node
rack	Yes	number	Rack number of the node

Table 3-320 Modules_ReadParameters_Parameters_Response (object)

Name	Required	Data type	Description
input_output	No	array of `Modules_ReadParameters_Parameters_InputOutput_Response`	The input and output address of the module or submodule. If the node does not represent a module or submodule, the value is not output.
submodule	No	object of data type `Modules_ReadParameters_Parameters_Submodule_Response`	Specific attributes of the submodule. This value is only output if the node is of the type `submodule`.
versions	No	array of `Modules_ReadParameters_Parameters_Versions_Response`	Extended version information about the node. This value is only output for type `module` and subtype `cpu`.

Table 3-321 Modules_ReadParameters_Parameters_Submodule_Response (object)

Name	Required	Data type	Description
alternate_number	Yes	string	The slot number of the node is encoded as a string, for example "`X1`".

Table 3-322 Modules_ReadParameters_Parameters_Versions_Response (object)

Name	Required	Data type	Description
bootloader	No	object of data type `Modules_ReadParameters_Parameters_MotionPackage_Response`	Bootloader version of the node, for example "`V2.2.1`" for a hardware CPU. This value is not output for Software Controllers and PLCSIM Advanced.
motion	No	object of data type `Modules_ReadParameters_Parameters_Versions_Motion_Response`	Array of motion packages

Table 3-323 Modules_ReadParameters_Parameters_Versions_Bootloader_Response (object)

Name	Required	Data type	Description
type	Yes	string	Version type, for example "`V`"
major	Yes	number	Major version
minor	Yes	number	Minor version
patch	Yes	number	Patch version

Table 3-324 Modules_ReadParameters_Parameters_InputOutput_Response (object)

Name	Required	Data type	Description
direction	Yes	string	The direction of the range. The following values are possible: • "input" • "output"
address	Yes	number	The address of the range.
length	Yes	number	The length of the addressable range.

Table 3-325 Modules_ReadParameters_Parameters_Motion_Packages_Response (object)

Name	Required	Data type	Description
packages	Yes	Array of `Modules_ReadParameters_Parameters_Versions_Motion_Package_Response`	The array contains a list of information about motion packages.

Table 3-326 Modules_ReadParameters_Parameters_Versions_Motion_Package_Response (object)

Name	Required	Data type	Description
name	Yes	string	Package name of the motion package, for example "`MC Base`". This value is not output for older projects.
internal	Yes	string	The internal version number of the motion package, for example "`7.1.13.0_205.0.0.0`".
external	Yes	string	The external version number of the motion package, for example "`7.0.8`".

Example 1

The following example shows a filtered response with general information only.

```
{
  "general":
  {
    "name": "S71500/ET200MP station_1",
    "class": "CPU 1516F-3 PN/DP",
    "type": "device",
    "subtype": "central_device",
    "attributes": ["failsafe", "firmware_update", "service_data",
"configuration_control"]
  }
}
```

Example 2

The following example shows a filtered response with a comment only.

```
{
  "comment":
  {
    "text": "abc"
  },
  "language": "en-US"
}
```

Example 3

The following example shows a filtered response with a comment only, but with the invalid language.

```
{
  "comment":
  {
    "text": ""
  },
  "language": "invalid"
}
```

Example 4

The following example shows a filtered response with a geographical address only, without configuration control.

```
{
  "geo_address":
  {
```

```
    "configured":
    {
      "iosystem": 1,
      "device": 2,
      "slot": 1,
      "subslot": 1,
      "rack": 1
    }
  }
}
```

Example 5

The following example shows a filtered response with a geographical address only, with active configuration control, but a node of the distributed I/O is accessible.

```
{
  "geo_address":
  {
    "configured":
    {
      "iosystem": 100,
      "device": 4,
      "slot": 1,
      "subslot": 1,
      "rack": 1
    }
  }
}
```

Example 6

The following example shows a filtered response with a geographical address only, with active configuration control, and a child node of the central device was requested.

```
{
  "geo_address":
  {
    "actual":
    {
      "iosystem": 1,
      "device": 2,
      "slot": 1,
      "subslot": 1,
      "rack": 1,
      "removed_by_configuration_control": false
    },
```

```
    "configured":
    {
      "iosystem": 1,
      "device": 2,
      "slot": 1,
      "subslot": 1,
      "rack": 1
    }
  }
}
```

Example 7

The following example shows a filtered response with parameters: Module with input and output address.

```
"parameters":
{
  "input_output":
  [
    {
      "direction": "input",
      "address": 0,
      "length": 8
    },
    {
      "direction": "output",
      "address": 8,
      "length": 4
    }
  ]
}
```

Example 8

The following example shows a filtered response with parameters: CPU with version information.

```
"parameters":
{
  "versions":
  {
    "bootloader":
    {
      "type": "V",
      "functional": 2,
      "bugfix": 2,
```

```
      "internal": 1
    },
    "motion":
    {
      "packages":
      [
        {
          "name": "MC Base",
          "internal": "7.1.13.0_205.0.0.0",
          "external": "7.0.8"
        }
      ]
    }
  }
}
```


Example 9

The following example shows a filtered response with parameters: Software Controller with version information.


```
"parameters":
{
  "versions":
  {
    "motion":
    {
      "packages":
      [
        {
          "name": "MC Base",
          "internal": "7.1.13.0_205.0.0.0",
          "external": "7.0.8"
        }
      ]
    }
  }
}
```

Example 10

The following example shows a filtered response with parameters: Module type.

```
"parameters":
{
  "module":
  {
    "alternate_number": "X100"
  }
}
```

Example 11

The following example shows a filtered response with parameters: Submodule type.

```
"parameters":
{
  "submodule":
  {
    "alternate_number": "X100"
  }
}
```

Example 12

The following example shows a filtered response with parameters: Subtype profinet_interface.

```
"parameters":
{
  "submodule":
  {
    "alternate_number": "X1"
  }
}
```

Example 13

The following example shows a filtered response with parameters: Subtype profinet_port.

```
"parameters":
{
  "submodule":
  {
    "alternate_number": "X1 P1"
  }
}
```

Example 14

The following example shows a filtered response with parameters: Subtype profinet_port with MRP support.

```
"parameters":
{
  "submodule":
  {
    "alternate_number": "X1 P1R"
  }
}
```

Possible error messages

The following table shows possible error messages of the Modules.ReadParameters method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
1100	Invalid hardware identifier	The specified hardware ID is not valid for the current request. Make sure that you have used the correct hardware ID.

6.18.3 Modules.ReadIdentificationMaintenance

This method reads out the current or expected identification and maintenance data of the module or device.

To call the Modules.ReadIdentificationMaintenance method, you require the "read_diagnostics" authorization.

More information

Detailed information on maintenance data (I&M data) can be found in the S7-1500 System Manual (https://support.industry.siemens.com/cs/ww/en/view/59191792), section "Identification and maintenance data".

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-327 Modules_ReadIdentificationMaintenance_Request (object)

Name	Required	Data type	Description
hwid	Yes	number	Identification of the module or device for which you are reading out the I&M data.
number	Yes	number	The entry read out is between 0 and 3
type	Yes	string	The type read out. The possible values depend on which of the data I&M0 to I&M3 you want to read out: • "actual": The current data is read from the module. • "configured": The expected data is read from the hardware configuration.

Example

In the following example, the current I&M0 data for hardware ID 49 is read out.

```
{
  "hwid": 49,
  "number": 0,
  "type": "actual"
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-328 Modules_ReadIdentificationMaintenance_Response (object)

Name	Required	Data type	Description
data	Yes	object of data type `Modules_ReadIdentificationMaintenance_IM*_Response`	The entry contains data according to the respective data structure.

Table 3-329 Modules_ReadIdentificationMaintenance_IM0_Response (object)

Name	Required	Data type	Description
manufacturer_id	Yes	number	Manufacturer ID of the module
order_number	Yes	string	Order number of the module
serial_number	Yes	string	Serial number of the module
hardware_revision	Yes	number	Hardware revision of the module
software_revision	Yes	object	Software revision of the module, for example "`V2.9.0`"
revision_counter	Yes	number	Not used
profile_id	Yes	number	Profile ID

Name	Required	Data type	Description
profile_specific_type	Yes	number	Profile type
im_version	Yes	object	Information about the version of the I&M data
im_supported	Yes	number	Information about the available I&M data (I&M1 to I&M3)

Table 3-330 Modules_ReadIdentificationMaintenance_IM0_Software_Revision_Response (object)

Name	Required	Data type	Description
type	Yes	string	Version type, for example "V"
major	Yes	number	Major version
minor	Yes	number	Minor version
patch	Yes	number	Patch version

Table 3-331 Modules_ReadIdentificationMaintenance_IM0_IM_Version_Response (object)

Name	Required	Data type	Description
major	Yes	number	Major version
minor	Yes	number	Minor version

Table 3-332 Modules_ReadIdentificationMaintenance_IM1_Response (object)

Name	Required	Data type	Description
plant_designation	Yes	string	Plant designation from the hardware configuration
location_identifier	Yes	string	Location identifier of the requested `hwid` from the hardware configuration

Table 3-333 Modules_ReadIdentificationMaintenance_IM2_Response (object)

Name	Required	Data type	Description
installation_date	Yes	string	Installation date. Date and time at which the module was added to the TIA Portal project, in the format in which it was downloaded from the TIA Portal. By default as UTC time.

Table 3-334 Modules_ReadIdentificationMaintenance_IM3_Response (object)

Name	Required	Data type	Description
additional_information	Yes	string	User-specific additional information, e.g. purpose of the device

Example 1

The following example shows a response with the current I&M0 data.

```
{
  "data"
  {
     "manufacturer_id": 42,
     "order_number": "6ES7 591-1BA02-0AA0 ",
     "serial_number": "S C745612018",
     "hardware_revision": 10001,
     "software_revision":
```

```
      {
         "type": "V",
         "functional": 2,
         "bugfix": 9,
         "internal": 0
      },
      "revision_counter": 0,
      "profile_id": 0,
      "profile_specific_type": 0,
      "im_version": {
        "major": 1,
        "minor": 1
      }
      "im_supported": 1
   }
}
```


Example 2

The following example shows a response with the configured I&M1 data.


```
{
  "data":
  {
    "plant_designation": "Company X21",
    "location_identifier": "Main City"
  }
}
```


Example 3

The following example shows a response with the configured I&M2 data.


```
{
  "data":
  {
    "installation_date": "2025-07-12 13:37"
  }
}
```

Example 4

The following example shows a response with the configured I&M3 data.

```
{
  "data":
  {
    "additional_information": "Pumping liquids"
 }
}
```

Possible error messages

The following table shows possible error messages of the Modules.ReadIdentificationMaintenance method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
1100	Invalid hardware identifier	The specified hardware ID is invalid. Check the correct ID or find the correct hardware ID.
1101	Invalid index	The specified index of the I&M data is invalid.
1102	Data not readable	The data is not readable. Check whether the device or the module is accessible.
1103	I&M data not supported	The specified hardware ID does not support the I&M data.

6.18.4 Modules.ReadStatus

Use this method to read out the status of a node available in the hardware configuration using the `hwid`.

To call the Methode Modules.ReadStatus method, you require the "read_diagnostics" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-335 Modules_ReadStatus_Request (object)

Name	Required	Data type	Description
language	No	string	The project language of the output text. If the parameter is invalid or missing, no text is output. You can read out the available project languages using the Project.ReadLanguages (Page 217) method.
hwid	Yes	number	Hardware ID of the node whose status you want to read out.

Example 1

In the following example, a diagnostic text is requested for hardware ID 49 for language "en-US".

```
{
  "hwid": 49,
  "language": "en-US"
}
```

Example 2

In the following example, a diagnostic text is requested for hardware ID 49 with an invalid language.

```
{
  "hwid": 49,
  "language": ""
}
```

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-336 **Modules_ReadStatus_Response (object)**

Name	Required	Data type	Description
status	Yes	object of type `Modules_Read-Status_Status_Response`	Status of the node
messages	Yes	array of data type `Modules_Read-Status_Message_Response`	Array of text messages
language	Yes	string	The project language in which you want to read out the text.

Table 3-337 **Modules_ReadStatus_Status_Response (object)**

Name	Required	Data type	Description
own	Yes	string	Status of the node. The following values are possible: • "good": Node available, no problems exist. • "deactivated": Node currently deactivated. • "maintenance_required": Maintenance required with medium priority. • "maintenance_demanded": Maintenance required with high priority. • "error": Problem at the node or at the child node. • "not_reachable": Node unavailable. • "unknown": The reason for the problem cannot be determined. • "io_not_available": Node configured, but IO data unavailable.

Name	Required	Data type	Description
subordinate	No	string	Status of the child nodes. The following values are possible: • "good": Child nodes available, no problems exist. • "error": Problem at the child node. If there is no child node, the value "good" is returned.

Table 3-338 **Modules_ReadStatus_Message_Response (object)**

Name	Required	Data type	Description
text	Yes	string	Contains a diagnostic message for the selected node or child node

Example 1

The following example shows a response with a subordinate error and two text messages.

```
{
  "status":
  {
    "own": "good",
    "subordinate": "error"
  },
  "messages":
  [
    {
      "text": "CPU status message: CPU not in RUN Current CPU
operating mode: STOP PLC_1516 / PLC_1516"
    },
    {
      "CPU maintenance demanded: OPC UA server: Provisioning state
for updating the security configuration is active.
      PLC_1516 / PLC_1516"
    }
  ],
  "language": "en-US"
}
```

Example 2

The following example shows a response with a subordinate error and an invalid language.

```
{
  "status":
  {
    "own": "good",
    "subordinate": "error"
  },
  "messages": [
```

```
    {
      "text": "#253, 17"
    }
  ],
  "language": "invalid"
}
```

Example 3

The following example shows a response with a subordinate error and a valid language, but one of the error texts cannot be resolved.

```
{
  "status":
  {
    "own": "good",
    "subordinate": "error"
  },
  "messages": [
    {
      "text": "#253, 17"
    },
    {
      "text": "CPU status message: CPU not in RUN Current CPU
operating mode: STOP PLC_1516 / PLC_1516"
    }
  ],
  "language": "en-US"
}
```

Example 4

The following example shows a response without errors.

```
{
  "status":
  {
    "own": "good",
    "subordinate": "good"
  },
  "messages": [],
  "language": "en-US"
}
```

Example 5

The following example shows a response without errors and without child nodes.

```
{
  "status":
  {
    "own": "good"
  },
  "messages": [],
  "language": "en-US"
}
```

Possible error messages

The following table shows possible error messages of the Modules.ReadStatus method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
1100	Invalid hardware identifier	The specified hardware ID is not valid for the current request. Make sure that you have used the correct hardware ID.

6.18.5 Modules.FlashLeds

This method sends a request to the desired CPU to make its LEDs flash. Flashing stops after 3 seconds. This method has no influence on the operation of the automation system.

To call the Modules.FlashLeds method, you require the "flash_leds" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-339 Modules_FlashLeds_Request (object)

Name	Required	Data type	Description
hwid	Yes	number	Hardware ID of the node for which the LEDs are to flash temporarily. The following values are possible: • 49 • 65149 • 65349 The values 65149 and 65349 are only available for R/H systems.

Response structure

If successful, the method returns the Boolean value "true".

Possible error messages

The following table shows possible error messages of the Modules.FlashLeds method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
7	Partner not access-ible	The other CPU of an R/H system is not available. This can be the case when the system is in SYNCUP operating state or RUN-Redundant system state or when the service data of the partner CPU is queried.
1100	Invalid hardware identifier	The specified hardware ID is not valid for the current request. Make sure that you have used the correct hardware ID.

6.18.6 Modules.ReadLeds

Use this method to read out the current status of the LEDs of the CPU.

To call the Modules.ReadLeds method, you require the "read_diagnostics" authorization.

Structure of the request

The following table provides information about the individual parameters of the request.

Table 3-340 Modules_ReadLeds_Request (object)

Name	Required	Data type	Description
hwid	Yes	number	Hardware ID of the node for which the LEDs are to flash temporarily. The following values are possible: • 49 • 65149 • 65349 The values 65149 and 65349 are only available for R/H systems.

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-341 Modules_ReadLeds_Response (object)

Name	Required	Data type	Description
leds	Yes	array of `Modules_ReadLeds_Led_Response`	Array of LEDs

Table 3-342 Modules_ReadLeds_Led_Response (object)

Name	Required	Data type	Description
type	Yes	string	Name of the LED. The following values are possible: • "run_stop" • "error" • "maintenance" • "ready" • "communication" • "optional"
status	Yes	string	Status of the LED. The following values are possible: • "off": LED is switched off. • "on": LED is permanently switched on. The color is defined with the colors parameter. • "flashing": LED flashes. The color is defined with the colors parameter. The flashing period is defined with the period parameter. • "unknown": The status of the LED cannot be determined.
colors	No	array of string	Color of the LED. The following values are possible: • "green": red • "yellow": yellow • "red": red
period	No	string of the time range, shown in accordance with ISO 8601	If status is `flashing`, this value shows the duration of each flashing phase. Otherwise, the value is not output.

Example 1

In this example, LEDs are read by the CPU in the RUN mode (hardware ID = 49).

```
{
  "leds":
  [
    {
      "type": "run_stop",
      "status": "on",
      "colors": ["green"]
    },
    {
      "type": "error",
      "status": "flashing",
      "colors": ["red"],
      "period": "PT0.500S"
    },
    {
      "type": "maintenance",
      "status": "off"
    }
  ]
```

```
}
```

Example 2

In this example, LEDs are read in by the CPU in STARTUP mode (hardware ID = 49 on the standard CPU).

```
{
  "leds":
  [
    {
      "type": "run_stop",
      "status": "flashing",
      "colors": ["green", "yellow"]
      "period": "PT0.500S"
    },
    {
      "type": "error",
      "status": "off"
    },
    {
      "type": "maintenance",
      "status": "off"
    }
  ]
}
```

Example 3

In this example, LEDs are read in by SIMATIC DC (hardware ID = 49).

```
{
  "leds":
  [
    {
      "type": "run_stop",
      "status": "flashing",
      "colors": ["green", "yellow"]
      "period": "PT0.500S"
    },
    {
      "type": "error",
      "status": "off"
    },
    {
      "type": "maintenance",
      "status": "off"
```

```
      },
      {
        "type": "ready",
        "status": "on",
        "colors": ["green"],
        "period": "PT0.500S"
      },
      {
        "type": "communication",
        "status": "off"
      },
      {
        "type": "optional",
        "status": "off"
      }
    ]
  }
```

Possible error messages

The following table shows possible error messages of the Modules.ReadLeds method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.
7	Partner not accessible	The data of the CPU of an R/H system is not available. This can be the case when the system is in SYNCUP operating state or RUN-Redundant system state or when the service data of the partner CPU is queried.
1100	Invalid hardware identifier	The specified hardware ID is not valid for the current request. Make sure that you have used the correct hardware ID.

6.19 Reading information from a redundant system

6.19.1 Redundancy.ReadSystemInformation

This method reads basic information on the redundant system and the pairing status of the R/H system S7-1500R/H.

To call the Redundancy.ReadSystemInformation method, you require the "read_diagnostics" authorization.

More information

You can find detailed information on the design and mode of operation of S7-1500R/H in the Redundant system S7-1500R/H System Manual (https://support.industry.siemens.com/cs/ww/en/view/109754833).

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-343 Redundancy_ReadSystemInformation_Response (object)

Name	Required	Data type	Description
pairing_state	Yes	string	Current pairing status of the redundant system S7-1500R/H Pairing is the mutual recognition of the two R/H-CPUs within a network. During pairing, the CPUs exchange information for mutual identification, for example checking for matching article number and firmware version.
syncup_lock	Yes	bool	The user may lock the SYNCUP or request the current SYNCUP status by calling the "RH_CTRL" instruction in the user program. Shows whether the SYNCUP is locked via the user program. One of the following states is possible: • true: The SYNCUP is currently blocked. The user cannot move the redundant system into the SYNCUP. • false: The SYNCUP is not blocked. The user can move the system in the SYNCUP.
standalone_operation	Yes	bool	The user can determine whether the CPU is running in single operation or not. Possible values are: • "true": The CPU works as an individual CPU (standalone) • "false": The CPU works in the normal redundancy mode of the R/H system. For firmware ≤ V3.1 the parameter is always "false".
connected_redundancy_id	Yes	number	By assigning the redundancy IDs, you define for the R/H system which project data an R/H-CPU uses for itself. Provides the redundancy ID of the R/H-CPU via which the HTTP connection was established.
plcs	Yes	Object of type `Redundancy_ReadSystemInformation_Plcs_Response`	This object shows the redundant system and its two R/H-CPUs.

Table 3-344 Redundancy_ReadSystemInformation_Plcs_Response (object)

Name	Required	Data type	Description
plc_1	Yes	Object of type `Redundancy_ReadSystemInformation_Plc_Response`	This object shows the R/H-CPU with redundancy ID 1.
plc_2	Yes	Object of type `Redundancy_ReadSystemInformation_Plc_Response`	This object shows the R/H-CPU with redundancy ID 2.

Table 3-345 Redundancy_ReadSystemInformation_Plc_Response (object)

Name	Required	Data type	Description
redundancy_id	Yes	number	The redundancy ID of the displayed R/H-CPU: • For object plc_1, this attribute always contains the value 1. • For object plc_2, this attribute always contains the value 2.

Name	Required	Data type	Description
role	Yes	string	The role of the displayed R/H-CPU: The following roles are possible: • "primary": Primary CPU • "backup": Backup CPU • "unknown" unknown
hwid	Yes	number	The hardware ID of the displayed R/H-CPU: • For object plc_1 the hardware ID is always 65149. • For object plc_2 the hardware ID is always 65349.

Example 1

The following example shows a correctly configured R/H system and single-pairing access for CPU with redundancy ID 1.

```
{
  "pairing_state": "paired_single",
  "syncup_lock": false,
  "connected_redundancy_id": 1,
  "standalone_operation": false,
  "plcs":
  {
    "plc_1":
    {
      "redundancy_id": 1,
      "role": "backup",
      "hwid": 65149
    },
    "plc_2":
    {
      "redundancy_id": 2,
      "role": "primary",
      "hwid": 65349
    }
  }
}
```

Example 2

The following example shows a non-paired R/H system for CPU with redundancy ID 2.

```
{
  "pairing_state": "not_paired_firmware_mismatch",
  "syncup_lock": false,
  "connected_redundancy_id": 2,
  "standalone_operation": false,
  "plcs":
```

```
    {
      "plc_1":
      {
        "redundancy_id": 1,
        "role": "unknown",
        "hwid": 65149
      },
      "plc_2":
      {
        "redundancy_id": 2,
        "role": "primary",
        "hwid": 65349
      }
    }
  }
```

Possible error messages

The following table shows possible error messages of the Redundancy.ReadSystemInformation method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.19.2 Redundancy.ReadSystemState

This method reads the current system state of the redundant system S7-1500R/H.

To call the Redundancy.ReadSystemState method, you require the "read_diagnostics" authorization.

More information

You can find detailed information on the design and mode of operation of S7-1500R/H in the Redundant system S7-1500R/H System Manual (https://support.industry.siemens.com/cs/ww/en/view/109754833).

Response structure

The following table shows you the structure of server responses to successful requests.

Table 3-346 Redundancy_ReadSystemState_Response (object)

Name	Required	Data type	Description
state	Yes	string	Possible system states with your Web API designation: • STOP: stop • ANLAUF: startup • RUN-Solo: run_solo • SYNCUP: syncup • RUN-Redundant: run_redundant

Example

In the following example, the system state RUN-Redundant is read.

```
{
  "state": "run_redundant"
}
```

Possible error messages

The following table shows possible error messages of the Redundancy.ReadSystemState method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.19.3 Redundancy.RequestChangeSystemState

With this method, you can change the system state of the redundant system S7-1500R/H.

To call the Redundancy.RequestChangeSystemState method, you require the "change_operating_mode" authorization.

NOTE

You can carry out this request in both CPUs of a coupled R/H system. However, if the request is made on a web server of the backup CPU, the primary CPU must have a project in which an Anonymous user exists and has at least one of the CPU access level function rights `Full access`, `Full access including fail-safe` or `Read access`. Therefore, a request to the backup CPU can be successful, but it cannot initiate a change in the system state.

More information

You can find detailed information on the design and mode of operation of S7-1500R/H in the Redundant system S7-1500R/H System Manual (https://support.industry.siemens.com/cs/ww/en/view/109754833).

Structure of the request

The following table contains information about the parameters of the request:

Table 3-347 Redundancy_RequestChangeSystemState_Request (object)

Name	Required	Data type	Description
state	Yes	string	The new system state Switching to the following system states is possible: • STOP: stop • RUN-Redundant: run_redundant

Example

In the following example, the new system state RUN-Redundant is read.

```
{
  "state": "run_redundant"
}
```

Possible error messages

The following table shows possible error messages of the Redundancy.RequestChangeSystemState method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

6.19.4 Redundancy.ReadSyncupProgress

This method reads the information via a running SYNCUP of the redundant system S7-1500R/H. During the syncup, the web server can temporarily not be reached. Whether the method can be called or not thus depends on the current syncup phase and the duration of the syncup phase.

To call the Redundancy.ReadSyncupProgress method, you require the "read_diagnostics" authorization.

More information

You can find detailed information on the design and mode of operation of S7-1500R/H in the Redundant system S7-1500R/H System Manual (https://support.industry.siemens.com/cs/ww/en/view/109754833).

Response structure

The following tables show the structure of server responses to successful requests.

Table 3-348 Redundancy_ReadSyncupProgress_Response (object)

Name	Required	Data type	Description
syncup_phase	Yes	string	Current SYNCUP phase of the redundant system S7-1500R/H. Possible phases are: • Copying the SIMATIC load memory (copying_memory_card) • Restarting of the backup CPU (rebooting_backup) • Finishing tasks (preparing_work_memory) • Copying the work memory (copying_work_memory) • Making up backup CPU lag (minimizing_delay)
copying_memory-_card	No	object of type `Redundancy_ReadSyncupProgress_CopyMemoryCard_Response`	If the "syncup_phase" parameter is in the "copying_memory_card" status, this object must be returned.
minimizing_delay	No	object of type `Redundancy_ReadSyncupProgress_MinimizingDelay_Response`	If the "syncup_phase" parameter is in the "minimizing_delay" status, this object must be returned.

Table 3-349 Redundancy_ReadSyncupProgress_MinimizingDelay_Response (object)

Name	Required	Data type	Description
hypothetical_cycle_time	Yes	string	ISO8601 time stamp as a string: The possible cycle duration in milliseconds
tolerable_cycle_time	Yes	string	ISO8601 time stamp as a string: The tolerable cycle duration in milliseconds

Table 3-350 Redundancy_ReadSyncupProgress_CopyMemoryCard_Response (object)

Name	Required	Data type	Description
current	Yes	number	The number of bytes from the SIMATIC load memory which was previously transferred to the backup CPU.
total	Yes	number	The overall number of the bytes to be processed of the SIMATIC load memory.

Example 1

In the following example, SYNCUP runs on the primary CPU: static content.

```
{
  "syncup_phase": "copying_memory_card",
  "copying_memory_card":
  {
   "current": 17024,
   "total": 2045000
  }
}
```

Example 2

In the following example, SYNCUP runs on the primary CPU: Making up backup CPU lag.

```
{
  "syncup_phase": "minimizing_delay",
  "minimizing_delay":
  {
   "hypothetical_time": "PT1S",
   "tolerable_time": "PT0.800S"
  }
}
```

Example 3

In the following example, SYNCUP runs on the primary CPU: Restart of the backup CPU.

```
{
  "syncup_phase": "rebooting_backup"
}
```

Example 4

In the following example, SYNCUP starts on the primary CPU:

```
{
  "syncup_phase": "checking_preconditions"
}
```

Example 5

In the following example, SYNCUP runs on the backup CPU.

```
{
  "syncup_phase": "in_progress"
}
```

Example 6

In the following example, no SYNCUP is running, the system is in the redundant state.

```
{
  "syncup_phase": "redundant"
}
```

Example 7

In the following example, no SYNCUP is running, the system is not in the redundant state.

```
{
  "syncup_phase": "not_redundant"
}
```

Possible error messages

The following table shows possible error messages of the Redundancy.ReadSyncupProgress method.

Error code	Error message	Meaning
2	Permission denied	The current authentication token is not authorized to call this method. Log in with a user account that has sufficient authorizations to call this method.

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SIMATIC

STEP 7 (TIA Portal) options Target 1500S™ for Simulink® V4.0 Update 2

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Introduction 1

1.1 Guide for this manual

Purpose of the documentation

This documentation provides important information about installing and setting up SIMATIC Target 1500S for Simulink and generating an ODK object.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the SIMATIC industrial automation system
- Knowledge of working with STEP 7
- Use of Microsoft Windows operating systems
- Proficiency with Mathworks MATLAB and Simulink

Validity of the documentation

This documentation is valid for the product SIMATIC Target 1500S for Simulink.

Notes

Please also observe notes labeled as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the part of the documentation to which particular attention should be paid.

Definitions and naming conventions

The following terms are used in this documentation:

- Target 1500S: This term refers to the product SIMATIC Target 1500S for Simulink.
- ODK: This term refers to the product Open Development Kit 1500S in the compatible version.
- SO: Shared Object. Output object after an ODK build.
- SCL: Structure Control Language. Programming language in STEP 7.
- STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal V15.1 or higher)".
- MATLAB: Mathworks MATLAB

  MATLAB and Simulink are registered trademarks of The MathWorks, Inc.
- TIA Portal Openness: TIA Portal automation interface

The documentation for the SIMATIC S7-1500 automation system and the SIMATIC ET 200MP distributed I/O system is arranged into three areas.
This arrangement enables you to access the specific content you require.

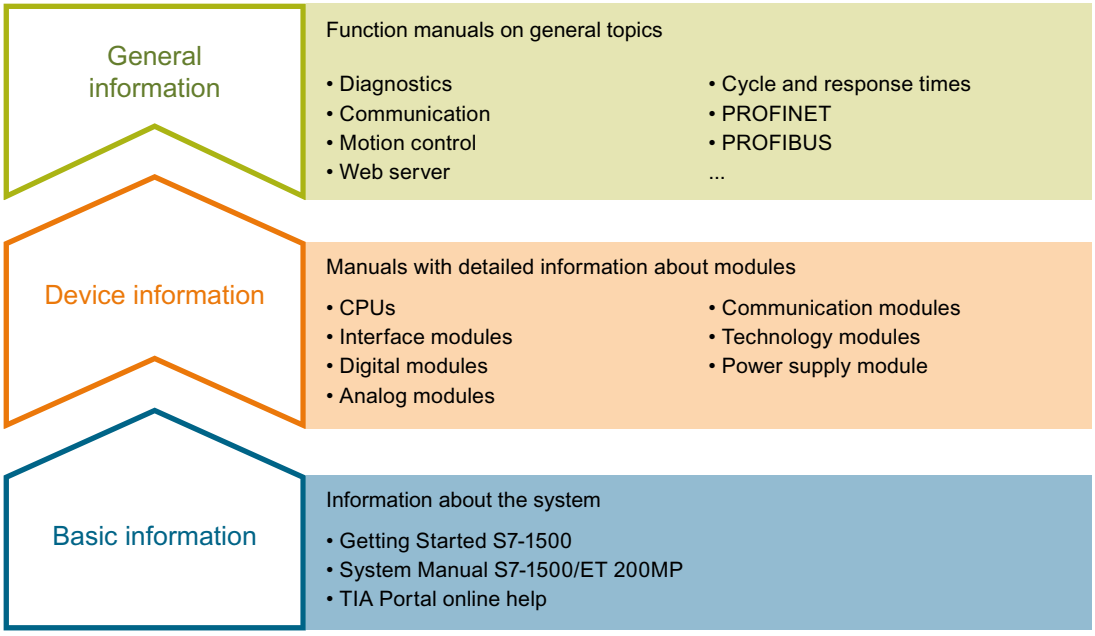

Basic information

The System Manual and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500 and ET 200MP systems. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics regarding the SIMATIC S7-1500 and ET 200MP systems, e.g. diagnostics, communication, motion control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742691).

Changes and supplements to the manuals are documented in a Product Information.

You can download the product information free of charge from the Internet (https://support.industry.siemens.com/cs/us/en/view/68052815).

Manual Collection S7-1500/ET 200MP

The Manual Collection contains the complete documentation on the SIMATIC S7-1500 automation system and the ET 200MP distributed I/O system gathered together in one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86140384).

SIMATIC S7-1500 comparison list for programming languages

The comparison list contains an overview of which instructions and functions you can use for which controller families.

You can find the comparison list on the Internet (https://support.industry.siemens.com/cs/ww/en/view/86630375).

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

The Manual Collection includes the complete documentation for distributed I/O system SIMATIC ET 200SP assembled in a single file.

You can find the Manual Collection on the Internet (http://support.automation.siemens.com/WW/view/en/84133942).

Security information 2

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (https://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed visit (https://www.siemens.com/industrialsecurity).

Siemens Industry Online Support 3

You can find current information on the following topics quickly and easily here:

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.

- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (http://www.siemens.com/automation/service&support).

Industry Mall

4

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com) and in the Information and Download Center.

Product overview 5

5.1 Overview of functions

Basics

Mathworks MATLAB is software for the primary solution of mathematical problems and their visualization.

Simulink is an add-on for MATLAB for graphical modeling of systems and their simulation.

Target 1500S

Target 1500S is an add-on for Simulink that generates an executable object from a Simulink model for an ODK-enabled controller. It enables you to run a Simulink model on a controller. In an automated process, Target 1500S integrates the generated program logic and the executable object. Target 1500S automatically generates all the required blocks and files for this. An SCL and SO file is created from the generated C/C++ code. The SCL file is imported as external source to STEP 7 and contains the generated function blocks. The SO file contains the C/C++ implementation and is available to the CPU after transfer to the Web server.

5.2 Basic procedure

Overview of the individual steps

To run a Simulink model on a controller, follow these steps:

1. Create a model in Simulink.
2. Configure the properties of the model in Simulink.
3. Under "Code Generation", select Target 1500S as System Target File.
4. Adapt the parameters for Simulink and Target 1500S.
   - Select a TIA Portal project in which to integrate the generated code.
   - Select the options for integration in the CPU user program.
   - Select the settings for External Mode, access to Model Dynamics, and Web visualization.
   - Set up automatic SO file transfer and loading to the CPU.

5. Start the build in Simulink.

   The SO and SCL files are generated and stored in the "outputs" output directory. Depending on your selected settings, these files are either automatically integrated into the TIA Portal project and loaded into the CPU, or you have to perform the integration into the TIA Portal project and loading into the CPU manually (see also Loading and running the ODK application (Page 45)).

Installing

6

6.1 System requirements

Requirements

Your PC must meet the following system requirements in order to use the Target 1500S:

Category	Requirement
Operating system	Microsoft Windows 10, 64-bit
Processor and memory	PC system: • 100 MB of free space on the hard disk C:\ • At least systems with Intel Core i5 processor • 1.2 GHz or higher • At least 4 GB RAM
Operator interface	Monitor, keyboard and mouse.
SIMATIC Software	• SIMATIC ODK 1500S V2.0 or higher • Optional: SIMATIC STEP 7 Professional (TIA Portal) V15.1 or higher with TIA Portal Openness • Optional: SIMATIC CPU 15xx that supports ODK 1500S V2.0 or higher • Optional: S7-PLCSIM Advanced V3.0 or higher
Additional software	• MATLAB 2020b (64-bit) in the following configuration: – MATLAB 9.9 – MATLAB Coder 5.1 – Simulink 10.2 – Simulink Coder 9.4 • Java Runtime Environment (32-bit)

6.2 Installing Target 1500S

To install Target 1500S, select the installation folder. Follow the instructions of the setup program.

If the setup program does not start automatically, manually start the "Start.exe" file by double clicking it.

NOTE

Use of antivirus software

To avoid problems during the installation, disable the antivirus software for the period of the installation or exclude the directory "C:\Program Files\Common Files\Siemens\Automation\Siemens Installer Assistant" and the directory in which Start.exe is located, for the antivirus software.

Order of the installed Target 1500S versions

When you install multiple versions, make sure that the older version is installed before the newer one. If problems occur, uninstall all versions and install these again in this order.

Requirements

- You have installed a compatible ODK 1500S version and a 32-bit Java Runtime Environment .
- You need administrator rights for this action.
- MATLAB and Simulink are installed in the required configuration.
- Close all MATLAB instances.

Procedure

You can also run the installation automatically with the batch file "SilentInstall_Target_1500S.bat".

To install Target 1500S manually, follow these steps:

1. Launch the "Start.exe" file manually with a double-click.
2. Select the language for performing the installation.
3. Confirm with "Next".

   The "Configuration" view opens.
4. Click "Next" to confirm the list of components that are to be installed.

   The check mark for Automation License Manager (ALM) cannot be removed.

   NOTE

   Target 1500S is already installed

   If Target 1500S is already installed, you can select between "Repair (Page 19)" and "Uninstall (Page 19)" here.

   ---
5. Confirm with "Next".

6. Agree to the license conditions and safety information.
7. Confirm with "Next".

   The "Overview" with the installation settings opens.
8. Start the installation with "Install"

   The following directory is created:

   ProgramFiles(x86)%\Siemens\Automation\Target1500S*<current version>*
9. Choose whether you want to carry out the licensing (Page 16) during the installation or at a later time.

Result

The installation is complete. All product languages were installed by default during the installation process. During the installation, Target 1500S was integrated in Simulink and the product help was created in the Windows Start menu.

NOTE

You can install ODK after Target. Close MATLAB and other applications and then restart it after the installation.

6.3 Licensing Target 1500S

The software requires a product-specific license key that you install with the Automation License Manager. Each SIMATIC software product for automation that is subject to license (e.g., STEP 7) has its own license key. You must install the license key for each product.

Working with the Automation License Manager

The Automation License Manager is a product of Siemens AG and is used for managing license keys. The Automation License Manager is supplied on the installation data medium of this product by default and is transferred automatically during the installation process.

Software products that require license keys for operation register the requirement for license keys automatically in the Automation License Manager. If the Automation License Manager finds a valid license key for this software, the software can be used according to the conditions of use associated with this license key.

Certificate of license

A Certificate of License is included in the scope of delivery. It contains your unique license number. The license certificate serves as proof that you have a valid license key. Store this certificate in a safe place.

NOTE

Obtaining a replacement license key

You must have a valid certificate of license to get a replacement license key.

Recovering the license key in case of defective mass storage

If an error has occurred on the mass storage or USB flash drive containing your license key file, you can restore the license using the license certificate. You can find additional information in a FAQ (https://support.industry.siemens.com/cs/ww/en/view/772175).

Validity of license keys for older versions of Target 1500S

With a valid license key for Target 1500S™ for Simulink® V4.0, you can also operate older versions of Target 1500S without restrictions.

License key

The download of Target 1500S allows you to access ordered license keys.

For access, you need:

- A personalized login that you can use to call all license keys assigned to you.
- An anonymous login that you can use to fetch an individual license key, and the corresponding license certificate. This document contains all data required for the anonymous download.

Additional information on the license key and the download is available in the Automation License Manager manual (https://support.industry.siemens.com/cs/ww/en/view/102770153).

Transferring the license key

The license key can be transferred during the installation or afterwards.

If the USB flash drive with the relevant license key is inserted in the USB port of the PC at the start of installation, the license key will be transferred automatically during the installation. If the USB flash drive is not inserted at the start of installation, you have three options for installing the license key subsequently:

- To transfer the license key **manually** from a network computer or other storage medium, select the "Manual license transfer" button.
- Insert the USB flash drive with license key, and select the "Retry license transfer" button. The Automation License Manager opens in order to transfer the license key.
- If you do not want to install a license key, select the "Skip license transfer" button.

Working without valid license key

For legal reasons, a valid license key is required for this product.

If no valid license key is present on your PC, you cannot generate any projects and the system indicates the non-licensed mode with a message. You have the one-time option of activating a trial license. However, this license is valid for a limited period only and expires after 21 days. Therefore, the system prompts you to activate your Trial License during the first build. The runtime of the license starts with the activation. When the trial license has expired, an error message appears during the build process.

Manually transferring the license key subsequently

A message is displayed if you start the Target 1500S without transferred license key. If the Automation License Manager is not yet installed on your computer, you must install it beforehand.

To **manually** transfer the license key for Target 1500S subsequently, follow these steps:

1. Start the installation of Target 1500S with administrator rights.
2. In the "License Transfer" section, select the "Manual license transfer" button.

   A dialog box for synchronization of the license opens.
3. Select the destination and the source of the license key.
4. To transfer the license key, click the "Synchronize" button.

   The license key is transferred.

6.4 Uninstalling Target 1500S

Requirement

- You need administrator rights for this action.
- You have already installed Target 1500S .
- Close all MATLAB instances.

Procedure

You can also run the uninstallation automatically with the batch file "SilentUnInstall_Target_1500S.bat".

To uninstall Target 1500S manually, follow these steps:

1. Launch the "Start.exe" file manually with a double-click.
2. Select the language for performing the installation.
3. Confirm with "Next".
   The "Configuration" view opens.
4. Select the "Uninstall" option.
5. Confirm with "Next".

Result

- Target 1500S is removed from the MATLAB environment.
- The entries in the Start menu are deleted.
- Target-specific folders are deleted.
  Previously generated output of Target 1500S is not deleted.

6.5 Repairing Target 1500S

Requirement

- You require administrator rights for this procedure.
- You have already installed Target 1500S .
- Close all MATLAB instances.

Procedure

1. Launch the "Start.exe" file manually with a double-click.
2. Select the language for performing the installation.
3. Confirm with "Next".
   The "Configuration" view opens.
4. Select the "Repair" option.
5. Confirm with "Next".

Result

Target 1500S is re-installed.

Example of a workflow

7

7.1 Creating a Simulink model

Procedure

1. In MATLAB, select the storage path for the model under "Current Folder".

   Alternatively, you can also set the storage path in the Simulink preferences under "File generation control".

2. Create the model in Simulink.

   You can also use an existing model or one provided by Simulink.

7.2 Description of Simulink parameters

Some configuration parameters are preset when you select Target 1500S as the System Target File . To do so, select the system target file for Target_1500S (*.tlc) of the required version in the "Configuration Parameters".

NOTE

Change/migrate the System Target File

If you change parameters in the "Configuration Parameters" and then want to change the System Target File, you need to first confirm the changes with the "Apply" button.

When you migrate from an older Target 1500S version to a newer version, the Target 1500S parameters that are identical in the versions are applied. Parameters that are not present in the older version are set to the default value by the system.

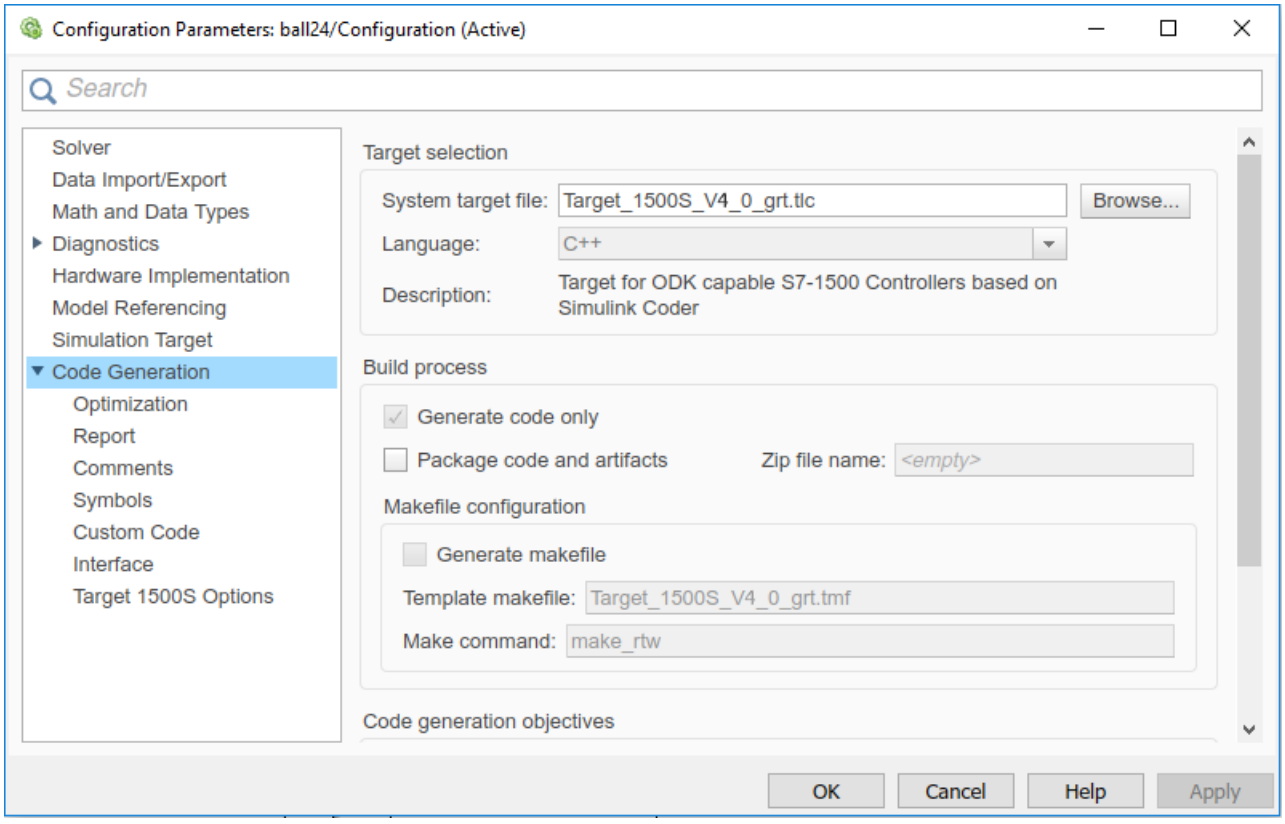

Figure 3-228 Configuration parameters using the System Target File for Target 1500S as an example

The default parameters are listed below. To successfully create an ODK object, you are not allowed to change some parameters. These parameters are marked in this product help with "(fixed)". Use the default values whenever possible.

You can also set special Target 1500S options here.

NOTE

Default parameters

The system assigns default parameters, and these may overwrite existing entries.

Requirement

You have selected Target 1500S as the System Target File .

Relevant parameters

Solver

A dynamic system is modeled as a mathematical calculation in Simulink. This calculation is performed at certain time intervals to simulate the execution of the system. The size of this time interval is referred to as the "Step-Size". The method for calculating the states of a model is referred to here as solving the model.

- Solver options

  Determine the solver selection

  - Type (fixed): Fixed Step
  - Solver: auto (Automatic solver selection)
- Tasking and sample time options
  - Periodic sample time constraint: Unconstrained
  - Tasking mode for periodic sample times: Treat each discrete rate as a separate task (disabled)

Data Import/Export

- Time (disabled)
- States (disabled)
- Output (disabled)
- Final States (disabled)
- Format ("Array" option activated)
- Limit data points to last (activated and "1000" value set)
- Decimation ("1" value set)

Hardware Implementation

- Device vendor (fixed): Intel
- Device type(fixed): x86-32 (Windows32)

Code Generation General

- Language (fixed): C++
- Makefile configuration (fixed): "Generate makefile" option disabled
- Generate code only (fixed): "Generate code only" option enabled
- Advanced parameters
  - Verbose Build

    This option is disabled by default. Only relevant information is displayed in the Diagnostic Viewer during the build process.

    Enable this option to get more detailed information during the build process.

Code Generation > Optimization

- Code generation

  You can select between "Tunable" and "Inlined" under "Default parameter behavior".

  Select "Tunable" if you want to allow parameter access from STEP 7. You can also change the parameter values during runtime.

  Select "Inlined" so that the values of the parameters are fixed and cannot be changed during runtime. The execution of the code is then faster.

Code Generation > Identifiers

- Maximum identifier length

  The default value is 256.

  You can enter a higher value, but be aware of the ODK limits.

Code Generation > Interface

- Code interface packaging (fixed): Nonreusable function
- Classic call interface (fixed): "Classic call interface" option disabled
- Single output/update function (fixed): "Single output/update function" option enabled
- MAT-file logging (fixed): "MAT-file logging" option disabled
- Data exchange interface

  Select "External mode (Page 52)" to use this. The settings are thereby made automatically.

  You can find the description of the individual parameters under "Setting communication parameters for external mode (Page 52)".

Code Generation > Target 1500S Options

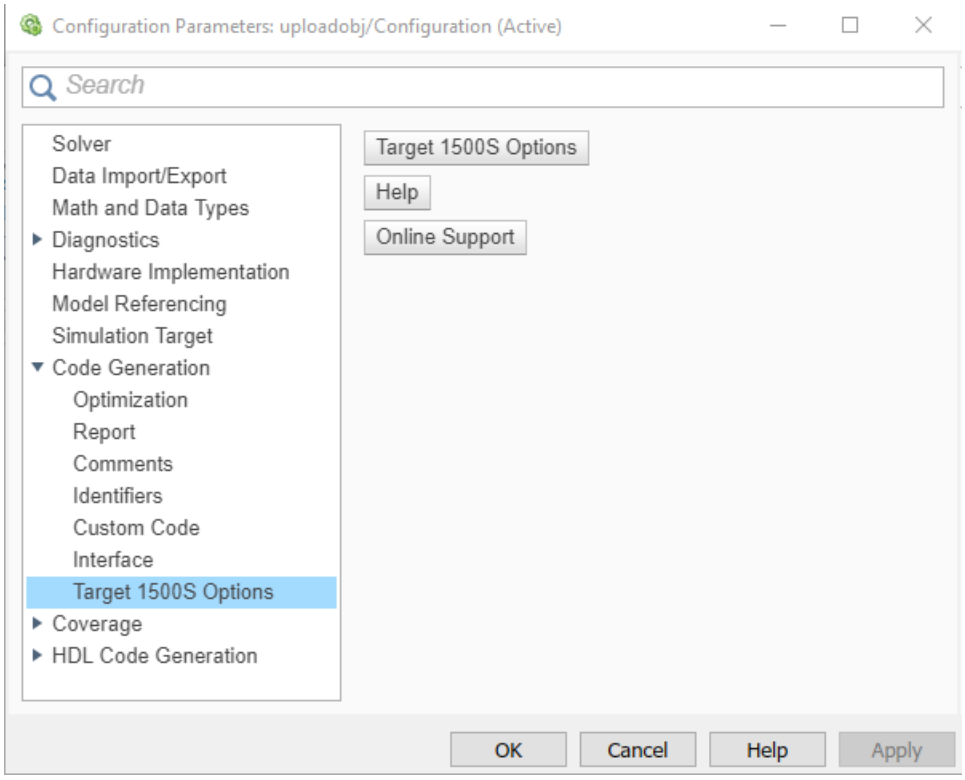

Figure 3-229 Target 1500S options

Target 1500S Options

When you click on this button, a new dialog opens with the Target 1500S options in individual tabs. The options are described in more detail in the following sections:

- Description of the TIA Portal integration options (Page 26)
- Description of the external mode options (Page 29)
- Description of the Accessibility options (Page 32)
- Description of the Post-build Options (Page 35)
- Description of the ODK options (Page 37)

Help

Click this button to open the online help for Target 1500S.

Online Support

To open the Support website, click this button.

7.3 Target 1500S configuration parameters

7.3.1 Description of the TIA Portal integration options

Requirement

- You have installed one of the following TIA Portal versions with STEP 7 Professional and the Openness plugin:
  - TIA Portal V15.1
  - TIA Portal V16
- You have selected Target 1500S as the System Target File.
- You are included in the Computer Management in the user group "Siemens TIA Openness" with your registered user and have restarted the operating system.

Parameters that can be set

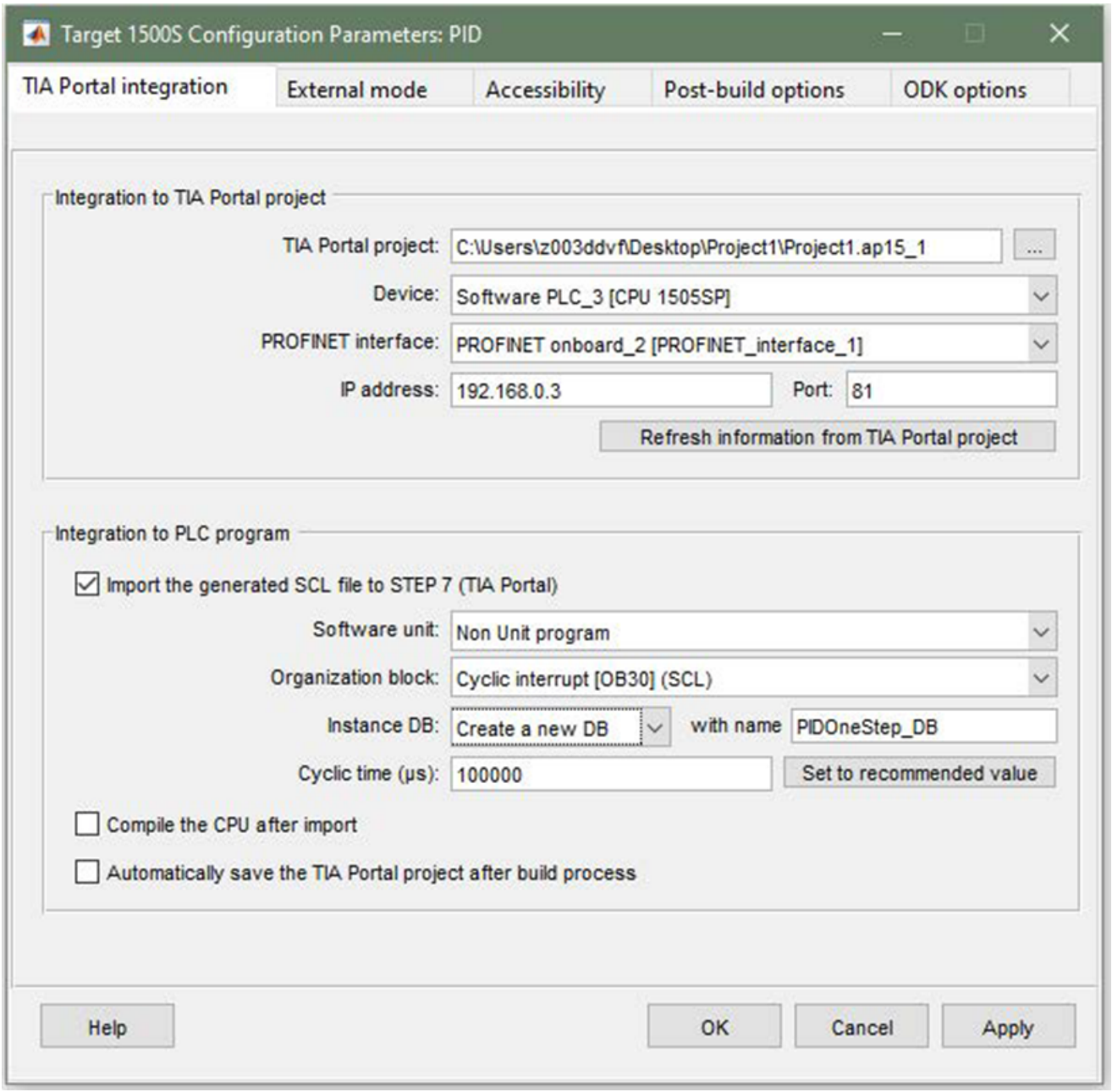

Figure 3-230 TIA Portal Integration options

TIA Portal project

Define the path to the STEP 7 project into which the generated SCL file is imported.

For example: D:\tiaprojects\project\project.ap15

Device

From this list, select the name of the CPU in the STEP 7 project into which the generated SCL file is to be imported.

PROFINET interface
Select the PROFINET interface of the selected CPU from this list.

The selected PROFINET interface is used for:

- External mode
- Import of the SO file

IP address
Displays the IP address of the PROFINET interface.

Port
Shows the used port number of the IP address.

NOTE

When you do not fill the input fields for integration into a TIA Portal project with values or configure the IP address and the port number using the command line, the "Port:" input field is not visible.

Import the generated SCL file to STEP 7 (TIA Portal)
Automatic import of the generated SCL file into the TIA Portal project once the build is complete.

Software unit
Select the software of the selected CPU from this list.

Organization block
From this list, select the organization block of the selected CPU into which the generated "OneStep" FB is to be imported. To create a new cyclic interrupt OB, click "Create a new OB".

Instance DB
From this list, select the instance DB for the generated "OneStep" FB. To create a new instance DB, click "Create a new DB".

Cyclic time (µs)
For cyclic interrupt OBs, enter the cycle time of the selected organizational block. To set the value recommended by the model, click "Set to recommended value". The recommended value is the "Fixed-step size (fundamental sample time)" setting of the model.

Compile the CPU after import
Compiles the CPU after the file import.

Automatically save the TIA Portal project after build process
Saves the TIA Portal project once the build is completed.

7.3.2 Description of the external mode options

Requirement

You have selected Target 1500S as the System Target File.

Parameters that can be set

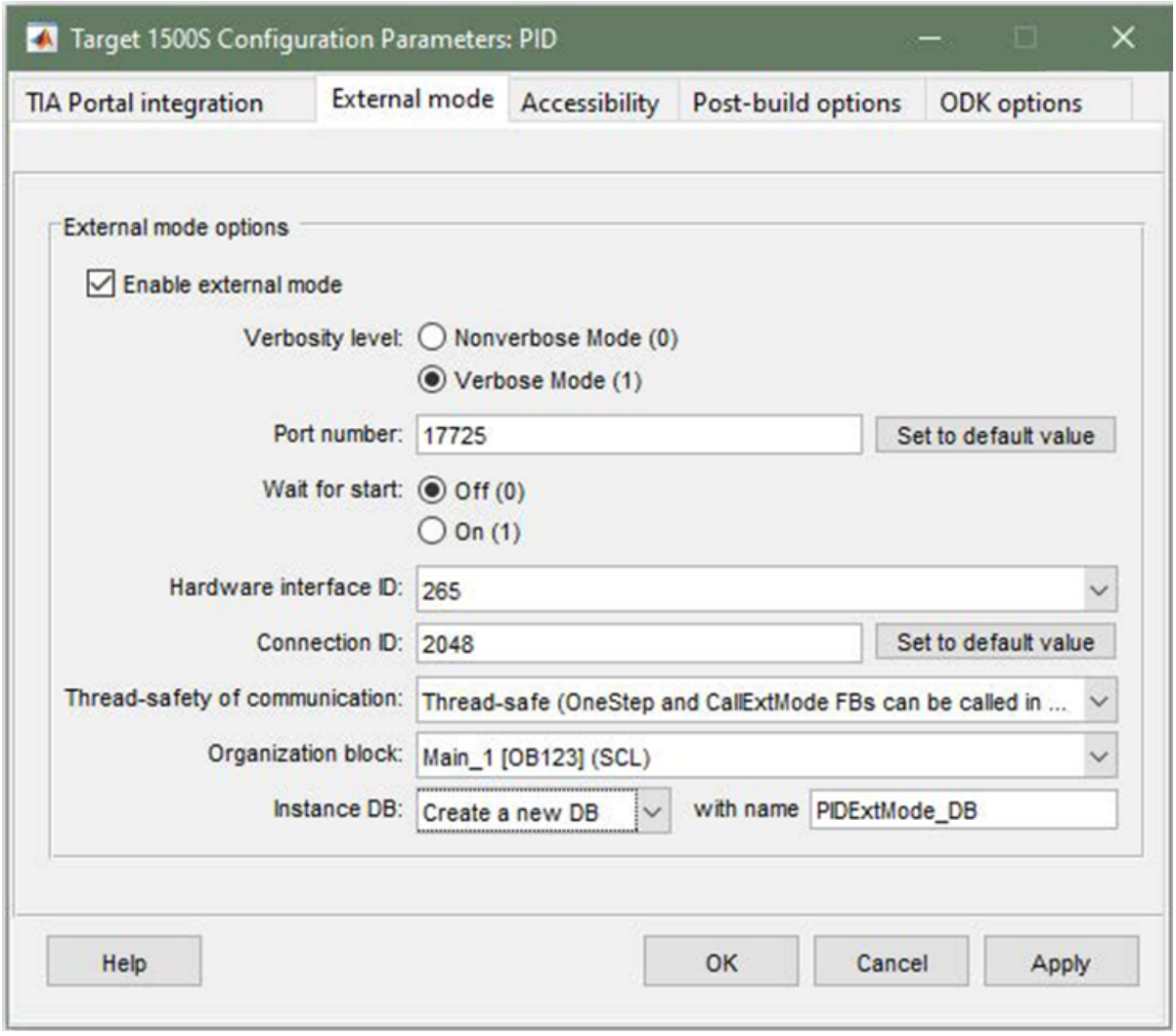

Figure 3-231 External mode options

Enable external mode

Enable this option to permit external mode communication for the model.

Verbosity level

Enable the "Verbose Mode (1)" option to get more detailed information during External mode communication in the "Diagnostic Viewer".

Port number

Enter the CPU-side port number for the TCP/IP connection during External mode communication.

Standard: 17725

Wait for start

The simulation starts automatically as soon as the "OneStep" function is executed. When you enable the "On (1)" option, the execution of the Simulink model does not start automatically. In this case, you need to start the simulation in the Simulink window after the connection is established using the " " button.

Hardware interface ID

Here, you can manually change the numeric value of the hardware ID of the corresponding communication interface. The value must correspond to the value assigned under "Hardware identifier" for a communication interface in the TIA Portal. If the values do not match, the connection between Simulink and the controller cannot be established via External Mode.

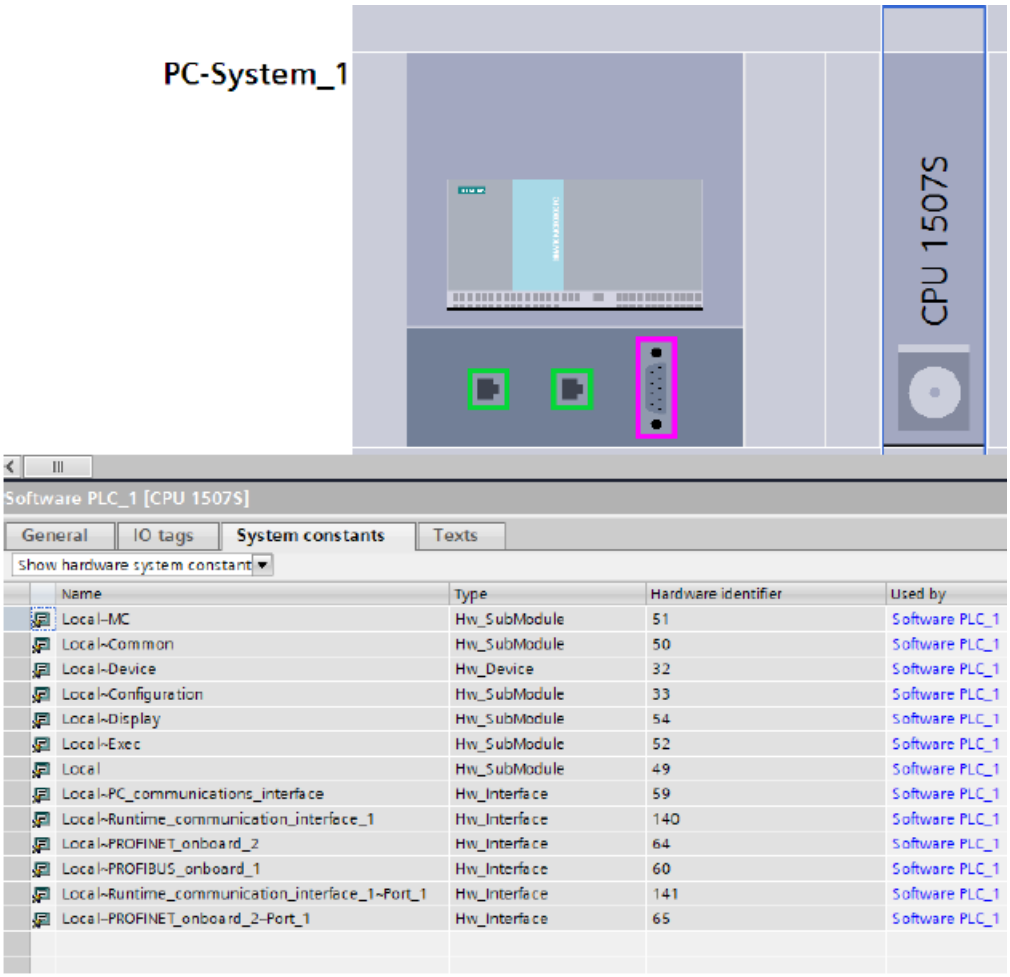

Figure 3-232 Example of a Hardware identifier setting

Connection ID

Enter a value between 1 and 4095 for the Open User Communication in STEP 7 for the communication of the External Mode.

The value must be unique for the STEP 7 user program.

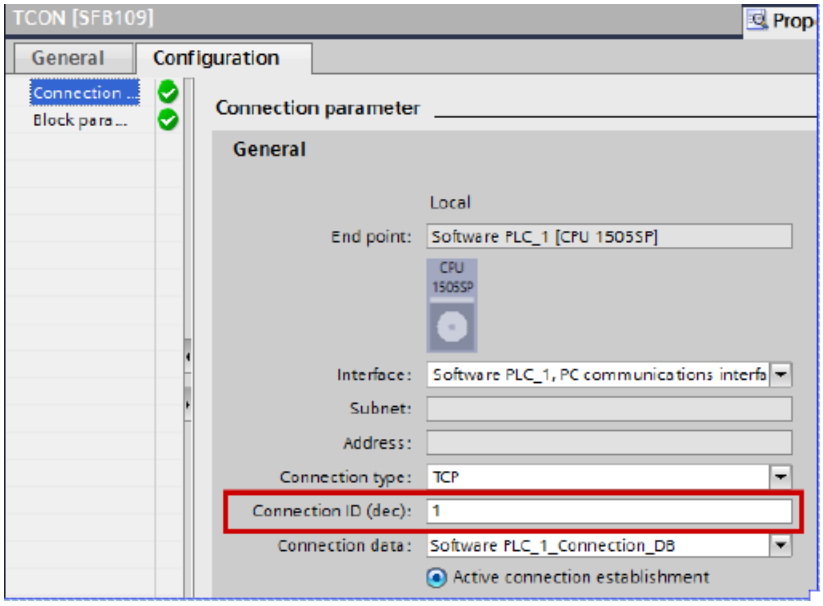

Figure 3-233 Example of the setting of the connection ID in STEP 7

Thread-safety of communication

Select the thread safety of the connection from this list. If the communication is thread-safe, you can call the "CallExtMode" FB and the "OneStep" FB in different OBs.

Organization block

From this list, select the OB of the selected CPU into which the generated "CallExtMode" FB is imported. To create a new OB, click "Create a new OB".

Instance DB

From this list, select the instance DB for the generated "CallExtMode" FB. To create a new instance DB, click "Create a new DB".

7.3.3 Description of the Accessibility options

Requirement

You have selected Target 1500S as the System Target File.

Parameters that can be set

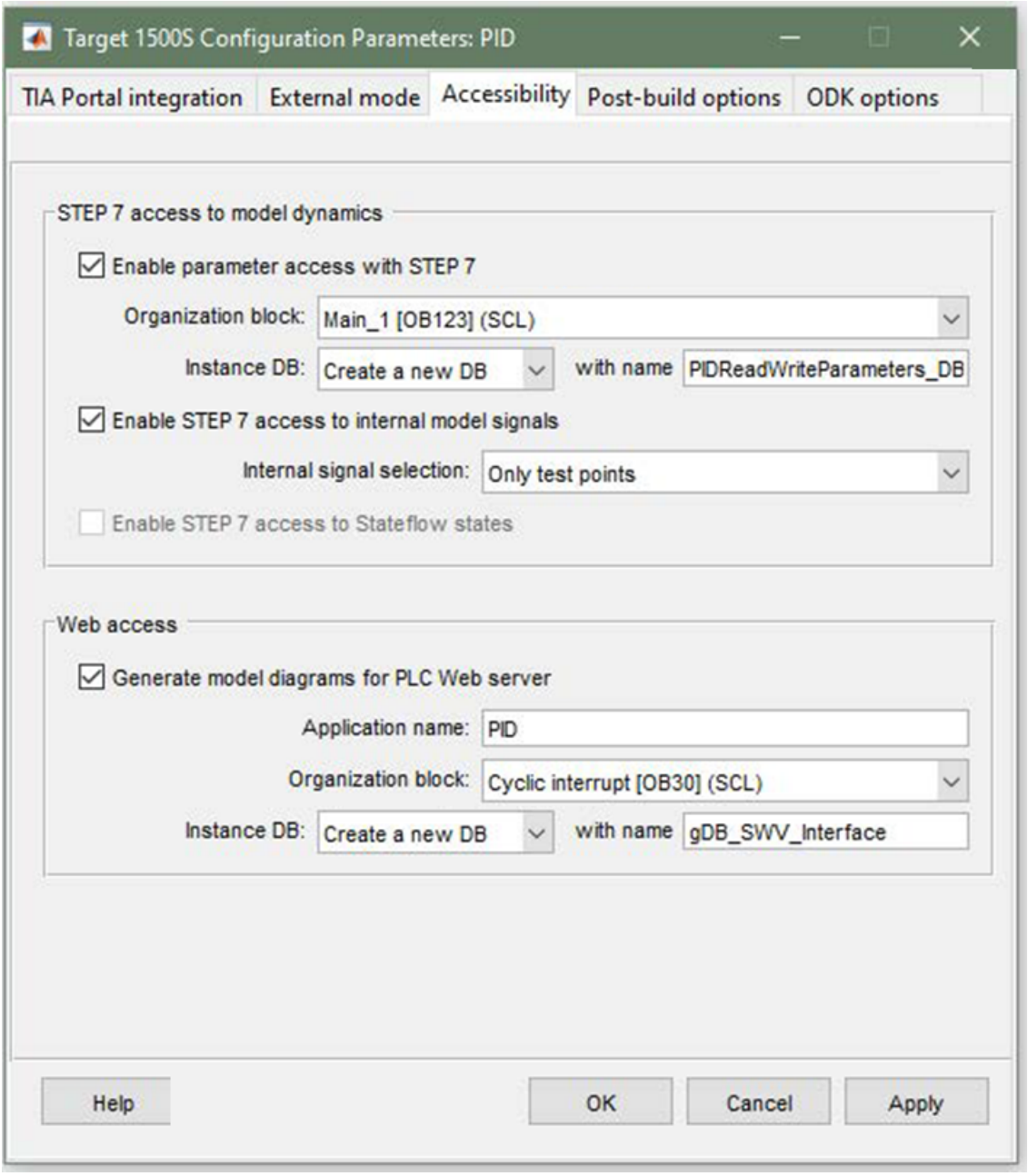

Figure 3-234 Accessibility options

Enable parameter access with STEP 7

Select this option to generate a special code for accessing the model parameters from the STEP 7 program.

NOTE

Enable / disable Parameter access with STEP 7.

If you enable "Parameter access with STEP 7" under "Optimization" in the "Code generation" area, select the setting "Tunable" from the "Default parameter behavior" selection.

If you disable "Parameter access with STEP 7" under "Optimization" in the "Code generation" area, select the setting "Inlined" from the "Default parameter behavior" selection.

- Organization block

  From this list, select the OB of the selected CPU into which the generated "ReadWriteParameters" FB is imported. To create a new OB, click "Create a new OB".

- Instance DB

  From this list, select the instance DB for the generated "ReadWriteParameters" FB. To create a new instance DB, click "Create a new DB".

Enable STEP 7 access to internal model signals

Enable this option to obtain defined measurement points (internal signals) in the Simulink model as output(s) of the "OneStep" FB.

You can find additional information in the section "Access to internal signals (Page 61)".

From the "Internal signal selection" list, select the type of internal signals for the access from STEP 7.

- All measurement points including test points

  All measurement points are used as internal signals.

- All measurement points excluding test points

  All measurement points, excluding test points, are used as internal signals.

- Only test points

  Only measurement points defined as test point are used as internal signals.

Enable STEP 7 access to Stateflow states

Allows STEP 7 access to Stateflow states defined in Simulink models.

Generate model diagrams for PLC Web server

To display the Simulink model in the Web server, enable this option.

You can find additional information in the section "Display model on the Web server (Page 63)".

- Application name

  Enter the name of the Web server application. If you do not enter a name, the model name is automatically assigned for the application.

- Organization block

  From this list, select the OB of the selected CPU into which the generated "WebReadWrite" FB is imported. To create a new OB, click "Create a new OB".

- Instance DB

  To create a new instance DB with the fixed name "gDB_SWV_Interface", select "Create a new DB" from the list.

7.3.4 Description of the Post-build Options

If you have selected Target 1500S as System Target File, you can set a number of configuration parameters specific to Target 1500S. These parameters are listed below.

Parameters that can be set

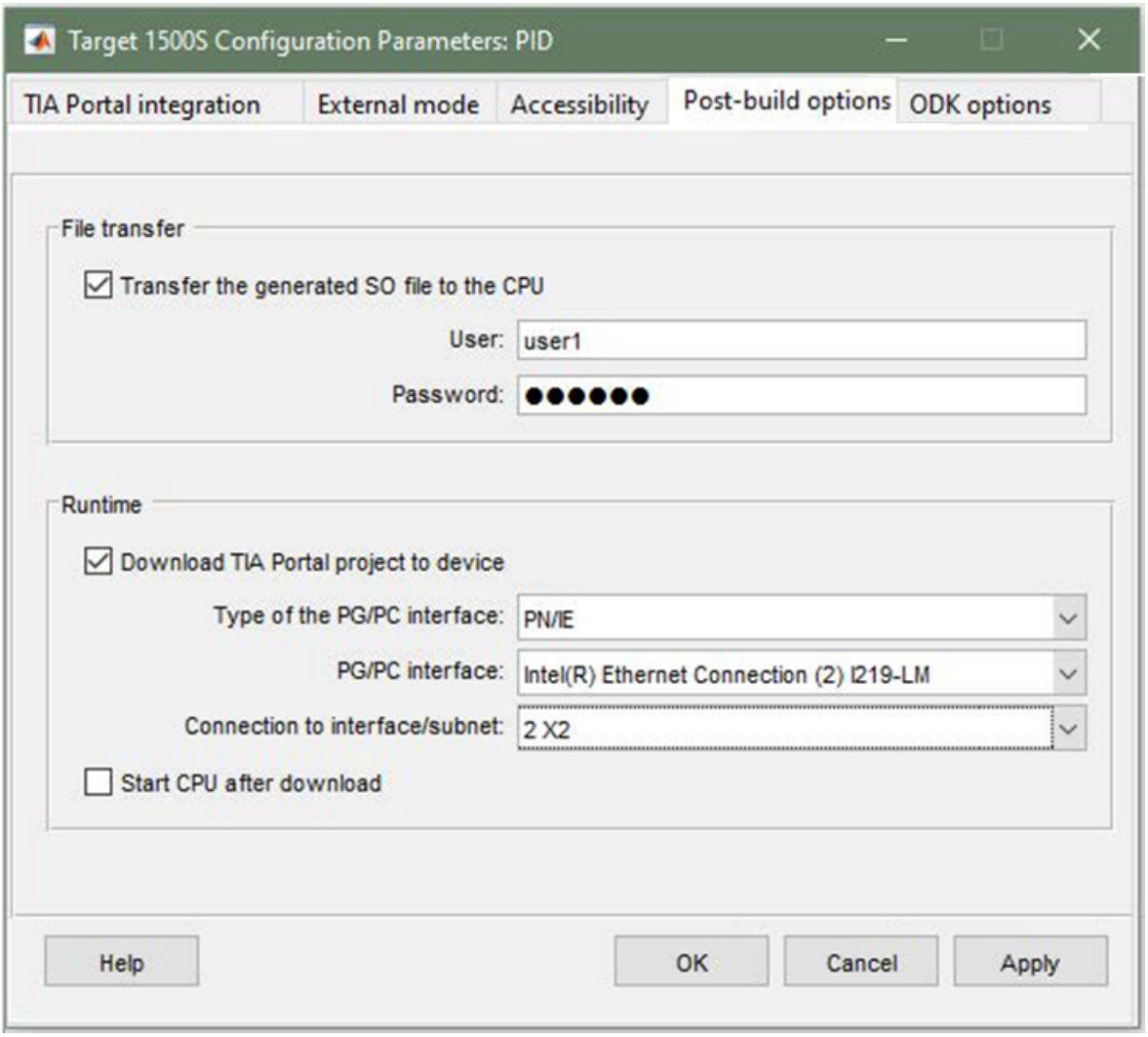

Figure 3-235 Post-build Options

Transfer the generated SO file to CPU

To automatically import the generated SO files into the CPU after the build, enable this option.

- User

  If a login is required, select a user for Web server access to the CPU from this list.
- Password

  If a login is required, enter the password for Web server access to the CPU.

NOTE

Note that neither the password nor the user name is saved for security reasons.

Download TIA Portal project to device

To automatically download the STEP 7 project to the CPU after the build, enable this option.

- Type of the PG/PC interface

  Select a PG/PC interface from this list. Only PN/IE is available.
- PG/PC interface

  Select a PG/PC interface from this list, depending on the selected interface type.
- Connection to interface/subnet

  Select a subnet from this list, depending on the selected interface.
- After the download, start the CPU.

NOTE

Automatic download to fail-safe CPUs

Note that automatic download of a STEP 7 project to a fail-safe CPU is not possible.

7.3.5 Description of the ODK options

In the "ODK options" tab, you can set the following configuration parameters.

Requirement

You have selected Target 1500S as the System Target File.

Parameters that can be set

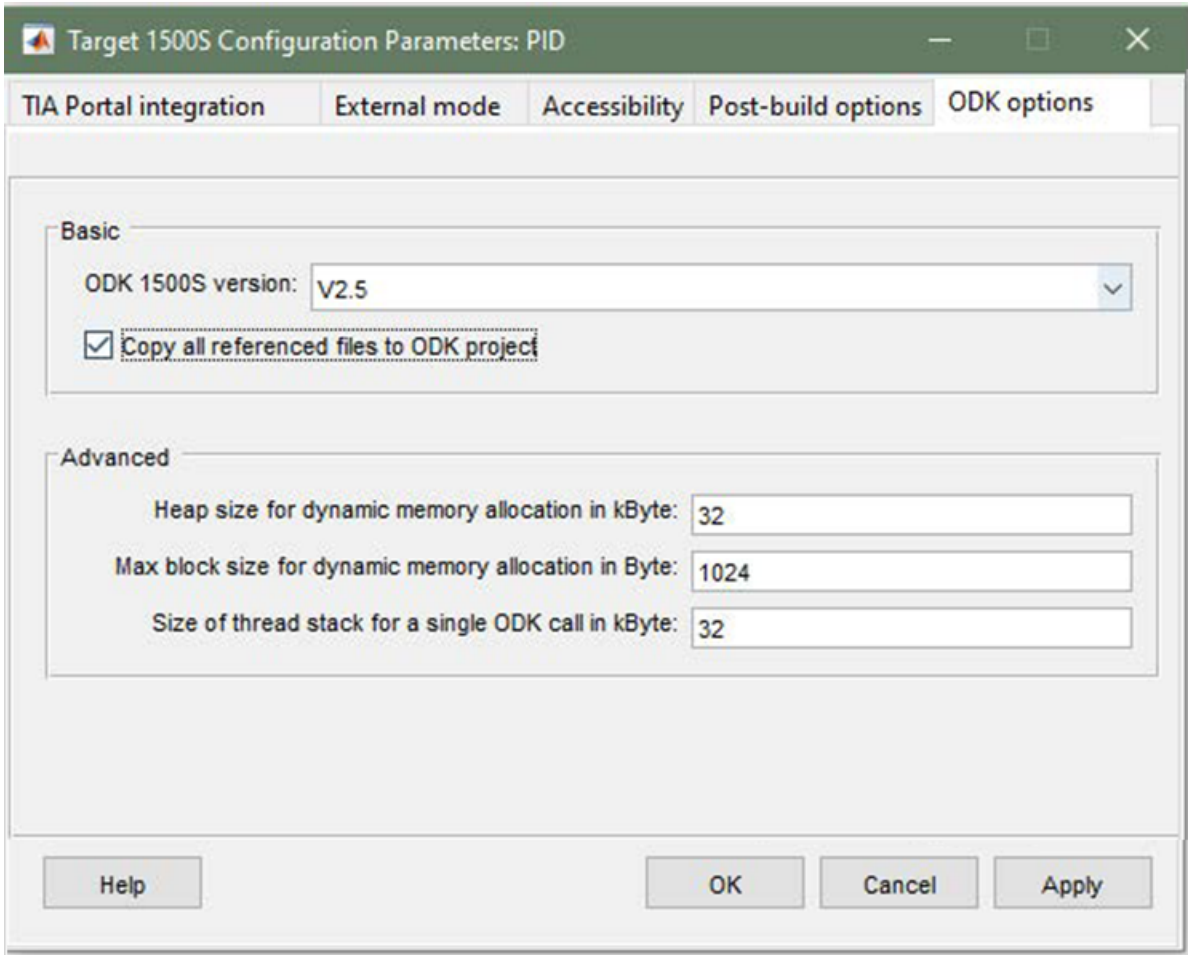

Figure 3-236 ODK options

ODK 1500S version

Choose an installed ODK version from this list. All versions that are compatible with the installed Target version are shown. Restarting MATLAB updates the list, if you have subsequently installed ODK.

Copy all referenced files to ODK project

To copy all MATLAB source files and other code into the ODK project, enable this option. The ODK project can then still be compiled on a PC without a MATLAB installation.

The referenced files are copied to the "references" folder under "<Model name>_Target_1500S_<Current version>_grt_Output".

Heap size for dynamic memory allocation in kByte

Specify the memory for dynamic memory allocation in the ODK object numerically. You need a greater memory allocation in the following cases:

- When you append additional source files to create an ODK project.
- When you are using "malloc".
- When you use new operations in your own functions.

  The value must be between 4 and [<available CPU memory>].

You can find additional information in the ODK documentation (https://support.industry.siemens.com/cs/ww/en/ps/13914/man).

Max block size for dynamic memory allocation in Byte

Specify the memory for dynamic memory allocation in the ODK object numerically. You need a greater memory allocation in the following cases:

- When you append additional source files to create an ODK project.
- When you are using "malloc".
- When you use new operations in your own functions.

  The value must be between 8 and [<Heap size>].

You can find additional information in the ODK documentation (https://support.industry.siemens.com/cs/ww/en/ps/13914/man).

Size of thread stack for a single ODK call in kByte

Numerically specify the memory for the thread stack of a call in the ODK application.

The value must be between 1 and 1024.

You can find additional information in the ODK documentation (https://support.industry.siemens.com/cs/ww/en/ps/13914/man).

7.4 Command line access to options

As an alternative to setting the Target 1500S parameters via the user interface, you can also access the parameters from the MATLAB command line window. To do this, use the command set_param as:

```
>> set_param ('<SimulinkModel>','ParameterName>','<NewValue');
```

NOTE

However, to maintain consistency, we recommend that you set the parameters via the user interface.

Callable options

The following tables show all callable options together with their parameter names in the program line, possible parameter values and mutual dependencies.

Table 3-351 TIA Portal integration

Option	Command line parameters	Possible parameter values	Requirements and dependencies
TIA Portal project	TiaPortalProject	A valid file path string and file extension	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group
Device	CpuName	Device name in the TIA Portal	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • A TIA Portal project has been specified
PROFINET interface	PNInterface	Interface name in the TIA Portal	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • 'Device' was selected
IP address	IPAddress	A valid IPv4 string	Manual setting: • No requirements Automatic extraction: • TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • PROFINET interface selected
Port	IPAddressPort	A positive number as string	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • PROFINET interface was assigned to the selected PC station
Import the generated SCL file to STEP 7 (TIA Portal)	ImportScl	'on', 'off'	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group
Software unit	SoftwareUnit	'Non Unit program' or unit name in the TIA Portal	• TIA Portal Openness is installed (V16 or later) • Windows user was added to the 'Siemens TIA Openness' group • 'Import the generated SCL file to STEP 7' is selected
Organization block	CyclicOB	OB name in the TIA Portal	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • 'Import the generated SCL file to STEP 7' is selected
Instance DB	CyclicDB	DB name in the TIA Portal	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • 'Import the generated SCL file to STEP 7' is selected

Option	Command line parameters	Possible parameter values	Requirements and dependencies
Cyclic time (µs)	CyclicOBTime	A value between 100 and 60000000 as a string	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • 'Import the generated SCL file to STEP 7' is selected • 'Organization block' is selected as cyclic interrupt OB
Compile the CPU after import	CompileCpuAfterImport	'on', 'off'	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • 'Import the generated SCL file to STEP 7' is selected
Automatically save the TIA Portal project after build process	SaveTiaPortalProj	'on', 'off'	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • 'Import the generated SCL file to STEP 7' is selected

Table 3-352 External mode options

Option	Command line parameters	Possible parameter values	Requirements and dependencies
Enable external mode	ExtMode	'on', 'off'	'Enable external mode' is selected
Verbosity level	ExtMode_VerbosityLevel	'on', 'off' or '1', '0'	
Port number	ExtMode_PortNumber	A positive number as string	
Wait for start	ExtMode_WaitForStart	'on', 'off' or '1', '0'	
Hardware interface ID	InterfaceID	A positive number as string	
Connection ID	ConnectionID	A value between 1 and 4095 as a string	
Thread-safety of communication	AllowExtModeInDifferentOB	'on', 'off'	
Organization block	ExtModeOB	OB name in the TIA Portal	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • 'Import the generated SCL file to STEP 7' is selected • 'Enable external mode' is selected
Instance DB	ExtModeDB	DB name in the TIA Portal	

Table 3-353 Accessibility options

Option	Command line parameters	Possible parameter values	Requirements and dependencies
Enable parameter access with STEP 7	Control_Parameters	'on', 'off'	
Organization block	ParamAccessOB	OB name in the TIA Portal	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • 'Import the generated SCL file to STEP 7' is selected • 'Enable parameter access with STEP 7' is selected
Instance DB	ParamAccessDB	DB name in the TIA Portal	
Enable STEP 7 access to internal model signals	GenerateCodeForInternalSignals	'on', 'off'	
Internal signal selection	InternalSignalSelection	• 'All measurement points including test points' • 'All measurement points excluding test points' • 'Only test points'	
Enable STEP 7 access to Stateflow states	StateflowAccess	'on', 'off'	Stateflow toolbox installed and valid license available
Generate model diagrams for PLC Web server	GenerateCodeForWebPage	'on', 'off'	
Application name	GenerateCodeForWebPage_AppName		
Organization block	WebAccessOB	OB name in the TIA Portal	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • 'Import the generated SCL file to STEP 7' is selected • 'Generate model diagrams for PLC Web server' is selected
Instance DB	WebAccessDB	DB name in the TIA Portal	

Table 3-354 Post-build options

Option	Command line parameters	Possible parameter values	Requirements and dependencies
Transfer the generated SO file to the CPU	UploadObject	'on', 'off'	
User	For security reasons, no tag is accessible via the command line	Web server user name in the TIA Portal	Manual setting: • 'Transfer the generated SO file to the CPU' is selected Automatic extraction: • TIA Portal Openness is installed (V16 or later) • Windows user was added to the 'Siemens TIA Openness' group • 'Transfer the generated SO file to the CPU' is selected

Option	Command line parameters	Possible parameter values	Requirements and dependencies
Password	For security reasons, no tag is accessible via the command line	Web server user password	'Transfer the generated SO file to the CPU' is selected
Download TIA Portal project to device	DownloadTiaProjToDevice	'on', 'off'	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group
Type of the PG/PC interface	PgPcInterfaceType	'PN/IE'	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • 'Download TIA Portal project to device' is selected
PG/PC interface	PgPcInterface	Interface name in the TIA Portal	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • 'Download TIA Portal project to device' is selected • 'Device' is selected
Connection to interface/subnet	PgPcInterfaceConnection	Connection name in the TIA Portal (e.g.: '1 X1', '2 X3')	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • 'Download TIA Portal project to device' is selected • 'PG/PC interface' is selected
Start CPU after download	StartCpuAfterDownload	'on', 'off'	• TIA Portal Openness is installed • Windows user was added to the 'Siemens TIA Openness' group • 'Download TIA Portal project to device' is selected

Table 3-355 ODK options

Option	Command line parameters	Possible parameter values	Requirements and dependencies
ODK 1500S version	ODK_Versiontype	'V2.0', 'V2.5'	A compatible ODK 1500S version
Copy all referenced files to ODK project	PortableProject	'on', 'off'	
Heap size for dynamic memory allocation in kByte	HeapSize	[4...<available CPU memory>]k	
Max block size for dynamic memory allocation in kByte	MaxBlockSize	[8...<HeapSize>]	
Size of thread stack for a single ODK call in kByte	SyncCallStackSize	[1...1024]k	

7.5 Running Simulink build

Procedure

1. Start the build process in Simulink via the menu "Code > C/C++ Code > Build Model".

   The system creates a new ODK Eclipse project in the following folder:

   C:\ProgramData\Siemens\Automation\ODK1500S\<ODK version>\workspace
2. If the ODK workspace is already being used by another Eclipse application, the dialog "ODK 1500S default workspace is locked" opens.

   Close the Eclipse application and confirm the dialog with "OK".
3. If there is already an ODK project of the same name in the ODK workspace, the "Existing ODK 1500S Project" dialog opens.

   Click "Yes" to replace the existing project in the ODK workspace.

   Click "No" to cancel the build process.

NOTE

Rebuild model with a different Target version

If you rebuild a model with the same ODK version but a different version of the Target 1500S, the existing ODK project is overwritten.

Results

- The Diagnostic Viewer (Page 45) displays information about the build process.
- A folder containing all generated files was created. The folder name is: <Model name>_Target_1500S_V<Current version>_grt_Output.
- The relevant files are stored in the "outputs" subfolder.
- Depending on the selected target settings, the generated code is loaded into the TIA Portal project, compiled and transferred to the CPU.

You can find more information on the generated files in the appendix (Page 49).

Integration of files in program/data blocks

If you configured integration in program/data blocks before running the build, the program blocks are arranged in the TIA Portal project for the corresponding CPU:

- Add instance DB calls to the selected program blocks (at the end of each program block)
- Overwrite existing DB calls in program blocks
- Remove instance DB calls whose functionality cannot be called for the new build

NOTE

If there is an instance DB call to a previous build in a function block (FB), that call cannot be modified during automatic integration into the STEP 7 project and can cause a compilation error in the affected CPU. In such a case, remove or edit the call manually before you run the build.

NOTE

Automatic program block operations are currently only supported for SCL.

Compatible devices

The generated SO file can be executed in the following environments:

- S7-1500 Software Controller
- ET 200SP Open Controller
- CPU 1518 MFP/ODK
- S7-PLCSIM Advanced (as of V3.0)

7.6 The Diagnostic Viewer

The Diagnostic Viewer displays information about the build process.

Layout

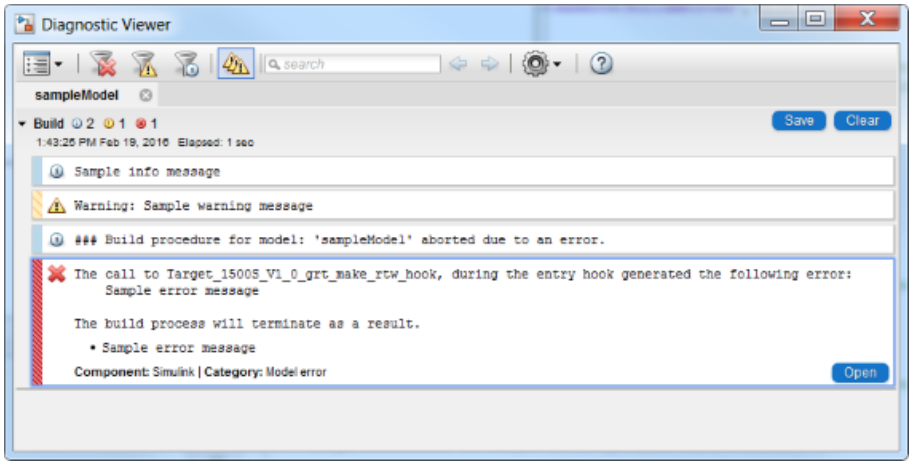

Symbol	Designation	Meaning
	Information	This alarm provides information about the progress of the build process.
	Warning	This alarm does not abort the build process. You are made aware of special considerations and possible problems.
	Error	This alarm indicates an error that results in termination of the build process.

You can find the possible information, warning and error messages under Alarms (Page 74).

7.7 Loading and running the ODK application

The procedure for loading and executing an ODK application is described in the next steps. More information about the individual steps is provided in the manual of the Open Development Kit 1500S (https://support.industry.siemens.com/cs/ww/en/ps/13914/man).

NOTE

If the ODK application is not loaded automatically during the build, you can load the ODK application into the CPU manually.

Procedure

1. Open the Web server of the ODK-enabled S7-1500 CPU.
2. Upload the SO file to the ODK 1500S folder via "Filebrowser".

   Steps 1 and 2 describe manual steps. Only perform these steps manually if automatic execution is disabled or not possible.

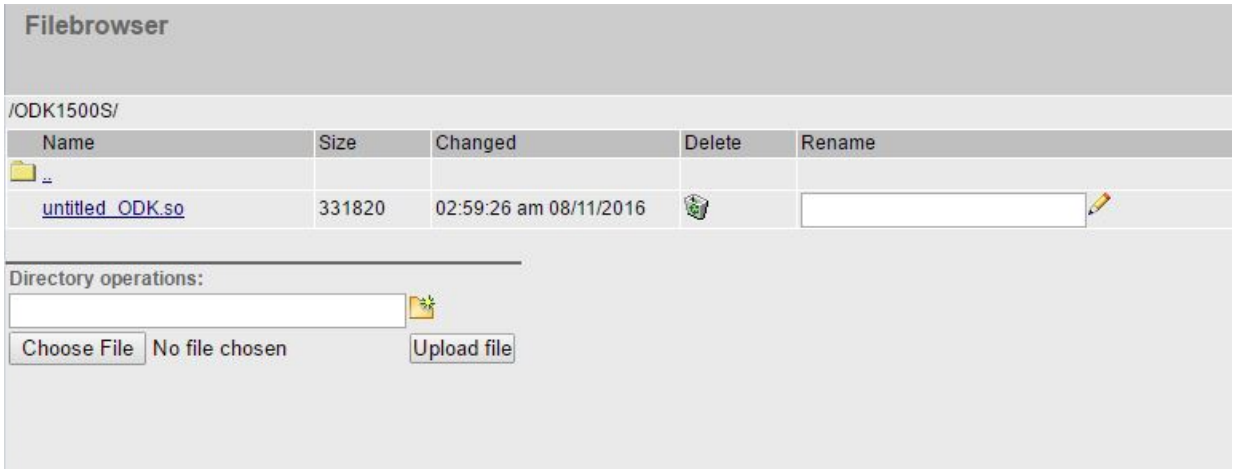

   The SO file is transferred to the load memory.

3. Insert the SCL file in the project tree in STEP 7 as an external source.
4. Generate the program blocks from the external source in STEP 7 by right-clicking on the SCL file > "Generate blocks from source".

   Depending on the parameters set, the following function blocks are created:

   – <Simulink model>_Load
   – <Simulink model>_Unload
   – <Simulink model>CallExtMode
   – <Simulink model>OneStep
   – <Simulink model>ReadWriteParameters
   – <Simulink model>WebReadWrite

   Steps 3 and 4 describe manual steps. Only perform these steps manually if automatic execution is disabled or not possible.

5. Load the application from the load memory to the work memory of the CPU with the instruction "<Simulink model>_ Load".

   NOTE
   Loading and unloading blocks
   Note that the "Load/Unload blocks" function is not automatically integrated into the TIA Portal project within the block options.

6. Run the application with the instruction "<Simulink model>OneStep".

NOTE

Run a modified SO file

A modified SO file is not executed until the old SO file is unloaded with the <Simulink model>_Unload function and the new SO file is loaded with the <Simulink model>_Load function to the work memory.

If previously loaded SO files are not unloaded, they remain in the work memory and reduce it. This can mean that no more SO files can be loaded because the available work memory is no longer sufficient. To empty the work memory, shut down your system and restart it.

Procedure:

1. Unload previously loaded SO files.
2. During the build, perform an automatic import of the new SCL file into the CPU of the TIA Portal project or manually import the new SCL file after the build.
3. During the build, perform an automatic transfer of the new SO file to the TIA Portal project CPU or manually transfer the new SO file after the build.
4. Load the new changed SO file.

Using an example project

8

An example project is ready for you on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109482830) to help getting started with the Target 1500S.

An application example for virtual commissioning with SIMATIC and Simulink is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109749187) under application case 3.

Files generated by coders

A

To create ODK-enabled data, the Target 1500S TLC is used based on the Simulink Coder. The generated files and their main functions are explained below.

Files created by Simulink Coder

- <Simulink model>.cpp

  This file has three main functions:

  – void <Simulink model>_step(void)

    This function is called by the OneStep FB and is casted to the Simulink model.

  – void <Simulink model>_initialize(void)

    This function is called by the <Simulink model>_Load FB.

  – void <Simulink model>_terminate(void)

    This function is called by the <Simulink model>_UnLoad FB.

- <Simulink model>.h

Files created by the Target 1500S TLC

- <Simulink model>_ODK.odk

  This file is used as input for the ODK code generator.

- <Simulink model>_ODK.cpp

  This file contains the execution of OnLoad, OnUnload and OneStep functions.

- <Simulink model>_ODK.scl.additional

  This file is only generated when external mode (Page 52) is activated.

Target 1500S TLC generated a comment with the following information in the files:

- Name and version of the Simulink model.
- Name and date of creation of file.
- Target 1500S version and the System Target File used.
- ODK 1500S version
- Versions of the MATLAB configuration

Referenced models

B

Since Version V1.0 Update 1, Target 1500S has been supporting the code generation of referenced models for controllers with ODK capability. With referenced models, a parent model contains one or more referenced models. A referenced model itself can refer to further referenced models.

Special considerations for code generation with referenced models

Target 1500S detects referenced models and processes the models from the referenced models to the parent model during the build. The system creates an ODK Eclipse project at the end of the build.

You can configure the parameters for the parent model and the referenced models differently under "Configuration Parameters (Page 21)". In the following table, you can see the response to the respective parameters.

Parameter	**Response to referencing**	
	Only the settings of the parent model are taken into considera-tion	**The settings are individually evaluated**
ODK 1500S version	✓	
Copy all referenced files to ODK project	✓	
Parameter access with STEP 7		✓
Enable STEP 7 access to internal model signals		✓
Enable STEP 7 access to Stateflow states		✓
Generate model diagrams for PLC Web server	✓	
Enable external mode	✓	
Settings for "Integration to TIA Portal project"	✓	
Import the generated SCL file to CPU(s)	✓	
Compile the CPU after import	✓	
Automatically save the TIA Portal project after build process	✓	
Transfer the generated SO file to the CPU	✓	
Download TIA Portal project to device	✓	
Start CPU after download	✓	

External mode

If the external mode (Page 52) is enabled in the parent model, it can also be used for the referenced models contained therein.

For code generation, the "Interface" settings of the referenced models are ignored and the settings of the parent model are used.

If you select a setting other than "External mode" or "None" for the referenced model under "Interface", an error message appears during the compiling.

External mode

C

C.1 The external mode

The external mode of Simulink enables you to monitor the model during runtime and change the parameters of the model online.

For Simulink to be able to communicate with the model on the controller via external mode, external mode must be activated before starting the build process. In this case, the code is supplemented by communication code for the data exchange between Simulink and the controller. The communication is realized on the basis of TCP/IP.

⚠ DANGER
Changes to the model only in the test environment Use the external mode for test purposes only. Changing the tag values while the plant is operating may result in severe damage to property and personal injury in the event of malfunctions or program errors. Make sure that dangerous states cannot occur before you use the "Modify" function. When using the external mode, note that no CPU password is required to control tags.

Activating external mode

To activate external mode, select the value "External mode" under "Code Generation > Interface > Data exchange interface" in the Simulink parameters (Page 21). Alternatively, activate the "Enable external mode" option in the user interface of the Target 1500S configuration parameters.

C.2 Setting communication parameters for external mode

- External mode options on the Target 1500 user interface
  - IP address:

    IP address of the ODK-enabled controller which is to run the application.

    Uses the IP address of the "IP Address" option of the "TIA Portal integration" tab of the Target 1500S user interface.
  - Verbosity level (optional):

    Set the value "1" in order to obtain detailed information about the external mode in the "Diagnostic Viewer (Page 45)".

- Port number (optional):

  The port number of the server for the TCP/IP connection (ODK-enabled controller).

  Default: 17725

- Wait for start (optional):

  If you set the value to "0", the simulation starts automatically when the "OneStep" function is executed.

  If you set the value to "1", the execution of the Simulink model does not start automatically. In this case, you need to start the simulation in the Simulink window after the connection is established using the " " button.

- Other external mode options in the Simulink configuration
  - Static memory buffer size

    This memory is required for communication of the external mode.

    Increasing "Static memory buffer size", however, simultaneously reduces the available memory for loading the ODK object. Adhere to the ODK limits. If necessary, you can enter a higher value or change your model.

You can find a description of the other options of the "External mode" tab in section "Description of the external mode options (Page 29)".

NOTE

Change the parameters of the external mode

If you change the parameters of the external mode, you need to rebuild the Simulink model. Then update the STEP 7 user program and the SO file on the CPU (see "Loading and running the ODK application (Page 45)").

C.3 The function block CallExtMode

Structure of the function block (FB)

If the block call is not generated automatically, you can also insert the block manually as described below.

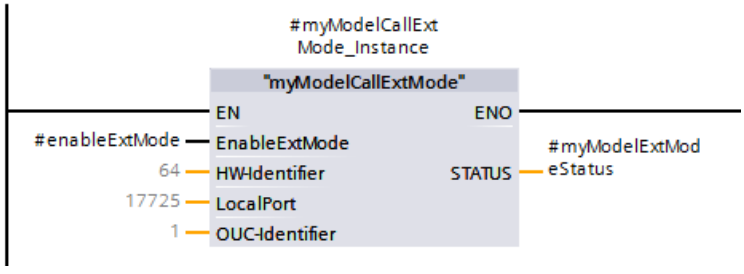

The "<Simulink model>CallExtMode" FB has the following input parameters:

- EnableExtMode (Bool)

  To establish an external mode connection, set this parameter to "true" using a tag.

- HW-Identifier (UInt)

  You specify the value of the hardware interface ID for the communication interface in the Target 1500S options.

  The default value is "64".

- LocalPort (UInt)

  The port number value is set in the Target 1500S options.

  Change the value to establish the external mode connection using a different CPU port.

- OUC-Identifier

  The value for the Connection ID is set in the Target 1500S options.

  The Connection ID is required for Open User communication and the value must be unique for the STEP 7 user program.

The "<Simulink model>CallExtMode" FB has the following output parameters:

- STATUS

  The status parameter has the type <Simulink model>ExtModeStatus_UDT (User Definied Datatype) and contains the following parameters:

  – Status_TCON (Word)
  – Status_TDISCON (Word)
  – Status_TRCV (Word)
  – Status_TSEND (Word)
  – Status_ODK (Int)
  – Status_ExtMode (Word)

  You can find the status descriptions for "TCON", "TDISCON", "TRCV", "TSEND" in the STEP 7 help.

  You can find the status descriptions for ODK in the manual (https://support.industry.siemens.com/cs/ww/en/ps/13914/man).

NOTE

Special features of the option "Thread-safety of communication"

If the option is set to "Not thread-safe", call the "CallExtMode" FB in the same block (OB, FB) as "OneStep". Otherwise, the model calculation is not performed synchronously with the data connection.

If the option is set to "Thread-safe", you can call the FB "CallExtMode" in a different "OneStep" block.

Note the following when option is "Thread-safe":

- The block which contains the FB "OneStep" must have a higher priority than the block with the FB "CallExtMode".
- The possible available memory for running ODK applications is reduced.
- Call the FB "CallExtMode" in a program cycle OB.
- If the cycle interruption time of the OB in which the FB "OneStep" is called is too short, interruptions may occur in the graphs (scope) during simulation of the model in Simulink.

Functionality of the block

The FB has the following tasks:

- Communication between Simulink and controller.
- Data transfer between Simulink and controller.

Return value for Status_ExtMode	Description
0x0000	Return value after successful execution or initial state.
0x0001	Not enough memory for the external mode. The allocated memory may be too small for a complex Simulink model. Increase the value in the interface options under "Static memory buffer size". To apply the value, generate the ODK object again. "Static memory Buffer size", however, reduces the space available for the application at the same time.

C.4 Establishing an external mode connection

Procedure

1. Call the FB "<SimulinkModel>CallExtMode" and enable access (EnableExtMode).

NOTE
Run the OneStep FB before the external mode connection is made.
Simulation steps are executed as soon as the OneStep FB of a cyclic OB is called. If the external mode connection is not yet established, these steps are lost.
To prevent this, set the "Wait for start" option to "On" (1) in the "External mode" dialog of the Target 1500S.

2. Select "External" as the simulation mode.

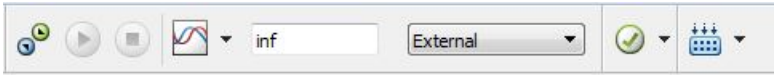

3. As the simulation stop time, select the value "inf" for endless simulation or an appropriate value for your model.

NOTE
Checking the solver settings
Check whether the setting "fixed-step-size (fundamental sample time)" under "Solver > Solver details" is set appropriately for your model.
You can find more information about parameters in the MATLAB and Simulink documentation.

4. To establish the external mode connection, click on the connect symbol " ".

Result

You can monitor the model during runtime of the controller and change parameters of the model online.

NOTE

When the simulation is completed or canceled, the CPU must be switched from "STOP" to "RUN" in order to start a new connection with subsequent simulation. Data from the previous simulation is overwritten.

Parameter access from STEP 7

D

D.1 Introduction

Certain parameters can be read and changed at runtime after you enable parameter access in the STEP 7 user program. These parameters can be user parameters used in the model or parameters integrated in the blocks of the model.

It is also possible to read and change the model parameters via External Mode in order to test and adapt your model at runtime.

D.2 Enabling parameter access

Parameter types

For a parameter used in a Simulink model, there are two different contexts for optimizing the parameters.

Block parameters

Block parameters are integrated parameters of a Simulink block in the model. To allow access to these parameters, select "Tunable" under "Default parameter behavior" in "Code Generation > Optimization".

Workspace parameters

You define the workspace parameters in a MATLAB workspace.

Procedure

1. Enable the "Parameter access with STEP 7" in the Target 1500S options.
2. In order to generate the UDT "<Simulink model>Params" and FB "<Simulink model>ReadWriteParameters" in the SCL file, select "Tunable" under "Default parameter behavior" in "Code Generation > Optimization".

   You can also configure parameters other than "Tunable". You can add the parameters defined in the MATLAB workspace in the "Model Parameter configuration" area.

   To do this, select a supported storage class.

Storage class	Support
Model default	Yes
ExportedGlobal	Yes
ImportedExtern	Yes
ImportedExternPointer	No

3. Compile the model, transfer the corresponding files to STEP 7 as before and load the STEP 7 project into the CPU.

D.3 The ReadWriteParameters function block

In order to read and change parameters, you need the UDT "<Simulink model>Params" and the FB "<Simulink model>ReadWriteParameters".

Structure of the function block (FB)

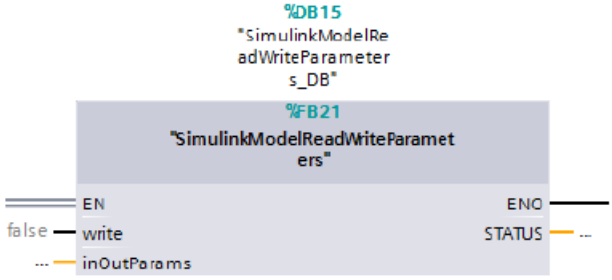

The "<Simulink model>ReadWriteParameters" FB has the following input parameters:

- write (Bool)

  To write the parameters from the S7 program to the Simulink model, set this value to "true". The values passed with the "inOutParams" parameter are processed by the Simulink model.

  To read the parameters from the Simulink model, set this value to "false". The current values of the Simulink model parameters are written to a tag interconnected to "inOutParams".

The "<Simulink model>ReadWriteParameters" FB has the following parameters:

- inOutParams

  The inOutParams has the type <Simulink model>Params UDT and is used for reading or writing parameters in the Simulink model.

The "<Simulink model>ReadWriteParameters" FB has the following output parameters:

- STATUS

  This return value is automatically generated by ODK.

  The return value is "0" when the execution is successful.

  You can find information on the other error codes in the ODK manual (https://support.industry.siemens.com/cs/ww/en/ps/13914/man)

The UDT parameter values are initialized with their default values as defined in MATLAB/Simulink.

D.4 Establishing parameter access

Procedure

If automatic block call is not possible, proceed as follows:

1. Generate blocks from the SCL file in STEP 7.
2. Use the blocks generated in STEP 7.
   - To set the values in the same cycle, call the "ReadWriteParameters" FB before "OneStep".
   - To set the values in the following cycle, call the "ReadWriteParameters" FB after "OneStep".

NOTE

Thread-safety requirement of the "ReadWriteParameters" FB

You cannot change the model parameters dynamically using the "OneStep" model function block.

To change the parameters dynamically, use the "ReadWriteParameters" FB in STEP 7.

NOTE

The "ReadWriteParameters" FB is thread-safe, i.e. you can call the "ReadWriteParameters" FB and the "OneStep" FB in different OBs.

The UDT parameter values are initialized with their default values set in MATLAB/Simulink.

NOTE

Changed model parameters in the S7 program are kept in the work memory. If the associated ODK object is re-initialized, the parameters are reset to their default values.

Access to internal signals

E

You can define measurement points in the Simulink model by giving names to the lines of a model. Measurement points are referred to as "internal signals" in the context of Target 1500S.

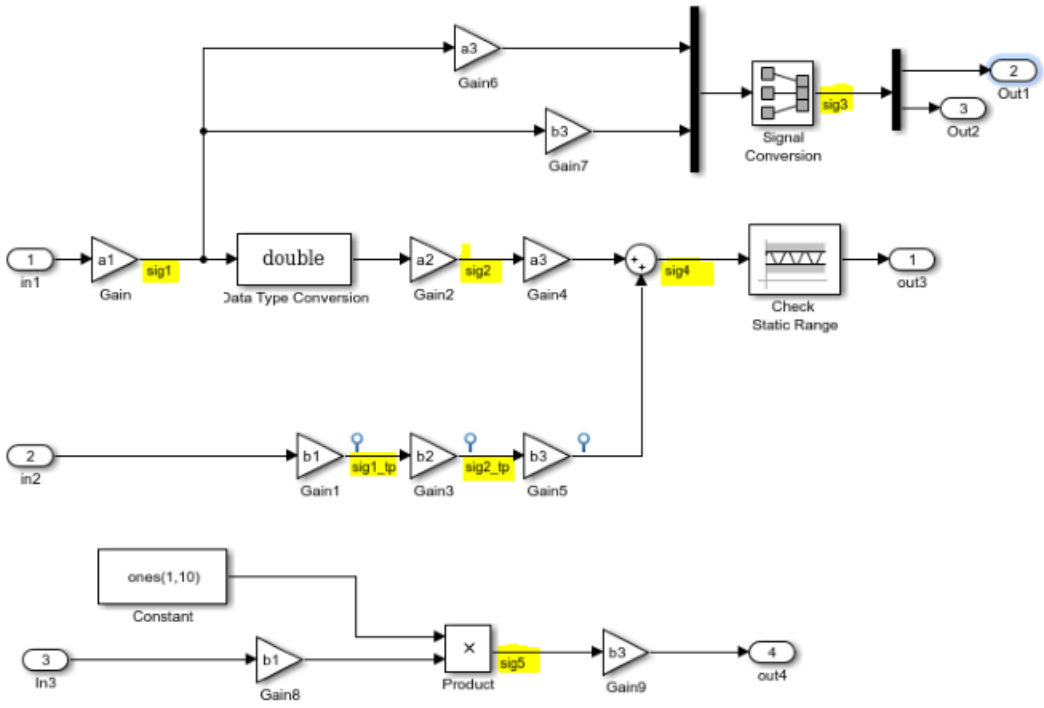

Figure 3-237 Example model with internal signals

If you enable the "Enable STEP 7 access to internal model signals" option in the Target 1500S options, these internal signals are defined as output of the "OneStep" FB during the generation of the code.

Special features for the FB "OneStep"

Target 1500S defines the internal signals during the generation of the code in an ODK_STRUCT with the name "InternalModelSignals". The FB "OneStep" needs a new output parameter "OUT" with the name "internalSignals" for this purpose.

Properties of the signal

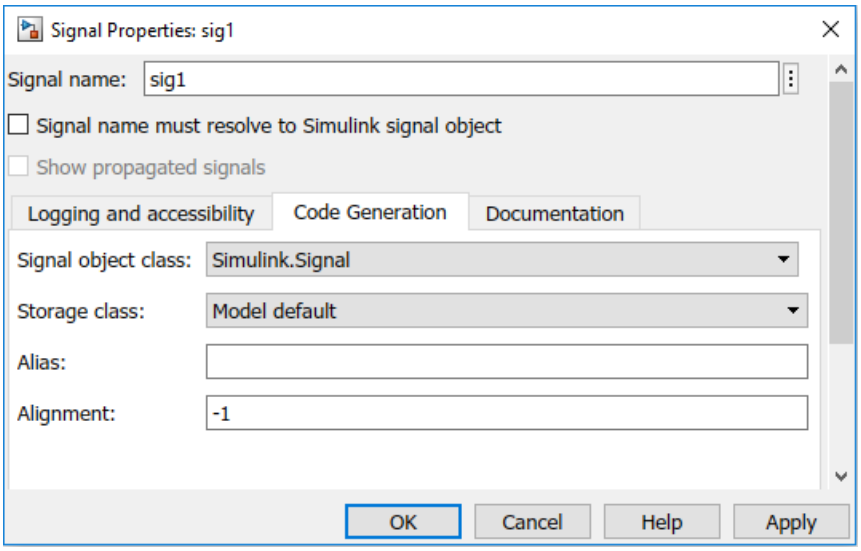

Figure 3-238 Dialog box Signal Properties

1. Under "Signal name:", enter the name of the signal.
2. Select a supported storage class for the signal under "Storage class:".

Storage class	Support
Auto	Yes, if it is casted to a supported storage class.
Model default	Yes
ExportedGlobal	Yes
ImportedExtern	Yes
ImportedExternPointer	No
Custom storage class	No

Display model on the Web server

F

F.1 Notes on protection

Configuration of the Web server

A user with the name "Everybody" is created by default in the user list of the Web server. The user stands for any user who uses the Web server without a user name. By default, the user has minimal access rights, such as read access to the intro and start page. Because the user "Everybody" does not have a password assigned in STEP 7, pay close attention to the access rights you assign to this user. Individual authorizations, such as the option to change the operating mode, may represent a security risk.

To assign safety-related authorizations, configure a new user and always assign a password in STEP 7. Assign secure passwords to users during configuration. An example of a secure password is one which is only used for a single application, is more than 8 characters long, and consists of lower-case and upper-case letters as well as special characters and numbers (?!+%$1234...).

Whenever possible, select the option "Permit access only with HTTPS" as soon as you have assigned a password to at least one user.

Reference

You will find more information on the configuration of the Web server in the Web Server (http://support.automation.siemens.com/WW/view/en/59193560) function manual.

F.2 The WebReadWrite function block

Since version V3.0, Target 1500S supports a Web interface to display and control a Simulink model using all values on the CPU's Web server.

Structure of the function block (FB)

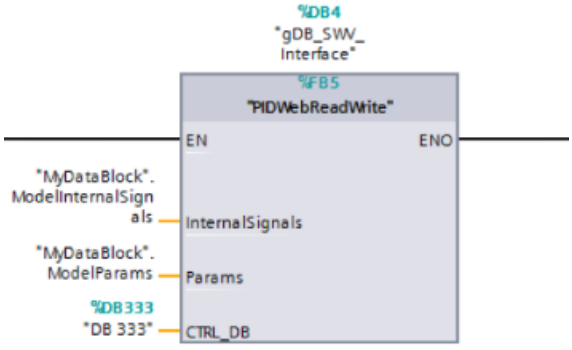

Figure 3-239 WebReadWrite

The "<Simulink model>WebReadWrite" FB has the following input parameter:

- InternalSignals

  The parameter is available when you enable the Access to internal signals (Page 61).
- Params

  The parameter is available when you enable the Parameter access (Page 58).
- CTRL_DB

  Specify the start number of the first data block of the generated Web server blocks. The value corresponds to the Web DB number in the STEP 7 settings.

Calling the FB

Call "WebReadWrite" in the same OB as "OneStep" and "ReadWriteParameters". The name of the instance DB for calling the "WebReadWrite" FB in the STEP 7 user program must be "gDB_SWV_Interface".

F.3 Adding files to a STEP 7 project

Generating files for Web access

To create all required files for access via the Web server, enable the "Generate model diagrams for PLC Web server" option.

The files are generated during the build in the folder "website" under "<Model_name>_Target_1500S_<current version>_grt_Output".

Adding files automatically to a STEP 7 project

To create all required files for access via the Web server, enable the "Generate model diagrams for PLC Web server" option.

All required settings for "user pages" are performed automatically in the TIA Portal project:

- Set the HTML directory as the "website" folder generated during the build
- Set the default HTML pages as "home.html" in the folder
- Set the application name as specified by the user
- Add ".json" to the list of files with dynamic content
- Generation of blocks for Web access

NOTE

The automatic steps described are only possible as of TIA Portal V16.

Adding files manually to a STEP 7 project

To create the required data blocks for the Web server from the generated Web content, proceed as follows:

1. Open your project in STEP 7.
2. In the properties of the CPU in the "General" tab, select the "User-defined pages" property in the "Web server" group.

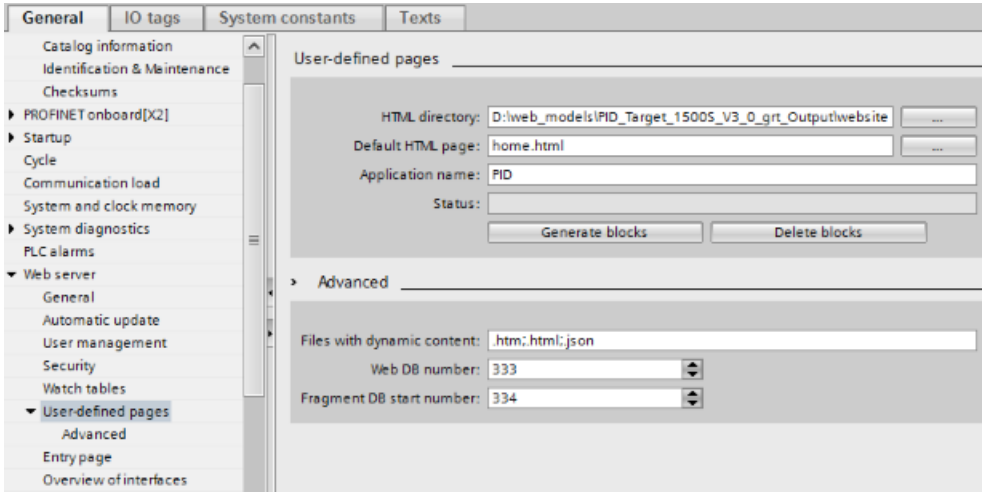

3. Make the following settings under "User-defined pages":
   - HTML directory: Enter the path of the "website" folder.
   - Default HTML page: Specify the created file "home.html".
   - Application name: Enter the name of the application.
4. In addition to ".htm" and ".html" enter the type ".json" under "Advanced" in the "Files with dynamic content" input field.
5. Create the data blocks for the Web server by clicking on "Generate blocks".

Result

The data blocks for the Web server are generated, starting with the value defined under "Web DB number".

F.4 Using the Web server

Requirement

- You have installed one of the following browsers:
  - Google Chrome
  - Microsoft Edge
  - Microsoft Internet Explorer 11
  - Mozilla Firefox 31 or later
- You have loaded the STEP 7 project.
- The model runs on the CPU.

Procedure

Follow these steps to access the model from the Web server:

1. Enter the IP address of the CPU in the Web browser.
2. Select the user interface language.

   Log on to the system if needed. The user requires authorization to open user pages.
3. Select "User-defined pages".
4. To display the model, click "Start page of the application <application name>:".

   A new page with the diagram of the model opens.

Properties of the Web page

The following properties are available to you on the page:

- To get to the main diagram, click "Home".
- To gain Web access to the parameters (Page 67), click on the respective ("Params", "WorkspaceParams" or "ModelWorkspaceParams") parameter in the menu.
- Referenced models, subsystems, visualizable Stateflow blocks (e.g. charts and state transition tables) can be opened via the menu or by clicking on the block in the diagram.
- Clicking on a "Scope" block opens a pop-up window that graphically displays the current values of internal signals.
- You can run "OpenFcn" callbacks defined in Simulink via the diagram.

- Commented out model parts are grayed-out.
- In "RUN" mode of the CPU, internal signals are displayed dynamically at the corresponding connection in the diagram.

F.5 Web access to parameters

You can read and write the parameters on the Web server.

Requirement

- You have enabled parameter access.
- The parameter is used in the model.

Parameter categories

There are three parameter categories in Simulink that you can select in the Web server.

- Model parameters

  Parameters of the blocks in a model.
- Base workspace parameters

  These parameters are defined in the basic workspace of MATLAB and can be used on every level of the model hierarchy.
- Model workspace parameters

  These parameters are defined in the context of a model and only apply to the respective model.

To open a list with the parameters, click on the respective parameter category in the menu.

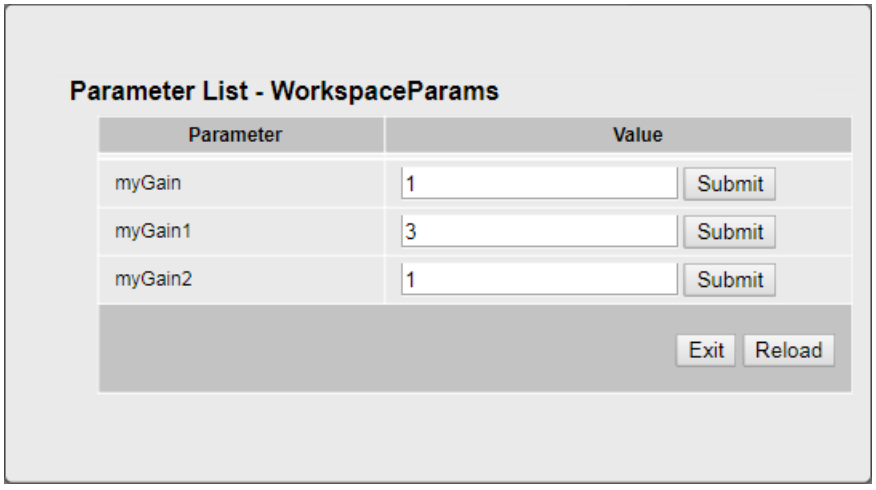

You can change the value of the parameter using the input field. To send the new value, click "Submit" for the relevant parameter. To update all parameters in the list, click "Reload".

Click "Exit" to close the list with the parameters.

F.6 Display signals on the Web server

You can display and monitor the internal signals of your model in a graph. Only internal signals that are connected to a "Scope" block are displayed.

Requirements

- You have enabled access to internal signals.
- You have assigned names for the signals.

Procedure

1. To open the graph, click the "Scope" block in the model.

   A window with the graph opens. The individual signals are shown in different colors.

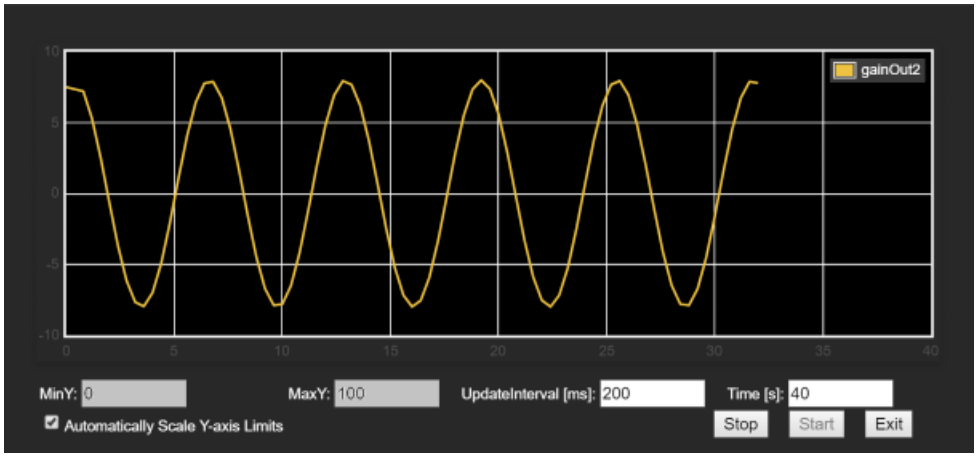

   – MinY; MaxY:

     Specify the range of the Y axis.

   – Automatically Scale Y-axis Limits

     To dynamically scale the area of the Y-axis, enable this option. The input fields "MinY" and "MaxY" are blocked when the option is enabled.

   – UpdateInterval [ms]:

     Enter in milliseconds the interval at which the values are read from the CPU.

   – Time [s]:

     Specify the size of the X axis.

2. To start the recording, click "Start". To stop the recording, click "Stop".
3. To close the window with the graph, click "Exit".

F.7 Show active Stateflow states on the Web server

Mathworks offers the licensed "Stateflow" toolbox for modeling and simulation of decision-making logic via flowcharts. Target 1500S supports the use of Stateflow. In Simulink, you can visualize the active states in the charts and transition tables of states. This feature is also available in the Web server of the CPU.

You can use the Web server of the CPU to check the current state without Simulink.

To handle complex logical decision-making algorithms, Stateflow provides three main blocks:

- TruthTables
- Charts
- State Transition Tables

Parameters for accessing states

To display the active Stateflow states on the Web server, you need enabled Target 1500S parameters in the Accessibility options (Page 32).

Enable STEP 7 access to Stateflow states

To have access to the active Stateflow states in the created project, enable the "Enable STEP 7 access to Stateflow states" parameter.

During the build process, Target 1500S creates an ODK_STRUCT named "StateflowChartStates" that contains string tags. These string tags contain the names of the active states. They are divided into two classes of string tags with different naming conventions:

- Chart state variables

  Representation of the active states at the top level of a chart. The name of the tag consists of the name of the chart and an ID, e.g. "myChart_2".

- Parent state variables

  Representation of the active child states of a parent state. The name of the tag consists of the name of the chart, the name of the parent state and an ID, for example "myChart_myParentState_3".

ODK_STRUCT "StateflowChartStates" is an output type in the "chartStates" tag in the FB "<Simulink model>OneStep".

Generate model diagrams for PLC Web server

To display the Stateflow blocks and activities on the Web server, enable the "Generate model diagrams for PLC Web server".

You can navigate in the Web server over the Stateflow blocks and state changes are displayed.

Restrictions of the Stateflow toolbox

The visualization is identical to a normal simulation in Simulink. However, there are some restrictions in the Stateflow blocks and activities.

Supported Stateflow blocks

Stateflow block type or use case	Can be displayed and navigated on the Web server
Charts	Yes
Simulink functions in charts	Yes
Simulink states in charts	Yes
Graphic functions in charts	Yes
Hierarchies of parent and child states in charts	Yes
Grouping of states in charts	Yes (as ungrouped states)
MATLAB functions in charts	No
TruthTables in charts	No
Subcharts in subcharts	No
Preview of subcharts and subcharts	Yes
Atomic subcharts in charts	Yes
Boxes	Yes
Transition tables of states	Yes (as underlying Stateflow chart)
TruthTables	No

Supported Stateflow activities

Type of Stateflow activity	Can be displayed on the Web server
Active states in charts	Yes
Active Simulink states in charts	Yes
Active subcharts in charts	Yes
Active Simulink states / states in subcharts	No
Active atomic subcharts in charts	Yes
Active Simulink states / States in atomic subcharts	Yes
Active paths in graphic functions	No
Active transitions in charts	No
Active states in previews of charts	No
Active states in previews of subcharts	Yes
Parallel execution of states	No
Active states in 'moore' charts	No

Additional restrictions

Using state names in programs:

For a Simulink model with stateflow® charts in which state names are used in the program as an argument in another state, runtime access to states is not possible and build operations can fail. An example of this is the use of the in operator in a stateflow® chart with parallel state decomposition to verify that a state is active within a certain time step during chart execution. Additional information is available under:

https://www.mathworks.com/help/stateflow/ug/checking-state-activity.html
(https://www.mathworks.com/help/stateflow/ug/checking-state-activity.html)

Using data types

G

G.1 Bus objects

You can define bus objects in the Simulink model. These objects can contain simple data types or other bus objects.

Converting bus objects

Bus objects are compiled with the Simulink build in PLC data types for the S7 program.

The following figure shows bus objects in Simulink on the right and the generated PLC data types in STEP 7 on the left.

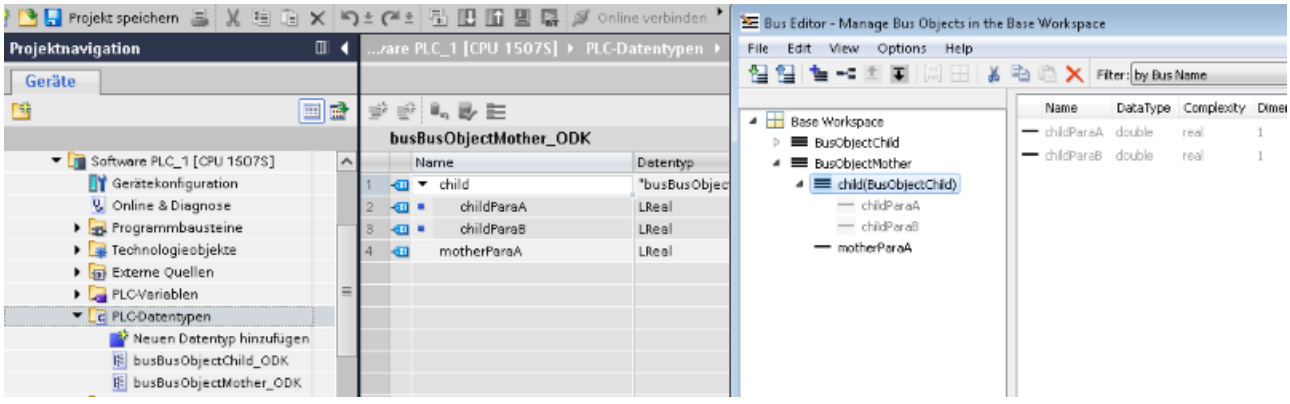

A bus object can be used as a data type for a signal of the Simulink model.

Reference

You can find more information about using PLC data types in the STEP 7 help system.

G.2 Supported basic data types

The following table represents the supported basic data types in Simulink and their assignment in ODK, STEP 7 and C/C++:

Simulink	ODK	C++	STEP 7	Description
double	ODK_DOUBLE	double	LREAL	64-bit Floating Point, IEEE 754
single	ODK_FLOAT	float	REAL	32-bit Floating Point, IEEE 754
int8	ODK_INT8	char	SINT	8-bit signed integer
uint8	ODK_UINT8	unsigned char	USINT	8-bit unsigned integer

Simulink	ODK	C++	STEP 7	Description
int16	ODK_INT16	short	INT	16-bit signed integer
uint16	ODK_UINT16	unsigned short	UINT	16-bit unsigned integer
int32	ODK_INT32	int	DINT	32-bit signed integer
uint32	ODK_UINT32	unsigned int	UDINT	32-bit unsigned integer
int64	ODK_INT64	long long	LINT	64-bit signed integer
uint64	ODK_UINT64	unsigned long long	ULINT	64-bit unsigned integer
boolean	ODK_BOOL	bool	BOOL	1 bit bitstring

G.3 Complex data types

The following table represents the complex data types for STEP 7 access:

Contents	Complex types			
	Arrays	Bus objects	Enumeration types	Complex numbers
Inputs/Outputs	✓	✓	✓	✓
Parameters	✓	✓	✓	✓
Internal signals	✓	✓	✓	✓

✓: Supported

X: Not supported

The following table represents the complex data types for Web server access:

Contents	Complex types			
	Arrays	Bus objects	Enumeration types	Complex numbers
Parameters	✓	✓	X	✓
Internal signals	X	X	X	X
Scoping	X	X	X	X

✓: Supported

X: Not supported

Alarms

H

H.1 Alarms during the build process

Meaning of the alarms

- Information messages (Page 74)

  This alarm provides information about the progress of the build process.
- Warnings (Page 77)

  This alarm does not abort the build process. You are made aware of special considerations and possible problems.
- Error messages (Page 80)

  This alarm indicates an error that results in termination of the build process.

H.2 Information messages

Info no.	Alarm	Meaning
1	"Build of <SimulinkModel> with Target 1500S <Version> is started"	The build process starts
2	"Generating Target 1500S specific files:"	Target 1500S is creating files.
3	"<Filename> is generated"	Target 1500S has created files.
4	"Generating Simulink Model sources"	The Simulink Coder is generating source files.
5	"Creating ODK 1500S project <SimulinkModel>_ODK under <OutputPath>"	Target 1500S is creating an ODK project.
6	"ODK 1500S Project <SimulinkModel>_ODK is created successfully"	The ODK project has been successfully created.
7	"Building ODK 1500S project <SimulinkModel>_ODK"	An ODK project is being built. If you have selected the "Verbose" option in the Options menu of the code generator, the Diagnostic Viewer displays each output.
8	"<SimulinkModel>_ODK project build is finished successfully"	The ODK project build was completed successfully.
9...12	"<SimulinkModel> build is finished successfully. <SimulinkModel>_ODK.scl and <SimulinkModel>_ODK.so files are available in folder "outputs". TIA Portal: 1. Navigate to the CPU / 'External Source' area and import the <SimulinkModel>_ODK.scl file. 2. Select the imported file and generate blocks out of this source (right-click or Toll menu) 3. Integrate the blocks into your CPU program in order to load and execute it.	The Simulink build was completed successfully. The files "<Simulink model>_ODK.scl" and "<Simulink model>_ODK.so" are available in the "outputs" folder. TIA Portal:

Info no.	Alarm	Meaning
	Web server (CPU): 1. <SimulinkModel>_ODK.so file has to be uploaded using the Web server into ODK1500S folder. You can find details about deploying an ODK 1500S Object to CPU in ODK 1500S documentation (https://support.industry.siemens.com/cs/ww/en/view/109752683)." For Web access to the runtime model, the file 'home.html' is available in folder "website" TIA Portal: 1. Navigate to Web server > User-defined pages in CPU properties 2. Select the path to the 'website' folder as HTML directory 3. Set the default HTML page as 'home.html' 4. Define an application name 5. Make sure that '.htm', '.html' and '.json' are defined in files with dynamic content 6. Generate blocks 7. Integrate the generated FB for Web access into your CPU program and name its DB as 'gDB_SWV_Interface'	This message is only output when the option "Import the generated SCL file to STEP 7 (TIA Portal)" is disabled or the process was unsuccessful. 1. Navigate to the CPU in the "External sources" area and import the file "<SimulinkModel>_ODK.scl". 2. Mark the imported files and generate blocks from the source with a right-click. 3. Integrate the blocks into your program to download and execute it. Web server of the controller: This message is only displayed if the "Generated model diagrams for PLC Web server" option is enabled and the process was successful. 1. Download the file "<SimulinkModel>_ODK.so" over the Web server to the ODK 1500S folder. If you have disabled the option "Import the SCL file generated by the build to a CPU" or if the execution was unsuccessful, you can update the sources manually via the TIA Portal. Proceed as follows for this: You can find additional information in the ODK manual (https://support.industry.siemens.com/cs/ww/en/view/109752683).
13	"Removing <SimulinkModel>_ODK from ODK 1500S default workspace"	You have confirmed the "Existing ODK Project" dialog with "Yes". The existing project is overwritten.
14	"<SimulinkModel>_ODK is removed from ODK 1500S default workspace"	You have confirmed the "Existing ODK Project" dialog with "Yes". The existing project was overwritten.
15	"Terminating all running Eclipse instances"	The running Eclipse instances are being terminated.
16	"All running Eclipse instances are terminated successfully. Proceeding with build"	The running Eclipse instances are terminated.
17	"Generating Simulink Model sources"	The Simulink Coder is generating source files.
18	"Creating the static library project <ProjectName> under <ProjectPath>"	The process requires another static library besides the ODK project.
19	"Building the static library project <ProjectName>"	The static library is being built.
20	"Importing the static library project <ProjectName>"	The static library is being imported.
21	"The project <ProjectName> is imported successfully."	The project was imported successfully.
101	"SCL file import started"	The SCL file import starts.
102	"Checking for compatible TIA Portal and Openness installations"	The compatibility of STEP 7 and Openness plugin is being checked.
103	"Opening / attaching to the TIA Portal project <TiaPortalProjectName>"	The STEP 7 instance used is being attached to the STEP 7 project.
104	"CPU <CpuName>: Searching for it in the TIA Portal project"	Searching for CPU(s) in the STEP 7 project.
105	"CPU <CpuName>: <SimulinkModel>_ODK.scl is being imported"	The SCL file is being imported.
106	"CPU <CpuName>: Blocks are being generated out of the imported SCL source"	Blocks are being generated from the SCL file.

Info no.	Alarm	Meaning
107	"CPU <CpuName>: CPU is being compiled"	You have selected the option "Compile the CPU after import". The CPU is being compiled.
108	"The TIA Portal project is being saved"	The STEP 7 project is being saved.
109	"SCL file import finished successfully"	The SCL file import was finished successfully.
110	"In order to manually import the SCL file: 1. In TIA Portal project tree, double click on '<CPUName> > External source files > Add new external file' 2. Select the SCL file in folder "outputs". 3. Right click on the added file '<ModelName>_ODK.scl' and select 'Generate blocks from source'	To import the SCL file manually, follow these steps: 1. In the project view in STEP 7, double-click "<CPUName> > External source files > Add new external file". 2. Select the SCL file in the "outputs" folder. 3. In the shortcut menu of the added "<ModelName>_ODK.scl" file, select the command "Create blocks from the source".
111	"In order to manually complete the SCL import process: 1. In TIA Portal project tree, right click on the added file '<ModelName>_ODK.scl' under '<CpuName> > External source files' and select 'Generate blocks from source'	To complete the SCL import manually, follow these steps: 1. In the project view in STEP 7, navigate to "<CPU name> > External source files". 2. In the shortcut menu of the added "<ModelName>_ODK.scl" file, select the command "Create blocks from the source".
121	"TIA Portal project download is started"	The download of the STEP 7 project begins.
122	"TIA Portal project download finished successfully"	The download of the STEP 7 project was successfully completed.
123	"Configuration of the user defined page is started""	The configuration of the customized page begins.
124	"Configuration of the user defined page is finished successfully""	The configuration of the customized page was successfully completed.
125	"Program block operations started"	The calculation of the program block begins.
126	"Program block operations finished successfully"	The calculation of the program block has been successfully completed.
201	"Generation of Web content for <ModelName> is started"	Process for generation of the Web content for the model starts.
202	"Checking preconditions for generation of Web content"	The requirements for generating the Web content are being checked.
203	"Clearing existing content"	Any existing content is being deleted.
204	"Getting internal signal info"	The information of the internal signals is being obtained.
205	"Getting workspace parameter info"	The information of the "Base workspace parameters" is being obtained.
206	"Getting model workspace parameter info"	The information of the "Model workspace parameters" is being obtained.
207	"Getting external input info"	The port information of the inputs is being obtained.
208	"Getting external output info"	The port information of the outputs is being obtained.
209	"Getting scope info"	The graph (scope) information is being obtained.
210	"Getting model hierarchy"	The model hierarchy is being obtained.
211	"Creating SVG files for model view"	The SVG files are being created.
212	"Generating JSON files for parameters"	The JSON file for the parameters is being created.

Info no.	Alarm	Meaning
213	"Generating JSON files for model"	The JSON file for the model is being created.
214	"Generating JSON files for internal signals"	The JSON file for the internal signals is being created.
215	"Generating JSON files for scopes"	The JSON file for the graphs (scopes) is being created.
216	"Generating files for Web application"	The files for the Web application are being created.
217	"Generation of Web content for <ModelName> completed successfully"	Process for generation of the Web content for the model was completed successfully.
301	"SO file transfer started"	The SO file import starts.
302	"Logging in to the CPU Web server over <IP-Address>"	Logging in to the CPU Web server.
303	"Deleting a possibly existing file on the server"	If a file already exists, it is deleted.
304	"Uploading the SO file to ODK1500S folder on <IP-Address>"	The SO file is being uploaded to the ODK 1500S folder.
305	"SO file transfer finished successfully"	The SO file import was finished successfully.
306	"SO file transfer finished with an error"	The process for import of the SO file was completed with an error.

H.3 Warnings

Warning no.	Alarm	Meaning
1	"Using 'External Mode' can cause serious damage to property or injury to persons if there are functional disturbances or program errors. Make sure that no dangerous situations can arise before you conduct a test with the 'External Mode' function."	If "External Mode" is enabled in the settings under "Code Generation", this alarm appears at the end of the build process.
2	"'Default parameter behavior' shall be set to 'Tunable' for STEP 7 access also tunable block parameters of the model. Otherwise STEP 7 access only to global tunable parameters will be possible."	You have activated the "Parameter access with STEP 7" option and selected "Inlined" under "Default parameter behavior". Set the selection to "Tunable".
3	"The syntax of the current MEX-file arguments is not correct. It might happen, that the External Mode cannot be established. The correct syntax: '<IPAddress>' <VerbosityLevel> <PortNumber> <WaitForStart> • IPAdress and PortNumber is related with your PLC. • Set VerbosityLevel to 1 for getting detailed information in diagnostic viewer. • If WaitForStart is set to 1, the application will wait for the Simulink start command Please check the SIMATIC Target 1500S documentation for further information."	The structure of the "MEX-file arguments" is incorrect. External mode may not run properly. The correct structure is: '<IPAddress>' <VerbosityLevel> <PortNumber> <WaitForStart> • The IP address and port number depends on your controller. • Set the VerbosityLevel to 1 to get detailed information in the Diagnostic Viewer. • If WaitforStart is set to 1, the application waits for the start command from Simulink.
4	Establishing external mode communication will not be possible since 'UpdateModelReferenceTargets' is set to 'Always' for the model <SimulinkModel>. Please change it to another option in order to be able to use external mode.	Communication for the external mode cannot be set up because the "UpdateModelReferenceTargets" setting for the <SimulinkModel> is set to "Always". Change this to another setting to use external mode.

Warning no.	Alarm	Meaning
5	Since multiple number of instances of <ChildModel> is allowed to be referenced, STEP 7 access to some internal signals of this model may not be possible because 'Model default' or 'Auto' storage class definition has been detected. For <ChildModel>, set 'Total number of instances allowed per top model' to 'One' or set storage class for internal signals to 'ExportedGlobal' or 'ImportedExtern' in order to access all internal signals.	Since multiple instances of the referenced model can be referenced, access from STEP 7 to some internal signals of this model may not be possible because the storage class "Model default" or "Auto" was selected. To access all internal signals, set "Total number of instances allowed per top model" to "One" for the referenced model or set the storage class for internal signals to "ExportedGlobal" or "ImportedExtern".
701	"The required dll for <OperationName> import does not exist in the bin folder. Please repair or uninstall/install Target 1500S setup."	The required DLL for the output operation does not exist in the directory "<TARGET_ROOT_DIR>\bin\tools". Repair or uninstall/install the Target 1500S.
703	"Empty or invalid field: <OptionName>"	You have installed no compatible Openness plugin. You can find the compatible Openness plugin at "Description of the TIA Portal integration options (Page 26)".
704	"The required functionality is not supported by the TIA Openness version."	An error has occurred while loading the Openness.dll.
705	"An error occurred during TIA Openness operation: <OperationName>"	An error occurred during the TIA Openness operation <OperationName>.
750	"Download provider is NULL"	The download provider is set to ZERO.
751	"Download configuration does not seem to be correct"	The configured download options do not correspond to the selectable options in the TIA Portal.
752	"PCStation download has just failed"	Error downloading the HW Config (PC station download)
753	"CPU download has just failed"	Error downloading to the CPU.
799	"Unknown error"	An unknown error occurred during a TIA Portal Openness operation.
801	"Error while extracting internal signal info"	Error while extracting the information of the internal signals.
802	"Error while extracting workspace parameter info"	Error while extracting the information of the "Base workspace parameters".
803	"Error while extracting model workspace parameter info"	Error while extracting the information of the "Model workspace parameters".
804	"Error while extracting external input info"	Error while obtaining the port information of the inputs.
805	"Error while extracting external output info"	Error while obtaining the port information of the outputs.
806	"Error while extracting scope info"	Error while obtaining the graph (scope) information.
807	"Error while extracting model hierarchy"	Error referencing the model hierarchy.
808	"Error while creating SVG file <SvgFileName>"	Error while creating the SVG file.
809	"Error while modifying SVG file <SvgFileName>"	Error while modifying the SVG file.
810	"Error while extracting field <FieldName> from model data structure."	A data field required for creating the SVG file could not be read.
811	"Error while generating JSON files for parameters"	Error while creating the JSON file for the parameters.
812	"Error while generating JSON files for model"	Error while creating the JSON file for the model.

Warning no.	Alarm	Meaning
813	"Error while generating JSON files for internal signals"	Error while creating the JSON file for the internal signals.
814	"Error while generating JSON files for scopes"	Error while creating the JSON file for the graph (scope).
815	"The file <FileName> could not be opened"	Unable to open a temporary file.
899	"Unknown error"	An unknown error occurred during Web file generation.
901	“Error while renaming the file or directory - Memory Card is write-protected”	Error while renaming the file or the directory. The memory card is write-protected.
902	“Error while renaming the file or directory - name already exists”	Error while renaming the file or the directory. The name has already been assigned.
903	“Error while renaming the file or directory - Memory Card is full”	Error while renaming the file or the directory. The memory card is full.
904	“Error while creating the directory”	Error while creating the directory.
905	“Error while creating the directory - Memory Card is write-protected”	Error while creating the directory. The memory card is write-protected.
906	“Error while creating the directory - name already exists”	Error while creating the directory. The name has already been assigned.
907	“Error while creating the directory - Memory Card is full”	Error while creating the directory. The memory card is full.
908	“Error while uploading the file”	Error while uploading the file.
909	“Error while uploading the file - name already exists”	Error while uploading the file. The memory card is write-protected.
910	“Error while uploading the file - Memory Card is write-protected”	Error while uploading the file. The name has already been assigned.
951	“IP address is empty. Please provide IP address of the CPU to transfer the SO file”	No IP address assigned. Enter the IP address of the CPU.
952	“IP address is not in correct format”	Enter the IP address in the correct format.
953	“Connection Error”	The host is not reachable.
954	“Invalid login information”	Login has failed.
955	"Error while uploading the file - file too big"	Error while uploading the SO file. The SO file must not be larger than 2147483648 bytes.
956	"Allowed characters are a-z A-Z 0-9 ._- (){}[]$!=~ (space)"	An invalid character was used for the name of the SO file.
957	“The file could not be found”	The SO file was not found.
958	“IO Exception”	An error occurred while reading the content for opening the SO file.
959	“Unauthorized Access”	An authorization error occurred while accessing the SO file.
960	"File write protected"	File is read-only
961	"An error occurred while uploading the so file: <ErrorString>"	Error uploading the SO file
999	“Unknown error”	Unknown error
1000	Building model with Target 1500S trial mode: <RemainingDaysInTrialPeriod> day(s) left	The model was created with the Target 1500S test version.

H.4 Error messages

Error no.	Alarm	Meaning
1	Depending on the error, the corresponding error message is displayed.	Appears in case of Simulink Coder errors.
10	"Eclipse workspace is locked. Please close any Eclipse instance(s) that might have locked ODK 1500S default workspace."	Close all affected Eclipse instances with a standard ODK Workspace, which is also used by Target 1500S.
600	"ODK 1500S Code Generator gives the following error for <SimulinkModel>_ODK project: <Error text of the ODK Code Generator> Please refer to ODK 1500S documentation (https://support.industry.siemens.com/cs/ww/en/view/109752683) or contact customer support!"	If the code generator of ODK detects an error during the build process, this alarm appears. You can find additional information in the ODK manual (https://support.industry.siemens.com/cs/ww/en/view/109752683) or by contacting Customer Support.
30	**For MATLAB versions older than R2016b:** "Only 'SingleTasking' is allowed as tasking mode for Target 1500S <Version>. Please choose 'SingleTasking' in the solver options menu in order to proceed with build." **For MATLAB version R2016b or higher:** "Only 'SingleTasking' is allowed as tasking mode for Target 1500S <Version>. Please uncheck the option 'Treat each discrete rate as a separate task' under the solver options in order to proceed with build."	Disable the option "Treat each discrete rate as a separate task" in the properties of the code generator under "Solver".
31	"'ImportedExternPointer' is not allowed as Storage Class for tunable parameters for Target 1500S <Version>. Please change Storage Class of <ParameterName> to other than 'ImportedExternPointer' in order to proceed with build."	Select a different memory class than "ImportedExternPointer".
20	"No compatible ODK 1500S version is installed. Please first install a compatible version and restart MATLAB in order to proceed with build. A list of compatible ODK 1500S versions can be found in the Target 1500S documentation."	No compatible ODK version available. Install a compatible ODK 1500S version (Page 14) and restart MATLAB.
22	"The selected ODK 1500S version doesn't work properly. The reason could be installation of the selected ODK 1500S version failed due to some reason. ODK 1500S <OdkVersion> documentation describes, how to check the functionality of the ODK 1500S installation."	The selected ODK version is not working properly. The reason can be the installation of the selected ODK version failed. You can find information on checking the functionality in the ODK manual (https://support.industry.siemens.com/cs/ww/en/view/109752683).
519	"Size of input and output parameters of <SimulinkModel> reaches to the limits of ODK 1500S. Please reconsider your model and try to reduce the size of your parameters in order to proceed with build."	The maximum ODK data volume is exceeded. Check the model and reduce the parameter size.
520	"A parameter which exceeds limits of ODK 1500S maximum array size is defined in <SimulinkModel>. Please reconsider your model and try to reduce the size of array which exceeds ODK 1500S limits in order to proceed with build."	The maximum array size is exceeded. Check the model and reduce the array size.

Error no.	Alarm	Meaning
515	"<SimulinkModel> causes to exceed limits of ODK 1500S naming rules for generated functions or structs. Please perform one of the following actions in order to proceed with build: 1- Set 'Maximum identifier length' in symbols options to a smaller value. 2- Set <SimulinkModel> to a shorter name."	Prefix and function name are too long. Reduce the value of "maximum identifier length" in the properties of the code generator under "Symbols" or shorten the name of the Simulink model.
516	"<Variable> name exceeds the limits of ODK 1500S maximum variable name size. Please perform one of the following actions in order to proceed with build: 1- Set 'Maximum identifier length' in symbols option to a smaller value. 2- Set <Variable> to a shorter name."	The tag name is too long. Decrease the value of "maximum identifier length" in the properties of the code generator under "Symbols" or shorten the name of the tag.
32	"Because of the length of <SimulinkModel> name and path of your model, some generated files reach to the path limits of Windows. Please perform one of the following actions in order to proceed with build: 1- Set your <SimulinkModel> name to a shorter string. 2- Move your <SimulinkModel> to a shorter path."	The maximum Windows path length has been exceeded. Shorten the name of the Simulink model or move your Simulink model to a shorter path.
11	"A project with same name as <SimulinkModel>_ODK exists in ODK 1500S default workspace. In order to proceed, either change the name of the existing project or remove/rename it from workspace manually."	The ODK workspace already contains an ODK project with the same name. Change the name of the Simulink model or delete/rename the existing project manually.
12	"An error occurred during removing <SimulinkModel>_ODK project from default workspace of ODK 1500S. Please either change name of your <SimulinkModel> or remove/rename the project from workspace manually"	Removal of the ODK project from the workspace was unsuccessful. Change the name of the Simulink model or delete/rename the project manually from the work-space.
40	"Build of <SimulinkModel>_ODK is failed due to the following error(s): <Error text coming from gcc compiler with the complete line and multiple errors> Please enable 'Verbose' mode in Code Generation Options to see the stack trace and contact customer support!"	Generation of the ODK project was unsuccessful due to a compiler error. Enable "Verbose" mode in the properties of the code generator to see the stack trace and contact Customer Support.
33	"'Device vendor' can be only selected as 'Intel' and 'Device type' can be only selected as 'x86-32 (Windows32)' in hardware implementation options. Please select the proper values in order to proceed with build."	Select "x86-32 (Windows32)" in the properties under "Device type".
34	"The maximum data size for external mode is 64k. The current used data (<sizeOfData>) exceeds this limit. Please reconsider your model and try to reduce the size of the parameters."	The maximum data size for external mode is 64k. The data currently used exceeds this limit. Revise your model and reduce the size of the parameters.

Error no.	Alarm	Meaning
23	"An incompatible version of Java Runtime Environment (JRE) could be installed. Please prove, if the installed Java Runtime Environment (JRE) and its architecture (x86, x64) is compatible with the selected ODK 1500S Version. ODK 1500S <ODK Version> documentation describes, how to check the functionality of the ODK 1500S installation."	No compatible JRE is installed on the PC. You can find information on checking the functionality in the ODK manual (https://support.industry.siemens.com/cs/ww/en/view/109752683).
14	"An error occurred while creating the shared object file"	The SO file could not be created.
1000	License key missing	The Target 1500S license was not transferred and the test version has expired.
1001	Retrieving license key not possible	ALM is not installed, cannot be reached or unknown error occurred during the license check.

SIEMENS

SIMATIC

S7-PLCSIM Advanced

Function Manual

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Introduction 1

1.1 General information

Purpose of the documentation

This function manual describes the simulation software, SIMATIC S7-PLCSIM Advanced. You can use this software to simulate and test your SIMATIC STEP 7 programs on a simulated PLC instance. You can also use an API to connect the simulated PLC instance to a system or machine simulation (co-simulation).

Basic knowledge required

The software must only be used by qualified staff.
The following knowledge is required:

- Industrial Automation and Automation Technology
- Programming with STEP 7 (TIA Portal)
- SIMATIC CPUs and CPU programming
- PC-based automation using S7-1500 and WinCC Runtime Advanced
- Knowledge of programming with C++ or C#
- PC technology
- Windows operating system

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "SIMATIC STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Scope

This function manual is valid for the following product variants:

Article number	Product variants
6ES7823-1FA06-0YA5	SIMATIC S7-PLCSIM Advanced V8.0
6ES7823-1FE06-0YA5	SIMATIC S7-PLCSIM Advanced V8.0 Download
6ES7823-1FA06-0YE5	SIMATIC S7-PLCSIM Advanced V8.0 Upgrade V1.0 -> V8.0
6ES7823-1FE06-0YE5	SIMATIC S7-PLCSIM Advanced V8.0 Upgrade V1.0 -> V8.0 Download
6ES7823-1FE06-0YA7	SIMATIC S7-PLCSIM Advanced V8.0 POC
6ES7823-1FE00-0YN5	SIMATIC S7-PLCSIM Advanced Subscription Download

The articles each contain one license, which is valid for two instances.

NOTE

You can obtain online readme updates to the S7-PLCSIM Advanced manuals on the Internet (https://support.industry.siemens.com/cs/us/en/view/109824282). Use the Edition dropdown list to select the correct product version.

You can find the following application examples for S7-PLCSIM Advanced on the Internet:

- SIMATIC S7-PLCSIM Advanced: Co-Simulation via API (https://support.industry.siemens.com/cs/ww/de/view/109739660/en)
- Digitalization with TIA Portal: Virtual commissioning with SIMATIC and Simulink (https://support.industry.siemens.com/cs/ww/en/document/109749187)

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal service and dispose of the equipment according to the applicable regulations in your country.

Industry Mall

The Industry Mall (https://mall.industry.siemens.com) is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

1.2 S7-PLCSIM Advanced documentation guide

The control panel buttons display the English S7-PLCSIM Advanced Function Manual and API Manual in PDF format. Download the free Adobe Reader if necessary to view PDFs. The installation folder of S7-PLCSIM Advanced includes German PDFs and English PDFs.

Other display formats are available at Siemens Industry Online Support (//https://support.industry.siemens.com/) (SIOS).

Accessing documentation on SIOS

Documentation for this product is available at Siemens Industry Online Support (//https://support.industry.siemens.com/). Formats include the following for display or download:

- PDF document
- Multimedia document (HTML5 Web site)
- Website with chapter structure (useful for providing a specific topic link to other people)

From the Web site, search for your product name. Filter the search results by manuals if you are only looking for documentation. For your product, select the edition that corresponds to the version of your product. You can switch the display language for the page and the documents from the menu.

The various document formats provide navigation and search features based on their documentation format.

Navigating an HTML5 site

When you open an HTML5 Web site, click Begin from the Start page.

The table of contents displays on the left. Each chapter collapses as you navigate from one chapter to the next to optimize screen space on devices such as phones and tablets. You can also click the button to hide the table of contents. Click to restore it.

Left and right arrow buttons allow to navigate back and forward through topics that you have previously viewed:

Previous and next page buttons allow you to navigate sequentially through topics and chapters in the order of the table of contents:

Searching in an HTML5 site

To search an HTML5 Web site, click the button on the right. When you enter your search text, you see a list of topics that contain the search text. Click any topic to view it. The page highlights occurrences of the matched search text.

To see where the topic exists in the table of contents, click the button to switch from the search view to the table of contents view. To switch back to your search, click again. The search functions much the same as any search from a Web browser. Ctrl+F searches within the displayed topic.

Changing the language of the HTML5 site

The S7-PLCSIM Advanced HTML5 documentation includes German and English. Click the button to switch to another language.

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.3 Tool support

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/us/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.4 Administrator rights

NOTE

Administrator rights

For normal operation, the standard user rights are sufficient. You need administrator rights only when you install or repair S7-PLCSIM Advanced or change the network configuration.

Industrial cybersecurity 2

2.1 Introduction

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the relevant system manual of the devices used for general information and measures regarding industrial cybersecurity.

2.1.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

2.2 Basic information on industrial cybersecurity

2.2.1 Definition of industrial cybersecurity

Industrial cybersecurity is generally understood to mean all measures to protect against the following threats:

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability (for example, due to the destruction of data or denial of service (DoS))

2.2.2 Objectives of industrial cybersecurity

The objectives of industrial cybersecurity are:

- Ensuring trouble-free operation of industrial plants and production processes
- Preventing threats to people and production from cybersecurity attacks
- Protection of industrial plants against espionage and manipulation
- Protection of industrial automation systems and components against unauthorized access and data loss
- Provision of a practical and cost-effective concept for securing existing plants and devices that do not have their own security functions
- Use of existing, open, and proven industrial cybersecurity standards
- Compliance with legal requirements

An optimized and adapted security concept applies to automation and drive technology. The security measures must not impede or endanger production.

2.3 Operational application environment and security assumptions

2.3.1 Intended use

SIMATIC products are intended for use in industry. If you plan to use the product in a different environment, check the conditions required for such use.

The product may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety information. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products.

2.3.2 Requirements for the operational application environment and security assumptions

Siemens recommends the following security measures:

- Threat and Risk Assessments (as part of security management)
- Network security concepts
  - Network segmentation
  - Asset and network management
  - Network protection
  - Remote access
- Access control concepts (utilizing access control systems)
  - Physical protection
  - Physical corporate security
  - Physical product security

Threat and Risk Assessment

Vulnerabilities and risks are identified, and countermeasures are proposed to ensure the security of the system, networks, and data.

Network security concepts

You can find information on network security in the whitepaper "Industrial Network Security Architecture", available at the Download Center (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security/downloads.html) on the Industrial Cybersecurity (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html) website.

Access control concepts

Physical protection

In addition to closing off and/or monitoring entire production facilities, it may be necessary to physically secure cabinets or even individual components such as circuit breakers.

Physical corporate security

You can ensure physical corporate security by the following measures, among others:

- Closed off and monitored company premises
- Access control, locks/card readers, and/or security personnel
- Accompaniment of non-employees by company personnel
- Employees are trained on and embrace security processes within the company

Physical production security

You can ensure the physical production security by, among others, the following measures:

- Separate access control for critical areas, such as production zones.
- Installation of critical components in lockable cabinets/control rooms with monitoring and alarm capabilities. The cabinets/control rooms must be secured with a cylinder lock. Do not use simple locks, such as universal, triangular/square, or double-bit locks.
- Radio field planning to limit WLAN coverage areas, preventing them from extending beyond defined zones (e.g. factory floor).
- Guidelines that prohibit the use of external data storage media (such as USB flash drives) and IT devices (such as laptops) classified as unsafe on systems.

2.4 Secure operation

This section describes measures that Siemens recommends to protect against manipulation and unauthorized access.

Guidelines

Observe the following guidelines for secure operation:

- Use only the original version as provided on the Internet and follow the Installation notes.
- Check regularly whether there are new versions available for download and use the latest version.

Dependencies on other software components

Verify that your computer meets the System requirements.

2.4.1 Security update notification

Read the special information on maintaining the operational safety of your plant in the Introduction (Page 14) section.

Set up notification of security updates

To receive notifications about security updates, proceed as follows:

1. Register with mySiePortal (https://sieportal.siemens.com/en-ww/mysieportal).
2. Enter the keyword "Security" in the search engine.
3. Choose the "Search in Knowledge base" option.
4. Enter the name or article number of the product in the product search.
5. Select the "Other types" option from the filter menu for "Type," and then choose "Download" and "Product note".

6. For the document you want to be informed about, select "Add to my favorites" using the 3 dots on the right.

   For example, if you want to receive notifications about all firmware versions of the S7-1500 CPUs, select the entry "Firmware update S7-1500 CPUs incl. Displays and ET 200 CPUs (ET 200SP, ET 200pro)".

7. In the following dialog, enter a name for the favorite, select the storage location and select the "Notify me" option. Then click the "+ Add to my favorites" button.

Result: You will be notified by email each time the document is changed.

Under "mySiePortal" > "Lists & notifications" > "My notifications", you can display your notifications and delete them if necessary.

2.4.2 Hardening measures

System hardening, also simply referred to as hardening, is the secure configuration of products or systems. The aim is to close security gaps and take various measures to reduce the attack surfaces for cyberattacks.

Measures for system hardening include, for example:

- Secure configuration in which only necessary software components and services are installed or activated for proper operation.
- Access control, by which a restrictive user and rights management system is implemented.

2.4.3 Access control

In addition to physical protection, also establish logical safeguards to control access to your system:

- Use a restrictive user and rights management system, for example, for accessing the CPUs and TIA Portal.
- Refer to the information about password management in the section Users and roles (https://docs.tia.siemens.cloud/access?ft:originId=./100365717643/100365717643_enUS.htm&ft:clusterId./100365717643/100365717643.htm) and in the STEP 7 online help (TIA Portal).

2.4.4 Notifications about security vulnerabilities (Siemens Security Advisories)

A vulnerability is a security vulnerability in information security. A vulnerability can pose a threat as it provides intruders with the opportunity to access system resources and manipulate or steal data. Many vulnerabilities allow availability to be impaired.

Siemens ProductCERT

If Siemens identifies or fixes Security Vulnerabilities in the products, this will be published in the Security Advisories.

You can find the documents for SIMATIC on the following website of the Siemens Aktiengesellschaft: Siemens ProductCERT and Siemens CERT (https://new.siemens.com/global/en/products/services/cert.html?s=SIMATIC#SecurityPublications)

"Search Security Advisories" is the default entry in the "SIMATIC" search field. You can also enter other product names or other terms in the search field and search for them.

On this page, you will also find all the required information on how to deal with vulnerabilities:

- Contact persons for matters related to vulnerabilities
- Options for automated notifications regarding vulnerabilities
- Notifications are also possible in CSAF format
- Option to subscribe to RSS feeds and newsletters
- List of all current vulnerabilities and detailed information such as:
  - Description
  - Classification according to Common Vulnerability Scoring System (CVSS)
  - Measures
  - Availability
  - Etc.

Set up Security feeds (https://www.siemens.com/cert) to receive notifications about security-related topics.

If you suspect or have discovered a vulnerability in a Siemens product, please let us know immediately. To do this, press the "Contact" button on the CERT Services page (https://www.siemens.com/cert) and follow the instructions.

2.4.5 Data backup

Secure your configuration and parameter settings so that you can quickly restore this data if needed.

2.4.6 Secure uninstallation

Use the Windows control panel to uninstall the product and follow the dialog prompts.

Product overview 3

3.1 What is S7-PLCSIM Advanced?

You use S7-PLCSIM Advanced to simulate your CPU programs on a simulated PLC instance. You do not need any real controllers for simulation. You configure your CPU with STEP 7 in TIA Portal, program your application logic and then load the hardware configuration and the program into the simulated CPU. From STEP 7, you run your program logic, monitor the effects of simulated inputs and outputs, and adapt your programs.

In addition to communication via Softbus, which limits communication to a local PC or virtual machine, S7-PLCSIM Advanced offers a full Ethernet connection and thus also supports distributed I/O systems.

S7-PLCSIM Advanced also includes an application programming interface (API), which enables interaction with native C++/C# programs or simulation software. The API extends simulation capabilities and provides features such as the following:

- Simulation of hardware interrupts
- Stopping a simulation
- Synchronization with simulation partners

For these and other API functions, refer to the S7-PLCSIM Advanced API manual included with your release.

Application areas

Typical application areas of S7-PLCSIM Advanced are:

- Verification of the user program (TIA Portal)
- Testing of the STEP 7 program
- Software in the loop simulation for the virtual commissioning of machine tools/production machines, production cells, and production lines in a plant.
- Operator training through the connection of a real HMI

Advantages

S7-PLCSIM Advanced offers numerous advantages:

- Improve the quality of automation projects by early error detection
- Avoid costs for hardware in simulation environments
- Shorten commissioning time
- Reduce risk for commissioning
- Train operators earlier
- Increase production efficiency by optimizing program components

- Increase efficiency during replacement of machine components
- Increase efficiency during expansion of existing plants

3.2 S7-PLCSIM products

Comparison of S7-PLCSIM simulation software products

Function	S7-PLCSIM Advanced	S7-PLCSIM Vxx	S7-PLCSIM V5.x
User interface	S7-PLCSIM Advanced Control Panel	S7-PLCSIM UI	Look&Feel of STEP 7 V5.x
Communication	Softbus [4], TCP/IP	Softbus [4], TCP/IP[5]	Softbus [4]
Supported CPU families	Supported CPUs (Page 22)	S7-1200 S7-1200 (F), S7-1500 (C, T, F), 1500R/H, SIMATIC Drive Controller, ET 200SP, ET 200SP F, SIPLUS CPUs (S7-1500; Standard and F-CPUs, S7-1500R/H and ET 200SP; Standard and F-CPUs) Software/Open Controller	S7-300, S7-300F, S7-400, S7-400F
API for co-simulation[1]	✓	-	✓
Web server	✓ via TCP/IP	-	-
ODK	✓	-	-
OPC UA	✓ via TCP/IP	-	-
Process diagnostics	✓	✓	-
S7 communication	✓	Using Softbus	Using Softbus
Open user communication	✓ UDP via TCP/IP	Using Softbus	-
Secure Communication	✓ via TCP/IP	-	-
Traces[2]	✓ Limit of 8	-	-
Motion	✓	✓[3]	-
Protected blocks (KHP)	✓	✓ for S7-1500 CPUs only	-
Parallel running Instances per computer	Up to 16	Up to 2	Up to 8
Support of distributed instances	✓ via TCP/IP	-	-
Virtual time	✓	-	-

1 Via C++ and C# programs and simulation software

2 Can be monitored with S7-PLCSIM V16 and higher in the TIA Portal; can also be monitored with S7-PLCSIM Advanced V3.0 and higher on the Web server.

3 With S7-PLCSIM V16 and higher, the axes are always in simulation mode irrespective of the axis configuration.
With S7-PLCSIM Advanced V3.0 and higher, the axes can also be operated in "Real" mode over the API.

4 You can find more information on Softbus (online access PLCSIM) in the "Communication" section.

5 S7-PLCSIM supports TCP/IP only for Advanced instances.

Function	S7-PLCSIM Advanced	S7-PLCSIM Vxx	S7-PLCSIM V5.x
Connection of real CPUs/HMIs	✓ via TCP/IP	-	✓
DHCP/DNS use	✓ via TCP/IP	-	-
Virtual memory card	✓	-	-
Communication between the instances	-	S7-PLCSIM as of V12 and S7-PLCSIM V5.x can be installed and operated on the same PC or the same virtual machine.	
	-	Instances of S7-PLCSIM as of V12 can communicate via Softbus with S7-PLCSIM V5.x.	
	S7-PLCSIM Advanced V3.0 and higher and S7-PLCSIM V15 and higher can be installed and operated on the same PC or the same virtual machine. The communication between the two applications **cannot** be simulated.		-
	Instances of S7-PLCSIM Advanced can communicate via Softbus with S7-PLCSIM ≥ V5.4 SP8.		

1 Via C++ and C# programs and simulation software

2 Can be monitored with S7-PLCSIM V16 and higher in the TIA Portal; can also be monitored with S7-PLCSIM Advanced V3.0 and higher on the Web server.

3 With S7-PLCSIM V16 and higher, the axes are always in simulation mode irrespective of the axis configuration.
With S7-PLCSIM Advanced V3.0 and higher, the axes can also be operated in "Real" mode over the API.

4 You can find more information on Softbus (online access PLCSIM) in the "Communication" section.

5 S7-PLCSIM supports TCP/IP only for Advanced instances.

3.3 Supported CPUs

S7-PLCSIM Advanced supports the simulation of the following CPUs:

Type	Firmware version V1.8 to V4.1	
	Standard	**Fail-safe**
CPUs[1]	CPU 1511-1 PN CPU 1513-1 PN CPU 1515-2 PN CPU 1516-3 PN/DP CPU 1517-3 PN/DP CPU 1517-3 PN CPU 1518-4 PN/DP CPU 1518-4 PN/DP ODK CPU 1518-4 PN/DP MFP	CPU 1511F-1 PN CPU 1513F-1 PN CPU 1515F-2 PN CPU 1516F-3 PN/DP CPU 1517F-3 PN/DP CPU 1517F-3 PN CPU 1518F-3 PN CPU 1518F-4 PN/DP CPU 1518F-4 PN/DP ODK CPU 1518F-4 PN/DP MFP
Compact CPUs[2]	CPU 1511C-1 PN CPU 1512C-1 PN	-

[1] SIPLUS and SIPLUS RAIL CPUs are supported. They are of the same design as the standard and fail-safe CPUs listed here but have their own article numbers.

[2] The on-board I/O of the CPUs is not simulated. The simulation interface corresponds to the process image. For the R/H CPUs, S7-PLCSIM Advanced supports firmware version 2.9 and higher.

[3] Versions 30.0, 30.1, 31.1, 40.0 (except T/TF), and 40.1. S7-PLCSIM Advanced simulates only the controller's CPU functionality for Software/Open Controller versions. It does not simulate the underlying PC platform or its station configuration. You must set the IP address of the network interface on the simulated PLC to match the STEP 7 project. If you change the firmware version in the STEP 7 project, you must delete the simulated PLC instance at the former version and simulate a new PLC instance for the changed version. You can then download from the TIA Portal to the new instance.

Type	Firmware version V1.8 to V4.1	
	Standard	**Fail-safe**
ET 200SP CPUs[1]	CPU 1510SP-1 PN CPU 1512SP-1 PN CPU 1514SP-2 PN CPU 1514SP T-2 PN	CPU 1510SP F-1 PN CPU 1512SP F-1 PN CPU 1514SP F-2 PN CPU 1514SP TF-2 PN
Technology CPUs	CPU 1511T-1 PN CPU 1515T-2 PN CPU 1516T-3 PN/DP CPU 1516T-3 PN CPU 1517T-3 PN/DP CPU 1517T-3 PN CPU 1518T-3 PN CPU 1518T-4 PN/DP	CPU 1511TF-1 PN CPU 1515TF-2 PN CPU 1516TF-3 PN/DP CPU 1516TF-3 PN CPU 1517TF-3 PN/DP CPU 1517TF-3 PN CPU 1518TF-3 PN CPU 1518TF-4 PN/DP
R/H-CPUs [1, 2]	CPU 1513R-1 PN CPU 1515R-2 PN CPU 1517H-3 PN CPU 1517H-4 PN	CPU 1518HF-4 PN
ET 200pro CPUs	CPU 1513pro-2 PN CPU 1516pro-2 PN	CPU 1513pro F-2 PN CPU 1516pro F-2 PN
SIMATIC Drive Controller		CPU 1504D TF CPU 1507D TF
S7-1500 Software/Open Controller[3]	CPU 1505SP CPU 1505SP T CPU 1507S CPU 1508S CPU 1508S T	CPU 1505SP F CPU 1505SP TF CPU 1507S F CPU 1508S F CPU 1508S TF
S7-1200 G2 CPUs	CPU 1212C CPU 1214C CPU 1216 CPU 1217	CPU 1212FC CPU 1214FC

[1] SIPLUS and SIPLUS RAIL CPUs are supported. They are of the same design as the standard and fail-safe CPUs listed here but have their own article numbers.

[2] The on-board I/O of the CPUs is not simulated. The simulation interface corresponds to the process image. For the R/H CPUs, S7-PLCSIM Advanced supports firmware version 2.9 and higher.

[3] Versions 30.0, 30.1, 31.1, 40.0 (except T/TF), and 40.1. S7-PLCSIM Advanced simulates only the controller's CPU functionality for Software/Open Controller versions. It does not simulate the underlying PC platform or its station configuration. You must set the IP address of the network interface on the simulated PLC to match the STEP 7 project. If you change the firmware version in the STEP 7 project, you must delete the simulated PLC instance at the former version and simulate a new PLC instance for the changed version. You can then download from the TIA Portal to the new instance.

Unsupported CPUs

S7-PLCSIM Advanced does not simulate S7-1200 CPUs and CPU 151xV(F).

To simulate CPUs of the S7-1200 product family, use the latest edition of S7-PLCSIM (https://support.industry.siemens.com/cs/ww/en/view/109826203).

If you download a TIA Portal project whose configuration includes an unsupported CPU, the following error message appears:

"Loading of hardware configuration failed (0020 -3 2 0). Please check the diagnostic buffer of the target hardware."

3.4 Compatibility in case of updates

When you install S7-PLCSIM Advanced, you update any earlier version to the current version.

Compatibility with TIA Portal and with CPU firmware versions

A simulated PLC instance in S7-PLCSIM Advanced corresponds to that of a CPU S7-15xx V4.0.

NOTE

Password encryption in case of updates

When a TIA Portal project is updated from CPU firmware version < V2.0 to CPU firmware version ≥ V2.0, the following error message is displayed during a download of the project to SIMATIC S7-PLCSIM Advanced:

"Loading of hardware configuration failed (0020 -3 2 0). Please check the diagnostic buffer of the target hardware."

To successfully download such a project to SIMATIC S7-PLCSIM Advanced, click the "Update password encryption" button while updating the project.

3.5 Security for S7-PLCSIM Advanced

Restrictions for security

S7-PLCSIM Advanced does not provide options for authentication and authorization. Communication is not protected by authentication.

Communication

- A TCP/IP port is opened on the PC for cross-network communication.
- The installed Npcap program library provides access to TCP/IP network communication.

NOTE

For cross-computer communication, use a closed simulation network that is not connected to a production network.

Know-how protection

NOTE
Know-how protected blocks
If know-how-protected blocks for the simulation support are enabled, the know-how protection is limited.

NOTE
CPU function libraries for ODK
The SO files (shared object files) for ODK are not know-how-protected. The customer is responsible for the SO files and its know-how protection.

3.6 Supporting simulation

Requirement for simulation

NOTE
Enable simulation capability
To use a STEP 7 project with simulation, you must select the "Support simulation during block compilation" option in the "Protection" tab in the properties of the project and confirm with OK.

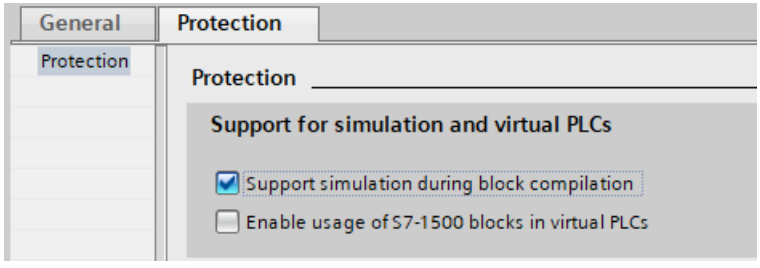

Know-how protection

If a know-how-protected block is to be used for the simulation, it must be unlocked by entering a password.

After you have unlocked the know-how-protected block, you can activate the option "Can be simulated with SIMATIC S7-PLCSIM". You will find the option in the properties of the block in the "General > Compilation" tab.

Additional information can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109754928).

Global libraries

You cannot use know-how protection with global libraries, because the libraries are write-protected.

The "Can be simulated with SIMATIC S7-PLCSIM" option must be set when generating the blocks (source of the blocks).

3.7 Differences between a simulated and a real CPU

A simulated PLC instance cannot fully simulate a real CPU down to the individual details. Even if a program is downloaded (Page 58) without errors to the simulated CPU and running successfully, this does not necessarily mean that the simulated CPU behaves exactly like a real CPU.

Deterministic

S7-PLCSIM Advanced runs on a PC with the Windows operating system. The scan cycle time and the exact time of actions in S7-PLCSIM Advanced are not the same as when these actions run on physical hardware. This is because several programs share the processing resources on your PC.

To provide the best possible deterministic behavior under these conditions, S7-PLCSIM Advanced requires one free Core (CPU core) per instance. Information on the minimum requirements for the computer hardware or a virtual machine can be found in the section System Requirements (Page 31).

If your program depends heavily on the time required to execute actions, then make sure that you do not evaluate your program based only on the results of the simulation time.

Know-how protection

Projects with know-how protection for blocks can only be simulated if they are enabled for simulation. You need the block password for this purpose.

Instructions

Instructions are simulated with a few exceptions, see Restrictions for instructions (Page 84).

Programs that are based on the instructions behave differently than real CPUs in the simulation.

S7-1500R/H

For communication with other devices, you can configure system IP addresses in STEP 7 for a redundant S7-1500R/H system.

3.7.1 Restrictions for all supported CPUs

Fieldbus systems

S7-PLCSIM Advanced does not simulate fieldbus systems (PROFINET IO, PROFIBUS DP).

Intelligent I/O devices (I-devices)

S7-PLCSIM Advanced does not simulate I-Device functionality.

I/O

S7-PLCSIM Advanced simulates the real CPU, but not configured I/O modules and the on-board I/O of the compact CPUs.

Removal and insertion

In contrast to real systems, S7-PLCSIM Advanced allows the removal and insertion of head modules in distributed I/O systems.

Communications modules and communications processors

S7-PLCSIM Advanced does not support CMs and CPs and the related features such as "Access to PLC via communications module".

Diagnostics / diagnostic alarms

The S7-PLCSIM Advanced control panel does not enable simulation of diagnostic buffer entries.

Online and diagnostic functions

Certain online and diagnostic functions are not supported. For example, the "Firmware update" function.

Traces

S7-PLCSIM Advanced allows up to eight traces for any PLC type.

Copy protection

S7-PLCSIM Advanced does not simulate copy protection.

Limited support

S7-PLCSIM Advanced simulates some functions to a limited extent. You can find an overview in the section Restrictions, messages, and solution (Page 81).

3.7.2 Notes

Password applied during CPU swap

Depending on the firmware version of the CPUs affected (the CPU to be replaced and the replacement CPU), you are either offered an update to the latest algorithm or prompted to assign a new password because the replacement CPU cannot use the existing password configuration.

If the CPU to be replaced and the replacement CPU are identical in terms of the algorithm used, no action is required: the password configuration and the other parameter settings are transferred.

S7-PLCSIM Advanced does not support any password encryption for CPU versions with firmware less than V2.0.

In order to use protection levels, the Web server and the access protection of the F-CPU in the simulation, click on the "Update password encryption" button. The button is located in the CPU properties in the "Protection & Security" tab under "Access level".

HMI devices and CPU protection levels

- S7-PLCSIM Advanced supports SIMATIC HMI devices as of version 14. Connections to SIMATIC HMI devices prior to V14 are not supported.
- S7-PLCSIM Advanced supports protection levels if the virtual S7-1500 controller is configured with a firmware version V2.0 or higher.
- It is possible to connect SIMATIC HMI devices as of V14 to virtual S7-1500 controllers that are configured with a firmware version V2.0 or higher, with or without protection levels.
- It is possible to connect SIMATIC HMI devices as of V14 to virtual S7-1500 controllers which are configured with a firmware version lower than V2.0 without protection levels.

Solution

To establish a connection to the SIMATIC HMI device V13 or earlier, you must update this SIMATIC HMI device to version V14.

To establish a connection from the simulated PLC instance that is configured with a CPU firmware version lower than V2.0 to the SIMATIC HMI device, you must remove existing protection levels from the project.

Safety system versions

To successfully simulate and test a project with fail-safe input and output modules, you need to use safety system version V1.6, V2.0, V2.1, V2.2, V2.3, V2.4, V2.5, or V2.6. Simulation of the fail-safe input and output modules does not work correctly with an older version.

Technology module TM Count - Error message of instruction High_Speed_Counter

When you are using S7-PLCSIM Advanced for the simulation of a high-speed counter in a TM Count technology module, the instruction High_Speed_Counter signals an error 16#80C7.

The instruction High_Speed_Counter expects that the module has set a bit for "Status ready" (STS_READY). Because S7-PLCSIM Advanced does not simulate the module behavior, the instruction signals an error.

The STS_READY bit is located in the input area of the module at offset 13.4. When the input area of your TM Count module starts at %I32, for example, the STS_READY bit is located at %I45.4.

To prevent this error message of the High_Speed_Counter instruction, set the STS_READY bit accordingly.

3.8 Password to protect confidential configuration data

As of STEP 7 V17, you have the option of assigning a password to protect confidential configuration data of the respective CPU as of FW version V2.9. This refers to data such as private keys that are required for the proper functioning of certificate-based protocols.

Assign a password to protect confidential configuration data

You assign the password in STEP 7, in the CPU properties, in the area "Protection & Security > Protection of the PLC configuration data".

You can use the same password for an S7-PLCSIM Advanced instance as for the real CPU. This makes it easier for you to assign it uniquely.

S7-PLCSIM Advanced stores the password encrypted in a file on the virtual memory card. The handling of the password is the same as with the real CPU.

Only the current, active Windows user and no other user is allowed to read the password for the protection of confidential configuration data on the computer.

NOTE

Note that your Windows password protects the password used to protect confidential configuration data. Therefore, do not share the Windows password with other, untrustworthy users.

Detailed information on the protection of confidential configuration data and on secure communication can be found in the Communication function manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

Resetting to factory settings

A reset to factory settings causes the instance to start in fault mode under these circumstances:

- The CPU instance is protected with a password to protect PLC confidential data.
- You perform a reset to factory settings and select only the option "Delete password for protection of confidential PLC configuration data".

The instance is in fault mode because the password is missing. You cannot make an online connection or download to the instance.

You must reset the CPU instance with the "Format memory card" selection. With this selection, the instance is not in fault after the reset to factory settings. The storage is, however, cleared out.

Moving the virtual SIMATIC memory card to another virtual machine, for example, SIMIT

If you have not set a password to protect confidential configuration data, there are no restrictions on move operations.

If you have specified the password to protect confidential configuration data, the following restriction applies:

When you move the virtual memory card from one computer to another, you cannot start the S7-PLCSIM Advanced instance on the new system.

NOTE

To ensure maximum security on your systems, the password for protecting confidential configuration data is not available on a new system. You must reset the password again in the new system.

Solution:

The computer is part of an Active Directory.

The password encryption is linked to the Windows user. When you use the same Active Directory user in your domain on another computer, you can start S7-PLCSIM Advanced instances there.

When SIMIT archives the virtual SIMATIC memory card as a ZIP file and another user/computer is trying to restart this simulation

To recover from this situation, follow these steps:

1. Remove the password for protecting confidential configuration data from the STEP 7 project.
2. Load the project to the simulated PLC instance.

You can move the virtual memory card to other computers without any restrictions.

Switching on the S7-PLCSIM Advanced instance without a valid password

When you switch on an instance and the password for the protection of confidential configuration data is incorrect, the instance restarts automatically and switches to STOP mode. The ERROR LED flashes red.

Installing 4

4.1 Introduction

4.1.1 System requirements

For S7-PLCSIM Advanced to operate efficiently, the following minimum requirements for computer hardware or for a virtual machine must be met.

	Hardware
Processor	• A modern multi-core processor with sufficient performance • One core per simulation instance started • At least one additional core for the operating system • At least one additional core for extra active applications For virtual machines: A corresponding number of processors must be physically available on the host.
RAM	• 16 GB minimum Memory requirements increase with the number of instances and the complexity of the simulation
Free hard disk space	20 GB
Screen resolution	Minimum 1920 x 1080 (Full HD)

Operating systems and virtualization platforms

S7-PLCSIM Advanced supports the same operating systems, virtualization, and hard disk encryption technology as the corresponding STEP 7 Basic version, with the exception of the Windows Home operating systems. S7-PLCSIM does not support the Windows Home operating systems. See the TIA Portal Information System for a full list of supported technologies.

Refer to online information (https://support.industry.siemens.com/cs/ww/en/view/78788417) for installing STEP 7 (TIA Portal) and S7-PLCSIM Advanced on a virtual machine.

4.1.2 Restrictions due to antivirus programs

NOTICE
Restrictions due to virus scanners and Advanced Threat Protection software (ATP software) Virus scanners and ATP software that monitor the behavior of processes and communication can have a significant influence on the performance of the runtime and communication of S7-PLCSIM Advanced and even prevent S7-PLCSIM Advanced instances from starting.

Solution

You can decrease restrictions during installation and runtime of S7-PLCSIM Advanced. To do so, define exceptions for the virus scanner for secure files and folders. Add the following folders to the exceptions:

- "C:\Program Files\Common Files\Siemens\PLCSIMADV\Drivers"
- "C:\Program Files (x86)\Common Files\Siemens\PLCSIMADV"
- "C:\Program Files (x86)\SIEMENS\Automation\PLCSIMADV\bin"

If the virus scanner only allows files as exceptions, add all files from the listed folders to the exceptions. The procedure is described in the instructions of the respective manufacturer.

NOTE

Refer to the latest readme (https://support.industry.siemens.com/cs/us/en/view/109824282) on the Siemens Industry Online Support site for updates. Select the Edition that corresponds to your release version.

Virus scanner and security software support

Refer to "General software and hardware requirements" in the TIA Portal information system for the supported virus scanners and security software.

Siemens recommends Windows Defender that is part of the Windows operating system.

Symantec Endpoint Protection 14.3

Note the following restriction for Symantec Endpoint Protection 14.3 when using TCP/IP Single Adapter or TCP/IP Multiple Adapter:

If you use Npcap with Symantec Endpoint Protection, select one of the following options:

- Uninstall Symantec Endpoint Protection.
- Use Symantec Endpoint Protection with Npcap V1.60 or earlier.

4.1.3 Licenses

Floating license

S7-PLCSIM Advanced is supplied with a floating type license which is version and/or time-dependent. The license can be stored locally and shared for a network.

NOTE

Validity

A license is valid for two instances within an S7-PLCSIM Advanced installation.

You must use the correct license for your version.

Handling of licenses is described in the Help for SIMATIC Automation License Manager (ALM).

4.1.4 Trial License

A license is available for the limited period of 21 days for S7-PLCSIM Advanced. After this Trial License has elapsed, you can no longer start the instance.

Activating the Trial License

When you start an instance in the Control Panel, the Automation License Manager (ALM) searches the network for a valid license. If a Floating License is available for S7-PLCSIM Advanced, the ALM offers the Trial License for activation.

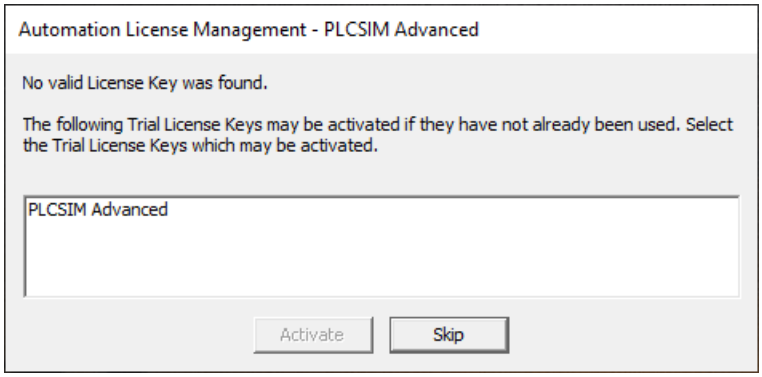

Figure 3-240 Activating the Trial License

A message at the start of an instance shows the remaining number of days.

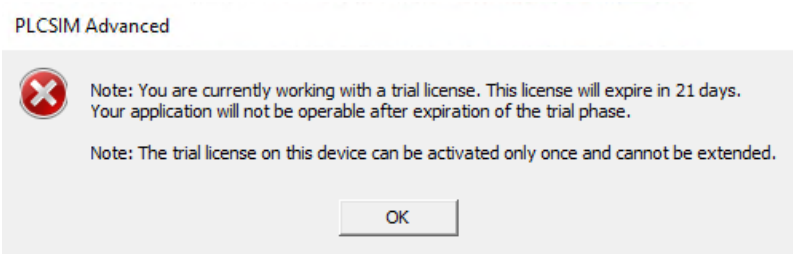

Figure 3-241 Trial License

NOTE

Remote access

With remote access you have to confirm the message on the PC on which the instance was started.

Timeout

If you do not confirm the message for the license in a certain amount of time, the instance is not started and you see an error message.

Start the instance again and confirm the message for the license.

4.1.5 Installation log

The log files contain automatically recorded information on the following installation processes:

- Installation of S7-PLCSIM Advanced
- Change or update of installation of S7-PLCSIM Advanced
- Repair of an existing installation of S7-PLCSIM Advanced
- Uninstallation of S7-PLCSIM Advanced

You can evaluate installation errors and warnings using the log files. You can troubleshoot the installation yourself or contact Siemens Technical Support. Product Support personnel need information from the installation log to analyze the problem. Send the folder with the log files as a ZIP file to Support.

Memory location of the installation log

The memory location of the log file depends on the operating system. To open the folder with the log files, enter the environment variable "%autinstlog%" in the address bar in Windows Explorer. Alternatively, you reach the appropriate folder by entering "cd %autinstlog%" in the command line.

The log files are named as follows:

- "SIA_S7-PLCSIM_Advanced_<version number>@<DATE_TIME>.log"
- "SIA_S7-PLCSIM_Advanced_<version number>@<DATE_TIME>_summary.log"

Setup_Report (CAB file)

The installation log and other required files are stored in a log file. This file can be found at "%autinstlog%\Reports\Setup_report.cab".

A separate CAB file with a date ID is saved for each installation.

If you need help during installation, send this CAB file to Siemens Technical Support for troubleshooting.

4.1.6 Contents of the S7-PLCSIM Advanced package

The S7-PLCSIM Advanced package contains the following software:

- S7-PLCSIM Advanced
- Automation License Manager
- .NET Framework
- Npcap

The S7-PLCSIM Advanced binaries are signed with a trusted certificate that is signed by Siemens. Siemens advises configuring your operating system policies to block unsigned or tampered code.

The package is available as a download and on DVD. Floating product licenses and product upgrade licenses are available.

If you installed from a DVD, keep the DVD in a secure, easily accessible place.

Setup program

You can use the Setup program to change, repair, or uninstall your installation, if necessary.

4.2 Installing S7-PLCSIM Advanced

Installation requirements

Make sure that the following conditions are met before you begin the installation process:

- The hardware and software of the computer meet the System requirements (Page 31).
- You have administrator rights on the installation computer.
- No other programs are active. This also applies to the Siemens Automation License Manager and other Siemens applications.
- All TIA Portal versions prior or equal to V14 are uninstalled.

NOTE
Security settings
For licensing via the ALM, you must agree during installation that port 4410 for TCP can be entered as an exception in the Windows Firewall (procedure step 5).

NOTE
Use of virus scanners
Note the information provided in section Restrictions due to antivirus programs (Page 31).

Installing S7-PLCSIM Advanced

Use one of the following two options to start the S7-PLCSIM Advanced setup:

Option 1: Using a Downloaded ISO File	Option 2: Using a USB Stick
1. Double-click your downloaded ISO file to create a drive on your computer. 2. Open the new drive and double-click "setup.exe" in the drive's root directory to begin.	1. Insert the USB stick and open the USB drive. 2. Double-click "setup.exe" in the drive's root directory to begin.

To finish the installation, follow these steps:

1. Click the "Read installation notes" button.
2. Click the "Read product information" button.
3. Click "Next". The window with the products to be installed is displayed.
4. Select the products to be installed.

5. Click the "Browse" button if you want to change the default installation path. The installation path must not exceed 89 characters. Do not use special characters, such as currency symbols, Chinese characters, or mathematical symbols in the installation path name. If you select a different installation path than the default installation path, the desktop icon may not be displayed correctly.
6. Click "Next". The window with the security settings is displayed. To continue the installation, select the check box at the bottom of the screen to accept changes to the security and permissions settings of your system.
7. Click "Next". The window with the installation settings is displayed. You can save or print a report of the settings by clicking "Save report" or "Print report". Check the settings for correctness. If you want to make any changes, click "Back" until you reach the point in the installation process where you want to make changes. Once you have completed your changes, click "Next".
8. The overview screen shows your installation details. Click the "Install" button. The installation then starts.
9. After completion of the setup program, you must restart your computer. Select "Yes, I want to restart the computer now" to restart the computer immediately or select "No, I will restart computer later" to restart the computer later.
10. Click "Restart". If the computer is not restarted, click "Finish".

Error during installation of S7-PLCSIM Advanced

The installation of S7-PLCSIM Advanced recognizes an already existing installation of S7-PLCSIM Advanced.

A requirement for the installation of S7-PLCSIM Advanced is that no other S7-PLCSIM installation prior or equal to TIA Portal version V14 is located on the same computer.

Even though no installation of S7-PLCSIM is displayed in the "Programs and Features" list, it is still possible that the computer has an existing installation.

Remedy

Run the setup for S7-PLCSIM prior or equal to TIA Portal version V14 and uninstall S7-PLCSIM.

If the setup is not available, download the setup files for S7-PLCSIM via Siemens Mall (https://support.industry.siemens.com/cs/ww/en/view/65601780).

4.3 Changing an installation

Requirements

The following conditions must be met before you can change the installation:

- The hardware and software of the computer meet the system requirements.
- You have administrator rights on the installation computer.
- No other programs are active.

Procedure

To change your S7-PLCSIM Advanced installation, follow these steps:

1. Double-click the download package or insert the installation medium into the drive. The setup program starts up automatically, provided you have not disabled the Autostart function on the computer. If the setup program does not start up automatically, start it manually by double-clicking the "Start.exe" file.
2. Follow the prompts until you reach the "Configuration" window.
3. Select the "Change upgrade" check box.
4. Follow the remaining prompts to change your installation.
5. Complete the installation operation by restarting your computer.

NOTE
Target directory
You cannot change the target directory because you are changing an existing installation.

4.4 Repairing an installation

Requirements

The following conditions must be met before you can repair S7-PLCSIM Advanced:

- The hardware and software meet the system requirements.
- You have administrator rights on the installation computer.
- No other programs are active.

Procedure

To repair your installation, follow these steps:

1. Double-click the download package or insert the installation medium into the drive. The setup program starts up automatically, provided you have not disabled the Autostart function on the computer. If the setup program does not start up automatically, start it manually by double-clicking the "Start.exe" file.
2. Follow the prompts until you reach the "Configuration" window. Select the "Repair" check box.
3. Follow the remaining prompts to repair your installation.
4. Complete the repair operation by restarting your computer.

4.5 Uninstalling the product

You have two options for uninstalling S7-PLCSIM Advanced:

- Uninstalling the program via the Windows Control Panel
- Uninstalling the entire product via the Setup program

Uninstalling S7-PLCSIM Advanced using the Windows Control Panel

Proceed as follows from the Control Panel:

1. Double-click your S7-PLCSIM Advanced product version in the Programs and Features.
2. Follow the prompts for uninstallation.
3. Complete the uninstallation operation by restarting your computer.

   If you do not perform a restart, the Runtime Manager continues running.

If problems occur when uninstalling S7-PLCSIM Advanced using the Windows Control Panel, use the installation medium for uninstalling.

Uninstalling S7-PLCSIM Advanced using the Setup program

Proceed as follows:

1. Double-click the download package or insert the installation medium into the drive. The setup program starts up automatically, provided you have not disabled the Autostart function on the computer. If the setup program does not start up automatically, start it manually by double-clicking the "Start.exe" file.

   If you do not perform a restart, the Runtime Manager continues running.
2. Follow the prompts until you reach the "Configuration" window. Your previous installation is detected. Select the "Uninstall" check box.
3. Follow the prompts for uninstallation.
4. Complete the uninstallation operation by restarting your computer.

   If you do not perform a restart, the Runtime Manager continues running.

Uninstalling additional software

When you uninstall S7-PLCSIM Advanced via the setup program, the following software from the S7-PLCSIM Advanced package remains installed:

- Automation License Manager
- .NET Framework
- Npcap

If you also want to uninstall this software, use the Windows Control Panel.

NOTE

User data, such as instance data, is not removed by the uninstallation.

Communication paths

5

Local and distributed communication

The following paths are open for communication between STEP 7 V15 or higher and the instances of S7-PLCSIM Advanced user interfaces:

Table 3-356 Local and distributed communication

Communication paths	Local	Local	Distributed
Protocol	Softbus	TCP/IP	TCP/IP
Online access (Page 53) setting in S7-PLCSIM Advanced	PLCSIM	TCP/IP Single Adapter or TCP/IP Multiple Adapter	TCP/IP Single Adapter or TCP/IP Multiple Adapter
STEP 7 and instances	On a PC / VM	On a PC / VM	Distributed
Communication...			
Between STEP 7 and instances	Yes	Yes	Yes
Among instances	Yes	Yes	Yes
Via OPC UA server and Web server	No	Yes	Yes
Between an instance and a real hardware CPU	No	No	Yes
Between an instance and a real HMI V14 and higher	No	No	Yes
Between an instance and a simulated HMI V14 and higher	Yes	Yes	Yes
Secure communication...			
Via Secure Open User Communication (secure TCP communication) V17 and higher	No	Yes	Yes
Via OPC UA Server V17 and higher	No	Yes	Yes
Via HTTPS connections to the Web server TIA Portal version V17 and higher	No	Yes	Yes

PLCSIM online access (Softbus)

Softbus is a communication path via a virtual software interface.

The communication is limited to a local PC or a virtual machine. The advantage here is that no data can be accidentally downloaded to a hardware CPU or communicate with real hardware.

Communication with S7-1500 R/H CPUs

NOTE

Communication with system IP address

Communication with S7-1500 R/H CPUs over the system IP address is possible with a TCP/IP connection. You cannot use the PLCSIM online access setting (Softbus protocol) to reach the system IP address.

Selecting a network mode

You select the network mode for communication in the Control Panel under "Online Access". The setting is valid for all generated instances. The default setting is the communication via "PLCSIM" (Softbus).

Additional network settings are necessary for the distributed communication over a TCP/IP adapter setting, see Network addresses in the simulation (Page 61).

5.1 Local communication

Local communication can be performed via the "PLCSIM" online access point (Softbus protocol) or TCP/IP.

For local communication, the S7-PLCSIM Advanced instance is on the same PC or on the same virtualization platform such as STEP 7 or another communication partner.

Local communication via Softbus

Local communication is performed via Softbus in S7-PLCSIM Advanced by default. You select "PLCSIM" for the online access point on the control panel to use the Softbus protocol.

Local communication via Softbus prevents:

- An accidental download to a hardware CPU
- Communication with real hardware

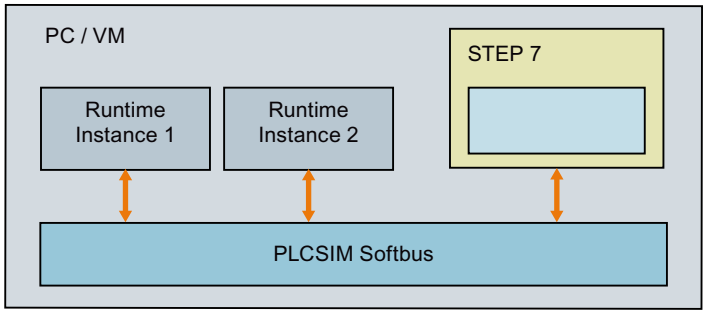

Figure 3-242 Local communication via Softbus

Local communication via TCP/IP

When you choose TCP/IP Single Adapter or TCP/IP Multiple Adapter for the Online Access point, communication is performed via a simulated network interface that behaves like a real network interface.

NOTE

Local communication via TCP/IP

Make sure that communication is only local and cannot be downloaded to real hardware. For this, you must have no other adapters of your Windows PC configured in the physical network and on the subnet of your simulated PLC instance. Microsoft KB 175767 provides background.

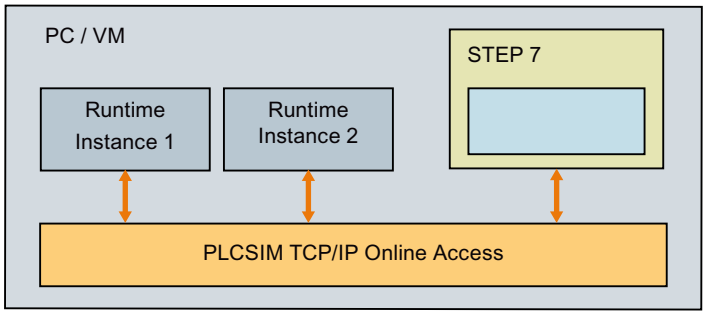

Figure 3-243 Local communication via TCP/IP

5.2 Communication via TCP / IP

5.2.1 Communication via TCP/IP in Single Adapter Network Mode (promiscuous mode)

Distributed communication

Distributed communication via TCP/IP means that the S7-PLCSIM Advanced instances communicate with other devices via the S7-PLCSIM Advanced Virtual Switch. Communication is possible with real or simulated CPUs, real or simulated HMIs.

You must activate the S7-PLCSIM Advanced Virtual Switch in Windows (Page 47) for instances on the network to be visible.

The network interface you configure as the S7-PLCSIM Advanced Virtual Switch must be in the same IP subnet as the IP address of the simulated PLC instance. If the virtual switch is not in the same subnet, you can assign it an IP address that is in the same subnet. Each CPU interface requires an IP address that is unique throughout the entire, accessible network.

Example 1: Distributed communication

In the following example, STEP 7 is on a PC and the S7-PLCSIM Advanced instances are on another PC or a virtual machine. The PCs are connected via their real Ethernet adapter.

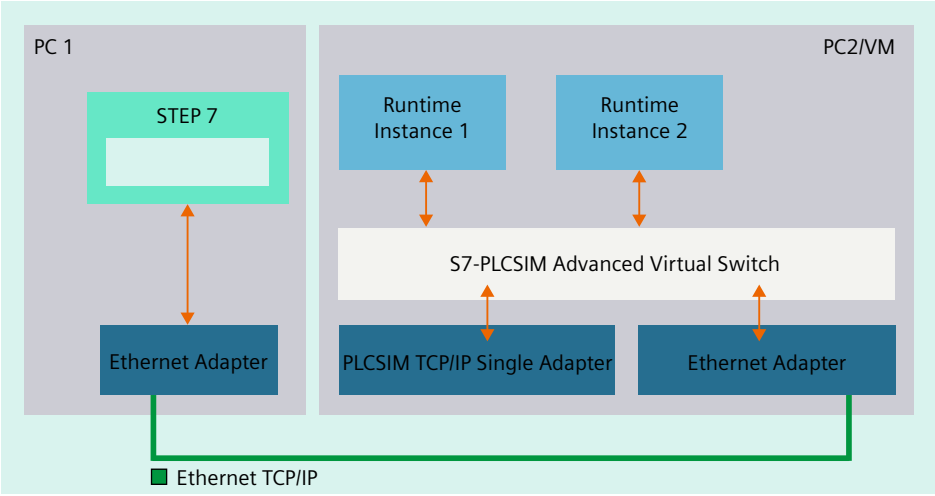

Figure 3-244 Distributed communication via Ethernet

Example 2: Distributed communication on a PC

In the following example, STEP 7 is on a PC and the S7-PLCSIM Advanced instances are on a virtual machine on the same PC. The PC and virtual machine are connected via the (virtual) network adapters.

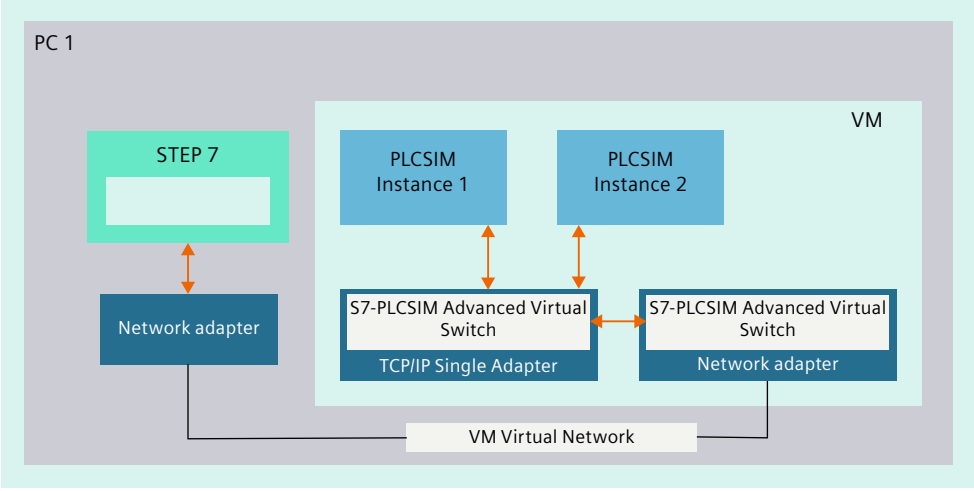

Figure 3-245 Distributed communication via network adapters

Required settings in the "Virtual Machine Settings" dialog using the VMware visualization platform as an example

If you have opened STEP 7 (TIA Portal) and your project within the virtual machine, enable the following options for your online connection as follows:

1. Right-click on the VM and select "Settings" or select the menu "VM > Settings".
2. Open the "Virtual Machine Settings" dialog via the menu command "Player > Manage > Virtual Machine Settings".
3. Then click "Network Adapter" in the "Hardware" tab and activate the following options in the right window:
   - Connected
   - Connect at power on
   - Bridged: Connected directly to the physical network
   - Replicate physical network connection state
4. Click the "Configure Adapters" button and activate your network connection, for example "Intel(R)82574L LM Gigabit Network Connection".
5. Confirm the setting with OK and exit the "Virtual Machine Settings" dialog with OK.

Example 3: Distributed communication

The following example shows a structure with PCs on which distributed STEP 7, S7-PLCSIM Advanced instances and virtual machines with S7-PLCSIM Advanced instances are running.

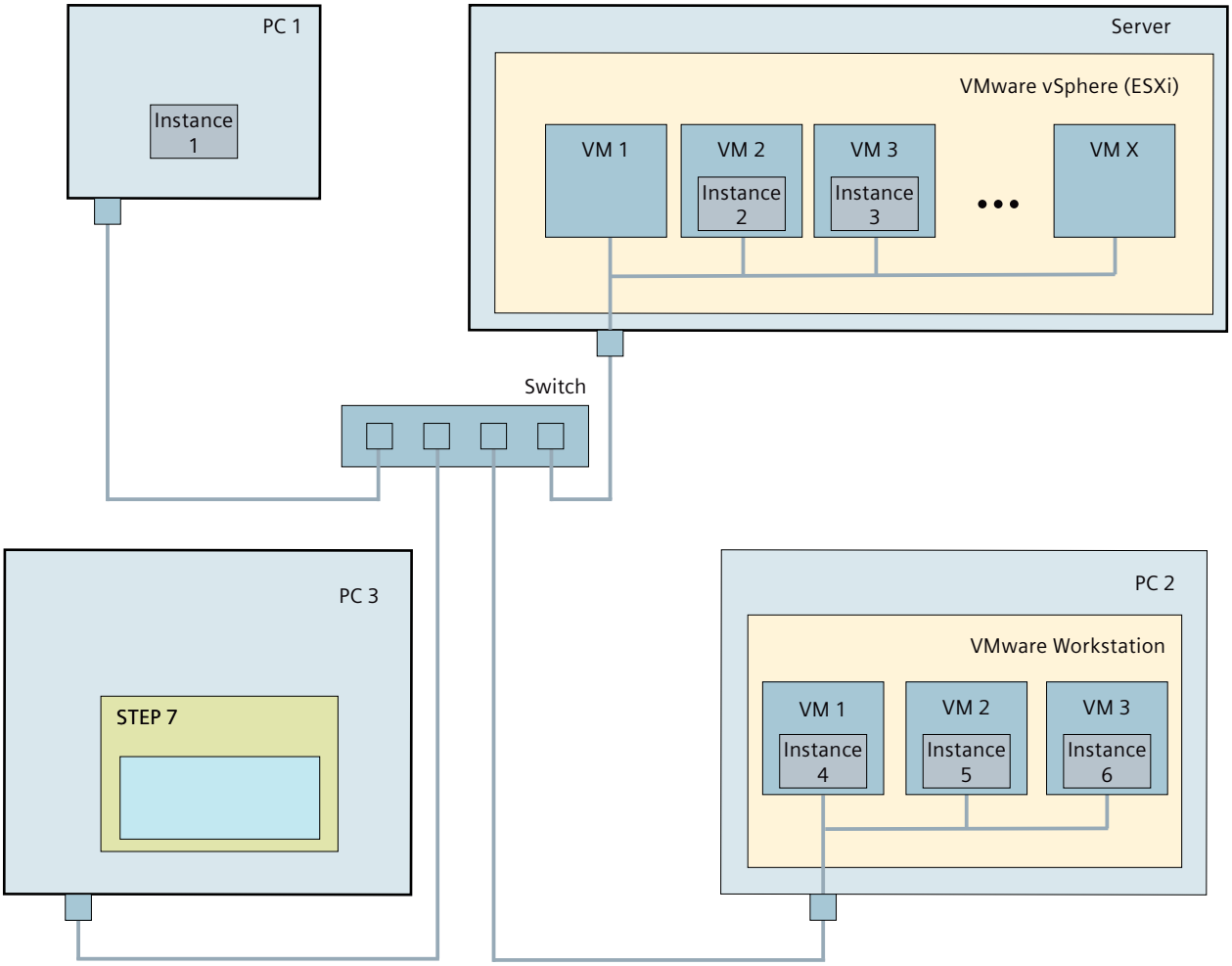

Figure 3-246 Distributed communications with PCs and virtual machines

5.2.2 Communication via TCP/IP in Multiple Adapter Network Mode (non-promiscuous mode)

In TCP/IP Single Adapter Network Mode (promiscuous mode), the network adapter reads all incoming telegrams. The network adapter also reads telegrams that are not intended for the network adapter. The network adapter then forwards the data to the operating system for processing.

In TCP/IP Multi-Adapter Network Mode (non-promiscuous mode), the evaluation of MAC addresses ensures that only data intended for the network adapter reaches the operating system.

However, on virtualization platforms or corporate networks, it is often not permitted to run the network interface of the PC in TCP/IP Single Adapter Network Mode (promiscuous mode) for security reasons.

Overview

The following figure provides an overview of the possibilities and differences between the following communication options:

- Local TCP/IP communication
- Single Adapter Network Mode (promiscuous mode)
- Multi-Adapter Network Mode (non-promiscuous mode)

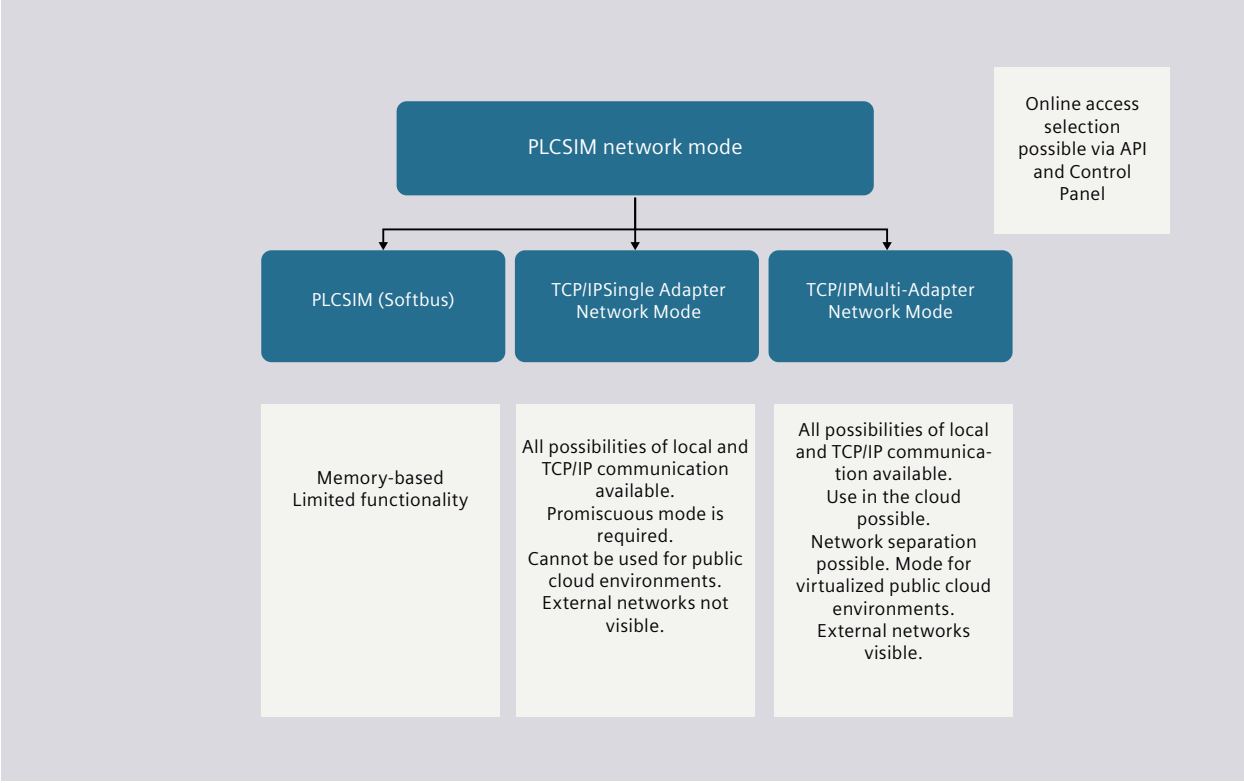

Figure 3-247 S7-PLCSIM networking

Applications

The following applications describe how you can also communicate in TCP/IP Multi-Adapter Network Mode (non-promiscuous mode). You communicate in this mode by performing a one-to-one mapping of the MAC addresses between the CPU network interfaces and the network adapters of the PC.

The following applications assume that you are working in an environment where security restrictions apply and you have therefore switched to TCP/IP Multi-Adapter Network Mode (non-promiscuous mode).

Application 1:

You start multiple instances. Each CPU interface is assigned to the MAC address of the respective physical or virtual PC adapter.

Precondition: Each interface of a running instance is assigned to its own physical or virtual PC interface (one-to-one mapping).

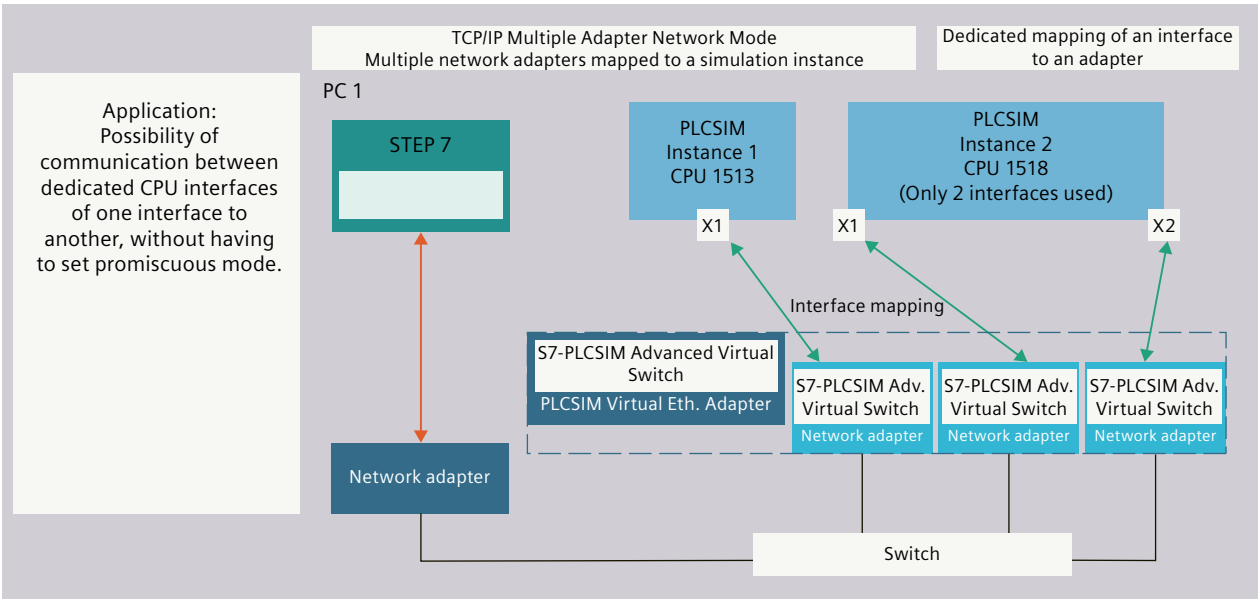

Figure 3-248 Application 1

Application 2:

The following application shows the behavior with multiple instances that have the same MAC addresses. Each CPU interface is assigned to the corresponding physical or virtual PC adapter.

The scenario is only valid if only one instance is running at a time.

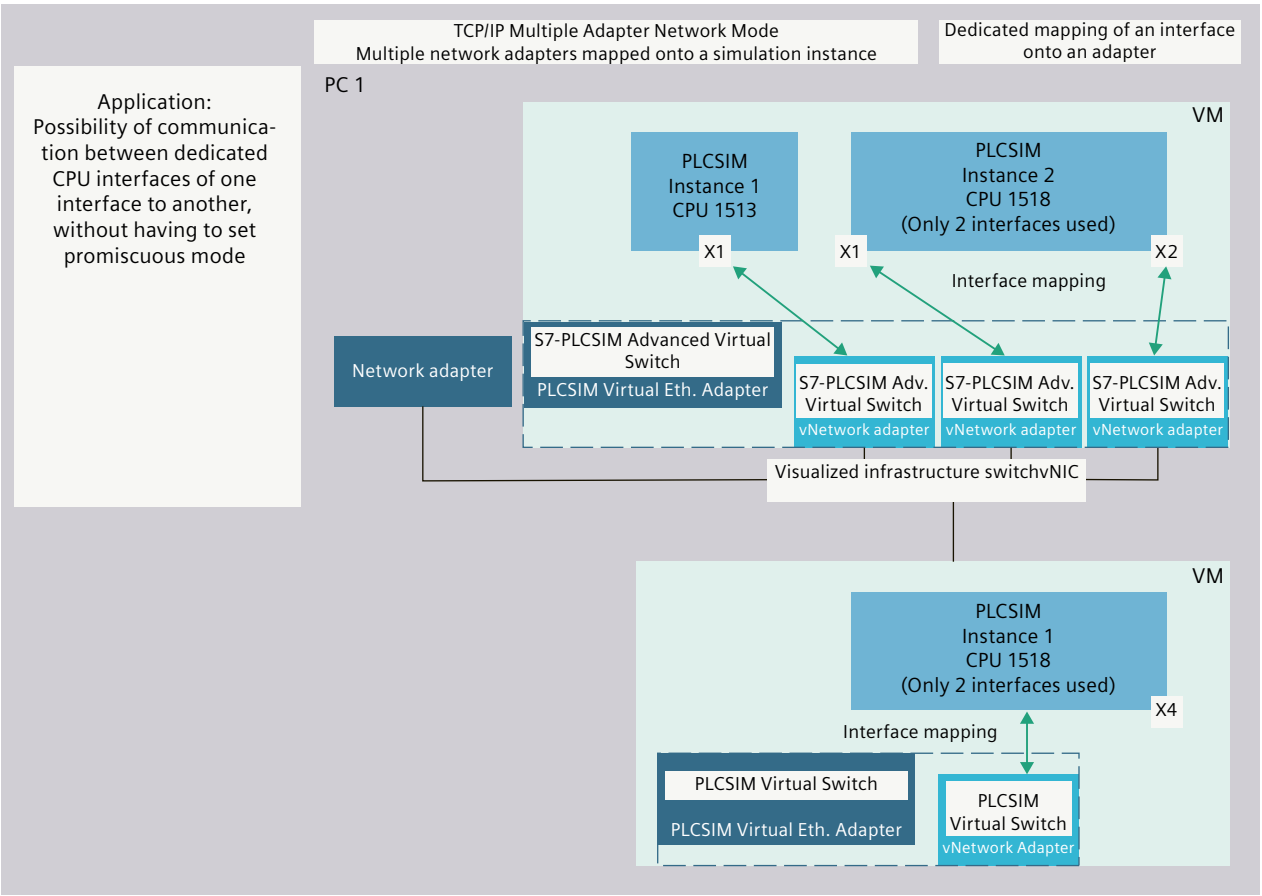

Figure 3-249 Application 2

Refer to the S7-PLCSIM Advanced API manual for a procedure to perform external communication in TCP/IP Multi-Adapter Network Mode.

5.3 Enable distributed communication

By default, the S7-PLCSIM Advanced Virtual Switch is not enabled for communication connection properties. For distributed communication to be possible, that is cross-computer communication, you must activate the S7-PLCSIM Advanced Virtual Switch for a real network adapter.

NOTE

Network adapter

If using TCP/IP Single Adapter mode, make sure that the S7-PLCSIM Advanced Virtual Switch is activated for only one network adapter. The Control Panel of S7-PLCSIM Advanced checks the activation and can report an incorrect configuration (error code -50).

Activating the S7-PLCSIM Advanced Virtual Switch

To make the S7-PLCSIM instances visible on the network and to reach other devices, activate the S7-PLCSIM Advanced Virtual Switch in Windows:

1. To do this, open the "Network and Sharing Center" in the Windows Control Panel.
2. Open the properties of the desired network adapter, for example, for the "Local Area Connection".
3. Select the check box for the "S7-PLCSIM Advanced Virtual Switch" and confirm with OK.

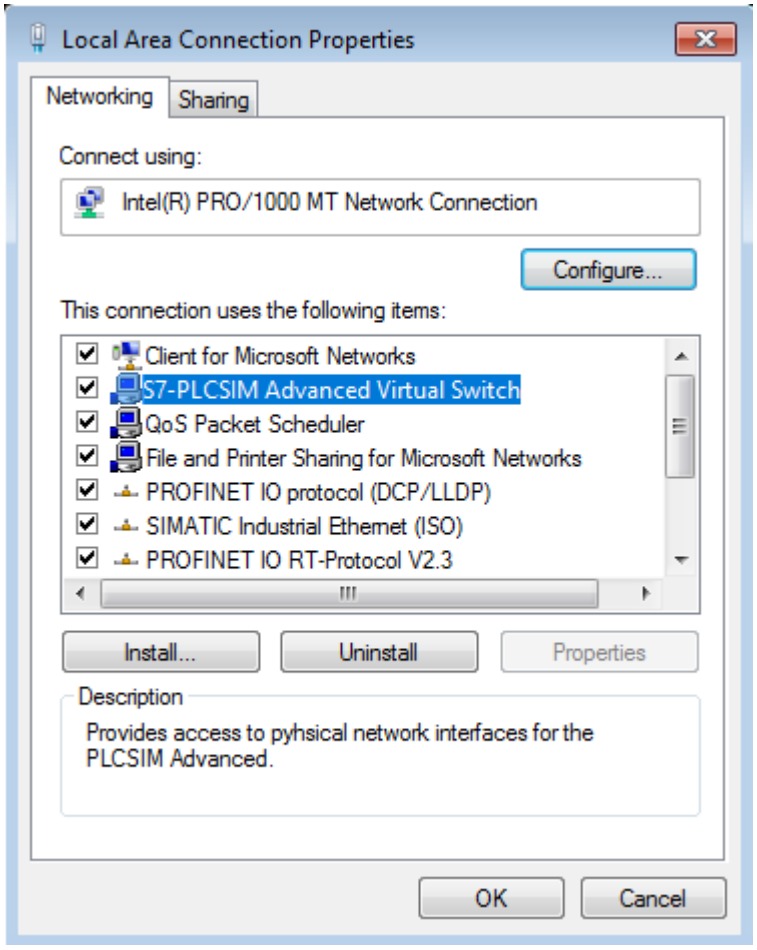

Figure 3-250 Activating the S7-PLCSIM Advanced Virtual Switch

Accessible devices

On the local computer, the S7-PLCSIM Advanced instances are always displayed in the TIA Portal as accessible devices of the Siemens PLCSIM Virtual Ethernet Adapter.

The S7-PLCSIM Advanced instances are not visible locally via the configured network, even if the S7-PLCSIM Advanced Virtual Switch is activated.

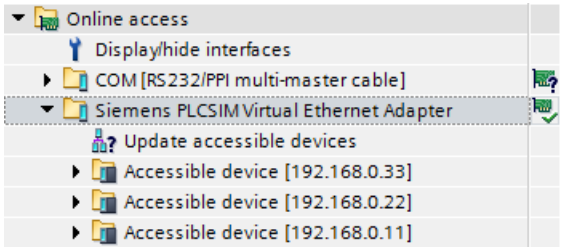

Figure 3-251 Accessible devices on the Siemens PLCSIM Virtual Ethernet Adapter

Distributed communication via WLAN

When using distributed communication via WLAN, it can happen that the Npcap program library installed by S7-PLCSIM Advanced does not work with the integrated WLAN adapter of the PC. In this case, no WLAN connection can be established.

Remedy

Use the wired network adapter of the PC/notebook and connect a WLAN adapter upstream.

NOTE

S7-PLCSIM Advanced does not support TCP/IP Single Adapter communication using wireless adapters.

Simulating

6

6.1 Simulating a CPU

6.1.1 Basic procedure for the simulation

The following overview shows the basic steps to perform simulation with a simulated PLC instance.

Requirements

The following requirements must be met for starting simulation via local communication:

- STEP 7 (V14 or higher) and S7-PLCSIM Advanced are installed on the same PC.
- The CPU hardware is configured in STEP 7.

NOTE

Enable simulation support

To support simulation (Page 25), select the check box "Support simulation during block compilation" from the "Protection" tab in the properties of the project in STEP 7,

---

Create and activate an instance from the Control Panel

1. Open the S7-PLCSIM Advanced Control Panel. (Page 51)
2. Open the "Start Simulated PLC Instance" options.
3. Enter a valid name (Page 84) for an instance.
4. Select the CPU family.
5. Create an instance using the "Start" button.

NOTE

You can create a maximum of 16 simulated PLC instances from the Control Panel from the "Start" button. The S7-PLCSIM Advanced application displays a notification (Page 95) if you attempt to add more than 16 instances.

In STEP 7, perform the download and start the simulation

- Download the program (Page 58) to the simulated PLC instance
- Switch the simulated PLC instance to RUN to start the simulation
- Perform diagnostics

6.1.2 Control Panel - User interface

6.1.2.1 S7-PLCSIM Advanced Symbol

After installing S7-PLCSIM Advanced, the following icons are on the Windows desktop:

Figure 3-252 S7-PLCSIM Advanced Symbol

A double-click on the symbol opens the Control Panel for S7-PLCSIM Advanced. If the Control Panel is in the background, it is moved to the foreground with another double-click.

You can use Windows functions to permanently display the icon in the system tray of the taskbar.

Opening the Control Panel or viewing status from the taskbar

Right-clicking the icon in the taskbar opens the Control Panel with the quick view. Double-click to start the Control Panel as a window.

You can use the mouse-over function to display messages about the current status of the instances.

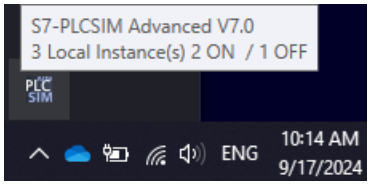

Figure 3-253 Example: Message in the taskbar

6.1.2.2 Control Panel quick view and window

S7-PLCSIM Advanced provides the Control Panel with two views:

- **Control Panel as quick view**

  Right-clicking on the icon in the taskbar opens the quick view.

  Clicking on an empty area on the desktop minimizes the quick view. The instances are not affected.

- **Control Panel as window**

  Double-clicking the icon on the desktop or in the taskbar opens the Control Panel as a window.

Control Panel as window

Unlike the quick view, you can operate the Control Panel with the buttons in the title bar.

You can close this window without exiting the simulation Runtime process.

① Stores the Control Panel as icon in the taskbar.

② Restores the Control Panel to full view if it appears shrunken or partially obscured in a virtual machine (VM) or remote desktop environment.

③ Closes the Control Panel and stores it in the system tray of the taskbar.
The instances and the simulation Runtime process remain active.
This function therefore differs from the Exit function ⊗.
The Exit function switches off the local instances, logs them off and closes the Control Panel.

④ Pins the Control Panel on the screen so that it remains in the foreground.

Figure 3-254 Control Panel: Title bar

6.1.2.3 S7-PLCSIM Advanced Control Panel

The S7-PLCSIM Advanced Control Panel is only available in English.

Features of the Control Panel

The figure below shows the structure of the S7-PLCSIM Advanced Control Panel.

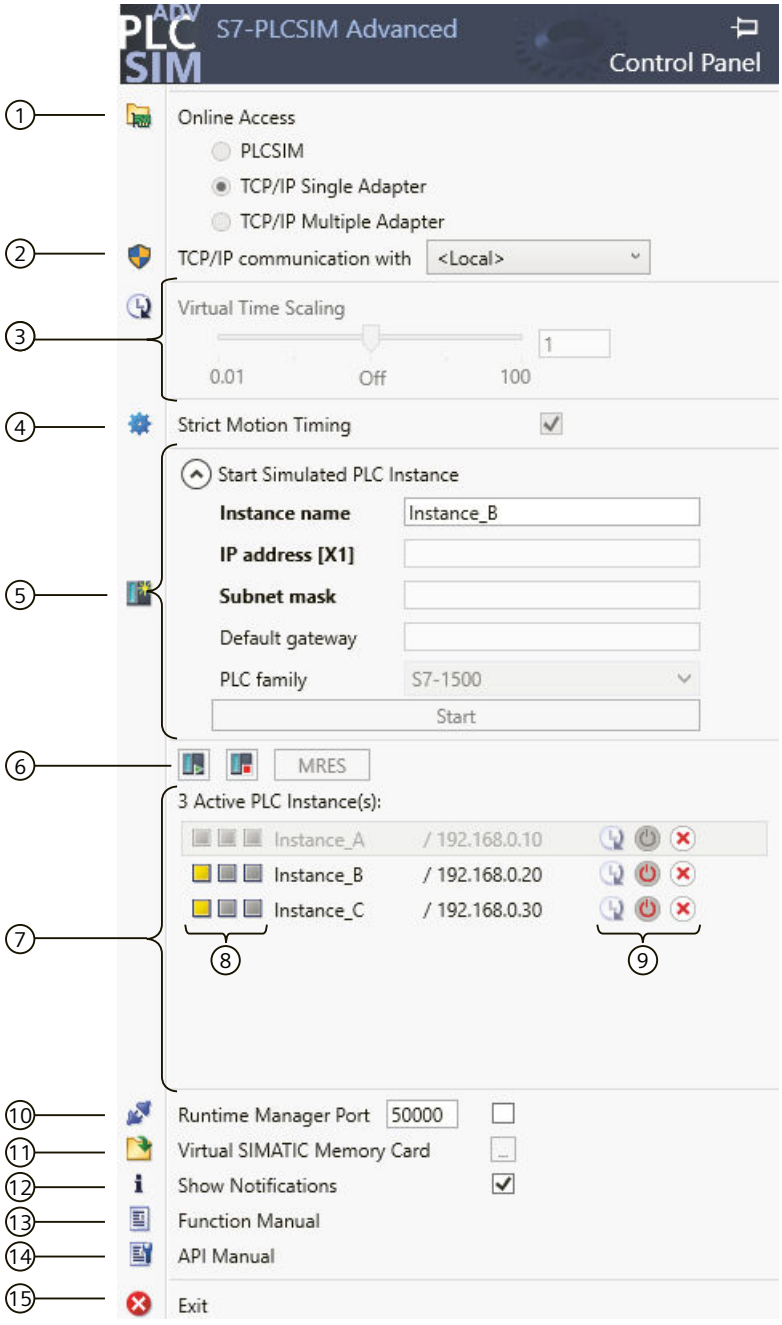

①	Online access	Selection of the network mode
②	TCP/IP communication	Selection of network adapter for distributed communication

③	Virtual time Scaling	Slider to adjust the scaling factor
④	Strict Motion Timing	Check box to disable the overrun detection for Motion Control (OB MC-Servo [OB91]). When you select the check box for Strict Motion Timing, PLC instances detect overruns. You can only change the Strict Motion Timing setting for overrun detection when you have started no PLC instances. All instances that you subsequently start use the Strict Motion Timing setting to either detect or ignore overruns.
⑤	Start Simulated PLC Instance	Selector to open and close the input boxes for creating the instance
	• Instance name	Unique name for the instance. If the name is unique in the network, you can click the "Start" button.
	• IP address, Subnet mask, Default gateway	Input boxes that are visible when you switch the communication interface to a TCP/IP mode.
	• PLC family	PLC family to be simulated
	• "Start" button	Button to start the instance that you selected
⑥	Buttons	Buttons for operating the selected instances
⑦	Instance list	List of available local instances, which you can sort by dragging and dropping
⑧	LEDs	LED indicators, which display a tooltip definition when you move the mouse over them
⑨	Icons	Icons for operating the instance
⑩	Runtime Manager Port	Port on the local PC to be opened when you select the check box or press Enter
⑪	Virtual SIMATIC Memory Card	Clickable region where you open the storage location of the virtual memory card With the "..." Browse icon you can change the path to the virtual memory card.
⑫	Show Notifications	Check box to disable S7-PLCSIM Advanced messages in the Windows task bar for the duration of the operation. Note that even If you have the "Show Notifications" setting enabled in the Control Panel, your Windows settings (Page 95) might still prevent you from receiving notifications from S7-PLCSIM Advanced.
⑬	Function manual	Icon for opening the S7-PLCSIM Advanced Function Manual
⑭	API manual	Icon for opening the S7-PLCSIM Advanced API Manual
⑮	Exit	Exit button and bottom region of control panel for logging off all instances and closing the Control Panel

Online access selection

Choose one of the following for the communication interface to use for all instances you create:

- S7-PLCSIM: Local communication via Softbus (default).
- TCP/IP Single Adapter (Page 41)
- TCP/IP Multiple Adapter (Page 44)

The setting applies to all other instances. The selected communication interface for starting an instance is maintained until all instances are shut down.

When an instance is already started, it sets "its" communication interface as the default for other instances.

To change the communication interface, switch off all instances and enable the other interface.

TCP/IP communication

After you select TCIP/IP Single Adapter or TCP/IP Multiple Adapter for the online access, you can select a real network adapter from the drop-down list during operation. You thus activate the S7-PLCSIM Advanced Virtual Switch and establish TCP/IP communication between the instances and the real network.

The <Local> setting deactivates the S7-PLCSIM Advanced Virtual Switch and disconnects the instances from the real network. Only local TCP/IP communication over the virtual adapter is possible in this case.

Virtual time

You must enable the virtual time for each instance using the icon . Use the slider or the mouse wheel to select the scaling factor for the virtual time.

The selected scaling factor applies to the instances for which the virtual time is enabled.

Clicking on "Off" restores the default (1) again. For more information see Virtual and Real Time (Page 79).

Creating a local instance and starting it

To create an instance, enter a unique name under "Instance Name".

The following rules apply to the creation of an instance name:

- The minimum length of an instance name is 3 characters; the maximum length is 29 characters.
- The instance name must not start or end with a dot (.) or a space.
- The instance name can only contain the following:
  - Uppercase letters from A to Z
  - Lowercase letters from a to z
  - Numbers from 0 to 9
  - Special characters: Spaces ., _ - + @ ! ; # ~ ' ( ) [ ] { } ^ $ % &

NOTE

If the name already exists in the folder of the Virtual SIMATIC Memory Card, this already existing instance is started.

In the "PLC family" drop-down list, you select a CPU family:

- S7-1500
- S7-1500R/H
- ET 200SP
- ET 200pro
- Software/Open controller

Create the instance with the "Start" button and start this instance.

The instance is initialized with the first download from the TIA Portal.

Instance list

The list contains the instances that have been started and are available locally on the PC or virtualization platform.

To change the operating mode, select one or more instances and click the "RUN" or "STOP" button. To reset memory, select one or more instances and click the "MRES" button.

The LEDs correspond to hardware PLC LEDs and show the status and operating mode of each instance.

You can "operate" the instance with these icons:

- Enable or disable the virtual time scaling factor
- Power on/off the instance
- Unregister instance

Runtime Manager Port

A remote connection can be established to another Runtime Manager via the specified port. The value must be greater than 1024.

If you select the check box, the port value is retained. You can use the remote connection without having to make this setting every time you start the Control Panel. To use this functionality, the Control Panel must be started and running in the background.

NOTE

For secure communication, only open ports and connect to remote runtime managers on trusted local networks. Without restricting access, unwanted users could access a running remote runtime manager.

Virtual SIMATIC Memory Card

The user program, the hardware configuration, and the retentive data are stored on the Virtual SIMATIC Memory Card. Use the buttons to adapt the path to the virtual memory card or open the previously saved path in an Explorer window.

Showing notifications

Each time the Panel starts, help information and messages relating to the Control Panel are displayed, for example, when changing the IP address or when a license is missing. Disable "Show Notifications" if you do not need the messages.

Exit - Log off all instances

The command switches off all local instances on the PC or the virtual memory card, logs them off from the Runtime Manager, and closes the Control Panel.

This command closes the Runtime Manager if there are no remote connections to other Runtime Managers.

If the Runtime Manager has remote connections to instances on additional PCs, these instances and the Runtime Manager continue to run.

6.1.2.4 Importing instances

Requirement

If you start S7-PLCSIM with "Run as administrator", you cannot import instances as described below. To be able to import instances, do not select "Run as administrator" when starting the control panel.

Importing instances

You can use the drag-and-drop function to import instances from a folder directly into the instance list of the Control Panel.

1. Open a folder with instances, for example, using the "Virtual SIMATIC Memory Card" button.
2. Select one or more instances from the folder and drag them to the "Drop Instances Here" area.

NOTE

Stored files can contain sensitive information. It is your responsibility to handle this information securely.

6.1.3 Downloading a STEP 7 project

Requirements

You can download the STEP 7 project to the simulated PLC instance when the following conditions are met:

- The instance is created via the Control Panel.
- The check box "Support simulation during block compilation" is selected in STEP 7.

Selecting the communication interface

In the Download dialog box, select the PG/PC interface:

- "PLCSIM" for download via Softbus
- "Siemens PLCSIM Virtual Ethernet Adapter" for download via TCP/IP
- For distributed communication the real adapter that is connected to the network

Display in the download dialog

The dialog in STEP 7 at the first download of the CPU shows the compatible S7-PLCSIM Advanced instances.

If the instance has not yet been configured after the first download only **one** interface is visible and it appears with the device type "CPU-1500 Simulation".

If the instance has been configured, the number of interfaces visible is determined by the number the CPU type has.

The dialog shows the interfaces of an instance with their IP addresses.

Perform download

To download a project to the simulated PLC instance, follow these steps:

1. Select the PG/PC interface.
2. Click "Download".

   → In the "Load preview" window, STEP 7 shows the message "The downloads are performed on a simulated CPU".

   → After the first download, the S7-PLCSIM Advanced instance displays the CPU type.

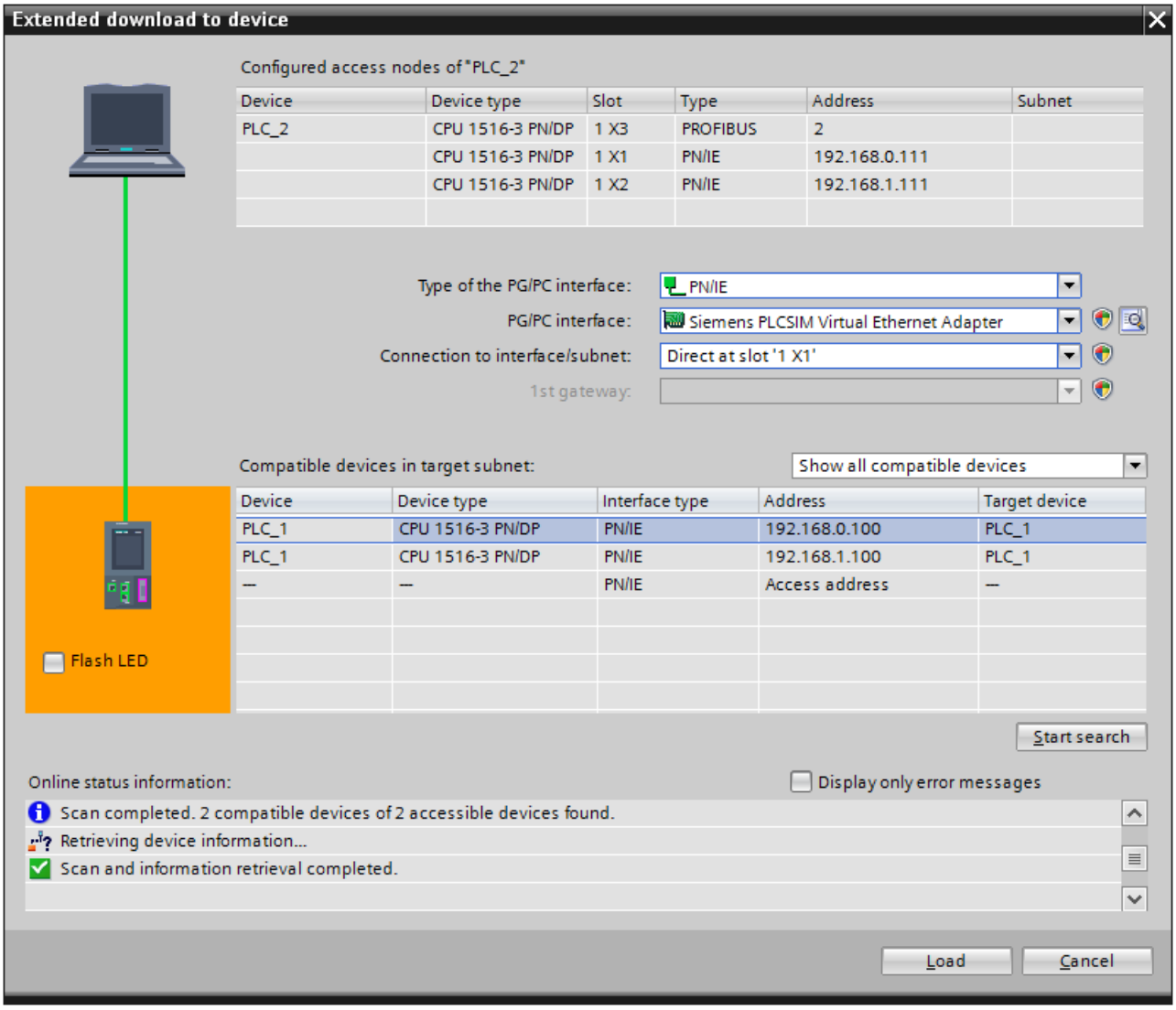

Figure 3-255 Example: Download via the "PLCSIM Virtual Ethernet Adapter" (TCP/IP) after naming

Quantity structures

STEP 7 allows you to use the specific allocations for quantity structures and memory usage for an S7-PLCSIM Advanced PLC instance.

To use this feature, you must do the following:

1. Download your STEP 7 project to a simulated S7-PLCSIM Advanced PLC instance.
2. Power cycle the instance after the download.

In STEP 7, the maximum quantity structure for an unconfigured PLC instance is based on the following CPUs:

PLC family	Based on CPU
S7-1200 G2[1] S7-1500 ET 200SP ET 200Pro	CPU 1518TF-3 PN
Software/Open controller	CPU 1508S TF
S7-1500 R/H	CPU 1518HF-4 PN

[1] The memory capacity for motion applications is identical to the published memory specifications of the S7-1200 G2 CPUs.

Software/Open controller sets the maximum retentive memory size as if the option "PC mass storage" was selected, regardless of the STEP 7 project settings.

Downloading to Software/Open controller

Do not select the W1 interface connection when downloading to Software/Open controller.

Additionally, if you change the firmware version of the Software/Open controller in the STEP 7 project after your created a simulated Software/Open controller instance in S7-PLCSIM Advanced , you must delete the simulated PLC instance and simulate a new PLC instance for the changed version. You can then download from the TIA Portal to the new instance.

Going online from STEP 7

Observe the following requirements for user authentication based on the "Online Access" mode:

- In PLCSIM (Softbus) mode, you can go online from STEP 7 with a local project user, but not a central user (global user).
- In either TCP/IP mode, you can go online from STEP 7 with a central user (global user), but only from programming devices that can access the UMC server on which you configured the central users.

Loading an additional CPU to one instance

Example in TIA Portal:

1. Assign an IO device (e.g. IM 153-4 PN) to a CPU (e.g. CPU 1518-4 PN/DP).
2. Add another CPU of the same product family (e.g. CPU 1511-1 PN) to your project.
3. Start the simulation with online access via PLCSIM Virtual Ethernet Adapter.

4. Load the configuration onto the CPU 1518-4 PN/DP with the assigned IO device (IM 153-4 PN) via the interface X1 with TCP/IP.
5. Load the configuration of the other CPU (CPU 1511-1 PN) using the same instance.

   If you go online after this scenario and check the entries in the diagnostic buffer under "Online & Diagnostics", the following message appears: "Error: Multi-interface mismatch - Inconsistent parameterization for sending LLDP data)."

To avoid this error scenario, use one of the following solutions:

- In the "General" tab under PROFINET interface [X1] > Advanced options > Interface options, enable "Use IEC V2.2 LLDP mode" for the PROFINET interface [X1] for both CPUs (CPU 1511-1 PN and CPU 1511-1 PN).
- After the second download, log out the instance and log it in again.
- Power cycle the instance.

6.1.4 Network addresses in the simulation

6.1.4.1 Siemens PLCSIM Virtual Ethernet Adapter

IP address

For the PLCSIM Virtual Ethernet Adapter (either TCP/IP Single Adapter or TCP/IP Multiple Adapter (Page 53)), you assign a static IP address in the Windows network settings or obtain an IP address via DHCP (default).

MAC address

The PLCSIM Virtual Ethernet Adapter (either TCP/IP Single Adapter or TCP/IP Multiple Adapter) has its own MAC address.

S7-PLCSIM Advanced only uses MAC addresses that are designated as "locally administered" (bit 2 in LSB) (Page 62).

The Siemens-specific prefix is: 02-1B-1B. Three bytes follow, which are determined at random.

Storage location

This MAC address is stored in the registry key "PlcsimvminiMacAddress". You can overwrite this value.

6.1.4.2 S7-PLCSIM Advanced instances

Detect CPUs and instances

If Ethernet interfaces of CPUs and S7-PLCSIM Advanced instances are mixed in a network, the instances are recognizable by the "PLCSIM" suffix of the device type during the search for accessible nodes in STEP 7.

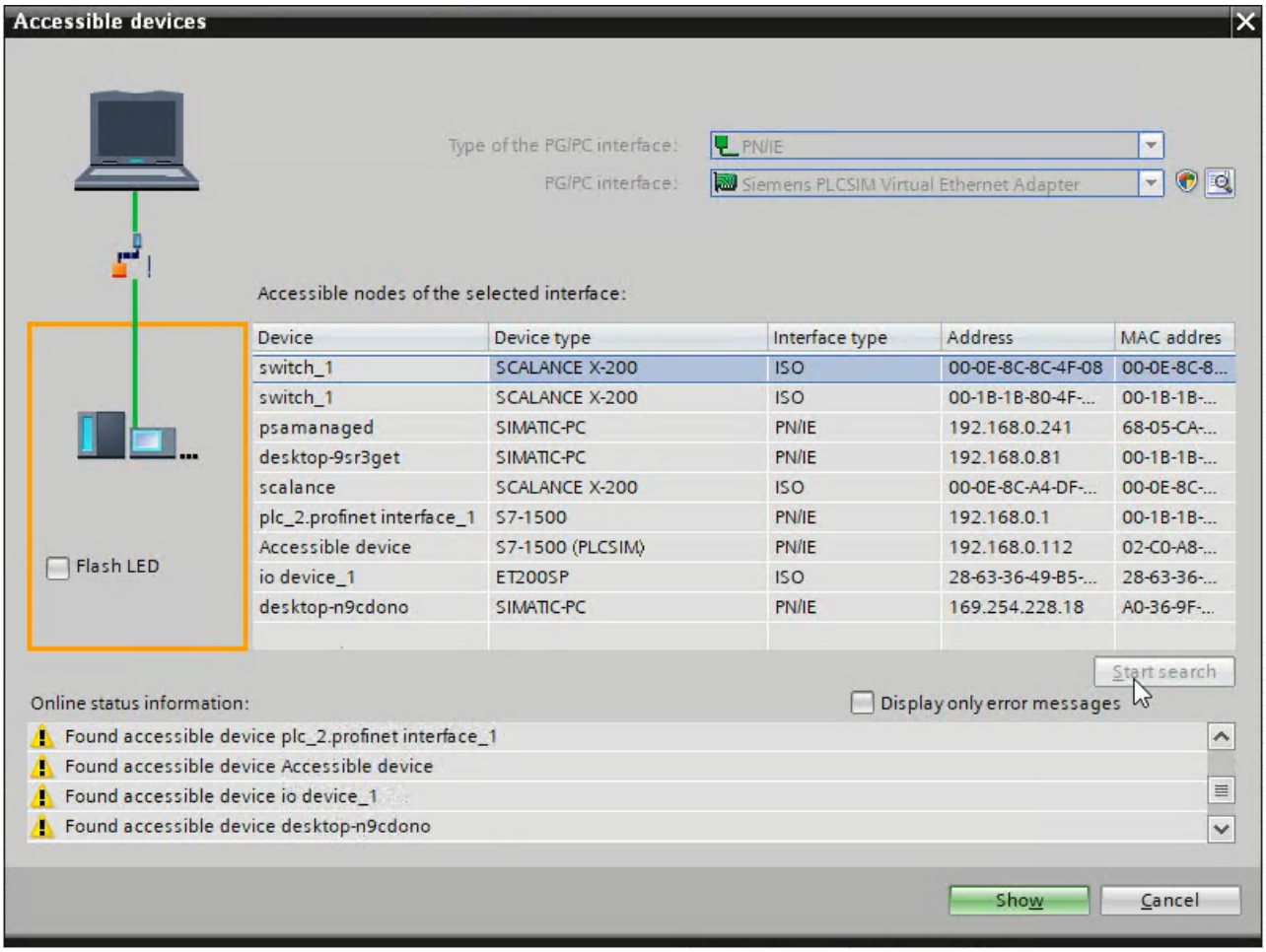

Figure 3-256 Search for the devices that are accessible in STEP 7

Structure of the MAC address for an instance

The following figure shows the structure of the dynamically generated, locally managed MAC address:

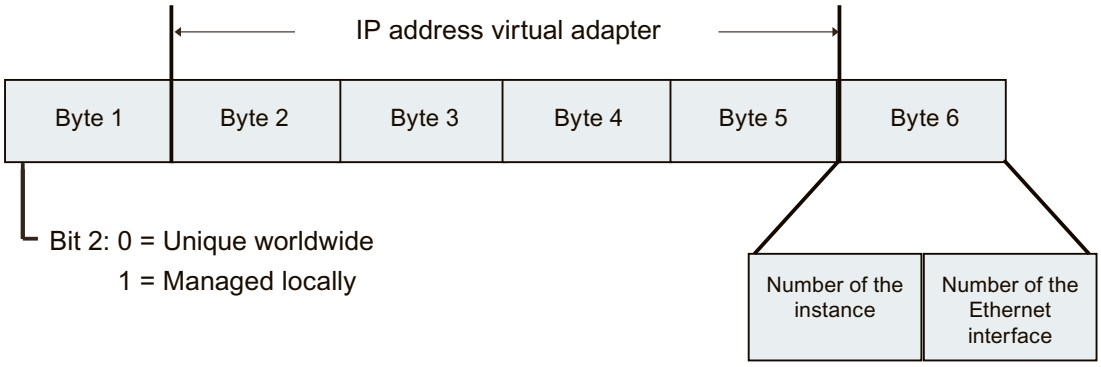

The MAC address tells you the PC on which an S7-PLCSIM Advanced instance has been started.

Assignment of the Ethernet interfaces

Port configurations of the Ethernet interfaces cannot be simulated in S7-PLCSIM Advanced. Topological interconnection is not supported. A MAC address for a port is reserved internally for each Ethernet interface.

Table 3-357 Assignment of the Ethernet interfaces, for example, for a CPU 1518-4 PN/DP

Ethernet interface	Last digit of the MAC Address
IE 1 IE 1 / Port 1	0 1
IE 2 IE 2 / Port 1	2 3
IE 3 IE 3 / Port 1	4 5

Example

02-C0-A8-00-83-10 means:

02 → locally managed MAC address of an S7-PLCSIM Advanced instance

C0-A8-00-83 → IP of the Siemens PLCSIM Virtual Ethernet adapter = 192.168.0.131

1 → Instance 1

0 → Ethernet interface IE 1

If no Virtual SIMATIC Memory Card is loaded during startup of S7-PLCSIM Advanced, the interfaces of S7-PLCSIM Advanced display instances with their locally managed MAC address.

6.1.5 Simulate communication

6.1.5.1 Communication services that can be simulated

S7-PLCSIM Advanced supports the following communication options:

Table 3-358 Supported communication options

Communications options	Functionality / instructions
PG communication	On commissioning, testing, diagnostics
Open communication using TCP/IP	• TSEND_C / TRCV_C • TSEND / TRCV • TCON[1] • T_DISCON
Secure Open user communication (secure TCP communication)	• TSEND_C / TRCV_C • TCON
Open communication using ISO-on-TCP	• TSEND_C / TRCV_C • TSEND / TRCV • TCON • T_DISCON
Open communication via UDP[2]	• TUSEND / TURCV • TCON • T_DISCON
Communication via Modbus TCP[3]	• MB_CLIENT • MB_SERVER
E-mail[2, 3]	• TMAIL_C
S7 communication	• PUT / GET • BSEND / BRCV • USEND / URCV
OPC UA server[2, 3]	Secure data exchange with OPC UA clients
Web server[2, 3]	Data exchange via HTTP, HTTPS

[1] When the online access is the "S7-PLCSIM" (Softbus) interface, communication is performed **internally** via ISO-on-TCP.

[2] Communication is only possible when the online access is TCP/IP Single Adapter or TCP/IP Multiple Adapter, collectively also called the PLCSIM Virtual Ethernet Adapter.

[3] "Access to PLC via communications module" is not supported.

Special conditions apply when communicating with TUSEND/TURCV, see Restrictions for communications services (Page 84).

NOTE

Secure Communication

When simulating communication services, also consider the basics of secure data exchange (Secure Communication). For detailed information on Secure Communication, refer to the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) function manual.

Additional information

For more information on the various communication services, please refer to the Communication function manual (https://support.industry.siemens.com/cs/ww/en/view/59192925).

Restrictions for MODBUS communication via Softbus

For communication via Softbus, use the supported Modbus versions shown in the following table or, alternatively, communication via TCP/IP.

Table 3-359 Modbus communication via Softbus

MODBUS TCP Lib	MB_CLIENT	MB_SERVER	SOFTBUS
V6.0	V6.0	V5.3	✓
V5.2	V5.2	V5.2	x
	V5.1	V5.1	x
	V5.0	V5.0	x
V4.2	V4.1	V4.2	x
	V4.1	V4.1	x
	V4.0	V4.0	✓

✓ = Communication possible

x = Communication not possible

TMAIL_C

When the TMAIL_C instruction is used, the mail server might not be located on the same PC as the S7-PLCSIM Advanced instance.

Solution

Make the mail server available via a different PC in the network.

6.1.5.2 Communication between instances

S7-PLCSIM Advanced supports communication between instances. An instance might be a simulation in S7-PLCSIM Advanced or a simulation in WinCC Runtime as of V14.

You can run two instances of S7-PLCSIM Advanced, which then communicate with each other. To enable instances to communicate with each other, they must have a unique IP address.

Each simulated CPU requires a unique IP address

If the CPUs have the same IP address, you cannot run multiple simulations. Each simulated CPU requires a unique IP address.

Make sure that the IP addresses in STEP 7 are unique before you start your simulations.

T-block instructions and UDP

S7-PLCSIM Advanced simulates T-block connections for which the UDP protocol is configured only using the TCP/IP Single Adapter or TCP/IP Multiple Adapter communication interface (PLCSIM Virtual Ethernet Adapter).

T-block instructions and data segmentation

S7-PLCSIM Advanced implements T-block instructions with a data segmentation of 4 KB. A real CPU has data segmentation of 8192 bytes.

If you send more than 4 KB in a single TSEND instruction and receive data in ad hoc mode with a TRCV instruction, the TRCV instruction generates new data with only 4 KB. You must perform the TRCV instruction several times to receive additional bytes.

6.1.6 Provide project data offline for simulation

Simulations regardless of STEP 7

To perform simulations independent of STEP 7, you can save the user program and the hardware configuration in STEP 7 in a folder.

Saving retentive data securely

The retentive data is automatically saved when the simulated PLC instances are shut down.

To save the retentive data safely in the virtual SIMATIC Memory Card, you must log instances off correctly. Use one of the following functions for this:

- Power on/off the instance
- Unregister instance
- Unregister all running instances and exit the control panel

Provide project data offline

1. Create a "User-defined Card Reader" for your project data in the "Card Reader/USB storage" folder in the project tree of STEP 7 for the CPU. Do not use Unicode characters in your card reader name.
2. In the "Load preview" dialog for the target device, select "PLC Simulation Advanced" for the target device.
   → The project is saved to the <Virtual Memory Card>\SIMATIC.S7S\OMSSTORE folder.

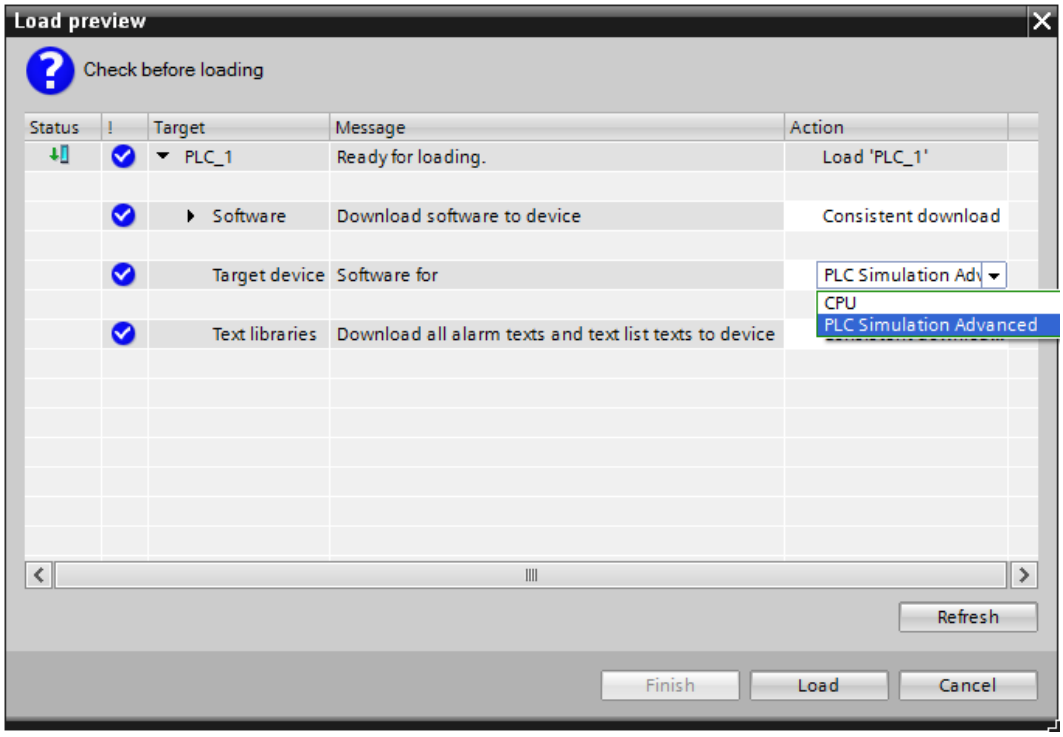

Figure 3-257 Preview of download dialog

3. Save the folder "\SIMATIC.S7S" with the project data to a medium of your choice.

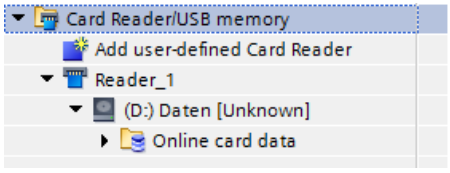

Figure 3-258 Add card reader

Provide project data for simulation

1. On the PC on which S7-PLCSIM Advanced is installed, create the folder "\SIMATIC_MC" in the folder in which the instance saves its data.
2. Move the "\SIMATIC.S7S" folder to the folder you have created.

The instances can be started with the project data.

6.2 Simulating a CPU with ODK functionality

Introduction

The ODK is an engineering tool that allows the creation of high-level language applications for S7-1500 CPUs. You use it to generate function libraries that are used in the STEP 7 user program.

The ODK for S7-PLCSIM Advanced supports the C++ programming language.

S7-PLCSIM Advanced only supports libraries created by ODK1500S V2.5 and later.

You can find the description of the ODK in the Programming and Operating Manual "S7-1500 Open Development Kit 1500S", as of V2.5 Edition 12/2017: SIMATIC STEP 7 (TIA Portal) Options ODK 1500S (https://support.industry.siemens.com/cs/ww/en/ps/13914/man)

Supported CPUs

S7-PLCSIM Advanced supports the ODK functionality of the following controllers:

- CPU 1518(F)-4 PN/DP ODK
- CPU 1518(F)-4 PN/DP MFP
- CPU 150XS (P/T/F) (Software/Open Controller family)

6.2.1 Special features of ODK

Simulating CPU with ODK functionality with S7-PLCSIM Advanced

The simulation of a CPU with ODK functionality requires a special start procedure.:

- From the PLC family dropdown list, select the CPU type. For example, for a CPU1518MFP, select S7-1500. For a Software Controller or Open Controller, select Software/Open Controller.
- Start the instances on the Virtual SIMATIC memory card that contain the project data for the CPU with ODK functionality.
- After the first download from the TIA Portal, select the functions "Switch off instance" and "Shutdown instance" in the Control Panel.

NOTE

When you perform the first download to a CPU of the "S7-1500" family, for example, via the S7-PLCSIM Advanced Control Panel, no ODK1500S folder is created on the virtual SIMATIC Memory Card. The CPU cannot be switched to RUN. In this case, you will find messages about missing ODK blocks (e.g. SFC 2013) in the diagnostics buffer.

Supported function libraries

S7-PLCSIM Advanced supports the following function libraries for the real-time environment:

- CPU function library: Original Shared Object, SO file as for the hardware CPUs
- S7-PLCSIM Advanced function library (Windows Sync):
  - a 32-bit Windows DLL for ODK Runtime
  - a 64-bit Windows DLL for ODK Runtime

NOTE

Do not mix function libraries

When simulating with S7-PLCSIM Advanced, you cannot load 32-bit and 64-bit function libraries simultaneously. If you want to use one function library, first remove the function library of the other type.

If you want to use function libraries with a different binary format, all others must be unloaded first.

NOTE

Limitations for the execution of CPU function libraries (Windows Sync) with an infinite loop in the class constructor

When the CPU function library (DLL file) contains an object of a class in whose constructor an infinite loop is programmed, the corresponding "ODK client" process gets permanently stuck in this loop when instantiating the object.

Even after reaching the timeout, the infinite loop cannot be interrupted automatically. The S7-PLCSIM Advanced instance remains in RUN even though the entry "Time error - CPU changes to STOP mode" is displayed in the diagnostics buffer.

NOTE

Limitations for traces in the execution of CPU function libraries (Windows Sync)

Avoid using traces when developing a CPU function library (DLL file) in the class constructor (call of the "ODK_TRACE()" function) to prevent trace messages with faulty parameter values.

NOTE

Know-how protection

The SO files for ODK are not know-how-protected.

Debugging an S7-PLCSIM Advanced function library (DLL file)

To debug a function library, attach the Visual Studio Debugger to the corresponding ODK client process that has loaded the respective function library.

S7-PLCSIM Advanced supports versions ≥ Visual Studio 2017.

Simulation of the ODK with S7-PLCSIM Advanced

If you have loaded the TIA project on the S7-PLCSIM Advanced and the instruction "*<STEP7Prefix>*_Load" was called for the first time, each S7-PLCSIM Advanced instance starts another Windows process ("ODK client") in which the ODK application is executed synchronously with the STEP 7 user program.

Which ODK client is started depends on the function library to be loaded:

- "Siemens.Simatic.PlcSim.Vplc1500.ODKClient.**so**.exe" for an original Shared Object
- "Siemens.Simatic.PlcSim.Vplc1500.ODKClient.**x86**.exe" for a 32-bit application
- "Siemens.Simatic.PlcSim.Vplc1500.ODKClient.**x64**.exe" for a 64-bit application

The executable files of these processes are located in the same folders as those of the S7-PLCSIM Advanced Instances ("Siemens.SIMATIC.Simulation.Runtime.Instance.exe").

NOTE

S7-PLCSIM Advanced does not support asynchronous ODK functions.

Error codes

The same error codes as described in the Programming and Operating Manual "S7-1500 Open Development Kit 1500S" apply to the instructions in the real-time environment. Error codes are also available for S7-PLCSIM Advanced because the ODK client processes can be closed unexpectedly and therefore an error handling is required.

Restrictions for stack processing

NOTE

Limitations for stack processing in the version of CPU function libraries for real-time-environment

S7-PLCSIM Advanced ignores the stack size for a CPU function library that is adjusted via the parameter <SyncCallStackSize>. S7-PLCSIM Advanced always provides the maximum stack size of 1 MB.

Additional information may be found in the programming and operating manual S7-1500 Open Development Kit 1500S (https://support.industry.siemens.com/cs/ww/en/view/109783714) . Search for content about CPU function libraries and SyncCallStackSize.

S7-PLCSIM Advanced cannot catch any Exceptions of the type "Stack Overflow" while CPU function libraries for the real-time environment (SO files) are being executed.

When developing a CPU function library (SO file), make sure that the maximum stack size of 1 MB is not exceeded. An overflow of the stack leads to an undefined behavior and can lead to the termination of the ODK client process.

NOTE

Limitations for heap processing in the version of CPU function libraries (Windows Sync)

If a heap corruption occurs when executing a C/C++ function from a CPU function library (DLL file), then this program error is first ignored and execution of the function continues. Only after fully processing the function is the corresponding error code returned (0x8090).

When developing a CPU function library (DLL file), make sure to avoid heap corruption. This way you ensure that after fully processing a C/C++ function no error code is returned.

6.2.2 Loading functions

Loading functions - Instruction "*<STEP7Prefix>*_Load"

If you have loaded the TIA project on the S7-PLCSIM Advanced and the instruction "*<STEP7Prefix>*_Load" was called for the first time, each S7-PLCSIM Advanced instance starts another Windows process. The ODK client then attempts to load the function library that is specified in the SCL file. This is in the folder "<storage path of the instance> \SIMATIC_MC\ODK1500S". The storage path of the instance is the Virtual SIMATIC Memory Card location.

The ODK client process continues until the instruction "*<STEP7Prefix>*_Unload" is called to unload the last loaded function library or until the process of the S7-PLCSIM Advanced instance ends.

The function call is synchronous and returns after completion of the operation. The output parameter provides information on the progress status.

ODK error code for S7-PLCSIM Advanced

The following table lists the error codes that apply in addition to the error codes that apply to the CPU specifically for ODK applications with S7-PLCSIM Advanced:

Table 3-360 ODK: Output parameter - Load functions

DONE	BUSY	ERROR	STATUS	Description
0	0	1	0x80A4 = -32604	• The ODK client process cannot be started. • A connection to the ODK client cannot be established or has been interrupted.
0	0	1	0x8095 = -32619	The ODK client process that is currently running expects a function library with a different binary format.

6.2.3 Calling functions

Call functions - Instruction "*<STEP7Prefix>*SampleFunction"

When calling ODK functions, data is exchanged between the simulated PLC instance and the function library.

The execution of a single function can be interrupted by the execution of higher prioritized OBs.

Technically, the execution of a function is an asynchronous instruction because it is executed in another process. However, the processes are synchronized in the simulated PLC instance. This means that the function call does not return before the function returns or the ODK client process is closed during the execution.

ODK error code for S7-PLCSIM Advanced

The following table lists the error codes that apply in addition to the error codes that apply to the CPU specifically for ODK applications with S7-PLCSIM Advanced:

Table 3-361 ODK: Output parameter - Call functions

DONE	BUSY	ERROR	STATUS	Description
0	0	1	0x80A4 = -32604	The connection to the ODK client was interrupted.

6.2.4 Unloading functions

Unload functions - Instruction "*<STEP7Prefix>*_Unload"

The CPU function library is unloaded by calling the instruction "*<STEP7Prefix>*_Unload". If no other function library is loaded or if the process of the S7-PLCSIM Advanced instance is closed, then the ODK client process is shut down.

The function call is asynchronous, the call returns immediately. The output parameter informs about the progress status.

6.3 Simulating Motion Control

Restrictions

S7-PLCSIM Advanced simulates the real CPU but not configured, connected technology modules or other I/O devices.

It is possible to download a STEP 7 project with technology modules for operation of motion control. However, the built-in logic of the technology modules is not part of the simulation. Therefore, the corresponding motion control instructions are not supported.

In contrast to a real CPU, S7-PLCSIM Advanced does not support isochronous mode for centralized I/O in S7-1500 with local send clock.

OB MC-Servo [OB91] and OB MC-Interpolator [OB 92]

If you convert a motion control project that contains OB 91 and OB 92 from STEP 7 V13, then you cannot load this project to a S7-PLCSIM Advanced.

Solution

Delete OB 91 and OB 92 in the project and recompile the project.

The OBs are then created again with the simulation support required for S7-PLCSIM Advanced.
Compilation resets the properties of the blocks to the default values.
Restore the required settings in the properties.

Diagnostic buffer message "Overflow" for OB MC servo [OB91]

If there are overflows of the OB MC-Servo [OB91] in the diagnostic buffer, the time for the application cycle (ms) has been exceeded, because the calculation of this application cycle could not be completed within the required time.

Solution

The overflows of OB MC-Servo [OB91] in the diagnostic buffer decrease under these conditions:

- When fewer additional Windows processes are executed
- When the computing power of the CPU is higher

Overflow detection is activated for S7-PLCSIM Advanced as of V3.0 for exact simulation of the technology objects. If diagnostic buffer overflows occur on your PC for OB MC-Servo [OB91] and your instance goes into the STOP operating state, the following solutions are available to you:

- Use the virtual time of S7-PLCSIM Advanced and start with the lowest possible scaling factor for the virtual clock. Increase the value step-by-step until the first overflows occur in the diagnostic buffer. Repeat this procedure until you have determined the maximum scaling factor for which you do not yet get any overflows in the diagnostic buffer.

  Information on the scaling factor can be found in section Speed up and slow down simulation (Page 80).
- Set a longer application cycle (ms) for the OB MC-Servo [OB91] in STEP 7.

NOTE

Load on an S7-PLCSIM Advanced instance is too high

If the load on an S7-PLCSIM Advanced instance becomes too large, the instance may no longer switch to the STOP operating state despite numerous diagnostic buffer overflows.

In such a case, shut down the S7-PLCSIM Advanced instance and follow the workarounds described above.

Simulation with external simulation software

NOTE

In a simulated PLC instance, the technology objects are connected to the process image. Simulation software can thus access the process image and simulate the behavior of the other connected axes.

The simulation mode in STEP 7 is a standard function of the technology objects and is independent of S7-PLCSIM Advanced.

If you want to move an axis in simulation mode, select the "Activate simulation" check box in STEP 7 under "Technology Object > Configuration> Basic Parameters > Simulation". No additional setting is required for a virtual axis.

Feedback of the axis position

The speed setpoint of the simulated drive is integrated into the actual position value with a time delay (PT1). The result of this calculation is returned to the technology object as position actual value of the axis.

Reference point approach of the axis

If you selected "Use zero mark via PROFIdrive frame" in STEP 7 for the reference point approach, S7-PLCSIM Advanced responds immediately to any active (mode 2, 3, 8) or passive (mode 4, 5) reference point approach command (MC_Home). The actual position is predefined as the reference point.

More information

You can find information on the technology functions of the CPU in the S7-1500/S7-1500T Motion Control (https://support.industry.siemens.com/cs/ww/en/view/109751049) function manuals.

For more information, refer to the manuals of the supported SIMATIC controllers. (https://support.industry.siemens.com/cs/ww/en/view/109744173)

6.4 Simulating the SIMATIC Drive Controller

Introduction

The SIMATIC Drive Controller is a drive-based controller in the SIMATIC S7-1500 range.

A SIMATIC Drive Controller combines the following functionalities in a SINAMICS S120 Booksize Compact housing:

- Fail-safe SIMATIC S7-1500 technology CPU with integrated technology I/Os
- SINAMICS S120 drive control

Both components are called "CPU" and "SINAMICS Integrated" in the documentation.

The SIMATIC Drive Controller supports PROFINET and PROFIBUS DP communication.

Supported SIMATIC Drive Controllers

S7-PLCSIM Advanced supports the SIMATIC Drive Controllers as of firmware version V2.9:

- CPU 1504D TF (6ES7615-4DF10-0AB0)
- CPU 1507D TF (6ES7615-7DF10-0AB0)

Special features

Unlike other SIMATIC S7-1500 technology CPUs, the SIMATIC Drive Controllers also have:

- Integrated inputs/outputs (onboard I/O)
- Integrated drive control SINAMICS Integrated

Restrictions

S7-PLCSIM Advanced only simulates the standard CPU functionality of the SIMATIC Drive Controller.

Not simulated are:

- the technology functions of the onboard I/O
- the SINAMICS Integrated
- PROFINET IO
- PROFIBUS DP

The integrated inputs/outputs of the X122, X132 and X142 interfaces can only be simulated as binary inputs/outputs.

Technological functions are not simulated, for example, Timer DI/DQ, Oversampling DI/DQ. Channel parameter assignments, such as signal inversion, input delay and edge detection are not possible.

The functionality of the SINAMICS Integrated is not simulated – but the SINAMICS Integrated is shown as a valid node.

Simulations are possible as with SINAMICS S120 CU320-2 based on the drive telegrams (e.g. by reading and forcing the telegram addresses).

Coupled isochronous mode

In coupled isochronous mode, the relevant clock systems use a shared system clock, for example, from PROFINET IO or the local send clock of the technology I/Os. The leading clock system provides its own system clock to the other clock systems.

NOTE

Leading clock system

Clock synchronization with technology I/Os X142 (local send clock) as leading clock system is not possible with S7-PLCSIM Advanced. In this case, you configure the PROFINET IO interface X150 as leading clock system.

The information provided in the section Simulation of Motion Control (Page 72) still applies.

Additional information

The SIMATIC Drive Controller system manual (https://support.industry.siemens.com/cs/ww/en/view/109766665) describes in detail the configuration, installation, wiring and commissioning of the SIMATIC Drive Controller. The STEP 7 online help supports you in the configuration and programming.

The SIMATIC Drive Controller equipment manual (https://support.industry.siemens.com/cs/ww/en/view/109766666) contains a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

6.5 Simulating a redundant S7-1500R/H system

Introduction

In a redundant S7-1500R/H system, the CPUs are duplicated, in other words, redundant. The two CPUs process the same project data and the same user program in parallel. The two CPUs are synchronized over two redundancy connections. If one CPU fails, the other CPU maintains control of the process.

S7-PLCSIM Advanced supports the R/H CPUs (Page 22) of the redundant S7-1500R/H system as of firmware version V2.9 as described below.

Supported operating and system states

Like standard S7-1500 CPUs, the S7-1500R/H CPUs have the operating states STOP, STARTUP and RUN. For operation as a redundant system, one of the two CPUs can take on an additional operating state, SYNCUP, for synchronizing the two subsystems. The RUN operating state is divided into the following states for redundant systems:

- RUN
- RUN-Syncup
- RUN-Redundant

The system states of the redundant S7-1500R/H system result from the combination of the operating states of the individual CPUs as follows:

- STOP
- STARTUP
- RUN-Solo
- SYNCUP
- RUN-Redundant

NOTE

RUN-Solo system state is supported by S7-PLCSIM Advanced

The simulation of a redundant S7-1500R/H system is possible in the RUN-Solo system state (RUN operating state of the CPU). In the RUN operating state, the (leading) primary CPU behaves just like an S7-1500 standard CPU. The MAINT LED on the CPU is always yellow (maintenance request) because no partner CPU was found for redundant operation.

No simulation is possible with S7-PLCSIM Advanced in redundant system operation.

Unsupported events

The following event is not supported by the R/H CPUs of the redundant S7-1500R/H system:

RackOrStationFault

NOTE

The occurrence of a RackOrStationFault event does not trigger an OnLedChanged event for R/H CPUs. The ERROR LED is not flashing even though a corresponding device fault message is displayed in the diagnostic buffer.

Supported functions as of firmware version V3.0

As of FW version V3.0, the S7-1500H redundant system supports PROFINET system redundancy R1 with the following devices:

- ET 200SP IM 155-6 PN R1
- ET 200SP HA IM 155-6 PN HA
- ET 200iSP IM 152-1 PN

R1 devices are equipped with two interface modules compared to S2 devices. If one interface module fails, the R1 device can still be reached by the H-CPUs via the second interface module.

The redundant S7-1500H system thus supports the following additional setup variants:

- Configuration of PROFINET rings with R1 devices
- Line topology configuration with R1 devices, S2 devices, switched S1 devices
- Combined topology configuration with R1 devices and S2 devices

You can load projects consisting of R1 and/or S2 devices in S7-PLCSIM Advanced and simulate them. Reading and writing input and output values of simulated R1 and S2 devices works in the same way as for other simulated IO devices. The simulated R1 and S2 devices support simulation of external events, such as failure of a redundancy connection. Note the removal and insertion of R1 devices is not supported by S7-PLCSIM Advanced.

More information

The Redundant system S7-1500R/H System Manual (https://support.industry.siemens.com/cs/ww/en/view/109754833) describes in detail the configuration, installation, wiring and commissioning of the redundant S7-1500R/H system. The STEP 7 online help supports you in the configuration and programming.

The equipment manuals of the R-, H- and HF-CPUs contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications of the CPUs.

Virtual time response

7

The simulated PLC instance uses two types of internal clocks for the simulation: A virtual clock and a real clock. The virtual clock is always the basis for the user program. It is used by components that are relevant for running the STEP 7 user program, such as cyclic OBs, cycle time monitoring, minimum cycle time, virtual system time and time calculations. Also, the time between two cycle control or single step control points is measured in virtual time.

The virtual time can be accelerated or slowed for simulation and optimization purposes.

The real clock always runs unchanged. It is used by components that are not subject to control processes, for example, communication with STEP 7.

Interruption of the process

Since S7-PLCSIM Advanced runs in a Windows environment, Windows might temporarily suspend the simulated PLC instance process. In such a case, both the virtual and the real clock stop in the simulated PLC instance. They only continue to run when Windows resumes processing.

Virtual system time

When you start S7-PLCSIM Advanced, the virtual system time of the instance starts with the system time of Windows.

The virtual system time is based on the virtual clock. If a scaling factor is used, the system time runs correspondingly faster or slower.

All events from the simulated PLC instance provide a time stamp based on the system time.

NOTE

Difference between system time and local time

- System time**:** UTC ± 0 with daylight saving / standard time
- Local time: UTC ± time zone with daylight saving time / standard time

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Time offset

NOTE

Keep in mind that the time information of virtual system time and real local time differs by the time offset that is formed in addition to the selected scaling factor from the time zone offset and the daylight saving time/standard time offset.

Scaling factor

Using a scaling factor, you can speed up or slow down the virtual clock of the simulated PLC instance for simulations.

To set the required scaling factor, enable the grayed out icon on the control panel to the right of your S7-PLCSIM Advanced instance. The symbol then becomes active and you can use the scaling function.

- The default setting is 1, i.e. the virtual time passes the same as the real time.
- **Fast forward:** A scaling factor greater than 1 accelerates the virtual clock.

  Example: Scaling factor 2.0 → The virtual time is running twice as fast.
- **Slow motion**: A scaling factor less than 1 decelerates the virtual clock.

  Example: Scaling factor 0.5 → The progress of the virtual time slows down to 50%.

7.1 Speed up and slow down simulation

Influence of fast forward and slow motion

Simulations can be accelerated and slowed down. Fast forward and slow motion only affect time-based components, for example, cyclic OBs. Compared to the real time, they are performed more frequently with fast forward and less frequently with slow motion.

Fast forward and slow motion do not change the execution speed of the CPU machine codes. For example, the speed at which all operations of an OB1 cycle are executed does not change. The execution speed depends on the processor of the PC on which the simulated PLC instance is running. If you change the scaling factor, more or fewer cycle control points are reached in a given period of virtual time.

NOTE

Performance

The performance depends on the size of your project, among other things.

If the scaling factor is too high and the cycle-time monitoring indicates that the PC was incapable of calculating the OB1 or cyclic OBs in the specified time, the simulated PLC instance goes to STOP.

Recommendation: To avoid this, start with a small scaling factor and gradually increase it step-by-step while keeping the simulated PLC instance in RUN.

If an overflow of events occurs, slow down the speed of the simulation. See Monitoring overflow (Page 89).

Fast forward

To speed up the virtual time, select a scaling factor greater than 1.

Slow motion

To slow down the virtual time, select a scaling factor less than 1.

Restrictions, messages, and solution 8

Certain actions or events can lead to behavior in S7-PLCSIM Advanced or in STEP 7 that deviates from a hardware CPU. Differences, messages, and possible solutions can be found in this chapter on restrictions.

8.1 OPC UA server

With OPC UA, data exchange is performed through an open, standardized and manufacturer-independent communication protocol. The CPU as OPC UA server can communicate with OPC UA clients, for example, with HMI panels and SCADA systems.

Configuring an OPC UA server

In S7-PLCSIM Advanced, start the simulated PLC instances via one of the TCIP/IP adapter online access points, also known as the PLCSIM Virtual Ethernet Adapter".

The OPC UA server functionality is not available if communication takes place via the PLCSIM online access point (Softbus).

User authorization for OPC UA

The S7-PLCSIM Advanced license also contains the user authorization for OPC UA.

The user authorization applies for two simulated PLC instances.

8.2 Web server

The web server integrated in a CPU enables authorized users to monitor and manage the CPU via a network. This permits evaluation and diagnostics over long distances.

Each S7-PLCSIM Advanced instance can simulate its own Web server.

The simulation of the Web server is restricted under S7-PLCSIM Advanced. The freeze state of a simulated PLC instance is not shown as an internal operating state.

Configuring the Web server

In S7-PLCSIM Advanced, start the simulated PLC instances via one of the TCIP/IP adapter online access points, also known as the "PLCSIM Virtual Ethernet Adapter".

The Web server functionality is not available if the communication is performed via the PLCSIM online access point (Softbus).

In STEP 7, configure the Web server in the CPU properties.

Restricted Web server functionality

The following Web server features are restricted as follows:

- The information may not be fully displayed on some websites due to different data handling.
- There is no topology information.
- FW updates are not supported.

8.3 Backing up and restoring the configuration of an S7-PLCSIM Advanced instance

Backing up and restoring the configuration

You can backup and restore an S7-PLCSIM Advanced instance.

You can create as many backups as you want and store a variety of configurations for an S7-PLCSIM Advanced instance.

You perform the backup and restore in the TIA Portal as you would in a real CPU.

S7-PLCSIM Advanced supports backup and restore via web servers.

A backup that was created with S7-PLCSIM Advanced can only be used with S7-PLCSIM Advanced.

It is not possible to restore the configuration of a real CPU with a backup from S7-PLCSIM Advanced.

Requirements

- The configuration of an S7-PLCSIM Advanced instance is backed up and restored over the TCP/IP protocol. Softbus (Page 39) is not supported.
- It is only possible to restore the configuration of an S7-PLCSIM Advanced instance with the corresponding backup from S7-PLCSIM Advanced.

8.4 Update of a TIA Portal project to a new CPU firmware

NOTE

Password encryption in case of updates

When a TIA Portal project is updated from CPU firmware version < V2.0 to CPU firmware version ≥ V2.0, the following error message is displayed during a download of the project to S7-PLCSIM Advanced ≥ V4.0:

"Loading of hardware configuration failed (0020 -3 2 0). Please check the diagnostic buffer of the target hardware."

To successfully download such a project to SIMATIC S7-PLCSIM Advanced ≥ V4.0, click the "Update password encryption" button while updating the project. If the "Update password encryption" button is not visible in the settings for the CPU's Protection & Security > Access control, collapse the pane on the right side to make the button visible

8.5 Restrictions for storage paths

Synchronization of the storage path in cloud memory

If the Persistence folder (<...\Persistence\<Instance Name>) is in a path that is synchronized to a cloud storage, this can lead to the following undesirable behavior:

- Instability or disconnection of active TIA Portal online connections
- Problems with TIA Portal downloads

To prevent this behavior from occurring, you have the following options:

- Do not place the folder of the Virtual SIMATIC Memory Card in a path that is synchronized to a memory on the cloud.
- Turn off the synchronization of such a folder.

Inaccessible storage path

If the folder of the Virtual SIMATIC Memory Card is on removable media and you remove the media, S7-PLCSIM Advanced cannot create an instance on the virtual memory card. It also cannot access a runtime instance at that location. The Control Panel displays a notification if it cannot access the path. To correct, replace the media or select a different path for the Virtual SIMATIC Memory Card from the control panel.

Character restrictions

Storage paths must not include Unicode characters.

8.6 Restrictions for instance names

Instance names must be between 3 and 64 characters, inclusive.

When you name instances in S7-PLCSIM Advanced, you can use basic Latin alphanumeric characters (A-Z, a-z, 0-9), "!", "=", and "-". It does not support most other special characters, such as currency, Chinese characters, or mathematical symbols. If you use an unsupported character, the instance name input box highlights in red, displays an exclamation mark, and shows an explanatory tooltip.

8.7 Restrictions for communications services

TUSEND / TURCV

When you run the UDP blocks TUSEND and TURCV via the "PLCSIM" online access (Page 53) (Softbus), you get error code 0x80C4 at the transmission end and receiving end:

Temporary communications error. The specified connection is temporarily down.

Solution

Set TCP/IP Single Adapter or TCP/IP Multiple Adapter as the online access in S7-PLCSIM Advanced.

8.8 Restrictions for instructions

S7-PLCSIM Advanced simulates instructions for CPUs S7-1500 and ET 200SP as close to reality as possible. S7-PLCSIM Advanced checks the input parameters for validity and returns outputs that are valid but do not necessarily correspond to those that a real CPU with physical inputs/outputs would return.

Instructions not supported

Unsupported instructions are treated as non-operational. The value of unsupported instructions is always "OK". S7-PLCSIM Advanced does not support the following instructions:

- DP_TOPOL
- PORT_CFG
- InitIOSystemSync
- StartIOSystemSync
- GetIOSystemSync
- GetPNWorkingClock

T_CONFIG instruction

The instruction T_CONFIG works in S7-PLCSIM Advanced via TCP/IP, but not via Softbus.

8.9 Restrictions to local communication via Softbus

Identical IP addresses for instances

If you are using the "PLCSIM" (Softbus) communication interface when you create instances through the Control Panel, they all have the same default IP address.

STEP 7, therefore, displays only one instance in the download dialog.

Working with multiple instances

When you are working with instances **without unique IP addresses**, note the following procedure for downloading from TIA Portal via "PLCSIM" (Softbus):

1. Start **only one** instance with the symbol in the Control Panel.
2. In TIA Portal, download the CPU with its specific IP address to this instance.
3. Repeat the steps until you have created all instances and downloaded all projects.

Online and diagnostics

If the "PLCSIM" (Softbus) communication interface is set, no details are displayed for the "Online and Diagnostics" function under the PROFINET interface (IP address, MAC address, etc.).

8.10 Unknown data records

Support of unknown data records

The S7-1500 hardware CPUs return an error code in case of an unknown data record. The behavior of S7-PLCSIM Advanced differs from the behavior of an S7-1500 hardware CPU. To enable simulation of the program flow, S7-PLCSIM Advanced does not return an error code for an unknown data record (e.g. ID 0x9999), but acknowledges the unknown data record with "OK".

8.11 Messages for communication via TCP/IP

Error codes

If an error occurs, a message with an error code and description appears in the notification area of the taskbar. You can find an overview of possible error messages and their associated error codes in the S7-PLCSIM Advanced API manual in the topic ERuntimeErrorCode in the Enumerations chapter.

Messages and remedy

The messages related to TCP/IP communication (Page 53) and corresponding remedies are listed below:

Message

"Siemens PLCSIM Virtual Ethernet Adapter was not found. Please reinstall S7-PLCSIM Advanced."

Remedy

The PLCSIM Virtual Ethernet Adapter cannot be found on the system.

Run the S7-PLCSIM Advanced setup again:

1. Double-click the download package or insert the installation medium into the drive. The setup program starts up automatically, provided you have not disabled the Autostart function on the computer. If the setup program does not start up automatically, start it manually by double-clicking the "Start.exe" file.
2. Follow the prompts until you reach the "Configuration" window. Select the "Repair" check box.
3. Follow the remaining prompts to repair your installation.
4. Complete the repair operation by restarting your computer.

Message

"Siemens PLCSIM Virtual Ethernet Adapter is disabled. Please enable it."

Remedy

The PLCSIM Virtual Ethernet Adapter is deactivated on the system. In the Control Panel, under "Network and Sharing Center" > "Change Adapter Settings" and activate the network adapter.

Message

"Npcap service is not running. When installed start it from elevated command prompt with 'net start npcap'."

Remedy

The Npcap is not active on the system. Open a command line in administrator mode and enter the command "net start npcap".

Message

"You have to set a valid IP address for the Siemens PLCSIM Virtual Ethernet Adapter."

Remedy

Assign a static IP address to the Siemens PLCSIM Virtual Ethernet Adapter or obtain an IP address via DHCP (default setting).

8.12 Time synchronization via NTP mode

Time synchronization via NTP mode with S7-PLCSIM Advanced

You can simulate time synchronization using NTP methods.

8.13 Restrictions of security with VMware vSphere Hypervisor (ESXi)

The following information is only important if you want to communicate with the "outside world". This means when you access a VM on which the TIA Portal is running from another virtualization platform on which an instance is running. The following changes are only necessary if you are not using TCP/IP on the local PC.

- When you use the virtualization platform VMware vSphere Hypervisor (ESXi), you must change the policy exception to communicate over TCP/IP.
- Accept the "Promiscuous mode" and "Forged transmit" options for the Virtual Switch of the ESXi.

Promiscuous mode

In promiscuous mode, the network adapter reads all incoming telegrams, including those that are not intended for the network adapter, and forwards the data to the operating system for processing.

The promiscuous mode is necessary for the simulation with S7-PLCSIM Advanced so that telegrams can be forwarded by the Ethernet adapter to the PC or the VM for processing, for example, data for additional S7-PLCSIM Advanced instances in the network.

NOTICE
Restrictions of security For security reasons, Promiscuous mode is disabled by default. If you accept the Promiscuous mode, the real Ethernet adapter even receives telegrams that are not addressed to it.

The following figure shows the "Security" category for selecting the security settings for the virtual switch in VMware vSphere Hypervisor (ESXi).

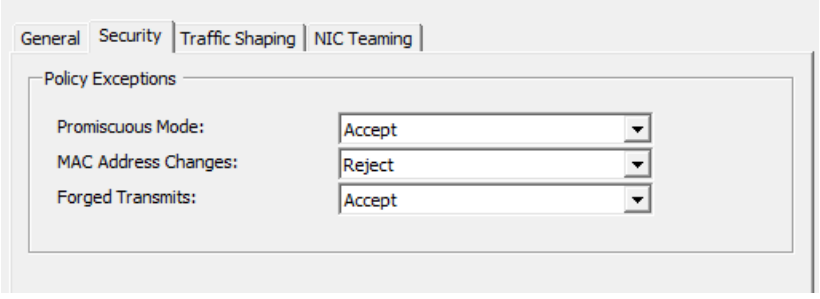

Figure 3-259 Policy exceptions for VMware vSphere Hypervisor (ESXi)

8.14 Restrictions for Hyper-V

The following information is only important if you want to communicate with the "outside world". Communication with the "outside world" means that you access another VM running TIA Portal from a virtualization platform running an instance. When you are using TCP/IP on the local PC, the following settings are not necessary.

When you use the virtualization platform Hyper-V, you must change the following setting to be able to use the communication over TCP/IP.

1. In the Hyper-V Manager, select the Hyper-V server.
2. Select the VM and its settings via "Settings...".
3. In the "Extended Functions", select "MAC Address Spoofing".

This setting is necessary for the simulation with S7-PLCSIM Advanced so that telegrams can be forwarded by the Ethernet adapter to the PC or the VM for processing, for example, data for additional S7-PLCSIM Advanced instances in the network.

NOTICE
Restrictions of security For security reasons, "TCP/IP Single Adapter" network mode is disabled by default. If you accept the "TCP/IP Single Adapter" network mode, the real Ethernet adapter even receives telegrams that are not addressed to it.

8.15 Restrictions for AWS Cloud

The AWS Cloud Connector does not support Layer2 Communication. S7-PLCSIM Advanced does not fully support cloud-based server use cases within Layer2 communication. Therefore, the TIA Portal cannot find the simulated PLC instance by ARP Request. As a workaround, set the IP Address of the instance before starting the download.

If you use TCP/IP Multiple Adapter network mode, you must map network adapters to CPU interfaces. In case of only the X1 interface, you can use the Control Panel to set the Interface association to the appropriate network adapter.

For a successful download from the TIA Portal, you need to set only the IP address of the simulated PLC instance interface (for example, X1) to which you are downloading.

If you need to adapt additional interfaces, use the API. Refer to the SetNetInterfaceMapping() method in the S7-PLCSIM Advanced API Manual, section "Interfaces for IInstances".

8.16 Monitoring overflow

Monitoring of main cycle

The maximum cycle time monitoring for S7-PLCSIM Advanced is one minute.

Monitoring of cyclical events

If your simulation contains cyclic interrupts, the queue of S7-PLCSIM Advanced can overflow for cyclic events. Due to the runtime speed of S7-PLCSIM Advanced compared to real hardware, the time needed to create the diagnostic buffer entry might be longer than the time until the next cyclic interrupt.

In this case, an additional entry is placed in the queue, causing another overflow. In the event of an overflow, S7-PLCSIM Advanced provides diagnostics buffer messages and a red error icon in the project tree in STEP 7.

8.17 Deviating I/O values in the STEP 7 user program

If a watch table in the TIA Portal changes an input value, S7-PLCSIM Advanced does not read the changed value.

8.18 Multiple simulations and possible collision of IP addresses

You can simultaneously simulate multiple CPUs, but each simulated CPU interface requires a unique IP address.

Make sure your CPUs have different IP addresses before starting the simulation.

8.19 Lacking access to an IP address

Special feature of distributed communication

If you use multiple network nodes on the same subnet through different virtual or real adapters, the operating system may search for the node on the wrong adapter.

Remedy

Repeat your requests or enter "arp -d <IP address>" in the command line editor of Windows.

8.20 Simulation in standby mode

S7-PLCSIM Advanced does not support Standby, Sleep, or Hibernation mode on physical PC or virtual machine (VM) environments.

8.21 Simulation start of SIMIT with S7-PLCSIM Advanced

Error message during simulation start of SIMIT with S7-PLCSIM Advanced

You have configured an S7-PLCSIM Advanced connection in SIMIT. When starting the simulation, SIMIT aborts and the following error message is returned:
`"-14 InstanceNotRunning"`

When the error has occurred, you can also no longer open the S7-PLCSIM Advanced instance using TCP/IP Single Adapter or TCP/IP Multiple Adapter (the PLCSIM Virtual Ethernet Adapter).

Solution

You have the following solution options:

- Repair your S7-PLCSIM Advanced installation.
- Install S7-PLCSIM Advanced once again.

The procedures are described in the section Installing (Page 31).

A repair or new installation will install the Npcap program library once again, which solves the problem.

8.22 Known restrictions when operating with a co-simulation, for example, SIMIT

In case of a simulation in S7-PLCSIM Advanced in connection with SIMIT, a TIA Portal download in RUN may result in an MC error (MC message 431: Communication to the device under logical address [...] is disturbed. Sign of life of drive faulty).

This error can occur with the following project settings:

- Bus-synchronous operating mode in SIMIT or event-synchronous operating mode to MC servo process image partition (PIP)
- the S7-PLCSIM Advanced feature "Strict Motion Timing" = true

The error causes the activated axes to be switched off. You can acknowledge the error via an MC_Reset or via the TIA Portal. After that, the axis can be switched on again.

8.23 ET 200SP CPUs: Use of BusAdapters with fiber-optic interface

ET 200SP CPUs: Use of BusAdapters with fiber-optic interface

If you use BusAdapters with fiber-optic interface for connecting fiber-optic cables (e.g. BA 2xLC), then download via TCP/IP is not possible.

Remedy

Use the communication interface "S7-PLCSIM" (Softbus) in S7-PLCSIM Advanced.

8.24 Installing SIMATIC NET

Problems after installing SIMATIC NET PC software products

If you are using one of the following operating systems with S7-PLCSIM Advanced on your PC, problems may arise with the S7-PLCSIM Advanced instances via TCP/IP if you have installed SIMATIC NET PC software products on your PC:

- Windows 10 Pro, Version 1809
- Windows Server 2019

After installing the SIMATIC NET PC software products, you may no longer be able to start the S7-PLCSIM Advanced instances via TCP/IP.

Remedy

Update the operating system on your PC:

- Windows 10, Version ≥ 1903 or
- Windows Server version > 2019

8.25 No simulation for configuration control

S7-PLCSIM Advanced does not simulate configuration control, which is also known as option handling. Refer to the TIA Portal information system for details about configuration control.

8.26 Communication interface is not updated on the control panel when using an older API

If you are using an S7-PLCSIM Advanced API version older than V6.0, the communication interface might not display correctly on the S7-PLCSIM Advanced Control Panel.

8.27 Trace jobs with duplicate timestamps for motion OBs

A trace for an isochronous OB, for example, MC Servo, could sporadically have two values with the same timestamp.

8.28 The control panel shows VPNs

When using TCP/IP Single Adapter for online access, the list of adapters can include VPNs. You cannot use these VPNs as network adapters.

8.29 Downloading a central CP with S7-1500R/H CPU family using TCP/IP

If a central CP exists next to an S7-1500R/H CPU and you start download from STEP 7 to a simulated PLC instance with an ISO IP (0.0.0.0) in TCP/IP communication, the download fails. To prevent a failed download, define the IP address of the instance before the download.

If you have already attempted a download, download a second time. The second download will be successful.

8.30 Axis control panel functionality

If you add a large quantity of axis related Technology objects to your TIA Portal project and attempt to simulate the PLC with S7-PLCSIM Advanced, you might encounter issues during commissioning. If you are unable to select "Activate" under Master control or "Enable" under Axis in the Axis control panel, do one or more of the following:

- Increase the cycle time of the MC-Servo OB
- Lower the virtual time scaling (Page 79) of the S7-PLCSIM Advanced instance

  Setting a scaling factor less than 1 scales the virtual time proportionately. For example, a scale factor of 0.25 means the virtual time is 4 times slower than the system time.
- Use a higher performance PC

8.31 Cannot locate S7-PLCSIM Advanced Instances

If you are unable to locate your S7-PLCSIM Advanced instances, follow these steps:

1. From your Windows OS, open the Network and Sharing Center.
2. Click the network that corresponds to the "Siemens PLCSIM Virtual Ethernet Adapter".
3. Select Properties.
4. If any of the following services appear in "This connection uses the following items", ensure the checkboxes for these services are deselected for the "Siemens PLCSIM Virtual Ethernet Adapter":
   - Fortinet VPN service
   - Juniper Network Service
   - Reliable Multicast Protocol

8.32 Synchronization of IRT systems

Synchronization between different IRT IO-Systems is not supported.

8.33 Simulated PLC will not RUN with local I/O send clock

If you configure an isochronous OB in your STEP 7 project to run with the send clock of the central I/O system, you cannot set the simulated PLC instance to RUN. Synchronization with the central I/O bus-system is not supported. To mitigate this issue, follow these steps:

1. Access the properties of the OB in your STEP 7 project.
2. Under the "General" tab, select "Cycle time".
3. Click the radio button to change the Cycle time to "cyclic".

You can now set the simulated PLC instance to RUN.

8.34 Download error after change to "IP address from DHCP server" in STEP 7

If you change the selection in your STEP 7 project to set "IP address from DHCP server", STEP 7 displays an error the first time you download the new settings to your instance. However, your instance retains the new IP address assigned from the DHCP server.

To resolve the error, download the project to your simulated instance a second time.

8.35 Software PLC interfaces not showing after download

The total number of Software PLC interfaces is limited to two. If your STEP 7 project has more than two Software PLC interfaces configured, some interfaces will not be available after a download.

Software PLC interfaces will appear in the download in the order they were assigned in your STEP 7 project. For example: If you assign the ports of the CP (Communication Processor) card before you assign the X2 interface in the project, then the CP card configures the addresses for these two interfaces.
To ensure the desired Software PLC interface is available after the download, even when the total number of configured interfaces exceeds the limit of two, follow these recommendations:

1. Assign the desired interface first in the TIA project.
2. Add any additional interfaces.
3. Download the new configuration.

8.36 Out of memory error when creating instances

When you create and power on multiple instances from the control panel, you might receive an error indicating that the computer is out of memory. Out of memory can especially occur if you are creating multiple instances and the instances are unspecified instances. Unspecified instances are instances for which you have not downloaded a specific PLC from the TIA Portal to the instance.

When powered on, S7-PLCSIM Advanced allocates the maximum quantity structures for these instances. Instances that correspond to a specific PLC have the quantity structures for the specific PLC.

When you power on an instance from the control panel, S7-PLCSIM Advanced attempts to allocate the memory for the instance. The out of memory error can occur when the computer has insufficient memory.

Corrective actions

If you encounter an out of memory error try one of the following actions:

- Add more RAM to your computer.
- Download a specific PLC to each instance rather than creating an "unspecified" instance.
- Increase the Windows virtual memory paging file size.

Increasing virtual memory paging size

To increase the virtual memory paging size, follow these steps:

1. From the Advanced system settings of Windows, navigate to the Advanced tab of the System properties.
2. Click Settings.
3. From the Advanced tab of Performance options, click "Change" for Virtual memory.

4. Deselect the option for automatically managing paging file size.
5. Select the drive letter for your S7-PLCSIM Advanced instances, and select custom size.
6. Increase the maximum size and check whether you can power on your instances without error.

8.37 Input area within the Startup OB resets upon execution

When simulating an S7-PLCSIM Advanced instance in STEP 7, data written to the input area within the Startup OB, or any other OB that runs before the Main OB, will be reset when the Main OB begins executing.

8.38 "Show Notifications" enabled in the Control Panel but notifications are not showing

If you are not receiving notifications from S7-PLCSIM Advanced even though you have selected "Show Notifications" in the Control Panel, it might be due to your Windows settings.

To ensure your Windows settings do not interfere with notifications from S7-PLCSIM Advanced, verify that all of the following Windows System "Settings" are configured properly:

- Notifications are turned on.
- Do not disturb mode is turned off.
- Focus assist is disabled (if applicable).

8.39 Starting an instance from a virtual memory card that has a safety program

S7-PLCSIM Advanced cannot start a simulation instance from a Virtual SIMATIC Memory Card that contains a safety program for an F-CPU. The typical process for creating a Virtual SIMATIC Memory Card from a user-defined card of your CPU causes an error.

When you start the instance that you created on the Virtual SIMATIC Memory Card from the user-defined card, the Error LED flashes red. If you have notifications enabled, you see a message stating that no TIA Portal project was downloaded on your instance.

The reason this error occurs is because the Virtual SIMATIC Memory Card for S7-PLCSIM Advanced has invalid contents when the simulation instance contains a safety program.

Modifying the sim_hwdb.ini in your Virtual SIMATIC Memory Card

To enable S7-PLCSIM Advanced to start an instance from a Virtual SIMATIC Memory Card that contains a safety program that originated from a user-defined card, you must modify the sim_hwdb.ini file. By default, the sim_hwdb.ini uses a simulation CPU ordering number, but for safety programs on F-CPUs, the CPU Ordering Number must be the actual article number of your F-CPU. To modify the file follow these steps:

1. Open the sim_hwdb.ini file for your Virtual SIMATIC Memory Card instance in a text editor. This file is at the same level as the SIMATIC_MC folder. The contents appear as follows (for a simulated S7-1500 instance):

```
{
    "CPU Ordering Number": "6ES7 SIM-01500-APLC ",
    "CPU Serial Number": "10S C-n058624505",
    "HWDB Version Major": 1,
    "HWDB Version Minor": 1,
    "User-defined MAC IE1": "FF-FF-FF-FF-FF-FF",
    "User-defined MAC IE2": "FF-FF-FF-FF-FF-FF",
    "User-defined MAC IE3": "FF-FF-FF-FF-FF-FF",
    "CPU Family": "VPLC1500"
}
```

2. Replace the CPU Ordering Number with the article number of your F-CPU in your STEP 7 project. Note there is an additional space at the end.
3. Save the file.

Result

You can now start the simulation instance from the Virtual SIMATIC Memory Card that contains your user-defined card structure and your modified sim_hwdb.ini file.

8.40 Connecting to interface/subnet in STEP 7

Do not use the W1 interface in STEP 7 when downloading your project to an S7-PLCSIM Advanced instance.

8.41 Using "Protection of confidential PLC configuration data" with a TIA Portal V20 project

To use "Protection of confidential PLC configuration data" in a TIA Portal V20 project with your simulated PLC instance, select the check box and set the password for it in the STEP 7 project. Download "Hardware and software" to the simulated PLC instance.

NOTE

Problems from downloading

If you select "Protection of confidential PLC configuration data" and set a password in the STEP 7 project, then download only "Hardware configuration" to a simulated PLC instance, this causes a password error on the instance.

If you receive a password error, follow these steps:

1. In the Project tree, expand "Online access".
2. Expand the PLCSIM access point.
3. Double click "Update accessible devices".
4. Expand your PLC and double click to open "Online & diagnostics".
5. In the "Online access" window, expand "Functions".
6. Select "Specify password to protect the PLC configuration data".
7. Click "Setup" and enter the same password you set in your project.

Now you can download the hardware configuration.

8.42 Maximum quantity structure for Software/Open Controller

S7-PLCSIM Advanced does not support the maximum quantity structure for Software/Open Controller V40.0 CPUs.

8.43 Out of memory error when creating instances

When you create and power on multiple instances from the control panel or from the API, you might receive an error indicating that the computer is out of memory. Out of memory can especially occur if you are creating multiple instances and the instances are unspecified instances. Unspecified instances are instances for which you have not downloaded a specific PLC from the TIA Portal to the instance.

When powered on, S7-PLCSIM Advanced allocates the maximum quantity structures for these instances. Instances that correspond to a specific PLC have the quantity structures for the specific PLC.

When you power on an instance, either from the control panel or from the API PowerOn() method, S7-PLCSIM Advanced attempts to allocate the memory for the instance. The out of memory error can occur when the computer has insufficient memory.

Corrective actions

If you encounter an out of memory error try one of the following actions:

- Add more RAM to your computer.
- Download a specific PLC to each instance, or if registering an instance from the API, register an instance for a specific CPU type.
- Increase the Windows virtual memory paging file size.

Increasing virtual memory paging size

To increase the virtual memory paging size, follow these steps:

1. From the Advanced system settings of Windows, navigate to the Advanced tab of the System properties.
2. Click Settings.
3. From the Advanced tab of Performance options, click "Change" for Virtual memory.
4. Deselect the option for automatically managing paging file size.
5. Select the drive letter for your S7-PLCSIM Advanced instances, and select custom size.
6. Increase the maximum size and check whether you can power on your instances without error.

8.44 Motion restrictions for the S7-1200 G2 family CPUs

S7-PLCSIM Advanced does not support motion PTO (Pulse Train Output) for the S7-1200 G2 family CPUs.

8.45 Restriction for "Optional I/O device" selection in STEP 7

S7-PLCSIM Advanced does not support the "ReconfigIOSystem" function block when an I/O System has the "Optional IO-Device" setting enabled in your STEP 7 project. To download your configuration and simulate, you must disable this setting.

8.46 Restricted support for onboard I/O devices with S7-1200 G2 instances

S7-PLCSIM Advanced does not support the following special functionalities for onboard I/O devices with S7-1200 G2 CPU simulated instances:

- Pulse Width Modulation (PWM)
- Pulse Train Output (PTO)
- High-Speed Counter (HSC)
- Associated instructions:
  - CTRL_PWM
  - CTRL_PTO
  - CTRL_HSC_EXT

8.47 Restriction for Ethernet/IP instruction

S7-PLCSIM Advanced does not support the Ethernet/IP instruction "LCCF_EnetScanner".

8.48 Restriction for using "Upload as new station" in STEP 7 with an S7-1200 G2 CPU

You must set the communication mode for your simulated S7-1200 G2 instance (1212/1214, V4.1) to "TCP/IP" to "Upload device as new station" in STEP 7.

List of abbreviations

A

Abbreviation	Term
ALM	Automation License Manager Tool for managing license keys in STEP 7
API	Application Programming Interface
arp	Address resolution protocol
CPU	Central Processing Unit (Synonym for PLC)
DLL	Dynamic Link Library
HMI	Human Machine Interface user interface
I-device	Intelligent IO device
IE	Industrial Ethernet
ISO	International Organization for Standardization on Transport Control Protocol
LAN	Local Area Network Computer network that is limited to a local area.
MFP	Multifunctional platform
MRES	Memory Reset
OB	Organization Block
ODK	Open Development Kit
OPC UA	Open Platform Communications Unified Architecture
PA	Process image output (PIQ)
PG	Programming device
PLC	Programmable Logic Controller
PN	PROFINET
RAM	Random Access Memory
RT	Runtime
SO	Shared Object
TCP/IP	Transmission Control Protocol/Internet Protocol
TIA	Totally Integrated Automation
PIP	Process Image Partition
UTC	Coordinated Universal Time
VM	Virtual Machine
WinCC	Windows Control Center

SIEMENS

SIMATIC

S7-PLCSIM Advanced API

Programming Manual

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Introduction 1

1.1 General information

Purpose of the documentation

This manual describes the API for the simulation software, SIMATIC S7-PLCSIM Advanced. You can use the API to simulate and test your SIMATIC STEP 7 programs on a simulated PLC instance. You can also use the API to connect the simulated PLC instance to a system or machine simulation (co-simulation).

Basic knowledge required

The API must only be used by qualified staff.
The following knowledge is required:

- Industrial Automation and Automation Technology
- Programming with STEP 7 (TIA Portal)
- SIMATIC CPUs and CPU programming
- PC-based automation using S7-1500 and WinCC Runtime Advanced
- Knowledge of programming with C++ or C#
- PC technology
- Windows operating system

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "SIMATIC STEP 7 (TIA Portal)".

Also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Scope

This manual is valid for the following product variants:

Article number	Product variants
6ES7823-1FA06-0YA5	SIMATIC S7-PLCSIM Advanced V8.0
6ES7823-1FE06-0YA5	SIMATIC S7-PLCSIM Advanced V8.0 Download
6ES7823-1FA06-0YE5	SIMATIC S7-PLCSIM Advanced V8.0 Upgrade V1.0 -> V8.0
6ES7823-1FE06-0YE5	SIMATIC S7-PLCSIM Advanced V8.0 Upgrade V1.0 -> V8.0 Download
6ES7823-1FE06-0YA7	SIMATIC S7-PLCSIM Advanced V8.0 POC
6ES7823-1FE00-0YN5	SIMATIC S7-PLCSIM Advanced Subscription Download

The articles each contain one license, which is valid for two instances.

NOTE

You can obtain online readme updates to the S7-PLCSIM manuals on the Internet (https://support.industry.siemens.com/cs/us/en/view/109824282).

You can find the following application examples for S7-PLCSIM Advanced on the Internet:

- SIMATIC S7-PLCSIM Advanced: Co-Simulation via API (https://support.industry.siemens.com/cs/ww/de/view/109739660/en)
- Digitalization with TIA Portal: Virtual commissioning with SIMATIC and Simulink (https://support.industry.siemens.com/cs/ww/en/document/109749187)

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal service and dispose of the equipment according to the applicable regulations in your country.

Industry Mall

The Industry Mall (https://mall.industry.siemens.com) is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

1.2 S7-PLCSIM Advanced documentation guide

The control panel buttons display the English S7-PLCSIM Advanced Function Manual and API Manual in PDF format. Download the free Adobe Reader if necessary to view PDFs. The installation folder of S7-PLCSIM Advanced includes German PDFs and English PDFs.

Other display formats are available at Siemens Industry Online Support (//https://support.industry.siemens.com/) (SIOS).

Accessing documentation on SIOS

Documentation for this product is available at Siemens Industry Online Support (//https://support.industry.siemens.com/). Formats include the following for display or download:

- PDF document
- Multimedia document (HTML5 Web site)
- Website with chapter structure (useful for providing a specific topic link to other people)

From the Web site, search for your product name. Filter the search results by manuals if you are only looking for documentation. For your product, select the edition that corresponds to the version of your product. You can switch the display language for the page and the documents from the menu.

The various document formats provide navigation and search features based on their documentation format.

Navigating an HTML5 site

When you open an HTML5 Web site, click Begin from the Start page.

The table of contents displays on the left. Each chapter collapses as you navigate from one chapter to the next to optimize screen space on devices such as phones and tablets. You can also click the button to hide the table of contents. Click to restore it.

Left and right arrow buttons allow to navigate back and forward through topics that you have previously viewed:

Previous and next page buttons allow you to navigate sequentially through topics and chapters in the order of the table of contents:

Searching in an HTML5 site

To search an HTML5 Web site, click the button on the right. When you enter your search text, you see a list of topics that contain the search text. Click any topic to view it. The page highlights occurrences of the matched search text.

To see where the topic exists in the table of contents, click the button to switch from the search view to the table of contents view. To switch back to your search, click again. The search functions much the same as any search from a Web browser. Ctrl+F searches within the displayed topic.

Changing the language of the HTML5 site

The S7-PLCSIM Advanced HTML5 documentation includes German and English. Click the button to switch to another language.

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.4 Tool support

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/us/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.5 Administrator rights

NOTE

Administrator rights

For normal operation, the standard user rights are sufficient. You need administrator rights only when you install or repair S7-PLCSIM Advanced or change the network configuration.

Industrial cybersecurity 2

2.1 Introduction

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the relevant system manual of the devices used for general information and measures regarding industrial cybersecurity.

2.1.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

2.2 Basic information on industrial cybersecurity

2.2.1 Definition of industrial cybersecurity

Industrial cybersecurity is generally understood to mean all measures to protect against the following threats:

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability (for example, due to the destruction of data or denial of service (DoS))

2.2.2 Objectives of industrial cybersecurity

The objectives of industrial cybersecurity are:

- Ensuring trouble-free operation of industrial plants and production processes
- Preventing threats to people and production from cybersecurity attacks
- Protection of industrial plants against espionage and manipulation
- Protection of industrial automation systems and components against unauthorized access and data loss
- Provision of a practical and cost-effective concept for securing existing plants and devices that do not have their own security functions
- Use of existing, open, and proven industrial cybersecurity standards
- Compliance with legal requirements

An optimized and adapted security concept applies to automation and drive technology. The security measures must not impede or endanger production.

2.3 Operational application environment and security assumptions

2.3.1 Intended use

SIMATIC products are intended for use in industry. If you plan to use the product in a different environment, check the conditions required for such use.

The product may be operated only by personnel qualified for the specific task in accordance with the relevant documentation, in particular its warning notices and safety information. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products.

2.3.2 Requirements for the operational application environment and security assumptions

Siemens recommends the following security measures:

- Threat and Risk Assessments (as part of security management)
- Network security concepts
  - Network segmentation
  - Asset and network management
  - Network protection
  - Remote access
- Access control concepts (utilizing access control systems)
  - Physical protection
  - Physical corporate security
  - Physical product security

Threat and Risk Assessment

Vulnerabilities and risks are identified, and countermeasures are proposed to ensure the security of the system, networks, and data.

Network security concepts

You can find information on network security in the whitepaper "Industrial Network Security Architecture", available at the Download Center (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security/downloads.html) on the Industrial Cybersecurity (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html) website.

Access control concepts

Physical protection

In addition to closing off and/or monitoring entire production facilities, it may be necessary to physically secure cabinets or even individual components such as circuit breakers.

Physical corporate security

You can ensure physical corporate security by the following measures, among others:

- Closed off and monitored company premises
- Access control, locks/card readers, and/or security personnel
- Accompaniment of non-employees by company personnel
- Employees are trained on and embrace security processes within the company

Physical production security

You can ensure the physical production security by, among others, the following measures:

- Separate access control for critical areas, such as production zones.
- Installation of critical components in lockable cabinets/control rooms with monitoring and alarm capabilities. The cabinets/control rooms must be secured with a cylinder lock. Do not use simple locks, such as universal, triangular/square, or double-bit locks.
- Radio field planning to limit WLAN coverage areas, preventing them from extending beyond defined zones (e.g. factory floor).
- Guidelines that prohibit the use of external data storage media (such as USB flash drives) and IT devices (such as laptops) classified as unsafe on systems.

2.4 Secure operation

This section describes measures that Siemens recommends to protect against manipulation and unauthorized access.

Guidelines

Observe the following guidelines for secure operation:

- Use only the original version as provided on the Internet and follow the Installation notes.
- Check regularly whether there are new versions available for download and use the latest version.

Dependencies on other software components

Verify that your computer meets the System requirements.

2.4.1 Security update notification

Read the special information on maintaining the operational safety of your plant in the Introduction section.

Set up notification of security updates

To receive notifications about security updates, proceed as follows:

1. Register with mySiePortal (https://sieportal.siemens.com/en-ww/mysieportal).
2. Enter the keyword "Security" in the search engine.
3. Choose the "Search in Knowledge base" option.
4. Enter the name or article number of the product in the product search.
5. Select the "Other types" option from the filter menu for "Type," and then choose "Download" and "Product note".

6. For the document you want to be informed about, select "Add to my favorites" using the 3 dots on the right.

   For example, if you want to receive notifications about all firmware versions of the S7-1500 CPUs, select the entry "Firmware update S7-1500 CPUs incl. Displays and ET 200 CPUs (ET 200SP, ET 200pro)".

7. In the following dialog, enter a name for the favorite, select the storage location and select the "Notify me" option. Then click the "+ Add to my favorites" button.

Result: You will be notified by email each time the document is changed.

Under "mySiePortal" > "Lists & notifications" > "My notifications", you can display your notifications and delete them if necessary.

2.4.2 Hardening measures

System hardening, also simply referred to as hardening, is the secure configuration of products or systems. The aim is to close security gaps and take various measures to reduce the attack surfaces for cyberattacks.

Measures for system hardening include, for example:

- Secure configuration in which only necessary software components and services are installed or activated for proper operation.
- Access control, by which a restrictive user and rights management system is implemented.

2.4.3 Access control

In addition to physical protection, also establish logical safeguards to control access to your system:

- Use a restrictive user and rights management system, for example, for accessing the CPUs and TIA Portal.
- Refer to the information about password management in the section Users and roles (https://docs.tia.siemens.cloud/access?ft:originId=./100365717643/100365717643_enUS.htm&ft:clusterId./100365717643/100365717643.htm) and in the STEP 7 online help (TIA Portal).

2.4.4 Notifications about security vulnerabilities (Siemens Security Advisories)

A vulnerability is a security vulnerability in information security. A vulnerability can pose a threat as it provides intruders with the opportunity to access system resources and manipulate or steal data. Many vulnerabilities allow availability to be impaired.

Siemens ProductCERT

If Siemens identifies or fixes Security Vulnerabilities in the products, this will be published in the Security Advisories.

You can find the documents for SIMATIC on the following website of the Siemens Aktiengesellschaft: Siemens ProductCERT and Siemens CERT (https://new.siemens.com/global/en/products/services/cert.html?s=SIMATIC#SecurityPublications)

"Search Security Advisories" is the default entry in the "SIMATIC" search field. You can also enter other product names or other terms in the search field and search for them.

On this page, you will also find all the required information on how to deal with vulnerabilities:

- Contact persons for matters related to vulnerabilities
- Options for automated notifications regarding vulnerabilities
- Notifications are also possible in CSAF format
- Option to subscribe to RSS feeds and newsletters
- List of all current vulnerabilities and detailed information such as:
  - Description
  - Classification according to Common Vulnerability Scoring System (CVSS)
  - Measures
  - Availability
  - Etc.

Set up Security feeds (https://www.siemens.com/cert) to receive notifications about security-related topics.

If you suspect or have discovered a vulnerability in a Siemens product, please let us know immediately. To do this, press the "Contact" button on the CERT Services page (https://www.siemens.com/cert) and follow the instructions.

2.4.5 Data backup

Secure your configuration and parameter settings so that you can quickly restore this data if needed.

2.4.6 Secure uninstallation

Use the Windows control panel to uninstall the product and follow the dialog prompts.

Product overview

3

3.1 What is S7-PLCSIM Advanced?

You use S7-PLCSIM Advanced to simulate your CPU programs on a simulated PLC instance. You do not need any real controllers for simulation. You configure your CPU with STEP 7 in TIA Portal, program your application logic and then load the hardware configuration and the program into the simulated CPU. From STEP 7, you run your program logic, monitor the effects of simulated inputs and outputs, and adapt your programs.

In addition to communication via Softbus, which limits communication to a local PC or virtual machine, S7-PLCSIM Advanced offers a full Ethernet connection and thus also supports distributed I/O systems.

S7-PLCSIM Advanced also includes an application programming interface (API), which enables interaction with native C++/C# programs or simulation software. The API extends simulation capabilities and provides features such as the following:

- Simulation of hardware interrupts
- Stopping a simulation
- Synchronization with simulation partners

For these and other API functions, refer to the S7-PLCSIM Advanced API manual included with your release.

Application areas

Typical application areas of S7-PLCSIM Advanced are:

- Verification of the user program (TIA Portal)
- Testing of the STEP 7 program
- Software in the loop simulation for the virtual commissioning of machine tools/production machines, production cells, and production lines in a plant.
- Operator training through the connection of a real HMI

Advantages

S7-PLCSIM Advanced offers numerous advantages:

- Improve the quality of automation projects by early error detection
- Avoid costs for hardware in simulation environments
- Shorten commissioning time
- Reduce risk for commissioning
- Train operators earlier
- Increase production efficiency by optimizing program components

- Increase efficiency during replacement of machine components
- Increase efficiency during expansion of existing plants

3.2 Functions for licenses

API functions for licenses

S7-PLCSIM Advanced regularly checks whether a license is available. The following return values provide information about the status (for example, for C++):

- Return values for API function `PowerOn()` and callback function `OnOperatingStateChanged`
  - `SREC_OK` when a floating license is available.
  - `SREC_WARNING_TRIAL_MODE_ACTIVE` when an instance is started with the Trial License.
  - `SREC_WARNING_RUNNING_ON_TIA_PORTAL_TEST_SUITE` when no valid license for S7-PLCSIM Advanced is available, but a "TIA Portal Test Suite" license is available.

    S7-PLCSIM Advanced starts with this license. A download from the TIA Portal is possible, but the instance terminates without feedback if the download was not made from the TIA Portal Test Suite.
  - `SREC_NOT_EMPTY` when no valid license for S7-PLCSIM Advanced is available, but a "TIA Portal Test Suite" license is available.

    If this is the case, power-up from the Virtual SIMATIC Memory Card is not supported.
- Return value for callback function `OnOperatingStateChanged`
  - `SREC_LICENSE_NOT_FOUND` when the instance is automatically shut down after 21 days.

Components of the Simulation Runtime

The following components are relevant for handling the Simulation Runtime of S7-PLCSIM Advanced:

Table 3-362 Components of the Simulation Runtime

Components	Description
• "Siemens.Simatic.Simulation. Runtime.Manager.exe"	A Windows process that runs in the background. Main component of Runtime that manages all other Runtime components. The process is started automatically as soon as an application attempts to initialize the Runtime API. It is ended automatically as soon as there is no longer any application running that initialized the Runtime API.
• "Siemens.Simatic.Simulation. Runtime.Instance.exe"	The process of the instance that loads a DLL of a simulated PLC instance. Each simulated PLC instance generates its own process.
• "Siemens.Simatic.Simulation. Runtime.Api.x86.dll" • "Siemens.Simatic.Simulation. Runtime.Api.x64.dll"	API libraries that must load an application to use the Simulation Runtime. The libraries contain interfaces for native code and managed code. The "Runtime.Api.x86.dll" is loaded exclusively by 32-bit applications, and the "Runtime.Api.x64.dll" by 64-bit applications.

Components	Description
• "SimulationRuntimeApi.h"	Header file that describes all data types that require a native C++ application to use the API library.
• "Siemens.Simatic.PlcSim.Vplc1500.ODKClient.so.exe"	ODK client process for a CPU function library (original Shared Object)
• "Siemens.Simatic.PlcSim.Vplc1500.ODKClient.x86.exe"	ODK client process for a 32-bit application
• "Siemens.Simatic.PlcSim.Vplc1500.ODKClient.x64.exe"	ODK client process for a 64-bit application

External applications and Simulation Runtime

The following figure schematically presents the access of external applications to Simulation Runtime via the Runtime API. The Simulation Runtime Manager manages the Runtime instances. These load the libraries of the simulated PLC instances.

An external application can be, for example, another simulation software or a graphical user interface (GUI).

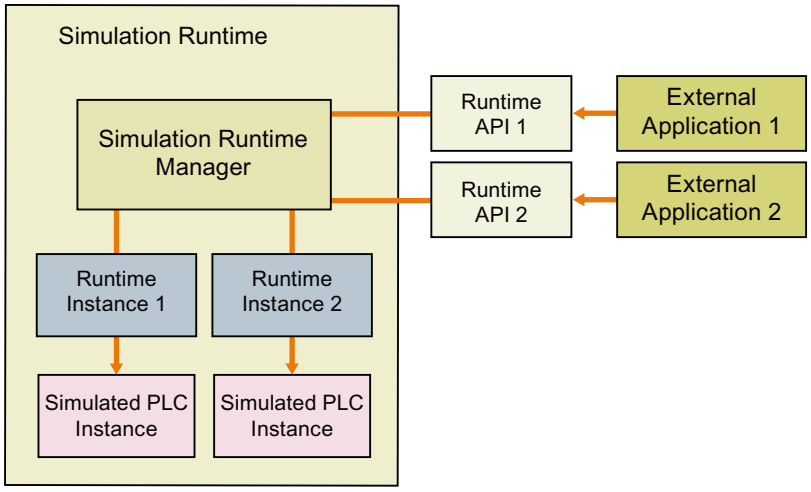

Figure 3-260 External applications and Simulation Runtime

3.3 System requirements

For S7-PLCSIM Advanced to operate efficiently, the following minimum requirements for computer hardware or for a virtual machine must be met.

	Hardware
Processor	• A modern multi-core processor with sufficient performance • One core per simulation instance started • At least one additional core for the operating system • At least one additional core for extra active applications For virtual machines: A corresponding number of processors must be physically available on the host.

	Hardware
RAM	• 16 GB minimum Memory requirements increase with the number of instances and the complexity of the simulation
Free hard disk space	20 GB
Screen resolution	Minimum 1920 x 1080 (Full HD)

Operating systems and virtualization platforms

S7-PLCSIM Advanced supports the same operating systems, virtualization, and hard disk encryption technology as the corresponding STEP 7 Basic version, with the exception of the Windows Home operating systems. S7-PLCSIM does not support the Windows Home operating systems. See the TIA Portal Information System for a full list of supported technologies.

Refer to online information (https://support.industry.siemens.com/cs/ww/en/view/78788417) for installing STEP 7 (TIA Portal) and S7-PLCSIM Advanced on a virtual machine.

3.4 Restrictions due to antivirus programs

NOTICE
Restrictions due to virus scanners and Advanced Threat Protection software (ATP software) Virus scanners and ATP software that monitor the behavior of processes and communication can have a significant influence on the performance of the runtime and communication of S7-PLCSIM Advanced and even prevent S7-PLCSIM Advanced instances from starting.

Solution

You can decrease restrictions during installation and runtime of S7-PLCSIM Advanced. To do so, define exceptions for the virus scanner for secure files and folders. Add the following folders to the exceptions:

- "C:\Program Files\Common Files\Siemens\PLCSIMADV\Drivers"
- "C:\Program Files (x86)\Common Files\Siemens\PLCSIMADV"
- "C:\Program Files (x86)\SIEMENS\Automation\PLCSIMADV\bin"

If the virus scanner only allows files as exceptions, add all files from the listed folders to the exceptions. The procedure is described in the instructions of the respective manufacturer.

NOTE

Refer to the latest readme (https://support.industry.siemens.com/cs/us/en/view/109824282) on the Siemens Industry Online Support site for updates. Select the Edition that corresponds to your release version.

Virus scanner and security software support

Refer to "General software and hardware requirements" in the TIA Portal information system for the supported virus scanners and security software.

Siemens recommends Windows Defender that is part of the Windows operating system.

Symantec Endpoint Protection 14.3

Note the following restriction for Symantec Endpoint Protection 14.3 when using TCP/IP Single Adapter or TCP/IP Multiple Adapter:

If you use Npcap with Symantec Endpoint Protection, select one of the following options:

- Uninstall Symantec Endpoint Protection.
- Use Symantec Endpoint Protection with Npcap V1.60 or earlier.

3.5 Access to instances

Access via the Control Panel and the API

You can access a local instance on the PC via the Control Panel. It does not matter on which PC an instance was created and started. With distributed communication, the Runtime API accesses the instance of the other PCs via the Simulation Runtime Manager.

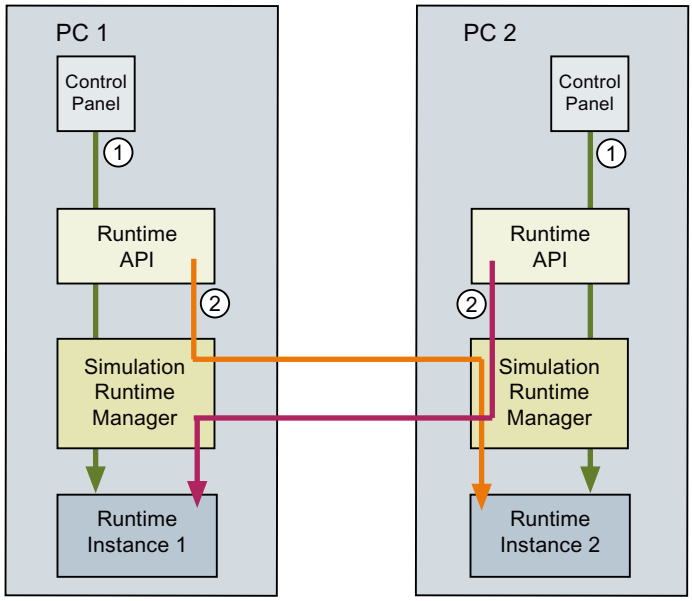

① Access to a local instance via the Control Panel

② Access to a remote instance on the Runtime API

Figure 3-261 Access to instances with distributed communication

API functions

The following interfaces are available for native C++ (Page 27) and managed code (Page 32):

- Overview of interfaces for native C++ (Page 27)
- Overview of interfaces for managed code (Page 32)

3.6 Interfaces of the Simulation Runtime

The user interfaces of the Simulation Runtime include functions you use for tasks such as the following:

- Creating instances
- Changing the operating mode of a simulated PLC instance
- Exchanging I/O data

Simulation Runtime has the following user interfaces:

- IBaseRuntimeManager
- ISimulationRuntimeManager
- IInstances
- IRemoteRuntimeManager

ISimulationRuntimeManager and IRemoteRuntimeManager are derived from IBaseRuntimeManager.

API and external applications

The Runtime API makes the interfaces available to an external application.

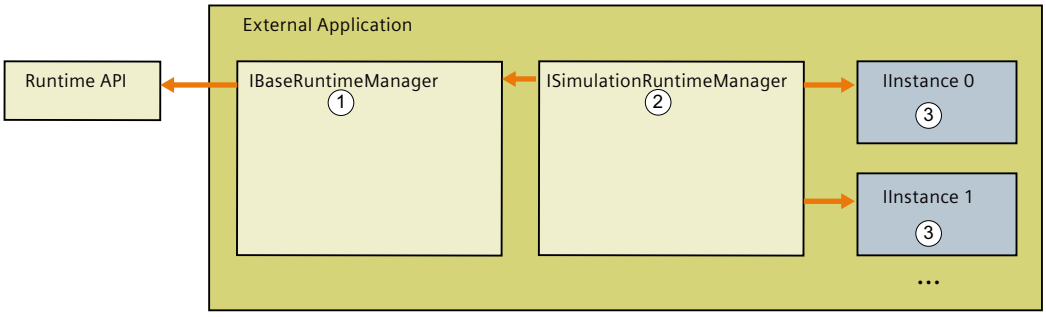

① **IBaseRuntimeManager**
Base interface of the Runtime Manager. It is used to register new Runtime instances, to search through existing Runtime instances, and to receive an interface of a registered instance. Up to 16 instances can be registered in one Runtime Manager.

② **ISimulationRuntimeManager**
Derived from IBaseRuntimeManager. It is used to handle events, manage connections with other Runtime Managers, and check API and Runtime Manager status.

③ **IInstances**
Interface of a Runtime instance. It is used to change the operating state of a simulated PLC instance and to exchange I/O data. Each instance has a unique name and an ID.

Figure 3-262 API and external applications

Access to API functions and data types

Required functions and data types are available for native C++ and .NET (C#).

- Overview of interfaces for native C++ (Page 27)
- Overview of data types for native C++ (Page 35)
- Overview of interfaces for managed code (Page 32)
- Overview of data types for managed code (Page 36)

NOTE

The list of tables in this manual gives you direct access to the description of the individual functions and data types.

Transfer parameters for API functions

All API functions that return a value using the function parameters expect a user-allocated memory area as a transfer parameter. Null pointers are not permitted. Exceptions to this are the functions that return an interface of a simulated PLC instance:

- An IBaseRuntimeManager interface
- An ISimulationRuntimeManager interface
- An IRemoteRuntimeManager interface
- An IInstance interface

3.7 Overview of interfaces for native C++

Initializing and shutting down API

Table 3-363 Overview of initializing and shutting down API - Native C++

Actions	Functions
Initialize API (Page 39)	`InitializeApi` `RuntimeApiEntry_Initialize`
Shut down API (Page 42)	`DestroyInterface` `RuntimeApiEntry_DestroyInterface`
Logging off API library (Page 44)	`FreeApi` `ShutdownAndFreeApi`

Global functions

Table 3-364 Overview of global functions - Native C++

Actions	Functions

Global functions (Page 46)	`GetNameOfAreaSection()`
	`GetNameOfCPUType()`
	`GetNameOfCommunicationInterface()`
	`GetNameOfDataType()`
	`GetNameOfLEDMode()`
	`GetNameOfLEDType()`
	`GetNameOfOperatingMode()`
	`GetNameOfOperatingState()`
	`GetNameOfPrimitiveDataType()`
	`GetNameOfTagListDetails()`
	`GetNameOfErrorCode()`
	`GetNameOfRuntimeConfigChanged()`
	`GetNameOfInstanceConfigChanged()`
	`GetNameOfDiagSeverity()`
	`GetNameOfDirection()`
	`GetNameOfRackOrStationFaultType()`
	`GetNameOfProcessEventType()`
	`GetNameOfPullOrPlugEventType()`
	`GetNameOfCycleTimeMonitoringMode()`
	`GetNameOfDiagProperty()`
	`GetNameOfAutodiscoverType()`
	`GetNameOfSoftwareConfigChanged()`
	`GetNameOfNetworkMode()`

API IBaseRuntimeManager

Table 3-365 Overview of IBaseRuntimeManager functions - Native C++

Settings	Functions

Interface (Page 57)	`GetVersion()`
	`GetPort()`
	`GetStrictMotionTiming()`
	`SetStrictMotionTiming()`
	`GetNetworkMode()`
	`SetNetworkMode()`
	`GetNetInterfaces()`
	`SetNetInterfaceBindings()`
	`ResetNetInterfaceBindings()`
	`GetDefaultStoragePath()`
	`SetDefaultStoragePath()`

Simulation Runtime instances (Page 51)	`GetRegisteredInstancesCount()`
	`GetRegisteredInstanceInfoAt()`
	`RegisterInstance()`
	`RegisterCustomInstance()`
	`CreateInterface()`

API ISimulationRuntimeManager

Table 3-366 Overview of API ISimulationRuntimeManager functions - Native C++

Settings	Functions

Interface (Page 65)	`IsInitialized()`
	`IsRuntimeManagerAvailable()`
	`Shutdown()`

Remote connections (Page 66)	`OpenPort()`
	`ClosePort()`
	`GetRemoteConnectionsCount()`
	`GetRemoteConnectionInfoAt()`
	`RemoteConnect()`
	`RunAutodiscover()`

Table 3-367 Overview of API ISimulationRuntimeManager events - Native C++

Events	Functions

OnConfigurationChanged (Page 73)	`RegisterOnConfigurationChangedCallback()`
	`UnregisterOnConfigurationChangedCallback()`
	`RegisterOnConfigurationChangedEvent()`
	`UnregisterOnConfigurationChangedEvent()`
	`WaitForOnConfigurationChangedEvent()`

OnRuntimeManagerLost (Page 75)	`RegisterOnRuntimeManagerLostCallback()`
	`UnregisterOnRuntimeManagerLostCallback()`
	`RegisterOnRuntimeManagerLostEvent()`
	`UnregisterOnRuntimeManagerLostEvent()`
	`WaitForOnRuntimeManagerLostEvent()`

OnAutodiscover (Page 77)	`RegisterOnAutodiscoverCallback()` `UnregisterOnAutodiscoverCallback()`

API IInstance

Table 3-368 Overview of IInstance functions - Native C++

Settings	Functions

Interface (Page 80)	`GetID()`
	`GetName()`
	`GetCPUType()`
	`SetCPUType()`
	`GetCommunicationInterface()`
	`SetCommunicationInterface()`
	`GetInfo()`
	`UnregisterInstance()`
	`GetStrictMotionTiming()`
	`SetStrictMotionTiming()`

Controller (Page 88)	`GetControllerName()`
	`GetControllerShortDesignation()`
	`GetControllerIPCount()`
	`GetControllerIP()`
	`GetControllerIPSuite4()`
	`SetIPSuite()`
	`GetStoragePath()`
	`SetStoragePath()`
	`ArchiveStorage()`
	`RetrieveStorage()`
	`CleanupStoragePath()`

Settings	Functions

Operating state (Page 98)	`PowerOn()`
	`PowerOff()`
	`Run()`
	`Stop()`
	`GetOperatingState()`
	`MemoryReset()`

Tag list (Page 111)	`UpdateTagList()`
	`GetTagListStatus()`
	`GetTagInfoCount()`
	`GetTagInfos()`
	`CreateConfigurationFile()`

I/O access via address - Reading (Page 117)	`GetAreaSize()`
	`ReadBit()`
	`ReadByte()`
	`ReadBytes()`
	`ReadSignals()`

I/O access via address - Writing (Page 122)	`WriteBit()`
	`WriteByte()`
	`WriteBytes()`
	`WriteSignals()`

I/O access via tag name - Reading (Page 127)	`Read()`
	`ReadBool()`
	`ReadChar(), ReadWChar()`
	`ReadDouble()`
	`ReadFloat()`
	`ReadInt8(), ReadInt16(), ReadInt32(), ReadInt64()`
	`ReadUInt8(), ReadUInt16(), ReadUInt32(), ReadUInt64()`
	`ReadSignals()`
	`ReadString()`
	`ReadWString()`

I/O access via tag name - Writing (Page 149)	`Write()`
	`WriteBool()`
	`WriteChar(), WriteWChar()`
	`WriteDouble()`
	`WriteFloat()`
	`WriteInt8(), WriteInt16(), WriteInt32(), WriteInt64(),`
	`WriteUInt8(), WriteUInt16(), WriteUInt32(), WriteUInt64()`
	`WriteSignals()`
	`WriteString()`
	`WriteWString()`

Virtual time (Page 78)	`GetSystemTime()`
	`SetSystemTime()`
	`GetScaleFactor()`
	`SetScaleFactor()`

Cycle control (Page 171)	`GetOperatingMode()`
	`SetOperatingMode()`
	`SetSendSyncEventInDefaultModeEnabled()`
	`IsSendSyncEventInDefaultModeEnabled`
	`GetOverwrittenMinimalCycleTime_ns()`
	`SetOverwrittenMinimalCycleTime_ns()`
	`RunToNextSyncPoint()`
	`StartProcessing()`
	`SetCycleTimeMonitoringMode()`
	`GetCycleTimeMonitoringMode()`

Acyclic services (Page 186)	

Table 3-369 Overview of IInstance events - Native C++

Events	Functions

OnOperatingStateChanged (Page 206)	`RegisterOnOperatingStateChangedCallback()`
	`UnregisterOnOperatingStateChangedCallback()`
	`RegisterOnOperatingStateChangedEvent()`
	`UnregisterOnOperatingStateChangedEvent()`
	`WaitForOnOperatingStateChangedEvent()`

OnLedChanged (Page 209)	`RegisterOnLedChangedCallback()`
	`UnregisterOnLedChangedCallback()`
	`RegisterOnLedChangedEvent()`
	`UnregisterOnLedChangedEvent()`
	`WaitForOnLedChangedEvent()`

OnSoftwareConfigurationChanged (Page 211)	`RegisterOnSoftwareConfigurationChangedCallback()`
	`UnregisterOnSoftwareConfigurationChangedCallback()`
	`RegisterOnSoftwareConfigurationChangedEvent()`
	`UnregisterOnSoftwareConfigurationChangedEvent()`
	`WaitForOnSoftwareConfigurationChangedEvent()`

OnIPAddressChanged (Page 213)	`RegisterOnIPAddressChangedCallback()`
	`UnregisterOnIPAddressChangedCallback()`
	`RegisterOnIPAddressChangedEvent()`
	`UnregisterOnIPAddressChangedEvent()`
	`WaitForOnIPAddressChangedEvent()`

OnSyncPointReached (Page 215)	`RegisterOnSyncPointReachedCallback()`
	`UnregisterOnSyncPointReachedCallback()`
	`RegisterOnSyncPointReachedEvent()`
	`UnregisterOnSyncPointReachedEvent()`
	`WaitForOnSyncPointReachedEvent()`

OnHardwareConfigChanged (Page 217)	`RegisterOnHardwareConfigChangedCallback()`
	`UnregisterOnHardwareConfigChangedCallback()`
	`RegisterOnHardwareConfigChangedEvent()`
	`UnregisterOnHardwareConfigChangedEvent()`
	`WaitForOnHardwareConfigChangedEvent()`

API IRemoteRuntimeManager

Table 3-370 Overview of IRemoteRuntimeManager functions - Native C++

Settings	Functions

Interface (Page 229)	`GetIP()`
	`GetRemoteComputerName()`
	`Disconnect()`

Table 3-371 Overview of IRemoteRuntimeManager events - Native C++

Events	Functions

OnConnectionLost (Page 232)	`RegisterOnConnectionLostCallback()`
	`UnregisterOnConnectionLostCallback()`
	`RegisterOnConnectionLostEvent()`
	`UnregisterOnConnectionLostEvent()`
	`WaitForOnConnectionLostEvent()`

3.8 Overview of interfaces for managed code

Initializing and shutting down API

Table 3-372 Overview of initializing and shutting down API - .NET (C#)

Actions	Functions
Initialize API (Page 41)	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeManager`
Shut down API (Page 45)	

API IBaseRuntimeManager

Table 3-373 Overview of IBaseRuntimeManager functions - .NET (C#)

Settings	Functions

Interface (Page 57)	`Version { get; }`
	`Port { get; }`
	`StrictMotionTiming { get; set; }`
	`NetworkMode { get; set; }`
	`NetInterfaces { get; }`
	`SetNetInterfaceBindings();`
	`ResetNetInterfaceBindings();`
	`DefaultStoragePath { get; set; }`

Simulation Runtime instances (Page 51)	`RegisteredInstanceInfo { get; }`
	`RegisterInstance();`
	`RegisterCustomInstance();`
	`CreateInterface();`

API ISimulationRuntimeManager

Table 3-374 Overview of ISimulationRuntimeManager functions - .NET (C#)

Settings	Functions

Interface (Page 65)	`IsInitialized { get; }`
	`IsRuntimeManagerAvailable { get; }`
	`Shutdown()`
	`StrictMotionTiming { get; }`

Remote connections (Page 66)	`OpenPort()`
	`ClosePort()`
	`Port { get; }`
	`RemoteConnectionInfo { get; }`
	`RemoteConnect()`
	`RunAutodiscover()`

Table 3-375 Overview of ISimulationRuntimeManager events - .NET (C#)

Events	Functions

OnConfigurationChanged (Page 73)	`OnConfigurationChanged()`
	`RegisterOnConfigurationChangedEvent()`
	`UnregisterOnConfigurationChangedEvent()`
	`WaitForOnConfigurationChangedEvent()`

OnRuntimeManagerLost (Page 75)	`OnRuntimeManagerLost()`
	`RegisterOnRuntimeManagerLostEvent()`
	`UnregisterOnRuntimeManagerLostEvent()`
	`WaitForOnRuntimeManagerLostEvent()`

OnAutodiscover (Page 77)	`OnAutodiscoverData()`

API IInstance

Table 3-376 Overview of IInstance functions - .NET (C#)

Settings	Functions

Interface (Page 80)	`Dispose ()`
	`ID { get; }`
	`Name { get; }`
	`CommunicationInterface { get; }`
	`CPUType { get; set; }`
	`Info { get; }`
	`UnregisterInstance()`
	`StrictMotionTiming { get; set; }`

Controller - Information and settings (Page 88)	`ControllerName { get; }`
	`ControllerShortDesignation { get; }`
	`ControllerIPSuite4 { get; }`
	`SetIPSuite()`
	`StoragePath { get; set; }`
	`ArchiveStorage()`
	`RetrieveStorage()`
	`CleanupStoragePath()`

Operating state (Page 98)	`PowerOn()`
	`PowerOff()`
	`Run()`
	`Stop()`
	`OperatingState { get; }`
	`MemoryReset()`

Tag list (Page 111)	`UpdateTagList()`
	`GetTagListStatus()`
	`TagInfos { get; }`
	`CreateConfigurationFile()`

I/O access via address - Reading (Page 117)	`InputArea | MarkerArea | OutputArea { get; }`
	`AreaSize { get; }`
	`ReadBit()`
	`ReadByte()`
	`ReadBytes()`
	`ReadSignals()`

I/O access via address - Writing (Page 122)	`WriteBit()`
	`WriteByte()`
	`WriteBytes()`
	`WriteSignals()`

I/O access via tag name - Reading (Page 127)	`Read()`
	`ReadBool()`
	`ReadChar(), ReadWChar()`
	`ReadDouble()`
	`ReadFloat()`
	`ReadInt8(), ReadInt16(), ReadInt32(), ReadInt64()`
	`ReadUInt8(), ReadUInt16(), ReadUInt32(), ReadUInt64()`
	`ReadSignals()`
	`ReadString()`
	`ReadWString()`

I/O access via tag name - Writing (Page 149)	`Write()`
	`WriteBool()`
	`WriteChar(), WriteWChar()`
	`WriteDouble()`
	`WriteFloat()`
	`WriteInt8(), WriteInt16(), WriteInt32(), WriteInt64(),`
	`WriteUInt8(), WriteUInt16(), WriteUInt32(), WriteUInt64()`
	`WriteSignals()`
	`WriteString()`
	`WriteWString()`

Settings	Functions
Virtual time (Page 78)	`SystemTime { get; set; }` `ScaleFactor { get; set; }`

Cycle control (Page 171)	`OperatingMode { get; set; }`
	`IsSendSyncEventInDefaultModeEnabled { get; set; }`
	`OverwrittenMinimalCycleTime_ns { get; set; }`
	`RunToNextSyncPoint()`
	`StartProcessing()`
	`SetCycleTimeMonitoringMode()`
	`GetCycleTimeMonitoringMode()`

Acyclic services (Page 186)	

Table 3-377 Overview of IInstance events - .NET (C#)

Events	Functions

OnOperatingStateChanged (Page 206)	`OnOperatingStateChanged()`
	`RegisterOnOperatingStateChangedEvent()`
	`UnregisterOnOperatingStateChangedEvent()`
	`WaitForOnOperatingStateChangedEvent()`

OnLedChanged (Page 209)	`OnLedChanged()`
	`RegisterOnLedChangedEvent()`
	`UnregisterOnLedChangedEvent()`
	`WaitForOnLedChangedEvent()`

OnSoftwareConfigurationChanged (Page 211)	`OnSoftwareConfigurationChanged()`
	`RegisterOnSoftwareConfigurationChangedEvent()`
	`UnregisterOnSoftwareConfigurationChangedEvent()`
	`WaitForOnSoftwareConfigurationChangedEvent()`

OnIPAddressChanged (Page 213)	`OnIPAddressChanged()`
	`RegisterOnIPAddressChangedEvent()`
	`UnregisterOnIPAddressChangedEvent()`
	`WaitForOnIPAddressChangedEvent()`

OnSyncPointReached (Page 215)	`OnSyncPointReached()`
	`RegisterOnSyncPointReachedEvent()`
	`UnregisterOnSyncPointReachedEvent()`
	`WaitForOnSyncPointReachedEvent()`

OnHardwareConfigChanged (Page 217)	`OnHardwareConfigChanged()`
	`RegisterOnHardwareConfigChangedEvent()`
	`UnregisterOnHardwareConfigChangedEvent()`
	`WaitForOnHardwareConfigChangedEvent()`

API IRemoteRuntimeManager

Table 3-378 Overview of IRemoteRuntimeManager functions - .NET (C#)

Settings	Functions

Interface (Page 229)	`Dispose()`
	`IP { get; }`
	`RemoteComputerName { get; }`
	`Disconnect()`
	`StrictMotionTiming { get; }`

Table 3-379 Overview IRemoteRuntimeManager events - .NET (C#)

Events	Functions

OnConnectionLost() (Page 232)	`OnConnectionLost()`
	`RegisterOnConnectionLostEvent()`
	`UnregisterOnConnectionLostEvent()`
	`WaitForOnConnectionLostEvent()`

3.9 Restrictions for file paths

The following restrictions apply for user interfaces which expect a path or a complete file name as the transfer parameter:

Restrictions for local paths	Write permissions to system-critical folders such as the Windows folder (%Windows%) or the program folders (%Program Files%, %Program Files (x86)%) are not allowed. In this case the C++ user interface returns the error code `SREC_WRONG_ARGUMENT`. In this case the managed user interface returns an exception with the error code `RuntimeErrorCode.WrongArgument`.
Restrictions for network paths	In order to be able to use network paths, you must incorporate them as a network drive. Otherwise, the C++ user interface returns the error code `SREC_WRONG_ARGUMENT`. The managed user interface returns an exception with the error code `RuntimeErrorCode.WrongArgument`.

3.10 Overview of data types for native C++

The following table shows which data types are available for the simulation in Runtime Manager.

Table 3-380 Overview of data types - Native C++

Data type	
DLL import functions (Page 235)	`ApiEntry_Initialize` `ApiEntry_DestroyInterface`

Event callback functions (Page 236)	`EventCallback_VOID`
	`EventCallback_SRCC_UINT32_UINT32_INT32`
	`EventCallback_SRRSI_AD`
	`EventCallback_IRRTM`
	`EventCallback_II_SREC_ST_SROS_SROS`
	`EventCallback_II_SREC_ST_UINT32_INT64_INT64_UINT32`
	`EventCallback_II_SREC_ST`
	`EventCallback_II_SREC_ST_SRLT_SRLM`
	`EventCallback_II_SREC_ST_SDRI`
	`EventCallback_II_SREC_ST_SDRI_BYTE`
	`EventCallback_II_SREC_ST_UINT32_UINT32`
	`EventCallback_II_SREC_ST_UINT32_UINT32_EPET_UINT32`
	`EventCallback_II_SREC_ST_UINT32_EPPET_UINT32`
	`EventCallback_II_SREC_ST_UINT32_ERSFET`
	`EventCallback_II_SREC_ST_UINT32`
	`EventCallback_II_SSCCP`

Definitions and constants (Page 251)	
Unions (Page 252)	`UIP` `UDataValue`

Structures (Page 254)	`SDataValue`
	`SDVBNI`
	`SDataValueByAddress`
	`SDataValueByName`
	`SConnectionInfo`
	`SInstanceInfo`
	`SDimension`
	`STagInfo`
	`SIP`
	`SIPSuite4`
	`SOnSyncPointReachedResult`
	`SDataValueByAddressWithCheck`
	`SDataValueByNameWithCheck`
	`SDataRecordInfo`
	`SDataRecord`
	`SConfiguredProcessEvents`

Data type	
	SDiagExtChannelDescription SAutodiscoverData SOnSoftwareConfigChangedParameter
Enumerations (Page 270)	ERuntimeErrorCode EArea ECommunicationInterface EOperatingState EOperatingMode ECPUType ENetworkMode EPLCInterface ELEDType ELEDMode EPrimitiveDataTypes EDataType ETagListDetails ERuntimeConfigChanged EPullOrPlugEventType EProcessEventType EDirection EDiagProperty EDiagSeverity ERackOrStationFaultType ECycleTimeMonitoringMode EAutodiscoverType

3.11 Overview of data types for managed code

The following table shows which data types are available for the simulation in Runtime Manager.

Table 3-381 Overview of data types - .NET (C#)

Data type	
Delegate definitions (Page 244) - Event handler methods	Delegate_Void Delegate_SRCC_UINT32_UINT32_INT32 Delegate_SRRSI_AD Delegate_IRRTM Delegate_II_EREC_DT_EOS_EOS Delegate_II_EREC_DT_UINT32_INT64_INT64_UINT32 Delegate_II_EREC_DT Delegate_II_EREC_DT_ELT_ELM Delegate_II_EREC_DT_SDRI Delegate_II_EREC_DT_SDR Delegate_SREC_ST_UINT32_UINT32 Delegate_SREC_ST_UINT32_UINT32_EPET_UINT32 Delegate_SREC_ST_UINT32_EPPET_UINT32 Delegate_SREC_ST_UINT32_ERSFET Delegate_SREC_ST_UINT32
Definitions and constants (Page 251)	
Structures (Page 254)	SDataValue SDVBNI SDataValueByAddress SDataValueByName SConnectionInfo SInstanceInfo SDimension STagInfo SIP SIPSuite4 SOnSyncPointReachedResult SDataValueByAddressWithCheck SDataValueByNameWithCheck

Data type	
	SDataRecordInfo SDataRecord SConfiguredProcessEvents SDiagExtChannelDescription SAutodiscoverData
Enumerations (Page 270)	ERuntimeErrorCode EArea ECommunicationInterface EOperatingState EOperatingMode ECPUType ELEDType ELEDMode ENetworkMode EPrimitiveDataTypes EDataType ETagListDetails ERuntimeConfigChanged EPullOrPlugEventType EProcessEventType EDirection EDiagProperty EDiagSeverity ERackOrStationFaultType ECycleTimeMonitoringMode EAutodiscoverType

Initialize API

4

4.1 Load API library

Description

For S7-PLCSIM Advanced, the interfaces of the API V8.0 are not compatible with the interfaces of previous API versions. However, the Runtime Manager of S7-PLCSIM Advanced V8.0 is compatible with the API of previous S7-PLCSIM Advanced versions.

Earlier versions of the API are also installed during the installation of S7-PLCSIM Advanced V8.0.

The default path is C:\Program Files (x86)\Common Files\Siemens\PLCSIMADV\API

NOTE

API versions

To access and use the latest features and bug fixes, use the latest API version.

The installation path of S7-PLCSIM Advanced is contained in the registry:

- Key: "HKEY_LOCAL_MACHINE\SOFTWARE\Wow6432Node\Siemens\Shared Tools\PLCSIMADV_SimRT"
- Value: "Path"

To maintain the path to the API, add the character string of the following subdirectory at the end: "API\<API version>".

When you use this path the API library (DLL) is loaded directly from the installation directory.

Reference

Additional information can be found in:

- For Native C++ in section InitializeApi() (Page 39).
- For .NET via the call of the function "System.Reflection.Assembly.LoadFile(string)" in the online documentation for MSDN.

4.2 Native C++

4.2.1 InitializeApi()

Description

The `InitializeApi` function loads the API library (DLL) and initializes the API. The function loads the version of the DLL that is compatible with the architecture of your application and with the header file of the API ("SimulationRuntimeApi.h").

To load the DLL, the function `InitializeApi` searches in the following folders one after the other:

- Folder to which the parameter of the function leads (`in_SimulationRuntimeApiDllPath`)
- Folder, which also contains your application that calls this function
- Installation directory of S7-PLCSIM Advanced

If no DLL is available, the function accesses the next folder.

The function returns an interface to the Simulation Runtime Manager. Use this interface to create a new simulated PLC instance or to obtain access to an existing instance.

Table 3-382 InitializeApi() - Native C++

Syntax	`ERuntimeErrorCode InitializeApi(ISimulationRuntimeManager** out_SimulationRuntimeManagerInterface);` `ERuntimeErrorCode InitializeApi(WCHAR* in_SimulationRuntimeApiDllPath,ISimulationRuntimeManager** inout_SimulationRuntimeManagerInterface);`	
Parameters	• `ISimulationRuntimeManager** out_SimulationRuntimeManagerInterface`: Pointer to a Runtime Manager interface pointer. The pointer must be initialized with `NULL`. The interface is created within the function. See Data types (Page 235). • `WCHAR* in_SimulationRuntimeApiDllPath`: The path to the Runtime API library.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_WRONG_ARGUMENT`	The pointer to the Runtime Manager interface does not equal `NULL`.
	`SREC_WRONG_VERSION`	• The required version of the interface is incompatible with the version used to compile the API. • The version of the API is not compatible with Runtime. See the topic on compatibility in the S7-PLCSIM Advanced Function Manual.
	`SREC_CONNECTION_ERROR`	Unable to establish a connection to the Runtime Manager.
	`SREC_ERROR_LOADING_DLL`	The API library cannot be loaded.
	`SREC_RUNTIME_NOT_AVAILABLE`	No Runtime Manager runs in this Windows user session.
	`SREC_CONFIG_FILE_ERROR`	Operation regarding the configuration file "UserInterfaceConfiguration.xml" has failed, for example, create, read, write.

Example C++	`// Include The Headerfile Of The API`
	`#include "SimulationRuntimeApi.h"`
	
	`// Prepare The Variables`
	`ERuntimeErrorCode result = SREC_INVALID_ERROR_CODE;`
	`ISimulationRuntimeManager* api = NULL;`
	
	`// Initialize The API And Get The RuntimeManager Interface`
	`result =` **InitializeApi**`(&api);`

NOTE

If you no longer require the interface, delete the interface.

See DestroyInterface() (Page 42).

4.2.2 RuntimeApiEntry_Initialize

Description

Use the function `RuntimeApiEntry_Initialize` only if the API library (DLL) is to be loaded from a different folder than the folder of your application calling this function.

When the API is initialized, the API library is first loaded and the `Initialize` function is then imported and called.

The function returns an interface to the Simulation Runtime Manager. Use this interface to create a new simulated PLC instance to obtain access to an existing instance.

Table 3-383 RuntimeApiEntry_Initialize - Native C++

Syntax	`__declspec(dllexport) ERuntimeErrorCode RuntimeApiEntry_Initialize(ISimulationRuntimeManager** out_SimulationRuntimeManagerInterface,UINT32 in_InterfaceVersion);`	
Parameters	• `ISimulationRuntimeManager** out_SimulationRuntimeManagerInterface:` Pointer to a Runtime Manager interface pointer. The pointer must be initialized with `NULL`. The interface is created within the function. See Data types (Page 235). • `UINT32 in_InterfaceVersion:` Version of the API interface to be downloaded: `DAPI_DLL_INTERFACE_VERSION`.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_WRONG_ARGUMENT`	The pointer to the Runtime Manager interface does not equal `NULL`.
	`SREC_WRONG_VERSION`	• The required version of the interface is incompatible with the version used to compile the API. • The version of the API is not compatible with Runtime. See information about compatibility in the S7-PLCSIM Advanced Function Manual.
	`SREC_CONNECTION_ERROR`	Unable to establish a connection to the Runtime Manager.
	`SREC_RUNTIME_NOT_AVAILABLE`	No Runtime Manager runs in this Windows user session.
	`SREC_CONFIG_FILE_ERROR`	Operation regarding the configuration file "UserInterfaceConfiguration.xml" has failed, for example, create, read, write.

Example C++	`// Include The Headerfile Of The API`
	`#include "SimulationRuntimeApi.h"`
	
	`// Prepare The Variables`
	`ERuntimeErrorCode result = SREC_INVALID_ERROR_CODE;`
	`HMODULE dllHandle = NULL;`
	`ApiEntry_Initialize Initialize = NULL;`
	`ISimulationRuntimeManager* api = NULL;`
	
	`// Load The DLL And Import The "Initialize" Function (using the Windows API)`
	`dllHandle = LoadLibrary(DAPI_DLL_NAME_X86);`
	`if (dllHandle != NULL)`
	`{`
	`Initialize = (ApiEntry_Initialize)GetProcAddress(dllHandle, DAPI_ENTRY_INITIALIZE);`
	`}`
	
	`// Initialize The API And Get The RuntimeManager Interface`
	`if ( Initialize != NULL )`
	`{`
	`result = Initialize(&api, DAPI_DLL_INTERFACE_VERSION);`
	`}`

NOTE

If you no longer require the interface, delete the interface.

SeeDestroyInterface() (Page 42).

4.3 .NET (C#)

4.3.1 Initialize

Description

The entry point to the API is the static class `Siemens.Simatic.Simulation.Runtime.SimulationRuntimeManager`.
The API is initialized when a function of this class is used for the first time.

Table 3-384 Initialize - .NET (C#)

Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationInitializationException`	
	Runtime error code	Description
	`ERuntimeErrorCode.ConnectionError`	Unable to establish a connection to the Runtime Manager.
	`ERuntimeErrorCode.WrongVersion`	The version of the API is not compatible with Runtime. See information about compatibility in the S7-PLCSIM Advanced Function Manual.
	`ERuntimeErrorCode.RuntimeNotAvailable`	No Runtime Manager runs in this Windows user session.
	`ERuntimeErrorCode.ConfigFileError`	Operation regarding the configuration file "UserInterfaceConfiguration.xml" has failed, for example, create, read, write.

Shut down API

5

5.1 Native C++

Basic procedure for deleting the user interfaces

To delete all user interfaces, generally follow these steps:

1. Delete the interfaces IInstances and IRemoteRuntimeManager.
2. Call the `Shutdown()` function of the ISimulationRuntimeManager interface.
3. Delete the ISimulationRuntimeManager interface.
4. Unload the API library (DLL) with the Window API function `FreeLibrary()`.

Deleting the user interfaces via functions

Deleting the user interfaces is also possible via functions.

If the API was initialized using the `InitializeApi()` function, you delete the user interfaces using the following functions:

- FreeApi() (Page 44)
- ShutdownAndFreeApi() (Page 44)

5.1.1 DestroyInterface()

Description

`DestroyInterface()` is a function pointer that points to the `RuntimeApiEntry_DestroyInterface` function. It is only valid if you have successfully called the `InitializeApi` function.

The function unloads the memory of an ISimulationRuntimeManager, IRemoteRuntimeManager or IInstance interface.

If you call `DestroyInterface()` on an instance and the number of interfaces reaches zero, the instance becomes unregistered.

Table 3-385 DestroyInterface() - Native C++

Syntax	`ERuntimeErrorCode DestroyInterface(IBaseInterface* in_Interface);`	
Parameters	• `IBaseInterface* in_Interface:` The interface to be deleted.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_WRONG_ARGUMENT`	The pointer to the interface is `NULL`.

Example C++	`// Include The Headerfile Of The API`
	`#include "SimulationRuntimeApi.h"`
	
	`// The Interfaces`
	`ERuntimeErrorCode result;`
	`ISimulationRuntimeManager* api = NULL;`
	`IInstance* instance = NULL;`
	
	`// Init the DLL and create an instance`
	`result = InitializeApi(&api);`
	`result = api->RegisterInstance(&instance);`
	
	`// Destroy Instance Interfaces`
	`result =` **DestroyInterface**`(instance);`
	`instance = NULL;`

5.1.2 RuntimeApiEntry_DestroyInterface

Description

Use the `RuntimeApiEntry_DestroyInterface` function only if the API library (DLL) is to be loaded from a different directory than the Startup folder of the application calling this function.

If the API was initialized using the `InitializeApi` function, you select the DestroyInterface() (Page 42) function.

The function unloads the memory of an ISimulationRuntimeManager, IRemoteRuntimeManager or IInstance interface.

Table 3-386 RuntimeApiEntry_DestroyInterface() - Native C++

Syntax	`__declspec(dllexport) ERuntimeErrorCode RuntimeApiEntry_DestroyInterface(IBaseInterface* in_Interface);`	
Parameters	• `IBaseInterface* in_Interface:` The interface to be deleted.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_WRONG_ARGUMENT`	The pointer to the interface is `NULL`.

Example C++	`// Include The Headerfile Of The API`
	`#include "SimulationRuntimeApi.h"`
	
	`// Prepare The Variables`
	`ERuntimeErrorCode result = SREC_INVALID_ERROR_CODE;`
	`HMODULE dllHandle = NULL;`
	`ApiEntry_DestroyInterface Destroy = NULL;`
	`IInstance* instance = NULL;`
	
	`// Load The DLL And Import The "DestroyInterface" Function (using the Windows API)`
	`dllHandle = LoadLibraryA(DAPI_DLL_NAME_X86);`
	`if ( dllHandle != NULL )`
	`{`
	`Destroy = (ApiEntry_ DestroyInterface)GetProcAddress(dllHandle, DAPI_ENTRY_DESTROY_INTERFACE);`
	`}`
	`…`
	`// Frees the memory of an IInstance interface`
	`result =` **Destroy**`(instance);`	

5.1.3 FreeApi()

Description

The `FreeApi()` function unloads the library of the Runtime API.

This function can only be called after the successful call of the `InitializeApi` If the `InitializeApi` function was not called, the library must be unloaded using the Windows API function `FreeLibrary()`.

Table 3-387 FreeApi() - Native C++

Syntax	`ERuntimeErrorCode FreeApi();`	
Parameters	None	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_API_NOT_INITIALIZED`	The `InitializeApi` function was not called successfully.

Example C++	`// Include The Headerfile Of The API`
	`#include "SimulationRuntimeApi.h"`
	
	`// The Interfaces`
	`ERuntimeErrorCode result;`
	`ISimulationRuntimeManager* api = NULL;`
	`IInstance* instance = NULL;`
	
	`// Init the API`
	`result = InitializeApi(&api);`
	
	…
	
	`// Shutdown The API`
	`api->Shutdown();`
	`result = DestroyInterface(api);`
	`api = NULL;`
	`result = FreeApi();`	

5.1.4 ShutdownAndFreeApi()

Description

The `ShutdownAndFreeApi()` function shuts down the Runtime API, deletes the IRuntimeManager interface and unloads the library of the Runtime API.

This function can only be called after the successful call of the `InitializeApi` If the `InitializeApi` function was not called, the library must be unloaded using the Windows API function `FreeLibrary()`.

Table 3-388 ShutdownAndFreeApi() - Native C++

Syntax	`ERuntimeErrorCode ShutdownAndFreeApi(ISimulationRuntimeManager* in_SimulationRuntimeManagerInterface);`	
Parameters	• `ISimulationRuntimeManager* in_SimulationRuntimeManagerInterface:` The interface of the Runtime Manager to be deleted.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.

Return values	SREC_API_NOT_INITIALIZED	The InitializeApi function was not called successfully.
	SREC_WRONG_ARGUMENT	The pointer to the interface is NULL.

Example C++	`// Include The Headerfile Of The API`
	`#include "SimulationRuntimeApi.h"`
	
	`// The Interfaces`
	`ERuntimeErrorCode result;`
	`ISimulationRuntimeManager* api = NULL;`
	`IInstance* instance = NULL;`
	
	`// Init the API`
	`result = InitializeApi(&api);`
	
	…
	
	`// Shutdown The API`
	`result = ShutdownAndFreeApi(api);`
	`api = NULL;`	

5.2 .NET (C#)

5.2.1 Shut down API

You can terminate the .NET components of the API for the IInstance and IRemoteRuntimeManager interfaces by calling the Dispose function.

These interfaces can also be cleared automatically with the .NET Garbage Collector.

Manually clearing the API

To manually clear the API, follow these steps:

1. Delete all interfaces.

   You can find more information at Interfaces for IInstances (Page 80).
2. Call the Shutdown() (Page 65) function of the ISimulationRuntimeManager interface.

Global functions (Native C++) 6

The global functions `GetNameOf...` return the name of the enumeration entry (`const WCHAR*`).

GetNameOfAreaSection()

Table 3-389 GetNameOfAreaSection() - Native C++

Syntax	`const WCHAR* GetNameOfAreaSection(EArea in_AreaSection);`
Parameters	`EArea in_AreaSection:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfCPUType()

Table 3-390 GetNameOfCPUType() - Native C++

Syntax	`const WCHAR* GetNameOfCPUType(ECPUType in_CPUType);`
Parameters	`ECPUType in_CPUType:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfCommunicationInterface()

Table 3-391 GetNameOfCommunicationInterface() - Native C++

Syntax	`const WCHAR* GetNameOfCommunicationInterface(ECommunicationInterface in_CommunicationInterface);`
Parameters	`ECommunicationInterface in_CommunicationInterface:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfDataType()

Table 3-392 GetNameOfDataType() - Native C++

Syntax	`const WCHAR* GetNameOfDataType(EDataType in_DataType);`
Parameters	`EDataType in_DataType:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfErrorCode()

Table 3-393 GetNameOfErrorCode() - Native C++

Syntax	`const WCHAR* GetNameOfErrorCode(ERuntimeErrorCode in_ErrorCode);`
Parameters	`ERuntimeErrorCode in_ErrorCode:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfLEDMode()

Table 3-394 GetNameOfLEDMode() - Native C++

Syntax	`const WCHAR* GetNameOfLEDMode(ELEDMode in_LEDMode);`
Parameters	`ELEDMode in_LEDMode:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfLEDType()

Table 3-395 GetNameOfLEDType() - Native C++

Syntax	`const WCHAR* GetNameOfLEDType(ELEDType in_LEDType);`
Parameters	`ELEDType in_LEDType:` Enumeration entry.
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfOperatingMode()

Table 3-396 GetNameOfOperatingMode() - Native C++

Syntax	`const WCHAR* GetNameOfOperatingMode(EOperatingMode in_OperatingMode);`
Parameters	`EOperatingMode in_OperatingMode:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfOperatingState

Table 3-397 GetNameOfOperatingState() - Native C++

Syntax	`const WCHAR* GetNameOfOperatingState(EOperatingState in_OperatingState);`
Parameters	`EOperatingState in_OperatingState:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfPrimitiveDataType

Table 3-398 GetNameOfPrimitiveDataType() - Native C++

Syntax	`const WCHAR* GetNameOfPrimitiveDataType(EPrimitiveDataType in_DataType);`
Parameters	`EPrimitiveDataType in_DataType:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfTagListDetails

Table 3-399 GetNameOfTagListDetails() - Native C++

Syntax	`const WCHAR* GetNameOfTagListDetails(ETagListDetails in_TagListDetails);`
Parameters	`ETagListDetails in_TagListDetails:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfRuntimeConfigChanged()

Table 3-400 GetNameOfRuntimeConfigChanged() - Native C++

Syntax	`const WCHAR* GetNameOfRuntimeConfigChanged(ERuntimeConfigChanged in_RuntimeConfigChanged);`
Parameters	`ERuntimeConfigChanged in_RuntimeConfigChanged:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfDirection()

Table 3-401 GetNameOfDirection() - Native C++

Syntax	`const WCHAR* GetNameOfDirection(EDirection in_Direction);`
Parameter	`EDirection in_Direction:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfDiagSeverity()

Table 3-402 GetNameOfDiagSeverity() - Native C++

Syntax	`const WCHAR* GetNameOfDiagSeverity(EDiagSeverity in_DiagSeverity);`
Parameter	`EDiagSeverity in_DiagSeverity:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfRackOrStationFaultType()

Table 3-403 GetNameOfRackOrStationFaultType() - Native C++

Syntax	`const WCHAR* GetNameOfRackOrStationFaultType(ERackOrStationFaultType in_RackOrStationFaultType);`
Parameter	`ERackOrStationFaultType in_RackOrStationFaultType:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfProcessEventType()

Table 3-404 GetNameOfProcessEventType() - Native C++

Syntax	`const WCHAR*(GetNameOfProcessEventType(EProcessEventType in_ProcessEventType);`
Parameters	`EProcessEventType in_ProcessEventType:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfPullOrPlugEventType()

Table 3-405 GetNameOfPullOrPlugEventType() - Native C++

Syntax	`const WCHAR* GetNameOfPullOrPlugEventType(EPullOrPlugEventType in_PullOrPlugEventType);`
Parameters	`EPullOrPlugEventType in_PullOrPlugEventType:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfCycleTimeMonitoringMode()

Table 3-406 GetNameOfCycleTimeMonitoringMode() - Native C++

Syntax	`const WCHAR* GetNameOfCycleTimeMonitoringMode(ECycleTimeMonitoringMode in_CycleTimeMonitoringMode);`
Parameters	`ECycleTimeMonitoringMode in_CycleTimeMonitoringMode:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfDiagProperty()

Table 3-407 GetNameOfDiagProperty() - Native C++

Syntax	`const WCHAR* GetNameOfDiagProperty(EDiagProperty in_DiagProperty);`
Parameters	`EDiagProperty in_DiagProperty:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfAutodiscoverType()

Table 3-408 GetNameOfAutodiscoverType() - Native C++

Syntax	`const WCHAR* GetNameOfAutodiscoverType(EAutodiscoverType in_AutodiscoverType);`
Parameters	`EAutodiscoverType in_AutodiscoverType:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfSoftwareConfigChanged()

Table 3-409 GetNameOfSoftwareConfigChanged() - Native C++

Syntax	`const WCHAR* GetNameOfSoftwareConfigChanged(ESoftwareConfigChanged in_SoftwareConfigChanged);`
Parameters	`ESoftwareConfigChanged in_SoftwareConfigChanged:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

GetNameOfNetworkMode()

Table 3-410 GetNameOfNetworkMode() - Native C++

Syntax	`const WCHAR* GetNameOfNetworkMode(ENetworkMode in_NetworkMode);`
Parameters	`ENetworkMode in_NetworkMode:` Enumeration entry
Return values	`const WCHAR*:` Name of the enumeration entry

IBaseRuntimeManager

7

7.1 Simulation runtime instances

CreateInterface()

Creates and returns an interface of an already registered instance of a simulated PLC.

The instance could have been registered via the application or another application that uses the Simulation Runtime API.

Table 3-411 CreateInterface() - Native C++

Syntax	`ERuntimeErrorCode CreateInterface(WCHAR* in_InstanceName, IInstance** out_InstanceInterface);` `ERuntimeErrorCode CreateInterface(INT32 in_InstanceID, IInstance** out_InstanceInterface);`	
Parameters	• `INT32 in_InstanceID:` The ID of the registered instance from which you want to receive the interface. • `WCHAR* in_InstanceName:` The name of the registered instance from which you want to receive the interface. • `IInstance** out_InstanceInterface:` Pointer to a Simulation Runtime interface pointer. The pointer must be initialized with `NULL`. The interface is created within the function.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The interface is disconnected from the remote Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The name, the ID or the IInstance- pointer is invalid.
	`SREC_DOES_NOT_EXIST`	The instance is not registered in Runtime Manager.

Example C++	`ISimulationRuntimeManager * api = NULL;`
	`ERuntimeErrorCode result = InitializeApi(&api);`
	
	`IInstance* psa1 = NULL;`
	`IInstance* psa2 = NULL;`
	`if (result == SREC_OK)`
	`{`
	` result = api->`**CreateInterface**`(0, &psa1);`
	`result = api->`**CreateInterface**`(0, &psa2); // psa2 will be the same as psa1`
	`}`	

Example C++	`ISimulationRuntimeManager * api = NULL;`
	`ERuntimeErrorCode result = InitializeApi(&api);`
	
	`IInstance* psa = NULL;`
	`if (result == SREC_OK)`
	`{`
	` result = api->`**CreateInterface**`(L"My SimulationRuntime Instance", &psa);`
	`}`	

NOTE
Native C++
If you no longer require the interface, delete the interface.
See DestroyInterface() (Page 42)

Table 3-412 CreateInterface() - .NET (C#)

Syntax	`IInstance CreateInterface(string in_InstanceName);` `IInstance CreateInterface(INT32 in_InstanceID);`	
Parameters	• `INT32 in_InstanceID:` The ID of the registered instance from which you want to receive the interface. • `string in_InstanceName:` The name of the registered instance from which you want to receive the interface.	
Return values	If the function is successful, an interface of a simulated PLC instance; otherwise, a Null pointer.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The interface is disconnected from the remote Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The name or the ID is invalid.
	`ERuntimeErrorCode.DoesNotExist`	The instance is not registered in Runtime Manager.

GetRegisteredInstanceInfoAt()

Returns information about an already registered instance.

You can use the ID or name to create an interface of this instance (see `CreateInterface()`).

Table 3-413 GetRegisteredInstanceInfoAt() - Native C++

Syntax	`ERuntimeErrorCode GetRegisteredInstanceInfoAt(UINT32 in_Index, SInstanceInfo* out_InstanceInfo);`	
Parameters	• `UINT32 in_Index:` Index of the created instance from which you want to receive the information. The index must be less than the value you receive when you call `GetRegisteredInstanceCount()`. • `SInstanceInfo* out_InstanceInfo:` The information with name and ID of the instance.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The interface is disconnected from the remote Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INDEX OUT_OF_RANGE`	There is no instance information for this index.

RegisteredInstanceInfo { get; }

Returns information about an already registered instance. You can use the ID or name of this instance to create an interface of this instance, see `CreateInterface()`.

Table 3-414 RegisterInstanceInfo { get; } - .NET (C#)

Syntax	`SInstanceInfo[] RegisteredInstanceInfo { get; }`	
Parameters	None	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The interface is disconnected from the remote Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

GetRegisteredInstancesCount()

Returns the number of instances that are registered in Runtime Manager. If the function fails, the return value is 0.

Table 3-415 GetRegisteredInstancesCount() - Native C++

Syntax	`UINT32 GetRegisteredInstancesCount();`
Parameters	None
Return values	`UINT32`: Number of available instances.

RegisterInstance()

Registers a new instance of a simulated PLC instance in Runtime Manager. Creates and returns an interface of this instance.

Table 3-416 RegisterInstance() - Native C++

Syntax	`ERuntimeErrorCode RegisterInstance(IInstance** out_InstanceInterface);`
	`ERuntimeErrorCode RegisterInstance(WCHAR* in_InstanceName, IInstance** out_InstanceInterface);`
	`ERuntimeErrorCode RegisterInstance(ECPUType in_CPUType, IInstance** out_InstanceInterface);`
	`ERuntimeErrorCode RegisterInstance(ECPUType in_CPUType, WCHAR* in_InstanceName, IInstance** out_InstanceInterface);`
	`ERuntimeErrorCode RegisterInstance(WCHAR* in_ArticleNumber, WCHAR* in_InstanceName, IInstance** out_InstanceInterface);`

Parameters	• `ECPUType in_CPUType`: Defines which CPU type is simulated at the start of the instance. The default setting is `"SRCT_1500_Unspecified"`. When a different CPU type is loaded via STEP 7 or from the Virtual SIMATIC Memory Card, this CPU type applies. • `WCHAR* in_InstanceName`: Name to be assigned to the instance. Every instance must have a unique name. If no name is assigned when registering a new instance, the instance is given the name `"Instance_#"` (# is the ID of the instance). If this name already exists, the name `"Instance_#.#"` is used, in which the second # is a counter that is incremented until the name is unique. The length of the name must be less than `DINSTANCE_NAME_LENGTH`. You can use basic Latin alphanumeric characters (A-Z, a-z, 0-9), "!", "=", and "-" to name the instance, but most other special characters, such as currency, Chinese characters, or mathematical symbols are unsupported. See Data types (Page 235). • `IInstance** out_InstanceInterface`: Pointer to a Simulation Runtime interface pointer. The pointer **must** be initialized with `NULL`. The interface is created within the function. • `WCHAR* in_ArticleNumber`: Article number for a specific PLC device. The article number must be 19 characters long.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_CONFIG_FILE_ERROR`	Error found in configuration file.
	`SREC_INTERFACE_REMOVED`	The interface is disconnected from the remote Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	One or more of the following parameters are invalid: • The instance name • The IInstance pointer • The length of `in_ArticleNumber`
	`SREC_LIMIT_REACHED`	There are already 16 instances registered in Runtime Manager.
	`SREC_ALREADY_EXISTS`	An instance with this name already exists.
Example C++		

```
ISimulationRuntimeManager * api = NULL;
ERuntimeErrorCode result = InitializeApi(&api);

// Example: How To Create And Register An Instance
// And To Get An Interface Of The Instance The Same Time
IInstance* psa = NULL;
if (result == SREC_OK)
{
 result = api->RegisterInstance(&psa);
}
```

NOTE

Native C++

If you no longer require the interface, delete the interface.

See DestroyInterface() (Page 42).

Table 3-417 RegisterInstance() - .NET (C#)

Syntax	`IInstance RegisterInstance();`
	`IInstance RegisterInstance(string in_InstanceName);`
	`IInstance RegisterInstance(ECPUType in_CPUType);`
	`IInstance RegisterInstance(ECPUType in_CPUType string in_InstanceName);`
	`IInstance RegisterInstance(string in_ArticleNumber, string in_InstanceName);`	

Parameters	• `ECPUType in_CPUType:` Defines which CPU type is simulated at the start of the instance. The default setting is `"ECPUType.Unspecified"`. When a different CPU type is loaded via STEP 7 or from the Virtual SIMATIC Memory Card, this CPU type applies. • `string in_InstanceName:` Name to be assigned to the instance. Every instance must have a unique name. If no name is assigned when registering a new instance, the instance is given the name `"Instance_#"` (# is the ID of the instance). If this name already exists, the name `"Instance_#.#"` is used, in which the second # is a counter that is incremented until the name is unique. The length of the name must be less than `DINSTANCE_NAME_LENGTH`. You can use basic Latin alphanumeric characters (A-Z, a-z, 0-9), "!", "=", and "-" to name the instance, but most other special characters, such as currency, Chinese characters, or mathematical symbols are unsupported. See Data types (Page 235). • `string in_ArticleNumber:` Article number for a specific PLC device. The article number must be 19 characters long.	
Return values	If the function is successful, an interface of a simulated PLC. Otherwise, a Null pointer.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.ConfigFileError`	Error found in configuration file.
	`ERuntimeErrorCode.InterfaceRemoved`	The interface is disconnected from the remote Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	One or more of the following parameters are invalid: • The instance name • The IInstance pointer • The length of `in_ArticleNumber`
	`ERuntimeErrorCode.LimitReached`	There are already 16 instances registered in Runtime Manager.
	`ERuntimeErrorCode.AlreadyExists`	An instance with this name already exists.

RegisterCustomInstance()

Registers a new simulated PLC instance in the Runtime Manager. Creates and returns an interface of this instance.

Table 3-418 RegisterCustomInstance() - Native C++

Syntax	`ERuntimeErrorCode RegisterCustomInstance(WCHAR* in_VplcDll, IInstance** out_InstanceInterface);` `ERuntimeErrorCode RegisterCustomInstance(WCHAR* in_VplcDll, WCHAR* in_InstanceName, IInstance** out_InstanceInterface);`	
Parameters	• `WCHAR* in_VplcDll:` The complete path to the DLL of the simulated PLC instance that Siemens.Simatic.Simulation.Runtime.Instance.exe loads at PowerOn. • `WCHAR* in_InstanceName:` Name to be assigned to the instance. Every instance must have a unique name. If no name is assigned when registering a new instance, the instance is given the name `"Instance_#"` (# is the ID of the instance). If this name already exists, the name `"Instance_#.#"` is used, in which the second # is a counter that is incremented until the name is unique. The length of the name must be less than `DINSTANCE_NAME_LENGTH`. See Data types (Page 235). • `IInstance** out_InstanceInterface:` Pointer to a Simulation Runtime interface pointer. The pointer must be initialized with `NULL`. The interface is created within the function.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The interface is disconnected from the remote Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The DLL name, the instance name or the IInstance pointer is invalid.
	`SREC_LIMIT_REACHED`	There are already 16 instances registered in Runtime Manager.
	`SREC_ALREADY_EXISTS`	An instance with this name already exists.

Example C++	`ISimulationRuntimeManager * api = NULL;`
	`ERuntimeErrorCode result = InitializeApi(&api);`
	
	`// Example: How To Create And Register An Instance`
	`// And To Get An Interface Of The Instance The Same Time`
	`IInstance* psa = NULL;`
	`if (result == SREC_OK)`
	`{`
	` result = api->`**RegisterCustomInstance**`(L"C:\\Temp\\vplc.dll", &psa);`
	`}`	

NOTE

Native C++

If you no longer require the interface, delete the interface.

See DestroyInterface() (Page 42).

Table 3-419 RegisterCustomInstance() - .NET (C#)

Syntax	`IInstance RegisterCustomInstance(string in_VplcDll);` `IInstance RegisterCustomInstance(string in_VplcDll, string in_InstanceName);`	
Parameters	• `string in_VplcDll:` The complete path to the DLL of the simulated PLC instance that Siemens.Simatic.Simulation.Runtime.Instance.exe loads at PowerOn. • `string in_InstanceName:` Name to be assigned to the instance. Every instance must have a unique name. If no name is assigned when registering a new instance, the instance is given the name `"Instance_#"` (# is the ID of the instance). If this name already exists, the name `"Instance_#.#"` is used, in which the second # is a counter that is incremented until the name is unique. The length of the name must be less than `DINSTANCE_NAME_LENGTH`. See Data types (Page 235).	
Return values	If the function is successful, an interface of a simulated PLC instance; otherwise, a Null pointer.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The interface is disconnected from the remote Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The name or the ID is invalid.
	`ERuntimeErrorCode.LimitReached`	There are already 16 instances registered in Runtime Manager.
	`ERuntimeErrorCode.AlreadyExists`	An instance with this name already exists.

7.2 Interfaces for IBaseRuntimeManager

GetPort() / Port { get; }

Returns the open port of the PC on which the Runtime Manager is running. If the function fails, the return value is 0.

Table 3-420 GetPort() - Native C++

Syntax	`UINT16 GetPort();`
Parameters	None
Return values	`UINT16`: Open port of the PC on which the remote Runtime Manager is running.

Table 3-421 Port { get; } - .NET (C#)

Syntax	`UInt16 Port { get; }`
Parameters	None
Return values	`UInt16`: Open port of the PC on which the remote Runtime Manager is running.

GetVersion() / Version { get; }

Returns the version of the Runtime Manager. If the function fails, version 0.0 is returned.

Table 3-422 GetVersion() - Native C++

Syntax	`UINT32 GetVersion();`
Parameters	None
Return values	`UINT32`: Remote Runtime Manager Version (`HIWORD` = Major, `LOWORD` = Minor)

Table 3-423 Version { get; } - .NET (C#)

Syntax	`UInt32 Version { get; }`
Parameters	None
Return values	`Uint32`: Remote Runtime Manager Version (`HIWORD` = Major, `LOWORD` = Minor)

GetStrictMotionTiming() / StrictMotionTiming { get; }

Returns the current global setting for the "Strict Motion Timing" feature that has an effect on newly created instances. The "Strict Motion Timing" feature is located on the S7-PLCSIM Advanced Control Panel.

Table 3-424 GetStrictMotionTiming() - Native C++

Syntax	`ERuntimeErrorCode GetStrictMotionTiming(bool* enabled);`	
Parameters	bool* enabled: Receives the current setting. `true`: Active `false`: Inactive	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_CONFIG_FILE_ERROR`	The setting could not be read from the configuration file UserInterfaceConfiguration.xml.

Table 3-425 StrictMotionTiming { get; } - .NET (C#)

Syntax	`bool StrictMotionTiming { get; }`	
Parameters	None	
Return values	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.ConfigFileError`	The setting could not be read from the configuration file UserInterfaceConfiguration.xml.

SetStrictMotionTiming() / StrictMotionTiming { set; }

Sets the global setting for the "Strict Motion Timing" feature that has an effect on newly created instances. The "Strict Motion Timing" feature is located on the S7-PLCSIM Advanced Control Panel.

Table 3-426 SetStrictMotionTiming() - Native C++

Syntax	`ERuntimeErrorCode SetStrictMotionTiming(bool enable);`	
Parameters	bool enable: The value to be set. `true`: Active `false`: Inactive	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_ALREADY_EXISTS`	An instance is registered. No instance must be registered to change the setting.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_ACCESS_DENIED`	No write rights for the configuration file.
	`SREC_CONFIG_FILE_ERROR`	The setting could not be written to the configuration file UserInterfaceConfiguration.xml.

Table 3-427 StrictMotionTiming { set; } - .NET (C#)

Syntax	`bool StrictMotionTiming { set; }`	
Parameters	None	
Return values	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.AlreadyExists`	An instance is registered. No instance must be registered to change the setting.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.AccessDenied`	No write rights for the configuration file.
	`ERuntimeErrorCode.ConfigFileError`	The setting could not be written to the configuration file UserInterfaceConfiguration.xml.

GetNetworkMode

Returns the current network mode settings that are used in the network adapter for distributed communication.

Table 3-428 GetNetworkMode() - Native C++

Syntax	`ERuntimeErrorCode IBaseRuntimeManager::GetNetworkMode(ENetworkMode* out_Mode);`	
Parameters	`ENetworkMode* out_Mode` Receives the network mode as #`ENetworkMode` that is currently set in the driver of the S7-PLCSIM Advanced Virtual Switch	
Return values	Runtime error code	Description
	`SREC_OK`	The function call is successful.

SetNetworkMode()

Sets the network mode as used in the network adapter for distributed communication.

Check that the binding on the network interfaces is correct.

Table 3-429 SetNetworkMode() - Native C++

Syntax	`ERuntimeErrorCode SetNetworkMode(const ENetworkMode in_mode);`	
Parameters	`ENetworkMode in_Mode` Type of network communication mode to be set	
Return values	Runtime error code	Description
	`SREC_OK`	The function call is successful.
	`SREC_VIRTUAL_SWITCH_MISCONFIGURED`	The driver of the S7-PLCSIM Advanced Virtual Switch is not running.
	`SREC_INSTANCE_ALREADY_RUNNING`	Network mode cannot be changed because there is already a running instance.
	`SREC_PCAP_DRIVER_NOT_RUNNING`	The Nmap Packet Capture Driver (Npcap) is not active on the system. Remedy: 1. Start the command line in administrator mode. 2. Execute this command: net start npcap

NetworkMode { get; set; };

Returns or sets the network mode used on the network adapter for distributed communication.

Check that the binding on the network interfaces is correct.

Table 3-430 NetworkMode { get; } - .NET (C#)

Syntax	`ENetworkMode NetworkMode { get; };`
Return value	`ENetworkMode` Reveives the network mode as #`ENetworkMode` that is currently set in the driver of the S7-PLCSIM Advanced Virtual Switch
Exceptions	None

Table 3-431 NetworkMode { set; } - .NET (C#)

Syntax	`ENetworkMode NetworkMode { set; };`	
Parameters	None	
Exceptions	Runtime error code	Description
	`ERuntimeErrorCode.VirtualSwitchMisconfigured`	The S7-PLCSIM Advanced Virtual Switch driver is not running.
	`ERuntimeErrorCode.InstanceAlreadyRunning`	Network mode cannot be changed because there is already a running instance.
	`ERuntimeErrorCode.PCAPDriverNotRunning`	The Nmap Packet Capture Driver (Npcap) is not active on the system. Remedy: 1. Start the command line in administrator mode. 2. Execute this command: `net start npcap`

GetNetInterfaces() / NetInterfaces { get; }

Provides information on the PC interfaces, which you can use for `SetNetInterfaceMapping`.

Table 3-432 GetNetInterfaces() - Native C++

Syntax	`ERuntimeErrorCode GetNetInterfaces(SNetInterfaceInfo* inout_InterfaceInfo, UINT* inout_InterfaceCount);`	

Parameters	`SNetInterfaceInfo* inout_InterfaceInfo:`
	Address of the first item of the SNetInterfaceInfo array, which contains information about PC network adapters. If the value is NULL, only the number of network adapters has been requested.
	`UINT* inout_InterfaceCount:`
	For the input: Number of SNetInterfaceInfo items assigned by the user.
	For the output: Number of network adapters (array items)	

Return values	Runtime error code	Description
	`SREC_OK`	The function call is successful.
	`SREC_INDEX_OUT_OF_RANGE`	The number of array units is lower than the number of network adapters.
	`SREC_INTERNAL_ERROR`	The system call has caused an internal error.

Example C++	`#include <iostream>`
	`#include "SimulationRuntimeApi.h"`
	
	`ISimulationRuntimeManager* rtm = nullptr;`
	`ERuntimeErrorCode result = SREC_INVALID_ERROR_CODE;`
	
	`//init connection`
	`InitializeApi(&rtm);`
	
	`//get count of network interfaces`
	`UINT count;`
	`result = rtm->GetNetInterfaces(nullptr, &count);`
	
	`//get actual network interfaces`
	`std::unique_ptr<SNetInterfaceInfo[]> netInterfaces =`
	`std::make_unique<SNetInterfaceInfo[]>(count);`
	`result = rtm->GetNetInterfaces(netInterfaces.get(), &count);`
	
	`ShutdownAndFreeApi(rtm);`	

Table 3-433 NetInterfaces { get; } - .NET (C#)

Syntax	`SNetInterfaceInfo[] NetInterfaces { get; }`	
Return values	Runtime error code	Description
	`SNetInterfaceInfo[]`	Information about the PC network interfaces
Exceptions	`ERuntimeErrorCode.InternalError`	The system call has caused an internal error.

SetNetInterfaceBindings()

Sets the binding of an S7-PLCSIM Advanced Virtual Switch to PC interfaces based on the network mode and the mapping configuration of the network interfaces for the instance.

You must call the function from a parent session (administrator mode), otherwise you cannot access it, and the message `SREC_ACCESS_DENIED` appears. This function is not valid for the Softbus NetworkMode.

Table 3-434 SetNetInterfaceBindings() - Native C++

Syntax	`ERuntimeErrorCode SetNetInterfaceBindings(DWORD in_PCInterfaceIndex = 0);`	
Parameters	`DWORD in_PCInterfaceIndex = 0:` • When Single Adapter Network Mode (promiscuous mode) is set, you can specify the index of the PC interfaces for network communication. To enable only local PC communication, use the value (0). • When Multi-Adapter Network Mode (non-promiscuous mode) is set, this parameter is not used and the binding is set according to the configured mapping of the interfaces.	
Return values	Runtime error code	Description
	`SREC_OK`	The function call is successful.
	`SREC_INVALID_CONFIGURATION`	The configuration is invalid because an invalid adapter is mapped on an instance. For example, a sim_hwdb.ini file of a registered instance uses the MAC address of an invalid adapter such as a PLCSIM vAdapter, a disabled adapter, or an adapter that does not support PLCSIM vSwitch.
	`SREC_ACCESS_DENIED`	You do not have authorization to connect to the PC network interfaces.
	`SREC_WRONG_COMMUNICATION_INTERFACE`	The PC interface does not exist or is disabled.
	`SREC_INTERNAL_ERROR`	The system call has caused an internal error. Enable the traces to obtain detailed information.
	`SREC_INSTANCE_ALREADY_RUNNING`	In Single Adapter Network Mode (promiscuous mode), bindings cannot change while an instance is running.
	`SREC_VIRTUAL_SWITCH_MISCONFIGURED`	The configuration of an S7-PLCSIM Advanced Virtual Switch is not correct or the driver is not functioning properly.
	`SREC_NOT_SUPPORTED`	You cannot call the function in the Softbus NetworkMode.

Table 3-435 SetNetInterfaceBindings() - .NET (C#)

Syntax	`void SetNetInterfaceBindings();` `void SetNetInterfaceBindings(DWORD in_PCInterfaceIndex);`	
Exceptions	Runtime error code	Description
	`ERuntimeErrorCode.InvalidConfigura-tion`	The configuration is invalid because, for example, a non-existent adapter was used.
	`ERuntimeErrorCode.AccessDenied`	You do not have authorization to connect to the PC network interfaces.
	`ERuntimeErrorCode.WrongCommunica-tionInterface`	The PC interface does not exist or is disabled.

Exceptions	`ERuntimeErrorCode.InternalError`	The system call has caused an internal error. Enable the traces to obtain detailed information.
	`ERuntimeErrorCode.InstanceAlreadyRunning`	In Single Adapter Network Mode (promiscuous mode), bindings cannot change while an instance is running.
	`ERuntimeErrorCode.VirtualSwitchMisconfigured`	The configuration of an S7-PLCSIM Advanced Virtual Switch is not correct or the driver is not functioning properly.
	`ERuntimeErrorCode.NotSupported`	You cannot call the function in the Softbus NetworkMode.

ResetNetInterfaceBindings()

Deactivates the binding of an S7-PLCSIM Advanced Virtual Switch to PC interfaces. The binding on the Siemens PLCSIM Virtual Ethernet Adapter remains.

You must call the function from a parent session (administrator mode), otherwise you cannot access it, and the message `SREC_ACCESS_DENIED` appears. For local runtime manager, the application using the API must be in an elevated session; for remote use, the remote runtime manager must be in the elevated session. This function is not valid for the Softbus NetworkMode.

Table 3-436 ResetNetInterfaceBindings() - Native C++

Syntax	`ERuntimeErrorCode ResetNetInterfaceBindings();`	
Parameters	None	
Return values	Runtime error code	Description
	`SREC_OK`	The function call is successful.
	`SREC_ACCESS_DENIED`	You do not have authorization to connect to the PC network interfaces.
	`SREC_INSTANCE_ALREADY_RUNNING`	In Single Adapter Network Mode (promiscuous mode), the bindings cannot change while an instance is running.
	`SREC_INTERNAL_ERROR`	The system call has caused an internal error. Enable the traces to obtain detailed information.
	`SREC_NOT_SUPPORTED`	You cannot call the function in the Softbus NetworkMode.

ResetNetInterfaceBindings() - .NET (C#)

Syntax	`void ResetNetInterfaceBindings();`	
Exceptions	Runtime error code	Description
	`ERuntimeErrorCode.AccessDenied`	You do not have authorization to connect to the PC network interfaces.

Exceptions	`ERuntimeErrorCode.InternalError`	The system call has caused an internal error. Enable the traces to obtain detailed information.
	`ERuntimeErrorCode.InstanceAlreadyRunning`	In Single Adapter Network Mode (promiscuous mode), the bindings cannot change while an instance is running.
	`ERuntimeErrorCode.NotSupported`	You cannot call the function in the Softbus NetworkMode.

GetDefaultStoragePath()

Returns the full path of the default folder in which the instance stores its data.

Table 3-437 GetDefaultStoragePath() - Native C++

Syntax	`ERuntimeErrorCode GetDefaultStoragePath(WCHAR* out_DefaultStoragePath);`	
Parameters	• `WCHAR* out_DefaultStoragePath` Output parameter that is filled with the path of the default folder.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.

SetDefaultStoragePath()

Sets the full path of the default folder in which the instance stores its data.

Table 3-438 SetDefaultStoragePath() - Native C++

Syntax	`ERuntimeErrorCode SetDefaultStoragePath(const WCHAR* in_DefaultStoragePath);`	
Parameters	• const WCHAR* in_DefaultStoragePath Input parameter that specifies the path of the default folder.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_WRONG_ARGUMENT`	The path contains invalid characters.
	`SREC_CONFIG_FILE_ERROR`	The configuration file UserInterfaceConfiguration.xml could not be read.

DefaultStoragePath { get; set; }

Returns or sets the full path of the default folder in which the instance stores its data.

Table 3-439 DefaultStoragePath { get; set; } - .NET (C#)

Syntax	string DefaultStoragePath { get; set; }	
Return values	Runtime error code	Description
	`OK`	The function is successful.
	`WrongArgument`	The path contains invalid characters.
	`ConfigFileError`	The configuration file UserInterfaceConfiguration.xml could not be read.

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IsInitialized() / IsInitialized { get; }

Returns a value that indicates whether the API was successfully initialized.

Table 3-474 IsInitialized() - Native C++

Syntax	`bool IsInitialized();`
Parameters	None
Return values	• `false`: If the API was not initialized. • `true`: If the API was initialized.

Table 3-475 IsInitialized { get; } - .NET (C#)

Syntax	`bool IsInitialized { get; }`
Parameters	None
Return values	• `false`: If the API was not initialized. • `true`: If the API was initialized.

IsRuntimeManagerAvailable() / IsRuntimeManagerAvailable { get; }

The function returns `false` when the connection to Runtime Manager is interrupted. This happens only when the Runtime Manager process is closed.

Subscribe to the `OnRuntimeManagerLost()` event to find out whether the connection is interrupted. See Events (Page 72).

Table 3-476 IsRuntimeManagerAvailable() - Native C++

Syntax	`bool IsRuntimeManagerAvailable();`
Parameters	None
Return values	• `false`: If the connection is interrupted. • `true`: If the connection is active.

Table 3-477 IsRuntimeManagerAvailable { get; } - .NET (C#)

Syntax	`bool IsRuntimeManagerAvailable{ get; }`
Parameters	None
Return values	• `false`: If the connection is interrupted. • `true`: If the connection is active.

Shutdown()

Ends communication with Runtime Manager and clears the interfaces.

Call this function in the following cases:

- Immediately before the API library (DLL) is unregistered (native C++).
- When your application is no longer using Runtime Manager.

Table 3-478 Shutdown() - Native C++

Syntax	`ERuntimeErrorCode Shutdown()`	
Parameters	None	
Return values	Runtime error code	Description
	`SREC_OK`	The function call is successful.

Table 3-479 Shutdown() - .NET (C#)

Syntax	`void Shutdown()`
Parameters	None
Return values	None

8.1 Remote connections

Remote connections use TLS and temporary self-signed certificates to provide increased security.

NOTE

For secure communication, only open ports and connect to remote runtime managers on trusted local networks. Without restricting access, unwanted users could access a running remote runtime manager.

OpenPort()

Opens a port to which another Runtime Manager can connect. The default communication using only the inPort parameter is secured communication. Setting the in_SecurityMode to UNSECURED provides the ability to use legacy communication, but this mode is not recommended.

Table 3-440 OpenPort() - Native C++

Syntax	`ERuntimeErrorCode OpenPort(UINT16 in_Port);` `ERuntimeErrorCode ISimulationRuntimeManager::OpenPort(UINT16 in_Port, ESecurityMode in_SecurityMode);`	
Parameters	• `UINT16 in_Port:` The port. The value must be greater than 1024. • `ESecurityMode in_SecurityMode` Security mode	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.

Return values	SREC_ALREADY_EXISTS	A port is already open.
	SREC_WRONG_ARGUMENT	The port is invalid.
	SREC_CONNECTION_ERROR	The port cannot be opened.
	SREC_WARNING_UNSECURED_COMMUNICATION	The port was opened without secured protection level. ESecurityMode::UNSECURED.

NOTE

Check for the security warning in the return value of the function. If communication is unsecured, the port communication is not encrypted.

Table 3-441 OpenPort() - .NET (C#)

Syntax	`void OpenPort(UInt16 in_Port);` `void SimulationRuntimeManager::OpenPort(UINT16 in_Port, ESecurityMode in_SecurityMode);`	
Parameters	• `UInt16 in_Port:` The port. The value must be greater than 1024. • `ESecurityMode in_SecurityMode` Security mode	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.AlreadyExists	A port is already open.
	ERuntimeErrorCode.WrongArgument	The port is invalid.
	ERuntimeErrorCode.ConnectionError	The port cannot be opened.
	ERuntimeErrorCode.WarningUnsecured-Communication	The port was opened without secured protection level. ESecurityMode::UNSECURED.

ClosePort()

Closes an open port and all open connections that another Runtime Manager has created to this open port.

Table 3-442 ClosePort() - Native C++

Syntax	`ERuntimeErrorCode ClosePort();`	
Parameters	None	
Return values	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	SREC_OK	The function is successful.
	SREC_TIMEOUT	The function does not return on time.
	SREC_WARNING_INVALID_CALL	No port is open.

Table 3-443 ClosePort() - .NET (C#)

Syntax	`void ClosePort();`
Parameters	None
Return values	None

Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

GetRemoteConnectionsCount()

Supplies the number of open remote connections to which you have connected.

Table 3-444 GetRemoteConnectionsCount() - Native C++

Syntax	`UINT32 GetRemoteConnectionsCount();`
Parameters	None
Return values	`UINT32`: Number of open remote connections.

GetRemoteConnectionInfoAt()

Returns information about an open connection to which you are connected.

Table 3-445 GetRemoteConnectionInfoAt()- Native C++

Syntax	`ERuntimeErrorCode GetRemoteConnectionInfoAt(UINT32 in_Index, SConnectionInfo* out_ConnectionInfo);`	
Parameters	• `UINT32 in_Index:` Index of the connection information that is expected. • `SConnectionInfo* out_ConnectionInfo:` The connection information for this index.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INDEX_OUT_OF_RANGE`	Connection information for this index does not exist.

RemoteConnectionInfo { get; }

Returns an array of information about all open connections to which you are connected.

Table 3-446 RemoteConnectionInfo { get; } - .NET (C#)

Syntax	`SConnectionInfo[] RemoteConnectionInfo { get; }`	
Parameters	None	
Return values	`SConnectionInfo[]`: An array of information about all open connections.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

RemoteConnect()

Creates a new connection to a remote Runtime Manager or uses an existing connection to create an IRemoteRuntimeManager interface.

Table 3-447 RemoteConnect() - Native C++

Syntax	`ERuntimeErrorCode RemoteConnect(UINT8 in_IP3, UINT8 in_IP2, UINT8 in_IP1, UINT8 in_IP0, UINT16 in_Port, IRemoteRuntimeManager**out_RemoteRuntimeManagerInterface);` `ERuntimeErrorCode RemoteConnect(UIP in_IP, UINT16 in_Port, IRemoteRuntimeManager** out_RunTimeManagerInterface);`	
Parameters	• `UINT8 in_IP3:` First part of the IP address of the remote PC. • `UINT8 in_IP2:` Second part of the IP address of the remote PC. • `UINT8 in_IP1:` Third part of the IP address of the remote PC. `UINT8 in_IP0:` Last part of the IP address of the remote PC. • `UIP in_IP:` IP address of the remote PC. • `UINT16 in_Port:` The port that is open on the remote PC. • `IRemoteRuntimeManager** out_RemoteRuntimeManagerInterface:` Pointer to a remote Runtime Manager interface pointer. The pointer **must** be initialized with `NULL`. The interface is created in the function.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_CONNECTION_ERROR`	The connection to the remote Runtime Manager cannot be established because secured connection requirements are not met.
	`SREC_WRONG_ARGUMENT`	IP, port or IInstance pointer is invalid.
	`SREC_WRONG_VERSION`	The version of the API is not compatible with Runtime. See information on compatibility in the S7-PLCSIM Advanced Function Manual.
	`SREC_WARNING_UNSECURED_COMMUNICATION`	The remote session is not protected.

Example C++	`ISimulationRuntimeManager* api = NULL;`
	`ERuntimeErrorCode result = InitializeApi(&api);`
	
	`IRemoteRuntimeManager * client = NULL;`
	
	`if (result == SREC_OK)`
	`{`
	` result = api->`**`RemoteConnect`**`(192,203,145,144, 4444, &client);`
	`}`	

NOTE

After calling this method, check the return value for unsecure communication warnings. If the connection is unsecured, the communication is not encrypted.

NOTE
Native C++
If you no longer require the interface, delete the interface.
See DestroyInterface() (Page 42).

Table 3-448 RemoteConnect() - .NET (C#)

Syntax	`IRemoteRuntimeManager RemoteConnect(string in_ConnectionString);`
	`IRemoteRuntimeManager RemoteConnect(SIP in_IP, UInt16 in_Port);`
	`IRemoteRuntimeManager RemoteConnect(Byte in_IP3, Byte in_IP2, Byte in_IP1, Byte in_IP0, UInt16 in_Port);`	

Parameters	• `Byte in_IP3:` First part of the IP address of the remote PC. • `Byte in_IP2:` Second part of the IP address of the remote PC. • `Byte in_IP1:` Third part of the IP address of the remote PC. • `Byte in_IP0:` Last part of the IP address of the remote PC. • `string in_ConnectionString:` A string in the form of "<IP3>.<IP2>.<IP1>.<IP0>:<Port>" Example: "182.203.145.144:4444". • `SIP in_IP:` IP address of the remote PC. • `UInt16 in_Port:` The port that is open on the remote PC.	
Return values	`IRemoteRuntimeManager:` Interface to the remote Runtime Manager.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.ConnectionError`	Connection to the remote Runtime Manager cannot be established.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	IP or port is invalid.
	`ERuntimeErrorCode.WrongVersion`	The version of the API is not compatible with Runtime. See information on compatibility in the S7-PLCSIM Advanced Function Manual.

NOTE
After calling this function, call GetSecurityMode() (Page 229) to check the security mode (Page 289) of the connected remote runtime manager. If the connection is unsecured, the communication is not encrypted.

GetSecurityMode()

GetSecurityMode returns the current ESecurityMode of the opened port.

Table 3-449 GetSecurityMode - Native C++

Syntax	`ESecurityMode ISimulationRuntimeManager::GetSecurityMode(););`	
Parameters	None	

Return values	Runtime error code	Description
	`ESecurityMode::UNSECURED`	No security is used.
	`ESecurityMode::ENCRYPTED_COMMUNICATION`	Secure communication
	`ESecurityMode::UNKNOWN`	No port is opened.

Table 3-450 GetSecurityMode - .NET (C#)

Syntax	`ESecurityMode SimulationRuntimeManager::SecurityMode { get; };`	
Parameters	None	
Return values	Runtime error code	Description
	`ESecurityMode::Unsecured`	No security is used.
	`ESecurityMode::EncryptedCommunication`	Secure communication
	`ESecurityMode::Unknown`	No port is opened.

8.1.1 RunAutodiscover()

Description

This function identifies all Runtime Managers that are on the network and that are ready to establish a remote connection.

NOTE

The function identifies Runtime Managers as of S7-PLCSIM Advanced V5.0.

Requirements

- The Runtime Manager must be running and allowing remote connections.
- The firewall of the remote PC must not block traffic on the selected UDP port.
- Devices in the local network (such as routers, switches, firewalls) must not block multicast packets of the selected class.

RunAutodiscover()

The function starts the identification of the Runtime Manager in the network.

Table 3-451 RunAutodiscover() - Native C++

Syntax	`ERuntimeErrorCode RunAutodiscover(UINT32 in_Timeout = 2000);`	
Parameters	• `UINT32 in_Timeout` A timeout value in milliseconds that defines how long the local Runtime Manager waits for responses from the Remote Manager. A value between 500 ms and 30000 ms is valid. Default: 2000 ms.	
Return values	Runtime error code	Description

Return values	SREC_OK	The function is successful.
	SREC_WRONG_ARGUMENT	The timeout value is outside the permissible range.
	SREC_AUTODISCOVER_ALREADY_RUNNING	A RunAutodiscover() call is already running in the background. Wait for the message SRRSI_DISCOVER_FINISHED in the callback function. See EAutodiscoverType (Page 289).
	SREC_TIMEOUT	Communication errors in the local Runtime Manager.

Table 3-452 RunAutodiscover() - .NET (C#)

Syntax	void RunAutodiscover(UInt32 in_Timeout = 2000);	
Parameters	• UInt32 in_Timeout A timeout value in milliseconds that defines how long the local Runtime Manager waits for responses from the Remote Manager. A value between 500 ms and 30000 ms is valid. Default: 2000 ms.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.WrongArgument	The timeout value is outside the permissible range.
	ERuntimeErrorCode.Autodiscover-AlreadyRunning	A RunAutodiscover() call is already running in the background. Wait for the message AutodiscoverFinished in the callback function. See EAutodiscoverType (Page 289).
	ERuntimeErrorCode.Timeout	Communication errors in the local Runtime Manager.

8.2 Events for ISimulationRuntimeManager

Events for runtime instances and remote connections

The following events are triggered for the ISimulationRuntimeManager interface:

Table 3-453 Events for ISimulationRuntimeManager

Event	Cause
OnConfigurationChanged events (Page 73)	The Runtime Manager configuration has changed. The Control Panel uses this event to update the list of available instances.
OnRuntimeManagerLost (Page 75)	The connection to the Runtime Manager is interrupted.
OnAutodiscoverData events (Page 77)	The network searches for Runtime Managers which are ready to establish a remote connection.

8.2.1 OnConfigurationChanged events

OnConfigurationChanged

The OnConfigurationChanged event reports configuration changes.

Table 3-454 OnConfigurationChanged() - .NET C#

Syntax	`event Delegate_SRCC_UINT32_UINT32_INT32 OnConfigurationChanged();` `event Delegate_SRCC_UINT32_UINT32_INT32 OnConfigurationChanged(ERuntimeConfigChanged in_RuntimeConfigChanged, uint in_Param1, uint in_Param2, int in_Param3);`
Parameters	in_RuntimeConfigChanged, in_Param1,in_Param2, in_Param3
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnConfigurationChangedCallback()

When receiving the event the registered callback function will be called. The callback function runs in a separate thread. More callback functions can be registered to the event.

Table 3-455 RegisterOnConfigurationChangedCallback() - Native C++

Syntax	`void RegisterOnConfigurationChangedCallback(EventCallback_SRCC_UINT32_UINT32_INT32 in_CallbackFunction);`
Parameters	in_CallbackFunction
Return values	None
Note	A callback function to subscribe to the event

RegisterOnConfigurationChangedEvent()

When receiving the event, the registered event object is set to signaled state. There can be only one event object registered to the event. Registering a new one will automatically unregister the previous one

Table 3-456 RegisterOnConfigurationChangedEvent() - Native C++

Syntax	`void RegisterOnConfigurationChangedEvent();` `void RegisterOnConfigurationChangedEvent(HANDLE* in_Event);`
Parameters	• `None` An internal event object is registered. • `HANDLE*` A handle for a user-specific event object. The event object is registered.
Return values	None

UnregisterOnConfigurationChangedCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 3-457 UnregisterOnConfigurationChangedCallback() - Native C++

Syntax	`void UnregisterOnConfigurationChangedCallback();`
Parameters	None
Return values	None

UnregisterOnConfigurationChangedEvent()

Unregisters the event object.

Table 3-458 UnregisterOnConfigurationChangedEvent() - Native C++

Syntax	`void UnregisterOnConfigurationChangedEvent();`
Parameters	None
Return values	None

Table 3-459 UnregisterOnConfigurationChangedEvent() - .NET (C#)

Syntax	`void UnregisterOnConfigurationChangedEvent();`
Parameters	None
Return values	None

WaitForOnConfigurationChangedEvent()

The function will block until the registered event object is in the signaled state or the timeout interval elapses.

Table 3-460 WaitForOnConfigurationChangedEvent() - Native C++

Syntax	`bool WaitForOnConfigurationChangedEvent();` `bool WaitForOnConfigurationChangedEvent(uint in_Time_ms);`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.
Note	The function blocks the CoSimulation program until a software download is set to the signaled state or the timeout interval is exceeded.

Table 3-461 WaitForOnConfigurationChangedEvent() - .NET (C#)

Syntax	`bool WaitForOnConfigurationChangedEvent();` `bool WaitForOnConfigurationChangedEvent(uint in_Time_ms);`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.

Return values	• `true`: If the event object was set to the signaled state. • `false`: If no event was received during the defined time limit.
Note	The function blocks the CoSimulation program until a software download is set to the signaled state or the timeout interval is exceeded.

8.2.2 OnRuntimeManagerLost events

OnRuntimeManagerLost

Registers or unregisters an event handler method.

Table 3-462 OnRuntimeManagerLost - .NET (C#)

Syntax	`event Delegate_Void OnRuntimeManagerLost;`
Parameters	None. See Delegate_Void (Page 244).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnRuntimeManagerLostCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-463 RegisterOnRuntimeManagerLostCallback() - Native C++

Syntax	`void RegisterOnRuntimeManagerLostCallback(EventCallback_VOID in_CallbackFunction);`
Parameters	• `EventCallback_VOID in_CallbackFunction:` A callback function that subscribes to the event. See EventCallback_VOID (Page 236).
Return values	None
Note	The event handler method runs in a separate thread.

RegisterOnRuntimeManagerLostEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registration of a new event object causes the previous event object to be deleted.

Table 3-464 RegisterOnRuntimeManagerLostEvent() - Native C++

Syntax	`void RegisterOnRuntimeManagerLostEvent();` `void RegisterOnRuntimeManagerLostEvent(HANDLE* in_Event);`
Parameters	• `None:` An internal event handle is registered. • `HANDLE* in_Event:` A user-specific event handle is registered.
Return values	None

Table 3-465 RegisterOnRuntimeManagerLostEvent() - .NET (C#)

Syntax	`void RegisterOnRuntimeManagerLostEvent();`
Parameters	None
Return values	None

UnregisterOnRuntimeManagerLostCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 3-466 UnregisterOnRuntimeManagerLostCallback() - Native C++

Syntax	`void UnregisterOnRuntimeManagerLostCallback();`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

UnregisterOnRuntimeManagerLostEvent()

Unregisters the event object.

Table 3-467 UnregisterOnRuntimeManagerLostEvent() - Native C++

Syntax	`void UnregisterOnRuntimeManagerLostEvent();`
Parameters	None
Return values	None

Table 3-468 UnregisterOnRuntimeManagerLostEvent() - .NET (C#)

Syntax	`void UnregisterOnRuntimeManagerLostEvent();`
Parameters	None
Return values	None

WaitForOnRuntimeManagerLostEvent()

The function will block the program until the registered event object is set to the signaled state or the timeout interval is exceeded.

Table 3-469 WaitForOnRuntimeManagerLostEvent() - Native C++

Syntax	`bool WaitForOnRuntimeManagerLostEvent();` `bool WaitForOnRuntimeManagerLostEvent(UINT32 in_Time_ms);`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined timeout interval.

Table 3-470 WaitForOnRuntimeManagerLostEvent() - .NET (C#)

Syntax	`bool WaitForOnRuntimeManagerLostEvent();` `bool WaitForOnRuntimeManagerLostEvent(UInt32 in_Time_ms);`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UInt32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined timeout interval.

8.2.3 OnAutodiscoverData events

OnAutodiscoverData

Registers or unregisters an event handler method.

Table 3-471 OnAutodiscoverData - .NET (C#)

Syntax	`event Delegate_SRRSI_AD OnAutodiscoverData`
Parameters	None. See Delegate_SRRSI_AD (Page 245).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnAutodiscoverCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-472 RegisterOnAutodiscoverCallback() - Native C++

Syntax	`void RegisterOnAutodiscoverCallback(EventCallback_SRRSI_AD in_CallbackFunction);`
Parameters	• `EventCallback_SRRSI_AD in_CallbackFunction:` Pointer to a user-defined callback function. See EventCallback_SRRSI_AD (Page 237).
Return values	None

UnregisterOnAutodiscoverCallback()

Unregisters the callback function.

Table 3-473 UnregisterOnAutodiscoverCallback() - Native C++

Syntax	`void UnregisterOnAutodiscoverCallback();`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

IInstance

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GetSystemTime()

Returns the virtual system time of the simulated PLC instance. Returns an empty structure when the function fails.

Table 3-633 GetSystemTime() - Native C++

Syntax	`SYSTEMTIME GetSystemTime();`
Parameters	None
Return values	`SYSTEMTIME:` System time of the simulated PLC instance.

SetSystemTime()

Sets the virtual system time of the simulated PLC instance. A system time between "Jan 1 1970 00:00:00:000" and "Dec 31 2200 23:59:59:999" is valid.

Table 3-634 SetSystemTime() - Native C++

Syntax	`ERuntimeErrorCode SetSystemTime(SYSTEMTIME in_SystemTime);`	
Parameters	• `SYSTEMTIME in_SystemTime:` System time that is to be set for the simulated PLC instance.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The value is outside the limits.

SystemTime { get; set; }

Sets or returns the virtual system time of the simulated PLC instance. A system time between "Jan 1 1970 00:00:00:000" and "Dec 31 2200 23:59:59:999" is valid.

Table 3-635 SystemTime { get; set; } - .NET (C#)

Syntax	`DateTime SystemTime { get; set; }`	
Parameters	None	
Return values	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The value is outside the limits.

GetScaleFactor()

Returns the scaling factor with which the virtual time advances.

Table 3-636 GetScaleFactor() - Native C++

Syntax	`double GetScaleFactor();`
Parameters	None
Return values	`double:` Scaling factor of the virtual time.

SetScaleFactor()

Sets the scaling factor with which the virtual time advances.

Siemens recommends that you start with a small scaling factor and gradually work your way up to a scaling factor where the simulated PLC instance remains in RUN.

A value between 0.01 and 100 is valid. The default setting is 1.

- If the value is less than 1, the virtual time of the simulated PLC instance runs X-times slower than the real time.
- If the value is greater than 1, the virtual time of the simulated PLC instance runs X-times faster than the real time.

A change in the value during runtime only takes effect at the cycle control point.

Table 3-637 SetScaleFactor() - Native C++

Syntax	`ERuntimeErrorCode SetScaleFactor (double in_Value);`	
Parameters	• `double in_Value:` Scaling factor of the virtual time.	
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The value is outside the limits.

ScaleFactor { get; set; }

Sets or returns the scaling factor with which the virtual time advances.

Start with a small scaling factor and incrementally approach a scaling factor at which the simulated PLC instance remains in RUN.

A value between 0.01 and 100 is valid. The default setting is 1.

- If the value is less than 1, the virtual time of the simulated PLC instance runs X-times slower than the real time.
- If the value is greater than 1, the virtual time of the simulated PLC instance runs X-times faster than the real time.

A change in the value during runtime only takes effect at the cycle control point.

Table 3-638 ScaleFactor { get; set; } - .NET (C#)

Syntax	`double ScaleFactor { get; set; }`	
Parameters	None	
Return values	`double`: Scaling factor of the virtual time.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The value is outside the limits.

9.1 Interfaces for IInstances

Dispose()

Deletes the managed interface and unloads the native components of the user interfaces.

Table 3-480 Dispose() - .NET (C#)

Syntax	`void Dispose()`
Parameters	None
Return values	None

GetID() / ID { get; }

Returns the instance ID. The ID is assigned by Runtime Manager when the instance is registered.

Table 3-481 GetID() - Native C++

Syntax	`INT32 GetID();`
Parameters	None
Return values	`INT32`: Instance ID

Table 3-482 ID { get; } - .NET (C#)

Syntax	`UInt32 ID { get; }`
Parameters	None
Return values	`Uint32`: Instance ID
Exceptions	None

GetName() / Name { get; }

Returns the name of the instance.

Table 3-483 GetName() - Native C++

Syntax	`ERuntimeErrorCode GetName(WCHAR inout_Name[], UINT32 in_ArrayLength);`	
Parameters	• `WCHAR inout_Name[]:` A user-allocated storage for the name of the instance. The field length should be at least as long as `DINSTANCE_NAME_MAX_LENGTH`. See Definitions and constants (Page 251). • `UINT32 in_ArrayLength:` Field length (Wide character)	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_WRONG_ARGUMENT`	The name does not fit in the storage.

Example C++	`ISimulationRuntimeManager * api = NULL;`
	`ERuntimeErrorCode result = InitializeApi(&api);`
	`IInstance* psa = NULL;`
	`if (result == SREC_OK)`
	`{`
	`  result = api->RegisterInstance(&psa);`
	`}`
	
	`WCHAR name[DINSTANCE_NAME_MAX_LENGTH];`
	`if (result == SREC_OK)`
	`{`
	`  result = psa->`**`GetName`**`(name, DINSTANCE_NAME_MAX_LENGTH);`
	`}`	

Table 3-484 Name { get; } - .NET (C#)

Syntax	`string Name { get; }`	
Parameters	None	
Return values	Name of the instance.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.

GetCPUType()

Returns the CPU type of the simulated PLC instance.

Table 3-485 GetCPUType() - Native C++

Syntax	`ECPUType GetCPUType();`
Parameters	None
Return values	An enumeration element that defines the CPU type. See ECPUType (Page 275).

SetCPUType()

Sets the CPU type of the simulated PLC instance. A change of CPU type occurs only when the controller is restarted.

NOTE

When you create a new instance and set the CPU type, S7-PLCSIM Advanced uses precise simulation to simulate the PLC after `PowerOn`. The API loads the quantity structure based on the selected type. You can only overload the CPU type using a hardware-compatible PLC.

Table 3-486 SetCPUType() - Native C++

Syntax	`void SetCPUType(ECPUType in_Value);`
Parameters	• `ECPUType in_Value:` Defines which CPU type is simulated at the start of the instance. When a different CPU type is loaded via STEP 7 or from the Virtual Memory Card, this CPU type applies.
Return values	None

CPUType { get; set; }

Returns or sets the CPU type of the simulated PLC instance. A change of CPU type occurs only when the controller is restarted.

When a different CPU type is loaded via STEP 7 or from the Virtual Memory Card, this CPU type applies.

NOTE

When you create a new instance and set the CPU type, S7-PLCSIM Advanced uses precise simulation to simulate the PLC after `PowerOn`. The API loads the quantity structure based on the selected type. You can only overload the CPU type using a hardware-compatible PLC.

Table 3-487 CPUType { get; set; } - .NET (C#)

Syntax	`ECPUType CPUType { get; set; }`
Parameters	None
Return values	An enumeration element that defines the CPU type.
Exceptions	None

GetArticleNumber() / ArticleNumber { get; }

Returns the set ArticleNumber of the simulated instance. If you only set the CPU type, the method returns the article number of the specified CPU type.

To use this method, you must first create a 20-character array for the article number using the constant `HWDB_B1_ORDER_ID_LEN` in SimulationRuntimeAPI.h. Pass a pointer to the array into the method. The method fills the array with a string containing the article number plus a zero in position 19.

Table 3-488 GetArticleNumber() - Native C++

Syntax	`GetArticleNumber(WCHAR *out_ArticleNumber);`
Parameters	`WCHAR *out_ArticleNumber`
Return values	None

Table 3-489 ArticleNumber{ get; } - .NET (C#)

Syntax	`System::String^ ArticleNumber { System::String^ get(); }`
Parameters	None
Return values	`System::String^` containing the article number

GetCommunicationInterface()

This property is now read-only. To set the network mode, refer to the NetworkMode section.

Returns the communication interface of the simulated controller: Local communication (Softbus) or TCPIP.

Table 3-490 GetCommunicationInterface() - Native C++

Syntax	`ECommunicationInterface GetCommunicationInterface();`
Parameters	None
Return values	• `SRCI_NONE` Cannot be selected. Is returned if the instance interface is no longer valid. • `SRCI_SOFTBUS` Is returned if the simulated controller uses the Softbus. • `SRCI_TCPIP` Is returned if the simulated controller communicates over the virtual adapter.

CommunicationInterface { get; }

This property is now read-only. To set the network mode, refer to the NetworkMode section (Page 65).

Returns the communication interface of the simulated controller: Local communication (Softbus) or TCPIP.

Table 3-491 CommunicationInterface { get; } - .NET (C#)

Syntax	`ECommunicationInterface CommunicationInterface { get; }`
Parameters	None

Return values	• `ECommunicationInterface.None` Cannot be selected. Is returned if the instance interface is no longer valid. • `ECommunicationInterface.Softbus` Is returned if the simulated controller uses the Softbus. • `ECommunicationInterface.TCPIP` Is returned if the simulated controller communicates over the virtual adapter.
Exceptions	None

GetInfo() / Info { get; }

Returns a structure that provides information about the instance.

Table 3-492 GetInfo() - Native C++

Syntax	`SInstanceInfo GetInfo();`
Parameters	None
Return values	`SInstanceInfo`: A structure that provides information about the instance. See SInstanceInfo (Page 260).

Table 3-493 Info { get; } - .NET (C#)

Syntax	`SInstanceInfo Info { get; }`
Parameters	None
Return values	`SInstanceInfo`: A structure that provides information about the instance.
Exceptions	None

GetNetInterfaceMapping()

Returns an interface index of the PC interface to which a specific CPU interface is mapped. Use the `GetNetInterfaces()` function to get a list of PC interfaces with interface index. The value 0 means that no mapping has been set.

Note that GetNetInterfaceMapping() only returns a mapping table and not the actual address while the instance is running.

NOTE

If two network adapters have the same MAC address, the `GetNetInterfaceMapping()` function might not return the adapter that you previously set using the `SetNetInterfaceMapping()` function. This issue can occur specifically with adapters that use the 'MAC Address Pass-through' feature, leading to potential conflicts in adapter identification and mapping.

Table 3-494 GetNetInterfaceMapping() - Native C++ und .NET (C#)

Syntax C++	`INT32 GetNetInterfaceMapping(EPLCInterface in_PLCInterfaceID);`	
Syntax .NET (C#)	`int GetNetInterfaceMapping(EPLCInterface in_PLCInterfaceID);`	
Parameters	`EPLCInterface in_PLCInterfaceID`: ID of the PLC interface for which you want to get the mapping.	
Return values	Value	Description

Return values	Greater than 0	Index of mapped computer interface
	0	No mapping is defined for the PLC interface or the NetworkMode is Softbus
	-1	Cannot get the mapping

SetNetInterfaceMapping()

Sets interface mappings between CPU interface and PC interface. Ethernet packets that a certain PC interface receives are forwarded to the assigned CPU interface. Use the `GetNetInterfaces()` function to get a list of PC interfaces.

The function is not valid for the Softbus NetworkMode.

Table 3-495 SetNetInterfaceMapping() - Native C++

Syntax	`ERuntimeErrorCode SetNetInterfaceMapping(EPLCInterface in_PLCInterfaceID, DWORD in_PCInterfaceIndex);`
	`ERuntimeErrorCode SetNetInterfaceMapping(EPLCInterface in_PLCInterfaceID, const WCHAR* in_PCInterfaceName);`
	`ERuntimeErrorCode SetNetInterfaceMapping(EPLCInterface in_PLCInterfaceID, const SMACAddress* in_MACAddressParam);`	

Parameters	`EPLCInterface in_PLCInterfaceID:`
	ID of the CPU interface for which a MAC address is to be set.
	`DWORD* in_PCInterfaceIndex:`
	Index of the PC interface; if this value is 0, the mapping is deleted.
	`const WCHAR* in_PCInterfaceName:`
	Name of the PC interface
	`const UMACAddress* in_MACAddressParam:`
	Hardware MAC address of the PC interface in the form FF-FF-FF-FF-FF-FF, where the octet separator is a "-".
	You get these values with the function `GetNetInterfaces()`.	

Return values	Runtime error code	Description
	`SREC_OK`	The function call is successful.
	`SREC_WRONG_COMMUNICATION_INTERFACE`	This error is returned in TCPIP modes in case the specified/mapped computer interface in the sim_hwdb.ini file is disabled or it is the PLCSIM Virtual Adapter.
	`SREC_ALREADY_EXISTS`	The PC interface has already been assigned to another CPU interface.
	`SREC_CONFIG_FILE_ERROR`	An error occurred when writing the configuration to the file "sim_hwdb.ini".
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_INSTANCE_ALREADY_RUNNING`	Bindings cannot change while the instance is running.
	`SREC_NOT_SUPPORTED`	You cannot call the function in Softbus NetworkMode.

Table 3-496 SetNetInterfaceMapping() - .NET (C#)

Syntax	`SetNetInterfaceMapping(EPLCInterface in_PLCInterfaceID, uint in_PCInterfaceIndex);`
	`SetNetInterfaceMapping(EPLCInterface in_PLCInterfaceID, const String in_PCInterfaceName);`
	`SetNetInterfaceMapping(EPLCInterface in_PLCInterfaceID, const SMACAddress in_MACAddressParam);`	

Exceptions	Runtime error code	Description
	`ERuntimeErrorCode.WrongCommunicationInterface`	This error is returned in TCPIP modes in case the specified/mapped computer interface in the sim_hwdb.ini file is disabled or it is the PLCSIM Virtual Adapter.
	`ERuntimeErrorCode.AlreadyExists`	The PC interface has already been assigned to another CPU interface.
	`ERuntimeErrorCode.ConfigFileError`	An error occurred when writing the configuration to the file "sim_hwdb.ini".
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.InstanceAlreadyRunning`	Bindings cannot change while the instance is running.
	`ERuntimeErrorCode.NotSupported`	You cannot call the function in Softbus NetworkMode.

CheckNetInterfaceMapping()

The function checks the validity of the interface mapping in order to start the instance. All PC instances already running are checked for possible duplicate mappings. The function also checks whether the binding to the PC network interfaces is valid. The function is not valid for the Softbus NetworkMode.

Table 3-497 CheckNetInterfaceMapping() - Native C++

Syntax	`ERuntimeErrorCode CheckNetInterfaceMapping();`	
Parameters	None	
Return values	Runtime error code	Description
	`SREC_OK`	The function call is successful.
	`SREC_INVALID_CONFIGURATION`	The configuration is invalid. Examples: • The current instance has a mapped PC network interface that is already in use by another running instance. • A mapped PLCSIM Virtual Ethernet Adapter exists. • You have set the Multi-Adapter Network Mode (non-promiscuous mode) without interface mapping.

Return values	SREC_VIRTUAL_SWITCH_MISCONFIGURED	The binding of an S7-PLCSIM Advanced Virtual Switch on a PC network interface is not correct, or the driver of an S7-PLCSIM Advanced Virtual Switch is not functioning properly. If the binding is not correct, call the SetNetInterfaceBindings() function or set the binding manually before starting the instance.
	SREC_INTERNAL_ERROR	The system call has caused an internal error.
	SREC_WRONG_COMMUNICATION_INTERFACE	This error is returned in TCPIP modes in case the specified/mapped computer interface in the sim_hwdb.ini file is disabled or it is the PLCSIM Virtual Adapter.
	SREC_INTERFACE_REMOVED	The instance is not registered in Runtime Manager.
	SREC_PCAP_DRIVER_NOT_RUNNING	The PCAP driver is not running.
	SREC_NOT_SUPPORTED	You cannot call the function in the Softbus NetworkMode.

Table 3-498 CheckNetInterfaceMapping() - .NET (C#)

Syntax	ERuntimeErrorCode CheckNetInterfaceMapping();	
Return values	Runtime error code	Description
	ERuntimeErrorCode.OK	The function call is successful.
	ERuntimeErrorCode.InvalidConfiguration	The configuration is invalid. Examples: • The current instance has a mapped PC network interface that is already in use by another running instance. • A mapped PLCSIM Virtual Ethernet Adapter exists. • You have set the Multi-Adapter Network Mode (non-promiscuous mode) without interface mapping.
	ERuntimeErrorCode.VirtualSwitchMisconfigured	The binding of an S7-PLCSIM Advanced Virtual Switch on a PC network interface is not correct, or the driver of an S7-PLCSIM Advanced Virtual Switch is not functioning properly. If the binding is not correct, call the SetNetInterfaceBindings() function or set the binding manually before starting the instance.
	ERuntimeErrorCode.InternalError	The system call has caused an internal error.
	ERuntimeErrorCode.WrongCommunicationInterface	This error is returned in TCPIP modes in case the specified/mapped computer interface in the sim_hwdb.ini file is disabled or it is the PLCSIM Virtual Adapter.
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.PCAPDriverNotRunning	The PCAP driver is not running.
	ERuntimeErrorCode.NotSupported	You cannot call the function in the Softbus NetworkMode.

UnregisterInstance()

Unregisters this instance from Runtime Manager.

NOTE
Loss of the interfaces
Other applications that are connected to this instance will lose their interface to this instance.

NOTE
Do not unregister an instance or free the API while either the control panel or the API is starting an instance. Wait until the PowerOn action for this instance is complete.

Table 3-499 UnregisterInstance() - Native C++

Syntax	`ERuntimeErrorCode UnregisterInstance();`	
Parameters	None	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-500 UnregisterInstance() - .NET (C#)

Syntax	`void UnregisterInstance();`	
Parameters	None	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

9.2 Controller - Information and settings

GetControllerName() / ControllerName { get; }

Returns the downloaded name of the simulated PLC instance.

Table 3-501 GetControllerName() - Native C++

Syntax	`ERuntimeErrorCode GetControllerName(WCHAR inout_Name[], UINT32 in_ArrayLength);`	
Parameters	• `WCHAR inout_Name[]:` A user-allocated storage for the name. • `UINT32 in_ArrayLength:` The length of the storage.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.

Return values	SREC_INTERFACE_REMOVED	The instance is not registered in Runtime Manager.
	SREC_TIMEOUT	The function does not return on time.
	SREC_INDEX_OUT_OF_RANGE	The name does not fit in the storage.

Table 3-502 ControllerName { get; } - .NET (C#)

Syntax	string ControllerName { get; }	
Parameters	None	
Return values	string: The downloaded name of the simulated PLC instance.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.

GetControllerShortDesignation() / ControllerShortDesignation { get; }

Returns the downloaded short designation of the simulated PLC instance.

Table 3-503 GetControllerShortDesignation() - Native C++

Syntax	ERuntimeErrorCode GetControllerShortDesignation(WCHAR inout_ShortDesignation[], UINT32 in_ArrayLength);	
Parameters	• WCHAR inout_ShortDesignation[]: A user-allocated storage for the short designation. • UINT32 in_ArrayLength: The length of the storage.	
Return values	Runtime error code	Description
	SREC_OK	The function is successful.
	SREC_INTERFACE_REMOVED	The instance is not registered in Runtime Manager.
	SREC_TIMEOUT	The function does not return on time.
	SREC_INDEX_OUT_OF_RANGE	The name does not fit in the storage.

Table 3-504 ControllerShortDesignation { get; } - .NET (C#)

Syntax	string ControllerShortDesignation { get; }	
Parameters	None	
Return values	string: The downloaded short designation of the simulated PLC instance.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.

GetControllerIPCount()

Returns the number of configured IP addresses of the simulated PLC instance. If the function fails, the return value is 0.

Table 3-505 GetControllerIPCount() - Native C++

Syntax	`UINT32 GetControllerIPCount();`
Parameters	None
Return values	`INT32:` Number of configured IP addresses of the simulated PLC instance.

GetControllerIP() / ControllerIP { get; }

Returns a configured IP address of the instance.

Table 3-506 GetControllerIP() - Native C++

Syntax	`UIP GetControllerIP();` `UIP GetControllerIP(UINT32 in_Index);`
Parameters	• `WCHAR in_Index:` The index of the IP address you want to receive. The index must be less than the value you receive from `GetControllerIPCount()`. The default setting is 0.
Return values	`UIP:` IP address of the simulated PLC instance. If the function fails, the return value is 0.

Table 3-507 ControllerIP { get; } - .NET (C#)

Syntax	`string[] ControllerIP { get; }`
Parameters	None
Return values	`string:` All downloaded IP addresses of the simulated PLC instance. If the function fails, the field is empty.
Exceptions	None

GetControllerIPSuite4() / ControllerIPSuite4 { get; }

Returns the IP suite instance. If the "Softbus" communication interface is used, the subnet mask and default gateway are 0.

Table 3-508 GetControllerIPSuite4() Native C++

Syntax	`SIPSuite4 GetControllerIPSuite4();` `SIPSuite4 GetControllerIPSuite4(UINT32 in_Index);`
Parameters	• `WCHAR in_Index:` The index of the IP address you want to receive. The index must be less than the value you receive from `GetControllerIPCount()`. The default setting is 0.
Return values	`SIPSuite4`: The IP suite of the simulated PLC instance. If the function fails, the return values are 0.

Table 3-509 ControllerIPSuite4 { get; } - .NET (#)

Syntax	`SIPSuite4[] ControllerIPSuite4 { get; };`
Parameters	None
Return values	`SIPSuite4[]`: All downloaded IP suites of the simulated PLC instance. If the function fails, the field is empty.
Exceptions	None

SetIPSuite()

Sets the IP suite of the network interface of a simulated PLC instance.

To change the subnet mask or gateway, you must also change the IP address. If you do not change the IP address, the API does not apply your other changes.

Table 3-510 SetIPSuite() - Native C++

Syntax	`ERuntimeErrorCode SetIPSuite(UINT32 in_InterfaceID, SIPSuite4 in_IPSuite, bool in_IsRemanent);`	
Parameters	• `UINT32 in_InterfaceID:` The ID of the network interface. • `SIPSuite4 in_IPSuite:` The IP suite that is to be assigned to the network interface. The IP suite contains the IP address, the subnet mask and the standard gateway. If the communication interface is "Softbus", the subnet mask and standard gateway are ignored. • `bool in_IsRemanent:` If `true`, the IP suite is saved after restart of the simulated PLC instance. If the communication interface is "Softbus", this flag is ignored.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_DOES_NOT_EXIST`	There is no network interface with this ID.
	`SREC_INVALID_OPERATING_STATE`	The simulated PLC instance has not yet completed the boot process or is already in the shutdown phase.

Table 3-511 SetIPSuite() - .NET (C#)

Syntax	`void SetIPSuite(UInt32 in_InterfaceID, SIPSuite4 in_IPSuite, bool in_IsRemanent);`	
Parameters	• `UInt32 in_InterfaceID:` The ID of the network interface. • `SIPSuite4 in_IPSuite:` If the communication interface is "Softbus", the subnet mask and standard gateway are ignored. • `bool in_IsRemanent:` If `true`, the IP suite is saved after restart of the simulated PLC instance. If the communication interface is "Softbus", this flag is ignored.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.DoesNotExist`	There is no network interface with this ID.
	`ERuntimeErrorCode.InvalidOperating-State`	The simulated PLC instance has not yet completed the boot process or is already in the shutdown phase.

GetStoragePath()

Returns the full path of the folder in which the instance stores its data.

Table 3-512 GetStoragePath() - Native C++

Syntax	`ERuntimeErrorCode GetStoragePath(WCHAR inout_StoragePath[], UINT32 in_ArrayLength);`	
Parameters	• `WCHAR inout_StoragePath[]:` A user-allocated storage for the storage path. The length of the array should be at least as long as `DSTORAGE_PATH_MAX_LENGTH`. See Data types (Page 235). • `UINT32 in_ArrayLength:` Length of the array (Wide character)	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INDEX_OUT_OF_RANGE`	The path does not fit in the storage.

SetStoragePath()

Sets the full path of the folder in which the instance stores its data. This can also be a network share.

Set the path before you start the instance. A change to the path takes effect only when the controller is restarted.

If no path is set, the default setting:
<My Documents>\Siemens\Simatic\Simulation\Runtime\Persistence\<Instance Name> is used.

Table 3-513 SetStoragePath() - Native C++

Syntax	`ERuntimeErrorCode SetStoragePath(WCHAR* in_StoragePath);`	
Parameters	• `WCHAR* in_StoragePath:` Full name of the storage path. The length of the name must be less than `DSTORAGE_PATH_MAX_LENGTH`. You can use basic Latin alphanumeric characters (A-Z, a-z, 0-9), "!", "=", and "-" to name the instance, but most other special characters, such as currency, Chinese characters, or mathematical symbols are unsupported. See Data types (Page 235).	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INDEX_OUT_OF_RANGE`	The length of the path exceeds the limit.
	`SREC_WRONG_ARGUMENT`	The path contains invalid characters.

StoragePath { get; set; }

Returns or sets the full path of the folder in which the instance stores its retentive data. This can also be a network share.

Set the path before you start the instance. A change to the path takes effect only when the controller is restarted.

If no path is set, the default setting:
<My Documents>\Siemens\Simatic\Simulation\Runtime\Persistence\<Instance Name> is used.

Table 3-514 StoragePath { get; set; } - .NET (C#)

Syntax	`string StoragePath { get; set; }`	
Parameters	None	
Return values	`string`: The configured storage path.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.IndexOutOfRange`	The length of the path exceeds the limit.
	`ERuntimeErrorCode.WrongArgument`	The path contains invalid characters.

ArchiveStorage()

The user program, the hardware configuration, and the retentive data are stored in a file to the Virtual SIMATIC Memory Card. `ArchiveStorage()` stores this file as a ZIP file. The simulated PLC instance must be in OFF operating state for this. You must call the `PowerOn()` function at least once to avoid errors.

NOTE

Stored files can contain sensitive information. It is your responsibility to handle this information securely.

Table 3-515 ArchiveStorage() - Native C++

Syntax	`ERuntimeErrorCode ArchiveStorage(WCHAR* in_FullFileName);`	
Parameters	• `WCHAR in_FullFileName:` The full path to the ZIP file. The path relates to directories of the computer where the API is being called.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INVALID_OPERATING_STATE`	The instance is not in OFF operating state.
	`SREC_INVALID_ARCHIVE_PATH`	The archive path is invalid.
	`SREC_CREATE_DIRECTORIES_FAILED`	The folder for the ZIP file could not be created.
	`SREC_ARCHIVE_STORAGE_FAILED`	The ZIP file could not be created.
	`SREC_STORAGE_TRANSFER_ERROR`	Error during network data transfer. Memory data between client and server computers do not match.
	`SREC_NO_STORAGE_PATH_SET`	No storage path is set. You must execute the SetStoragePath() function beforehand.
	`SREC_ARCHIVE_STORAGE_NOT_CREATED`	The storage file could not be created. You must call the `PowerOn()` function at least once.

Table 3-516 ArchiveStorage() - .NET (C#)

Syntax	`void ArchiveStorage(string in_FullFileName);`	
Parameters	• `string in_FullFileName:` The full path to the ZIP file. The path relates to folders of the computer where the API is being called.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InvalidOperating-State`	The instance is not in OFF operating state.
	`ERuntimeErrorCode.InvalidArchivePath`	The archive path is invalid.
	`ERuntimeErrorCode.CreateDirectories-Failed`	The folder for the ZIP file could not be created.
	`ERuntimeErrorCode.ArchiveStorageN-otCreated`	The ZIP file could not be created.
	`ERuntimeErrorCode.StorageTransferEr-ror`	Error during network data transfer. Memory data between client and server computers do not match.

RetrieveStorage()

`RetrieveStorage()` creates a Virtual SIMATIC Memory Card from the archived ZIP file. The simulated PLC instance must be in OFF operating state for this.

Table 3-517 RetrieveStorage() - Native C++

Syntax	`ERuntimeErrorCode RetrieveStorage(WCHAR* in_FullFileName);`	
Parameters	• `WCHAR* in_FullFileName:` The full path to the ZIP file. The path relates to folders of the computer where the API is being called.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INVALID_OPERATING_STATE`	The instance is not in OFF operating state.
	`SREC_INVALID_ARCHIVE_PATH`	The archive path is invalid.
	`SREC_DELETE_EXISTING_STORAGE_FAILED`	The old storage cannot be deleted.
	`SREC_RETRIEVE_STORAGE_FAILURE`	The ZIP file cannot be unzipped.
	`SREC_STORAGE_TRANSFER_ERROR`	Error during network data transfer. Memory data between client and server computers do not match.
	`SREC_NO_STORAGE_PATH_SET`	No storage path is set. The user has to execute the SetStoragePath() function beforehand.

Table 3-518 RetrieveStorage() - .NET (C#)

Syntax	`void RetrieveStorage(string in_FullFileName);`	
Parameters	• `string in_FullFileName:` The full path to the ZIP file. The path relates to folders of the computer where the API is being called.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InvalidOperating-State`	The instance is not in OFF operating state.
	`ERuntimeErrorCode.InvalidArchivePath`	The archive path is invalid.
	`ERuntimeErrorCode.DeleteExisting-StorageFailed`	The old storage cannot be deleted.
	`ERuntimeErrorCode.RetrieveStorage-Failure`	The ZIP file cannot be unzipped.
	`ERuntimeErrorCode.StorageTransferEr-ror`	Error during network data transfer. Memory data between client and server computers do not match.

NOTE

Editing an instance created with S7-PLCSIM Advanced using S7-PLCSIM Advanced API V3.0 with the functions ArchiveStorage() and RetrieveStorage()

When you edit an instance created with S7-PLCSIM Advanced V4.0 or higher with the API functions ArchiveStorage() and RetrieveStorage() of V3.0, API V3.0 does not save the entire card content of the virtual memory card. The retain.pms and sim_hwdb.ini files are missing.

This means that the password to protect confidential configuration data is not saved and will be lost.

Solution:

You have a variety options:

- Set the password to protect the confidential configuration data before each simulation again using STEP 7, the SIMATIC Automation Tool, or TIA Portal Openness.
- Establish a remote connection of the instance via the Runtime Manager even when the instance communicates locally. In this case, the password is saved to the virtual memory card.
- Do not assign a password to protect confidential configuration data.

CleanupStoragePath()

The function deletes the folder with the Virtual SIMATIC Memory Card of a local instance or a remote instance. To do this, the function checks whether required and invalid files are available. Even if the folder is missing, the function is considered successful.

To make sure that the correct folder is deleted, the function checks whether there are any files that need to be present in the Virtual SIMATIC Memory Card:

- ".\sim_hwdb.ini"
- ".\SIMATIC_MC\SIMATIC.S7S\"
- ".\SIMATIC_MC\RData\"

To permanently delete the folder, only the following folders with files are also allowed:

- ".\CrashDump\"
- ".\Traces\"
- ".\retain.pms"

The instance must be in OFF operating state ("`PowerOff`").

Table 3-519 CleanupStoragePath() - Native C++

Syntax	`ERuntimeErrorCode CleanupStoragePath();`	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INVALID_OPERATING_STATE`	The instance is not in OFF operating state.
	`SREC_DELETE_EXISTING_STORAGE_FAILED`	The folder with the memory cannot be deleted.
	`SREC_INVALID_STORAGE`	The memory is invalid. It contains files or folders that are not permitted.

Table 3-520 CleanupStoragePath() - .NET (C#)

Syntax	`void CleanupStoragePath();`	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InvalidOperating-State`	The instance is not in OFF operating state.
	`ERuntimeErrorCode.DeleteExisting-StorageFailed`	The folder with the memory cannot be deleted.
	`SREC_INVALID_STORAGE`	The memory is invalid. It contains files or folders that are not permitted.

GetStrictMotionTiming() / StrictMotionTiming { get; }

Returns the current instance setting for the "Strict Motion Timing" feature. The "Strict Motion Timing" feature is located on the S7-PLCSIM Advanced Control Panel.

Table 3-521 GetStrictMotionTiming() - Native C++

Syntax	`ERuntimeErrorCode GetStrictMotionTiming(bool* enabled);`	
Parameters	bool* enabled: Receives the current setting. `true`: Active `false`: Inactive	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-522 StrictMotionTiming { get; } - .NET (C#)

Syntax	`bool StrictMotionTiming { get; }`	
Parameters	None	
Return values	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

SetStrictMotionTiming() / StrictMotionTiming { set; }

Sets the instance setting for the "Strict Motion Timing" feature. The "Strict Motion Timing" feature is located on the S7-PLCSIM Advanced Control Panel.

Table 3-523 SetStrictMotionTiming() - Native C++

Syntax	`ERuntimeErrorCode GetStrictMotionTiming(bool* enabled);`	
Parameters	bool enabled: The value to be set. `true`: Active `false`: Inactive	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INVALID_OPERATING_STATE`	The instance is in Power On. The instance must not be in Power On to change the setting.

Table 3-524 StrictMotionTiming { set; } - .NET (C#)

Syntax	`bool StrictMotionTiming { set; }`	
Parameters	None	
Return values	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InvalidOperating-State`	The instance is in Power On. The instance must not be in Power On to change the setting.

9.3 Operating state

PowerOn()

The function creates the process for the Simulation Runtime instance and starts the firmware of the simulated PLC instance.

The PowerOn() state is reached without a timeout value:

1. As soon as an instance was created
2. Before the user program has been started on the CPU

Table 3-525 PowerOn() - Native C++

Syntax	`ERuntimeErrorCode PowerOn();` `ERuntimeErrorCode PowerOn(UINT32 in_Timeout_ms);`	
Parameters	• `UInt32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns as soon as an instance is created and before the user program has been started on the CPU. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a timeout value of at least 8500 ms is recommended), the function returns when the operation has been completed or after a timeout. – Expected operating states when this function is successful: { `SROS_STOP` or `SROS_RUN, SROS_FREEZE, SROS_HOLD` }	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The expected operating state does not occur on time.
	`SREC_ERROR_LOADING_DLL`	The "Siemens.Simatic.Simulation.Runtime.Instance.exe" cannot load the "Siemens.Simatic.PlcSim.Vplc1500.dll" or the "Siemens.Simatic.PlcSim.Vplc1200g2.dll".
	`SREC_STORAGE_PATH_ALREADY_IN_USE`	The selected path for this instance is already being used by another instance.
	`SREC_NO_STORAGE_PATH_SET`	No storage path is set. The user has to execute the SetStoragePath() function beforehand.
	`SREC_WARNING_ALREADY_EXISTS`	Warning: The instance is started.
	`SREC_VIRTUAL_SWITCH_MISCONFIGURED`	• The S7-PLCSIM Advanced Virtual Switch is configured incorrectly. • The binding of an S7-PLCSIM Advanced Virtual Switch on a PC network interface is not correct, or the driver of an S7-PLCSIM Advanced Virtual Switch is not functioning properly. If the binding is not correct, call the `SetNetInterfaceBindings()` function or set the binding manually before starting the instance.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is no longer running.

Return values	SREC_UNSUPPORTED_PCAP_DRIVER	The PCAP driver used is not supported. S7-PLCSIM Advanced supports Npcap as of V0.9995. TCP/IP communication is not possible.
	SREC_WARNING_TRIAL_MODE_ACTIVE	Warning: No license available. You can use the instance without restrictions with the Trial License. Afterwards, the instance is shut down.
	SREC_WARNING_RUNNING_ON_TIA_PORTAL_-TEST_SUITE	Warning: No valid license is available, but a "TIA Portal Test Suite" license. S7-PLCSIM Advanced starts with this license. A download from the TIA Portal is possible, but the instance terminates without feedback if the download was not made from the TIA Portal Test Suite.
	SREC_NOT_EMPTY	Warning: No valid license for S7-PLCSIM Advanced is available, but a "TIA Portal Test Suite" license. If this is the case, power-up from the Virtual SIMATIC Memory Card is not supported.
	SREC_COMMUNICATION_INTERFACE_NOT_AV-AILABLE	**For local communication via Softbus** S7-PLCSIM Advanced cannot connect to the Softbus. **Solution** • Try again to establish the connection. • Close S7-PLCSIM Advanced and the TIA Portal and restart the applications. • Reboot the PC. • Repair the S7-PLCSIM Advanced installation. **For TCP/IP communication** Another application is connected to the Softbus on your PC. **Solution** • Close all SIMATIC applications, e.g. TIA Portal, WinCC, PLCSIM. • Reboot the PC. • Repair the S7-PLCSIM Advanced installation.
	SREC_ACCESS_DENIED	No write access in the Storage Directory.
	SREC_PCAP_DRIVER_NOT_RUNNING	The Nmap Packet Capture Driver (Npcap) is not active on the system. **Remedy** 1. Start the command line in administrator mode. 2. Execute the command "net start npcap".
	SREC_WRONG_COMMUNICATION_INTERFACE	• You have tried to supply the second instance with the communication interface that is different from the first instance that is already switched on. – **Example:** 1. PowerOn() of the first instance with Softbus is successful. 2. PowerOn() of the second instance with TCP/IP; the error code is returned. • The specified/mapped computer interface in the sim_hwdb.ini file is disabled or it is the PLCSIM Virtual Adapter.

Return values	SREC_WARNING_PASSWORD_PROTECTION_ERROR	The password protection prevented the memory from being opened. View the restrictions with activated password protection.
	SREC_INVALID_CONFIGURATION	The configuration is invalid. Examples: • The current instance has a mapped PC network interface that is already in use by another running instance. • A mapped PLCSIM Virtual Ethernet Adapter exists. • You have set the Multi-Adapter Network Mode (non-promiscuous mode) without interface mapping.
	SREC_INTERNAL_ERROR	The system call has caused an internal error.
	SREC_LICENSE_NOT_FOUND	This error occurs under one of the following conditions: • There is no valid license available in the Automation License Manager • The Automation License Manager is corrupt
	SREC_CONFIGURED_DEVICE_NOT_FOUND	The article number you provided is invalid.
	SREC_OUT_OF_MEMORY	The computer has insufficient memory. This can occur when you create multiple unspecified instances. **Solution** If you encounter an out of memory error try one of the following actions: • Add more RAM to your computer. • Register an instance for a specific CPU type. • Increase the Windows virtual memory paging file size.

Table 3-526 PowerOn() - .NET (C#)

Syntax	`ERuntimeErrorCode PowerOn();` `ERuntimeErrorCode PowerOn(UInt32 in_Timeout_ms);`	
Parameters	• `UInt32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns as soon as an instance is created and before the user program has been started on the CPU. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a timeout value of at least 8500 ms is recommended), the function returns when the operation has been completed or after a timeout. – Expected operating states when this function is successful: { `EOperatingState.Run` or `EOperatingState.Stop, EOperatingState.Freeze, EOperatingState.Hold`}	
Return values	Runtime error code	Description
	`ERuntimeErrorCode.OK`	The function is successful.
	`ERuntimeErrorCode.WarningAlreadyExists`	Warning: The instance is started.
	`ERuntimeErrorCode.UnsupportedPcapDriver`	The PCAP driver used is not supported. S7-PLCSIM Advanced supports Npcap as of V0.9995. TCP/IP communication is not possible.

Return values	`ERuntimeErrorCode.WarningTrialModeActive`	Warning: No license available. You can use the instance without restrictions with the Trial License. Afterwards, the instance is shut down.
	`ERuntimeErrorCode.WarningRunningOnTiaPortalTestSuite`	Warning: No valid license is available, but a "TIA Portal Test Suite" license. S7-PLCSIM Advanced starts with this license. A download from the TIA Portal is possible, but the instance terminates without feedback if the download was not made from the TIA Portal Test Suite.
	`ERuntimeErrorCode.NotEmpty`	Warning: No valid license for S7-PLCSIM Advanced is available, but a "TIA Portal Test Suite" license. If this is the case, power-up from the Virtual SIMATIC Memory Card is not supported.
	`ERuntimeErrorCode.CommunicationInterfaceNotAvailable`	**For local communication via Softbus** S7-PLCSIM Advanced cannot connect to the Softbus. **Solution** • Try again to establish the connection. • Close S7-PLCSIM Advanced and the TIA Portal and restart the applications. • Reboot the PC. • Repair the S7-PLCSIM Advanced installation. **For TCP/IP communication** Another application is connected to the Softbus on your PC. **Solution** • Close all SIMATIC applications, e.g. TIA Portal, WinCC, PLCSIM. • Reboot the PC. • Repair the S7-PLCSIM Advanced installation.
	`ERuntimeErrorCode.AccessDenied`	No write access in the Storage Directory.
	`ERuntimeErrorCode.PCAPDriverNotRunning`	The Nmap Packet Capture Driver (Npcap) is not active on the system. **Remedy** 1. Start the command line in administrator mode. 2. Execute the command "net start npcap".
	`ERuntimeErrorCode.WrongCommunicationInterface`	• You have tried to supply the second instance with the communication interface that is different from the first instance that is already switched on. – Example: 1. PowerOn() of the first instance with Softbus is successful. 2. PowerOn() of the second instance with TCP/IP; the error code is returned. • The specified/mapped computer interface in the sim_hwdb.ini file is disabled or it is the PLCSIM Virtual Adapter.
	ERuntimeErrorCode.`WarningPasswordForProtectionError`	The password protection prevented the memory from being opened. View the restrictions with activated password protection.

Return values	`ERuntimeErrorCode.InvalidConfiguration`	The configuration is invalid. Examples: • The current instance has a mapped PC network interface that is already in use by another running instance. • A mapped PLCSIM Virtual Ethernet Adapter exists. • You have set the Multi-Adapter Network Mode (non-promiscuous mode) without interface mapping.
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The expected operating state does not occur on time.
	`ERuntimeErrorCode.ErrorLoadingDll`	The "Siemens.Simatic.Simulation.Runtime.Instance.exe" cannot load the "Siemens.Simatic.PlcSim.Vplc1500.dll" or the "Siemens.Simatic.PlcSim.Vplc1200g2.dll".
	`ERuntimeErrorCode.StoragePathAlreadyInUse`	The selected path for this instance is already being used by another instance.
	`ERuntimeErrorCode.NoStoragePathSet`	The path could not be created. The length of the `DSTORAGE_PATH_MAX_LENGTH` characters might be exceeded.
	`ERuntimeErrorCode.VirtualSwitchMisconfigured`	• The S7-PLCSIM Advanced Virtual Switch is configured incorrectly. • The binding of an S7-PLCSIM Advanced Virtual Switch on a PC network interface is not correct, or the driver of an S7-PLCSIM Advanced Virtual Switch is not functioning properly. If the binding is not correct, call the `SetNetInterfaceBindings()` function or set the binding manually before starting the instance.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is no longer running.
	`ERuntimeErrorCode.InternalError`	The system call has caused an internal error.
	`ERuntimeErrorCode.LicenseNotFound`	This error occurs under one of the following conditions: • There is no valid license available in the Automation License Manager • The Automation License Manager is corrupt
	`ERuntimeErrorCode.ConfiguredDeviceNotFound`	The article number you provided is invalid.

	`ERuntimeErrorCode.OutOfMemory`	The computer has insufficient memory. This can occur when you create multiple unspecified instances. **Solution** If you encounter an out of memory error try one of the following actions: • Add more RAM to your computer. • Register an instance for a specific CPU type. • Increase the Windows virtual memory paging file size.

PowerOff()

Shuts down the Simulation Runtime and closes its process.

Table 3-527 PowerOff() - Native C++

Syntax	`ERuntimeErrorCode PowerOff();` `ERuntimeErrorCode PowerOff(UINT32 in_Timeout_ms);`	
Parameters	• `UINT32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a timeout value of at least 800 ms is recommended), the function returns when the operation has been completed or after a timeout. Expected operating state when this function is successful: `{ SROS_OFF }`	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The expected operating state does not occur on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.

Table 3-528 PowerOff() - .NET (C#)

Syntax	`void PowerOff();` `void PowerOff(UInt32 in_Timeout_ms);`	
Parameters	• `UInt32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a timeout value of at least 800 ms is recommended), the function returns when the operation has been completed or after a timeout. Expected operating state when this function is successful: `{ EOperatingState.Stop }`	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description

Exceptions	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The expected operating state does not occur on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.

Run()

Changes the simulated PLC instance to the RUN operating state.

Table 3-529 Run() - Native C++

Syntax	`ERuntimeErrorCode Run();` `ERuntimeErrorCode Run(UINT32 in_Timeout_ms);`	
Parameters	• `UINT32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a timeout value of at least 20 ms is recommended), the function returns when the operation has been completed or after a timeout. Expected operating states if this function is successful: `{ SROS_STOP , SROS_RUN }`	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The expected operating state does not occur on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_IS_EMPTY`	One of the following two conditions applies here: **Condition:** After creating and starting an instance, you have tried to switch the simulated PLC instance to the RUN operating state without downloading a STEP 7 project. **Condition:** After creating and enabling an instance with download of a STEP 7 project with enabled password for the protection of confidential configuration data, you have moved the virtual memory card from one system to another. You have tried to start the instance on the new system. The following error code is returned after the start: "SREC_WARNING_PASSWORD_PROTECTION_ERROR" Afterwards, you have tried to switch the simulated PLC instance to the RUN operating state.

Table 3-530 Run() - .NET (C#)

Syntax	`void Run();` `void Run(Uint32 in_Timeout_ms);`	
Parameters	• `UInt32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a timeout value of at least 20 ms is recommended), the function returns when the operation has been completed or after a timeout. Expected operating states when this function is successful: `{ EOperatingState.Run }`	
Exceptions	Runtime error code	Description
	ERuntimeErrorCode.IsEmpty	One of the following two conditions applies here: **Condition:** After creating and starting an instance, you have tried to switch the simulated PLC instance to the RUN operating state without downloading a STEP 7 project. **Condition:** After creating and enabling an instance with download of a STEP 7 project with enabled password for the protection of confidential configuration data, you have moved the virtual memory card from one system to another. You have tried to start the instance on the new system. The following error code is returned after the start: "SREC_WARNING_PASSWORD_PROTECTION_ERROR" Afterwards, you have tried to switch the simulated PLC instance to the RUN operating state.
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The expected operating state does not occur on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.

RUN operating state after enabling an instance

When you expect the RUN operating state after enabling an instance, check whether the instance is already in RUN by subscribing to the event `OnOperatingStateChanged()`. As an alternative, call `Run()` immediately after enabling the API function to switch the instance to the RUN operating state.

Stop()

Changes the simulated PLC instance to the STOP operating state.

Table 3-531 Stop() - Native C++

Syntax	`ERuntimeErrorCode Stop();` `ERuntimeErrorCode Stop(UINT32 in_Timeout_ms);`	
Parameters	• `UINT32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a timeout value of at least 200 ms is recommended), the function returns when the operation has been completed or after a timeout. Expected operating state when this function is successful: `{ SROS_STOP }`	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The expected operating state does not occur on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.

Table 3-532 Stop() - .NET (C#)

Syntax	`void Stop();` `void Stop(UInt32 in_Timeout_ms:);`	
Parameters	• `UInt32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a timeout value of at least 200 ms is recommended), the function returns when the operation has been completed or after a timeout. Expected operating state if this function is successful: `{ EOperatingState.Stop }`	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The expected operating state does not occur on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.

GetOperatingState() / OperatingState { get; }

Returns the operating state of the simulated PLC instance. When the operating state changes, the OnOperatingStateChanged() (Page 206) event is triggered. For details about the operating state, see Data types (Page 274).

Table 3-533 GetOperatingState() - Native C++

Syntax	`EOperatingState GetOperatingState();`
Parameters	None
Return values	• `SROS_INVALID_OPERATING_STATE:` If the function fails. • `SROS_OFF:` If the Simulation Runtime instance is not running. • `SROS_BOOTING:` If `PowerOn()` was called while in this state and the simulated PLC instance is not yet ready to start the user program. • `SROS_STOP:` If the simulated PLC instance is in STOP state. • `SROS_STARTUP:` If the user program is currently changing from STOP to RUN. • `SROS_RUN:` If the user program is running. • `SROS_FREEZE:` If the user program is being stopped (Freeze status). • `SROS_HOLD:` If the user program is set to HOLD when the breakpoint is reached. • `SROS_SHUTTING_DOWN`: If `PowerOff()` was called but the simulated PLC instance is still in the Shutdown phase.

Table 3-534 OperatingState { get; } - .NET (C#)

Syntax	`EOperatingState OperatingState { get; }`
Parameters	None
Return values	• `EOperatingState.InvalidOperatingState:` If the function fails. • `EOperatingState.Off:` If the Simulation Runtime instance is not running. • `EOperatingState.Booting:` If `PowerOn()` was called while in this state and the simulated PLC instance is not yet ready to start the user program. • `EOperatingState.Stop:` If the simulated PLC instance is in STOP state. • `EOperatingState.Startup:` If the user program is currently changing from STOP to RUN. • `EOperatingState.Run:` If the user program is running. • `EOperatingState.Freeze:` If the user program is being stopped (Freeze status). • `EOperatingState.Hold`: If the user program is set to HOLD when the breakpoint is reached. • `EOperatingState.ShuttingDown`: If `PowerOff()` was called but the simulated PLC instance is still in the Shutdown phase.

MemoryReset()

Shuts down the simulated PLC instance, closes its processes and performs a restart.

Closing the processes automatically performs a general reset.

Table 3-535 MemoryReset() - Native C++

Syntax	`ERuntimeErrorCode MemoryReset();` `ERuntimeErrorCode MemoryReset(UINT32 in_Timeout_ms);`	
Parameters	• `UINT32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a value of 60000 is recommended), the function returns when the operation has been completed or after a timeout. Expected operating states if this function is successful: `{ SROS_STOP , SROS_RUN }`	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The expected operating state does not occur on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.

Table 3-536 MemoryReset() - .NET (C#)

Syntax	`void MemoryReset();` `void MemoryReset(UInt32 in_Timeout_ms);`	
Parameters	• `UInt32 in_Timeout_ms:` A timeout value in milliseconds. – If no timeout value is set, the function returns immediately. Subscribe to the `OnOperatingStateChanged()` event to find out when the operation has been completed. – If the value is greater than 0 (a value of 60000 is recommended), the function returns when the operation has been completed or after a timeout. Expected operating states when this function is successful: `{ EOperatingState.Run, EOperatingState.Stop }`	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The expected operating state does not occur on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.

9.4 Stop simulation

Freeze state of the simulated PLC instance

To stop a simulation and synchronize simulation partners, you can set a simulated PLC instance to a freeze state via the API. When the instance has reached a synchronization point, the instance sends the event `OnSyncPointReached` to the API clients.

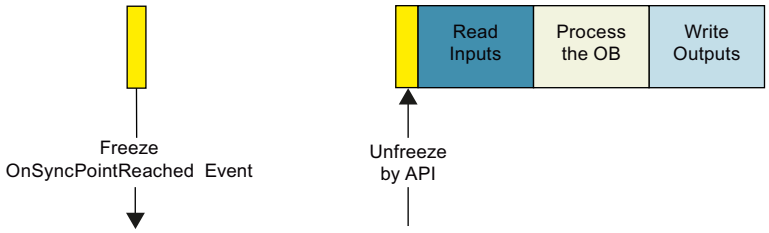

Figure 3-263 Freeze state of the simulated PLC instance

The following occurs in the freeze state:

- The virtual time is stopped.
- The OBs currently being executed are stopped.

  The procedure corresponds to the behavior of a program that has reached a breakpoint.
- The user program is no longer executed.
- The simulated PLC instance is still accessible from the TIA Portal.

NOTE

Freeze state during downloading

To complete a download in freeze state, the simulated PLC instance must pass through a suspended or terminated freeze state.

NOTE

Freeze-state ≠ operating state

The freeze state is an internal operating state of the simulated PLC instance. It does not correspond to RUN/STOP mode of a CPU. In the freeze state, the instance maintains the last operating state.

- The LED display on the Control Panel and on the Web server accordingly shows RUN or STOP for the instance.
- The instance shows the operating state `SROS_FREEZE` / `Freeze`, see EOperatingState (Page 274).

NOTE

Reaction of an S7-PLCSIM Advanced API to a freeze state

If you use a SingleStep operating mode, you must register a callback function for the `OnSyncPointReached` event. Calling the mode-specific `RunToNextSyncPoint` method ensures that the freeze state of the simulated PLC instance is exited again.

Synchronization points

A synchronization point always exists **before** inputs are read in, for example at the cycle control point or at the beginning of a cyclic OB.

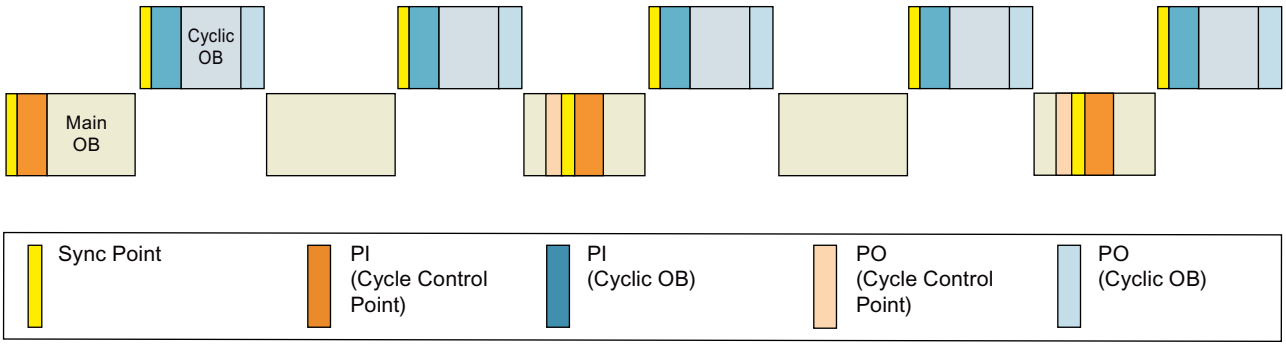

Figure 3-264 Overview of the synchronization points

Trigger freeze state

To trigger the freeze state, following modes are available for the simulated PLC instance:

- SingleStep operating modes
  See Synchronize simulation partner cycle-controlled (Page 200).
- TimespanSynchronized operating modes
  See Synchronize simulation partner time-controlled (Page 204).

In Default operating mode, the simulated PLC instance does not change into a freeze state.

API functions

- Settings for the cycle control (Page 171)
- GetOperatingMode() (Page 171)
- SetOperatingMode() (Page 171)
- OperatingMode { get; set; } (Page 171)
- EOperatingMode (Page 274)

9.5 Tag list

NOTE

Elements with data types not known to the API (`EDataType.Unknown`) are not included in the tag list.

UpdateTagList()

The function reads the tags from the simulated PLC instance and writes them to the shared storage arranged by name.

If the tag is an array or a structure, there are multiple entries.

In the case of a structure, there is an entry for the structure itself and an additional entry for each structure element.

Entry_1: "StructName"

Entry_2: "StructName.ElementName_1"

..

Entry_N: "StructName.ElementName_n"

In the case of an array, in this example a two-dimensional array, there is an entry for the array itself and an additional entry for each array element.

Entry_1: "ArrayName"

Entry_2: "ArrayName[a,b]", {a} and {b} correspond to the first index of the respective dimension)

..

Entry_N: "ArrayName[x,y]", {x} and {y} correspond to the last index of the respective dimension)

Memory for up to 500000 entries (not PLC tags) is reserved for the list. If the list becomes too large, the function returns the error/exception "NOT_ENOUGH_MEMORY".

If there are problems with the maximum number of entries and not all tags are needed, two filters can be used when refreshing the tag table.

Table 3-537 UpdateTagList() - Native C++

Syntax	`ERuntimeErrorCode UpdateTagList();`
	`ERuntimeErrorCode UpdateTagList(ETagListDetails in_TagListDetails);`
	`ERuntimeErrorCode UpdateTagList(ETagListDetails in_TagListDetails, bool in_IsHMIVisibleOnly);`
	`ERuntimeErrorCode UpdateTagList(ETagListDetails in_TagListDetails, bool in_IsHMIVisibleOnly, WCHAR* in_DataBlockFilterList);`

Parameters	• `ETagListDetails in_TagListDetails:` Every combination of the following four areas: **IO**: Inputs and Outputs **M**: Bit memory **CT**: Counters and Timers **DB**: Data Blocks The default setting is **IOMCTDB**. **Example: IOM** reads only the tags from the area Inputs / Outputs and Bit memory. • `bool in_IsHMIVisibleOnly:` If `true`, only tags marked with "HMI Visible" are read. The default setting is `true`. • `WCHAR* in_DataBlockFilterList:` A string that includes the name of all data blocks that are supposed to be available in the tag table. The string must be in quotation marks. **Example:** ""\"DB_1\", \"DB_2\" \"DB_3\"|\"DB_4\"\"DB_5\"" All characters within the quotation marks are interpreted as a DB name. If the data block does not exist in the PLC program, it is not added to the tag table memory. No error is triggered in the process. For this list to be taken into consideration, `in_DataBlockFilterList` has to be unequal to NULL and `in_TagListDetails` has to contain "DB".	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_NOT_ENOUGH_MEMORY`	More than 500000 entries are requested.
	`SREC_WARNING_ALREADY_EXISTS`	The tag table is current.
	`SREC_WRONG_ARGUMENT`	The syntax of `in_DataBlockFilterList` is invalid. The list has to be 3 characters long; the first and last character have to be a quotation mark.

Example C++	`ISimulationRuntimeManager * api = NULL;`
	`ERuntimeErrorCode result = InitializeApi(&api);`
	
	`IInstance* psa = NULL;`
	`if (result == SREC_OK)`
	`{`
	`result = api->RegisterInstance(&psa);`
	`}`
	
	`if (result == SREC_OK)`
	`{`
	`// Example: How to filter data blocks`
	`// DB Name: TEST_DB, DB Number: 2`
	`result = psa->UpdateTagList(SRTLD_MDB, false, L"\"TEST_DB\"");`
	`}`	

Table 3-538 UpdateTagList() - .NET (C#)

Syntax	`void UpdateTagList();`
	`void UpdateTagList(`
	` ETagListDetails in_TagListDetails`
	`);`
	`void UpdateTagList(`
	` ETagListDetails in_TagListDetails,`
	`bool in_IsHMIVisibleOnly`
	`);`
	`ERuntimeErrorCode UpdateTagList(`
	` ETagListDetails in_TagListDetails,`
	`  bool in_IsHMIVisibleOnly,`
	`  string in_DataBlockFilterList`
	`);`	

Parameters	• `ETagListDetails in_TagListDetails:` Every combination of the following four areas: **IO**: Inputs and Outputs **M**: Bit memory **CT**: Counters and Timers **DB**: Data Blocks The default setting is **IOMCTDB**. **Example: IOM** reads only the tags from the area Inputs / Outputs and Bit memory. • `bool in_IsHMIVisibleOnly:` If `true`, only tags marked with "HMI Visible" are read. The default setting is `true`. • `string in_DataBlockFilterList:` A string that includes the name of all data blocks that are supposed to be available in the tag table. The string must be in quotation marks. **Example:** ""\"DB_1\", \"DB_2\" \"DB_3\"|\"DB_4\"\"DB_5\"" All characters within the quotation marks are interpreted as a DB name. If the data block does not exist in the PLC program, it is not added to the tag table memory. No error is triggered in the process. For this list to be taken into consideration, `in_DataBlockFilterList` has to be unequal to NULL and `in_TagListDetails` has to contain "DB".	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.NotEnoughMemory`	More than 500000 entries are requested.
	`ERuntimeErrorCode.WrongArgument`	The syntax of `in_DataBlockFilterList` is invalid. The list has to be 3 characters long; the first and last character have to be a quotation mark.

GetTagListStatus()

Returns the current update status of the tag list storage.

"`inout_TagListDetails`" is `NONE`, if the list needs to be updated.

Table 3-539 GetTagListStatus() - Native C++

Syntax	`ERuntimeErrorCode GetTagListStatus(ETagListDetails* out_TagListDetails, bool* out_IsHMIVisibleOnly);`	
Parameters	• `ETagListDetails out_TagListDetails:` Status of the tag list details. `SRTLD_NONE` when an update of the list is required. • `bool out_IsHMIVisibleOnly:` If `true`, only tags marked with "HMI Visible" are available in the list.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-540 GetTagListStatus() - .NET (C#)

Syntax	`void GetTagListStatus(out ETagListDetails out_TagListDetails, out bool out_IsHMIVisibleOnly);`	
Parameters	• `out ETagListDetails out_TagListDetails:` Status of the tag list details. `ETagListDetails.None` when an update of the list is required. • `out bool out_IsHMIVisibleOnly:` If `true`, only tags marked with "HMI Visible" are available in the list.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

GetTagInfoCount()

Returns the number of entries in the tag list storage. If the function fails, the return value is 0.

Table 3-541 GetTagInfoCount() - Native C++

Syntax	`UINT32 GetTagInfoCount();`
Parameters	None
Return values	Number of entries in the tag list storage.

GetTagInfos() / TagInfos { get; }

Returns a list of all tags.

Table 3-542 GetTagInfos() - Native C++

Syntax	`ERuntimeErrorCode GetTagInfos(UINT32 in_BufferLength, STagInfo* inout_TagInfos, UINT32* out_TagCount);`	
Parameters	• `UINT32 in_BufferLength:` The number of elements that the storage can accommodate. • `STagInfo* inout_TagInfos:` The user-allocated storage that accommodates the tags. • `UINT32* out_TagCount:` Returns the number of tags that were written to the storage.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The elements do not fit in the storage.

Table 3-543 TagInfos { get; } - .NET (C#)

Syntax	`STagInfo[] TagInfos { get; }`	
Parameters	None	
Return values	An array that contains all available entries of the storage.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.

CreateConfigurationFile()

Writes all entries from the tag list to an XML file.

Table 3-544 CreateConfigurationFile() - Native C++

Syntax	`ERuntimeErrorCode CreateConfigurationFile(WCHAR* in_FullFileName);`	
Parameters	• `WCHAR* in_FullFileName:` Full file name of the XML file: <Path> + <File name> + <File extension>.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The file name is invalid.

Table 3-545 CreateConfigurationFile() - .NET (C#)

Syntax	`void CreateConfigurationFile(string in_FullFileName);`	
Parameters	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The file name is invalid.

9.6 I/O access

9.6.1 Synchronizing inputs and outputs

Description

In S7-PLCSIM Advanced the complete scope of the input and output area is used (see GetAreaSize/AreaSize (Page 117)). This is also possible when no I/O module is configured.

Inputs and outputs which are defined via configured I/O modules are synchronized to the defined update of the process image partition (PIP).

Inputs and outputs which are not assigned to an I/O module are synchronized in the cycle control point.

Note the following when synchronizing these inputs and outputs:

- Inputs can only be used as inputs.

  You can write values via the API. However, values written via STEP 7 or via communication to the input area will not be visible in the API. For example, if you go online in the TIA Portal and write data to the input area, those data values are not visible in the API. Methods such as ReadBytes() only read values written from the API.

- Outputs can be used as output and as input.

  You can write values via the API and via the CPU / STEP 7 user program. If API and user program write to the same area, the values from the API will overwrite the values from the user program.

NOTE

Conditions for synchronizing Fail-safe I/O

Fail-safe inputs and outputs are only synchronized if a Fail-safe module is plugged in and the Fail-safe program uses at least one bit of the module.

9.6.2 Simulate peripheral I/O

S7-PLCSIM Advanced writes to and reads from a memory area. This memory is synchronized with the internal process image of the simulated S7-1500 controller at the cycle control point and when calling cyclic and acyclic OBs (process image partitions, interrupts, events). The direct I/O accesses are made to this memory area. Only one process can access this memory at a given time.

The instance must be in RUN mode to apply changes made by the API.

NOTE

Precedence of write operations

If the STEP 7 user program is writing to a memory range at the same time an API application is writing to the same memory range, the writes from the API application take precedence. Writes from the API application override writes from the STEP 7 program to the simulated PLC instance.

9.6.3 I/O access via address - Reading

InputArea { get; }, MarkerArea { get; }, OutputArea { get; }

Returns an interface that you use to call the .NET functions in this section.

Table 3-546 InputArea { get; } MarkerArea { get; } OutputArea { get; } - .NET (C#)

Syntax	`IIOArea InputArea { get; }`
	`IIOArea MarkerArea { get; }`
	`IIOArea OutputArea { get; }`

Parameters	None
Return values	`IIOArea:` The interface is used to call the "I/O access via address" functions.

GetAreaSize() / AreaSize { get; }

Returns the size of the area in bytes.

Table 3-547 GetAreaSize() - Native C++

Syntax	`UINT32 GetAreaSize(EArea in_Area);`
Parameters	• `EArea in_Area:` The area whose size you want to receive. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 273).
Return values	`UINT32:` Size of the area in bytes. If the function was successful, the value is not equal to 0.

Table 3-548 AreaSize { get; } - .NET (C#)

Syntax	`UInt32 InputArea.AreaSize { get; }`
	`UInt32 MarkerArea.AreaSize { get; }`
	`UInt32 OutputArea.AreaSize { get; }`

Parameters	None
Return values	`Uint32:` Size of the area in bytes. If the function was successful, the value is not equal to 0.

ReadBit()

Reads an individual bit from the area.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-549 ReadBit() - Native C++

Syntax	`ERuntimeErrorCode ReadBit(EArea in_Area, UINT32 in_Offset, UINT8 in_Bit, bool* out_Value);`	
Parameters	• `EArea in_Area:` The area to be read from. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 273). • `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `GetAreaSize()` returns. • `UINT8 in_Bit:` The bit offset within the byte. The value must be between 0 and 7. • `bool* out_Value:` Returns the bit value.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	Offset or bits are invalid.
	`SREC_WRONG_ARGUMENT`	The area is invalid.

Table 3-550 ReadBit() - .NET (C#)

Syntax	`bool InputArea.ReadBit(UInt32 in_Offset, Byte in_Bit);`
	`bool MarkerArea.ReadBit(UInt32 in_Offset, Byte in_Bit);`
	`bool OutputArea.ReadBit(UInt32 in_Offset, Byte in_Bit);`	

Parameters	• `UInt32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `AreaSize` returns. • `Byte in_Bit:` The bit offset within the byte. The value must be between 0 and 7.	
Return values	`bool:` Bit value	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	Offset or bits are invalid.

ReadByte()

Reads an individual byte from the area.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-551 ReadByte() - Native C++

Syntax	`ERuntimeErrorCode ReadByte(EArea in_Area, UINT32 in_Offset, BYTE* out_Value);`	
Parameters	• `EArea in_Area:` The area from which you want to read. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 116). • `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `GetAreaSize()` returns. • `BYTE* out_Value:` Returns the byte value.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	Offset is invalid.
	`SREC_WRONG_ARGUMENT`	The area is invalid.

Table 3-552 ReadByte() - .NET (C#)

Syntax	`Byte InputArea.ReadByte(UInt32 in_Offset);`
	`Byte MarkerArea.ReadByte(UInt32 in_Offset);`
	`Byte OutputArea.ReadByte(UInt32 in_Offset);`	

Parameters	• `UInt32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `AreaSize` returns.	
Return values	`Byte:` Byte value.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	Offset is invalid.

ReadBytes()

Reads a byte array from the area.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-553 ReadByte() - Native C++

Syntax	`ERuntimeErrorCode ReadBytes(EArea in_Area, UINT32 in_Offset, UINT32 in_BytesToRead, UINT32* out_BytesRead, BYTE inout_Values[]);`	
Parameters	• `EArea in_Area:` The area from which you want to read. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 273). • `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `GetAreaSize()` returns. • `UINT32 in_BytesToRead:` Contains the size of the value storage. • `UINT32* out_BytesRead:` Returns the number of bytes that were just written to the value storage. • `BYTE inout_Values[]:` The storage for the bytes that are read from the area.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No byte could be read.
	`SREC_WRONG_ARGUMENT`	The area is invalid.

Table 3-554 ReadBytes() - .NET (C#)

Syntax	`Byte[] InputArea.ReadBytes(UInt32 in_Offset, UInt32 in_BytesToRead);`
	`Byte[] MarkerArea.ReadBytes(UInt32 in_Offset,UInt32 in_BytesToRead);`
	`Byte[] OutputArea.ReadBytes(UInt32 in_Offset,UInt32 in_BytesToRead);`	

Parameters	• `UInt32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `AreaSize` returns. • `UInt32 in_BytesToRead:` The number of bytes to be read.	
Return values	`Byte[]:` The read bytes.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No byte could be read.

ReadSignals()

Structures and fields can be emulated through signal lists and be read by using the `ReadSignals()` function.

The function also takes into consideration the byte order (Endianness).

Only primitive data type signals are supported, but the function is not type-safe.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-555 ReadSignals() - Native C++

Syntax	`ERuntimeErrorCode ReadSignals(EArea in_Area, SDataValueByAddress* inout_Signals, UINT32 in_SignalCount, bool validateAddressTag = false);` `ERuntimeErrorCode ReadSignals(EArea in_Area, SDataValueByAddressWithCheck* inout_Signals, UINT32 in_SignalCount, bool* out_SignalsHaveChanged, bool validateAddressTag = false);`	
Parameters	• `EArea in_Area` The area from which you want to read. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 273). • `SDataValueByAddress* inout_Signals` The signal list that is read. The result is stored in the structure. • `SDataValueByAddressWithCheck* inout_Signals` The signal list that is read. The result is stored in the structure. "`ValueHasChanged`" is set to `true` if the value of the signal has changed since the preceding call. • `UINT32 in_SignalCount` Number of signals in the list. • `bool* out_SignalsHaveChanged` Returns `true` if the value of at least one signal has changed since the preceding call. • `bool validateAddressTag` Boolean value to enable or disable the Memory Address to Tag association check.	
Signal error	Error code	Description
	`SREC_OK`	The signal operation is successful.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_WRONG_ARGUMENT`	The area is invalid.
	`SREC_SIGNAL_CONFIGURATION_ERROR`	At least one signal error is in the list.

Table 3-556 ReadSignals() - .NET (C#)

Syntax	`void ReadSignals(ref SDataValueByAddress[] inout_Signals, bool validateAddressTag);` `void ReadSignals(ref SDataValueByAddressWithCheck[] inout_Signals out bool out_SignalsHaveChanged, bool validateAddressTag);`

Parameters	• `ref SDataValueByAddress[] inout_Signals` The signal list that is read. • `ref SDataValueByAddressWithCheck[] inout_Signals` The signal list that is read. The result is stored in the structure. "`ValueHasChanged`" is set to `true` if the value of the signal has changed since the preceding call. • `out bool out_SignalsHaveChanged` Returns `true` if the value of at least one signal has changed since the preceding call. • `bool validateAddressTag` Optional boolean value to enable or disable the Memory Address to Tag association check.	
Signal error	Runtime error code	Description
	`ERuntimeErrorCode.OK`	The signal operation is successful.
	`ERuntimeErrorCode.IndexOutOfRange`	Offset or bits are invalid.
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.SignalConfigura-tionError`	At least one signal error is in the list.

9.6.4 I/O access via address - Writing

WriteBit()

Writes an individual bit to the area.

NOTE
Data can be overwritten
The function allows access to the entire storage area of the simulated PLC instance. Therefore, use access via the tag name (Page 149) and not via the address areas.

Table 3-557 WriteBit() - Native C++

Syntax	`ERuntimeErrorCode WriteBit(EArea in_Area, UINT32 in_Offset, UINT8 in_Bit, bool in_Value);`	
Parameters	• `EArea in_Area:` The area that is to be written. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 273). • `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `GetAreaSize()` returns. • `UINT8 in_Bit:` The bit offset within the byte. The value must be between 0 and 7. • `bool in_Value:` Bit value.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.

Return values	SREC_TIMEOUT	The function does not return on time.
	SREC_INSTANCE_NOT_RUNNING	The process of the simulated PLC instance is not running.
	SREC_INDEX_OUT_OF_RANGE	Offset or bits are invalid.
	SREC_WRONG_ARGUMENT	Area is invalid.

Table 3-558 WriteBit() - .NET (C#)

Syntax	`void InputArea WriteBit(UInt32 in_Offset, Byte in_Bit, bool in_Value);`
	`void MarkerArea WriteBit(UInt32 in_Offset, Byte in_Bit, bool in_Value);`
	`void OutputArea WriteBit(UInt32 in_Offset, Byte in_Bit, bool in_Value);`	

Parameters	• `UInt32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `AreaSize` returns. • `Byte in_Bit:` The bit offset within the byte. The value must be between 0 and 7. • `bool in_Value:` Bit value.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	Offset or bits are invalid.

WriteByte()

Writes an individual byte to the area.

NOTE
Data can be overwritten
The function allows access to the entire storage area of the simulated PLC instance.
Therefore, use access via the tag name (Page 149) and not via the address areas.

Table 3-559 WriteByte() - Native C++

Syntax	`ERuntimeErrorCode WriteByte(EArea in_Area, UINT32 in_Offset, BYTE in_Value);`	
Parameters	• `EArea in_Area:` The area that is to be written. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 273). • `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `GetAreaSize()` returns. • `BYTE in_Value:` Byte value.	
Return values	Runtime error code	Description

Return values	SREC_OK	The function is successful.
	SREC_INTERFACE_REMOVED	The instance is not registered in Runtime Manager.
	SREC_TIMEOUT	The function does not return on time.
	SREC_INSTANCE_NOT_RUNNING	The process of the simulated PLC instance is not running.
	SREC_INDEX_OUT_OF_RANGE	Offset is invalid.
	SREC_WRONG_ARGUMENT	Area is invalid.

Table 3-560 WriteByte() - .NET (C#)

Syntax	`void InputArea.WriteByte(UInt32 in_Offset, Byte in_Value);`
	`void MarkerArea.WriteByte(UInt32 in_Offset, Byte in_Value);`
	`void OutputArea.WriteByte(UInt32 in_Offset, Byte in_Value);`	

Parameters	• `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `AreaSize` returns. • `BYTE in_Value:` Byte value.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	Offset is invalid.

WriteBytes()

Writes a byte array to the area.

NOTE

Data can be overwritten

The function allows access to the entire storage area of the simulated PLC instance.

In particular, do not write to bytes that belong to other applications or contain internal data, for example, qualifier bits for fail-safe I/O modules.

Therefore, use access via the tag name (Page 149) and not via the address areas.

Table 3-561 WriteBytes() - Native C++

Syntax	`ERuntimeErrorCode WriteBytes(EArea in_Area, UINT32 in_Offset, UINT32 in_BytesToWrite, UINT32* out_BytesWritten, BYTE in_Values[]);`	
Parameters	• `EArea in_Area:` The area that is to be written. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 273). • `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `GetAreaSize()` returns. • `UINT32 in_BytesToWrite:` Contains the size of the array value to be written. • `UINT32* out_BytesWritten:` Contains the number of bytes that were just written. • `BYTE in_Values[]:` Byte array that is to be written to the area.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No byte could be written.
	`SREC_WRONG_ARGUMENT`	The area is invalid.

Table 3-562 WriteBytes() - .NET (C#)

Syntax	`UInt32 InputArea.WriteBytes(UInt32 in_Offset, Byte[] in_Values);`
	`UInt32 InputArea.WriteBytes(UInt32 in_Offset, UInt32 in_BytesToWrite, Byte[] in_Values);`
	`UInt32 MarkerArea.WriteBytes(UInt32 in_Offset, Byte[] in_Values);`
	`UInt32 MarkerArea.WriteBytes(UInt32 in_Offset, UInt32 in_BytesToWrite, Byte[] in_Values);`
	`UInt32 OutputArea.WriteBytes(UInt32 in_Offset, Byte[] in_Values);`
	`UInt32 OutputArea.WriteBytes(UInt32 in_Offset, UInt32 in_BytesToWrite, Byte[] in_Values);`	

Parameters	• `UINT32 in_Offset:` The byte offset within the area. The value must be between 0 and the value that `AreaSize` returns. • `UInt32 in_BytesToWrite:` Contains the number of bytes to be written. The value must be between 1 and the size of the array value. • `BYTE in_Value:` Byte value.	
Return values	`Uint32:` Contains the number of bytes that were just written.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.

Exceptions	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No byte could be written.

WriteSignals()

Writes multiple signals within an API call.

The function also takes into consideration the byte order (Endianness).

The function supports only primitive data type signals, but it is not typical.

NOTE
Data can be overwritten
The function allows access to the entire storage area of the simulated PLC instance.
Therefore, use access via the tag name (Page 149) and not via the address areas.

Table 3-563 WriteSignals() - Native C++

Syntax	`ERuntimeErrorCode WriteSignals(EArea in_Area, SDataValueByAddress* in_Signals, UINT32 in_SignalCount, bool validateAddressTag = false);`	
Parameters	• `EArea in_Area` The area that is to be written. Permissible values: `{SRA_INPUT, SRA_MARKER, SRA_OUTPUT}`. See EArea (Page 273). • `SDataValueByAddress* inout_Signals` The signal list to be written. • `UINT32 in_SignalCount` Number of signals in the list. • `bool validateAddressTag` Boolean value to enable or disable the Memory Address to Tag association check.	
Signal error	Error code	Description
	`SREC_OK`	The signal operation is successful.
	`SREC_INDEX_OUT_OF_RANGE`	Offset or bits are invalid.
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_SIGNAL_CONFIGURATION_ERROR`	At least one signal error is in the list.
	`SREC_WRONG_ARGUMENT`	The area is invalid.

Table 3-564 WriteSignals() - .NET (C#)

Syntax	`void WriteSignals( SDataValueByAddress[ ] in_Signals, bool validateAddressTag );`	
Parameters	• `SDataValueByAddress[] in_Signals` The signal list to be written. • `bool validateAddressTag` Optional boolean value to enable or disable the Memory Address to Tag association check.	
Signal error	Error code	Description
	`ERuntimeErrorCode.OK`	The signal operation is successful.
	`ERuntimeError-Code.IndexOutOfRange`	Offset or bits are invalid.
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.SignalConfigura-tionError`	At least one signal error is in the list.

9.6.5 I/O access via tag name - Reading

Individual access to I/O data is used for displaying and writing values that are not refreshed regularly in a graphical user interface (GUI).

NOTE

To simulate a regular exchange of signals, create a signal list for each set of signals. Use this signal list for all further accesses. Create a new list as soon as the set of signals changes.

For the signal lists use the functions `ReadSignals()` and `WriteSignals()`.

Read()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-565 Read() - Native C++

Syntax	`ERuntimeErrorCode Read(WCHAR* in_Tag, SDataValue* inout_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `SDataValue* inout_Value:` Contains the value and the expected type of the PLC tag. If the expected type is `UNSPECIFIC`, it is set to the stored type when the function was successful. The `STRUCT` type is not supported. Structures and fields can be emulated through signal lists and be read by using the `ReadSignals()` function.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.

Return values	SREC_TIMEOUT	The function does not return on time.
	SREC_INSTANCE_NOT_RUNNING	The process of the simulated PLC instance is not running.
	SREC_INDEX_OUT_OF_RANGE	The offset lies outside the area range. No value could be read.
	SREC_DOES_NOT_EXIST	The entry does not exist in the stored tag list.
	SREC_NOT_SUPPORTED	Access to entire structures or arrays is not supported.
	SREC_TYPE_MISMATCH	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-566 Read() - .NET (C#)

Syntax	SDataValue Read(string in_Tag)	
Parameters	• string in_Tag: The name of the PLC tag that is to be read.	
Return values	SDataValue: Contains the value and the type of the PLC tag.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be read.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types.
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

ReadBool()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-567 ReadBool() - Native C++

Syntax	`ERuntimeErrorCode ReadBool(WCHAR* in_Tag, bool* out_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `bool* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be read.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-568 ReadBool() - .NET (C#)

Syntax	`bool ReadBool(string in_Tag)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`bool:` Contains the value of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be read.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.

Exceptions	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

ReadInt8()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-569 ReadInt8() - Native C++

Syntax	`ERuntimeErrorCode ReadInt8(WCHAR* in_Tag, INT8* out_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `INT8* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be read.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-570 ReadInt8() - .NET (C#)

Syntax	`Int8 ReadInt8(string in_Tag)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`Int8:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description

Exceptions	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be read.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

ReadInt16()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-571 ReadInt16() - Native C++

Syntax	`ERuntimeErrorCode ReadInt16(WCHAR* in_Tag, INT16* out_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `INT16* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be read.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).

Return values	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-572 ReadInt16() - .NET (C#)

Syntax	Int16 ReadInt16(string in_Tag)	
Parameters	• string in_Tag: The name of the PLC tag that is to be read.	
Return values	Int16: Contains the value and the type of the PLC tag.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be read.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

ReadInt32()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-573 ReadInt32() - Native C++

Syntax	ERuntimeErrorCode ReadInt32(WCHAR* in_Tag, INT32* out_Value);	
Parameters	• WCHAR* in_Tag: The name of the PLC tag that is to be read. • INT32* out_Value: Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	SREC_OK	The function is successful.
	SREC_INTERFACE_REMOVED	The instance is not registered in Runtime Manager.

Return values	SREC_TIMEOUT	The function does not return on time.
	SREC_INSTANCE_NOT_RUNNING	The process of the simulated PLC instance is not running.
	SREC_INDEX_OUT_OF_RANGE	The offset lies outside the area range. No value could be read.
	SREC_DOES_NOT_EXIST	The entry does not exist in the stored tag list.
	SREC_NOT_SUPPORTED	Access to entire structures or arrays is not supported.
	SREC_TYPE_MISMATCH	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-574 ReadInt32() - .NET (C#)

Syntax	`Int32 ReadInt32(string in_Tag)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`Int32:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be read.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

ReadInt64()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-575 ReadInt64() - Native C++

Syntax	`ERuntimeErrorCode ReadInt64(WCHAR* in_Tag, INT64* out_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `INT64* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be read.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-576 ReadInt64() - .NET (C#)

Syntax	`Int64 ReadInt64(string in_Tag)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`Int64:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be read.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.

Exceptions	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

ReadUInt8()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-577 ReadUInt8() - Native C++

Syntax	`ERuntimeErrorCode ReadUInt8(WCHAR* in_Tag, UINT8* out_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `UINT8* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be read.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-578 ReadUInt8() - .NET (C#)

Syntax	`UInt8 ReadUInt8(string in_Tag)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`UInt8:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description

Exceptions	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be read.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

ReadUInt16()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-579 ReadUInt16() - Native C++

Syntax	`ERuntimeErrorCode ReadUInt16(WCHAR* in_Tag, UINT16* out_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `UINT16* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be read.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).

Return values	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-580 ReadUInt16() - .NET (C#)

Syntax	UInt16 ReadUInt16(string in_Tag)	
Parameters	• string in_Tag: The name of the PLC tag that is to be read.	
Return values	UInt16: Contains the value and the type of the PLC tag.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be read.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

ReadUInt32()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-581 ReadUInt32() - Native C++

Syntax	ERuntimeErrorCode ReadUInt32(WCHAR* in_Tag, UINT32* out_Value);	
Parameters	• WCHAR* in_Tag: The name of the PLC tag that is to be read. • UINT32* out_Value: Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	SREC_OK	The function is successful.
	SREC_INTERFACE_REMOVED	The instance is not registered in Runtime Manager.

Return values	SREC_TIMEOUT	The function does not return on time.
	SREC_INSTANCE_NOT_RUNNING	The process of the simulated PLC instance is not running.
	SREC_INDEX_OUT_OF_RANGE	The offset lies outside the area range. No value could be read.
	SREC_DOES_NOT_EXIST	The entry does not exist in the stored tag list.
	SREC_NOT_SUPPORTED	Access to entire structures or arrays is not supported.
	SREC_TYPE_MISMATCH	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-582 ReadUInt32() - .NET (C#)

Syntax	UInt32 ReadUInt32(string in_Tag)	
Parameters	• string in_Tag: The name of the PLC tag that is to be read.	
Return values	Uint32: Contains the value and the type of the PLC tag.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be read.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

ReadUInt64()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-583 ReadInt64() - Native C++

Syntax	`ERuntimeErrorCode ReadUInt64(WCHAR* in_Tag, UINT64* out_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `UINT64* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be read.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-584 ReadUInt64() - .NET (C#)

Syntax	`UInt64 ReadUInt64(string in_Tag)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`UInt64:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be read.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.

Exceptions	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

ReadFloat()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-585 ReadFloat() - Native C++

Syntax	`ERuntimeErrorCode ReadFloat(WCHAR* in_Tag, float* out_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `float* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be read.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-586 ReadFloat() - .NET (C#)

Syntax	`float ReadFloat(string in_Tag)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`float:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description

Exceptions	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be read.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

ReadDouble()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-587 ReadDouble() - Native C++

Syntax	`ERuntimeErrorCode ReadDouble(WCHAR* in_Tag, double* out_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `double* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be read.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).

Return values	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-588 ReadDouble() - .NET (C#)

Syntax	double ReadDouble(string in_Tag)	
Parameters	• string in_Tag: The name of the PLC tag that is to be read.	
Return values	double: Contains the value and the type of the PLC tag.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be read.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

ReadChar()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-589 ReadChar() - Native C++

Syntax	ERuntimeErrorCode ReadChar(WCHAR* in_Tag, char* out_Value);	
Parameters	• WCHAR* in_Tag: The name of the PLC tag that is to be read. • char* out_Value: Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	SREC_OK	The function is successful.
	SREC_INTERFACE_REMOVED	The instance is not registered in Runtime Manager.

Return values	SREC_TIMEOUT	The function does not return on time.
	SREC_INSTANCE_NOT_RUNNING	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be read.
	SREC_DOES_NOT_EXIST	The entry does not exist in the stored tag list.
	SREC_NOT_SUPPORTED	Access to entire structures or arrays is not supported.
	SREC_TYPE_MISMATCH	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-590 ReadChar() - .NET (C#)

Syntax	sbyte ReadChar(string in_Tag)	
Parameters	• string in_Tag: The name of the PLC tag that is to be read.	
Return values	sbyte: Contains the value and the type of the PLC tag.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be read.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

ReadWChar()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-591 ReadWChar() - Native C++

Syntax	`ERuntimeErrorCode ReadWChar(WCHAR* in_Tag, WCHAR* out_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `WCHAR* out_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be read.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-592 ReadWChar() - .NET (C#)

Syntax	`char ReadWChar(string in_Tag)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`char:` Contains the value and the type of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be read.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.

Exceptions	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

ReadSignals()

Reads multiple signals within an API call.

When the function is called for the first time, it stores internal information in the structures `SDataValueByName*` to improve the performance of the subsequent calls.

NOTE

To simulate a regular exchange of signals, create a signal list for each set of signals. Use this signal list for all further accesses. Create a new list as soon as the set of signals changes.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-593 ReadSignals() - Native C++

Syntax	`ERuntimeErrorCode ReadSignals(SDataValueByName* inout_Signals, UINT32 in_SignalCount);` `ERuntimeErrorCode ReadSignals(SDataValueByNameWithCheck* inout_Signals, UINT32 in_SignalCount bool* out_SignalsHaveChanged);`	
Parameters	• `SDataValueByName* inout_Signals:` Contains the name, the value and the expected type of the PLC tag. If the expected type is `UNSPECIFIC`, it is set to the stored type when the function was successful. The `STRUCT` type is not supported. • `SDataValueByNameWithCheck* inout_Signals:` Contains the name, the value and the expected type of the PLC tag. If the expected type is `UNSPECIFIC`, it is set to the stored type when the function was successful. The `STRUCT` type is not supported. "`ValueHasChanged`" is set to `true` if the value of the signal has changed since the preceding call. • `UINT32 in_SignalCount:` The number of signals to be read. • `bool* out_SignalsHaveChanged:` Returns `true` if the value of at least one signal has changed since the preceding call.	
Signal error	Runtime error code	Description
	`SREC_OK`	The signal operation is successful.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_INDEX_OUT_OF_RANGE`	Offset or bits are invalid.
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.

Return values	SREC_INTERFACE_REMOVED	The instance is not registered in Runtime Manager.
	SREC_TIMEOUT	The function does not return on time.
	SREC_INSTANCE_NOT_RUNNING	The process of the simulated PLC instance is not running.
	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_SIGNAL_CONFIGURATION_ERROR	At least one signal error is in the list.

Table 3-594 ReadSignals() - .NET (C#)

Syntax	`void ReadSignals(ref SDataValueByName[] inout_Signals)` `void ReadSignals(ref SDataValueByNameWithCheck[] inout_Signals out bool out_SignalsHaveChanged);`	
Parameters	• `ref SDataValueByName[] inout_Signals:` Contains the name, the value and the expected type of the PLC tag. If the expected type is `UNSPECIFIC`, it is set to the stored type when the function was successful. The `STRUCT` type is not supported. • `ref SDataValueByNameWithCheck[] inout_Signals:` Contains the name, the value and the expected type of the PLC tag. If the expected type is `UNSPECIFIC`, it is set to the stored type when the function was successful. The `STRUCT` type is not supported. "`ValueHasChanged`" is set to `true` if the value of the signal has changed since the preceding call. • `out bool out_SignalsHaveChanged:` Returns `true` if the value of at least one signal has changed since the preceding call.	
Return values	`SDataValue:` Contains the value and the type of the PLC tag.	
Signal error	Runtime error code	Description
	`ERuntimeErrorCode.OK`	The signal operation is successful.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.IndexOutOfRange`	Offset or bits are invalid.
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.

ReadString()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-595 ReadString() - Native C++

Syntax	`ERuntimeErrorCode IInstance::ReadString(`
	`const WCHAR* in_Tag,`
	`CHAR* out_Value,`
	`const UINT32 in_BufferSize,`
	`UINT32* out_CharsRead`
	`);`	

Parameters	• `const WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `CHAR* out_Value:` Contains the value of the PLC tag • `const UINT32 in_BufferSize:` Size of the buffer provided • `UINT32* out_CharsRead:` Number of characters read	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be read.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_BUFFER_OVERFLOW`	The buffer provided is too small.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-596 ReadString() - .NET (C#)

Syntax	`string ReadString(`
	`string in_Tag`
	`);`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be read.	
Return values	`string`: Contains the value of the PLC tag.	
Exceptions	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

Exceptions	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be read.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.BufferOverflow`	The buffer provided is too small.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

ReadWString()

Reads the value of a PLC tag.

See Synchronizing inputs and outputs (Page 116) for information on the API handling of I/O values.

Table 3-597 ReadWString() - Native C++

Syntax	`ERuntimeErrorCode IInstance::ReadWString(`
	`const WCHAR* in_Tag,`
	`WCHAR* out_Value,`
	`const UINT32 in_BufferSize,`
	`UINT32* out_CharsRead`
	`);`	

Parameters	• `const WCHAR* in_Tag:` The name of the PLC tag that is to be read. • `WCHAR* out_Value:` Contains the value of the PLC tag • `const UINT32 in_BufferSize:` Size of the buffer provided • `UINT32* out_CharsRead:` Number of characters read	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be read.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.

Return values	SREC_TYPE_MISMATCH	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_BUFFER_OVERFLOW	The buffer provided is too small.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-598 ReadWString() - .NET (C#)

Syntax	`wstring ReadWString(`
	`wstring in_Tag`
	`);`	

Parameters	• `wstring in_Tag:` The name of the PLC tag that is to be read.	
Return values	`wstring`: Contains the value of the PLC tag.	
Exceptions	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be read.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.BufferOverflow	The buffer provided is too small.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

9.6.6 I/O access via tag name - Writing

Individual access to I/O data is used for displaying and writing values that are not refreshed regularly in a graphical user interface (GUI).

NOTE

To simulate a regular exchange of signals, create a signal list for each set of signals. Use this signal list for all further accesses. Create a new list as soon as the set of signals changes.

For the signal lists use the functions `ReadSignals()` and `WriteSignals()`.

Write()

Writes the value of a PLC tag.

Table 3-599 Write() - Native C++

Syntax	`ERuntimeErrorCode Write(WCHAR* in_Tag, SDataValue* in_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `SDataValue* in_Value:` Contains the value and the expected type of the PLC tag. The `UNSPECIFIC` and `STRUCT` types are not supported. Structures and fields can be emulated through signal lists and then be read by using the `ReadSignals()` function and written by using the `WriteSignals()` function.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be written.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_WRONG_ARGUMENT`	The expected type is `UNSPECIFIC`.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-600 Write() - .NET (C#)

Syntax	`void Write(string in_Tag SDataValue in_Value)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `SDataValue in_Value:` Contains the value and the expected type of the PLC tag. The `UNSPECIFIC` and `STRUCT` types are not supported. Structures and fields can be emulated through signal lists and then be written by using the `WriteSignals()` function.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.

Exceptions	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be written.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.WrongArgument`	The expected type is `UNSPECIFIC`.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

WriteBool()

Writes the value of a PLC tag.

Table 3-601 WriteBool() - Native C++

Syntax	`ERuntimeErrorCode WriteBool(WCHAR* in_Tag, bool in_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `bool in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be written.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-602 WriteBool() - .NET (C#)

Syntax	`void WriteBool(string in_Tag bool in_Value)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `bool in_Value:` Contains the value of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be written.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types.
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

WriteInt8()

Writes the value of a PLC tag.

Table 3-603 WriteInt8() - Native C++

Syntax	`ERuntimeErrorCode WriteInt8(WCHAR* in_Tag, INT8 in_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `INT8 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be written.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.

Return values	SREC_TYPE_MISMATCH	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-604 WriteInt8() - .NET (C#)

Syntax	void WriteInt8(string in_Tag Int8 in_Value)	
Parameters	• string in_Tag: The name of the PLC tag that is to be written. • Int8 in_Value: Contains the value of the PLC tag.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be written.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

WriteInt16()

Writes the value of a PLC tag.

Table 3-605 WriteInt16() - Native C++

Syntax	ERuntimeErrorCode WriteInt16(WCHAR* in_Tag, INT16 in_Value);	
Parameters	• WCHAR* in_Tag: The name of the PLC tag that is to be written. • INT16 in_Value: Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	SREC_OK	The function is successful.
	SREC_INTERFACE_REMOVED	The instance is not registered in Runtime Manager.

Return values	SREC_TIMEOUT	The function does not return on time.
	SREC_INSTANCE_NOT_RUNNING	The process of the simulated PLC instance is not running.
	SREC_INDEX_OUT_OF_RANGE	The offset lies outside the area range. No value could be written.
	SREC_DOES_NOT_EXIST	The entry does not exist in the stored tag list.
	SREC_NOT_SUPPORTED	Access to entire structures or arrays is not supported.
	SREC_TYPE_MISMATCH	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-606 WriteInt16() - .NET (C#)

Syntax	void WriteInt16(string in_Tag Int16 in_Value)	
Parameters	• string in_Tag: The name of the PLC tag that is to be written. • Int16 in_Value: Contains the value of the PLC tag.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be written.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

WriteInt32()

Writes the value of a PLC tag.

Table 3-607 WriteInt32() - Native C++

Syntax	`ERuntimeErrorCode WriteInt32(WCHAR* in_Tag, INT32 in_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `INT32 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be written.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-608 WriteInt32() - .NET (C#)

Syntax	`void WriteInt32(string in_Tag Int32 in_Value)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `Int32 in_Value:` Contains the value of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be written.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).

Exceptions	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

WriteInt64()

Writes the value of a PLC tag.

Table 3-609 WriteInt64() - Native C++

Syntax	`ERuntimeErrorCode WriteInt64(WCHAR* in_Tag, INT64 in_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `INT64 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be written.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-610 WriteInt64() - .NET (C#)

Syntax	`void WriteInt64(string in_Tag Int64 in_Value)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `Int64 in_Value:` Contains the value of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

Exceptions	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be written.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

WriteUInt8()

Writes the value of a PLC tag.

Table 3-611 WriteUInt8() - Native C++

Syntax	`ERuntimeErrorCode WriteUInt8(WCHAR* in_Tag, UINT8 in_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `UINT8 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be written.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-612 WriteUInt8() - .NET (C#)

Syntax	`void WriteUInt8(string in_Tag UInt8 in_Value)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `UInt8 in_Value:` Contains the value of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be written.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

WriteUInt16()

Reads the value of a PLC tag.

Table 3-613 WriteUInt16() - Native C++

Syntax	`ERuntimeErrorCode WriteUInt16(WCHAR* in_Tag, UINT16 in_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `UINT16 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be written.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.

Return values	SREC_TYPE_MISMATCH	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-614 WriteUInt16() - .NET (C#)

Syntax	void WriteUInt16(string in_Tag UInt16 in_Value)	
Parameters	• string in_Tag: The name of the PLC tag that is to be written. • UInt16 in_Value: Contains the value of the PLC tag.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be written.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

WriteUInt32()

Writes the value of a PLC tag.

Table 3-615 WriteUInt32() - Native C++

Syntax	ERuntimeErrorCode WriteUInt32(WCHAR* in_Tag, UINT32 in_Value);	
Parameters	• WCHAR* in_Tag: The name of the PLC tag that is to be written. • UINT32 in_Value: Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	SREC_OK	The function is successful.
	SREC_INTERFACE_REMOVED	The instance is not registered in Runtime Manager.

Return values	SREC_TIMEOUT	The function does not return on time.
	SREC_INSTANCE_NOT_RUNNING	The process of the simulated PLC instance is not running.
	SREC_INDEX_OUT_OF_RANGE	The offset lies outside the area range. No value could be written.
	SREC_DOES_NOT_EXIST	The entry does not exist in the stored tag list.
	SREC_NOT_SUPPORTED	Access to entire structures or arrays is not supported.
	SREC_TYPE_MISMATCH	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-616 WriteUInt32() - .NET (C#)

Syntax	void WriteUInt32(string in_Tag UInt32 in_Value)	
Parameters	• string in_Tag: The name of the PLC tag that is to be written. • UInt32 in_Value: Contains the value of the PLC tag.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be written.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

WriteUInt64()

Writes the value of a PLC tag.

Table 3-617 WriteUInt64() - Native C++

Syntax	`ERuntimeErrorCode WriteUInt64(WCHAR* in_Tag, UINT64 in_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `UINT64 in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be written.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-618 WriteUInt64() - .NET (C#)

Syntax	`void WriteUInt64(string in_Tag UInt64 in_Value)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `UInt64 in_Value:` Contains the value of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be written.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).

Exceptions	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

WriteFloat()

Writes the value of a PLC tag.

Table 3-619 WriteFloat() - Native C++

Syntax	`ERuntimeErrorCode WriteFloat(WCHAR* in_Tag, float in_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `float in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be written.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-620 WriteFloat() - .NET (C#)

Syntax	`void WriteFloat(string in_Tag float in_Value)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `float in_Value:` Contains the value of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

Exceptions	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be written.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

WriteDouble()

Writes the value of a PLC tag.

Table 3-621 WriteDouble() - Native C++

Syntax	`ERuntimeErrorCode WriteDouble(WCHAR* in_Tag, double in_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `double in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be written.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-622 WriteDouble() - .NET (C#)

Syntax	`void WriteDouble(string in_Tag double in_Value)`	
Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `double in_Value:` Contains the value of the PLC tag.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be written.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

WriteChar()

Writes the value of a PLC tag.

Table 3-623 WriteChar() - Native C++

Syntax	`ERuntimeErrorCode WriteChar(WCHAR* in_Tag, char in_Value);`	
Parameters	• `WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `char in_Value:` Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be written.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.

Return values	SREC_TYPE_MISMATCH	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-624 WriteChar() - .NET (C#)

Syntax	void WriteChar(string in_Tag sbyte in_Value)	
Parameters	• string in_Tag: The name of the PLC tag that is to be written. • sbyte in_Value: Contains the value of the PLC tag.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be written.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

WriteWChar()

Writes the value of a PLC tag.

Table 3-625 WriteWChar() - Native C++

Syntax	ERuntimeErrorCode WriteWChar(WCHAR* in_Tag, WCHAR in_Value);	
Parameters	• WCHAR* in_Tag: The name of the PLC tag that is to be written. • WCHAR in_Value: Contains the value of the PLC tag.	
Return values	Runtime error code	Description
	SREC_OK	The function is successful.
	SREC_INTERFACE_REMOVED	The instance is not registered in Runtime Manager.

Return values	SREC_TIMEOUT	The function does not return on time.
	SREC_INSTANCE_NOT_RUNNING	The process of the simulated PLC instance is not running.
	SREC_INDEX_OUT_OF_RANGE	The offset lies outside the area range. No value could be written.
	SREC_DOES_NOT_EXIST	The entry does not exist in the stored tag list.
	SREC_NOT_SUPPORTED	Access to entire structures or arrays is not supported.
	SREC_TYPE_MISMATCH	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-626 WriteWChar() - .NET (C#)

Syntax	void WriteWChar(string in_Tag char in_Value)	
Parameters	• string in_Tag: The name of the PLC tag that is to be written. • char in_Value: Contains the value of the PLC tag.	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	SREC_INDEX_OUT_OF_RANGE	The offset lies outside the area range. No value could be written.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

WriteSignals()

Writes multiple signals within an API call.

When the function is called for the first time, it stores internal information in the structures `SDataValueByName*` to improve the performance of the subsequent calls.

NOTE

To simulate a regular exchange of signals, create a signal list for each set of signals. Use this signal list for all further accesses. Create a new list as soon as the set of signals changes.

Table 3-627 WriteSignals() - Native C++

Syntax	`ERuntimeErrorCode WriteSignals(SDataValueByName* inout_Signals, UINT32 in_SignalCount);`	
Parameters	• `SDataValueByName* inout_Signals:` Contains the name, the value and the expected type of the PLC tag. The `UNSPECIFIC` and `STRUCT` types are not supported. • `UINT32 in_SignalCount:` Number of signals.	
Signal error	Error code	Description
	`SREC_INDEX_OUT_OF_RANGE`	Offset or bits are invalid.
Return values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_WRONG_ARGUMENT`	The expected type is `UNSPECIFIC`.

Table 3-628 WriteSignals() - .NET (C#)

Syntax	`void WriteSignals(SDataValueByName[] in_Signals)`	
Parameters	• `SDataValueByName` Contains the name, the value and the expected type of the PLC tag. The `UNSPECIFIC` and `STRUCT` types are not supported.	
Signal error	Error code	Description
	`ERuntimeErrorCode.IndexOutOfRange`	Offset or bits are invalid.
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

Exceptions	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types.
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.WrongArgument`	The expected type is `UNSPECIFIC`.

WriteString()

Writes the value of a PLC tag.

Table 3-629 WriteString() - Native C++

Syntax	`ERuntimeErrorCode IInstance::WriteString(`
	`const WCHAR* in_Tag,`
	`const CHAR* in_Value,`
	`const UINT32 in_CharsToWrite`
	`);`	

Parameters	• `const WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `CHAR* in_Value:` Contains the value of the PLC tag • `const UINT32 in_CharsToWrite:` Number of characters to write	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_INDEX_OUT_OF_RANGE`	The offset lies outside the area range. No value could be written.
	`SREC_DOES_NOT_EXIST`	The entry does not exist in the stored tag list.
	`SREC_NOT_SUPPORTED`	Access to entire structures or arrays is not supported.
	`SREC_TYPE_MISMATCH`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`SREC_NOT_UP_TO_DATE`	The stored tag list must be updated.
	`SREC_BUFFER_OVERFLOW`	The characters to be written are greater than the maximum value of the tag.
	`SREC_NOT_ENOUGH_MEMORY`	Unexpected error occurred; turn on logging and contact support.
	`SREC_INTERNAL_ERROR`	Internal error occurred; turn on logging and contact support.

Table 3-630 WriteString() - .NET (C#)

Syntax	`void WriteString(`
	`string in_Tag,`
	`string in_Value`
	`);`	

Parameters	• `string in_Tag:` The name of the PLC tag that is to be written. • `string in_Value:` The value to be written to the PLC tag.	
Exceptions	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.IndexOutOfRange`	The offset lies outside the area range. No value could be written.
	`ERuntimeErrorCode.DoesNotExist`	The entry does not exist in the stored tag list.
	`ERuntimeErrorCode.NotSupported`	Access to entire structures or arrays is not supported.
	`ERuntimeErrorCode.TypeMismatch`	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	`ERuntimeErrorCode.NotUpToDate`	The stored tag list must be updated.
	`ERuntimeErrorCode.BufferOverflow`	The characters to be written are greater than the maximum value of the tag.
	`ERuntimeErrorCode.NotEnoughMemory`	Unexpected error occurred; turn on logging and contact support.
	`ERuntimeErrorCode.InternalError`	Internal error occurred; turn on logging and contact support.

WriteWString()

Writes the value of a PLC tag.

Table 3-631 WriteWString() - Native C++

Syntax	`ERuntimeErrorCode IInstance::WriteWString(`
	`const WCHAR* in_Tag,`
	`const WCHAR* in_Value,`
	`const UINT32 in_CharsToWrite,`
	`);`	

Parameters	• `const WCHAR* in_Tag:` The name of the PLC tag that is to be written. • `const WCHAR* in_Value:` Contains the value of the PLC tag • `const UINT32 in_CharsToWrite:` Number of characters that are to be written.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.

Return values	SREC_INSTANCE_NOT_RUNNING	The process of the simulated PLC instance is not running.
	SREC_INDEX_OUT_OF_RANGE	The offset lies outside the area range. No value could be written.
	SREC_DOES_NOT_EXIST	The entry does not exist in the stored tag list.
	SREC_NOT_SUPPORTED	Access to entire structures or arrays is not supported.
	SREC_TYPE_MISMATCH	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	SREC_NOT_UP_TO_DATE	The stored tag list must be updated.
	SREC_BUFFER_OVERFLOW	The characters to be written are greater than the maximum value of the tag.
	SREC_NOT_ENOUGH_MEMORY	Unexpected error occurred; turn on logging and contact support.
	SREC_INTERNAL_ERROR	Internal error occurred; turn on logging and contact support.

Table 3-632 WriteWString() - .NET (C#)

Syntax	`void WriteWString(`
	`wstring in_Tag,`
	`wstring in_Value`
	`);`	

Parameters	• `wstring in_Tag:` The name of the PLC tag that is to be written. • `wstring in_Value:` The value to be written to the PLC tag.	
Exceptions	Runtime error code	Description
	ERuntimeErrorCode.InterfaceRemoved	The instance is not registered in Runtime Manager.
	ERuntimeErrorCode.Timeout	The function does not return on time.
	ERuntimeErrorCode.InstanceNotRunning	The process of the simulated PLC instance is not running.
	ERuntimeErrorCode.IndexOutOfRange	The offset lies outside the area range. No value could be written.
	ERuntimeErrorCode.DoesNotExist	The entry does not exist in the stored tag list.
	ERuntimeErrorCode.NotSupported	Access to entire structures or arrays is not supported.
	ERuntimeErrorCode.TypeMismatch	The expected type does not match the stored type. See Compatible primitive data types (Page 280).
	ERuntimeErrorCode.NotUpToDate	The stored tag list must be updated.
	ERuntimeErrorCode.BufferOverflow	The characters to be written are greater than the maximum value of the tag.
	ERuntimeErrorCode.NotEnoughMemory	Unexpected error occurred; turn on logging and contact support.
	ERuntimeErrorCode.InternalError	Internal error occurred; turn on logging and contact support.

9.7 Cycle control

GetOperatingMode()

Returns the operating mode (Page 274) of the simulated PLC instance.

Table 3-639 GetOperatingMode() - Native C++

Syntax	`EOperatingMode GetOperatingMode();`
Parameters	None
Return values	`EOperatingMode`: Operating mode of the simulated PLC instance

SetOperatingMode()

Sets the operating mode of the simulated PLC instance.

A change in the value during runtime only takes effect at the synchronization point.

Table 3-640 SetOperatingMode() - Native C++

Syntax	`void SetOperatingMode(EOperatingMode in_OperatingMode);`
Parameters	• `EOperatingMode in_OperatingMode`: Operating mode of the simulated PLC instance

OperatingMode { get; set; }

Returns or sets the operating mode of the simulated PLC instance.

A change in the value during runtime only takes effect at the synchronization point.

Table 3-641 OperatingMode { get; set; } - .NET (C#)

Syntax	`EOperatingMode OperatingMode { get; set; }`	
Parameters	None	
Return values	`EOperatingMode`: Operating mode of the simulated PLC instance	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

SetSendSyncEventInDefaultModeEnabled()

Sets the `SendSyncEventInDefault` mode. In this mode the `OnSyncPointReached` event is triggered after each cycle end in the Default operating mode. See OnSyncPointReached (Page 215).

Table 3-642 SetSendSyncEventInDefaultModeEnabled() - Native C++

Syntax	`ERuntimeErrorCode SetSendSyncEventInDefaultModeEnabled(bool in_Enable);`	
Parameters	• `bool in_Enable:` If `true`, the `OnSyncPointReached` event is triggered after each cycle in the Default operating mode.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.

IsSendSyncEventInDefaultModeEnabled()

Returns the `SendSyncEventInDefaultMode` mode. When the function fails, the return value is `false`.

Table 3-643 IsSendSyncEventInDefaultModeEnabled() - Native C++

Syntax	`bool IsSendSyncEventInDefaultModeEnabled();`
Parameters	None
Return values	• `false`: The event is not triggered (unless the Sync-Freeze mode is active). • `true`: The event is triggered after every cycle.

IsSendSyncEventInDefaultModeEnabled { get; set; }

Returns or sets the `SendSyncEventInDefaultMode` mode. In this mode the `OnSyncPointReached` event is triggered after each cycle end for every operating mode. If the event is also to be received in the Default operating mode, set the return value to `true`. See OnSyncPointReached (Page 215).

Table 3-644 IsSendSyncEventInDefaultModeEnabled { get; set; } - .NET (C#)

Syntax	`bool IsSendSyncEventInDefaultModeEnabled { get; set;}`	
Parameters	None	
Return values	• `false`: The event is not triggered (unless the Sync-Freeze mode is active). • `true`: The event is triggered after every cycle.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

GetOverwrittenMinimalCycleTime_ns()

Returns the overwritten minimum cycle time (in nanoseconds) that is used in the `SingleStep_CT` and `SingleStep_CPT` operating modes.

Table 3-645 GetOverwrittenMinimalCycleTime_ns() - Native C++

Syntax	`INT64 GetOverwrittenMinimalCycleTime_ns();`
Parameters	None
Return values	`INT64`: The overwritten minimum cycle time in nanoseconds.

SetOverwrittenMinimalCycleTime_ns()

Sets the overwritten minimum cycle time (in nanoseconds) that is used in the `SingleStep_CT` and `SingleStep_CPT` operating modes.

A value between 0 and 6000000000 is valid. The default setting is 100 ms.

A change in the value during runtime only takes effect at the cycle control point.

Table 3-646 SetOverwrittenMinimalCycleTime_ns() - Native C++

Syntax	`ERuntimeErrorCode SetOverwrittenMinimalCycleTime_ns(INT64 in_CycleTime_ns);`	
Parameters	• `INT64 in_CycleTime_ns:` The overwritten minimum cycle time in nanoseconds.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The value is outside the limits.

OverwrittenMinimalCycleTime_ns { get; set; }

Returns or sets the overwritten minimum cycle time in nanoseconds that is used in the `SingleStep_CT` and `SingleStep_CPT` operating modes.

A value between 0 and 6000000000 is valid. The default setting is 100 ms.

A change in the value during runtime only takes effect at the cycle control point.

Table 3-647 OverwrittenMinimalCycleTime_ns { get; set; } - .NET (C#)

Syntax	`Int64 OverwrittenMinimalCycleTime_ns { get; set; }`	
Parameters	None	
Return values	`Int64`: The overwritten minimum cycle time in nanoseconds.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The value is outside the limits.

RunToNextSyncPoint()

If the simulated PLC instance is running in a SingleStep operating mode, it is stopped at the synchronization point (Freeze state). The `RunToNextSyncPoint()` function cancels the freeze state. The simulated PLC instance continues to run until the next synchronization point.

Table 3-648 RunToNextSyncPoint() - Native C++

Syntax	`ERuntimeErrorCode RunToNextSyncPoint();` `ERuntimeErrorCode RunToNextSyncPoint(UINT32 in_IoSystemId, UINT64 in_BusTimeStamp_ns);`	
Parameters	The call with parameters is only valid for the `SingleStep_Bus` operating mode. • `UINT32 in_IoSystemId:` Number of the I/O system (PROFIBUS 1..32, PROFINET 100..115) that is to be used for the cycle-controlled synchronization of the simulated PLC instance. • `UINT64 in_BusTimeStamp_ns:` Time stamp in nanoseconds of the respective I/O system at the start of each cycle.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INVALID_OPERATING_STATE`	The instance is in an invalid operating state for processing the call (BOOTING, SHUTTING_DOWN, OFF)
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_WRONG_ARGUMENT`	For the `SingleStep_Bus` operating mode: The ID of the I/O system is invalid. For all other operating modes: The function call with parameters is invalid.

Table 3-649 RunToNextSyncPoint() - .NET (C#)

Syntax	`void RunToNextSyncPoint();` `void RunToNextSyncPoint(UINT32 in_IoSystemId, UINT64 in_BusTimeStamp_ns);`	
Parameters	The call with parameters is only valid for the `SingleStep_Bus` operating mode. • `UINT32 in_IoSystemId:` Number of the I/O system (PROFIBUS 1..32, PROFINET 100..115) that is to be used for the cycle-controlled synchronization of the simulated PLC instance. • `UINT64 in_BusTimeStamp_ns:` Time stamp in nanoseconds of the respective I/O system at the start of each cycle.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InvalidOperatingS tate`	The instance is in an invalid operating state for processing the call (BOOTING, SHUTTING_DOWN, OFF)
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.WrongArgument`	For the `SingleStep_Bus` operating mode: The ID of the I/O system is invalid. For all other operating modes: The function call with parameters is invalid.

StartProcessing()

If the simulated PLC instance is running in a TimespanSynchronized operating mode, it is stopped at the synchronization point (Freeze state). The `StartProcessing()` function cancels the freeze state. The simulated PLC instance will now run for at least the requested time before it changes to Freeze state at the next synchronization point.

NOTE

StartProcessing() time value represents simulation time

The specified time-value parameter in `StartProcessing()` is not the normal PC time. This time value specifies the simulation time in S7-PLCISM Advanced. The simulation time differs from PC time because it pauses when waiting for the Windows scheduler to allocate calculation time to the S7-PLCSIM Advanced process. Additionally, it takes some time until the next SyncPoint is reached. This means that the longer the application runs, the time difference between the console application and S7-PLCSIM Advanced increases.

Table 3-650 StartProcessing() - Native C++

Syntax	`ERuntimeErrorCode StartProcessing(INT64 in_MinimalTimeToRun_ns);`	
Parameters	• `INT64 in_MinimalTimeToRun_ns:` The minimum virtual time (in nanoseconds) that the simulated PLC instance runs before it changes to Freeze state.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_INSTANCE_NOT_RUNNING`	The process of the simulated PLC instance is not running.
	`SREC_WRONG_ARGUMENT`	The value is less than 0.

Table 3-651 StartProcessing() - .NET (C#)

Syntax	`void StartProcessing(Int64 in_MinimalTimeToRun_ns);`	
Parameters	• `Int64 in_MinimalTimeToRun_ns:` The minimum virtual time (in nanoseconds) that the simulated PLC instance runs before it changes to Freeze state.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.InstanceNotRunning`	The process of the simulated PLC instance is not running.
	`ERuntimeErrorCode.WrongArgument`	The value is less than 0.

More information

For more information, see sections Virtual and real time (Page 176), Stop simulation (Page 109).

9.8 Virtual and real time

The simulated PLC instance uses two types of internal clocks for the simulation: A virtual clock and a real clock. The virtual clock is always the basis for the user program. It is used by components that are relevant for running the STEP 7 user program, such as cyclic OBs, cycle time monitoring, minimum cycle time, virtual system time and time calculations. Also, the time between two cycle control or single step control points is measured in virtual time.

The virtual time can be accelerated or slowed for simulation and optimization purposes.

The real clock always runs unchanged. It is used by components that are not subject to control processes, for example, communication with STEP 7.

Interruption of the process

Since S7-PLCSIM Advanced runs in a Windows environment, Windows might temporarily suspend the simulated PLC instance process. In such a case, both the virtual and the real clock stop in the simulated PLC instance. They only continue to run when Windows resumes processing.

Virtual system time

When you start S7-PLCSIM Advanced, the virtual system time of the instance starts with the system time of Windows.

The virtual system time is based on the virtual clock. If a scaling factor is used, the system time runs correspondingly faster or slower.

All events from the simulated PLC instance provide a time stamp based on the system time.

NOTE

Difference between system time and local time

- System time**:** UTC ± 0 with daylight saving / standard time
- Local time: UTC ± time zone with daylight saving time / standard time

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Time offset

NOTE

Keep in mind that the time information of virtual system time and real local time differs by the time offset that is formed in addition to the selected scaling factor from the time zone offset and the daylight saving time/standard time offset.

Scaling factor

Using a scaling factor, you can speed up or slow down the virtual clock of the simulated PLC instance for simulations.

To set the required scaling factor, enable the grayed out icon on the control panel to the right of your S7-PLCSIM Advanced instance. The symbol then becomes active and you can use the scaling function.

- The default setting is 1, i.e. the virtual time passes the same as the real time.
- **Fast forward:** A scaling factor greater than 1 accelerates the virtual clock.

  Example: Scaling factor 2.0 → The virtual time is running twice as fast.
- **Slow motion**: A scaling factor less than 1 decelerates the virtual clock.

  Example: Scaling factor 0.5 → The progress of the virtual time slows down to 50%.

SetCycleTimeMonitoringMode()

With this function you can chanage the source of the timer for the maximum cycle time monitoring.

Table 3-652 SetCycleTimeMonitoringMode() - Native C++

Syntax	`ERuntimeErrorCode SetCycleTimeMonitoringMode(ECycleTimeMonitoringMode in_CycleTimeMonitoringMode)` `ERuntimeErrorCode SetCycleTimeMonitoringMode(ECycleTimeMonitoringMode in_CycleTimeMonitoringMode, INT64 in_MaxCycleTime_ns)`	
Parameters	• `ECycleTimeMonitoringMode in_CycleTimeMonitoringMode:` Select one of the following options for the maximum cycle time monitoring: – `SRCTMM_DOWNLOADED:` The maximum cycle time from the project that was downloaded from STEP 7 is used as maximum cycle time monitoring. – `SRCTMM_IGNORED` **(default)**: A timer value of one minute is used as maximum cycle time monitoring to prevent a potential error in case of an overflow of cyclic events. See Monitoring overflow (Page 179). – `SRCTMM_SPECIFIED:` A value that is specified with the `in_MaxCycleTime_ns` parameter is used as maximum cycle time monitoring. Default: 150 ms. • `INT64 in_MaxCycleTime_ns:` The user-specific value for the maximum cycle time monitoring. A value between 1000000 and 60000000000 ns (1 millisecond to 1 minute) is valid. If no value is specified in the API, the default value of 150 ms applies.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.
	`SREC_WRONG_ARGUMENT`	The cycle time monitoring mode is invalid.
	`SREC_INDEX_OUT_OF_RANGE`	The user-specific value for the maximum cycle time monitoring is outside the limits.

Table 3-653 SetCycleTimeMonitoringMode() - .NET (C#)

Syntax	`void SetCycleTimeMonitoringMode(ECycleTimeMonitoringMode in_CycleTimeMonitoringMode)` `void SetCycleTimeMonitoringMode(ECycleTimeMonitoringMode in_CycleTimeMonitoringMode, Int64 in_MaxCycleTime_ns)`	
Parameters	• `ECycleTimeMonitoringMode in_CycleTimeMonitoringMode:` Select one of the following options for the maximum cycle time monitoring: – `ECycleTimeMonitoringMode.Downloaded:` The maximum cycle time from the project that was downloaded from STEP 7 is used as maximum cycle time monitoring. – `ECycleTimeMonitoringMode.Ignored` **(default)**: A timer value of one minute is used as maximum cycle time monitoring to prevent a potential error in case of an overflow of cyclic events. See Monitoring overflow (Page 179). – `ECycleTimeMonitoringMode.Specified:` A value that is specified with the `in_MaxCycleTime_ns` parameter is used as maximum cycle time monitoring. Default: 150 ms. • `Int64 in_MaxCycleTime_ns:` The user-specific value for the maximum cycle time monitoring. A value between 1000000 and 60000000000 ns (1 millisecond to 1 minute) is valid. If no value is specified in the API, the default value of 150 ms applies.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.
	`ERuntimeErrorCode.WrongArgument`	The cycle time monitoring mode is invalid.
	`ERuntimeErrorCode.IndexOutOfRange`	The user-specific value for the maximum cycle time monitoring is outside the limits.

GetCycleTimeMonitoringMode()

This function returns information on the source of the timer for the maximum cycle time monitoring.

Table 3-654 GetCycleTimeMonitoringMode() - Native C++

Syntax	`ERuntimeErrorCode GetCycleTimeMonitoringMode(ECycleTimeMonitoringMode* out_CycleTimeMonitoringMode, INT64* out_MaxCycleTime_ns)`	
Parameters	• `ECycleTimeMonitoringMode* out_CycleTimeMonitoringMode:` The configured mode for cycle time monitoring. The default setting is `SRCTM_IGNORED`. • `INT64 in_MaxCycleTime_ns:` The user-specific value for the maximum cycle time monitoring. If no value is specified in the API, the default value of 150 ms is returned.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-655 GetCycleTimeMonitoringMode() - .NET (C#)

Syntax	`void GetCycleTimeMonitoringMode(out ECycleTimeMonitoringMode out_CycleTimeMonitoringMode, out Int64 out_MaxCycleTime_ns)`	
Parameters	• `ECycleTimeMonitoringMode out_CycleTimeMonitoringMode:` The configured mode for cycle time monitoring. The default setting is `ECycleTimeMonitoringMode.Ignored`. • `Int64 in_MaxCycleTime_ns:` The user-specific value for the maximum cycle time monitoring. If no value is specified in the API, the default value of 150 ms is returned.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

9.9 Monitoring overflow

Monitoring of main cycle

The maximum cycle time monitoring for S7-PLCSIM Advanced is one minute.

Monitoring of cyclical events

If your simulation contains cyclic interrupts, the queue of S7-PLCSIM Advanced can overflow for cyclic events. Due to the runtime speed of S7-PLCSIM Advanced compared to real hardware, the time needed to create the diagnostic buffer entry might be longer than the time until the next cyclic interrupt.

In this case, an additional entry is placed in the queue, causing another overflow. In the event of an overflow, S7-PLCSIM Advanced provides diagnostics buffer messages and a red error icon in the project tree in STEP 7.

9.10 Display functions and events

9.10.1 Display functions

The display functionality allows you to access the display content of a simulated PLC that is equipped with an integrated display.

For unspecified instances or PLC types that do not have an integrated display in their physical hardware, the API returns simulation-specific display data indicating the absence of a display.

The output is returned as raw bitmap data, which you can then integrate and display in your applications.

NOTE

Display functionality is only available for local use and cannot be utilized for remote connections.

NOTE

Restrictions in Softbus mode

It is not possible to access address settings in the display when using Softbus mode.

Display content scenarios

The following display data is returned based on the state of the instance:

Instance has a display and is switched on	Instance does not have a display and is switched on	Instance is unspecified and switched on	Instance is switched off
Returned data contains the current display content, which is identical to the one a real PLC would show.	Simulation-specific display content is returned, indicating that the PLC does not have a display.	Simulation-specific display content is returned, indicating that the PLC does not have a display and that overload behavior must be considered.	Simulation-specific display content with a PLCSIM Advanced logo on a black background is returned, indicating that the PLC is off.
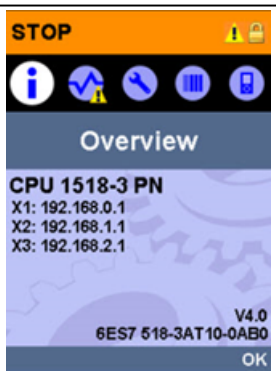	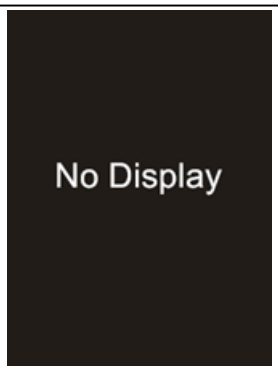	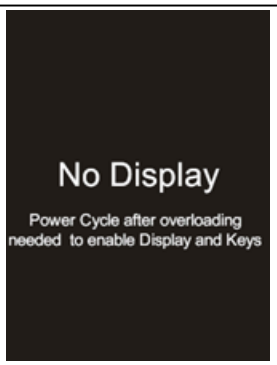	

NOTE

To obtain the correct display behavior for an unspecified PLC that has been overloaded with a specified PLC type, a restart of the PLC must be performed. Without restarting, the display behavior stays as described for unspecified instances.

GetDisplayData()

Returns the display data.

The display data does not always occupy the full length of the provided `displayData` buffer within the `SDisplayData` struct. Therefore, a second parameter named `dataLength` within the structure indicates the current length of the valid display data.

The data stored in this struct constitutes the raw bitmap data.

Table 3-656 GetDisplayData() - Native C++

Syntax	`ERuntimeErrorCode GetDisplayData(SDisplayData& displayData);`	
Parameters	`SDisplayData& displayData`: • `struct SDisplayData` (Page 260) `{ uint8_t displayData[MAX_SIZE_DISPLAY_DATA]; uint32_t dataLength; };` – Struct where the display data gets written into – Contains current bitmap data with a maximum length of MAX_SIZE_DISPLAY_DATA (=153666) – `dataLength` tells the length of the data inside "displayData"	
Return Values	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-657 GetDisplayData() - .NET C#

Syntax	`SDisplayData GetDisplayData()`	
Parameters	None	
Return Values	`SDisplayData& displayData`: • `struct SDisplayData` (Page 260) `{ uint8_t displayData[MaxSizeDisplayData]; uint32_t dataLength; };` – Struct where the display data gets written into – Contains current bitmap data with a maximum length of MaxSizeDisplayData (=153666) – `dataLength` tells the length of the data inside "displayData"	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Condition
	`SREC_TIMEOUT`	The function does not return on time.

DisplayKeyPress()

Used for performing display key presses on the PLC.

If the PLC does not have a display, is powered off, or is unspecified, key presses are not supported.

Table 3-658 DisplayKeyPress() Native C++

Syntax	`ERuntimeErrorCode DisplayKeyPress(EDisplayKey keyId);`	
Parameters	`EDisplayKey keyId`: • `enum EDisplayKey` (Page 277) `{ SRFK_UP, SRFK_DOWN, SRFK_LEFT, SRFK_RIGHT, SRFK_OK, SRFK_ESC, SRFK_LONGESC };` • Enum containing the key to be pressed	
Return Values	Runtime error code	Condition

Return Values	SREC_OK	The Key press was executed succesfully.
	SREC_NOT_SUPPORTED	The PLC does not support key presses.
	SREC_INSTANCE_NOT_RUNNING	The PLC is not powered on.

Table 3-659 DisplayKeyPress() .NET C#

Syntax	ERuntimeErrorCode DisplayKeyPress(EDisplayKey keyId);	
Parameters	EDisplayKey keyId: • enum EDisplayKey (Page 277) { SRFK_UP, SRFK_DOWN, SRFK_LEFT, SRFK_RIGHT, SRFK_OK, SRFK_ESC, SRFK_LONGESC }; • Enum containing the key to be pressed	
Return Values	Runtime error code	Condition
	SREC_OK	The Key press was executed succesfully.
	SREC_NOT_SUPPORTED	The PLC does not support key presses.
	SREC_INSTANCE_NOT_RUNNING	The PLC is not powered on.
Exceptions	None	

HasDisplay()

Informs you as to whether an instance has a display.

A return value of `true` confirms the presence of a display, while `false` indicates that the instance does not have a display.

To use this functionality, the PLC must be powered on.

Table 3-660 HasDisplay() Native C++

Syntax	ERuntimeErrorCode HasDisplay(bool& hasDisplay)	
Parameters	bool& hasDisplay: Reference parameter that indicates whether the PLC has a display	
Return Values	Runtime error code	Condition
	SREC_OK	The function finished succesfully.
	SREC_INSTANCE_NOT_RUNNING	The PLC is not powered on.

Table 3-661 HasDisplay() .NET C#

Syntax	bool HasDisplay();	
Parameters	None	
Return values	bool: Returns true if the PLC has a display Returns false if the PLC does not have a display	
Exceptions	Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException	
	Runtime error code	Condition
	SREC_INSTANCE_NOT_RUNNING	The PLC is not powered on.

9.10.2 OnDisplayDataChanged events

The subscription to the callback can be made as soon as the PLC exists, regardless of whether it is powered on or what its display integration state is.

When the display data changes, the registered callback is triggered. The call of the callback informs that the display data has been changed and new bitmap data is accessible.

The display data is not delivered by the callback itself.

OnDisplayDataChanged()

Registers or unregisters an event handler method.

After registration an event will be fired when the Display Data has changed.

NOTE

The event handler method runs in a separate thread.

Table 3-662 OnDisplayDataChanged() .NET C#

Syntax	`event Delegate_DisplayDataChanged OnDisplayDataChanged;`	
Parameters	`Delegate_DisplayDataChanged`	
	Syntax	`delegate void Delegate_DisplayDataChanged ( IInstance in_Sender, ERuntimeErrorCode in_ErrorCode, System::DateTime in_DateTime);`
	Parameters	• `IInstance in_Sender`: An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode`: A possible error code. • `DateTime in_DateTime`: The virtual system time of the virtual controller at the time when this event was triggered.
	Return Values	None
Return Values	None	
Exceptions	None	

RegisterOnDisplayDataChangedCallback()

When the event occurs, the registered callback function is called. Only one callback function can be registered for the event. Registering a new callback function causes the previous callback function to be deleted.

NOTE

The event handler method runs in a separate thread.

Table 3-663 RegisterOnDisplayDataChangedCallback() Native C ++

Syntax	`void RegisterOnDisplayDataChangedCallback(EventCallback_II_SREC_ST in_CallbackFunction);`		
Parameters	`EventCallback_II_SREC_ST in_CallbackFunction`: • A callback function that subscribes to an event		
	Syntax		`typedef void (*EventCallback_II_SREC_ST ){ IInstance* in_Sender, ERuntimeErrorCode in_ErrorCode, SYSTEMTIME in_SystemTime };`
	Parameters		• `IInstance* in_Sender`: An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode`: A possible error code. • `SYSTEMTIME in_SystemTime`: The virtual system time of the virtual controller at the time when this event was triggered.
	Return Values		None
Return Values	Runtime error code	Condition	
	`SREC_OK`	The function is successful.	
	`SREC_TIMEOUT`	The function does not return on time.	

RegisterOnDisplayDataChangedEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registration of a new event object causes the previous event object to be deleted.

The event signals that the display data changed.

Table 3-664 RegisterOnDisplayDataChangedEvent() - Native C++

Syntax	`void RegisterOnDisplayDataChangedEvent();` `void RegisterOnDisplayDataChangedEvent( HANDLE* in_Event );`
Parameters	• None: An internal event object is registered. • `HANDLE* in_Event`: A handle for a user-specific event object. The event object is registered.
Return Values	None

Table 3-665 RegisterOnDisplayDataChangedEvent() - .NET C#

Syntax	`void UnregisterOnDisplayDataChangedEvent ();`
Parameters	None
Return Values	None

UnregisterOnDisplayDataChangedCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 3-666 UnregisterOnDisplayDataChangedCallback() - Native C++

Syntax	`void UnregisterOnDisplayDataChangedCallback();`
Parameters	None
Return Values	None

UnregisterOnDisplayDataChangedEvent()

Unregisters the event object. The information that the display data got changed is now not signaled anymore.

Table 3-667 UnregisterOnDisplayDataChangedEvent() - Native C++

Syntax	`void UnregisterOnDisplayDataChangedEvent();`
Parameters	None
Return Values	None

Table 3-668 UnregisterOnDisplayDataChangedEvent() - .NET C#

Syntax	`void UnregisterOnDisplayDataChangedEvent();`
Parameters	None
Return Values	None

WaitForOnDisplayDataChangedEvent()

The function blocks the program until the registered event object is set to the signaled state or the timeout interval is exceeded.

This means the program can be blocked until a change of display data occurs.

Table 3-669 WaitForOnDisplayDataChangedEvent() - Native C++

Syntax	`bool WaitForOnDisplayDataChangedEvent();` `bool WaitForOnDisplayDataChangedEvent( UINT32 in_Time_ms );`
Parameters	• None: The time limit is set to INFINITE. • `UINT32 in_Time_ms`: Value for the time limit in milliseconds.
Return Values	• true: If the event object was set to the signaled state. • false: If no event was received during the defined time limit.

Table 3-670 WaitForOnDisplayDataChangedEvent() - .NET #

Syntax	`bool WaitForOnDisplayDataChangedEvent();` `bool WaitForOnDisplayDataChangedEvent( UINT32 in_Time_ms );`
Parameters	• None: The time limit is set to INFINITE. • `UINT32 in_Time_ms`: Value for the time limit in milliseconds.
Return Values	• true: If the event object was set to the signaled state. • false: If no event was received during the defined time limit.

9.11 Acyclic services

9.11.1 Overview

The acyclic services of S7-PLCSIM Advanced include:

- Read and write processes of parameter and status data from the user program of the PLC to the I/O modules
- Interrupt and event information which the I/O modules send to the CPU.

Read and write operations

Events triggered by the STEP 7 user program that have logged on for the notification:

Table 3-671 Events: Read and write operations

SFB	Name	API method (alarm)	API event for triggering the SFB
52	RDREC	ReadRecordDone (Page 188)	OnDataRecordRead (Page 220)
53	WRREC	WriteRecordDone (Page 188)	OnDataRecordWrite (Page 220)

Flowchart

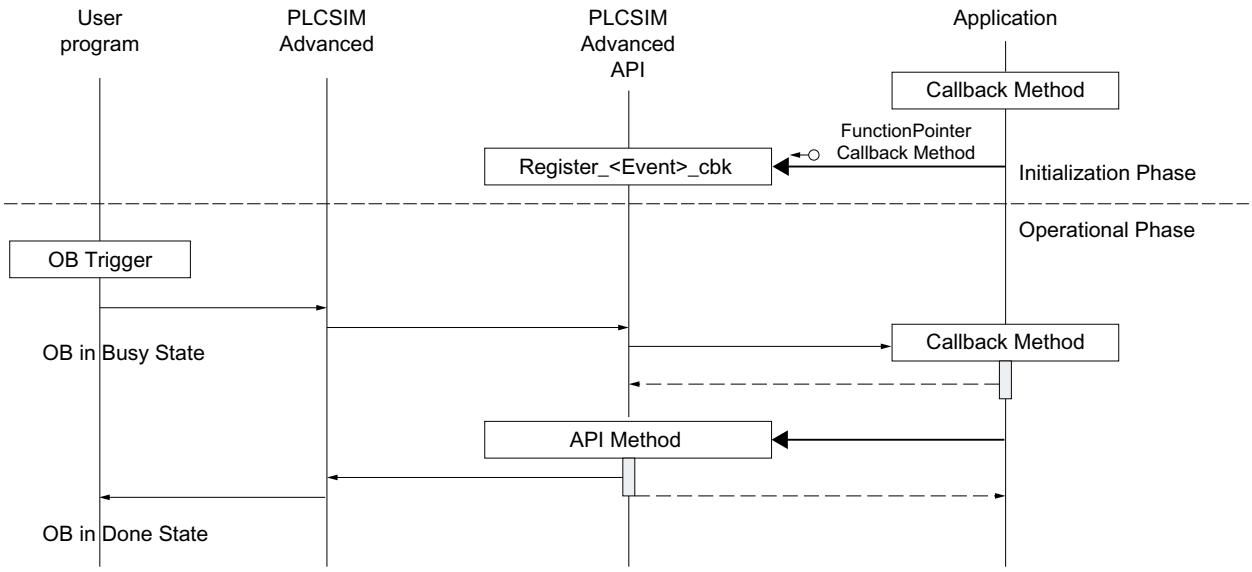

Figure 3-265 Read and write operations flowchart

API methods and associated events

Events which are triggered by the I/O modules and associated API methods:

Table 3-672 API methods and associated events

OB	Name	API methods for triggering the OB (query)	API event after OB execution (alarm)
82	Diagnostic error Interrupt	AlarmNotification (Page 190)	OnAlarmNotificationDone (Page 222)
4x	Hardware Interrupt	ProcessEvent (Page 192)	OnProcessEventDone (Page 223)
83	Pull or Plug of module	PullOrPlugEvent (Page 193)	OnPullOrPlugEventDone (Page 224)
55	Status	StatusEvent (Page 195)	OnStatusEventDone (Page 225)
57	Profile	ProfileEvent (Page 196)	OnProfileEventDone (Page 226)
56	Update	UpdateEvent (Page 197)	OnUpdateEventDone (Page 227)
86	Rack or station failure	RackOrStationFaultEvent (Page 198)	OnRackOrStationFaultEventDone (Page 228)

Flowchart

Flowchart for the simulation of events which are triggered by the I/O modules.

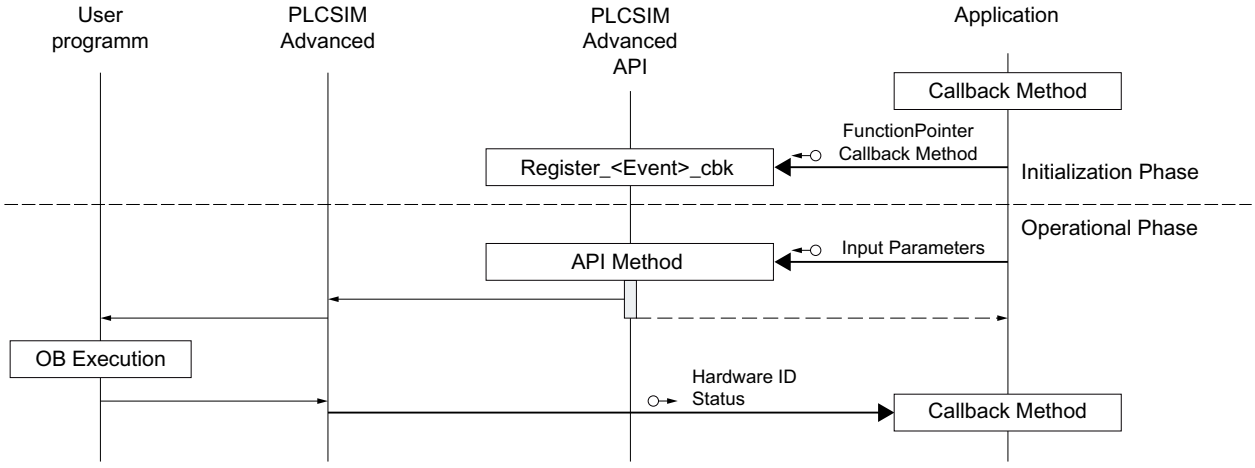

Figure 3-266 Flowchart for the simulation of events

9.11.2 ReadRecordDone/WriteRecordDone

ReadRecordDone()

With this API method, the simulation of an I/O module signals to the CPU that the asynchronous reading of a data record has been completed. The simulation hereby makes the read information available.

Table 3-673 ReadRecordDone() - Native C++

Syntax	`ERuntimeErrorCode ReadRecordDone(SDataRecordInfo in_RecordInfo, BYTE* in_Data, UINT32 in_Status);`	
Parameters	• `SDataRecordInfo in_RecordInfo:` Structure which contains the data record information. See SDataRecordInfo (Page 265). • `BYTE* in_Data:` Byte array of the read data record with the length defined by `DataSize` in the structure `SDataRecordInfo`. • `UINT32 in_Status:` Status of the job execution	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_DOES_NOT_EXIST`	No hardware identifier of the module.
	`SREC_INDEX_OUT_OF_RANGE`	The byte array of the read data record exceeds the length `DDATARECORD_MAX_SIZE` = 64000.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-674 ReadRecordDone() - .NET (C#)

Syntax	`void ReadRecordDone(SDataRecordInfo in_RecordInfo, BYTE[] in_Data, UInt32 in_Status);`	
Parameters	• `SDataRecordInfo in_RecordInfo:` Structure which contains the data record information. See SDataRecordInfo (Page 265). • `BYTE[] in_Data:` Byte array of the read data record with the length defined by `DataSize` in the structure `SDataRecordInfo`. • `UInt32 in_Status:` Status of the job execution	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.DoesNotExist`	No hardware identifier of the module.
	`ERuntimeErrorCode.IndexOutOfRange`	The byte array of the read data record exceeds the length `DataRecordMaxSize` = 64000.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

WriteRecordDone()

With this API method, the simulation of an I/O module signals to the CPU that the asynchronous writing of a data record has been completed.

Table 3-675 WriteRecordDone() - Native C++

Syntax	`ERuntimeErrorCode WriteRecordDone(SDataRecordInfo in_RecordInfo, UINT32 in_Status);`	
Parameters	• `SDataRecordInfo in_RecordInfo:` Structure which contains the data record information. See SDataRecordInfo (Page 265). • `UINT32 in_Status:` Status of the job execution	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_DOES_NOT_EXIST`	No hardware identifier of the module.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-676 WriteRecordDone() - .NET (C#)

Syntax	`void WriteRecordDone(SDataRecordInfo in_RecordInfo, UInt32 in_Status);`	
Parameters	• `SDataRecordInfo in_RecordInfo:` Structure which contains the data record information. See SDataRecordInfo (Page 265). • `UInt32 in_Status:` Status of the job execution	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description

Exceptions	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.DoesNotExist`	No hardware identifier of the module.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

NOTE

Return values of a written data record

The return values of the status of a written data record in S7-PLCSIM Advanced can differ from the return values of a real hardware CPU.

9.11.3 AlarmNotification

AlarmNotification()

This function triggers diagnostic alarms according to the PROFINET standard.

Each call of this function calls the diagnostic interrupt OB (OB 82) once, regardless of the number and the severity level of the transferred diagnostic entries.

Table 3-677 AlarmNotification() - Native C++

Syntax	`ERuntimeErrorCode AlarmNotification(UINT16 in_HardwareIdentifier, UINT16 in_ModuleState, UINT16 in_NumberOfDiagnosisEvents, SDiagExtChannelDescription* in_ArrayOfDiagnosisEvents, UINT16* out_SequenceNumber);`	
Parameters	• `UINT16 in_HardwareIdentifier:` The hardware identifier of the module or submodule which sends the diagnostics entry. The identifier must belong to a hardware component in the currently loaded project. • `UINT16 in_ModuleState:` Module status. The following statuses are valid: DMODULE_STATE_OK = 0, DMODULE_STATE_ERROR = 1, DMODULE_STATE_MAINT_DEMANDED = 2, DMODULE_STATE_MAINT_REQUIRED = 4 The `in_ModuleState` parameter is derived from the sum (ORed) of the severity level in the `SDiagExtChannelDescription` field. If a diagnostic interrupt should be generated for both "Maintenance demanded" as well as "Maintenance required", select "6" as the module status. • `UINT16 in_NumberOfDiagnosisEvents:` Multiple diagnostic entries can be sent to the CPU with a single API call. Valid range: 0 to 16. 0 means that no diagnostics entry should appear for the submodule or the channel. • `SDiagExtChannelDescription* in_ArrayOfDiagnosisEvents:` Pointer to a field with diagnostic entries. The field must match the number of diagnostic entries. It can also be a null pointer. For definitions, see SDiagExtChannelDescription (Page 267). • `UINT16* out_SequenceNumber:` S7-PLCSIM Advanced assigns a unique consecutive number to each interrupt event. According to PROFINET standard the sequence number is 10 bits wide (1 to $7FF_H$). When the highest number is reached the numbering starts again at 1.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_WRONG_MODULE_STATE`	The module is currently unplugged.

Return values	SREC_DOES_NOT_EXIST	No hardware identifier of the module.
	SREC_WRONG_MODULE_TYPE	The channel number does not exist for the module.
	SREC_WRONG_ARGUMENT	The value for the module status is invalid.
	SREC_TIMEOUT	The function does not return on time.

Table 3-678 AlarmNotification() - .NET (C#)

Syntax	`void AlarmNotification(ushort in_HardwareIdentifier, ushort in_ModuleState, ushort in_NumberOfDiagnosisEvents, SDiagExtChannelDescription [] in_ArrayOfDiagnosisEvents, Out ushort out_SequenceNumber);`	
Parameters	• `ushort in_HardwareIdentifier:` The hardware identifier of the module or submodule which sends the diagnostics entry. The identifier must belong to a hardware component in the currently loaded project. • `ushort in_ModuleState:` Module status. The following statuses are valid: ModuleState.Ok = 0, ModuleState.Error = 1, ModuleState.MaintenanceDemanded = 2, ModuleState.MaintenanceRequired = 4 The `in_ModuleState` parameter is derived from the sum (ORed) of the severity level in the `SDiagExtChannelDescription` field. If a diagnostic interrupt should be generated for both "Maintenance demanded" as well as "Maintenance required", select "6" as the module status. • `ushort in_NumberOfDiagnosisEvents` Multiple diagnostic entries can be sent to the CPU with a single API call. Valid range: 0 to 16. 0 means that no diagnostics entry should appear for the submodule or the channel. • `SDiagExtChannelDescription [] in_ArrayOfDiagnosisEvents:` Pointer to a field with diagnostic entries. The field must match the number of diagnostic entries. It can also be a null pointer. For definitions, see SDiagExtChannelDescription (Page 267). • `Out ushort out_SequenceNumber:` S7-PLCSIM Advanced assigns a unique consecutive number to each alarm event. According to PROFINET standard the sequence number is 10 bits wide (1 to $7FF_H$). When the highest number is reached the numbering starts again at 1.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.WrongModuleState`	The module is currently unplugged.
	`ERuntimeErrorCode.DoesNotExist`	No hardware identifier of the module.
	`ERuntimeErrorCode.WrongArgument`	The value for the module status is invalid.
	`ERuntimeErrorCode.WrongModuleType`	The channel number does not exist for the module.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

Example	`ushort seqNumber;`
	`var In_ArrayOfDiagnosisEvent = new SDiagExtChannelDescription[] {`
	`new SDiagExtChannelDescription() {ChannelNumber = 0x8000, ErrorType = 0x0001,`
	`ExtErrorType = 0, Direction = EDiagProperty.Appear,Severity =EDiagSeverity.MaintDemanded},`
	
	`new SDiagExtChannelDescription() {ChannelNumber = 0x8000, ErrorType = 0x0002,`
	`ExtErrorType = 0, Direction = EDiagProperty.Appear,Severity =EDiagSeverity.Failure},`	

	`new SDiagExtChannelDescription() {ChannelNumber = 0x8000, ErrorType = 0x0003,`
	`ExtErrorType = 0, Direction = EDiagProperty.Appear,Severity =EDiagSeverity.MaintRequired},`
	
	`Instance.AlarmNotification(269, 7, 3, In_ArrayOfDiagnosisEvent, out seqNumber);`
	`//ModuleState parameter is sum of the severities in the SDiagExtChannelDescription array above: 4+2+1`

9.11.4 ProcessEvent

ProcessEvent()

Process events from central and distributed input modules can be simulated with this function.

Table 3-679 ProcessEvent() - Native C++

Syntax	`ERuntimeErrorCode ProcessEvent(UINT16 in_HardwareIdentifier, UINT16 in_Channel, EProcessEventType in_ProcessEventType, UINT16* out_SequenceNumber);`	
Parameters	• `UINT16 in_HardwareIdentifier:` The hardware identifier of the module or submodule which sends the process event. The identifier must belong to a hardware component in the currently loaded project. • `UINT16 in_Channel:` The channel of the I/O module which sends the process event. • `EProcessEventType in_ProcessEventType:` A value from the list of predefined types of events for S7 modules, see EProcessEventType (Page 286). • `UINT16* out_SequenceNumber:` S7-PLCSIM Advanced assigns a unique consecutive number to each interrupt event. According to PROFINET standard the sequence number is 10 bits wide (1 to $7FF_H$). When the highest number is reached the numbering starts again at 1.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_WRONG_MODULE_STATE`	The module is currently unplugged.
	`SREC_DOES_NOT_EXIST`	No hardware identifier of the module.
	`SREC_NOT_SUPPORTED_BY_MODULE`	The module is not supported by this user action.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-680 ProcessEvent() - .NET (C#)

Syntax	`void ProcessEvent(ushort in_HardwareIdentifier, ushort in_Channel, EProcessEventType in_ProcessEventType, Out ushort out_SequenceNumber);`	
Parameters	• `ushort in_HardwareIdentifier:` The hardware identifier of the module or submodule which generates the process event. The identifier must belong to a hardware component in the currently loaded project. • `ushort in_Channel:` The channel of the I/O module which generates the process event. • `EProcessEventType in_ProcessEventType:` A value from the list of predefined types of events for S7 modules, see EProcessEventType (Page 286). • `Out ushort out_SequenceNumber:` S7-PLCSIM Advanced assigns a unique consecutive number to each interrupt event. According to PROFINET standard the sequence number is 10 bits wide (1 to $7FF_H$). When the highest number is reached the numbering starts again at 1.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.WrongModuleState`	The module is currently unplugged.
	`ERuntimeErrorCode.DoesNotExist`	No hardware identifier of the module.
	`ERuntimeErrorCode.NotSupportedByMod-ule`	The module is not supported by this user action.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

Priority for hardware interrupt OB

The hardware interrupts triggered via the S7-PLCSIM Advanced API are transmitted in sequence to the user program.

The priority of the assigned hardware interrupt OB determines the sequence of execution only if events occur simultaneously.

9.11.5 PullOrPlugEvent

PullOrPlugEvent()

This function triggers pull/plug events. The interrupt OB (OB 83) "Pull or plug of modules" is executed for these events.

NOTE

Removing and inserting head modules of distributed I/O systems and R1 devices

An actual PLC cannot detect a pull or plug of a head module in a distributed I/O system, except for R1 devices.

In contrast, a simulated PLC in S7-PLCSIM Advanced does allow the removal and insertion of head modules in distributed I/O systems and R1 devices. Your program can use this event for such a case, but it does not correspond to an event that would occur with an actual PLC.

NOTE
PN/PC Coupler devices
With a physical PN/PN Coupler device, you cannot pull or plug the module.
S7-PLCSIM Advanced allows a pull or plug of PN/PN Couplers if Proxy HwID is used as input for pull/plug events.

Table 3-681 PullOrPlugEvent() - Native C++

Syntax	`ERuntimeErrorCode PullOrPlugEvent(UINT16 in_HardwareIdentifier, EPullOrPlugEventType in_PullOrPlugEventType, UINT16* out_SequenceNumber);`	
Parameters	• `UINT16 in_HardwareIdentifier:` The hardware identifier of the module or submodule which generates the pull/plug event. The identifier must belong to a hardware component in the currently loaded project. • `EPullOrPlugEventType in_PullOrPlugEventType:` A value from the list of predefined types of pull/plug events, see EPullOrPlugEventType (Page 286). • `UINT16* out_SequenceNumber:` S7-PLCSIM Advanced assigns a unique consecutive number to each interrupt event. According to PROFINET standard the sequence number is 10 bits wide (1 to $7FF_H$). When the highest number is reached the numbering starts again at 1.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_WRONG_MODULE_STATE`	The module is currently unplugged.
	`SREC_WRONG_MODULE_TYPE`	The wrong module type was selected, e.g. if an onboard I/O of a compact CPU is to be pulled.
	`SREC_NOT_SUPPORTED_BY_MODULE`	The module is not supported by this user action.
	`SREC_DOES_NOT_EXIST`	No hardware identifier of the module.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-682 PullOrPlugEvent() - .NET (C#)

Syntax	`void PullOrPlugEvent(ushort in_HardwareIdentifier, EPullOrPlugEventType in_PullOrPlugEventType, Out ushort out_SequenceNumber);`	
Parameters	• `ushort in_HardwareIdentifier:` The hardware identifier of the module or submodule which generates the pull/plug event. The identifier must belong to a hardware component in the currently loaded project. • `EPullOrPlugEventType in_PullOrPlugEventType:` A value from the list of predefined types of pull/plug events, see EPullOrPlugEventType (Page 286). • `Out ushort out_SequenceNumber` S7-PLCSIM Advanced assigns a unique consecutive number to each interrupt event. According to PROFINET standard the sequence number is 10 bits wide (1 to $7FF_H$). When the highest number is reached the numbering starts again at 1.	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.WrongModuleState`	The module is currently unplugged.
	`ERuntimeErrorCode.WrongModuleType`	The wrong module type was selected, e.g. if an onboard I/O of a compact CPU is to be pulled.

Exceptions	`ERuntimeErrorCode.DoesNotExist`	No hardware identifier of the module.
	`ERuntimeErrorCode.NotSupportedByModule`	The module is not supported by this user action.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

9.11.6 StatusEvent

StatusEvent()

This function is used to trigger the status event OB (OB 55). Status events are only supported for modules in a distributed I/O system.

Table 3-683 StatusEvent() - Native C++

Syntax	`ERuntimeErrorCode StatusEvent(UINT16 in_HardwareIdentifier, UINT16 in_Specifier);`	
Parameters	• `UINT16 in_HardwareIdentifier:` The hardware identifier of the module that generates the status event. The identifier must belong to a hardware component in the currently loaded project. • `UINT16 in_Specifier:` The parameter is transferred to the interrupt frame as interrupt specifier. It is available as input parameter of the OB 55 call.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_WRONG_MODULE_STATE`	The module is currently unplugged.
	`SREC_NOT_SUPPORTED_BY_MODULE`	The module is not supported by this user action.
	`SREC_DOES_NOT_EXIST`	No hardware identifier of the module.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-684 StatusEvent() - .NET (C#)

Syntax	`void StatusEvent(ushort in_HardwareIdentifier, ushort in_Specifier);`	
Parameters	• `ushort in_HardwareIdentifier:` The hardware identifier of the module that generates the status event. The identifier must belong to a hardware component in the currently loaded project. • `ushort in_Specifier:` The parameter is transferred to the interrupt frame as interrupt specifier. It is available as input parameter of the OB 55 call.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.WrongModuleState`	The module is currently unplugged.
	`ERuntimeErrorCode.DoesNotExist`	No hardware identifier of the module.
	`ERuntimeErrorCode.NotSupportedByModule`	The module is not supported by this user action.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

9.11.7 ProfileEvent

ProfileEvent()

This function is used to trigger the Profile event OB (OB 57). Profile events are only supported for modules in a distributed I/O system.

Table 3-685 ProfileEvent() - Native C++

Syntax	`ERuntimeErrorCode ProfileEvent(UINT16 in_HardwareIdentifier, UINT16 in_Specifier);`	
Parameters	• `UINT16 in_HardwareIdentifier:` The hardware identifier of the module that generates the profile event. The identifier must belong to a hardware component in the currently loaded project. • `UINT16 in_Specifier:` The parameter is transferred to the interrupt frame as interrupt specifier. It is available as input parameter of the OB 57 call.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_WRONG_MODULE_STATE`	The module is currently unplugged.
	`SREC_NOT_SUPPORTED_BY_MODULE`	The module is not supported by this user action.
	`SREC_DOES_NOT_EXIST`	No hardware identifier of the module.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-686 ProfileEvent() - .NET (C#)

Syntax	`void ProfileEvent(ushort in_HardwareIdentifier, ushort in_Specifier);`	
Parameters	• `ushort in_HardwareIdentifier:` The hardware identifier of the module that generates the profile event. The identifier must belong to a hardware component in the currently loaded project. • `ushort in_Specifier:` The parameter is transferred to the interrupt frame as interrupt specifier. It is available as input parameter of the OB 57 call.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.WrongModuleState`	The module is currently unplugged.
	`ERuntimeErrorCode.DoesNotExist`	No hardware identifier of the module.
	`ERuntimeErrorCode.NotSupportedByMod-ule`	The module is not supported by this user action.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

9.11.8 UpdateEvent

UpdateEvent()

This function is used to trigger the Update event OB (OB 56). Update events are only supported for modules in a distributed I/O system.

Table 3-687 UpdateEvent() - Native C++

Syntax	`ERuntimeErrorCode UpdateEvent(UINT16 in_HardwareIdentifier, UINT16 in_Specifier);`	
Parameters	• `UINT16 in_HardwareIdentifier:` The hardware identifier of the module that triggers the update event. The identifier must belong to a hardware component in the currently loaded project. • `UINT16 in_Specifier:` The parameter is transferred to the interrupt frame as interrupt specifier. It is available as input parameter of the OB 56 call.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_WRONG_MODULE_STATE`	The module is currently unplugged.
	`SREC_NOT_SUPPORTED_BY_MODULE`	The module is not supported by this user action.
	`SREC_DOES_NOT_EXIST`	No hardware identifier of the module.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-688 UpdateEvent() - .NET (C#)

Syntax	`void UpdateEvent(ushort in_HardwareIdentifier, ushort in_Specifier);`	
Parameters	• `ushort in_HardwareIdentifier:` The hardware identifier of the module that triggers the update event. The identifier must belong to a hardware component in the currently loaded project. • `ushort in_Specifier:` The parameter is transferred to the interrupt frame as interrupt specifier. It is available as input parameter of the OB 56 call.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.WrongModuleState`	The module is currently unplugged.
	`ERuntimeErrorCode.DoesNotExist`	No hardware identifier of the module.
	`ERuntimeErrorCode.NotSupportedByMod-ule`	The module is not supported by this user action.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

9.11.9 GetConfiguredProcessEvent

GetConfiguredProcessEvents()

With this API method, the process events configured in the TIA Portal can be read out during runtime.

If no process events are present, `SREC_OK` is returned. The value for `EventsCount` is then 0.

Table 3-689 GetConfiguredProcessEvents() - Native C++

Syntax	`ERuntimeErrorCode GetConfiguredProcessEvents(UINT16* out_EventsCount,);`	
Parameters	• `SConfiguredProcessEvents* inout_ProcessEvents:` Pointer or reference to a user-defined memory which contains the field with the downloaded configured process events. The structure SConfiguredProcessEvents (Page 266) contains information about these process events. • `UINT16* out_EventsCount:` Pointer or reference to a tag which contains the number of configured process events.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-690 GetConfiguredProcessEvents() - .NET (C#)

Syntax	`SConfiguredProcessEvents [] GetConfiguredProcessEvents();`	
Parameters	None	
Return values	Field with configured process events and field size provide the number of configured process events.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

9.11.10 RackOrStationFaultEvent

Description

This function is used to trigger the RackOrStationFault event OB (OB 86). These events are only supported for distributed devices.

Table 3-691 RackOrStationFaultEvent() - Native C++

Syntax	`ERuntimeErrorCode RackOrStationFaultEvent(UINT16 in_HardwareIdentifier, ERackOrStationFaultType in_EventType);`	
Parameter	• `UINT16 in_HardwareIdentifier:` The hardware identifier of the device that sends the event. Use the hardware identifier of the Hw_Device type. • `ERackOrStationFaultType in_EventType:` A value from the list of predefined types of events, see ERackOrStationFaultType (Page 288).	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The instance is not registered in Runtime Manager.

Return values	SREC_WRONG_MODULE_TYPE	The specified HW identifier is not that of a distributed device.
	SREC_WRONG_MODULE_STATE	The device with the specified HW identifier already reports the status Fault/Return.
	SREC_DOES_NOT_EXIST	The specified HW identifier of the device does not exist.
	SREC_TIMEOUT	The function does not return on time.

Table 3-692 RackOrStationFaultEvent() - .NET (C#)

Syntax	`void RackOrStationFaultEvent(ushort in_HardwareIdentifier, ERackOrStationFaultType in_EventType);`	
Parameter	• `ushort in_HardwareIdentifier:` The hardware identifier of the device that sends the event. Use the hardware identifier of the Hw_Device type. • `ERackOrStationFaultType in_EventType:` A value from the list of predefined types of events, see ERackOrStationFaultType (Page 288).	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The instance is not registered in Runtime Manager.
	`ERuntimeErrorCode.DoesNotExist`	The specified HW identifier of the device does not exist.
	`ERuntimeErrorCode.WrongModuleType`	The specified HW identifier is not that of a distributed device.
	`ERuntimeErrorCode.WrongModuleState`	The device with the specified HW identifier already reports the status Fault/Return.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

More information

You can find more information on the HW identifier in the STEP 7 online help.

9.12 Events for IInstances

9.12.1 Events for operating state and cycle control

The following events are triggered for the IInstances interface:

Table 3-693 Events for IInstances

Event	Cause
OnOperatingStateChanged (Page 206)	The operating state of the simulated PLC instance has changed.
OnLedChanged (Page 209)	The LED display of the simulated PLC instance has changed.
OnSoftwareConfigurationChanged (Page 211)	The software configuration of the simulated PLC instance changed: • After power up from the Virtual SIMATIC Memory Card • At the end of a download with changed software configuration When this event is triggered, the stored tag list is reset.

Event	Cause
OnIPAddressChanged (Page 213)	The IP Address of the simulated PLC has changed.
OnSyncPointReached (Page 215)	The simulated PLC instance has reached a synchronization point. If the simulated PLC instance is being operated in `Default` mode, the `SendSyncEventInDefaultMode` flag must be set to receive the event. See SendSyncEventInDefaultMode (Page 171).
OnHardwareConfigChanged (Page 217)	When the hardware configuration of the simulated PLC instance has changed, the event is triggered at the following times: • After power up from the Virtual SIMATIC Memory Card • During the Hardware Config download

9.12.1.1 Synchronize simulation partner

Synchronize simulation partner cycle-controlled

SingleStep operating modes

The SingleStep modes of operation of the simulated PLC instance are used to synchronize multiple simulation partners (clients) using synchronization points. The operating modes define the synchronization point at which the instance changes to the freeze state and sends the `OnSyncPointReached` event.

Table 3-694 Cycle-controlled operating modes (SingleStep)

Operating mode[1]	Synchronization point		Minimum cycle time[2]	Send clock "Bus"[3]
	Cycle control point	Before reading in the process image partition		
	"C"	"P"	"T"	
`SingleStep_C`[4]	✓			
`SingleStep_P`		✓		
`SingleStep_CP`[4]	✓	✓		
`SingleStep_CT`[4]	✓		✓	
`SingleStep_CPT`[4]	✓	✓	✓	
`SingleStep_Bus`	✓			✓

[1] A change from one SingleStep operating mode to another during operation would result in the input parameter `TimeSinceSameSyncPoint_ns / TimeSinceAnySyncPoint_ns` being set to 0 in the first SyncPointReached callback event in the new operating mode. We recommend that the SingleStep operating mode not be changed during operation.

[2] In addition, the minimum scan cycle time of OB 1 is overwritten in this operating mode. When you define a minimum cycle time of 200 ms, the minimum distance between two cycle control points is 200 virtual milliseconds. The default setting is 100 ms.

[3] Send clock of the I/O system (PROFIBUS or PROFINET) that is to be used for the cycle-controlled synchronization of the simulated PLC instance. You set the send clock of the respective I/O system in the STEP 7 properties, for example, in the properties of the PROFINET interface of the CPU (Advanced options > Real time settings > I/O communication > Send clock).

[4] During the execution of these operating modes, the input parameter of the first callback event returns the value 0 for TimeSinceSameSyncPoint_ns / TimeSinceAnySyncPoint_ns. Subsequent callback events for TimeSinceSameSyncPoint_ns / TimeSinceAnySyncPoint_ns then return values other than 0.

API functions / events

- GetOverwrittenMinimalCycleTime_ns() (Page 171)
- SetOverwrittenMinimalCycleTime_ns() (Page 171)
- OverwrittenMinimalCycleTime_ns { get; set; } (Page 171)
- RunToNextSyncPoint() (Page 215)
- OnSyncPointReached (Page 215)
- EventCallback_II_SREC_ST_UINT32_UINT32_EPET_UINT32 (Page 242) / Delegate_II_EREC_DT_UINT32_INT64_INT64_UINT32 (Page 247)

Conditions for the `SingleStep_Bus` operating mode:

The following conditions must be met for the `SingleStep_Bus` operating mode:

- You must have configured outputs on the controller.
- To synchronize the process image of the outputs, you must call the SYNC_PO instruction in the isochronous mode interrupt OB.

NOTE

In addition to the send clock of the bus, the cycle control point is also used as a synchronization point. In the cycle control point, the transferred ID has the value 0xFFFF. The in_parameters "in_TimeSinceSameSyncPoint_ns" and "in_TimeSinceAnySyncPoint_ns" have the value 0.

A synchronization of OBs and process image partitions is only possible if the OBs call the instructions "SYNC_PI" and "SYNC_PO". To use process image partition 1 (PIP 1) for an F-runtime group, configure the "Pre/Post processing of the F-runtime group" in the Safety Administration editor.

To configure the preprocessing and postprocessing of the F-runtime group you need new standard FCs for "SYNC_PI" and "SYNC_PO" with the following properties:

- Name of the FC: SYNC_PI

  #RET_VAL_PI := SYNC_PI(PART := "PIP 1", FLADDR => #FLADDR_PI);
- Name of the FC: SYNC_PO

  #RET_VAL_PO := SYNC_PO(PART := "PIP 1", FLADDR => #FLADDR_PO);

To synchronize the process image partition 1 (PIP 1), add the FCs in the Safety Administration editor under "Pre/Post processing of the F-runtime group".

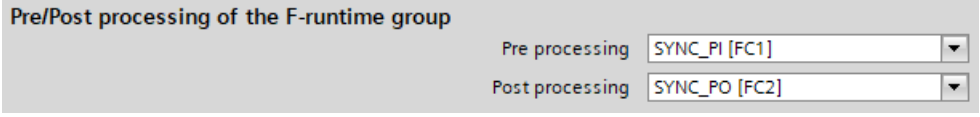

Figure 3-267 Safety Administration Editor

After compiling these changes, process image partition 1 (PIP 1) is also available for the fail-safe organization block (FOB).

Notes regarding the `SingleStep_P`, `SingleStep_Bus`, and `SingleStep_CP` operating modes

NOTE

Loss of a `OnSyncPointReached` event when downloading a clock-synchronous OB in RUN mode.

If you are registered for the `OnSyncPointReached` event in the `SingleStep_P` and `SingleStep_Bus` operating modes, the simulated PLC instance does not send this event to the API client when downloading a clock-synchronous OB.

Solution:

1. Use the `OnSoftwareConfigurationChanged` event to determine the start and end of a download
2. Register and log off the `OnSyncPointReached` event, or handle the loss of the `OnSyncPointReached` event accordingly.

NOTE

Note on SingleStep_CP operating mode

Downloading software changes in RUN mode.

If you perform a software download in RUN mode in SingleStep_CP operating mode, the download may not be possible and the simulation may stop. An overload during the download in RUN may be the reason for this.

Solution:

1. Use the "Virtual Time Scaling" function and select a low scaling factor (e.g. scaling factor of 0.25).
2. Provide sufficient resources to increase the runtime performance and the S7-PLCSIM Advanced communication performance.

Terminating the freeze state

The `RunToNextSyncPoint()` function cancels the freeze state and induces the simulated PLC instance to continue running until the next synchronization point.

Switching to the Default operating mode also terminates the freeze state.

Example

The figure schematically shows the sequence in the `SingleStep_CP` operating mode.

In addition to the `OnSyncPointReached` event the simulated PLC instance also sends the virtual time since the last synchronization point of the same process image partition ID or of any process image partition ID has been reached (`TimeSinceSameSyncPoint_ns` / `TimeSinceAnySyncPoint_ns`).

The `RunToNextSyncPoint()` function cancels the freeze state.

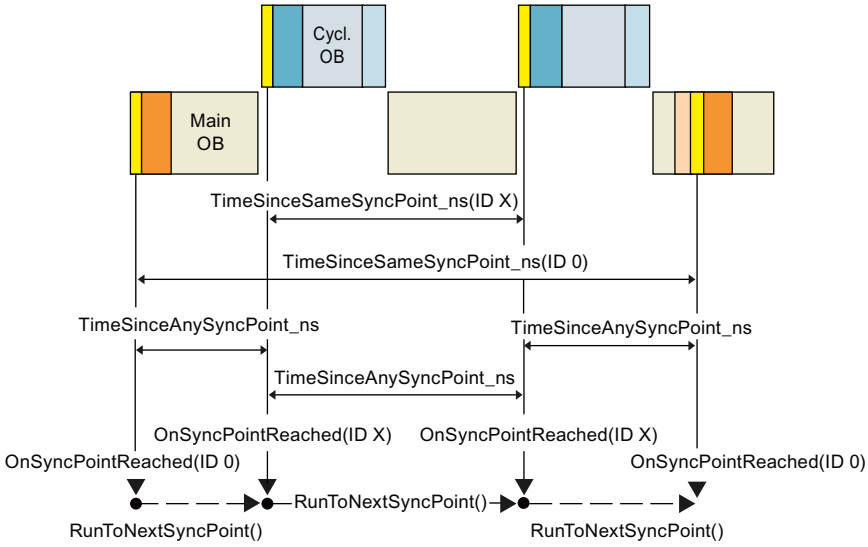

Figure 3-268 Example: Sequence in the SingleStep_CP operating mode

Changing the settings in the watch table

NOTE

Selecting triggers for monitoring of tags in the SingleStep operating modes

In TIA Portal the watch table in basic mode shows the values for outputs and bit memories **before** the processing.

To display the tag values **after** processing, proceed as follows:

1. Select the extended mode for the watch table.
2. In the "Monitor with trigger" column, select "End of cycle, permanent".

Synchronize simulation partner time-controlled

TimespanSynchronized operating modes

Several simulation partners (clients) are synchronized time-controlled with the TimespanSynchronized operating modes of the simulated PLC instance. The operating modes define the synchronization point at which the instance changes to the freeze state and sends the `OnSyncPointReached` event.

Table 3-695 Time-controlled operating modes (TimespanSynchronized)

Operating mode	Synchronization point	
	Cycle control point	Before reading in the process image partition
	"C"	"P"
`TimespanSynchronized_C`	✓	
`TimespanSynchronized_CP`	✓	✓
`TimespanSynchronized_P`		✓

API functions / events

- Settings for cycle control (Page 171)
- StartProcessing() (Page 171)
- OnSyncPointReached (Page 215)

Terminating the freeze state

The `StartProcessing(t)` function cancels the freeze state and induces the simulated PLC instance to continue running at least as long as required (on the basis of the virtual time) before it changes back to the freeze state at the next synchronization point.

Switching to the Default operating mode also terminates the freeze state.

Example

The figure schematically shows the sequence in the `TimespanSynchronized_CP` operating mode.

In addition to the `OnSyncPointReached` event the simulated PLC instance also sends the runtime since the last call of the `StartProcessing(t)` (`TimeSinceSameSyncPoint_ns` / `TimeSinceAnySyncPoint_ns`) function.

The `StartProcessing()` function cancels the freeze state.

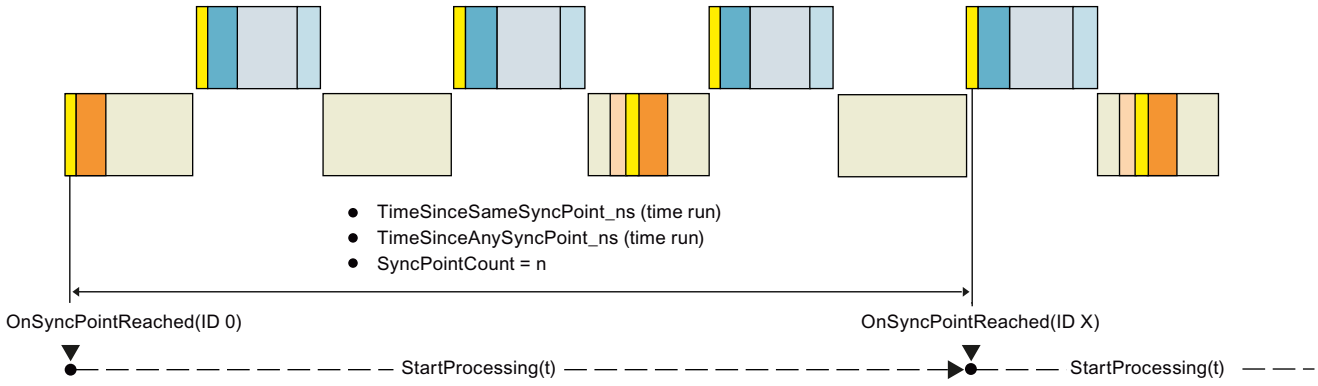

Figure 3-269 Example: Sequence in the TimespanSynchronized_CP operating mode

Description

At least two clients are synchronized on the basis of a virtual period for the time-controlled operating modes. A client can be an instance of a simulated PLC instance or an application that uses the Runtime API (API client). The synchronization must be performed by a synchronization master.

The synchronization master instructs a client to run for a specific period. The time period is specified by the master in nanoseconds. The client then runs for the expected period before the client goes into the freeze state at the next synchronization point. Before switching to the freeze state, the client sends the master the exact amount of time that he currently needed. Thereafter, the master signals the next client to catch up.

NOTE

StartProcessing(t) time value represents simulation time

The specified time-value (t) parameter in `StartProcessing(t)` is not the normal PC time. This time value specifies the simulation time in S7-PLCISM Advanced. The simulation time differs from PC time because it pauses when waiting for the Windows scheduler to allocate calculation time to the S7-PLCSIM Advanced process. Additionally, it takes some time until the next SyncPoint is reached. This means that the longer the application runs, the time difference between the console application and S7-PLCSIM Advanced increases.

API client as master

The API client as master signals each client when it should start. The master receives events from every client when they occur.

An API client can only "time manage" instances of a simulated PLC instance. The API client does not receive events from other API clients. It cannot send messages to other API clients.

9.12.1.2 OnOperatingStateChanged events

OnOperatingStateChanged

Registers or unregisters an event handler method.

Table 3-696 OnOperatingStateChanged - .NET (C#)

Syntax	`event Delegate_II_EREC_DT_EOS_EOS OnOperatingStateChanged;`
Parameters	None. See Delegate_II_EREC_DT_EOS_EOS (Page 246).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnOperatingStateChangedCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-697 RegisterOnOperatingStateChangedCallback() - Native C++

Syntax	`void RegisterOnOperatingStateChangedCallback(EventCallback_II_SREC_ST_SROS_SROS in_CallbackFunction);`
Parameters	• `EventCallback_II_SREC_ST_SROS_SROS in_CallbackFunction:` A callback function that subscribes to the event. See EventCallback_II_SREC_ST_SROS_SROS (Page 238).
Return values	None
Note	The callback function runs in a separate thread.

RegisterOnOperatingStateChangedEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registering a new event object causes the previous event object to be deleted.

Table 3-698 RegisterOnOperatingStateChangedEvent() - Native C++

Syntax	`void RegisterOnOperatingStateChangedEvent();` `void RegisterOnOperatingStateChangedEvent(HANDLE* in_Event);`
Parameters	• `None:` An internal event object is registered. • `HANDLE* in_Event:` A handle for a user-specific event object. The event object is registered.
Return values	None

Example C++	`// Thread 1 ----------`
	`ISimulationRuntimeManager * api = NULL;`
	`ERuntimeErrorCode result = InitializeApi(&api);`
	
	`IInstance* psa = NULL;`
	`if (result == SREC_OK)`
	`{`
	` result = api->RegisterInstance(&psa);`
	`}`
	
	`// Register the internal event object`
	`psa->`**RegisterOnOperatingStateChangedEvent**`();`
	
	`// Thread 2 ----------`
	`while (condition)`
	`{`
	`// Wait for the event to be set (timeout after 10s)`
	`bool isEventSet = psa->WaitForOnOperatingStateChangedEvent(10000);`
	`if (isEventSet)`
	`{`
	`// Do Something`
	`…`
	`}`
	`}`

Example C++	`// Thread 1 ----------`
	`ISimulationRuntimeManager * api = NULL;`
	`ERuntimeErrorCode result = InitializeApi(&api);`
	
	`IInstance* psa = NULL;`
	`if (result == SREC_OK)`
	`{`
	` result = api->RegisterInstance(&psa);`
	`}`
	
	`// Create an event object`
	`HANDLE eventHandle = CreateEvent(NULL, FALSE, FALSE, NULL);`
	
	`// Register the user created event object`
	`psa->`**RegisterOnOperatingStateChangedEvent**`(&eventHandle);`
	
	`// Do Something`
	`…`
	`// Clean up the handle`
	`CloseHandle(eventHandle);`
	
	`// Thread 2 ----------`
	`while (condition)`
	`{`
	`// Wait for the event to be set //OR:`
	`WaitForSingleObject(eventHandle, INFINITE); //psa-`
	`>WaitForOnOperatingStateChangedEvent();`
	
	`// Do Something`
	`…`
	`}`

Table 3-699 RegisterOnOperatingStateChangedEvent() – .NET (C#)

Syntax	`void RegisterOnOperatingStateChangedEvent();`
Parameters	None
Return values	None

UnregisterOnOperatingStateChangedCallback()

Unregisters the callback function.

Table 3-700 UnregisterOnOperatingStateChangedCallback() - Native C++

Syntax	`void UnregisterOnOperatingStateChangedCallback(EventCallback_II_SREC_ST_SROS-_SROS in_CallbackFunction = nullptr);`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

UnregisterOnOperatingStateChangedEvent()

Unregisters the event object.

Table 3-701 UnregisterOnOperatingStateChangedEvent() - Native C++

Syntax	`void UnregisterOnOperatingStateChangedEvent();`
Parameters	None
Return values	None

Table 3-702 UnregisterOnOperatingStateChangedEvent() - .NET (C#)

Syntax	`void UnregisterOnOperatingStateChangedEvent();`
Parameters	None
Return values	None

WaitForOnOperatingStateChangedEvent()

The function blocks the program until the registered event object is in the signaled state or the timeout interval is exceeded.

Table 3-703 WaitForOnOperatingStateChangedEvent() - Native C++

Syntax	`bool WaitForOnOperatingStateChangedEvent();` `bool WaitForOnOperatingStateChangedEvent(UINT32 in_Time_ms);`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

Table 3-704 WaitForOnOperatingStateChangedEvent() - .NET (C#)

Syntax	`bool WaitForOnOperatingStateChangedEvent();` `bool WaitForOnOperatingStateChangedEvent(UInt32 in_Time_ms);`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UInt32 in_Time_ms:` Value for the time limit in milliseconds.

Return values	• `true`: If the event object was set to the signaled state. • `false`: If no event was received during the defined time limit.

9.12.1.3 OnLedChanged events

OnLedChanged

Registers or unregisters an event handler method.

Table 3-705 OnLedChanged - .NET (C#)

Syntax	`event Delegate_II_EREC_DT_ELT_ELM OnLedChanged;`
Parameters	None. See Delegate_II_EREC_DT_ELT_ELM (Page 246).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnLedChangedCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-706 RegisterOnLedChangedCallback() - Native C++

Syntax	`void RegisterOnLedChangedCallback(EventCallback_II_SREC_ST_SRLT_SRLM in_CallbackFunction);`
Parameters	• `EventCallback_II_SREC_ST_SRLT_SRLM in_CallbackFunction:` A callback function that subscribes to an event. See EventCallback_II_SREC_ST_SRLT_SRLM (Page 240).
Return values	None
Note	The callback function runs in a separate thread.

RegisterOnLedChangedEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registering a new event object causes the previous event object to be deleted.

Table 3-707 RegisterOnLedChangedEvent() - Native C++

Syntax	`void RegisterOnLedChangedEvent();` `void RegisterOnLedChangedEvent(HANDLE* in_Event);`
Parameters	• `None:` An internal event object is registered. • `HANDLE* in_Event:` A handle for a user-specific event object. The event object is registered.
Return values	None

Table 3-708 RegisterOnLedChangedEvent() – .NET (C#)

Syntax	`void RegisterOnLedChangedEvent();`
Parameters	None
Return values	None

UnregisterOnLedChangedCallback()

Unregisters the callback function.

Table 3-709 UnregisterOnLedChangedCallback() - Native C++

Syntax	`void UnregisterOnLedChangedCallback();`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

UnregisterOnLedChangedEvent()

Unregisters the event object.

Table 3-710 UnregisterOnLedChangedEvent() - Native C++

Syntax	`void UnregisterOnLedChangedEvent();`
Parameters	None
Return values	None

Table 3-711 UnregisterOnLedChangedEvent() - .NET (C#)

Syntax	`void UnregisterOnLedChangedEvent();`
Parameters	None
Return values	None

WaitForOnLedChangedEvent()

The function blocks the program until the registered event object is in the signaled state or the timeout interval is exceeded.

Table 3-712 WaitForOnLedChangedEvent() - Native C++

Syntax	`bool WaitForOnLedChangedEvent();` `bool WaitForOnLedChangedEvent(UINT32 in_Time_ms);`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

Table 3-713 WaitForOnLedChangedEvent() - .NET (C#)

Syntax	`bool WaitForOnLedChangedEvent();` `bool WaitForOnLedChangedEvent(UInt32 in_Time_ms);`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UInt32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

9.12.1.4 OnSoftwareConfigurationChanged events

OnSoftwareConfigurationChanged()

Reports software changes in STOP and RUN modes.

Table 3-714 OnSoftwareConfigurationChanged

Syntax	`event Delegate_SRSCC OnSoftwareConfigurationChanged();`
Parameters	IInstance, ERuntimeErrorCode, SYSTEMTIME, ESoftwareConfigChanged
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnSoftwareConfigurationChangedCallback()

When the event occurs, the registered callback function is called. Only one callback function can be registered for the event. The registration of a new callback function causes the previous callback function to be deleted.

Table 3-715 RegisterOnSoftwareConfigurationChangedCallback() - Native C++

Syntax	`void RegisterOnSoftwareConfigurationChangedCallback();`
Parameters	CallbackFunction
Return values	None
Note	The event handler method runs in a separate thread.

RegisterOnSoftwareConfigurationChangedEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registration of a new event object causes the previous event object to be deleted.

Table 3-716 RegisterOnSoftwareConfigurationChangedEvent() - Native C++

Syntax	`void RegisterOnSoftwareConfigurationChangedEvent();`
Parameters	• `None` An internal event object is registered. • `HANDLE*` A handle for a user-specific event object. The event object is registered.
Return values	None

UnregisterOnSoftwareConfigurationChangedCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 3-717 UnregisterOnSoftwareConfigurationChangedCallback() - Native C++

Syntax	`void UnregisterOnSoftwareConfigurationChangedCallback();`
Parameters	None
Return values	None

UnregisterOnSoftwareConfigurationChangedEvent()

Unregisters the event object.

Table 3-718 UnregisterOnSoftwareConfigurationChangedEvent() - Native C++

Syntax	`void UnregisterOnSoftwareConfigurationChangedEvent();`
Parameters	None
Return values	None

Table 3-719 UnregisterOnSoftwareConfigurationChangedEvent() - .NET (C#)

Syntax	`void UnregisterOnSoftwareConfigurationChangedEvent();`
Parameters	None
Return values	None

WaitForOnSoftwareConfigurationChangedEvent()

The function blocks the program until the registered event object is set to the signaled state or the timeout interval is exceeded.

Table 3-720 WaitForOnSoftwareConfigurationChangedEvent() - Native C++

Syntax	`void WaitForOnSoftwareConfigurationChangedEvent();`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.
Note	The function blocks the CoSimulation program until a software download is set to the signaled state or the timeout interval is exceeded.

Table 3-721 WaitForOnSoftwareConfigurationChangedEvent() - .NET (C#)

Syntax	`void WaitForOnSoftwareConfigurationChangedEvent();`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.
Note	The function blocks the CoSimulation program until a software download is set to the signaled state or the timeout interval is exceeded.

9.12.1.5 OnIPAddressChanged events

RegisterOnIPAddressChangedCallback()

Register function for receiving callback functions when an IP address has changed.

Table 3-722 RegisterOnIPAddressChangedCallback() - Native C++

Syntax	`RegisterOnIPAddressChangedCallback();`
Parameters `in_CallbackFunc-tion`	• `IInstance* in_Sender` Instance object • `ERuntimeErrorCode in_ErrorCode` Result of operation • `SYSTEMTIME in_SystemTime` CPU system time of the event • `UINT8 in_InterfaceId` ID of the CPU interface involved • `const SIPSuite4& in_SIP` Reference of the SIPSuite4 structure
Return values	None
Note	The event handler method runs in a separate thread.

UnregisterOnIPAddressChangedCallback()

Unregister function for receiving callback functions when an IP address has changed.

Table 3-723 UnregisterOnIPAddressChangedCallback() - Native C++

Syntax	`void UnregisterOnIPAddressChangedCallback();`
Parameters `in_CallbackFunc-tion`	Address of the specific function or nullptr for removing the last registered callback function
Return values	None

RegisterOnIPAddressChangedEvent()

Register function for receiving events when an IP address has changed.

Table 3-724 RegisterOnIPAddressChangedEvent() - Native C++

Syntax	`void IInstance::RegisterOnIPAddressChangedEvent()` `void IInstance::RegisterOnIPAddressChangedEvent(HANDLE* in_Event);`
Parameters `in_Event`	HANDLE* (a user-specific event object is registered)
Return values	None

UnregisterOnIPAddressChangedEvent()

Unregister function for receiving events when an IP address has changed.

Table 3-725 UnregisterOnIPAddressChangedEvent() - Native C++

Syntax	`void IInstance::UnregisterOnIPAddressChangedEvent();`
Parameters	None
Return values	None

OnIPAddressChanged()

The event is called when the IP configuration of the CPU interface has changed.

Table 3-726 OnIPAddressChanged() - .NET (C#)

Syntax	`void IInstance::OnIPAddressChanged();`
Parameters	• `IInstance in_Sender` Instance object • `ERuntimeErrorCode in_ErrorCode` Result of operation • `DateTime in_SystemTime` CPU system time of the event • `UINT8 in_InterfaceId` ID of the CPU interface involved • `SIPSuite4 in_SIP` IP address of the interface
Return values	None
Note	The event handler method runs in a separate thread.

WaitForOnIPAddressChangedEvent()

Blocking function up to the change of the IP address.

Table 3-727 WaitForOnIPAddressChangedEvent() - Native C++

Syntax	`bool IInstance::WaitForOnIPAddressChangedEvent();` `bool IInstance::WaitForOnIPAddressChangedEvent(UINT32 in_Time_ms)`
Parameters `in_Time_ms`	Time in milliseconds
Return values	Returns `True` if the change was made within a set period, otherwise `False`
Note	None

Table 3-728 WaitForOnIPAddressChangedEvent() - .NET (C#)

Syntax	`bool IInstance::WaitForOnIPAddressChangedEvent();` `bool IInstance::WaitForOnIPAddressChangedEvent(uint in_Time_ms);`
Parameters `in_Time_ms`	Time in milliseconds
Return values	Returns `True` if the change was made within a set period, otherwise `False`
Note	The event handler method runs in a separate thread.

9.12.1.6 OnSyncPointReached events

OnSyncPointReached

Registers or unregisters an event handler method.

Table 3-729 OnSyncPointReached - .NET (C#)

Syntax	`event Delegate_II_EREC_DT_UINT32_INT64_INT64_UINT32 OnSyncPointReached;`
Parameters	None. See Delegate_II_EREC_DT_UINT32_INT64_INT64_UINT32 (Page 247).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnSyncPointReachedCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-730 RegisterOnSyncPointReachedCallback() - Native C++

Syntax	`void RegisterOnSyncPointReachedCallback(EventCallback_II_SREC_ST_UINT32_INT6-4_INT64_UINT32 in_CallbackFunction);`
Parameters	• `EventCallback_II_SREC_ST_UINT32_INT64_INT64_UINT32 in_CallbackFunction:` A callback function that subscribes to an event. See EventCallback_II_SREC_ST_UINT32_INT64_INT64_UINT32 (Page 238).
Return values	None
Note	The callback function runs in a separate thread.

RegisterOnSyncPointReachedEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registering a new event object causes the previous event object to be deleted.

Table 3-731 RegisterOnSyncPointReachedEvent() - Native C++

Syntax	`void RegisterOnSyncPointReachedEvent();` `void RegisterOnSyncPointReachedEvent(HANDLE* in_Event);`
Parameters	• `None:` An internal event object is registered. • `HANDLE* in_Event:` A handle for a user-specific event object. The event object is registered.
Return values	None

Table 3-732 RegisterOnSyncPointReachedEvent() – .NET (C#)

Syntax	`RegisterOnSyncPointReachedEvent() – .NET (C#)`
Parameters	None
Return values	None

UnregisterOnSyncPointReachedCallback()

Unregisters the callback function.

Table 3-733 UnregisterOnSyncPointReachedCallback() - Native C++

Syntax	`void UnregisterOnSyncPointReachedCallback();`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

UnregisterOnSyncPointReachedEvent()

Unregisters the event object.

Table 3-734 UnregisterOnSyncPointReachedEvent() - Native C++

Syntax	`void UnregisterOnSyncPointReachedEvent();`
Parameters	None
Return values	None

Table 3-735 UnregisterOnSyncPointReachedEvent() - .NET (C#)

Syntax	`void UnregisterOnSyncPointReachedEvent();`
Parameters	None
Return values	None

WaitForOnSyncPointReachedEvent()

The function blocks the program until the registered event object is in the signaled state or the timeout interval is exceeded.

Table 3-736 WaitForOnSyncPointReachedEvent() - Native C++

Syntax	`SOnSyncPointReachedResult WaitForOnSyncPointReachedEvent();` `SOnSyncPointReachedResult WaitForOnSyncPointReachedEvent(UINT32 in_Time_ms);`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `SOnSyncPointReachedResult:` A structure that supplies information about the event. See SOnSyncPointReachedResult (Page 264).

Table 3-737 WaitForOnSyncPointReachedEvent() - .NET (C#)

Syntax	`SOnSyncPointReachedResult WaitForOnSyncPointReachedEvent();` `SOnSyncPointReachedResult WaitForOnSyncPointReachedEvent(UInt32 in_Time_ms);`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UInt32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `SOnSyncPointReachedResult:` A structure that supplies information about the event. See SOnSyncPointReachedResult (Page 264).

9.12.1.7 OnHardwareConfigChanged events

OnHardwareConfigChanged

Registers or unregisters an event handler method.

Table 3-738 OnHardwareConfigChanged - .NET (C#)

Syntax	`event Delegate_II_EREC_DT OnHardwareConfigChanged;`
Parameters	None; see Delegate_II_EREC_DT
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnHardwareConfigChangedCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-739 Table: RegisterOnHardwareConfigChangedCallback() – Native C++

Syntax	`void RegisterOnHardwareConfigChangedCallback(EventCallback_II_SREC_ST in_CallbackFunction);`
Parameters	`EventCallback_II_SREC_ST in_CallbackFunction` A callback function that subscribes to an event; see EventCallback_II_SREC_ST()
Return values	None
Note	The callback function runs in a separate thread.

RegisterOnHardwareConfigChangedEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registration of a new event object causes the previous event object to be deleted.

Table 3-740 RegisterOnHardwareConfigChangedEvent() – Native C++

Syntax	`void RegisterOnHardwareConfigChangedEvent();` `void RegisterOnHardwareConfigChangedEvent(Handle* in_Event);`
Parameters	• `None:` An internal event object is registered. • `Handle* in_Event` A handle for a user-specific event object. The event object is registered.
Return values	None

Table 3-741 RegisterOnHardwareConfigChangedEvent() – .NET (C#)

Syntax	`void RegisterOnHardwareConfigChangedEvent();`
Parameters	None
Return values	None

UnregisterOnHardwareConfigChangedCallback()

UnregisterOnHardwareConfigChangedCallback()Unregisters the callback function.

Table 3-742 UnregisterOnHardwareConfigChangedCallback() – Native C++

Syntax	`void UnregisterOnHardwareConfigChangedCallback();`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

UnregisterOnHardwareConfigChangedEvent()

Unregisters the event object.

Table 3-743 UnregisterOnHardwareConfigChangedEvent() – Native C++

Syntax	`void UnregisterOnHardwareConfigChangedEvent();`
Parameters	None
Return values	None

Table 3-744 UnregisterOnHardwareConfigChangedEvent() – .NET (C#)

Syntax	`void UnregisterOnHardwareConfigChangedEvent();`
Parameters	None
Return values	None

WaitForOnHardwareConfigChangedEvent()

The function blocks the program until the registered event object is in the signaled state or the timeout interval is exceeded.

Table 3-745 WaitForOnHardwareConfigChangedEvent() – Native C++

Syntax	`bool WaitForOnHardwareConfigChangedEvent();` `bool WaitForOnHardwareConfigChangedEvent (in_Time_ms);`
Parameters	• `None:` The time limit is set to INFINITE. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

Table 3-746 WaitForOnHardwareConfigChangedEvent() – .NET (C#)

Syntax	`bool WaitForOnHardwareConfigChangedEvent();` `bool WaitForOnHardwareConfigChangedEvent (UINT32 in_Time_ms);`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

9.12.2 Events for acyclic services

OnDataRecordRead

Registers or unregisters an event handler method.

Table 3-747 OnDataRecordRead - .NET (C#)

Syntax	`event Delegate_II_EREC_DT_SDRI OnDataRecordRead;`
Parameter	None. See Delegate_II_EREC_DT_SDRI (Page 248).
Return values	None
Exceptions	None
Note	The Event-Handler Methode runs in a separate thread.

OnDataRecordWrite

Registers or unregisters an event handler method.

Table 3-748 OnDataRecordWrite - .NET (C#)

Syntax	`event Delegate_II_EREC_DT_SDR OnDataRecordWrite;`
Parameter	None. See Delegate_II_EREC_DT_SDR (Page 248).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnDataRecordReadCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-749 RegisterOnDataRecordReadCallback() - Native C++

Syntax	`void RegisterOnDataRecordReadCallback (Event Callback_II_SREC_ST_SDRI in_CallbackFunction);`
Parameters	• `EventCallback_II_SREC_ST_SDRI in_CallbackFunction:` A callback function that subscribes to the event. See EventCallback_II_SREC_ST_SDRI (Page 240).
Return values	None
Note	The callback function runs in a separate thread.

UnregisterOnDataRecordReadCallback()

Unregisters the callback function.

Table 3-750 UnregisterOnDataRecordReadCallback() - Native C++

Syntax	`void UnregisterOnDataRecordReadCallback();`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

RegisterOnDataRecordWriteCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-751 RegisterOnDataRecordWriteCallback() - Native C++

Syntax	`void RegisterOnDataRecordWriteCallback (EventCallback_II_SREC_ST_SDRI_BYTE in_CallbackFunction);`
Parameters	• `EventCallback_II_SREC_ST_SDRI_BYTE in_CallbackFunction:` A callback function that subscribes to the event. See EventCallback_II_SREC_ST_SDRI_BYTE (Page 241).
Return values	None
Note	The callback function runs in a separate thread.

UnregisterOnDataRecordWriteCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 3-752 UnregisterOnDataRecordWriteCallback() - Native C++

Syntax	`void UnregisterOnDataRecordWriteCallback();`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

9.12.2.1 OnAlarmNotification events

OnAlarmNotificationDone()

Registers or unregisters an event handler method.

Table 3-753 OnAlarmNotificationDone() - .NET (C#)

Syntax	`event Delegate_SREC_ST_UINT32_UINT32 OnAlarmNotificationDone;`
Parameters	None. See Delegate_SREC_ST_UINT32_UINT32 (Page 250).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnAlarmNotificationDoneCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-754 RegisterOnAlarmNotificationDoneCallback() - Native C++

Syntax	`void RegisterOnAlarmNotificationDoneCallback (Event Callback_II_SREC_ST_SDRI in_CallbackFunction);`
Parameters	• `EventCallback_II_SREC_ST_UINT32_UINT32 in_CallbackFunction:` A callback function that subscribes to the event. See EventCallback_II_SREC_ST_UINT32_UINT32 (Page 241).
Return values	None
Note	The callback function runs in a separate thread.

UnregisterOnAlarmNotificationDoneCallback()

Unregisters the callback function.

Table 3-755 UnregisterOnAlarmNotificationDoneCallback() - Native C++

Syntax	`void UnregisterOnAlarmNotificationDoneCallback ();`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

9.12.2.2 OnProcessEvent events

OnProcessEventDone()

Registers or unregisters an event handler method.

Table 3-756 OnProcessEventDone() - .NET (C#)

Syntax	`event Delegate_SREC_ST_UINT32_UINT32_EPET_UINT32 OnProcessEventDone;`
Parameters	None. See Delegate_SREC_ST_UINT32_UINT32_EPET_UINT32. (Page 249)
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnProcessEventDoneCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-757 RegisterOnProcessEventDoneCallback() - Native C++

Syntax	`void RegisterOnProcessEventDoneCallback (EventCallback_II_SREC_ST_UINT32_UINT32_EPET_UINT32 in_CallbackFunction);`
Parameters	`EventCallback_II_SREC_ST_UINT32_UINT32_EPET_UINT32 in_CallbackFunction:` A callback function that subscribes to the event. See EventCallback_II_SREC_ST_UINT32_UINT32_EPET_UINT32 (Page 242)
Return values	None
Note	The callback function runs in a separate thread.

UnregisterOnProcessEventDoneCallback()

Unregisters the callback function.

Table 3-758 UnregisterOnProcessEventDoneCallback() - Native C++

Syntax	`void UnregisterOnProcessEventDoneCallback ();`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

9.12.2.3 OnPullOrPlugEvent events

OnPullOrPlugEventDone()

Registers or unregisters an event handler method.

Table 3-759 OnPullOrPlugEventDone() - .NET (C#)

Syntax	`event Delegate_SREC_ST_UINT32_EPPET_UINT32 OnPullOrPlugEventDone;`
Parameters	None. See Delegate_SREC_ST_UINT32_EPPET_UINT32 (Page 249).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnPullOrPlugEventDoneCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-760 RegisterOnPullOrPlugEventDoneCallback() - Native C++

Syntax	`void RegisterOnPullOrPlugEventDoneCallback (EventCallback_II_SREC_ST_UINT32_EPPET_UINT32 in_CallbackFunction);`
Parameters	`EventCallback_II_SREC_ST_UINT32_EPPET_UINT32 in_CallbackFunction:` A callback function that subscribes to the event. See EventCallback_II_SREC_ST_UINT32_EPPET_UINT32 (Page 242).
Return values	None
Note	The callback function runs in a separate thread.

UnregisterOnPullOrPlugEventDoneCallback()

Unregisters the callback function.

Table 3-761 UnregisterOnPullOrPlugEventDoneCallback() - Native C++

Syntax	`void UnregisterOnPullOrPlugEventDoneCallback ();`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

9.12.2.4 OnStatusEvent events

OnStatusEventDone()

Registers or unregisters an event handler method.

Table 3-762 OnStatusEventDone() - .NET (C#)

Syntax	`event Delegate_SREC_ST_UINT32 OnStatusEventDone;`
Parameters	None. See Delegate_SREC_ST_UINT32 (Page 250).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnStatusEventDoneCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-763 RegisterOnStatusEventDoneCallback() - Native C++

Syntax	`void RegisterOnStatusEventDoneCallback (EventCallback_II_SREC_ST_UINT32 in_CallbackFunction);`
Parameters	`EventCallback_II_SREC_ST_UINT32 in_CallbackFunction:` A callback function that subscribes to the event. See EventCallback_II_SREC_ST_UINT32 (Page 243).
Return values	None
Note	The callback function runs in a separate thread.

UnregisterOnStatusEventDoneCallback()

Unregisters the callback function.

Table 3-764 UnregisterOnStatusEventDoneCallback() - Native C++

Syntax	`void UnregisterOnStatusEventDoneCallback ();`
Parameters	Optional parameter of the same type as for the Register*()function. If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

9.12.2.5 OnProfileEvent events

OnProfileEventDone()

Registers or unregisters an event handler method.

Table 3-765 OnProfileEventDone() - .NET (C#)

Syntax	`event Delegate_SREC_ST_UINT32 OnProfileEventDone;`
Parameters	None. See Delegate_SREC_ST_UINT32 (Page 250).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnProfileEventDoneCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-766 RegisterOnProfileEventDoneCallback() - Native C++

Syntax	`void RegisterOnProfileEventDoneCallback (EventCallback_II_SREC_ST_UINT32 in_CallbackFunction);`
Parameters	`EventCallback_II_SREC_ST_UINT32 in_CallbackFunction:` A callback function that subscribes to the event. See EventCallback_II_SREC_ST_UINT32 (Page 243).
Return values	None
Note	The callback function runs in a separate thread.

UnregisterOnProfileEventDoneCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 3-767 UnregisterOnProfileEventDoneCallback() - Native C++

Syntax	`void UnregisterOnProfileEventDoneCallback ();`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

9.12.2.6 OnUpdateEvent events

OnUpdateEventDone()

Registers or unregisters an event handler method.

Table 3-768 OnUpdateEventDone() - .NET (C#)

Syntax	`event Delegate_SREC_ST_UINT32 OnUpdateEventDone;`
Parameters	None. See Delegate_SREC_ST_UINT32 (Page 250).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnUpdateEventDoneCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-769 RegisterOnUpdateEventDoneCallback() - Native C++

Syntax	`void RegisterOnUpdateEventDoneCallback (EventCallback_II_SREC_ST_UINT32 in_CallbackFunction);`
Parameters	`EventCallback_II_SREC_ST_UINT32 in_CallbackFunction:` A callback function that subscribes to the event. See EventCallback_II_SREC_ST_UINT32 (Page 243).
Return values	None
Note	The callback function runs in a separate thread.

UnregisterOnUpdateEventDoneCallback()

Unregisters the callback function.

Table 3-770 UnregisterOnUpdateEventDoneCallback() - Native C++

Syntax	`void UnregisterOnUpdateEventDoneCallback ();`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

9.12.2.7 RackOrStationFault events

OnRackOrStationFaultEvent

Registers or unregisters an event handler method.

Table 3-771 OnRackOrStationFaultEvent - .NET (C#)

Syntax	`event Delegate_SREC_ST_UINT32_ERSFET OnRackOrStationFault;`
Parameter	None. See Delegate_SREC_ST_UINT32_ERSFET (Page 251).
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnRackOrStationFaultEventCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-772 RegisterOnRackOrStationFaultEventCallback() - Native C++

Syntax	`void RegisterOnRackOrStationFaultEventCallback ( EventCallback_II_SREC_ST_UINT32_ERSFET in_CallbackFunction );`
Parameter	`EventCallback_II_ SREC_ST_UINT32_ERSFET in_CallbackFunction.` A callback function that subscribes to the event. See EventCallback_II_SREC_ST_UINT32_ERSFET (Page 243)
Return values	None
Note	The callback function runs in a separate thread.

UnregisterOnRackOrStationFaultEventCallback()

Unregisters the callback function.

Table 3-773 UnregisterOnRackOrStationFaultEventCallback() - Native C++

Syntax	`void UnregisterOnRackOrStationFaultEventCallback ();`
Parameter	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

IRemoteRuntimeManager 10

10.1 Interfaces - Information and settings

Dispose()

Deletes the managed interface and unloads the native components of the user interfaces.

NOTE

When the interface of the Remote Runtime Manager is deleted, no IInstance interface which was generated by the IRemoteRuntimeManager interface can be used.

The .NET Garbage Collector clears its IRemoteRuntimeManager interface when no active references are present.

Table 3-774 Dispose() - .NET (C#)

Syntax	`void Dispose()`
Parameters	None
Return values	None

GetIP() / IP { get; }

Returns the IP address of the PC on which the remote Runtime Manager is running. If the function fails, the return value is 0.

Table 3-775 GetIP() - Native C++

Syntax	`UIP GetIP();`
Parameters	None
Return values	`UIP`: Returns the IP address of the PC on which the Runtime Manager is running.

Table 3-776 IP { get; } - .NET (C#)

Syntax	`SIP IP { get; }`
Parameters	None
Return values	`SIP`: Returns the IP address of the PC on which the Runtime Manager is running.

GetRemoteComputerName() / RemoteComputerName { get; }

This method returns the NetBIOS name of the PC on which the remote Runtime Manager is running.

When the name of the PC cannot be identified, the method returns the IP address.

Table 3-777 GetRemoteComputerName() - Native C++

Syntax	`ERuntimeErrorCode GetRemoteComputerName(WCHAR* inout_Name,UINT32 in_ArrayLength);`	
Parameters	• `WCHAR* inout_Name:` A user-allocated array for the computer name. • `UINT32 in_ArrayLength:` The array length. The array should be longer than `MAX_COMPUTERNAME_LENGTH`.	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The interface is disconnected from the remote Runtime Manager.
	`SREC_INDEX_OUT_OF_RANGE`	The array is too small to accommodate the computer name.

Table 3-778 RemoteComputerName { get; } - .NET (C#)

Syntax	`string RemoteComputerName { get; }`	
Parameters	None	
Return values	`string`: Name of the PC on which the remote Runtime Manager is running.	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The interface is disconnected from the remote Runtime Manager.
	`ERuntimeErrorCode.IndexOutOfRange`	The array is too small to accommodate the computer name.

Disconnect()

Closes the connection to the remote Runtime Manager.

NOTE

All applications that are connected to the remote Runtime Manager lose this connection.

Table 3-779 Disconnect() - Native C++

Syntax	`ERuntimeErrorCode Disconnect();`	
Parameters	None	
Return values	Runtime error code	Description
	`SREC_OK`	The function is successful.
	`SREC_INTERFACE_REMOVED`	The interface is disconnected from the remote Runtime Manager.
	`SREC_TIMEOUT`	The function does not return on time.

Table 3-780 Disconnect() - .NET (C#)

Syntax	`void Disconnect();`	
Parameters	None	
Return values	None	
Exceptions	`Siemens.Simatic.Simulation.Runtime.SimulationRuntimeException`	
	Runtime error code	Description
	`ERuntimeErrorCode.InterfaceRemoved`	The interface is disconnected from the remote Runtime Manager.
	`ERuntimeErrorCode.Timeout`	The function does not return on time.

GetSecurityMode()

GetSecurityMode returns the current ESecurityMode of the opened connection.

Table 3-781 GetSecurityMode - Native C++

Syntax	`ESecurityMode IRemoteRuntimeManager::GetSecurityMode(););`	
Parameters	None	
Return values	Runtime error code	Description
	`ESecurityMode::UNSECURED`	No security is used.
	`ESecurityMode::ENCRYPTED_COMMUNICATION`	Secure communication
	`ESecurityMode::UNKNOWN`	No connection is opened.

Table 3-782 GetSecurityMode - .NET (C#)

Syntax	`ESecurityMode RemoteRuntimeManager::SecurityMode { get; };`	
Parameters	None	
Return values	Runtime error code	Description
	`ESecurityMode::Unsecured`	No security is used.
	`ESecurityMode::EncryptedCommunication`	Secure communication
	`ESecurityMode::Unknown`	No connection is opened.

10.2 Events for IRemoteRuntimeManager

10.2.1 OnConnectionLost events

Description

The event is triggered when the connection to the Remote Runtime Manager has been terminated.

OnConnectionLost

Registers or unregisters an event handler method.

Table 3-783 OnConnectionLost - .NET (C#)

Syntax	`event Delegate_IRRTM OnConnectionLost;`
Parameters	None. See Delegate_IRRTM (Page 247)
Return values	None
Exceptions	None
Note	The event handler method runs in a separate thread.

RegisterOnConnectionLostCallback()

When the event occurs, the registered callback function is called. Multiple callback functions can be registered for the event.

Table 3-784 RegisterOnConnectionLostCallback() - Native C++

Syntax	`void RegisterOnConnectionLostCallback(EventCallback_IRRTM in_CallbackFunction);`
Parameters	`EventCallback_IRRTM in_CallbackFunction:` A callback function that subscribes to an event. See EventCallback_IRRTM (Page 238).
Return values	None
Note	The callback function runs in a separate thread.

RegisterOnConnectionLostEvent()

When the event occurs, the registered event object is set to the signaled state. Only one event object can be registered for the event. Registration of a new event object causes the previous event object to be deleted.

Table 3-785 RegisterOnConnectionLostEvent() - Native C++

Syntax	`void RegisterOnConnectionLostEvent();` `void RegisterOnConnectionLostEvent(HANDLE* in_Event);`
Parameters	• `None:` An internal event object is registered. • `HANDLE* in_Event:` A handle for a user-specific event object. The event object is registered.

Return values	None

Table 3-786 RegisterOnConnectionLostEvent() - .NET (C#)

Syntax	`void RegisterOnConnectionLostEvent();`
Parameters	None
Return values	None

UnregisterOnConnectionLostCallback()

Unregisters the callback function. When the event occurs, no callback function is called.

Table 3-787 UnregisterOnConnectionLostCallback() - Native C++

Syntax	`void UnregisterOnConnectionLostCallback();`
Parameters	Optional parameter of the same type as for the Register*() function If you use the parameter, it uninstalls the specific function; otherwise, the last registered callback function is unregistered.
Return values	None

UnregisterOnConnectionLostEvent()

Unregisters the event object.

Table 3-788 UnregisterOnConnectionLostEvent() - Native C++

Syntax	`void UnregisterOnConnectionLostEvent();`
Parameters	None
Return values	None

Table 3-789 UnregisterOnConnectionLostEvent() - .NET (C#)

Syntax	`void UnregisterOnConnectionLostEvent();`
Parameters	None
Return values	None

WaitForOnConnectionLostEvent()

The function blocks the program until the registered event object is in the signaled state or the timeout interval is exceeded.

Table 3-790 WaitForOnConnectionLostEvent() - Native C++

Syntax	`bool WaitForOnConnectionLostEvent();` `bool WaitForOnConnectionLostEvent(UINT32 in_Time_ms);`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UINT32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

Table 3-791 WaitForOnConnectionLostEvent() - .NET (C#)

Syntax	`bool WaitForOnConnectionLostEvent();` `bool WaitForOnConnectionLostEvent(UInt32 in_Time_ms);`
Parameters	• `None:` The time limit is set to `INFINITE`. • `UInt32 in_Time_ms:` Value for the time limit in milliseconds.
Return values	• `true:` If the event object was set to the signaled state. • `false:` If no event was received during the defined time limit.

Data types

11

Supported data types

The S7-PLCSIM Advanced Runtime API supports the data types of S7-1500 CPUs.

Converting data types

When writing, data types are not transferred BCD-coded but mapped onto primitive data types.

The data types Counter, Date and Time must be transferred to the API BCD-coded so that the values are written to the counter and no incorrect values are returned when reading.

For these data types, you must perform a BCD conversion before writing and a BCD back-conversion after reading.

Example:
If the value 999 is transferred to the API as 2457_H, then `Write` modifies the value 2457_H to 999. Without BCD conversion, there is no `UInt16` value and `Write` writes no value at all.

Additional information

For information on data types and conversion, refer to section "Data types" in the SIMATIC STEP 7 Basic/Professional (https://support.industry.siemens.com/cs/ww/en/view/109755202) System Manual.

11.1 DLL import functions (Native C++)

11.1.1 ApiEntry_Initialize

Description

Type of the central entry point for the API library (DLL).

Table 3-792 ApiEntry_Initialize - Native C++

Syntax	`typedef ERuntimeErrorCode(*ApiEntry_Initialize)(ISimulationRuntimeManager** out_RuntimeManagerInterface);`	
Parameters	• `ISimulationRuntimeManager** out_SimulationRuntimeManagerInterface:` Pointer to a Runtime Manager interface pointer. The pointer must be initialized with NULL. The interface is created within the function. • `UINT32 in_InterfaceVersion:` Version of the API interface to be downloaded: `API_DLL_INTERFACE_VERSION`.	
Return values	Runtime error code	Condition

Return values	SREC_OK	The function is successful.
	SREC_WRONG_ARGUMENT	The pointer to the Runtime Manager interface is NULL.
	SREC_WRONG_VERSION	The version of the interface in use does not match the version of the API library (DLL).
	SREC_CONNECTION_ERROR	Unable to establish a connection to the Runtime Manager.
	SREC_CONFIG_FILE_ERROR	Operation regarding the configuration file "UserInterfaceConfiguration.xml" has failed, for example, create, read, write.

11.1.2 ApiEntry_DestroyInterface

Description

Type of the entry point for DestroyInterface (Page 42).

Table 3-793 ApiEntry_DestroyInterface - Native C++

Syntax	`typedef ERuntimeErrorCode(*ApiEntry_DestroyInterface)(IBaseInterface* in_Interface);`	
Parameters	`IBaseInterface* in_Interface:` The interface to be deleted.	
Return values	Runtime error code	Condition
	SREC_OK	The function is successful.
	SREC_WRONG_ARGUMENT	The pointer to the interface is NULL.

11.2 Event callback functions (Native C++)

11.2.1 EventCallback_VOID

Description

Table 3-794 EventCallback_VOID - Native C++

Syntax	`typedef void (*EventCallback_VOID)();`
Parameters	None
Return values	None

11.2.2 EventCallback_SRCC_UINT32_UINT32_INT32

Description

Table 3-795 EventCallback_SRCC_UINT32_UINT32_INT32 - Native C++

Syntax	`ERuntimeConfigChanged in_RuntimeConfigChanged, UINT32 in_Param1, UINT32 in_Param2, INT32 in_Param3);`			
Parameters	`ERuntimeCon-figChanged in_RuntimeCon-figChanged`	`UInt32 in_Param1`	`UInt32 in_Param2`	`Int32 in_Param3`
	`SRCC_INSTANCE_RE-GISTERED`	–	–	ID of the registered instance
	`SRCC_INSTANCE_UN-REGISTERED`	–	–	ID of the unregistered instance
	`SRCC_CONNECTION_-OPENED`	IP of the remote Runtime Manager	Port of the remote Runtime Manager	–
	`SRCC_CONNECTION_-CLOSED`	IP of the remote Runtime Manager	Port of the remote Runtime Manager	–
	`SRCC_PORT_OPENED`	The open port	–	–
	`SRCC_PORT_CLOSED`	–	–	–
Return values	None			

11.2.3 EventCallback_SRRSI_AD

Description

Table 3-796 EventCallback_SRRSI_AD - Native C++

Syntax	`typedef void (*EventCallback_SRRSI_AD)(EAutodiscoverType in_AutodiscoverMsg, SAutodiscoverData in_AutodiscoverData);`
Parameters	• `in_AutodiscoverMsg`: A value from the list of predefined types of events, see EAutodiscoverType (Page 289). – `SRRSI_DISCOVER_STARTED`, if the identification process was started by successfully calling the function `RunAutodisover()`. – `SRRSI_DISCOVER_DATA`, if a Runtime Manager in the network was determined by the identification process. For detailed information about the found Runtime Manager, see parameter `in_AutodiscoverData`. – `SRRSI_DISCOVER_FINISHED`, if the identification process was completed after the time defined by the "in_Timeout" parameter had elapsed. – `SRRSI_DISCOVER_STARTED` and `SRRSI_DISCOVER_FINISHED` are always triggered, even if no data is received. • `in_AutodiscoverData`: Data from the Remote Runtime Manager. The parameter contains valid data only if `in_AutodiscoverMsg` = `SRRSI_DISCOVER_DATA`. Otherwise it is initialized with 0. See SAutodiscoverData (Page 269).
Return values	None

11.2.4 EventCallback_IRRTM

Description

Table 3-797 EventCallback_IRRTM - Native C++

Syntax	`typedef void (*EventCallback_IRRTM)(IRemoteRuntimeManager* in_Sender);`
Parameters	• `IRemoteRuntimeManager* in_Sender:` An interface of the remote Runtime Manager that receives this event.
Return values	None

11.2.5 EventCallback_II_SREC_ST_SROS_SROS

Description

Table 3-798 EventCallback_II_SREC_ST_SROS_SROS - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST_SROS_SROS)(IInstance* in_Sender, ERuntimeErrorCode in_ErrorCode, SYSTEMTIME in_SystemTime, EOperatingState in_PrevState, EOperatingState in_OperatingState);`	
Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SystemTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `EOperatingState in_PrevState:` The operating state before the change. • `EOperatingState in_OperatingState:` The current operating state.	
Return values	None	
Error codes	Runtime error code	Condition
	`SREC_OK`	The function is successful.
	`SREC_WARNING_TRIAL_MODE_ACTIVE`	No license available. You can use the instance without restrictions with the Trial License. Afterwards, the instance is shut down.
	`SREC_LICENSE_NOT_FOUND`	Test mode has expired.
	`SREC_COMMUNICATION_INTERFACE_NOT_AVAILABLE`	A problem has occurred with the selected communication interface. Check your settings.

11.2.6 EventCallback_II_SREC_ST_UINT32_INT64_INT64_UINT32

Description

Table 3-799 EventCallback_II_SREC_ST_UINT32_INT64_INT64_UINT32 - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST_UINT32_INT64_INT64_UINT32)(IInstance* in_Sender, ERuntimeErrorCode in_ErrorCode, SYSTEMTIME in_SystemTime, UINT32 in_Id, INT64 in_TimeSinceSameSyncPoint_ns, INT64 in_TimeSinceAnySyncPoint_ns, UINT32 in_SyncPointCount);`

Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SystemTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UINT32 in_Id:` For the `SingleStep_Bus` operating mode: The ID of the I/O system that is used for cycle-controlled synchronization of the simulated PLC instance. For all other operating modes: The ID of the process image partition (PIP) that triggers this event. 0 for the cycle control point (End of cycle). • `INT64 in_TimeSinceSameSyncPoint_ns:` The virtual time (in nanoseconds) since the last synchronization point of the same process image partition ID was reached. For the time-controlled operating modes: The runtime since the last call of the `StartProcessing()` function. • `INT64 in_TimeSinceAnySyncPoint_ns:` The virtual time (in nanoseconds) since the last synchronization point of any process image partition ID was reached. For the time-controlled operating modes: The runtime since the last call of the `StartProcessing()` function. • `UINT32 in_SyncPointCount:` The number of synchronization points since the last event. If the events are triggered faster than they are received, multiple events are combined into one event. In this case, this value contains the number of cycles since the last event was received.
Return values	None

11.2.7 EventCallback_II_SREC_ST

Description

Table 3-800 EventCallback_II_SREC_ST - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST)(IInstance* in_Sender, ERuntimeErrorCode in_ErrorCode, SYSTEMTIME in_SystemTime);`
Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SystemTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered.
Return values	None

11.2.8 EventCallback_II_SREC_ST_SRLT_SRLM

Description

Table 3-801 EventCallback_II_SREC_ST_SRLT_SRLM - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST_SRLT_SRLM)(IInstance* in_Sender, ERuntimeErrorCode in_ErrorCode, SYSTEMTIME in_SystemTime, ELEDType in_LEDType, ELEDMode in_LEDMode);`
Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SystemTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `ELEDType in_LEDType:` The LED type that changed its state. • `ELEDMode in_LEDMode:` The new state of the LED display.
Return values	None

11.2.9 EventCallback_II_SREC_ST_SDRI

Description

Table 3-802 EventCallback_II_SREC_ST_SDRI - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST_SDRI)(IInstance* in_Sender, ERuntimeErrorCode in_ErrorCode, SYSTEMTIME in_SystemTime, SDataRecordInfo in_DataRecordInfo);`
Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SystemTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `SDataRecordInfo in_DataRecordInfo:` The structure `SDataRecordInfo` contains the following information: – The HW identifier from which the CPU is to read the data record – The index of the collected data record – The maximum size of the data record which the IO device can transfer.
Return values	None

11.2.10 EventCallback_II_SREC_ST_SDRI_BYTE

Description

Table 3-803 EventCallback_II_SREC_ST_SDRI_BYTE - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST_SDRI_BYTE)(IInstance* in_Sender, ERuntimeErrorCode in_ErrorCode, SYSTEMTIME in_SystemTime, SDataRecordInfo in_DataRecordInfoconst BYTE* in_Data);`
Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SystemTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `SDataRecordInfo in_DataRecordInfo:` The structure `SDataRecordInfo` contains the following information: – The HW identifier to which the CPU wants to write the data record – The index of the supplied data record – Size of data record • `const BYTE* in_Data:` The data record. This pointer becomes invalid after the callback function has returned.
Return values	None

11.2.11 EventCallback_II_SREC_ST_UINT32_UINT32

Description

Table 3-804 EventCallback_II_SREC_ST_UINT32_UINT32 - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST_UINT32_UINT32)(IInstance* in_Sender, ERuntimeErrorCode in_ErrorCode, SYSTEMTIME in_SystemTime, UINT32 in_HardwareIdentifier), UINT32 in_SequenceNumber);`
Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SYSTEMTIME:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UINT32 in_HardwareIdentifier:` The hardware identifier of the module or submodule which sends the diagnostics event. • `UINT32 in_SequenceNumber:` S7-PLCSIM Advanced assigns a unique consecutive number to each interrupt event. According to PROFINET standard the sequence number is 10 bits wide (1 to $7FF_H$). When the highest number is reached the numbering starts again at 1. **Note** In a real hardware system the IO controller uses the sequence number to check if it has lost a hardware interrupt. During the simulation, the sequence number creates the relation between interrupt request and the associated acyclic alarm.
Return values	None

11.2.12 EventCallback_II_SREC_ST_UINT32_UINT32_EPET_UINT32

Description

Table 3-805 EventCallback_II_SREC_ST_UINT32_UINT32_EPET_UINT32 - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST_UINT32_UINT32_EPET_UINT32)(IInstance* in_Sender, ERuntimeErrorCode in_ErrorCode, SYSTEMTIME in_SystemTime, UINT32 in_HardwareIdentifier, UINT32 in_Channel, EProcessEventType in_ProcessEventType, UINT32 in_SequenceNumber);`
Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SystemTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UINT32 in_HardwareIdentifier:` The hardware identifier of the I/O module that sends the process event. • `UINT32 in_Channel:` The channel of the I/O module which sends the process event. • `EProcessEventType in_ProcessEventType:` A value from the list of predefined types of events for S7 modules, see EProcessEventType (Page 286). • `UINT32 in_SequenceNumber:` S7-PLCSIM Advanced assigns a unique consecutive number to each interrupt event. According to PROFINET standard the sequence number is 10 bits wide (1 to $7FF_H$). When the highest number is reached the numbering starts again at 1. **Note** In a real hardware system the I/O controller uses the sequence number to check if it has lost a hardware interrupt. During the simulation, the sequence number creates the relation between interrupt request and the associated acyclic alarm.
Return values	None

11.2.13 EventCallback_II_SREC_ST_UINT32_EPPET_UINT32

Description

Table 3-806 EventCallback_II_SREC_ST_UINT32_EPPET_UINT32 - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST_UINT32_EPPET_UINT32)(IInstance* in_Sender, ERuntimeErrorCode in_ErrorCode, SYSTEMTIME in_SYSTEMTIME, UINT32 in_HardwareIdentifier, EPullOrPlugEventType in_PullOrPlugEventType, UINT32 in_SequenceNumber);`
Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SYSTEMTIME:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UINT32 in_HardwareIdentifier:` The hardware identifier of the module or submodule which sends the pull/plug event. • `EPullOrPlugEventType in_PullOrPlugEventType:` A value from the list of predefined types of events for S7 modules, see EPullOrPlugEventType (Page 286).

	• `UINT32 in_SequenceNumber:` S7-PLCSIM Advanced assigns a unique consecutive number to each interrupt event. According to PROFINET standard the sequence number is 10 bits wide (1 to $7FF_H$). When the highest number is reached the numbering starts again at 1. **Note** In a real hardware system the IO controller uses the sequence number to check if it has lost a hardware interrupt. During the simulation, the sequence number creates the relation between interrupt request and the associated acyclic alarm.
Return values	None

11.2.14 EventCallback_II_SREC_ST_UINT32_ERSFET

Description

Table 3-807 EventCallback_II_SREC_ST_UINT32_ERSFET - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST_UINT32_ERSFET)(IInstance* in_Sender, ERuntimeErrorCode in_ErrorCode, SYSTEMTIME in_SystemTime, UINT32 in_HardwareIdentifier, ERackOrStationFaultType in_EventType);`
Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SYSTEMTIME:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UINT32 in_HardwareIdentifier:` The hardware identifier of the module or submodule which sends the diagnostics event. • `ERackOrStationFaultType in_EventType:` A value from the list of predefined RackOrStationFault event types. See ERackOrStationFaultType (Page 288).
Return values	None

11.2.15 EventCallback_II_SREC_ST_UINT32

Description

Table 3-808 EventCallback_II_SREC_ST_UINT32 - Native C++

Syntax	`typedef void (*EventCallback_II_SREC_ST_UINT32)(IInstance* in_Sender, ERuntimeErrorCode in_ErrorCode, SYSTEMTIME in_SystemTime, UINT32 in_HardwareIdentifier);`
Parameters	• `IInstance* in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `SYSTEMTIME in_SYSTEMTIME:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UINT32 in_HardwareIdentifier:` The hardware identifier of the module or submodule which generates the status, update or Profile event. The identifier must belong to a hardware component in the currently loaded project.
Return values	None

11.3 Delegate definitions (managed code)

11.3.1 Delegate_Void

Description

Table 3-809 Delegate_Void - .NET (C#)

Syntax	`delegate void Delegate_Void();`
Parameters	None
Return values	None

11.3.2 Delegate_DisplayDataChanged

Description

Table 3-810 Delegate_DisplayDataChanged - .NET C#

Syntax	`delegate void Delegate_DisplayDataChanged (IInstance in_Sender, ERuntimeErrorCode in_ErrorCode, System::DateTime in_DateTime);`
Parameters	• `IInstance in_Sender`: An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode`: A possible error code. • `DateTime in_DateTime`: The virtual system time of the virtual controller at the time when this event was triggered.
Return values	None

11.3.3 Delegate_SRCC_UINT32_UINT32_INT32

Description

Table 3-811 Delegate_SRCC_UINT32_UINT32_INT32 - .NET (C#)

Syntax	`delegate void Delegate_SRCC_UINT32_UINT32_INT32(ERuntimeConfigChanged in_RuntimeConfigChanged, UInt32 in_Param1, UInt32 in_Param2, Int32 in_Param3);`			
Parameters	`ERuntimeCon-figChanged in_RuntimeCon-figChanged`	`UInt32 in_Param1`	`UInt32 in_Param2`	`Int32 in_Param3`
	`InstanceRe-gistered`	–	–	ID of the registered instance
	`InstanceUnre-gistered`	–	–	ID of the unregistered instance
	`ConnectionOpened`	IP of the Remote Runtime Manager	Port of the remote Runtime Manager	–
	`ConnectionClosed`	IP of the Remote Runtime Manager	Port of the remote Runtime Manager	–

Parameters	PortOpened	The open port	–	–
	PortClosed	–	–	–
Return values	None			

11.3.4 Delegate_SRRSI_AD

Description

Table 3-812 Delegate_SRRSI_AD - .NET (C#)

Syntax	`delegate void Delegate_SRRSI_AD(EAutodiscoverType in_AutodiscoverType, SAutodiscoverData in_AutodiscoverData);`
Parameters	• `in_AutodiscoverType` A value from the list of predefined types of events, see EAutodiscoverType (Page 289). – `AutodiscoverStarted`, if the identification process was started by successfully calling the function `RunAutodisover()`. – `AutodiscoverData`, if a Runtime Manager in the network was determined by the identification process. For detailed information about the found Runtime Manager, see parameter `in_AutodiscoverData`. – `AutodiscoverFinished`, if the identification process is completed after the time defined by the parameter "in_Timeout" has elapsed. – `AutodiscoverStarted` and `AutodiscoverFinished` are always triggered, even if no data is received. • `in_AutodiscoverData` Data from the Remote Runtime Manager. The parameter contains valid data only if `in_AutodiscoverType` = `AutodiscoverData`. Otherwise it is initialized with 0. See SAutodiscoverData (Page 269).
Return values	None

11.3.5 Delegate_II_EREC_DT

Description

Table 3-813 Delegate_II_EREC_DT - .NET (C#)

Syntax	`delegate void Delegate_II_EREC_DT (IInstance in_Sender, ERuntimeErrorCode in_ErrorCode, DateTime in_DateTime);`
Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered.
Return values	None

11.3.6 Delegate_II_EREC_DT_EOS_EOS

Description

Table 3-814 Delegate_II_EREC_DT_EOS_EOS - .NET (C#)

Syntax	`delegate void Delegate_II_EREC_DT_EOS_EOS(IInstance in_Sender, ERuntimeErrorCode in_ErrorCode, DateTime in_DateTime, EOperatingState in_PrevState, EOperatingState in_OperatingState);`	
Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `EOperatingState in_PrevState:` The operating state before the change. • `EOperatingState in_OperatingState:` The current operating state.	
Return values	None	
Error codes	Runtime error code	Condition
	`ERuntimeErrorCode.OK`	The function is successful.
	`ERuntimeErrorCode.WarningTrialMode-Active`	No license available. You can use the instance without restrictions with the Trial License. Afterwards, the instance is shut down.
	`ERuntimeErrorCode.LicenseNotFound`	Test mode has expired.
	`ERuntimeErrorCode.CommunicationInterfaceNotAvailable`	A problem has occurred with the selected communication interface. Check your settings.

11.3.7 Delegate_II_EREC_DT_ELT_ELM

Description

Table 3-815 Delegate_II_EREC_DT_ELT_ELM - .NET (C#)

Syntax	`delegate void Delegate_II_EREC_DT_ELT_ELM(IInstance in_Sender, ERuntimeErrorCode in_ErrorCode, DateTime in_DateTime, ELEDType in_LEDType, ELEDMode in_LEDMode);`
Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `ELEDType in_LEDType:` The LED type that changed its state. • `ELEDMode in_LEDMode:` The new state of the LED display.
Return values	None

11.3.8 Delegate_II_EREC_DT_UINT32_INT64_INT64_UINT32

Description

Table 3-816 Delegate_II_EREC_DT_UINT32_INT64_INT64_UINT32 - .NET (C#)

Syntax	`delegate void Delegate_II_EREC_DT_UINT32_INT64_INT64_UINT32 (IInstance in_Sender, ERuntimeErrorCode in_ErrorCode, DateTime in_DateTime, UInt32 in_Id, Int64 in_TimeSinceSameSyncPoint_ns, Int64 in_TimeSinceAnySyncPoint_ns, UInt32 in_SyncPointCount);`
Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UInt32 in_Id:` For the `SingleStep_Bus` operating mode: The ID of the I/O system that is used for cycle-controlled synchronization of the simulated PLC instance. For all other operating modes: The ID of the process image partition (PIP) that triggers this event. 0 for the cycle control point (End of cycle). Note: In the SingleStep operating modes, the transferred ID "in_Id" for the cycle control point has the value 0xFFFF. In this case, the time values are set to 0. • `Int64 in_TimeSinceSameSyncPoint_ns:` The virtual time (in nanoseconds) since the last synchronization point of the same process image partition ID was reached. Or the process time for the time-controlled operating modes. • `Int64 in_TimeSinceAnySyncPoint_ns:` The virtual time (in nanoseconds) since the last synchronization point of any process image partition ID was reached. Or the process time for the time-controlled operating modes. • `UInt32 in_SyncPointCount:` The number of synchronization points since the last event. If the events are triggered faster than they are received, multiple events are combined into one event. In this case, this value contains the number of cycles since the last event was received.
Return values	None

11.3.9 Delegate_IRRTM

Description

Table 3-817 Delegate_IRRTM - .NET (C#)

Syntax	`delegate void Delegate_IRRTM(IRemoteRuntimeManager in_Sender);`
Parameters	• `IRemoteRuntimeManager in_Sender:` An interface of the remote Runtime Manager that receives this event.
Return values	None

11.3.10 Delegate_II_EREC_DT_SDRI

Description

Table 3-818 Delegate_II_EREC_DT_SDRI - .NET (C#)

Syntax	`delegate void Delegate_II_EREC_DT_SDRI (IInstance in_Sender, ERuntimeErrorCode in_ErrorCode, DateTime in_DateTime, SDataRecordInfo in_DataRecordInfo);`
Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `SDataRecordInfo in_DataRecordInfo:` The structure `SDataRecordInfo` contains the following information: – The HW identifier to which the CPU wants to write the data record – The index of the supplied data record – Size of data record – The data record
Return values	None

11.3.11 Delegate_II_EREC_DT_SDR

Description

Table 3-819 Delegate_II_EREC_DT_SDR - .NET (C#)

Syntax	`delegate void Delegate_II_EREC_DT_SDR (IInstance in_Sender, ERuntimeErrorCode in_ErrorCode, DateTime in_DateTime, SDataRecord in_DataRecord);`
Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `SDataRecord in_DataRecord:` The structure `SDataRecord` contains the following information: – The HW identifier to which the CPU writes the data record – The index of the supplied data record – Size of the data record – The data record
Return values	None

11.3.12 Delegate_SREC_ST_UINT32_EPPET_UINT32

Description

Table 3-820 Delegate_SREC_ST_UINT32_EPPET_UINT32 - .NET (C#)

Syntax	`delegate void Delegate_SREC_ST_UINT32 (IInstance in_Sender, ERuntimeErrorCode in_ErrorCode, DateTime in_DateTime, UInt32 in_HardwareIdentifier, EPullOrPlugEventType in_PullOrPlugEventType, UInt32 in_SequenceNumber);`
Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UInt32 in_HardwareIdentifier:` The hardware identifier of the module or submodule that generated the pull/plug event. • `EPullOrPlugEventType in_PullOrPlugEventType:` A value from the list of predefined types of events for S7 modules (Page 286). • `UInt32 in_SequenceNumber:` S7-PLCSIM Advanced assigns a unique consecutive number to each interrupt event. According to the PROFINET standard, the sequence number is only 10 bits wide, from 1 to 0x7FF. When the highest number is reached the numbering starts again at 1. **Note** In a real hardware system the IO controller uses the sequence number to check if it has lost a hardware interrupt. During the simulation, the sequence number creates the relation between interrupt request and the associated acyclic alarm.
Return values	None

11.3.13 Delegate_SREC_ST_UINT32_UINT32_EPET_UINT32

Description

Table 3-821 Delegate_SREC_ST_UINT32_UINT32_EPET_UINT32 - Native C++

Syntax	`delegate void Delegate_SREC_ST_UINT32_UINT32_EPET_UINT32(IInstance in_Sender, ERuntimeErrorCode in_ErrorCode, DateTime in_DateTime, UInt32 in_HardwareIdentifier, UInt32 in_Channel, EProcessEventType in_ProcessEventType, UInt32 in_SequenceNumber);`
Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UInt32 in_HardwareIdentifier:` The hardware identifier of the module or submodule that generates the process event. • `UInt32 in_Channel:` The channel of the I/O module which sends the process event. • `EProcessEventType in_ProcessEventType:` A value from the list of predefined types of events for S7 modules, see EProcessEventType (Page 286).

	• `UInt32 in_SequenceNumber:` S7-PLCSIM Advanced assigns a unique consecutive number to each interrupt event. According to PROFINET standard the sequence number is 10 bits wide (1 to $7FF_H$). When the highest number is reached the numbering starts again at 1. **Note** In a real hardware system the I/O controller uses the sequence number to check if it has lost a hardware interrupt. During the simulation, the sequence number creates the relation between interrupt request and the associated acyclic alarm.
Return values	None

11.3.14 Delegate_SREC_ST_UINT32

Description

Table 3-822 Delegate_SREC_ST_UINT32 - .NET (C#)

Syntax	`delegate void Delegate_SREC_ST_UINT32 (IInstance in_Sender, ERuntimeErrorCode in_ErrorCode, DateTime in_DateTime, UInt32 in_HardwareIdentifier);`
Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UInt32 in_HardwareIdentifier:` The ID of the module that generates the status event, update event, or profile event.
Return values	None

11.3.15 Delegate_SREC_ST_UINT32_UINT32

Description

Table 3-823 Delegate_SREC_ST_UINT32_UINT32 - .NET (C#)

Syntax	`delegate void Delegate_SREC_ST_UINT32 (IInstance in_Sender, ERuntimeErrorCode in_ErrorCode, DateTime in_DateTime, UInt32 in_HardwareIdentifier, UInt32 in_SequenceNumber);`
Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UInt32 in_HardwareIdentifier:` The hardware identifier of the module or submodule which sends the diagnostics entry. • `UInt32 in_SequenceNumber:` S7-PLCSIM Advanced assigns a unique consecutive number to each interrupt event. According to PROFINET standard the sequence number is 10 bits wide (1 to $7FF_H$). When the highest number is reached the numbering starts again at 1. **Note** In a real hardware system the IO controller uses the sequence number to check if it has lost a hardware interrupt.

Return values	None

11.3.16 Delegate_SREC_ST_UINT32_ERSFET

Description

Table 3-824 Delegate_SREC_ST_UINT32_ERSFET - .NET (C#)

Syntax	`delegate void Delegate_SREC_ST_UINT32_ERSFET(IInstance in_Sender, ERuntimeErrorCode in_ErrorCode, DateTime in_DateTime, UInt32 in_HardwareIdentifier, ERackOrStationFaultType in_EventType);`
Parameters	• `IInstance in_Sender:` An interface of the instance that receives this event. • `ERuntimeErrorCode in_ErrorCode:` A possible error code. • `DateTime in_DateTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UInt32 in_HardwareIdentifier:` The hardware identifier of the module or submodule which sends the diagnostics entry. • `ERackOrStationFaultType in_EventType:` A value from the list of predefined RackOrStationFault event types (Page 288).
Return values	None

11.4 Definitions and constants

The following identifiers are used in the API:

Table 3-825 Definitions - Native C++

Identifier	Value	Description
`DINSTANCE_NAME_MAX_LENGTH`	64	The unique name of an instance must be less than this value.
`DSTORAGE_PATH_MAX_LENGTH`	130	The maximum path length to the virtual memory card. Including NULL termination.
`DTAG_NAME_MAX_LENGTH`	300	The maximum length of the name of a PLC tag. Including NULL termination.
`DTAG_ARRAY_DIMENSION`	6	The maximum number of dimensions for a multi-dimensional field.
`DCONTROLLER_NAME_MAX_LENGTH`	128	The maximum length of the controller name. Including NULL termination.
`DCONTROLLER_SHORT_DESIGNATION_MAX_L-ENGTH`	32	The maximum length of the abbreviation of the controller (CPU type). Including NULL termination.
`DALARM_NOTIFICATION_MAX_DIAG_EVENTS`	100	The maximum number of diagnostic events that are sent in a diagnostic alarm.
`DPROCESS_EVENT_NAME_MAX_LENGTH`	123	The maximum length of the name for the process event. Including NULL termination.
`DPROCESS_EVENTS_MAX_ITEMS`	256	The maximum number of configurable process events.
`DMODULE_STATE_OK`	0	AlarmNotification: Module status OK

Identifier	Value	Description
DMODULE_STATE_ERROR	1	AlarmNotification: Module status faulty
DMODULE_STATE_MAINT_DEMANDED	2	AlarmNotification: Maintenance demanded
DMODULE_STATE_MAINT_REQUIRED	4	AlarmNotification: Maintenance required
MAX_SIZE_DISPLAY_DATA	153666	Maximum length of display bitmap data

Table 3-826 Constants - .NET (C#)

Identifier	Value	Description
RuntimeConstants.InstanceNameLength	64	The unique name of an instance must be less than this value.
RuntimeConstants.StoragePath-MaxLength	130	The maximum path length to the virtual memory card. Including NULL termination.
RuntimeConstants.TagNameMaxLength	300	The maximum length of the name of a PLC tag. Including NULL termination.
RuntimeConstants.TagArrayDimension	6	The maximum number of dimensions for a multi-dimensional field.
RuntimeConstants.Controller-NameMaxLength	128	The maximum length of the controller name. Including NULL termination.
RuntimeConstants.ControllerShortDes-ignationMaxLength	32	The maximum length of the abbreviation of the controller (CPU type). Including NULL termination.
ModuleState.Ok	0	AlarmNotification: Module status OK
ModuleState.Error	1	AlarmNotification: Module status faulty
ModuleState. MaintenanceDemanded	2	AlarmNotification: Maintenance demanded
ModuleState. MaintenanceRequired	4	AlarmNotification: Maintenance required
RuntimeConstants.MaxSizeDisplayData	153666	Maximum length of display bitmap data

11.5 Unions (Native C++)

11.5.1 UIP

Description

Contains an IPv4 address.

Table 3-827 UIP - Native C++

Syntax	`union UIP`
	`{`
	`DWORD IP;`
	`BYTE IPs[4];`
	`};`

Member	• `DWORD IP:` The IP address in a single DWORD • `BYTE IPs[4]:` The four elements of IP in descending order
Example	Example for an IP address: 192.168.0.1 UIP.IP = 0xC0A80001 UIP.IPs[3] = 192, UIP.IPs[2] = 168, UIP.IPs[1] = 0, UIP.IPs[0] = 1

11.5.2 UDataValue

Description

Contains the value of a PLC tag.

Table 3-828 UDataValue - Native C++

Syntax	`union UDataValue`
	`{`
	`bool Bool;`
	`INT8 Int8;`
	`INT16 Int16;`
	`INT32 Int32;`
	`INT64 Int64;`
	`UINT8 UInt8;`
	`UINT16 UInt16;`
	`UINT32 UInt32;`
	`UINT64 UInt64;`
	`float Float;`
	`double Double;`
	`CHAR Char;`
	`WCHAR WChar;`
	`};`

Member	• `bool Bool:` 1 byte boolean value • `INT8 Int8:` 1 byte integer with sign • `INT16 Int16:` 2 byte integer with sign • `INT32 Int32:` 4 byte integer with sign • `INT64 Int64:` 8 byte integer with sign • `UINT8 UInt8:` 1 byte integer without sign • `UINT16 UInt16:` 2 byte integer without sign • `UINT32 UInt32:` 4 byte integer without sign • `UINT64 UInt64:` 8 byte integer without sign • `float Float:` 4 byte floating-point value • `double Double:` 8 byte floating-point value • `CHAR Char:` 1 byte value character • `WCHAR WChar:` 2 byte value character

11.6 Structures

The following structures are available:

- SDataValue (Page 254)
- SDVBNI (Page 255)
- SDataValueByAddress (Page 256)
- SDataValueByAddressWithCheck (Page 257)
- SDataValueByName (Page 258)
- SDataValueByNameWithCheck (Page 259)
- SConnectionInfo (Page 259)
- SInstanceInfo (Page 260)
- SDimension (Page 261)
- STagInfo (Page 261)
- SIP (Page 263)
- SIPSuite4 (Page 263)
- SOnSyncPointReachedResult (Page 264)
- SDataRecordInfo (Page 265)
- SDataRecord (Page 266)
- SConfiguredProcessEvents (Page 266)
- SDiagExtChannelDescription (Page 267)
- SAutodiscoverData (Page 269)

11.6.1 SDataValue

Description

The structure contains the value and type of a PLC tag.

Table 3-829 SDataValue - Native C++

Syntax	`struct SDataValue`
	`{`
	`UDataValue Value;`
	`EPrimitiveDataType Type;`
	`};`

Member	• `UDataValue Value:` The value of the PLC tags • `EPrimitiveDataType Type:` Type of PLC tag

Table 3-830 SDataValue - .NET (C#)

Syntax	`struct SDataValue`
	`{`
	`bool Bool { get; set; }`
	`Int8 Int8 { get; set; }`
	`Int16 Int16 { get; set; }`
	`Int32 Int32 { get; set; }`
	`Int64 Int64 { get; set; }`
	`UInt8 UInt8 { get; set; }`
	`UInt16 UInt16 { get; set; }`
	`UInt32 UInt32 { get; set; }`
	`UInt64 UInt64 { get; set; }`
	`float Float { get; set; }`
	`double Double { get; set; }`
	`sbyte Char { get; set; }`
	`char WChar { get; set; }`
	`EPrimitiveDataType Type { get; set; }`
	`}`

Member	• `bool Bool:` 1 byte boolean value • `Int8 Int8:` 1 byte integer with sign • `Int16 Int16:` 2 byte integer with sign • `Int32 Int32:` 4 byte integer with sign • `Int64 Int64:` 8 byte integer with sign • `UntT8 UInt8:` 1 byte integer without sign • `UInt16 UInt16:` 2 byte integer without sign • `UInt32 UInt32:` 4 byte integer without sign • `UInt64 UInt64:` 8 byte integer without sign • `float Float:` 4 byte floating-point value • `double Double:` 8 byte floating-point value • `sbyte Char:` 1 byte value character • `char WChar:` 2 byte value character • `EPrimitiveDataType Type:` Type of PLC tag

11.6.2 SDVBNI

Description

This structure is for internal use only. Do not change this structure.

Table 3-831 SDVBNI - Native C++

Syntax	`struct SDVBNI`

Table 3-832 SDVBNI - .NET (C#)

Syntax	`struct SDVBNI`

11.6.3 SDataValueByAddress

Description

This structure represents a PLC tag that is accessed via its address.

Table 3-833 SDataValueByAddress - Native C++

Syntax	`struct SDataValueByAddress`
	`{`
	`UINT32 Offset;`
	`UINT8 Bit;`
	`SDataValue DataValue;`
	`ERuntimeErrorCode ErrorCode;`
	`}`

Member	• `UINT32 Offset` The byte offset of the tag if it is not located in a data block. • `UINT8 Bit` The bit offset of the tag if it is not located in a data block. • `SDataValue DataValue` The value of the PLC tags • `ERuntimeErrorCode ErrorCode` – `SREC_TIMEOUT` if no event was triggered during the defined time interval. – `SREC_WARNING_INVALID_CALL` if no function RegisterOnSyncPointReachedEvent was called before, see `ERuntimeErrorCode`.

Table 3-834 SDataValueByAddress - .NET (C#)

Syntax	`struct SDataValueByAddress`
	`{`
	`UInt32 Offset;`
	`UInt8 Bit;`
	`SDataValue DataValue;`
	`ERuntimeErrorCode ErrorCode;`
	`}`

Member	• `UINT32 Offset` The byte offset of the tag if it is not located in a data block. • `UINT8 Bit` The bit offset of the tag if it is not located in a data block. • `SDataValue DataValue` The value of the PLC tags • `ERuntimeErrorCode ErrorCode` – `SREC_TIMEOUT` if no event was triggered during the defined time interval. – `SREC_WARNING_INVALID_CALL` if no function RegisterOnSyncPointReachedEvent was called before, see `ERuntimeErrorCode`.

11.6.4 SDataValueByAddressWithCheck

Description

This structure represents a PLC tag that is accessed via its address.

Table 3-835 SDataValueByAddressWithCheck - Native C++

Syntax	`struct SDataValueByAddressWithCheck`
	`{`
	`UINT32 Offset;`
	`UINT8 Bit;`
	`SDataValue DataValue;`
	`ERuntimeErrorCode ErrorCode;`
	`bool ValueHasChanged;`
	`}`

Member	• `UINT32 Offset` The byte offset of the tag if it is not located in a data block. • `UINT8 Bit` The bit offset of the tag if it is not located in a data block. • `SDataValue DataValue` The value of the PLC tags • `ERuntimeErrorCode ErrorCode` – `SREC_TIMEOUT` if no event was triggered during the defined time interval. – `SREC_WARNING_INVALID_CALL` if no function RegisterOnSyncPointReachedEvent was called before, see `ERuntimeErrorCode`. • `bool ValueHasChanged` _____

Table 3-836 SDataValueByAddressWithCheck - .NET (C#)

Syntax	`struct SDataValueByAddressWithCheck`
	`{`
	`UInt32 Offset;`
	`UInt8 Bit;`
	`SDataValue DataValue;`
	`ERuntimeErrorCode ErrorCode;`
	`bool ValueHasChanged;`
	`}`

Member	• `UINT32 Offset` The byte offset of the tag if it is not located in a data block. • `UINT8 Bit` The bit offset of the tag if it is not located in a data block. • `SDataValue DataValue` The value of the PLC tags • `ERuntimeErrorCode ErrorCode` – `SREC_TIMEOUT` if no event was triggered during the defined time interval. – `SREC_WARNING_INVALID_CALL` if no function RegisterOnSyncPointReachedEvent was called before, see `ERuntimeErrorCode`. • `bool ValueHasChanged` _____

11.6.5 SDataValueByName

Description

This structure represents a PLC tag that is called by its name.

Table 3-837 SDataValueByName - Native C++

Syntax	`struct SDataValueByName`
	`{`
	`WCHAR Name[DTAG_NAME_MAX_LENGTH];`
	`SDataValue DataValue;`
	`ERuntimeErrorCode ErrorCode;`
	`SDVBNI Internal;`
	`}`

Member	• `WCHAR Name[DTAG_NAME_MAX_LENGTH]` The name of the tag • `SDataValue DataValue` The value of the PLC tags • `ERuntimeErrorCode ErrorCode` – `SREC_TIMEOUT` if no event was triggered during the defined time interval. – `SREC_WARNING_INVALID_CALL` if no function RegisterOnSyncPointReachedEvent was called before, see `ERuntimeErrorCode`. • `SDVBNI Internal` _____

Table 3-838 SDataValueByName - .NET (C#)

Syntax	`struct SDataValueByName`
	`{`
	`String Name;`
	`SDataValue DataValue;`
	`ERuntimeErrorCode ErrorCode;`
	`SDVBNI Internal;`
	`}`

Member	• `String Name` The name of the tag • `SDataValue DataValue` The value of the PLC tags • `ERuntimeErrorCode ErrorCode` – `SREC_TIMEOUT` if no event was triggered during the defined time interval. – `SREC_WARNING_INVALID_CALL` if no function RegisterOnSyncPointReachedEvent was called before, see `ERuntimeErrorCode`. • `SDVBNI Internal` _____

11.6.6 SDataValueByNameWithCheck

Description

This structure represents a PLC tag that is called by its name.

Table 3-839 SDataValueByNameWithCheck - Native C++

Syntax	`struct SDataValueByNameWithCheck`
	`{`
	`WCHAR Name[DTAG_NAME_MAX_LENGTH];`
	`SDataValue DataValue;`
	`ERuntimeErrorCode ErrorCode;`
	`SDVBNI Internal;`
	`bool ValueHasChanged;`
	`};`

Table 3-840 SDataValueByNameWithCheck - .NET (C#)

Syntax	`struct SDataValueByNameWithCheck`
	`{`
	`String Name;`
	`SDataValue DataValue;`
	`ERuntimeErrorCode ErrorCode;`
	`SDVBNI Internal;`
	`bool ValueHasChanged;`
	`}`

11.6.7 SConnectionInfo

Description

This structure contains the IP address and port of a remote runtime connection.

Table 3-841 SConnectionInfo - Native C++

Syntax	`struct SConnectionInfo`
	`{`
	`UIP IP;`
	`UINT16 Port;`
	`};`

Table 3-842 SConnectionInfo - .NET (C#)

Syntax	`struct SConnectionInfo`
	`{`
	`SIP IP;`
	`UInt16 Port;`
	`}`

11.6.8 SDisplayData

Description

Struct to manage the display data. The data stored in this struct constitutes the raw bitmap data.

Table 3-843 SDisplayData() - Native C++

Syntax	`struct SDisplayData`
	`{`
	`uint8_t displayData[MAX_SIZE_DISPLAY_DATA];`
	`uint32_t dataLength;`
	`};`

Member	• `uint8_t displayData[MAX_SIZE_DISPLAY_DATA]`: Current bitmap data with a maximum length of MAX_SIZE_DISPLAY_DATA (=153666) • `uint32_t dataLength`: Tells the length of the data inside `displayData`

Table 3-844 SDisplayData() - .NET C#

Syntax	`struct SDisplayData`
	`{`
	`byte[] displayData;`
	`UInt32 dataLength;`
	`};`

Member	• `byte[] displayData`: Current bitmap data with a maximum length of MaxSizeDisplayData (=153666) • `UInt32 dataLength`: Tells the length of the data inside `displayData`

11.6.9 SInstanceInfo

Description

This structure contains an IPv4 address.

Table 3-845 SInstanceInfo - Native C++

Syntax	`struct SInstanceInfo`
	`{`
	`INT32 ID;`
	`WCHAR Name[DINSTANCE_NAME_MAX_LENGTH];`
	`};`

Member	• `INT32 ID`: The ID of the instance • `WCHAR Name[DINSTANCE_NAME_MAX_LENGTH]`: The name of the instance

Table 3-846 SInstanceInfo - .NET (C#)

Syntax	`struct SInstanceInfo`
	`{`
	`Int32 ID;`
	`String Name;`
	`}`

Member	• `Int32 ID:` The ID of the instance • `String name:` The name of the instance

11.6.10 SDimension

Description

This structure contains information about the dimension of a field.

Table 3-847 SDimension - Native C++

Syntax	`struct SDimension`
	`{`
	`INT32 StartIndex;`
	`UINT32 Count;`
	`};`

Table 3-848 SDimension - .NET (C#)

Syntax	`struct SDimension`
	`{`
	`Int32 StartIndex;`
	`UInt32 Count;`
	`}`

11.6.11 STagInfo

Description

This structure contains information about a PLC tag.

Table 3-849 STagInfo - Native C++

Syntax	`struct STagInfo`
	`{`
	`WCHAR Name[DTAG_NAME_MAX_LENGTH];`
	`EArea Area;`
	`EDataType DataType;`
	`EPrimitiveDataType PrimitiveDataType;`
	`UINT16 Size;`
	`UINT32 Offset;`
	`UINT8 Bit;`
	`UINT8 DimensionCount;`
	`UINT32 Index;`
	`UINT32 ParentIndex;`
	`SDimension Dimension[DTAG_ARRAY_DIMENSION];`
	`};`

Member	• `WCHAR Name[DTAG_NAME_MAX_LENGTH]:` The name of the tag • `EArea area:` The CPU area where the tag is located. • `EDataType DataType:` The CPU data type of the tag • `EPrimitiveDataType PrimitiveDataType:` The primitive data type of the tag • `UINT16 size:` The size of the tag in bytes • `UINT32 offset:` The byte offset of the tag if it is not located in a data block. • `UINT8 bit:` The bit offset of the tag if it is not located in a data block. • `UINT8 DimensionCount:` The number of dimensions of the array. 0 if the tag is not a field. • `UINT32 index:` The index of the tag • `UINT32 ParentIndex:` If this tag is embedded in another tag (for example, an element of a structure), this value then displays the index of the parent tag. The value is 0 if the tag has no parent tag. • `SDimension Dimension[DTAG_ARRAY_DIMENSION]:` Information about each dimension of the field

Table 3-850 STagInfo - .NET (C#)

Syntax	`public struct STagInfo`
	`{`
	`String Name;`
	`EArea Area;`
	`EDataType DataType;`
	`EPrimitiveDataType PrimitiveDataType;`
	`UInt16 Size;`
	`UInt32 Offset;`
	`UInt8 Bit;`
	`UInt32 Index;`
	`UInt32 ParentIndex;`
	`SDimension[] Dimension;`
	`}`

Member	• `String name:` The name of the tag • `EArea area:` The CPU area where the tag is located. • `EDataType DataType:` The CPU data type of the tag • `EPrimitiveDataType PrimitiveDataType:` The primitive data type of the tag • `UInt16 size:` The size of the tag in bytes. • `UInt32 offset:` The byte offset of the tag if it is not located in a data block. • `UInt8 bit:` The bit offset of the tag if it is not located in a data block. • `UInt32 index:` The index of the tag • `UInt32 ParentIndex:` If this tag is embedded in another tag (for example, an element of a structure), this value then displays the index of the parent tag. The value is 0 if the tag has no parent tag. • `SDimension[] Dimension:` Information about each dimension of the field. Empty, if the tag is not an array.

11.6.12 SIP

Description

This structure contains an IPv4 address.

Table 3-851 SIP - .NET (C#)

Syntax	`struct SIP`
	`{`
	`byte[] IPArray { get; set; }`
	`UInt32 IPDWord { get; set; }`
	`string IPString { get; set; }`
	`}`

Member	• `UInt32 IPDWord:` The IP address in a single DWORD • `byte[] IPArray:` The four elements of IP in descending order • `string IPString:` The IPv4 address as a string
Example	Example for an IP address: 192.168.0.1 SIP.IPDWord = 0xC0A80001 SIP.IPArray[3] = 192, SIP.IPArray[2] = 168, SIP.IPArray[1] = 0, SIP.IPArray[0] = 1 SIP.IPString = "192.168.0.1"

11.6.13 SIPSuite4

Description

This structure contains an IPv4 suite.

Table 3-852 SIPSuite4 - Native C++

Syntax	`struct SIPSuite4`
	`{`
	`UIP IPAddress;`
	`UIP SubnetMask;`
	`UIP DefaultGateway;`
	`};`

Member	• `UIP IPAddress:` The IP address • `UIP SubnetMask:` The subnet mask • `UIP DefaultGateway:` The standard gateway

Table 3-853 SIPSuite4 - .NET (C#)

Syntax	`struct SIPSuite4`
	`{`
	`SIP IPAddress;`
	`SIP SubnetMask;`
	`SIP DefaultGateway;`
	`}`

Member	• `SIP IPAddress:` The IP address • `SIP SubnetMask:` The subnet mask • `SIP DefaultGateway:` The standard gateway

11.6.14 SOnSyncPointReachedResult

Description

This structure contains the results of the OnSyncPointReached event.

Table 3-854 SOnSyncPointReachedResult - Native C++

Syntax	`struct SOnSyncPointReachedResult`
	`{`
	`ERuntimeErrorCode ErrorCode;`
	`SYSTEMTIME SystemTime;`
	`UINT32 Id;`
	`INT64 TimeSinceSameSyncPoint_ns;`
	`INT64 TimeSinceAnySyncPoint_ns;`
	`UINT32 SyncPointCount;`
	`};`

Member	• `ERuntimeErrorCode ErrorCode:` – `SREC_TIMEOUT` if no event was triggered during the defined time interval. In such a case, the struct values are not used. – `SREC_WARNING_INVALID_CALL`, if no function `RegisterOnSyncPointReachedEvent` was called before. See ERuntimeErrorCode. • `SYSTEMTIME SystemTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UINT32 Id:` For the `SingleStep_Bus` operating mode: The ID of the I/O system that is used for cycle-controlled synchronization of the simulated PLC instance. For all other operating modes: The ID of the process image partition (PIP) that triggers this event. 0 for the cycle control point (End of cycle). Note: In the SingleStep operating modes, the transferred ID for the cycle control point has the value 0xFFFF. In this case, the time values are set to 0. • `INT64 TimeSinceSameSyncPoint_ns:` The virtual time (in nanoseconds) since the last synchronization point of the same process image partition ID was reached. For the time-controlled operating modes: The runtime since the last call of the `StartProcessing()` function. • `INT64 TimeSinceAnySyncPoint_ns:` The virtual time (in nanoseconds) since the last synchronization point of any process image partition ID was reached. For the time-controlled operating modes: The runtime since the last call of the `StartProcessing()` function. • `UINT32 SyncPointCount:` The number of synchronization points since the last event. If the events are triggered faster than they are received, multiple events are combined into one event. In this case, this value contains the number of cycles since the last event was received.

Table 3-855 SOnSyncPointReachedResult - .NET (C#)

Syntax	`struct SOnSyncPointReachedResult`
	`{`
	`ERuntimeErrorCode ErrorCode;`
	`DateTime SystemTime;`
	`UInt32 Id;`
	`Int64 TimeSinceSameSyncPoint_ns;`
	`Int64 TimeSinceAnySyncPoint_ns;`
	`UInt32 SyncPointCount;`
	`}`

Member	• `ERuntimeErrorCode ErrorCode:` – `ERuntimeErrorCode.Timeout`, if no event was triggered during the defined time interval. – `WarningInvalidCall`, if no function `RegisterOnSyncPointReachedEvent` was called before. See ERuntimeErrorCode. • `DateTime DateTime:` The virtual system time of the simulated PLC instance at the time when this event was triggered. • `UInt32 Id:` For the `SingleStep_Bus` operating mode: The ID of the I/O system that is used for cycle-controlled synchronization of the simulated PLC instance. For all other operating modes: The ID of the process image partition (PIP) that triggers this event. 0 for the cycle control point (End of cycle). • `Int64 TimeSinceSameSyncPoint_ns:` The virtual time (in nanoseconds) since the last synchronization point of the same process image partition ID was reached. For the time-controlled operating modes: The runtime since the last call of the `StartProcessing()` function. • `Int64 TimeSinceAnySyncPoint_ns:` The virtual time (in nanoseconds) since the last synchronization point of any process image partition ID was reached. For the time-controlled operating modes: The runtime since the last call of the `StartProcessing()` function. • `UInt32 SyncPointCount:` The number of synchronization points since the last event. If the events are triggered faster than they are received, multiple events are combined into one event. In this case, this value contains the number of cycles since the last event was received.

11.6.15 SDataRecordInfo

Description

This structure contains read/write data record information.

Table 3-856 SDataRecordInfo - Native C++

Syntax	`struct SDataRecordInfo`
	`{`
	`UINT32 HardwareId;`
	`UINT32 RecordIdx;`
	`UINT32 DataSize;`
	`};`

Member	• `UINT32 HardwareId:` The ID of the hardware module (hardware identifier) • `UINT32 RecordIdx:` The data record number • `UINT32 DataSize:` The data record size

Table 3-857 SDataRecordInfo - .NET (C#)

Syntax	`struct SDataRecordInfo`
	`{`
	`UInt32 HardwareId;`
	`UInt32 RecordIdx;`
	`UInt32 DataSize;`
	`}`

Member	• `UInt32 ID:` The ID of the hardware module • `UInt32 RecordIdx:` The data record number • `UInt32 DataSize:` The data record size

11.6.16 SDataRecord

Description

This structure contains read/write data record information and data records.

Table 3-858 SDataRecord - .NET (C#)

Syntax	`struct SDataRecord`
	`{`
	`UInt32 HardwareId;`
	`byte[] Data`
	`}`

Member	• `SDataRecordInfo Info:` The data record information, see SDataRecordInfo (Page 265) • `byte[] Data:` The array length

11.6.17 SConfiguredProcessEvents

Description

This structure contains information about the configured process events.

Table 3-859 SConfiguredProcessEvents - Native C++

Syntax	`struct SConfiguredProcessEvents`
	`{`
	`UINT16 HardwareIdentifier;`
	`UINT16 Channel;`
	`EProcessEventType ProcessEventType;`
	`WCHAR Name[DPROCESS_EVENT_NAME_MAX_LENGTH];`
	`};`

Member	• `UINT16 HardwareIdentifier:` The HW identifier • `UINT16 Channel:` The channel of the I/O module which generates the process event. • `EProcessEventType ProcessEventType:` The type of the configured process event • `WCHAR Name[DPROCESS_EVENT_NAME_MAX_LENGTH]:` The name of the process event

Table 3-860 SConfiguredProcessEvents - .NET (C#)

Syntax	`public struct SConfiguredProcessEvents`
	`{`
	`ushort HardwareIdentifier;`
	`ushort Channel;`
	`EProcessEventType ProcessEventType;`
	`string Name;`
	`}`

Member	• `ushort HardwareIdentifier:` The HW identifier • `ushort Channel:` The channel of the I/O module which generates the process event. • `EProcessEventType ProcessEventType:` The type of the configured process event • `String name:` The name of the process event

11.6.18 SDiagExtChannelDescription

Description

This structure contains read/write data record information and data records.

Table 3-861 SDiagExtChannelDescription - Native C++

Syntax	`struct SDiagExtChannelDescription`
	`{`
	`UINT16 ChannelNumber;`
	`UINT16 ErrorType;`
	`UINT16 ExtErrorType;`
	`EDiagSeverity Severity;`
	`EDiagProperty Direction;`
	`};`

Member	• `UINT16 ChannelNumber:` If the interrupt relates to a specific channel of the IO device (e.g. short circuit), this parameter must contain the number of the faulty channel. If the interrupt was generated by a module or submodule, the number of the channel must be set to 0x8000. • `UINT16 ErrorType:` The parameter defines error types according to PROFINET standard, see "Error types" section. • `EDiagSeverity Severity:` The value of the severity for the diagnostics, see EDiagSeverity (Page 288). • `EDiagProperty Direction:` The value for the incoming/outgoing information, see EDiagProperty (Page 287). • `UINT16 ExtErrorType:` This parameter provides the option of defining more details for the diagnostic interrupt. This is helpful in combination with PDEV error types which are generated for CPU-internal modules. Should be 0 by default.

Table 3-862 SDiagExtChannelDescription - .NET (C#)

Syntax	`struct SDiagExtChannelDescription`
	`{`
	`UInt16 ChannelNumber;`
	`UInt16 ErrorType;`
	`UInt16 ExtErrorType;`
	`EDiagSeverity Severity;`
	`EDiagProperty Direction;`
	`};`

Member	• `UInt16 ChannelNumber:` If the interrupt relates to a specific channel of the IO device (e.g. short circuit), this parameter must contain the number of the faulty channel. If the interrupt was generated by a module or submodule, the number of the channel must be set to 0x8000. • `UInt16 ErrorType:` The parameter defines error types according to PROFINET standard, see "Error types" section. • `EDiagSeverity Severity:` The value of the severity for the diagnostics, see EDiagSeverity (Page 288). • `EDiagProperty Direction:` The value for the incoming/outgoing information, see EDiagProperty (Page 287). • `UInt16 ExtErrorType:` This parameter provides the option of defining more details for the diagnostic interrupt. This is helpful in combination with PDEV error types which are generated for CPU-internal modules. Should be 0 by default.

Error types

The following table contains important error types (`ErrorType`) according to PROFINET standard:

Table 3-863 Error types according to PROFINET standard

Value	Meaning
0x0000	Reserved / unknown error
0x0001	Short-circuit
0x0002	Undervoltage
0x0003	Overvoltage
0x0004	Overload
0x0005	Overtemperature
0x0006	Wire break
0x0007	High limit violated
0x0008:	Low limit violated
0x0009	Error

The following table contains error types `ExtChannelErrorType` for `ChannelErrorType` "Remote mismatch":

Table 3-864 ExtChannelErrType error types

Value	Meaning	Use
0x0000	Reserved	-
0x0001 to 0x7FFF	Manufacturer ID	Interrupt/diagnostics
0x8000	Peer name of station mismatch	Interrupt/diagnostics
0x8001	Peer name of port mismatch	Interrupt/diagnostics
0x8002	Peer RT_CLASS_3 mismatch	Interrupt/diagnostics
0x8003	Peer MAU Type mismatch	Interrupt/diagnostics

11.6.19 SAutodiscoverData

Description

This structure contains the IP address, the port, the Runtime version, and the name of the computer that has a Runtime Manager ready to make a remote connection.

Table 3-865 SAutodiscoverData - Native C++

Syntax	`public struct SAutodiscoverData`
	`{`
	`UIP IP;`
	`UINT16 Port;`
	`DWORD RuntimeVersion;`
	`WCHAR ComputerName[MAX_COMPUTERNAME_LENGTH + 1];`
	`};`

Table 3-866 SAutodiscoverData - .NET (C#)

Syntax	`public struct SAutodiscoverData`
	`{`
	`public SIP IP;`
	`public ushort Port;`
	`public uint RuntimeVersion;`
	`public string ComputerName;`
	`}`

11.6.20 SMAC address

Description

Defines the structure of a MAC address.

Table 3-867 SMACAddress - Native C++

Syntax	`#define DMAC_ADDRESS_LEN 6`
	
	`struct SMACAddress`
	`{`
	`BYTE Octets[DMAC_ADDRESS_LEN];`
	`};`

11.6.21 SNetInterfaceInfo

Description

Describes the structure of a network interface.

Table 3-868 SNetInterfaceInfo - Native C++

Syntax	`struct SNetInterfaceInfo`
	`{`
	`DWORD interfaceIndex;`
	`UMACAddress MACAddress;`
	`WCHAR interfaceName[64];`
	`WCHAR interfaceDescription[64];`
	`};`

11.7 Enumerations

The following enumerations are available:

- ERuntimeErrorCode (Page 271)
- EArea (Page 273)
- EOperatingState (Page 274)
- EOperatingMode (Page 274)
- ECPUType (Page 275)
- ECommunicationInterface (Page 277)
- EDisplayKey (Page 277)
- ENetworkMode (Page 278)
- EPLCInterface (Page 278)
- ELEDType (Page 279)
- ELEDMode (Page 279)
- EPrimitiveDataType (Page 280)
- EDataType (Page 282)
- ETagListDetails (Page 284)
- ERuntimeConfigChanged (Page 285)
- EPullOrPlugEventType (Page 286)
- EProcessEventType (Page 286)
- ESoftwareConfigChanged (Page 287)
- EDirection (Page 287)
- EDiagProperty (Page 287)
- EDiagSeverity (Page 288)
- ERackOrStationFaultType (Page 288)
- ECycleTimeMonitoringMode (Page 288)
- EAutodiscoverType (Page 289)
- ESecurityMode (Page 289)

11.7.1 ERuntimeErrorCode

Description

This enumeration contains all error codes that are used by the Simulation Runtime API. Most API functions return one of these error codes. If the function is successful, the return value is always `SREC_OK` / `OK`. Errors are returned with negative values, warnings with positive values.

Table 3-869 ERuntimeErrorCode - Native C++

Syntax	`enum ERuntimeErrorCode`
	`{`
	`SREC_OK = 0,`
	`SREC_INVALID_ERROR_CODE = -1,`
	`SREC_NOT_IMPLEMENTED = -2,`
	`SREC_INDEX_OUT_OF_RANGE = -3,`
	`SREC_DOES_NOT_EXIST = -4,`
	`SREC_ALREADY_EXISTS = -5,`
	`SREC_UNKNOWN_MESSAGE_TYPE = -6,`
	`SREC_INVALID_MESSAGE_ID = -7,`
	`SREC_WRONG_ARGUMENT = -8,`
	`SREC_WRONG_PIPE = -9,`
	`SREC_CONNECTION_ERROR = -10,`
	`SREC_TIMEOUT = -11,`
	`SREC_MESSAGE_CORRUPT = -12,`
	`SREC_WRONG_VERSION = -13,`
	`SREC_INSTANCE_NOT_RUNNING = -14,`
	`SREC_INTERFACE_REMOVED = -15,`
	`SREC_SHARED_MEMORY_NOT_INITIALIZED = -16,`
	`SREC_API_NOT_INITIALIZED = -17,`
	`SREC_WARNING_ALREADY_EXISTS = 18,`
	`SREC_NOT_SUPPORTED = -19,`
	`SREC_WARNING_INVALID_CALL = 20,`
	`SREC_ERROR_LOADING_DLL = -21,`
	`SREC_SIGNAL_NAME_DOES_NOT_EXIST = -22,`
	`SREC_SIGNAL_TYPE_MISMATCH = -23,`
	`SREC_SIGNAL_CONFIGURATION_ERROR = -24,`
	`SREC_NO_SIGNAL_CONFIGURATION_LOADED = -25,`
	`SREC_CONFIGURED_CONNECTION_NOT_FOUND = -26,`
	`SREC_CONFIGURED_DEVICE_NOT_FOUND = -27,`
	`SREC_INVALID_CONFIGURATION = -28,`
	`SREC_TYPE_MISMATCH = -29,`
	`SREC_LICENSE_NOT_FOUND = -30,`
	`SREC_NO_LICENSE_AVAILABLE = -31,`
	`SREC_WRONG_COMMUNICATION_INTERFACE = -32,`
	`SREC_LIMIT_REACHED = -33,`
	`SREC_NO_STORAGE_PATH_SET = -34,`
	`SREC_STORAGE_PATH_ALREADY_IN_USE = -35,`
	`SREC_MESSAGE_INCOMPLETE = -36,`
	`SREC_ARCHIVE_STORAGE_NOT_CREATED = -37,`
	`SREC_RETRIEVE_STORAGE_FAILURE = -38,`
	`SREC_INVALID_OPERATING_STATE = -39,`
	`SREC_INVALID_ARCHIVE_PATH = -40,`
	`SREC_DELETE_EXISTING_STORAGE_FAILED = -41,`
	`SREC_CREATE_DIRECTORIES_FAILED = -42,`
	`SREC_NOT_ENOUGH_MEMORY = -43,`
	`SREC_WARNING_TRIAL_MODE_ACTIVE = 44,`
	`SREC_NOT_RUNNING = -45,`
	`SREC_NOT_EMPTY = -46,`
	`SREC_NOT_UP_TO_DATE = -47,`
	`SREC_COMMUNICATION_INTERFACE_NOT_AVAILABLE = -48,`
	`SREC_WARNING_NOT_COMPLETE = 49,`
	`SREC_VIRTUAL_SWITCH_MISCONFIGURED = -50,`
	`SREC_RUNTIME_NOT_AVAILABLE = -51,`
	`SREC_IS_EMPTY = -52,`
	`SREC_WRONG_MODULE_STATE = -53,`
	`SREC_WRONG_MODULE_TYPE = -54,`

	SREC_NOT_SUPPORTED_BY_MODULE = -55, SREC_INTERNAL_ERROR = -56, SREC_STORAGE_TRANSFER_ERROR = -57, SREC_ANOTHER_VARIANT_OF_PLCSIM_RUNNING = -58, SREC_ACCESS_DENIED = -59, SREC_NOT_ALLOWED_DURING_DOWNLOAD = -60, SREC_AUTODISCOVER_ALREADY_RUNNING = -61, SREC_INVALID_STORAGE = -62, SREC_WARNING_UNSUPPORTED_PCAP_DRIVER = 63, // (Deprecated since V4) SREC_WARNING_RUNNING_ON_TIA_PORTAL_TEST_SUITE = 64, SREC_PCAP_DRIVER_NOT_RUNNING = -65, SREC_UNSUPPORTED_PCAP_DRIVER = -66, SREC_CONFIG_FILE_ERROR = -67, SREC_WARNING_PASSWORD_PROTECTION_ERROR = 68, SREC_BUFFER_OVERFLOW = -69, SREC_NOT_ALLOWED = -70, SREC_WARNING_NO_EXTERNAL_COMMUNICATION = 71 SREC_INSTANCE_ALREADY_RUNNING = -72 SREC_OUT_OF_MEMORY = -73 SREC_WARNING_UNSECURED_COMMUNICATION = -74 };

Table 3-870 ERuntimeErrorCode - .NET (C#)

Syntax	enum ERuntimeErrorCode { OK = 0, InvalidErrorCode = -1, NotImplemented = -2, IndexOutOfRange = -3, DoesNotExist = -4, AlreadyExists = -5, UnknownMessageType = -6, InvalidMessageId = -7, WrongArgument = -8, WrongPipe = -9, ConnectionError = -10, Timeout = -11, MessageCorrupt = -12, WrongVersion = -13, InstanceNotRunning = -14, InterfaceRemoved = -15, SharedMemoryNotInitialized = -16, ApiNotInitialized = -17, WarningAlreadyExists = 18, NotSupported = -19, WarningInvalidCall = 20, ErrorLoadingDll = -21, SignalNameDoesNotExist = -22, SignalTypeMismatch = -23, SignalConfigurationError = -24, NoSignalConfigurationLoaded = -25, ConfiguredConnectionNotFound = -26, ConfiguredDeviceNotFound = -27, InvalidConfiguration = -28, TypeMismatch = -29, LicenseNotFound = -30, NoLicenseAvailable = -31, WrongCommunicationInterface = -32, LimitReached = -33, NoStartupPathSet = -34, StartupPathAlreadyInUse = -35, MessageIncomplete = -36, ArchiveStorageNotCreated = -37, RetrieveStorageFailure = -38, InvalidOperatingState = -39, InvalidArchivePath = -40, DeleteExistingStorageFailed = -41, CreateDirectoriesFailed = -42, NotEnoughMemory = -43,

	WarningTrialModeActive = 44, NotRunning = -45, NotEmpty = -46, NotUpToDate = -47, CommunicationInterfaceNotAvailable = -48, WarningNotComplete = 49, VirtualSwitchMisconfigured = -50, RuntimeNotAvailable = -51, IsEmpty = -52, WrongModuleState = -53, WrongModuleType = -54, NotSupportedByModule = -55, InternalError = -56, StorageTransferError = -57, AnotherVariantOfPlcsimRunning = -58, AccessDenied = -59, NotAllowedDuringDownload = -60, AutodiscoverAlreadyRunning = -61, InvalidStorage = -62, WarningUnsupportedPcapDriver = 63, //(Deprecated since V4) WarningRunningOnTiaPortalTestSuite = 64, PCAPDriverNotRunning = -65, UnsupportedPcapDriver = -66, ConfigFileError = -67, WarningPasswordForProtectionError = 68, BufferOverflow = - 69, NotAllowed = -70, WarningNoExternalCommunication = 71 InstanceAlreadyRunning = -72 OutOfMemory = -73 WarningUnsecuredCommunication = -74 }

11.7.2 EArea

Description

This enumeration contains all PLC areas that contain the available PLC tags.

Table 3-871 EArea - Native C++

Syntax	enum EArea
	{
	SRA_INVALID_AREA = 0,
	SRA_INPUT = 1,
	SRA_MARKER = 2,
	SRA_OUTPUT = 3,
	SRA_COUNTER = 4,
	SRA_TIMER = 5,
	SRA_DATABLOCK = 6,
	SRA_ENUMERATION_SIZE = 7
	};

Table 3-872 EArea - .NET (C#)

Syntax	public enum EArea
	{
	InvalidArea = 0,
	Input = 1,
	Marker = 2,
	Output = 3,
	Counter = 4,
	Timer = 5,
	DataBlock = 6,
	}

11.7.3 EOperatingState

Description

This enumeration contains the operating states of a simulated PLC instance.

Table 3-873 EOperatingState - Native C++

Syntax	`enum EOperatingState`
	`{`
	`SROS_INVALID_OPERATING_STATE = 0,`
	`SROS_OFF = 1,`
	`SROS_BOOTING = 2,`
	`SROS_STOP = 3,`
	`SROS_STARTUP = 4,`
	`SROS_RUN = 5,`
	`SROS_FREEZE = 6,`
	`SROS_SHUTTING_DOWN = 7,`
	`SROS_HOLD = 8,`
	
	`SROS_ENUMERATION_SIZE = 9`
	`};`

Table 3-874 EOperatingState - .NET (C#)

Syntax	`enum EOperatingState`
	`{`
	`InvalidOperatingState = 0,`
	`Off = 1,`
	`Booting = 2,`
	`Stop = 3,`
	`Startup = 4,`
	`Run = 5,`
	`Freeze = 6,`
	`ShuttingDown = 7,`
	`Hold = 8`
	`}`

11.7.4 EOperatingMode

Description

This enumeration contains the operating modes of a simulated PLC instance.

Table 3-875 EOperatingMode - Native C++

Syntax	`enum EOperatingMode`
	`{`
	`SROM_DEFAULT = 0,`
	`SROM_SINGLE_STEP_C = 1,`
	`SROM_SINGLE_STEP_CT = 2,`
	`SROM_TIMESPAN_SYNCHNRONIZED_C = 3,`
	`SROM_SINGLE_STEP_P = 4,`
	`SROM_TIMESPAN_SYNCHNRONIZED_P = 5,`
	`SROM_SINGLE_STEP_CP = 6,`
	`SROM_SINGLE_STEP_CPT = 7,`
	`SROM_TIMESPAN_SYNCHNRONIZED_CP = 8`
	`SROM_SINGLE_STEP_BUS = 9`
	`};`

Table 3-876 EOperatingMode - .NET (C#)

Syntax	`public enum EOperatingMode`
	`{`
	`Default = 0,`
	`SingleStep_C = 1,`
	`SingleStep_CT = 2,`
	`TimespanSynchronized_C = 3,`
	`SingleStep_P = 4,`
	`TimespanSynchronized_P = 5,`
	`SingleStep_CP = 6,`
	`SingleStep_CPT = 7,`
	`TimespanSynchronized_CP = 8`
	`SingleStep_Bus = 9`
	`}`

11.7.5 ECPUType

Description

This enumeration contains all CPU types that can be loaded in a simulated PLC instance.

Table 3-877 ECPUType - Native C++

Syntax	`enum ECPUType`
	`{`
	`SRCT_1500_Unspecified = 0x000005DC,`
	`SRCT_1511 = 0x000005E7,`
	`SRCT_1513 = 0x000005E9,`
	`SRCT_1515 = 0x000005EB,`
	`SRCT_1516 = 0x000005EC,`
	`SRCT_1517 = 0x000005ED,`
	`SRCT_1518 = 0x000005EE,`
	`SRCT_1511C = 0x000405E7,`
	`SRCT_1512C = 0x000405E8,`
	`SRCT_1511F = 0x000105E7,`
	`SRCT_1513F = 0x000105E9,`
	`SRCT_1515F = 0x000105EB,`
	`SRCT_1516F = 0x000105EC,`
	`SRCT_1517F = 0x000105ED,`
	`SRCT_1518F = 0x000105EE,`
	`SRCT_1511T = 0x000805E7,`
	`SRCT_1515T = 0x000805EB,`
	`SRCT_1516T = 0x000805EC,`
	`SRCT_1517T = 0x000805ED,`
	`SRCT_1511TF = 0x000905E7,`
	`SRCT_1515TF = 0x000905EB,`
	`SRCT_1516TF = 0x000905EC,`
	`SRCT_1517TF = 0x000905ED,`
	`SRCT_1518ODK = 0x001005EE,`
	`SRCT_1518FODK = 0x001105EE,`
	`SRCT_1518MFP = 0x004005EE,`
	`SRCT_1518FMFP = 0x004105EE,`
	`SRCT_1518T = 0x000805EE,`
	`SRCT_1518TF = 0x000905EE,`
	`SRCT_1504DTF = 0x000905E0,`
	`SRCT_1507DTF = 0x000905E3,`
	`SRCT_ET200SP_Unspecified = 0x000205DC,`
	`SRCT_1510SP = 0x000205E6,`
	`SRCT_1512SP = 0x000205E8,`
	`SRCT_1510SPF = 0x000305E6,`
	`SRCT_1512SPF = 0x000305E8,`
	`SRCT_1514SP = 0x000205E7,`
	`SRCT_1514SPT = 0x000205E9,`
	`SRCT_1514SPF = 0x000305E7,`
	`SRCT_1514SPTF = 0x000305E9,`
	`SRCT_1514PA = 0x000305EB,`

	SRCT_1500_RH_Unspecified = 0x008005DC, SRCT_1513R = 0x008005E9, SRCT_1515R = 0x008005EB, SRCT_1517H = 0x008005ED, SRCT_1518HF = 0x008105EE, SRCT_ET200PRO_Unspecified = 0x002005DC, SRCT_1513PRO = 0x002005E9, SRCT_1513PROF = 0x002105E9, SRCT_1516PRO = 0x002005EC, SRCT_1516PROF = 0x002105EC, SRCT_1500_SW_OC_Unspecified = 0x010005DC, SRCT_1507S = 0x010005E3, SRCT_1507SF = 0x010105E3, SRCT_1508S = 0x010005E4, SRCT_1508SF = 0x010105E4, SRCT_1508ST = 0x010805E4, SRCT_1508STF = 0x010905E4, SRCT_1505SP = 0x010005E1, SRCT_1505SPF = 0x010105E1, SRCT_1505SPT = 0x010805E1, SRCT_1505SPTF = 0x010905E1 }

Table 3-878 ECPUType - .NET (C#)

Syntax	enum ECPUType { CPU1500_Unspecified = 0x000005DC, CPU1511 = 0x000005E7, CPU1513 = 0x000005E9, CPU1515 = 0x000005EB, CPU1516 = 0x000005EC, CPU1517 = 0x000005ED, CPU1518 = 0x000005EE, CPU1511C = 0x000405E7, CPU1512C = 0x000405E8, CPU1511F = 0x000105E7, CPU1513F = 0x000105E9, CPU1515F = 0x000105EB, CPU1516F = 0x000105EC, CPU1517F = 0x000105ED, CPU1518F = 0x000105EE, CPU1511T = 0x000805E7, CPU1515T = 0x000805EB, CPU1516T = 0x000805EC, CPU1517T = 0x000805ED, CPU1511TF = 0x000905E7, CPU1515TF = 0x000905EB, CPU1516TF = 0x000905EC, CPU1517TF = 0x000905ED, CPU1518ODK = 0x001005EE, CPU1518FODK = 0x001105EE, CPU1518MFP = 0x004005EE, CPU1518FMFP = 0x004105EE, CPU1518T = 0x000805EE, CPU1518TF = 0x000905EE, CPU1504DTF = 0x000905E0, CPU1507DTF = 0x000905E3, CPUET200SP_Unspecified = 0x000205DC, CPU1510SP = 0x000205E6, CPU1512SP = 0x000205E8, CPU1510SPF = 0x000305E6, CPU1512SPF = 0x000305E8, CPU1514SP = 0x000205E7, CPU1514SPT = 0x000205E9, CPU1514SPF = 0x000305E7, CPU1514SPTF = 0x000305E9, SRCT_1514PA = 0x000305EB, CPU1500_RH_Unspecified = 0x008005DC, CPU1513R = 0x008005E9,

	CPU1515R = 0x008005EB, CPU1517H = 0x008005ED, CPU1518HF = 0x008105EE, CPUET200PRO_Unspecified = 0x002005DC, CPU1513PRO = 0x002005E9, CPU1513PROF = 0x002105E9, CPU1516PRO = 0x002005EC, CPU1516PROF = 0x002105EC, SRCT_1500_SW_OC_Unspecified = 0x010005DC, SRCT_1507S = 0x010005E3, SRCT_1507SF = 0x010105E3, SRCT_1508S = 0x010005E4, SRCT_1508SF = 0x010105E4, SRCT_1508ST = 0x010805E4, SRCT_1508STF = 0x010905E4, SRCT_1505SP = 0x010005E1, SRCT_1505SPF = 0x010105E1, SRCT_1505SPT = 0x010805E1, SRCT_1505SPTF = 0x010905E1 }

11.7.6 ECommunicationInterface

Description

This enumeration contains the available communication interfaces of a simulated controller.

Table 3-879 ECommunicationInterface - Native C++

Syntax	enum ECommunicationInterface
	{
	SRCI_NONE = 0,
	SRCI_SOFTBUS = 1,
	SRCI_TCPIP = 2,
	SRCI_ENUMERATION_SIZE = 3
	};

Table 3-880 ECommunicationInterface - .NET (C#)

Syntax	enum ECommunicationInterface
	{
	None = 0,
	Softbus = 1,
	TCPIP = 2,
	}

11.7.7 EDisplayKey

Description

Enum containing the IDs of possible keys to be pressed on the display of an instance.

Table 3-881 EDisplayKey - Native C++

Syntax	enum EDisplayKey { SRFK_UP = 0, SRFK_DOWN = 1, SRFK_LEFT = 2, SRFK_RIGHT = 3, SRFK_OK = 4, SRFK_ESC = 5,

	SRFK_LONGESC = 6 };

Table 3-882 EDisplayKey - .NET C#

Syntax	enum EDisplayKey
	{
	SRFK_UP = 0,
	SRFK_DOWN = 1,
	SRFK_LEFT = 2,
	SRFK_RIGHT = 3,
	SRFK_OK = 4,
	SRFK_ESC = 5,
	SRFK_LONGESC = 6
	};

11.7.8 ENetworkMode

Description

This enumeration contains the communication modes of a simulated PLC instance.

Table 3-883 ENetworkMode - Native C++

Syntax	`enum class ENetworkMode`
	`{`
	`STATE_UNKNOWN = -1,`
	`  TCPIP_MULTIPLE_ADAPTER = 0,`
	`  TCPIP_SINGLE_ADAPTER = 1,`
	`  SOFTBUS = 2`
	`};`

Table 3-884 ENetworkMode - .NET (C#)

Syntax	`public enum class ENetworkMode`
	`{`
	`UnknownState`
	`  TCPIPMultipleAdapter`
	`  TCPIPSingleAdapter`
	`  Softbus`
	`};`

11.7.9 EPLCInterface

Description

This enumeration includes the available interfaces of a simulated PLC instance.

Table 3-885 EPLCInterface - Native C++

Syntax	`enum class EPLCInterface`
	`{`
	`IE1 = 0,`
	`IE2,`
	`IE3`
	`};`

11.7.10 ELEDType

Description

This enumeration contains the types of LEDs for a simulated PLC instance.

Table 3-886 ELEDType - Native C++

Syntax	`enum ELEDType`
	`{`
	`SRLT_STOP = 0,`
	`SRLT_RUN = 1,`
	`SRLT_ERROR = 2,`
	`SRLT_MAINT = 3,`
	`SRLT_REDUND = 4,`
	`SRLT_FORCE = 5,`
	`SRLT_BUSF1 = 6,`
	`SRLT_BUSF2 = 7,`
	`SRLT_BUSF3 = 8,`
	`SRLT_BUSF4 = 9,`
	`SRLT_ENUMERATION_SIZE = 10`
	`};`

Table 3-887 ELEDType - .NET (C#)

Syntax	`enum ELEDType`
	`{`
	`Stop = 0,`
	`Run = 1,`
	`Error = 2`
	`Maint = 3,`
	`Redund = 4,`
	`Force = 5,`
	`Busf1 = 6,`
	`Busf2 = 7,`
	`Busf3 = 8,`
	`Busf4 = 9`
	`}`

11.7.11 ELEDMode

Description

This enumeration contains the LEDs of a simulated PLC instance.

Table 3-888 ELEDMode - Native C++

Syntax	`enum ELEDMode`
	`{`
	`SRLM_OFF = 0,`
	`SRLM_ON = 1,`
	`SRLM_FLASH_FAST = 2,`
	`SRLM_FLASH_SLOW = 3,`
	`SRLM_INVALID = 4`
	`};`

Table 3-889 ELEDMode - .NET (C#)

Syntax	`enum ELEDMode`
	`{`
	`Off = 0,`
	`On = 1,`
	`FlashFast = 2,`
	`FlashSlow = 3,`
	`Invalid = 4`
	`}`

11.7.12 EPrimitiveDataType

Description

This list contains all the primitive data types that are used by the I/O access functions.

Table 3-890 EPrimitiveDataType - Native C++

Syntax	`enum EPrimitiveDataType`
	`{`
	`SRPDT_UNSPECIFIC = 0,`
	`SRPDT_STRUCT = 1,`
	`SRPDT_BOOL = 2,`
	`SRPDT_INT8 = 3,`
	`SRPDT_INT16 = 4,`
	`SRPDT_INT32 = 5,`
	`SRPDT_INT64 = 6,`
	`SRPDT_UINT8 = 7,`
	`SRPDT_UINT16 = 8,`
	`SRPDT_UINT32 = 9,`
	`SRPDT_UINT64 = 10,`
	`SRPDT_FLOAT = 11,`
	`SRPDT_DOUBLE = 12,`
	`SRPDT_CHAR = 13,`
	`SRPDT_WCHAR = 14`
	`};`

Table 3-891 EPrimitiveDataType - .NET (C#)

Syntax	`enum EPrimitiveDataType`
	`{`
	`Unspecific = 0,`
	`Struct = 1,`
	`Bool = 2,`
	`Int8 = 3,`
	`Int16 = 4,`
	`Int32 = 5,`
	`Int64 = 6,`
	`UInt8 = 7,`
	`UInt16 = 8,`
	`UInt32 = 9,`
	`UInt64 = 10,`
	`Float = 11,`
	`Double = 12,`
	`Char = 13,`
	`WChar = 14`
	`}`

Compatible primitive data types

The following tables shows the primitive data types of the user interface (API) and the data types of the S7-PLCSIM Advanced instance that are configured in the stored tag list. The compatible data types are marked with "X".

Table 3-892 Compatible primitive data types - Reading

API	S7-PLCSIM Advanced instance												
	Bool	INT				UINT				Float	Double	Char	WChar
		8	16	32	64	8	16	32	64				
Bool	X												
INT8		X											
INT16		X	X			X							
INT32		X	X	X		X	X						
INT64		X	X	X	X	X	X	X					
UINT8						X							
UINT16						X	X						
UINT32						X	X	X					
UINT64						X	X	X	X				
Float										X			
Double											X		
Char												X	
WChar													X

Table 3-893 Compatible primitive data types - Write

API	S7-PLCSIM Advanced instance												
	Bool	INT				UINT				Float	Double	Char	WChar
		8	16	32	64	8	16	32	64				
Bool	X												
INT8		X	X	X	X								
INT16			X	X	X								
INT32				X	X								
INT64					X								
UINT8			X	X	X	X	X	X	X				
UINT16				X	X		X	X	X				
UINT32					X			X	X				
UINT64									X				
Float										X			
Double											X		
Char												X	
WChar													X

11.7.13 EDataType

Description

This enumeration contains all the PLC data types (STEP 7).

Table 3-894 EDataType - Native C++

Syntax	`enum EDataType`
	`{`
	`SRDT_UNKNOWN = 0,`
	`SRDT_BOOL = 1,`
	`SRDT_BYTE = 2,`
	`SRDT_CHAR = 3,`
	`SRDT_WORD = 4,`
	`SRDT_INT = 5,`
	`SRDT_DWORD = 6,`
	`SRDT_DINT = 7,`
	`SRDT_REAL = 8,`
	`SRDT_DATE = 9,`
	`SRDT_TIME_OF_DAY = 10,`
	`SRDT_TIME = 11,`
	`SRDT_S5TIME = 12,`
	`SRDT_DATE_AND_TIME = 14,`
	`SRDT_STRUCT = 17,`
	`SRDT_STRING = 19,`
	`SRDT_COUNTER = 28,`
	`SRDT_TIMER = 29,`
	`SRDT_IEC_Counter = 30,`
	`SRDT_IEC_Timer = 31,`
	`SRDT_LREAL = 48,`
	`SRDT_ULINT = 49,`
	`SRDT_LINT = 50,`
	`SRDT_LWORD = 51,`
	`SRDT_USINT = 52,`
	`SRDT_UINT = 53,`
	`SRDT_UDINT = 54,`
	`SRDT_SINT = 55,`
	`SRDT_WCHAR = 61,`
	`SRDT_WSTRING = 62,`
	`SRDT_LTIME = 64,`
	`SRDT_LTIME_OF_DAY = 65,`
	`SRDT_LDT = 66,`
	`SRDT_DTL = 67,`
	`SRDT_IEC_LTimer = 68,`
	`SRDT_IEC_SCounter = 69,`
	`SRDT_IEC_DCounter = 70,`
	`SRDT_IEC_LCounter = 71,`
	`SRDT_IEC_UCounter = 72,`
	`SRDT_IEC_USCounter = 73,`
	`SRDT_IEC_UDCounter = 74,`
	`SRDT_IEC_ULCounter = 75,`
	`SRDT_ERROR_STRUCT = 97,`
	`SRDT_NREF = 98,`
	`SRDT_CREF = 101,`
	`SRDT_AOM_IDENT = 128,`
	`SRDT_EVENT_ANY = 129,`
	`SRDT_EVENT_ATT = 130,`
	`SRDT_EVENT_HWINT = 131,`
	`SRDT_HW_ANY = 144,`
	`SRDT_HW_IOSYSTEM = 145,`
	`SRDT_HW_DPMASTER = 146,`
	`SRDT_HW_DEVICE = 147,`
	`SRDT_HW_DPSLAVE = 148,`
	`SRDT_HW_IO = 149,`
	`SRDT_HW_MODULE = 150,`
	`SRDT_HW_SUBMODULE = 151,`
	`SRDT_HW_HSC = 152,`
	`SRDT_HW_PWM = 153,`

	SRDT_HW_PTO = 154, SRDT_HW_INTERFACE = 155, SRDT_HW_IEPORT = 156, SRDT_OB_ANY = 160, SRDT_OB_DELAY = 161, SRDT_OB_TOD = 162, SRDT_OB_CYCLIC = 163, SRDT_OB_ATT = 164, SRDT_CONN_ANY = 168, SRDT_CONN_PRG = 169, SRDT_CONN_OUC = 170, SRDT_CONN_R_ID = 171, SRDT_PORT = 173, SRDT_RTM = 174, SRDT_PIP = 175, SRDT_OB_PCYCLE = 192, SRDT_OB_HWINT = 193, SRDT_OB_DIAG = 195, SRDT_OB_TIMEERROR = 196, SRDT_OB_STARTUP = 197, SRDT_DB_ANY = 208, SRDT_DB_WWW = 209, SRDT_DB_DYN = 210, SRDT_DB = 257 };

Table 3-895 EDataType - .NET (C#)

Syntax	public enum EDataType { Unknown = 0, Bool = 1, Byte = 2, Char = 3, Word = 4, Int = 5, DWord = 6, DInt = 7, Real = 8, Date = 9, TimeOfDay = 10, Time = 11, S5Time = 12, DateAndTime = 14, Struct = 17, String = 19, Counter = 28, Timer = 29, IEC_Counter = 30, IEC_Timer = 31, LReal = 48, ULInt = 49, LInt = 50, LWord = 51, USInt = 52, UInt = 53, UDInt = 54, SInt = 55, WChar = 61, WString = 62, LTime = 64, LTimeOfDay = 65, LDT = 66, DTL = 67, IEC_LTimer = 68, IEC_SCounter = 69, IEC_DCounter = 70, IEC_LCounter = 71, IEC_UCounter = 72, IEC_USCounter = 73,

	IEC_UDCounte = 74, IEC_ULCounter = 75, ErrorStruct = 97, NREF = 98, CREF = 101, Aom_Ident = 128, Event_Any = 129, Event_Att = 130, Event_HwInt = 131, Hw_Any = 144, Hw_IoSystem = 145, Hw_DpMaster = 146, Hw_Device = 147, Hw_DpSlave = 148, Hw_Io = 149, Hw_Module = 150, Hw_SubModule = 151, Hw_Hsc = 152, Hw_Pwm = 153, Hw_Pto = 154, Hw_Interface = 155, Hw_IEPort = 156, OB_Any = 160, OB_Delay = 161, OB_Tod = 162, OB_Cyclic = 163, OB_Att = 164, Conn_Any = 168, Conn_Prg = 169, Conn_Ouc = 170, Conn_R_ID = 171, Port = 173, Rtm = 174, Pip = 175, OB_PCycle = 192, OB_HwInt = 193, OB_Diag = 195, OB_TimeError = 196, OB_Startup = 197, DB_Any = 208, DB_WWW = 209, DB_Dyn = 210, DB = 257 }

11.7.14 ETagListDetails

Description

This list contains all PLC areas that can be used as a filter to update the tag table.

Table 3-896 ETagListDetails - Native C++

Syntax	enum ETagListDetails { SRTLD_NONE = 0, SRTLD_IO = 1, SRTLD_M = 2, SRTLD_IOM = 3, SRTLD_CT = 4, SRTLD_IOCT = 5, SRTLD_MCT = 6, SRTLD_IOMCT = 7, SRTLD_DB = 8, SRTLD_IODB = 9, SRTLD_MDB = 10, SRTLD_IOMDB = 11,

	SRTLD_CTDB = 12, SRTLD_IOCTDB = 13, SRTLD_MCTDB = 14, SRTLD_IOMCTDB = 15 };

Table 3-897 ETagListDetails - .NET (C#)

Syntax	enum ETagListDetails
	{
	None = 0,
	IO = 1,
	M = 2,
	IOM = 3,
	CT = 4,
	IOCT = 5,
	MCT = 6,
	IOMCT = 7,
	DB = 8,
	IODB = 9,
	MDB = 10,
	IOMDB = 11,
	CTDB = 12,
	IOCTDB = 13,
	MCTDB = 14,
	IOMCTDB = 15
	}

11.7.15 ERuntimeConfigChanged

Description

This list contains all possible causes of an OnConfigurationChanged event that the Runtime Manager sends.

Table 3-898 ERuntimeConfigChanged - Native C++

Syntax	enum ERuntimeConfigChanged
	{
	SRCC_INSTANCE_REGISTERED = 0,
	SRCC_INSTANCE_UNREGISTERED = 1
	SRCC_CONNECTION_OPENED = 2,
	SRCC_CONNECTION_CLOSED = 3,
	SRCC_PORT_OPENED = 4,
	SRCC_PORT_CLOSED = 5
	SRCC_NETWORK_MODE_CHANGED = 6,
	SRCC_STRICT_MOTION_CHANGED = 7
	};

Table 3-899 ERuntimeConfigChanged - .NET (C#)

Syntax	enum ERuntimeConfigChanged
	{
	InstanceRegistered = 0,
	InstanceUnregistered = 1,
	ConnectionOpened = 2,
	ConnectionClosed = 3,
	PortOpened = 4,
	PortClosed = 5,
	NetworkModeChanged = 6,
	StrictMotionChanged = 7
	}

11.7.16 EPullOrPlugEventType

Description

This enumeration contains predefined types of pull/plug events for S7 modules.

Table 3-900 EPullOrPlugEventType - Native C++

Syntax	`enum EPullOrPlugEventType`
	`{`
	`SR_PPE_UNDEFINED = 0,`
	`SR_PPE_PULL_EVENT = 1,`
	`SR_PPE_PLUG_EVENT = 2,`
	`SR_PPE_PLUG_EVENT_ERROR_REMAINS = 3,`
	`SR_PPE_PLUG_WRONG_MODULE_EVENT = 4`
	`};`

Table 3-901 EPullOrPlugEventType - .NET (C#)

Syntax	`enum EPullOrPlugEventType`
	`{`
	`Undefined = 0,`
	`Pull = 1,`
	`Plug = 2,`
	`PlugErrorRemains = 3,`
	`PlugWrongModule = 4`
	`}`

11.7.17 EProcessEventType

Description

This enumeration contains predefined types of process events for S7 modules.

Table 3-902 EProcessEventType - Native C++

Syntax	`enum EProcessEventType`
	`{`
	`SR_PET_UNDEFINED = 0,`
	`SR_PET_RISING_EDGE = 1,`
	`SR_PET_FALLING_EDGE = 2,`
	`SR_PET_LIMIT1_UNDERRUN = 3,`
	`SR_PET_LIMIT1_OVERRUN = 4,`
	`SR_PET_LIMIT2_UNDERRUN = 5,`
	`SR_PET_LIMIT2_OVERRUN = 6`
	`};`

Table 3-903 EProcessEventType - .NET (C#)

Syntax	`enum EProcessEventType`
	`{`
	`Undefined = 0,`
	`RisingEdge = 1,`
	`FallingEdge = 2,`
	`Limit_1_Underrun = 3,`
	`Limit_1_Overrun = 4,`
	`Limit_2_Underrun = 5,`
	`Limit_2_Overrun = 6`
	`}`

11.7.18 ESoftwareConfigChanged

Description

This enumeration contains download case indicators for an OnSoftwareConfigurationChanged event.

Table 3-904 ESoftwareConfigChanged - Native C++

Syntax	`enum ESoftwareConfigChanged`
	`{`
	` SRSCC_SOFTWARE_CHANGED_IN_STOP,`
	` SRSCC_SOFTWARE_CHANGED_IN_RUN`
	`};`

11.7.19 EDirection

Description

This enumeration contains properties of the diagnostic alarm.

Table 3-905 EDirection - Native C++

Syntax	`enum EDirection`
	`{`
	`SRD_DIRECTION_INPUT = 0,`
	`SRD_DIRECTION_OUTPUT = 1`
	`};`

Table 3-906 EDirection - .NET (C#)

Syntax	`enum EDirection`
	`{`
	`Input = 0,`
	`Output = 1`
	`}`

11.7.20 EDiagProperty

Description

This enumeration contains the incoming/outgoing information of the diagnostic alarm.

Table 3-907 EDiagProperty - Native C++

Syntax	`enum EDiagProperty`
	`{`
	`SRP_DIAG_APPEAR = 1,`
	`SRP_DIAG_DISAPPEAR = 2`
	`};`

Table 3-908 EDiagProperty - .NET (C#)

Syntax	`enum EDiagProperty`
	`{`
	`Appear = 1,`
	`Disappear = 2`
	`}`

11.7.21 EDiagSeverity

Description

This enumeration contains the severity of the diagnostic alarm (error, maintenance demanded, maintenance required).

Table 3-909 EDiagSeverity - Native C++

Syntax	`enum EDiagSeverity`
	`{`
	`SRDS_SEVERITY_FAILURE = 0,`
	`SRDS_SEVERITY_MAINTENANCE_DEMANDED = 1,`
	`SRDS_SEVERITY_MAINTENANCE_REQUIRED = 2`
	`};`

Table 3-910 EDiagSeverity - .NET (C#)

Syntax	`enum EDiagSeverity`
	`{`
	`Failure = 0,`
	`MaintDemanded = 1,`
	`MaintRequired = 2`
	`}`

11.7.22 ERackOrStationFaultType

Description

This enumeration contains the types of the RackOrStationFault event.

Table 3-911 ERackOrStationFaultType - Native C++

Syntax	`enum ERackOrStationFaultType`
	`{`
	`SR_RSF_FAULT = 0,`
	`SR_RSF_RETURN = 1`
	`};`

Table 3-912 ERackOrStationFaultType - .NET (C#)

Syntax	`enum ERackOrStationFaultType`
	`{`
	`Fault = 0,`
	`Return = 1`
	`}`

11.7.23 ECycleTimeMonitoringMode

Description

This enumeration contains the sources of the timer for the maximum cycle time monitoring.

Table 3-913 ECycleTimeMonitoringMode - Native C++

Syntax	`enum ECycleTimeMonitoringMode`
	`{`
	`SRCTMM_DOWNLOADED = 0,`
	`SRCTMM_IGNORED = 1,`
	`SRCTMM_SPECIFIED = 2`
	`};`

Table 3-914 ECycleTimeMonitoringMode - .NET (C#)

Syntax	`enum ECycleTimeMonitoringMode`
	`{`
	`Downloaded = 0,`
	`Ignored = 1,`
	`Specified = 2`
	`}`

11.7.24 EAutodiscoverType

Description

This enumeration is used in the Autodiscover Callback function.

Table 3-915 EAutodiscoverType - Native C++

Syntax	`enum EAutodiscoverType`
	`{`
	`SRRSI_DISCOVER_STARTED = 0,`
	`SRRSI_DISCOVER_DATA = 1,`
	`SRRSI_DISCOVER_FINISHED = 2`
	`};`

Table 3-916 EAutodiscoverType - .NET (C#)

Syntax	`public enum EAutodiscoverType`
	`{`
	`AutodiscoverStarted = 0,`
	`AutodiscoverData = 1,`
	`AutodiscoverFinished = 2`
	`}`

11.7.25 ESecurityMode

Description

This enumeration is used in the OpenPort API function to set the protection level of remote runtime communication.

Table 3-917 EAutodiscoverType - Native C++

Syntax	`enum class ESecurityMode`
	`{`
	`UNSECURED = 0,`
	`ENCRYPTED_COMMUNICATION = 1,`
	`UNKNOWN = -1`
	`};`

Table 3-918 EAutodiscoverType - .NET (C#)

Syntax	`public enum class ESecurityMode`
	`{`
	`Unsecured,`
	`EncryptedCommunication,`
	`Unknown`
	`}`

Examples/applications

12

12.1 Example: Communication via TCP/IP in Single Adapter Network Mode (promiscuous mode)

In Single Adapter Network Mode (promiscuous mode), the network adapter reads all incoming telegrams. The network adapter also reads telegrams that are not intended for the network adapter. The network adapter then forwards the data to the operating system for processing.

However, on virtualization platforms or corporate networks, it is often not permitted to run the network interface of the PC in Single Adapter Network Mode (promiscuous mode) for security reasons. For an example on Multi-Adapter Mode (non-prmiscuous mode), see the next topic (Page 291).

The following figure provides an overview of the possibilities and differences between the following communication options:

- Local TCP/IP communication
- Single Adapter Network Mode (promiscuous mode)
- Multi-Adapter Network Mode (non-promiscuous mode)

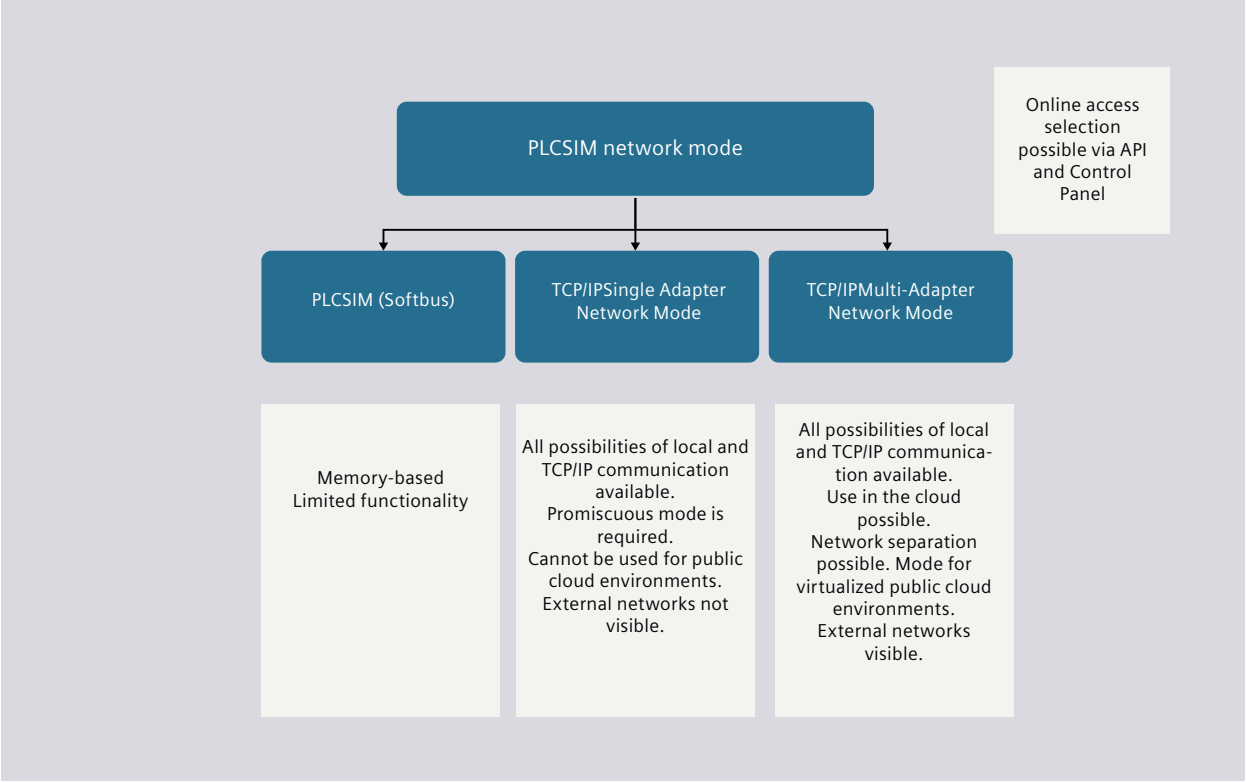

Figure 3-270 PLCSIM_networking

Example code

In this example, the physical interface is set to promiscuous mode and receives all packets; PCAP is filtering traffic. Each PLC interface has its own unique MAC address. Only two network adapters can be connected to the PLCSIM virtual switch.

```
#include "SimulationRuntimeApi.h"


ISimulationRuntimeManager* rtm = nullptr;
IInstance* instance0 = nullptr;
IInstance* instance1 = nullptr;
ERuntimeErrorCode result = SREC_INVALID_ERROR_CODE;


//initialize connection
InitializeApi(&rtm);


//set TCPIP single adapter mode (softbus mode is default)
rtm->SetNetworkMode(ENetworkMode::TCPIP_SINGLE_ADAPTER);


rtm->RegisterInstance(&instance0);
rtm->RegisterInstance(&instance1);
instance0->PowerOn(60000);
instance1->PowerOn(60000);


ShutdownAndFreeApi(rtm);
```

12.2 Example: Communication via TCP/IP in Multi-Adapter Network Mode (non-promiscuous mode)

In Multi-Adapter Network Mode (non-promiscuous mode), the evaluation of MAC addresses ensures that only data intended for the network adapter reaches the operating system.

Overview

The following figure provides an overview of the possibilities and differences between the following communication options:

- Local TCP/IP communication
- Single Adapter Network Mode (promiscuous mode)
- Multi-Adapter Network Mode (non-promiscuous mode)

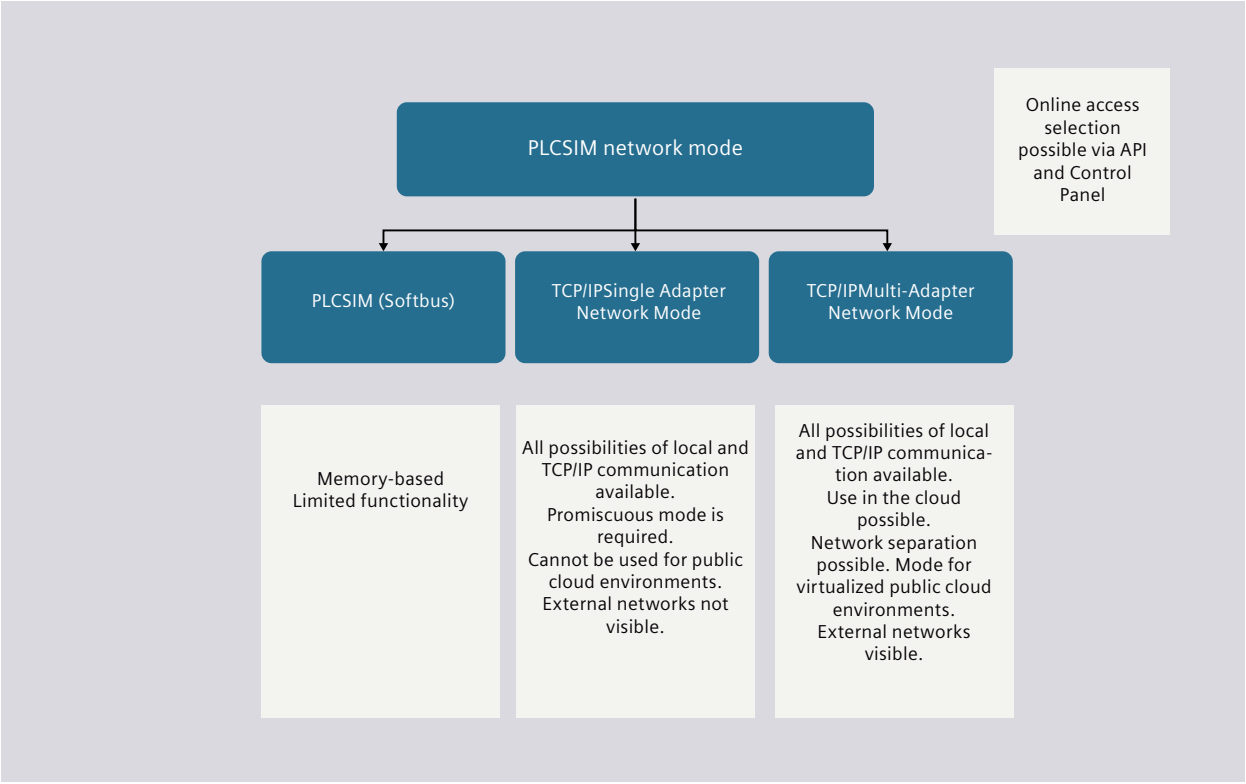

Figure 3-271 PLCSIM networking

Applications

The following applications describe how you can also communicate in Multi-Adapter Network Mode (non-promiscuous mode). You communicate in this mode by performing a one-to-one mapping of the MAC addresses between the CPU network interfaces and the network adapters of the PC.

The following applications assume that you are working in an environment where security restrictions apply and you have therefore switched to Multi-Adapter Network Mode (non-promiscuous mode).

Application 1:

You start multiple instances. Each CPU interface is assigned to the MAC address of the respective physical or virtual PC adapter.

Precondition: Each interface of a running instance is assigned to its own physical or virtual PC interface (one-to-one mapping).

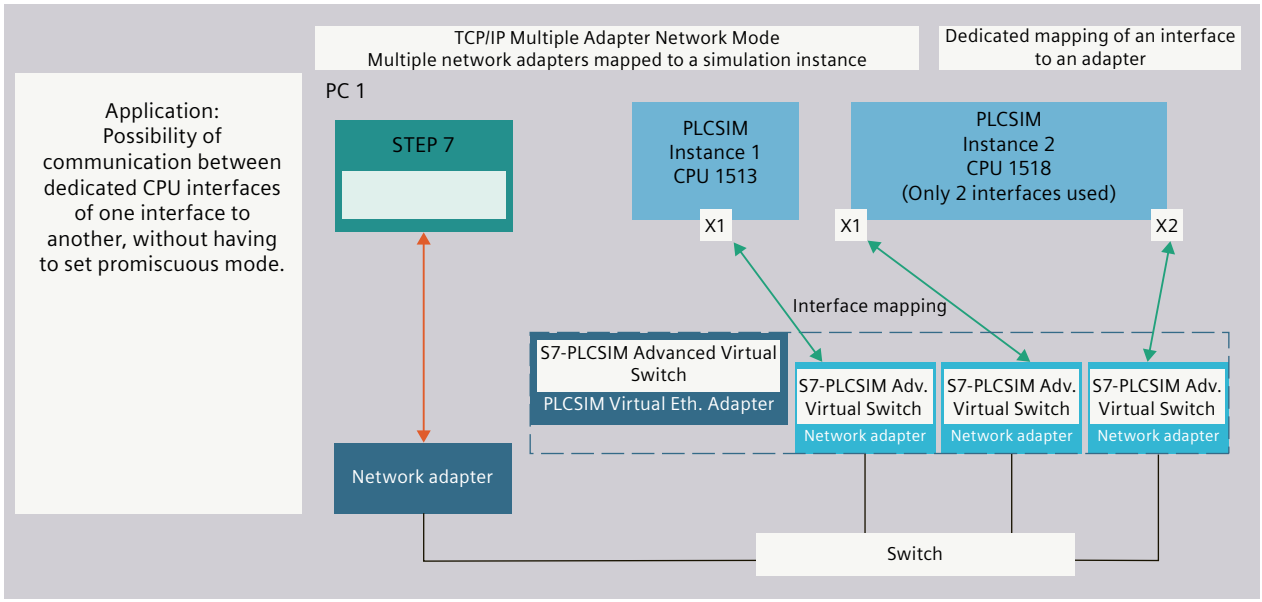

Figure 3-272 Application 1

Application 2:

The following application shows the behavior with multiple instances that have the same MAC addresses. Each CPU interface is assigned to the corresponding physical or virtual PC adapter.

The scenario is only valid if only one instance is running at a time.

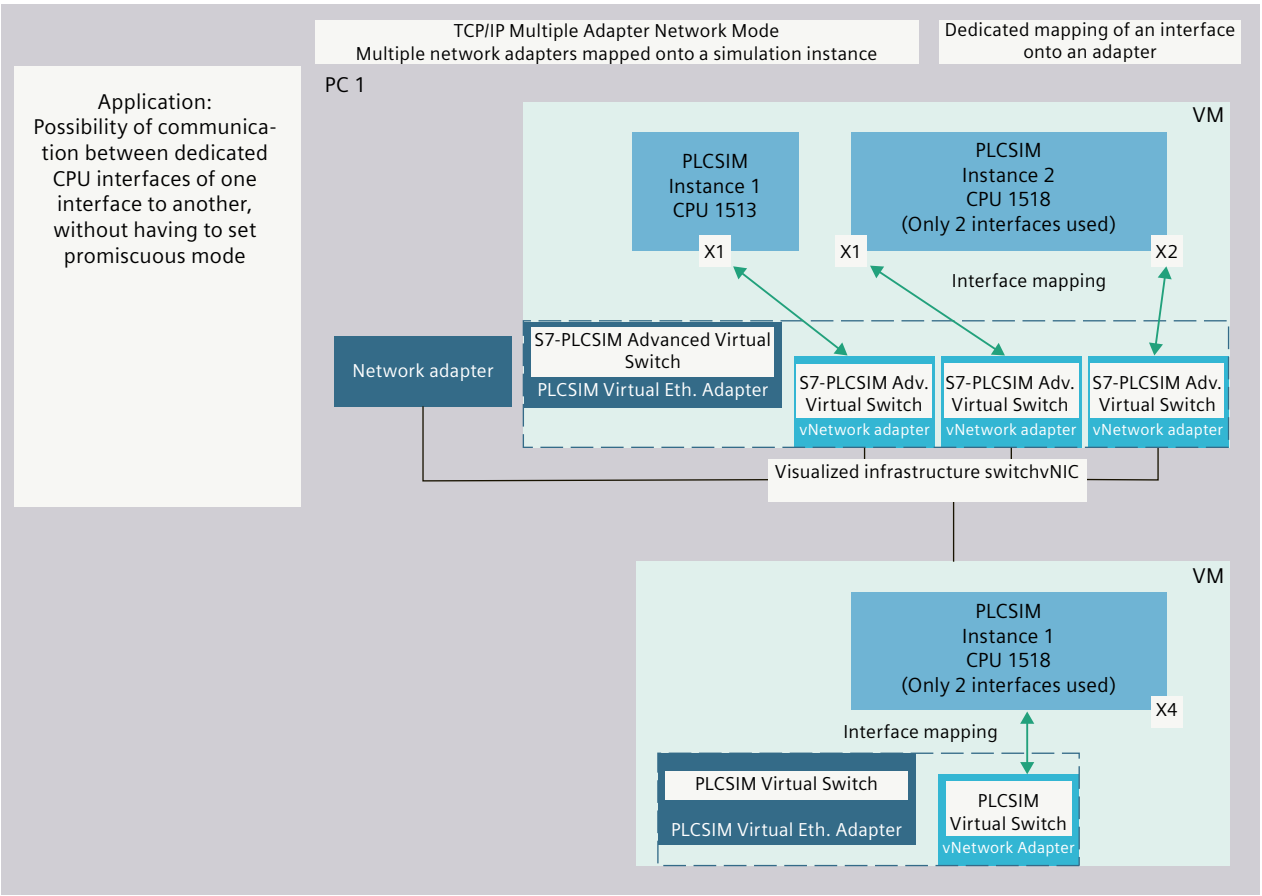

Figure 3-273 Application 2

Procedure

For external communication in Multi-Adapter Network Mode (non-promiscuous mode), the following steps are necessary depending on your application.

1. Use the following instruction to switch to Multi-Adapter Network Mode (non-promiscuous mode):
   `SetNetworkMode(SRCM_VSWITCH_NON_PROMISCUOUS)`
2. To register a new instance, call `RegisterInstance()`.
3. To select which PC interface is assignable to which CPU interface by means of a list of PC interfaces, call `GetNetInterfaces()`.
4. To execute an interface mapping between CPU and PC interface, call `SetNetInterfaceMapping(0, 23)`.
5. To check whether the configuration is correct, call `CheckNetInterfaceMapping()`.
6. To start the instance, call `PowerOn()`.

   Before starting, the instance performs an internal check.

NOTE

Setting a storage path for a new instance

If you use the `SetStoragePath()` function to set a storage path for a new instance, call this function before the MAC address is set. Otherwise, the MAC address is discarded.

This procedure is also valid for the stored CPU type and CPU serial number.

The `CleanupStoragePath()` function deletes not only the storage path but also the assignments of the network interfaces.

Examples in C++

The following examples show possible network configurations in C++.

For scenarios with more than one adapter, make sure to register the instance with a CPU that has the required number of interfaces. In the following examples we use three interfaces. Therefore we register the instance with a CPU with 3 PROFINET interfaces, such as the CPU 1518-4 PN/DP.

Example 1: Simplified settings

```
#include "SimulationRuntimeApi.h"

ISimulationRuntimeManager* rtm = nullptr;
IInstance* instance0 = nullptr;
IInstance* instance1 = nullptr;
ERuntimeErrorCode result = SREC_INVALID_ERROR_CODE;

//initialize connection
InitializeApi(&rtm);

//set NON-P mode
```

```
rtm->SetNetworkMode(ENetworkMode::TCPIP_MULTIPLE_ADAPTER);

rtm->RegisterInstance(ECPUType::SRCT_1518, &instance0);
instance0->SetNetInterfaceMapping(EPLCInterface::IE1, L"Ethernet");
instance0->SetNetInterfaceMapping(EPLCInterface::IE2, L"Ethernet
2");
instance0->SetNetInterfaceMapping(EPLCInterface::IE3, L"Ethernet
3");
instance0->PowerOn(60000);

rtm->RegisterInstance(ECPUType::SRCT_1518, &instance1);
instance1->SetNetInterfaceMapping(EPLCInterface::IE1, L"Ethernet
4");
instance1->SetNetInterfaceMapping(EPLCInterface::IE2, L"Ethernet
5");
instance1->SetNetInterfaceMapping(EPLCInterface::IE3, L"Ethernet
6");
instance1->PowerOn(60000);

ShutdownAndFreeApi(rtm);
```

Example 2: Complete settings

```
#include <iostream>
#include "SimulationRuntimeApi.h"

ISimulationRuntimeManager* rtm = nullptr;
IInstance* instance0 = nullptr;
IInstance* instance1 = nullptr;
ERuntimeErrorCode result = SREC_INVALID_ERROR_CODE;

// initialize connection
InitializeApi(&rtm);

// User can get the current network mode using GetNetworkMode. The
default mode is softbus.
ENetworkMode netMode;
rtm->GetNetworkMode(&netMode);

// If TCPIP_MULTIPLE_ADAPTER is set, the SetNetworkMode will not set
it again.
rtm->SetNetworkMode(ENetworkMode::TCPIP_MULTIPLE_ADAPTER);

rtm->RegisterInstance(ECPUType::SRCT_1518, &instance0);
rtm->RegisterInstance(ECPUType::SRCT_1518, &instance1);
```

```
// gather network interfaces in computer
// get count of network interfaces
UINT count;
result = rtm->GetNetInterfaces(nullptr, &count);

// get network interfaces
// GetNetInterfaces will return adapters with disabled
vSwitch and/or not connected as well
std::unique_ptr<SNetInterfaceInfo[]> netInterfaces =
std::make_unique<SNetInterfaceInfo[]>(count);
result = rtm->GetNetInterfaces(netInterfaces.get(), &count);

// map desired interface on instance interface
// each instance interface must have unique or no mapping
// we can map interface by these three overloads
//
// interfaceIndex
result = instance0->SetNetInterfaceMapping(EPLCInterface::IE1,
netInterfaces.get()[0].interfaceIndex);
// friendly name
result = instance0->SetNetInterfaceMapping(EPLCInterface::IE2,
netInterfaces.get()[1].interfaceName);
// MAC address
result = instance0->SetNetInterfaceMapping(EPLCInterface::IE3,
&netInterfaces.get()[2].MACAddress);

// set mapping on second instance
result = instance1->SetNetInterfaceMapping(EPLCInterface::IE1,
&netInterfaces.get()[3].MACAddress);
result = instance1->SetNetInterfaceMapping(EPLCInterface::IE2,
&netInterfaces.get()[4].MACAddress);
result = instance1->SetNetInterfaceMapping(EPLCInterface::IE3,
&netInterfaces.get()[5].MACAddress);

// we can also check what is mapped on the interface
INT32 mappedInterfaceIndex = instance0-
>GetNetInterfaceMapping(EPLCInterface::IE1);
if (mappedInterfaceIndex == 0)
{
std::cout << "No mapping is set";
}

if (mappedInterfaceIndex == netInterfaces.get()[0].interfaceIndex)
{
std::cout << netInterfaces.get()[0].interfaceName << "is mapped on
EPLCInterface::IE1";
```

```
}

// set S7-PLCSIM Advanced Virtual Switch according to set mapping
// !! requires elevated (admin) mode !!
rtm->SetNetInterfaceBindings();

// check whether setting is valid - optional -
CheckNetInterfaceMapping() function is also called inside PowerOn()
result = instance0->CheckNetInterfaceMapping();
if (result != SREC_OK)
{
return result;
}

instance0->PowerOn(60000);
instance1->PowerOn(60000);

ShutdownAndFreeApi(rtm);
```

SIEMENS

SIMATIC

S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro, ET 200eco PN Diagnostics

Function Manual

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11/2024

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Introduction 1

Purpose of the documentation

This Function Manual provides an overview of the diagnostics options for the SIMATIC S7-1500 automation system, for 1513pro-2 PN and 1516pro-2 PN CPUs based on SIMATIC S7-1500, and for the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems.

The documentation covers the following:

- Illustration of the uniformity and consistency of system diagnostics
- Overview of the options for obtaining system diagnostics information

Basic knowledge required

The following knowledge is required in order to understand the function manual:

- General knowledge in the field of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge of working with STEP 7, WinCC , and WinCC Unified
- Knowledge about the use of Microsoft Windows operating systems

Scope of the documentation

This documentation is the basic documentation for all products of the S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200eco PN systems, as well as for the 1513pro-2 PN and 1516pro-2 PN CPUs. The product documentation is based on this documentation.

What's new in the Diagnostics Function Manual, Edition 11/2024 compared with Edition 11/2023

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Configuring system diagnostics in the CPU properties	You receive information on the settings options for the system diagnostics in the CPU properties.	Section Configuring system diagnostics in the CPU properties (Page 27)
Changed contents	Configuring alarms for system diagnostics in the project	You receive information on how to configure system diagnostics settings for your project	Section Configuring alarms for system diagnostics in the project (Page 28)

What's new in the Diagnostics Function Manual, Edition 11/2023 compared with Edition 11/2022

What's new?		What are the customer benefits?	Where can I find the information?
Changed contents	Addition to section "Showing diagnostic information on an HMI device"	You receive information on configuring system diagnostics in WinCC Unified.	Section System diagnostics in WinCC Unified (Page 70)

What's new in the Diagnostics Function Manual, Edition 11/2022 compared with Edition 11/2019

What's new?		What are the customer benefits?	Where can I find the information?
Changed contents	Addition to section "Diagnostics of the S7-1500R/H redundant system"	You receive information on diagnostics of R1 devices. An example shows you how to perform diagnostics for a faulty connection.	Section Diagnostics of the S7-1500R/H redundant system (Page 101)

What's new in the Diagnostics function manual, Edition 11/2019 compared to Edition 10/2018

What's new?		What are the customer benefits?	Where can I find the information?
Changed contents	Updated restrictions for the S7-1500R/H redundant system	Functions with which you are familiar from the SIMATIC S7-1500 automation system are implemented for the S7-1500R/H redundant system.	Section Diagnostics of the S7-1500R/H redundant system (Page 101)

What's new in the Diagnostics function manual, Edition 10/2018 compared to Edition 09/2016

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Description of the diagnostics of the S7-1500R/H redundant system	You obtain information in compact form on the special features of the diagnostics in S7-1500R/H redundant systems.	Section Diagnostics of the S7-1500R/H redundant system (Page 101)
Changed contents	Scope of the Function Manual expanded to include the S7-1500R/H redundant system	Functions with which you are familiar from the SIMATIC S7-1500 automation system are implemented for the S7-1500R/H redundant system.	Redundant System S7-1500R/H System Manual (https://support.industry.siemens.com/cs/ww/en/view/109754833)

What's new in the Diagnostics function manual, Edition 09/2016 compared to Edition 06/2014

What's new?		What are the customer benefits?	Where can I find the information?
New contents	Extended functionality of the Web server		Section Diagnostics information using the web server (Page 50),

What's new?		What are the customer benefits?	Where can I find the information?
New contents		• You obtain information about: – Know-how protection or copy protection of the PLC program – Program/communication load and cycle time – Collective signatures, cycle times, and runtimes of the F-runtime group(s) (with an F-CPU) • You can monitor statuses, errors, technology alarms and the current values of technology objects (TOs) with the Web server. • You can read, view and save trace recordings via the Web server and thus obtain plant and project information for diagnostics and maintenance without STEP 7. • You can set four additional languages for the Web server interface.	Web server (http://support.automation.siemens.com/WW/view/en/59193560) function manual, Using the trace and logic analyzer function (https://support.industry.siemens.com/cs/ww/en/view/64897128) function manual
	Assignment of different project languages extended	You can assign up to three different project languages for comments and alarm texts to the user interface languages of display devices.	Section Editing alarms in the alarm editor (Page 83)
Changed contents	Scope of the function manual expanded to include CPU 1516pro-2 PN	Functions that you will be familiar with from the SIMATIC S7-1500 CPUs are implemented in the CPU 1516pro-2 PN (degree of protection IP65, IP66, and IP67).	Operating instructions CPU 1516pro-2 PN (https://support.industry.siemens.com/cs/ww/en/view/109482416)
	Security events added	You know which types of events are registered as security events in the diagnostics buffer and can configure group alarms for them.	Section CPU diagnostics buffer (Page 44)
	Influence of the value status explained	You know which factors influence the bit in the value status and can take this into account during configuration.	Section System diagnostics using process image inputs (Page 78)
	Note added on the maximum configuration limits of program alarms.		Section Creating alarms with the "Program_Alarm" instruction (Page 82).

Conventions

STEP 7: We refer to "STEP 7" in this documentation as a synonym for the configuration and programming software "STEP 7 as of V12 (TIA Portal)" and subsequent versions.

This document contains illustrations of the described devices. The illustrations may differ slightly from the device supplied.

You should also pay particular attention to notes such as the one shown below:

NOTE

A note contains important information on the product, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

1.1 Function Manuals documentation guide

1.1.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information

- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Overview of system diagnostics 3

3.1 Properties of system diagnostics

Introduction

In the SIMATIC environment, the term "system diagnostics" refers to diagnostics of devices and modules.

All SIMATIC products have integrated diagnostic functions that you can use to detect and remedy faults. The components automatically flag a potential fault in the operation and provide detailed information. You can minimize unscheduled standstill times with plant-wide diagnostics.

The SIMATIC automation system monitors the following states in the running plant:

- Device failure/recovery
- Insert/remove event
- Module fault
- I/O access error
- Channel fault
- Parameter assignment error
- Failure of the external auxiliary voltage

Properties ofSIMATIC system diagnostics

- Integrated as standard in the hardware
- System-wide across bus limits
- Automatic localization of the error source
- Automatic output of the cause of the error in plain text
- Plant-wide diagnostics of all components
- Archiving and logging of alarms
- Configurability of alarms

Consistent diagnostics from the field level all the way to the management level

The various diagnostics media give you a uniform view of maintenance-related information of every automation component in the plant: System status (module and network status, alarms for system errors) are available plant-wide in a uniform display.

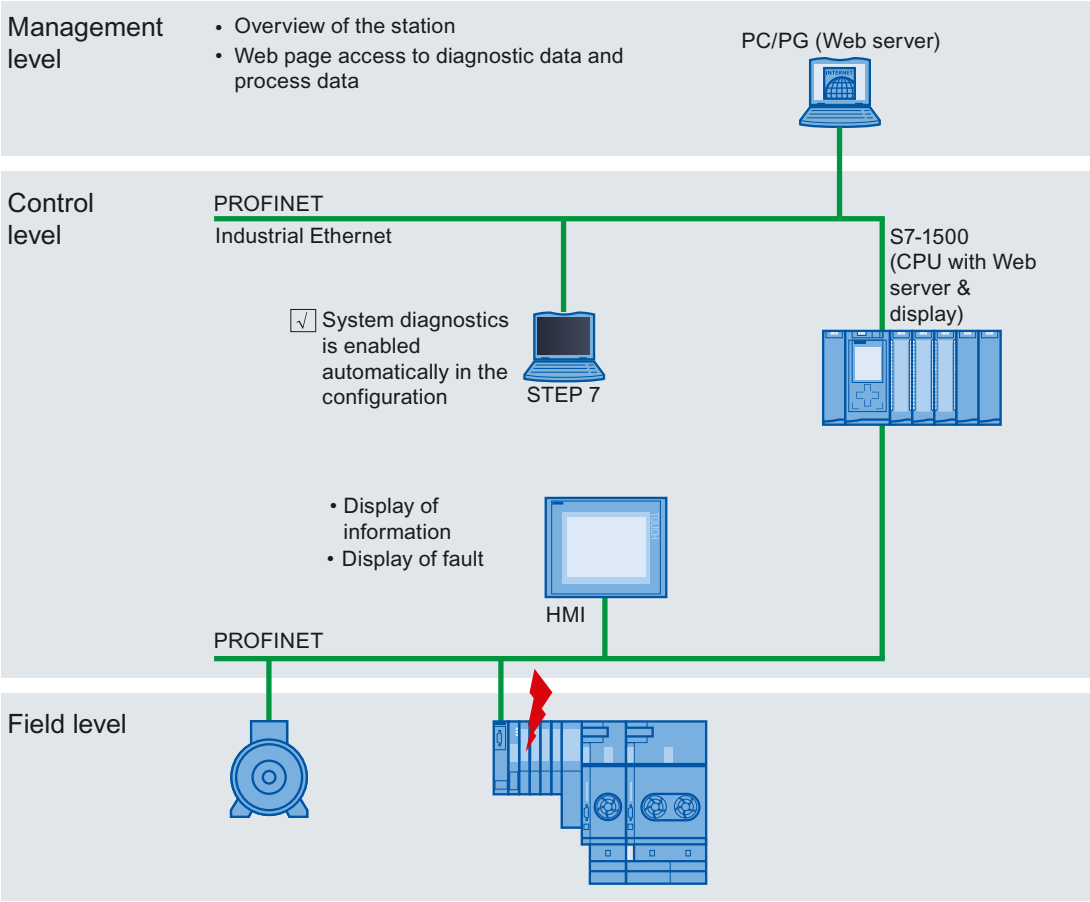

Figure 3-274 Overview of system diagnostics in a plant

3.2 Benefits of innovative system diagnostics

System diagnostics is also possible in STOP

The system diagnostics is integrated in the firmware of the CPU and works independently of the cyclic user program. This means it is also available in the STOP CPU operating mode. Faults are detected immediately and signaled to the higher-level HMI devices, the Web server and the display of the SIMATIC S7-1500 CPU, even in STOP mode. This makes system diagnostics consistent with the actual plant state at all times.

Uniform display concept

All clients of a system are provided with diagnostics information by a uniform mechanism. The same system diagnostics information is used regardless of the display medium.

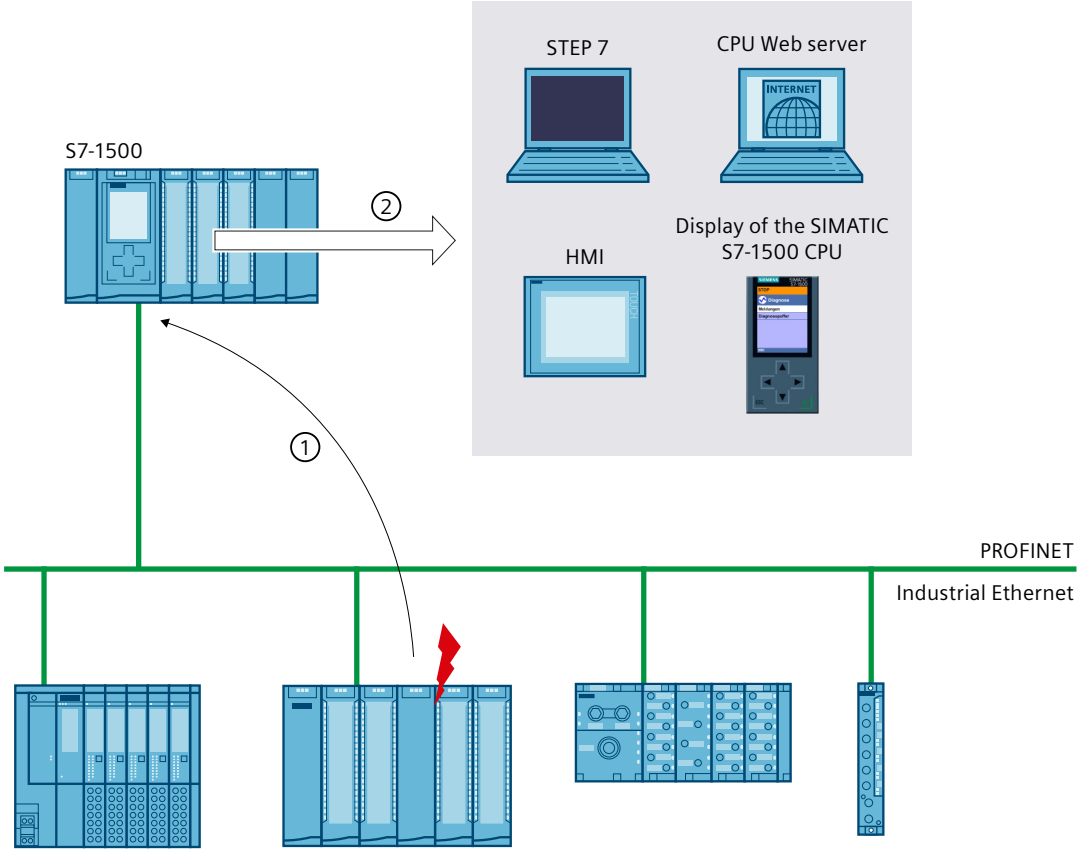

Step	Description
①	The device detects an error and sends diagnostics data to the assigned CPU.
②	The CPU informs the connected display media. The display of the system diagnostics is updated.

Figure 3-275 Sequence of the system diagnostics

Quick start

4

Introduction

The following chapters of this documentation describe the different options for establishing system diagnostics. All described options can be used independently of one another.

This chapter gives you an overview of the basic procedure to get initial diagnostics information fast.

NOTE

System diagnostics is generally available for the devices of the SIMATIC series.

4.1 Using the display of the CPU

The display of the SIMATIC S7-1500 CPU offers a fast and direct option to get diagnostics information. You can call up status information in different menus on the display.

Requirements

- A project has been created.
- The project has been downloaded to the CPU.

Determining diagnostics information using the display of the SIMATIC S7-1500 CPU

To determine diagnostics information using the display, follow these steps:

1. Select the "Diagnostics" menu on the display.
2. Select the "Diagnostics buffer" command from the "Diagnostics" menu.

Figure 3-276 Display of SIMATIC S7-1500 CPU

Result

The diagnostics events are displayed in the diagnostics buffer in the sequence in which they occur.

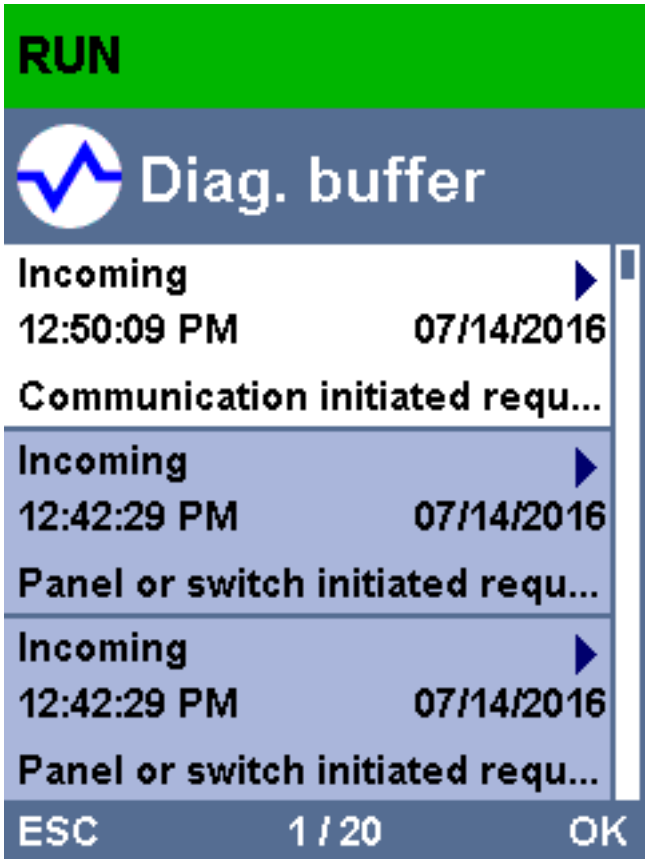

Figure 3-277 Display of the diagnostics buffer in the display of the SIMATIC S7-1500 CPU

NOTE

Automatic updating of diagnostics information

You set automatic updating of the diagnostics information under: "Display" > "DiagnosticRefresh".

Additional information

You can find information about the configuration of alarms in the section Configuring alarms for system diagnostics in the project (Page 28).

4.2 Using STEP 7

Getting started with STEP 7 gives you fast access to detailed diagnostics information.

Requirements

- A project has been created.
- The project has been downloaded to the CPU.
- An error has occurred.
- The programming device must be able to establish a connection to the CPU via an interface.

Determining diagnostics information using STEP 7

To determine diagnostics information using STEP 7, follow these steps:

1. Open the respective project in STEP 7.
2. Open the portal view of STEP 7.
3. Select the "Online & Diagnostics" portal.
4. Select the "Online status" action.

   The "Select device" dialog opens. The dialog is an image of the configured devices in the project.

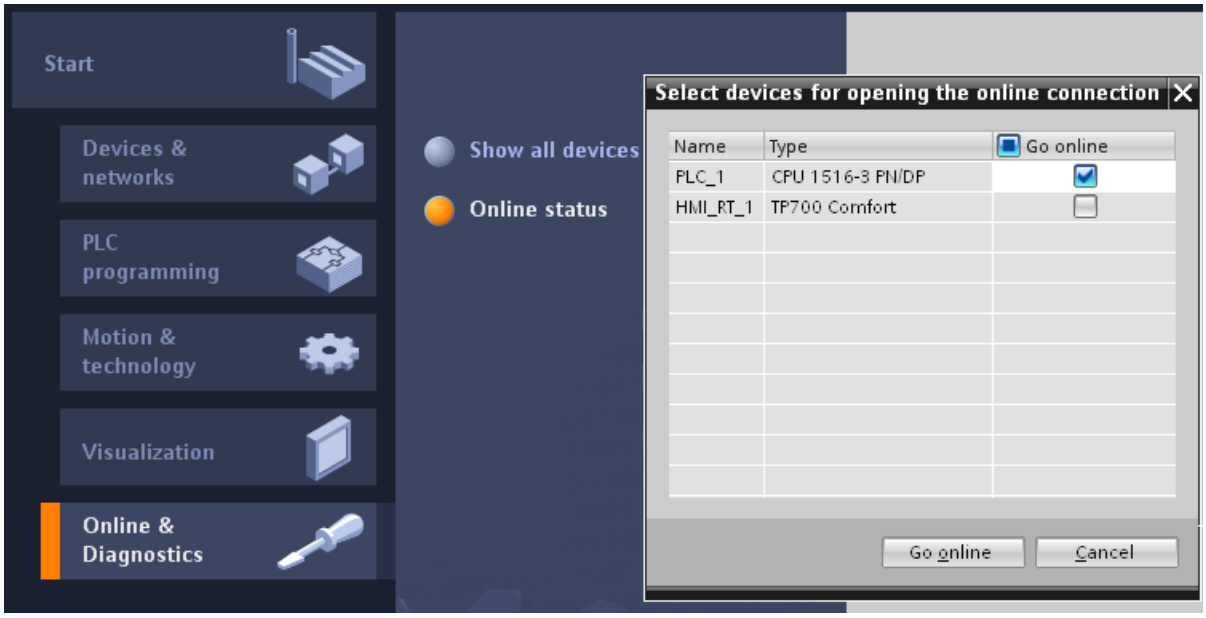

Figure 3-278 Device selection for online connection in the portal view

5. Activate the "Go online" option button for the device that you want to use to establish an online connection.
6. Click on the "Go online" button.

7. The "Go online" dialog opens.

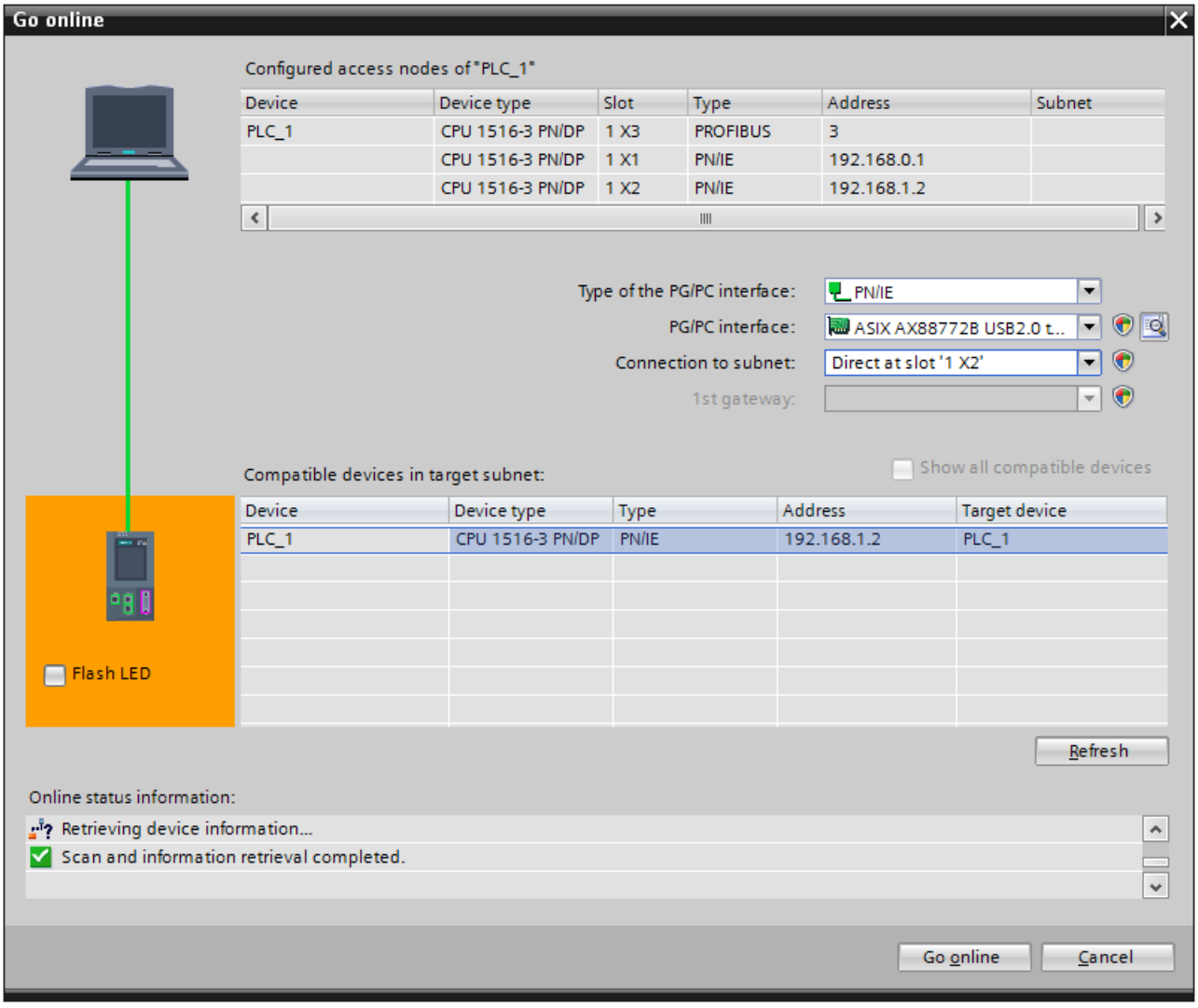

Figure 3-279 Establishing an online connection

8. Make the settings for the interface.

9. Click on the "Go online" button.
   The project view of STEP 7 opens. The network view is opened in the work area.
   The symbols in the project tree provide initial information about the faulty modules.

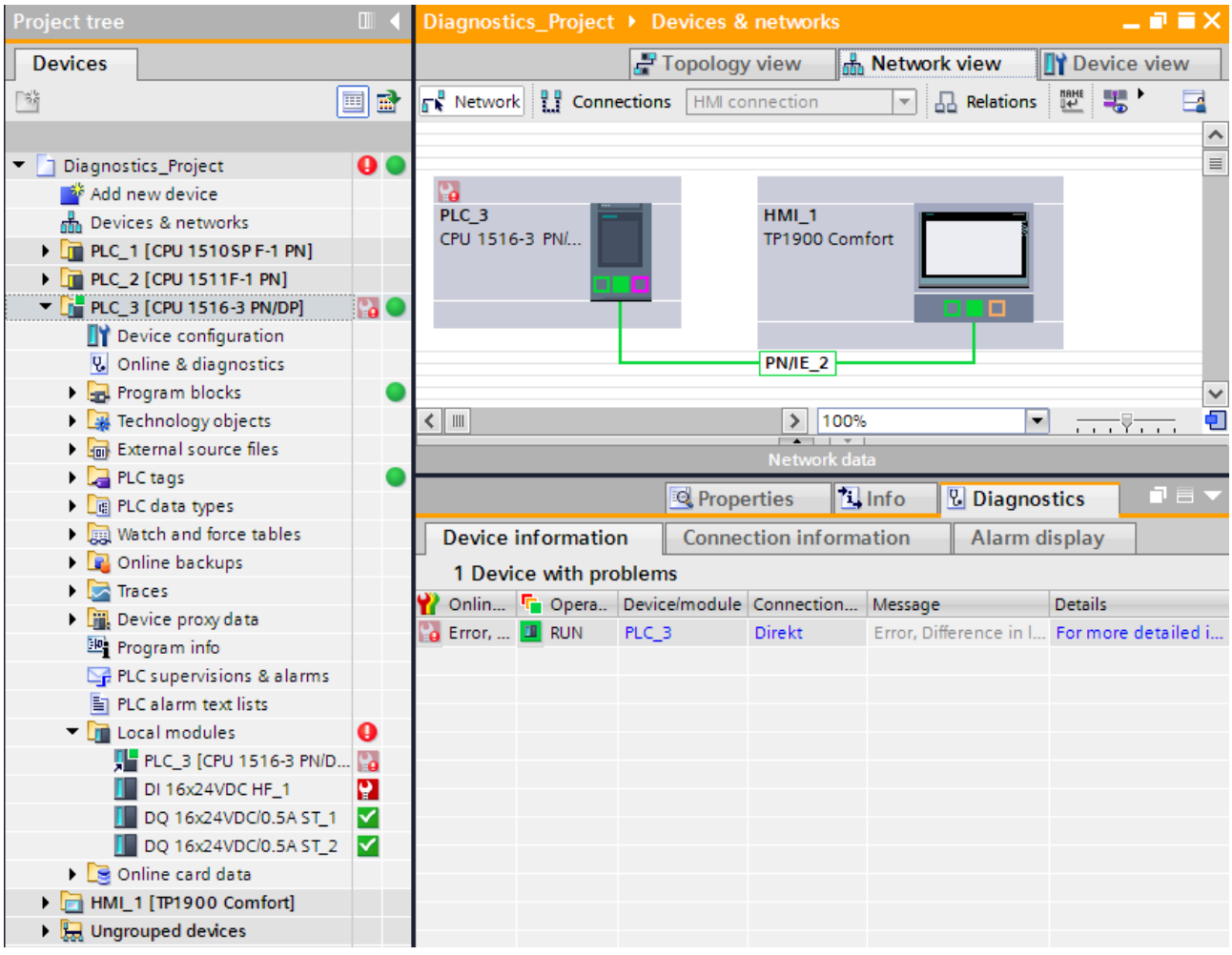

Figure 3-280 Display of the fault in the network view

10. Double-click the device which displays an alarm message to access the faulty module directly. This is the CPU in the example.

    The device view of the CPU is opened in the work area. In this view you can see directly in which module the error has occurred.

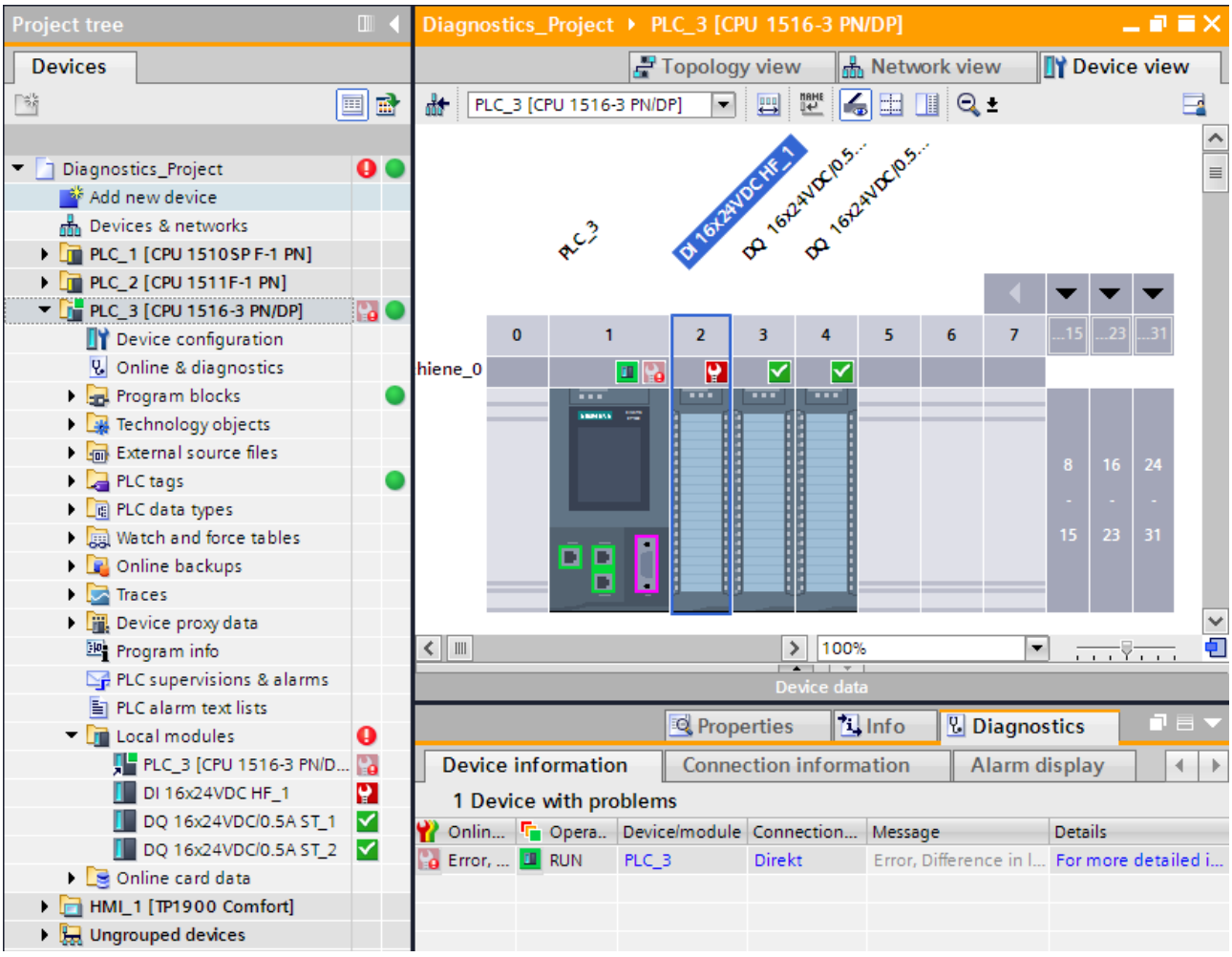

Figure 3-281 Display of the faulty module in the device view

11. Open the "Diagnostics" tab and the subordinate "Device information" tab in the Inspector window for a more detailed error description.

Result

The link in the "Details" table column takes you to the online and diagnostics view of the device and to the diagnostics buffer there, for example. This includes more information on all diagnostics events in the order in which they occurred.

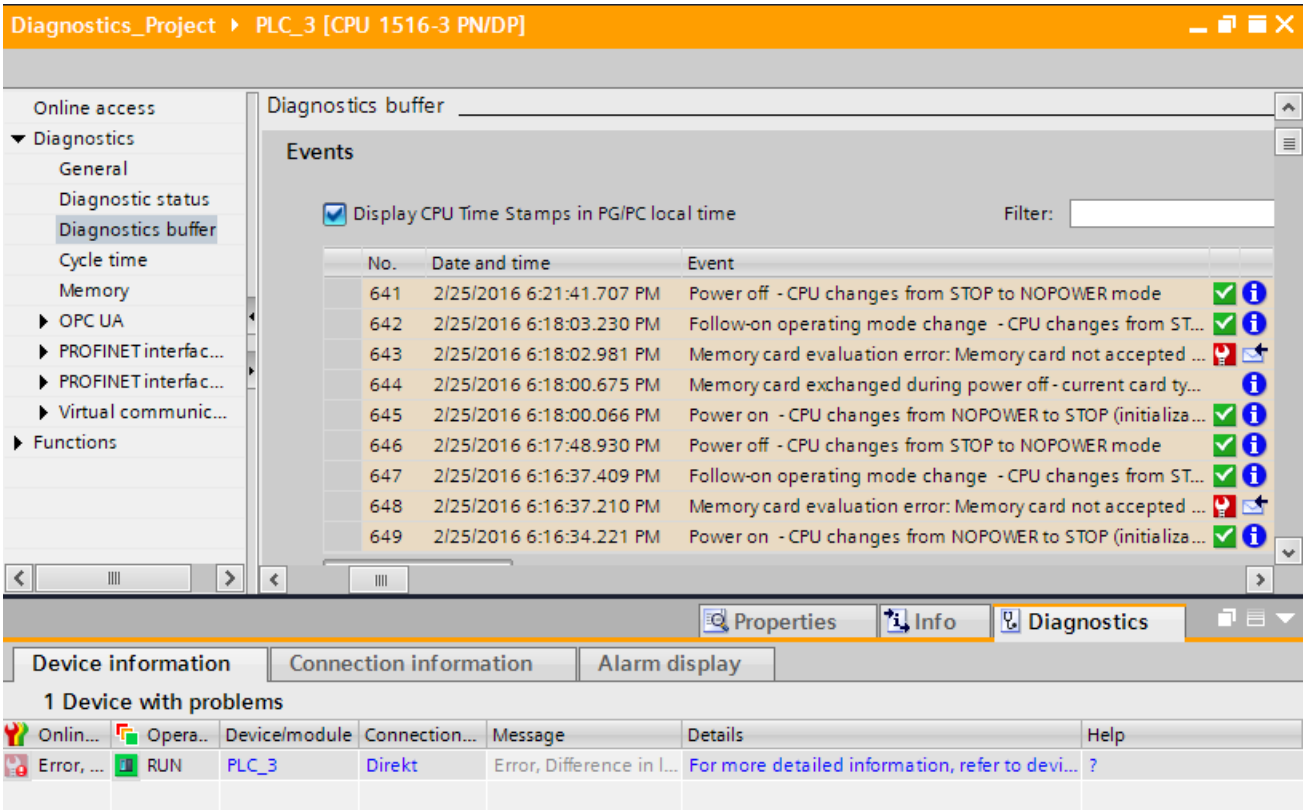

Figure 3-282 Diagnostics buffer with detailed error description

NOTE

Symbols and their meaning

You can find a legend with the meaning of each symbol in Explanation of diagnostics symbols (Page 33) and in the online help for STEP 7.

Configuring and determining system diagnostics 5

Introduction

System diagnostics is the recording, evaluation and reporting of an error within the automation system. The generated alarms contain a textual error description and the error location.

For SIMATIC CPUs, system diagnostics is enabled by default and cannot be disabled. For each individual CPU in your project, you can specify which diagnostic alarms you want or do not want to receive on your display device. The settings in the CPU properties act like a filter. Only the system diagnostics alarms you need are forwarded to the display devices. You can use the following devices to display alarms:

- Display of the CPU (only for S7-1500 CPUs)
- CPU Web server
- HMI device

In the system diagnostics settings in the project tree, you can make the following settings for the entire project:

- The alarm categories for which an alarm is issued
- Whether or not the alarms issued require acknowledgment

To learn how to set system diagnostics in CPU properties and in the project, see the following sections.

5.1 Configuring system diagnostics in the CPU properties

Requirements

- A project is open
- STEP 7 displays the network view

Procedure

To configure the system diagnostics in the CPU properties, proceed as follows:

1. Select the required CPU in the network view of STEP 7.
2. In the Inspector window, go to "Properties > System diagnostics".
3. Select the events for which the CPU should or should not issue an alarm.
   Depending on the firmware version of the CPU used, the following options are available:

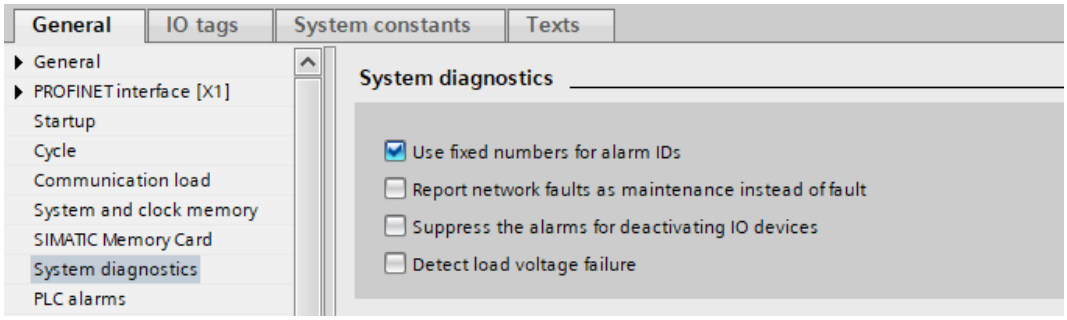

Figure 3-283 System diagnostics in the CPU properties

   – Use fixed numbers for alarm IDs:
     This option is available on all CPUs and is activated in the basic settings.
     The system diagnostic alarms receive fixed alarm numbers from 1 to 512. If, for example, the user changes the order of the alarm types, the alarm numbers remain the same.

   – Report network faults as maintenance instead of fault:
     This option is available on all CPUs as of FW version V2.5 and is deactivated in the basic settings.
     If you activate this option, the CPU will report any network errors as "Maintenance demanded".

- Suppress the alarms for deactivating IO devices:
  This option is available on all CPUs as of FW version V3.0 and is deactivated in the basic settings.
  If you activate this option, the CPU does not output any alarms for inactive but configured IO devices on the PROFINET IO system.
- Detect load voltage failure:
  This option is available on all CPUs as of FW version V3.1 and is deactivated in the basic settings.
  If you activate this option, the CPU reports a failure of the load voltage supply to central or distributed I/O in the user program.

Result: You have configured the alarm settings for system diagnostics in the CPU properties.

5.2 Configuring alarms for system diagnostics in the project

Predefined alarm texts are available for establishing the system diagnostics.

Requirements

- STEP 7 is open.
- A project is open.

Procedure

To configure alarm settings for system diagnostics of the project in STEP 7, proceed as follows:

1. Open the "Common data" folder in the project tree.
2. Double-click on the "System diagnostics settings" entry.
   STEP 7 displays the following configuration options.

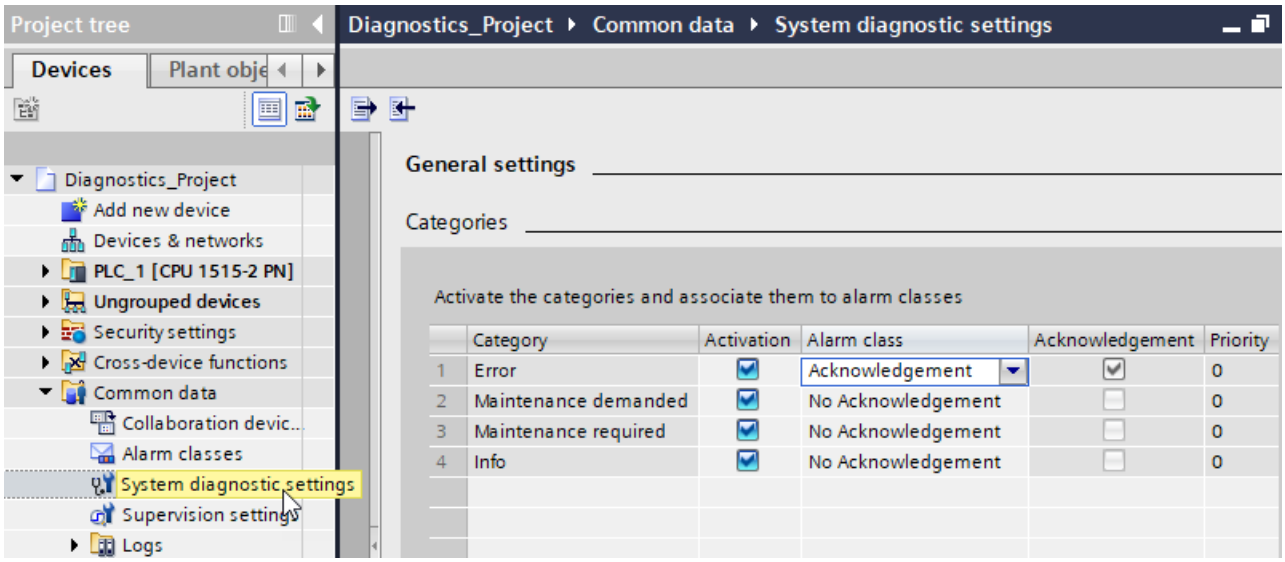

Figure 3-284 Properties of system diagnostics and alarm settings

3. Select the alarm categories for which you need an alarm in the "Activation" column.
   Alarms are activated for all categories in the basic settings. When you disable all check boxes, the status of the HMI system diagnostics view is still updated with the "Info Report" functionality.
4. Select one of the following options in the respective drop-down list of the "Alarm class" column:
   - No Acknowledgement (default):
     Alarms in this category do not have to be acknowledged.
     The corresponding option in the "Acknowledgement" column is not activated.
   - Acknowledgement:
     Alarms in this category must be acknowledged.
     The corresponding option in the "Acknowledgement" column is automatically activated.

Result: You have configured the alarms for system diagnostics of the project in STEP 7. The set priority of the respective alarm class is displayed in the "Priority" column.

The settings are saved with the project and become effective after the compiling and downloading of the hardware configuration to the involved components.

Maintenance events (maintenance demanded, maintenance required) are entered in the alarm buffer of the CPU just like any other event.

5.3 Options for displaying system diagnostics

Example

This section includes a diagnostics example to show how system diagnostics is established with the help of different display options. The example includes a CPU from the SIMATIC S7-1500 product series that is connected to an ET 200S distributed I/O system and an HMI Comfort Panel via PROFINET.

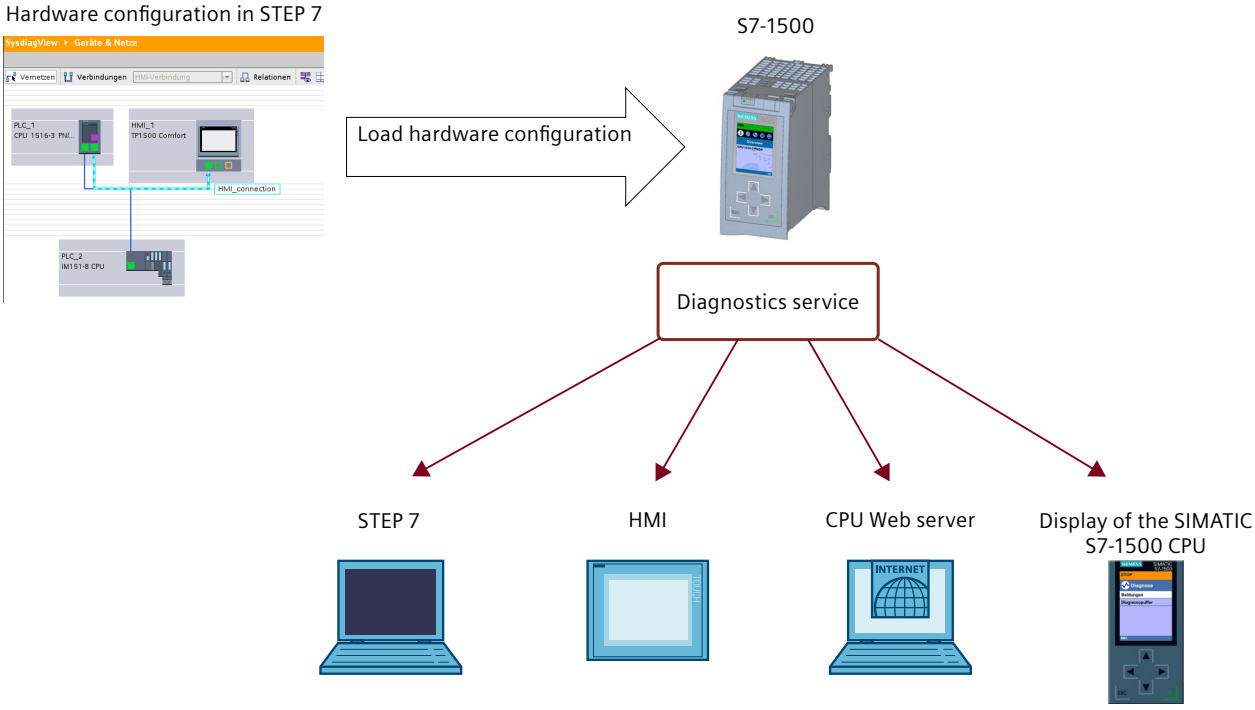

Figure 3-285 System diagnostics display options

The following sections include figures that illustrate how diagnostics information is displayed with the help of different display options.

- Using the LEDs on the hardware (Page 31)
- Local error analysis via the display of the CPU (Page 32)
- Using STEP 7 as of V12 (Page 33)
- Remote diagnostics using the Web server (Page 50)
- Stationary system diagnostics using the HMI diagnostics view (Page 60)

5.3.1 Diagnostics information at the devices

5.3.1.1 LEDs

Overview

All hardware components, such as CPUs, interface modules and modules, provide information about their operating mode as well as internal and external errors through their LEDs. Diagnostics by means of LEDs is an initial tool for error localization.

The graphics below include examples for the arrangement of LEDs on some modules.

Table 3-919 LED displays on the modules

	CPU 1516-3 PN/DP	IM 155-5 PN ST	DI 32x24VDC HF	PS 25W 24VDC
	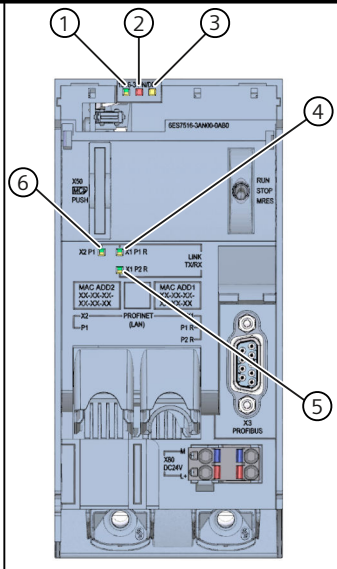	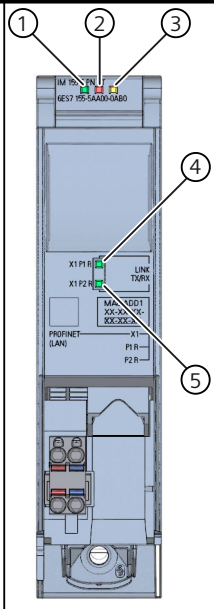	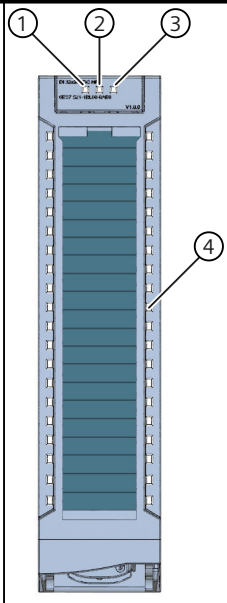	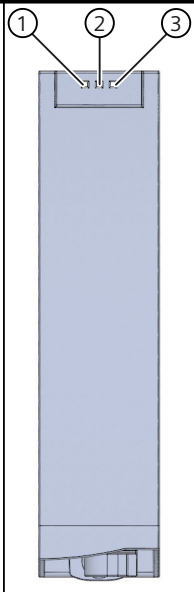
①	RUN/STOP LED (two-colored LED: green/yellow)	RUN LED (two-colored LED: green/yellow)	RUN LED (single-colored LED: green)	RUN LED (single-colored LED: green)
②	ERROR LED (single-colored LED: red)	ERROR LED (single-colored LED: red)	ERROR LED (single-colored LED: red)	ERROR LED (single-colored LED: red)
③	MAINT LED (single-colored LED: yellow)	MAINT LED (single-colored LED: yellow)	without function	MAINT LED (single-colored LED: yellow)
④	X1 P1 (two-colored LED: green/yellow)	X1 P1 (single-colored LED: green)	LED CHx (two-colored LED: green/red)	
⑤	X1 P2 (two-colored LED: green/yellow)	X1 P2 (single-colored LED: green)		
⑥	X2 P1 (two-colored LED: green/yellow)			

Additional information

The meaning of the individual LED displays, their different combinations and the remedial measures resulting from them in case of errors are device-specific. The explanation can be found in the manuals of the modules.

5.3.1.2 Display of the CPU

Introduction

Each CPU in the S7-1500 automation system has a front cover with a display and operating keys. You can display status information in various menus on the display of the CPU. You use the operating keys to navigate through the menus.

Figure 3-286 Display - diagnostics screen

Display options

The display of the SIMATIC S7-1500 CPU shows the following diagnostics information:

- CPU operating state

"Diagnostics" menu

- Error and alarm texts (system diagnostics alarms)
- Information entered in the diagnostics buffer
- Watch tables
- Information on the cycle times of the user program
- Utilization of the CPU memory

"Modules" menu

- Information on modules and the network
- Detailed device view with diagnostics symbols
- Order number, CPU version and central I/O modules
- Module status for central and distributed modules
- Information about the currently installed firmware

Additional information

For additional information on the topic "Functions and operation of the display of the SIMATIC S7-1500 CPU", see the documentation for the S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792).

You can find detailed information on the individual options, a training course and a simulation of the available menu commands of the display for the CPU in the SIMATIC S7-1500 Display Simulator (http://www.automation.siemens.com/salesmaterial-as/interactive-manuals/getting-started_simatic-s7-1500/disp_tool/start_en.html).

5.3.2 Diagnostics information in STEP 7

5.3.2.1 Explanation of diagnostics symbols

Diagnostics symbols for modules and devices

When the online connection to a device is established in STEP 7, the diagnostics status of the device and its lower-level components and, if applicable, the device operating mode are also determined. The following table shows the possible symbols and their meaning.

Table 3-920 Diagnostics symbols for modules and devices

Symbol	Meaning
	The connection with a CPU is being established.
	The CPU is not reachable at the set address.
	The configured CPU and the CPU actually present are of incompatible types. Example: An existing CPU 315-2 DP is incompatible with a configured CPU 1516-3 PN/DP.
	On establishment of the online connection to a protected CPU, the password dialog was terminated without specification of the correct password.
	No fault
	Maintenance required
	Maintenance demanded
	Error
	The module or device is deactivated.
	The module or the device cannot be reached from the CPU (valid for modules and devices below a CPU).

Symbol	Meaning
	Diagnostics data is not available because the current online configuration data differ from the offline configuration data.
	The configured module or device and the module or device actually present are incompatible (valid for modules or devices under a CPU).
	The configured module does not support display of the diagnostics status (valid for modules under a CPU).
	The connection is established, but the module status has not yet been determined or is unknown.
	Hardware error in lower-level component: A hardware fault has occurred in at least one lower-level hardware component (occurs as a separate symbol only in the project tree).

Symbols for the comparison status

The diagnostics symbols can be combined at the bottom right with additional smaller symbols that indicate the result of the online/offline comparison. The following table shows the possible comparison symbols and their meaning.

Table 3-921 Symbols for the comparison status

Symbol	Meaning
	Hardware error in lower-level component: The online and offline versions differ (only in the project tree) in at least one lower-level hardware component.
	Software error in lower-level component: The online and offline versions differ (only in the project tree) in at least one lower-level software component.
	Online and offline versions of the object are different
	Object only exists online
	Object only exists offline
	Online and offline versions of the object are the same

Operating mode symbols for CPUs and CPs

The following table shows the possible symbols and their respective operating states.

Table 3-922 Operating mode symbols for CPUs and CPs

Symbol	Operating mode
	RUN
	STOP
	STARTUP
	DEFECTIVE
	Unknown operating mode
	The configured module does not support display of the operating mode.

Event table

The following information is displayed in the table for each diagnostics event:

- Sequential number of the entry
  The first entry contains the latest event.
- Date and time of the diagnostics event
  If no date and time are shown, the module has no integrated clock.
- Short designation of the event and, if applicable, the reaction of the CPU
- Symbol for information on incoming/outgoing status

The following table shows the possible symbols and their meaning.

Table 3-923 Symbols in the event table

Symbol	Meaning
	Incoming event
	Outgoing event
	Incoming event for which there is no independent outgoing event
	User-defined diagnostics event

Additional information

For additional information on the individual symbols, please refer to the online help for STEP 7.

5.3.2.2 Accessible devices (without project)

Accessible devices

Accessible devices are all devices that are connected to a PG/PC either directly by an interface or by means of a subnet and that are switched on. These devices can display diagnostic information even without an offline project.

Requirements

- STEP 7 is open.
- The portal view or project view is open.

Procedure

To display diagnostic information for specific devices even without an offline project, follow these steps:

1. Establish a connection to the respective CPU.
2. Select the command "Accessible devices" from the "Online" menu.

   The "Accessible devices" dialog opens.

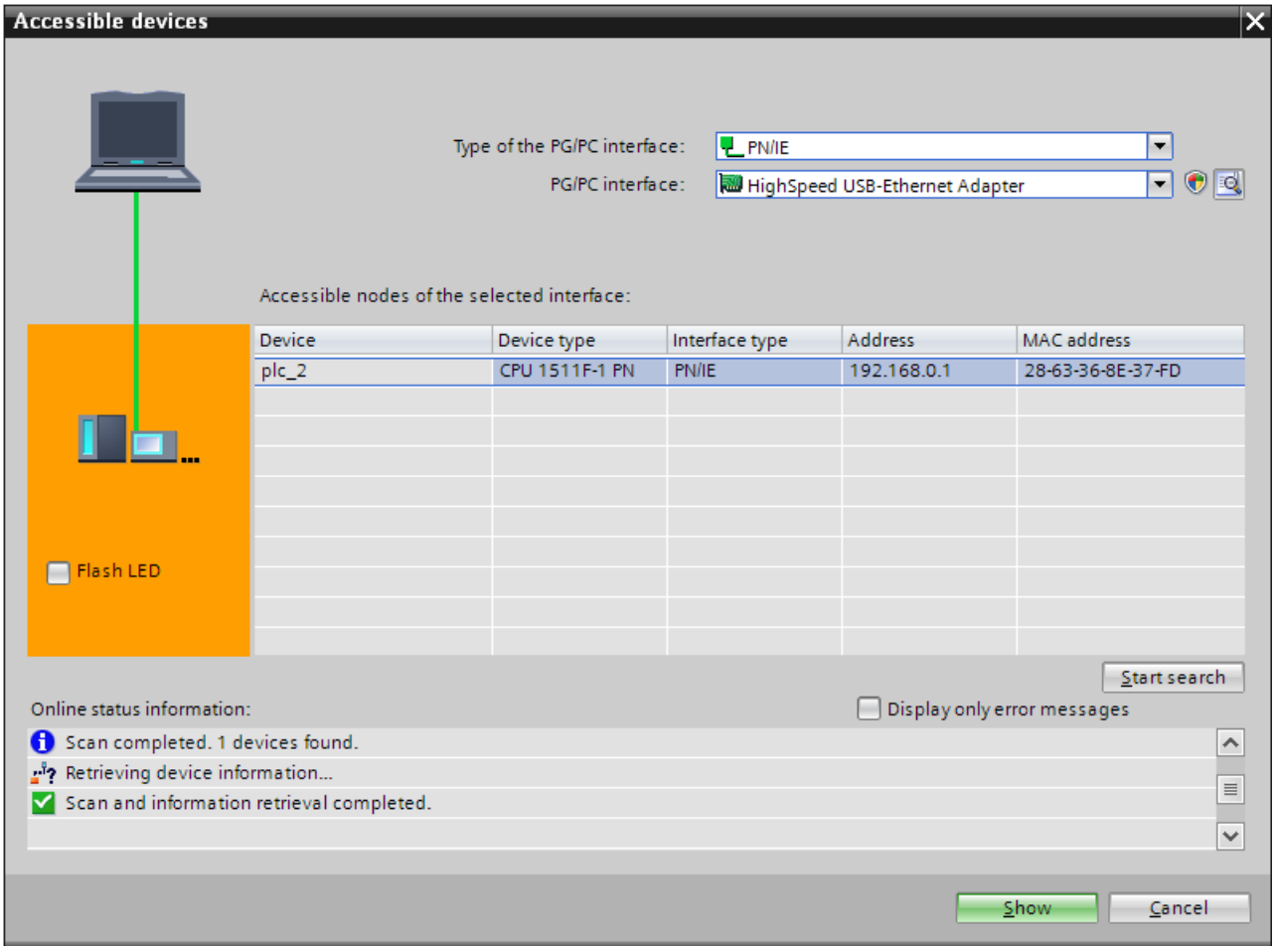

Figure 3-287 "Accessible devices" dialog

3. Make the settings for the interface.
4. Select the respective device under "Accessible nodes of the selected interface".
5. Confirm the dialog with the "Display" button.

Result

The device is displayed in the project tree. You open the diagnostic information in the work area with a double-click on "Online & Diagnostics".

Information is available on the diagnostic status, cycle times, memory usage and the diagnostics buffer.

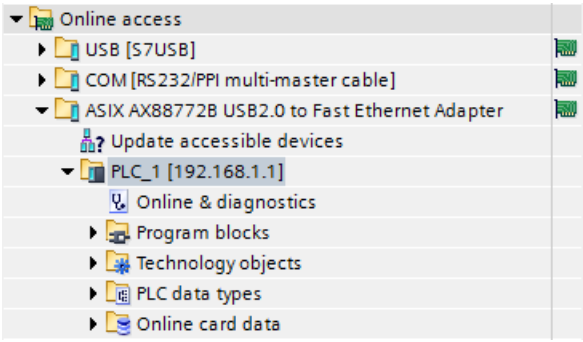

Figure 3-288 Device in the project tree

5.3.2.3 Devices & networks

Devices & networks - Go online

You can get an overview of the current state of your automation system in the device view or network view.

You implement the following tasks in the device view:

- Device configuration and parameter assignment
- Module configuration and parameter assignment

You implement the following tasks in the network view:

- Device configuration and parameter assignment
- Networking devices

Requirements

- STEP 7 is open.
- A project is open.
- The project view is open.

Procedure

To get an overview of the current state of your automation system, follow these steps:

1. Open the "Network view" in the working area.
2. Select the CPU.
3. Click the "Go online" Go online button in the toolbar.
   The "Go online" dialog opens.

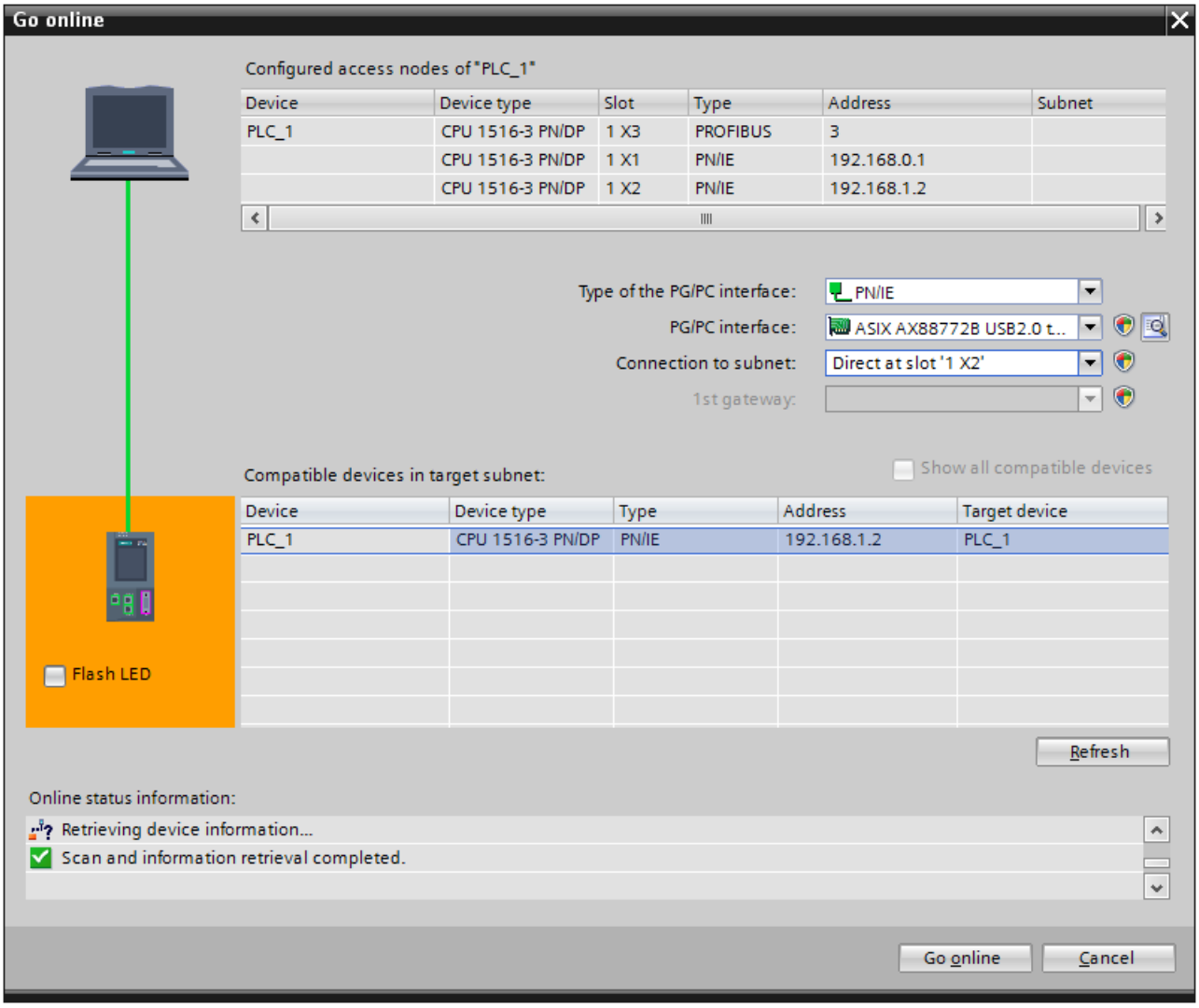

Figure 3-289 Go online

4. Make the settings for the interface.
5. Select the respective device under "Compatible devices in the target subnet".
6. Confirm the dialog with the "Connect" button.
   The online mode is started.

Result

The connected devices are now displayed with diagnostic information in the network view in the working area. Here you get an overview of the current state of your automation device.

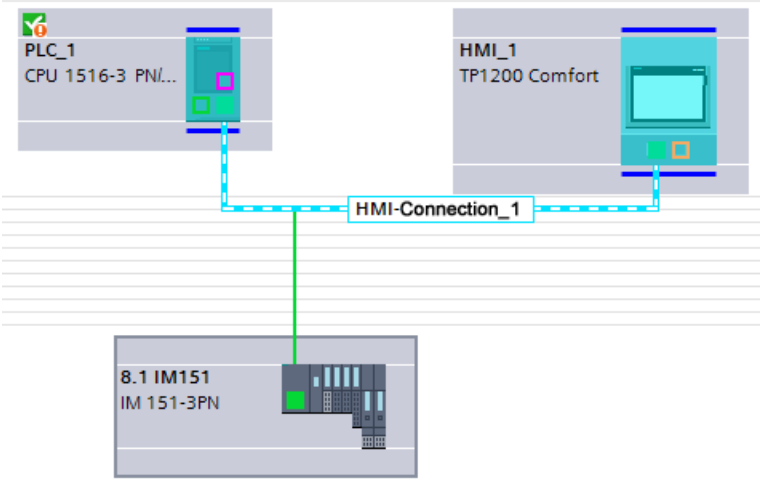

Figure 3-290 CPU with diagnostic information

You get to the "Device view" with a double-click on the device. The diagnostic information for the individual modules is displayed in this view.

NOTE

Symbols and their meaning

You will find a legend with the meaning of each symbol in Explanation of diagnostics symbols (Page 33) and in the online help for STEP 7.

5.3.2.4 Online & diagnostics

Online mode

In online mode there is an online connection between your PG/PC and one or several devices. Depending on the properties of a device, you are offered specific diagnostics options and certain functions in online mode.

- Diagnostics
  - General module information
  - Diagnostics status
  - Cycle time
  - Memory
  - Diagnostics buffer
  - Display
  - Interface information (e.g. IP parameter, port information)

- Functions
  - Assign IP address
  - Set time and date of the CPU
  - Firmware update (e.g. for PLC, display)
  - Assign device name
  - Reset to factory settings
  - Format memory card
  - Save service data

To establish an online connection at least one PG/PC interface must be installed that is physically connected with a device, for example, with an Ethernet cable. The current online status of a device is indicated by a symbol to the right of the device in the project tree.

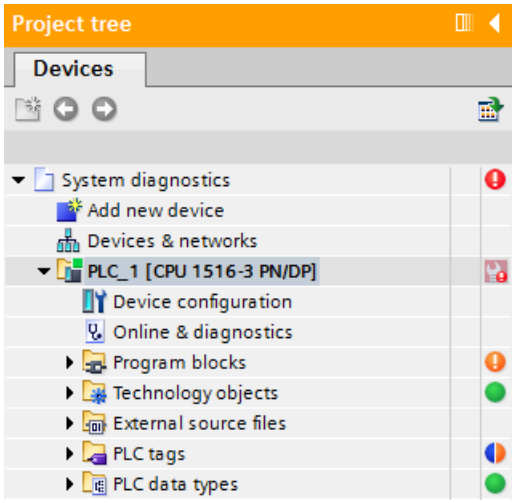

Figure 3-291 Partial view of network view

Requirements

- STEP 7 is open.
- A project is open.
- The project view is open.

Procedure

To display an overview of the faulty devices, follow these steps:

1. Select the affected device folder in the project tree.
2. Select the shortcut menu command "Online & Diagnostics".

   The online and diagnostics view of the module to be diagnosed is started.

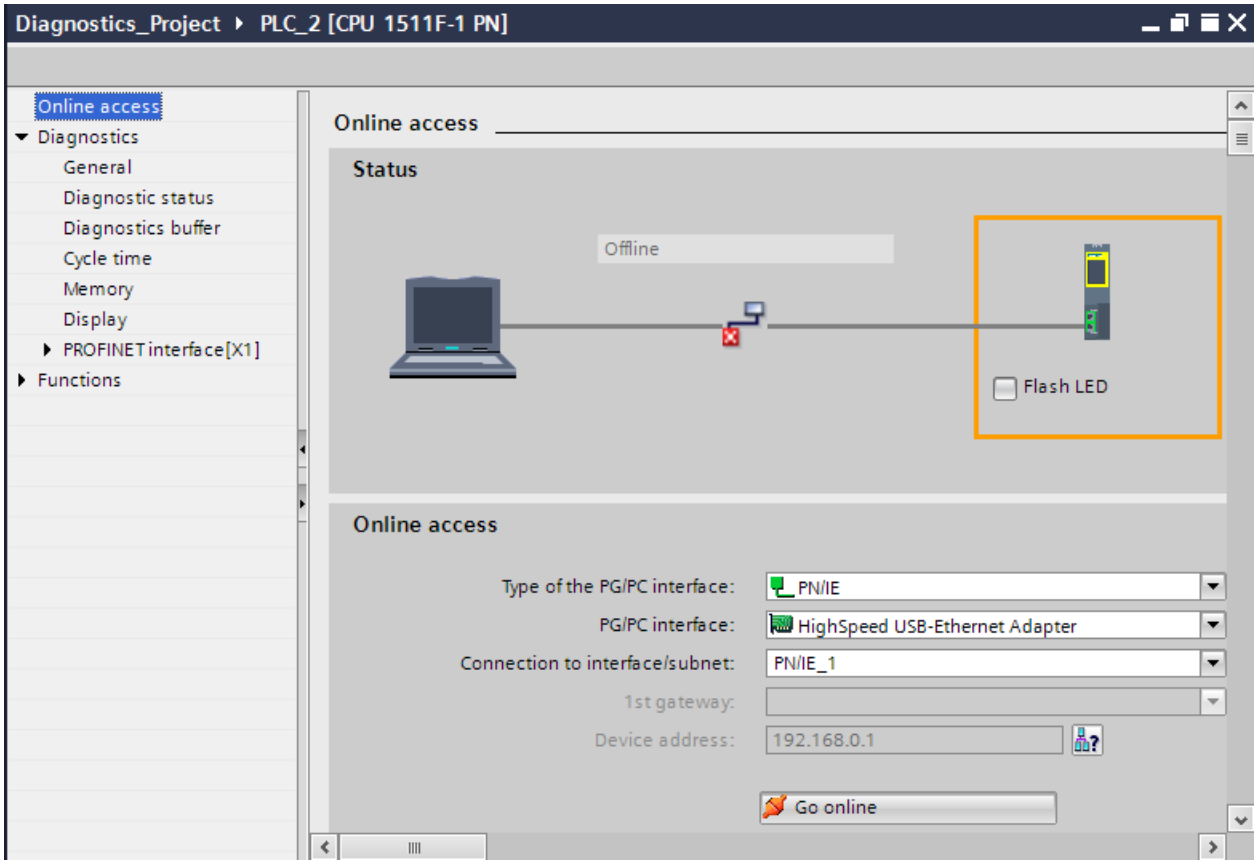

Figure 3-292 Setting online access

3. Make the settings for the interface.

   Here you can change an interface access that has already been set for an online connection that was successfully established previously.
4. Click on the "Go online" button.

   The online connection is established.

Result

You can find detailed diagnostics information on each device in the Inspector window, in the "Diagnostics" section of the area navigation on the "Properties" tab.

5.3.2.5 "Diagnostics" tab in the Inspector window

"Diagnostics" tab in the Inspector window

The "Diagnostics" tab of the Inspector window includes information on diagnostics events and configured alarm events.

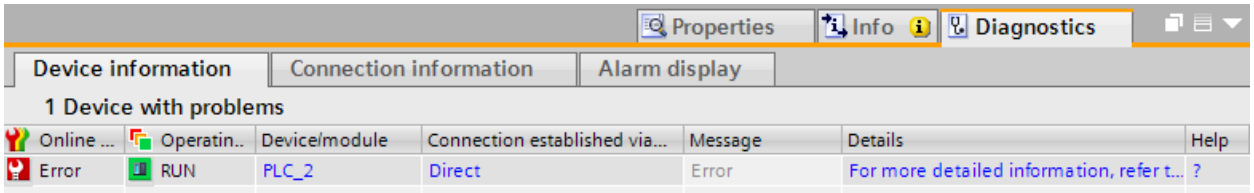

Figure 3-293 Diagnostics in the Inspector window, "Device information" tab

NOTE

Symbols and their meaning

You can find a legend with the meaning of each symbol in Explanation of diagnostics symbols (Page 33) and in the online help for STEP 7.

Subordinate "Device information" tab

This tab gives you an overview of faulty devices to which an online connection exists or has existed. The table provides the following diagnostics information on the faulty devices:

- Online status: Includes the online status as diagnostics symbol and in words
- Operating mode: Includes the operating mode as symbol and in words
- Device/module: Name of the affected device or the affected module
- Connection established via ...: Specifies the path used to establish the connection to the failed device.
- Alarm: This explains the entry in the previous columns and displays an alarm, if necessary
- Details: The link opens the online and diagnostics view associated with the device or puts it in the foreground.
  If the device cannot be reached, the link opens the "Go online" dialog.
- Help: The link provides additional information on the fault.

NOTE

Communication and access errors

Errors that occur in the user program (e.g., communication errors, access errors) are not reported in the "Diagnostics" tab of the device information. You must read out the diagnostics buffer of the CPU in the online and diagnostics view to get this information. The link in the "Details" column opens the diagnostics buffer.

Subordinate "Connection information" tab

The "Connection information" tab displays detailed diagnostics information for connections.

There will only be information on the "Connection information" tab if there is an active online connection to at least one end point of the relevant connection.

If a connection has been selected (connection table), the tab contains the following groups:

- Connection details
- Address details of the connection

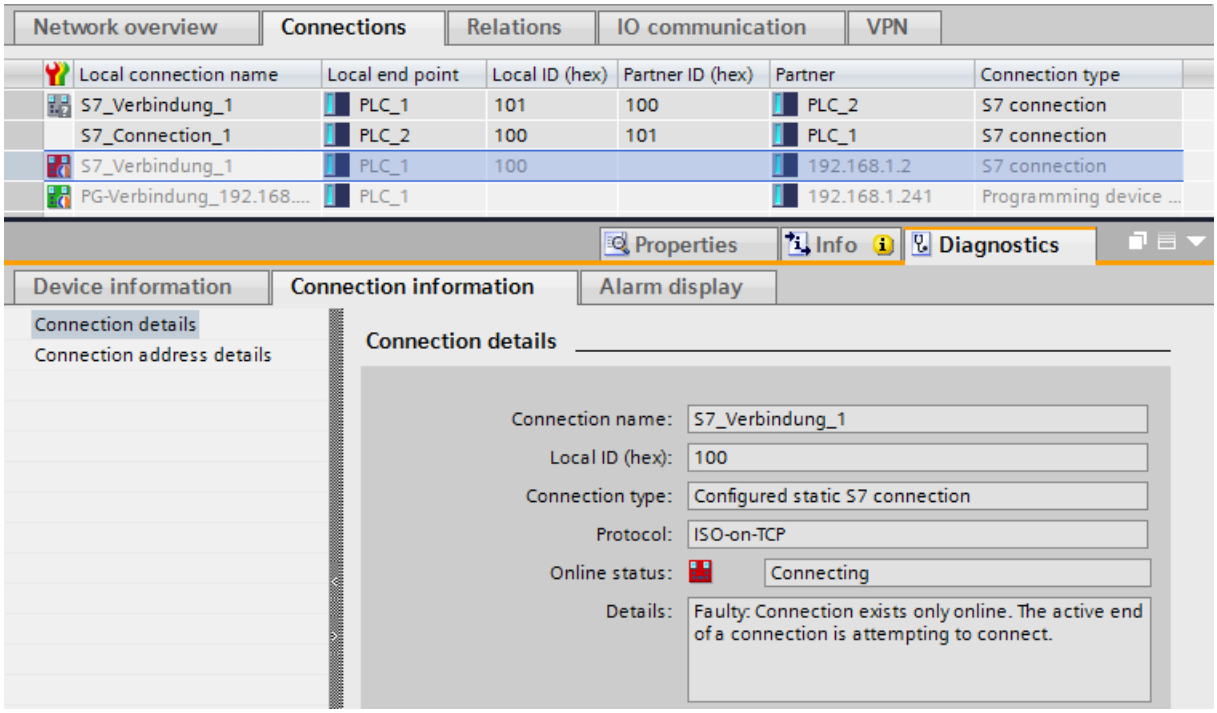

Figure 3-294 "Connection information" tab and open connection overview

If a module has been selected (network view), the tab contains the following group:

- Connection resources

Subordinate "Alarm display" tab

System diagnostics alarms are output in the "Alarm display" tab.

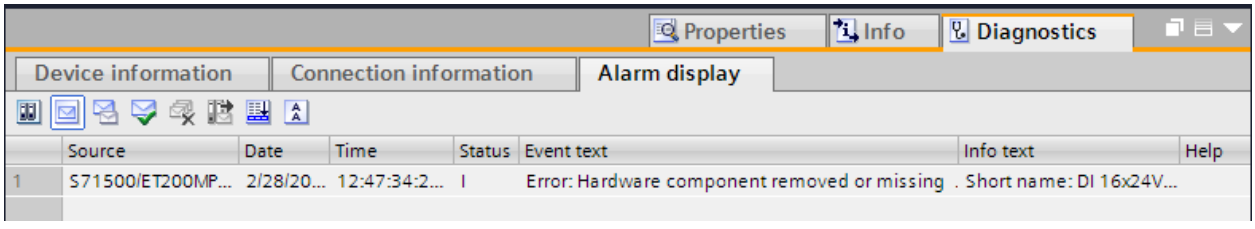

Figure 3-295 "Alarm display" tab

To receive alarms in STEP 7, follow these steps:

1. Open the project view.
2. Select the required CPU in the project tree.
3. To connect online with the respective CPU, select the shortcut menu command "Go online".
4. Select the required CPU once again in the project tree and select the shortcut menu command "Receive alarms".

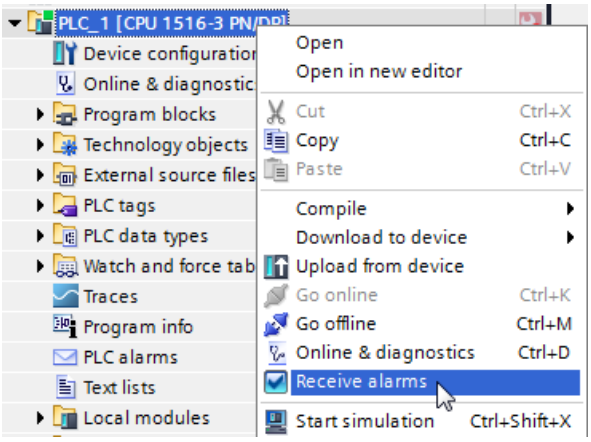

Figure 3-296 Receive alarms

5. Alarms are now displayed in the alarm display. "Archive view" is enabled by default.
6. To display the latest alarms, click the "Active alarms" icon .

5.3.2.6 CPU diagnostics buffer

Definition

Each CPU and some other modules have their own diagnostics buffer, in which detailed information on all diagnostic events is entered in the order in which they occurred.

The CPU diagnostics buffer can be displayed on all display media (STEP 7, SIMATIC HMI devices, SIMATIC S7-1500 Web server and display of the CPU).

Diagnostic events

The entries available in the diagnostics buffer include:

- Internal and external errors on a module
- System errors in the CPU
- Operating mode transitions (e.g., from RUN to STOP)
- Errors in the user program
- Removal/insertion of modules
- Security events

The contents of the diagnostics buffer are stored in the retentive memory in case of a memory reset of the CPU. Errors or events can be evaluated even after a longer period of time thanks to the diagnostics buffer to determine the cause of a STOP or to trace the occurrence of a single diagnostic event and to be able to assign it.

Procedure

To display the diagnostics buffer of a CPU in STEP 7, follow these steps:

1. Select the respective CPU.
2. Select the shortcut menu command "Online & Diagnostics".
   The "Online access" view is opened in the work area.

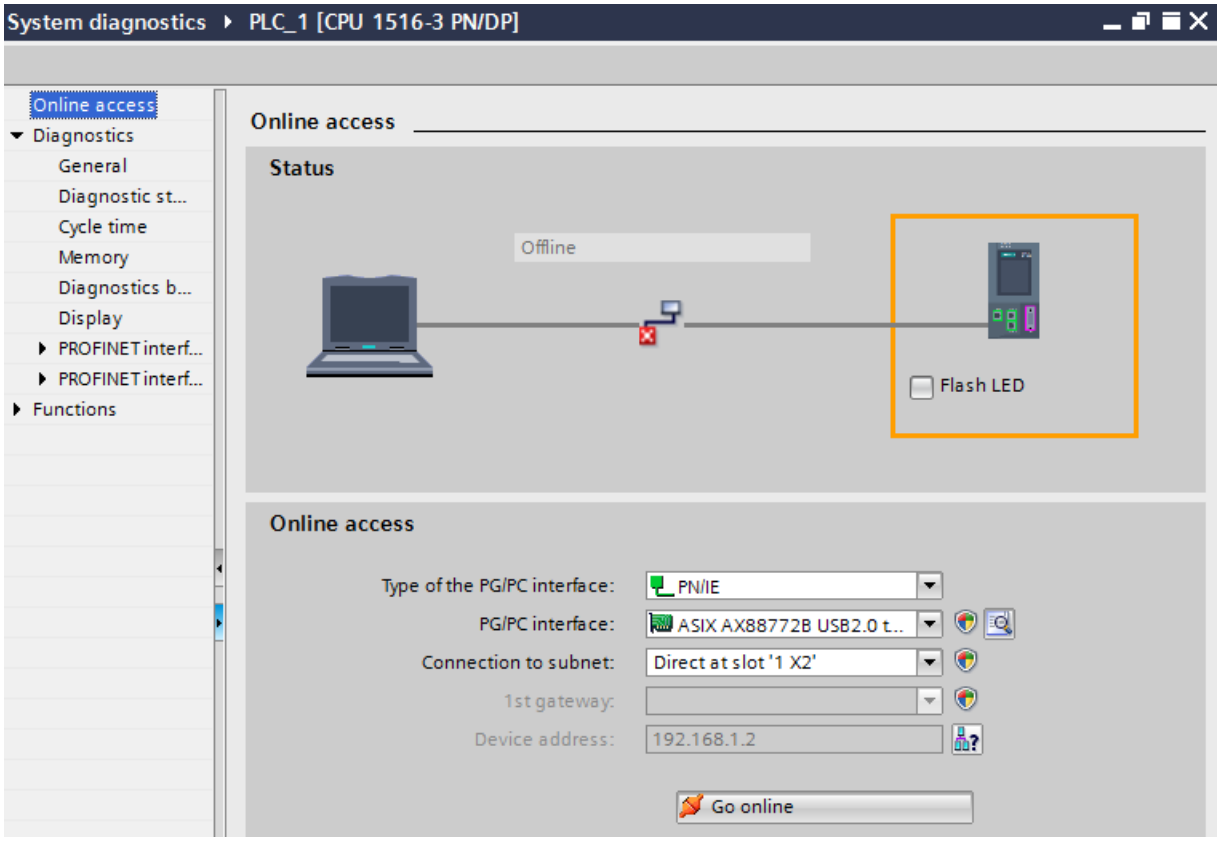

Figure 3-297 Setting up online access

3. Set the interface.
4. Click Go online.

5. Select the area "Diagnostics buffer".

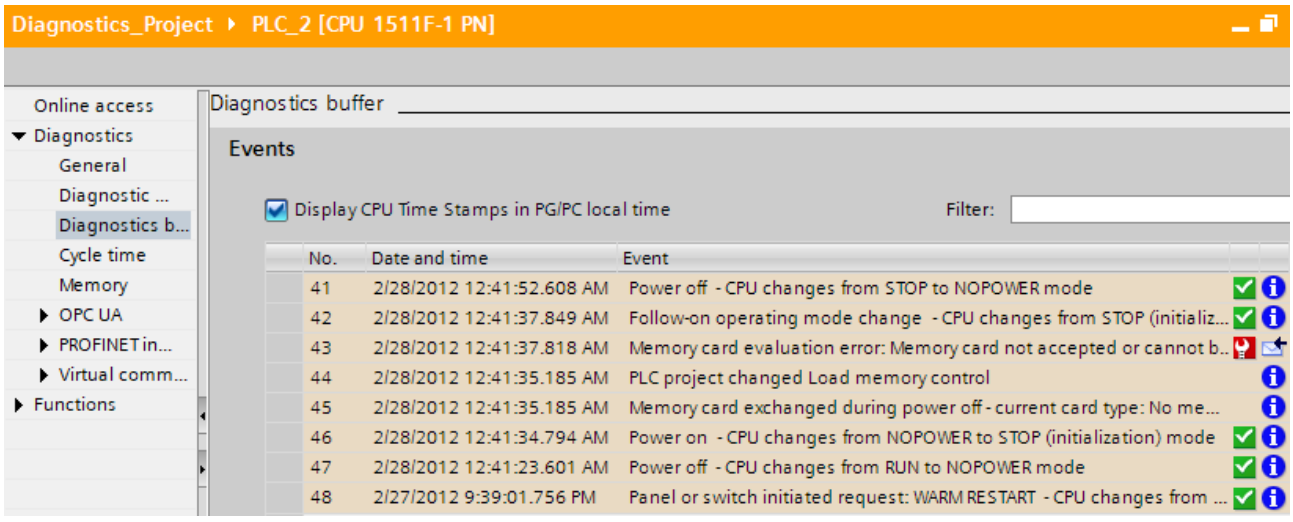

Figure 3-298 Diagnostics buffer in STEP 7

NOTE

Filtering events

You can filter the entries in the diagnostics buffer in the settings of the "Diagnostics buffer" area to only display specific types of events. This means that specific events, such as "CPU and configuration-internal events" or "Connection diagnostics events", can be displayed separately.

Security events

The following security events (event types) result in an entry in the diagnostics buffer.

- Going online with the correct or incorrect password
- Manipulated communications data detected
- Manipulated data detected on memory card
- Manipulated firmware update file detected
- Changed protection level (access protection) downloaded to the CPU
- Password legitimization restricted or enabled (by instruction or CPU display)
- Online access denied due to the possible number of simultaneous access attempts being exceeded
- Timeout when an existing online connection is inactive
- Logging on to the Web server with the correct or incorrect password
- Creating a backup of the CPU
- Restoring the CPU configuration (Restore)

To prevent the diagnostics buffer being "swamped" by large numbers of identical security events, you can set parameters so that these events are entered in the diagnostics buffer as a

group alarm. For every interval (monitoring time), the CPU then only generates one group alarm per event type.

Configuring a group alarm for security events

To configure group alarms for security events, follow these steps:

1. Click on the CPU icon in the network view.

   The properties of the CPU are displayed in the Inspector window.
2. Navigate to the "Protection" > "Security event" area.
3. Click "Security event".
4. Select the option "Summarize security events in case of high message volume" to enable group alarms for security events.
5. Set the duration of an interval (monitoring period); the default is 20 seconds.

5.3.2.7 "Online tools" task card

Online view in the "Online tools" task card

The following requirements must be met to display the online view of the "Online tools" task card in STEP 7:

- An online connection to the CPU is available.
- You have selected the CPU in the topology view, network view or device view.

The "Online tools" task card provides an overview of the CPU state, the cycle time and the memory usage.

- The "CPU operator panel" pane displays the current state of some LEDs and the mode selector of a CPU.
- The "Cycle time" pane displays the cycle time diagram and below it the measured cycle times as absolute values.

- The "Memory" pane contains the current memory usage of the associated CPU. The free memory is shown both as a bar graph and as a numerical value (percentage).
  The display for "Load memory" contains, in addition to the online project data (program code, data blocks, hardware configuration etc.), all other data that may be on the SIMATIC memory card, such as recipes, data logs, HMI backups or non-SIMATIC files that have been copied to the memory card via the Web server of the CPU or offline in Explorer (for example, PDF files).

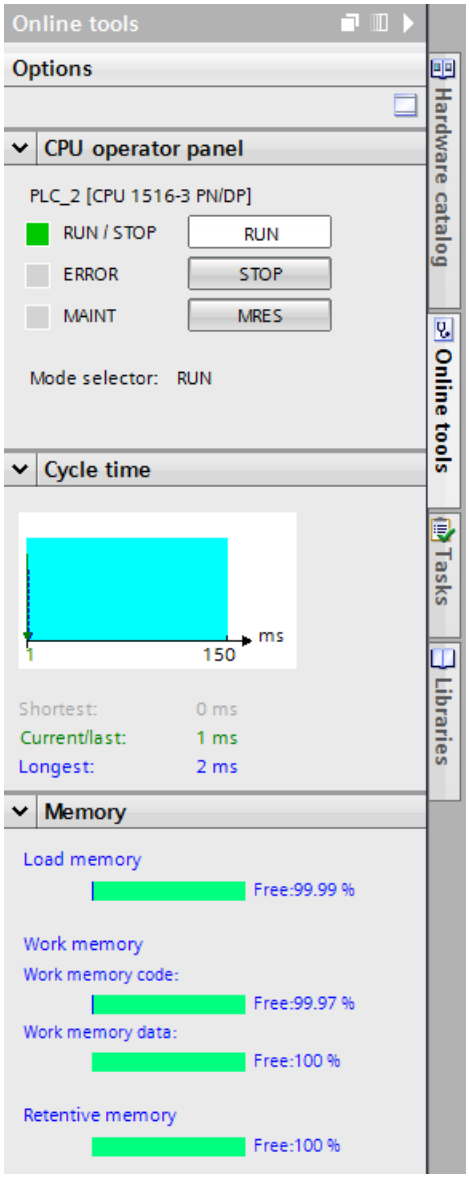

Figure 3-299 "Online tools" task card

5.3.2.8 Configuring the settings for I/O modules in STEP 7

You can also make settings for system diagnostics in STEP 7 for I/O modules. The parameters you have to configure depend on the I/O module.

The settings are optional.

Requirements

- STEP 7 is open.
- A project is open.
- The project view is open.
- A design with I/O modules has been configured.

Procedure

To make settings for system diagnostics of I/O modules in STEP 7, follow these steps:

1. Select the respective I/O module in the device view.
2. Open the "Properties" tab in the Inspector window.
3. Select the area "Inputs", for example.

   You have access to the settings for system diagnostics of the I/O module. If you select "Wire break", for example, a possible wire break for the channel is signaled during operation.

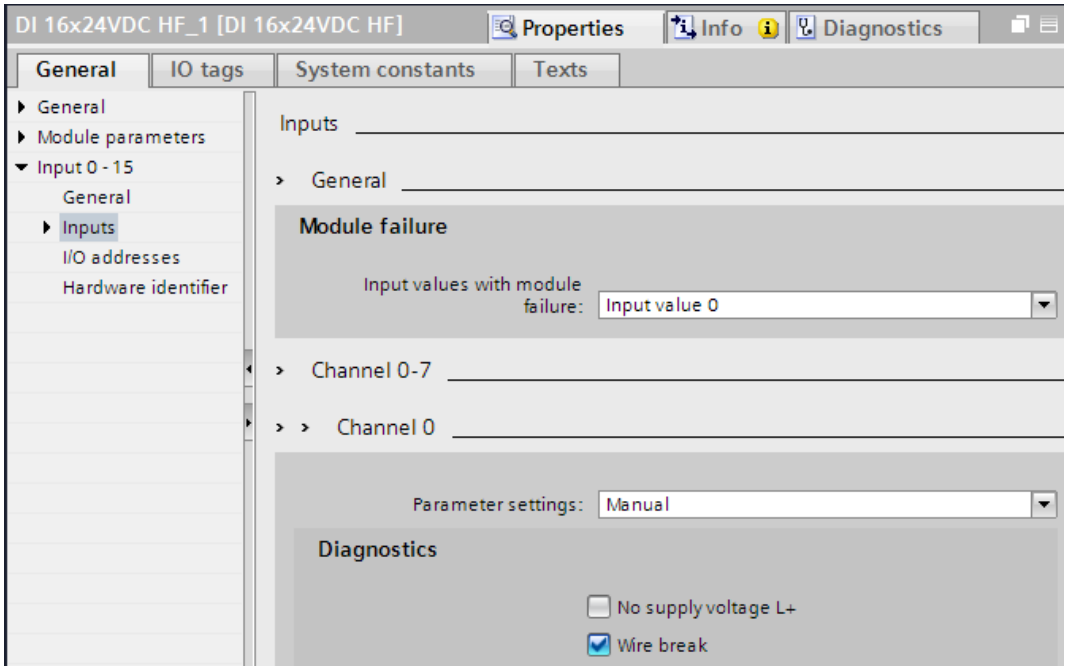

Figure 3-300 I/O setting with a digital input module

4. Save the hardware configuration.
5. Download the new hardware configuration to the CPU.

Additional information

The documentation for the respective module includes additional information on parameter assignment of I/O modules.

5.3.3 Diagnostics information using the web server

System diagnostics using the CPU Web server

The CPUs of the SIMATIC series have an integrated Web server and let you display the system diagnostics information by means of PROFINET. Any terminal devices, such as PCs or smartphones, can thus access module data, user program data and diagnostics data of a CPU by using an Internet browser. This means access to CPUs is possible without installed STEP 7.

In addition to normal websites, the Web server provides so-called basic websites with reduced content that are adapted to the requirements of small screens with low resolution.

Using CPU 1516-3 PN/DP as an example, the following figure shows the start page of the Web server:

Figure 3-301 Web server, Start page

The following diagnostics options are available with the integrated Web server:

- Start page with general CPU information
- Information on diagnostics
- Contents of the diagnostics buffer
- Module information
- Alarms
- Information about communication
- PROFINET topology
- Motion Control diagnostics
- Trace

Configuring the Web server in STEP 7

Proceed as follows to activate the Web server:

Requirements

- You have opened STEP 7.
- You have added a CPU to the project.
- You have opened the project view.

Procedure

1. Open the network view.
2. Select the CPU.
3. Open the "Properties" tab in the Inspector window.
4. Select the entry "Web server" in the "General" area navigation.

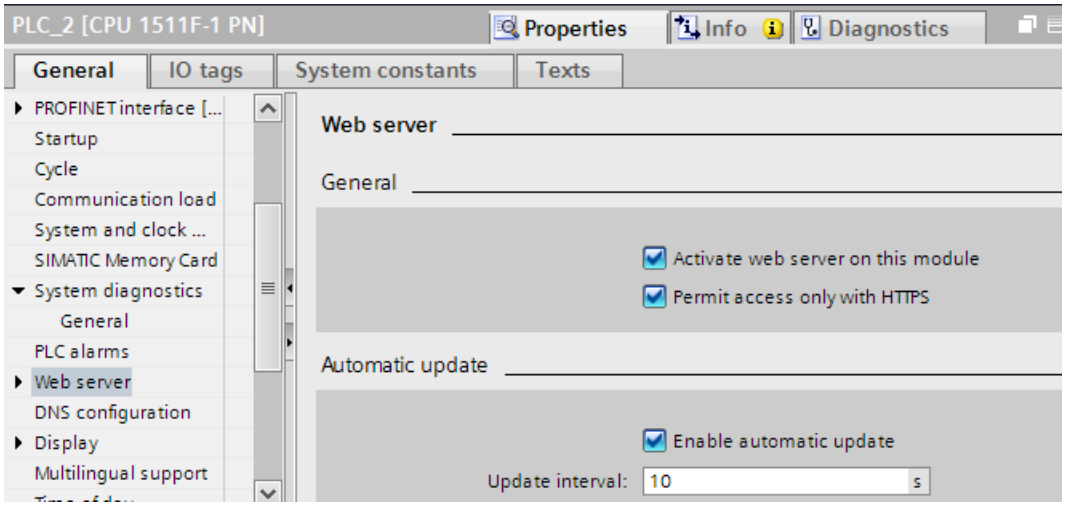

Figure 3-302 Activate the Web server

5. Select the "Activate web server on this module" check box.

6. "Permit access only with HTTPS": The activation of the Web server using the secure transmission protocol "HTTPS" requires a valid Web server certificate in the CPU.

NOTICE
Utilizing the full functionality of the Web server A valid CA-signed Web server certificate in the CPU is a requirement for: – User management with password-protected users – Saving and downloading diagnostic information in csv files – Using the following safety-related functions: – Backing up and restoring the CPU configuration To use the full functionality of the Web server, we recommend that you create a CA-signed server certificate and assign it to the CPU. To create a CA-signed Web server certificate, you must enable the Certificate Manager in the global security settings of STEP 7 and assign a CA-signed server certificate to the Web server in the properties of the CPU. You can find additional information on handling Web server certificates in the "Configuring the Web server" section of the Web server function manual (http://support.automation.siemens.com/WW/view/en/59193560). Detailed information on Certification Authority (CA) certificates, device certificates (End Entity certificate), "Public Key Infrastructure" (PKI) and certificate management can be found in the Communication function manual (https://support.industry.siemens.com/cs/ww/en/view/59192925) and in the online help for STEP 7, keyword "Secure communication".

7. Automatic updating is activated in the default setting of a configured CPU.
8. Activate the Web server also for each interface via which you want to access the Web server.
   To do this, open the "Properties" tab in the Inspector window and select the "Web server" entry in the "General" area navigation. In the "Overview of interfaces" area, select the "Enabled web server access" check box for the corresponding interface.
9. Compile and load the configuration into the CPU.

Accessing the Web server

To access the Web server, proceed as follows:

1. Connect the display device (PG/PC, HMI, mobile terminal device) with the CPU or a communication module using a PROFINET interface.
   If you are working with WLAN, activate the WLAN on the display device and establish a connection to the access point (e.g. SCALANCE W788-1RR or SCALANCE W784-1), which is in turn connected to the CPU.
2. Open the web browser on the display device.
3. Enter the IP address of the interface of the CPU which is connected to the client in the "Address" field of the web browser in the following format: http://a.b.c.d or https://a.b.c.d (example input: https://192.168.3.141).
   The intro page of the CPU opens.

4. You need to perform the installation of the CA certificate again for each display device you want to use. A valid CA certificate is available for download from the "Intro" web page under "Download certificate". You can find instructions for installing the certificate in the help system of your Web browser and in the FAQ with the entry ID 103528224 at the Service&Support (https://support.industry.siemens.com/cs/ww/en/view/103528224) website.
5. Click the NEXT link to go to the Web server pages.

NOTE

Managing access rights

In STEP 7, you can create users, define access rights and assign passwords under "Web server > User management". Users only have access to the options that are permanently linked to the access rights.

You can find additional information on managing access rights in the "Configuring the Web server" section of the Web server function manual (http://support.automation.siemens.com/WW/view/en/59193560).

"Diagnostics" option

The "Diagnostics" web page provides more information about the tabs:

- Identification

  This tab contains the characteristics of the CPU (serial number, article number, hardware and firmware version, etc.).
- Program protection

  This tab provides information on whether the PLC program contains know-how protection or copy protection.
- Memory

  This tab contains current values on the memory currently in use.
- Runtime information

  Current information on program/communication load and cycle time can be found in this tab.
- Fail-safe (only with an F CPU)

  The safety program of an F-CPU consists of one or two F-runtime groups. You can find their cycle time (F-monitoring time) and runtime in this tab.

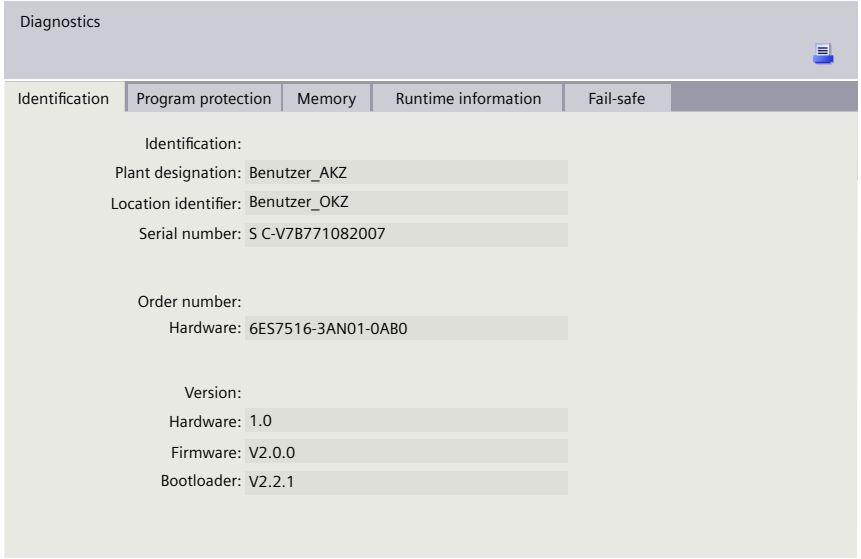

Figure 3-303 Web server, "Diagnostics" Web page

Diagnostics option "Diagnostics buffer"

The browser displays the content of the diagnostics buffer on the "Diagnostics buffer" Web page.

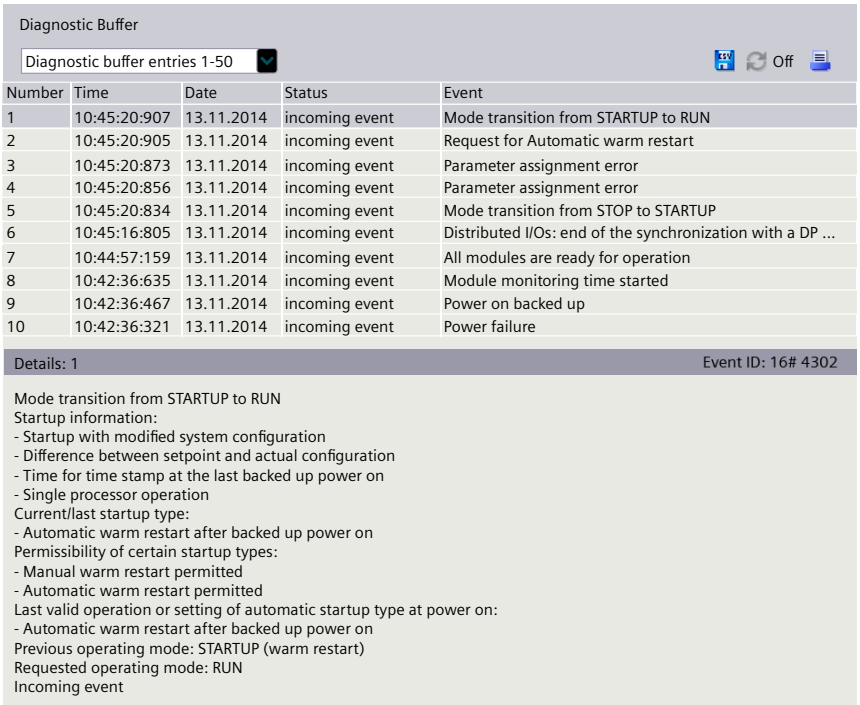

Number	Time	Date	Status	Event
1	10:45:20:907	13.11.2014	incoming event	Mode transition from STARTUP to RUN
2	10:45:20:905	13.11.2014	incoming event	Request for Automatic warm restart
3	10:45:20:873	13.11.2014	incoming event	Parameter assignment error
4	10:45:20:856	13.11.2014	incoming event	Parameter assignment error
5	10:45:20:834	13.11.2014	incoming event	Mode transition from STOP to STARTUP
6	10:45:16:805	13.11.2014	incoming event	Distributed I/Os: end of the synchronization with a DP ...
7	10:44:57:159	13.11.2014	incoming event	All modules are ready for operation
8	10:42:36:635	13.11.2014	incoming event	Module monitoring time started
9	10:42:36:467	13.11.2014	incoming event	Power on backed up
10	10:42:36:321	13.11.2014	incoming event	Power failure

Figure 3-304 Web server, "Diagnostics buffer" Web page

Diagnostics option "Module information"

The status of a device is indicated by the Web browser with symbols and comments on the "Module information" Web page.

Modules are displayed on the "Module information" Web page in the "Name" column with a link. You can thus get to the faulty module in hierarchical order.

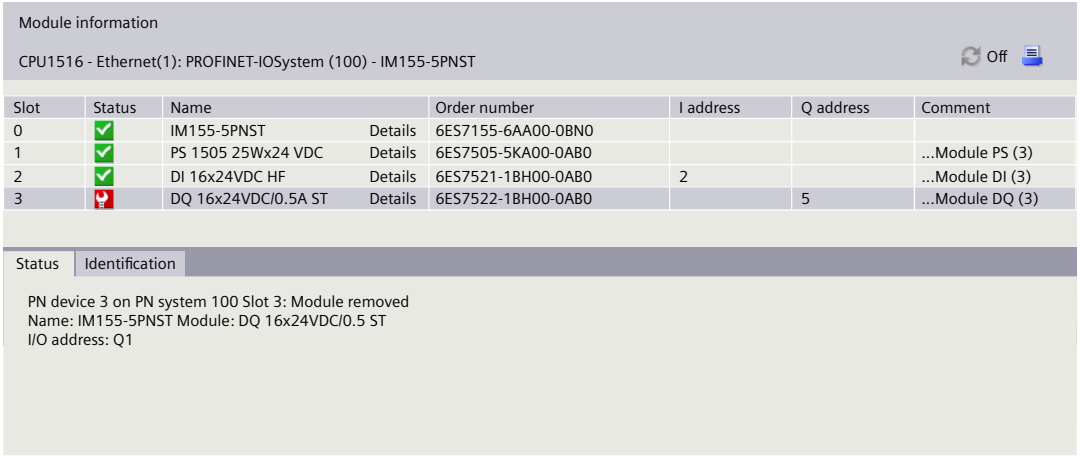

Figure 3-305 Web server, "Module information" Web page

Diagnostics option "Messages"

The Web browser displays the content of the message buffer on the "Messages" Web page. The messages can be acknowledged via the Web server if you have the appropriate user rights.

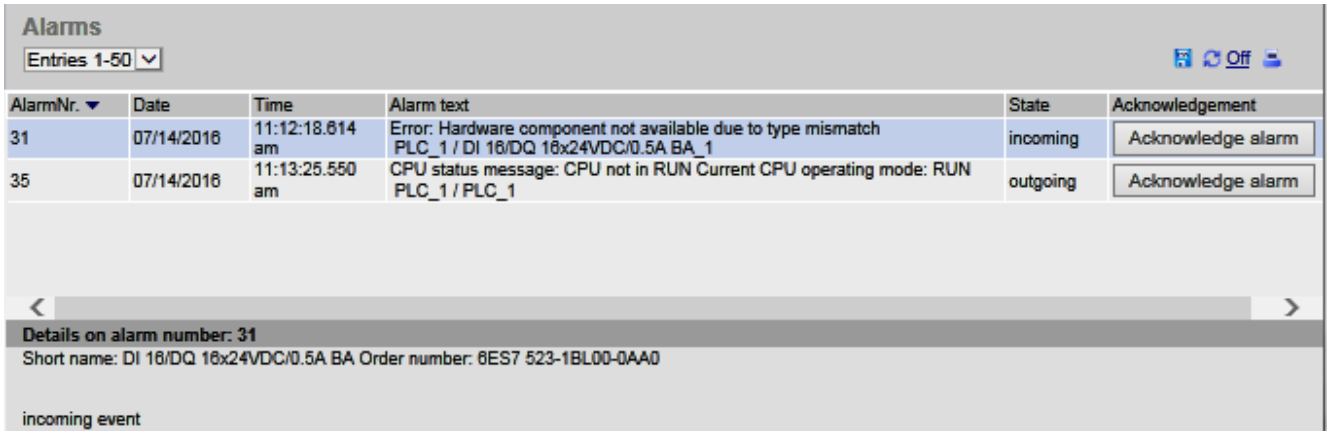

Figure 3-306 Web server, "Messages" Web page

Diagnostics option "Communication"

The "Communication" web page provides detailed information about the following tabs:

- Parameter

  A summary of the information on the PROFINET and Ethernet interfaces of the selected CPU is available in this tab.
- Statistics

  You will find information on data transmission in this tab.
- Resources

  Information about the resource consumption of the connections is available in this tab.
- Connections

  Information about the status of the communication connections is available in this tab.

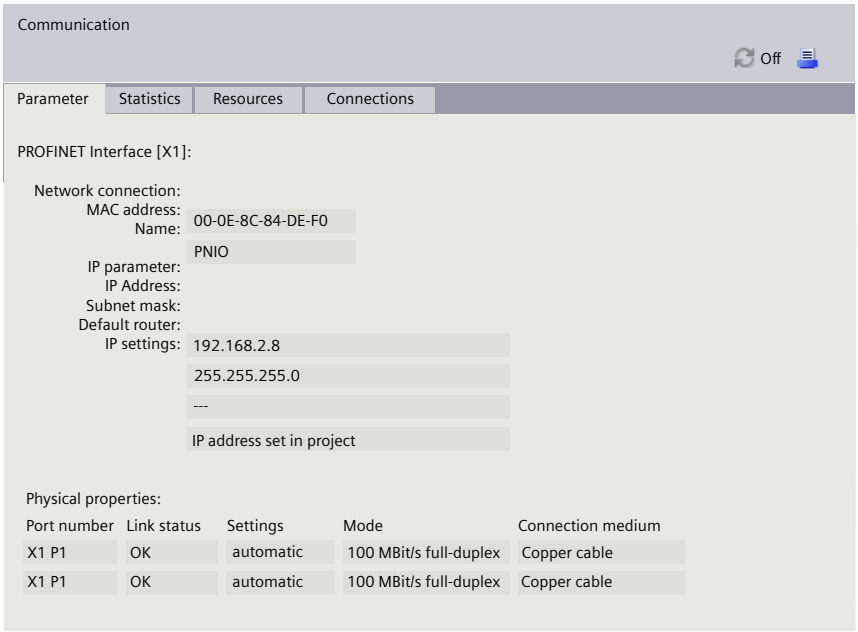

Figure 3-307 Web server, "Communication" Web page

"Topology" diagnostics option

The "Topology" Web page provides information on the topological configuration and status of the PROFINET devices in your PROFINET IO system.

Topology

PLC_1 [X1]

Off

Graphic view | Table view | Status overview

Port				Partner port	
Status	Name	Module type	Port	Name	Port
	CPU 1516-3PN/DP	CPU 1516-3PN/DP			
			port-001	SCALANCE-X-204IRT	port-001
	IM155-6PN-2	IM 155-6PN ST			
	IM155-5PN	IM 155-5PN ST			
			port-001	SCALANCE-X-204IRT	port-004
			port-002	cpux6-7-1xet200mp	port-002
	SCALANCE-X-204IRT	SCALANCE-X-204IRT			
			port-001	CPU1516-3PN/DP	port-001
			port-002		
			port-003		
			port-004	IM155-5PN	port-001
	SCALANCE-X-208	SCALANCE-X-208			
	cpux6-7-1xet200mp				
			port-002	IM155-5PN	port-002

Figure 3-308 Web server, "Topology" Web page

"Motion Control Diagnostics" diagnostic option

The Web server displays statuses, errors, technology alarms and the current values of the configured technology objects (TOs).

The "Motion Control Diagnostics" web page provides detailed information on the configured technology objects in the following views:

- Diagnostics

  This view provides an overview list of configured technology objects, the status and error messages of a selected technology object, as well as values and limits of the movement status for a selected axis.

- Service overview

  This view contains diagnostic information for multiple technology objects and a filter option for selecting the displayed technology objects.

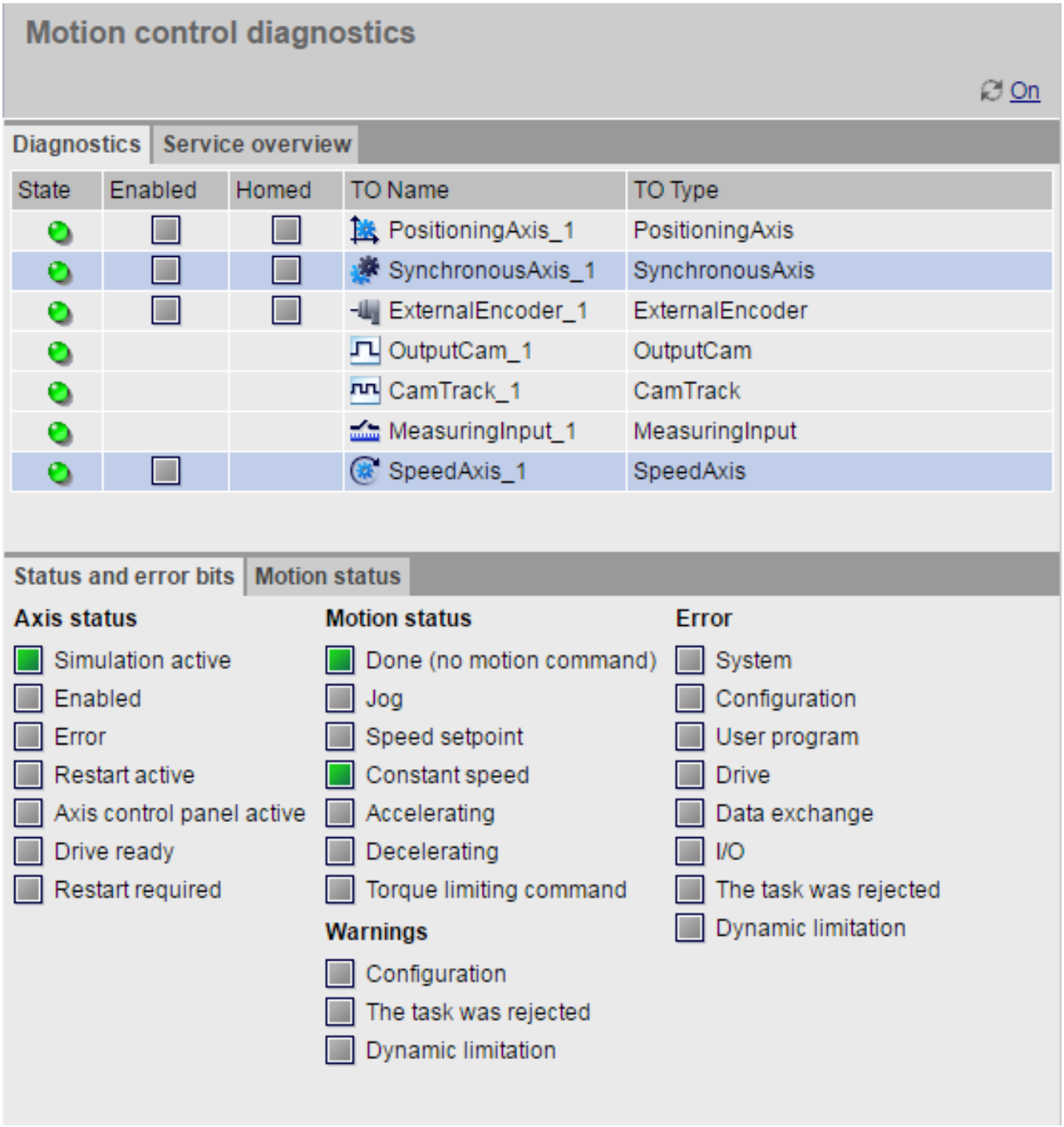

Figure 3-309 Web server, "Motion Control diagnostics" webpage

"Trace" diagnostic options

You can read, view and save the trace recordings via the Web server and thus obtain plant and project information for diagnostics and maintenance.

The web page of the trace and logic analyzer function consists of several areas. The example in the figure below shows how the Web server user interface is divided when the "Trace" web page is first called.

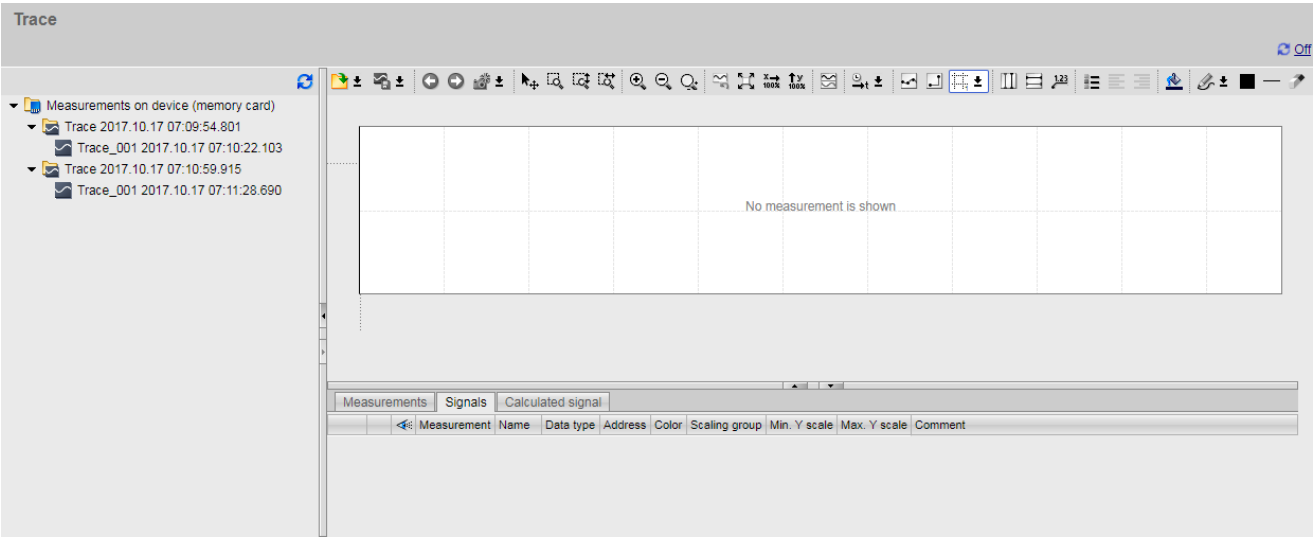

Figure 3-310 Web server, "Trace" home page (without measurement)

Additional information

Additional information on the topic is available in the Web server function manual (http://support.automation.siemens.com/WW/view/en/59193560).

You can find additional information on the trace function in the Using the trace and logic analyzer function (https://support.industry.siemens.com/cs/ww/en/view/64897128) function manual.

5.3.4 Showing diagnostic information on an HMI device

Components and objects for system diagnostics

You can use the functionality of system diagnostics via HMI devices with the following components:

- SIMATIC components:
  - Basic Panels
  - Comfort Panels
  - Mobile Panels
  - WinCC RT Advanced
- SIMATIC Unified components:
  - Unified Basic Panels
  - Unified Comfort Panels
  - WinCC Unified PC

The following table provides an overview of the SIMATIC components with their supported diagnostics objects in WinCC.

Table 3-924 SIMATIC components and system diagnostics objects in WinCC

Component	System diagnostics indicator	System diagnostics view	System diagnostics window
Basic Panel	-	X[1)]	-
Comfort Panel	X	X	X
Mobile Panel	X	X	X
WinCC RT Advanced	X	X	X

1) Only diagnostics buffer view possible

The following sections and paragraphs describe the objects and procedures for WinCC devices and WinCC software.

You can find information on objects and procedures in WinCC Unified devices and WinCC Unified software in the section System diagnostics in WinCC Unified (Page 70).

System diagnostics indicator

The system diagnostics indicator shows the overall status of your plant in one of two states as follows:

- Green with white checkmark: No error
- Red with white wrench: Error

If at least one CPU indicates an error, the overall status also indicates an error.

System diagnostics view

The system diagnostics view reflects the current status of all accessible devices in your plant. You navigate directly to the cause of the error and the associated device. You have access to all diagnostics-capable devices that you have configured in the STEP 7 hardware and network editor.

System diagnostics window

The system diagnostics window is an operating element and display object.

The functions of the system diagnostics window are the same as for the system diagnostics view. Because the system diagnostics window is configured in the "Global screen", you can also specify, for example, whether the object can be closed in WinCC Runtime.

5.3.4.1 Configuring system diagnostics

Introduction

You can add a system diagnostics view or a system diagnostics window to your project to get a diagnostics overview of all devices available in your plant.

The system diagnostics window behaves like the system diagnostics view but is only available in the global screen.

Requirements

- At least one CPU has been set up in the project.
- An HMI device (e.g. Comfort Panel) has been set up in the project.
- The CPU and the HMI device are connected with each other by an HMI connection.
- You have created a screen (for the system diagnostics view).
- The global screen is open (for the system diagnostics window).
- The "Toolbox" task card is open.

Procedure

Proceed as follows to configure the system diagnostics view:

1. Insert a system diagnostics view in your project:
   - To insert in the global screen: Double-click the "System diagnostics window" object in the "Toolbox" task card in the "Controls" pane. The object is added to the global screen.
   - To insert in any screen: Double-click the "System diagnostics view" object in the "Toolbox" task card in the "Controls" pane. The object is added to the opened screen.

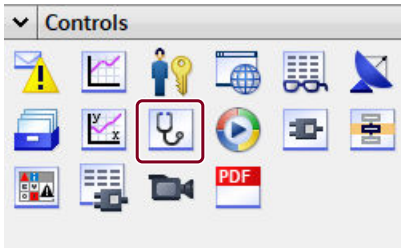

Figure 3-311 Adding a system diagnostics view

2. Select the "Properties" tab in the Inspector window.
3. Select the area "Columns".
4. Enable the columns that you require in the device view for WinCC Runtime, for example:
   - Operating mode
   - Slot
   - Type
   - Article number
   - Address

   The "Status" and "Name" columns are enabled by default and cannot be deselected.
5. Change the default values under "Device view column width" if necessary. You can also adapt the column widths during runtime.
6. Enable the columns that you require in the details view for WinCC Runtime, for example:
   - Operating mode
   - Rack
   - Slot
   - Address
   - Plant designation
   - Error description
7. Change the headers for the columns under "Column header", if required.
8. To close the system diagnostics window in WinCC Runtime, select the "Close button:" option in the "Header" area under "Properties > Window" in the "Properties" tab of the Inspector window.

Result: Any screen result

The system diagnostics view has been added to the screen. The diagnostics status of the entire plant is displayed in the system diagnostics view in WinCC Runtime.

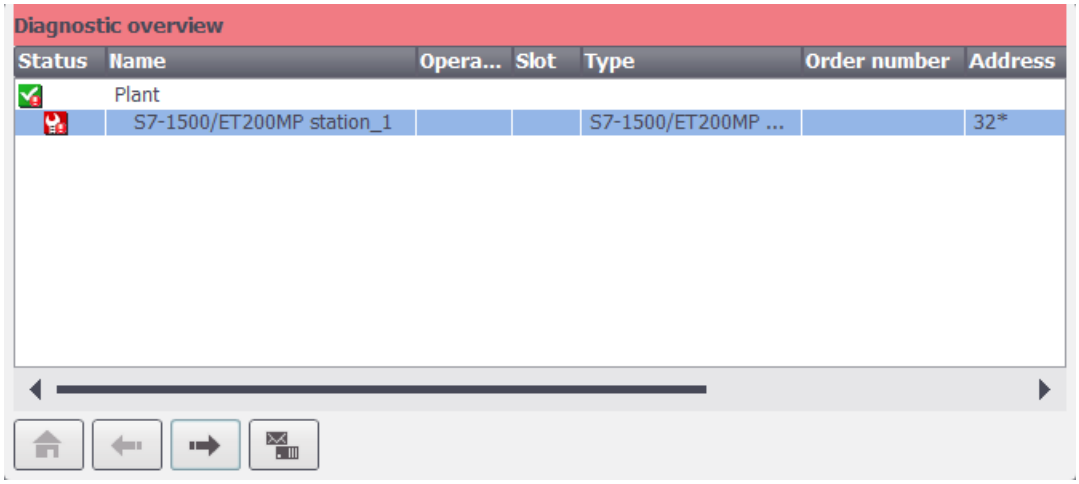

Figure 3-312 System diagnostics view in the screen

Result: Global screen result

The system diagnostics window has been added to the global screen. If there is an error message in the plant, the system diagnostics window responds and displays the affected device.

5.3.4.2 Different views of the system diagnostics view

Introduction

The following views are available in the system diagnostics view and the system diagnostics window in WinCC Runtime:

- Diagnostic overview
- Device view
- Details view
- Distributed I/O view (only for PROFIBUS and PROFINET- systems)
- Diagnostics buffer view

Diagnostic overview

The "Diagnostic overview" screen is the start screen of the system diagnostics view in WinCC Runtime. In this view, you can select the station for which you want to display additional diagnostic information.

The "Status" column shows the status of the overall plant and the associated stations using symbols.

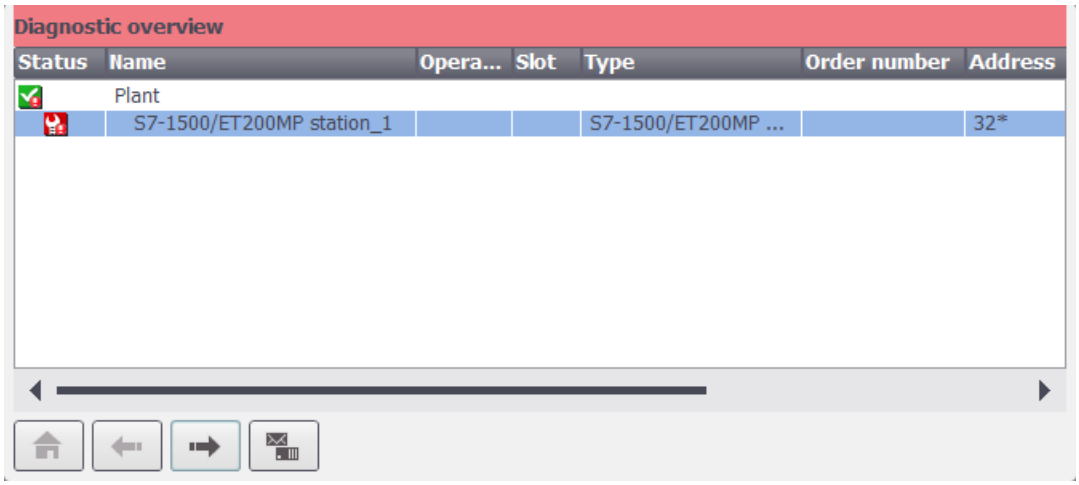

Figure 3-313 Diagnostic overview

Device view

The device view shows all the available devices of a layer in a table. Double-clicking on a device opens either the lower-level devices or the details view. The symbols in the first column provide information about the current state of the device.

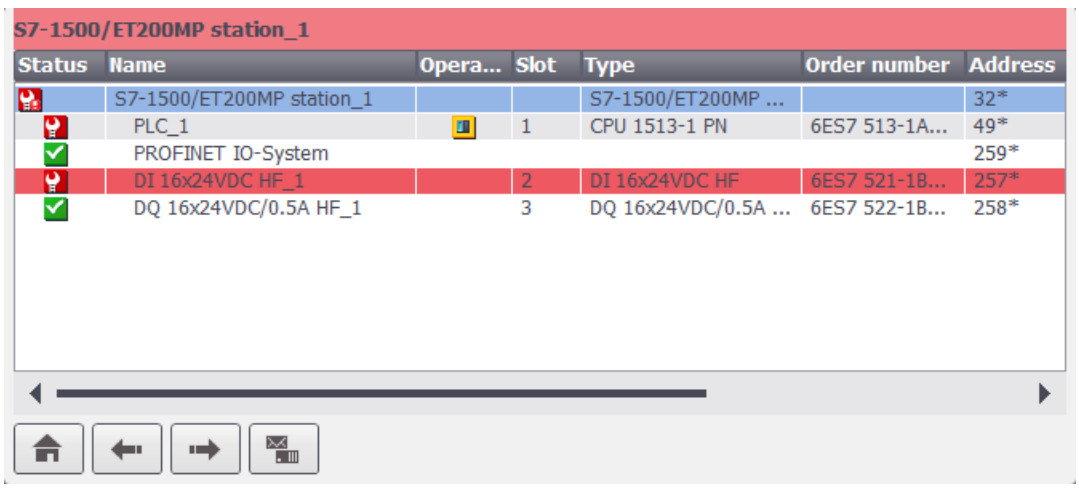

Figure 3-314 Device view

Details view

The details view gives detailed information about the selected device. Check whether the data is correct in the details view.

The error text shows a detailed description of the pending errors and suggestions on resolving the errors.

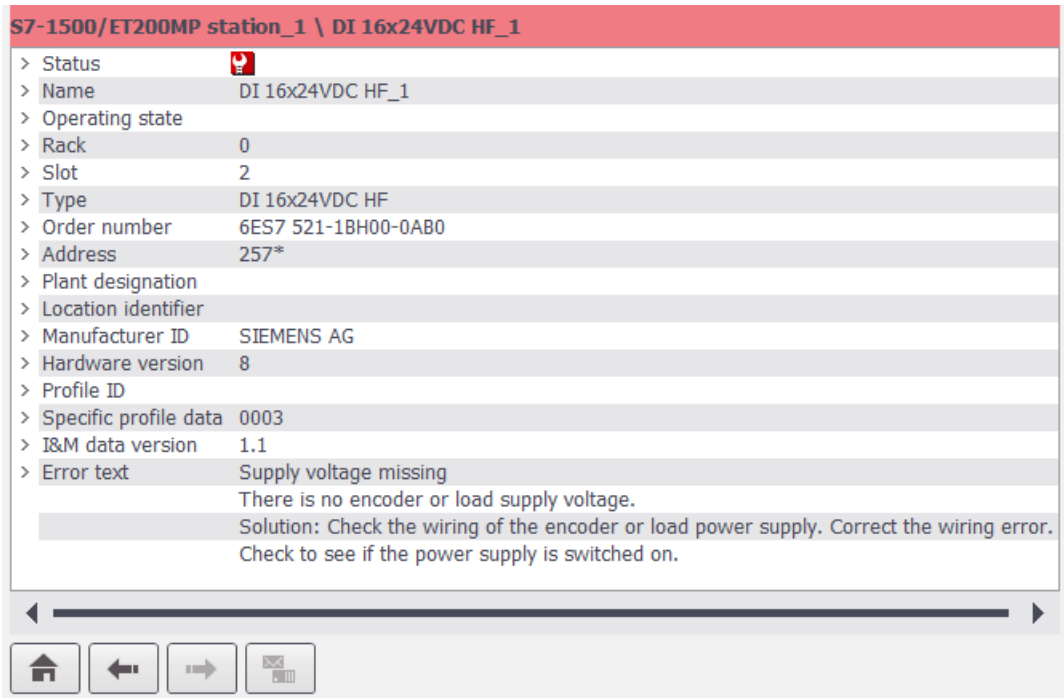

Figure 3-315 Details view

Distributed I/O view

The distributed I/O view is only available for distributed I/O systems. The distributed I/O view shows the status of the devices of the PROFIBUS/PROFINET-subnet.

Each element in the view shows the following information:

- Device name
- Device type
- The IP- or PROFIBUS address.

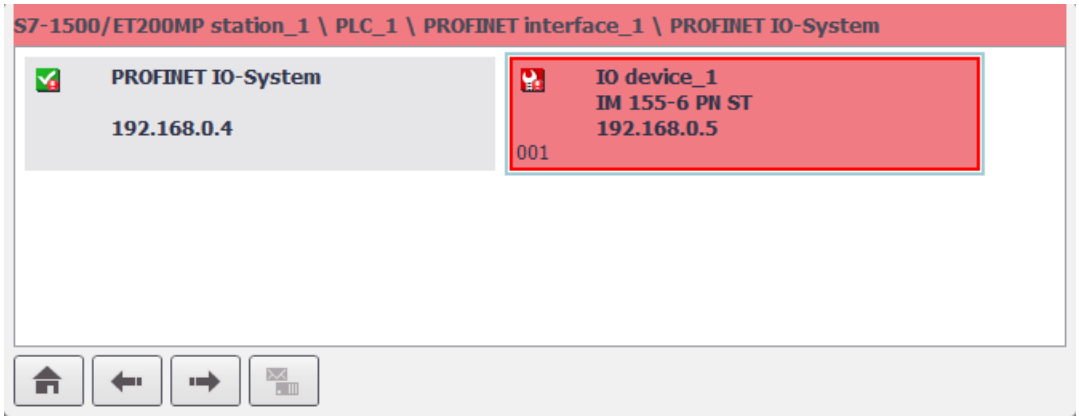

Figure 3-316 Distributed I/O view

Diagnostics buffer view

The diagnostics buffer view shows the current data from the diagnostic buffer of a station, e.g. a CPU. You can obtain detailed information on the event by double-clicking on the corresponding entry.

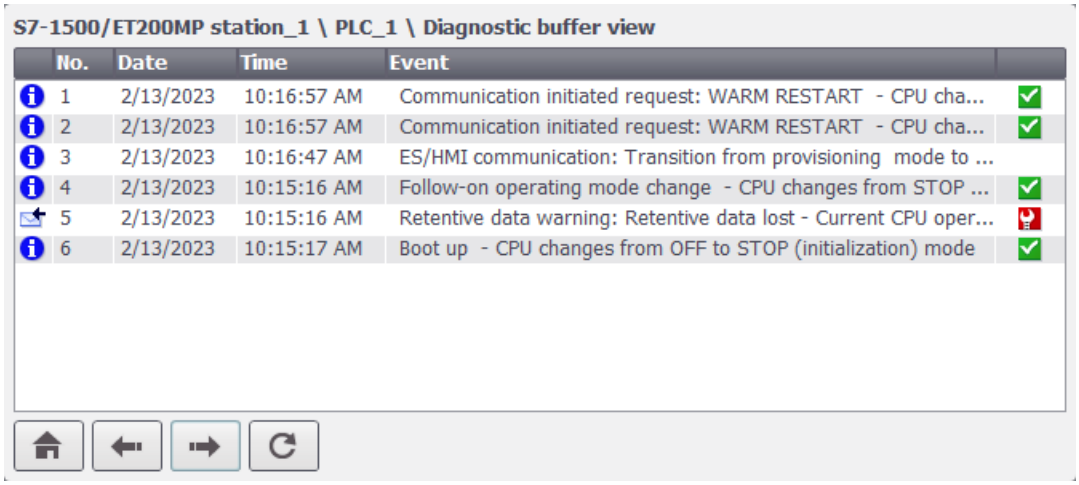

Figure 3-317 Diagnostics buffer view

Navigation buttons

Button	Function
	Opens the diagnostic overview.
	Opens the higher-level device, or the device view if there is no higher-level device.

Button	Function
	Opens the lower-level devices, or the details view if there are no lower-level devices.
	Opens the diagnostics buffer view. Can only be selected if a station is selected.
	Updates the diagnostics buffer view. Can only be selected in the diagnostic buffer view.

5.3.4.3 Inserting system diagnostics indicator

Introduction

The system diagnostics indicator is a predefined graphic library object which alerts you to errors in your plant.

The library object shows the overall status of your plant in one of two states as follows:

- Green with white checkmark: No error
- Red with white wrench: Error

If at least one CPU indicates an error, the overall status also indicates an error.

Requirements

- At least one CPU has been set up in the project.
- An HMI- device (e.g. Comfort Panel) has been set up in the project.
- The CPU and the HMI device are connected with each other via an HMI connection.
- The "Libraries" task card is opened.
- The global library "Buttons-and-Switches > Master copies > DiagnosticsButtons" is open.
- A screen is open.
- The system diagnostics window has been set up in the global screen.

Procedure

1. Select the "DiagnosticsIndicator" object in the global library.
2. Drag-and-drop the library object to the position in the open screen where you want to insert the object.

   The library object is added.
3. Open the "Events" tab in the Inspector window.

   The "ShowSystemDiagnosticsWindow" function is preset for the "Click" event.

4. Next to "Object name", select the system diagnostics window in the global screen.

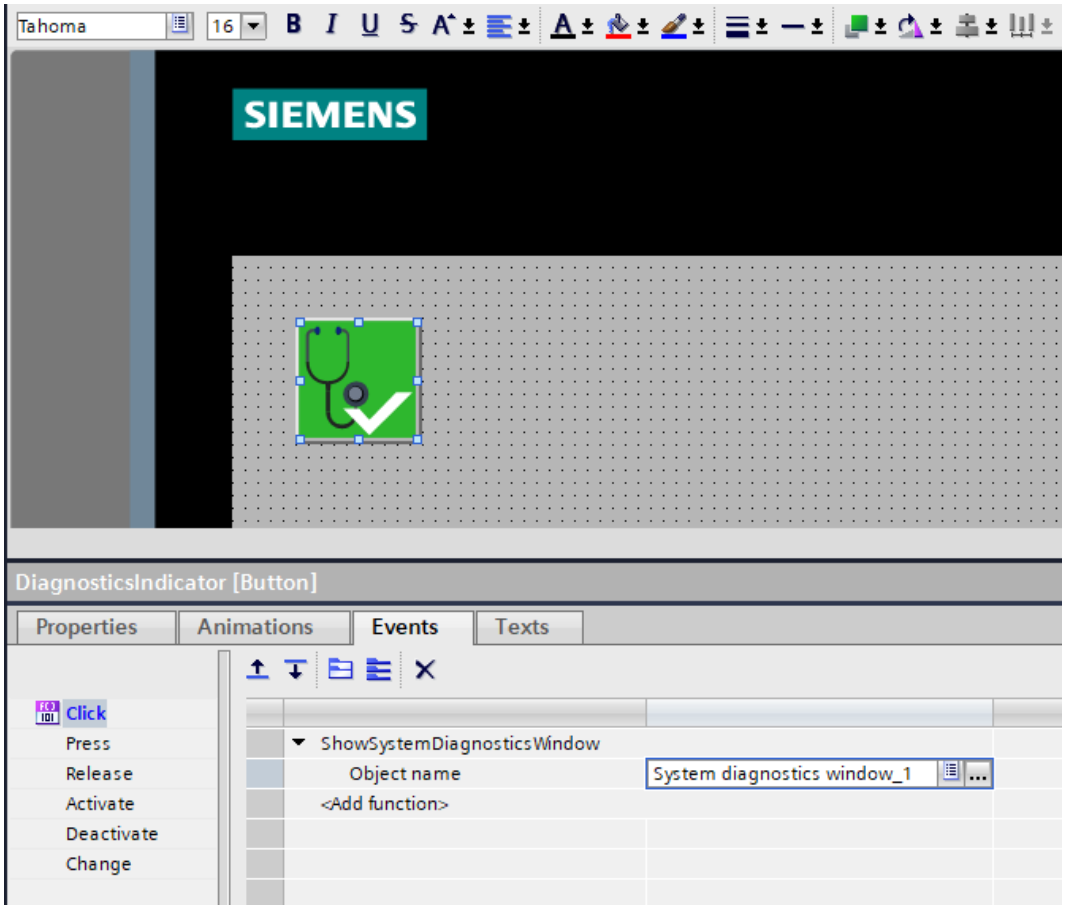

Figure 3-318 Inserting library object in the work area

Result

The system diagnostics indicator has been added to the project and connected with the system diagnostics window.

The system diagnostics indicator changes its appearance if an error message is output in WinCC Runtime. The system diagnostics window opens when you click on the system diagnostics indicator. The system diagnostics window shows the details view of the affected device.

Configuring access protection for the system diagnostics window

Configure access protection for the system diagnostics indicator to prevent unauthorized access to the system diagnostics window.

1. Select the "DiagnosticsIndicator" object in the screen.
2. Open the "Properties" tab in the Inspector window.
3. Navigate to "Security".
4. Select an authorization in the "Security in Runtime" area.

A logon dialog opens when you click on the system diagnostics indicator in WinCC Runtime. The system diagnostics window does not open unless you have the required authorization.

5.3.4.4 Configuring button as system diagnostics indicator

Introduction

Instead of using the "DiagnosticsIndicator" object from the library, you can configure a button in "Graphics" mode, for example, to indicate errors in your plant.

Requirements

- At least one CPU has been created.
- An HMI device (e.g. Comfort Panel) has been set up in the project.
- The CPU and the HMI device are connected with each other via an HMI connection.
- A screen is open.
- The "Toolbox" task card is open.
- A graphics list has been created with two different graphics for the states "Error" and "No error".
- You have created a system diagnostics view.

Procedure

Follow these steps to configure a button as system diagnostics indicator:

1. Double-click the "Button" object in the "Toolbox" task card. A button is added to the screen.
2. Select the "Properties" tab in the Inspector window.
3. Select the "Graphics" option in the "General > Mode" area.
4. Select the "Graphics list" option in the "General > Graphics" area.
5. Select the created graphics list as the graphics list.
6. Select the "@DiagnosticsIndicatorTag" under "Tag" in the "General > Process" area.
7. To assign a function to the button, select the "Events" tab in the Inspector window.
8. Select the "Click" event.

9. Click on "Add function" in the table.
10. Select "EnableSystemDiagnosticsView".
11. Add the settings as follows:
    - Next to "Screen name", select the screen in which the system diagnostics view was created.
    - Select the system diagnostics view next to "Screen object".
12. Correct the height and width of the button as required.

Result

You have configured an interface that reacts to error events from the CPU. The button changes when an error event occurs in Runtime.

The button has two states.

- Error

  The system diagnostics view opens when you click on the button. The system diagnostics view shows the details view of the affected device.
- No error

  The system diagnostics view opens when you click on the button. The system diagnostics view shows the diagnostic overview.

More information

You can find detailed information and procedures for visualization in the TIA Portal online help under "Visualizing processes (Basic Panels, Panels, Comfort Panels, RT Advanced, RT Professional) > Using diagnostics functions".

5.3.4.5 System diagnostics in WinCC Unified

Objects for system diagnostics in WinCC Unified

The following diagnostics objects are available to display system diagnostics on WinCC Unified components:

- Diagnostics indicator
- System diagnostics view

You can use each of the diagnostics objects on all WinCC Unified components.

Configuring a diagnostics indicator

A diagnostics indicator shows the overall status of your plant. If at least one CPU indicates an error, the overall status also indicates an error.

In WinCC Unified, you can configure a diagnostics indicator using dynamically scalable vector graphics (DynamicSVGs). The following figure shows the pre-programmed objects provided by WinCC Unified:

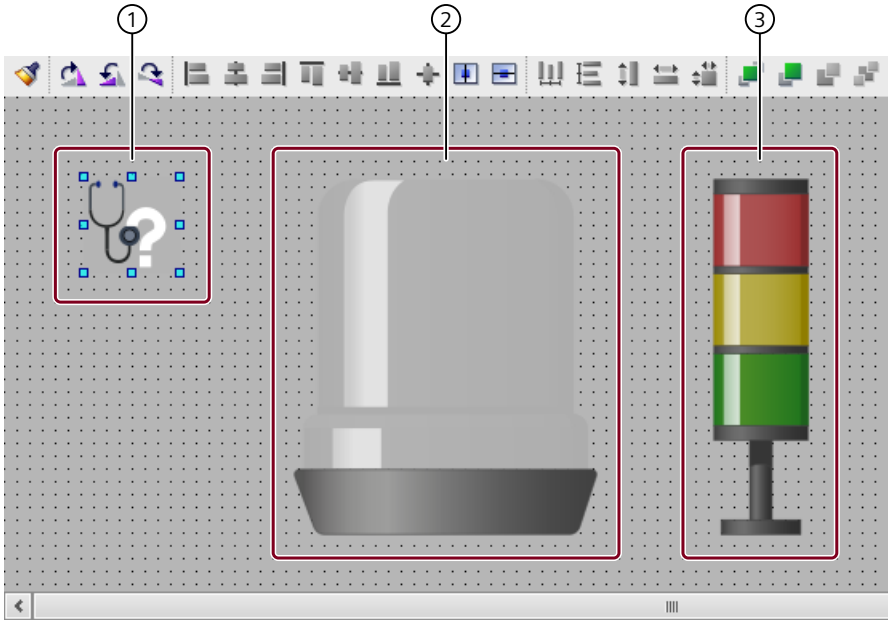

① Diagnostics indicator

② Signal lamp

③ Signal tower

To configure a diagnostics indicator in an open screen, follow these steps:

1. Open the "Toolbox" task card.
2. Select the "IndustryGraphicLibrary > SIMATIC > SystemDiagnostic" folder in the "Dynamic widgets" pane.
   You see the pre-programmed objects below.

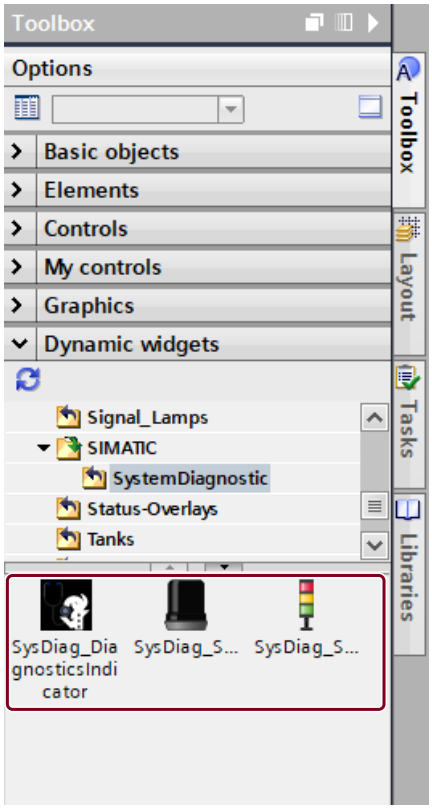

Figure 3-319 "Dynamic widgets" pane

3. Drag-and-drop the desired object onto an open screen.
4. Open the "Properties" tab in the Inspector window.
5. For the "State" parameter, configure dynamization by means of a variable.

6. Select the "@DiagnosticsIndicatorTag" in the "Process" area.

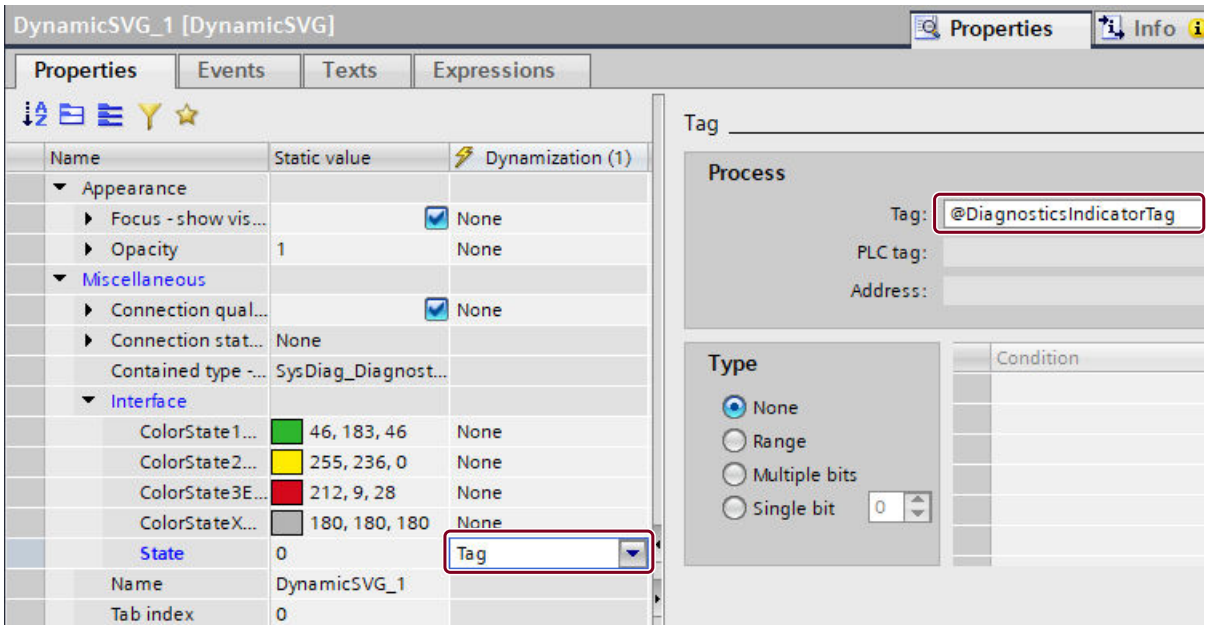

Figure 3-320 Configuring a diagnostics indicator

Result: You have configured a diagnostics indicator and dynamized the status using a tag.

The colors of the dynamized SVGs change according to the defined tag values in Runtime.

Table 3-925 Possible diagnostic values

Status	Diagnostic value	Color
Indeterminate	0	Gray
Good	1	Green
Maintenance	2	Yellow
Error	3	Red

Configuring the system diagnostics view

You configure the system diagnostics view in WinCC Unified in the same way as in WinCC.

However, while system diagnostics in WinCC shows each view in table form, WinCC Unified has a matrix view. In the matrix view, you see an overview of your devices and the associated details view in the same window during runtime.

The matrix view shows stations and devices as tiles. When you click on a tile of a device, the lower part of the view shows detailed information about the device. To show detailed information about the higher-level station, click the "Enable/disable details view" button.

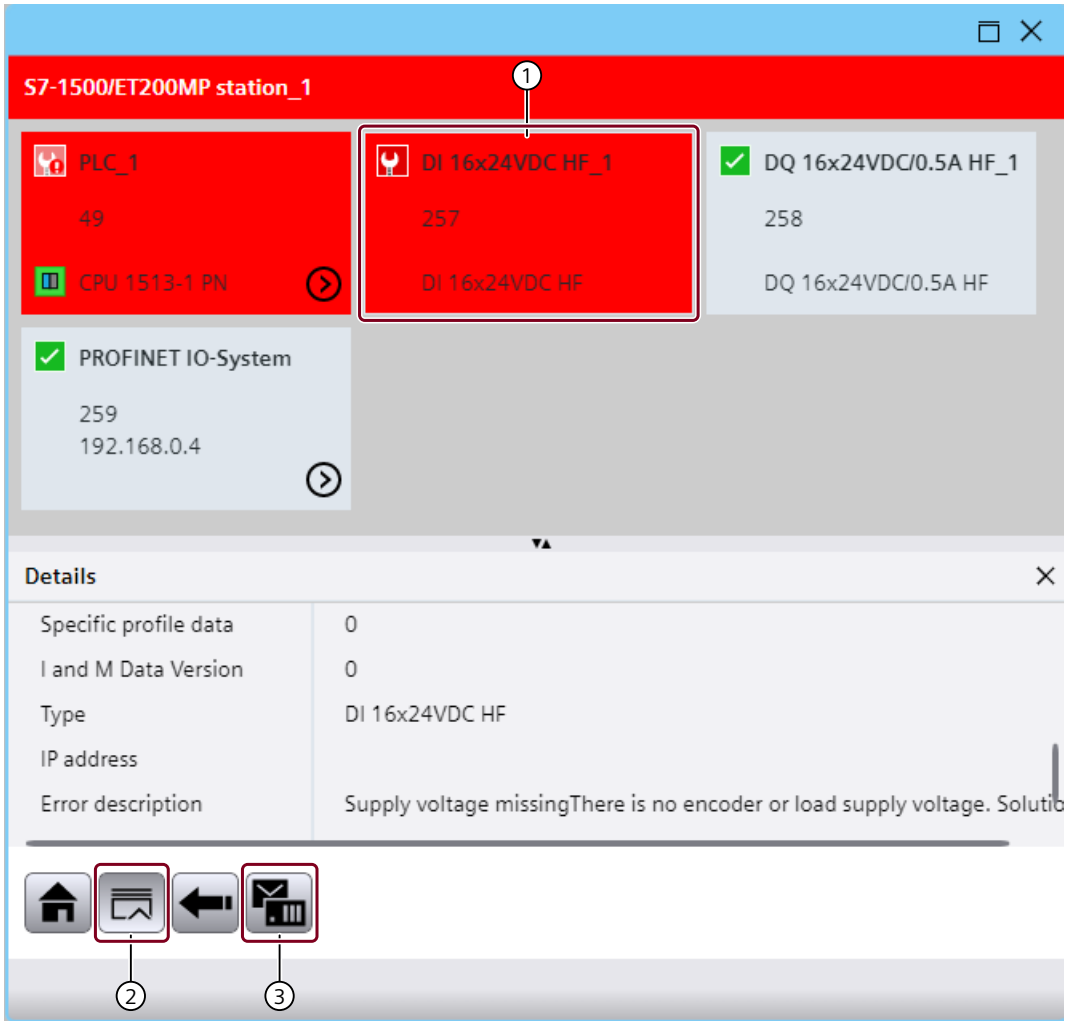

① Tile of a faulty device

② "Enable/disable details view" button

③ "Show diagnostics buffer" button

Figure 3-321 Matrix view during runtime

NOTE

System diagnostics in WinCC Unified for S7-1500R/H systems

For S7-1500R/H systems, system diagnostics in WinCC Unified is available as of TIA Portal V20.

In the matrix view, you can switch to the diagnostics view with the "Show diagnostics buffer" button.

The diagnostics view shows the diagnostics buffer with the diagnostic events of the selected CPU. In WinCC Unified, unlike in WinCC, the diagnostic alarms are loaded from the diagnostics

buffer of the selected CPU and displayed during runtime. Errors in the diagnostics view due to non-updated text lists on the HMI devices are prevented in this way.

When you click on the "Enable/disable details view" button, the lower part of the diagnostics view shows detailed information about the selected event.

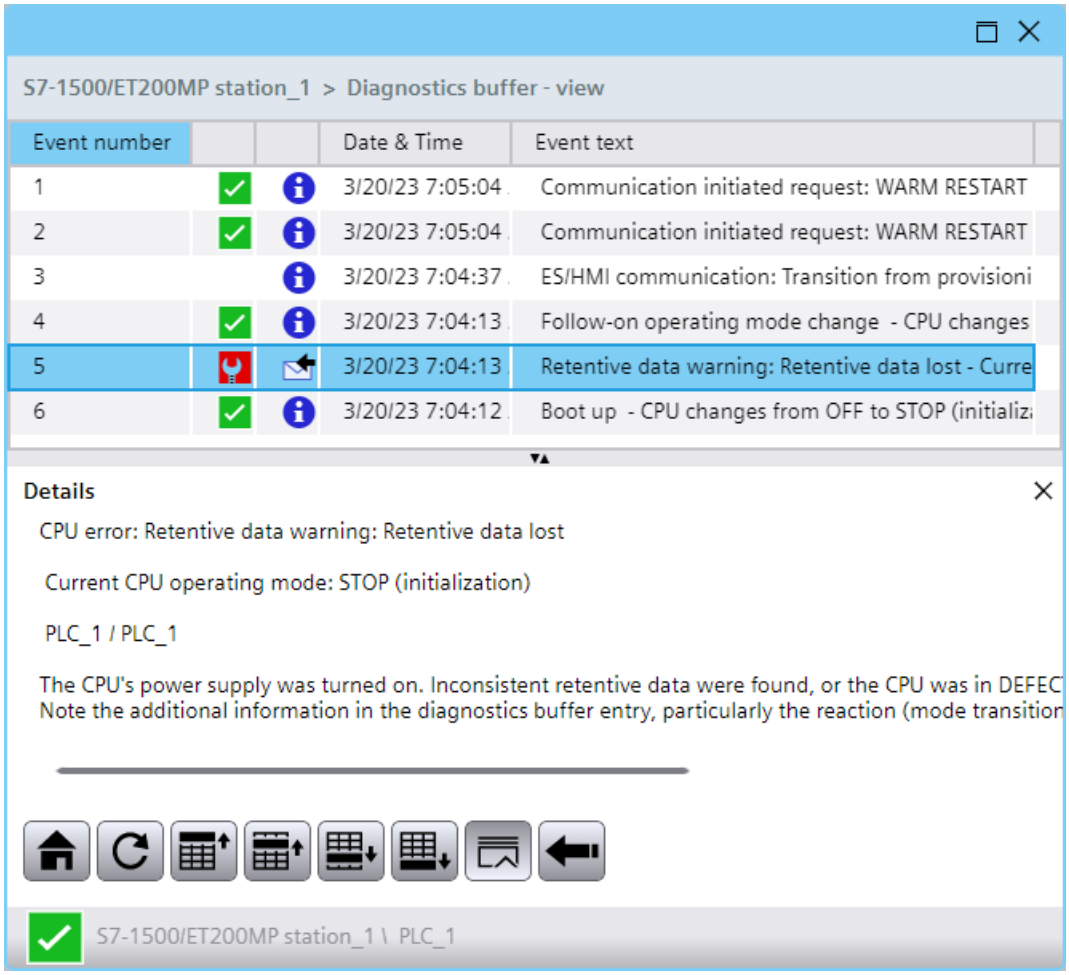

Figure 3-322 Diagnostics buffer view

In the Runtime settings, you can select the languages you need for your display. A CPU supports three languages that you configure in the engineering. If the Runtime language and the configured language of the CPU do not match, the diagnostic alarms are displayed in the configured substitute language of the CPU.

More information

You can find detailed information and procedures for visualization in the TIA Portal online help under "Visualizing processes (RT Unified)> Using diagnostics functions".

System diagnostics by means of the user program 6

6.1 Options of system diagnostics in the user program

Introduction

You can configure responses to diagnostics alarms in the user program. You can, for example, specify that your plant is stopped in case of specific diagnostics alarms.

Instructions

A vendor-independent structure of data records with diagnostics information applies. The following instructions are available for determining the system diagnostics of a device:

Table 3-926 Instructions for determining the system diagnostics

Instruction	Description
RDREC	• Reads data records of a component (module or submodule) of a DP slave/IO device that may contain error information • Works asynchronously, which means processing takes place across several calls
DPNRM_DG	• Reads the current diagnostics data of a DP slave (DP standard diagnostics) • Works asynchronously, which means processing takes place across several calls
T_DIAG	• Provides diagnostic and status information on a connection • Works asynchronously, which means processing takes place across several calls
Get_IM_Data	• Reads the identification and maintenance data of the CPU • Works asynchronously, which means processing takes place across several calls
GetStationInfo	• Reads address information of a PROFINET IO device • IO device may also be located in a lower-level IO system (connection via CP/CM) (except in S7-1500R/H systems). • Works asynchronously, which means processing takes place across several calls
GetChecksum	• Reads the checksum of a group of objects • Works asynchronously, which means processing takes place across several calls
GetSMCinfo	• Reads information about the inserted SIMATIC Memory Card • Works asynchronously, which means processing takes place across several calls
RALRM	• Reads the start information of the OB when calling the diagnostics interrupt OB (OB 82) • Provides information on cause and location of error
GEN_DIAG	• Generates diagnostics information • To generate diagnostics information, the module or submodule is identified with its logical address
Gen_UsrMsg	• Generates an alarm that is entered in the diagnostics buffer
GET_DIAG	• Provides diagnostics information • To provide diagnostics information, the module or submodule is selected
GET_Name	• Reads the name of an IO device

Instruction	Description
RD_SINFO	• Reads the start information of the OB called last that has not been processed completely and the startup OB started last • Provides general error information
LED	• Reads the status of the module LED
DeviceStates	• Outputs the state of all devices of an IO system
ModuleStates	• Outputs the state of all modules of a device
RT_INFO	• Provides statistics on the runtime of certain organization blocks of the communication or the user program
GetClockStatus	• Reads information about the internal CPU clock

Additional information

Online help

In the online help for STEP 7, you can find:

- Additional information on instructions for system diagnostics
- Information about further options for evaluating diagnostic information in the user program (e.g. with the "RDREC", "RALRM", "GET_DIAG" instructions)
- Information on SIMATIC ProDiag. This functionality enables targeted and fast machine and plant diagnostics for SIMATIC S7-1500 and SIMATIC HMI:
  - Standardized diagnostics concept for different SIMATIC components
  - No additional configuration work for diagnostics functionality
  - Reduces the load on PLC memory and program run time

  You can find details in the online help under "Supervising machinery and plants with ProDiag".

Manuals

You can find additional information about evaluating diagnostic information in the user program in the following manuals:

- PROFINET function manual (http://support.automation.siemens.com/WW/view/en/49948856)
- From PROFIBUS DP to PROFINET IO (https://support.industry.siemens.com/cs/ww/en/view/19289930) programming manual
- Manual for the respective module

Application examples

You can find detailed application examples with further documentation and example projects on the Service&Support Website:

- Diagnostic overview for SIMATIC S7-1200 and S7-1500 (https://support.industry.siemens.com/cs/ww/en/view/109752283)

FAQ

For more information about how to realize channel diagnostics in the user program of the SIMATIC S7-1500, refer to the FAQ with entry ID 109480387 on the Service&Support Website (https://support.industry.siemens.com/cs/ww/en/view/109480387).

6.2 System diagnostics using process image inputs

Introduction

In addition to event-driven system diagnostics, the input and output modules of the SIMATIC series provide diagnostics information using the process image input.

The system diagnostics described in the preceding sections is made available asynchronously to the program processing. To ensure the correct processing of the input and output data in the case of faults while reading the input and output data, some modules offer the so-called value status (QI = Quality Information) for evaluation.

Requirement for evaluation of the value status

The diagnostics information about the process image input is transmitted synchronized with the user data. Select the "Value status" check box in the properties of the I/O module in STEP 7 if you want to evaluate the value status of the channel.

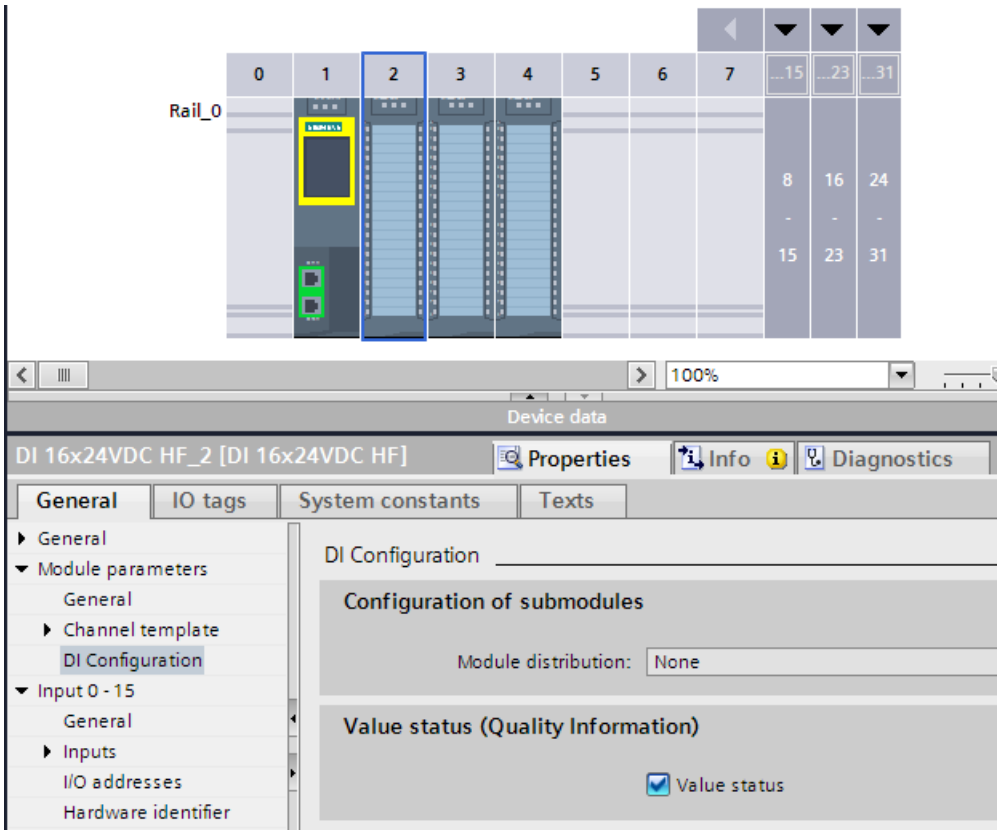

Figure 3-323 Enable value status

Evaluation of the value status

If you have enabled the value status for an I/O module, this module provides additional information on the value status in addition to the user data. This information is available directly in the process image input and can be retrieved with simple binary operations without having the evaluate the module diagnostics. Configured diagnostics in STEP 7 is not necessary for output of the value status.

Each channel is uniquely assigned one bit in the value status. The bit in the value status indicates the validity of the read-in value in the user data.

Table 3-927 Example for evaluation of the user datum in case of a wire break for a digital input module

	Bit in user datum	Bit in value status	Value in user datum
Faulty channel	Logical 0	0	Invalid
Fault-free channel	Logical 0 (actual value)	1	Valid

Influence of the value status

The value status of an active channel is "Invalid" when any **one** of the following factors is given:

- Channel diagnostics pending (regardless of whether diagnostics, for example wire break, is configured for this channel)
- For output channels: "Reaction to CPU STOP" feature is active (due to CPU STOP, interrupted connection)
- For output channels of the digital on-board I/O of compact CPUs: If a channel is used for technology functions, it returns the value status 0 ("Invalid"). It does not matter in this context whether the output value is incorrect or not.
- PROFIenergy is active, i.e. hibernation is enabled (except in "Continue working mode")

When working with non-fail-safe modules, note that an invalid active channel also sets the value status of all other active channels to "Invalid". We therefore recommend that you disable all unconnected or unused channels.

Example - Evaluation of the value status for the input channel of an analog input module

The example below shows the basic evaluation of the value status for the input channel of an analog input module in the user program. The diameter of a cylinder is measured by means of a channel and its circumference is calculated.

- If the value status indicates the channel is error-free, the circumference is to be calculated.
- If the value status indicates the channel is defective, the value "0" is to be output as substitute value for the circumference.

The figure below shows the evaluation of the value status in the user program.

Perimeter

	Name	Data type	Default value	Comment
1	Input			
2	Diameter	Real	0.0	Tag for analog input channel
3	QualityInformation	Bool	false	Tag for QI of analog input channel
4	Output			
5	Perimeter	Real	0.0	Tag for result of calculation
6	InOut			
7	Static			
8	Temp			
9	Constant			
10	PI	Real	3.14	Constant for pi
11	SubstituteValue	Real	0.0	Constant for substitute value

IF... CASE... OF... FOR... TO DO.. WHILE.. DO... (*...*)

```
1 IF #QualityInformation = true                //Validity check of diameter
2
3     THEN                                     //Program run, if quality information is positive
4         #Perimeter := #Diameter * #PI;       //Calculation of perimeter
5
6     ELSE                                     //Program run, if quality information is negative
7         #Perimeter := #SubstituteValue;      //Substitute value assigned to perimeter
```

Figure 3-324 Example - Evaluation of the value status in the user program

Additional information

Depending on the I/O module, the value status reserves different addresses in the process image input. The manual for the module used includes specific information on the assignment and arrangement.

Alarms

7

Introduction

Alarms allow you to display events from processing in the automation system and to quickly detect errors, to precisely localize them and to remove them. Downtimes are significantly reduced in a plant.

Before alarms can be output, they need to be configured.

You can create, edit and compile event-dependent alarms along with their alarm texts and alarm attributes and display them on display devices.

In STEP 7, you create program alarms in the user program with the "Program_Alarm" instruction. You edit the attributes and alarm texts in the alarm editor in STEP 7.

You can output the alarm status with the "Get_AlarmState" instruction.

Advantages of program alarms

Compared to other alarm methods, such as HMI discrete alarms, program alarms offer the following advantages:

- Central engineering in STEP 7: You only configure a program alarm once for the CPU. The program alarm is automatically transferred from the CPU to all registered HMI devices.
- System-supported acknowledgment: The acknowledgment of a program alarm on an HMI device is automatically updated on other HMI devices by the CPU.
- Time stamping close to the event in the CPU
- Identical time stamps of the alarms on multiple HMI devices without time synchronization

7.1 Creating alarms with the "Program_Alarm" instruction

"Program_Alarm" instruction

You create a program alarm in STEP 7 with the "Program_Alarm" instruction.

The figure below shows the "Program_Alarm" instruction with the most important input tags.

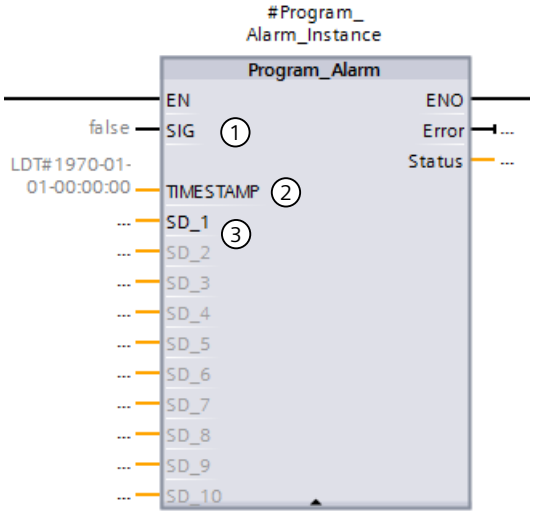

① The "Program_Alarm" instruction monitors the signal at the SIG block input and generates a program alarm in case of a signal change at the SIG parameter. The instruction generates an incoming alarm when the signal changes from 0 to 1 and an outgoing program alarm if the signal changes from 1 to 0. The program alarm is triggered synchronously to program execution.

② The time stamp is automatically created when the alarm event occurs in the automation system and is passed along with the alarm.

③ You can append up to ten associated values to the program alarm at the parameters SD_i (1 ≤ i ≤10). The associated values are acquired at the time of the signal change at the SIG parameter and assigned to the program alarm.
Associated values are used to display dynamic contents in alarms.
Example: The temperature in the tank <associated value 1> is <associated value 2> °C.
You can find more information on associated values in the STEP 7 online help.

Figure 3-325 "Program_Alarm" instruction

NOTE

The "Program_Alarm" instruction can only be called in a function block.

A program alarm can be up to 256 bytes long in total (with associated values and texts from the text list).

The associated values can be a maximum of 512 bytes in length. Text lists are not affected by this.

The CPUs of the SIMATIC S7-1500 product series have the following memory for text lists:

- CPU 1510-x to CPU 1513-x: 4.5 MB
- CPU 1515-x to CPU 1516-x: 6.5 MB
- CPU 1517-x to CPU 1518-x: 50 MB

The number of configurable program alarms depends on the CPU used. With a CPU 1515-2 PN, for example, a maximum of 10,000 program alarms are possible. You can find this information in the Equipment Manual for the respective CPU under "Number of configurable alarms".

The number of simultaneously active "Program_Alarms" depends on the CPU used. With a CPU 1515-2 PN, for example, a maximum of 1,000 program alarms are possible. You can find this information in the Equipment Manual for the respective CPU under "Number of reserved user interrupts".

Sometimes, it is not possible for all program alarms that are active at the same time to be output within one cycle. Query the status of each "Program_Alarm" and activate the instruction again, if necessary. The cycle time is increased for a short time by simultaneously activating/sending multiple "Program_Alarms".

A maximum of 40,000 program alarms should be configured in a STEP 7 project on a 64-bit operating system.

More information

You can find more information on creating program alarms in the STEP 7 online help under "Creating and editing alarms".

7.2 Editing alarms in the alarm editor

Introduction

You can edit the created alarms in STEP 7 either in the program editor or in the alarm editor.

You can find additional information on editing alarms in the program editor in the STEP 7 online help under "Creating and editing alarms".

Editing alarms in the alarm editor

You can edit alarm texts in the alarm editor and specify attributes such as alarm class or priority for the alarms.

1. Double-click "PLC supervisions & alarms" in the project tree. Select the "Alarms" tab. The alarm editor opens.
2. Enter the required texts and attributes in the appropriate columns.

The figure below shows the layout of the alarm editor.

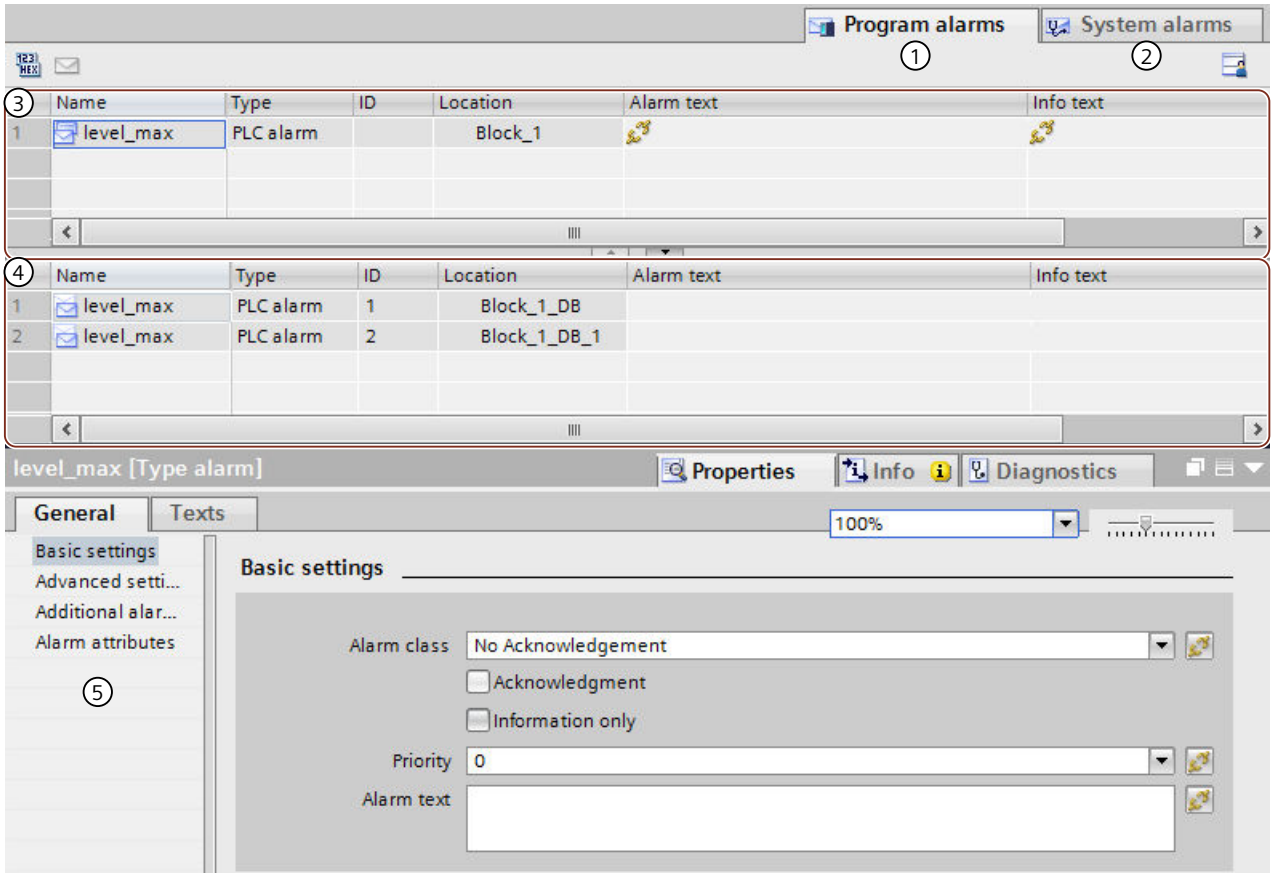

① "Program alarms" tab: You can edit program alarms here.

② "System alarms" tab: System alarms can only be viewed but not edited. To edit these alarms, you must navigate to the device view ("Go to device" menu command), where you can modify the system diagnostics alarms in the Inspector window.

③ "Type alarms" area:
This is where the type alarms created in a function block with the "Program_Alarm" instruction are displayed. Type alarms serves as templates for instance alarms (④).
All the inputs you make for the type alarm are automatically included in the instance alarms derived from it.
You can find more information on type alarms in the STEP 7 online help under "Alarm types and alarms".

④ "Instance alarms" area:
When you assign an instance DB to the message block (for example, call in an OB, FB, FC), instance alarms are automatically generated based on the template of the type alarm and alarm numbers are assigned.
You can modify the instance alarms for specific instances.
You can find more information on instance alarms in the STEP 7 online help under "Alarm types and alarms".

⑤ Properties of the selected type and instance alarm in the Inspector window

Figure 3-326 Layout of the alarm editor

You can enter or modify the necessary parameters, texts and attributes in the table or in the Inspector window.

Multilingual alarms

You can have program alarms displayed in multiple languages by assigning different project languages to the interface languages of the display devices.

NOTE

The project languages you want to assign must be activated and the corresponding texts (translations) must be available in the project. The project language selection can be found in the project tree under "Languages & Resources".

To create the texts of the program alarm as multilingual, follow these steps:

1. In the Inspector window of the alarm editor, open the "Properties" tab and the lower-level "Texts" tab.
2. Enter the text in the desired project language.
3. Open the "Properties" tab in the Inspector window of the CPU and select the "Display" command in the "General" area navigation. Under "Multilingual", assign one of the activated project languages to each interface language of the display devices. Overall, you can assign up to three different project languages to the user interface languages. All assigned project languages are loaded into the CPU.

More information

You can find additional information on texts and attributes in the STEP 7 online help under "Texts and attributes".

You can find more information on text lists in the STEP 7 online help under "Text lists for alarms".

7.3 Display of program alarms

Program alarms you create with the "Program_Alarm" instruction are automatically made available to the display devices.

You have the following options to display the alarms:

- STEP 7
- HMI
- Web server of the CPU
- Display of the CPU

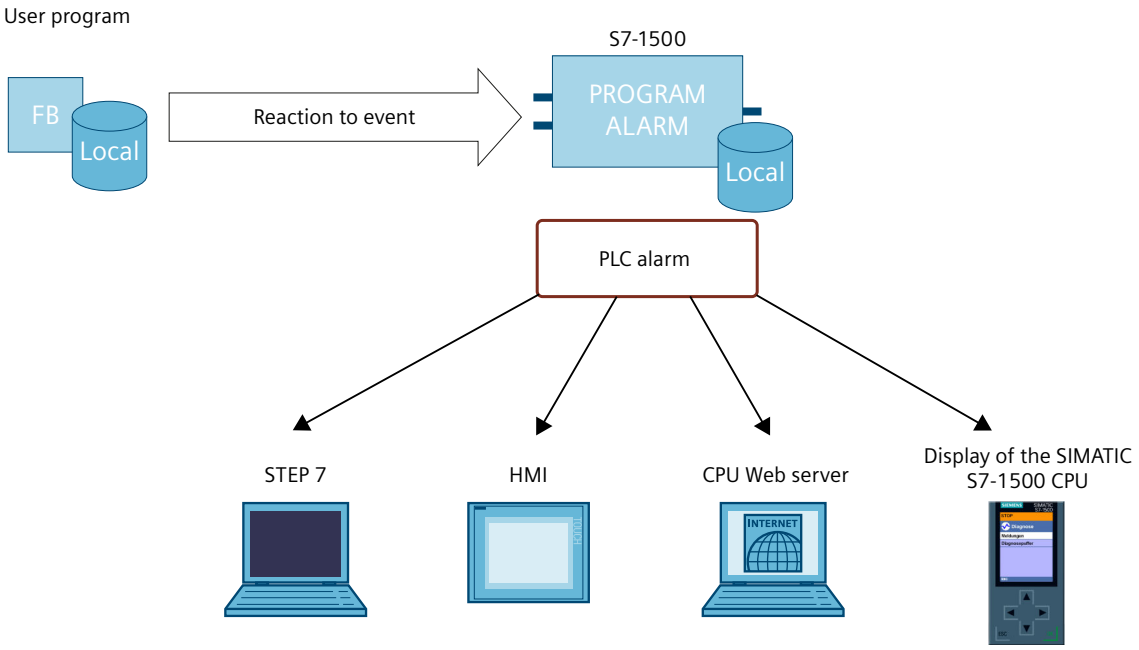

Figure 3-327 Display of program alarms

Multilingual alarms

You can have program alarms displayed in multiple languages by assigning different project languages to the interface languages. See section Editing alarms in the alarm editor (Page 83).

7.4 Output of the alarm state with the "Get_AlarmState" instruction

"Get_AlarmState" instruction

The "Get_AlarmState" instruction outputs the alarm state of a program alarm. The output of the alarm state always refers to a program alarm that was created using the "Program_Alarm" instruction.

The program alarm is selected with the "Alarm" input parameter. Specify the instance DB of the "Program_Alarm" instruction at the "Alarm" parameter.

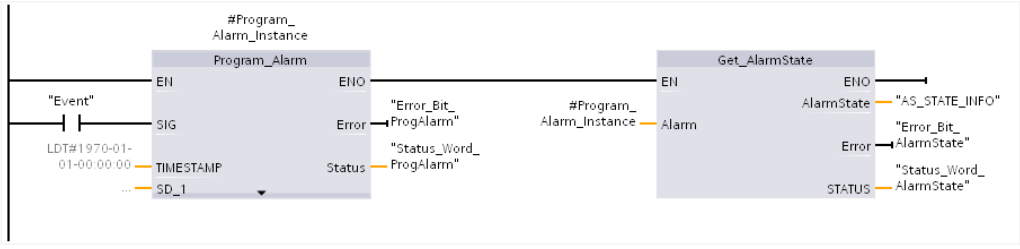

Figure 3-328 Call - Get_AlarmState

Additional information

You can find additional information on evaluation of the "Get_AlarmState" instruction in the STEP 7 online help.

7.5 Example program for program alarms

7.5.1 Task

Introduction

This section describes the basic configuration of program alarms with the "Program_Alarm" instruction based on two examples. The two examples solve the same problem but use a different approach. Example 1 does not use associated values. In example 2, an associated value is assigned to the program alarm to reference a text list.

Example - Minimum/maximum fill level of a tank

A tank is filled with a liquid. The fill level is monitored by two sensors.

If the liquid in the tank drops below a minimum fill level, an alarm is output for low fill level.

If the liquid in the tank exceeds a maximum fill level, an alarm is output for high fill level.

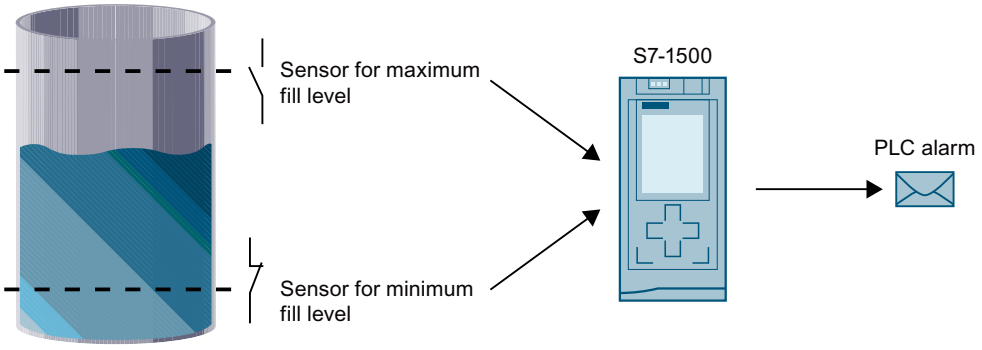

Figure 3-329 Example for fill level alarms

7.5.2 Example 1: Program alarm without associated values

Introduction

In this example, you create a program alarm for the maximum and the minimum fill level.

How the example works

When the maximum fill level is exceeded in the tank, a program alarm with the alarm text for the excessive fill level is output.

When the minimum fill level is undershot in the tank, a program alarm with the alarm text indicating that the fill level is too low is output.

Steps

The following steps are necessary for this example:

1. Define tags for signal acquisition
2. Create function block
3. Create program alarms
4. Call function block
5. Edit alarm text

Define tags for signal acquisition

The following table shows the tags that are used in this example. Define these tags in the standard tag table. The standard tag table is available in the project tree under "PLC tags".

Table 3-928 Tags for fill level alarms

Name	Data type	Description
max	BOOL	Tag for maximum fill level If "max" = 1, the maximum fill level is exceeded.
min	BOOL	Tag for minimum fill level If "min" = 1, the minimum fill level is undershot.

The figure below shows the standard tag table with the defined tags "max" and "min".

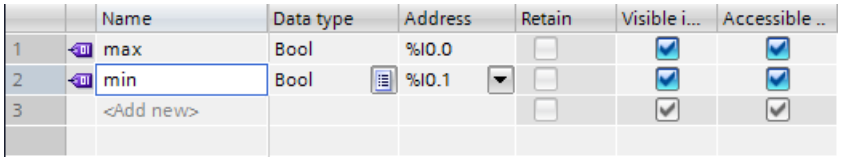

Figure 3-330 Define tags

Create function block

To create a function block, follow these steps:

1. Open the "Program blocks" folder in the project tree.
2. Double-click "Add new block".
   The "Add new block" dialog opens.
3. Select the button "Function block".

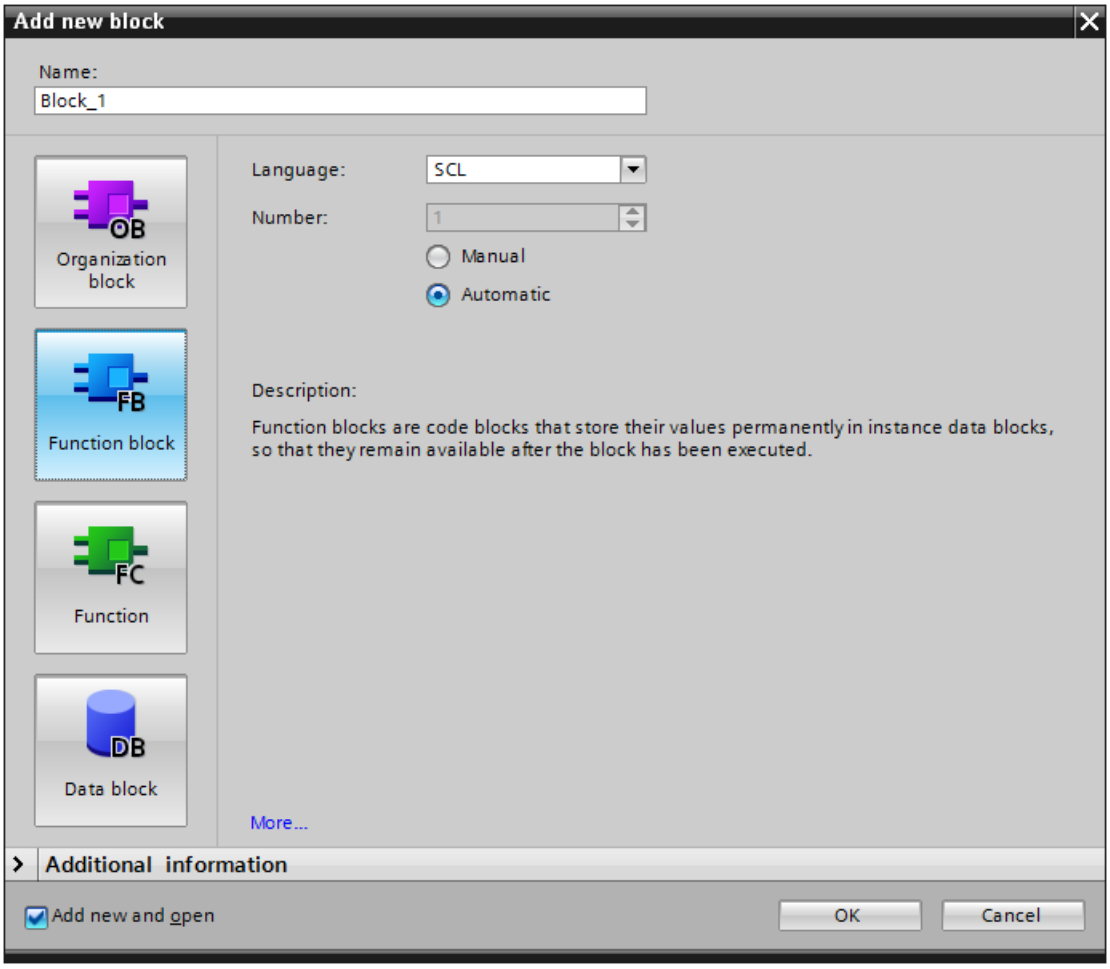

Figure 3-331 Create FB

4. Enter a name for the new block.
5. Select the language SCL.
6. Click on "OK" to confirm your input.

Result: You have created a function block.

Create program alarms

To create the program alarm for the example program, follow these steps:

1. Select the created function block (FB) in the "Program blocks" folder in the project tree and double-click the function block to open it.
2. Insert the call of the "Program_Alarm" instruction in the instruction part of the function block. The "Program_Alarm" instruction is available in the "Instructions" task card under "Extended instructions" > "Alarms".

   The "Call options" window opens.

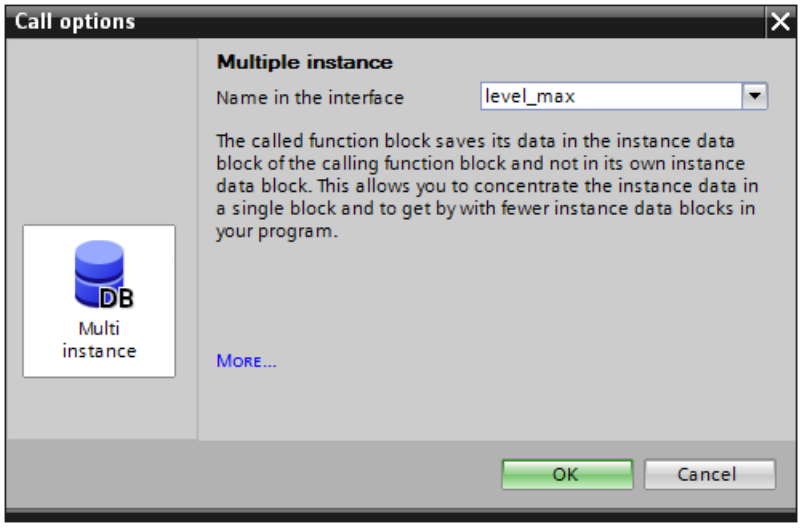

Figure 3-332 Call Program_Alarm

3. Enter "level_max" as the name and confirm the call options by clicking "OK".

   Result: The input tags of the "Program_Alarm" instruction are displayed in the instruction part.
4. Supply the SIG input tag of the "Program_Alarm" instruction with the tags for the maximum fill level.
   `#level_max(SIG:="max");`
   SIG: If a signal change occurs at the SIG input tag, the "Program_Alarm" instruction generates a program alarm.
5. Insert another call of the "Program_Alarm" instruction.
   The "Call options" window opens.
6. Enter "level_min" as the name and confirm the call options by clicking "OK".

   Result: The input tags of the "Program_Alarm" instruction are displayed in the instruction part.
7. Supply the SIG input tag of the "Program_Alarm" instruction with the tags for the minimum fill level.
   `#level_min(SIG:="min");`

Result: You have created two type alarms.

Call function block

To call the function block in the user program, follow these steps:

1. In the "Program blocks" folder, select the cycle OB (e.g., OB1) in which you want to call the function block and open the cycle OB with a double-click.
2. Select the function block you want to call in the "Program blocks" folder.
3. Drag the function block into the instruction part of the cycle OB.
   The "Call options" window opens.

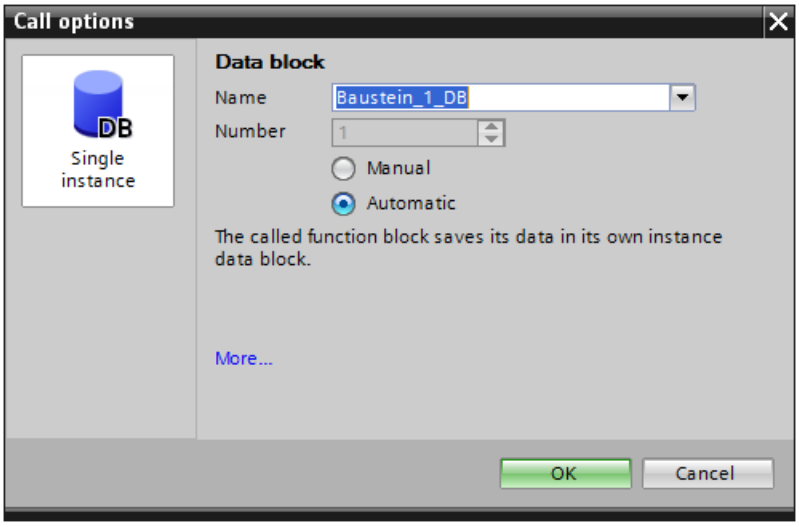

Figure 3-333 Call function block

4. Confirm the call options by clicking "OK".

Result: You have called the alarm block in the user program and created an instance alarm.

Edit alarm text

To edit the alarm text, follow these steps:

1. Double-click "PLC supervisions & alarms" in the project tree. Select the "Alarms" tab. The alarm editor opens.
2. Select the type alarm for the maximum fill level.
3. Enter the alarm text for the maximum fill level in the "Alarm text" column.
4. Select the type alarm for the minimum fill level.
5. Enter the alarm text for the minimum fill level in the "Alarm text" column.

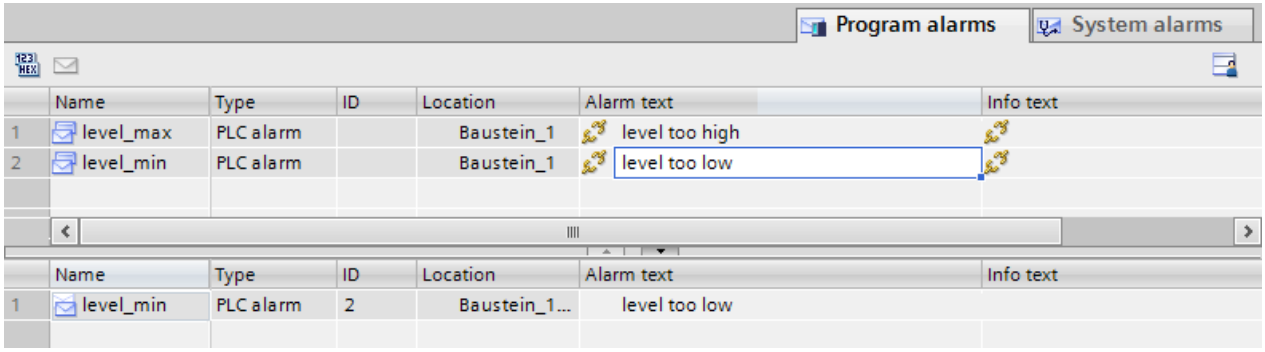

Figure 3-334 Edit alarm text

Result: You have created the alarm texts for both type alarms.

Additional information

You can learn how to create multilingual texts under "Multilingual alarms" in the section Editing alarms in the alarm editor (Page 83).

7.5.3 Example 2: Program alarm with associated value

Introduction

In this example, you create a shared program alarm for the maximum and the minimum fill level. The program alarm is given an associated value. The program alarm uses the associated value to access a text list entry and outputs a separate alarm text for the minimum and the maximum fill level.

How the example works

The program alarm is output if either the minimum fill level is undershot or the maximum fill level is exceeded.

The associated value 1 of the "Program_Alarm" instruction is assigned the tag for the maximum fill level. The associated value references a text list with the entries "0" and "1".

The following scenarios are possible for output of the alarm text:

- Associated value is "0": The entry "0" of the text list with the alarm text for the undershot fill level is output.
- Associated value is "1": The entry "1" of the text list with the alarm text for the excessive fill level is output.

Steps

The following steps are necessary for this example:

1. Define tags for signal acquisition
2. Create function block
3. Create program alarm
4. Call function block
5. Create a text list
6. Edit alarm text

Define tags for signal acquisition

The following table shows the tags that are used in this example. Define these tags in the standard tag table. The standard tag table is available in the project tree under "PLC tags".

Table 3-929 Tags for fill level alarms

Name	Data type	Description
max	BOOL	Tag for maximum fill level If "max" = 1, the maximum fill level is exceeded.
min	BOOL	Tag for minimum fill level If "min" = 1, the minimum fill level is undershot.

The figure below shows the standard tag table with the defined tags "max" and "min".

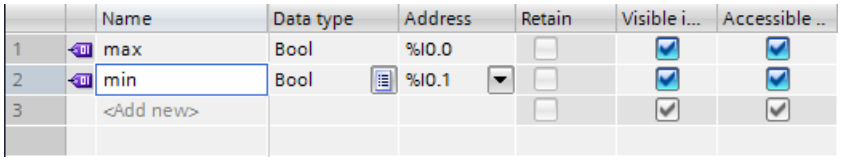

Figure 3-335 Define tags

Create function block

To create a function block, follow these steps:

1. Open the "Program blocks" folder in the project tree.
2. Double-click "Add new block".
   The "Add new block" dialog opens.

3. Select the button "Function block".

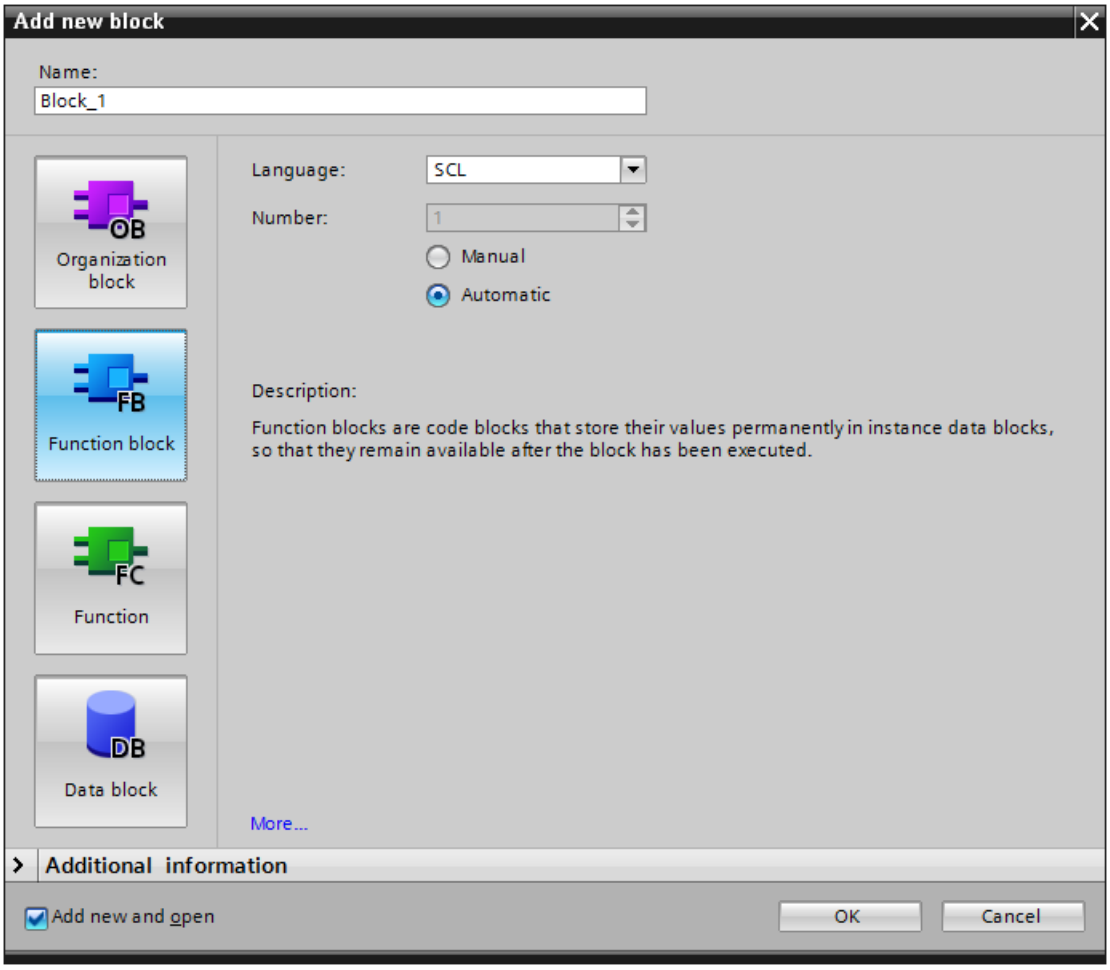

Figure 3-336 Create FB

4. Enter a name for the new block.
5. Select the language SCL.
6. Click on "OK" to confirm your input.

Result: You have created a function block.

Create program alarm

To create the program alarm for the example program, follow these steps:

1. Select the created function block (FB) in the "Program blocks" folder in the project tree.
2. Insert the call of the "Program_Alarm" instruction in the instruction part of the function block. The "Program_Alarm" instruction is available in the "Instructions" task card under "Extended instructions" > "Alarms".
   The "Call options" window opens.

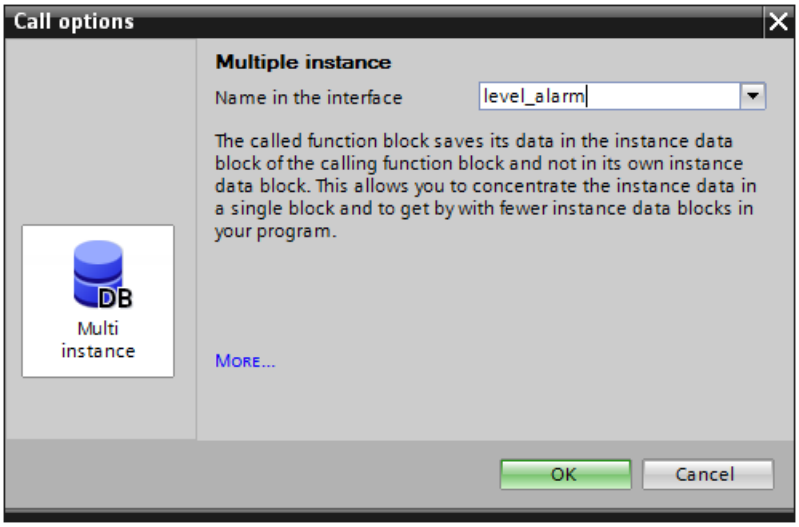

Figure 3-337 Call Program_Alarm

3. Enter "level_alarm" as the name and confirm the call options by clicking "OK".

   Result: The input tags of the "Program_Alarm" instruction are displayed in the instruction part.
4. Supply the SIG input tag of the "Program_Alarm" instruction with the XOR logic operation of the tags for minimum and maximum fill level and the input tag SD_1 with the tag for the maximum fill level.
   `#level_alarm(SIG:="min"XOR"max",SD_1:="max");`
   SIG: If a signal change occurs at the SIG input tag, the "Program_Alarm" instruction generates a program alarm.
   SD_1: The associated value is acquired at the time of the signal change at the input tag and assigned to the program alarm.

Result: You have created a type alarm.

Call function block

To call the function block in the user program, follow these steps:

1. In the "Program blocks" folder, select the cycle OB (e.g., OB1) in which you want to call the function block and open the cycle OB with a double-click.
2. Select the function block you want to call in the "Program blocks" folder.

3. Drag the function block into the instruction part of the cycle OB.
   The "Call options" window opens.

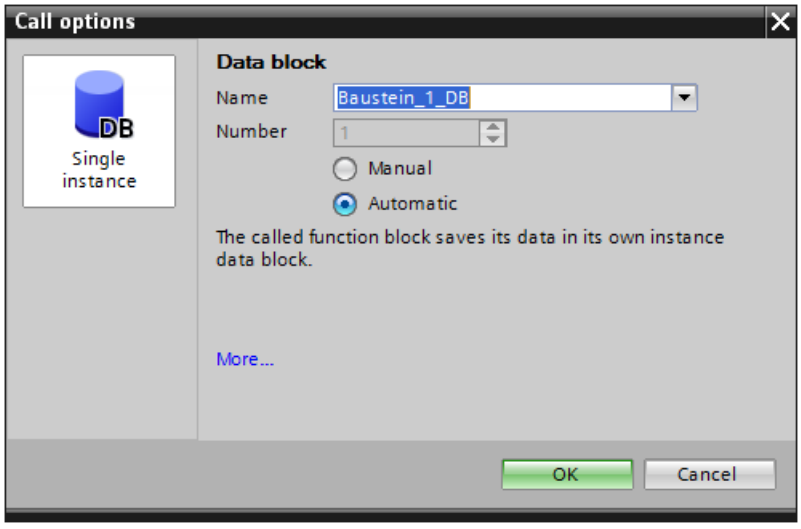

Figure 3-338 Call function block

4. Confirm the call options by clicking "OK".

Result: You have called the alarm block in the user program and created an instance alarm.

Creating a text list

To create the text list for the example program, follow these steps:

1. Double-click on the "Text lists" command in the program tree.
   The text list editor opens.
2. Double-click "<Add>" in the Text lists area.
   A new text list is added.
3. Name the text list "level_textlist".
4. Double-click "<Add>" in the Text list entries area of level_textlist.
   A new text list entry is added in the level_textlist text list.
5. Enter the alarm text for the maximum fill level in the "Entry" column.
6. Add another entry in the text list.
7. Enter the alarm text for the minimum fill level in the "Entry" column.

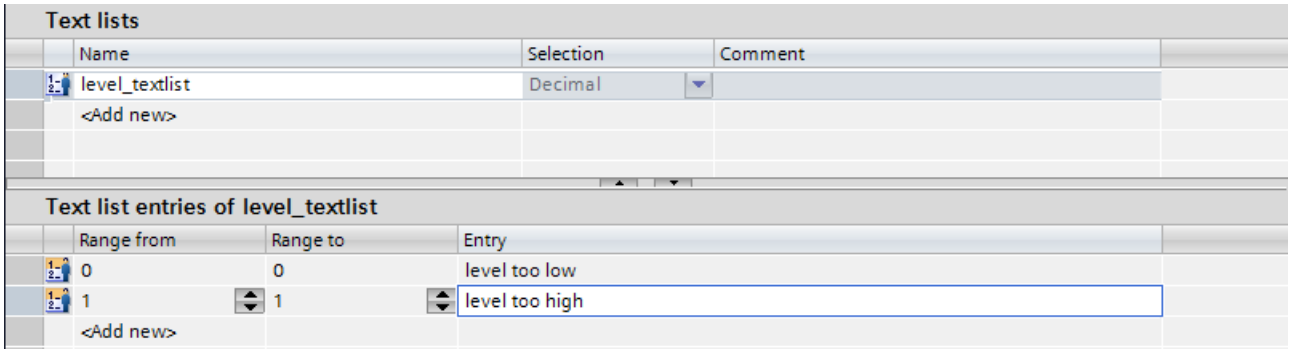

Figure 3-339 Creating a text list

Result: You have created the text list for the alarm text.

Edit alarm text

To edit the alarm text for the example program, follow these steps:

1. Double-click "PLC supervisions & alarms" in the project tree. Select the "Alarms" tab. The alarm editor opens.
2. Select the type alarm created for the example.
3. Click in the "Alarm text" column.
4. Open the shortcut menu and select the command "Insert a dynamic parameter (text list)".

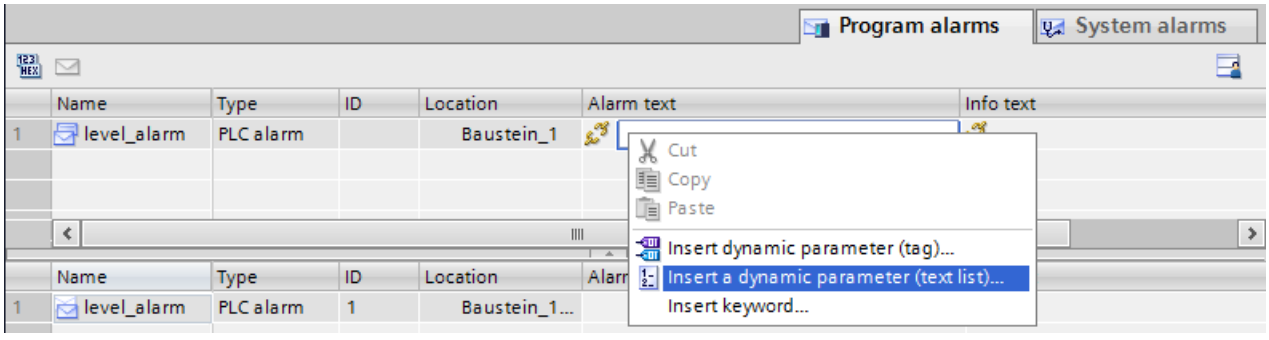

Figure 3-340 Edit alarm text

The window below opens.

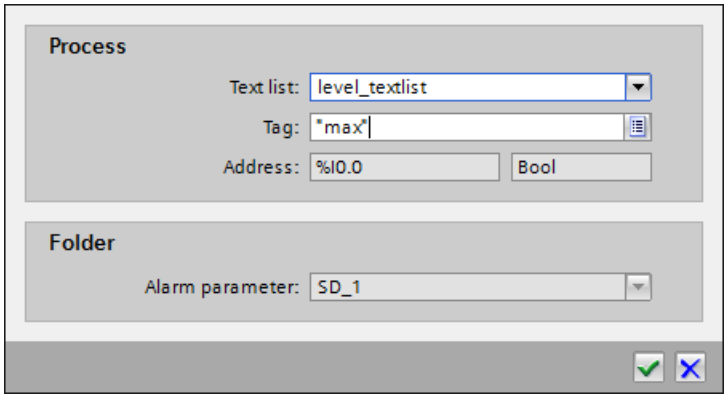

Figure 3-341 Insert a dynamic parameter (text list)

5. Select the text list "level_textlist" and the tag "max". Confirm your selection by clicking "OK".

Result: You have created the alarm text for the type alarms.
If the tag "max" (associated value 1) is 0, the alarm text "level too low" is output.
If the tag "max" (associated value 1) is 1, the alarm text "level too high" is output.

Additional information

You can learn how to create multilingual texts under "Multilingual alarms" in the section Editing alarms in the alarm editor (Page 83).

7.5.4 Displaying the alarm

Displaying the alarm in the Web server

The figure below shows the display of the alarm in the Web server for both examples.

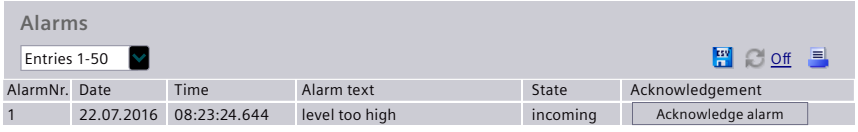

Figure 3-342 Displaying the alarm in the Web server

Displaying the alarm in STEP 7

NOTE

Displaying alarms in STEP 7

To display alarms in STEP 7, enable the option "Receive alarms" in the shortcut menu of the CPU.

The figure below shows the display of the alarm in STEP 7 for both examples.

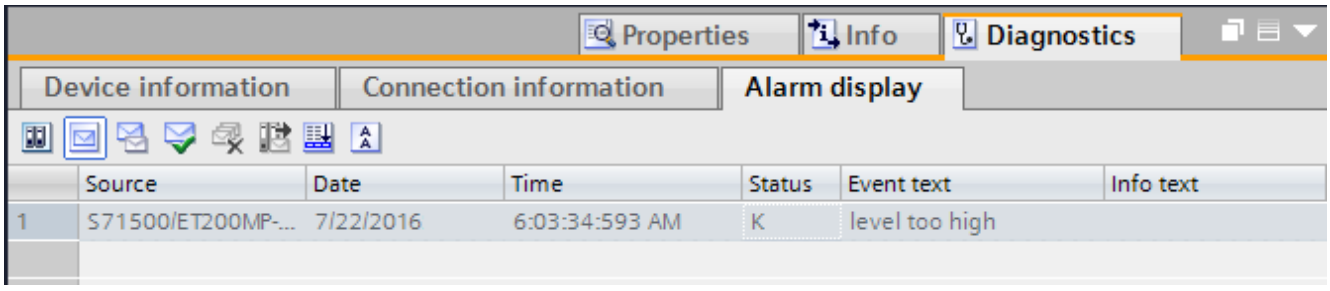

Figure 3-343 Display in STEP 7

Diagnostics of the S7-1500R/H redundant system 8

S7-1500R/H diagnostics

Diagnostics for a S7-1500R/H redundant system is basically the same as a standard S7-1500. You have the following display options:

- Via STEP 7
- Via HMI devices
- Via the display of the CPUs

The CPUs provide information about their operating states as well as internal and external errors through their LEDs.

The special features of the diagnostics of S7-1500R/H redundant systems are described below. In addition, the information of the current function manual and the STEP 7 online help also apply to S7-1500R/H redundant systems.

Diagnostics information in STEP 7

Hardware diagnostics can be performed as follows:

- Via the Online and Diagnostics view
- Via the "Online Tools" task card
- Via the "Diagnostics > Device Information" area of the Inspector window
- Via diagnostics icons, for example, in the device view and in the project tree

Diagnostics view in STEP 7 in dependence on the online connection and system states

The diagnostics view for S7-1500R/H redundant systems is partly dependent on:

- Which of the two CPUs the programming device / PC currently has a connection to
- The current system state in the redundant system

The table below provides an overview. The following sections illustrate the diagnostics view for S7-1500R/H using examples.

Table 3-930 Diagnostics view in dependence on the online connection and system states

Diagnostics view in STEP 7	An online connection is available to the	System state	Examples in section
Online data and diagnostics of the redundant system	Primary CPU or backup CPU	RUN-Redundant	Online and Diagnostics view (Page 103)
Online data and diagnostics of the primary CPU The following are not displayed: • Online data and diagnostics from the backup CPU	Primary CPU	RUN-Solo or STOP	Online and Diagnostics view (Page 103) and

Diagnostics view in STEP 7	An online connection is available to the	System state	Examples in section
Online data and diagnostics of the backup CPU The following are not displayed: • Online data and diagnostics from the primary CPU • Online data and diagnostics of the distributed I/O	Backup CPU	RUN-Solo or STOP	Restrictions in the RUN-Solo system state (Page 125)
Display of the 3 operator panels in the "Online Tools" task card	Primary CPU or backup CPU	Not relevant	"Online Tools" task card (Page 106)
Cycle time of the primary CPU (of the system) and memory of the primary CPU in "Online Tools" task card	Primary CPU or backup CPU	RUN-Redundant	
Cycle time and memory of the primary CPU in the "Online Tools" task card	Primary CPU	RUN-Solo or STOP	
Cycle time and memory of the backup CPU in the "Online Tools" task card	Backup CPU	RUN-Solo or STOP	
Memory reset of the primary CPU via "Online Tools" task card	Primary CPU	STOP	
Memory reset of the backup CPU via "Online Tools" task card	Backup CPU	RUN-Solo or STOP	
"Alarm display" tab: Alarms from the primary CPU	Primary CPU	Not relevant	Diagnostics view in the project tree and in the device view and network view (Page 110)
"Alarm display" tab: Alarms from the backup CPU	Backup CPU	Not relevant	
Diagnostics of the distributed I/O	Primary CPU or backup CPU	RUN-Redundant	Diagnostics in the RUN-Redundant system state (Page 119)
Diagnostics of the distributed I/O	Primary CPU	RUN-Solo	Restrictions in the RUN-Solo system state (Page 125)

Accessible devices

As for standard S7-1500 systems, the following can be displayed in STEP 7:

- All devices accessible from programming device/PC
- The diagnostics information of devices of a redundant system, for example, from the R/H CPUs

The procedure is described in the section Accessible devices (without project) (Page 35).

8.1 Online and Diagnostics view

Introduction

You open the Online and Diagnostics view for the redundant system or for each CPU of the redundant system.

Online & diagnostics for the redundant system

"Online access":

For the S7-1500R/H redundant system, it is displayed whether an online connection exists between the programming device/PC and a CPU. The additional note "Online (via Primary CPU)" or "Online (via Backup CPU)" indicates which role the "Online" connected CPU has.

If you enable "Receive alarms", you receive asynchronous alarms of diagnostics events from the CPU with online connection. The display corresponds to the representation for standard CPUs.

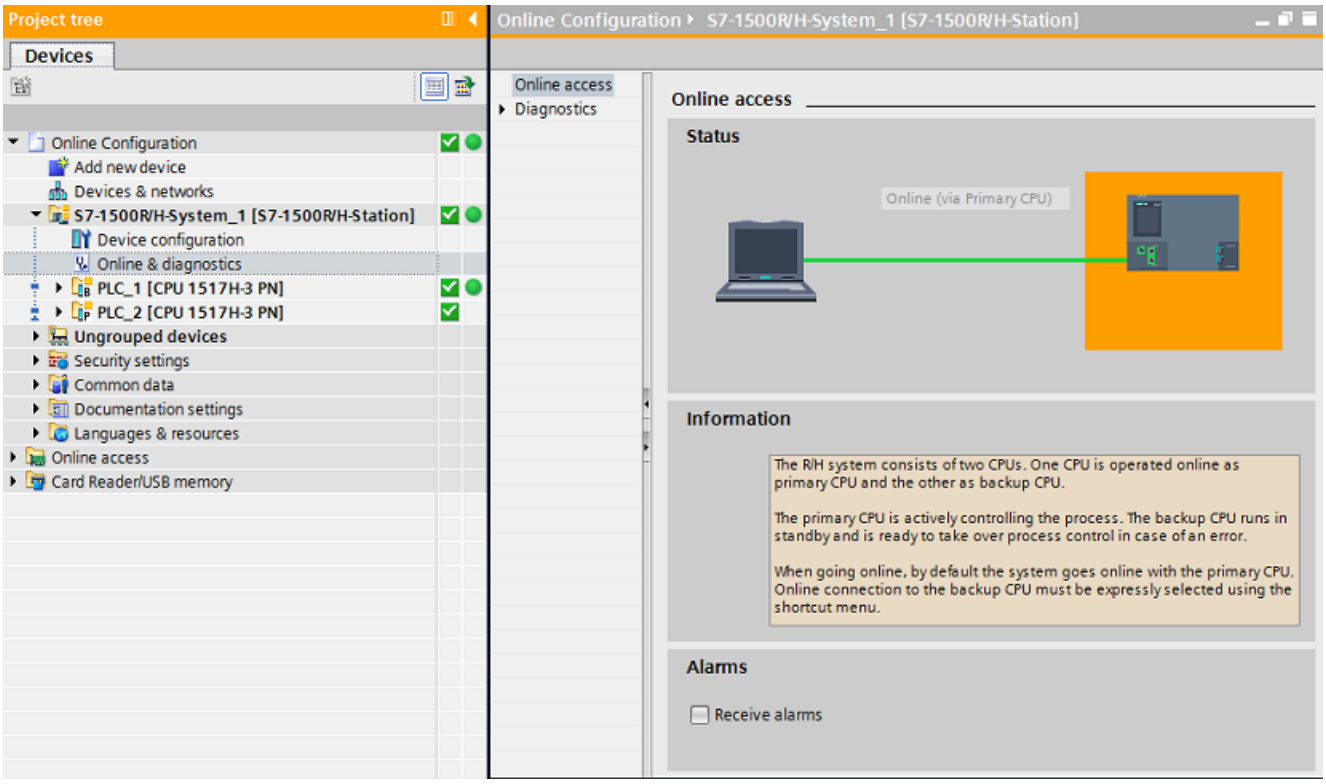

Figure 3-344 Online and Diagnostics view: Redundant system S7-1500R/H

"Diagnostics":
"Diagnostics" provides an overview for the redundant system about the:

- System state
- Pairing state
- Operating states of the CPU
- Status of which CPU is the primary CPU and which CPU is the backup CPU

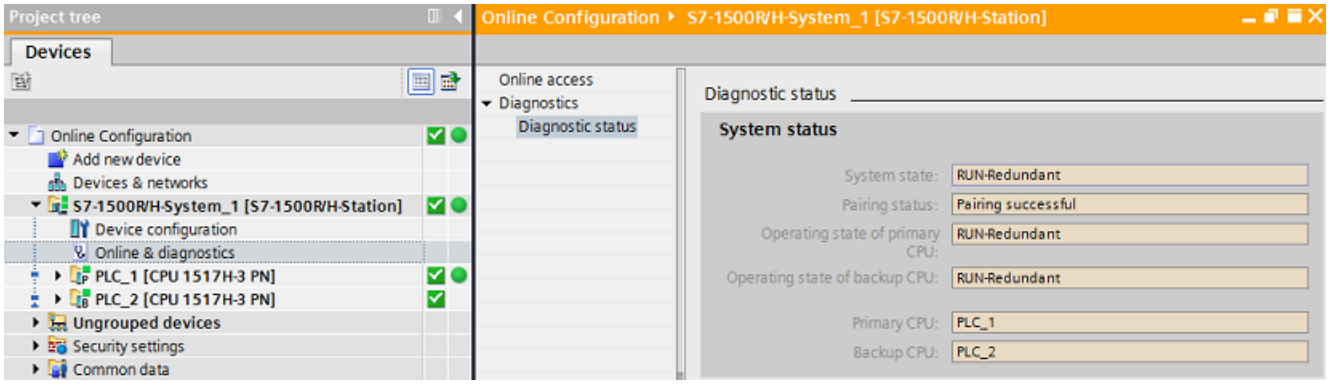

Figure 3-345 Online and Diagnostics view: Diagnostics status of the S7-1500R/H system

Online & diagnostics for the primary CPU or backup CPU

The Online and Diagnostics view for the CPUs of the redundant system match the display for standard CPUs.

In the RUN-Redundant system state, the primary and backup CPUs display the online data of the redundant system irrespective of which of the two CPUs has the online connection.

In non-redundant mode, the programming device/PC displays the data of the CPU that has an online connection.

You select the CPU for display of the online data in the project tree.

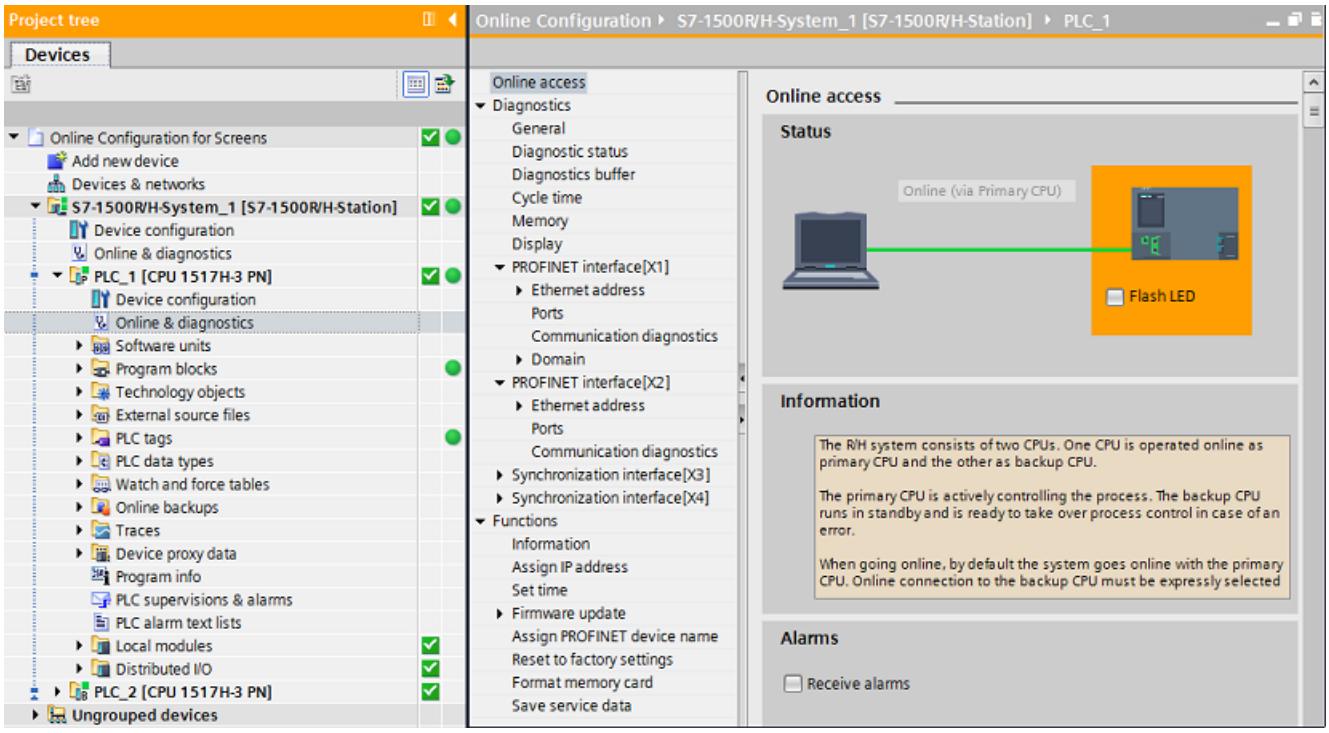

Figure 3-346 Online and Diagnostics view: CPU (RUN-Redundant system state)

Reference

You can find information on the operating and system states in the Redundant System S7-1500R/H System Manual (https://support.industry.siemens.com/cs/ww/en/view/109754833).

Online & diagnostics for IO devices in a line topology in the S7-1500H system

As of STEP 7 V18, you have the option to configure R1 devices. You assign each interface module of an R1 device to one of the two H-CPUs.

In the device view of the IO device, open the "Online & diagnostics" window. You will find the "Redundancy" dialog in the "Diagnostics" menu. It is divided as follows:

- "Module" column: The interface modules of the IO device.
- "Controller" column: The CPU assigned in each case.
- "Connection status" column: The current status of the connection between the interface module and assigned CPU and which interface module is currently being used.

The "Online & diagnostics" function for IO devices is independent of the configuration variant of the redundant S7-1500H system. You can use the "Online & diagnostics" function for ring or line topologies or a combination topology.

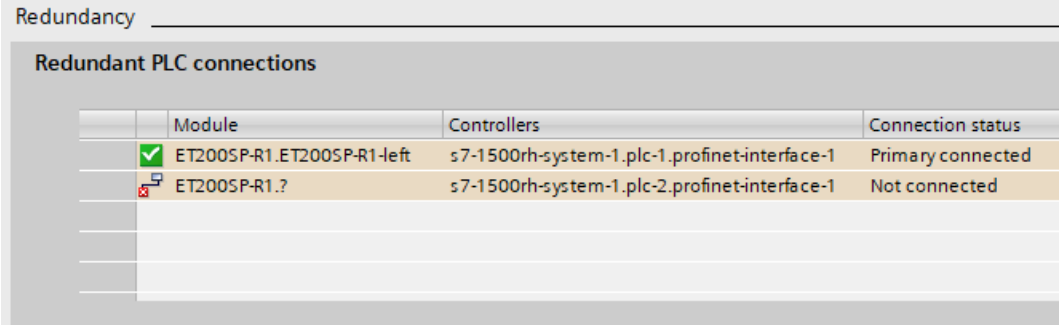

Figure 3-347 View of the "Redundancy" dialog window

NOTE

View of the interface module of an S2 device

In contrast to an R1 device, an S2 device has only one interface module. For this reason, the "Interface module" column shows only one interface modules for an S2 device.
The interface module is assigned to both H-CPUs.

8.2 "Online Tools" task card

Introduction

If an online connection exists to a CPU of the redundant system, the "Online Tools" task card displays online information for the redundant system.

For a S7-1500R/H redundant system, "Online Tools" displays:

- 3 panes operator panel
- Cycle time
- Memory

R/H system operator panel

For the redundant system, the "R/H system operator panel" pane shows the:

- Current states of the LEDs of the primary CPU
- System state
- Status of which CPU is the primary CPU and which CPU is the backup CPU with their current operating states

The "STOP R/H-System" button can be used to switch the S7-1500R/H system to the system state STOP.

NOTE

Reaching RUN-Redundant system state

Note that you cannot switch the S7-1500R/H to RUN-Redundant system state using the R/H-System operator panel. You reach the RUN-Redundant system state only by switching the operating state for each CPU to RUN in your CPU operator panel.

CPU operator panel

The two "CPU operator panel" panes show for the respective CPU of the redundant system:

- The role of the CPU, primary CPU or backup CPU
- The current states of the LEDs
- The operating state of the CPU

Use the "RUN / STOP" button to change the operating state for the respective CPU.

Use the "MRES" button to perform a memory rest for the CPU, under the following conditions:

- Online connection to this CPU is available
- The CPU is in STOP operating state.

The switch position at the real CPU is displayed under "Mode selector".

Example

The following figure shows an example of the "Online Tools" task card for the RUN-Solo system state. The primary CPU is in RUN operating state, the backup CPU in STOP operating state.

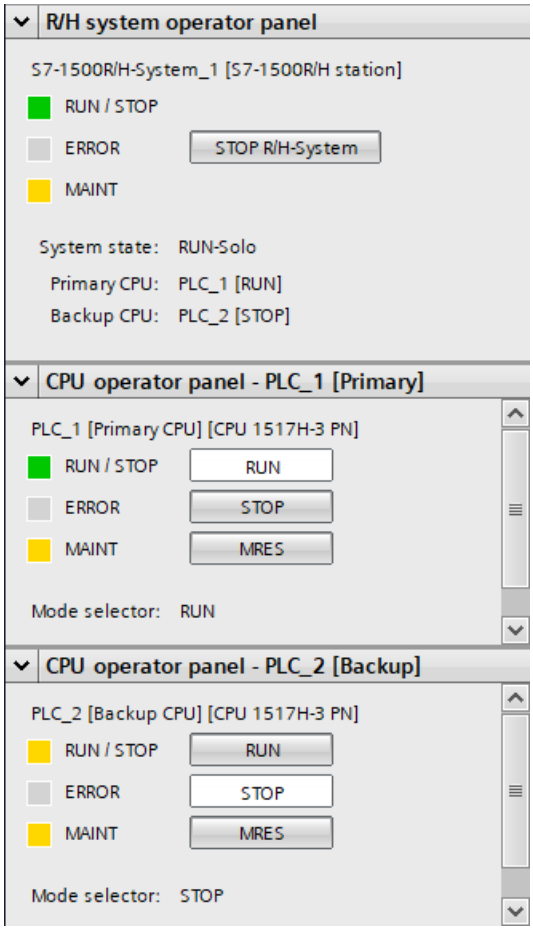

Figure 3-348 "Online Tools" task card: Operator panel (RUN-Solo system state)

Cycle time and memory

In the RUN-Redundant system state, the "Cycle time" and "Memory" panes show the current values of the primary CPU. In redundant mode, the cycle time of the primary CPU matches the cycle time of the system.

In the RUN-Solo system state, the panes show the current values for the CPU for which there is an online connection.

The display corresponds to the representation for standard CPUs.

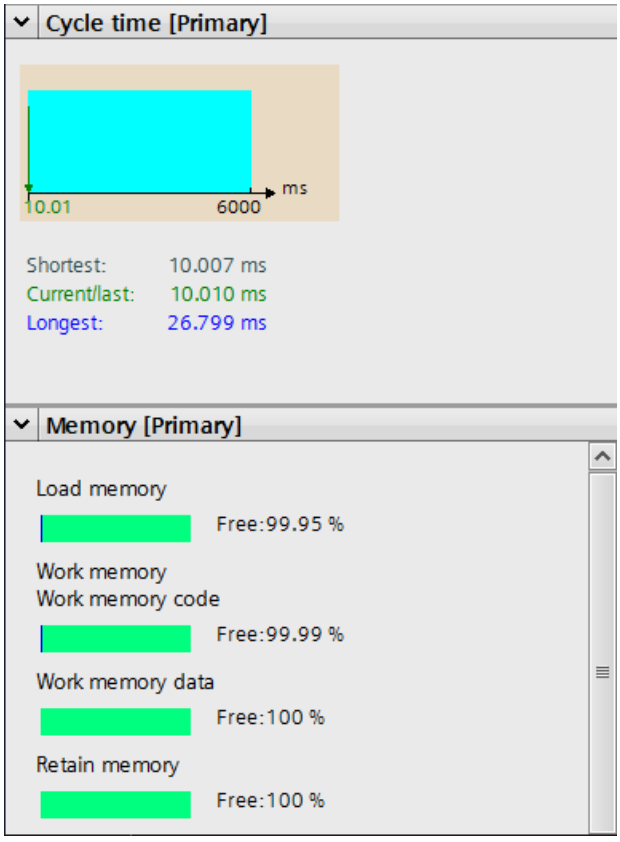

Figure 3-349 "Online Tools" task card: Cycle time and memory of the primary CPU

Reference

You can find information on the operating and system states in the Redundant System S7-1500R/H System Manual (https://support.industry.siemens.com/cs/ww/en/view/109754833).

8.3 Diagnostics view in the project tree and in the device view and network view

Additional icons for redundant systems in the project tree

Table 3-931 Icons for redundant systems in the project tree of STEP 7

Icon in the project tree	Meaning
	Identifier of the folder S7-1500R/H-System: RUN-Redundant system state
	Identifier of the folder S7-1500R/H-System: RUN-Solo system state
	Identifier of the folder S7-1500R/H-System: STARTUP system state
	Identifier of the folder S7-1500R/H-System: STOP system state
	Identifier of the folder for the primary CPU: RUN operating state
	Identifier of the folder for the backup CPU: RUN operating state
	Identifier of the folder for the primary CPU: STARTUP operating state
	Identifier of the folder for the backup CPU: SYNCUP operating state
	Identifier of the folder for the primary CPU: STOP operating state
	Identifier of the folder for the backup CPU: STOP operating state
	Identifier of the folder of a CPU of the redundant system: "Online via partner": The other CPU of the redundant system is connected online to the programming device / PC.

Example: Diagnostics view in the project tree and in the device view and network view

An example of the diagnostics view for a S7-1500R/H system is shown below.

The example configuration consists of two CPUs S7-1517H-3 PN and one interface module IM 155-6 PN HF as PROFINET IO device. PLC_1 is the primary CPU (in RUN operating state). PLC_2 is the backup CPU (in STOP operating state). The hardware configuration and the user program were loaded in the primary CPU.

The system is connected online via PLC_1 (primary CPU) and is in RUN-Solo system state.

View of the system in the project tree

The system is in RUN-Solo system state . PLC_1 is in RUN operating state , PLC_2 is in STOP operating state .

Because the system is in RUN-Solo system state, the following is displayed:

- For the system, maintenance demanded with problem in lower-level component
- For PLC_1, maintenance demanded

For PLC_2, online connection via partner is displayed, as the programming device/PC is connected online to PLC_1.

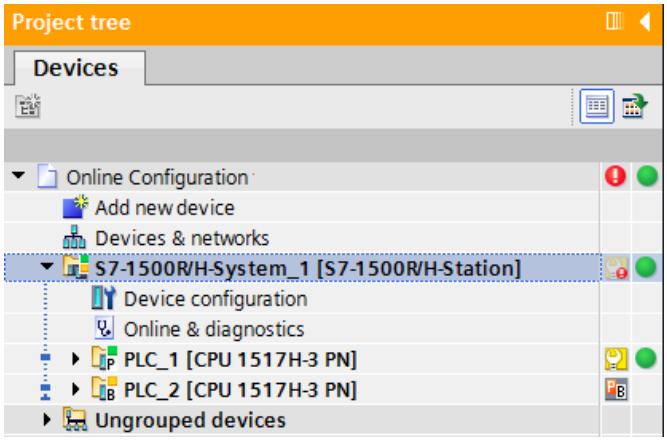

Figure 3-350 Diagnostics example: Redundant system project tree (RUN-Solo)

Network view of the system

The network view shows no faults for the H-CPUs or the IO device.

Maintenance demanded in lower-level component indicated for the system, since the system is not in the RUN-Redundant system state.

No operating states and system states of the redundant system are displayed in the network view.

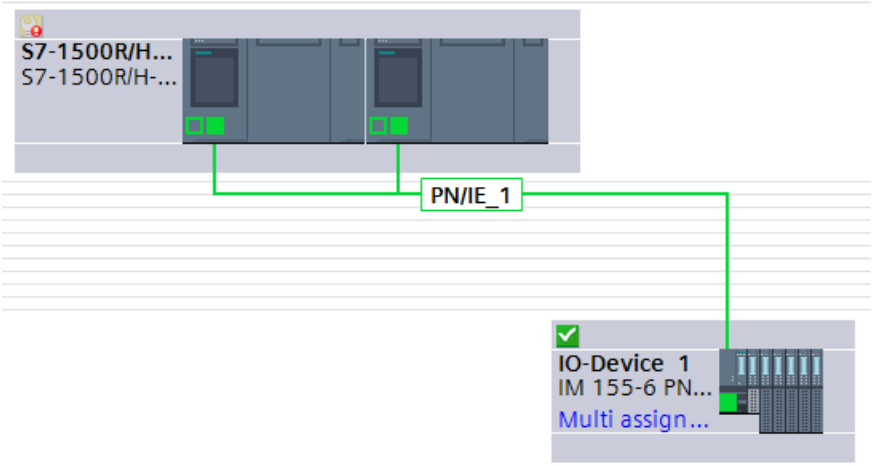

Figure 3-351 Diagnostics example: Network view of redundant system (RUN-Solo)

Doubling-clicking on the system gives you access to the device view of both CPUs.

Device view of the system

The device view shows you the operating states of the CPUs based on the icons next to PLC_1:

- Green icon: PLC_1 is in the RUN operating state.
- Yellow icon (wrench) for maintenance demanded: PLC_2 is in the STOP operating state.

The icon next to PLC_2 indicates that the online connection exists via the partner (PLC_1).

You can find more detailed information on the system faults in the "Diagnostics" tab, in "Device information". The device information indicates maintenance demanded and RUN operating state for PLC_1.

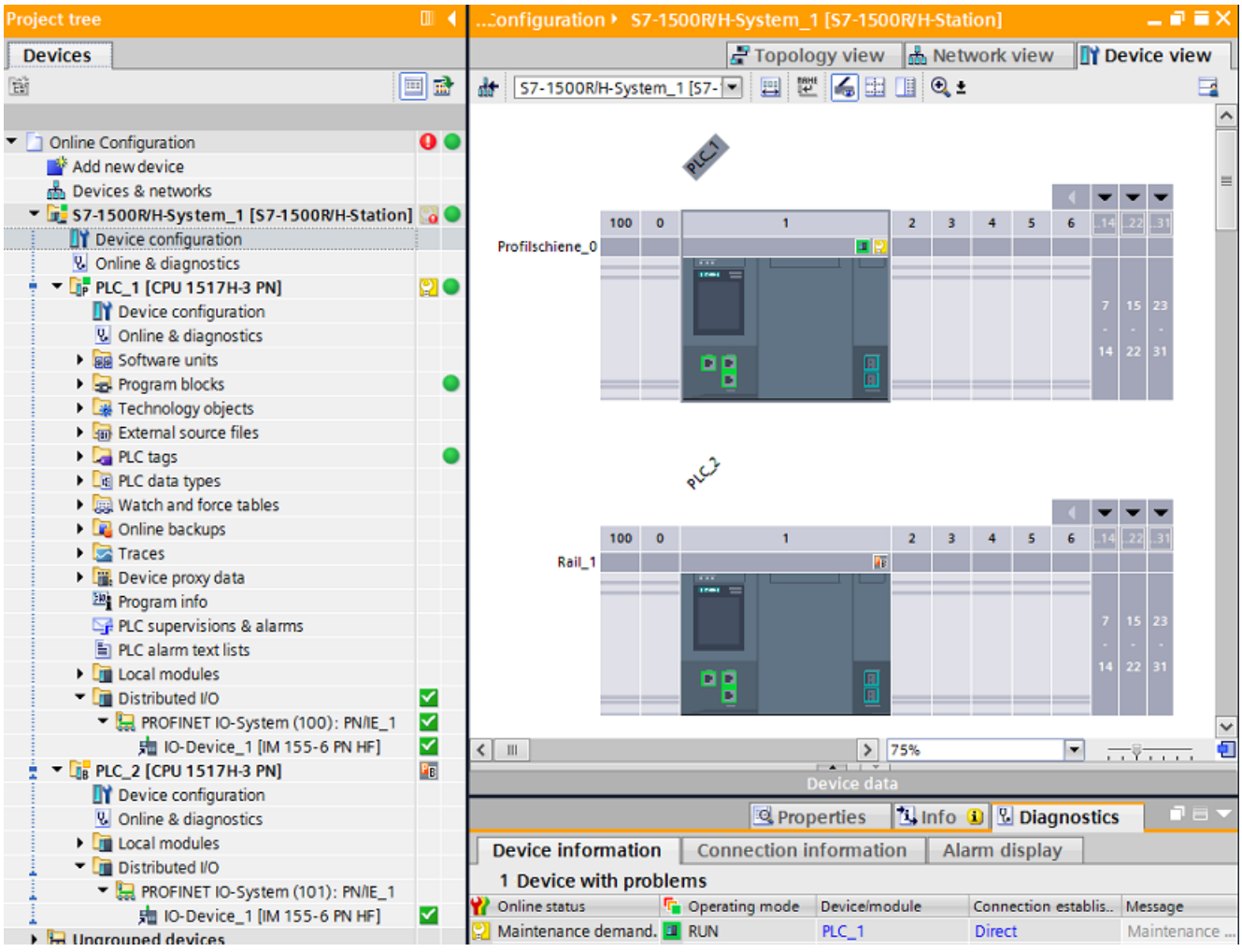

Figure 3-352 Diagnostics example: Device view of redundant system (RUN-Solo)

Alarm display of the system

As in the RUN-Solo system state, the alarms of the CPU for which there is an online connection are displayed via the "Alarm display" tab (in the example from PLC_1).

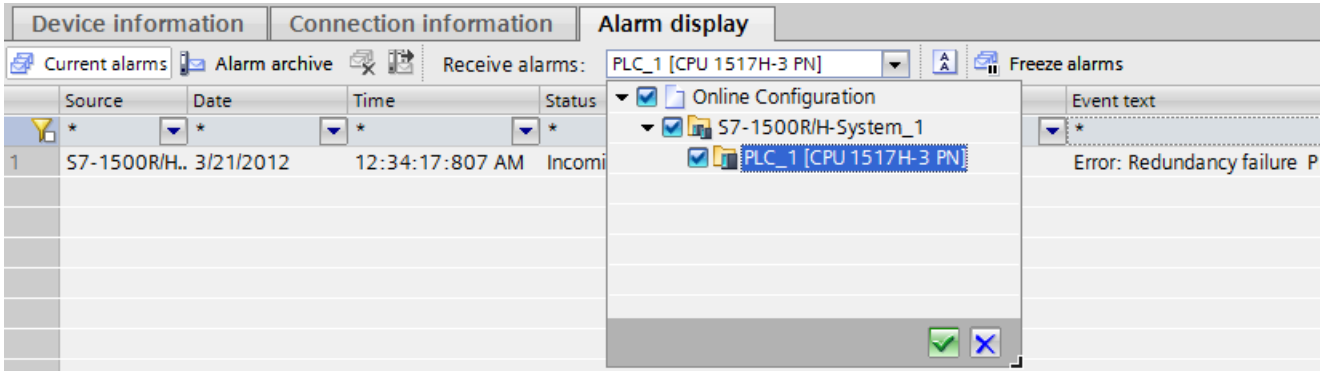

Figure 3-353 Diagnostics example: Alarm display of redundant system (RUN-Solo)

Device view of the IO device

The IO device is an interface module IM 155-6 PN HF with two I/O modules and one server module. The device view shows that there is no faults in the modules.

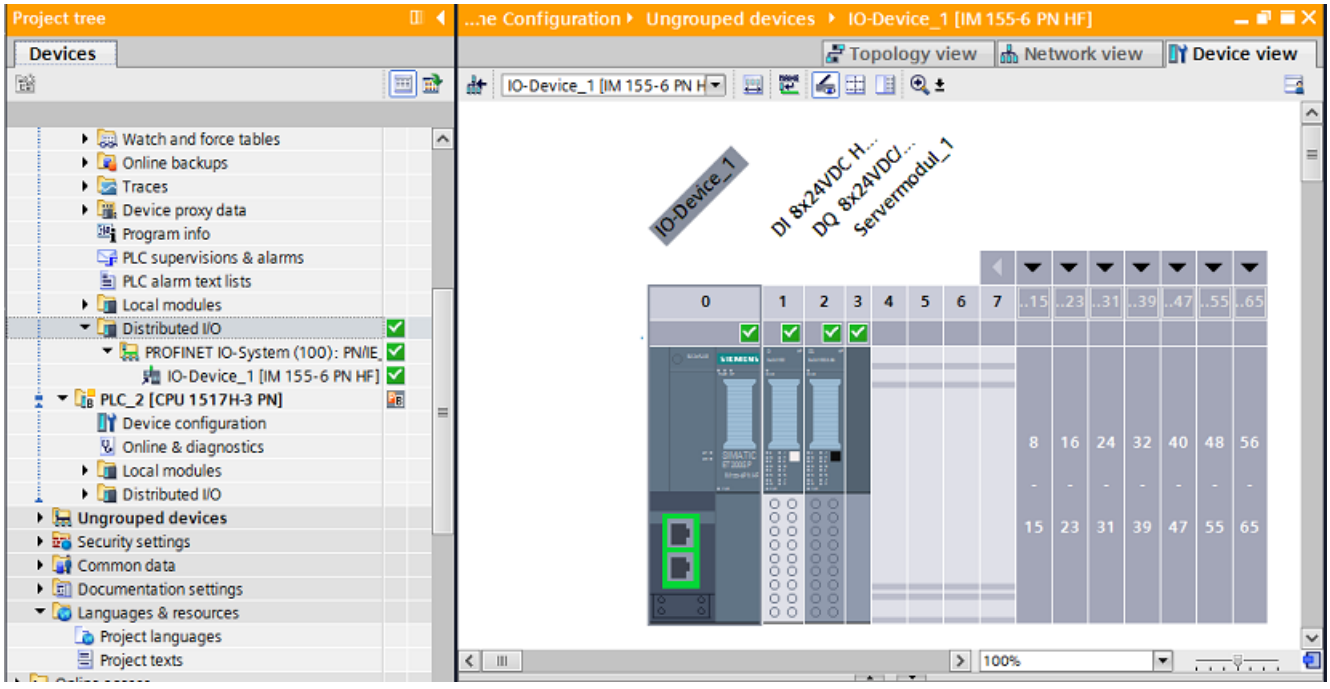

Figure 3-354 Diagnostics example: Device view of IO device

Diagnostics display for IO devices in the S7-1500H system

With the diagnostics display, you identify the following error scenarios, for example, based on the diagnostics icons:

- The PROFINET connection to an IO device is interrupted.
- An I/O module of an S2 device has been removed or is faulty.
- The PROFINET connection to an R1 device is interrupted.
- An interface module of an R1 device has been removed or is faulty.

The first two error scenarios are comparable to the diagnostics display of standard S7-1500 systems. The diagnostics of R1 devices is described in the next section.

Example: Diagnostics display of a faulty R1 device

An example of the diagnostics display for IO devices in the redundant S7-1500H system is shown below. The example configuration consists of the following components:

- 2 CPUs S7-1517H-3 PN
- R1 device: Interface module ET 200SP IM 155-6 PN R1
- S2 device: Interface module ET 200SP IM 155-6 PN HF

Requirements:

- You have an online connection to the redundant S7-1500H system.
- All connected IO devices are accessible via all interface modules.

In the project tree, you see the diagnostics display of the IO devices as follows:

- In the device folder of a CPU under "Distributed I/O > PROFINET IO system", you see the status of the assigned interface modules in each case.
- In the "Ungrouped devices" folder, you see the overall status of the IO devices. If you open the folder of an IO device, you also see the status of the interface modules.

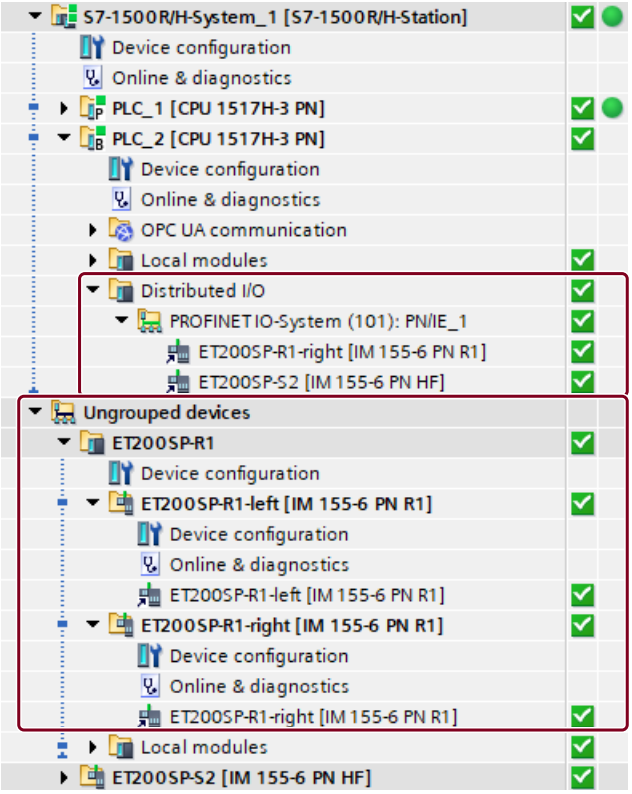

Figure 3-355 Diagnostics display of an R1 device in the project tree

The right interface module of the R1 device is removed or is faulty.

In the project tree, you see to the right of the device folder of the CPU the diagnostic information "Maintenance demanded, error in lower-level component" .

In the network view, the CPU and the R1 device also display the error through "Maintenance demanded, error in lower-level component" .

To display the diagnostics of the assigned interface modules, proceed as follows:

1. Open the device folder of the CPU.
2. Open the "Distributed I/O > PROFINET IO system" folder.
3. Displayed to the right of the interface modules is a corresponding diagnostics icon.

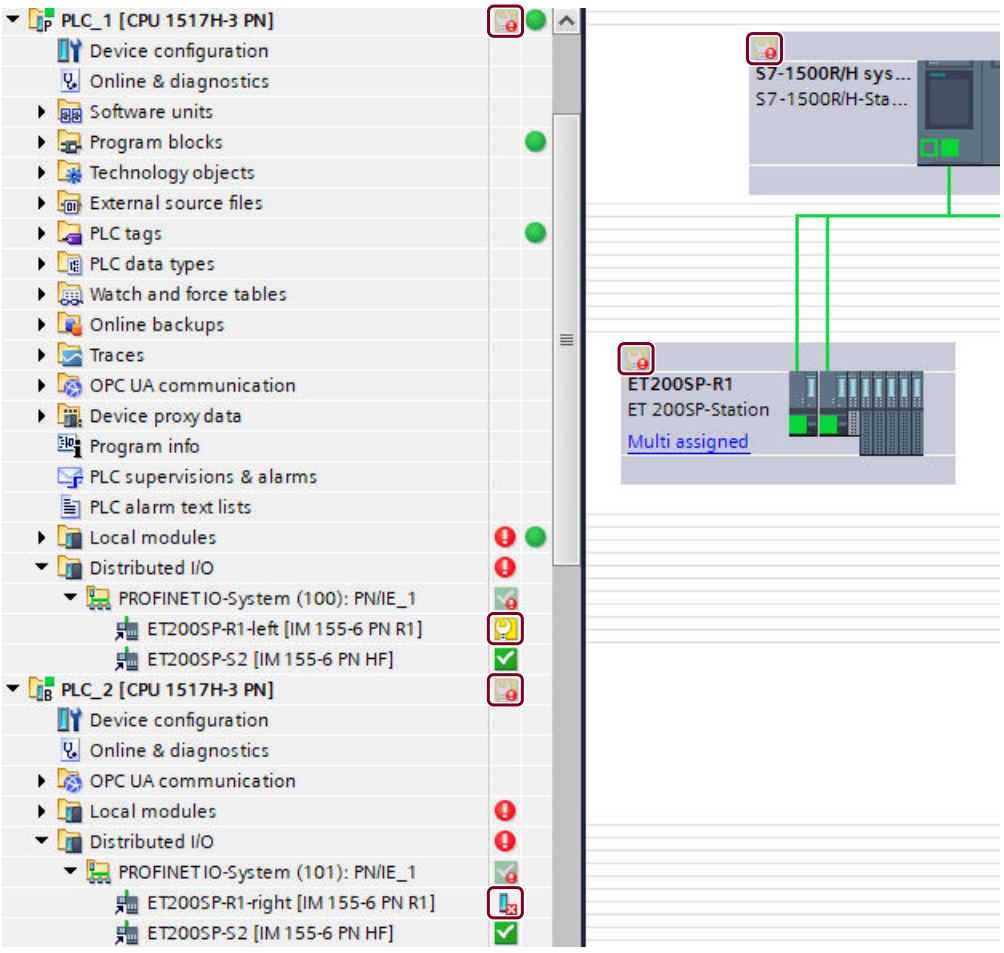

Figure 3-356 Project tree and network view of a faulty R1 device.

In the device view of the faulty IO device, you see the status of the individual interface modules.

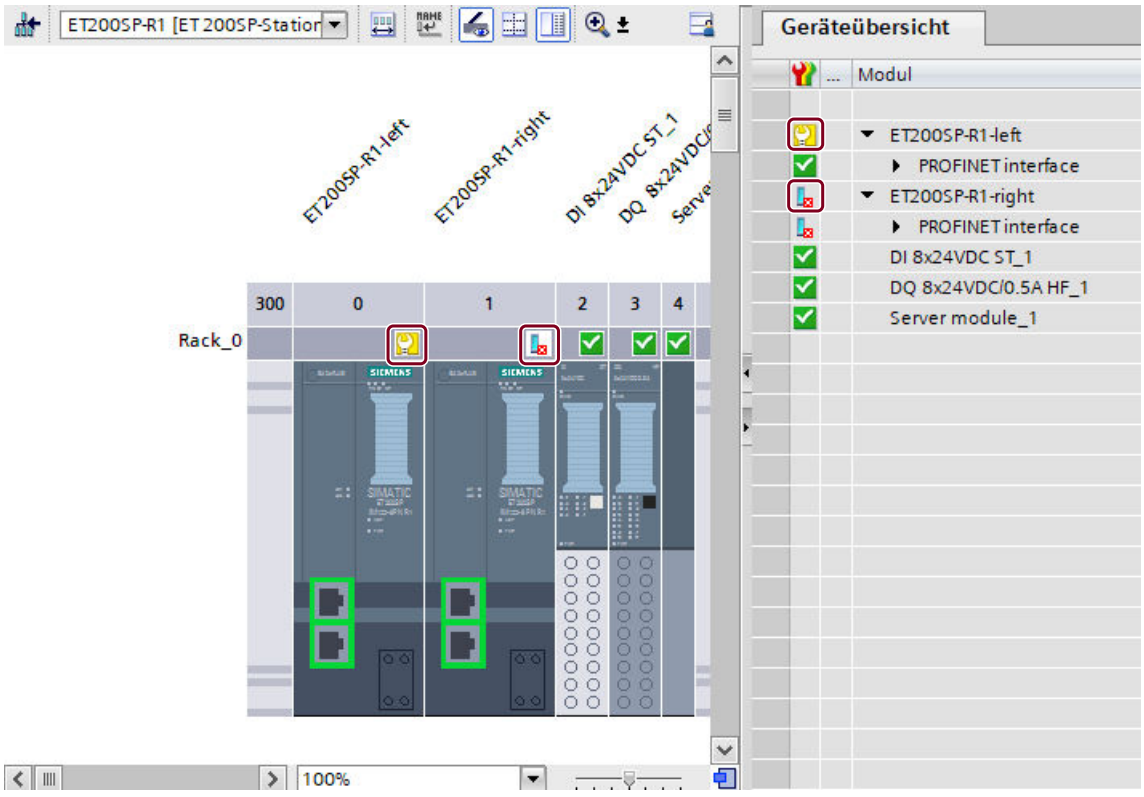

Figure 3-357 Diagnostics display of a faulty R1 device in the device view

To display extended diagnostics of the interface modules, proceed as follows:

1. Right-click the faulty interface module to open the shortcut menu.
2. Click the "Online and diagnostics" function.
3. Open the "Diagnostics" menu of the "Online and diagnostics" function and click "Redundancy".

In the "Redundancy" dialog window, you see the following information:

- "Icon" column: The diagnostics display of the interface module
- "Module" column: The interface modules of the IO device.
- "Controller" column: The CPU assigned in each case.
- "Connection status" column: The current status of the connection between the interface module and assigned CPU and which interface module is currently being used.

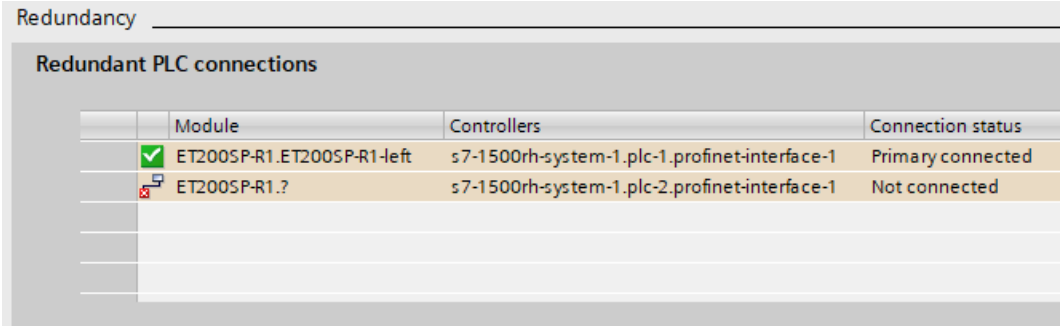

Figure 3-358 View of the "Redundancy" dialog window

NOTE

Deviating diagnostics display

If you remove an interface module of an R1 device, the other interface module signals this error with a red flashing ERROR LED. The LED error display has no effect on the process because the second interface module of the R1 device takes over.

In the STEP 7 online diagnostics, the R1 device is shown only as "Maintenance demanded, error in lower-level component". The reason for this is the different diagnostics views of the R1 device and H-CPU.

The IO device has only a local view and signals a missing module. The H-CPU, on the other hand, has a higher-level view of the redundancy of the two interface modules. The redundancy then results in the understated diagnostic information.

Therefore, when evaluating diagnostic information, pay attention not only to the LED error display on the devices. For a complete evaluation of diagnostic information, you must also look at the STEP 7 online diagnostics and evaluate the diagnostics buffer.

8.4 Diagnostics in the RUN-Redundant system state

Diagnostics view in redundant mode

Primary CPU and backup CPU are each in the RUN-Redundant operating state.

In the RUN-Redundant system state, the primary and backup CPUs display the online data of the redundant system irrespective of which of the two CPUs has the online connection.

The diagnostics between the two CPUs is synchronized (diagnostics entries, diagnostics events).

The "Alarm display" tab shows the alarms of the redundant system.

You can find more information in the Diagnostics view in the project tree and in the device view and network view (Page 110).

No error in RUN-Redundant system state

If no error is detected in the RUN-Redundant system state, all diagnostics icons in the project tree and in the network view show "No fault" ✅.

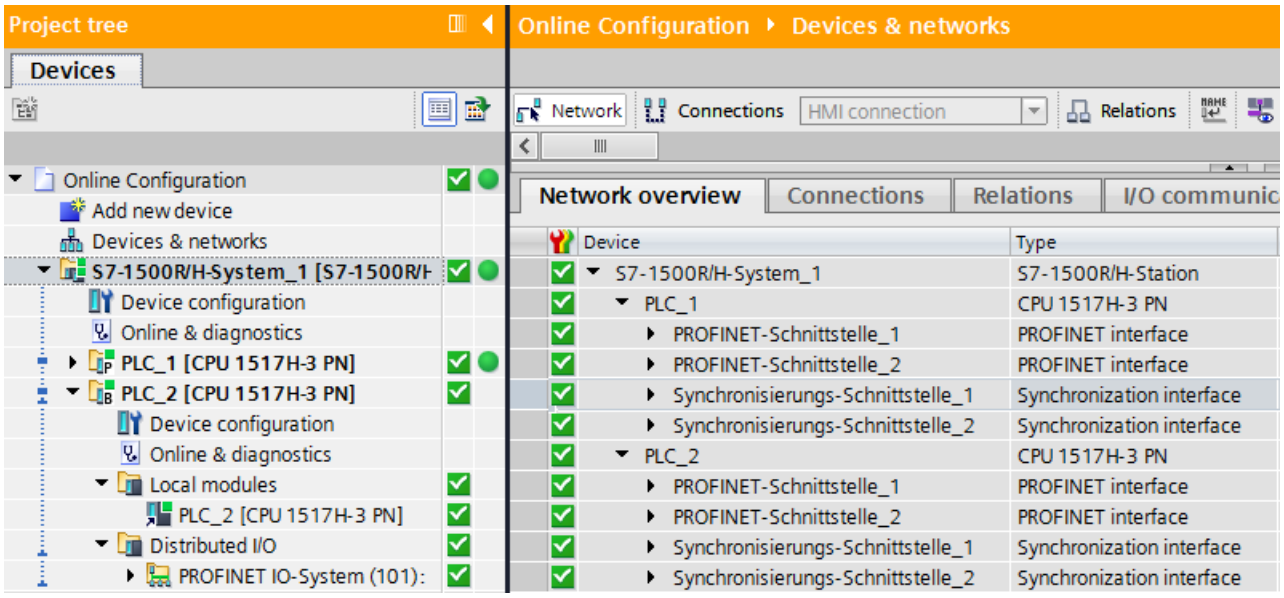

Figure 3-359 Diagnostics example: No fault in the RUN-Redundant project tree

Error in the RUN-Redundant system state

Most errors in the redundant system do not result in a loss of redundancy. The RUN-Redundant system state is retained, for example, if a module in an IO device fails. The diagnostics view is similar to the standard S7-1500 systems.

In the RUN-Redundant system state the redundancy of the system can be restricted, e.g. during the interruption of one of the two redundancy connections in S7-1500H. You can find information on the redundancy scenarios in the Redundant System S7-1500R/H System Manual (https://support.industry.siemens.com/cs/ww/en/view/109754833).

Special examples of a redundant system S7-1500H are shown below:

S7-1500H Example 1:

The PROFINET ring between the CPU of the redundant S7-1500H system and an IO device was interrupted.

Requirements:

- No topology has been configured in the project.
- Both CPUs are in the same PROFINET ring.

Evaluate diagnostics via LINK TX/RX LEDs on the CPU

TX/RX X1 P1 LED is not illuminated. This means:

- No Ethernet connection between the P1 port of the respective PROFINET interface and the communication partner

Diagnostics in STEP 7

The diagnostics buffer of the CPU that was "MRP Manager' at this time indicates that the PROFINET ring is open.

The diagnostics in the project tree shows:

- Maintenance demanded in lower-level component in the S7-1500H system
- Maintenance demanded in lower-level components of PLC_1 and PLC_2
- Maintenance demanded in lower-level components of local modules of PLC_2

The diagnostics in the network view indicates errors at the affected port of the PROFINET interfaces of PLC_2.

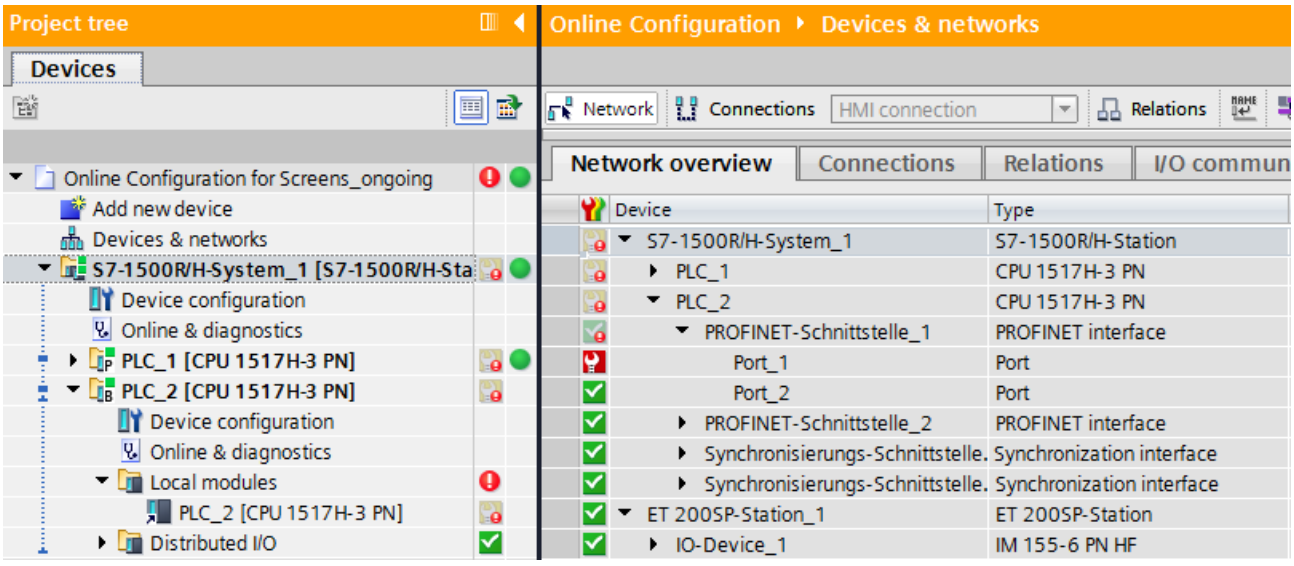

Figure 3-360 Diagnostics example: RUN-Redundant system state, open PROFINET ring

You can evaluate the diagnostics using the displays of the CPUs via the "Diagnostics" menu as with standard CPUs. You can find additional information in the section Display of the CPU (Page 32).

S7-1500H Example 2:

A synchronization module has been removed from a CPU of the redundant S7-1500H system.

Evaluating diagnostics via X3 and X4 LEDs on the CPU

The X3 LED on PLC_2 CPU is not illuminated. This means:

- The redundancy connection on the synchronization module was interrupted at the H-Sync interface X3.

  or

- There is no synchronization module at the H-Sync interface X3.

Diagnostics in STEP 7

The diagnostics buffer of the CPU displays:

- that there is only one redundancy connection
- which synchronization module has failed on which CPU

The diagnostics in the project tree shows:

- Maintenance demanded in lower-level component in the S7-1500H system
- Maintenance demanded in lower-level components of PLC_1 and PLC_2
- Maintenance demanded in lower-level components of local modules of PLC_1 and PLC_2

The diagnostics in the network view displays:

- Errors for the Synchronisationsmodul_1 of the Synchronisationsschnittstelle_2 of PLC_1
- Synchronisationsmodul_1 of Synchronisationsschnittstelle_1 of PLC_2 not reachable

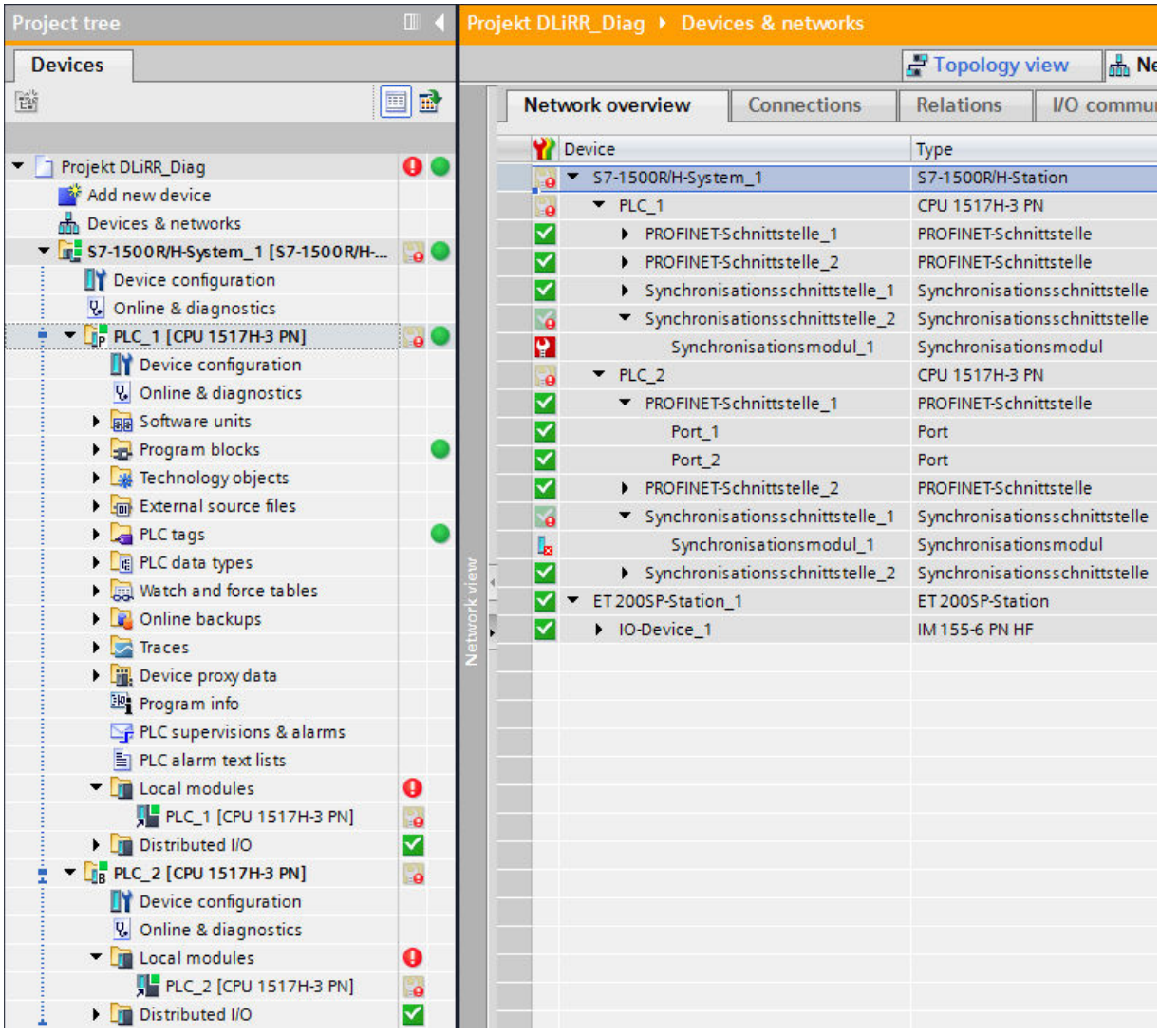

Figure 3-361 Diagnostics example: RUN-Redundant system state, a synchronization module fails

Evaluate diagnostics on the display

For example 2, display of the PLC_2 CPU shows:

- In the "Overview" menu command: A message is available in the next lower level page.
- In the "Diagnostics" menu command: A message is available in the next lower level page.
- In the Module menu command: An error has occurred.

To evaluate the display, proceed as follows:

1. Navigate to "Pairing state" via the menu commands "Overview" > "Redundancy".
2. This is displayed as the pairing state: Single paired (X4).

   This means that the redundancy connection is available at the H-Sync interface X4, but not at the X3.
3. Navigate to "Alarms" via the "Diagnostics" menu command.
4. View the details of the alarm (evaluate diagnostics buffer).

S7-1500H Example 3:
A redundancy connection in S7-1500H is interrupted.

Evaluating diagnostics via X3 and X4 LEDs on the CPU
The LED X4 on CPU PLC_1 does not light up. This means:

- The redundancy connection on the synchronization module was interrupted at the H-Sync interface X4.

  or
- There is no synchronization module at the H-Sync interface X4.

Diagnostics in STEP 7
The diagnostics buffer of the CPU displays:

- that there is only one redundancy connection
- Fiber-optic error with specification of the CPU and the synchronization module

The diagnostics in the project tree shows:

- Maintenance demanded in lower-level component in the S7-1500H system
- Maintenance demanded in lower-level components of PLC_1 and PLC_2
- Maintenance demanded in lower-level components of local modules of PLC_1 and PLC_2

The diagnostics in the network view displays:

- Errors for the Synchronisationsmodul_1 of the Synchronisationsschnittstelle_2 of PLC_1
- Errors for the Synchronisationsmodul_1 of the Synchronisationsschnittstelle_1 of PLC_2

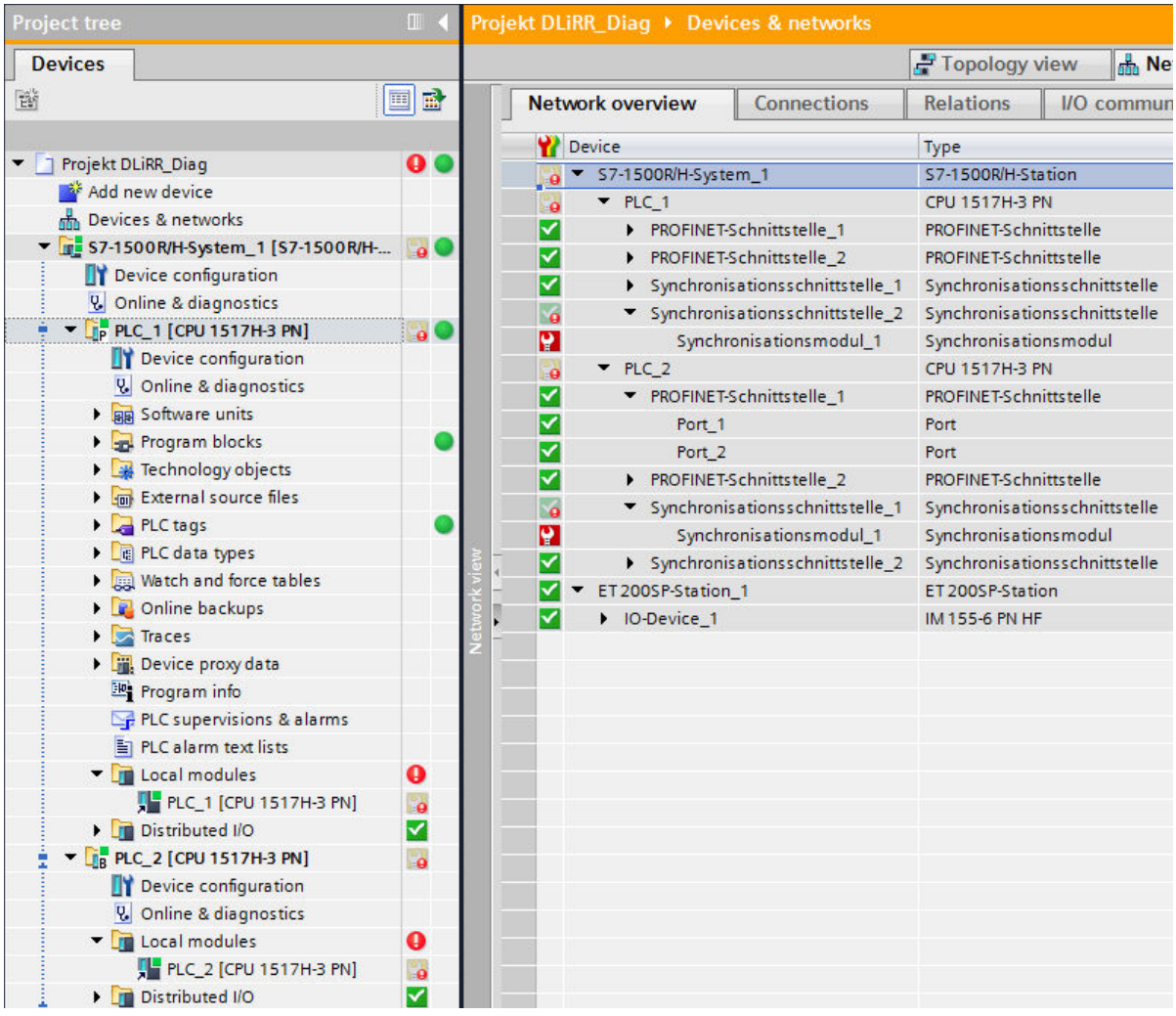

Figure 3-362 Diagnostics example: RUN-Redundant system state, a redundancy connection has failed

Evaluate diagnostics on the display

Perform the analysis of the display of PLC_2 CPU exactly as for example 2.

8.5 Restrictions in the RUN-Solo system state

The primary CPU is in RUN operating state. The Backup CPU is in STOP operating state, is switched off, defective, or not available.

Restrictions in the RUN-Solo system state

The primary CPU records the diagnostics states of the distributed I/O.

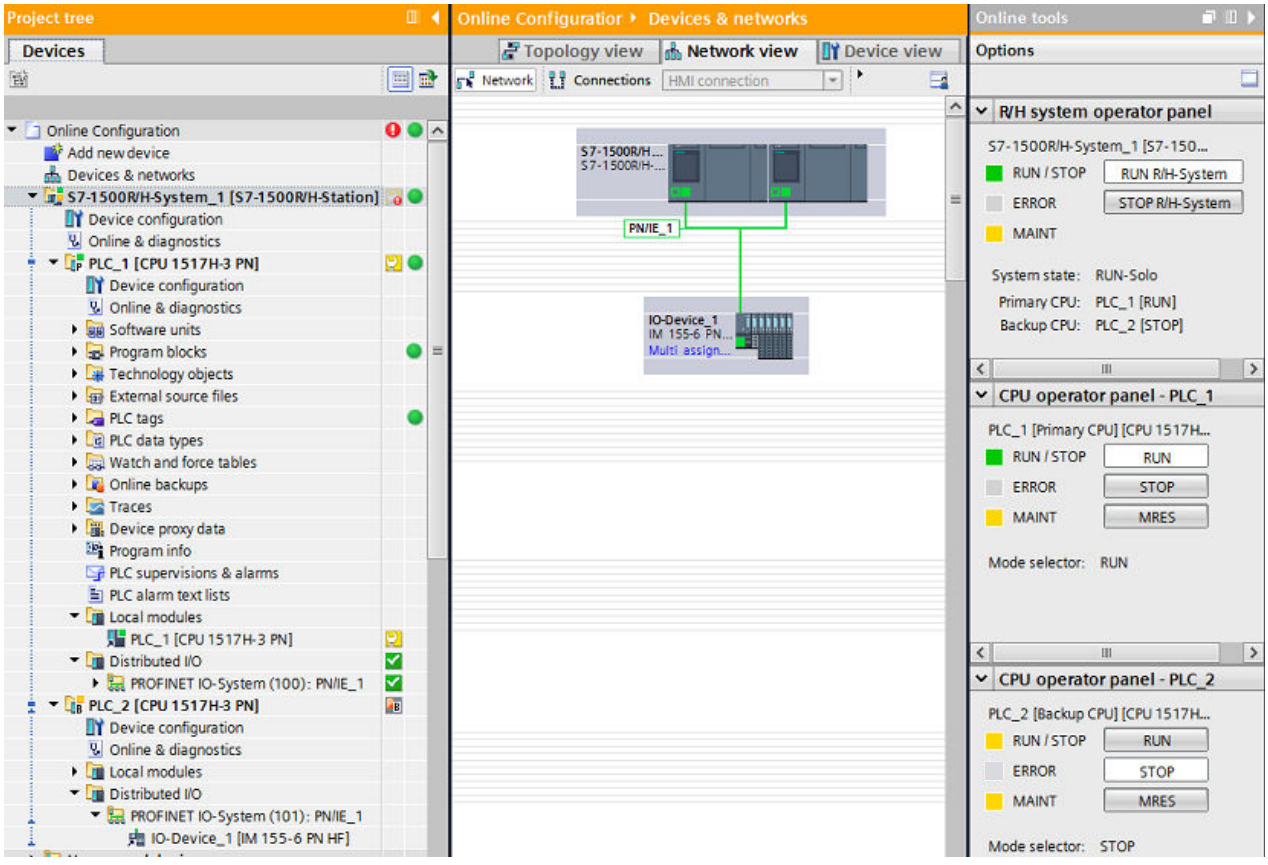

Figure 3-363 Diagnostics of the primary CPU and backup CPU in RUN-Solo system state

Diagnostics of the backup CPU

The following restrictions apply to the backup CPU:

- Diagnostics information from the backup CPU is only available when there is an online connection to the backup CPU.
- A memory reset can only be performed with the backup CPU operator panel when an online connection to the backup CPU is available.

Reference

You can evaluate the diagnostics using the displays of the CPUs via the "Diagnostics" menu as with standard CPUs. You can find additional information in the section Display of the CPU (Page 32).

8.6 System diagnostics by means of the user program

Instructions

Instructions for determining the system diagnostics are listed in the section System diagnostics options in the user program (Page 76).

The following instruction for diagnostics cannot be used for S7-1500R/H redundant systems:

- DPNRM_DG: Read diagnostics data from a DP slave

Organization blocks

You can find the description of the applicable OBs for S7-1500R/H in the S7-1500R/H redundant system (https://support.industry.siemens.com/cs/ww/en/view/109754833) system manual.

SIEMENS

SIMATIC

S7-1500, S7-1200
Trace and logic analyzer function

Function Manual

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Safety instructions 2

Industrial cybersecurity 3

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Introduction 1

Purpose of the documentation

The diagnostics options available with the trace and logic analyzer function are described in this documentation. Depending on the device used, the recording options can vary.

Required basic knowledge

In order to understand this documentation, the following knowledge is required:

- General knowledge in the field of automation
- Knowledge about the use of Windows-based computers
- S7-1200/1500 CPUs, ET 200SP, ET 200Pro
  - Knowledge of the SIMATIC industrial automation system
  - Knowledge of working with STEP 7
- SINAMICS Drives
  - Knowledge of working with the drive
- SIRIUS SIMOCODE pro, SIRIUS Soft Starter 3RW
  - Proficiency in using these systems

Validity of the documentation

This documentation applies to all products of the product series S7-1200, S7-1500, S7-1500 Software Controller, S7-1500 Drive Controller, ET 200SP, ET 200SP Open Controller, CPU 1513(F)pro-2 PN, CPU 1516(F)pro-2 PN, SINAMICS drives, SIRIUS SIMOCODE pro and SIRIUS Soft Starter 3RW as of TIA Portal V16.

Conventions

This documentation contains pictures of the devices described. The pictures may differ slightly from the devices supplied.

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product and on the section of the documentation to which particular attention should be paid.

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Further support

- The range of technical documentation for the individual SIMATIC products and automation systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the online ordering system is available on the Internet (https://mall.industry.siemens.com).

1.1 Function Manuals documentation guide

1.1.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.1.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.1.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

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You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 General safety instructions

The safety instructions can be found in section "Safety instructions" in the System Manual "SIMATIC S7-1500, ET 200MP Automation System" (https://support.industry.siemens.com/cs/ww/en/view/59191792) document.

Cybersecurity-relevant information can be found in the Industrial Cybersecurity (Page 15) section.

2.2 Warnings in this document

You can find explanations of the warnings used in this document in the "Legal information" section.

Industrial cybersecurity 3

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

3.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Overview of functions

4

4.1 Application areas for trace and logic analyzer functions

Use the trace and logic analyzer functions to monitor highly dynamic processes. They record tags from one or more devices and evaluate the recordings. Tags, for example, are drive parameters or the system and user tags of a CPU.

The trace and logic analyzer functions offer you the following recording options:

- Recording tags of a device over a certain duration with a trace (Page 17)
- Recording tags of a device without a time limit with a long-term trace (Page 21)
- Recording tags from multiple devices over a certain duration with a project trace (Page 24)
- Recording of tags from multiple devices without a time limit with a long-term project trace (Page 28)
- Recording events from technology objects on an S7-1500 CPU

The trace and logic analyzer functions are also used in the commissioning editors of technology objects (for example, an axis control panel or kinematic trace). Active recordings from the axis control panel are displayed in the "Traces" folder as traces. The measurements on the memory card can also be read and displayed via the diagnostic interface of the Web server.

To record and analyze tags from multiple projects, you can interconnect the projects by coupling the Ethernet subnets with a PN/PN coupler. You can find more information on using a PN/PN coupler in the help under "Bus coupling with PN/PN coupler".

The recorded values can be permanently saved as a measurement. When the recording is reactivated, the current values are overwritten. Recordings can be added to the measurements in the curve diagram of the axis control panel or the PID via a context menu command.

A variety of options are available for evaluating the recording, e.g.:

- Evaluation of a certain instant of an ongoing recording (Page 64)
- Monitor an ongoing recording (Page 55)
- Evaluation of the difference between two samples (Page 76)

The recording options may vary depending on the device used.

You can find a video demonstration of the recording with the trace function and export for further diagnostics under (https://support.industry.siemens.com/cs/us/en/view/109822276).

NOTE

- Always protect your exported files and network shares.
- User management and access control are available to avoid security risks in the project.

4.2 Measured value recording with a trace

You can use a trace to record selected tags from a device over a specific duration.

You can find a device overview with the respective supported trace in the section "Supported hardware (Page 31)".

4.2.1 How a trace works

The following section shows how a trace works:

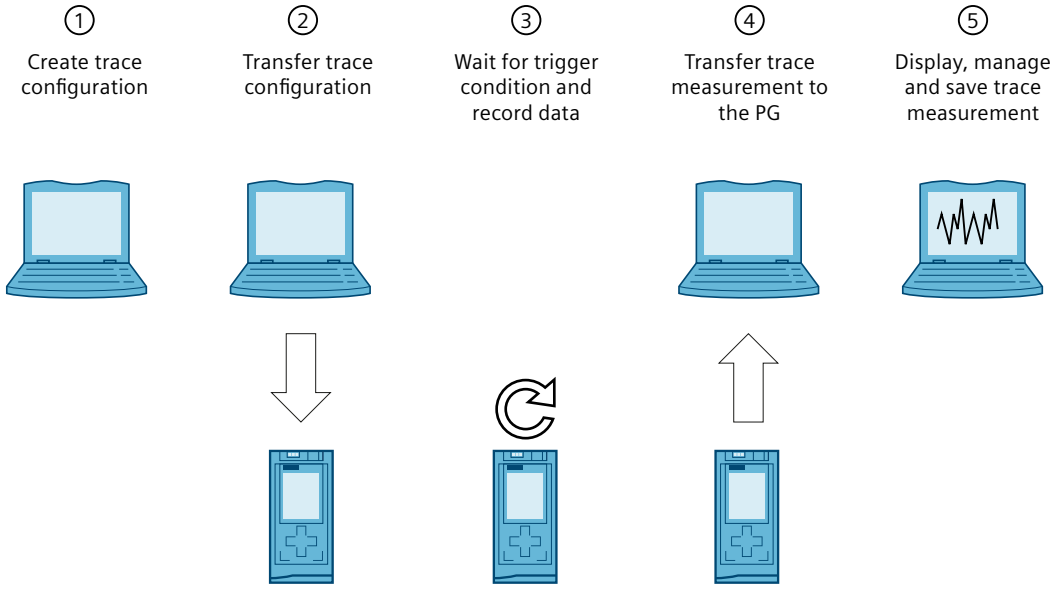

① Trace configuration on the programming device (PG) in the TIA Portal

---

NOTE

The following description provides an example for an S7-1500 CPU. The configuration depends on the device and is described for each device (Page 92).

In the trace configuration (Page 36), you select the signals to be recorded and define the conditions for the sampling and the trigger. Optionally, you can either activate the recording of events from technology objects or set the measurement in the device (memory card).

② Transfer the trace configuration from the PG to the device

You transfer the complete trace configuration to the device (Page 50) with an existing online connection.

NOTE

Note that problems with online access between the PG and the CPU can result in errors or even failure of the recording.

If possible, connect the PG directly to the CPU.

---

③ Wait for the recording

When the trace configuration is activated (Page 54), recording occurs independently of the PG. The recording is started as soon as the trigger condition is met.

A recording in the device is not retentive (it is lost after the device is switched off/on), but can be saved permanently as a measurement in the project or on the memory card in the device.

④ **Transfer the trace measurement from the device to the PG**

The saving of the measurement in the project (Page 64) stores the measurement in the opened project of the TIA Portal. A measurement consists of a trace configuration and a recording, provided that recorded data is present. Each installed trace can be saved as a measurement in the project. The recording of a measurement can be viewed offline. The measurement is saved regardless of the time of the measurement and can also be saved at any time once the recording is completed. The configuration data is displayed write-protected.

⑤ **Evaluate, manage and save the trace measurement**

A wide range of options are available for evaluating the measurement in the curve diagram and in the signal table (Page 70) (e.g. grouping displays, inserting formulas, etc.). Various display types are possible, for example, a bit representation for binary signals. Signal curves from different measurements can be compiled as a combined measurement and compared with each other (Page 68).

Changes to the settings for measurements within the combined trace measurement have no impact on the original measurements. The original measurements remain unchanged. Completed measurements can be exported (Page 65) and imported (Page 65).
When the project is saved in TIA Portal, the measurements transferred to the project are also saved.

The event recording function is available running diagnostics on any events of technology objects as of version V9.0 on an S7-1500 CPU.

NOTE

To be able to use the recording data for external evaluation, export the measurement (Page 65) as a CSV file.

See also

Display of the recording in the curve diagram (Page 56)

4.2.2 Functionality of an installed trace

An installed trace consists of a trace configuration, which was transferred to the device via TIA Portal and optionally a recording.

The following diagram shows how an installed trace works:

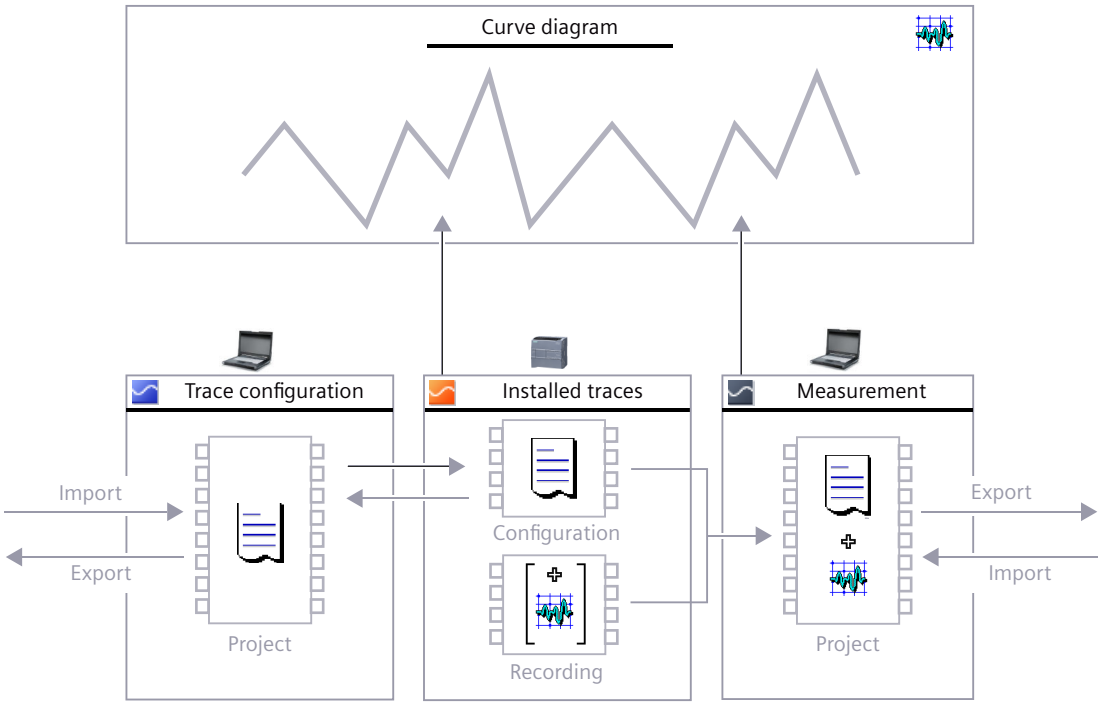

NOTE

Save the trace configuration and measurement

You save the trace configuration and measurement with the project in TIA Portal.

If you close the project without saving, the trace configurations and the measurements transferred to the project are discarded. The trace editor can be closed and reopened without loss of data until the project is closed.

See also

Configuring (Page 36)
Recording (Page 54)
Save recordings as measurements (Page 64)
Evaluating the measurement (Page 67)

4.2.3 Configuration overview

NOTE

The following description provides an example for an S7-1500 CPU. The configuration depends on the device and is described for each device (Page 92).

Make the following settings in the trace configuration :

- Signals (Page 37) to be recorded
- Optional: Event recording
- Recording conditions
  - Sampling (Page 37)
  - Trigger (Page 38)
  - Optional: Measurements on the device (memory card) (Page 39)

NOTE

Note that the "Event recording" function and the "Measurement in the device (memory card)" function cannot be activated at the same time.

Trace configuration with the same name in the project

Usually, there is a trace configuration in the project with the same name for an installed trace. When there is an online connection, this trace is displayed with the icon in the project tree.

Copy and apply configuration

You can copy trace configurations to the "Traces" folder using drag-and-drop or the clipboard. The application of a configuration depends on the device type. The following sources are possible:

- Trace configuration
- Measurement
- Measurements on the device (memory card)
- Combined measurement (selection of a measurement contained in it)

The trace configuration is stored retentively on the device. Depending on the device, the retentive storage of the trace configuration can also be configurable, e.g. on the S120.

The configuration data is displayed write-protected.

4.2.4 Evaluation options

The following options are available for evaluating a trace recording:

- Time diagram
- Compare recordings (combined measurement) (Page 68)
- FFT diagram
- Bode diagram

See also

Displaying and analyzing measured values (Page 32)

4.3 Measured value recording with a long-term trace

With a long-term trace, you can continuously record data from a device without limiting the recording duration. If you activate the long-term trace, the recording is started and continues until you deactivate the long-term trace. The recording data is stored in a selected target path on the programming device.

You can find a device overview with the respective supported trace in the section "Supported hardware (Page 31)".

4.3.1 How a long-term trace works

The following section shows how a long-term trace works:

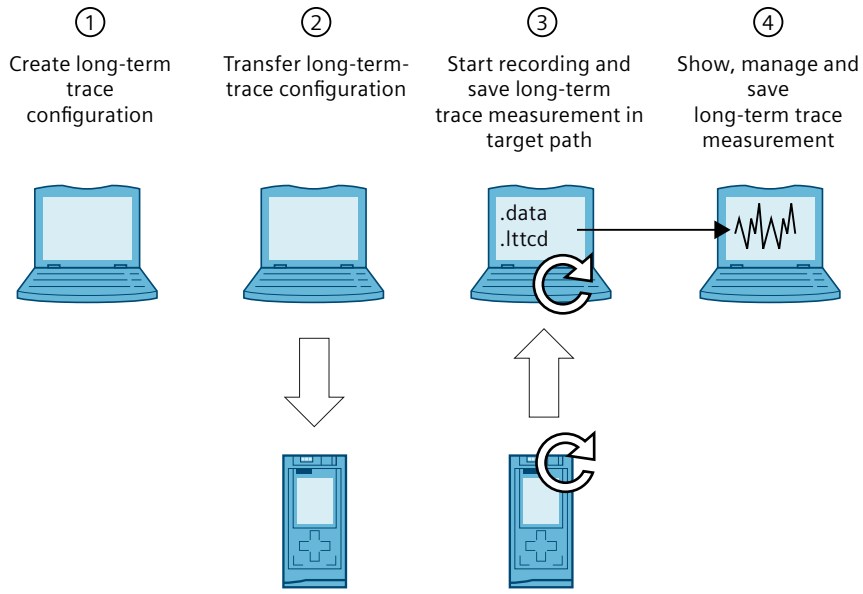

① **Long-term trace configuration on the programming device (PG) in the TIA Portal**

In the long-term trace configuration (Page 41), you select the signals to be recorded and define the conditions for sampling and the target path for the recording. The configuration depends on the device and is described for each device (Page 92).

② **Transfer the long-term trace configuration from the PG to the device**

The complete long-term trace configuration can be transferred to the device (Page 50) when an online connection is established.

NOTE

Note that problems with online access between the PG and the CPU can result in errors or even failure of the recording.

If possible, connect the PG directly to the CPU.

③ **Start long-term project trace recording and save to target path.**

You start the long-term trace recording by activating the configuration (Page 54). The long-term trace recording is displayed in the time diagram and saved in the configured target path.

NOTE

As of TIA Portal V20, the recording is saved as binary code in ".dat" format. To be able to use the recording data for external evaluation, export the measurement as a CSV file.

④ **Display, manage, and evaluate the long-term trace measurement**

You can save the long-term trace recording as a measurement in the project (Page 64) for evaluation. The configuration data is displayed write-protected.

Completed measurements can be exported (Page 65) and imported (Page 65).

A wide range of options are available for evaluating the measurement in the curve diagram (Page 56) and in the signal table (Page 70) (e.g. grouping displays, embedding formulas, etc.). Various display types are possible, for example, a bit representation for binary signals.

Signal curves from different measurements can be compiled as a combined measurement (Page 68) and compared with each other. The combined long-term trace measurements can be synchronized with each other and displayed in combination.

Changes to the settings of long-term trace measurements within the combined long-term trace measurement do not affect the original long-term trace measurements. The original long-term trace measurements remain unchanged.

NOTE

A maximum of 400000 samples are shown in the curve diagram.

If a recording contains more samples, you will only see the corresponding part of the measurement.

4.3.2 Configuration overview

NOTE

The following description provides an example for an S7-1500 CPU. The configuration depends on the device and is described for each device (Page 92).

Make the following settings in the long-term trace configuration :

- Signals (Page 42) to be recorded
- Recording conditions
  - Sampling (Page 42)
- Target path for the recording (Page 43)

In the long-term trace configuration, you define a target path for the recording. The long-term trace recording data is saved together with the configuration file (*.lttcd) in the configured target path.

NOTE

As of TIA Portal V20, the recording is saved as binary code in ".dat" format. To be able to use the recording data for external evaluation, export the measurement (Page 65) as a CSV file.

Copy and apply configuration

Long-term trace configurations are copied and transferred in the same way as with Trace (Page 20).

See also

Long-term trace recording (Page 97)

4.3.3 Evaluation options

The following options are available for evaluating a long-term trace recording:

- Time diagram
- Compare recordings (combined measurement) (Page 68)

See also

Displaying and analyzing measured values (Page 32)

4.4 Measured value recording with a project trace

With a project trace, you record selected tags across multiple devices over a specific duration. A project trace contains trace configurations from several devices. Each device can trigger the recording on all participating devices. After receiving the global trigger, the devices with a valid project trace configuration start recording.

You can find a device overview with the respective supported trace in the section "Supported hardware (Page 31)".

4.4.1 How a project trace works

The following section shows how a project trace works:

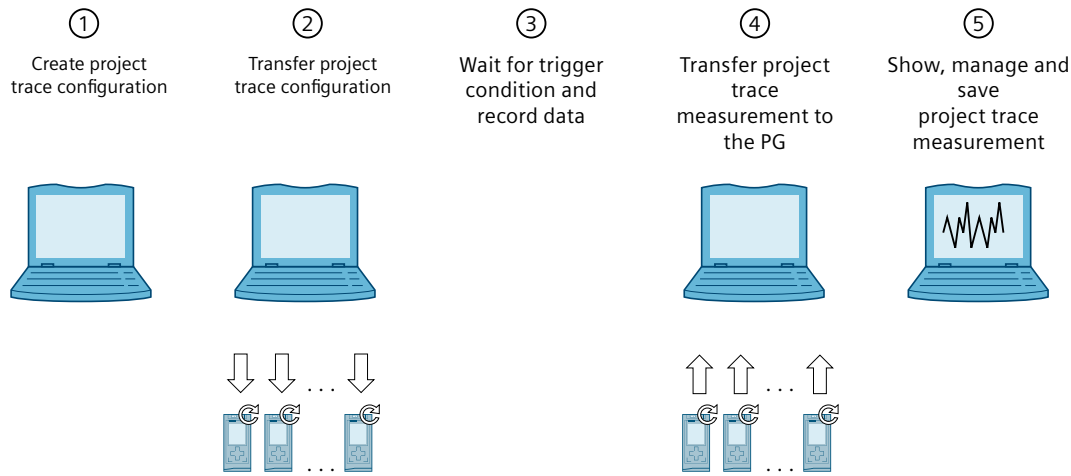

① **Project trace configuration on the programming device (PG) in the TIA Portal**

Select the participating devices in the Project trace configuration (Page 43). In the Inspector window of the respective participating device, select the signals to be recorded and define the conditions for sampling and the trigger. The project trace configuration depends on the device and is described for the respective devices (Page 92).

② **Transfer the project trace configuration from the PG to all the participating devices**

You transfer the complete project trace configuration (Page 50) to all participating devices with an existing online connection.

NOTE

Note that problems with online access between the PG and the CPU can result in errors or even failure of the recording.
If possible, connect the PG directly to the CPU.

---

③ **Wait for the recording**

When the project trace configuration is activated (Page 54), recording occurs independently of the PG. As soon as the trigger condition is met, recording is started on all participating devices.

④ **Transfer the project trace measurement from the device to the PG**

The saving of the measurement in the project (Page 64) stores the measurement in the opened project of the TIA Portal. A project trace measurement consists of a project trace configuration and a recording, if recorded data is available. The recording of a measurement can be analyzed offline. The measurement is saved regardless of the time of the measurement and can also be saved at any time once the recording is completed. The configuration data is displayed write-protected.

⑤ **Evaluate, manage and save the project trace measurement**

A wide range of options are available for evaluating the measurement in the curve diagram (Page 56) and in the signal table (Page 70) (e.g. grouping displays, embedding formulas, etc.). Various display formats are possible, for example a bit display for binary signals. Completed measurements can be exported (Page 65) and imported (Page 65).
When the project is saved in TIA Portal, the measurements transferred to the project are also saved.

4.4.2 Configuration overview

NOTE

The following description provides an example for an S7-1500 CPU. The configuration depends on the device and is described for each device (Page 92).

Make the following settings in the project trace configuration :

- Select participating devices (Page 44)
- Signals (Page 44) to be recorded
- Recording conditions
  - Sampling (Page 45)
  - Trigger (Page 46)

Requirements

The following requirements must be fulfilled for recording with project trace:

- PROFINET RT or IRT communication
- All devices are on a subnet (no routing)
- An online connection from the TIA Portal to all devices to transfer the project trace to the devices.
- The "Record immediately" trigger mode may be configured for a maximum of one device.
- A trigger must be configured for at least one device.

Copy and apply configuration

Project trace configurations are copied and transferred in the same way as with Trace (Page 20).

4.4.3 Time synchronization

The accuracy of the time synchronization depends on how the trace sample event is determined. Isochronous communication provides the highest accuracy because the IRT cycle is used. In all other cases, the respective time of the device in which the signals are recorded is used.

For a synchronous display of the signals, the X axis must be set in "Time (relative)" mode. In this representation, the measurements are arranged in time so that their trigger events are at 0 ms.

To facilitate evaluation with absolute time, you must synchronize the time of day on the devices.

You can find information on the recording time in the device-specific descriptions.

4.4.4 Trigger time for RT communication

Devices which receive the trigger from another device, have a time-delayed trigger event. For RT communication, the time of a trigger event is derived from the transfer time and the recording time. The trigger event is first detected at the end of the recording OB and uses this time as the trigger time. The time delay between the original trigger time and the evaluation in the OB cannot be determined for RT communication. This means the signal trends of devices which receive the trigger from another device appear moved forward. After saving the measurements, you can manually correct these signals with a time offset.

Example of a recording with project trace

The following figure shows a recording with project trace and the correction of the display with an offset:

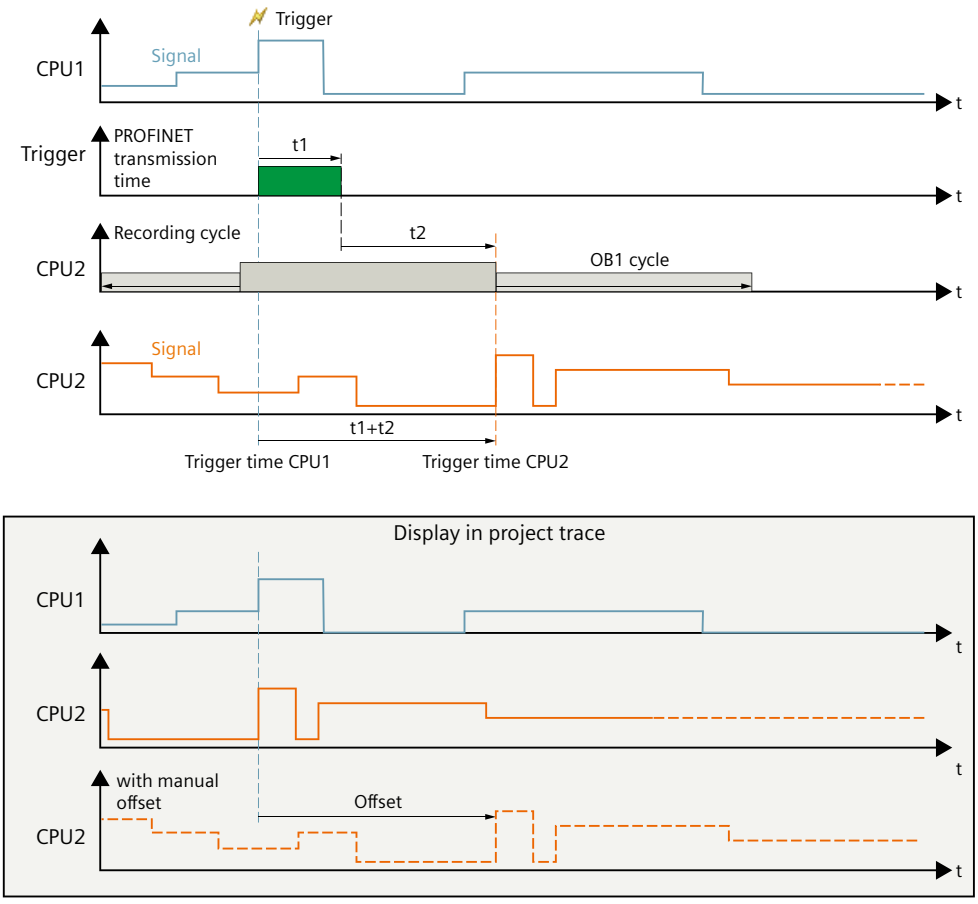

4.4.5 Evaluation options

The time diagram is available for evaluating a project trace recording.

See also

Displaying and analyzing measured values (Page 32)

4.5 Measured value recording with a long-term project trace

With a long-term project trace, you can continuously record selected tags across multiple devices without limiting the recording duration. A long-term project trace contains long-term trace configurations of several devices. If you activate the long-term project trace, recording is started on all participating devices and continues until you deactivate the long-term project trace. The recording data is stored in a selected target path on the programming device.

You can find a device overview with the respective supported trace in the section "Supported hardware (Page 31)".

NOTE

The number of devices that can be in the respective long-term project trace configuration is limited to 5.

4.5.1 How a long-term project trace works

The following section shows how the long-term project trace works:

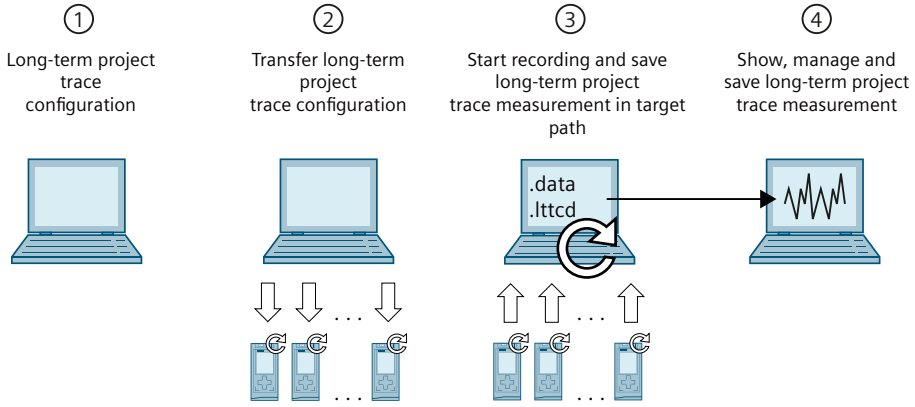

① Long-term project trace configuration on the programming device (PG) in the TIA Portal

Select the participating devices in the long-term project trace configuration (Page 47). In the Inspector window of the respective participating device, select the signals to be recorded and define the conditions for sampling and the target path for the recording. The configuration depends on the device and is described for each device (Page 92).

② Transfer the long-term project trace configuration from the PG to all participating devices

You transfer the complete long-term project trace configuration (Page 50) to all participating devices with an existing online connection.

NOTE

Note that problems with online access between the PG and the CPU can result in errors or even failure of the recording.
If possible, connect the PG directly to the CPU.

③ **Start long-term project trace recording and save to target path.**

You start the recording by activating the configuration (Page 54). The long-term project trace recording is displayed in the time diagram and saved in the configured target path.

NOTE

If a measured variable is renamed during the recording of a long-term project trace, the display in the diagram is lost. However, the signals are still recorded and stored in the target path. To make the values visible in the diagram again, you need to rename the tag back to its original name.

The data of the long-term project trace recording is saved together with the configuration file (*.lttcd) in the configured target path.

NOTE

As of TIA Portal V20, the recording is saved as binary code in ".dat" format. To be able to use the recording data for external evaluation, export the measurement (Page 65) as a CSV file.

④ **Display, manage, and evaluate the long-term project trace measurement**

For evaluation purposes, you can save the long-term project trace recording as a measurement in the project (Page 64). The configuration data is displayed write-protected.

Completed measurements can be exported (Page 65) and imported (Page 65).

A wide range of options are available for evaluating the measurement in the curve diagram (Page 56) and in the signal table (Page 70) (e.g. grouping displays, embedding formulas, etc.). Various display types are possible, for example, a bit representation for binary signals.

NOTE

A maximum of 400000 samples are shown in the curve diagram.

If a recording contains more samples, you will only see the corresponding part of the measurement.

4.5.2 Configuration overview

NOTE

The following description provides an example for an S7-1500 CPU. The configuration depends on the device and is described for each device.

Make the following settings in the long-term project trace configuration :

- Select participating devices (Page 48)
- Signals (Page 48) to be recorded
- Recording conditions
  - Sampling (Page 48)
- Target path for the recording (Page 48)

In the long-term project trace configuration, you define a target path for the recording. The data of the long-term project trace recording is saved together with the configuration file (*.lttcd) in the configured target path.

NOTE

As of TIA Portal V20, the recording is saved as binary code in ".dat" format. To be able to use the recording data for external evaluation, export the measurement (Page 65) as a CSV file.

Requirements

The following requirements must be fulfilled for recording with long-term project trace:

- S7-1500 CPU
- PROFINET RT or IRT communication
- All devices are located in a PROFINET subnet (no routing)
- An online connection from the TIA Portal to all devices in order to transfer the long-term project trace to the devices

Copy and apply configuration

Long-term project trace configurations are copied and transferred in the same way as with Trace (Page 20).

See also

Long-term project trace recording (Page 99)

4.5.3 Time synchronization

Time synchronization works in the same way as with the project trace (Page 26).

4.5.4 Trigger time for RT communication

The trigger time for real-time communication works in the same way as for the project trace (Page 26).

4.5.5 Evaluation options

The time diagram is available for evaluating a long-term project trace recording.

See also

Displaying and analyzing measured values (Page 32)

4.6 Supported hardware

If a device supports the trace and logic analyzer function, "Traces" is offered for selection in the project tree below the device.

The following devices support the trace and logic analyzer function:

- SIMATIC S7-1200 CPUs (as of firmware version V4.0)
- SIMATIC S7-1500, ET 200SP, CPU 1513pro-2 PN and CPU 1516pro-2 PN CPUs
- SIMATIC Drive Controller
- SIMATIC S7-1500 Software Controller
- ET 200SP Open Controller
- SINAMICS Drives that are supported in Startdrive
- SINAMICS V90 (with HSP 0185)
- SIRIUS SIMOCODE pro (with Simocode ES)
- SIRIUS Soft Starter 3RW (with Soft Starter ES)

Overview of the supported trace functions by device family

The following table shows the trace functions that are available for the respective device family:

Device family	Trace	Long-term trace	Project trace	Long-term project trace
SIMATIC S7-1200 CPUs (as of firmware version V4.0)	✓	-	-	-
SIMATIC S7-1500, ET 200SP, CPU 1513pro-2 PN and 1516pro-2 PN CPUs	✓	✓	✓ (as of firmware V2.8)	✓ (as of firmware V2.8)
SIMATIC Drive Controller	✓	✓	✓ (as of firmware V2.8)	✓ (as of firmware V2.8)

Device family	Trace	Long-term trace	Project trace	Long-term project trace
SIMATIC S7-1500 Software Controller	✓	✓	✓ (as of firmware V2.8)	✓ (as of firmware V2.8)
ET 200SP Open Controller	✓	✓	✓ (as of firmware V20.8)	✓ (as of firmware V20.8)
SINAMICS drives that are configured in Startdrive	✓	-	-	-
SINAMICS V90 (with HSP 0185)	✓	-	-	-
SIRIUS SIMOCODE pro (with Simocode ES)	✓	-	-	-

4.7 Displaying and analyzing measured values

The curve diagrams show the signals of a recording selected in the signal table.

The display area can be zoomed as required. Using the measurement cursors and formula editor, individual values can be selected for display in the signal table and calculated using formulas.

Time diagram

The time diagram shows the selected signals of a recording. Analog signals are displayed in the upper curve diagram. Binary signals are displayed in the lower diagram as a bit trace. You can adapt the display of the signals in the signal table and with the toolbar of the curve diagram.

Individual bits can be selected for some data types and displayed as a bit track. Binary signals cannot be grouped.

In the project trace, the curve diagram shows a completed or aborted recording. You can monitor any recording under the device.

The following figure shows an example of the display:

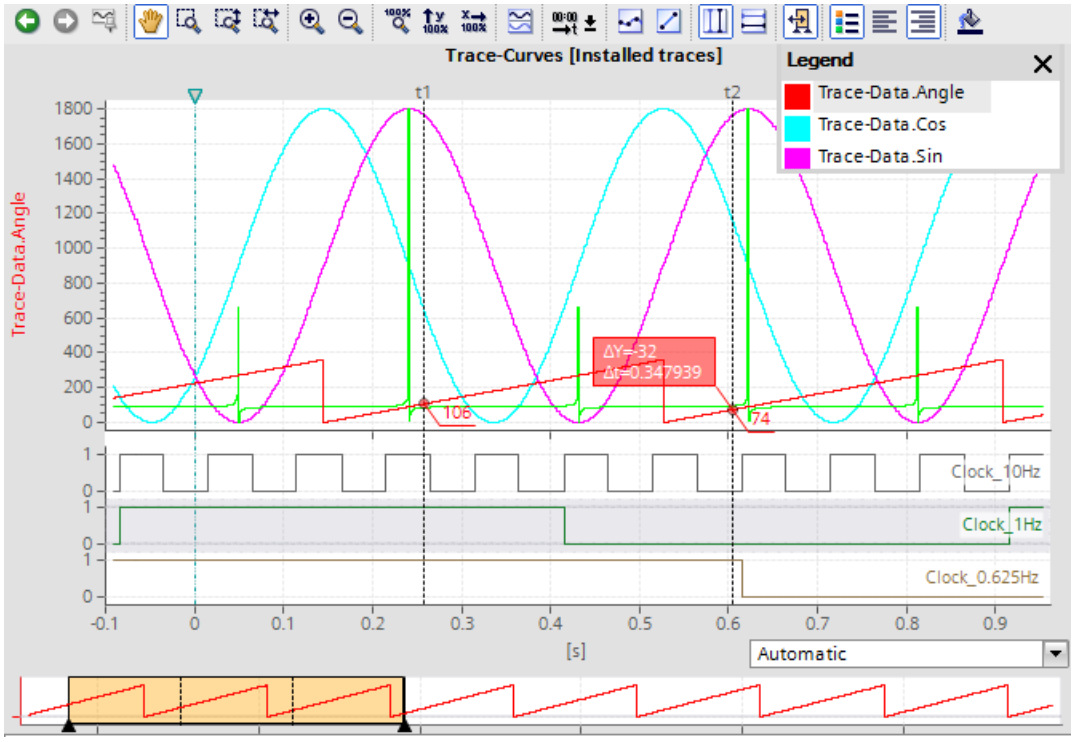

FFT diagram

The FFT diagram shows the frequency spectra of measured signals calculated with the FFT formula. The Y axis shows the amplitude. The display of values on the Y axis is linear. The X axis represents the frequency in Hertz.

Below the curve diagram, you can change the partitioning of the X axis with the options "Linear" and "Logarithmic".

The following figure shows an example of the display:

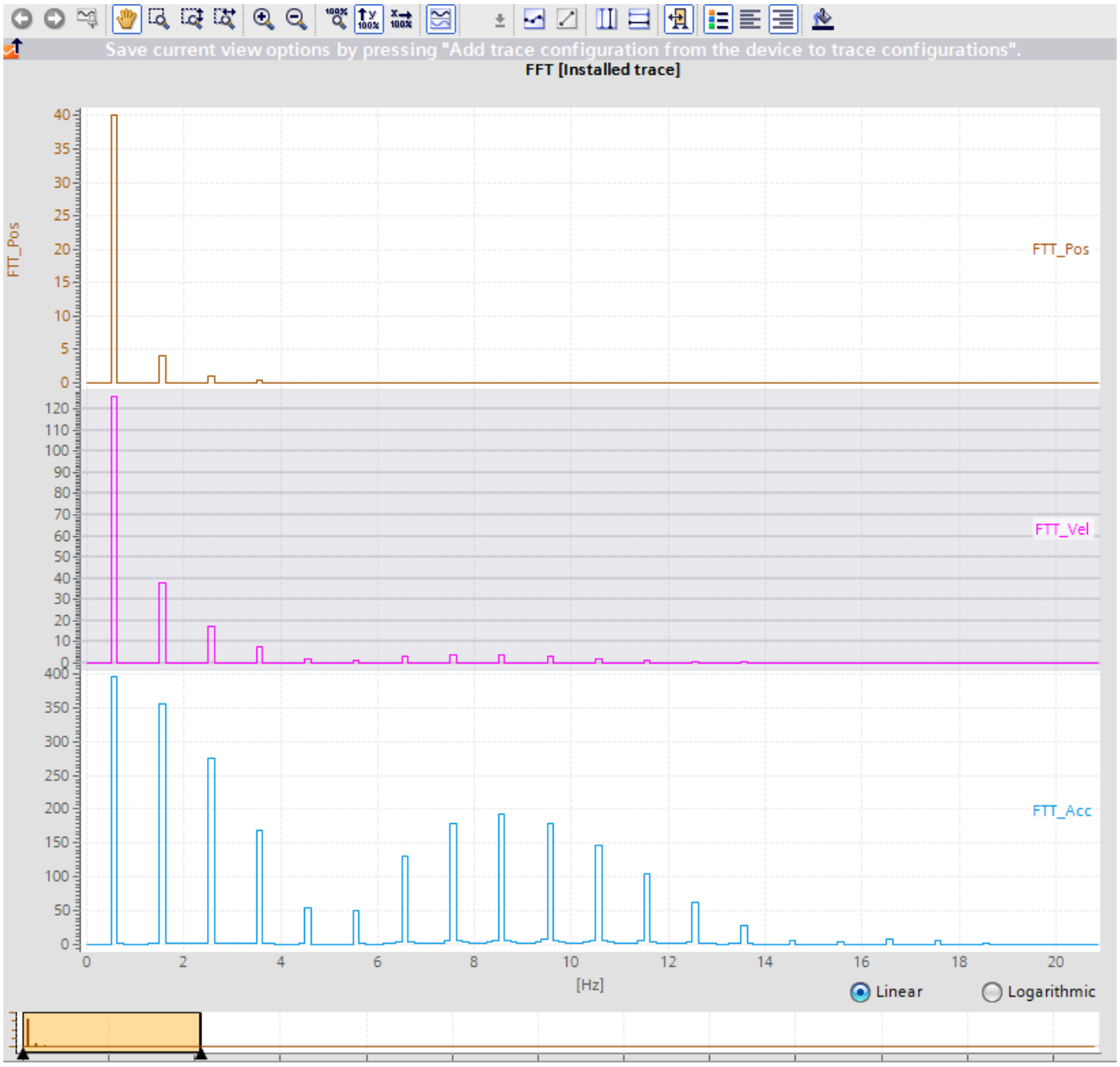

Bode diagram

The Bode diagram shows the amplitude and phase of the transfer function as a function of the frequency. The X axis shows the frequency in Hertz.
The Y axis shows the following values:
- Amplitude response in the upper curve diagram, values linear in decibels
- Phase response in the lower curve diagram, values linear in degrees

The following requirements must be met for the calculation and display of the Bode diagram:
- The recording cycle must be isochronous.

• The input signal must contain at least 3 samples.
The curve diagram is calculated using two measured signals with the Bode formula in the formula editor and displayed.

Below the curve diagram, you can change the partitioning of the X axis with the options "Linear" and "Logarithmic".

The following figure shows an example of the display:

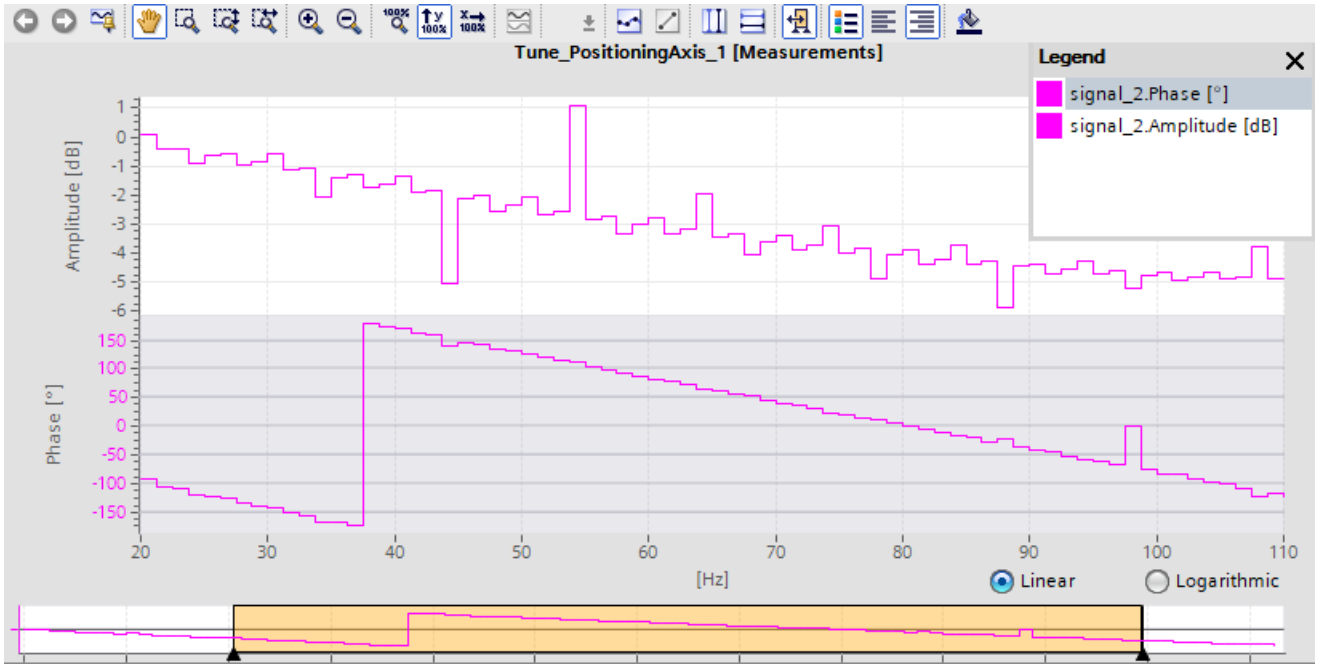

Signal table and formula editor

The signal table shows the signals of an installed trace or a measurement. The preselected signals in the signal selection are displayed with a combined measurement. In the table, you can show or hide individual signals for the display, adapt properties for the display, create signal groups and add formulas. You can use signal groups to uniformly scale individual signals, which makes it easier to compare curves, for example.

The formula editor offers various mathematical functions for analyzing signals.

See also

Create an FFT diagram (Page 85)

Create a Bode diagram (Page 87)

Set the view of the curve diagram (Page 56)

Working with the signal table (Page 70)

Using trace functions 5

5.1 Configuring

5.1.1 Configuring the trace

5.1.1.1 Guide to using a trace

NOTE

The following description provides an example for an S7-1500 CPU. The configuration depends on the device and is described for each device.

1. Add a new trace to the project (Page 36)
2. Select the signals (Page 37), define criteria for sampling (Page 37) and the trigger (Page 38)
3. Optional: Activate event recording, or set measurements in the device (memory card) (Page 39)
4. Transfer the configuration to the device (Page 50)
5. Activate recording (Page 54), monitor (Page 55) and deactivate recording (Page 54)
6. Save the recording as measurement in the project (Page 64)
7. Select signals (Page 67)

5.1.1.2 Add a new trace to the project

Procedure:

1. Open the "Traces" folder in the project tree under the selected device.
2. Double-click on the "Add new trace" entry.

   A new trace configuration is created in the project tree and the configuration window is opened in the work area.
3. Click on the name of the trace configuration in the project tree to customize it.

   Or:

   Right-click on the name of the trace configuration in the project tree and select the "Rename" command in the context menu.

5.1.1.3 Selecting signals

Requirement

- The "Signals" area is open in the "Configuration" tab.

Procedure

To configure the signals to be recorded, proceed as follows:

1. Select a signal.

   The following options are available:

   – In the "Name" column, click the button and select a tag.
   – Enter the symbolic tag name in the cell in the "Name" column.
   – Enter the address directly in the "Address" column.
   – Drag a signal to the table using drag-and-drop.

2. Click in the "Comment" column and enter a comment for the signal.
3. Repeat the procedure from step 1 until all the signals to be recorded have been entered in the table.

5.1.1.4 Activate event recording

NOTE

The "Event recording" function is only available on an S7-1500 CPU with an installed trace and is available for all technology objects as of version V9.0.

You can find more information on configuration in the "Recording and diagnostics of events with the trace" manual in section "AUTOHOTSPOT".

5.1.1.5 Configure sampling

NOTE

The following description provides an example for an S7-1500 CPU. The configuration depends on the device and is described for each device (Page 92).

Requirement

- The "Sampling" area is open in the "Configuration" tab.

Procedure

To configure the cycle and the duration of a recording, proceed as follows:

1. Click the button.
2. Select an OB for the recording time (Page 94).
3. Select a unit for the reduction factor in the drop-down list for "Record every".
4. Enter the factor for the reduction in the input field for "Record every".
5. Select a unit in the drop-down list for "Recording duration".
6. Specify the recording duration.

   The following options are available:

   – Enter a value for the duration in the input field for "Recording duration".
   – Select the "Use max. recording duration" check box.

5.1.1.6 Configure trigger mode

NOTE

The following description provides an example for an S7-1500 CPU. The configuration depends on the device and is described for each device (Page 92).

Requirements

- The "Trigger" area is opened in the "Configuration" tab.

Trigger mode "Monitor without trigger"

Proceed as follows to start recording immediately without it being ended automatically:

1. Select the "Monitor without trigger" entry in the "Trigger mode" drop-down list.

   The input fields for the trigger tag are hidden. After you stop recording, the maximum number of measured values in the device is the number you have configured under Recording duration. The trigger mode is particularly suitable for monitoring slow signals.

"Record immediately" trigger condition

To start the recording immediately, proceed as follows:

1. In the "Trigger mode" drop-down list, select the "Record immediately" entry.

   The input fields for the trigger tag are hidden.

"Trigger on tag" trigger mode

To start the recording depending on a condition, proceed as follows:

1. In the "Trigger mode" drop-down list, select the "Trigger on tag" entry.
2. Select a trigger tag. The following options are available:
   - Click for the trigger tag and select a tag.
   - Enter the address or the symbolic name of the tag directly in the input field for the trigger tag.

   A drop-down list with events and input fields is displayed. The display depends on the data type of the trigger tag (Page 112).
3. Configure the event.
4. Select a unit for the pretrigger in the drop-down list for "Pretrigger".
5. In order to record a period before the trigger event, enter a value greater than 0 in the input field for the pretrigger.

NOTE

Cyclic test of the trigger condition

The trigger condition is checked in the cycle of the OB in which the trigger tag is processed, regardless of the setting in "Record every". To reliably identify the trigger, the trigger signal must be present for at least one full cycle.

5.1.1.7 Set the measurement in the device (memory card)

NOTE

The following description applies to an S7-1500. These settings are device-specific and are described for the respective device.

Requirement

- The "Event recording" function is not used.
- The "Trigger on tag" trigger mode is set.
- The "Recording conditions" area is open in the "Configuration" tab.
- The firmware on the device supports the recording of an installed measurement.

Procedure

To save the measurement in the device (memory card), proceed as follows:

1. Select the "Save measurements on device (memory card)" check box.
2. Enter the number of measurements that ought to be saved on the card in the "Number of measurements" entry field.

3. In the "Response when number reached" drop-down list, set the response when the "Number of measurements" has been reached:
   - "Deactivate recording"
     The measurements are repeated until the configured "Number of measurements" is reached.
   - "Overwrite oldest recording"
     The measurements are saved in a ring buffer and repeated until you deactivate the recording. As soon as the number of measurements exceeds the configured "Number of measurements", the oldest measurement on the card is overwritten in each case.

Result

The measurements are stored in the "Measurements on device (memory card)" folder in the project tree. The folder is only visible when the device is actively connected online.

These measurements are retentive and can only be deleted by you as the user.

NOTE

The measurements on the device (memory card) can be transferred to the "Measurements" folder using drag-and-drop and thus saved as a measurement in the project.

Required information on the measurement in the device (memory card)

Note the following when using the "Measurement in the device" function:

- Only completed measurements are stored in the device. A recording that you have deactivated is not saved in the device.
- No new trigger can be evaluated as long as the recording is being saved.
- Frequently repeated write operations can damage the memory card.
- Do not delete any measurements on the device as long as an installed trace still generates new measurements on the memory card.
- Following a device reboot, the maximum number of measurements saved in the device is the number configured under "Number of measurements". Repeated restarts will not overwrite measurements that have already been saved and the configured "Number of measurements" will be saved in the device again.
- The memory in the device (memory card) is partly used by system-relevant functions or reserved for that purpose. It is therefore not possible for the entire memory to be used for saving measurements.
  You can find more information in the Structure and Use of the CPU Memory (https://support.industry.siemens.com/cs/ww/en/view/59193101) Function Manual.

5.1.2 Configuring the long-term trace

5.1.2.1 Guide to using a long-term trace

1. Add a new long-term trace to the project (Page 41)
2. Select signals (Page 42), define criteria for sampling (Page 42) and set the target path for the recording (Page 43).
3. Transfer the configuration to the device (Page 50)
4. Activate recording, monitor and deactivate recording
5. Save the recording as measurement in the project
6. Select signals (Page 67)

NOTE

Due to the essential connection between TIA Portal and the CPU, we recommend limiting the use of the long-term trace as follows:

- Simultaneous recording of max. two long-term traces installed on the CPU
- Maximum of 32 signals of the "LREAL" data type per long-term trace
- Minimum recording cycle 1 ms"

5.1.2.2 Add a new long-term trace to the project

Procedure:

1. Open the "Long-term traces" subfolder, which is located in the "Traces" folder in the project tree under the selected CPU.
2. Double-click on the "Add new long-term trace" entry.

   A new long-term trace configuration is created and the configuration window is opened in the work area.
3. Click on the name of the long-term trace configuration in the project tree to customize it.

   Or:

   Right-click on the name of the long-term trace configuration in the project tree and select the "Rename" command in the context menu.

5.1.2.3 Select signals

The signals are selected (Page 37) in the same way as for a trace.

5.1.2.4 Configure sampling

NOTE

The following description applies to an S7-1500 CPU. These settings are device-specific and are described for the respective device.

Requirement

- The "Sampling" area is open in the "Configuration" tab.

Procedure

To configure the cycle of a long-term trace recording, proceed as follows:

1. Click for the recording time.
2. Select an OB for the recording time (Page 94).
3. Select a unit for the reduction factor in the drop-down list for "Record every".
4. Enter the factor for the reduction in the input field for "Record every".

5.1.2.5 Configure target path for long-term trace recording

Requirement

- The "Long-term trace" area is opened in the "Configuration" tab.

Procedure

The default target path is the "UserFiles" folder in the STEP 7 project directory. To change the target path, follow these steps:

1. Click the ... button for the target path setting.

   The "Select folder" window opens.
2. In the folder structure, navigate to the target folder or enter the target path under "Folder".
3. Click "Select folder".

   The long-term trace recording data is saved together with the configuration file (*.lttcd) in the configured target path.

NOTE

As of TIA Portal V20, the recording is saved as binary code in ".dat" format. To be able to use the recording data for external evaluation, export the measurement (Page 65) as a CSV file.

See also

Long-term trace recording (Page 97)

5.1.3 Configuring the project trace

5.1.3.1 Guide to using a project trace

1. Add a new project trace to the project (Page 44)
2. Select participating devices (Page 44)
3. In the "Participating devices" interface, select a device for which the recording conditions are configured.

   In the Properties tab of the Inspector window, select the signals to be recorded (Page 44), define criteria for sampling (Page 45) and for the trigger (Page 46). Repeat this step for each participating device.
4. Transfer the configuration to the devices (Page 50)
5. Activate recording (Page 54), monitor (Page 55) and deactivate recording (Page 54)
6. Save the recording as measurement in the project (Page 64)
7. Select signals (Page 67)

5.1.3.2 Add a new project trace to the project

Procedure:

1. Open the "Project traces" folder located in the "Cross-device functions" folder in the project tree.
2. Double-click the "Add new project trace" entry.

   A new project trace configuration is created and the "Participating devices" interface is opened in the work area.
3. Click on the name of the project trace configuration in the project tree to customize it.

   Or:

   Right-click on the name of the project trace configuration in the project tree and select the "Rename" command in the context menu.

5.1.3.3 Select participating devices

Requirement

- At least two devices that support the cross-device functions are configured.
- The "Participating devices" interface is open in the work area.

Procedure

To select participating devices, proceed as follows:

1. In the "Participating devices" interface, use the button to select the devices that are to participate in the project trace recording.

5.1.3.4 Selecting signals

Requirement

- A device is selected in the "Participating devices" interface.
- The "Properties" tab is open in the Inspector window.
- The "Signals" area is open in the "Properties" tab.

Procedure

To configure the signals to be recorded, proceed as follows:

1. Select a signal.

   The following options are available:

   – In the "Name" column, click the button and select a tag.
   – Enter the symbolic tag name in the cell in the "Name" column.
   – Enter the address directly in the "Address" column.
   – Drag a signal to the table using drag-and-drop.

2. Click in the "Comment" column and enter a comment for the signal.
3. Repeat the procedure from step 1 until all the signals to be recorded have been entered in the table.

5.1.3.5 Configure sampling

NOTE

The following description provides an example for an S7-1500 CPU. The configuration depends on the device and is described for each device (Page 92).

Requirement

- A device is selected in the "Participating devices" interface.
- The "Properties" tab is open in the Inspector window.
- The "Sampling" area is opened in the "Properties" tab.

Procedure

To configure the cycle and duration of the project trace recording, proceed as follows:

1. Click the button.
2. Select an OB for the recording time (Page 94).
3. Select a unit for the reduction factor in the drop-down list for "Record every".
4. Enter the factor for the reduction in the input field for "Record every".
5. Select a unit in the drop-down list for "Recording duration".
6. Specify the recording duration.

   The following options are available:

   – Enter a value for the duration in the input field for "Recording duration".
   – Select the "Use max. recording duration" check box.

5.1.3.6 Configure trigger mode

NOTE

The following description provides an example for an S7-1500 CPU. The configuration depends on the device and is described for each device (Page 92).

Requirement

- A device is selected in the "Participating devices" interface.
- The "Properties" tab is open in the Inspector window.
- The "Trigger" area is open in the "Properties" tab.

"Record immediately" trigger condition

This trigger mode is selected in the same way as for a trace (Page 38).

"Trigger on tag" trigger mode

This trigger mode is selected in the same way as for a trace (Page 38).

Trigger mode "Trigger from another device"

To start recording on the participating device depending on the trigger condition of another participating device, proceed as follows:

1. Select the "Trigger from another device" entry in the "Trigger mode" drop-down list.
2. Select a unit for the pretrigger in the drop-down list for "Pretrigger".
3. In order to record a period before the trigger event, enter a value greater than 0 in the input field for the pretrigger.

NOTE

Devices which receive the trigger from another device, have a time-delayed trigger event. You can find more information on this in the Time synchronization (Page 26) section.

5.1.4 Configure long-term project trace

5.1.4.1 Guide to using a long-term project trace

1. Add a new long-term project trace to the project (Page 47)
2. Select participating devices (Page 48)
3. In the "Participating devices" interface, select a device for which the recording conditions are configured.

   In the Properties tab of the Inspector window, select the signals (Page 48), define criteria for sampling (Page 48) and set the target path for the recording (Page 48). Repeat this step for each participating device.
4. Transfer the configuration to the devices (Page 50)
5. Activate recording (Page 54), monitor (Page 55) and deactivate recording (Page 54)
6. Save the recording as measurement in the project (Page 64)
7. Select signals (Page 67)

5.1.4.2 Add a new long-term project trace to the project

Procedure:

1. Open the "Long-term project traces" folder, which is located in the "Cross-device functions" folder in the project tree.
2. Double-click on the "Add new long-term project trace" entry.

   A new long-term project trace configuration is created and the "Participating devices" interface is opened in the work area.
3. Click on the name of the long-term project trace configuration in the project tree to customize it.

   Or:

   Right-click on the name of the long-term project trace configuration in the project tree and select the "Rename" command in the context menu.

5.1.4.3 Select participating devices

Participating devices are selected in the same way as for a project trace (Page 44).

5.1.4.4 Select signals

The signals are selected in the same way as for a project trace (Page 44).

5.1.4.5 Configure sampling

NOTE

The following description provides an example for an S7-1500 CPU. The configuration depends on the device and is described for each device (Page 92).

Requirement

- A device is selected in the "Participating devices" interface.
- The "Properties" tab is open in the Inspector window.
- The "Sampling" area is opened in the "Properties" tab.

Procedure

To configure the cycle of the long-term project trace recording, proceed as follows:

1. Click the button.
2. Select an OB for the recording time (Page 94).
3. Select a unit for the reduction factor in the drop-down list for "Record every".
4. Enter the factor for the reduction in the input field for "Record every".

5.1.4.6 Configure target path for long-term project trace recording

Change the target path for a participating device

Requirements:

- A device is selected in the "Participating devices" interface.
- The "Properties" tab is open in the Inspector window.
- The "Long-term trace" area is open in the "Properties" tab.

The default target path is the "UserFiles" folder in the STEP 7 project directory.

To change the target path, follow these steps:

1. Click the button for the target path setting.

   The "Select folder" window opens.

2. In the folder structure, navigate to the target folder or enter the target path under "Folder".

3. Click "Select folder".

   The data of the long-term project trace recording is saved together with the configuration file (*.lttcd) in the configured target path.

Change target path for all participating devices

Requirements:

- No device is selected in the "Participating devices" interface.
- The "Properties" tab is open in the Inspector window.
- The "General" area is open in the "Properties" tab.

  Or:

- The "Properties" window was opened in the project tree via the context menu of the long-term project trace.

The default target path is the "UserFiles" folder in the STEP 7 project directory.

To change the target path, follow these steps:

1. Click the button for the target path setting.

   The "Select folder" window opens.

2. In the folder structure, navigate to the target folder or enter the target path under "Folder".

3. Click "Select folder".

   The data of the long-term project trace recording is saved together with the configuration file (*.lttcd) in the configured target path.

NOTE

As of TIA Portal V20, the recording is saved as binary code in ".dat" format. To be able to use the recording data for external evaluation, export the measurement as a CSV file.

See also

Long-term project trace recording (Page 99)

5.1.5 Transfer configuration

Transfer the configuration to the device (trace and long-term trace)

Requirements:

- A trace or long-term trace is configured.
- The trace or long-term trace is open in the work area.

Procedure:

1. Click the "Transfer the configuration to the devices" button in the toolbar.

   An online connection to the device is established and the display switches to the "Time diagram" tab.

Transfer configuration to all participating devices (project trace and long-term project trace)

Requirements:

- A project trace or long-term project trace is configured.
- The project trace or long-term project trace is open in the work area.

Procedure:

1. Click the "Transfer the configuration to the devices" button in the toolbar.

   An online connection to all participating devices is established and the display switches to the "Time diagram" tab.
2. Click the "Status overview" button to check the status of the devices.

Result

The trace or long-term trace is prepared and the recording can be activated (Page 54).

See also

Status overview of the participating devices (Page 90)

5.1.6 Transfer installed trace to the project as a configuration

Requirement

- There is an installed trace or long-term trace.
- There is an online connection to the device.
- The installed trace or long-term trace is opened in the work area.

Procedure

To transfer a trace or long-term trace as a new configuration to the "Traces" or "Long-term traces" folder, proceed as follows:

1. Click the button "Transfer installed trace to the project as a configuration" in the toolbar.

   The current display options remain in the new configuration. A configuration having the same name in the folder is overwritten.

5.1.7 Deleting a trace from the device

Delete trace from the device (trace and long-term trace)

Requirements:

- There is an installed trace .
- There is an online connection to the device.
- The installed trace is open in the work area.

Procedure:

1. Click the "Delete trace from device" button in the toolbar.

   The trace is deleted from the device.

Delete traces from the participating devices (project trace and long-term project trace)

Requirements:

- There are installed traces .
- There is an online connection to at least one device.
- The project trace or long-term project trace is open in the work area.

Procedure:

1. Click the "Delete traces from devices" button in the toolbar.

   The traces are deleted from the participating devices that are accessible online.

5.1.8 Export configuration

Requirement

- The trace or long-term trace configuration is opened in the work area.

Procedure

To save the configuration in a specified location as a file in ".ttcfgx" format, proceed as follows:

1. Click the "Export configuration" button in the toolbar.

   Or:

   Right-click on the configuration to be exported in the project tree and select the "Export configuration" command in the context menu.

   The "Save as" window opens.
2. In the folder structure, navigate to the target folder or enter the target path under "Folder".
3. Click "Save".

   The configuration is exported to the specified storage location in the ".ttcfgx" format.

NOTE

When exporting a long-term trace configuration there is an increased storage capacity requirement. Before exporting ensure that you have enough storage capacity.

5.1.9 Import configuration

Requirement

- A trace or long-term trace configuration exists in the ".ttcfgx" format.

Procedure

To import a configuration in the "Traces" or "Long-term traces" folder, proceed as follows:

1. Right-click on the "Traces" or "Long-term traces" folder in the project tree.
2. Select the "Import configuration" command in the context menu.

   The "Open" window opens.
3. In the folder structure, navigate to the file you want to import or enter the target path under "Folder".
4. Click the "Open" button.

   The configuration is imported into the folder.

5.1.10 Create a configuration from an existing measurement

Creating a configuration from a measurement

Requirement:

- A measurement is available in the "Traces → Measurements" or "Long-term traces → Measurements" folder.
- The measurement is open in the work area.

The following procedures are available to create a new configuration from an existing measurement.

- Click the "Create configuration from measurement" button in the toolbar.

  The configuration is added to the "Traces" or "Long-term traces" folder.
- Drag-and-drop the measurement in the project tree into the "Traces" or "Long-term traces" system folder.

  The configuration is created in the folder.

NOTE

To create a configuration from a long-term trace measurement stored in the format ".lttcd", right-click in the project tree on the folder "Long-term traces", and select the "Import long-term trace configuration..." command in the context menu.

Creating a configuration from a combined measurement

Requirement:

- A combined measurement in the folder "Traces → Combined measurements" or "Long-term traces → Combined measurements" (or "Project traces → Measurements" or "Long-term project traces → Measurements") is available.
- The measurement is open in the work area.

The following procedures are available to create a new configuration from an existing combined measurement.

- Drag-and-drop the measurement from the "Measurements" tab into the "Traces" or "Long-term traces" folder.

  The configuration is created in the folder.
- Copy the measurement from the "Measurements" tab into the Clipboard and insert it into the "Traces" or "Long-term traces" folder.

  The configuration is created in the folder.

5.2 Recording

5.2.1 Activating/deactivating a recording

Requirement

- The configuration is transferred (Page 50).
- The configuration is opened in the work area.

Activate recording

Proceed as follows to activate the recording:

1. Click the "Activate recording" button in the toolbar.

   Recording is started according to the configured trigger condition.

   The trigger condition is device-specific and is described under the respective device (Page 92).

   If the recording is repeated, the settings relevant for the display (curve diagram and signal table) are also retained for the new recording.

NOTE

When a recording is restarted, the previously recorded values are lost.

To save the recorded values, save the measurement in the project (Page 64) before you activate the recording again.

Deactivate recording

To deactivate an active recording, proceed as follows:

1. Click the "Deactivate recording" button in the toolbar.

   The recording is deactivated.

NOTE

Deactivation of the recording with active event recording

Manual deactivation of a recording with active event recording results in the recording being incomplete. Data are not recorded until the end of the recording.

5.2.2 Automatically repeat recording

The recording is automatically re-activated at the end of each recording. The display in the curve diagram is similar to the display of an oscilloscope.

Requirements

- There is an online connection to the device.
- There is an installed trace.
- The "Event recording" function is not used.

Procedure

To monitor the progress of a fast signal, proceed as follows:

1. Select an installed trace.
2. Double-click the selected trace.
3. Activate the "Monitoring On/Off" button to monitor the recording.
4. Click "Automatically repeat recording" button to automatically repeat the recording.

5.2.3 Monitor ongoing recording in the time diagram

To monitor a running recording in the time diagram, proceed as follows:

1. Click the button "Monitoring on/off" button in the toolbar.
   The display switches to the "Time diagram" tab.

NOTE

If monitoring and automatic scaling are activated at the same time, no more actions can be undone using the "Undo" button.

When a recording is started for the first time, the display in the curve diagram is preset to automatic scaling. If you start the recording again, note that changed scaling settings are retained. Reactivate automatic scaling manually if necessary in order to monitor the recording.

See also

Additional display options for the trend diagram (Page 59)

5.3 Set the view of the curve diagram

5.3.1 Display of the recording in the curve diagram

The following figure shows an example of a recording in the time diagram, using named value data types:

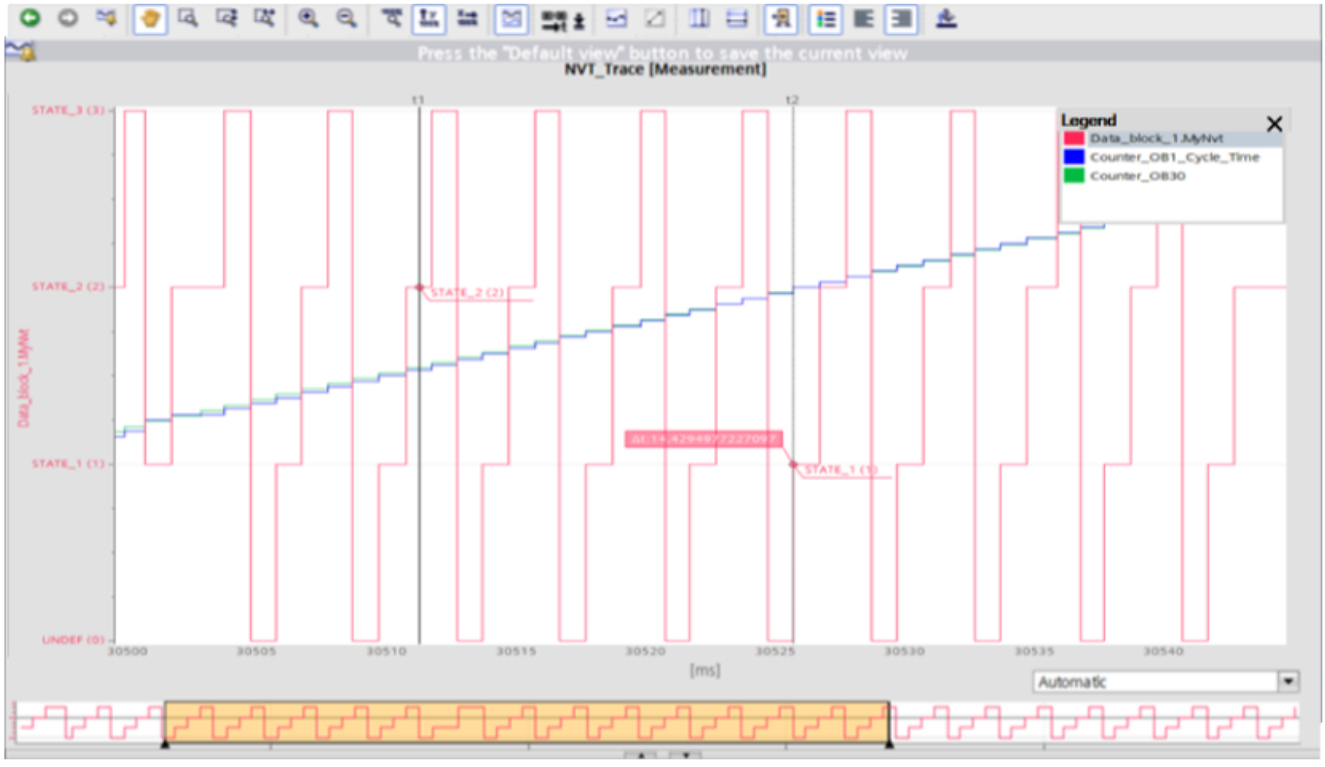

The scale in the diagram applies to the selected signal (highlighted in gray) in the legend. The legend can be moved and resized using the mouse.

When using named value data types in the recording, the corresponding data type values are displayed on the Y axis.

Invalid floating point numbers such as NaN (Not a Number) or TOD (Time of Day) are displayed as hexadecimal numbers on the Y axis. Infinite numbers in the number range +Inf/-Inf (Infinity) are shown as gaps in the diagram.

The icon shows the trigger time with a vertical line with the trigger time from the device.

With the "Time (relative)" setting for the time axis, a drop-down list for selecting the unit is available below the curve diagram. The "Automatic" setting automatically adjusts the unit according to the displayed time range.

The time range display below the diagram shows the display range in the curve diagram as a yellow area based on a selected signal. In the FFT and Bode diagram, this area shows the frequency range.

You can move the yellow area with the mouse. In case of a very long recording the time range display can be displayed as a vertical line. In such a case you can move the area with the mouse while keeping the <Ctrl> button pressed. You change the horizontal size at the limits of the time range display.

NOTE

Non-interpretable data types

Some data types require a defined format, e.g. the S7 data type `LTime_of_Day`. If this format is not available, the data type is interpreted as INT.

5.3.2 Bring a signal into the foreground

To bring a signal to the foreground in the curve diagram, proceed as follows:

1. Show/hide the legend using the "Show/hide chart legend" button.

   NOTE

   The display of the legend depends on the track arrangement setting. If the track arrangement is active, signal legends are displayed in the respective tracks. If the track arrangement is inactive, a legend table is displayed.

2. Click on a signal in the track or in the legend table.

   Or:

   Click a signal in the curve diagram.

   Or:

   Select a signal in the signal table (Page 70).

5.3.3 Scale the display in the curve diagram

Scale view

The following procedures are available to reduce or enlarge the entire view:

- Click the "Zoom in" or "Zoom out" buttons in the toolbar.
- Turn the mouse wheel while holding down the <Ctrl> key. The mouse pointer must be positioned over the curve diagram.
- Press the <Ctrl++> or <Ctrl+-> shortcut on the keyboard.
- Right-click on the curve diagram and select the "Zoom in" or "Zoom out" commands in the context menu.

Scale a specific area

To scale a specific area in the curve diagram, proceed as follows:

1. Click the "Activate zoom selection" button in the toolbar.
2. Select any area by holding down the mouse button.

   The display is scaled to the range selection.

To scale a specific vertical area, proceed as follows:

1. Click the "Select vertical zoom" button in the toolbar.
2. Select a vertical area with the mouse button held down.

   The display is scaled to the range selection. Selection affects either amplitude response or phase response depending on the mouse position.

To scale a specific horizontal area, proceed as follows:

1. Click the "Select horizontal zoom" button in the toolbar.
2. Select a horizontal area by holding down the mouse button.

   The display is scaled to the range selection.

Show all

The following procedures are available to scale the display so that the entire time range and all values are displayed:

- Click the "Display all" button in the toolbar.
- Press the shortcut <Ctrl+0> on the keyboard.
- Right-click on the curve diagram and select the "Display all" command in the context menu.

See also

Additional display options for the trend diagram (Page 59)

5.3.4 Show or hide individual signals and adapt color

To show or hide individual signals and change their color display in the curve diagram, proceed as follows:

1. In the signal table, click on the symbol next to the respective signal to deselect or select it for display.

   The selected signal is shown or hidden in the curve diagram.
2. In the signal table, click in the "Color" column for the respective signal and select a color.

   The default color for the signal changes.

See also

Setting options and displays in the signal table (Page 73)

5.3.5 Additional display options for the trend diagram

Use default view (measurements only)

To use the current view in the curve diagram as the default view, proceed as follows:

1. Click the "Set measurement settings default view" button in the toolbar.

   The measurement settings are restored for a later display.

Move view

The following procedures are available to move the view in the curve diagram:

- Click the "Move view" button in the toolbar and move the display by holding down the mouse button.
- Move the display vertically by turning the mouse wheel or horizontally by turning the mouse wheel while holding down the <Shift> key. The mouse pointer must be positioned above the curve diagram with the analog signals. If the signals are arranged in traces, the display of the group is shifted below the cursor.

Scale the value axis automatically

The following procedures are available to scale the display for the entire value range in the configured time range:

- Click the "Automatic scaling of the value axis" button in the toolbar.
- Right-click on the curve diagram and activate the "Automatic scaling of the value axis" check box in the context menu.

NOTE

The automatic scaling of the value axis is stopped when the zoom function is activated for the value axis. This button reactivates the automatic adjustments to the minimum/maximum values.

Scale the time range automatically

The following procedures are available to display the entire time range in the curve diagram:

- Click the "Display entire time range" button in the toolbar.
- Right-click on the curve diagram and activate the "Display entire time range" check box in the context menu.

NOTE

Automatic scaling of the time range is stopped when a zoom function of the value axis is activated. This button reactivates the automatic adjustments to the minimum/maximum values.

Arranging signals in tracks

The following procedures are available to arrange the signals one below the other with the respective value axes and to display signal groups in the same track:

- Click the "Arrange in tracks" button in the toolbar.
- Right-click on the curve diagram and activate the "Arrange in tracks" check box in the context menu.

Switching the time axis units

To switch the unit of the time axis, proceed as follows:

1. Click the "Change X axis unit" button in the toolbar.

   The following units are available for selection:

   – "Samples"

   – "Time (relative)"

     Relative time in relation to the trigger time.

   – "Time stamp of the samples"

NOTE

Unit switchover is only possible in the time diagram.

Display samples

To display the samples of the recording as small circles, proceed as follows:

1. Click the "Display samples" button in the toolbar.

Displaying linear interpolation

To display the linear interpolation between two consecutive samples for floating-point numbers, proceed as follows:

1. Click the "Interpolated view (linear)" button in the toolbar.

NOTE

If linear interpolation is not activated (default), the connection between measuring points is drawn in steps.

Show/hide measurement cursor

The following procedures are available to display the vertical measurement cursor:

- Click the "Show vertical measurement cursor" button in the toolbar.
- Right-click on the curve diagram and activate the "Show or hide vertical measurement cursors" check box in the context menu.
- Press the <Ctrl+Spacebar> shortcut on the keyboard.

The following procedures are available to display the horizontal measurement cursor:

- Click the "Show horizontal measurement cursor" button in the toolbar.
- Right-click on the curve diagram and activate the "Show or hide horizontal measurement cursors" check box in the context menu.

NOTE

The values of the measurement cursors are displayed in the signal table and in the "Measurement cursor" palette.

Show/hide time range display

To show/hide the time range display, proceed as follows:

1. Click the "Show/hide time range display" button in the toolbar.

   The time range display shows the area in the curve diagram in yellow based on a selected signal. In the FFT and Bode diagram, this area shows the frequency range.

   You can move the yellow area with the mouse. In case of a very long recording the time range display can be displayed as a vertical line. In such a case you can move the area with the mouse while keeping the <Ctrl> button pressed. You change the horizontal size at the limits of the time range display.

Show legend in the curve diagram

To show/hide the legend in the curve diagram and display it aligned, proceed as follows:

1. Click the "Show/hide chart legend" button in the toolbar.

To display the legend on the left side of the curve diagram, proceed as follows:

1. Click the "Display legend left-aligned" button in the toolbar.

To display the legend on the right side of the curve diagram, proceed as follows:

1. Click the "Display legend right-aligned" button in the toolbar.

Changing the background color

To change the color of the background in the curve diagram, proceed as follows:

1. Click the "Change background color" button. Click this button again to switch between other background colors.

Automatically adapt the height of the bit tracks

To automatically adapt the height of the bit tracks and thereby define the size of the lower curve diagram, proceed as follows:

1. Right-click on the curve diagram and activate the "Automatic bit track height" check box in the context menu.

   The setting is automatically deactivated as soon as you manually change the space allocation between the curve diagrams.

NOTE

You can change the vertical space allocation between the upper and lower curve diagram. To do this drag the time axis of the upper curve diagram up or down with the mouse.

Undo / redo display adjustments

The following procedures are available to undo your last display adjustments step-by-step:

- Click the "Undo" button in the toolbar.
- Right-click on the curve diagram and select the "Undo" command in the context menu.

The following procedures are available to repeat the last display adjustments you undid step-by-step:

- Click the "Redo" button in the toolbar.
- Right-click on the curve diagram and select the "Redo" command in the context menu.

NOTE

Applicable to the following display adjustments:

- Show all
- Display entire time range
- Automatic scaling of the value axis
- Move view
- Zoom selection
- Vertical zoom selection
- Horizontal zoom selection
- Zoom in
- Zoom out

Save the current display of the diagram as an image

To save the current display of the curve diagram in a graphic format as a file, e.g. for printing, proceed as follows:

1. Right-click on the curve diagram and select the "Save diagram as image" command in the context menu.

   The "Save as image file" window opens.
2. In the folder structure, navigate to the target folder or enter the target path under "Folder".
3. Select the graphic format.
4. Click "Save".

   The diagram display is saved in the specified storage location in the selected graphic format.

Copy the current display to the clipboard

To copy the current display of the curve diagram to the clipboard, e.g. to insert it into another file, proceed as follows:

1. Right-click on the curve diagram and select the "Copy image to clipboard" command in the context menu.
2. Navigate to the destination for pasting the image from the clipboard (e.g. Microsoft Excel) and paste the image.

5.4 Save recordings as measurements

A measurement consists of a configuration and a recording, if recorded data is available. The recording of a measurement can be viewed offline.

The configuration data is displayed write-protected.

NOTE

- Always protect your exported files and network shares.
- User management and access control are available to avoid security risks in the project.

5.4.1 Save the recording as measurement in the project

Requirement

- There is an online connection to the device.
- The data of the recording must have been displayed at least once in the curve diagram. The recording data is loaded from the device for the display.

Procedure

To save a recording as a measurement in the project, proceed as follows:

1. Open the installed trace with the recorded data.
2. If necessary, ensure that the current data is loaded from the device by activating the "Monitoring On/Off" button.
3. Wait until all data has been loaded and is displayed.
4. Click the "Add to measurements" button.

   The measurement is added to the "Measurements" folder.
5. Save the project in the TIA Portal.

NOTE

A measurement can be made from a current recording at any time without affecting the current recording. The recording continues to run uninterrupted. This function is therefore suitable for analyzing any areas of a running recording.

5.4.2 Import measurement

Requirement

- A trace or long-term trace measurement is available in the ".ttrecx" or ".lttcd" format.

Procedure

To import a measurement into the folder "Traces → Measurements" or "Long-term object traces → Measurements", proceed as follows:

1. Right-click on the respective "Measurements" folder into which you want to import the measurement and select the "Import measurement" command in the context menu.

   The "Open" window opens.
2. In the folder structure, navigate to the file you want to import or enter the target path under "Folder".
3. Click the "Open" button.

   The measurement is imported into the folder.

5.4.3 Export measurement

Requirement

- A measurement is available in the "Traces → Measurements" or "Long-term traces→ Measurements" folder.
- The measurement is open in the work area.

Procedure

To export an existing measurement, proceed as follows:

1. Click the "Export measurement with the settings of the current view" button in the toolbar.

   Or:

   Right-click on the measurement to be exported and select the "Export measurement" command in the context menu.

   The "Open" window opens.
2. In the folder structure, navigate to the target folder or enter the target path under "Folder".
3. Select the file extension.
4. Click "Save".

   The measurement is saved in the specified location.

NOTE

When exporting a long-term trace measurement there is an increased storage capacity requirement. Before exporting ensure that you have enough storage capacity.

5.4.4 Add a measurement in the device to measurements in the project

Requirement

- There is an online connection to the device in which the measurement is available.
- The measurement is displayed in the "Measurements on device (memory card)" folder in the project tree.

Procedure

To save a measurement in the device (memory card) together with the project, proceed as follows:

1. Drag-and-drop the measurement from the "Measurements on device (memory card)" folder into the "Measurements" folder.
2. Save the project.

NOTE

Transferring trace measurements from the device to the project increases the memory requirement. Avoid copying a large number of measurements with large amounts of data at the same time because this can cause consume excessive work memory and extend the time needed for copying.

5.4.5 Setting options and displays in the Measurements tab

The following figure shows an example of the Measurements tab:

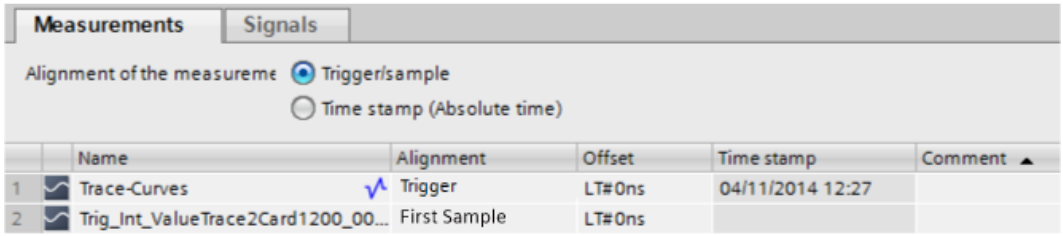

The following table shows the settings and displays for the measurements:

Column	Description
	Static display of the measurement icon
"Name"	Display and change options for the measurement name The name must be a unique one and can be changed.
"Alignment"	Alignment of the measurement (only adjustable with the "Trigger/measurement point" check box activated) Determines the individual zero point for a measurement. All signals for the measurement are displayed in relation to this zero point. The following settings are possible: • Trigger • First sample after the trigger event • First sample • Last measurement point This setting is not available for the Bode diagram.
"Offset"	Offset related to the time axis Moves the measurement left or right by the offset stated on the time axis. The offset can also be transferred via the clipboard to the cell from the ΔX value of the measurement cursor. This setting is not available for the Bode diagram.
"Time stamp"	Display of the trigger time
"Comment"	Display and input option for a comment about the signal

5.5 Evaluating the measurement

NOTE

When evaluating your measurements, take into account that the recording condition may not have been fulfilled between the activation time and the trigger time.

5.5.1 Compare measurements (combined measurement)

Requirements

The following is assumed for the actions described in this section:

- At least two measurements are available in the "Traces → Measurements" or "Long-term traces→ Measurements" folder.
- For "Import measurement":

  A measurement is available in the ".ttrecx" or ".lttcd" format.

5.5.1.1 Apply combined measurement

The following procedures are available to create a new combined measurement:

- Double-click on the "Add new combined measurement" entry in the "Combined measurements" folder.

  A new combined measurement is added. This combined measurement does not contain any measurement data and you must add the measurements for comparison.
- Drag-and-drop a measurement from the "Measurements" folder to the "Combined measurements" folder.

  A new combined measurement is added to the project tree. This combined measurement contains the measurement data of the measurement that you drag-in-drop. More information Adding measurements for comparison.
- In the "Measurements" folder, select all the measurements that you want to add to the combined measurement and drag-and-drop them into the "Combined measurements" folder.

  A new combined measurement is added to the project tree. This combined measurement contains the measurement data from the measurements that you drag-in-drop.

5.5.1.2 Adding measurements for comparison

To add measurements to a combined measurement for comparison, you can use the following procedures:

- In the project tree, drag one or more measurements from the "Traces → Measurements" or "Long-term traces → Measurements" folder to the icon for the combined measurement .
- Double-click on the combined measurement so that it is displayed in the work area. Click the "Import measurement" button in the toolbar and navigate to the measurement that you want to import in the folder structure or enter the target path under "Folder".
- Right-click on the symbol of the combined measurement and select the "Import measurement" command in the context menu. In the folder structure, navigate to the measurement that you want to import or enter the target path under "Folder".

See also

Aligning measurements with measurement cursor (Page 77)

5.5.1.3 Export combined measurement

Requirement

- A combined measurement or a long-term project trace measurement is created and opened in the work area.

Procedure

To export a combined measurement or a long-term project trace measurement from the project, proceed as follows:

1. Click the "Export combined measurement" button in the toolbar.

   Or:

   Right-click the combined measurement to be exported in the project tree and select the "Export combined measurement" command in the context menu.

   The "Save as" window opens.
2. Navigate to the target path in the folder structure or enter the target path under "Folder" and select the file extension.
3. Click "Save".

   The combined measurement is saved in the specified location.

NOTE

When exporting a combined long-term trace measurement there is an increased storage capacity requirement. Before exporting ensure that you have enough storage capacity.

5.5.1.4 Import combined measurement

Requirement

- A combined trace measurement is available in the ".ttrecx" format .

  Or:
- A combined long-term trace measurement or long-term project trace measurement is available in the ".lttcbmx" format.

Core statement

To import a combined measurement into the folder "Traces → Combined measurements" or "Long-term traces→ Combined measurements" or "Long-term project traces → Measurements", proceed as follows:

1. Right-click on the folder in the project tree in which you want to import the measurement and select the "Import combined measurement" or "Import long-term project trace measurement" command in the context menu.

   The "Open" window opens.

2. In the folder structure, navigate to the measurement that you want to import or enter the target path under "Folder".
3. Click the "Open" button.

   The combined measurement is imported into the folder.

5.5.2 Working with the signal table

The signal table lists the signals of the selected measurement and offers setting options for some properties.

In online mode, trace settings can be changed in the device. Use the button to apply the changes to the display options to the project. Otherwise, the changes are discarded during the switch to offline mode.

When adding the installed trace to the measurements, the current settings of the signal table are saved in the measurement.

The signals can be sorted using drag-and-drop. You can re-sort the bits of a signal within a signal.

Requirements

The following is assumed for the actions described in this section:

- An installed trace or a measurement has been opened in the "Time diagram" tab.
- The "Monitoring On/Off" button is activated in the device for a trace.
- For displaying individual bits as a bit trace:

  At least one recorded signal supports the display as a bit track.
- For assigning signals to a signal group:

  At least two signals that are not of type BOOL are in the signal table.

5.5.2.1 Select signals of the measurements for the signal table

To display the activated signals in the signal table of the "Time diagram" tab, proceed as follows:

1. Double-click on the icon for the combined measurement in the project tree.

   The tabs for the combined measurement will be displayed in the working area.
2. Click the "Signal selection" tab in the working area.

   The signals for all measurements are displayed in the table.
3. Activate or deactivate the signal check box for those signals that should be visible or should not be visible in the signal table.

5.5.2.2 Show or hide individual signals in the signal table and change the color

To show or hide individual signals in the signal table and change their color, proceed as follows:

1. Click the icon of the respective signal in the column to select or deselect it for the display.
2. Click in the "Color" column for the respective signal and select a color.

   The default color for the signal changes.

5.5.2.3 Selecting individual bits for display as a bit track

To deselect or select the individual bits for display, proceed as follows:

1. Click the symbol of a signal in the signal table.
2. Click the icon in the open bit selection of the signal.

NOTE

Displaying the individual bits as a bit track in the lower curve diagram is supported for the following data types:

- Byte, Word, DWord, LWord
- SInt, USInt, Int, UInt, DInt, UDInt, LInt, ULInt

5.5.2.4 Bring a signal from the signal table to the foreground

To bring the curve of a signal to the foreground in the curve diagram, proceed as follows:

1. In the signal table, select the line of the signal.

   The Y-scale of the signal is displayed.

5.5.2.5 Use signal group in the signal table

Individual signals can be scaled identically in a signal group, which makes it easier to compare the curve characteristics.

Binary signals cannot be grouped.

The following operating instructions describe how to work with the signal group.

Assigning signals to a signal group

To apply a signal group and assign signals to this group, proceed as follows:

1. In the signal table, select the row or cell of the signal.
2. Click the gray field in the "Signal group" column.

   The chain icon is displayed in the gray field and the name of the signal group is pre-assigned: Group
3. Click the gray fields of further signals that are to be assigned to this signal group.

Or:

1. Click in the text field of the "Signal group" column for a signal to be grouped.
2. Enter a name for the group.
3. Enter the same group name in the respective text fields for further signals or select the group name via the drop-down list.

The Y-scales of the grouped signals are scaled with the values of the signal that was selected first. Changes to a scale value always affect the entire group.

Removing signals from a signal group

To delete the assignment of a signal to a signal group, proceed as follows:

1. Click the sequence icon for the signal in the "Signal group" column.

Or:

1. Click the text field for the signal in the "Signal group" column.
2. Press <Del>.

Or:

1. Select the respective text box in the "Signal group" column for several signals using the <Shift> and <Ctrl> keys.
2. Press <Del>.

The signals are removed from the signal group or the signal group is deleted.

Save signal groups

The signal groups can be saved individually for each measurement using the "Set measurement settings default view" button.

If the signal groups and the project are not saved, then the signal groups created will be lost when the "Time diagram" tab is closed.

5.5.2.6 Setting options and displays in the signal table

The following figure shows an example of how the signal table is displayed:

			Si...	Name	Data type	Display format	Address	Formula		Color	Scaling gro...	Min. Y scale	Max. Y scale	Y(t1)	Y(t2)	Delt...	Unit	Comment
1			$0	"Trace-Data"....	Int	Dec +/-					Temp	0	1800	106	74	-32		
2			$1	"Trace-Data".C...	Real	Floating point					Temp	0	1800	-27....	27....	55....		
3			$2	"Trace-Data".Sir	Real	Floating point						-99.99971	99.99997	96....	96....	-0.0...		

The following table shows the settings and displays of the recorded signals:

Column	Description
Signal or error symbol	
	Signal
	Failsafe signal
	Signal from a data block
	Signal from a failsafe data block
	Calculated signal (formula)
	Error in the formula of the calculated signal
	Selection for display in the curve diagram - a maximum of 16 signals can be selected. The point indicates that at least one bit has been selected for display as bit track for the signal in the bit selection.
"Signal reference"	Automatically generated number of the signal The signal are accessed via the signal reference in the formulas.
"Device"	Display of the device name
"Name"	Display of the signal name A click on the name of a displayed signal updates the scale in the curve diagram. It is possible to enter a name for a calculated signal in the last line without a signal symbol. The calculated signal is created when the name is entered.
"Measurement" (Only combined measurements)	Display of the measurement Shows the name of the measurement to which the signal belongs.

Column	Description
	Open bit selection Individual bits can also be selected for the following data types for display as a bit track in the lower curve diagram: • Byte, Word, DWord, LWord • SInt, USInt, Int, UInt, DInt, UDInt, LInt, ULInt Example of an opened bit selection for the DWORD data type: $0 "Tag_1" Byte Dez %MB10 $1 "Tag_2" DWord Dez %MD20 $1.x0 Bool Bin %M23.0 $1.x1 Bool Bin %M23.1 $1.x2 Bool Bin %M23.2 Click the button to select or deselect the respective bit for display.
Bode	Automatically generated Bode signals Bode signals are automatically generated for amplitude and phase after entering a Bode formula for a signal. Click on the arrow to display the Bode signals.
"Data type"	Display of the data type
"Display format"	Display format of the signal The display formats supported for the signal are offered for selection. A display format suitable for the data type is set with "Default".
"Address"	Display of the address of the signal The field remains empty with optimized / type correct tags.
"Formula"	Display or entry of a formula A formula can contain mathematical functions with numbers and signals. Use the formula editor to conveniently create formulas.
	Call of the formula editor for calculated signals Click the button to open the formula editor. You can find more information on using the formula editor in the section Calculating signals (Page 81).
"Color"	Display and setting option for the color of the signal
"Signal group"	Display or input of the scaling group name for one scaling group The Y-scales are scaled identically for all signals of one scaling group. Enter an identical scaling group name for those signals that are to be scaled identically. Remove signals from the signal group by deleting the signal group name The signal groups are saved using the "Set measurement settings default view" button. **Notes** You cannot group binary signal events. In hex display format, group only the signals with a format compatible to the sign for the display. This setting is not available for the Bode diagram.
Gray field for chain icon	Move the cursor over the gray field or the chain icon (or) to add the signal to a scaling group or delete the signal from the scaling group. Clicking the chain icon adds the signal to a scaling group or creates a new scaling group. Clicking the chain icon removes the signal from the scaling group. For a selected signal with scaling group, the chain icon displays all signals of the same scaling group.
Input field	The input field displays the scaling group name. As an alternative to the chain icon, you can assign or delete a group name via text input in this field.
"Min. Y-scale"	Display or input of the minimum value for the scaling of the signal

Column	Description
"Max. Y-scale"	Display or input of the maximum value for the scaling of the signal
"Y(t1)"	Display of the value at the position of the first measurement cursor
"Y(t2)"	Display of the value at the position of the second measurement cursor
"ΔY"	Display of the value difference between the first and the second measurement cursor
	Selection of the automatic scaling of the value axis for the signal When the check box is selected, the minimum and maximum values for scaling the signal are adjusted so that all values are displayed for the currently displayed time range. The "Automatic scaling of the value axis" button in the toolbar of the curve diagram activates automatic scaling for all scalable signals.
"Unit"	Display of the unit For example, for unit-based values from technology objects
"Comment"	Display and input option for a comment about the signal

NOTE

Filter signal table

To filter the signal table for signals that match the diagram type, the signal filter is available via the button in the toolbar.

If you are in the Bode diagram tab, for example, only calculated Bode signals are displayed in the signal table when the signal filter is set.

The signal filter does not hide a signal when an invalid value is listed in the "Formula" column of the signal table.

The following context menu commands are also available in the signal table:

Shortcut menu command	Description
"Insert calculated signal"	Inserts a re-calculated signal at the top in the table
"Edit formula"	Opens the formula editor for the calculated signal
"Cut"	Cannot be selected
"Copy"	Copies the contents of the selected lines to the clipboard.
"Paste"	Cannot be selected
"Delete"	Cannot be selected
"Rename"	Cannot be selected
"Display format"	Allows you to switch the display format The display formats supported for the signal are offered for selection.
"Display signal(s)"	Displays the selected signals in the curve diagram.
"Hide signal(s)"	Hides the selected signals in the curve diagram.

5.5.3 Use measurement cursor

Requirements

The following is assumed for the actions described in this section:

- An installed trace or a measurement has been opened in the "Time diagram" tab.
- The "Monitoring On/Off" button is activated in the device for a trace.
- For the alignment of the measurements for comparison:
  - An combined measurement is applied.
  - Measurements for comparison are added to the combined measurement.
  - Signals of the measurements for the signal table are selected.

5.5.3.1 Check that a certain value has been reached

To check whether a value has been reached in the curve diagram, proceed as follows:

1. Show the horizontal measurement cursors in one of the following ways:
   - Click the "Show horizontal measurement cursor" button in the toolbar.
   - Right-click on the curve diagram and activate the "Show or hide horizontal measurement cursors" check box in the context menu.
2. Use the mouse to move a measurement cursor to a value of the recording or position the measurement cursor in the "Measurement cursor" palette by entering the position.

The values of the measurement cursors for the selected signal are displayed in the "Measurement cursor" palette of the "Trace" task card.

5.5.3.2 Evaluation of the difference between two samples

To evaluate the difference between two samples, proceed as follows:

1. Click the "Show vertical measurement cursor" button in the toolbar.
2. Use the mouse to move the two measurement cursors to the desired measuring points in the recording, or position the measurement cursor in the "Measurement cursor" palette by entering the position.

The values of the signals and the difference are displayed in the signal table and in the "Measurement cursor" palette of the "Trace" task card.

NOTE

Restricted display of intersection points with a vertical measurement cursor

As soon as there is a vertical measurement cursor outside the area shown in the time diagram without recorded data, a "NaN" is shown for this measurement cursor in the "Trace > Measurement cursor" task card for the intersection with the selected signal "Y(tn)".

If a "NaN" is shown for at least one measurement cursor with "Y(tn)", "NaN" is also shown with Δ Y.

5.5.3.3 Aligning measurements with measurement cursor

To align the time axis of two measurements to the measured position difference Δt, proceed as follows:

1. Click the "Show vertical measurement cursor" button in the toolbar.
2. Enlarge the time range until you can position the first measurement cursor exactly on the reference point of the first measurement.
3. Move the first measurement cursor with the mouse to the right position.
4. Search for the reference point of the second measurement.
5. Extend the time range until you can position the second measurement cursor exactly on the reference point of the second measurement.
6. Move the second measurement cursor with the mouse to the correct position.
7. Open the "Trace" task card.
8. In the "Measurement cursor" pane, select the position difference value Δt.
9. Copy the value to the clipboard.
10. Insert the value from the clipboard into the Offset cell of the first or second measurement.

NOTE

When inserting the position difference as the offset make sure that you also adjust the leading character as necessary.

5.5.3.4 Setting options and displays of the "Measurement cursor" palette

The "Measurement cursor" pane shows the position of the measurement cursor in the curve diagram and the values at the intersection points.

The following figure shows an example of the "Measurement cursor" palette:

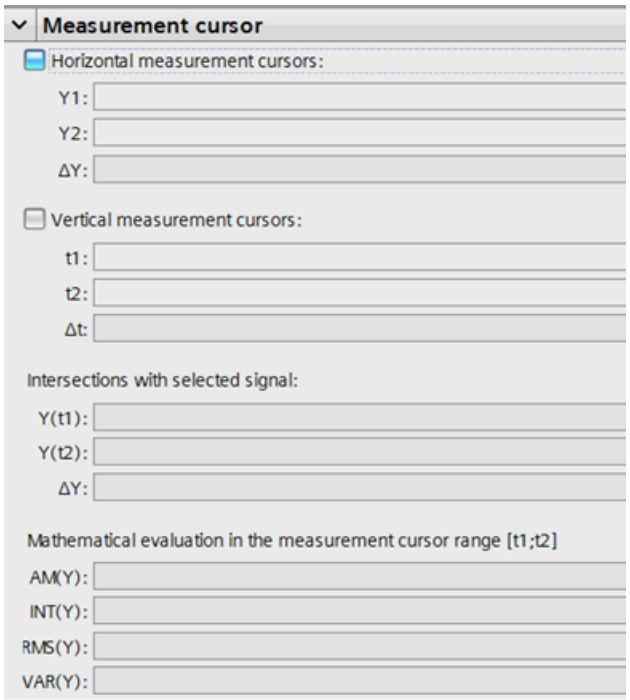

The following table describes the settings and displays:

Setting/display		Description
Horizontal measurement cursor		
	Y1	Position of first measurement cursor The value indicates the position in relation to the scale of the currently selected signal. You also have the option of specifying a new position for the measurement cursor in this entry field for moving with the mouse.
	Y2	Position of the second measurement cursor The value indicates the position in relation to the scale of the currently selected signal. You also have the option of specifying a new position for the measurement cursor in this entry field for moving with the mouse.
	ΔY	Display of the position difference between the first and the second measurement cursor
Vertical measurement cursor		
	t1	Position of first measurement cursor You also have the option of specifying a new position for the measurement cursor in this entry field for moving with the mouse.
	t2	Position of the second measurement cursor You also have the option of specifying a new position for the measurement cursor in this entry field for moving with the mouse.

Setting/display		Description
	Δt	Display of the position difference between the first and the second measurement cursor
Intersection points with selected signal		
	Y(t1)	Display of the value at the position of the first measurement cursor
	Y(t2)	Display of the value at the position of the second measurement cursor
	ΔY	Display of the value difference between the first and the second measurement cursor
Mathematical analysis in the range of the measurement cursor·[t1;t2] for the selected signal (not for Bode diagram)		
	AM(Y)	Mean The arithmetic mean is calculated for the range between the vertical measurement cursors.
	INT(Y)	Integral The integral is calculated for the range between the vertical measurement cursors.
	RMS(Y)	RMS value The root-mean square (RMS value) is calculated for the range between the vertical measurement cursors.
	VAR(Y)	Variance value The variance value is calculated for the range between the vertical measurement cursors.

5.5.3.5 Keyboard and context menu commands

Keyboard commands

The following table shows which keyboard commands are possible for using measurement cursors when the focus is on the curve diagram:

Keyboard shortcut	Description
Select a measurement cursor	
<Ctrl+Shift+1>	The vertical measurement cursor t1 is selected or deselected.
<Ctrl+Shift+2>	The vertical measurement cursor t2 is selected or deselected.
<Ctrl+Shift+3>	The horizontal measurement cursor Y1 is selected or deselected.
<Ctrl+Shift+4>	The horizontal measurement cursor Y2 is selected or deselected.
<Tab>	The next measurement cursor is selected.
Position a vertical measurement cursor	
<Left>, <Right>	In the "Samples" unit, the selected measurement cursor is moved one sample away from the signal in the foreground. With the "Time (relative)" unit, the measurement cursor is moved by one pixel.
<Shift+Left>, <Shift+Right>	The selected measurement cursor is shifted by 10 measuring points from the signal in the foreground for the "Samples" unit. With the "Time (relative)" unit, the measurement cursor is moved by 10 pixels.

Keyboard shortcut	Description
Position a horizontal measurement cursor	
<Up>, <Down>	The selected measurement cursor is shifted by one pixel along the value axis.
<Shift+Up>, <Shift+Down>	The selected measurement cursor is moved by 10 pixels along the value axis.
Vertical measurement cursors display	
<Ctrl+Space>	The vertical measurement cursors are shown or hidden.
<Ctrl+Shift+Space>	The vertical measurement cursors are shown and centered for the current view.
Change the view	
<Space>	Move view
<Ctrl+0>	Set 100% view in open editor
<Ctrl++>	Apply zoom in with 10%
<Ctrl+->	Apply zoom out with 10%

Shortcut menu commands

The following table shows which context menu commands are possible for using measurement cursors when the focus is on the curve diagram:

Shortcut menu command	Description	
"Measurement cursor"	You can find the following options in this submenu:	
	"Shows or hides vertical measurement cursors"	Display of vertical measurement cursor. The vertical position of the two measurement cursors can be moved with the mouse. The associated measured values and the difference of the measurement cursors corresponding to the position are shown in the signal table. Display the "Measurement cursor" palette in the Trace task card in order to display more information. Also use the cursor keys. The following actions are possible for vertical measurement cursors with the cursor keys: • Select • Positioning • Show or hide measurement cursor • Center measurement cursors

Shortcut menu command	Description	
"Measurement cursor"	"Shows or hides horizontal measurement cursors"	Display of the horizontal measurement cursors. The horizontal position of the two measurement cursors can be moved with the mouse. Display the "Measurement cursor" palette in the Trace task card in order to display the values or to reposition the measurement cursor through entering the position. Also use the cursor keys. The following actions are possible for horizontal measurement cursors with the cursor keys: • Select • Positioning
	"Center measurement cursors"	Positions the activated measurement cursors at a central point in the current display.

5.5.4 Calculate signals with formula editor

The formula editor is available for calculating and analyzing recorded signals using various mathematical functions. You can use the formula editor in the same way as for a recording for a measurement. The data type of the formula is preset with a floating-point number of the LREAL type and cannot be changed.

The following figure shows an example of the formula editor:

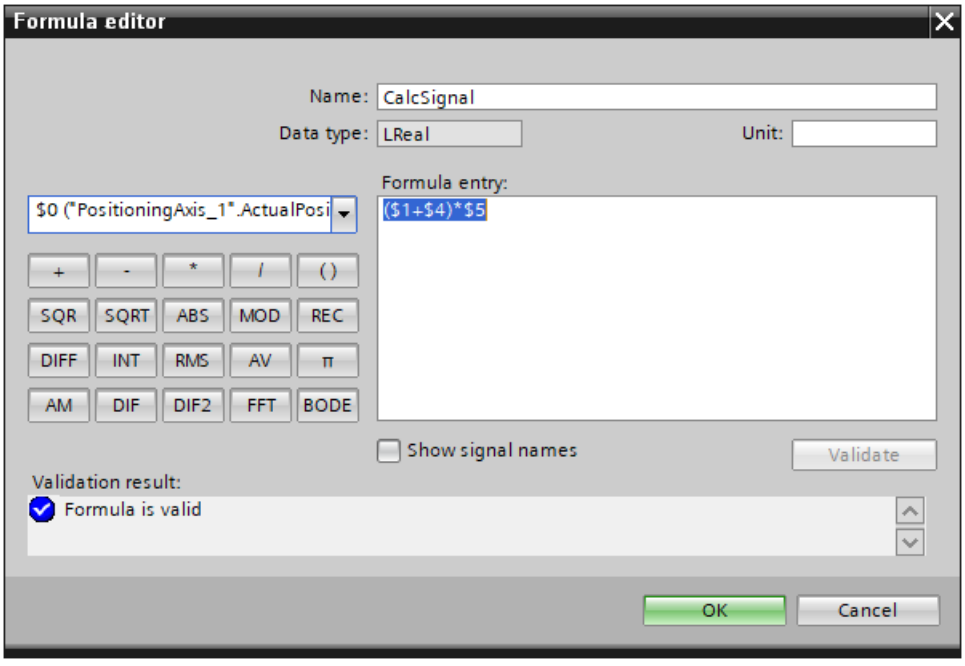

Requirement

The following is assumed for the actions described in this section:

- Signals for the calculation are displayed in a measurement or a recording in the curve diagram.
- The signal table is displayed.

5.5.4.1 Create and edit formulas

To create and edit the formulas, proceed as follows:

1. Click in the last line in the signal table and enter a name of the calculated signal.

   Or:

   Right-click on the line of the signal you want to use for the calculation and select the "Insert new calculated signal" command in the context menu.
   A new line for the calculated signal is added. The default setting for the name is "CalcSignal". You can change the name of the calculated signal at any time by clicking in the "Name" line. The name must be unique and only contain characters that are allowed in Windows file names.
2. Click the icon in the line of the calculated signal in the signal table to open the "Formula editor" dialog box. When editing an existing formula, the formula editor is also available via the "Edit formula" context menu command by right-clicking on the "Formula" line.
3. Optional: Enter a name for the calculated signal in the "Name" field of the dialog window.
4. Optional: Enter a unit for the calculated value in the "Unit" field of the dialog window. You can enter this freely.
5. Optional: Activate or deactivate the "Show signal names" check box to switch the formula display between signal references and signal names.
6. In the "Formula editor" dialog box, select signals using the drop-down list and mathematical functions using the buttons for the calculation. These are added to the "Formula input" field.

   NOTE
   Restrictions:
   - Bits from a bit selection (e.g. below the INT data type) are not allowed in the formula.
   - In a formula, do not use signal references to a variable that begins with "$", e.g. $0("$0").
7. Click the "Validate" button to check the validity of the formula. The result is displayed in the "Validation result" field.

   If the formula is invalid, the symbol is displayed next to the calculated signal in the signal table.
8. Click "OK".

   The signal is displayed in the curve diagram

NOTE

Entering the formulas manually

You can edit the formulas in the "Formula input" field of the formula editor. You can reference signals in the formula text box by using either the signal reference preceded by a $ sign or the name in double quotation marks. Mixed input is possible.

You can also create or edit the formulas manually via the signal table by inserting the formula in the "Formula" line for the calculated signal. The formula is applied directly during this process. The signal is displayed in the curve diagram

See also

Mathematical functions of the formula editor (Page 83)
Setting options and displays in the signal table (Page 73)

5.5.4.2 Mathematical functions of the formula editor

The following table shows the mathematical functions of the formula editor:

Field/Button	Description
+	Addition
-	Subtraction
*	Multiplication
/	Division
()	Brackets Grouping expressions
SQR	Square
SQRT	Square root
ABS	Absolute value Calculates the size of a number. **Examples** `ABS(5)` → 5 `ABS(-3)` → 3 `ABS(-3.14)` → 3.14
MOD	Modulo Calculates the residual value of a division **Examples** `MOD(5,3)` → 2 `MOD(3.14,3)` → 0.14
REC	Reciprocal value (1/x)
DIFF [1)]	Numerical differentiation **Examples** Formula: `DIFF($0,SAMPLETIME)`
INT [1)]	Numerical integration **Examples** Formula: `INT($0,SAMPLETIME)`

[1)] The constant `SAMPLETIME` is only available for equidistant recording cycles. Time unit for `SAMPLETIME` is always µs.

Field/Button	Description
RMS [1]	Quadratic mean The squares of all measured values are totaled and then divided by the number of measured values. The quadratic mean is the square root of this value. **Examples** Formula: `RMS($0,SAMPLETIME)`
AV	Mean value filter from 1st to 5th order If the specification of an order is missing, the mean filter of the 1st order is used. **Examples** `AV($0,1)` → Average value filter 1st order `AV($0,5)` → Average value filter 5th order
π	Mathematical constant Pi
AM	Arithmetic mean The arithmetic mean is a moving average over five samples.
DIF	Simple subtraction with mean filter from 1st to 5th order If the specification of an order is missing, simple subtraction is performed with a 1st order filter. **Examples** `DIF($0,1)` → Single subtraction with 1st order filter `DIF($0,5)` → Single subtraction with 5th order filter `DIF($0)` → Single subtraction with 1st order filter **Example: Calculate an acceleration curve from a velocity signal** `$0`: Velocity signal in meters per second Cycle time of the constant cycle velocity recording: 1 ms Formula: `DIF($0,1)/0.001` Unit: m/s^2
DIF2	Double subtraction with mean filter from 1st to 5th order If the specification of an order is missing, then double subtraction is executed with a 1st order filter. **Examples** `DIF2($0,1)` → Double subtraction with 1st order filter `DIF2($0,5)` → Double subtraction with 5th order filter `DIF2($0)` → Double subtraction with 1st order filter **Example: Calculate an acceleration curve from a position sequence** `$0`: Position sequence in meters Cycle time of the constant cycle position recording: 1 ms Formula: `DIF2($0,1)/SQR(0.001)` Unit: m/s^2
FFT	The Fast Fourier Transform (FFT) is used to break down complex signals into their individual components and analyze them. You can find more information on using this function in the section Creating an FFT diagram (Page 85).
BODE	The Bode function is used to analyze and describe the frequency behavior of a system. You can find more information on using this function in the section Creating a Bode diagram (Page 87).

[1] The constant `SAMPLETIME` is only available for equidistant recording cycles. Time unit for `SAMPLETIME` is always µs.

NOTE

The functions DIF, DIF2, DIFF, AM, RMS, AV and INT can only process one recorded signal as argument. Not all invalid formulas are marked as errors.

5.5.4.3 Create an FFT diagram

To apply an FFT formula, proceed as follows:

1. Click the icon in the line of the calculated signal in the signal table.

   When editing an existing formula, you can right-click on the "Formula" line and select the "Edit formula" command from the context menu.

   The "Formula editor" dialog box opens.

2. Click the "FFT" button in the formula editor.

   The FFT formula is displayed in the "Formula input" field.

3. Enter an analog signal as an input parameter for the formula. You can select the signal from the drop-down list or insert it manually as a signal reference or signal name in the formula in the "Formula input" field.

   The input parameter must be an analog signal. Calculated signals and further calculations with the FFT function are not permitted.

   Permitted data types are: SINT, INT, DINT, LINT, USINT, UINT, UDINT, ULINT, REAL, LREAL, BYTE, WORD, DWORD, LWORD.

4. Optional: Enter the following parameters:
   - "RemoveDirectCurrent", to remove the direct current component.

     The data type for this parameter is Bool. If the parameter is not set, it is assumed by default that the DC component is to be removed.
   - "RangeStart", to specify the index of the first sample to be displayed on the X axis in the FFT diagram.

     If the parameter is not set, the first sample of the measurement is used by default.
   - "RangeEnd" (RangeStart required) to specify the index of the last sample to be displayed on the X axis in the FFT diagram.

     If the parameter is not set, the last sample of the measurement is used by default.

Valid examples:

$0=Input signal

FFT($0,true)

FFT($0,false,0,1000)

Invalid examples:

$0=Input signal

FFT($0,20)

FFT($0)+SQRT($5)

The following figure shows an example of the FFT diagram:

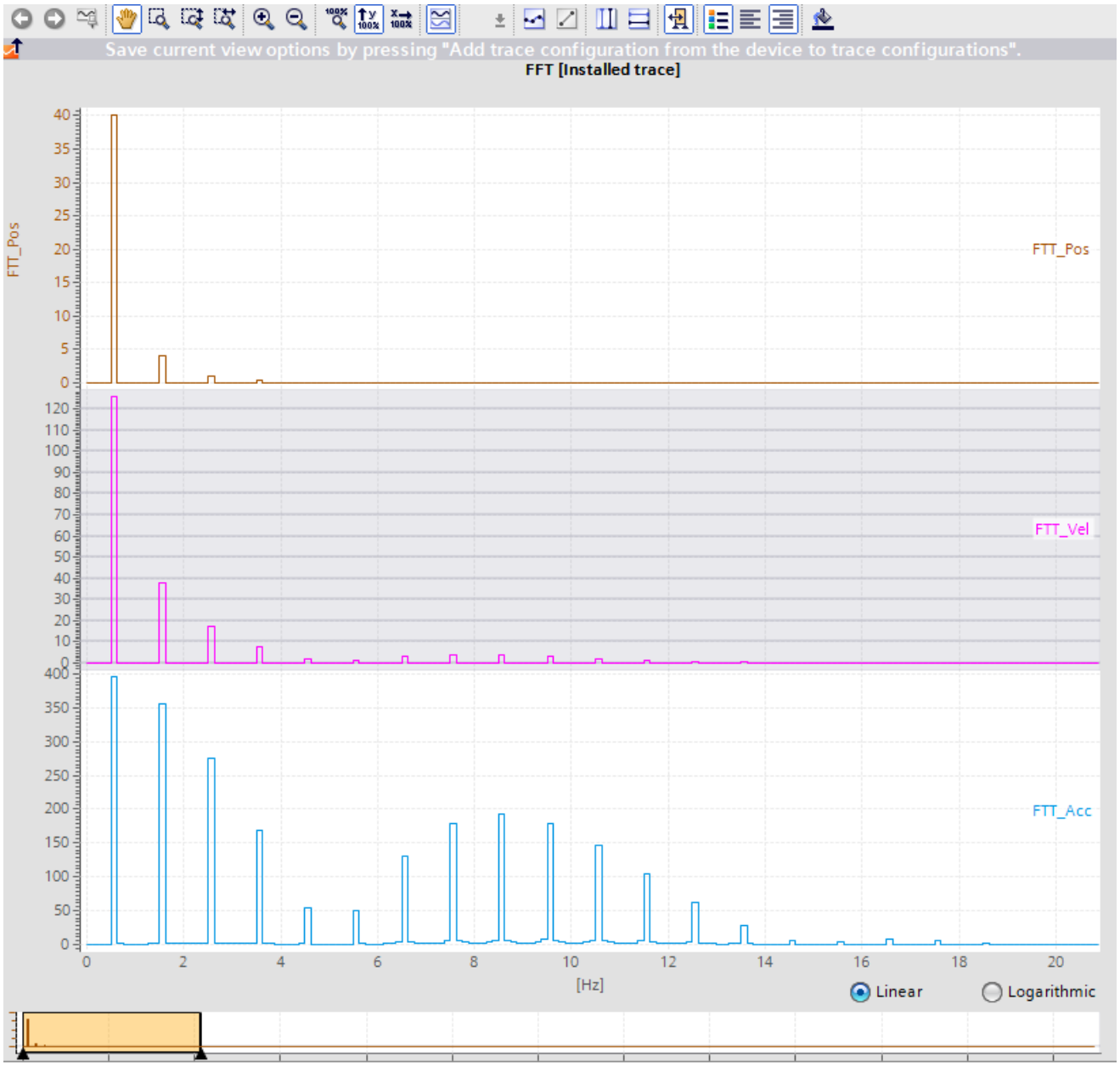

5.5.4.4 Create a Bode diagram

To apply a Bode formula, proceed as follows:

1. Click the icon in the line of the calculated signal in the signal table.

   When editing an existing formula, you can right-click on the "Formula" line and select the "Edit formula" command from the context menu.

   The "Formula editor" dialog box opens.

2. Click the "BODE" button in the formula editor.

   The Bode formula is displayed in the "Formula input" field.

3. Enter an analog signal as the input and output signal for the formula. You can select the signal from the drop-down list or enter it manually as a signal reference or signal name in the formula in the "Formula input" field.

   Analog signals must be entered for input and output signal parameters. Calculated signals and further calculations with the Bode function are not permitted.

   Permitted data types are: SINT, INT, DINT, LINT, USINT, UINT, UDINT, ULINT, REAL, LREAL, BYTE, WORD, DWORD, LWORD

4. Optional: Enter the following parameters:
   - "RangeStart", to specify the index of the first sample to be displayed on the X axis in the Bode diagram.

     If the parameter is not set, the first sample of the measurement is used by default.
   - "RangeEnd" (RangeStart required) to specify the index of the last sample to be displayed on the X axis in the Bode diagram.

     If the parameter is not set, the last sample of the measurement is used by default.

Valid examples:

$0=Input signal, $1=Output signal

BODE($0,$1)

BODE($0,$1,0,1000)

Invalid examples:

$0=Input signal, $1=Output signal

BODE($0,20)

BODE($0,$1)+SQRT($5)

The following figure shows an example of the display of the Bode diagram:

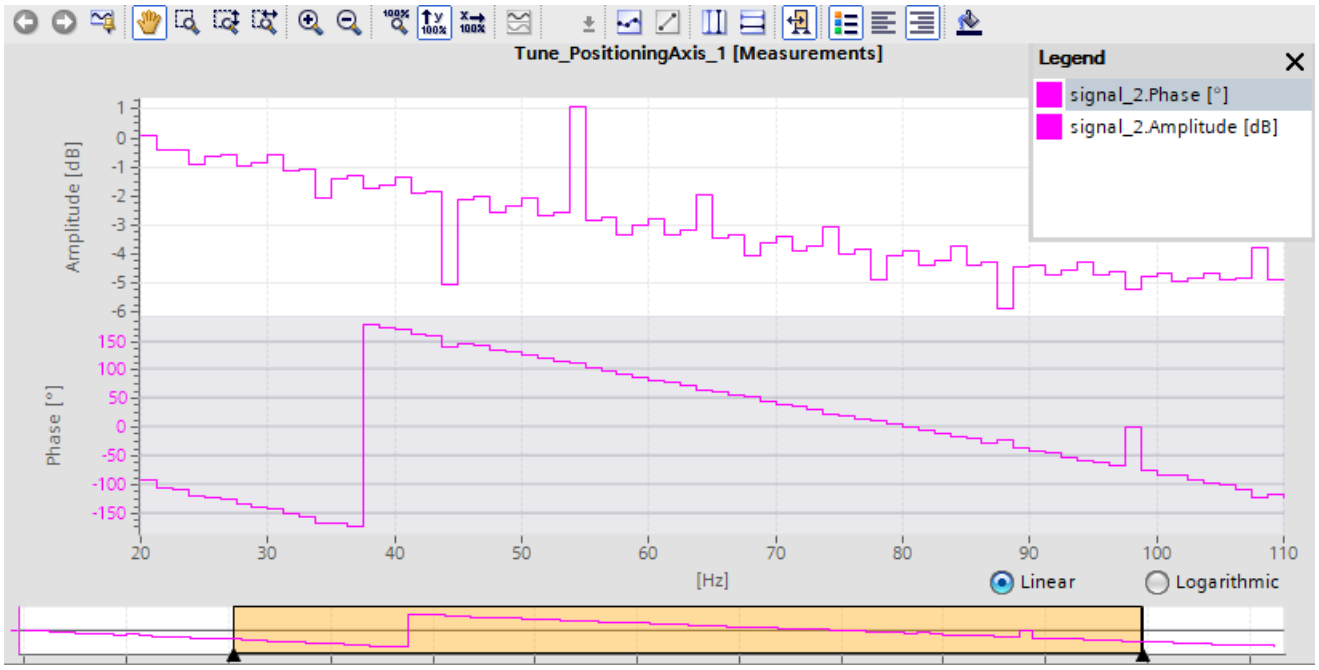

5.6 Snapshots

The "Snapshots" palette of the "Trace" task card allows you to save and restore different views of a measurement.

A snapshot can be created of a current view in the "Time diagram" or "Bode diagram" tab. The snapshots are saved in the measurement with the project.

The following figure shows an example of the "Snapshots" palette:

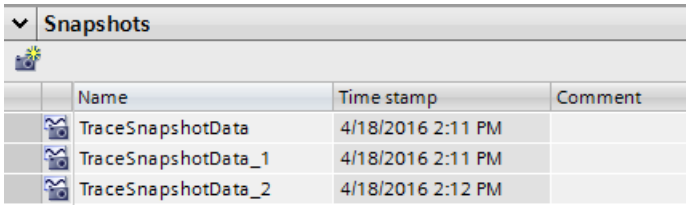

The following table explains the displays:

Column	Description
	Static display of the snapshot symbol
"Name"	Display and change options for the name
"Time stamp"	Display of the snapshot generation time
"Comment"	Display and input option for a comment

Create a snapshot

Requirements:

- A measurement is displayed in the curve diagram.

To save the current view in the "Time diagram" or "Bode diagram" tab as a snapshot in the measurement, proceed as follows:

1. Open the "Snapshots" palette in the "Trace" task card.
2. Click the "Create snapshot of current view" button.

The snapshot is displayed in the "Snapshots" palette.

Rename snapshot

Requirements:

- A snapshot is available in the "Snapshots" palette.

The following procedures are available to change the name of the snapshot:

- Right-click on your snapshot in the "Snapshots" palette and select the "Rename" command in the context menu.
- Click in the "Name" column of the snapshot in the "Snapshots" palette.

Restore snapshot

Requirements:

- A snapshot is available in the "Snapshots" palette.

To display your saved view in the "Time diagram" or "Bode diagram" tab, you can use the following procedures:

- Double-click on the snapshot in the "Snapshots" palette.
- Right-click on your snapshot in the "Snapshots" palette and select the "Restore snapshot" command in the context menu.

Deleting a snapshot

Requirements:

- A snapshot is available in the "Snapshots" palette.

The following procedures are available to delete the snapshots from the measurement:

- Click the button in the "Snapshots" palette. Select the snapshot you want to delete and press the <Del> key.
- Right-click on your snapshot in the "Snapshots" palette and select the "Delete" command in the context menu.

NOTE

Several rows can be selected and deleted.

5.7 Status overview of the participating devices

The "Status overview" dialog box displays status information on the participating devices.

For participating devices with status without error, you can apply trace configurations to the devices.

Display in the status overview table

The following table shows the displays of the status overview:

Column	Description
-	Display of whether there is an error for the long-term project trace in the participating device or whether the trace configuration is faulty. A tooltip above the symbol displays information about the cause of the error.
	Meaning in offline mode • Trace configuration is faulty **Meaning in online mode** • Trace configuration is faulty • Recording was interrupted • Connection error
Device	Display of the device name
Device status	Status display of the online connection
	Offline
	Connect or disconnect
	Online
Trace status	Status display of the devices If there is an existing online connection, a symbol indicates the status of the trace configuration for the corresponding device. In addition, the trace status for the device is displayed, for example, "Monitoring". **Note** If only one device in the long-term project trace shows the "Monitoring" trace status, the long-term project trace is not working correctly; there is no time synchronization between the devices.
	Online and offline configuration are identical
	Online and offline configuration are different
	Configuration only exists offline

5.8 Remedy for errors

The following list shows possible sources of error and the remedy.

Firmware

With the devices (Page 92) it is described if and as of which firmware a device supports the respective trace function.

Configuration

Check the configuration of the respective trace function (Page 36). For cross-device functions, check the settings for all participating devices.

Canceled recording

You can restart an interrupted recording by transferring the configuration (Page 50) again.

Requirements

Ensure that the general requirements for the employed trace function are fulfilled.

Devices 6

6.1 S7-1200/1500 CPUs

6.1.1 Recordable variables

Device-dependent recording of tags

The following list shows the operand areas from which tags can be recorded:

- Process image input
- Process image output
- Bit memory
- Data blocks
- I/O devices

The recording of tags that are in the InOut area of a function block is not supported.

Data types

A selection of elementary and composite data types can be recorded. The availability of the individual data types depends on the device used.

For more information, see the help under "Overview of valid data types".

The following table lists the supported data types:

Data types	Note
Binary numbers	
BOOL	-
Bit strings	
BYTE	-
WORD	-
DWORD	-
LWORD [1)]	Symbolic name required
Integers	
SINT	-
USINT	-
INT	-
UINT	-

1) Not supported by S7-1200.

Data types	Note
DINT	-
UDINT	-
LINT [1]	Symbolic name required
ULINT [1]	Symbolic name required
Floating-point numbers	
REAL	-
LREAL	Symbolic name required
Timers	
TIME	-
LTIME [1]	-
Date and time	
DATE	-
TOD	-
LTOD [1]	-
LDT [1]	-
Named value data types	
	You can find more information on using named value data types in the help under "Named value data types".

1) Not supported by S7-1200.

6.1.2 Lifetime of the configuration and recorded values in the device

Configurations in the device are retained when the power is switched off. The recording is activated again after the restart of the CPU.

Recorded values are lost during the restart.

NOTE

Downloading a configuration to the device in the "STOP" operating state

Note that after downloading a configuration in the "STOP" operating state, you must check the installed traces and, if required, reactivate them or transfer them again.

NOTE

If changes are made to trigger tags that affect the address, the configuration must also be transferred to the device again.

This is the case for example, when a data block is shortened or extended or the data type is changed.

6.1.3 Recording levels

All runtime levels can be used for the recording cycle. The cyclic execution levels are offered for selection via the button . In non-periodic recording levels, the recording time is undefined.

NOTE

The measured values are recorded at the end of the OB after the processing of the user program.

NOTE

Trace sample event with Motion Control

The time reference for the measured values is determined differently if a Motion Control organization block is configured as trace sample event and the device is time synchronized via IRT. This behavior is described in Time synchronization with Motion Control (Page 94).

See also

Time synchronization of SIMATIC S7 CPUs
(https://support.industry.siemens.com/cs/ww/en/view/82203451)

6.1.4 Time synchronization with Motion Control

With Motion Control, a time reference to the cycle limits of the application cycle is required for the analysis. For this reason, the time reference for the measured values in the configuration of Motion Control organization blocks is determined differently than trace sample event. The synchronized (absolute) time from the start of the current application cycle is always stored as the time for the measured value. The tags of the technology objects are always consistently related to cycle limits.

The described behavior applies to the following Motion Control organization blocks:

- MC-Servo [OB91]
- MC-PreServo [OB67]
- MC-PostServo [OB95]
- MC-Interpolator [OB92]
- MC PreInterpolator [OB68]

The devices must communicate via IRT.

The following figure shows the stored times of the measured values with an application cycle of 3 and MC interpolator as configured trace sample event:

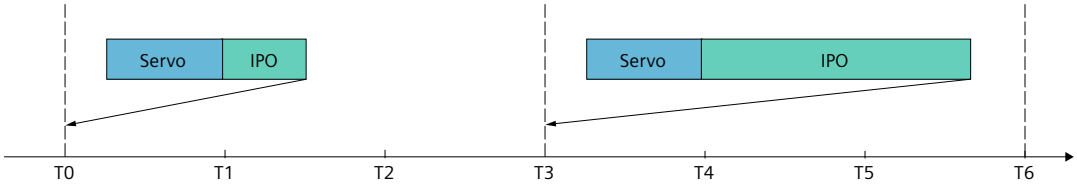

T0 to T6	IRT cycle
T0	Start of application cycle n
T3	Start of application cycle n+1
T6	Start of application cycle n+2

NOTE

OB61-OB63 as trace sample event

With these OBs as configured trace sample event, the system time is used independently of the communication. The recording behavior is the same as for devices without IRT communication.

To facilitate the evaluation with absolute time, synchronize the clock times of the devices.

NOTE

Measured values with identical timers

An overflow of the recording level (such as MC-Interpolator OB in the example above) can result in measured values with identical time stamp.

6.1.5 Quantity structure

The following table shows the maximum quantity structure that you can record using the trace and logic analyzer function:

Device	Maximum number of installed traces	Maximum number of signals per trace configuration
S7-1200 (as of firmware version V4.0)	2[1]	16
S7-1500, ET 200SP, CPU 1513pro-2 PN, CPU 1516pro-2 PN, S7-1500 Software Controller, S7-1500 Drive Controller, ET 200SP Open Controller	Minimum 4[2] (depending on the CPU type)	16
S7-1500, ET 200SP, CPU 1513pro-2 PN, CPU 1516pro-2 PN, S7-1500 Software Controller, S7-1500 Drive Controller, ET 200SP Open Controller (as of firmware version V3.0)	Minimum 4[2] (depending on the CPU type)	64

1) The S7-1200 does not support long-term trace

2) In STEP 7 as of V18, the S7-1500 supports maximum two long-term traces which are recorded at the same time.

NOTE

Maximum number of signals per trace configuration exceeded

Signals that exceed the maximum number of signals are marked in the configuration.

You cannot load a trace configuration with more than the maximum number of signals into the device.

The maximum number of signals is exceeded during the following actions:

- Copy: A trace configuration with more than 16 signals is copied into a device that only supports 16 signals per trace configuration.
- Device replacement: A device in which a trace configuration with more than 16 signals is created is replaced with a device that supports a maximum of 16 signals per trace configuration.

To load the trace configuration into the device, delete the excess, selected signals.

The same quantity structures apply for the project trace as for the devices.

Example CPU 1516-3 PN/DP

- Maximum of 7281 samples for 16 signals from PLC tags of the DWORD data type
- Maximum of 21844 samples for 16 signals from PLC tags of the BOOL data type
- Maximum of 58250 samples for 1 signal from a PLC tag of the BOOL data type

You can also find more information in the form of FAQs under the ID 102781176 (http://support.automation.siemens.com/WW/view/en/102781176).

6.1.6 Long-term trace recording

NOTE

As of TIA Portal V20, the recording is saved as binary code in ".dat" format. To be able to use the recording data for external evaluation, export the measurement (Page 65) as a CSV file.

Requirement

To record a long-term trace, you need at least 4 GB of free space on your hard disk.

Starting the recording

The DAT file is saved in the target path with the following name:

<Name of CPU>_<Name of long-term trace>_<Time stamp>_<Consecutive number>.dat

Structure of the time stamp:

<YYYYMMDD>_<HHMMSS>_<ms(3 places)>

Example

PLC_1_Long-term Trace_20220721_120422_356_0001.dat

Behavior during operation

As soon as the recording of the long-term trace in a DAT file has reached a file size of 2 GB, a new DAT file is created. The new file has the same time stamp as the file that has overflowed and the running serial number is incremented by 1. The recording is continued without any break.

You can use the "Monitoring on/off" button to interrupt the recording. If you click the "Monitoring on/off" button again, a new DAT file is created. The new DAT file has the same time stamp as the DAT file of the interrupted recording and the running serial number is incremented by 1. The recording is continued.

Example

Overflowed/Canceled recording

PLC_1_Long-term Trace_20220721_120422_356_0001.dat

Continued recording:

PLC_1_Long-term Trace_20220721_120422_356_0002.dat

CAUTION

Inconsistent data when opening the DAT file during the recording

Opening the DAT file during recording can lead to inconsistent data and therefore render it unusable.

Do not open the DAT file during the recording.

Cancellation of the recording

CAUTION

Do not close the editor window during a long-term trace recording!

If you close the editor window during a running long-term trace recording, the recording is interrupted. As a result no data will be saved in the DAT file.

To resume the interrupted recording, open the respective configuration in the editor window again. The recording is continued. The missing data appears as a gap in the time diagram.

After a recording has been canceled, a new DAT file is created with the current time stamp when a new recording is started.

Example

Interrupted recording:

PLC_1_Long-term Trace_20220721_120422_356_0001.dat

New recording

PLC_1_Long-term Trace_20220721_121212_999_0001.dat

Output formats of the data types in the CSV file

NOTE

Displaying the values in Excel

If you open the CSV file directly with a double-click, Excel can show the values wrongly formatted.

To display the values correctly, always import the data from the CSV file to Microsoft Excel.

Invalid values (e.g.Time Of Day values less than 0 or greater than 24) are displayed as hexadecimal numbers.

The table below provides an overview of the data formats in which the data types in the CSV file are output:

Data type	Output format		Example	
Bool	True = 1 False = 0		1	
Int	Full decimal number		-12	
Int			-123	
DInt			-1234	
LInt			-123456	
USInt			12	
UInt			123	
UDInt			1234	
ULInt			123456	
Real	Scientific notation	Hexadecimal for Infinite/Denormal/NaN	3.713193E+29	16#7F80_0000
LReal				
Byte	Full decimal number		12	

Data type	Output format	Example
Word	Full decimal number	123
DWord		1234
Lword		12345
Date	YYYY-MM-DD	1970-01-01
Time	Seconds without measurement unit	62.78
LTime		0.00307
Time Of Day	HH:MM:SS.ms (ms up to 3 places)	00:00:54.078
Long Time Of Day	HH:MM:SS.ms (ms up to 9 places)	00:00:00.000033566
Long Date Time	YYYY-MM-DD-HH:MM:SS.ms (ms up to 9 places)	1970-01-01-00:00:00.000033566

Unsupported data types

The following data types are not supported by the CSV file:

- Date_And_Time
- Date_And_LTime
- Char
- WChar
- String
- S5Count
- S5Time

6.1.7 Long-term project trace recording

NOTE

As of TIA Portal V20, the recording is saved as binary code in ".dat" format. To be able to use the recording data for external evaluation, export the measurement as a CSV file.

Requirement

To record a long-term project trace you need at least 4 GB free space on your hard disk.

Starting the recording

The DAT file is saved in the target path with the following name:

<Name of CPU>_<Name of long-term project trace>_<Time stamp>_<Consecutive number>.dat

Structure of the time stamp:

<YYYYMMDD>_<HHMMSS>_<ms(3 places)>

Example

PLC_1_Long-term Trace_20220721_120422_356_0001.dat

Behavior during operation

As soon as the recording of the long-term trace in a DAT file has reached a file size of 2 GB, a new DAT file is created. The new file has the same time stamp as the file that has overflowed and the running serial number is incremented by 1. The recording is continued without any break.

You can use the "Monitoring on/off" button to interrupt the recording. If you click the "Monitoring on/off" button again, a new DAT file is created. The new DAT file has the same time stamp as the DAT file of the interrupted recording and the running serial number is incremented by 1. The recording is continued.

Example

Overflowed/Canceled recording

PLC_1_Long-term Trace_20220721_120422_356_0001.dat

Continued recording:

PLC_1_Long-term Trace_20220721_120422_356_0002.dat

CAUTION

Inconsistent data when opening the DAT file during the recording

Opening the DAT file during recording can lead to inconsistent data and therefore render it unusable.

Do not open the DAT file during the recording.

Cancellation of the recording

CAUTION

Do not close the editor window during a long-term project trace recording!

If you close the editor window during a long-term project trace recording, the recording is interrupted. As a result no data will be saved in the DAT file.

To resume the interrupted recording, open the respective configuration in the editor window again. The recording is continued. The missing data appears as a gap in the time diagram.

After a recording has been canceled, a new .dat file is created with the current time stamp when a new recording is started.

Example

Interrupted recording:

PLC_1_Long-term Trace_20220721_120422_356_0001.dat

New recording

PLC_1_Long-term Trace_20220721_121212_999_0001.dat

Output formats of the data types in the CSV file

NOTE

Displaying the values in Excel

If you open the CSV file directly with a double-click, Excel can show the values wrongly formatted.

To display the values correctly, always import the data from the CSV file to Microsoft Excel.

Invalid values (e.g.Time Of Day values less than 0 or greater than 24) are displayed as hexadecimal numbers.

The table below provides an overview of the data formats in which the data types in the CSV file are output:

Data type	Output format		Example	
Bool	True = 1 False = 0		1	
Int	Full decimal number		-12	
Int			-123	
DInt			-1234	
LInt			-123456	
USInt			12	
UInt			123	
UDInt			1234	
ULInt			123456	
Real	Scientific notation	Hexadecimal for Infinite/Denormal/NaN	3.713193E+29	16#7F80_0000
LReal				
Byte	Full decimal number		12	
Word			123	
DWord			1234	
Lword			12345	
Date	YYYY-MM-DD		1970-01-01	
Time	Seconds without measurement unit		62.78	
LTime			0.00307	
Time Of Day	HH:MM:SS.ms (ms up to 3 places)		00:00:54.078	
Long Time Of Day	HH:MM:SS.ms (ms up to 9 places)		00:00:00.000033566	
Long Date Time	YYYY-MM-DD-HH:MM:SS.ms (ms up to 9 places)		1970-01-01-00:00:00.000033566	

Unsupported data types

The following data types are not supported by the CSV file:

- Date_And_Time
- Date_And_LTime
- Char
- WChar
- String
- S5Count
- S5Time

See also

Export measurement (Page 65)

6.1.8 CPU load through trace recording

An activated trace recording increases the runtime of the respective recording level that can result in an execution level overflow with high utilization of the CPU.

Remedy for execution level overflow:

- **Change the trace configuration**

  1) Configure fewer tags and signals.

  2) Then increase the number of tags and signals up to the maximum number of signals step-by-step without an execution level overflow.
- **Select a slower recording level**

6.1.9 Project trace

Note the required firmware version of the devices for the support of the project trace and the long-term project trace.

The following table lists the devices supported by the project trace and long-term project trace.

Device	Support as of firmware
SIMATIC S7-1500, ET 200SP, CPU 1513pro-2 PN and CPU 1516pro-2 PN CPUs	V2.8
SIMATIC S7-1500 Software Controller	V2.8
SIMATIC Drive Controller	V2.8
ET 200SP Open Controller	V20.8

6.1.10 Software user interface of the configuration

6.1.10.1 Layout of the trace user interface

The settings options differ depending on the configured device.

Display in the "Configuration" tab of the working area

The following figure shows an example of the display of a S7-1500 CPU:

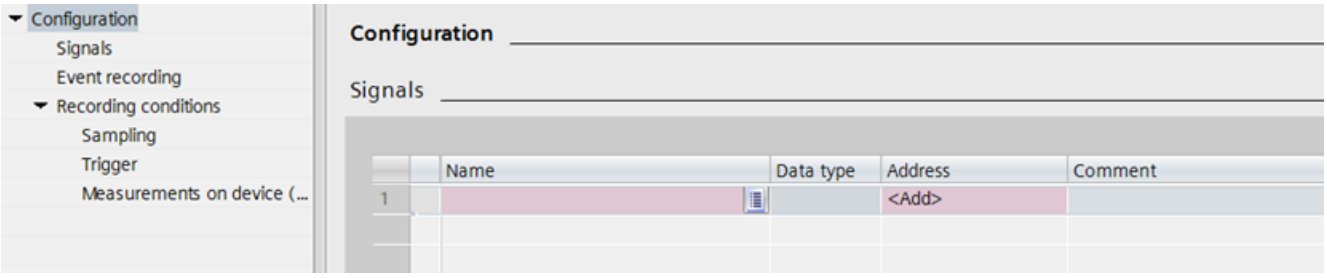

The area navigation provides the following entries for selection:

- Configuration
  - Signals (Page 106)
  - Event recording
  - Recording conditions (Page 107)

Displaying and changing the properties of a trace configuration

A trace is selected in the project tree and displayed in the "Configuration" tab.

You change the trace configuration offline. Online, the trace configuration is displayed read-only.

6.1.10.2 Layout of the long-term trace user interface

The settings options differ depending on the configured device.

Display in the "Configuration" tab of the working area

The following figure shows an example of the display:

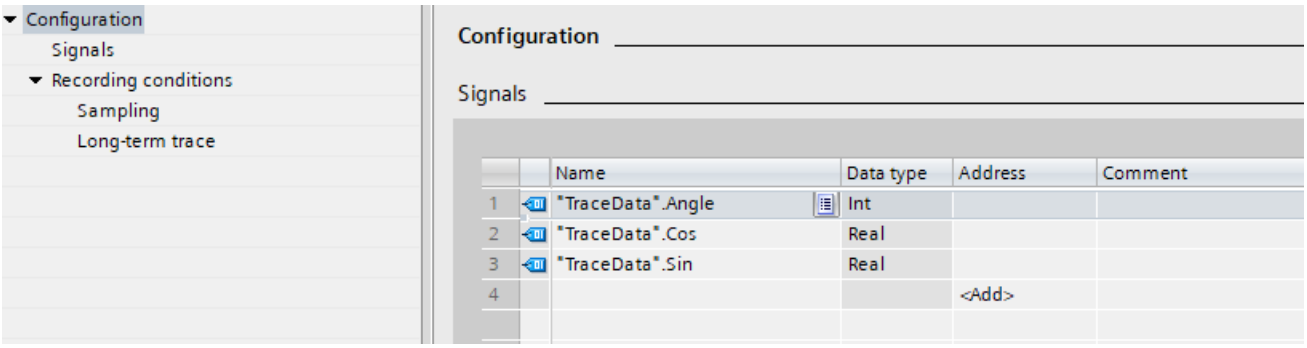

The area navigation provides the following entries for selection:

- Configuration
  - Signals (Page 106)
  - Recording conditions (Page 106)

Displaying and changing properties of a long-term trace configuration

A long-term trace is selected in the project tree and displayed in the "Configuration" tab.

You can change the long-term trace configuration offline. Online, the long-term trace configuration is displayed read-only.

See also

Recording conditions (Page 107)

6.1.10.3 Layout of the project trace user interface

The device-dependent project trace configuration is displayed in the Inspector window when a device is selected in the configuration tab of the "Participating devices" table.

Configuration in the "Properties" tab of the Inspector window

The following figure shows an example of the display for a selected device:

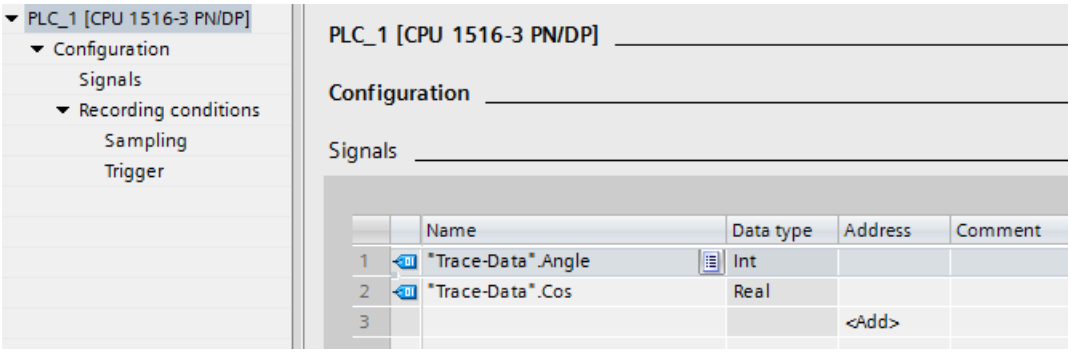

The area navigation provides the following entries for selection:

- Configuration
  - Signals (Page 106)
  - Recording conditions (Page 107)

6.1.10.4 Layout of the interface for long-term project trace

The device-dependent long-term project trace configuration is displayed in the Inspector window when a device is selected in the configuration tab of the "Participating devices" table.

Configuration in the "Properties" tab of the Inspector window

The following figure shows an example of the display for a selected device:

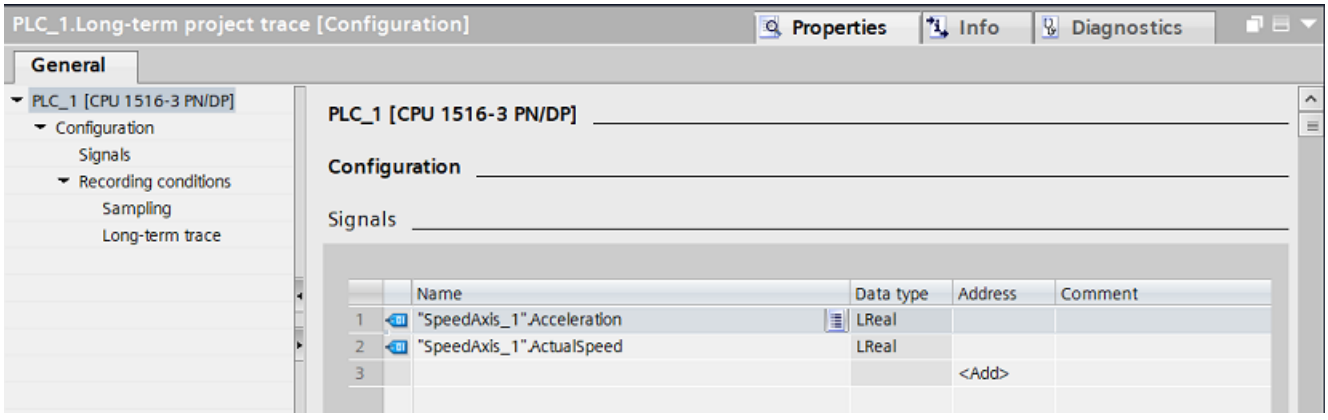

The area navigation provides the following entries for selection:

- Configuration
  - Signals (Page 106)
  - Recording conditions (Page 107)

6.1.10.5 User interface - Signals

The "Signals" area shows a table in which the signals to be recorded are configured for the selected trace configuration.

Signals can also be inserted in the table using drag-and-drop.
The signals can be sorted using drag-and-drop.

Setting options and displays in "Signals"

The following figure shows an example of the display:

		Name	Data type	Address	Comment
1		"Tag_1"	Byte	%MB10	
2		"Tag_2"	Byte	%MB11	
3		"Tag_3"	Word	%MW14	
4		"Tag_4"	DWord	%MD16	

The following table shows the settings and displays:

Column	Icon	Description
-		Display of the signal icon for a selected signal.
"Name"	-	Input field for the name or address of the signal. **Examples:** • "Data_block_1".pressure • M0.0 • DB1.DBW3
-		Button to open the signal selection table. The button is displayed when the table line is selected. Clicking the icon opens a table which offers possible signals for selection. The selected signal is displayed in the input field.
"Data type"	-	Text field with display of the data type for the signal.
"Address"	-	Input field for the address of the signal. The field remains empty with optimized / type correct tags.
"Comment"	-	Input field for a comment on the signal.

Shortcut menu commands

The following table shows the context menu commands of the table:

Shortcut menu command	Description
"Cut"	Cannot be selected
"Copy"	Copies the contents of the selected lines to the clipboard.
"Paste"	Pastes the contents of the clipboard to the selected line. The existing contents are overwritten.
"Delete"	Deletes the selected lines from the table or deletes the content of the selected cell.
"Rename"	Switches the selected cell to the editing mode.

See also

Layout of the long-term trace user interface (Page 104)
Layout of the project trace user interface (Page 105)
Layout of the interface for long-term project trace (Page 105)

6.1.10.6 Recording conditions

User interface - Recording conditions

The "Recording conditions" area shows the trigger condition for the selected trace configuration and in which cycle, how fast and how long the recording is made.

You cannot specify a recording duration or trigger for a Long-term trace configuration (Page 23).

Sampling

The following figure shows an example of the settings for the sampling:

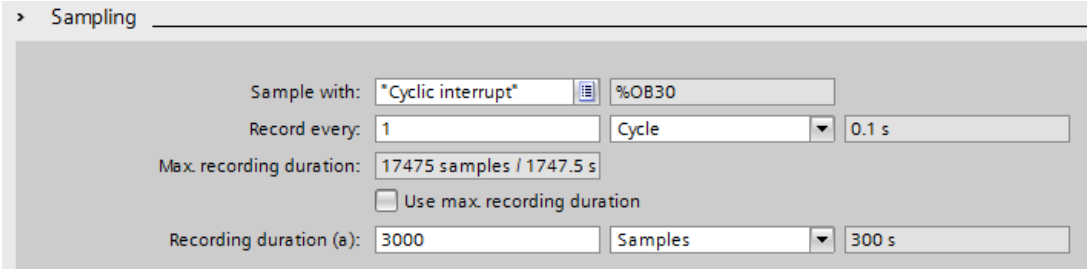

The following table explains the settings and displays:

Setting/display		Description
"Trace sample event"		
	Recording level entry field	Selection of the trace sample event. See Recording levels (Page 94)
	Address of the OB text field	Detailed information on the selected trace sample event.
"Record every"		

Setting/display		Description
	Reduction entry field	Input of the reduction in relation to the reduction ratio and the unit.
	Reduction ratio drop-down list	Selection of the reduction ratio unit The following settings are possible: • "Cycle" • "s" for seconds The setting depends on the recording level selected in "Trace sample event".
	Sampling time text field	Display of the sampling time, taking into account the configured reduction and the selected unit (only for constant bus cycle time OBs).
"Max. recording duration"		
	Max. recording duration text field	Displays the calculated maximum recording duration. The "Max. recording duration" depends on how many signals are recorded and the data type of these signals.
	"Use max. recording duration"	Set the recording duration to the maximum value. When the checkbox is activated, the recording duration is set to the maximum possible recording duration. The set reduction in the "Record every" input field is taken into account. If more signals are added, the recording duration will be adjusted. You can also find more information in the form of FAQs under the ID 102781176 (http://support.automation.siemens.com/WW/view/en/102781176).
"Recording duration"		
	Recording duration entry field	Input of the recording duration in relation to the selected unit. If the "Recording duration = max. recording duration" checkbox is activated, entries are overwritten by the value displayed in "Max. recording duration".
	Unit drop-down list	Selection of the unit for the recording duration. The following settings are possible: • "Samples" The maximum number of samples recorded is the number for which parameters are assigned under recording duration. • "s" for seconds The setting depends on the recording level selected in "Trace sample event".
	Calculated recording duration text field	Display of the calculated recording duration (only for constant bus cycle time OBs)

Trigger

The following figure shows an example of the settings for the trigger:

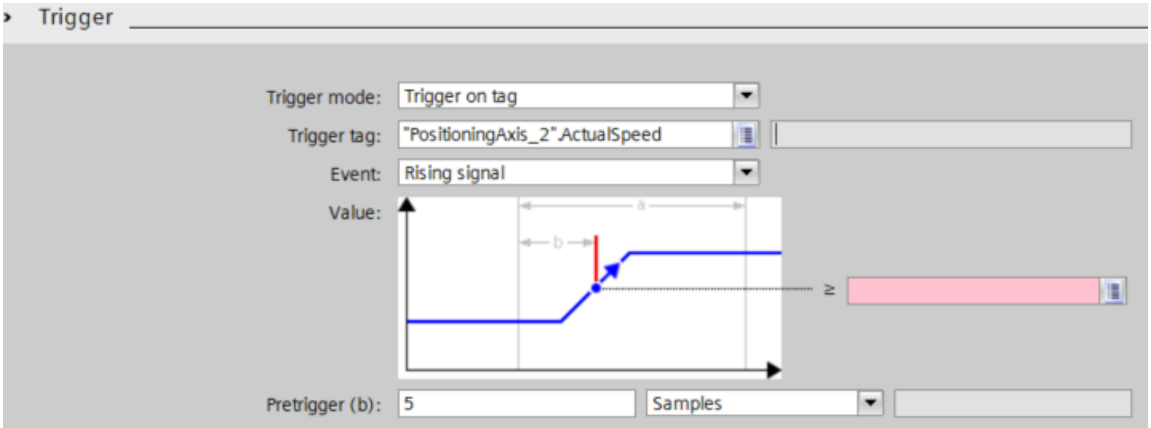

The following table explains the settings and displays:

Setting/display			Description
"Trigger mode"			Selection of the trigger mode.
	Trigger mode drop-down list		The following settings are possible: • "Record immediately" Recording is started immediately after the activation in the device. The global trigger is triggered immediately, regardless of the operating state of the device. • "Trigger on tag" The recording is made as soon as the installed trace is activated and the configured trigger condition is fulfilled. • "Monitor without trigger" (traces) The recording takes place as soon as the installed trace is activated and is not automatically terminated. After you stop recording, the maximum number of measured values in the device is the number you have configured under Recording duration. This trigger mode is particularly suitable for monitoring slow signals and is only available for traces. • "Trigger from another device" (project trace) The global trigger for the start of the trace is triggered by another device. This trigger mode is only available for a project trace.
	Text field		-
"Trigger tag"			The "Trigger tag" specifies a signal that triggers the recording.
	Trigger tag entry field		Enter a signal. **Examples:** • "DataBlock_1".Temperature • M0.0 • DB1.DBW3 See also Data types for trigger tags (Page 112).
			Opens the signal selection table. Click the button to open a table that offers possible signals for selection as trigger tags. The selected signal is displayed in the input field.

Setting/display		Description
	Trigger tag address text field	Display of the trigger tag address. With purely symbolic signals the field remains empty.
"Event"		The events that can be used on this trigger tag are offered for selection according to the data type of the trigger tag. The event can be configured provided a valid signal is entered as trigger tag.
	Trigger events drop-down list	Event selection for which the trigger tag is checked. The entries in the drop-down list are described in Section Trigger event (Page 113).
	Text field	-
"Value"		Configuration of the selected event. The configuration options differ depending on the format of the trigger tag and the selected event. See Trigger event (Page 113).
"Pretrigger"		"Pretrigger" defines the number of samples that are already recorded before the actual trigger condition is fulfilled. If the trigger event occurs immediately or shortly after the recording has been activated, this may result in a shorter recording duration. Examples of "Recording duration (a)" = 20 samples and "Pretrigger (b)" = 5 samples: • Case 1: Trigger event occurs 50 samples after activation of the recording Actual recording duration (a) = 20 samples • Case 2: Trigger event occurs 2 samples after activation of the recording Actual recording duration (a) = 17 samples
	Duration entry field	Input of the duration in relation to the selection in the drop-down list.
	Unit drop-down list	Selection of the unit The following settings are possible: • "Samples" • "s" for seconds The setting depends on the recording level selected in "Trace sample event".
	Resulting pretrigger duration text field	Display of the calculated "Pretrigger" duration The duration is displayed when recording in constant bus cycle time OBs.

Measurements on the device (memory card)

The following figure shows an example of the settings for the saving of installed measurements:

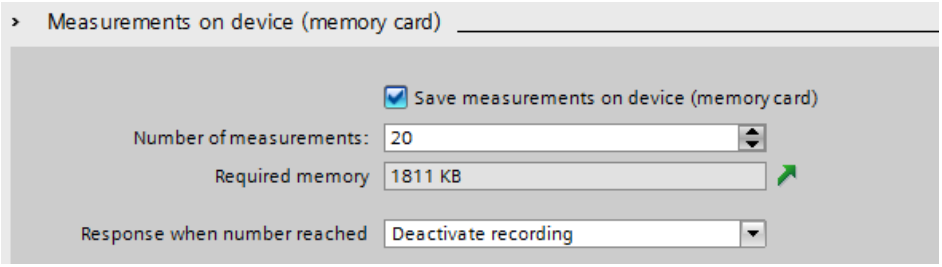

Saving measurements on device (memory card) is not possible with project traces.

NOTE
Deleting measurements on device (memory card) (S7-1200)
Do not delete any measurements on the device as long as an installed trace still generates new measurements on the memory card.

NOTE
Available memory in the device (memory card)
The memory in the device (memory card) is partly used by system-relevant functions or reserved for that purpose.

It is therefore not possible for the entire memory to be used for saving measurements.

You can find more information in the Structure and Use of the CPU Memory (https://support.industry.siemens.com/cs/us/en/view/59193101) Function Manual.

NOTE
Memory requirements upon restart
Following a device reboot the maximum number of measurements saved in the device is the number configured under "Number of measurements".

With repeated restarts note that the measurements already saved are not overwritten and the "Number of measurements" configured in the device is saved once again.

The following table explains the settings and displays:

Setting/display	Description
"Save of installed measurements (memory card)"	Repeat measurement automatically and store in the device retentively This setting is only possible with "Trigger on tag" trigger mode. The measurements are stored on the "primary" memory card. For traces which have been saved in the device (memory card), the function for automatically repeating the recording is not available. **Note** Only completed measurements are stored in the device. A recording that you have deactivated is not saved in the device. **This function is available with the following firmware versions:** • S7-1200 as of V4.2 • S7-1500 as of V2.0 The function is not supported by CPU S7-1500 R/H.
"Number of measurements"	Enter the number of reserved measurements on the memory card for this trace configuration. The CPU supports a maximum of 999 measurements on the memory card.
"Memory requirements"	Display of the expected memory requirement for all measurements
	Displaying memory usage Shows the tab with the memory usage

Setting/display	Description
"Behavior if number reached"	Selection for the behavior once "Number of measurements" is reached The following settings are possible: • "Deactivating a recording" The measurements are repeated until the "Number of measurements on the card" is reached. • "Overwrite oldest recording" The measurements are saved in a ring buffer and repeated until you deactivate the recording. Once the number of measurements exceeds the "Number of measurements on the card" the oldest measurement on the card is overwritten in each case. **Note** Note that write processes that are repeated frequently may damage the card.

Long-term trace

The following figure shows an example of the settings for the saving of installed measurements:

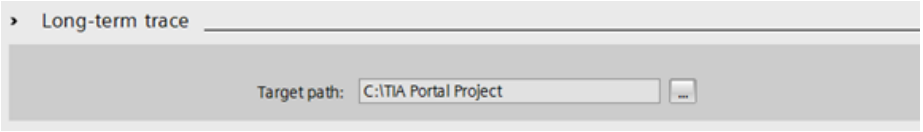

The following table explains the settings and displays:

Setting/display	Description
"Target path"	Display of the folder used for recording the long-term traces. Configuring the recording cycle and target path for long-term trace (Page 120) Long-term trace recording (Page 97)

Data types for trigger tags

The following table shows the supported data types for the trigger tag:

Memory requirement and format of the number	Data type
1 byte	BOOL
8-bit integers	SINT, USINT, BYTE
16-bit integers	INT, UINT, WORD, DATE
32-bit integers	DINT, UDINT, DWORD, TIME, TOD
64-bit integers [1)]	LINT, ULINT, LWORD, LTIME, LTOD, LDT
32-bit floating-point numbers	REAL
64-bit floating-point numbers	LREAL

1) Not supported by S7-1200.

Trigger event

Depending on the selection in the drop-down list, the further settings differ for the "event".

The individual events are described below.

"=TRUE"

Supported data types: Bit (Page 112)

The recording starts when the state of the trigger is TRUE.

"=FALSE"

Supported data types: Bit (Page 112)

The recording starts when the state of the trigger is FALSE.

"Rising edge"

Supported data types: Bit (Page 112)

The recording is started when the trigger state changes from FALSE to TRUE.
After activation of the installed trace, at least two cycles are required to identify the edge.

"Rising signal"

Supported data types: Integers and floating-point numbers (Page 112) (no times, date and time of day)

The recording is started when the rising value of the trigger reaches or exceeds the value configured for this event.
After activation of the installed trace, at least two cycles are required to identify the edge.

"Falling edge"

Supported data types: Bit (Page 112)

The recording is started when the trigger state changes from TRUE to FALSE.
After activation of the installed trace, at least two cycles are required to identify the edge.

"Falling signal"

Supported data types: Integers and floating-point numbers (Page 112) (no times, date and time of day)

The recording is started when the falling value of the trigger reaches or falls below the value configured for this event.
After activation of the installed trace, at least two cycles are required to identify the edge.

"In the range"

Supported data types: Integers and floating-point numbers (Page 112)

The recording starts as soon as the value of the trigger is in the value range configured for this event.

"Outside of the range"

Supported data types: Integers and floating-point numbers (Page 112)

The recording starts as soon as the value of the trigger is outside the value range configured for this event.

"Value change"

All data types are supported.

The value is checked for change when the recording is activated. The recording starts when the value of the trigger changes.

This trigger event is supported as of V13 SP1. Older versions of the TIA Portal cannot interpret the trigger. Note that no explicit information is output in this case. This can occur, for example, when the trace is transferred from a CPU to TIA Portal V13 SP1 or lower or a trace configuration is imported.

"= value"

Supported data types: Integers (Page 112)

The recording starts when the value of the trigger is equal to the value configured for this event.

"<> value"

Supported data types: Integers (Page 112)

The recording starts when the value of the trigger is not equal to the value configured for this event.

"= bit pattern"

Supported data types: Integers and floating-point numbers (Page 112) (no times, date and time of day)

The recording starts when the value of the trigger matches the bit pattern configured for this event.

The following figure shows the setting options for a "bit pattern":

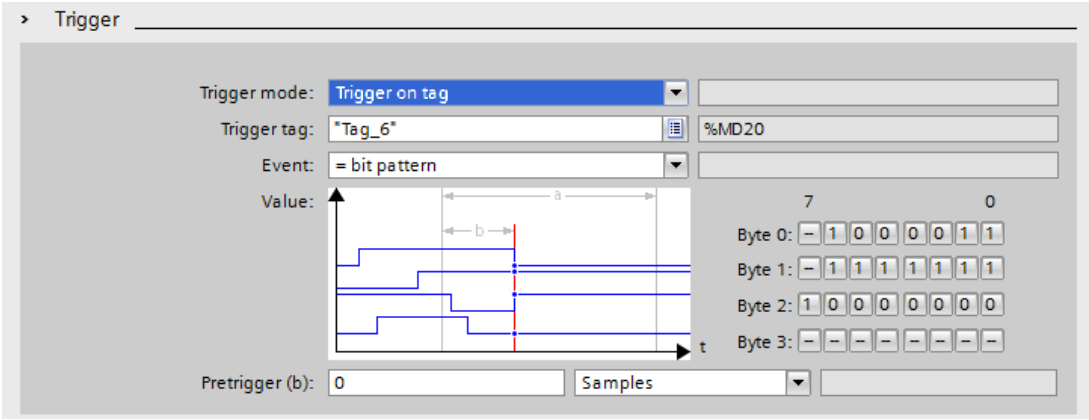

It is possible to switch between the icons by clicking the respective button.

The following table shows the icons:

Icon	Description
–	Bit is not evaluated
0	Bit is checked for FALSE
1	Bit is checked for TRUE

"<> bit pattern"

Supported data types: Integers and floating-point numbers (Page 112) (no times, date and time of day)

The recording starts when the value of the trigger does not match the bit pattern configured for this event.

See also

Configuring the trigger conditions (Page 119)

Recordable variables (Page 92)

6.1.11 Configuration

6.1.11.1 Trace configuration - overview

The configuration of the recording conditions and the signals to be recorded is device-specific.

Requirement

A trace configuration has been created and opened in the work area of the "Configuration" tab.

Procedure

The following table shows an example of the procedure for configuring a trace.

Step	Description
1	Documentation of the configuration (optional) Enter a comment and an author for the configuration in the Inspector window.
2	Selecting signals (Page 117) Select the signals to be recorded in the "Signals" area.
3	Activate event recording (optional) In the "Event recording" area, specify whether the events of technology objects should be recorded during recording
4	Configuring the recording cycle and duration (Page 118) Select a recording time, a cycle and the duration in the "Recording conditions" area.
5	Configuring the trigger conditions (Page 119) In the "Recording conditions" area, select whether the recording is to be performed immediately or depending on a trigger condition.
6	Configure installed measurements (memory card) (optional) (Page 120) In the "Recording conditions" area, specify whether the measurement in the device (memory card) is to be saved.

6.1.11.2 Long-term trace configuration – overview

The configuration of the recording conditions and the signals to be recorded is device-specific.

Requirement

A long-term trace configuration has been created and opened in the working area of the "Configuration" tab.

Procedure

The following table shows the procedure for configuring.

Step	Description
1	Selecting signals (Page 117) Select the signals to be recorded in the "Signals" area.
2	Configuring the recording cycle and target path for long-term trace (Page 120) In the "Recording conditions" tab, define the recording cycle and change the target path, if necessary.

See also

Configuring the recording cycle and duration (Page 118)

6.1.11.3 Configuring long-term project trace - Overview

The configuration of the recording conditions and the signals to be recorded is device-specific.

Procedure

The following table shows the procedure for configuring.

Step	Description
1	Select participating devices In the area "Participating devices" area, select the devices for the long-term project trace configuration
2	Selecting signals Select the signals to be recorded in the "Signals" area.
3	Configuring recording cycle and target path for long-term project trace In the "Recording conditions" tab, define the recording cycle and change the target path, if necessary.

6.1.11.4 Select participating devices

Requirement

- At least two devices are created that support the project or long-term project trace
- A project or long-term project trace is created

Procedure

To select participating devices for a project or long-term project trace, proceed as follows:

1. Select the project or long-term project trace in the project tree.

2. In the "Participating devices" interface, select the devices you want to use for the project or long-term project trace.

6.1.11.5 Selecting signals

Requirement

- A trace, project trace, long-term trace or long-term project trace configuration is created and opened.
- The "Signals" area is open in the "Configuration" tab.

Procedure

To configure the signals to be recorded, proceed as follows:

1. Select a signal. The following options are available:
   - In the "Name" column, click the button and select a tag.
   - Enter the symbolic tag name in the cell in the "Name" column.
   - Enter the address directly in the "Address" column.
   - Drag a signal to the table using drag-and-drop.
2. Click in the "Comment" column and enter a comment for the signal.
3. Repeat the procedure from step 1 until all the signals to be recorded have been entered in the table.

6.1.11.6 Configuring the recording cycle and duration

Requirement

- A trace configuration has been created and opened.
- The "Recording conditions" area is open in the "Configuration" tab.

Procedure

To configure the cycle and the duration of a recording, proceed as follows:

1. Click for the recording time.
2. Select an OB for the recording time (Page 94).
3. Select a unit for the reduction factor in the drop-down list for "Record every".
4. Enter the factor for the reduction in the input field for "Record every".
5. Select a unit in the drop-down list for "Recording duration".
6. Specify the recording duration.
   The following options are available:
   - Enter a value for the duration in the input field for "Recording duration".
   - Select the "Use max. recording duration" check box.

6.1.11.7 Configuring the trigger conditions

Requirements

- A trace configuration has been created and opened.
- The "Recording conditions" area is open in the "Configuration" tab.

"Record immediately" trigger condition

To start the recording immediately, proceed as follows:

1. Select the "Record immediately" entry in the drop-down list for "Trigger mode".

   The input fields for the trigger tag are hidden.

"Trigger on tag" trigger condition

To start the recording depending on a condition, proceed as follows:

1. Select the "Trigger on tag" entry in the drop-down list for "Trigger mode".
2. Select a trigger tag. The following options are available:
   - Click for the trigger tag and select a tag.
   - Enter the address or the symbolic name of the tag directly in the input field for the trigger tag.

   A drop-down list with events and input fields is displayed. The display depends on the data type of the tag.
3. Configure the event.
4. Select a unit for the pretrigger in the drop-down list for "Pretrigger".
5. In order to record a period before the trigger event, enter a value greater than 0 in the input field for the pretrigger.

NOTE

Cyclic test of the trigger condition

The trigger condition is checked in every cycle irrespective of the setting in "Record every". To reliably identify the trigger, the trigger signal must be present for at least one full cycle.

6.1.11.8 Configure installed measurements (memory card)

Requirement

- A trace configuration has been created and opened.
- The "Recording conditions" area is open in the "Configuration" tab.
- The "Trigger on tag" trigger mode is set.
- The firmware on the device supports the recording of an installed measurement.
- The "Event recording" function is not used.

Procedure

To save the measurement in the device (memory card), proceed as follows:

1. Select the "Save measurements on device (memory card)" check box.
2. Enter the number of measurements that ought to be saved on the card in the "Number of measurements" entry field.
3. In the "Response when number reached" drop-down list, set the response when the "Number of measurements" has been reached:

NOTE
No evaluation of the trigger during saving
No new trigger can be evaluated as long as the recording is being saved.

6.1.11.9 Configuring the recording cycle and target path for long-term trace

Requirement

- A long-term trace configuration has been created and opened.
- The "Recording conditions" area is open in the "Configuration" tab.

Procedure

To configure the cycle of a recording, proceed as follows:

1. Click the button for the trace sample event.
2. Select an OB for the trace sample event.
3. Enter the factor for the reduction in the import field for "Record every".
4. Select a unit for the reduction factor in the drop-down list for "Record every".

The default target path is the folder of the STEP 7 project.

To change the target path, follow these steps:

1. Click the button for the target path.
   The "Select folder" window opens.
2. In the folder structure, navigate to the target folder or enter the target path under "Folder".
3. Click "Select folder".

6.1.11.10 Configuring recording cycle and target path for long-term project trace

You can change the target path either individually for each participating device or simultaneously for all participating devices.

Requirements

- A long-term project trace configuration has been created and opened.
- At least one CPU has been created as a participating device.

Configuring recording cycle and target path for a participating device

To reach the configuration of a participating device, first select the device in the "Participating devices" table. You can find the configuration for this device in the Inspector window under "Properties" > "General" > "<Name of CPU>" > "Configuration".

To configure the cycle of a recording for a participating device of a long-term project trace, proceed as follows:

1. Click on the button for the recording point.
2. Select an OB for the trace sample event.
3. Enter the factor for the reduction in the import field for "Record every".
4. Select a unit for the reduction factor in the drop-down list for "Record every".

The default target path is the folder of the STEP 7 project.

1. Click the button for the target path.
   The "Select folder" window opens.
2. In the folder structure, navigate to the target folder or enter the target path under "Folder".
3. Click "Select folder".

Changing the target path for all participating devices

Requirements: No participating device has been selected.

You can find the configuration for the target path in the Inspector window under "Properties" > "General".

To change the target path for all participating devices of a long-term project trace, follow these steps:

1. Click the ... button in the "Target path:" row.
   The "Select folder" window opens.
2. In the folder structure, navigate to the target folder or enter the target path under "Folder".
3. Click "Select folder".

SIEMENS

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S7-1500, ET 200MP, ET 200SP, ET 200BL,ET 200AL, ET 200pro, ET 200eco PN, ET 200clean Communication

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Introduction 1

Purpose of the documentation

This function manual provides an overview of the communication options offered by the CPUs, communication modules and processors, and PC systems of the SIMATIC S7-1500, ET 200 and SIMATIC Drive Controller systems. This Function Manual describes connection-oriented, asynchronous communication.

The documentation covers the following:

- Overview of communications services
- Properties of communications services
- Overview of user activities for setting up communications services

Basic knowledge required

The following knowledge is required in order to understand the Function Manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about how to use STEP 7 (TIA Portal)

Scope of the documentation

This documentation is the basic documentation for all products of the SIMATIC S7-1500 and ET 200 systems. The product documentation is based on this documentation.

What's new in the Communication Function Manual, Edition 11/2025 compared to Edition 11/2024?

What's new?	What are the customer benefits?	Where can I find the information?
Information on the validity period of certificates	Information on the validity period of certificates and the special case when a certificate expires while a protected connection is established.	Section Certificate management with TIA Portal (Page 66)
Access control with OPC UA server	You can read how to configure user roles and authorizations for OPC UA namespaces.	Section Role-based security in OPC UA (Page 220)

What's new?	What are the customer benefits?	Where can I find the information?
Automatic generation of the application URI	The application URI is the unique identifier of the application. As of FW version V4.1, the application URI is automatically generated from the application name. You can read the relationships between the application name and application URI as well as the dependencies in the event of changes.	Section Enabling the OPC UA server (Page 257)
Standard security settings of the OPC UA server	For CPUs as of FW version V4.1, the security policy "No security" is deactivated by default. The information on the individual security policies has been updated.	Section Handling client and server certificates (Page 267)
Managing certificates of OPC UA clients at runtime	With CPUs as of FW version V4.1, you can manage the certificates of the OPC UA client at runtime.	Section Handling client certificates during runtime (Page 390)
Enabling/disabling IP forwarding via data record	You can activate IP forwarding by writing a data record, e.g. during commissioning, and deactivate it during operation without having to change the hardware configuration of the CPU in STEP 7.	Section Enabling and disabling IP forwarding (Page 429)
Increased number of method calls for OPC UA client instructions	With CPUs as of FW version V4.1, you can use a higher number of method calls for OPC UA client instructions.	Section Number of client instructions that can be used simultaneously (Page 367)
GDS (certificate management at runtime) for S7-1500R/H	With R/H CPUs as of FW version V4.1, you can use the certificate management services of the OPC UA server and transfer certificates at runtime. The following elements can be updated automatically via GDS Push Management functions: • OPC UA server certificate • Trust lists • Certificate Revocation Lists (CRL) • Web server certificate	Section Using an OPC UA server in an S7-1500R/H system (Page 481)

What's new in the Communication Function Manual, Edition 11/2024 as compared to Edition 11/2023

What's new?	What are the customer benefits?	Where can I find the information?
Table for communication protocols and port numbers used in Ethernet communication interface modules	Information on protocols and ports used by interface modules. You can see at first glance which default settings apply. This allows you to specifically adjust only those settings that are relevant to your application.	Section Communications protocols and port numbers used for Ethernet communication (Page 36)
OPC UA: Increased configuration limits for the following S7-1500 CPUs as of FW version V4.0 • CPU 151x(F)-3 PN • CPU 151xT(F)-3 PN	The S7-1500 CPUs 151x(F)-3 PN and 151xT(F)-3 PN from FW version V4.0 allow the creation of a larger number of nodes for server interfaces and a larger number of server methods. In addition, the performance for read, write and subscriptions has been improved.	Equipment Manual of the respective CPU

What's new?	What are the customer benefits?	Where can I find the information?
OPC UA: Simultaneous receipt of messages in multiple languages	For S7-1500 CPUs, OPC UA clients as of firmware V4.0 can, for example, select one of the available languages for messages. In addition, an OPC UA client can request the message texts in all three active project languages simultaneously. For example, the messages are collected on a central server so that the messages can be evaluated by people in different languages.	Section Simultaneous receipt of messages in multiple languages (Page 341)
OPC UA: Role-based security for S7-1500 CPUs as of FW version V4.0	With the implementation of the role-based concept for the S7-1500 CPUs as of FW version V4.0, the OPC UA server can manage in detail the access of specific OPC UA clients to the address space.	Section Role-based security in OPC UA (Page 220)
OPC UA: Support of the "Transfer Subscription" function for S7-1500	The "Transfer Subscription" function is available for S7-1500 CPUs as of version V3.1.4 to support applications for load distribution on different OPC UA clients. With this, a subscription can be transferred to another OPC UA client. It is not necessary to configure the function.	Section Using the TransferSubscription service (Page 266)

What's new in the Communication Function Manual, Edition 11/2023 as compared to Edition 11/2022?

What's new?	What are the customer benefits?	Where can I find the information?
"Industrial cybersecurity" section	Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities. The section contains the following information: • Basic information on the subject of industrial cybersecurity • Measures to protect individual components and the entire system against manipulation and unwanted access.	Industrial cybersecurity (Page 25)
Revision of the tables for communication protocols and port numbers used in Ethernet communication	Updated information on protocols and ports used. You can see at first glance which default settings apply. This allows you to specifically adjust only those settings that are relevant to your application.	Communications protocols and port numbers used for Ethernet communication (Page 36)
Updated information about the connection resources of the CPU and HMI.	Updated information on the following connection resources: • Maximum number of connection resources supported for some CPU types • Maximum occupied connection resources for different HMI devices	Connection resources (Page 441)

What's new?	What are the customer benefits?	Where can I find the information?
Expanding the redundant system with communications processors	As of STEP 7 V19, you can expand an S7-1500R/H redundant system as of FW version V3.1 with the CP 1543-1 communications processors.	System IP addresses for communications processors (Page 464).
Secure Open User Communication with the redundant system	As of STEP 7 V19, an S7-1500R/H redundant system FW version V3.1 and higher also supports Secure Open User Communication.	Open User Communication with the redundant system S7-1500R/H (Page 474)

What's new in the Communication Function Manual, Edition 11/2022 as compared to Edition 05/2021?

What's new?	What are the customer benefits?	Where can I find the information?
Revision of the tables for communication protocols and port numbers used in Ethernet communication	Updated information on protocols and ports used. You can see at first glance which default settings apply. This allows you to specifically adjust only those settings that are relevant to your application.	Communications protocols and port numbers used for Ethernet communication (Page 36)
Activate / Deactivate the SNMP	Depending on the FW version of the S7-1500 CPUs, the SNMP is activated or deactivated in the default settings. You can change the default settings as required.	SNMP (Page 121)
Revision of the virtual interface for IP-based applications	With a CP 1543-1 with firmware version V3.0 or higher, the internal CP firewall is available. This is used to secure data traffic via the virtual interface.	Virtual interface for IP-based applications (Page 437)
OPC UA server: Reading the diagnostics status of the own address space	By using the OPC UA instruction for reading ("OPC_UA_ReadList"), the own namespace of the OPC UA Server can be accessed. This makes it possible to read out the status of the own OPC UA server as well as the connections of OPC UA clients, the session as well as the subscriptions and to react to them in the user program. This allows connection problems to be quickly detected, for example, and plant availability to be increased.	Running diagnostics for OPC UA servers in the program (Page 352)
OPC UA server: Time stamping of the source time of nodes	By using the OPC UA instruction for writing ("OPC_UA_WriteList"), it is possible to change the "SourceTimestamp" as well as the status code of an OPC UA variable (node). This makes it possible to distinguish between the "Source" and "Server" time as of V18.	Client accesses and local accesses to the OPC UA server (Page 242)
OPC UA GDS mechanism: Now also usable for Web server certificates	The Web server certificate for HTTPS communication can now also be managed via the OPC UA GDS mechanism, without separate download of the hardware configuration.	What you should know about the certificate management (Page 65) Automated certificate management with GDS (Page 202)

What's new in the Communication Function Manual, Edition 05/2021 as compared to Edition 11/2019?

What's new?	What are the customer benefits?	Where can I find the information?
Improved security for SIMATIC PG/HMI communication	• Allows unique identification of each PLC based on individual certificates • Provides additional confidentiality protection through encrypted communication • Protection of the configuration data through individual passwords	Secure PG/HMI communication (Page 110)
Security wizard for new PLC security mechanisms	• Quick and easy configuration of the new security mechanisms of the PLC in one operation • Supporting information to select suitable settings for own application	Protection of confidential configuration data (Page 80)
Certificate management via OPC UA Global Discovery Server (GDS)	• Certificate update during runtime • Support of CRLs • Access protection for certificate management	Certificate management via Global Discovery Server (GDS) (Page 202)
Transferring CPU alarms to OPC UA clients	• Subscriptions allow clients to subscribe to CPU alarms as "Alarms and Conditions" from the OPC UA server of the CPU. • Program messages including associated values are made available by the OPC UA server • Alarms requiring acknowledgment can be acknowledged by the OPC UA client (can be disabled) • An alarm burst is displayed as "overload" and clients can be reloaded with the refresh method	Providing alarms on the OPC UA server (Page 326)
Dynamic assignment of the network configuration with DHCP	Deployment of the CPU in IT managed networks using the following functions: • Connection of the CPU to an existing network without additional manual configuration of the network interface • Request for network parameters for the CPU according to RFC 2131 from a DHCPv4 server (IP address and subnet mask, default IP router address and further optional network parameters such as DNS and NTP server addresses)	Addressing via DHCP (Page 404)
Name-based addressing with DNS	• DNS server addresses can be obtained from the CPU via DHCP • The CPU can obtain host and domain names from a DHCP server for applications that are implemented with OPC UA or (Secure) OUC. • The CPU may transfer configured host or domain names to DHCP servers coupled with DNS servers for dynamic matching (Dynamic DNS). • The NTP client of the CPU can address NTP servers with names • Network parameters can be written with the new "CommConfig" instruction, for example, IP address parameters, DNS server, host and domain name	DHCP with DNS (Page 408)

What's new in the Communication Function Manual, Edition 11/2019 as compared to Edition 10/2018?

What's new?	What are the customer benefits?	Where can I find the information?
IP forwarding	Simple access from the control level to the field level for configuration and parameter assignment of devices, e.g. via PDM or Web browser.	IP forwarding (Page 422)
OPC UA server expansion	For S7-1500 CPUs as of firmware V2.8 and TIA Portal version 16, with a corresponding Runtime license, you can benefit from the following expansions of the integrated OPC UA server: • Improved diagnostics: The OPC UA user receives information on the status of the OPC UA server via alarms in the diagnostics buffer, an OPC UA category in the Online & Diagnostics area of TIA Portal as well as an improved connection resources display. • Download behavior: In RUN mode, the OPC UA server only performs a restart during download from the TIA Portal when the newly downloaded data has an effect on the data management of the OPC UA server. • Server interface modeling: It is now possible in the TIA Portal to model server interfaces or import OPC UA Companion Specifications and map them to the PLC data management.	Section OPC UA communication (Page 172)

What's new in the Communication Function Manual, Edition 10/2018 as compared to Edition 12/2017?

What's new?	What are the customer benefits?	Where can I find the information?
Description of communication with the S7-1500R/H redundant system	You receive information on the particularities of communication with the S7-1500R/H redundant system	Section Communication with the redundant system S7-1500R/H (Page 457)
Scope of the Function Manual expanded to include the S7-1500R/H redundant system	Functions with which you are familiar from the SIMATIC S7-1500 automation system are implemented for the S7-1500R/H redundant system.	S7-1500R/H redundant system System Manual (https://support.industry.siemens.com/cs/ww/en/view/109754833)

What's new in the Communication Function Manual, Edition 12/2017 compared to Edition 09/2016

What's new?	What are the customer benefits?	Where can I find the information?
OPC UA Companion Specification	Through OPC UA Companion Specification, methods can be specified in a uniform and manufacturer-neutral way. Using these specified methods, you can easily integrate devices from various manufacturers into the plant and the production processes.	Section OPC UA server interface configuration (Page 282)

What's new?	What are the customer benefits?	Where can I find the information?
Setting up a secure connection to a mail server over the CPU interface	You can set up a secure connection to a mail server without additional hardware.	Section Secure OUC via e-mail (Page 107)
Secure communication over Modbus TCP	You can establish secure TCP connections between a Modbus TCP client and a Modbus TCP server.	Section Secure OUC with Modbus TCP (Page 105)

What's new in the Communication Function Manual, Edition 09/2016 compared to Edition 12/2014

What's new?	What are the customer benefits?	Where can I find the information?
OPC UA server	OPC UA is a uniform standard for data communication and is independent of any particular operating system platforms. OPC UA uses integrated safety mechanisms on various automation systems, for example with data exchange, at application level, for the legitimation of the user. The OPC UA server provides a large amount of data: • Values of PLC tags that clients can access • Data types of these PLC tags • Information about the OPC UA server itself and the CPU In this way, clients can gain an overview of the tag management and can read and write values.	Section OPC UA communication (Page 172)
Secure Open User Communication	Secure data exchange with other devices.	Section Secure Open User Communication (Page 93)
Certificate handling in STEP 7	You can manage certificates for the following applications in STEP 7: • OPC UA server • Secure Open User Communication • Web server of the CPU	Section Certificate management with TIA Portal (Page 66)
Deactivating SNMP for the CPU	You can deactivate SNMP for the CPU. This can make sense under certain conditions, for example if the security guidelines in your network do not permit SNMP.	Section SNMP (Page 121)

Conventions

STEP 7: We refer to "STEP 7" in this documentation as a synonym for the configuration and programming software "STEP 7 as of V12 (TIA Portal)".

Due to continuous controller functions, the term "S7-1500 CPUs" also usually refer to the CPU variants S7-1500F, S7-1500T, S7-1500TF, S7-1500C, S7-1500R/H, S7-1500pro, ET200SP, S7-1500 Software Controller, as well as SIMATIC Drive Controller. Variations arise due to different designs and applications between Advanced Controllers, Distributed Controllers, and Software Controllers.

This documentation contains pictures of the devices described. The figures may differ slightly from the device supplied.

You should also pay particular attention to notes such as the one shown below:

NOTE

A note contains important information on the product, on handling of the product and on the section of the documentation to which you should pay particular attention.

1.1 SiePortal

You can find current information on the following topics quickly and easily here:

- **Catalog and ordering system**

  Ordering system for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).
- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.
- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.
- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.
- **Forums**

  For answers and solutions concerning automation technology.
- **mySiePortal**

  Your personal work area in the SiePortal for notifications, support requests, and configurable documents.

This information is provided by SiePortal on the Internet (https://sieportal.siemens.com/).

1.2 Function Manuals documentation guide

1.2.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.2.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.2.3 S7 Port Configuration Tool (S7-PCT)

SIMATIC S7-PCT

The Port Configuration Tool (PCT) is a PC-based software for the parameter assignment of Siemens IO-Link Master modules and IO-Link devices from any manufacturer.

You integrate IO-Link-devices using the standardized device description "IODD", which you get from the respective device manufacturer. S7-PCT supports version 1.0 and V1.1 of the IODD.

S7-PCT is called via the hardware configuration of the IO-Link Master from STEP 7. When STEP 7 is not used or the IO-Link Master is not operated on a SIMATIC controller, "standalone"-operation is also possible.

You can find additional information on IO-Link on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/io-link.html).

1.2.4 S7 Failsafe Configuration Tool (S7-FCT)

SIMATIC S7-FCT

Failsafe Configuration Tool (FCT) enables you to GSD configure the following devices in third-party engineering systems:

- Selected, functionally fail-safe SIMATIC I/O devices
- Functionally fail-safe SIRIUS ACT PROFINET interfaces

The engineering system must meet the following requirements for this:

- Support of the CPD system integration acc. to "PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO"
- TCI implementation to Conformance Class C3

Additional information on S7-FCT can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

1.2.5 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.2.6 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
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Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Security information 2

2.1 General security information

Note the security-relevant information provided in the corresponding system manual.

You can find information relevant to cybersecurity in the section Industrial cybersecurity (Page 25).

Industrial cybersecurity 3

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the System Manual and the Security guidelines for SIMATIC HMI devices (https://support.industry.siemens.com/cs/us/en/view/109481300) for general information and measures regarding industrial cybersecurity.

This section provides an overview of security-related information pertaining to the communication of your SIMATIC system.

NOTE

Security-relevant changes to software or devices are documented in the section Introduction (Page 9).

3.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

3.2 Security-relevant information in this manual

Observe all security-relevant notes on topics in this Communication manual.

Security-relevant notes on ...	Section
Interfaces	Product overview (Page 27)
Ports and protocols	Overview of communication options (Page 33) Communications protocols and port numbers used for Ethernet communication (Page 36)
Secure communication	Secure communication (Page 54)
Activate/deactivate services	Activating and deactivating SNMP (Page 121) Addressing via DHCP (Page 404) IP forwarding (Page 422)
Security functions of OPC UA communication (authentication, certificates, user creation and roles, secure message transmission)	OPC UA communication (Page 172)
Activating security functions in the communications modules	Virtual interface for IP-based applications (Page 437)
Communication with the redundant system S7-1500R/H	Communication with the redundant system S7-1500R/H (Page 457)
Protection by Industrial Ethernet Security with CP 1543-1	Industrial Ethernet Security with CP 1543-1 (Page 497)
Secure PG/HMI communication	Secure PG/HMI communication (Page 110)
Protection of confidential data	Protection of confidential configuration data (Page 80)
Protection against tampering during loading and unauthorized access	PG communication (Page 130)

Product overview

4

PC systems, CPUs, communications modules and processors, and interface modules of the S7-1500 and ET 200 systems provide you with interfaces for communication via PROFINET, PROFIBUS and point-to-point connections.

CPUs, communications modules and communications processors

PROFINET and PROFIBUS DP interfaces are integrated in the S7-1500 CPUs. The CPU 1516-3 PN/DP for example has 2 PROFINET interfaces and 1 PROFIBUS DP interface. Other PROFINET and PROFIBUS DP interfaces are available by using communications modules (CM) and communications processors (CP).

CPU 1516-3 PN/DP

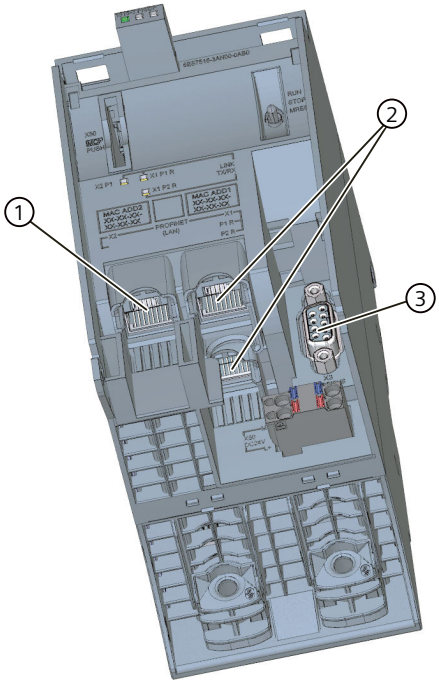

CPU 1512SP-1 PN

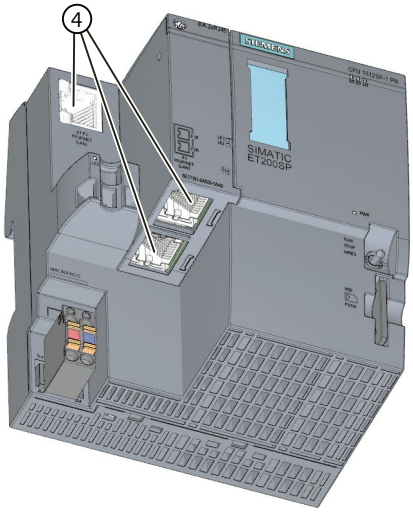

① PROFINET interface (X2) with 1 port

② PROFINET interface (X1) with 2-port switch

③ PROFIBUS DP interface (X3)

④ PROFINET interface (X1) with 3-port switch

Figure 3-364 Interfaces of the CPU 1516-3 PN/DP and CPU 1512SP-1 PN

Interfaces of communications modules

Interfaces of communications modules (CMs) extend the interfaces of CPUs (for example, the communication module CM 1542-5 adds a PROFIBUS interface to S7-1500 automation system).

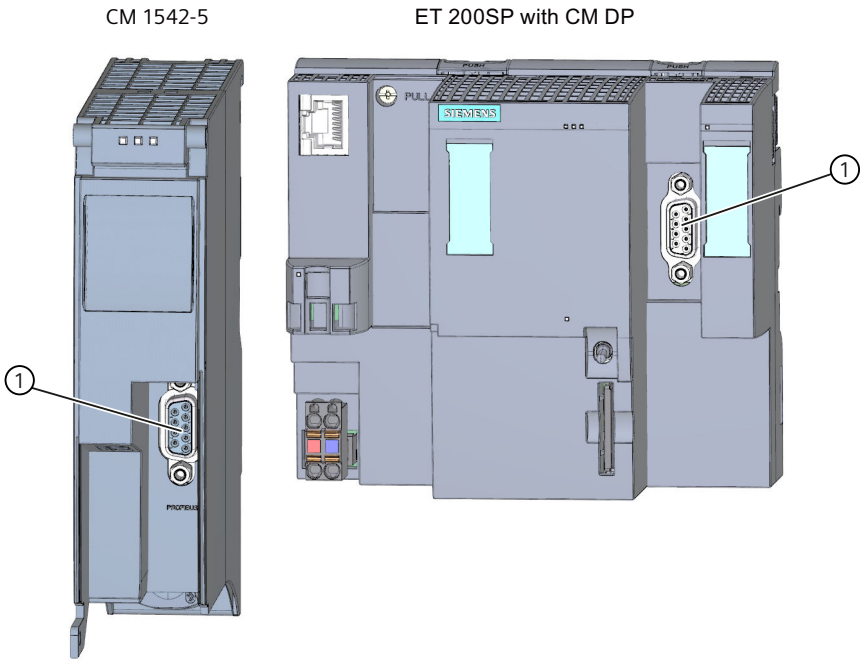

① PROFIBUS DP interface

Figure 3-365 PROFIBUS DP interface of the CM 1542-5 and CM DP (to an ET 200SP CPU)

Interfaces of communications processors

Interfaces of communication processors (CP) offer additional functionality to what is provided by the integrated interfaces of the CPUs. CPs allow special applications, for example the CP 1543-1 provides security functions for protecting Industrial Ethernet networks via its Industrial Ethernet interface.

CP 1543-1

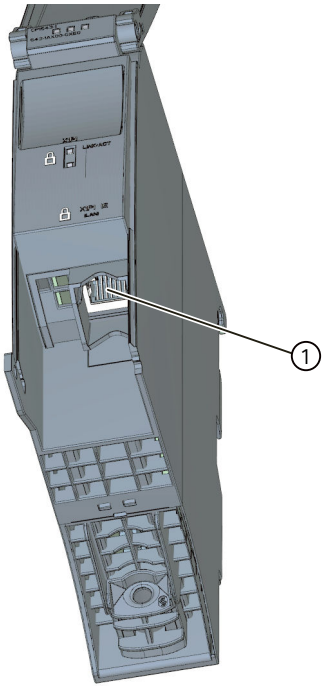

① Industrial Ethernet interface

Figure 3-366 Industrial Ethernet interface of the CP 1543-1

Interfaces of communications modules for point-to-point connections

The communication modules for point-to-point connections provide communication via their RS 232-, RS 422- and RS 485 interfaces, for example, Freeport or Modbus communication.

CM PtP RS422/485 BA

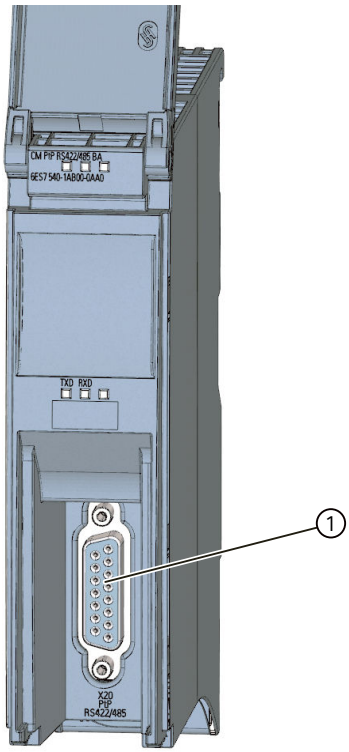

① Interface for point-to-point connections

Figure 3-367 Example of interface for point-to-point connection at the CM PtP RS422/485 BA

Interfaces of interface modules

PROFINET and PROFIBUS DP interfaces of interface modules (IM) are used to connect the ET 200 distributed I/O systems to PROFINET or PROFIBUS of the higher-level IO controller or DP master.

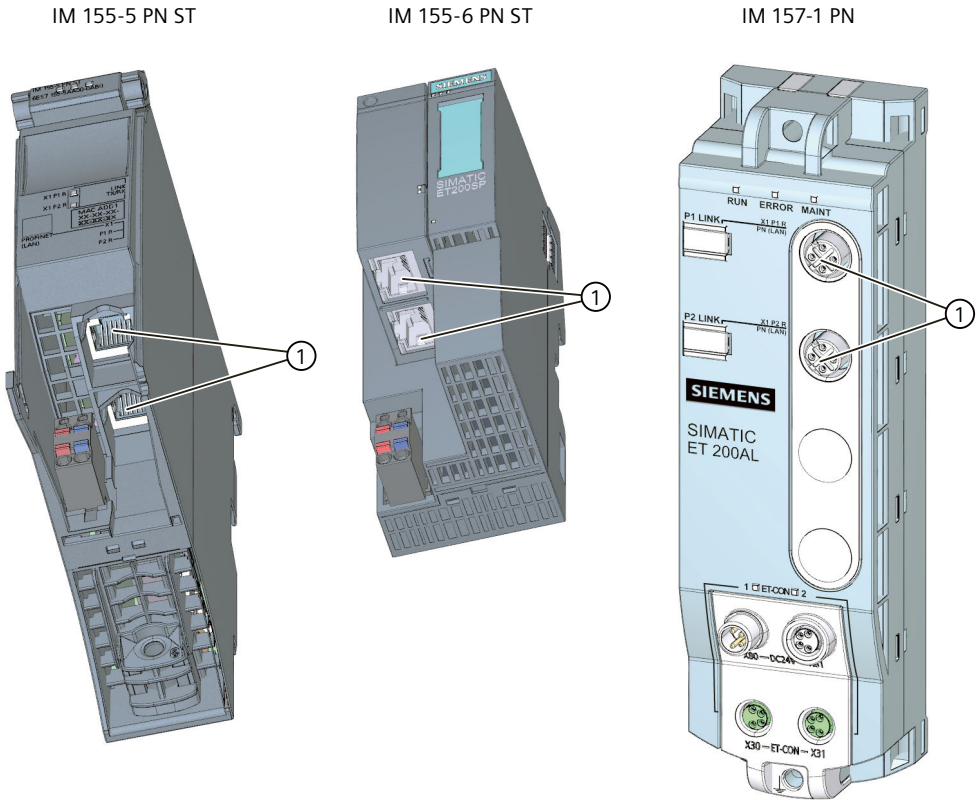

① PROFINET interface with 2-port switch

Figure 3-368 PROFINET interfaces IM 155-5 PN ST (ET 200MP), IM 155-6 PN ST (ET 200SP), and IM 157-1 PN (ET 200AL)

Deactivating the port of a PROFINET interface

Activated ports represent a potential risk of unauthorized access to the network and programs.
To minimize the risk, deactivate all unused ports.
Procedure:

1. Select the port of the PROFINET interface in the device view of the CPU/IM in STEP 7.
2. In the Inspector window, navigate to "Advanced options > Port [x]> Port options > Activate".
3. Clear the "Activate" check box.

At least one port of a CPU/IM remains activated.

Communications services

The communications services described below use the interfaces and communication mechanisms provided by the system via CPUs, communication modules and processors.

Communications services 5

5.1 Overview of communication options

Overview of communications options

The following communications options are available for your automation task.

Table 3-932 Communications options

Communications options	Functionality	Via interface:		
		PN/IE[1]	DP	serial
PG communication[2]	On commissioning, testing, diagnostics	X	X	-
HMI communication[2]	On operator control and monitoring	X	X	-
Open communication via TCP/IP[2]	Data exchange via PROFINET/Industrial Ethernet with TCP/IP Instructions: • TSEND_C/TRCV_C • TSEND/TRCV • TCON • T_DISCON	X	-	-
Open communication using ISO-on-TCP[2]	Data exchange via PROFINET/Industrial Ethernet with ISO-on-TCP Instructions: • TSEND_C/TRCV_C • TSEND/TRCV • TCON • T_DISCON	X	-	-
Open communication via UDP[2]	Data exchange via PROFINET/Industrial Ethernet with UDP Instructions: • TSEND_C/TRCV_C • TUSEND/TURCV • TCON • T_DISCON	X	-	-
Open communication via ISO (only CPs with PROFINET/Industrial Ethernet interface)	Data exchange via PROFINET/Industrial Ethernet with the ISO protocol Instructions: • TSEND_C/TRCV_C • TSEND/TRCV • TCON • T_DISCON	X	-	-

1 IE - Industrial Ethernet

2 Observe the special characteristics for S7-1500R/H

3 Only via internal PROFINET interface of the CPU and via Ethernet interface CP 1543 1 with activated "Access to PLC via communication module" function

Communications options	Functionality	Via interface:		
		PN/IE[1]	DP	serial
Open communication with FDL (only CM 1542-5 as of firmware V2.0)	Data exchange via PROFIBUS with the FDL protocol Instructions: • TSEND_C/TRCV_C • TSEND/TRCV • TUSEND/TURCV • TCON • T_DISCON	-	X	-
OPC UA server[3]	Data exchange with OPC UA clients	X	-	-
Communication via Modbus TCP	Data exchange via PROFINET with Modbus TCP protocol Instructions: • MB_CLIENT • MB_SERVER	X	-	-
Email	Sending process alarms via email Instruction: • TMAIL_C	X	-	-
FTP (only CPs with PROFINET/Industrial Ethernet interface)	File management and file access via FTP (File Transfer Protocol); CP can be FTP client and FTP server Instruction: • FTP_CMD	X	-	-
Fetch/Write (only CPs with PROFINET/Industrial Ethernet interface)	Server services via TCP/IP, ISO-on-TCP and ISO Via special instructions for Fetch/Write	X	-	-
S7 communication	Data exchange via PROFINET/PROFIBUS with the S7 protocol. Instructions: • PUT/GET • BSEND/BRCV • USEND/URCV	X	X	-
Serial point-to-point connection	Data exchange via point-to-point with Freeport, 3964(R), USS or Modbus protocol Via special instructions for PtP, USS or Modbus RTU	-	-	X
Web server	Data exchange via HTTP(S), for example for diagnostics	X	-	-
SNMP (Simple Network Management Protocol)	For monitoring and error recognition of IP networks, possibly parameterization of the IP network components via standard SNMP protocol	X	-	-
Time-of-day synchronization	Via PN/IE interface: CPU is NTP client (Network Time Protocol)	X	-	-
	Via DP interface: CPU/CM/CP is time-of-day master or time slave	-	X	-

1 IE - Industrial Ethernet

2 Observe the special characteristics for S7-1500R/H

3 Only via internal PROFINET interface of the CPU and via Ethernet interface CP 1543 1 with activated "Access to PLC via communication module" function

Information on S7-1500R/H

You can find information on the communication options with the S7-1500R/H redundant system in the section Communication with the redundant system S7-1500R/H (Page 457) and in the S7-1500R/H System Manual (https://support.industry.siemens.com/cs/us/en/view/109754833).

More information

- An application example for the configuration of the TLS-based PG/HMI communication and protection of confidential configuration data of the CPU can be found in this Application example (https://support.industry.siemens.com/cs/ww/en/view/109798583).
- A general application example for CPU-CPU communication with SIMATIC controllers (compendium) can be found in this application example (https://support.industry.siemens.com/cs/ww/en/view/20982954).
- A TIA library "LOpcUa", which provides you with function blocks for the implementation of OPC UA PubSub for SIMATIC S7-1500, can be found in this Application example (https://support.industry.siemens.com/cs/ww/en/view/109782455).

- This FAQ (https://support.industry.siemens.com/cs/ww/en/view/102420020) describes how to configure fetch/write communication via CP1543-1 with S7-1500.
- More information about the Fetch/Write services is available in the STEP 7 online help.

- You can find more information on the PtP connection in the function manual CM PtP - Configurations for Point-to-Point Connections (https://support.industry.siemens.com/cs/us/en/view/59057093).
- You will find the description of the web server functionality in the function manual Web server (https://support.industry.siemens.com/cs/us/en/view/59193560).

- You can find general information about the standard protocol SNMP on the Service & Support pages on the Internet (https://support.industry.siemens.com/cs/us/en/view/15166742). Answers to the question of which SNMP requests support S7-1500 CPUs and S7-1200 CPUs can be found in this FAQ (https://support.industry.siemens.com/cs/at/en/view/79993228).
- You will find information about time-of-day synchronization in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/86535497).

5.2 Communications protocols and port numbers used for Ethernet communication

This section provides an overview of the supported protocols and port numbers used for communication over PN/IE interfaces. For each protocol the address parameters, the respective communications layer as well as the communications role and the communications direction are specified.

This information makes it possible to match the security measures for protection of the automation system to the used protocols (for example firewall). Because the security measures are limited to Ethernet or PROFINET networks, the tables do not include PROFIBUS protocols.

NOTE

Port numbers used

The specified port numbers are the standard port numbers used by S7-1500 CPUs, communications modules and ET 200 interface modules. Many communication protocols and implementations enable you to use other port numbers.

The following tables show the different layers and protocols used in S7-1500 CPUs, S7-1500 communications modules and ET 200 interface modules.

Layers and protocols of the S7-1500 CPUs and Software Controllers (via PROFINET interface of the CPU)

The following table shows the protocols supported by S7-1500 CPUs, ET 200SP CPUs, and the 1513/1516pro-2 PN CPUs. The S7-1500 Software Controllers also support the protocols listed in the following table for the Ethernet interfaces that are assigned to the Software Controller.

Table 3-933 Layers and protocols of the S7-1500 CPUs and Software Controllers (via PROFINET interface of the CPU)

Protocol / Role	Port number	(2) Link layer (4) Transport layer	Description / function	Default setting / notes
PROFINET protocols				
DCP	Not relevant	(2) Ethertype 0x8892 (PROFINET)	PROFINET Discovery and Basic Configuration Protocol. DCP determines PROFINET devices and enables the basic settings.	Default: Up to FW version V3.0 enabled, as of FW version V3.1 write protection enabled. DCP does not allow DCP Set commands from the outside in write-protected mode during an active communication relationship. Function can be deactivated in the CPU properties by Boundary "End of detection of accessible nodes" of the interface.
DHCP Client	68	(4) UDP	Dynamic Host Configuration Protocol. The IP address suite is obtained from a DHCP server during the startup of the PROFINET interface.	Default: Deactivated. Can be changed in the CPU properties (as of FW version 2.9).

[1] Note: OUC (Open User Communication) provides direct access to the UDP and TCP protocols. You must take into consideration the IANA (Internet Assigned Numbers Authority) port restrictions and definitions.

[2] Do not use ports for OUC, which are already used by other protocols.

Protocol / Role	Port number	(2) Link layer (4) Transport layer	Description / function	Default setting / notes
LLDP	Not relevant	(2) Ethertype 0x88CC (LLDP)	PROFINET Link Layer Discovery Protocol. LLDP determines and manages neighborhood relations between PROFINET devices.	Default: Activated. Send function can be deactivated by Boundary "End of topology discovery" in the CPU properties; readiness to receive remains active. LLDP uses the special multicast MAC address 01-80-C2-00-00-0E.
MRP	Not relevant	(2) Ethertype 0x88E3 (IEC 62493-2)	Media Redundancy Protocol. MRP enables control of redundant transmission paths in a ring topology.	Default: "Manager (Auto)". Can be changed in the CPU properties. If you configure the CPU and connect the PN interface with a subnet, the default setting in the TIA Portal is "Not device in the ring". MRP uses standard-compliant multicast MAC addresses.
PROFINET IO data	Not relevant	(2) Ethertype 0x8892 (PROFINET)	PROFINET Cyclic IO Data Transfer. With PROFINET IO telegrams, IO data is transferred cyclically between the PROFINET IO controller and IO devices via Ethernet.	Default: Deactivated. The protocol is only activated for PROFINET IO data traffic.
PROFINET Context Manager	34964	(4) UDP	PROFINET communication. Management of application and communication relationships between IO controller and IO devices.	Default: Activated (UDP port open). This function cannot be deactivated.
PTCP	Not relevant	(2) Ethertype 0x8892 (PROFINET)	PROFINET Precision Transparent Clock Protocol, based on IEEE 1588. PTCP provides a time delay measurement between RJ45 ports and thus the send clock and time synchronization.	Default: Deactivated. Can be activated by the following configurations: • IRT with a sync domain. • Port interconnection with a specified cable length. Function can be deactivated in the CPU properties by "End of sync domain" Boundary of the interface. PTCP uses standard-compliant multicast MAC addresses.
Connection-oriented communication protocols				
HTTP Server	80	(4) TCP	Hypertext Transfer Protocol. HTTP is used for communication with the CPU-internal web server.	Default: Deactivated. Can be enabled in the CPU properties. Requirement: Web server in the CPU properties is enabled.
HTTPS Server	443	(4) TCP	Hypertext Transfer Protocol Secure. HTTPS is used for communication with the CPU-internal Web server via Secure Socket Layer (SSL).	Default: Deactivated. Can be enabled in the CPU properties. Requirement: Web server in the CPU properties is enabled.

[1] Note: OUC (Open User Communication) provides direct access to the UDP and TCP protocols. You must take into consideration the IANA (Internet Assigned Numbers Authority) port restrictions and definitions.

[2] Do not use ports for OUC, which are already used by other protocols.

Protocol / Role	Port number	(2) Link layer (4) Transport layer	Description / function	Default setting / notes
IGMPv2	Not relevant	(3) Network layer	Internet Group Management Protocol. IGMPv2 is a network protocol for the organization of multicast groups (UDP multicast only).	IGMPv2 is a functionality of the IP stack. This system function is activated by the multicast function.
ISO-on-TCP Server	102	(4) TCP	ISO-on-TCP protocol (according to RFC 1006). The S7 protocol uses ISO-on-TCP according to RFC 1006 for PG/HMI communication with the engineering system (TIA Portal).	Default: Activated. This function cannot be deactivated.
Modbus TCP Server / Client	502	(4) TCP	Modbus Transmission Control Protocol. Modbus/TCP is used by MB_CLIENT/MB_SERVER instructions in the user program.	Default: Deactivated. Can be activated via Modbus instructions in the user program.
NTP Client	49152 ... 65535	(4) UDP	Network Time Protocol. NTP is used for synchronization of the CPU system time with the time of an NTP server.	Default: Deactivated. Can be enabled in the CPU properties.
OPC UA Server / Client	4840	(4) TCP	Open Platform Communications Unified Architecture (based on TCP/IP protocol). A communication standard ranging from the enterprise level to the field level.	Default: Deactivated. Server and client function can be enabled in the CPU properties. Client access can be configured in the user program.

[1] Note: OUC (Open User Communication) provides direct access to the UDP and TCP protocols. You must take into consideration the IANA (Internet Assigned Numbers Authority) port restrictions and definitions.

[2] Do not use ports for OUC, which are already used by other protocols.

Protocol / Role	Port number	(2) Link layer (4) Transport layer	Description / function	Default setting / notes
OUC[1] Secure OUC Server / Client	1 ... 1999 can be used to limited extent[2] 2000 ... 5000 Recommended As of FW version V3.0, the following applies to programmed and configured connections: 5001 ... 65535 can be used to limited extent[2]	(4) TCP (4) UDP (4) ISO-on-TCP (Port: 102)	Open User Communication (TCP/UDP). Secure Open User Communication (TLS). OUC instructions enable connection establishment, connection termination and data transfer via the user program.	Default: Deactivated. You activate the respective protocol with the corresponding Open User Communication instruction in the user program or with the configuration of connections in the network view. The following applies to FW versions lower than V3.0: • Programmed connections: 5001 ... 49152 • Configured connections: 5001 ... 65535
SMTP Client	25	(4) TCP	Simple Mail Transfer Protocol. SMTP is used for sending emails.	Default: Deactivated. Can be enabled via TMAIL_C instruction in the user program.
SMTPS (SMTP over TLS) Client	465	(4) TCP	Simple Mail Transfer Protocol Secure. SMTP is used for sending emails over secure connections.	Default: Deactivated. Can be enabled via TMAIL_C instruction in the user program.
SMTP with STARTTLS Client	25 587	(4) TCP	Simple Mail Transfer Protocol with the SMTP command "STARTTLS". SMTP is used for sending emails.	Default: Deactivated. Can be enabled via TMAIL_C instruction in the user program.
SNMP Agent	161	(4) UDP	Simple Network Management Protocol. SNMP is used for reading and setting of network management data (SNMP-managed objects) by the SNMP manager. The SNMP agent does not support traps.	Default: Activated up to FW version V2.9, deactivated as of FW version V3.0. Can be enabled via data record in the user program. Can be enabled in the CPU properties as of FW version V3.0. As of FW version V3.1, can additionally be enabled as write-protected in the CPU properties.

1 Note: OUC (Open User Communication) provides direct access to the UDP and TCP protocols. You must take into consideration the IANA (Internet Assigned Numbers Authority) port restrictions and definitions.

2 Do not use ports for OUC, which are already used by other protocols.

Protocol / Role	Port number	(2) Link layer (4) Transport layer	Description / function	Default setting / notes
Syslog Client	6514 514	(4) TCP (4) UDP	System logging. Syslog is an IETF standard protocol (RFC 5424) for the transmission of events that a CPU detects.	Default: Deactivated. Can be enabled in the CPU properties. You can configure the forwarding of syslog messages to a syslog server in the CPU properties. The collection of system logging events within a CPU cannot be disabled as of FW version V3.1.
Reserved	49152 ... 65535	(4) TCP (4) UDP	If an application does not address a local port, then the CPU uses this port range for the active connection point. For connected IO devices, an IO controller opens a further port (client port) from this area for each protocol used. The port is selected at random.	-

1 Note: OUC (Open User Communication) provides direct access to the UDP and TCP protocols. You must take into consideration the IANA (Internet Assigned Numbers Authority) port restrictions and definitions.

2 Do not use ports for OUC, which are already used by other protocols.

Layers and logs of the S7-1500 Software Controller (via Ethernet interface on the Windows side)

The following table shows the protocols that are supported by the S7-1500 Software Controller via the Ethernet interfaces assigned by Windows.

Table 3-934 Layers and logs of the S7-1500 Software Controller (via Ethernet interface on the Windows side)

Protocol / Role	Port number	(2) Link layer (4) Transport layer	Description / function	Notes / default setting
PROFINET protocols				
DCP	Not relevant	(2) Ethertype 0x8892 (PROFINET)	PROFINET Discovery and Basic Configuration Protocol. DCP determines PROFINET devices and enables the basic settings.	Default: Enabled up to version V30.0. Write-protection enabled as of version V30.1 . DCP does not allow DCP Set commands from the outside in write-protected mode during an active communication relationship. Function can be disabled with Boundary "End of detection of accessible nodes" in the CPU properties.
DHCP Client	68	(4) UDP	Dynamic Host Configuration Protocol. The IP address suite is obtained from a DHCP server during the startup of the PROFINET interface.	Default: Deactivated. Can be changed in the CPU properties (as of FW version 2.9).

1 Default setting for Windows assigned interfaces: 81

2 Note: OUC (Open User Communication) provides direct access to the UDP and TCP protocols. You must take into consideration the IANA (Internet Assigned Numbers Authority) port restrictions and definitions.

3 Do not use ports for OUC, which are already used by other protocols.

4 Do not use ports for OUC, which are already used by other Windows applications.

Protocol / Role	Port number	(2) Link layer (4) Transport layer	Description / function	Notes / default setting
Connection-oriented communication protocols				
HTTP Server	Adjustable [1]	(4) TCP	Hypertext Transfer Protocol. HTTP is used for communication with the CPU-internal web server.	Default: Deactivated. Can be changed in the CPU properties. Adapt the port number to avoid conflicts with other web servers under Windows. If you use the Web server access of the S7-1500 Software Controller, you must enable the assigned port in the Windows firewall.
IGMPv2	Not relevant	(3) Network layer	Internet Group Management Protocol. IGMPv2 is a network protocol for the organization of multicast groups (UDP multicast only).	IGMPv2 is a functionality of the IP stack. This system function is activated by the multicast function.
ISO-on-TCP Server	102	(4) TCP	ISO-on-TCP protocol (according to RFC 1006). The S7 protocol uses ISO-on-TCP according to RFC 1006 for PG/HMI communication with the engineering system (TIA Portal).	Default: Deactivated.
OUC[2] and Secure OUC	1 ... 1999 can be used to limited extent[3, 4]	(4) TCP (4) UDP (4) ISO-on-TCP (Port: 102)	Open User Communication (TCP/UDP). Secure Open User Communication (TLS). OUC instructions enable connection establishment, connection termination and data transfer based on the socket layer.	Default: Deactivated. Can be enabled via data record in the user program. If you want to use OUC, you must activate the ports in the Windows Firewall.
	2000 ... 5000 recommended[4]			
	5001 ... 49151 can be used to limited extent[3, 4]			
SMTP Client	25	(4) TCP	Simple Mail Transfer Protocol. SMTP is used for sending emails.	Default: Deactivated. Can be activated by calling the block in the user program or as of version V3.0 via CPU settings.
Syslog Client	6514 514	(4) TCP (4) UDP	System logging. Syslog is an IETF standard protocol (RFC 5424) for the transmission of events that a CPU detects.	Default: Deactivated. Can be enabled in the CPU properties. You can configure the forwarding of syslog messages to a syslog server in the CPU properties. The collection of system logging events within a CPU cannot be disabled as of FW version V3.1.

Protocol / Role	Port number	(2) Link layer (4) Transport layer	Description / function	Notes / default setting
Reserved	49152 ... 65535	(4) TCP (4) UDP	If the application does not specify the local port number, this dynamic port range is used for the active connection end point.	If you want to use this communication, you must activate the ports in the Windows Firewall.

1 Default setting for Windows assigned interfaces: 81

2 Note: OUC (Open User Communication) provides direct access to the UDP and TCP protocols. You must take into consideration the IANA (Internet Assigned Numbers Authority) port restrictions and definitions.

3 Do not use ports for OUC, which are already used by other protocols.

4 Do not use ports for OUC, which are already used by other Windows applications.

Layers and protocols of S7-1500 communications modules

The documentation for the protocols of S7-1500 communications modules (e.g. CP 1543-1) can be found here (https://support.industry.siemens.com/cs/ww/en/view/67700710).

Layers and protocols of interface modules

The following table shows the protocols supported by ET 200 interface modules. To find out which protocols your ET 200 interface module supports, refer to the technical specifications in the relevant equipment manual.

Table 3-935 Layers and protocols of the ET 200 interface modules

Protocol / Role	Port number	(2) Link layer (4) Transport layer	Description / function	Default setting / notes
PROFINET protocols				
DCP	Not relevant	(2) Ethertype 0x8892 (PROFINET)	PROFINET Discovery and Basic Configuration Protocol. DCP determines PROFINET devices and enables the basic settings.	Default setting for supported interface modules if the higher-level IO controller also supports DCP: • Write-protection enabled DCP does not allow DCP Set commands from the outside in write-protected mode during an active communication relationship. Function can be deactivated in the properties of the PROFINET interface.
LLDP	Not relevant	(2) Ethertype 0x88CC (LLDP)	PROFINET Link Layer Discovery Protocol. LLDP determines and manages neighborhood relations between PROFINET devices.	Default: Activated. Send function can be deactivated by Boundary "End of topology discovery" in the properties of the PROFINET interface; readiness to receive remains active. LLDP uses the special multicast MAC address 01-80-C2-00-00-0E.

Protocol / Role	Port number	(2) Link layer (4) Transport layer	Description / function	Default setting / notes
MRP	Not relevant	(2) Ethertype 0x88E3 (IEC 62493-2)	Media Redundancy Protocol. MRP enables control of redundant transmission paths in a ring topology.	Default: "Not device in the ring". Can be changed in the properties of the PROFINET interface. If you want to configure the interface module and activate MRP, assign the "Client" media redundancy role to the interface module. MRP uses standard-compliant multicast MAC addresses.
PROFINET IO data	Not relevant	(2) Ethertype 0x8892 (PROFINET)	PROFINET Cyclic IO Data Transfer. With PROFINET IO telegrams, IO data is transferred cyclically between the PROFINET IO controller and IO devices via Ethernet.	Default: Deactivated. Is activated indirectly as soon as the interface module receives a valid configuration.
PROFINET Context Manager	34964	(4) UDP	PROFINET communication. Management of application and communication relationships between IO controller and IO devices.	Default: Activated (UDP port open). This function cannot be deactivated.
PTCP	Not relevant	(2) Ethertype 0x8892 (PROFINET)	PROFINET Precision Transparent Clock Protocol, based on IEEE 1588. PTCP enables the following functions: • Time delay measurement between two ports • Send clock and time synchronization	Default setting for time delay measurement: Activated for supported interface modules. PTCP cannot be deactivated for time delay measurement. Default setting for send clock and time synchronization: Deactivated. Can be activated by the higher-level IO controller according to the configuration. PTCP uses standard-compliant multicast MAC addresses.
Connection-oriented communication protocols				
IGMPv2	Not relevant	(3) Network layer	Internet Group Management Protocol. IGMPv2 is a network protocol for the organization of multicast groups (UDP multicast only).	IGMPv2 is a functionality of the IP stack. This system function is activated by the multicast function.
MODBUS TCP Slave	502	(4) TCP	MODBUS Transmission Control Protocol.	Default: Deactivated. Can be activated via MultiFieldbus Configuration Tool (MFCT).
SNMP Agent	161	(4) UDP	Simple Network Management Protocol. SNMP is used for reading and setting of network management data (SNMP-managed objects) by the SNMP manager. The SNMP agent does not support traps.	Default setting for supporting interface modules: • Synchronize default values from IO controller • Deactivated
EtherNet/IP	44818	(4) TCP	The EtherNet/IP protocol and Com-	Default: Deactivated.

Protocol / Role	Port number	(2) Link layer (4) Transport layer	Description / function	Default setting / notes
CIP	(TCP) 2222 (UDP)	(4) UDP	mon Industrial Protocol (CIP) protocols enable communication between interface modules and CPUs. EtherNet/IP use MultiFieldbus devices for data exchange. CIP Implicit Messaging is used for the continuous transmission of real-time data in time-critical applications. CIP Explicit Messaging is used for the targeted retrieval or transmission of configuration and diagnostic data.	Can be activated via MultiFieldbus Configuration Tool (MFCT).
TCP/IP	Not relevant	(4) TCP	Transmission Control Protocol. TCP ensures a reliable connection between 2 communication partners.	Default: Activated. This function cannot be deactivated.
UDP	Not relevant	(4) UDP	User Datagram Protocol. UDP works without a connection and is based on the unsecured Internet Protocol (IP).	Default: Activated. This function cannot be deactivated.
ARP	Not relevant	(2) Ethertype 0x0806	Address Resolution Protocol. Assignment of the IP addresses to the MAC addresses.	Default: Activated. This function cannot be deactivated.
IPv4	Not relevant	(3) Network layer	Internet Protocol Version 4. Identification of devices by IP addresses. IPv4 is used to send data packets from their origin to their destination.	Default: Activated. This function cannot be deactivated.
Reserved	49152 ... 65535	(4) TCP (4) UDP	If an application does not address a local port, then the CPU uses this port range for the active connection point. For connected IO devices, an IO controller opens a further port (client port) from this area for each protocol used. The port is selected at random.	-

5.3 Overview of connection resources

Connection resources

Some communications services require connections. Connections allocate resources on the CPUs, CPs and CMs involved (for example memory areas in the CPU operating system). In most cases one resource per CPU/CP/CM is allocated for a connection. In HMI communication, up to 3 connection resources are required per HMI connection.

The connection resources available depend on the CPU being used, the CPs and CMs and must not exceed a defined high limit for the automation system.

Available connection resources in a station

The maximum number of resources of a station is determined by the CPU.

Each CPU has reserved connection resources for PG, HMI and web server communication. In addition, there are available resources for other communication services, e.g. for SNMP, e-mail connections, HMI and S7 communication as well as for open communication.

When are connection resources allocated?

The time for allocation of connection resources depends on how the connection is set up, automatic, programmed or configured (see section Setting up a connection (Page 46)).

Additional information

You will find more detailed information on the allocation of connection resources and the display of connection resources in STEP 7 in the section Connection resources (Page 441).

5.4 Setting up a connection

Automatic connection

STEP 7 sets up a connection automatically (for example PG or HMI connection) if you have connected the PG/PC interface to an interface of the CPU physically and have made the interface assignment in STEP 7 in the "Go online" dialog.

Setting up a programmed connection

You set up the programmed connection in the program editor of STEP 7 in the context of a CPU by assigning instructions for communication, for example TSEND_C.

When specifying the connection parameters (in the Inspector window, in the properties of the instruction), you are supported by the easy-to-use user interface.

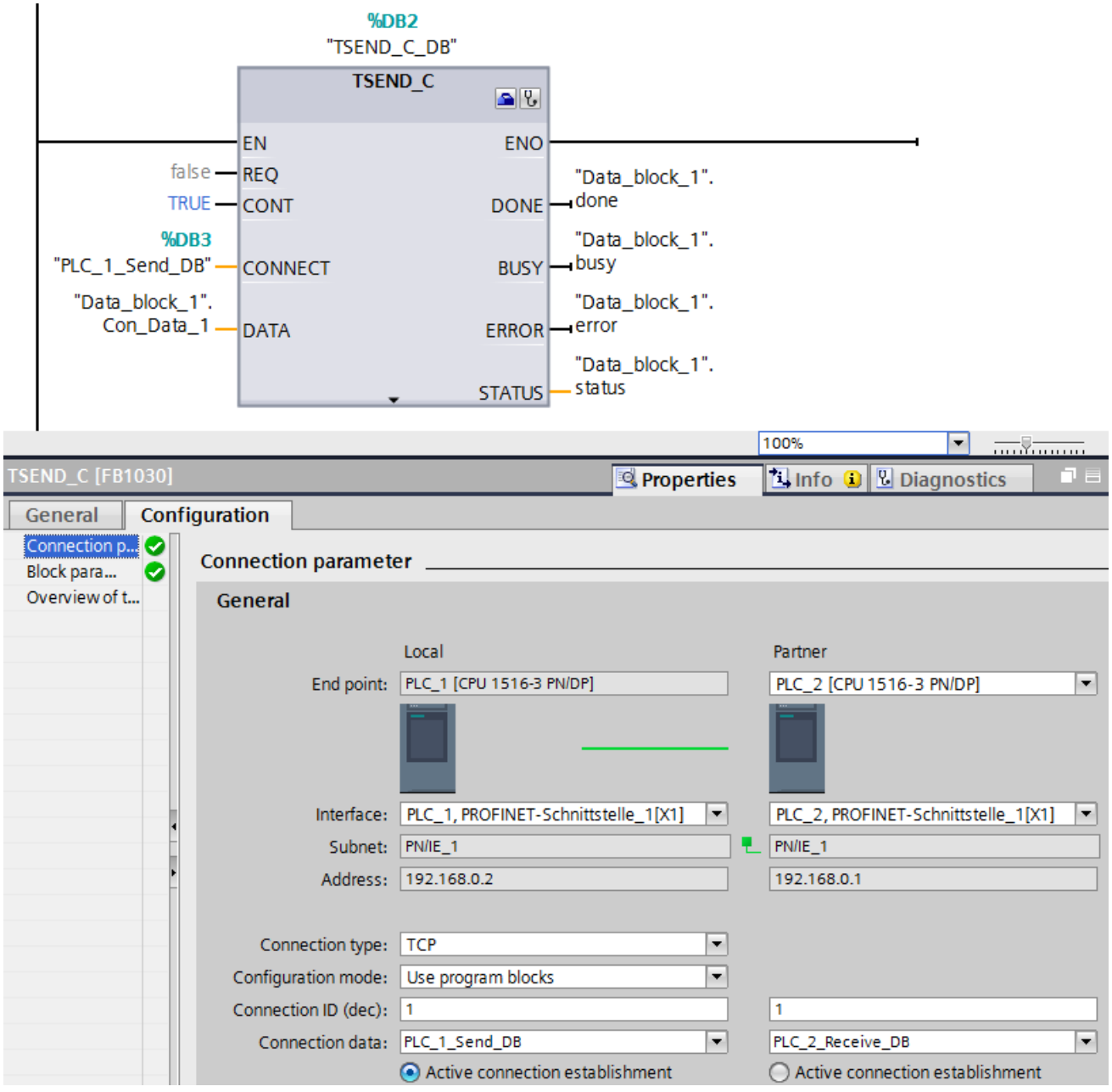

Figure 3-369 Programmed setup

Setting up a configured connection

You set up the configured connection in the network view of the Devices & networks editor of STEP 7 in the context of a CPU or a software controller.

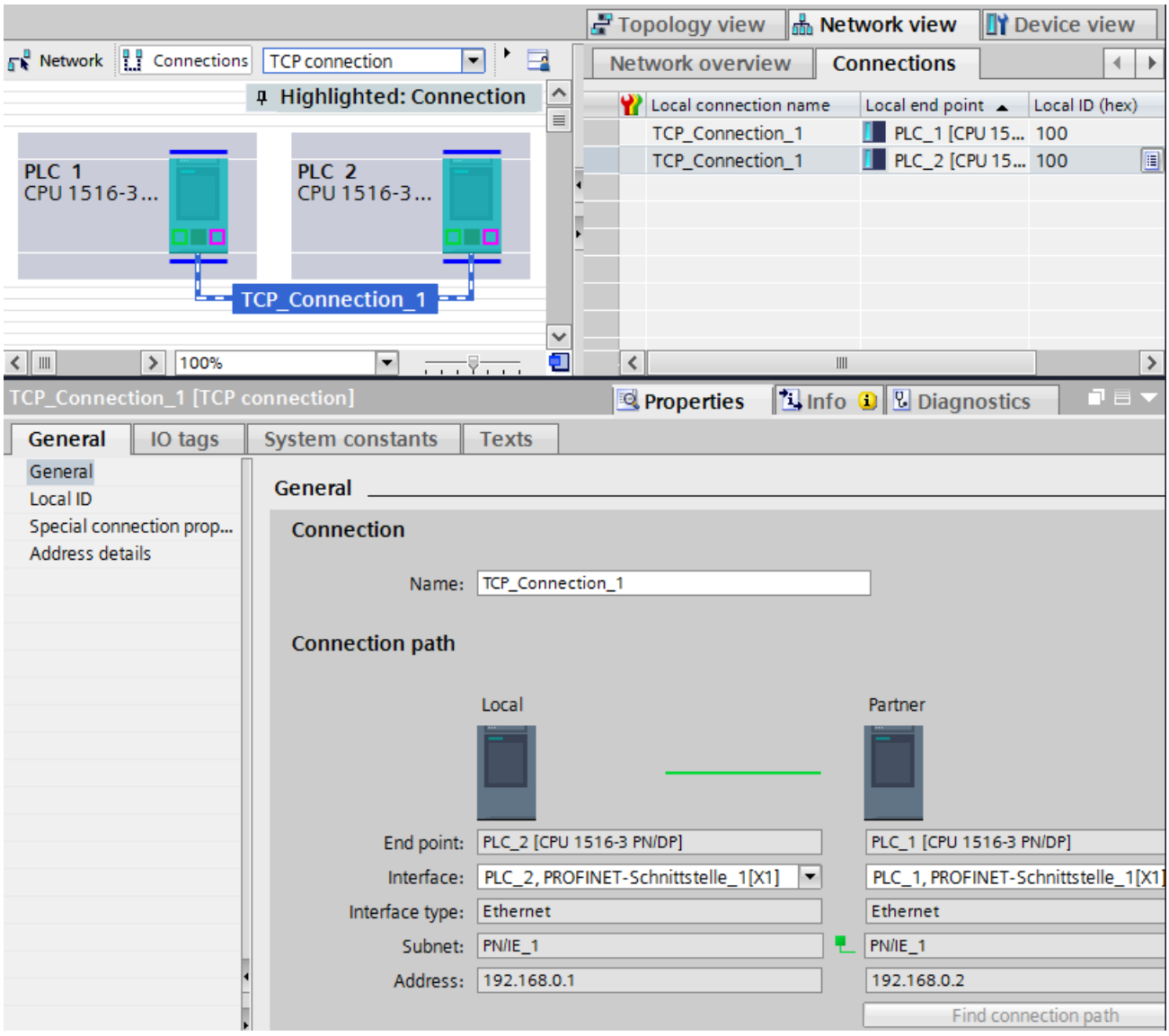

Figure 3-370 Configured setup

Effects on the connection resources of the CPU

You can often choose between a configured or a programmed connection. Programmed connection setup allows connection resources to be released following data transfer. Like routed connections, programmed connections are not guaranteed, meaning that they are only established when resources are available. With configured connection setup, the resource is available after download of the configuration until the configuration changes again. Corresponding resources are therefore reserved for connection establishment via

configured connections. The "Connection resources" table in the Inspector window of the CPU displays an overview of connection resources already used and those still available.

How do I set up a connection?

Table 3-936 Setting up the connection

Connection	Automatically	Programmed setup	Configured setup
Programming device connection	X	-	-
HMI connection	X	-	X
Web communication	X	-	-
OPC UA server communication	X	-	-
OPC UA client communication	-	X	-
Open communication via TCP/IP connection	-	X	X
Open communication via ISO-on-TCP connection	-	X	X
Open communication via UDP connection	-	X	X
Open communication via ISO connection	-	X	X
Open communication via FDL connection	-	X	X
Communication via Modbus TCP connection	-	X	-
E-mail connection	-	X	-
FTP connection	-	X	-
S7 connection*	-	-	X

* Note that for an S7-1500 CPU you must enable the use of PUT/GET communication in the properties of the CPU. You can find more information on this topic in the STEP 7 online help.

Additional information

You will find further information on the allocation of connection resources and the display of connection resources in STEP 7 in the section Connection resources (Page 441).

5.5 Data consistency

Definition

Data consistency is important for data transfer and you need to take this into account when configuring the communication task. Otherwise, malfunctions may occur.

A data area which cannot be modified by concurrent processes is called a consistent data area. There is a maximum size for consistent data areas for the transfer of CPU data.
If a data area that belongs together is larger than the maximum size of the consistent data area, it can consist of new and old data at any one time.

An inconsistency can occur when an instruction for communication is interrupted, for example by a hardware interrupt OB with higher priority. This interrupts the transfer of the data area. If the user program in this OB now changes the data that has not yet been processed by the communication instruction, the transferred data originates from different times:

The following figure shows a data area that is smaller than the maximum size of the consistent data area. In this case, when transferring the data area, it is ensured that there is no interruption by the user program during data access so that the data is not changed.

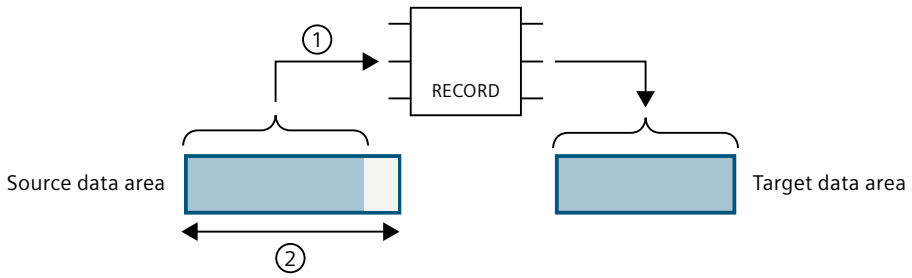

① The source data area is smaller than the maximum size of the consistent data area (②). The instruction transfers the data together to the destination data area.

② Maximum size of the consistent data area

Figure 3-371 Consistent transfer of data

The following figure shows a data area that is larger than the maximum size of the consistent data area. In this case, the data can be changed during an interruption of the data transfer. An interruption also occurs if, for example, the data area needs to be transferred in several parts. If the data is changed during the interruption, the transferred data originates from different times.

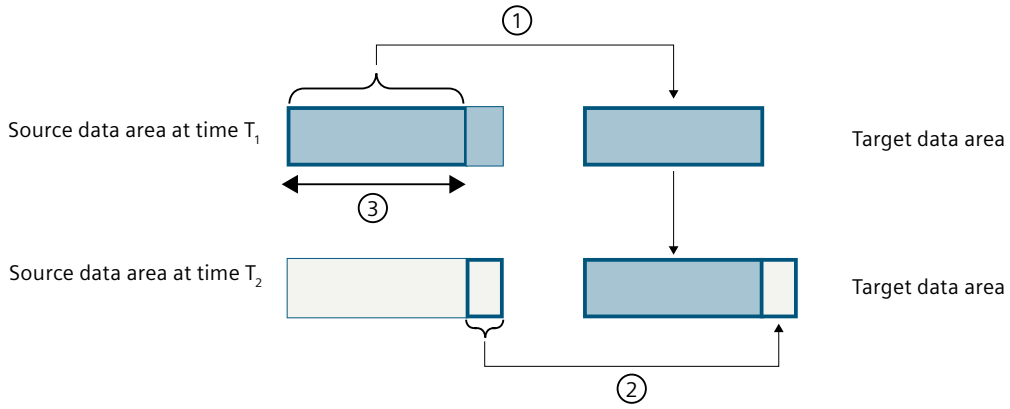

① The source data area is larger than the maximum size of the consistent data area (③). At time T1, the instruction only transfers as much data from the source data area into the destination data area as fits in the consistent data area.

② At time T2, the instruction transfers the rest of the source data area to the destination data area. After the transfer, data from different points in time exist in the destination data area. If the data in the source data area has changed in the meantime, an inconsistency may result.

③ Maximum size of the consistent data area

Figure 3-372 Transfer of data larger than the maximum consistency area

Example of an inconsistency

The figure below shows an example of changing data during the transfer. The destination data area contains data from different points in time.

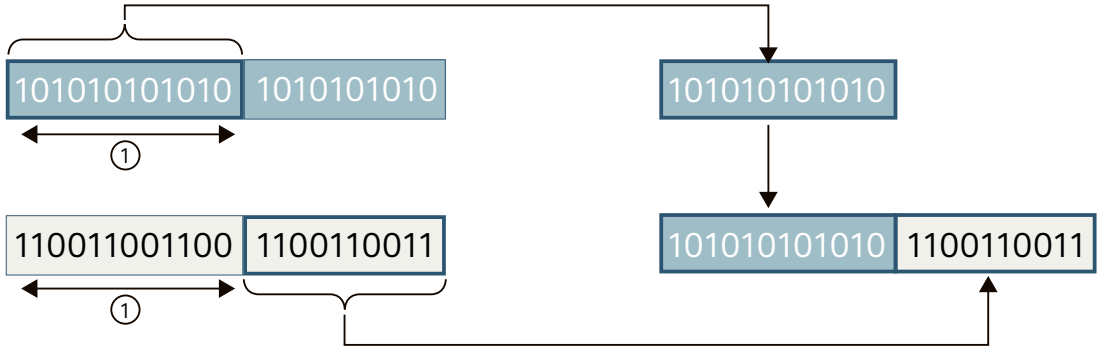

① Maximum size of the consistent data area

Figure 3-373 Example: Changing data during the transfer

System-specific maximum data consistency for S7-1500:

No inconsistency occurs if the system-specific maximum size of the consistent data is kept to. With an S7-1500, communication data is copied consistently into or out of the user memory in blocks of up to 512 bytes during the program cycle. Data consistency is not ensured for larger data areas. Where defined data consistency is required, the length of communication data in the user program of the CPU must not exceed 512 bytes. You can then access these data areas consistently, for example from an HMI device by reading/writing tags.

If more data than the system-specific maximum size needs to be transferred consistently, you yourself must ensure the data consistency with suitable measures in the user program.

Ensuring data consistency

Use of instructions for access to common data:

If the user program contains instructions for communication that access common data, for example TSEND/TRCV, you can coordinate access to this data area yourself, for example using the "DONE" parameter. The data consistency of the data areas that are transferred with an instruction for communication can therefore be ensured in the user program.

NOTE

Measures in the user program

To achieve data consistency, you can copy transferred data to a separate data area (for example, global data block). While the user program continues to work with the original data, you can transfer the data saved in the separate data area consistently with the communication instruction.

For the copying, use uninterruptible instructions such as UMOVE_BLK or UFILL_BLK. These instructions ensure data consistency up to 16 KB.

Use of PUT/GET instructions or Write/Read via HMI communication:

In S7 communication with the PUT/GET instructions or Write/Read via HMI communication, you need to take into account the size of the consistent data areas during programming or configuration. In the user program of an S7-1500 as server, there is no instruction available that can coordinate the data transfer in the user program. The data exchanged using PUT/GET instructions updates the S7-1500 while the user program is running. There is no point in time within the processing of the cyclic user program at which the data is exchanged consistently. The length of the data area to be transferred should be smaller than 512 bytes.

More information

- You will also find the maximum amount of consistent data in the device manuals of the communications modules in the Technical Specifications.
- You will find further information on data consistency in the description of the instructions in the STEP 7 online help.

5.6 Secure Communication

5.6.1 Basics of Secure Communication

5.6.1.1 Useful information on Secure Communication

For STEP 7 (TIA Portal) as of V14 and for S7-1500 CPUs as of firmware V2.0, the options for "Secure Communication" have been broadened considerably.

"S7-1500 CPUs" also refers to CPU versions S7-1500F, S7-1500T, S7-1500C as well as S7-1500pro CPUs and ET200SP CPUs.

In subsequent versions, additional components will support Secure Communication (e.g. secure OUC), see next section.

As of firmware version V4.4, S7-1200 CPUs also support Secure Communication.

Requirement

- CPUs that support connection description DBs with the structure of the SDT TCON_IP_V4_SEC or SDT TCON_QDN_SEC. These are the following CPUs:
  - S7-1200 as of firmware V4.4
  - S7-1500 as of firmware V2.0
- Also optional via the following CPs:
  - CP 1243-1 as of firmware V3.2
  - CP 1243-8 IRC as of firmware V3.2
  - CP 1543-1 as of firmware V2.0
  - CP 1545-1
  - CP 1543SP-1

  Secure Communication via CP 1242-7 GPRS V2 is not possible.

Public Key Infrastructure (PKI)

The attribute "secure" is used for the identification of communication mechanisms that are based on a Public Key Infrastructure (PKI) (for example RFC 5280 for Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List Profile). A Public Key Infrastructure (PKI) is a system that can issue, distribute and check digital certificates. The digital certificates issued are used in the PKI to secure computer-based communication. If a PKI uses asymmetric key cryptography, the messages in a network can be digitally signed and encrypted.

Components that you have configured in STEP 7 (TIA Portal) for secure communication use an asymmetric key encryption scheme with a Public Key and Private Key. TLS (Transport Layer Security) is used as the encryption protocol. TLS is the successor for the SSL (Secure Sockets Layer) protocol.

Objectives of secure communication

Secure communication is used to achieve the following objectives:

- Confidentiality
  i.e. the data are secret / cannot by read by eavesdroppers.
- Integrity
  i.e. the message that reaches the recipient is the same message, unchanged, that the sender sent. The message has not been altered on the way.
- End point authentication
  i.e. the end point communication partner is exactly who it claims to be and the party who is to be reached. The identity of the partner has been checked.

These objectives were in the past primarily relevant to IT and networked computers. Now, industrial machinery and control systems with sensitive data are at equally high risk, as they are also networked, and consequently pose strict security requirements for data exchange.

Protection of the automation cell by means of the cell protection concept through firewall, or via connection through VPN, for example with the security module, was common in the past and remains so.

However, it is becoming increasingly necessary to also transfer data to external computers in encrypted form via Intranet or public networks.

Common principles of secure communication

Independent of the context, secure communication is based on the concept of the Public Key Infrastructure (PKI) and contains the following components:

- An asymmetric encryption scheme that allows:
  - Encryption or decryption of messages using public or private keys.
  - The verification of signatures in messages and certificates.

    The messages/certificates are signed by the sender/certificate subject with their private key. The recipient/verifier checks the signature with the public key of the sender/certificate subject.
- Transport and storage of the public key using X.509 certificates:
  - X.509 certificates are digitally signed data that allow public key authentication in terms of the bound identity.
  - X.509 certificates can contain information that describes in more detail or restricts use of the public key. For example the date as of which a public key in a certificate is valid and when it expires.
  - X.509 certificates contain information about the issuer of the certificate in secure form.

The following paragraphs give an overview of these basic concepts, which are required for managing certificates in STEP 7 (TIA Portal), for example, and for programming communication instructions for secure Open User Communication (sOUC).

Secure communication with STEP 7

STEP 7 as of V14 provides the required PKI for the configuration and operation of secure communication.

Examples:

- The Hypertext Transfer Protocol (HTTP) becomes the Hypertext Transfer Protocol Secure (HTTPS) using TLS (Transport Layer Security) protocol. Since HTTPS is a combination of HTTP and TLS, it is called "HTTP over TLS" in the corresponding RFC. You can see in the browser that HTTPS is being used; this is indicated by the URL "https://" instead of "http://" in the address bar of the browser. Most browsers highlight such secure connections.
- Open User Communication turns into secure Open User Communication. The underlying protocol is also TLS.
- Email providers also offer access over the "Secure SMTP over TLS" protocol to increase the security of email communication.

The figure below shows the TLS protocol in the context of communication layers.

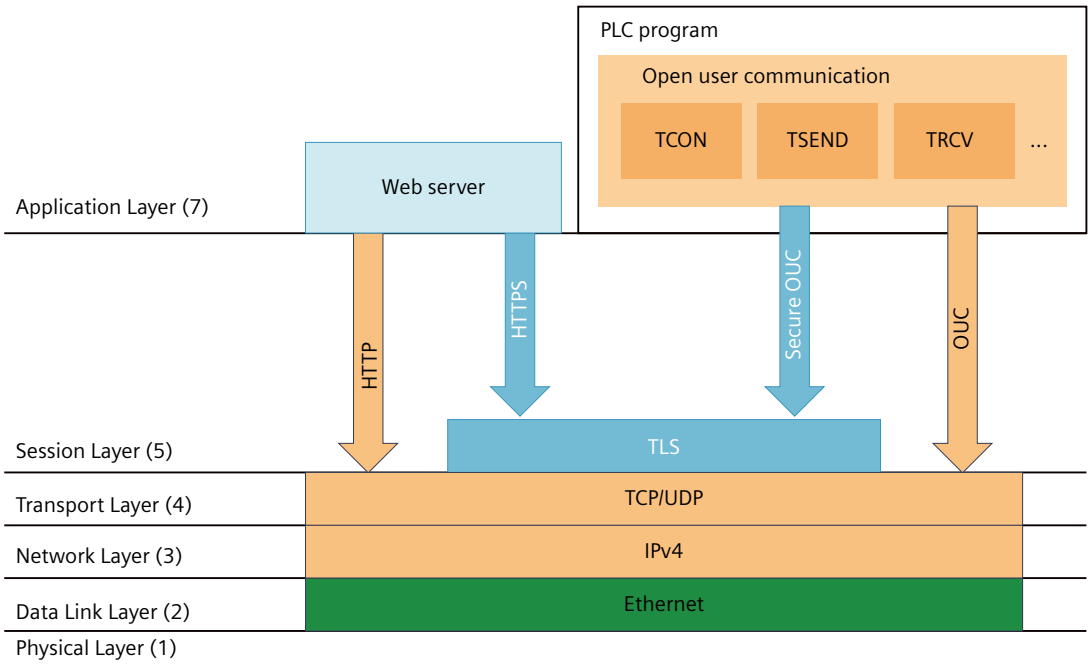

Figure 3-374 TLS protocol in the context of communication layers

Secure communication with OPC UA

An OPC UA server is implemented in S7-1500 CPUs as of firmware V2.0. OPC UA Security also covers authentication, encryption and data integrity with digital X.509 certificates and also uses a Public Key Infrastructure (PKI). Depending on the requirements placed by the application, you can select different security levels for the end point security. The description of the OPC UA server functionality is covered in a separate section.

Secure communication for PG/HMI communication

With the central components of the TIA Portal, STEP 7 and WinCC, an innovative and standardized Secure PG/PC and HMI Communication - PG/HMI communication for short - is implemented starting with version V17 together with the latest controllers and latest HMI devices.

More information

You can find more information on OPC UA in the section Using the S7-1500 as an OPC UA server (Page 233).

For more information on secure programming device/HMI communication, refer to the section Secure PG/HMI communication (Page 110).

5.6.1.2 Device-dependent security features

Transport Layer Security (TLS) is a widespread security protocol that improves the data security for communications. For the S7-1500 automation system, TLS is used for secure communication for the following certificate-based applications:

- Web server (HTTPS protocol variant)
- Secure Open User Communication (OUC) including secure email (TMAIL_C instruction)
- Secure PG/HMI communication

TLS takes care of the authenticity, confidentiality and integrity of the communication between client and server for the listed applications, for example, between the web server of CPU and web browsers, which, for example, have to display a diagnostics web page of the CPU.

The OPC UA server and OPC UA client applications do not actually directly use TLS, but the cryptographical processes used are comparable.

TLS is continuously being further developed, resulting in various TLS versions, which are distinct with regard to the cipher suites (standardized collection of cryptographic methods) supported and the performance.

The Internet Engineering Task Force (IETF) is responsible for the description of the TLS protocol. The following correlation applies:

- TLS 1.3 corresponds to RFC 8446
- TLS 1.2 corresponds to RFC 5246

In addition, not every device supports all the cryptographic methods defined in the RFCs. Therefore, after establishing the connection, the client and server negotiate a method that both support (Handshake) as well as the parameters to be used.

Supported TLS versions S7-1500

The following table shows, which TLS versions are supported in a given CPU firmware version.

CPU firmware version	Supported TLS version
as of V2.9	TLS 1.2, TLS 1.3
V2.8 ... V2.0	TLS 1.2

Supported encryption methods and parameters for creating certificates

To generate the public key for a new certificate, in the TIA Portal, set the encryption method and encryption parameters. These certificate parameters are device-dependent and dependent on the application used

One possibility: In the CPU properties, go to "Protection & Security > Certificate manager" and generate a new device certificate. You can find settings for the encryption method and the encryption parameters under "Certificate Parameters" in the "Generate Certificates" dialog.

Example: RSA 2048 stands for asymmetric RSA encryption method with cryptographic key length 2048 bits.

NOTE

Key lengths no longer recommended

RSA key lengths less than 3000 bits are no longer considered secure and lead to a warning during compiling as of TIA Portal V21 and a configured CPU with FW version V4.1.

As of TIA Portal V21 and a configured CPU with FW version V4.1, using the 1024-bit RSA key length leads to an error.

The following table shows the supported encryption methods and encryption parameters depending on the CPU application or services.

Encryption method/parameters S7-1500	Web server (HTTPS) Secure PG/HMI communication Secure OUC	OPC UA
EC prime256v1	Yes	No
EC secp384r1	Yes	No
EC secp256k1	No	No
RSA 1024	Yes, up to FW V4.0*	Yes, up to FW V4.0*
RSA 2048	Yes	Yes
RSA 3072	Yes	Yes
RSA 4096	Yes	Yes
RSA 8192	No	No

* A CPU with FW version V4.1 or higher only supports RSA 1024 in a spare part scenario, i.e. you load the configuration of a CPU with FW version up to V4.0 onto a CPU with FW version V4.1.

5.6.1.3 Confidentiality through encryption

Message encryption is an important element of data security. When encrypted messages are intercepted by third parties during communication, these potential eavesdroppers cannot access the information they contain.

There is a wide range of mathematical processes (algorithms) for encrypting messages.

All algorithms process a "key" parameter to encrypt and decrypt messages.

- Algorithm + key + message => encrypted message
- Encrypted message + key + algorithm => (decrypted) message

Symmetric encryption

The central aspect of symmetric encryption is that both communication partners use the same key for message encryption and decryption, as shown in the figure below. Bob uses the same key for encryption as Alice uses for decryption. In general, we also say that the two sides share the secret key with which they encrypt or decrypt a message as a secret.

① Bob encrypts his message with the symmetric key

② Alice decrypts the encrypted message with the symmetric key

Figure 3-375 Symmetric encryption

The process can be compared to a briefcase to which the sender and recipient have the same key, which both locks and opens the case.

- Advantage: Symmetric encryption algorithms (such as AES, Advanced Encryption Algorithm) are fast.
- Disadvantages: How can the key be sent to a recipient without getting into the wrong hands? This is a key distribution problem. If enough messages are intercepted, the key can also be worked out and must therefore be changed regularly.

If there are a large number of communication partners, there is also a large number of keys to distribute.

Asymmetric encryption

Asymmetric encryption works with a pair of keys consisting of one public key and one private key. Used with a PKI, it is also known as Public Key cryptography or simply PKI cryptography. A communication partner, Alice in the figure below, has a private key and a public key. The public key is provided to the public, in other words any potential communication partner. Anyone with the public key can encrypt messages for Alice. In the figure below, this is Bob.

Alice's private key, which she must not disclose, is used by Alice to decrypt an encrypted message addressed to her.

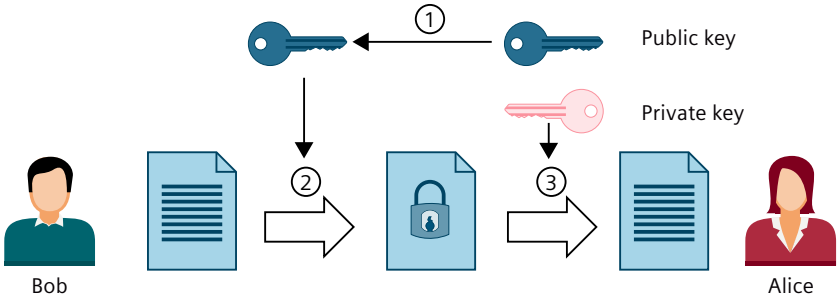

① Alice provides Bob with her public key. No precautionary measures are required to this purpose: Anyone can use the public key for messages to Alice if they are sure that it is actually Alice's public key.

② Bob encrypts his message with Alice's public key.

③ Alice decrypts the encrypted message from Bob with her private key. As only Alice has the private key and never discloses it, only she can decrypt the message. With her private key, she can decrypt any message encrypted with her public key - not only messages from Bob.

Figure 3-376 Asymmetric encryption

The system can be compared to a mailbox into which anyone can put a message, but from which only the person with the key can remove messages.

- Advantages: A message encrypted with a public key can only be decrypted by the owner of the private key. As another (private) key is required for decryption, it is also much harder to work out the decryption key on the basis of large numbers of encrypted messages. This means that the public key does not have to be kept strictly confidential, unlike with symmetric keys.

  Another advantage is easier distribution of public keys. No specially secured channel is required in asymmetric cryptography to transfer the public key from the recipient to the sender encrypting the messages. Less work is thus required in managing the keys than would be the case in symmetric encryption procedures.

- Disadvantages: Complex algorithm (e.g. RSA, named after the three mathematicians Rivest, Shamir and Adleman), and therefore poorer performance than with symmetric encryption.

Encryption processes in practice

In practice, for example with a CPU Web server and Secure Open User Communication, the TLS protocol is used below the relevant application layer. Application layers are HTTP or SMTP, for example, as detailed above.

TLS (Transport Layer Security) uses a combination of asymmetric encryption and symmetric encryption (hybrid encryption) for secure data transfer, for example, over the Internet, and uses the following subprotocols:

- TLS Handshake Protocol, responsible for authentication of communication partners and negotiation of the algorithms and keys to be used for subsequent data transfer on the basis of asymmetric encryption.
- TLS Record Protocol, responsible for encryption of user data with symmetric encryption and data exchange.

Both asymmetric and symmetric encryption are considered secure encryption schemes - there is basically no difference in security between the two procedures. The degree of security depends on parameters such as the selected key length.

Abuse of encryption

You cannot tell what identity is assigned to a public key from the bit string. A fraud could provide their public key and claim to be someone else. If a third party then uses this key thinking that they are addressing their required communication partner, confidential information could end up with the fraud. The fraud then uses their private key to decrypt the message that was not intended for them, and sensitive information falls into the wrong hands.

To prevent this type of abuse, the communication partners must be confident that they are dealing with the right communication partner. This trust is established by using digital certificates in a PKI.

5.6.1.4 Authenticity and integrity through signatures

Attacks from programs that intercept communication between the server and client and act as if they themselves were client or server, are called man-in-the-middle attacks. If the false identity of these programs is not detected, they can obtain important information about the S7 program, for example, or set values in the CPU and attack a machine or plants. Digital certificates are used to avoid such attacks.

Secure communication uses digital certificates that meet the X.509 standard of the International Telecommunication Union (ITU). This allows the identity of a program, a computer or an organization to be checked (authenticated).

How certificates establish trust

The main role of X.509 certificates is to bind an identity with the data of a certificate subject (for example, e-mail address or computer name) to the public key of the identity. Identities can be people, computers or machines.

Certificates are issued by certificate authorities (Certificate Authority, CA) or by the subject of a certificate itself. PKI systems specify how users can trust the certificate authorities and the certificates that they issue.

The certificate process:

1. Anyone wishing to own a certificate submits a certificate application to a registration authority linked to the certificate authority.
2. The certificate authority assesses the application and applicant on the basis of set criteria.
3. If the identity of the applicant can be clearly established, the certificate authority confirms that identity by issuing a signed certificate. The applicant has now become the certificate subject.

The figure below is a simplified overview of the process. It does not show how Alice can check the digital signature.

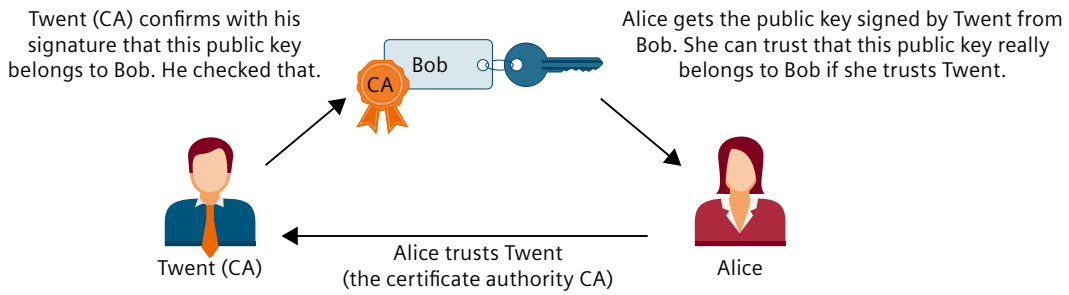

Figure 3-377 Signing of a certificate by a certificate authority

Self-signed certificates

Self-signed certificates are certificates whose signature comes from the certificate subject and not from an independent certificate authority.

Examples:

- You can create and sign a certificate yourself, for example, to encrypt messages to a communication partner. In the example above, Bob (instead of Twent) could himself sign his certificate with his private key. Using Bob's public key, Alice can check that the signature and public key from Bob match. This procedure is sufficient for simple internal plant communication that is to be encrypted.
- A root certificate is, for example, a self-signed certificate, signed by the certificate authority (CA), that contains the public key of the certificate authority.

Features of self-signed certificates

The "CN" (Common Name of Subject) for the certificate subject and "Issuer" attributes of self-signed certificates are identical: You have signed your certificate yourself. The "CA" (Certificate Authority) field must be set to "False"; the self-signed certificate should not be used to sign other certificates.

Self-signed certificates are not embedded in a PKI hierarchy.

Certificate content

A certificate to the X.509 V3 standard, the standard that is also used by STEP 7 and the S7-1500 CPUs, consists primarily of the following elements:

- Public key
- Details of the certificate subject (i.e. the holder of the key), for example, the Common Name (CN) of Subject .
- Attributes such as serial number and validity period
- Digital signature from the certificate authority (CA) confirming that the information is correct.

There are also extensions, for example:

- Specification of what the public key may be used for (Key Usage), for example, signing or key encryption.
  When you create a new certificate with STEP 7, for example in the context of Secure Open User Communication, select the correct entry from the list of possible usages, e.g. "TLS".
- Specification of a Subject Alternative Name ("SAN"), which is used in secure communication with Web servers (HTTP over TLS), for example, to ensure that the certificate in the address bar of the Web browser also belongs to the Web server specified in the URL.

How signatures are generated and verified

Asymmetric key usage ensures that certificates can be verified: The example of the "MyCert" certificate illustrates the "Sign" and "Verify signature" processes.

Generating a signature:

1. The authority of the "MyCert" certificate generates a hash value from the certificate data using a specific hash function (for example SHA-1, Secure Hash Algorithm).

   The hash value is a bit string of a constant length. The advantage of the constant length of the hash value is that it always takes the same amount of time to sign.
2. Using the hash value generated in this way and the private key, the authority of the certificate then generates a digital signature. The RSA signature scheme is often used.
3. The digital signature is saved in the certificate. The certificate is now signed.

Verifying a signature:

1. The authenticator of the "MyCert" certificate obtains the certificate of the issuer and thus the public key.
2. A new hash value is formed from the certificate data with the same hash algorithm that was used for signing (for example SHA-1).

3. This hash value is then compared with the hash value that is determined by means of the public key of the certificate authority and the signature algorithm for checking the signature.
4. If the signature check produces a positive result, both the identity of the certificate subject as well as the integrity, meaning authenticity and genuineness, of the certificate content are proven. Anyone who has the public key, i.e. the certificate from the certificate authority, can check the signature and thus recognize that the certificate was actually signed by the certificate authority.

The figure below shows how Alice uses the public key in the certificate from Twent (who represents the certificate authority, CA) to verify the signature on Bob's public key. All that is required for verification is therefore the availability of the certificate from the certificate authority at the moment of checking. The validation itself is executed automatically in the TLS session.

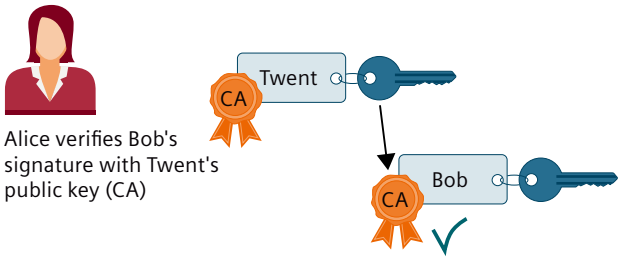

Figure 3-378 Verification of a certificate with the public key of the certificate of a certificate authority

Signing messages

The method described above for signing and verifying certificates also uses the TLS session for signing and verifying messages:

If a hash value is generated by a message and this hash value is encrypted with the private key of the sender and attached to the original message, the receiver of the message is able to check the integrity of the message. The recipient decrypts the hash value with the public key of the sender, puts together the hash value from the message received and compares the two values. If the values are different, the message or the encrypted hash value has been corrupted in transit.

Chain of certificates to root certificate

The certificates of a PKI are often organized hierarchically: The top of the hierarchy is formed by root certificates. Root certificates are certificates that are not signed by a higher-level certificate authority. The certificate subject and certificate issuer of root certificates are identical. Root certificates enjoy absolute trust. They form the "anchor" of trust and must therefore be known to the receiver as trusted certificates. They are stored in an area provided for trusted certificates.

Depending on the PKI, the function of root certificates is, for example, to sign certificates from lower-level certificate authorities, so-called intermediate certificates. This transfers the trust from the root certificate to the intermediate certificate. An intermediate certificate can sign a certificate just like a root certificate; both are therefore referred to as "CA certificates".

This hierarchy can be continued over multiple intermediate certificates until the end-entity certificate. The end-entity certificate is the certificate of the user who is to be identified.

The validation process runs through the hierarchy in the opposite direction: As described above, the certificate authority is established and the signature checked with the authority's public key. Then the certificate of the higher-level certificate authority is established along the entire chain of trust to the root certificate.

Conclusion: The chain of intermediate certificates to the root certificate, the certificate path, must be available in every device that is to validate an end-entity certificate of the communication partner, irrespective of the type of secure communication that you configure.

5.6.2 Managing certificates

5.6.2.1 What you should know about the certificate management

This section shows the available certificate management options of an S7-1500 CPU depending on the service (CPU application) used and on the versions of the TIA Portal / the CPU firmware.

Overview of certificate management options

Since TIA Portal version V14 and CPU firmware version V2.0, it has been possible to manage certificates for secure communications for different services of S7-1500 CPU in the TIA Portal and load them in the CPU.

TIA Portal as of version V17, along with the S7-1500 CPUs as of version V2.9 support another option of certificate management: With GDS push methods, you can transfer or renew certificates in the CPU at runtime without having to reload the CPU.

Using the same route, as of TIA Portal version V18, you can also transfer web server certificates for a S7-1500 CPU (as of firmware V3.0).

The following table provides an overview of the certificate management options depending on the service used and the TIA Portal firmware version or CPU firmware version.

Service	Certificate management with TIA Portal (TIA Portal version / S7-1500 CPU-FW version)	Certificate management with OPC UA GDS push methods (TIA Portal version / S7-1500 CPU-FW version)
Web server	as of V14 / as of V2.0	as of V18 / as of V3.0
Secure OUC communication	as of V14 / as of V2.0	-
OPC UA server	as of V14 / as of V2.0	as of V17 / as of V2.9
OPC UA client	as of V15.1 / as of V2.6	as of V21 / as of V4.1
Secure PG/HMI Communication	as of V17 / as of V2.9	-

You can find information on the certificate management options for R/H CPUs in the section Using an OPC UA server in an S7-1500R/H system (Page 481).

More information

Click here for a description of the certificate management with GDS push methods: Certificate management via Global Discovery Server (GDS) (Page 202).

If you do not need to load new certificates, but need to renew a certificate, e.g. because the validity period has expired, this is also possible in RUN while adhering to the conditions: See Tip: Updating loaded certificates in RUN (Page 79).

5.6.2.2 Certificate management with TIA Portal

STEP 7 as of version V14 together with the S7-1500 CPUs as of FW version 2.0 support the Internet PKI (RFC 5280) to such an extent that an S7 1500 CPU is able to communicate with devices that also support the Internet PKI.

The usage of X.509 certificates for verifying certificates as described in the preceding sections, for example, is a result of this.

STEP 7 as of V14 uses a PKI similar to the Internet PKI, with restrictions. Certificate Revocation Lists (CRLs), for example, are not supported.

You can find more information on X.509 certificates and CRLs on the Internet (https://www.rfc-editor.org/rfc/rfc5280).

Creating or assigning certificates in the TIA Portal

You create certificates for various applications in STEP 7 for devices with security properties, such as an S7-1500 CPU as of firmware V2.0.

The following areas in the Inspector window of the CPU allow the creation of new certificates or the selection of existing ones:

- "Web server > Security" - for the generation and assignment of Web server certificates.
- "Protection & Security > Access control" - for the assignment of user management server certificates (UMC server certificates - from TIA Portal V20).
- "Protection & Security > Connection mechanisms" - for the generation or assignment of PLC communication certificates (Secure PG/HMI communication, as of TIA Portal V17).
- "Protection & Security > Certificate manager" - for generating and assigning all types of certificates.
- "Protection & Security > Syslog" - for managing syslog client and server certificates (as of TIA Portal V19).
- "OPC UA > Server > Security" - for the generation or assignment of OPC UA server certificates.

You can find the areas listed above in the following places in the CPU properties.

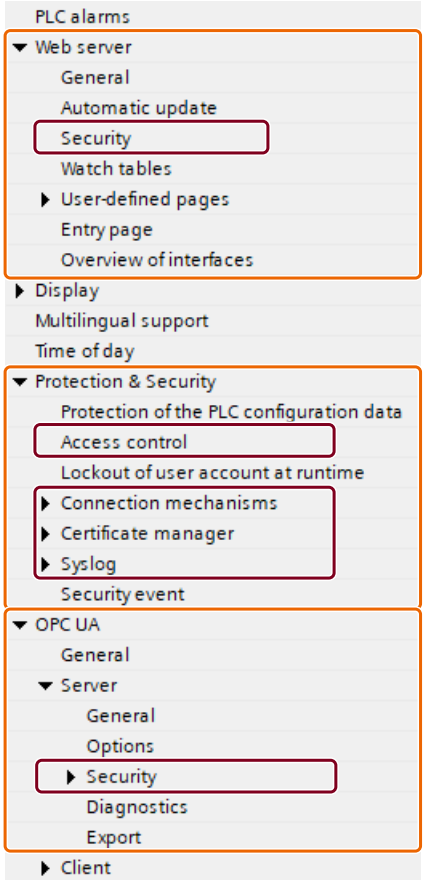

Figure 3-379 Certificate management in the properties of an S7-1500 CPU in STEP 7

Certificates have a validity period

WARNING

Certificates have a limited period of validity

If you generate certificates or adopt existing certificates in the TIA Portal when configuring devices and networks, then the limited validity period of the certificates is not obvious at this point in time.

For certificates generated automatically in the TIA Portal, the validity period expires well in the future. Once the validity period has expired, a secure connection from an HMI device or programming device to the CPU can no longer be established.

The system informs the operator or integrator of the system about the validity periods of the certificates used. This allows precautions to be taken for updating certificates.

To transfer certificates with an updated validity period to the CPU, either reload the TIA Portal project or use the certificate management at runtime. Not all services support certificate management at runtime.

If certificates with short validity periods are required, check whether automated certificate management, which provides certificates at runtime (OPC UA GDS Push methods), is an option.

Example

Settings in the "Protection & Security > Connection mechanisms > Communication mode to TIA Portal and HMI" area of the CPU:

A certificate for a protected connection is automatically created in the "Communication mode to TIA Portal and HMI" area. The properties of this initial certificate, including the validity period, are selected by the TIA Portal.

To see the validity period, open the extended display.

Depending on the client (connection partner), a connection establishment is rejected if the PLC communication certificate has expired.

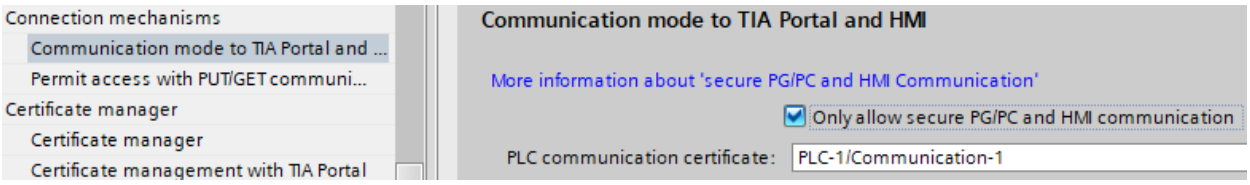

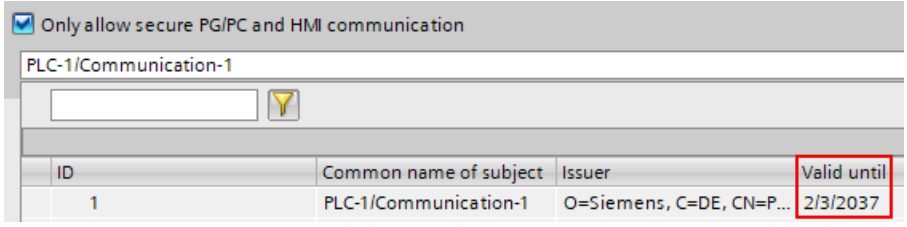

You can easily set the validity period when creating new certificates. If the global security settings for the certificate manager are activated, you can change the validity period using the "Renew" function, e.g. move it further into the future.

You cannot update the PLC communication certificate shown in the example via the certificate management at runtime.

Special case: Expiration of the certificate while the protected connection is established

As the expiration date in the certificate is checked when the connection is established, an existing connection remains active even if the certificate expires in the meantime. When the connection is re-established, e.g. after a disconnection or temporary failure of the communication partner, the validity period of the certificate is checked and a connection is rejected.

Within an OPC UA session, a periodic connection establishment is enforced over the lifetime of the SecureChannel. This prevents certificate expiration or revoked certificates from remaining ineffective or undetected for long periods of time.

Special features of the section "Protection & Security > Certificate manager"

In this area of the Inspector window, you can switch between the global, i.e. project-wide, and local, i.e. device-specific, certificate manager (option "Use global security settings for certificate manager"). The option decides whether you have access to all the certificates in the project or not. The option determines which certificates you have access to as follows:

- If you **do not** use the certificate manager in the global security settings, you only have access to the local certificates of the CPU. You do not have access to imported certificates or root certificates. Without these certificates, only limited functionality is available: You can only generate self-signed certificates.
- If you use the certificate manager in the global security settings, you have access to the global, project-wide certificates. You can assign imported certificates or root certificates to the CPU. You can also create new certificates that are issued and signed by the project CA (certification authority of the project).
  A user requires a role with the following engineering rights for certificate handling in the certificate manager in the global security settings:
  - View configuration of security modules
  - Edit configuration of security modules

The following requirements must be met to access the global certificate manager:

- The project must be protected.
- The logged-in user must be assigned a role with the above-mentioned engineering rights.

The following figure shows the "Global security settings" in the project navigation after the option "Use global security settings for certificate manager" has been activated in the Inspector window of the CPU.

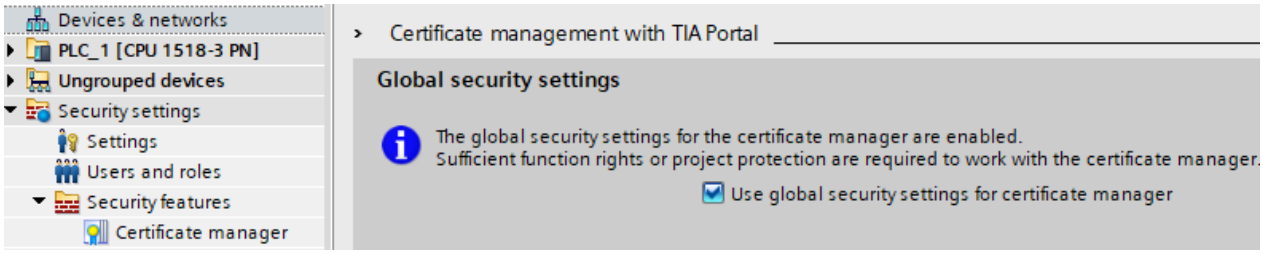

Figure 3-380 Use global security settings for certificate manager

When you double-click the "Certificate manager" line, you obtain access to all the certificates in the project, divided into the tabs "CA" (certificate authorities), "Device certificates" and "Trusted certificates and root certificate authorities".

Private keys

With asymmetric encryption, the confidentiality of private keys must be guaranteed. Private keys are used to decrypt or encrypt messages or to create digital signatures.

STEP 7 generates private keys when creating device certificates for client or server applications (end-entity certificates). The location where the private key is stored encrypted depends on the use of the global security settings for the certificate manager:

- If you use global security settings, the private key is stored encrypted in the global (project-wide) certificate memory.
- If you do not use global security settings, the private key is stored encrypted in the local (CPU-specific) certificate memory.

The existence of the private key is displayed in the "Private key" column in the "Device certificates" tab of the certificate manager in the global security settings.

When loading the hardware configuration, all certificates assigned to this CPU and the corresponding private keys are loaded into the CPU.

NOTICE
Enabling the "Use global security settings for certificate manager" option - Consequences The "Use global security settings for certificate manager" option influences the previously used private key: If you have already created certificates without using the certificate manager in the global security settings and then change the option for using the certificate manager, the private keys are lost and the certificate ID can change. All self-signed certificates in the device-specific certificate manager are removed from the configuration. The self-signed certificates in the global security settings remain unaffected. A warning draws your attention to this fact. Therefore specify at the beginning of the project configuration which option is required for the certificate manager.

More information

You can find more information on handling certificates in the application example "Using certificates with TIA Portal" (https://support.industry.siemens.com/cs/ww/en/view/109769068).

5.6.2.3 Examples for the management of certificates.

As explained in the preceding sections, certificates are required for every type of secure communication. The following section shows as an example how you handle the certificates with STEP 7 so that the requirements for Secure Open User Communication are fulfilled.

The devices which are involved at the respective communication partners are differentiated below. The respective steps for supplying the required certificates to the communications participants are described. An S7-1500 CPU or an S7-1500 Software Controller as of firmware version 2.0 is always required.

The general rule is:

While establishing a secure connection ("handshake"), the communication partners only transmit their end-entity certificates (device certificates).

Therefore the CA certificates required to verify the transmitted device certificate must be located in the certificate memory of the respective communication partner.

NOTE

The current date/time must be set in the CPU. The same date/time must be set for all communication partners involved.

When using secure communication (for example, HTTPS, secure OUC, OPC UA), make sure that the corresponding modules have the current time of day and the current date. Otherwise, the modules evaluate the used certificates as invalid and secure communication does not work.

Secure Open User Communication between 2 S7-1500 CPUs

Two S7-1500 CPUs PLC_1 and PLC_2 are to exchange data with each other via Secure Open User Communication.

You generate the required device certificates with STEP 7 and assign them to the CPUs as described below.

STEP 7 project certificate authorities (CA of the project) are used to sign the device certificates.

The certificates are to be referenced by their certificate ID in the user program (TCON communication instruction in combination with the associated system data type, for example TCON_IPV4_SEC). STEP 7 assigns the certificate ID automatically during the generation or creation of certificates.

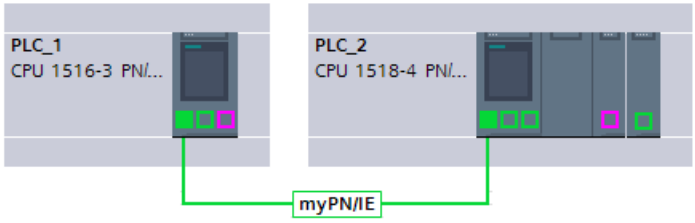

Figure 3-381 Secure OUC between two S7-1500 CPUs

Procedure

STEP 7 automatically loads the required CA certificates together with the hardware configuration to the participating CPUs so that the requirements for certificate verification exist for both CPUs. You therefore only have to generate the device certificates for the respective CPU; STEP 7 does the rest for you.

1. Mark PLC_1 and activate the "Use global security settings for certificate manager" option in the "Protection & Security" section.
2. Log in as a user in the project tree in the "Global security settings" section. For a new project, the "Administrator" role is planned for the first login.

3. Return to the PLC-1 in the "Protection & Security" section. Click in an empty line in the "Certificate subject" column in the "Device certificates" table to add a new certificate.
4. In the drop-down list for selecting a certificate click the "Add" button.

   The "Create Certificate" dialog opens.
5. Leave the default settings in this dialog. They are tailored to the usage of Secure Open User Communication (usage: TLS).

   Tip: Supplement the default name of the certificate subject, in this case the CPU name. In order to differentiate you better leave the default CPU name in case you have to manage a large number of device certificates.

   Example: PLC_1/TLS becomes PLC_1-SecOUC-Chassis17FactoryState.
6. Compile the configuration.

   The device certificate and the CA certificate are part of the configuration.
7. Repeat the steps described above for PLC_2.

In the next step you have to create the user programs for the data exchange and load the configurations together with the program.

Using self-signed certificates instead of CA certificates

When creating device certificates you can select the "Self-signed" option. You can create self-signed certificates without being logged in for the global security settings. This procedure is not recommended because the resulting certificates do not exist in the global certificate memory and can therefore not be assigned directly to a partner CPU.

As described above, you should select the name of the certificate subject with care so that the right certificate can be assigned to a device without any doubt.

Verification with the CA certificates of the STEP 7 project is not possible for self-signed certificates. To ensure that self-signed certificates can be verified you have to include the self-signed certificates of the communication partner into the list of trusted partner devices for each CPU. To this purpose you must have activated the "Use global security settings for certificate manager" option and be logged in as a user in the global security settings.

Proceed as follows to add the self-signed certificate of the communication partner of the CPU:

1. Mark PLC_1 and navigate to the "Certificates of partner devices" table in the "Protection & Security" section.
2. Click in an empty line in the "Certificate subject" column in the "Device certificates" table to add a new certificate.
3. Select the self-signed certificate of the communication partner from the drop-down list and confirm the selection.

In the next step you have to create the user programs for the data exchange and load the configurations together with the program.

Secure Open User Communication between S7-1500 CPU as a TLS client and an external device as a TLS server

Two devices are to exchange data with each other via TLS connection or TLS session, for example, exchanging recipes, production data or quality data:

- An S7-1500-CPU (PLC_1) as TLS client; the CPU uses Secure Open User Communication
- An external device (for example a Manufacturing Execution System (MES)) as TLS server

The S7-1500 CPU establishes the TLS connection / session to the MES system as TLS client.

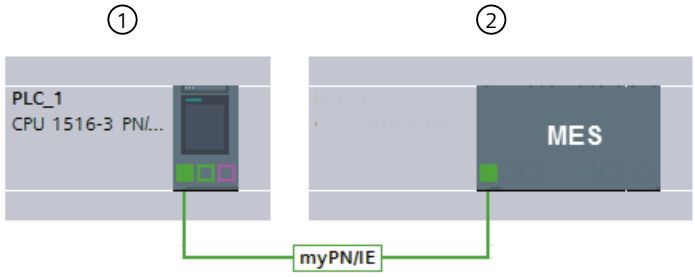

① TLS client

② TLS server

Figure 3-382 Secure OUC between S7-1500 CPU and a third-party device

The S7-1500 CPU requires the CA certificates of the MES system to authenticate the TLS server: The root certificate and, if appropriate, the intermediate certificates for verifying the certificate path.

You have to import these certificates into the global certificate memory of the S7-1500 CPU.

Proceed as follows to import certificates of the communication partner:

1. Open the certificate manager in the global security settings in the project tree.
2. Select the appropriate table (trusted certificates and root certificate authorities) for the certificate to be imported.
3. Right-click in the table to open the context menu. Click "Import" and import the required certificate or the required CA certificates.

   As a result of the import, the certificate has a certificate ID assigned to it and can be assigned to a module in the next step.
4. Mark PLC_1 and navigate to the "Certificates of partner devices" table in the "Protection & Security" section.
5. Click in an empty line in the "Common name of subject" column to add the imported certificates.
6. Select the required CA certificates of the communication partner from the drop-down list and confirm the selection.

Optionally the MES system can also request a device certificate of the CPU to authenticate the CPU (i.e., the TLS client). In this case, the CA certificates of the CPU must be made available to the MES system. The prerequisite for importing the certificates into the MES system is a preceding export of the CA certificates from the STEP 7 project of the CPU. Follow these steps:

1. Open the certificate manager in the global security settings in the project tree.
2. Select the matching table (CA certificate) for the certificate to be exported.
3. Right-click the selected certificate to open the context menu.
4. Click "Export".
5. Select the export format of the certificate.

In the next step you have to create the user programs for the data exchange and load the configurations together with the program.

Secure Open User Communication between an S7-1500 CPU as TLS server and an external device as TLS client

If the S7-1500 CPU acts as TLS server and the external device, for example an ERP system (Enterprise Resource Planning System) establishes the TLS connection / session, you require the following certificates:

- For the S7-1500 CPU, you generate a device certificate (server certificate) with a private key and download it with the hardware configuration into the S7-1500 CPU. You use the "Signed by certificate authority" option when generating the server certificate.

  The private key is required for the key exchange as explained in the figure for the example "HTTP over TLS (Page 76)".
- You have to export the CA certificate of the STEP 7 project for the ERP system and import / load it into the ERP system. With the CA certificate the ERP system verifies the server certificate of the S7-1500 that was transferred from the CPU to the ERP system during the establishment of the TLS connection / session.

① TLS server

② TLS client

Figure 3-383 Secure OUC between an S7-1500 CPU and ERP system

You can find the description of the necessary steps in the previous sections.

Secure Open User Communication to a mail server (SMTP over TLS)

An S7-1500 CPU can establish a secure connection to an e-mail server with the communication instruction TMAIL-C.

The system data types TMail_V4_SEC and TMail_QDN_SEC allow you to determine the partner port of the e-mail server and thus to reach the e-mail server via "SMTP over TLS".

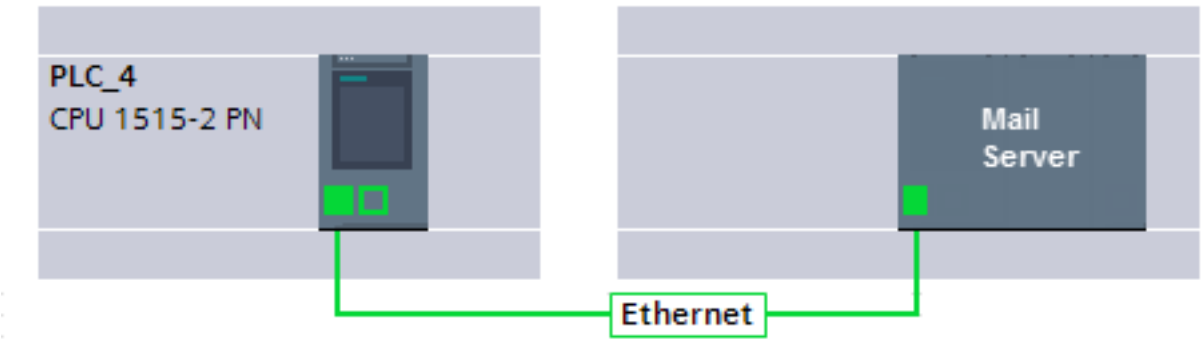

Figure 3-384 Secure OUC between a S7-1500 CPU and a mail server

Requirement for secure email connection is the importing of the root certificate and the intermediate certificates of the mail server (provider) into the global certificate memory of the S7-1500 CPU. By means of these certificates the CPU can check the server certificate that is sent by the mail server during the establishment of the TLS connection / session.

Proceed as follows to import certificates of the mail server:

1. Open the certificate manager in the global security settings in the project tree.
2. Select the appropriate table (trusted certificates and root certificate authorities) for the certificate to be imported.
3. Right-click in the table to open the context menu. Click "Import" and import the required certificate or the required CA certificates.

   As a result of the import, the certificate has a certificate ID assigned to it and can be assigned to a module in the next step.
4. Mark PLC_1 and navigate to the "Certificates of partner devices" table in the "Protection & Security" section.
5. Click in an empty line in the "Common name of subject" column to add the imported certificates.
6. Select the required CA certificates of the communication partner from the drop-down list and confirm the selection.

In the next step you have to create the user programs for the email client function of the CPU and load the configurations together with the program.

5.6.2.4 How communication with certificates works: HTTP over TLS

The following paragraphs show how the mechanisms described are used to establish a secure communication between a Web browser and the Web server of an S7-1500 CPU.

Initially the changes for the "Permit access only with HTTPS" option in STEP 7 are described. As of STEP 7 V14 you have the possibility to influence the server certificate of the Web server of an S7-1500 CPU as of firmware V2.0: The server certificate is generated as of these versions with STEP 7.

In addition it illustrates the processes that are executed when a website of the CPU Web server is called with a Web browser of a PC through an encrypted HTTPS connection.

Using Web server certificates for S7-1500 CPUs, FW V2.0 or higher

For S7-1500 CPUs with a firmware version before V2.0, you were able to set "Permit access only with HTTPS" when setting the Web server properties, without specific requirements applying.

You did not have to handle certificates for these CPUs; the CPU automatically generates the certificates required for the Web server.

For S7-1500 CPUs as of firmware V2.0, STEP 7 generates the server certificate (end-entity certificate) for the CPU. You assign a server certificate to the Web server in the properties of the CPU (Web server > Security).

Because a server certificate name is always preset, there is no change to the easy configuration of the Web server: You activate the Web server. The "Permit access only with HTTPS" option is enabled by default - STEP 7 generates a server certificate with the default name during compiling.

Irrespective of whether you use the certificate manager in the global security settings or not: STEP 7 has all the information required to generate the server certificate.

In addition, you have the possibility to determine the properties of the server certificate, for example, the name or the validity period.

NOTE

The current date/time must be set in the CPU.

When using secure communication (for example, HTTPS, secure OUC, OPC UA), make sure that the corresponding modules have the current time of day and the current date. Otherwise, the modules evaluate the used certificates as invalid and secure communication does not work.

Loading the Web server certificate

The server certificate generated by STEP 7 is then automatically also loaded to the CPU when the hardware configuration is loaded.

- If you use the certificate manager in the global security settings, the certificate authority of the project (CA certificate) signs the server certificate of the Web server: During loading the CA certificate of the project is loaded as well automatically.
- If you do not use the certificate manager in the global security settings, STEP 7 generates the server certificate as a self-signed certificate.

When you address the Web server of the CPU over the IP address of the CPU, a new server certificate (end-entity certificate) must be generated and loaded with each change in the IP address of an Ethernet interface of the CPU. This is necessary because the identity of the CPU changes with the IP address – and the identity requires a signature in accordance with the PKI rules.

You can avoid this problem by addressing the CPU with a domain name instead of its IP address, for example "myconveyer-cpu.room13.myfactory.com". For this purpose, you have to manage the domain names of the CPU via a DNS server.

Supplying a Web browser with a CA certificate of the Web server

In the Web browser the user who accesses the websites of the CPU through HTTPS should install the CA certificate of the CPU. If no certificate is installed, a warning is output recommending that you do not use the page. To view this page, you must explicitly "Add an exception".

The user receives the valid root certificate for download from the "Intro" Web page of the CPU Web server under "Download certificate".

STEP 7 offers a different possibility: Export the CA certificate of the project with the certificate manager into the global security settings in STEP 7. Subsequently import the CA certificate into the browser.

Course of the secure communication

The figure below shows, in simplified terms, how communication is established ("handshake") focusing on the negotiation of keys used for data exchange (here with HTTP over TLS).

However, the procedure can be applied to all communication options that are based on the usage of TLS, i.e. also to Secure Open User Communication (see Basics for secure communication (Page 54)).

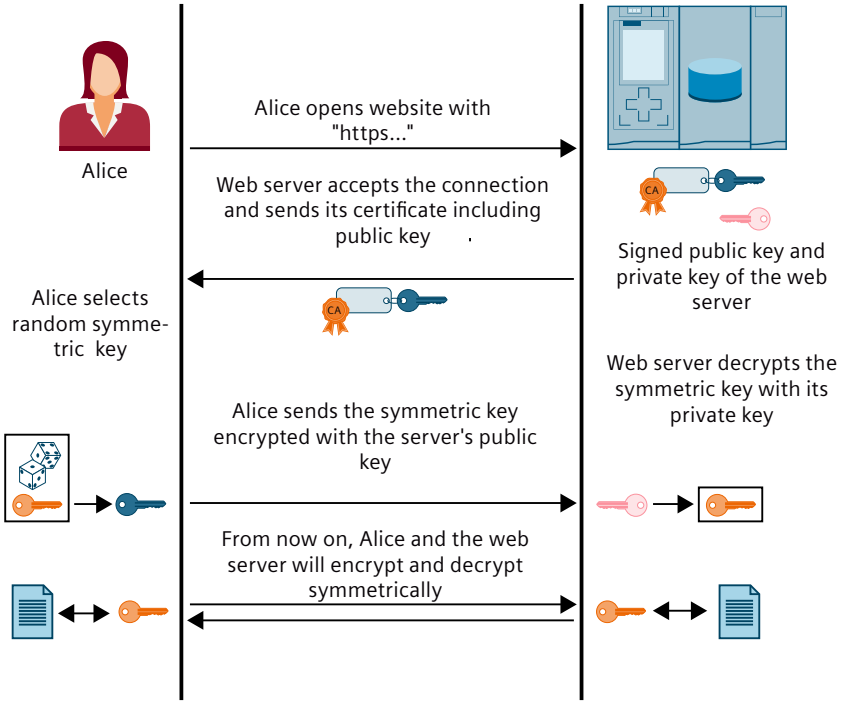

Figure 3-385 Handshake with https

The figure does not show the measures taken at Alice's end (browser) to verify the certificate sent by the Web server. Whether Alice can trust the Web server certificate received and therefore the identity of the Web server, and can accept the exchange of data, depends on positive verification.

The steps for verifying the authenticity of the Web server:

1. Alice must know the public keys of all relevant certificate authorities, which means she requires the complete certificate chain to verify the Web server certificate (i.e. the end-entity certificate of the Web server):

   Alice will generally have the required root certificate in her certificate memory. When a Web browser is installed, a range of trusted root certificates is also installed. If she does not have the root certificate, she must download it from the certificate authority and install it in the certificate authority of the browser. The certificate authority can also be the device on which the Web server is located.

You have the following options for obtaining the intermediate certificates:

– The server itself sends the required intermediate certificates to Alice along with its end-entity certificate – in the form of a signed message so that Alice can verify the integrity of the certificate chain.
– The certificates often contain the URLs of the certificate issuer. Alice can load the required intermediate certificates from these URLs.

When you work with certificates in STEP 7 it is always assumed that you have imported the intermediate certificates and the root certificate into the project and assigned them to the module.

2. Alice validates the signatures in the certificate chain with the public keys of the certificates.
3. The symmetric key must be generated and transferred to the Web server.
4. If the Web server is addressed by its domain name, Alice also verifies the identity of the Web server in accordance with the Internet PKI rules defined in RFC 2818. She is able to do this because the URL of the Web server, in this case the "Fully Qualified Domain Name" (FQDN), is saved in the end-entity certificate of the Web server. If the certificate entry in the "Subject Alternative Name" field corresponds to the entry in the address bar of the browser, everything is fine.

The process continues with the exchange of data with the symmetric key, as shown in the figure above.

See also

Examples for the management of certificates. (Page 70)

5.6.2.5 Tip: Updating loaded certificates in RUN

As of TIA Portal V19 and firmware version V3.1 of the S7-1500 CPUs (incl. R/H-CPUs) you have the possibility to update certificates during runtime, i.e. in RUN mode of the CPU.

These are certificates that were configured through the TIA Portal and downloaded.

This allows this you, for example, to renew or replace expired certificates without interrupting the running process.

Requirements

- Project protection is activated.
- The project administrator (Engineering-Administrator) is logged on with the corresponding security rights.
- No further changes to the hardware configuration are present. These changes would require a STOP of the CPU to be loaded.

Rule

The existing ID of the certificate to be updated must not change.

Procedure

1. In TIA Portal (project navigation), navigate to the certificate manager (Security settings > Security functions).
2. Select the "Certificate authority (CA)" tab or the "Device certificates" tab - depending on which certificate you want to update.
3. Select the certificate to be updated.
4. In the context menu, select the "Renew" or "Replace" command, depending on whether you want to replace the existing certificate with a certificate from the file system or only update the validity data of the existing certificate, for example.

   When CA certificates are replaced, all derived device certificates are automatically digitally signed with the renewed CA certificate.
5. Load the changes to the CPU (Load to device > Hardware configuration).

5.6.3 Requirements for secure communication

5.6.3.1 Protection of confidential configuration data

As described in the basic information on secure communication, the proper functioning of certificate-based protocols requires private keys that must be protected as best as possible.

As of STEP 7 V17, you can use a password to protect these keys and other data worth protecting: The password to protect confidential PLC configuration data.

As of STEP 7 V21 and a CPU FW version V4.1, you can choose whether you also want to protect the entire configuration of the CPU in addition to protecting the configuration data. The data is stored encrypted in the SIMATIC.S7S folder on the SIMATIC Memory Card and can only be decrypted with the password for protection of confidential configuration data.
If you revoke or add the setting for protection of all data, the contents of the SIMATIC.S7S folder on the SIMATIC Memory Card will be deleted at the next download to the CPU. Other files, such as recipes or backup files on the SIMATIC Memory Card, are not deleted. After the deletion, the CPU performs a restart.

If you have activated protection for the entire configuration, you will need the assigned password to upload from a SIMATIC memory card to STEP 7. Without a password, uploading from a SIMATIC memory card to STEP 7 is no longer possible.

It is possible to do without the password if you have implemented measures to prevent unauthorized access to the TIA Portal project and the configuration of the CPU.

independently of whether you assign a password or not: The TIA Portal generates a key information that provides for the protection of the confidential PLC configuration data. This password has no influence on the secure communication process. However, the complexity of the password for the protection of confidential PLC configuration data determines how well the private keys, for example, are protected.

The presence of key information is a prerequisite for secure communication such as TLS-based secure PG/HMI communication: The CPU can handle certificates which are required for Secure Communication only if this key information is available.

The following figure shows the described contexts.

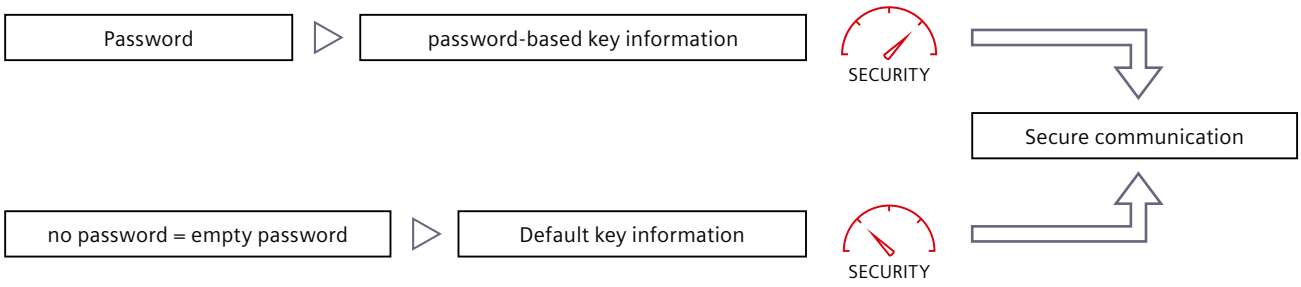

Figure 3-386 Contexts for protecting confidential configuration data

Security settings wizard

When you add a CPU to the project that supports secure PG/HMI communication in the TIA Portal from the hardware catalog, a wizard starts for the security settings of the CPU. The wizard guides you step-by-step through the security settings of the CPU.

Each of these settings is explained in detail in the wizard. At the end, all settings are once again summarized in an overview.

The wizard also starts, for example, when you replace a module in the network view of the TIA Portal and the new CPU, unlike the replaced CPU, supports secure PG/HMI communication.

All settings in the wizard are applied in the Inspector window (CPU properties).

You can start the wizard at any time using a Start button in the "Protection & Security" area of the CPU properties.

Requirement

- TIA Portal as of version V17
- CPU supports secure PG/HMI communication (for S7-1500 CPUs as of firmware version 2.9)
- The CPU is not yet loaded or the CPU is reset to factory settings with the option "Delete password for protection of confidential PLC configuration data"

Procedure

1. Open the CPU properties in the network view or in the device view.
2. Navigate to the area "Protection & Security > Protection of the PLC configuration data".

   Result: The "Protect confidential PLC configuration data" option is enabled first and the empty field for password entry is highlighted in red.
3. Configure the password (recommended) via the "Set" button or disable the "Protect confidential PLC configuration data" option.
4. Complete the configuration and create the user program.

5. Load the CPU.
   When loading the hardware configuration, you will be asked once to re-enter the password.
   Background: The configured password is used in the TIA Portal to generate the key information to protect confidential configuration data and thus to protect this data. For security reasons, however, neither the password nor the key information is saved in the project. In order for the key information to reach the CPU, it is re-generated when the hardware configuration is loaded, so that the password must be entered once at this point.

Certificate-based communication also between PG/HMI and CPU

Because, as of TIA Portal version V17 and CPU firmware version V2.9 (S7-1500) or V4.5 (S7-1200), the PG/HMI communication is also certificate-based, you will be prompted to accept the server certificate in the course of the commissioning.

Tips and rules for password management

- Manage your passwords in a password manager.
- To check the newly entered passwords for compliance and, for example, prevent trivial passwords, use the settings for checking the password policies in the TIA Portal:
  - In the project tree, navigate to the area "<Project name> > Security settings > Settings" area and select the "Password policies" area.
  - Specify, for example, the minimum number of characters the password must have or the minimum number of special characters.
- You do not have to assign different passwords for each CPU in a system or machine. If the requirements are met, you can also define the same password for a group of CPUs. This strategy also has advantages in the replacement parts scenario: If the group password is also assigned to the replacement CPU, the workload of replacing the CPU is reduced.

  Note here the risk that if the password of one of these CPUs is compromised, all CPUs with the same password are vulnerable.
- The definition of passwords also has an impact on the replacement part case, as the password for confidential PLC configuration data must be transferred to the new (replacement) CPU in addition to the configuration (see Rules for the replacement parts scenario (Page 92)).
- With **S7-1500R/H CPUs**, the password for confidential PLC configuration data is only loaded onto one of the two CPUs during loading. In order that the sync-up process works and that the partner CPU also works properly, the password must be transferred to the partner CPU before the sync-up, using the Online and Diagnostics editor:
  - In the Online and diagnostics view, you specify the area "Password to protect confidential PLC configuration data".
  - Enter the required password and click the "Set" button.

    If the correct password has been entered, the partner CPU can use the protected PLC configuration data and start the sync-up process.

5.6.3.2 Useful information for the protection of confidential PLC configuration data

The concept for Secure Communication protected by security standards comprises the following components:

- A password-based key information that is used for protecting confidential configuration data (e.g. private keys for certificates, passwords).
- A standardized log (TLS) that ensures communication between the participants (e.g. programming device and CPU).

Principle of "Protection of confidential configuration data" and "Additional protection of downloadable configuration data"

The following simplified illustration shows how confidential configuration data, e.g. of a standard S7-1500 CPU, is protected: The two components project and key information are placed in different memory areas when loaded for the first time. The project in the load memory (memory card), the key information in a memory area in the CPU.

For other target systems (e.g. S7-1200 CPU, software controller) with different storage concepts, the implementation is adapted to the corresponding storage concepts, but the principle is the same.

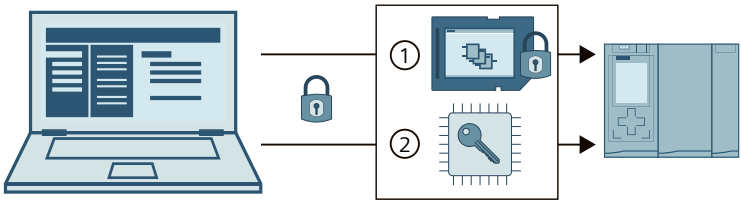

① Project with password-protected confidential configuration data (here: in load memory = memory card)

② Key information (generated from password) to use the protected confidential configuration data (here: in the memory area in the CPU)

Figure 3-387 Principle for protection of confidential configuration data

Two memory areas for more security

The charged components are related to each other like two matching puzzle pieces: The project is bound to the loaded key information, the loaded key information is bound to the password that was assigned during configuration.

Project and key information must match, otherwise the CPU will not start.

The principle of two separate memory areas also applies to the S7-1200 CPUs and to S7-1500 CPU variants without a memory card, such as the SW controller or PLCSIM/PLCSIM Advanced. In the versions without memory card, two separate partitions are used so that the two items of information can be managed independently of one another.

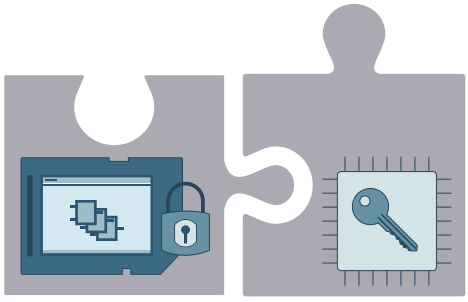

Figure 3-388 Principle of two separate memory areas

5.6.3.3 Changing your password

It makes a difference whether the CPU has already been loaded or not. If the CPU has already been loaded, it has the key information with which the password-protected PLC configuration data can be used.

Change password - configuration not yet loaded

As long as you have not yet loaded a configuration into the CPU, you can change an entered password or you can revoke the activation of the password protection.

Requirement

- The CPU is not yet loaded

Procedure

1. Open the CPU properties in the network view or in the device view.
2. Navigate to the area "Protection & Security > Protection of the PLC configuration data".
3. Click the "Change" button or deactivate the option "Protect confidential PLC configuration data".
4. Enter the previously valid password in the dialog. In case of a password change, also enter the new password and confirm the new password.

As long as you have not yet loaded a configuration into the CPU, the CPU is in a provisioning phase (see CPU behavior from loading to operational readiness (Page 114)) and you can load any valid configuration with your configured password.

Change password - configuration is already loaded

If the CPU has already been loaded with a configuration and the configuration is protected with a password for confidential PLC configuration data, you must first either reset the CPU to the factory settings and delete the password for confidential PLC configuration data in the CPU or delete it directly online and then set it.

Requirements

- You have write access to the CPU
- The CPU must be in STOP mode.

Procedure

1. Select the CPU in the network view.
2. Select the "Online & Diagnostics" command from the shortcut menu.
3. If you also change the project on the memory card, i.e. then want to reload the configuration:
   - Select the "Reset to factory settings" area in the opened online and diagnostics view.
   - Activate the option "Delete password to protect confidential PLC configuration data". To avoid a repeated start-up of the CPU, also select the "Format memory card" option.
   - Then load the project with the changed configuration and the desired password.
4. If you do not have to change the project on the memory card, i.e. only the wrong password is set:
   - In the Online and diagnostics view, you specify the area "Password for the protection of confidential PLC configuration data".
   - Click the "Delete" button. If the "Delete" button is not available, no password has been set in the CPU yet.
   - Enter the required password and click the "Set" button.

   If the correct password has been entered, the CPU can use the protected PLC configuration data.

No write access to the CPU

If you do not have write access to the load memory (read access level), remove the memory card from the CPU or delete the memory card externally, e.g. in your computer, before you reset to factory settings with the option "Delete password to protect confidential PLC configuration data".

NOTE

Reset to factory settings via the mode switch/mode selector keys of the CPU

Restoring the factory settings of the CPU via the mode switch/mode selector keys also deletes the IP address of the CPU, but not the password for protecting confidential PLC configuration data.

NOTE
Reset to factory settings via the display of the CPU
Resetting the CPU to factory settings via the display deletes the password for the protection of confidential PLC configuration data.

More information

Information on how to proceed in case of a spare part can be found in section Rules for the replacement parts scenario (Page 92).

5.6.3.4 Resetting the password

The protection of the confidential PLC configuration data can be reset. This may be necessary, for example, if you want to change the password but no longer know the current password.

Password lost - configuration not yet loaded

Since you have to enter the password when loading the CPU via TIA Portal for the first time, the CPU configuration for this CPU can no longer be used. To change the password in the CPU properties, you must also enter the previously valid password. If you forget your password, do the following:

Requirement

- The CPU is not yet loaded

Procedure

1. Open the CPU properties in the network view or in the device view.
2. Navigate to the area "Protection & Security > Protection of the PLC configuration data".
3. Click "Reset".

   Please note that the certificates of the CPU (e.g. certificates for web server, for OPC UA server, for PG/PC communication and HMI communication) may no longer be used after the reset and may have to be created again and reassigned.

   – If you use the global security settings for the certificate manager, you must reassign the certificates from the certificate manager.
   – If you do not use the global security settings for the certificate manager, you must recreate and reassign the certificates.
4. Confirm the reset of the password.

The option for the protection of confidential PLC configuration data is still activated.

Delete password – Configuration is already loaded

If the CPU has already been loaded with a configuration and the configuration is protected with a password for confidential PLC configuration data, you can, for loading a new project, delete the password for confidential PLC configuration data online and then specify a new password.

Requirements

- You have write access to the CPU
- The CPU must be in STOP mode.

Procedure

1. Select the CPU in the network view.
2. Select the "Online & Diagnostics" command from the context menu.
3. In the area "Password to protect confidential PLC configuration data", click the "Delete" button.
   If the "Delete" button is not available, no password has been set in the CPU yet.

NOTICE
Deleting the password for confidential configuration data If a loaded project is password-protected and the password is deleted, this project may no longer work without a password. The CPU also generates a corresponding entry in the diagnostics buffer.

4. If required, now enter a new password via the "Set" button.
5. Perform a restart of the CPU.

NOTE

Password for protecting confidential configuration data after resetting the CPU to factory settings

- **Via the mode switch / mode selector keys (SIMATIC Memory Card is not inserted):** The password for protection of confidential configuration data is retained.
- **Using the display:** The password for protection of confidential configuration data is deleted.
- **Using STEP 7:** The password for protection of confidential configuration data is retained. The password is only deleted when the "Delete password for protection of confidential PLC configuration data" option is set.

More information

Information on changing the password can be found in section Changing your password (Page 84).

5.6.3.5 Assign password via SIMATIC Memory Card

If you want to transfer the password to protect confidential PLC configuration data to a CPU without using TIA Portal, you can also use a SIMATIC memory card for this function.

The use of a SIMATIC memory card is suitable for the following purposes:

- Preparing a new CPU

  If a CPU is set up again, it should be configured with a password to protect the confidential PLC configuration data. After this configuration is completed, it is possible to use another SIMATIC memory card with the desired project.

  (S7-1200 CPU: A "transfer" card with transfer job can also be used to install the program on the CPU).
- CPU has a password to protect confidential PLC configuration data, but the password does not match the project

  If the passwords are not identical, you can set the correct password with the memory card in the CPU.

  (S7-1200 CPU: equipped either with SIMATIC "transfer" card or with SIMATIC "Program" card).
- reset the password for the protection of confidential PLC configuration data in the CPU

  As preparation for a disposal of the CPU or as preparation for a new project for the CPU.

Requirement

- TIA Portal as of version V17

Basic procedure

1. Creating a SIMATIC memory card with "SET PASSWORD" job

   This action creates a folder and file structure following a special pattern and writes a password for the protection of the confidential PLC configuration data as plain text to a special file on the SIMATIC memory card. See description below.
2. Insertion of a prepared SIMATIC memory card in the CPU and switch on the CPU.

   The PLC reads the password, processes it and stores the result in the internal memory. Any existing entry is overwritten.
3. Remove the SIMATIC memory card and restart the CPU.

   Results (S7-1500): While the CPU is reading the SIMATIC memory card, the LED shows the same behavior as with a firmware update. The RUN/STOP LED flashes while the CPU is setting the password. After the process has been completed successfully, the RUN/STOP LED lights up yellow and the MAINT LED flashes yellow.

The result of the operation is displayed in the diagnostics buffer as success or error message. If the password could not be set, the error LED flashes together with the other LEDs.

Creating a SIMATIC memory card with "SET PASSWORD" job

1. Create a folder in the root directory named "SET_PWD.S7S".
2. Create a text file named "PWD.TXT" with the password as text-only in the folder just created on the memory card.
3. Create a text file named "S7_JOB.S7S" in the root directory of the memory card with the content "SET_PWD".

   This file is the "Job file" for assigning a password for the protection of the confidential PLC configuration data of the PLC.
4. The file structure on the SIMATIC memory card then looks as follows:

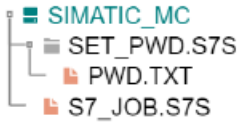

NOTE

Safe storage of the SIMATIC memory card

Store the SIMATIC memory card in a safe location to which only authorized persons have access.

Rules and recommendations

- Setting the password must be done in a secure environment.
- The content of the text file "PWD.TXT" defines the password for the protection of confidential PLC configuration data. It must match the password that you have also assigned in the CPU configuration.
- To reset an existing password of a PLC, the text file "PWD.TXT" must be empty, i.e. the file size is 0 bytes.
- Use any text editor to create the text file. The recommended text format is "UTF-8".
- The folder and file names are not case-sensitive. However, the password itself is case-sensitive.
- Do not enter a CR/LF character at the end (PWD.TXT or S7_JOB.S7S).

5.6.3.6 Special features when backing up and restoring a CPU

You can back up a functional configuration of a CPU in the TIA Portal and access it at a later time; this means you can then restore the originally backed-up configuration. This allows you to load a modified configuration, for example, to test product enhancements, to change programs for troubleshooting in the system or you can replace components on a test basis. You can then restore the originally backed-up configuration of the CPU.

Backing up the configuration

In backing up a CPU ("Online" menu, "Load backup from online device" in TIA Portal), the password for the protection of confidential PLC configuration data is backed up as well.

Restoring the backup

When restore the backup of a CPU (menu "Online", command "Download to device" with marked backup in TIA Portal) the CPU can only communicate with a PG/PC or HMI if the following condition is fulfilled:

- After the restoration of a configuration protected with a password to protect confidential PLC configuration data, exactly this password must be present in the CPU.
  Otherwise the CPU cannot access the configuration data. As a result, the CPU cannot restore the backup.
- With a CPU as of FW version V4.1, the password for protecting confidential PLC configuration data when restoring the backup must be the same as that used when the backup was created. Otherwise, the backup cannot be restored.

Possible causes of errors when restoring the backup

For CPUs as of FW version 4.1:
You must set the correct password to protect confidential PLC configuration data before restoring the project. Otherwise, a successful recovery process cannot be guaranteed.

For CPUs with FW version lower than V4.1:
You can also restore a backup if the password entered to protect confidential PLC configuration data does not match the password stored in the CPU. In this case, the CPU performs a restart, but cannot evaluate the contents of the SIMATIC Memory Card. Consequently, the CPU remains in STOP and displays an error.

Remedy

If one of these errors occurs, you must delete the password for protecting confidential PLC configuration data in the CPU and then set the correct password. After a restart the CPU, the backup is functional.

5.6.3.7 Tips for error avoidance and error handling

The following description lists some use cases that may result in CPU error messages.

Diagnostic buffer provides information

The CPU detects when the password protecting confidential configuration data and the loaded configuration do not match. A message in the diagnostic buffer indicates possible causes and remedies and usually leads to a solution of the problem.

Typical "pitfalls"

You should pay attention to the following circumstances in order to avoid or correct errors:

- Configuration loaded?
  Regardless of whether you protect your confidential configuration data with a password or not: without a loaded configuration, the CPU does not leave the provisioning phase.
- You are trying to load the CPU with a configured password and the CPU has already received another password.
  Example: CPU is exchanged for another CPU from the stock. The replacement CPU was not completely reset (reset to factory settings with option "Delete password for protection of confidential PLC configuration data").
  Solution:
  - Always prepare replacement CPUs with the appropriate option (password deleted).
  - For the configuration to be loaded, use the same password that was already used for the configuration already loaded.
  - It is also possible that the wrong project / CPU configuration was loaded. Check whether the correct CPU configuration is available.
  - Use the online function "Set password to protect confidential PLC configuration data" to delete the password or to set the same password as in the CPU configuration. Then, restart the device.
- The same error occurs if your CPU configuration does not use a password and the already loaded configuration requires a user-defined password.
  Solution:
  - Use the online function "Set password to protect confidential PLC configuration data" to delete the password or to set the same password as in the CPU configuration. Then, restart the device.

5.6.3.8 Rules for the replacement parts scenario

The assignment of passwords to protect confidential PLC configuration data also has an impact on the replacement parts scenario.

Rules for the replacement parts scenario

Observe the following rules for the replacement parts scenario:

Configuration of the replacement CPU via TIA Portal

- A CPU as replacement for an existing CPU should not have a configuration or a configured password to protect confidential PLC configuration data.
  Advantage: You can load the project into the replacement CPU without any further preparation - regardless of whether a password is configured or not.
- If the replacement CPU has already been configured, you must reset the CPU to the factory settings with the following options set:
  - "Delete password for protection of confidential PLC configuration data"
  - "Format memory card"

Replacement CPU is supplied with configuration data via memory card

- If you have **not** assigned a password to a CPU in your project to protect confidential PLC configuration data, you can insert the memory card of the CPU to be replaced into a brand-new, unused CPU without any further action needed.
  If the replacement CPU has already been configured with a password to protect confidential PLC configuration data, you must first reset this CPU to the factory settings using the option "Delete password for protection of confidential PLC configuration data".
- If you have assigned the same password to a group of CPUs, you can also assign the group password to the replacement CPU via the TIA Portal or via an appropriately prepared memory card (see Protection of confidential configuration data (Page 80)).
  In this case you can, for example, insert a memory card with the current project into the CPU and put it into operation without any further password handling.
- If you assign different passwords to each CPU in your project, you must first set the password valid for the respective CPU with the online and diagnostics editor when using the replacement CPU (area "Set password for protection of confidential PLC configuration data", see Changing your password (Page 84)).

More information

In section Assign password via SIMATIC Memory Card (Page 88) you can read how to use the SIMATIC Memory Card to assign the password to protect confidential PLC configuration data.

5.6.4 Secure Open User Communication

5.6.4.1 Secure OUC of an S7-1500 CPU as TLS client to an external PLC (TLS server)

The following section describes how you can set up Open User Communication via TCP from an S7-1500 CPU as TLS client to a TLS server.

Setting up a secure TCP connection from an S7-1500 CPU as TLS client to a TLS server

S7-1500 CPUs as of firmware version V2.0 support secure communication with addressing via a Domain Name System (DNS).

For secure TCP communication over the domain name you need to create a data block with the TCON_QDN_SEC system data type yourself, assign parameters and call it directly at one of the instructions TSEND_C, TRCV_C or TCON.

Requirements:

- Current date and time are set in the CPU.
- Your network includes at least one DNS server.
- You have configured at least one DNS server for the S7-1500 CPU.
- TLS client and TLS server have all the required certificates.

To set up a secure TCP connection to a TLS server, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_QDN_SEC in the global data block.

   The example below shows the global data block "Data_block_1" in which the tag "DNS ConnectionSEC" of the data type TCON_QDN_SEC is defined.

Data_block_1

	Name	Data type	Start value	Comment
1	Static			
2	DNS Connection SEC	TCON_QDN_SEC		
3	ConnPara	TCON_QDN		parameter of the TCP connection
4	InterfaceId	HW_ANY	0	not relevant
5	ID	CONN_OUC	5	connection reference / identifier
6	ConnectionType	Byte	11	type of connection: 16#0B=11=TCP/IP, 16#13
7	ActiveEstablished	Bool	true	active/passive connection establishment
8	RemoteQDN	String[254]	'plc_1.factory127.'	fully or partially qualified domain name of rem
9	RemotePort	UInt	4000	remote UDP / TCP port number
10	LocalPort	UInt	0	local UDP / TCP port number
11	ActivateSecureConn	Bool	true	activate the security functionality of that conn
12	TLSServerReqClientCert	Bool	false	Just for server side: The TLS server requests a
13	ExtTLSCapabilities	Word	16#0	Bit 0: Just for client side: validate given IPv4 a
14	TLSServerCertRef	UDInt	7	for Server side: Reference to own X.509 V3 se
15	TLSClientCertRef	UDInt	0	for Client side: add id of own X.509 V3 client c

Figure 3-389 Data type TCON_QDN_SEC

3. Set the connection parameters of the TCP connection in the "Start value" column. Enter the fully qualified domain name (FQDN) of the TLS server, for example, for "RemoteQDN".

4. Set the parameters for secure communication in the "Start value" column.
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   - "ExtTLSCapabilities": If you enter the value 1, the client validates the subjectAlternateName in the X.509v3 certificate of the server to verify the identity of the server. This validation is executed in the context of the instruction.
   - "TLSServerCertRef": ID of the X.509v3 certificate (usually a CA certificate) that is used by the TLS client to validate the TLS server authentication. If this parameter is 0, the TLS client uses all (CA) certificates currently loaded in the client certificate store to validate the server authentication.

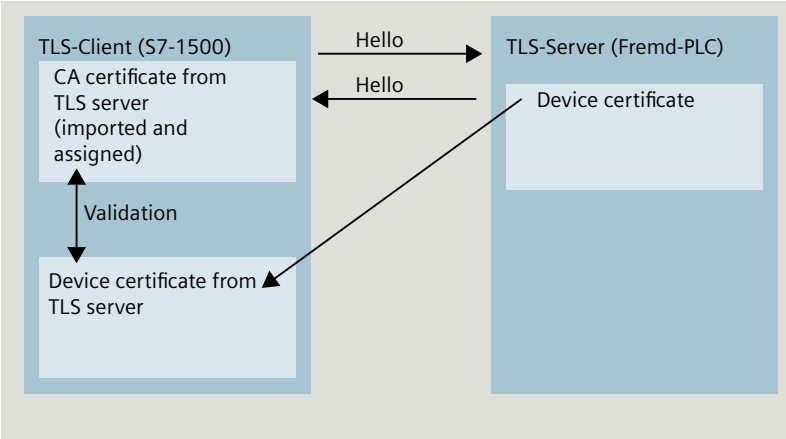

Figure 3-390 Certificate handling from the perspective of the S7-1500 as a TLS client

   - "TLSClientCertRef": ID of your own X.509v3 certificate.

5. Create one of the instructions TSEND_C, TRCV_C or TCON in the program editor.
6. Interconnect the CONNECT parameter of one of the instructions TSEND_C, TRCV_C or TCON with the tags of the data type TCON_QDN_SEC.

   In the example below, the CONNECT parameter of the TCON instruction is interconnected with the tag "DNS connectionSEC" (data type TCON_QDN_SEC).

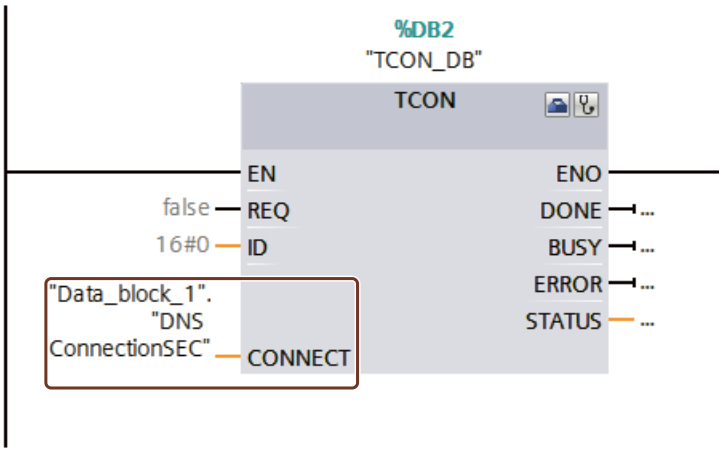

Figure 3-391 TCON instruction

Additional information

You can find more information on the TCON_QDN_SEC system data type in the STEP 7 online help.

For additional information on secure communication, refer to the section Secure Communication (Page 54).

5.6.4.2 Secure OUC of an S7-1500 CPU as TLS server to an external PLC (TLS client)

The following section describes how you can set up Open User Communication via TCP from an S7-1500 CPU as TLS server to a TLS client.

Setting up a secure TCP connection via the domain name of the communication partner

S7-1500 CPUs as of firmware version V2.0 support secure communication with addressing via a Domain Name System (DNS).

For secure TCP communication over the domain name you need to create a data block with the TCON_QDN_SEC system data type yourself, assign parameters and call it directly at one of the instructions TSEND_C, TRCV_C or TCON.

Requirements:

- Current date and time are set in the CPU.
- Your network includes at least one DNS server.
- You have configured at least one DNS server for the S7-1500 CPU.
- TLS client and TLS server have all the required certificates.

To set up a secure TCP connection to a TLS client, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_QDN_SEC in the global data block.

   The example below shows the global data block "Data_block_1" in which the tag "DNS ConnectionSEC" of the data type TCON_QDN_SEC is defined.

Data_block_1

	Name	Data type	Start value	Comment
1	Static			
2	DNS Connection SEC2	TCON_QDN_SEC		
3	ConnPara	TCON_QDN		parameter of the TCP connection
4	InterfaceId	HW_ANY	0	not relevant
5	ID	CONN_OUC	8	connection reference / identifier
6	ConnectionType	Byte	11	type of connection: 16#0B=11=TCP/IP, 16#13
7	ActiveEstablished	Bool	false	active/passive connection establishment
8	RemoteQDN	String[254]	''	fully or partially qualified domain name of rem
9	RemotePort	UInt	0	remote UDP / TCP port number
10	LocalPort	UInt	2010	local UDP / TCP port number
11	ActivateSecureConn	Bool	true	activate the security functionality of that conn
12	TLSServerReqClientCert	Bool	false	Just for server side: The TLS server requests a
13	ExtTLSCapabilities	Word	16#0	Bit 0: Just for client side: validate given IPv4 a
14	TLSServerCertRef	UDInt	5	for Server side: Reference to own X.509 V3 se
15	TLSClientCertRef	UDInt	0	for Client side: add id of own X.509 V3 client c

Figure 3-392 TCON_QDN_SEC_Server

3. Set the connection parameters of the TCP connection in the "Start value" column. Enter, for example, the local ID of the TCP connection for "ID".
4. Set the parameters for secure communication in the "Start value" column.
   – "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   – "TLSServerReqClientCert": Request for an X.509v3 certificate from the TLS client.
   – "TLSServerCertRef": ID of your own X.509v3 certificate.

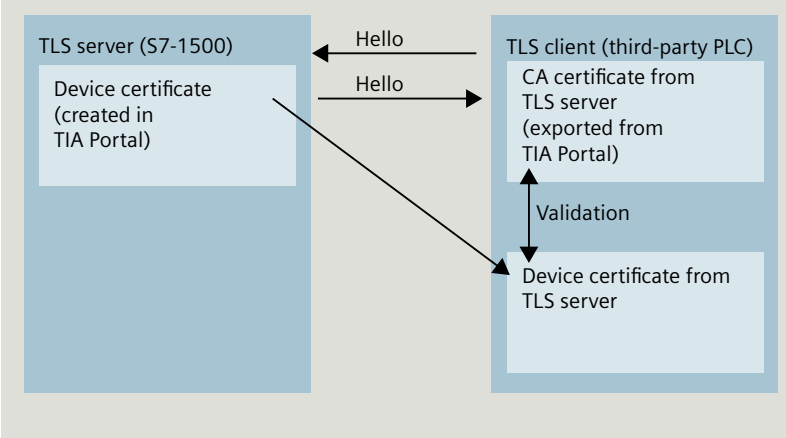

Figure 3-393 Certificate handling from the perspective of the S7-1500 as TLS server

   – "TLSClientCertRef": ID of the X.509v3 certificate (or a group of X.509v3 certificates) that is used by the TLS server to validate TLS client authentication. If this parameter is 0, the TLS server uses all (CA) certificates currently loaded in the server certificate store to validate the client authentication.
5. Create one of the instructions TSEND_C, TRCV_C or TCON in the program editor.
6. Interconnect the CONNECT parameter of one of the instructions TSEND_C, TRCV_C or TCON with the tags of the data type TCON_QDN_SEC.

   In the example below, the CONNECT parameter of the TCON instruction is interconnected with the tag "DNS connectionSEC" (data type TCON_QDN_SEC).

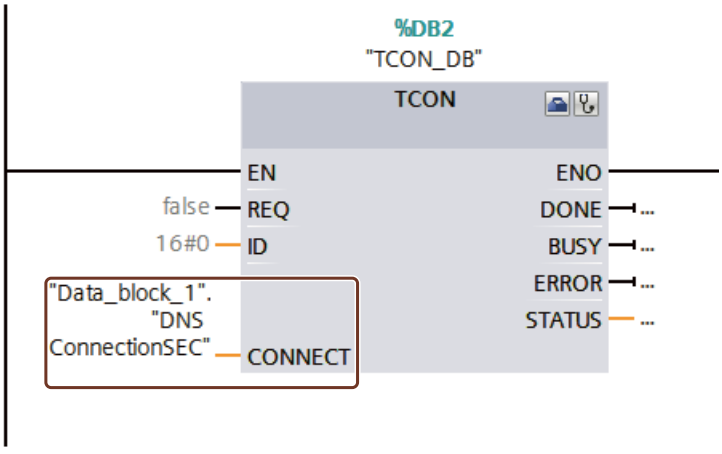

Figure 3-394 TCON instruction

More information

You can find more information about the system data types TCON_QDN_SEC in the STEP 7 online help.

For more information on secure communication, refer to the section Secure Communication (Page 54).

5.6.4.3 Secure OUC between two S7-1500 CPUs

The following section describes how you can set Secure Open User Communication via TCP between two S7-1500 CPUs. In the process one S7-1500 CPU acts as TLS client (active establishing of the connection) and the other S7-1500 CPU as TLS server (passive establishing of the connection).

Setting up a secure TCP connection between two S7-1500 CPUs

For secure TCP communication between two S7-1500 CPUs you need to create a data block with the TCON_IP_V4_SEC system data type yourself in every CPU, assign parameters and call it directly at one of the instructions TSEND_C, TRCV_C or TCON.

Requirements:

- The current date and time are set in the CPUs.
- Both S7-1500 CPUs have at least firmware version V2.0
- TLS client and TLS server have all the required certificates.

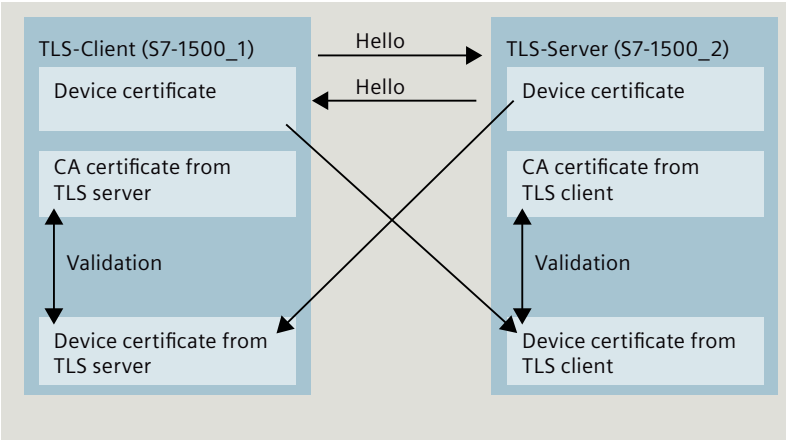

Figure 3-395 Certificate handling for Secure OUC between two S7-1500 CPUs

Settings at the TLS client

To set up a secure TCP connection in the TLS client, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_IP_V4_SEC in the global data block.

   The example below shows the global data block "Data_block_1" in which the tag "SEC connection 1 TLS-Client" of the data type TCON_IP_V4_SEC is defined.

Data_block_1

	Name	Data type	Start value	Comment
1	Static			
2	SEC connection 1 TLS-Client	TCON_IP_V4_SEC		
3	ConnPara	TCON_IP_v4		parameter of the TCP connection
4	InterfaceId	HW_ANY	72	HW-identifier of IE-interface submodule
5	ID	CONN_OUC	10	connection reference / identifier
6	ConnectionType	Byte	11	type of connetion: 11=TCP/IP, 19=UDP (17=TCP/IP)
7	ActiveEstablished	Bool	true	active/passive connection establishment
8	RemoteAddress	IP_V4		remote IP address (IPv4)
9	ADDR	Array[1..4] of Byte		IPv4 address
10	ADDR[1]	Byte	192	IPv4 address
11	ADDR[2]	Byte	168	IPv4 address
12	ADDR[3]	Byte	1	IPv4 address
13	ADDR[4]	Byte	100	IPv4 address
14	RemotePort	UInt	4711	remote UDP/TCP port number
15	LocalPort	UInt	4711	local UDP/TCP port number
16	ActivateSecureConn	Bool	true	activate the security functionality of that connection in general
17	TLSServerReqClientCert	Bool	false	Just for server side: The TLS server requests a client certificate
18	ExtTLSCapabilities	Word	16#0	Bit 0: Just for client side: validate given IPv4 address against th
19	TLSServerCertRef	UDInt	1	for Server side: Reference to own X.509 V3 server certificate; fo
20	TLSClientCertRef	UDInt	5	for Client side: add id of own X.509 V3 client certificate; for Serv

Figure 3-396 IP_V4_SEC_Client

3. Set the connection parameters of the TCP connection in the "Start value" column. For example, enter the IPv4 address of the TLS server for "RemoteAddress".

NOTE

Connection parameter Interface ID

Note that you can enter the value "**0**" for the interface ID in the data type TCON_IP_V4_SEC. In this case, the CPU itself searches for a suitable local CPU interface.

---

4. Set the parameters for secure communication in the "Start value" column.
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   - "TLSServerCertRef": Enter the value 2 (reference to the CA certificate of the TIA Portal project (SHA256)) or the value 1 (reference to the CA certificate of the TIA Portal project (SHA1)). If you use a different CA certificate, enter the corresponding ID from the certificate manager of the global security settings.
   - "TLSClientCertRef": ID of your own X.509v3 certificate.

5. Create one of the instructions TSEND_C, TRCV_C or TCON in the program editor.
6. Interconnect the CONNECT parameter of one of the instructions TSEND_C, TRCV_C or TCON with the tags of the data type TCON_IP_V4_SEC.

Settings at the TLS server

To set up a secure TCP connection in the TLS server, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_IP_4_SEC in the global data block.

   The example below shows the global data block "Data_block_1" in which the tag "SEC connection 1 TLS-Server" of the data type TCON_IP_V4_SEC is defined.

Data_block_1

	Name	Data type	Start value	Comment
1	Static			
2	SEC connection 1 TLS-Server	TCON_IP_V4_SEC		
3	ConnPara	TCON_IP_v4		parameter of the TCP connection
4	InterfaceId	HW_ANY	120	HW-identifier of IE-interface submodule
5	ID	CONN_OUC	10	connection reference / identifier
6	ConnectionType	Byte	11	type of connetion: 11=TCP/IP, 19=UDP (17=TCP/IP)
7	ActiveEstablished	Bool	false	active/passive connection establishment
8	RemoteAddress	IP_V4		remote IP address (IPv4)
9	ADDR	Array[1..4] of Byte		IPv4 address
10	ADDR[1]	Byte	192	IPv4 address
11	ADDR[2]	Byte	168	IPv4 address
12	ADDR[3]	Byte	1	IPv4 address
13	ADDR[4]	Byte	10	IPv4 address
14	RemotePort	UInt	4711	remote UDP/TCP port number
15	LocalPort	UInt	4711	local UDP/TCP port number
16	ActivateSecureConn	Bool	true	activate the security functionality of that connection in general
17	TLSServerReqClientCert	Bool	true	Just for server side: The TLS server requests a client certificate
18	ExtTLSCapabilities	Word	16#0	Bit 0: Just for client side: validate given IPv4 address against the
19	TLSServerCertRef	UDInt	6	for Server side: Reference to own X.509 V3 server certificate; fo
20	TLSClientCertRef	UDInt	1	for Client side: add id of own X.509 V3 client certificate; for Serv

Figure 3-397 IP_V4_SEC_Server

3. Set the connection parameters of the TCP connection in the "Start value" column. For example, enter the IPv4 address of the TLS client for "RemoteAddress".
4. Set the parameters for secure communication in the "Start value" column.
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   - "TLSServerReqClientCert ": Request for an X.509v3 certificate from the TLS client. Enter the value "true".
   - "TLSServerCertRef": ID of your own X.509v3 certificate.
   - "TLSClientCertRef": Enter the value 2 (reference to the CA certificate of the TIA Portal project (SHA256)) or the value 1 (reference to the CA certificate of the TIA Portal project (SHA1)). If you use a different CA certificate, enter the corresponding ID from the certificate manager of the global security settings.
5. Create one of the instructions TSEND_C, TRCV_C or TCON in the program editor.

6. Interconnect the CONNECT parameter of one of the instructions TSEND_C, TRCV_C or TCON with the tags of the data type TCON_IP_V4_SEC.

   In the example below, the CONNECT parameter of the TSEND_C instruction is interconnected with the "SEC connection 1 TLS server" tag (data type TCON_IP_4_SEC).

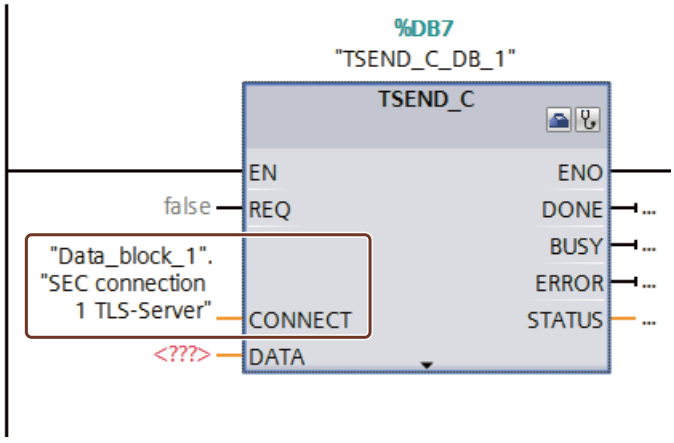

Figure 3-398 TSEND_C

More information

You can find more information about the system data types TCON_IP_4_SEC in the STEP 7 online help.

For additional information on secure communication, refer to the section Secure Communication (Page 54).

5.6.4.4 Secure OUC via CP interface

The following sections describes the particular points to be taken into consideration in the case of Secure Open User Communication via a CP interface. At least one station is an S7-1500 station with the following modules:

- S7-1500 CPU as of firmware version V2.0 (except for S7-1500 Software Controller)
- CP
  - CP 1543-1 as of firmware version V2.0
  - CP 1545-1 as of firmware version V1.0
  - CP 1543SP-1 as of firmware version V1.0

The CP acts in an S7-1500 station as a TLS client (active connection establishment) or a TLS server (passive connection establishment).

The fundamental procedure and the concept for using secure communication via a CP interface is similar to that of secure communication via the interfaces of the S7-1500 CPUs. Essentially, you have to assign the certificates to the CPU in the role of a TLS server or TLS client and not to the CPU. Other rules and procedures therefore apply. These are described below.

Handling certificates for CPs

The following applies in general: You have to be logged on at the certificate manager in the global security settings. The generation of self-signed certificates also requires logon for the global security settings. You have to have sufficient rights as a user (administrator or user with the "Standard" role with the right to "Configure security").

The starting point for the generation or assignment of certificates at the CP is the section "Security > Security properties". In this section, you log on for the global security settings.

Procedure:

1. In the network view of STEP 7, mark the CP and select the section "Security > Security properties" in the Inspector window.
2. Click on the "User logon" button.
3. Log on using your user name and password.
4. Enable the "Activate security functions" option.

   The security properties are initialized.
5. Click in the first line of the "Device certificates" table to generate a new certificate or select an existing device certificate.
6. If the communication partner is also an S7-1500 station, you also have to assign a device certificate to the communication partner with STEP 7 as described here or for the S7-1500 CPU.

Example: Setting up a secure TCP connection between two S7-1500 CPUs via CP interfaces

In order to establish secure TCP communication between two S7-1500 CPs you have to create a data block with the system data type TCON_IP_V4_SEC in each CPU, carry out the parameter assignment and call it directly at the instruction.

Requirements:

- Both S7-1500 CPUs have one of the firmware versions specified above.
- The CPs have one of the firmware versions specified above.
- TLS client and TLS server have all the required certificates.
  - A device certificate (end-entity certificate) for the CP must be generated and be located in the certificate memory of the CP. If a communication partner is an external device (for example an MES or ERP system), a device certificate also has to exist for this device.
  - The root certificate (CA certificate) with which the device certificate of the communication partner is signed must also be located in the certificate memory of the CP or in the certificate memory of the external device. If you use intermediate certificates, you have to ensure that the complete certificate path exists in the validating device. A device uses these certificates to validate the device certificate of the communication partner.
- The communication partner must always be addressed via its IPv4 address, not via its domain name.

The following figure shows the different certificates in the devices for a scenario in which both communication partners communicate via one CP. In addition, the figure shows the transfer of the device certificates during establishment of the connection ("Hello").

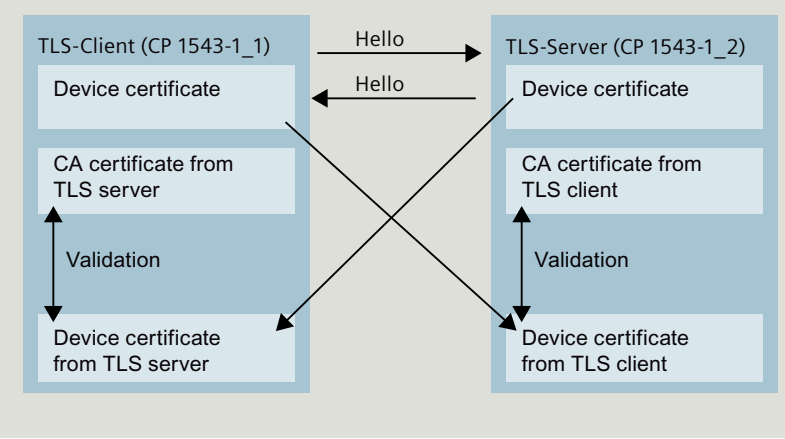

Figure 3-399 Certificate handling in secure OUC between two S7-1500 CPUs via CP interfaces.

Settings at the TLS client

To set up a secure TCP connection in the TLS client, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_IP_4_SEC in the global data block. To do so, enter the string "TCON_IP_V4_SEC" in the "Data type" field.

   The example below shows the global data block "Data_block_1" in which the tag "SEC connection 1 TLS-Client" of the data type TCON_IP_V4_SEC is defined.

   The Interface ID has the value of the HW identifier of the IE interface of the local CP (TLS client).

Data_block_1

	Name	Data type	Start value	Comment
1	Static			
2	SEC connection 1 TLS-Client	TCON_IP_V4_SEC		
3	ConnPara	TCON_IP_v4		parameter of the TCP connection
4	InterfaceId	HW_ANY	258	HW-identifier of IE-interface submodule
5	ID	CONN_OUC	10	connection reference / identifier
6	ConnectionType	Byte	11	type of connetion: 11=TCP/IP, 19=UDP (17=TCP/IP)
7	ActiveEstablished	Bool	true	active/passive connection establishment
8	RemoteAddress	IP_V4		remote IP address (IPv4)
9	ADDR	Array[1..4] of Byte		IPv4 address
10	ADDR[1]	Byte	192	IPv4 address
11	ADDR[2]	Byte	168	IPv4 address
12	ADDR[3]	Byte	1	IPv4 address
13	ADDR[4]	Byte	100	IPv4 address
14	RemotePort	UInt	4711	remote UDP/TCP port number
15	LocalPort	UInt	4711	local UDP/TCP port number
16	ActivateSecureConn	Bool	true	activate the security functionality of that connection in general
17	TLSServerReqClientCert	Bool	false	Just for server side: The TLS server requests a client certificate
18	ExtTLSCapabilities	Word	16#0	Bit 0: Just for client side: validate given IPv4 address against th
19	TLSServerCertRef	UDInt	1	for Server side: Reference to own X.509 V3 server certificate; fc
20	TLSClientCertRef	UDInt	5	for Client side: add id of own X.509 V3 client certificate; for Sen

Figure 3-400 IP_V4_SEC_Client

3. Set the connection parameters of the TCP connection in the "Start value" column. For example, enter the IPv4 address of the TLS server for "RemoteAddress".
4. Set the parameters for secure communication in the "Start value" column.
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   - "TLSServerCertRef": Enter the value 2 (reference to the CA certificate of the TIA Portal project (SHA256)) or the value 1 (reference to the CA certificate of the TIA Portal project (SHA1)).
   - "TLSClientCertRef": ID of your own X.509v3 certificate.
5. Create a TCON instruction in the program editor.
6. Connect the CONNECT parameter of the TCON instruction with the variable of data type TCON_IP_V4_SEC.

Settings at the TLS server

To set up a secure TCP connection in the TLS server, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_IP_4_SEC in the global data block.

   The example below shows the global data block "Data_block_1" in which the tag "SEC connection 1 TLS-Server" of the data type TCON_IP_V4_SEC is defined.

   The interface ID has the value of the HW identifier of the IE interface of the local CP (TLS server).

Data_block_1

	Name	Data type	Start value	Comment
1	Static			
2	SEC connection 1 TLS-Server	TCON_IP_V4_SEC		
3	ConnPara	TCON_IP_v4		parameter of the TCP connection
4	InterfaceId	HW_ANY	260	HW-identifier of IE-interface submodule
5	ID	CONN_OUC	10	connection reference / identifier
6	ConnectionType	Byte	11	type of connetion: 11=TCP/IP, 19=UDP (17=TCP/IP)
7	ActiveEstablished	Bool	false	active/passive connection establishment
8	RemoteAddress	IP_V4		remote IP address (IPv4)
9	ADDR	Array[1..4] of Byte		IPv4 address
10	ADDR[1]	Byte	192	IPv4 address
11	ADDR[2]	Byte	168	IPv4 address
12	ADDR[3]	Byte	1	IPv4 address
13	ADDR[4]	Byte	10	IPv4 address
14	RemotePort	UInt	4711	remote UDP/TCP port number
15	LocalPort	UInt	4711	local UDP/TCP port number
16	ActivateSecureConn	Bool	true	activate the security functionality of that connection in general
17	TLSServerReqClientCert	Bool	true	Just for server side: The TLS server requests a client certificate
18	ExtTLSCapabilities	Word	16#0	Bit 0: Just for client side: validate given IPv4 address against the
19	TLSServerCertRef	UDInt	6	for Server side: Reference to own X.509 V3 server certificate; fo
20	TLSClientCertRef	UDInt	1	for Client side: add id of own X.509 V3 client certificate; for Serv

Figure 3-401 IP_V4_SEC_Server

3. Set the connection parameters of the TCP connection in the "Start value" column. For example, enter the IPv4 address of the TLS client for "RemoteAddress".
4. Set the parameters for secure communication in the "Start value" column.
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   - "TLSServerReqClientCert": Request for an X.509v3 certificate from the TLS client. Enter the value "true".
   - "TLSServerCertRef": ID of your own X.509v3 certificate.
   - "TLSClientCertRef": Enter the value 2 (reference to the CA certificate of the TIA Portal project (SHA256)) or the value 1 (reference to the CA certificate of the TIA Portal project (SHA1)).

5. Create a TCON instruction in the program editor.
6. Connect the CONNECT parameter of the TCON instruction with the variable of data type TCON_IP_V4_SEC.

Upload device as new station

When you upload a configuration with certificates and configured secure Open User Communication as a new station into your STEP 7 project, the certificates of the CP are not uploaded, in contrast to the certificates of the CPU. After the device has been loaded as a new station, no more certificates are contained in the corresponding tables of the CPs for the device certificates.

You have to perform configuration of certificates again after the upload. Otherwise, renewed loading of the configuration results in the certificates that originally exist in the CP being deleted so that secure communication does not function.

Secure OUC connections via CPU and CP interfaces - similarities

- Connection resources:
  No differences between OUC and secure OUC. A programmed secure OUC connection uses a connection resource just like an OUC connection, irrespective of which IE/PROFINET interface communicates with the station.
- Connection diagnostics:
  No differences between OUC and secure OUC connection diagnostics.
- Loading of projects with secure OUC connections into the CPU:
  Only possible in STOP of the CPU, if certificates are loaded as well. For information on the requirements for updating loaded certificates in RUN mode, see Tip: Updating loaded certificates in RUN (Page 79).
  Recommendation: Load to device > Hardware and software. Reason: Ensuring consistency between programs with secure OUC, hardware configuration and certificates.
  The reloading of blocks that utilize further secure OUC connections is only possible in RUN mode if the certificates required for this purpose are already located on the module.

5.6.4.5 Secure OUC with Modbus TCP

For secure Modbus TCP connection you need to create a data block with one of the system data types TCON_IP_V4_SEC or TCON_QDN_SEC yourself, assign parameters and call it directly at the MB_Server or MB_CLIENT instruction.

Requirements

- S7-1500 CPU CPU firmware version V2.5 or higher
- The Modbus client (TLS client) can reach the Modbus server (TLS server) over IP communication in the network.
- TLS client and TLS server have all the required certificates.

Example: Setting up a secure Modbus TCP connection to a Modbus TCP server

The following section describes how you can set up a Secure Open User Communication over Modbus TCP from a Modbus TCP client to a Modbus TCP server.

To set up a secure connection from a Modbus TCP client (TLS client) to a Modbus TCP server (TLS server), proceed as follows:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_IP_V4 SEC in the global data block.

Data_block_1

	Name	Data type	Start value	Comment
1	Static			
2	SEC_ModbusTCP_1	TCON_IP_V4...		
3	ConnPara	TCON_IP_v4		parameter of the TCP connection
4	InterfaceId	HW_ANY	64	HW-identifier of IE-interface submodule
5	ID	CONN_OUC	15	connection reference / identifier
6	ConnectionType	Byte	11	type of connection: 11=TCP/IP, 19=UDP (17=TCP/IP)
7	ActiveEstablished	Bool	true	active/passive connection establishment
8	RemoteAddress	IP_V4		remote IP address (IPv4)
9	ADDR	Array[1..4] of B...		IPv4 address
10	ADDR[1]	Byte	192	IPv4 address
11	ADDR[2]	Byte	168	IPv4 address
12	ADDR[3]	Byte	10	IPv4 address
13	ADDR[4]	Byte	100	IPv4 address
14	RemotePort	UInt	502	remote UDP/TCP port number
15	LocalPort	UInt	502	local UDP/TCP port number
16	ActivateSecureConn	Bool	true	activate the security functionality of that connection in general
17	TLSServerReqClientCert	Bool	false	Just for server side: The TLS server requests a client certificate
18	ExtTLSCapabilities	Word	0	Bit 0: Just for client side: validate given IPv4 address against the subjectAlt
19	TLSServerCertRef	UDInt	2	for Server side: Reference to own X.509 V3 server certificate; for Client side:
20	TLSClientCertRef	UDInt	7	for Client side: add id of own X.509 V3 client certificate; for Server side: add

Figure 3-402 TCON_IP_V4_SEC

3. Set the connection parameters of the TCP connection in the "Start value" column. For example, enter the IPv4 address of the communication partner in "RemoteAddress".
4. Set the parameters for secure communication in the "Start value" column as follows:
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. In this case you can set up an unsecured Modbus TCP connection.
   - "TLSServerCertRef": Reference to the X.509v3 (CA) certificate of the Modbus TCP server, which is used by the TLS client to validate the authentication of the Modbus TCP server.
5. Create an MB_CLIENT instruction in the program editor.
6. Interconnect the CONNECT parameter of the MB_Client instruction with the tags of the data type TCON_IP_4_SEC.

5.6.4.6 Secure OUC via e-mail

Setting up a secure connection to a mail server over the CPU interface

For secure communication to a mail server you need to create a data block with one of the system data types TMAIL_V4_SEC, TMAIL_QDN_SEC yourself, assign parameters and call it directly at the TMAIL_C instruction.

Requirements

- TMAIL_C instruction version V5.0 or higher
- STEP 7 V15 and higher
- S7-1500 CPU V2.5 and higher
- You have assigned all the CA certificates of the mail server (TLS server) to the CPU (TLS client) and have downloaded the configuration to the CPU.
- Current date and time are set in the CPU.

Process for establishing a secure connection to the mail server

You can choose between two processes for establishing the secure connection to the mail server:

- SMTPS: The client attempts to immediately establish a TLS connection to the mail server ("handshake" process). If the mail server does not support TLS, then no connection is established.
- STARTTLS: Client establishes a TCP connection to the mail server. The client sends a request to "upgrade" the existing connection to a secure TLC connection over the TCP connection. If the mail server supports TLS, the client sends the command to establish a secure connection. The mail server uses the SMTP command "STARTTLS" to do this. The client then establishes a secure connection to the mail server. Advantage: If the mail server does not support TLS, client and mail server can communicate unsecured with each other.

You use the "Remote Port" setting in the data types at the block parameter "MAIL_ADDR_PARAM" to define which process is used for the communication.

Table 3-937 Port numbers for the SMTPS and STARTTLS processes

Process	Port
SMTPS:	465[1]
STARTTLS	Any (≠465)[2]

[1] The TMAIL_C instruction uses SMTPS only for port 465. For all other ports STARTTLS is used.

[2] According to RFC, mail servers use ports 25 and 587 for secure connections with STARTTLS. The use of other port numbers for SMTP is not RFC-compliant, successful communication with such a mail server is not guaranteed.

Example: Setting up a secure connection to a mail server over IPv4

The following section describes how to set up a secure connection to an IPv4 mail server with the TMAIL_C communication instruction.

To set up a secure connection via the IP4 address of the mail server, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TMAIL_V4_SEC in the global data block.

   The example below shows the global data block "MailConnDB" in which the tag "MailConnectionSEC" of the data type TMAIL_V4_SEC is defined.

MailConnDB

Name	Datentyp	Startwert	Kommentar
Static			
MailConnectionSEC	TMail_V4_SEC		
InterfaceId	HW_ANY	"Local~CP_1543-1_1~Ethernet-Schnittstelle_1"	Use HW-identifier of the IE-interface to specify th
ID	CONN_OUC	100	connection reference / identifier
ConnectionType	Byte	16#20	type of connection 16#20=32=TMail_V4 or TMai
ActiveEstablished	Bool	true	active / passive connection establishment
WatchDogTime	Time	T#5000ms	watchdog time to monitor SMTP server associa
MailServerAddress	IP_V4		IPv4 address of mail server
ADDR	Array[1..4] of Byte		IPv4 address
ADDR[1]	Byte	144	IPv4 address
ADDR[2]	Byte	145	IPv4 address
ADDR[3]	Byte	2	IPv4 address
ADDR[4]	Byte	20	IPv4 address
UserName	String[254]	'myName'	user name which is necessary to login into the
PassWord	String[254]	'myPW'	user password which is necessary to login into
From	EMAIL_ADDR		source mail address
LocalPartPlusAt...	String[64]	'Mustermann@'	local part of e-mail address plus "@" sign
FullQualifiedD...	String[254]	'siemens.com'	full qualified domain name part of e-mail addre
RemotePort	UInt	587	remote TCP port number
ActivateSecureConn	Bool	TRUE	activate the security functionality of that conne
ExtTLSCapabilities	Byte	16#0	for further capability extensions of the TLS hand
TLSServerCertRef	UDInt	7	Reference to the X.509 V3 (CA-) certificate of the

Figure 3-403 Data type TMAIL_V4_SEC

3. Set the connection parameters of the TCP connection in the "Start value" column. For example, enter the IPv4 address of the mail server for the "MailServerAddress".

   NOTE

   Connection parameter Interface ID

   As of instruction version V5.0 of TMAIL_C instruction in the TMAIL_V4_SEC data type, note that you need to enter the value "**0**" for the Interface ID. In this case, the CPU itself searches for a suitable local CPU interface.

4. Set the parameters for secure communication in the "Start value" column as follows:
   - "ActivateSecureConn": Activation of secure communication for this connection. If this parameter has the value FALSE, the subsequent security parameters are irrelevant. You can set up a non-secure TCP or UDP connection in this case.
   - "TLSServerCertRef": Reference to the X.509v3 (CA) certificate of the mail server, which is used by the TLS client to validate the authentication of the mail server.

5. Create a TMAIL_C instruction in the program editor.
6. Interconnect the MAIL_ADDR_PARAM parameter of the TMAIL_C instruction with the tag of the data type TMAIL_V4_SEC.

   In the following example, the MAIL_ADDR_PARAM parameter of the TMAIL_C instruction is interconnected with the tag "MailConnectionSEC" (data type TMAIL_V4_SEC).

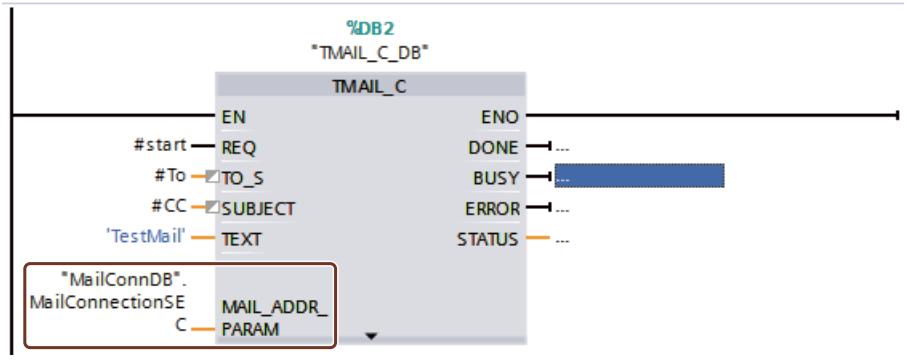

Figure 3-404 TMAIL_C instruction

Setting up a secure connection to a mail server over the interface of a communication module

For secure communication to a mail server over a communications module, you need to create a data block with one of the system data types TMAIL_V4_SEC, TMAIL_QDN_SEC or TMAIL_V6_SEC (CP only), assign parameters and call it directly in the TMAIL_C instruction.

Requirements:

- TMAIL_C instruction with version **V4.0**
- S7-1500 CPU as of firmware version V2.0 with communication module CP 1543-1 as of firmware version V2.0
- ET 200SP CPU as of firmware version V2.0 with communication module CP 1542SP-1 (IRC) as of firmware version V1.0
- You have assigned all the CA certificates of the mail server (TLS server) to the CP (TLS client) and have downloaded the configuration to the CPU.
- Current date and time are set in the CPU.

The STEP 7 online help describes how to set up a secure connection to a mail server over the interface of a communications module.

Application example

This application example (https://support.industry.siemens.com/cs/ww/en/view/46817803) shows how you can use the CP of an S7-1500 or S7-1200 station to set up a secure connection to an email server and send an email with the default application "TMAIL_C" from the S7 CPU.

More information

You can find more information about the system data types TMAIL_V4_SEC and TMAIL_QDN_SEC in the STEP 7 online help.

For additional information on secure communication, refer to the section Secure Communication (Page 54).

5.6.5 Secure PG/HMI communication

5.6.5.1 PG/HMI communication based on standardized security mechanisms

With the central components of the TIA Portal, STEP 7 and WinCC, an innovative and standardized Secure PG/PC and HMI Communication - PG/HMI communication for short - is implemented starting with version V17 together with the latest controllers and latest HMI devices.

The following CPU families are referred to in detail:

- S7-1500 controller family as of firmware version V2.9
- S7-1200 controller family as of firmware version V4.5
- Software controllers as of firmware version V21.9
- SIMATIC Drive controllers as of firmware version V2.9
- PLCSIM and PLCSIM Advanced Version V4.0

Furthermore, HMI components have been updated to support Secure PG/HMI Communication:

- Panels or PCs configured with WinCC Basic, Comfort and Advanced
- PCs with WinCC RT Professional
- WinCC Unified PCs and Comfort Panels

Also updated are SINAMICS RT SW as of version V6.1 and STARTDRIVE as of version V17.

Properties of PG/HMI communication

One characteristic of PG communication and HMI communication above all is their simplicity: Establishing an online connection from a programming device with installed TIA Portal to a CPU, for example, to load a program, requires little effort. This online connection also meets criteria such as confidentiality and integrity - based on a proven SIMATIC communication standard.

In the course of integrating machines and systems into an open IT environment, however, it must be ensured that the communication between the programming device / HMI device and the CPU is not only secure in the sense of maintaining integrity and confidentiality for sensitive data but also that this security meets generally accepted standards and is thus ready for the challenges of the future.

With TIA Portal version V14, the "Open User Communication" procedure for communication based on user programs has already been extended by the "**Secure** Open User Communication" variant. Other certificate-based communication mechanisms have become established (HTTPS, Secure SMTP over TLS or OPC UA). As of TIA Portal Version V17, PG/HMI communication has also been upgraded: Here, too, the TLS (Transport Layer Security) protocol is used to secure PG/HMI communication using standardized security mechanisms.

What has changed

Additional optional password for more security

The most noticeable change in the frame of the configuring of the above devices is the ability to assign a password to protect sensitive configuration data of the respective CPU. This refers to data such as private keys that are required for the proper functioning of certificate-based protocols (Secure Communication) - as of TIA Portal V17 also for PG/HMI communication. You can use a policy setting to check the assigned passwords as they are entered into the TIA Portal. This will ensure that your company complies with prescribed password policies.

If your machine or system does not require this protection based on the Siemens Industrial Defense-in-Depth concept, you can dispense with password assignment, for example, because another equivalent protection is present. It is possible to do without the password if you have implemented measures to prevent unauthorized access to the TIA Portal project and the configuration of the CPU.

WARNING

Without password, weak protection of private keys

Note that without a password to protect trusted configuration data, the private keys for certificates required for secure communication are only weakly protected.

Certificate-based communication between PG/HMI and CPU

Because PG/HMI communication is certificate-based, you will be asked to accept the server certificate during commissioning.

Additional parameter assignment options allow you to determine the behavior of the CPU during operation: For example, you can specify that the CPU also allows connection to devices that do not support Secure PG/HMI communication.

Maintenance / replacement parts scenario

For the problem-free exchange of the CPU in replacement parts scenario, you must observe specific rules (see Rules for the replacement parts scenario (Page 92)).

More information

An overview of how to protect confidential configuration data can be found in section Protection of confidential configuration data (Page 80).

5.6.5.2 Additional settings for the secure PG/HMI communication

In addition to the assignment of a password to protect confidential PLC configuration data, you have further setting options for the behavior of the CPU during operation.

PG/PC and HMI communication mode

You can set how the CPU can communicate with programming devices and HMI devices:

- Only via secure PG/HMI communication
- Both via Secure PG/HMI communication and via the previously used PG/HMI communication, "Legacy PG/HMI communication" for short.

Procedure

1. In the CPU properties, navigate to the area "Protection & Security > Connection mechanisms".
2. Select the option you want to use.

Select certificate or generate a new certificate

If you select the connection mechanism for PG/HMI communication, you can select a PLC communication certificate for the protection of the connection in the same context or have it generated by the TIA Portal. If you have assigned a password or if you have deactivated the option to protect confidential PLC configuration data (i.e. no password has been set), then a certificate with suitable settings and a valid default name is already preset in the "Protection & Security > Connection mechanisms" area.

Procedure

If you want to have a new certificate generated by the TIA Portal or if you want to select another existing certificate:

1. In the "PLC communication certificate" field, click the three points to expand the field.
2. Select the certificate you want or click the "Add" button.
3. When adding a certificate, a dialog appears with setting options for the certificate.
   The purpose is set to "TLS server", you can change other parameters (such as name, hash algorithm).

The general rules for certificate management apply. For example, if you want to generate a CA certificate, the option "Global settings for the certificate manager" must be selected. You also have the option of generating a self-signed PLC certificate.

More information

Basic information on the subject of certificate management can be found in section Certificate management with TIA Portal (Page 66).

5.6.5.3 Tip for certificate-based communication between PG and CPU

The certificate-based PG/PC communication (Secure PG/PC communication) means that the communication partner of the CPU – the programming device with installed TIA Portal – must trust the device certificate of the CPU so that a connection can be loaded.

To put it simply, from the TIA Portal perspective you have the following options to trust the certificate of a CPU:

- The PG with TIA Portal is in possession of the device certificate of the CPU because it was, for example, created or imported in the project. In this case, the certificate check runs automatically and without prompting.
- The PG with TIA Portal is not in possession of the device certificate of the CPU, because the CPU was determined via "Accessible stations", for example, and is not available in the project. In this case, the TIA Portal asks the TIA Portal user whether the certificate can be trusted. This may be possible only with great effort because the CPU is not in sight, for example, and the authenticity can therefore not be checked immediately.
- The PG with TIA Portal is in possession of the CA certificate (certification authority) and all CPUs that can be reached in the network from the TIA Portal have device certificates issued by this CA certificate.

  Advantage of this solution: TIA Portal can check device certificates automatically, even if the device certificates of the communication partners are not available in TIA Portal.

The solution with a CA certificate (certification authority) is explained in more detail below.

Requirement

You can use the certification authority of the TIA Portal to create device certificates for a CPU and use the existing CA certificates to sign the device certificates. However, you can also import another certification authority into TIA Portal and use it.

Enabling the global security policies for the certificate manager is a requirement. Only with this setting you can generate CA-signed certificates.

See also here: Certificate management with TIA Portal (Page 66)

Exporting CA certificate for programming devices

To export the corresponding CA certificate after creating and assigning a certificate, follow these steps:

1. Open the certificate manager in the global security settings in the project tree.
2. Select the table "CA certificates" for the certificate to be exported.
3. Right-click to open the shortcut menu of the selected certificate.
4. Click "Export".
5. Select the export format of the certificate and the storage location.

Store CA certificate in the TIA Portal

To make the exported certificate known to a PG with TIA Portal and thus enable automatic certificate checking, follow these steps:

1. Copy the CA certificate exported in the previous step to the following directory:

   C:\ProgramData\Siemens\Automation\Certstore\Trusted

2. Start TIA Portal.

   In the "Info" tab of the Inspector window, a message appears for each CA certificate which provides information on whether the CA certificate could be successfully transferred to the CA store of TIA Portal.

   However, no detailed causes are output in case of failure.

Adding device certificates to the TIA Portal certificate revocation list (CRL)

You have the option to add individual device certificates to a certificate revocation list (CRL), for example, because the associated key is no longer considered secure.

When the TIA Portal establishes a connection to a CPU whose device certificate is in the certificate revocation list, a dialog appears in the TIA Portal asking whether you still want to trust the certificate. If you decline, the connection will not be established.

To add a device certificate to the certificate revocation list, follow these steps:

1. Copy the device certificate to the following directory:

   C:\ProgramData\Siemens\Automation\Certstore\CRL

2. Start TIA Portal.

   In the "Info" tab of the Inspector window, a message appears for each certificate which provides information about whether the certificate could be successfully transferred to the CRL store of TIA Portal.

   However, no detailed causes are output in case of failure.

5.6.5.4 CPU behavior from loading to operational readiness

To ensure that communication between the CPU and a programming device or HMI device is secure, it must first have a certificate. However, the certificate for productive operation is only issued when the project is loaded into the CPU.

To ensure that the initial loading is also secured, the CPU first creates a self-signed certificate. The following description explains the different phases of establishing a connection.

Requirement for the initial establishment of connection to load the CPU

- No password for confidential PLC configuration data available in the CPU.

  If the CPU has already been loaded and therefore already has a password for confidential PLC configuration data, this password must then match the project that is to be loaded.

- Project with CPU configuration (including password for confidential PLC configuration data) and user program is available.

- The CPU is in STOP mode.
- Programming device and CPU are directly connected to each other and are located in a protected environment, i.e. you can identify the CPU to be loaded and control the connection between CPU and programming device.

Initial establishment of connection to the CPU - provisioning phase

The first connection establishment for loading the CPU is secured by the TLS procedure in terms of Secure PG/HMI Communication.

However, the CPU uses its manufacturer device certificate (if available) or a self-signed certificate to establish this connection. The CPU can only be used to a limited extent in this phase. In this phase, the CPU waits for the provision of the password-based key information - or more simply stated, it is expecting the password for confidential PLC configuration data. This phase is referred to below as the provisioning phase. A message in the diagnostic buffer indicates that the CPU is in the provisioning phase.

When a project is loaded into the CPU, the CPU receives the project data:

- Hardware configuration including configured certificates for secure communication (OPC UA, HTTPS, Secure OUC, Secure PG/HMI Communication)
- User program

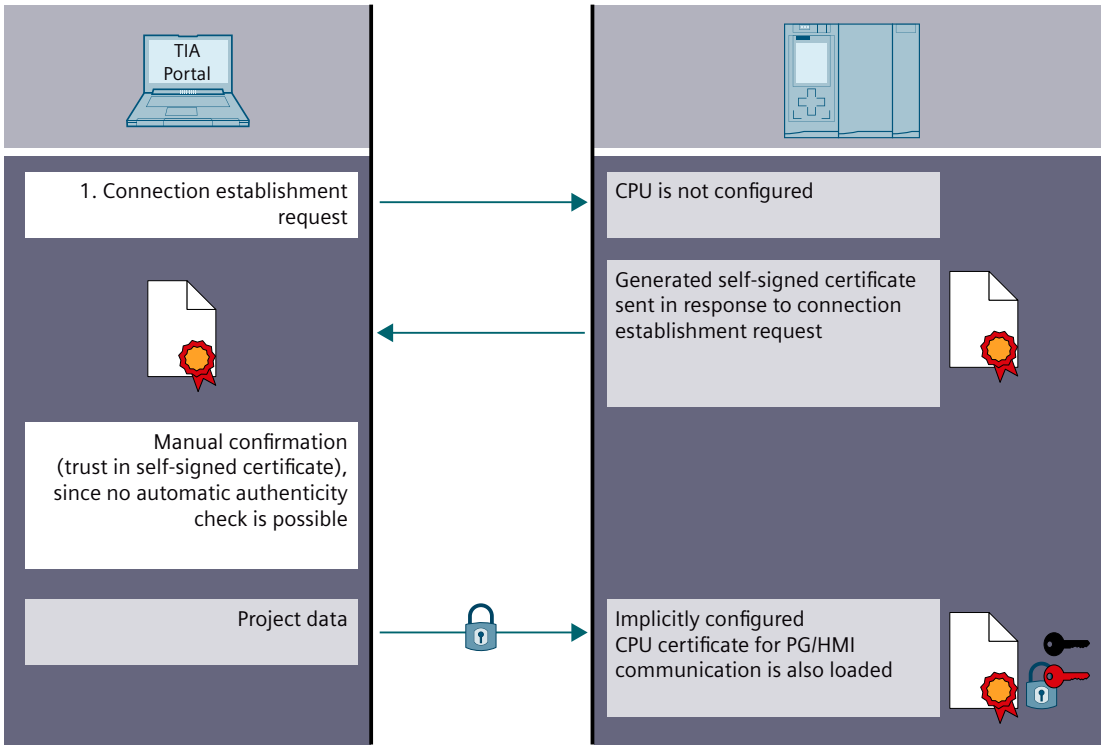

Figure 3-405 Connection establishment, provisioning phase

WARNING

Potential security risks during commissioning

During commissioning, the CPU provides a manufacturer device certificate (if available) or a self-signed certificate that you must trust in order to establish a connection. Only trust this certificate if the programming device and the CPU are in a protected network and are directly connected to each other. In an unprotected environment, these certificates can be manipulated and allow attackers to access the communication between the programming device/HMI and CPU (e.g. through man-in-the-middle attacks).

Ending the provisioning phase

TIA Portal does not store the password for confidential PLC configuration data itself or the key information generated from the password in the project.

Therefore, the password is requested in a dialog when loading the project for the first time or when loading a new project and transferred to the CPU as key information. Only after this step the CPU is able to use the protected PLC configuration data - this completes the provisioning phase and the CPU can start operating.

If you do not protect the confidential PLC configuration data with a password, there is no need to enter the password when loading the CPU for the first time. This has no influence on the flow of the PG/HMI communication but you have to consider that the confidential PLC configuration data (e.g. private keys) offer almost no protection against unauthorized access in this case.

Startup of PG/HMI communication

When the CPU is loaded and has received the CPU certificate for Secure PG/HMI Communication, the programming device connects again - this time based on the loaded CA certificate.

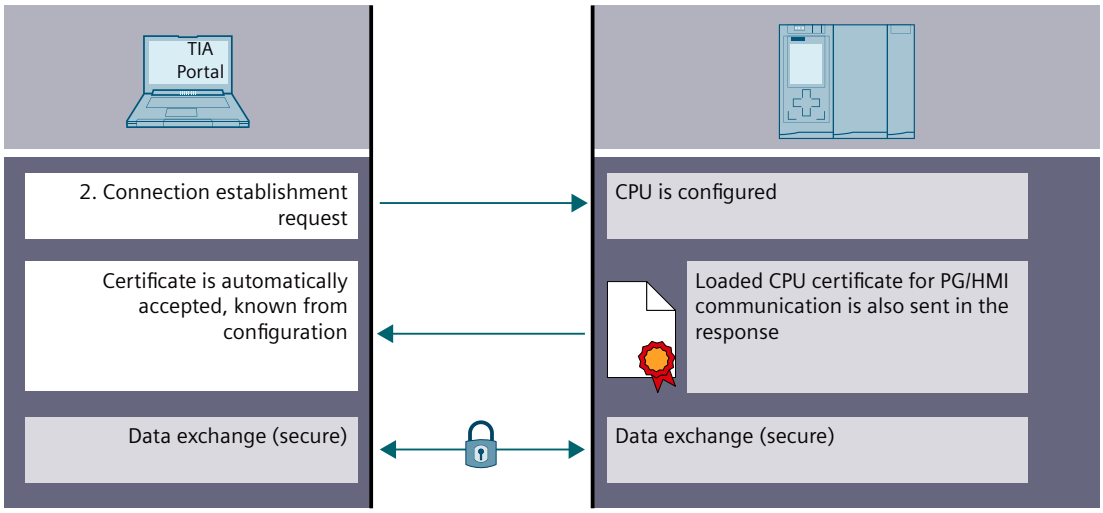

Figure 3-406 Startup of PG/HMI communication

5.6.5.5 Using secure HMI communication

As of TIA Portal version V17, the CPU and the HMI device communicate via secure HMI communication if both devices meet the requirements for this type of communication.

The basis of secure HMI communication is that the HMI device can verify the authenticity of the CPU, using the PLC communication certificate that the CPU sends when establishing communication, and considers the CPU to be "trustworthy". Secure HMI communication is only possible when this turns out to be the case.

This section describes the measures you must take for the various HMI devices to manually label the PLC communication certificate as "trustworthy".

Requirement

- CPU and HMI device support secure HMI communication.
- A current project is available on the CPU (TIA Portal V17 and higher).

Configuring secure HMI communication

1. Configure the HMI device with an alarm view.

   NOTE

   Without an alarm view you cannot identify the errors during connection establishment.

2. Configure the CPU with the required security settings. Select a PLC communication certificate to protect the HMI connection or have the TIA Portal generate a PLC communication certificate.
3. Configure the HMI connection between the CPU and the HMI device.
4. Download the project to the CPU and the HMI device. During the project transfer, the PLC communication certificate and, if necessary, a CA (Certificate Authority) certificate is transferred to the CPU and the HMI device.

   NOTE

   Updating and loading the CPU configuration requires reloading into the HMI device

   If you change the CPU configuration and this change causes a change to the PLC communication certificate (e.g. when changing the IP address of an interface), you must also reload the PLC communication certificate of the connected HMI device.

   Otherwise, communication between the HMI device and CPU is not possible.

Trusting the PLC communication certificate

During connection setup, the CPU transfers the PLC communication certificate to the HMI device.

- When the PLC communication certificate is already available on the HMI device with the "trustworthy" status, a secure HMI communication is automatically set up between the CPU and the HMI device.
- When the PLC communication certificate is not available with the "trusted" status on the HMI device, you will see an alarm in the alarm view of the HMI device informing you that the CPU is not trusted along with an error code.

NOTE

For HMI devices (Runtime V17 to V20), it is not possible to manually trust the PLC communication certificate, unless the "ChangeConnection" system function is used.

Depending on the type of your HMI device, follow these steps.

Basic Panels 2nd Generation

1. In the Start Center, select "Settings > Internet Settings > Certificate store".
2. In the "Available certificates in Device" list, select the PLC communication certificate of the CPU.
3. Press "Trust".
4. Restart the HMI runtime software.

Unified Comfort Panels

1. Open the Control Panel.
2. Select "Security > Certificates".
3. In the "Certificate store" selection list, select the entry "Other Certificates".
4. In the "Other certificates" list, select the PLC communication certificate of the CPU.
5. Press "Trust".
6. Restart the HMI runtime software.

Comfort Panels, Mobile Panels 2nd Generation

1. Open the file manager via the Windows CE desktop icon "My Device".
2. Navigate to the directory "\flash\simatic\SystemRoot\OMS\Untrusted". There you will find the PLC communication certificate of the CPU.
3. Copy the PLC communication certificate of the CPU to the directory "\flash\simatic\SystemRoot\OMS\Trusted".
4. Restart the HMI runtime software.

When the PLC communication certificate is already available on the HMI device with the "trustworthy" status, secure HMI communication can be set up. You can find more information in the operating instructions of the HMI device.

More information

You can find more information on handling certificates in the application example Application example: Using certificates with TIA Portal (https://support.industry.siemens.com/cs/ww/en/view/109769068).

5.6.5.6 Using Legacy PG/PC communication for TIA Portal

As of TIA Portal version V17, the TIA Portal and the S7-1200/S7-1500 CPU as of firmware version V4.5/V2.9 automatically communicate "securely" - the connection partners set their connection mechanisms automatically to the highest possible security method.

Only special circumstances (see Information about compatibility (Page 120)) cause a fallback to the old PG/PC communication, called "Legacy PG/PC communication".

There may be some cases in which the higher security is not desirable because it can impact the transmission rate of CPUs with weak communication performance.

Requirement

- There may be no online connections to the CPUs.
- For CPUs that are to be reached online, the option "Only permit secure PG/PC and HMI communication" must be disabled (CPU parameters in the area "Connection mechanisms").
- The communication partners are in a protected environment, for example, during the commissioning phase.

Setting the Legacy PG/PC communication

1. In the "Online" menu, select the command "Use only Legacy PG/PC communication".
2. Select the check box in front of the menu command.

Result: All online connections are set up as for TIA Portal versions < V17.

The setting remains active for the duration of the session. When you open a project, the option "Use only legacy PG/PC communication" is not set.

Behavior with enabled option "Use only Legacy PG/PC communication"

- A password to protect confidential PLC configuration data cannot be specified, modified or deleted online for CPUs. These functions require disabling the "Use only Legacy PG/PC communication" option.
- A CPU that is set to only permit secure PG/PC and HMI communication can no longer be reached online.

5.6.5.7 Information about compatibility

The following description provides information about the interaction between different TIA Portal versions with different CPU firmware versions and the effects on the type of PG/HMI connection.

Projects created with TIA Portal < V17

For example, if you have created a project with TIA Portal version V16 for an S7-1500 CPU (e.g. version V2.8), then the corresponding configuration with TIA Portal V17 can also be loaded into an S7-1500 CPU V2.9, e.g. in a spare part scenario - with the same behavior as a configuration on an S7-1500 CPU V2.8.

Even projects created with TIA Portal < V17 and transferred to a memory card work without problems in an S7-1500 CPU V2.9.

However, the concept of protecting confidential PLC configuration data applies as soon as you open the project with TIA Portal ≥ V17, update the firmware version of the CPU via a device replacement and thus save it as a CPU with a firmware version ≥ V2.9 (see Useful information for the protection of confidential PLC configuration data (Page 83)). The project can no longer be edited with previous versions of TIA Portal V17.

PG/HMI and CPU connected differently

As explained in the previous sections, the secure PG/HMI connection as of V17 between the PG/HMI device and CPU (current version) is characterized by the employed standardized communication procedure, TLS (Transport Layer Security).

You have the option of connecting a V2.9 CPU to a current programming device with TIA Portal V17 or higher and additionally, for example, to an HMI device with a runtime from the previous version: The devices automatically adjust their connection mechanisms accordingly. In order to be able to better differentiate between the two connection mechanisms, we call the previous procedure, which is based on a variant of S7 communication, "Legacy procedure".

In summary ("PG" here stands for a programming device with TIA Portal):

- PG/HMI and CPU come with the V17 (or subsequent version): TLS procedure is used.
- PG/HMI comes from a predecessor version (< V17): Legacy procedure is used - provided that you have deactivated the option "Only allow secure PG/PC and HMI communication" in the CPU properties.
- CPU comes with V17 (or higher), several PGs/HMIs are connected and come from both V17 (or higher) and previous versions: TLS + legacy procedures are used - provided that you have deactivated the option "Only allow secure PG/PC and HMI communication" in the CPU properties.

When the CPU state changes

The diagnostics buffer provides you with information if its status changes due to events in connection with the Secure PG/HMI Communication.

Examples:

- After successfully loading a configuration with a configured password, the diagnostics buffer reports that the CPU is changing from the provisioning phase to Secure Mode (TLS procedure).
- You have connected a PG with TIA Portal V17 to a CPU V2.9. If "Use only Legacy PG/PC communication" is deactivated in the Online menu, the Secure PG/HMI Communication (TLS procedure) is established automatically.

More information

Information on device or firmware-specific features such as the TLS version used can be found in section Device-dependent security features (Page 57).

5.7 SNMP

5.7.1 Activating and deactivating SNMP

The network management protocol SNMP (Simple Network Management Protocol) is used for performing monitoring and diagnostics of the network topology. SNMP uses the transport protocol UDP and knows two roles: the SNMP manager (client) and SNMP agent (server).

- The SNMP manager monitors the network nodes:
- The SNMP agents collect the various network-specific information in the individual network nodes and store it in structured form in the MIB (Management Information Base). Various services and tools (as SNMP manager) can run detailed network diagnostics with the help of these data.

SNMP is also used in a PROFINET IO system for managing the network infrastructure and the IO controller/IO devices.

NOTE

If SNMP is deactivated for a device, various options for diagnostics of the network topology (for example, using the PRONETAtool) are no longer available to you.

Example: For the topology comparison Online-Offline, the TIA Portal determines which ports are actually connected and uses SNMP for this function.

Default settings depending on the firmware version

S7-1500 CPUs have an integrated SNMP agent. Depending on the firmware version, different defaults apply to SNMP (SNMP activated or deactivated).

With S7-1500 CPUs with a FW version < V3.0, the SNMP agent is **activated** by default and can only be deactivated via a data record in the user program.

Under certain conditions, it may be useful to deactivate SNMP. Examples:

- The security guidelines in your network do not allow the use of SNMP.
- You use your own SNMP solution, e.g. with your own communications instructions.

With S7-1500 CPUs as of FW version V3.0, the SNMP agent is **deactivated** by default. The default setting "disabled" is also in effect if no configuration has been loaded or if no memory card is plugged in. STEP 7 V18 offers the following options for changing the SNMP settings for S7-1500 CPUs as of FW version V3.0:

- Configure SNMP in the CPU properties of TIA Portal.
- Activate/deactivate SNMP in the use program by transferring a data record to a PROFINET interface.

NOTE

Replacement part scenario

For compatibility reasons, an S7-1500 CPU as of firmware version V3.0 with a loaded predecessor project (CPU firmware < V3.0) behaves like the CPU in the predecessor project:

SNMP is activated and "public" and "private" community strings are in effect.

Configuring SNMP

As of CPU firmware version V3.0 and TIA Portal version V18, you can change the following settings for SNMP in the CPU properties:

- Activate SNMP (default: deactivated)
- Read-only community string (default: "public")
- Read-write community string (default: "private")

You can find the settings in the "Advanced configuration > SNMP" area.

As of CPU firmware version V3.1 and TIA Portal version V19, you can additionally enable write-protected access for SNMP when SNMP is activated.

Meaning and properties of community strings

An SNMP community string, also referred to as a "community name", is like an ID or a password, which allows access to information/statistics of a device such as a router.
In this respect, to increase the security, you should change the default community strings in the CPU properties. An SNMP manager authenticates itself with the SNMP agent by transferring the community strings when there is a request.

The community strings are transferred as plain text.

- The default community string for SNMP read-only operations (GET) is "public".
- The default community string for SNMP read-write operations (SET) is "private".

Number of characters for the community string: 1-240.

You can use the following characters for the community string:

- a-z
- A-Z
- 0-9
- -
- .

Activating/deactivating SNMP in the user program

In addition to the configuration in the CPU properties, you can also activate or deactivate SNMP in the user program. To do this, transfer a data record 0xB071 to a PROFINET interface of the CPU. In this data record, it is encoded whether SNMP is to be enabled/disabled. No matter to which PROFINET interface you transfer the data record, the data record applies to all interfaces of the CPU.

One way to transfer the 0xB071 data record: Define the data set structure in a data block and transfer it in the program cycle OB (e.g. OB 1) with the "WRREC" (write record) instruction to a PROFINET interface of the CPU.

To do this, follow these steps:

1. In STEP 7, create a data block that contains the structure of data record 0xB071.
   The following table shows the structure of the data record 0xB071.

Byte	Element	Code	Explanation
0-1	BlockID	0xF003	Header The data record length is counted starting at byte 4 "Version".
2-3	BlockLength	8	
4	Version	0x01	
5	Subversion	0x00	
6-7	Reserved	-	-
8-11	SNMP controller	0.1	0: Deactivate SNMP. 1: Activate SNMP.

2. Transfer the record 0xB071 to an organization block (OB) with the "WRREC" (write record) instruction to the CPU. As a hardware identifier, use an integrated PROFINET interface of the CPU.

Interplay of SNMP configuration and user program

- The SNMP setting "activated/deactivated" via the user program is not stored permanently in the CPU. The configured setting takes effect again, for example, after each POWER OFF/POWER ON transition, loading of a new hardware configuration, or resetting to factory settings.
- When loading the configuration from the CPU ("Upload device as new station"), the configured SNMP setting (activated/deactivated) is taken into consideration. An SNMP setting previously set by data record in the user program is ignored.
- The community strings can only be changed in the configuration; the community strings cannot be set through a data record in the user program.
  However, you can activate the configured community strings by data record.
  Example:
  You have set SNMP to deactivated in the configuration of an S7-1500 CPU. You change the default community strings in the CPU properties and then load the configuration into the CPU.
  Then, you activate SNMP via data record transfer.
  Result: The changed community strings take effect.
- For S7-1500 CPUs with a firmware version < V3.0, the preset community strings ("public" and "private") are always in effect when SNMP is activated.

5.7.2 Activating/deactivating SNMP by data record transfer: Example for a CPU 1516-3 PN/DP

Introduction

You need to activate the SNMP for a CPU 1516-3 PN/DP to manage your network infrastructure, CPUs and IO devices with SNMP. The example below shows the 0xB071 data record being transferred to a PROFINET interface for this purpose.

Requirement

- CPU 1516-3 PN/DP as of FW version V2.0
- STEP 7 version V14 or higher

Solution

Transfer the data record 0xB071 to a PROFINET interface of the CPU. As a result, SNMP is enabled in all PROFINET interfaces of the CPU.

The following example shows how you can create the data record in a global data block and transfer it in a program cycle OB (for example, OB 1) to the PROFINET interface (Local~PROFINET_interface_1).

To activate SNMP for the addressed PROFINET interface of the CPU 1516-3 PN/DP, follow these steps:

1. Create a global data block.
2. Assign a name, for example, "ActivateSnmp".
3. Under "Static", create the structure of the 0xB071 data record (in the figure: "snmpRecord") and other variables for transferring the data record. The following figure shows the data block structure "ActivateSnmp".

ActivateSnmp

		Name	Data type	Start value	Re...	Ac...	Wr...	Vis...	Comment
1		Static							
2		snmpWrite	Bool	TRUE		✓	✓	✓	Start writing Data record 16#B071
3		snmpRecord	Struct			✓	✓	✓	Data record 16#B071
4		blockID	UInt	16#F003		✓	✓	✓	Data record ID
5		blockLength	UInt	8		✓	✓	✓	Length of block
6		version	USInt	1		✓	✓	✓	Byte 1 of blockversion
7		subversion	USInt	0		✓	✓	✓	Byte 2 of blockversion
8		reserved	UInt	0		✓	✓	✓	Reserverd for future usage
9		snmpControl	UDInt	1		✓	✓	✓	0: deactivate SNMP, 1: activate SNMP
10		snmpWrDone	Bool	false		✓	✓	✓	writing done
11		snmpWrError	Bool	false		✓	✓	✓	error while writing
12		snmpWrStatus	DWord	16#0		✓	✓	✓	status of writing

Figure 3-407 Structure of the global data block "ActivateSnmp"

4. Transfer the 0xB071 data record in an OB program cycle (for example, OB 1), with the "WRREC" (write data record) instruction to the CPU 1516-3 PN/DP. You can find an example program in the next section.

Programming example for the data record transfer in OB 1

The data record 0xB071 is transferred in the following program code:

```
//-----------------------------------------
// Start writing SNMP settings
//-----------------------------------------
IF "ActivateSnmp".snmpWrite THEN
 IF (NOT "ActivateSnmp".snmpWriteDone)
 AND (NOT "ActivateSnmp".snmpWriteError) THEN
 "instWrrec_1"(REQ := "ActivateSnmp".snmpWrite,
 ID := "Local~PROFINET-Schnittstelle_1",
 INDEX := 16#B071,
 DONE => "ActivateSnmp".snmpWriteDone,
 ERROR => "ActivateSnmp".snmpWriteError,
 STATUS => "ActivateSnmp".snmpWriteStatus,
 RECORD := "ActivateSnmp".snmpRecord);
 END_IF;
 IF "ActivateSnmp".snmpWriteError THEN
```

```
 ; // add error handling
 END_IF;
 IF "ActivateSnmp".snmpWriteDone THEN
 "ActivateSnmp".snmpWrite := FALSE;
 END_IF;
END_IF;
```

Deactivating SNMP again

You can use the program code used above, with small changes, to deactivate SNMP. Assign the value "0" to the tag "ActivateSnmp".snmpRecord.snmpControl in the user program:

```
"ActivateSnmp".snmpRecord.snmpControl := 0;
```

The next time the "WRREC" instruction is called, SNMP will be deactivated again.

5.7.3 Activating/deactivating SNMP by data record transfer with S7-1500R/H CPUs

In S7-1500R/H systems, activate/deactivate SNMP in the user program as with standard CPUs. However, the PROFINET interfaces (X1, X2,...) of both CPUs have different hardware IDs. The PROFINET interface X1 of the left CPU, for example, has a different hardware ID as the PROFINET interface X1 of the right CPU. The S7-1500R/H system does not automatically synchronize the SNMP status (activated/deactivated) for both CPUs. An SNMP status (activated/deactivated) set by the "WRREC" instruction only affects the CPU whose PROFINET interface addresses the "WRREC" instruction.

Example:

The S7-1500R/H system is in the "RUN redundant" system state. If a PROFINET interface of the left CPU is addressed with the "WRREC" instruction, for example, the SNMP status of the left CPU is changed. The SNMP status of the right CPU remains unchanged. If the left CPU fails or is replaced, the unchanged SNMP status is in place after the SYNCUP.

Solution:

Call the "WRREC" instruction 2 times. In the first call of "WRREC", address the hardware ID of a PROFINET interface of the left CPU. Call the "WRREC" instruction again. This time, address the hardware ID of a PROFINET interface of the right CPU.

Hardware IDs for PROFINET interface X1:

- The PROFINET interface X1 of the left CPU has the hardware ID 65164 (default name: Local1~PROFINET-interface_1).
- The PROFINET interface X1 of the right CPU has the hardware ID 65364 (default name: Local2~PROFINET-interface_1).

The addressing by means of the respective hardware IDs of the PROFINET interfaces X1 is also used in the following example for calling the "WRREC" instruction for both R/H CPUs.

NOTE

Transferring the data record to the backup CPU

Call the "WRREC" instruction for the addressed PROFINET interface of the backup CPU only when the S7-1500R/H system has reached the "RUN REDUNDANT" system state. Otherwise, the data record cannot be transferred to the addressed PROFINET interface of the backup CPU.

The S7-1500R/H system signals changes to its system state, e.g. the change to "Run REDUNDANT", by calling the CPU redundancy error OB (OB 72) with the corresponding "Fault_ID".

Example: WRREC calls for both R/H CPUs

To activate/deactivate SNMP for the addressed PROFINET interface of both the CPUs by transferring data records, proceed as follows:

1. Create a global data block.
2. Assign a name, for example, "ActivateSnmp".
3. Under "Static", create the structure of the 0xB071 data record (in the figure: "snmpRecord") and other tags for transferring the data record. The following figure shows the structure of the data block "ActivateSnmp".

ActivateSnmp

	Name	Data type	Start value	Re...	Ac...	Wr...	Vis...	Comment
1	Static							
2	snmpWrite	Bool	TRUE		✓	✓	✓	Start writing Data record 16#B071
3	snmpRecord	Struct			✓	✓	✓	Data record 16#B071
4	blockID	UInt	16#F003		✓	✓	✓	Data record ID
5	blockLength	UInt	8		✓	✓	✓	Length of block
6	version	USInt	1		✓	✓	✓	Byte 1 of blockversion
7	subversion	USInt	0		✓	✓	✓	Byte 2 of blockversion
8	reserved	UInt	0		✓	✓	✓	Reserverd for future usage
9	snmpControl	UDInt	1		✓	✓	✓	0: deactivate SNMP, 1: activate SNMP
10	plcLeft	Struct			✓	✓	✓	Writing status of left plc
11	snmpWrDone	Bool	false		✓	✓	✓	writing done
12	snmpWrError	Bool	false		✓	✓	✓	error while writing
13	snmpWrStatus	DWord	16#0		✓	✓	✓	status of writing
14	plcRight	Struct			✓	✓	✓	Writing status of right plc
15	snmpWrDone	Bool	false		✓	✓	✓	writing done
16	snmpWrError	Bool	false		✓	✓	✓	error while writing
17	snmpWrStatus	DWord	16#0		✓	✓	✓	status of writing

Figure 3-408 Structure of the global data block "ActivateSnmp"

4. Add the organization block "CPU redundancy error" (OB 72) to your user program. You can find a program example for OB 72 in the next paragraph.

5. Open the program cycle OB (OB 1).
6. In OB 1, execute two "" instructions for transferring the data record to the respective addressed PROFINET interface of both CPUs. You can find a program example for OB 1 in the next paragraph.

   Result: The 0xB071 data record was transferred to the PROFINET interface of both the CPUs addressed in each case.

Programming example for the organizational blocks OB 72 and OB 1

Open the added OB 72. With the following program code, determine whether the R/H system has assumed the "RUN-REDUNDANT" state and set the starting command for the "WRREC" instructions:

```
//---------------------------------------------
// Check redundancy state and set "snmpWrite"
//---------------------------------------------
IF #Fault_ID = B#16#03 OR #Fault_ID = B#16#06 THEN
 "ActivateSnmp".snmpWrite := TRUE;
END_IF;
```

Open the program cycle OB (OB 1). With the following program code, you can run 2 "WRREC" instructions for transferring the data record to the respective addressed PROFINET interface of both the CPUs:

```
//----------------------------------------
// Start writing SNMP settings
//----------------------------------------
IF "ActivateSnmp".snmpWrite THEN
 IF (NOT "ActivateSnmp".plcLeft.snmpWrDone)
 AND (NOT "ActivateSnmp".plcLeft.snmpWrError) THEN
 // write SNMP settings for the left PLC
 "instWrrec_1"(REQ := "ActivateSnmp".snmpWrite,
 ID := "Local1~PROFINET_interface_1",
 INDEX := 16#B071,
 DONE => "ActivateSnmp".plcLeft.snmpWrDone,
 ERROR => "ActivateSnmp".plcLeft.snmpWrError,
 STATUS => "ActivateSnmp".plcLeft.snmpWrStatus,
 RECORD := "ActivateSnmp".snmpRecord);
 END_IF;
 IF "ActivateSnmp".plcLeft.snmpWrError THEN
 ; // add error handling for left plc
 END_IF;
 IF (NOT "ActivateSnmp".plcRight.snmpWrDone)
 AND (NOT "ActivateSnmp".plcRight.snmpWrError) THEN
 // write SNMP settings for the right PLC
 "instWrrec_2"(REQ := "ActivateSnmp".snmpWrite,
 ID := "Local2~PROFINET_interface_1",
 INDEX := 16#B071,
 DONE => "ActivateSnmp".plcRight.snmpWrDone,
 ERROR => "ActivateSnmp".plcRight.snmpWrError,
 STATUS =>
 "ActivateSnmp".plcRight.snmpWrStatus,
 RECORD := "ActivateSnmp".snmpRecord);
 END_IF;
 IF "ActivateSnmp".plcRight.snmpWrError THEN
 ; // add error handling for right plc
```

```
 END_IF;
 IF "ActivateSnmp".plcLeft.snmpWrDone
 AND "ActivateSnmp".plcRight.snmpWrDone THEN
 "ActivateSnmp".snmpWrite := FALSE;
 END_IF;
END_IF;
```

Deactivating SNMP again

You can use the program code used above, with small changes, to deactivate SNMP. Assign the value "0" to the tag "ActivateSnmp".snmpRecord.snmpControl in the user program:

```
"ActivateSnmp".snmpRecord.snmpControl := 0;
```

The next time the "WRREC" instructions are called, SNMP will be deactivated again.

PG communication

6

Properties

Using PG communication, the CPU or another module capable of communication exchanges data with an engineering station (for example PG, PC). The data exchange is possible via PROFIBUS and PROFINET subnets. The gateway between S7 subnets is also supported.

PG communication provides functions needed to load programs and configuration data, run tests, and evaluate diagnostic information. These functions are integrated in the operating system of the module capable of communication.

NOTE

As of TIA Portal version V17, the TLS (Transport Layer Security) protocol is supported for programming device/HMI communication to secure the data exchange between programming device/PC and CPU using standardized security mechanisms.

For more information, refer to the following sections:

- Requirements for secure communication (Page 80)
- Secure PG/HMI communication (Page 110)

Requirements

- The PG/PC is physically connected to the communication-capable module.
- If the communication-capable module is to be reached via S7 routing, the hardware configuration has to be loaded in the participating stations (S7 router and end point).

Procedure for connecting online

You must establish an online connection to the CPU for the programming device communication:

1. Select the CPU in the project tree in STEP 7.
2. Select the "Online > Go online" menu command.
3. In the "Go online" dialog, make the following settings for your online connection:
   - In the "Type of the PG/PC interface" drop-down menu, select the interface type (e.g. PN/IE)
   - In the "PG/PC interface" drop-down menu, select the PG/PC interface (e.g. ind. Ethernet card) via which you want to establish the online connection.

– Select the interface or the S7 subnet with which the programming device/PC is physically connected from the "Connection to interface/subnet" drop-down menu.
– If the communication-capable module is accessible via an S7 router (gateway), select the S7 router that connects the affected subnets to one another in the "1st gateway" drop-down menu.

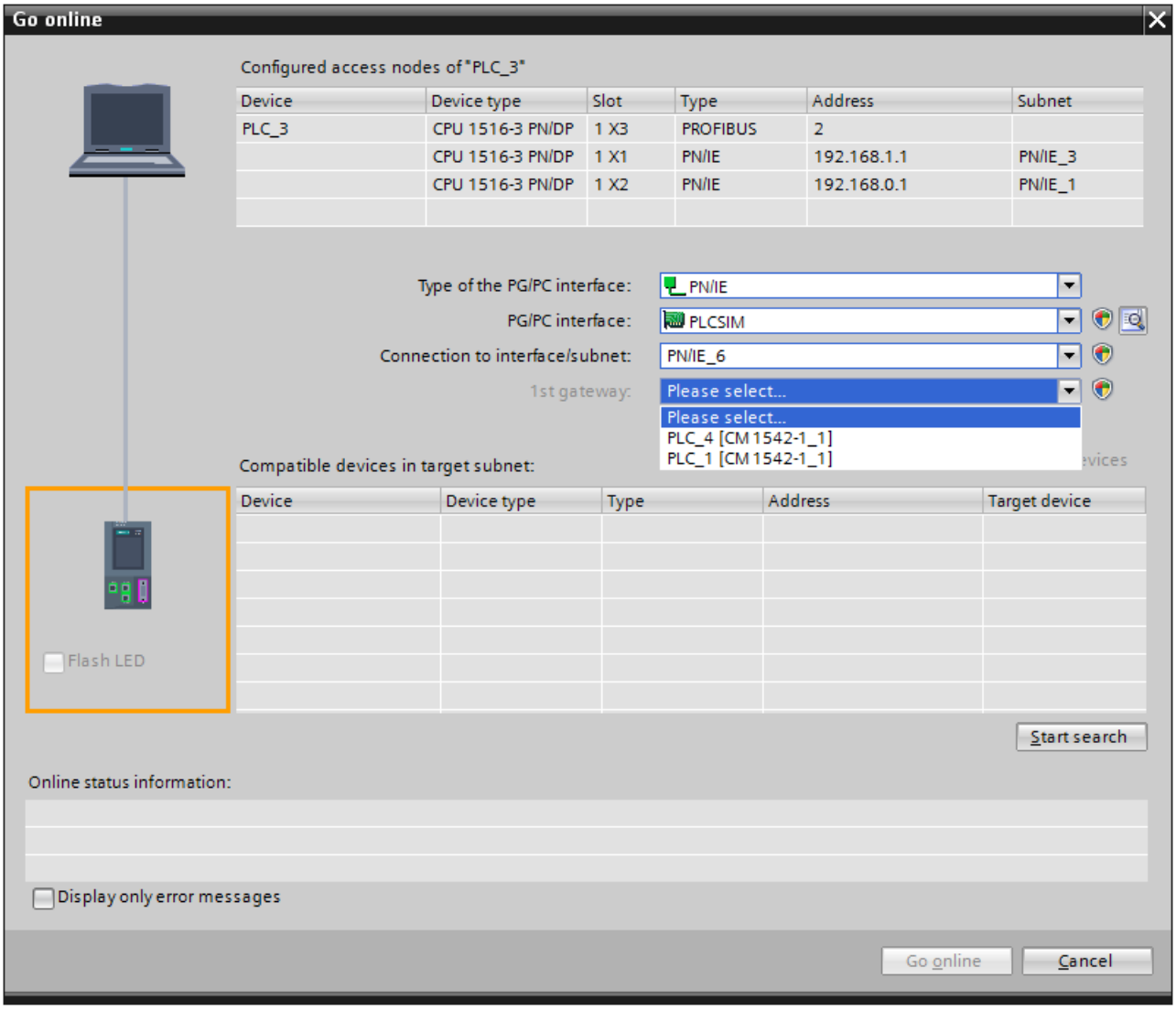

Figure 3-409 Setting up PG communication

4. Click "Start search".
   All devices that you can address with PG communication appear shortly thereafter in the table "Compatible devices in target subnet".
5. In the "Compatible devices in target subnet" table, select the relevant CPU and confirm with "Go online".

More information

You can find more information on "Go online" in the STEP 7 online help.

For information on how to protect your CPU against manipulation during loading and unauthorized access, refer to the "Protection" section in the relevant system manual, e.g. S7-1500/ET 200MP System Manual (https://support.industry.siemens.com/cs/ww/en/view/59191792).

HMI communication 7

Properties

Using HMI communication, one or more HMI devices (for example HMI Basic/Comfort/Mobile Panel) exchanges data with a CPU for operator control and monitoring with via the PROFINET or PROFIBUS DP interface. The data exchange is via HMI connections.

If you want to set up several HMI connections to a CPU, use for example:

- The PROFINET and PROFIBUS DP interfaces of the CPU
- CPs and CMs with the relevant interfaces

NOTE

As of TIA Portal version V17, the TLS (Transport Layer Security) protocol is supported for programming device/HMI communication to secure the data exchange between programming device/PC and CPU using standardized security mechanisms.

For more information, refer to the following sections:

- Requirements for secure communication (Page 80)
- Secure PG/HMI communication (Page 110)

Procedure for setting up HMI communication

As soon as you drag-and-drop a tag, for example a tag from a global data block into an HMI screen or into the HMI tag table, STEP 7 automatically sets up an HMI connection. Alternatively, you can also set up the HMI connection yourself.

To set up an HMI connection, follow these steps.

1. Configure the HMI device in an existing configuration with a CPU in the network view of the Devices & networks editor of STEP 7.
2. Select the "Connections" button and then "HMI connection" from the drop-down list.
3. Drag-and-drop a line between the end points of the connection (HMI device and CPU). The end points are highlighted in color. If the required S7 subnet does not yet exist, it is created automatically.

4. In the "Connections" tab, select the row of the HMI connection.

   In the "General" area of the "Properties" tab, you see the properties of the HMI connection, some of which you can change.

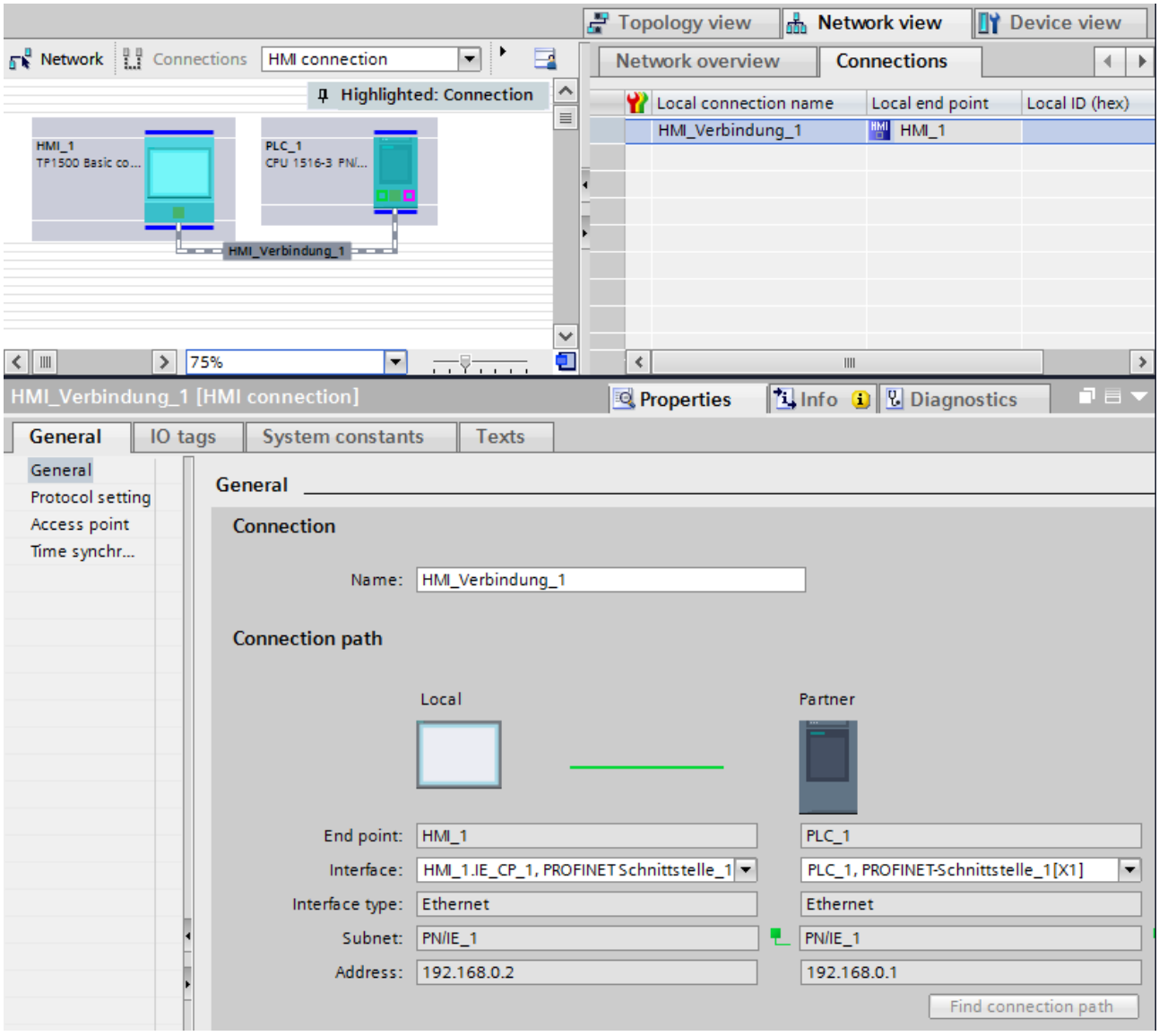

Figure 3-410 Setting up HMI communication

5. Download the hardware configuration to the CPU.
6. Download the hardware configuration to the HMI device.

More information

You can find information on S7 routing for HMI connections in the section S7 Routing (Page 417).

You can find more information on setting up HMI connections in the STEP 7 online help.

Open User Communication 8

8.1 Overview of Open User Communication

Features of Open User Communication

Through Open User Communication, also called "open communication", the CPU exchanges data with another device capable of communication. Open User Communication has the following features and characteristics:

- Open standard (communication partners can be two SIMATIC CPUs or a SIMATIC CPU and a suitable third-party device).
- Communication via various protocols (in STEP 7 known as "Connection types")
- High degree of flexibility in terms of the data structures transferred; this allows open data exchange with any communications devices as long as these support the connection types available.
- Secure Communication: To protect your automation system, you can exchange data securely over Open User Communication. With Secure Open User Communication, the data is sent signed and encrypted, see also Secure Open User Communication (Page 93).
- Open User Communication is possible in various automation systems, see technical specifications of the respective manuals.
  Examples:
  - Integrated PROFINET / Ind. Ethernet interfaces of CPUs (S7-1500, ET 200SP CPU, S7-1500 Software Controller, CPUs 1513/1516pro 2 PN)
  - PROFINET / Ind. Ethernet interfaces of communications modules (for example CP 1543-1, CM 1542-1, CP 1543SP-1)

Information on Secure Open User Communication is available in the section Secure Communication (Page 54).

Information on S7-1500R/H

You can find information on Open User Communication with the S7-1500R/H redundant system in section Communication with the redundant system S7-1500R/H (Page 457).

8.2 Protocols for Open User Communication

Protocols for Open User Communication

The following protocols are available for open communication:

Table 3-938 Transport protocols for open communication

Transport protocol	Via interface
TCP according to RFC 793	PROFINET/Industrial Ethernet
ISO-on-TCP according to RFC 1006 (Class 4)	PROFINET/Industrial Ethernet
ISO according to ISO/IEC 8073	Industrial Ethernet (only CP 1543-1)
UDP according to RFC 768	PROFINET/Industrial Ethernet
FDL	PROFIBUS

Table 3-939 Application protocols for open communication

Application protocol	Used transport protocol
Modbus TCP	**TCP** according to RFC 793
E-mail	**TCP** according to RFC 793
FTP	**TCP** according to RFC 793

TCP, ISO-on-TCP, ISO, UDP

Prior to data transfer, these protocols (except UDP) establish a transport connection to the communication partner. Connection-oriented protocols are used when potential loss of data needs to be avoided.

The following is possible with UDP:

- Unicast to one device or broadcast to all devices on PROFINET via the PROFINET interface of the CPU or the Industrial Ethernet interface of the CP 1543-1
- Multicast to all receivers of a multicast group via the PROFINET interface of the CPU or the PROFINET/Industrial Ethernet interface of the CP 1543-1

Maximum number of supported multicast groups and maximum user data lengths: See technical specifications of the respective Equipment Manuals.

Protocol for communication via PROFIBUS: FDL

Data transfer via an FDL connection (Fieldbus Data Link) is suitable for the transfer of related blocks of data to a communication partner on PROFIBUS that supports the sending and receiving of data according to the FDL service SDA (Send Data with Acknowledge) according to EN 50170, Vol 2. Both partners have the same rights; in other words, each partner can initiate sending and receiving event-driven.

In keeping with the FDL service SDN (Send Data with No Acknowledge) according to EN 50170, Vol 2, the following is possible with FDL:

- Broadcast to all devices on PROFIBUS via the PROFIBUS interface of the CM 1542-5
- Multicast to all recipients of a multicast group via the PROFIBUS interface of the CM 1542-5

Modbus TCP

The Modbus protocol is a communication protocol with linear topology based on a master/slave architecture. In the Modbus TCP (Transmission Control Protocol), the data is transmitted as TCP/IP packets.

Communication is controlled solely by suitable instructions in the user program.

E-mail and FTP

You can use email to send for example, data block contents (e.g. process data) as an attachment.

You can use the FTP connection (FTP = File Transfer Protocol) to transmit files to and from S7 devices.

The communication is controlled by instructions in the user program at the client end.

Application example: MQTT Publisher for the SIMATIC S7-1500 CPU

The "Message Queue Telemetry Transport" (MQTT) is a simple protocol on the TCP/IP level. It is suitable for the exchange of messages between devices with lower functionality and for the transfer via unreliable networks.

The application example provides a function block with which you can implement the MQTT protocol into the SIMATIC S7-1500.

You can find the application example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109772284).

See also

SYSLOG (https://support.industry.siemens.com/cs/ww/en/view/51929235)

8.3 Instructions for Open User Communication

Introduction

You set up Open User Communication via the corresponding connection (for example, TCP connection) as follows:

- By programming in the user programs of the communications partners or
- By configuring the connection in STEP 7 in the hardware and network editor

Regardless of whether you set up the connection by programming or configuring, instructions are always required in the user programs of both communications partners for sending and receiving the data.

Setting up the connection via the user program

If the connection is set up by programming, the connection establishment and termination is implemented using instructions in the user program.

In certain application areas, it is advantageous not to set up the communication connections statically via hardware configuration, but via the user program instead. You can set up the connections via a specific application program-controlled and therefore when necessary. Programmed connection setup also allows connection resources to be released following data transfer.

A data structure is necessary for each communications connection that contains the parameters for establishing the connection (for example system data type "TCON_IP_v4" for TCP).

The system data types (SDT) are provided by the system and have a predefined structure that cannot be changed.

The various protocols have their own data structures (see table below). The parameters are stored in a data block ("connection description DB") for example of the system data type TCON_IP_v4.

There are two ways in which you can specify the DB with the data structure:

- Recommendation: Have the data block created automatically in the properties in the program editor during parameter assignment of the connection for the TSEND_C, TRCV_C and TCON instructions.
- Create the data block manually, assign parameters to it and write it directly to the instruction
  Necessary for:
  - Secure OUC
  - Connection over DNS
  - E-mail
  - FTP

You can modify the connection parameters in the "connection description DB".

This FAQ (https://support.industry.siemens.com/cs/ww/en/view/58875807) describes how to program the TCON instruction to set up a connection for Open User Communication between two S7-1500 CPUs.

Protocols, system data types and employable instructions for programmed setup

The following table shows the protocols of the Open User Communication and the matching system data types and instructions.

Table 3-940 Instructions for programmed setup of the connection

Protocol	System data type	Instructions
TCP	• TCON_QDN • TCON_IP_v4	Establish connection and send/receive data via: • TSEND_C/TRCV_C or • TCON, TSEND/TRCV or • TCON, TUSEND/TURCV (connection can be terminated via TDISCON)
ISO-on-TCP	• TCON_IP_RFC	
ISO according to ISO/IEC 8073 (Class 4)	• TCON_ISOnative[1] • TCON_Configured	
UDP	• TCON_IP_v4 • TADDR_Param • TADDR_SEND_QDN • TADDR_RCV_IP	Establish connection and send/receive data via: • TSEND_C/TRCV_C • TUSEND/TURCV/TRCV (connection can be terminated via TDISCON)
FDL[1]	• TCON_FDL	Establish connection and send/receive data via: • TSEND_C/TRCV_C or • TCON, TSEND/TRCV or • TCON, TUSEND/TURCV (connection can be terminated via TDISCON)
Modbus TCP	• TCON_IP_v4 • TCON_QDN • TCON_Configured	• MB_CLIENT • MB_SERVER
Email	• TMAIL_v4 • TMAIL_v6 • TMAIL_FQDN	• TMAIL_C
FTP[2]	• FTP_CONNECT_IPV4[3] • FTP_CONNECT_IPV6[3] • FTP_CONNECT_NAME[3]	• FTP_CMD

[1] This protocol can only be used with the CM 1542-5

[2] This protocol can only be used with the CP 1543-1

[3] User-defined data type

The following table shows you the different connections of the Secure Open User Communication and the matching system data types and instructions.

Secure OUC connection	System data type	Instructions
Secure TCP connection from an S7-1500 CPU as TLS client to a third-party PLC (TLS server) Secure TCP connection from an S7-1500 CPU as TLS server to a third-party PLC (TLS client)	• TCON_QDN_SEC	• TSEND_C/TRCV_C • TCON, TSEND/TRCV
Secure TCP connection between two S7-1500 stations	• TCON_IP_V4_SEC[1]	
Secure connection to a mail server[2]	• TMAIL_V4_SEC • TMAIL_QDN_SEC	• TMAIL_C (V5.0 or higher)
Secure Modbus TCP connection	• TCON_IP_V4_SEC[1] • TCON_QDN_SEC	• MB_Client • MB_Server

1 Also possible for CP 1543-1

2 Secure connection to a mail server also possible with CP1543-1 und TMAIL_C (V4.0)

Setting up the connection with connection configuration

When setting up through the configuration of the connection, the address parameters of the connection are specified in the hardware and network editor of STEP 7.

To send and receive the data, use the same instructions as when the connections are set up by programming:

Table 3-941 Instructions for sending/receiving with configured connections

Protocol	Send/receive with configured connections
Supported instructions:	
TCP	Send/receive data via: • TSEND_C/TRCV_C or • TSEND/TRCV or • TUSEND/TURCV
ISO-on-TCP	
ISO according to ISO/IEC 8073 (Class 4)	
UDP	Send/receive data via: • TSEND_C/TRCV_C or • TUSEND/TURCV
FDL	Send/receive data via: • TSEND_C/TRCV_C or • TSEND/TRCV or • TUSEND/TURCV
Modbus TCP	Not supported
Email	Not supported
FTP	Not supported

Additional instructions for open communication

You can use the following instructions for connections set up in the user program as well as for configured connections:

- T_RESET: Terminating and establishing a connection
- T_DIAG: Check the connection

Basic examples for Open User Communication

The Siemens Online Support offers you function blocks (FBs) that facilitate the handling of the instructions of the Open User Communication. You can find the function block with corresponding examples on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109747710).

More information

The STEP 7 online help describes:

- The user and system data types
- The instructions for open communication
- The connection parameters

You will find information about the allocation and release of connection resources in the section Allocation of connection resources (Page 444).

Information about the Secure Open User Communication is available in the section Secure Open User Communication (Page 93).

8.4 Open User Communication with addressing via domain names

As of firmware version V2.0, S7-1500 CPUs, ET 200SP CPUs and the CPUs 1513/1516pro-2 PN support Open User Communication with addressing via Domain Name System (DNS). A DNS client is integrated in the CPU. In the case of communication via DNS, you use domain names as an alias for IP addresses to address communication partners. Addressing of the communication partners via domain names is possible for open communication via TCP and UDP.

At least one DNS server must be located in your network as a requirement for communication via DNS.

The S7-1500 software controller supports communication via DNS for all interfaces that are assigned to the software controller.

Setting up communication via DNS

The DNS client of the CPU must know the IPv4 address of at least one DNS server so that a CPU can establish a connection to a communication partner via its domain name. The CPU supports up to 4 different DNS servers.

To set up communication via domain names for an S7-1500 CPU, follow these steps:

1. Select the CPU in the network view of STEP 7.
2. In the Inspector window, navigate to "Properties" > "General" > "Advanced configuration" > "DNS configuration".
3. Enter the IPv4 address of a DNS server in the "DNS server addresses" column of the "Server list" table.
   You can enter up to 4 IPv4 addresses of DNS servers.

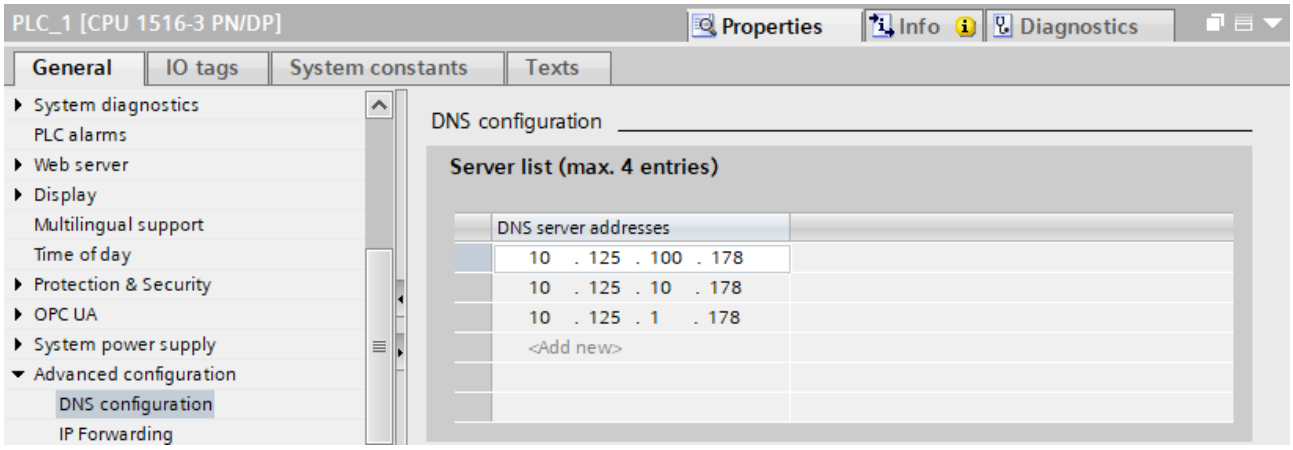

Figure 3-411 Entering DNS server addresses using a CPU 1516-3 PN/DP as an example

Setting up a TCP connection via the domain name of the communication partner

For TCP communication via the domain name you need to create a data block with the TCON_QDN system data type yourself, assign parameters and call it directly at the instruction. The TCON, TSEND_C and TRCV_C instructions support the system data type TCON_QDN:
To set up a TCP connection via the domain name of the communication partner, follow these steps:

1. Create a global data block in the project tree.
2. Define a tag of the data type TCON_QDN in the global data block.

   The example below shows the global data block "Data_block_1" in which the tag "DNS Connection1" of data type TCON_QDN is defined.

Data_block_1

	Name	Datentyp	Startwert	Kommentar
1	Static			
2	DNS Connection1	TCON_QDN		
3	InterfaceId	HW_ANY	0	not relevant
4	ID	CONN_OUC	16#0	connection reference / identifier
5	ConnectionType	Byte	16#0B	type of connection: 16#0B=11=TCP/IP, 16#13=19=UDP
6	ActiveEstablished	Bool	false	active/passive connection establishment
7	RemoteQDN	String[254]	''	fully or partially qualified domain name of remote partner
8	RemotePort	UInt	0	remote UDP / TCP port number
9	LocalPort	UInt	0	local UDP / TCP port number

Figure 3-412 Data type TCON_QDN

3. Program the parameters of the TCP connection (for example the fully qualified domain name (FQDN)) in the tag of data type TCON_QDN.
4. Create a TCON instruction in the program editor.
5. Interconnect the CONNECT parameter of the TCON instruction with the tag of the data type TCON_QDN.

   In the example below, the CONNECT parameter of the TCON instruction is interconnected with the tag "DNS connection1" (data type TCON_QDN).

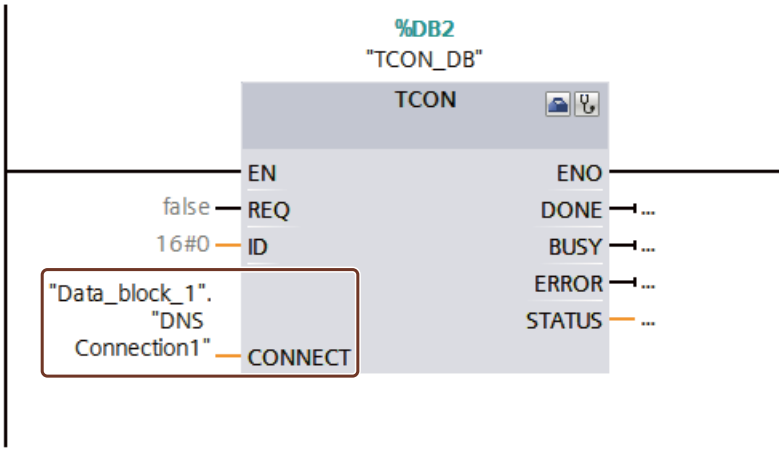

Figure 3-413 TCON instruction

Addressing a UDP connection via the domain name of the communication partner

For S7-1500 CPUs as of firmware version V2.0, you can address the recipient with its fully qualified domain name (FQDN) when sending data via UDP. With the instruction TUSEND at the parameter ADDR, you hereby reference a structure of the type TADDR_SEND_QDN.

The receiver can return an IPv4 or an IPv6 address. With the TURCV instruction at the ADDR parameter, you therefore reference a structure of the TADDR_RCV_IP type. Only this structure can include both IP address types.

NOTE

Network load

In contrast to the TCP the UDP protocol does not work connection-oriented. For every edge at the block parameter REQ, the TUSEND or TURCV command performs queries of the DNS server. This can lead to high network load or load on the DNS server.

Additional information

You can find more information about the system data types TCON_QDN, TADDR_SEND_QDN and TADDR_RCV_IP in the STEP 7 online help.

How to set up a secure TCP connection via the domain name of the communication partner is described in the section Secure Open User Communication (Page 93).

8.5 Setting up Open User Communication via TCP, ISO-on-TCP, UDP and ISO

Configuring a connection for the TSEND_C, TRCV_C or TCON instructions

Requirement: A TSEND_C, TRCV_C or TCON instruction is created in the programming editor.

1. Select a TCON, TSEND_C or TRCV_C block of Open User Communication in the program editor.
2. Open the "Properties > Configuration" tab in the inspector window.
3. Select the "Connection parameters" group. Until you select a connection partner, only the empty drop-down list for the partner end point is enabled. All other input options are disabled.

   The connection parameters already known are displayed:

   – Name of the local end point
   – Interface of the local end point

– IPv4 address of the local end point

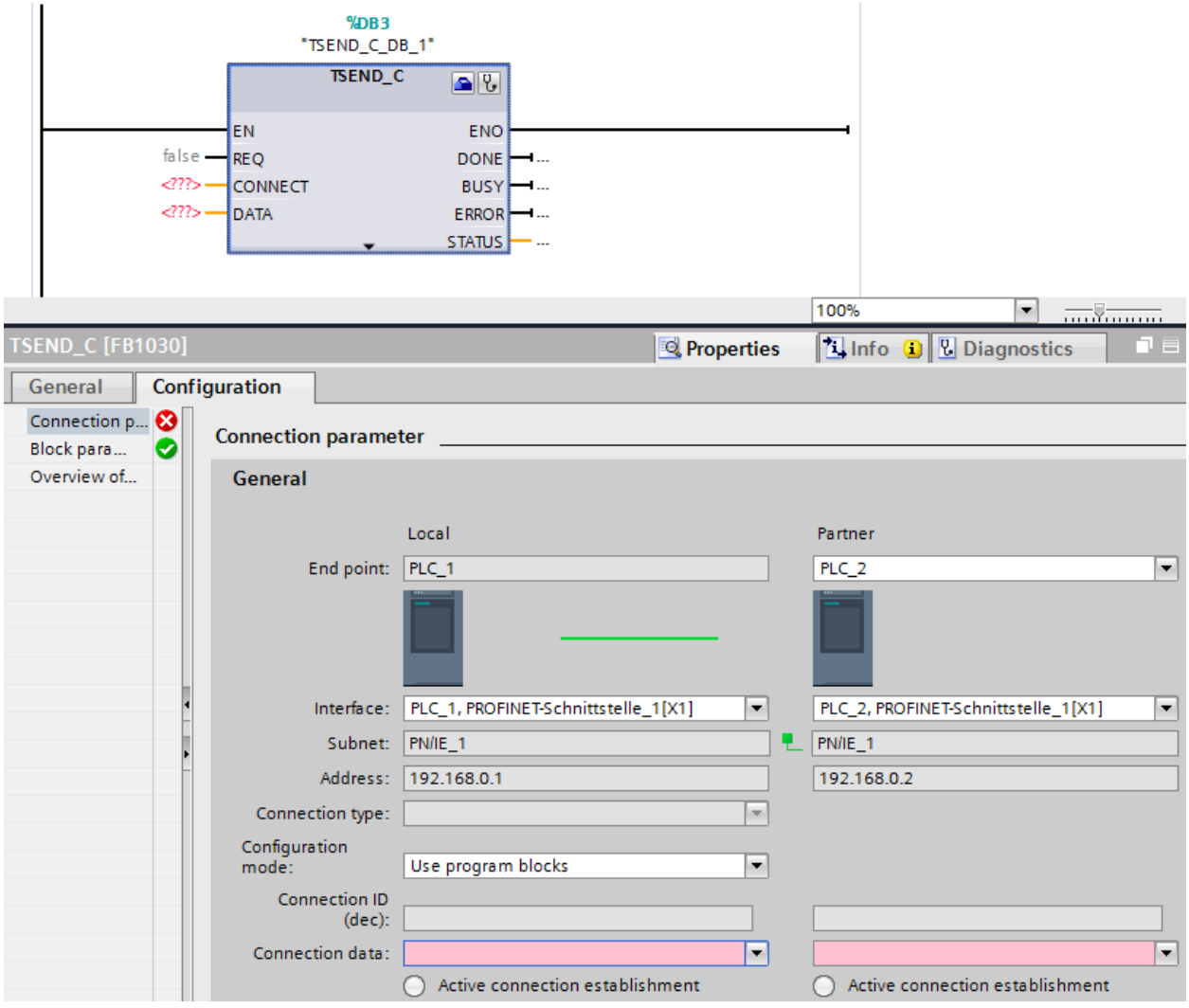

Figure 3-414 Connection parameters for TSEND_C

4. In the drop-down list box of the partner end point, select a connection partner. You can select an unspecified device or a CPU in the project as the communication partner. Certain connection parameters are then entered automatically.

   The following parameters are set:

   – Name of the partner end point
   – Interface of the partner end point
   – IPv4 address of the partner end point

   If the connection partners are networked, the name of the subnet is displayed.

5. In the "Configuration type" drop-down list, select between using program blocks or configured connections.

6. Select an existing connection description DB in the "Connection data" drop-down list or for configured connections select an existing connection under "Connection name". You can also create a new connection description DB or a new configured connection. Later, you can still select other connection description DBs or configured connections or change the names of the connection description DBs in order to create new data blocks:
   - You can also see the selected data block at the interconnection of the CONNECT input parameter of the selected TCON, TSEND_C or TRCV_C instruction.
   - If you have already specified a connection description DB for the connection partner using the CONNECT parameter of the TCON, TSEND_C or TRCV_C instruction, you can either use this DB or create a new DB.
   - If you edit the name of the displayed data block in the drop-down list, a new data block with the changed name but with the same structure and content is generated and used for the connection.
   - Changed names of a data block must be unique in the context of the communication partner.
   - A connection description DB must have the structure TCON_Param, TCON_IP_v4 or TCON_IP_RFC, depending on CPU type and connection.
   - A data block cannot be selected for an unspecified partner.

   Additional values are determined and entered after the selection or creation of the connection description DB or configured connection.

   The following is valid for specified connection partners:
   - ISO-on-TCP connection type
   - Connection ID with default of 1
   - Active connection establishment by local partner
   - TSAP ID
     for S7-1200/1500: E0.01.49.53.4F.6F.6E.54.43.50.2D.31

   The following is valid for unspecified connection partners:
   - TCP connection type
   - Partner port 2000

   The following applies for a configured connection with a specified connection partner:
   - TCP connection type
   - Connection ID with default of 257
   - Active connection establishment by local partner
   - Partner port 2000

   The following applies for a configured connection with an unspecified connection partner:
   - TCP connection type
   - Local port 2000

7. Enter a connection ID as needed for the connection partner. No connection ID can be assigned to an unspecified partner.

   NOTE

   You must enter a unique value for the connection ID at a known connection partner. The uniqueness of the connection ID is not checked by the connection parameter settings and there is no default value entered for the connection ID when you create a new connection.

8. Select the desired connection type in the relevant drop-down list. Default values are set for the address details depending on the connection type. You can choose between the following:
   - TCP
   - ISO-on-TCP
   - UDP
   - ISO (only with Configuration mode "Use configured connection")

   You can edit the input boxes in the address details. Depending on the selected protocol, you can edit the ports (for TCP and UDP) or the TSAPs (for ISO-on-TCP and ISO).
9. Use the "Active connection establishment" check box to set the connection establishment characteristics for TCP, ISO and ISO-on-TCP. You can decide which communication partner establishes the connection actively.

Changed values are checked immediately for input errors by the connection configuration and entered in the data block for the connection description.

NOTE

Open User Communication between two communication partners can only work when the program section for the partner end point has been downloaded to the hardware. To achieve fully functional communication, make sure that you load not only the connection description of the local CPU on the device but also that of the partner CPU as well.

Configuring connections, e.g. for TSEND/TRCV

If you want to use the instructions for TSEND/TRCV for open communication, for example, you first need to configure a connection (e.g. TCP connection).

To configure a TCP connection, follow these steps:

1. Configure the communications partners in the network view of the Devices & networks editor of STEP 7.
2. Click the "Connections" button and select the "TCP connection" connection type from the drop-down list.
3. Using drag-and-drop, connect the communication partner with each other (via an interface or local end point). If the required S7 subnet does not yet exist, it is created automatically.

   You can also set up a connection to unspecified partners.

4. Select the created connection in the network view.
5. Set the properties of the connection in the "Properties" tab in the "General" area, for example the name of the connection and the interfaces of the communications partner that will be used.

   For connections to an unspecified partner, set the address of the partner.
   You can find the local ID (reference of the connection in the user program) in the "Local ID" area.
6. In the Project tree, select the "Program blocks" folder for one of the CPUs and open OB1 in the folder by double-clicking on it. The program editor opens.
7. Select the required instruction from the "Instructions" task card, "Communication" area, "Open user communication", for example TSEND and drag it to a network of OB1.
8. At the ID parameter of the instruction, assign the local ID of the configured connection to be used for the transmission of data.
9. Interconnect the "DATA" parameter of the TSEND instruction with the user data, for example in a data block.
10. Download the hardware configuration and user program to the CPU.

Based on the procedure described above, set up the connection on the partner CPU with the instruction for receiving, TRCV, and download it to the CPU.

Point to note with ISO connections with CP 1543-1

If you use the "ISO connection" connection type, you will need to select the "Use ISO protocol" check box in the properties of the CP so that addressing using MAC addresses will work.

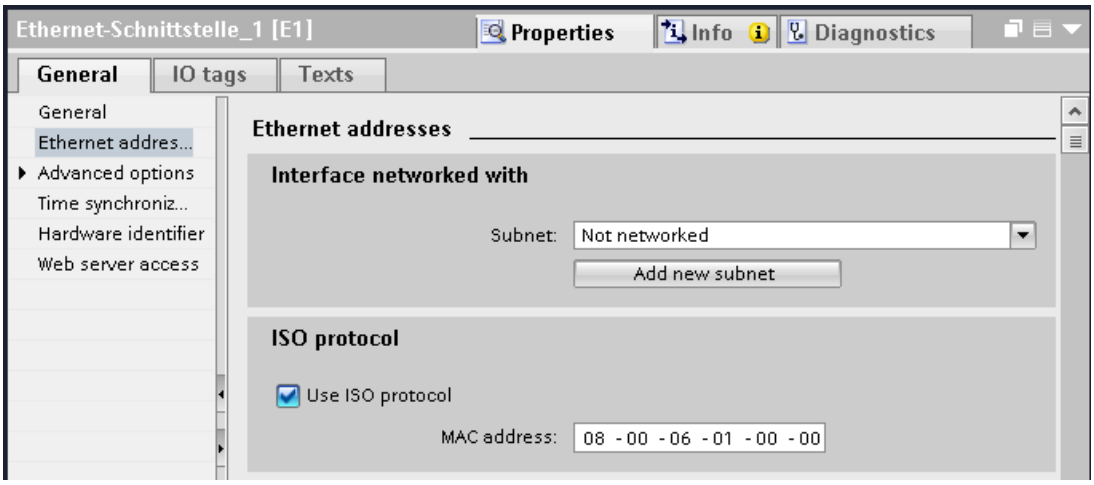

Figure 3-415 Select CP 1543-1 ISO protocol

Additional information

The STEP 7 online help describes:

- The instructions for open communication
- The connection parameters

This FAQ (https://support.industry.siemens.com/cs/ww/en/view/109479564) describes how the instructions TSEND_C and TRCV_C behave in the S7-1500.

8.6 Setting up communication over FDL

Requirements

- Configuration software: STEP 7 Professional V14
- End point of the connection: CPU S7-1500 firmware version V2.0 or higher with communication module CM 1542-5 with firmware version V2.0

Setting up a configured FDL connection

Proceed as follows to set up a configured FDL connection in STEP 7:

1. Create a TSEND_C instruction in the program editor.
2. Select the TSEND_C instruction and go to "Properties" > "General" > "Connection parameters" in the Inspector window.
3. Under End point, select the partner end point. Use one of the two partner end points below:
   - CPU S7-1500 with CM 1542-5
   - Unspecified
4. Under Configuration type, select "Use configured connection".
5. Under Connection type, select "FDL".
6. Under Interface, select the following interfaces:
   - Local: PROFIBUS interface of CM 1542-5
   - Specified partner: PROFIBUS interface of CM 1542-5
7. Under Connection data, select the setting <new>.

The figure below shows a fully configured FDL connection in STEP 7.

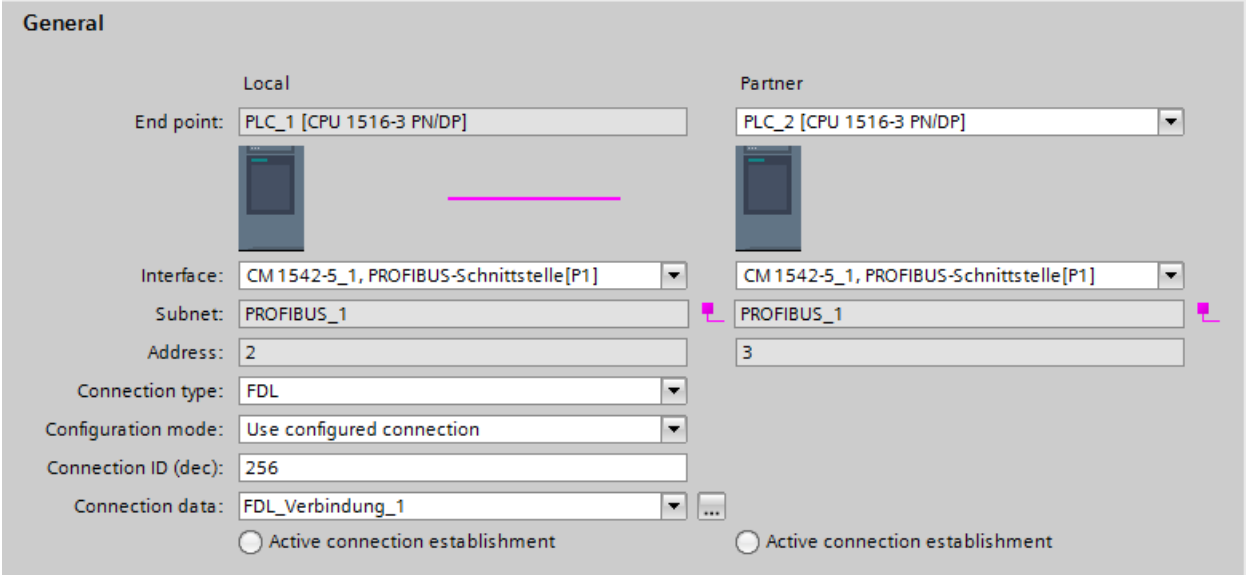

Figure 3-416 Configuring the FDL connection

Setting up an FDL connection in the user program

For communication via FDL, you need to create the data block of the TCON_FDL system data type yourself in each case, assign parameters and call it directly at the instruction. Follow these steps:

1. Create a global data block in the project tree.
2. In the global data block, define a tag of the data type TCON_FDL.

   The example below shows the global data block "FDL_connection" in which the tag "FDL_connection" of the data type TCON_FDL is defined.

FDL_connection

	Name	Data type	Start val..	R...	A...	...	V...	S...	Super...	Comment
1	Static									
2	FDL_connection	TCON_FDL			☑	☑	☑			
3	InterfaceId	HW_ANY	0		☑	☑	☑			HW identifier of PB interface submodule
4	ID	CONN_OUC	16#0		☑	☑	☑			connection reference / identifier
5	ConnectionType	Byte	16#15		☑	☑	☑			type of connection: 21= FDL connection
6	ActiveEstablished	Bool	false		☑	☑	☑			active/passive connection establishment
7	ServiceId	Byte	16#0		☑	☑	☑			service id: 0 – default, 1 – SDA, 2 – SDN
8	RemotePBAddress	Byte	16#0		☑	☑	☑			remote ProfiBus partner address
9	LocalPBAddress	Byte	16#0		☑	☑	☑			local ProfiBus partner address
10	RemoteLSAP	Byte	16#0		☑	☑	☑			remote PB link-layer service access point
11	LocalLSAP	Byte	16#0		☑	☑	☑			local PB link-layer service access point

Figure 3-417 Programming an FDL connection

3. Program the parameters of the FDL connection (e.g. the PROFIBUS addresses) in the tag of the data type TCON_FDL.
4. Create a TCON instruction in the program editor.

5. Interconnect the CONNECT parameter of the TCON instruction with the tag of the data type TCON_FDL.

   In the example below, the CONNECT parameter of the TCON instruction is interconnected with the tag "FDL_Connection" (data type TCON_FDL).

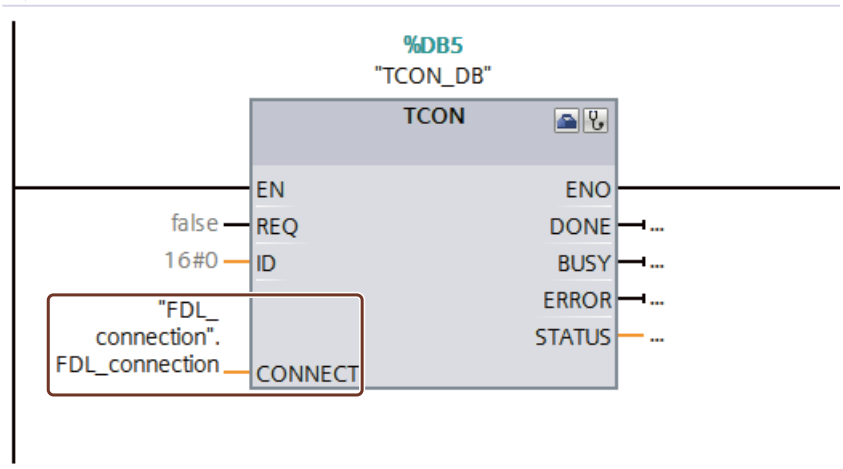

Figure 3-418 Example: TCON Instruction for FDL connection

8.7 Setting up communication with Modbus TCP

Setting up a connection for Modbus TCP via the user program

The parameter assignment takes place in the program editor at the instruction MB_CLIENT or MB_SERVER.

Procedure for setting up communication using Modbus TCP

The MB_CLIENT instruction communicates as a Modbus TCP client via the TCP connection. You establish a connection between the client and the server with the instruction, send Modbus requests to the server and receive the corresponding Modbus responses. You also control the setup of the TCP connection with this instruction.

The MB_SERVER instruction communicates as a Modbus TCP server via the TCP connection. The instruction processes connection requests of a Modbus client, receives and processes Modbus requests and sends responses. You also control the setup of the TCP connection.

Requirement: The client can reach the server via IP communication in the network.

1. Configure an S7-1500 automation system with CPU in the network view of the Devices & networks editor of STEP 7.
2. In the Project tree, select the "Program blocks" folder and open OB1 in the folder by double-clicking on it. The program editor opens.
3. Select the required instruction, for example MB_CLIENT, from the "Instructions" task card, "Communication" area, "Other", "MODBUS TCP" and drag it to a network of OB1.

4. Assign the parameters of the MB_CLIENT or MB_SERVER instruction. Observe the following rules:

   An IPv4 server address must be specified for each MB_CLIENT connection.

   Each MB_CLIENT or MB_SERVER connection must use a unique instance DB with one of the data structures TCON_IP_v4, TCON_QDN or TCON_Configured.

   Each connection requires a unique connection ID. The connection ID and instance DB belong together in pairs and must be unique for each connection.

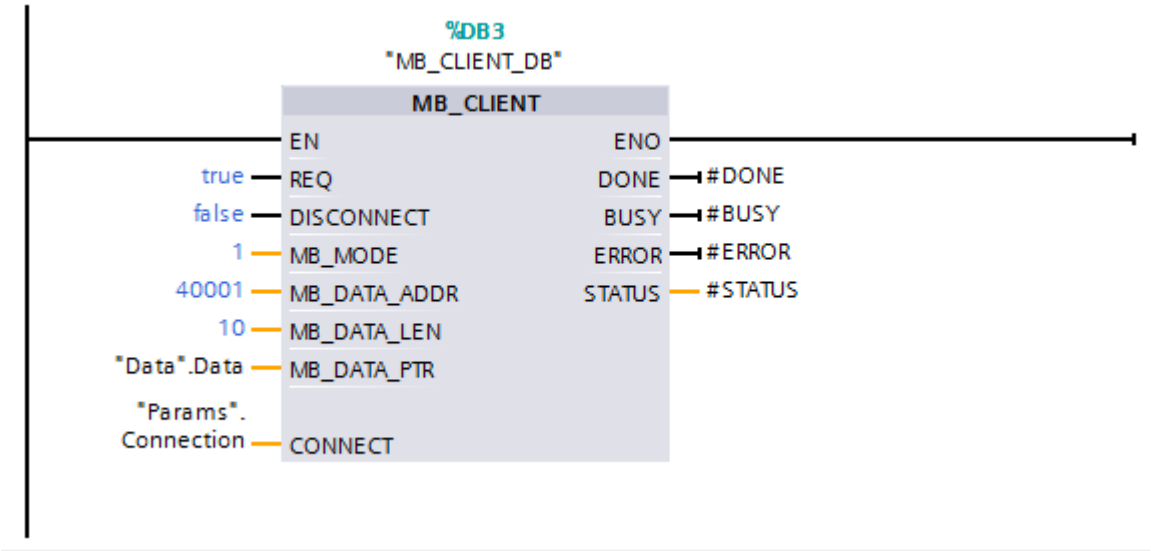

Figure 3-419 MB_CLIENT

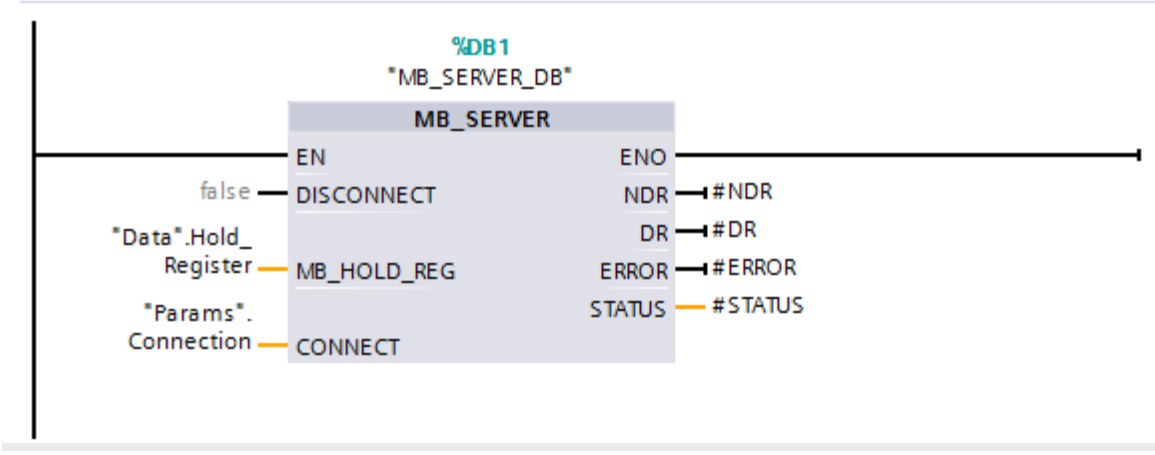

Figure 3-420 MB_SERVER

5. Download the hardware configuration and user program to the CPU.

Redundant communication over Modbus TCP

Assign parameters for redundant communication via Modbus TCP using the MB_RED_CLIENT or MB_RED_SERVER instructions:

MB_RED_CLIENT instruction:
Use the instruction "MB_RED_CLIENT" to establish a redundant connection between the client and the server, send Modbus requests, receive responses and control the connection termination of the Modbus TCP client.

MB_RED_SERVER instruction:
The "MB_RED_SERVER" instruction processes the connection requests of a Modbus TCP client, receives and processes Modbus requests and sends responses. The CPUs can:

- processing multiple server connections and
- accepting multiple connections from different clients simultaneously at one server port.

For more information on the MB_RED_CLIENT or MB_RED_SERVER instructions, refer to the STEP 7 online help.

Modbus TCP server as gateway to Modbus RTU

If you use a Modbus TCP server as a gateway to a Modbus RTU protocol, address the slave device in the serial network using the static parameter, MB_UNIT_ID. The MB_UNIT_ID parameter corresponds to the field of the slave address in the Modbus RTU protocol. The MB_UNIT_ID parameter in this case would forward the request to the correct Modbus RTU slave address.

You do not have to program the gateway function yourself.

You can find the MB_UNIT_ID parameter in the instance data block associated with MB_CLIENT instruction.

You can find more information on the MB_UNIT_ID parameter in the STEP 7 online help.

Reference

- This FAQ (https://support.industry.siemens.com/cs/ww/en/view/94766380) describes how to program and configure the Modbus TCP communication between two S7-1500 CPUs.
- This FAQ (https://support.industry.siemens.com/cs/ww/en/view/102020340) describes how to program and configure Modbus TCP communication between an S7-1500 CPU and an S7-1200 CPU.

8.8 Setting up communication via e-mail

Setting up a connection for e-mail via the user program

For communication using e-mail, you need to create the data block of the relevant system data type yourself, assign parameters and call the instruction directly. This procedure is introduced below.

Procedure for setting up communication using e-mail

A CPU can send e-mails. To send e-mails from the user program of the CPU, use the TMAIL_C instruction.

Requirement: The SMTP server can be reached via the IPv4 network.

1. Configure an S7-1500 automation system with CPU in the network view of the Devices & networks editor of STEP 7.
2. Assign parameters to the instruction TMAIL_C, for example enter the subject of the e-mail in Subject.
3. In a global data block create a variable of the type TMAIL_v4, TMAIL_v6 (only CP 1543-1) or TMAIL_FQDN (only CP 1543-1).
4. Set the connecting parameters of the TCP connection in the variable in the "Start value" column. Enter the IPv4 address of the mail server, for example, for the "MailServerAddress" (for TMAIL_v4)

   NOTE
   Connection parameter Interface ID
   Note that you can enter the value "**0**" for the interface ID with instruction version V5.0 or higher of the instruction TMAIL_C in the data type TMAIL_V4_SEC. In this case, the CPU itself searches for a suitable local CPU interface.

   Interconnect the variable to the MAIL_ADDR_PARAM parameter of the TMAIL_C instruction.
5. Download the hardware configuration and user program to the CPU.

Additional information

The STEP 7 online help describes:

- The system data types
- The instructions for open communication
- The connection parameters

8.9 Setting up communication via FTP

Setting up a connection for FTP via the user program

For communication via FTP, you need to create the data block of the relevant system data type yourself, assign parameters and call the instruction directly. This procedure is introduced below.

FTP client and server functionality

Files can be sent by a CPU to an FTP server and can be received from the FTP server. Communication with FTP is only possible for the S7-1500 using the CP 1543-1. The CP can be an FTP server, FTP client or both. FTP clients can also be third-party systems/PCs.

For the FTP server functionality, configure the CP accordingly in STEP 7.

You can use the FTP client functionality to implement, for example, the establishment and termination of an FTP connection, the transfer and deletion of files on the server. For the FTP client functionality, use the FTP_CMD instruction.

Procedure for setting up FTP server functionality

Requirement: The FTP server can be reached via the IPv4 network.

1. Configure an S7-1500 automation system with CPU and CP 1543-1 in the device view of the Devices & networks editor of STEP 7.

   At the same time, you need to select the option "Permit access with PUT/GET communication from remote partner (PLC, HMI, OPC, ...)" in the HW configuration of the S7-1500 CPU under the "Protection" area navigation in the section "Connection mechanisms".

2. Make the following settings in the properties of the CP under "FTP configuration":
   - Select the "Use FTP server for S7 CPU data" check box.
   - Assign the CPU, a data block and a file name under which the DB for FTP will be stored.

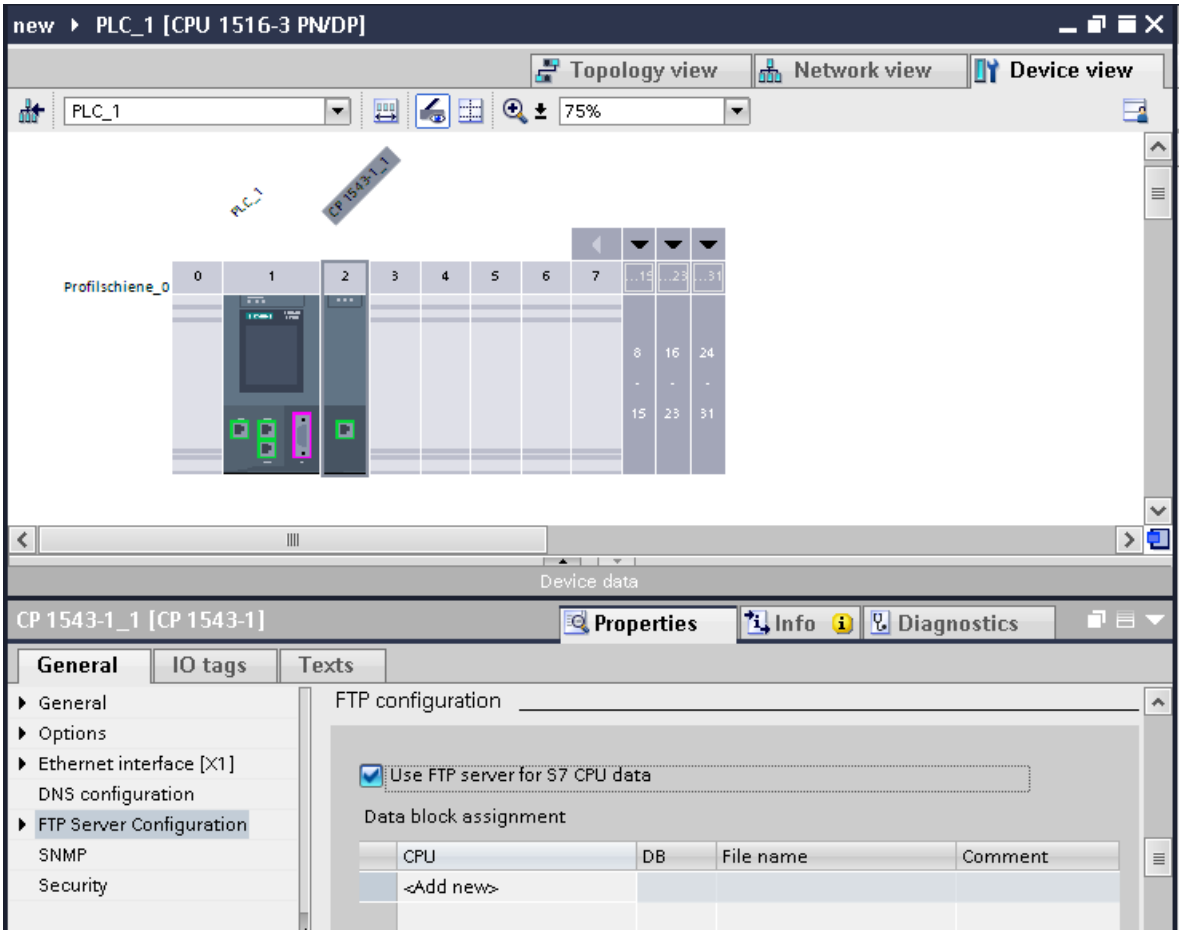

Figure 3-421 Setting up the FTP configuration

3. Download the hardware configuration to the CPU.

Procedure for setting up FTP client functionality

Requirement: The FTP server can be reached via the IPv4 network**.**

1. Configure an S7-1500 automation system with CPU and CP 1543-1 in the device view of the Devices & networks editor of STEP 7.

   At the same time, you need to select the check box "Permit access with PUT/GET communication from remote partner (PLC, HMI, OPC, ...)" in the HW configuration of the S7-1500 CPU under the "Protection" area navigation in the section "Connection mechanisms".
2. Call the FTP_CMD instruction in the user program of the CPU.
3. Set the connection parameters for the FTP server in the FTP_CMD instruction.
4. Create a global DB and within this DB a tag of the type FTP_CONNECT_IPV4, FTP_CONNECT_IPV6 or FTP_CONNECT_NAME.
5. Interconnect the tag within the data block with the FTP_CMD instruction.
6. For the connection to the FTP server, specify the following in the DB:
   – The user name, the password and the IP address for the FTP access in the relevant data type (FTP_CONNECT_IPV4, FTP_CONNECT_IPV6 or FTP_CONNECT_NAME)
7. Download the hardware configuration and user program to the CPU.

Application examples

- Application example: FTP communication with S7-1500 and CP 1543-1
  You can find the application example on the Internet
  (https://support.industry.siemens.com/cs/ww/en/view/103550797).
- Application example: FTP client communication with S7-1200/1500
  You can find the application example on the Internet
  (https://support.industry.siemens.com/cs/ww/en/view/81367009).

Additional information

The STEP 7 online help describes:

- The system data types
- The instructions for open communication
- The connection parameters

8.10 Establishment and termination of communications relations

Establishment and termination of communications

The table below shows the establishment and termination of communications as part of open communication.

Table 3-942 Establishment and termination of communications

Setting up the connection	Establishing communication	Terminating communication
With the user program	After downloading the user program to the CPUs: The passive communications partner sets up the local connection access by calling TSEND_C/TRCV_C or TCON. Calling TSEND_C/TRCV_C or TCON on the active partner starts connection establishment. If the connection could be established, there is positive feedback to the instructions in the user program. After you have terminated a connection using the instruction T_RESET, the connection is reestablished. If the connection aborts, the active partner attempts to re-establish the connection. This applies only if the connection was successfully established beforehand with TCON.	• Using the TSEND_C/TRCV_C, TDISCON and T_RESET instructions • When the CPU changes from RUN to STOP mode • With POWER OFF/POWER ON on a CPU
By configuring a connection	After downloading the connection configuration and the user program to the CPUs.	By deleting the connection configuration in STEP 7 and downloading the changed configuration to the CPU.

S7 communication

9

Characteristics of S7 communication

S7 communication as homogeneous SIMATIC communication is characterized by vendor-specific communication between SIMATIC CPUs (not an open standard). S7 communication is used for migration and for connecting to existing systems (S7-300, S7-400).

For data transfer between two S7-1500 automation systems, we recommend that you use open communication (see section Open User Communication (Page 135)).

Properties of S7 communication

Using S7 communication, the CPU exchanges data with another CPU. Once the user has received the data at the receiver end, the reception data is automatically acknowledged to the sending CPU.

The data is exchanged via configured S7 connections. S7 connections can be configured at one end or at both ends.

S7 communication is possible via:

- Integrated PROFINET or PROFIBUS DP interface of a CPU
- Interface of a CP/CM

S7 connections configured at one end

For an S7 connection configured at one end, the configuration for this connection takes place in only one communication partner and is only downloaded to it.

A one-sided S7 connection can be configured to a CPU that is only a server of an S7 connection (e.g. CPU 315-2 DP). The CPU is configured and the address parameters and interfaces are thus known.

In addition, a one-sided S7 connection can be configured to a partner who is not in the project and whose address parameters and interface are therefore not known. You need to enter the address; it is not checked by STEP 7. The partner is initially unspecified (no partner address is registered when you create the S7 connection). Once you enter the address, it is "unknown" (i.e. it is named, but the project is unknown).

This makes it possible to use S7 connections beyond the boundaries of a project. The communication partner is unknown to the local project (unspecified) and is configured in another STEP 7 or third-party project.

S7 connections configured at both ends

When an S7 connection is configured at both ends, the configuration and download of the configured S7 connection parameters takes place in both communication partners.

Instructions for S7 communication

For S7 communication with S7-1500, the following instructions can be used:

- PUT/GET

  You write data to a remote CPU with the PUT instruction. You can use the GET instruction to read data from a remote CPU. The PUT and GET instructions and are one-sided instructions, i.e. you need only an instruction in one communication partner. You can easily set up the PUT and GET instructions via the connection configuration.

  NOTE

  Data blocks for PUT/GET instructions

  When using the PUT/GET instructions, you can only use data blocks with absolute addressing. Symbolic addressing of data blocks is not possible.

  You must also enable this service for protection in the CPU configuration in the "Protection" area.

  This FAQ (https://support.industry.siemens.com/cs/ww/en/view/82212115) provides information about how to configure and program an S7 instruction and the GET and PUT communication instructions for data exchange between two S7-1500 CPUs.

- BSEND/BRCV

  The BSEND instruction sends data to a remote partner instruction of the type BRCV. The BRCV instruction receives data from a remote partner instruction of the type BSEND. You use the S7 communication via the BSEND/BRCV instruction pair for secure transmission of data.

- USEND/URCV

  The USEND instruction sends data to a remote partner instruction of the type URCV. The URCV instruction receives data from a remote partner instruction of the type USEND. You use the S7 communication via the USEND/URCV instruction pair for fast, non-secure transmission of data regardless of the timing of the processing by the communications partner; for example for operating and maintenance messages.

S7 communication via PROFIBUS DP interface in slave mode

You can find the "Test, commissioning, routing" check box in STEP 7 in the properties of the PROFIBUS DP interface of communications modules (e.g. CM 1542-5). Using this check box, you decide whether the PROFIBUS DP interface of the DP slave is an active or passive device on PROFIBUS.

- Check box selected: The slave is an active device on PROFIBUS.
- Check box cleared: The DP slave is a passive device on PROFIBUS. You can only set up S7 connections configured at one end for this DP slave.

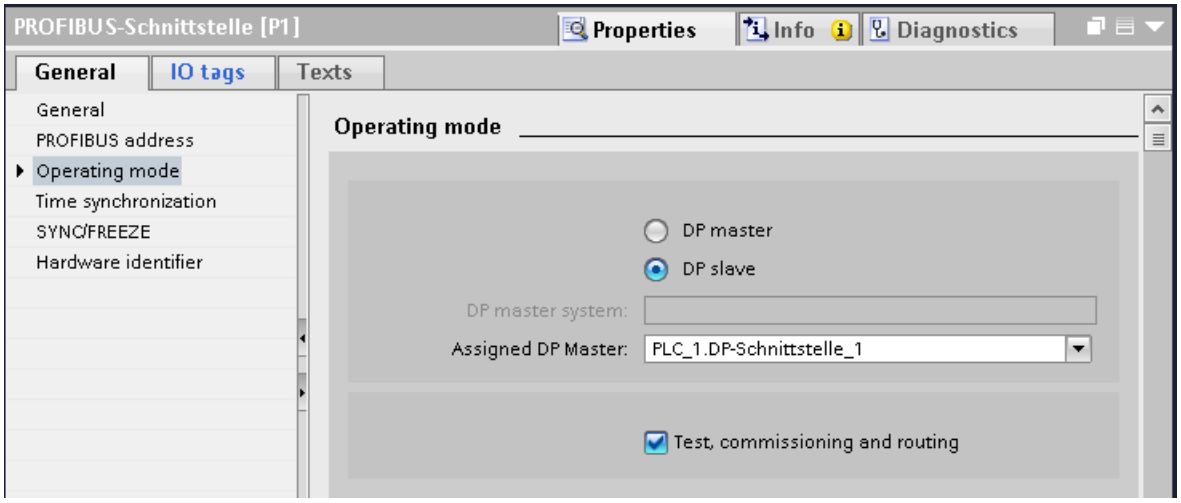

Figure 3-422 "Test, commissioning, routing" check box

Configuring S7 connections for PUT/GET instructions

You can create S7 connections and assign the parameters for these in the connection parameter assignment of the PUT/GET instructions. Changed values are checked immediately by the connection parameter assignment for input errors.

Requirement: A PUT or GET instruction is created in the programming editor.

To configure an S7 connection using PUT/GET instructions, follow these steps:

1. In the program editor, select the call of the PUT or GET instruction.
2. Open the "Properties > Configuration" tab in the inspector window.
3. Select the "Connection parameters" group. Until you select a connection partner, only the empty drop-down list for the partner end point is enabled. All other input options are disabled.

   The connection parameters already known are displayed:

   – Name of the local end point
   – Interface of the local end point

– IPv4 address of the local end point

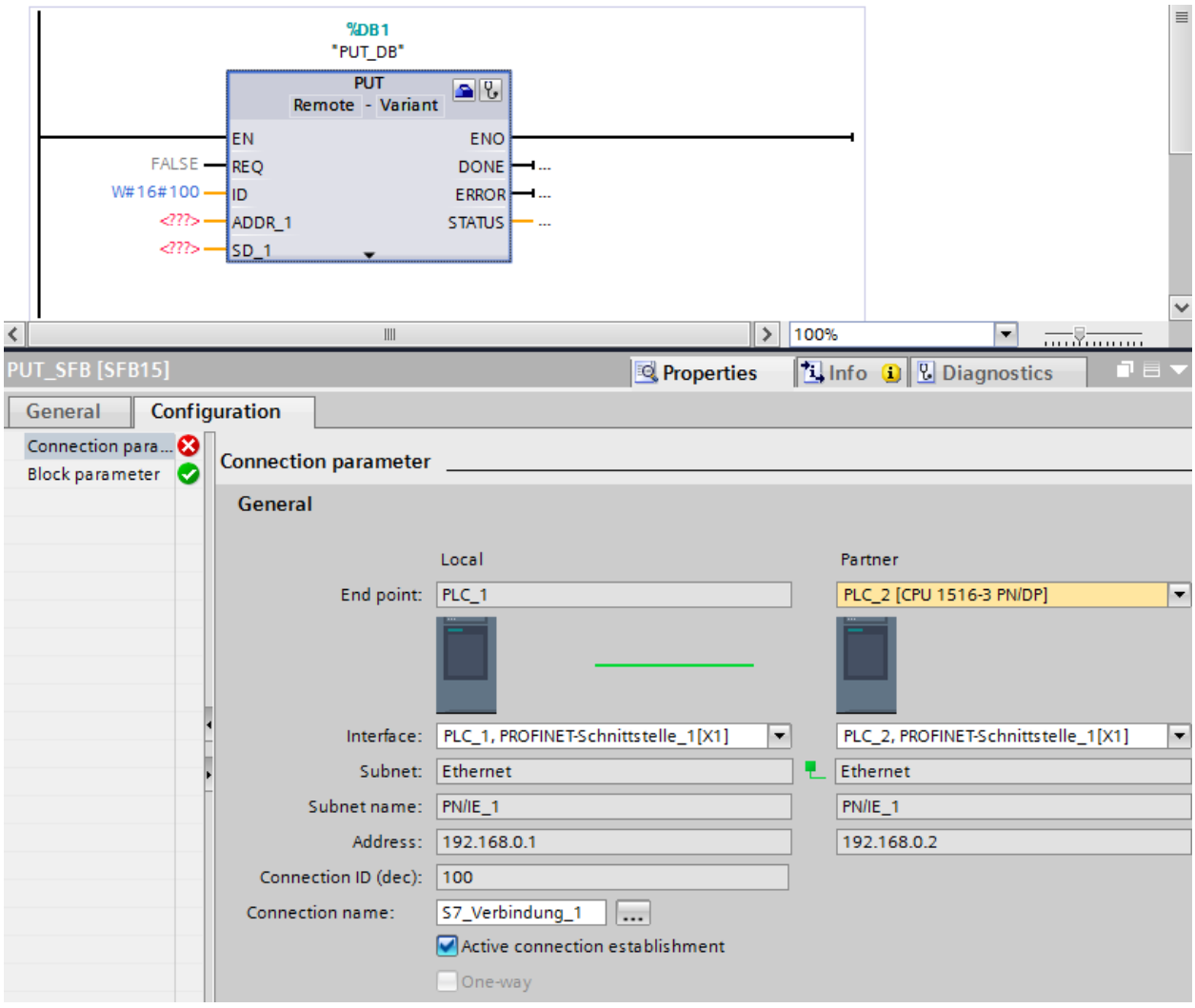

Figure 3-423 Connection configuration for PUT instruction

4. In the drop-down list box of the partner end point, select a connection partner. You can select an unspecified device or a CPU in the project as the communication partner.

   The following parameters are automatically entered as soon as you have selected the connection partner:

   – Name of the partner end point
   – Interface of the partner end point. If several interfaces are available, you can change the interface as required.
   – Interface type of the partner end point
   – Subnet name of both end points
   – IPv4 address of the partner end point
   – Name of the connection which is used for the communication.

5. If required, change the connection name in the "Connection name" input box. If you want to create a new connection or edit an existing connection, click on the "Select connection" button on the right side next to the input box for the connection name.

NOTE

The PUT and GET instructions between two communication partners can only run if both the hardware configuration and the program part for the partner end point have been loaded into the hardware. To achieve fully functional communication, make sure that you load not only the connection description of the local CPU on the device but also that of the partner CPU as well.

Configuring S7 connections for e.g. BSEND/BRCV

If you want to use the instructions for BSEND/BRCV for S7 communication, for example, you first need to configure an S7 connection.

To configure a S7 connection, follow these steps:

1. Configure the communications partners in the network view of the Devices & networks editor of STEP 7.
2. Select the "Connections" button and the "S7 connection" entry from the drop-down list.
3. Using drag-and-drop, connect the communication partner with each other (via an interface or local end point). If the required S7 subnet does not yet exist, it is created automatically.

   You can also set up a connection to unspecified partners.
4. In the "Connections" tab, select the row of the S7 connection.
5. Set the properties of the S7 connection in the "Properties" tab in the "General" area, for example the name of the connection and the interfaces of the communications partner that will be used.

   For S7 connections to an unspecified partner, set the address of the partner.
   You can find the local ID (reference of the S7 connection in the user program) in the "Local ID" area.
6. In the Project tree, select the "Program blocks" folder for one of the CPUs and open OB1 in the folder by double-clicking on it. The program editor opens.
7. In the program editor, call the relevant instructions for S7 communication in the user program of the communication partner (configured at one end) or in the user programs of the communication partners (configured at both ends). Select the BSEND and BRCV instructions from the "Communication" area of the "Instructions" task card, for example, and drag them to a network of OB1.
8. At the ID parameter of the instruction, assign the local ID of the configured connection to be used for the transmission of data.
9. Assign the parameters for the instructions indicating which data will be written to where and which data will be read from where.
10. Download the hardware configuration and user program to the CPU(s).

S7 communication via CP 1543-1

If you set up S7 communication via the Industrial Ethernet interface of the CP 1543-1, you can select the transport protocol for data transfer in the properties of the S7 connection under "General":

- "TCP/IP" check box selected (default): ISO-on-TCP (RFC 1006): for S7 communication between S7-1500 CPUs
- "TCP/IP" check box cleared: ISO protocol (ISO/IEC 8073): Addressing using MAC addresses

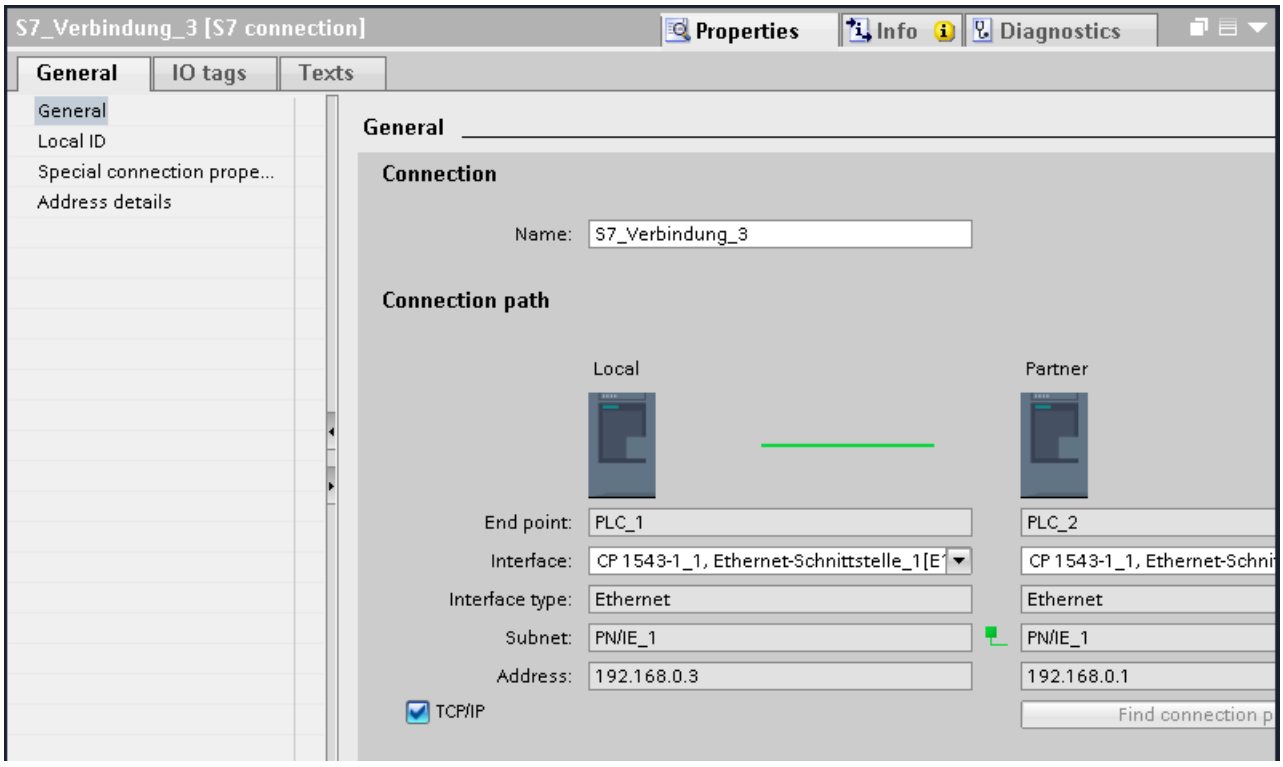

Figure 3-424 Selecting the CP 1543-1 transport protocol

Procedure for setting up an S7 connection via different S7 subnets

You have the option of using an S7 connection over multiple S7 subnets (PROFIBUS, PROFINET/Industrial Ethernet) (S7 routing (Page 417)).

1. Configure the communications partners in the network view of the Devices & networks editor of STEP 7.
2. Select the "Network" button.
3. Connect the relevant interfaces with the S7 subnets (PROFIBUS, PROFINET/Industrial Ethernet) using drag-and-drop.
4. Select the "Connections" button and the "S7 connection" entry from the drop-down list.

5. Using drag-and-drop in our example, connect PLC_1 in the left S7 subnet (PROFIBUS) to PLC_3 in the right S7 subnet (PROFINET).

   The S7 connection between CPU 1 and CPU 3 is configured.

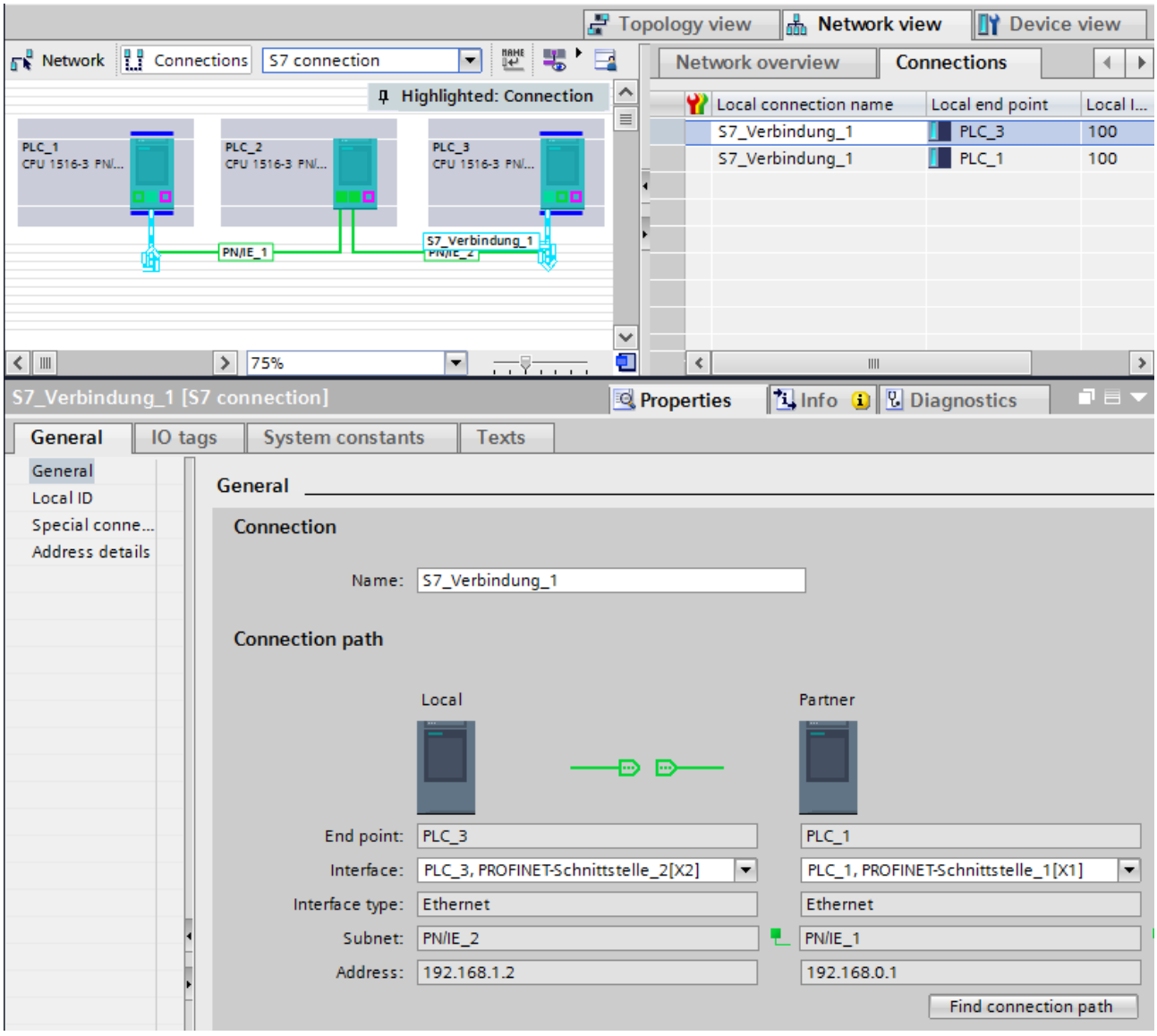

Figure 3-425 S7 connections via different subnets

ET 200SP Open Controller as router for S7 connections

If you assign the "PROFINET onboard [X2]" interface to the CPU 1515SP PC (F) of the SIMATIC PC station, the CPU 1515SP PC (F) can be used as a router for S7 connections. If you use the CP interface for "None, or a different Windows setting", you cannot use the Open Controller as a router for routed S7 connections.

An existing S7 connection routed by the CPU 1515SP PC (F) becomes invalid if the assignment of the interface of the CPU 1515SP PC (F) is changed from "SIMATIC PC station" to

"None, or a different Windows setting". Since the PLC now no longer handles routing functions for this connection, when the CPU 1515SP PC (F) is compiled, no message relating to the invalid connection is displayed. The invalid routed S7 connection is displayed only when the end points of the connection are compiled.

The interfaces required for routed S7 connections must remain explicitly assigned on the CPU 1515SP PC (F) . You can edit the assignment of the interface of the CPU 1515SP PC (F) in the properties under "PROFINET onboard [X2] > Interface assignment".

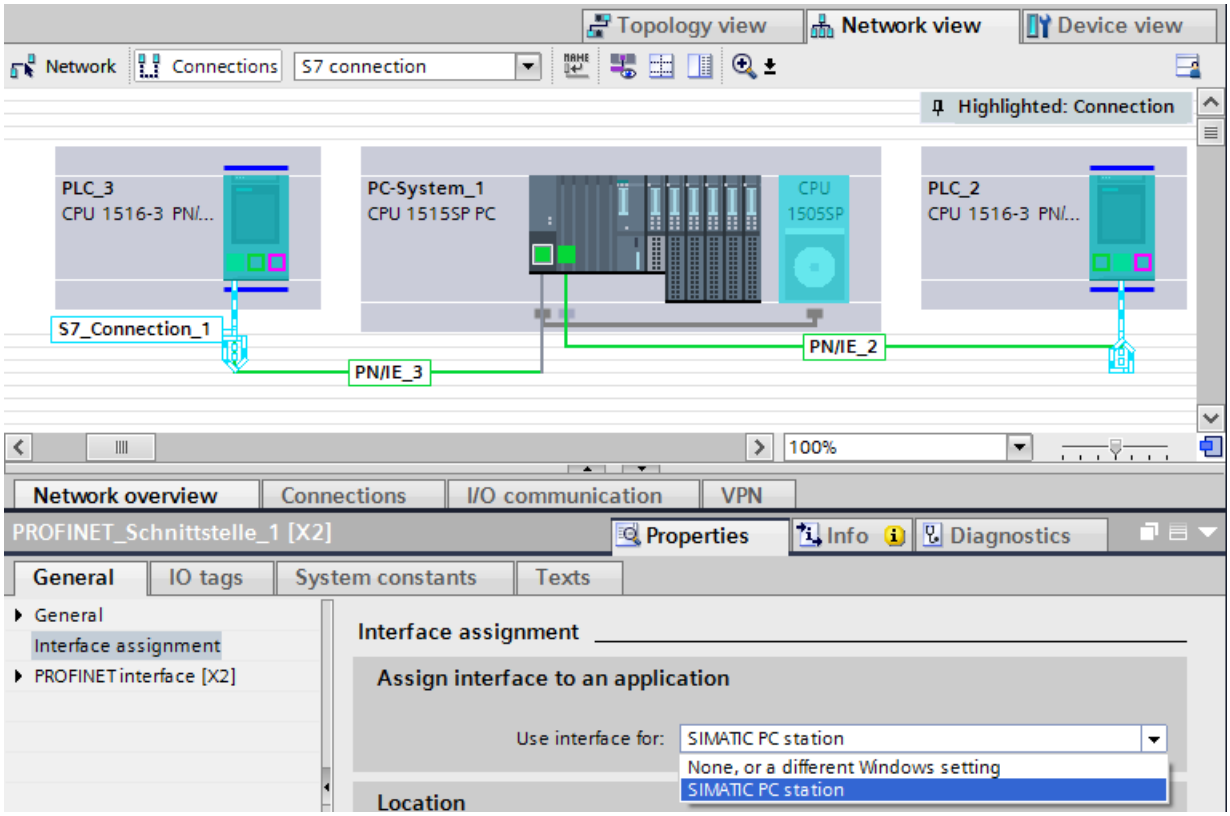

Figure 3-426 S7 routing PC station

More information

You can find detailed information on configuring S7 connections and how to use the instructions for S7 communication in the user program in the STEP 7 online help.

Point-to-point link 10

Functionality

A point-to-point connection for S7-1500, ET 200MP and ET 200SP is established via communications modules (CMs) with serial interfaces (RS232, RS422 or RS485):

- S7-1500/ET 200MP:
  - CM PtP RS232 BA
  - CM PtP RS422/485 BA
  - CM PtP RS232 HF
  - CM PtP RS422/485 HF
- ET 200SP:
  - CM PtP

The bidirectional data exchange via a point-to-point connection works between communications modules or third-party systems or devices capable of communication. At least 2 communication partners are required for communication ("point-to-point"). With RS422 and RS485, more than two communications partners are possible.

Protocols for communication via a point-to-point connection

- Freeport protocol (also called ASCII protocol)
- Procedure 3964(R)
- Modbus protocol in RTU format (RTU: Remote Terminal Unit)
- USS protocol (universal serial interface protocol)

The protocols use different layers according to the ISO/OSI reference model:

- Freeport: Uses layer 1 (physical layer)
- 3964 (R), USS and Modbus: Use layer 1 and 2 (physical layer and data link layer; therefore greater transmission reliability than with Freeport). USS and Modbus use additionally layer 4.

Properties of the Freeport protocol

- The recipient recognizes the end of the data transfer by means of a selectable end criterion (e.g. character delay time elapsed, receipt of end character, receipt of a fixed amount of data).
- The sender cannot recognize whether the sent data arrived free of errors at the recipient.

Properties of procedure 3964 (R)

- When the data is sent, control characters are added (start, end and block check characters). Make sure that these control characters are not included as data in the frame.
- Connection establishment and termination makes use of control characters.
- If transfer errors occur, data transfer is automatically repeated.

Data exchange using Freeport or 3964 (R) communication

The data to be sent is stored in the user program of the corresponding CPU in data blocks (send buffer). A receive buffer is available on the communications module for the received data. Check the properties of the receive buffer and adapt them if necessary. You must create a data block for receiving in the CPU.

In the user program of the CPU, the "Send_P2P" and "Receive_P2P" instructions handle the data transfer between the CPU and CM.

Procedure for setting up Freeport or 3964 (R) communication

1. Configure an S7-1500 configuration with CPU and CM in the device view of the hardware and network editor of STEP 7.
2. Select the interface of the CM in the device view of STEP 7.
3. Assign the parameters of the interface (for example connection communication, configuration of message sending) in the Inspector window of STEP 7 under "Properties" > "General".
4. Select the "Send_P2P" or "Receive_P2P" instruction in the "Instructions" task card under "Communication" > "Communications processor" and drag-and-drop the instruction into the user program (for example into a FB).
5. Assign the parameters for the instructions according to your configuration.
6. Download the hardware configuration and user program to the CPU.

Otherwise: Dynamic parameter assignment of the communications module

In certain types of application it is an advantage to set up communication dynamically; in other words, program-controlled by a specific application.

Typical applications for this, could be, for example manufacturers of serial machines. To make the user interfaces as convenient as possible for their customers, these manufacturers adapt the communications services to the particular operator entries.

Instructions for Freeport communication

There are 3 instructions available for the dynamic configuration in the user program for Freeport communication. The following applies to all 3 instructions: the previously valid configuration data is overwritten but not stored permanently in the target system.

- The "Port_Config" instruction is used for the program-controlled configuration of the relevant port of the communications module.
- The "Send_Config" instruction is used for the dynamic configuration, for example of time intervals and breaks in transmission (serial transmission parameters) for the relevant port.
- The "Receive_Config" instruction is used for dynamic configuration, for example of conditions for the start and end of a message to be transferred (serial receive parameters) for the relevant port.

Instructions for 3964 (R) communication

There are 2 instructions available for dynamic configuration in the user program for 3964 (R) communication. The following applies to the instructions: the previously valid configuration data is overwritten but not stored permanently in the target system.

- The "Port_Config" instruction is used for the program-controlled configuration of the relevant port of the communications module.
- The "P3964_Config" instruction is used for the dynamic configuration of protocol parameters.

Properties of the USS protocol

- Simple, serial data transfer protocol with cyclic message frame traffic in half duplex mode that is tailored to the requirements of drive technology.
- Data transfer works according to the master-slave principle.
  - The master has access to the functions of the drive and can, among other things, control the drive, read status values and read and write the drive parameters.

Data exchange using USS communication

The communications module is the master. The master continuously sends frames (job frames) to the up to 16 drives and expects a response frame from each addressed drive.

A drive sends a response frame under the following conditions:

- When a frame is received without errors
- When the drive is addressed in this frame

A drive must not send if these conditions are not met or the drive was addressed in the broadcast.

The connection to the relevant drives exists for the master once it receives a response frame from the drive after a specified processing time (response delay time).

Procedure for setting up USS communication

1. Configure an S7-1500 configuration with CPU and CM in the device view of the hardware and network editor of STEP 7.
2. In the Project tree, select the "Program blocks" folder and open OB1 in the folder by double-clicking on it. The program editor opens.
3. Select the instructions for USS communication according to your task in the "Communication" area, "Communications processor" folder of the "Instructions" task card and drag them to a network of OB1:
   - The "USS_Port_Scan" instruction allows you to communicate via the USS network.
   - The "USS_Drive_Control" instruction prepares send data for the drive and evaluates the response data of the drive.
   - The "USS_Read_Param" instruction is used to read out parameters from the drive.
   - The "USS_Write_Param" instruction is used to change parameters on the drive.
4. Assign the parameters for the instructions according to your configuration.
5. Download the hardware configuration and user program to the CPU.

Properties of the Modbus protocol (RTU)

- Communication takes the form of serial, asynchronous transfer with a transmission speed of up to 115.2 kbps, half duplex.
- Data transfer works according to the master-slave principle.
- The Modbus master can send jobs for reading and writing operands to the Modbus slave:
  - Reading inputs, timers, counters, outputs, memory bits, data blocks
  - Writing outputs, memory bits, data blocks
- Broadcast to all slaves is possible.

Data exchange using Modbus communication (RTU)

The communications module can be a Modbus master or Modbus slave. A Modbus master can communicate with one or more Modbus slaves (the number depends on the physical interface). Only the Modbus slave explicitly addressed by the Modbus master is permitted to return data to the Modbus master. The slave detects the end of the data transfer and acknowledges it. If an error occurs, it provides an error code to the master.

Procedure for setting up Modbus communication (RTU)

1. Configure an S7-1500 configuration with CPU and CM in the device view of the hardware and network editor of STEP 7.
2. In the Project tree, select the "Program blocks" folder and open OB1 in the folder by double-clicking on it. The program editor opens.

3. Select the instructions for Modbus communication according to your task in the "Communication" area, "Communications processor" folder of the "Instructions" task card and drag them to a network of OB1:
   - The "Modbus_Comm_Load" instruction configures the port of the CM for Modbus communication.
   - The "Modbus_Master" instruction is used for Modbus master functionality.
   - The "Modbus_Slave" instruction is used for Modbus slave functionality.
4. Assign the parameters for the instructions according to your configuration.
5. Download the hardware configuration and user program to the CPU.

Additional information

- You can find more detailed information on communication via point-to-point connections and basics of serial data transmission in the function manual CM PtP communication module - Configurations for point-to-point connections (https://support.industry.siemens.com/cs/us/en/view/59057093).
- You can find a description of how to use the instructions for point-to-point connections in the user program in the STEP 7 online help.
- You can find information about the communications modules with a serial interface in the manual of the particular communications module.

OPC UA communication 11

11.1 What you need to know about OPC UA

11.1.1 OPC UA and Industry 4.0

Uniform standard for information and data exchange

Industry 4.0 stands for the intensive utilization, evaluation and analysis of the large volumes of data from production in IT systems at the enterprise level. With Industry 4.0, data exchange between the production and enterprise levels is rapidly increasing. However, a prerequisite for success is a uniform standard for the information and data exchange.

Classic OPC only runs on Windows operating systems. To get around this restriction, the OPC Foundation developed the OPC UA (OPC Unified Architecture) standard.

The OPC UA standard is particularly suitable for data exchange across different levels thanks to its independence from specific operating systems, its secure transfer procedures and the semantic description of data. Machine data (controlled variables, measured values or parameters) can also be transferred in this way.

An important component of this concept is that OPC UA communication can take place in parallel with real-time communication for time-critical, machine-level data transfer.

OPC UA is highly scalable so that a consistent information exchange between sensors, controllers and MES or ERP systems is possible.

OPC UA makes available not only data but also information about the data (data types), at the same time making possible machine-interpretable access to the data.

OPC UA topic page

For an overview of the most important articles and links on the subject of OPC UA, refer to the SIEMENS Industry Online Support.

OPC UA topic page (https://support.industry.siemens.com/cs/ww/en/view/109770435)

11.1.2 General features of OPC UA

OPC UA and PROFINET

OPC UA and PROFINET can be used together. The two protocols use the same network infrastructure.

Independence from the operating system

The OPC UA standard is platform-independent and uses an optimized TCP-based binary protocol for high-performance applications.

OPC UA can be used, for example, under Windows, Linux, Mac OS X, a real-time operating system or a mobile operating system (Android or iOS).

Independence of a specific transport layer

OPC UA currently supports the following transport mechanisms and protocols:

- The transfer of messages as a binary stream directly via TCP/IP
- The transfer of messages with XML via TCP/IP and HTTP. This transport mechanism allows only a slow transfer and is therefore almost never used. S7-1500 CPUs do not support this transport mechanism.

Binary data exchange is supported by all OPC UA applications (required in OPC UA specification).

Simple client-server principle

An OPC UA server provides a great deal of information within a network, e.g. relating to the CPU, the OPC UA server itself, the data and the data types. An OPC UA client accesses this information.

Implementation in different programming languages

The OPC Foundation has implemented the OPC UA standard in several programming languages: Stacks for .NET, ANSI C and Java are available, although maintenance has been discontinued for the stacks for ANSI C and Java.

The OPC Foundation offers the .NET stack as well as example programs as open source software. See Github (https://github.com/opcfoundation).

A number of companies offer Software Development Kits (SDK). These development packages contain the stacks of the OPC Foundation and other functions that facilitate the development of solutions.

Advantages of using SDKs:

- Support from the supplier
- Tested software
- Detailed documentation
- Clear license conditions (important for selling of solutions)

Scalability

OPC UA can be used for devices of different performance classes:

- Sensors
- Embedded systems
- Controllers
- PC systems
- Smartphones
- Servers running MES or ERP applications.

The performance class of the devices is differentiated by profiles. Different OPC UA profiles offer the possibility to scale OPC UA for very small and simple devices as well as for very high-performance devices.

An OPC UA profile describes functions and services that must be supported by the server and client. In addition, other functionalities/services that are not required by the profile can be optionally provided.

OPC UA profiles differ from PROFINET profiles; the latter define additional cross-vendor properties and behavior for installations and systems in the sense of a vendor-neutral software interface.

Nano Embedded Device 2017 Server Profile

For the smallest devices with severely limited functionality, there is the "Nano Embedded Device.2017 Server Profile" of the OPC Foundation. This profile is functionally equivalent to the core server facet and defines the OPC UA TCP binary protocol as the required transport profile. The profile allows for connections without UA Security and does not allow subscriptions or method calls. Support for diagnostic objects and variables is optional for this profile.

Additional profiles build on the "Nano Embedded Device 2017 Server Profile", requiring more resources and offering more functionality.

Micro Embedded Device 2017 Server Profile

This profile provides limited functionality; it requires at least two parallel connections. Additionally, it allows subscriptions/data monitoring, but no UA Security and no method calls.

- The S7-1200 Basic Controllers support the "Micro Embedded Device 2017 Server Profile", the S7-1200 also supports UA Security.

Embedded 2017 UA Server Profile

This profile has been developed for devices with more than 50 MB RAM and a more high-performance processor. It is based on the Micro Embedded Device Server profile. In addition, it requires UA security and method calls.

In addition, the servers must make their used type model (data types, reference types, variable types, etc.) available.

- S7-1500 Advanced Controllers support the "Embedded 2017 UA Server Profile".

Standard and global discovery profiles

The "OPC UA Specification Part 7" defines additional profiles:

- The "Standard 2017 UA Server Profile", which is suitable for PC-based OPC UA servers
- 2 global profiles, "Global Discovery Server 2017 Profile" and "Global Discovery and Certificate Management 2017 Server Profile", that cover the required service and information models of a Global Discovery Server

Type-instance concept

OPC UA offers a fully networked (full-meshed network), object-oriented information model for namespaces, including metadata for the object description. Any object structures can be generated via referencing of the instances among each other and their types. Because servers disclose their instance and type systems, clients can navigate through this network and obtain all the information they need. Both instances and their type definitions are available in runtime.

Procedures or concepts on how to handle references to types are optimized over time. These optimizations lead to new versions of the OPC UA Specification (e.g. V1.03 => V1.04).

PLC tag mapping

The information of the OPC UA server (for example the PLC tags) is modeled as nodes connected to one another via references. The semantics are displayed by the server in the address space and can be acquired by clients (while navigating). This makes it possible to browse from node to node with an OPC UA client and find out what content can be read, monitored or written.

Integrated security mechanisms

OPC UA uses security mechanisms at various levels:

- A secure connection can only be established between an OPC UA server and an OPC UA client if the client and server can register with X.509v3 certificates and accept each other's certificates (security at the application level). Various security policies are possible, including an unsecured connection between server and client (Security Policy: "No security").
- A server can always request the following information from the user for authorized access (authentication):

  - A user certificate (not configurable in STEP 7)

  - User name and password

  - No user authorization

The security mechanisms are optional and configurable.

More information

You can find more information on the website of the OPC Foundation (https://opcfoundation.org).

11.1.3 OPC UA for S7-1200/S7-1500 CPUs

In OPC UA, one system operates as a server and provides data the existing information to other systems (clients).

OPC UA clients, for example, have read and write access to data on an OPC UA server. OPC UA clients call methods on the OPC UA server.

You can access this data online with a client, including e.g. information on performance and diagnostics. In OPC UA terminology, this function is called "Browse". The "Subscription" function eliminates regular reading of a tag; with this function, the server informs a client about value changes.

If a system supports the OPC UA client and the OPC UA server, the system can be both a client and a server at the same time.

OPC UA server of the S7-1500 CPU

As of firmware version 2.0, an S7-1500 CPU is equipped with an OPC UA server.

The following sections describe how you configure the OPC UA server of the S7-1500 CPU to make data and methods available for OPC UA clients so that clients have read or write access to PLC tags on the CPU and can call server methods.

The following sections also set out how to integrate companion specifications into the address space of the OPC UA server.

OPC UA server of the S7-1200 CPU

As of firmware V4.4, an S7-1200 CPU is equipped with an OPC UA server.

The OPC UA server is generally configured as it is for an S7-1500 CPU; the scope of functions and the quantity limits are limited according to the supported "Micro Embedded Device 2017 Server Profile". Unlike for an S7-1500 CPU, the functions "Registered Read" and "Registered Write" are **not** available.

As of firmware V4.5, S7-1200 CPUs support server methods as well as structured data types (structures and arrays).

You can find additional information in the STEP 7 online help.

OPC UA client of the S7-1500 CPU

As of firmware version V2.6, an S7-1500 CPU is additionally equipped with an OPC UA client.

The following sections show how to use standardized instructions (PLCopen function blocks) to create a user program that, as an OPC UA client, provides the following functions:

- Reading data from an OPC UA server
- Writing data to an OPC UA server
- Calling methods of an OPC UA server

STEP 7 (TIA Portal) assists you in creating user programs by providing an editor for client interfaces and a parameter assignment for OPC UA connections.

The OPC UA instructions for an S7-1500 CPU as client are described in detail in the help to the instructions (Instructions > Communication > OPC UA).

OPC UA client for test purposes

The following description uses various different OPC UA clients to illustrate the use of OPC UA clients:

- "UaExpert" of Unified Automation. An extensive client that can be used free of charge:
  Link for downloading UaExpert (https://www.unified-automation.com/downloads/opc-ua-clients.html)
- "UA Sample Client" of the OPC Foundation. This client is available free of charge for users who are registered with the OPC Foundation :
  Link for downloading the example client of the OPC Foundation
  (https://opcfoundation.org)

Application example in Industry online support

Siemens Industry Online Support provides a free application example with a client API for various applications. You use the functions of this interface to create your own OPC UA clients that match your application. To simplify handling the API, we offer a higher-level .NET helper class.

The client API is based on the .NET OPC UA stack of the OPC Foundation.

The application example shows how to establish connections between servers and clients, for example. It also demonstrates the reading and writing of PLC tags.

Link to download: OPC UA .NET client for the SIMATIC S7-1500 OPC UA Server
(https://support.industry.siemens.com/cs/us/en/view/109737901)

11.1.4 Access to OPC UA applications

The access possibilities that an S7-1500 CPU with an OPC UA application (client or server) has via a CP in the same station are described below. In addition, an approach for combining these access possibilities with the "IP Forwarding" function to allow access to devices of another IP subnet via an S7-1500 station is presented.

All the settings for this can be found in the CPU properties, "Advanced configuration" area in the Inspector window.

The possibility of accessing the OPC UA application in the CPU via CP interface is subject to the following requirements:

- S7-1500 CPU (Advanced Controller) firmware version V2.8 or higher, S7-1500R/H CPUs firmware version V3.1 or higher
- CP 1543-1 firmware version V2.2 or higher

Recommendation: Use a CP 1543-1 with firmware V3.0 or higher. As of this version, the security functions (firewall) are also available for the virtual interface (W1) and no additional firewall needs to be installed between the station and an insecure network.

Principle: Interface for access via communications module

For a CPU application, such as OPC UA, to be accessed via CP interface, you must configure a virtual interface (W1). IP-based applications can then be accessed via the IP address parameters of this virtual interface.

The schematic is shown in the following figure.

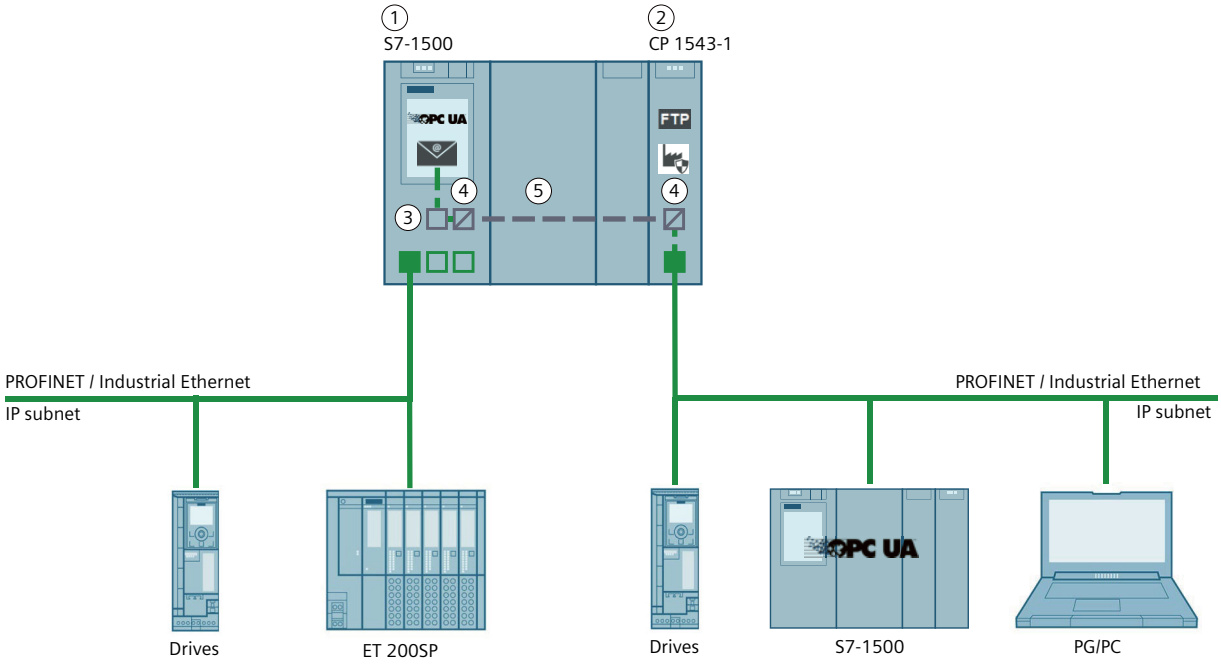

① CPU S7-1500 FW V2.8 or higher (e.g. CPU 1515-2 PN)

② CP 1543-1 (FW V2.2 or higher)

③ Virtual interface (W1)

④ Protocol conversion PROFINET / Industrial Ethernet on backplane bus or backplane bus on PROFINET / Industrial Ethernet

⑤ Backplane bus

Figure 3-427 Principle: Interface for access via communications module

Example: Access of OPC UA clients to the OPC UA server of the CPU

For access of an OPC UA client to the OPC UA server of the CPU, the following interfaces of the S7-1500 station are available:

- The local PROFINET interfaces of the S7-1500 CPU
- The Ethernet interface of a CP 1543-1 (firmware version V2.2 and higher)

The following figure shows an example of a possible configuration: The CPU could also have the role OPC UA client and the device on the subnet of the CP could have the role OPC UA server.

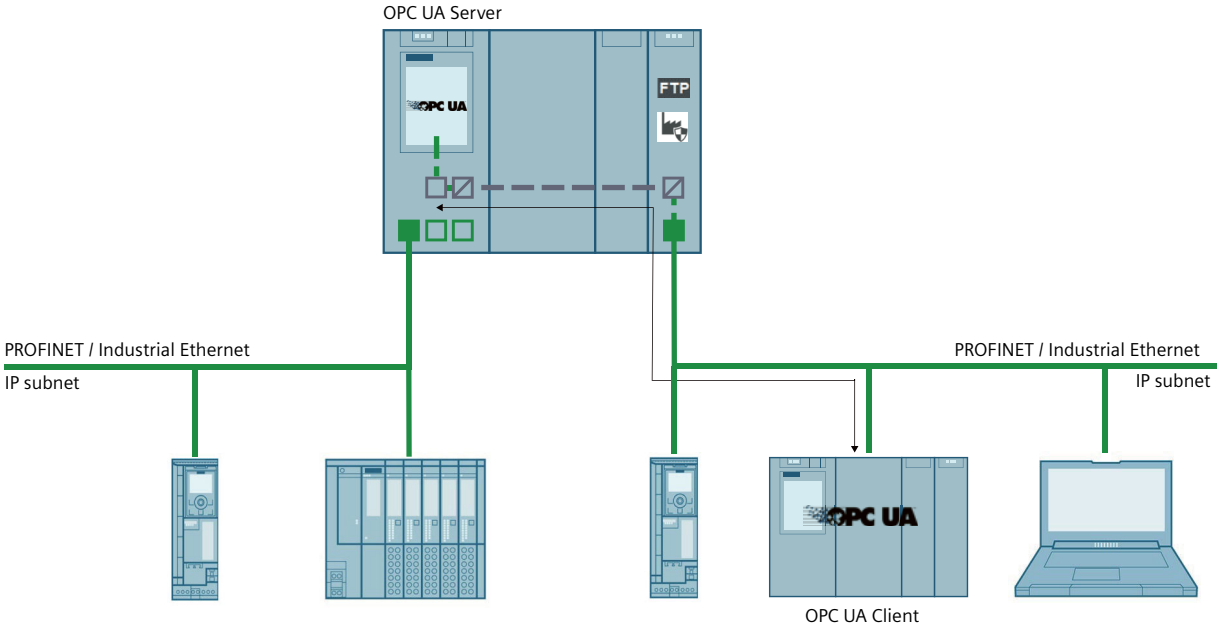

Figure 3-428 Example: Access of OPC UA clients to the OPC UA server of the CPU

Example: Access of OPC UA clients to OPC UA servers via S7-1500 CPU with activated IP Forwarding

OPC UA client and OPC UA server can also be connected to one another via an S7-1500 CPU, in which case the S7-1500 CPU operates as an IP Forwarder. This configuration option allows for flexible expansion of existing systems.

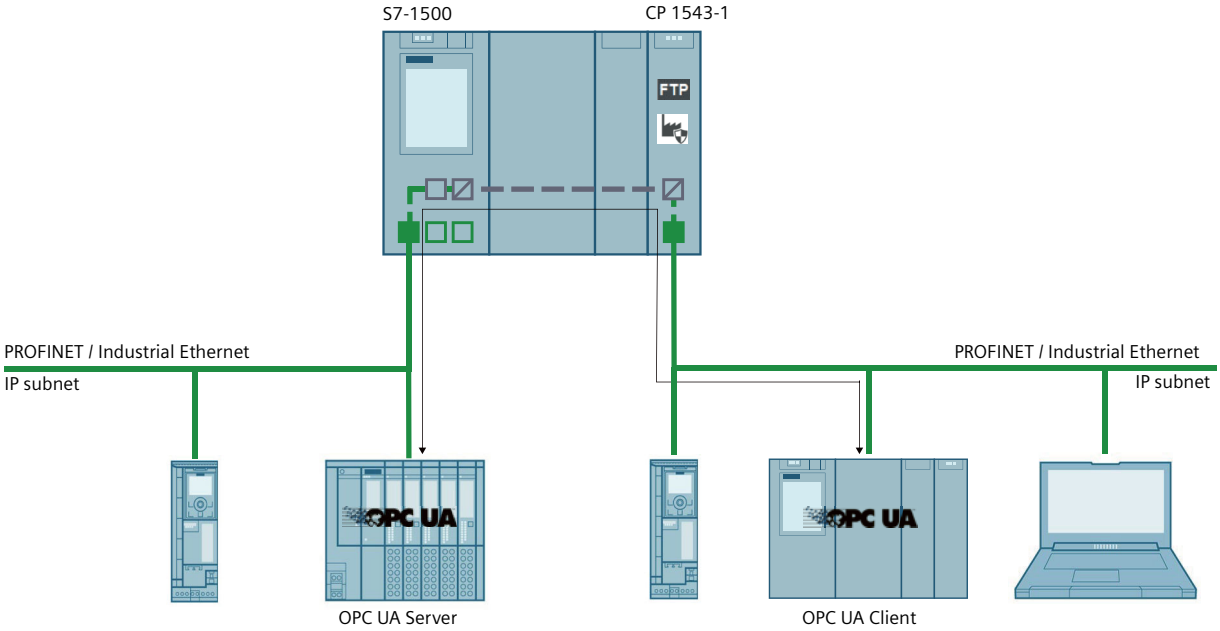

Figure 3-429 Example: Access of OPC UA clients to OPC UA servers via S7-1500 CPU with activated IP Forwarding

More information

More information on access options via the virtual interface and via IP forwarding can be found in the following sections:

- IP forwarding (Page 422)
- Virtual interface for IP-based applications (Page 437)

11.1.5 Addressing nodes

Nodes are the basic elements of OPC UA, they are comparable with objects from object-oriented programming. Nodes are used, for example, for user data (tags) or other metadata. Nodes are used to model an OPC UA address space that also contains a type model with type definitions.

Node ID (NodeId)

Nodes in the OPC UA address space are uniquely identified by a NodeId (Node Identifier).

The NodeId consists of an identifier, identifier type and a namespace index. Namespaces are used to avoid naming conflicts.

The OPC Foundation has defined a wide range of nodes that provide information about the given OPC UA server. These nodes can be found in the namespace of the OPC Foundation and have the index 0.

The OPC Foundation also defines data types and tag types.

Namespace (Namespace)

In addition to the above-described namespace of the OPC Foundation, the namespace for accessing CPU data is of interest: All the tags or methods of an S7-1500 OPC UA server are contained in the namespace (Namespace) of the standard server interface "http://www.siemens.com/simatic-s7-opcua".

By default this namespace has the Index 3. The index may change later if additional namespaces are inserted into the server or if existing ones are deleted. It is therefore necessary for an OPC UA client to request the current index of the namespace (e.g. "http://www.siemens.com/simatic-s7-opcua") from the server before reading or writing its values.

The following figure shows an example of the result of such a request.

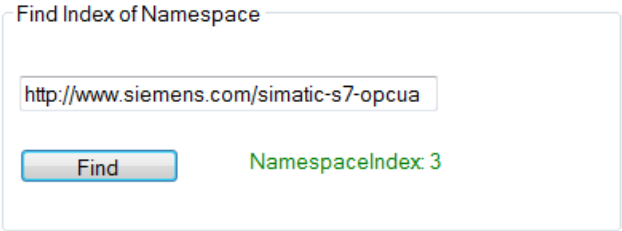

Identifier

The Identifier corresponds to the name of the PLC tag in quotation marks. The quotation mark is the only sign that is not permitted as part of a name in STEP 7. Quotation marks avoid naming conflicts.

The following example reads the value of the "StartTimer" tag:

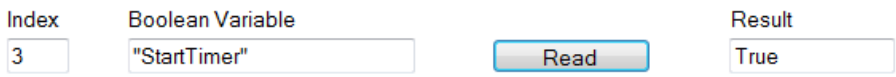

The Identifier can consist of several components. The individual components are then separated by a dot.

The following example reads the "MyDB" array data block completely. This data block contains an array with ten integer values. All ten values should be read in one pass. Therefore, "0:9" is entered at the array range.

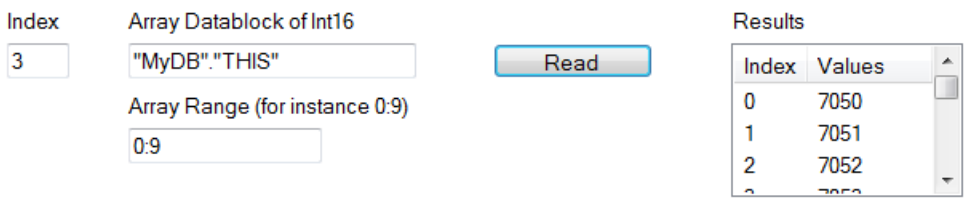

Example of NodeIds, identifiers and namespaces

The following figure illustrates the relation between NodeIds, identifiers and namespaces: It is no problem if two nodes have the same identifiers but belong to different namespaces.

STEP 7 (TIA Portal) allows you to easily import namespaces via a server interface.

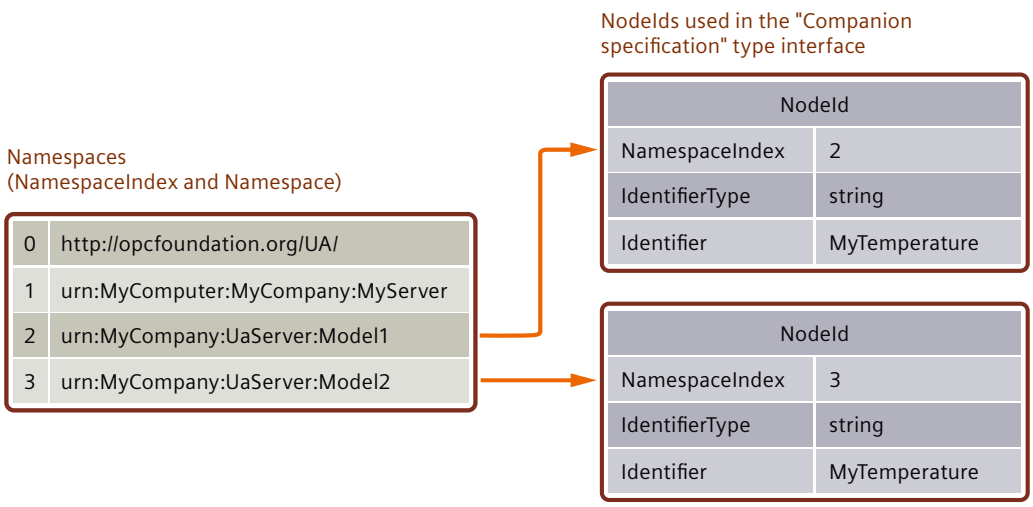

PLC tags in the address space of the OPC UA server

The figure below shows where the PLC tags in the example are located in the address space of the OPC UA server (excerpt from UA client):

The "MyDB" data block is a global data block. The data block is therefore located below the node "DataBlocksGlobal". "StartTimer" is a memory tag and is therefore stored below the "Memory" node.

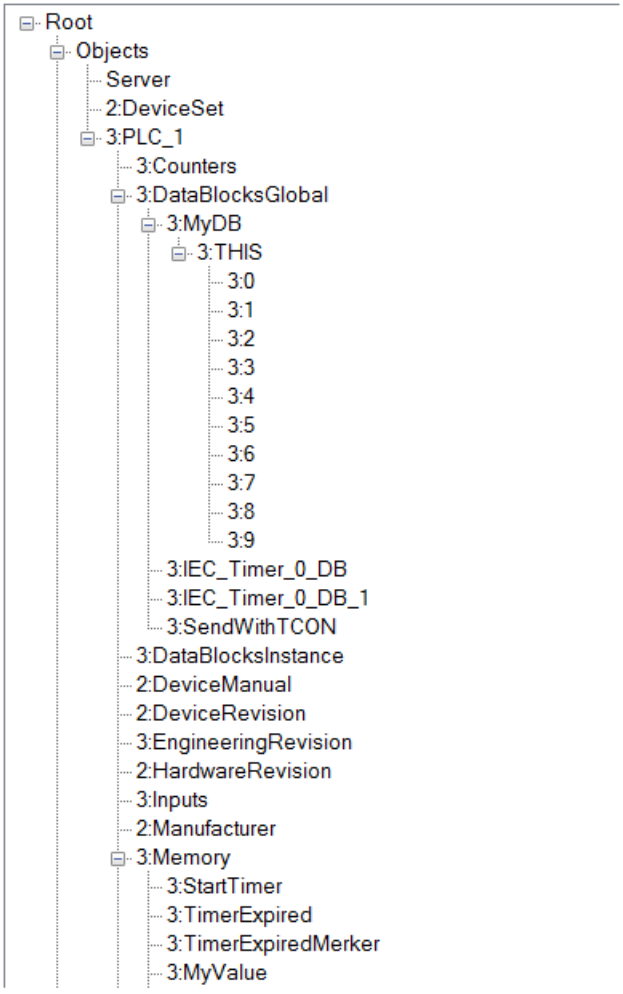

Figure 3-430 PLC tags in the address space of the OPC UA server

Methods in the address space of the OPC UA server

If you implement a method via your user program, it takes the following form in the address space of the OPC UA Server

(see Providing methods on the OPC UA server (Page 321)):

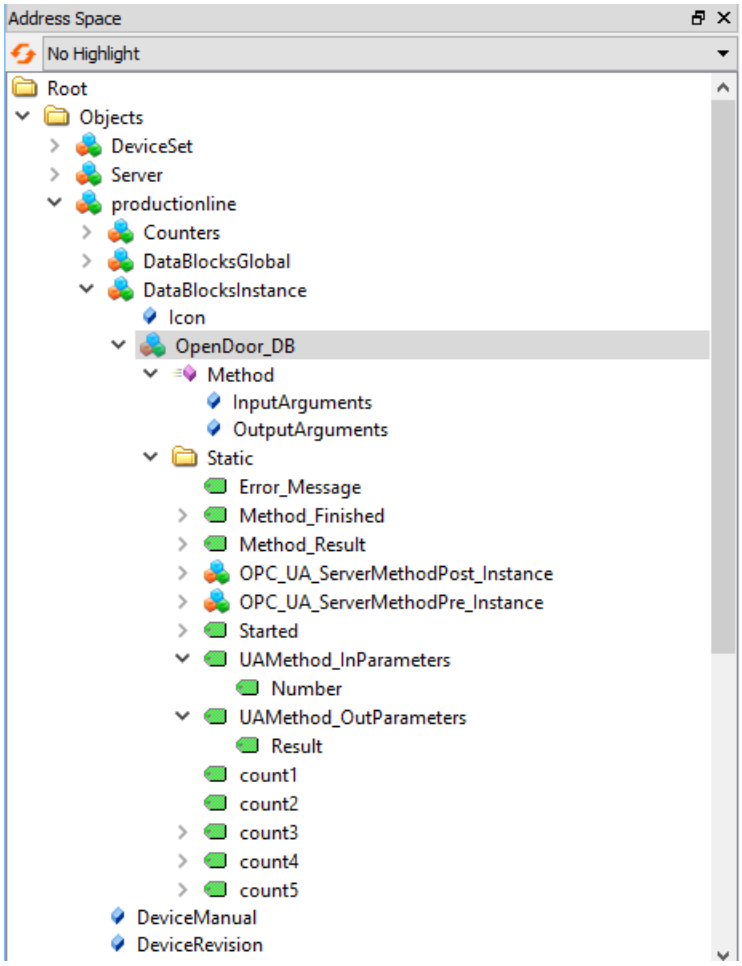

Figure 3-431 Methods in the address space of the OPC UA server

11.1.6 Namespace overview for the OPC UA server of the S7-1200/1500 CPUs

As already written for the topic "Addressing of nodes", the namespace index is part of the node ID. To ensure that a node ID is always unique in the address space, namespaces are used in OPC UA; the BrowseName as the sole means of identifying a node can be ambiguous.

Namespaces are specified at OPC UA through different "Naming Authorities" which develop the OPC UA information models, for example by a working group, the OPC Foundation or organizations that develop standard information models.

Namespaces are identified through a namespace URI; the namespace URI identifies the Naming Authority.

A namespace index is used to optimize accesses to the nodes of the server instead of the namespace URI. The namespace index is a pointer to a namespace array that the server

manages. A client reads the namespace index once from the server to be able to access the nodes of the server afterwards with a simple integer instead of a URI string.

The following table contains the assignment between namespace URIs and namespace indexes of S7-1500 and S7-1200 CPUs.

Assignment between namespace URI and namespace index

The namespace indexes are fixed at S7-1200 and S7-1500 CPUs for the namespace indexes 0 to 3. Further namespace indexes are currently not specified.

Namespace URI	Namespace index	Description
http://opcfoundation.org/UA/	0	Namespace for the node IDs and BrowseNames of the OPC UA specification (OPC 10000-3). **Example** 0:EngineeringUnits
Local Server URI ("urn:SIMATIC:" + application name as configured in TIA Portal (area "OPC UA > General" in the CPU properties))	1	Namespace for nodes that are defined in the local server (OPC 10000-5). **Example** urn:SIMATIC:PLC_1
http://opcfoundation.org/UA/DI/	2	Namespace for node IDs and BrowseNames of the OPC UA specification for devices (OPC 10000-100). **Example** 2:DeviceRevision
http://www.siemens.com/simatic-s7-opcua	3	Namespace for node IDs and BrowseNames that are defined product-specifically for an S7-1200/S7-1500 CPU. In this namespace instances (CPU, tags, DBs, etc.) as well as their types (UDTs, LDTs, FBs, etc.) are defined. **Example** 3:DataBlocksGlobal
URIs of additional namespaces for further instances and types **Examples** http://machinesupplier.org/implementedPackML http://opcfoundation.org/UA/PackML	> 3	Not specified. Can, for example, be defined with SiOME. **Examples** 4:MyPackMLMachineInstance 5:PackMLBaseObjectType

11.1.7 What you need to know about OPC UA clients

Basics of OPC UA clients

OPC UA clients are programs that do the following:

- Access the information from an OPC UA server (for example an S7-1500 CPU): read/browse access, write access, subscriptions
- Execute methods through the OPC UA server

However, OPC UA clients can only access data that is enabled for this purpose (see "Managing write and read rights (Page 247)").

You need the endpoint of the server to establish a connection to an OPC UA server (see "Endpoints of the OPC UA servers (Page 235)").

Reading out information from the OPC UA server

When a connection to an end point of the server exists, you can use the navigation function of the client: You navigate starting from a defined starting point (from the "root" node) through the address space of the server.

The following information is provided in the process:

- Enabled PLC tags, data blocks and data block components
- Namespace index and identifiers of these PLC tags, data blocks and DB components
- Data types of the PLC tags and DB components
- Number of components in arrays (required for reading and writing arrays)

In addition, you receive information about the OPC UA server itself as well as information about the S7-1500 based on the "OPC UA for Devices" standard of the OPC Foundation (for example, serial number, firmware version).

Reading data from the server and writing to the server

You now know the namespace, identifier and data type of PLC tags. This means that you can now specifically read individual PLC tags and DB components as well as complete arrays and structures.

You can find examples of the reading of Boolean tags and array data blocks in Addressing nodes (Page 182).

Rules for access to structures are available here (Page 382).

With the information that you obtain while navigating through the address space of the server (index, identifier and data type), you can also transfer values to the S7-1500 with the OPC UA client. The following example overwrites the first three values in the array data block "MyDB".

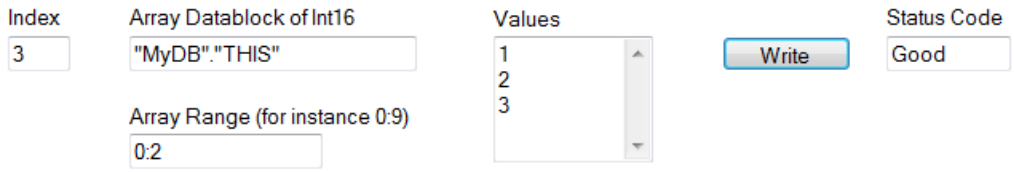

For "Array Range" you specify which components of the array you want to overwrite. The "Good" status code indicates that the values were transferred successfully. However, you can only write the values to the S7-1500 but not the time stamps of these values. The time stamps can only be read.

Faster access through registration

Registered Read/Write lends itself to repeated, optimized access to data – with maximum performance. When tag nodes are registered, the OPC UA server creates a numerical Identifier (numerical NodeId) that directly references the registered node. For read or write jobs of the client to this numerical Identifier, the server does not have to resolve any strings as Identifier and can access the requested tag in an optimized manner.

This Identifier applies solely to the current session and has to be queried again when the session connection is terminated/lost.

In the following example, the "StartTimer" tag is first registered on the server. Afterwards, the rapid function "RegisteredWrite" is used for setting the value.

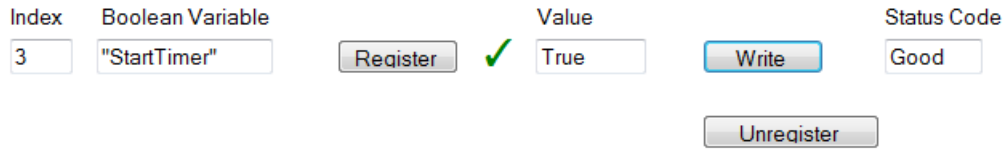

In accordance with the same scheme, the "RegisteredRead" function can also be used, which is particularly useful for recurring data readouts. Take into account, however, that depending on the application it may be advisable to use a Subscription instead.

Recommendation: It is best to place registrations in the startup program of the OPC UA client, since the registration takes up time.

Please note that you can set the maximum number of registered nodes in the properties of the S7-1500 CPU and that the Clients have to respect this number, see General settings of the OPC UA server (Page 262).

Subscription

The term "Subscription" is used for a function in which only those tags for which an OPC UA client has registered at the OPC UA server are transferred. The OPC UA server only sends a message to the OPC UA client for these registered tags (monitored Items) when a value has changed. The monitoring of these tags makes constant sampling (Polling) by the OPC UA client superfluous; the network load is thus reduced.

You have to create a Subscription to use this function. For this purpose, you specify the "Publishing Interval" at the UA client and click the "Create" button. The publishing interval is the time interval in which the server sends new values to the client in a notification (data change notification).

In the following example a subscription has been created: The client receives a message with the new values (publishing interval 50 ms) every 50 milliseconds here.

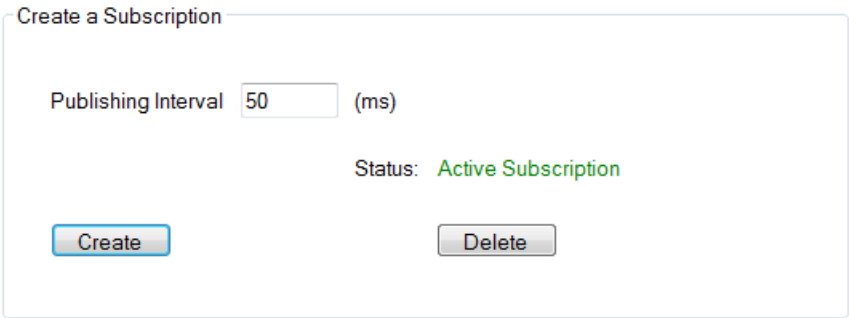

Preventing server overload

You can set the OPC UA server of the S7-1500 CPU by means of the "Minimum publishing interval" so that it does not serve extremely short send intervals requested by the client, see Settings of the server for subscriptions (Page 264).

Example: A client wants to be operated at a publishing interval of 50 ms as detailed above. Such a short publishing interval would, however, result in a high network and server load. You should therefore set 1000 ms as the "Minimum publishing interval" for the server. Clients whose subscription requires shorter publishing intervals are "slowed" to 1000 ms and the server is protected from overload.

Sampling and transmission (Sampling & Publishing) within the scope of a subscription are communication processes which, like other communication processes (TCP/UDP/Web server communication...), are processed by the CPU with priority 15. OBs with higher priority interrupt the communication. If you set the sampling and transmission intervals too short, this setting causes a high communication load. Therefore, select intervals as large as possible, which are still sufficient for the application.

For information about the consistency of tags, refer to Consistency of CPU tags (Page 252).

Monitoring of PLC tags

When the Subscription has been created, you inform the server which tags are to be monitored with it. In the following example, the "Voltage" tag was added to the subscription.

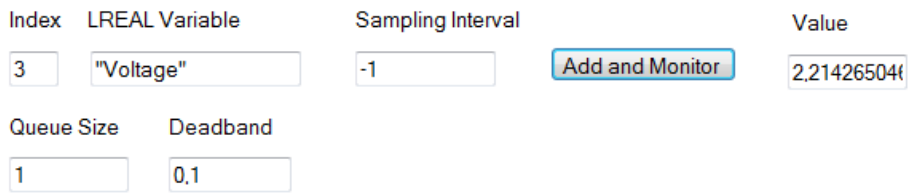

The "Voltage" tag contains the value of a voltage that is detected by an S7-1500 CPU.

The sampling interval ("Sampling Interval") contains a negative value (-1). This determines that the default setting of the OPC UA server is used for the sampling interval. The default setting is defined by the transmission interval ("Publishing Interval") of the subscription. If you want to set the smallest possible sampling interval, select the value "0".

In this example, the length of the queue is set to "1": Only one value is read from the CPU at an interval of 50 milliseconds and subsequently sent to the OPC UA client when the value has changed.

The "Deadband" parameter in this example is "0.1": Changes in value have to amount to 0.1 Volt; only then does the sender send the new value to the client. The server does not send smaller changes in value. You can use this parameter, for example, to disable signal noise: Slight changes in a process variable which do not have a real meaning.

11.2 Security at OPC UA

11.2.1 Security settings

Addressing risks

OPC UA allows the exchange of data between different systems, both within the process and production levels and to systems at the control and enterprise level.

This possibility also entails security risks. That is why OPC UA provides a range of security mechanisms:

- Verification of the identity of OPC UA server and clients.
- Checking of the identity of the users.
- Signed/encrypted data exchange between OPC UA server and clients.

These security policies should only be bypassed in cases where it is absolutely necessary:

- During commissioning
- In stand-alone projects without external Ethernet connection

If you have selected the endpoint "None" for "UA Sample Client" of the OPC Foundation, for example, the program issues a clear warning:

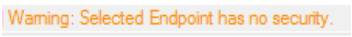

When STEP 7 compiles your project it also checks whether you have considered the setting options for the protection and warns you of possible risks. This also includes an OPC UA security policy with the setting "no security", which corresponds to the end point "None".

NOTE

Disabling security policies you do not want

If you have enabled all security policies in the secure channel settings of the S7-1500 OPC UA server – thus, also the end point "None" (no security) – unsecured data traffic (neither signed nor encrypted) between the server and client is also possible. The OPC UA server of the S7-1500 CPU also sends its public certificate to the client at "None" (No security). And some clients check this certificate. However, the client is not forced to send a certificate to the server. The identity of the client may possibly remain unknown. Each OPC UA client can then connect to the server irrespective of any subsequent security settings.

When configuring the OPC UA server, make sure that only security policies that are compatible with the security concept of your machine or plant are selected. All other security policies should be disabled.

Recommendation: Use the setting "Basic256Sha256 - Sign and Encrypt", which means that the server only accepts Sha256 certificates. The security policies "Basic128Rsa15" and "Basic256" are deactivated by default and should not be used as an end point. Select end points with a higher security policy.

Additional security rules

- Only use the end point "None" in exceptional cases.
- Only use the "guest authentication" of the user in exceptional cases.
- Only allow access to PLC tags and DB components via OPC UA if it is genuinely necessary.
- Use the list of trusted clients in the settings of the S7-1500 OPC UA server to allow access to certain clients only.

11.2.2 Certificates pursuant to ITU X.509

Security mechanisms are integrated in several layers in OPC UA. Digital certificates have an important role here. An OPC UA client can only establish a secure connection to an OPC UA server when the server accepts the digital certificate of the client and classifies it as trusted.

See section Handling client and server certificates (Page 267).

The client must also check and trust the certificate of the server. The server and client must show their identities and prove that they are what they claim to be: They must prove their identity. Mutual authentication of client and server, for example, prevents man-in-the-middle attacks.

Man-in-the-middle attacks

A "man-in-the-middle" could have positioned itself between server and client. A man-in-the-middle is a program that intercepts communication between server and client and claims to be a client or server, and is thus able to obtain information about the S7 program or to set values in the CPU and attack a machine or plant.

OPC UA uses digital certificates that meet standard X.509 of the International Telecommunication Union (ITU).

This allows the identity of a program, a computer or an organization to be proven (authenticated).

X.509 certificates

An X.509 certificate includes the following information:

- Version number of the certificate
- Serial number of the certificate
- Information on the algorithm used by the certificate authority to sign the certificate.
- Name of the certificate authority
- Start and end of the validity period of the certificate
- Name of the program, person or organization for which/whom the certificate has been signed by the certificate authority.
- The public key of the program, person or organization.

An X509 certificate thus links an identity (name of a program, person or an organization) to the public key of the program, person or organization.

Check during connection establishment

When a connection is being established between the client and server, the devices check all information from the certificate that is required to determine its integrity, such as signature, period of validity, application name (URN) and, in case of firmware version V2.5 only, also the IP address of the client in the client certificate.

NOTE

The validity period stored in the certificate is also checked. The CPU clock must therefore be set and date/time must be within the validity period, otherwise no communication takes place.

Signing and encryption

To allow you to check whether a certificate has been manipulated, certificates are signed.

There are various possible procedures here:

- Within the TIA Portal you have the possibility to generate and sign certificates. If you have protected your project and are logged in as a user with the function right to make security settings, you can use the global security settings. The global security settings allow access to the certificate manager and therefore to the certificate authority (CA) of the TIA Portal.
- Additional options are available for creating and signing certificates. In the TIA Portal, you can import certificates into the global certificate manager.
  - You contact a certificate authority (CA) and have your certificate signed.

    In this case, the certificate authority checks your identity and signs your certificate with the private key of the certificate authority. For this purpose you send a CSR (Certificate Signing Request) to the certificate authority.
  - You yourself create a certificate and sign it.

    To this purpose you use, for example, the "Opc.Ua.CertificateGenerator" program of the OPC Foundation. Alternatively, you use OpenSSL.
    You can find more information in Generating PKI key pairs and certificates yourself (Page 196).

Useful information: Certificate types

- Self-signed certificate:

  Each device generates and signs its own certificate. Application examples: Static configuration with limited number of communication nodes.

  No new certificates can be derived from a self-signed certificate. However, you need to load all self-signed certificates from partner devices to the CPU (STOP required).
- CA certificate:

  All certificates are generated and signed by a certificate authority. Application examples: Dynamically growing plants.

  You only need to download the certificate from the certificate authority to the CPU. The certificate authority can generate new certificates (partner devices can be added without CPU STOP).

Signing

The signature makes it possible to prove the integrity and source of a message as detailed below.

Signing starts with the sender creating a hash value from the plain text (plain text message). The sender then encrypts the hash value with its private key and subsequently transfers the plain text together with the encrypted hash value to the recipient. To verify the signature, the recipient needs the public key of the sender (this is contained in the X509 certificate of the sender). The recipient uses the sender's public key to decrypt the hash value received. The recipient then forms the hash value themselves from the plain text received (the hash process is contained in the sender's certificate). The recipient compares the two hash values:

- If the two hash values are identical, the plain text message has reached the receiver unchanged and has not been manipulated.
- If the two hash values do not match, the plain text message has not reached the receiver unchanged. The plain text message has been manipulated or has been distorted during transfer.

Encryption

Encrypting data prevents unauthorized parties from reading the content. X509 certificates are not encrypted; they are public and can be viewed by anyone.

Encryption involves the sender encrypting the plain text message with the public key of the recipient. To do so, the sender requires the recipient's X509 certificate, as it contains the public key of the recipient. The recipient decrypts the message with their private key. Only the recipient can decrypt the message: They alone hold the private key. The private key must therefore never be disclosed.

Secure channel

OPC UA uses the private and public key of client and server to establish a secure connection, the secure channel. Once the secure connection has been established, the client and server generate an internal key only known to them which they both use for signing and encrypting messages. This symmetric process (a shared key) is much faster than asymmetric processes (private and public key).

More information

An application example for the use of certificates with the TIA Portal can be found here: Using certificates with TIA Portal (https://support.industry.siemens.com/cs/ww/en/view/109769068).

11.2.3 Certificates with OPC UA

Usage of X509 certificates with OPC UA

OPC UA uses various types of X.509 certificates for establishing a connection from client to server:

- OPC UA application certificates

  Such X.509 certificates identify the software instance, the installation of client or server software. For the "Organization name" attribute, you enter the name of the company that uses the software.

  NOTE

  The OPC UA server of the S7-1500 uses application certificates even for the security setting "None" (no security). This ensures compatibility to OPC UA V1.1 and earlier versions.

- OPC UA software certificates

  This X-509 certificate identifies a specific version of the client or server software. These certificates contain attributes that describe which tests this version of the software has passed during certification by the OPC Foundation (or recognized test laboratories). For the "Organization name" attribute, you enter the name of the company that has developed or markets the software.

  NOTE

  Software certificates are not supported in STEP 7.

- OPC UA user certificates

  This X.509 certificate identifies the specific user who, for example, retrieves process data from the OPC UA server. This certificate is not required if the user can authenticate itself with a password, or if anonymous access is configured.

  NOTE

  User certificates are not supported in STEP 7.

The described certificates are end-entity certificates: They identify, for example, a person, an organization, a company or an instance (installation) of a software.

11.2.4 Creating self-signed certificates

Using the client's certificate generator

Many OPC UA client applications or SDKs are integrated in a sample application that allows you to generate certificates for the client from this application.

The description for certificate generation can generally be found in the context for describing the OPC UA client application.

Example client from the online support

The OPC UA .NET client for the SIMATIC S7-1500 OPC UA server (https://support.industry.siemens.com/cs/ww/en/view/109737901) creates a self-signed software certificate of the client application in the Windows Certificate Store during the first program start. The documentation for this example describes the procedure for handling these certificates.

Using the certificate generator of the TIA Portal

If you use an OPC UA client that does not generate a client certificate, you can create self-signed certificates with STEP 7.

To do this, follow these steps:

1. In the properties of the CPU, double-click "<Add new>" under "Protection & Security > Certificate manager > Device certificates".
2. Click "Add".
3. In the "Create a new certificate" dialog, select the "OPC UA client" option for "Usage".
4. Click "OK".

In the field "Subject Alternative Name" STEP 7 automatically enters the URI for the generated certificate. In the program-specific certificate generation by means of the .NET stack of the OPC Foundation, the field is called, for example, "ApplicationUri" - it can have a different name in other tools for certificate generation.

More information

For more information on handling client certificates, refer to the section Handling of the client certificates of the S7-1500 CPU (Page 387).

11.2.5 Generating PKI key pairs and certificates yourself

This section is only relevant if you want to use an OPC UA client that cannot itself create a PKI key pair and a client certificate. In this case, you generate a private and a public key using OpenSSL, generate an X.509 certificate, and sign the certificate yourself.

Using OpenSSL

OpenSSL is a tool for Transport Layer Security that you can use to create certificates. You can also use other tools, for example XCA, a type of key management software with a graphical user interface for an improved overview of certificates issued.

To work with OpenSSL under Windows, follow these steps:

1. Install OpenSSL under Windows. If you are using a 64-bit version of the operating system, install OpenSSL in the "C:\OpenSSL-Win64" directory, for example. You can obtain OpenSSL-Win64 as a download from various providers for open source software.
2. Create a directory, for example "C:\demo".

3. Open the command prompt. To do so, click "Start" and enter "cmd" or "command prompt" in the search field. Right-click "cmd.exe" in the results list and run the program as an administrator. Windows opens the command prompt.
4. Change to the "C:\demo" directory. To do this, enter the following command: "cd C:\demo".
5. Set the following network variables:
   - set RANDFILE=c:\demo\.rnd
   - set OPENSSL_CONF=C:\OpenSSL-Win64\bin\openssl.cfg

   The figure below shows the command line with the following commands:

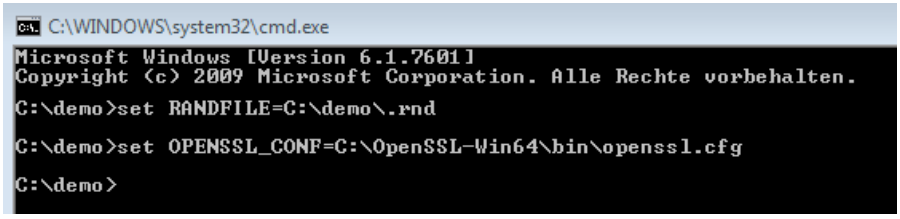

6. Now start OpenSSL. If OpenSSL has been installed in the C:\OpenSSL-Win64 directory, enter the following: C:\OpenSSL-Win64\bin\openssl.exe The figure below shows the command line with the following command:

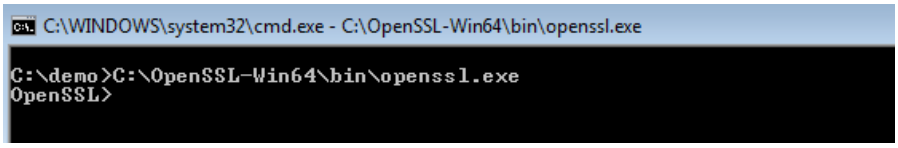

7. Generate a private key. Save the key to the "myKey.key" file. The key in this example is 1024 bits long; for greater RSA security, use 3072 bits in practice. Enter the following command: "genrsa -out myKey.key 3072" ("genrsa -out myKey.key 1024" in the example). The figure below shows the command line with the command and the output of OpenSSL:

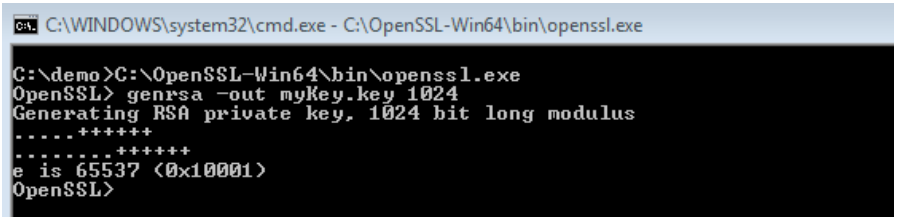

8. Generate a CSR (Certificate Signing Request). To do this, enter the following command: "req -new -key myKey.key -out myRequest.csr". During execution of this command, OpenSSL queries information about your certificate:
   - Country name: for example "DE" for Germany, "FR" for France
   - State or province name: for example "Bavaria".
   - Location Name: for example "Augsburg".
   - Organization Name: Enter the name of your company.
   - Organizational Unit Name: for example "IT"
   - Common Name: for example "OPC UA client of machine A"
   - Email Address:

NOTE

Note for S7-1500 CPU as server with firmware version V2.5

The IP address of the client program has to be stored in the "Subject Alternative Name" field of the created certificate for S7-1500 CPUs version V2.5 (only for this version); otherwise, the CPU will not accept the certificate.

The information you enter is added to the certificate. The figure below shows the command line with the command and the output of OpenSSL:

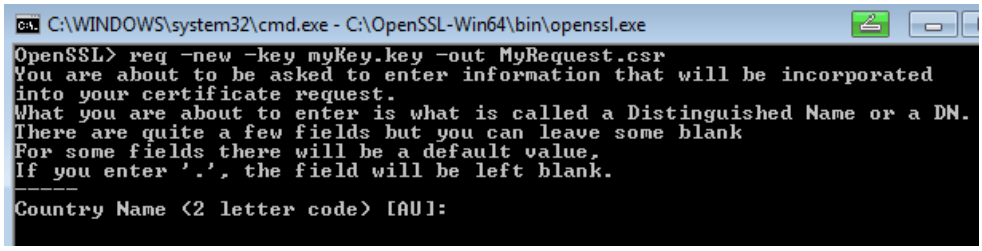

The command creates a file in the C:\demo directory containing the Certificate Signing Request (CSR); in the example, this is "myRequest.csr".

Using the CSR

There are two ways to use a CSR:

- You send the CSR to a certificate authority (CA): Read the information of the respective certification authority. The certificate authority (CA) checks your information and identity (authentication) and signs the certificate with the private key of the certificate authority. You receive the signed X.509 certificate and use this certificate for OPC UA, HTTPS or Secure OUC (secure open user communication), for example. Your communication partners use the public key of the certificate authority to check whether your certificate was really issued and signed by that CA (i.e. that the certificate authority has confirmed your information).
- You sign the CSR yourself: Using your private key. This option is shown in the next step.

Signing the certificate yourself

Enter the following command so that you can generate and sign your certificate (self-signed certificate) yourself: "x509 -req -days 365 -in myRequest.csr -signkey myKey.key -out myCertificate.crt".

The figure below shows the command line with the command and OpenSSL:

The command generates an X.509 certificate with the attributes that you transfer with the CSR (in the example "myRequest.csr"), for example with a validity of one year (-days 365).

The command also signs the certificate with your private key ("myKey.key" in the example). Your communication partners can use your public key (contained in your certificate) to check that you are in possession of the private key that belongs to this public key. This also prevents your public key from being misused by an attacker.

With self-signed certificates, you yourself confirm that the information in your certificate is correct. There is no independent body that checks your information.

More information

You will find information about the handling of client certificates of the S7-1500 CPU in the section Handling of the client certificates of the S7-1500 CPU (Page 387).

11.2.6 Secure transfer of messages

Establishing secure connections with OPC UA

OPC UA uses secure connections between client and server. OPC UA checks the identity of the communication partners. For the authentication of client and server, OPC UA uses certificates in accordance with X.509 V3 the ITU (International Telecommunication Union). Exception: A secure connection is not established with the "No security" security policy.

Message security mode

OPC UA uses the following security policies to protect messages:

- No security

  All messages are unsecured. In order to use this security policy, establish a connection to a None end point of a server.

- Signing

  All message are signed. This allows the integrity of the messages received to be checked. Manipulations are detected. In order to use this security policy, establish a connection to a Sign end point of a server.

- Sign & Encrypt

  All messages are signed and encrypted. This allows the integrity of the messages received to be checked. Manipulations are detected. What is more, no attacker can read the content of the message (protection of confidentiality). In order to use this security policy, establish a connection to a "Sign & Encrypt" end point of a server.

The security policies are also named according to the algorithms used. Example: "Basic256Sha256 - Sign & Encrypt" means: Secure endpoint, supports a series of algorithms for 256-bit hashing and 256-bit encryption.

Layers required

The figure below shows the three layers that are always required for establishing a connection: the transport layer, the secure channel and the session.

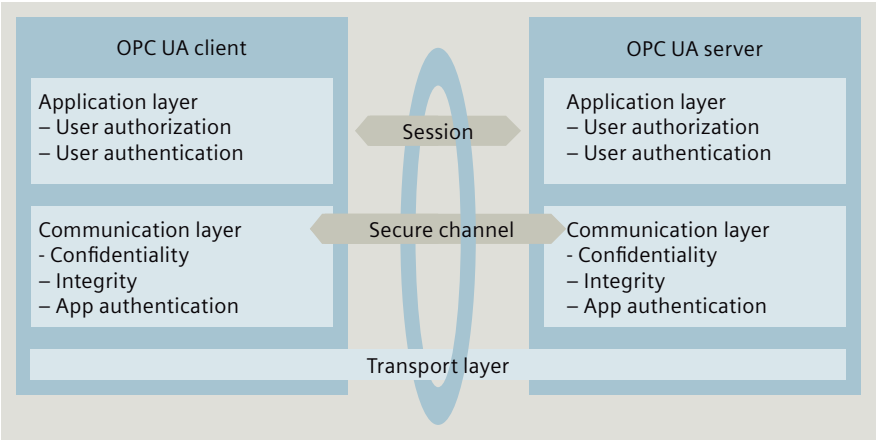

Figure 3-432 Necessary layers: transport layer, secure channel and session

- Transport layer:

  This layer sends and receives messages. OPC UA uses an optimized TCP-based binary protocol here. The transport layer is the basis for the subsequent secure channel.

- Secure channel

  The secure channel receives the data received from the transport layer, and forwards that data to the session. The secure channel forwards data of the session that is to be sent to the transport layer.

  In "Sign" security mode, the secure channel signs the data (messages) that is sent. When a message is received, the secure channel checks the signature to detect any manipulations.

  With a "Sign & Encrypt" security policy, the secure channel signs and encrypts the send data. Data received is decrypted by the secure channel, and the secure channel then checks the signature.

  With the "No security" security policy, the message packages pass the secure channel unchanged (the messages are received and sent in plain text).

- Session

  The session forwards the messages from the secure channel to the application, or receives from the application the messages that are to be sent. The application uses the process values or provides the values.

Establishing the secure channel

The secure channel is established as follows:

1. The server starts establishing the secure channel when it receives a request to this effect from the client. This request is signed or signed and encrypted, or the message is sent in plain text (security mode of the selected server end point). With "Sign" and "Sign & Encrypt", the client sends a "secret" (random number) with the request.
2. The server validates the client certificate (contained in the request, unencrypted) and checks the identity of the client. If the server trusts the client certificate,
   - it decrypts the message and checks the signature ("Sign & Encrypt"),
   - checks the signature only ("Sign"),
   - or leaves the message unchanged ("No security")
3. The server then sends a response to the client (same level of security as the request). The server secret is contained in the response. The client and server calculate a symmetric key from the client and server secret. The secure channel is now established.

The symmetric key (instead of the private and public key of client and server) is now used for signing and encrypting messages.

Establishment of the session

The session is executed as follows:

1. The client starts establishing the session by sending a CreateSessionRequest to the server. This message contains a Nonce, a random number that is only used once. The server must sign this random number (Nonce) to prove that it is the owner of the private key. The private key belongs to the certificate that the server uses to establish the secure channel. This message (and all subsequent messages) is secured in line with the security policies of the selected server endpoint (selected security policies).
2. The server responds with the CreateSession Response. This message contains the public key of the server and the signed Nonce. The client checks the signed Nonce.
3. If the server passes the test, the client sends a SessionActivateRequest to the server. This message contains the information that is required for user authentication:
   - User name and password, or
   - X.509 certificate of the user (not supported in STEP 7), or
   - No data (if anonymous access is configured).
4. If the user has the necessary rights, the server returns a message to the client (ActivateSessionResponse). This activates the session.

The secure connection between the OPC UA client and server has been established.

Establishing a connection to PLCopen function block

The PLCopen specification defines a range of IEC 61131 function blocks for OPC UA clients. The instruction UA_Connect initiates both a secure channel and a session following the pattern described above.

11.2.7 Certificate management via Global Discovery Server (GDS)

11.2.7.1 Automated certificate management with GDS

As of TIA Portal version V21 and S7-1500 CPU firmware version V4.1, you can also use the GDS push management functions for OPC UA client certificates. If there are several instances of the OPC UA client, a separate certificate can be created and customized for each instance. You can find information or restrictions in the section Handling client certificates during runtime (Page 390).

NOTICE
High resource consumption poses risks when using GDS If you use GDS, high resource consumption can have an impact on general security services. For example, the management of users or certificates can be affected with OPC UA. As soon as general security services are affected, the CPU reports this as an alarm in the diagnostics buffer and generates a syslog message. Adapt the use of resources to your actual requirements.

As of TIA Portal version V18 and S7-1500 CPU firmware version V3.0, you can also use the GDS Push Management function for web server certificates. The sequence of, for example, certificate updates via GDS Push management functions is identical here in principle to the certificate update of OPC UA server certificates. Instead of OPC UA server certificates, you transfer web server certificates to the CPU at runtime or during operation. The differences or restrictions are explained in the following description at the corresponding places.

As of TIA Portal V17 and S7-1500 CPU firmware version V2.9, you can use the certificate management services of the OPC UA server to transfer OPC UA server certificates during runtime.

OPC UA certificates, trust lists and certificate revocation lists (CRLs) for the OPC UA server of the S7-1500 CPU can be updated automatically using GDS Push Management functions. The automation of the certificate management eliminates any manual work required for reconfiguring the CPU, for example, after the period of validity of a certificate has expired, and a fresh download of the CPU. You can also use the GDS Push Management functions to transfer updated certificates and lists in the STOP and RUN operating states of the CPU.

The certificate management information model is specified in OPC UA Part 12 (OPC 10000-12: OPC Unified Architecture, Part 12: Discovery and Global Services).

The following sections provide a general overview of Global Discovery Services and the function of an automated certificate update supported as of TIA Portal V17 / CPU firmware version V2.9.

Discovery server

To connect to an OPC UA server, an OPC UA client requires information about its endpoint such as the endpoint URL and the security policy. When a large number of possible servers are available in the network, a discovery server can take over the search and management of this server information.

- OPC UA servers register with the discovery server.
- OPC UA clients request a list of accessible servers from the discovery server and then connect to the desired OPC UA server.

Global Discovery Server (GDS)

The OPC UA GDS concept allows the configuration of cross-subnet discovery services on the one hand and provides interfaces for central certificate management on the other hand.

A Global Discovery Server (GDS) makes mechanisms available for the central management of the following components:

- CA-signed certificates and self-signed certificates
- Trusted Lists and Certificate Revocation Lists (CRL)

A GDS thus provides an access point to central certificate management and takes over the task of a security server within an OPC UA network.

The main application of GDS is the management of CA-signed certificates with the corresponding CRLs:

- Initial creation of an OPC UA application certificate, for example, for the OPC UA server or for the web server
- Regular update of the trust list and the CRLs
- Renovation of an application certificate

Certificate management

Certificate management has the task of automating the administration and distribution of certificates and trust lists for different services or UA applications.

In this context, a distinction is made between the following roles:

- Certificate manager - an OPC UA application that provides certificate management functions
- Certificate recipient – an OPC UA application that receives certificates, trust lists and CRLs from the certificate manager.

There are two models for certificate management: Pull and push management.

- With pull management, the OPC UA application acts as a client of the GDS server and uses certificate management methods to request certificate updates and trust list updates.
- With push management, the OPC UA application acts as a server and provides methods for an OPC UA GDS as OPC UA client. The GDS in the role of certificate manager uses these methods to transfer ("push") certificates and trusted list updates, see explanation of the concept for automated certificate update below.

System configuration with GDS

The figure below shows an example of the tasks of the devices involved in combination with a GDS that provides certificate management functions.

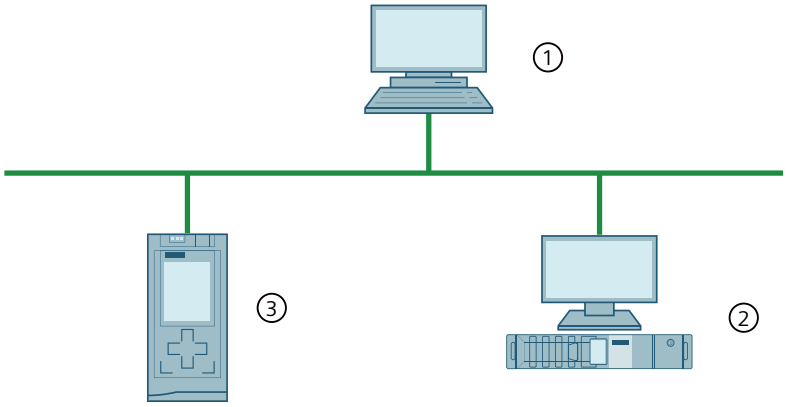

① Root CA - device that issues certificates for the system (these certificates can also be transmitted in other ways, for example, by email)

② OPC UA GDS with certificate manager creates or signs device certificates, manages trust lists and certificate revocation lists (CRLs), and writes certificates and lists to the devices (push function). This device requires OPC UA client functionality for the push function.

③ Device with OPC UA application receives "pushed" certificates and lists

Concept for automated certificate update for STEP 7 version V17 and higher

GDS and certificate manager are usually combined into one application; however, in the figure below, they are two separate components.

Devices such as "normal" OPC UA clients are also suitable as certificate managers, but they need to support the Bytestring data type that is required to transfer certificates, for example, an S7-1500 CPU firmware V2.9 and higher as OPC UA client or the UA Expert tool (Unified Automation) with GDS plugin.

The OPC UA server of the S7-1500 CPU as certificate receiver provides the standardized methods and attributes that the OPC UA client certificates need to read and write trust lists and CRLs.

The focus in the context of the OPC UA server of the S7-1500 CPU is the description of the push function in contrast to the usual manner in which certificates are provided to the CPU: By loading the hardware configuration.

The figure below shows how to transfer certificates and lists for OPC UA in an S7-1500 CPU FW V2.9 or higher:

- Either by loading the hardware configuration (if appropriate, in STOP mode of the CPU; the certificates are part of the hardware configuration and can only be loaded in RUN mode under specific conditions; see Tip: Updating loaded certificates in RUN (Page 79))
- Or via GDS push methods in RUN or in STOP mode of the CPU.

It is not possible to use both transmission paths in parallel. If, for example, you have opted for transfer of OPC UA server certificates with GDS push functions at runtime, you must also transmit all the other certificate types to the CPU via this route.

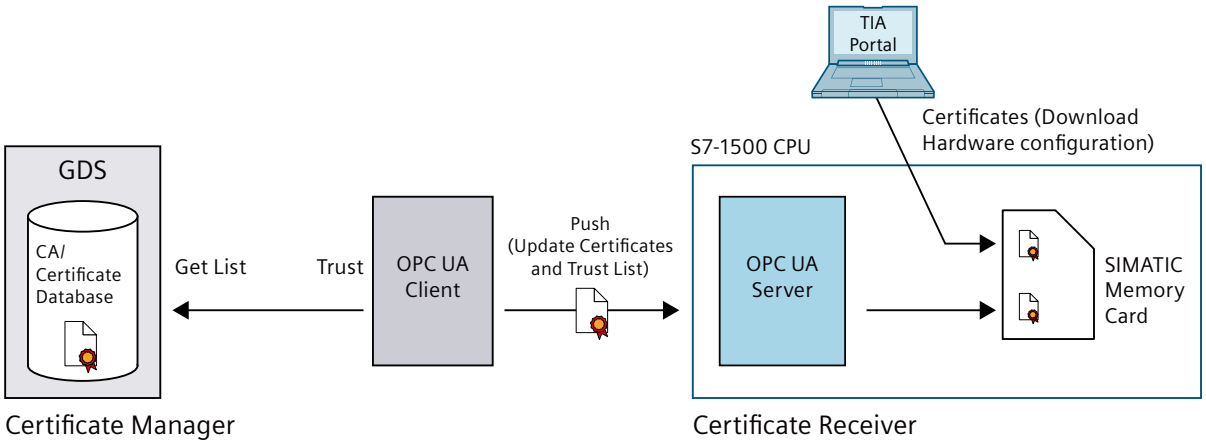

More information

You can find more information on the certificates for OPC UA in the section What you should know about the certificate management (Page 65) and Certificates with OPC UA (Page 195).

11.2.7.2 Configuration limits for Push function

Number of certificates for Push function

For the OPC UA Push function, an S7-1500 CPU, regardless of the type, has a configuration limit of 62 trust list entries as of firmware version V2.9.

- Each activated certificate-based service (CPU application) "consumes" one entry each for a certificate and an entry for the private key.
- A Certificate Revocation List entry (CRL) counts just as an entry in the list of trusted certificates.
- A certificate that is used by different services (CPU applications) counts as a single trust list entry.

Size of elements for Push function (e.g. certificates)

Max. 4096 bytes

Example

You want to grant access to the OPC UA server for up to 62 OPC UA clients and fill the trusted list accordingly.

When you add a Certificate Revocation List entry in the trusted list, you can only trust up to 61 client certificates.

Additional OPC UA certificates can **not** be transferred by loading the hardware configuration to the CPU.

Tip

To keep the number of required certificates low, we recommend having the OPC UA client certificates signed by the same CA.

In this case, the CPU as OPC UA server only needs the corresponding CA certificate and CRLs. With these elements, the OPC UA server can then verify all client certificates signed by the CA. This means you do not have to add the individual client certificates to the trusted list.

11.2.7.3 Setting and loading GDS parameters

The following describes the settings required for the certificate update.

Requirement

- Depending on the application certificate, the corresponding STEP 7/TIA Portal version and S7-1500 CPU firmware version is required.

  See also here: What you should know about the certificate management (Page 65)

  – For OPC UA server certificates, for example, TIA Portal as of V17, CPU as of FW version V2.9
  – For web server certificates, for example, TIA Portal as of V18, as of CPU FW version V3.0
  – For OPC UA client certificates, e.g. TIA Portal V21, CPU as of FW version V4.1
- Timet/date of the CPU is set (generally applies to certificate-based communication)
- The OPC UA server is enabled.
- The service that the GDS push management uses must be enabled. For example, the web server must be enabled for the transfer of web server certificates.
- At least one endpoint with the "Sign & Encrypt" security policy must be configured for the OPC UA server. The partner must use this endpoint

- An authenticated user with sufficient function rights is configured
  The user must have a role that has the **"Manage certificates" function right**.

  This function right, in turn, has the following requirements:

  – **Project protection** must be enabled in the project tree: Project tree: "Security settings > Settings > Project protection".

  – The user with a role that has the "Manage certificates" function right is configured in the project navigation "Security Settings > Users and Roles".
  TIA Portal < V19: In the "OPC UA > General" area of the CPU settings, the following general user management setting must be enabled: "Enable additional user management via project security settings"

The Users and roles with OPC UA function rights (Page 278) section describes how to set the function rights.

Activating GDS

When the requirements listed above are met, you must still enable the GDS:

1. In the Inspector window (CPU parameters), go to the "OPC UA > Server > General" area.
2. Enable the "Enable Global Discovery Services (Push)" option.

Determining the certificate store used

Certificates that are managed using GDS, are in a different memory area than the certificates that are downloaded via the TIA Portal (STEP 7).

When GDS push certificate management is enabled, the services (applications) of the CPU also use certificates from the certificate store whose certificates are managed at runtime.

1. In the CPU settings, navigate to the area "Protection & Security > Certificate management".
2. Select the option "Use certificates provided by certificate management during runtime".

   The other option (use certificates configured and downloaded using TIA Portal) uses the certificates that are downloaded from the TIA Portal to the CPU with the configuration or configuration changes. In this certificate store, no certificates or trust lists can be updated at runtime and certificates can only be updated within specific constraints (see Tip: Updating loaded certificates in RUN (Page 79)).

Enabling the diagnostics for the lapsing of certificates

If you wish to be informed in advance about the lapsing of a certificate, select the "Enable system diagnostics event for the certificate lapsing" option in the area "Protection & Security > Certificate management".

Enter a percentage value in the text box "Show event at remaining certificate validity period of:".

Effect of these settings:

- At the instant when this value is reached by a certificate, a corresponding system diagnostics message appears till the certificate lapses or is refreshed.
- If the end of the validity period of a certificate has been reached, the CPU generates a corresponding system diagnostics message as well as an entry in the diagnostics buffer and the maintenance LED lights up.

Example:
The certificate transferred via GDS on June 01, 2022 has a validity from June 01, 2022 to June 30, 2022 (30 days). You have input a percent value of 10 for the diagnostics event. On June 27, 2022, when 90% of the period of validity lapses, a corresponding message will appear stating that the certificate that had been transferred will lapse on June 30, 2022. Regardless of the configured percentage value, upon lapsing of the period of validity of a certificate, a corresponding message is displayed in any case, an entry is made in the diagnostics buffer, and the maintenance LED lights up.

Download to CPU

When downloading the configuration to the CPU, you can delete the certificates that are managed via GDS before the download. When you confirm the deletion, the download is followed by a provisioning phase (see section on commissioning).

When you download the memory card outside of the CPU (card reader), this certificate store is always deleted.

When Global Discovery Services (Push) is activated and no pushed certificates are available, then no separate certificate, trust list or CRL is available for the OPC UA server.

11.2.7.4 GDS commissioning

Part 12 of the OPC UA specification distinguishes between a provisioning phase and a run time phase during certificate management.

In the provisioning phase, a GDS or OPC UA client provides initial trust lists and CRLs for clients of the OPC UA server. In this phase, the OPC UA server of the CPU accepts all client certificates and lists it is offered – similar to the "Trusted clients" setting for the OPC UA server that all client certificates are accepted during runtime. This is the only way in which a connection to clients not known to the server is possible. For example, clients that the server cannot authenticate using existing certificates or trust lists until it has received the corresponding client certificate or the corresponding trust list.

The provisioning phase is characterized by lower security; therefore, the provisioning phase is indicated by a lit Maintenance LED and a corresponding diagnostics buffer entry (Maintenance demanded).

During the runtime phase, the existing CRLs are updated, for example, and the certificates and trust lists are renewed. Communication is secure in this phase.

Requirement

Only authorized users with sufficient function rights can set up a connection in the provisioning phase. The users must have a role with the function right "Manage certificates".

See also Setting and loading GDS parameters (Page 206).

Rules for the provisioning phase

In the provisioning phase, the OPC UA server of the CPU cannot authenticate the OPC UA clients that initiate connection establishment. Therefore, the following rules must be observed:

- Ensure a secure environment, e.g:
  - Only the commissioning personnel have access to the CPU.
  - The CPU and programming device are directly connected to each other.
  - Check that the correct devices are communicating with each other.
- Limit the time for this phase.

The CPU signals that it is in the provisioning phase by the lit Maintenance LED as well as a corresponding diagnostics buffer entry (Maintenance demanded).

Sequence of the provisioning phase

The following provides an outline of the process of the provisioning phase for OPC UA server certificates and trust lists.

The process of the provisioning phase for web server certificates is comparable. In contrast to OPC UA, the GDS client only pushes web server certificates but not trust lists into the corresponding certificate store.

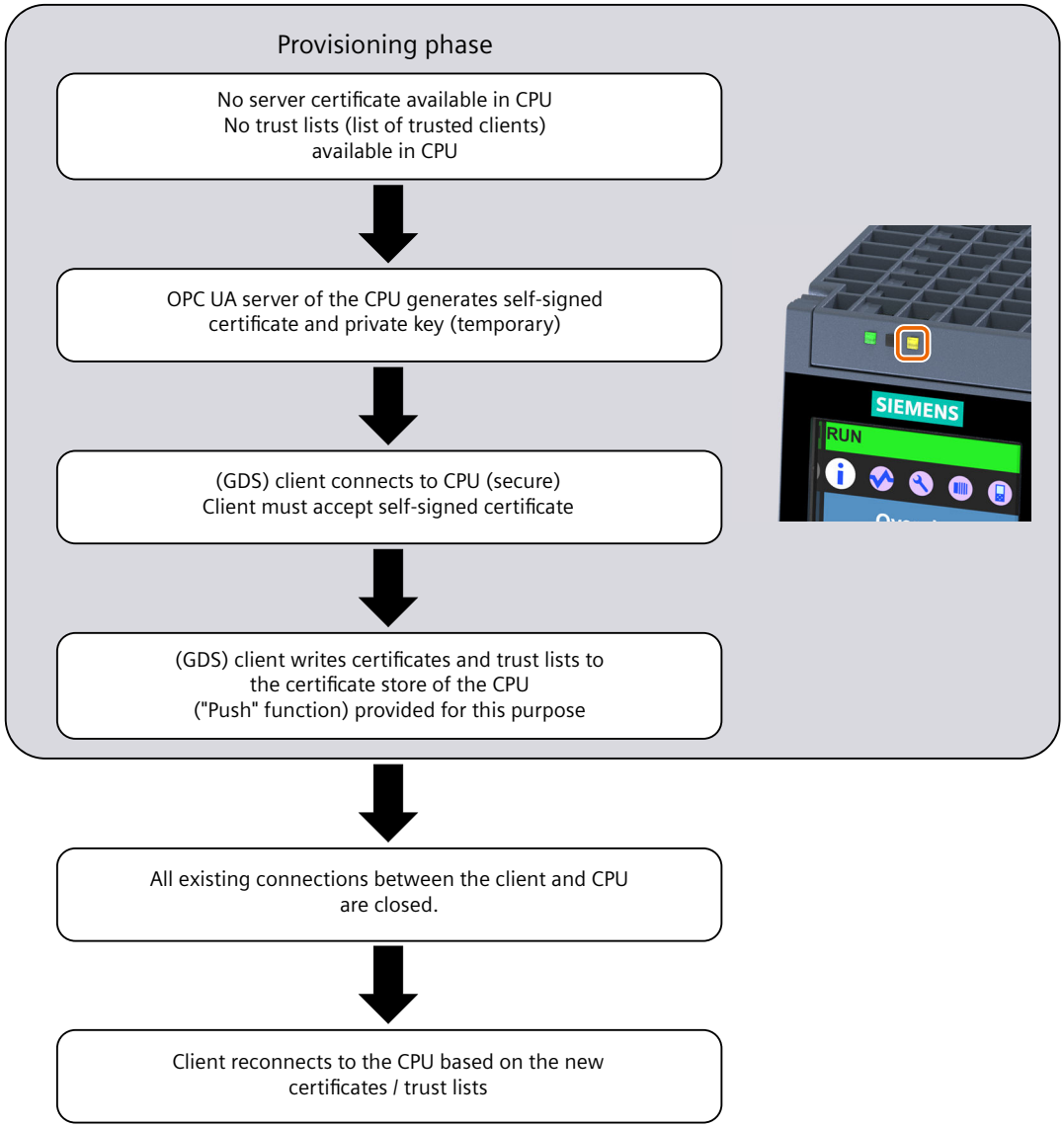

Entering the provisioning phase

After startup of the OPC UA server, the CPU automatically enters the provisioning phase when one of the following conditions is met:

- The OPC UA server certificate is the initial self-signed certificate generated by the CPU and has not yet been replaced by a valid server certificate.
- The trust list (list of trustworthy clients) is empty.

The OPC UA server certificate generated by the CPU contains the most important parameters of the OPC UA server and is re-generated, including the private key, after each startup of the OPC UA server following POWER ON - until the valid server certificate is present. For this reason, the OPC UA server may take longer to start up after a POWER ON.

After the hardware configuration is downloaded, the certificate store for certificates that can be updated during runtime is deleted on download or the certificates are retained, depending on the setting. This means that if GDS is activated and the certificate store has been deleted, the CPU is in the provisioning stage after the hardware configuration has be loaded.

Provisioning phase diagnostics

In addition to the lit Maintenance LED, the GDS address model has two nodes that provide information on whether the OPC UA server of the CPU is in the provisioning phase:

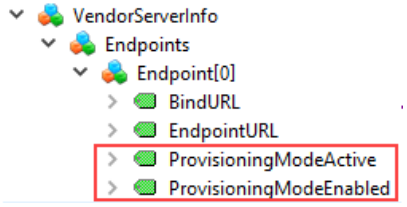

You can only use the two nodes as marked in the figure for diagnostics if the requirements for GDS are met (endpoint security signed & encrypted plus administrator function rights available).

ProvisioningModeEnabled: Indicates that a provisioning phase is supported

ProvisioningModeActive: Indicates that the OPC UA server of the CPU is in the provisioning phase.

End of the provisioning phase

The CPU ends the provisioning phase automatically when the following conditions are met:

- The certificate generated and self-signed by the CPU for the provisioning phase has been overwritten by a valid server certificate. This valid server certificate can be a self-signed certificate or a CA-signed certificate.
- The trust list in the CPU is not empty, i.e. client certificates of the OPC UA clients to be trusted or CA certificates for checking the client certificates are available.

If the OPC UA client transfers a CA-signed certificate and also adds the CA certificate to the trust list, the OPC UA server of the CPU can automatically accept all other certificates from OPC UA clients that were signed by the same CA.

Request of a valid server certificate

As of TIA Portal version V18 / S7-1500 CPU version V3.0, in addition to OPC UA server certificates, certificates for other services can also be transferred to the CPU, for example, for the web server.

The corresponding service, for example, the OPC UA server of the CPU, receives a valid certificate in the following steps:

1. A GDS client (OPC UA client) calls the method "CreateSigningRequest" to request a server certificate: with a Certificate Signing Request (CSR).
2. This CSR must be signed by a Certificate Authority (CA).
3. The signed CSR must then be transferred back to the OPC UA server of the CPU as a certificate.

The OPC UA server of the CPU makes this method available if the client has the required function right "Manage certificates".

The "CreateSigningRequest" method allows for the following variants:

- Certificate update without creating a new key pair (internal CPU keys that are already available are used)
- Certificate update with creation of a new key pair (CPU-internal)

There is also the possibility to generate certificates with externally created key pairs.

NOTICE
Recommended procedure to generate certificates Transport of private keys should be avoided; a private key should not leave a device. We, therefore, recommend the generation of a certificate without creating a new key pair or with the creation of a key pair inside the CPU.

Create certificate without key pair

- The "CreateSigningRequest" method returns a Certificate Signing Request (CSR), that is, a file (*.csr) with specific information on the server or on the service, for example, application name and URL.
- Outside of the CPU, this CSR must be validated and signed by a Certificate Authority (CA) and the certificate must be returned.
- The certificate must then be transferred to the CPU ("pushed") using the "UpdateCertificate" method.

The key does not leave the CPU in this scenario.

Create certificate with internally created key pair

The procedure is similar to the method explained in the previous section; the only difference is that a key pair is generated in addition to the CSR. You specify in the parameter of the "CreateSigningRequest" method that it is to generate a key pair.

The private key does not leave the CPU in this procedure either.

The generation of a new key pair creates a very heavy load on the CPU. The CPU processes this request over a longer period of time with lower priority in the reserved area for the communication load. The duration of this time period depends on the performance of the CPU.

Because the share of the set communication load is fully utilized during key generation over a longer period of time, set the "Cycle load due to communication" share so that the maximum cycle time is not exceeded and sufficient reserves are available. For this, use the web server page "Diagnostics > Runtime information" of the CPU. This page shows information about the current program/communication load and cycle time of your user program. Via a controller, you can get help on the effects of a changed communication load on the cycle time.

Create certificate with externally created key pair

The certificate is generated with the help of tools, for example, that can generate additional keys.

Certificate and keys are transferred to the CPU using the "UpdateCertificate" method.

Due to low security, this procedure is not recommended.

NOTICE
Different keys for different target systems Always use newly generated keys for a production system. If you simulate and test your project, e.g. with PLCSIM Advanced on your PC, do not under any circumstances use the keys used for the simulation also for a productive system. Restrict the access to PC-based controllers by setting up appropriate permissions.

11.2.7.5 Address model for the push certificate management

The OPC UA specification Part 12 (OPC 10000-12: Discovery, Global Services) defines methods and attributes for OPC UA servers, for example, that enable GDS or OPC UA clients to update certificates and trust lists on the server ("Push certificate management"). These methods and attributes are also included in the address model of the OPC UA server.

The relevant section in the address model of the OPC UA server of the S7-1500 CPU is explained below.

Requirement

The following requirements must be met for the relevant methods and attributes to become visible for the GDS push functionality:

- GDS is activated.
- The set security policy supports the integrity and confidentiality of the data through signature and encryption (Sign & Encrypt).
- Access with runtime function right "Manage certificates"

Address model for the GDS push functionality

The address model for the GDS push functionality corresponds to the "Information Model for Push Certificate Management" of the OPC UA specification OPC 10000-12: Discovery, Global Services.

You will find the following structure below the "ServerConfiguration" node:

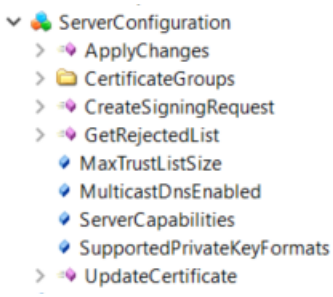

Methods and attributes for access to the address model

The methods and attributes are briefly described below with special features and restrictions of the specific address model of the S7-1500 CPU. The OPC UA specification listed above contains the general description.

You can find a detailed description of the individual methods below this overview table.

Method / Attribute (Variable)	Description
CreateSigningRequest	Method for generating a PKCS#10-encoded certificate request signed with the private key of the service (for example, OPC UA server).
UpdateCertificate	Method for updating the server certificate, for example, for the OPC UA server.
ApplyChanges	Method for applying a security-relevant change if the "ApplyChangesRequired" attribute was set when executing a previously executed method. **Note** If, as a result of "ApplyChanges", a certificate is changed, the CPU interrupts the connections/sessions that are secured via this certificate. Background: The basis for the secured connections - the certificate - is no longer valid.
GetRejectedList	Method that returns a list of certificates that were rejected by the OPC UA server. Rejected certificates are currently not stored by the OPC UA server of the S7-1500 CPUs. The method returns an empty array (RejectedList).
ServerCapabilities	Variable is not supported by the OPC UA server of the S7-1500 CPU.
SupportedPrivateKeyFormats	Variable that specifies permitted formats of the private key. For S7-1500 CPUs only "PEM" (String Array)
MaxTrustListSize	Variable that specifies the maximum size of the trust list.
MulticastDnsEnabled	Variable that specifies whether multicast DNS is supported. For S7-1500 CPUs, the value is "False".

Method / Attribute (Variable)	Description
CertificateGroups	Object (folder) that organizes all certificate groups supported by the OPC UA server. The certificate groups contain the objects that can be updated dynamically during runtime: For example, one trust list each and one or multiple certificates that are assigned to a service (for example, OPC UA application). Details on the structure of the CertificateGroups object and the methods and attributes that are available in the object are described in the next section.

CreateSigningRequest

The method has the following parameters:

Parameter	Data type	Description
[in] certificateGroupId	NodeId	NodeId of the CertificateGroup object.
[in] certificateTypeId	NodeId	Requested certificate type. List of permitted certificate types is specified by the "CertificateTypes" variable of the certificate group. For the OPC UA server for example, certificate type "RsaSha256ApplicationCertificateType", for the web server the certificate type "HttpsCertificateType"
[in] subjectName	String	Subject Name that is requested in the Certificate Request. If not specified, the current Subject Name of the certificate is used.
[in] regeneratePrivateKey	Boolean	True: Server generates a new private key. This key is saves until the UpdateCertificate methods with the matching signed certificate is called. False: Server uses the available private key.
[in] nonce	ByteString	Additional nonce for generating the new private key (see regeneratePrivateKey). Must be at least 32 bytes long.
[out] certificateRequest	ByteString	PKCS #10 - DER coded Certificate Request.

Method Result Codes

Result Code	Description
Bad_InvalidArgument	certificateTypeId, certificateGroupId or subjectName is invalid.
Bad_UserAccessDenied	The current user does not have the required function rights.

UpdateCertificate

Applications:

- Generation of certificate with CreateSigningRequest. No private key is available.
- New private key and new certificate were generated outside of the server. Both are updated with UpdateCertificate.
- Certificate generated and signed with the private key of the existing certificate. No private key is available.

Parameter	Data type	Description
[in] certificateGroupId	NodeId	NodeId of the CertificateGroup object.
[in] certificateTypeId	NodeId	Requested certificate type. List of permitted certificate types is specified by the "CertificateTypes" variable of the certificate group.
[in] certificate	ByteString	DER-coded certificate that replaces the existing certificate.
[in] issuerCertificates	ByteString	Issuer certificates
[in] privateKeyFormat	String	Format of the private key. Currently only PEM is supported. If the privateKey is not specified: zero or empty string.
[in] privateKey	ByteString	Privater key coded as specified in privateKeyFormat.
[out] applyChangesRequired	Boolean	Indicates that the "ApplyChanges" method must be called before you use the new certificate.

Method Result Codes

Result Code	Description
Bad_InvalidArgument	certificateTypeId or certificateGroupId is invalid.
Bad_CertificateInvalid	The certificate is invalid or the format is not supported.
Bad_NotSupported	The private key is invalid or the format is not supported.
Bad_UserAccessDenied	The current user does not have the required function rights.
Bad_SecurityChecksFailed	Error occurred when verifying the integrity of the certificate.

Apply Changes

The method has no parameters.

Method Result Codes

Result Code	Description
Bad_UserAccessDenied	The current user does not have the required function rights.

GetRejectedList

The method has the following parameters:

Parameter	Data type	Description
[out] certificates	ByteStrings	DER-coded list of rejected certificates. The method currently returns an empty list (empty array), because rejected certificates are not stored.

Method Result Codes

Result Code	Description
Bad_UserAccessDenied	The current user does not have the required function rights.

11.2.7.6 CertificateGroups in the address model

Certificates and trust lists for services or applications of the CPU (for example, OPC UA servers) that can be updated during runtime are located in the address model in the "CertificateGroups" object - there is one certificate group each for the various services of the S7-1500 CPU. For the OPC UA server certificate, the certificate group has the name "OPC UA server".

CertificateGroup in the address model

The following figure shows an example structure of the "CertificateGroups" object below the "ServerConfiguration" node. In this example, the OPC UA server and the web server of the CPU use certificates that can be updated during runtime.

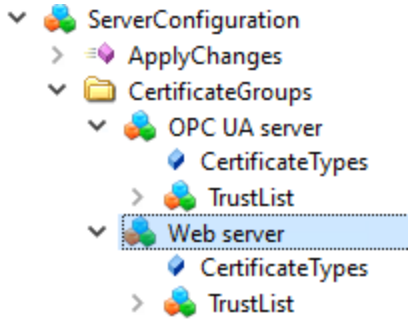

You can change the name of the certificate store at runtime (e.g. "OPC UA server ") in STEP 7 (TIA Portal):

1. In the Inspector window (CPU properties), navigate to the area "Protection & Security > Certificate management".
2. Enable the option "Use certificates provided by certificate management during runtime" option.
3. Change the name of the certificate store at runtime in the table below. 1-64 characters in 7-bit ASCII format are permitted.
   The first column shows the activated service for which certificates can be transferred in runtime. The "ID" column contains a fixed numerical identifier that is used internally by the CPU to reference the certificates. The respective application URI is generated automatically based on the entry in the "Certificate store at runtime" column. If you change the name of the certificate store at runtime, the respective application URI also changes.

Here is an example for the display in the area "Certificate management":

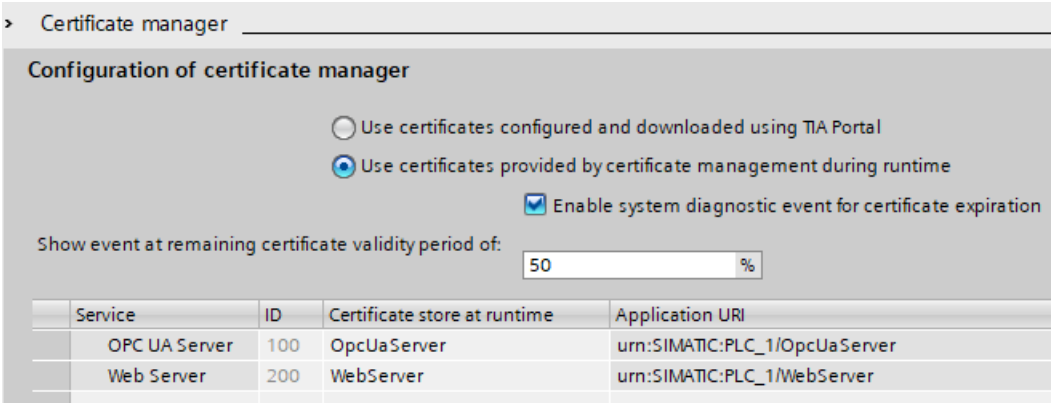

Figure 3-433 Certificate management settings

If you have activated the OPC UA client of the CPU and also enabled certificate management during runtime, you can change the IDs of the individual certificates. Each ID can only be assigned once in the project. STEP 7 shows duplicate IDs as incorrect.

"CertificateTypes" node

The "CertificateTypes" variable specifies the NodeIds of the certificate types that are assigned to the server application.

For the OPC UA server service, for example, the "RsaSha256ApplicationCertificateType" CertificateType is supported, for the web server, it is the "HttpsCertificateType CertificateType".

"TrustList" node

The node for the trust list object (TrustList file) defines an OPC UA file type (Binary encoded stream) that contains information on the certificates and CRLs that can be read and updated in the "pki store\trusted\issuer" directory of the Memory Card. This node provides methods and attributes that make reading and updating possible.

The node is an instance of the OPC UA data type "TrustListDataType" with the following structure:

Parameter	Data type	Description
specifiedLists	TrustListsMasks	Bit mask that shows which lists contain information.
trustedCertificates	ByteStrings	List of the application certificates and CA certificates that can be trusted.
trustedCrls	ByteStrings	CRLs for the certificates in the "trustedCertificates" list.
issuerCertificates	ByteStrings	List of the CA certificates that are required for validating the CA signed certificates.
issuerCrls	ByteStrings	CRLs of the CA certificates in the "issuerCertificates" list.

Structure of the "TrustList" node

The "TrustList" node has the following structure:

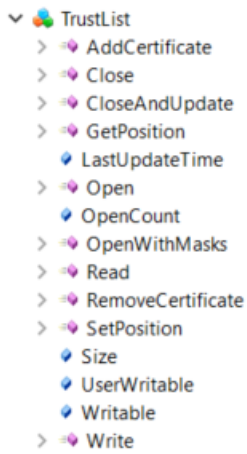

Methods and attributes for the "TrustList" node

Below is a description of the nodes under "TrustList" that supplement the methods of the Object Type "FileType". The TrustList Type is derived from FileType (see OPC 10000-5: OPC Unified Architecture, Part 5: Information Model).

Method / Attribute (Variable)	Description
LastUpdateTime	Variable that shows the time of the last update.
OpenWithMasks	Method that permits a client to only read a part of the TrustList.
CloseAndUpdate	Method for closing the TrustList file and applying the changes.
AddCertificate	Method for adding a single certificate to the TrustList.
RemoveCertificate	Method for removing a single certificate from the TrustList.

Description of the methods

The description of the methods with their result codes, attributes and types of the TrustList object is available in the OPC UA specification Part 12, Discovery and Global Services.

11.2.8 Role-based security in OPC UA

11.2.8.1 Interesting facts about role-based security

In OPC UA, the concept for role-based security is defined in Part 18 of the OPC UA specification (OPC 10000-18: UA Part 18: Role-Based Security). Parts 3 and 5 of the OPC UA specification, which contain individual aspects of the role definition, are also relevant, e.g. which roles a server should support with which permissions and which objects are defined with which attributes or properties in the address space.

With the implementation of the role-based concept for the S7-1500 CPUs as of FW version V4.0, the OPC UA server can manage in detail the access of specific clients to the address space.

Individual OPC UA access rights to nodes in the address space

Using role-based security in OPC UA, you can configure roles with permissions and access restrictions to nodes in existing namespaces.

The configuration options for roles and permissions in the server interface together with the user management in the TIA Portal (users and roles) enable effective access management.

Requirements for using role-based security

- S7-1500 CPU as of FW version V4.0
- TIA Portal:
  - To add user-defined roles to OPC UA, you need TIA Portal as of version V20 Update 3.

Relationship between roles/permissions for OPC UA and roles/function rights for users and roles

The following permissions are required to perform actions in a namespace, e.g. reading or writing to a node:

- Access to the OPC UA server of a CPU
- Permissions for the namespace

To access the OPC UA server of a CPU, a user from the local or central user management requires a role with the "OPC UA server access" function right. You can add/edit users and roles in the security settings of the project under "Users and roles".

You configure the permissions for the namespace in the "Access control at OPC UA server" editor of a CPU. Open the editor by double-clicking the entry of the same name in the project navigation (PLC > OPC UA communication). There you have the following configuration options for OPC UA communication:

- Assignment of existing roles (from the Security settings of the project > Users and roles) to the OPC UA user roles.
  Only roles that contain the "OPC UA server access" function right can be assigned to an OPC UA user role.
- Assignment of default permissions for the namespace of the server interface.
- Configure access restrictions, e.g. that the messages must be signed and encrypted.

The connection between users and OPC UA user roles is formed by the roles in the project with the "OPC UA server access" function right. Mapping the roles in the "Access control at OPC UA server" editor creates a hierarchy of responsibilities that regulate user access:

- Local or central user management of the CPU:
  Responsible for authenticating the users (OPC UA clients) who access the OPC UA server.
- OPC UA server of the CPU:
  Responsible for authorizing users (OPC UA clients). The OPC UA server of the CPU checks whether a user is allowed to perform the requested action (e.g. read or write to a node).

During operation, a user (OPC UA client) who is assigned a role with the "OPC UA server access" function right can be authenticated by the OPC UA server and can access the OPC UA server.
The user can perform actions in the namespace in accordance with the OPC UA user role assigned to this role.

User roles on the OPC UA server

When importing companion specifications with user management data, you can choose whether or not you want to import the configuration of the user management data. It is also possible to import individual OPC UA roles.

You can assign (map) roles from the project to the OPC UA roles contained in the Companion specification. You can only assign roles that contain the "OPC UA server access" function right.

You can also see next to each OPC UA role in which namespace this OPC UA role is defined and the configured standard authorizations for this namespace. An OPC UA role can also be valid for several namespaces.

For some pre-defined OPC UA roles in namespace 0, there are no direct equivalents in "Users and roles", e.g. the "AuthenticatedUser" role. Users who successfully authenticate themselves with username/password receive the access rights that were assigned to the "AuthenticatedUser" role.

In addition to the role permissions, you can also define the access restrictions for the companion specification to be imported. A companion specification to be imported can also contain namespaces that already exist with the same name in a server interface. In this case, you can choose whether the configured settings in the project or the import file should apply to this namespace.

NOTE

Naming the standard OPC UA user roles

The pre-defined standard OPC UA roles are sometimes named like users, which can lead to misunderstandings. The OPC UA roles and their rights are initially independent of the user management. Only by assigning the role authorizations (OPC UA user role - Assigned role in the project) do you connect the OPC UA roles with the user administration in the TIA Portal.

Example: There is the "Anonymous" **user** in the user management. OPC UA has the **standard OPC UA user role** "Anonymous".

Well-Known Roles

The OPC Foundation has pre-defined roles in namespace 0 (http://opcfoundation.org/UA/). These roles are available without a separate role definition for every OPC UA server that supports role-based security.

Examples of "Well-Known Roles":

- Anonymous
- AuthenticatedUser
- Observer
- Operator
- Engineer
- Supervisor
- ConfigureAdmin
- SecurityAdmin

You can easily add these roles as standard OPC UA roles in the TIA Portal.

Roles and permissions for OPC UA

You can assign OPC UA user roles and OPC UA authorizations for complete namespaces (i.e. for all nodes in the namespace).

You use either pre-defined standard OPC UA roles or the OPC UA roles imported with a nodeset. You can also create custom OPC UA user roles for custom namespaces of OPC UA server interfaces and assign them to these namespaces.

You can assign the following OPC UA permissions to an OPC UA user role:

- Browse - A client with this permission can see references to/from this node, i.e. also for all attributes with the exception of the Value and RolePermissions attributes.
- Read - A client with this permission can read the Value attribute.
- Write - A client with this permission can write to the Value attribute.
- Call - A client with this permission can call the corresponding method; valid for objects, object types or methods.
- Receive events - A client with this permission can receive events (alarms and conditions).
- Read Role Permissions - A client with this permission may read the RolePermissions attribute.

You can also activate access restrictions for namespaces:

- Signing Required - A client only has access to the nodes if a SecureChannel is used that digitally signs the messages. See also the explanation of the "Apply Restrictions to Browse" access restriction.
- Encryption Required - A client only has access to the nodes if a SecureChannel is used that encrypts the messages. See also the explanation of the "Apply Restrictions to Browse" access restriction.
- Apply Restrictions to Browse - If this access restriction is enabled, the requirements described for "Signing required" and "Encryption required" also apply to the browse permission.

To assign an OPC UA user role to a user, create a role with the "OPC UA server access" function right in the editor for users and roles. Only roles that contain this function right can be assigned to OPC UA user roles.

Rules

- To assign roles to users or user groups, use the editor for users and roles (Security settings > Users and roles in the project tree).

  These users and user groups are also used by the OPC UA server. The CPU or a connected UMC server carries out the authentication service when logging on.
- The logged-in user must have a role with the "OPC UA server access" function right.
- Adding additional roles during runtime is not possible. All roles and associated OPC UA permissions for the address space have to be configured before commissioning and loaded in the CPU.

  You can achieve greater flexibility with regard to users if you use a UMC server for central user management and combine users into groups.

- OPC UA offers various criteria for authorizing server access; in OPC UA jargon these are "mapping rules", for example:
  - User identity: Access depends on the identity of the user
  - Application identity: Access depends on the ApplicationUri specified in the client certificate
  - Endpoint: Access depends on the URL used to access the server.

  The OPC UA server of the S7-1500 CPU only validates the permission via the user identity.
- The OPC UA server of the S7-1500 CPU supports "Well-Known Roles", which are defined in OPC 10000-3: UA Part 3: Address Space Model.

More information

You can find the latest information on configuring the role-based security for S7-1500 CPUs in the product information (https://support.industry.siemens.com/cs/ww/en/view/68052815).

11.2.8.2 Configuring role-based access control for OPC UA

The following sections describe how to configure permissions for OPC UA roles in the editor for OPC UA communication.

Requirement

- TIA Portal as of Version V20 Update 3
- S7-1500 CPU as of FW version V4.0 with the following parameterization:
  - Access control for local user management is enabled (Protection & Security > Access control)
  - The OPC UA server of the CPU **and** the access control for the OPC UA server are enabled (OPC UA > Server > General)
- You have configured the required users and their roles:
  - Users who are to have access to the OPC UA server have been assigned a role that contains the "OPC UA server access" function right.
  - Users who are to manage certificates have been assigned a role that contains the "Manage certificates" function right.

    In the "Access control on the OPC UA server" editor, you must assign a role for this user in the project to the standard OPC UA role "SecurityAdmin".

Overview: Editor for OPC UA role permissions and access restrictions

You can find the editor for managing roles and permissions in the project navigation under the desired CPU ("OPC UA communication > Access control at OPC UA server"). Double-click the "Access control at OPC UA server" entry to open the editor. After opening, the editor shows the "Role permissions" tab.

If the access control for the CPU is not configured as described in the requirements, the editor displays a message in the upper area. The message contains a link to the corresponding area in the CPU properties. The message only disappears when the CPU is configured as described in the requirements.

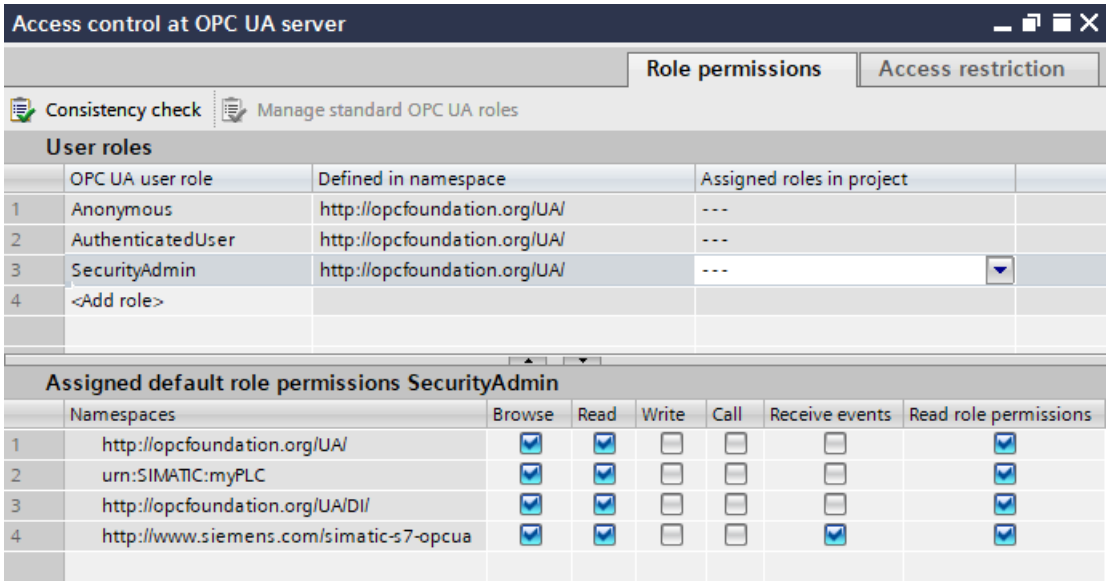

Figure 3-434 Access control with OPC UA server

The "User roles" area shows the OPC UA user roles with their namespace details and the assigned role in the project.

If you have previously imported a node set file with role definitions, the OPC UA user roles defined there are also listed.

You can easily add additional standard OPC UA roles by clicking the "Manage standard OPC UA roles" button and activating the desired roles. The activated standard OPC UA roles are defined in the OPC UA namespace (http://opcfoundation.org/UA/) and are added in the "User roles" area.

The editor also offers the option of creating custom OPC UA user roles. You can only create self-defined OPC UA user roles for self-defined namespaces of OPC UA server interfaces.

You can check the configuration of the OPC UA user roles by clicking the "Consistency check" button. You can see the result of the consistency check in the Inspector window (Info tab > General). A configuration is faulty in the following cases, for example, and cannot be loaded onto the CPU:

- You use more than 52 role assignments.
- No role from the local user management is assigned to an OPC UA user role.
- An incorrect role from the local user management is assigned to an OPC UA user role:
  - The role is no longer available in the local user management.
  - The "OPC UA server access" function right has been removed from the role.

You configure the access restrictions for namespaces of the OPC UA server in the "Access restrictions" tab. For example, you can specify that client access is restricted to encrypted connections.

Mapping OPC UA user roles

In the "Access control for the OPC UA server" editor, assign a role from the project to the OPC UA user roles. The role from the project must contain the "OPC UA server access" function right.

The editor shows the existing OPC UA user roles in the "User roles" area. The following OPC UA user roles are available by default, with their namespace details for the OPC UA namespace (http://opcfoundation.org/UA/):

- Anonymous: Role for a user without credentials
- AuthenticatedUser: Role that every user with valid credentials automatically has
- SecurityAdmin: Role for the administration of security settings and user permissions

You cannot assign a role from the project to the OPC UA user roles "Anonymous" and "AuthenticatedUser". You must assign a role to the "SecurityAdmin" OPC UA user role that also includes the "Manage certificates" function right.

To assign a role from the project to an OPC UA user role, select the corresponding role in the "Assigned roles in project" column.

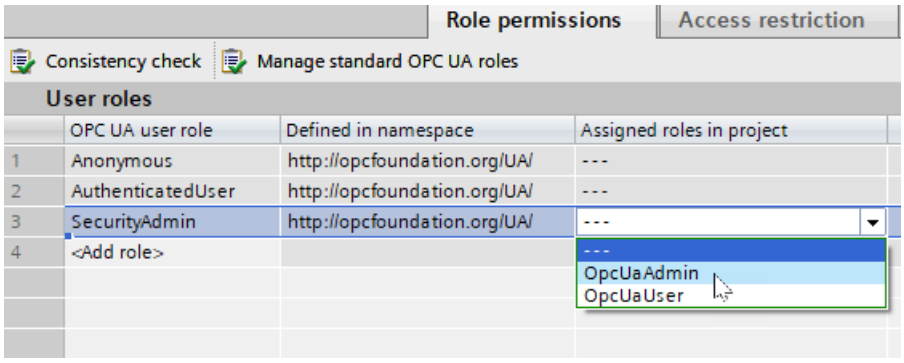

Figure 3-435 Assigning role from the project

Assigning permissions for namespaces

To be able to perform actions in the respective namespaces, you must assign the corresponding permissions for the namespaces to the OPC UA user roles. To do this, select the desired OPC UA user role in the "Access control on the OPC UA server" editor. Then activate the required permissions for the namespaces in the "Assigned default role permissions" area.

Assigned default role permissions SecurityAdmin

	Namespaces	Browse	Read	Write	Call	Receive events	Read role permissions
1	http://opcfoundation.org/UA/	☑	☑	☐	☐	☐	☑
2	urn:SIMATIC:myPLC	☑	☑	☐	☐	☐	☑
3	http://opcfoundation.org/UA/DI/	☑	☑	☐	☐	☐	☑
4	http://www.siemens.com/simatic-s7-opcua	☑	☑	☐	☐	☑	☑

Figure 3-436 Editing permissions for namespaces

By default, no permissions are enabled for the OPC UA user roles "Anonymous" and "AuthenticatedUser" for the namespaces. If you assign permissions for these two OPC UA user roles, this has the following effect on other OPC UA user roles:

- Add permissions:
  - Permissions that you add to the "Anonymous" OPC UA user role are automatically added to all other OPC UA user roles.
    These permissions can only be changed for the "Anonymous" OPC UA user role. All other OPC UA user roles display these permissions in gray and enabled, since each OPC UA user role must have at least the permissions of the "Anonymous" OPC UA user role.
  - Permissions that you add to the "AuthenticatedUser" OPC UA user role are automatically added to all other OPC UA user roles except "Anonymous".
    These permissions can only be changed for the "AuthenticatedUser" OPC UA user role. All other OPC UA user roles, except "Anonymous", show these permissions in gray and enabled.
  - Permissions that you add to the other OPC UA user roles are not added to the "Anonymous" and "AuthenticatedUser" OPC UA user roles.
- Remove permissions:
  - If you remove permissions for the "Anonymous" OPC UA user role, these permissions become subject to editing for the "AuthenticatedUser" OPC UA user role. All other OPC UA user roles show these permissions in gray and enabled.
  - If you remove permissions for the "AuthenticatedUser" OPC UA user role, these permissions become subject to editing for all other OPC UA user roles except "Anonymous".

The following figure shows an example of the permissions assigned to the OPC UA user role "AuthenticatedUser" in namespace 0 (http://opcfoundation.org/UA/). Because the permissions for browse and read access have been added to the "Anonymous" OPC UA user role, the permissions for "AuthenticatedUser" are displayed in gray and enabled. The permission for write access has also been added to the OPC UA user role "AuthenticatedUser".

Assigned default role permissions AuthenticatedUser

	Namespaces	Browse	Read	Write	Call	Receive events	Read role permissions
1	http://opcfoundation.org/UA/	☑	☑	☑	☐	☐	☐
2	urn:SIMATIC:myPLC	☐	☐	☐	☐	☐	☐
3	http://opcfoundation.org/UA/DI/	☐	☐	☐	☐	☐	☐
4	http://www.siemens.com/simatic-s7-opcua	☐	☐	☐	☐	☐	☐

11.2.8.3 How the OPC UA server evaluates permissions on nodes

The following describes how the OPC UA server evaluates a client request (session setup) and manages access depending on the assigned roles and permissions. The node attributes or properties of OPC UA objects mentioned here are set automatically by your configuration of the OPC UA access control in the TIA Portal.

Requirements

For different users you have, for example, assigned names and passwords in the local user management of the CPU.

You have defined several user roles for the OPC UA server of an S7-1500 CPU. These user roles have the "OPC UA server access" function right under "Security settings > Users and roles". The roles are assigned to different users.

The names of the roles in the project and the OPC UA user roles are mapped in the "Access control at OPC UA server" editor.

The user "Joe" is assigned the role "MaintenanceEngineer" in the project.

The "MaintenanceEngineer" role has display and read rights (Browse and Read) for the namespace of a server interface (e.g. "http://server-interface-machine1").

A client requests read access to the "HealthState" node as user "Joe" in the namespace "http://server-interface-machine1".

Example of the review process

In the following example, user "Joe" is assigned the "MaintenanceEngineer" role in the project. The "MaintenanceEngineer" role has browse and read rights for the namespace of a server interface (e.g. "http://server-interface-machine1").

A client requests read access to the "HealthState" node as user "Joe" in the namespace "http://server-interface-machine1".

The check is performed as follows:

1. Authentication: The client with the user name "Joe" logs onto the server of the S7-1500 CPU.
   The CPU authenticates Joe using his credentials (user name and password in the UserNameIdentityToken).
2. Role assignment: After successful authentication, the OPC UA server of the CPU assigns the configured "MaintenanceEngineer" role to the user "Joe".
3. Access request: As a MaintenanceEngineer, "Joe" wants to query maintenance information for a machine. This information is represented by the "HealthState" node in the "http://server-interface-machine1" namespace.
4. Verification of permission and decision: The server first checks whether the "RolePermissions" attribute is set on the "HealthState" node.
   This attribute defines the permissions that apply to a node for all roles that have access to this node.
   - If the attribute exists and the "MaintenanceEngineer" role with the "Read" permission exists in this attribute and there are no access restrictions, access is granted.
     The attribute is only set if permissions have been adapted at node level. This adapting of authorizations on the node level is currently not supported.
   - If the "RolePermissions" attribute does not exist on the node, the server uses the value of the DefaultRolePermissions property from the NamespaceMetadata object that is linked to the node.

     This property is set when permissions are assigned at the namespace level in TIA Portal.

     If the "MaintenanceEngineer" role with the "Read" permission exists in the "http://server-interface-machine1" namespace and there are no access restrictions, access is granted.
   - If none of the above conditions are met, the user "Joe" does not have access to the "HealthState" node.

Users with more than one role

In the example above, only one role is assigned to the user "Joe". If a user has more than one role, the OPC UA server checks the permissions for each role on the node. The resulting permissions result from the OR link of the role permissions.

Example: If at least one of the assigned user roles has the "Write" permission for the node, the user has write permission for this node.

11.2.8.4 Importing nodeset files with role definitions

As of STEP 7 V20, you can also import an included access control configuration when importing nodeset files.

These nodeset files are created with tools outside the TIA Portal, e.g. Siemens OPC UA Modeling Editor SiOME (https://support.industry.siemens.com/cs/ww/en/view/109755133).

Procedure: Import nodeset file with configuration for access control

To import a nodeset file with access control information (role permissions and access restrictions), proceed as follows:

1. Select the entry "OPC UA communication > Server interfaces > Add new server interface" for the desired CPU in the project navigation.
   The "Add new server interface" dialog opens.
2. Select the "Companion specification" type.
3. Select the path to the corresponding XML file.
4. Click the "OK" button.
   STEP 7 displays a warning if there are any abnormalities. Click "OK" to confirm the warning.
   You can find messages about the anomalies in the Inspector window in the "Info > General" area.

Result: You have selected the desired XML file. STEP 7 opens the "Import configuration of the access control " dialog.

Editing and importing the access control configuration

In the "Import configuration of the access control " dialog, select whether or not you want to load the access control configuration from the XML file. If you select the "Keep access control configuration" option, the configuration contained in the XML file will be imported. The dialog offers the following configuration options for the import:

- "Role permissions" tab:
  Shows the OPC UA roles contained in the XML file with the configured permissions for the respective namespaces.
  - Disable OPC UA roles that you do not want to import.
    If an OPC UA role is valid for multiple namespaces, i.e. the role also has permissions in other namespaces, this is displayed in the "OPC UA role" and "Role valid for namespace" columns.
  - You can assign roles from the project to the OPC UA roles contained directly in this dialog.
    In the "Role in project" column, you can select a role from the project in addition to the OPC UA role. Only roles that contain the "OPC UA server access" function right are available for selection.

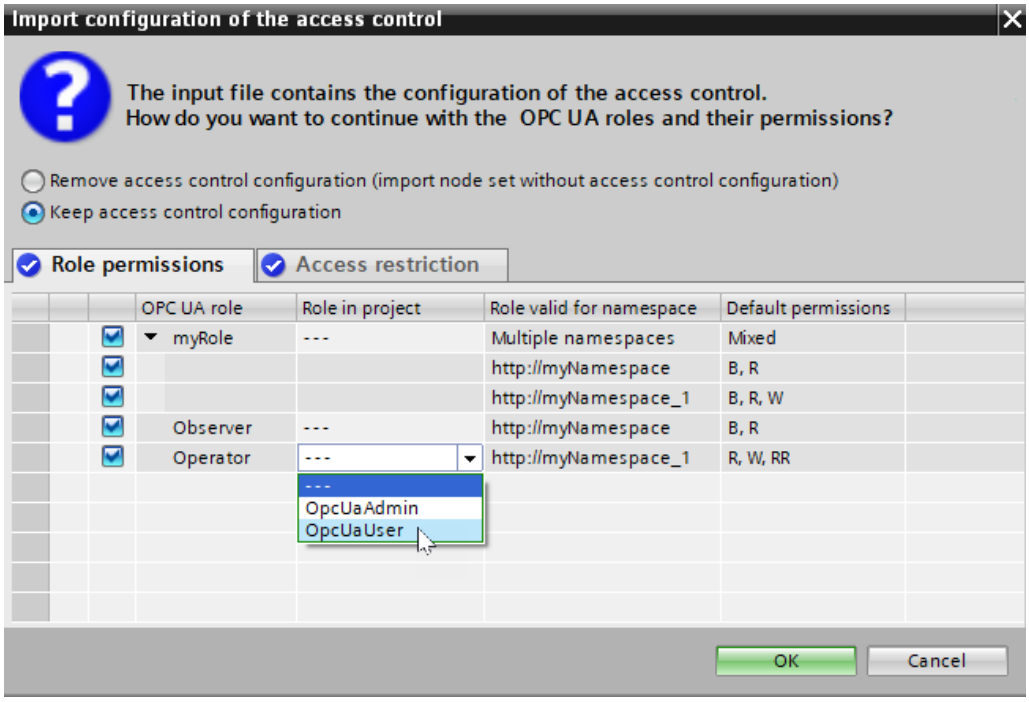

Figure 3-437 Import role permissions

- "Access restrictions" tab:
  If the project already contains namespaces of the same name with differently configured access restrictions, the "Access restrictions" tab displays a warning symbol. Click the tab to compare the access restrictions in the import file and the configured access restrictions in the project for these namespaces.
  Select the desired option for each namespace. Only the selected access restrictions then apply to this namespace after the import.

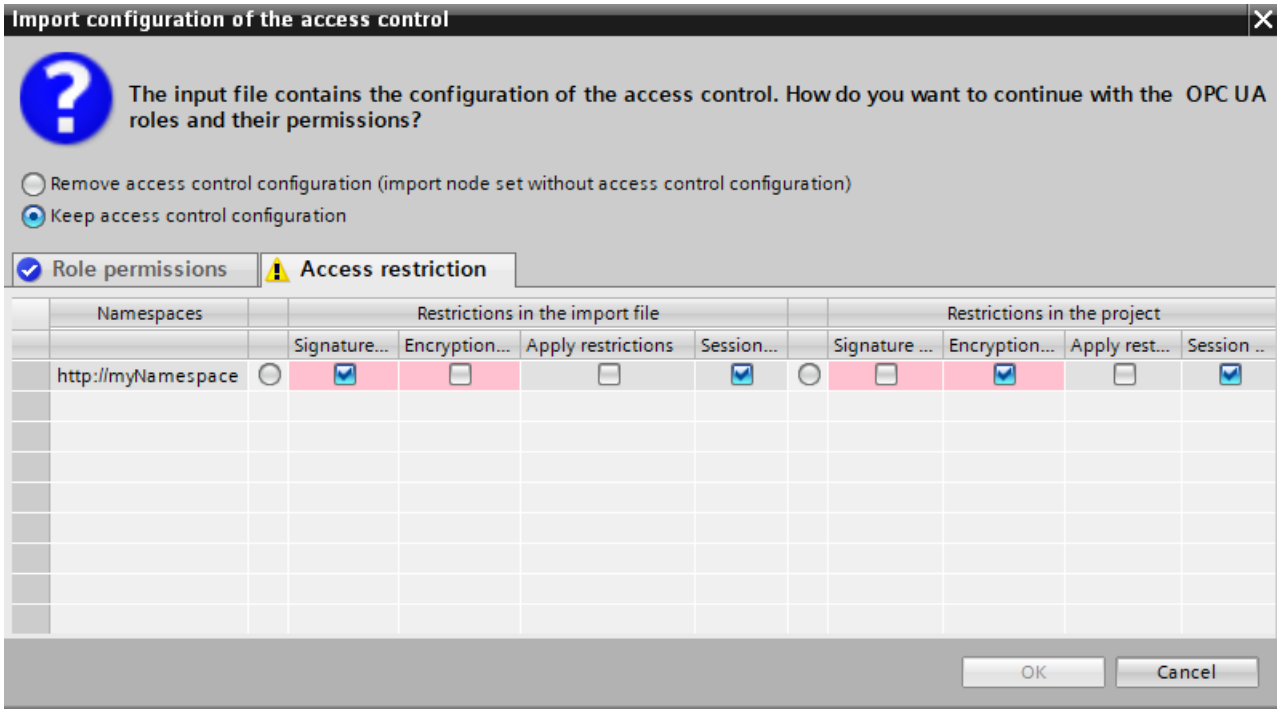

Figure 3-438 Select access restrictions

11.3 Using the S7-1500 as an OPC UA server

11.3.1 Interesting information about the OPC UA server of the S7-1500 CPUs

11.3.1.1 The OPC UA server of the S7-1500 CPUs

The S7-1500 CPUs as of firmware V2.0 are equipped with an OPC UA server. Apart from the Standard-S7-1500 CPUs this applies to the variants S7-1500F, S7-1500T, S7-1500C, S7-1500pro CPUs, ET 200SP CPUs, SIMATIC S7-1500 SW controllers and PLCSIM Advanced.

Convention: "S7-1500 CPUs" also includes the above-mentioned CPU variants.

S7-1500 CPU OPC UA server basics

Access to the OPC UA server of the CPU is possible via all integrated Ethernet interfaces of the S7-1500 CPU.

Direct access to the OPC UA server of the CPU over the backplane bus of the automation system is not possible via CPs under the following conditions:

- Configuration with TIA Portal Version V16 or higher
- S7-1500 CPU firmware version 2.8 or higher and CP 1543-1 firmware version V2.2 or higher

For configuration, see Access to OPC UA applications (Page 178).

Direct access to the OPC UA server of the CPU over the backplane bus of the automation system is not possible via CMs.

For access by clients, the server saves the enabled PLC tags and other information in the form of nodes (see Accessing OPC UA server data (Page 242)). These nodes are interconnected and form a network. OPC UA defines access points to this network (well-known nodes) that enable navigation to subordinate nodes.

With an OPC UA client you can read, observe or write values of tags of the PLC program as well as call methods that are available to the server. As of firmware version 2.5 you can implement methods, see Useful information about server methods (Page 321).

Node classes

OPC UA servers provide information in the form of nodes. A node can be, for example, an object, a tag, a method or a property.

The example below shows the address space of the OPC UA server of an S7-1500 CPU (extract from the OPC UA client "UaExpert" from Unified Automation).

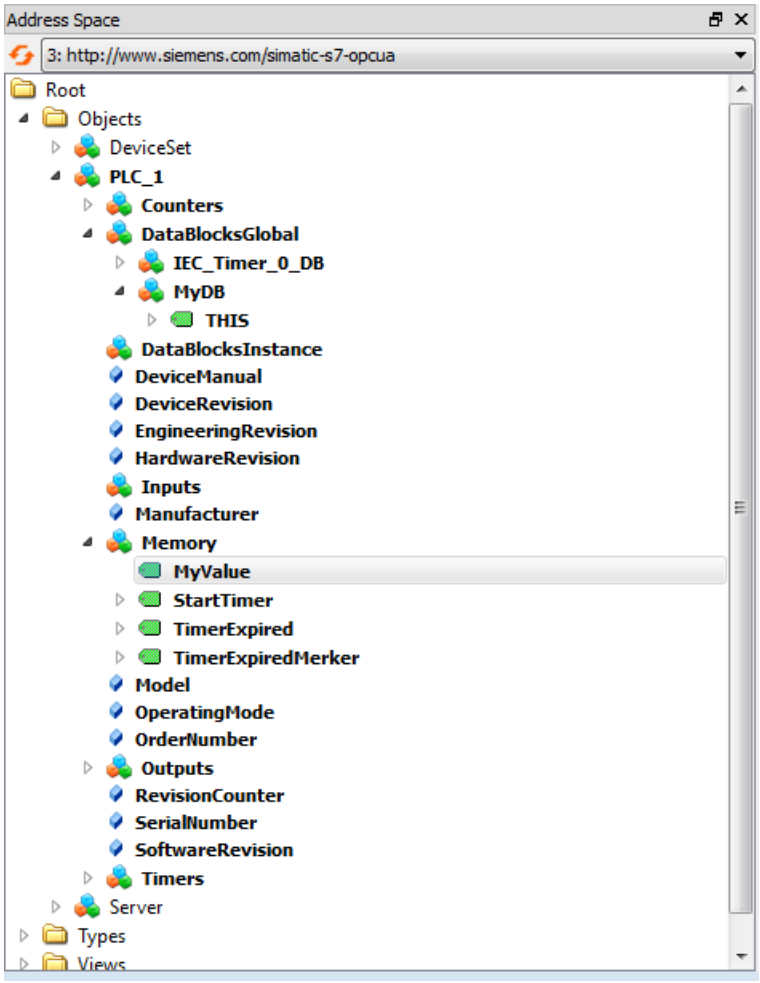

Figure 3-439 Example of the address space of the OPC UA server of an S7-1500 CPU

In the figure above, the "MyValue" tag is selected (highlighted in gray).

This tag is located below the "Memory" node, which has the node class "Object".

"Memory" is below the "PLC_1" node (also an Object).

Address space

The nodes are interconnected via references, e.g. via the "HasComponent" reference, which represents a hierarchical relationship between a node and its subordinate nodes. With their references, the nodes form a network that can, for example, take the form of a tree.

A network of nodes is also called an address space. Starting from the root, all nodes can be reached in the address space.

11.3.1.2 End points of the OPC UA server

The end points of the OPC UA server define the security level for a connection. Depending on the purpose of use or desired security level, you have to carry out the corresponding settings for the connection at the end point.

Different security settings

Before establishing a secure connection, OPC UA clients ask the server with which security settings connections are possible. The server returns a list with all the security settings (endpoints) that the server offers.

Structure of end points

End points consist of the following components:

- Identifier for OPC: "opc.tcp"
- IP address: 192.168.178.151 (in the example)
- Port number for OPC UA: 4840 (standard port)

  The port number can be configured.
- Security setting for messages (Message Security Mode): None, Sign, SignAndEncrypt.
- Encryption and hash procedures (Security Policy): None, Basic128Rsa15, Basic256, Basic256Sha256 (in the example).

The following figure shows the "UA Sample Client" of the OPC Foundation.

The client has established a secure connection to the OPC UA server of an S7-1500 CPU to the end point "opc.tcp://192.168.178.151:4840 - [SignAndEncrypt: Basic256Sha256:Binary]". The security settings "SignAndEncrypt:Basic256Sha256" are contained in the end point.

NOTE

Select an endpoint with a security policy that is as strict as possible for the server

- Only activate the most secure endpoints on the OPC UA server that a client still supports.
- Deactivate the security policy with a lower security policy on the OPC UA server.

Establishing a connection to the server (client-side)

- To establish a connection to the server, select the appropriate security policy for the application.
- Corresponding certificates are required for the activated endpoints of the OPC UA server of the CPU (e.g. a Sha256 certificate for Basic256Sha256).

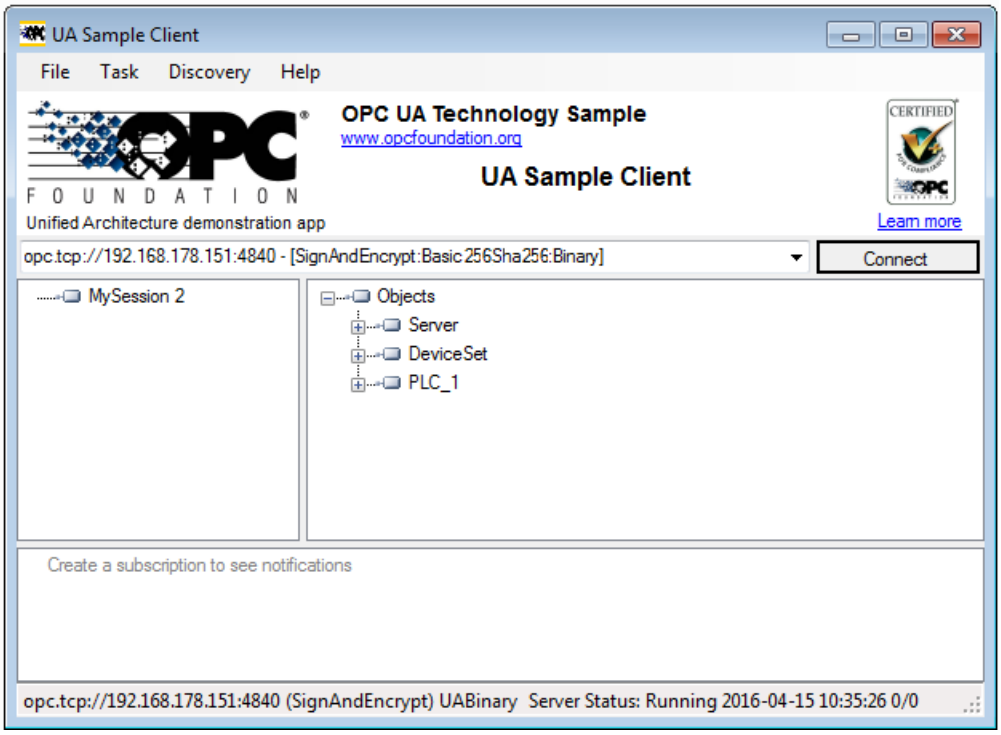

Figure 3-440 "UA Sample Client" program of the OPC Foundation

A connection to a server end point is only established if the OPC UA client complies with the security policies of that end point.

Through the information provided by the OPC UA server

OPC UA servers provide a wide range of information:

- The values of PLC tabs and DB components which clients may access.
- The data types of these PLC tags and DB components.
- Information on the OPC UA server itself and on the CPU.

This gives clients an overview and allows them to read out specific information. Previous knowledge of the PLC program and the CPU data is not required. You do not need to ask the developer of the PLC program when PLC tags are to be read. All necessary information is stored on the server itself (for example, the data types of the PLC tags).

Display of the information of the OPC UA server

You have the following options:

- Online: You have all the available information displayed during the runtime of the OPC UA server. To do so, navigate (browse) the address space of the server.
- Offline: You export an XML file that is based on the XML schemes of the OPC Foundation.

  Server methods created by the user (FB instance that can be called by an OPC UA client) are not exported as of STEP 7 V15.1, see Providing methods on the OPC UA server (Page 321).
- Offline with the Openness API: In your program, you use the API (Application Programming Interface) of the TIA Portal to access the function for exporting all PLC tags that can be read by OPC UA. This requires .NET Framework 4.0; see TIA Portal Openness, Automating SIMATIC projects with scripts (https://support.industry.siemens.com/cs/ww/en/view/109477163).
- If you already know the syntax and the PLC program, you can access the OPC UA server without first researching the information.

11.3.1.3 Mapping of data types

SIMATIC and OPC UA data types

SIMATIC data types do not always correspond with OPC UA data types.

S7-1500 CPUs provide SIMATIC tags (with SIMATIC data types) to their own OPC UA server as OPC UA data types. OPC UA clients can then access these tags with OPC UA data types via the server interface.

A client can read the attribute "DataType" from such a tag and reconstruct the original data type in SIMATIC.

Example

A tag has the SIMATIC data type "COUNTER". You read COUNTER → UInt16 in the table. You now know that you do not need to convert; the COUNTER value is sent over the line as a UInt16 data type.

The client detects from the attribute "DataType" that the tag is actually the SIMATIC data type "COUNTER". With this knowledge, the client reconstructs the data type.

Table 3-943 SIMATIC and OPC UA data types

SIMATIC data type	OPC UA data type
BOOL	Boolean
BYTE	BYTE → Byte
WORD	WORD → UInt16
DWORD	DWORD → UInt32
LWORD	LWORD → UInt64
SINT	SByte

SIMATIC data type	OPC UA data type
INT	Int16
DINT	Int32
LINT	Int64
USINT	Byte
UINT	UInt16
UDINT	UInt32
ULINT	UInt64
REAL	Float
LREAL	Double
S5TIME	S5TIME → UInt16
TIME	TIME → Int32
LTIME	LTIME → Int64
DATE	DATE → UInt16
TIME_OF_DAY (TOD)	TOD → UInt32
LTIME_OF_DAY (LTOD)	LTOD → UInt64
DATE_AND_TIME (DT)	DT → Byte[8]
LDT	DateTime
DTL Special note: You can only describe the structure completely with an OPC UA client. You have read-only access individual elements of this structure (e.g. "YEAR")	mapped as structure
CHAR	CHAR → Byte
WCHAR	WCHAR → UInt16
STRING (Code page 1252 or Windows-1252)	STRING → String
WSTRING (UCS-2; Universal Coded Character Set)	String
TIMER	TIMER → UInt16
COUNTER	COUNTER → UInt16

Arrays

A read or write job with OPC UA is always an array access, which means that it always has an index and length. A single tag is a special case of an array (index 0 and length 1). The data type is simply sent repeatedly on the line. For the tags, the "DataType" attribute indicates the basic data type. The attributes "ValueRank" and "ArrayDimensions" show whether or not you are dealing with an array and how large the array is.

Data types based on arrays

There are SIMATIC data types for which an OPC UA value is mapped to an array of bytes. An array of these data types is then mapped to a two-dimensional array.

Example: The SIMATIC data type DATE_AND_TIME (DT) is mapped on the OPC UA side to an 8-byte array (Byte[8]), see table above. When you define an array of the SIMATIC data type DATE_AND_TIME (DT), then it is considered as two-dimensional array.

This fact affects the use of system data types such as OPC_UA_NodeAdditionalInfo and OPC_UA_NodeAdditionalInfoExt, for example:

For the data types described above, you must use the system data type OPC_UA_NodeAdditionalInfoExt for multidimensional arrays instead of OPC_UA_NodeAdditionalInfo.

Structures

Structures are transferred as ExtensionObject. The S7-1500 server uses binary representation for transmission of the ExtensionObjects over the line; the individual structure elements come one after the other. At the front is the NodeId of the data type; this is used by the client to establish the structure.

For OPC UA Specification <= V1.03, a client has to read, decode and interpret the complete DataTypeDictionary for this (unless it has already learned this library offline through an XML import).

AS of OPC UA V1.04, the DataTypeDefinition attribute is available, which can be read and interpreted more quickly and easily. A client only determines the setup of the structure once, before or during the first access, and then uses this information for the duration of the session.

Special SIMATIC data types

SIMATIC data types that are not in the table above and cannot be defined as elements of a structure or PLC data type are not supported by the OPC UA client.

These are, for example, "ANY" or "POINTER" pointers, function block "Block_FB", function "Block_FC" or hardware data type "REMOTE".

The selection of an unsupported data type leads to an error message.

Additional information

More details on mapping of basic data types, arrays and structures can be found in the OPC UA Specification Part 6, "Mappings" (see OPC UA BINARY there).

What must be considered with arrays and data types DTL and LDT in the OPC UA server of a SIMATIC S7-1500? FAQ (https://support.industry.siemens.com/cs/ww/en/view/109766726)

11.3.1.4 Runtime behavior of the OPC UA server

OPC UA server in operation

The OPC UA server of the S7-1500 CPU starts when you activate the server and download the project to the CPU.

How to activate the OPC UA server is described here.

Behavior in the operating state STOP of the CPU

An activated OPC UA server remains in operation even if the CPU switches to "STOP". The OPC UA server continues to respond to requests from OPC UA clients.

Server response in detail:

- If you request the values of PLC tags, you will get what were the latest values before the CPU switched to or was set to "STOP".
- If you write values to the OPC UA server, the OPC UA server will accept those values.

  However, the CPU will not process the values because the user program is not executed in "STOP" mode.

  An OPC UA client can nonetheless read the values written at STOP from the OPC UA server of the CPU.

  During restart, the CPU overwrites the values written at STOP with the start of the PLC tags.
- If you call a server method, the error message 16#00AF_0000 (BadInvalidState) is output because the server method (user program) is not running.
- Connections to the OPC UA server remain active during an operating mode transition (STOP > RUN or RUN > STOP). Exception: OPC UA-relevant data is loaded, see next section.

Download to the CPU may affect OPC UA server

If you load a CPU with running OPC UA server, you may need to stop and restart the server depending on the loaded objects. In this case, active connections are interrupted and must be re-established once the server restarts.

The duration of the restart depends mainly on the following parameters:

- The scope of the data structure
- The number of variables visible in the OPC UA address space
- The setting for downward compatible data type definition according to OPC UA specification to V1.03 (TypeDictionary enabled)
- Settings for the communication load and minimum cycle time, you can find additional information here (Page 400)

With CPU FW versions older than V2.8, the OPC UA server was stopped at each download to the CPU and then restarted.

As of FW version V2.8, the behavior of the OPC UA server has been optimized as follows:

- When objects are downloaded in STOP operating state of the CPU, the OPC UA server still always stops and then restarts. STEP 7 does not show a warning in this case.
- When objects are downloaded in RUN operating state of the CPU, the OPC UA server only stops if the downloaded objects are, or could be, OPC UA-relevant. The OPC UA server restarts after re-initialization due to the modified OPC UA data.

  Before OPC-UA-relevant objects are loaded into the CPU and stop the OPC UA server, STEP 7 displays a warning in the preview dialog for loading. You can then decide whether a server restart is compatible for the running process or whether you want to cancel the download. These warnings are only displayed when the OPC UA server is running. If the OPC UA server is not enabled, modified OPC UA data have no influence on the download process.

Examples

- You only want to add another code module to the program.
  Neither data blocks nor inputs, outputs, flags, times or counters are affected.
  Reaction during loading: A running OPC UA server is not interrupted.
- You want to load a new data module and you have flagged the data module as non-OPC-UA-relevant:
  Reaction during loading: A running OPC UA server is not interrupted.
- You want to overwrite a data module.
  Reaction during loading: A warning appears that the server will be restarted.
  Background: STEP 7 cannot determine whether the changes refer to OPC-UA-relevant data or not.

Reading CPU operating mode over OPC UA server

The OPC UA server allows you to read out the CPU mode, see figure below:

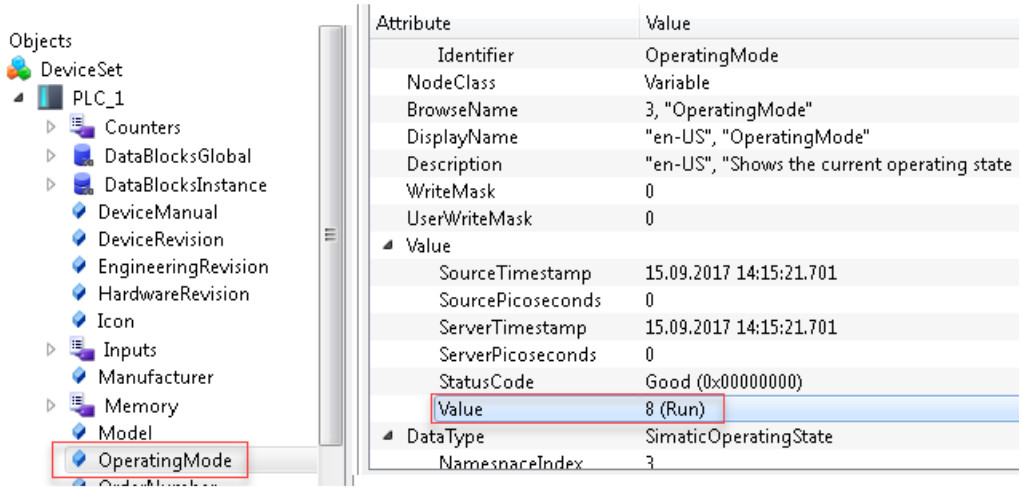

Figure 3-441 Reading CPU operating mode over OPC UA server

In addition to the operating mode of the CPU, you can also read out information about the manual (DeviceManual) or the hardware version (HardwareRevision), for example.

11.3.2 Accessing OPC UA server data

11.3.2.1 Client accesses and local accesses to the OPC UA server

An OPC UA server provides a lot of information for OPC UA clients within a network. The following section describes options for making CPU tags (PLC tags and DB elements) available in the address space of your own OPC UA server.

Provide CPU tags via server interfaces in the OPC UA address space

The easiest way to transfer CPU tags automatically into the address space of the OPC UA server:

- Activate the standard SIMATIC server interface in the OPC UA properties of the CPU.

  All CPU tags released for OPC UA are then automatically also available in the OPC UA address space under the name of the CPU.

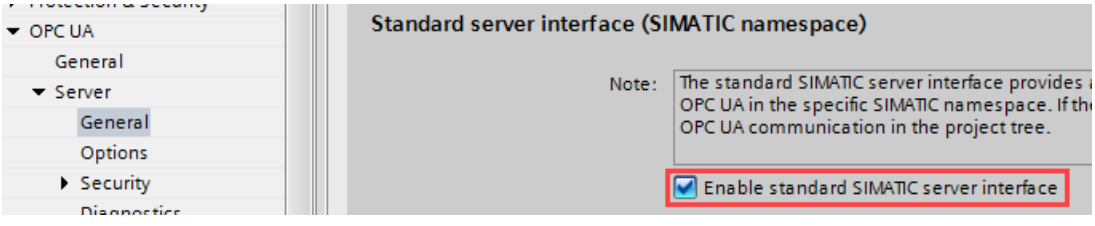

Figure 3-442 Standard SIMATIC server interface of the OPC UA server

The use of OPC UA server interfaces is more flexible and clearer because you configure the server interfaces in the project tree (below the CPU, "OPC UA Communication" folder). User-defined OPC UA server interfaces allow you to easily map OPC UA tags and CPU tags (local data).

OPC UA server interface

Browse name	Node type	Access level	Local data
myServerInterface	Interface	---	
myOPC_UA_Variable	BOOL	RD	"myDataBlock"."myVarBool"
myOPC_UA_Variable2	Word	RD/WR	"myDataBlock"."myVarWord"

Figure 3-443 Creating a user-defined server interface with mapped CPU tags

The data exchange between OPC UA client and OPC UA server is clearly illustrated in the following example of two S7-1500 CPUs.

Here, an S7-1500 CPU as client writes values to an OPC UA tag of the OPC UA server. The mapping between CPU variable and OPC UA tag makes it look as though the OPC UA client writes a value directly into the CPU variable. For an S7-1500 client CPU, use the "OPC_UA_WriteList" instruction in conjunction with additionally required instructions for the data exchange.

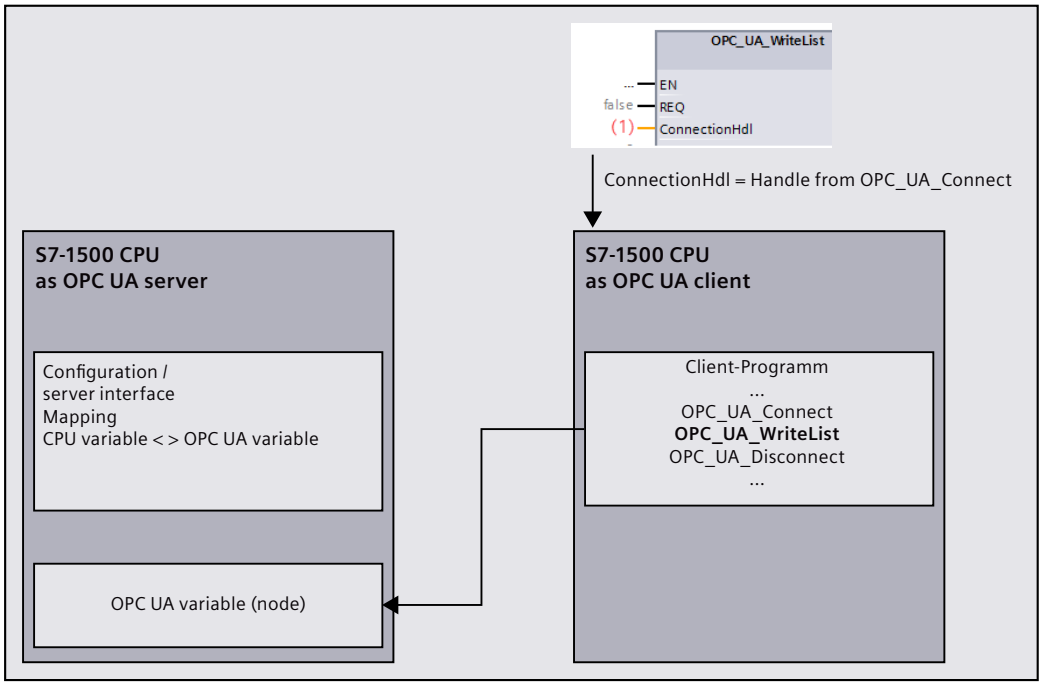

Figure 3-444 Client access to the server's OPC UA tag

Writing CPU tag values directly to OPC UA tags (set OPC UA DataValue)

From firmware version V3.0, S7-1500 CPUs also offer the option of writing values directly to local OPC UA variable nodes on the server using the "OPC_UA_WriteList" instruction in addition to mapping tags. Normally, the "OPC_UA_WriteList" instruction in the client program of the CPU is used to write values to OPC UA tags of a remote OPC UA server.

Advantage of using "OPC_UA_WriteList" in the server: In addition to the value, you can provide the OPC UA tag node with the following additional information:

- SourceTimestamp
- StatusCode

OPC UA provides a built-in "DataValue" data type. DataValue is a structure that records both the Value as well as the SourceTimestamp and StatusCode as additional information for the value. The DataValue structure is only used by OPC UA services and you cannot write directly in the program of the CPU to the elements of this structure. Write access is only possible via a special use of the "OPC_UA_WriteList" instruction.

Application options

CPU variables cannot record a time stamp indicating when a value was last written to the CPU variable. If you map CPU tags and OPC UA tags via server interfaces, the OPC UA server does not therefore set the SourceTimestamp to the time when the CPU tag changed, but to the time when the value was "collected" in the server, such as by a read service or by sampling in the context of a subscription.

If you write DataValue directly with "OPC_UA_WriteList" to an OPC UA tag node, for example, you can provide a time stamp determined in the program as the SourceTimestamp for the value.

Principle functionality of the "OPC_UA_WriteList" instruction for setting DataValues

The DataValue structure is, for example, modeled as a UDT and a tag of this data type is transferred to the "OPC_UA_WriteList" instruction. The instruction then consistently transfers the elements of the tag to the OPC UA tag node.

The value of the "ConnectionHdl" instruction parameter determines the function of the "OPC_UA_WriteList" instruction: Either "Normal" client instruction or instruction to write to local OPC UA tag nodes. OPC UA clients can read the value with additional information in the latter case and evaluate it accordingly.

This principle is illustrated in the following figures, once with any client and once with an S7-1500 CPU as OPC UA client. In the case of the S7-1500 CPU client, the assignment of the DataValue elements to the corresponding instruction parameters of the "OPC_UA_ReadList" instruction is shown. You have full access to all elements of the DataValue structure.

The value of "Read" (-42) of the "OPC_UA_WriteList" instruction causes the server to write to local OPC UA tag nodes.

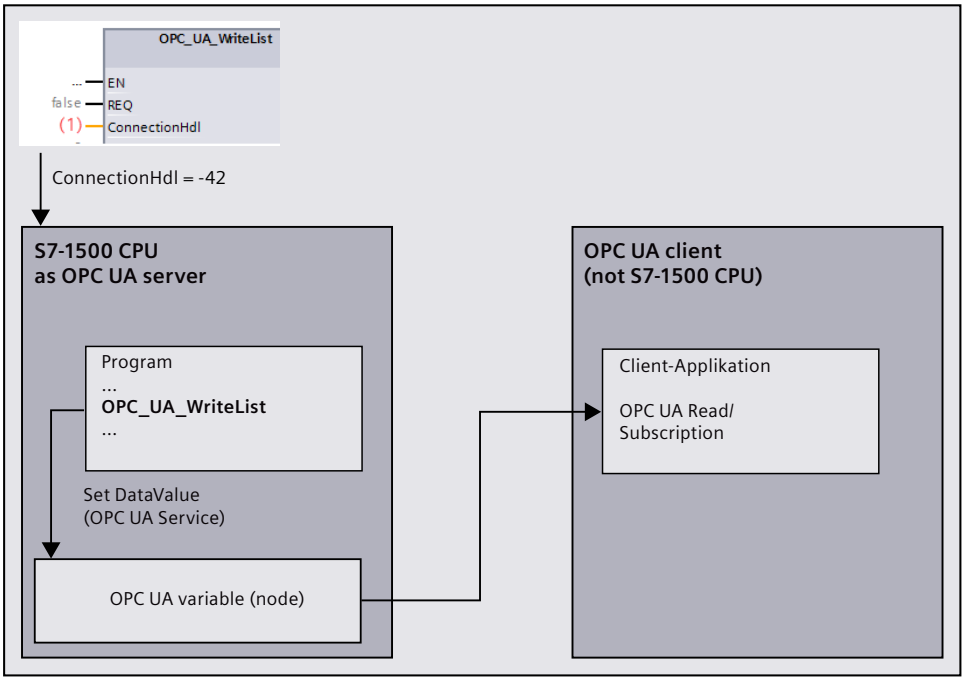

Figure 3-445 Set data value on local OPC UA tag of the server

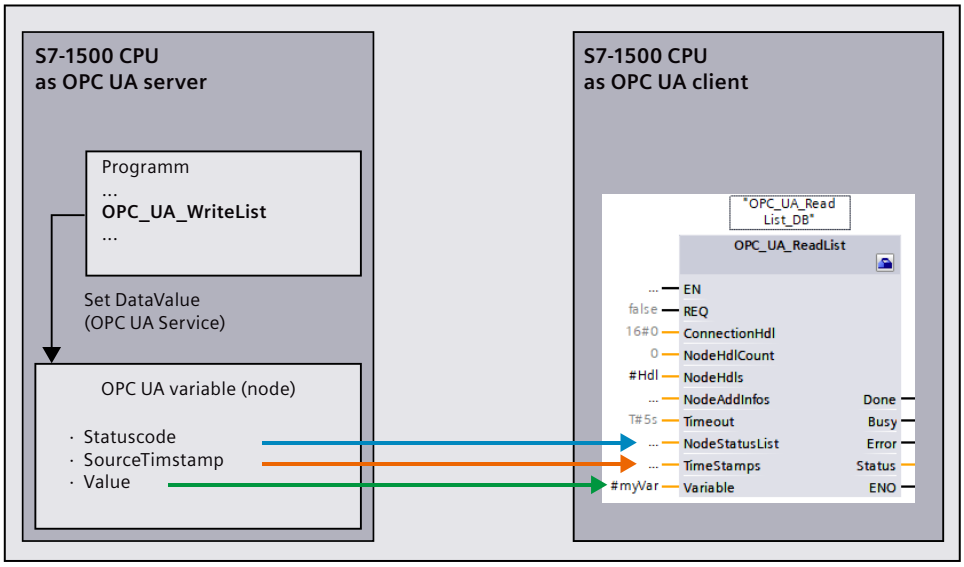

Figure 3-446 Client reads data value (OPC UA tag of the server of the S7-1500 CPU)

Other application options

If OPC UA clients log on with an S7-1500 CPU for value changes (monitored items) in the context of a subscription and you supply the corresponding DataValue with both the value and the additional information mentioned above, then changes to the additional information can also trigger a notification.

Example: A binary value changes so fast that it falls back to its original value in the sampling interval (fast change TRUE > FALSE > TRUE). A change of the value is not detected. But the change of the time stamp is detected. Similarly, a notification can be triggered when the StatusCode changes - even without the value changing.

Constraints

- OPC UA clients are only allowed to read the OPC UA tag; the "AccessLevel" attribute for read/write permissions must be set accordingly for the OPC UA tag.
- Only OPC UA tags of the user-defined server interfaces can be set locally.
- In the user-defined server interface, there must be no mapping to CPU tags for the directly written OPC UA tags.

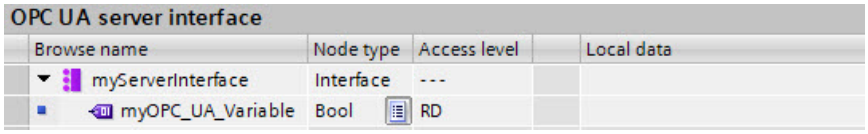

OPC UA server interface

Browse name	Node type	Access level	Local data
myServerInterface	Interface	---	
myOPC_UA_Variable	Bool	RD	

Figure 3-447 User-defined server interface

Details on how to use the "OPC_UA_WriteList" instruction in the "Set OPC UA DataValue" context can be found in the corresponding section of the communication instruction help.

Setting OPC UA DataValue attributes for arrays and structures

When OPC UA tags of type structure or array are set using "OPC_UA_WriteList" for setting OPC UA DataValue attributes, all elements of this structure or array are filled.

You should not model individual elements of structures or arrays additionally as lower-level OPC UA tags.
Reason: If you model individual elements of arrays or structures additionally as separate lower-level nodes in the address space of the server, then these nodes are **not** automatically filled. For the OPC UA server, these separate nodes are independent of the higher-level OPC UA tags of the structure or array type, because they are not mapped to CPU tags.

To fill these separately modeled nodes, you must create each individual element as its own DataValue structure in the program.

Tip: In order for OPC UA clients to be able to simultaneously learn about changes to relevant nodes in this case, set the values of all OPC UA tags involved in the same "OPC_UA_WriteList" call.

More information

An application example (https://support.industry.siemens.com/cs/us/en/view/109820694) is provided to assist you on the topic of "Setting OPC UA DataValue attributes".

You can find information on how to coordinate read and write permissions for CPU-tags in the Coordinating read and write permissions for CPU tags (Page 250) section.

You can find information how to create user-defined server interfaces in the Creating a user-defined server interface (Page 296) section.

11.3.2.2 Managing write and read rights

Enabling PLC tags and DB tags for OPC UA

OPC UA clients can have read and write access to PLC tags and DB tags if the tags are enabled for OPC UA (default setting). For an enabled tag the check box "Accessible from HMI/OPC UA" is activated.

You can change the default setting in the settings of the TIA Portal: Command "Settings > PLC programming > General" in "Options" menu. You will find the corresponding options in the "Block interface/data block elements" area.

The following example shows an array data block:

MyDB

Name	Data type	Accessible from HMI/OPC UA	Writable from HMI/OPC UA	Visible in HMI engineering
MyDB	Array[0..9] o...	☑	☑	☑
MyDB[0]	Int	☑	☑	☑
MyDB[1]	Int	☑	☑	☑
MyDB[2]	Int	☑	☑	☑
MyDB[3]	Int	☑	☑	☑
MyDB[4]	Int	☑	☑	☑
MyDB[5]	Int	☑	☑	☑
MyDB[6]	Int	☑	☑	☑
MyDB[7]	Int	☑	☑	☑
MyDB[8]	Int	☑	☑	☑
MyDB[9]	Int	☑	☑	☑

Figure 3-448 Enabling PLC tags and DB tags for OPC UA tags

This array can be read completely in one pass by OPC UA clients (see Addressing nodes (Page 182)). The check boxes at "Accessible from HMI/OPC UA" and "Writable from HMI/OPC UA" are activated for all the components of the array.

Result: OPC UA clients can both read and write these components.

Removing write rights

If you want to write-protect a tag, deselect the "Writable from HMI/OPC UA" option for that tag. This removes the write right for the OPC UA clients and HMI devices.

Result: Only read access by OPC UA clients and HMI devices is possible. OPC UA clients cannot assign values to this tag and therefore cannot influence execution of the S7 program.

Removing write and read rights

To write-protect and read-protect a tag, disable the "Accessible from HMI/OPC UA" option for that tag (checkbox not selected). This makes the OPC UA server remove the tag from its address space. OPC UA clients can no longer see that CPU tag.

Result: OPC UA clients and HMI devices can neither read nor write the tag.

Write and read rights of structures

If you remove the read or write right for the component of a structure, the structure or the data block cannot be written or read as a whole.

If you remove read and write rights for individual components of a PLC data type (UDT), the rights will also be removed from any data block based on that data type!

Visible in HMI engineering

The option "Visible in HMI Engineering" applies to Siemens engineering tools. If you disable the option "Visible in HMI Engineering" (check mark not set), you can no longer configure the tag in WinCC (TIA Portal).

The option does not have any effect on OPC UA.

Rules

- Only allow read access to PLC tags and tags of data blocks in STEP 7 if this is necessary for communication with other systems (controllers, embedded systems or MES).

  You should not enable other PLC tags.
- Only allow write access over OPC UA if write rights are genuinely necessary for specific PLC tags and tags of data blocks.
- If you have reset the "Accessible from HMI/OPC UA" option for all elements of a data block, the data block for an OPC UA client is no longer visible in the address space of the OPC UA server of the S7-1500 CPU.
- You can also prevent access to an entire data block centrally (see Managing write and read rights for a complete DB (Page 248)). This setting "overrules" the settings for the components in the DB editor.

More information

For information on how to coordinate write and read rights for CPU tags, refer to the section Coordinating write and read rights for CPU tags (Page 250).

11.3.2.3 Managing write and read rights for a complete DB

Hiding DBs or DB contents for OPC UA clients

You can easily prevent access to a complete data block by an OPC UA client.

With this option, the data of the corresponding DB, including instance DBs of function blocks, remains hidden for OPC UA clients.

In the default setting, data blocks can be read and written from OPC UA clients. You can change this default setting in the settings of the TIA Portal: Command "Settings > PLC programming > General" in "Options" menu. You will find the corresponding option in the "Default settings for new blocks" area.

Procedure

Proceed as follows to completely hide a data block for OPC UA clients or to protect a data block from write access from OPC UA clients:

1. Select the data block to be protected in the project tree.
2. Select the "Properties" shortcut menu.
3. Select the "Attributes" area.
4. Select/clear the "DB accessible from OPC UA" checkbox as required.

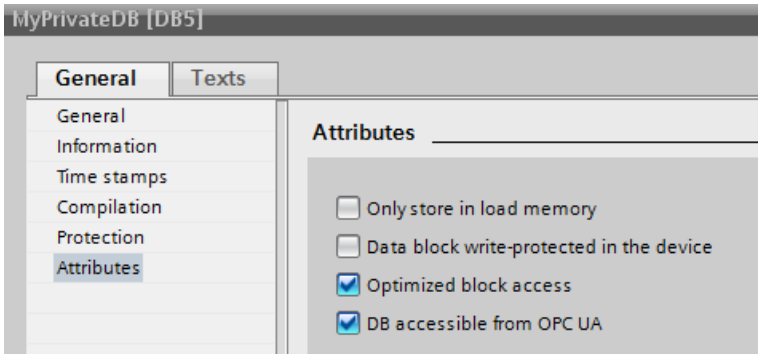

Figure 3-449 Hiding DBs or DB contents for OPC UA clients

NOTE

Effect on settings in the DB editor

If you hide a DB using the DB attribute described here, the settings for the components in the DB editor are no longer relevant; individual components can no longer be accessed or written.

Tip: Using the overview of all program blocks

If you are using multiple data blocks, it is appropriate to use the detailed overview of the "Program blocks" folder for selective activation or deactivation of the OPC UA accessibility.

Follow these steps:

1. Select the "Program blocks" folder in the project tree.
2. Select the "Overview" command in the "View" menu.
3. Select the "Details" tab.

   An overview of the blocks with their attributes is displayed.

4. Ensure that the "Data block accessible via OPC UA" column is selected.
5. Select only the data blocks that are to be accessible via OPC UA.

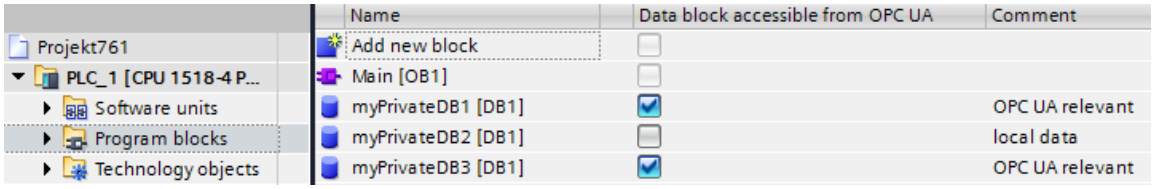

Figure 3-450 Overview of the program blocks

11.3.2.4 Coordinating write and read rights for CPU tags

Definition of write and read rights in the information model (OPC UA XML)

In the OPC UA information model, the attribute "AccessLevel" regulates access to tags.

AccessLevel is defined bit by bit:

Bit 0 = CurrentRead and Bit 1 = CurrentWrite. The meaning of the bit combinations is as follows:

- AccessLevel = 0: no access
- AccessLevel = 1: read only
- AccessLevel = 2: write only
- AccessLevel = 3: read+write

Example of the assignment of write and read rights (read+write)

```
<UAVariable NodeId="ns=3;s=&quot;Data_block_2&quot;.&quot;Static_1&quot;"
BrowseName="3:Static_1"
ParentNodeId="ns=3;s=&quot;Data_block_2&quot;"
DataType="INT"
AccessLevel="3">
    <DisplayName>Static_1</DisplayName>
```

Definition of write and read rights in STEP 7

When you define tags, you specify the access rights using the properties "Accessible from HMI/OPC UA" and "Writable from HMI/OPC UA".

Example of the assignment of write and read rights

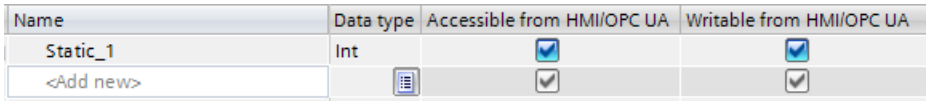

Figure 3-451 Example of the assignment of write and read rights

Interaction between write and read rights

If you have imported an OPC UA server interface and AccessLevel attributes are set in this OPC UA XML file, the write and read rights are defined by the following rule: The least extensive access rights for each setting apply.

Example

- AccessLevel = 1 (read only) in the OPC UA server interface
- Both "Accessible from HMI/OPC UA" and "Writable from HMI/OPC UA" are selected in the PLC tag table

Result: This tag can only be read.

Rules

If write rights are required:

- AccessLevel = 2 oder 3
- "Writable from HMI/OPC UA" enabled

If read rights are required:

- AccessLevel = 1 (AccessLevel 3 is also possible, but misleading. The settings suggests that an OPC UA client has write and read rights)
- "Accessible from HMI/OPC UA" enabled, "Writable from HMI/OPC UA" disabled

If neither read nor write rights are to be granted (no access):

- AccessLevel = 0
- "Accessible from HMI/OPC UA" disabled

  Only one of the two conditions needs to be met to block all access. In this case, review whether the tag in the OPC UA server interface is actually necessary at all.

Access table

"Accessible from HMI/OPC UA" must be set if access over OPC UA is to be possible at all. "Writable from HMI/OPC UA" must be set to allow an OPC UA client to write a tag / DB element.

Please see the table for the resulting access right.

Table 3-944 Access table

OPC UA XML	STEP 7 (TIA Portal), for example tag table		
AccessLevel	**Accessible from HMI/OPC UA**	**Writable from HMI/OPC UA**	**Resulting access right**
0	x	x	No access
x	0	x	No access
1	Enabled	x	Read only
2	Enabled	Disabled	No access
3	Enabled	Disabled	Read only
2	Enabled	Enabled	Write only
3	Enabled	Enabled	Read+write

(x = don't care)

11.3.2.5 Consistency of CPU tags

"AccessLevelEx" attribute extends access properties

As of firmware version V2.6, the OPC UA server of the S7-1500 CPU supports not only the attribute "AccessLevel" (see Coordinating write and read rights for CPU tags (Page 250)) but also the attribute "AccessLevelEx" which, in addition to the already explained bits for read access and write access, provides information on the consistency of a OPC UA tag. The new attribute was introduced with version V1.04 of the OPC UA specification (Part 3, Address Space Model).

Reading consistency properties

In the OPC UA information model of the OPC UA server, the attribute "AccessLevel" defines the access.

AccessLevelEx is defined bit by bit; in this case the relevant bits are:

- Bit 0 = CurrentRead
- Bit 1 = CurrentWrite
- Bits 2 to 7 are not relevant for the OPC UA server of an S7-1500 CPU

The meaning of the bit combinations is explained in the section on read and write rights.

The following bits for consistency are also added:

- Bit 8 = NonatomicRead; the bit is set if the tag cannot be read consistently. For read consistency of tags, bit 8=0.
- Bit 9 = NonatomicWrite; is set if the tag cannot be written consistently. For write consistency of tags, or if no write access is granted, bit 9=0.

Examples

An OPC UA tag (structure) is readable and writable; but inconsistent for reading and writing access.

Consequently: Bits 0, 1, 8 and 9 are set: AccessLevelEx = "771" (1+2+256+512).

Another structure is read-only.

Consequently: Bits 0 and 8 are set, bit 1 and bit 9 are not set: AccessLevelEx = "257" (1+0+256+0).

Handling of the attribute in the server

The "AccessLevelEx" attribute is only available in the OPC UA server. The attribute is not present in a node set file (XML export file).

However, the attribute "AccessLevel", which is exported, includes the information from "AccessLevelEx", see next section.

Export

During XML export of the standard SIMATIC server interface, the server sets the "AccessLevel" attribute, which was expanded to 32 bits in V1.04 compared to V1.03, to the value of the "AccessLevelEx" attribute.

Import

When importing a node set file (e.g. from an export of a server interface), the S7-1500 CPU sets the attribute "AccessLevelEx" according to its own estimate of the consistency of the imported data type, see next section. The imported value is ignored.

Consistency of data types at the server interface

The consistency of tags ("atomicity" in the language usage of OPC UA) within a program cycle of an S7-1500 CPU is ensured at the nodes of the server interface for the following data types:

- BOOL, BYTE, WORD, DWORD, LWORD
- SINT, INT, LINT, DINT, USINT, UINT, ULINT, UDINT
- REAL, LREAL
- DATE, LDT, TIME, LTIME, TIME_OF_DAY, LTIME_OF_DAY, S5TIME
- CHAR, WCHAR
- System data types and hardware data types that are based on the above-mentioned data types are also consistent.

  Example: HW_ANY, derived from UINT (UInt16).

Tip: If you browse in the address space of the S7-1500 CPU (e.g. with the OPC UA Client UaExpert), you can find the consistent data types under Types > BaseDataType > Enumeration/Number/String.

Tags of the following data types are **not** consistent (in the language usage of OPC UA: "nonatomic"):

- SIMATIC structures are generally not consistent. This means that all tags which, for example, have unknown structures or a UDT data type are not consistent.
- System data types such as DTL, IEC_Counter, IEC_TIMER, etc. are data types that are derived from structures.
- Strings (Array of Char) are not consistent.

Tip: If you browse in the address space of the S7-1500 CPU (e.g. with the OPC UA Client UaExpert), you can find data types based on structures under Types > BaseDataType > Structure.

11.3.2.6 Write accesses to OPC UA variables from S7-1500 Motion Control.

In addition to the consistency of the data types, the CPU examines the variables of the technology objects for plausibility and validity.

If an OPC UA client writes an invalid or implausible value to a variable, the original value is retained in the variable of the technology object.

Despite an unsuccessful write access, the status "Good" is output.

Example 1

Interpolation type of the cyclic cam

The variable "Cam_1".InterpolationSettings.InterpolationMode is of type INT, but may only assume the values 1...2.

If you want to change the variable using OPC UA to an invalid value, for example, 3, then the status code "Good" is output, but the variable is not changed.

Example 2

Position the software limit switch at a positioning axis

The position of the positive HW limit switch must be more positive than the position of the negative SW limit switch.

"PosAxis_1".PositionLimits_SW.MaxPosition > "PosAxis_1".PositionLimits_SW.MinPosition

If you want to change the variable using OPC UA to a value that does not meet this condition, then the status code "Good" is output, but the variable is not changed.

Which values are valid for variables of the technology objects can be looked up in the documentation of the technology objects (https://support.industry.siemens.com/cs/ww/en/view/109751049).

11.3.2.7 Accessing OPC UA server data

High performance in line with application

OPC UA is designed for the transfer of a high volume of data within a short period of time. You can increase the performance significantly if you do not access individual PLC tags, but rather read and write arrays and structures as a whole.

It is fastest to access arrays. Therefore, you should combine the data for OPC UA clients into arrays.

Recommendations for access to the OPC UA server by the OPC UA client

- For one-off or infrequent data access, use standard read/write access.
- For cyclic access to small amounts of data (up to ca. every 5 seconds), use subscriptions.

  Optimize the settings for the smallest publishing interval and the smallest sampling interval at the OPC UA server.
- If you access specific tags regularly (recurring access), you should use the functions "RegisteredRead" and "RegisteredWrite".

Allow a greater communication load for the PLC by increasing the value for "Cycle load due to communication". Make sure that your application still works properly with the changed settings.

Procedure for creating an array DB

You can create arrays for example in global data blocks, in the instance data block of a function block or as an array DB . The following sections describe how to create an Array-DB.

To create a data block with an array (array data block), follow these steps:

1. Select the CPU with the OPC UA server in the project tree.
2. Double-click "Program blocks".
3. Double-click "Add new block".
4. Click "Data block".
5. Select a unique name for the data block and accept the name that is already entered.
6. Select the "Array DB" entry from the drop-down list for "Type".
7. Select the data type for the individual components of the array from the drop-down list for "Array data type".
8. Enter the high limit of the array for "Array limit".
9. Click "OK".

11.3.2.8 MinimumSamplingInterval attribute

MinimumSamplingInterval attribute of tags

In addition to "Value", "DataType" and "AccessLevel", you can also set the "MinimumSamplingInterval" attribute for a tag in the XML file that represents the server address space.

The attribute specifies how fast the server can sample the tag value.

The OPC UA server of the S7-1500 CPU handles the values for MinimumSamplingInterval as follows:

- Negative values and values greater than 4294967 are set to -1; this means: The minimum sampling rate is indeterminate. The server does not specify how fast the tag value can be sampled.
- Decimal numbers are rounded to three decimal places.

11.3.2.9 Export OPC UA XML file

Generating an OPC UA export file

The OPC Foundation has specified a standard XML-based format for describing information models. It allows the information model of an OPC UA server to be provided to a client in advance, or information models can be downloaded to an OPC UA server. A file in this format is called a node set file because it describes an information model as a set of nodes.

With STEP 7 (TIA Portal), you can easily export the standard SIMATIC information model of the S7-1500 CPU as a server to an OPC UA XML file (node set file); including the following elements that you have enabled for OPC UA:

- CPU variables (PLC tags and DB elements)
- Function blocks with their inputs/outputs

Elements that exist in the CPU but are not used in the program do not appear in the OPC UA XML file after the export. Examples of such unused elements are:

- UDTs that are not mapped to a data block
- Function blocks with inputs/outputs without assigning inputs/outputs to CPU tags

You use the OPC UA XML file for the offline configuration of an OPC UA client; it is structured according to the OPC UA specification and acts as a standard SIMATIC server interface.

To create and export the OPC UA XML file, follow these steps:

1. Select the CPU. Click on the CPU symbol (for example in the network view).
2. Click "General > OPC UA > Server > Export" in the properties of the CPU.
3. Click "Export OPC UA XML file".
4. Select the directory in which you want to save the export file.
5. Select a new name for the file or keep the name that is already entered.
6. Click "Save".

NOTE

As of STEP 7 (TIA Portal) V15.1, server methods are contained in the OPC UA export file (node set) together with their input and output parameters.

Exporting all array elements separately

If the "Export all array elements as separate nodes" option is selected in the CPU properties under "OPC UA > Server > Export", the OPC UA XML file contains all elements of arrays as individual XML elements. In addition, the arrays themselves are each described in an XML element in the XML file.

If an array contains many array elements, the XML file can be very large.

Tip

The following FAQ contains a converter with which you can convert the export file into CSV format. You then obtain a list of the tags of the CPU that can be accessed by OPC UA.

You can find the FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742903).

11.3.3 Configuring the OPC UA server

11.3.3.1 Enabling the OPC UA server

Requirement

- If you use **certificates** for secured communication, e.g. HTTPS, Secure OUC, OPC UA, make sure that the modules involved have the **current time of day and the current date**. Otherwise, the modules evaluate the used certificates as invalid and secure communication does not work.
- You have acquired a runtime license for the operation of the OPC UA functions, see License for OPC UA (Page 282).
- If access control is enabled and you are using user management (local or central): The users must have the "OPC UA server access" function right.
  You can find information on the assignment of the "OPC UA server access" function right in the Siemens Industry Online Support under the following entry ID: SIOS Entry ID 109954947 (https://support.industry.siemens.com/cs/us/en/view/109954947)

Commissioning an OPC UA server

By default, the OPC UA server of the CPU is not enabled for reasons of security: OPC UA clients have neither write nor read access to the S7-1500 CPU.

Follow these steps to activate the OPC UA server of the CPU:

1. Select the CPU in STEP 7. To do this, click the CPU symbol in the device or network view of STEP 7.
2. In the CPU properties, navigate to "OPC UA > Server".
3. Activate the OPC UA server of the CPU.
4. Confirm the security notes.
5. In the CPU properties, navigate to the "Runtime licenses" area and set the purchased Runtime license for the OPC UA server.
6. Compile the project.
7. Download the project to the CPU.

   The OPC UA server of CPU now starts.

Settings remain stored

If you have already enabled the server and made settings, those settings are not lost if the server is disabled. The settings are saved as before and are available when you enable the server again.

Application name

The application name is the name of the OPC UA application and applies to the server and the client. The name is displayed as follows under "OPC UA > General":

- Up to STEP 7 V20:
  - The default setting is made up of "SIMATIC.S7-1500.OPC-UA.Application:" and the name of the CPU as assigned under "General > Project information > Name".
  - If, for example, the name "PLC_1" has been assigned to the CPU, the default setting for the application name is: "SIMATIC.S7-1500.OPC-UA.Application:PLC_1".
- As of STEP 7 V21 and a CPU as of FW version V4.1:
  - The default setting for the application name is the name of the CPU as assigned under "General > Project information > Name", e.g. "PLC_1".
- The OPC UA server uses this application name to identify itself to a communication partner (OPC UA client), for example, when an OPC UA client uses the discovery service to detect accessible servers.
- The displayed application name uses the OPC UA client of the CPU to establish a connection to an OPC UA server. This means that the CPU automatically carries this application name as "ApplicationName" for the "OPC_UA_Connect" instruction ("OPC_UA_SessionConnectInfo" type variable at the "SessionConnectInfo" parameter of "OPC_UA_Connect").

  When you program the instruction "OPC_UA_Connect" you must therefore assign an empty string to the "ApplicationName". You can use the application name, for example, to identify the client with its sessions (SessionNames) for diagnostic purposes.

If you have activated the server, you can also use a different name that is meaningful in your project and that fulfills the requirements of your project, e.g. for worldwide uniqueness.
The application name is also used for the server name. If you change the application name, the changes are automatically applied to the server name. Changes to the server name by the user are not possible.

The example below originates from UaExpert:

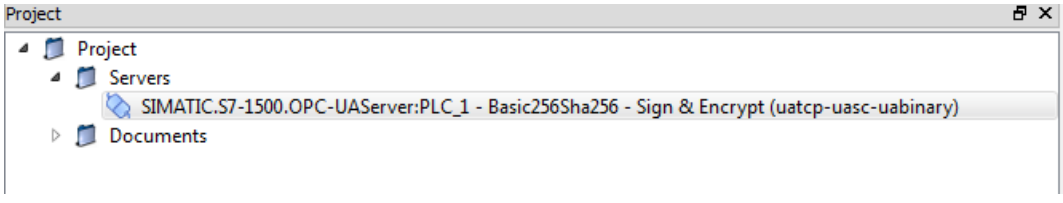

Application URI

The application URI is the unique identifier of the application and applies to the server. The structure of an application URI must comply with the syntactic rules specified for it. In STEP 7 from V21, CPUs as of FW version V4.1 are appended to the prefix "urn:" and the namespace identifier "SIMATIC:" is followed by the application name, e.g. "PLC_1". The application URI generated in this case is: "urn:SIMATIC:PLC_1". Special characters in the application name are encoded using the syntactic rules when the application URI is generated.
You can find information on the application name and the generated application URI in the CPU properties under "OPC UA > General".

The application URI is also used for the server URI. If you change the applications URI, the changes are automatically applied to the server URI. Changes to the server URI by the user are not possible. The server URI designates the namespace for the server and is located in the NamespaceArray under the fixed index 1. The client URIs are also derived from the server URI.

The server URI is also entered in the certificate (Subject Alternative Name). If the server URI changes, you must create a previously created certificate again so that the certificate contains the correct server URI.

Dependencies for name changes

In the basic settings, the following dependencies apply between the assigned CPU name, application name and application URI:

- The assigned CPU name is adopted as the application name.
- The application URI contains the application name that was taken from the assigned CPU name.
- If you change the CPU name, the changes are applied to the application name and consequently to the application URI.

If you change the application name or the application URI manually, the dependencies mentioned above will be lost. The changes have the following effect:

- Changes to the application name:
  - The application URI is regenerated with the changed application name.
  - The assigned CPU name remains unchanged.
  - Changes to the CPU name are no longer applied to the application name and therefore to the application URI.
- Changes to the application URI:
  - Changes to the application name are no longer applied to the application URI.

To restore the basic settings for the application name or URI text boxes, proceed as follows:

1. Select the CPU in STEP 7. To do this, click the CPU symbol in the device or network view of STEP 7.
2. In the CPU properties, navigate to "OPC UA > General".
3. Remove the entry in the "Application name" or "Application URI" field. Depending on which dependency you want to restore.
4. Confirm with the Enter key.
5. Optional: Repeat steps 3 and 4 to re-establish another dependency.

Result: You have restored the dependency or dependencies from the basic settings.

11.3.3.2 Access to the OPC UA server

Server addresses

The OPC UA server of the S7-1500 CPU can be reached over all integrated PROFINET interfaces of the CPU (firmware V2.0 and higher).

Direct access to the OPC UA server of the CPU over the backplane bus of the automation system is not possible via CPs under the following conditions:

- Configuration with TIA Portal Version V16 or higher, S7-1500 CPU firmware version 2.8 or higher and CP 1543-1 firmware version V2.2 or higher.

  For configuration, see Access to OPC UA applications (Page 178).

Direct access to the OPC UA server of the CPU over the backplane bus of the automation system is not possible via CMs.

With SIMATIC S7 1500 SW controllers, access to the OPC UA server is possible via PROFINET interfaces that are assigned to the software PLC.

Additional access options of SW controllers are described in the following application example: Internal and external OPC UA connection via the virtual Ethernet interface of the software controller V2.5 or higher (https://support.industry.siemens.com/cs/ww/en/view/109760541).

Example for URLs (Uniform Resource Locator) that can be used to set up connections to the OPC UA server of the CPU:

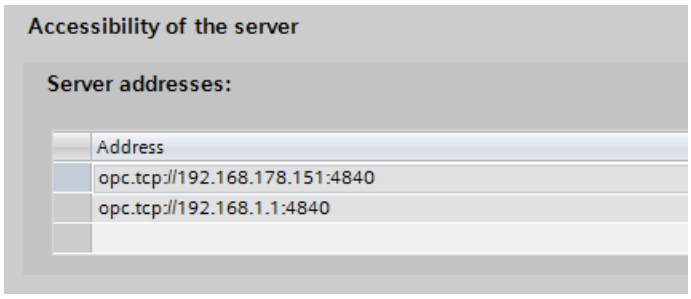

Figure 3-452 Display of the server addresses

The URLs are structured as follows:

- Protocol identifier "opc.tcp://"
- IP address
  - 192.168.178.151

    The IP address at which the OPC UA server can be accessed from the Ethernet subnet 192.168.178.
  - 192.168.1.1

    The IP address at which the OPC UA server can be accessed from the Ethernet subnet 192.168.1.
- TCP Port number
  - Default: 4840 (standard port)

    The port number can be changed under "OPC > UA > Server > Port".

Dynamic IP addresses

In the example below, the IP address for the PROFINET interface [X2] has not yet been specified.

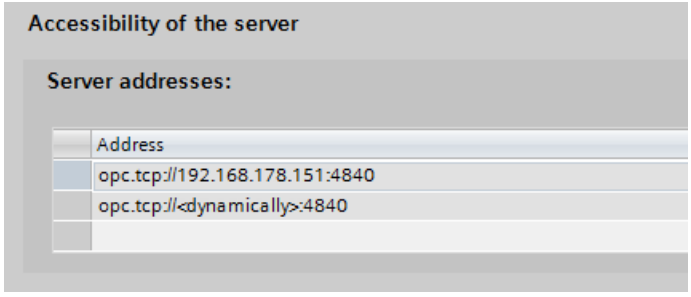

Figure 3-453 Display of the server addresses with dynamic IP address

The placeholder "<dynamically>" appears in the table.

The IP address of this PROFINET interface is set later on the device, e.g. via the display of the CPU.

Activating the standard SIMATIC Server interface

If the "Enable standard SIMATIC server interface" option is selected, the OPC UA server of the CPU provides the enabled PLC tags and server methods to the clients, as was specified by SIEMENS in the self-defined namespace.

This option is selected in the default setting.

Leave the option selected so that OPC UA clients can automatically connect to the OPC UA server of the CPU and exchange data.

If you do not select this option, you must add the server interface by entering the "OPC UA communication" entry in the project tree. This interface is then used as OPC UA server interface, see OPC UA server interface configuration (Page 282).

NOTE

General device information is readable even with deactivated standard SIMATIC server interface

Even if you disable the standard SIMATIC server interface, OPC UA clients can read general device information about the OPC UA server of the CPU.

Examples of such device information: DeviceManual, DeviceRevision, OrderNumber. In this case, however, all objects of the application program remain invisible to clients.

If you want to prevent that this device information is not visible, you have to disable the OPC UA server of the CPU.

11.3.3.3 General settings of the OPC UA server

TCP port for OPC UA

By default, OPC UA uses TCP port 4840. You can, however, select a different port. Entries from 1024 to 49151 are possible. You must, however, make sure that there are no conflicts with other applications. OPC UA clients must use the selected port when establishing a connection.

In the example below, port 48400 is selected:

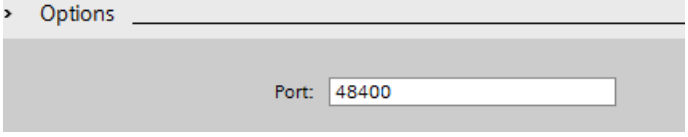

Figure 3-454 TCP port for OPC UA

An overview of the supported protocols and the port numbers used by the S7-1500 CPUs can be found in section Communications protocols and port numbers used for Ethernet communication (Page 36).

Settings for sessions

- Maximum timeout for sessions

  In this field, you specify the maximum time period before the OPC UA server closes a session without data exchange.

  Possible values between 1 and 600000 seconds.

- Maximum number of OPC UA sessions

  In this field, you specify the maximum number of sessions the OPC UA server starts and simultaneously operates.

  The maximum number of sessions is dependent on the performance capability of the CPU. Each session ties up resources.

Maximum number of registered nodes

In this field, you specify the maximum number of nodes the OPC UA server registers.

The maximum number of registered nodes depends on the capacity of the CPU and is displayed when you configure the field content (place cursor in field). Each registration ties up resources.

NOTE

No error message following attempt to register more than the configured maximum number of registrable nodes

If a client tries to register more nodes during runtime than the configured maximum number, the server of the S7-1500 CPU only registers the configured maximum number. Starting from the configured maximum number of registrable nodes, the server returns the regular string node IDs unchanged to the client so that the speed advantage gained by registration for these nodes is lost. The client does not receive an error message.

When configuring, make sure you have a sufficient reserve by taking into account the maximum number of nodes that can be registered (for example, using the technical data of the CPU).

Additional information

Details on which ports are used by the various services for data transfer via TCP and UDP, and what are the points to note when using routers and firewalls can be found in the FAQ (https://support.industry.siemens.com/cs/ww/en/view/8970169).

Backward compatible data type definitions according to OPC UA specification ≤ V1.03

The OPC UA specification (<= V1.03) defines mechanisms in order to read out data type definitions, for example for user-defined structures (UDTs), from a server by means of the TypeDictionaries.

In the OPC UA server properties of the CPU, you can set whether the CPU generates these backward compatible data type definitions according to the OPC UA specification ≤ V1.03 for the standard SIMATIC server interface or not.

Because TypeDictionaries are complex and result in large OPC UA XML files (server interfaces) which the client has to interpret, a simpler solution was introduced with OPC UA Specification V1.04 (attribute "DataTypeDefinition" at the data type node). If your client supports the OPC UA specification V1.04 or higher, then disable the option.

Advantages of the data type definitions according to OPC UA specification as of V1.04:

- The server starts faster
- The memory is used more efficiently
- The "Browse" function is faster

11.3.3.4 Settings of the server for subscriptions

Subscription instead of cyclic queries

An alternative to cyclic queries for a PLC tag (polling) is to monitor this value. Use a Subscription: The server informs the client if the value of PLC tags changes.

One server usually monitors a large number of PLC values. For this reason, the server sends notifications to the client at regular intervals containing the new values of the PLC tags.

Advantages of subscriptions:

- The server starts faster
- The memory is used efficiently

How frequently does the server send notifications?

When a Subscription is set up, the OPC UA client specifies the intervals at which it wants to be sent the new values in the event of changes. To limit the communication load through OPC UA, set a minimum interval for the messages. For this purpose, use the parameters for the minimum publishing interval and the minimum sampling interval.

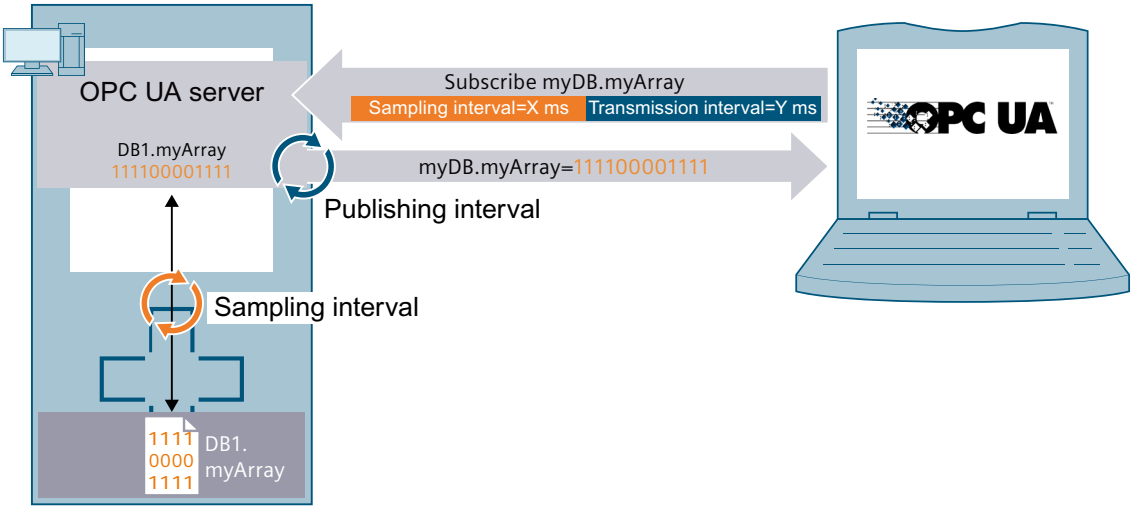

Figure 3-455 Principle of a subscription

Minimum publishing interval

With "Minimum publishing interval", you set the time intervals at which the server sends a message to the client with the new values in the event of changes.

250 ms is used as the "Minimum sampling interval" in the figure below. The value 200 ms is entered as the "Minimum publishing interval".

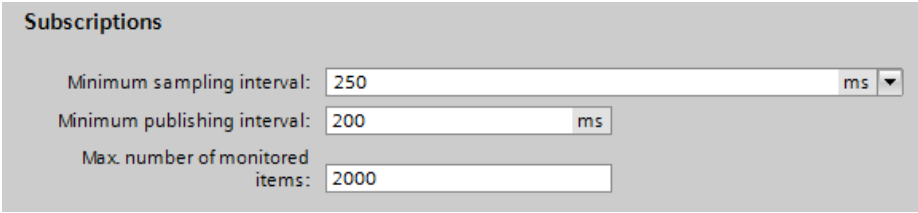

Figure 3-456 Subscription settings

In the example, following a value change the OPC UA server will send a new message every 200 ms if the OPC UA client requests an update.

If the OPC UA client requests an update every 1000 ms, the OPC UA server will only send a message with the new values once every 1000 ms (one second).

If the OPC UA client requests an update every 100 ms, the server will still only send a message every 200 ms (minimum publishing interval).

Minimum sampling interval

With "Minimum sampling interval", you set the time intervals at which the OPC UA server records the value of a CPU tag and compares it with the previous value to detect any changes.

If the sampling interval is selected smaller than the publishing interval and an OPC UA client requests a high sampling rate for certain PLC tags, two or more values may be measured during each publishing interval.

In this case, the OPC UA server writes the value changes into the queue and sends all value changes to the client after the completion of the publishing interval. If more value changes occur in the publishing interval than fit in the queue, the OPC UA server overwrites the oldest values (depending on the set "Discard Policy" of the client subscribing to the data, the option "Discard Oldest" has to be activated in this case). The most recent values are sent to the client.

Maximum number of monitored elements (monitored items)

In this field, you specify the maximum number of elements that the OPC UA server of the CPU simultaneously monitors for a value change.

The monitoring ties up resources. The maximum number of monitored elements is dependent on the utilized CPU.

More information

Information about the system limits of the OPC UA server of the S7-1500 CPUs (firmware V2.0 and V2.1) regarding subscriptions, sampling intervals and publishing intervals can be found in the following FAQ (https://support.industry.siemens.com/cs/ww/en/view/109755846).

When using subscriptions, certain status codes of errors provide information on the error that occurred. For information on causes and remedies for status codes of OPC UA client that appear, see the list of error codes in the online help of STEP 7 (TIA Portal) or in the following FAQ (https://support.industry.siemens.com/cs/ww/en/view/109755860).

The rules for subscriptions are available in section Rules for subscriptions (Page 400).

You will find information about the diagnostics of subscriptions in the section Subscription diagnostics (Page 358).

11.3.3.5 Using the TransferSubscription service

Useful information on transferring subscriptions

The OPC UA specification provides that OPC UA clients may transfer a subscription with its monitored items from one session to another session (see OPC 10000-4: UA Part 4: Services – in particular, "TransferSubscriptions" section).

The OPC UA server of an S7-1500 CPU supports the transfer of subscriptions as of firmware version V3.1.4.

Application examples:

- Interruption/timeout of an active session: e.g. due to a communication disruption: subscription transfer from an interrupted session to an active session to avoid data loss.
- A client is to be shut down; another client takes over the subscription.
- Load distribution: subscription transfer from one active session to another active session or to a new session.

Benefits of a subscription transfer:

- The transfer of a subscription prevents data loss (in the event of client failure, disconnection or overload).

  The TransferSubscription service enables the transfer of subscribed data. With this service, you solve the encountered connection termination problem in the following way:

  If the connection of the client taking over the subscription to the server has been established, it is not necessary to re-create the subscription with all monitored items. The accumulated, i.e. unsent, notification messages can be republished after the successful subscription transfer. See also OPC 10000-4: UA Part 4: Services, section "Re-establishing connections".
- The transfer of a subscription spares the OPC UA client the time- and resource-intensive process of creating a subscription.

  When a subscription with a large number of monitored items is created, a high CPU load is generated.

Requirement

A configuration for the S7-1500 OPC UA server is not required; the "TransferSubscription" service is provided on request of an OPC UA client.

All S7-1500 CPUs as of firmware V3.1.4 support the transfer of subscriptions.

Additional requirements:

- Users (clients) must have a role that grants them Read permission.
- If a subscription of an already closed session is to be transferred, the process must be completed within the subscription timeout.
- Subscriptions can be transferred both between sessions of an authenticated user and between sessions of anonymous users.
  - For authenticated users, both sessions must be assigned to the same user.
  - For anonymous users, the connection must also be encrypted and the sessions must have been created by clients with identical application URIs.

11.3.3.6 Handling client and server certificates

A secure connection between the OPC UA server and an OPC UA client is only established when the server can prove its identity to the client. This is done with the server certificate.

Certificate of the OPC UA server

When you have activated the OPC UA server and have confirmed the security prompts, STEP 7 automatically generates the certificate for the server and saves it in the local certificate directory of the CPU. You can view and manage this directory with the local certificate manager of the CPU (exporting or deleting certificates).

The figure below shows the local certificate manager of the CPU with the automatically generated certificate for the OPC UA server:

Figure 3-457 Local certificate manager of the CPU

Alternatively, you can also generate a server certificate yourself.

The certificate of the server is transferred from the server to the client during establishment of a connection. The client checks the certificate.

The client user decides whether the server certificate is to be trusted.

The user at the client side now has to decide whether the server certificate is to be trusted. If the user trusts the server certificate, the client stores the server certificate in its directory containing the trusted server certificates.

The following example shows a dialog of the client "UA Sample Client". When the user clicks the "Yes" button, the client trusts the server certificate:

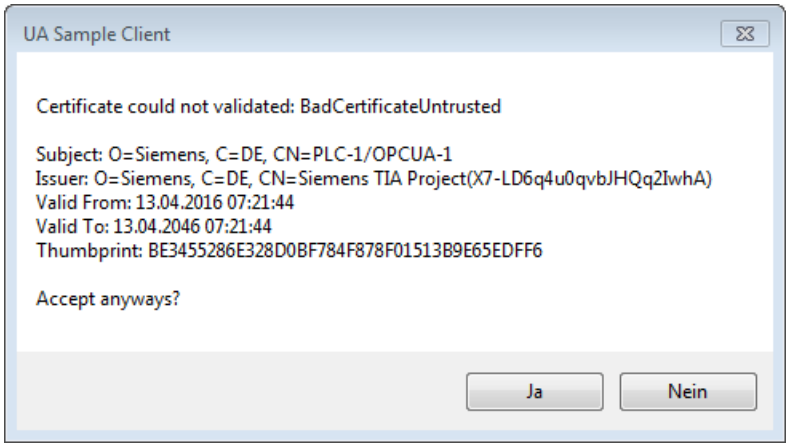

Figure 3-458 Dialog of the client "UA Sample Client"

Where does a client certificate come from?

Client of the S7-1500

If you are using the OPC UA client of an S7-1500 CPU (OPC UA client enabled), you can create certificates for these clients with STEP 7 as of V15. As of STEP 7 V21 and FW version V4.1 of a CPU, you can also manage the client certificates via a GDS (Global Discovery Server).

If you want to configure and manage the client certificates via GDS, continue reading in the section Handling client certificates during runtime (Page 390).
To create a local client certificate, proceed as follows:

1. In the "Project navigation", select the CPU that functions as the client.
2. Double-click "Device configuration".
3. In the properties of the CPU, click "Protection & Security > Certificate manager".
4. In the "Device certificates" table, double-click "<Add new>".

   STEP 7 opens a dialog.
5. Click the "Create" button.
6. Select the "OPC UA client" entry from the "Usage" list.

   Note:

   The URI and IP addresses under which the CPU can be accessed in your system must be entered under "Subject Alternative Name (SAN)".

   You must therefore configure the name and the IP interfaces of the CPU before you generate a client certificate.

7. Click "OK".

   STEP 7 now shows the client certificate in the "Device certificates" table.
8. Right-click this line and select the "Export certificate" entry from the context menu.
9. Select a directory where you will store the client certificate.

Clients of other manufacturers

When you use UA clients from manufacturers or the OPC Foundation, a client certificate is generated automatically during installation or upon the first program call. You have to import these certificates via the global certificate manager in STEP 7 and use them for the corresponding CPU (as shown above).

When you program an OPC UA client yourself, you can have the certificates generated by the program; see the section "Instance certificate for the client". Alternatively, you can generate certificates with tools, for example with OpenSSL or the certificate generator of the OPC Foundation:

- The procedure for OpenSSL is described here: "Generating PKI key pairs and certificates yourself".
- Working with the certificate generator of the OPC Foundation is described here: "Creating self-signed certificates".

Announcing client certificates to the server

You need to send client certificates to the server to allow a secure connection to be established.

To do this, follow these steps:

1. Select the "Use global security settings for certificate manager" option in the local certificate manager of the server. This makes the global certificate manager available.

   You will find this option under "Protection & Security > Certificate manager" in the properties of the CPU that is acting as server.

   If the project is not yet protected, select "Security settings > Settings" in the STEP 7 project tree, click the "Protect this project" button and log on.

   STEP 7 now displays the entry "Security functions" in the "Project navigation" under "Security settings".
2. Double-click "Security functions".
3. Double click "Certificate manager".

   STEP 7 opens the global certificate manager.
4. Click on the "Trusted certificates" tab.
5. Right-click in the tab on a free area (not on a certificate).
6. Select the "Import" command from the context menu.

   The dialog for importing certificates is displayed.
7. Select the client certificate that the server is to trust.

8. Click "Open" to import the certificate.

   The certificate of the client is now contained in the global certificate manager.

   Note the ID of the client certificate just imported.
9. Click the "General" tab in the properties of the CPU that is acting as server.
10. Click the area "OPC UA > Server > Security > Certificates".
11. In the Inspector window, scroll down to the "Trusted clients" section.
12. In the table, double-click on the empty row with "<Add new>". A browse button is displayed in the row.
13. Click this button.
14. Select the client certificate that you have imported.
15. Click the button with the green check mark.
16. Compile the project.
17. Load the configuration onto the S7-1500 CPU.

Result:

The server now trusts the client. If the server certificate is also considered trusted, the server and client can establish a secure connection.

Accepting client certificates automatically

When you select the option "Automatically accept all client certificates during runtime" (below the "Trusted clients" list), the server automatically accepts all client certificates.

NOTICE
Setting after commissioning In order to avoid security risks, deactivate the "Automatically accept client certificates during runtime" option again after commissioning.

Configuring security settings of the server

The figure below shows the available server security settings for signing and encrypting messages.

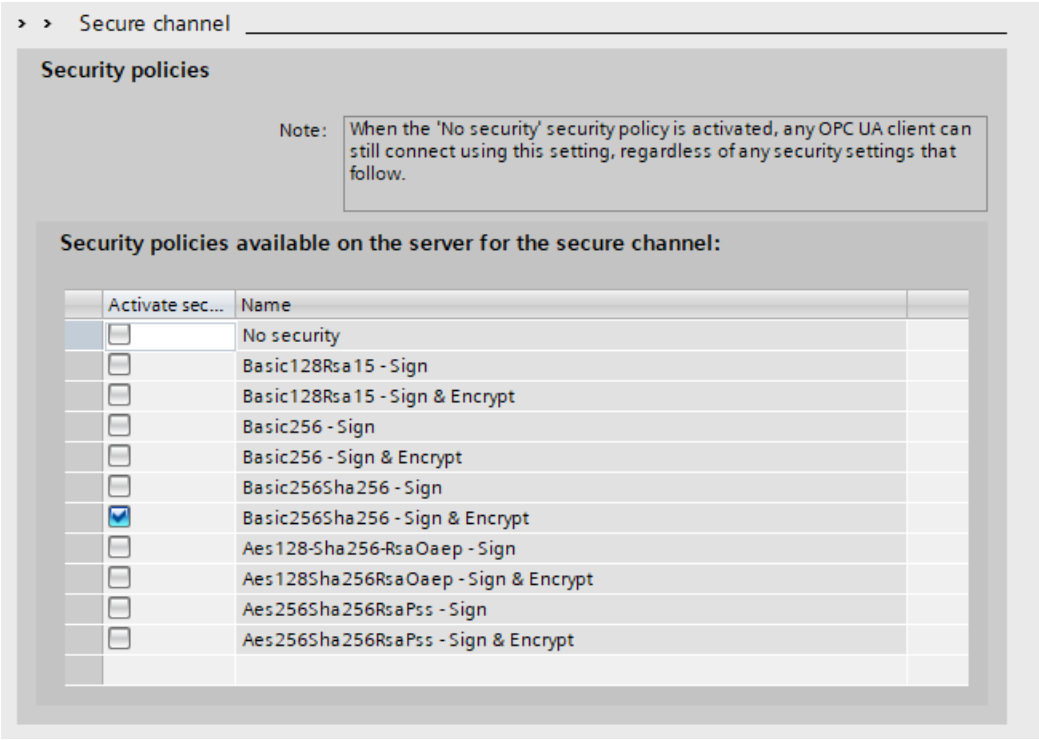

Figure 3-459 Configuring security settings of the server

By default, a server certificate is created that uses SHA256 signing. The following security policies are enabled:

- None
  Unsecured end point

  NOTE
  Disabling security policies you do not want
  If you have enabled all security policies in the secure channel settings of the S7-1500 OPC UA server – including the "No security" endpoint – data traffic between the server and client can also be unsecured (neither signed nor encrypted). The identity of the client remains unknown with "No security". Each OPC UA client can then connect to the server irrespective of any subsequent security settings.
  When configuring the OPC UA server, make sure that only security policies that are compatible with the security concept of your machine or plant are selected. All other security policies should be disabled.
  Recommendation: If possible, use the setting "Aes256Sha256RsaPss".

- Basic128Rsa15 -Sign
  Insecure end point, supports a series of algorithms that use the hash algorithm RSA15 and 128-bit encryption.
  This endpoint protects the integrity of the data through signing.

- Basic128Rsa15 -Sign & Encrypt
  Secure endpoint, supports a series of algorithms that use the hash algorithm RSA15 and 128-bit encryption.
  This endpoint protects the integrity and confidentiality of the data through signing and encrypting.
- Basic256 - Sign
  Secure endpoint, supports a series of algorithms that use the hash algorithm RSA15 and 256-bit encryption.
  This endpoint protects the integrity of the data through signing.
- Basic256 - Sign & Encrypt
  Secure endpoint, supports a series of algorithms that use the hash algorithm RSA15 and 256-bit encryption.
  This endpoint protects the integrity and confidentiality of the data through signing and encrypting.
- Basic256Sha256 - Sign
  Secure endpoint, supports a series of algorithms for 256-bit hashing and 256-bit encryption.
  This endpoint protects the integrity of the data through signing.
- Basic256Sha256 - Sign & Encrypt
  Secure endpoint, supports a series of algorithms for 256-bit hashing and 256-bit encryption.
  This endpoint protects the integrity and confidentiality of the data through signing and encryption.
- Aes128Sha256RsaOaep - Sign
  Secured endpoint, supports a range of algorithms for 256-bit hashing and 128-bit encryption.
  All certificates must use at least Sha256 signatures. This endpoint protects the integrity of the data by signing it.
  For high security requirements. PKI infrastructure required.
- Aes128Sha256RsaOaep - Sign & Encrypt
  Secured endpoint, supports a range of algorithms for 256-bit hashing and 128-bit encryption.
  All certificates must use at least Sha256 signatures. This endpoint ensures the integrity and confidentiality of the data by signing and encrypting it. For high security requirements. PKI infrastructure required
- Aes256Sha256_RsaPss - Sign
  Secured endpoint, supports a range of algorithms for 256-bit hashing and 256-bit encryption.
  All certificates must use at least Sha256 signatures. This endpoint protects the integrity of the data by signing it.
  For high security requirements. PKI infrastructure required.
- Aes256Sha256_RsaPss - Sign & Encrypt
  Secured endpoint, supports a range of algorithms for 256-bit hashing and 256-bit encryption.
  All certificates must use at least Sha256 signatures. This endpoint protects the integrity and confidentiality of data by signing and encrypting it.
  For high security requirements. PKI infrastructure required.

To enable the security setting, click the check box in the relevant line.

NOTE

If you use the settings "Basic256Sha256 -Sign" and "Basic256Sha256 -Sign & Encrypt", the OPC UA server and OPC UA clients must use "SHA256"-signed certificates.

For the settings "Basic256Sha256 -Sign" and "Basic256Sha256 -Sign & Encrypt", the certificate authority of STEP 7 automatically signs the certificates with "SHA256".

"No Security" security policy and authentication via user name and password

You can set the following combination:

Security policy = "No Security" and authentication via user name and password.

- The OPC UA server of the S7-1500 supports this combination. OPC UA clients can connect and encrypt the authentication data or not.
- OPC UA client of the S7-1500 CPU also supports this combination: However, in runtime it only connects if it can send the authentication data encrypted via cable!

11.3.3.7 Generating server certificates with STEP 7

The description below shows the procedure for generating new certificates with STEP 7 and applies in principle to various uses of the certificates. STEP 7 sets the appropriate purpose depending on which area of the CPU properties is used to start the following dialog.

Recommendation: To use the full functionality for the security of the OPC UA server, use the global security settings.

The global security settings are enabled in the CPU properties under "Protection & Security > Certificate manager".

Customizing server certificates

STEP 7 automatically generates a certificate for the OPC UA server of the S7-1500 when you activate the server (see "Activating the OPC UA server (Page 257)"). In the process STEP 7 uses the default values for the parameters of the certificate. If you want to change the parameters, follow these steps:

1. Click the three-dot button in the properties of the CPU under "General > OPC UA > Server > Security > Certificates".
   A dialog appears showing locally available certificates.
2. Click the "Create" button.

3. The dialog for generating new certificates is displayed (figure below). The values for an example are already entered:

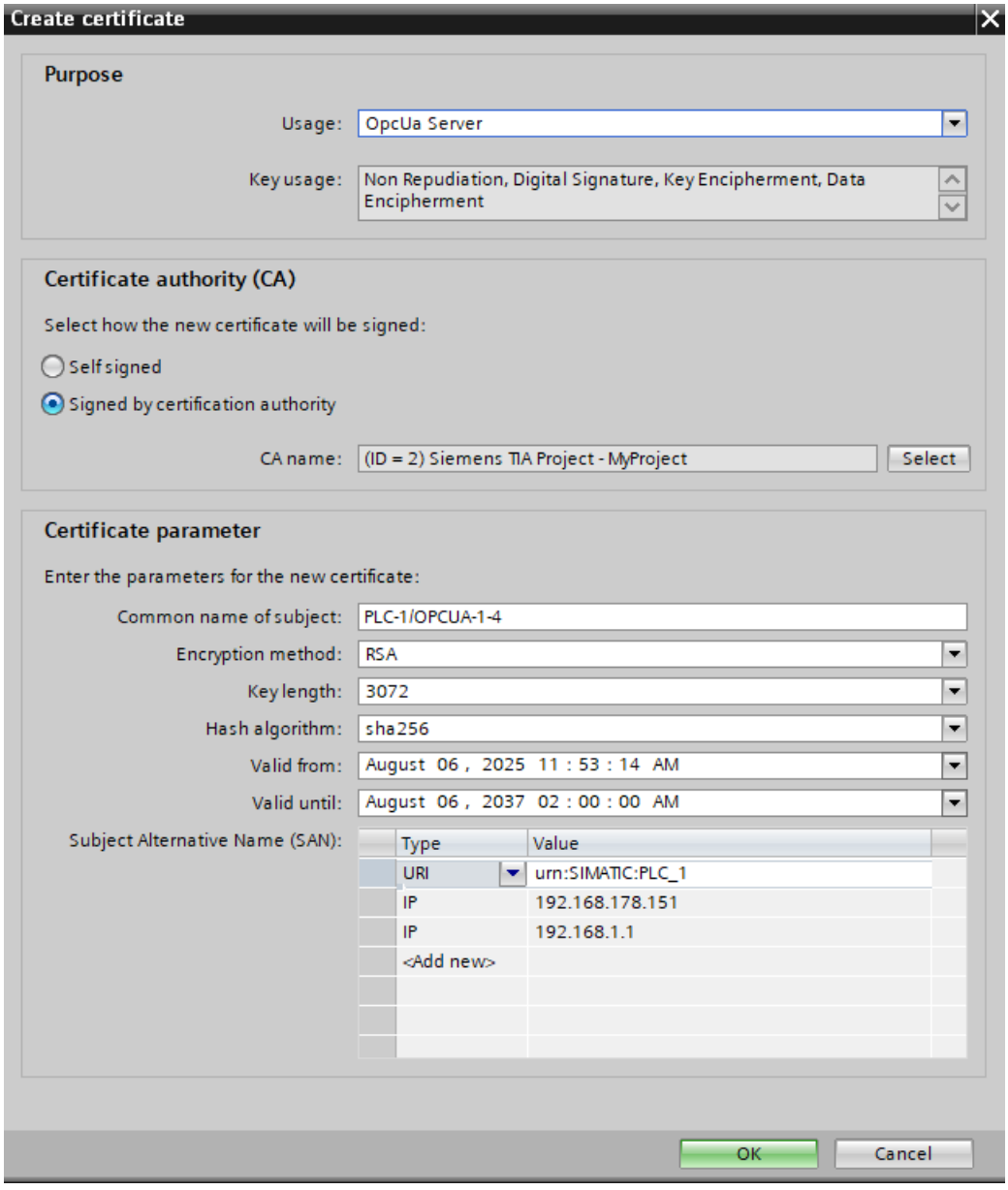

Figure 3-460 Customizing server certificates

4. Use other parameters if this is necessary in accordance with the security specifications in your company or your customer.

Explanation of fields for certificate generation

- Usage

  The default setting is "OPC UA server". Keep this default for the OPC UA server. The "Create a new certificate" dialog can be called up from several places in STEP 7. For example, if you open this dialog for the web server of the CPU, "Web server" is entered under "Usage". The following entries are available in the Usage drop-down list:

  – "OPC UA client"
  – "OPC UA client & server"
  – "OPC UA server"
  – "TLS"
  – "Web server"

- Certificate authority (CA)

  Select whether the certificate is to be self-signed or signed by one of the CA certificates of the TIA Portal. The certificates are described under "Certificates with OPC UA". If you want to generate a certificate that is to be signed by one of the CA certificates of the TIA-Portal, the project must be protected and you must be logged in as a user with all the required function rights. Further information can be found under "Basics of user administration in the TIA Portal".

- Common name of subject

  The default setting always consists of the name of the project and "\OPCUA-1". In the example, the project name is "PLC1". In the properties of the CPU set the project name under "General > Project information" > Name". Keep the default or enter a different name that is more meaningful for the OPC-UA server under "Certificate holder".

- Encryption methods

  The encryption method determines the algorithm (RSA or EC) for which the corresponding keys are to be generated.

- Key length

  Select the key length to be used when signing the certificate. The following entries are available:

  – "1024"
  – "2048"
  – "3072"
  – "4096"
  – "8192"

  You can find information on supported key lengths in the section Device-dependent security features (Page 57).

- Hash algorithm

  Select the hash algorithm to be used when signing. The following entries are available:

  – "sha1"
  – "sha256"
  – "sha384"
  – "sha512"

- Valid from

  Here you enter the date and time for the beginning of the validity of the server certificate.

- Valid until

  Here you enter the date and time for the end of the validity of the server certificate. Ensure that the certificate is valid not only for one year or a few years. In the example the certificate is valid for 30 years. However, for reasons of security you should renew the certificate at much shorter intervals. The long period of validity gives you the opportunity to decide when a suitable moment would be, for example, when the system is being serviced.

- Subject Alternative Name (SAN)

  The following is entered in the example above: "URI:urn:SIMATIC:PLC1,IP:192.168.178.151,IP:192.168.1.1". This URI must be correctly entered because it is checked against the communicated application description.

  The following entry would also be valid: "IP: 192.168.178.151, IP: 192.168.1.1". The important thing here is that the IP addresses via which the OPC UA server of the CPU can be accessed are entered here.

  See "Access to the OPC UA server (Page 260)".

  This allows OPC UA clients to verify whether a connection to the OPC UA server of the S7-1500 is really to be established or whether in fact an attacker is trying to send manipulated values from another PC to the OPC UA client.

11.3.3.8 User authentication

Types of user authentication

For the OPC UA server of the S7-1500, you can set what authentication is required for a user of the OPC UA client wishing to access the server.

You have the following options:

- **Guest authentication**

  The user does not have to prove their authorization (anonymous access). The OPC UA server does not check the authorization of the client user

  For CPUs up to firmware version V3.0: If you want to use this type of user authentication, select the "Enable guest authentication" option under "OPC UA > Server > Security > User authentication".

For CPUs as of firmware version V3.1: Use the local user management to implement the guest authentication via the "Anonymous" user.

NOTE

To increase security, you should only allow access to the OPC UA server with user authentication.

- **User name and password authentication**

  The user has to prove their authorization (no anonymous access). The OPC UA server checks whether the client user is authorized to access the server. Authorization is given by the user name and the correct password.

  For CPUs up to firmware version V3.0: If you want to use this type of user authentication, proceed as follows:

  – Select the "Enable user name and password authentication" option under "OPC UA > Server > Security > User authentication".
  – Deactivate the guest authentication.
  – Enter the user in the "User management" table.

    To do so, click the "<Add new user>" entry. A new user is created with an automatically assigned name. You can edit the user name and enter the password for the user name. You can add a maximum of 21 users.

- **Additional user administration via the security settings of the project**

  For CPUs up to firmware version V3.0, the "Enable additional user management via project security settings" option is available. You can find this setting under the general OPC UA settings (CPU properties: OPC UA > General). If you select this option, the user management for the open project will also be used for user authentication for the OPC UA server: The same user names and passwords are then valid in OPC UA as in the current project.

  Proceed as follows to activate user management for the project:

  – Click "Security settings > Settings" in the project tree.
  – Click the "Protect this project" button.
  – Enter your user name and your password.
  – Enter additional users under "Security settings > Users and roles".

  If you configure an additional OPC UA server in your project, also select the option "Enable additional user administration via the security settings of the project". Repeated input of user names and passwords is then unnecessary.

Transfer of user authentication via the secure channel

In OPC UA, identification data for user authentication, such as user name and password, is transferred with a separate security policy. This security policy is referred to as the "UserTokenPolicy".

Regardless of the configured security policies for the secure channel, an OPC UA client selects an appropriate "UserTokenPolicy" during connection establishment when user authentication

is required. This UserTokenPolicy ensures that a UserIdentityToken (e.g. user name and password) is always transferred with adequate security settings.

The OPC UA client is then able to transfer the user name and password with encryption if "No security" applies for the secure channel based on the configured security policy. For information on the process of establishing a secure connection in OPC UA, see Secure transfer of messages (Page 199).

11.3.3.9 Users and roles with OPC UA function rights

The following options for user authentication use central project settings for project users:

- For the server:

  For configuration of CPU properties (OPC UA > Server > Security > User authentication). Option: "Enable additional user administration via the security settings of the project"

- For the client:

  For configuration of client interface ("Configuration" tab, "Security"). Option: "User (TIA Portal - security settings)"

Requirement

Before you can edit the security settings, the project must be protected and you must be logged on with sufficient rights, for example as administrator.

Settings in the project tree > "Security settings"

You access the central user settings and roles in the protected project in the project tree under "Security settings". This is where you centrally define users with user name, password and function rights. You can simply use these settings elsewhere.

Figure 3-461 Setting user and roles

Reusing central security settings

Examples for reusing elsewhere:

- User selection for user authentication for OPC UA server

  With this setting, you tell the server which client (user) with which user name and which password is allowed to access the server.

- User selection for OPC UA client authentication

  With this setting, you tell the client the user name and password that it is to use for client authentication for the server.

The settings for the client and server must correspond: The user name and password used by the client to log on must have been set up on the server and assigned the required authorizations.

Function rights for server and client

The corresponding function rights for the client or the server must also be enabled for users of the client function and users of the server function on an S7-1500 CPU. It is not enough simply to save the user name and password centrally.

Here is an example to illustrate this type of rights use.

1. Under "Security settings > Users and roles", you define a new role in the "Roles" tab with the name "PLC-opcua-role-all-inclusive", for example.
   Tip: The tab may be covered by an information window ("The current status has not yet been checked..."). In this case, first close the information window.
2. In the "Function rights categories" section, you navigate to the runtime rights and then to the CPU function rights, and select the CPU whose function rights you want to set.
3. You will find the following function rights in the "Function rights" section:
   - **OPC UA server access**

     This function right applies on the OPC UA server of the S7-1500 CPU. Only when this option is selected, can the user with the role "PLC-opcua-role-all-inclusive" transfer certificates, CRLs or trusted lists to the CPU at runtime (push function). This function right is required for automated certificate handling, for example, in the context of GDS (Global Discovery Service).
   - **Managing certificates**

     This function right applies on the OPC UA server of the S7-1500 CPU. Only when this option is enabled, can the user with the role "PLC-opcua-role-all-inclusive" transfer certificates, CRLs or trusted lists to the CPU at runtime (push function). This function right is required for automated certificate handling, for example, in the context of GDS (Global Discovery Service).

– **User authentication of the OPC UA client**

  This function right applies on the OPC UA client of the S7-1500 CPU (with client instructions). Only when this option is selected, can the user with the role "PLC-opcua-role-all-inclusive" use the user name and password for authentication to establish a session with a server.

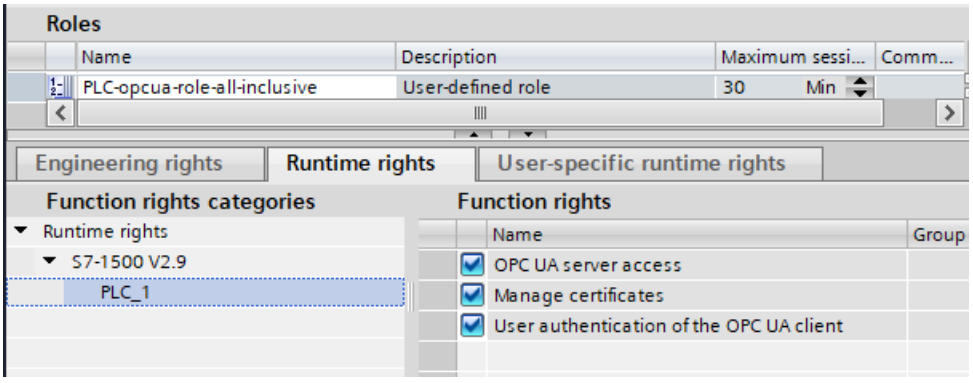

Figure 3-462 Setting function rights

4. The role "PLC-opcua-role-all-inclusive" still needs to be assigned to the relevant users ("Users" tab under "Security settings" in the project tree).

NOTE

"Runtime timeout" for users with OPC UA function rights

The value in the column "Runtime timeout" (max. session duration) in the table for user configuration does not evaluate the CPU for OPC UA runtime rights.

Therefore, a user is not automatically logged out after a certain period of time. For this purpose use OPC UA specific mechanisms such as the parameter "Max. session timeout" (area OPC UA > Server > Settings).

11.3.3.10 Diagnostic settings of the server

Diagnostics

You can specify the scope of the diagnostics of the OPC UA server in the CPU settings.

To change the diagnostics scope, navigate to the "OPC UA > Server > Diagnostics" area.

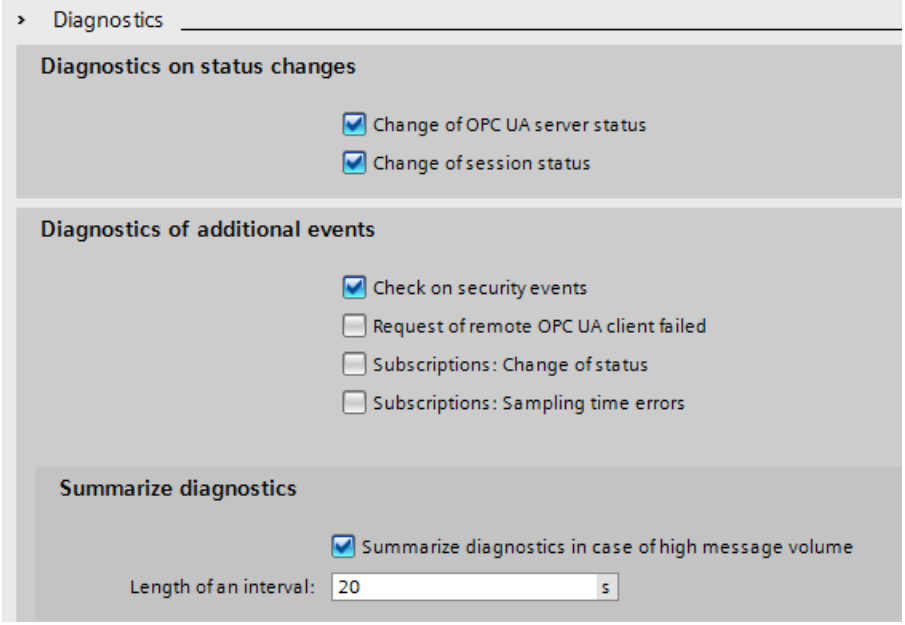

Figure 3-463 Diagnostic settings of OPC UA server

Default setting

The default setting is a diagnostics behavior that supports the most important diagnostics without appreciably increasing the communication load.

You enable diagnostics for subscriptions when the OPC UA server also uses subscriptions, i.e. if necessary during the commissioning phase only.

Reason: A large volume of diagnostic activity generates a high communication load in the CPU and may suppress other important messages. Or, the high volume of diagnostics may result in important messages disappearing in the mass of messages and being ignored.

Additional information

You will find additional information on the meaning and effect of the settings shown above here (Page 351).

11.3.3.11 License for OPC UA

Runtime licenses

A license is required to run the OPC UA server of the S7-1500 CPU. The type of license required depends on the performance of the respective CPU. The following license types are differentiated:

- SIMATIC OPC UA S7-1500 small (required for CPU 1511, CPU 1512, CPU 1513, ET 200SP CPUs, CPU 1515SP PC)
- SIMATIC OPC UA S7-1500 medium (required for CPU 1515, CPU 1516, Software Controller CPU 1507, CPU 1516pro-2PN)
- SIMATIC OPC UA S7-1500 large (required for CPU 1517, CPU 1518)

The required license type is displayed under "Properties > General > Runtime licenses > OPC-UA > Type of required license":

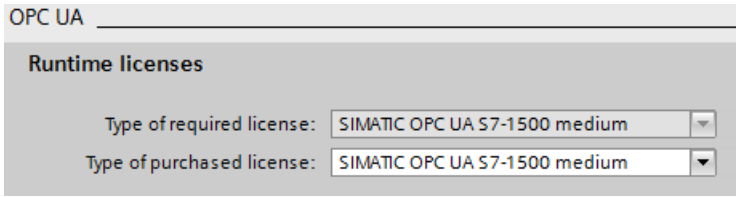

Figure 3-464 OPC UA server Runtime licenses

To confirm purchase of the required license, follow these steps:

1. Click "Runtime licenses > OPC UA" in the properties of the CPU.
2. Select the required license from the "Type of purchased license" drop-down list.

11.3.4 OPC UA server interface configuration

11.3.4.1 What is a server interface?

Definition

A server interface combines nodes of an OPC UA address space of a CPU into a unit, so that a specific view on this CPU is provided for OPC UA clients.

Each server interface defines one or more namespaces in the OPC UA server of the CPU.

STEP 7 (TIA Portal) differentiates between the following types of server interfaces:

- Companion specification

  For this type of server interface, you use a Companion Specification created by a workgroup, for example.

  The workgroup is typically composed of members of the OPC Foundation and another industry organization who have jointly specified an OPC UA information model for a specific purpose (for example, for data exchange with RFID devices or with injection molding machines).

  This information model is realized in the form of OPC UA nodes in the address space of an OPC UA server. OPC UA clients can access these OPC UA nodes.

You can also use the server interface type "Companion specification", for example, to download company-internal information models, e.g. in SiOME.

If you implement a certain companion specification in your project, you apply the specifications of this companion specification into your project as server interface.

For "Companion specification"-type server interfaces, you can import multiple namespaces which the Companion specification uses.

Additional information on companion specifications is available here (Page 284).

Additional information on SiOME is available here (https://support.industry.siemens.com/cs/ww/en/view/109755133).

– When companion specifications refer to type definitions in dependent specifications, use the reference namespaces for this. You import reference namespaces as you would the actual companion specifications.

  See Creating a server interface for companion specification (Page 291).

– If you want to make instance data from FBs or UDTs of the CPU accessible to OPC UA clients, you can have these instance data assignments automatically made as of TIA Portal version V17. You only need to map the FB types or the UDTs to suitable OPC UA data types of an imported reference namespace. For this mapping to be possible, enable the option "Generate OPC UA nodes based on the local data mapping" in the dialog for creating an OPC UA server interface of the type companion specification/reference namespace.

  See Generating OPC UA nodes based on local data mappings of FB types and UDTs (Page 315)

- User-defined server interface:

  For this type of server interface you combine OPC UA nodes of an OPC UA server into a unit.

  To do this, use the specifications for your project or the requirements for your machine or your plant as a basis.

  Additional information on the user-defined server interface is available here (Page 296).

Injection molding machine as an example for companion specification

In this example, a server interface contains the following elements:

- OPC UA nodes which you can write with an OPC UA client to receive information about this injection molding machine (in readable PLC tags)
- OPC UA nodes which you can write with an OPC UA client to transfer values to the injection molding machine (in writable PLC tags)
- OPC UA nodes which you can call with an OPC UA client to start functions of the injection molding machine (via server methods)

This server interface enables a default view of a CPU, which can be used to control an injection molding machine.

For injection molding machines, the companion specifications "OPC UA specifications for plastics and rubber machines" (previously "Euromap") define a whole series of OPC UA nodes which you can apply as a server interface.

Other OPC UA nodes of the CPU are not included in this server interface. This provides a better overview.

Example of user-defined server interface

A CPU should control the production of workpieces. Production begins when a production job arrives from the higher-level control system.

The production jobs are transferred via a server method: A control system transmits information on a workpiece by calling the server method in the CPU. This server method also starts production.

The control system, i.e. the connected OPC UA client, should only see this one server method. Therefore, you create a user-defined server interface in the CPU and assign the server method to this server interface. You enable only this server interface for OPC UA clients and thus limit the view of the CPU to this one function.

11.3.4.2 Using OPC UA companion specifications

Introduction

OPC UA is universally applicable: The standard itself does not, for example, specify how PLC tags are to be named. It is also up to the individual user (application developer) to program and name server methods that can be called over OPC UA.

Information modeling and standardization for devices and sectors

For applications of the same kind, it is worth standardizing your device or machine interface with the "OPC UA toolkit".

Many different bodies and working groups have driven forward standardization and developed a range of companion specifications.

These specifications define:

- The objects, methods and tags with which a typical device or machine is to be described.
- The namespace intended for the specified objects.

Machines are typically structured in functional or technological units, and these units are then standardized.

Companion specifications offer machine and plant operators the benefits of a standardized interface. For example, all RFID readers that comply with the AutoID specifications can be integrated in the same way. This means that all RFID readers that comply with the AutoID specifications can be addressed by OPC UA clients in the same way irrespective of manufacturer.

Another example of companion specifications is the Euromap 77 Companion Specifications from the injection molding machinery sector.

The following section uses the example of Euromap 77 to detail how to apply companion specifications in STEP 7 (TIA Portal) and create the necessary PLC tags.

NOTE

EUROMAP and the OPC Foundation have established the Joint Working Group "OPC UA Plastics and Rubber Machinery".

The existing EUROMAP recommendations EUROMAP 77 (data exchange between injection moulding machines and MES), 82.1 (temperature control devices) and 83 (general definitions) were published under the neutral umbrella of the OPC Foundation as OPC 40077, 40082-1 and 40083.

A major change it the change of the namespace, for example, for EUROMAP 77: Currently "http://opcfoundation.org/UA/PlasticsRubber/IMM2MES/".

The examples listed below use the previously valid designations and references.

Example Euromap 77 (currently: OPC 40077)

Euromap 77 or the successor standard OPC 40077 standardizes the exchange of data between injection molding machines and the higher-level MES (Manufacturing Execution System). This allows the MES to connect all lower-level injection molding machines in the same way.

The standardized data interface facilitates the integration of injection molding machines into a plant.

Using companion specifications: Overview

Euromap 77 is described in the OPC UA XML file "Opc_Ua.EUROMAP77.NodeSet2.xml".

NOTE

Euromap 77, Euromap 83 and OPC UA for Devices (DI)

With Release Candidate 2, some of the Euromap definitions have been transferred from Euromap 77 to Euromap 83 (currently OPC 40083). You will therefore also need to import the OPC UA server interface of Euromap 83.

"OPC UA for Devices" is a generally applicable information model for the configuration of hardware and software components. The information model also serves as the basis for other companion standards and is therefore also imported.

The OPC UA XML files are available here:

Euromap77 (https://www.euromap.org/euromap77)

Euromap83 (https://www.euromap.org/euromap83)

OPC UA for Devices (https://opcfoundation.org/UA/schemas/DI/)

These XML files define an OPC UA interface of an injection molding machine that complies with Euromap 77.

Using Euromap 77: Overview

To use Euromap 77, proceed as follows:

1. Generate an XML file by creating an instance of the type "IMM_MES_InterfaceType" using the SiOME program.

   How to proceed is described below in "Step 1: Create instances in SiOME".

2. In STEP 7 (TIA Portal), create PLC tags and server methods that correspond to the instance of the type "IMM_MES_InterfaceType" (created in Step 1).

   See below for information on how to proceed in "Step 2: Create PLC tags in STEP 7".

   An example of OPC UA nodes and the corresponding PLC tags can be found in section "Creating a server interface for companion specification (Page 291)".

3. In STEP 7 (TIA Portal), add a new server interface of companion specification type and import the XML file you created in step 1.

   The "Creating a server interface for companion specification (Page 291)" section describes how to proceed.

4. Assign the OPC UA nodes of the new server interface to the corresponding PLC tags, which you created in step 2.

   The "Creating a server interface for companion specification (Page 291)" section describes how to proceed.

Step 1: Create instances in SiOME

The following section describes how to use the free program "SiOME", the "Siemens OPC UA Modeling Editor".

With SiOME, you can create an OPC UA XML file, which describes the server interface (an information model).

Download link and explanations about SiOME are available here (https://support.industry.siemens.com/cs/ww/en/view/109755133).

Procedure in STEP 7

To use the new server interface, import the server interface into the STEP 7 project, see section "Creating a server interface for companion specification (Page 291)".

When the project is loaded into the CPU, the new server interface is available for OPC UA clients.

Procedure in SiOME 1.7.3

NOTE

The following description shows the work steps in SiOME 1.7.3.

Follow-up versions of SiOME make it easier for you, for example, to create corresponding DBs, structures, variables or methods in the user program. Using a drag-and-drop operation, you can transfer data, for example, from SiOME to the TIA Portal (user program). In this case, the variables, etc. are already mapped correctly or, for methods, the corresponding FB elements are also generated correctly in the user program.

Download the current SiOME version using the download link listed above, and follow the instructions in the documentation included in the download.

The following description shows the work steps in SiOME 1.7.3.

To use Euromap 77, create an XML file with an instance of "IMM_MES_InterfaceType".

The object type must be instantiated in order for the information model of the specific machine to appear in the address space of the OPC UA server.

The object type "IMM_MES_InterfaceType" is the root object type of Euromap 77. "IMM" stands for "Injection Moulding Machine".

Follow these steps:

1. Download the files "Opc_Ua.EUROMAP77.NodeSet2.xml" and "Opc_Ua_EUROMAP83_NodeSet2.xml" from the Euromap website (see above).
2. Download the file "Opc.Ua.Di.NodeSet2.xml" from the OPC Foundation website.

   The "Opc.Ua.Di.NodeSet2.xml" file contains type definitions which Euromap 77 uses.
3. Start SiOME.
4. First, import the namespace "http://opcfoundation.org/UA/DI/".

   To do so, click the "Import XML" button in the "Information model" area.

   Figure 3-465 "Import XML" button in SiOME

   SiOME displays the dialog for the opening files.
5. To import the file, select the "Opc.Ua.Di.NodeSet2.xml" file and click "Open".
   Result: SiOME imports the XML file and shows the namespace "http://opcfoundation.org/UA/DI/" in the "Namespaces" area.

   The standard namespace "http://opfoundation.org/UA/" is always available in SiOME and does not have to be imported.
6. Now import the namespace "http://www.euromap.org/euromap83/"

   To do so, click the "Import XML" button again in the "Information model" area.

   Select the file "Opc_Ua.EUROMAP83.NodeSet2.xml".

   Result: SiOME imports the XML file and shows the namespace "http://www.euromap.org/euromap83/" in the "Namespaces" area.
7. Now import the namespace "http://www.euromap.org/euromap77/"

   To do so, click the "Import XML" button again in the "Information model" area.

   Select the file "Opc_Ua.EUROMAP77.NodeSet2.xml".
8. Create your own namespace for your project.

   To do this, right-click in the "Namespaces" area on "OPC UA Modelling Editor Project" or on "Namespaces" and select "Add Namespace".

   SiOME opens the "Add Namespace" dialog.

9. Enter the name of a new namespace.

   The "YourCompany.org" namespace is used in the example.

   SiOME now also displays the new namespace:

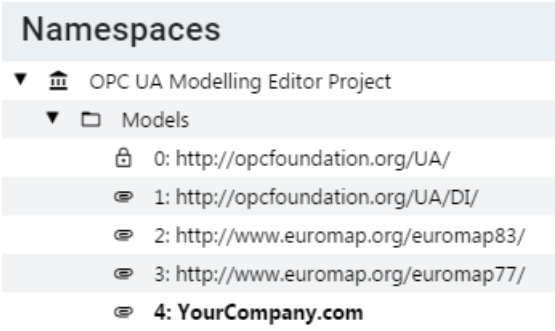

   Figure 3-466 Display of the namespace in SiOME

10. Create an instance from the root object type IMM_MES_InterfaceType of the Companion specification Euromap 77.
    To do so, in the "Information model" area, right-click the "DeviceSet" directory and select "Add Instance".

    SiOME displays the "Add Instance" dialog.

11. For "Name", enter a meaningful name for your instance.

    In the example, enter "IMM_Manufacturer_01234".

    For "TypeDefinition", select "IMM_MES_InterfaceType".

    This object type is the root object type of Euromap 77: If you generate an instance of this object type, then use the Euromap 77 once in the address space of your OPC UA server.

12. Click "OK".

    SiOME shows the new instance "IMM_Manufacturer_01234" in the "Information model" area under "DeviceSet":

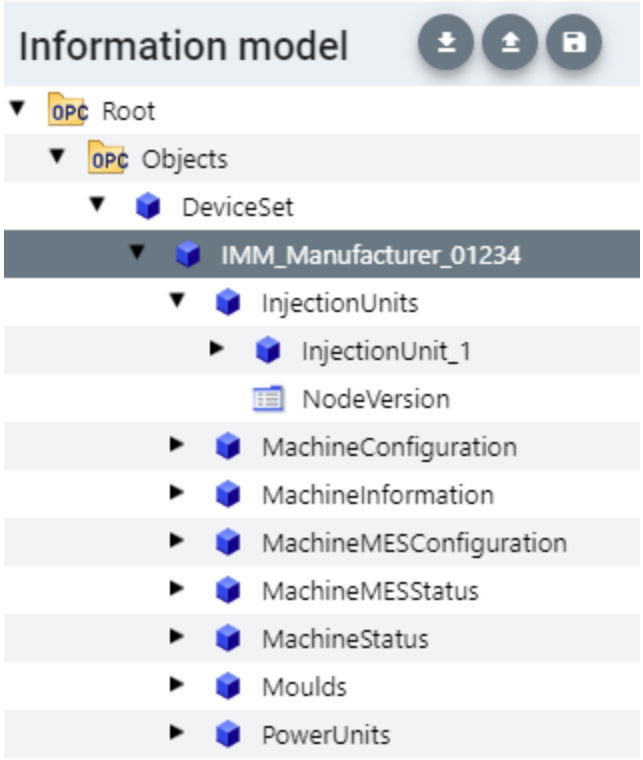

Figure 3-467 Display information model

13. Create an instance of the data type "InjectionUnitType".

    To do this, right-click on the "InjectionUnits" directory in the "Information model" area and select "Add Instance".

    SiOME displays the "Add Instance" dialog.

    For "Name", enter a meaningful name for the instance.

    In the example, enter "InjectionUnit_1".

    For "TypeDefinition", select "InjectionUnitType".

    Click "OK".

14. Create a new "Mould_1" instance of the "MouldType" object type in the "Moulds" directory.

15. Create a new instance "PowerUnit_1" of the "PowerUnitType" object type in the "PowerUnits" directory.

16. Save the XML file.

    To do so, click the "Quick save" button in the "Information model" area:

Figure 3-468 "Quick save" button in SiOME

17. Export the XML file.

    To do so, click the "Export XML" button in the "Information model" area.

Figure 3-469 "Export XML" button in SiOME

SiOME shows the "Export XML" dialog.

18. Leave all namespaces activated and click "OK".

    SiOME displays the "Save as" dialog.

19. Select a meaningful name and save the exported file.

    In the example, name the XML file "IMM_Manufacturer_01234".

Result:

You have now created an XML file which uses the companion specification "Euromap 77" once (with one instance).

Step 2: Creating PLC tags for the Euromap 77 instance in STEP 7.

For Euromap 77, you must provide PLC tags and server methods in your user program and assign the instance of the "IMM_MES_InterfaceType" type.

To create PLC tags for the instance of the "IMM_MES_InterfaceType" type, proceed as follows.

1. Create a user-defined data type (UDT).

   The figure below shows the beginning of the user-defined data type "InjectionUnit" as example.

   This data type has the same structure as "InjectionUnit" in the type "IMM_MES_InterfaceType".

   Make sure that you use SIMATIC data types that are compatible with the OPC UA data types (see "Mapping of data types" below).

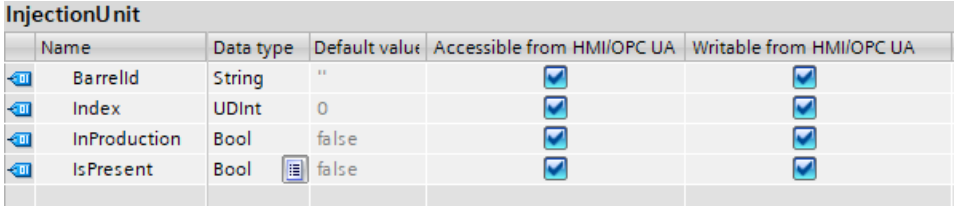

InjectionUnit

	Name	Data type	Default value	Accessible from HMI/OPC UA	Writable from HMI/OPC UA
	BarrelId	String	''	☑	☑
	Index	UDInt	0	☑	☑
	InProduction	Bool	false	☑	☑
	IsPresent	Bool	false	☑	☑

Figure 3-470 Creating a UDT in STEP 7

2. Add a new global data block to your STEP 7 project.

   In the example, name the data block "IMM_Manufacturer_01234", so that there is a reference to the injection molding machine of the respective manufacturer and the serial number.

3. Create a new element in this data block.

   In the example, name this element "InjectionUnit_1"

4. Assign the new user-defined data type "InjectionUnit" to this element.

Result

In your STEP 7 project, you have created a tag for the Euromap 77 in the "IMM_Manufacturer_01234" data block.

11.3.4.3 Creating a server interface for companion specification

For basic information on companion specifications, refer to the section "Using OPC UA companion specifications (Page 284)". The benefits of the Euromap 77 companion scpecification, which provides a model for injection molding machines, is also discussed in detail there.

Using this companion standard, the S7-1500 CPU can control an injection molding machine, for example, and provide an OPC UA client, such as a higher-level MES system, with an interface for accessing the functions and tags of injection molding machine.

An OPC UA server interface of the type "Companion Standard" limits the access of clients to exactly those functions and tags that are required, for example, for higher-level systems (MES systems).

The following description shows how to create a server interface in STEP 7 (TIA Portal) which contains only the Euromap 77 companion specification.

If you want to make OPC UA clients accessible to other tags or methods than those required for the management of an injection molding machine, simply create another OPC UA server interface. In this way, you can clearly arrange the functionality of the CPU as OPC UA server.

Creating a server interface for a companion specification

To create a server interface for a companion specification with STEP 7 (TIA Portal), proceed as follows:

1. Select the CPU that you want to use as an OPC UA server.
2. In the project tree, click "OPC UA communication > Server interfaces".
3. Double-click "Add new server interface".
4. To select this type of server interface, click "Companion specification".

   A general name for the new server interface is entered in the dialog, for example "Server_Interface_1".

5. Change the name of the new server interface so that it is descriptive in your project.

   The name should have the following structure according to Euromap 77: "IMM_<Manufacturer>_<Serial number>".

   The example uses the name "IMM_Manufacturer_01234".

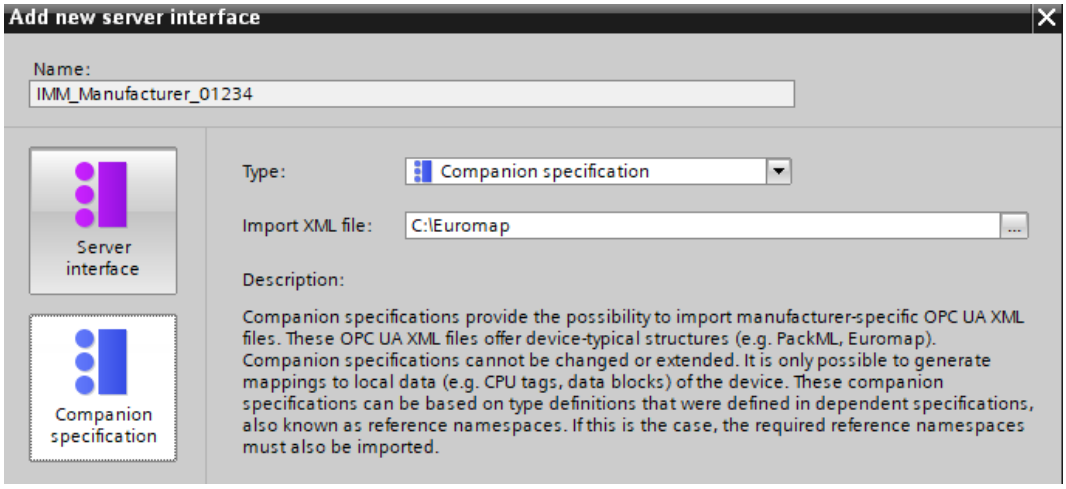

6. In the "Import XML file" field, select an XML file that describes an information model.

   The "Using OPC UA companion specifications (Page 284)" section describes how to create such an XML file with the SiOME tool.

   The figure below shows a section from the information model: "IMM_MANUFACTURER_0123456" an instance (use) of the type "IMM_MES_InterfaceType" which was defined by Euromap 77 . "InjectionUnit_1" is an instance of the "InjectionUnitType" type of Euromap 77.

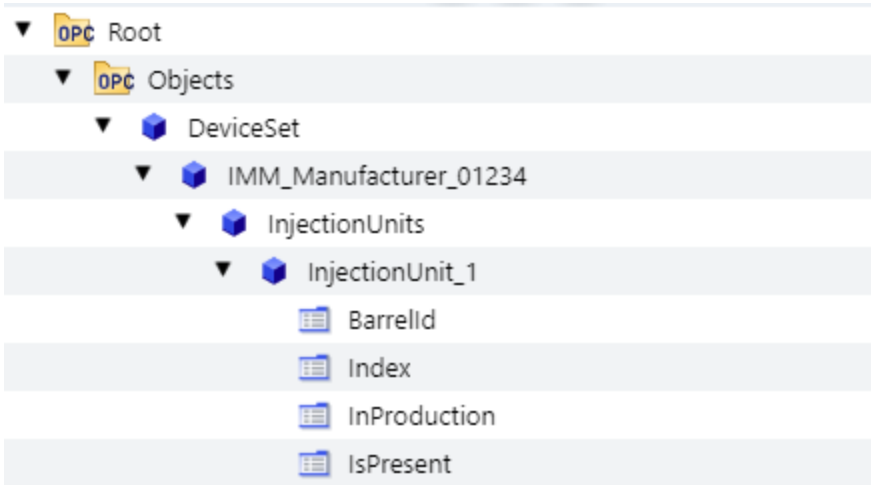

7. Click "OK".

   STEP 7 (TIA Portal) imports the information model described in the selected XML file.

   An error occurs when type definitions are used in the imported XML file that are not yet present in STEP 7 (TIA Portal) and that are also not contained in the imported XML file.

In the example, an XML file is imported that uses type definitions defined in the following namespaces (Namespaces):

– http://opcfoundation.org/UA/DI/
– http://www.euromap.org/euromap83/
– http://www.euromap.org/euromap77/

Tip: STEP 7 displays missing namespaces in the lower area of the OPC UA interface editor ("Properties" tab).

To do this, select the server interface in the project tree (here: IMM_Manufacturer_01234) and select the "Namespaces" area in the inspector window. Missing namespaces are selected.

If one or more namespaces are missing in your STEP 7 project, create a new server interface of the "Reference namespace" type for each namespace.

The "Creating a server interface for reference namespace (Page 313)" section describes the procedure.

If all reference namespaces are available, STEP 7 displays the table without errors:

DeviceSet	Object
IMM_Manufacturer_01234	Object
InjectionUnits	Object
InjectionUnit_1	Object
TemperatureZones	Object
BarrelId	String
Index	UInt32
InProduction	Boolean
IsPresent	Boolean

8. Drag the OPC UA elements from the right area of the table (OPC UA elements) to the left part of the table (OPC UA server interface) so that the respective OPC UA elements (the local PLC tags) are assigned to the respective OPC UA nodes of Euromap 77.

   The figure below shows a section from the assignment of the local data (PLC tags) to the OPC UA nodes of the Euromap 77:

OPC UA-Server-Schnittstelle

Name	Node type	Local data	Data type
DeviceSet	Object		
IMM_Manufacturer_01234	Object		
InjectionUnits	Object		
InjectionUnit_1	Object		
TemperatureZones	Object		
NodeVersion	String		
BarrelId	String	"IMM_Manufacturer_01234"."InjectionUnit_1"."BarrelId"	String
Index	UInt32	"IMM_Manufacturer_01234"."InjectionUnit_1"."Index"	UDInt
InProduction	Boolean	"IMM_Manufacturer_01234"."InjectionUnit_1"."InProduction"	Bool
IsPresent	Boolean	"IMM_Manufacturer_01234"."InjectionUnit_1"."IsPresent"	Bool

NOTICE
Checking the mapping of CPU local data on nodes of the OPC UA server interface When invalid assignments (mappings) exist in the server interface, they can result in incorrect read and write operations. Check the assignments and run a consistency check.

Information on the server interface

The editor for configuring the OPC UA server interface is structured as a table and provides the following information:

- **Name**

  The top node (root node) is named "IMM_Manufacturer_01234" in the example. If a client browses in the address space of the server, this node is the container for all lower-level nodes. BrowseName and the DisplayName of this node depend on the name you have assigned for the server interface.

  In this case, for example, this name stands for the injection molding machine as a whole. It is the name of the instance of the Euromap 77 companion specification that is used here. According to the companion specification, the instance name should begin with "IMM", followed by the name of the manufacturer of the injection molding machine; the serial number of the machine is added to the end. This allows a unique identification of the machine.

  The names of all other (lower-level) nodes are defined by the specification (in the example above by Euromap 77). These node names must not be changed. This ensures a uniform view of all injection molding machines, which complies with the specification.

- **Node type**

  Type of the OPC UA node. The type is specified by the companion specification that is used.

  In the following cases, STEP 7 marks a node type in the table in color:

  – No definition is included for this in the imported XML file or

  – The namespace in which the type was defined is not available in STEP 7.

  In this case, create a server interface of the "Reference namespace" type for the missing namespace or for each of the missing namespaces.

  The missing namespaces can be found under "Namespaces" in the properties of the server interface.

- **Local data**

  STEP 7 displays the data block which is assigned to the OPC UA node: The CPU reads the value of the OPC UA node from this data block.

  If a data block is highlighted in color (e.g. after a consistency check), the specified data block is not available in the CPU.

  In this case, you have to create the missing data block in the CPU (of user program) and supply it with values.

- **Data type**

  The SIMATIC data type of the PLC tag (e.g. element of a data block) in the CPU, from which the value of an OPC UA node (UAVariable type) is read, or to which a value is assigned.

Updating the interface

You can update the server interface for companion specifications.

Example: After importing companion specifications and then importing reference namespaces on which the companion specifications depend, the type definitions of the reference namespaces do not take effect immediately.

When you click the "Update interface" button, the missing type definitions of the companion specifications are resolved.

"Update interface" button:

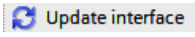

Generate local data

You have the option of generating local data for all or for selected nodes of the server interface that are not already assigned ("mapped") to local data of the CPU. The newly created local data are mapped automatically.

You trigger the automatic generation of local data by clicking the "Generate local data" button (all nodes that are not already mapped) or by selecting individual nodes and then clicking the "Generate local data" shortcut menu.

"Generate local data" button:

Figure 3-471 "Generate local data" button:

You can only generate nodes that can be mapped to local data, which means no objects, no folders, no methods or input/output arguments of methods.

After you have clicked the button or selected the shortcut menu, you must select in the follow-up dialog box whether the local data should be created in a new DB or in an existing DB.

Consistency check

You have the option to check the server interface.

STEP 7 (TIA Portal) checks whether the OPC UA node of the server interface PLC tags (data blocks) has been assigned compatible SIMATIC data types.

To check the consistency of the server interface, click on the following icon in the toolbar of the OPC UA server interface editor:

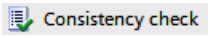

Figure 3-472 "Consistency check" button

Export interface

You have the option of exporting the OPC UA server interface as an XML file. This XML file contains all data type definitions referenced by the server interface.

To export the OPC UA server interface, click on the following icon in the toolbar of the OPC UA server interface editor:

Figure 3-473 "Export interface" button

11.3.4.4 Creating a user-defined server interface

Introduction

The description is based on the following example:

A protective fence surrounds the production cell "Cell_1". The fence is equipped with the gate "Gate_1".

An S7-1500 CPU controls the entire production cell and also controls access through Gate_1.

A robot packs drugs into boxes in the production cell and then stacks the boxes on pallets.

Self-driving vehicles for automated material transport move the pallets to the central warehouse, thereby passing through Gate_1.

The CPU publishes a server interface via which the driverless transport systems arrange for Gate_1 to open.

The server interface contains the server method "smOpenGate" for opening the gate and the tag "Gate_1_State" which indicates the status of the gate (open or closed).

Creating a user-defined server interface

To create a server interface, follow these steps:

1. Select the CPU that you have used and configured as OPC UA server.
2. Click "OPC UA communication > Server interfaces".
3. Double-click "Add new server interface".

   STEP 7 displays the following dialog.

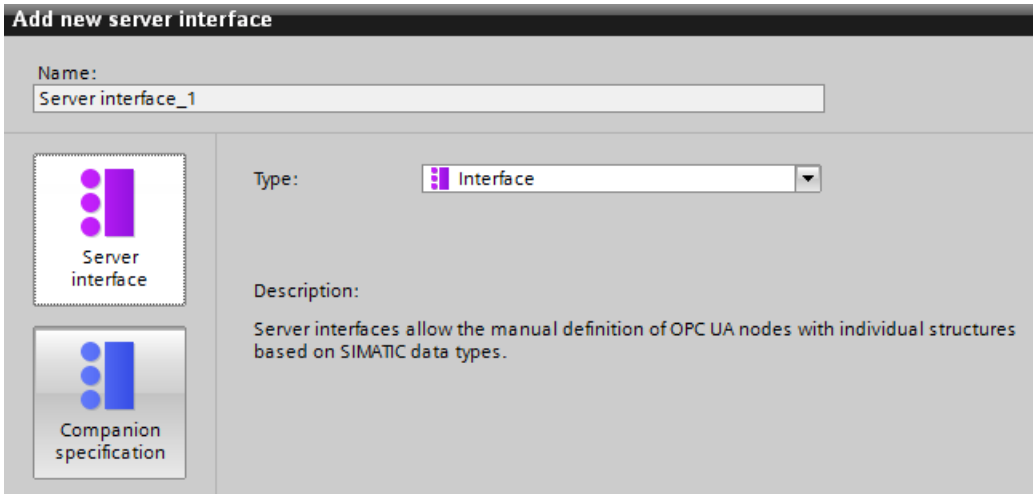

Figure 3-474 Adding the server interface

4. Change the name of the new server interface so that it is descriptive in your project.

   In the example, change the name "Server-interface_1" suggested by STEP 7 to "Cell_1".
5. Click "Server interface" and then "OK".
6. Click on the triangle in front of "Program blocks" in the area "OPC UA elements" to open the "Program blocks" folder.

   STEP 7 displays the following table for editing:

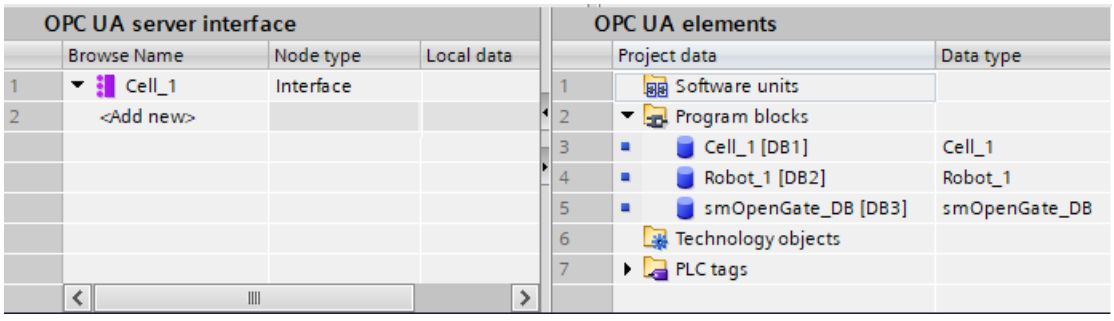

Figure 3-475 Editing the server interface

The editor is divided into two areas.

– **OPC UA server interface**

  On the left is the root node of the server interface "Cell_1".

  This interface is currently still empty: No OPC UA elements have been added to the server interface yet.

– **OPC UA elements**

  On the right are the OPC UA elements.

  OPC UA elements are objects that have been created so far in the STEP 7 project and have the property "Accessible from HMI/OPC UA".

  You can add the OPC UA elements to the new server interface "Cell_1".

7. Drag the OPC UA elements into the "<Add new>" line of the new server interface.

NOTE

The following applies in general: If you store data blocks or technology objects in the left area of the table, STEP 7 (TIA Portal) creates an object in the server interface. The elements of the data blocks are arranged as separate nodes below this.

If you store structures in the left area of the table, STEP 7 creates a node for the structure as a whole and nodes for each element of the structure.

The same applies to arrays: Again, STEP 7 creates a node for the array as a whole and nodes for each element of the array.

When you place a method in the left area of the table, STEP 7 creates a single node; the arguments of the inserted method are displayed for information purposes.

In the example, you drag the "Gate_1_State" tag from the right area to the left area to "<Add new>".

Then, drag the server method into the left area.

This server method is located within the "smOpenGate_DB [DB3]" data block in the right area.

STEP 7 (TIA Portal) displays the dialog as follows:

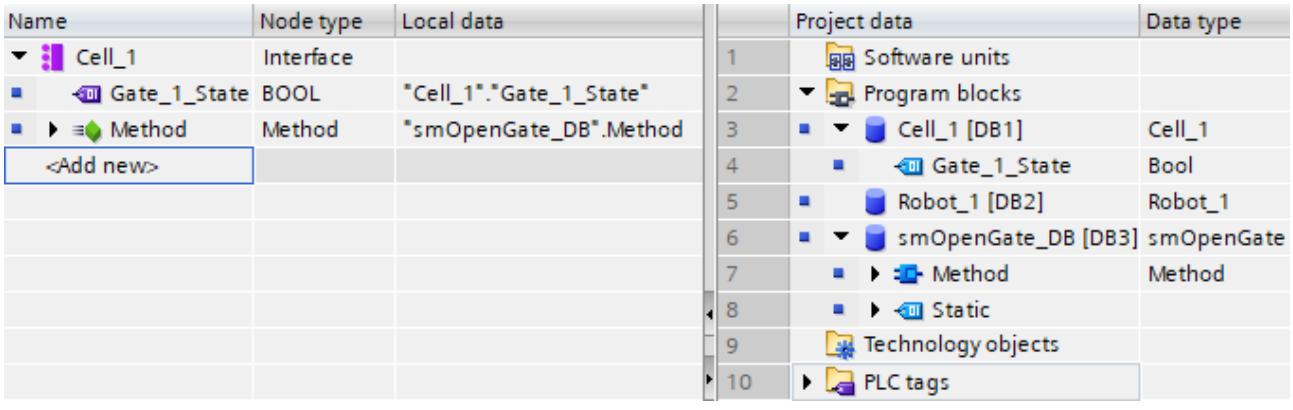

Figure 3-476 Adding OPC UA elements to the server interface

NOTICE
Checking the mapping of CPU local data on nodes of the OPC UA server interface When invalid assignments (mappings) exist in the server interface, they can result in incorrect read and write operations. Check the assignments and run a consistency check. Since the TIA Portal only generates warnings and not errors for invalid assignments, you can proceed step-by-step as follows: For example, in the first step, you can modify the program/local data so that the program runs without errors. The next step is to modify the OPC UA server interface and eliminate the inconsistencies. At the points at which the TIA Portal generates warnings, the OPC UA server interface does not function during runtime. The OPC UA server generates runtime errors.

Limiting the view to OPC UA servers

By selecting the OPC UA elements, you limit the view to the OPC UA server and the options of the OPC UA clients.

In the server interface of the example, the "Robot_1" data block is missing because industrial trucks do not need access to the server methods and tags of the robot.

In this case, it is best to disable the standard server interface (SIMATIC namespace) in the OPC UA properties of the S7-1500 CPU so that the filtered nodes cannot be accessed any other way.

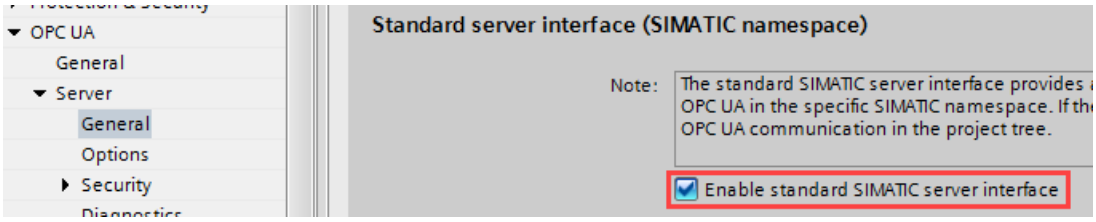

Figure 3-477 Disabling the standard server interface

You can also disable the visibility of each configured OPC UA server interface in the properties of the server interface and thus prevent that this server interface can be used by clients during operation.

- To do this, select the server interface and right-click on the "Properties" command.

This option lets you define multiple server interfaces centrally, for example, and enable and download only the required server interface.

Once a server interface has been defined, you can drag it to another CPU in the project tree.

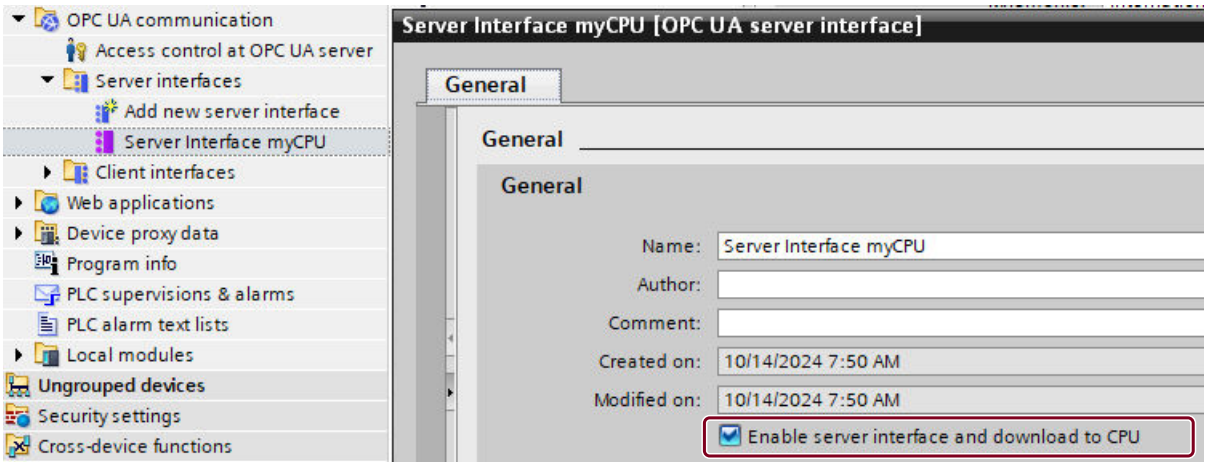

Figure 3-478 Disabling the visibility of the server interface

Information on the server interface

The "OPC UA Server Interface" editor is structured as a table and provides the following information:

Note that not all columns are displayed initially. You determine what is displayed by right-clicking on the header line of the table.

When a row is selected, you can display the OPC UA attributes of the node in the Inspector window ("OPC UA attributes" area), such as node ID, node class, node type, and description.

- **BrowseName**

  The language neutral name of the user-defined server interface is at the top (BrowseName). This name can be freely selected.

  The names (BrowseNames) of the individual OPC UA nodes that have been added to the server interface are under the name of the interface.

  You cannot change the name of an OPC UA node in this dialog. The names come from the STEP 7 project.

  You can delete an OPC UA node from the table. This means that it no longer belongs to the server interface and is no longer visible to OPC UA clients.

- **DisplayName**

  Similar to BrowseName. However, the name can be translated and is displayed, if available, in the corresponding language.

- **Node ID**

  NodeId of the OPC UA node, e.g. http://Server-Node_1; i=1

- **Node type**

  Type of the OPC UA node, for example BOOL, BYTE, INT.

  These node types were defined by Siemens, not by the OPC Foundation. For example, the OPC Foundation uses the Boolean node type for BOOL. BOOL is directly derived from Boolean.

  The specified node type cannot be changed in this dialog: If you want to use a different node type, you must change the type of the respective PLC tags in the STEP 7 project.

- **Data type**

  The SIMATIC data type used in the STEP 7 project is specified, for example, Bool, Byte, Int. etc.

- **Access level**
  - If an OPC UA node is a tag (UAVariable type), the node can only be readable (RD) or readable and writable (RD/WR).
  - If an OPC UA node is a method (UAMethod type), this node can always be called.

- **Local data**

  The SIMATIC data type of the data block in the CPU, from which the value of an OPC UA node (UAVariable type) is read, or to which a value is written.

Generate local data

You have the option of generating local data for all or for selected nodes of the server interface that are not already assigned ("mapped") to local data of the CPU. The newly created local data are mapped automatically.

You trigger the automatic generation of local data by clicking the "Generate local data" button (all nodes that are not already mapped) or by selecting individual nodes and then clicking the "Generate local data" shortcut menu.

"Generate local data" button:

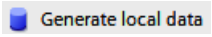

Figure 3-479 "Generate local data" button:

You can only generate nodes that can be mapped to local data, which means no objects, no folders, no methods or input/output arguments of methods.

After you have clicked the button or selected the shortcut menu, you must select in the follow-up dialog box whether the local data should be created in a new DB or in an existing DB.

Consistency check

You have the option to check the consistency of the server interface.

During the consistency check, STEP 7 checks whether the OPC UA nodes of the server interface are each assigned to a suitable OPC UA element (identical data type) or whether the used element still exists in the CPU.

To check the consistency of the server interface, click on the following icon in the toolbar of the OPC UA server interface editor:

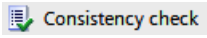

Figure 3-480 "Consistency check" button

Export interface

You have the option of exporting the OPC UA server interface as an XML file. This XML file contains all data type definitions referenced by the server interface.

To export the OPC UA server interface, click on the following icon in the toolbar of the OPC UA server interface editor:

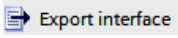

Figure 3-481 "Export interface" button

More information

You can find information on master copies for the OPC UA communication in the section Master copies for OPC UA communication (Page 402).

See also

Client accesses and local accesses to the OPC UA server (Page 242)

11.3.4.5 Data types for companion specifications

Mapping of data types

The table below shows the compatible SIMATIC data type for each OPC UA data type.

Assign the data types as shown below (SIMATIC data type - OPC UA data type). Other assignments are not permitted. STEP 7 does not check the observance of this rule and does not prevent an incorrect assignment. You are responsible for the rule-compliant selection and assignment of the data types.

You can also use the listed data types, for example, as elements of structures/UDTs for input and output parameters of self-created server methods (UAMethod_InParameters and UAMethod_OutParameters).

Table 3-945 Mapping of data types

SIMATIC data type	OPC UA data type
BOOL	Boolean
SINT	SByte
INT	Int16
DINT	Int32
LINT	Int64
USINT	Byte
UINT	UInt16
UDINT	UInt32
ULINT	UInt64
REAL	Float
LREAL	Double
LDT	DateTime
WSTRING	String
DINT	Enumeration (Encoding Int32) and all derived data types
User-defined data type required (UDT, user-defined data type) The user-defined data type must be created with the prefix "Union_", for example "Union_MyDatatype". See example below the table. The first element (Selector) in this UDT must have the data type "UDINT".	UNION and all derived data types
See LocalizedText and ByteString data types (Page 304)	LocalizedText ByteString

User-defined data type for UNION required

The figure below shows the tag "MyVariable", which has the "Union_MyDatatype" data type.

This SIMATIC data type corresponds to an OPC UA tag with the data type UNION.

The figure shows an example of the declaration: When Selector = 1, Union takes a ByteArray; when Selector = 2, Union takes a WString.

Name	Data type
Static	
Selector	UDInt
ByteArray	Array[0..1] of Byte
WString	WString[42]

11.3.4.6 LocalizedText and ByteString data types

As of TIA Portal version V17 and S7-1500 CPU firmware version V2.9, the two OPC UA Built-in data types "LocalizedText" and "ByteString" are available for mapping to corresponding SIMATIC data structures. For the definition of these OPC UA data types, see also OPC 10000-3 DataType definitions.

These data types are used in companion specifications, for example, and can be easily handled by the user program with the OPC UA interface editor.

LocalizedText

A structure containing a string with locale identifier (e.g. 'en-US').

The structure has three elements with a defined order and the following structure in SIMATIC:

- **Encoding** (data type OPC_UA_LocalizedTextEncodingMask): Indicates in bit 0 whether the "Locale" field has a content and in bit 1 whether the "Text" field has a content. Both fields should have a content. We therefore recommend setting the "Encoding" value for SIMATIC to 2#00000011.
- **Local** (WString data type): Locale, for example, 'en-US'.
- **Text** (WString data type): Text box, for example, 'Text'.

ByteString

A sequence of octets.

The structure is built up as follows:

- **ActualLength** (data type "OPC_UA_ByteStringActualLength"): Length of the ByteString array that is filled
- **ByteString** ("Array of Byte" data type): Byte array

Requirement

An OPC UA server interface has been created.

Application

You can import a companion specification or a reference namespace that contains definitions of the "LocalizedText" or "ByteString" type.

Likewise, you can create a server interface and define an address model yourself with the data types "LocalizedText" or "ByteString". The procedure is described in the next section.

Procedure

You will learn how to create a node of the type "LocalizedText" or "ByteString" with the interface editor and then have a SIMATIC data structure created automatically for this node in the paragraphs below.

To define OPC UA nodes of the type "Localized Text"/"ByteString" in a server interface, follow these steps:

1. Create nodes of the type "LocalizedText" or "ByteString" in the "OPC UA server interface" area. These node types are included in the list of selectable node types.

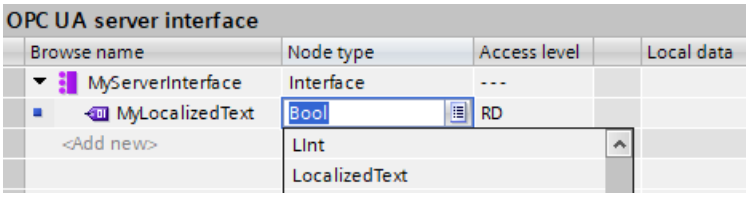

2. Select the "Generate local data" command from the shortcut menu. To generate the local data, select a data block, for example, a new DB with the name "MyServerInterface_Data".

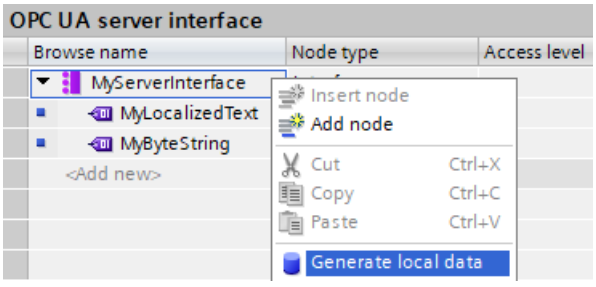

Result: STEP 7 generates the corresponding structure for the mapping in which you still need to adjust the required text length (Text) and the required locale (Locale) for "LocalizedText".

The same is true for "ByteString"; in this case, you must adjust the length and the array.

The consistency check generates a warning to indicate the required adjustments.

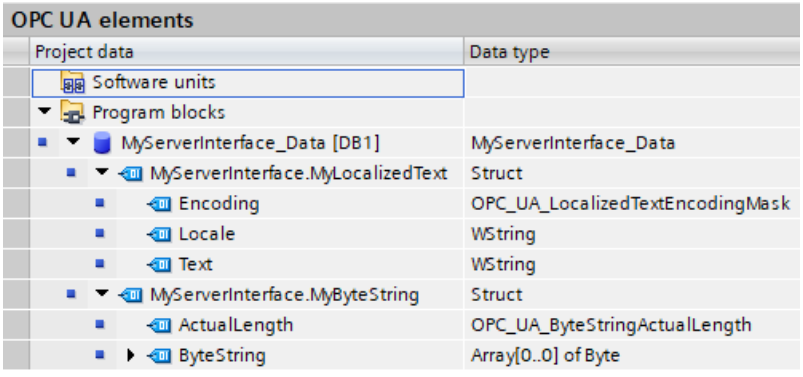

Rules

- You can also create UDTs with the structure as shown above for the node types "LocalizedText" or "ByteString" and use them for DB elements.
- You can use the node types "LocalizedText" or "ByteString" in other structures (nests).
- The SIMATIC structures for "LocalizedText" or "ByteString" may only be used completely; an isolated data type, such as "OPC_UA_LocalizedTextEncodingMask" for other purposes, is not provided.
- Input and output parameters of methods can also be of the data type/node type "LocalizedText" or "ByteString".

11.3.4.7 Using additional OPC UA data types for companion specifications

Apart from the OPC UA data types listed in the section "Mapping of data types" and their correspondences on the SIMATIC side, there are the following OPC UA basic data types which you can also use:

- OpcUa_NodeId
- OpcUa_QualifiedName
- OpcUa_Guid
- OpcUa_XmlElement
- OpcUa_ByteString (Page 304)
- OpcUa_LocalizedText (Page 304)

Requirement for the use of the basic data types listed above as variables in the application program: The basic data types have to exist as complex data types that are structured exactly like the corresponding OPC UA basic data types.

- OpcUa_NodeId and OpcUa_QualifiedName exist as system data types; that's why you can use these data types not only for single variables but also as elements of a structure.
- For the basic data types or built-in data types GUID and XmlElement you have to create a PLC data type in accordance with the OPC UA specification and subsequently use it as an element in a structure so that the data types of the elements can be resolved. What each PLC data type must look like is described below for every single basic data type.
- For OpcUa_ByteString and OpcUa_LocalizedText, the requirements have been created in TIA Portal V17 to simply use these data types in the server interface of the "Companion Specification" type:
  - You create the corresponding node type in the server interface (for example, OpcUa_LocalizedText)
  - You click on "Generate local data"

  STEP 7 then automatically generates the appropriate data structures in a DB.
- For OpcUa_Guid, these requirements have been met in TIA Portal V19. Proceed as described in the previous section.

System data type "OPC_UA_NodeId"

For the OPC UA basic data type "OpcUa_NodeId", please refer to the following table for the meaning of the parameters. Use OPC_UA_NodeId for the identification of a node in the OPC UA server.

Parameter	S7 data type	Meaning
NamespaceIndex	UINT	Namespace index of the node in the OPC UA server. A node can, for example, be a tag.
Identifier	WSTRING[254]	The designation of the node (object or tag) depends on the identifier type: • Numeric identifier: The node is labeled with a number, for example "12345678". • String identifier: The node is labeled with a name, for example "MyTag". No distinction is made between upper and lower case.
IdentifierType	UDINT	Type of identifier • 0: Numeric identifier • 1: String identifier • 2: GUID • 3: Opaque

System data type "OPC_UA_QualifiedName"

See the following table for the structure of the system data type "OPC_UA_QualifiedName":

Name	S7 data type	Meaning
NamespaceIndex	UINT	The namespace index of the name.
Name	WSTRING[64]	Name of the node or tag.

System data type "GUID"

The "Guid" data type is available as a node type as of TIA Portal V19. For the definition of this OPC UA data type, see also OPC 10000-6 mappings.

The figure shows the assignment of the "Guid" data type for a tag node in a server interface.

The next figure shows the data block with the GUID elements that is created automatically with "General local data".

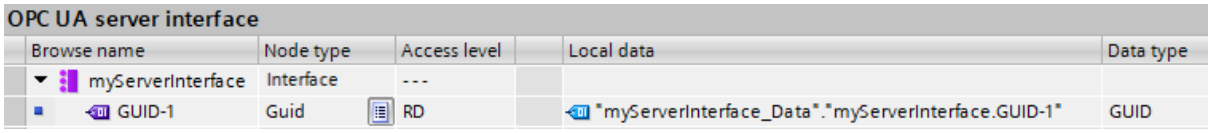

Figure 3-482 GUID node in the server interface

The next figure shows the data block with the GUID elements that is created automatically with "General local data".

Name	Data type	Start value
Static		
myServerInterface.GUID-1	GUID	
Data1	UDInt	16#C4965784
Data2	UInt	16#0DFE
Data3	UInt	16#4B8F
Data4	Array[0..7] of Byte	
Data4[0]	Byte	16#87
Data4[1]	Byte	16#0A
Data4[2]	Byte	16#74
Data4[3]	Byte	16#52
Data4[4]	Byte	16#38
Data4[5]	Byte	16#C6
Data4[6]	Byte	16#AE
Data4[7]	Byte	16#AE

Figure 3-483 Data block with SDT GUID

UDT for basic data type XmlElement

An XmlElement is a serialized XML fragment (UTF-8 string).

For the basic data type "XmlElement", create the following PLC data type:

XmlElement			
	Name	Data type	Default value
1	XmlElement	WString	WSTRING#''

11.3.4.8 Dynamic arrays

Useful information on dynamic arrays

As of TIA Portal V19 and S7-1500 CPU FW version V3.1, you can use so-called "dynamic arrays" for your OPC UA server and OPC UA client interfaces. The following description explains the principle and functionality of the server interface. The structure of the structure/UDT for a dynamic array is identical for client and server applications.

With dynamic arrays, it is possible to define data structures whose number of elements can be changed at runtime on the server interface side. On the CPU side, the dynamic array is mapped to a fixed-size structure.

Example: Process data from production for quality assurance purposes is transferred to a higher-level management system. The number of process data elements is different, depending on the product type. If the product type is changed during runtime, the number of process data elements needed also changes.

In STEP 7 (TIA Portal), an array is a data type that you can assign to a tag. An array represents a data structure that consists of a fixed number of components of the same data type. All data types except ARRAY are permitted for the components.

By contrast, OPC UA does not define an array as a data type. Any variable value (Value) can be an array. The following attributes and properties of Variable NodeClass are used in OPC UA to define how a variable is structured with respect to its "geometry" as an array (excerpt from https://reference.opcfoundation.org/Core/Part3/v104/docs/5.6):

Attribute / Property	Data type	Possible values, meaning
ValueRank (Mandatory)	Int32	• n > 1: Value is an array with dimension n. • 1: Value is an array with one dimension • 0: Value is an array with one or more dimensions • -1: Value is a scalar (not an array) • -2: Value is a scalar or an array with any number of dimensions • -3: Value can be a scalar or a one-dimensional array
ArrayDimensions (Optional)	UInt32[]	Maximum supported length of each dimension. 0 or empty: Unknown length.
MaxArrayLength (Optional)	UInt32	For DataVariables with ValueRank attribute not set to scalar: Maximum length of the array. Example: A three-dimensional array with lengths 2x3x10 has the length 60.

The name "dynamic array" is used here to establish a counterpart on the SIMATIC data type end for the dynamics of the variable geometry defined in OPC UA, so that mapping of array data is possible. You can change the geometry of a mapped array during runtime using your STEP 7 program. On the OPC UA end, you define a node in the OPC UA server interface via which a client can access the mapped CPU data (the dynamic array).

Principle

In order for OPC UA variables to be mapped to CPU tags of Array type, you use a structure or UDT with the new system data type "OPC_UA_ArrayBoundaries".

The structure or UDT has the following structure elements and is structured as follows:

- The first structure element (array size) is itself an array and defines the current size of the dynamic array. The system data type "OPC_UA_ArrayBoundaries" defines the index range available in the server interface for each dimension (with lower and higher boundary elements in each case).
- The second structure element (array data) contains all array elements with a selectable data type permitted for OPC UA.

STEP 7 (TIA Portal) automatically ensures that, for example, negative indexes on the SIMATIC end are converted to non-negative indexes (starting at "0") on the OPC UA end (server interface).

Example of one-dimensional array

The following example shows the structure for a simple, one-dimensional array with a maximum of 10 elements. The current size of the array is set to 3 elements [0..2].

Name	Data type	Possible values / Description
1-Dim-Struct	Struct (UDT)	
- **ArraySizeAct**	Array [0..0] of OPC_UA_ArrayBoundaries	**Current array size**
- - ArraySizeAct[0]	OPC_UA_Boundaries	One dimension
- - - Lower	DInt	0 (lower index)
- - - Upper	DInt	2 (possible upper index values: 0..9)
- **MyDataArray**	Array[**0**..9] of Byte	**Array data (all array elements)**
- - MyDataArray[0]	Byte	First element
...	...	...
- - MyDataArray[9]	Byte	Last element

Example of two-dimensional array

The following example shows the structure for a two-dimensional array with 10x6 = 60 elements. The lower indexes of both dimensions are not "0" in this case. The current size of the array is set to 2x6 = 12 elements.

Name	Data type	Possible values / Description
2-Dim-Struct	Struct (UDT)	
- **ArraySizeAct**	Array [0..1] of OPC_UA_ArrayBoundaries	**Current array size**
- - ArraySizeAct[0]	OPC_UA_Boundaries	First dimension
- - - Lower	DInt	**-9** (lower index)
- - - Upper	DInt	-8 (possible upper index values: -9..0)
- - ArraySizeAct[1]	OPC_UA_Boundaries	Second dimension
- - - Lower	DInt	**5** (lower index)
- - - Upper	DInt	10 (possible upper index values: 5..10)
- **MyDataArray**	Array[-**9**..0, **5**..10] of Byte	**Array data (all array elements)**
- - MyDataArray[-9,5]	Byte	First element
- - MyDataArray[-9,6]	Byte	Second element
...	...	...
- - MyDataArray[0,9]	Byte	Second to last element
- - MyDataArray[0,10]	Byte	Last element

Effects on the server interface

Appearance in the server interface: If you drag a dynamic array (e.g. 2-Dim-Struct) and drop it onto the server interface in the editor for the server interface, STEP 7 (TIA Portal) creates a node of the same name without the subelements. The node indicates type "ARRAY" in the "Node type" column with the maximum possible lengths of the array.

Browse: The dynamic array is available as a node in the OPC UA address space. Unlike for static arrays, the subelements of the array are not visible as child nodes.

Read: The dynamic array can be read with the Read service. The client can specify whether it wants to read the entire array or only parts of it (IndexRange). Only the read parts that lie within the boundaries of the current array range return the status "Good". If the array size is "0" in every dimension, an empty array is returned with status "Good".
If an array of size "0" is read in a dimension, then an empty array with status "Good" is returned.

Write: If the range to be written is less than or equal to the maximum array size, all elements are written (status "Good"). If the range to be written is greater than the maximum array size, nothing is written and status 8074_0000 is returned (OpcUa_BadTypeMismatch). If part of an array is written (IndexRange), the behavior is exactly the same: All dimensions of the array range to be written must lie completely within the maximum array size. Only then is the data written and the status "Good" returned.
If an array of size "0" is written in at least one dimension, then this value is set correctly in the CPU data. The elements "Lower" and "Upper" in the corresponding OPC_UA_ArrayBoundaries structure are adjusted accordingly ("Upper" = "Lower-1").

Rules and specific features

- You can also use dynamic arrays for input parameters and output parameters in methods.
- Avoid inconsistencies caused by changing the current size of the array while a client is accessing the array. The result of the access is undefined in this case.
  Use the uninterruptible instruction UMOVE_BLK for changing the current array size.
- In contrast to the SIMATIC data type Array, there can be "empty" arrays in OPC UA. You define an array with 0 elements in one dimension with OPC_UA_ArrayBoundaries by setting the highest index value (Upper) less than the lowest index value (Lower), e.g. with the following values: Upper = Lower-1.

  If you define a multidimensional array in the server interface (or client interface) and at least one dimension is "0" (empty), then by definition it is an empty array (all dimensions are 0).
- The values for the current array size and the values for the array data must be consistent. Otherwise, error code 803A_0000 (OpcUa_BadNotReadable) is output.
  - The values you set for "Lower" for the current array size in a dimension must also be set as the lower index value in the range of the array data in the corresponding dimension.
  - The values you have set for "Upper" for the current array size for a dimension must also lie within the range of the array data for this dimension.
- If an OPC UA client writes a dynamic array in the server, the client must write an array with the same dimension (ValueRank). Otherwise, the status 8074_0000 is returned (OpcUa_BadTypeMismatch).

11.3.4.9 Rules for OPC UA XML files

Importing exported OPC UA XML files to an S7-1500 CPU

Please note the following information when importing server interfaces that come from the OPC UA XML export of an S7-1500.

NOTE

Import blocked for namespace "http://www.siemens.com/simatic-s7-opcua"

You cannot import server interfaces with the namespace "http://www.siemens.com/simatic-s7-opcua" to an S7-1500 CPU because this namespace is reserved for S7-1500 CPUs (standard SIMATIC server interface) and is not available for imports.

If you want to import a server interface with the namespace "http://www.siemens.com/simatic-s7-opcua", open the server interface to be imported (OPC UA XML file) and change the namespace in the relevant places. The file thus changed can then be imported.

Integrity of the OPC UA XML files

OPC UA XML files represent the server address space. These files are, for example, imported by you in the context of OPC UA Companion specifications as a server interface after adaptation to the application, loaded into the S7-1500 CPU and tested.

⚠ WARNING

No checking of imported OPC UA XML files

Protect these OPC UA XML files against unauthorized manipulation since STEP 7 does not check the integrity of these files.

Recommendation

To minimize risks in the case of an extension or adaptation of the server address space, follow these steps:

1. Protect the project (project navigation: Security settings > Settings).
2. Export the corresponding server interface before the extension or adaptation.
3. Revise this OPC UA XML file.
4. Import the file again as a server interface.

11.3.4.10 Creating a server interface for reference namespace

Companion specifications and referenced namespaces

A series of OPC UA object types (as well as additional definitions) are defined in a companion specification. These object types are each defined in namespaces so that the names of the object types (type definitions) are unique.

To use a companion specification in your project, create instances of object types of this companion specification.

To do this the object definitions must be available in your STEP 7 project. If this is not the case, you must import the object definitions. To import all definitions of a namespace, create a server interface of type "Reference namespace" for each namespace in STEP 7.

NOTE

EUROMAP and the OPC Foundation have established the Joint Working Group "OPC UA Plastics and Rubber Machinery".

The existing EUROMAP recommendations EUROMAP 77 (data exchange between injection moulding machines and MES), 82.1 (temperature control devices) und 83 (general definitions) were published under the neutral umbrella of the OPC Foundation as OPC 40077, 40082-1 and 40083. However, the examples listed below use the previously valid designations and references.

Example Euromap 77 (currently OPC 40077)

You have added a server interface for the companion specification Euromap 77 (currently OPC 40077).

The server interface uses object types defined in OPC UA DI as well as in Euromap 83 and Euromap 77 in their corresponding namespaces.

Therefore, in addition to the server interface Euromap 77 of the "Companion Specification" type, create additional server interfaces of "Reference namespace" type in STEP 7, in each case for the following namespaces:

- http://opcfoundation.org/UA/DI/
- http://www.euromap.org/euromap83/
- http://www.euromap.org/euromap77/

The following description shows you how to proceed.

Creating a server interface for a reference namespace

To create a server interface for a namespace, proceed as follows:

1. Select the CPU that you want to use as an OPC UA server.
2. Click "OPC UA communication > Server interfaces".
3. Double-click "Add new server interface".

   STEP 7 (TIA) now displays the dialog "Add new server interface".

   A general name for the new server interface is entered in the dialog, for example "Server_Interface_1".
4. Assign a descriptive name for the new server interface.

   In the example, select the name "OPC.Ua.Di" or a similar name that clearly references the namespace "http://opcfoundation.org/UA/DI/".

   This namespace must be imported first. It contains basic definitions (for example, the UAObjectType "DeviceType").
5. Click the "Companion specification" button and select the "Reference namespace" type.
6. Click the three dots next to the "Import XML file" field.
7. Select an XML file that contains the definitions of the namespace "http://opcfoundation.org/UA/DI/".

   Select the file "Opc.Ua.Di.NodeSet2.xml" in the example. You can download this file here:

   Opc.Ua.Di.NodeSet2.xml (https://opcfoundation.org/UA/schemas/DI/)

   Note: If the file cannot be imported, this may be because the OPC UA ("CORE") model version available in TIA Portal does not match the OPC UA for Devices ("DI") model version. In this case, select a different version of the DI model (for example a previous version).

   The figure below shows the dialog with the entries:

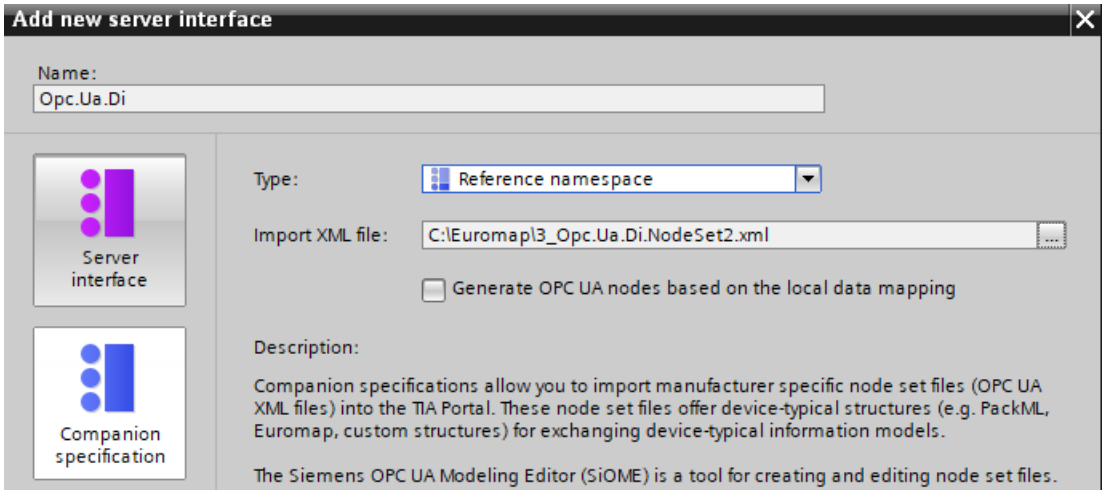

Figure 3-484 Adding a reference namespace

8. Click "OK".

   STEP 7 (TIA) now generates the new server interface.

You can find the server interface in the project tree of STEP 7 (TIA Portal) under "OPC UA Communication > Server interfaces > Reference namespace".

If a companion specification uses additional namespaces, add a new server interface for each namespace.

Add additional server interfaces for Euromap77

For Euromap 77, you still need the following namespaces:

- http://www.euromap.org/euromap83/
- http://www.euromap.org/euromap77/

First, add a server interface for the namespace "http://www.euromap.org/euromap83/".

This namespace contains basic definitions for Euromap 77, therefore it is required here first. All definitions of this namespace are included in the XML file "Opc_Ua.EUROMAP83NodeSet2.xml", which you can download from the Euromap website (https://www.euromap.org/en/euromap83).

Then add a server interface for the namespace "http://www.euromap.org/euromap77". All definitions of this namespace are included in the XML file "Opc_Ua.EUROMAP77.NodeSet2.xml", which you can also download from the Euromap website (https://www.euromap.org/en/euromap77).

11.3.4.11 Generating OPC UA nodes based on local data mappings of FB types and UDTs

If you want to make instance data from FBs or UDTs of the CPU accessible to OPC UA clients you can, as of TIA Portal version V17, have these instance data assignments automatically made.

You only have to map the FB types or the UDTs to suitable OPC UA data types of imported reference namespaces. Based on these mappings, STEP 7 (TIA Portal) then generates the required nodes in the server interface for each FB instance or for each UDT usage during compilation.

If you extend your program and add more FB instances or UDT usages, or if you add existing instances delete, you do not need to worry about adapting the server interface: STEP 7 automatically adjusts the server interface when compiling the program.

Example

- You create a function block (FB) in the user program of the CPU and define in the "Static" area of the interface of the FB the parameters that form the "memory" of the FB. The instances (values) of this parameter are to be accessible for OPC UA clients.
- You create an OPC UA data type (e.g. with SiOME) with elements that correspond to the data type the parameters in the static area of interface of the FB. The order of the elements does not matter. Then import the reference node set file (reference namespace) as a reference name space.

The following figure shows the assignment of elements as comparison of the reference namespace view (server interface) and the OPC UA elements view (program).

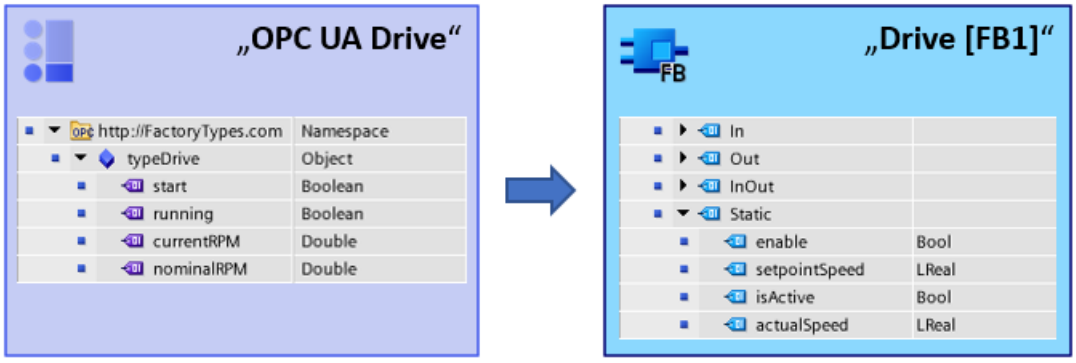

Mapping of data types (FB interface - OPC UA interface): Principle

The following figure shows the assignment of the elements from the user program of the CPU to the elements of the OPC UA server interface. The order of the elements does not have to match.

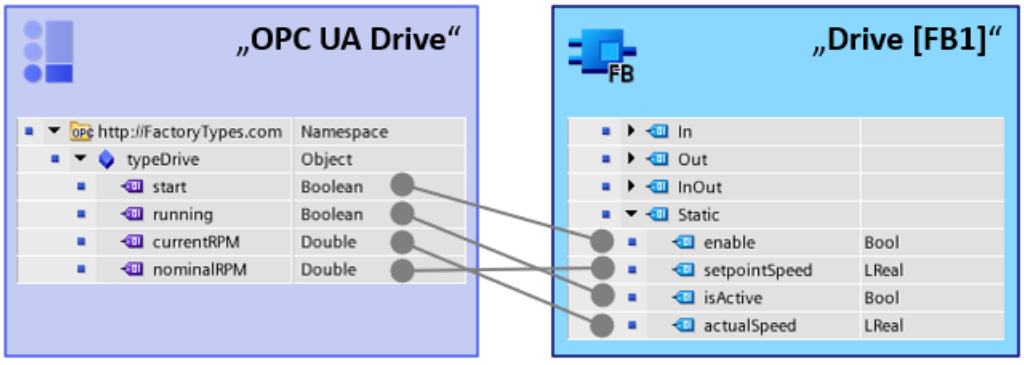

Automatic generation of the OPC UA server instances in the server interface: Principle

The figure below shows the compilation of the project. The instances of the user program are also generated in the server interface.

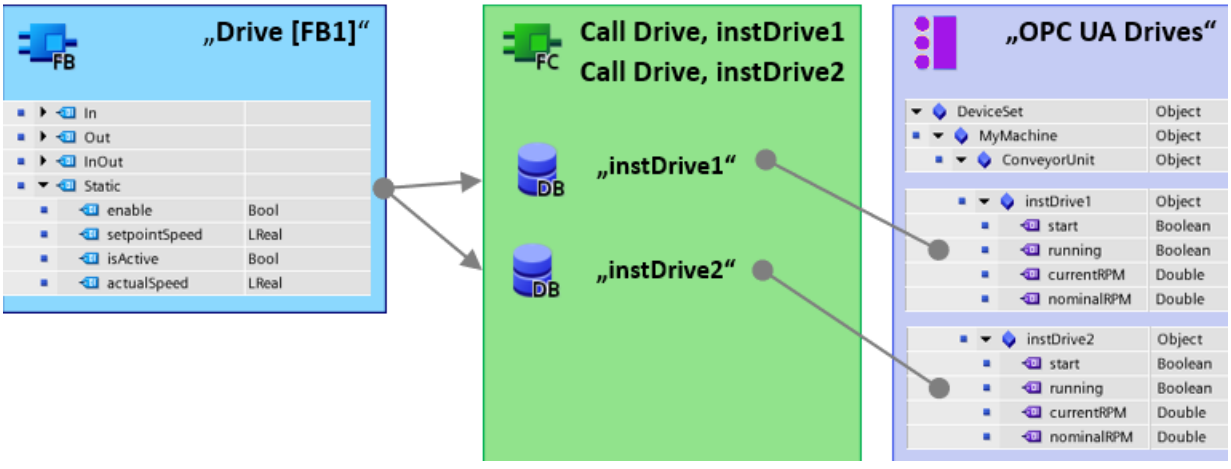

By mapping between FB type information / UDT type information and OPC UA type information, STEP 7 is able to create all instances present in the program as nodes in the server interface.

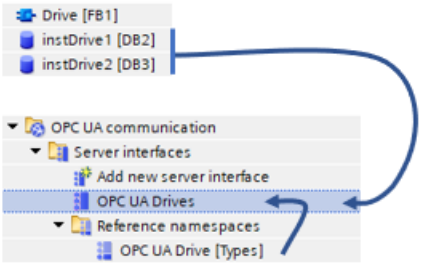

Rules

- Only the FB elements in the "Static" area of an FB interface can be mapped to OPC UA type descriptions.
- When mapping the data types, OPC UA elements from the same FB interface or from the same UDT must always be selected for an object. Mapping from different FBs or UDTs to an object is not permitted.

Requirement

- The FB types used, defined in the "Static" area of an FB, must be configured as "Accessible for OPC UA".
- The UDTs used must be configured as "Accessible for OPC UA".
- A nodeset file (XML file) is available with OPC UA data type definitions that match the FB types or UDTs defined in user program (can be mapped).
  Use the "SiOME" tool to create your node set file (Siemens Industry Online Support).
- The user program with the FB instances and UDT usages is available.

Procedure

To map a data type from a reference namespace to an FB type or UDT data type, follow these steps:

1. Select the CPU that you want to use as an OPC UA server.
2. Import the prepared node set file (XML file) with the type definitions as a reference namespace.
   – In the "Add new server interface" dialog, enable the option "Generate OPC UA nodes based on the local data mapping".

     Only when this option is enabled can you map FB types or UDTs by dragging them to the OPC UA type descriptions.

3. Double-click the icon for the server interface of the "Reference namespace" type that you just generated.

   The editor for mapping between OPC UA server interface and OPC UA elements opens. In the properties area of the editor, in the "Mapping of local data" area, the option "Generate OPC UA nodes based on the local data mapping" is enabled. If not, enable the option now.

   In the "Interface name" field, adapt the name of the server interface to be created. A new server interface of the "Companion specification" type with this name is created during the compile.

4. Assign the existing FB types or UDTs to the nodes of the server interface (reference namespace) by dragging the OPC UA element (right side of the editor) to the corresponding node of the server interface (reference namespace, "Local data" column).

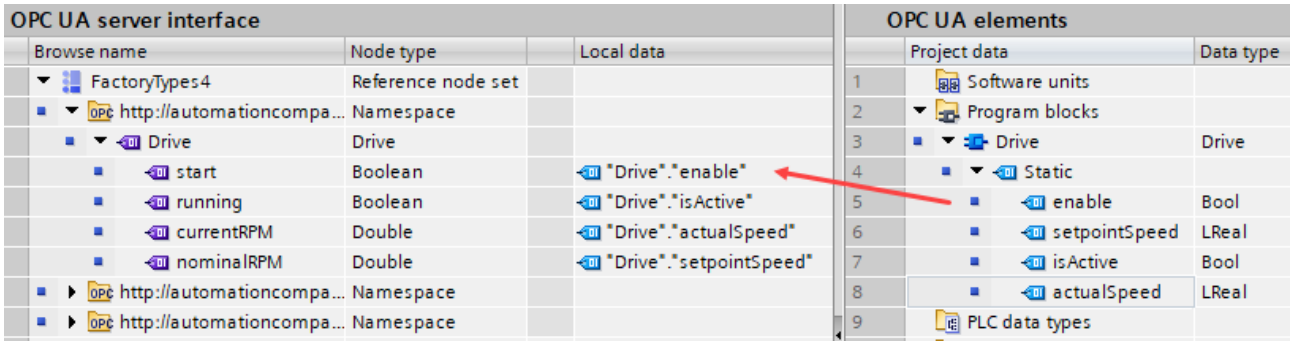

5. Compile the project.

   After compilation, the newly generated nodes of the instances are located in the generated server interface of the "Companion specification" type. STEP 7 creates an object for each instance DB. The generated elements are located under each of these objects.

   Similarly, STEP 7 also creates an object for each global DB that is created when a UDT is instantiated.

   The generated companion specification interface cannot be changed (no longer possible: generating local data, importing companion specification). This measure provides protection against data loss in the event that the server interface was manually added and is then overwritten by a recompilation. Only the name of the generated companion specification interface can be modified.

   Furthermore, group folders that you have created to structure your data in the project tree of your TIA project are applied as "Folder" (node type) in the generated companion specification interface.

Create user program with FB types or UDT

How to create FBs and UDTs is not explained in detail here; for this purpose use the description for creating a user program, e.g. declare block interface and declare PLC data types (UDT).

Consistency check

The consistency check ("Consistency check" button of the editor) also checks the mapping of the data types and updates the display of the data types in the corresponding column of the editor.

Mapping FBs/UDTs to OPC UA type information

By mapping function blocks (FBs) or UDTs to suitable OPC UA data types / OPC UA object types from imported reference namespaces, TIA Portal can provide the following function when compiling:

For each FB instance (instance DB) and each UDT instance in global DBs or instance DBs, the TIA Portal generates the required OPC UA nodes in the generated companion specification during compiling based on the reference namespace.

A generated OPC UA node always has the same access level in the server interface that the corresponding FB/UDT has.

Example: If the FB (type)/UDT has the read and write access level, the created OPC UA node has the access level "RD/WR".

New as of TIA Portal V20

For certain use cases it may be required that the tag nodes within OPC UA object types determine the access level and this is not determined by UDTs or FBs.

As of TIA Portal V20, you can set the access level for tags within OPC UA object types (not within OPC UA data types!) in the reference namespace.

The nodes created in the server interface also have this access level then.

Requirement

- A server interface of the "Reference namespace" type was imported.
- In the reference namespace, the tag to be mapped (an instance declaration within an object type) is provided with the desired access level, e.g. "RD" for readable.

  The access level is visible in the "General" area in the properties of the selected UA tags.
- The program contains the corresponding OPC UA elements (UDTs, FBs), which can be mapped to UA tags below object types.

Procedure

The description of the procedure uses a UDT as an example. The same procedure applies to FBs (types).

To put the "AccessLevel" attribute of OPC UA tags into effect within object types for the generation of tags in a server interface, follow these steps:

1. Open the server interface of "Reference namespace" type.
2. Drag a UDT (under PLC data type) from the "OPC UA elements" area to the corresponding UA tag within a UA object type in the OPC UA server interface area ("Local data" column).
3. Compile the configuration.

The access levels that were set in the reference namespace apply to generated OPC UA nodes that are based on local data mapping.

Using string node IDs for generated nodes

For reference namespaces, as of TIA Portal version V20, you can specify whether the node ID should be generated as a string node ID in the generated server interface.

As of TIA Portal version V21, you can also activate string node IDs for server interfaces.

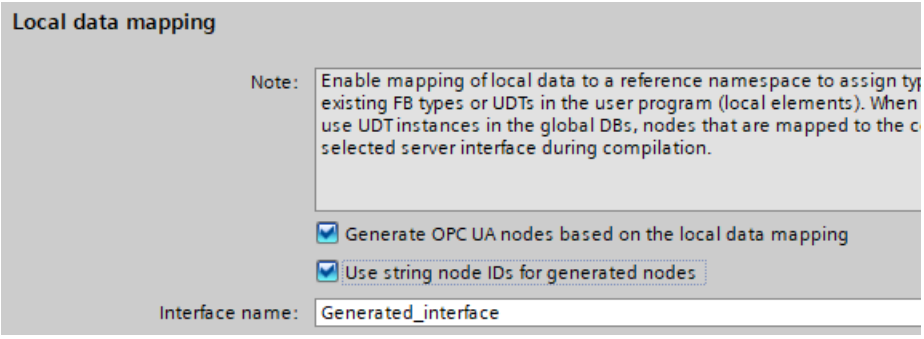

Figure 3-485 OPC UA local data mapping with string node IDs

11.3.4.12 Notes on configuration limits when using server interfaces

When you use OPC UA server interfaces, you must comply with limits for the following objects in line with the S7-1500 CPU performance class:

- Number of server interfaces
- Number of OPC UA nodes
- Load object data volume
- If you have implemented methods: Number of server methods or server method instances

Configuration limits for OPC UA server interfaces and methods

The configuration limits of the OPC UA server interfaces and the methods can be found in the technical specifications of the Equipment Manuals for the respective CPUs. Up-to-date technical specifications of the CPUs can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/td).

A violation of configuration limits results in an error message.

11.3.5 Providing methods on the OPC UA server

11.3.5.1 Useful information about server methods

Providing user program for server methods

On the OPC UA server of an S7-1500 CPU (as of firmware V2.5), you have the option of providing methods via your user program. These methods can be used by OPC UA clients, for example to start a manufacturing job using the method call of the S7-1500 CPU.

OPC UA methods, an implementation of "Remote Procedure Calls", provide an efficient mechanism for interactions between different communication nodes. The mechanism provides both job confirmation and feedback values so you no longer have to program handshaking mechanisms.

Using OPC UA methods, you can transfer data consistently without trigger bits/handshaking, for example, or trigger specific actions on the controller.

How does an OPC UA method work?

An OPC UA method in principle operates like a know-how protected function block that is called by an external OPC UA client in runtime.

The OPC UA client only "sees" the defined inputs and outputs. The content of the function block, the method or algorithm, remains hidden to the external OPC UA client. The OPC UA client receives feedback on successful execution and values returned by the function block (method), or an error message if execution has not been successful.

As the programmer, you have full control over and responsibility for the program context in which the OPC UA method runs.

Rules for programming a method and runtime behavior

- Make sure that the values returned by the OPC UA method are consistent with the input values provided by the OPC UA client.
- Follow the rules on assigning name and the structure of parameters, and the permitted data types (see description of the OPC UA server instructions).
- Behavior during runtime: The OPC UA server accepts **one** call per instance. The method instance is not available for other OPC UA clients until the call has been processed by the user program or has timed out.

The basic procedure for implementing a user program as a server method is set out below.

Implementing a server method

A program (function block) for implementing a server method is structured as follows:

1. **Querying the server method call with OPC_UA_ServerMethodPre**

   You first call the "OPC_UA_ServerMethodPre" instruction in your user program (i.e. in your server method).

   This instruction has the following tasks:

   – With this instruction you ask the OPC UA server of the CPU whether your server method was called from an OPC UA client.

   – If the method was called and the server method has input parameters, your server method now receives the input parameters.

     The input parameters of the server method come from the calling OPC UA client.

2. **Editing the server method**

   In this section of the server method, you provide the actual user program.

   You have the same options as in any other user program (for example, access to other function blocks or global data blocks).

   If the server method uses input parameters, these parameters are available to you.

   This section of the server method should only be executed if an OPC UA client has called the server method.

   After successful execution of the method, you set the output parameters of the server method if the method has output parameters.

3. **Responding to server method with OPC_UA_ServerMethodPost**

   To complete the server method, call the "OPC_UA_ServerMethodPost" instruction.

   Use the parameters to notify the "OPC_UA_ServerMethodPost" instruction whether or not the user program has been processed.

   If the user program has been successfully executed, the OPC UA server is notified via the relevant parameters. The OPC UA server then sends the output parameters of the server method to the OPC UA client.

Always call the instructions "OPC_UA_ServerMethodPre" and "OPC_UA_ServerMethodPost" as a pair irrespective of whether the user program is processed by both instructions or continued in the next cycle.

You will find an example of a server method implementation in the STEP 7 online help.

Integrating the server method

The diagram below shows how an OPC UA client (A) calls the server method "Cool":

The CPU executes the instance "Cool1" of the server method "Cool" in the cyclic user program ⑥.

The CPU first uses the instruction "OPC_UA_ServerMethodPre" to query ④ whether an OPC UA client has called the server method "Cool" ①.

- If the server method has not been called, program execution returns directly to the cyclic user program over ④ and ⑥. The CPU resumes the cyclic user program after "Cool1".
- If the server method has been called, this information is returned to the server method "Cool" over ④. The actual functionality is now executed in the Cool server method, see"<Method Functionality>" in the graphic.

  The server method then uses the instruction "OPC_UA_ServerMethodPost" ⑤ to notify the firmware (B) that the instruction has been executed ③.

  The firmware returns this information over ② to the calling OPC UA client (A).

  The CPU resumes the cyclic user program after "Cool1".

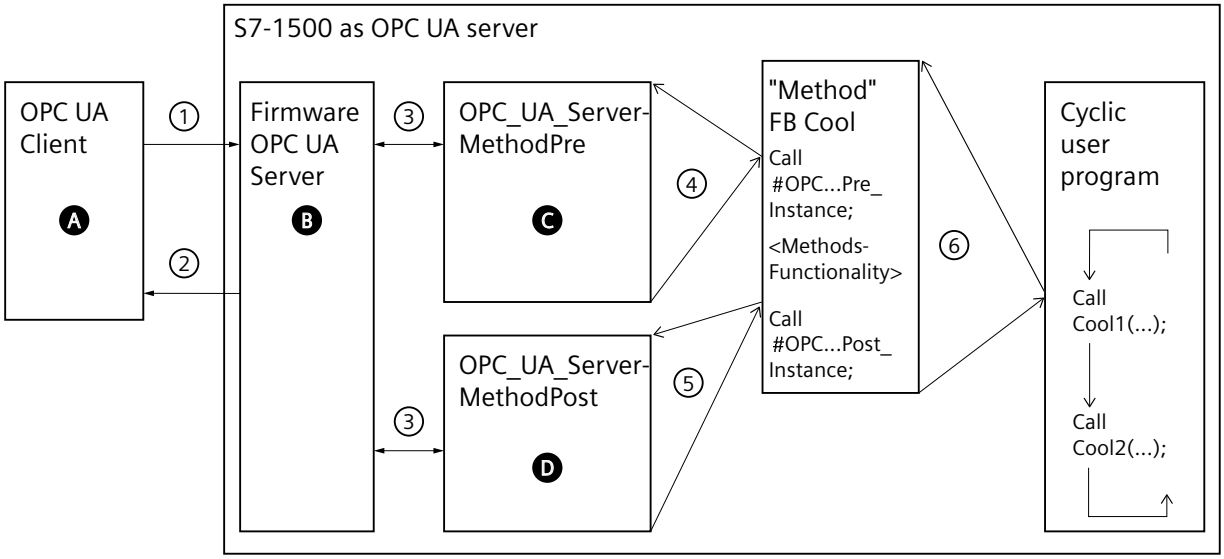

A	Call of the server method and management of the "Done" information (method complete)
①	Asynchronous call of the server method
②	Asynchronous "Done" information for the method called (method complete)
B	Wait for OPC UA client calls, management of calls in the queue, forwarding of "Done" information from the cyclic user program to the OPC UA client
③	Data transfer from the OPC UA server to the method instances of the user program and vice versa
C	Check whether method has been called. If it has, forwarding of input data from the OPC UA server to the method instance of the user program and feedback to the method instance that the method has been called ("called")
④	Synchronous call of the instruction OPC_UA_ServerMethodPre as a multi-instance stating the storage area for the input data from the OPC UA server. The return value indicates whether or not the method has been called by the OPC UA client.

⑤ Check whether the method has been completed or is still active ("busy").

D Check whether the method has been completed.
If it has, the output data of the method instance is forwarded to the OPC UA server and the method instance is notified that the method has been completed. The OPC UA server is notified.

⑥ Call of the method FB (in this case: FB Cool) with the required instance and the process parameters

Figure 3-486 Example: Calling the "Cool" server method

Information about server instructions

The "OPC_UA_ServerMethodPre" and "OPC_UA_ServerMethodPost" are described in detail in the help to the Instructions > Communication > OPC UA > OPC UA server.

11.3.5.2 Boundary conditions for using server methods

Permitted data types

If you provide server methods, observe the following rule:

- Assign the data types as shown below (SIMATIC data type - OPC UA data type). Other assignments are not permitted.

STEP 7 does not check the observance of this rule and does not prevent an incorrect assignment. You are responsible for the rule-compliant selection and assignment of the data types.

You can also use the listed data types, for example, as elements of structures/arrays/UDTs for input and output parameters of self-created server methods (UAMethod_InParameters and UAMethod_OutParameters).

SIMATIC data type	OPC UA data type
BOOL	Boolean
SINT	SByte
INT	Int16
DINT	Int32
LINT	Int64
USINT	Byte
UINT	UInt16
UDINT	UInt32
ULINT	UInt64
REAL	Float
LREAL	Double
LDT	DateTime
WSTRING	String
DINT	Enumeration (Encoding Int32) and all derived data types

SIMATIC data type	OPC UA data type
User-defined data type required (UDT, user-defined data type) The user-defined data type must be created with the prefix "Union_", for example "Union_MyDatatype". The first element (Selector) in this UDT must have the data type "UDINT".	UNION and all derived data types
See LocalizedText and ByteString data types (Page 304)	LocalizedText ByteString
GUID See Using additional OPC UA data types for companion specifications (Page 306)	GUID

Number of implementable server methods and number of arguments

If you implement server methods via your user program, the number of usable methods is limited depending on the CPU type. You can find this information in the equipment manuals of the corresponding CPUs or the latest technical specifications of the CPUs on the Internet (https://support.industry.siemens.com/cs/ww/en/ps/td).

Error message when exceeded

If the maximum number of server methods is exceeded, the OPC_UA_ServerMethodPre or OPC_UA_ServerMethodPost instructions report the error code 0xB080_B000 (TooManyMethods).

Amount of data which can be transferred using server method to an S7-1500 CPU

Max. 2097152 bytes (= 2.1 megabytes MaxMessageSize).

Supply of structured data types with nested arrays

If a structured data type (Struct/UDT) contains an array, the OPC UA server does not provide information about the length of this array.

If you use such a structure as the input or output parameter of a server method, for example, you must ensure that the nested array is supplied with the correct length when the method is called.

If you do not adhere to this rule, the method fails with the error code "BadInvalidArgument".

11.3.6 Providing alarms on the OPC UA server

11.3.6.1 Useful information on alarms

Alarms allow you to detect errors in process control in the automation system quickly, to localize them precisely, and to eliminate them. This leads to a significant reduction in downtimes in a plant. The OPC UA information model "Alarms & Conditions" provides a standardized and platform-independent way of message processing.

As of firmware version V2.9, the OPC UA server of an S7-1500 CPU supports the OPC UA information model "Alarms and Conditions". In this way, the OPC UA server provides access to controller alarms.

The following sections describe which alarm types available in SIMATIC are supported at the OPC UA interface of the OPC UA server.

The following sections also describe how you configure the OPC UA server of the S7-1500 CPU for Alarms & Conditions, the main points of how the Alarms & Conditions model is structured with OPC UA, and which special points must be taken into consideration when using alarms from the address space of the OPC UA server as compared to the SIMATIC controller alarms of the CPU alarm system.

Basis for the converting alarms to OPC UA Alarms & Conditions

The Alarms and Conditions information model is specified in the "OPC 10000-9: OPC Unified Architecture Part 9: Alarms & Conditions" specification.

Controller alarms in SIMATIC

The OPC UA server of the S7-1500 CPUs supports the controller alarms listed below, which are available to S7-1500 CPUs. You configure or program these alarms in the usual way, without the need to consider additional rules for use of these alarms by OPC UA clients.

The added benefit of OPC UA Alarms and Conditions is that these alarm types can be displayed not only by HMI devices, web browsers, the CPU display or the TIA Portal, but also by all OPC UA clients that support OPC UA Alarms and Conditions.

- PLC supervision alarms with ProDiag
  You can integrate simple supervisions in your program with just a few configuring steps and without having to change the program code. The configuration of the supervisions is independent of the programming languages of the TIA Portal because only individual operands are supervised, and you do not need any additional programming sections.
- System diagnostics alarms
  Configuration-dependent module events are known by the hardware configuration of the CPU and can be evaluated by connected display devices. They can only be viewed in the alarm editor and cannot be edited.
- Program alarms (Program_Alarm instruction)
  For reporting program synchronous events, program alarms are assigned to one block at a time. They are created in the program editor and edited in the alarm editor (TIA Portal).
- GRAPH alarms
  For GRAPH function blocks, you can also enable alarms; e.g. for interlocks, supervisions and GRAPH warnings (step-time supervisions).

Important information on the alarm types

The following characteristics are significant to the differences in the behavior of alarms:

- Do alarms have a state (e.g. are they incoming, outgoing - with the corresponding time stamps)?
- Do alarms require acknowledgment?

If none of these characteristics apply, which means the alarms have no state and do not require acknowledgment, alarms simply provide information about an event that has occurred ("Fire and Forget"). It is up to the device receiving the alarm to buffer the alarm for further use or only for display.

Alarm class determines acknowledgment behavior

This section covers the setting options for program alarms. You can also set the behavior of the alarms for system diagnostics alarms and PLC supervision alarms (e.g. ProDiag supervision settings) - refer to the linked more information for details.

You can find the setting options for program alarms in the alarm editor (double-click on "PLC supervisions and alarms" in the project tree, select the "Alarms" tab).

For the S7-1500 CPU, you set here via the alarm class whether an alarm needs to be acknowledged or not. In addition to the acknowledgment behavior, when creating a new alarm class, you define the default priority of alarms of this alarm class.

You set whether an alarm has a state or not by means of the "Information only" option, for example, at the alarm type; this results in "Fire-and-Forget" behavior of the alarm.

Here is an example with settings in the alarm editor with different alarm classes ("PLC supervisions and alarms" in the project tree):

- First line "Program_Alarm": Does not require acknowledgment, information only ("Fire and Forget").
- Second line "Program_Alarm_1": Requires acknowledgment and has a state, which means the alarm includes information on whether it is incoming or outgoing.
- Third line "Program_Alarm_2": Does not require acknowledgment and has a state, which means the alarm includes information on whether it is incoming or outgoing.

Alarm types

Name	Type	ID	Location	Alarm text	Info text	Alarm class	Acknowle...	Information only
Program_Alarm	PLC alarm		AlarmType	myText	myINFO	No Acknowledgement	☐	☑
Program_Alarm_1	PLC alarm		AlarmType			Acknowledgement	☑	☐
Program_Alarm_2	PLC alarm		AlarmType			No Acknowledgement	☐	☐

Display of alarms in the TIA Portal

During runtime, you have the option of viewing the alarms in the TIA Portal: The alarm display is located directly under the alarm editor ("Diagnostics" tab > "Alarm display" tab).

The following applies to the state and acknowledgment behavior:

- When you click on the "Current alarms" button, alarms that have been recently incoming, outgoing or acknowledged are displayed. Only alarms with a state and alarms requiring acknowledgment are displayed here. You can also acknowledge an alarm requiring acknowledgment (blue font) in this view via the shortcut menu or using the "Acknowledge" button.
- If you want to observe the chronological development (e.g. alarm came in, was acknowledged and went out), you need to click the "Alarm archive" button. The three events that belong to this alarm are listed one after another only in this view. You can only find the current state in the "Current alarms" view.
- Info reports (alarms with the "Information only" property) are only displayed in the "Alarm archive" view. Because these alarms are only triggered once and not buffered, they do not appear in the "Current alarms" view.
- PLC supervisions are also shown in the alarm display.
- System alarms usually belong to the "No Acknowledgment" alarm class with the "Information only" option. These alarms are logged in the diagnostics buffer in the CPU and thus allow the sequence of system alarms to be analyzed over a limited period. In contrast, operating state changes that are also logged in the diagnostics buffer have a state, which means it is indicated that or when a CPU went into STOP state and if or when it exited this state again, for example, entered RUN state. This information is displayed with the states "incoming/outgoing".

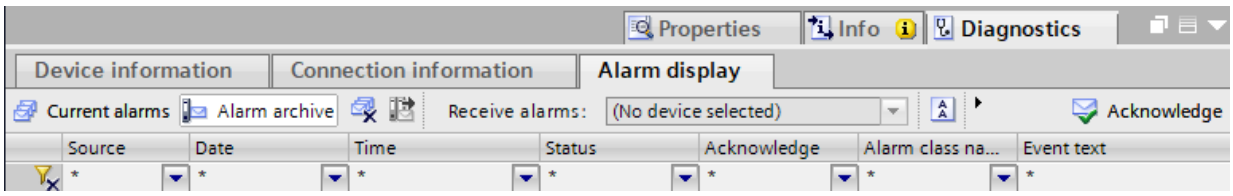

Provision of controller alarms by the OPC UA server

When an OPC UA client wants to receive alarms of the S7-1500 CPU, it needs to subscribe to OPC UA events (MonitoredEventItems).

For this purpose, the address space of the OPC UA server of the S7-1500 CPU contains corresponding nodes that are "Event-Notifiers" and create a subscription for the OPC UA clients to receive the alarms.

For completeness, we also mention that further type definitions are contained in the server address space for this purpose as nodes under "Types". Type definitions under "BaseEventType" and "ConditionType" ensure that the fields used by SIMATIC alarms are also provided in the OPC UA server.

After the activation of OPC UA Alarms and Conditions (CPU properties in the hardware configuration), the OPC UA address space of the S7-1500 CPU thus reflects the various alarm types (controller alarms) as described above:

- ProcessDiagnostics
  Corresponds to the PLC supervision alarms with ProDiag
- SystemDiagnostics
  Corresponds to the system diagnostics alarms
- UserProgram
  Corresponds to the program alarms
- Graph
  Corresponds to GRAPH alarms

By selecting the node for a subscription, you determine which alarm types are received by the OPC UA client. For example, the "Server" node enables receipt of all alarms, the "UserProgram" node only the receipt of program alarms.

Details about the OPC UA model for Alarms and Conditions are given in the next selection, especially for the "Overloads" node, you can find more information here: Handling memory limits for OPC UA Alarms and Conditions (Page 348).

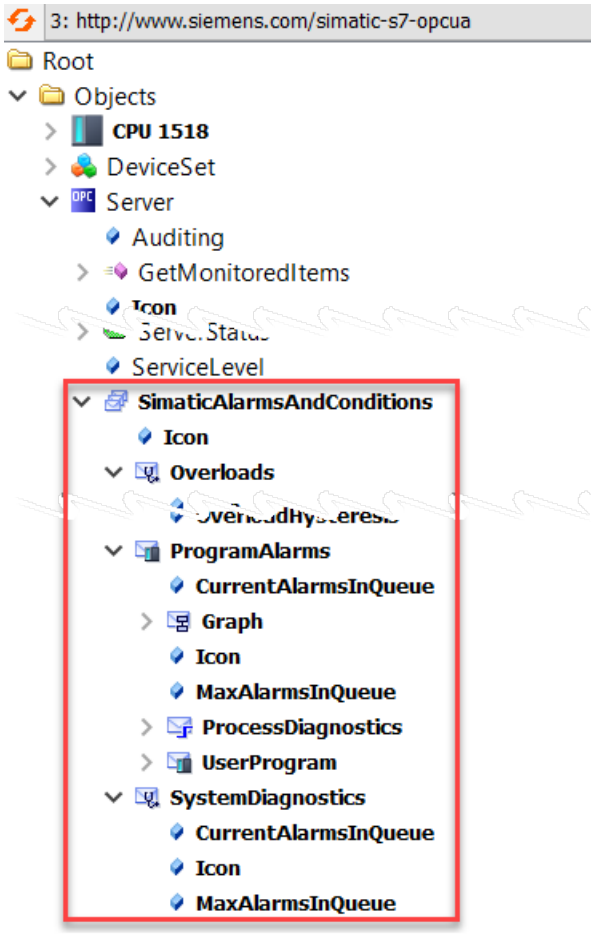

More information on the alarm types

The concepts and configuration options for controller alarms are not described further here. For information on alarm configuration, alarm display and the associated instructions, such as "Program_Alarm", refer to the STEP 7 online help.

11.3.6.2 OPC UA Events

The basic concepts for alarm processing in OPC UA are expanded on here - the basic concept of "Events" is covered here. The terms used in the various parts of the OPC UA specification have been retained here.

Properties of events

In the address model of the OPC UA server, as of CPU firmware version V2.9, you not only have the option to access PLC tags (read, write) via nodes and to use methods - you can also receive events or alarms via nodes. In OPC UA terminology, these are called "events".

An event includes an event text (Message), time stamp (Time) and event source (SourceNode).

The information supplied with an event from the server depends on the event type. OPC UA defines a BaseEventType in part 5 of the specification (Information Model).

Other event types that provide different alarm behavior are derived from the BaseEventType. This type information of the different event types is visible in the address space of an OPC UA server ("Types" folder). This also applies, for example, to the event types of "Conditions" and "Alarms", which are discussed in the next section.

The OPC UA specification defines for the BaseEventType and for derived EventTypes which properties (fields) of an event are mandatory and which are optional.

The following figure shows the hierarchical structure of BaseEventType.

The following sections show how specialized EventTypes are derived from the root of the derivation hierarchy, the BaseEventType. The SIMATIC-specific derivations ensure that the information supplied in SIMATIC with an alarm and displayed on an HMI device, for example, can also be subscribed to by an OPC UA client in the address space of the OPC UA server.

An event itself is not available as a node in the address space. Events are only triggered by nodes or objects that have the "Event-Notifier" property. These nodes are often also referred to as event signaling objects. Only nodes with this property can be specified as EventMonitoredItem in a subscription to receive corresponding events in the client.

Nodes that can trigger events with an S7-1500 CPU are objects such as "Server", the "SimaticAlarmsAndConditions" object below it, and the three objects below that, ProcessDiagnostics, SystemDiagnostics and UserProgram. The "EventNotifier" attribute is set for these objects in the address space of the OPC UA server of the CPU.

Definition of SimaticEventType

The figure below shows that the type "SimaticEventType" is derived directly from BaseEventType.

BaseEventType is the basic type definition for events with OPC UA.

All event types for OPC UA can be defined, directly or indirectly, based on BaseEventType.

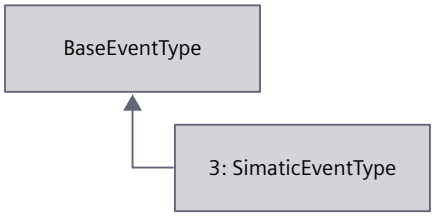

The "SimaticEventType" type is defined in the SIMATIC namespace (http://www.siemens.com/simatic-s7-opcua).

SimaticEventType has all properties of BaseEventType as well as the special properties which are an image of the field structure of SIMATIC alarms.

Description of the event fields for SimaticEventType

The following table contains information on the fields of SimaticEventType for alarms of the type "Information only". Fields that are optional according to OPC UA and are not used by the OPC UA server of the CPU are omitted. You can also find a general description of the fields in the specification OPC 10000-5: OPC Unified Architecture, Part 5: Information Model, Release 1.04.

BrowsePath	DataType	Explanations
EventId	ByteString	Unique Event ID of the event
EventType	NodeId	Node ID of the event type
Time	UtcTime	Time stamp of the event (Event occurrence)
ReceiveTime	UtcTime	Current time stamp at which the OPC UA event was generated.
Message	LocalizedText	Event text
Severity	UInt16	Priority of the alarm from SIMATIC (0..16), spread into a range from 1..1000 with OPC UA, see following table. The priority indicates the urgency with which the event needs a response.
3:AdditionalText_01	LocalizedText	Optional additional text 1
...	...	...
3:AdditionalText_09	LocalizedText	Optional additional text 9
3:AssociatedValue_01	3:SimaticAssociate-dAlarmValue	Optional associated value 1 (not for system diagnostics)
...	...	...
3:AssociatedValue_10	3:SimaticAssociate-dAlarmValue	Optional associated value 10 (not for system diagnostics)
3:InfoText	LocalizedText	Info text

BrowsePath	DataType	Explanations
3:ID	UInt16	Alarm number - A number (ID) assigned by the system that is unique within the CPU and identifies an alarm.
3:DisplayClass	UInt16	Display class (used by HMI devices. Determines the events displayed on specific HMI devices.
3:GroupID	UInt8	Acknowledgment group for alarms that are acknowledged together.

Assignment of Priority (SIMATIC) - Severity (OPC UA)

The following table shows how the 17 priorities that you can assign to alarms in the SIMATIC environment are mapped to the 1000-level Severity with the OPC UA server of the S7-1500 CPU.

This assignment depends on the manufacturer. Different assignments may apply to other devices.

OPC Range	Priority 0..16 (SIMATIC)	Severity 1..1000 (OPC UA)
HIGH (667 – 1 000)	16	1000
	15	930
	14	860
	13	790
	12	720
MEDIUM (334 – 666)	11	650
	10	600
	9	550
	8	500
	7	450
	6	400
	5	350
LOW (1 – 333)	4	300
	3	225
	2	150
	1	75
	0	1

11.3.6.3 OPC UA conditions and OPC UA alarms

The following goes further in depth about the basic concepts for OPC UA Conditions and OPC UA Alarms based on the explanations of events in the previous sections. Again, the terms used in the various parts of the OPC UA specification have been retained here.

Properties of Conditions

A prerequisite for understanding is the concept of "Events" in OPC UA.

In OPC UA, if an event alarm object provides status information in addition to its ability to fire Events, we speak of Conditions. Conditions represent a state of a system or one of its components. Basic states are "enabled" and "disabled", other state definitions are also possible.

In turn, interested OPC UA clients are notified of state changes by means of events (Condition Events).

An example of a Condition is state information, for example, that a device requires maintenance.

Properties of Alarms

However, the properties of ConditionType are not sufficient to completely map the characteristics of SIMATIC alarms in the OPC UA server.

From the ConditionType, which is derived from the BaseEventType, OPC UA defines further derived event types such as AcknowledgeableConditionType and AlarmConditionType.

AcknowledgeableConditionType supplements the properties of ConditionType with the "Acknowledgeable" characteristic (AckedState).

AlarmConditionType thus adds the "ActiveState" characteristic to the properties of ConditionType and the AcknowledgeableConditionType. In SIMATIC terminology, this is an incoming alarm. The ActiveState signals that the situation, which the Condition represents, is currently present or has occurred.

Example: A temperature has exceeded a limit. If "ActiveState" is not set, the situation that represents the condition no longer exists - this is usually referred to as a "normal state". In SIMATIC terminology, this corresponds to an outgoing alarm.

In OPC UA, other statuses such as SilenceState and ShelvingState are defined, but these are not relevant to mapping to the SIMATIC alarm system and will therefore not be described further here.

The SimaticAlarmConditionType is derived from the AlarmConditionType and contains all event fields to map the state and acknowledgment information of SIMATIC messages.

Definition of SimaticAlarmConditionType

The following figure shows how events of the type "SimaticAlarmConditionType" are defined by a series of expansions to the OPC UA "BaseEventType".

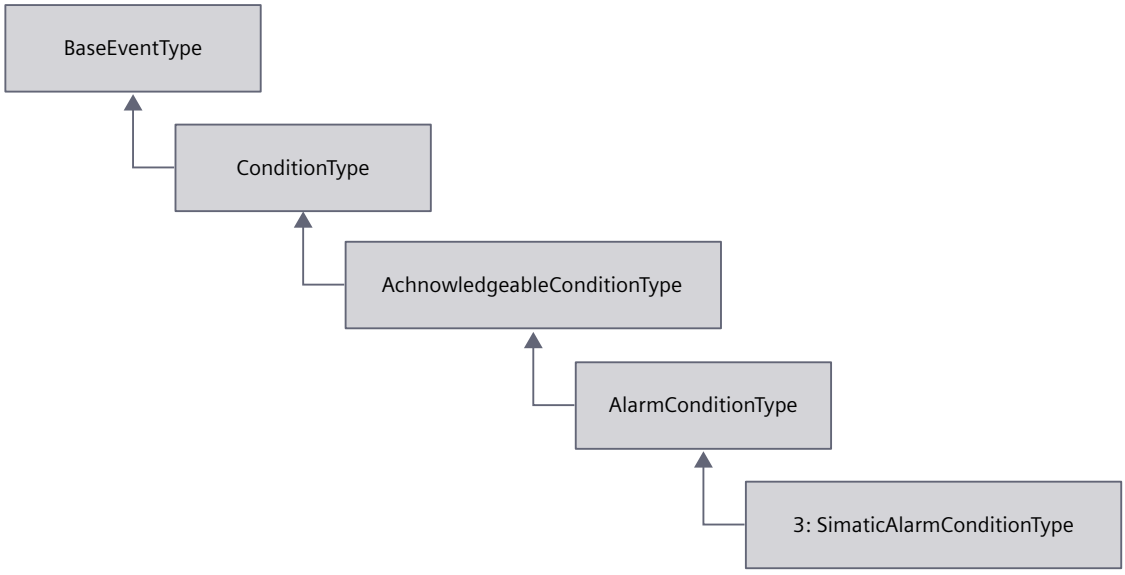

Description of the event fields for SimaticAlarmConditionType

The following table contains information about the fields of SimaticAlarmConditionType for stateful and acknowledgeable alarms, which are added to the event fields such as SimaticEventType. Fields that are optional according to OPC UA and are not used by the OPC UA server of the CPU are omitted. You can also find a description of the fields in the specification OPC 10000-9: OPC Unified Architecture, Part 9: Alarms & Conditions, Release 1.04.

BrowsePath	DataType	Explanations
ConditionClassId	NodeId	Node IDs for SystemConditionClassType, ProcessConditionClassType or BaseConditionClassType are possible
ConditionClassName	LocalizedText	Display name of the ConditionClassId
Retain	Boolean	Indicates that the alarm is still relevant for OPC UA clients (set if alarm is still pending and not acknowledged).
Comment	LocalizedText	• Most recent comment entered using the "AddComment" or "Acknowledge" method. • ZERO after a server restart and if no comment was entered.
Comment.SourceTimestamp	UtcTime	Time stamp for the last change of the comment field
AckedState	LocalizedText	"Acknowledged" or "Unacknowledged"
AckedState.Id	Boolean	Set, if acknowledged

BrowsePath	DataType	Explanations
AckedState.TransitionTime	UtcTime	Time at which the alarm was acknowledged. ZERO if not acknowledged or not acknowledgeable.
ActiveState	LocalizedText	"Active" or "Inactive"
ActiveState.Id	Boolean	Set when "active"

11.3.6.4 Activating Alarms and Conditions

Requirements

- S7-1500 CPU firmware version V2.9 or higher.
- Runtime license for OPC UA purchased according to the license specifications and set in the CPU properties.
- "Central alarm management in the PLC" parameter is enabled ("PLC messages" area in the CPU properties).

Procedure

To activate alarms through OPC UA Alarms and Conditions, follow these steps:

1. In the CPU properties, go to the "OPC UA > Server > General" area.
2. Select the "Enable alarms and conditions on the OPC UA server" option.
   The corresponding types and objects that can trigger events only become visible in the address space when the option is activated.
3. If required, also activate the option "Allow message acknowledgment by OPC UA client".
   In this case, any connected OPC UA client can acknowledge an alarm requiring acknowledgment with the "Acknowledge" method.

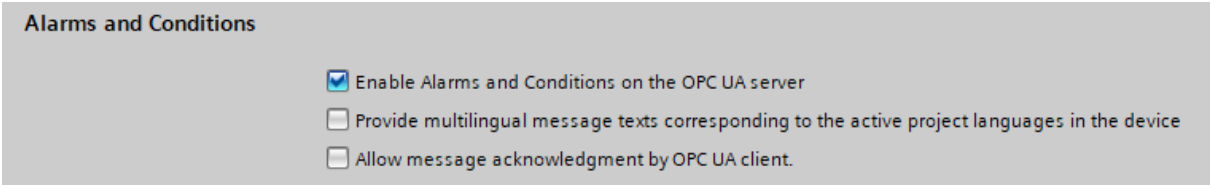

Recommendation: Activate diagnostics "Requests of a remote OPC UA client failed"

When the OPC UA server cannot allocate sufficient memory, it is not possible to generate OPC UA alarms in this state; message loss for OPC UA clients may occur.

Therefore, you should activate the diagnostics "Requests of a remote OPC UA client failed" to diagnose this state (Properties of the CPU > OPC UA > Server > Diagnostics).

In addition, you should also activate the option "Summarize diagnostics in case of high message volume".

As soon as sufficient memory is available again, OPC UA clients should call the ConditionRefresh method to receive the current state of the alarm system.

More information

You can find information on methods for OPC UA Alarms and Conditions in the section Methods for OPC UA Alarms and Conditions (Page 343).

You can find information on failed requests of a remote client in the section Request of a remote client failed (Page 356).

11.3.6.5 Subscribing to events of an OPC UA server

Subscribing to all events via the "Server" node

OPC UA servers provide events via the "Server" node and lower-level nodes. When OPC UA clients subscribe to the "Server" node, they receive all events and alarms of the OPC UA server.

The "Server" node is located in the "Objects" folder below "Root".

OPC UA servers inform OPC UA clients which event types they use (under "Root > Types > EventTypes" in the address space).

Filter options for events

OPC UA clients can choose and only subscribe to specific nodes under the "Server" node and thus to specific event types, for example, only the "UserProgram" node. This reduces the number of events from the OPC UA server to program alarms.

Another way of filtering is to select the event fields, known as "Select Clause" in OPC UA terminology.

This means that in the subscription, the OPC UA client makes a selection of the event fields in addition to the event alarm object (e.g. the "UserProgram" node). You select the event fields via the browse name of the corresponding field.

OPC UA also defines so-called "Where Clauses". A Where Clause in the event filter is used to further limit the number of events that are supplied by the OPC UA server for the selected object, for example, by filtering to a severity range.

Configure Where Clause for event filter

To configure a Where Clause for an event filter, you need operands and operators. The operands provide the required values or data. The operators determine the filter criteria for the operands and thus limit the number of events.

If you configure a filter for the events of the OPC UA server of a CPU on the OPC UA client, only one filter may be active for Where Clauses. Otherwise, no messages are issued by the OPC UA server of the CPU. If several filters are active, the OPC UA server returns the error code "BadFilterElementInvalid".

The following tables show the operands and operators from the OPC UA specification Part 4 and which of them are supported by the OPC UA server of a CPU.

Table 3-946 Operands for Where Clauses of an event filter

Operand	Description	Supported by the OPC UA server of a CPU
ElementOperand	Refers to the position of another operand via an index in the element array. In this way, a logical tree structure of linked sub-elements can be created.	Yes[1]
LiteralOperand	Refers to a fixed, directly entered value (literal), e.g: • Number • String • Boolean value	Yes
AttributesOperand	Refers to any attribute of an object or variable node using a node in the type system and a path constructed from ReferenceTypes and BrowseNames.	No
SimpleAttributeOperand	Refers to any attribute of an object or variable node using a TypeDefinition and a path constructed from BrowseNames.	Yes

1 When using "ElementOperand", the error code "BadFilterElementInvalid" is returned, as the filter depth on the OPC UA server of a CPU is limited to 1.

Table 3-947 Operators for Where Clauses of an event filter

Operator	Number of addresses	Result type	Supported by the OPC UA server of a CPU
Equals_0	2	Boolean	Yes
IsNull_1	1	Boolean	Yes
GreaterThan_2	2	Boolean	Yes
LessThan_3	2	Boolean	Yes
GreaterThanOrEqual_4	2	Boolean	Yes
LessThanOrEqual_5	2	Boolean	Yes
Like_6	2	Boolean	Yes
Not_7	1	Boolean	Yes
Between_8	3	Boolean	Yes
InList_9	2 ... n	Boolean	Yes
And_10	2	Boolean	Yes
Or_11	2	Boolean	Yes
Cast_12	2	Type from Operand[1]	No
InView_13	1	Boolean	No
OfType_14	1	Boolean	Yes
RelatedTo_15	6	Boolean	No
BitwiseAnd_16	2	Integer	Yes
BitwiseOr_17	2	Integer	Yes

Example client UaExpert

The example of the UaExpert OPC UA client shows how events of an OPC UA server can be received via a subscription. Here is the most important information on the displayed events/alarms:

- Event View is a separate view of events in addition to the Data Access View.
- The "Configuration" area contains the selected event signaling object with the fields for the Select Clause. A configuration of Where clauses is currently not possible in UaExpert.
- In the "Events" area, "Events" tab: Corresponds to the TIA alarm view with activated "Alarm archive" button; events of the "Information only" category and outgoing alarms are also visible there, because UaExpert buffers them in the background for display. These events are not visible in the "Alarms" tab.
- In the "Events" field, "Alarms" tab: Corresponds to the TIA alarm display with activated "Current alarms" button; alarms are visible here with their status, e.g. "active" (corresponds to "incoming") and these alarms can also be acknowledged using the context menu. Outgoing alarms are no longer visible in this view.

In the columns of the Event area, a selection of event fields is offered, for example, the event text (Message) and whether the alarm was acknowledged (A=Acknowledged).

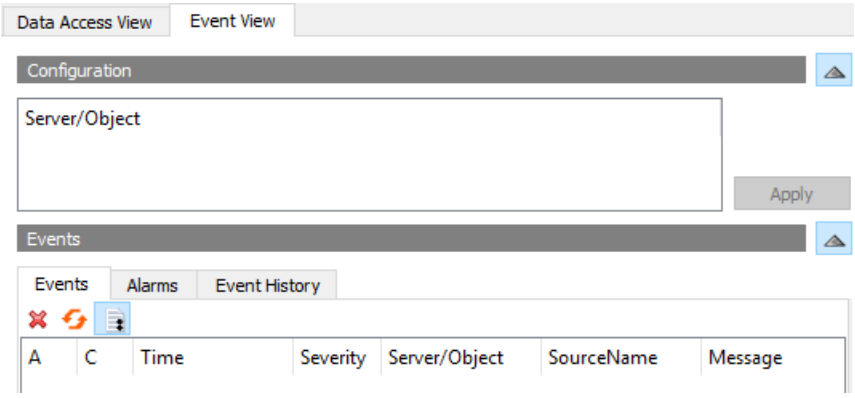

Special features of the display of alarms via the OPC UA server of the CPU

The following once again summarizes the special features of the alarm display via OPC UA Alarms and Conditions for the current status.

Topic	Explanation
Comment	Via OPC UA, you can add a comment to a alarm using the "AddComment" method or the "Acknowledge" method. This comment is no longer available after a server restart.
Pending alarms are not lost after a server restart	The OPC UA server supports the "ConditionRefresh" method with which it makes the current state of the system available to the OPC UA client, for example, after download of a new data block (requires server restart and re-establishment of the connection).

11.3.6.6 Processing associated values of alarms

You can specify placeholders for SIMATIC alarms. With placeholders you can integrate up to 10 associated values (SD_1 to SD_10) into the alarm text. Placeholders can also be specific text list entries.

When you are using alarms with placeholder, you must observe the following rules:

- Placeholders that represent values in the alarm are only inserted automatically for system diagnostic alarms or security event alarms. For other categories of alarms (e.g. program alarms), the placeholders for values are not resolved. The OPC UA clients must resolve these alarms.
- Placeholders that reference text lists are resolved by the CPU (format, e.g.: %t#<name of the text list>).

Example of how values and placeholders are assigned through UaExpert

1. Make sure that you have selected all fields that you need in the UaExpert configuration.

   Note that each field that is not needed causes a communication load. Therefore, you should avoid a complete selection as shown in the example below.

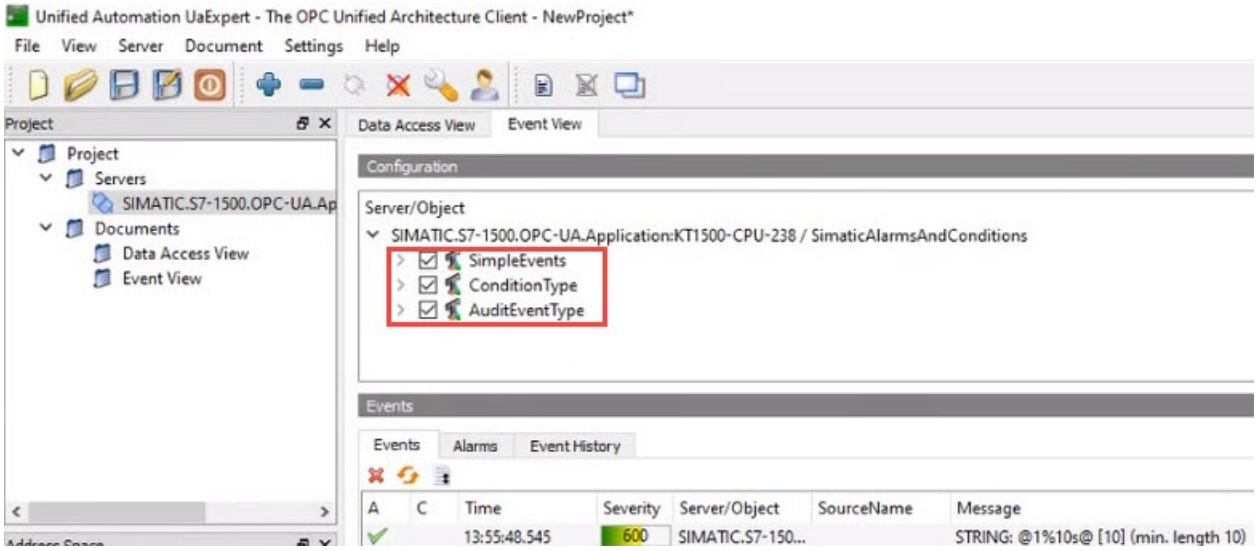

Figure 3-487 ServerObject-Configuration_neutral120

2. In the "Events" tab of UaExpert, you select the alarm with the integrated associated values. In the "Details" area of the alarm, you will find the value that is to be integrated into the alarm.
   Example: "AssociatedValue_01" is assigned to SD_1 (format @1% ...@).
   You will find explanations on the formats for associated values in the TIA Portal information system (e.g. by searching for "Example of associated values").

Support of simple data types as associated values

The field type from "AssociatedValue_01 to ..._10 is of the Union type and is limited to some simple types. The OPC UA data type is SimaticAssociatedAlarmValue. The following simple data types are supported:

3:AssociatedValue_01	SimaticAssociatedAlarmValue
Switch Field	2
Boolean	True
3:AssociatedValue_02	SimaticAssociatedAlarmValue
Switch Field	6
SByte	123
3:AssociatedValue_03	SimaticAssociatedAlarmValue
Switch Field	3
Int16	1234
3:AssociatedValue_04	SimaticAssociatedAlarmValue
Switch Field	4
Int32	12345
3:AssociatedValue_05	SimaticAssociatedAlarmValue
Switch Field	7
Byte	123
3:AssociatedValue_06	SimaticAssociatedAlarmValue
Switch Field	8
UInt16	1234
3:AssociatedValue_07	SimaticAssociatedAlarmValue
Switch Field	11
Float	1
3:AssociatedValue_08	SimaticAssociatedAlarmValue
Switch Field	12
Double	2
3:AssociatedValue_09	SimaticAssociatedAlarmValue
Switch Field	9
UInt32	12345
3:AssociatedValue_10	SimaticAssociatedAlarmValue
Switch Field	13
String	HelloWorld

Figure 3-488 UnionDataTypes_neutral120

Mapping to SIMATIC data types

The following assignment SIMATIC data type => OPC UA data type applies:

Supported data types for SD_1 to SD_10	Mapping to OPC UA
BOOL	Boolean
BBOOL	Boolean
BYTE	Byte
CHAR	Byte
SINT	SByte
USINT	Byte
WORD	UInt16
WChar	UInt16
INT	Int16
UINT	UInt16

Supported data types for SD_1 to SD_10	Mapping to OPC UA
DWORD	Uint32
DINT	Int32
UDINT	Uint32
REAL	Float
LREAL	Double
String	String
WString	String

11.3.6.7 Simultaneous receipt of messages in multiple languages

Alarms are transmitted from the OPC UA server to the OPC UA client in the default or reference language. In the "Multilingual support" area of the CPU parameters, you can set the loaded project languages in which the alarms are to be transmitted.

As of Version 4.0 of the S7-1500 CPUs, you have the option of having the languages of connected OPC UA clients selected:

- When establishing the session, a client can request message texts in one or more active project languages using the parameter "LocaleIds []"; see OPC 10000-4: Services, ActivateSession Service Parameters.

  Only message texts can be requested from the OPC UA server of the CPU in this way; the parameter has no effect on other localized texts in the address space.

  Requirement: The "Provide multilingual message texts corresponding to the active project languages in the device" option has been enabled.
- A client can request the message texts in all three active project languages simultaneously, e.g. to collect the alarms on a central server, so that they can be evaluated by people in different languages.

Requirements

- S7-1500 CPU as of firmware version 4.0
- The OPC UA client supports the LocaleIds "qst" and "mul" for multilingual texts.
- The "Provide multilingual message texts corresponding to the active project languages in the device" option has been enabled ("Alarms and Conditions" area in the CPU properties).

Effect of the LocaleId "qst" and "mul"

OPC UA specification (OPC 10000-3: UA Part 3: Address Space Model) describes the built-in data type "LocalizedText", which is used for texts in different languages.

The elements of the structure for the data type LocalizedText are defined as follows:

Name	Type	Description
LocalizedText	Structure	
Locale	LocaleId	Identifier for the language (language code) <language>-<Country/Region>, e.g. "en-US" Specified by IETF RFC 5646
Text	String	Localized text (language-specific translation)

LocaleId = "qst"

"qst" is not an abbreviation but merely a defined string for a LocaleId, which contains replacement texts in addition to the contents, as in the case of "mul".

When an OPC UA client requests a LocalizedText with the LocaleId "qst", it receives the message texts in all loaded project languages on the CPU. In addition to the Array of LocaleId, the JSON text element has a section with the definition of replacement texts (replacement section). The client must carry out the provided replacements in the message text.

Example texts in two languages; "t" stands for "text", "r" for "replacement":

```
{
 "t": [
 ["de-DE","mein Text @1@ /2/"],
 ["en-US","my text @1@ /2/"]
 ],
 "r": [
   ["@1@", "myCompany"]
   ["/2/", 1.2345]
 ]
}
```

Resulting text:

```
de-DE: "mein Text myCompany 1,2345"
en-US: "my text myCompany 1.2345"
```

Because the decimal number 1.2345 in the replacement section is not formatted as String, it can be written correctly in the different languages (with decimal point in en-US and with decimal comma in de-DE) – provided that this function has been implemented in the client.

LocaleId = "mul"

If an OPC UA client requests a LocalizedText with the "mul" LocaleId, this request is ignored by the OPC UA server. The reason for this is that the OPC UA server does not support the "mul" LocaleId. It is only returned as a response to a request via the "qst" LocaleId if no replacement texts are contained in the response.

Rules

Alarm texts are assembled by the server according to the following rules, and provided to the client:

- To simplify the handling of multilingual message texts, only the LocaleId "qst" is allowed for the server of the S7-1500.

  If you request multilingual message texts with "qst" and there are placeholders (associated values) in the text, the placeholders are provided in the replacement section. If no placeholders are present in the text, the text is returned as LocaleId "mul" without replacement section.

  If only one language is returned (e.g. because there is only one active language or alignment with the requested languages results in a single language) and no placeholder is present in the text, the message text is not returned as JSON but rather is returned directly as localized text in the appropriate language.
- A client can retrieve the alarms in all languages provided by the server or only some of these languages. The client defines the selection through an Array of LocaleIds, which follows the LocaleId "qst". If no other LocaleIds follow the LocaleId "qst", all available languages are provided by the server.
- Multilingual replacement texts are not returned in the replacement section. You implement multilingual replacement tests using text lists.

Reading out supported languages

The OPC UA server publishes the supported languages under the node "Server Capabilities > LocaleIdArray".

11.3.6.8 Methods for OPC UA Alarms and Conditions

The OPC UA specification Part 9 (OPC 10000-9: Alarms & Conditions) defines methods for OPC UA servers to enable OPC UA clients to react to state changes, for example.

In the following, the methods are described that are supported by the OPC UA server of the S7-1500 CPU with their special features.

Requirement

Using the relevant methods for the Alarms and Conditions functionality requires the following:

- Alarms and Conditions is activated
- For the "Acknowledge" method, the acknowledgment of alarms by OPC UA clients must be allowed on the server side.

Methods for OPC UA Alarms and Conditions

In the following, the methods are briefly explained with the special features and restrictions caused by the implementation for the OPC UA server of the S7-1500 CPU.

The methods are visible in the type space.

The OPC UA specification listed above contains the general description.

You can find a detailed description of the individual methods below this overview table.

Method	Description
Acknowledge	Method for acknowledging an alarm object that is uniquely identified by a EventId.
ConditionRefresh	Method for requesting an update of all alarm objects (in SIMATIC language: updating of all pending alarms). All monitored items of the subscription are updated. Synchronization of pending alarm objects from the OPC UA server of the CPU is indicated e.g. in the following situations: • Connecting for the first time or resuming the connection (after interrupting the communication) • Screen change on an operator screen of an HMI device
AddComment	Method for adding comments to alarm objects.

Calling the "Acknowledge" and "AddComment" methods

Method calls in OPC UA use MethodId and ObjectId.

In the case of an alarm object, ObjectId is the node ID for the instance of the alarm object.

Since the address model of Simatic Alarms and Conditions does not provide instances for alarm objects, the OPC UA specification provides in this case that the OPC UA client uses the ConditionId as ObjectId.

You can find information on how to determine the ConditionId using a SimpleAttributeOperands in the SelectClause of the event filter, see also the OPC UA specification Part 9 (OPC 10000-9: Alarms & Conditions):

Name	Type	Description
SimpleAttributeOperand		
typeId	NodeId	*NodeId* of the *ConditionType Node*
browsePath[]	QualifiedName	empty
attributeId	IntegerId	Id of the *NodeId Attribute*

Acknowledge

The Acknowledge method (MethodId: i=9111) has the following parameters:

Parameter	Data type	Description
[in] EventId	ByteString	EventId identifies a specific event notification. Only events whose AckedState.Id field has the value "False", can be acknowledged with the "Acknowledge" method.
[in] comment	LocalizedText	Text for commenting the acknowledgment, e.g. by an operator. See also supplementary description of the "AddComment" method.

Method Result Codes

Result Code	Description
Good	Method was successfully executed.
BadNotSupported	Method cannot be called because the option for acknowledging for Alarms and Conditions by OPC UA clients is deactivated in the CPU properties for OPC UA.
BadConditionBranchAlreadyAcked	Acknowledgment has already been made.
BadNodeIdUnknown	Method was called with the wrong ConditionId (see notes on ObjectId).
BadEventIdUnknown	Method was called with the wrong EventId.

ConditionRefresh

The ConditionRefresh method (MethodId: i=3875) has the following parameters:

Parameter	Data type	Description
[in] SubscriptionId	Uint32	SubscriptionId of the subscription to be updated.

Method Result Codes

Result Code	Description
Bad_SubscriptionIdInvalid	The SubscriptinId is not valid.
Bad_RefreshInProgress	The "ConditionRefresh" is currently running.
Bad_UserAccessDenied	The method "ConditionRefresh" runs in the context of a wrong session. This means that the subscription belongs to a different session.

NOTE
ConditionRefresh2 method
The OPC UA server of the S7-1500 CPU does not support the ConditionRefresh2 method which can specifically synchronize a monitored item (MonitoredItem) in a subscription. In this case, the OPC UA Server returns the result code "Bad_MethodInvalid". Use the method "ConditionRefresh" instead.

AddComment

You have the possibility to add comments to Alarms- objects of the SimaticAlarmConditionType type because the support of comments is mandatory for OPC UA Alarms and Conditions .

A comment was save in the "Comment" event field.

The following time stamp event fields belong to the comment:

- "Comment.SourceTimestamp" for the time when the comment is transferred to the CPU
- "Time" for the time when the Alarms object was modified

When the "AddComment" method is called, "Time" and "Comment.SourceTimestamp" are identical.

Special features of Alarms and Conditions comments for the OPC UA server of the CPU

The AddComment method (MethodId: i=9029) has the following parameters:

Parameter	Data type	Description
[in] EventId	ByteString	EventId identifies the event notification for which a state was reported.
[in] comment	LocalizedText	Text for commenting the specified Alarms object.

Method Result Codes

Result Code	Description
Good	Method was successfully executed.
BadNodeIdUnknown	Method was called with the wrong ConditionId (see notes on calling the methods "Acknowledge" and "AddComment").
BadEventIdUnknown	Method was called with the wrong EventId.

Special features of Alarms and Conditions comments for the OPC UA server of the CPU

You have the possibility to add comments to alarm objects of the "SimaticAlarmConditionType" type with the AddComment method. A comment is also set when the Acknowledge method is called. The "AddComment" method can be called several times.

- A comment was save in the "Comment" event field. The "Comment.SourceTimestamp" indicates the last time at which a **comment** was set.
- The "Time" time stamp marks the **last modification time of the alarm object**.

When the "AddComment" method is called, "Time" and "Comment.SourceTimestamp" are identical.

When the "Acknowledge" method is called, the two time stamps may differ, since the acknowledgment is asynchronous.

The support of comments for OPC UA Alarms and Conditions is mandatory. The SIMATIC alarm system does not know corresponding comments for alarms. Therefore, some special features have to be considered:

- There is only one comment:
  There is only one comment for an alarm object, so that an existing comment is always overwritten when several method calls are made in succession.
- Lifetime and time stamp:
  Comments are only stored at the current alarm object. If the alarm object no longer exists, e.g. after a server restart, the comment no longer exists either. The corresponding "Comment" and "Comment.SourceTimestamp" event fields are then reset (zero).
  The "Time" event field is then set as if the method call "AddComment" did not exist.
  Example: If you comment on an unacknowledged Alarms object, the "Time" event field receives the time of this comment change. After a server restart, the "Time" event field does not show the time when the comment was set, but the time when the corresponding Event arrived.

11.3.6.9 Handling memory limits for OPC UA Alarms and Conditions

The OPC UA server of the S7-1500 CPU has product-specific limited memory capacity for the "Alarms and Conditions" function (see CPU specifications).

Two memory pools for different categories of alarms are available:

- Pool only for ProgramAlarms (corresponds to program-related alarm originators (producers) such as program alarms via Program_Alarm, ProDiag, Graph)
- Pool only for SystemDiagnostics (corresponds to system diagnostic alarms)

Under unfavorable conditions (e.g. alarm burst) the CPU cannot make all pending alarms (ProgramAlarms or SystemDiagnostics) from the SIMATIC alarm area available to the OPC UA Alarms and Conditions system. However, alarms are not lost in this case.

You have the possibility to react to this overload event in the user program. According to your application you can use the "ConditionRefresh" method to make alarms that "did not make it into the OPC UA Alarms and Conditions system" available to the OPC UA Alarms and Conditions system again.

Requirement

- Alarms and Conditions is activated
- Event subscriptions are set up in the OPC UA client

Principle

The following figure shows a simplified process for temporarily storing ProgramAlarms to make them available again at another time for the OPC UA Alarms and Condition System. The nodes mentioned in the caption are visible in the following image of the address model.

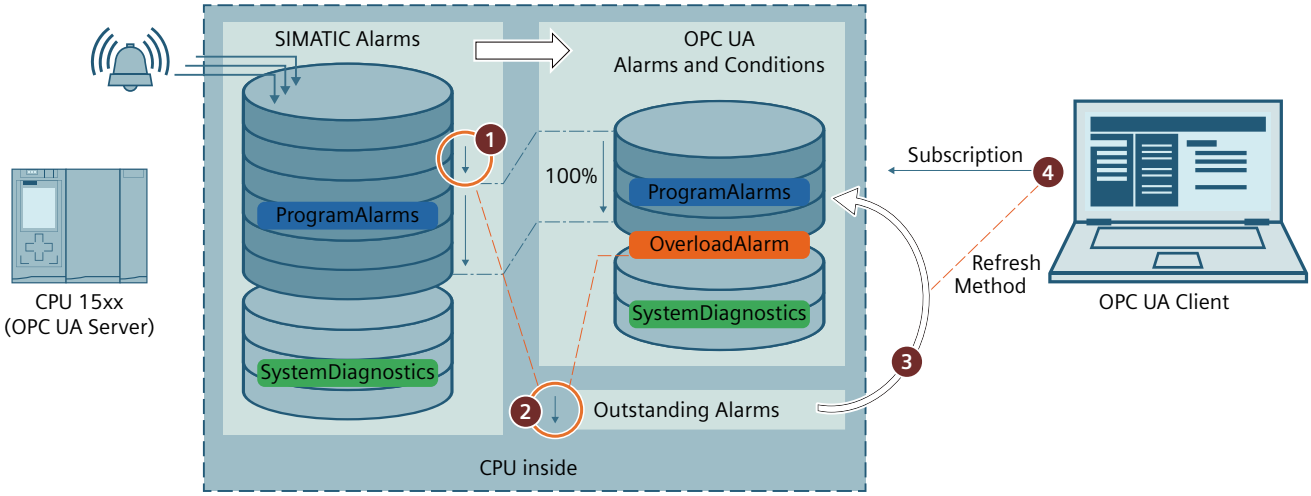

① Number of active alarms is too high to make all alarms accessible via OPC UA Alarms and Conditions

② Overloads alarm (overload alarm) is triggered. This overload alarm is active until the following situation occurs:
- No more alarms are pending for the OPC UA Alarms and Conditions system (OutstandingProgramAlarms = 0) and
- Number of alarms in the OPC UA Alarms and Conditions system < Hysteresis-cleaned maximum value for OPC UA alarms (= MaxAlarmsInQueue - OverloadHysteresis)

Alarms that are not available in the OPC UA Alarms and Conditions system due to the overload situation are buffered by the CPU as "OutstandingAlarms".

③ When an OPC UA client executes the ConditionRefresh method, not only are all alarm objects of the relevant subscription synchronized, but also the alarms outstanding for OPC UA Alarms and Conditions (OutstandingAlarms) are transferred to the Alarms and Conditions memory area - until the maximum number of alarms is reached. "Oldest" alarms are transferred first. After that every subscription to these alarms receives the transferred alarms - not only the OPC UA client that called the ConditionRefresh method.

④ The OPC UA client controls the handling of pending alarms via the information of the Overloads nodes.

Address model for Alarms and Conditions

The following figure shows the nodes of the OPC UA Alarms and Conditions address model.

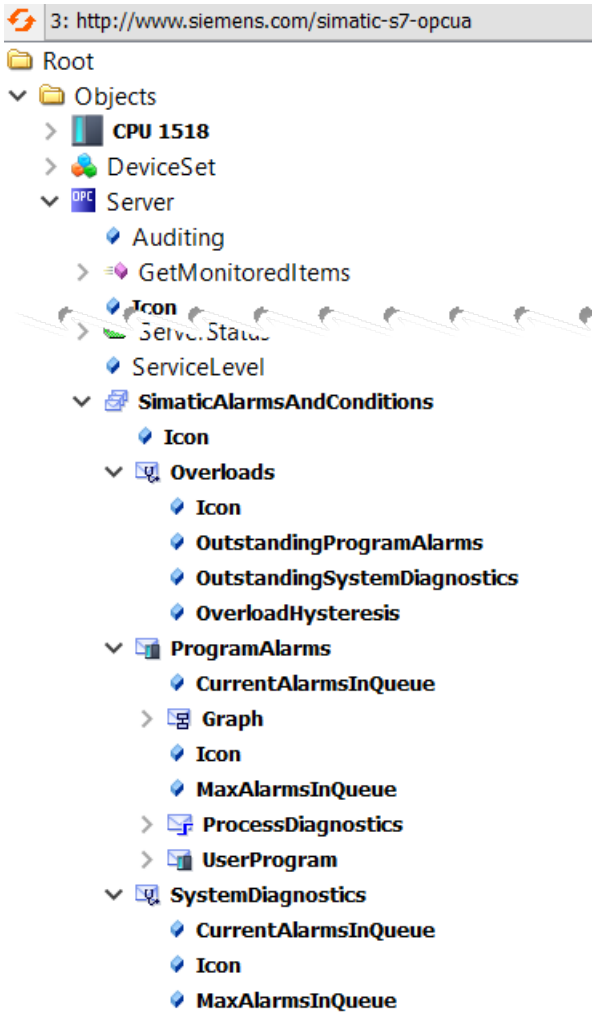

Special features

- When pending alarms go out or are acknowledged, they no longer enter the OCP UA Alarms and Conditions system area via the ConditionRefresh method. They are then "invisible" to OPC UA Alarms and Conditions and thus to the connected OPC UA clients. This fact influences e.g. statistical evaluations of alarm progressions.
- To avoid a high alarm frequency for the Overloads Alarm if the number of alarms oscillates around the maximum value, the limit for triggering the alarm is higher than the limit for canceling this alarm: The value for this difference is displayed in the "OverloadHysteresis" node.
  Example: Maximum number of alarms: 200, OverloadHysteresis: 3.
  Overloads alarm is triggered starting with 200 alarms and is only canceled if there are fewer than 197 alarms. If the number of alarms increases again, it will be triggered again when 200 alarms are exceeded.

11.3.7 Using diagnostics options

11.3.7.1 Diagnostics of the OPC UA server

Online diagnostics of the OPC UA server

The S7-1500 CPU OPC UA server can be diagnosed online with standard OPC UA clients, such as UaExpert.

The diagnostic information is subdivided into the following areas:

- Server Diagnostics
- Sessions Diagnostics
- Subscription Diagnostics

In the address space of the server, for example, the following nodes are available with diagnostic information:

- **ServerDiagnosticsSummary**: Server diagnostics summary
  - CurrentSessionCount: Number of active sessions
  - SecurityRejectedSessionCount: Number of sessions rejected due to mismatching end point security settings between client and server
- **SessionsDiagnosticsSummary**: Session diagnostics summary
  - ActualSessionTimeout: Set time that a session lasts, e.g. in the event of disconnection
- **SubscriptionDiagnosticsArray**: ARRAY with one element per subscription for each session

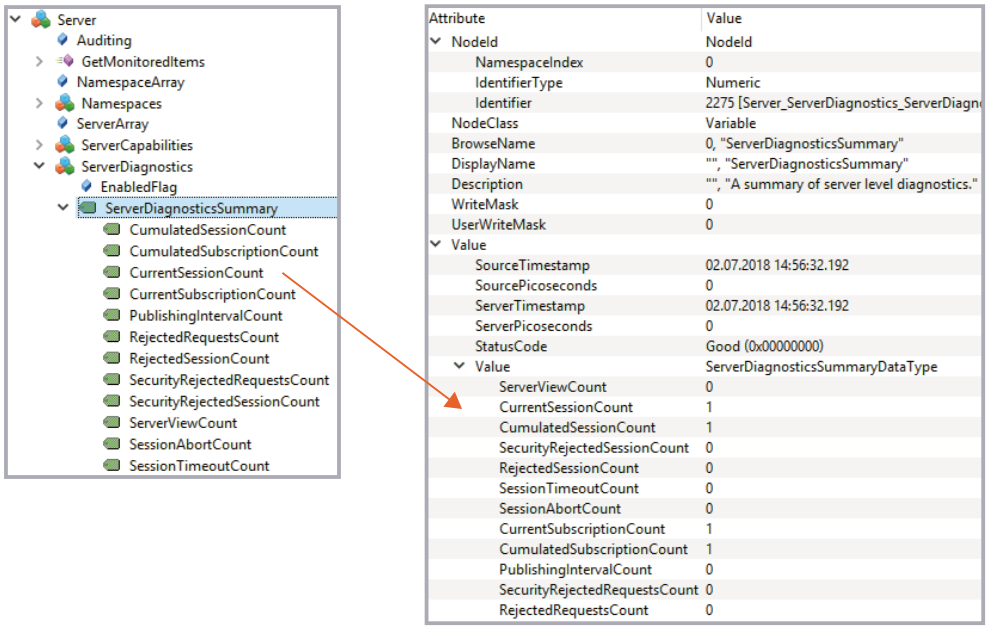

Figure 3-489 Server diagnostics

The SessionsDiagnosticsSummary node also shows the properties of the client application accessing the server within the session.

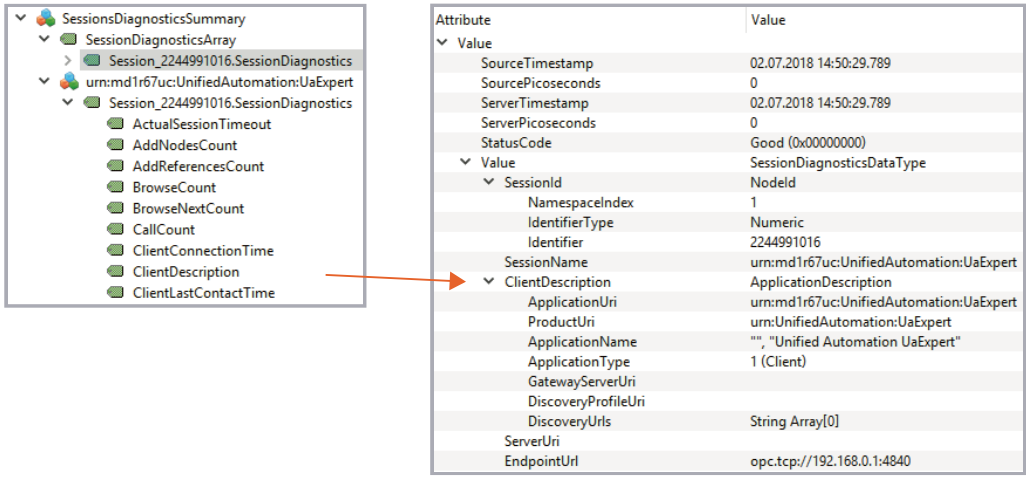

Figure 3-490 Sessions diagnostics with the properties of the client application

Diagnostics of the connection between client and server

To diagnose the status of the connection during program runtime in the client, use the following instruction:

OPC_UA_ConnectionGetStatus: Read connection status.

11.3.7.2 Running diagnostics for OPC UA servers in the program

From STEP 7 (TIA Portal) V18 onwards, you can access nodes in the OPC UA address space of an S7-1500 CPU (firmware version V3.0 onwards) to evaluate the contents for diagnostic purposes in the program.

Functional principle

In the local address space of the CPU, there are numerous nodes where the OPC UA server of the CPU stores data and states. The "OPC_UA_ReadList" instruction enables you to access this information and evaluate it in the user program.

Example: "ServerState" is a node in the address space of the CPU that contains values for the server state or for state transitions (Running, Shutdown, Failed, etc.).

You do not use the instruction as a client instruction, but instead as an instruction for reading nodes of the own local OPC UA address space. In this regard, special rules and requirements apply to this application case.

More information

You can find more information on calling the "OPC_UA_ReadList" instruction for diagnostic purposes in the TIA Portal help, topic "Diagnosing OPC UA servers with OPC_UA_ReadList".

11.3.7.3 Server state transition diagnostics

Information on the server state

S7-1500 CPUs as of firmware version V2.8 are able to create an entry in the diagnostic buffer upon state changes of the OPC UA server.

The diagnostic buffer displays the new state.

The cause of the state change is also displayed, such as download to the CPU, POWER OFF - POWER ON transition, user program instruction or service request from a partner (client).

Requirement

The "Change of OPC UA server status" option is selected (OPC UA > Server > Diagnostics) in the OPC UA properties of the CPU.

NOTE

If this option is selected, the CPU also automatically enters the lowest set security policy into the diagnostic buffer after startup.

Examples

If the OPC UA server of the CPU shuts down due to a download process and then starts with a valid new configuration, the diagnostic buffer shows new server state, e.g. Shutdown => Starting => Running.

If the OPC UA server shuts down due to a download process and the server cannot start because the type dictionary is too large, the diagnostic buffer finally shows the state "Failed" (Shutdown => Starting => Failed).

Server states and state transitions

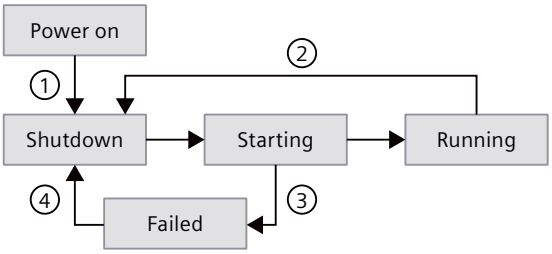

①, ④ POWER ON or Load in RUN, if OPC UA relevant data could be affected.

② Loading the hardware configuration with deactivated OPC UA server. The server remains shut down.
Loading the hardware configuration with activated OPC UA server and faulty OPC UA data (for example, too many structures with the result that the type dictionary becomes too large). In this case, the server cannot start (see ③).

③ OPC UA server cannot start due, for example, to faulty configuration.

Figure 3-491 Server states and state transitions

Description of the server states

The individual states that the OPC UA server can assume are explained below.

Server states	Explanation
Shutdown	Initial status • After POWER ON • After loading the hardware configuration with activated or deactivated OPC UA server. • After loading OPC UA relevant data
Starting	OPC UA address space in server is initialized.
Running	OPC UA server running (normal productive state for OPC UA server).
Failed	Error state. OPC UA server cannot start due, for example, to faulty configuration.

11.3.7.4 Session state transition diagnostics

Information on the session state

S7-1500 CPUs as of firmware version V2.8 are able to create an entry in the diagnostic buffer for state changes of an OPC UA session.

The diagnostic buffer displays the new state. The corresponding session ID is also displayed.

Requirement

The "Change of session states" option (OPC UA > Server > Diagnostics) is selected in the OPC UA properties of the CPU.

Example

A client transmits incorrect authentication data (for example, incorrect password) when a connection is established. The new state of the "ActivationFailed" session is entered with the corresponding session ID in the diagnostic buffer.

Subscription states and state transitions

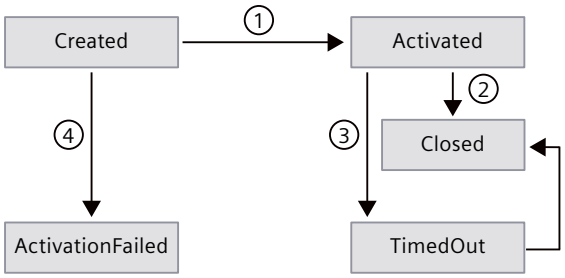

① Client connects to server, login with correct authentication data (correct credentials).

② Client closes connection correctly.

③ Client no longer sends messages; session ends with timeout.

④ Client connects to server, login with incorrect authentication data.

Figure 3-492 Session states and state transitions

11.3.7.5 Check for security events

If the CPU diagnostics detects a security event during the OPC UA communication, it can enter it in the diagnostic buffer.

Requirements

- S7-1500 CPUs as of firmware version 2.8
- The "Check for security events" option is activated (properties of the CPU > OPC UA > Server > Diagnostics).

Security events detected in diagnostics

S7-1500 CPUs perform diagnostics on the following OPC UA relevant security events:

- Client-certificate is invalid (for example, syntactically or semantically incorrect, incorrect signature, current date is not in the validity period)
- User name/password login failed (deactivated or incorrect data)

- Client wants to use a specific security policy or a specific message security mode; the server does not support the security policy or the requested security mode.
- Client does not establish connection according to specification (OPC UA Spec) (for example, unexpected SecureChannelID/SessionID/client Nonce)

Example

If an attempt is made to compromise communications (for example, by session hijacking, man-in-the-middle attacks etc.), the server detects this via analysis.

11.3.7.6 Request of a remote client failed

S7-1500 CPUs as of firmware version V2.8 are able to create an entry in the diagnostic buffer for the following events:

- Bad client requests (incorrect use)
- Service error occurred
- CPU-specific high limits of the OPC UA server were violated

Example of a faulty client request

For example, there is an incorrect request when a client addresses a node (tag) that does not exist or if a resource is requested that does not exist.

In this case, the corresponding service that caused the fault is entered in the diagnostic buffer and the corresponding session ID is also entered.

Service fault

If a service itself fails, the server returns a ServiceFault. In this case, the status code (Bad...) and the according session ID are entered in the diagnostics buffer.

Example of limit violations

If a service request exceeds a CPU-specific limit, for example, number of sessions, number of monitored items, number of subscriptions, etc., this diagnostics is entered in the diagnostics buffer. Together with the message, it is indicated which limit has been violated.

Exception: If you summarize diagnostics and the message occurs frequently, the limit causing the error is not entered. You receive general information that the supported configuration limit has been violated.

Possible entries for the service that is causing the error

Depending on the client application used, requests to the server can be triggered differently from the user's viewpoint, for example, by an online tool with a graphical user interface or by instructions in a client's program.

With its service-oriented architecture, OPC UA follows a request-response paradigm, therefore the respective client application converts the requests into the service requests defined in OPC UA.

The names of these services are defined and grouped according to their use. You can find more information on the website of the OPC Foundation (https://opcfoundation.org/).

In the case of an incorrect use, you can find precisely these names of the services, together with the corresponding session ID, in the diagnostic buffer as the service that caused the error.

The services available with OPC UA are listed below.

Discovery Service Set

FindServers

GetEndpoints

Session Service Set

CreateSession

ActivateSession

CloseSession

Cancel

View Service Set

Browse

BrowseNext

TranslateBrowsePathsToNodeIds

RegisterNodes

UnregisterNodes

Attribute Service Set

Write

Read

Method Service Set

Call

Monitored Item Service Set

CreateMonitoredItems

ModifyMonitoredItems

DeleteMonitoredItems

SetMonitoringMode

SetTriggering

Subscription Service Set

CreateSubscription

ModifySubscription
DeleteSubscriptions
TransferSubscriptions
Publish
Republish
SetPublishingMode

11.3.7.7 Subscription diagnostics

Information about a subscription

S7-1500 CPUs as of firmware version V2.8 are able to create an entry in the diagnostic buffer at state changes of a subscription.

The diagnostic buffer displays the new state; exception: "KeepAlive".

Requirement

In the OPC UA properties of the CPU, the option "Subscriptions: Change of status" (OPC UA > Server > Diagnostics) is selected.

Example

An OPC UA client is connected to an S7-1500 CPU as OPC UA server and generates a subscription in the server.

The diagnostic options for subscriptions are selected in the OPC UA properties of the CPU.

The "Creating" and "Normal" states are entered one after the other with the corresponding subscription ID in the diagnostic buffer.

Subscription states and state transitions

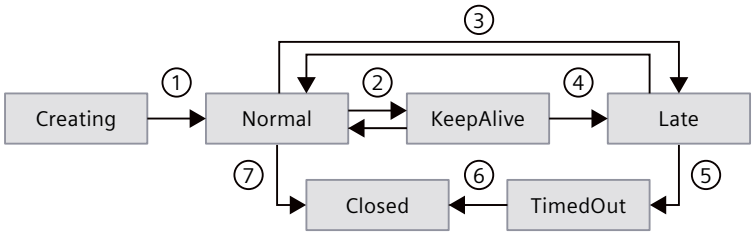

① Subscription is generated and is then active.

② Status change is not entered in the diagnostic buffer because too many entries may be made in the diagnostic buffer depending on the amount of data.

③ See explanation in table for "Late"; for example, no requests to send from client.

④ Maximum KeepAlive value reached.

⑤ See explanation in table for "TimedOut".

⑥ Maximum lifetime of subscription reached.

⑦ Client has deleted subscription.

Figure 3-493 Subscription states and state transitions

Description of the subscription states

A subscription in the OPC UA server can have the following states:

Status	Meaning
Creating	Client has requested a subscription in the server; the server creates the subscription.
Normal	Subscription is created in the server and active.
Closed	Client has deleted the subscription.
KeepAlive	Status if the monitored items do not change over a long period of time. These state transitions are not entered in the diagnostic buffer.
Late	Client has generated a subscription with minimal sampling and publishing intervals. The amount of monitored items is not transmitted to the client during this time. Client no longer transmits requests to send (for example, due to failure).
TimedOut	The client has requested a subscription. The server can only honor the subscription (send Publish Response) when there is a sufficient number of send requests (Publish Requests) from the client. When the client stops sending subscription requests, the subscription enters the "TimedOut" state after a certain time.

Subscription: Error in the sampling times

As of firmware V2.5 of the SIMATIC S7-1500 CPU, the OPC UA server can transmit the status code "GoodOverload" when using subscriptions, if an overload of the CPU occurs when sampling the items.

As of firmware V2.8 of the SIMATIC S7-1500 CPU, the OPC UA server can also enter this event into the diagnostic buffer.

Requirement

In the OPC UA properties of the CPU, the option "Subscriptions: Sampling time errors" (OPC UA > Server > Diagnostics) is selected.

Error-free subscription

In the case of an OPC UA subscription to various elements (such as tags), the OPC UA server of the SIMATIC S7-1500 must check the elements for value changes at specified intervals (sampling interval). This check, referred to as "sampling", requires some time, which depends on the number and the data type of the items. After the sampling is completed and a publishing request has been received, the server sends the elements to the client.

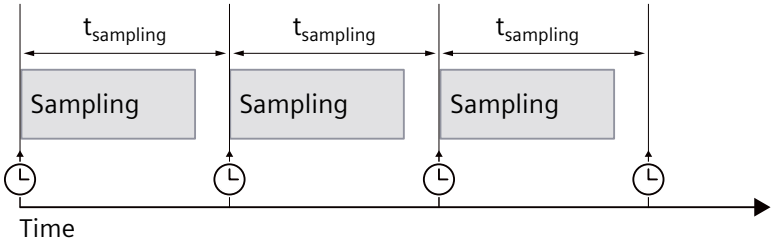

Figure 3-494 Error-free subscription

Subscription with error

If there are too many elements in the queue, there may be an overload of the communication stack. The CPU cannot check all elements in the given sampling interval and must therefore skip the next sampling job.

In this case, the CPU sends the status code "GoodOverload" (0x002F0000) per element, even though the elements were not checked. The meaning of the status code according to IEC 61131-3 is as follows: "Sampling has slowed down due to resource limitations".

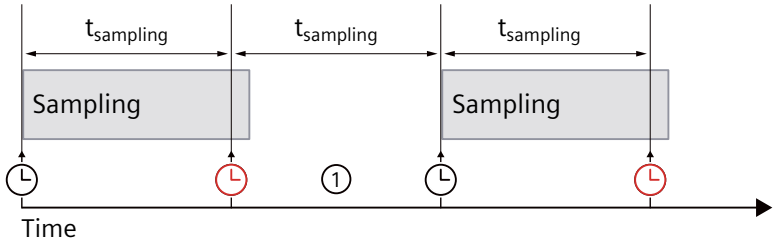

① Sampling job is skipped

Figure 3-495 Subscription with error

See also FAQ 109763090 (https://support.industry.siemens.com/cs/ww/en/view/109763090).

More information

You can find information about the server settings for subscriptions in the section Settings of the server for subscriptions (Page 264).

11.3.7.8 Summarizing diagnostics

To prevent the diagnostics buffer being "swamped" by large numbers of identical OPC UA diagnostics, as of STEP 7 V16 service pack 1, you can set parameters so that these diagnostics are entered in the diagnostics buffer as group alarm. Per interval (monitoring time), the CPU then only generates one group alarm per OPC UA diagnostics.

The following sections describe which diagnostics the CPU groups together and how the process runs with a high message volume.

Requirement

The "Summarize diagnostics in case of high message volume" option is activated in the OPC UA properties of the CPU (OPC UA > Server > Diagnostics, "Summarize diagnostics" area).

Example

An OPC UA client repeatedly "overloads" an S7-1500 CPU as OPC UA server with a sampling rate that the server cannot handle (overload).

The "Summarize diagnostics in case of high message volume" setting is activated.

A message appears in the diagnostics buffer for this diagnostic option. It states that the sampling rate cannot be reached; followed by the number of these events within the configured interval.

OPC UA diagnostics that can be summarized

The diagnostics listed below each form their own groups (type). Diagnostic events from the same group are combined using the setting "Summarize diagnostics in case of high message volume":

- Incorrect use of an OPC UA service
- OPC UA Service error
- Subscription status has changed
- Sampling rate could not be achieved (subscriptions, overload)
- OPC UA security check failed
- Configuration limit of the OPC UA server violated

Principle of operation

The CPU enters the first three events of an event type in the diagnostics buffer. It then ignores all subsequent diagnostics of this group.

At the end of the monitoring time (interval), the CPU generates a group alarm in which it enters the diagnostics and the frequency of this diagnostics during the elapsed interval. If these diagnostics also occur in the intervals that follow, the CPU only generates one group alarm per subsequent interval.

A diagnostic surge leaves the following pattern in the diagnostics buffer: Three individual messages followed by a series of group alarms. This series can consist of two, three or more group alarms depending on the selected monitoring time and duration of the diagnostic surge.

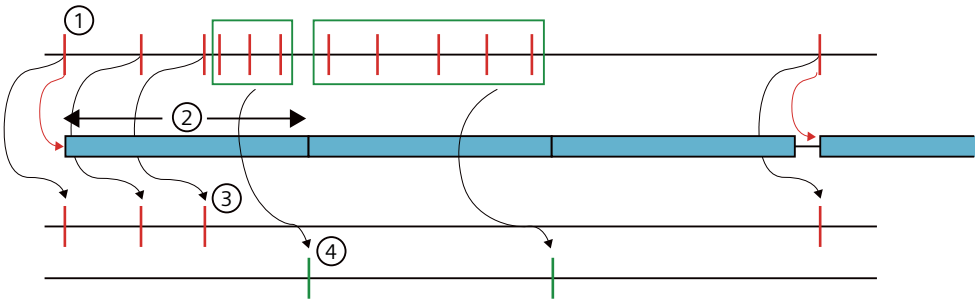

① Diagnostic results of a group (of a type), for example "Sampling rate could not be reached".

② Interval (monitoring time): When a diagnostic event occurs the first time (or reoccurs), the monitoring time is started (or restarted).

③ Single alarms: The first three diagnostic events from the same group are entered in the diagnostics buffer immediately. Starting with the fourth diagnostic event, the CPU generates only group alarms. If a diagnostic event of this group occurs after a pause of at least one interval, the CPU enters a single alarm in the diagnostics buffer and restarts the monitoring time.

④ Group alarms: After three diagnostic events, the CPU only generates a group alarm as a summary of all additional diagnostic events in this interval. If these diagnostic events also occur in the intervals that follow, the CPU only generates one group alarm per subsequent interval.

Figure 3-496 Summary of diagnostics

11.4 Using the S7-1500 CPU as an OPC UA client

11.4.1 Overview and requirements

With STEP 7 (TIA Portal) Version V15.1 and higher, you can assign parameters and program an OPC UA client that can read PLC tags in an OPC UA server. Furthermore it is possible to transfer new values for PLC tags to an OPC UA server. In addition, you can call methods that an OPC UA server provides in your user program. You use the instructions for OPC UA clients in your user program for this.

The instructions of the OPC UA client are based on the standard "PLCopen OPC UA Client for IEC61131-3".

PLCopen specification

With these standardized instructions, you can develop an OPC UA client functions in your user program that can be executed in an S7-1500 CPU.

In addition, it is possible with just a few adaptations to run this user program in controllers of other manufacturers if these manufacturers have also implemented the OPC UA Specification "PLCopen OPC UA client for IEC61131-3".

Convenient editors in STEP 7

For the parameter assignment of the instructions for OPC UA clients, a convenient editor is available in the TIA Portal – the connection parameter assignment (Page 257).

As of Version 15.1, STEP 7 also features an editor for client interfaces (Page 369).

This section describes how you work with these editors.

First, you will be shown how to create and configure a new interface with the interface editor, because you need this type of interface for the subsequent connection parameter assignment.

The description uses an example for better comprehensibility, see Description of the example (Page 368).

Requirements

- You have the required runtime license for OPC UA and have configured the license in STEP 7 (CPU Properties > Runtime Licenses).
- The client of the S7-1500 CPU is activated.

To use the client of the S7-1500 CPU, you must enable it:

1. Select the area "OPC UA > Client" in the properties of the CPU.
2. Select the "Enable OPC UA client" option.

If you do not enable the client, the connection is not established. You receive a corresponding error message at the instructions, for example "OPC_UA_Connect".

For information about the application name, which also applies to the server and the client, see here (Page 257).

Overview

To use the editor and the connection parameter assignment, follow these steps:

1. First, specify a client interface. Add to this the PLC tags and PLC methods interface that you want to access ("First step (Page 369)").
2. Next, configure the connection to the OPC UA server (Second step (Page 384)).
3. Finally, use the configured connection for the OPC UA client instructions (Third step (Page 394)).

11.4.2 Useful information about the client instructions

With the standardized OPC UA client instructions you are able to control communication for the following tasks with the S7-1500 CPU as an OPC UA client:

- Read/write tags of the OPC UA server
- Call methods in the OPC UA server

Optional instructions can be used to determine the following information:

- The status of the connection between the OPC UA client and OPC UA server
- Node IDs of nodes with known hierarchy of the address space

Standardized sequence of OPC UA communication

The sequence of the communication, and thus the order of the instructions, follows a pattern that is illustrated in the following.

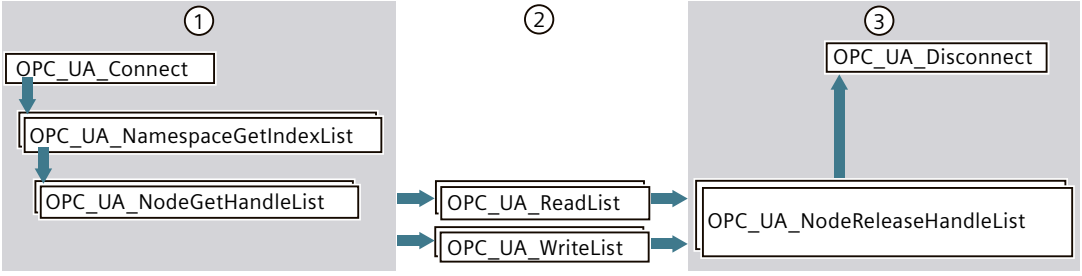

① Instructions for preparation of read and write operations

② Read and write instructions

③ Instructions for "clean-up" after a completed read or write operation

Figure 3-497 Run sequence for a read or write operation

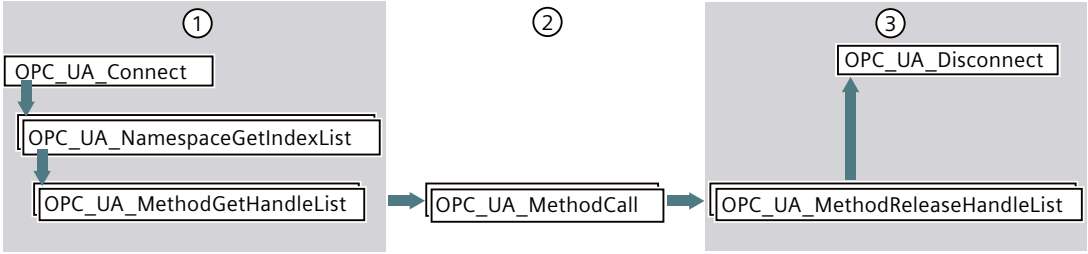

① Instructions for preparation of method calls

② Method calls

③ Instructions for "clean-up" after completed method calls

Figure 3-498 Run sequence for a method call in the OPC UA server

Optional instructions (reading out the status of a connection / reading out node IDs of nodes with known hierarchy of the address space)

- OPC_UA_ConnectionGetStatus
- OPC_UA_TranslatePathList

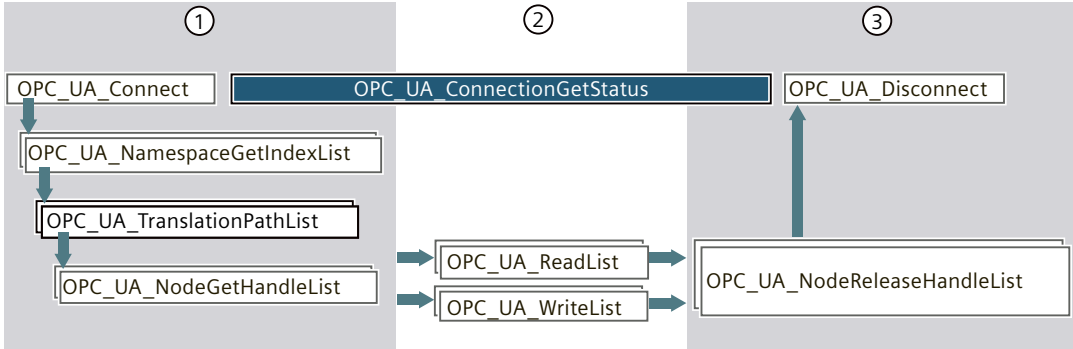

① Instructions for preparation of read and write operations with inserted instruction for requesting, for example, the NodeIDs of nodes of the OPC UA server.

② You can determine the connection status between the establishment and termination of the connection in parallel with other instructions.

③ Instructions for "clean-up"

Figure 3-499 Run sequence of optional instructions

Convenient editors in STEP 7

The OPC UA client instructions are described in detail in the reference part (STEP 7 information system). For parameter assignment of the instructions, a convenient editor is available in the TIA Portal – the connection parameter assignment (Page 384).

We recommend starting with the connection parameter assignment for the first program draft and using additional instructions and manually optimizing the program as required.

Information about the client instructions

The client instructions are described in detail in the help to the Instructions > Communication > OPC UA > OPC UA client.

Application example in Online Support

This application example (https://support.industry.siemens.com/cs/ww/en/view/109762770) provides you with an S7 user block "OpcUaClient" that summarizes the most important functions of the OPC UA instructions, accelerates the implementation for you and simplifies the programming. The OPC UA server in the example is an S7-1500 controller with a simple simulation program for process values.

The S7 user block performs the following:

- Establishment and termination of the connection to the server
- Diagnostics of the connection and automatic reconnection after connection terminations
- Registered Read
- Registered Write
- Registered Method Call

11.4.3 Number of client instructions that can be used simultaneously

Maximum number of simultaneously running jobs for asynchronous instructions for OPC UA

The maximum number of simultaneously running jobs for asynchronous instructions for OPC UA can be found in the respective equipment manual in the technical specifications section or on the Internet (https://sieportal.siemens.com/su/blVMV).

For the OPC UA instructions for session management or data access, you need the following values from the technical specifications to calculate the maximum number of jobs running at the same time:

- Number of connections, max.
- Number of simultaneous calls of the client instructions for session management, per connection, max.
- Number of simultaneous calls of the client instructions for data access, per connection, max.

In addition to the OPC UA instructions, the following table shows the use and calculation of the maximum number of jobs running at the same time.

OPC UA instruction	Use	Calculation
OPC_UA_Connect	Session management	"Number of connections, max." multiplied by "Number of simultaneous calls of the client instructions for session management, per connection, max."
OPC_UA_NamespaceGetIndexList		
OPC_UA_NodeGetHandleList		
OPC_UA_MethodGetHandleList		
OPC_UA_TranslatePathList		
OPC_UA_NodeReleaseHandleList		
OPC_UA_MethodReleaseHandleL-ist		
OPC_UA_Disconnect		
OPC_UA_ConnectionGetStatus		
OPC_UA_ReadList	Data access	"Number of connections, max." multiplied by "Number of simultaneous calls of the client instructions for data access, per connection, max."
OPC_UA_WriteList		
OPC_UA_MethodCall		The value can be taken directly from the technical specifications.

Maximum number of usable OPC UA client interfaces

If you create OPC UA client interfaces using the connection parameter assignment, the number of client interfaces is limited to 40.

Create the OPC UA client interfaces by double-clicking the "Add new client interface" symbol in the project tree of the "OPC UA communication" area.

The maximum number of OPC UA client interfaces is independent of whether you also use the CPU as OPC UA server.

11.4.4 Example configuration for OPC UA

The following sections describe how you can use the client interfaces editor and the connection parameter assignment.

The description is based on a specific example: Two S7-1500 CPUs operate in the system: One CPU serves as the OPC UA client and the other as the OPC UA server.

You can, of course, also use controllers, sensors and IT systems of other manufacturers as OPC UA clients or servers. In particular, the data exchange between different systems (interoperability) is a major advantage of OPC UA.

Connection parameter assignment using an example:

The plant produces blanks in a production line.

The following controllers are used:

1. An S7-1511 CPU serves as the controller of the production line.

   The controller is named "**Productionline**" in the example.

   The OPC UA server of the controller is enabled.

   The CPU has the IP address 192.168.1.1 in the example.

   This CPU publishes the values of following tags via the OPC UA server:

   – **NewProduct**

     The tag has the data type "BOOL".

     When this PLC tag has the value TRUE, the production line has processed a blank.

     The blank is ready for pick-up.

   – **ProductNumber**

     This tag contains the identification number of the blank.

     The tag has the data type "Int".

   – **Temperature**

     This tag contains temperature values recorded during the production of the blank.

     The tag is an array with elements of the "Real" data type.

   In addition, this CPU provides the following writable tag:

   – **ProductionEnabled**

     The tag is set by the OPC UA client.

     The tag has the data type "BOOL".

     If the value is set to TRUE, the production line is released and may produce blanks.

   In addition, this CPU provides the following method via the OPC UA server:

   – **OpenDoor**

     OPC UA clients can hereby arrange for an access door to be opened to the production line.

2. An S7-1516 CPU controls the interaction with other production lines.

   This CPU is named "**Supervisor**" in the example.

   The OPC UA client of this CPU is enabled.

   Using OPC UA, this CPU can read the NewProduct and ProductNumber tags, set the ProductionEnabled tag and call the OpenDoor method.

   The CPU has the IP address 192.168.1.2 in the example.

The following figure shows the example in the network view of the TIA Portal:

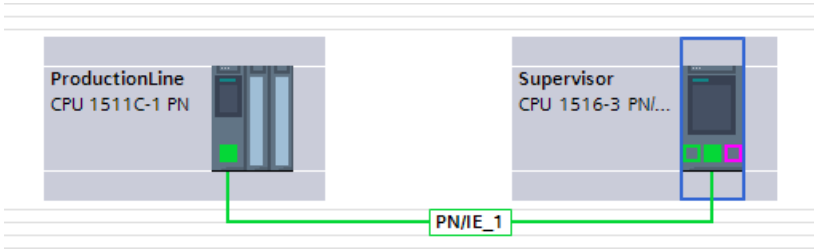

Figure 3-500 Example of assigning connection parameters in the network view

11.4.5 Creating client interfaces

As of Version 15.1, the TIA Portal has an editor for client interfaces.

You group all PLC tags that you want to read or write from an OPC UA server in a client interface.

In addition, the client interface contains all methods that the OPC UA server provides and that you want to call with your user program (that acts as an OPC UA client).

If you create a client interface, STEP 7 also creates data blocks for the parameter assignment of the connection to the OPC UA server from which you want to read data or to which you want to write data.

Maximum number of client interfaces

You can create a maximum of 40 client interfaces.

Editor for client interfaces

To create a client interface, follow these steps:

1. Select the project view in the TIA Portal.
2. In the "Devices" area, select the CPU you want to use as an OPC UA client.
3. Click "OPC UA communication > Client interfaces".

4. Double-click "Add new client interface".

   STEP 7 creates a new client interface and display in the editor.

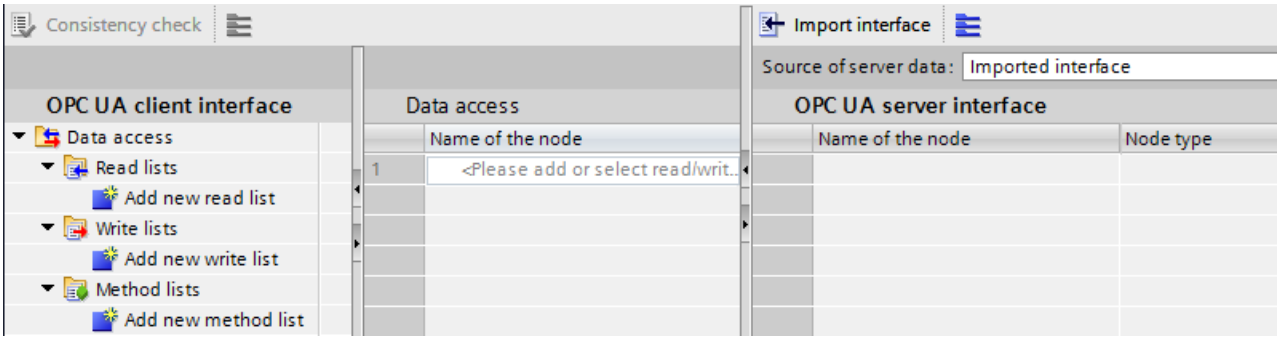

Figure 3-501 Adding OPC UA client interface

   STEP 7 names the new interface "Client interface_1". If a "Client interface_1" already exists, the new interface receives the designation "Client interface_2" etc.

   In addition, STEP 7 creates the following data blocks:

   – Client_Interface_1_Configuration

     The data block already contains all system data types that are needed for the instructions of the OPC UA client.

     This data block is filled when you configure the connection to the OPC UA server.

     You configure a connection in the properties of the client interface, see: Example configuration for OPC UA (Page 368).

   – Client_Interface_1_Data

     A data block for the PLC tags that you want to read or write from an OPC UA server as well as for methods that you want to call in the OPC UA server.

     You use this data block in your user program.

     This data block is currently still empty.

5. Select a descriptive name for the new client interface.

   Select "Productionline" in the example.

   This also changes the names of the associated data blocks to:

   – Productionline_Data

   – Productionline_Configuration

6. To import an OPC UA server interface, click the "Import interface" button in the top right of the editor.

   This allows you to import an XML file which describes the server interface of an OPC UA server.

   Alternative: To determine online the server interface of a connected OPC UA server, see: Determine server interface online (Page 377).

7. STEP 7 displays a dialog with which you can select an XML file.

   This XML file describes a address space of an OPC UA server.

   The address space of an OPC UA server contains all PLC tags and server methods published by an OPC UA server.

OPC UA clients can access this address space:

- Read PLC tags
- Write PLC tags
- Calling Server Methods

The address space of an OPC UA server can be divided into one or more server interfaces.

For creating server interfaces, see: Creating a server interface for companion specification (Page 291).

8. Create a **read list** in this client interface.

   To do this, follow these steps:

   – Click "Add new read list" in the left section of the editor.

     STEP 7 adds a new list named "ReadList_1".

     For the example, change the name to "ReadListProduct"

   – Now add the new read list of the PLC tags that you want to read from the OPC UA server.

     In the example the "NewProduct" and "ProductNumber" tags are added to the "ReadListProduct" read list.

     Select the "NewProduct" tag in the right-hand field of the editor ("OPC UA Server interface"). Drag the "NewProduct" tag to the "ReadProduct" read list in the middle field of the editor. Follow the same procedure with the "ProductNumber" tag.

   The figure below shows the right field of the editor.

OPC UA server interface

Name of the node	Node type	Access level	Node ID
Productionline	Object		http://www.sie...
DataBlocksGlobal	Folder		http://www.sie...
Data_for_OPC_UA_Clients	Object		http://www.sie...
NewProduct	Boolean	RD	http://www.sie...
ProductNumber	Int16	RD	http://www.sie...
Temperature	Array of Float	RD	http://www.sie...
Data_from_OPC_UA_Clients	Object		http://www.sie...
ProductionEnabled	Boolean	RD/WR	http://www.sie...
DataBlocksInstance	Folder		http://www.sie...
OpenDoor_DB	Object		http://www.sie...
InOuts	Folder		http://www.sie...
Static	Folder		http://www.sie...
Method	Method		http://www.sie...

Figure 3-502 Read list in the OPC UA server interface

Alternative:

You can also select a new read list by dragging the right field of the editor ("OPC UA Server interface") to a node of the type Object or Folder and then dragging it to "Add new read list" in the left field of the editor. The new read list then contains all PLC tags of the node that has been moved.

In the example, select the object "Data_for_OPC_UA_Clients", which contains the tags "NewProduct" and "ProductNumber". STEP 7 generates the new read list "Data_for_OPC_UA_Clients". In addition, the object contains the tag "Temperature". Delete the "Temperature" tag from the read list. Since they should not be read in the example.

Change the name of the read list in "ReadListProduct".

The following figure shows the content of the read list:

ReadListProduct

Name of the node	Node type	Access level	Node ID
NewProduct	BOOL	RD	http://www.siemen...
ProductNumber	INT	RD	http://www.siemen...

Figure 3-503 Read list

NOTE

Read and write lists do not support all node types.

The OPC UA client of the S7-1500 CPU does not support all OPC UA data types (node types) that can be made available via an OPC UA server interface. If you place an unsupported node type, for example, in a read list or write list a corresponding error signal appears. In this case, you cannot include the corresponding node in the read or write list.

Which types are supported is described here: Mapping of data types (Page 237)

---

9. If you want assign new values to PLC tags, create a **write list** in this client interface.

   To do this, follow these steps:

   – Click "Add new write list" in the left section of the editor.

     STEP 7 adds a new list with the name "ReadList_1".

     For the example, change the name to "WriteListStatus".

   – Now add the new write list of all OPC UA server tags to which you want to assign new values.

     In the example, add the "WriteListStatus" tag to the write list "ProductionEnabled".

     Select the Tag of right field of the editor ("OPC UA Server interface"). Drag the tag to the write list in the middle field of the editor.

   Alternative:

   You can also create a new write list by selecting a node of the type Object or Folder in the right field of the editor ("OPC UA server interface") and then dragging to "Add new write list" in the left field of the editor.

   The new write list then contains all tags of the relevant node.

   In the example, select the object "Data_from_OPC_UA_Clients", which contains the tag "ProductionEnabled". STEP 7 generates the new write list "Data_from_OPC_UA_Clients". Change the name in "WriteListStatus".

   The following figure shows the content of the write list:

WriteListStatus

Name of the node	Node type	Access level	Node ID
ProductionEnabled	BOOL	RD/WR	http://www.siemen...

Figure 3-504 Write list

10. If you want to call a method of this OPC UA server, generate a new method list.

    To do this, follow these steps:

    – In the left section of the editor, click "Add new method list".

      STEP 7 adds a new list with the name "Method list_1".

      For the example, change the name to "MethodListOpenDoor".

    – Now add a method of the OPC UA server to the new method list.

      In this example, add the method "OpenDoor" to the method list "MethodListOpenDoor".

      Select the method of right field of the editor ("OPC UA Server interface"). Drag the method to the method list in the middle field of the editor.

    Alternative:

    You can also generate a new method list by selecting a method (node of the type Object) in the right field of the editor (OPC UA Server interface) and then dragging it to "Add new method list" in the left field of the editor. The new method list then contains the method of the relevant node.

    The following figure shows the content of the method list:

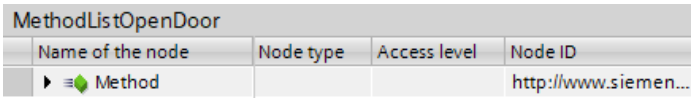

Figure 3-505 Methods list

See also Useful information about server methods (Page 321).

11. Compile the project.

    To do so, select the project and click the following button in the toolbar:

STEP 7 compiles the project and updates the data blocks that belong to the "Productionline" client interface.

NOTE

During compilation, STEP 7 overwrites all data in the data blocks belonging to the client interface. For this reason, you should not add to or modify these data blocks manually.

NOTE

Renaming nod names (DisplayNames)

In read lists, write lists and method lists you can rename the name of a node by means of the shortcut menu. This is the "DisplayName" in the OPC UA language usage.

If you rename the name of a method list node and the node is already used in a programmed block for the method call "OPC_UA_MethodCall", the compilation of the project leads to consistency errors: During the compilation the UDTs of the method are generated with the changed name. The references to the method used in the program are then no longer correct.

To correct the consistency errors, you can either undo the name change of the method in the client interface or navigate to the method call and assign the relevant parameters again there under "Properties > Block parameters" ("Configuration" tab).

Data blocks of client interface

The following data blocks belong to the "Productionline" client interface:

- **Productionline_Configuration**

  A data block for the configuration.

  In the example, this data block is called "Productionline_Configuration".

  The data block already contains all system data types that are needed for the instructions of the OPC UA client.

  In addition, the data block contains general default values for parameter assignment of the connection to an OPC UA server.

  If you are working with connection parameter assignment, this data block will be filled.

- **ProductionLine_Data**

  A data block for the PLC tags that you have entered in the client interface editor.

  In the example, this data block is called "Productionline_Data".

  The figure below shows the data block.

Static	
ReadListProduct	Struct
Variable	"Productionline.ReadListProduct"
NewProduct	Bool
ProductNumber	Int
NodeStatusList	Array[0..1] of DWord
NodeStatusList[0]	DWord
NodeStatusList[1]	DWord
TimeStamps	Array[0..1] of LDT
TimeStamps[0]	LDT
TimeStamps[1]	LDT
WriteListStatus	Struct
Variable	"Productionline.WriteListStatus"
ProductionEnabled	Bool
NodeStatusList	Array[0..0] of DWord
NodeStatusList[0]	DWord
MethodListOpenDoor	Struct
MethodStatusList	Array[0..0] of DWord
MethodStatusList[0]	DWord
MethodResultList	Array[0..0] of DWord
MethodResultList[0]	DWord
Method	Struct
Inputs	"Productionline.MethodListOpendoor.Method.Inputs"
Number	Int
Outputs	"Productionline.MethodListOpendoor.Method.Outputs"
Result	Int

Figure 3-506 "Productionline_Data" data block

Use the "Productionline_Data" data block in your user program and access the read values of the "NewProduct" and "ProductNumber" PLC tags. This is explained in the following section using an example.

Reading and writing PLC tags of the client interface

Example: Reading the "ProductNumber" value

For example, you write in an SCL program:

```
#MyLocalVariable :=
"Productionline_Data".ReadListProduct.Variable.ProductNumber;
```

You use this, for example, to assign the number of the blank that was just produced in the production line to the local tag "#MyLocalVariable".

Requirements:

- A connection exists to the OPC UA server of the CPU, which controls the production line.
- The OPC UA client has read the current values.

For this reason you check whether a read value is valid:

- Check whether the value in "Productionline_Data".ReadListProduct.NodeStatusList[1] is equal to 0.
- Optional: Check when this value was sent from the OPC UA server. This value is in "Productionline_Data".Product.TimeStamps[1]. If no time stamp is requested, the communication load is reduced.

Example: Writing the "ProductEnabled" value

Transfer the new values for PLC tags, in the example for the "ProductionEnabled" tag, to the OPC UA server using the data block.

With the following assignment, you enable the production line in the example plant:

```
"Productionline_Data".WriteListStatus.Variable.ProductionEnabled :=
TRUE;
```

This is only successful, however, if the following requirements are met:

- A connection exists to the OPC UA server of the CPU, which controls the production line.
- Current values are being written via the OPC UA client

Consistency check

Finally, check the consistency of the read/write list or method list.

1. Select the list that you want to check.
2. Click the "Consistency check" button above the "OPC UA client interface" area.

A green check mark indicates an error-free assignment of the tags or methods to the corresponding elements of the server interface.

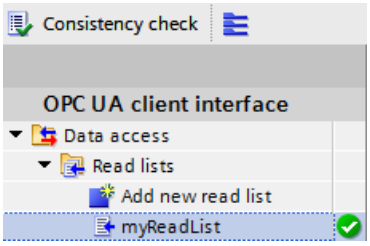

You can assume that the data exchange between client and server and method calls operate without problem in runtime.

In the event of an error a list appears in the Inspector window. From this list you can jump to the respective error.

During the consistency check, STEP 7 checks:

- Whether all elements that you use in the respective list are also present in the server.
- Do the data types used match?
- For methods: Do the number, name, order, and data types of method arguments match?

11.4.6 Determine server interface online

With STEP 7 (TIA Portal) you can determine the interface of an OPC UA server online. This provides information on which tags of a connected OPC UA server you can read or set (write) with OPC UA clients. It also provides information on which server methods of the OPC UA server are available for OPC UA clients.

If you are work offline you can create the interface of the OPC UA server by means of an OPC UA XML file. The address space of the server is described in the OPC UA XML file, see: Export OPC UA XML file (Page 256).

Determine online server interfaces

To determine a server interface online, follow these steps:

1. In the STEP 7 project tree, select the CPU which is configured as OPC UA client (Supervisor in the example).
2. Select the client interface (in the example, OPC UA Communication > Client interfaces > Productionline).

   If no client interface has been created, double-click "Add new client interface".
3. Double-click the selected client interface.

   The editor for client interfaces is displayed.

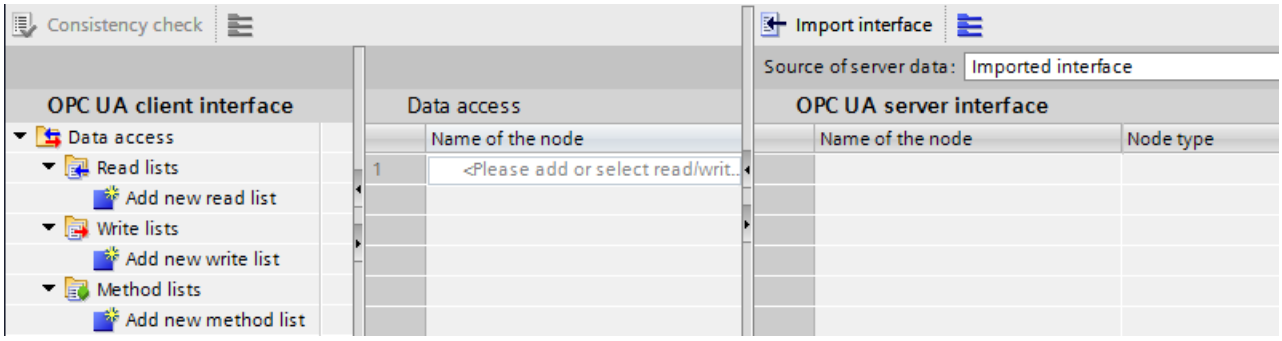

Figure 3-507 Editor for client interface

4. In the left section of the editor, click "Add new read list", "Add new write list", or "Add new method list".
5. In the right field of the editor, select "Online[]" as data source for "Source of server data":

6. Click the "Online Access" button.

   STEP 7 displays the "Connect to OPC UA server" dialog.

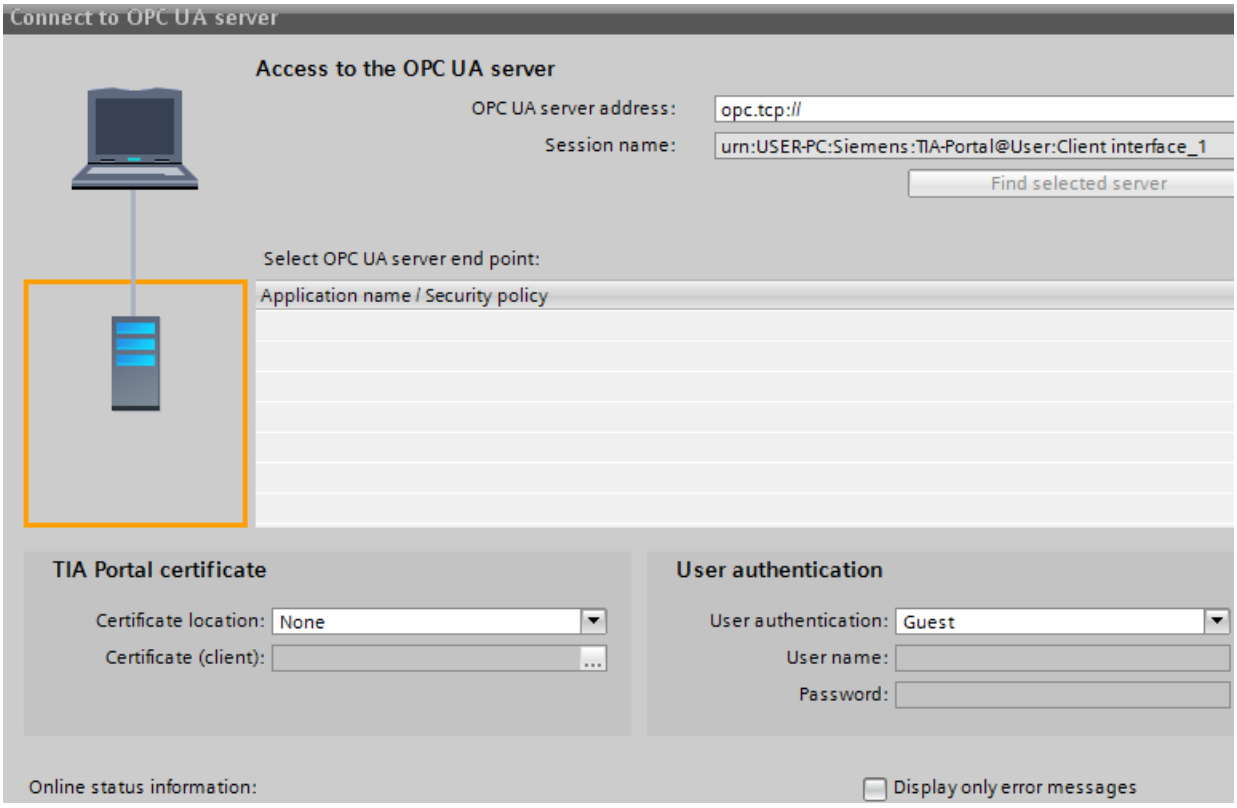

Figure 3-508 "Connect to OPC UA server" dialog

Tip: When establishing an online connection to an OPC UA server for the first time, use the "Online access" button. When reconnecting after a disconnection, select the "Connect to Online Server" button next to the "Online" selection field.

In the top right, enter the IP address of the OPC UA server whose server interface you want to determine online.

7. Click "Find selected server".

   STEP 7 establishes a connection to the OPC UA server and determines all security settings (server endpoints) that the server holds in readiness.

   STEP 7 displays the end points as list:

Figure 3-509 Found OPC UA server with all server endpoints

8. Click on the end point you want to use for a connection of STEP 7 to the OPC UA server.

9. Do you want to use a secure connection?
   - If you have selected a secure end point, then select the entry "TIA Portal" for the "Certificate location".

     And under "Certificate (Client)", select a client certificate for your PC on which STEP 7 (TIA Portal) is currently running.

     If a client certificate does not yet exist for your PC, you can generate a client certificate here in the TIA Portal.

     Proceed as follows to generate a certificate for your PC:

     - Click on the button in the "Certificate (Client)" input field.

     - Click "Add".

     - For "Certificate owners" enter "STEP 7 (TIA Portal)".

     - Select the "OPC UA client" entry at "Usage".

     - For "Subject Alternative Name (SAN)", enter the IP address of your PC, on which you are currently running STEP 7 (TIA Portal), under "Value". Overwrite the already entered IP address.

     - If your PC uses a second IP address, enter this address as well. If your PC does not use a second IP address, delete the second IP address already entered.

     - Click "OK".
   - If you have not selected a secure end point, then keep the default ("None").
10. How do you want log on?
    - If you want to log onto the OPC UA server as guest, then apply the default with "User authentication".
    - If you want to log on with user name and password, select "User name and password".

      Use the user name and password which was stored during the configuration of the OPC UA server in the properties of the CPU under "General > OPC UA > Server > Security > User authentication > User management".
11. Click on the "Go online" button.

    When a secure connection is established, a message appears that you must accept the server certificate for the secure connection to be established. In the message window, you can display further details about the server certificate via a link.

    This standard Windows window only provides information about the server certificate. If you click on the button to install the server certificate, the server certificate is not saved to the certificate memory of the TIA Portal, i.e. at the next connection attempt you will be prompted again to accept the server certificate.

    STEP 7 then establishes a connection to the OPC UA server and again displays the editor for client interfaces.

    In the right field of the editor, STEP 7 displays the uppermost level of the address space of the OPC UA server:

12. Click on the small black triangle next to "Objects".

    STEP 7 now also displays the level below Objects.

13. Click on the small black triangle next to "Productionline".

    STEP 7 now also displays the level below Productionline.

14. Now open additional lower-level folders:

OPC UA server interface

Name of the node	Node type	Access level
Server	Object	
DeviceSet	Object	
Productionline	Object	
Counters	Object	
DataBlocksGlobal	Object	
Icon	ImagePNG	RD
Data_from_OPC_UA_Clients	Object	
ProductionEnabled	Boolean	RD/WR
Data_for_OPC_UA_Clients	Object	
ProductNumber	Int16	RD
Temperature	Array of Float	RD
NewProduct	Boolean	RD
DataBlocksInstance	Object	
Icon	ImagePNG	RD
OpenDoor_DB	Object	
DeviceManual	String	RD

Figure 3-510 Online view of OPC UA server interface

More information

You can find information about mapping of data types in the section Mapping of data types (Page 237).

For information on how to create a client interface, refer to the section Creating client interfaces (Page 369).

11.4.7 Using multilingual texts

In the client interface editor, you are also importing texts that can be displayed in different languages with the OPC UA XML files (information models). Multilingualism is optional, and each node can be defined differently regarding the languages it offers.

In the XML file, these are the following fields that can be prepared for different languages:

- Display name
- Description

Example for multilingual texts in an OPC UA XML file

In the XML file below, the display name and the description, for example, are entered with a "default" text and multiple localizable texts.

- Default text is the first entry without localization information.
- Localized text is the text after "Locale=" followed by a language code, e.g. "it-IT" for Italian

```
<UAVariable NodeId="ns=3;i=6070" BrowseName="3:EngineeringRevision" ParentNodeId="ns=3;i=1002"
DataType="String">
    <DisplayName>EngineeringRevision</DisplayName>
    <DisplayName Locale="en-US">EngineeringRevision</DisplayName>
    <DisplayName Locale="de-DE">Revisionsstand</DisplayName>
    <Description>Revision Level of the engineering environment.</Description>
    <Description Locale="en-US">Revision Level of the engineering environment.</Description>
    <Description Locale="de-DE">Revisionsstand der Engineeringumgebung.</Description>
    <Description Locale="fr-FR">Niveau de révision de l'environnement d'ingénierie.</Description>
    <Description Locale="it-IT">Livello di revisione dell'ambiente di ingegneria.</Description>
<References>
    <Reference ReferenceType="HasTypeDefinition">i=68</Reference>
    <Reference ReferenceType="HasModellingRule">i=78</Reference>
</References>
</UAVariable>
```

Figure 3-511 Example of multilingual texts in an OPC UA XML file

Display of multilingual texts

When importing a server interface, the available multilingual texts are saved internally and downloaded to a CPU together with the project.

The client editor displays the text from the OPC UA XML file in the columns "Name of the node" (corresponds to "DisplayName") and "Description" (corresponds to "Description").

The following cascading rules determine which language is shown for a node:

- When the node contains text in the currently used editing language, the text is also displayed in the editing language.

  (Setting the editing language: In the project tree, select the area "Languages & resources > Project languages")
- When the node does not contain text in the editing language but a default text is defined there (without language code), the default text is displayed.
- "Name of the node" column: If no default text is defined either but a text in any other language exists, the DisplayName text is displayed in the first available language. This rule does not apply to description texts.
- If none of the conditions listed above is met, no text is displayed.

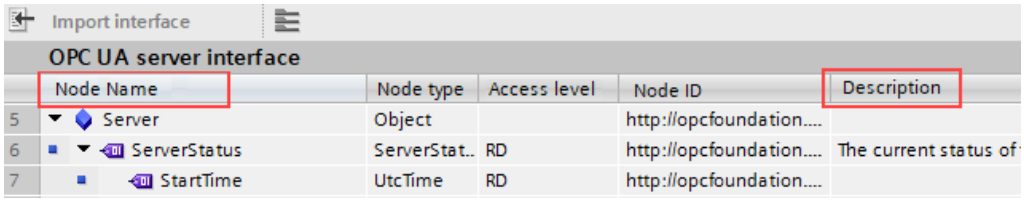

Figure 3-512 Display for multilingual texts

When you change the editing language, the multilingual text in the imported interface will also change according to the rules explained above.

You can then apply the nodes in the corresponding lists (read list, write list, method list) with drag and drop.

You cannot change the language in the lists (read list, write list, method list).

Applying the displayed description texts as comment in PLC data types

When you compile the program, STEP 7 automatically creates PLC data types (UDTs) for each read list, for each write list and for inputs or outputs of each method. These UDTs each have one element for each node.

The UDTs apply the description text as comment according to the rules stated above. STEP 7 creates the comment in only one language, just like the texts in the OPC UA server interface can only be displayed in one language.

11.4.8 Rules for the access to structures

The rules for the access to structures are explained below. Note these rules when reading and writing values of complete structures provided by an OPC UA server.

How the client of the S7-1500 CPU accesses structures

The OPC UA client of the S7-1500 CPU uses neither TypeDictionaries nor DataTypeDefinition attributes, which a server offers for the resolution of these structures.

These options of the OPC UA client for checking structural elements in runtime are limited in the client.

Rules for the access to structures

If you use the client interfaces to configure the read and write lists (connection parameterization) and assign the PLC data types to the imported or online determined address model of the server, the read and write accesses to structures operate trouble-free in runtime.

The configuration by means of client interface automatically ensures that the sequence and the data type of the structural elements are coordinated on client and server side.

Recommendation: Update an S7-1500 CPU (as server) to the current firmware version (e.g. V2.0 > V2.5.2 or higher).

In runtime the OPC UA client only checks the total length of the transmitted value; more detailed checks are not possible.

Strings (WSTRING, STRING and OPC UA ByteString) are also permitted in structures. Strings do have a variable length, but OPC UA surmounts this variability: At the time of transfer, a length field in which the length of the string is encoded is prefixed to each string. Therefore, a S7-1500 CPU as a OPC UA client can check the length of a string and determine whether the string "fits into" the assigned CPU tag. In this manner, the CPU can also check the total length of the structure.

Mapping rules apply to the assignment of OPC UA structures to PLC tags or DB tags (see Mapping of data types (Page 237)).

Example of an error-free assignment of the structure elements

In the imported node set file (XML export), the structure is defined as follows:

opcUaStruct	Object
allOk	Boolean
myOPCstruct1	myOPCUAstruct
varA	Int64
VarB	Byte
nestedStructZ	"myOPCUAstruct"."nestedStructZ"
varD	Float
varE	Double
varC	Double
DeviceManual	String

The structure mapped in the read list matches, both in the order and in the assigned data types, the corresponding nodes of the node set file.

myOPCstruct1	myOPCUAstruct
varA	LINT
VarB	USINT
nestedStructZ	"myOPCUAstruct"."nestedStructZ"
varD	REAL
varE	LREAL
varC	LREAL

If the structure now changes on the server, for example tagA and tagB are swapped, and the read list remains the same in the client, the assignment is no longer correct:

- The total length of the data remains the same (only the order has changed)
- The configuration of the structure is different for client and server!

WARNING

No error message in the case of different structure configuration between client and server

If the structures of client and server do not match, this rule violation will possibly not generate any error during compilation and also not in runtime.

Make sure not to change the configured assignments for structures in runtime. If required, reconfigure the assignment in the read and write lists!

11.4.9 Using connection parameter assignment

11.4.9.1 Creating and configuring connections

With the instructions for OPC UA clients, you create a user program that exchanges data with an OPC UA server. A series of system data types are required for this.

To simplify your work with these system data types, a connection parameter assignment for OPC UA clients is available starting in STEP 7 (TIA Portal) Version 15.1.

Use of the connection parameter assignment is optional and not mandatory. You can also manually create the required system data types.

We use an example to make the description easier to follow, see description of the example (Page 368).

Opening the connection parameter assignment

To configure the connection to an OPC UA server, follow these steps:

1. In the "OPC UA communication" area, double-click the client interface whose parameters you want to assign in the project tree.

   For the example configuration: Double-click the "ProductionLine" client interface.

   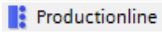

   The section "Create client interface (Page 369)" describes how to create a client interface.
2. Click the "Properties" tab (Inspector window) if the tab is not already displayed.

   STEP 7 now displays the connection parameter assignment for the instructions of the OPC UA client.

   The "General" tab is open.
3. Click on the "Configuration" tab and set the connection to the OPC UA server.

Setting the connection parameters

1. Select a descriptive name for the session. For the example, select the name "OPC UA Connection to ProductionLine".
2. In the "Address" field, enter the IP address of the OPC UA server to which your user program (that operates as an OPC UA client) is to establish a connection. In the example configuration, the CPU that controls the production line has the IP address "192.168.1.1". A connection to the OPC UA server of this CPU is to be established. For this reason, you enter this IP address in the "Address" field. In this case, the OPC UA server uses the default port 4840.
   Alternatively, you can enter a valid DNS name in the "Address" field. The length of the DNS name is limited to 242 characters.
   If the address is not valid, the error message is shown: "Enter a valid address".
   If the string of the "Address", "Port" and "Path" fields contains more than 254 characters, an error message is also displayed.

3. Enter a path within the OPC UA server to restrict access to this path. The information is optional. However, some servers only establish a connection if a server path is specified.

   When you specify a path, it is automatically entered at the "ServerEndpointUrl" entry in the configuration DB for the client interface. The entry then consists of the components "OPC Schematic Prefix", "IP address", "Port number" and "Server path", for example: "opc.tcp://192.168.0.10:4840/example/path".

   The following figure shows the entry of the IP address for the OPC UA server:

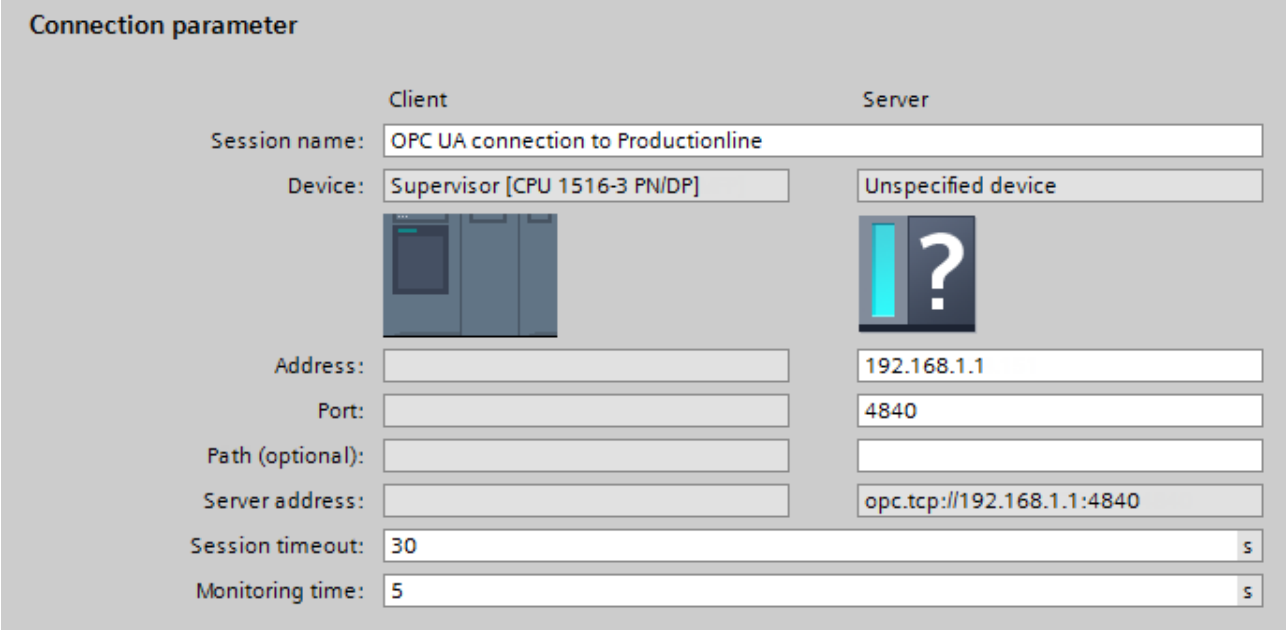

Figure 3-513 Connection parameters

4. If the OPC UA server is not using the standard port 4840, you must insert the port number here.

   For example, enter the number 65535 in the field, if the OPC UA server to which you want to establish a connection uses this port number.

5. In addition, you accept the default settings for session timeout (30 seconds) and monitoring time (5 seconds).

Setting the security parameters

1. Click the "Security" area in the "Configuration" tab.

   This area contains all security settings for the connection to the OPC UA server.

The following settings are possible, for example:

"General" area

Security mode:

In the drop-down menu, select the security mode that the connection to the OPC UA server must fulfill.

If the server does not meet the selected mode, a session is not established.

The following settings are available:

- No security: No secure connection!
- Sign: OPC UA server and OPC UA client sign the data transmission (all messages): Manipulations can thus be detected.
- Sign & Encrypt: OPC UA server and OPC UA client sign and encrypt the data transmission (all messages):

Security policy:

Set the encryption techniques for the signing and encryption of messages.

The following settings are possible:

- No security
- Basic128Rsa15
- Basic256
- Basic256Sha256

To configure a secure connection, you must observe the following items:

- A certificate is required for the client for a secure connection.
- You have to make the client certificate known to the server.

To find out how to proceed, see the section "Handling client and server certificates (Page 267)" under "Certificate of the OPC UA client".

"Certificates" area

Client certificate/client certificate folder:

Depending on the selected certificate handling (via TIA Portal or via GDS), select either a client certificate or the desired client certificate folder. Both options confirm the authenticity of the OPC UA client.

Click the following icon to select:

STEP 7 displays a list of certificates and services.

Select the certificate that you have made known to the server.
For client certificate management via GDS, select the corresponding client certificate folder.

Click the symbol with the green check mark:

Or create a new certificate or a new certificate folder. To do this, click the "Create" symbol.

If you create a new certificate, you must make this certificate known to the server.

"User authentication" area

The following settings are possible for user authentication:

- Guest
- User name and password
- Users (TIA Portal - Security Settings)

For more information, see Users and roles with OPC UA function rights (Page 278).

Setting languages

UA tags of the String type can be localized with OPC UA, that is, texts (values for the UA tag) can be available in different languages for the server. For example, localized texts can be available for DisplayName (Name of the node) and Description (Description).

In the "Languages" area of the "Configuration" tab you can, for example, influence the language of the texts returned by the server as follows:

In the "Languages" area, enter a number of languages that the server transfers to the client during connection setup.

The language or the local ID ("language code") associated with it that you enter in the first line is the language preferred by the client.

- If the server can provide the UA tag in the requested language, it is transferred to the client.
- If the server cannot provide the UA tag in the requested language, it checks whether it can provide the UA tag in the language you have entered in the second line (first substitute language).
- The server works its way down the list, and when it can provide neither the requested language nor a substitute language, it will provide the default language.

More information

What causes the connection to an OPC UA server to fail? FAQ.
(https://support.industry.siemens.com/cs/ww/en/view/109766709)

11.4.9.2 Handling of the client certificates of the S7-1500 CPU

Where does the client certificate come from?

If you are using the OPC UA client of an S7-1500 CPU (OPC UA client enabled), you can create certificates for these clients with STEP 7 V15.1 and higher as described in the following sections.

When you use UA clients from manufacturers or the OPC Foundation, a client certificate is generated automatically during installation or upon the first program call. You have to import these certificates with the global certificate manager in STEP 7 and use them for the respective CPU.

If you program an OPC UA client yourself, you can generate certificates through the program. Alternatively, you can generate certificates with tools, for example with OpenSSL or the certificate generator of the OPC Foundation:

- The procedure for OpenSSL is described here: "Generating PKI key pairs and certificates yourself (Page 196)".
- Working with the certificate generator of the OPC Foundation is described here: "Creating self-signed certificates (Page 195)".

Certificate of the OPC UA client of the S7-1500 CPU

A secure connection between the OPC UA server and an OPC UA client is only established if the server classifies the certificate of the client as trusted.

Therefore you have to make the client certificate known to the server.

The following sections describe how you can initially generate a certificate for the OPC UA client of the S7-1500 CPU and then make it available to the server.

1. Generate and export a certificate for the client

For a secure connection you have to generate a client certificate and - if the server and client are located in different projects - export the certificate.

If client and server are in the same project, exporting the client certificate and subsequent import are not necessary.

Requirements

The IP interface of the CPU is configured, an IP address is available.

Background: The IP address under which the CPU can be accessed in your system is entered under "Subject Alternative Name (SAN)".

Creating an OPC UA Client certificate

The easiest way to generate a client certificate for an S7-1500 CPU is to configure a client interface.

The configuration of the client interface provides for the selection or generation of a client certificate, see Creating and configuring connections (Page 384).

Alternatively, you can generate the client certificate as follows:

1. In the project tree, select the CPU you want to use as a client.
2. Double-click "Device configuration".
3. In the properties of the CPU, click "Protection & Security > Certificate manager".
4. Double-click "<Add new>" in the "Device certificates" table.

   STEP 7 opens a dialog.
5. Click the "Add" button.
6. Select the "OPC UA client" entry from the "Usage" list.
7. Click "OK".

   STEP 7 now shows the client certificate in the "Device certificates" table.
8. If the server is in another project: Right-click this line and select "Export certificate" from the shortcut menu.
9. Select a directory where you will store the client certificate.

2. Announcing the client certificate to the server

You have to make the client certificate available to the server to allow a secure connection to be established.

To do this, follow these steps:

1. If the client was configured in another project and you created and exported the client certificate there:
   - Select the "Use global security settings for certificate manager" option in the local certificate manager of the server. This makes the global certificate manager available.

     You will find this option under "Protection & Security > Certificate manager" in the properties of the CPU that is acting as server.
   - If the project is not yet protected, select "Security settings > Settings" in the STEP 7 project tree, click the "Protect this project" button and log on.

     The "Global security settings" item is now displayed under "Security settings" in the STEP 7 project tree.
   - Double click "Global security settings".
   - Double click "Certificate manager".

     STEP 7 opens the global certificate manager.
   - Click the "Device certificates" tab.
   - Right-click in the tab on a free area (not on a certificate).
   - Select the "Import" shortcut menu.

     The dialog for importing certificates is displayed.
   - Select the client certificate that the server is to trust.
   - Click "Open" to import the certificate.

     The certificate of the client is now contained in the global certificate manager. Note the ID of the client certificate just imported.
2. Click the "General" tab in the properties of the CPU that is acting as server.
3. Click "OPC UA > Server > Security > Secure Channel".
4. Scroll down in the "Secure Channel" dialog to the section "Trusted clients".
5. Double-click in the table on the empty row with "<add new>". A browse button is displayed in the row.
6. Click this button.
7. Select the prepared client certificate.
8. Click the button with the green check mark.
9. Compile the project.
10. Load the configuration onto the S7-1500 CPU (server).

Result

The server now trusts the client. If the server certificate is also considered trusted, the server and client can establish a secure connection.

11.4.9.3 Handling client certificates during runtime

For CPUs with FW version V4.0, the OPC UA server and the web server already support certificate management during runtime via GDS (Global Discovery Server). If you are using a CPU as of FW version V4.1, the certificate manager informs you in the CPU properties that additional services (OPC UA client) support certificate management during runtime. This also applies if you change an already configured CPU to FW version V4.1.

Effects of the update

CPUs with FW version V4.1 offer the option of integrating additional services into the certificate management during runtime in the CPU properties (Protection & Security > Certificate manager). To be able to update the certificate management for the OPC UA client during runtime, the OPC UA server and GDS Push of the CPU must be enabled. If these requirements are met, you can update the certificate management in runtime. Updating the certificate management in runtime has the following effects:

- Certificate management in runtime is enabled for the OPC UA client of the CPU.
- Existing certificates are still stored on the CPU or in STEP 7 and must be deleted manually.
- When updating the certificate management during runtime, existing certificates and the associated IDs are not transferred. Consequently, the user must adapt the user program in the appropriate places, e.g. in the program blocks for OPC UA.
- The "ManagedApplications" node is created in the namespace of the OPC UA server. After the update, this node contains all certificates that do not belong to the OPC UA server, e.g. the certificates of OPC UA clients or the web server.

NOTE

Previous settings can only be restored by performing a complete reset

The updated certificate management during runtime cannot be undone.

To restore the previous settings, you must replace the CPU with a CPU with FW version V4.0 in STEP 7. In addition, STEP 7 V21 must be reset to STEP 7 V20.

Procedure for updating the certificate management in runtime

The "Update certificate management at runtime" button can only be selected if you replace a configured CPU with FW version lower than V4.1 with a CPU with FW version V4.1.

To activate the certificate management at runtime, proceed as follows:

1. Select the required CPU in the device or network view of STEP 7.
2. In the Inspector window, navigate to "Properties > General > Protection & Security > Certificate manager".
3. In the "Configuration of certificate manager" area, select the option "Use certificates provided by certificate manager during runtime".

4. Click the "Update certificate management during runtime" button.
   STEP 7 displays a warning with the additional services and possible cases in which you need to adapt the user program.
5. Click Yes if you want to perform the update.

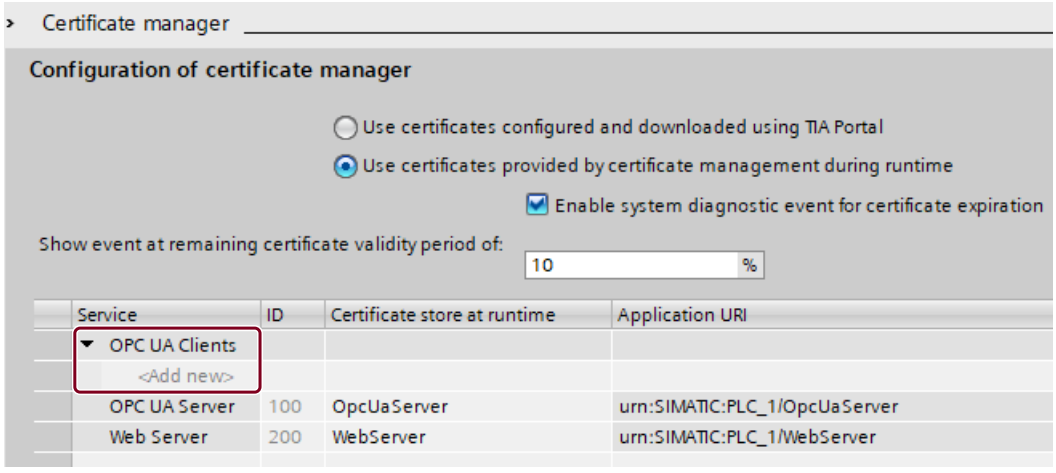

Figure 3-514 Certificate manager after activated certificate management during runtime

Result: You have activated certificate management during runtime. The note and the button for updating the certificate management in runtime are no longer displayed. The table shows the "OPC UA clients" service.

You can find out how to create, edit or delete the certificate stores for the "OPC UA clients" service during runtime in the next sections.

Creating and deleting OPC UA client certificate stores at runtime

For the "OPC UA Clients" service, you can create different certificate stores at runtime and use them for different connections or applications. The generated certificate stores are displayed under the "OPC UA clients" service.

To generate a certificate store for the OPC UA client at runtime, proceed as follows:

1. Under the "OPC UA clients" service, double-click <Add new>.
   STEP 7 creates a new entry, in this case "OPC UA client".
2. Optional: Assign the desired ID for the certificate store in the "ID" column.
   STEP 7 uses consecutive numbering by default. Each ID can only be assigned once in the project. STEP 7 shows duplicate IDs as incorrect.

3. Optional: Change the name of the client certificate folder in runtime.
   By default, STEP 7 generates the name from the service and a consecutive numbering.
   If you change the name, STEP 7 automatically applies the changes to the associated application URI.

   NOTE
   Possible consequence of name changes to the client certificate folder
   The name of the client certificate store at runtime is also used in the BrowseName and the NodeId for the nodes in the address space of the OPC UA server. If you change the name of the client certificate store, you may need to re-register your applications with your certificate management software.

4. Repeat steps 1 to 3 to generate further certificate stores.
5. Use the IDs from step 2 in the OPC_UA_Connect instructions in the user program to be able to use the certificate from the certificate store to establish the connection.
   If you are already using the OPC UA client with certificates, you can reuse the existing IDs in the certificate store in the "ID" column. In this case, you do not need to change the user program.

Result: You have created and edited various certificate stores for the OPC UA client at runtime. The following figure shows an example of two generated certificate stores for the OPC UA client. The certificate store with ID 1 was generated by STEP 7 by default. The name of the certificate store with ID 2 has been changed.

Service	ID	Certificate store at runtime	Application URI
OPC UA Clients			
OPC UA Client	1	OpcUaClient1	urn:SIMATIC:PLC_1/OpcUaClient1
OPC UA Client	2	MyOpcUaClient	urn:SIMATIC:PLC_1/MyOpcUaClient
<Add new>			
OPC UA Server	100	OpcUaServer	urn:SIMATIC:PLC_1/OpcUaServer
Web Server	200	WebServer	urn:SIMATIC:PLC_1/WebServer

Figure 3-515 Generate client certificate store for certificate management at runtime

To delete a created client certificate store, right-click on the desired certificate store and select "Delete" from the context menu. Deleted certificate stores are no longer available once they have been loaded into the CPU and can no longer be used.

Use the generated certificate stores as already described in the section Creating and configuring connections (Page 384).

Deleting existing certificates on the CPU

When you load your configuration into the CPU, the load preview dialog shows the existing certificate store on the CPU. You can select the certificates you wish to delete. If you select the "OPC UA clients" service, all existing certificates in all OPC UA client certificate stores will be deleted.

11.4.9.4 User authentication

In the OPC UA client interface of the S7-1500, you can set what authentication is required for a user of the OPC UA client wishing to access the server. To do so, you must select the corresponding client interface in the project tree of the requested S7-1500 CPU under "OPC UA communication > Client interfaces" and select the type of user authentication in the Inspector window under "Properties > Configuration > Security".

Types of user authentication

The following options are available for user authentication:

- **Guest**

  The user does not need to verify authorization (anonymous access). The CPU creates an anonymous session for the user, and the OPC UA server does not check the authorization of the client user.

- **User name and password**

  The user must prove authorization (no anonymous access). The OPC UA server checks whether the client user is authorized to access the server. Authorization is given by the user name and the correct password. These inputs cannot be checked by the client interface, which means all values are accepted as being valid.

  NOTE

  STEP 7 stores user name and password unencrypted in the data block/instance data block. Recommendation: Use the user authentication for the "User (TIA Portal - Security Settings)" TIA project.

- **Users (TIA Portal - Security Settings)**

  You can enter a user name from the list of users entered in the project for authentication. The names of the registered users for the current project are available in the user administration in the project tree under "Security Settings > Users and roles". There you can also enter additional users.

  You can also enter a name that is not listed in the user administration of the project or leave the field blank. This is necessary when the corresponding user name is only provided by a different source during runtime, for example, via HMI or from a different OPC UA client.

"No Security" security policy and authentication via user name and password

You can set the following combination:

Security policy = "No Security" and authentication via user name and password.

- The OPC UA server of the S7-1500 supports this combination. OPC UA clients can connect and encrypt the authentication data or not.
- OPC UA client of the S7-1500 CPU also supports this combination: However, in runtime it only connects if it can send the authentication data encrypted via cable!

Result: With the following configuration, no connection can be established at runtime:

- S7-1500 as OPC UA client
- OPC UA server which supports no encryption of authentication data when "No Security" (="none") is set as security policy.

More information

You can find information about the users and roles with OPC UA function rights in the section Users and roles with OPC UA function rights (Page 278).

11.4.9.5 Using a configured connection

Introduction

This section shows you how to use a configured connection for OPC UA instructions (third step).

Requirements

- You have created a client interface and added PLC tags and PLC methods to this interface, see ("First step (Page 369)").
- You have configured a connection to an OPC UA server (Second step (Page 384)).

Overview

To read data from an OPC UA server or write data to an OPC UA server, use the following instructions:

- OPC_UA_Connect
- OPC_UA_NamespaceGetIndexList
- OPC_UA_NodeGetHandleList
- OPC_UA_ReadList or OPC_UA_WriteList
- OPC_UA_NodeReleaseHandleList
- OPC_UA_Disconnect

Order of the OPC UA instructions

The following figure shows the order in which the OPC UA instructions are called in a user program in order to use these instructions to read or write PLC tags:

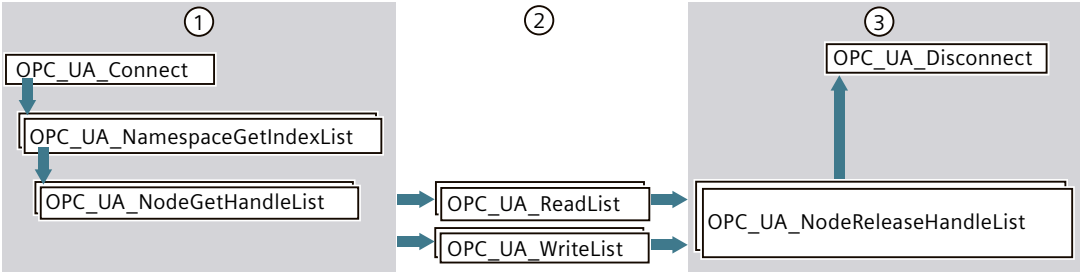

① Instructions for preparation of read and write operations

② Read and write instructions

③ Instructions for "clean-up" after a completed read or write operation
The "OPC_UA_NodeReleaseHandleList" instruction can be omitted if "OPC_UA_Disconnect" is called immediately afterwards.

Figure 3-516 Call sequence for write and read operations

STEP 7 (TIA Portal) automatically supplies the parameters of these instructions if you are using a client interface and a configured connection to an OPC UA server.

The procedure is shown in the following section.

Using a client interface and configured connection

To use a configured OPC UA connection, follow these steps:

1. Open your user program in the TIA Portal.
2. Using drag-and-drop, move the "**OPC_UA_Connect**" instruction into the program editor.

   You will find the instruction under "Instructions > Communication > OPC UA" in the TIA Portal.
3. Select a call option for the instruction

   The example uses a multi-instance.

   STEP 7 displays the instruction in the program editor.

   The editor for the Function Block Diagram (FBD) programming language uses the following display:

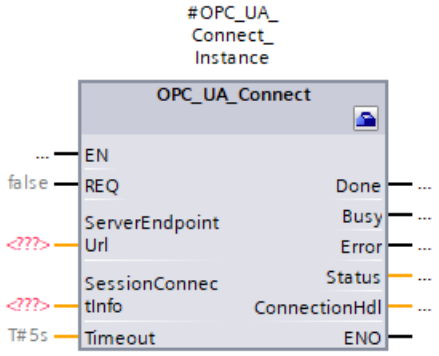

The editor for the Ladder Logic (LAD) programming language displays the instruction similarly.

4. Click the toolbox symbol in the editor for FBD or LAD.

   The symbol is located in the heading of the instruction:

   If you are using the editor for STL or SCL: Click the small green rectangle below the first character of the instance name:

   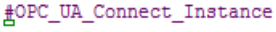

   The example (Page 368) uses "#OPC_UA_Connect_Instance" as the instance name.

   STEP 7 displays the properties of the instruction in a separate dialog.

5. For "Client interface" select the client interface that you want to use for the instruction.

   In the example, we select the "ProductionLine" client interface.

   STEP 7 now interconnects the "ProductionLine" client interface with the parameters of the OPC_UA_Connect instruction:

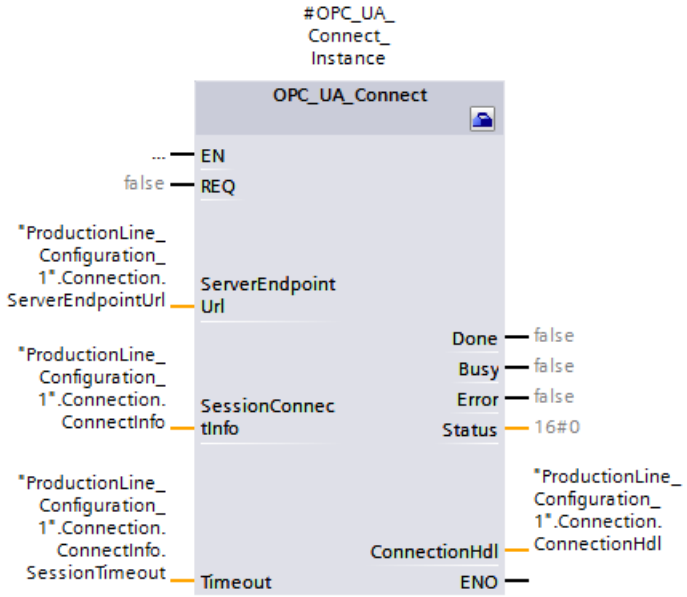

   "ProductionLine" is the interface that the OPC UA client of the example (Page 368) uses for data exchange with the OPC UA server "ProductionLine".

6. Using drag-and-drop, move the "**OPC_UA_NamespaceGetIndexList**" instruction into the program editor.

   You will find the instruction under "Instructions > Communication > OPC UA" in the TIA Portal.

   Select the "Multi-instance" call option.

   Click the toolbox symbol (LAD and FBD) or the small green box below the instance name (STL and SCL) if the editor is not already open.

   Select the client interface that you want to use (in the example "ProductionLine").

   STEP 7 now automatically interconnects all parameters of the "OPC_UA_NamespaceGetIndexList" instruction:

7. Using drag-and-drop, move the "**OPC_UA_NodeGetHandleList**" instruction into the program editor.

   Select the "Multi-instance" call option.

   Click the toolbox symbol (LAD and FBD) or the small green box below the instance name (STL and SCL) if the editor is not already open.

   Select the client interface that you want to use. The example uses the "ProductionLine" client interface.

   Under "Data access > Read/Write list" select the read or write list that you want to use (in the example the read list "Product").

STEP 7 now automatically interconnects all parameters of the "OPC_UA_NodeGetHandleList" instruction:

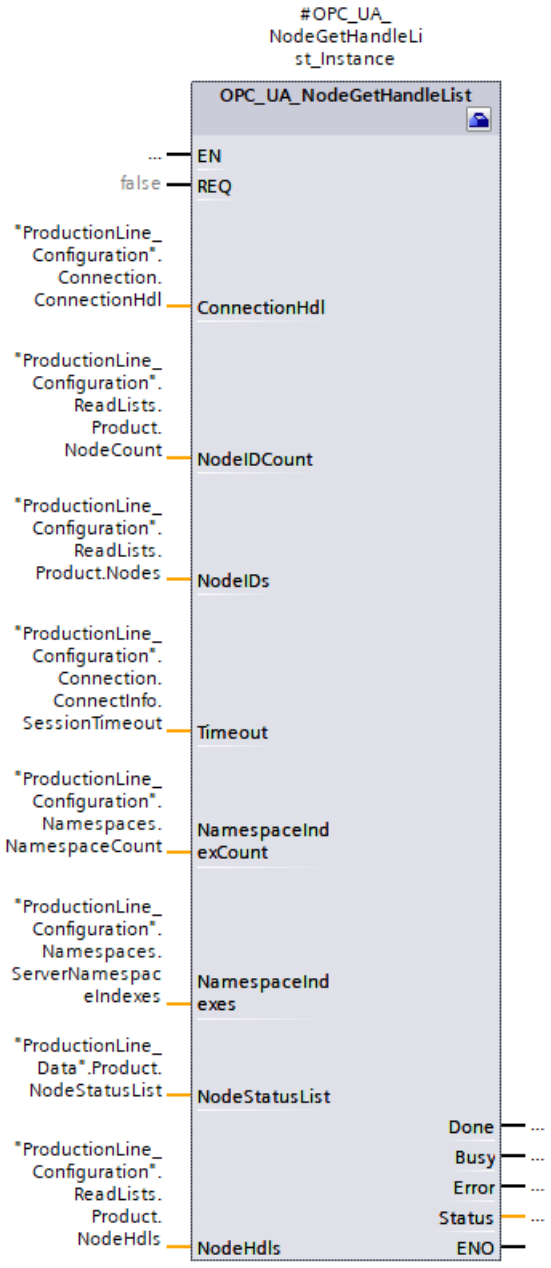

If you want to write data to an OPC UA server, select the write list you want to use under "Data access > Write list" (the "ProductionStatus" write list in the example).

8. Using drag-and-drop, move the "**OPC_UA_ReadList**" instruction into the program editor.

   Select the "Multi-instance" call option.

   Click the toolbox symbol (LAD and FBD) or the small green box below the instance name (STL and SCL) if the editor is not already open.

   Select the client interface that you want to use. The example uses the "ProductionLine" client interface.

Under "Data access > Read list" select the read list that you want to use (in the example the "Product" read list).

STEP 7 now automatically interconnects all parameters of the "OPC_UA_ReadList" instruction.

If you want to write data to an OPC UA server, use the "**OPC_UA_WriteList**" instruction and select the list of tags you want to send to the server under "Data access > Write list" ("ProductionStatus" write list in the example).

9. If you use different read lists or write lists as program-controlled lists in your user program, move the "**OPC_UA_NodeReleaseHandleList**" instruction to the program editor using drag-and-drop operation.

   Select the client interface that you want to use.

   Now select a read list or write list that you want to release: Only release read or write lists that you rarely use, since re-registering is time-consuming.

   Then, repeat the steps starting with step 7 with the "OPC_UA_NodeGetHandleList" instruction.

10. Using drag-and-drop, move the "**OPC_UA_Disconnect**" instruction into the program editor.

    Select the "Multi-instance" call option.

    Click the toolbox symbol (LAD and FBD) or the small green box below the instance name (STL and SCL) if the editor is not already open.

    Select the client interface that you want to use. The example uses the "ProductionLine" client interface.

    STEP 7 now automatically interconnects all parameters of the "OPC_UA_Disconnect" instruction.

Supported instructions

For the following instructions, STEP 7 automatically supplies the parameters if you are using a client interface and a configured connection to an OPC UA server:

- OPC_UA_Connect
- OPC_UA_NamespaceGetIndexList
- OPC_UA_NodeGetHandleList
- OPC_UA_MethodGetHandleList
- OPC_UA_MethodReleaseHandleList
- OPC_UA_ReadList
- OPC_UA_WriteList
- OPC_UA_MethodCall
- OPC_UA_NodeReleaseHandleList
- OPC_UA_Disconnect

Compact instructions

As of TIA Portal V17, compact instructions are available for OPC UA which summarize the write job/read job/method call and the connection establishment:

- OPC_UA_ReadList_C for generating a connection and reading tags
- OPC_UA_WriteList_C for generating a connection and writing tags
- OPC_UA_MethodCall_C for generating a connection and calling methods

You will find information about the compact instructions services in the TIA Portal Help.

11.5 Tips and recommendations

11.5.1 Rules for subscriptions

The following rules apply to subscriptions:

- Group subscriptions in the client according to different sampling and publishing intervals and distribute the monitored elements (variables) to these groups.

  Example: Create a subscription for longer publishing intervals (e.g. 5 seconds) and a subscription for shorter publishing intervals (e.g. 0.1 second).
- Disable unneeded subscriptions.

  Reason: The "Deactivated" subscription mode reduces resource consumption.
- To further optimize resource consumption, reduce the subscription timeout for the client. The subscription timeout cannot be specified directly, this time results from the subscription settings "PublishingInterval" and "LifetimeCount" confirmed by the server. Background: When a client has created subscriptions and the session is terminated, the subscriptions initially remain in the server and occupy memory resources. The OPC UA server only releases the resources needed for this when the subscription timeout ends the lifetime of the subscriptions.
- Consider the maximum number of monitored items of subscriptions for the corresponding S7-1500 CPU.

  The information can be found in the technical specification of the respective CPU. The information is based on a sampling / publishing interval of 1 second.

  You can find more information in the FAQ 109755846 (https://support.industry.siemens.com/cs/us/en/view/109755846).
- Select the same sampling and publishing intervals for the OPC UA client and for the OPC UA server.
- Avoid arrays and structures as elements of subscriptions – if the process allows.

  Reason: If even one value of an array/structure changes, the entire structure is transferred, creating an unnecessary communication load.
- Occasional non-compliance with the required sampling rate is acknowledged by the OPC UA server of the S7-1500 CPU according to OPC UA specification with a "GoodOverload" error code, see also TIA Portal Help. Different OPC UA clients handle "Good" error codes unequal to "0" differently. Consider this behavior and, if needed, reduce the communication load according to the measures described above.

More information

For information on how to set the server for subscriptions, refer to the section Settings of the server for subscriptions (Page 264).

11.5.2 Rules for the user program

User programs for OPC UA

The following rules apply to user programs:

- If your application allows it and the communication load is high, you should set a minimum time for cycle OBs.

  Advantages:

  – The cycle time remains constant for the most part

  – The CPU has more time for communication tasks throughout

  Tip: Use the instruction "Runtime_Info"; mode 21 or mode 25 (see TIA Portal Help) to analyze the CPU utilization (e.g. communication).

- Reduce the number of variables or data blocks that can be reached from OPC UA/HMI. By default, all variables from OPC UA/HMI are accessible when creating variables/DBs/IDBs. This measure leads to improved performance when loading in RUN.

  Tip: Using the detailed object display in the TIA Portal, you can easily mark the non-OPC-UA-relevant data blocks as "not accessible from OPC UA".

- Consistent transfer of data beyond the limits of simple data types is only possible with OPC UA methods. If you use other OPC UA functions (Subscriptions, Read/Write), you must ensure data consistency in the application.

- OPC UA offers the "RegisterNodes" service for repeated read and write accesses to the same variables. Servers can use this service to prepare for optimized access to variables. The instruction "OPC_UA_NodeGetHandleList" of the S7-1500 as OPC UA client implicitly calls this service to prepare the server for optimized accesses (in OPC UA usage "Registered Read/Write").

Calling detailed object display in the TIA Portal

To call up the detailed object display, proceed as follows:

1. Switch to the "PLC Programming" portal in the portal view.
2. Select "Show all objects".
3. Switch to the "Details" tab in the selection window.

4. In the "DB accessible from OPC UA" column, disable the accessibility from OPC UA for individual objects.

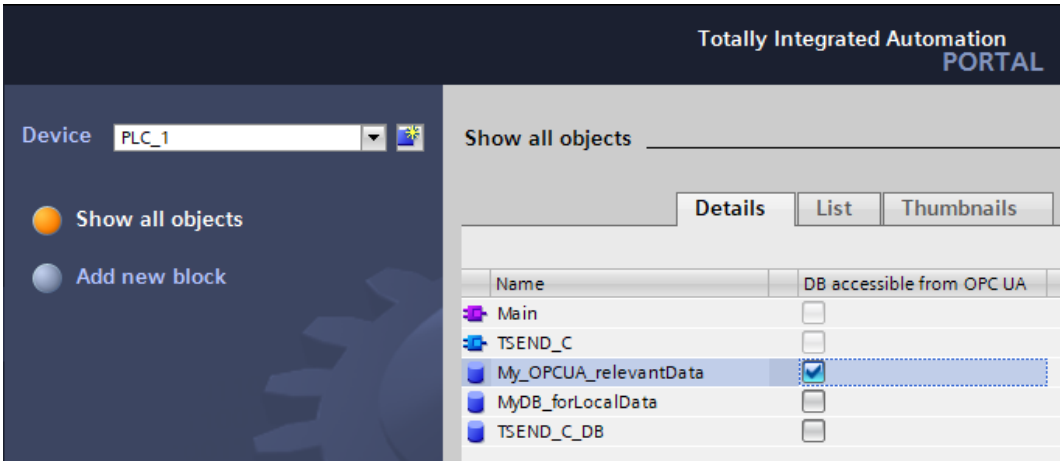

Figure 3-517 Calling detailed object display in the TIA Portal

11.5.3 Master copies for OPC UA communication

Master copies for the OPC UA interfaces

Interfaces of OPC UA servers and OPC UA clients that you want to use multiple times can be stored either in the project library or in a global library. Master copies in the project library can only be used within the project. When you create the master copy in a global library, it can be used in different projects.

The OPC UA capable CPUs differentiate between 3 interface types of the OPC UA server:

- Standard OPC UA server interface
- Companion specification interface
- Namespace reference

When adding the OPC UA interface in the project tree under "OPC UA Communication" each interface type gets its own symbol. The same symbol is used by the master copy.

Create either single master copies or a master copy with multiple interfaces.

Creating multiple master copies from selection

You select one or more elements and create individual master copies from them

1. Open the library in the "Libraries" task card.
2. Select the desired elements.
3. Using a drag-and-drop operation, move the elements to the "Master copies" folder or any subfolder of "Master copies".

Creating a master copy from selection

You select multiple elements and create a single master copy from them that contains all selected elements.

1. Copy to the clipboard the elements that you want to create as master copies.
2. Right-click on the "Master copies" folder or any of its subfolders in the library.
3. In the shortcut menu, select "Paste as a single master copy" command.

If multiple interfaces are added to a master copy from the OPC UA server or OPC UA client, the label and the symbol in the library are changed accordingly.

A symbol with "+" is displayed instead of the simple symbol.

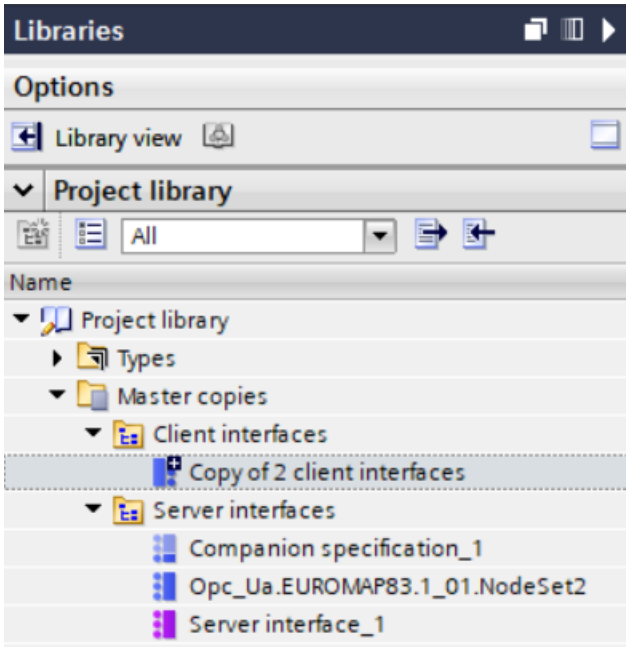

Figure 3-518 Create copy template in STEP 7

More information

For information on how to create a user-defined server interface, refer to the section Creating a user-defined server interface (Page 296).

Addressing via DHCP

12

In order to provide future-proof, efficient and flexible automation, more and more components from the production area support IT standards. Worldwide Ethernet standards, integrated communication and versatility make IT-supported automation an economical solution for your requirements. Functional expansions of the communication options of the S7-1500 CPUs in this direction give you more freedom for the possible uses of your system or machine. You use IT technology to automate efficiently. With the introduction of DHCP and the expansions of DNS for S7-1500 CPU as of firmware version V2.9, you gain more flexibility for the design of your automation solution.

For the interfaces of an S7-1500 CPU you can set that address parameters such as the IP address with subnet mask, can be got from a DHCPv4 server (hereinafter DHCP server).

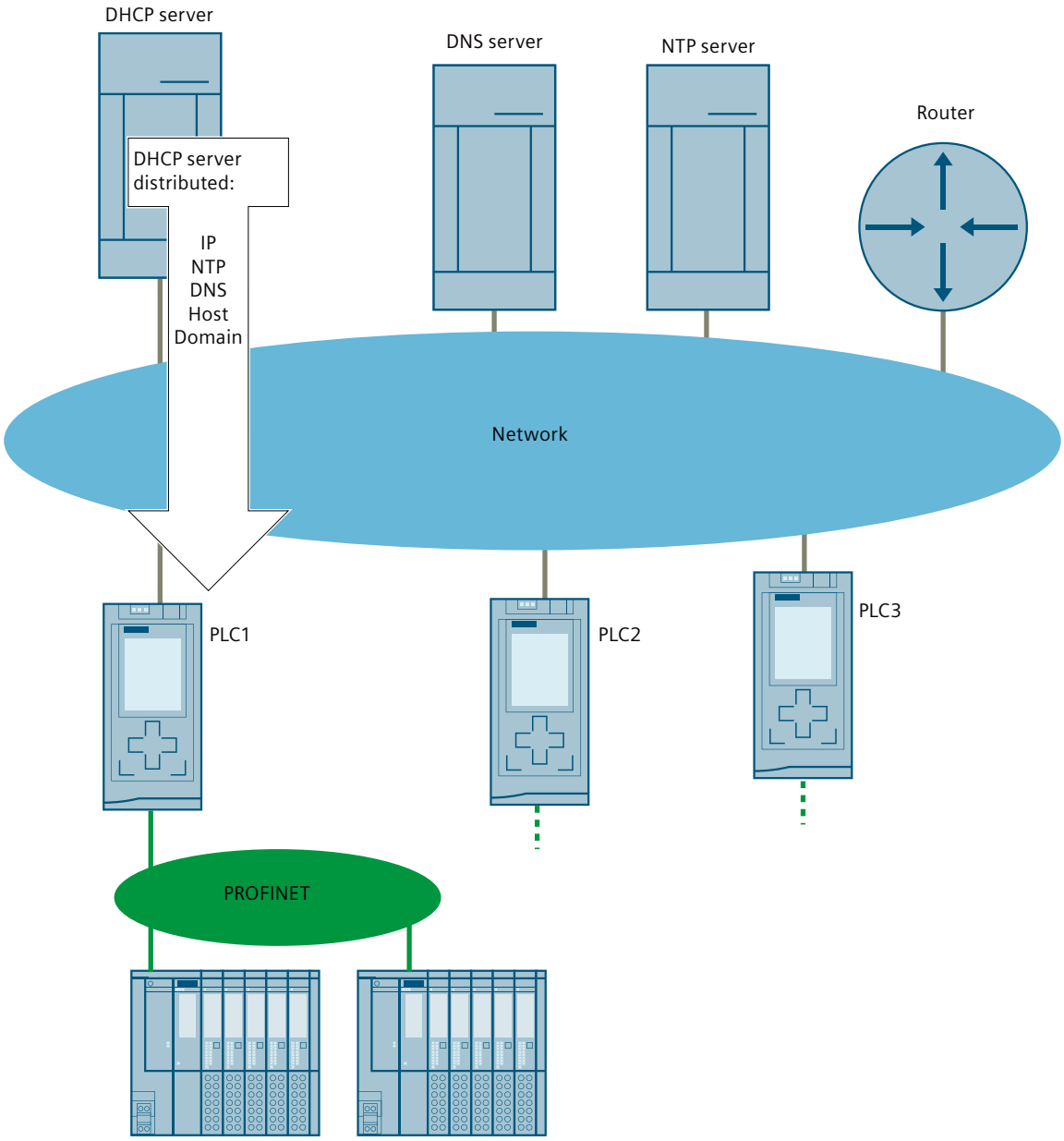

Figure 3-519 Overview of DHCP

Areas of application

- Use of the S7-1500 CPU in a managed IT environment
- Adding new devices in a modular manufacturing structure

12.1 Principle of address assignment via DHCP

Requirement configuration

The following requirements must be met so that a PROFINET interface of the S7-1500 CPU can obtain IP address parameters via a DHCP server:

- The address assignment via a DHCP server is configured.

  Activate DHCP (Page 412)
- No PROFINET IO communication may be configured for the interface.

Principle of DHCP address assignment

The process begins as soon as the project is loaded into the CPU or the CPU is switched on with configured DHCP address assignment and started up, the process of DHCP assignment begins:

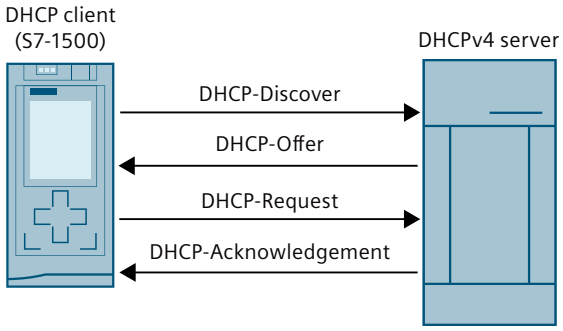

DHCP Discover	The DHCP client searches for a suitable DHCP server via broadcast. The DHCP client identifies itself to the DHCP server with the configured client ID or with its MAC address.
DHCP Offer	The DHCP server offers the DHCP-client IP address parameters (IPv4 address, subnet mask, optional default router) and if necessary further data (options).
DHCP Request	The DHCPclient requests the IP address parameters and options offered in the DHCP offer. The DHCP client of the S7-1500 CPU always accepts the first DHCP offer of a DHCP server that meets the requirements (IP address with subnet mask).
DHCP Acknow-ledgment	The DHCP server confirms and transmits the IP address parameters and options offered in the DHCP offer. The DHCP server also notifies the DHCP client how long the DHCP client can use the address parameters (lease time).

Figure 3-520 Principle of address assignment with DHCP

The IP address parameters and options are stored in the load memory of the CPU. After a general reset or restart of the CPU, the IP address parameters and options are obtained again via DHCP.

DHCP address assignment options

For the S7-1500 CPU you can configure that the following options are obtained via a DHCP server:

- Addresses of up to four DNS servers

  Get addresses of the DNS servers via DHCP (Page 414)
- Address of up to four NTP servers

  Get addresses of the NTP servers via DHCP (Page 415)
- Host and domain name

  Obtain host and domain name via DHCP (Page 415)

If necessary, the DHCP server also supplies the address of a router (default gateway) as option.

How long can the S7-1500 CPU use the DHCP address parameters?

In addition to the address parameters, the DHCP server also notifies the S7-1500 CPU (DHCP client)of the lease time. The lease time defines how long the CPU can use the address parameters.

When the lease time has fully expired, the CPU returns the assigned address parameters. The CPU has an internal time monitoring for the lease time.

At certain times when the lease time expires, the CPU has the option of extending the lease time:

- Renewal: Half of the lease time has expired: The CPU contacts the original DHCP server and asks for an extension of the lease time. The original DHCP server can either confirm the existing lease time or assign a new lease time. With a new lease time, the time monitoring in the CPU is reset.
- Rebinding: 7/8 of the lease term has expired: The CPU contacts all available DHCP servers via broadcast and asks for an extension of the lease time. A DHCP server can either confirm the existing lease time or assign a new lease time. With a new lease time, the time monitoring in the CPU is reset.

  In the event of a negative response from DHCP server during rebinding or if no DHCP server replies, the CPU returns the address parameters after 8/8 of the lease time.

If the CPU has returned the address parameters after the lease time has expired, the CPU starts a new cycle for DHCP addressing with a new DHCP discover.

More information

For information on how to configure client ID, refer to the section Configuring the client ID (Page 413).

12.2 DHCP with DNS

As of STEP 7 V17, the S7-1500 CPU supports the host name and domain address parameters used in name-based communication (DNS).

For specific communication services, name-based addressing via the complete name consisting of host name and domain, is useful:

- The CPU is addressable under the complete name, for example at OPC UA, Open User Communication. In the case of dynamic IP address assignment by the DHCP server, unique addressing is always possible through the DNS name.
- Certificates of the S7-1500 CPU may contain the complete name, for example, for OPC UA communication, web server, secure communication.
  - Only if you configure host name and domain for the S7-1500 CPU in STEP 7, then the complete name is entered in the device certificates in the project as subject alternate name (SAN).
  - As soon as you obtain the host name and/or domain via DHCP or assign it via the user program, the complete name is not stored in the device certificates in the project.

How you set the DNS configuration for your CPU depends on how you assign the host name and domain in your network .

- Central assignment of host name and domain

  You assign the host name and domain centrally in your network, for example via a configured DNS server. In STEP 7 you configure that the CPU obtains the host name and domain via DHCP.

  In the following configuration, only the client ID is configured in the S7-1500 CPU. At the DHCP address assignment the DHCP-server returns the host name and domain options to the CPU.

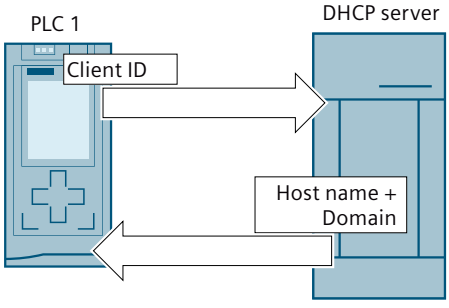

Figure 3-521 Obtain host and domain name via DHCP

For this configuration, you must first activate the host name and domain configuration in STEP 7. You then configure that the host and domain name are obtained via DHCP.

Obtain host and domain name via DHCP (Page 415)

- Local assignment of host name and domain

  You can configure the host name and domain in STEP 7 or assign them in the user program.

NOTE

Validity of the data obtained from DHCP

If you change the host name and/or domain in the user program, then all data obtained via DHCP (IP suite, host name, domain, NTP server, DNS server) becomes invalid and is retrieved again from DHCP server. Therefore, you should only change the Hostname and/or Domain in urgent cases and not during operation.

All connections can be dropped if the IP address of the interface changes.

In the following configuration, the host name and its domain are configured in the S7-1500 CPU in addition to its client ID. During DHCP address assignment, the CPU supplies the host name and the domain to the DHCP server in addition to the client ID. The DHCP server receives the information to update, for example a DNS server with the address data of the CPU.

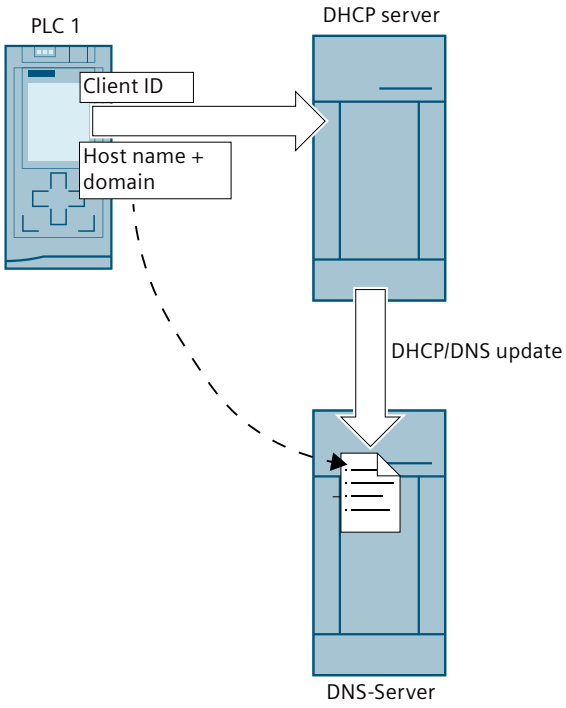

Figure 3-522 Configure host and domain name

For this configuration, you must first activate the host name and domain configuration in STEP 7. You then configure the host name and domain in STEP 7.

- Central assignment of the domain and local assignment of host name.
  - You configure in STEP 7 that the CPU gets the domain via DHCP.
  - You can configure the host name in STEP 7 or assign it via the user program.

  In the following configuration, the host name is also configured in the S7-1500 CPU in addition to its client ID. When assigning DHCP addresses, the CPU supplies the client ID as

well as the host name to the DHCPv4 server. The DHCP server supplies the domain option to the CPU.

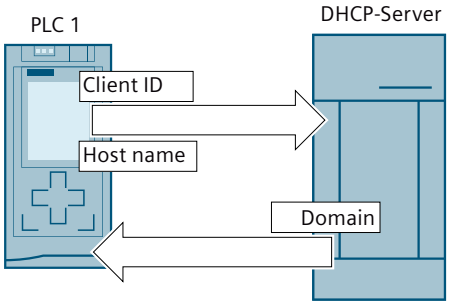

Figure 3-523 Configure host name, obtain domain name via DHCP

For this configuration, you must first activate the host name and domain configuration in STEP 7. Then configure the host name in STEP 7 and configure that the domain is obtained via DHCP.

Requirements

- You have activated the address assignment via DHCP for at least one interface of the S7-1500 CPU.

Configuration of host and domain name

To activate the host name and domain configuration in STEP 7, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name" > "Host and domain name configuration".
3. Select the "Enable host name and domain" check box.

Configuring the host name in STEP 7

To configure the host name in STEP 7, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name" > "Host and domain name configuration"> "Host name".
3. For "Host name configuration:" select "Set host name in the project" from the drop-down list.
4. Enter the host name for "Host name:".
   - Enter your desired host name.
   - If you select the "Host name identical to device name" check box, STEP 7 automatically assigns the device name as the host name.

Only if you have configured the host and domain name in STEP 7, the full name is displayed for "Full name:".

Assign host name in the user program

To assign the host name in the user program, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name" > "Host and domain name configuration" > "Host name".
3. Under "Host name configuration:" select "Set hostname directly on the device (e.g. PLC program, display)" in the drop-down list.
4. Call the instruction "CommConfig" in the user program. The DATA parameter must point to a UDT "Conf_Hostname" where the host name is defined.

You can find more information on the "CommConfig" instruction and on the UDT "Conf-Hostname" in the STEP 7 online help.

Configuring a domain in STEP 7

To configure the domain in STEP 7, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name" > "Host and domain name configuration" > "Domain".
3. For "Domain configuration:" select "Set domain in the project" from the drop-down list.
4. Enter your desired domain under "Domain:".

Only if you have configured the host and domain name in STEP 7, the full name is displayed for "Full name:".

Assigning a domain in the user program

To assign the domain in the user program, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name" > "Host and domain name configuration" > "Domain".
3. Under "Hostname configuration:" select "Set domain directly on the device (for example PLC program, display)" in the drop-down list.
4. Call the instruction "CommConfig" in the user program. The DATA parameter must point to a UDT "Conf_Domainname" where the domain name is specified.

You can find more information on the "CommConfig" instruction and on the UDT "Conf-Domainname" in the STEP 7 online help.

Rules for maximum lengths of host name, domain and client ID

Note the following maximum lengths in bytes. One byte corresponds to one character:

- Host name: Maximum 63 bytes
- Domain: Maximum 252 bytes
- Client ID: Maximum 254 bytes
- Host + Domain name: Maximum 254 bytes
- Host + Domain name + Client ID: Maximum 260 bytes

  Applies only when host and domain name must be sent to the DHCP server.

12.3 Activate DHCP

Requirements

- S7-1500 CPU firmware V2.9 or higher

Procedure

To activate DHCP for the PROFINET interface of an S7-1500 CPU, follow these steps:

1. Select the PROFINET interface of the S7-1500 CPU in STEP 7.
2. In the properties of the interface, navigate to "Ethernet addresses" > "Internet Protocol Version 4 (IPv4)".
3. Select the option "IP address of DHCP server".

Result

You have set the interface so that it obtains your IP address via a DHCP server.

"Use MAC address as client ID" is set as the operating mode for DHCP on the S7-1500 CPU. How to adjust the client ID is described under Configuring the client ID (Page 413).

12.4 Configuring the client ID

The client ID

The S7-1500 CPU always identifies itself to a DHCP server with the client ID (DHCP option 61). The client ID is interface specific.

The S7-1500 CPU supports the following two operating modes with regard to the client ID:

- Use the MAC address as the client ID: The MAC address of the CPU is used as the client ID for the DHCP client. Note, if you execute a device exchange of the CPU in this operating mode, the MAC address and therefore also the client ID changes.
- User-defined client ID: With this option you specify the client ID in the configuration in STEP 7. You also have the option of adapting the client ID during runtime, for example, in the user program using the "CommConfig" instruction.
  If you perform a device exchange of the CPU in this operating mode, the new CPU is assigned the configured client ID.

Requirement

- You have activated address assignment via DHCP for the interface.

Configuring the client ID

To configure the client ID in STEP 7, follow these steps:

1. Select the PROFINET interface of the S7-1500 CPU in STEP 7.
2. In the properties of the interface, navigate to "Ethernet addresses" > "Internet Protocol Version 4 (IPv4)"> "IP address of DHCP server".
3. For "Operating mode:" select the required operating mode from the drop-down list:
   - Use MAC address as client ID (default setting)
   - User-defined client ID

   If you have selected the option "Use MAC address as client ID", then you are already finished here. For "User-defined client ID", continue with step 4.
4. Enter a valid client ID for "Client ID".
   - A character string with 7-bit ASCII characters is allowed in the area from 0x21 to 0x7e.
   - Some DHCP servers expect a leading "0" (e.g. some SCALANCE devices). In this case, enter "\ 0" followed by your client ID.
   - You can also leave the field blank. In this case, you must select the "Client ID can be changed at runtime" check box.
5. In order to make the user-defined client ID adaptable during runtime, select the "Client ID can be changed during runtime" check box.

Adapting the client ID during runtime

You can use the "CommConfig" instruction to adapt the client ID via the user program. Call the instruction. The DATA parameter must point to a UDT "Conf_ClientId" or a UDT "Conf_ClientId_Opaque". The client ID must be specified in the UDT.

If you have left the user-defined client ID free in the configuration in STEP 7, then the CPU uses the MAC address as the client ID until the client ID is adapted for the first time.

NOTE

Validity of data obtained via DHCP

If you change ClientId with "CommConfig", all data obtained via DHCP will be invalid: IP Suite, domain name, NTP server, DNS server. Therefore, you should only change ClientId in urgent cases and not during operation.

You can find more information on the instruction "CommConfig" and the UDTs "Conf_ClientId" and "Conf_ClientId_Opaque" in the STEP 7 online help.

12.5 Get addresses of the DNS servers via DHCP

Requirements

- You have activated the address assignment via DHCP for at least one interface of the S7-1500 CPU.

Get addresses from DNS servers via DHCP

To obtain the addresses of up to 4 DNS servers via DHCP, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "DNS configuration" > "Server list".
3. For "Name resolution via DNS:" select "Set DNS server remotely (e.g. DHCP)" in the drop-down list.

Result: If the DHCP server supplies addresses from DNS servers as option, the CPU uses up to 4 addresses.

12.6 Get addresses of the NTP servers via DHCP

Requirements

- You have activated the address assignment via DHCP for at least one interface of the S7-1500 CPU.

Obtaining addresses from NTP servers via DHCP

To obtain the addresses of up to four NTP servers via DHCP, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Time of day" > "Time synchronization"> "NTP mode".
3. For "Time synchronization:" select "Set NTP server remotely (e.g. DHCP)" in the drop-down list.

Result: If the DHCP server supplies addresses from NTP servers as option , the CPU uses up to 4 addresses.

12.7 Obtain host and domain name via DHCP

Requirement

- You have activated the address assignment via DHCP for at least one interface of the S7-1500 CPU.
- You have activated the host name and domain configuration in STEP 7.

Obtain host name via DHCP

To obtain the host name via DHCP, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name"> "Host and domain name configuration"> "Host name".
3. For "Host name configuration:" select "Set host name remotely (e.g. DHCP)" in the drop-down list.

Result: If the DHCP server supplies a host name as option, the CPU uses this host name.

Obtaining a domain via DHCP

To obtain the domain via DHCP, follow these steps:

1. Select the S7-1500 CPU in STEP 7.
2. In the properties of the CPU, navigate to "Advanced configuration" > "Host and domain name" > "Host and domain name configuration" > "Domain".
3. For "Domain configuration:" select "Set domain remotely (e.g. DHCP)" in the drop-down list.

Result: If the DHCP server delivers a domain as option, the CPU uses this domain.

Routing 13

13.1 Overview of the routing mechanisms of S7-1500 CPUs

The following table gives an overview of the routing mechanisms of the S7-1500 CPU.

Routing mechanism	Description	Applications	Section
S7 routing	S7 routing is the transfer of data beyond S7 subnet boundaries. You can send information from a transmitter to a receiver across several s7 subnets.	Download user programs Load hardware configuration Execute testing and diagnostics functions	S7 routing (Page 417)
IP forwarding	IP forwarding is a function of devices to forward IP packets between two connected IP subnets.	Simple access from the control level to the field level for configuration and parameter assignment of devices, e.g. via PDM or Web browser. Simplified integration of devices for remote access, e.g. for diagnostics during remote maintenance or firmware update.	IP forwarding (Page 422)
Data record routing	Data can be sent over PROFINET from an engineering station to field devices via multiple networks. Since the engineering station addresses the field devices using standardized records and these records are routed via S7 devices, the term "data record routing" is used to refer to this type of routing.	Data record routing is used, for example, when field devices of different manufacturers are used. The field devices are addressed using standardized data records (PROFINET) for configuration and diagnostics.	Data record routing (Page 435)

13.2 S7 routing

Definition of S7 routing

S7 routing is the transfer of data beyond S7 subnet boundaries. You can send information from a transmitter to a receiver across several s7 subnets. The gateway from one S7 subnet to one or more other subnets is provided by the S7 router The S7 router is a device which has interfaces to the respective S7 subnets. S7 routing is possible via various S7 subnets (PROFINET/Industrial Ethernet and/or PROFIBUS).

Requirements for S7 routing

- All devices that can be reached in a network have been configured in a project in STEP 7 and downloaded.
- All devices involved in the S7 routing must receive routing information about the S7 subnets that can be reached through specific S7 routers. The devices obtain the routing information by downloading the hardware configuration to the CPUs, since the CPUs play the role of an S7 router.

  In a topology with several consecutive S7 subnets, the following order must be kept to when downloading: First download the hardware configuration to the CPU(s) directly connected to the same S7 subnet as the PG/PC, then download one by one the CPUs of the S7 subnets beyond this starting with the nearest S7 subnet through to the S7 subnet furthest away.
- The PG/PC you want to use to establish a connection via a S7 router must be assigned to the S7 subnet it is physically connected to. You can assign the PG/PC to a PG/PC in STEP 7 under Online & Diagnostics > Online accesses > Connection to interface/subnet.
- For S7 subnets of the type PROFIBUS: Either the CPU must be configured as DP master or, if it is configured as a DP slave, the "Test, commissioning, routing" check box must be selected in the properties of the DP interface of the DP slave.
- S7 routing for HMI connections is possible as of STEP 7 V13 SP1.

NOTE

Firewall and S7 routing

A firewall does not recognize the IP address of the sender during S7 routing when the sender is located outside the S7 subnet adjacent to the firewall.

An overview of the devices that support the "S7 routing" function is provided in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/584459).

S7 routing for online connections

With the PG/PC, you can reach devices beyond S7 subnets, for example to do the following:

- Download user programs
- Download a hardware configuration
- Execute test and diagnostics functions

In the following figure, CPU 1 is the S7 router between S7 subnet 1 and S7 subnet 2.

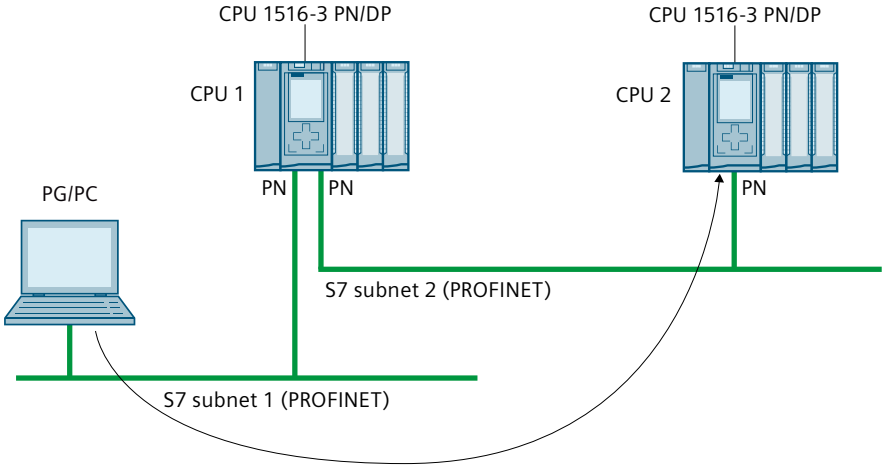

Figure 3-524 S7 routing: PROFINET - PROFINET

The following figure shows the access from a PG via PROFINET to PROFIBUS. CPU 1 is the S7 router between S7 subnet 1 and S7 subnet 2; CPU 2 is the S7 router between S7 subnet 2 and S7 subnet 3.

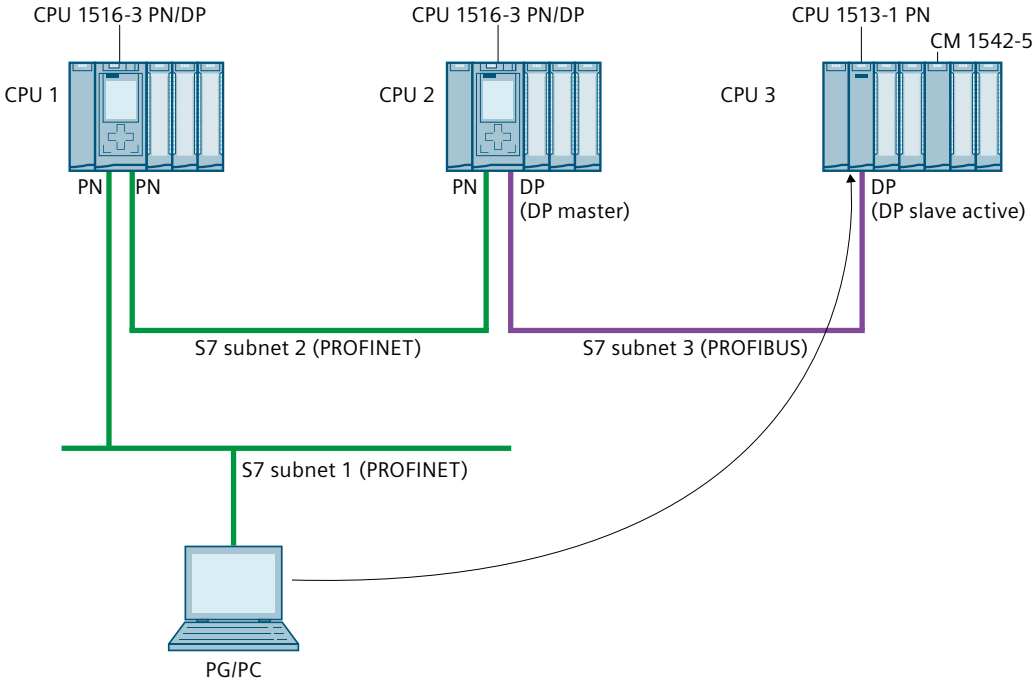

Figure 3-525 S7 routing: PROFINET - PROFIBUS

S7 routing for HMI connections

You have the option of setting up an S7 connection from an HMI to a CPU via different subnets (PROFIBUS and PROFINET or Industrial Ethernet). In the following figure, CPU 1 is the S7 router between S7 subnet 1 and S7 subnet 2.

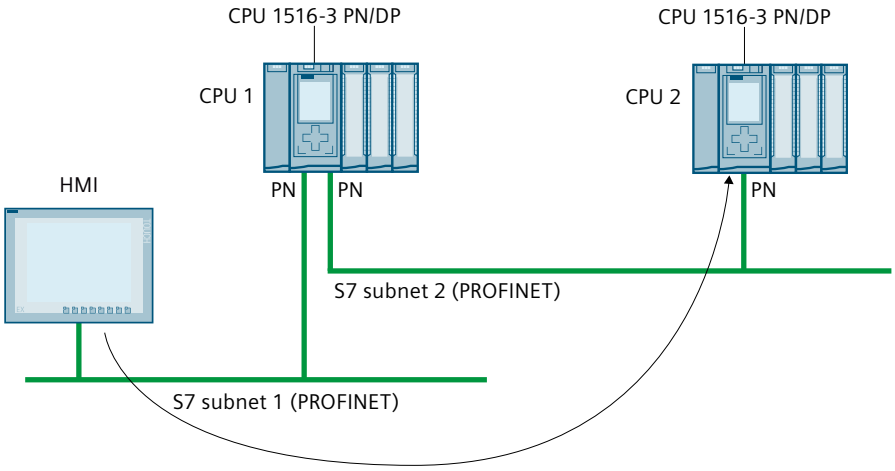

Figure 3-526 S7 routing via HMI connections

S7 routing for CPU-CPU communication

You have the option of setting up an S7 connection from a CPU to another CPU via different subnets (PROFIBUS and PROFINET or Industrial Ethernet). The procedure is described based on examples in the section S7 communication (Page 159).

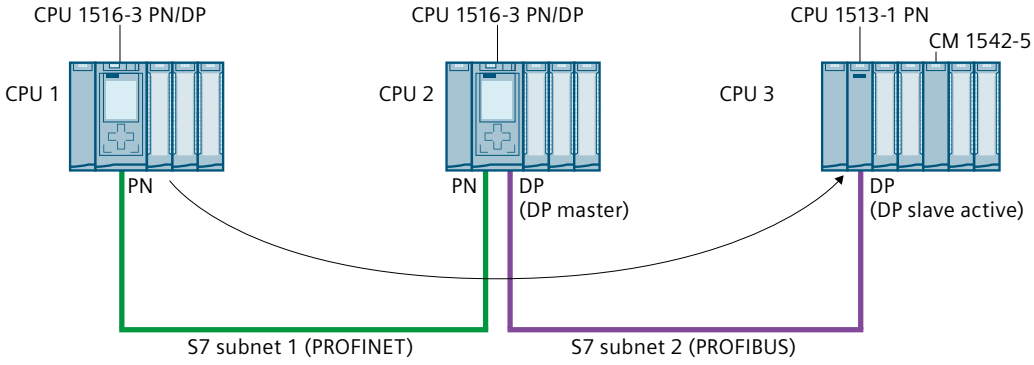

Figure 3-527 S7 routing via CPU-CPU communication

Using S7 routing

For the CPU, select the PG/PC interface and the S7 subnet in the "Go online" dialog of STEP 7. S7 routing is performed automatically.

Number of connections for S7 routing

The number of connections available for S7 routing in the S7 routers (CPUs, CMs or CPs) can be found in the technical specifications in the manuals of the relevant CPU/CM/CP.

S7 routing: Example of an application

The figure below shows the example of an application for remote maintenance of a system using a PG. The connection is made here beyond two S7 subnets via a modem connection.

You configure a remote connection via TeleService in STEP 7 using "Online access" or "Go online".

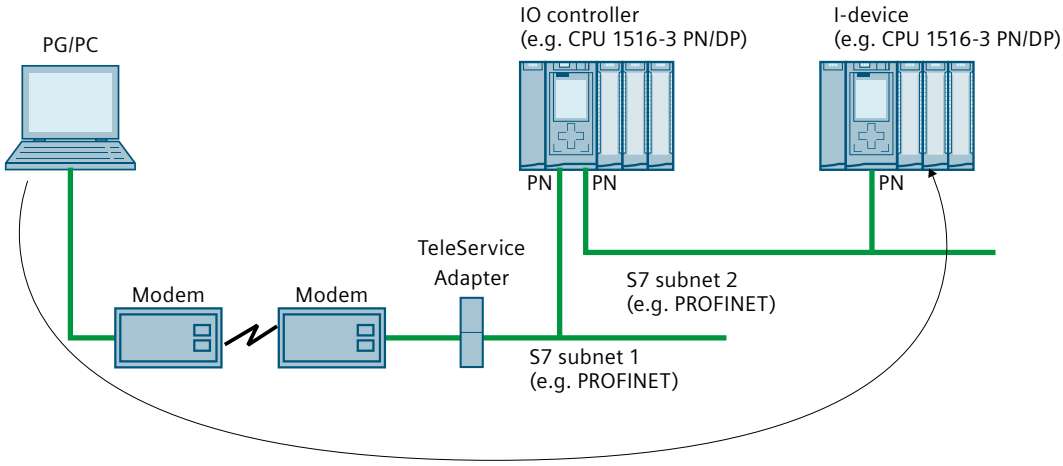

Figure 3-528 Remote maintenance of a plant using TeleService

More information

- The allocation of connection resources with S7 routing is described in the section Allocation of connection resources (Page 444).
- You can find more information on setting up TeleService in the STEP 7 online help.
- For information on HMI communication, refer to the section HMI communication (Page 133).
- You can find more information on S7 routing and TeleService adapters when you search the Internet using the following links:
  - Device manual Industrial Software Engineering Tools TS Adapter IE Basic (https://support.industry.siemens.com/cs/us/en/view/51311100)
  - Downloads for the TS Adapter (https://support.industry.siemens.com/cs/us/en/ps/16006/dl)

13.3 IP forwarding

Forwarding of IP packets with IP forwarding

IP forwarding is a device function to pass along IP packets between connected IP subnets.

Enable/disable the IP forwarding function in STEP 7. For CPUs as of FW version V4.1, you can also enable/disable the IP forwarding function in the user program by transferring a data record.

When IP forwarding is enabled, the S7-1500 CPU forwards received IP packets not addressed to the CPU to locally connected IP subnets or to a configured router.

The following figure shows how a programming device accesses data on an HMI device. Programming device and HMI device are located in different IP subnets. The IP subnets are connected to the two interfaces X1 and X2 of the CPU.

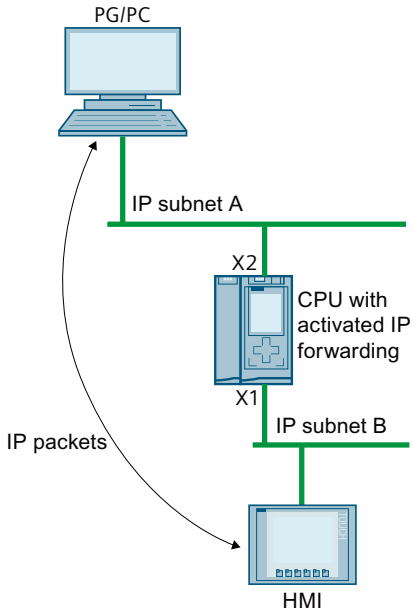

Figure 3-529 Access of a programming device to an HMI via IP forwarding

Areas of application

- Easy access from the control level to the field level for configuration and parameter assignment of field devices, e.g. via PDM or web browser
- Simplified integration of devices for remote access, e.g. for diagnostics during remote maintenance or firmware update

Requirements for using IP forwarding

- S7-1500 CPU as of firmware version V2.8
- Number of Ethernet interfaces:
  - The CPU has at least two Ethernet interfaces.
  - Or the CPU has one Ethernet interface, and a CP 1543-1 as of firmware version V2.2 provides the other Ethernet interface. In this case, the "Access to PLC via communication module" function must be enabled for the CP in the CPU.
- IP forwarding is enabled.
- Suitable standard gateways/routes are configured in each participating device along the outgoing and return paths of the IP packets.

IP route table

When IP forwarding is enabled, the CPU forwards received IP packets that are not addressed to itself. How the CPU forwards the IP packets is defined in its internal IP route table.

The CPU automatically creates the IP route table from the following information of the loaded hardware configuration:

- IP configuration of the Ethernet interfaces
- Configured router

Example of a configuration with IP forwarding

The following figure shows a sample configuration along with the required IP address settings and router settings.

- A PC on the IP subnet 192.168.4.0 communicates with an HMI device on the IP subnet 192.168.2.0.
- The IP address of a router ("Standard gateway") is configured at the CPU, Ethernet interface X3; in the figure below, it is the device that is designated as "IP router".
  In STEP 7, you configure a router in the interface properties under "Ethernet addresses" > "IP protocol".

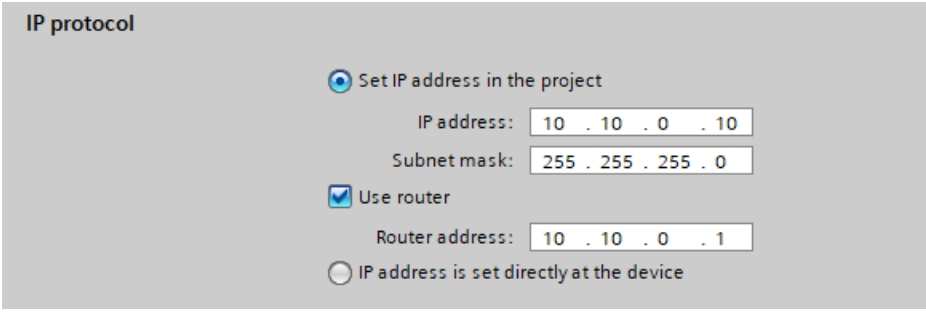

Figure 3-530 Configuring the router

- For the PC, the IP router, the IO device and the HMI device, the IP addresses of a standard gateway or the corresponding routes are also entered.

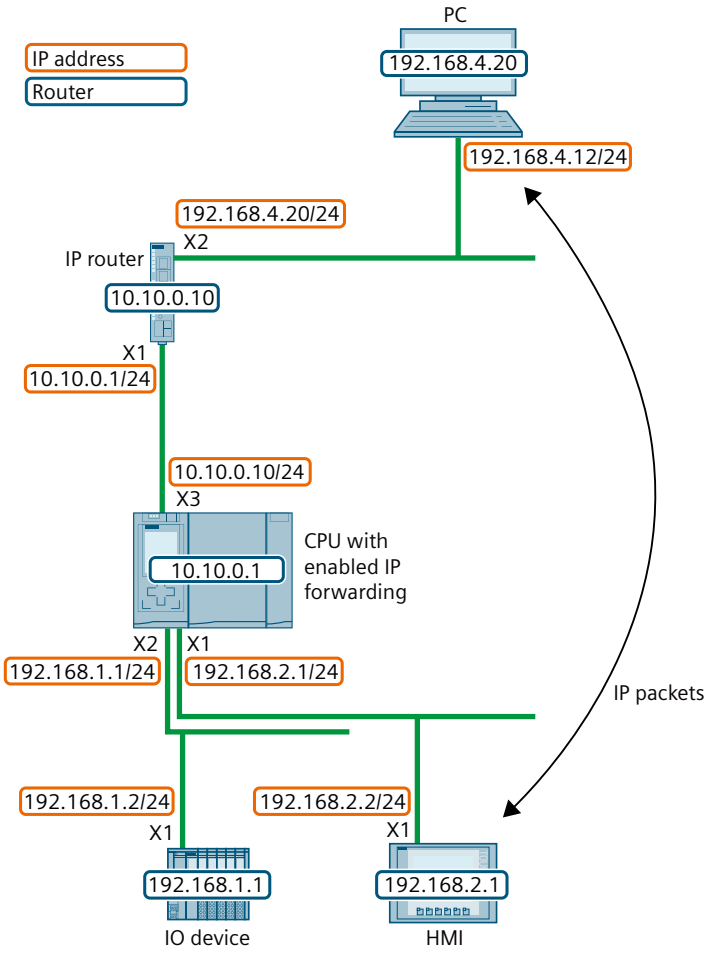

Figure 3-531 Sample configuration

This example configuration results in the following IP routing table for the CPU.

Table 3-948 IP route table of the CPU

Network destination	Interface	Gateway
0.0.0.0/0	10.10.0.10	10.10.0.1
192.168.1.0/24	192.168.1.1	-
192.168.2.0/24	192.168.2.1	-
10.10.0.0/24	10.10.0.10	-

For IP communication between the PG/PC and the HMI device, you need to set up additional IP routes to the IP subnet of the HMI device both in the PC and in the IP router. In the HMI device, you configure the IP address of the CPU interface X1 as the standard gateway.

In a Windows computer, for example, you set up an additional IP route from the command prompt using the command "route add <destination IP subnet> mask <subnet mask> <gateway>". However, you need administrative access rights to do this. For this example, enter the following prompt:

- "route add 192.168.2.0 mask 255.255.255.0 192.168.4.20"

In an IP router, you set up additional routes, e.g. via a web interface. Set up the following route for this example:

- Destination IP subnet: 192.168.2.0
- Subnet mask: 255.255.255.0
- Gateway: 10.10.0.10

Restrictions

You cannot configure any additional IP routes other than the router ("Standard Gateway") for an S7-1500 CPU. The network destination is either a connected IP subnet, or the network destination can be reached via exactly one configurable router. Because the S7-1500 CPU does not support additional IP routes, you cannot build bi-directional IP router cascades.

In the following configuration, you can configure either "Router 1" or "Router 2" in the CPU. "Router 1" is configured as an example. In this case, you cannot configure "Router 2". IP communication between the PC and the HMI device is not possible because the route is not continuous in both directions.

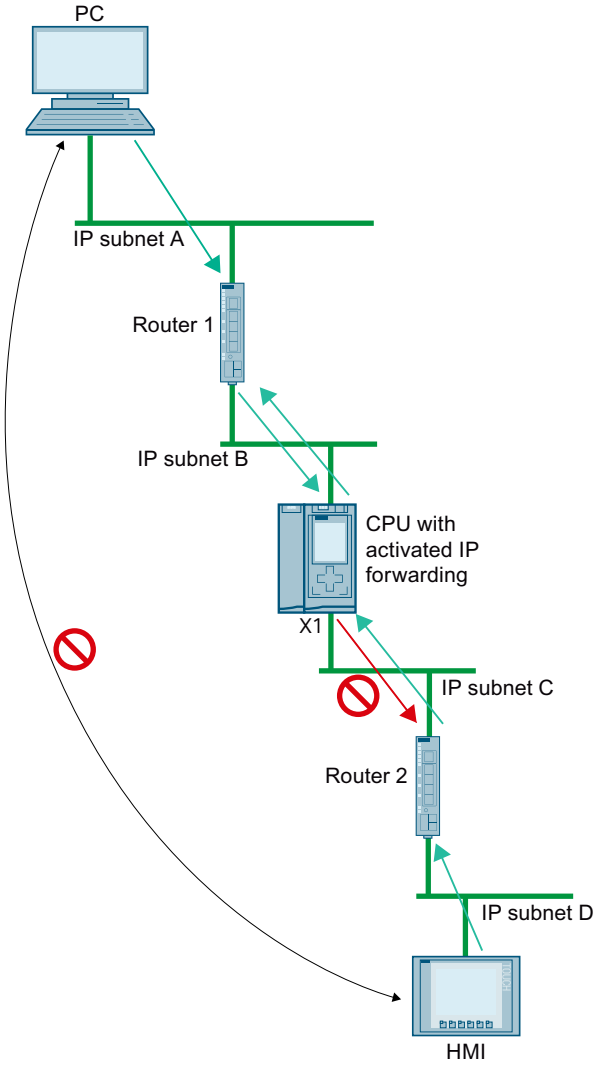

Figure 3-532 Unsupported IP router cascade

IP forwarding via the interface of a CP

IP forwarding also works via the interface of a CP. For this you have to activate the "Access to PLC via communication module" function for this CP in the CPU.

How you enable the "Access to PLC via communication module" function is described in the online help of STEP 7.

IP forwarding via the interface of a CP is **not** supported by the CPs (IE) for the ET 200SP CPUs.

Reaching C/C++ Runtime of the CPU 1518 4 PN/DP MFP via interfaces X1 or X2

If you activate PN/DP MFP IP forwarding for the CPU 1518 4 PN/DP, you will not only reach devices in the IP subnet of interface X3 via interfaces X1 and X2, but also C/C++ Runtime. From the C/C++ Runtime of the CPU 1518 4 PN/DP MFP, you reach all devices in the IP subnets of the interfaces X1, X2 and X3.

Conditions:

- IP forwarding is enabled for the CPU 1518 4 PN/DP MFP.
- The IP address of C/C++ Runtime and the IP address of interface X3 are located in the same IP subnet.
- The routes to the IP subnets at X1 and X2 are entered in C/C++ Runtime.
  In C/C++ Runtime, enter a route with the following command: "Route add-net <destination IP subnet> mask <subnet mask> gw <gateway>

The following figure shows a configuration in which a PC accesses the C/C++ Runtime of CPU 1518-4 PN/DP MFP via interface X2.

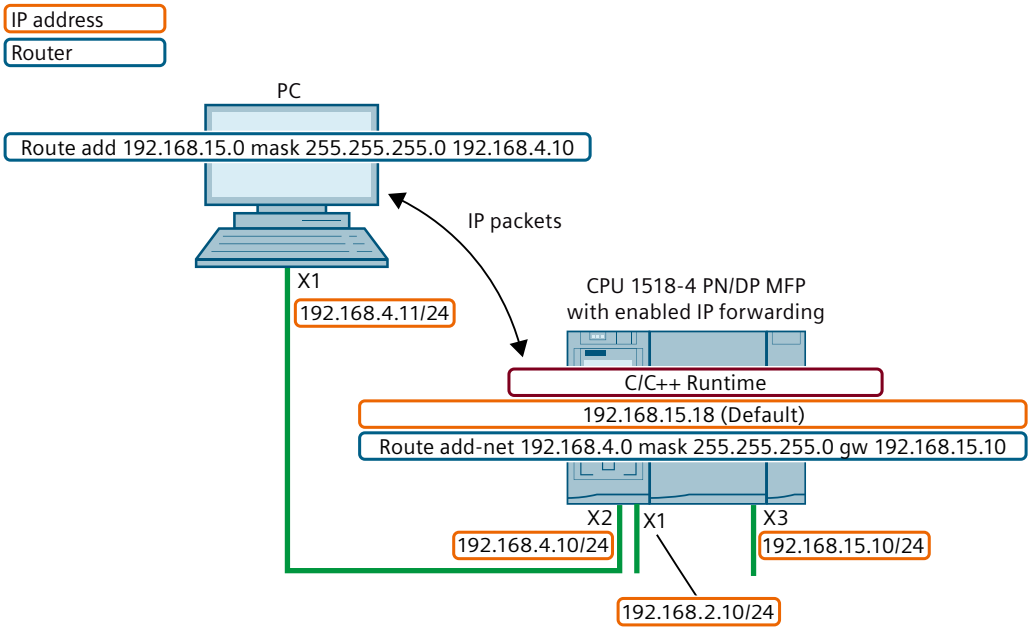

Figure 3-533 Access to C/C++ Runtime via interface X2

Take network security into account for IP forwarding

If you activate IP forwarding for a CPU, you enable "external" access to devices that are actually only accessible and controlled by the CPU. These devices are therefore usually not protected against attacks.

The following figure shows how to protect your automation system against unauthorized access.

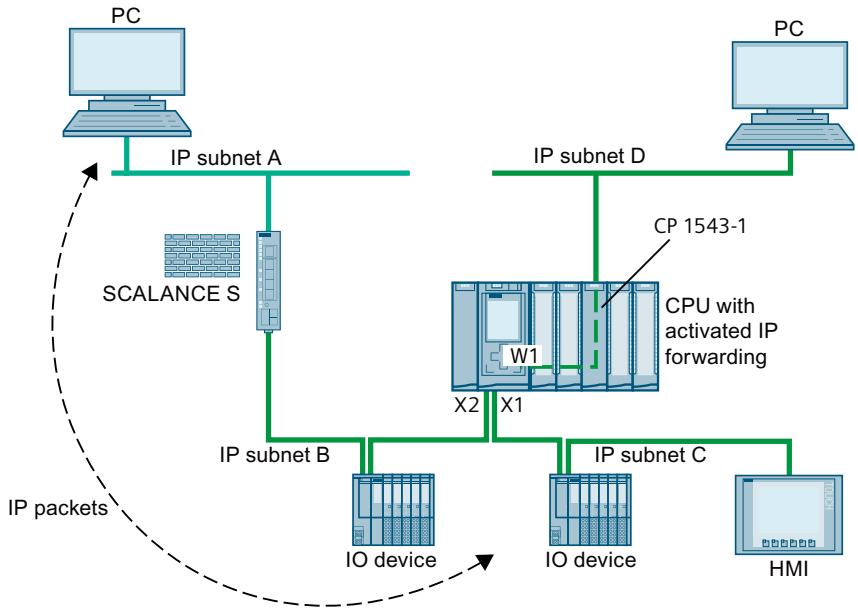

Figure 3-534 Network security for IP forwarding

- The CPU accesses all devices within the dark green IP subnets B and C close to the CPU via the interfaces X1 and X2.
- A SCALANCE S router is configured in the CPU. The CPU accesses the devices in the remote, light green IP subnet A via the router.
- The "Access to PLC via communication module" function is enabled for the CP 1543 in the CPU. The CPU reaches all devices within the IP subnet D via W1 interface.

If IP forwarding is activated in the CPU, a device from IP subnet A can access any device within IP subnets B, C and D close to the CPU.

Protect your automation system and connected devices against unauthorized access from outside.

Separate the CPU-related IP subnets from the remote IP subnets with a firewall. For example, use the SCALANCE S security modules with integrated firewall.
This application example (https://support.industry.siemens.com/cs/ww/en/view/22376747) describes how to protect an automation cell with a firewall using the SCALANCE S602 V3 and SCALANCE S623 security modules.

13.3.1 Enabling and disabling IP forwarding

You can set IP forwarding both in the CPU properties and via the CPU user program. To be able to set IP forwarding via the user program, use a CPU with FW version V4.1 or higher.

> **⚠ WARNING**
>
> **Activated IP forwarding reduces security**
>
> When IP forwarding is enabled, the device forwards the IPv4 data traffic between the IP subnets that can be reached via its PROFINET interfaces. Forwarding reduces the protection of devices located in the IP subnets against unauthorized access via the network.
>
> You should only enable IP forwarding in a protected environment (commissioning phase) or separate the CPU-related IP subnets from the remote IP subnets with a firewall. For example, you can use the SCALANCE S Security Modules with integrated firewall.

Enabling/disabling IP forwarding in the CPU properties

To enable IP forwarding, proceed as follows:

1. Select the CPU in the network view of STEP 7 (TIA Portal).
2. In the properties of the CPU of the Inspector window, navigate to "General > Advanced Configuration > IP forwarding".
3. In the "Configuration IPv4 forwarding" area, select the "Enable IPv4 forwarding for interfaces of this PLC" check box.

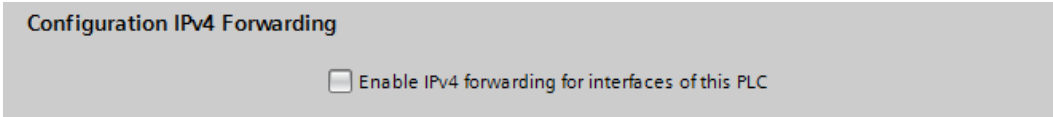

Figure 3-535 Enabling IP forwarding

Result: IP forwarding is enabled for all interfaces of the S7-1500 CPU.

You disable IP forwarding by clearing the check box "Enable IPv4 forwarding for interfaces of this PLC".

Enabling/disabling IP forwarding via the user program

To enable or disable IP forwarding via the user program, proceed as follows:

1. Create a data block in STEP 7 that contains the following data record.

Byte	Element	Code	Explanation
0-1	BlockID	0x3021	Header The data record length is counted starting at byte 4 "Version".
2-3	BlockLength	8	
4	Version	0x01	
5	Subversion	0x00	

Byte	Element	Code	Explanation
6-7	Reserved	0x0000	-
8-9	IP forwarding control	0, 1	0: Disabling IP forwarding. 1: Enabling IP forwarding.
10-11	Reserved	0x0000	-

2. Transfer the data record in an organization block (OB) with the "WRREC" (write data record) instruction to the CPU.
   - Use an integrated PROFINET interface of the CPU as the hardware component in the "ID" parameter of the "WRREC" instruction.
     Recommendation: Use PROFINET interface X1; this interface is available with every CPU.
     Address the interface using its system constant (e.g. ID := "Local~PROFINET_interface_1").
   - The index is 0x3021 (INDEX := 16#3021)

You can also use the data record to determine which IP forwarding status is active in the CPU. To do this, use the instruction "RDREC" (read data record) with the index 0x3021 to an integrated PROFINET interface, e.g. X1 of the CPU.

Interplay of IP forwarding configuration and user program

The CPU does not retentively save the activation status of IP forwarding set by record transfer. After each POWER OFF > POWER ON transition, memory reset or loading of the hardware configuration, the CPU applies the activation status of IP forwarding stored in the hardware configuration.
A transition from RUN > STOP or STOP > RUN has no effect on the current activation status of IP forwarding of the CPU.

13.3.2 Enabling/disabling IP forwarding via data record transfer: Example for a CPU 1516-3 PN/DP

Introduction

In the commissioning phase, you want to control the "IP forwarding" function via the user program. To enable the function, data record 0x3021 is transferred to a PROFINET interface of the CPU in the following example.

Requirement

- CPU 1516-3 PN/DP as of FW version V4.1
- STEP 7 as of version V21

Solution

Transfer the data record 0x3021, with the "Enable IP forwarding" option set, to a PROFINET interface of the CPU. This enables IP forwarding for all interfaces of the CPU.

The following example shows how you can create the data record in a global data block and transfer it in a program cycle OB (for example, OB 1) to the PROFINET interface (Local~PROFINET_interface_1).

To activate IP forwarding for the addressed PROFINET interface of the CPU 1516-3 PN/DP, follow these steps:

1. Create a global data block.
2. Assign a name, for example "ActivateIP_Fwd".
3. Under "Static", create the structure of the 0x3021 data record (in the figure: "IP_FwdRecord") and other tags for transferring the data record. The following figure shows the structure of the data block "ActivateIP_Fwd".

ActivateIP_Fwd

	Name	Data type	Start value	Re...	Ac...	Wr...	Vi...	Comment
1	Static							
2	IP_FwdStartWrite	Bool	false		✓	✓	✓	Start writing Data record 16#3021
3	IP_FwdRecord	Struct			✓	✓	✓	Data record 16#3021
4	blockID	UInt	16#3021		✓	✓	✓	Data record ID
5	blockLength	UInt	8		✓	✓	✓	Length of block
6	version	USInt	1		✓	✓	✓	Byte 1/2 of blockversion
7	subversion	USInt	0		✓	✓	✓	Byte 2/2 of blockversion
8	reserved_1	UInt	0		✓	✓	✓	Reserved for future usage
9	IP_FwdControl	UInt	1		✓	✓	✓	0: deactivate IP_Fwd, 1: activate IP_Fwd
10	reserved_2	UInt	0		✓	✓	✓	Reserved for future usage
11	IP_FwdWritingDone	Bool	false		✓	✓	✓	Writing done
12	IP_FwdWritingError	Bool	false		✓	✓	✓	Error while writing
13	IP_FwdWritingStatus	DWord	16#0		✓	✓	✓	Status of writing

Figure 3-536 Structure of the global data block "ActivateIP_Fwd"

4. Transfer the 0x3021 data record in a program cycle OB (for example, OB 1), with the "WRREC" (write data record) instruction to the CPU 1516-3 PN/DP. You can find an example program in the next section.

Programming example for the data record transfer in OB 1

Data record 0x3021 is transferred in the following program code:

```
//-----------------------------------------
// Start writing IP Forwarding settings
//-----------------------------------------
IF "ActivateIP_Fwd".IP_FwdStartWrite THEN
 IF (NOT "ActivateIP_Fwd".IP_FwdWritingDone)
 AND (NOT "ActivateIP_Fwd".IP_FwdWritingError) THEN
 "instWrrec_1"(REQ := "ActivateIP_Fwd".IP_FwdStartWrite,
 ID := "Local~PROFINET_interface_1",
 INDEX := 16#3021,
 DONE => "ActivateIP_Fwd".IP_FwdWritingDone,
 ERROR => "ActivateIP_Fwd".IP_FwdWritingError,
 STATUS => "ActivateIP_Fwd".IP_FwdWritingStatus,
 RECORD := "ActivateIP_Fwd".IP_FwdRecord);
```

```
END_IF;
IF "ActivateIP_Fwd".IP_FwdWritingError THEN
; // add error handling
END_IF;
IF "ActivateIP_Fwd".IP_FwdWritingDone THEN
"ActivateIP_Fwd".IP_FwdStartWrite := FALSE;
"ActivateIP_Fwd".IP_FwdWritingDone := FALSE;
END_IF;
END_IF;
```

Disable IP forwarding again

With a small change, you can use the program code used above to disable IP forwarding. Assign the value "0" to the tag "ActivateIP_Fwd".IP_FwdRecord.IP_FwdControl in the user program:

```
"ActivateIP_Fwd".IP_FwdRecord.IP_FwdControl := 0;
```

The next time the "WRREC" instruction is called, IP forwarding is disabled.

13.3.3 Enabling/disabling IP forwarding via data record transfer with S7-1500R/H CPUs

The S7-1500R/H system does not synchronize the IP forwarding status (enabled/disabled) for both CPUs. IP forwarding enabled by the "WRREC" instruction only affects the CPU whose PROFINET interface addresses the "WRREC" instruction. This allows you to enable IP forwarding on the S7-1500R/H system specifically on only one R/H CPU by data record transfer.
If you want to enable IP forwarding on both R/H CPUs of the S7-1500R/H system, you must call the "WRREC" instruction twice. Use the hardware component of a PROFINET interface, e.g. X1 of the left and right R/H CPU.

Example:

The S7-1500R/H system is in the "RUN-Redundant" system state.

If a PROFINET interface of the left CPU is addressed with the "WRREC" instruction, for example, the IP forwarding setting of the left CPU is changed. The IP forwarding status of the CPU on the right remains unchanged.

If the left CPU fails or is replaced, the loaded setting from the configuration in the CPU properties takes effect again after the SYNCUP. Only after the "WRREC" is executed for a PROFINET interface of the left CPU, the IP forwarding setting of the left CPU is changed again.

Solution:

Call the "WRREC" instruction twice. In the first call of "WRREC", address the hardware component of a PROFINET interface of the left-hand CPU. Call the "WRREC" instruction again. This time, address the hardware component of a PROFINET interface of the CPU on the right.

Hardware component for PROFINET interface X1:

- The hardware component of the PROFINET X1 interface of the left-hand CPU is Local1~PROFINET_interface_1.
- The hardware component of the PROFINET X1 interface of the right-hand CPU is Local2~PROFINET_interface_1.

Result: IP forwarding is enabled on both R/H CPUs of the S7-1500R/H system.

NOTE

Transferring the data record to the backup CPU

Call the "WRREC" instruction for the addressed PROFINET interface of the backup CPU only when the S7-1500R/H system has reached the "RUN REDUNDANT" system state. Otherwise, the data record cannot be transferred to the addressed PROFINET interface of the backup CPU and the "WRREC" will output an error.

The S7-1500R/H system signals changes to its system state, e.g. the change to "Run REDUNDANT", by calling the CPU redundancy error OB (OB 72) with the corresponding "Fault_ID".

Example: WRREC calls for both R/H CPUs

To enable/disable IP forwarding for the addressed PROFINET interface of both the CPUs by transferring data records, proceed as follows:

1. Create a global data block.
2. Assign a name, for example, "ActivateIP_Fwd".
3. Under "Static", create the structure of the 0x3021 data record (in the figure: "IP_FwdRecord") and other tags for transferring the data record. The following figure shows the structure of the data block "ActivateIP_Fwd".

ActivateIP_Fwd

	Name	Data ty..	Start val..	Re...	Ac...	Wr..	Vi...	Comment
1	Static							
2	IP_FwdStartWrite	Bool	false		☑	☑	☑	Start writing Data record 16#3021
3	IP_FwdRecord	Struct			☑	☑	☑	Data record 16#3021
4	blockID	UInt	16#3021		☑	☑	☑	Data record ID
5	blockLength	UInt	8		☑	☑	☑	Length of block
6	version	USInt	1		☑	☑	☑	Byte 1/2 of blockversion
7	subversion	USInt	0		☑	☑	☑	Byte 2/2 of blockversion
8	reserved_1	UInt	0		☑	☑	☑	Reserved for future usage
9	IP_FwdControl	UInt	1		☑	☑	☑	0: deactivate IP_Fwd, 1: activate IP_Fwd
10	reserved_2	UInt	0		☑	☑	☑	Reserved for future usage
11	plcLeft	Struct			☑	☑	☑	Writing status of left plc
12	IP_FwdWritingDone	Bool	false		☑	☑	☑	Writing done
13	IP_FwdWritingError	Bool	false		☑	☑	☑	Error while writing
14	IP_FwdWritingStatus	DWord	16#0		☑	☑	☑	Status of writing
15	plcRight	Struct			☑	☑	☑	Writing status of right plc
16	IP_FwdWritingDone	Bool	false		☑	☑	☑	Writing done
17	IP_FwdWritingError	Bool	false		☑	☑	☑	Error while writing
18	IP_FwdWritingStatus	DWord	16#0		☑	☑	☑	Status of writing

Figure 3-537 Structure of the global data block "ActivateIP_Fwd"

4. Add the organization block "CPU redundancy error" (OB 72) to your user program. You can find a program example for OB 72 in the next paragraph.

5. Open the program cycle OB (OB 1).
6. In OB 1, execute two "WRREC" instructions for transferring the data record to the respective addressed PROFINET interface of both CPUs. You can find a program example for OB 1 in the next paragraph.

   Result: The 0x3021 data record was transferred to the PROFINET interface of both the CPUs addressed in each case.

Programming example for the organizational blocks OB 72 and OB 1

Open the added OB 72. Use the following program code to determine whether the R/H system has assumed the "RUN-REDUNDANT" system state and set the starting command for the "WRREC" instructions:

```
//---------------------------------------------
// Check redundancy state and set "IP_FwdWrite"
//---------------------------------------------
IF #Fault_ID = B#16#03 OR #Fault_ID = B#16#06 THEN
 "ActivateIP_Fwd".IP_FwdStartWrite := TRUE;
END_IF;
```

Open the program cycle OB (OB 1). With the following program code, you can run two "WRREC" instructions for transferring the data record to the respective addressed PROFINET interface of both the CPUs:

```
//-----------------------------------------
// Start writing IP Forwarding settings
//-----------------------------------------
IF "ActivateIP_Fwd".IP_FwdStartWrite THEN
 IF (NOT "ActivateIP_Fwd".plcLeft.IP_FwdWritingDone)
 AND (NOT "ActivateIP_Fwd".plcLeft.IP_FwdWritingError) THEN
 // write IP Forwarding settings for the left PLC
 "instWrrec_1"(REQ := "ActivateIP_Fwd".IP_FwdStartWrite,
 ID := "Local1~PROFINET_interface_1",
 INDEX := 16#3021,
 DONE => "ActivateIP_Fwd".plcLeft.IP_FwdWritingDone,
 ERROR => "ActivateIP_Fwd".plcLeft.IP_FwdWritingError,
 STATUS => "ActivateIP_Fwd".plcLeft.IP_FwdWritingStatus,
 RECORD := "ActivateIP_Fwd".IP_FwdRecord);
 END_IF;
 IF "ActivateIP_Fwd".plcLeft.IP_FwdWritingError THEN
 ; // add error handling for left plc
 END_IF;
 IF (NOT "ActivateIP_Fwd".plcRight.IP_FwdWritingDone)
 AND (NOT "ActivateIP_Fwd".plcRight.IP_FwdWritingError) THEN
 // write IP Forwarding settings for the right PLC
 "instWrrec_2"(REQ := "ActivateIP_Fwd".IP_FwdStartWrite,
 ID := "Local2~PROFINET_interface_1",
 INDEX := 16#3021,
 DONE => "ActivateIP_Fwd".plcRight.IP_FwdWritingDone,
 ERROR => "ActivateIP_Fwd".plcRight.IP_FwdWritingError,
 STATUS => "ActivateIP_Fwd".plcRight.IP_FwdWritingStatus,
 RECORD := "ActivateIP_Fwd".IP_FwdRecord);
 END_IF;
 IF "ActivateIP_Fwd".plcRight.IP_FwdWritingError THEN
 ; // add error handling for right plc
 END_IF;
 IF ("ActivateIP_Fwd".plcLeft.IP_FwdWritingDone)
 AND ("ActivateIP_Fwd".plcRight.IP_FwdWritingDone) THEN
```

```
"ActivateIP_Fwd".IP_FwdStartWrite := FALSE;
"ActivateIP_Fwd".plcLeft.IP_FwdWritingDone := FALSE;
"ActivateIP_Fwd".plcRight.IP_FwdWritingDone := FALSE;
END_IF;
END_IF;
```

Disabling IP forwarding

With a small change, you can use the program code used above to disable IP forwarding. Assign the value "0" to the tag "ActivateIP_Fwd".IP_FwdRecord.IP_FwdControl in the user program:

```
"ActivateIP_Fwd".IP_FwdRecord.IP_FwdControl := 0;
```

The next time the "WRREC" instruction is called, IP forwarding is disabled.

13.4 Data record routing

Definition of data record routing

Data can be sent over PROFINET from an engineering station to field devices via multiple networks. Since the engineering station addresses the field devices using standardized records and these records are routed via S7 devices, the term "data record routing" is used to refer to this type of routing.

The data sent using data record routing include the parameter assignments for the participating field devices (slaves) and device-specific information (e.g. setpoint values, limit values).

Data record routing is used, for example, when field devices of different manufacturers are used. The field devices are addressed using standardized data records (PROFINET) for configuration and diagnostics.

Data record routing with STEP 7

You can perform data routing with STEP 7 by calling a device tool (for example, PCT) via the TCI interface (Tool Calling Interface) and passing call parameters. The device tool uses the communication paths that STEP 7 also uses for communication with the field device.

No configuration is required for this type of routing except the installation of the TCI tools on the STEP 7 computer.

Example: Data record routing with the Port Configuration Tool (PCT)

You can use the Port Configuration Tool (PCT) to configure the IO link master of the ET200 and assign parameters to connected IO link devices. The subnets are connected via data record routers. Data record routers are, for example, CPUs, CPs, IMs, IO link master.

You can learn about the constellations of data record routers supported by the PCT in this FAQ (https://support.industry.siemens.com/cs/us/en/view/87611392).

The figure below shows an example configuration with the data record routing with PCT.

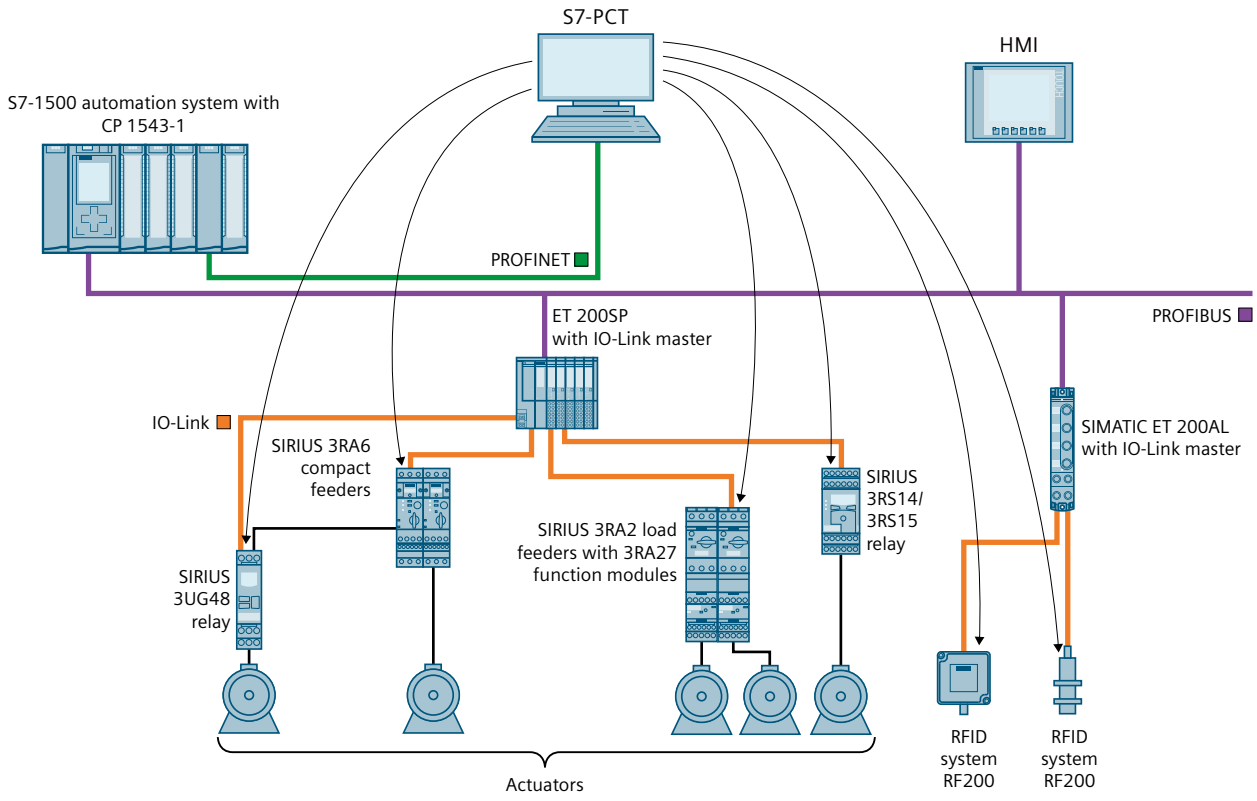

Figure 3-538 Example configuration for data record routing with PCT

Additional information

- The differences that exist between "normal" routing and data record routing are described in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/7000978).
- Whether or not the CPU, CP or CM you are using supports data record routing can be found in the relevant manuals.
- The allocation of connection resources with data record routing is described in the section Allocation of connection resources (Page 444).
- You can find additional information on configuration with STEP 7 in the STEP 7 online help.

13.5 Virtual interface for IP-based applications

As of firmware version 2.8, the S7-1500 CPU offers the option of reaching its IP-based applications, such as OPC UA, not only via its local (PN) interfaces, but also via the interfaces of communications processors in the same station. The supported communications processors can be found in the requirements. A communication partner can access these IP-based applications via a virtual interface that can be configured in the TIA Portal as of version V16. The virtual interface is called W1 (according to IEC 81346-2).

Features of the virtual interface

The virtual interface is not a fully diagnosable interface with the familiar properties of conventional interfaces. The virtual interface is not displayed in the graphical views, because the internal connection via the backplane bus does not represent an S7 subnet and does not have any ports. Therefore, a physical connection by means of a network cable cannot be established.

The IP address of the virtual interface is displayed (in the CPU display in the TIA Portal) and can be configured.

The following communication options can be used via the virtual interface W1:

- OPC UA (client and server)
- Programmed OUC connections
- Programming device/HMI communication
- Partner access from S7 CPUs via PUT/GET instructions

The activated interface can be used in dialogs where IP-based connections are configured.

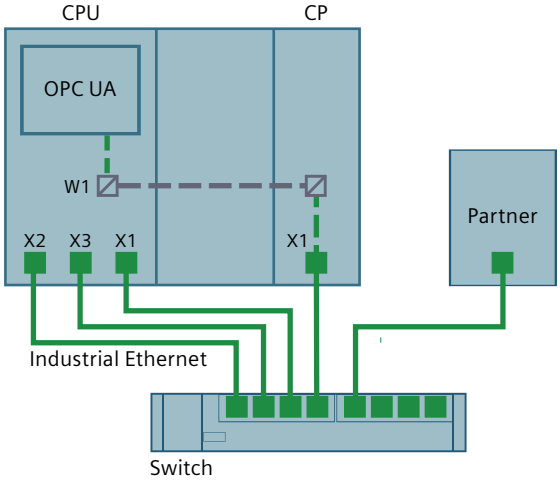

Figure 3-539 Principle of the virtual interface

Compared to conventional interfaces, the virtual interface has the following restrictions:

- No access to the web server over the virtual interface.
- Online backup is not possible via a connected programming device with the TIA Portal.
- If the CPU and communication partners are connected via the virtual interface, they cannot exchange data via LLDP (Link Layer Discovery Protocol).
- The S7 routing service does not use the virtual interface W1.

Requirement

For a CPU service to be accessible via the Ethernet interface of a CP, the following requirements must be fulfilled:

- S7-1500 CPU as of firmware version V2.8
- CP 1543-1 as of firmware version V2.2

Recommendation: Use a CP 1543-1 as of firmware version V3.0. As of this version, the security functions (firewall) are also available for the virtual interface and no additional firewall needs to be installed between the station and an insecure network.

Configuration of the virtual interface W1

In the properties of an S7-1500 CPU as of firmware version V2.8, you can assign a plugged communications module to the W1 virtual interface under "Advanced configuration > Access to PLC via communication module". You can then use this for external access to the CPU. If no CPs are plugged in or the plugged CPs do not support access to the CPU, the selection is empty.

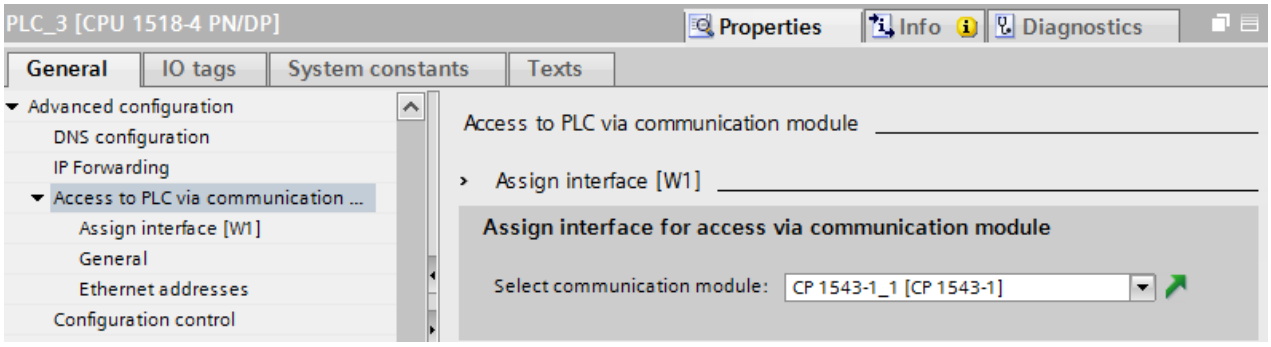

Figure 3-540 Selecting the CP in the CPU properties

After selecting the CP, the specifications and parameters for the virtual interface are displayed. You can edit the settings for the IP protocol and the PROFINET parameters here.

- The IP subnet is freely selectable, just like with the CP. The IP subnet is entered via the subnet mask and IP address of the virtual interface.
- When entering the IP subnet for the virtual interface, note that you are not using the same IP subnet as for the local interfaces of the CPU.

Once the IP address is entered, it is shown in the properties dialog of the OPC UA server in the list of server addresses. These settings provide the CPU with the new W1 virtual interface, via which the CPU services described above, such as the OPC UA server, can be accessed via a

communications module. The corresponding connections and S7 communication (e.g. HMI and BSEND, BRCV) are made via this interface. The OPC UA server does not allow selection of a specific interface (selection via an IP address), it is only possible to select either all or none.

NOTE

The IP address of the virtual interface is not listed as W1 in the device display under the currently displayed local interfaces (Xn) but is available under "Addresses" in the "Settings" section. The virtual interface is also visible when no CP is plugged or when the virtual interface is not activated. If no IP suite is available, the IP address and the subnet mask are 0.0.0.0.

If you change the configured and loaded IP address parameters of the virtual interface via display, T_CONFIG instruction, or online, the loaded configuration is active again after the CPU restarts.

Configuration changes on the CP

A change in the assigned communications module may have an effect on the configuration of the virtual interface:

- In the properties of the CPU:
  - Assignment of a different CP: The configuration is used for the new CP.
  - Deselect the assigned CP: The virtual interface W1 is deactivated and the configuration is lost.
    When a CP is assigned again, the configuration must be performed again.
- On the device:
  - Moving the CP: If the CP is only moved to another slot of the device, the configuration continues to be valid.
  - Removing the CP: If the CP is deleted or moved to another device, the configuration is retained. In the drop-down list of the CPU, the CP is displayed as missing and compiling the configuration indicates an error. The missing CP can be deselected or assigned to another CP.

Display in the diagnostics and the system constants

The virtual interface W1 is displayed in the diagnostics view under "Online & Diagnostics". The hardware ID of the virtual interface is displayed in the system constants of the CPU properties.

Settings in the communications module (CP 1543-1 as of FW version V3.0)

Starting with firmware version V3.0 you can use the CP internal firewall to secure the data traffic via the virtual interface. To activate the firewall in the communications module, follow these steps in the protected project:

1. Select the communications module in the STEP 7 work area.
2. In the Inspector window, go to "Properties > Security".
3. Activate the "Enable security functions" option.
   The configurable security functions now appear in the Inspector window.
4. Activate the options "Enable firewall".
   In the Inspector window you can now allow the use of the virtual interface W1.

You can only secure data traffic via the W1 virtual interface of the CPU for the OPC UA service.

NOTE

Checking the manual configuration

If the firewall is enabled, you need to manually check whether the desired services are allowed by the firewall. Only enable those services for the IP and MAC filters that you also want to access via the CP interface. See the notes on security settings and firewall rules of the S7-1500 CPs in the information system of the TIA Portal.

Settings in the communications module (CP 1543-1, FW version V2.2, < V3.0)

The security functions of the CP 1543-1 with a firmware version lower than V3.0 cannot secure data traffic via the virtual interface. Although you can activate the security functions in the TIA Portal, it is not possible to compile such a configuration.

NOTICE

Connecting to non-secure networks

If you connect the CP to a non-secure network, it is imperative that you place an additional firewall between the CP and the non-secure network. You can use the SCALANCE S602 V3 and SCALANCE S623 Security Modules with integrated firewall, for example.

Connection resources 14

14.1 Connection resources of a station

Introduction

Some communications services require connections. Connections occupy resources in the automation system (station). The connection resources are made available to the station by the CPUs, communications processors (CPs) and communications modules (CMs).

Connection resources of a station

The connection resources available depend on the CPUs, CPs and CMs being used and must not exceed a maximum number per station.

The maximum number of resources of a station is determined by the CPU.

Reserved connection resources

Each CPU has reserved connection resources for PG, HMI and Web server communication. This ensures, for example, that a PG can always establish at least one online connection with the CPU regardless of how many other communications services are already using connection resources.

Dynamic connection resources

In addition, dynamic resources exist. The difference between the maximum number of connection resources and the number of reserved connection resources is the maximum number of dynamic connection resources.

The communications services PG Communication, HMI Communication, S7 Communication, Open User Communication, Web Communication, OPC UA Client/Server Communication and other communication from the pool of dynamic connection resources are used.

The figure below shows an example of how individual components make connection resources available to an S7-1500 station.

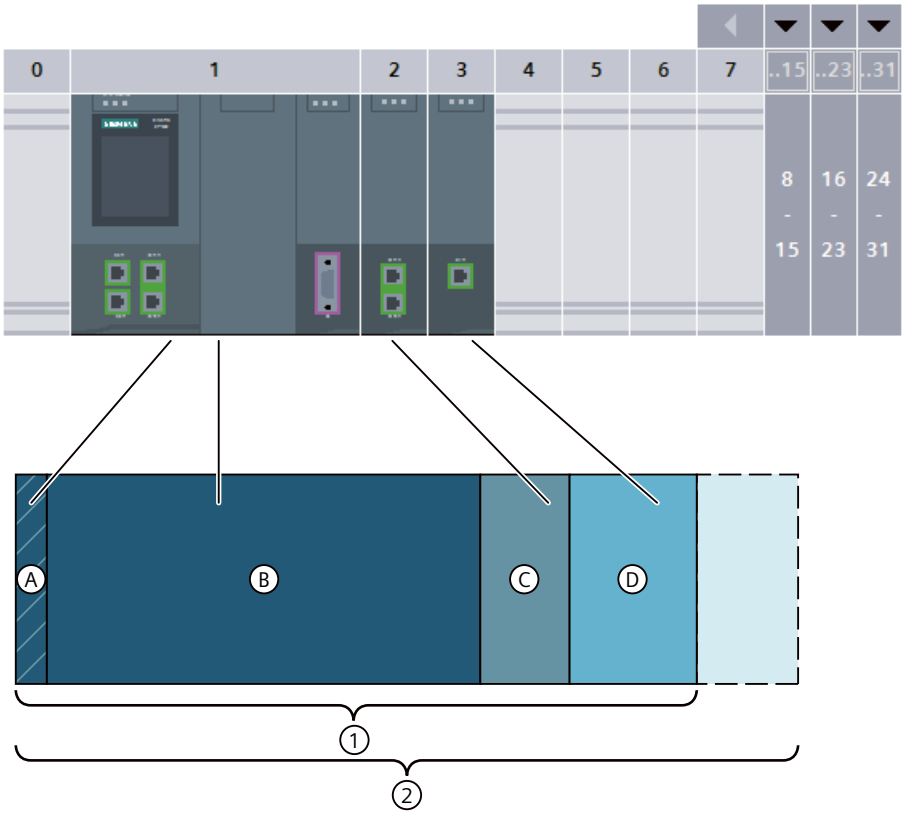

① Available connection resources of the station, of which

- A Reserved connection resources of the station
- A + B Connection resources of CPU 1518
- C Connection resources of communications module CM 1542-1
- D Connection resources of communications processor CP 1543-1

② Maximum communications resources of the station using the example of a configuration from CPU 1518, CM 1542-1 and CP 1543-1

Figure 3-541 Connection resources of a station

Number of connection resources of a station

Table 3-949 Maximum number of connection resources supported for some CPU types

Connection resources of a station		**1511 1511C 1512C 1513**	**1515 1516**	**1517**	**1518**
Maximum connection resources of the station		128	256	320	384
	of which reserved	10			
	of which dynamic	118	246	310	374

Connection resources of a station	1511 1511C 1512C 1513	1515 1516	1517	1518
Connection resources of the CPU	88	128	288	320
Max. additionally usable connection resources by plugging in CMs/CPs	40	128	32	64
Additional connection resources CM 1542-1	64			
Additional connection resources CP 1543-1	118			
Additional connection resources CM 1542-5	48			
Additional connection resources CP 1542-5	16			

The number of connection resources supported by a CPU or a communications module is described in the technical specifications section of the Equipment Manuals.

Example

You have configured a CPU 1516-3 PN/DP with a CM 1542-1 communications module and a CP 1542-5 communications processor.

- Maximum connection resources of the station: **256**
- Available connection resources:
  - CPU 1516-3 PN/DP: 128
  - CM 1542-1: 64
  - CP 1542-5: 16
  - Total: **208**

The setup provides 208 connection resources. By adding further communications modules, the station can support a maximum of 48 additional connection resources.

Reserved connection resources

10 connection resources are reserved for stations with S7-1500 CPU, ET 200SP CPU and ET 200pro CPU based on S7-1500:

- 4 for PG communication required by STEP 7, for example, for test and diagnostics functions or downloading to the CPU
- 4 for HMI communication which are occupied by the first HMI connections configured in STEP 7
- 2 for communication with the Web server

More information

Information on the connection resources of the S7-1500R/H redundant system is available in the section Connection resources of the redundant system S7-1500R/H (Page 470).

14.2 Allocation of connection resources

Overview - occupation of connection resources

The following figure shows how different connections occupy the resources of the S7-1500.

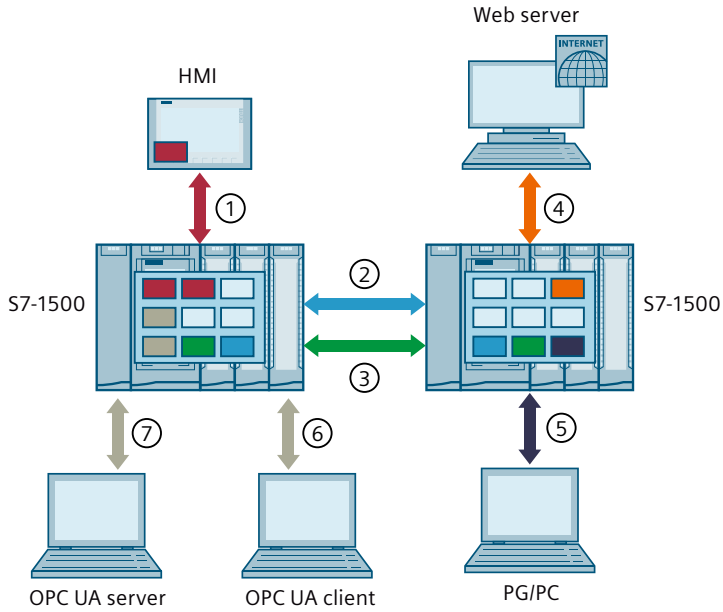

① HMI communication: See below.

② Open User Communication: Connections of Open User Communication occupy a connection resource in every end point.

③ S7 communication: Connections of S7 communication occupy a connection resource in every end point.

④ Web communication: The Web server connection occupies at least one connection resource in the station. The number of occupied connections depends on the browser.

⑤ PG communication: The PG connection occupies one connection resource in the station.

⑥ OPC UA client/server communication: Connection resource allocation for the server, see below

⑦ OPC UA client/server communication: Connection resource allocation for the client, see below

Connection resource for HMI communication

Connection resource for Open User Communication

Connection resource for S7 communication

Connection resource for Web communication

Connection resource for PG communication

Connection resources for OPC UA server communication

Figure 3-542 Allocation of connection resources

Connection resources for HMI communication

With HMI communication, the occupation of connection resources in the station depends on the HMI device being used.

Table 3-950 Maximum occupied connection resources for different HMI devices

HMI device	Maximum occupied connection resources of the station per HMI connection
Basic Panel	1
Unified Basic Panel	3
Comfort Panel	2[1]
Unified Comfort Panel	3
Mobile Panel	2[1]
RT Advanced	2[1]
RT Professional	3
Unified PC	3

[1] If you do not use system diagnostics or alarm configuration, the station occupies only one connection resource per HMI connection.

Example: You have configured the following HMI connections for a CPU 1516-3 PN/DP:

- Two HMI connections to an HMI TP700 Comfort. (2 connection resources each)
- One HMI connection to an HMI KTP1000 Basic. (1 connection resource)

In total 5 connection resources are occupied for HMI communication in the CPU.

Connection resources for OPC UA client communication

Each connection that the OPC UA client of the CPU has established to an OPC UA server occupies a connection resource in the station.

When establishing and closing an OPC UA connection, the OPC UA client temporarily occupies an additional connection resource. According to RFC 793, this connection resource is released again after a wait of approx. 60 seconds.

NOTE

Lack of resources due to temporary connection resources

A lack of connection resources occurs in the following situation:

- The OPC UA client of the CPU establishes or closes several connections simultaneously.
- The number of available connection resources of the station is insufficient for permanent and temporary connection resources of the OPC UA client communication.

Ensure that there are always enough available connection resources in the station to establish and end OPC UA connections.

Measures:

- Plan enough reserve for the OPC UA client connections.
- If necessary, establish or close the OPC UA connections one after the other.

Connection resources for routing

To transfer data beyond S7 subnets ("S7 routing"), an S7 connection is established between two CPUs. The S7 subnets are connected via gateways known as S7 routers. CPUs, CMs and CPs in S7-1500 are S7 routers.

The following applies for a routed S7 connection:

- A routed connection occupies one connection resource each in both end points. STEP 7 shows these connection resources in the "Connection resources" table.
- On the S7 router, two special connection resources are occupied for S7 routing. STEP 7 does not show the special connection resources for S7 routing in the "Connection resources" table. The number of resources for S7 routing depends on the CPU. You will find the resources for S7 routing in the technical specifications of the CPU in "Number of S7 routing connections".

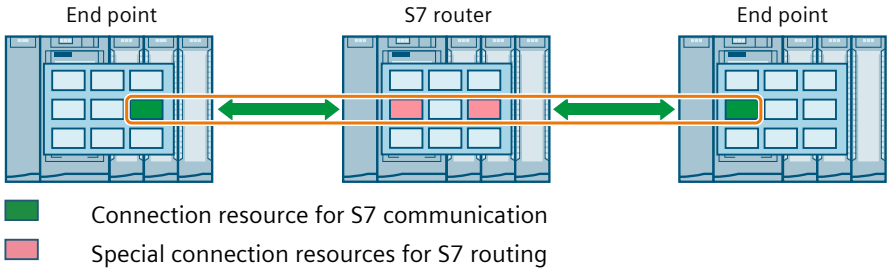

Figure 3-543 Connection resources with S7 routing

Data record routing also enables transfer of data beyond S7 subnets from an engineering station connected to PROFINET to various field devices via PROFIBUS.

With data record routing, as with S7 routing, two of the special connection resources for S7 routing are also occupied on every data record router.

NOTE

Connection resources with data record routing

With data record routing, on the data record router, two special connection resources for S7 routing are occupied. Neither the data record connection nor the allocated connection resources are displayed in the table of connection resources.

When are connection resources occupied?

The time for the occupation of connection resources depends on how the connection is set up (see section Setting up a connection (Page 46)).

- **Programmed setup of a connection**:
  As soon as an instruction to establish a connection is called in the user program (TSEND_C/TRCV_C or TCON), a connection resource is occupied.

  With suitable parameter assignment of the CONT parameter of the TSEND_C/TRCV_C instructions or by calling the TDISCON instruction, the connection can be terminated following data transfer and the connection resource is available again. When the connection is terminated, the connection resources on the CPU/CP/CM are available again.

- **Configured connections** (e.g. S7 connection):
  If you have configured a connection in STEP 7, the connection resource is occupied as soon as the hardware configuration is downloaded to the CPU.

  After using a configured connection for data transfer, the connection is not terminated. The connection resource is permanently occupied. To release the connection resource again, you need to delete the configured connection in STEP 7 and download the modified configuration to the CPU.
- **PG connection**:
  As soon as you have connected the PG to a CPU online in STEP 7, connection resources are occupied.
- **Web server**:
  As long as you have opened the Web server of the CPU in a browser, connection resources are occupied in the CPU.
- **OPC UA server**
  Each connection to the OPC UA server of the CPU occupies a connection resource in the station. This connection resource is released immediately when the connection is terminated.
- **OPC UA client**
  Each connection that the OPC UA client of the CPU has established to an OPC UA server occupies a connection resource in the station. When an OPC UA connection is established, the OPC UA client temporarily occupies an additional connection resource. When an OPC UA connection is terminated, the connection resource is not released again until after a wait time of approx. 60 seconds in accordance with RFC 793.

Monitoring the maximum possible number of connection resources

Offline

During configuration of connections, STEP 7 monitors the occupation of the connection resources. If the maximum possible number of connection resources is exceeded, STEP 7 signals this with a suitable warning.

Online

The CPU monitors the use of connection resources in the automation system. If you establish more connections in the user program than those provided by the automation system, the CPU acknowledges the instruction to establish the connection with an error.

S7-1500 and S7-300 comparison

You will find a comparison of how the communication resources of the S7-1500 and S7-300 are managed in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109747092).

14.3 Display of the connection resources

Display of the connection resources in STEP 7 (offline view)

You can display the connection resources of an automation system in the hardware configuration. You will find the connection resources in the Inspector window in the properties of the CPU.

Connection resources

	① Station resources			② Module resour...	Module resour...	Module resour...
	Reserved		Dynamic	PLC_1 [CPU 15...	CM 1542-1_1 [...	CP 1543-1_1 [...
Maximum number of resources:		10	246	128	64	118
	Maximum	Configured	Configured	Configured	Configured	Configured
PG communication:	4	-	-	-	-	-
HMI communication:	4	4	6	6	0	4
S7 communication:	0	-	7	4	3	0
Open user communication:	0	-	13	8	5	0
Web communication:	2	-	-	-	-	-
OPC UA client/server communicatio...	0	-	-	-	-	-
Other communication:	-	-	0	0	0	0
Total resources used:		4	26	18	8	4
Available resources:		6	220	110	56	114

Figure 3-544 Example: Reserved and available connection resources (offline view)

① **Station-specific connection resources**

The columns of the station-specific connection resources provide information about the used and available connection resources of the station.

In the example, a maximum of 256 station-specific connection resources are available for the automation system.

- 10 reserved connection resources, of which 4 are already in use and a further 6 available. The used resources are divided up as follows:
  - 4 Resources for HMI communication
- 246 dynamic connection resources, of which 26 are already in use and a further 220 available.
  The used resources are divided up as follows:
  - 6 resources for HMI communication
  - 7 resources for S7 communication
  - 13 resources for Open User Communication

The warning triangle in the column of the dynamic station resources is displayed because the sum of the maximum available connection resources of CPU, CP and CM (= 310 connection resources) exceeds the station limit of 256.

NOTE

Available connection resources exceeded

STEP 7 signals the exceeding of the station-specific connection resources with a warning. To make full use of the connection resources from the CPU, CP and CM, either use a CPU with a higher maximum number of available station-specific connection resources or reduce the number of communications connections.

---

② **Module-specific connection resources**

The columns of the module-specific connection resources provide information about the use of resources on the CPUs, CPs and CMs of an automation system:

The display is per module and not per interface.

In the example, the CPU makes a maximum of 128 connection resources available, of which 18 are already in use and 110 still available.
The used resources are divided up as follows:

- 6 resources for HMI communication
- 4 resources for S7 communication
- 8 resources for Open User Communication

Display of the connection resources in STEP 7 (online view)

If you are connected to the CPU online, you can also see how many resources are currently being used under "Connection information".

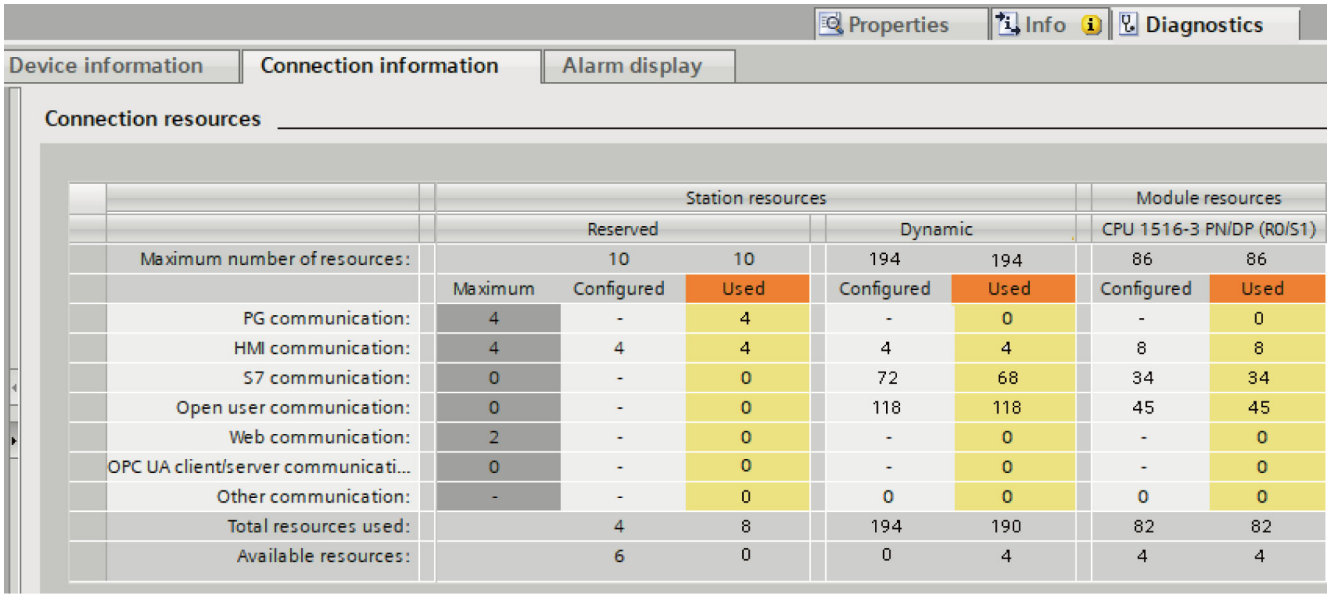

	Station resources					Module resources	
		Reserved		Dynamic		CPU 1516-3 PN/DP (R0/S1)	
Maximum number of resources:		10	10	194	194	86	86
	Maximum	Configured	Used	Configured	Used	Configured	Used
PG communication:	4	-	4	-	0	-	0
HMI communication:	4	4	4	4	4	8	8
S7 communication:	0	-	0	72	68	34	34
Open user communication:	0	-	0	118	118	45	45
Web communication:	2	-	0	-	0	-	0
OPC UA client/server communicati...	0	-	0	-	0	-	0
Other communication:	-	-	0	0	0	0	0
Total resources used:		4	8	194	190	82	82
Available resources:		6	0	0	4	4	4

Figure 3-545 Connection resources - online

The online view of the "Connection resources" table in addition to the offline view also contains columns with the connection resources currently being used. Thus, the online view displays **all** used connection resources in the automation system, regardless of how the connection was set up.

The "Other communication" row displays connection resources assigned for communication with external devices. The table is updated automatically.

NOTE

If a routed S7 connection goes through a CPU, the required connection resources of the CPU do not appear in the table of connection resources.

Display of the connection resources for HMI

For information regarding the availability and assignment of connection resources for HMI connections, refer to the "Connection resources" properties in the Inspector window of the offline view (in the context of the HMI device).

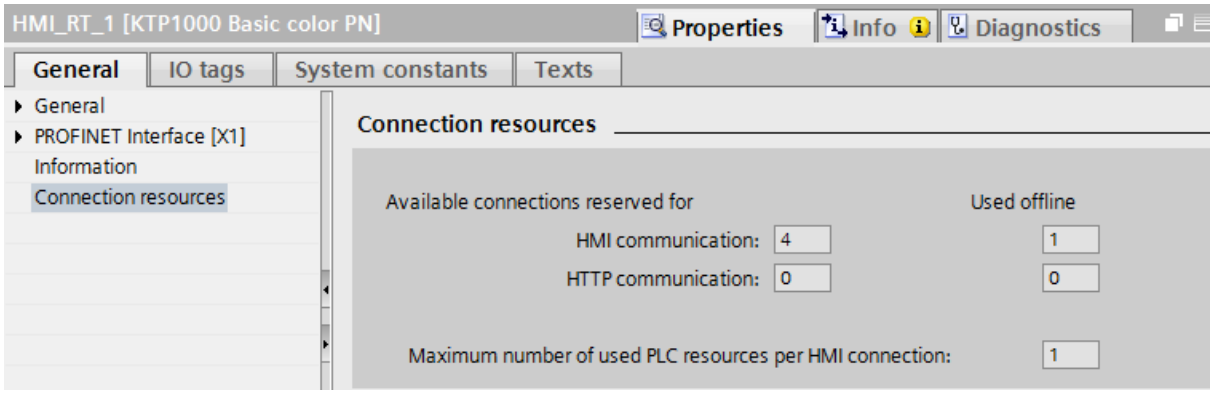

Figure 3-546 Connection resources - HMI communication

The following is displayed in the connection resources area:

- Number of available connections on the HMI reserved for HMI communication and HTTP communication
- Number of connection resources for HMI communication and HTTP communications used offline in the HMI

  If the maximum number of available connection resources for an HMI device is exceeded, a corresponding message is output by STEP 7.
- "Maximum number of used PLC resources per HMI connection". This parameter is a factor that is to be multiplied by the number of HMI connections used offline. The product is the number of HMI resources occupied on the CPU.

Displaying the connection resources in the Web server

You can display the connection resources not only in STEP 7, but also with a browser that displays the relevant page of the Web server.

You will find information on displaying connection resources in the Web server in the Web Server (https://support.industry.siemens.com/cs/us/en/view/59193560) function manual.

Diagnostics and fault correction

15

15.1 Connection diagnostics

Connections table in the online view

After selecting a CPU in the Devices & networks editor of STEP 7, you will see the status of your connections displayed in the online view of the connections table.

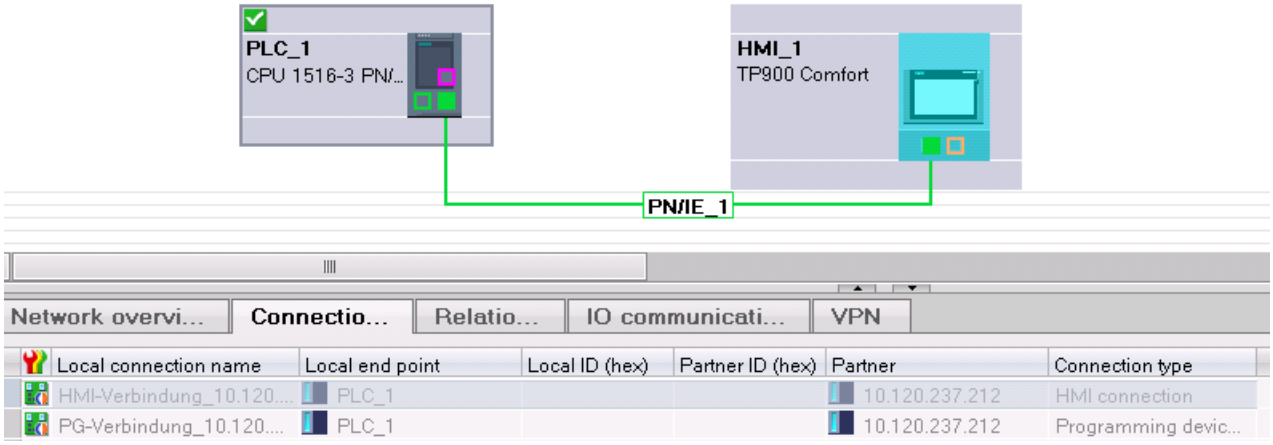

Figure 3-547 Online view of the connections table

After selecting the connection in the connections table, you obtain detailed diagnostic information in the "Connection information" tab.

"Connection information" tab: Connection details

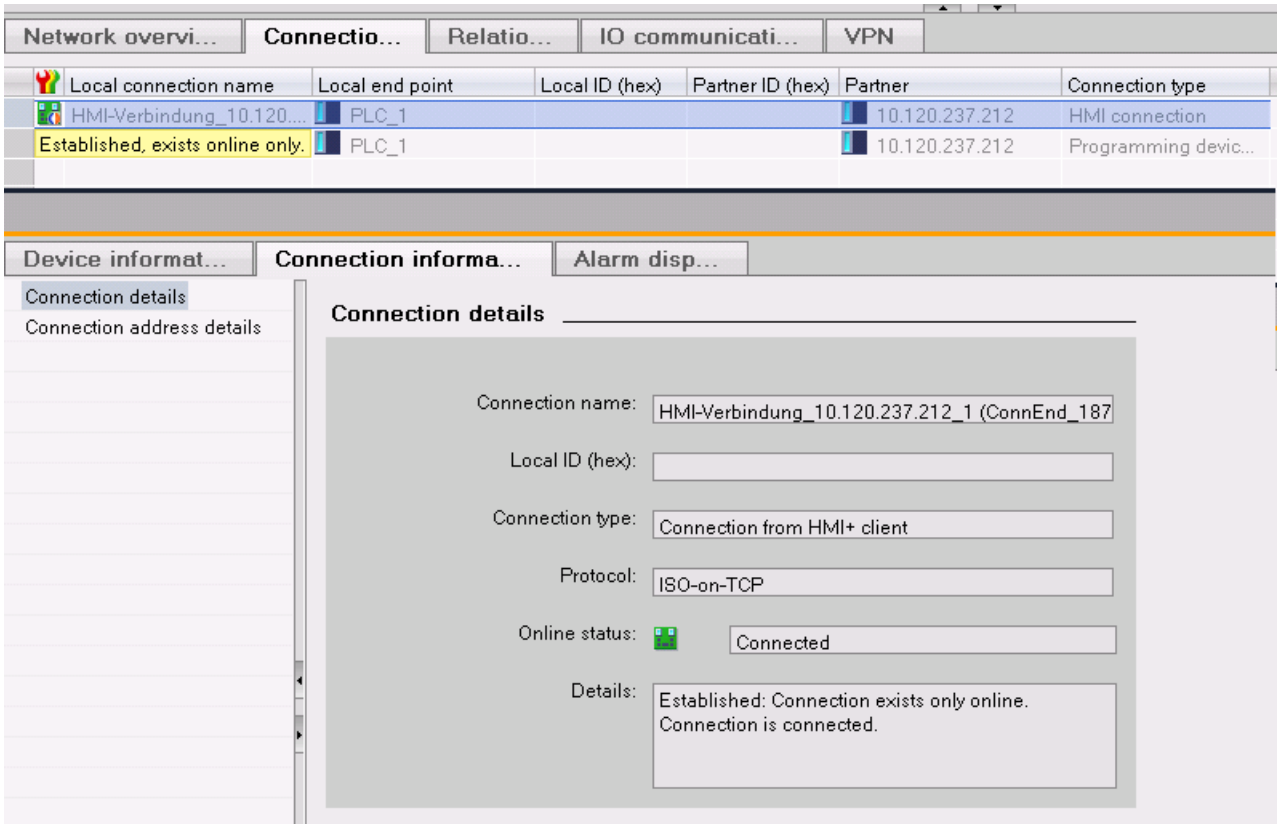

Figure 3-548 Diagnostics of connections - connection details

"Connection information" tab: Address details

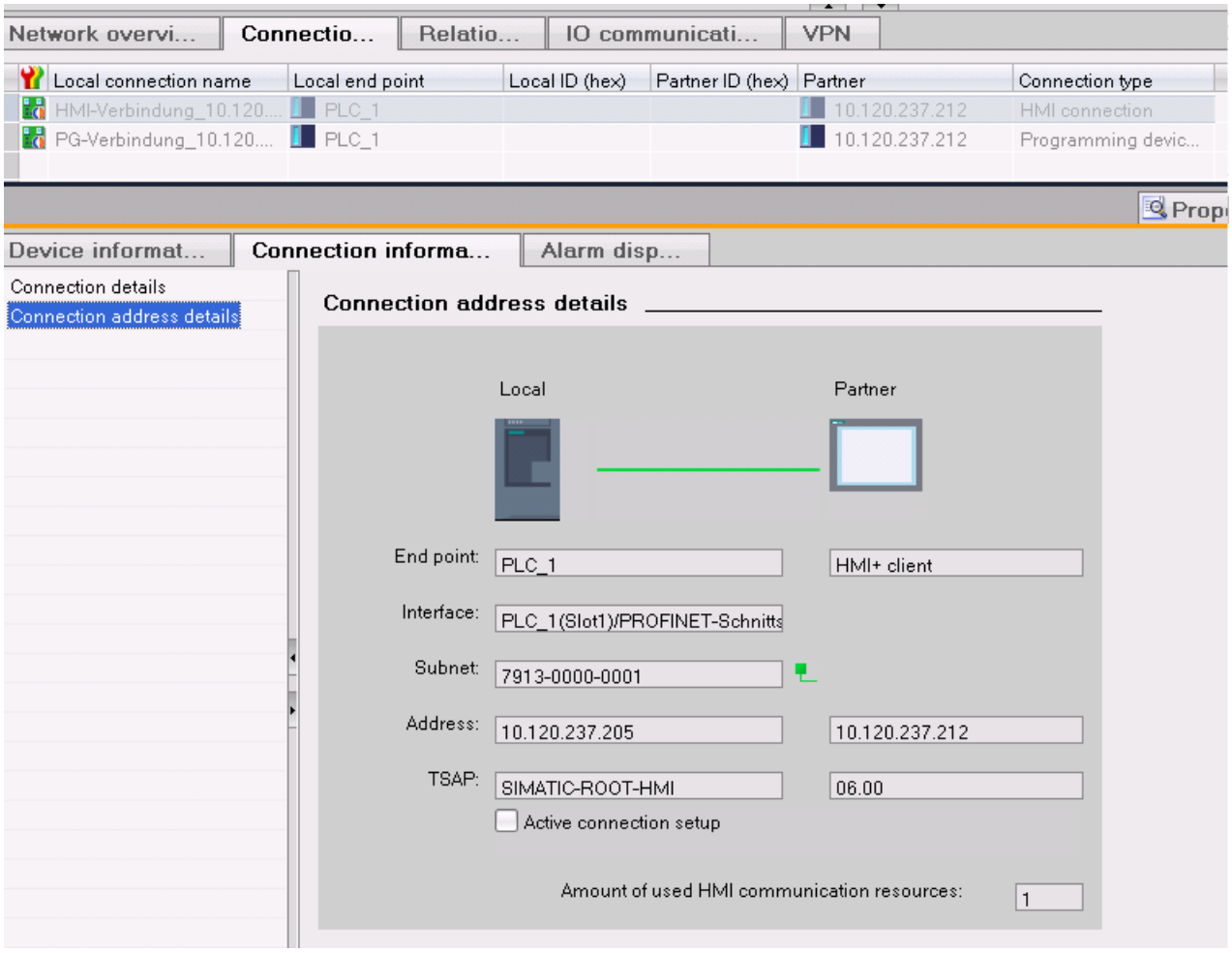

Figure 3-549 Diagnostics of connections - address details

Diagnostics via web server

You can evaluate diagnostic information from the CPU using a web browser via the integrated web server of a CPU.

On the "Communication" Web page, you will find the following information about communication via PROFINET in various tabs:

- Information on the PROFINET interfaces of the CPU (for example addresses, subnets, physical properties).
- Information on the quality of the data transfer (for example number of data packets sent/received error-free).
- Information about the allocation/availability of connection resources.
- The "Connection status" page is similar to the online view in STEP 7 and also provides an overview of all connections with detail view.

Diagnostics with the user program

When you program the T_DIAG instruction, you can evaluate diagnostic information about the configured and programmed connections of the CPU using the user program. For CPUs as of FW version V3.1, you can only use the T_DIAG instruction to evaluate the diagnostics information of OUC connections.

Additional information

You will find the description of the web server functionality in the function manual Web server (https://support.industry.siemens.com/cs/us/en/view/59193560).

15.2 Emergency address

If you cannot reach the CPU via the IP address, you can set a temporary emergency address (emergency IP) for the CPU. Via this emergency address, you can re-establish the connection with a CPU in order to load a device configuration with a valid IP address.

You can set an emergency address regardless of the protection level of the CPU

When do you need an emergency address?

Your CPU cannot be reached in the following cases:

- The IP address of your PROFINET interface is assigned twice.
- The subnet mask is set incorrectly.

Requirements

- You have selected "Set IP address in the project" for the IP protocol in the device configuration in STEP 7.
- No configuration with enabled DCP write protection loaded.
- The CPU is in STOP mode.

Restoring a valid device configuration with an emergency address

1. Set the emergency address for the interface of the CPU with a DCP tool. For example, the SIMATIC Automation Tool has a DCP command "Define IP address".
   The maintenance LED of the CPU lights up. The diagnostic buffer also shows that an emergency address was activated for an Ethernet interface.
2. Load a STEP 7 project with a valid IP address into the CPU.
3. Switch the CPU off and on again.
   The emergency address is reset.

Result

The CPU starts up with the valid IP address.

Communication with the redundant system S7-1500R/H

16

Introduction

Communication with the S7-1500R/H redundant system basically functions as with the S7-1500 standard system.

This chapter describes the special features and restrictions for communication with the S7-1500R/H redundant system.

Communication options for the S7-1500R/H redundant system

- Open User Communication via TCP/IP, UDP, ISO on-TCP and Modbus/TCP
- Secure Open User Communication with exception of the "Secure OUC via e-mail" function (see also Secure Open User Communication (Page 93))
- S7 communication as server
- HMI communication, PG communication
- Data exchange via OPC UA as server
- Secure PG/HMI communication (see also Secure PG/HMI communication (Page 110))
- SNMP
- Time-of-day synchronization via NTP
- Web server (only via Web API)
- Support of the CP 1543-1 communications processor as central plugged module (see also S7-1500R/H System Manual (https://support.industry.siemens.com/cs/us/en/view/109754833))

Restrictions for communication with the S7-1500R/H redundant system

- Open User Communication:
  - no configured connections
  - Email: The S7-1500R/H CPUs support only the versions < V5.0 of the "TMAIL_C" instruction. Versions from V5.0 are not supported.
  - No support of connection descriptions according to "TCON_Param"
- no S7 communication as client
- PG communication: It is not possible to access two CPUs online at the same time. You can either access the primary CPU or the backup CPU.

16.1 System IP addresses for R/H CPUs

Introduction

In addition to the device IP addresses of the CPUs, the S7-1500R/H redundant system also supports these system IP addresses:

- System IP address for the PROFINET interfaces X1 of the two CPUs (system IP address X1)
- System IP address for the PROFINET interfaces X2 of the two CPUs (system IP address X2)
- System IP address for the PROFINET interfaces X3 of the two CPUs (system IP address X3)

You use the system IP addresses for communication with other devices (for example, HMI devices, CPUs, PCs). The devices always communicate over the system IP address with the primary CPU of the redundant system. This ensures, for example, that the communication partner can communicate with the new primary CPU (previously backup CPU) in the RUN-Solo system state after failure of the original primary CPU in redundant operation.

There is a virtual MAC address for each system IP address.

You enable the system IP addresses in STEP 7.

Advantages of system IP addresses compared to device IP addresses

- The communication partner communicates specifically with the primary CPU.
- The S7-1500R/H redundant system can continue to communicate over a system IP address even if the primary CPU fails.

Applications

You use the system IP addresses for the following applications:

- HMI communication with the S7-1500R/H redundant system: You can use an HMI device to control or monitor the process on the redundant S7 1500R/H system.
- Open User Communication with the S7-1500R/H redundant system:
  - Another CPU or an application on a PC accesses data of the S7-1500R/H redundant system.
  - The S7-1500R/H redundant system accesses a different device.

  TCP, UDP and ISO-on-TCP-connections are possible.
- IP forwarding: If you use the system IP addresses as the gateway/default route for IP routes through the S7-1500R/H redundant system, IP packets are forwarded even if a CPU fails.

Requirements

- The interface of the communication partner is connected to both CPUs, each via the same interface (e.g. X2).
- The system IP address for the interfaces of the S7-1500R/H system is enabled.

Communication via the system IP addresses X2 and X3

If the CPUs of the redundant S7-1500R/H system have two or three PROFINET interfaces, it is preferable to use the PROFINET interface X2 or X3 for communication with other devices.

The following figure shows a configuration in which the communication partners are connected via the respective PROFINET interfaces X2 with the CPUs of the S7-1500R/H redundant system.

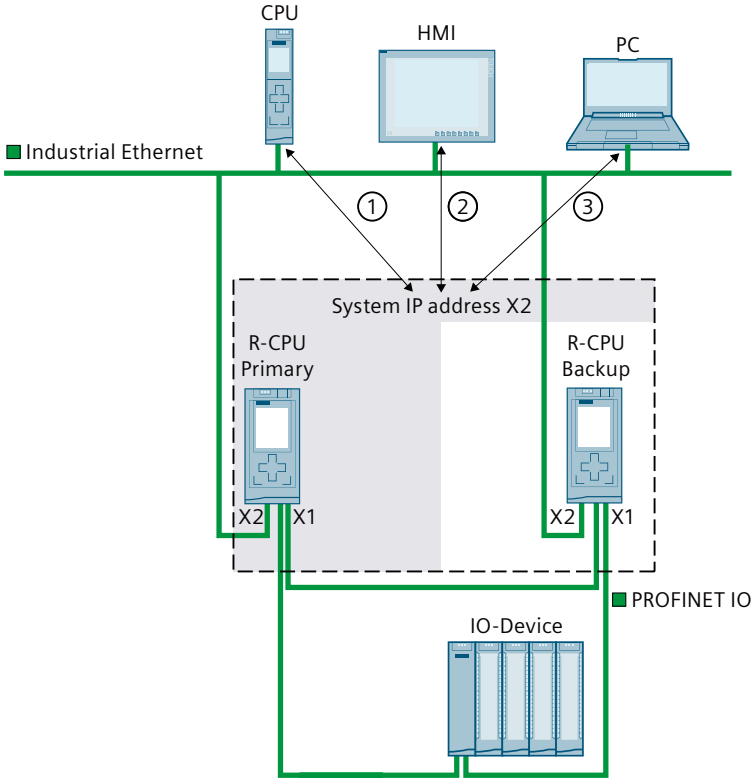

① Open User Communication between another CPU and the S7-1500R redundant system

② HMI communication with the S7-1500R redundant system

③ Open User Communication between the S7-1500R redundant system and a PC

Figure 3-550 Example: Communication of the S7-1515R redundant system via the system IP address X2

Communication via the system IP address X1

The following diagram shows a configuration where the communication partners are connected with a switch to the PROFINET ring of the S7-1500R/H redundant system. The PROFINET ring connects the communication partners with the respective PROFINET interfaces X1 of the two CPUs.
Since the CPU 1513R-1 PN only has one PROFINET interface, connection via the PROFINET ring is the only possibility of communicating via the system IP address X1.

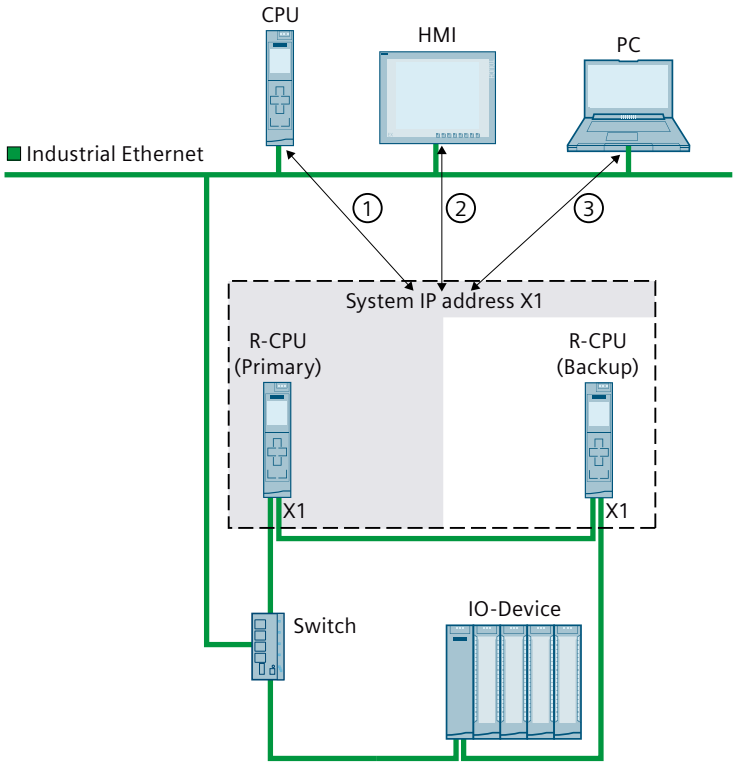

① Open User Communication between the S7-1500R redundant system and another CPU

② HMI communication with the S7-1500R redundant system

③ Open User Communication between the S7-1500R redundant system and a PC

Figure 3-551 Example: Communication of the S7-1513R redundant system via the system IP address X1

Communication via the system IP addresses X1, X2, and X3

You can use one system IP address for each PROFINET interface of the redundant S7-1500R/H system. PROFINET devices which are connected to X1 interfaces of the CPUs communicate via the system IP address X1. PROFINET devices which are connected to X2 interfaces of the CPUs communicate via the system IP address X2. PROFINET devices which are connected to the X3 interfaces of the CPUs communicate via the system IP address X3.

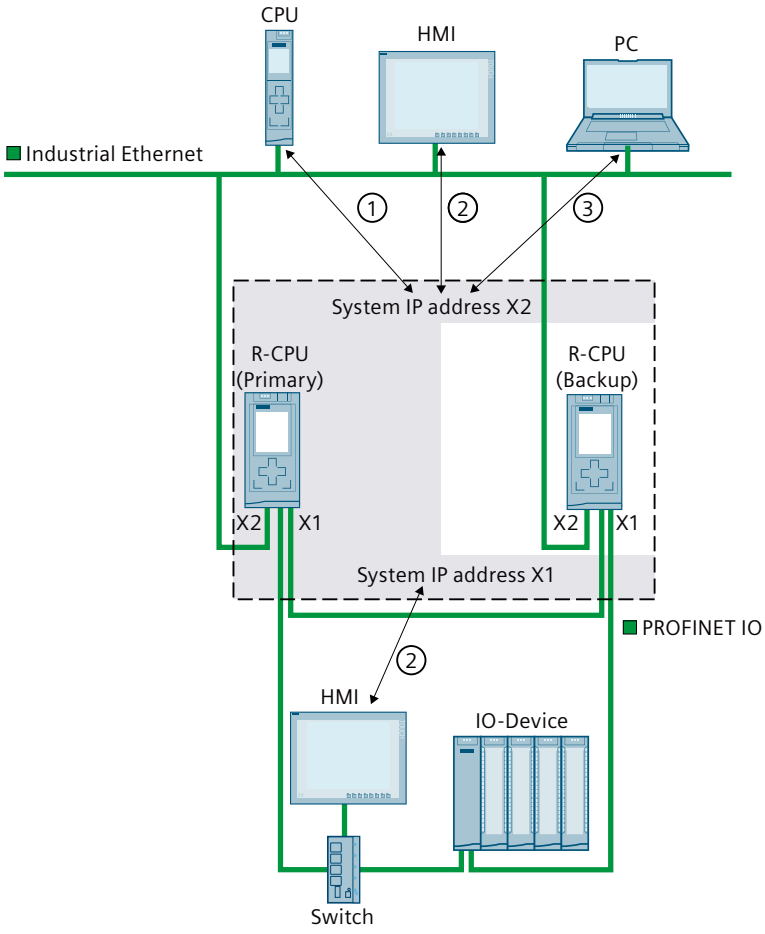

① Open User Communication between the S7-1500R redundant system and another CPU

② HMI communication with the S7-1500R redundant system

③ Open User Communication between the S7-1500R redundant system and a PC

Figure 3-552 Example: Communication of the S7-1515R redundant system via the system IP addresses X1 and X2

With an S7-1500H(F) system, you also have the option of dividing your system into several PROFINET rings.

In this case, you must connect the required S1/S2 devices in a separate PROFINET ring behind a Y-switch.

Recommendation: For increased availability of the S1/S2 devices, you need two Y-switches with DNA redundancy (SCALANCE XF204-2BA DNA). One Y-switch takes on the roles of MRP manager and DNA manager. Another Y-switch takes on the roles of MRP client and DNA client. DNA redundancy is only possible with a connected PROFINET ring.

You can find more information on configuration scenarios with Y-switches in the S7-1500R/H Redundant System (https://support.industry.siemens.com/cs/ww/en/view/109754833) System Manual.

IP forwarding via system IP addresses

If you use the system IP addresses as gateway/default routes for IP routes through the S7-1500R/H redundant system, IP packets are forwarded even if a CPU fails.

In the following figure, the PC is connected to the two X2 interfaces of the S7-1500R CPUs. Enter the system IP address X2 as a gateway in the PC for the route to the HMI device. The HMI device is connected to the PROFINET ring of the S7-1500 redundant system via a switch. The system IP address X1 is configured as the router in the HMI device.

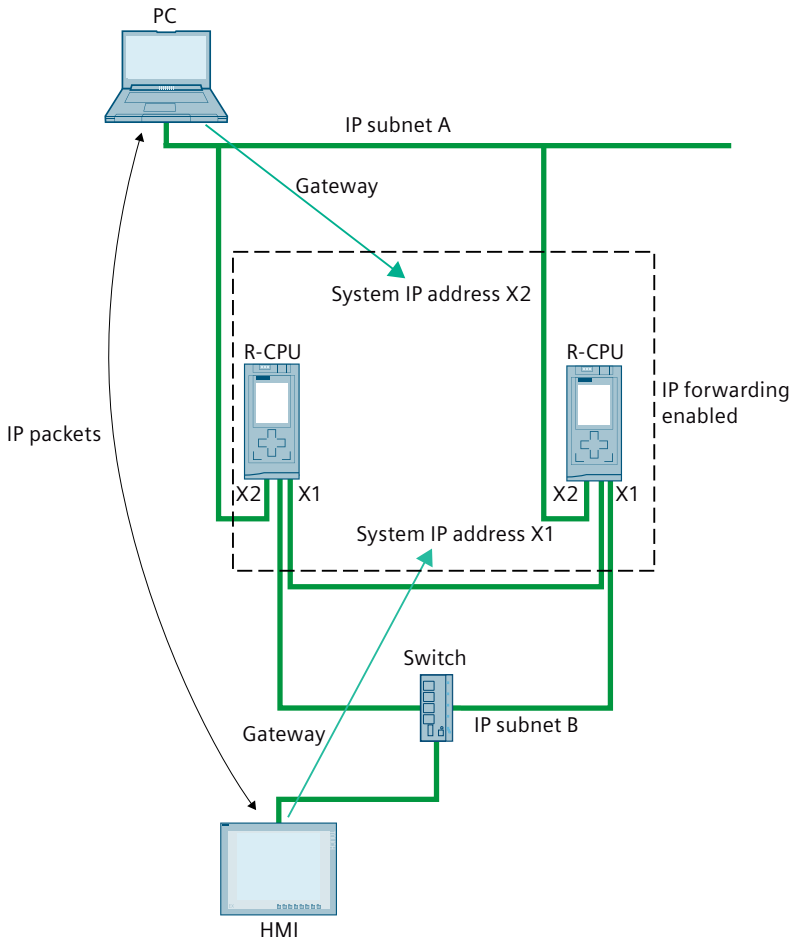

Figure 3-553 Example: IP forwarding via system IP addresses

Enable system IP addresses

Requirements:

- STEP 7 from V15.1
- S7-1500R/H redundant system with two CPUs, e.g. two 1513R-1 PN CPUs

If the CPUs of the S7-1500R/H redundant system have two PROFINET interfaces (X1 and X2), then you can use a system IP address for both PROFINET interfaces. The following describes how to enable the system IP address for the X1 interface.

To activate the system IP address for your S7-1500R/H redundant system, follow these steps:

1. In the network view of STEP 7, select the X1 interface of one of the two CPUs.
2. In the Inspector window, navigate to "Properties > General > Ethernet addresses" in the "System IP address for switched communication" area.
3. Select the check box "Enable the system IP address for switched communication".

   STEP 7 automatically creates a system IP address.

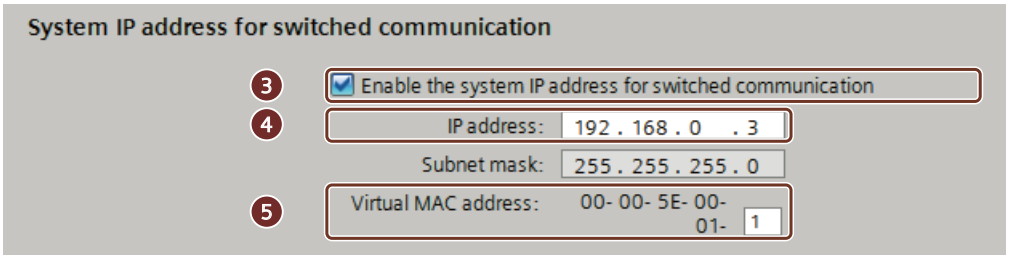

Figure 3-554 Configuring the system IP address

4. Adjust the system IP address as required.
5. If necessary, change the virtual MAC address. To do this, in "Virtual MAC address", assign a project-wide unique value (value range 01_H to FF_H) for the last byte.

NOTE

Uniqueness of the virtual MAC address

The S7-1500R/H redundant system uses a MAC address from the address range 00-00-5E-00-01-00 to 00-00-5E-00-01-00 for each system IP address. This address range is also used for VRRP (Virtual Redundancy Protocol).

If you use devices with VRRP, e.g. switches, ensure the uniqueness of the MAC addresses within an Ethernet broadcast domain.

Result: The X1 system IP address for the X1 PROFINET interface of the two CPUs is enabled.

16.2 System IP addresses for communications processors

Introduction

As of STEP 7 V19, you have the option of expanding redundant S7-1500R/H systems as of FW-version V3.1 with CP 1543-1 communications processors as of FW-version V3.0. When extended with CP 1543-1 communications processors, R/H-CPUs support the configuration of a W1 virtual interface with device and system IP-addresses. The communication partners connected to the CPs communicate with the R/H-CPUs via these IP addresses.

You can enable the system IP address of W1 in STEP 7.

There is a virtual MAC address for each system IP address.

Failure of a communications processor

In the event of a CP 1543-1 communications processor failure, the S7-1500R/H redundant system behaves as follows:

- S7-1500R:
  When a CP fails, the corresponding CPU changes to STOP mode. The S7-1500R system changes to the RUN-Solo system state.
  When the CP at the primary CPU fails, the S7-1500R redundant system performs a primary-backup switchover. The assigned system IP address changes to the new primary CPU. Establishing the new communication connection then takes place via the redundant CP.
  If the CP at the backup CPU fails, this failure has no effect on the existing communication via the system IP address.
- S7-1500H with active backplane bus:
  When a CP fails, the S7-1500H system remains in the RUN-Redundant system state.
  If the CP at the primary CPU fails, the redundant S7-1500H system does not perform a primary-backup switchover. The system IP address W1 is assigned to the failed CP via the primary CPU. To switch the system IP address W1 to the backup CPU, call the "RH_CTRL" instruction with mode=15 in the user program. As a result, the system IP address W1 is assigned to the backup CPU. The new communication connection is then established via the redundant CP of the backup CPU.

  If another CP on the primary CPU fails, the establishment of a new communication connection at the redundant CP is only possible via the assigned device IP address.

  NOTE

  If you communicate with the redundant system via the device IP addresses, you should preferably use the device IP address of the primary CPU. The transfer rate is better and the communication load is lower via the device IP address of the primary CPU.

You can find more information about the "RH_CTRL" instruction in the online help for STEP 7.

You can find information about configuring the system IP address for the W1 virtual interface and the virtual MAC address in the Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/us/en/view/109754833) System Manual.

Advantages of expansion with CP 1543-1 communications processors

If you expand your redundant system with CP 1543-1 communications processors, additional communications interfaces become available. Use this advantage for a CPU 1513R-1 PN with only one PROFINET interface, e.g. for a network separation.

Requirements for using the W1 system IP address

- A CP 1543-1 is assigned to the W1 virtual interface.
- The system IP address of the W1 virtual interface is activated.
- A system IP address is assigned to the W1 virtual interface.
- A communication partner reaches both CPs via the assigned system IP address.

Communication via the W1 system IP address

The following figure shows the configuration of an S7-1513R redundant system with expansion by CPs. The communication partners communicate with the redundant system via the assigned W1 system IP address.

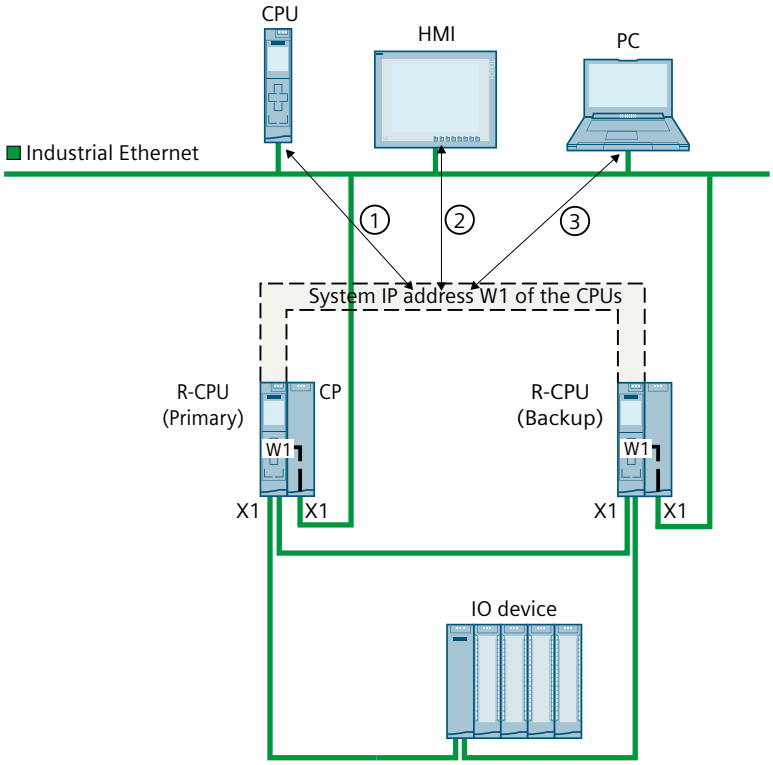

① Communication between the S7-1500R redundant system and another CPU

② HMI communication with the S7-1500R redundant system

③ Communication between the S7-1500R redundant system and a PC

Figure 3-555 Example: Communication of the S7-1513R redundant system via the assigned W1 system IP address

IP forwarding via system IP addresses

If you use the system IP addresses as gateway/default routes for IP routes through the redundant S7-1500R system, IP packets are forwarded even if a CP fails.

NOTE

Primary-backup switchover in S7-1500H systems with an active backplane bus

If there is a failure of a CP in an S7-1500H system with an active backplane bus, no primary-backup switchover takes place. In this case, set up the primary-backup switchover in your user program if required.

In the following figure, the PC is connected to the two X1 interfaces of the CPs 1543-1. For the route to the HMI device, the assigned W1 system IP address is entered in the PC as the router. The HMI device is connected via a switch to the PROFINET ring of the S7-1500R redundant system. In the HMI device, the X1 system IP address of the CPUs is entered as the router.

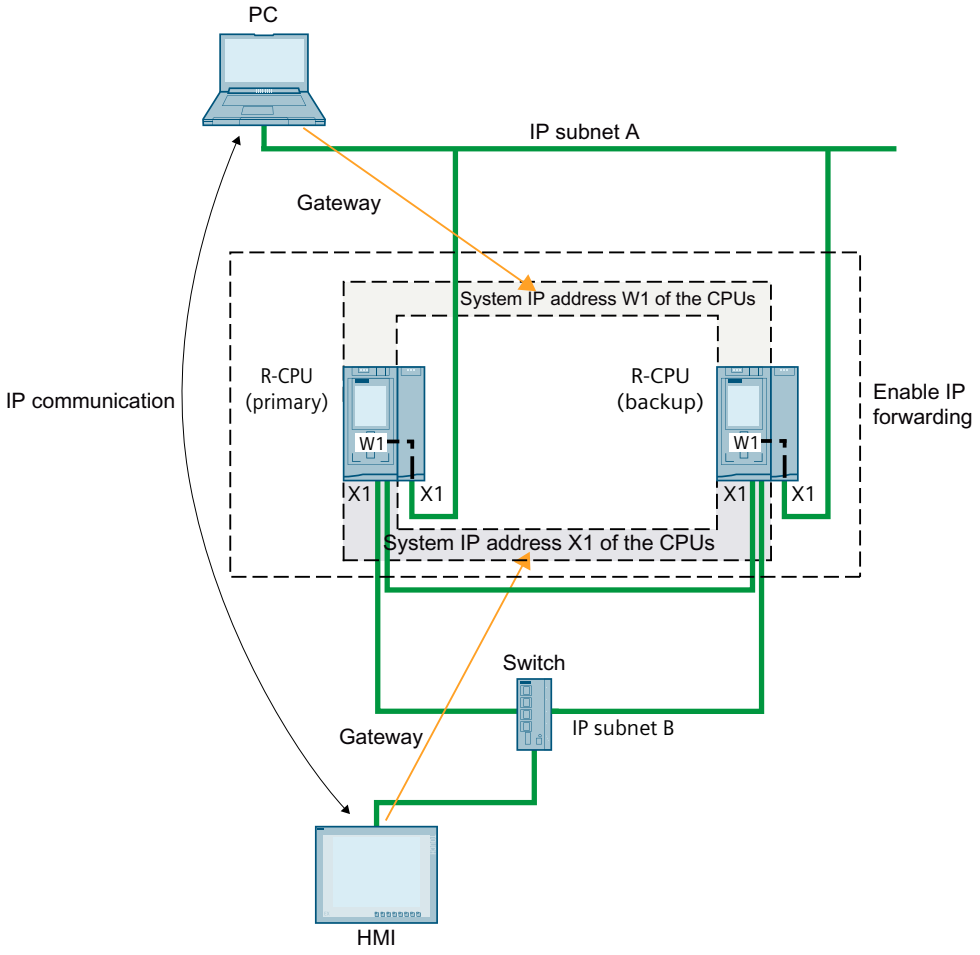

Figure 3-556 Example: IP forwarding via the system IP addresses of CPUs and CPs

Assigning the system IP address to the W1 virtual interface of R/H CPUs

Starting with STEP 7 V19, it is possible to assign a system IP address to the W1 virtual interface of R/H-CPUs. The communication partners that you have connected to the CPs communicate with the R/H system via the assigned system IP address.

To change the system IP address of the W1 virtual interface of the R/H CPUs, follow these steps:

1. Select the R/H CPU on rail_0 in the device view.
2. In the Inspector window, navigate to "Advanced configuration > Access to PLC via communications module".
3. Select the required CP from the "Select communication module" selection list in the "Assign interface [W1]" section.
   After selection, a warning message appears to inform you of possible risks associated with this setting. If you confirm the warning message, the configuration options for the W1 virtual interface are displayed.
4. Navigate to the "Internet protocol version 4 (IPv4)" area.
5. Accept the suggestion or assign a new IP address.
6. Navigate to the "System IP address for switched communication" area.
7. Select the option "Enable the system IP address for switched communication".
8. Accept the suggestion or assign a new system IP address (and virtual MAC address).

9. The R/H CPU on rail_1 automatically adopts the settings.

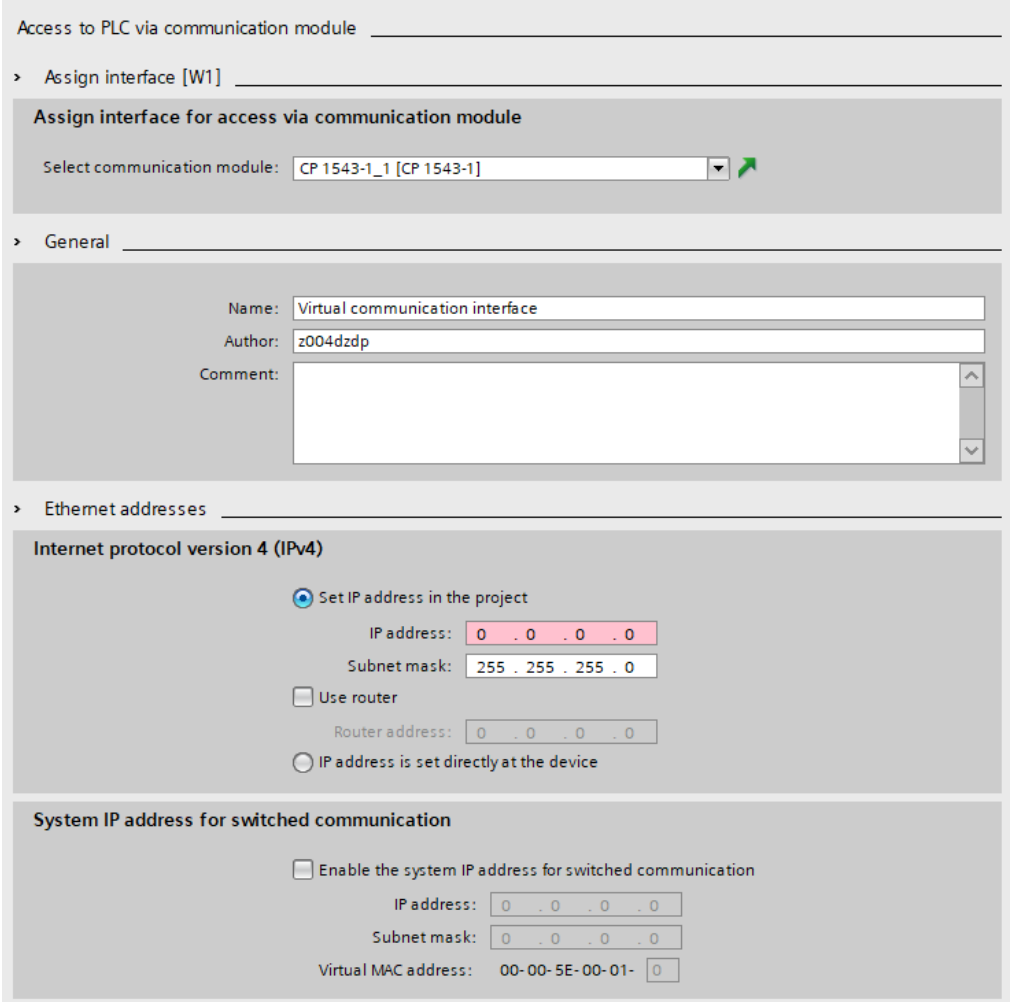

Figure 3-557 Configuring the system IP address of W1

Result: You have assigned a CP 1543-1 to the W1 virtual interface and configured the device/system IP address.

16.3 Improved accessibility by switching the system IP address

Switching the system IP address when CPU cannot be accessed

By default, the system IP addresses are assigned to the primary CPU.

From STEP 7 V20 (CPU firmware version as of V4.0), you can use the "RH_CTRL" instruction to switch the system IP addresses from the primary CPU to the backup CPU and back. For example, you can maintain communication if the primary CPU is not available.

More information

A description of the program-controlled switching of the system IP addresses can be found under the special instructions for redundant systems S7-1500R/H in the System Manual S7-1500R/H (https://support.industry.siemens.com/cs/us/en/view/109754833).

16.4 Behavior during SYNCUP

Response of communication connections via the system IP address in the system state SYNCUP

- HMI, PG- and S7-connections are temporarily closed. For a short time during the SYNCUP it is not possible to establish connections to the S7-1500R/H redundant system.
- All existing connections of Open User Communication are interrupted:
  - Connections set up by the CPUs of the redundant system as an active connection partner are set up again after the SYNCUP.
  - The S7-1500R/H redundant system sets up connection endpoints again for the passive connection establishment after the SYNCUP.
- The processing of running instances of the instructions TSEND and TRCV is stopped. The block parameter STATUS returns $80C4_H$ (temporary communication error).

16.5 Response to primary-backup switchover

Response of communication connections via the system IP address during a primary-backup switchover

- Running instances of the instructions TSEND and TRCV are stopped and return the status $80C4_H$ (temporary communication error).
- Connections successfully established by the S7-1500R/H redundant system are established again by the new primary CPU.
- The new primary CPU sets up connection endpoints again for the passive connection establishment.

NOTE

Increased duration of connection interruption

If the remote system does not transmit actively after the primary-backup switchover, the connection monitoring (e.g. TCP-Keep-Alive or application) may have to be performed by the remote system until the connection can be re-established.

16.6 Connection resources of the redundant system S7-1500R/H

Maximum number of connection resources of the S7-1500R/H redundant system

The maximum number of connection resources for the R/H CPUs depends on the following conditions:

- CPU type
- Firmware version
- Presence of communications processors CPs

You can find the different values in sec. Technical specifications of the equipment manuals of the R/H CPUs.

Allocation of connection resources

Communication connections occupy communication resources in the S7-1500R/H redundant system.

Each communication connection to the redundant system S7 1500R/H occupies connection resources in the S7 1500R/H station. The S7-1500R/H station comprises the hardware setup of both CPUs of the redundant S7-1500R/H system.

Depending on the IP address used, a communication connection also uses connection resources in one or both CPUs of the redundant S7-1500R/H system. The S7-1500R/H station can also be used to establish a communication connection.

The following table shows in which CPU a communication connection occupies connection resources depending on the IP address used.

Connect via...	Connection resources of the station	Connection resources CPU with redundancy ID 1	Connection resources CPU with redundancy ID 2
a system IP address	X	X	X
a device IP address of the CPU with redundancy ID 1	X	X	-
a device IP address of the CPU with redundancy ID 2	X	-	X

Display of the occupied connection resources in STEP 7

Requirement: Online connection to the redundant system S7-1500R/H

You will find the online display of the connection resources in the inspector window under "Diagnostics" > "Connection information". STEP 7 always displays the connection resources of the selected CPU and the S7-1500R/H-station.

Connection resources

	Station resources					Module resources	
		Reserved		Dynamic		CPU 1517H-3 PN (R0/S1)	
Maximum number of resources:		10	10	150	150	160	160
	Maximum	Configured	Used	Configured	Used	Configured	Used
PG communication:	4	-	2	-	0	-	2
HMI communication:	4	0	0	0	0	0	0
S7 communication:	0	-	0	0	0	0	0
Open user communication:	0	-	0	0	0	0	0
Web communication:	2	-	0	-	0	-	0
Other communication:	-	-	0	0	0	0	0
Total resources used:		0	2	0	0	0	2
Available resources:		10	8	150	150	160	158

Figure 3-558 Display of the connection resources of the S7-1500R/H redundant system in STEP 7

16.7 HMI communication with the redundant system S7-1500R/H

16.7.1 HMI connection via the system IP address

Requirements

- A S7-1500R/H redundant system, e.g. CPU 1513R-1PN
- System IP address is enabled
- HMI device with PROFINET interface

Procedure

To set up a HMI connection to an S7-1500R/H redundant system, follow these steps:

1. In the network view of STEP 7, select a PROFINET interface of the HMI device.
2. Using a drag&drop operation, draw a line between the PROFINET interface of the HMI device and a PROFINET interface of the S7-1500R/H redundant system.
   The HMI device and the S7-1500R/H redundant system are networked together.

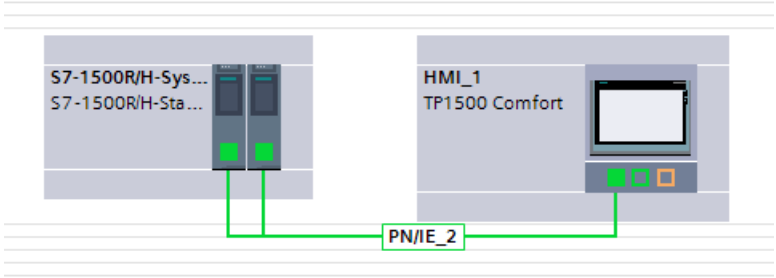

Figure 3-559 Networking an HMI device with the S7-1500R/H redundant system

3. In the list of functions, click the "Connections" icon. This activates connection mode.
4. Using a drag-and-drop operation, draw a line between the HMI device and a CPU of the S7-1500R/H redundant system.
   The list "Connection partners" opens.

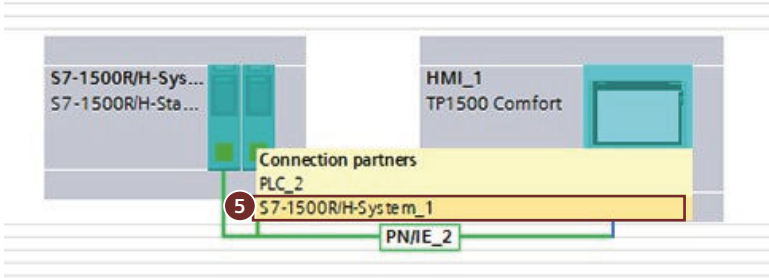

Figure 3-560 Setting up an HMI connection to the S7-1500R/H redundant system

5. Select the S7-1500R/H redundant system in the list "Connection partners".

Result: You have set up a HMI connection between the HMI device and the S7-1500R/H redundant system. The HMI connection uses the system IP address. The HMI device always connects to the primary CPU.

Changing the HMI connection over to the device IP address

To permanently change the HMI connection over to the selected CPU, clear the check box "Use the system IP address for switched communication" in the properties of the HMI connection. The HMI connection then uses the device IP address of the PROFINET interface. In the event of the failure of this CPU, then the HMI connection to this CPU permanently fails.

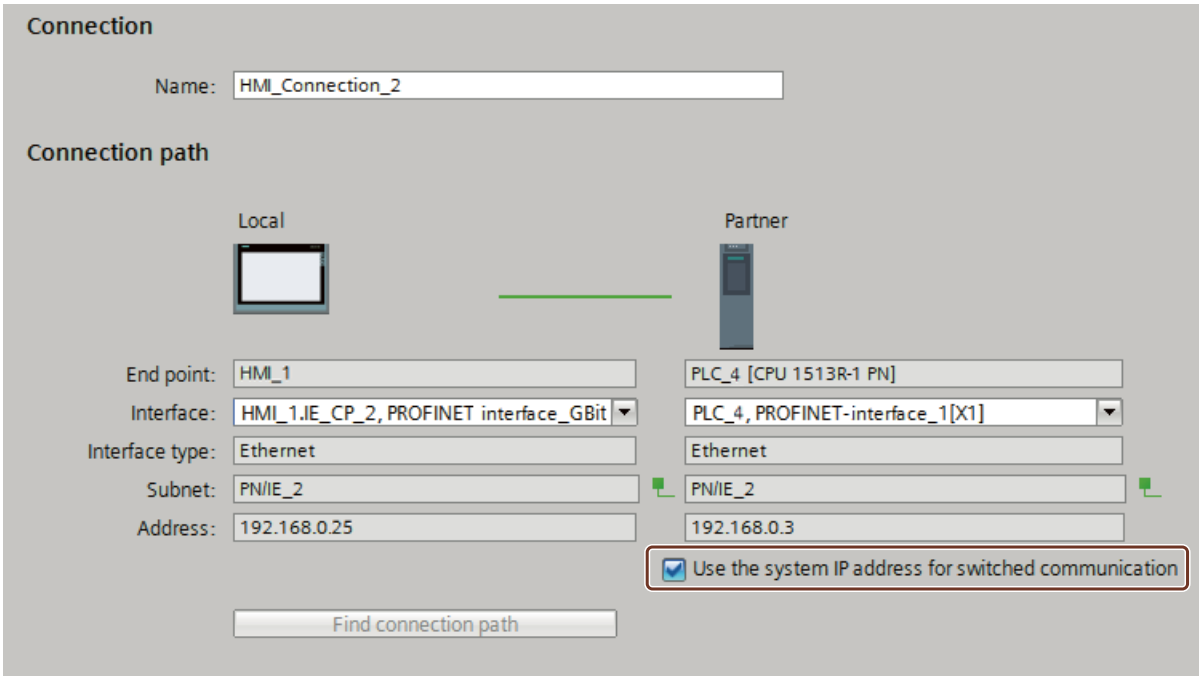

Figure 3-561 Properties of the HMI connection

NOTE

Automatic setup of HMI connection

When you drag-and-drop a tag from the S7-1500R/H redundant system into an HMI screen or into the HMI tag table, STEP 7 automatically sets up an HMI connection. This HMI connection exists by default between the PROFINET interface of the HMI device and the PROFINET interface X1 of the CPU with redundancy ID 1. The connection uses the device IP address of the PROFINET interface X1.

You can change the HMI connection to a system IP address in the properties of the HMI connection.

More information

You can set up an HMI connection to the S7-1500R/H redundant system via the devices IP address. With help of scripts in the HMI configuration, the connection of the failed CPU are switched automatically to the still running CPU. A description to this procedure can be found in the following FAQ (https://support.industry.siemens.com/cs/us/en/view/109781687).

16.8 Open User Communication with the redundant system S7-1500R/H

Introduction

S7-1500R/H systems as of FW version V3.1 also support Secure Open User Communication (Secure OUC).

If you extend an S7-1500R/H system as of FW version V3.1 with CP 1543-1 communications processors, you can also use Secure OUC via these connected CPs.

Requirements:

- STEP 7 as of V19
- CP 1543-1 as of FW version V3.0

Secure Open User Communication protocols for the S7-1500R/H redundant system

The following table shows which protocols of the Open User Communication you can use for the S7-1500R/H redundant system and the matching system data types and instructions.

Table 3-951 Protocols, system data types, and instructions that can be used for Open User Communication with the S7-1500R/H redundant system

Protocol	System data type	Instructions
TCP	• TCON_QDN • TCON_QDN_SEC • TCON_IP_v4 • TCON_IP_V4_SEC	Establish connection and send/receive data via: • TSEND_C/TRCV_C or • TCON, TSEND/TRCV or • TCON, TUSEND/TURCV (connection can be terminated via TDISCON)
TLS over TCP		
ISO-on-TCP	• TCON_IP_RFC	
UDP	• TCON_IP_v4 • TADDR_Param • TADDR_SEND_QDN • TADDR_RCV_IP	Establish connection and send/receive data via: • TSEND_C/TRCV_C • TUSEND/TURCV/TRCV (connection can be terminated via TDISCON)
Modbus TCP	• TCON_IP_v4 • TCON_IP_V4_SEC • TCON_QDN • TCON_QDN_SEC	• MB_CLIENT • MB_RED_CLIENT • MB_SERVER • MB_RED_SERVER

16.8.1 Setting up the connection of the Open User Communication with the redundant S7-1500R/H system

Open User Communication via integrated PROFINET interfaces of the CPU

The S7-1500R/H redundant system can communicate with other devices via Open User Communication.

You set up the connections in the user program, e.g. via the "TSEND_C" instruction. The S7-1500R/H redundant system does not support configured connections.

You can set up the connections via the following IP addresses of the integrated PROFINET interfaces:

- Device IP addresses:
  In redundant mode, the redundant system can establish or terminate connections and send or receive data via all device IP addresses of the redundant system.
  If you set up the connection via a device IP address, communication is routed via the associated CPU. If the CPU fails, then all communication through the device IP addresses of that CPU fails.
- System IP addresses:
  If you set up the connection via a system IP address, communication is always routed via the primary CPU.

Decide how you want to set up the connections based on your use case.

Open User Communication via CP 1543-1 communications processors

If you extend an S7-1500R/H redundant system with CP 1543-1 communications processors, you can then also use the following communication options:

- Local X1 interface of the CP 1543-1
- Own device IP address for the W1 virtual interface of each R/H CPU
- Common system IP address for the W1 virtual interface of the R/H system

You can find information on how to use a CP 1543-1 for a S7-1500R/H system in the System IP addresses for communications processors (Page 464) section.

Setting up a connection via a system IP address

The following describes how to set up a connection to a partner CPU via a system IP address of an integrated PROFINET interface of the redundant S7-1500R/H system.

You can set up the connection in the user program of the redundant S7-1500R/H system, e.g. with a TSEND_C instruction. In the user program of the partner CPU, create a corresponding TRCV_C instruction.

The procedure is described using the example of a TCP connection between the S7-1500R/H redundant system and a CPU 1516-3PN/DP.

Requirements

- A redundant S7-1500R/H system as TCP client, e.g. 2 CPUs 1513-1PN
- System IP address of the PROFINET interface X1 is enabled
- Connection partner as TCP server, e.g. CPU 1516-3 PN/DP
- The X1 PROFINET interfaces of the redundant 1513R CPUs and the X2 PROFINET interface of the CPU 1516-3PN/DP are located in the same subnet.

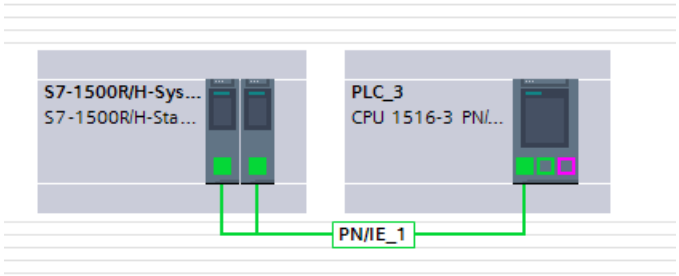

Figure 3-562 Example configuration for TCP-connection

TSEND_C instruction in the user program of the S7-1500R/H redundant system

To set up a TCP-connection to a different CPU, follow these steps:

1. Create a "TSEND_C" instruction in the user program.

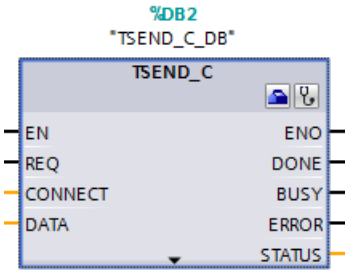

Figure 3-563 S7-1500R/H: "TSEND_C" instruction

2. Select the "TSEND_C" instruction.
3. In the Inspector window, go to "Properties" > "Configuration" > "Connection parameters". On the left-hand side you can see the S7-1500R/H redundant system as a local end point of the connection:
   - "Interface:": X1 is the preset interface.
   - "Subnet:": If the interface X1 is assigned to an S7-subnet, then STEP 7 displays the name of the S7-subnet.
   - The "Use system IP address" check box is enabled. The system IP address of the S7-1500R/H redundant system is in "Address".

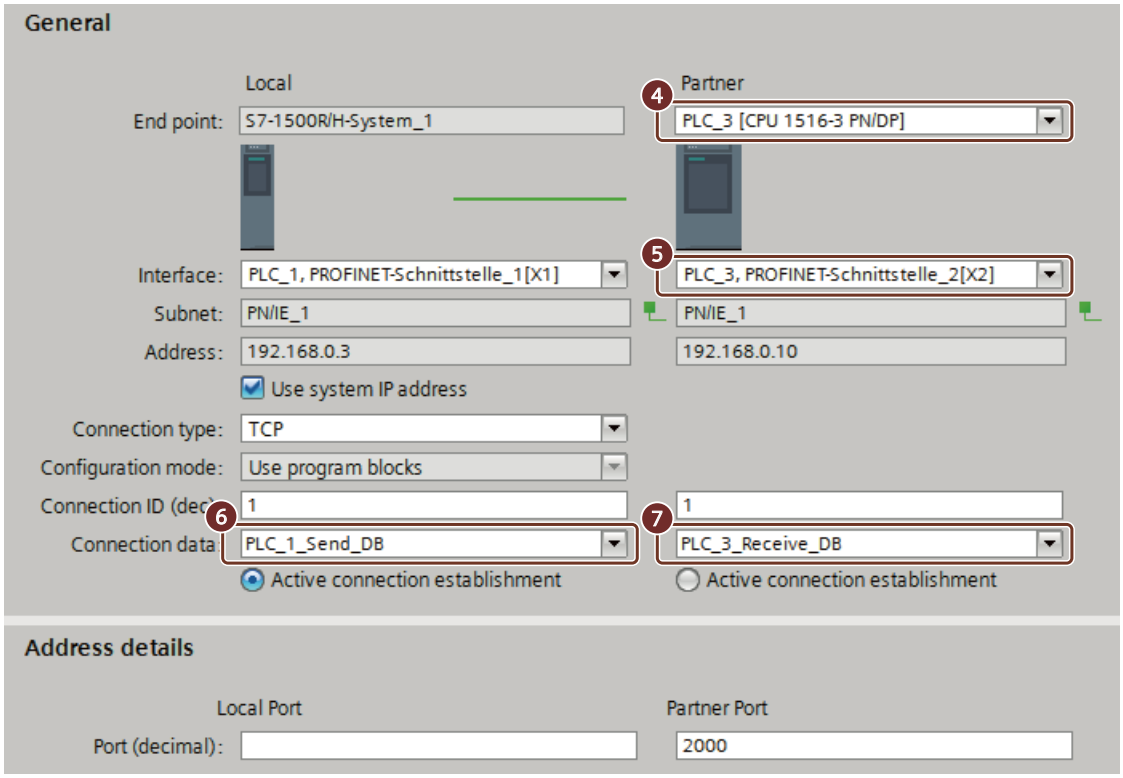

Figure 3-564 S7-1500R/H: Assigning parameters to the TSEND_C instruction in STEP 7

4. In "Partners" under "End point:" select the CPU 1516-3PN/DP as the communication partner.
5. In "Partners" under "Interface:" select the PROFINET interface X2 of the CPU 1516-3PN/DP.
6. In "Local" under "Connection data" select the setting "<new>".
   STEP 7 creates a data block for the connection data in the user program of the S7-1500R/H redundant system, for example "PLC_1_Send_DB".
   "TCP" is set by default as the connection type.
7. In "Partners" under "Connection type" select the setting "NEW".
   STEP 7 creates a data block for the connection data in the user program of the other CPU, for example "PLC_3_Receive_DB".

TRCV_C instruction in the user program of the CPU 1516 3PN/DP

Create a TRCV_C instruction in the user program of the CPU 1516-3PN/DP and assign parameters as below:

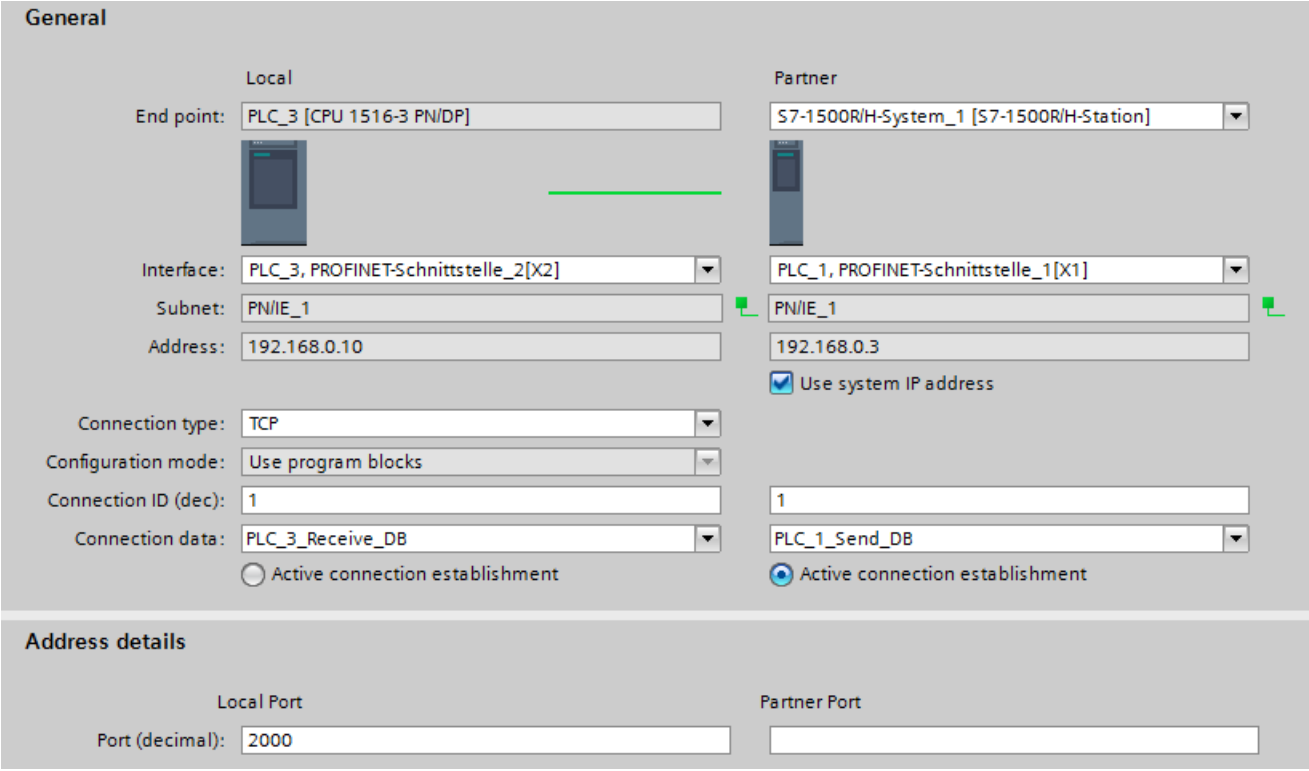

Figure 3-565 S7-1500-3PN/DP: Assigning parameters to the TRCV_C instruction in STEP 7

Setting up a connection via a device IP address

To set up an OUC-connection via a device IP address of one of the two CPUs:

- Select a suitable PROFINET interface of the S7-1500R/H redundant system.
- Clear the "Use system IP address" check box.

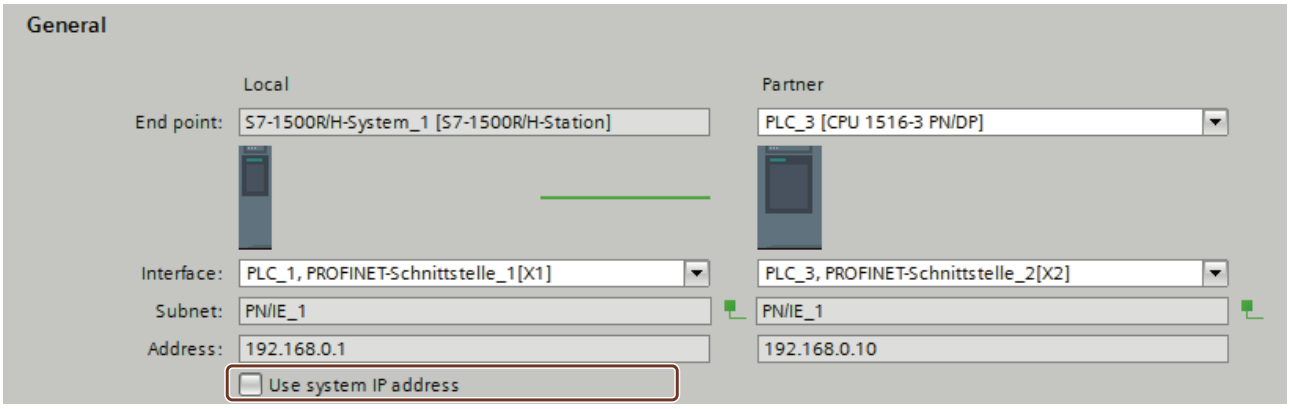

Figure 3-566 OUC-connection via a device IP address

More information

You can find more information on system states in the S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833) system manual.

You can find more information on the configuration and parameter assignment of your PROFINET IO system in the PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856).

16.8.2 Open User Communication with CP 1543-1 communications processors

Introduction

You can use both Open User Communication (OUC) as well as Secure OUC via the CP 1543-1 communications processors.

If you want to use Secure OUC, the following additional requirements must be met so that you can handle the device and CA certificates:

- Project protection is activated
- Security functions are enabled in each CP 1543-1 you want to use for Secure OUC.
- Same security settings in each CP on both primary and backup CPUs in the same slot
- The same CA certificates are configured for both CPs
- The device certificates of the CPs each refer to both CPs, e.g. configure an Subject Alternative Name (SAN) in both device certificates

---

NOTE

No automatic synchronization of the security settings

In STEP 7, the security settings are not automatically synchronized between the CPs. Therefore, configure the CPs in the same slot of the primary and backup CPUs identically.

Connection options for Open User Communication via CPs

For the following configurations, the OUC connection to a partner always goes via the local CP interface, regardless of whether OUC or Secure OUC is being used. Depending on which configuration you use, you have to adapt the connection parameters when setting up the communication connection. Select the corresponding HW identifier of the interface at the connection parameters using one of the following options:

- Use the CP interface with a local IP address:
  For the "InterfaceId" connection parameter, specify the HW identifier of the local Ethernet interface of a CP, e.g. "Local1~CP_1543-1_1~Ethernet_interface_1". Use the CP interfaces of both primary and backup CPUs in the RUN-Redundant system state.
- Use the W1 virtual interface of the CPU with a configured device IP address:
  For the "InterfaceId" connection parameter, specify the HW identifier of the virtual interface of a CPU, e.g. "Local1~Virtual_communication_interface". Use the virtual W1 interfaces of both the primary and backup CPUs in the RUN-Redundant system state
- Use the virtual W1 interface of the CPU with a configured system IP address:
  For the "InterfaceId" connection parameter, specify the HW identifier of the object with the string "...HSystemIPRef..." and the "Virtual" identifier in the default name, e.g. "Local1~Virtual_communication_interface~HsystemIPRef_1". This object then references the system IP address of the virtual W1 interface of the CPU.

Creating a connection via CPs

You can create the connection as for an integrated PROFINET interface of the S7-1500R/H redundant system. However, you have to adapt the connection parameters accordingly. Select the CP 1543-1 communications processor to be used in the "Interface" selection list.

If you want to use the "Use system IP address" option, a system IP address must be configured for the W1 virtual interface.

Selecting certificates for Secure Open User Communication via CPs

Depending on how you configure the S7-1500R/H station with a CP 1543-1, the following certificate rules are valid for communication with connection partners:

- Communication via CP interface with local IP address:
  Use the device certificate of the CP for authentication. For the connection partner to be able to validate the device certificate, the CA certificate of the CP must be available there under "Certificates of the partner devices".
- Communication via the virtual W1 interfaces of the CPUs with configured system IP address:
  Use a device certificate of the CPU for authentication. So that the connection partner can validate the device certificate, the certificate authority of the CPU must be present there under "Certificates of the partner devices".

More information

You can find information on how to create or assign certificates in the Managing certificates (Page 65) section.

You can find information about Secure Open User Communication via a CP interface in the Secure OUC via CP interface (Page 100) section.

16.9 Using an OPC UA server in an S7-1500R/H system

16.9.1 Information worth knowing on the OPC UA server in the S7-1500R/H system

As of firmware version V3.1, S7-1500R/H CPUs support OPC UA server functions. An OPC UA client is not supported.
As of firmware version V4.1, the OPC UA server and the web server of S7-1500R/H CPUs support the management of certificates, trust and revocation lists at runtime via GDS Push. You can find information on certificate management via GDS in the section Certificate management via Global Discovery Server (GDS) (Page 202).

The extensions for the OPC UA server of S7-1500R/H systems comply with the OPC 10000-4 specification: Services (Rel. 1.04), taking into account the restrictions described below.

The OPC UA server is accessible via all the integrated interfaces of the CPUs as well as via a CP 1543-1. To this end, the CP must be connected via the virtual interface W1 of the CPU (area "Access to PLC via communication module" in the CPU properties).

An OPC UA server facilitates open and standardized access to the CPU. In the R/H system, an OPC UA server runs on each of the two CPUs. The OPC UA servers of the primary and backup

CPUs synchronize via redundancy mechanisms. In redundant operation, it is 1 server application from the perspective of an OPC UA client.

Compared to standard CPUs, S7-1500R/H CPUs offer an advanced information model. With this advanced information model, it is possible for clients to take into account the specific features of the redundant system.

From the perspective of an OPC UA client, the same mechanisms are used to access the S7-1500R/H system (e.g. Discovery Service) as when accessing standard S7-1500 CPUs.

Restrictions for the OPC UA servers

When the OPC UA server is used in the S7-1500R/H system, there are restrictions as compared to the scope of capabilities of standard S7-1500 CPUs:

- Data access only via server interfaces. The standard SIMATIC server interface is not supported. Therefore, a nodeset export (OPC UA XML file of the standard SIMATIC server interface) is also not supported.
- No support of Alarms & Conditions.
- No access to the address space of a CPU's own OPC UA server via the OPC_UA_ReadList and OPC_UA_WriteList instructions.

  That is, the functions described in the following sections of the TIA Portal information system are not possible:

  – Diagnosing the OPC UA server with OPC_UA_ReadList
  – Set OPC UA-DataValue with OPC_UA_WriteList
- The resolution of the time stamps provided by the server is 1 ms (standard CPU: 1 ns).

An overview of the general restrictions of the S7-1500R/H redundant system compared to the S7-1500 automation system can be found in the section "Application planning > Restrictions" in the S7-1500R/H redundant system System Manual (https://support.industry.siemens.com/cs/ww/en/view/109754833).

You can find a description of how to configure an OPC UA server (e.g. creating server interfaces) in the OPC UA communication (Page 172) section or in the information system of the TIA Portal.

Limiting the amount of data for read and write accesses

The limitation of the data volume for write and read accesses applies to all R-CPUs. For H-CPUs as of FW version V4.0, the limitation does not apply.

In order to limit the time variance ("jitter") when accessing large amounts of data, the amount of data for read and write accesses is limited to **32 KB** when the OPC UA server is enabled.

- The write accesses also include the input arguments of method calls.
- The read accesses also include subscriptions and output arguments of method calls.

The limitation affects the OPC UA side, i.e. after S7 data has been encoded for transfer on the line or before it has been mapped to S7 data. It is therefore not just pure "Net data" or payload, but also contains metadata for coding.

The amount of metadata depends on the data types used. With basic data types or elementary data types, the amount of user data is large in relation to the metadata.

Complex data types require more metadata. The limitation on the OPC UA side concerns the OPC UA data type OPC UA variant, see OPC UA variant specification (https://reference.opcfoundation.org/Core/Part6/v105/docs/5.1.9).

Influence on cycle and response times

If you enable the OPC UA server of an S7-1500R/H system, this will affect the cycle and response times.

You must consider the following effects:

- The cycle time for an S7-1500R/H system in the RUN-Redundant system state is extended by activating the OPC UA server.
- The accuracy with which higher-priority alarms interrupt a cycle OB, for example, decreases. Example: The "Jitter" for a cyclic interrupt increases.
- Otherwise, the basic rules from the following document apply: Function Manual "Cycle and Response Times" (https://support.industry.siemens.com/cs/us/en/view/59193558).

⚠ CAUTION

Thorough testing of the maximum cycle time during the commissioning phase

During the commissioning phase, check whether the S7-1500R/H system works reliably with the set maximum cycle time even under worst-case conditions (alarms, communication load from maximum number of clients including connection/disconnection).

Requirements

- TIA Portal V19 with installed Hardware Support Package (HSP) "HSP_V19_0445_001_S71500_RH_3.1".

  The S7-1500R/H CPUs are installed with this HSP.

Redundancy at OPC UA

The redundant system consisting of two or more servers is called a "Redundant Server Set" in OPC UA. Server redundancy in accordance with the OPC UA specification recognizes the following operating modes (Modes of Redundancy):

- Transparent Mode (transparent Redundancy)

  In transparent operating mode, the server is solely responsible for failover in the event of an error (Failover). The OPC UA client does not require any redundancy knowledge to continue the data exchange. To work in Transparent Mode, the client must connect to the system IP address of the CPU interface. If you are using a CP 1543-1, use the virtual interface W1 of the CPU with the configured system IP address.

- Non-transparent Mode (non-transparent Redundancy)

  In non-transparent mode, the client is responsible for switching from one server to the other in the event of an error (Failover). The client must initiate the required actions in order to benefit from the redundant system. To work in non-transparent Mode, the client must connect to the corresponding device IP addresses of the R/H CPUs. If you are using a CP 1543-1, use the virtual interfaces W1 of the CPUs with configured device IP addresses

An S7-1500R/H system supports both operating modes.

The Redundant Server Set provides access to information on availability via the "ServiceLevel" variable; a byte that numerically reflects the "Health status" of a server.

The ServiceLevel allows conclusions to be drawn about the redundancy status, e.g. whether the CPU is the primary or backup CPU or whether the system is in the RUN-Redundant system state. You can find information on the ServiceLevel in the section on non-transparent mode (Page 486).

More information

You can find additional and up-to-date information on using the OPC UA server with S7-1500R/H systems in the following entry: FAQ How do you use the OPC UA server in an S7-1500 R/H system? (https://support.industry.siemens.com/cs/ww/en/view/109822965)

16.9.2 Transparent Mode (transparent Redundancy)

Details on transparent redundancy are explained below - an operating mode that allows a client to deal with the redundant system as with a single system or with an OPC UA server of a standard CPU.

Primary CPU always accessible via system IP address

For an S7-1500R/H station, use the system IP address for transparent redundancy. With the system IP address, a client accesses the primary CPU, i.e. the CPU that is currently hosting this IP address.

The following figure shows an example of the use of the transparent redundancy according to OPC UA 10000-4.

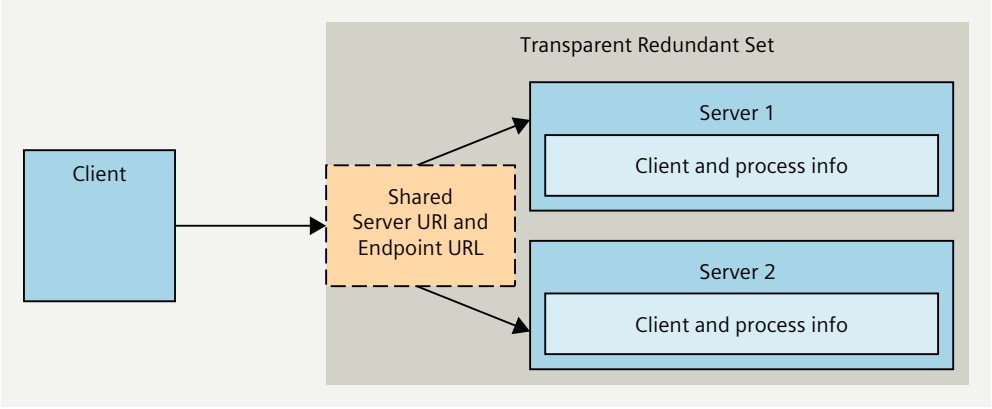

Response upon loss of primary CPU (RUN-Redundant > RUN-Solo)

In the event of an error (failover), communication between the client and server is briefly interrupted. All established sessions and subscriptions are retained and can be resumed - with the new primary CPU. In this case, the behavior from the client's point of view corresponds to the behavior in the event of temporary communication errors in which the session is also resumed.

As soon as the new primary CPU can be accessed after the failover via the system IP address, the client can resume communication (reactivate session).

Behavior when restoring redundancy (SYNCUP > RUN-Redundant)

If the initial state of the redundant system is restored after a failover, e.g. after replacing the faulty CPU, the system performs a SYNCUP.

During SYNCUP, the OPC UA servers are restarted in both CPUs. All existing sessions and subscriptions are deleted.

As soon as the server of the primary CPU is accessible again, the client must recreate the sessions and subscriptions.

Relevant nodes in the information model for transparent redundancy

Information in the information model on transparent mode of the R/H station can be found under the "ServerRedundancy" object (namespace index "0" or namespace "http://opcfoundation.org/UA/").

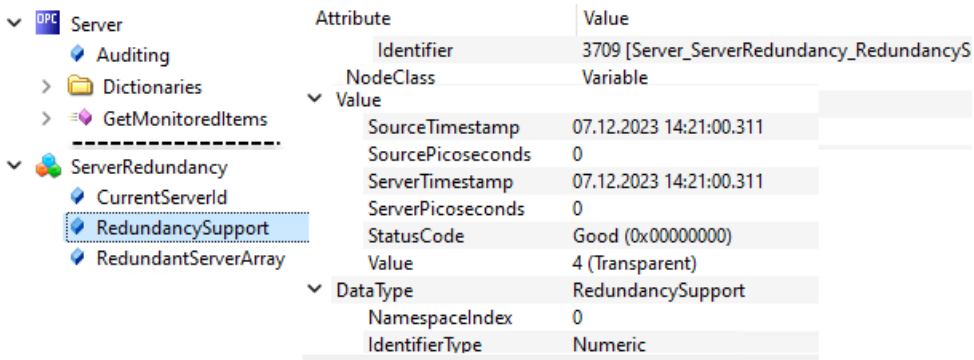

You can determine the ServerState and ServiceLevel of the redundant servers using the RedundantServerArray:

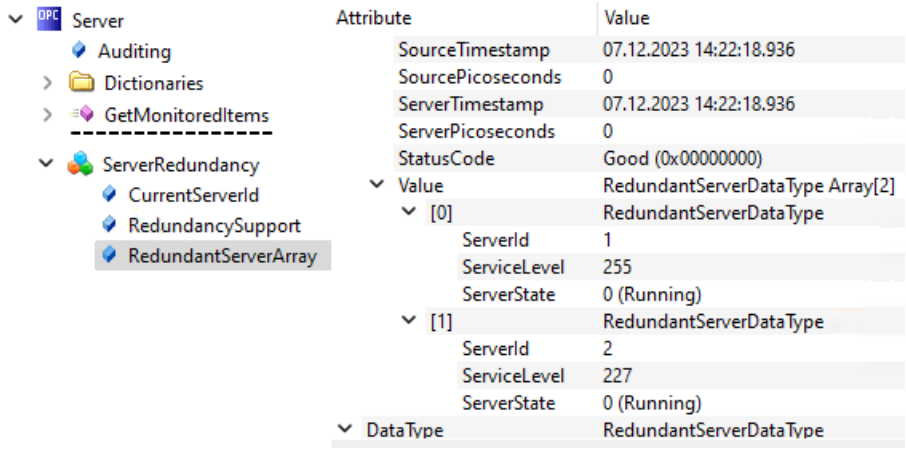

You can find more information on the ServiceLevel in the next section.

16.9.3 Non-transparent Mode (non-transparent Redundancy)

In the following, details on non-transparent redundancy are explained. In this operating mode, OPC UA provides the following information for a client:

- Which servers are available in the Redundant Server Set
- Which types of failover between the available servers are supported

This information allows the client to determine what it needs to do to achieve switchover. The client must not only be able to interpret the ServerRedundancy attribute, but also know the extended information model of the redundant server.

Address parameters of the redundant OPC UA server in an R/H system

In contrast to transparent redundancy, the servers in the R/H system are addressed via their unique IP address (device IP address or virtual IP address in the case of a configured CP 1543-1).

The following figure shows an example of the use of the non-transparent redundancy according to OPC UA 10000-4.

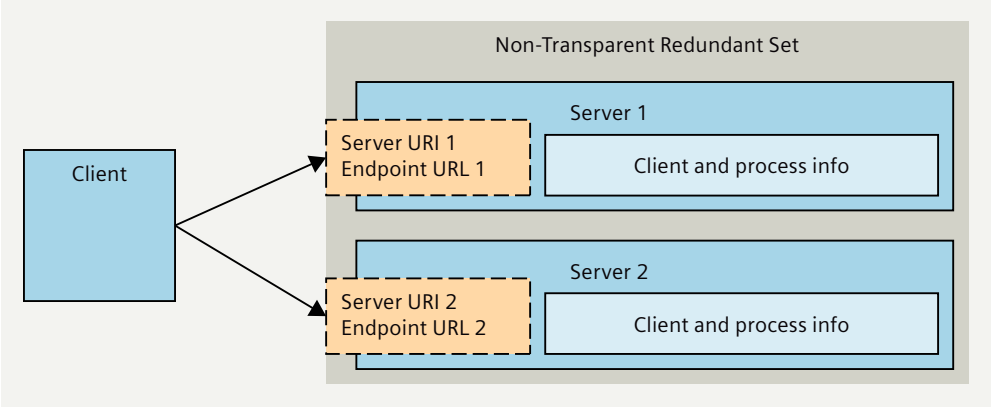

Response upon loss of primary CPU: Failover modes

According to OPC 1000-4: Services, servers can support different failover modes: Cold, Warm, Hot and HotAndMirrored.

The OPC UA server of an S7-1500R/H CPU supports "HotAndMirrored" failover mode.

The client must know that the OPC UA server is a redundant server and must perform the failover process in a certain way due to the supported Failover modes.

The way in which the failover process should take place is described in the OPC 10000-4 specification: Services, section "Client failover behavior - HotAndMirrored". The client is responsible for tracking the status of the server, i.e. periodically querying the ServiceLevel and switching to the alternative server (in the case of an S7-1500R/H system, this means the backup CPU) in the event of an error. This type of redundancy control offers the following advantages:

- The client has full control in the selection of the alternative server.
- The client can access the OPC UA server via separate networks.

The following figure from the specification OPC 10000-4: Services shows the steps that the client goes through when it receives the signal to switch to the "Alternate server" due to a low ServiceLevel value for the "Source server".

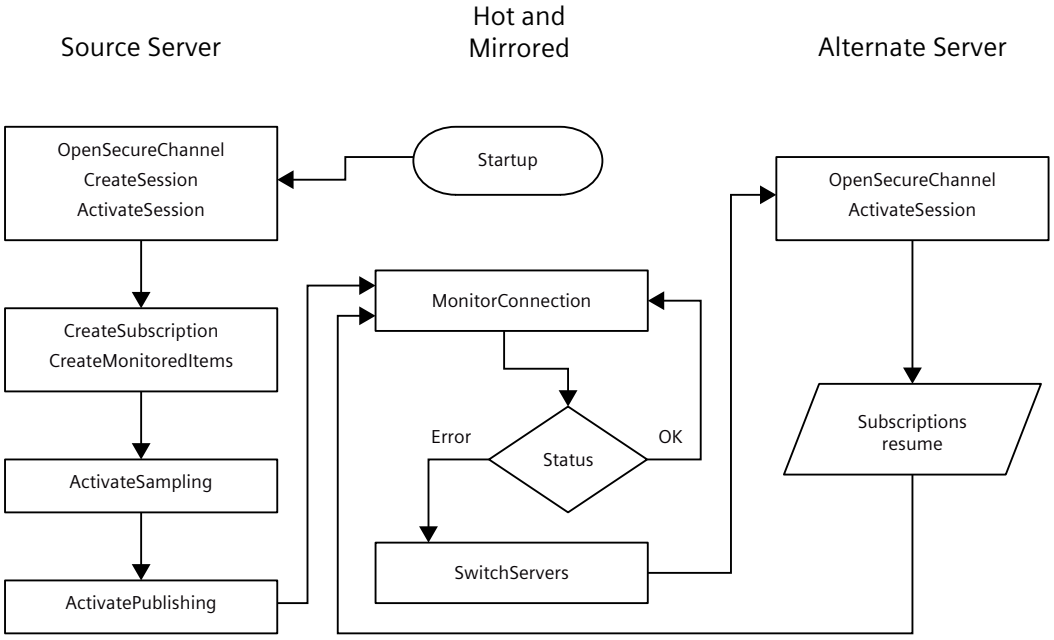

ServiceLevel

ServiceLevel is a variable that is modeled as a property of the ServerType object in the address space of the server. You use the ServiceLevel to find out whether the addressed server is still supplying data, for example. The ServiceLevel is a numerical value for the "Health status" of the server and thus provides the client with a trigger for switching the server.

The structure of the ServerType object is described in the OPC 10000-5: Information Model specification, section "ServerType".

For S7-1500R/H, the following ServiceLevel values apply to the respective OPC UA server:

- **RUN-Redundant**: ServiceLevel primary CPU = 255 (CPU in RUN), service level backup CPU = 227 (CPU in RUN).
- **CPU in STOP**: ServiceLevel of the failed CPU (RUN STOP transition) = 1 (NoData). This is the trigger for the client for the failover.

Example for a primary CPU in RUN:

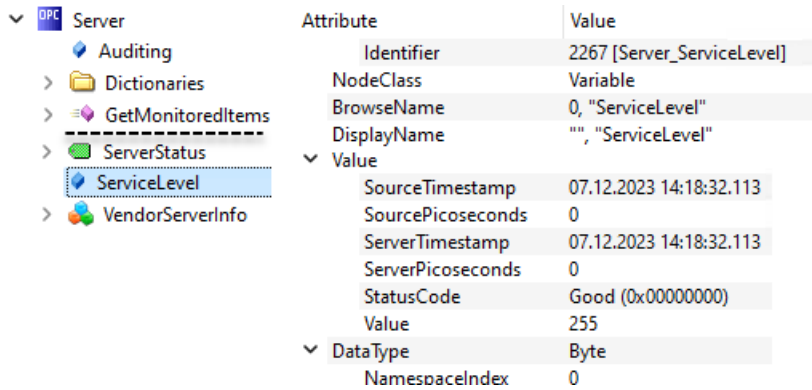

Application of non-transparent redundancy

If a client accesses the OPC UA server via different, i.e. independent subnets, transparent redundancy using the system IP address is not possible.

The following figure shows a configuration with an H system that is connected to a client via two subnets.

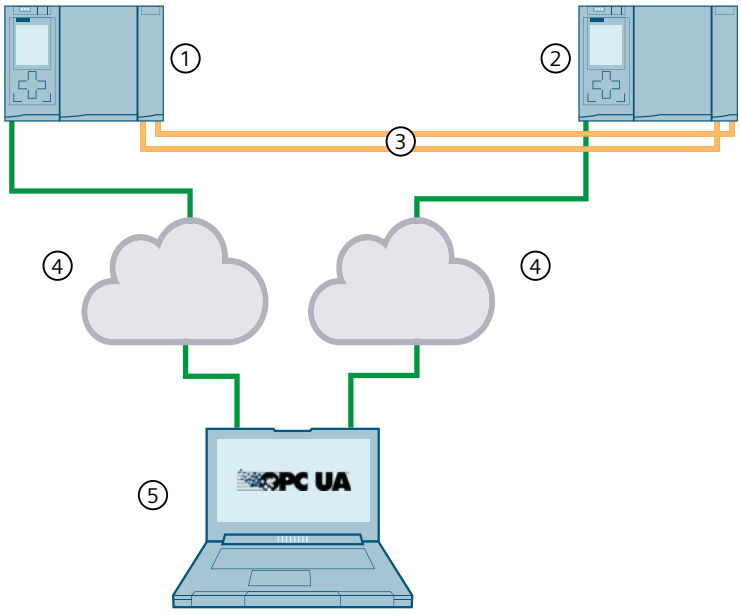

The client can connect to the H system via the two independent networks. The two H CPUs are not connected via one of the networks. In this way, the failure of a network can be tolerated.

Independent subnets are not a requirement for non-transparent mode. You can also use non-transparent mode for configurations with a subnet.

Relevant nodes in the information model for non-transparent redundancy

The information in the information model of the R/H station that is relevant for non-transparent mode is located under the "VendorServerInfo" object, a placeholder object for vendor-specific information about the OPC UA server. This vendor-specific node and the nodes below it are located in the namespace for the local server,
e.g. urn: SIMATIC.S7-1500.OPC-UA.Application:PLC_1 with namespace index 1.

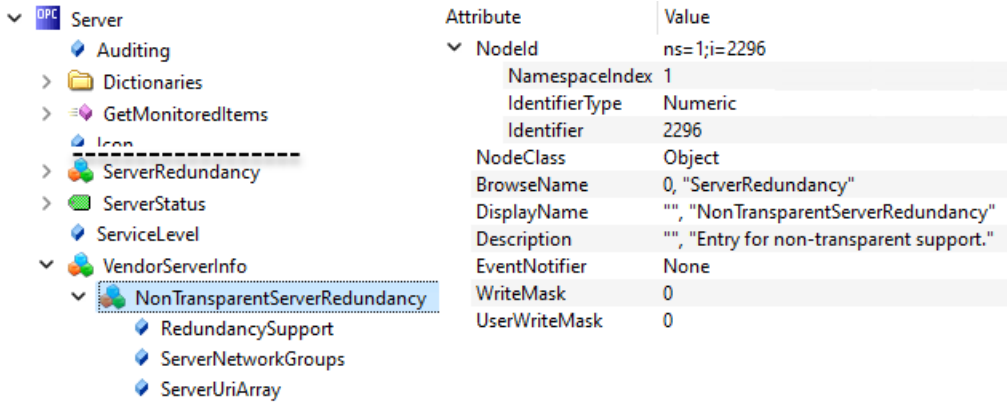

In the ServerRedundancy object below, a client can find all the required information to connect to the R/H system.

The ServerUriArray-Property allows a client to select a suitable server. The information on which network paths can be used to access the servers can be found via the object type NonTranparentNetworkRedundancyType - a subtype of NonTransparentRedundancyType. The object type NonTranparentNetworkRedundancyType references the ServerNetworkGroups variable, which contains an array of servers (EndpointUrlList) together with information on which redundant network paths exist for each server (NetworkPaths).

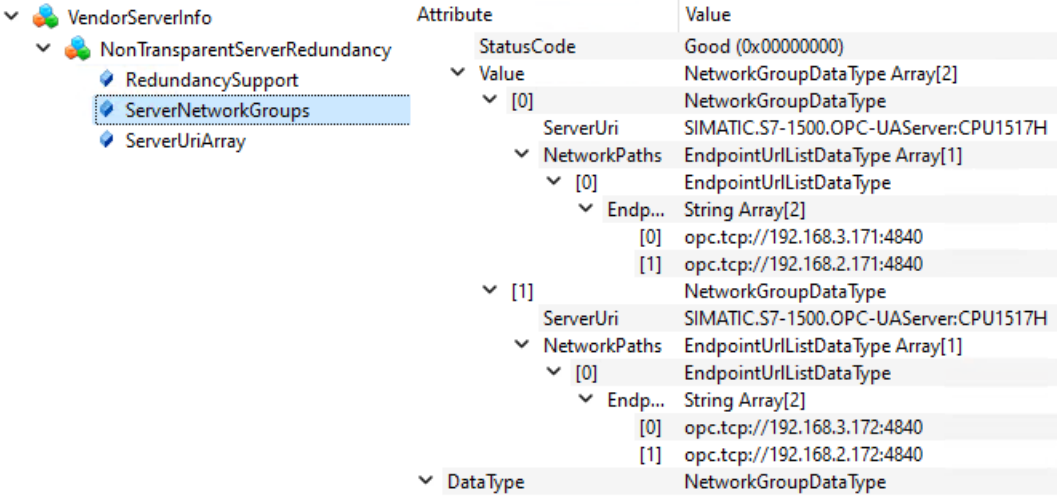

You can find a detailed description of the relevant nodes with their references below the VendorServerInfo node in the OPC UA specification (OPC 10000-5: Information Model).

For an S7-1500R/H system, the EndpointUrlList contains an entry for each device IP address or virtual device IP address (if configured together with a CP 1543-1) via which the servers of the S7-1500R/H system can be accessed. In the event of a failure, the client can decide whether to connect to the same server via a different path or whether to choose the redundant server.

16.9.4 Information model in detail

The following sections show the structure of the information model of an S7-1500R/H system in detail. The information model is suitable for both clients that access the R/H system like a standard CPU and clients that want to have full control over the R/H system.

Advanced information model for redundant systems

The following figure shows by way of example how the R/H system is modeled in the DeviceSet node as a separate object next to the individual R/H CPUs.

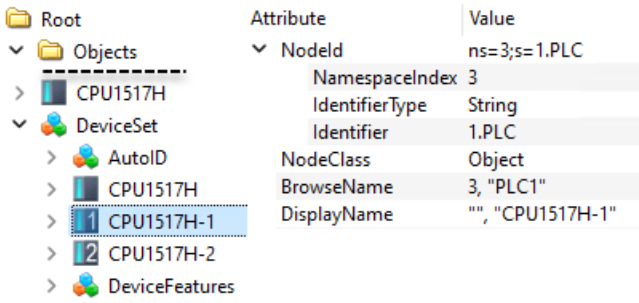

R/H system as a separate node in the information model

Under the DeviceSet node, in addition to the nodes for each R/H CPU, there is also a node as a representative for the R/H system.

The OPC UA server is temporarily not available in the SYNCUP system state (RUN-Syncup mode for primary CPU). The server restarts in this state.

The nodes represent the following information:

Node <configured name>	Contents	Accessible data in the RUN-Redundant system state	Accessible data in the RUN-Solo system state
<R/H system>	Information regarding the R/H system	Server interface data (identical for both CPUs) CPU-specific information of the primary CPU	Client is connected with: • Primary CPU: Data of the server interface of the primary CPU. • Backup CPU: Server interface data (if ServiceLevel = NoData: server interface data is invalid or not available).

Node <configured name>	Contents	Accessible data in the RUN-Redundant system state	Accessible data in the RUN-Solo system state
<PLC 1>	Information via R/H CPU with redundancy ID 1	Server interface data (identical for both CPUs) CPU-specific information of the CPU with redundancy ID 1	Client is connected with: • PLC 1 (= primary CPU): Data of the server interface of the primary CPU. • PLC 1 (= backup CPU): Server interface data (ServiceLevel = NoData signifies the data is invalid or not available). • PLC 2 (= backup CPU): No data (access error BadInvalidState / (BadResourceUnavailable))
<PLC 2>	Information via R/H CPU with redundancy ID 2	Server interface data (identical for both CPUs) CPU-specific information of the CPU with redundancy ID 2	Client is connected with: • PLC 2 (= primary CPU): Data of the server interface of the primary CPU. • PLC 2 (= backup CPU): Server interface data (ServiceLevel = NoData signifies the data is invalid or not available). • PLC 1 (= backup CPU): No data (access error BadInvalidState / (BadResourceUnavailable))

Nodes below the device nodes

Device nodes are the nodes below the DeviceSet node (R/H system, PLC 1, PLC 2).

The "OperatingMode" and "RedundancyMode" attributes are of particular interest.

Operating mode

The OperatingMode-Property below the R/H system node shows the operating mode of the primary CPU for the R/H system node.

The following values are defined for the individual CPUs of the R/H system and for the R/H system:

OperatingMode	R/H system	R/H CPU
1 (STOP - FW update)	x	x
3 (STOP - Initialization)	x	x
4 (STOP)	x	x
6 (Startup)	x	x
8 (RUN)	x	x
9 (RUN-Redundant)	x	x
10 (HOLD)	x	x
13 (Defective)	x	x
14 (Troubleshooting)	x	x
15 (No power)	x	x

OperatingMode	R/H system	R/H CPU
17 (STOP - no de-energized/substitute value switch for outputs)	x	x
18 (RUN - de-energized/substitute value switch for outputs)	x	x
19 (Program test)	x	x
20 (Run program test)	8 (RUN)	x (primary; backup in test mode)
21 (RUN Syncup)	8 (RUN)	x
22 (Syncup)	8 (RUN)	x
31 (Remote unknown)	x	-

Example with node attributes for OperatingMode:

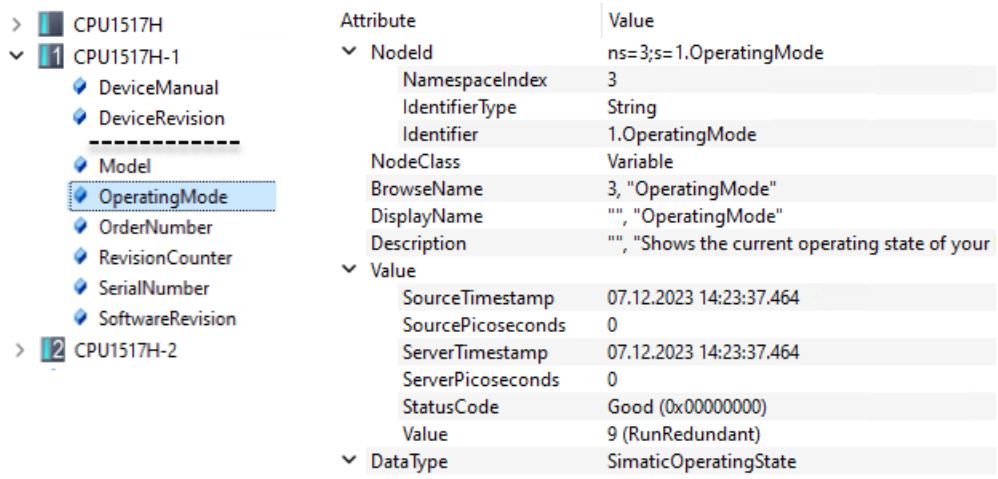

RedundancyMode

The RedundancyMode-Property shows the system status of the R/H system and is only available in the R/H system node.

RedundancyMode	R/H system	R/H CPU
32 (No power)	x	-
33 (STOP)	x	-
34 (HOLD)	x	-
35 (Startup)	x	-
37 (RUN-Solo)	x	-
38 (Syncup)	x	-
39 (Program test)	x	-
40 (Redundant)	x	-

Example with node attributes for RedundancyMode:

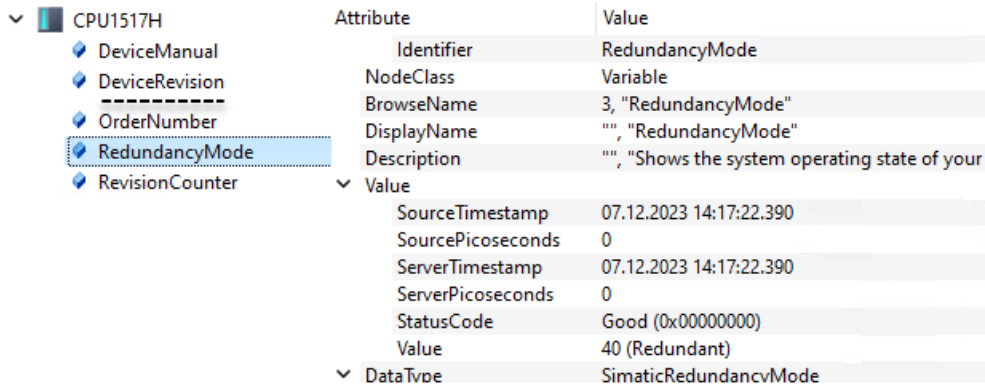

16.9.5 Updated instructions for server methods

To implement server methods in an S7-1500 CPU, use the "OPC_UA_ServerMethodPre" and "OPC_UA_ServerMethodPost" instructions. Details of the new version V1.1 of these two instructions are explained below.

- For S7-1500R/H CPUs as of FW version V3.1, version V1.1 of the server instructions is mandatory - the use of version V1.0 is not permitted.
- The recommendation applies to S7-1500 standard CPUs: For new projects starting from TIA Portal V19 and CPU firmware version V3.1, always use the new server instruction version V1.1 or higher.
- Within a project, you can use both the instructions with version V1.0 and the instructions with version V1.1. You can only use one version within a CPU user program.

To implement server methods in the user program, use the example program published here and not the example from the TIA Portal help system.

Implementing server methods in the user program

First, here is a brief summary of the procedure for providing an OPC UA method to the OPC UA server of an S7-1500 CPU via the user program. This method can then be called by any OPC UA client.

- A function block (FB) represents the server method in the user program.
- This FB must be called cyclically (e.g. by OB 1).
- In the FB, the "OPC_UA_ServerMethodPre" instruction must first be called in order to map the input parameters of the method that the client has given to the call to the corresponding CPU variables (input data transfer).
- After the "OPC_UA_ServerMethodPre" instruction has been called, the programmed algorithm (the method itself with processing of the input parameters and preparation of the output parameters) is processed.
- Once the programmed algorithm has been run and the output parameters have been calculated, the "OPC_UA_ServerMethodPost" instruction must be called. The "OPC_UA_ServerMethodPost" instruction ensures that the valid output data of the method is made available to the client.

- Observe the naming conventions when creating the OPC UA methods:
  - When calling the server methods, the function must be created as a multi-instance; the name of the multi-instance must be "OPC_UA_ServerMethodPre_Instance"/"OPC_UA_ServerMethodPost_Instance" so that the method is created in the address space.
  - When defining input parameters for the OPC UA method in the static area of the block, the name of the variable must be "UAMethod_InParameters" so that the input parameters of the method are displayed.
  - When defining the output parameters of the OPC UA method in the static area of the block, the name of the variable must be "UAMethod_OutParameters" so that the output parameters of the method are displayed.

Sequence of the user program

The two "OPC_UA_ServerMethodPre" and "OPC_UA_ServerMethodPost" instructions are asynchronous instructions that do not have a "REQ input" that triggers the start of the respective instruction.

The "OPC_UA_ServerMethodPre" instruction is triggered implicitly by the OPC UA client calling the OPC UA method (edge trigger). This means that, whenever the method has not been called by the client in a cycle and is called in the following cycle, the following happens:

- The STATUS changes from 0x7000 (no call) to 0x7001 (first call). The BUSY output parameter is set to "1".
- If the data transfer takes longer than one cycle, the status changes to 0x7002 (intermediate call) after the first cycle.
- When the input data transfer is complete:
  - DONE changes to "1".
  - UAMethodCalled changes to "1".
  - BUSY is reset to "0".
- "OPC_UA_ServerMethodPre" and "OPC_UA_ServerMethodPost":
  - When the output data transfer is completed for the OPC_UA_ServerMethodPost instruction, DONE changes to "1".
    This is the condition for resetting the input parameters "UAMethod_Finished" and "UMethod_Result" (see example program).
  - After a further cycle, all output parameters are reset (corresponds to a falling edge for REQ-triggered instructions).
  - The respective instances of the instructions are then released again (max. 20 instances can be active at the same time).

Compatibility between version V1.0 and V1.1 of the instructions

There are the following differences between version V1.0 and V1.1 with regard to the server instructions:

- Resetting the output parameter "UAMethod_Called" of the server instruction "OPC_UA_ServerMethodPre":
  - V1.0: "UAMethod_Called" is automatically reset if both "DONE" of the "OPC_UA_ServerMethodPre" instruction and "DONE" of the "OPC_UA_ServerMethodPost" instruction are reset. "UAMethod_Called" is therefore only reset when "OPC_UA_ServerMethodPost" is completed.
  - V1.1: "UAMethod_Called" is automatically reset when output parameter "DONE" of the "OPC_UA_ServerMethodPre" instruction is reset.
- Release of the instances of "OPC_UA_ServerMethodPre" and "OPC_UA_ServerMethodPost":
  - V1.0: No cyclic call of the server instructions required.
  - V1.1: Mandatory cyclical call of the server instructions required.

NOTE

When switching to the OPC UA server methods from version V1.0 to version V1.1, check whether your user program takes into account the described rules and the adapted functionality. Adjust the program if necessary.

Example program

```
FUNCTION_BLOCK "mySERVER_METHOD"
{ S7_Optimized_Access := 'TRUE' }
VERSION : 0.1
 VAR DB_SPECIFIC
 UAMethod_InParameters : Struct
 IN_BOOL : Bool;
 IN_INT : Int;
 END_STRUCT;
 UAMethod_OutParameters : Struct
 OUT_BOOL : Bool;
 OUT_INT : Int;
 END_STRUCT;
 END_VAR
 VAR
OPC_UA_ServerMethodPre_Instance {InstructionName :=
'OPC_UA_ServerMethodPre'; LibVersion := '1.1'} :
OPC_UA_ServerMethodPre;
 DONE_PRE { S7_SetPoint := 'True'} : Bool;
 BUSY_PRE : Bool;
 ERROR_PRE : Bool;
 STATUS_PRE : DWord;
 UAMethod_Called : Bool;
 OPC_UA_ServerMethodPost_Instance {InstructionName :=
'OPC_UA_ServerMethodPost'; LibVersion := '1.1'} :
OPC_UA_ServerMethodPost;
 UAMethod_Result { S7_SetPoint := 'True'} : DWord;
 UAMethod_Finished : Bool;
 DONE_POST { S7_SetPoint := 'True'} : Bool;
 BUSY_POST : Bool;
 ERROR_POST : Bool;
```

```
 STATUS_POST : DWord;
 END_VAR
BEGIN
 #OPC_UA_ServerMethodPre_Instance(Done => #DONE_PRE,
 Busy => #BUSY_PRE,
 Error => #ERROR_PRE,
 Status => #STATUS_PRE,
 UAMethod_Called => #UAMethod_Called,
 UAMethod_InParameters := #UAMethod_InParameters);

//Method is called
IF #UAMethod_Called AND NOT #ERROR_PRE THEN

(* Functionality:
InParameters are valid
and copied to OutParameters *)

#UAMethod_OutParameters.OUT_BOOL := #UAMethod_InParameters.IN_BOOL;

#UAMethod_OutParameters.OUT_INT := #UAMethod_InParameters.IN_INT;


(* If Method is finished without errors
prepare output parameters of OPC_UA_ServerMethodPost accordingly *)

#UAMethod_Result := 0;
 #UAMethod_Finished := TRUE;
 END_IF;



#OPC_UA_ServerMethodPost_Instance(UAMethod_Result :=
#UAMethod_Result,
 UAMethod_Finished := #UAMethod_Finished,
 Done => #DONE_POST,
 Busy => #BUSY_POST,
 Error => #ERROR_POST,
 Status => #STATUS_POST,
 UAMethod_OutParameters := #UAMethod_OutParameters);

//Reset Input Parameters after OPC_UA_ServerMethodPost is done
IF #DONE_POST OR #ERROR_POST THEN

#UAMethod_Finished := FALSE;
 #UAMethod_Result := 0;

END_IF;



END_FUNCTION_BLOCK
```

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All-round protection - the task of Industrial Ethernet Security

With Industrial Ethernet Security, individual devices, automation cells or network segments of an Ethernet network can be protected. Data transfer can also be protected by a combination of different security measures:

- Data espionage
- Data manipulation
- Unauthorized access

Security measures

- Firewall
  - IP firewall with stateful packet inspection (layer 3 and 4)
  - Firewall also for Ethernet "non-IP" frames according to IEEE 802.3 (layer 2)
  - Bandwidth limitation
  - Global firewall rules

  All network nodes located in the internal network segment of a CP 1543-1 are protected by its firewall. Exception: If you access the CPU via the interface of the CP with the "Access to PLC via communication module" function, the firewall does not protect this connection.
- Logging

  To allow monitoring, events can be stored in log files that can be read out using the configuration tool or can be sent automatically to a Syslog server.
- HTTPS

  For encrypted transfer of websites, for example during process control.
- FTPS (explicit mode)

  For encrypted transfer of files.
- Secure NTP

  For secure time-of-day synchronization and transmission.
- SNMPv3

  For secure transmission of network analysis information safe from eavesdropping.

- VPN groups
  You can combine the CP 1543-1 with other security modules into VPN groups through configuration. IPsec tunnels are established between all the security modules of a VPN group (VPN). All internal nodes of these security modules can communicate securely with each other through this tunnel.
- Protection for devices and network segments

  The firewall and VPN groups protective functions can be applied to the operation of single devices, multiple devices, or entire network segments.

Additional information

An overview with links to the most important contributions on Industrial Security is available in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/92651441).

17.1 Firewall

Tasks of the firewall

The purpose of the firewall functionality is to protect networks and stations from outside influences and disturbances. This means that only certain previously specified communications relations are permitted.

To filter the data traffic, IPv4 addresses, IPv4 subnets, port numbers or MAC addresses among other things can be used.

The firewall functionality can be configured for the following protocol levels:

- IP firewall with stateful packet inspection (layer 3 and 4)
- Firewall also for Ethernet "non-IP" frames according to IEEE 802.3 (layer 2)

Firewall rules

Firewall rules describe which packets are permitted or forbidden in which direction.

17.2 Logging

Functionality

For test and monitoring purposes, the security module has diagnostics and logging functions.

- Diagnostics functions

  These include various system and status functions that you can use in online mode.

- Logging functions

  This involves the recording of system and security events. Depending on the event type, the recording is made in volatile or non-volatile local buffer areas of the CP 1543-1. As an alternative, it is also possible to record on a network server.

  The parameter assignment and evaluation of these functions is only possible with a network connection.

Recording events with logging functions

You specify which events should be recorded with the log settings. Here you can configure the following recording variants:

- Local logging

  With this variant, you record the events in local buffers of the CP 1543-1. In the online dialog of the Security Configuration Tool, you can then access these recordings, visualize them and archive them on the service station.

- Network Syslog

  With the network Syslog, you use a Syslog server in the network. This records the events according to the configuration in the log settings.

17.3 NTP client

Functionality

To check the time validity of a certificate and the time stamp of log entries, the date and time are maintained on the CP 1543-1 as on the CPU. This time can be synchronized with NTP. The CP 1543-1 forwards the synchronized time to the CPU via the backplane bus of the automation system. This way the CPU also receives a synchronized time for the time events in program execution.

The automatic setting and periodic synchronization of the time takes place either via a secure or non-secure NTP server. You can assign a maximum of 4 NTP servers to the CP 1543-1. A mixed configuration of non-secure and secure NTP servers is not possible.

17.4 SNMP

Functionality

Like the CPU, the CP 1543-1 supports the transfer of management information using the Simple Network Management Protocol (SNMP). To achieve this, an "SNMP agent" is installed on the CP/CPU that receives and responds to the SNMP queries. Information about the properties of devices capable of SNMP is contained in so-called MIB files (Management Information Base) for which the user needs to have the appropriate rights.

With SNMPv1, the "community string" is also sent. The "community string" is like a password that is sent along with the SNMP query. The requested information is sent when the "community string" is correct. The request is discarded when the string is incorrect.

With SNMPv3, data can be transferred encrypted. To do this, select either an authentication method (e.g. SHA) or an authentication and encryption method (e.g AES).

You can activate and deactivate the use of SNMP for the CP/CPU. Deactivate SNMP if the security guidelines in your network do not permit SNMP or if you use your own SNMP solution.

To find out how to activate and deactivate SNMP for the CPU, refer to section SNMP (Page 121).

17.5 VPN

Functionality

For security modules that protect the internal network, VPN (Virtual Private Network) tunnels provide a secure data connection through the non-secure external network.

The module uses the IPsec protocol (tunnel mode of IPsec) for tunneling.

In STEP 7 you can assign VPN groups to security modules. VPN tunnels are automatically established between all modules of a VPN group. A module in one project can belong to several different VPN groups at the same time in the process.

SIEMENS

SIMATIC

S7-1500, ET 200MP, ET 200SP, ET 200BL, ET 200AL, ET 200pro, ET 200eco PN, ET 200clean PROFINET with STEP 7

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Introduction 1

Purpose of the documentation

This Function Manual provides an overview of the PROFINET communications system together with SIMATIC STEP 7.

STEP 7 is integrated into the high-performance, graphical Totally Integrated Automation Portal (TIA Portal), the integration platform for all automation software tools.

This Function Manual supports you in planning a PROFINET system. The manual is structured into the following subject areas:

- PROFINET basics
- PROFINET diagnostics
- PROFINET functions

Basic knowledge required

The following knowledge is required in order to understand the manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Knowledge about how to use STEP 7 (TIA Portal)

Scope

This documentation is the basic documentation for all SIMATIC products from the PROFINET environment. The product documentation is based on this documentation.

The examples are based on the functionality of the S7-1500 automation system.

What's new in the PROFINET Function Manual, Edition 11/2025 compared to Edition 11/2024?

Function	What are the customer benefits?	Where can I find this information?
Confirming authenticity of PROFINET GSD files with distributor ID	As of STEP 7 V21, you can add your distributor ID to an I-device. This allows you to digitally sign the exported GSD file in a GSDX file and thus confirm the authenticity of the GSD file. For the I-device, use the PROFINET interface of an S7-1500 CPU as of FW version V4.1 in order to be able to add a distributor ID.	Section PROFINET Security Class 1 (Page 37)

Function	What are the customer benefits?	Where can I find this information?
Operating multiple projects isochronously	You can implement IRT clock synchronization in multiple projects with a S7-1500 CPU as of FW version V4.1. The CPU must support the "PROFINET with IRT" functionality on several PROFINET interfaces.	Section Operating multiple projects isochronously (Page 250)

What's new in the PROFINET Function Manual, Edition 11/2024 compared to Edition 11/2023

Function	What are the customer benefits?	Where can I find this information?
Implementation of PROFINET Security Class 1	You read which configuration options for protocols and processes in STEP 7 V20 have been adapted for PROFINET Security Class 1.	Section PROFINET Security Class 1 (Page 37)
Shared device	As of STEP 7 V20, S7-1500 Software Controllers also support the shared I-device functionality. As of STEP 7 V20, you can also use CM 1542-1 communications modules as assigned IO controllers for shared devices. As of STEP 7 V20, you can also load shared device configurations into a project that is not empty.	Section Shared device (Page 153)
Configuring SNMP and DCP	As of STEP 7 V20, you can configure the SNMP and DCP settings for an entire PROFINET IO system centrally. IO devices that support configuration of SNMP and DCP synchronize to the SNMP/DCP settings of the PROFINET interface of their higher-lever IO controller by default.	Section PROFINET Security (Page 321)
Increase of the configuration limits	For S7-1500 CPUs as of FW version V4.0, you can connect a larger number of IRT-capable devices per PROFINET interface through skillful configuration.	Section PROFINET with performance upgrade (Page 219)
Operating several PROFINET networks in isochronous mode	As of STEP 7 V20, you can operate multiple PROFINET networks in isochronous mode at S7-1500 CPUs. The CPU must support the PROFINET functionality "PROFINET with IRT" at both PROFINET interfaces.	Section Operating multiple PROFINET networks in isochronous mode (Page 241)
	You implement IRT isochronous mode between S7-1500 CPUs as of FW version V4.0 in multiple projects through use of PN/PN couplers as of FW version V6.0.	Function Manual SIMATIC S7-1500/S7-1500T Synchronous operation functions (https://support.industry.siemens.com/cs/ww/en/view/109817888)

What's new in the PROFINET Function Manual, 11/2023 edition compared to 11/2022 edition

Function	What are the customer benefits?	Where can I find this information?
Implementation of PROFINET Security Class 1	You read which configuration options for protocols and processes in STEP 7 V19 have been adapted for PROFINET Security Class 1.	Section PROFINET Security Class 1 (Page 37)
Configuring SNMP and DCP	As of V19, STEP 7 offers extended configuration options for the SNMP and DCP protocols in order to meet the requirements for PROFINET Security Class 1.	Section PROFINET Security (Page 321)
Project-internal shared device / shared I-device	As of STEP 7 V19, a shared device/shared I-device can be created together with a maximum of two IO controllers in a project. Previously, the 2nd IO controller required a separate project.	Section Shared device (Page 153)
Handling timeouts during data exchange	In the case of high network loads, timeouts may occur during data record communication in PROFINET IO devices. Previously, PROFINET IO communication was terminated by the CPU in this case. As of STEP 7 V19 and FW version V3.1, you can configure the behavior of the respective PROFINET interface.	Section Dealing with timeouts while exchanging data (Page 313)

What's new in the PROFINET Function Manual, 11/2022 edition compared to 05/2021 edition

Function	What are the customer benefits?	Where can I find this information?
Project-internal shared device	As of STEP 7 V18, it is also possible to configure project-internal shared devices under certain conditions.	Section Shared device (Page 153)
Maintenance of the communication relation (AR)	In the event of high network load, the communication relation is terminated by the CPU. As of FW version V3.0, the communication relation can be maintained by writing a data record.	Section Dealing with timeouts while exchanging data (Page 313)
Support PROFINET system redundancy R1	As of FW version V3.0, the S7-1500H supports PROFINET system redundancy R1. R1 devices are equipped with two interface modules compared to S2 devices. If one interface module fails, the R1 device can still be reached by the H-CPUs via the second interface module. Thus, R1 devices have a higher availability than S2 devices.	Section PROFINET with redundant S7-1500R/H system (Page 331)
MRP interconnection	As of FW version V3.0, the CPUs of the S7-1500H redundant system may be located in 1 or 2 rings during MRP interconnection.	Section MRP Interconnection with the redundant S7-1500R/H system (Page 356)

What's new in the PROFINET Function Manual, Edition 05/2021 compared to Edition 11/2018

Function	What are the customer benefits?	Where can I find this information?
MRP interconnection	The MRP interconnection procedure is an extension of MRP. MRP interconnection allows the redundant coupling of 2 or more rings with MRP in PROFINET networks. MRP interconnection offers the following advantages: There is no limit to the maximum number of 50 devices in a ring when setting up redundant network topologies. Monitoring of larger topologies with ring redundancy.	Section MRP interconnection (Page 201) Section MRP interconnection with the redundant system S7-1500R/H (Page 356)
Enable/disable the I-device	You can use the "D_ACT_DP" instruction to locally disable or enable the I-device function in the user program of the I-device CPU.	Section Enabling/disabling I-device in the user program of the I-device CPU (Page 149)

What's new in the PROFINET Function Manual, Edition 11/2019 compared to Edition 10/2018

Function	What are the customer benefits?	Where can I find this information?
Direct data exchange	In the case of direct data exchange, an S7-1500 CPU provides cyclic net data from the I/O area to one or more partners. The "Direct data exchange" function enables deterministic, isochronous IO communication between multiple S7-1500 CPUs.	Section Direct data exchange (Page 257)
Switched S1 device	The "Switched S1 device" function of the CPU enables operation of standard IO devices in the S7-1500R/H redundant system.	Section Switched S1 device (Page 338)

What's new in the PROFINET Function Manual, Edition 10/2018 compared to Edition 12/2017

This manual (version 10/2018) includes the following new functions compared to the previous version (version 12/2017):

Function	Applications	Your benefits
PROFINET IO with the redundant S7-1500R/H system	In a PROFINET IO system with the redundant S7-1500R/H system, the IO communication continues even when one CPU fails.	The redundant S7-1500R/H system offers a high degree of reliability and system availability. A redundant configuration of the most important automation components reduces the probability of production downtimes and the consequences of component failures.

What's new in the PROFINET Function Manual, version 12/2017 compared to version 09/2016

This manual (version 12/2017) encompasses the following new functions compared to the previous version (version 09/2016):

Function	Applications	Your benefits
Specifying the router for a PROFINET IO device	You can specify the IP address of a router for each IO device. You reach the IO device from outside the IP subnet through the router.	In the past, it was only possible to specify a router for a PROFINET IO interface at the IO controller. The IO devices inherited the setting of the IO controller interface. Now you can set the router address independently of the IO controller setting. This allows, for example, a router address at the IO device although you have not set a router address or have set a different address at the IO controller.
Configuring an IO device through hardware detection	You can detect an existing IO device and enter it in your project.	STEP 7 inserts the IO device with all the modules and submodules into the project. Article numbers and firmware versions between real and configured IO devices match. You reduce the configuration effort required.
Asset management	You can centrally manage non-PROFINET components (assets) of a PROFINET device. The PROFINET device makes the identification data of the assets available for evaluation via a standardized data record.	The new standardized PROFINET service makes it possible to manage all the hardware and firmware components of PROFINET devices centrally. The possibilities available for filtering device data, for example, depend on the range of performance of the evaluating application.
Asset management data record for I-devices	Special application of asset management: From the point of view of a higher-level IO controller, the modules plugged into the I-device represent assets. The user program in the I-device compiles the asset management data record. The IO controller can read identification data of the I-device modules through this data record.	See Asset management.

What's new in the PROFINET Function Manual, Version 09/2016 compared to Version 12/2014

This manual (version 09/2016) encompasses the following new functions compared to the previous version (version 12/2014):

Function	Applications	Your benefits
PROFINET IO on the 2nd PROFINET interface	You can operate another PROFINET IO system on the CPU or connect additional IO devices.	You use a fieldbus type in the plant. The CPU can perform fast and deterministic data exchange as an I-device with a higher-level controller (PROFINET/Ethernet) through the second line.
IRT with very short data cycle times down to 125 µs	You realize high-end applications with IO communication which place very high performance demands on the IO processing.	You make PROFINET IO communication and standard communication possible via one cable even with a send clock of 125 µs.

Function	Applications	Your benefits
MRPD: Media Redundancy with Planned Duplication of frames	PROFINET IO IRT enables you to realize applications that place particularly high demands on the reliability and accuracy (isochronous mode).	By sending the cyclic IO data in both directions in the ring, the communication to the IO devices is maintained even when the ring is interrupted and does not result in device failure even with fast update times. You achieve higher reliability than with MRP.
PROFINET performance upgrade	You can implement applications with high speed and send clock requirements. This is of interest to applications with high demands on performance.	Better utilization of the bandwidth results in short reaction times.
Limitation of the data infeed into the network	You limit the network load for standard Ethernet communication to a maximum value.	You flatten peaks in the data feed. You share the remaining bandwidth based on demand.

Conventions

STEP 7: We refer to "STEP 7" in this documentation as a synonym for the configuration and programming software "STEP 7 as of V12 (TIA Portal)" and subsequent versions.

This documentation contains pictures of the devices described. The figures may differ slightly from the device supplied.

You should also pay particular attention to notes such as the one shown below:

NOTE

A note contains important information on the product, on handling of the product and on the section of the documentation to which you should pay particular attention.

1.1 SiePortal

You can find current information on the following topics quickly and easily here:

- **Catalog and ordering system**

  Ordering system for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.
- **mySiePortal**

  Your personal work area in the SiePortal for notifications, support requests, and configurable documents.

This information is provided by SiePortal on the Internet (https://sieportal.siemens.com/).

1.2 Function manuals documentation guide

1.2.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.2.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information

- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.2.3 S7 Port Configuration Tool (S7-PCT)

SIMATIC S7-PCT

The Port Configuration Tool (PCT) is a PC-based software for the parameter assignment of Siemens IO-Link Master modules and IO-Link devices from any manufacturer.

You integrate IO-Link-devices using the standardized device description "IODD", which you get from the respective device manufacturer. S7-PCT supports version 1.0 and V1.1 of the IODD.

S7-PCT is called via the hardware configuration of the IO-Link Master from STEP 7. When STEP 7 is not used or the IO-Link Master is not operated on a SIMATIC controller, "standalone"-operation is also possible.

You can find additional information on IO-Link on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/io-link.html).

1.2.4 S7 Failsafe Configuration Tool (S7-FCT)

SIMATIC S7-FCT

Failsafe Configuration Tool (FCT) enables you to GSD configure the following devices in third-party engineering systems:

- Selected, functionally fail-safe SIMATIC I/O devices
- Functionally fail-safe SIRIUS ACT PROFINET interfaces

The engineering system must meet the following requirements for this:

- Support of the CPD system integration acc. to "PROFIsafe - Profile for Safety Technology on PROFIBUS DP and PROFINET IO"
- TCI implementation to Conformance Class C3

Additional information on S7-FCT can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109762827).

1.2.5 MultiFieldbus Configuration Tool (MFCT)

MultiFieldbus Configuration Tool

MultiFieldbus Configuration Tool (MFCT) is a PC-based software and supports the configuration of MultiFieldbus- and DALI-devices. In addition, the MFCT offers convenient options for mass firmware updates of ET 200 devices with MultiFieldbus- support and reading service data for many other Siemens devices.

Functional scope of the MFCT

- MultiFieldbus configuration:
  Engineering, configuration and diagnostics of MultiFieldbus-devices, provision of the required project files (project, UDT-, CSV- and EDS-file), transfer/export of the files to device and/or data memory.
- DALI configuration:
  Device selection and online configuration of DALI devices.
- TM FAST:
  Generation and download of FPGA-UPD- and FPGA-DB-files.
- Maintenance:
  Topology scan of a Ethernet network, reading of service data, parameter assignment and firmware update.
- Settings:
  Language switching German / English, network scanner speed, setting of the network adapter, installation of GSDML-and EDS-files.

System/installation requirements for MFCT

The MFCT runs under Microsoft Windows and does not require installation or administrator rights.

For MFCT you must also install the following software:

- Microsoft .NET Framework 4.8 (You can find an Offline Installer on the Internet. (https://support.microsoft.com/en-us/topic/microsoft-net-framework-4-8-offline-installer-for-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0))
- NPcap from directory "Misc"
- PG/PC interface from directory "Misc"
- Microsoft C++ Redistributable for x86-systems (you can find the installation data for download on the Internet. (https://aka.ms/vs/15/release/vc_redist.x86.exe))

The download of the tool and further information as well as documentation on the individual functions of the MFCT can be found on the Internet.
(https://support.industry.siemens.com/cs/de/en/view/109773881)

1.2.6 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 General security information

Note the security-relevant information provided in the corresponding system manual.

You can find information relevant to cybersecurity in the section Industrial cybersecurity (Page 22).

Industrial cybersecurity 3

3.1 Introduction to industrial cybersecurity

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the System Manual and the Security guidelines for SIMATIC HMI devices (https://support.industry.siemens.com/cs/us/en/view/109481300) for general information and measures regarding industrial cybersecurity.

This section provides an overview of security-related information pertaining to the communication of your SIMATIC system.

NOTE

Security-related changes to software or devices are documented in the section Introduction (Page 7).

3.2 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

3.3 Cybersecurity-related information in this manual

Observe all security-related notes on topics in this Function Manual.

Security-relevant notes on ...	Section
PROFINET Security Class 1	PROFINET Security Class 1 (Page 37)

You can find security-relevant information on communication-specific topics, e.g. information on protocols in the Communication (https://support.industry.siemens.com/cs/us/en/view/59192925) Function Manual.

You can find information on creating a network concept and a secure network design in the following Internet entry (https://support.industry.siemens.com/cs/ww/en/view/109802750).

Description

4

4.1 Introduction to PROFINET

What is PROFINET IO?

Within the framework of Totally Integrated Automation (TIA), PROFINET IO is the logical further development of:

- PROFIBUS DP, the long-established fieldbus and
- Industrial Ethernet

PROFINET IO is based on 20 years of experience with the successful PROFIBUS DP and combines the normal user operations with the simultaneous use of innovative concepts of Ethernet technology. This ensures the integration of PROFIBUS DP into the PROFINET world.

PROFINET IO as the Ethernet-based automation standard of PROFIBUS/PROFINET International defines a cross-vendor communication, automation, and engineering model.

Objectives of PROFINET

The objectives of PROFINET:

- Industrial networking, based on Industrial Ethernet (open Ethernet standard)
- Compatibility of Industrial Ethernet and standard Ethernet components
- High robustness due to Industrial Ethernet devices. Industrial Ethernet devices are suited to the industrial environment (temperature, noise immunity, etc.).
- Use of IT standards such as TCP/IP, http.
- Real-time capability
- Seamless integration of other fieldbus systems

Implementation of PROFINET in SIMATIC

PROFINET is implemented in SIMATIC as follows:

- We have implemented communication between field devices in SIMATIC with **PROFINET IO**.
- Installation technology and network components are available as SIMATIC NET products.
- Ethernet standard protocol and procedures (e.g., SNMP = Simple Network Management Protocol for network parameter assignment and diagnostics) are used for remote maintenance and network diagnostics.

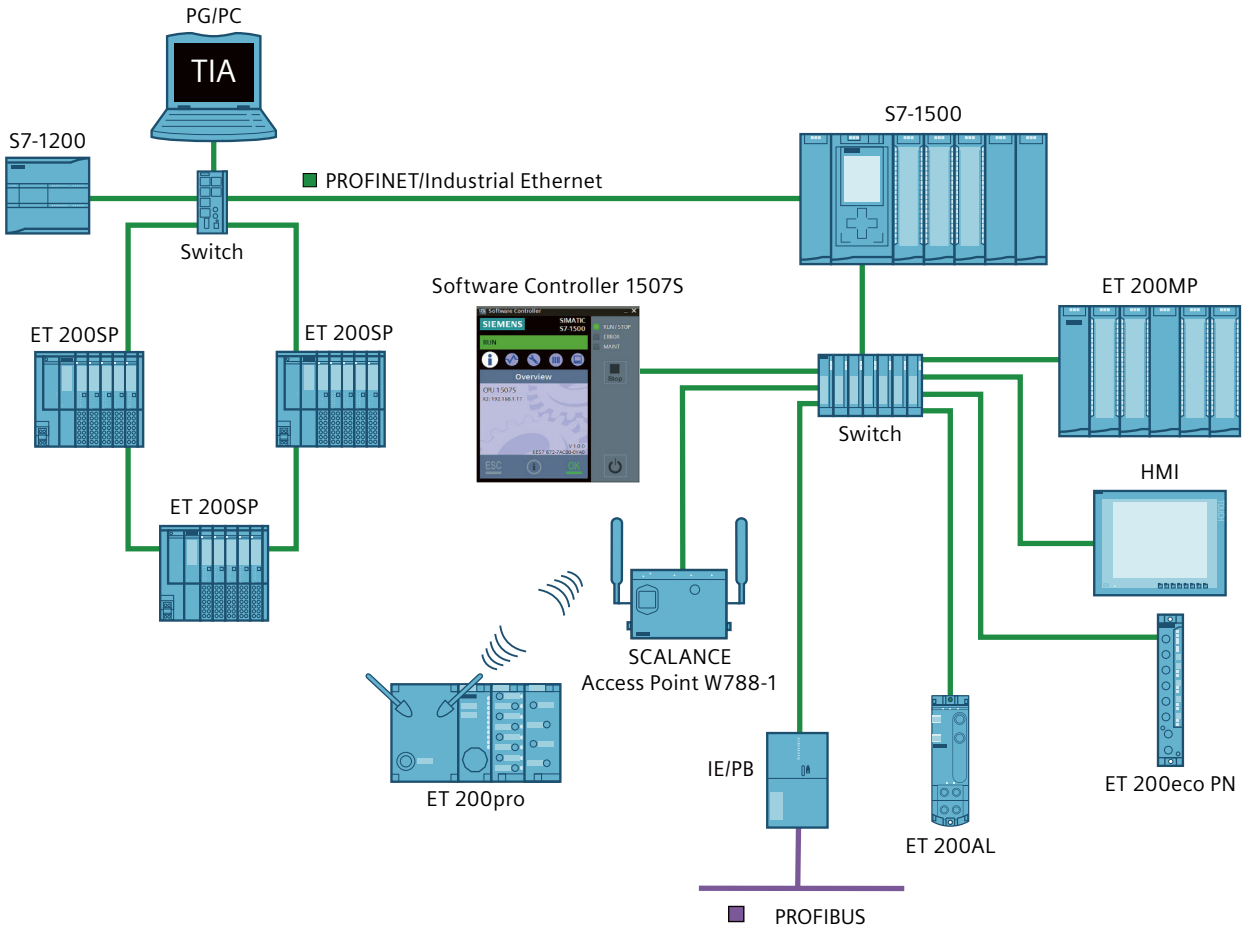

Figure 3-567 PROFINET overview configuration

STEP 7

The STEP 7 engineering tool supports you in setting up and configuring an automation solution. STEP 7 provides a uniform application view over all bus systems.

Documentation from PROFIBUS & PROFINET International on the Internet

You will find numerous documents on the topic of PROFINET at the Internet address (http://www.profibus.com) of the "PROFIBUS & PROFINET International" PROFIBUS user organization, which is also responsible for PROFINET.

Additional information can be found on the Internet (http://www.siemens.com/profinet).

Overview of the most important documents and links

A compilation of the most important PROFINET application examples, FAQs and other contributions in the Industry Online Support is available in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/108165711).

4.1.1 PROFINET terms

Definition: Devices in the PROFINET environment

In the PROFINET environment, "device" is the generic term for:

- Automation systems (PLC, PC, for example)
- Distributed I/O systems
- Field devices (for example, hydraulic devices, pneumatic devices)
- Active network components (for example, switches, routers)
- Gateways to PROFIBUS, AS interface or other fieldbus systems

PROFINET IO devices

The following graphic shows the general names used for the most important devices in PROFINET. In the table below the graphic you can find the names of the individual components in the PROFINET IO context.

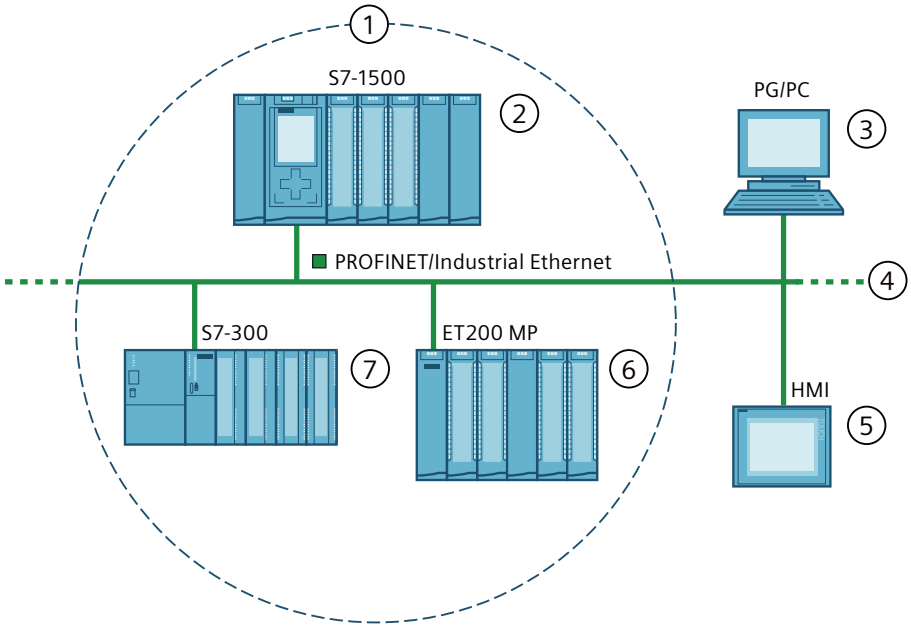

Number	PROFINET	Explanation
①	PROFINET IO System	
②	IO controller	Device used to address the connected IO devices. This means that: The IO controller exchanges input and output signals with field devices.
③	Programming device / PC (PROFINET IO supervisor)	PG/PC/HMI device used for commissioning and for diagnostics
④	PROFINET/Industrial Ethernet	Network infrastructure
⑤	HMI (Human Machine Interface)	Device for operating and monitoring functions.
⑥	IO device	A distributed field device that is assigned to one of the IO controllers (e.g., Distributed IO, valve terminals, frequency converters, switches with integrated PROFINET IO functionality)
⑦	I-device	Intelligent IO device

Figure 3-568 PROFINET devices

IO communication via PROFINET IO

The inputs and outputs of distributed I/O devices are read and written by means of PROFINET IO using what is referred to as IO communication. The following figure provides an overview of IO communication by means of PROFINET IO.

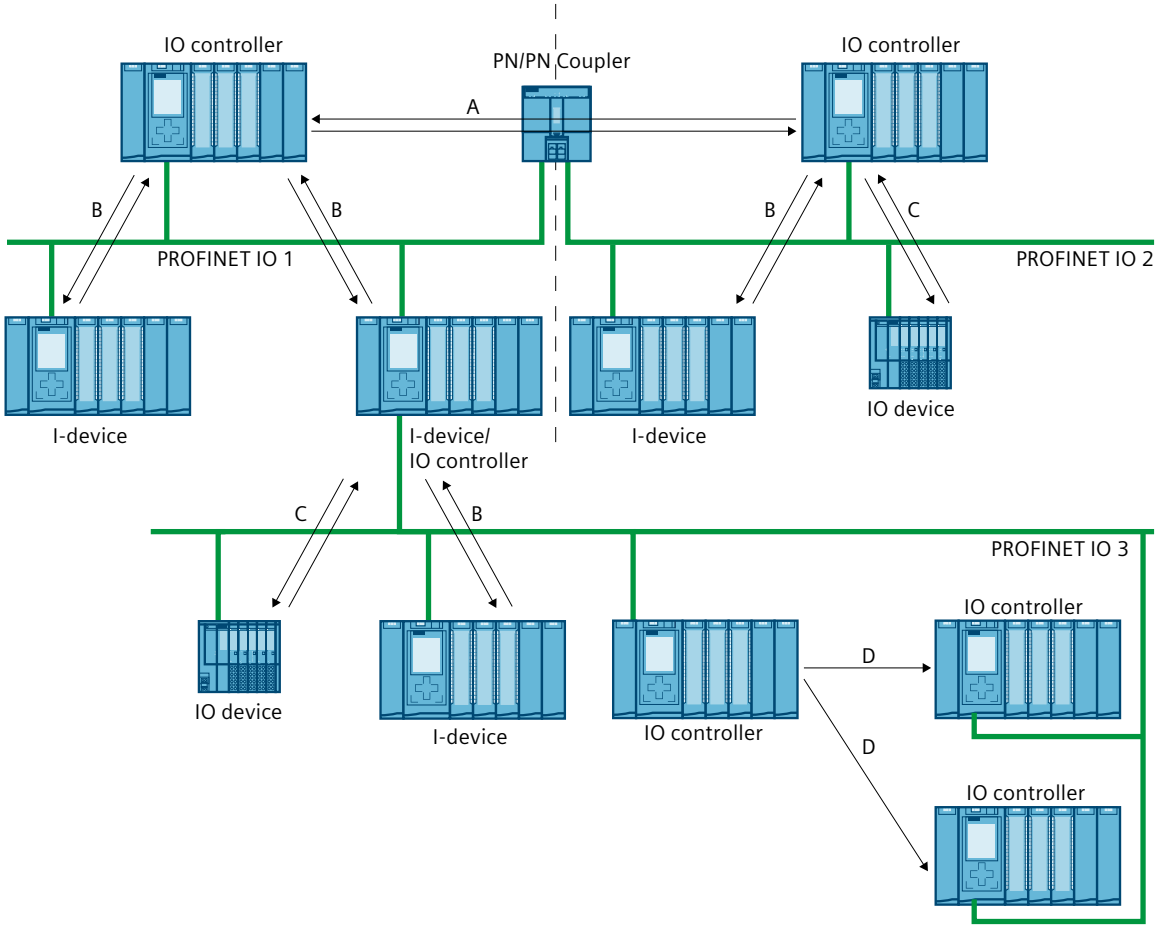

A IO controller - IO controller communication via PN/PN coupler

B IO controller - I-device communication

C IO controller - IO-device communication

D Direct data exchange between S7-1500-CPUs

Figure 3-569 IO communication via PROFINET IO

IO communication via PROFINET IO

Table 3-952 IO communication via PROFINET IO

Communication between ...	Explanation
IO controllers and IO devices	The IO controller sends data cyclically to the IO devices of its PROFINET IO system and receives data from these devices.
IO controller and I-device	A fixed quantity of data is transferred cyclically between the user programs in CPUs of IO controllers and I-devices.

Communication between ...	Explanation
	The IO controller does not access the I/O module of the I-device, but instead accesses configured address ranges, i.e. transfer ranges, which may be located inside our outside the process image of the CPU of the I-device. If parts of the process image are used as transfer ranges, it is not permitted to use these for real I/O modules. Data transfer takes place using load- and transfer operations via the process image or via direct access.
IO controller and IO controller (PN/PN coupler)	A fixed quantity of data is cyclically transferred between the user programs in CPUs of IO controllers. A PN/PN coupler is required as additional hardware. The IO controllers mutually access configured address ranges, i.e. transfer ranges, which may be located inside or outside the process image of the CPU. If parts of the process image are used as transfer ranges, it is not permitted to use these for real I/O modules. Data transfer takes place using load- and transfer operations via the process image or via direct access. I/O communication with PN/PN coupler is possible between two PROFINET IO systems.
S7-1500-CPU and S7-1500-CPU (direct data exchange)	In the case of direct data exchange, an S7-1500 CPU provides cyclic user data from the I/O area to one or more partners. The direct data exchange is based on PROFINET with IRT and isochronous mode. The data exchange takes place via transfer areas.

More information

You can find more information in the sections Network security (Page 49) and Functions (Page 122) as well as in the Communication (http://support.automation.siemens.com/WW/view/en/59192925) Function Manual.

4.1.2 Basic terminology of communication

PROFINET communication

PROFINET communication takes place via Industrial Ethernet. The following transmission types are supported:

- Acyclic transmission of engineering and diagnostics data and interrupts
  - Acyclic PROFINET communication is used for non-time-critical data (non-real-time).
- Cyclic transmission of user data
  - The PROFINET-IO communication takes place in real-time.

Transparent data access

Access to process data from different levels of the factory is supported by PROFINET communication. By using Industrial Ethernet, standard mechanisms of communication and information technology such as OPC can now be used along with standard protocols such as UDP/TCP/IP and HTTP in automation engineering. This allows transparent access from company management level directly to the data from the automation systems at the control level and production level.

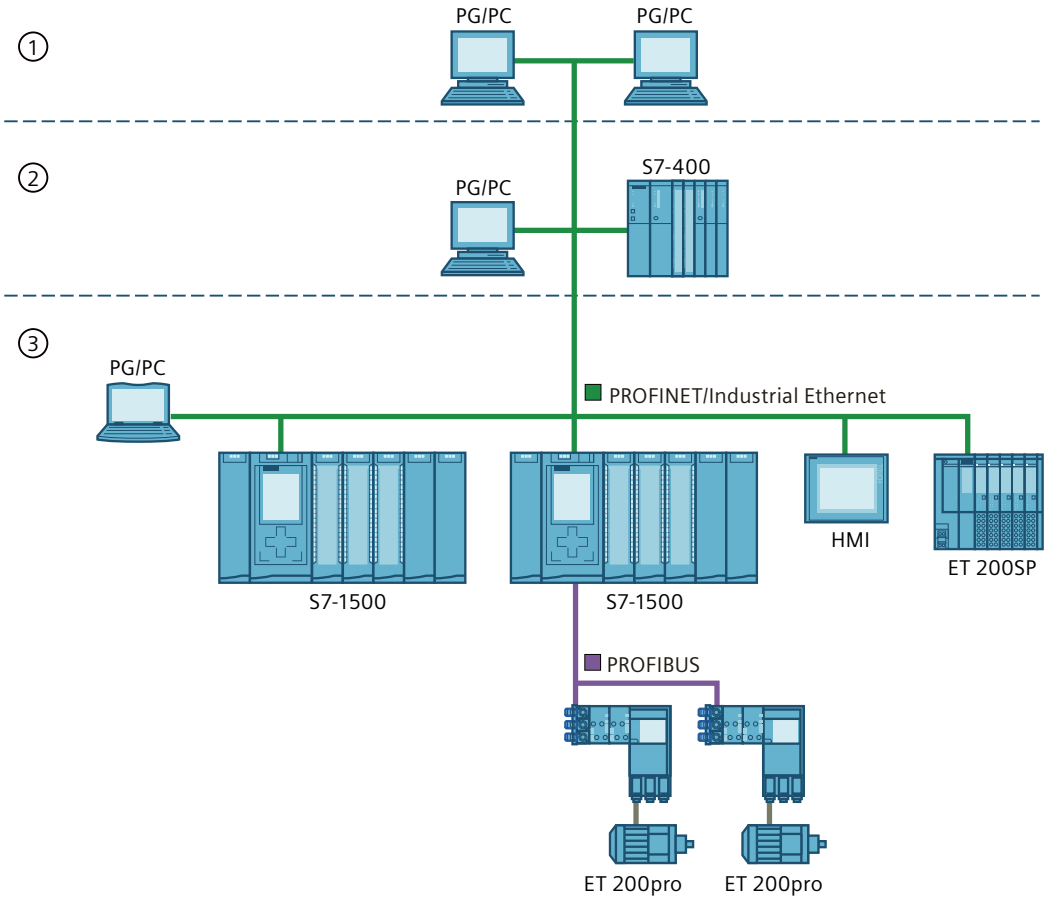

① Management level

② Control level

③ Production level

Figure 3-570 Access to process data

Update time

The update time is the time interval within which the IO controller and the IO device / I-device exchange IO data cyclically in the IO system. The time interval can be configured separately for each IO device and determines the following time intervals:

- Sending the output data from the IO controller to the IO device / I-device (output module/submodule)
- Sending the input data from the IO device / I-device to the IO controller (input module/submodule)

STEP 7 calculates the update time automatically in the default setting for each IO device of the PROFINET IO system, taking into account the volume of data to be exchanged as well as the set send clock.

Watchdog time

The watchdog time is the time interval that an IO controller or IO device permits, without receiving IO data. If the IO device is not supplied by the IO controller with data within the watchdog time, the IO device detects the missing frames and outputs substitute values. This is reported in the IO controller as a station failure.

In STEP 7, the watchdog time is made up from an integral multiple of the update time and can be set by the user.

Send clock

The period of time between two consecutive communication cycles. The send clock is the shortest possible interval in data exchange and thus also the smallest value that can be set for the update time.

Relationship between the update time and send clock

The calculated update times are reduction ratios (1, 2, 4, 8, ..., 512) of the send clock. The minimum possible update time thus depends on the minimum send clock of the IO controller that can be set and the efficiency of the IO controller and IO device. Depending on the send clock, it can be that only some of the reduction ratios are available (STEP 7 guarantees this through a pre-selection).

The following tables illustrate the dependency of the update time that can be set on the send clock, using an example of the CPU 1516-3 PN/DP. The update times satisfy the requirements of the PROFINET standard IEC 61158.

Table 3-953 With real-time communication the following applies:

Send clock	Update time	Reduction ratios
250 µs	250 µs to 128 ms	1,2, ..., 512
500 µs	500 µs to 256 ms	1,2, ..., 512

Send clock	Update time	Reduction ratios
1 ms	1 ms to 512 ms	1,2, ..., 512
2 ms	2 ms to 512 ms	1,2, ..., 256
4 ms	4 ms to 512 ms	1,2, ..., 128

More information

You can find more information on real-time communication and the update time in the Real-time communication (Page 204) section.

4.1.3 PROFINET interface

Overview

PROFINET devices of the SIMATIC product family have one or more PROFINET interfaces (Ethernet controller/interface). The PROFINET interfaces have one or more ports (physical connection options).

In the case of PROFINET interfaces with multiple ports, the devices have an integrated switch.

PROFINET devices with two ports on one interface allow you to configure the system in a line or ring topology. PROFINET devices with three or more ports on one interface are also ideal for setting up tree topologies.

Properties and rules for naming the PROFINET interface and its representation in STEP 7 are explained in the following.

Properties

Every PROFINET device on the network is uniquely identified via its PROFINET interface. For this purpose, each PROFINET interface has:

- A MAC address (cannot be changed)
- A PROFINET device name
- An IP address

Identification and numbering of the interfaces and ports

Interfaces and ports for all modules and devices in the PROFINET system are identified with the following characters:

Table 3-954 Identification for interfaces and ports of PROFINET devices

Element	Symbol	Description
Interface	X	In ascending order starting from number 1
Port	P	In ascending order starting from number 1 (for each interface)
Ring port	R	These ports can be used for a ring topology.

Examples of identification

Three examples illustrate the rules for identifying PROFINET interfaces:

Table 3-955 Examples for identifying PROFINET interfaces

Sample labeling	Interface	Port
X2 P1	2	1
X1 P2	1	2
X1 P1 R	1	1 (ring port)

Representation of PROFINET Interfaces in the Topology Overview in STEP 7

You can find the PROFINET interface in the topology overview in STEP 7. The PROFINET interface for an IO controller and an IO device is represented as follows in STEP 7:

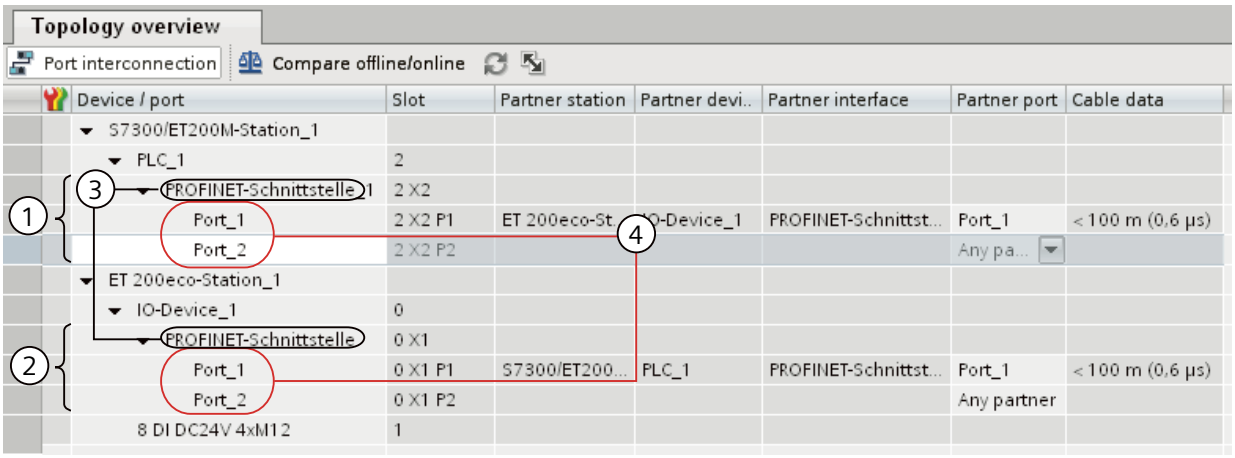

Number	Description
①	PROFINET interface of an IO controller in STEP 7
②	PROFINET interface of an IO device in STEP 7
③	These lines represent the PROFINET interface.
④	These lines represent the ports of a PROFINET interface.

Figure 3-571 Representation of the PROFINET interfaces in STEP 7

Schematic Representation of a PROFINET Interface with Integrated Switch

The following schematic diagram shows the PROFINET interface with integrated switch and its ports for all PROFINETdevices.

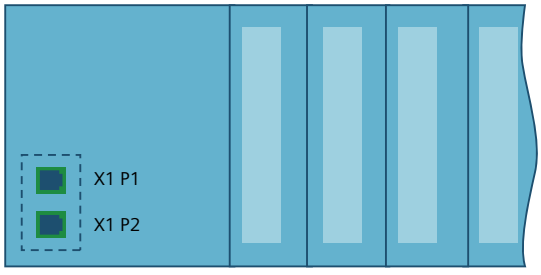

Figure 3-572 PROFINET interface with integrated switch

Functional differences of the PROFINET interfaces

PROFINET interfaces can provide different functions. PROFINET interface functions include identification, configuration, diagnostics and communication services (e.g., open communication). PROFINET interfaces that provide PROFINET IO functions and network security functions are also available.

The following table illustrates the differences using the example of the CPU 1516-3 PN/DP (as of firmware version V2.0), which features two PROFINET interfaces with different functionality.

Table 3-956 Differences between the PROFINET interfaces of the CPU 1516-3 PN/DP (as of firmware version V2.0)

PROFINET interface (X1) with 2 ports	PROFINET interface (X2) with 1 port
Identification, configuration and diagnostics	
PG communication	
HMI communication	
S7 communication	
Time-of-day synchronization	
Web server	
Open communication	
OPC UA server	
IO controller	
I-device	
RT	
IRT	-
Isochronous mode	-
Media redundancy	-
Prioritized startup	-

S7-1500 CPUs with two ports each at PROFINET interfaces X1 and X2 support the same functionalities at the PROFINET interface X2 as at the PROFINET interface X1, with the exception of prioritized startup. This includes, for example the following CPUs as of firmware version V4.0:

- CPU 1517(F)-3 PN
- CPU 1518(F)-3 PN
- CPU 1516T(F)-3 PN
- CPU 1517T(F)-3 PN
- CPU 1518T(F)-3 PN

S7-1500H CPUs as of FW version V4.0 have two ports at PROFINET interface X2, but do not support media redundancy (ring topology) at this PROFINET interface.

To find out which protocols are supported by IO devices, refer to the relevant equipment manual.

Additional Information on the Functionality of PROFINET interfaces

You can find information on the number and functionality of the interfaces of a PROFINET device in the documentation for the specific PROFINET device.

PROFINET communication services are described in the Communication function manual (http://support.automation.siemens.com/WW/view/en/59192925).

In the Network security (Page 49) section you can find components that are used to protect networks against hazards.

The Functions (Page 122) section describes the PROFINET IO functions.

4.1.4 Implementation of the PROFINET device model in SIMATIC

Slots and modules

A PROFINET device can have a modular and compact structure. A modular PROFINET device consists of slots into which the modules are inserted. A module can contain multiple submodules. The modules have channels which are used to read and output process signals. A compact device has the same design and can include modules, however, it cannot be physically expanded, which means that no modules can be inserted.

This is illustrated by the following graphic.

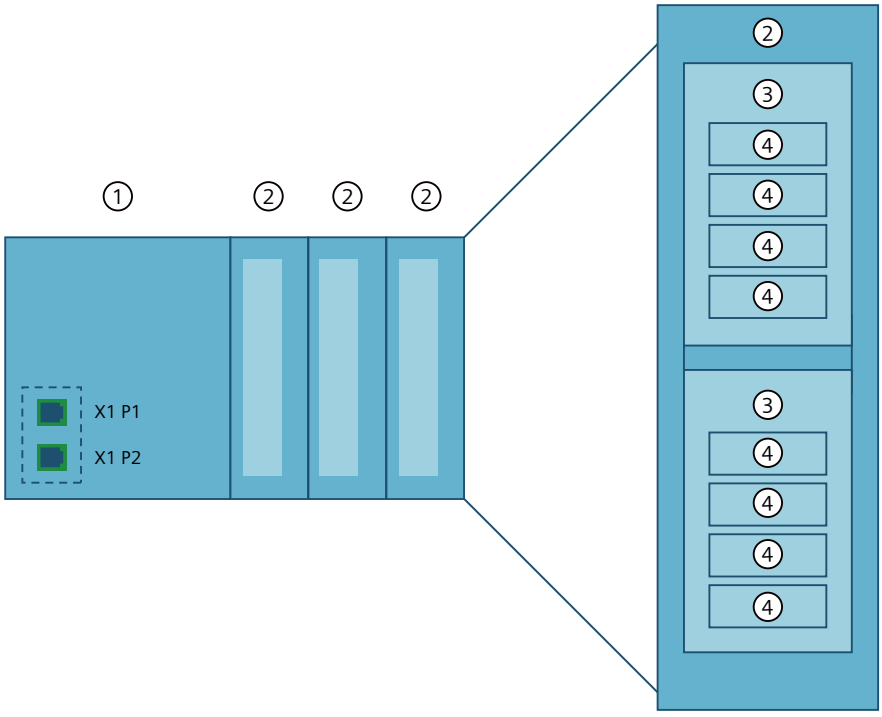

Figure 3-573 Configuration of a PROFINET device

Number	Description
1	Slot with bus interface

②	Slot with module
③	Subslot with submodule
④	Channel

Representation of PROFINET Device Model in the Device View of STEP 7

The following figure shows the representation of the PROFINET device model in the device view of STEP 7, based on the example of a distributed I/O system ET 200MP:

Device overview

Module	Rack	Slot	I address	Q address	Type
IO-Device_1	0	1			IM 155-5 PN ST
PROFINET-Schnittstelle	0	1 X1			PROFINET interface
Port_1	0	1 X1 P1			Port
Port_2	0	1 X1 P2			Port
DI 32x24VDC HF_1	0	2	16...19		DI32 x 24VDC HF
DQ 32x24VDC/0.5A ST_1	0	3		0...3	DQ32 x 24VDC / 0.5A ST

Figure 3-574 PROFINET device model in the device view of STEP 7

4.2 PROFINET Security Class 1

Introduction

With the introduction of the PROFINET Security Class 1, additional security settings were integrated to harden the PROFINET network.

Like in other areas of IT security, PROFINET security is based on the Defense-in-Depth concept. Multiple independent methods provide multi-layered protection against attacks or inadvertent changes.

PROFINET Security Class 1 includes the following security mechanisms for protecting your PROFINET network:

- Configuration options for the SNMP and DCP protocols
- Digital signature of PROFINET GSD files

These introductory sections provide information on which configuration options have been modified for PROFINET Security Class 1.

Simple Network Management Protocol (SNMP)

SNMP is used for simple, network-based device management. For example, PROFINET devices support the following SNMP functions:

- Monitoring and diagnostics of the network topology through network management services
- Reading device-specific information

Since STEP 7 V18, SNMP has been disabled in the basic settings of a CPU. You can enable or disable SNMP via the configuration or by writing a data record from the user program. You enter the community strings for read and write access via the configuration.
As of STEP 7 V19, you can configure SNMP both for CPUs and for IO devices for the following access types:

- Read and write access
- Read access only

As of STEP 7 V20, you can configure SNMP for an entire PROFINET IO system at the PROFINET interface of the IO controller. The SNMP settings on the PROFINET interface do not affect the IO controller but serve as a central specification for the connected PROFINET IO system.

If IO devices support the configuring of SNMP, the PROFINET interface of the higher-level IO controller synchronizes the SNMP settings in the device properties of the IO devices by default. Changes to the SNMP settings are also automatically synchronized. Alternatively, you can change the default behavior in the module properties of IO devices and set your own SNMP settings.

To determine whether IO devices support the configuration of SNMP, refer to the respective equipment manuals. IO devices that support the configuration of SNMP behave as follows during configuration or initial loading of the hardware configuration:

- STEP 7 < V19: SNMP is enabled on the IO device. When SNMP is enabled, the community strings are set to the following default values:
  - Read-only (read-only community string): public
  - Read and write access (read-write community string): private
- STEP 7 V19 and higher: SNMP is deactivated as default. Changed SNMP settings do not take effect until the hardware configuration has been loaded.

Discovery Configuration Protocol (DCP)

DCP helps locate PROFINET devices in the network and enables the basic settings, e.g. assignment of IP address or PROFINET device name.

Since STEP 7 V19, the "Activate DCP write protection" option is available for DCP. This "PROFINET Security Class 1" function prevents write access to PROFINET devices via DCP during IO data exchange and thus, for example, provides protection from unwanted interruptions of application relationships (ARs).

As of STEP 7 V20, you can configure DCP for an entire PROFINET IO system at the PROFINET interface of the IO controller. If IO devices support the configuring of DCP, the PROFINET interface of the higher-level IO controller synchronizes the DCP settings in the device properties of the IO devices by default. Changes to the DCP settings are also automatically synchronized.

If the IO controller and IO device support the write protection function for DCP, this option is enabled by default for the corresponding communication relation. An enabled DCP write protection function takes effect in the following cases:

- On the IO controller side: An IO controller sets up the communication relation with a corresponding IO device (the IO device does not need to be accessible for this purpose).
- On the IO device side: There is an active communication relation between the IO controller and the IO device.

When the write protection function of DCP is in effect, for example, Set commands (DCP Set) are rejected.

When the write protection option of DCP is enabled, ongoing operation is secured as follows:

- DCP only has read access to the device information of the IO device.
- Changes to the basic settings of IO devices are no longer possible.

Authenticity of PROFINET GSD files

The manufacturer provides a general station description file (GSD file) for each PROFINET device. The GSD file describes the properties of the device in a machine readable XML format and contains all properties of a PROFINET-device that are needed for configuring.

With the introduction of PROFINET Security Class 1, GSD files together with other related files, such as images or text files, are provided in a GSDX file with a verified manufacturer signature. A GSDX file can contain multiple GSD files, such as all GSD files of a device family. The included signature confirms the integrity and authenticity of the contained files. This ensures that the files contained in the GSDX file originate from the expected manufacturer and have not been altered after generation of the signature.

If your engineering system does not support the import of GSDX files, continue using GSD files as up to now.

Confirming authenticity of PROFINET GSD files with the distributor ID

If a GSDX file contains a digital signature, the signature confirms the authenticity and integrity of the GSD files it contains. A GSDX file can only contain a single signature. Only signed GSDX files fulfill the requirements of PROFINET Security Class 1.

When importing GSDX files for standard IO devices, STEP 7 uses the signature to check whether the GSD files in the GSDX file originate from the corresponding device manufacturer. A GSDX file that contains the manufacturer's own devices as GSDML files is successfully checked during import based on the signature it contains.

In addition to checking the digital signature, the identity of the creator of the GSDX file is also verified. Because both device manufacturers and suppliers (distributors) can create and sign GSDX files, identity verification is also mandatory for suppliers. A distinction must therefore be made between the following roles:

- The device manufacturer (vendor):
  A device manufacturer, e.g. SIEMENS, can export the devices it manufactures as a GSD file, pack them into a GSDX file and sign the GSDX file. When importing, STEP 7 can successfully check the file, since the identity of the device manufacturer matches the vendor ID in the GSD file.
- The supplier (distributor):
  A supplier, e.g. system manufacturer, uses the devices of a third-party manufacturer. The supplier would like to publish these third-party devices as GSD file in the form of a signed GSDX file. Because the provider is not the device manufacturer, the provider needs its own identity for the signature process.

Both device manufacturers and suppliers can apply for a signature card (smart card) from the PNO (https://www.profibus.com/products/gsd-files/gsd-signing). The signature card is issued

for the corresponding identity (vendor ID or distributor ID). This signature card can be used to create valid GSDX files and make them available for use in engineering tools, such as STEP 7.

In STEP 7 from V21, you can add a distributor ID to an I-device during configuration. In this case, you must create the I-device from a CPU with FW version V4.1 or higher. When exporting the configured I-device, the distributor ID is transferred to the generated GSD file. You can pack this generated GSD file into a GSDX file and sign it.

More information

You can find detailed information on SNMP in the Communication (https://support.industry.siemens.com/cs/us/en/view/59192925) Function Manual.

For information on how to configure SNMP in your PROFINET network, see section Configuring the SNMP (Page 321).

For information on how to configure DCP in your PROFINET network, see section Configuring DCP (Page 327).

You can read how to add a distributor ID to an I-device in the section Configuring the I-device (Page 134).

4.3 Setting up PROFINET

Contents of this chapter

The following chapter provides background information on building your communication network.

- Overview of the most important passive network components: These are network components that forward a signal without the possibility of actively influencing it, for example, cables, connectors, etc.
- Overview of the most important active network components: These are network components that actively affect a signal, for example switches, routers, etc.
- Overview of the most common network structures (topologies).

Physical connections of industrial networks

The networking of PROFINET devices in industrial systems is generally possible in 2 different physical ways:

- Connected line
  - By means of electrical pulses via copper cables
  - By means of optical pulses via fiber-optic cables
- Wireless via wireless network using electromagnetic waves

PROFINET devices and cabling technology in SIMATIC are suited for industrial use, as they are based on Fast Ethernet and Industrial Ethernet.

- **Fast Ethernet**

  With Fast Ethernet, you transfer data at a speed of 100 Mbps. This transfer technology uses the 100 Base-T standard for this.

- **Industrial Ethernet**

  Structure of Ethernet in industrial environment.

  The biggest difference from standard Ethernet is the mechanical current carrying capacity and noise immunity of the individual components.

4.3.1 Active Network Components

Introduction

The following active network components are available for PROFINET:

- Switch
- Router

Switched Ethernet

PROFINET IO is based on switched Ethernet with full-duplex operation and a bandwidth of 100 Mbps. In this way, the network can be used much more efficiently through the simultaneous data transfer of several devices. The PROFINET IO frames are processed with high priority.

Switches

Switches are network components used to connect several terminal devices or network segments in a local network (LAN).

For the communication of a device with several other devices on PROFINET, the device is connected to the port of a switch. Other communication devices (including switches) can then be connected to the other ports of the switch. The connection between a communication device and the switch is a point-to-point connection.

A switch has the task of receiving and distributing frames. The switch "learns" the Ethernet address(es) of a connected PROFINET device or additional switches and only forwards those frames that are intended for the connected PROFINET device or the connected switch.

Switch variants

Switches are available in two models:

- Integrated into a PROFINET device

  PROFINET devices with multiple ports per interface are devices with an integrated switch (for example, CPU 1516-3 PN/DP)
- As autonomous device (for example, switches of the SCALANCE product family)

Selection Guide for Switches

To use PROFINET with the RT class "RT", you can use any switch of "PROFINET Conformance Class A" or higher. All switches of the SCALANCE product family meet these requirements.

If you want to use PROFINET functions that provide an additional value, such as topology recognition, diagnostics, device exchange without exchangeable medium/programming device, you have to use a switch of the "PROFINET Conformance Class B" or higher.

To use PROFINET with the RT class "IRT", you must use a switch of "PROFINET Conformance Class C". With switches of the SCALANCE product family, watch out for the catalog feature "IRT PROFINET IO switch".

To select appropriate switches, we recommend the SIMATIC NET Selection Tool on the Internet (http://support.automation.siemens.com/WW/view/en/39134641).

Switches of the SCALANCE product family

Use the switches of the SCALANCE product family if you want to use the full scope of PROFINET. They are optimized for use in PROFINET IO.

In the SCALANCE X device family, you will find switches with electrical and optical ports and with a combination of both variants. SCALANCE X202-2IRT, for example, has two electrical ports and two optical ports and supports IRT communication.

Beginning with the SCALANCE X200, you can configure, diagnose and address switches of the SCALANCE X device series as PROFINET IO devices using STEP 7.

Router

A router connects separated network segments with each other (e.g. management level and control level). The volume of data volume must be coordinated with the services of the respective network segment. A router also separates two networks and acts as a mediator between both networks. It thus reduces the network load. Routing functionality is provided in the SCALANCE X device family, with SCALANCE X300 or higher.

Communication devices on different sides of a router can only communicate with one another if you have explicitly enabled communication between them via the router.

If you want to access manufacturing data directly from SAP, for example, use a router to connect your Industrial Ethernet in the factory with the Ethernet in your office.

NOTE

If devices need to communicate beyond the limits of a network, you must configure the router so that it allows this communication to take place.

Information on routing with STEP 7 is available in the function manual Communication (http://support.automation.siemens.com/WW/view/en/59192925).

4.3.2 Cabling technology

Cables for PROFINET

Electrical and optical cables are available for PROFINET. The type of cable depends on the data transfer requirements and on the ambient conditions.

Simple method for the prefabrication of twisted pair cables

When you set up your PROFINET system, you can cut the twisted-pair cable to the required length on site, strip it with the *stripping tool* (for Industrial Ethernet), and fit the *Industrial Ethernet Fast Connect RJ45 plugs* using the cut-and-clamp method. For more information on installation, refer to the installation instructions in the "SIMATIC NET Industrial Ethernet Network Manual" (http://support.automation.siemens.com/WW/view/en/8763736).

NOTE

A maximum of four connector pairs are allowed between two switches per Ethernet path.

Simple method for the prefabrication of fiber-optic cables

The FastConnect FO cabling system is available for the easy, fast and error-free prefabrication of fiber-optic cables. The glass-fiber optic cable consists of:

- FC FO Termination Kit for SC and BFOC plug (cleave tool, Kevlar scissors, buffer grip, fiber remains container)
- FC BFOC Plug
- FC SC Duplex plug
- FO FC Standard cable
- FO FC Trailing cable

Simple method for the prefabrication of POF and PCF cables

The following special tools provide an easy and safe way to prefabricate POF / PCF cables and fit the SC RJ POF plugs:

- POF cable

  Prefabrication case IE Termination Kit SC RJ POF plug
- PCF cable

  Prefabrication case IE Termination Kit SC RJ PCF plug

Overview of transmission media with PROFINET

The following table summarizes the technical specifications of a PROFINET interface with integrated switch or an external switch, and possible transmission media.

Table 3-957 Transmission media with PROFINET

Physical properties	Connection methods	Cable type / transmission medium standard	Transmission rate / mode	Max. segment length (between two devices)	Advantages
Electrical	RJ45 connector ISO 60603-7	100Base-TX 2x2 twisted, symmetrical and shielded copper cable, CAT 5 transmission requirement IEEE 802.3	100 Mbps, full duplex	100 m	Simple and cheap cable connection
Optical	SCRJ 45 ISO/IEC 61754-24	100Base-FX POF fiber-optic cable (Polymer Optical Fiber, POF) 980/1000 µm (core diameter / external diameter) ISO/IEC 60793-2	100 Mbps, full duplex	50 m	Use when there are large differences in potential Insensitive towards electromagnetic radiation Low line attenuation Considerably longer segments possible[1]
		Plastic-cladded glass fiber (Polymer Cladded Fiber, PCF) 200/230 µm (core diameter / external diameter) ISO/IEC 60793-2	100 Mbps, full duplex	100 m	
	BFOC (Bayonet Fiber Optic Connector) and SC	Monomode glass fiber optic cable 10/125 µm (core diameter / external diameter) ISO/IEC 60793-2	100 Mbps, full duplex	26 km	

[1] Applies for fiber-optic cables only

Physical properties	Connection methods	Cable type / transmission medium standard	Transmission rate / mode	Max. segment length (between two devices)	Advantages
Optical	(Subscriber Connector) ISO/IEC 60874	Multimode glass fiber optic cable 50/125 µm and 62.5/125 µm (core diameter / external diameter) ISO/IEC 9314-4	100 Mbps, full duplex	3000 m	Use when there are large differences in potential Insensitive towards electromagnetic radiation Low line attenuation Considerably longer segments possible[1]
	LC (Lucent Connector) ISO/IEC 61754-20	Fiberglass FOC single-mode fiber 9/125 µm (core diameter / external diameter) ISO/IEC 60793-2	100 Mbps, full duplex	10 km (IRT) 20 km (RT)	
Electromagnetic wave	-	IEEE 802.11 x	Depends on the extension used (a, g, h, etc.)	100 m	Greater mobility Cost-effective networking to remote, difficult to access devices

[1] Applies for fiber-optic cables only

More information

For information on the PROFINET interface, refer to the section PROFINET interface (Page 32).

More information about Industrial Ethernet networks with the help of SIMATIC NET components can be found in the SIMATIC NET (http://support.automation.siemens.com/WW/view/en/27069465) System Manual.

You can find the installation guideline for PROFINET in the following Internet entry (https://www.profibus.com/download).

4.3.3 Wireless design

4.3.3.1 Basics

What is Industrial Wireless LAN?

In addition to data communication in accordance with the IEEE 802.11 standard, the SIMATIC NET Industrial Wireless LAN provides a number of enhancements which offer significant benefits for industrial customers. IWLAN is particularly suitable for demanding industrial applications that require reliable wireless communication. This is supported by the following properties:

- Automatic roaming when the connection to Industrial Ethernet is interrupted (Forced Roaming)
- Cost savings generated by using a single wireless network for reliable operation of a process with both process-critical data (alarm message, for example) and non-critical communication (service and diagnostics, for example)
- Cost-effective connection to devices in remote environments that are difficult to access

- Predictable data traffic (deterministic) and defined response times
- Cyclical monitoring of the wireless link (link check)

Objectives and advantages of Industrial Wireless LAN

Wireless data transmission achieves the following objectives:

- Seamless integration of PROFINET devices into the existing bus system via the wireless interface
- Mobile use of PROFINET devices for different production-linked tasks
- Flexible configuration of the system components for fast development in accordance with customer requirements
- Maintenance costs are minimized by savings in cables

Application examples

- Communication with mobile subscribers (mobile controllers and devices, for example), conveyor lines, production belts, translation stages , and rotating machines
- Wireless coupling of communication segments for fast commissioning or cost-effective networking where routing of wires is extremely expensive (e.g. public streets, railroad lines)
- Stacker trucks, automated guided vehicle systems and suspended monorail systems

The following graphic illustrates the many possible applications and configurations for SIMATIC device family wireless networks.

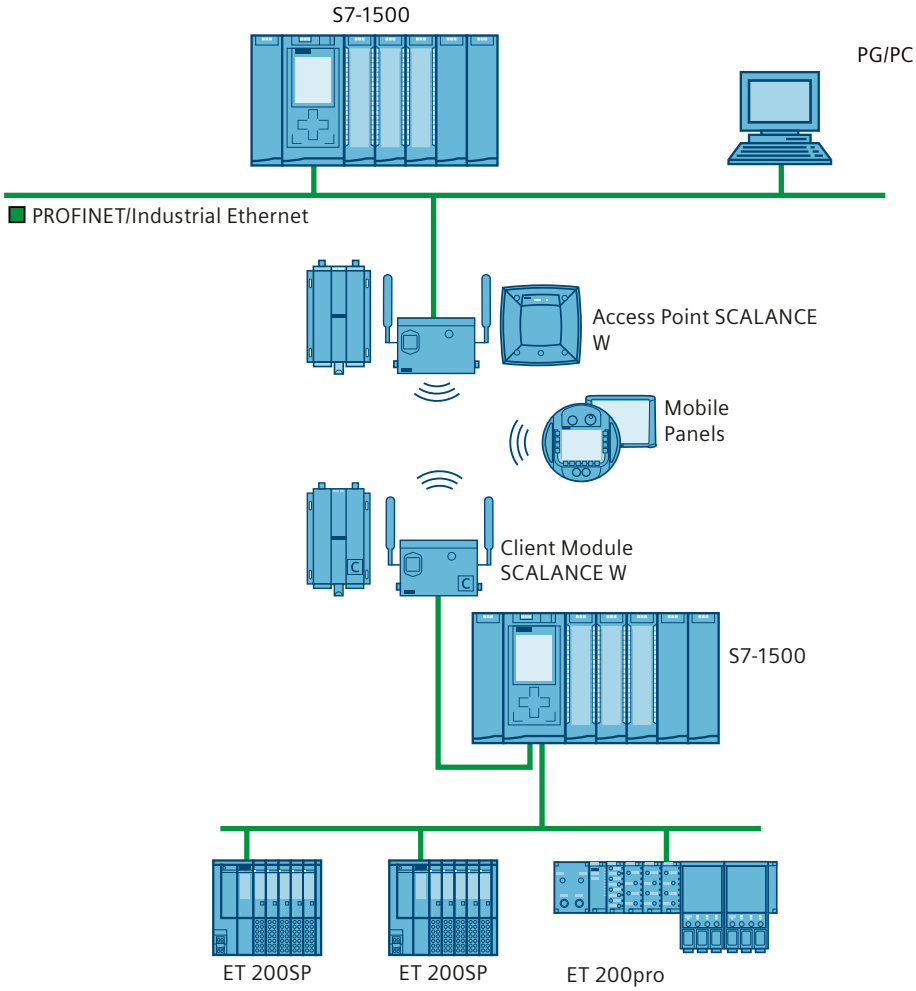

Figure 3-575 Application example for the use of Industrial Wireless LAN

Data transmission rate

In Industrial Wireless LAN, gross data transmission rates of 11 Mbps or 54 Mbps without full duplex are permitted.

Range

With SCALANCE W (access points), wireless networks can be set up indoors and outdoors. Multiple access points can be installed to create large wireless networks in which mobile subscribers are transferred seamlessly from one access point to another (roaming).

As an alternative to a wireless network, point-to-point connections of Industrial Ethernet segments can also be set up over large distances (several hundred meters). In this case, the range and characteristics of the RF field are determined by the antennas used.

NOTE

Range

The range can be considerably less, depending on spatial factors, the wireless standard used, the data rate, and the antennas on the send and receive sides.

4.3.3.2 Tips on assembly

Wireless networks, SCALANCE device family

With PROFINET, you can also set up wireless networks with Industrial Wireless Local Area Network (IWLAN) technology. We recommend implementing the SCALANCE W device line for this.

Update time in STEP 7

If you set up PROFINET with Industrial Wireless LAN, you may have to increase the update time for the wireless devices. The IWLAN interface provides lower performance than the wired data network: Several communication stations have to share the limited transmission bandwidth. For wired solutions, 100 Mbps is available for each communication device.

The Update time parameter can be found in the "Realtime settings" section in the Inspector window of IO devices in STEP 7.

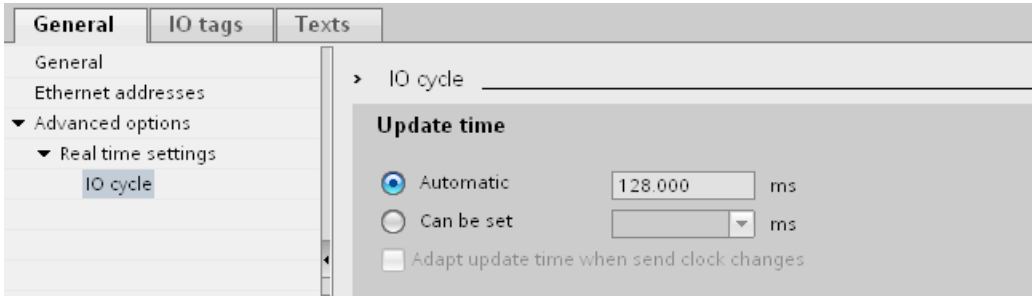

Figure 3-576 Update time in STEP 7

Additional information

More information about SCALANCE W Industrial Wireless LAN components can be found in the manual SIMATIC NET SCALANCE W-700 (http://support.automation.siemens.com/WW/view/en/42784493).

More information about wired data transmission can be found in the manual SIMATIC NET Twisted Pair and Fiber Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736).

More information about wireless data transmission can be found in the manual Basics for configuring an industrial wireless LAN (http://support.automation.siemens.com/WW/view/en/9975764).

You should also read the PROFINET installation guideline of the PROFIBUS User Organization on the Internet (http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/). Various documents that assist with the setting up of your PROFINET automation solution are available here:

- PROFINET planning guideline
- PROFINET installation guideline
- PROFINET commissioning guideline
- Additional documents for setup of PROFINET

4.3.4 Network security

4.3.4.1 Basics

Introduction

The topic of data security and access protection (Security) has become increasingly important in the industrial environment. The increased networking of entire industrial systems, vertical integration and networking of levels within a company and new techniques such as remote maintenance all result in higher requirements for protecting the industrial plant.

Data security solutions for office environments cannot simply be transferred one-to-one to industrial applications to protect against manipulation in sensitive systems and production networks.

Requirements

Additional security requirements arise from the specific communication requirements in the industrial environment (real-time communication, for example):

- Protection against interaction between automated cells
- Protection of network segments
- Protection against faulty and unauthorized access
- Scalability of network security
- Must not influence the network structure

Definition of security

Generic term for all the measures taken to protect against:

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability due to destruction of data, for example, through faulty configuration and denial-of-service attacks

Threats

Threats can arise from external and internal manipulation. The loss of data security is not always caused by intentional actions.

Internal threats can arise due to:

- Technical errors
- Operator errors
- Defective programs

Added to these internal threats there are also external ones. The external threats are not really any different to the known threats in the office environment:

- Software viruses and worms
- Trojans
- Man-in-the-middle attacks
- Password Phishing
- Denial of Service

Protective measures

The most important precautions to prevent manipulation and loss of data security in the industrial environment are:

- Physical access protection to the devices
- Filtering and control of data traffic by means of firewall
- A virtual private network (VPN) is used to exchange private data on a public network (Internet, for example).

  The most common VPN technology is IPsec. IPsec (Internet Protocol Security) is a collection of security protocols that are used as the basis for the IP protocol at the mediation level and allow a secured communication via potentially unsecure IP networks.
- Segmenting in protected automation cells

  This concept has the aim of protecting the lower-level network devices by means of security modules. A group of protected devices forms a protected automation cell.

- Authentication (identification) of the devices

  The security modules identify each other over a safe (encrypted) channel using authentication procedures. It is therefore impossible for unauthorized parties to access a protected segment.
- Encrypting the data traffic

  The confidentiality of data is ensured by encrypting the data traffic. Each security module is given a VPN certificate which includes the encryption key.

4.3.4.2 Network components and software

Protection against unauthorized access

The following solutions may be used to connect industrial networks to the intranet and Internet to protect against internal and external threats:

- Communication processors, such as the SIMATIC CP 1543-1
- SCALANCE X-300 and SCALANCE S - the data security components of the SIMATIC NET product family
- SOFTNET security client for use on PCs

Features

Both of these products have a wide variety of features, such as:

- Easy integration of existing networks without configuration, with integrated firewall.
- Segmenting in protected automation cells
- Authentication (identification) of the devices
- Encrypting the data traffic

4.3.4.3 Application example

Data security at the office and production levels

The following graphic contains an application example with protected areas at different levels of the company created using SCALANCE S and the security client. The protected areas are highlighted in light gray.

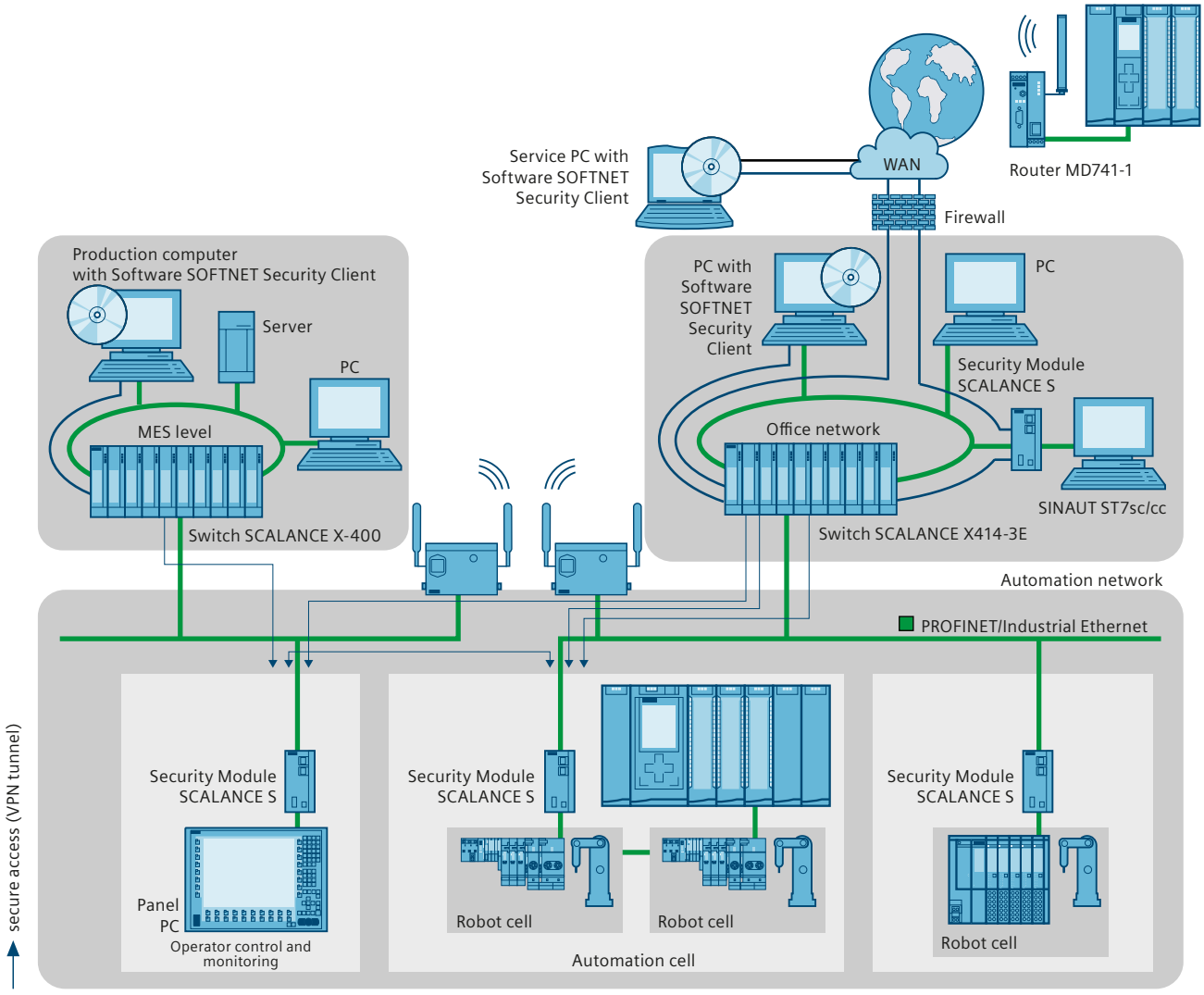

Figure 3-577 Network configuration with the SCALANCE S security module and the SOFTNET security client

Additional information

Additional information on the configuration of a security standard in PROFINET, is available:

- In the PROFINET security guideline. These guidelines can be found on the homepage of the PROFIBUS user organization on the Internet (http://www.profinet.com).
- In the Industrial Ethernet Security (https://support.industry.siemens.com/cs/ww/en/view/109742946) manual
- In the SCALANCE S and SOFTNET Security Client (http://support.automation.siemens.com/WW/view/en/21718449) manual

You can find general information on industrial security concepts, functions and news on the Industrial Security website (http://www.siemens.com/industrialsecurity).

Parameter assignment/addressing 5

To set up an automation system, you will need to configure, assign parameters and interlink the individual hardware components. In STEP 7, the work needed for this is undertaken in the device, topology and network view.

Configuring

"Configuring" is understood to mean arranging, setting and networking devices and modules within the device, topology or network view.

An I/O address is automatically assigned to each module. The I/O addresses can be subsequently modified.

The CPU compares the configuration preset in STEP 7 with the actual current configuration of the system. In this way, potential errors can be detected and reported straight away.

The exact procedure for configuring devices is described in detail in the STEP 7 online help.

Assigning parameters

"Assigning parameters" is understood to mean setting the properties of the components used. The settings for the hardware components and for data communication are configured at the same time.

In STEP 7, you can "assign parameters" for the following settings PROFINET:

- Device name and IP address parameters
- Port parameters
- Module properties / parameters

The parameters are loaded into the CPU and transferred to the corresponding modules when the CPU starts up. Modules are easy to replace from spare parts, as the parameters assigned for the SIMATIC CPUs are automatically loaded into the new module at each startup.

Adjusting the hardware to the project requirements

You need to configure hardware if you want to set up, expand or change an automation project. To do this, add hardware components to your structure, link these with existing components, and adapt the hardware properties to the tasks.

The properties of the automation systems and modules are preset such that in many cases they do not have to be assigned parameters again.

Parameter assignment is however needed in the following cases:

- You want to change the default parameter settings of a module.
- You want to use special functions.
- You want to configure communication connections.

5.1 Assigning an IO device to an IO controller

PROFINET IO System

A PROFINET IO system is comprised of a PROFINET IO controller and its assigned PROFINET IO devices. After these devices have been placed in the network or topology view, STEP 7 assigns default values for them. Initially, you only have to worry about the assignment of IO devices to an IO controller.

Requirement

- You are in the network view of STEP 7.
- A CPU has been placed (e.g., CPU 1516-3 PN/DP).
- An IO device has been placed (e.g., IM 155-6 PN ST).

Procedure

To assign IO devices to an IO controller, proceed as follows:

1. Place the pointer of the mouse over the interface of the IO device.
2. Press and hold down the left mouse button.
3. Move the pointer.

   The pointer now uses the networking symbol to indicate "Networking" mode. At the same time, you see the lock symbol on the pointer. The lock symbol disappears only when the pointer is over a valid target position.
4. Now move the pointer onto the interface of the IO controller. You can keep the left mouse button pressed or release it when performing this action.
5. Now release the left mouse button or press it again (depending on your previous action).

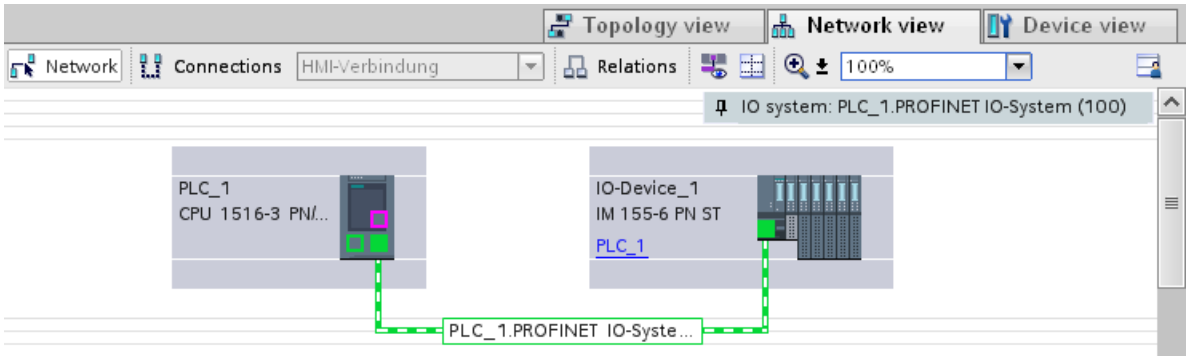

Figure 3-578 Assigning an IO device to an IO controller in the network view of STEP 7

Result

You have assigned an IO device to an IO controller.

Checking the assignment

You can find an overview of the communication relationships in the "IO communication" tab in the tabular area of the network view. This table is context-sensitive for selection in the graphic area:

- Selection of the interface shows the I/O communication of the respective interface.
- Selection of the CPU shows all I/O communication of the CPU (including PROFIBUS).
- Selection of the station (as in the above figure) interface shows the I/O communication of the complete station.

Information on S7-1500R/H

You can find the procedure for assigning an IO device with system redundancy S2 to the redundant S7-1500R/H system in section Assigning IO device to the redundant S7-1500R/H system (Page 350).

5.2 Device name and IP address

Introduction

In order that the PROFINET device can be addressed as node on PROFINET, the following are required:

- A unique PROFINET device name
- A unique IP address in the relevant IP subnet

STEP 7 assigns a device name during the arrangement of a PROFINET device in the hardware and network editor. The IP addresses are typically assigned automatically by STEP 7 and assigned to the devices based on the device name.

You can change the name and IP address manually.

In STEP 7

You can find the device name and the IP address under "Ethernet addresses" in the properties of the PROFINET interface in the Inspector window.

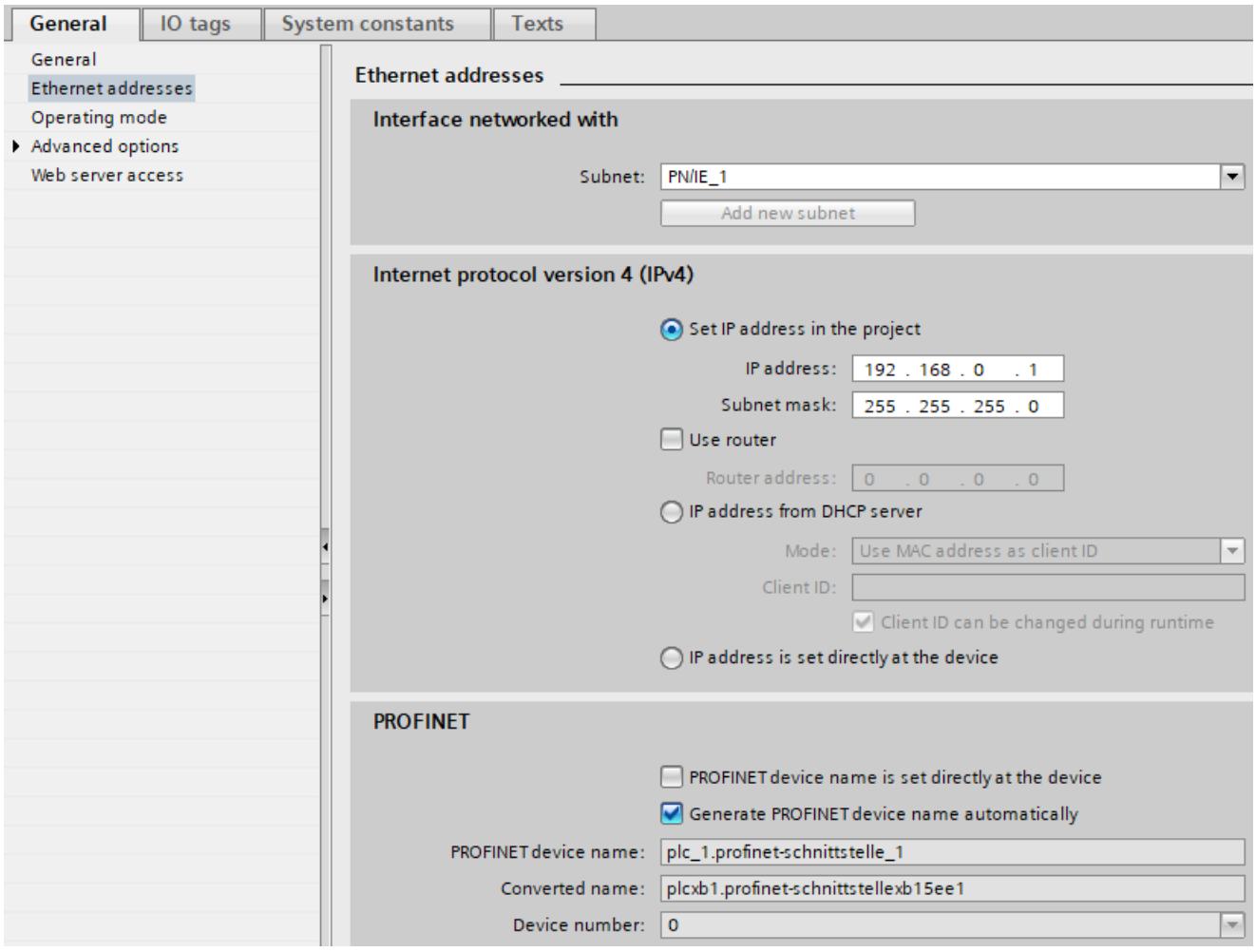

Figure 3-579 Device name and IP address in STEP 7

The function, the assignment and the changing of the device name and the IP address are described in the following sections.

5.2.1 Device name

Device names

Before an IO device can be addressed by an IO controller, it must have a device name. In PROFINET, this method was selected because it is simpler to work with names than with complex IP addresses.

In delivery state, an IO device does not have a device name. A device name must first be assigned before an IO device can be addressed by an IO controller, for example, for transferring configuration data during startup or for exchanging user data in cyclic mode. You assign the device names to the IO device, for example, with the programming device/PC.

With IO devices, the device name is stored directly by the IO devices, e.g. on removable media, the BusAdapter or directly in the interface module.

When a device is replaced by a device without removable medium, the IO controller assigns the device name based on topological configuration (see section Configuring topology (Page 76)).

Structured device names

The device name is automatically assigned by default for PROFINET devices when configured in STEP 7. The device names are formed from the name of the CPU or the name of the interface module. For devices with several PROFINET interfaces, the name of the interface is enhanced, for example, "plc_1.profinet-interface_2" or "io-device_1".

You can structure the device names using DNS conventions.

These conventions are defined by "Internationalizing Domain Names in Applications (IDNA). According to this, device names are written in lower case.

The "Domain Name System" (DNS) is a distributed database (http://iana.org), which manages the name space on the Internet. To structure the names, you use the dot (."). The hierarchy is shown in ascending order from left to right.

...<Subdomain name>.<Domain name>.<Top-level domain name>

If the name is not DNS-compliant, the name will be converted by STEP 7, for example, to "plcxb1.profinet-schnittstellexb2022c" or "io-devicexb15b32".

Device number

In addition to the device name, STEP 7 also assigns a device number beginning with "1" when an IO device is allocated.

The device number is located in the Inspector window in the properties of the PROFINET interface, under "Ethernet addresses" in the area PROFINET.

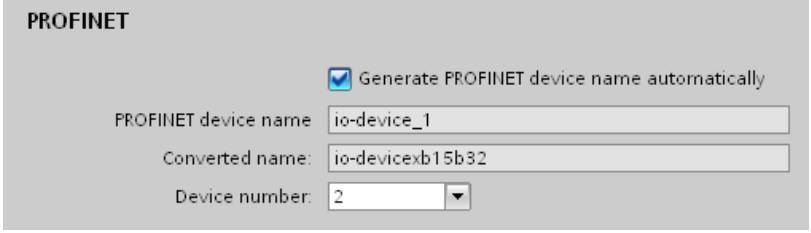

Figure 3-580 Device number

This device number can be used to identify an IO device in the user program (for example, with the instruction "LOG2GEO").

5.2.2 IP address

IP address

To allow a PROFINET device to be addressed as a device on Industrial Ethernet, this device also requires an IP address that is unique within the network. This applies to PROFINET devices that do not support PROFINET communication without an IP address.
For PROFINET devices that support PROFINET communication without an IP address, assigning an IP address is optional. Depending on whether other connections to this device require an IP address.

The IP addresses are typically assigned automatically by STEP 7 and assigned to the devices based on the device name. If it is a standalone network, you can apply the IP address and subnet mask suggested by STEP 7. If the network is part of an existing Ethernet company network, obtain the information from your network administrator.

Configuration of the IP address

In accordance with Internet Protocol version 4 (IPv4), the IP address is made up of four decimal numbers with a range of values from 0 through 255. The decimal numbers are separated by periods (for example, 192.162.0.0).

The IP address consists of the following:

- Address of the network
- Address of the device (PROFINET interface of the IO controller/IO device)

Generating IP addresses

You assign the IP addresses of the IO devices in STEP 7. The IO devices receive their IP addresses during parameter assignment by the IO controller.

In addition, for some IO devices (e.g., SCALANCE X, S7-300 CPs), it is possible not to obtain the IP address during startup of the IO controller, but rather to set it beforehand on the device (see Permitting changes to the device name and IP address directly on the device (Page 70)).

The IP addresses of the IO devices always have the same subnet mask as the IO controller and are assigned from the IP address of the IO controller in ascending order. The IP address can be changed manually, if necessary.

For devices with several PROFINET interfaces (e.g., CPU 1516-3 PN/DP), the IP addresses must be located in different subnets.

NOTE

Assignment of the IP address by a DHCP server

As of STEP 7 V17, you can select the option "IP address from DHCP server" for the PROFINET interface. With this option, the PROFINET interface is assigned an IP address by an DHCP server.

When you configure the option "IP address from DHCP server" for a PROFINET interface, this interface does no longer support the PROFINET IO functionality.

For more information on addressing by a DHCP server, please refer to the Communication (http://support.automation.siemens.com/WW/view/en/59192925) function manual.

Default router

The default router is used when data has to be forwarded via TCP/IP or UDP to a partner located outside the local network.

In STEP 7, the default router is named Router. For a CPU, activate the use of a router in the properties of a PROFINET interface. In the "Internet protocol version 4 (IPv4)" area, select the "Use router" check box. The check box is available for all PROFINET interfaces of the CPU in the respective properties. You can only configure one router for each CPU.
STEP 7 assigns the default router the IP address that was assigned to the PROFINET interface X1 of the CPU.

The router address that is set on the PROFINET interface of the IO controller is automatically transferred for the configured IO devices.

Subnet mask

The bits set in the subnet mask decide the part of the IP address that contains the address of the network.

In general, the following applies:

- The network address is obtained from the AND operation of the IP address and subnet mask.
- The device address is obtained from the AND NOT operation of the IP address and subnet mask.

Example of the subnet mask

Subnet mask: 255.255.0.0 (decimal) = 11111111.11111111.00000000.00000000 (binary)

IP address: 192.168.0.2 (decimal) = 11000000.10101000.00000000.00000010 (binary)

Meaning: The first 2 bytes of the IP address determine the network - i.e., 192.168. The last two bytes address the device, i.e. 0.2.

Relation between IP address and default subnet mask

An agreement exists relating to the assignment of IP address ranges and so-called "Default subnet masks". The first decimal number (from the left) in the IP address determines the structure of the default subnet mask with respect to the number of "1" values (binary) as follows:

IP address (decimal)	IP address (binary)	Address class	Default subnet mask
0 to 126	0xxxxxxx.xxxxxxxx....	A	255.0.0.0
128 to 191	10xxxxxx.xxxxxxxx...	B	255.255.0.0
192 to 223	110xxxxx.xxxxxxxx...	C	255.255.255.0

NOTE

Range of values for the first decimal point

A value between 224 and 255 is also possible for the first decimal number of the IP address (address class D etc.). However, this is not recommended because there is no address check for these values.

Masking other subnets

You can use the subnet mask to add further structures and form "private" subnets for a subnet that is assigned one of the address classes A, B or C. This is done by setting other, less significant bits of the subnet mask to "1". For each bit set to "1", the number of "private" networks doubles and the number of devices they contain is halved. Externally, the network continues to function as an individual network.

Example:

You have a subnet of address class B (for example, IP address 129.80.xxx.xxx) and change the default subnet mask as follows:

Masks	Decimal	Binary
Default subnet mask	255.255.0.0	11111111.11111111.00000000-.00000000
Subnet mask	255.255.128.0	11111111.11111111.10000000-.00000000

Result:

All devices with addresses from 129.80.001.000 to 129.80.127.254 are located in a subnet, all devices with addresses from 129.80.128.000 to 129.80.255.254 in a different subnet.

Reading out an IP address in the user program

You can read out the IP address of a PROFINET device in the user program of a S7-1500 CPU. You can find information in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/82947835).

5.2.3 Assigning a device name and IP address

Assigning an IP address and subnet mask for an IO controller for the first time

You have the following options:

- **Using a programming device or PC:**

  Connect your programming device/PC to the same network as the relevant PROFINET device. The interface of the programming device/PC must be set to TCP/IP mode. During the download, first of all display all available devices via the "Accessible devices" download dialog box. Select the target device via its MAC address and then assign its IP address before you download the hardware configuration including the configured IP address (IP address is saved retentively).

- **Using the display of a S7-1500 CPU:**

  The S7-1500 CPUs have a front cover with a display and operating keys. You can use this display to assign or change the IP address. To set the IP address, navigate on the display via the menu items "Settings" > "Addresses" > "X1 (IE/PN)" > "Parameters".

- **Using a memory card:**

  If your PROFINET device is equipped for a memory card (Micro Memory Card/SIMATIC memory card), plug this into your programming device/PC and save the hardware configuration together with the configured IP address on this memory card. Then plug the memory card into the PROFINET device. Once inserted, the PROFINET device automatically applies the IP address.

  If you have saved a configuration to the memory card with the "IP address is set directly at the device" option, you must assign the IP address using a different method after inserting the memory card (see section Permitting changes to the device name and IP address directly on the device (Page 70)).

Assigning device names and IP address for "Device replacement without exchangeable medium/programming device"

All PROFINET IO devices are assigned the device name via the topology. To do this, the IO device must be in the delivery state or reset to the factory settings. The IO controller can identify the device without a name from the neighborhood relationships specified by the target topology and the actual neighborhood relationships determined by the real PROFINET devices. The IO controller then assigns the PROFINET device the configured name and incorporates the PROFINET device in the user data traffic. (See also Device replacement without exchangeable medium (Page 268)).

IP address assignment when replacing IO devices with exchangeable mediumPG

The following is contained on the memory card of the programmable logic controller:

- On the IO controller: Device name and IP address
- On the IO device: Device name

When you remove the memory card from a PROFINET device and insert it in another PROFINET device with exchangeable medium (e.g., ET 200S), device-specific information and the device name are loaded to the device.

If an IO device has to be replaced in its entirety due to a device or module defect, the IO controller automatically assigns parameters and configures the replaced device or module. The cyclic exchange of user data is then restarted. In addition to this, before the power ON of the IO device, the memory card with the valid name must be removed from the faulty IO device and added to the replaced device.

In the event of an error in the PROFINET device, the memory card allows you to replace a module without a programming device/PC. You can also transfer the device data directly from the programming device/PC to the memory card.

Procedure: Changing the device name using properties of the PROFINET interface

You can change the PROFINET name via the properties of the PROFINET interface. This is useful when the PROFINET device has not received its previous name from the automatic generation, for example, in the case of a migration.

1. In the network or device view of the STEP 7 hardware and network editor, select the PROFINET interface of a PROFINET device.
2. In the Inspector window, go to "Ethernet addresses" in the PROFINET area.
3. Clear the "Generate PROFINET device name automatically" check box.
4. Enter the new PROFINET device name in the relevant field.

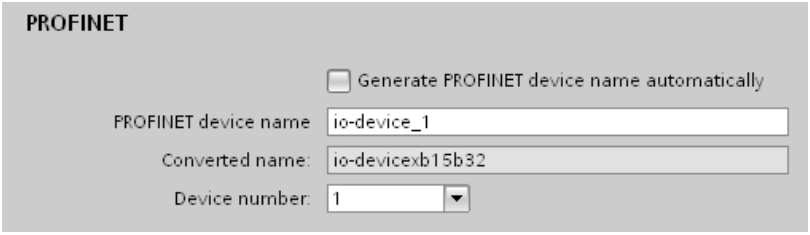

Figure 3-581 Changing the device name of a PROFINET device in the properties

Alternative procedure: Changing the device name of a PROFINET device in the network view

Requirement: The "Generate PROFINET device name automatically" check box is selected.

1. In STEP 7, select the "Network overview" tab in the tabular area of the network view.
2. In the "Device" column, overwrite the name in the row of the relevant PROFINET device.

The name is also changed accordingly in the graphic area of the network view.

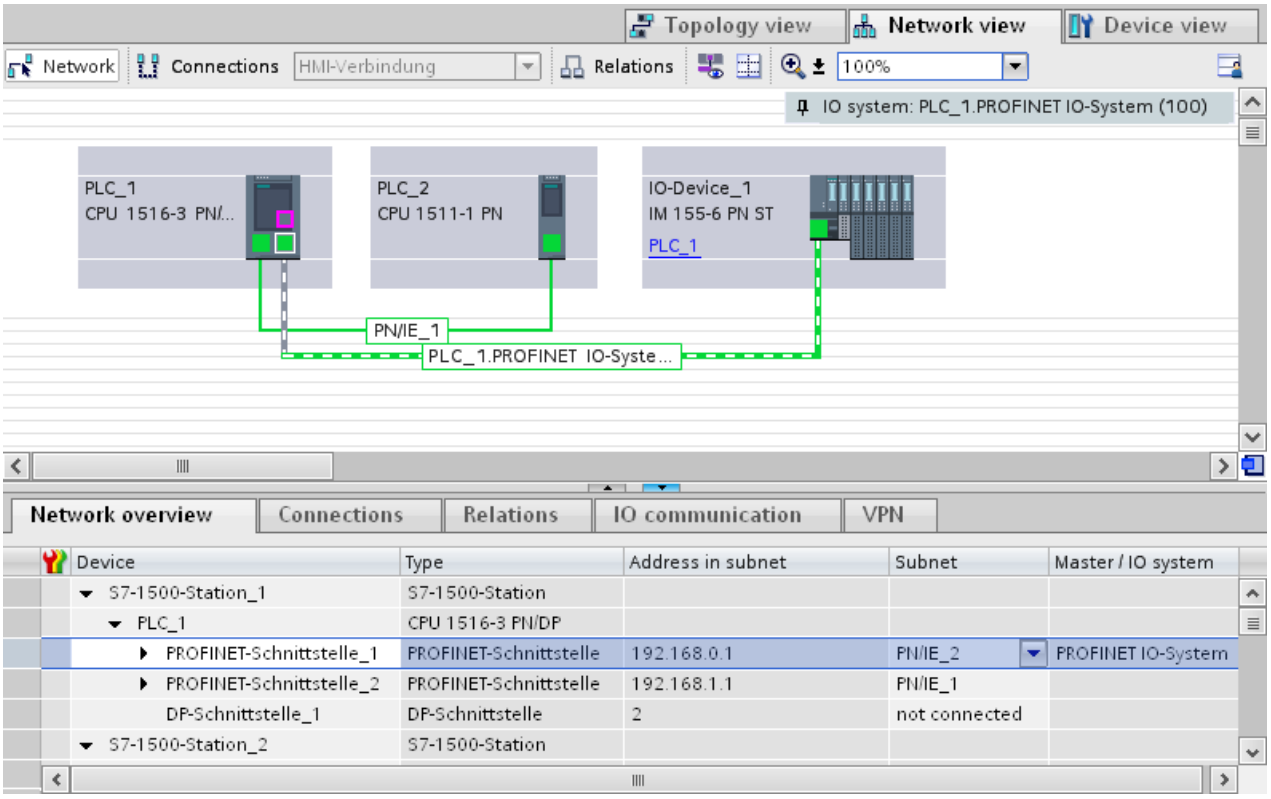

Figure 3-582 Changing the device name of a PROFINET device in STEP 7

Procedure: Changing the IP address

To change the IP address, follow these steps:

1. In the network or device view of the STEP 7 hardware and network editor, select the PROFINET interface of a PROFINET device.
2. In the Inspector window, go to "Ethernet addresses" in the "IP protocol" area.
3. Check that the option "Set IP address in the project" is selected.

4. Enter the new IP address in the relevant field.

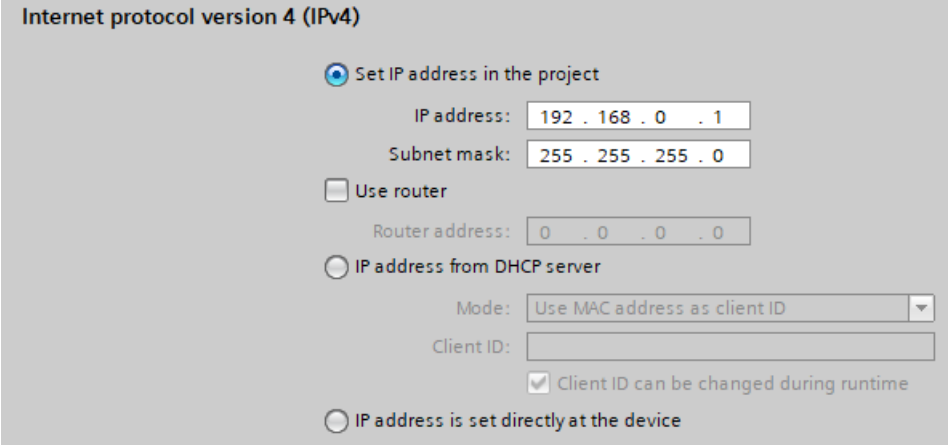

Figure 3-583 Changing the IP address of a PROFINET device in STEP 7

Downloading configured device name to IO device

To load the configured device names to the IO device, follow these steps:

1. Connect your programming device/PC to the same network as the relevant IO device. The interface of the programming device/PC must be set to TCP/IP mode.
2. In STEP 7, select the relevant IO device in the "Accessible devices" dialog based on the MAC address.
3. Click "Assign name" to download the configured device name to the IO device.

   The IO controller recognizes the IO device automatically by its device name and automatically assigns the configured IP address to it.

Identification of the PROFINET device

To clearly identify a device from several identical devices in a control cabinet, for example, you can flash the link LED of the PROFINET device.

To do this, select the menu command **Online > Accessible devices...** in STEP 7. In the "Accessible devices" dialog, set the "PG/PC" interface by means of which you are connected to the devices. STEP 7 now automatically searches for the accessible devices and displays them in the "Accessible devices in target subnet" table. Select the desired PROFINET device and click on the "Flash LED" button. The PROFINET device is identified based on its MAC address.

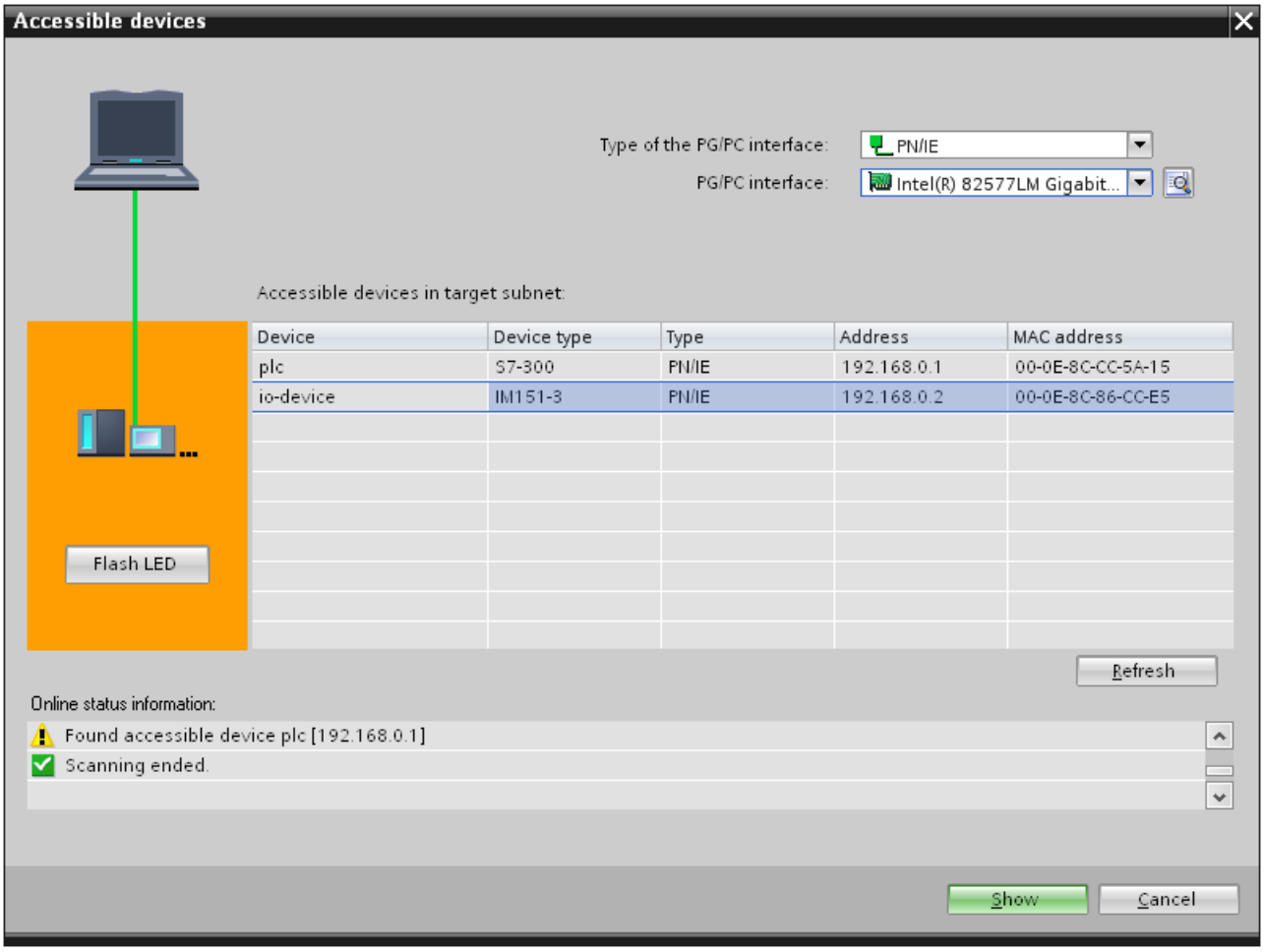

Figure 3-584 "Accessible devices" dialog

Using an different way to assign IP addresses for IO devices

Various IO devices, for example, SCALANCE X,S7-300 CPs, support the option of not having the IP addresses assigned by the IO controller during startup. In this case, the IP address is assigned in a different way. For additional information, refer to the manual of the respective PROFINET device of the SIMATIC device family.

More information

You can find a detailed description of the operation and functions of the display of the S7-1500 CPUs in the system manual S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792).

5.2.4 Assign device name via communication table

Introduction

You can assign the device names of PROFINET IO devices configured offline to the devices online. You can do this in the table area of the network view in the table "I/O communication". You can also assign the device names to several devices at the same time.

"Online assignment" tab

In the I/O communication table, you will find the tabs "Offline configuration" and "Online assignment". In the "Online assignment" tab, you can assign the PROFINET device names that were assigned offline to the corresponding IO devices online. To do this, use the buttons "Check devices" and "Assign now".

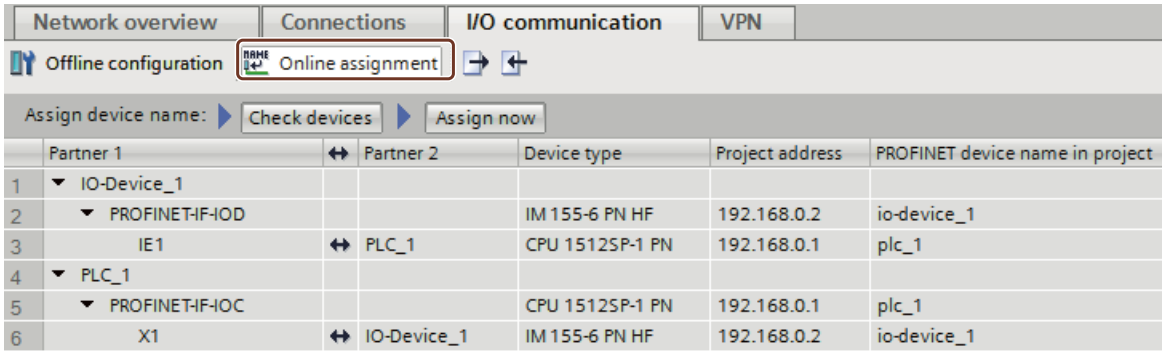

	Partner 1		Partner 2	Device type	Project address	PROFINET device name in project
1	IO-Device_1					
2	PROFINET-IF-IOD			IM 155-6 PN HF	192.168.0.2	io-device_1
3	IE1	↔	PLC_1	CPU 1512SP-1 PN	192.168.0.1	plc_1
4	PLC_1					
5	PROFINET-IF-IOC			CPU 1512SP-1 PN	192.168.0.1	plc_1
6	X1	↔	IO-Device_1	IM 155-6 PN HF	192.168.0.2	io-device_1

Figure 3-585 Assign device name via communication table

The objects displayed in the table of the "Online assignment" tab depend on the setting of the filter function. If only selected objects should be displayed, only objects of the corresponding context are displayed depending on the selection in the network view.

- PROFINET subnet: All connected devices and their PROFINET interfaces
- IO system All devices involved and their PROFINET interfaces
- Sync domain: All devices involved and their PROFINET interfaces
- Devices: The device and any existing PROFINET interfaces
- Other subnets or interfaces such as MPI or PROFIBUS are not displayed

If the display is set for all devices using the filter function, all devices are displayed that have a PROFINET interface, regardless of whether they are connected via a PROFINET subnet or are part of an IO system. Devices without a PROFINET interface, for example only with a DP or MPI interface, are not displayed.

General procedure

To assign PROFINET device names, you must first detect the IO devices available online. With this procedure, it matters whether the MAC addresses are known or unknown. This results in a general procedure in two steps:

1. Detecting the IO devices available online
2. Assigning configured PROFINET device names to the IO devices available online

Requirements

- You are in the network view.
- There is an online connection to the devices.

Procedure (step 1)

To detect IO devices available online from the I/O communication table, follow these steps:

1. Optional: Entered known MAC addresses in the "MAC address" column. After every valid entry, the check box under "Assign device" is selected for the relevant row.

   NOTE

   You can enter, insert or import the MAC address in different formats. The correct format is automatically entered in the cell. The following entries are supported and then converted to the required format:

   – "08:00:06:BA:1F:20"
   – "08 00 06 BA 1F 20"
   – "080006BA1F20"

   The formats used in the example are automatically converted to "08-00-06-BA-1F-20".

2. Click "Check devices" to start the check of the IO devices available online.
3. Set the PG/PC interface in the dialog window and click "Start".

Intermediate result

After the check, the result is displayed for every device in the table. Online data found is automatically entered in the table and the check box "Assign device" is set to "checked" in the rows in which a MAC address was entered or found online. The result of the check is shown as an icon in the "Status" column.

Status	Meaning
	Matching device and compatible type
	Matching device and incompatible type

Status	Meaning
	Non-matching device
	Device cannot be reached (with a known MAC address)
	Ready for assignment (with known MAC address)

NOTE

The icon "Ready for assignment" appears when a MAC address exists and matching device data was found, but no PROFINET device name was found online.

You can update the data of the detected devices again via their MAC addresses at any time. To do this, you specify the MAC address and the status of the device is displayed immediately without having to re-detect the device.

Procedure (step 2)

All PROFINET device names configured offline will be assigned to the devices available online in a bulk operation.

1. Click the "Assign now" button.

   NOTE

   The bulk operation cannot be reversed. A message to this effect appears in a dialog window.

2. Click "Start" in the dialog window to start the assignment of the PROFINET device names.

Result

The PROFINET device names configured offline will be assigned to the devices available online. This relates to devices in whose row the check box under "Assign device" is selected, that have a MAC address and have the status "Ready for assignment".

Importing and exporting data

Using the import and export button, you can import or export the data of the I/O communication table for the online assignment:

- When you export, the currently displayed data of the table is exported to a CSV file. Using the filter function of the table, you can select which data will be exported.
- When you import, the data of the CSV file is written to the table. If there are conflicts with values already existing in the table, you can decide whether the data should be overwritten or whether the import needs to be stopped.

5.2.5 Permitting changes to the device name and IP address directly on the device

Introduction

Machines are frequently commissioned on site or integrated into the existing infrastructure without STEP 7. You can find typical applications in all areas of the series machine building. Alternative means for assigning the IP address are available for this.

Procedure

1. In the network or device view of the STEP 7 Hardware and Network editor, select the PROFINET interface of an IO controller.
2. Navigate in the Inspector window to "Ethernet addresses".
3. Select the "IP address is set directly at the device" option in the "IP protocol" area.
4. In the "PROFINET" area, select the " PROFINET device name is set directly at the device" check box.

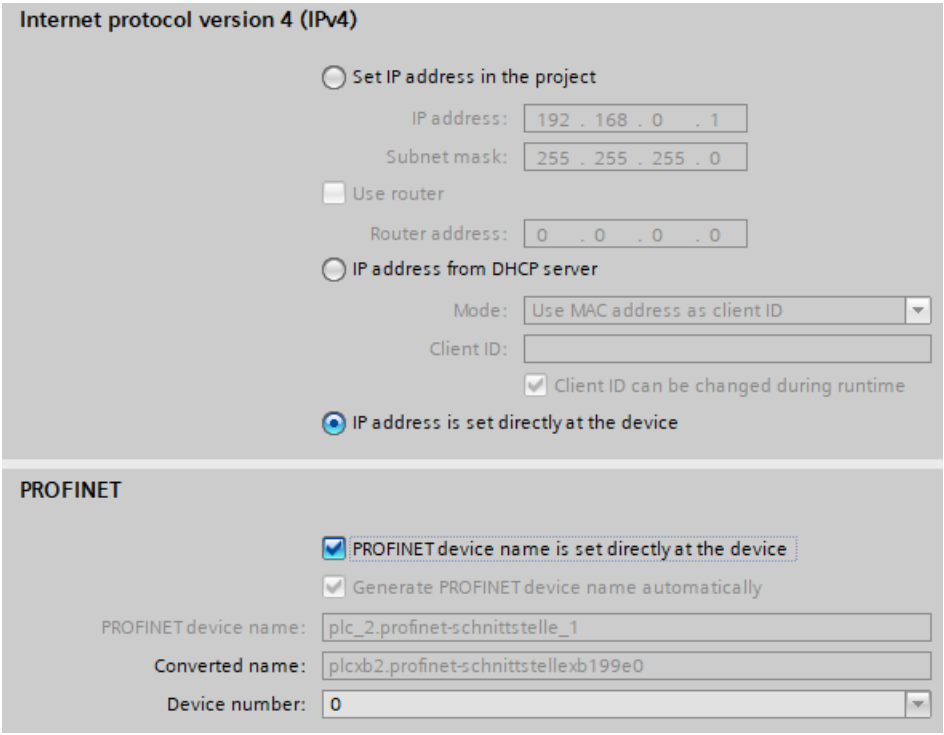

Figure 3-586 Setting the device name and IP address on the device

NOTE

Gateway

When you operate a PROFINET device with the option "Allow adaption of the device name/IP address directly on device", you cannot use this PROFINET device as gateway for S7 routing.

Options for assigning IP addresses and device names

Apart from the known address and device name assignment in the "Ethernet addresses" section of the Inspector window, there are other ways in which the IP address and name can be assigned:

- Assigning by means of the user program with the instruction "T_CONFIG"
- Assignment when downloading the configuration to the target system via the "Extended download to device" dialog box.
- Assignment via the Primary Setup Tool (PST)
- Assignment via the PRONETA ("PROFINET network analysis") commissioning and diagnostics tool
- Assignment via the SIMATIC Automation Tool

Additional information

For information on the "T_CONFIG" instruction and on downloading to the target system, refer to the STEP 7 online help.

A free Download (https://support.industry.siemens.com/cs/ww/en/view/109776941) of the Primary Setup Tool (PST) can be found on the Internet. On this Internet page, you will also find a list of devices for which the PST is approved.

5.3 Configuring an IO device through hardware detection

Introduction

As of STEP 7 V15, you have the possibility to detect a real existing IO device and to import it into your project.

You find the IO device in STEP 7 through the "Hardware detection" function. A detected device can be imported into your project. STEP 7 inserts the IO device with all the modules and submodules.

Requirements

- STEP 7 (TIA Portal) as of V15
- It must be possible to technically access the IO device via IP

Procedure

To detect one or more existing IO devices in STEP 7 and add them to the project, follow these steps:

1. In STEP 7, navigate to "Online" > "Hardware detection".
2. Click "PROFINET devices from network...".
   STEP 7 opens the "Hardware detection of PROFINET devices" window.

3. Select the interface of your programming device at "PG/PC interface:".
4. Click "Start search".
   STEP 7 begins with the hardware detection. When the hardware detection is completed, STEP 7 displays the detected IO devices.
5. Select the IO devices that you want to add to the project by clicking the corresponding check box before the IO device.
6. Click "Add devices".
   After a brief moment, a window is opens to report about the success or failure of the hardware detection.

Result of the hardware detection

If the hardware detection is successful, STEP 7 inserts the IO device with all the modules and submodules into the project.

An IO device configured via hardware detection responds as follows:

- Modules configured through the "Hardware detection" are configured as if they have been inserted from the catalog.
- MAC address: STEP 7 imports the MAC address of the detected IO device into the project.
- IP settings:
  - If the detected IO device already has an IP address, STEP 7 imports the IP address into the project.
  - If the detected IO device does not have an IP address, STEP 7 automatically assigns an IP address in the project.

  PROFINET device name:
  - If the detected IO device already has a PROFINET device name, STEP 7 imports the PROFINET device name into the project.
  - If the detected IO device does not have a PROFINET device name, STEP 7 automatically assigns a PROFINET device name in the project.
- IO devices configured through "Hardware detection" have neither an IP subnet nor an IO controller assigned.

5.4 Specifying the router for a PROFINET IO device

Introduction

You always require a router (also referred to as a "Standard Gateway") when the PROFINET device has to communicate with a node whose IP addresses lie outside the own IP subnet. If the PROFINET device sends an IP packet to an IP address outside its own IP subnet, the IP packet first goes to the configured router. The router in turn checks the IP address. If this lies outside its own subnet, the router passes the IP packet on to the next router. The IP packet is routed to the next router until it has reached the target address.

Like all S7-1500 CPUs, S7-1500 CPUs with several PROFINET interfaces provide the possibility to configure the IP address of a router. However, there is the restriction that you can only enter the IP address of a router at a PROFINET interface.

You cannot configure an IP address of a router for the other PROFINET interfaces of the CPU. IO devices that are connected to this PROFINET interface adopt this setting. Up to and including STEP 7 V14 SP1, these IO devices did not have any possibility to reach devices in a different IP subnet.

As of STEP 7 V15, you have the possibility to assign the address of a router for an IO device independent of the setting of the IO controller. You can now, for example, set a router address at the IO device in the following cases as well:

- You have not set an IP address of a router for the interface of the associated IO controller.
- You have already set a router address for a different interface in the CPU.

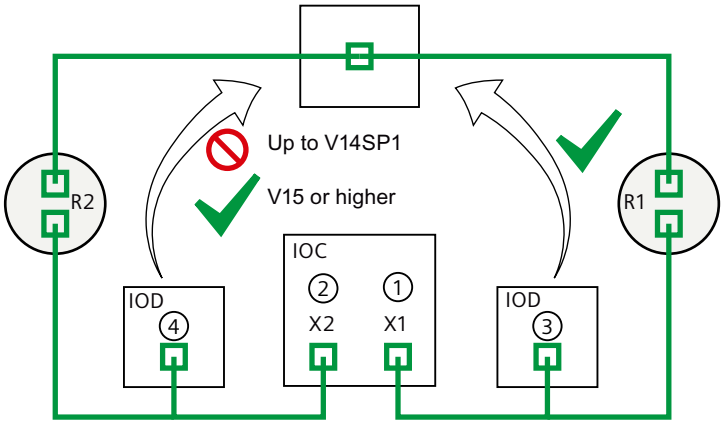

① Router R1 configured at PROFINET X1

② If a router is configured at X1, you cannot configure a router at X2.

③ Because a router is configured at X1, the IO device adopts the IP address of the router R1. The IO device can be reached from a different IP subnet.

④ As of STEP 7 V15, you set the IP address of the router R2 at the IO device irrespective of the setting at the interface X2. The IO device can be reached from a different IP subnet.

Figure 3-587 Specifying the router for an IO device

Further information about the "User router" setting

You have the possibility to configure the use of a router including IP address of the router in the "IP protocol" section of the settings for the PROFINET interface (Ethernet addresses).

Rules

Observe the following rules if you want to configure a router for the PROFINET interface of an IO controller:

- A PROFINET IO device supports exactly one router, irrespective of the number of interfaces.
- You can configure a router for exactly one PROFINET interface. All IO devices that are assigned to the PROFINET interface adopt the configured router from the IO controller.
- You cannot configure a router for the further PROFINET interfaces of the CPU. The further PROFINET interfaces take on the IP address "0.0.0.0" as the router and pass it on to their IO devices.

As of STEP 7 V15, you can configure the use of a router for an IO device. This allows the IO device to communicate with a node outside its own IP subnet, irrespective of the setting of the PROFINET interface of the IO controller.

Configuration example: Configuring a router for an IO device

The following example shows a configuration in which you configure a router at the IO device so that the IO device reaches IP addresses in the higher-level network.

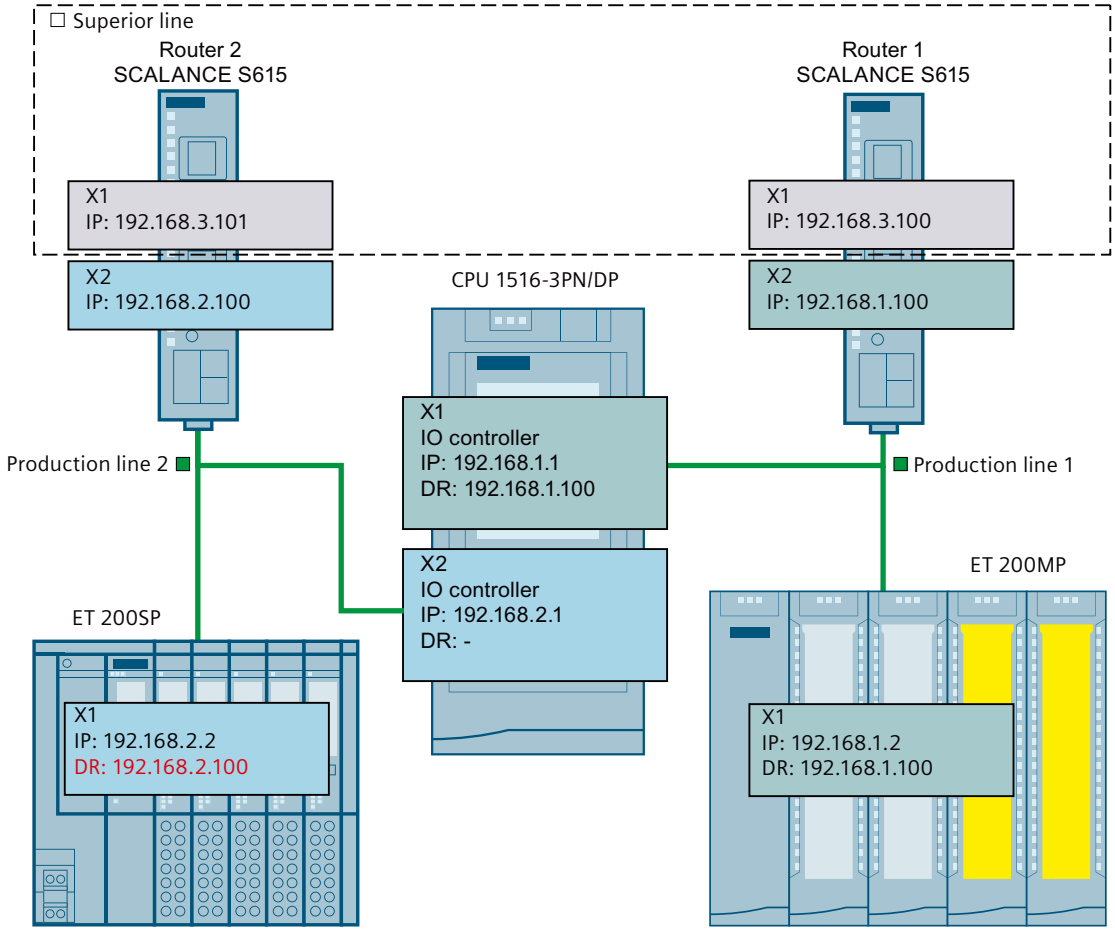

Figure 3-588 Configuration example: Configuring a router for an IO device

You have a CPU 1516-3PN/DP. The two PROFINET interfaces X1 and X2 of the CPU work in the "IO controller" operating mode. The PROFINET interface X1 is connected with the subnet "Production line 1". PROFINET interface X2 is connected with the subnet "Production line 2". The two subnets "Production line 1" and "Production line 2" are each connected via a router with the higher-level network "Superior line".

For PROFINET X1, you configure the router "Router 1" with the IP address 192.168.1.100.

The IO device (ET 200SP) in the "Production line 1" subnet adopts the router from the IO controller.

You cannot configure a router for the PROFINET interface X2 because you have already configured a router for the PROFINET interface X1 of the CPU.

No router is transferred by the PROFINET interface X2 to the IO device in the subnet "Production line 2".

In order for the IO device in the subnet "Production line 2" to reach nodes in the higher-level "Superior line", configure the router "Router 2" with the IP address 192.168.2.100 for the IO device.

Configuring the router for the IO controller

Requirements: You use the "Set IP address in the project" option for the PROFINET interface.

Follow these steps to configure a router for the IO controller in STEP 7:

1. In the network view of STEP 7, select the PROFINET interface of the IO controller.
2. In the Inspector window, navigate to "Properties" > "General" > "Ethernet addresses".
3. Select the "Use router" check box in the "IP protocol" field.
4. Enter the IP address of the router at "Router address".

Configuring a router for an IO device

Requirements:

- STEP 7 as of V15
- CPU 1500 as of firmware version V2.5
- IO device is assigned to the PROFINET interface of an IO controller. The PROFINET interface of the IO controller uses the "Set IP address in the project" option.

Follow these steps to configure a router for the IO device in STEP 7:

1. In the network view of STEP 7, select the PROFINET interface of the IO device.
2. In the Inspector window, navigate to "Properties" > "General" > "Ethernet addresses".
3. Clear the "Synchronize router settings with IO controller" check box.
4. Select the "Use router" check box.
5. Enter the IP address of the router at "Router address".

5.5 Configuring topology

Introduction

If an IO device is assigned to an IO controller, this does not yet specify how the ports are connected to each other.

A port interconnection is not required to use RT, but it provides the following advantages:

- A set topology is assigned with the port interconnection. Based on an online-offline comparison, it is possible to conduct a set-actual comparison with all devices that support this function.
- The "Device replacement without exchangeable medium" function can be used.

A port interconnection is an essential requirement for using IRT.

An overview of various options for setting up a PROFINET network is given below.

Line

All the communication devices are connected in a linear bus topology.

In PROFINET, the linear bus topology is implemented with switches that are already integrated into the PROFINET devices. Therefore, the linear bus topology at PROFINET is merely a special form of tree / star topology.

If a link element (switch, for example) fails, communication across the failed link element is no longer possible. The network is then divided into 2 subsegments.

Linear bus topology structures require the least cabling.

Star

If you connect communication devices to a switch with more than two PROFINET ports, you automatically create a star network topology.

If an individual PROFINET device fails, this does not automatically lead to failure of the entire network, in contrast to other structures. It is only if a switch fails that part of the communication network will fail as well

Tree

If you interconnect several star structures, you obtain a tree network topology.

Ring

In order to increase the availability of a network, use ring structures. In principle, a linear bus topology is connected to a ring through a so-called redundancy manager.

The task of the redundancy manager is managed by an external switch SCALANCE X, a CPU that supports the Media Redundancy Protocol MRP (e.g., CPU 1516-3 PN/DP) or a CP (e.g., CP 343-1 Lean).

If there is a break in the network, the redundancy manager ensures that the data is redirected over an alternative network connection in the ring.

Example for topology

The following example shows a combination of different topologies.

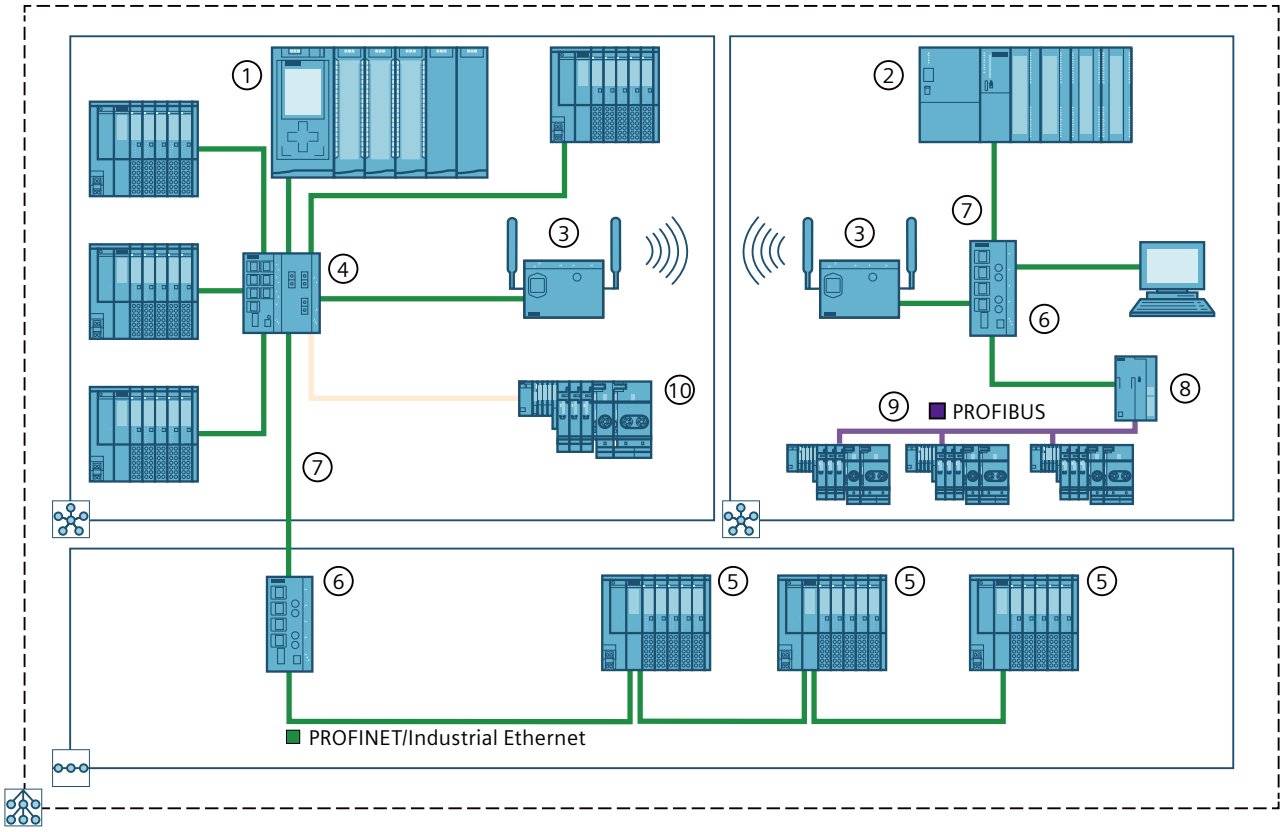

Number	Meaning
①	S7-1500 as IO controller
②	S7-300 as IO controller
③	Industrial WLAN with SCALANCE W
④	SCALANCE X 307-3 with seven electrical and three optical ports
⑤	ET 200SP with integrated 2-port switch
⑥	SCALANCE X 204 with four electrical ports
⑦	PROFINET/Industrial Ethernet
⑧	IE/PB-Link PN IO
⑨	PROFIBUS DP
⑩	ET 200S with two optical ports
	Star topology
	Linear bus topology
	The combination of topology forms results in a tree topology.

Figure 3-589 Combined topology

Additional information

Observe the PROFINET Installation Guideline (http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/) of the PROFIBUS User Organization when planning your PROFINET topology.

For more detailed information, see the SIMATIC NET Twisted Pair and Fiber Optic Networks (http://support.automation.siemens.com/WW/view/en/8763736) manual.

You can find basic information in the Communication with SIMATIC (http://support.automation.siemens.com/WW/view/en/1254686) manual.

5.5.1 Topology view in STEP 7

Introduction

The topology view is one of three working areas of the hardware and network editor. You undertake the following tasks here:

- Displaying the Ethernet topology
- Configuring the Ethernet topology
- Identify and minimize differences between the set and actual topology (online)

The topology view in STEP 7 consists of a graphic area and a table area.

Graphic area

The graphic area of the topology view displays PROFINET devices with their appropriate ports and port connections. Here you can add more PROFINET devices.

The following figure shows the graphic area of the topology view.

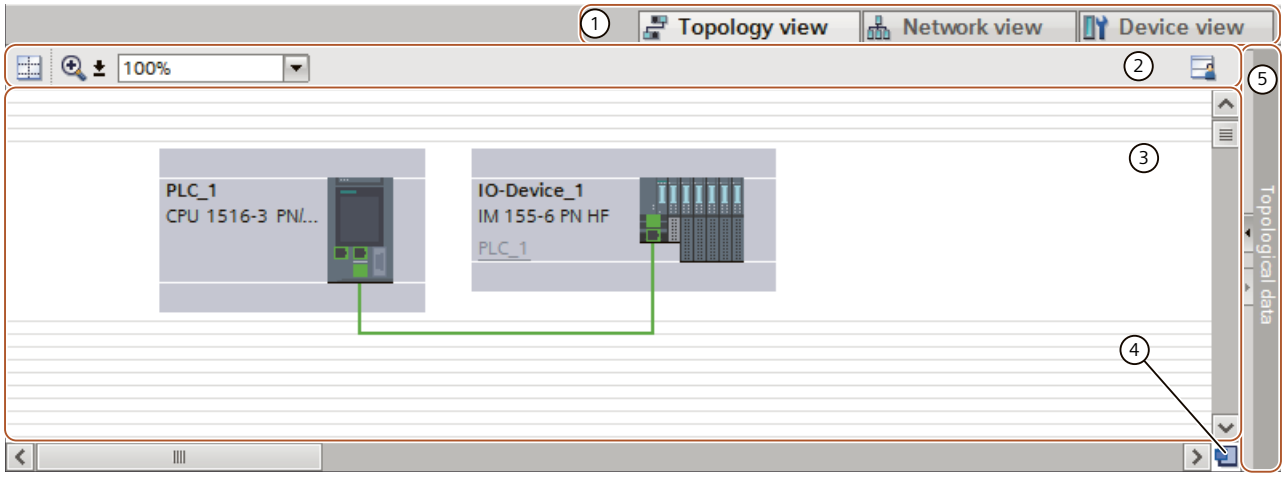

① Selector: Device view/Network view/Topology view

② Toolbar

③ Graphic area of the topology view

④ Overview navigation

⑤ Selector for the table area of the topology view

Figure 3-590 Graphic area of the topology view

Overview navigation

Click in the overview navigation to obtain an overview of the created objects in the graphic area. By holding down the mouse button, you can quickly navigate to the desired objects and display them in the graphic area.

Table area

- Topology overview: This displays the Ethernet or PROFINET devices with their appropriate ports and port connections in a table. This table corresponds to the network overview table in the network view.
- Topology comparison: Here you can import devices and port interconnections automatically through offline/online comparison or extended Offline/Online comparison into STEP 7.

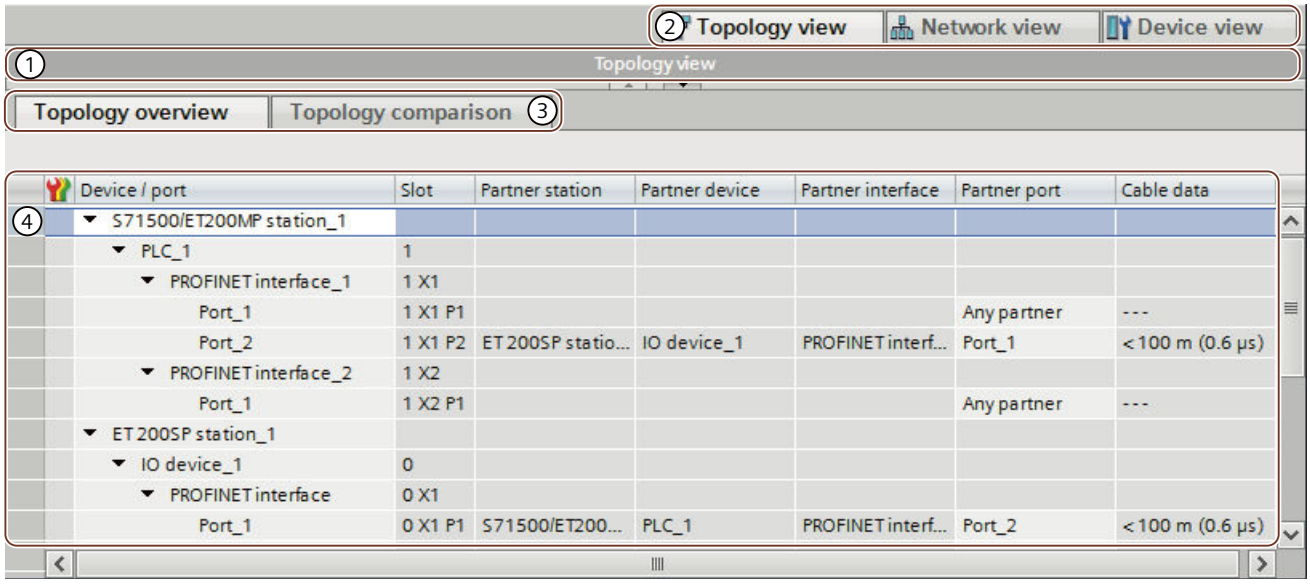

① Selector for the graphic area of the topology view

② Selector: Device view/Network view/Topology view

③ Selector: Topology overview/Topology comparison

④ Table area of the topology view

Figure 3-591 Table area of the topology view

5.5.2 Interconnecting ports in the topology view

Requirement

You are in the graphic view of the topology view.

Procedure

To interconnect ports in the topology view, follow these steps:

1. Place the pointer of the mouse on the port you want to interconnect.
2. Press and hold down the left mouse button.
3. Move the pointer.

   The pointer now uses the networking symbol to indicate "Interconnecting" mode. At the same time, you see the lock symbol on the pointer. The lock symbol disappears only when the pointer is over a valid target position.
4. Now drag the pointer to the target port. You can keep the left mouse button pressed or release it when performing this action.
5. Now release the left mouse button or press it again (depending on your previous action).

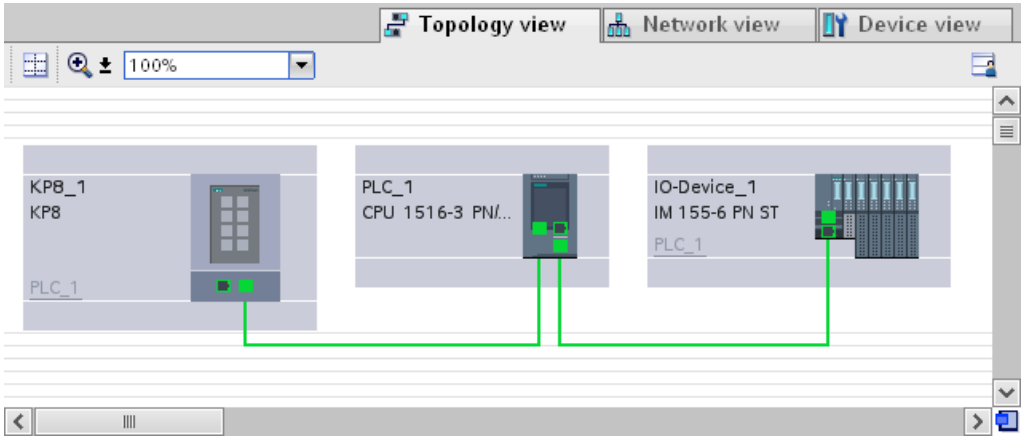

Figure 3-592 Interconnecting ports in the topology view

Result

You have created a port interconnection.

5.5.3 Interconnecting ports - Inspector window

Interconnecting ports in the Inspector window

To interconnect ports, follow these steps:

1. In the device or network view, select the PROFINET device or PROFINET interface.
2. In the Inspector window, navigate to the port property "Port interconnection".

   When the PROFINET interface is selected, you can find this setting in the Inspector window as follows: "Properties > General > Advanced Options > Port [...] > Port Interconnection."

3. In the "Local port" section, you can find the settings at the local port. In the case of fiber-optic cable you can, for example, set the cable names here.

   In the "Partner port" area, select the drop-down list for "Partner port" in order to display the available partner ports and make a selection.

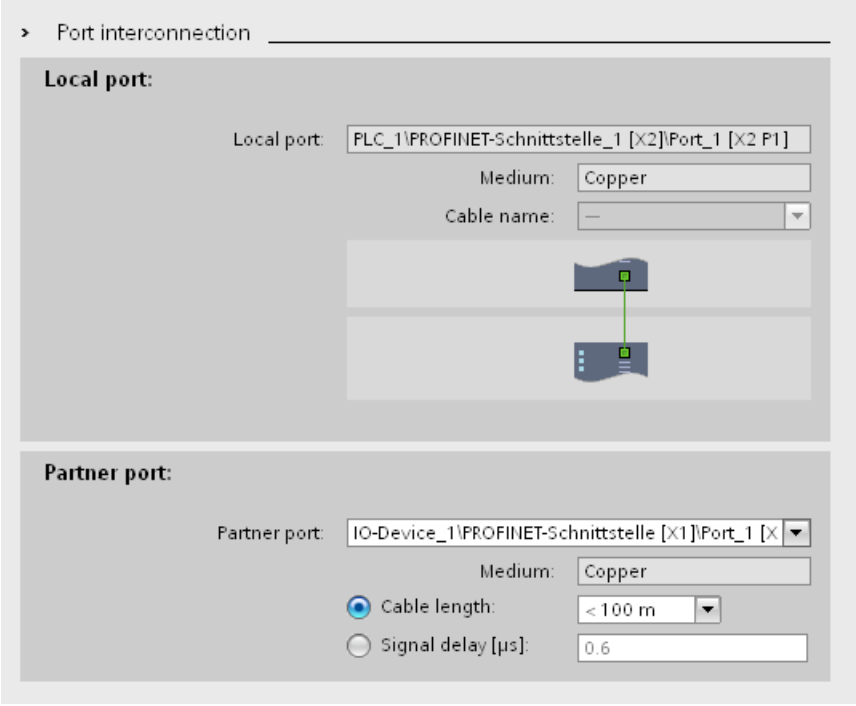

Figure 3-593 Interconnecting ports in the Inspector window in STEP 7

If the PROFINET interface was disconnected, it is automatically connected by this action. In the properties of the subnet you can set whether this subnet should or should not be used for the networking.

5.5.4 Automatic assignment of devices by offline/online comparison

Overview

During the offline/online comparison, the configured topology is compared with the actual existing topology. Devices identified online are automatically assigned to configured devices as far as this is possible.

Start of availability detection

You start the availability detection the first time by clicking the "Compare offline/online" button in the toolbar of the "Topology comparison" tab.

You restart availability detection by clicking the "Update" button.

NOTE

The availability detection can take several seconds. During this time, no user input is possible.

Automatic assignment of a PNIO device

A PNIO device identified online is automatically assigned to a configured device if the following properties of the two devices match up:

- Article no.
- Type
- PROFINET device name

No automatic assignment

In the following situations, no automatic assignment is possible:

- No device can be identified online to match a configured device. (This means that the corresponding columns in the "Online topology" area of the topology comparison table are empty.)

  In this case, you should add the already configured device to your system or delete the configured device from the configuration.
- A device identified online can be assigned to a configured device, but there are differences in the port interconnections.

  In this case, you can Apply the port interconnections identified online manually to the project (Page 85).
- A device identified online cannot be assigned to a configured device. (In this case, the corresponding columns in the "Offline topology" area of the topology comparison table are empty.)

  In this case, you can Include the devices identified online manually in the project (Page 86).

5.5.5 Apply the port interconnections identified online manually to the project

Requirements

You have run an offline/online comparison in the topology view. The result of this is that at least one device identified online was automatically assigned to a configured device, but that there are differences relating to the interconnection.

Procedure

To adopt one more port interconnections identified online in the project manually, follow these steps:

1. Select the row belonging to the port interconnection.
2. If applicable, select further roles using multi-selection.
3. Select "Apply" > "Use selected" in the shortcut menu.

   The content of the corresponding table cells in the "Action" column changes to "Apply".
4. If you have mistakenly prepared too many port interconnections to be included in the project:

   Select the rows belonging to the port interconnections you have mistakenly prepared for inclusion in the project using multi-selection.

   Select "Reset" > "Reset selected" in the shortcut menu.

   The content of the corresponding table cells in the "Action" column change to "No action".
5. Click the "Synchronize" button.

Result

The port interconnections identified online for the corresponding devices are included in the project. Successful adoption is indicated by the diagnostics icon "Identical topology information" for each port.

NOTE

If other port interconnections are recognized for a device identified online and these differ from those that exist in the project, adopting these in the project means that the port interconnections that were previously in the project are replaced by those identified online. If no port interconnections are detected for a device identified online, adopting in the project means that all the port interconnections of this device are deleted in the project.

5.5.6 Include the devices identified online manually in the project

Requirements

You have run an offline/online comparison in the topology view. The result of this is that at least one device identified online could not be assigned to any configured device.

Procedure

To adopt one more devices identified online in the project manually, follow these steps:

1. For a configured device without an online partner, move the mouse pointer to the "Device/port" column of the online topology.
2. Select the device you want to assign to the configured device from the drop-down list of this box.
3. Repeat the previous steps if necessary for other configured devices without an online partner.

Result

The selected device that was identified online is moved up from the end of the table. Following this, it is in the row of the configured device to which you have just assigned it.

5.5.7 Automatic assignment of devices by advanced offline/online comparison

Overview

With the advanced offline/online comparison, ICMP is also used alongside DCP to be able to detect devices that do not support DCP.

Automatic assignment of devices detected by ICMP

With devices detected by ICMP, no type is available.

With passive devices, no article number is available. For this reason, passive devices can only be assigned automatically if you have not assigned an article number in the configured data and the offline and online IP addresses match.

With switches, automatic assignment is possible if the offline and online article number, IP address and PROFINET device name match.

Diagnostics and maintenance

6

LEDs for diagnostics on PROFINET

Each port of a PROFINET interface of a SIMATIC device has one LED.

The following table shows a summary of the meaning of these LEDs in the S7-1500, ET 200MP, ET 200SP and ET 200AL systems.

Table 3-958 S7-1500, ET 200MP, ET 200SP, ET 200AL: LEDs for diagnostics on PROFINET

LED image	Meaning	S7-1500	ET 200MP	ET 200SP	ET 200AL
		LINK/TX/RX LED		LK LED	P1 Link LED P2 Link LED
LED off	There is no Ethernet connection between the PROFINET interface of the PROFINET device and the communication partner. No data is currently being sent/received via the PROFINET interface.	X	X	X	X
LED green	There is an Ethernet connection between the PROFINET interface of your PROFINET device and a communication partner.	X	X	X	X
LED flashes green	The "LED flashing test" is being performed.	X	X	X	X
LED flickers yellow	Data is currently being received from or sent to a communications partner on Ethernet via the PROFINET interface of the PROFINET device.	X	X	-	-

Additional information

You can find a detailed description of all LEDs of the module with cause of the error and remedies in the relevant documentation for the module.

6.1 Diagnostics mechanisms of PROFINET IO

Totally Integrated Diagnostics Concept

All SIMATIC products have integrated diagnostics functions that they can use to detect and remedy faults. The components automatically flag a potential fault in the operation and provide detailed information.

Each individual error or several errors occurring concurrently are transferred from the IO device to the IO controller. If you require the full status of the IO device including any pending errors, you can also read the status directly from the IO device.

The following sections provide basic information on using diagnostics via PROFINET IO. You can find a detailed description of the system diagnostics for S7-1500, ET 200MP, ET 200SP and ET 200AL in the Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual.

Accessing the status of an IO device with a PG/PC or an HMI device

If you are connected to the Industrial Ethernet via a PG/PC with STEP 7 or an HMI device, you can also call up diagnostics information online. This is illustrated by the following graphic.

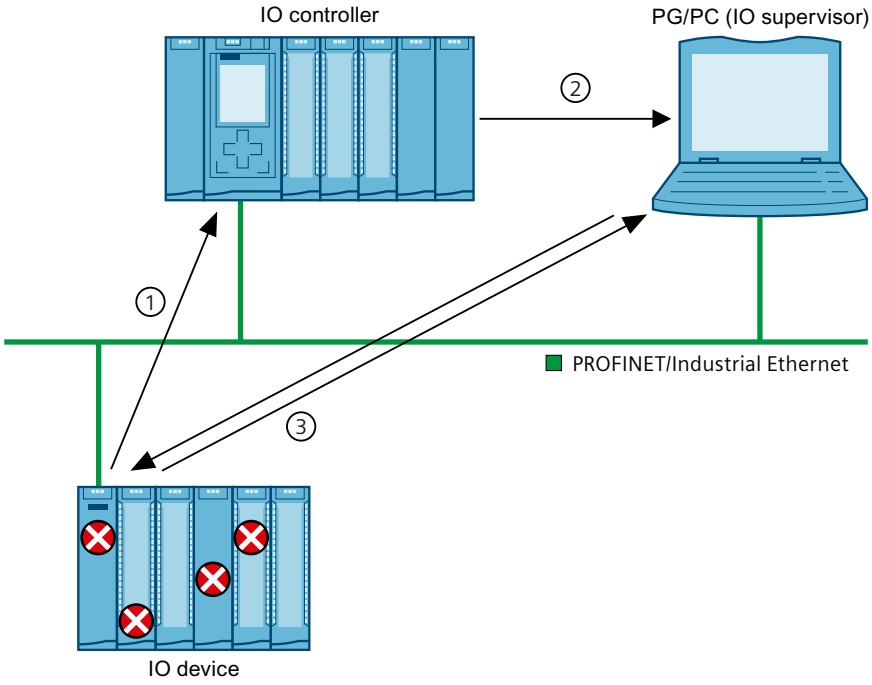

Number	Description
①	The IO device detects an error and sends diagnostics data to the IO controller.
②	The IO controller notifies the programming/HMI device. The display of the system diagnostics is updated.
③	In STEP 7, you can read the station status for "Accessible devices" directly from the IO device regardless of the IO controller. This is only possible if the programming device is connected to Industrial Ethernet. This means that you can access diagnostics information during the commissioning phase or for servicing even if the IO controller is not operational.

Figure 3-594 PROFINET IO diagnostics with PG/PC or HMI device

6.1.1 Diagnostics levels in PROFINET IO

Concept

The IO device sends all error messages that occur to the IO controller. The scope and volume of diagnostics information varies according to the level of diagnostics data evaluation and the PROFINET devices you are using.

Diagnostics levels

You can evaluate diagnostics data at different levels. The number and type of channels is selected, for example, at the diagnostics level 4.

The following figure shows the diagnostics levels with PROFINET IO.

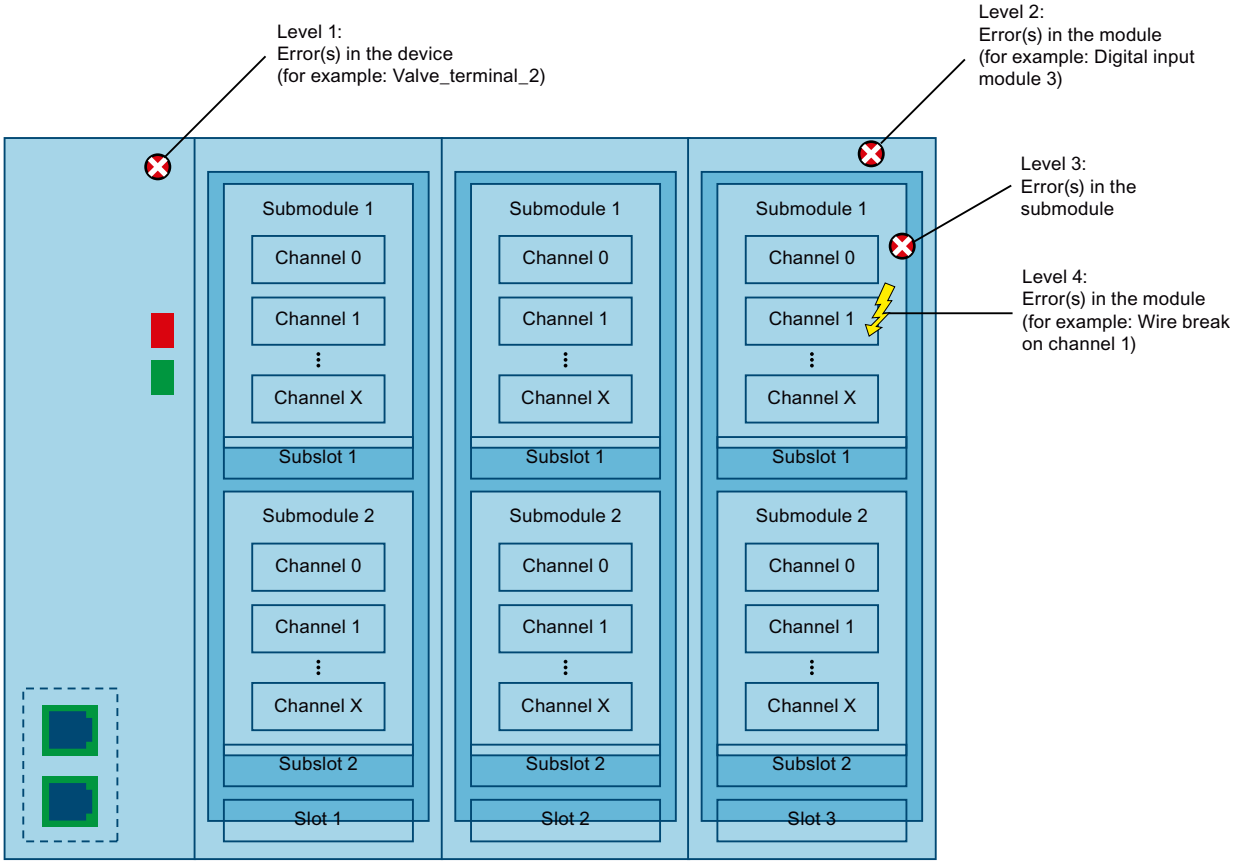

Figure 3-595 Diagnostics levels with PROFINET IO

Representation of diagnostics levels in the device view in STEP 7

The following figure shows the representation of the PROFINET device model in the device view of STEP 7, based on the example of a distributed I/O system ET 200MP:

Number	Description	
①	Level 1:	Error(s) in the device
②	Level 2:	Error(s) in the module

Figure 3-596 Diagnostics levels in the device view of STEP 7

Which PROFINET nodes support the extended PROFINET diagnostics?

An overview of the PROFINET nodes that support extended PROFINET diagnostics and of what you have to configure is provided in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/23678970).

6.2 Diagnostics via the display of the S7-1500 CPUs

Display

The S7-1500 CPU has a display and operating keys. The display of the CPU shows you the control and status information in different menus. You use operating keys to navigate through the menus and make a variety of settings in the process.

Diagnostics via the display

The following indicators can be evaluated for diagnostics purposes on the display:

- Error and alarm texts (system diagnostics, alarm messages)
- Module status for central and distributed modules

In the following example of a display of the CPU 1516-3 PN/DP, you can see a warning on the diagnostics icon and an exclamation mark on the icon for module.

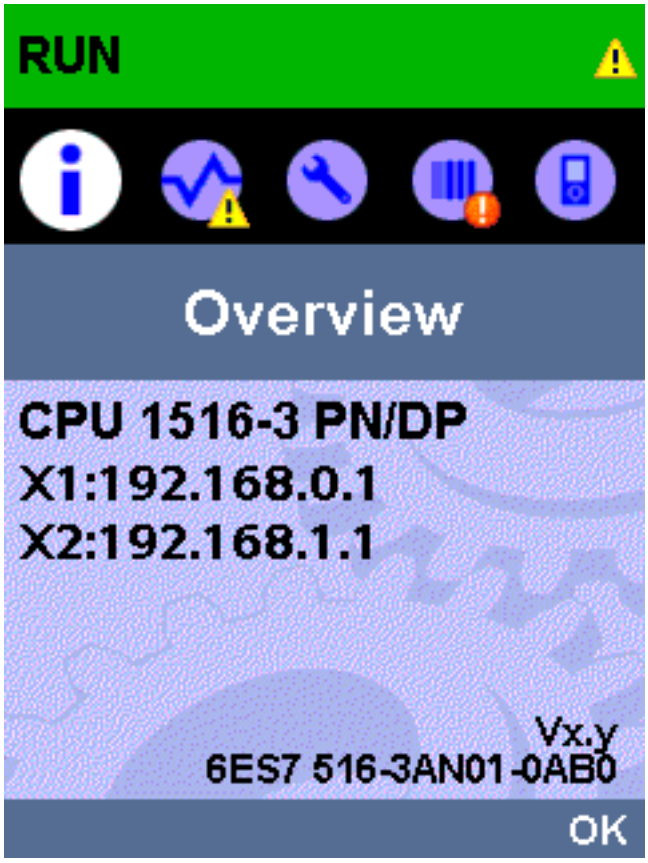

Figure 3-597 Display of overview

Module status

To show the module status, navigate on the display through the menu items "Module" > "PROFINET I/O (X1)" > "Station" > "Slot" > "Status" > "Module status".

The module status indicates that a fault has occurred in the module. The "lower-level status" is the status of the module in the diagnostics level below this. In the example, the status is "good", i.e., the fault is not in the lower diagnostics level submodule or channel, but instead in the module.

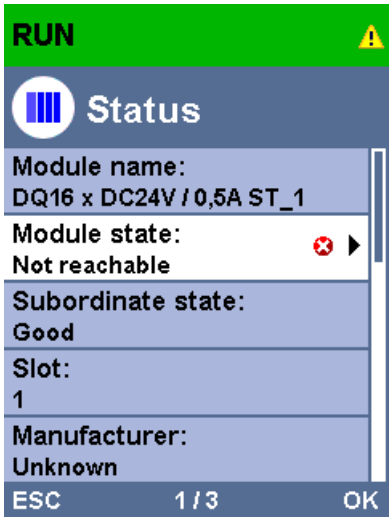

Figure 3-598 Display of module status

Error and alarm texts

You can show diagnostics buffer entries and alarm messages for the relevant automation system on the display.

To show the diagnostics buffer entries of the CPU, navigate on the display via the menu items "Diagnostics" > "Diagnostics buffer".

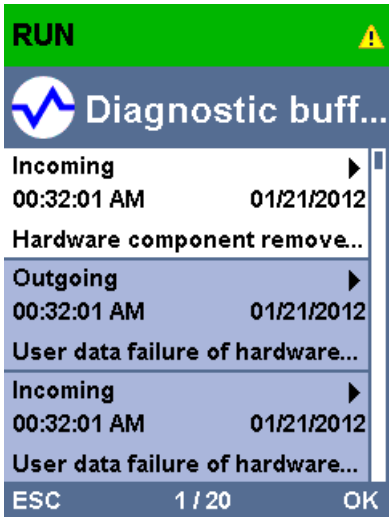

Figure 3-599 Display of diagnostics buffer

To show the alarm messages of the automation system, navigate through the menu items "Diagnostics" > "Alarms" > "Alarm text" on the display.

NOTE

Updating the alarm display

The display shows the currently read status of the CPU in static form, the display is not automatically updated. The alarm display is updated after it has been exited and opened again.

You set the automatic updating of the diagnostics information under: "Display" > "DiagnosticRefresh".

Figure 3-600 Display of alarms

Figure 3-601 Display of alarm message

Additional information

You can find the description of the operation and functions of the display in the SIMATIC S7-1500 Display Simulator (http://www.automation.siemens.com/salesmaterial-as/interactive-manuals/getting-started_simatic-s7-1500/disp_tool/start_de.html).

6.3 Diagnostics via Web server

The CPUs belonging to the S7 family have their own integrated Web server with a wide range of functions.

The following diagnostics options are available to you:

- Start page with general CPU information
- Information on diagnostics
- Contents of the diagnostics buffer
- Module information
- Alarms
- Information about communication
- PROFINET topology
- Motion Control diagnostics
- Trace
- Contents of the diagnostic buffer
- Module status
- Actual topology of the PROFINET system
- Set topology of the PROFINET system (from the configuration)

Set topology and actual topology - graphic view

Requirements for displaying the set and actual topology:

- You have configured the PROFINET ports in the topology editor of the hardware and network editor of STEP 7.
- You have loaded the entire project with STEP 7 in the CPU.

The following shows an example of the graphic view.

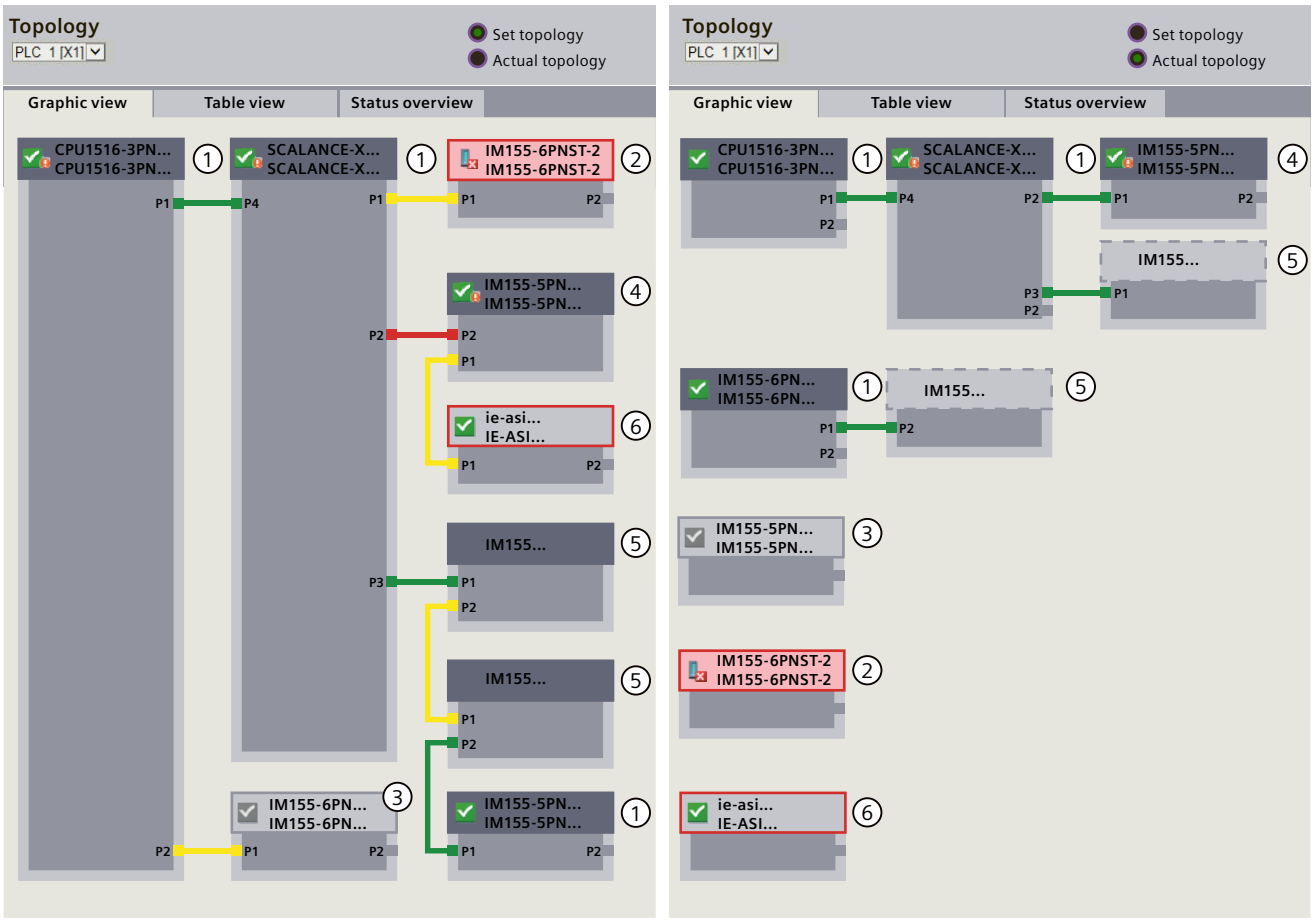

Figure 3-602 Topology - graphic view via the Web server

Meaning of the colored connections in the set/actual topology:

Table 3-959 Meaning of the colored connections in the set/actual topology:

Connection	Meaning	
	Set topology	**Actual topology**
green	The current actual connection matches the configured set connection.	detected connections
red	The current actual connection does not match the configured set connection (e.g., port interchanged).	-
yellow	The connection cannot be diagnosed. Causes: • The communication to an IO device has been disrupted (e.g., cable removed) • Connection to a passive component • Connection to PROFINET devices of another IO controller or PROFINET system	-

① Configured and accessible PROFINET devices

Configured and accessible PROFINET devices are displayed dark-gray. Connections show the ports through which the PROFINET devices of a station are connected.

① Configured but not accessible PROFINET devices

The configured but not accessible PROFINET devices are displayed in pink with red border (e.g., device has failed, cable disconnected).

③ Disabled devices

All disabled, configured PROFINET devices are displayed light-gray.

④ Interchanged ports

Interchanged ports are marked red in the set topology view. The currently connected ports are displayed in the actual topology, the configured set connection in the set topology.

⑤ PROFINET devices of another PROFINET IO system

- In the set topology:

  A PROFINET device of another PROFINET IO system is displayed with a green connection (or red connected if the ports have been interchanged), when it is directly adjoining a configured and accessible PROFINET device ① and it is also accessible. When the PROFINET device of another PROFINET IO system is not accessible, a yellow connection line is displayed.

  The connection between two PROFINET devices that both belong to a different PROFINET IO system, cannot be determined and is always displayed in yellow.
- In the actual topology:

  A PROFINET device of another PROFINET IO system is only displayed if the PROFINET device is in direct proximity to a configured PROFINET device. The PROFINET device is displayed light-gray and with dashed line.

For PROFINET devices of a different PROFINET IO system, **no** status display is shown on the device head.

⑥ Representation of faulty neighbor relations

The devices whose neighbor relations cannot be read out completely or correctly are displayed light-gray with red border.

Additional information

The tabular view of the actual topology and the status overview of the PROFINET devices in the project are possible.

You can find these views, additional topology examples, and detailed information on the operation and the functions of the Web server in the Web server (http://support.automation.siemens.com/WW/view/en/59193560) manual.

6.4 Online diagnostics with STEP 7

For PROFINET, you have the following options to evaluate diagnostics in STEP 7:

- Online & diagnostics - Devices & networks
- Online & diagnostics - diagnostics of PROFINET ports

Online & diagnostics network view

In the hardware and network editor (launched from the "Project tree" by double-clicking "Devices & networks"), you can get an overview of the current state of your system by clicking on the "Go online" button. It also shows the configuration information (for example, non-configured modules). This option is also available in the topology view in similar form.

Schematic drawing of the network view (online):

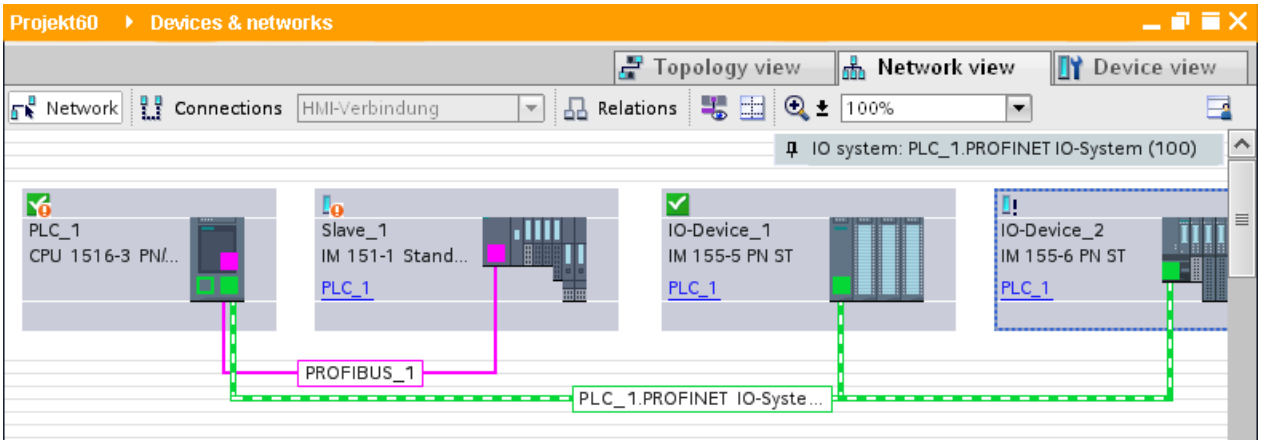

Figure 3-603 Online & diagnostics network view

Online & diagnostics device view

In STEP 7, you can display an overview of the modules in which faults have occurred. To do this, select the menu command "Online > Online & diagnostics". Once you are connected, you can see the status of the accessible devices in the project tree.

Double-click the device which displays an alarm message to access the faulty module directly. The device view is opened in the work area. In the device view of the device that reports the fault you can see directly in which module the fault occurs.

Open the "Diagnostics" tab and the subordinate "Device information" tab in the Inspector window for a more detailed error description.

Schematic drawing of the device view (online):

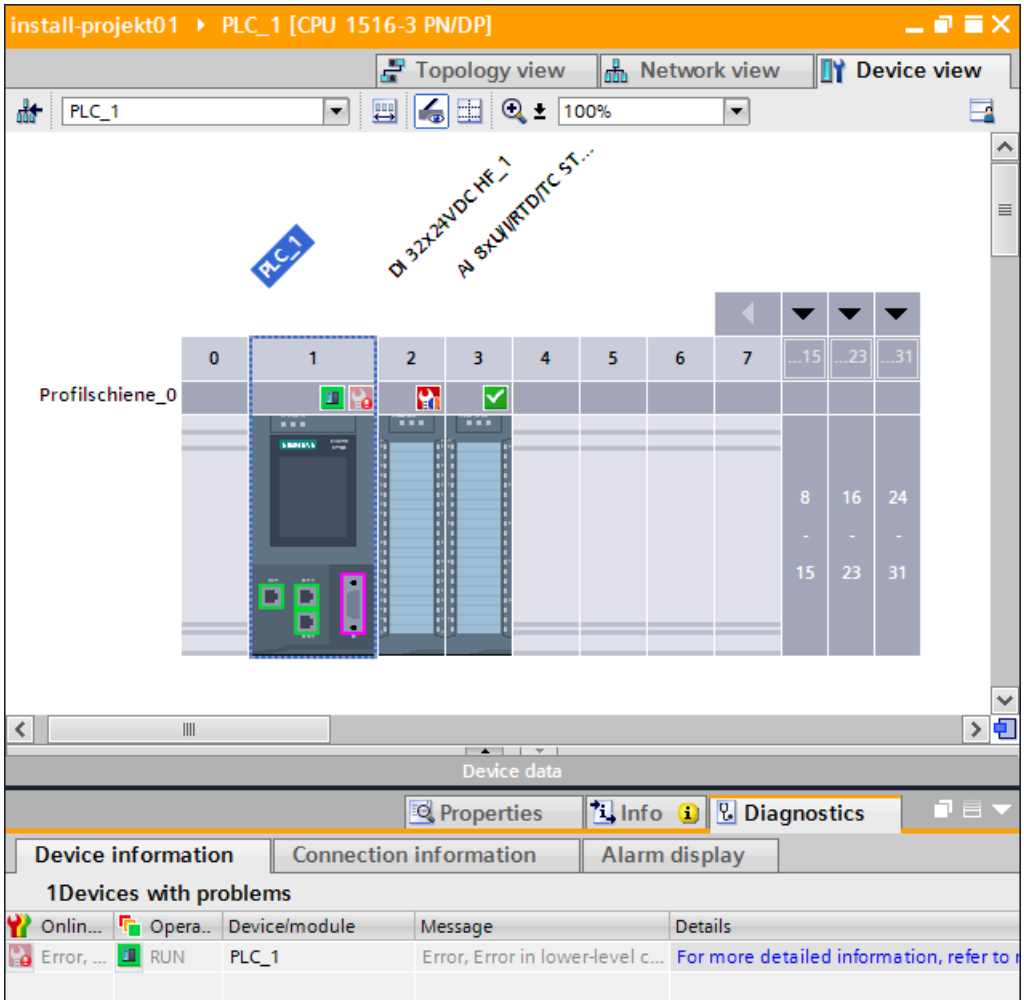

Figure 3-604 Online & diagnostics device view

Diagnostics of PROFINET ports

If you select "PROFINET interface > Ports" in the Diagnostics area in the online & diagnostics device view of a PROFINET device, the ports of the PROFINET interface are listed in a table.

The table provides you with the following information about the ports of the PROFINET interface.

- Name
- Status
- Settings
- Operating mode

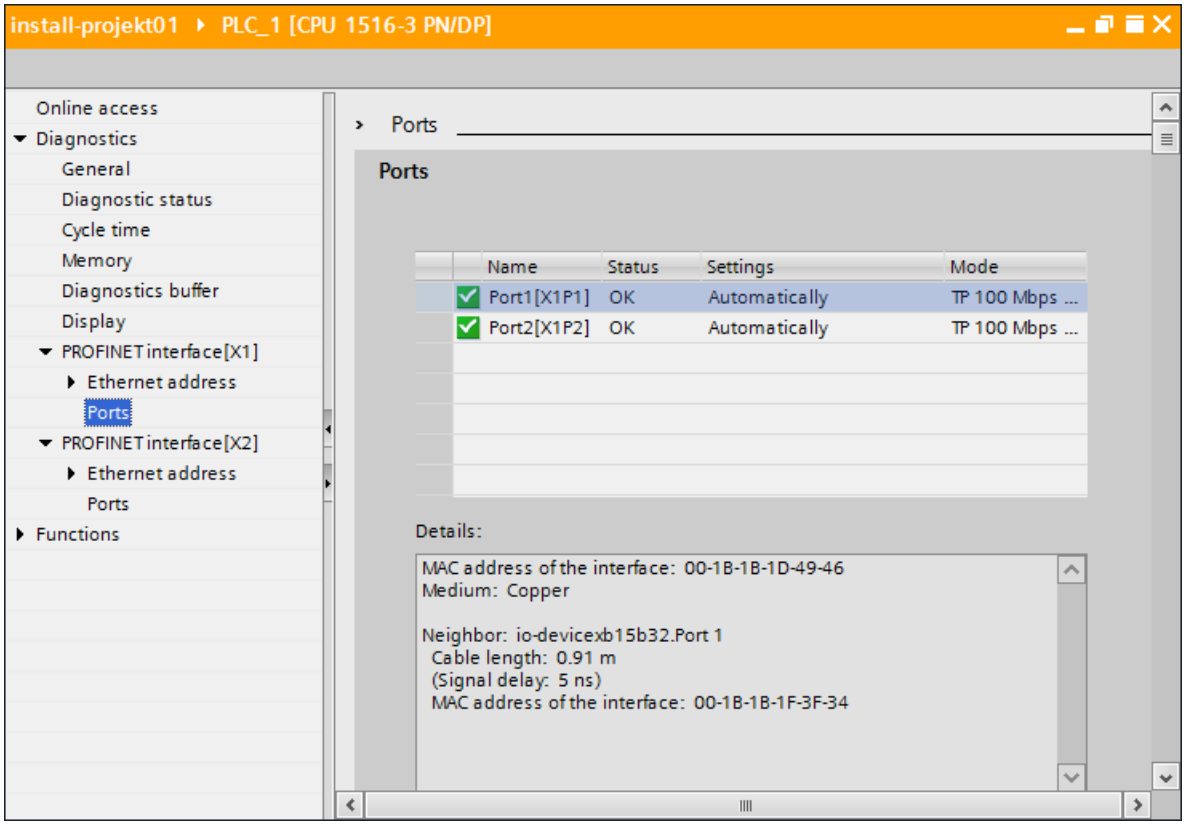

Figure 3-605 Diagnostics of PROFINET ports in STEP 7

Additional information

You can find information on the system diagnostics for S7-1500, ET 200MP, ET 200SP and ET 200AL in the Diagnostics (http://support.automation.siemens.com/WW/view/en/59192926) function manual and online help for STEP 7.

6.5 Extended maintenance concept

Extended maintenance concept

The PROFINET interfaces with integrated switch of the SIMATIC devices support the four-level diagnostics concept in accordance with PROFINET specification Version V2.3 or higher with the following status:

Table 3-960 Classification of the diagnostic status

Diagnostic status	Symbol		Severity of the error
Good	White check mark on a green background	✔	

Diagnostic status	Symbol		Severity of the error
Maintenance required	White wrench on a green background		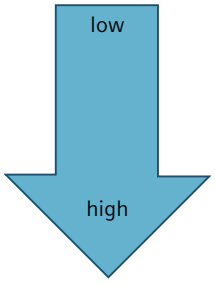
Maintenance demanded	White wrench on a yellow background		
Bad	White wrench on a red background		

The aim of the diagnostics concept is the early detection and elimination of potential faults - before they cause a production outage.

Other status information is defined in addition to the Good (no fault) and Bad (fault) status information for a PROFINET device.

The maintenance information is generated with the maintenance required and maintenance demanded system alarms.

The times at which the two system alarms are generated can be customized for most wear parameters.

Example: Maintenance demanded for a PROFINET cable

The following graphic illustrates how diagnostics information is transmitted when the transmission quality on the optical cable decreases due to aging, for example. In this example, the scenario is considered after a maintenance required has already been diagnosed.

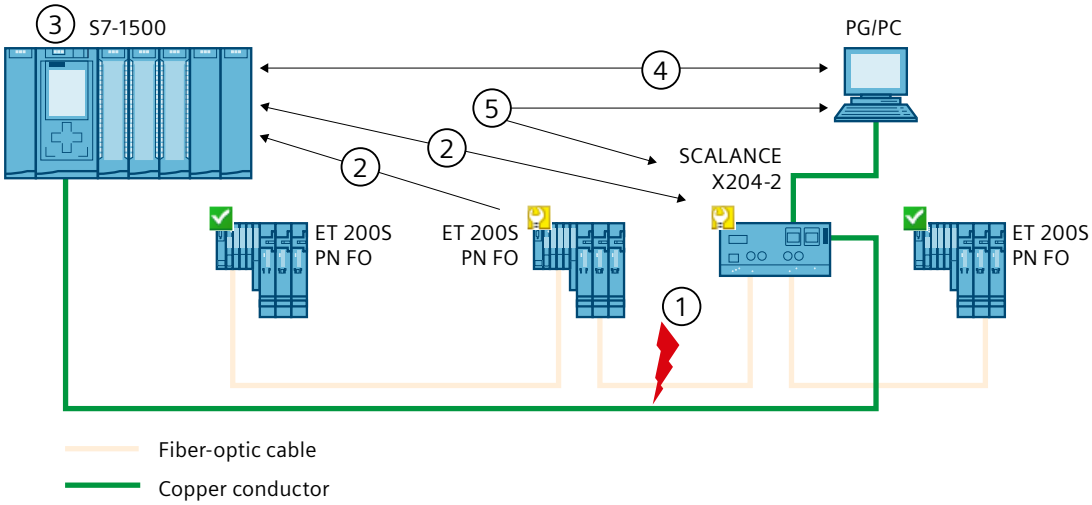

Number	Description
①	The system reserve of the fiber-optic cable drops below 0 dB.
②	Both the ET 200S PN FO and the switch send the maintenance demanded alarm to the IO controller.
③	Based on the interrupts, the IO controller detects the maintenance demanded from the switch and from the IO device. The module information data is updated in the IO controller and the corresponding error OBs are called. Note: To be able to start the error OBs in the IO controller, the "Call the user program if communication errors occur" property must be selected in STEP 7 for the relevant IO controller.
④	In STEP 7 (on the programming device/PC), the IO device and switch indicate maintenance demanded with a white wrench on a yellow background.
⑤	STEP 7 can also read out detailed information directly from the switch.

Figure 3-606 Maintenance demanded for a PROFINET cable

6.6 Diagnostics of the network topology

Availability

As an open standard, you can use any SNMP based systems or software solutions for diagnostics in PROFINET.

Network diagnostics

The network management protocol SNMP (Simple Network Management Protocol) uses the wireless UDP transport protocol. It consists of two network components, similar to the client/server model. The SNMP manager monitors the network nodes and the SNMP clients collect the various network-specific information in the individual network nodes and store it in a structured form in the **MIB** (Management Information Base). This information allows a network management system to run detailed network diagnostics.

MIB

The MIB (Management Information Base) is the database of a device. SNMP clients access this database in the device. The S7 device family supports the following standard MIBs:

- MIB II, standardized in the RFC 1213
- LLDP-MIB, standardized in the international standard IEC 802.1AB
- LLDP-PNIO-MIB, standardized in the international standard IEC 61158-6-10

You will find the MIBs for ET 200 interface modules and couplers with PROFINET interface in this product note (https://support.industry.siemens.com/cs/ww/en/view/109770525).

Detecting the network topology

LLDP (Link Layer Discovery Protocol) is a protocol that is used to detect the closest neighbor. LLDP enables a device to send information about itself and to receive information from its neighbor devices. This information is then saved in the LLDP MIB, for example, and can be queried using SNMP. This information allows a network management system to determine the network topology.

Use of SNMP (Simple Network Management Protocol)

SNMP can be used as follows:

- By users to integrate network diagnostics into a central HMI/SCADA system using the SIMATIC NET OPC server
- By the IT administration of machine and plant operators to monitor their Industrial Ethernet network using standard network management systems.
- By the IT administration, to monitor the automation network, alongside the office network, using standard network management systems.

Use of SNMP in the SIMATIC NET environment

SNMP-compliant devices from the SIMATIC NET family can be monitored and operated via a conventional standard Internet browser. The management system known as web-based management offers a wide range of device-specific information (network statistics, status of redundant supply, for example).

6.7 Diagnostics in the user program

6.7.1 Diagnostics and configuration data records

Diagnostics mechanism

The IO device outputs a diagnostics interrupt to the IO controller when it detects faults such as wire break on an IO module. This interrupt calls a corresponding organization block in the user program (diagnostics interrupt OB82), in order to generate a defined (programmed) response to the fault and passes a diagnostics data record.

Diagnostics data records in PROFINET IO

There are two different types of diagnostics data record:

1. Channel diagnostics data records

   Channel diagnostics data records are generated if a channel is in an error state and / or has triggered an interrupt.

   A diagnostics data record of length 0 is returned if there is no fault.

2. Vendor-specific diagnostics data records

   The structure and size of vendor-specific diagnostics data records depend on the vendor's settings.

   For information about vendor-specific diagnostics data records, refer to the appropriate device manual.

Addressing levels of diagnostics data records

Diagnostics and configuration data is evaluated at the following addressing levels:

- Device level
- AR (Application Relation)
- API (Application Process Identifier)
- Slot
- Subslot

A group of diagnostics and configuration data records are available for each address level (exception: device level always 0xF80c). In HEX representation, the individual groups of data records are distinguished by the first letter of the data record number.

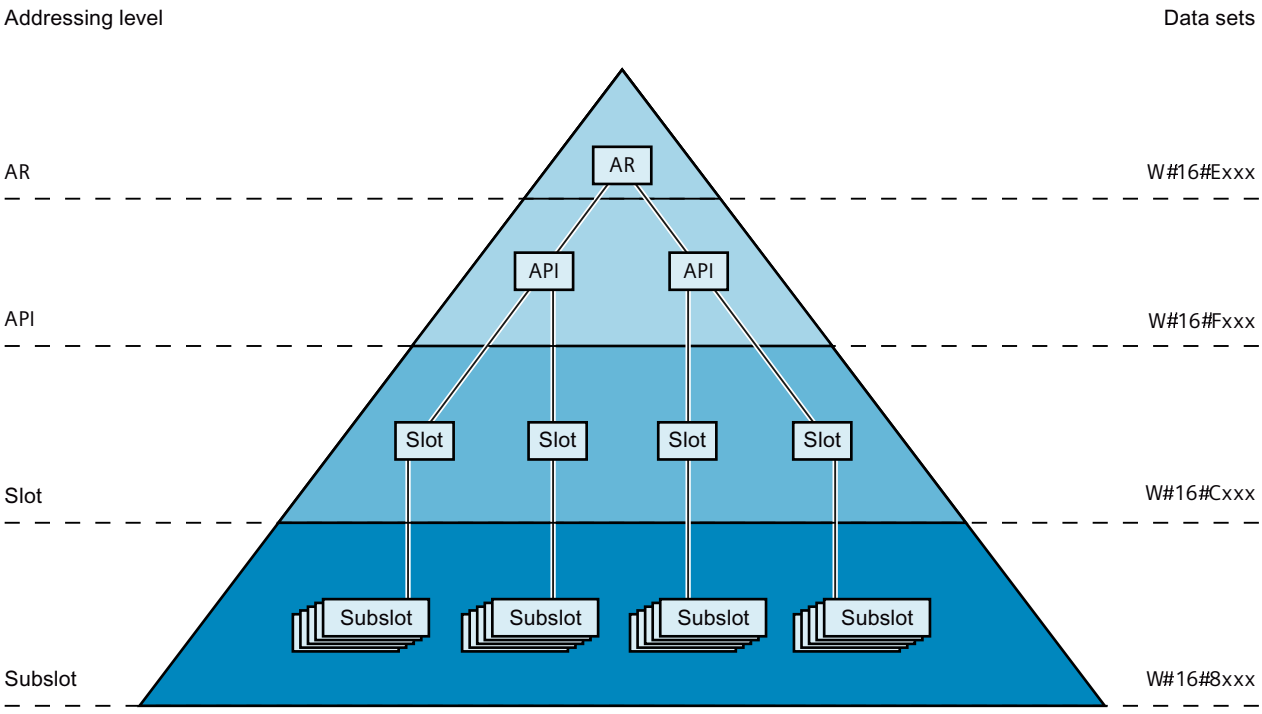

Figure 3-607 Addressing levels of diagnostics data records

The information for each IO device (addressing level AR), module (addressing level slot) or submodule (addressing level subslot) is always transferred in separate diagnostics or configuration data records. The data record returns diagnostics data or configuration data for one or more subslots, slots and APIs, depending on the addressing level.

NOTE

The diagnostics information is only generated for configured modules / submodules / channels.

Library for PROFINET data records

The "LPNDR" block library contains various function blocks. You can use these blocks to read out various device and status information from a PROFINET device and write parameters.

You can execute the following functions using the library blocks:

- Read device information:
  - Information about the interface, e.g. IP and MAC address
  - Information about the device interface, e.g. status, medium, name
  - Information about the link status of the interfaces, e.g. link down, link up
  - Information about the role of the device for MRP, e.g. client, manager
  - Information about the port statistics, e.g. number of received bytes
- Read the MRP status
- Modification of the parameters of analog input module of the ET 200SP in runtime, e.g. in order to disable/enable the channel diagnostics.

The finished functions are freely adaptable and can therefore be used universally.

The "LPNDR" block library with an example project can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109753067).

6.7.2 Evaluate diagnostics in the user program

Diagnostics in the user program

For PROFINET IO, a cross-vendor structure of data records with diagnostics information applies. Diagnostics information is created only for channels on which a fault has occurred. With PROFINET, there are two basic ways to obtain diagnostics information.

1. Evaluating the diagnostics status

Read out the diagnostics of your PROFINET IO system using the instructions "DeviceStates" and "ModuleStates" to localize faulty stations / modules or station / modules with maintenance demanded or maintenance required within a PROFINET IO system.

The instruction RDREC (read data record) is then used to read various diagnostics data records directly from the module concerned and thus obtain detailed information about the error.

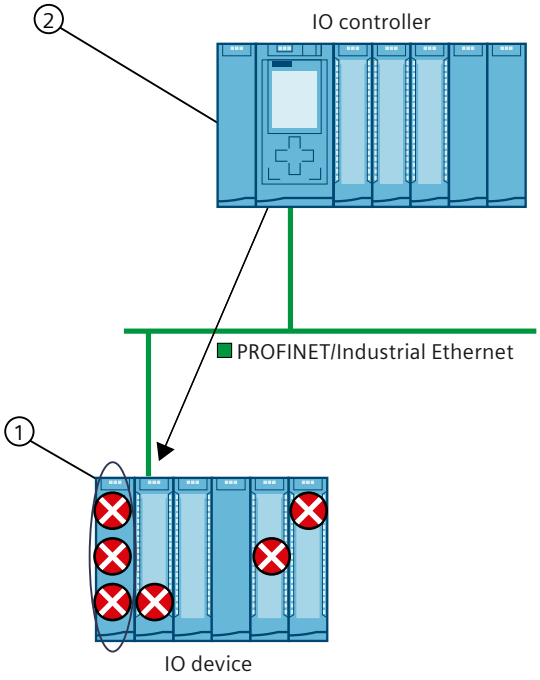

Number	Description
①	All individual errors are collected in a single data record on the interface module.
②	In your user program, the instruction "RDREC" reads the entire station status asynchronously directly from the IO device.

Figure 3-608 Example: Evaluating diagnostics data records with the instruction "RDREC"

2. Evaluation of interrupts

When the error OB (OB 82) is called, the OB's start information provides you with information on the cause and location of the error. Detailed information on the error event can be obtained in the error OB using the instruction "RALRM" (read additional interrupt information).

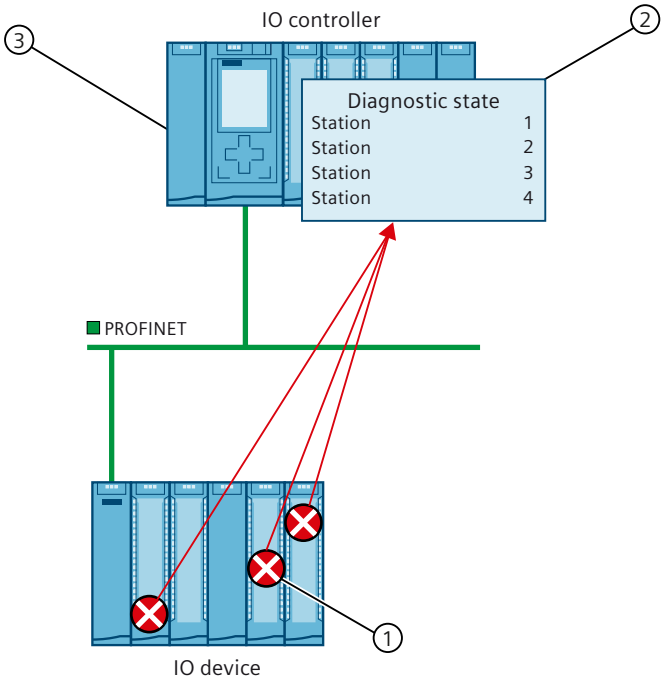

Number	Description
①	Every error is sent to the IO controller individually as channel diagnostics information in the form of an interrupt.
②	In the IO controller, the module status data is updated automatically and the error OB (OB 82) is started.
③	In your user program in the error OB (OB 82), the instruction "RALRM" reads the error synchronously from the IO controller without addressing the IO device.

Figure 3-609 Diagnostics with OB 82 and the instruction "RALRM"

Instructions and OBs

You will find information on the instructions and OBs in the STEP 7 online help.

6.8 Maintenance

6.8.1 I&M data (identification and maintenance)

Definition and properties

Identification and maintenance data (I&M) is information saved to module memory in order to provide support when:

- Checking the plant configuration
- Locating hardware changes in a plant

Identification data (I data) is module information (some of which may be printed on the module housing) such as the order and serial number. I data is read-only vendor-specific module data.

Maintenance data (M data) is plant-specific information such as the location identifier and installation date. M data is created during configuration.

The modules can be uniquely identified in online mode by means of the I&M data.

Further information

To find out whether and to what extent a PROFINET device supports I&M data, refer to the documentation of the relevant device.

6.8.2 Loading I&M data to PROFINET IO devices and your modules

Which I&M data can be loaded to PROFINET IO devices and your modules?

You can load I&M 1 data (plant designation and location identifier) and/or I&M 2 data (installation date) and/or I&M 3 data (additional information) to the actual hardware.

Requirements

- In the project settings (Options > Settings, Hardware configuration > Compiling and downloading), the option "Download I&M data" must be enabled.
- There is an online connection to the PROFINET IO devices and the modules to which you want to load I&M data.
- You have entered the I&M data you want to download in the properties of the respective PROFINET IO devices and your modules (Inspector window: "Properties" tab > "General" tab, Settings > Identification & Maintenance).

Where do I specify which I&M data is downloaded to which PROFINET IO devices?

You specify which I&M data you want to download to which PROFINET IO devices in the "Load preview" dialog. You will find the following alternatives in the drop-down list of the "Identification and maintenance data (I&M)" row:

- Load nothing

  The check boxes for all PROFINET IO devices as well as the check boxes for the loadable I&M data are cleared.

  No I&M data is transferred to the actual hardware during loading with this setting.

- Load data

  The check boxes for all PROFINET IO devices as well as the check boxes for the loadable I&M data are selected.

  The respective I&M 1, I&M 2 and I&M 3 data is transferred to all PROFINET IO devices during loading with this setting.

- Load selected

  You select the check boxes of those PROFINET IO devices to which you want to load I&M data. You also select the check boxes of the identification data you want to load.

  With this setting, you transfer the selected I&M data to the selected PROFINET IO devices during loading.

NOTE

Language dependency of the I&M data to be loaded

The I&M data are loaded to the real hardware in the form that you specified in the properties of the relevant PROFINET IO devices and your modules. There is no language dependency.

6.8.3 Asset management

6.8.3.1 Further information about asset management at PROFINET

Operation of machines and plants without a detailed knowledge of devices and assets is difficult to imagine.

Maintenance requires data for this – data that is extensive and up-to-date as far as possible.

The requirement of greater transparency with regard to the data made available by plant components has been fulfilled by PROFIBUS & PROFINET International (PI): The identification and maintenance data familiar since PROFIBUS times have been extended.

The current PROFINET fulfills this requirement through the definition of a special data record: the Asset Management Record (AMR).

The aim of this definition is to enable you to acquire **all** the components to be maintained online - and not only those components that can be addressed and accessed through the PROFINET device model (Device / Module / Submodule). PROFINET now also reaches non-PROFINET components!

Assets general and asset management data records

Assets are components (hardware and software / firmware) of a machine, for example a laser welding machine, or a plant.

A large number of these device components can already be identified through tried-and-tested I&M functions or corresponding data records (I&M0 to I&M5) in the PROFINET context: The device itself as well as its modules and submodules. Meaning all components that can be addressed through the PROFINET device model.

Components that **cannot** be addressed via the PROFINET device model, but whose data it should be possible to acquire online for operation and maintenance, can be identified through **asset management** functions. This asset management data (short: AM data) is stored in a defined structure in a special data record, the **asset management record** (AMR) mentioned above.

The PROFINET Guideline "Identification & Maintenance Functions" differentiates here between I&M functions (I&M data) and asset management functions (AM data): The following sections only deal with the AM data.

The components that can be read additionally online through asset management data records include both hardware components, such as backplane bus modules of a device as well as firmware components such as a drive control unit with own versioning.

Application examples

Importing asset management records enables you to read the following information during installation or operation, for example:

- Are only approved devices being used (whitelist check)?
- A firmware update is due. Obtain a fast overview: Which devices or components are affected and have to be upgraded?

Making asset management data available

The concept for the asset management of PROFINET devices stipulates that the manufacturers of PROFINET devices have to ensure that non-PROFINET automation components are made available through an asset management record. This data record is assigned to the PROFINET device.

In contrast to a "standard" IO device, with an I-device the project engineer has to make the asset management record available. In this case, the central modules of the I-device are assets. From the perspective of PROFINET, these central modules are not visible from the point of view of the higher-level IO controller. The higher-level IO controller only "sees" the transfer areas through which it exchanges IO data with the I-device.

The principle of this provision is explained in the section.

Reading asset management data

The asset management record has the index 0xF880 and is read with standard PROFINET mechanisms by the user of the records, for example a tool or program for evaluating these data.

A user program in the S7-1500 IO controller, for example, can read out the AMR of an IO device with the RDREC instruction (Index 0xF880).

It is not possible to write to this data record.

Further information

Whether and to which extent a PROFINET device supports asset management data, meaning whether it makes an AMR available, is specified in the documentation of the respective device.

6.8.3.2 Content and structure of an asset management record

Basic structure of the asset management record

You are first provided with an overview of the general structure of the record. The following table describes the framework within which the asset management data blocks are embedded. Each data block represents an asset, a terminal block for example.

Element of the data structure	Designation according to IEC 61158-6-10	Code	Data type / length in bytes
Header AssetManagementData	BlockType	0x0035	UINT / 2
	BlockLength	Number of bytes without counting the bytes for BlockType and BlockLength	UINT / 2
	BlockVersion	0x0100	UINT / 2
AssetManagementInfo AssetManagementBlocks (n)	NumbersOfEntries	Number of AssetManagementBlocks	UINT / 2
	AssetManagementBlock 1	See the table below	
	AssetManagementBlock 2		
	...		
	AssetManagementBlock n		

Structure of asset management blocks

Each AssetManagementBlock contains identification data and localization information for an asset. An AssetManagementBlock has a substructure with basic characteristics described below.

The header of an AssetManagementBlock contains the coded information about which of the three possible AM data compilations the data record contains. Devices make a suitable BlockType available in accordance with the various device types:

- Complex devices with information about the hardware and firmware (BlockType "AM_FullInformation")
- Complex devices with information about the hardware (BlockType "AM_HardwareOnlyInformation")
- Devices with information about the firmware (BlockType "AM_FirmwareOnlyInformation")

The differentiation provides an efficient data structure below the header. Nevertheless, the data record can have a considerable size (maximum of 64 KB, depending on the number of assets that the IO device supplies).

Table 3-961 Structure of AssetManagementBlock

Element of the data structure	Designation according to IEC 61158-6-10	Code	Data type / length in bytes
Header AssetManagementBlock	BlockType	0x0036 (AM_FullInformation) 0x0037 (AM_HardwareOnlyInformation) 0x0038 (AM_FirmwareOnlyInformation)	UINT / 2
	BlockLength	Number of bytes without counting the bytes for BlockType and BlockLength	UINT / 2
	BlockVersion	0x0100	UINT / 2
	Padding	0x0000 (padding byte)	USINT / 1
	Padding	0x0000 (padding byte)	USINT / 1
AssetManagementBlock (Structure depends on the BlockType. Here it is shown using AM_FullInformation as an example)	IM_UniqueIdentifier	Manufacturer-generated Universal Unique Identifier (UUID) conforming to ISO/IEC 9834-8. Used as a reference key to uniquely identify this asset. Example: 550c5300-d34a-22b4-11d3-5533991111b3	Array of Byte / 16
	AM_Location	Description of the location of the asset: Either slot-oriented ("Slot and SubslotNumber format") or hierarchical ("Twelve level tree format"). See following description	Array of Byte / 16
	IM_Annotation	Manufacturer-specific notation Example: "Terminal block, Type xyz123 ". 64 bytes are always used. Spaces are used for padding if the string is shorter.	Array of Char / 64
	IM_OrderID	Manufacturer-specific article number Example: "6ES7131-6BF00-0BA0 ". 64 bytes are always used. Spaces are used for padding if the string is shorter.	Array of Char / 64

Element of the data structure	Designation according to IEC 61158-6-10	Code	Data type / length in bytes
AssetManagementBlock (Structure depends on the BlockType. Here it is shown using AM_FullInformation as an example)	AM_SoftwareRevision (not at AM_HardwareOnlyInformation)	Manufacturer-specific SW version Example: "V6.3.8 ". 64 bytes are always used. Spaces are used for padding if the string is shorter. If the asset supports IM_Software_Revision, the AM_SoftwareRevision is padded with spaces.	Array of Char / 64
	AM_HardwareRevision (not at AM_FirmwareOnlyInformation)	Manufacturer-specific hardware version Example: "A4 ". 64 bytes are always used. Spaces are used for padding if the string is shorter. If the asset supports IM_Hardware_Revision, the AM_HardwareRevision is padded with spaces.	Array of Char / 64
	IM_Serial_Number	Manufacturer-specific unique production-related number. The characters come from the visible range (0x20 ... 0x7E), no control characters. Example: "A78C-1C82 ". 16 bytes are always used. Spaces are used for padding if the string is shorter.	Array of Char / 16
	IM_Software_Revision (not at AM_HardwareOnlyInformation)	Software version, follows a strict structure (SW version prefix, for example "V", digits for functional extension, digits for BugFix, digits for internal change). Example: 'V' 0x01 0x2 0x3 If AM_SoftwareRevision is padded with spaces, you should evaluate IM_Software_Revision. If the asset does not support any hardware, the coding 'V' 0x00 0x00 0x00.	Array of Byte / 4 Prefix (character "V", "R", "P", "U", or "T"), then 3 digits "0" to "9"
	AM_DeviceIdentification	Identification of the device. The structure is as follows: AM_DeviceIdentification.DeviceSubID (for SIEMENS e.g. 0x0000) AM_DeviceIdentification.DeviceID (Device ID from manufacturer, 0x0000 to 0xFFFF) AM_DeviceIdentification.VendorID (Example for Siemens assets: 0x002A) AM_DeviceIdentification.Organization: Example for Siemens assets: 0x0000 (PROFINET)	Array of Byte / 8
	AM_TypeIdentification	Manufacturer-allocated type identification: 0x0000: Unspecified 0x0001: Controller (PLC) 0x0002: PC-based 0x0003: IO module, IO submodule 0x0004: Communications module / submodule	UINT / 2

Element of the data structure	Designation according to IEC 61158-6-10	Code	Data type / length in bytes
AssetManagementBlock (Structure depends on the BlockType. Here it is shown using AM_FullInformation as an example)		0x0005: Interface module / submodule 0x0006: Active network component 0c0007: Media attached unit (bus adapter) 0x0100 to 0x7FF: Manufacturer-specific	
	IM_Hardware_Revision (not at AM_FirmwareOnlyInformation)	Version of the hardware (0x0000 to 0xFFFF) Example: 0x0003 If AM_HardwareRevision is padded with spaces, you should evaluate IM_Hardware_Revision.	UINT / 2

AM_Location

Asset management at PROFINET supports two formats for coding the location of an asset:

- Slot-oriented format ("Slot and SubslotNumber format")
- Hierarchical format ("Twelve **L**evel **T**ree format" abbreviated **LT** format)

Assets that are part of the PROFINET device use the slot-oriented format. These assets are bound completely to the PROFINET modules and submodules.

Assets that are located outside the PROFINET device use the hierarchical format (LT format) for coding the location of an asset.

These assets are localized by their tree level. The tree level begins with Level 0. The value of Level 0 provides information about the proximity to the PROFINET device:

- If the asset is connected to a module that can be addressed through the PROFINET device model, Level 0 has the value 0. The subsequent levels (Level 1 to Level 3) then have the meaning of slot address, subslot address and channel number. If further assets are connected to this asset, the next Level 4 is used. The limit is reached at Level 11.
- If the asset belongs to a PROFINET device but is not connected to a module that can be addressed through the PROFINET device model, Level 0 has a value between 1 and 0x1FF. An example of such an asset is a power supply unit in the PROFINET device. If a further asset is connected to this power supply unit, for example a sensor, the next tree level is used to localize this sensor (Level 1).
- If the asset is located outside the PROFINET device, but, for example, belongs to a machine into which the PROFINET device is installed, Level 0 has a value between 0x200 and 0x3FE.

The value 0x3FF for a tree level shows that this tree level is not used. This means that no further asset is connected. In this case, all the lower tree levels down to Level 11 must also have this value.

Example AM_Location slot-oriented

A rack and the terminal blocks located on it each supply AM data. The slot assignments are shown in the figure.

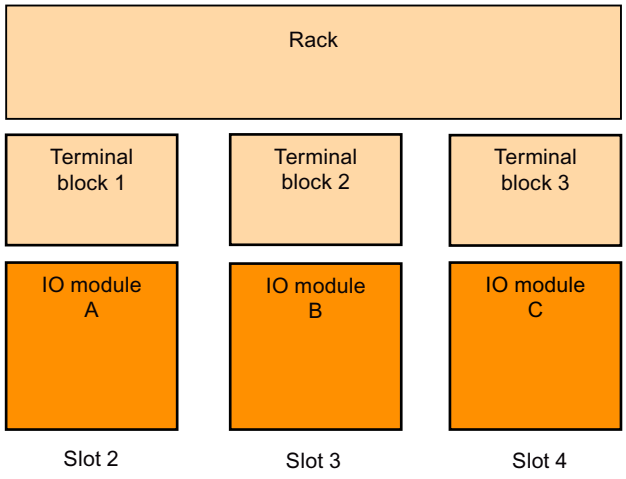

Figure 3-610 Example of assets with slot-oriented AM_Location coding.

Code the AM_Location as an asset for each module as follows:

Bit 0 – 7: AM_Location.Structure = 0x02 (coding "Slot and SubslotNumber format")

Bit 8 – 15: AM_Location.Reserved1 = 0x00 (padding byte)

Bit 16 – 31: AM_Location.BeginSlotNumber = 2 (the "Rack" asset begins from Slot 2 on)

Bit 32 – 47: AM_Location.BeginSubslotNumber = 0xFFFF (the asset encompasses all the subslots of Slot 2. Otherwise you specify the no. of the subslot at which the asset begins)

Bit 48 – 63: AM_Location.EndSlotNumber = 4 (the asset ends at Slot 4)

Bit 64 – 79: AM_Location.EndSubslotNumber = 0xFFFF (the asset encompasses all the subslots of Slot 4. Otherwise you specify the no. of the subslot at which the asset ends)

Bit 80 – 95: AM_Location.Reserved2 = 0x0000 (padding byte)

Bit 96 – 111: AM_Location.Reserved3 = 0x0000

Bit 112 – 127: AM_Location.Reserved4 = 0x0000

Example AM_Location level-oriented

A complex sensor is connected to an IO module (Slot 5, Subslot 1, Channel 1). Two simple sensors, in turn, are connected to the complex sensor. The module can be addressed within the PROFINET device model. Level 0 therefore has the value 0x0000. The next level (Level 1) is specified by the assigned slot. This is followed by the further levels for the subslot and channel and, if appropriate, further subordinate layers.

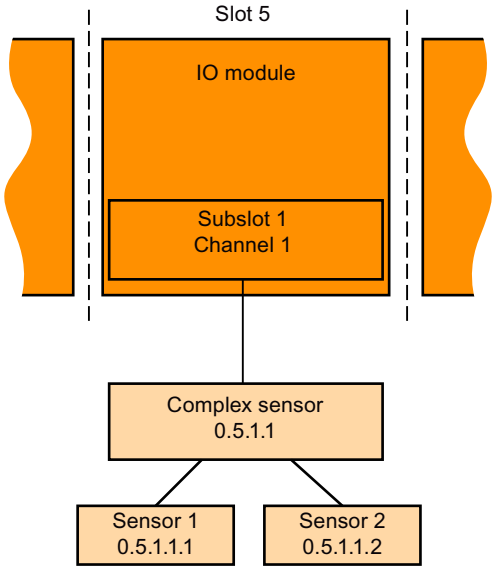

Figure 3-611 Example of assets with hierarchical AM_Location coding.

Detailed coding for the example:

Bit 0 – 7: AM_Location.Structure = 0x01 (LT format)

Bit 8 – 17: AM_Location.Level0 = 0x000 (assets that are assigned to modules always have the Level 0 value 0x000)

Bit 18 – 27: AM_Location.Level1 = 0x005 (Slot 5)

Bit 28 – 37: AM_Location.Level2 = 0x001 (Subslot 1)

Bit 38 – 47: AM_Location.Level3 = 0x001 (Channel 1)

Bit 48 – 57: AM_Location.Level4 = 0x3FF (coding for "Level not used")

Bit 58 – 67: AM_Location.Level5 = 0x3FF (coding for "Level not used")

...

Bit 118 – 127: AM_Location.Level11 = 0x3FF (coding for "Level not used")

Notation used in the screen for the LT coding of complex sensors: 0.5.1.1

The following correspondingly applies for the remaining sensors:

LT coding for simple Sensor 1 at complex sensor: 0.5.1.1.1

LT coding for second simple Sensor 2 at complex sensor: 0.5.1.1.2

6.8.3.3 Asset management data record for I-devices

With STEP 7 (TIA Portal) as of V15 and with S7-1500 CPUs as of firmware V2.5.2, you can compile an asset management data record via a user program. Configured as an I-device, these CPUs then supply the data from centrally plugged modules to a requesting IO controller as assets.

"S7-1500 CPUs" also refers to the CPU variants S7-1500F, S7-1500T, S7-1500C, S7-1500 SW Controller, S7-1500pro CPUs and ET 200SP CPUs.

Asset management records for I-devices

I-devices often represent machines. The PROFINET IO controller to which the I-device is assigned only sees the PROFINET interface (also configured as an IO device) and the transfer areas of the I-device configured by the machine manufacturer. The local modules of the I-device are not visible or cannot be accessed.

The assigned IO controller can read the central modules as assets of the I-device by means of an asset management record that the user program of the I-device compiles.

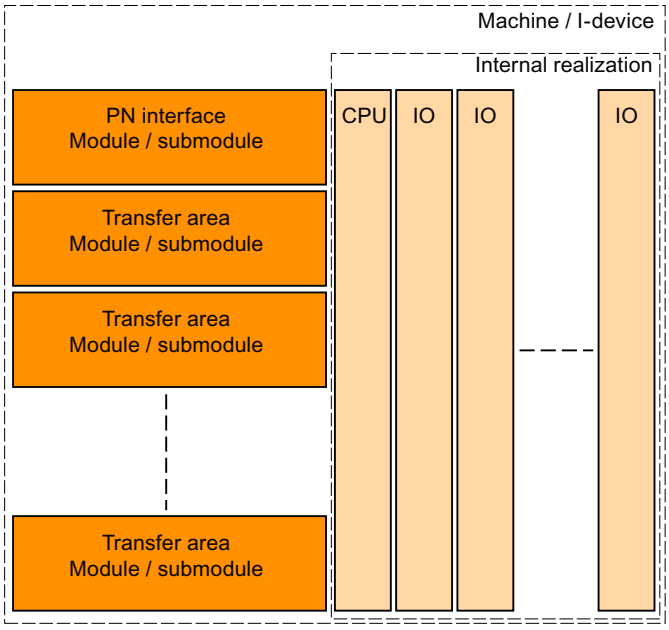

Figure 3-612 Assets of an I-device

Requirement

- S7-1500 CPU as of firmware V2.5.2, configured as I-device
- STEP 7 (TIA Portal) as of V15
- If an IO controller is to read the asset management record:

  The PROFINET IO controller is programmed correspondingly to read an asset management record.

  For a SIMATIC IO controller, for example, you call a read instruction (RDREC) with record index 0xF880. The instruction addresses any submodule of the I-device, for example the first configured transfer area submodule.

Basic procedure

The following steps are fundamentally required to create the requirements so that an I-device can make its local modules available as an asset management record to a requesting IO controller:

1. Make the settings in the properties of the PROFINET interface of the CPU.
   - Activate "IO device" operating mode
   - Activate the "Activate asset management using user program" option

     PROFINET interface forwards a request of an IO controller to the user program of the I-device for reading the asset management record only if the option is selected.

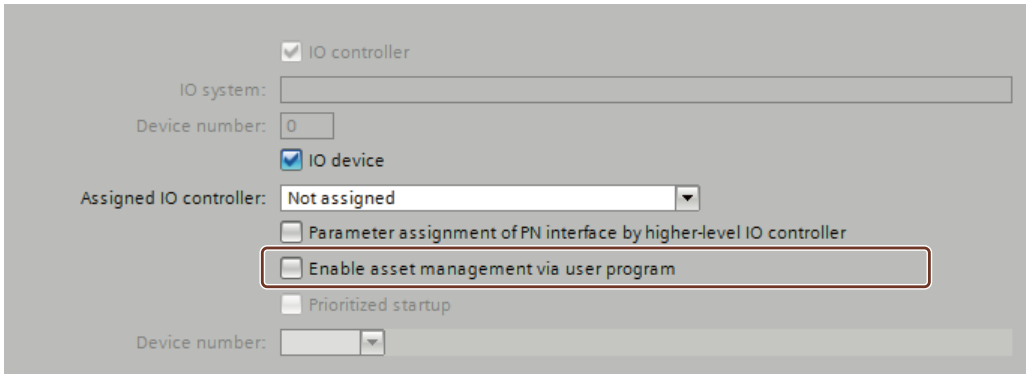

Figure 3-613 Activating asset management using a data record

2. Configure the program routine for compiling the asset management record. The program part collects the required I&M0 data of the plugged central modules and stores them in the corresponding fields of the data record structure of the asset management record.
3. Configure the program part for coordinating the data record provision:
   For this, call the instruction PRVREC (Provide Record) in accordance with the following templates in the corresponding modes:
   - Cyclic calling (for example in the cycle OB) of the PRVREC instruction with Mode 0, in order to recognize the AMR request.

- When the AM record request is recognized, the PRVREC program has to acknowledge within one second that the request has been recognized. This means that PRVREC must be called with the Mode 2, and with the required AM record. If the I-device does not adhere to the time frame, the I-device acknowledges the record request of the IO controller as negative.

  Particular aspect for configuration of the PRVREC call: PRVREC has to be called with **F_ID = 0**. This codes that this is an IO-device-specific data record. The SLOT and SUBSLOT output parameters therefore also return the value 0.
- Within 10 seconds the AM record now has to be completed and PRVREC be called with Mode 3 (positive response to the IO controller with provision of the AM record). If the I-device does not adhere to the time frame, the I-device acknowledges the record request of the IO controller as negative.

A detailed description of the PRVREC instruction and possible error codes for evaluating the function can be found in the online help of STEP 7 (TIA Portal).

Compilation of the asset management record

You have various possibilities for compiling the asset management record for an I-device:

- Recommendation: The Siemens Industry Online Support makes an application available to you that helps you to compile the asset management record.
  The data area of the asset management record is divided in two. The first part consists of an automatically determined area that packages the IM0 data of the slots of the I-device into an asset management block. The second part consists of the user-specific asset management blocks. You configure the user-specific asset management blocks based on pre-configured asset management record structures, fill them with information and make them available to the application.
  The application performs the following:
  - The application determines the required size of all the asset management blocks.
  - The application fills the data block in accordance with the specifications of an asset management record with the automatically determined asset management blocks and your user-specific asset management blocks.
  - The application makes this asset management record available to the higher-level IO controller.

  The application is described in this application example (https://support.industry.siemens.com/cs/ww/en/view/109748894)
- You create the asset management record yourself.
  The following section describes how you can compile an asset management record for an I-device yourself.
  The concept assumes you yourself determine the I&M data for each centrally plugged module and fill the asset management record with this information. The I&M0 data of a module contains basic information about the module such as the manufacturer's code, article number, serial number, hardware and firmware version. These are the data that are also required in the AM record for an asset.

Determine the I&M data of centrally plugged modules

The central structure consists of an optionally plugged power supply unit (Slot 0), followed by the I-device CPU (Slot 1), and then followed by the further modules, such as digital modules, analog modules, etc. (as of Slot 2).

You determine the I&M data with the "Get_IM_Data" instruction for the plugged modules with exception of the CPU:

To assign parameters for the "Get_IM_Data" instruction, you require the hardware identifier (LADDR input parameter). You determine the hardware identifier for each occupied slot with the "GEO2LOG" instruction (Determine hardware identifier from slot).

Summary of the theoretical steps:

1. In a loop, determine the hardware identifiers of the plugged modules with the "GEO2LOG" instruction.
2. For each hardware identifier found, determine the I&M data by using the "Get_IM_Data" instruction and store these data in a data block that you address with the input parameter DATA. Use ARRAY of BYTE for the data storage. This corresponds to the description of the AM record contents in the preceding section.

Forming an AM record with the determined I&M data

The following sections are based on the description of the fundamental structure of the AM record, see the preceding section.

Since each module of an S7-1500 contains hardware and firmware information, select the coding for "AM_FullInformation" for the assigned BlockType.

For the data types used:

- IM_Annotation, IM_OrderID, AM_SoftwareRevision and AM_HardwareRevision: Characters (UTF-8)
- IM_Serial_Number: Characters ("ASCII characters") with the exception of the characters for DEL (0x7F)
- Do not use String data types. They require additional bytes and therefore do not conform to the conventions of the PROFINET standard 61158-6-10 "Application layer protocol specification".

Form the AM_FullInformationBlock for each module as follows:

Table 3-962 AM_FullInformationBlock for modules

Data record element	Description
IM_UniqueIdentifier	Generate a (pseudo) random UUID (hash value) in accordance with ISO 9834-8 as follows: • Generate an 8-byte hash value across the I&M0 data of the module (as of Slot 2). Use the algorithm Fowler-Noll-Vo (in short: FNV); an algorithm for generating variance coefficients (hash values) across data field, see corresponding example code in the Internet or online support. • Generate an 8-byte hash value across the I&M0 data of the CPU. (Use the algorithm Fowler-Noll-Vo (in short: FNV) as described above)

Data record element	Description
	• IM_UniqueIdentifier Byte 0 to 7: Hash value of module I&M0 data Bytes 8 to 15: Hash value for CPU-I&M0 data Required customizations to ISO 9834-8: Byte 8, Bit 7 has to be set to 1, and Byte 8, Bit 6 to 0 (result of the AND operator with **00**11 1111, subsequent OR operator with **10**00 0000) Byte 6, Bit 4 to 7 have to be set to 0100 (result of the AND operation with 0000 1111, then OR operation with 0001 0000) Since this algorithm is based on the I&M0 data of the CPU as well as of the modules, it generates a constant IM_UniqueIdentifier for an individual module. When the configuration changes the IM_UniqueIdentifier also changes.
AM_Location	Byte 0 = 0x02 (slot-oriented coding), see description in the preceding section.
IM_Annotation	Example: "S7-1500 module" and pad the remaining bytes of IM_Annotation with spaces (0x20).
IM_OrderID	Copy 20 bytes of the I&M0 data of the module (beginning with offset 2 of the I&M0 data). Pad the remaining 44 bytes with spaces (0x20)
AM_SoftwareRevision	Pad the field with 64 spaces (0x20)
AM_HardwareRevision	Pad the field with 64 spaces (0x20)
IM_Serial_Number	Copy 16 bytes of the I&M0 data of the module (beginning with offset 22 of the I&M0 data)
IM_Software_Revision	Copy 4 bytes of the I&M0 data of the module (beginning with offset 40 of the I&M0 data)
AM_DeviceIdentification	Byte 0, 1, 2, 6, 7 = 0x00 Byte 3 = 0x2A (Vendor = Siemens) Byte 4 = 01, Byte 5 = DeviceID (e.g. CPU 15xx = 0x0E)
AM_TypeIdentification	Copy 2 bytes of the I&M0 data of the module (beginning with offset 48 of the I&M0 data)
IM_Hardware_Revision	Copy 2 bytes of the I&M0 data of the module (beginning with offset 38 of the I&M0 data)

Functions

7

Introduction

The following section describes the PROFINET IO functions for field of application, properties and configuration in STEP 7.

Refer to the documentation for the respective device to see to what extent the PROFINET devices support the described functions.

You can find a tabular overview of the PROFINET devices and the functions these support on the Internet (https://support.industry.siemens.com/cs/ww/en/view/102325771).

7.1 Connecting other bus systems

Fieldbus integration

PROFINET allows you to use a proxy-capable PROFINET device to integrate existing fieldbus systems (for example, PROFIBUS, AS interface). The devices of these fieldbus systems are mapped on proxy PROFINET devices. In this way, you can set up any hybrid systems consisting of fieldbus and Ethernet-based subsystems. This allows a continuous exchange of information.

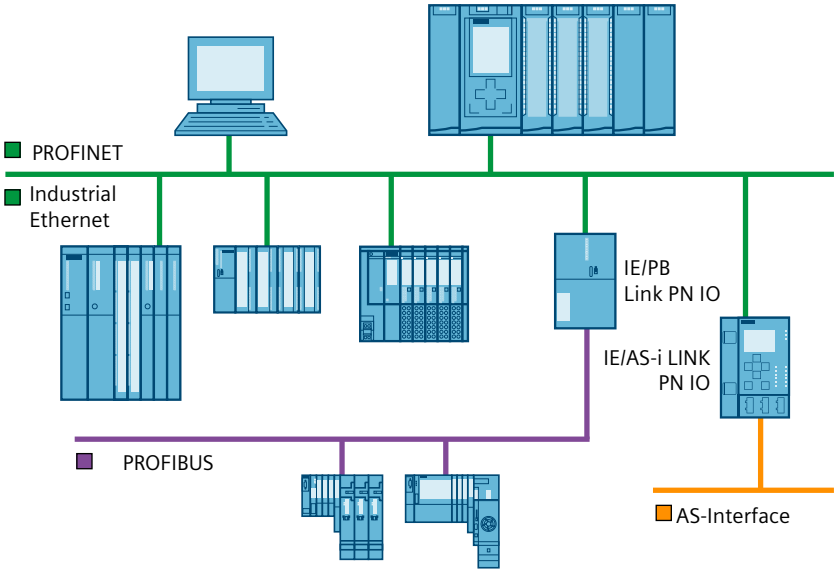

Figure 3-614 Gateways on PROFINET IO

Gateways of an S7-1500 CPU

An overview of the gateways at an S7-1500 CPU is provided in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/88778900).

Connecting to building busses

- BACnet: You can find the procedure for configuring communication between a SIMATIC PLC and a BACnet network with a gateway in this application example (https://support.industry.siemens.com/cs/ww/en/view/109476182).
- M-bus: You can find the procedure for configuring communication between a SIMATIC PLC and an M-bus network with a gateway in this application example (https://support.industry.siemens.com/cs/ww/en/view/109478527).
- DALI: You can find the procedure for configuring communication between a SIMATIC PLC and a DALI network with a gateway in this application example (https://support.industry.siemens.com/cs/ww/en/view/109740160).
- KNX: You can find the procedure for configuring communication between a SIMATIC PLC and a KNX network with a gateway in this application example (https://support.industry.siemens.com/cs/ww/en/view/109739689).

7.1.1 Linking PROFINET and PROFIBUS

Linking PROFINET and PROFIBUS

With a proxy-capable PROFINET device which is equipped with a PROFINET interface in addition to a PROFIBUS interface (for example, IE/PB Link PN IO), you can integrate existing PROFIBUS configurations into the PROFINET configuration.

The following figures shows how a PROFIBUS system is connected via IE/PB Link to a CPU S7-1500 (as of firmware version 1.7).

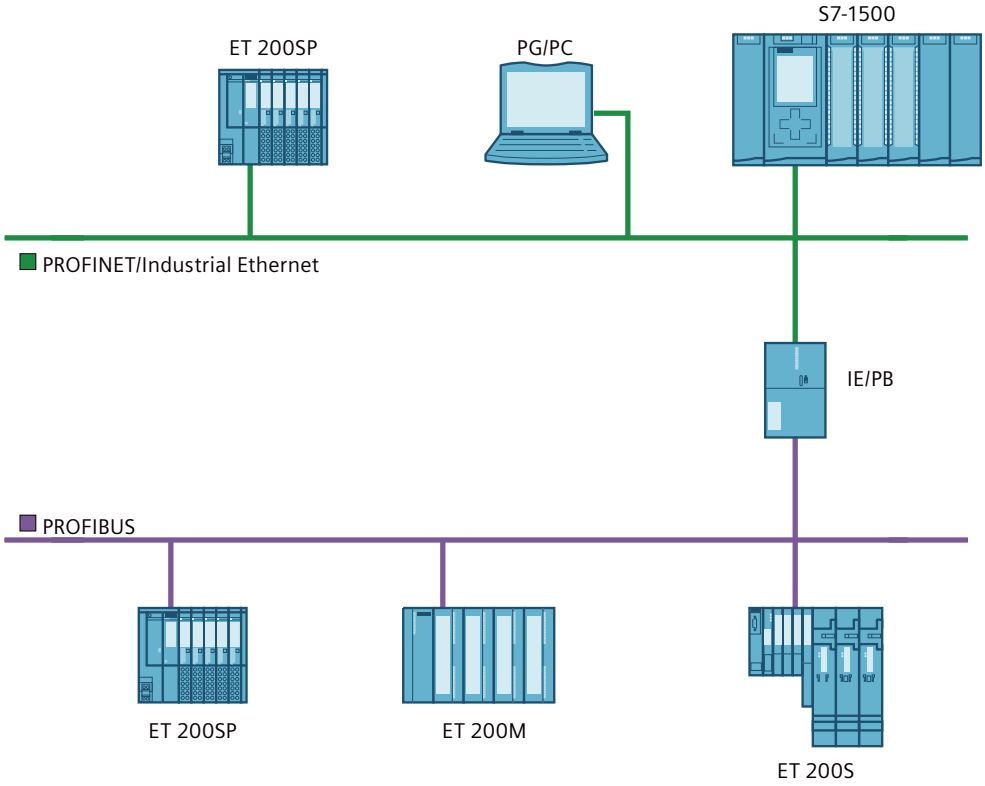

Figure 3-615 Gateway from PROFINET and PROFIBUS via IE/PB link

PROFINET device with proxy functionality

The PROFINET device with proxy functionality is the substitute for a PROFIBUS device on Ethernet. The proxy functionality allows a PROFIBUS device to communicate not only with its master but also with all devices on PROFINET.

With PROFINET you can connect an existing PROFIBUS system to an IO controller, for example with the help of an IE/PB Link PN IO.

From the IO controller perspective, the PROFIBUS DP slaves are connected to the same network as the IE/PB Link PN IO. These slaves have the same device name and IP address as the IE/PB Link PN IO, but different device numbers. Furthermore, each also has a specific PROFIBUS address.

In this way, you can link both DPV0 and DPV1 slaves to PROFINET.

For information on how to connect a DP slave to a PROFINET IO system, refer to section Connect the DP slave via the IE/PB Link to a PROFINET IO system (Page 125).

Diagnostic options with a CPU S7-1500 as IO controller

The CPU S7-1500 (as of firmware version 1.7) as IO controller detects disrupted DP slaves behind the IP/PB link.

7.1.2 Connect the DP slave via the IE/PB Link to a PROFINET IO system

Requirements

- STEP 7 as of V13 SP1
- CPU supports IE/PB link, e.g.:
  - S7-1500 CPU as of firmware version 1.7
  - S7-1500 Software Controller as of firmware version 1.7
  - S7-300/400 CPU

Procedure for connecting a DP slave via an IE/PB Link

To connect a DP slave to a PROFINET IO system via an IE/PB Link in STEP 7, follow these steps:

1. Drag-and-drop a PROFINET CPU, for example CPU 1513-1 PN, from the hardware catalog into the network view of STEP 7.
2. Drag-and-drop an IE/PB Link PN IO from the hardware catalog into the network view of STEP 7. The IE/PB Link PN IO is located under Network components > Gateways > IE/PB Link PN IO.
3. Assign the IE/PB Link PN IO to the CPU.
4. Drag a PROFIBUS interface module e.g. IM155-6 DP HF, from the hardware catalog to the network view.
5. Assign the interface module to the IE/PB Link.

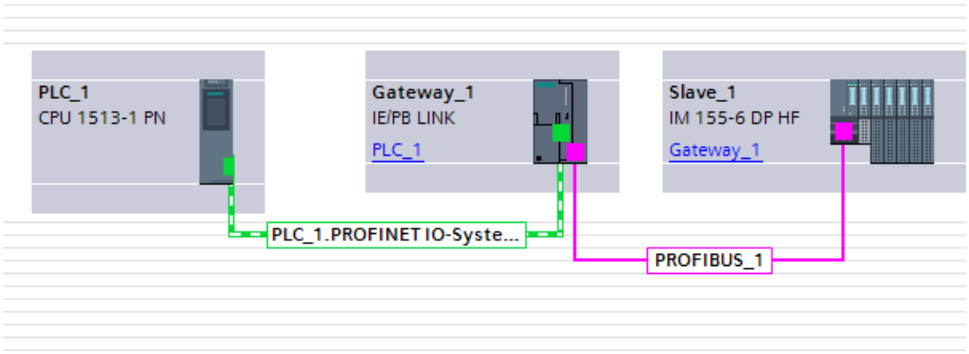

Figure 3-616 Configuring an IE/PB link

6. Select the IE/PB Link PN IO in the network view of STEP 7.

7. In the Inspector window, go to the "Gateway" area and select the "Network gateway as PROFINET IO proxy" option.

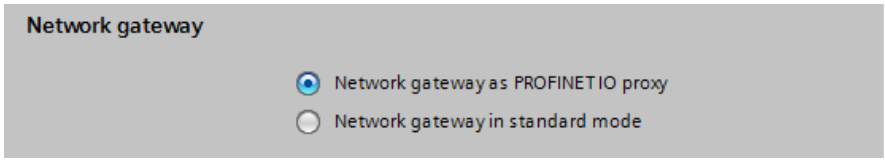

Figure 3-617 Setting a gateway

8. In the PROFINET device number area, you can assign a PROFINET device number for the DP slave.
If you have selected the "Device number = PB address" check box (default), STEP 7 automatically assigns the device number according to the PROFIBUS address of the slave. In addition, you no longer need to update the device number if the PROFIBUS address changes.

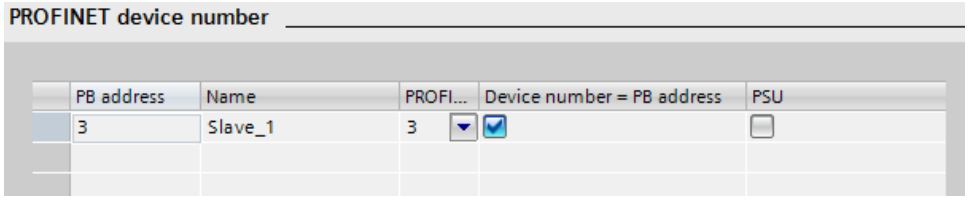

Figure 3-618 Assigning PN device numbers for IE/PB link

Result

You have connected the DP slave to the PROFINET IO system.

Reference

Additional information on the IE/PB link is available in the manual Gateway IE/PB Link PN IO (http://support.automation.siemens.com/WW/view/en/19299692).

7.2 Intelligent IO devices (I-devices)

7.2.1 I-device functionality

I-device functionality

The "I-device" (intelligent IO device) functionality of a CPU facilitates data exchange with an IO controller and operation of the CPU as intelligent preprocessing unit of sub processes, for example. The I-device is linked as an IO device to a "higher-level" IO controller.

The preprocessing is handled by the user program in the I-device. The process values acquired in the centralized or distributed (PROFINET IO or PROFIBUS DP) I/O are preprocessed by the user program and made available to the IO controller.

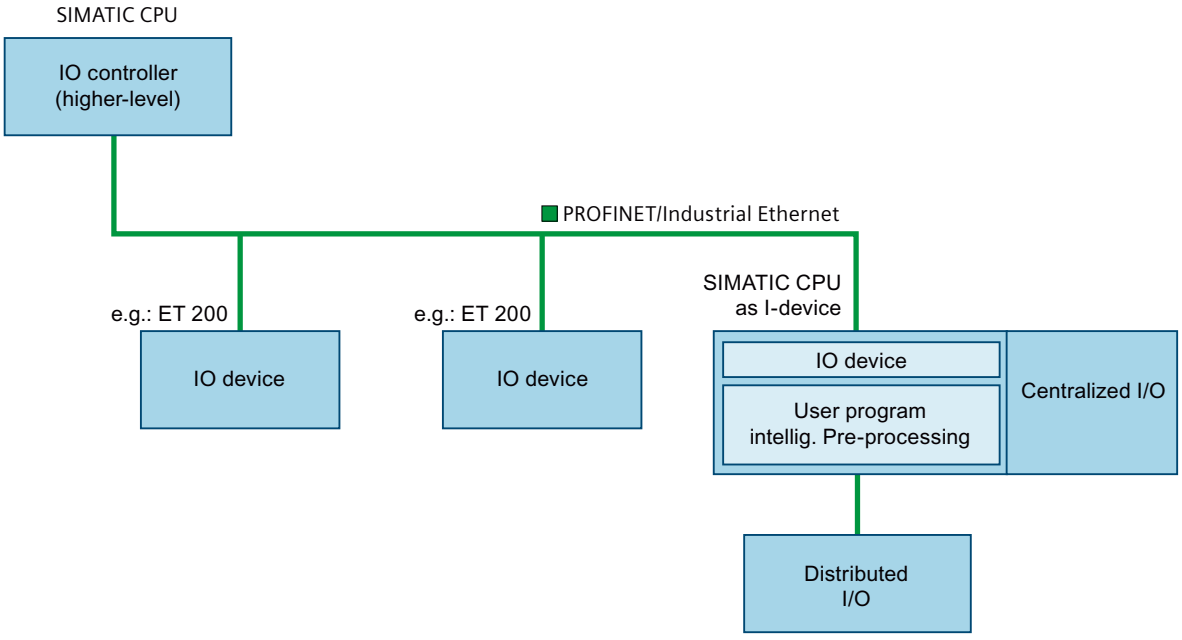

Figure 3-619 I-device

"I-device" naming conventions

In the remainder of this description, a CPU or a CP with I-device functionality is simply called an "I-device".

Application example: Configuration and application of the PROFINET I-device function

A detailed application example is available here (https://support.industry.siemens.com/cs/ww/en/view/109478798).

7.2.2 Properties and Advantages of the I-Device

Fields of application

Fields of application of the I-device:

- Distributed processing

  A complex automation task can be divided into smaller units/subprocesses. This results in manageable processes which lead to simplified subtasks.

- Separating subprocesses

  Complicated, widely distributed and extensive processes can be subdivided into several subprocesses with manageable interfaces by using I-devices. These subprocesses can be stored in individual STEP 7 projects if necessary, which can later be merged to form one master project.

- Know-how protection

  Components can only be delivered with a GSD file for the I-device interface description instead of with a STEP 7 project. The know-how of the user program may no longer be published.

Properties

Properties of the I-device:

- Unlinking STEP 7 projects

  Creators and users of an I-device can have completely separated STEP 7 automation projects. The GSD file forms the interface between the STEP 7 projects. This allows a link to standard IO controllers via a standardized interface.

- Real-time communication

  The I-device is provided with a deterministic PROFINET IO system via a PROFINET IO interface and therefore supports RT (real-time communication) and IRT (isochronous real time).

Advantages

The I-device has the following advantages:

- Simple linking of IO controllers
- Real-time communication between IO controllers
- Relieving the IO controller by distributing the computing capacity to I-devices.
- Lower communication load by processing process data locally.
- Manageable, due to processing of subtasks in separate STEP 7 projects

7.2.3 Characteristics of an I-Device

Principle

An I-device is included in an IO system like a standard IO device.

I-device without lower-level PROFINET IO system

The I-device does not have its own distributed I/O. The configuration and parameter assignment of the I-devices in the role of an IO device is the same as for a distributed I/O system (for example ET 200).

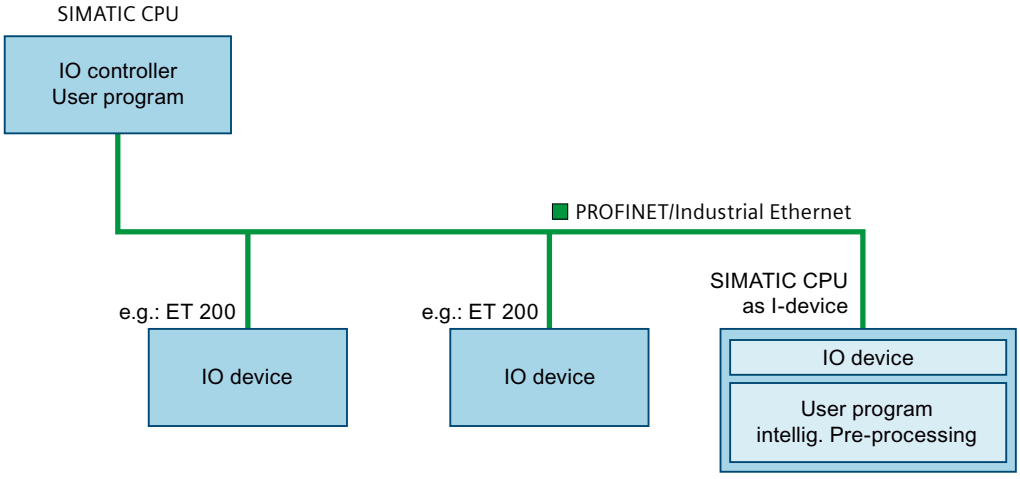

Figure 3-620 I-device without lower-level PROFINET IO system

I-device with lower-level PROFINET IO system

Depending on the configuration, an I-device can also be an IO controller on a PROFINET interface in addition to having the role of an IO device.

This means that the I-device can be part of a higher-level IO system via its PROFINET interface and as an IO controller can support its own lower-level IO system.

The lower-level IO system can, in turn, contain I-devices (see figure below). This makes hierarchically structured IO systems possible.

In addition to its role as IO controller, an I-device can also be used via a PROFIBUS interface as DP master for a lower-level PROFIBUS system.

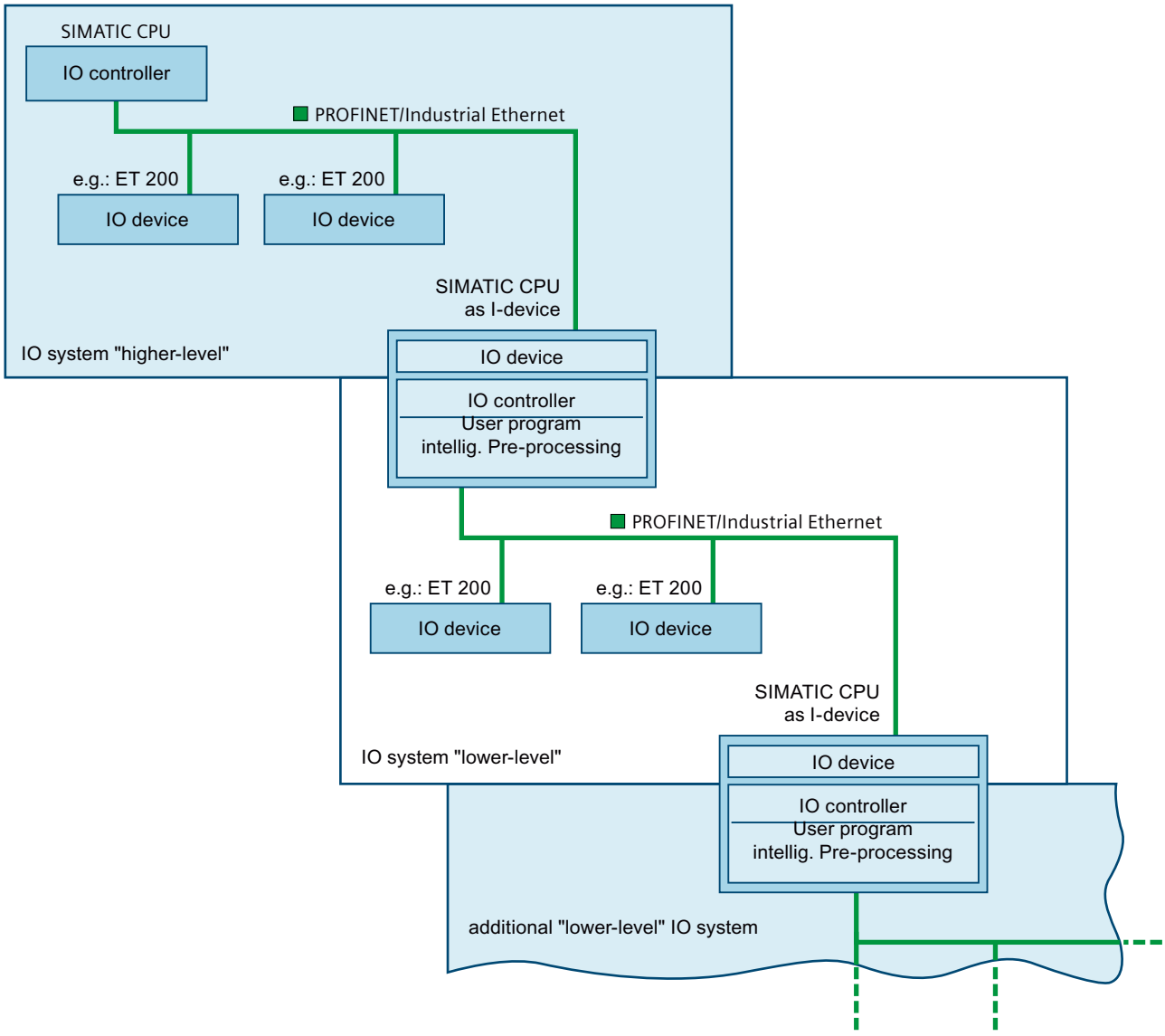

Figure 3-621 I-device with lower-level IO system

Example - the I-device as IO device and IO controller

The I-device as IO device and IO controller is explained based on the example of a print process. The I-device controls a unit (a subprocess). One unit is used, for example, to insert additional sheets such as flyers or brochures in a package of printed material.

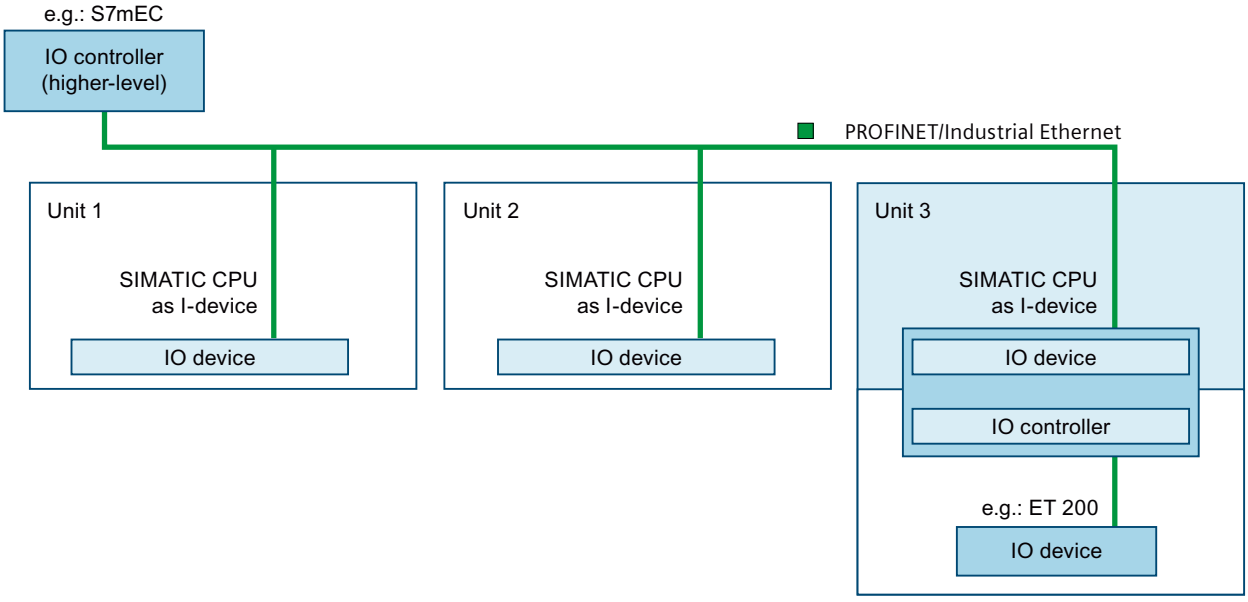

Figure 3-622 Example - the I-device as IO device and IO controller

Unit 1 and unit 2 each consist of an I-device with centralized I/O. The I-device along with the distributed I/O system (for example ET 200) forms unit 3.

The user program on the I-device is responsible for preprocessing the process data. For this task, the user program of the I-device requires default settings (for example control data) from the higher-level IO controller. The I-device provides the higher-level IO controller with the results (for example status of its subtask).

I-device as a shared device

An I-device can also be used simultaneously by multiple IO controllers as a shared device.

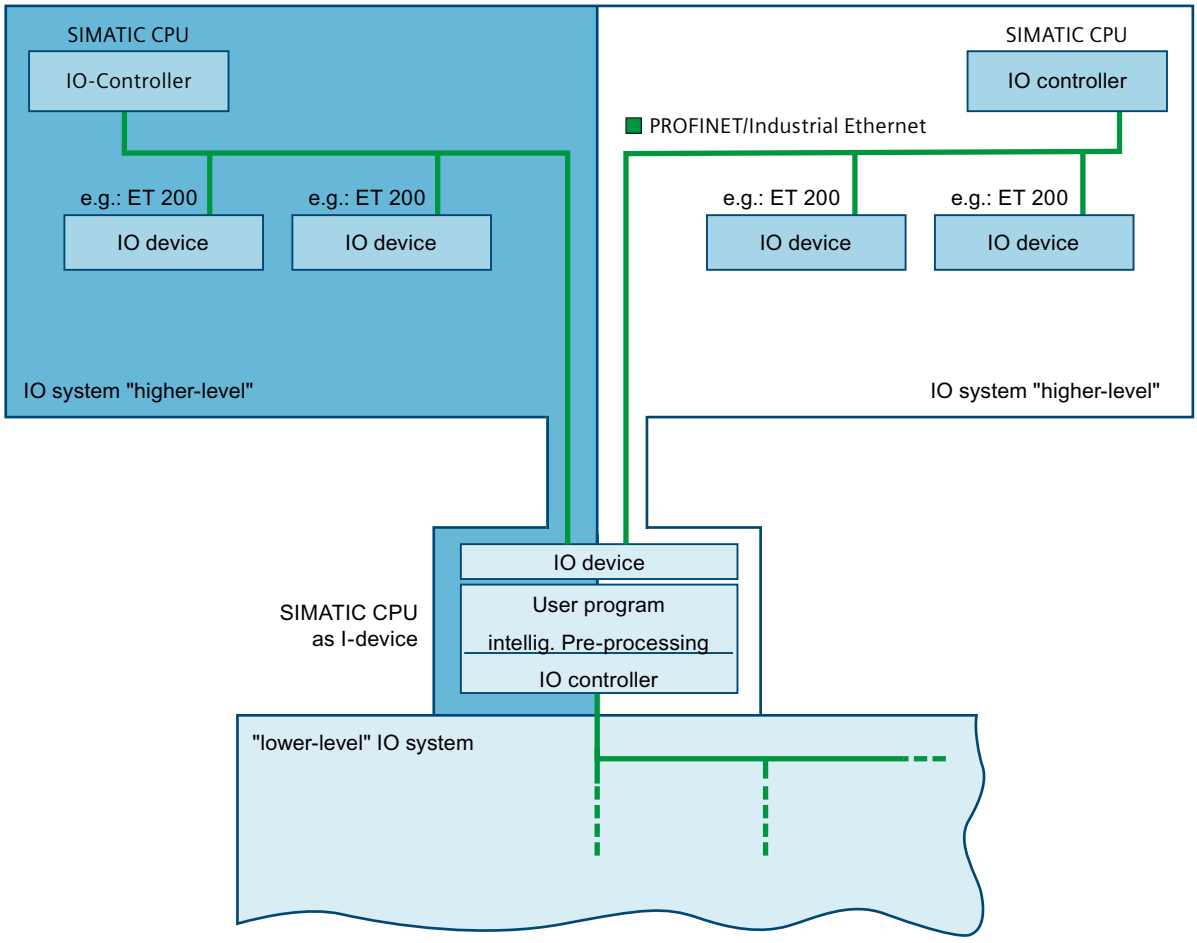

Figure 3-623 I-device as a shared device

Information about configuring an I-device as a shared device is available in the section Configuring a shared I-device in different projects (Page 173).

7.2.4 Data Exchange between higher- and lower-level IO system

Introduction

The next chapter shows the data exchange between the higher- and lower-level IO system.

Transfer areas

Transfer areas are an interface to the user program of the I-device CPU. Inputs are processed in the user program and outputs are the result of the processing in the user program.

The data for communication between IO controller and I-device is made available in the transfer areas. A transfer area contains an information unit that is exchanged consistently

between IO controller and I-device. You can find more information on configuration and use of transfer areas in the section Configuring the I-device (Page 134).

The next figure shows the data exchange between the higher- and lower-level IO system. The individual communication relations are explained below based on the numbers.

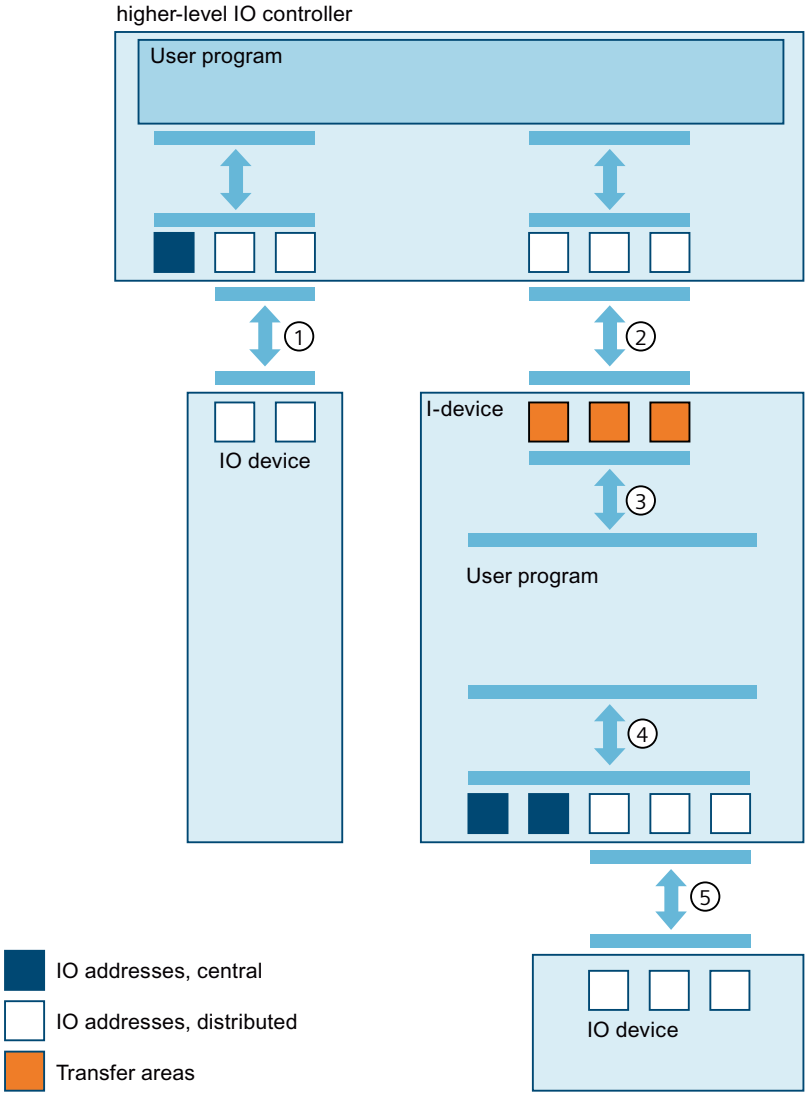

Figure 3-624 Data exchange between higher- and lower-level IO system

① Data exchange between higher-level IO controller and normal IO-device

In this way, the IO controller and IO devices exchange data through PROFINET.

② Data exchange between higher-level IO controller and I-device

In this way, the IO controller and the I-device exchange data through PROFINET.

The data exchange between a higher-level IO controller and an I-device is based on the conventional IO controller / IO device relationship.

For the higher-level IO controller, the transfer areas of the I-devices represent submodules of a preconfigured station.

The output data of the IO controller is the input data of the I-device. Analogously, the input data of the IO controller is the output data of the I-device.

③ **Transfer relationship between the user program and the transfer area**
In this way, the user program and the transfer area exchange input and output data.

④ **Data exchange between the user program and the I/O of the I-device**
In this way, the user program and the centralized / distributed I/O exchange input and output data.

⑤ **Data exchange between the I-device and a lower-level IO device**
In this way, the I-device and its IO devices exchange data. The data transfer is via PROFINET.

7.2.5 Configuring the I-device

Introduction

There are basically two possibilities for configuration:

- Configuration of an I-device within a project
- Configuration of an I-device that is used in another project or in another engineering system.

STEP 7 allows you to configure an I-device for another project or for another engineering system by exporting a configured I-device to a GSD file. You import the GSD file in other projects or engineering systems as with other GSD files. The transfer areas for the data exchange, among other data, are stored in this GSD file.

Configuration of an I-device within a project

1. Drag-and-drop a PROFINET CPU from the hardware catalog into the network view.
2. Drag-and-drop a PROFINET CPU, which can also be configured as an IO device, from the hardware catalog into the network view. This device is configured as I-device (e.g., CPU 1516-3 PN/DP).
3. Select the PROFINET interface for the I-device.
4. In the Inspector window in the area navigation choose "Operating mode" and select the check box "IO device".

5. Assign the I-device to an IO controller as follows:
   – For CPUs as of FW version V3.1:
     Click "Assign to new IO controller" in the "Assigned IO controllers" table.
     In the drop-down menu, select the PROFINET interface of the IO controller to which you want to assign the I-device.

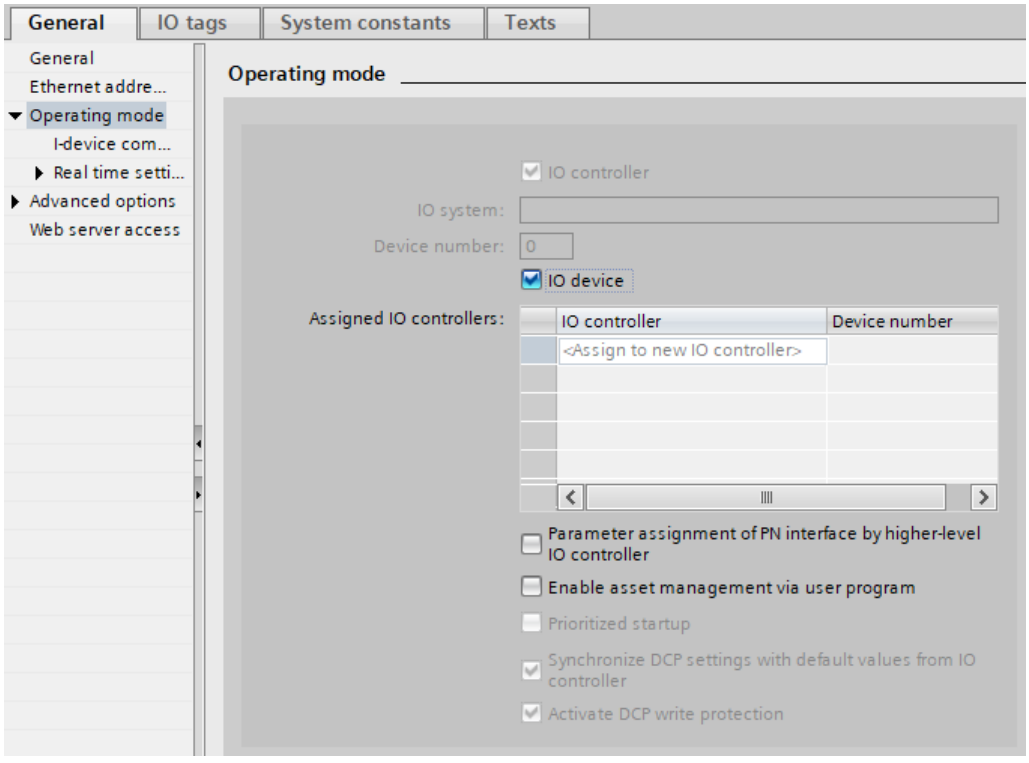

Figure 3-625 Configuring I-device with CPUs as of FW version V3.1

– For CPUs up to FW version V3.0:
  In the "Assigned IO controller" drop-down menu, select the PROFINET interface of the IO controller to which you want to assign the I-device.

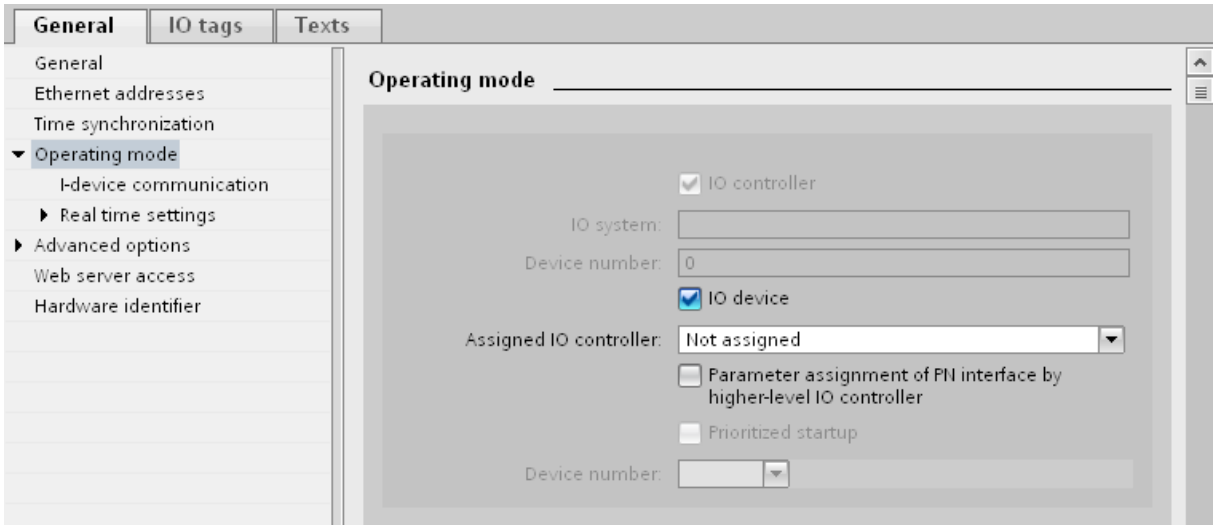

Figure 3-626 Configuring I-device for CPUs up to FW version V3.0

Once you have chosen the IO controller, the networking and the IO system between both devices are displayed in the network view.

6. Use the "Parameter assignment of the PN interface by higher-level IO controller" check box to determine whether the interface is configured by the I-device itself or by the higher-level IO controller.

   If you operate the I-device with a lower-level IO system, then the parameters of the I-device PROFINET interface (for example, port parameter) cannot be assigned with the higher-level IO controller.

7. Configure the transfer areas. The transfer areas are found in the area navigation section "I-device communication".
   – Click in the first field of the "Transfer area" column. STEP 7 assigns a default name that you can change.
   – Select the type of communication relation: you can currently only select CD or F-CD for "Controller-device communication relation".
   – Addresses are automatically preset; you can correct addresses if necessary, and determine the length of the transfer area which is to be consistently transferred.

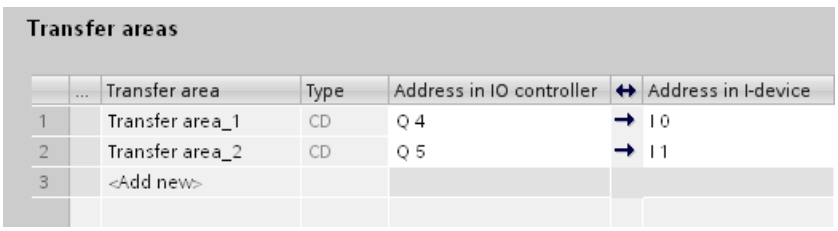

Transfer areas

	...	Transfer area	Type	Address in IO controller	↔	Address in I-device
1		Transfer area_1	CD	Q 4	→	I 0
2		Transfer area_2	CD	Q 5	→	I 1
3		<Add new>				

Figure 3-627 Configuring the transfer areas

8. A separate entry is created in the area navigation for each transfer area. If you select one of these entries, you can adjust the details of the transfer area, or correct them and comment on them.

NOTE

Device replacement in the configuration

If you want to exchange a configured CPU (I-device) with FW version < V3.1 for a CPU with FW version V3.1, the new I-device cannot be used as a shared I-device within the project.

To use the new I-device as a shared I-device within the project, you must deselect the "IO device" option at the relevant PROFINET interface of the current device before changing the module.

Configuring an I-device and exporting as a GSD file

If you use an I-device in another project, or if the I-device is used in another Engineering System, then configure the I-device as described above.

Once you have configured the I-device, you must export the I-device as a GSD file. This GSD file serves as a substitute for the configured I-device in other projects. If required, you can export an I-device that was created from a CPU as of FW version V4.1 as a GSD file for a signable GSDX file. This fulfills one of the requirements for PROFINET Security Class 1. You can find information on the use of GSD files in GSDX files in the section PROFINET Security Class 1 (Page 37).

To export a configured I-device as GSD file, proceed as follows:

1. In the Inspector window, navigate to the "Operating mode > I-device communication" area in the "Export generic station description file (GSD)" field.
2. Optional when using the GSD file in a GSDX file:
   - Select the "Use Distributor ID in the exported file" check box
     The text box for the distributor ID becomes editable.
   - Enter your distributor ID in the box.
     If the text box is empty or more than 40 characters have been entered, STEP 7 displays the text box in red.

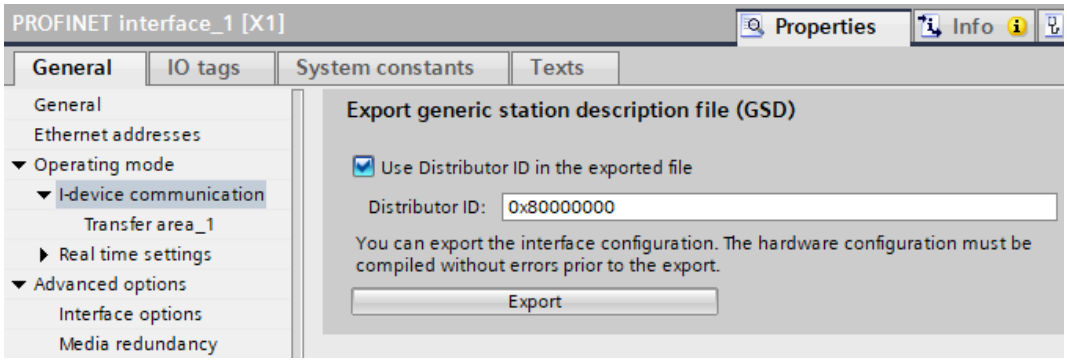

Figure 3-628 Export generic station description file (GSD)

3. Compile the CPU configured as an I-device.
   The export as GSD file only works immediately after the compiling process. If you change the configuration, you need to compile the CPU configured as an I-device again.
   The "Export" button in the "Operating mode > I-device communication > Export device description file (GSD)" area can be selected.
4. Click the "Export" button
   The export dialog opens.
5. Assign a name for the I-device proxy as well as a description and a storage location (path) in the fields provided. Click the "Export" button to complete the process.

Result: You have exported the configured I-device as a GSD file. You can then import the exported GSD file into other projects, for example, or make it available together with the I-device for integration into customer projects.

7.2.6 Program examples

Introduction

This simple program example shows how you use the transfer areas of an I-device.

Requirements

You have configured an I-device.

Task

The result of an "AND logic operation" of two inputs (preprocessing) in the I-device is to be provided to the higher-level IO controller. This result is to be assigned to a local output in the IO master (further processing).
Use a transfer area with the following addresses for this purpose:

- Address in the I-device: Q568
- Address in the IO controller: I68

Required steps

The following steps to solve the task:

1. Configuring the transfer area
2. Programming I-device
3. Programming IO controller

Configuring the transfer area

Configure a transfer area with the following properties in the I-device:

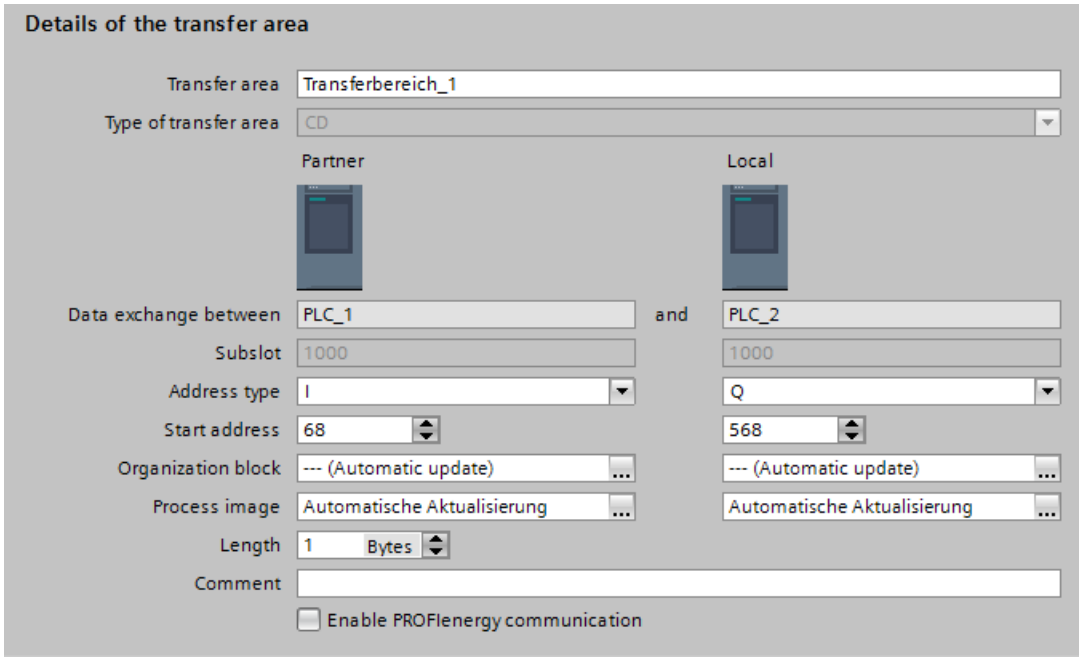

Figure 3-629 I-device transfer area, sample program

Programming I-device

To program the sample program for the I-device, follow these steps:

1. Using the SCL programming language, create a new function with the name "preprocessing" in the project tree in "Program blocks" > "Add new block". Open the function.
2. In the interface of the function "preprocessing", create the following tags:

Name	Data type	Input / output type
input 1	bool	Input
input 2	bool	Input
result	bool	Output

3. In the instruction window of the function "preprocessing", write the following program code:
   #result:=#input 1&#input 2;
4. Call the function "preprocessing" in a program cycle OB, for example, in OB1.

5. Wire the function "preprocessing" in the program cycle OB as follows:

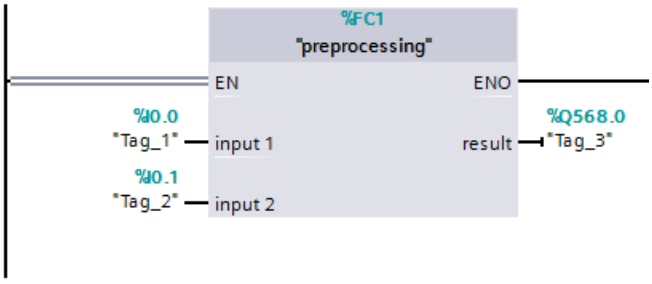

Figure 3-630 I-device sample program

Programming IO controller

To program the sample program for the IO controller, follow these steps:

1. Using the SCL programming language, create a new function with the name "further processing" in the project tree in "Program blocks" > "Add new block". Open the function.
2. In the interface of the function "further processing", create the following tags:

Name	Data type	Input / output type
result	bool	Input
output	bool	Output

3. In the instruction window of the function "further processing", write the following program code:
   #output:=#result;
4. Call the function "further processing" in a program cycle OB, for example, in OB1.
5. Wire the function "further processing" in the program cycle OB as follows:

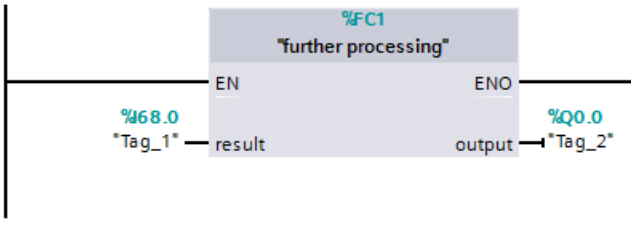

Figure 3-631 IO controller sample program

Result

The IO controller and the I-device can exchange data with each other through the input/output transfer areas.

7.2.7 Diagnostics and interrupt characteristics

Diagnostics and interrupt characteristics

S7 CPUs have numerous diagnostics and interrupt functions that can, for example, report errors or failures of lower-level IO systems. These diagnostics messages reduce down times and simplify localization and elimination of problems.

Diagnostics options in the higher-level IO controller and in the I-device

The following diagnostics functions are available to the higher-level IO controller and the I-device CPU:

- OB 83 (pull/plug)
- OB 86 (rack failure)
- OB 122 (I/O access error)

NOTE

The diagnostics messages of the I/O can be processed in the user program of the I-device CPU and passed on from there to the higher-level IO controller via transfer areas.

Operating state changes and station failure / station return

In the following table, you can see which consequences an operating state change or the failure of an IO controller / I-device of the SIMATIC family has on the respective other(s):

Table 3-963 Operating state changes and station failure / station return

Initial status	Event	I-device response	Higher-level IO controller
I-device CPU is in RUN, higher-level IO controller is in RUN	The I-device CPU changes to STOP	-	During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL. With direct IO access to all transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error).
I-device CPU is in STOP higher-level IO controller is in RUN	The I-device CPU is starting up	Call of OB 100 (startup). Call of OB 83 (pull/plug) for input transfer areas to the higher-level IO controller. Until call of OB 83 in the case of direct access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error).	Call of OB 83 (pull/plug) for all transfer areas to the I-device. Until call of OB 83 in the case of direct access to the transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error).

Initial status	Event	I-device response	Higher-level IO controller
I-device CPU is in RUN, higher-level IO controller is in RUN	The higher-level IO controller changes to STOP	During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL. With direct IO access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error). Note: Output transfer areas can still be accessed.	-
Higher-level IO controller is in STOP, I-device CPU in RUN	The higher-level IO controller starts up	Call of OB 83 (pull/plug) for input transfer areas to the higher-level IO controller. Until call of OB 83 in the case of direct access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error).	Call of OB 100 (startup).
I-device CPU is in RUN, higher-level IO controller is in RUN	Station failure I-device, for example, through bus interruption	If the I-device continues to run without a bus connection: Call of OB 86 (rack failure). During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL. With direct IO access to all transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error).	Call of OB 86 (rack failure). During the updating of the process image with the instructions "UPDAT_PI" and "UPDAT_PO" an error report is returned at the parameter RET_VAL. With direct IO access to all transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error).
I-device CPU is in RUN, higher-level IO controller is in RUN, communication connection between IO controller and I-device is interrupted (bus interruption).	The bus connection between the IO controller and I-device has been reestablished and the I-device is again included in the user data traffic.	Call of OB 86 (rack failure). Call of OB 83 (pull/plug) for input transfer areas to the higher-level IO controller. Until call of OB 83 in the case of direct access to the input transfer areas to the higher-level IO controller: depending on the type of error handling, e.g., call of OB 122 (IO access error).	Call of OB 86 (rack failure). Until reporting of station re-integration by OB 86 with direct IO access to all transfer areas to the I-device: depending on the type of error handling, e.g., call of OB 122 (IO access error)

NOTE

Special characteristic during startup of the higher-level IO controller

In contrast to the station return message from IO devices in the IO controller, which are covered completely by the call of the OB 86, the station return message of a higher-level IO controller in the I-device is separated into 2 parts:

1. Call of the OB 86: The initial values for the outputs of the I-device are set. However, the input values are not yet valid. These values will first be valid with the opening of OB 86 in the higher-level IO controller.
2. Call of OB 83 for each input transfer area; with this call, the validity of an input transfer area is displayed. The starting up of the I device is first complete when the OB 83 has been called for the input transfer areas. This step can be delayed or not occur at all in the following situations:
   - Higher-level IO controller is in STOP: OB 83 is first called at the STOP-RUN transition of the higher-level IO controller.
   - The IRT communication has been disrupted (sync-master failure, topology error, ...). OB 83 is opened only after the IRT communication has taken place.

Reference

For more information on error handling in the case of direct I/O access, refer to "Error handling" in the STEP 7 online help.

7.2.8 Rules for the Topology of a PROFINET IO System with I-Device

Introduction

The following recommendations for the structure and configuration of an IO system when using I-devices will help you to keep the bandwidths required for keeping communication small.

The following communication paths should not overlap:

- Communication paths between the IO controller and the IO device of its IO system.
- Communication paths of the I-device CPU and the IO devices of your IO system.

I-device with one port

Connect an I-device with only one port to a PROFINET switch that is uncoupled from the higher-level IO system. Connect the lower-level IO system to another port of the switch as shown in the following figure.

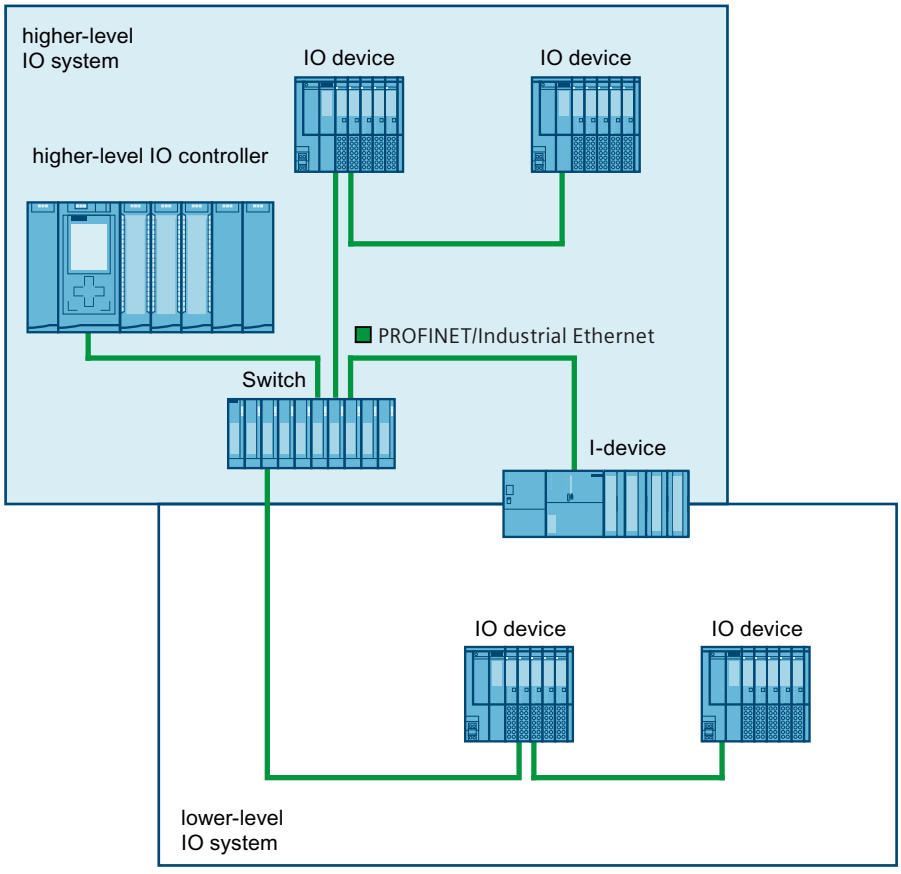

Figure 3-632 I-device with one port

I-device with two ports

With an I-device with two ports, connect one port, uncoupled from the higher-level IO system, to the port of the PROFINET switch. Use the second port for the lower-level IO system as shown in the following figure.

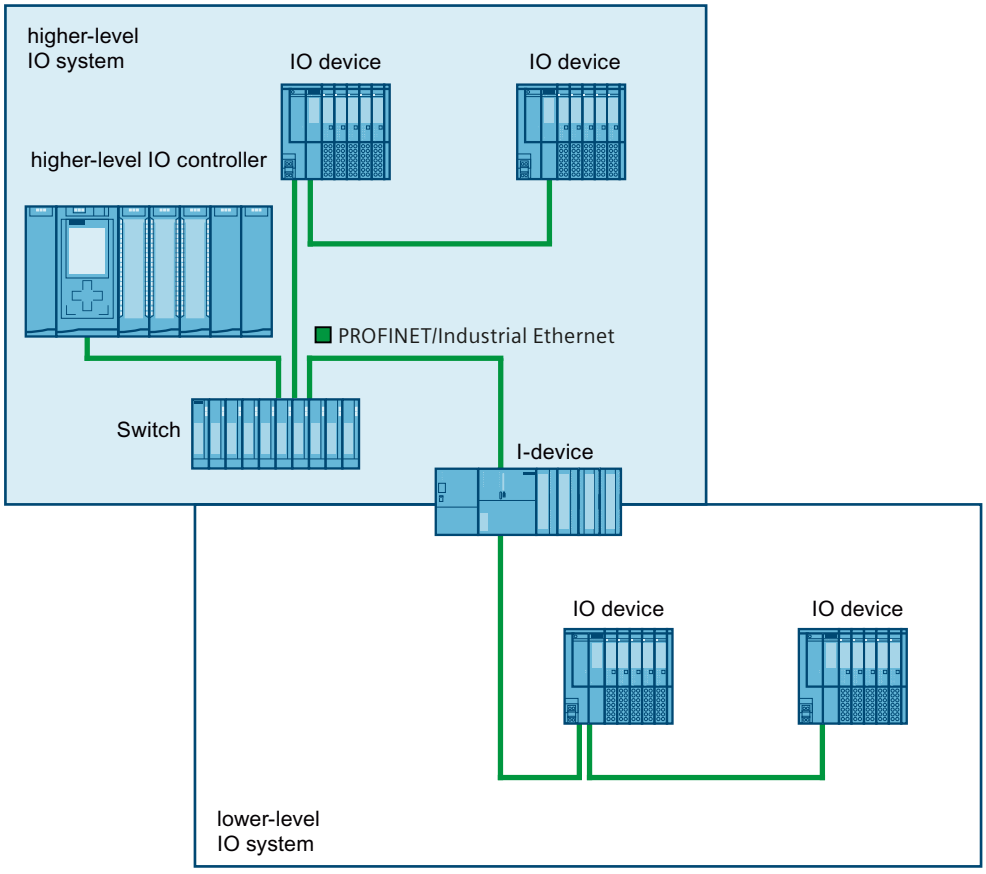

Figure 3-633 I-device with two ports

I-device with three or more ports

If you have an I-device with three or more ports, connect the I-device to one or both ports to the higher-level IO system in a linear bus topology. Connect the third port to the lower-level IO system uncoupled from the linear bus topology as shown in the following figure.

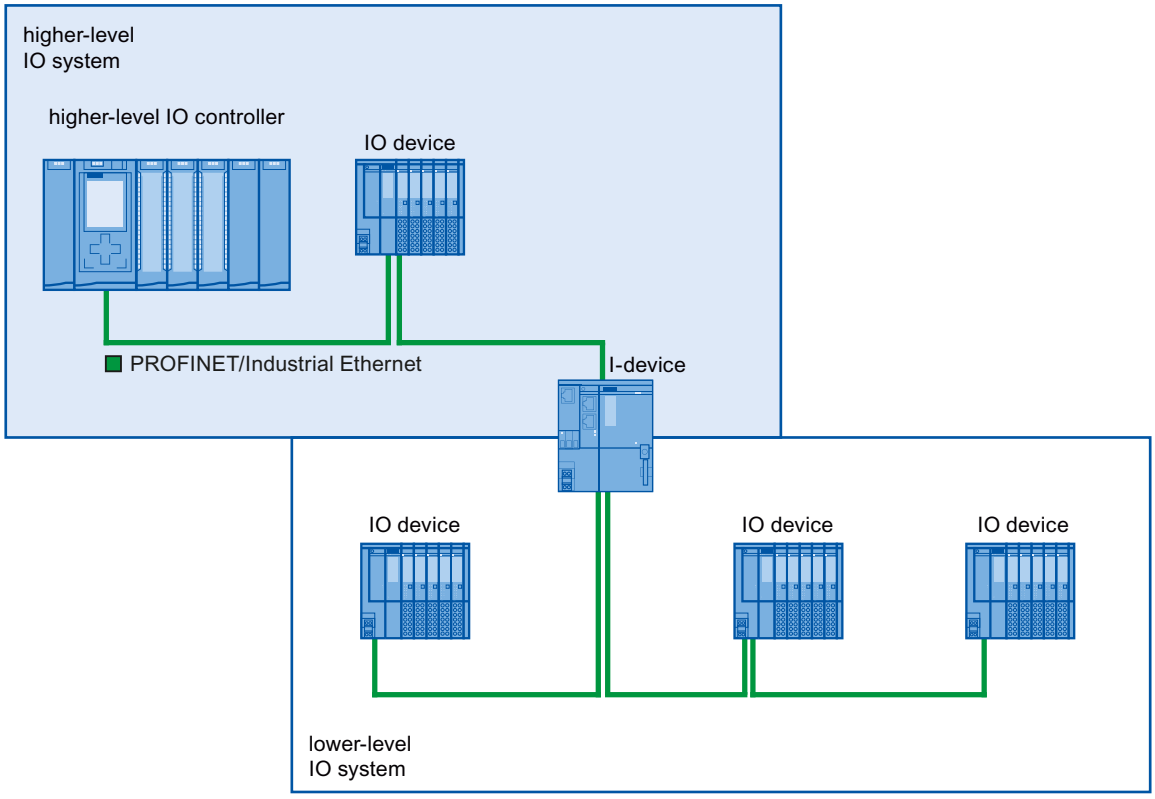

Figure 3-634 I-device with three or more ports

7.2.9 Boundary conditions when using I-devices

Note the following boundary conditions when using I-devices:

Bandwidth

The number of addresses of the configured transfer areas affects the usable bandwidth of the I-device:

- Bandwidth of the transfer areas + bandwidth of the lower-level IO system = total bandwidth used on the I-device

If the address space of the transfer areas is too large, this indicates a larger bandwidth requirement and can thus lead to longer update times.

Tip: Keep the address space of the transfer area as small as possible.

Rules for RT and IRT communication.

IO systems with I-devices are also suitable for setting up real-time applications with RT and IRT communication. The following rules must be followed for this:

- Both the higher-level and the lower-level IO system support RT communication. You can use RT communication for both IO systems at the same time.
- You can use IRT communication in one of the two IO systems. Use IRT either in a higher-level or in a lower-level IO system. The following restrictions apply to RT communication:
  - If you use IRT communication in the lower-level IO system, you can use RT communication in the higher-level IO system.
  - If you use IRT communication in the higher-level IO system, you can only use RT communication for isochronous I-devices in the lower-level IO system.
- If the PROFINET interface configured as an I-device uses RT communication, you can use IRT communication for a connected PROFINET IO system.

7.2.10 Configuring PROFIenergy with I-devices

The requirement for program-controlled pauses for saving energy with PROFINET devices is that the PROFINET devices support the PROFIenergy protocol.

Only if a PROFINET device (I/O device) supports the PROFIenergy protocol does an I/O controller actually send PE commands to this I/O device, for example to start or stop pauses.

If an I/O device supports the PROFIenergy protocol, this property is saved in its PROFINET GSD file and is available for configuration in an engineering system.

For S7-1500 CPUs as intelligent I/O devices (I-devices), you have the option with STEP 7 V13 service pack 1 or later to set PROFIenergy support for each transfer area.

If you have selected the "Enable PROFIenergy communication" option for a transfer area and import the generated PROFINET GSD file into another project, you can handle an I-device as a PE entity there.

Requirements

- STEP 7 as of V13 service pack 1
- CPU supports PROFIenergy with I-devices, for example CPU 1215C DC/DC/DC as of firmware version 4.2
- You use the PROFINET IO interface as an I-device and have created transfer areas.
- The user program in the I-device handles PROFIenergy commands

  Background: You need to program PROFIenergy functions with I-devices in the user program using the "PE_I_DEV" instruction and corresponding auxiliary blocks; this is different compared with IO devices for which this functionality is made available by the firmware. You may therefore only activate the PROFIenergy support for transfer areas if the user program in the I-device is configured correspondingly as well.

Enabling PROFIenergy for transfer areas of I-devices

Proceed as follows to assign parameters for the support of PROFIenergy:

1. Select the PROFINET interface (X1) of the CPU.
2. Select the required transfer area in the area navigation, for example:
   Operating mode > I-device communication > Transfer_area_1.
3. Select the check box "Enable PROFIenergy communication".

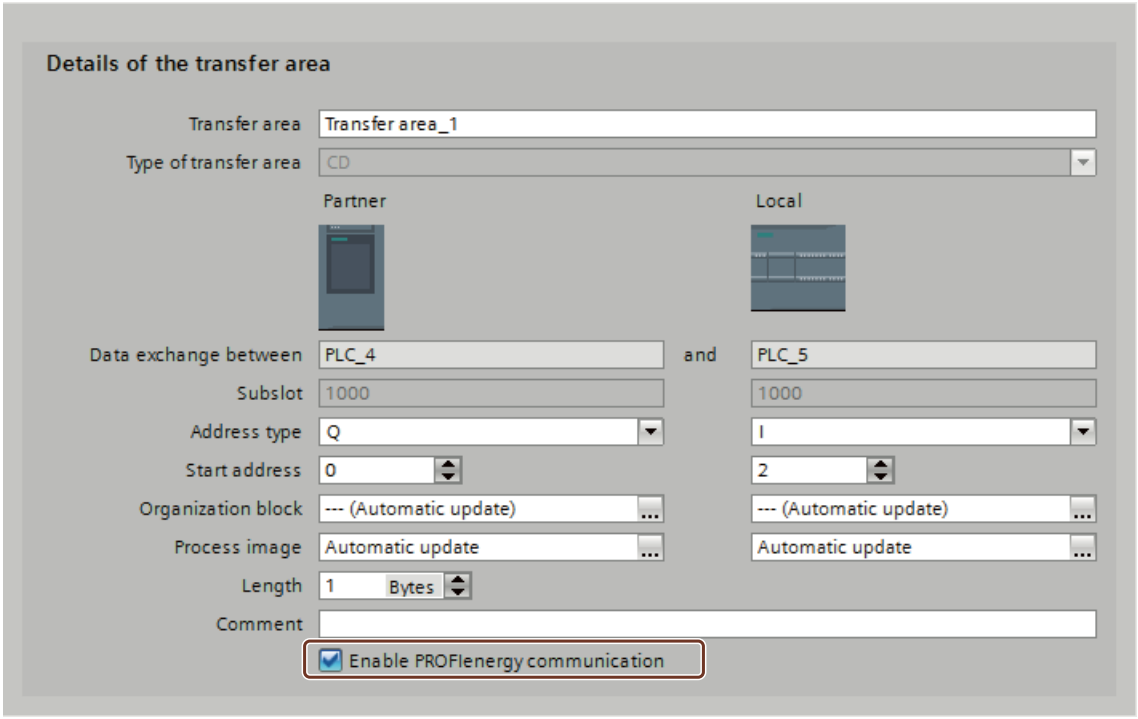

Figure 3-635 Configuring PROFIenergy with I-devices

Once the I-device is fully configured, generate the GSD file for the I-device and import this file in the project for the I/O controller. The GSD file generated contains an entry that specifies that the I-device supports the PROFIenergy profile.

To address the I-device, for example for the PE command "PE_START_END", use the hardware identifier of the "PROFIenergy supporting" transfer area in the I-device.

To address the IO controller for the PE command "PE_I_DEV", use the hardware identifier of the transfer area that is supplied with the data for PROFIenergy on the IO controller.

You can find more information on PROFIenergy in the sectoin Saving energy with PROFIenergy (Page 300).

7.2.11 Enabling/disabling I-device in the user program of the I-device CPU

When a PROFINET interface of a CPU was configured as an I-device in STEP 7, the I-device function is active after a status transition of the CPU from STOP > RUN. If no higher-level IO controller can be reached in this case, the I-device CPU signals an error using its ERROR LED.

As of firmware version 2.9 of an S7-1500/ET 200SP/ET 200pro CPU, you can locally disable or enable the I-device function in the user program of the I-device CPU. You use the "D_ACT_DP" instruction for this. After disabling the function, the I-device CPU no longer signals an error using its ERROR LED.

You can enable/disable the function with the user program at the CPU-internal PROFINET interfaces and for S7-1500 CM 1542-1 as of firmware version V3.0.

Application examples

From a machine OEM's point of view, there are numerous device options possible in **series production of machines**. However, each delivered machine includes only one combination of selected options. All possible machine options can be configured as I-devices by the manufacturer to create and maintain a common user program having all possible options.

A higher-level IO controller used for line control, for example, is not necessary in every machine. In this case, the user program can disable the I-device function in the I-device CPU with the instruction "D_ACT_DP", for example, during startup.

Two production lines are shown schematically in the figure below. The same user program runs in both CPUs with I-device configuration. The I-device in line 1 is controlled by a higher-level IO controller.

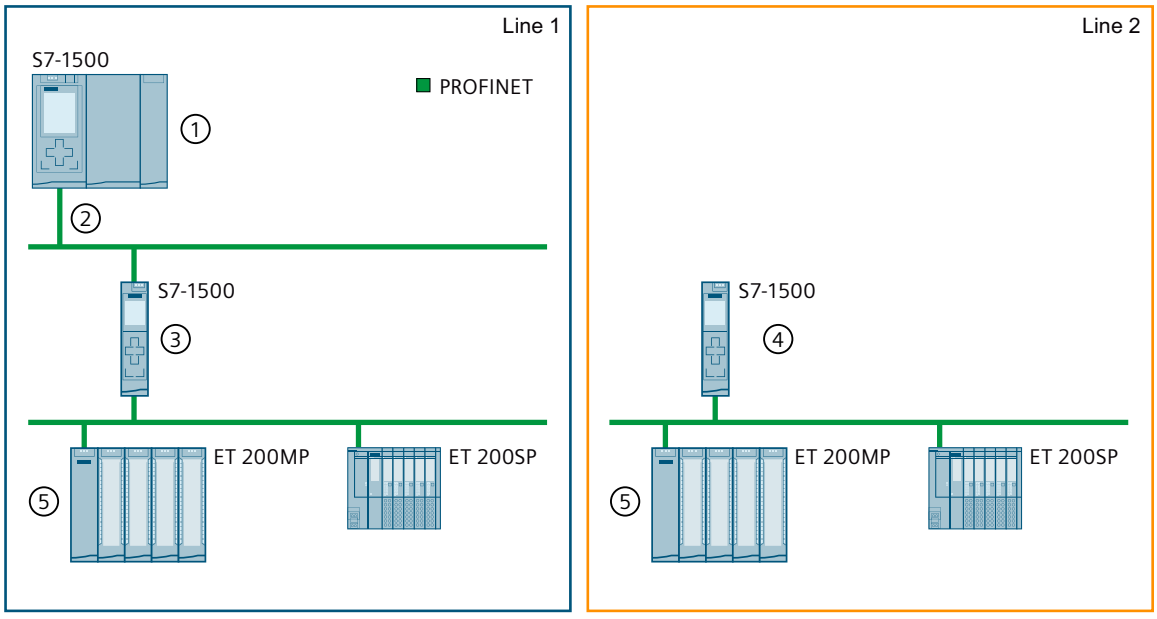

① Higher-level IO controller
② ... controls I-device CPU S7-1500 in the line
③ I-device function is enabled in the user program of this CPU
④ I-device function is disabled in the user program of this CPU
⑤ IO devices

Figure 3-636 Enable/disable the I-device function in the I-device CPU

Automation task control of vehicles in a ride

In a ride (ghost train), the vehicles are connected as I-devices to a higher-level controller via PROFINET.

Feature

The higher-level IO controller takes over the entire coordination and monitoring of the vehicles in the station. Among other things, the higher-level IO controller registers the following states:

- When the vehicles are available in the station
- When the vehicles exit the station

As soon as passengers are seated in the vehicle and the vehicle is closed, the higher-level IO controller issues the start signal.

Along the entire track, the vehicles are traveling independently and do not have a connection to the higher-level IO controller. Because this state does not represent an error, no errors should be signaled via the ERROR LEDs of the CPUs.

Solution

Depending on the position of the vehicle, inside or outside the station, the user program enables or disables the I-device function in the I-device CPU of the vehicle. No diagnostics were signaled via LED on the I-device CPU for enabling and disabling.

Requirements

You operate the CPU as an I-device on one or multiple IO controllers or you have configured the CPU as I-device ("IO device" check box is selected). In the following figure, the right CPU 1518-4 PN/DP is the I-device at the higher-level IO controller CPU 1518-4 PN/DP (PLC_2).

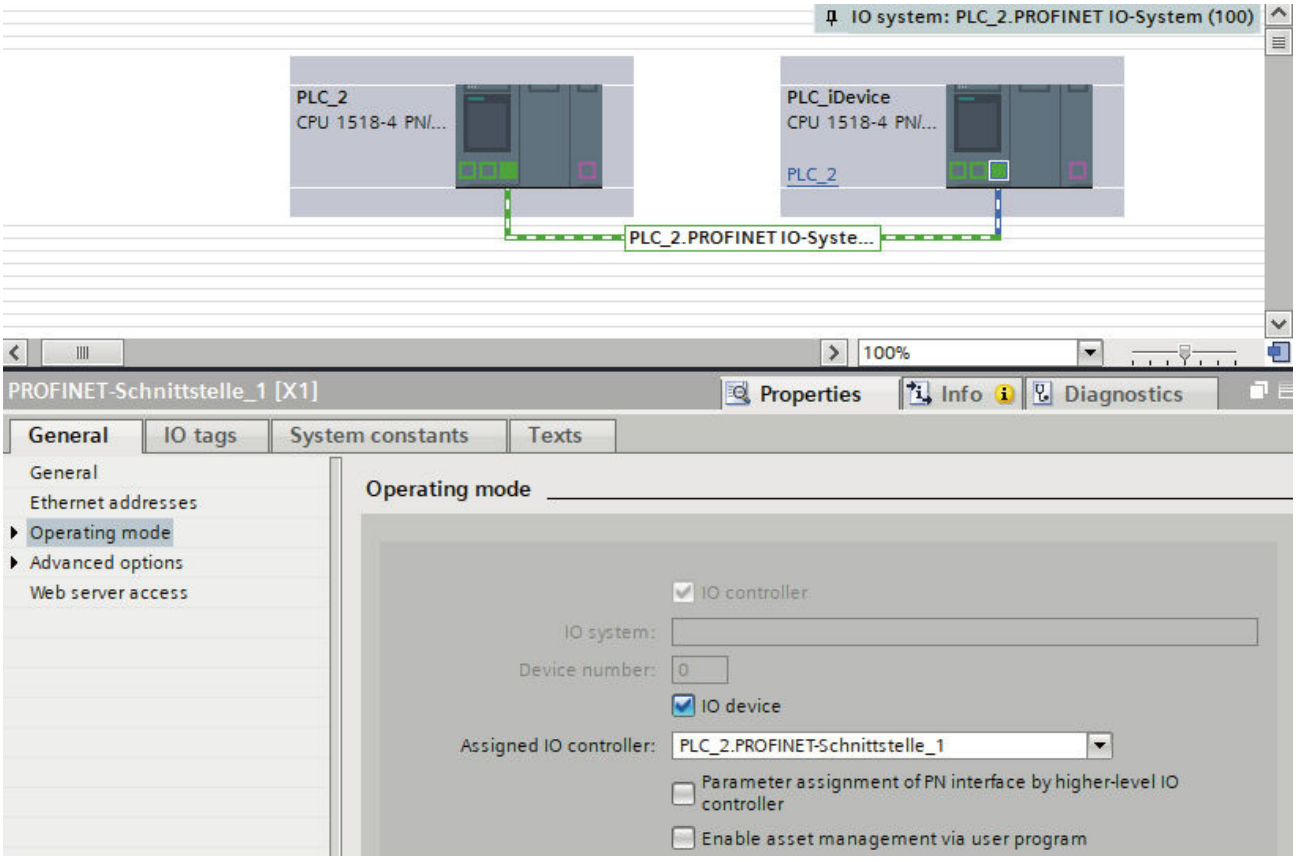

Figure 3-637 Example: Enable I-device

"D_ACT_DP" is an asynchronous instruction. Processing extends over multiple calls. You have started the job by calling "D_ACT_DP" with REQ = 1 in the startup OB of the I-device CPU.

You can find additional information on the "D_ACT_DP" instruction in the STEP 7 online help.

Disabling the I-device function at a PROFINET interface

NOTE

Only disable the I-device function in the I-device CPU when the I-device is not operated on a higher-level IO controller.

You disable the I-device function with the instruction "D_ACT_DP":

- Via the symbolic name or the hardware identification of the I-device of the respective PROFINET interface as LADDR parameter, in the example, HW identification 260
- Via the MODE parameter = 2

PLC_iDevice [CPU 1518-4 PN/DP] | Properties | Info | Diagnostics

General | IO tags | System constants | Texts

Show hardware system constant

Name	Type	Hardware identi.	Used by	Comment
PLC_iDevice~PROFINET-Schnittstelle_1~IODevice	Hw_Device	259	PLC_2	
PLC_iDevice~PROFINET-Schnittstelle_1~Transferbereich_1	Hw_SubModule	261	PLC_2	
Local~PROFINET-Schnittstelle_1~IODevice	Hw_Device	258	PLC_iDevice	
Local~PROFINET-Schnittstelle_1~Transferbereich_1	Hw_SubModule	260	PLC_iDevice	
Local~MC	Hw_SubModule	51	PLC_iDevice	
Local~Common	Hw_SubModule	50	PLC_iDevice	

Figure 3-638 Example: I-device system constants

Result: The goal has been accomplished: The CPU with disabled I-device function is no longer available for the data exchange with a higher-level IO controller. The higher-level IO controller can be reached again when the I-device function was enabled in the user program of the I-device CPU.

When an I-device that has been active on an IO controller disables itself, all application relations (ARs) that were set up between the I-device and the IO controller in the network are terminated. An IO device failure is signaled at the IO controller end. In the diagnostic buffer of the I-device CPU, "IO device user disable" is displayed with information on the associated PROFINET interface or the name of the IO controller.

Enabling the I-device function at a PROFINET interface

You use the instruction "D_ACT_DP" to enable an inactive I-device function:

- Via the symbolic name or the hardware identification of the I-device of the respective PROFINET interface as LADDR parameter, in the example, HW identification 260
- Via the MODE parameter = 1

Result: After enabling, the I-device can exchange data with a higher-level IO controller.

If at least one IO controller is missing or the connection does not exist, "Hardware component removed or missing" is entered in the diagnostic buffer of the I-device CPU.

NOTE

Temporary access errors

Enabling the I-device function in the user program can result in temporary access errors "I/O data failure in hardware component", for example, because access to the I/O data of the I-device is already possible even though the data has not been declared as valid by the IO controller yet.

These messages are incoming and outgoing error events that can be neglected.

The behavior of IO controller and I-device in case of a station failure and station return still applies as described in the section Diagnostics and alarm response (Page 141).

Calling up the status information of an I-device with the instruction "D_ACT_DP"

You are requesting the status information of an I-device:

- Via the hardware identification of the I-device of the respective PROFINET interface as LADDR parameter, in the example, HW identification 260
- Via the MODE parameter = 0

The status is returned in the RET_VAL parameter:

- RET_VAL = 0x0000: "D_ACT_DP" was completed without errors (disabling an inactive I-device/enabling an active I-device)
- RET_VAL = 0x0001: I-device is enabled
- RET_VAL = 0x0002: I-device is disabled

7.3 Shared device

7.3.1 Useful information on shared devices

Shared device functionality

Numerous IO controllers are often used in larger or widely distributed systems.

Without the "shared device" function, each IO module of an IO device is assigned to the same IO controller. If sensors that are physically close to each other must provide data to different IO controllers, several IO devices are required.

The "Shared Device" function allows the modules or submodules of an IO device to be divided up among different IO controllers. Thus allowing flexible automation concepts. You can, for example, combine IO modules that are physically close to one other in one IO device. Drives such as SINAMICS S120 also support the shared device functionality. As of STEP 7 V20, S7-1500 Software Controllers FW version V40 and higher also support the shared I-device functionality.

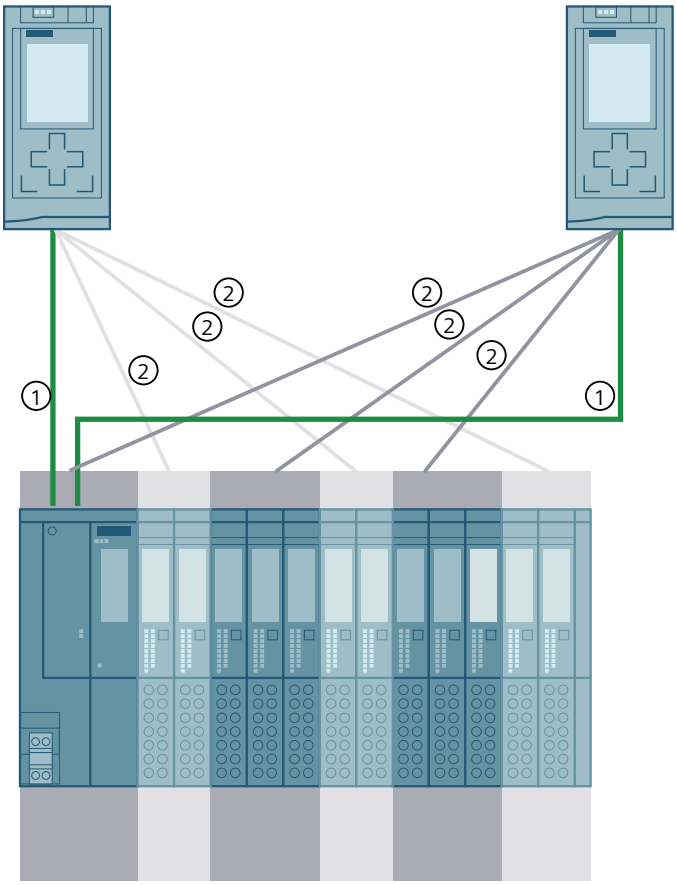

① PROFINET

② Logical assignment

Figure 3-639 Example: Shared device with two IO controllers

Principle

Access to modules and submodules of the shared device is then divided up among the individual IO controllers. Each module or submodule of the shared device is assigned exclusively to one IO controller.

Configuration possibilities of shared devices

You can configure a shared device and the IO controllers that access it in one of the following ways:

- In a common project
- Distributed among several projects

It is preferable to configure a shared device in a common project together with the IO controllers that access it. As a result, all components of a shared device configuration are known to the project. Therefore, configuration in a common project offers the following advantages compared to configuration in multiple projects:

- Reduction of possible sources of error: STEP 7 checks the complete consistency within a project.
- Less configuration effort: A common STEP 7 project contains all devices.
- Improved diagnostics: Complete diagnostics in one project.

Using a shared device and its IO controllers in a common project:

- Since STEP 7 V18: You can configure a shared device and two CPUs accessing it (IO controllers) in a single project.
- From STEP 7 V19: You can also configure a shared I-device and two CPUs accessing it (IO controllers) in a single project.
  - Requirement: Use an S7-1500 CPU FW version V3.1 or higher as the shared I-device.
- From STEP 7 V20: You can configure a shared device/shared I-device and all IO controllers that access it in a single project. You can also use a CM 1542-1 communications module with FW version V4.1 or higher as an IO controller.

If you use a shared device in multiple projects, the shared device must be configured in each project containing IO controllers that access it.

Using a shared device in multiple projects:

- Since STEP 7 V12 SP1, S7-1500 CPUs and SIMATIC distributed I/O devices support the "Shared Device" function. The shared device must be present in every project, although it is present only once in the installation. A separate project is required for each CPU accessing the shared device. To find out which components support the "Shared Device" function, see the following FAQ (https://support.industry.siemens.com/cs/us/en/view/102325771).

Setting of the real-time properties

If in addition to the CPUs in the project, other CPUs outside the project have access to the shared device, you must enter the number of project-external IO controllers for the PROFINET interface of the shared device. Only then does STEP 7 correctly calculate the communication load and thus the resulting update times.

The maximum possible number of IO controllers for the shared device depends on the device. You can find this number as follows:

- In the GSD file of the shared device.
- In the equipment manuals of the IO devices or CPUs that you intend to use as the shared device.

With a CPU used as an IO controller, you can set a very fast send clock. The send clock can be shorter than the shortest send clock supported by the shared device. In this case, the IO controller operates the shared device with a send clock it supports (send clock adaptation).

Example:

A CPU supports send clocks starting from 0.25 ms. One configured IO device also supports send clocks starting from 0.25 ms, while another IO device supports send clocks starting from 1 ms. In this case, you have the option of setting the short send clock of 0.25 ms for the CPU. The CPU operates the "slow" IO device with the send clock of 1 ms, for example.

Response in the event of fault

You can find out how PROFINET IO controllers behave in the event of an error when accessing the data of a shared device in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109572804).

7.3.2 Shared device and assigned IO controllers in the common project

Requirements

- The shared device and the IO controllers accessing it must be in the same subnet.
- The shared device must be assigned to each IO controller.
- There must be at least one module or submodule assigned to each connected IO controller.

If these conditions are not met, the configuration as a shared device is inconsistent. When an inconsistent configuration is compiled in STEP 7, a corresponding error message is displayed.

Restrictions

- In STEP 7 V18, only IO devices that have been installed in the hardware catalog via GSD files are permitted as shared devices in the common project.
  Starting from STEP 7 V19, you can insert and configure IO devices as shared devices in the common project directly from the STEP 7 hardware catalog without prior installation of GSD. You can find an overview of which IO devices support this usage in the following FAQ (https://support.industry.siemens.com/cs/us/en/view/102325771).
- In STEP 7 V19, a maximum of two IO controllers (CPUs) may access a shared device within a project. As of STEP 7 V20, this restriction no longer applies.
- The shared device does not support system redundancy.
- You can find specifics on handling fail-safe IO devices in the SIMATIC Safety - Configuring and Programming V19 (https://support.industry.siemens.com/cs/us/en/view/54110126) Programming and Operating Manual.

- "TIA Portal Openness" does not support shared device.
- Loading both CPUs as a new station into the same project is not supported. Load the two CPUs that share the shared device into different projects. As of STEP 7 V20, this restriction no longer applies.

Access to modules and submodules

Each IO controller only has access to the modules and submodules assigned to it. This means:

- Data is exchanged only with the assigned modules or submodules
- Alarms and diagnostics are only received from assigned modules or submodules
- Only parameters of assigned modules or submodules are configured

Rules for the configuration

The following rules apply to the configuration of a shared device in a common project and are checked automatically by STEP 7 when the configuration is compiled:

- Only one IO controller at a time may have full access to one submodule.
- I/O addresses of a module or submodule can only be edited in the address area of the IO controller to which the shared device is assigned.
- The send clock must be identical for all IO controllers that have access to the shared device.
- The following functions are only possible with the IO controller to which the interface module of the shared device is assigned:
  - Isochronous mode (IRT)
  - Media redundancy
  - Prioritized startup
  - Parameter assignment of the port properties
- STEP 7 V20 does not support the "Use name as extension for device name" option for shared devices.
- If you change the name of the shared device, then you must subsequently load all the CPUs that share this IO device.
- The maximum total of the communication relationships (ARs) for the shared device must not be exceeded. The maximum total of the communication relationships may be found, for example, in the Equipment Manual of the IO device you wish to use as the shared device.

  Example:
  An ET 200SP interface module supports up to four communication relations as a shared device. The shared device has already been assigned to two IO controllers in the project. A maximum of two more IO controllers that have been configured in other projects may access modules or submodules of this shared device. As of STEP 7 V20, you can configure the shared device and all IO controllers that access it in a single project.

7.3.3 Configuring a shared device in a common project

Below, you will find a description of how to configure a distributed I/O system as a shared device with STEP 7 version V18 or higher.

If your project contains a shared device that is accessed by IO controllers outside the project, read section "Configuring a shared device for different projects (Page 164)". These IO controllers are configured either in another TIA Portal project or with a different engineering tool.

A "distributed" configuration with different engineering tools for different IO controller families is generally possible. However, the description of the procedure is based exclusively on STEP 7 V18 or higher.

Since STEP 7 V18, only one project is needed for a shared device configuration. The project contains the shared device and a maximum of two IO controllers that access it. As of STEP 7 V20, you can configure a shared device and all IO controllers accessing it in a common project.

The following description is limited to two IO controllers of the S7-1500 family that share a shared device in a common project.

Requirements

- STEP 7 (TIA Portal) V18 or higher
- The IO controllers support the shared device function, e.g. CPU 1513-1 PN FW version V3.0 or higher.
- The IO device supports the shared device function, e.g. IM 155-5 PN ST interface module.
- STEP 7 V18: GSD files for the IO devices are installed and being used.
- STEP 7 as of V19: You can use IO devices from the hardware catalog of STEP 7 without prior installation of their GSD files. The desired IO device must support the shared device function when directly used from the hardware catalog.

Procedure - Creating project

To create a common project with two IO controllers and a shared device, follow these steps:

1. Start STEP 7.
2. Create a new project, for example with the name "Shared Device".
3. In the network view, insert an IO controller (e.g. CPU 1513-1 PN) from the hardware catalog.
4. Assign a name, for example "PLC_1".
5. Insert another IO controller (e.g. CPU 1513-1 PN) from the hardware catalog.
6. Assign a name, for example "PLC_2".
7. Connect the PROFINET interface X1 of the inserted IO controllers to each other. The PROFINET interfaces of the IO controllers are then in the same subnet.

8. Insert an IO device (e.g. IM 155-6 PN ST) from the hardware catalog as follows:
   - STEP 7 V19 or higher: Use the default entries, for example, under "Distributed I/O > ET 200SP > interface module > PROFINET".
   - STEP 7 V18: You can find the IO devices installed from the GSD files under "Other field devices > PROFINET IO > IO > SIEMENS AG".
9. Double-click the inserted IO device. The device view opens.
10. Insert all required modules and submodules from the hardware catalog into the device overview table. If the shared device was installed and inserted as GSD, also use the installed modules and submodules from the GSD files.
11. Assign parameters for the individual IO modules.
12. Switch to the network view.
13. Assign the IO device to the IO controllers one after the other, e.g. "PLC_1" and "PLC_2".
14. Save the project.

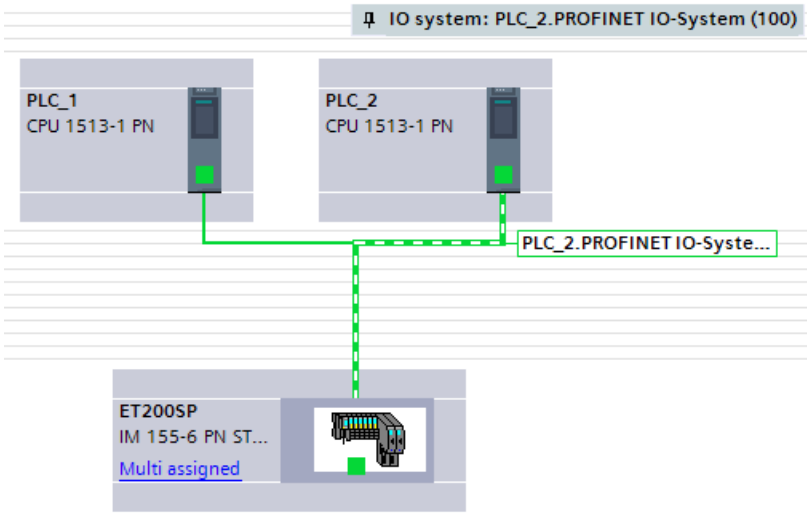

Figure 3-640 Shared device assigned in the common project

Procedure - Configuring the assignment of the modules or submodules

After the first assignment of the shared device to an IO controller, all modules or submodules are assigned to this IO controller.

Newly added modules or submodules are assigned to the IO controller to which the interface module is also assigned. If a shared device is disconnected from an IO controller, the assigned modules or submodules obtain the "unknown" access status.

To change the assignment, proceed as follows:

1. In the network view or the device view of the project, select the interface module of the shared device.
2. In the Inspector window, select the "Shared Device" tab under "Properties > General > Module parameters".

   A table shows which IO controller has access to the respective module or submodule. The default setting for all modules and submodules is the IO controller to which the shared device was first assigned.
3. Keep the "PLC_1" setting for all modules and submodules that are to remain in the address area.

   For all modules or submodules that you want to assign to the address area of the other IO controller, select the setting "PLC_2".

   Special consideration: With the "Outside of project" option, you can select IO controllers that are connected to the PROFINET IO system but are configured in another TIA project or engineering tool.

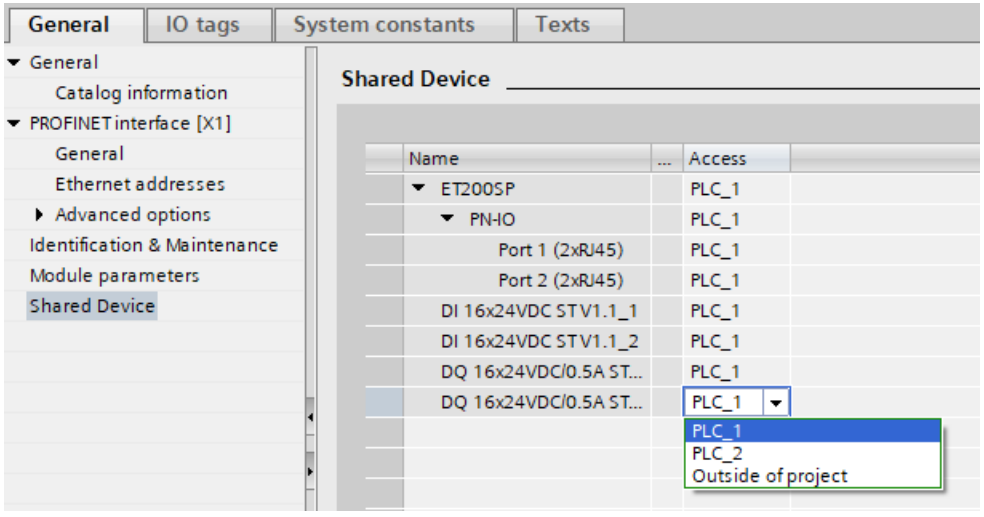

Figure 3-641 Configuring a project-internal shared device

Procedure - Adjusting the real-time settings

Adjusting and checking the settings listed below ensures the following properties:

- All IO controllers and shared devices are operated with the appropriate send clock.
- Update times are calculated correctly with respect to the communication load.

To adjust and check these settings, proceed as follows:

1. Select the interface module of the shared device in the network view.
2. In the Inspector window, navigate to the "PROFINET interface > Advanced options > Real time settings > IO cycle" area.

3. If IO controllers from other projects also access this shared device: Set the number of IO controllers outside the project in the "Shared Device" area. The maximum number depends on the IO device. You can find the maximum number as follows:
   - In the GSD file of the shared device.
   - In the Equipment Manual of the IO device you wish to use as the shared device.
4. For each IO controller that has access to modules or submodules of the shared device, you must adapt the real-time settings on a CPU-specific basis.
5. You must set the same send clock for each IO controller that has access to modules or submodules of the shared device:
   - If you configure an additional IO controller outside the project with STEP 7 (TIA Portal):

     Open the corresponding project.

     Select the PROFINET interface of the IO controller.

     Select the "Advanced options > Real time settings > IO communication" area in the Inspector window and set the same send clock.
   - If you configure an additional IO controller outside the project with a different engineering tool:

     Select the PROFINET interface of the shared device in STEP 7 (TIA Portal) and read out the send clock on the shared device ("Advanced options > Real time settings" area)

     Enter the read send clock in the engineering tool.
   - Special consideration: If you configure **all** IO controllers that have access to the shared device in a common STEP 7 project (STEP 7 V5.5 or higher), shorter send clocks can be set at the IO controller than are supported by the shared device (send clock adaptation).

Compiling and loading

When you select the shared device and click on "Compile" in the toolbar, the configuration of all IO controllers accessing it is checked for data consistency.

You must load the configurations for the various IO controllers into the IO controllers one after the other.

NOTE

Synchronizing router settings with the IO controller

The "Synchronize router settings with IO controller" option is selected by default for IO devices. If the connected IO controllers use the same router or no router, leave this setting as it is.

If the connected IO controllers use different routers, deselect the "Synchronize router settings with IO controller" option. In this case, manually configure the corresponding router address on the shared device.

7.3.4 Shared device and assigned IO controllers in different projects

Requirements

- STEP 7 V12 Service Pack 1 or higher.
- IO device supports the shared device function, e.g. IM 155-5 PN ST interface module.
- IO controller supports the shared device function, e.g. CPU 1516-3 PN/DP FW version V1.1 or higher or CPU 1215 DC/DC/DC FW version V4.1 or higher.

Configuring the access

The modules and submodules of an IO device must be assigned to the different IO controllers in the various projects. This requires the IO device to be present in all projects in which an IO controller accesses this IO device.

Use the "Shared Device" parameter of the interface module to define the modules or submodules to which the IO controller has access:

- If the local IO controller has access to the configured module, select the name of the IO controller from the list.
- If an IO controller from another project is to have access to the configured module, select the entry "Outside of project".

The configuration is consistent with regard to access when each module or submodule has been assigned to an IO controller in exactly one project.

Module or submodule is assigned to another IO controller

The following section is about the consequences of the "Outside of project" setting of the "Shared Device" parameter from the point of view of the local IO controller.

In this case, the local IO controller does not have access to the module configured in this way. Specifically, this means:

- No parameter assignment of the module or submodule
- No data exchange with the module or submodule
- No reception of alarms or diagnostics, which means no display of the diagnostics status in the online view

Rules for the configuration

- IO controllers that use the shared device are created in different projects. In each project, care must be taken that the shared device is configured identically in each station.
- If you have selected the "Use router" option for the IO controllers involved, you must have set the same router address in all these IO controllers. You as the user must ensure consistency.
- The shared device must have the same IP parameters and the same device name in each project.

- The S7 subnet ID of the subnet to which the shared device is connected must be identical in all projects.
- Only one IO controller at a time may have full access to one submodule. Inconsistencies in the configuration result in a failure of the shared device.
- I/O addresses of a module or submodule can only be edited if a module or submodule has been assigned to the IO controller in the same project.
- The send clock must be identical for all IO controllers that have access to the shared device.
- The following functions are only possible with the IO controller to which the interface module of the shared device is assigned:
  - Isochronous mode (IRT)
  - Media redundancy
  - Prioritized startup
  - Parameter assignment of the port properties
- If you change the name of the shared device, then you must subsequently load all the CPUs that share this IO device.
- The maximum total of the communication relationships (ARs) for the shared device must not be exceeded. The maximum total of the communication relationships may be found, for example, in the Equipment Manual of the IO device you wish to use as the shared device.

  Example:
  An ET 200SP interface module supports up to four communication relations as a shared device. The shared device has already been assigned to two IO controllers in the project. A maximum of two more IO controllers that have been configured in other projects may access modules or submodules of this shared device.

Constraints

The following constraints result because a shared device configuration is distributed across different projects:

- In the address overview of each IO controller that has access to a shared device, the addresses of modules or submodules that are not assigned to this IO controller are missing.
- The modules or submodules that are not assigned are not taken into consideration in the configuration limit calculation for the shared device during the consistency check. For this reason, you must yourself check that the maximum number of submodules or the maximum amount of cyclic IO data for the shared device is not exceeded.
  For information on the maximum configuration limits, refer to the documentation of the devices you are using.

- Configuration errors such as assignment of a module or submodule to more than one IO controller are not detected by STEP 7.
- CPUs that are loaded with a shared device configuration do not have any information on whether the IO device is a shared device. Modules or submodules that have been assigned to other IO controllers, and therefore other CPUs, are missing in the loaded configuration. These modules or submodules are therefore displayed neither in the CPU web server nor in the CPU display.

See also

Response in the event of fault
(https://support.industry.siemens.com/cs/ww/en/view/109572804)

7.3.5 Configuring a shared device for different projects

Below, you will find a description of how to configure a distributed I/O system as a shared device with STEP 7 version V12, Service Pack 1 or higher.

A "distributed" configuration with different engineering tools for different IO controller families is in principle possible. However, this description of the procedure is based exclusively on STEP 7 V12, Service Pack 1 or higher. The following description is limited to two IO controllers of the S7-1500 family that share a shared device in different projects.

Two projects are created (Shared-Device-1 and Shared-Device-2), each with one IO controller (PLC_1 and PLC_2). You must create the shared device in both projects, even though it is physically one and the same IO device.

Requirements

- STEP 7 (TIA Portal) as of V12 Service Pack 1
- The IO controllers support the shared device function, e.g. CPU 1513-1 PN, FW version V1.1 or higher.
- The IO device supports the shared device function, e.g. IM 155-5 PN ST interface module, FW version V2.0 or higher.

Procedure - Creating project 1

To create the first project with a shared device, follow these steps:

1. Start STEP 7.
2. Create a new project, for example with the name "Shared-Device-1".
3. In the network view, insert an IO controller (e.g. CPU 1513-1 PN) from the hardware catalog.
4. Assign a name, for example "PLC_1".
5. Insert an IO device (e.g. IM 155-6 PN ST) with the "Shared device" function from the hardware catalog.
6. Assign the IO device to the IO controller "PLC_1".
7. Double-click the IO device and insert all required modules and submodules from the hardware catalog into the device overview table.

8. Assign the module parameters.
9. Save the project.

Procedure - Creating project 2

To create the second project with a shared device, follow these steps:

1. Start STEP 7 once again.

   A new instance of STEP 7 opens.
2. In the new instance, create a new project, for example with the name "Shared-Device-2".
3. In the network view, insert an IO controller (e.g. CPU 1513-1 PN) from the hardware catalog.
4. Assign a name, for example "PLC_2".
5. Copy the IO device from the "Shared-Device-1" project and insert it into the network view of the "Shared-Device-2" project.
6. Assign the IO device to the IO controller "PLC_2".
7. Save the project.

Both projects now have an identically structured IO device that must be configured in the next step for the different IO controller accesses.

Procedure - Configuring the assignment of the modules or submodules

The modules and submodules you insert in the shared device are automatically assigned to the local CPU. To change the assignment, follow these steps:

1. Select the interface module in the network view or device view of the "Shared-Device-1" project.
2. In the Inspector window, select the "Shared Device" tab under "Properties > General > Module parameters".

   A table shows which CPU has access to the respective module or submodule for all configured modules. The default setting is that the local CPU has access to all modules and submodules.

3. Keep the "PLC_1" setting for all modules and submodules that are to remain in the address area of the local CPU.

   Select the "Outside of project" setting for all modules or submodules that are to be located in the address area of the CPU from the "Shared-Device-2" project ("PLC_2"). This means that an IO controller outside of the project is to have access to the module or submodule.

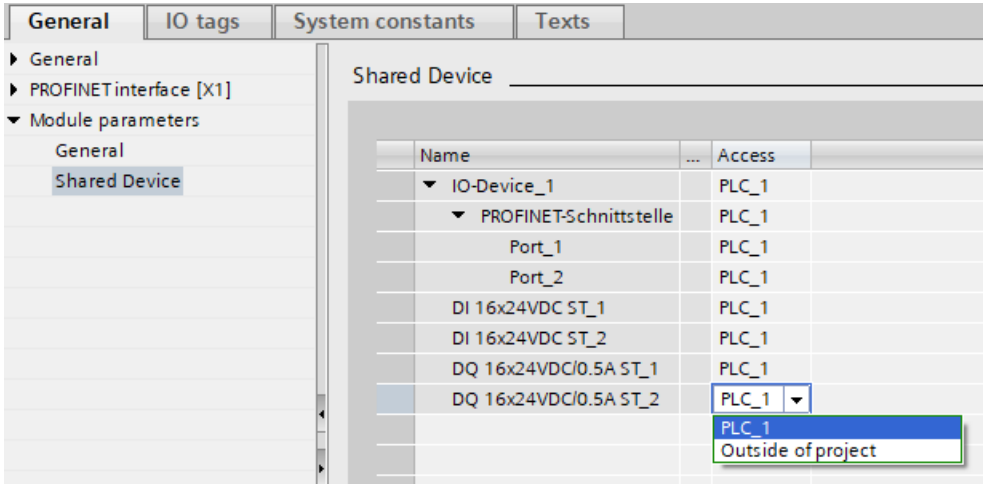

Figure 3-642 Configuring shared device

4. Select the interface module in the network view or device view of the "Shared-Device-2" project.
5. In the Inspector window, select the "Shared Device" tab under "Properties > General > Module parameters".

   A table shows which CPU has access to the respective module or submodule for all configured modules.
6. Select the "Outside of project" setting for all modules or submodules that are to be located in the address area of the CPU from the "Shared-Device-1" project ("PLC_1").
7. Finally, check whether the settings for access are "complementary" for each module or submodule in both projects. This means that if the local CPU has access in one project, the "Outside of project" option must be set in the other project and vice versa.

   Special consideration: The option "Outside of project" for the PROFINET interface and therefore for the ports makes the associated parameters read-only and not changeable. Parameters of the PROFINET interface and port parameters can only be edited in the project in which the PROFINET interface is assigned to the local CPU. The ports can be interconnected in both projects regardless of this.
8. Check whether the same IP address parameters and device name are set for the shared device in all projects.

   Check whether the same S7 subnet ID is set in all projects for the subnet to which the shared device is connected (subnet properties, "General" area in the Inspector window).

NOTE

If you make changes to the shared device: Make the same changes in each project on the shared device. Make sure that only one IO controller at a time has access to a module or submodule!

Procedure - Adjusting the real time settings

Adjusting and checking the settings listed below ensures the following properties:

- All IO controllers and shared devices are operated with the appropriate send clock.
- Update times are calculated correctly based on the communication load.

To adjust and check these settings, proceed as follows:

1. Select the project whose IO controllers have access to the PROFINET interface and the ports of the shared device.
2. Select the interface module of the shared device in the network view.
3. In the Inspector window, navigate to the "PROFINET interface > Advanced options > Real time settings > IO cycle" area.
4. In the "Shared Device" area, set the number of project-external IO controllers. The maximum number depends on the IO device (specification in GSD file).
5. For each IO controller that has access to modules or submodules of the project-internal shared device, you must adapt the real-time settings on a CPU-specific basis.
6. You must set the same send clock for each IO controller that has access to modules or submodules of the shared device:
   - If the IO controller is configured with STEP 7 (TIA Portal):

     Open the corresponding project.

     Select the PROFINET interface of the IO controller.

     Select the "Advanced options > Real time settings > IO communication" area in the Inspector window and set the same send clock.
   - If the IO controller is configured with a different engineering tool:

     Select the PROFINET interface of the shared device in STEP 7 (TIA Portal) and read out the send clock on the shared device ("Advanced options > Real time settings" area)

     Enter the read send clock in the engineering tool.
   - Special consideration: If **all** IO controllers that have access to the shared device are configured in STEP 7 (TIA Portal or STEP 7 V5.5 or higher), you can set shorter send clocks at the IO controller than are supported by the shared device (send clock adaptation).

Compiling and loading

You must compile the configurations for the different IO controllers and load them into the CPUs one after the other.

Due to the distributed configuration with separate projects, STEP 7 does not output consistency errors in the case of incorrect access parameter assignment. Example for incorrect access parameter assignment:

- Multiple IO controllers have access to the same module
- IP address parameters or send clocks are not identical

These errors do not show up until operation and are output as configuration errors, for example.

NOTE

After a configuration has been loaded in the IO controller, non-assigned modules or submodules retain their current parameterization state to ensure the independence from the parameterizations of other IO controllers.

See also

Module-internal shared input/shared output (MSI/MSO) (Page 181)

7.3.6 Shared I-device and assigned IO controllers in the common project

Requirements

- The I-device as shared device (shared I-device) and the IO controllers accessing it must be in the same subnet.
- The shared I-device must be assigned to each IO controller.

If these conditions are not met, the configuration as a shared I-device is inconsistent. When an inconsistent configuration is compiled in STEP 7, a corresponding error message is displayed.

Restrictions

- In STEP 7 V19, a maximum of two IO controllers (CPUs) may access a shared I-device within a project. As of STEP 7 V20, this restriction no longer applies.
- Devices of the SIMOTION product family do not support the shared I-device function.
- The shared I-device does not support system redundancy.
- "TIA Portal Openness" does not support shared I-device.
- The simultaneous loading of CPUs and shared I-device into a new project is not supported. Load each station individually into the new project. As of STEP 7 V20, this restriction no longer applies.

Access to modules and submodules

Each IO controller only has access to the modules and submodules of its IO devices that are assigned to it. This means:

- Data is exchanged only with the assigned modules or submodules
- Alarms and diagnostics are only received from assigned modules or submodules
- Only parameters of assigned modules or submodules are configured

Rules for the configuration

The following rules apply to the configuration of a shared I-device in a common project and are automatically checked by STEP 7 when the configuration is compiled:

- A maximum of two IO controllers share one shared I-device. As of STEP 7 V20, this restriction no longer applies.
- There must be at least one transfer area assigned to each connected IO controller.
- Only one IO controller at a time may have full access to one submodule.
- The send clock must be identical for all IO controllers that have access to the shared I-device.
- Isochronous mode (IRT) is only possible with the IO controller to which the interface module of the shared I-device is assigned.
- STEP 7 V20 does not support the "Use name as extension for device name" option for shared devices.
- If you change the name of the shared I-device, then you must subsequently load all the CPUs that share this shared I-device.

7.3.7 Configuring a shared I-device in the common project

Below, you will find a description of how to configure an S7-1500 CPU as a shared I-device with STEP 7 version V19 or higher.

If your project contains a shared I-device that is accessed by IO controllers outside the project, read section "Configuring a shared I-device in different projects (Page 173)". These IO controllers are configured either in another TIA Portal project or with a different engineering tool.

A "distributed" configuration with different engineering tools for different IO controller families is generally possible. However, the description of the procedure is based exclusively on STEP 7 from V19.

Since STEP 7 V19, only one project is needed for a configuration with a shared I-device. The project contains the shared I-device and a maximum of two IO controllers that access it. As of STEP 7 V20, you can configure a shared I-device and all IO controllers accessing it in a single project.

The following description is limited to two IO controllers of the S7-1500 family that share a shared I-device in a common project.

Requirements

- STEP 7 (TIA Portal) V19 or higher
- The IO controllers that access the shared I-device support the shared device function, e.g. CPU 1513-1 PN FW version V3.1 or higher.
- The IO controller that is used as a shared I-device supports the shared device function, e.g. CPU 1513-1 PN FW version V3.1 or higher.

Procedure - Creating project

To create a common project with two IO controllers and a shared I-device, follow these steps:

1. Start STEP 7.
2. Create a new project, for example with the name "Shared I-device".
3. In the network view, insert an IO controller (e.g. CPU 1513-1 PN) from the hardware catalog.
4. Assign a name, for example "PLC_1".
5. Insert another IO controller (e.g. CPU 1513-1 PN) from the hardware catalog.
6. Assign a name, for example "PLC_2".
7. Connect the PROFINET interface X1 of the inserted IO controllers to each other. The PROFINET interfaces of the IO controllers are then in the same subnet.
8. Insert another IO controller (e.g. CPU 1513-1 PN) from the hardware catalog.
9. Assign a name, for example "PLC_I-Device".

Procedure - Configuring I-device functionality

To configure I-device functionality for the PROFINET interface X1 of the IO controller "PLC_I-Device", follow these steps:

1. Select the PROFINET interface X1 of PLC_I-Device.
2. In the Inspector window, navigate to "Properties > General > Operating mode".
3. Enable the "IO device" option. The table below is editable.
4. Click on the entry "Assign to new IO controller" in the table.
5. Select the PROFINET interface of an IO controller from the drop-down list, for example, "PLC_1.PROFINET interface_1."
   The next free device number in the higher-level IO system will be assigned by default as the device number.
6. Repeat steps 4 and 5 for a further IO controller.
7. If required, activate the "Parameter assignment of PN interface by higher-level IO controller" option.
   The drop-down list below is activated. In this case, select a higher-level IO controller from the drop-down list, for example, PLC_1.

8. If necessary, enable additional options. The "Activate DCP write protection" option is enabled by default for all IO devices that support this function. If an I-device can additionally synchronize the default values from the IO controller, the "Synchronize DCP settings with default values from IO controller" option is shown and enabled by default.

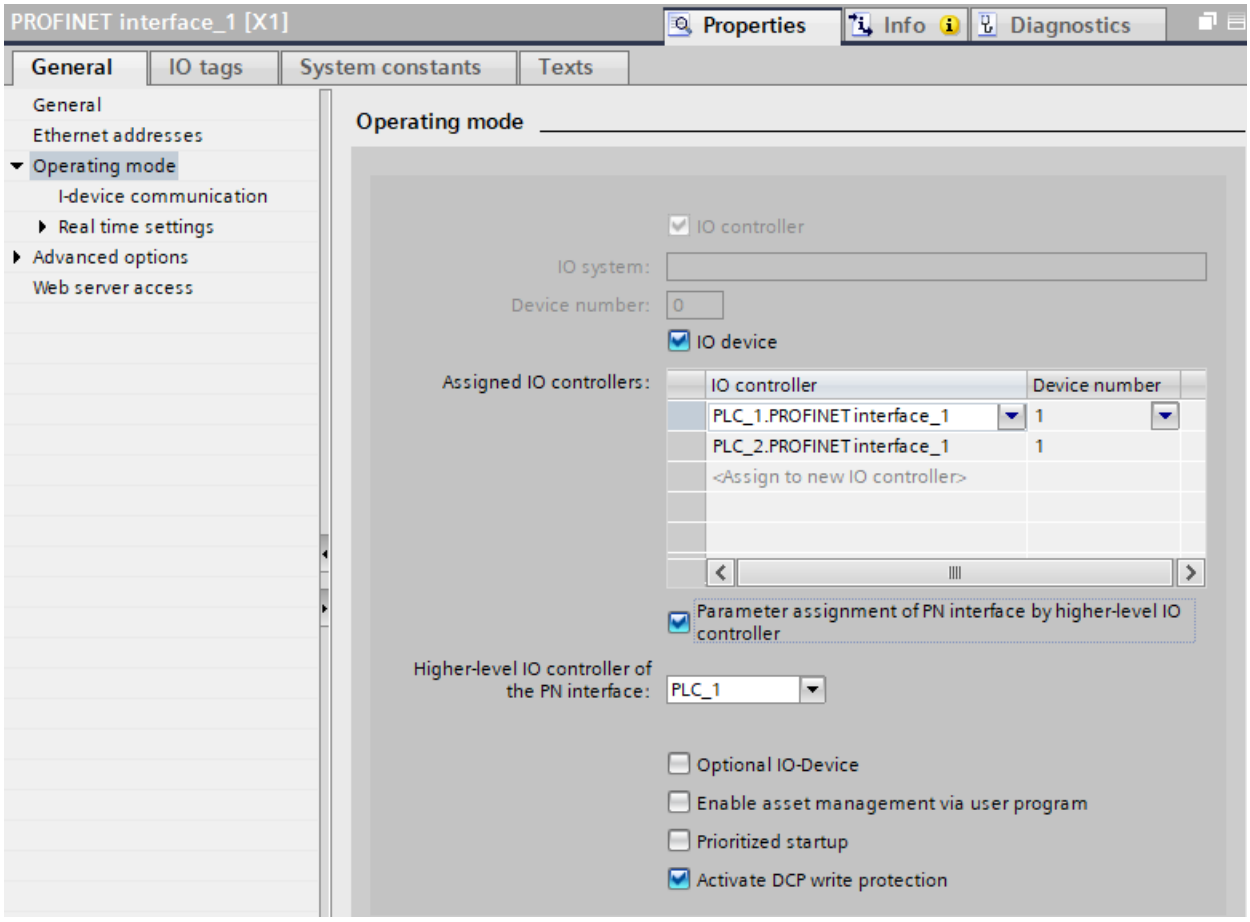

Figure 3-643 Configuring operating mode of I-device

Result: You have configured an S7-1500 CPU as an I-device and assigned it to two IO controllers.

Procedure - Creating and configuring transfer areas

Transfer areas that are assigned to IO controllers are defined as the I/O interface. At least one transfer area must be assigned to each IO controller accessing the shared I-device.
To configure a transfer area, follow these steps:

1. Select the PROFINET interface X1 of the IO controller PLC_I-device.
2. In the Inspector window, navigate to "Properties > General > Operating mode > I-device communication".
3. Double-click the table entry "Add new". A new transfer area is created.
4. Repeat steps 1 through 3 to create further transfer areas.

Intermediate result: You have created the required transfer areas. You can view the transfer areas with their basic settings in the Inspector window in the I-device communication area. To configure a transfer area, e.g. change an input area to an output area, follow these steps:

1. Select the desired transfer area, for example, Transfer area_1, in the Inspector window under "Properties > General > Operating mode > I-device communication".
   The selected transfer area is displayed in the Inspector window.
2. Select the desired type from the drop-down list "Address type" under "Partner" or "Local."
   The address type at the partner will be automatically adjusted in the event of changes.

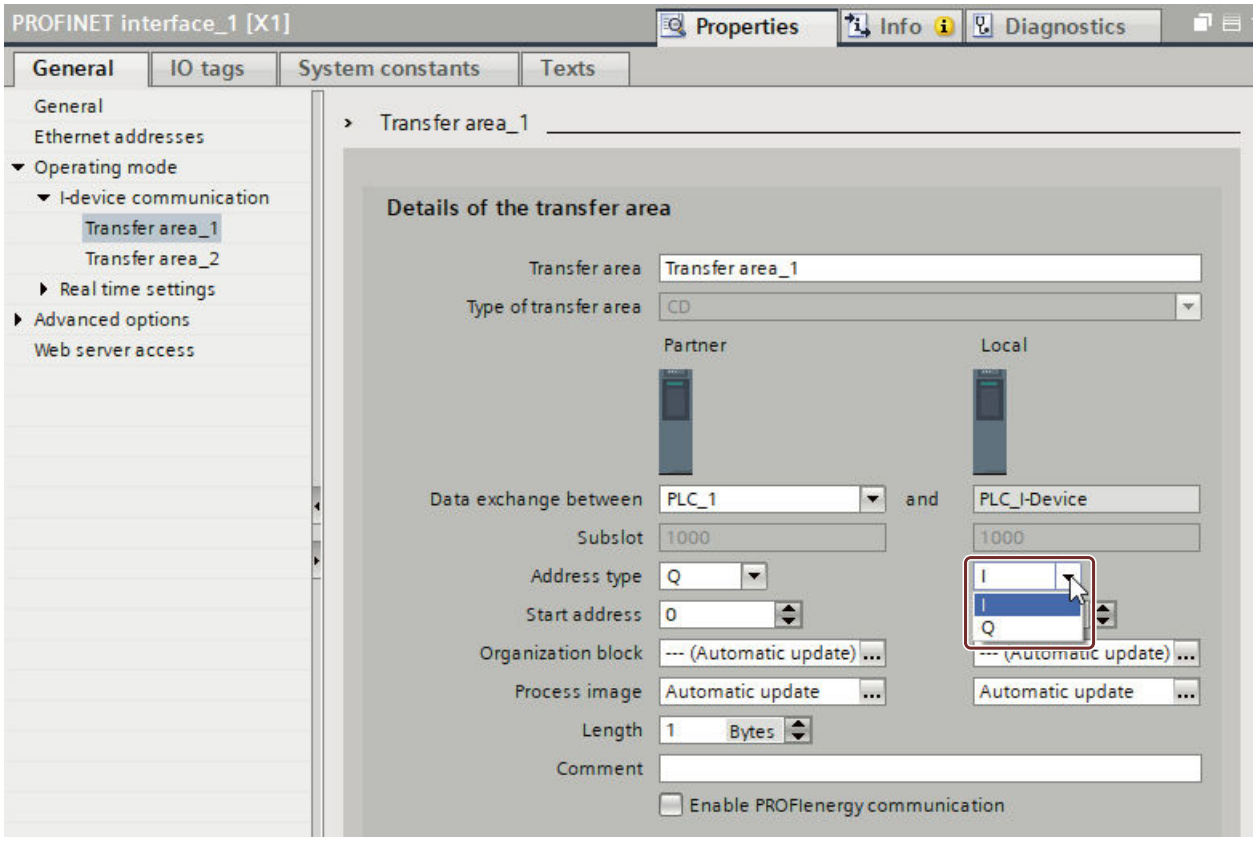

Figure 3-644 Configuring a transfer area of an I-device

Result: You have created and configured transfer areas of the I-device.

Procedure - Adapting the send clock in the real-time settings

You must set the same send clock for each IO controller that has access to modules or submodules of the shared I-device. This ensures that update times are calculated correctly with respect to the communication load.

To adjust and check these settings, proceed as follows:

1. At an assigned IO controller, select the PROFINET interface that is connected to the shared I-device.
2. In the Inspector window, navigate to the "General > Advanced options > Real-time settings > IO communication" area.
3. In the drop-down list, select a common send clock.
4. Repeat steps 1 to 3 for the other assigned IO controller.

In the common STEP 7 project, all the IO controllers that have access to the shared I-device are configured. In this case, it is possible to also set shorter send clocks on the IO controllers than supported by the shared I-device (send clock adaptation).

Compiling and loading

When you select an IO controller and click on "Compile" in the toolbar, the configuration of this IO controller and the shared I-device is checked for data consistency.
Alternatively, mark both IO controllers that access the shared I-device. When you click on "Compile" in the toolbar, the full configuration (both IO controllers and the shared I-device) is checked for data consistency.

You must compile the configurations for the different IO controllers and shared I-device and load them into the CPUs one after the other.

7.3.8 Configuring a shared I-device in different projects

Below, you can find a description of how you configure an S7-1500 as an I-device with STEP 7 Version 13 or higher and then use it in 2 projects as a shared device.

A "distributed" configuration with different engineering tools for different IO controller families is generally also possible here. The procedure described below is based on STEP 7 V13 and is limited to a configuration with 2 IO controllers of the S7-1500 family that share the transfer areas of an I-device as a shared device. The I-device itself is also an S7-1500 CPU.

Create 3 projects with one IO controller each (PLC-I-Device, PLC_1 and PLC_2).

The "PLC-I-Device" project is used to configure the I-device. The PROFINET GSD variant of "PLC-I-Device" is used in the "PLC_1" and "PLC_2" projects in order to assign the transfer areas in the respective higher-level IO controller.

Shared I-device concept

To introduce the shared I-device concept, 2 roles are introduced here:

- The role of manufacturer (e.g., machine manufacturer): The manufacturer configures and programs an I-device that performs a particular automation task. Transfer areas are defined as the I/O interface to the operator of the machine. These transfer areas can be assigned to different IO controllers. For the connection to higher-level IO controllers, the manufacturer provides a PROFINET GSD file and discloses the transfer areas via which the I-device can be accessed.
- The role of the operator: The operator uses the I-device as a PROFINET GSD variant during configuration of the PROFINET IO system and, in this process, specifies the I/O addresses under which the IO controllers access the transfer areas.

Manufacturer view

You assign the following parameters for an S7-1500 CPU as an I-device, with centralized and distributed I/O, the desired transfer areas, and the number of IO controllers having access to this I-device (always greater than 1 for a shared device!).

Special consideration: The I-device is configured without a higher-level IO controller. As a result, only the local I/O addresses of the transfer area are available (= "Address in the I-device") in order to create the user program for editing the addresses from the transfer area. The I-device that has been completely configured except for the connection to the higher-level IO controller is loaded to the S7-1500 CPU.

You export a PROFINET GSD file from the I-device configuration.

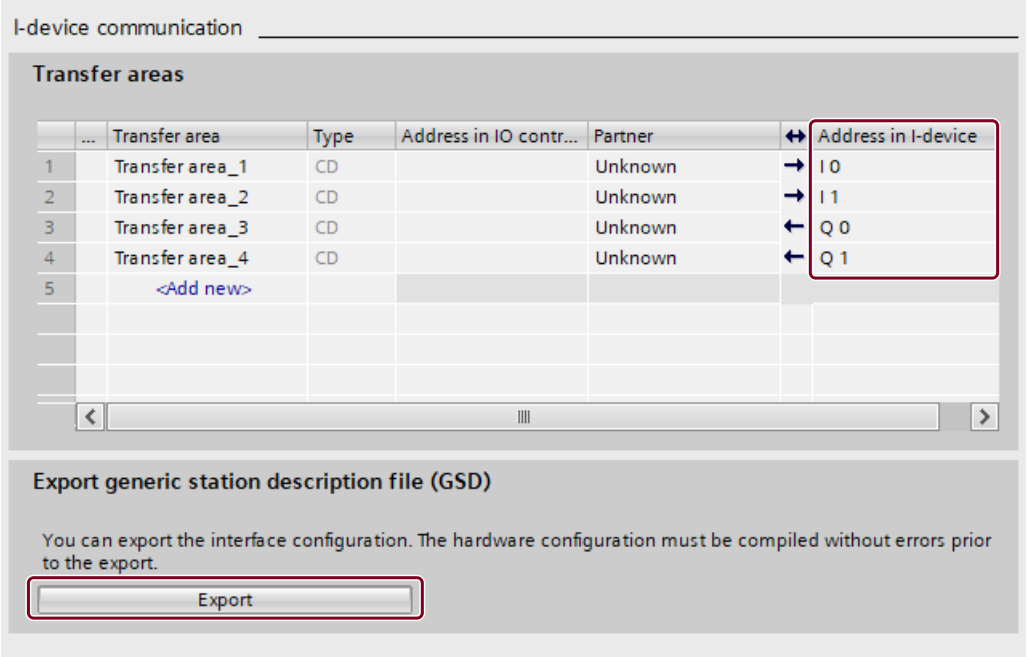

Figure 3-645 Exporting an I-device as a GSD file

Operator view

You must install the PROFINET GSD file created from the I-device configuration in all engineering systems that are involved in configuring a PROFINET IO system with this shared I-device. If all uses of this I-device will be configured with STEP 7 V13, it is sufficient to install the GSD file in STEP 7.

You configure the I-device as a GSD variant on the PROFINET IO system in the projects involved. In STEP 7 V13, this I-device can be found under "Other field devices > PROFINET IO > PLCs & CPs" following installation.

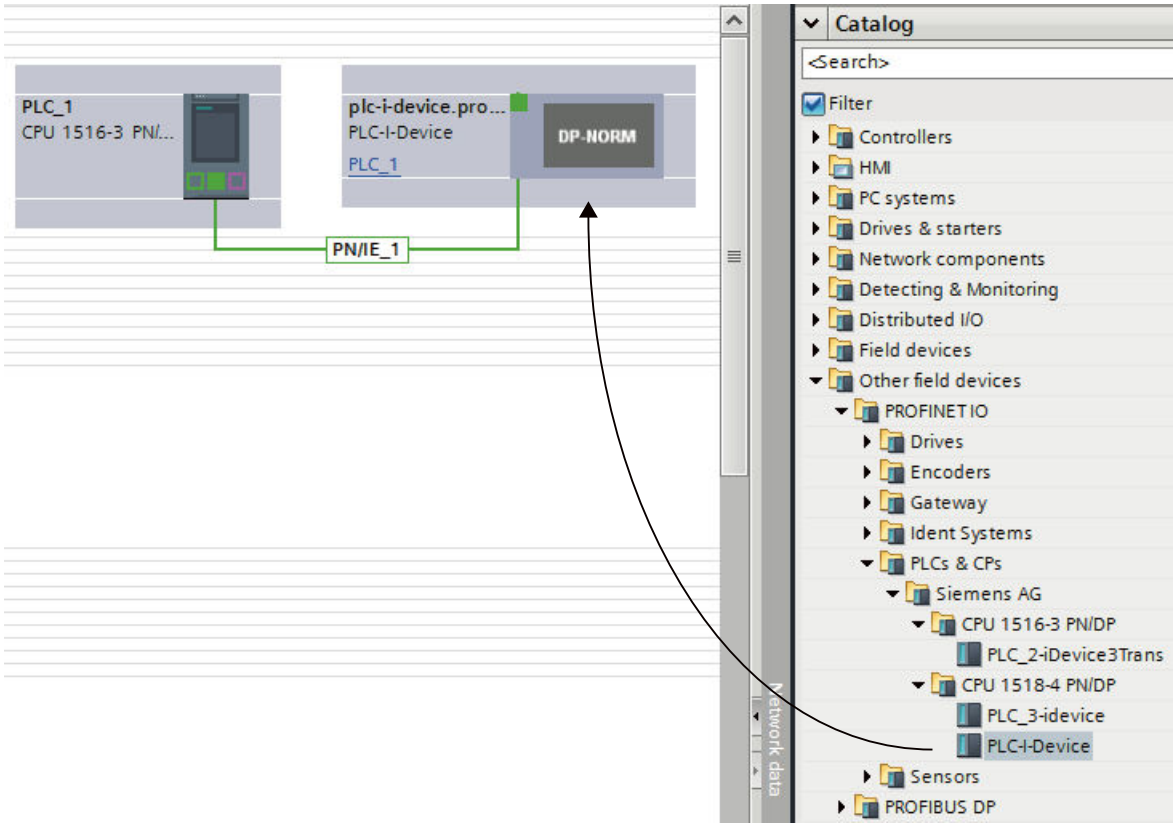

Figure 3-646 Configuring an I-device as a GSD file

In each of the projects involved, you define which transfer areas are assigned exclusively to the higher-level IO controller (default setting: all). Set the remaining transfer areas to "Outside of project". As a result of this setting, the local IO controller has no access to this transfer area and it can therefore be assigned to another IO controller in another project.

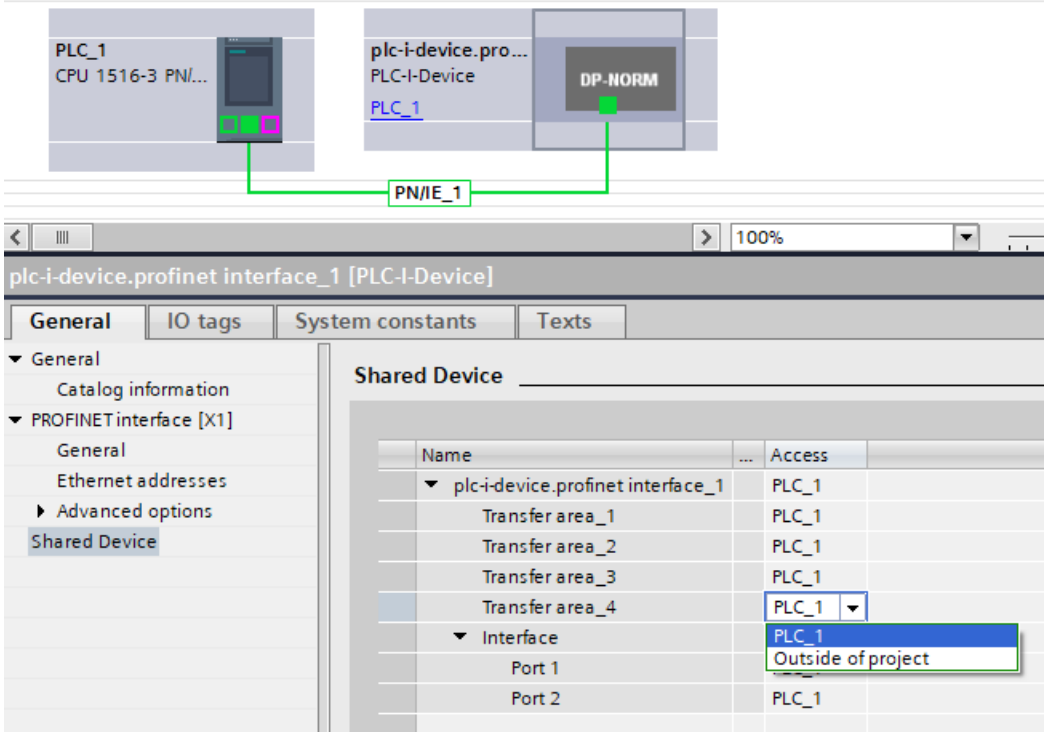

Figure 3-647 Setting the access to the shared I-device

You adapt the addresses from the view of the IO controller in the device overview. To open the device overview, double-click the I-device.

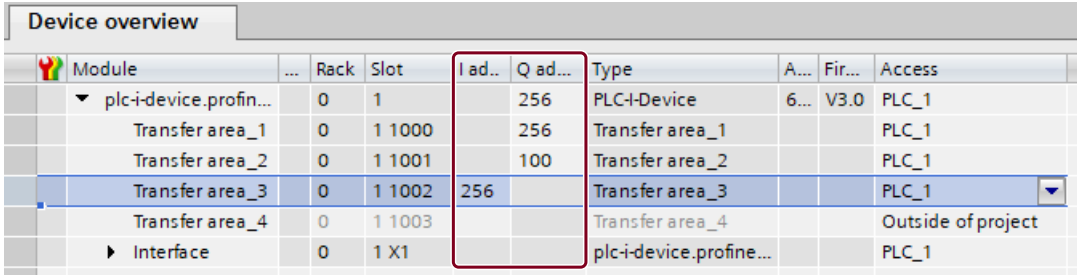

Figure 3-648 I/O addresses of the transfer areas in the device overview

Requirements

- STEP 7 as of V13

Procedure - Creating the PLC-I-device project

To create the project with a shared I-device, follow these steps:

1. Start STEP 7.
2. Create a new project with the name "PLC-I-device".
3. Insert, for example, a CPU 1518-4 PN/DP from the hardware catalog in the network view.
4. Assign a name, for example "PLC-I-Device".
5. Double-click the IO device and configure all required modules and submodules.
6. Assign the module parameters.

   In particular, the following settings for the CPU are necessary in the area of the PROFINET interface [X1]:

   – Activate the "IO device" option in the "Operating mode" area.
   – Activate the "Parameter assignment of PN interface by higher-level IO controller" option in the "Operating mode" area.
   – Configure the transfer areas in the "Operating mode > I-device communication" area. The "Address in IO controller" column remains empty because no IO controller is assigned.

     Note: To change an input area to an output area, and vice versa, you must navigate to the area of the corresponding transfer area.

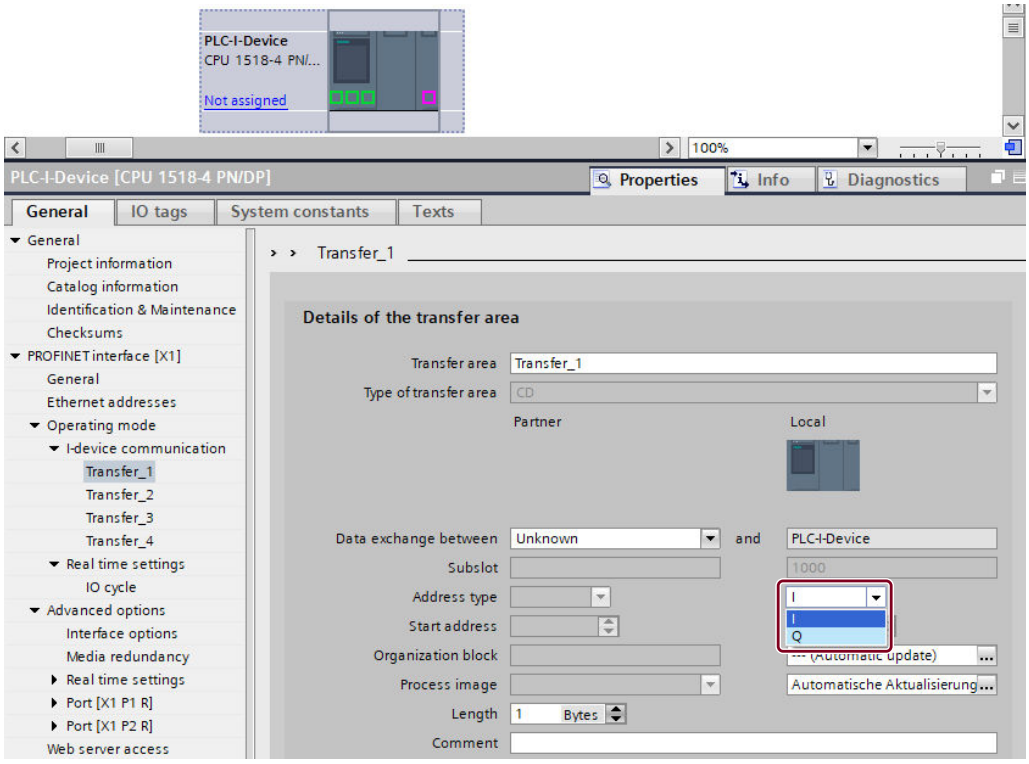

Figure 3-649 Changing the address type for the transfer area

   – Select the number of IO controllers outside the project with access to the I-device. If there is one IO controller outside the project, select "1" ("Operating mode > Real time settings", section "Shared device").

7. Click the "Compile" button in the toolbar to check your project for consistency errors. Inconsistent projects are not exported as GSD file by STEP 7.
8. Save the project.
9. Click the "Export" button ("Operating mode > I-device communication" area, "Export generic station description file (GSD) section").

   If you do not change the name in the Export dialog, the GSD file has a name in the form "GSDML-V2.31-#Siemens-PreConf_PLC-I-Device-20130925-123456", for example.

Procedure - Creating the PLC_1 project

To create the first project with a shared I-device, follow these steps:

1. Start STEP 7.
2. Install the PROFINET GSD file from the export of the I-device CPU (PLC-I-Device).
3. Create a new project with the name "PLC_1".
4. Insert, for example, a CPU 1516-3 PN/DP in the network view.
5. Assign a name, for example "PLC_1".
6. Insert the I-device from the hardware catalog (Hardware catalog: "Other field devices > PROFINET IO > PLCs & CPs").
7. Assign the I-device to the IO-controller "PLC_1".
8. Select the "Shared Device" area in the properties of the I-device.

   In the table, all transfer areas and the PROFINET interface are assigned to the local IO controller (PLC_1).
9. Define the transfer areas to which the "PLC_1" CPU should **not** have access. Select the "Outside of project" entry for these areas. These transfer areas are provided for the "PLC_2" CPU.
10. Save the project.

Procedure - Creating the PLC_2 project

To create the second project with a shared I-device, follow these steps:

1. Start STEP 7 once again.

   A new instance of STEP 7 opens.
2. In the new instance, create a new project with the name "PLC_2".
3. Insert, for example, a CPU 1516-3 PN/DP in the network view.
4. Assign a name, for example "PLC_2".
5. Insert the I-device from the hardware catalog (Hardware catalog: "Other field devices > PROFINET IO > PLCs & CPs").
6. Assign the I-device to the IO-controller "PLC_2".
7. Adapt the access to the transfer areas as in the "PLC_1" project. Ensure that no duplicate assignments result.

8. Adapt the parameters of the subnet and PROFINET interface. Because the shared I-device involves the same device in different projects, these data must match.
9. Save the project.

Both projects now have an identically configured shared I-device. The IO controller access and the parameters of the PROFINET interface must still be checked in the various projects during the next step.

Summary - Assigning parameters for access to the shared device

The transfer areas are automatically assigned to the local IO controller. To change the assignment, follow these steps:

1. Click the "PLC-I-Device" device in the network view of the "PLC_1" project, and select the "Shared Device" area.
2. A table shows which CPU has access to each of the configured transfer areas. The default setting is that the local CPU has access to all modules and submodules.
3. Keep the "PLC_1" setting for all transfer areas that are to remain in the address area of the local CPU

   Select the "Outside of project" setting for all transfer areas that are to be located in the address area of the "PLC_2" CPU from the "PLC_2" project. This means that an IO controller outside the project is to have access to the transfer area.
4. Follow the same procedure for the remaining projects.
5. Finally, check whether the settings for access are "complementary" for each module or submodule in both projects. This means that if the local CPU has access in one project, the "Outside of project" option must be set in the other project and vice versa.

   Special consideration: The "Outside of project" option for the PROFINET interface and therefore for the ports makes the associated parameters read-only and they cannot be changed. Parameters of the PROFINET interface and port parameters can only be edited in the project in which the PROFINET interface is assigned to the local CPU. The ports can be interconnected in both projects regardless of this.
6. Check whether the same IP address parameters and device name are set for the shared device in all projects.

   Check whether the same S7 subnet ID is set in all projects for the subnet to which the shared device is connected (subnet properties, "General" area in the Inspector window).

NOTE

If you make changes to the I-device (e.g., change the number or length of the transfer areas):

Export the I-device as a GSD file again. Re-install the GSD file in each project that uses the I-device as a shared device. Make sure that only one IO controller has access to a transfer area.

Procedure - Adapting the send clock in the real-time settings

You must set the same send clock for each IO controller that has access to modules or submodules of the shared I-device. This ensures that update times are calculated correctly with respect to the communication load.

To adjust and check these settings, use one of the following options:

- If you configure the IO controller with STEP 7 (TIA Portal):
  - Open the corresponding project.
  - At the IO controller, select the PROFINET interface that is connected to the shared I-device.
  - In the Inspector window, navigate to the "General > Advanced options > Real-time settings > IO communication" area.
  - In the drop-down list, select a common send clock.
- If you configure the IO controller with a different engineering tool:
  - Select the PROFINET interface of the shared device in STEP 7 (TIA Portal).
  - In the Inspector window, go to "General > Advanced options > Real-time settings >IO communication".
  - Read the send clock of the shared device.
  - Enter the read send clock in the other engineering tool.

Special consideration: If you configure **all** IO controllers that have access to the shared I-device in STEP 7 (TIA Portal or V5.5), you can set shorter send clocks on the IO controller than supported by the shared device (send clock adaptation).

Compiling and loading

You must compile the configurations for the different IO controllers and load them to the CPUs one after the other.

Due to the distributed configuration with separate projects, STEP 7 does not output consistency errors in the case of incorrect access parameter assignment. Example for incorrect access parameter assignment:

- Several IO controllers have access to the same module
- IP address parameters or send clocks are not identical

These errors do not show up until operation and are output as configuration errors, for example.

NOTE

After a configuration has been loaded in the IO controller, non-assigned modules or submodules in the IO device retain their current parameter assignment state. This ensures the independence to configurations of other IO controllers.

7.3.9 Module-internal shared input/shared output (MSI/MSO)

Introduction

This section describes the module-internal shared input/shared output (MSI/MSO) functionality for I/O modules that are operated on PROFINET.

Module-internal shared input/shared output functionality

The module-internal shared input (MSI) function allows an input module to make its input data available to up to 4 IO controllers. Each controller has read access to the same channels.

The following figure shows the MSI functionality.

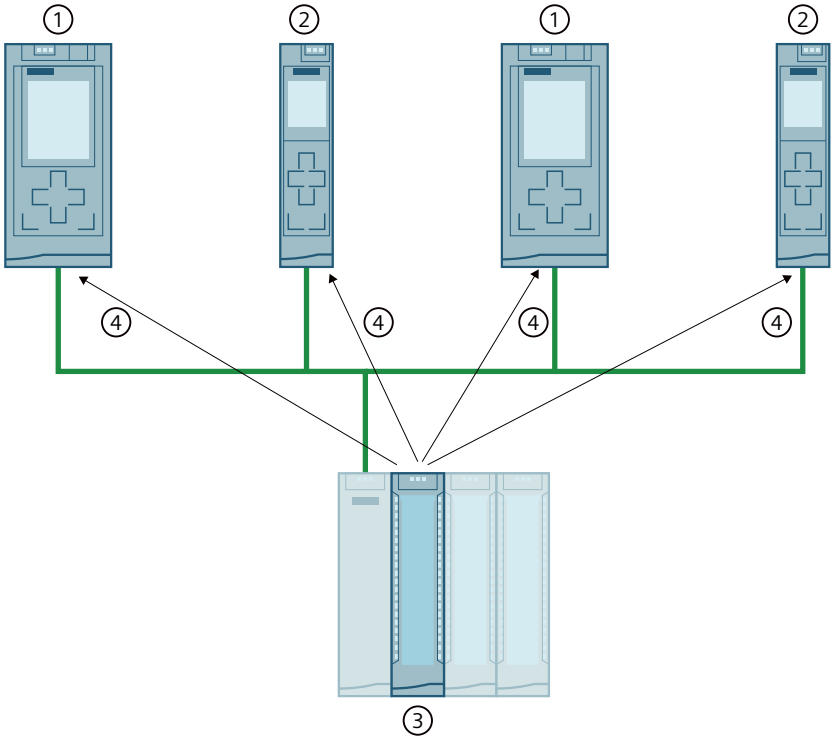

① CPU 1516-3 PN/DP as IO controller

② CPU 1511-1 PN as IO controller

③ Input module with MSI

④ Read access to the input channels of the input module

⑤ Write access to the channels of the I/O module (only with MSO)

Figure 3-650 Example configuration with MSI

The module-internal shared output (MSO) function allows an output module to make its output data available to up to 4 IO controllers. An IO controller has write access to the channels of the output module. Up to 3 IO controllers can additionally have read-access to the channels.

The following figure shows the MSO functionality.

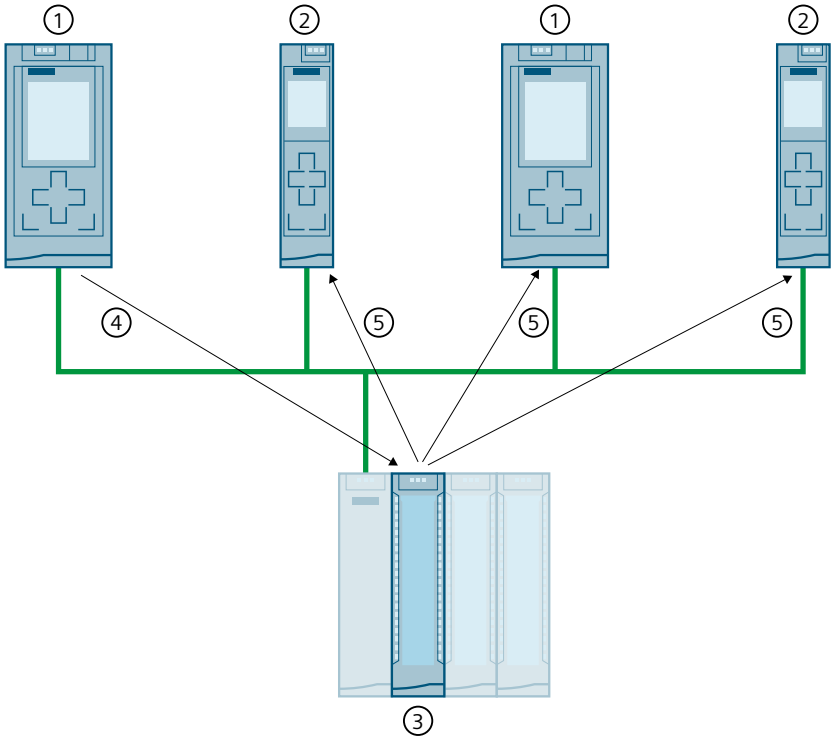

① CPU 1516-3 PN/DP as IO controller
② CPU 1511-1 PN as IO controller
③ Output module with MSO
④ Write access to the output channels of the output module
⑤ Read access to the output channels of the output module

Figure 3-651 Example configuration with MSO

Advantages of MSI/MSO

Module-internal shared input/shared output (MSI/MSO) offers the following advantages:

- Real-time acquisition in multiple CPUs
- Lower costs due to saving on additional IO devices and modules
- Lower space requirements due to saving on additional IO devices and modules
- Reduced communication load because no CPU-CPU communication is needed
- No additional programming effort is needed for CPU-CPU communication

Requirements for the use of MSI/MSO

Observe the following requirements:

- MSI/MSO can only be used with PROFINET IO
- Configuration software: STEP 7 (TIA Portal) as of V12 SP1 with GSD file; the modules are integrated in the hardware catalog as of V13.
- The IM 155-5 PN ST interface module and the modules support MSI/MSO as of firmware version V2.0.0.

Constraints for using of MSI/MSO

Note the following constraints:

- The use of MSI/MSO is not possible in the case of module grouping.
- Modules with MSI/MSO cannot be operated in isochronous mode.
- The maximum number of IO controllers is dependent on the interface module. You can find out how many IO controllers the interface module supports in the equipment manual for the respective interface module.

MSI submodules

The input values of all channels are copied to a basic submodule and up to 3 other MSI submodules during MSI configuration of an input module. The channels of the module are then available with identical input values in the basic submodule and the MSI submodules. The MSI submodules can be assigned to up to 3 IO controllers when the module is used in a shared device. Each IO controller has read access to the same channels.

The following figure shows a digital input module with the basic submodule and 3 MSI submodules. Each submodule is assigned to an IO controller. Diagnostics and parameter assignment of the digital input module can be performed from the IO controller 1 via the basic submodule.

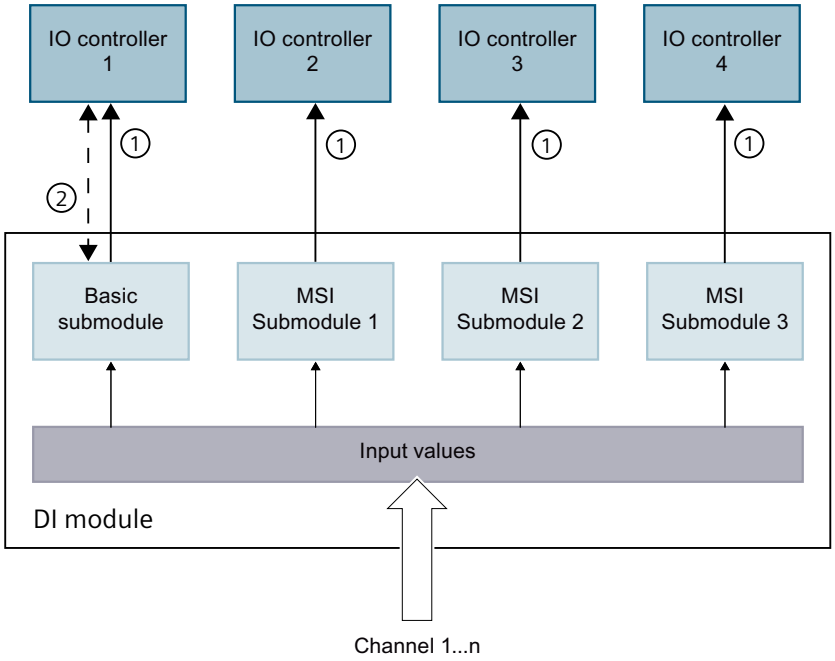

① Read access

② Parameter assignment and system diagnostics

Figure 3-652 DI module with MSI submodules

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule to which it pertains.

With basic submodule (= 1st submodule), the "0" value status indicates that the value is incorrect.

With an MSI submodule (2nd to 4th submodule), the "0" value status indicates that the value is incorrect or the basic submodule has not yet been configured (not ready).

MSO submodules

During MSO configuration of an output module, the output values of all channels of the module are copied from a basic submodule to up to 3 other MSO submodules. The channels of the module are then available with identical values in the basic submodule and the MSO submodules. The MSO submodules can be assigned to up to 3 IO controllers when the module is used in a shared device:

- The IO controller to which the basic submodule is assigned has write access to the outputs of the module. The basic submodule therefore occupies output addresses in the process image of the IO controller.
- The IO controllers to which the MSO submodules are assigned have read access to the outputs of the module. MSO submodules therefore occupy input addresses in the process image of the IO controller.

The following image shows a digital output module with the basic submodule and 3 MSI submodules. Each submodule is assigned to an IO controller. Diagnostics and parameter assignment of the digital output module can be performed from IO controller 1 via the basic submodule.

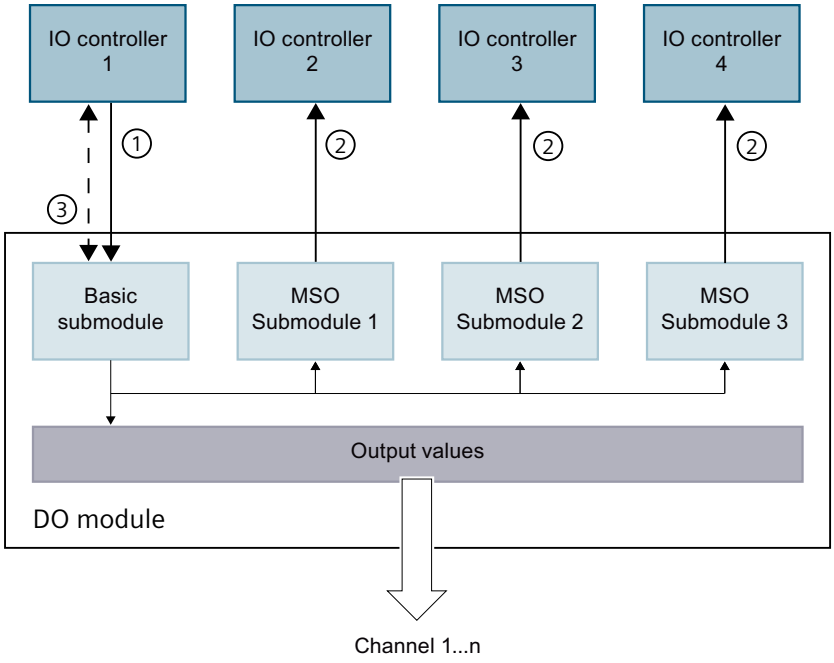

① Write access

② Read access

③ Parameter assignment and system diagnostics

Figure 3-653 DQ module with MSO submodule

Value status (Quality Information, QI)

The meaning of the value status depends on the submodule to which it pertains.

With basic submodule (= 1st submodule), the "0" value status indicates that the value is incorrect.

With MSO submodule (= 2nd to 4th submodule) the "0" value status indicates that the value is incorrect or one of the following errors has occurred:

- The basic submodule parameters have not yet been assigned (not ready for operation).
- The connection between the IO controller and the basic submodule has been interrupted.
- The IO controller from the basic submodule is in the "STOP" or "POWER OFF" state.

Configuring I/O modules with MSI/MSO submodules

Requirements

- STEP 7 as of V13
- IO device supports MSI/MSO (for example IM 155-5 PN ST as of firmware version 2.0.0)

Procedure

1. In the network view of STEP 7, insert an interface module, for example IM 155-5 PN ST as of V2.0.
2. Double-click the IO device.

   You are now in the device view.
3. Place the I/O modules from the hardware catalog in a suitable slot.
4. Add MSI/MSO submodules to the I/O modules:
   - Input modules: Select the number of MSI submodules under "Module parameters > DI Configuration" or "AI Configuration" in the area "Copy of module for Shared Device (MSI)".
   - Output modules: Select the number of MSO submodules under "Module parameters > DO configuration" or "AW configuration" in the area "Copy of module for shared device (MSO)".

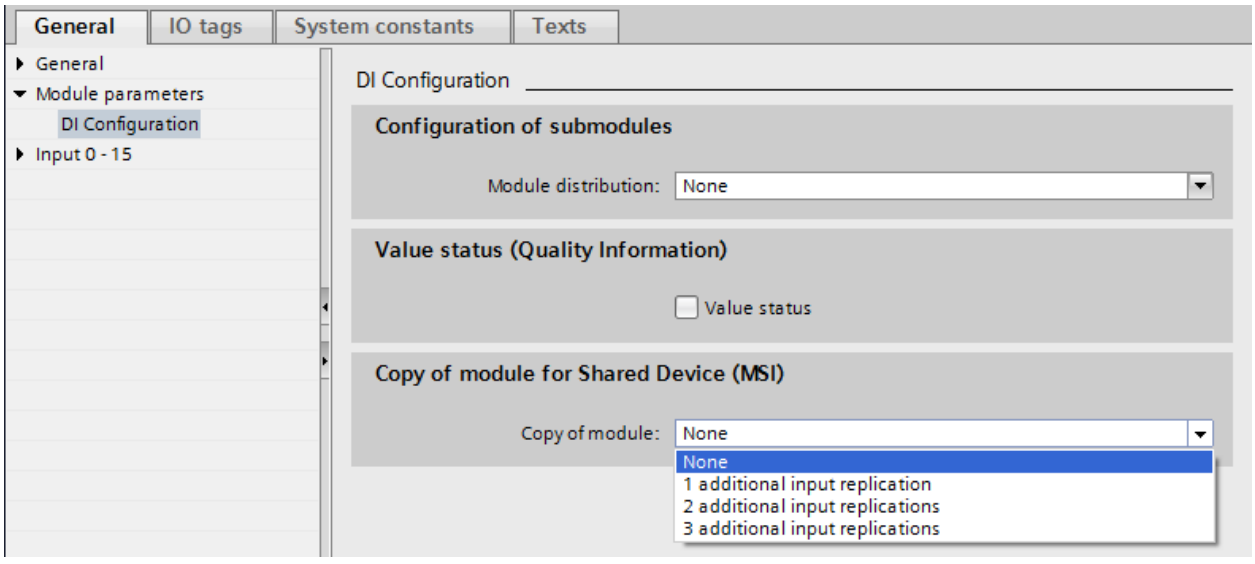

Figure 3-654 Configuring I/O modules with MSI/MSO

Assigning MSI/MSO submodules to an IO controller

You can assign the submodules in a shared device to an IO controller.

You can find additional information under "Configuring a shared device for different projects (Page 164)".

Configuring access to a shared device and the module-internal shared input / shared output (MSI /MSO) function

You can learn how to access a shared device and the MSI /MSO function in STEP 7 with this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109736536).

7.4 Media redundancy (ring topologies)

In order to increase the network availability of an Industrial Ethernet network with optical or electrical linear bus topologies, you can convert a linear bus topology to a ring topology by joining the ends together.

Media redundancy in ring topologies

Devices in a ring topology can be IO devices, IO controllers, external switches and/or the integrated switches of communication modules.

To set up a ring topology with media redundancy, you need to bring together the two free ends of a linear bus topology in one device. Closing the linear bus topology to form a ring is achieved with two ports (ring ports) of a device in the ring. One device of the resulting ring then takes over the role of the redundancy manager. All other devices in the ring are redundancy clients.

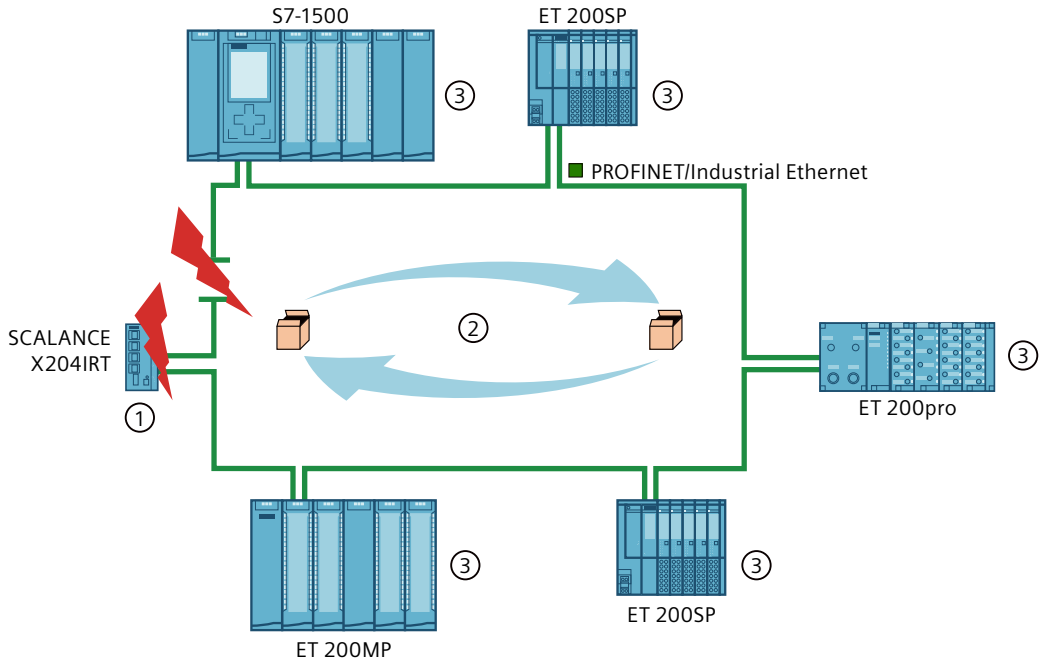

① Redundancy manager

② Test frames

③ Redundancy clients

Figure 3-655 Media redundancy in ring topology

The ring ports of a device are the ports that establish the connection to the two neighboring devices in the ring topology. The ring ports are selected and set in the configuration of the relevant device (is also preset, if applicable).

How media redundancy works in a ring topology

The data paths between the individual devices are automatically reconfigured if the ring is interrupted at any point. The devices are available again after reconfiguration.

In the redundancy manager, one of the two ring ports is blocked in uninterrupted network operation for normal communication so that no data frames are circulated. In terms of data transmission, the ring topology is a linear bus topology. The redundancy manager monitors the ring for interruptions. For this purpose, it sends test frames not only from ring port 1 but also from ring port 2. The test frames pass through the ring in both directions until they arrive at the other ring port of the redundancy manager.

An interruption of the ring can be caused by loss of the connection between two devices or by failure of a device in the ring.

If the test frames of the redundancy manager no longer arrive at the other ring port during an interruption of the ring, the redundancy manager connects its two ring ports. This substitute path once again restores a functioning connection between all remaining devices in the form of a linear bus topology.

The time between the ring interruption and restoration of a functional linear topology is known as the reconfiguration time.

As soon as the interruption has been eliminated, one of the two ring ports is blocked again in the redundancy manager. The redundancy clients are informed about the change and use the original paths to the other devices again.

Media redundancy method

The standard method of media redundancy in SIMATIC is MRP (Media Redundancy Protocol) with a typical reconfiguration time of 200 ms. Up to 50 devices can participate per ring.

In addition, the real-time capable media redundancy process MRPD (Media Redundancy with Planned Duplication of frames) is also available.

7.4.1 Media Redundancy Protocol (MRP)

Media Redundancy Protocol (MRP)

The "MRP" process works in conformity with the Media Redundancy Protocol (MRP) that is specified in the standard IEC 62439-2.

Requirements

- All devices in the ring support MRP.
- You have complied with the rules for topology set out below. STEP 7 monitors compliance with the rules during compilation and outputs corresponding alarms.

Topology

The following schematic shows a possible topology for devices in a ring with MRP. The devices inside the shaded oval are in the redundancy domain.

Example of a ring topology with the MRP media redundancy protocol:

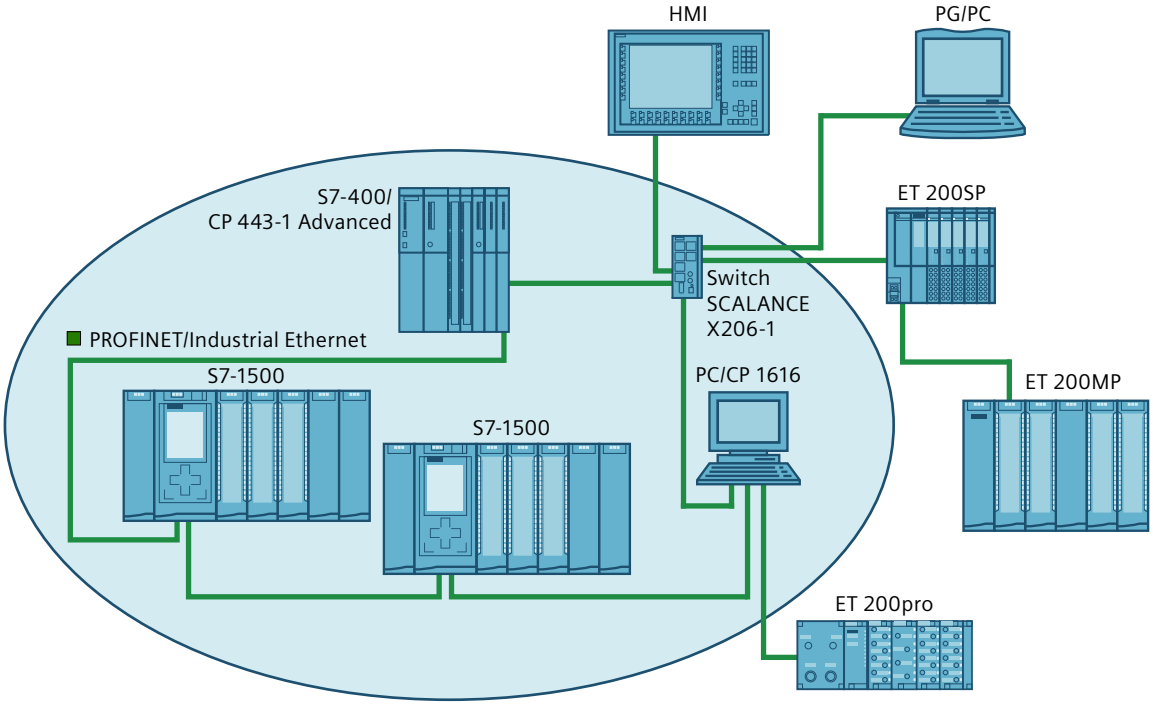

Figure 3-656 Example of a ring topology with the MRP media redundancy protocol:

The following rules apply to a ring topology with media redundancy using MRP:

- All devices must be connected to one other via their ring ports.
- All devices in the ring belong to the same redundancy domain.
- A device in the ring takes on the task of a redundancy manager.
  - One device only has the role of "Manager". No other device may have the role of "Manager". Or
  - One device or multiple devices in the ring have the role of "Manager (auto)". The devices with the role of "Manager (auto)" then negotiate between themselves which device is to take on the role of redundancy manager. In this case, no device is permitted to have the role of "Manager".
- All other devices in the ring are redundancy clients.
- You can connect up to 50 devices in a ring.

Non MRP-compliant devices can, for example, be connected to the ring via a SCALANCE X switch or via a PC with a CP 1616.

Rules for loading the devices of an MRP domain

When loading devices of an MRP domain, frame loops can occur and result in network failure if there is an invalid MRP configuration.

Example: You change the MRP roles of several devices and consecutively load the configuration into the devices involved. Configurations can arise that contradict the roles mentioned above, for example, there may be devices that simultaneously have the "Manager" and "Manager (auto)" roles in the ring.

To ensure that an invalid MRP configuration does not result in the failure of the network, open the ring before loading.

Follow these steps:

1. Open the ring.
2. Load the error-free and consistent MRP configuration from your project onto all the devices involved and ensure that the devices are in data exchange mode (i.e. the application relations (ARs) are set up).
3. Close the ring.

Boundary conditions

MRP and RT

RT operation is possible with the use of MRP.

NOTE

The RT communication is disrupted (station failure) if the reconfiguration time of the ring is greater than the selected response monitoring time of the IO device. This is why you should select a response monitoring time of the IO devices that is sufficiently large.

MRP and IRT

IRT mode is not possible together with MRP.

If you want to use media redundancy together with IRT in a ring, only use devices that support MRPD.

MRP and TCP/IP (TSEND, HTTP, ...)

The TCP/IP communication with MRP is possible, because lost data packages are resent, if applicable.

MRP and prioritized startup

If you configure MRP in a ring, you cannot use the "prioritized startup" function in PROFINET applications on the devices involved.

If you want to use the "prioritized startup" function, then you must disable MRP in the configuration (the device may also not be part of the ring).

Information on S7-1500R/H

You can find information on the media redundancy method MRP of the redundant S7-1500R/H system in section Configuring PROFINET IO on a redundant S7-1500R/H system (Page 343).

Application example: Reading the MRP status in the user program

The "LPNDR_ReadMRPState" function block from the "LPNDR" block library helps you to determine the status of the MRP ring per program. The block reads the MRP information from the PROFINET device (MRP Manager) and outputs the status.

The "LPNDR" block library and the corresponding documentation can be found in this application example (https://support.industry.siemens.com/cs/ww/de/view/109753067).

7.4.2 Configuring media redundancy

Configuring MRP

Proceed as follows to create a PROFINET IO configuration with MRP in STEP 7:

1. Generate a ring via the port interconnections in the topology view. First interconnect the devices to a line topology. Connect the unassigned port of the last device in the line with the unassigned port of the first device.
   The following example shows one CPU 1516-3 PN/DP and two interface modules IM 155-6 PN HF that are interconnected in a ring in the topology view of STEP 7.

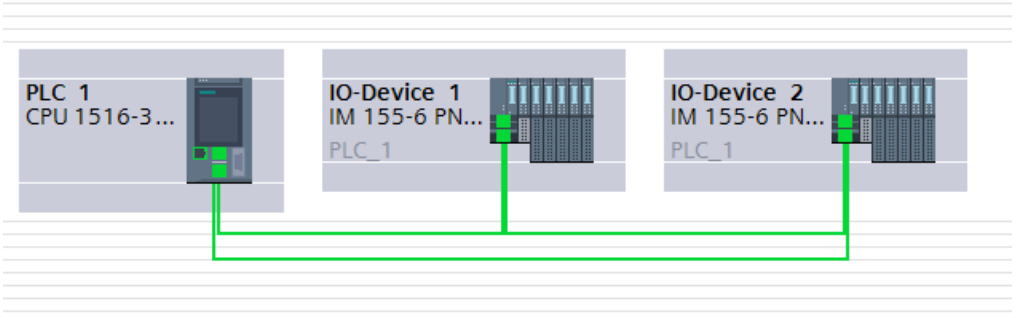

Figure 3-657 Configuring media redundancy

2. Select the PROFINET IO system in the network view.
3. In the Inspector window, navigate to "Properties" > "General" > "PROFINET" > "MRP domains" in the "Ring interconnections" field.
   This field shows you all the topological rings in the IO system with the associated MRP domains.
4. Select the ring generated above in the "Ring interconnections" field.
   The table below it shows all the PROFINET devices in the ring.

5. Set the media redundancy role for the PROFINET devices in the MRP role column.

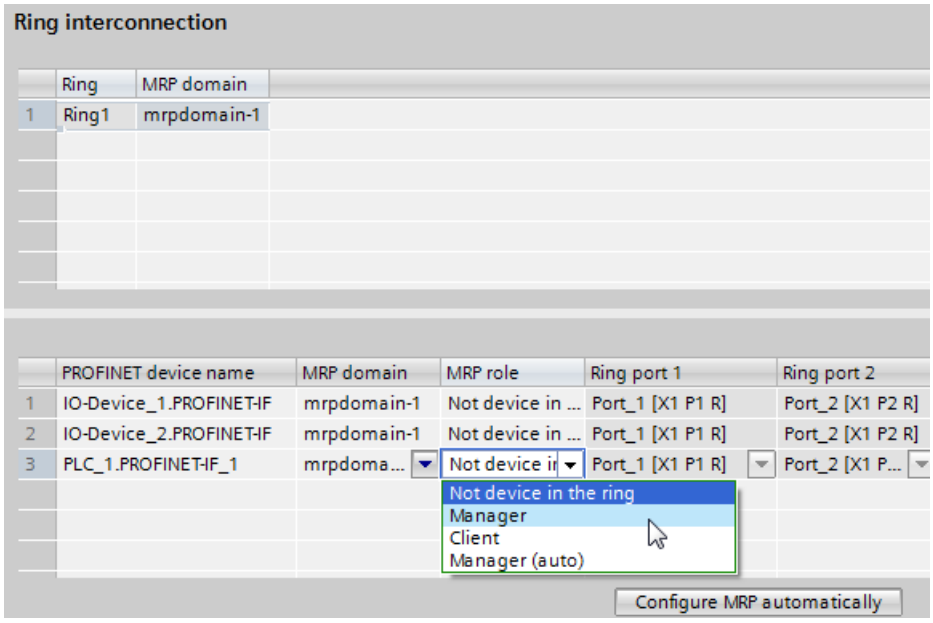

Figure 3-658 MRP domain

Automatic MRP configuration

You can also have the media redundancy roles assigned automatically for your PROFINET devices in the ring.

To have the media redundancy roles assigned automatically, click the "Configure MRP automatically" button. STEP 7 automatically assigns the media redundancy role for each device in the ring. After the automatic MRP configuration, you can make modifications to the media redundancy roles in the "MRP role" column.

"Media redundancy" setting options

Media redundancy role

Depending on the device used, the roles "Manager", "Manager (auto)", "Client" and "Not device in the ring" are available.

Rules:

- A ring must have precisely one device with the role "Manager". No additional devices with the role "Manager" or "Manager (auto)" are permissible. All the other devices may only have the "Client" role.
- If a ring has no device with the "Manager" role, the ring must at least have a device with the role "Manager (auto)". Any number of devices with the "Client" role may exist.
- Managers and clients of an MRP domain can be configured in different projects. In the project without a manager, you need to select the "Redundancy manager outside the project" option so that the configuration can be compiled. For multiple ring configurations, you need to set the option identically for each MRP domain.

Ring port 1 / Ring port 2

Select one at a time those ports you want to configure as ring port 1 or ring port 2. The drop-down list box shows the selection of possible ports for each device type. If the ports are set at the factory, then the fields are unavailable.

If you use single-stage commissioning, use the preset ring ports in STEP 7.

Diagnostic interrupts

If diagnostic interrupts to the MRP state are to be output in the local CPU, select the "Diagnostic interrupts" check box. The following diagnostic interrupts can be configured:

- Wiring or port error

  Diagnostic interrupts will be generated for the following errors in the ring ports:

  – A neighbor of the ring port does not support MRP.

  – A ring port is connected to a non-ring port

  – A ring port is connected to the ring port of another MRP domain.

- Interruption / return (redundancy manager only)

  – In case the ring is interrupted, a diagnostic interrupt "Ring open (incoming)" is generated.

  – When the ring is closed, the diagnostics "Ring open (outgoing)" is generated.

You can respond to these events in the user program by programming the appropriate response in the diagnostic error interrupt OB (OB 82).

Reference

You can find the procedure for configuring a common MRP ring and the topology with two projects in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109741671).

7.4.3 Media redundancy with planned duplication of frames (MRPD; not for S7-1500R/H)

MRP extension "Media Redundancy with Planned Duplication of frames" (MRPD)

The MRP extension "Media Redundancy with Planned Duplication of frames" (MRPD) provides the advantage that, in the case of a failure of a device or a line in the ring, all other devices continue to be supplied with IO data without interruption and with short update times.

MRPD is based on IRT and MRP. To realize media redundancy with short update times, the PROFINET devices participating in the ring send their data in both directions. The devices receive this data at both ring ports so that there is no reconfiguration time.

Requirements for media redundancy with MRPD

- All the devices of the ring must support MRPD, for example interface module IM 155-6 PN HS as of firmware version 4.0.
- You have configured MRP for all the devices of the ring. You have assigned the MRP role "Not device in the ring" to devices that are not located in the ring.
- You have configured IRT for all the involved components.

Configuring MRPD

You do not have to explicitly activate MRPD in STEP 7. The function is available automatically as soon as all the requirements for MRPD are fulfilled.

Redundancy levels of IO devices with MRPD

The redundancy level of an IO device specifies how strongly the real-time communication is influenced in the case of a power interruption between an IO device and its IO controller.

- Full redundancy: No influence, because the IO controller and IO device are located in the same ring.
- Partial redundancy:
  - If the interruption takes place on a non-redundant part (line) between the IO device and IO controller, real-time communication is influenced.
  - If the interruption takes place on a redundant part (ring), real-time communication is not influenced.
- No redundancy: No redundant path between the IO device and its IO controller, communication is always influenced.

The figure below shows the redundancy levels of the IO devices for an example configuration with MRPD. The three devices in the ring and the switch have the redundancy level "Full redundancy". Device 4 has the redundancy level "Partial redundancy", because the connection between the switch and the device is not redundant.

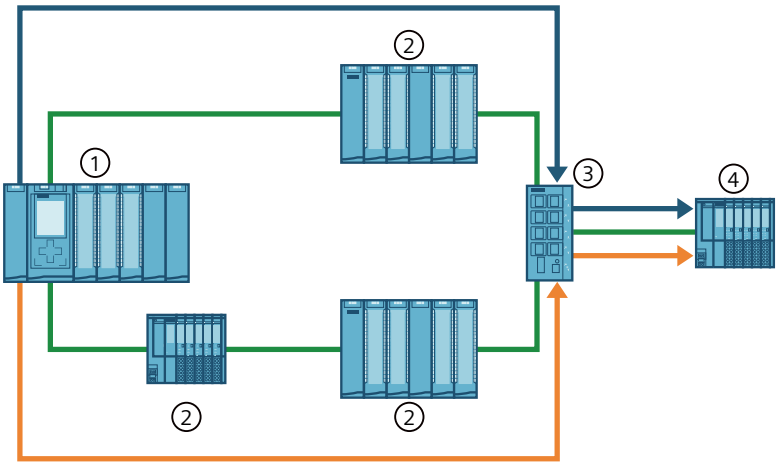

① IO controller in the ring

② IO device in the ring with redundancy level "Full redundancy"

③ Switch in the ring with redundancy level "Full redundancy"

④ IO device in the spur with the redundancy level "Partial redundancy"

Figure 3-659 Example configuration with MRPD

The figure below shows the display of the redundancy levels in STEP 7 for the example configuration.

IO devices

PROFINET device name	RT class	Synchronization role	Redundancy level	DFP group
plc_1.profinet interface_1	RT,IRT	Sync master		
io-device_1	IRT	Sync slave	Full redundancy	
io-device_2	IRT	Sync slave	Full redundancy	
io-device_3	IRT	Sync slave	Full redundancy	
io-device_4	IRT	Sync slave	Partial redundancy	
switch_1	IRT	Sync slave	Full redundancy	

Figure 3-660 Display of the redundancy levels in STEP 7

7.4.4 Multiple rings

Multiple rings

Use multiple rings to achieve higher availability for PROFINET IO networks with star topology.

In a multiple ring configuration, several PROFINET lines lead from a switch (star topology). The individual PROFINET lines lead from IO device to IO device. Redundant PROFINET cables run back to the switch from the last IO device on the individual lines.

The switch operates as a manager. The manager must have 2 ring ports for each ring. Depending on the number of available ring ports, several rings are possible.

The manager monitors all the rings individually: It checks for each particular ring (an MRP domain) whether the transmission path is intact. For this, the manager uses a separate MRP instance each time. An MRP instance is required for each connected ring (set up by STEP 7 automatically).

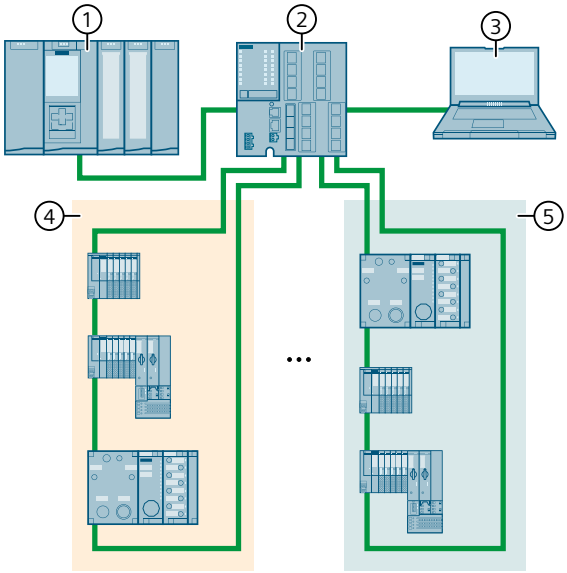

① IO controller
② Switch, e.g. SCALANCE XM416-4C
③ PG/PC
④ MRP ring 1
⑤ MRP ring n

Figure 3-661 Configuration with several rings

Requirements

- SCALANCE X414 as of Version V3.10
- SCALANCE X300 as of version 4.0 (configured via GSD file)
- SCALANCE XM416 as of Version V6.4

Rules for the configuration of multiple rings

- You can find the rules for configuring multiple rings, for example, in the following Internet entry (https://support.industry.siemens.com/cs/us/en/view/109820936)
- MRP role at multiple rings:
  - The device that belongs to all rings must take on the role of "Manager".
  - All the other devices must have the "Client" role.

Configuring multiple rings

To configure an MRP configuration with multiple rings, follow these steps:

1. In the topology view, interconnect the ring ports of the devices that are intended to belong to an MRP domain to form a ring.
2. Select the PROFINET IO system in the network view.
3. In the Inspector window, navigate to "Properties" > "General" > "PROFINET Subnet" > "MRP domains" in the "Ring interconnection" field.
   This field shows you all the topological rings in the IO system with the associated MRP domains.
4. Select one of the rings generated above in the "Ring interconnection" field.
   The table below shows all the PROFINET devices in the ring.
5. Set the media redundancy role for the PROFINET devices in the MRP role column.

Example of multiple rings on a SCALANCE XM416

The following figure shows an example configuration for multiple rings.

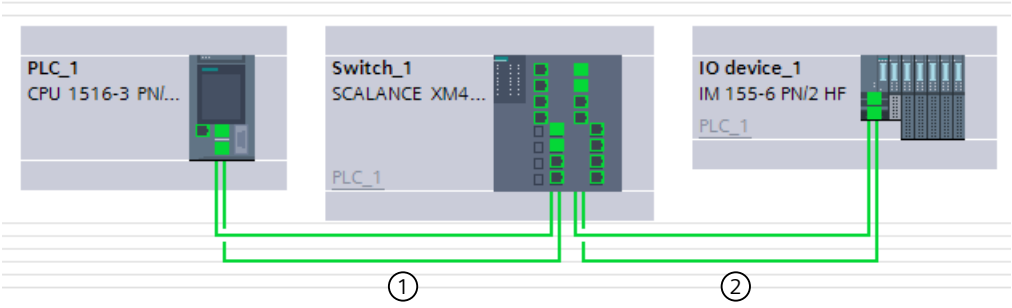

Figure 3-662 Example configuration with two rings ① and ②

In the example, Switch 1 belongs to two MRP rings. Ring 1 is formed by Switch 1 and PLC 1, Ring 2 by Switch 1 and IO device 1.

STEP 7 automatically assigns the "Manager" role to the switch. The other devices receive the "Client" role.

The manager is located at the point of intersection of the two rings 1 and 2. The manager monitors the two rings separately. To do this, it uses two MRP instances.

One MRP instance checks whether all devices in ring 1 are reachable, another instance monitors whether all devices in ring 2 are reachable (only one device in each case in the example).

You can configure each MRP instance separately.

The following figure shows the two MRP instances in the manager (PROFINET interface of the switch). Here in the example, MRP instance 1 checks whether the devices in the MRP domain "mrpdomain-1" can be reached. The MRP instance 2 is responsible for monitoring the devices of the MRP domain "mrpdomain-2".

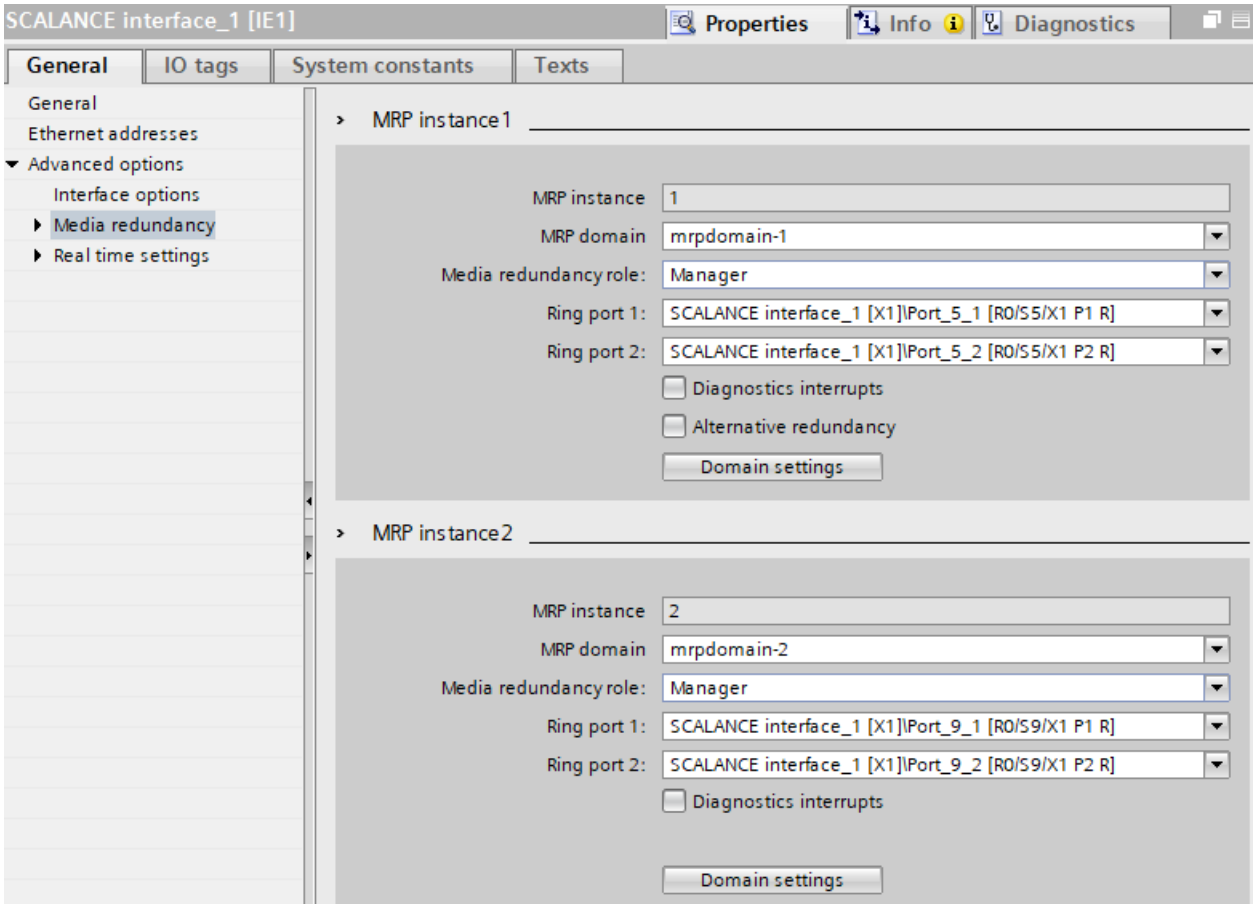

Figure 3-663 Setting media redundancy for multiple rings

The following figure shows Ring 1 (mrpdomain-1). The participants of the mrpdomain-1 are the PROFINET interface of the CPU as the "Client" and the MRP interface 1 of the PROFINET interface of the switch as the "Manager".

Ring interconnection

	Ring	MRP domain
1	Ring1	mrpdomain-1
2	Ring2	mrpdomain-2

	PROFINET device name	MRP instance	MRP domain	MRP role	Ring port 1	Ring port 2
1	PLC_1.PROFINET-IF_1		mrpdomain-1	Client	Port_1 [X1 P1 R]	Port_2 [X1 P2 R]
2	Switch_1.SCALANCE-IF_1	1	mrpdomain-1	Manager	Port_1 [R0/S5/X1 P1 R]	Port_2 [R0/S5/X1 P2 R]

Figure 3-664 Ring 1

The following figure shows Ring 2 (mrpdomain-2). The participants of the mrpdomain-2 are the PROFINET interface of the IO device as the "Client" and the MRP instance 2 of the PROFINET interface of the switch as the "Manager".

Ring interconnection

	Ring	MRP domain
1	Ring1	mrpdomain-1
2	Ring2	mrpdomain-2

	PROFINET device name	MRP instance	MRP domain	MRP role	Ring port 1	Ring port 2
1	IO-Device_1.PROFINET-IF		mrpdomain-2	Client	Port_1 [X1 P1 R]	Port_2 [X1 P2 R]
2	Switch_1.SCALANCE-IF_1	2	mrpdomain-2	Manager	Port_5 [R0/S9/X1 P1 R]	Port_6 [R0/S9/X1 P2 R]

Figure 3-665 Ring 2

7.4.5 MRP interconnection

Definition

The process MRP interconnection is an enhancement of MRP and allows the redundant coupling of two or more rings with MRP in PROFINET networks. MRP interconnection is - like MRP - specified in the standard IEC 62439-2 (Edition 3).

Advantages

MRP interconnection allows the monitoring of larger topologies with ring redundancy. With MRP interconnection, you are not limited to the maximum number of 50 devices in a ring when setting up redundant network topologies. For information on the quantity structure of MRP Interconnection, refer to the SCALANCE XM-400/XR-500 Web Based Management (WBM) (https://support.industry.siemens.com/cs/ww/en/view/109760840) configuration manual.

Requirements

- The media redundancy procedure MRP is used in the participating rings.
- Each ring has its own MRP domain with an MRP manager and MRP clients.
- As MRP managers in the rings, the PROFINET devices support MRP interconnection (see technical specifications of the devices).

  S7-1500 CPUs as of firmware version V2.9 support MRP interconnection.
- If you use PROFINET devices with more than 2 ports as MRP clients in the ring, then MRP interconnection is binding for these devices. For a device without MRP interconnection, telegrams leave the ring. This results in an additional load on the network.
- If you use PROFINET devices with only 2 ports in the ring as MRP clients, then MRP interconnection is recommended for all devices in the ring.

4 devices for MRP interconnection connections

2 MRP-interconnection connections provide redundant coupling between 2 MRP rings. Four devices are required for the 2 connections:

- A Media Redundancy Interconnection Manager (MIM)
- 3 media-redundancy interconnection clients (MIC):
  - Primary MIC
  - Primary Coupled MIC
  - Secondary Coupled MIC

Since each of the four devices is part of an MRP ring, each device also assumes a media redundancy role.

Each of the 4 devices can take over the MRP manager role or MRP client role.

Topology

The following screen shows the redundant coupling of 2 MRP rings.

Redundancy: If the primary connection (primary link) between the two rings is interrupted, the secondary connection (secondary link) takes over the data exchange between the rings after a short reconfiguration time.

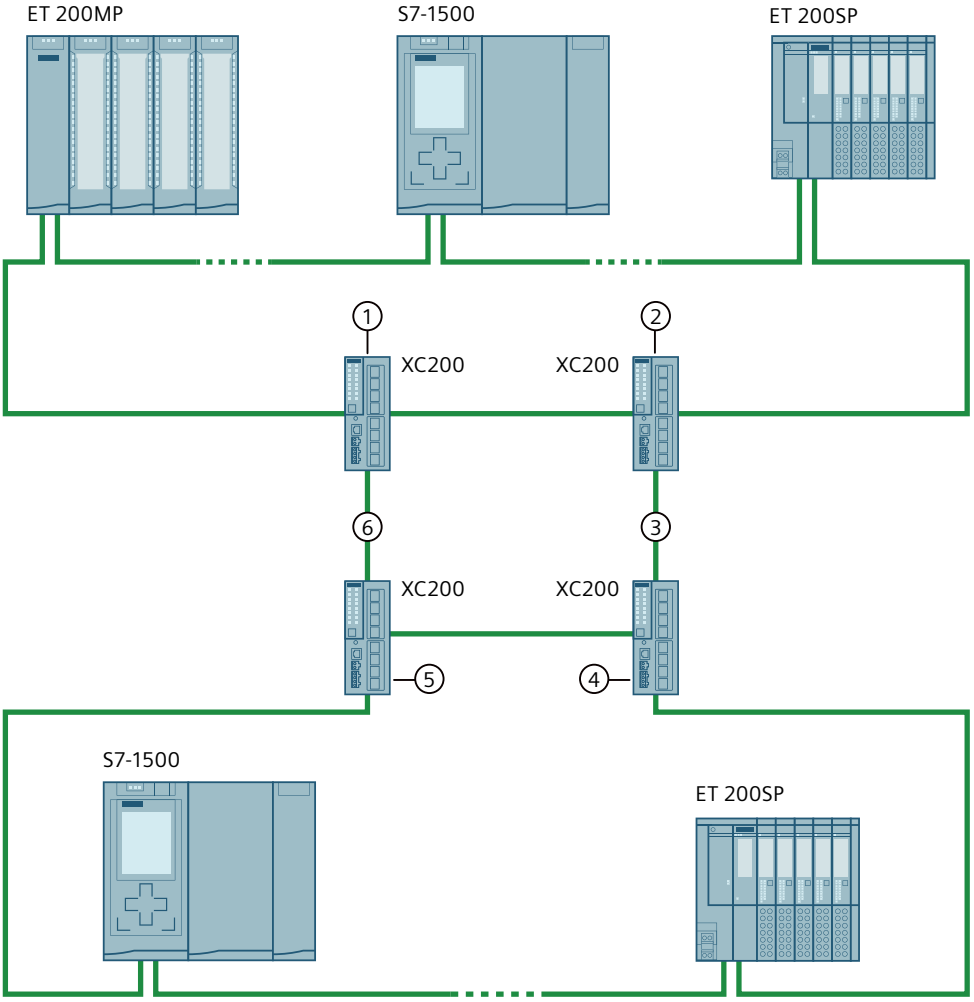

① Primary MIC
② Media Redundancy Interconnection Manager (MIM)
③ Secondary link
④ Secondary Coupled MIC
⑤ Primary Coupled MIC
⑥ Primary link

Figure 3-666 Example: Redundant connection of 2 rings with MRP interconnection

Function of the interconnection ports

Interconnection ports are appropriately configured PROFINET ports of the 4 devices for MRP interconnection. The primary or secondary connection of the rings exists between the interconnection ports.

Via the interconnection ports; the MIM is always informed about the connection status between the Primary MIC and the Primary Coupled MIC ("primary connection") as well as its own connection to the Secondary Coupled MIC ("secondary connection").

Depending on the connection status of the interconnection ports, each MIC sends a message to the MIM when its status changes (Link-Up or Link-Down).

In regular operation the data between the two rings is exchanged over the primary connection (primary link) and the MIM blocks its interconnection port.

Link-Down of the primary connection

In the figure below, the primary connection was interrupted (Link-Down).

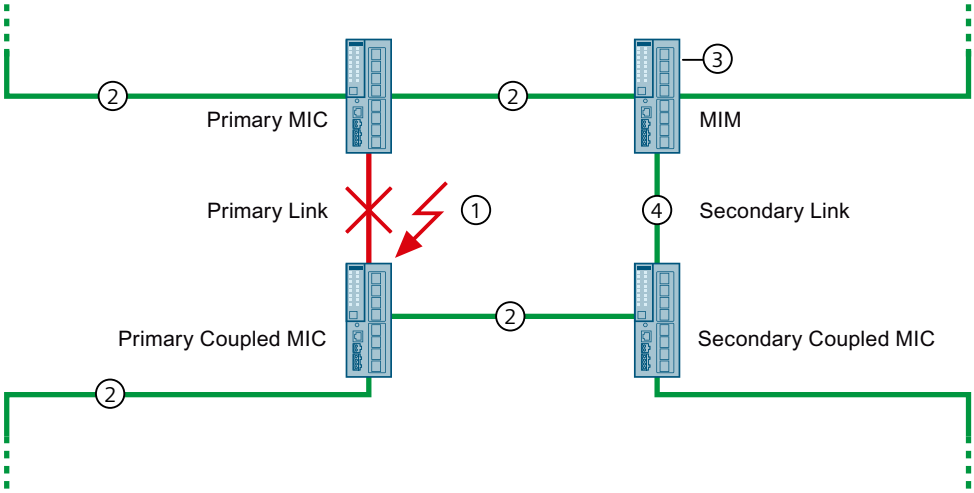

① Link-Down
② Status message: Link-Down primary connection
③ Blocking of the interconnection port is released
④ Data exchange via secondary connection

Figure 3-667 Link-Down of the primary connection

With a Link-Down of the primary connection ①, Primary MIC and Primary Coupled MIC send the status message "Link-Down" via all lines ②.

The MIM then unblocks its interconnection port at ③ and informs the MRP managers in both rings to trigger the reconfiguration of the rings.

After the reconfiguration, the data exchange between the two rings takes place via the secondary connection ④.

As soon as Primary MIC and Primary Coupled "Link-Up" for the primary connection, the MIM blocks its interconnection port and informs the MRP managers in both rings to trigger the reconfiguration of the rings.

After the reconfiguration, the data exchange is again carried out via the primary connection.

Configuring and assigning MRP interconnection parameters

NOTE

MRP interconnection is not integrated into the TIA Portal. This means you cannot configure, parameterize and diagnose MRP interconnection in STEP 7.

You configure and assign MRP interconnection parameters via the integrated web pages (Web Based Management) of the SCALANCE switches used as MIM and MIC (e.g. SCALANCE XC200, XM-400, XR-500).

For the configuration, follow the step-by-step instruction in the configuration manual SCALANCE XM-400/XR-500 Web Based Management (WBM) (https://support.industry.siemens.com/cs/ww/en/view/109760840).

Reconfiguration and watchdog timer

The reconfiguration time of the rings is typically less than 200 milliseconds.

In order for the data exchange to work after a reconfiguration, the watchdog timers of the IO devices must be set sufficiently large. Therefore, when using MRP interconnection, set the watchdog timer of the IO devices to 256 milliseconds or more.

7.5 Real-time communication

7.5.1 Introduction

Properties

PROFINET IO is a scalable real-time communication system based on the Layer 2 protocol for Fast Ethernet. With the RT transmission method, two real-time-support performance levels are available for time-critical process data and IRT for high-accuracy and also isochronous processes .

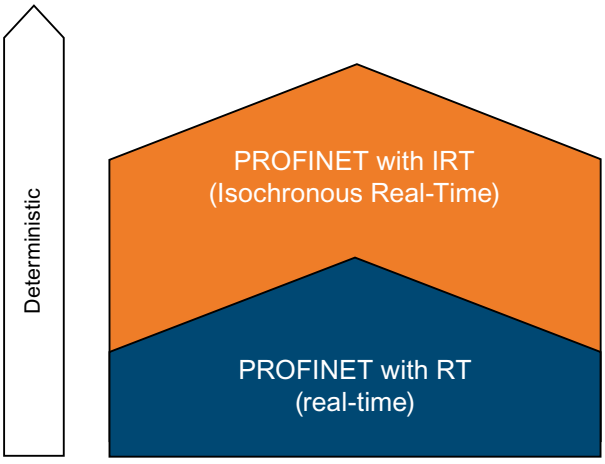

Figure 3-668 Real-time communication performance

Real-time communication and IT communication

Industrial communication, especially in the factory automation and process automation, requires a punctual and deterministic data transmission. This is why, for the cyclic exchange of time-critical IO user data, PROFINET IO does not use TCP/IP, it uses real-time communication (RT) or isochronous real-time communication (IRT) for the synchronized data exchange in reserved time intervals.

Fields of application of PROFINET with RT

PROFINET with RT is suited for:

- Time-critical applications in factory automation
- The implementation of large quantity structures in line process plants

Fields of application of PROFINET with IRT

PROFINET with IRT is particularly suitable for:

- Considerable deterministics with large quantity structures concerning the I/O user data communication (productive data)
- Considerable performance also with many devices concerning the I/O user data communication (productive data)
- Parallel transfer of productive and TCP/IP data via a cable, even with considerable data traffic whilst ensuring the forwarding of productive data by reserving the transmission bandwidth.

International standard IEC 61158

The communication procedures RT and IRT are standardized in the international standard IEC 61158.

7.5.2 RT

PROFINET IO with real-time communication (RT) is the ideal solution for integrating IO systems. This is a solution that also uses standard Ethernet in the devices and commercially available industrial switches as infrastructure components. A special hardware support is not required.

If you want to use PROFINET functions that provide an additional value, such as topology detection, diagnostics, device exchange without exchangeable medium/PG, you have to use switches that support the PROFINET standard according to the IEC 61158 standard. In the integrated switches of PROFINET devices and PROFINET switches (e.g., the SCALANCE product family), PROFINET functions in accordance with the PROFINET standard are implemented and can be used without restriction for integration in the PROFINET IO system (see also section Active network components (Page 41).

Real-time communication (RT)

PROFINET IO frames have priority over standard frames in accordance with IEEE802.1Q. This ensures the required determinism in the automation technology. The data is transferred via prioritized Ethernet frames. With RT, you can achieve update times ≥ 250 µs with RT.

Switching mechanisms

Switches in SIMATIC meet the real-time requirements with two mechanisms on PROFINET: "Store and forward" and "Cut through".

Store and forward

In the Store and forward method, the switch stores the frames completely and places them in a queue. If the switch supports the international standard IEEE 802.1Q, then the data is sorted according to its priority in the queue. The frames are then forwarded selectively to the specific port that can access the addressed node (Store and forward).

Cut through

In the Cut through process the entire data package is not stored temporarily in a buffer, it is passed directly onto the target port as soon as the target address and the target port have been determined.

The times required by the data package to pass through the switch are then minimal and independent of the frame length. The data are only stored temporarily in accordance with the Store and forward process as per priority when the section between the target segment and the port of the next switch is occupied.

7.5.3 IRT

Isochronous real-time communication (IRT)

IRT is a synchronized communication protocol for cyclic exchange of IRT data between PROFINET devices. A reserved bandwidth is available in the send cycle for IRT data. The reserved bandwidth ensures that the IRT data can be transferred at reserved synchronized intervals, without being influenced also by higher other network loads (such as TCP/IP communication, or additional real-time communication).

Advantages

PROFINET with IRT is synchronized communication in reserved time intervals. With IRT you have the option to be able to control time-critical applications such as motion control via PROFINET. With IRT you use further advantages:

- High-precision deterministics allow highest control quality and thus, for example, exact positioning of axes
- Simple and flexible integration of PROFINET devices for real-time applications in existing company networks

- Shortest response times and highest deterministics by means of bandwidth reservation and thus also for applications that have to satisfy highest performance requirements (e.g., printing control/position control for presses, print-mark recognition with packaging machines)
- Secured standard communication parallel to real-time communication via the same transmission medium
- You can continue to use standard components for your PROFINET IO system outside of the sync domain

Properties of isochronous real-time

Topology configuration is a prerequisite for IRT.

In addition to the reserved bandwidth, the frames from defined transmission paths are exchanged for the further optimization of data transfers. For this, the topological information from the configuration is used for planning the communication. Transmission and reception points of every individual data frame at every communication node are thus guaranteed. This allows you to achieve optimal usage of the bandwidth and reach the best possible performance in the PROFINET IO system.

Use of IRT allows you to achieve update times with very high deterministics ≥ 125 µs and a jitter accuracy of the send clock < 1 µs. Isochronous applications are possible with IRT (see section Isochronous mode (Page 229)).

* The minimum update time depends on the CPU used. The update times supported by a CPU are listed in the technical specifications of the CPU manual.

NOTE

IWLAN and IRT

PROFINET devices that are connected to PROFINET IO via access points, do not support IRT.

Synchronization

The prerequisite for the IRTcommunication is a synchronization cycle for all PROFINET devices in a sync domain for distributing a mutual time basis. A synchronism of the transmission cycle of the PROFINET devices within a sync domain is achieved with this basic synchronization.

A sync master specifies the clock to which sync slaves are synchronized. An IO controller or an IO device can have the role of sync master. If the sync master fails, all IO devices with IRT will fail.

Sync master and sync slaves are always devices in a sync domain. Bandwidth is reserved within the sync domain for IRT communication. Real-time and non-real-time communication (TCP/IP communication) is possible outside of the reserved bandwidth.

Default sync domain

If you have created a PROFINET subnet, a special sync domain is automatically created, the default sync domain. All PROFINET devices configured for the PROFINET subnet automatically belong to this sync domain.

For additional information on creating sync domains, refer to the STEP 7 online help.

Time ranges of the communication cycle

The communication cycle is divided into three time ranges, which are shown in the following chart:

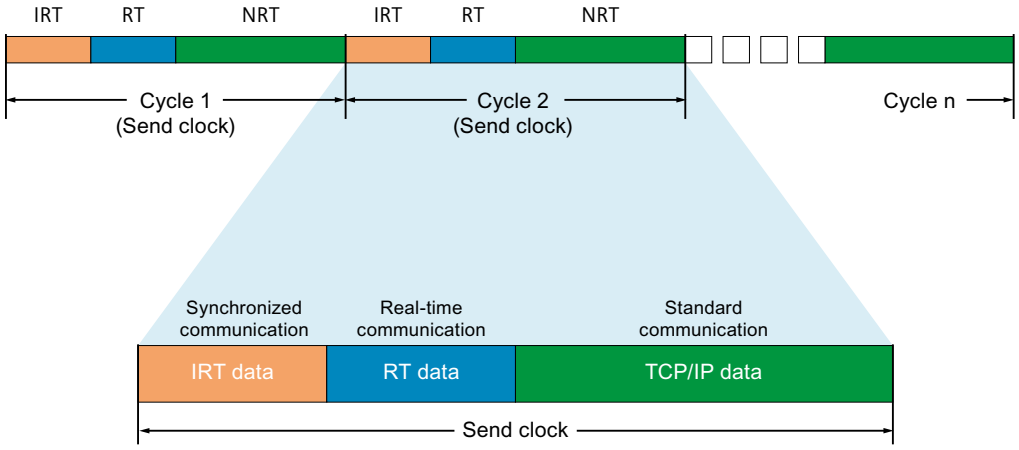

Figure 3-669 Reserving bandwidth

- IRT data (synchronized communication)

  This time range can be reserved in specific steps, depending on the send clock. Only IRT data is transmitted during this time range.

- RT data (real-time communication)

  The cyclic RT data is transferred in this time range. RT data is prioritized over "normal" TCP/IP data. TCP/IP data or Ethernet frames can have a priority of between 1 and 7. RT data have the Priority 6.

- TCP/IP data (standard communication)

  Standard communication (e.g., TCP/IP) is transmitted in the remaining interval of the communication cycle.

In STEP 7, you can set the ratio of the bandwidth usage of cyclic IO data to standard communication. For information on how to set the bandwidth usage, refer to the section Setting the bandwidth usage for the send clock (Page 212)

7.5.4 Comparison of RT and IRT

The most important differences between RT and IRT

Table 3-964 Comparison between RT and IRT

Property	RT	IRT
Transmission method	Prioritizing the RT frames through Ethernet priority (VLAN tag)	Path-based switching on the basis of a communication path plan; no transmission of TCP/IP frames in the time range with IRT communication.
Determinism	Variance of the duration of transmission by the shared use of the transmission bandwidth with other protocols (e.g., TCP/IP)	Exact, planned transmission, transmission and reception times are guaranteed for all topologies.
Hardware support through special Ethernet controllers is required	Not required	Required
Isochronous application	-	Yes
Starting time of the isochronous application	-	The point in time for the reception of the data is planned exactly. Application can be started synchronized to the cycle.

7.5.5 Configuring PROFINET IO with IRT

Introduction

If you want to configure a PROFINET IO system with IRT, you have to configure the PROFINET IO devices. These PROFINET devices must support IRT. Set which device acts as the sync master and synchronizes the other devices. This is done by configuring a sync domain with a sync master and at least one sync slave.

Requirement

- There is an IO system with an IO controller and at least one IO device.
- You have configured the topology for the IO system.
- The devices support IRT.

Procedure

Proceed as follows to enable an existing IO system for the use of IRT:

1. Select the PROFINET interface of the IO controller.
2. In the Inspector window, navigate to "Advanced options > Real time settings > Synchronization".

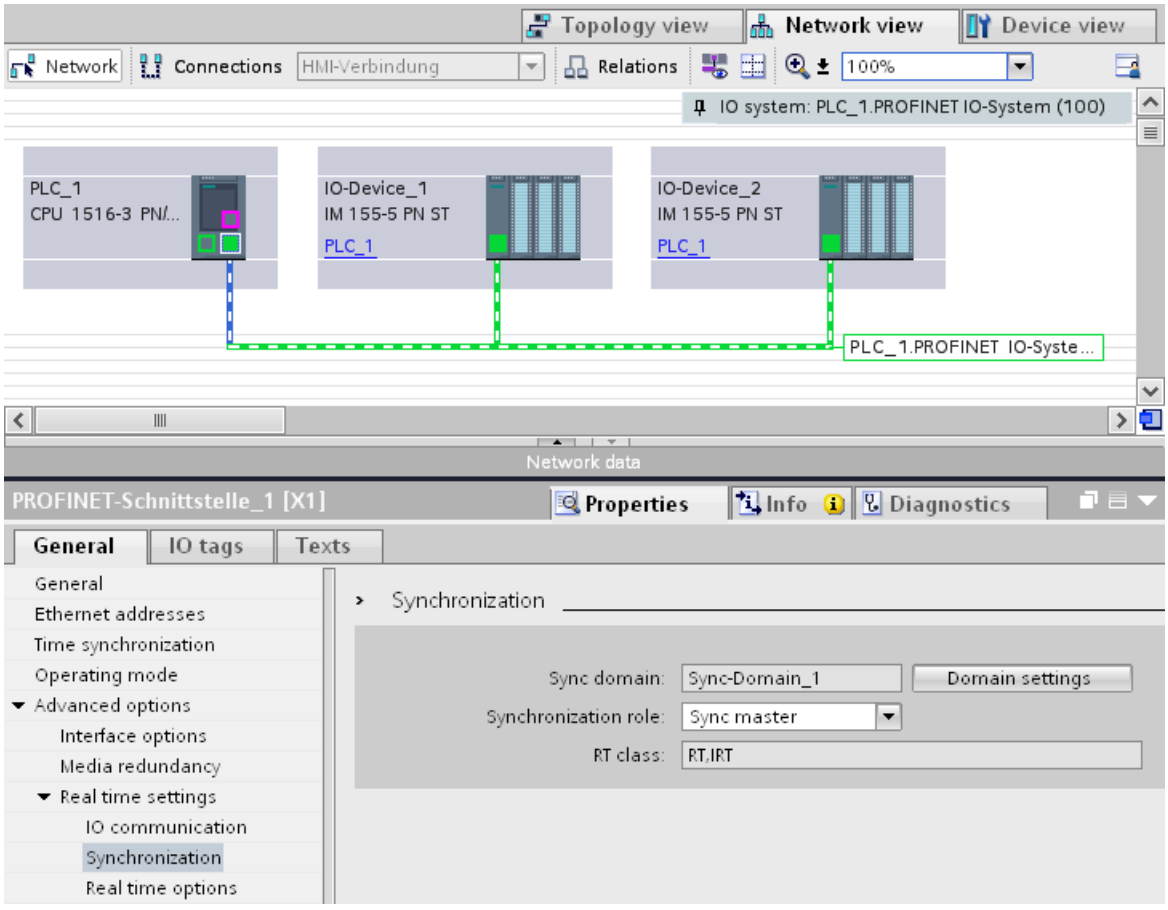

Figure 3-670 IRT configuring sync master

3. Assign the IO controller the role of sync master under "Synchronization role".
4. Select the PROFINET interfaces of an associated IO device.

5. In the Inspector window, navigate to "Advanced options > Real time settings > Synchronization".

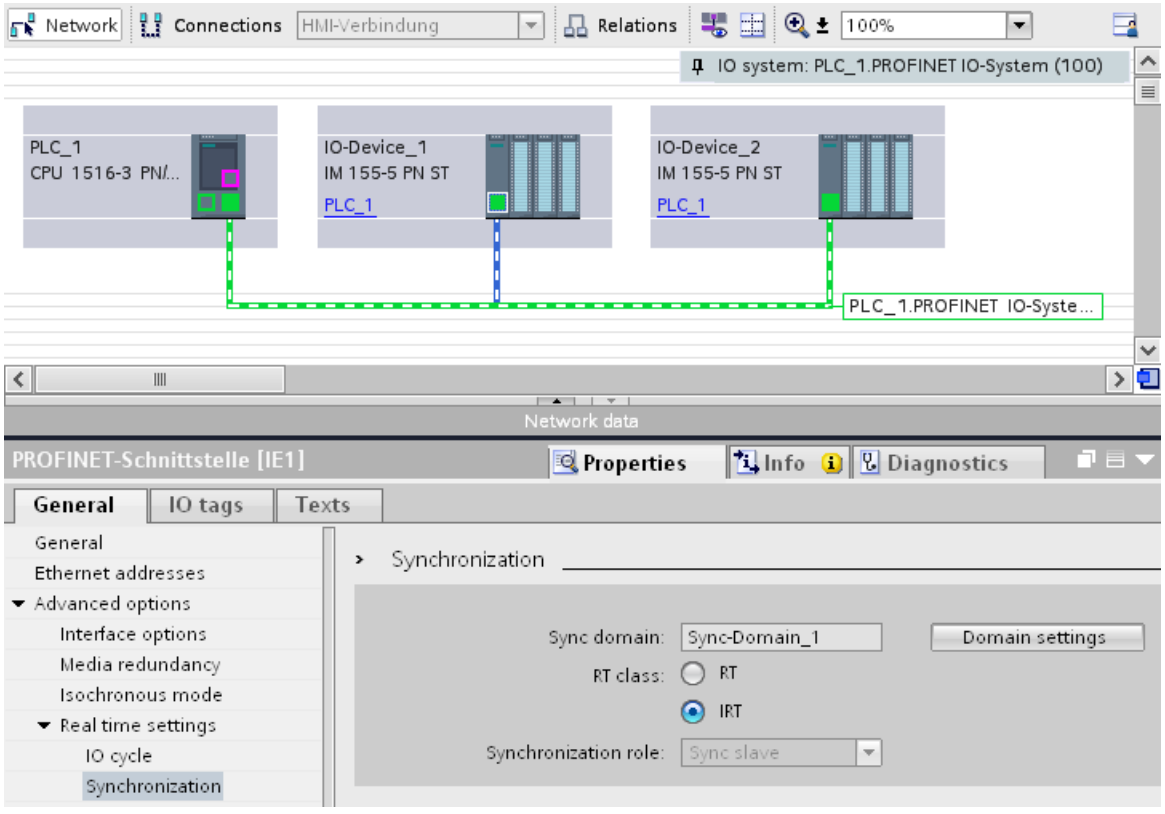

Figure 3-671 IRT configuring sync slave

6. Activate the RT class "IRT". The IO device will then automatically be assigned the synchronization role "sync slave".
7. You can check and correct your settings at any time using the "Domain settings" button.

Or

1. Highlight the PROFINET IO system in the network view.
2. Click on the PROFINET IO system.

3. Navigate to the device of the required sync domain in the Inspector window.

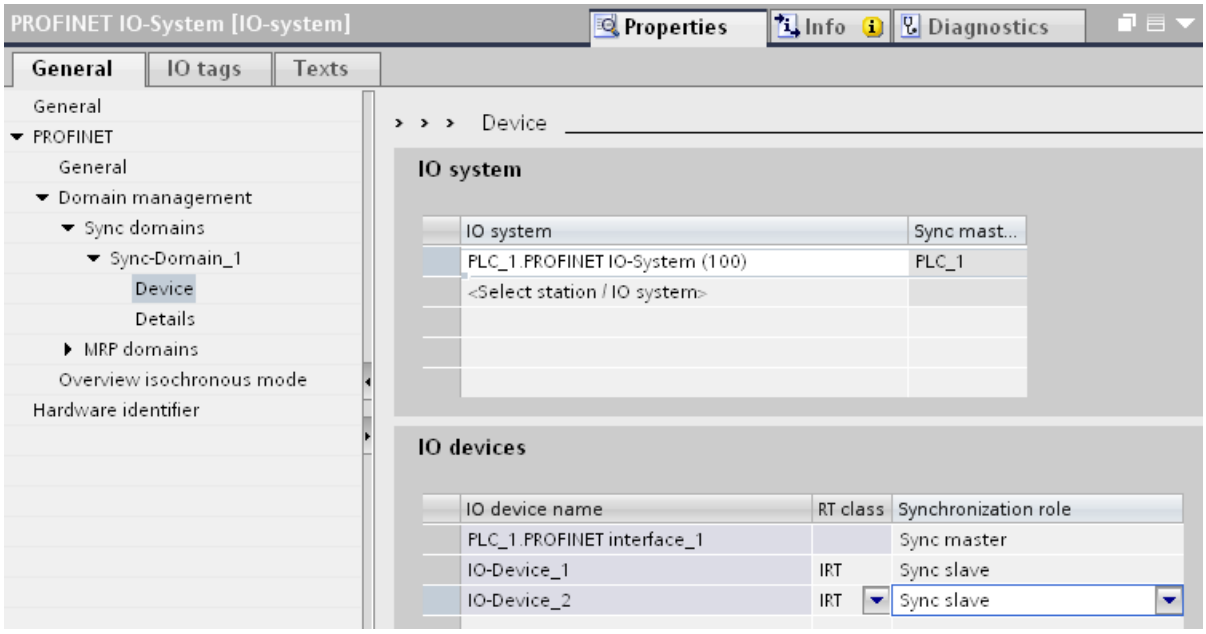

Figure 3-672 IRT configuring sync domain

4. Enter all necessary settings in the tables:
   - Select an IO system.
   - Set the synchronization role "sync master" for the IO controller.
   - Set the RT class for the IO devices to "IRT". The IO devices will then automatically be assigned the synchronization role "sync slave".

You can now load the configuration to the relevant devices with PROFINET IRT.

7.5.6 Setting the bandwidth usage for the send clock

Bandwidth level

For PROFINET IO with IRT, you can specify the maximum portion of the send cycle that you want to use for cyclic IO communication.

You have the following setting options for the bandwidth usage in STEP 7.

- Maximum 25% cyclic IO data. Focus on non-cyclic data.
- Maximum 37.5% cyclic IO data. Focus on non-cyclic data.
- Maximum 50% cyclic IO data. Balanced proportion.
- Maximum 90% cyclic IO data. Focus on cyclic IO data. (Requirement: The "Make 'high performance' possible" option is activated)

Setting the bandwidth usage

To set the bandwidth usage for a PROFINET IO system in STEP 7, follow these steps:

1. Select your IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain" > "Details".
3. Select the desired level of bandwidth usage from the "Bandwidth use" drop-drop down list box.

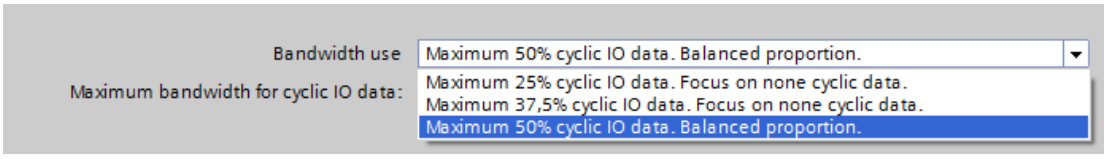

Figure 3-673 Setting the bandwidth usage

For information on how to set the bandwidth usage for IRT with maximum performance, refer to the section Configuration of IRT with high performance (Page 225)

7.5.7 Setup recommendations for optimizing PROFINET

Optimizing PROFINET with RT

PROFINET provides you with high-performance communication on all levels.

The following figures shows an example of an optimized PROFINET topology.

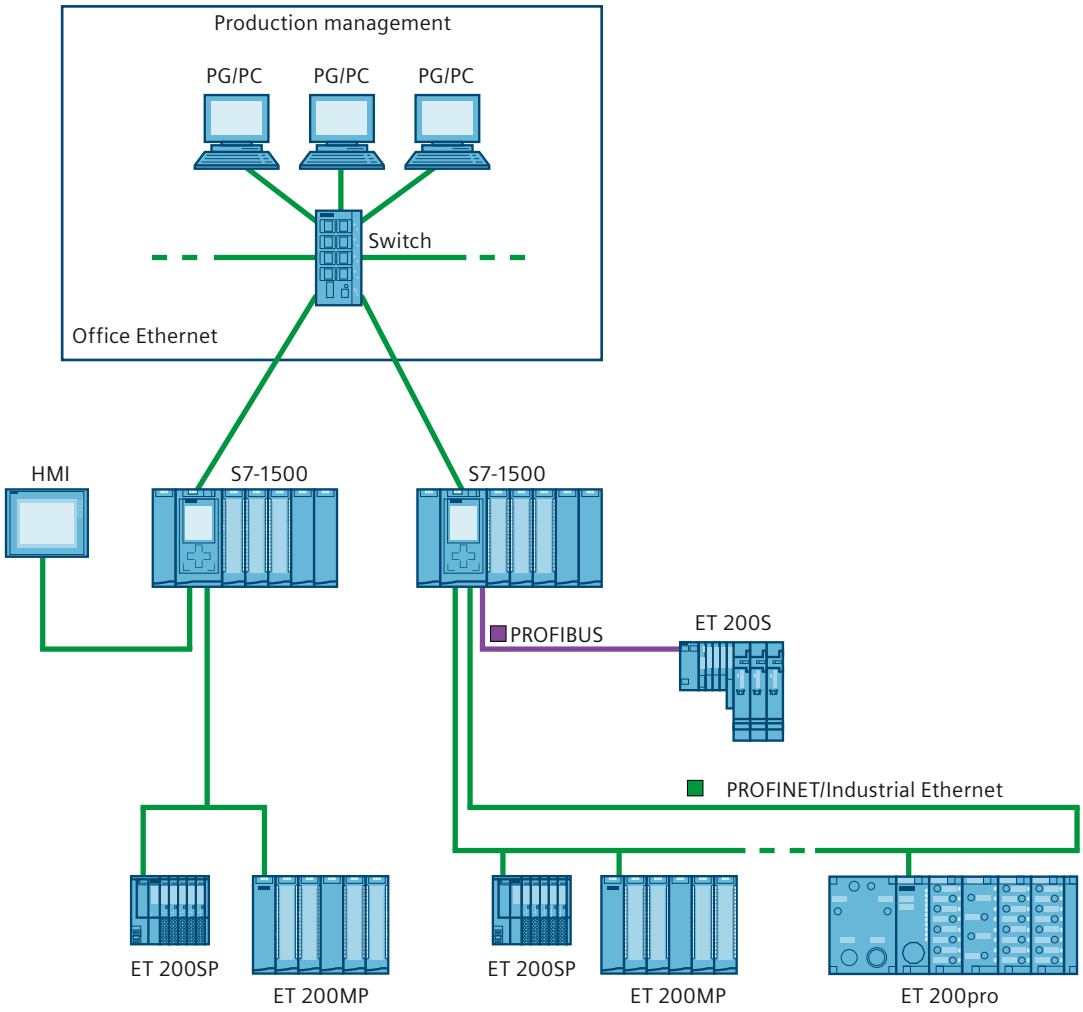

Figure 3-674 Optimized PROFINET topology

When setting up your PN network topology, take care that the various automation applications are distributed among separate network branches so that a sufficient bandwidth reserve will be available for future expansions.

- If you integrate standard Ethernet devices into the network topology or use standard Ethernet communication, take into account the network load caused by standard Ethernet and adapt the network topology as appropriate (max. bandwidth 100 Mbps).
- For communication with higher-level networks with a high data volume, use the most direct paths possible to the higher-level network infrastructure.

Also observe the Installation Guideline (http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/) of the PROFIBUS User Organization.

Setting up PROFINET with IRT

Keep in mind the following rules for setting up and operating a PROFINET IO system in IRT mode. These rules will ensure best possible operation of your PROFINET IO system.

- When using IRT, you must configure the topology. This will enable exact calculation of the update time, bandwidth, and other parameters.
- If you would like to use multiple sync domains, configure a sync boundary for the port which is currently connected to the PROFINET device of another sync domain.
- In a sync domain, you can only configure one sync master at a time.
- A PROFINET IO system may only be part of a single sync domain.
- If you configure PROFINET devices in a sync domain and want to synchronize with IRT, the PROFINET devices concerned must support IRT communication.
- If possible, use the same PROFINET device as the PROFINET IO controller and sync master.
- If only some of the PROFINET devices in a PROFINET IO system are synchronized, please keep in mind the following: Assign PROFINET devices that are not participating in the IRT communication to the RT class "RT" and the synchronization role "unsynchronized" in the sync domain.

Applications for CPU with multiple PROFINET IO interfaces

- Connecting machines: Your configuration contains machines located on separate IO lines. To operate the separate IO lines with real-time communication, select one of the following options:
  - Use an S7-1500 CPU that supports the same PROFINET functionalities at the PROFINET interface X2 as at the PROFINET interface X1. With these CPUs, you can operate a separate PROFINET IO system in isochronous mode at each of the PROFINET interfaces X1 and X2, or synchronize both PROFINET IO systems for a shared application. For information on how to operate the two PROFINET IO systems with each other in isochronous mode, refer to section Operating multiple PROFINET networks in isochronous mode (Page 241).
  - Alternatively, you can operate real-time communication between several CPUs via the PROFINET IO interface X2. Use the I-device or shared I-device function for this purpose. The figure below shows an example configuration for two machines connected over the X2 interface with an I-device relationship.

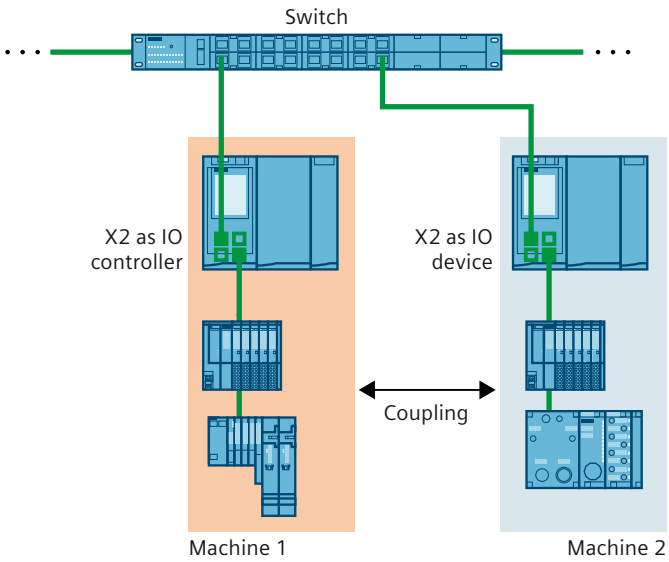

Figure 3-675 I-device connection over 2nd PNIO interface

- Distribution by automation tasks:
  - For automation tasks with high performance and deterministic requirements, use PROFINET with IRT over the X1 interface.
  - For other tasks that you can implement with RT, use the X2 interface.

If you use interface X2 as the PROFINET IO interface for a CPU with FW version up to V2.9, this can affect performance. You can find additional information in the section PROFINET interface (Page 32) and in the Cycle and Response Times (https://support.industry.siemens.com/cs/ww/en/view/59193558) function manual.

Topological overlap of IO systems in multi-controller applications

In a configuration with multiple IO controllers, shared paths are subject to the combined network loads of all connected PROFINET IO systems.

To avoid high communication loads in multi-controller applications, observe the following recommendations:

- Avoid paths that are shared by multiple IO systems.
  The figure below shows a configuration with two PROFINET IO systems that use the same paths.

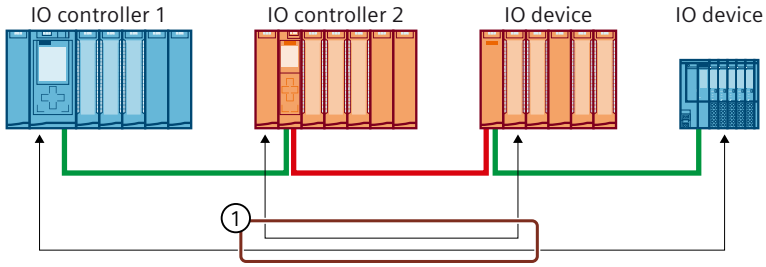

① Shared path

Figure 3-676 Multi-controller application with shared path

In the figure below, the two PROFINET IO systems do not use shared paths.

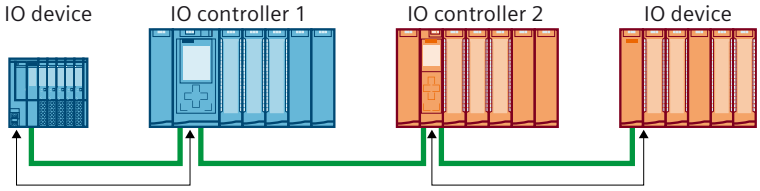

Figure 3-677 Multi-controller application with separate paths

- If separation is not possible: Increase the update time for the affected IO devices.

Installation guidelines of the PROFIBUS user organization

The installation guidelines can be found on the Internet (http://www.profibus.com/nc/download/installation-guide/downloads/profinet-installation-guide/display/).

7.5.8 Limitation of the data infeed into the network

Limiting the data infeed into the network on PROFINET interfaces

The "Limit data infeed into the network" function limits the network load of standard Ethernet communication which is fed into the network by the interface to a maximum value. This does not apply to cyclic real-time communication (RT/IRT).

In a PROFINET IO system, critical network loads can occur quickly with standard Ethernet communication, especially in line topologies. Devices which feed a lot of standard Ethernet communication into the PROFINET IO system, should support the function "Limit data infeed into the network". If necessary, you should optimize your topology by avoiding e.g. standard

Ethernet devices in line topologies. You can find additional information on this in section Setup recommendations for optimizing PROFINET (Page 214).

Depending on the performance capability of the PROFINET interface, you can set in its properties whether or not the data infeed into the network should be limited. Requirements for adjustability:

- The interface offers sufficient performance.
- No IO data transfer is configured

If the conditions are not met, the data infeed is always limited.

Depending on the interface, you can activate or deactivate the "Limit data infeed into the network" function. If you use the X1 interface of an S7-1500 CPU as the IO controller or I-device, the "Limit data infeed into the network" function is always enabled. Example: If you are not using the X1 interface of an S7-1500 CPU as IO controller or I-device, you can enable or disable the function.

Uses of the limitation of the data infeed to the network

- Division of the bandwidth for standard Ethernet communication between devices:
  In PROFINET networks cyclic real-time communication and standard Ethernet communication share the same network. This means that only a limited bandwidth remains for standard Ethernet communication. The limitation of the data infeed ensures that the remaining bandwidth for standard Ethernet communication is not used just by one device, but is divided between several devices.
- Smoothing peaks in the data infeed:
  The limitation of the data infeed smooths peak loads of standard Ethernet communication (for example, from Open User Communication, access by the Web server).
- Prevent excessive data at the source:
  If applications in a device generate too much data, this data is not forwarded to the PROFINET network. Negative effects (for example data loss, communication interruption) remain limited to the device feeding in the data and its communications partner. Other nodes are not disturbed.

Setting limitation of the data infeed into the network for a CPU

To set the limitation of the data infeed into the network, follow these steps:

1. In the network view of STEP 7, select the interface of the CPU.
2. In the Inspector window, go to "Properties" > "General" > "Advanced options" > "Interface options".
3. Select or clear the "Limit data infeed into the network" check box.

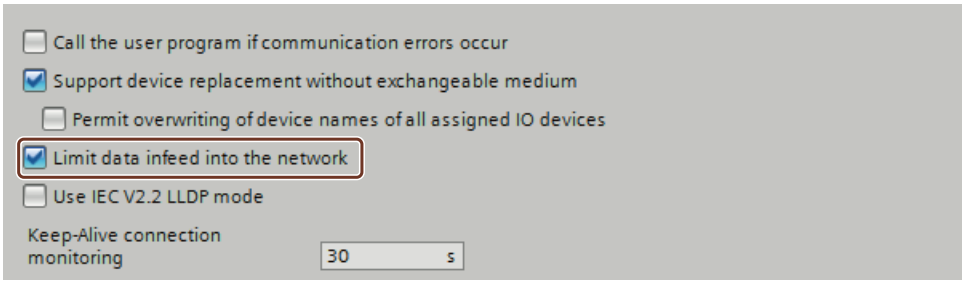

Figure 3-678 Limit data infeed into the network

7.6 PROFINET with performance upgrade

Performance upgrade

The performance upgrade implements the application class "High Performance" of the PROFINET specification V2.3.

The performance upgrade provides a series of measures that lead to the following improvements for PROFINET with IRT:

- Reduction of runtime delays in the IO devices
- Increase in the bandwidth for cyclic IO data
- Reduction of the bandwidth used for PROFINET frames
- Reduction of the send clocks

The improvements achieved with the performance upgrade mean that you can operate your PROFINET IO system with more devices with the same send clock or the same number of devices with a shorter send clock.

With PROFINET, it was previously possible to reach a send clock of 250 µs.

With the performance upgrade, it is now possible to achieve isochronous send clocks of up to 125 µs with the fast forwarding, dynamic frame packing and fragmentation procedures, depending on the performance capability of the CPU (see Technical Specifications in the device manuals). With short send clocks, standard communication remains possible.

The performance upgrade will help you to implement applications with high speed and send clock requirements.

7.6.1 Dynamic frame packing

Dynamic frame packing

Previously, individual PROFINET IO frames were sent for every PROFINET IO device.

The performance upgrade uses the dynamic frame packing procedure that is based on the summation frame method. With the summation frame method, a frame contains the user data for neighboring devices on a line. With Dynamic Frame Packing, every IO device takes its data from the frame and forwards the rest. The frame is shortened from IO device to IO device. Dynamic frame packing improves the use of the bandwidth in a line topology.

The following figure shows how Dynamic Frame Packing works based on the example of a frame containing the user data for 3 IO devices.

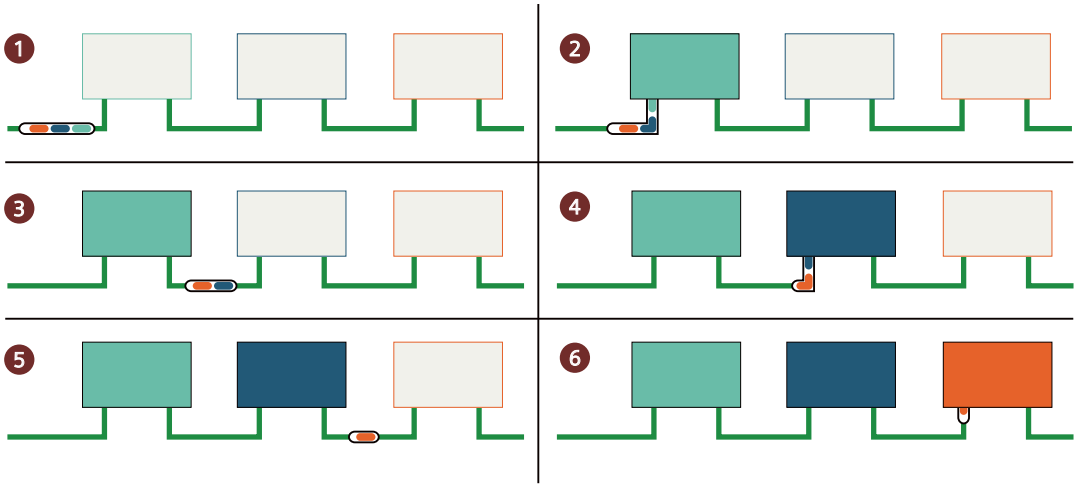

① The PROFINET IO frame contains the user data for all 3 IO devices (green, blue and orange).

② The PROFINET IO frame reaches the first IO device. The IO device takes its user data (green) from the frame and forwards the remaining frame.

③ The PROFINET IO frame contains the user data for two IO devices (blue and orange).

④ The PROFINET IO frame reaches the second IO device. The IO device takes its user data (blue) from the frame and forwards the remaining frame.

⑤ The PROFINET IO frame contains the user data for one IO device (orange).

⑥ The PROFINET IO frame reaches the last IO device. The IO device saves the entire frame including user data (orange).

Figure 3-679 Dynamic Frame Packing (DFP)

DFP groups

Dynamic frame packing automatically groups IO devices that support the performance upgrade into DFP groups. To be grouped together in a DFP group. the IO devices (IRT devices) must be located one after the other in a line and must have the same update time and watchdog timer.

The following circumstances automatically lead to the creation of a new DFP group; the TIA Portal takes over the division into DFP groups:

- The maximum frame size (1440 bytes) for the DFP group has been exceeded.
- The maximum sub-frame size (256 bytes) for an IO device has been exceeded. This means that a large I/O quantity structure (> 256 bytes) of an IO device causes an interruption of the DFP group. The first DFP-capable IO device after this device opens a new DFP group.
- The maximum number of DFP capable IO devices (63) for a DFP group has been reached.
- DFP-capable IO devices are not in a line one behind the other but are interrupted by "normal" IRT devices (non-DFP-capable IO devices). The first DFP-capable IO device after a "normal" IRT device opens a new DFP group.

The maximum number of DFP groups per PROFINET interface is 8.

STEP 7 displays the DFP groups in "Domain management" > "Sync domains" > "Name of the sync domain" > "Device" in the "IO devices" box.

IO devices

PROFINET device name	RT class	Synchronization role	Redundancy level	DFP group
plc_3.profinet interface_1	RT,IRT	Sync master		
io-device_2	IRT	Sync slave	No redundancy	2
io-device_3	IRT	Sync slave	No redundancy	2
io-device_4	IRT	Sync slave	No redundancy	3
io-device_5	IRT	Sync slave	No redundancy	3

Figure 3-680 Display of the DFP groups in STEP 7

NOTE

Dynamic frame packing with high watchdog times

If you set the "Accepted update cycles without IO data" parameter higher than 31 for an IO device, Dynamic Frame Packing does not place this IO device in a DFP group.

Increase of the quantity structure for IRT devices by DFP

You can also use a line configuration with DFP-capable IO devices (DFP-capable IRT devices) to increase the number of connectable IRT devices.

Example from the technical specifications of a CPU 1517-3 PN (firmware version V4.0):

- Number of IO devices that can be connected to PROFINET interface X1 or X2 with IRT: 64; with DFP: 256 IO devices in (max.) 8 DFP groups

The following section explains how to interpret this technical specifications and which rules need to be considered. To assist you, the TIA Portal reports rule violations when compiling the PROFINET configuration.

Rules for the maximum line depth: To ensure synchronization accuracy, only 64 IRT devices may be arranged in a line – even if more than 64 IRT devices can be connected. With a quantity structure of more than 64 IRT devices (with or without DFP), use IRT switches to comply with this rule.

Rules for the maximum number of communication relations: The number of communication relations to IRT devices and DFP groups is limited to 64.

The devices in a DFP group share a communication relationship, so when DFP-capable IRT devices are used, it is also possible to connect more than 64 IRT devices. A DFP group "uses up" an IRT communication relation just like a non-DFP-capable IRT device.

Example: **Valid configuration**

A configuration consists of 8 DFP groups with a total of 250 DFP-capable IRT devices. There are also 6 additional IRT devices (non-DFP-capable) between the DFP groups.

This ensures that the specified limits from the technical specifications are complied with:

- Number of IRT devices (DFP-capable or non-DFP-capable): 250 DFP-capable + 6 non-DFP-capable = 256 (which corresponds to the maximum number).
- Number of IRT devices (non-DFP-capable): 6 (which is below the limit of 64 IRT devices).
- Number of IRT communication relations: 8 DFP groups + 6 non-DFP-capable IRT devices = 14 (which is below the limit of 64 IRT communication relations).

If there are fewer DFP-capable IRT devices in the 8 groups and these devices are replaced by "normal" IRT devices (without DFP), the number of communication relations to IRT devices may be exceeded.

Example: **Invalid configuration**

The configuration consists of 8 DFP groups with a total of 195 DFP-capable IRT devices. There are also 61 additional IRT devices (non-DFP-capable) between the DFP groups.

- Number of IRT devices (DFP-capable or non-DFP-capable): 195 DFP-capable + 61 non-DFP-capable IRT devices = 256 (which corresponds to the maximum number).
- Number of IRT devices (non-DFP-capable): 61 (which is below the limit of 64 IRT devices).
- Number of IRT communication relations: 8 DFP groups + 61 non-DFP-capable IRT devices = 69 (which is above the limit of 64 IRT communication relations).

NOTE

Ensure sufficient program run time and reserves for other network loads.

When calculating the cycle time for isochronous applications, you must ensure that there is enough time available for other communication tasks and for processing data from the distributed I/O.

Use the "Details" area of the corresponding sync domain; here, the bandwidth for cyclic data is calculated and displayed from the PROFINET configuration.

You can access the "Details" area as follows: Properties of the PROFINET interface > Advanced options > Real time settings > Synchronization. In the "Synchronization" area, click on "Domain settings". Then navigate to the "Details" area under Domain Management > Sync domains > Sync domain_x.

The difference between "send clock" and "calculated bandwidth for cyclic data" is the maximum time available for the program to process the data. In addition, the update time for process image partitions reduces the program processing time (see the Function Manual Cycle and response times, section "Update time for process image partitions" – documented CPU-specific as copy time for distributed I/O via PROFINET).

To determine the program run time, use the "RUNTIME" instruction.

7.6.2 Fragmentation

The transfer of a complete standard Ethernet frame with TCP/IP data takes up to 125 µs. This means that the cycle time for PROFINET IO data cannot be reduced by any desired amount.

The performance upgrade uses the fragmentation procedure, which breaks down TCP/IP frames into sub-frames. These frame segments are transferred to the target device over multiple send clocks; there they are reassembled to the original TCP/IP frame.

Fragmentation is a requirement for cycle times lower than 250 µs. In these short send clocks, you can use more bandwidth for cyclic IO data, since the fragments of the standard Ethernet frames use significantly less bandwidth than a complete standard Ethernet frame.

For information on which send clocks a CPU supports, refer to the technical specifications in the Equipment Manual of the CPU. The following figure shows how fragmentation works at PROFINET interface X1 of a CPU 1518-4 PN/DP.

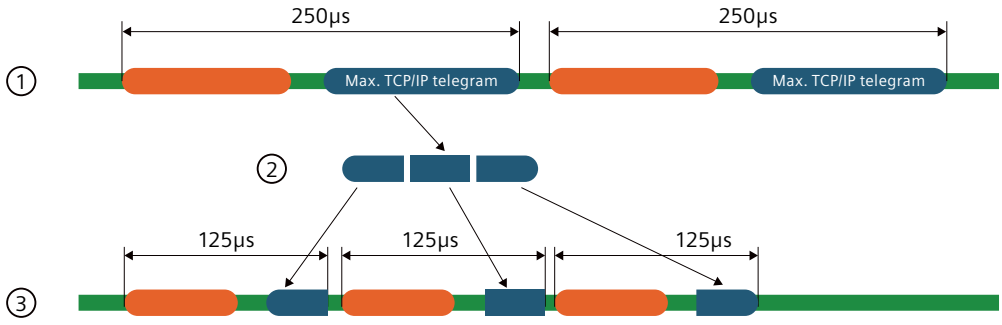

① A standard Ethernet frame with TCP/IP data is up to 125 µs.

② During fragmentation, the standard Ethernet frame is divided into frame segments.

③ The frame segments are divided into multiple short send clocks.

Figure 3-681 Fragmentation

NOTE

The PROFINET IO interface of the IO controller supports fragmentation if all the ports except one are deactivated.

Requirements for fragmentation

If you use the following combinations for send clock and bandwidth settings, the devices in the IO system use the fragmentation process.

- Send clock cycle 125 µs: Always fragmentation irrespective of the bandwidth setting.
- Send clock cycle 187.5 µs: Fragmentation with the bandwidth settings "Maximum 50% cyclic IO data. Balanced proportion." and "Maximum 90% cyclic IO data. Focus on cyclic IO data."

PROFINET interface X1 of the IO controller supports fragmentation as follows:

- CPUs up to FW version V3.1: Only one port may be active at PROFINET interface X1.
- CPUs as of FW version V4.0: Both ports may be active at PROFINET interface X1.

7.6.3 Fast forwarding

To be able to decide whether a frame should be forwarded or used, a PROFINET IO device requires the frame ID. It previously took 1440 ns until the frame ID was present in the IO device.

The performance upgrade uses the fast forwarding procedure in which the frame ID is located nearer the front of the frame. The throughput time in the device is reduced to 320 ns.

With fast forwarding, the throughput time of the frame is reduced in your PROFINET IO system. This results in decisive performance advantages, particularly in line, ring and tree topologies.

The figure below compares the throughput of a PROFINET IO frame in an IO device with and without fast forwarding.

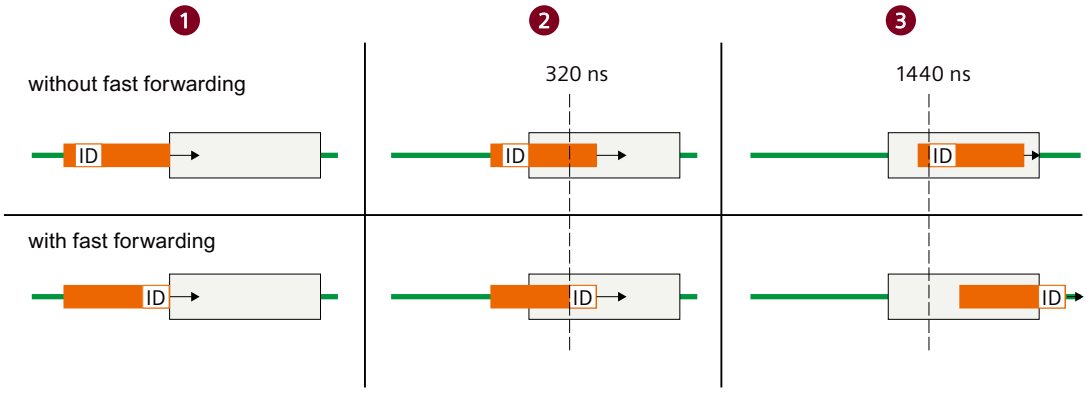

① Start:
- Both PROFINET frames reach the IO device.
  The IO devices start to check the frames for the frame ID

② After 320 ns:
- Without fast forwarding: The IO device is still checking the PROFINET frame for the frame ID.
- With fast forwarding: The IO device receives the frame ID from the PROFINET frame and forwards the frame.

③ After 1440 ns:
- Without fast forwarding: The IO device receives the frame ID from the PROFINET frame and forwards the frame.
- The PROFINET frame with fast forwarding is "ahead" of the PROFINET frame without fast forwarding.

Figure 3-682 Fast forwarding

7.6.4 Configuration of IRT with high performance

High-end applications with IO communication require excellent performance in IO processing, for example in the control of wind turbines (converter control).

To use IRT communication with the highest performance in your PROFINET IO system, enable the option "Make 'high performance' possible".

When you enable the "Make 'high performance' possible" option, this has the following effects:

- You can set send clocks of 187.5 µs and 125 µs (for example CPU 1518-4 PN/DP) or 187.5 µs (for example CPU 1517-3 PN/DP), see Technical specifications in the CPU device manuals.
- You can set more bandwidth use for cyclic IO data.
- You can use the option "Allows the use of 'fast forwarding'".

Requirements

- S7-1500 CPU as of firmware version V2.0

Enable the "Make 'high performance' possible" option.

Follow these steps to activate the "Make 'high performance' possible" option:

1. Select the PROFINET IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain".
3. Enable the "Make 'high performance' possible" option.

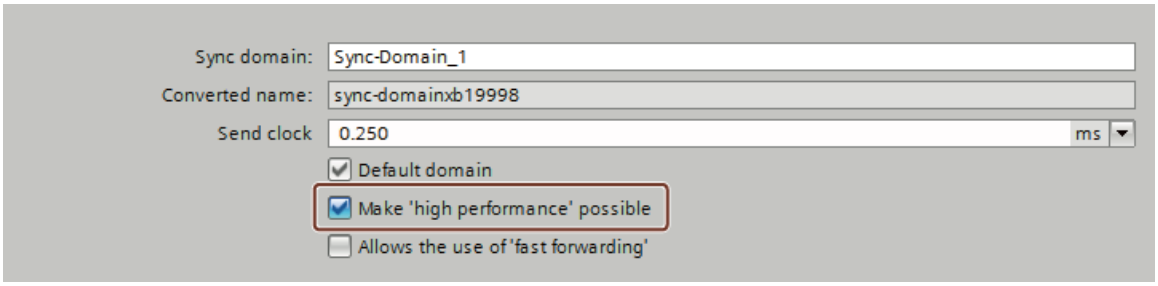

Figure 3-683 Activating high performance

Using more bandwidth for cyclic IO data

Requirement: The "Make 'high performance' possible" option is enabled.

To set more bandwidth for cyclic IO data for your PROFINET IO system, follow these steps:

1. Select your IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain" > "Details".

3. In the drop-down list, select "Maximum 90% cyclic IO data. Focus on cyclic IO data".

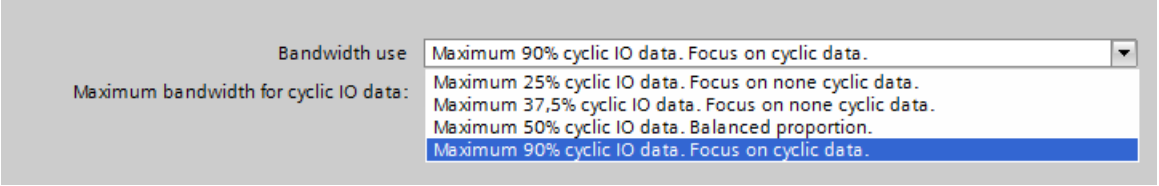

Figure 3-684 Using more bandwidth for cyclic IO data

NOTE

Bandwidth usage in isochronous mode

If you operate your PROFINET IO system in isochronous mode, avoid using the setting for the bandwidth usage "Maximum 90% cyclic IO data. Focus on cyclic IO data."

Setting low send clocks (example CPU 1518-4 PN/DP)

Requirement: The "Make 'high performance' possible" option is enabled.

1. Select the PROFINET IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain".
3. Select the send clock for "Send clock" in the drop-down list.

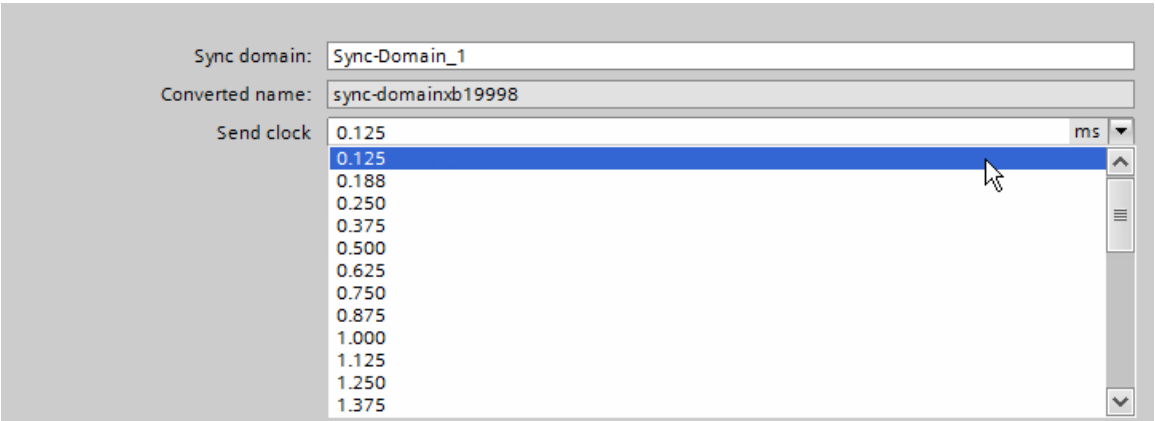

Figure 3-685 Setting low send clocks

Optimizing port settings for low send clocks

You can further optimize the bandwidth use in your PROFINET IO system by using cables with a short cable length (< 20 m) or a short signal delay (max. 0.12 µs) between the devices.

To configure cables with a shorter length or signal delay in STEP 7, follow these steps:

1. Select the port in the topology view of STEP 7.
2. Navigate in the Inspector window to "Port interconnection" in the "Partner port" box.

3. Select the option "Cable length" or "Signal delay:".
4. Select the cable length or enter the signal delay.

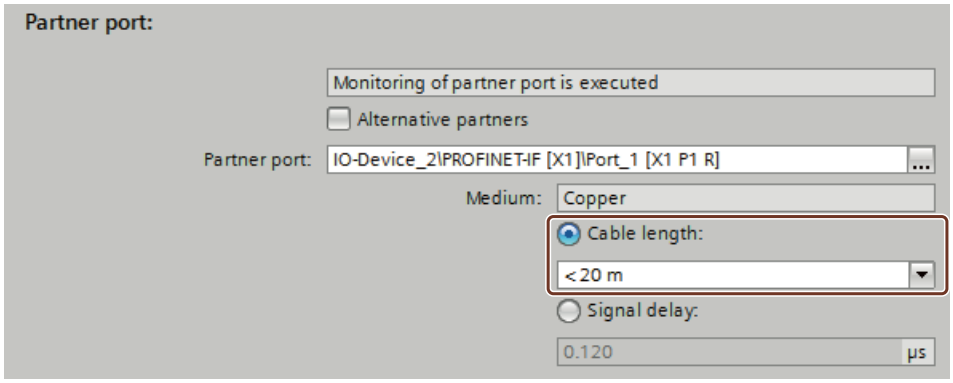

Figure 3-686 Optimizing port settings for low send clocks

Allowing fast forwarding

Requirements:

- The PROFINET IO device has to support the fast forwarding process so that the process can be used by the device.
- The "Make 'high performance' possible" option is enabled.
- The PROFINET IO interface supports fast forwarding if all the ports except one are deactivated.

Follow these steps to allow fast forwarding:

1. Select the PROFINET IO system in the network view of STEP 7.
2. In the Inspector window, go to "Properties" > "General" > "PROFINET" > "Domain management" > "Sync domains" > "Name of the sync domain".
3. Enable the "Allows the use of ‘fast forwarding'" option.

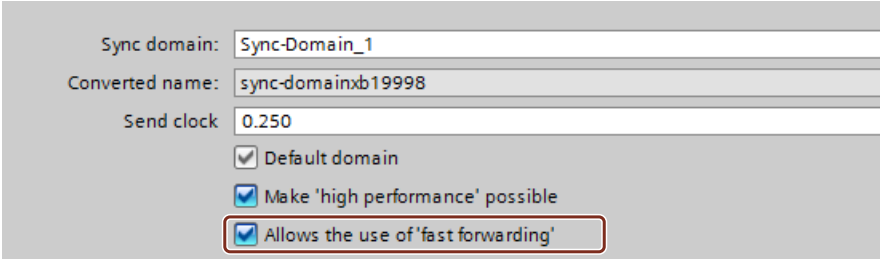

Figure 3-687 Allowing fast forwarding

NOTE

Fast forwarding and IPv6

The operation of fast forwarding in combination with IPv6 is not supported.

As soon as an IO device in the subnet uses an IPv6 address, you must not activate "fast forwarding".

7.6.5 Sample configuration for IRT with high performance

The figure below shows an example configuration with which you can achieve maximum performance.

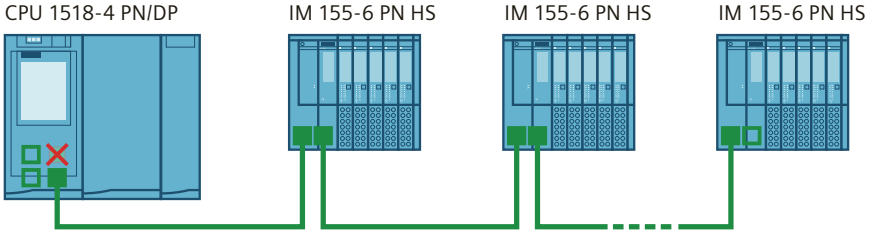

✕ Port 1 of the X1 interface of the CPU is deactivated.

■ Port 2 of the X1 interface and the ports of the interface modules on the bus use the following setting: Medium copper, cable length < 20 m or signal delay max. 0.12µs

□ A programming device connection to the CPU can be established via the interfaces X2 and X3 of the CPU or via the free port at the end of the line.

Figure 3-688 Example configuration for IRT with high performance

Use the following settings for the Sync domain:

- Enable the "Make 'high performance' possible" option.
- Set the send clock to 125 µs.
- Enable the "Allows the use of ‘fast forwarding'" option.

Standard Ethernet communication for IRT with high performance

Standard Ethernet communication is still possible even in a PROFINET IO system with high performance. Keep in mind that you first arrange the IRT nodes, as seen from the IO controller, and arrange the standard Ethernet nodes at the end of the line.

With a large volume of data through standard Ethernet communication, it makes sense to reduce the load on your network by separating standard Ethernet communication and cyclic real-time communication. Example: Use the interface X1 for the PROFINET IO communication and a different interface for the standard Ethernet communication.

7.7 Isochronous mode

7.7.1 What is isochronous mode?

Objectives of isochronous operation

PROFINET isochronous mode only works when using PROFINET with IRT.

Data transfer in automation technology is comparable with the transportation of people on public transport. The various road users, such as cars, trucks or buses, use the same traffic routes. This causes delays or bottlenecks when there is an increased volume of traffic. As a result, passengers (PN IOframes) arrive too late at the transfer point and miss their connecting bus (next cycle).

To maintain the specified schedule and reach the stops on their route unhindered, buses need their own lane (PROFINET with IRT) on the road. This lane is reserved exclusively for buses. When the bus schedule (bus clock cycle) is synchronized with the traffic lights (IRT switch) and additional bus lines (star topology), passengers will specifically transfer to their connecting bus. This achieves optimum time and response behavior.

Just-In-Time

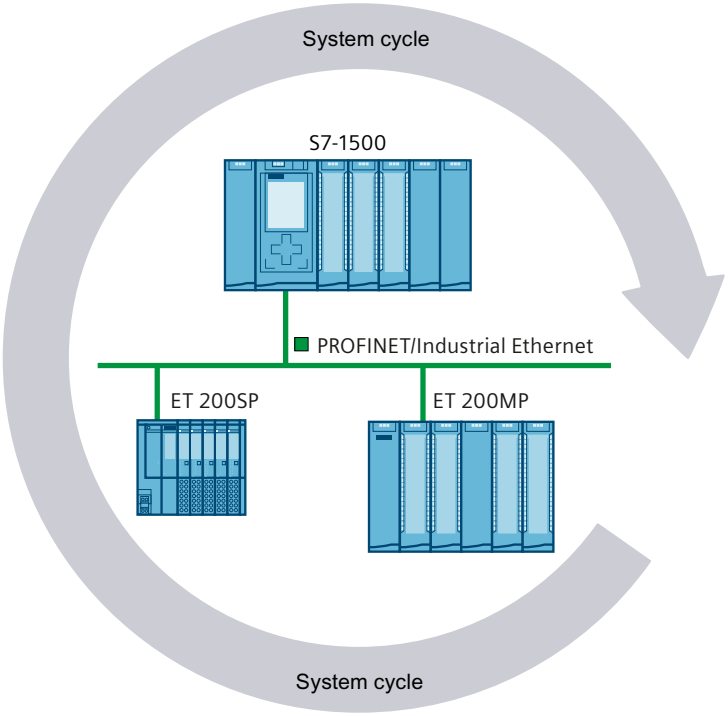

Figure 3-689 System cycle

The fast and reliable response time of a system operating in isochronous mode is due to the fact that all data is provided just-in-time. The basis for this is an equidistant cycle.

The isochronous mode function guarantees synchronization of the following at constant time intervals:

- Signal acquisition and output by the distributed I/O
- Signal transmission via PROFINET IO
- Program execution in the CPU in time with the equidistant PROFINET IO

The result is a system that acquires its input signals, processes them and outputs the output signals at constant time intervals. Isochronous mode guarantees precisely reproducible and defined process response times as well as equidistant and synchronous signal processing for distributed I/O.

Advantages of isochronous mode

The use of isochronous mode allows high-precision control.

- Optimized control loops through constant, calculable dead times
- Determinism, reliable reproducibility of response times
- Consistent (simultaneous) reading in of input data
- Consistent (simultaneous) output of output data

7.7.2 Use of isochronous mode

An isochronous system acquires measured values and process data within a fixed system cycle, processes the signals and outputs them synchronously to the process. Isochronous mode contributes to a high control quality and increased production accuracy. With isochronous mode, the possible fluctuations of process response times are drastically reduced. You make use of the time-assured processing to improve machine cycle times. Even fast processes can be reliably controlled thanks to the precise time reproducibility of all sequences. Shorter cycle times increase the processing speed and help to lower production costs.

In principle, isochronous mode is worthwhile whenever measured values must be acquired synchronously, movements must be coordinated, and process responses must be defined and simultaneously executed, as in the following example. Isochronous mode can thus be used in a wide variety of applications.

Example: Measuring at multiple measurement points with isochronous mode

Automation task

A camshaft production process requires precise measurement of the camshafts for quality assurance purposes.

Feature

For this purpose, a component is needed that can synchronously measure the positions and displacements of the cam during a rotation of the camshaft.

Solution

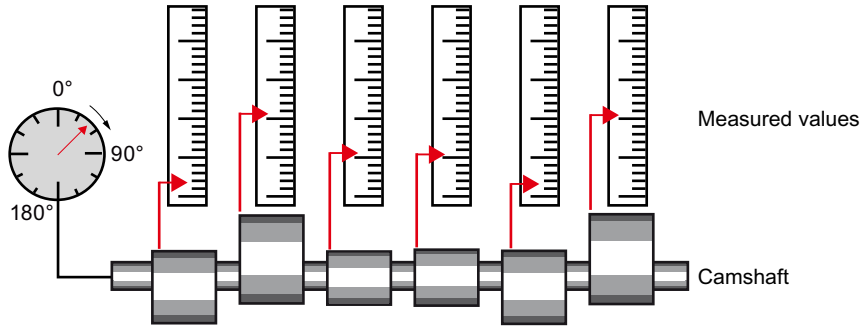

Figure 3-690 Measuring of camshafts

With use of isochronous mode, the measured values are simultaneously acquired at the various measuring points at fixed times. This results in the following workflow:

- Continuously rotate the camshaft
- During continuous rotation, synchronously measure the positions and cam displacements
- Process the next cam shaft

Thus, during a single rotation of the camshaft, all the positions of the camshaft and the associated measured values (red) are measured synchronously. The machine cycle time improves with the same or better measuring accuracy.

Advantage and benefits

The time required for measurement is reduced.

7.7.3 Time sequence of synchronization on PROFINET IO

Introduction

On PROFINET IO, you can isochronously operate I/O modules in distributed I/O systems on a CPU, e.g. in distributed I/O systems ET 200SP, ET 200MP.

Like the I/O modules, the interface modules of the I/O systems must support isochronous mode.

From reading in input data to outputting output data

The basic time sequence of all components involved in synchronization is explained below:

① Measured value acquisition in the process

② Isochronous read-in of input data

③ Transport of input data to the IO controller (CPU) via the subnet

④ Further processing in the isochronous application of the CPU

⑤ Transport of output data to the outputting IO device via the subnet

⑥ Isochronous output of output data

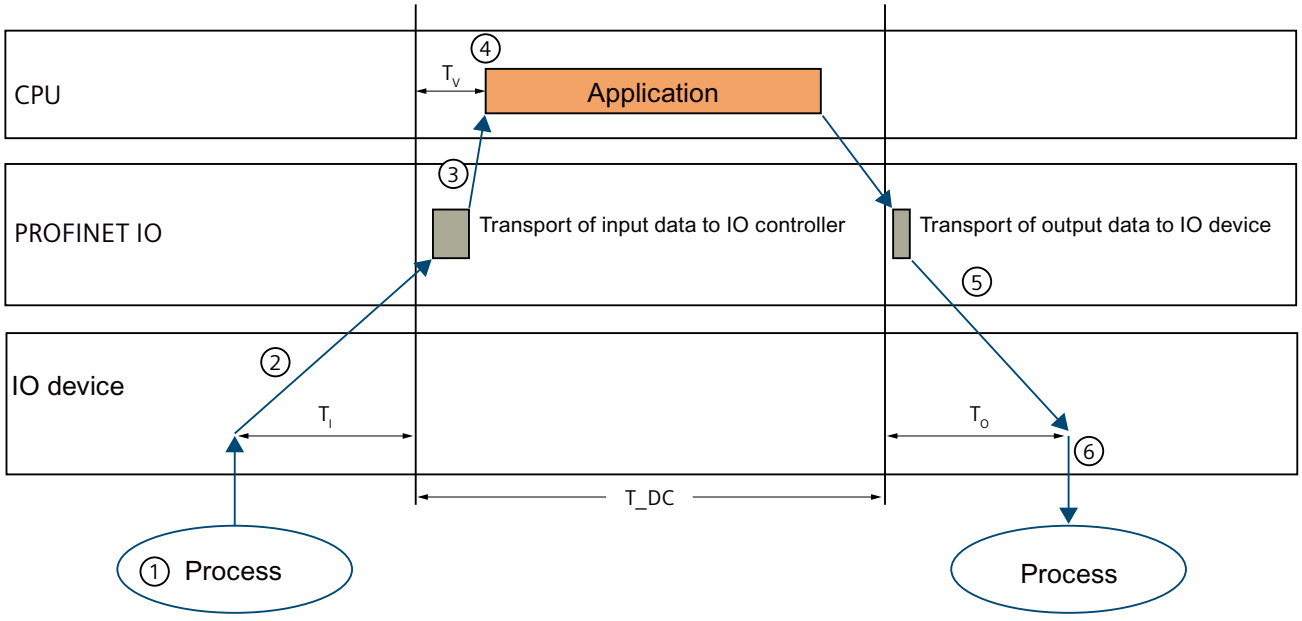

T_DC	Data cycle (Time_DataCycle)
T_I	Time for reading in the input data
T_O	Time for outputting the output data
T_V	Configured delay time

Figure 3-691 Time sequence of synchronization on PROFINET IO

To ensure that all input data is ready for transport via the subnet at the next start of the PROFINET IO cycle, the start of the I/O read-in cycle is advanced by the amount of lead time T_I.

T_I is the "flashbulb" for the inputs; at this instant, all synchronized inputs are read in. T_I is necessary in order to compensate for analog-to-digital conversion, backplane bus times, and the like. The lead time T_I can be configured by STEP 7 or by you. Let the lead time T_I be assigned automatically by STEP 7. With the default setting, STEP 7 ensures that a common, minimum T_I is set.

The subnet transports the input data to the IO controller/DP master. The application is started synchronized to the cycle. That is, the isochronous mode interrupt OB is called after a configurable delay time T_V. The user program in the isochronous mode interrupt OB defines the process response and provides the output data in time for the start of the next data cycle. The length of the data cycle (send clock/DP cycle time) is always configured by you.

T_O is the time for the compensation arising from the backplane bus and the digital-to-analog conversion within the IO device/DP slave. T_O is the "flashbulb" for the outputs. The synchronized outputs are output at this time. Time T_O can be configured by STEP 7 or by you. Let time T_O be assigned automatically by STEP 7. STEP 7 automatically calculates a common, minimum T_O.

7.7.4 Configuring isochronous mode

7.7.4.1 Introduction

Configuring at a glance

Setting parameters for isochronous operation of the I/O module

You use the properties of the I/O addresses of the corresponding I/O module to:

- Set isochronous mode for the module.
- Assign the inputs and outputs of the module to a process image partition and an isochronous mode interrupt OB.

  The data of the process image partition is updated synchronously to the assigned OB. Isochronous mode interrupts give you the option of starting programs isochronously with the PROFINET send clock. Isochronous mode interrupts are processed with high priority.

Setting the send clock

The send clock is the shortest possible transmission interval for the data exchange. In isochronous mode, the send clock corresponds to data cycle T_DC.

You set the send clock in the properties of the PROFINET interface of the CPU or in the sync domain.

Setting the application cycle

The application cycle is a multiple of data cycle T_DC. If the runtime of the isochronous mode interrupt OB is short, the application cycle can be identical to the data cycle (= send clock).

You can reduce the application cycle of the isochronous mode interrupt OB relative to the send clock of an isochronous PROFINET IO system. Set an integer multiple of the send clock as the reducing factor.

You use the factor to reduce the CPU utilization by executing the isochronous mode interrupt OB less frequently. You set the application cycle in the properties of the isochronous mode interrupt OB.

Setting the delay time

The delay time is the time between the start of the send clock and the start of the isochronous mode interrupt OB. During this time, the IO controller performs cyclic data exchange with the IO devices.

STEP 7 sets the default delay time in such a way that the isochronous update of the process image partition automatically falls within the execution window of the application cycle.

You set the delay time in the properties of the isochronous mode interrupt OB. A shorter delay time enables you to increase the processing time for your user program in the isochronous mode interrupt OB.

Additional configurations for isochronous mode on PROFINET IO:

- **Setting IRT as the RT class for the interconnected PROFINET interfaces**

  A precondition for isochronous operation on PROFINET IO is IRT communication (Isochronous Real Time Communication). IRT means synchronized data exchange at reserved time intervals.

- **Configuring the topology of the configuration**

  A precondition for IRT communication is the topology configuration. In addition to the reserved bandwidth, the exchange of frames on defined transmission paths is used for further optimization of data communication. For this, the topological information of the configuration is used for planning the communication.

- **Using a sync domain**, you assign the IO devices (sync slaves) to an IO controller (sync master) for the isochronous data exchange.

  A precondition for IRT communication is a synchronization cycle for all PROFINET devices in a sync domain, for distribution of a common time base. With this basic synchronization, synchronous operation of the transmission cycle of the PROFINET devices within a sync domain is achieved.

7.7.4.2 Configuring isochronous mode on PROFINET IO

Introduction

The configuring of isochronous mode for a module is described as IO device in the following based on the ET 200MP distributed I/O system. The procedure described also applies to other distributed I/O systems (e.g., ET 200S or ET 200SP).

The IO controller is an S7-1500 CPU.

Requirements

- The STEP 7 network view is open.
- A S7-1500 CPU has been placed (e.g., CPU 1516-3 PN/DP).
- An IM 155-5 PN HF interface module (ET 200MP) has been placed and networked with the CPU via PROFINET IO.

- All requirements for an IRT configuration are met:
  - The ports of the networked PROFINET interfaces of the CPU and interface module are interconnected (topology configuration).
  - The RT class of the PROFINET interface of the interface module is set to "IRT" (area "Advanced options > Real time settings > Synchronization").
  - The "sync master" and "sync slave" roles are assigned for the PROFINET interfaces of the CPU and interface module (in the properties of a PROFINET interface: "Advanced options > Real time settings > Synchronization > Domain settings" area).

Procedure

To create an isochronous connection between the I/O and user program, follow these steps:

1. Select the IM 155-5 PN HF in the network view of STEP 7. Change to the device view.
2. Insert an I/O module that can be operated isochronously (e.g. DI 16 x 24VDC HF).
3. Go to the "I/O addresses" area in the Inspector window of the selected I/O module.

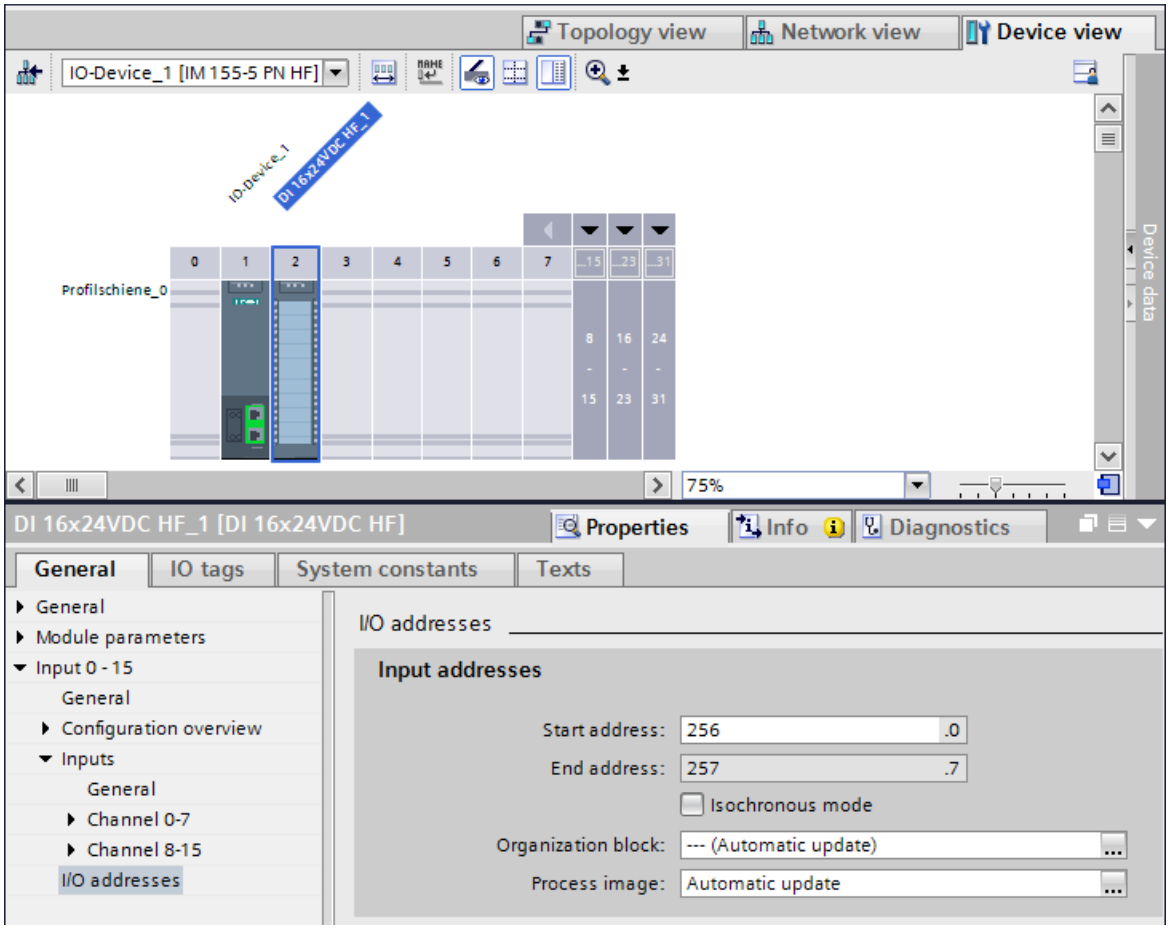

Figure 3-692 Configuring isochronous mode on PROFINET IO

4. Make the following settings in the I/O addresses area:
   - Select the "Isochronous mode" option.
   - Select a process image partition, e.g., process image partition 1.
   - Click the "Organization block" drop-down list. Click the "Add" button or select an existing OB. A dialog box for selecting organization blocks opens.
   - Select the "Synchronous Cycle" OB. Confirm the selection with "OK".

     In the case of automatic number assignment, OB 61 will be generated and opened.

     In the Inspector window, you can continue directly with the setting of the application cycle and delay time (Page 236) in the "Isochronous mode" area and start the programming of the OB in the instruction section.
5. If required, insert additional IO devices in the network view. Adapt the configuration and the settings for the isochronous mode.
6. You want to retrieve information about calculated bandwidths or on adapting the send clock. Select the sync domain in the network view and navigate to the corresponding area of the domain management in the Inspector window.

Reference

You can find examples of parameter assignment and possible settings of isochronous mode for distributed I/O and drives in STEP 7 in this FAQ on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109480489).

7.7.4.3 Setting the application cycle and delay time

Requirements

- You have created an isochronous mode configuration in STEP 7.
- You have created an isochronous mode interrupt OB Synchronous Cycle (OB 6x).
- The isochronous mode interrupt OB is open.

Setting the application cycle

The application cycle is a multiple of data cycle T_DC (send clock). You use the application cycle setting to reduce the CPU utilization caused by execution of the isochronous mode interrupt OB. In the following example, the OB is called only after every 2nd data cycle T_DC in the CPU.

To set the application cycle for your isochronous mode application, follow these steps:

1. Open the "Properties" dialog of the isochronous mode interrupt OB under consideration.
2. In the area navigation, click the "Isochronous mode" group .

3. Set the application cycle in "Application cycle (ms)". Open the drop-down list box and select the application cycle. The drop-down list offers multiples of data cycle T_DC as possible values for the application cycle. Data cycle T_DC is set to 2 ms in the following figure.

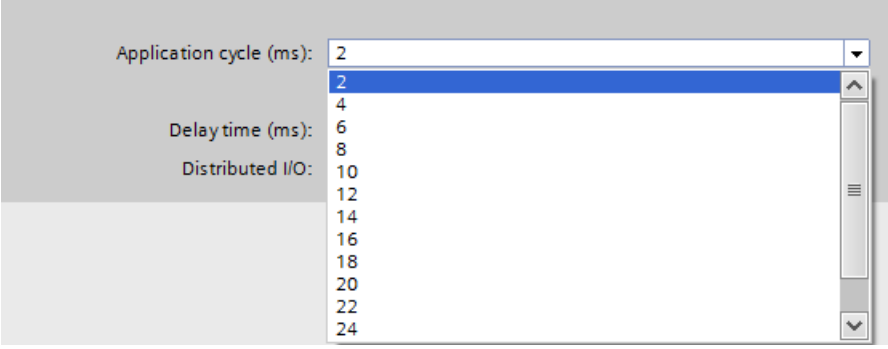

Figure 3-693 Setting the application cycle

Setting the delay time

The delay time is the time between the start of the send clock and the start of the isochronous mode interrupt OB. STEP 7 sets the delay time automatically to the start of the execution window by default. As a result, the isochronous mode update of the process image partition automatically falls within the execution window of the application cycle.

You can also set the delay time manually. A shorter delay time enables you to increase the processing time for your user program in the isochronous mode interrupt OB. If a manual setting is made, note that you must call the "SYNC_PI" and "SYNC_PO" instructions in the execution window of the application cycle.

To set the delay time for your isochronous mode application, follow these steps:

1. Open the "Properties" dialog of the isochronous mode interrupt OB under consideration.
2. In the area navigation, click the "Isochronous mode" group .
3. Clear the "Automatic setting" check box.
4. Enter your desired delay time in "Delay time (ms)".

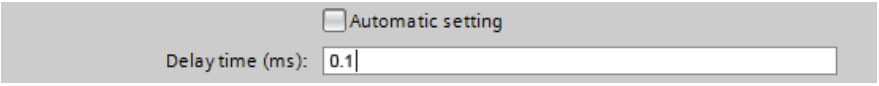

Figure 3-694 Setting the delay time

7.7.5 Programming isochronous mode

7.7.5.1 Basics of Programming

Programming in the isochronous mode interrupt OBs

You program the isochronous section of the program exclusively in the isochronous mode interrupt OBs Synchronous Cycle (OB 6x).

Because the isochronous mode interrupts are processed with high priority, only the time-critical sections of the program should be processed in the isochronous mode interrupt OB. The isochronous mode interrupt OB is called with a configured delay time.

Access to isochronous I/O through call of instructions

You access the isochronous I/O via a process image partition. That is, the addresses of the isochronous modules must be within one process image partition.

You program access to the isochronous IO in isochronous mode interrupt OB Synchronous Cycle (OB 6x) with the SYNC_PI and SYNC_PO instructions.

The isochronous I/O is updated by the call of the "SYNC_PI" and "SYNC_PO" instructions and therefore in the corresponding process image partition.

NOTE

Recommendation: To prevent inconsistent data from being returned to OB 6x, do not use the "DPRD_DAT" and "DPWR_DAT" instructions (direct data access) in the isochronous mode interrupt OB.

The "SYNC_PI" and "SYNC_PO" instructions update the process image partition only within the permitted execution window. The execution window stretches from the end of the cyclic data exchange to the point in time before the end of T_DC at which the outputs can still be copied in time. The data exchange must be started within this time window. If the execution window is violated by the processing of the "SYNC_PI" and "SYNC_PO" instructions, the instructions indicate a corresponding error message.

Program execution models

Depending on the order of the "SYNC_PI" and "SYNC_PO" instruction calls in OB 6x, there are two basic models for the program execution:

- **IPO** model (read **I**nputs - **P**rocessing - write **O**utputs)
- **OIP** model (write **O**utputs - read **I**nputs - **P**rocessing)

7.7.5.2 Program execution according to the IPO model

If the execution time of the isochronous mode interrupt OB is significantly shorter than one data cycle T_DC, use the IPO model. In the IPO model, you do not reduce the data cycle. That is, the application cycle of the isochronous mode interrupt OB is equal to data cycle T_DC.

The IPO model enables the shortest response times.

Programming according to the IPO model in the isochronous mode interrupt OB

For programming according to the IPO model:

1. Call the SYNC_PI instruction at the start of the isochronous mode interrupt OB.
2. Then call the actual user program.
3. Call the SYNC_PO instruction at the end of the isochronous mode interrupt OB.

Table 3-965 Programming according to the IPO model

Step	Action	Explanation
1	Read in (I)	The SYNC_PI instruction reads in the inputs of the process image partition and provides them to the isochronous mode interrupt OB.
2	Process (P)	You program the actual user program of the isochronous mode interrupt OB.
3	Output (O)	The SYNC_PO instruction outputs the data changed by the user program via the process image partition.

Signal sequence in the IPO model

The following figure shows the signal sequence in the IPO model from the acquisition and the processing in the CPU to the output of the process values:

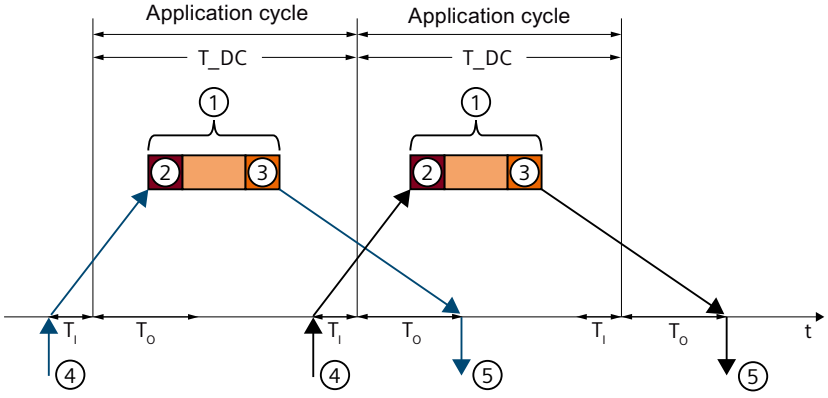

① Execution of isochronous mode interrupt OB

② "SYNC_PI" instruction

③ "SYNC_PO" instruction

④ Isochronous read-in of process values on I/O module at time T_I

⑤ Isochronous output of process values on I/O module at time T_O

Figure 3-695 Signal sequence in the IPO model

At time T_I the process values are read in isochronously on the I/O. The processing of the data in the IPO model is completed within one data cycle T_DC. The output data is always available on the I/O in the next data cycle T_DC at time T_O.

With the IPO model, there is a constant execution time from the "input terminal" to the "output terminal" of T_I + T_DC + T_O.

T_I + 2×T_DC + T_O can be guaranteed for the process response time.

7.7.5.3 Program execution according to the OIP model

Use the OIP model in the case of execution cycles of the isochronous mode interrupt OB of different lengths, if the application cycle is greater than data cycle T_DC.

The data exchange with the process is always deterministic in the OIP model, i.e. takes place at a precisely specified time.

Programming according to the OIP model in the isochronous mode interrupt OB

For programming according to the OIP model:

1. Call the SYNC_PO instruction at the start of the isochronous mode interrupt OB.
2. Then call the SYNC_PI instruction.
3. Then call the actual user program.

Table 3-966 Programming according to the OIP model

Step	Action	Explanation
1	Output (O)	The SYNC_PO instruction outputs the data that was changed by the user program in the previous cycle via the outputs of the process image partition.
2	Read in (I)	The SYNC_PI instruction reads in the inputs of the process image partition of the current cycle and provides the inputs to the isochronous mode interrupt OB.
3	Process (P)	You program the actual user program of the isochronous mode interrupt OB.

Signal sequence in the OIP model

The following figure shows the signal sequence in the OIP model from the acquisition of process values and the processing in the CPU to the output of the process values. The application cycle is twice as long as data cycle T_DC in this example.

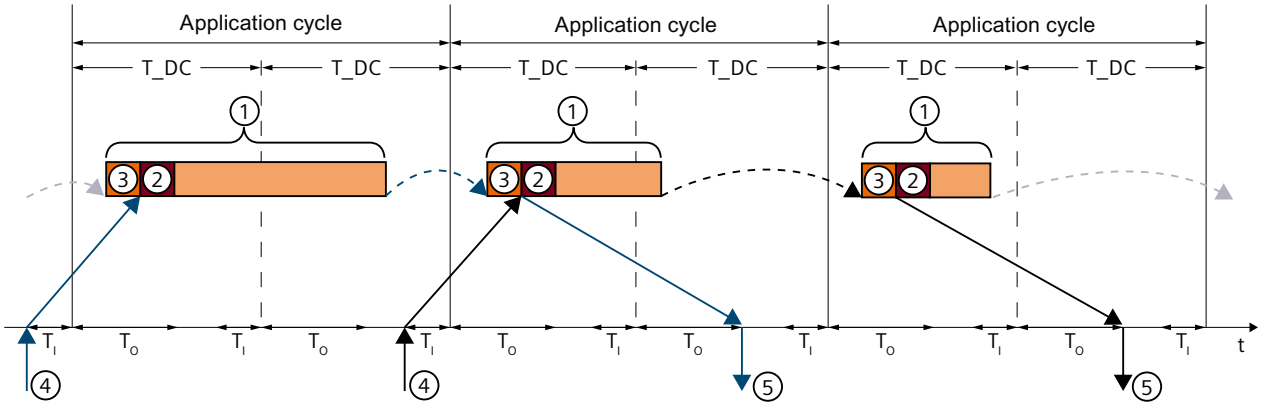

① Execution of isochronous mode interrupt OB

② "SYNC_PI" instruction

③ "SYNC_PO" instruction

④ Isochronous read-in of process values on I/O module at time T_I

⑤ Isochronous output of process values on I/O module at time T_O

Figure 3-696 Signal sequence in the OIP model

At time T_I the process values are read in isochronously on the I/O. The data is processed over 2 application cycles in the OIP model. The output data is always available on the I/O in the following application cycle at time T_DC + T_O.

With the IPO model, there is a constant execution time from the "input terminal" to the "output terminal" of T_I + application cycle + T_DC + T_O.

T_I + 2 x application cycle + T_DC + T_O can be ensured as the process response time.

7.7.6 Operating multiple PROFINET networks in isochronous mode

7.7.6.1 Useful information on the operation of several PROFINET networks in isochronous mode

Introduction

If several PROFINET interfaces of a S7-1500 CPU support the functionality "PROFINET with IRT", you can operate a separate PROFINET network in IRT mode at these PROFINET interfaces. Each PROFINET network has its own sync domain, for which a separate sync master must be configured. You determine the synchronization roles of the devices and the send clock in the sync domain settings of the PROFINET networks. You can use the following PROFINET interfaces, for example, as the sync master:

- Integrated PROFINET interface, e.g. X1 of the CPU
- PROFINET interface, e.g. X1 of another CPU in the same PROFINET IO system

Another CPU within the same PROFINET IO system is also considered to be an I-device that has been directly inserted into the project from the hardware catalog in STEP 7 or as a GSD file.

You can operate the various PROFINET networks for isochronous applications using the following options:

- Independently of each other with separate send clock.
- Coupled/synchronized with synchronized send clock for all PROFINET IO systems

The figure below shows a CPU 1517-3 PN with connected PROFINET networks at the PROFINET interfaces X1 and X2. The PROFINET interfaces X1 and X2 of the CPU are configured as sync master for their sync domains.

The PROFINET interface X2 is coupled or synchronized with the set send clock of the PROFINET interface X1.

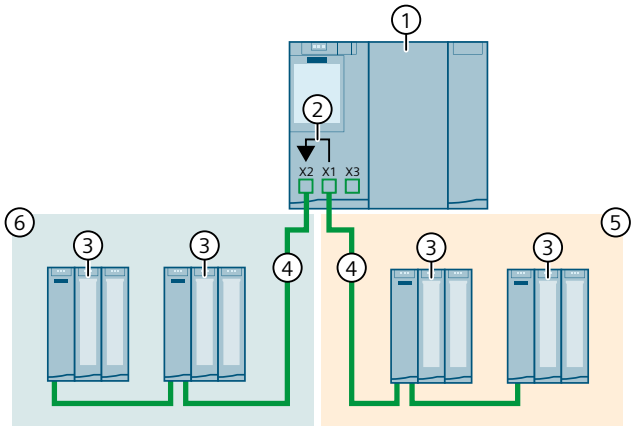

① CPU 1517-3 PN
② Coupling/synchronizing the send clock of the PROFINET interface X1
③ IO device, e.g. ET 200MP
④ PROFINET network at PROFINET interface X1 or X2
⑤ Sync domain of the PROFINET network at PROFINET interface X1
⑥ Sync domain of the PROFINET network at PROFINET interface X2

Coupled operation

In coupled operation, you use 2 PROFINET networks for a shared application. One PROFINET network is connected to the PROFINET interface X1 and the other PROFINET network to the PROFINET interface X2 of the CPU. The two PROFINET interfaces X1 and X2 take on the synchronization role sync master for their sync domain.

In coupled operation, one sync master synchronizes the send clock for its sync domain in a 1:1 ratio, based on the send clock of the other sync master. The 1:1 ratio is set by default as soon as 2 PROFINET networks are operated in isochronous mode.

As the PROFINET networks operate with a coupled send clock, the shared application requires only one isochronous mode interrupt OB (OB 61).

Synchronized operation

In synchronized operation, you use the two PROFINET networks for different applications. Also in this case, the two PROFINET interfaces X1 and X2 take on the synchronization role sync master for their sync domain.

In synchronized operation, a sync master adjusts the send clock for its sync domain proportionally, based on the send clock of the other sync master. The maximum selectable ratio depends on the following factors:

- The default value of the send clock to which the PROFINET interface should synchronize.
- Selected PROFINET interface on the CPU
- Supported send clocks of the devices connected to the PROFINET networks.

Due to the synchronized send clock in a 1 ratio, the send clocks in the two PROFINET networks differ. You need a separate isochronous mode interrupt OB for each send clock. The isochronous mode interrupt OBs 61 to 64 are available in STEP 7.

7.7.6.2 Configuring the synchronization of the send clocks of PROFINET interfaces

Requirements

- STEP 7 as of V20
- The CPU must support the PROFINET functionality "PROFINET with IRT" at the PROFINETinterfaces (X1 and X2). For this reason, use one of the following CPUs:
  - CPU 1517(F)-3 PN
  - CPU 1518(F)-3 PN
  - CPU 1516T(F)-3 PN
  - CPU 1517T(F)-3 PN
  - CPU 1518T(F)-3 PN
- A STEP 7 project is open.
- One of the CPUs mentioned above has been configured.
- A PROFINET network has been configured on each of the PROFINET interfaces X1 and X2 of the CPU.
- STEP 7 displays the network view.

Procedure - Configuring synchronization roles and send clock

To configure the synchronization roles and the send clock in a sync domain in STEP 7, proceed as follows:

1. Select the desired PROFINET network.
2. Navigate in the Inspector window to "PROFINET subnet > Domain management > Sync domains".

3. Make the following settings in the "Devices > I/O devices" area:
   – Assign the synchronization role "Sync Master" to the PROFINET interface of the CPU.
   – Select the RT class "IRT
   " for the required IO devices. The synchronization role changes from "unsynchronized" to "sync slave."
4. Select a suitable send clock from the selection menu in the "Sync domain" area. By default, the send clock is set to a time of 1,000 ms.

Result: You have configured the sync domain of the PROFINET network.

If you want to operate another PROFINET network with IRT at an S7-1500 CPU, then repeat steps 1 to 4 for the other PROFINET network.

Procedure - Synchronizing the send clock with another PROFINET interface

To synchronize the send clock with another PROFINET interface of the CPU, proceed as follows:

1. At the CPU, select the PROFINET interface, e.g. X2, to be synchronized based on the send clock of another integrated PROFINET interface.
2. In the Inspector window, navigate to "Advanced options > Real time settings > Synchronization".
3. Assign the synchronization role "Sync Master" to the PROFINET interface.
4. In the Inspector window, navigate to "Advanced options > Real time settings > IO communication".
5. In the selection menu next to "Alignment of send clock", select the entry "Based on the send clock of the PROFINET interface [X1]".
   STEP 7 adopts by default the send clock of the specifying PROFINET interface.
6. Depending on the application, select another possible send clock from the selection menu next to "send clock".

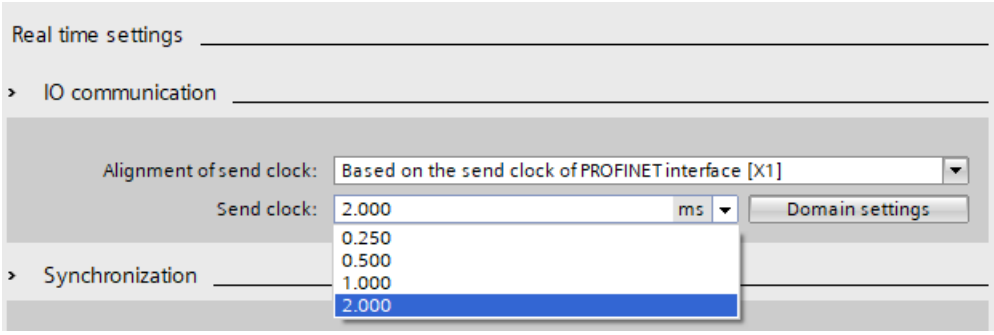

Result: The PROFINET interface X2 is coupled or synchronized with the set send clock of the PROFINET interface X1.

Alternatively, you can also configure the PROFINET interface X2 as the source for the shared send clock and synchronize the send clock of the PROFINET interface X1 to it.

If you change the default value for the send clock, you have to check the send clock settings of the PROFINET interfaces synchronized to it. The displayed send clock is displayed against a red background if the adopted or selected send clock is not supported by the synchronized

PROFINET interface. In this case, click on the selection menu next to "Send clock" and select a valid value.

7.7.6.3 Operating several CPUs in isochronous mode

Introduction

As of STEP 7 V20 you can operate an isochronous application in a CPU with more than one PROFINET network (isochronous coupling of several PROFINET networks). For this, the CPU must support the PROFINET functionality "PROFINET with IRT" at both PROFINET interfaces (X1 and X2) In this case, you can synchronize the send clock of the sync domain of one PROFINET network with another PROFINET network. Consequently, the send clock starts simultaneously, and the application cycle is also synchronized.

Similarly, you can operate multiple CPUs and their connected PROFINET networks in isochronous mode. For this, at a PROFINET interface, one CPU takes over the send clock of the sync domain from the leading PROFINET network. The other PROFINET interface of the CPU synchronizes the adopted send clock for the sync domain of its PROFINET network. During synchronization, the adopted send clock is coupled to the other PROFINET interface in a 1:1 ratio by default. Alternatively, you synchronize the send clock proportionally to the other PROFINET interface.

Synchronization roles during adoption and synchronization of the send clock

Assign one of the following synchronization roles to the PROFINET interface in the leading PROFINET network:

- Sync master:
  The PROFINET interface uses your local send clock.
- Sync slave:
  The PROFINET interface uses the send clock of the PROFINET interface of a further CPU (sync master) in the same PROFINET network.

Assign the synchronization role "sync master" to the synchronizing PROFINET interfaces of the CPUs. In this case, the synchronization of the send clock must be based on the other PROFINET interface of the CPU. This configuration will be referred to as "controlled sync master" in the following sections.

If both PROFINET interfaces of a CPU are configured as sync masters with a local send clock, no synchronization of the connected PROFINET networks will occur.

If you configure both PROFINET interfaces of a CPU as controlled sync master, STEP 7 will display an error message.

Example of the synchronization process

The PROFINET interfaces X1 of the CPUs "Lead" and "Follower" are located in the sync domain of the leading PROFINET network. The PROFINET interface X1 of the "lead" CPU is configured as the sync master with a local send clock in the sync domain. The PROFINET interfaces X1 of the "follower" CPUs are configured as sync slave in the sync domain and are synchronized to the "lead" CPU.

The PROFINET interfaces X2 of the "follower" CPUs are configured as controlled sync master and couple/synchronize the send clock for the sync domains of their connected PROFINET networks.

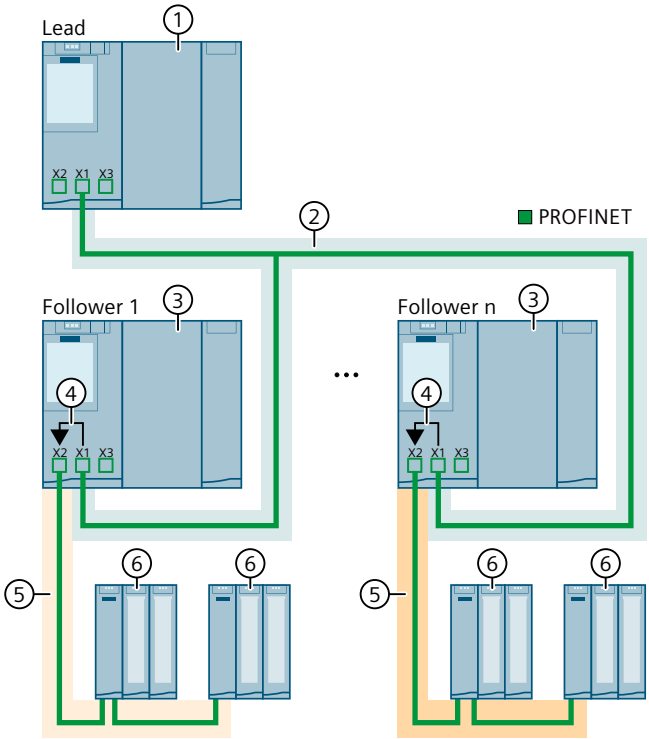

① S7-1500 CPU, PROFINET interface X1 configured as sync master

② Leading sync domain

③ S7-1500 CPU, PROFINET interface X1 configured as sync slave, PROFINET interface X2 configured as controlled sync master

④ Coupling/synchronizing the send clock: In the example, the send clock adjustment of PROFINET interface X2 is based on the send clock of PROFINET interface X1.

⑤ Coupled/synchronized sync domain

⑥ IO device, e.g. ET 200MP

Figure 3-697 Example of the synchronization process

Handling controlled sync masters

A sync slave always automatically synchronizes to the send clock of the sync master. If the sync master fails, a substitute clock of the same length is automatically generated at the sync slave.

The controlled sync master then synchronizes itself to the send clock of the sync slave. A controlled sync master synchronizes itself to the send clock of the sync domain of the leading IRT PROFINET IO system using one of the following options:

- Automatically:
  As soon as the controlled sync master detects a send clock, it synchronizes automatically to this cycle. This is the default response. You cannot influence this response.
- Manually:
  You determine the time of synchronization in the user program and can thus take suitable precautionary measures, e.g. deactivate devices and thus avoid system failures due to the synchronization process.
  The controlled sync master only synchronizes to the send clock when a valid send clock is detected and the corresponding instruction is called up as a start signal in the user program.

If you want to use manual synchronization on a controlled sync master, you must configure the controlling PROFINET interface as a sync slave. A controlling PROFINET interface that is configured as a sync master always generates a valid cycle. Synchronization is therefore not lost.

The instructions required to control and monitor synchronization are described in the following sections.

More information

Information on the exchange of data between the CPUs "Lead" and "Follower" is available in the section Direct data exchange (Page 257).

You can find information on cross-project isochronous mode in the section Operating multiple projects isochronously (Page 250).

7.7.6.4 Programming manual synchronization

Introduction

If a controlled sync master synchronizes to a PROFINET interface configured as a sync slave, you can also specify the time of synchronization in the user program. Define additional precautionary measures to avoid system failures caused by the synchronization process.

To specify manual synchronization in the user program, STEP 7 as of V20 contains the following instructions:

- GetIOSystemSync
- InitIOSystemSync
- StartIOSystemSync

Use these instructions to check the synchronization status and start the synchronization process. You can find these instructions under "Extended instructions > Distributed I/O".

The following sections describe the instructions and show the procedure for a manual synchronization process.

Determine type of synchronization

Use the InitIOSystemSync instruction to determine the type of synchronization. At the input mode, specify whether synchronization should take place manually or automatically. If InitIOSystemSync is not called, automatic synchronization is set by default.

You can find information on the parameters of the instructions in the STEP 7 online help.

Determine status of synchronization

The GetIOSystemSync instruction informs you about the status of synchronization. The SyncMode output displays the type of synchronization that was selected with the InitIOSystemSync instruction. The SyncStatus output displays the status of synchronization. This includes whether a send clock has been detected or whether a send clock is still being awaited.

You can find information on the parameters of the instructions in the STEP 7 online help.

Start synchronization

If you call the StartIOSystemSync instruction in the user program and all requirements are met, synchronization starts. The requirements include, for example, the correct configuration of the PROFINET interfaces. In addition, the GetIOSystemSync instruction must signal at the outputs that manual synchronization has been selected and a valid send clock has been detected.

You can find information on the parameters of the instructions in the STEP 7 online help.

Configuration example of manual synchronization

The figure below shows a configuration example where you can use manual synchronization. The PROFINET interface X1 is configured as the sync master at the "lead" CPU. The sync master uses the local send clock. The PROFINET interface X1 is configured as the sync slave at the "follower" CPU. The sync slave is in the same sync domain of the PROFINET network as the sync master and synchronizes to the send clock. The PROFINET interface X2 of the "follower" CPU is configured as the controlled sync master. The controlled sync master only starts the synchronization to the send clock of the PROFINET interface X1 for the sync domain of its connected PROFINET network once all requirements have been met.

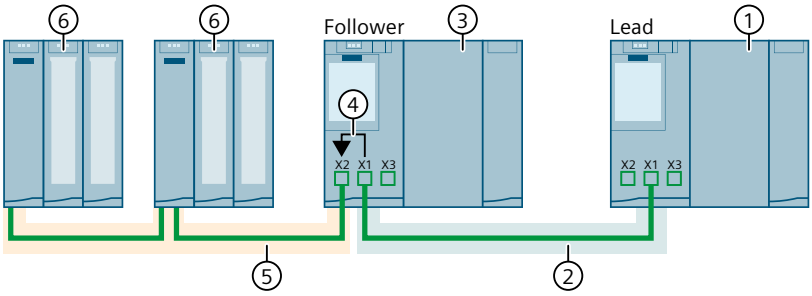

① S7-1500 CPU, PROFINET interface X1 configured as sync master

② Sync domain of the leading PROFINET network

③ S7-1500 CPU, PROFINET interface X2 configured as controlled sync master

④ Coupling/synchronizing the send clock of the PROFINET interface X1

⑤ Sync domain of the coupled/synchronized PROFINET network

⑥ IO device, e.g. ET 200MP

Figure 3-698 Configuration example of manual synchronization

Manual synchronization procedure

The figure below shows the manual synchronization procedure. The instructions and the associated input/output parameters are processed by the user program in the "follower" CPU. If manual synchronization was selected at InitIOSystemSync, the PROFINET interfaces remain synchronized until the connection to the sync master is interrupted. The GetIOSystemSync instruction immediately indicates a connection abort at the output SyncStatus. The StartSystemSync instruction outputs the value "0" at the Ret_Val output and starts manual synchronization only when the following conditions are met:

- The GetIOSystemSync instruction indicates at the output SyncStatus that a send clock has been detected.
- The requirements for starting synchronization manually have been met.

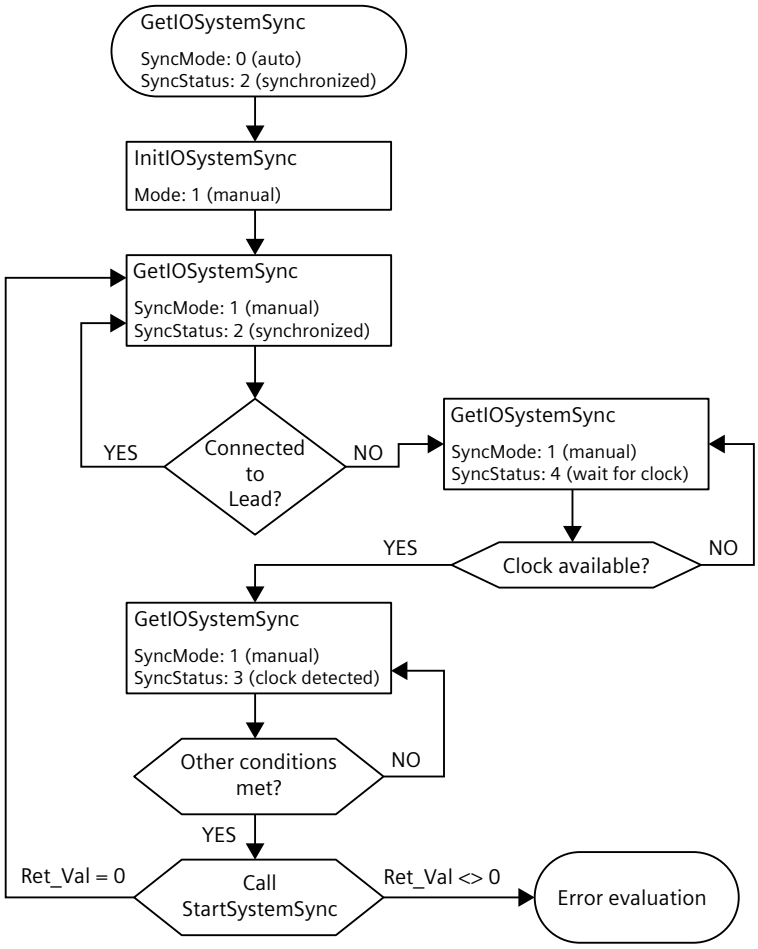

Figure 3-699 Manual synchronization procedure

7.7.7 Operating multiple projects isochronously

With IRT isochronous mode across several projects, you can transfer IRT synchronization from one project to other projects. This allows two CPUs to exchange data isochronously, even though each CPU is used in a separate project. This allows you to, for example, delimit the responsibilities of individual plant parts and create clearly defined interfaces.

To implement cross-project IRT clock synchronization, use one of the following devices:

- PN/PN coupler as of FW version V6.0:
  A PN/PN coupler can connect two subnets isochronously with each other, each of which you use in a separate project. You can use several PN/PN couplers within a subnet.
- Isochronous I-device with an S7-1500 CPU as of FW version V4.1:
  If the CPU supports the "PROFINET with IRT" functionality at several PROFINET interfaces, you can configure the CPU as an isochronous I-device in a separate project. The PROFINET interface configured as an I-device is used for isochronous data exchange with a higher-level IO controller. The other PROFINET interface can synchronize with the I-device interface and operate connected IO devices isochronously.
  In another project, import the I-device as a GSD file and assign the I-device to a higher-level IO controller.

Basics of configuration

In the first project, use the desired device from the hardware catalog and adapt the configuration. Then export the configured device as a GSD file. The exported GSD file is used in other projects as a substitute for the configured device from the first project.

You can read how to implement IRT clock synchronization across several projects with a PN/PN coupler in the Synchronous operation functions (https://support.industry.siemens.com/cs/ww/en/view/109974350) Function Manual.

The following sections describe the cross-project IRT clock synchronization with an S7-1500 CPU as I-device.

7.7.7.1 Cross-project clock synchronization with an I-device

If you want to implement cross-project clock synchronization with an S7-1500 CPU, use an S7-1500 CPU as of FW version V4.1. The CPU must support the "PROFINET with IRT" functionality on several PROFINET interfaces. A PROFINET interface (I-device), e.g. X2 is used for isochronous data exchange with the higher-level IO controller. The other PROFINET interface, e.g. X1 can couple/synchronize to the send clock and use the send clock for its connected PROFINET IO system.

NOTE

Operating a PROFINET interface as an I-device with IRT in isochronous mode

If you configure a PROFINET interface as an I-device with IRT in isochronous mode, this PROFINET interface cannot be an IO controller for IO devices with IRT. IO devices with RT are possible on this PROFINET interface.

Create the following projects in STEP 7 for cross-project clock synchronization with an S7-1500 CPU:

- "I-device" project:
  In this project, you configure an isochronous I-device with a fixed send clock and isochronous applications. To do this, use a PROFINET interface, e.g. X2 an S7-1500 CPU from the hardware catalog.
  If required, you can configure the synchronization of the send clock for both PROFINET interfaces. In this case, the PROFINET interface without I-device functionality, e.g. X1, can synchronize the send clock as a controlled sync master for a lower-level PROFINET IO system.
  You export the configured I-device as a GSD file. The GSD file serves as a substitute for the configured I-device in other projects.
- "IO controller" project:
  In this project, you install the GSD file exported from the "I-device" project. Use the GSD file in this project as a substitute for the I-device on a higher-level IO controller from the hardware catalog.
  An isochronously configured I-device requires clock synchronization in the IO controller. Therefore, in the sync domain settings, select the value for the send clock that was also set in the I-device.

The following figure shows the interaction between the "I-device" project and the "IO controller" project.

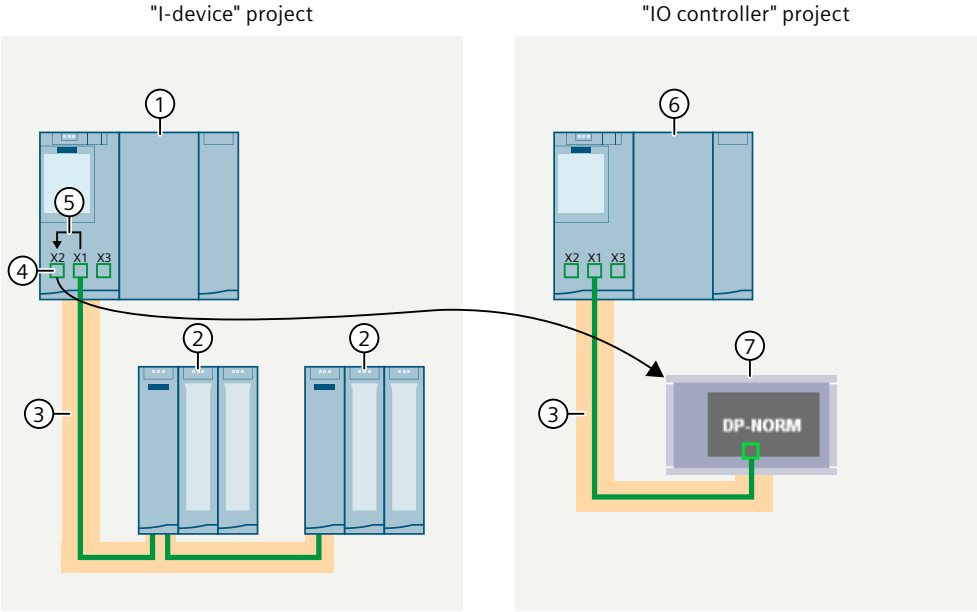

① CPU 1517-3 PN with connected isochronous PROFINET IO system on the PROFINET interface X1.

② IO device, e.g. ET 200MP

③ Sync domain

④ PROFINET interface X2, configured as an isochronous I-device.

⑤ Coupling/synchronizing the send clock of the PROFINET interface X1 (optional)

⑥ IO controller, e.g. CPU 1517-3 PN

⑦ Imported GSD file of the PROFINET interface X2 from the "I-device" project

Figure 3-700 Cross-project clock synchronization with an I-device

The following sections describe the configuration procedures in the "I-device" and "IO controller" projects.

Procedure - "I-device" project

In the "I-device" project, you configure a PROFINET interface, e.g. X2 of the desired CPU as an isochronous I-device. Optionally configure the synchronization of the send clock for the other PROFINET interface without I-device functionality.
You can find information on configuring I-devices in the section Configuring the I-device (Page 134). You can find out how to synchronize the PROFINET interfaces of a CPU in the section Configuring the synchronization of the send clocks of PROFINET interfaces (Page 243).

To use isochronous mode on the I-device, you must enable the option 'Parameter assignment of PN interface by higher-level IO controller' when configuring the I-device. Once you have configured your I-device and synchronized the PROFINET interfaces, configure the clock synchronization for various projects on the I-device as follows:

1. In the network view of STEP 7, select the PROFINET interface configured as an I-device, e.g. X2 of the CPU.
2. Optional, to avoid address conflicts in other projects:
   - In the Inspector window, navigate to the "General > Ethernet addresses" area.
   - In the "Internet Protocol Version 4 (IPv4)" area, select the "IP address is set directly in the device" option.
   - In the "PROFINET" area, activate the "PROFINET device name is set directly at the device" check box.
3. In the Inspector window, navigate to "General > Operating mode > Isochronous mode"
4. Select the "Isochronous mode" check box.
5. Configure the desired transfer areas for isochronous mode as follows:
   - Select a transfer area in the Inspector window under "General > Operating mode > I-device communication", e.g. "Transfer area_1"
     The Inspector window shows the selected transfer area.
   - Select the "Isochronous mode" check box.
   - Select or generate an isochronous mode interrupt OB for the transfer area, e.g. OB 61.

– Select the process image for the transfer area, e.g. PIP 1.

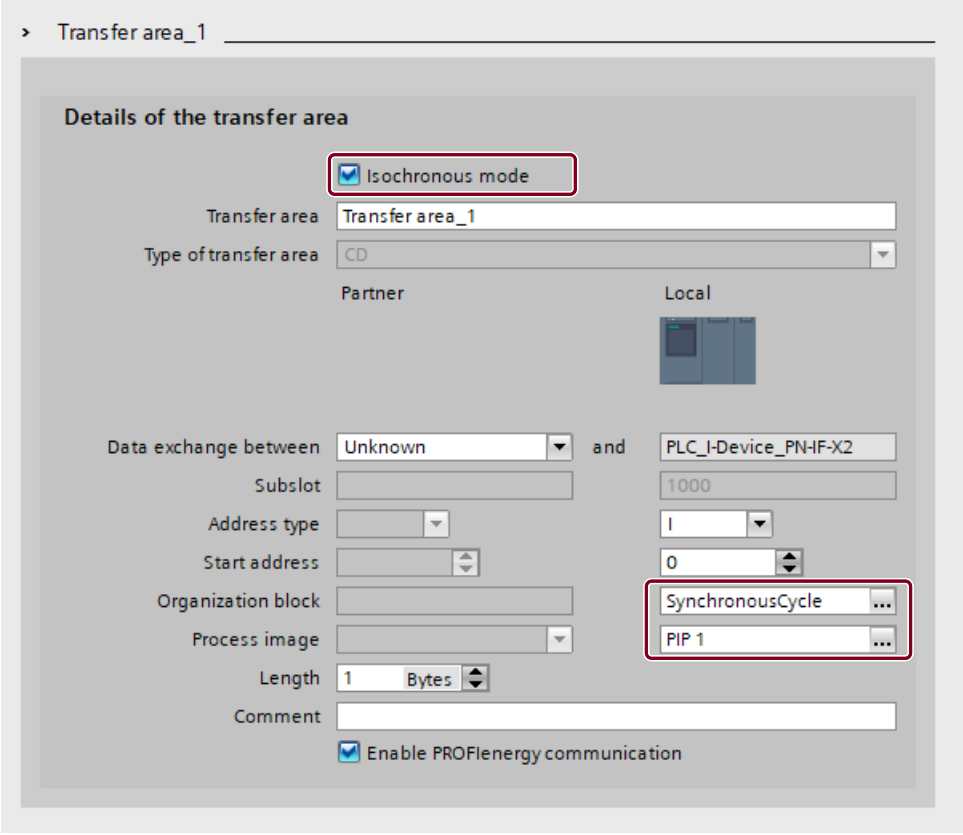

Figure 3-701 Configuring isochronous transfer range on the I-device

6. Repeat step 5 for each additional transfer area that you want to use isochronous mode.
7. In the Inspector window, go to "General > Advanced options > Real time settings".
8. Select the desired send clock.
   For a PROFINET interface that is configured as an I-device, you cannot change the "Alignment of send clock" option.
9. Compile the CPU configured as an I-device.
   The export as GSD file only works immediately after the compiling process. If you change the configuration, you need to compile the CPU configured as an I-device again.
   The "Export" button in the "Operating mode > I-device communication > Export device description file (GSD)" area can be selected.
10. Click the "Export" button
    The export dialog opens.
11. Assign a name for the I-device proxy as well as a description and a storage location (path) in the fields provided.
12. Click the "Export" button to complete the process.

Result: You have configured the I-device for isochronous mode in various projects and exported it as a GSD file.

Procedure - "IO controller" project

In the "IO controller" project, use the previously configured isochronous I-device as a GSD file on a higher-level IO controller.

To assign the imported I-device to a higher-level IO controller and configure the clock synchronization, proceed as follows:

1. Install the GSD file exported from the "I-device" project in STEP 7.
2. Add an IO controller (e.g. CPU 515-2 PN) from the hardware catalog in the network view using drag-and-drop.
3. Add the imported I-device from the hardware catalog using drag-and-drop.
   You can find information on the imported I-device under "Other field devices > PROFINET IO > PLCs & CPs > Siemens Aktiengesellschaft"
4. Connect the PROFINET interface of the I-device to the desired PROFINET interface of the IO controller.
5. Select the PROFINET network.
6. In the Inspector window, navigate to "PROFINET subnet > Domain management > Sync domains".
7. Make the following settings in the "Devices > IO devices" area:
   - Assign the "Sync master" synchronization role to the PROFINET interface of the IO controller.
   - Select the RT class "IRT" for the I-device.
     The synchronization role changes from "Unsynchronized" to "Sync Slave".
8. In the "Sync domain" area, select the same send clock that you selected in the I-device configuration.
9. Switch to the device view of the I-device.
10. Configure the isochronous transfer areas as follows:
    - Select a transfer area in the "Device overview" area, e.g. "Transfer area_1".
    - In the Inspector window, navigate to the "General > I/O addresses" area.
    - Select or generate an isochronous mode interrupt OB for the transfer area, e.g. OB 61.

– Select the process image for the transfer area, e.g. PIP 1.

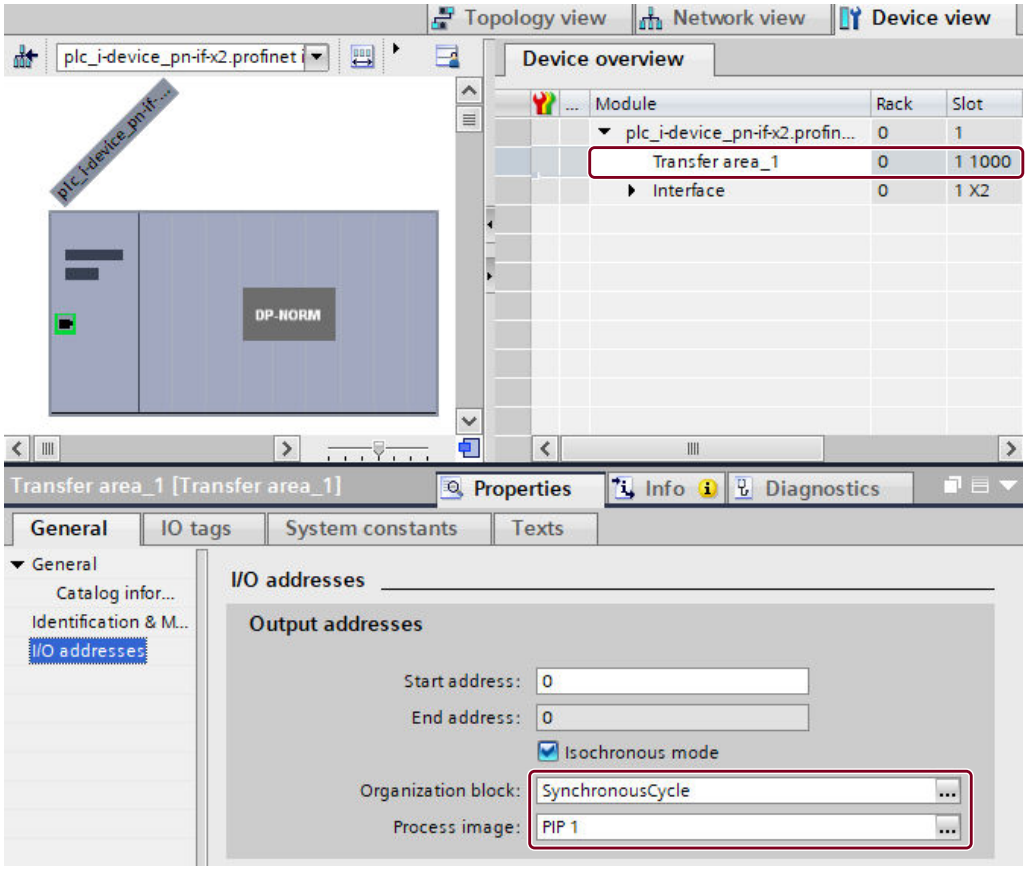

Figure 3-702 Configuring isochronous transfer range on the imported I-device

11. Repeat step 10 for each additional transfer area that you want to use isochronous mode.

12. Change to the topology view.

13. Configure the topology between the IO controller and I-device.

Result: You have assigned the imported I-device to a higher-level IO controller and configured the clock synchronization.

Set the same send clock in all projects

The send clock set in the I-device ("I-device" project) must match the send clock of the higher-level IO controller ("IO controller" project).

If you want to change the send clock at a later date, you do not need to export and import the I-device again. To change the send clock, proceed as follows:

1. Change the send clock in the I-device project.
2. In the I-device project, adjust the time for the application cycle in the isochronous mode interrupt OB.

3. Load the changes to the I-device CPU.
4. Change the send clock in the IO controller project.
5. In the IO controller project, adjust the time for the application cycle in the isochronous mode interrupt OB.
6. Load the changes into the higher-level IO controller.

Result: You have changed the send clock and loaded it into the I-device and the higher-level IO controller.

7.8 Direct data exchange

7.8.1 Introduction

This section describes the direct data exchange function.

Principle of operation

Starting with firmware version V2.8, the S7-1500 CPU supports direct data exchange (cross data traffic) with other S7-1500 CPUs.

In the case of direct data exchange, an S7-1500 CPU provides cyclic user data from the I/O area to one or more partners. The direct data exchange is based on PROFINET with IRT and isochronous mode.

The data exchange takes place via transfer areas.

Direct data exchange between two S7-1500 CPUs (1:1)

The figure below shows the direct data exchange between two S7-1500 CPUs. The output transfer areas of the sending S7-1500 CPU correspond to the input transfer areas of the receiving S7-1500 CPU.

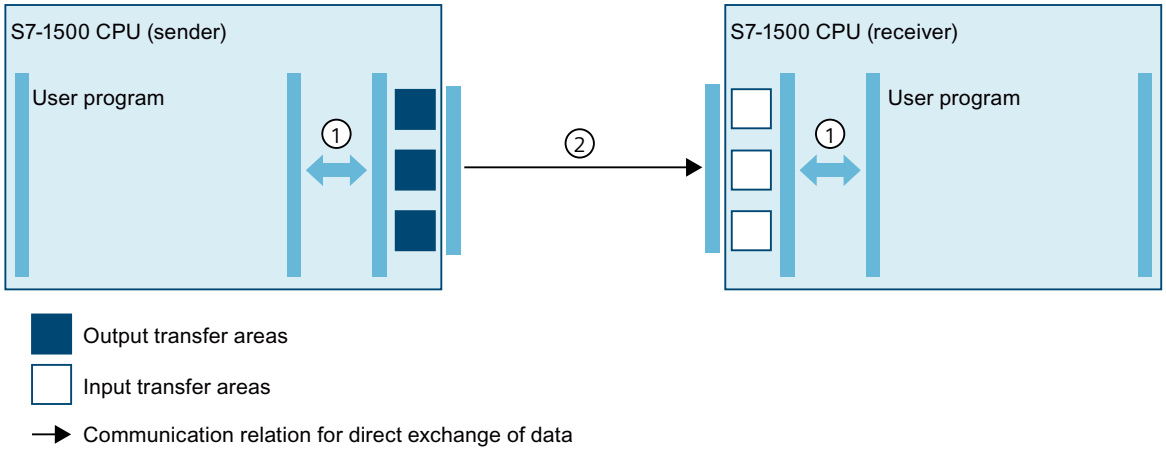

① Transfer relation between the user program and the transfer area. The user program and the transfer areas exchange input and output data via this path.

② Communication relation for direct data exchange You configure the communication relations in STEP 7. You create transfer areas for direct data exchange in the properties of the communication relations.

Figure 3-703 Direct data exchange between two S7-1500 CPUs (1:1)

Direct data exchange with multiple receivers (1:n)

The following figure shows the direct data exchange with multiple S7-1500 CPUs. In this case, the sending S7-1500 CPU provides the data of its output transfer areas to multiple S7-1500 CPUs. Each receiving S7-1500 CPU has its own input transfer areas.

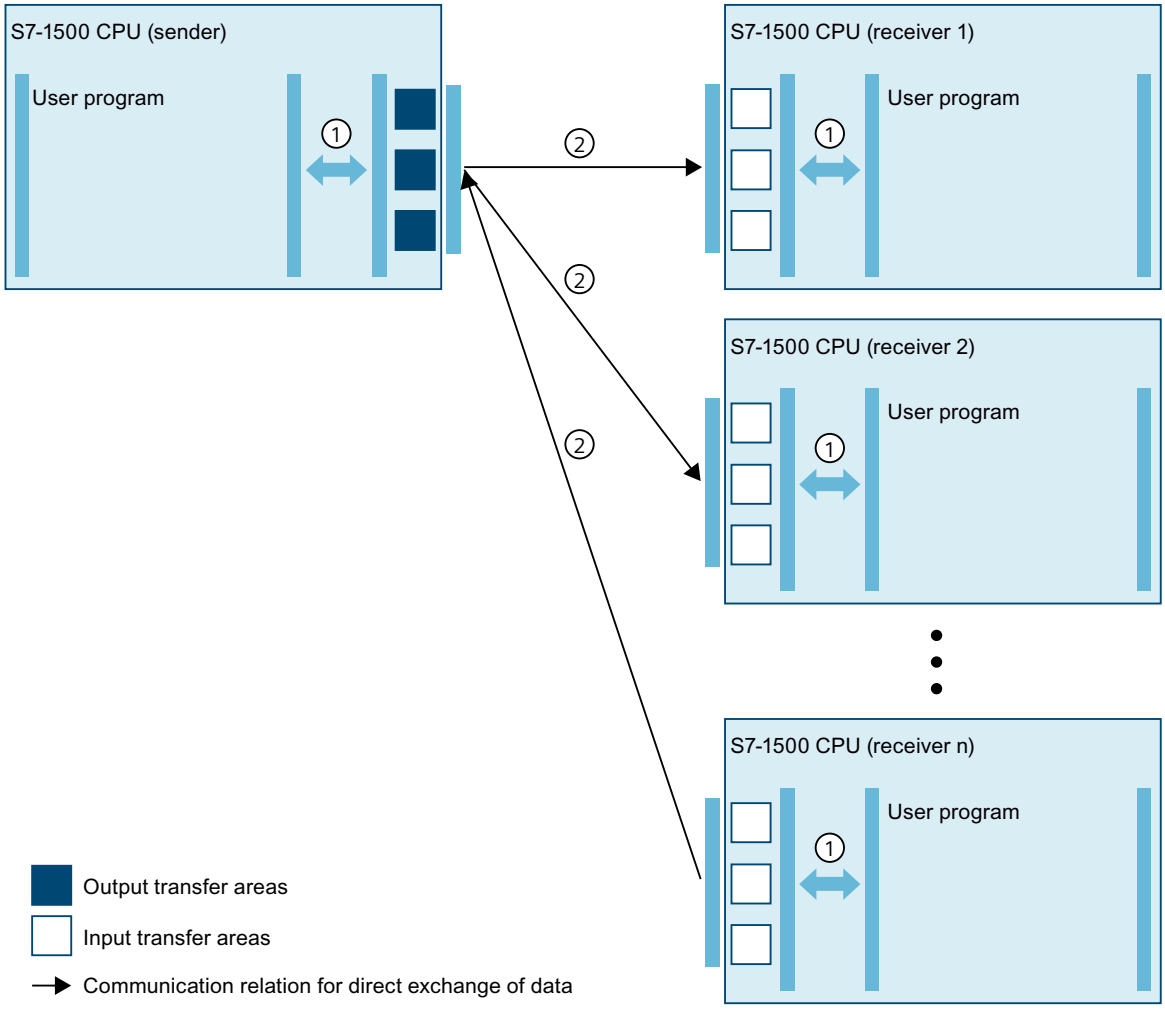

① Transfer relation between the user program and the transfer area. The user program and the transfer areas exchange input and output data via this path.

② Communication relation for direct data exchange You configure the communication relations in STEP 7. You create transfer areas for direct data exchange in the properties of the communication relations.

Figure 3-704 Direct data exchange with multiple receivers (1:n)

Applications

- Deterministic, isochronous I/O communication between multiple S7-1500 CPUs

Properties of direct data exchange

- Always isochronous
- Support of MRPD for MRP configuration
- No acyclic data exchange via PROFINET data record mechanisms
- No PROFINET alarms
- Configuration limits:
  - Maximum data length for direct data exchange 3075 bytes including user data qualifier
  - Maximum data length for a transfer area: 1024 bytes without user data qualifier
  - Maximum number of transfer areas of sender: 128
  - Maximum number of transfer areas of receiver: 512, distributed among a maximum of 64 receivable PROFINET frames and thus up to 64 sender CPUs

Diagnostics options of the receiver

Operating state change of sender:

- When the sender goes from RUN to STOP, the receiver behaves as follows:
  - The "SYNC_PI" and "SYNC_PO" instructions return an error message in parameter RET_VAL during synchronization of the process image.
  - With direct I/O access to the input transfer areas of the direct data exchange, OB 122 "I/O access error" is called, if present.
  - Incoming diagnostic message "I/O data failure in hardware component"
- When the sender goes from STOP to RUN, the receiver behaves as follows:
  - Call of OB 83 "Pull/plug interrupt" for input transfer areas of the direct data exchange
  - Up until the call of OB 83, OB 122 is called if present.
  - Outgoing diagnostic message "User data failure of hardware component"

Station failure/station recovery of the sender:

- When the sender fails, e.g. due to a bus interruption, the receiver behaves as follows:
  - Call of OB86 "Rack failure"
  - The "SYNC_PI" and "SYNC_PO" instructions return an error message in parameter RET_VAL during synchronization of the process image.
  - With direct I/O access to the input transfer areas of the direct data exchange, OB 122 "I/O access error" is called, if present.
- When the sender recovers after a station failure, e.g. because the bus connection is re-established, the receiver behaves as follows:
  - Call of OB86 "Rack failure"

7.8.2 Configuring direct data exchange between two S7-1500 CPUs

The procedure for configuring direct data exchange between two IO controllers is described below.

First, you create the communication relation for direct data exchange. You then configure transfer areas for the connection.

Requirements

- STEP 7 V16 or higher
- Two S7-1500 CPUs firmware version V2.8 or higher
- IRT is configured:
  - Both CPUs are in one sync domain.
  - One CPU is the sync master, and the other CPU is the sync slave.
  - Ports are interconnected.

Setting up the communication relation for direct data exchange

To set up the communication relation for direct data exchange between two S7-1500 CPUs, follow these steps:

1. Select the PROFINET interface X1 of the sending S7-1500 CPU.
2. Change to the table view of the network view, tab "I/O communication".
   The PROFINET interface X1 of the CPU is shown in the "Partner 1" column.
3. In the "Partner 2" column at "<Drop or select the device here>", select the PROFINET interface of the communication partner from the drop-down list as the connection partner.
   Note the communication direction:
   - ←: Communication partner is sender
   - →: Communication partner is receiver

The communication relation for direct data exchange between the two S7-1500 CPUs is set up.

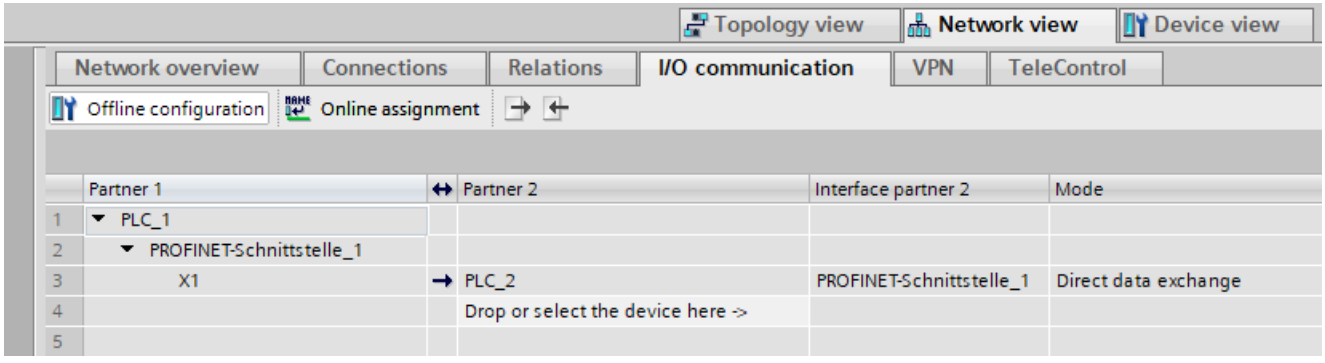

Figure 3-705 Communication relation for direct data exchange

Configuring transfer areas for direct data exchange

To configure a transfer area for direct data exchange, follow these steps:

1. Select the communication relation for direct data exchange.

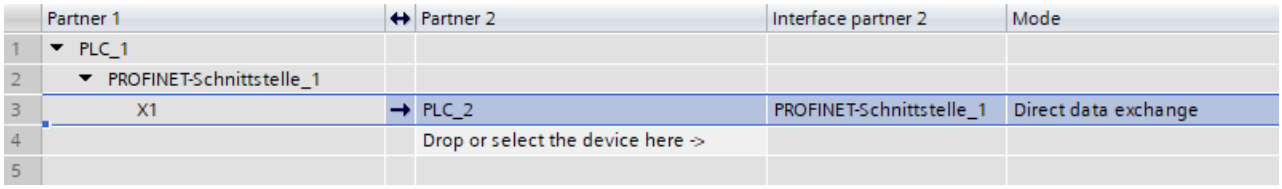

Figure 3-706 Communication relation for direct data exchange

2. Navigate to the properties of the communication relation to "General" > "Direct data exchange" > "Transfer areas".
3. Create a new transfer area by double-clicking on "<Add new>". Assign a meaningful name for the transfer area.

A transfer area for direct data exchange is created.

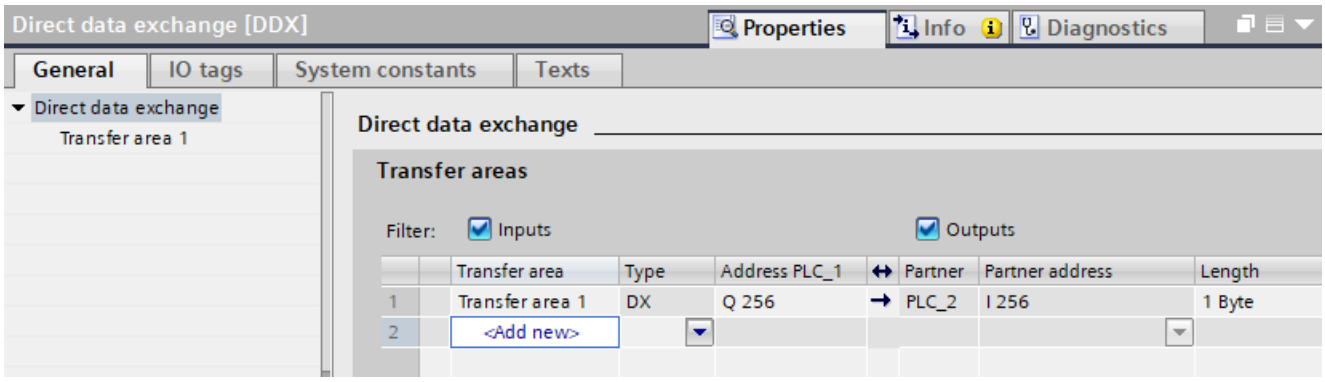

Figure 3-707 Transfer area for direct data exchange

The communication direction of the transfer area is specified by the communication relation. You cannot change the communication direction of the transfer area.

Editing the transfer area

Set the properties of the transfer area under "General" > "Direct data exchange" > "Name of transfer area" > "Detail of the transfer area".

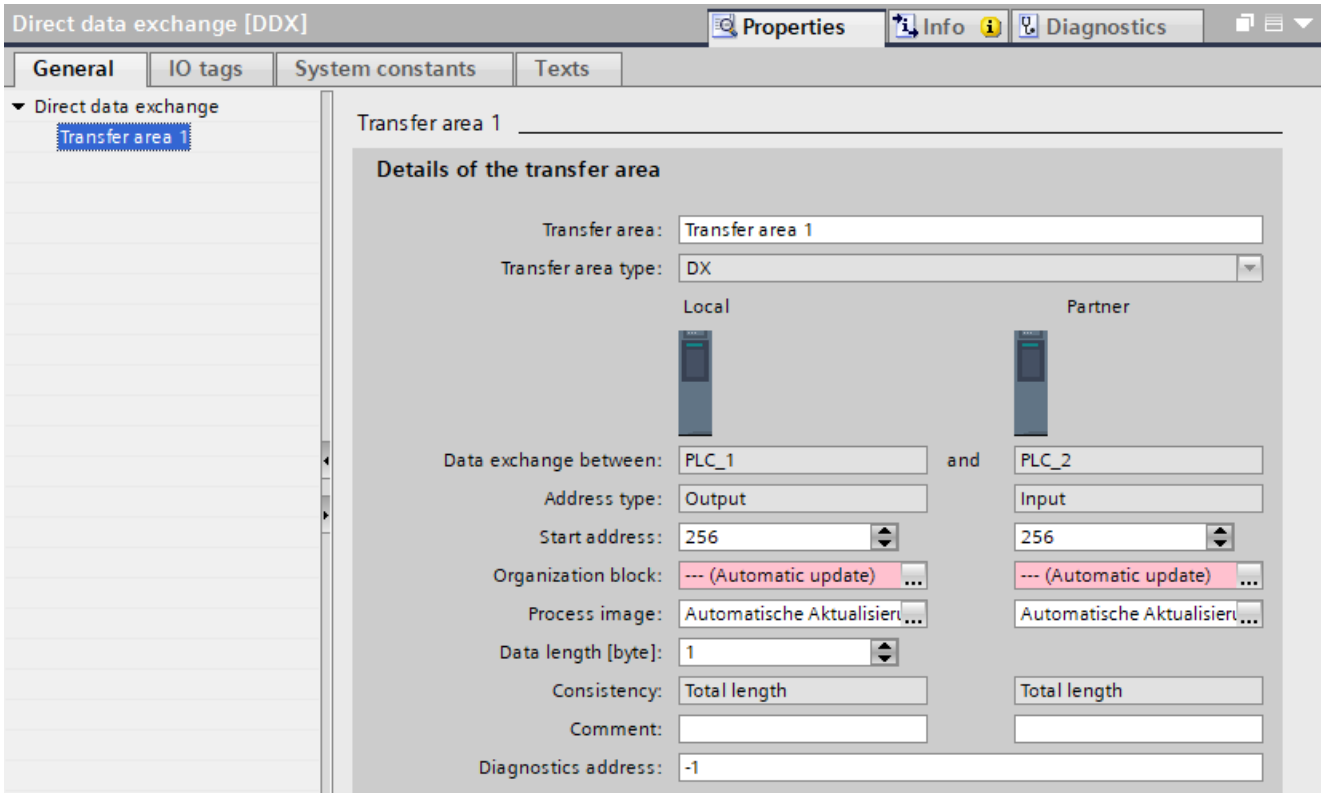

Figure 3-708 Properties of the transfer area

Table 3-967 Overview of the settings of the transfer area

Parameter	Local	Partner
Start address	Set the start address of the input or output transfer areas in the local CPU.	Set the start address of the input or output transfer areas in the partner CPU.
Organization block	Assign the transfer area to an isochronous mode interrupt OB or the "MC-Servo" OB.	Assign the transfer area to an isochronous mode interrupt OB or the "MC-Servo" OB.
Process image	Select a process image partition, e.g. PIP 1. If you have assigned "MC-Servo" as the organization block, STEP 7 automatically sets "PIP OB Servo" as the process image.	Select a process image partition, e.g. PIP 1. If you have assigned "MC-Servo" as the organization block, STEP 7 automatically sets "PIP OB Servo" as the process image.
Data length [bytes]	Set the size of the transfer area.	-

Downloading the configuration to devices

Rules:

- Download the configuration to all CPUs involved.
- If you make changes to the configuration of the direct data exchange, download these changes to all CPUs involved.

7.8.3 Configuring direct data exchange between multiple IO controllers

The procedure for configuring direct data exchange between multiple S7-1500 CPUs is described below.

First, you set up the communication relations for direct data exchange. You then configure transfer areas for the communication relations.

Requirements

- STEP 7 V16 or higher
- S7-1500 CPUs firmware version V2.8 or higher
- IRT is configured:
  - All CPUs are in one sync domain.
  - One CPU is the sync master, and the other CPUs are sync slaves.
  - Ports are interconnected.

Setting up the communication relations for direct data exchange

To set up the connection for direct data exchange between multiple S7-1500 CPUs, follow these steps:

1. Select the PROFINET interface X1 of the sending CPU.
2. Change to the table view of the network view, "I/O communication" tab.
   The PROFINET interface X1 of the CPU is shown in the "Partner 1" column.
3. In the "Partner 2" column at "<Drop or select the device here>", select the PROFINET interface of the communication partner from the drop-down list as the connection partner.
   Note the transfer direction:
   - ←: Connection partner is sender
   - →: Connection partner is receiver

   The connection for direct data exchange between the two S7-1500 CPUs is set up.
4. Repeat step 3 for every other receiving IO controller.

The connections for direct data exchange between the sending CPU and the receiving CPUs are set up.

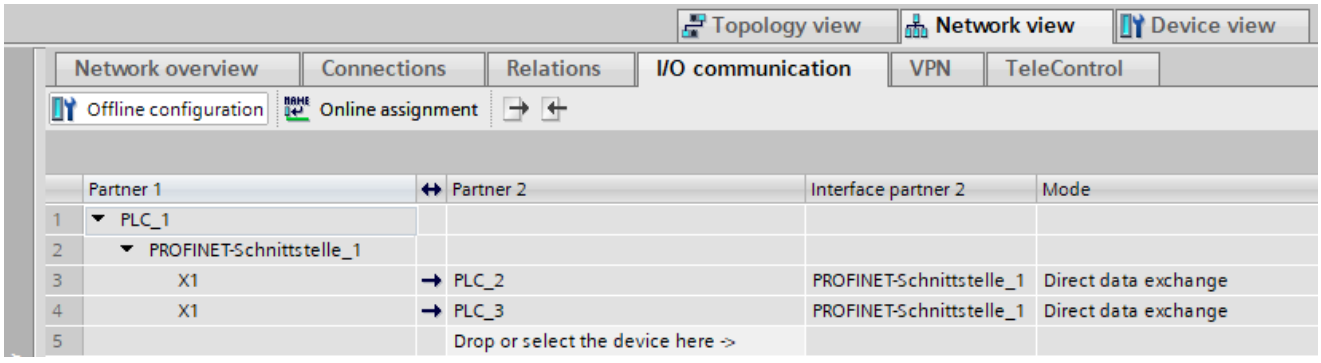

Figure 3-709 Connection for direct data exchange with multiple S7-1500 CPUs

Configuring transfer areas for direct data exchange

The following graphic shows the order for configuration of the transfer areas.

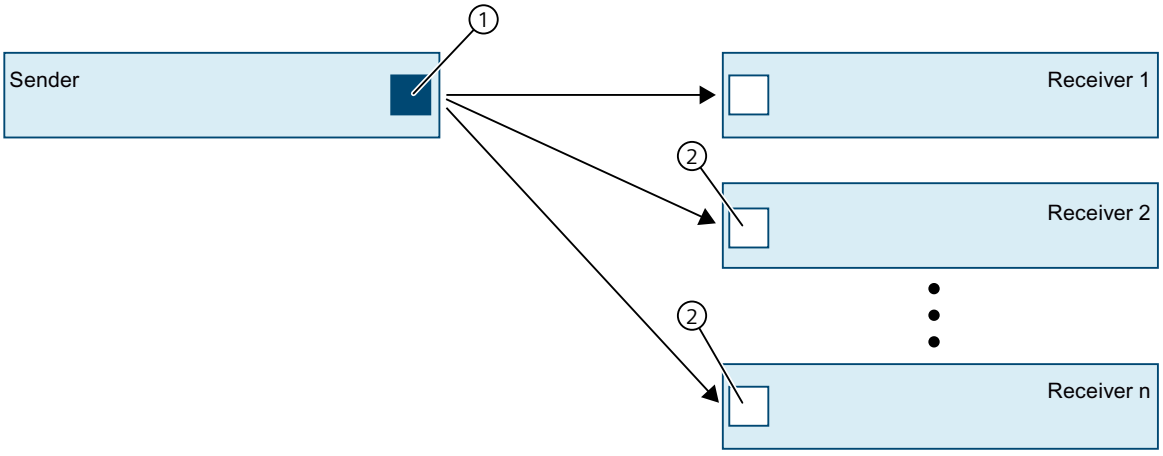

① First, you configure the transfer area between the sender and one receiver. You configure this transfer area at the PROFINET interface of the sender.

② You then configure the transfer areas between the sender and the other receivers. You configure these transfer areas at the PROFINET interfaces of the receivers.

Figure 3-710 Order of configuration of transfer areas in the case of multiple receivers

To configure a transfer area for direct data exchange, follow these steps:

1. Select the PROFINET interface X1 of the sending CPU and change to the table view, "I/O communication" tab.
2. In the table view of the network view, select a communication relation for direct data exchange between the sender and receiver 1.
3. Navigate to the properties of the I/O connection to "General" > "Direct data exchange" > "Transfer areas".

4. Create a new transfer area by double-clicking on "<Add new>". Assign a meaningful name for the transfer area.

   A transfer area for direct data exchange between the sender and receiver 1 is configured.

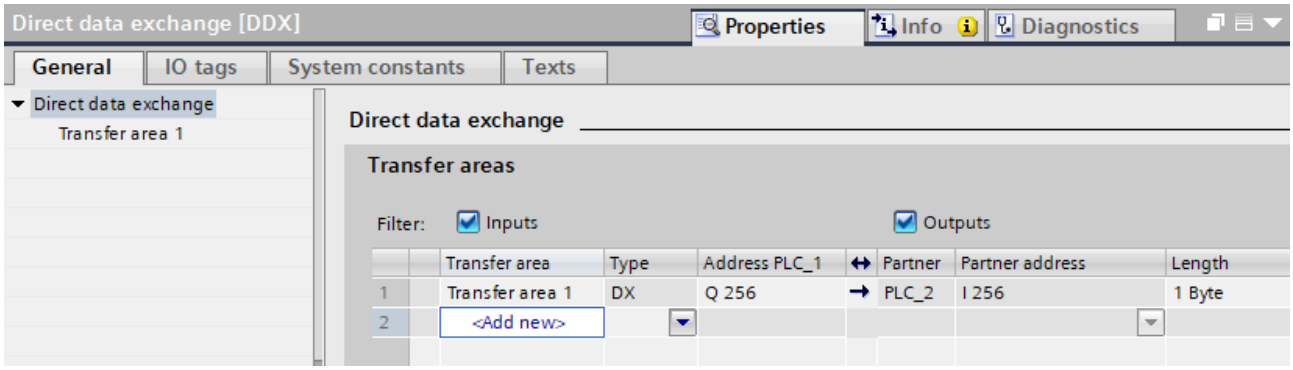

Figure 3-711 Transfer area for direct data exchange

5. Now, select the PROFINET interface of a receiver for which a transfer area is not yet set up, e.g. receiver 2.
6. Change to the table view of the network view to "I/O communication"
   The communication relation for direct data exchange with the sender is displayed.

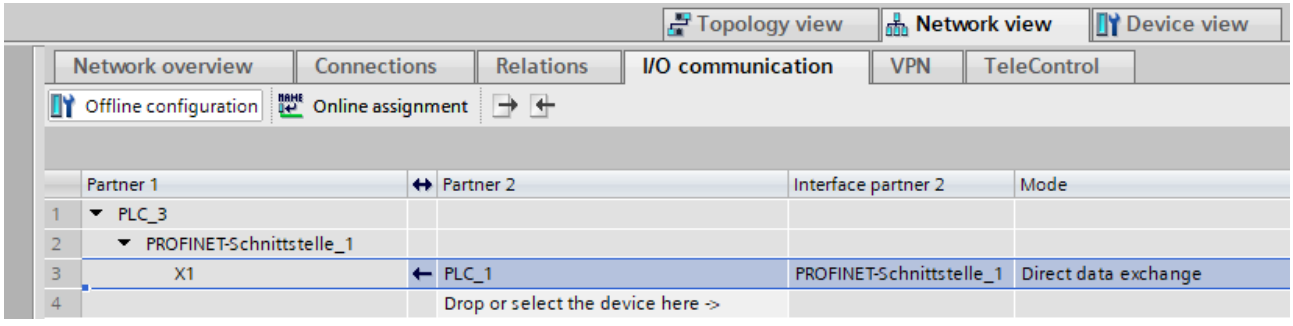

Figure 3-712 Connection for direct data exchange in receiver 2

7. Select the communication relation.
8. Navigate to the properties to "General" > "Direct data exchange" > "Transfer areas".
9. Create a new transfer area by double-clicking on "<Add new>". Assign a meaningful name for the transfer area.

   A transfer area for direct data exchange is configured.
10. Select the transfer area.

11. For "Partner address", select the existing address area in the sender as the output transfer area.

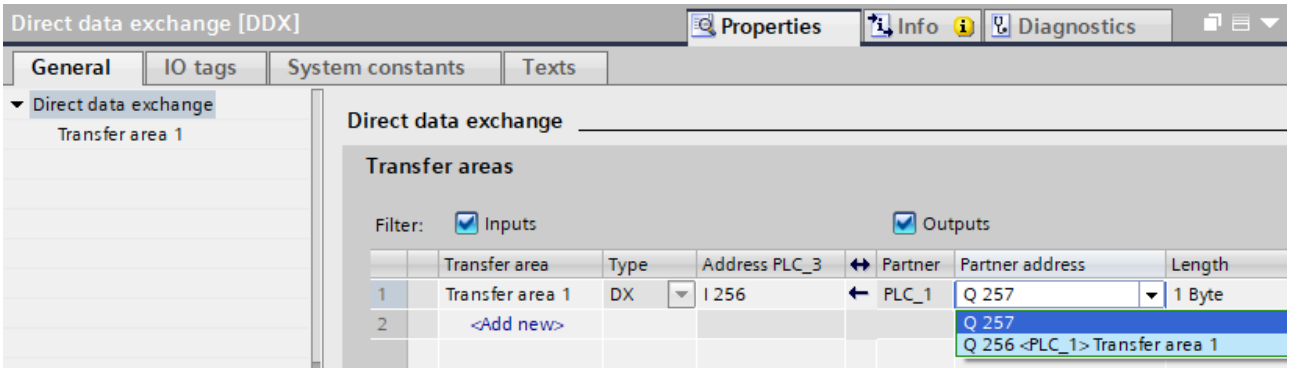

Figure 3-713 Transfer area for direct data exchange of multiple IO controllers

A transfer area for direct data exchange between receiver 2 and the sender is configured.

Editing the transfer area

Set the properties of the transfer area under "General" > "Direct data exchange" > "Name of transfer area" > "Detail of the transfer area".

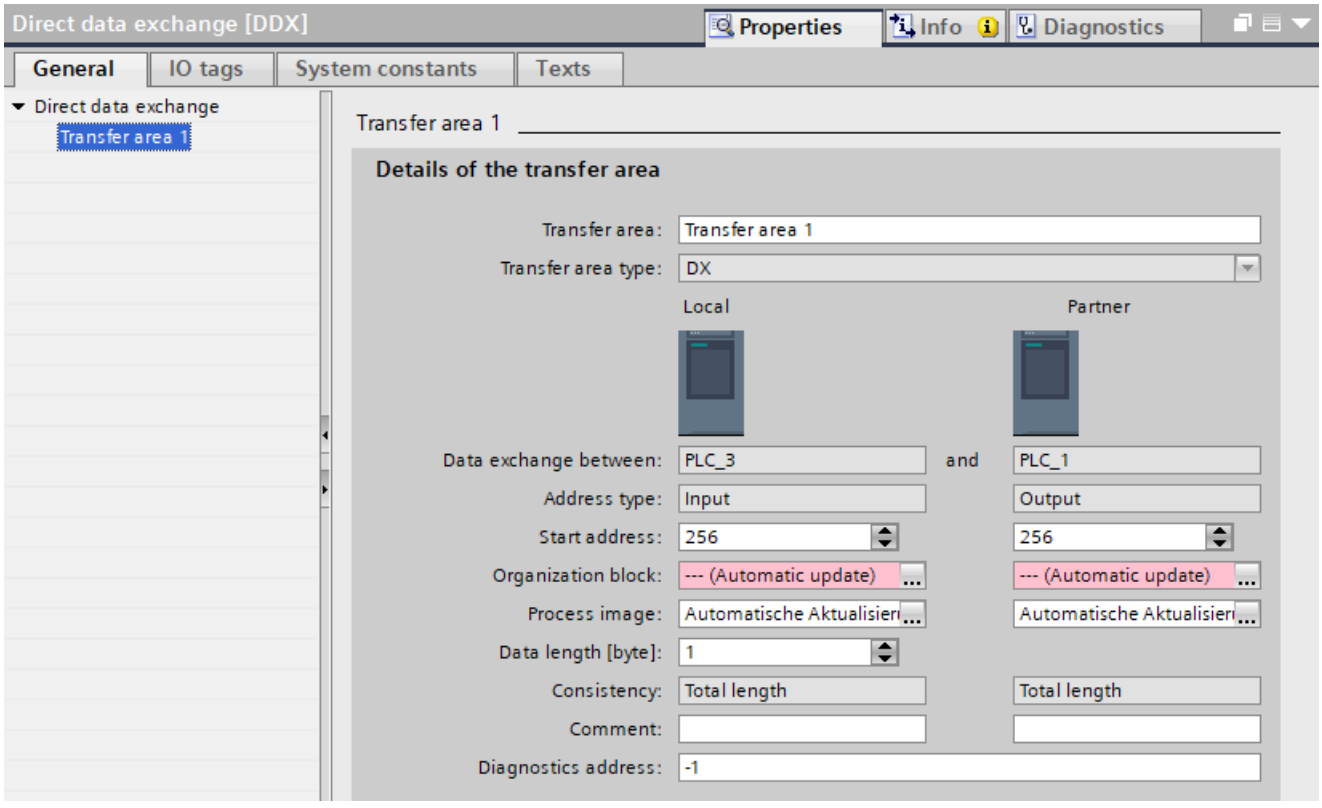

Figure 3-714 Properties of the transfer area

Table 3-968 Overview of the settings of the transfer area

Parameter	Local	Partner
Start address	Set the start address of the input or output transfer areas in the local CPU.	Set the start address of the input or output transfer areas in the partner CPU.
Organization block	Assign the transfer area to an isochronous mode interrupt OB or the "MC-Servo" OB.	Assign the transfer area to an isochronous mode interrupt OB or the "MC-Servo" OB.
Process image	Select a process image partition, e.g. PIP 1. If you have assigned "MC-Servo" as the organization block, STEP 7 automatically sets "PIP OB Servo" as the process image.	Select a process image partition, e.g. PIP 1. If you have assigned "MC-Servo" as the organization block, STEP 7 automatically sets "PIP OB Servo" as the process image.
Data length [bytes]	Set the size of the transfer area.	-

Downloading the configuration to the device

Rules:

- Download the configuration to all CPUs involved.
- If you make changes to the configuration of the direct data exchange, download these changes to all CPUs involved.

7.9 Device replacement without exchangeable medium

Definition

IO devices which have no slot for exchangeable medium (e.g. ET 200SP, ET 200MP) or IO devices which support the PROFINET functionality "Device replacement without exchangeable medium/PG" can be replaced without having an exchangeable medium with saved device names inserted and without having to assign the device name with the PG. The new IO device is given a device name by the IO controller and not by the exchangeable medium or the PG.

To assign the device name, the IO controller uses the configured topology and the neighborhood relations established from the IO devices.

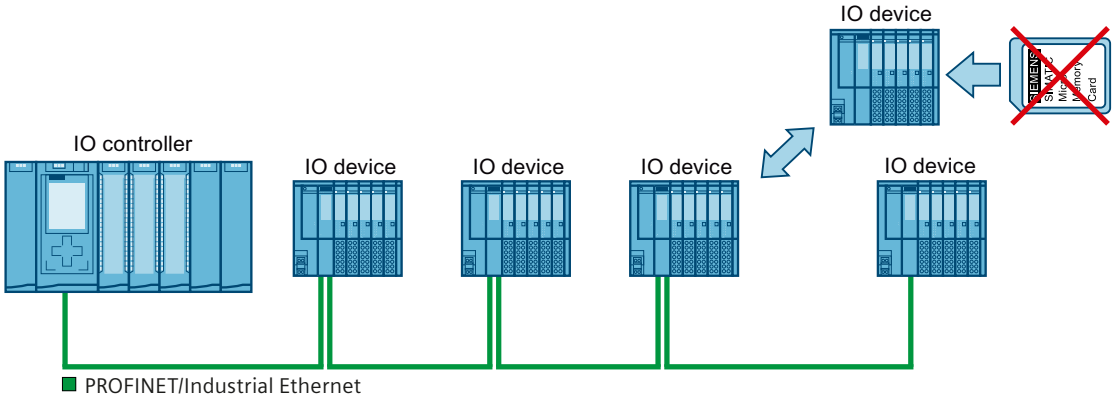

Figure 3-715 Device replacement without exchangeable medium

NOTE

When you exchange a device, make sure that the PROFINET cable is again inserted into the correct port, as it is configured in STEP 7.

Otherwise, the device names can be assigned incorrectly.

Advantages

With the Device replacement without exchangeable medium/PG PROFINET functionality, you can profit from the following advantages:

- After the replacement of the IO device, it automatically obtains its device name from the IO controller. You no longer have to assign device names with the PG or exchangeable medium.
- You can save on the storage medium for the IO device that replaces the removed one.
- Simple device name allocation with series machines that have the same configuration and set topology. It is no longer necessary to assign device names via exchangeable medium/PG.

Which devices support device replacement without exchangeable medium?

An overview of the devices that support the "Device replacement without exchangeable medium" function is provided in this FAQ (https://support.industry.siemens.com/cs/ww/en/view/36752540).

7.9.1 Device replacement without exchangeable medium/PG function

Neighborhood

Neighborhood is the physical relationship between two ports of adjacent PROFINET devices. A PROFINET device is connected in this case through one of its ports over a physical Ethernet line to a specific port of the second PROFINET device in close proximity (neighbors).

Both terminal devices, for example, IO controllers and IO devices with a port, and network components, for example, switches, IO controllers and IO devices with multiple ports, are considered PROFINET devices.

Failure and replacement of an IO device

The following example describes device replacement without exchangeable medium in the case of failure of an IO device.

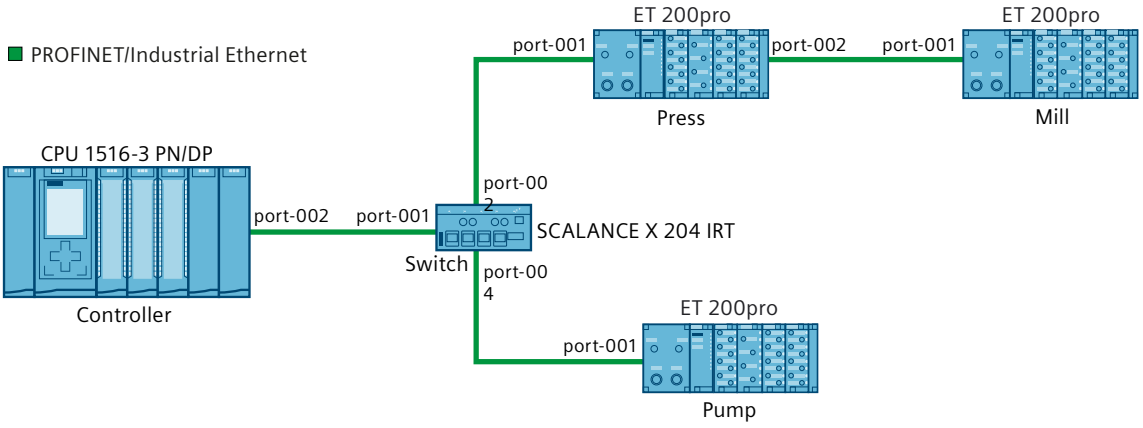

Figure 3-716 Example configuration of device replacement without exchangeable medium

For the device replacement, the following information is available to the IO controller:

PROFINET device	Device alias
Controller	"port-001.Switch"
Switch	"port-002.Controller", "port-001.Press", "port-001.Pump"
Press	"port-002.Switch", "port-001.Mill"
Mill	"port-002.Press"
Pump	"port-004.Switch"

The IO device with the device name "Mill" fails in this example:

Requirement

The PROFINET device replacing the removed one has no device name.

Principles of name assignment

The failure of the "Mill" IO device is considered here.

1. The IO controller queries the device name of the replaced IO device.
2. The IO controller detects that the IO device with the device alias "port-002.Press" does not have a device name.
3. The IO controller assigns the device name "Mill" to the replaced IO device via the device alias "port-002.Press" of the failed IO devices.

NOTE

If you insert a device with the Device replacement without exchangeable medium/PG PROFINET functionality at a different location than the configuration, a different device name is then assigned to the device.

Reset a wrongly inserted device to delivery state before you use it again.

7.9.2 Replacing an IO device without exchangeable medium

Introduction

Replacement of IO devices is sometimes frequently required in automation systems. The IO devices are generally assigned a device name by either inserting an exchangeable medium or via the programming device. The CPU identifies the IO device by using these device names.

Under certain circumstances, replacing an IO device can be done without inserting an exchangeable medium or without the PG.

Requirements

- The topology of the PROFINET IO system with the respective IO devices must be configured.

  By configuring the topology, the neighbor relationships of all the PROFINET devices located in the PROFINET IO system are announced to the PROFINET IO system or the IO controller. From the neighbor relationships specified by the set topology and the actual neighbor relationships established by the real PROFINET devices, the IO controller can identify the replaced IO device without a name and assign to it the configured name and the IP address and then again list it in the user data traffic.
- The affected IO devices in the automation system must support device replacement without exchangeable medium.

  If the individual IO devices in the automation system do not support device replacement without exchangeable medium, a corresponding alarm is output for the IO device.

NOTE

Use only new IO devices as replacements or restore configured IO devices to their delivery state.

Activating/deactivating device replacement without exchangeable medium

The "Device replacement without exchangeable medium" function is activated in the IO controller by default.

To deactivate device replacement without exchangeable medium, follow these steps:

1. In the device or network view of the STEP 7, select the PROFINET interface in the corresponding IO controller.
2. In the interface properties under "Advanced options > Interface options", clear the "Support device replacement without exchangeable medium" check box.

To reactivate device replacement without exchangeable medium, you must select the "Support device replacement without exchangeable medium" check box again.

7.9.3 Permit overwriting of PROFINET device name

With the option "Permit overwriting of PROFINET device names of all assigned IO devices", you can overwrite PROFINET device names of IO devices. This option reduces the effort during automatic commissioning, for example, when replacing a device.

Requirements

- IO controller supports the "Permit overwriting of device names of all assigned IO devices" option, for example CPU 1215C DC/DC/DC as of firmware version 4.0

How the "Permit overwriting of PROFINET device names of all assigned IO devices" option works

The IO controller (CPU) can overwrite the PROFINET device names of IO devices in the IO system when the "Permit overwriting of PROFINET device names of all assigned IO devices" option is enabled.

Multiple use IO systems can only be operated when this option is enabled. The IO controller checks prior to overwriting if the type of the IO device matches the configured type.

If the option is not selected, the IO controller cannot overwrite the device names of the IO devices. In this case, you must manually assign the PROFINET device name on the IO device if the PROFINET device name changes in the configuration or when a device is replaced, or delete the device names of the IO devices prior to an automatic commissioning.

Response during commissioning

Select the option "Permit overwriting of PROFINET device names of all assigned IO devices" only if the following requirements are fulfilled:

- All the configured IO devices are available.
- All IO devices are wired correctly in accordance with the topology configuration.
- No IO device is jumpered.

If configured IO devices are missing or are jumpered (partial commissioning), do not use the option.

You can also use the option for standard machine projects in which you adjust the configuration later via ReconfigIOSystem. Note that the valid configuration is always the one that was transferred to the IO controller in the control data record using the ReconfigIOSystem Mode:=2 instruction. As soon as you enable the reconfiguration with ReconfigIOSystem Mode:=3, the PROFINET device names are overwritten as defined in the data record.

CAUTION

Error at partial commissioning

If device names are assigned incorrectly during partial commissioning or incorrect wiring, these have to be deleted manually after a correction of the wiring in order to attain correct assignment of the device names.

Behavior during operation

As soon as you replace a device, the new device is overwritten with the configured PROFINET device name.

The PROFINET device name is not overwritten when the MAC address of the IO device is already actively being used in the project.

WARNING

Wrong PROFINET device name

When the "Permit overwriting of PROFINET device names of all assigned IO devices" option is enabled, incorrectly connected devices can be assigned an incorrect PROFINET device name from the configuration.

Depending on the connected I/O, there is risk of death, severe injuries or damage caused by malfunctions.

To rule out any danger, check whether the suitable replacement device has been connected in case of a device replacement and whether the port interconnection matches the configured preset topology.

Typical source of danger

When replacing an IO device ("standard case"), it is almost guaranteed that the replaced device will be connected according to the configured port interconnection.

The figure below shows a scenario whereby the connections of two identical PROFINET cables are swapped at two switch ports. Because the IO controller assigns the device names according to the preset topology, the incorrect connection of the devices has serious effects on the naming.

Due to the control of different actuators, the plant could become hazardous in this case.

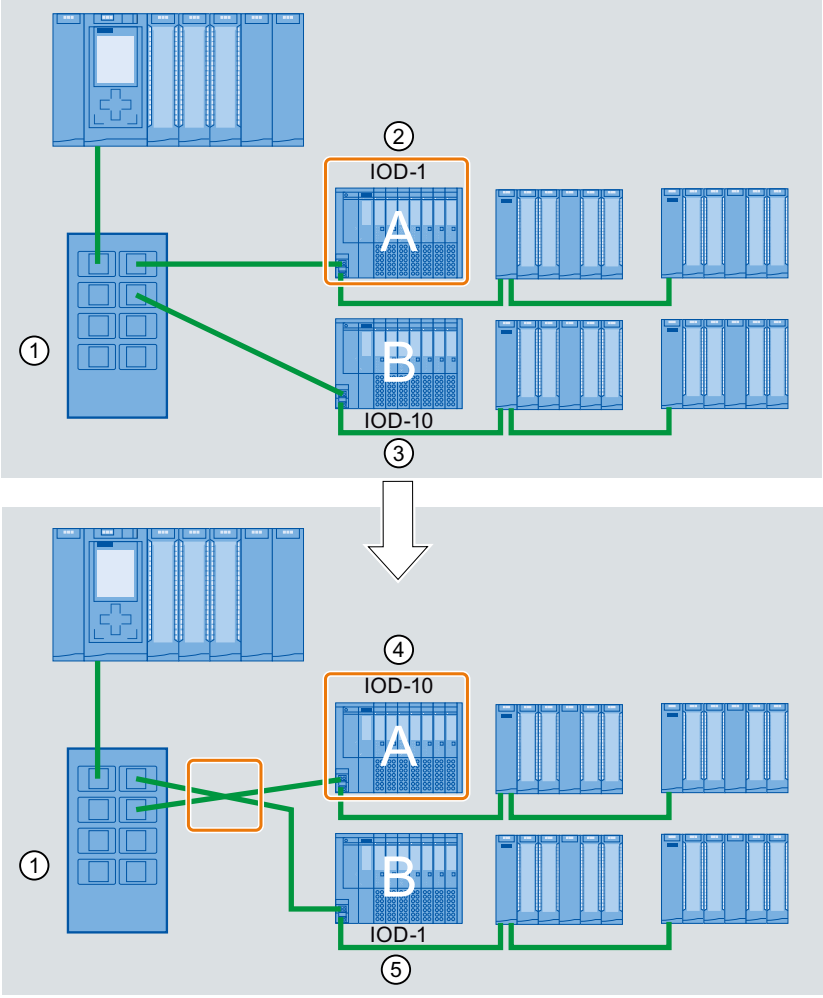

① Switch with connected PROFINET cables
② Device A, device name "IOD-1": controls motor 1
③ Device B, device name "IOD-10": controls motor 10
④ Device A controls motor 10!
⑤ Device B controls motor 1!

Procedure

Proceed as follows to change the "Permit overwriting of PROFINET device names of all assigned IO devices" option:

1. Select the PROFINET interface of the CPU for which you want to change the option in the network view or in the device view.
2. Select the area "Advanced options", section "Interface options".
3. Change the option.

7.10 Standard machine projects

Introduction

Standard machine projects are STEP 7 projects that use a set of innovative functions allowing simple configuration and commissioning of flexible automation solutions for standard machines or for machines with a modular structure.

A hardware configuration consisting of an IO controller and any number of connected IO devices represents a "PROFINET IO system master". This master is configured with a maximum configuration based on a template from which various options can be derived for different standard machines, for example with different configuration variants of the IO system.

Greater flexibility at all levels

Standard machine projects have the following central characteristics:

- Different variants of a standard machine can be loaded from precisely one project with an engineered maximum configuration (IO system options). The standard machine project covers all variants (options) of the IO system.
- An IO system option can be integrated in an existing network locally using simple tools.

Flexibility is provided in more ways than one:

- With suitable configuration, adaptation of the IP address parameters of the IO controller is possible locally using simple tools. This allows a standard machine to be integrated in different plants with little effort or to be included in a network several times.
  IO systems with this property are known as **multiple use IO systems**.
- With suitable configuration and programming, different setups of IO system options can be operated locally that differ in terms of the selection of IO devices used or in terms of the arrangement of the IO devices.
  Since the specific configuration of the IO system is controlled by the user program, this is known as **configuration control for IO systems**.
- Independently of the functions described above, with suitable configuration and programming, you can use different station options of central devices or distributed I/O devices in one project. The devices can be different in terms of the selection and arrangement of the modules.
  Since the concrete configuration of the station is controlled by the user program, this is also known as **configuration control at the device layer**.

Application examples

You can find application examples for configuration control at the device layer, configuration control for IO systems and multiple-use IO systems on the Internet (https://support.industry.siemens.com/cs/ww/en/view/29430270).

Additional information

For more information on multiple use IO systems, refer to section Multiple use IO systems (Page 276).

For more information on the configuration control for IO systems, refer to section Configuration control for IO systems (Page 284).

For more information on configuration control, refer to the system manual S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792).

7.10.1 Multiple use IO systems

7.10.1.1 What you should know about multiple use IO systems

Multiple use automation solutions

For a flexible reusable automation solution as is the case with series machines, the following use cases are typical:

- The machine (and therefore also the PROFINET IO system) is used more than once by the customers.
- The machine is used in different plants by various customers.

For this to be possible, the automation solution must meet the following requirements:

- A project (configuration and program) can be loaded on various machines of the same type without changes.
- Only a few easy adaptations need to be performed locally to integrate the machine into an existing network infrastructure.

The following figure shows how an automation solution with a multiple use IO system is loaded on different automation systems and then one automation system is adapted to the existing network infrastructure locally.

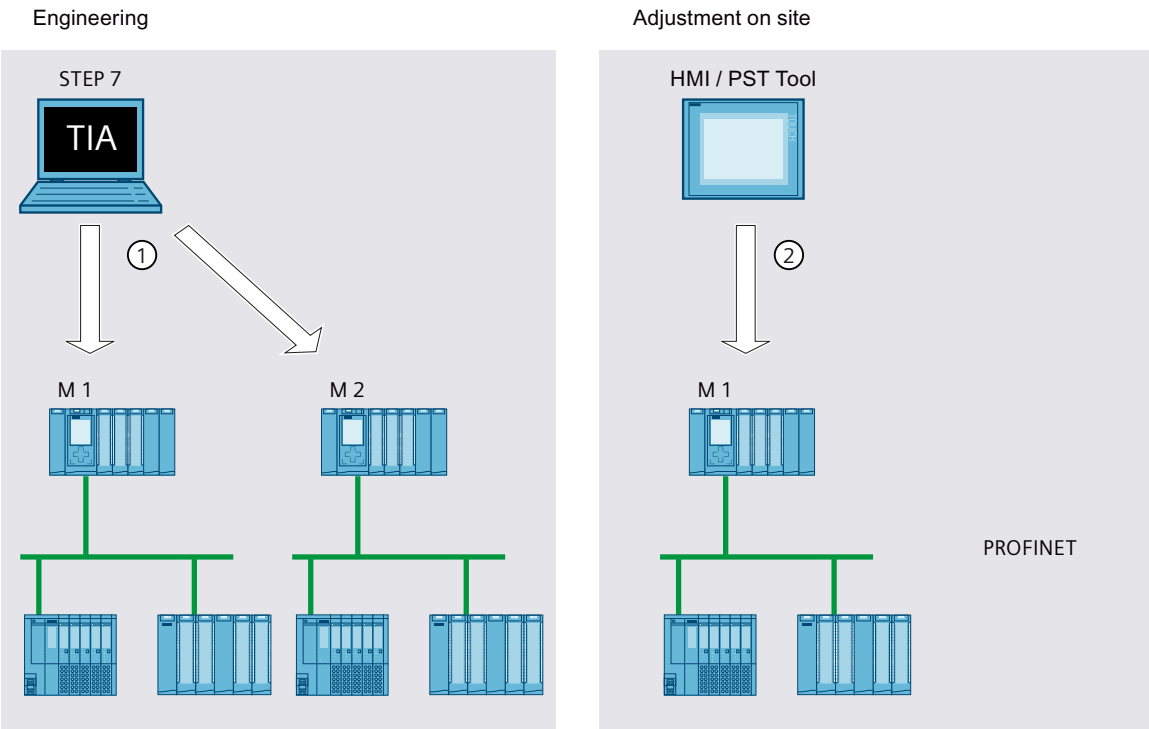

① Load configuration with multiple use IO system

② Set IP address and device name locally on the IO controller

Figure 3-717 "Multiple use IO system" principle

Principle

The automation components for a machine include a PROFINET IO system, consisting of an IO controller (PROFINET interface of a CPU) and the IO devices assigned to it.

With the "Multiple use IO system" setting for the IO system, you turn a STEP 7 project into a "Standard machine project".

The "Multiple use IO system" setting triggers various settings and checks of the configuration by STEP 7. The settings ensure that the IO system is self-contained and there are no dependencies on components outside the IO system.

Requirements

- STEP 7 as of V13
- The IO controller supports the "Multiple use IO system" function, for example a CPU 1512SP-1 PN as of firmware version 1.6.

Rules

The following rules apply to a multiple use IO system:

- No IO device can be configured as shared device.
- The ports of the devices must be interconnected.
  Devices for which no port interconnection is configured, for example, interface module IM 154-6 IWLAN (ET 200pro PN), cannot be operated with STEP 7 V13 as IO devices on a multiple use IO system.
- If an IO device in a multiple use IO system is an I-device (CPU as an "intelligent" IO device):
  - If the I-device has a lower-level IO system, this I-device cannot be connected to the same PROFINET interface as the higher-level IO controller.

    Note: If the I-device is configured using a PROFINET GSD, STEP 7 cannot check for compliance with this rule. In this case, you are responsible for ensuring compliance with the rule.

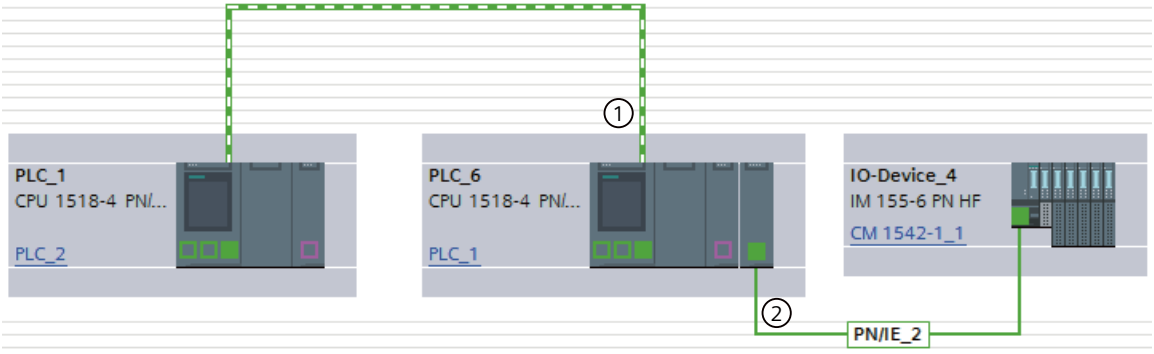

① I-device in multiple use IO system. The PROFINET interface is operated as IO device. No other IO system is connected here.

② A lower-level IO system on the I-device is connected to another PROFINET interface.

Figure 3-718 Example configuration for "Multiple use IO system" with I-device

  - The PROFINET interface of the I-device must be set to "Parameter assignment of PN interface by higher-level controller".
- If MRP (Media Redundancy Protocol) is configured:
  - All IO devices on the multiple use IO system must belong to the same MRP domain.
- If IRT (Isochronous Real Time) is configured:
  - All IO devices in multiple use IO systems must belong to the same sync domain.
  - The sync domain must not include any other IO devices.
- IE/PB Links cannot be operated as an IO device in a multiple use IO system with STEP 7 V13.

Configuration

You specify whether or not a configuration can be used multiple times in the properties of the IO system.

All other parameter settings for the configured devices are then set automatically by STEP 7 and checked during compilation.

Boundary conditions

To prevent a standard machine project from having dependencies on other devices outside of the machine, observe the following:

- A standard machine project consists of an IO controller and the corresponding IO devices. You should therefore configure only one CPU as IO controller and the corresponding IO devices in the standard machine project.
- Do not use connection configured at both ends for the communication. Instead, use only a connection configured at one end or unspecified connections if necessary.

  Background: To configure the communication in a STEP 7 project, it is always possible to set the IP address parameters in the project. For multiple use IO systems, however, this strategy is not possible since the IP address parameters of the IO controller and the assigned IO devices are assigned locally. At the time of the configuration, the IP address parameters are therefore unknown.

  If you nevertheless want to configure communication with devices on PROFINET, for example with a central coordinator, you can only use communications mechanisms that allow dynamic assignment of the IP address parameters in the user program.

  Example: Open User Communication

  If, for example, the device is configured as an active end point (initiator of the connection), the IP address parameters can be stored, for example, in a data block. You then supply the data block with the currently valid IP address parameters during commissioning. For this dynamic type of IP address parameter assignment, there is no system support; in other words, if you change the configuration of the system, the IP address parameters are not automatically adapted.

  You will find a description of handling instructions for Open User Communication under this keyword in the STEP 7 online help.

7.10.1.2 Configuring multiple use IO systems

Requirements

- STEP 7 as of V13
- The IO controller supports the "Multiple use IO system" function, for example a CPU 1512SP-1 PN as of firmware version 1.6.

Procedure

The configuration of a series machine using an S7-1500-CPU as an example is described below.

To create a standard machine project, follow these steps:

1. Create a project.
2. Configure a CPU as the IO controller, for example a CPU 1518-4 PN/DP as of firmware version 1.5.
3. Configure the required IO devices and assign the IO devices to the IO controller.
4. Configure the port interconnection between the devices.
5. Select the IO system so that you can edit the properties in the inspector window.
6. Select the "Multiple use IO system" check box in the "General" area of the inspector window.

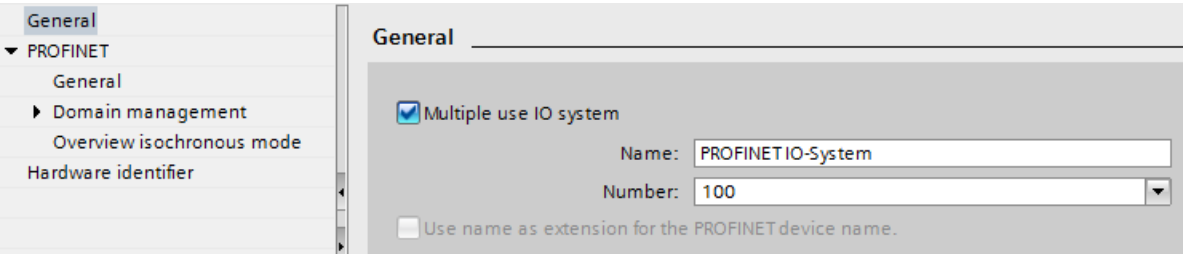

Figure 3-719 Activate "Multiple use IO system"

Result: The following settings are made by STEP 7:

- The device name of the IO controller (CPU) in the standard machine project is set to "PROFINET device name is set directly at the device". The IO controller (CPU) has no PROFINET device name initially.
- The IP protocol of the IO controller (CPU) is set to "IP address is set directly at the device". The CPU has no IP address initially.
- The "Support device replacement without exchangeable medium" option is selected automatically. This option enables automatic commissioning. A commissioning engineer does not have to assign device names to the IO devices locally. The IO controller assigns the device name and IP address to the IO devices based on the preset topology and other settings during startup.
- The device name of the IO devices is set to "Generate PROFINET device name automatically" (from the configured name of the IO device).
- The IP protocol of the IO devices is set to "IP address is set by the IO controller during runtime". The IO devices have no IP address initially. If an IO device is not a typical distributed I/O system (e.g., ET 200 systems), but rather another device such as an HMI device, change the option to "IP address is set directly at the device"; see below.
- The device number for the IO devices is automatically assigned and is used locally for making the IP address unique.

The option "Permit overwriting of PROFINET device name" must be selected (CPU parameters, properties of the PROFINET interface, Ethernet addresses area) so that the IO controller can adapt the device name later at the operator.

This option is disabled by default.

The following figure shows the above-described settings for the IP address and PROFINET device name.

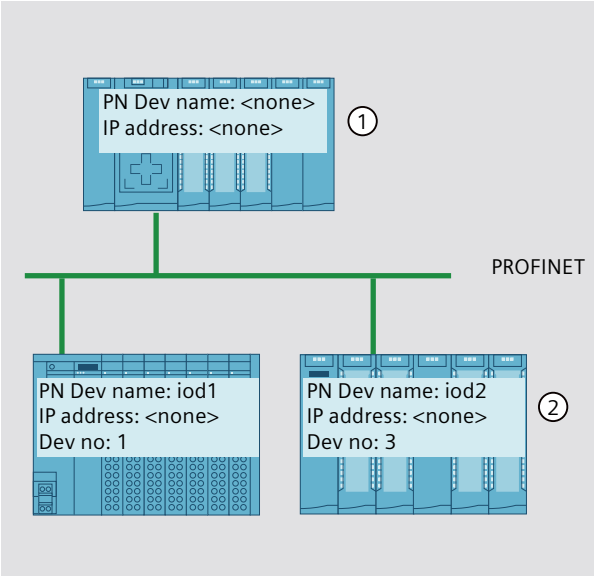

① After the configuration is loaded from the standard machine project, the IO controller has no device name and no IP address.

② Following loading, the IO devices have a device name and a device number but no IP address.

Figure 3-720 Settings for the IP address and the PROFINET device name

How an IO device obtains an IP address locally

Below, you will find an explanation of the "IP address is set by the IO controller during runtime" and "IP address is set directly at the device" options, which can generally be configured for a multiple use IO system.

If you have set the "Multiple use IO system" option for the IO system, STEP 7 automatically sets the "IP address is set by the IO controller during runtime" option for the IO devices.

In this case, the IO controller assigns the IO device an IP address that results from the locally assigned IP address of the IO controller (see next section). This option is appropriate if the IO device is a field device, e.g., ET 200MP, ET 200SP, ET 200AL, or another distributed I/O system.

If the IO device is not a "standard" field device, for example, an HMI device for a Windows operating system, the "IP address is set by the IO controller during runtime" option described above does not work. In this case, choose the "IP address is set directly at the device" option. You must then assign the IP address to the device locally and take steps to ensure that this address is suitable for the IP addresses of the other IO devices and the IP address of the IO controller.

7.10.1.3 Adapt multiple use IO systems locally

A few steps are needed to adapt the machine that was loaded with the standard machine project.

Only the device name and IP address of the IO controller must be adapted locally. The device names and IP addresses of the IO devices result from these adaptations. In this example, the effects of local settings are described for two specific machine modules.

The local settings are possible, for example, with the CPU display and commissioning tools such as Primary Setup Tool (PST) or PRONETA. You do not need a programming device with STEP 7 to make these settings, even though it is possible to do so.

Requirement

- The machine was loaded with a standard machine project (see Configuring multiple use IO systems (Page 279)).
- The display is ready for operation and the desired tool for assigning the IP address and device name is available (e.g., PST Tool, STEP 7).
- The ports of the IO controller and IO devices are interconnected according to the configuration.

Procedure

Observe the boundary conditions and instructions for commissioning an S7-1500. For more information on commissioning an S7-1500 CPU, refer to the system manual S7-1500, ET 200MP (http://support.automation.siemens.com/WW/view/en/59191792).

To adapt a standard machine locally, follow these steps:

1. Integrate the machine into the network.
2. Connect the device for assigning the IP address and device name to the CPU, for example a PG/PC with the appropriate software.
3. Assign the desired device name and IP address to the IO controller.

   NOTE
   Remove DCP write protection when assigning via PG/PC
   If write protection is enabled for DCP (Discovery Configuration Protocol), you cannot change the device name and IP address via PG/PC.
   You can find information on assigning in the section Assigning a device name and IP address (Page 62). You can find information on handling DCP in the section PROFINET Security Class 1 (Page 37).

4. Start up the CPU.

The IO controller then assigns the adapted PROFINET device name and a unique IP address to the IO devices.

The following rules apply to the assignment:

- The device names of the IO devices are formed by chaining together the following name components, separated by a period:

  <configured name of the IO device from the standard machine project>.<name of the associated IO controller set on the device>

- The IP addresses of the IO devices result from the locally configured IP address of the associated IO controller and the device number (sum).

NOTE

Make sure that duplicate IP addresses cannot be created on the subnet during the assignment. The IO controller does not assign a new IP address in this case.

In the following figure, the device name "m1" and the IP address 192.168.1.10 have been assigned to the IO controller of the first machine.

The device name "m2" and the IP address 192.168.1.20 has been assigned for the second machine.

Refer to the figure for the resulting device names and IP addresses.

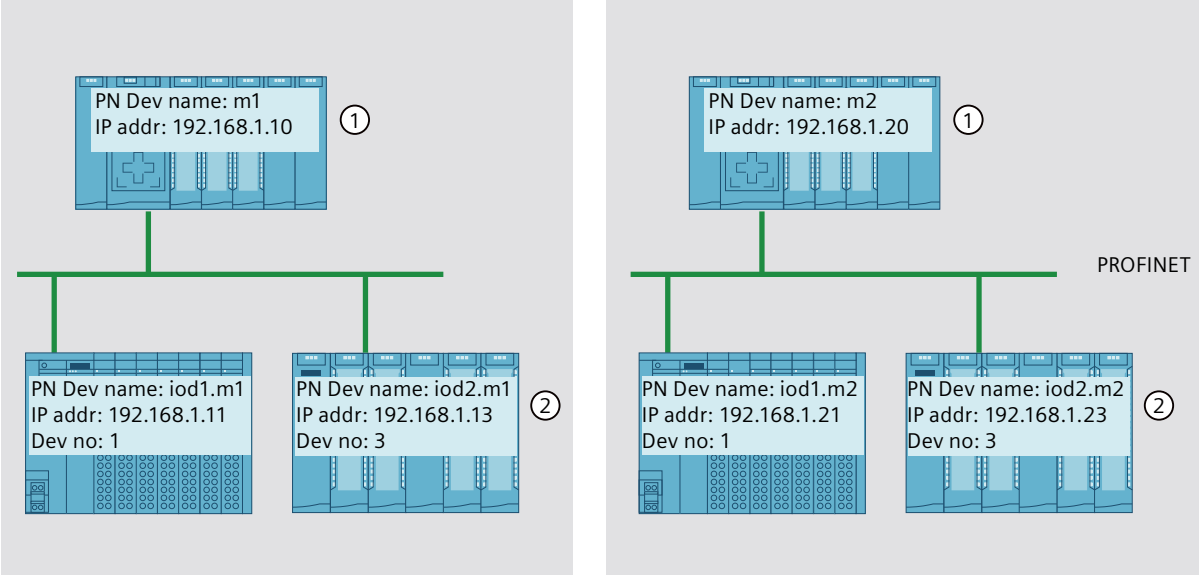

① Set device name and IP address on the IO controller

② After startup, the IO devices have an updated device name (<configured device name>.<device name of IO controller>) and an adapted IP address (= <IP address of IO controller> + <device number>)

Figure 3-721 Example of the assignment of IP addresses and device names at "Multiple use IO system"

See also

Configuring multiple use IO systems (Page 279)

7.10.2 Configuration control for IO systems

7.10.2.1 Information about configuration control of IO systems

Configuration control of IO systems makes it possible to generate several concrete versions of a standard machine from a standard machine project.

You are given the flexibility to vary the configuration of an IO system for a specific application as long as the real configuration can be derived from the set configuration. The configured configuration therefore represents the superset of all real configurations that can be derived from it.

The following figure shows an example of how two IO systems with a different number of IO devices arise from one standard machine project.

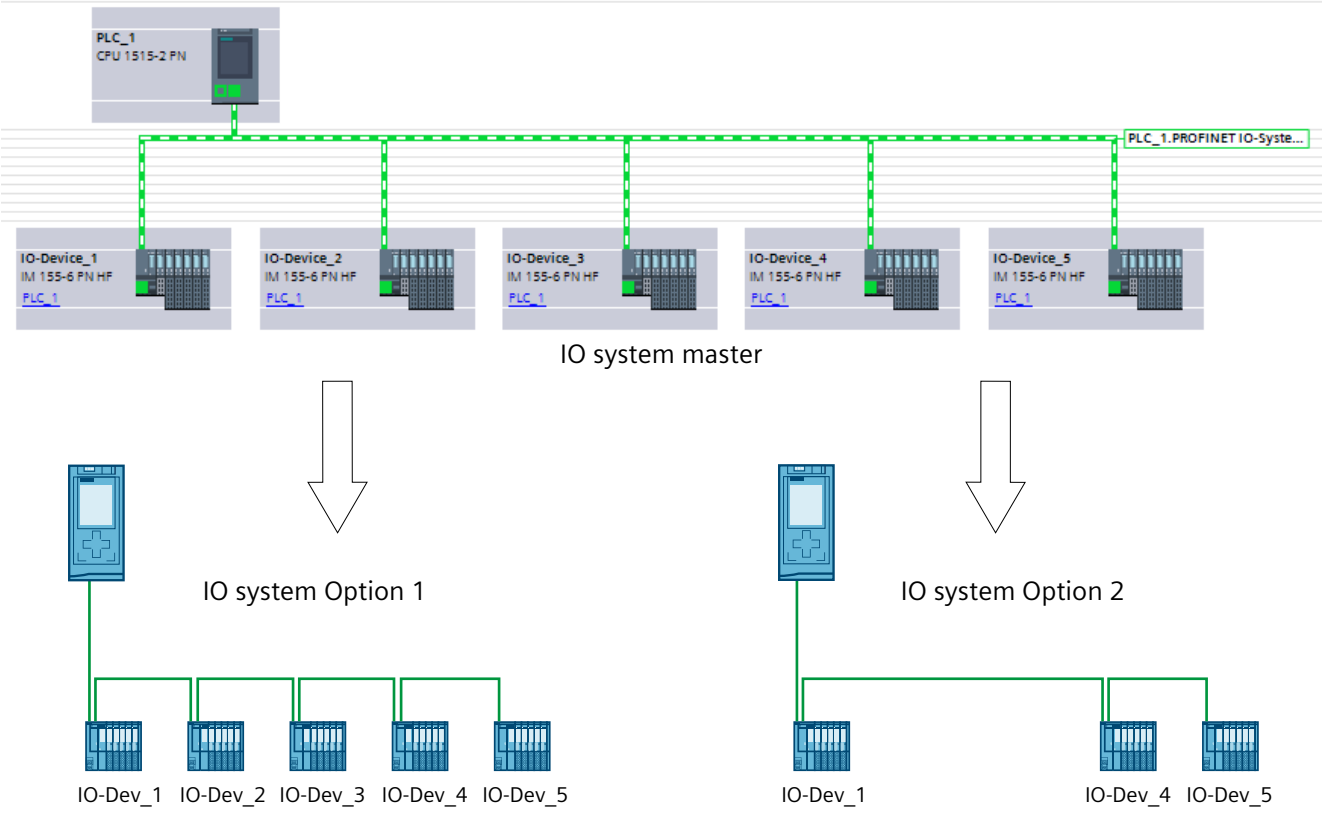

Figure 3-722 Example of configuration control for PROFINET IO systems

In the following sections, you find a description of how to configure and program a PROFINET IO system to commission, for example, a standard machine on-site without using configuration software.

Concept

The principle of configuration control is already known at the device level for the flexible use of submodules/modules ("option handling"). Different configurations can be derived from one engineering project both for central as well as for distributed I/O.

With S7-1500 CPUs as of firmware version V1.7, this principle can also be applied at the IO system level. You have the option of omitting, adding or changing the order of stations (IO devices) of a PROFINET IO system in a specific plant.

Configuration control for devices and configuration control for IO systems can be combined; the functions are independent of each other.

It is possible to operate variants deviating from a maximum configuration of an IO system. In a standard machine project, you can prepare a kit of IO devices which can be flexibly customized for various configurations using configuration control.

The following variations are available:

- Variation of the number of IO devices involved

  You include optional IO devices for the configuration control in the configuration by transferring a suitable data record with the required configuration in the user program.

- Variation of the order of IO devices involved

  You adapt the port interconnection of the IO devices to the topology being used by transferring a suitable data record with the required topology in the user program.

The following figure shows how you serve two different configurations with an IO device marked as optional in the network view of STEP 7.

- Configuration without the optional IO device:

  In this case, you use the instruction "ReconfigIOSystem" to transfer a data record to the PROFINET interface containing the information that no optional IO device is to be included in the configuration.

- Configuration with the optional IO device:

  In this case, you use the instruction "ReconfigIOSystem" to transfer a data record to the PROFINET interface adding the optional IO device to the configuration.

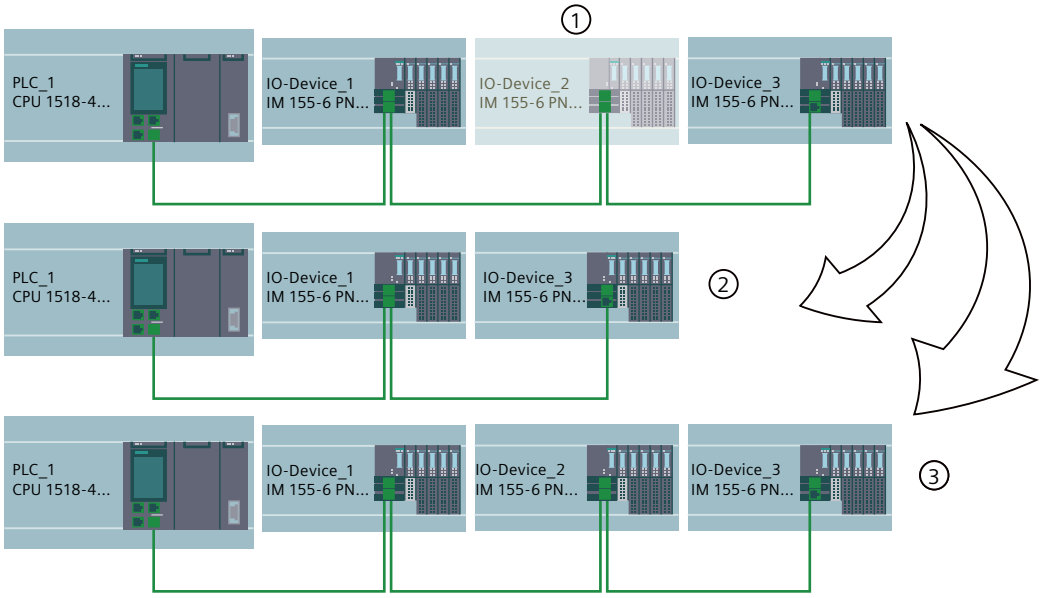

① Determined through parameter assignment: IO Device_2 is optional IO device

② Configuration without the optional IO device

③ Configuration with the optional IO device

Figure 3-723 Example configuration with "Optional IO device" and the associated configuration options

Summary: The procedure in principle

The following phases are distinguished when it comes to the implementation of a standard machine concept:

1. Engineering phase: Creating a standard machine project and loading into specific machine or plant:
   - Completely configuring all IO devices (options) ever required in a specific machine or plant
   - Configuring as optional those IO devices that will be omitted in specific machines or plants
   - Preparing user program (see Configuring flexible order of IO devices (Page 293)) with the possibility of selecting on-site the actually existing configuration via switch or HMI device
2. Commissioning phase: Preparing specific machine or plant for operation:
   - Integrating machine or plant in the on-site network (see Adapt multiple use IO systems locally (Page 282))
   - Selecting the currently existing configuration of the IO system via configured option

7.10.2.2 Configuring IO devices as optional

Requirements

- IO controller supports configuration control for IO systems, for example CPU 1516-3 PN/DP as of firmware version 1.7
- STEP 7 V13 SP1 or higher
- The rules (Page 298) for the establishment and operation of a standard machine project have been considered.

Port interconnection

As of STEP 7 V15.1, port interconnection is not necessary for optional IO devices.

A port interconnection between the devices of the IO system that you want to customize with the user program is mandatory in the following cases.

- You have configured IRT.
- You have configured MRP.
- You are using STEP 7 <= V15.

Procedure

To configure an IO device as optional IO device, proceed as follows:

1. Create a project.
2. Configure an S7-1500 CPU firmware version V1.7 or higher as IO controller.
3. Configure the required IO devices and assign the IO devices to the IO controller.
4. Select the IO device you want to mark as optional.
5. Select the area "PROFINET interface [X1]" > Advanced options".
6. Enable the "Optional IO device" option.

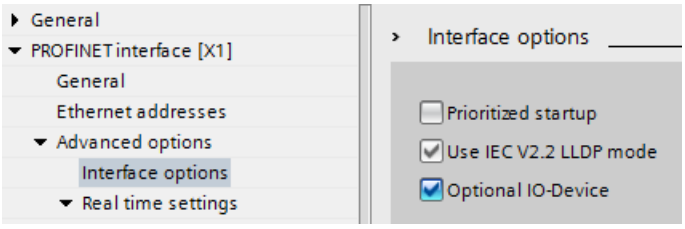

Figure 3-724 Configure the IO device as an optional IO device

7. Repeat steps 4 to 6 for all IO devices to be configured as optional.
8. Load the configuration onto the CPU.

Result: Once this configuration is loaded, the system behavior is as follows:

- The CPU is prepared for the configuration control of the IO system.
- All IO devices are disabled.

- Irrespective of whether you customize the configuration with the user program (adding optional IO devices) or make no changes to the loaded configuration: You must call the instruction "ReconfigIOSystem" in the user program and notify the current configuration to the system!

  The system will not be operational without calling the instruction "ReconfigIOSystem".

  For further information on the proceeding see Enabling optional IO devices in the program (Page 288).

Fast parameter assignment in the "IO communication" table

You can also specify whether or not an IO device is optional in the "IO communication" tab.

In an additional "Optional IO device" column, a selectable check box is available for each IO device that indicates whether or not an IO device is optional. Here, you can adjust the setting centrally.

7.10.2.3 Enabling optional IO devices in the program

Requirements

- IO controller supports configuration control for IO systems, for example CPU 1516-3 PN/DP as of firmware version 1.7
- STEP 7 V13 SP1 or higher
- At least one IO device was configured as optional IO device.
- The rules (Page 298) for the establishment and operation of a standard machine project have been considered.

Procedure

Observe the information on and rules for commissioning in the documentation for SIMATIC S7-1500, for the ET 200SP CPUs and for the CPU 1516pro-2 PN.

The following description of the proceeding only includes steps required to understand the program-controlled activation of an optional IO device.

To activate or deactivate IO devices, follow these steps:

1. Create a data record "CTRLREC" for the instruction "ReconfigIOSystem". You can find information on the structure of the data record in the STEP 7 online help.
2. Call the instruction "ReconfigIOSystem" and select MODE 1 to deactivate all IO devices.

   If you set the CPU to STOP or POWER OFF state in order to modify the plant in this status (for example to add an optional IO device), explicit deactivation using "ReconfigIOSystem" with mode 1 is not necessary. In this case, i.e. following a STOP-RUN transition and following a POWER-OFF > POWER-ON transition, all IO devices are deactivated automatically.

3. When you have brought the plant to a safe status that allows restructuring without any danger:

   Put the plant together according to your intended application. Add the required optional IO devices at the points at which you planned this in the configuration (observe the order!) or remove optional IO devices that you no longer require.

4. Network the IO devices.
5. Startup the S7-1500 system and call again the instruction "ReconfigIOSystem". Select MODE 2 to transfer the data record CTRLREC.
6. Following successful transfer of the data record, call again the instruction "ReconfigIOSystem". Select MODE 3 to activate all IO devices forming part of the current configuration.

   Result: The CPU **activates** the following IO devices:

   – All IO devices that you have not set as optional IO devices.
   – All optional IO devices listed in the control data record (CTRLREC).

   The following IO devices remain **disabled**:

   – Docking units (IO devices changing during operation).
   – Optional IO devices that are not listed in the control data record.

NOTE

Call the instruction "ReconfigIOSystem" for all values of the parameter MODE with the same control data record (CTRLREC)!

If you use different data records for the values of the MODE parameter, this results in an inconsistent customization of the configuration and thus to rather incomprehensible error messages.

Example: Data record structure for the activation of an IO device

The IO device "IO-Device_2" is to be activated as the only IO device in the user program.

To do this, you only require the hardware identifier of "IO-Device_2".

Recommendation: Use the system constants of the hardware identifiers instead of the absolute values as shown in this example. With this procedure, the content of the DB is not influenced by changes to the hardware identifiers as the result of changes to the configuration.

The data record is to be stored in a data block and to be transmitted to the PROFINET interface of the IO controller in the user program using the instruction "ReconfigIOSystem".

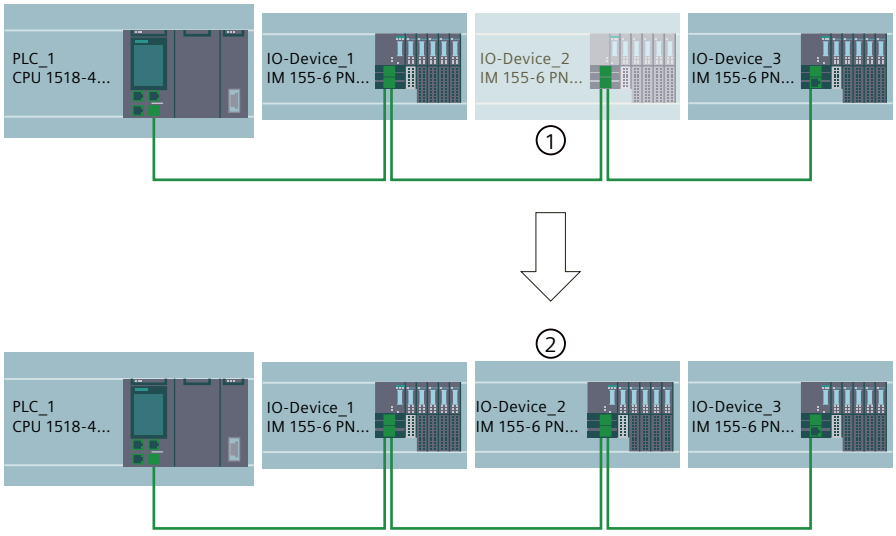

① IO device_2 is configured as optional IO device.

② Once the data record is transmitted and the configuration is activated using the instruction "ReconfigIOSystem" IO device_2 is included in the configuration and participates in the data exchange with the IO controller.

Figure 3-725 Example: Activating an optional IO device

Creating data block

In this example, the control data record is created in a data block. The data block is structured as follows:

Line 2: Array definition: Array of type Word with 4 elements. Array of Word is permitted as the data type.

Line 3: Version of the data record (currently: V1.0).

Line 4: Number of optional IO devices to be activated (here: 1).

Line 5: List of the hardware identifiers of the IO devices, inserted here as system constants.

Line 6: Number of port interconnections that are set in the user program (here: 0).

Line 7: Additional data records (optional)

myCTRLREC

	Name	Data type	Start value	Comment
1	Static			
2	ArrMachineConfig0	Array[0..3] of Word		Array for one optional IO device
3	ArrMachineConfig0[0]	Word	16#0100	
4	ArrMachineConfig0[1]	Word	16#0001	
5	ArrMachineConfig0[2]	Word	"IO-Device_2~IODevice"	
6	ArrMachineConfig0[3]	Word	16#0000	
7	ArrMachineConfig1	Array[0..8] of Word		

Figure 3-726 Data block with control records

Parameter MODE of instruction "ReconfigIOSystem"

You control how the "ReconfigIOSystem" instruction works with the MODE parameter.

The following values are possible for the MODE input parameter:

MODE	Description
1	All IO devices of the IO system can be disabled by calling the instruction with MODE 1. The "ReconfigIOSystem" instruction uses the "D_ACT_DP" instruction internally. "ReconfigIOSystem" returns errors that are detected by D_ACT_DP in the following output parameters: • STATUS (error code) • ERR_INFO (hardware identifier of the IO device causing the error). In STATUS and ERR_INFO, the CPU enters the last determined error/HW identifier and in so doing overwrites an existing error code. For this reason, additional errors can be present besides the entered error.
2	For controlling the actual configuration of the IO system, the instruction transfers the data record to the PROFINET interface, which is addressed with LADDR block parameter (HW identifier of the PROFINET interface).
3	All non-optional IO devices in the IO system and optional IO devices that are listed in the control data record CTRLREC are enabled. The optional IO devices that are **not** listed in the CTRLREC data record remain disabled. If IO devices that are part of docking units (alternating IO devices in operation) are listed in the CTRLREC control data record, the PN IO system reacts as follows: • IO devices of the docking units remain disabled when ReconfigIOSystem is called with MODE 3. This reaction corresponds to the reaction of a configuration without configuration-controlled IO devices. IO devices of docking units are disabled by default and must be enabled in the user program. For more information on docking units, refer to the section Docking systems (Page 302).

Rules for the call sequence of "ReconfigIOSystem"

- Always supply the instruction "ReconfigIOSystem" with the same control data record (CTRLREC input parameter)!
- Call sequence following POWER OFF -> POWER ON transition:
  - ReconfigIOSystem call with MODE 1 (optional).
  - ReconfigIOSystem call with MODE 2 (mandatory, even without previous reconfiguration!).
  - ReconfigIOSystem call with MODE 3 (mandatory).
- Call sequence following STOP > RUN transition:
  - ReconfigIOSystem call with MODE 1 (optional).
  - ReconfigIOSystem call with MODE 2 (mandatory, even when configuration was modified in STOP state). Otherwise not required).
  - ReconfigIOSystem call with MODE 3 (mandatory).

- Call sequence for reconfiguration in RUN state:
  - ReconfigIOSystem call with MODE 1 (mandatory).
  - ReconfigIOSystem call with MODE 2 (mandatory).
  - ReconfigIOSystem call with MODE 3 (mandatory).

Explanations and recommendations concerning the rules

- If you do not list an IO device to be configured as optional IO device in the control data record or data block resp. this IO device does not form part of the configuration and does not take part in data exchange with the CPU.
- If you do not activate any optional IO device at all and work with the loaded configuration without reconfiguration, you still have to follow the proceeding described in the above section and transmit the control data record to the CPU.

  The control data record has the simple structure with the following tags:
  - Version (High Byte =1, Low Byte = 0)
  - Number of optional devices to be activated = 0
  - Number of port interconnections that are set in the user program = 0
- Following a STOP > RUN transition and following a POWER-OFF > POWER-ON transition, all IO devices are deactivated automatically. For this reason, no ReconfigIOSystem call with MODE 1 is required for configuration control to function properly.

  If you use your project as a universally valid sample for programming the configuration control, we still recommend to perform the ReconfigIOSystem call with MODE 1 prior to any reconfiguration. This way, the sample can also be used for reconfigurations in RUN mode.
- Commissioning extensive I/O systems (more than 8 optional IO devices) while using IRT at the same time:

  To keep the startup times short when activating the optional IO devices (ReconfigIOSystem, mode 3), note the following tip: Check the device numbers of the IO devices. The device numbers should follow the topological interconnection starting at the IO controller in ascending order. The further an IO device is from the IO controller topologically, in other words the more IO devices there are between the IO controller and the IO device in question, the higher the device number should be.

  You set the device numbers in the "Ethernet addresses - PROFINET" area in the Inspector window with the PROFINET interface selected.

  Example of the assignment of device numbers with a linear topology:

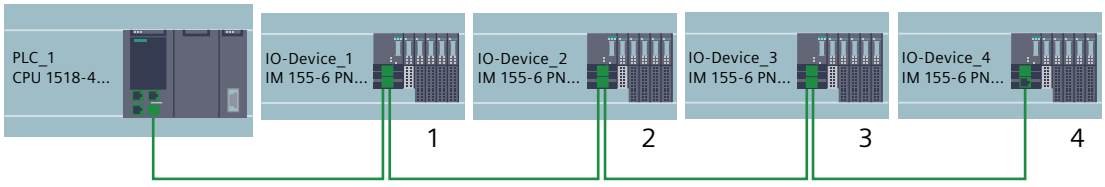

Figure 3-727 Example: Device numbers in a line topology

- The CPU processes the instruction "ReconfigIOSystem" to transfer the control data record asynchronously.

  For this reason, you must call "ReconfigIOSystem" in a loop repeatedly when calling the instruction in the startup program until the output parameter "BUSY" or "DONE" indicate that the data record has been transferred.

  Tip: To program the loop, use the SCL programming language with the instruction REPEAT ... UNTIL.

```
REPEAT
    "ReconfigIOSystem"(REQ := "start_config_ctrl",
                MODE := 1,
                LADDR := 64,
                CTRLREC := "myCTRLREC".ArrMachineConfig0,
                DONE => "conf_DONE",
                BUSY => "conf_BUSY",
                ERROR => "conf_ERROR",
                STATUS => "conf_STATUS");
UNTIL NOT "conf_BUSY"
END_REPEAT;
```

Additional information

For information on the basic structure of the data record and on using the instruction "ReconfigIOSystem" see the STEP 7 online help.

See also

Configuring IO devices as optional (Page 287)

7.10.2.4 Configuring flexible order of IO devices

The following section shows how you can create the conditions required to change the order of IO devices in a PROFINET IO system.

This function is also supported with optional IO devices. For simplicity, a maximum configuration without optional IO devices is shown below.

Concept

A typical application for a standard machine project consists of composing an entire plant from a set of various plant units which only differ with respect to the different arrangement of the units, e.g. in the case of transport systems. Each plant unit consists of a functional unit of mechanics (rails or conveyor belts) and electrics (power supply, IO device with IO modules, sensors, actuators, motors, PROFINET port for data exchange with central control ...).

The following figure shows how, simply by exchanging two rail segments, a new transport system is created that is adapted with an upstream points to the local conditions.

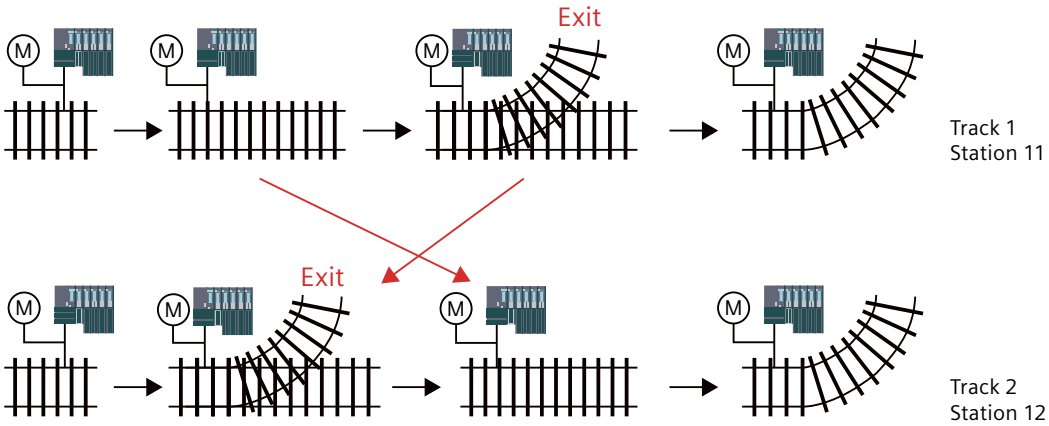

Figure 3-728 Example: Changing the arrangement of IO devices

From the automation viewpoint, no change in the project is required for the flexible adjustment of the PROFINET configuration.

The order of the IO devices is determined by the port interconnection. For each IO device, you define in the port properties the partner port and thus the neighboring device connected at the respective local port. If the partner port is to be defined by the user program, the option "Partner set by user program" is to be selected as partner port.

The figure below shows the initial configuration of the transport system shown above, which is to permit the order of the connected IO devices to be changed via the user program. In the example, the order of IO-Device_2 and IO-Device_3 is to be controlled via the user program.

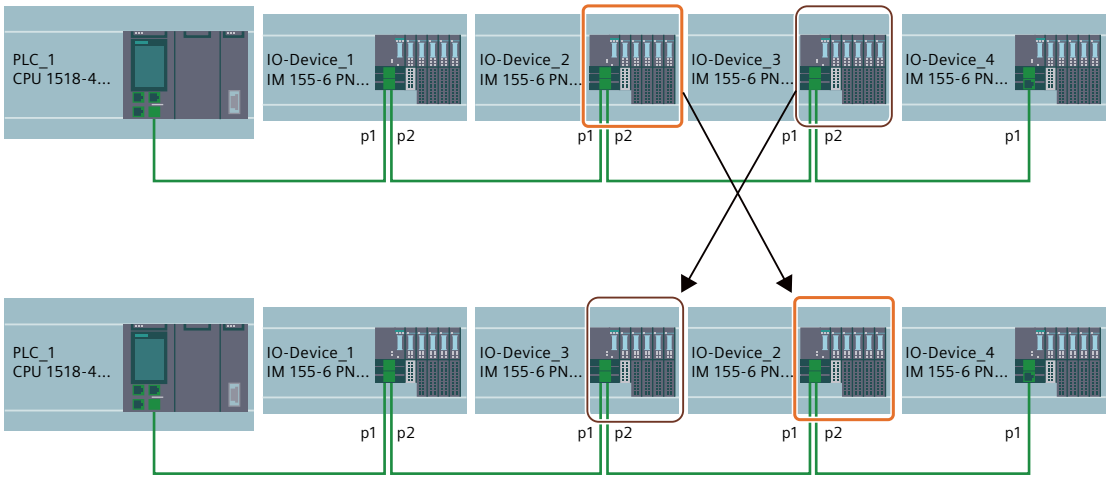

Figure 3-729 Example configuration: Configuring flexible order of IO devices

To determine how the partner port settings are to be selected, you must note for each device and each port of a device which partner can be interconnected.

- If the partner is always the same in the different configurations provided, you select the partner port for this partner.
- If the partners vary in the different configurations, you select "Setting partner by user program".

For the example in the figure above, the following port settings result:

Device	Local port	Partner port setting	Explanation
PLC_1	p1	p1 (IO device_1)	Partner of PLC_1 at port 1 is IO device_1 (always)
IO device_1	p1	p1 (PLC_1)	Partner of IO device_1 at port 1 is PLC_1 (always)
IO device_1	p2	Partner is set by user program	Partner of IO device_1 at port 2 is either IO device_2 or IO device_3 => Setting partner by user program
IO device_2	p1	Partner is set by user program	Partner of IO device_2 at port 1 is either IO device_1 or IO device_3 => Setting partner by user program
IO device_2	p2	Partner is set by user program	Partner of IO device_2 at port 2 is either IO device_3 or IO device_4 => Setting partner by user program
IO device_3	p1	Partner is set by user program	Partner of IO device_3 at port 1 is either IO device_2 or IO device_1 => Setting partner by user program
IO device_3	p2	Partner is set by user program	Partner of IO device_3 at port 2 is either IO device_4 or IO device_2 => Setting partner by user program
IO device_4	p1	Partner is set by user program	Partner of IO device_4 at port 1 is either IO device_3 or IO device_2 => Setting partner by user program
IO device_4	p2	Any partner	No partner planned at port 2

Requirement

- IO controller supports configuration control for IO systems, for example CPU 1515-2 PN as of firmware version 1.7
- STEP 7 V13 SP1 or higher
- The rules (Page 298) for the establishment and operation of a standard machine project have been considered.

Procedure

To set the partner port for a program controlled interconnection, proceed as follows:

1. Select the PROFINET interface of the device (IO controller or IO device) whose port you want to set.
2. In the properties of the PROFINET interface, select the area "Port interconnection" (Extended options > Port [...] > Port interconnection).
3. From the drop-down list, select "Setting partner by user program" as partner port.
4. Repeat steps 1 to 3 for each port to be interconnected via the user program.

See also

Customizing arrangement of IO devices in the program (Page 296)

7.10.2.5 Customizing arrangement of IO devices in the program

Requirements

- IO controller supports configuration control for IO systems, for example CPU 1516pro-2 PN as of firmware version 1.7 as an IO controller
- STEP 7 V13 SP1
- At least one partner port was configured as "Partner set by user program".
- The rules (Page 298) for the establishment and operation of a standard machine project have been considered.

Procedure

The proceedings corresponds to the proceeding for activating optional IO devices.

Only the structure of the data record must be extended for the program-controlled assignment of the ports. The extension is described in the following sections.

Example: Data record structure for the assignment of partner ports

For the data record structure, you need the HW identifications of the ports.

The data record is to be stored in a data block and to be transmitted to the PROFINET interface of the IO controller in the user program using the instruction "ReconfigIOSystem".

As the input parameter RECORD of the instruction "ReconfigIOSystem" is of the VARIANT data type, you first have to create a data type for the data block.

In the following sections, you find a description of the structure of the PLC data type as well as of the structure of the data block based on this type.

Selecting derived configuration

For the following selected configuration it is shown below what the data record must look like so that the IO devices are interconnected in the planned order by the user program.

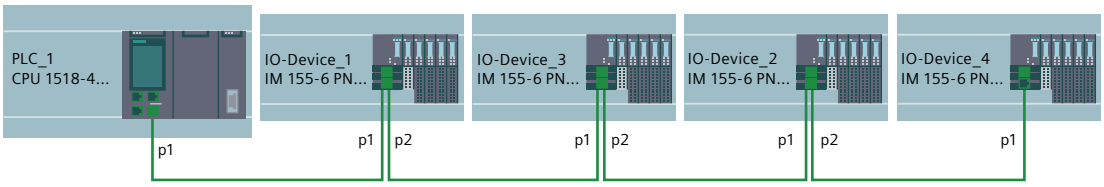

Figure 3-730 Example configuration: Customizing arrangement of IO devices in the user program

This example is based on the flexible configuration from the previous section (Page 293) with the settings for the respective partner ports described there.

The partner ports in the specific derived configuration have been defined so that it is possible to name the HW identifications of the ports involved.

The following table only contains those devices whose ports can be defined by the user program. Only these devices are relevant for the data record structure.

Device	Local port	Partner port setting	Partner port of the selected configuration
IO device_1	p2 = Port 2 HW identifier: 251	Partner is set by user program	Port 1 of IO device_3 HW identifier: 261
IO device_2	p1 = Port 1 HW identifier: 281	Partner is set by user program	Port 2 of IO device_3 HW identifier: 291
IO device_2	p2 = Port 2 HW identifier: 311	Partner is set by user program	Port 1 of IO device_4 HW identifier: 321

Creating data block

For the derived configuration, the structure of the data block "DB-IO-SYSTEM-Port-Interconnections" is explained as an example.

This data block is used when calling the instruction "ReconfigIOSystem" at input parameter "CTRLREC".

Instead of the absolute values for the hardware identifiers of the ports, the system constants of the hardware identifiers are used here.

The data block is structured as follows:

Line 2: Declaration of an Array of Word (only this data type is possible).

Line 3: Version of the control data record: V1.0.

Line 4: Number of optional IO devices: 0.

Line 5: Number of specified port interconnections: 3.

Line 6: Port interconnection 1, local port.

Line 7: Port interconnection 1, partner port.

Line 8: Port interconnection 2, local port.

Line 9: Port interconnection 2, partner port

Line 10: Port interconnection 3, local port.

Line 11: Port interconnection 3, partner port.

IO-SYSTEM-Port-Interconnections

	Name	Datentyp	Startwert	Kommentar
1	Static			
2	ArrMachineConfig	Array[0..8] of Word		data record for port interconn settings
3	ArrMachineConfig[0]	Word	16#0100	
4	ArrMachineConfig[1]	Word	16#0000	
5	ArrMachineConfig[2]	Word	16#0003	
6	ArrMachineConfig[3]	Word	"IO_device_1~PROFINET_interface~Port_2"	
7	ArrMachineConfig[4]	Word	"IO_device_3~PROFINET_interface~Port_1"	
8	ArrMachineConfig[5]	Word	"IO_device_2~PROFINET_interface~Port_1"	
9	ArrMachineConfig[6]	Word	"IO_device_3~PROFINET_interface~Port_2"	
10	ArrMachineConfig[7]	Word	"IO_device_2~PROFINET_interface~Port_2"	
11	ArrMachineConfig[8]	Word	"IO_device_4~PROFINET_interface~Port_1"	

Figure 3-731 Data block with data record for port interconnections

Interconnection not listed in data block

If the partner port was configured as "Setting partner by user program" in the port properties and this port is not listed in the data record or data block resp., then the CPU sets this port to the setting "any partner". If no data record is transmitted at all, the CPU sets this "any partner" setting for all program-controlled assignments.

Additional information

For information on the basic structure of the data record and on using the instruction "ReconfigIOSystem" see the STEP 7 online help.

7.10.2.6 System behavior and rules

Below, you find a description of how an IO system whose configuration is controlled by the user program behaves in operation.

In addition, rules and restrictions are listed here which must be considered when configuring the maximum structure of the configuration in a standard machine project.

System behavior

- System diagnostics:

  If an optional IO device is deactivated, the IO device is displayed as "deactivated" from the system diagnostics viewpoint (online view or Online & Diagnostics).

- Topology view:

  Offline view: As configured. No interconnection is shown for ports with partner ports configured as "Setting partner by user program".

  Online view: Ports and interconnections with deactivated IO devices are shown in a different shade of green as error-free ports and interconnections of activated IO devices.

- Representation in the Web server:

  The names of devices are shown as configured (Properties > General > Project information).

  The assigned PROFINET device name for the CPU is shown on the "Communication" website, at the "Parameter" tab.

  IP address parameters: Currently assigned IP address parameters are shown on the site "Module state".

  Topology: The current topology resulting from any customizations via user program is shown in the Web server. IO devices configured as optional are shown as "deactivated" IO devices in the Web server.

Rules

The rules for standard machine projects as described here (Page 276) apply.

For configuration-controlled IO systems, the following additional rules apply:

- When configuring MRP (Media Redundancy Protocol):

  The ports configured as ring ports must not be interlinked via user program.

  However, devices with ring ports (devices of an MRP domain) can be optional IO devices.

- When configuring docking stations (= IO devices changing during operation):

  Neither the docking station nor the first IO device of a docking unit may be optional IO devices.

  The ports of the docking units must not be interlinked via user program.

- When configuring IRT:

  The order of synchronized IO devices ("IRT devices") must be defined by the configuration and must not be changed in the different variants of a standard machine. For this reason, the ports of the IRT devices must not be interlinked via user program.

  However, you have the possibility to configure IRT devices primarily as optional IO devices.

  You also have the option to interconnect, by user program, RT devices that are, for example, separated from this line by a switchport (see figure).

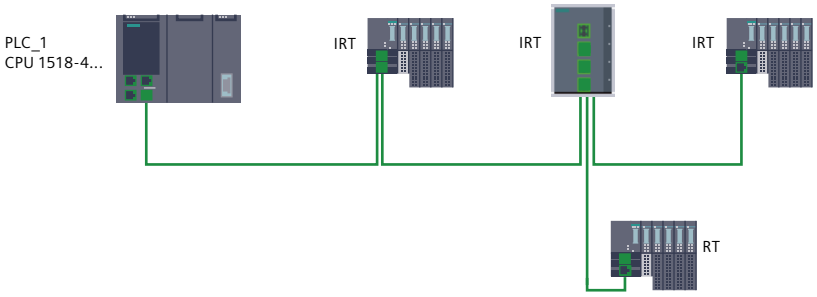

Figure 3-732 Example: Configuration control for IO systems with separated RT device

7.11 Saving energy with PROFIenergy

Saving energy with PROFIenergy

PROFIenergy is a PROFINET-based data interface for switching off consumers centrally and with full coordination during pause times regardless of the manufacturer or device type. Through this, the process should only be provided with the energy that is absolutely required. The majority of the energy is saved by the process; the PROFINET device itself only contributes a few watts of savings potential.

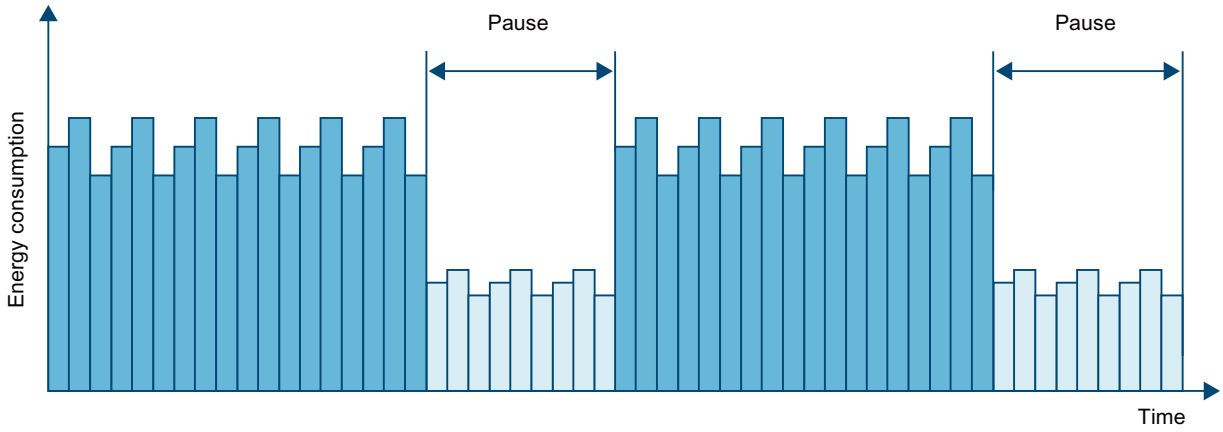

Figure 3-733 Energy savings during pauses with PROFIenergy

Basic information

In order to use the PROFIenergy functionality, the existing IO controller has to be "upgraded" to a so-called "PROFIenergy controller" by means of a function block in the PROFINET IO system and at least one PROFIenergy-capable IO device ("PROFIenergy device") has to exist. The PROFIenergy commands (for example to start or end a pause) are sent by the "PROFIenergy controller" to the individual "PROFIenergy devices". Each "PROFIenergy device" decides individually how it responds to the PROFIenergy command (response is device- and manufacturer-specific).

No additional hardware is needed; the PROFIenergy commands are directly interpreted by the PROFINET devices.

Principle of operation

At the beginning and end of pauses, the system manager enables or disables the pause function of the system; then the IO controller sends the PROFIenergy command "Start_Pause"/"End_Pause" to the PROFINET devices. The device interprets the contents of the PROFIenergy command and switches off or back on.

Through other PROFIenergy functions, device information can be accessed during pauses. The user can use this information in order to optimally time the transfer of the "Start_Pause"/"End_Pause" command.

PROFIenergy instructions for IO controllers

Two instructions are needed for controlling and monitoring the PROFIenergy functions.

The instruction PE_START_END allows you to easily activate and deactivate the idle state of PROFINET devices. This occurs by means of an incoming edge or outgoing edge. The instruction PE_START_END provides a simple interface for implementing the PROFIenergy commands Start_Pause and End_Pause.

The instruction PE_CMD allows you to transmit all PROFIenergy commands, including Start_Pause and End_Pause. The other commands can be used, for example, to query the current status of the PROFINET device or the behavior during the pauses. The instruction PE_CMD is a convenient means for handling all PROFIenergy functions.

PROFIenergy instruction for I-devices

The instruction PE_I_DEV allows you to also implement PROFIenergy on I-devices. The instruction receives PROFIenergy commands on the I-device and forwards these to the user program for execution. After executing the command, the user program calls the PE_I_DEV instruction again in order to send the acknowledgment to the IO controller. For these replies, each command offers you a helper instruction that supplies the reply data to the instruction.

The instructions can be found in the "Instructions" task card of the STEP 7 program editor.

Configuration and programming

The functions can be comfortably integrated into existing systems. No configuration is required for the use of PROFIenergy. However, amendments to the user program are required:

- Before the "Start_Pause" command, you must ensure that your system is brought into a condition that is suitable for a pause.
- A sequential control system for the beginning of the pause of the devices and for the punctual restarting of the device on break must be programmed (depending on the required startup times that the respective PROFINET device demands).
- The error messages of the PE_CMD instruction must be evaluated, and the required reaction must be programmed (for example, cancellation or continuation of further commands on lower-level PROFINET devices).

NOTE

In the case of the ET 200S distributed I/O system, you have to configure the application of PROFIenergy in STEP 7. You configure PROFIenergy by selecting the "Use energy saving for this potential group" check box in the PM-E DC24V/8A RO power module.

If you want to use PROFIenergy for an I-device, you have to configure this in STEP 7. Information about configuring PROFIenergy for an I-device is available in the section Configuring PROFIenergy with I-devices (Page 147).

Application examples

- SIMATIC S7 library for simple configuration of PROFIenergy.
  The application example is available here
  (https://support.industry.siemens.com/cs/ww/en/view/109478388).
- Application guide for implementation of shutdown concepts with PROFIenergy.
  The application example is available here
  (https://support.industry.siemens.com/cs/ww/en/view/96837137).
- Saving energy with SIMATIC S7 PROFIenergy with I-device
  The application example is available here
  (https://support.industry.siemens.com/cs/ww/en/view/41986454).

7.12 Docking systems

Using alternating IO devices ("alternating partners") during operation in a docking station

The following figure shows an automation cell with a docking station and several docking units.

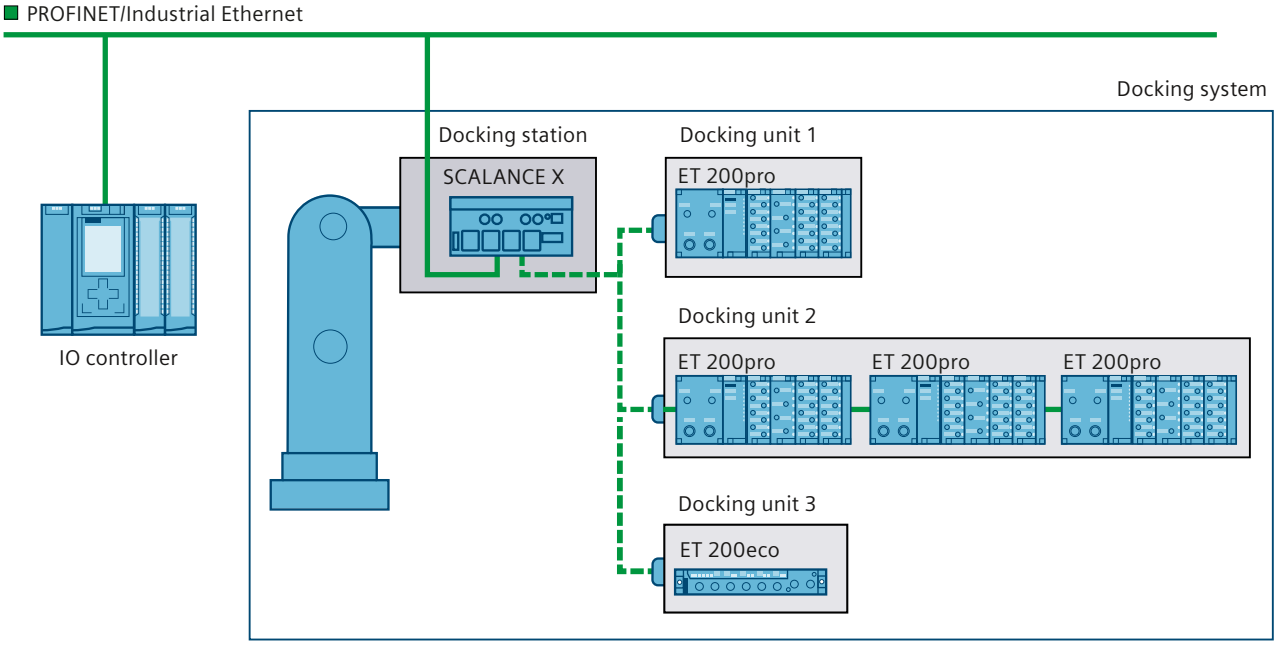

Figure 3-734 Alternating IO devices (partner ports) in a docking system

Area of application for alternating IO devices during operation

You can use the PROFINET function "Alternating IO devices during operation" ("alternating partners"), for the tool changeover for robots, for example. Typical tools include:

- Welding guns
- Positioning tools for manufacturing parts

Requirements for interconnecting alternating partner ports during operation

You can interconnect IO devices with alternating partner ports during operation in the following situations:

- The alternating IO device (docking unit) has no IRT communication configured.
- The PROFINET interface is connected to the Ethernet subnet.
- The PROFINET devices support topology configuration.
- The IO controller, the alternating IO devices (docking unit) and the switch (docking station) on which the alternating IO devices are to be operated support this feature.

NOTE

Unique IP address

Each docking unit of a docking system must be configured with a unique IP address in a shared project and operated on the same IO controller as all other docking units of the system.

Applicative conditions

The following points should be observed when implementing a docking system with alternating IO devices during operation:

- The IO devices of all docking units must be deactivated by default in the configuration.
- At any time, only one docking unit can be active, i.e., only the IO devices of one docking unit can be activated. All IO devices of other docking units must be deactivated or become deactivated before the IO devices of a docking unit can be activated. You activate an IO device with the "D_ACT_DP" instruction.
- A physical connection to this docking unit and its IO devices must be created in order to activate a docking unit. The IO devices are then switched on (power on). At the same time, all the IO devices of this docking unit must be activated in the user program with the "D_ACT_DP" instruction.

NOTE

Automatic deactivation in "Startup" mode of the CPU

If the CPU is in "Startup" mode, IO devices of a docking system that alternate during operation are deactivated automatically.

- After the feedback "IO device activated", you can access the IO device by means of direct I/O access.

- Call the "D_ACT_DP" instruction to activate and deactivate the IO device as close as possible to the start of the OB 1 cycle.

NOTE

Number of alternating IO devices during operation ("alternating partner port") - number of docking units

If you wish to achieve the shortest possible tool changeover times, you must observe the following points that are dependent on the CPU or the CP that is being used:

– Only those IO devices that have been configured with the PROFINET function "Prioritized startup" can start up in an optimized fashion. The number of IO devices with configuration for this PROFINET function is restricted.

– Only a limited number of IO devices can be activated at the same time. This number depends on the available "D_ACT_DP" resources. A docking unit should not contain more than the corresponding number of IO devices. If more IO devices are operated in a docking unit, the IO devices must be activated one after the other, which takes correspondingly longer.

Example: An S7-CPU 1516-3 PN/DP can operate a maximum of 32 IO devices with prioritized startup and can simultaneously activate 8 IO devices by means of "D_ACT_DP".

Therefore, for a scheduled optimum use, a docking unit should include no more than 8 IO devices and no more than 32 IO devices should be used in all the alternating docking units.

7.12.1 Configuring docking systems

Configuring docking systems

The possible connections to the individual IO devices must be configured in STEP 7.

Procedure in STEP 7

1. Configure your system as usual, but do not yet configure the topological interconnections of the individual PROFINET devices.
2. Navigate to the "Topology view" tab.
3. Select the port which you want to operate with alternating partners during operation.
4. Navigate to the "Properties" tab of the inspector window and select "Port interconnection" in the area navigation.
5. Under "Partner port", select the "Alternative partners" option.

6. Select the desired partner ports: To do this, click "<Add alternative partners... and choose a partner port. Repeat this process until all required partner ports are connected.

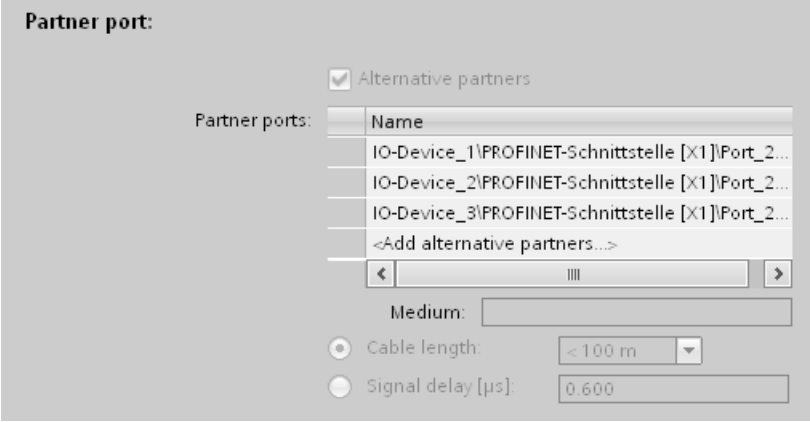

Figure 3-735 Configuring docking systems in STEP 7

Tip: You can also use drag-and-drop operation to connect alternative partner ports in the topology view.

Result

You have interconnected the respective port with one or more alternating IO devices. The connections with the individual alternating partner ports during operation are shown in the topology view by a green, dashed line.

Multiple IO devices as a docking unit ("Alternating partner port")

A docking unit may also consist of several IO devices connected in series. If you use IO devices connected in series as a docking unit, ensure that the topology of the IO devices is configured. A docking unit consisting of two IO devices connected in series (Tool_3_1 and Tool_3_2) is shown at the bottom right in the figure below.

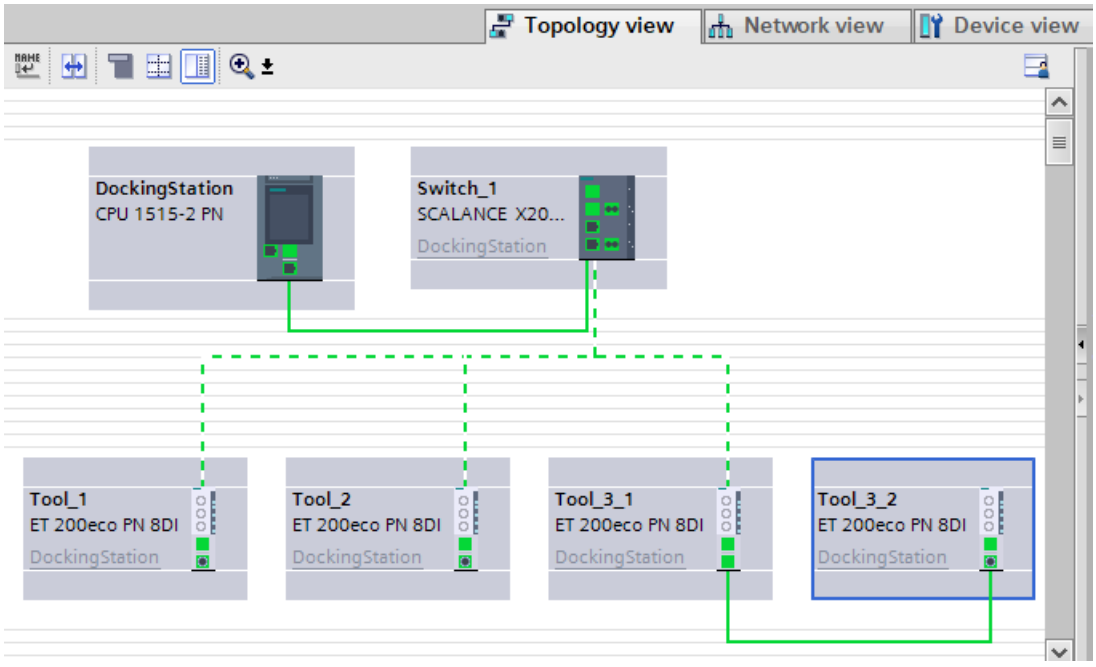

Figure 3-736 Docking system in the topology view of STEP 7

Restriction in the interconnection

The interconnection with a partner port is not possible in the following cases:

- The partner port does not have a suitable type of cable. In this case, a media convertor from the catalog must be inserted.
- The partner port is blocked (deactivated).
- The two ports that are to be interconnected belong to the same interface (it is only possible to interconnect the ports from different interfaces in a station).
- The two ports that are to be interconnected belong to different Ethernet subnets.

Deleting interconnections

Select the port of the alternating partner and remove the interconnection with the "Remove" button.

7.13 Accelerating startup

7.13.1 Options for accelerating the startup of IO devices

Reducing the startup time of IO devices

The time needed for the startup of IO devices depends on various factors and can be reduced in different ways.

You can achieve a significant reduction in the startup time using the "Prioritized startup" PROFINET function.

To further reduce the startup times, use the following measures in addition to the "Prioritized startup":

- Optimize the port settings
- Optimize the cabling of the ports
- Perform measures in the user program (for docking systems only)

These measures will accelerate the startup of IO devices even without "Prioritized startup". However, you can only achieve the fastest startup times of about 500 ms by combining all the measures with "Prioritized startup".

NOTE

Startup time up to 8 s

In the following situation, despite prioritized startup, a startup time of up to 8 s may occur:

On a docking point, multiple physical IO devices dock as an IO device with identical device names and identical IP configurations (for example, docking point for automatic transport system).

Dependencies

The length of the startup time for an IO device (distributed I/O) with the "Prioritized startup" PROFINET function depends on the following factors:

- IO devices (distributed I/O)
- IO structure of the IO device (distributed I/O)
- Modules of the IO device (distributed I/O)
- IO controller
- Switch
- Port setting
- Cabling

- Configured RT class of the IO device

NOTE
Startup time and RT class of the IO device
An IO device with IRT communication requires longer than an IO device with RT communication for the accelerated startup.
The longer startup for IRT is due to the necessity of synchronizing the IO device before the communication can be set up.

NOTE
IWLAN and prioritized startup
PROFINET devices which are connected via access points to PROFINET IO do not support the "Prioritized startup" PROFINET function.

7.13.2 Prioritized startup

Definition

Prioritized startup denotes the PROFINET functionality for accelerating the startup of IO devices in a PROFINET IO system with RT and IRT communication. It reduces the time that the correspondingly configured IO devices require in order to return to cyclic user data exchange in the following cases:

- After the power supply has returned
- After a station has returned
- After activation of IO devices

WARNING
Data exchange despite multiple use IP addresses/device names in PROFINET IO system
To achieve higher ramp-up times, the IO controller checks the uniqueness of device name of IP address parallel to the device ramp-up. In the case of incorrect or double assignment of device name or IP address, a short-time data exchange is possible until the IO controller reacts to the error. In this time the IO controller can exchange IO data with the false device.
During commissioning, ensure that no IP addresses / device names are assigned multiple times in the PROFINET IO system.

Advantages

The PROFINET functionality "prioritized startup" enables PROFINET IO applications in which machine parts or tools and their IO devices have been permanently replaced. Waiting times of several seconds between the scheduled processes of the restart are reduced to a minimum by this optimization. This accelerates the production process with alternating IO devices (PROFINET functionality "docking systems"), e.g. in tool changer applications, and enables a greater throughput in production.

The PROFINET functionality "prioritized startup" also offers a considerable increase in performance for applications where a quick startup time of the IO devices after "power on" or after station failure / station return is required, or when activating IO devices.

Area of application

You can use prioritized startup, for example, for changing tools for robots in the automotive industry. Typical tools are, for example:

- Welding guns
- Positioning tools for the manufacture of car body parts

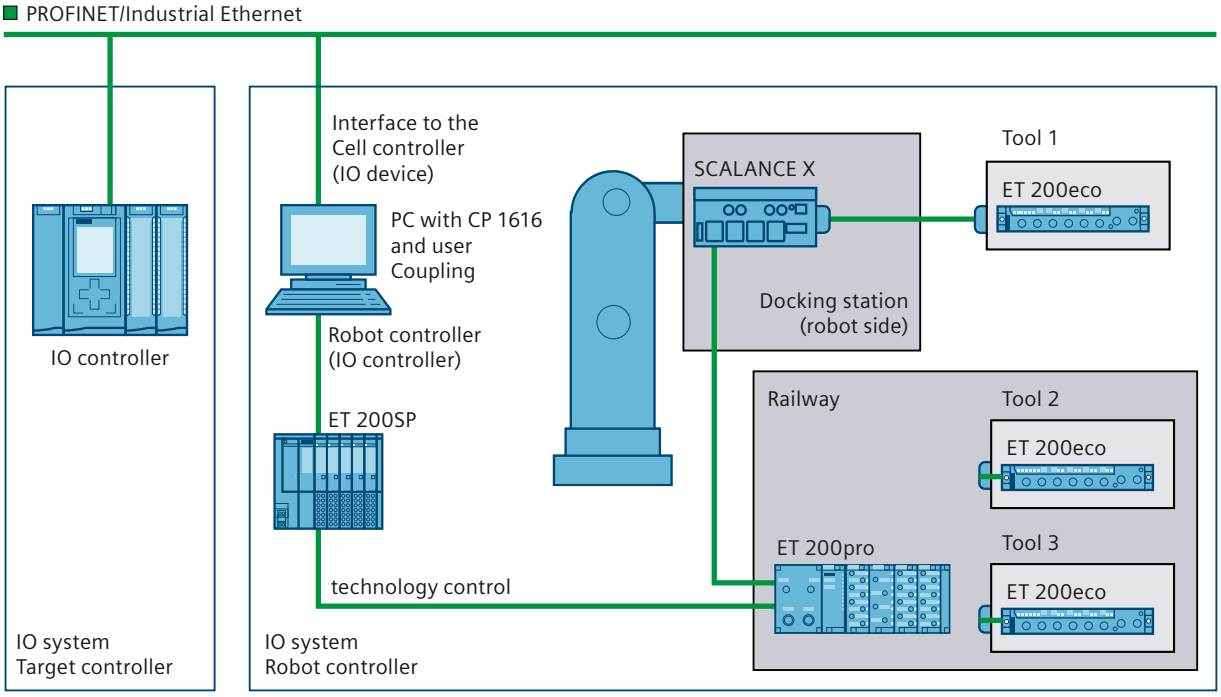

Figure 3-737 Example configuration of a tool changer: Tools 1-3 configured with "Prioritized startup".

7.13.3 Configuring prioritized startup

Requirements

You can enable the "Prioritized startup" PROFINET function for the IO devices (distributed I/O) only in the following cases:

- The IO controller used can prioritize selected IO devices during startup.
- The IO device used supports prioritization.

Procedure

1. Select the IO device in the network view or device view for which you wish to accelerate startup.
2. Open the IO device properties in the Inspector window.
3. Select "PROFINET interface > Advanced options > Interface options".
4. Select the "Prioritized startup" check box.

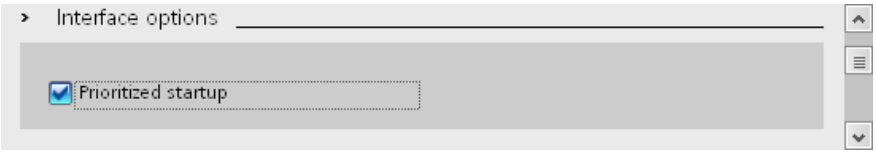

Figure 3-738 Configuring prioritized startup in STEP 7

5. Download the configuration to the IO controller.

NOTE

Prioritized startup after a startup for the first time

A prioritized startup of the IO device is always available to you after the first configuration of this IO device in the very first startup of the PROFINET IO system. Even in the case of spare parts or a reset to factory settings, the first startup is a standard startup for the respective configured IO devices.

NOTE

Number of IO devices (distributed I/O) with prioritized startup

You can only start up a maximum number of IO devices with the "Prioritized startup" PROFINET functionality within one PROFINET IO system. This maximum number depends on the IO controller used.

7.13.4 Optimize the port settings

Optimizing port settings on the IO device and IO controller

The transfer medium and the duplex option are checked during startup of the IO device in the case of copper cabling.

These checks require time, but with specific presets of these options you can save the time the check requires. Make certain that the settings made correspond to the actual conditions (using the correct cables).

Optimizing port settings for accelerated startup

To optimize port settings for accelerated startup, follow these steps:

1. Select the ports of the IO controller or the partner port of the corresponding IO device.
2. Navigate to "Port options > Connection" in the Inspector window. Select the setting "TP 100 Mbps full duplex" under "Transmission rate/duplex"

3. Clear the "Enable autonegotiation" check box.

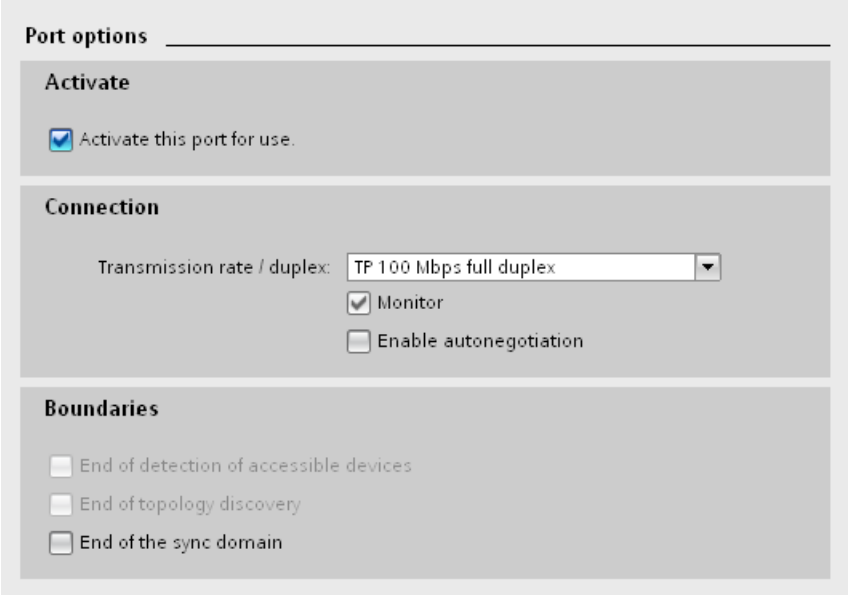

Figure 3-739 Optimizing port settings for accelerated startup in STEP 7

These settings are automatically applied during topology configuration for the partner port.

7.13.5 Optimize the cabling of the ports

Requirements

You have made the following settings for the port in question to reduce the startup time of the IO device:

- Fixed transmission rate
- Autonegotiation deactivated

The time for negotiating the transmission rate during startup is saved.

If you have disabled autonegotiation, you must observe the cabling rules.

Properties of ports

PROFINET devices have the following two types of ports:

Type of port	PROFINET devices
Switch port with crossed pin assignment	For IO devices: Port 2 For S7-CPUs with two ports: Ports 1 and 2
Terminal device port with normal pin assignment	For IO devices: Port 1 For S7-CPUs with one port: Port 1

Crossed pin assignment means that the pin assignment for the ports for sending and receiving between the respective PROFINET devices is inverted internally.

Validity of the cabling rules

The cabling rules described in the following paragraph apply exclusively for the situation in which you have specified a fixed port setting in STEP 7.

Rules for cabling

You can connect several IO devices in series using patch cables. To do this, connect port 2 of the IO device (distributed I/O) with port 1 of the next IO device. The following graphic provides an example with two IO devices.

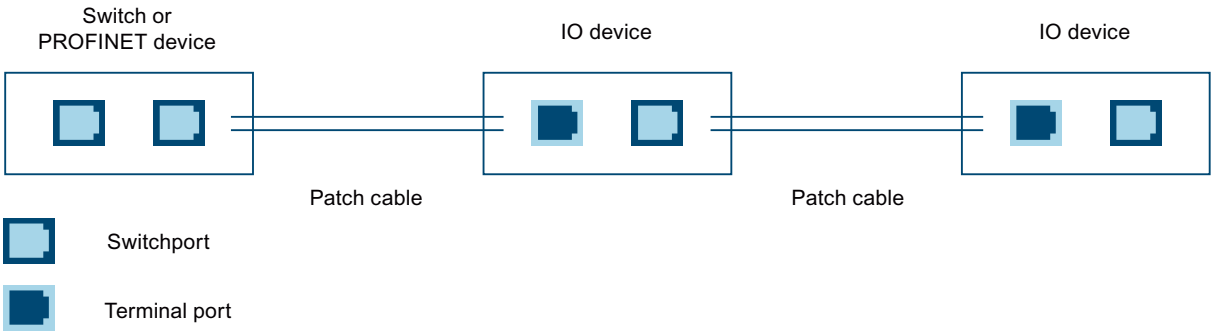

Figure 3-740 Optimized cabling for accelerated startup

7.13.6 Measures in the user program

Introduction

You can make certain changes in the user program to accelerate the startup for IO devices of docking systems that alternate during operation.

Making the required changes to the user program

To accelerate the startup by making changes to the user program, follow these steps:

1. Call the "D_ACT_DP" instruction to activate and deactivate the IO device at the start of the OB 1 cycle.

   If the IO device is replaced, the device that is no longer required must be deactivated and the new device must be activated.
2. If you control the "Power ON" command of the IO devices via the application, then start the activation of the IO devices via the corresponding call of the "D_ACT_DP" instruction as near to the same time as possible. The IO device has to be physically connected for this.
3. You access the IO device using direct access commands after the "D_ACT_DP" instruction has provided the feedback "IO device activated".

7.14 Dealing with timeouts while exchanging data

7.14.1 Terminating communication relation during faults

The prerequisite for data exchange between an IO controller and an IO device is an existing communication relation (Application Relation, AR).

In a communication relation, data is transmitted cyclically and acyclically. If a protocol error or a timeout is detected during acyclic data record communication (e.g. program instructions "RDREC" or "WRREC", or reading of a diagnostic data record), the IO controller terminates the communication relation. In this case, the IO controller assumes that a communication error has occurred. This also ends the cyclic IO data exchange. The error code is returned as a static error in the instruction to the data record transfer. The error is indicated in the diagnostics buffer of the IO controller as the event "IO device failure - Timeout in acyclic PROFINET services".

Possible causes for a termination of the communication relation include:

- A high network load
- Too many ARP telegrams (Address Resolution Protocol).
- Too many UDP frames (User Datagram Protocol).
- Erroneous RPC calls (Remote Procedure Call).

Maintain communication relation

If you can tolerate timeouts during the data record communication from the point of view of your application and no negative repercussions are to be feared, you can change the described default behavior. If, for example, timeouts occur during the data record communication, the communication relation is still preserved. Cyclic IO data exchange continues.
A data exchange error is then signaled as a temporary error (status code: 16#DE80_C300 or 16#DF80_C300) in the instruction for data record transfer.

Starting from STEP 7 V19, you have two options for enabling maintenance of the communication relation. Depending on the FW version of the S7-1500 CPU used, you can enable maintenance as follows:

- S7-1500 CPU as of FW version V3.1:
  - You can configure the maintenance in the CPU properties.
  - You can transfer a data record 0xB072 to an integrated PROFINET interface of the S7-1500 CPU.
- S7-1500 CPU as of FW version V3.0: You can transfer a data record 0xB072 to an integrated PROFINET interface of the S7-1500 CPU.

You must enable maintenance of the communication relation separately for each required PROFINET interface:

- When configuring in the CPU properties, you must enable maintenance for each required PROFINET interface separately.
- When transferring a data record 0xB072, you must transfer this data record separately to each required PROFINET interface.

You will find the various procedures for maintaining the communication relation in the sections below.

Maintaining the communication relation in S7-1500 R/H systems

For S7-1500 R/H CPUs, enable maintenance of the communication relation as described above. However, the S7-1500 R/H system does not synchronize all changes automatically. Therefore you must make the following changes:

- Enable in the CPU properties: Enable maintenance of the communication relation in the CPU properties of one CPU of the S7-1500 R/H system. STEP 7 automatically synchronizes this setting between the two CPUs.
- Transfer a data record: A PROFINET interface, e.g. X1, has different hardware identifiers for the two CPUs. Therefore, write the data record during runtime to the respective addressed PROFINET interface of both CPUs.

In the case of S7-1500 R/H systems, you can only maintain the communication relation at the PROFINET interface X1.

7.14.2 Enabling maintenance of the communication relation in the CPU properties

Requirements

If you want to enable maintenance of the communication relation in the CPU properties, the following requirements must be met:

- STEP 7 V19
- S7-1500 CPU FW version V3.1 or higher
- IO system, e.g. "PLC_1.PROFINET IO System (100)", has been configured at the relevant PROFINET interface

Procedure

The following procedure shows an example of how to enable maintenance of the communication relation at the integrated PROFINET interface X1. The procedure is identical for all integrated PROFINET interfaces of the S7-1500 CPU. To enable maintenance of the communication relation in the CPU properties, follow these steps:

1. Switch to the network view of STEP 7.
2. Configure an S7-1500 CPU, e.g. CPU 1516-3 PN/DP, with the required IO devices.
3. Select a PROFINET interface of the S7-1500 CPU, e.g. X1.
4. In the Inspector window, go to "General > Advanced options > Interface options".

5. In the "Interface options" area, select the "Maintain PROFINET IO communication on data record communication timeout" option.

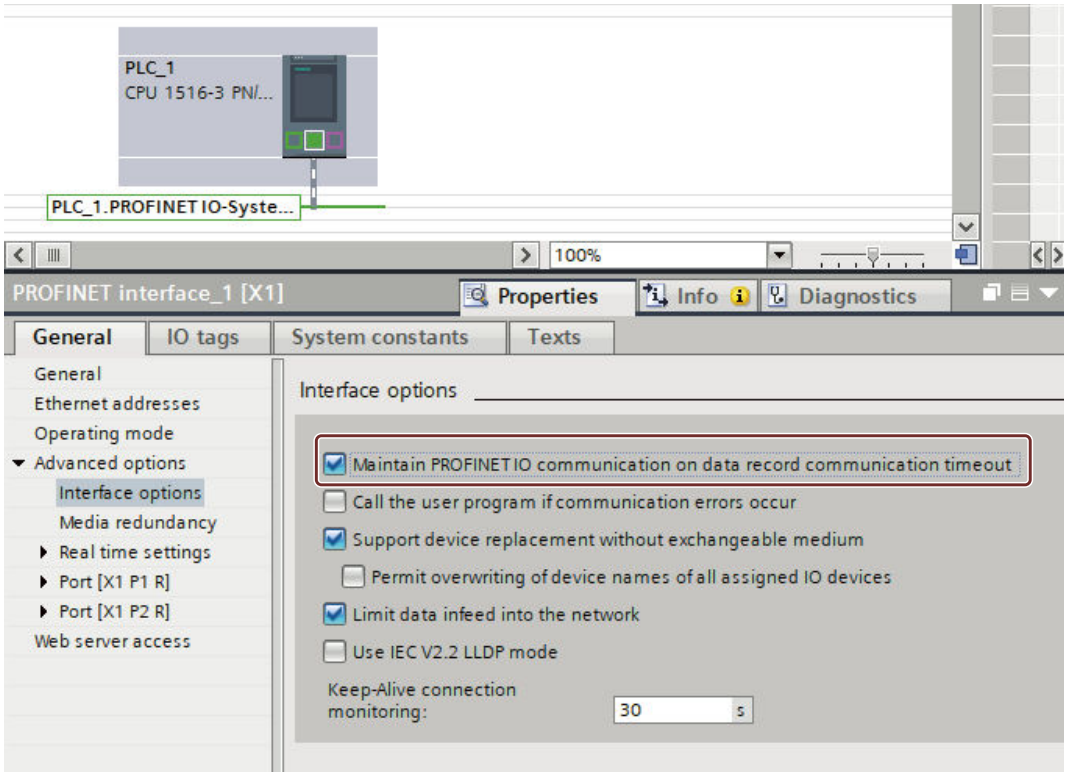

Figure 3-741 Selecting the "Maintain PROFINET IO communication on data record communication timeout" option

6. If required, repeat steps 3 to 5 for another integrated PROFINET interface of the S7-1500 CPU.
7. Load the changed settings into the S7-1500 CPU.

   Result: The communication relation is maintained at the respective configured PROFINET interface of the S7-1500 CPU.

The "Maintain PROFINET IO communication on data record communication timeout" option is only available if you have added an IO system to the relevant PROFINET interface of the S7-1500 CPU. If no IO system exists at this PROFINET interface, the option is displayed in gray. In this case, the option cannot be selected.

If you delete an existing IO system after selecting the "Maintain PROFINET IO communication on data record communication timeout" option, the check box remains selected. The option is displayed in gray in this case and cannot be changed.

Behavior of the option when replacing devices in STEP 7

The "Maintain PROFINET IO communication on data record communication timeout" option can only be selected in STEP 7 V19 for configured S7-1500 CPUs as of FW version V3.1. If you exchange or replace a S7-1500 CPU, the option behaves as follows, depending on the configured FW version:

- S7-1500 CPU with FW version V3.1 → S7-1500 CPU with FW version V3.1:
  STEP 7 applies the settings of the previous S7-1500 CPU to the new S7-1500 CPU.
- S7-1500 CPU with FW version V3.1 → S7-1500 CPU with FW version < V3.1:
  STEP 7 shows a warning message. The option is disabled and can no longer be selected.
- S7-1500 CPU with FW version V3.0 → S7-1500 CPU with FW version V3.1:
  STEP 7 shows an information message. The option can be selected and is deselected in the default settings.

The changes do not take effect on the new S7-1500 CPU until the configuration has been loaded. Therefore, load the changed configuration into the new S7-1500 CPU.

7.14.3 Enabling maintenance of the communication relation by data record transfer

Requirements

If you want to enable maintenance of the communication relation by transferring a data record, the following requirements must be met:

- STEP 7 version V18 or higher
- S7-1500 CPU FW version V3.0 or higher
- At least one IO device has been configured at the addressed PROFINET interface

Procedure

Transfer a data record 0xB072 to the PROFINET interface of the S7-1500 CPU. Coding in this data record indicates whether the communication relation is to be terminated or remain active following an error. The data record acts only on the addressed PROFINET interface.

Option for transferring the data record 0xB072: Definition of the data record structure in the static local data of a function block and call of this function block in the program cycle OB. To do this, follow these steps:

1. Create a function block in STEP 7.
2. For the static local data (Static) of the function block, create a structure of the data record 0xB072.
   – The following table shows the structure of the data record 0xB072:

Byte	Element	Coding	Explanation
0-1	BlockType	0xB072	Header The data record length is counted from byte 4 "BlockVersionHigh".
2-3	BlockLength	8	
4	BlockVersionHigh	0x01	

Byte	Element	Coding	Explanation
5	BlockVersionLow	0x00	
6-7	Reserved	-	-
8-9	ReadWriteBehaviorProperties	0, 1	0: Default behavior. The communication relation is terminated in the case of the scenarios described above. 1: The communication relation is maintained in the case of the scenarios described above.
10-11	Reserved	-	-

3. Call the created function block in the program cycle OB (OB 1) of your user program. A programming example for this function block can be found in the next section.

The newly set behavior is not permanently stored in the S7-1500 CPU. The default setting becomes active again after each POWER OFF/POWER-ON, memory reset, or loading of the hardware configuration. The changed behavior is not active until the write job in the program cycle OB has finished.

NOTE

Changing the communication behavior for each PROFINET interface

The call of the function block in the program cycle OB relates only to the addressed PROFINET interface of the S7-1500 CPU. If you want to maintain the communication relations for other PROFINET interfaces, you must call the function block separately in the program cycle OB for each additional integrated PROFINET interface of the S7-1500 CPU.

Maintaining the communication relation in S7-1500 R/H systems

You can also change the default behavior for S7-1500 R/H CPUs by transferring a data record 0xB072.

However, the S7-1500 R/H system does not automatically synchronize this change in behavior for the respective addressed PROFINET interface at both CPUs, since the PROFINET interfaces have different hardware identifiers. Therefore, write the data record during runtime to the respective addressed PROFINET interface of both CPUs. You can only maintain the communication relation at the PROFINET interface X1.

7.14.4 Example: Transfer data record for behavior change via FB

Task

You want to maintain the communication relation (AR) between the IO controller and IO device even in the event of a temporary data record transfer error, e.g. due to elevated network load.

Requirements

An S7-1500 CPU FW version V3.0 or higher with at least one configured IO device at the addressed PROFINET interface is required.

Solution

Transfer the data record 0xB072 to the PROFINET interface of the S7-1500 CPU. This instructs the S7-1500 CPU to maintain an existing communication relation with the IO device.

The following example shows you how to transfer the data record to the PROFINET interface using a function block (FB). Create a structure of the data record 0xB072 in the block interface under "Static". The following figure shows the structure of the data record in "Static" section.

FbBehaviorAR

	Name	Data type	Default value	Retain	Comment
1	Input				
2	Output				
3	InOut				
4	bStart	Bool	0	Set in IDB	Start writing Data record 16#B072
5	InterfaceID	HW_IO	64	Non-retain	Default for Interface X1
6	wBehaviorProperties	Word	16#1	Non-retain	0: AR will be dropped, 1: AR stays active
7	Static				
8	statArRecord	Struct		Non-retain	Data record 16#B072
9	statBlockType	Word	16#B072	Non-retain	Data record number
10	statBlockLength	Word	16#8	Non-retain	Length of block (default: 8)
11	statBlockVersionHigh	Byte	1	Non-retain	Byte 1 of blockversion
12	statBlockVersionLow	Byte	0	Non-retain	Byte 2 of blockversion
13	statReserved	Word	16#0	Non-retain	Reserved for future usage
14	statBehaviorProperties	Word	1	Non-retain	0: AR will be dropped, 1: AR stays active
15	statReserved1	Word	16#0	Non-retain	Reserved for future usage
16	instWrrec	WRREC			Instance of write record
17	Temp				
18	Constant				

Figure 3-742 Example: Interface of the function block for obtaining the communication relation

In addition to the data record 0xB072, the interface contains other tags that you use to transfer the data record. You need the tags in the "InOut" section to assign parameters for the "WRREC" instruction in the function block. The "WRREC" instruction is executed in an organization block (OB1) when the FB is called.

The program in the function block and the call in the program cycle OB are shown in the following sections.

Program in the function block

The data record is transferred at a positive signal at the "#bStart" tag. The parameters for the tags "#wBehaviorProperties", "#bStart" and "#InterfaceID" are passed to the function block when called in the program cycle OB.

```
//==========================================================
 // Called in OB1
 //==========================================================
 #statArRecord.statBehaviorProperties := #wBehaviorProperties;
 #instWrrec(REQ := #bStart,
```

```
ID := #InterfaceID,
INDEX := DWORD_TO_DINT(16#B072),
LEN := 12, // 0 : any length,
this record uses 12 Bytes,
RECORD := #statArRecord);
IF #instWrrec.ERROR THEN
RETURN; // add error handling
END_IF;
IF #instWrrec.DONE = TRUE THEN
#bStart := FALSE;
END_IF;
```

Calling in a program cycle OB

Drag-and-drop the created function block into the desired program cycle OB (e.g. OB1). The "InOut" parameters are not linked to tags in this example. Instead, they are controlled directly in the instance of the block call via a watch table.

```
//==========================================================
 // Call FbBehaviorAR
 //==========================================================
"Inst_FbBehaviorAR_1"(bStart:=_bool_inout_,
 InterfaceID:=_hw_io_inout_,
 wBehaviorProperties:=_word_inout_);
```

Control via the watch table

1. Create a new watch table.
2. Drag-and-drop the required tags from the instance of the function block into the watch table.

FHB_PN_AR-Uebersicht ▸ PLC_5 [CPU 1516-3 PN/DP] ▸ Watch and force tables ▸ Watch table_1

	i	Name	Address	Displa..	Monitor val...	Modify v...		Comment
1	// Parameters for control							
2		"Inst_FbBehaviorAR_1".InterfaceID		DEC				X1: 64, X2: 72
3		"Inst_FbBehaviorAR_1".wBehaviorProperties		Hex				0: AR default, 1: AR stays active
4		"Inst_FbBehaviorAR_1".bStart		BOOL				Start writing data record
5	// Parameters for the status display							
6		"Inst_FbBehaviorAR_1".Inst_WRREC.DONE		BOOL				Writing the record is done
7		"Inst_FbBehaviorAR_1".Inst_WRREC.BUSY		BOOL				Writing the record is in progress
8		"Inst_FbBehaviorAR_1".Inst_WRREC.ERROR		BOOL				Error while writing the record
9		"Inst_FbBehaviorAR_1".Inst_WRREC.STATUS		Hex				Function result/error message

Figure 3-743 Watch table for transferring the data record

3. Load your project into the S7-1500 CPU.
4. Click "Go online".

You transfer the data record to the PROFINET interface as follows:

1. For the "Inst_FbBehaviorAR_1".InterfaceID" tag, enter the appropriate value for the interface for which you want to change the behavior.
2. To change the behavior, enter the value "1" for the "Inst_FbBehaviorAR_1".wBehaviorProperties" tag.
3. Control the "Inst_FbBehaviorAR_1".bStart" tag to transfer the "TRUE" data record.
4. Repeat steps 1 to 3 for an additional interface where you want to change the behavior.

You can see the status of the transmission to the PROFINET interface as follows:

- "Inst_FbBehaviorAR_1".Inst_WRREC.DONE: The data record was successfully transferred to the PROFINET interface.
- "Inst_FbBehaviorAR_1".Inst_WRREC.BUSY: The data record is currently being transferred to the PROFINET interface.
- "Inst_FbBehaviorAR_1".Inst_WRREC.ERROR: The transfer of the data record to the PROFINET interface was faulty.
- "Inst_FbBehaviorAR_1".Inst_WRREC.STATUS: Output of block status or error information. The corresponding interpretations can be found in the STEP 7 help system.

Note that the variables „Inst_FbBehaviorAR_1“.Inst_WRREC.DONE and „Inst_FbBehaviorAR_1“.Inst_WRREC.ERROR are only present for the duration of a program cycle.

Additional steps for S7-1500R/H systems

Each addressed PROFINET interface of the two R/H CPUs has different hardware identifiers. Therefore, transfer the data record to the respective addressed PROFINET interface of both CPUs for S7-1500 R/H systems.

The values for the "Inst_FbBehaviorAR_1".InterfaceID" tag for S7-1500 R/H systems are listed in the following table:

Table 3-969 Overview of CPUs and associated hardware identifiers of the PROFINET interfaces

CPU	PROFINET interface	Hardware identifier of the PROFINET interface
CPU with redundancy ID "1" (prefixed name: PLC_1)	X1	65164 (prefixed name: Local1~PROFINET-interface_1)
	X2	PROFINET IO is currently not supported.
CPU with redundancy ID "2" (prefixed name: PLC_2)	X1	65364 (prefixed name: Local2~PROFINET-interface_1)
	X2	PROFINET IO is currently not supported.

NOTE

Transfer of the data record to the backup CPU

Do not transfer the data record to the addressed PROFINET interface of the backup CPU until after the S7-1500 R/H system has reached the "Run REDUNDANT" system state. Otherwise, the data record cannot be transferred to the addressed PROFINET interface of the backup CPU.

The CPU redundancy error OB (OB72) starts when the S7-1500 R/H system has reached the "Run REDUNDANT" system state. The "Fault_ID" tag of the OB72 contains the error code "B#16#03" or "B#16#06".

7.15 PROFINET Security

7.15.1 Configuring the SNMP

Component interaction

PROFINET networks use the SNMP protocol for managing devices and the network infrastructure.

For information exchange, authentication must take place through the transfer of community strings. When SNMP is used, a community string must always have been assigned. Empty community strings are not allowed.

You can find configuration options for SNMP in the properties of the following devices:

- S7-1500 CPU as an IO controller/I-device
- IO devices that support the configuration of SNMP

To learn how to configure SNMP for the various components, see the following sections.

NOTE
Avoidance of erroneous access attempts
Inform maintenance personnel about the SNMP-configuration in your plant.

Configuring SNMP for an IO controller

To configure SNMP for an IO controller, follow these steps:

1. Open the Properties of the IO controller in the network view or device view.
2. Navigate to the "Advanced configuration > SNMP" area in the Inspector window.
3. If you want to use SNMP, select the "Activate SNMP " option in the area "SNMP".
   Once you enable SNMP, a warning message appears informing you of the reduced protection against unauthorized access to functions and data of this device.
4. If you only need read access for SNMP, also select the "Enable read-only access for SNMP" option .
5. Change the Read-only and Read-write community strings.
   This increases the security of your system against cyber attacks. Empty community strings are not allowed.

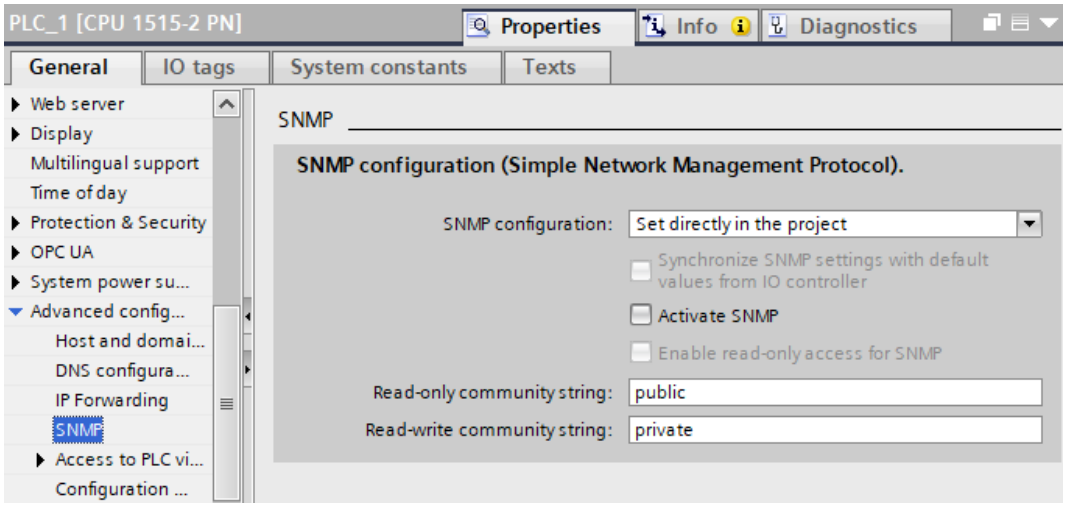

Result: You have configured SNMP in the properties of your IO controller.

You can find information on the "Synchronize SNMP settings with default values from IO controller" option under "Configuring SNMP for an I-device".

Configuring SNMP for the IO system of an IO controller

As of STEP 7 V20 and CPU FW version V4.0, you can configure SNMP parameters as default settings for an entire PROFINET IO system at the PROFINET interface of the IO controller. If IO devices support the configuring of SNMP, the SNMP settings in the device properties of the assigned IO devices are synchronized with these default settings at the PROFINET interface of the higher-level IO controller by default.

To configure the SNMP default settings for a PROFINET IO system, follow these steps:

1. Select the PROFINET interface of the IO controller to which the IO devices to be synchronized are connected in the network view or device view.
2. In the Inspector window, navigate to the "Advanced options > Security settings of the IO devices" area.
   STEP 7 as of V21 only displays this area if a PROFINET IO system has been added to the PROFINET interface of the IO controller.
3. If you want to use SNMP at assigned IO devices, enable the "Activate SNMP for assigned devices" option in the "Default settings for Simple Network Management Protocol (SNMP)" area.
4. If you need only read access for SNMP at the assigned IO devices, activate the "Enable read-only access for SNMP" option additionally.
5. Change the Read-only and Read-write community strings.
   This increases the security of your system against cyber attacks. Empty community strings are not allowed.

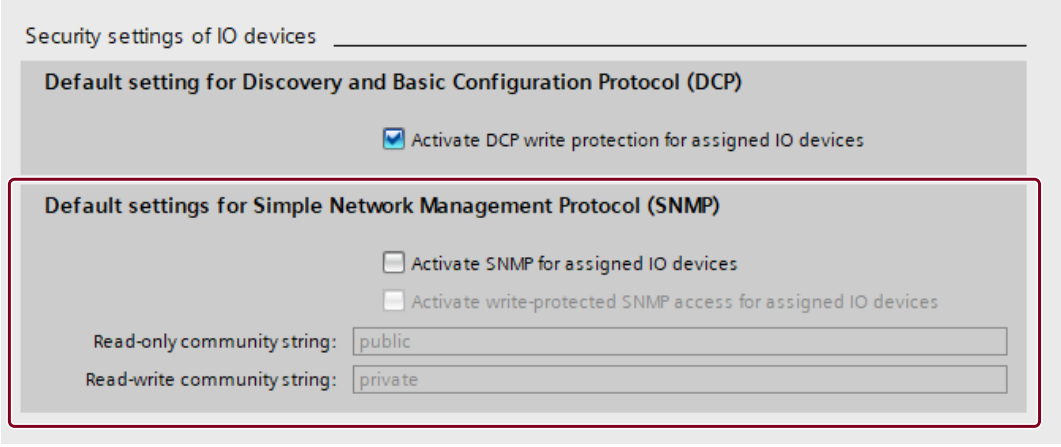

Result: You have configured the SNMP default settings for the entire PROFINET IO system at a PROFINET interface of the IO controller.

Configuring SNMP for an IO device

If an IO device supports the configuration of SNMP, you have the option of defining a separate SNMP configuration for this IO device as of STEP 7 V19. For IO devices that were imported as a GSD file, you can also modify the SNMP configuration in STEP 7 as of V19 or with other tools.

As of STEP 7 V20, IO devices are synchronized to the SNMP default settings of the PROFINET interface of their higher-level IO controller by default. Changes to the SNMP default settings are thus automatically synchronized at the IO devices.
Alternatively, you can define a separate SNMP configuration for each IO device.

To configure SNMP for an IO device in your PROFINET network, follow these steps:

1. Open the properties of the IO device in the network or device view.
2. Select "Advanced configuration" in the Inspector window.
   The option "Synchronize SNMP settings with default values from IO controller" is activated by default.
3. If you want to specify a different SNMP configuration for this IO device, deactivate the option "Synchronize SNMP settings with default values from IO controller".
   The following options can then be edited. The following settings are possible:
   – If you want to use SNMP, select the "Activate SNMP" option.
     Once you activate SNMP, a warning message appears informing you of the reduced protection against unauthorized access to functions and data of this device.
   – If you only need read access for SNMP, also select the "Enable read-only access for SNMP" option.
   – Change the Read-only and Read-write community strings.
     This increases the security of your system against cyber attacks. Empty community strings are not allowed.

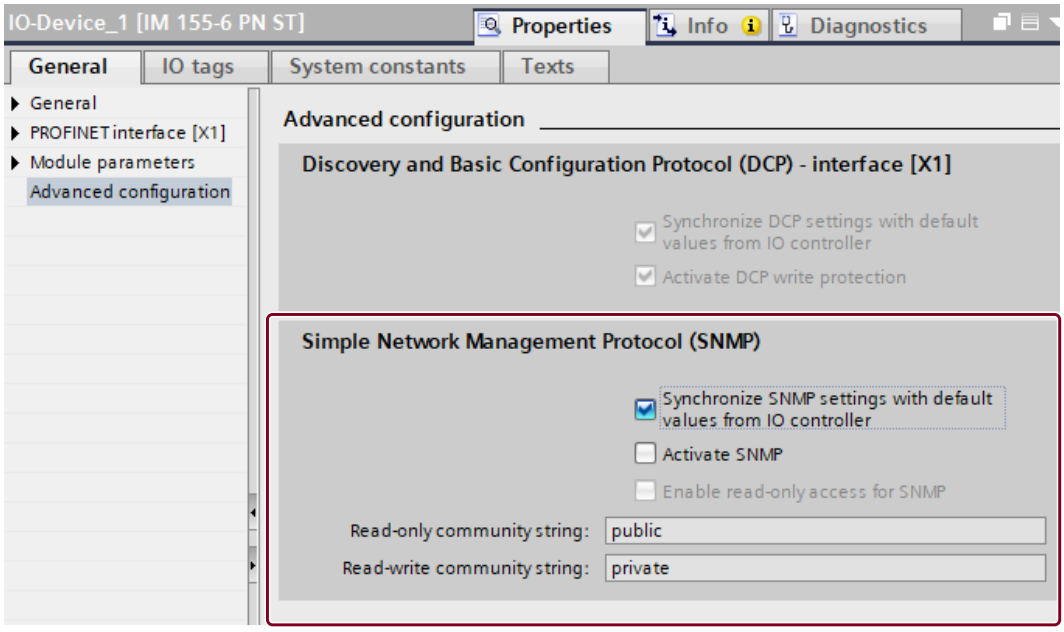

Figure 3-744 Configuring SNMP on an IO device

Result: You have configured SNMP in the properties of the IO device.

Configuring SNMP for an I-device (IO controller and I-device in the same project)

Since STEP 7 V18 you have the option of enabling SNMP in the CPU properties of an IO controller. When a CPU assumes the role of an I-device, you can also define the setting for SNMP in the CPU properties.

As of STEP 7 V20 and CPU FW version V4.0, you can configure SNMP parameters as default settings for an entire PROFINET IO system at the PROFINET interface of the higher-level IO controller. If I-devices support the configuring of SNMP by their higher-level IO controller, you

can synchronize the SNMP configuration in the device properties of the I-device with the default settings at the PROFINET interface of the higher-level IO controller.

To access the SNMP configuration options for an I-device, follow these steps:

1. Open the Properties of the CPU that has been configured as an I-device in the network or device view.
2. Navigate to "Advanced configuration > SNMP" in the Inspector window.
3. Select one of the following options from the drop-down list next to "SNMP configuration":
   - Set directly in the project:
     The I-device receives its SNMP configuration from the configuration that is loaded onto the I-device. Changes to the SNMP configuration by a higher-level IO controller are prevented.
     The "Synchronize SNMP settings with default values from IO controller" option is grayed out in this case and cannot be changed. Configure the SNMP settings as described in steps 4 to 6. Load the configuration into the I-device.
   - Via PROFINET interface ... (e.g. X1) from higher-level IO controller:
     Requirements:
     The "Parameter assignment of PN interface by higher-level IO controller" option is enabled at the I-device.
     An IO controller has been selected in the "Higher-level IO controller of the PN interface" drop-down list.
     The I-device receives its SNMP configuration from its higher-level IO controller. The "Synchronize SNMP settings with default values from IO controller" option is available for selection in this case. If you enable this option, the options underneath are disabled and indicate the synchronized SNMP default settings from the higher-level controller. Load the configuration into the lower-level IO controllers of the I-device. Because the SNMP parameters are transferred into the I-device by the higher-level IO controller, you do not have to reload the I-device configuration in this case.
4. If you want to use SNMP and the I-device is not being synchronized with the SNMP default settings, select the "Activate SNMP" option.
   After activation of SNMP, a warning message appears informing you of the reduced protection against unauthorized access to functions and data of this device.
5. If you only need read access for SNMP, also select the "Enable read-only access for SNMP" option .

6. Change the Read-only and Read-write community strings.
   This increases the security of your system against cyber attacks. Empty community strings are not allowed.

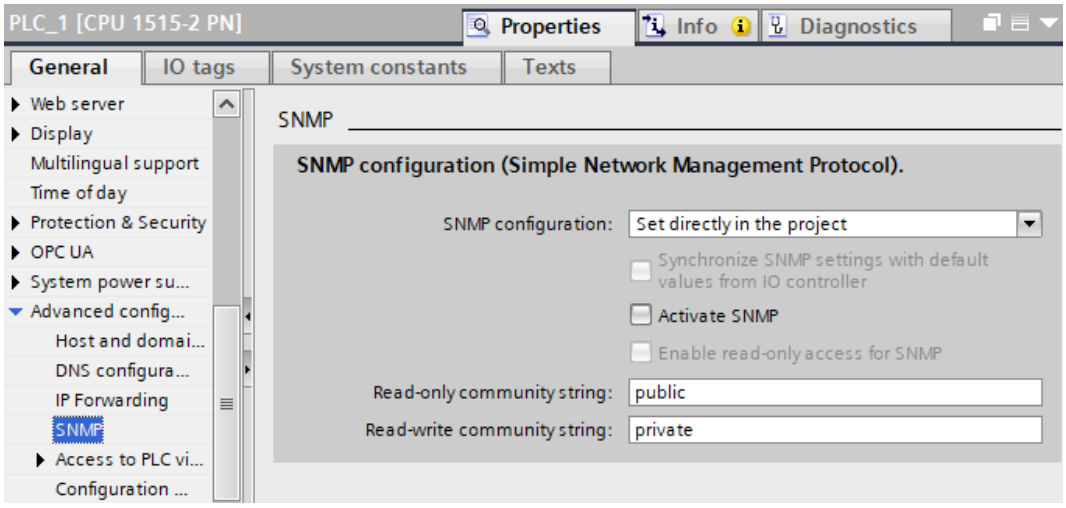

Result: You have configured SNMP in the properties of your project-integrated I-device.

Configuring SNMP for an I-device as a GSD file

To use an I-device in another project or Engineering System, export the configured I-device as a general station description file (GSD file) in STEP 7. When you import the GSD file in the desired project, STEP 7 shows the configured I-device as a GSD device (DP standard device) in the device or network view.

Before the GSD file export, define how you want to use SNMP on the DP standard device. As if STEP 7 V19, you have the following options in the settings of SNMP:

- Configuring of SNMP in the local settings of the I-device:
  Changes to the SNMP configuration in another project are prevented in the exported GSD file. The SNMP configuration options are not displayed on the inserted DP standard device.
- Configuring of SNMP by a higher-level IO controller in another project:
  The SNMP configuration must be created in the other project in the same way as for a standard IO device.
  Requirement:
  The option "Parameter assignment of PN interface by higher-level IO controller" is enabled at the I-device.

If you want to configure SNMP on the DP standard device in another project, make the following settings on the I-device CPU:

1. At the PROFINET interface of the CPU that is configured as an I-device:
   – Activate the "Parameter assignment of PN interface by higher-level IO controller" option in the Inspector window under "Properties > Operating mode".
2. In the SNMP settings of the I-device CPU:
   – Select the entry "via PROFINET interface ... (e.g. X1) from higher-level IO controller" from the drop-down list next to "SNMP configuration".
   In this case, the I-device takes over the SNMP configuration from the higher-level IO controller at its PROFINET interface X1.

Result: If using the I-device in another project as a DP standard device, you can configure SNMP the same as for a standard IO device.

If using the I-device as a shared I-device in multiple projects, the following applies: Configure SNMP only in the project with the controller to which the interface of the I-device was assigned.

7.15.2 Configuring DCP

Component interaction

DCP is a protocol for automatic detection and basic configuration of PROFINET devices. Consequently, DCP needs read and write access to the individual components in a PROFINET network.

To protect the components from malicious or inadvertent write access, the "Activate DCP write protection" function is available starting from STEP 7 V19.
When the "Activate DCP write protection" function is enabled on an IO device, the DCP write protection operates as follows on the individual components:

- The DCP write protection operates on the IO device and on the IO controller if an active communication relation exists between the IO device and the IO controller.
- The DCP write protection takes effect on the assigned IO controller of the IO device if the IO controller has established a communication relation with the IO device.

When configuring DCP, take into account the communication relations throughout the PROFINET network:

- An IO device has only one communication relation with its IO controller.
- A shared device/I-device has communication relations with all higher-level IO controllers.
- An IO controller has communication relations with all its assigned IO devices and shared devices/I-devices.

Consequently, DCP write access by the IO controller is only permitted again after all communication relations with DCP write protection with devices have been terminated and disabled (e.g. via one call each of D_ACT_DP).

To learn how to configure DCP, see the following sections.

NOTE
Avoidance of erroneous access attempts
Specific settings, such as changing of device names via DCP, only work for devices that are not currently participating in cyclic data exchange.

Configuring DCP for communication relations to all IO devices in the IO system

As of STEP 7 V20 and CPU FW version V4.0, you can configure DCP for an entire PROFINET IO system at the PROFINET interface of the IO controller. If IO devices support the configuring of DCP, the PROFINET interface of the higher-level IO controller synchronizes the DCP settings in the device properties of the IO devices by default. Changes to the DCP settings are also automatically synchronized.

Follow these steps to configure the DCP configuration for a PROFINET IO system:

1. Select the PROFINET interface of the IO controller in the network view or device view.
2. In the Inspector window, navigate to the "Advanced options > Security settings of the IO devices" area.
   STEP 7 as of V21 only displays this area if a PROFINET IO system has been added to the PROFINET interface of the IO controller.
3. If you want to use DCP write protection for communication with added IO devices, enable the "Activate DCP write protection for assigned IO devices" option in the "Default setting for Discovery and Basic Configuration Protocol (DCP)" area.

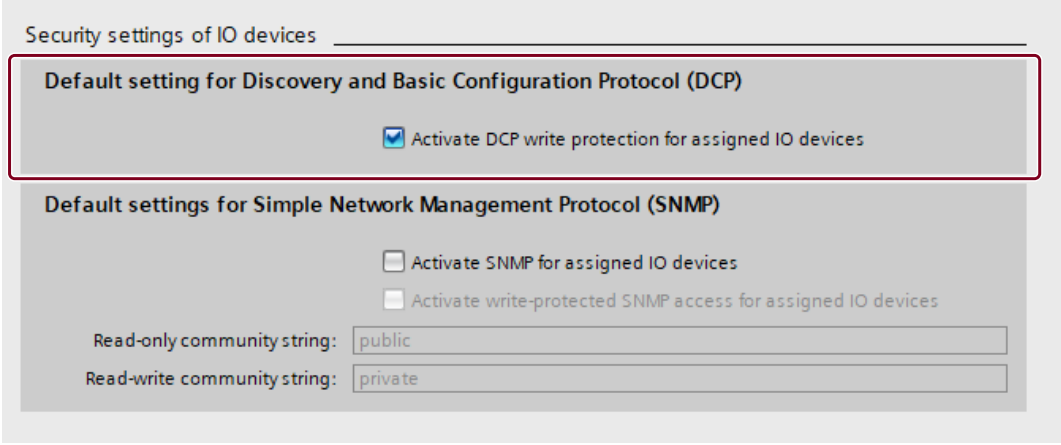

Result: You have configured DCP for the PROFINET IO system at a PROFINET interface of the IO controller.

Configuring DCP for a communication relation on an IO device

To configure DCP for a communication relation between IO controller and IO device, follow these steps:

1. Open the properties of the IO device in the network or device view.
2. Select the entry "Advanced configuration" under "General" in the Inspector window.

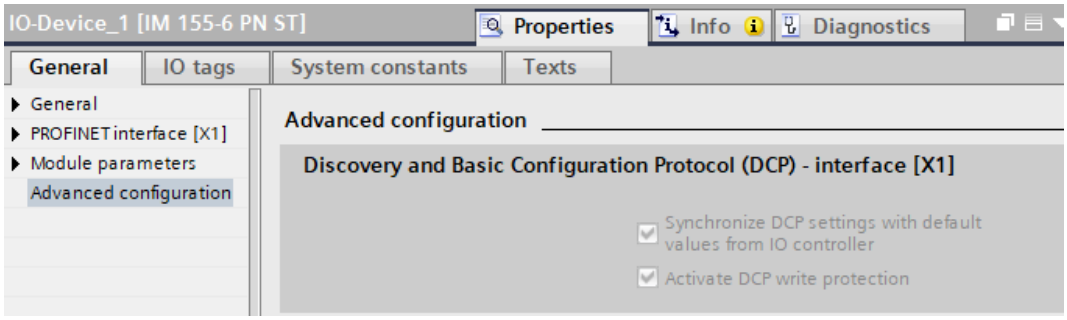

The "Synchronize DCP settings with default values from IO controller" and "Activate DCP write protection" options are enabled by default on all IO devices that support these functions. The options cannot be changed in the following cases:

- The IO device is not assigned to any IO controller.
- The IO controller to which the IO device is assigned does not support the "Activate DCP write protection" function.

Configuring DCP for a communication relation on an I-device

To configure DCP for a communication relation between an IO controller and I-device in a common project with the assigned IO controllers, follow these steps:

1. Open the properties of the required PROFINET interface, e.g. X1, in the network or device view.
2. Select the entry "Operating mode" under "General" in the Inspector window.

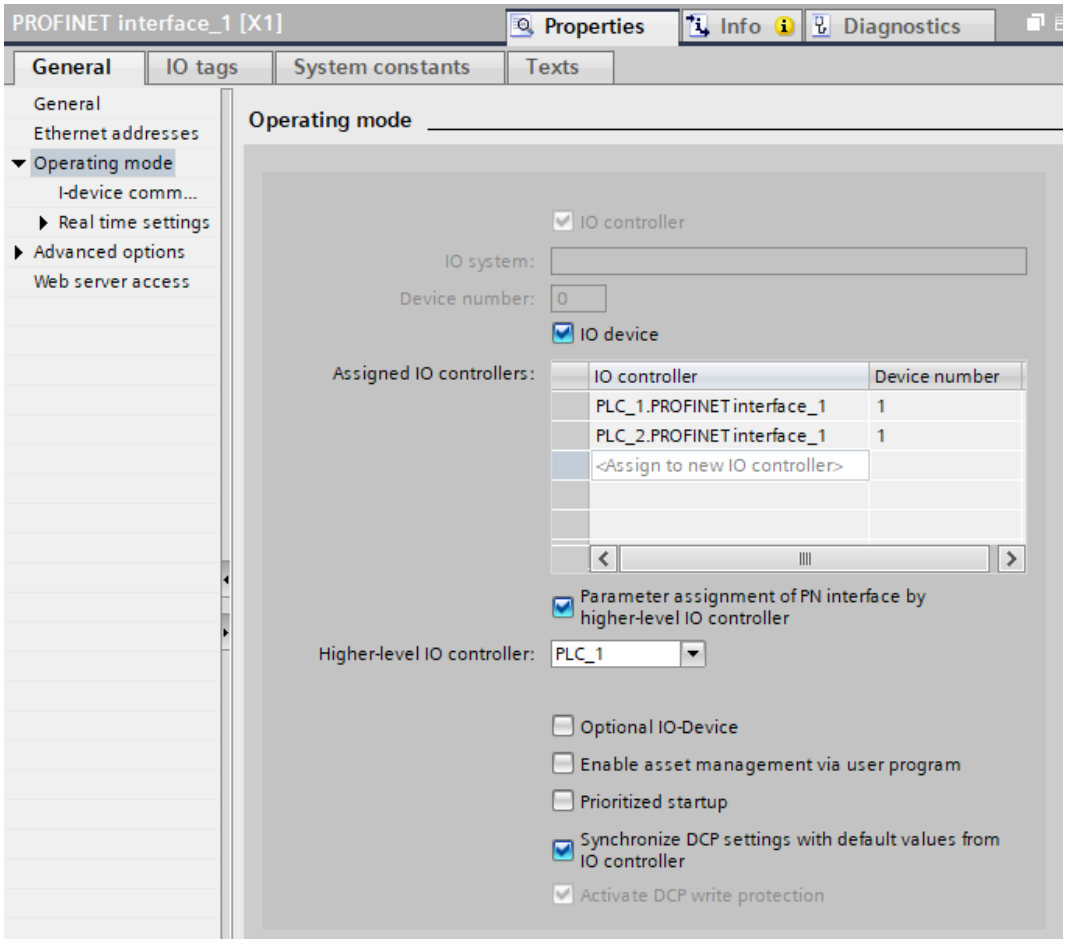

The "Activate DCP write protection" option is enabled by default on all I-devices that support this function. If an I-device can additionally synchronize the default values from the IO controller, the "Synchronize DCP settings with default values from IO controller" option is shown and enabled by default. The options cannot be changed in the following cases:

- The I-device is not assigned to any IO controller.
- The IO controller to which the I-device is assigned does not support the "Activate DCP write protection" function.

If you use an I-device as a shared I-device for IO controllers in different projects, the I-device will be inserted into other projects as a DP standard device. In this case, you therefore configure the DCP the same as for a standard IO device. The DCP write protection takes effect on each IO controller that has a communication relation with the shared I-device and supports the DCP write protection function.

PROFINET with the redundant S7-1500R/H system 8

Introduction

The same basic rules apply to PROFINET IO communication with the redundant S7-1500R/H as with the S7-1500 automation system. The redundant S7-1500R/H system exchanges IO data cyclically with the IO devices.

The redundant S7-1500R/H system supports a limited scope of PROFINET functions.

The redundant S7-1500R/H system supports media redundancy (MRP) in the PROFINET ring.

You can use the following IO devices on the redundant S7-1500R/H system:

- IO devices with system redundancy S2
- IO devices with system redundancy R1 (S7-1500H as of firmware version V3.0)
- Standard IO devices over the "Switched S1 device" function of the CPU

When configuring PROFINET with the redundant S7-1500R/H system, you must observe a few specifics, e.g. special configuration requirements.

Restrictions

- Real-time communication:
  - RT with a fixed send clock of 1 ms
  - No IRT
  - No MRPD redundancy procedure
  - No PROFINET with performance upgrade
- No isochronous mode
- No direct data exchange
- No operation as I-device
- No access to shared devices
- No support of docking systems
- No support of series machine projects
- Port options (only for PROFINET interface X1):
  - No port disabling possible
  - No configuring of boundaries possible
- Functionality as IO controller:
  - No prioritized startup
  - No enabling/disabling of IO devices
  - No support of series machine projects, e.g. IO systems that can be used multiple times

- PROFINET interface X2 does not support IO functionality (CPU 1515R/CPU 1517H/CPU 1518HF)
- No diagnostics using the web server
- No IP address assignment by the DHCP server

8.1 Media redundancy in the redundant S7-1500R/H system

You can use the redundant S7-1500R/H system in media redundancy networks (MRP). In this case, some or all PROFINET devices are connected to the S7-1500R/H with media redundancy via one or more PROFINET rings. If a PROFINET ring is interrupted, then a reconfiguration may occur. After a short reconfiguration time, the PROFINET devices can be accessed again via an alternative path. The PROFINET ring is mandatory for the redundant S7-1500R system.

S7-1500H CPUs as of FW version V4.0 have two ports at PROFINET interface X2, but do not support media redundancy (ring topology) at this PROFINET interface.

8.2 H-Sync Forwarding

Introduction

H-Sync Forwarding enables a PROFINET device with MRP to forward synchronization data (synchronization frames) of a S7-1500R redundant system only within the PROFINET ring.

In addition, H-Sync Forwarding forwards the synchronization data even during reconfiguration of the PROFINET ring. H-Sync Forwarding avoids a cycle time increase if the PROFINET ring is interrupted.

NOTE

Support of H-Sync Forwarding

The technical specifications typically state whether a PROFINET device supports H-Sync forwarding.

The GSD file will also indicate whether the device supports H-Sync Forwarding. The device supports H-Sync Forwarding when the "AdditionalForwardingRulesSupported" attribute in the "MediaRedundancy" element is set to "true".

Conditions

- H-Sync Forwarding is not relevant for redundant S7-1500H systems. With the redundant S7-1500H system, the H-Sync frames are transmitted exclusively via the fiber-optic cables.
- **When you use PROFINET devices with more than two ports (e.g. switch) in the PROFINET ring of an R-system, these devices must support H-Sync Forwarding.**

  H-Sync frames leave the PROFINET ring with a switch without H-Sync Forwarding. This results in an additional load on the network. Another serious result is that the redundancy of other R-systems in the network can fail or startup can be prevented.

- **H-Sync Forwarding is recommended if you are using PROFINET devices with only 2 ports in the PROFINET ring of an R-system.**

  When you operate PROFINET devices without H-Sync Forwarding in the PROFINET ring of the redundant S7-1500R/H system, the following scenario will result in an additional cycle time increase:

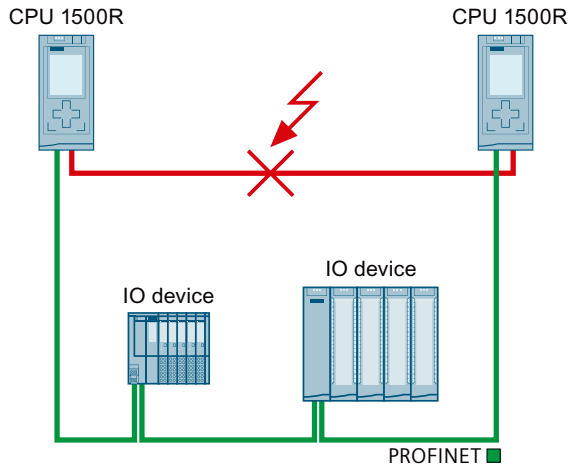

1. The redundant S7-1500R system is in the RUN-Redundant system state.
2. The PROFINET cable which directly connects the two CPUs fails.
3. The PROFINET ring is interrupted.
4. The PROFINET ring is being reconfigured.
5. PROFINET devices without H-Sync Forwarding do not forward any H-Sync frames during the reconfiguration time of the PROFINET ring.
6. The cycle time increases by the reconfiguration time of the PROFINET ring.

Figure 3-745 Failure of the PROFINET cable between the CPUs

If the cyclic program exceeds the cycle monitoring time, the time error OB (OB 80) may be started. Redundancy is lost if the time error OB (OB 80) is not present or the cycle time was exceeded twice with OB 80.

NOTE

If failure of the PROFINET cable that directly connects the two CPUs of the redundant S7-1500R system is unlikely, you can use PROFINET devices without H-Sync Forwarding in the PROFINET ring of the redundant S7-1500R system.

Example: Both CPUs of the redundant S7-1500R system are located directly next to each other in the control cabinet. In this case, it is unlikely that the PROFINET cable will fail.

8.3 System redundancy S2

Introduction

System redundancy S2 is the connection of an IO device via an interface module that supports two ARs to the IO controllers in the redundant system.

IO devices with system redundancy S2 enable uninterrupted process data exchange with the S7-1500R/H redundant system in the event of:

- a CPU fails
- Interruption of the PROFINET ring
- Interruption of the line topology (for S7-1500H as of FW version V3.0)

An IO device with system redundancy S2 supports system redundancy ARs.

In a redundant system, an IO device with system redundancy S2 has a system redundancy AR with each of the two CPUs (IO controllers). An IO device thus supports ARs of two IO controllers simultaneously (for the same modules).

A system redundancy AR can be either a primary AR or a backup AR. An IO device activates the data of the primary AR at the outputs. The data of the backup AR are not initially evaluated.

In STEP 7, you configure system redundancy S2 for an IO device by assigning the IO device to both CPUs of the S7-1500R/H redundant system.

Behavior in system state RUN-Redundant

Both CPUs are IO controllers. The PROFINET communication runs simultaneously on both system redundancy ARs, in each case between one of the CPUs (IO controllers) and the IO device. If the primary CPU fails or is switched to STOP, then the backup CPU becomes the primary CPU and also switches the backup AR to primary AR. The data of this AR becomes active at the outputs.

Abbreviations used for AR in the figure below:

- P-AR: Primary AR
- B-AR: Backup AR

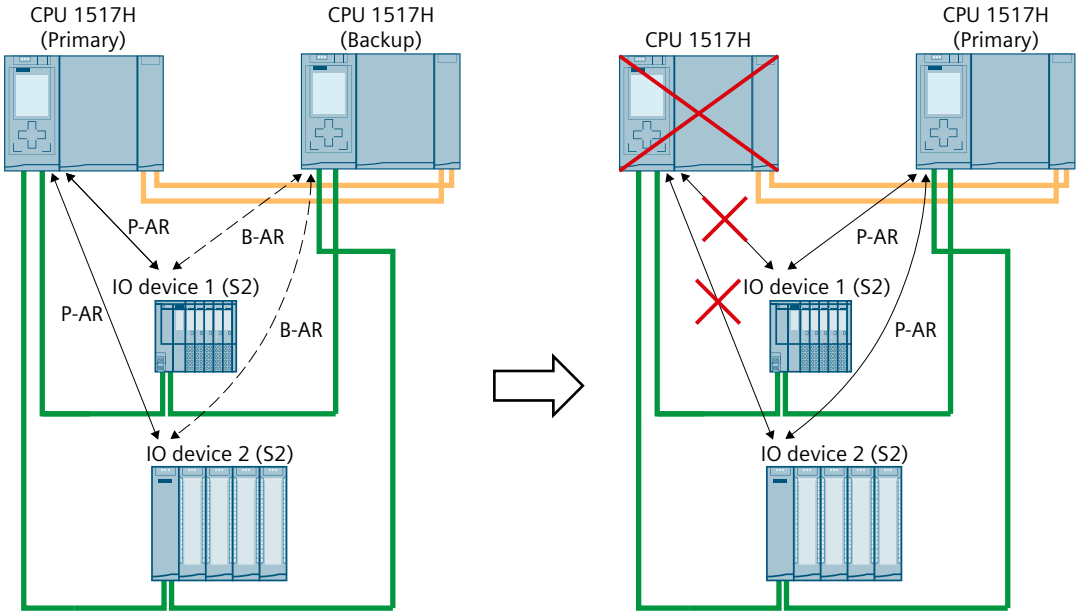

Figure 3-746 Primary backup AR

NOTE

S7-1500H with line topology

With line topology, only the primary AR can fail. In this case, the system switches to the backup AR, but the operating states and the roles of the CPUs remain unchanged.

Behavior in system state RUN-Solo

Only the primary CPU is an IO controller. The PROFINET communication runs on the primary AR between the primary CPU (IO controller) and the IO device. There is no AR between the backup CPU and the IO device.

8.4 System redundancy R1

Introduction

System redundancy R1 is the connection of an IO device via two interface modules, each of which supports an AR to the IO controllers in the redundant system.

IO devices with system redundancy R1 enable uninterrupted process data exchange with the S7-1500H redundant system when:

- a CPU fails
- an interface module fails
- a subnet fails.

Unlike system redundancy S2, system redundancy R1 has a separate interface module for each of the two ARs. Due to these redundant interface modules, the availability is higher than with an S2 device.

In STEP 7 you configure an IO device with system redundancy R1 by:

- Connecting the left interface module of the R1 device to the left H-CPU in the network view.
- Connecting the right interface module of the R1 device to the right H-CPU in the network view.

Reference

You can find information about the setup variants with the redundant system S7-1500R/H in the System Manual Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/us/en/view/109754833).

Behavior in system state RUN-Redundant

The PROFINET communication runs on both system redundancy ARs simultaneously, each between one of the CPUs (IO controller) and an interface module of the R1 device.

In the event of a failure of an interface module of an R1 device or a line break in the line topology, only the ARs switch over. The roles of the H-CPUs do not change.

Abbreviations used for AR in the figures below:

- P-AR: Primary AR
- B-AR: Backup AR

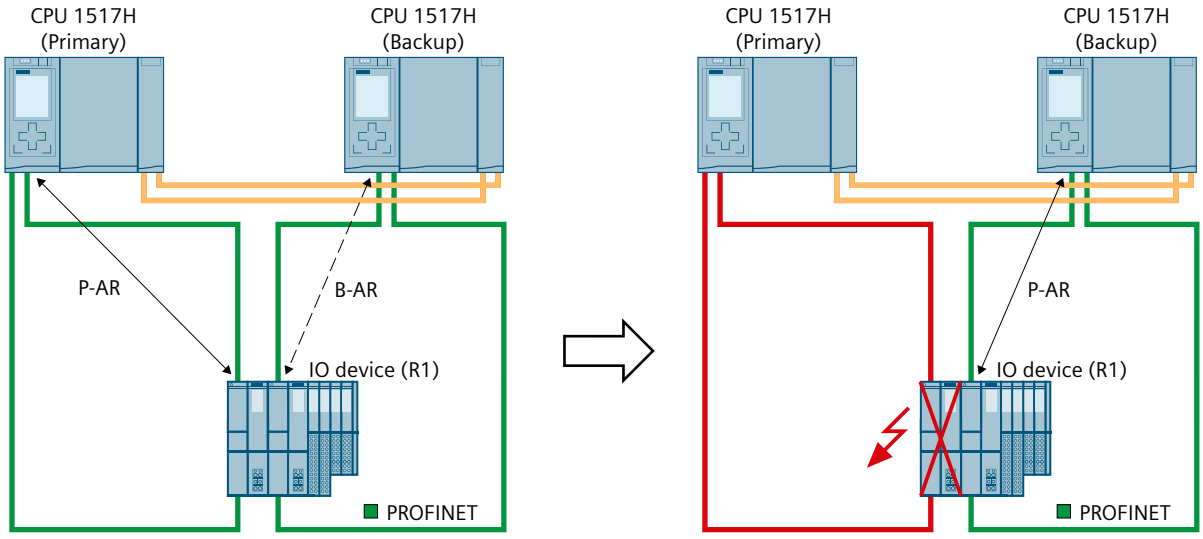

Figure 3-747 Failure of an interface module of an R1 device in the redundant S7-1500H system

If, however, the primary CPU fails or is switched to STOP, the S7-1500H redundant system then behaves as follows:

- The previous backup CPU becomes the new primary CPU.
- The new primary CPU uses the AR to the other, functioning interface module of the IO device and still has access to the inputs and control over the outputs of the IO device.
- The AR between the previous primary CPU and the assigned interface module is disconnected.

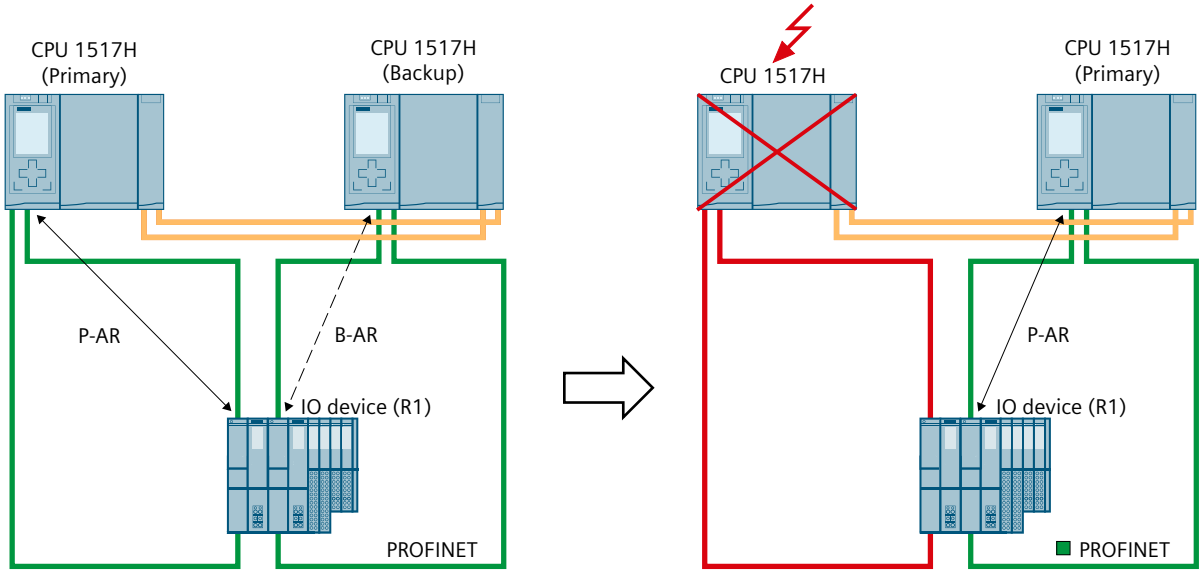

Figure 3-748 Failure of a CPU in the redundant S7-1500H system

NOTE

S7-1500H with line topology

With line topology, only the primary AR can fail. In this case, the system switches to the backup AR, but the operating states and the roles of the CPUs remain unchanged.

Behavior in system state RUN-Solo

Only the primary CPU is an IO controller. PROFINET communication runs on the AR between the primary CPU (IO controller) and the interface module of the IO device assigned to the primary CPU. The backup CPU separates all its ARs.

8.5 Switched S1 device

Introduction

As of FW version V2.8, the S7-1500R/H redundant system supports the "Switched S1 device" function.

The "Switched S1 device" function of the CPU enables operation of standard IO devices on the S7-1500R/H redundant system.

Standard IO devices, too, are always assigned to both CPUs of the S7-1500R/H redundant system. In contrast to an IO device with system redundancy S2, a standard IO device supports only one AR. The AR is available to the primary CPU of the redundant S7-1500R/H system.

In STEP 7 you configure an IO device connected via the "Switched S1 device" function by assigning a standard IO device to both CPUs of the redundant S7-1500R/H system.

As of FW version V3.0, the backup CPU of S7-1500H can establish an AR to an S1 device in a line topology. The primary CPU then receives data via the backup CPU.

NOTE

Standard IO devices in the redundant system S7-1500R

Standard IO devices usually do not support H-Sync Forwarding (Page 332).

To avoid a cycle time increase when the PROFINET ring is interrupted, integrate the standard IO devices downstream of a switch and not in the PROFINET ring.

Behavior in system state RUN-Redundant

The PROFINET communication runs on the AR between one of the CPUs (IO controller, in this example the primary CPU) and the standard IO device. There is no AR between the backup CPU and the standard IO device.
If the primary CPU fails or is switched to STOP, the S7-1500R/H redundant system responds as follows:

- The AR between the primary CPU and the standard IO device is disconnected.
- The previous backup CPU becomes the new primary CPU.
- The S7-1500R/H redundant system temporarily has no access to the inputs and no control over the outputs of the standard IO device. During this time, the configured substitute value behavior applies to the standard IO device.
- The new primary CPU builds an AR to the standard IO device.
- As soon as the new primary CPU has set up the AR, the S7-1500R/H redundant system has access to the inputs again and control over the outputs of the standard IO device.

Abbreviation used for AR in the figures below:

- AR: "normal" AR between a standard IO device and a CPU of the redundant system S7-1500R/H.

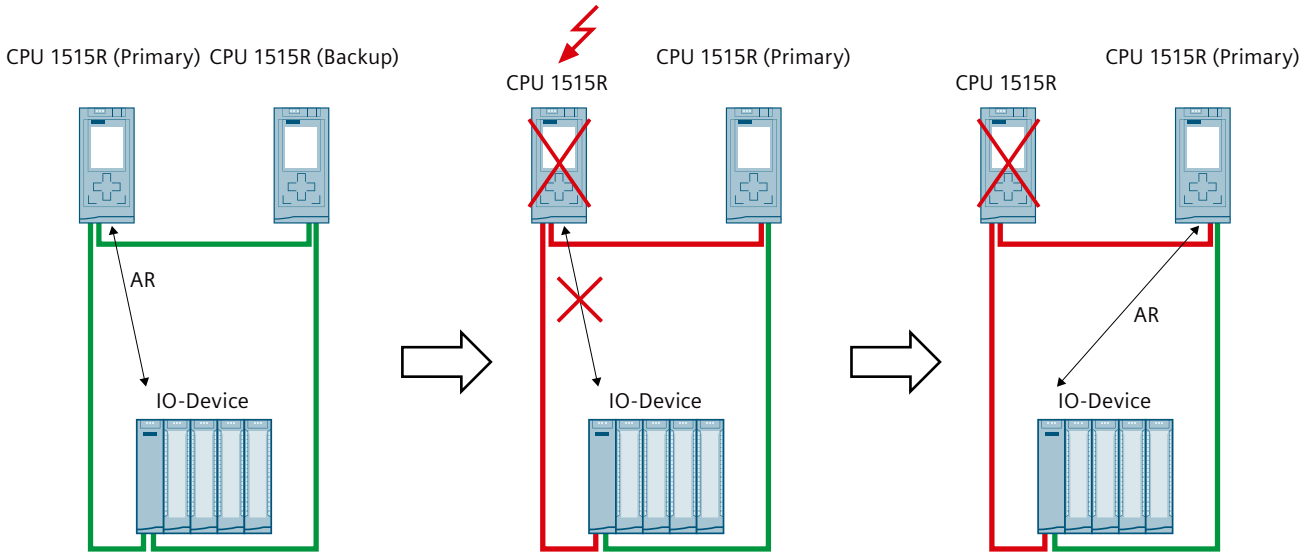

Figure 3-749 Behavior of standard IO devices in case of failure of the primary CPU

If a line in a line topology fails, the redundant S7-1500H system behaves as follows:

- If the line between the primary CPU and a standard IO device is interrupted, then the redundant S7-1500H system temporarily has no access to the inputs and no control over the outputs of the standard IO device. The status of the outputs depends on the substitute value behavior of the respective channels.
- The respective other CPU establishes an AR to the standard IO device.
- Once the new AR has been set up, the redundant S7-1500H system again has access to the inputs and control over the outputs of the standard IO device.

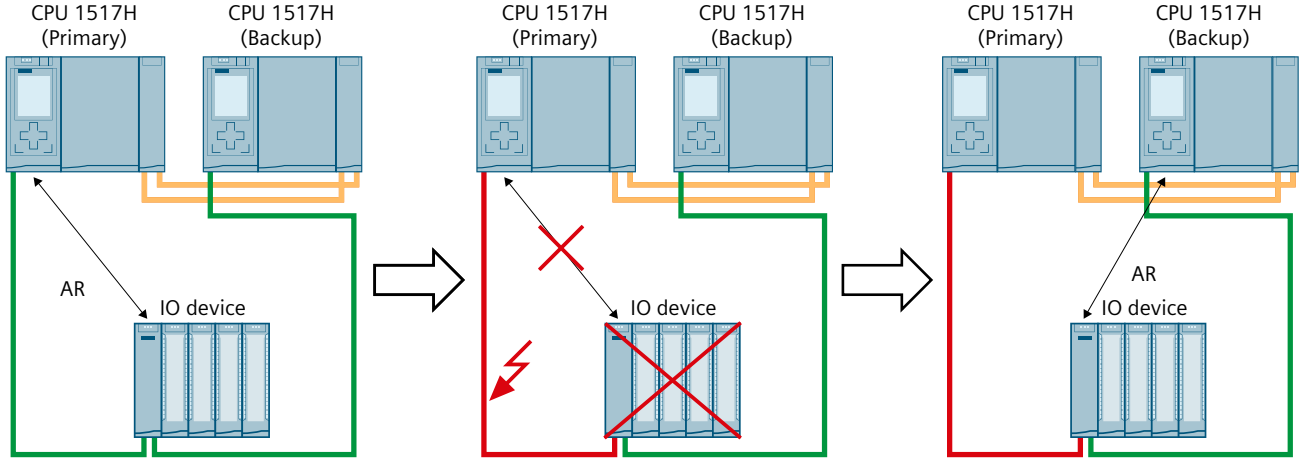

Figure 3-750 Behavior of standard IO devices in case of line failure

Behavior in system state RUN-Solo

Only the primary CPU is an IO controller. PROFINET communication runs on the AR between the primary CPU and the standard IO device. There is no AR between the backup CPU and the IO device.

OB behavior for standard IO devices with primary-backup switchover

If the primary CPU fails or goes to STOP, the standard IO devices temporarily fail. OB 72 "Redundancy error" is called, additional OB 86 "Module rack failure" for the failed IO devices are not called. To detect the failed IO devices, call the DeviceStates instruction in OB 72.

With the "Switched S1 device" function, the new primary CPU establishes the ARs to the standard IO devices again. OB 86 is called for each return of an IO device.

Influence changeover time of switched S1 devices

As of FW version V2.9, you can influence the changeover time between disconnection and return of switched S1 devices after a failure/STOP of the primary CPU.

Advantages:

- Optimization of the changeover time between disconnection and return of switched S1 devices
- Prioritization of the return of S1 devices in the PROFINET ring by setting a lower changeover time for S1 devices with important process functions.

The changeover time depends on the watchdog timer of the switched S1 device. The watchdog timer is the product of the update time multiplied by the accepted update cycles without IO data. With the parameters, you influence the time as of which the new primary CPU starts returning the S1 device. The return also depends on the amount of time that is required for the parameter assignment of the S1 device.
You set the parameters in STEP 7 in the properties of the interface of each S1 device:

- Update time: Advanced options > Real time settings > IO cycle > Update time
- Watchdog timer: Advanced options > Real time settings > IO cycle > Watchdog timer > Accepted update cycles without IO data

Setting a shorter changeover time of an S1 device: Reduce the values of the parameters/of a parameter.

Setting a longer changeover time of an S1 device: Increase the values of the parameters/of a parameter.

8.6 Main differences between IO device with system redundancy S2, R1 and standard IO device

Table 3-970 Main differences between IO device with system redundancy S2, R1 and standard IO device

Property	IO device with system redundancy S2	IO device with system redundancy R1	Standard IO device
Requirement for IO device	Device supports system redundancy S2	Device supports system redundancy R1	-
Maximum simultaneously supported ARs with regard to the same modules	2	2	1
Behavior when replacing the primary CPU	Continuous connection with S7-1500R/H redundant system Process data is transferred further.	Continuous connection with redundant S7-1500H system Process data is transferred further.	Temporary disconnection from S7-1500R/H redundant system. No process data is transferred until the standard IO device is available again. The status of the outputs depends on the substitute value behavior of the respective channels.
Behavior in case of failure of an interface module	Failure of the S2 device	R1 device continues to transmit process data via the redundant interface module	Failure of the standard IO device
Number of interface modules per device	1	2	1
Number of ARs per interface module	2	1	1

8.7 Installation guidelines

Configuration requirements for the topology with the redundant S7-1500R system

Topology properties	PROFINET ring
MRP role of the CPU	Manager (auto)
MRP role of the IO devices	Client
Other S7-1500R/H systems	No

Port interconnection:

- The two CPUs are directly interconnected via one of the two ports of PROFINET interface X1. No other devices of the ring are located in between.
- The two CPUs can be indirectly interconnected via the other two ports. The other devices of the ring are located in between. See the examples below.

Table 3-971 Number of PROFINET devices, IO devices in the redundant system

Maximum number of devices	Maximum number of S7-1500R
Maximum number of PROFINET devices in the PROFINET ring of the R system The maximum number includes switches, S7-1500R/H CPUs, S7-1500 CPUs (as of V2.5) and HMI devices. It does not include media converters.	50 (recommendation 16)[1]
Maximum number of IO devices that can be connected to the R-CPUs	64

[1] Recommendation: The number of devices in the PROFINET ring affects the availability of the S7-1500R system. The number of PROFINET devices including R-CPUs in the PROFINET ring should not exceed 16. If you operate significantly more devices in the PROFINET ring, the availability is reduced.
The technical specifications in the documentation are based on the recommended maximum of 16 PROFINET devices in the ring in S7-1500R.

Configuration requirements for the topologies with the redundant S7-1500H system

Topology properties	PROFINET ring	Line topology	Combined topology	H-CPUs without additional devices
MRP role of the CPU	Manager (auto)	Not device in the ring		Not device in the ring
MRP role of the IO devices	Client	Not device in the ring	Depending on the installation location: Not device in the ring **or** client	-
Other S7-1500R/H systems	No	Yes		Yes

Table 3-972 Number of PROFINET devices, IO devices in the redundant system

Maximum number of devices	Maximum number of S7-1500H
Maximum number of PROFINET devices in the PROFINET ring of the R/H system The maximum number includes switches, S7-1500R/H CPUs, S7-1500 CPUs (as of V2.5) and HMI devices. It does not include media converters.	50
Maximum number of IO devices that can be connected to the H-CPUs	256

8.8 Configuring PROFINET IO on a redundant S7-1500R/H system

PROFINET IO configurations with the redundant S7-1500R/H system

The following figures show you examples of PROFINET IO configurations with the redundant S7-1500R/H system.

Abbreviations of AR used in the following figures:

- SR-AR: System redundancy AR between an IO device (S2/R1) and a CPU of the redundant S7-1500R/H system
- AR: "normal" AR between a standard IO device and the associated IO controller

S2 IO devices in the PROFINET ring

The redundant S7-1500R system consists of the two CPUs 1515R and two S2 devices in the PROFINET ring. The IO devices support MRP and H-Sync forwarding.

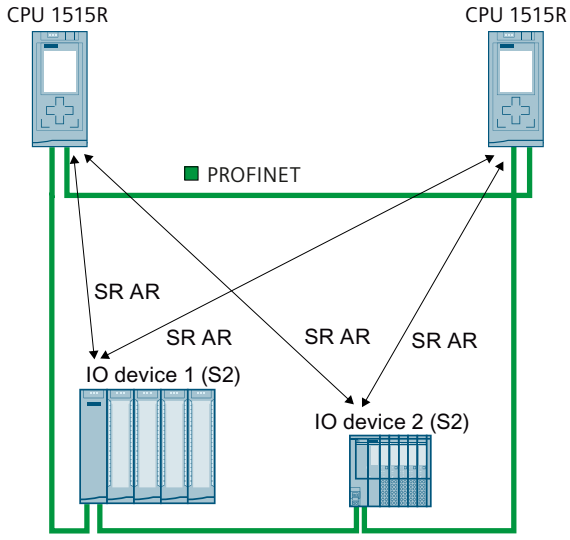

Figure 3-751 Example of a S7-1500R redundant system with two IO devices in the PROFINET ring

IO devices R1 in PROFINET rings

The redundant system S7-1500H consists of the two CPUs 1517H and two R1 devices in two PROFINET rings. The IO devices support MRP.

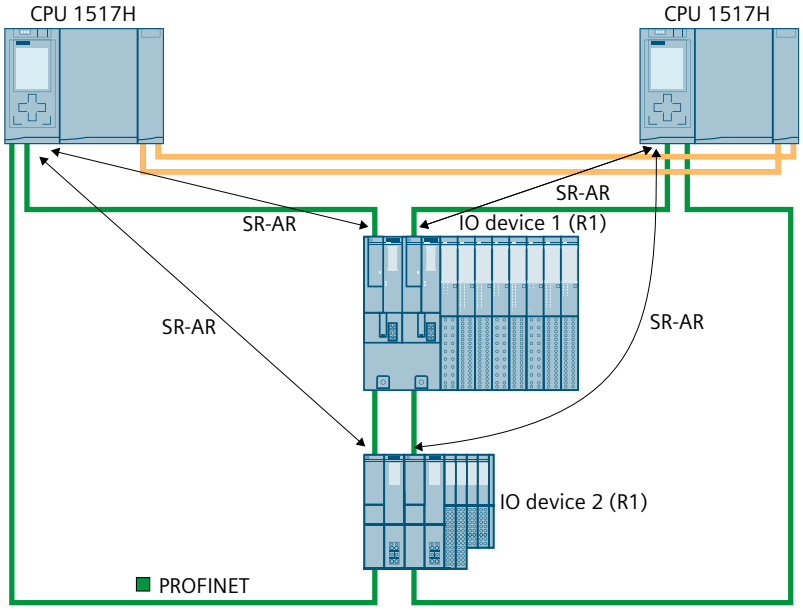

Figure 3-752 Example of a redundant S7-1500H system with two IO devices in two PROFINET rings

PROFINET devices downstream of a switch

To connect additional PROFINET devices to the PROFINET ring, use a switch. For the redundant S7-1500R system, ensure that a switch in the PROFINET ring supports H-SYNC Forwarding in addition to MRP.

You connect the following devices to the PROFINET ring with a switch.

- PROFINET devices with one port
- Non MRP-capable PROFINET devices
- PROFINET devices that do not support H-Sync Forwarding, such as standard IO devices.

The following figure shows a redundant S7-1500R system with connected PROFINET devices downstream of a switch.

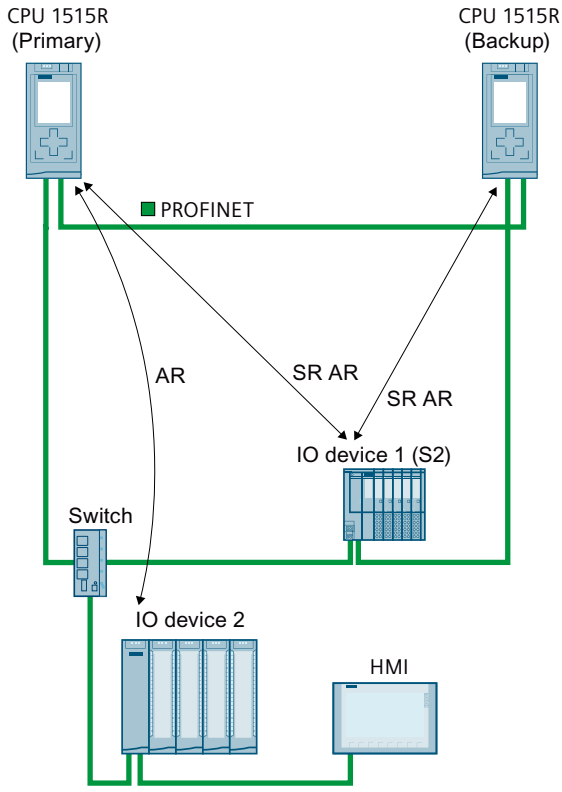

IO device 1 (S2)	IO device 1 is located in the PROFINET ring. The IO device 1 supports system redundancy S2, MRP and H-Sync Forwarding.
Switch	The switch is located in the PROFINET ring. The switch supports MRP and H-SYNC Forwarding.
IO device 2	The IO device 2 is connected to the PROFINET ring via the switch. IO device 2 is a standard IO device that is connected to the redundant S7-1500R system via the "Switched S1 device" function.
HMI device	The HMI device is connected to the PROFINET ring via the switch.

Figure 3-753 PROFINET devices downstream of a switch

Additional PROFINET IO system in the configuration

The configuration can also contain additional IO controllers with their own IO devices. To have enough bandwidth in the PROFINET ring for the redundant S7-1500R/H system, place additional IO controllers with their I/O devices downstream of a switch.

When determining the maximum number of IO devices inside and outside the PROFINET ring, the redundant system in STEP 7 does not recognize the S7-1500 CPUs. If you use S7-1500 CPUs, you must check the maximum number yourself.

The CPU supports H-Sync forwarding and thus may be a node of the PROFINET ring.

The following figure shows a redundant S7-1515R system. An additional PROFINET IO system with a CPU 1516 as IO controller is located downstream of the switch. A separate standard IO device has been assigned to the IO controller.

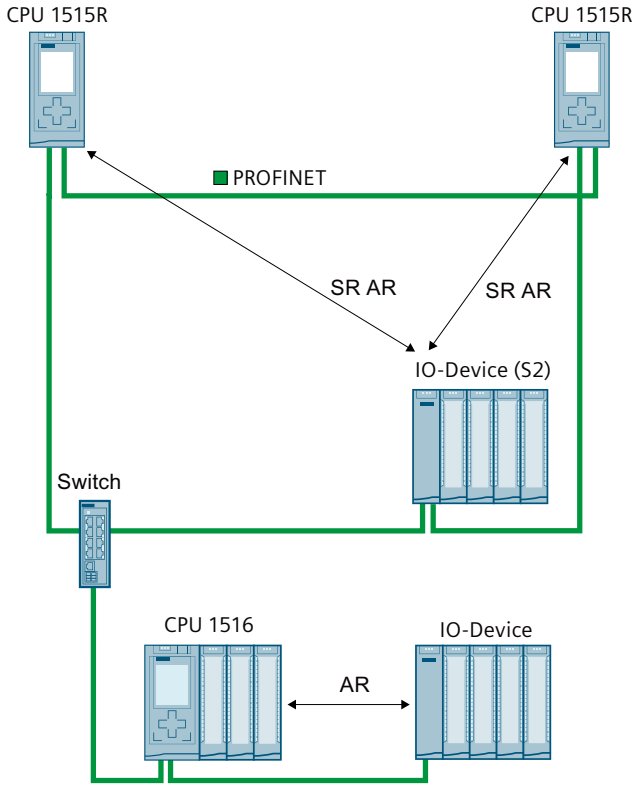

Figure 3-754 Example of a redundant S7-1500R system with an additional PROFINET IO system

Additional IO controllers can also be connected as I-device to the redundant S7-1500R/H system. An I-device is connected like a standard IO device to the redundant S7-1500R/H system.
The redundant S7-1500R/H system supports the use of I-devices only via GSD file and as standard IO device.

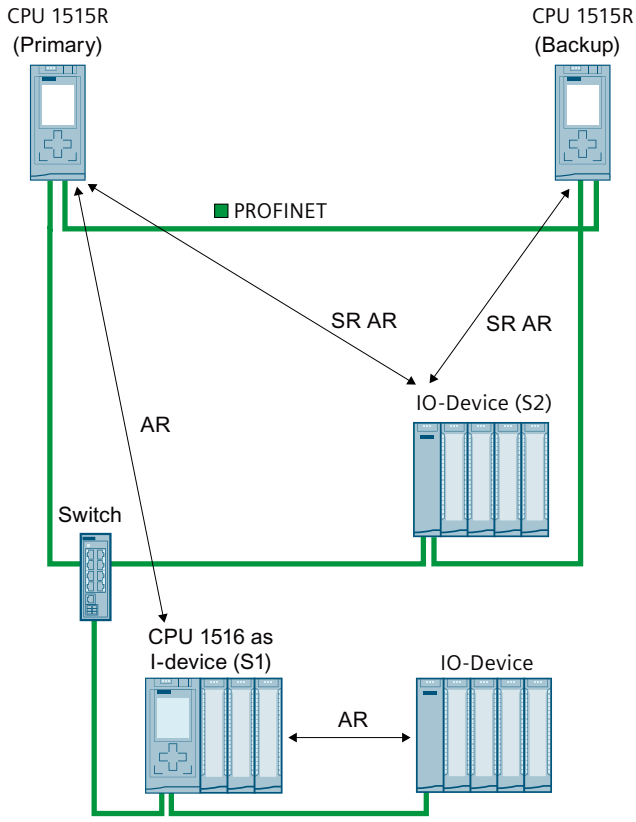

Figure 3-755 I-device downstream of a switch

Connection to another PROFINET IO system via the PN/PN coupler

The redundant S7-1500R/H system cyclically exchanges IO data with another PROFINET IO system via a PN/PN coupler.

In the following figure, the PN/PN coupler connects a redundant S7-1515R system to another PROFINET IO system. The left side of the PN/PN coupler is assigned to the redundant S7-1515R system. The assignment is system-redundant and media-redundant. The right side of the PN/PN coupler is assigned to the CPU 1516 (IO controller). The PROFINET IO system of the CPU 1516 has no redundancy in this example.

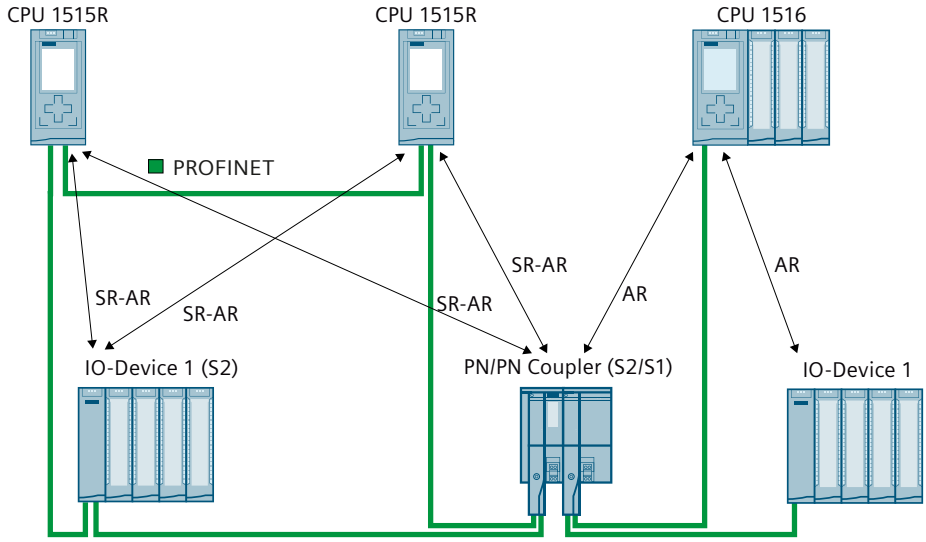

Figure 3-756 Configuration with the PN/PN coupler with one-sided system redundancy (S2/S1)

Connection to an additional redundant S7-1500R/H system via the PN/PN coupler

Two redundant S7-1500R/H systems cyclically exchange IO data via the PN/PN coupler.

In the following figure, the PN/PN coupler connects two redundant S7-1515R systems to each other. Each of the two PN/PN coupler sides are assigned to a redundant S7-1515R system. Each of the two sides of the PN/PN coupler are connected to the respective redundant S7-1515R system in a system-redundant and media-redundant manner.

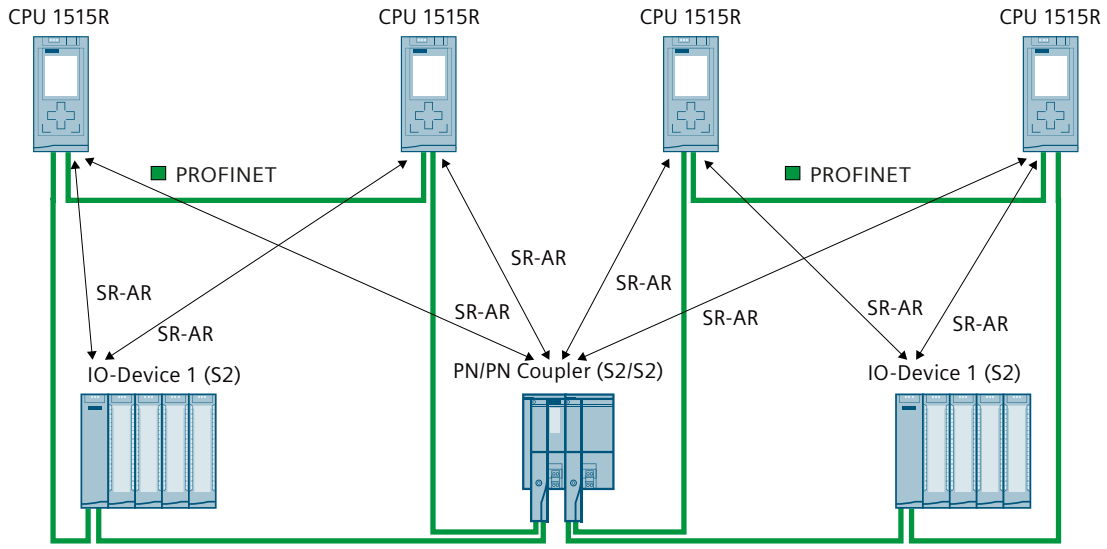

Figure 3-757 Configuration with the PN/PN coupler with two-sided system redundancy (S2/S2)

Reference

You can find more information on the PN/PN coupler in the PN/PN Coupler (https://support.industry.siemens.com/cs/ww/en/view/44319532) manual.

Gateway from a PROFINET IO system to PROFIBUS DP nodes

You can extend the redundant S7-1500R/H system by a gateway from PROFINET IO to PROFIBUS DP with an IE/PB LINK HA. Related information and configuration options can be found in the S7-1500R/H System Manual (https://support.industry.siemens.com/cs/ww/en/view/109754833).

8.9 Assigning IO device to the redundant S7-1500R/H system

Using two examples, this section describes how to assign IO devices to the redundant S7-1500R/H system.

- Procedure for S7-1500R with S2 or S1 devices.
- Procedure for S7-1500H with R1 devices.

Requirements

- Redundant S7-1500R/H system
- IO device:

Redundant system	Switched S1 device (Standard IO device)	IO device with System redundancy S2	IO device with System redundancy R1
S7-1500H as of firmware version V3.0	X	X	X
S7-1500R/H as of firmware version V2.8	X	X	-
S7-1500R/H with firmware version less than V2.8	-	X	-

Procedure for S7-1500R/H with S2/S1 devices

To assign S2 or S1 devices to the redundant S7-1500H system, connect the interface module of the IO device to each S7-1500H CPU.

1. In the network view of STEP 7, select the PROFINET interface of the IO device.
2. Drag-and-drop a line between the PROFINET interface of the IO device and the PROFINET interface X1 of the left CPU.

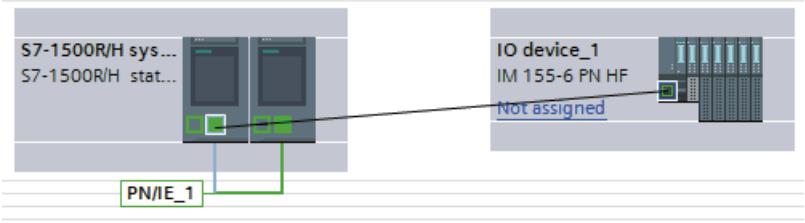

Figure 3-758 Assign IO device to the left CPU

3. Drag-and-drop a line between the PROFINET interface of the IO device and the PROFINET interface X1 of the right CPU.

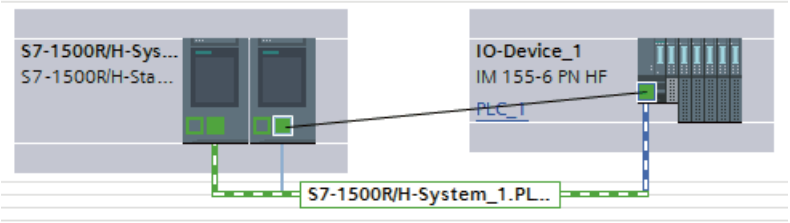

Figure 3-759 Assign IO device to the right CPU

Result: The IO device is connected to the redundant S7-1500R system.

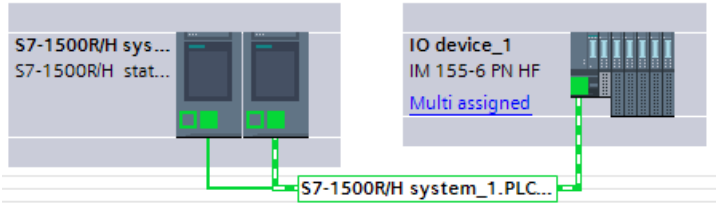

Figure 3-760 S2 device assigned

Procedure for S7-1500H with R1 devices

To assign R1 devices to the redundant S7-1500H system, connect each interface module of the R1 device to an H-CPU.

The left interface module of each R1 device must be connected to the left H-CPU in the network view. The right interface module of each R1 device must be connected to the right H-CPU in the network view.

To do so, proceed as follows:

1. Switch to the network view.
2. Drag-and-drop a line between the PROFINET interface of the left interface module of the ET200SP-R1_1 station and the PROFINET interface X1 of the left H-CPU.
3. Drag-and-drop a line between the PROFINET interface of the right interface module of the ET200SP-R1_1 station and the PROFINET interface X1 of the right H-CPU.
4. Switch to the device view of the ET200SP-R1_1 station and set the watchdog timer for both interface modules. To do this, navigate in the Inspector window to "Properties > PROFINET interface [X1] > Advanced options > Real-time settings > IO cycle".

5. Repeat steps 1 to 4 for the ET200SP-R1_2 station.

   Result: The R1 devices are connected to the S7-1500H redundant system.

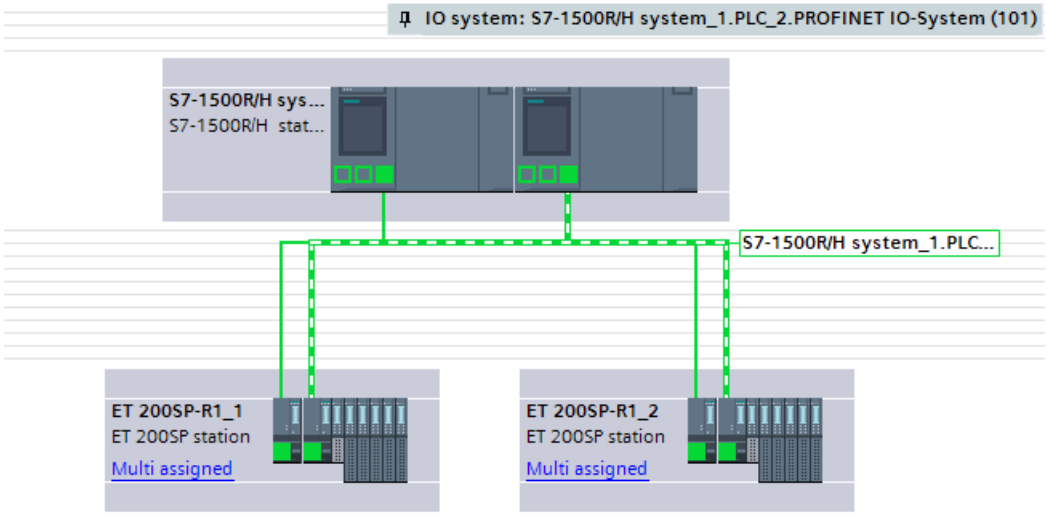

Figure 3-761 R1 devices assigned in the network view with system redundancy

---

NOTE

Alternative method for assigning IO devices.

For larger projects, we recommend assigning the IO devices as follows:

1. Switch to the network view.
2. Move the cursor over the station you want to assign.
3. Press the right mouse button and select "Assign to new DP master/IO Controller" in the shortcut menu.
4. Select both IO Controllers in the following dialog and then click on "Ok". This assigns the left interface module to the left IO Controller and the right interface module to the right IO Controller.
5. Repeat steps 2 through 4 for additional IO devices or mark several stations simultaneously.

I-device as standard IO device

If you want to assign an I-device to the redundant S7-1500R/H system, you have to include the configured I-device via its exported GSD file.

To operate an I-device as standard IO device on the redundant S7-1500R/H system, always use the GSD file of the I-device in the H-system configuration.

- SIMATIC CPU as I-device
  - First, configure the SIMATIC CPU in STEP 7 as an I-device with all transfer areas.
  - Export the I-device as a GSD file. The GSD export can be found in the properties of the PROFINET interface under "Operating mode > I-device communication > Export Generic System Description file (GSD)".
  - Install the GSD file in STEP 7.
- HMI device as I-device ("Direct key" function)
  - The GSD files for SIMATIC Comfort Panel and SIMATIC Mobile Panel can be found under the link at the end of this section.

Assign the I-device integrated via GSD file to the redundant system S7-1500R/H.

See also

GSD file HMIs (https://support.industry.siemens.com/cs/ww/en/view/73502293)

8.10 Configuring media redundancy (MRP) for a configuration with the redundant S7-1500R/H system

This section describes by means of two examples how to configure media redundancy (MRP) for a configuration with the redundant S7-1500R/H system.

- Configuring MRP for a configuration with S2 devices (ET 200SP) with the redundant S7-1500R system.
- Configuring MRP for a configuration with R1 devices (ET 200SP) with the redundant S7-1500H system.

Requirements

- Redundant S7-1500R/H system.
- All devices in the ring support the media redundancy protocol MRP.
- IO devices are assigned to the redundant S7-1500R/H system.
- The MRP domain "mrpdomain-2" was created in the domain settings (S7-1500H).

Configuring MRP for a configuration with S2 devices (ET 200SP) with the redundant S7-1500R system

Specifying MRP role and MRP domain of the CPUs of the redundant S7-1500R system

As soon as you create a redundant S7-1500R system in STEP 7, STEP 7 automatically assigns the MRP role "Manager (auto)" for the PROFINET interfaces X1 of the two CPUs.

Specifying MRP role and MRP domain for the S2 devices of the redundant S7-1500R system in STEP 7

To specify the media redundancy for additional devices in the ring, follow these steps:

1. In the network view of STEP 7, select the PROFINET interface X1 of one of the two CPUs of the redundant S7-1500R system.
2. In the Inspector window, navigate to "Properties > General > Advanced options > Media redundancy".
3. Click the "Domain settings" button.

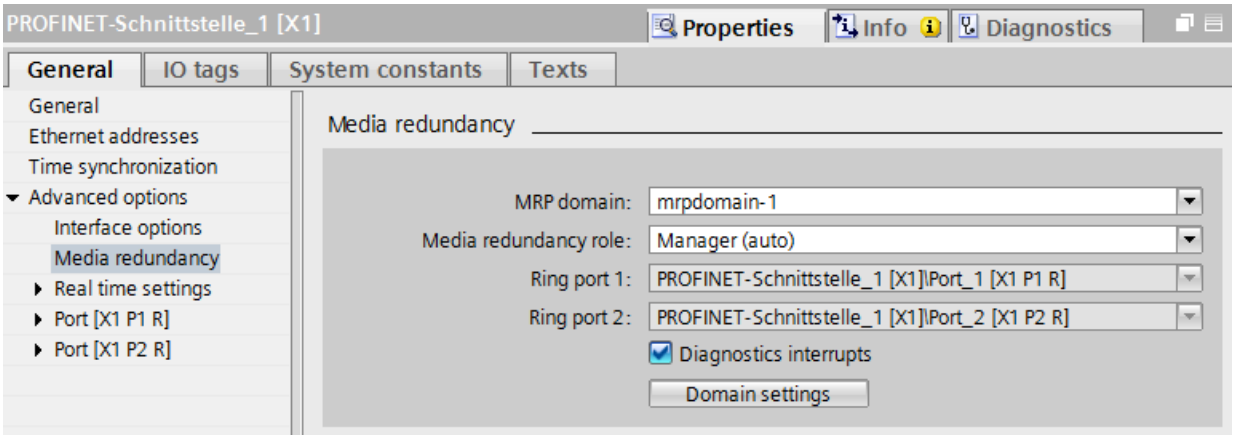

Figure 3-762 S7-1500R: MRP role "Manager (auto)"

In the Inspector window, STEP 7 displays the properties of the MRP domain in which the PROFINET interface X1 of the CPU is located.

4. In the "MRP role" column of the "Devices" table, assign the MRP role "Client" to all the other devices of the ring.

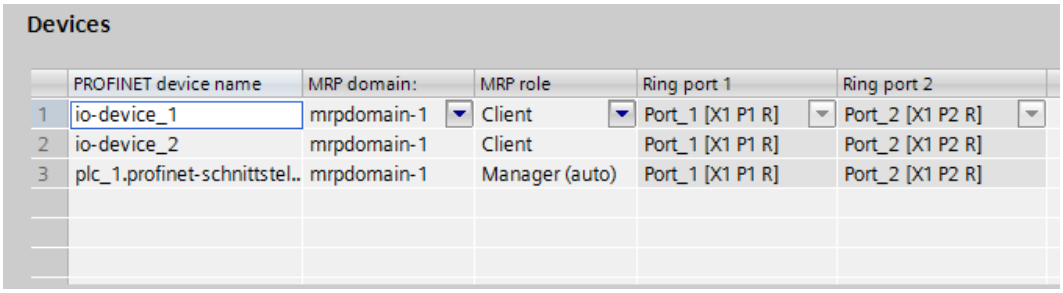

Figure 3-763 S7-1500R: Assigning MRP roles for ring devices

Configuring MRP for a configuration with R1 devices (ET 200SP) with the redundant S7-1500H system

Set MRP role and MRP domain of the CPUs of the redundant S7-1500H system

As soon as you create a S7-1500H redundant system in STEP 7, STEP 7 automatically assigns the MRP role "Not device in the ring" for the PROFINET interfaces X1 of the two CPUs. For the project engineering as PROFINET ring you have to change the MRP role to "Manager (auto)".

To change the MRP role of the redundant system, follow these steps:

1. Switch to the device view of the S7-1500H redundant system.
2. Select the PROFINET interface X1 of the upper H-CPU (mounting rail_0) of the S7-1500H redundant system.
3. In the Inspector window, navigate to "Properties > General > Advanced options > Media redundancy".
4. Change the MRP domain to "mrpdomain-1" (if required) and the media redundancy role for the H-CPU to "Manager (auto)".
5. Select the PROFINET interface X1 of the lower H-CPU of the S7-1500H redundant system.
6. Change the MRP domain to "mrpdomain-2" (if required) and the media redundancy role for the H-CPU to "Manager (auto)".
7. Enable the "Diagnostic interrupts" option.

NOTE

If the "Diagnostic interrupts" option is enabled, diagnostic interrupts are generated at the ring ports in the event of the following errors:

Wiring or port error:

- A neighbor of the ring port does not support media redundancy MRP.
- A ring port is connected to a non-ring port.
- A ring port is connected to the ring port of a different MRP domain.

You can find additional information in the STEP 7 online help.

Specifying MRP role and MRP domain for the R1 devices of the redundant S7-1500H system in STEP 7.

To define the media redundancy for the other devices (IO devices) of the rings, proceed as follows:

1. Switch to the device view of the left ET 200SP (ET200SP-R1_1).
2. Click on the PROFINET interface X1 of the left IM 155-6 PN R1.
3. Change the MRP domain to "mrpdomain-1" (if required) and the media redundancy role to "Client".
4. Click on the PROFINET interface X1 of the right IM 155-6 PN R1.
5. Change the MRP domain to "mrpdomain-2" and the media redundancy role to "Client".
6. Switch to the device view of the right ET 200SP (ET200SP-R1_2) and repeat steps 2 to 5.

NOTE

Alternative method for assigning MRP role and MRP domain.

1. Switch to the network view.
2. Click the connection PN/IE_1.
3. In the Inspector window, navigate to "Properties > General > MRP domains".
4. Scroll down to the "Devices" section.

- Under "PROFINET IO system", select the controller interface.
- Under "Devices" you configure the respective MRP domain and the MRP role.

8.11 MRP interconnection with the redundant system S7-1500R/H

- The S7-1500H CPUs support system redundancy R1 as of firmware version V3.0.
- The S7-1500R/H CPUs support MRP interconnection as of firmware version V2.9.

MRP interconnection enables the redundant data exchange via S7-1500R/H across two or more MRP rings.

Requirements for S7-1500R/H

In addition to the requirements for S7-1500, the following requirements are in effect for S7-1500R/H:

- For S7-1500R/H: The two CPUs of the redundant system are located in the same ring (as of firmware version V2.9).
- For S7-1500H: The two CPUs of the redundant system are located in one or two rings (as of firmware version V3.0).

- You have configured the media redundancy role of the two CPUs as "Manager (auto)" in the ring with the two R/H CPUs.

  You have configured the following in the other rings:

  – For one or more PROFINET devices the media redundancy role "Manager (auto)" or
  – For exactly one PROFINET device the media redundancy role "Manager"

  You have assigned the MRP client role to the other devices in all rings.

Topology with S2 devices

Topology with two rings, using the example of S7-1500R

The following figure shows the redundant coupling based on the example of S7-1500R in 2 rings.

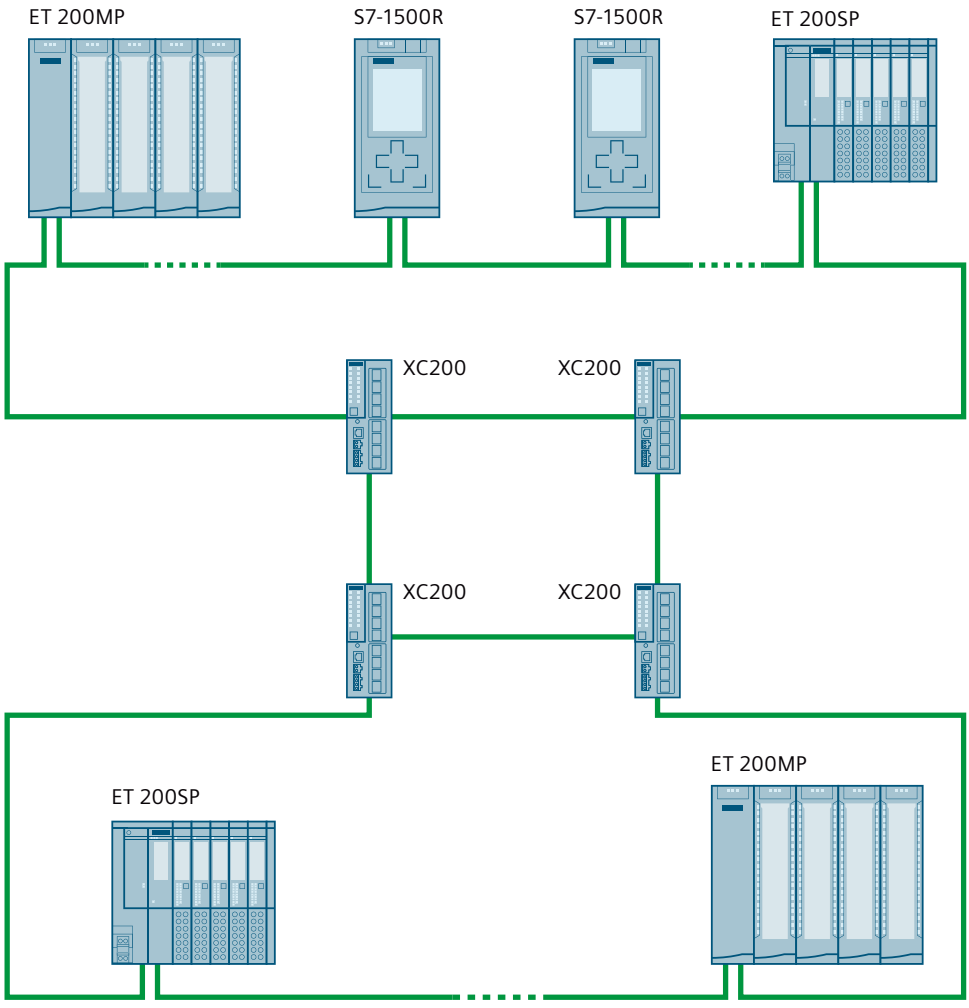

Figure 3-764 Example: Redundant connection of S7-1500R in 2 rings with MRP interconnection

Topology with two rings, using the example of S7-1500H

The figure below shows the redundant coupling, using the example of S7-1500H in two rings.

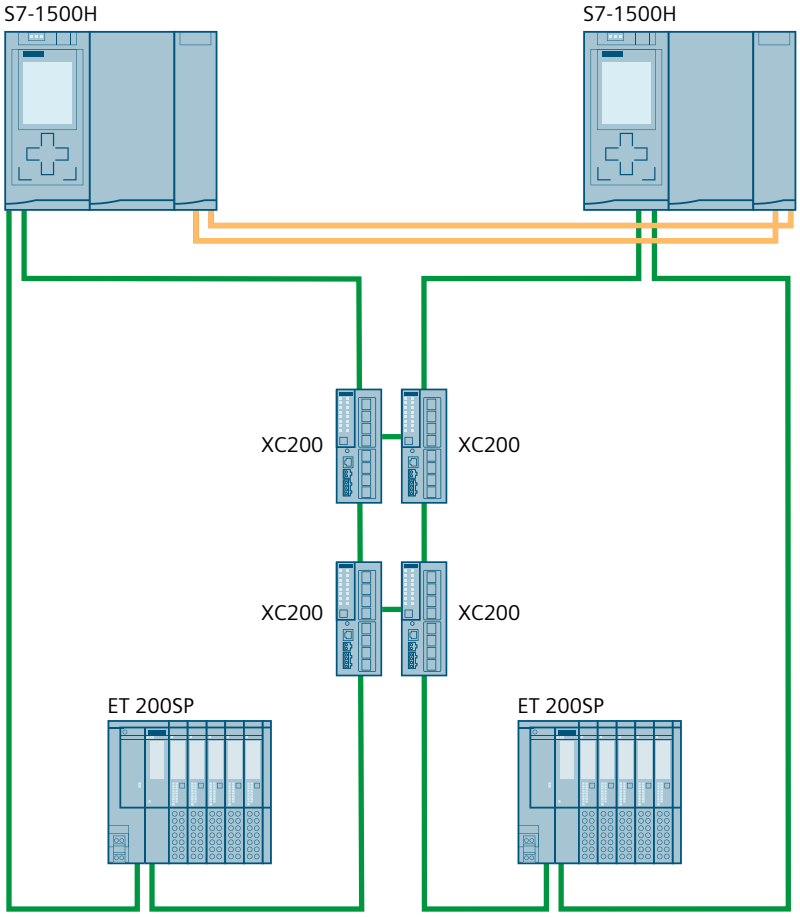

Figure 3-765 Example: Redundant connection of S7-1500H in two rings with MRP interconnection

Topology with multiple rings, using the example of S7-1500H

The figure below shows the redundant coupling, using the example of S7-1500H in four rings.

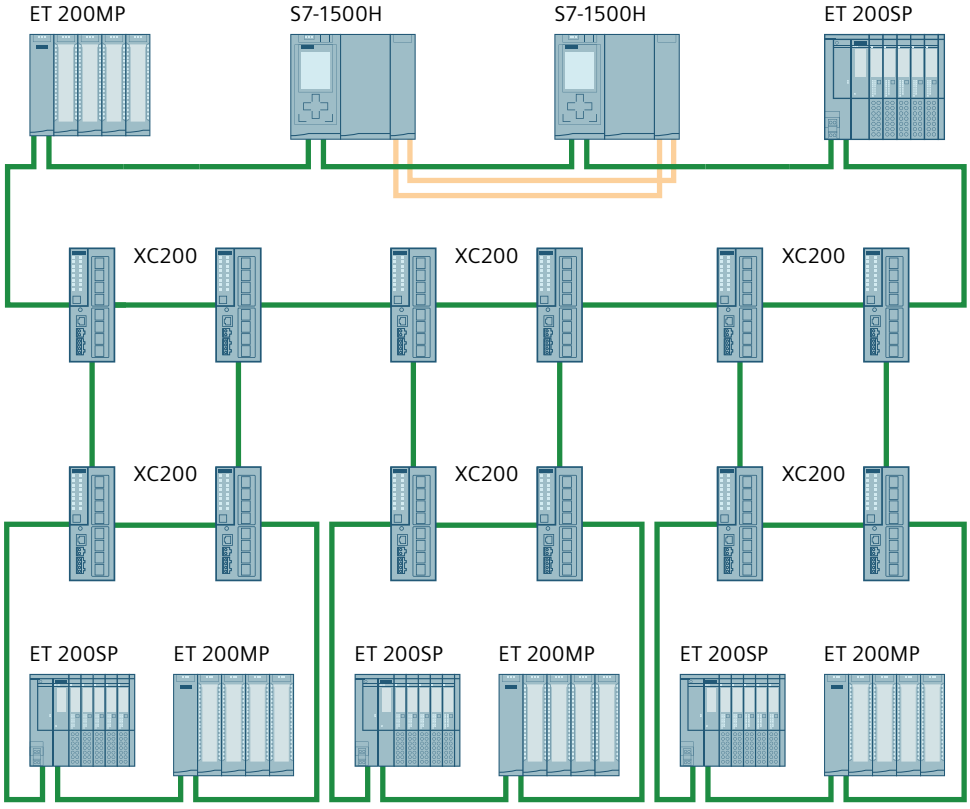

Figure 3-766 Example: Redundant coupling, using the example of S7-1500H in four rings

Topology with R1 devices

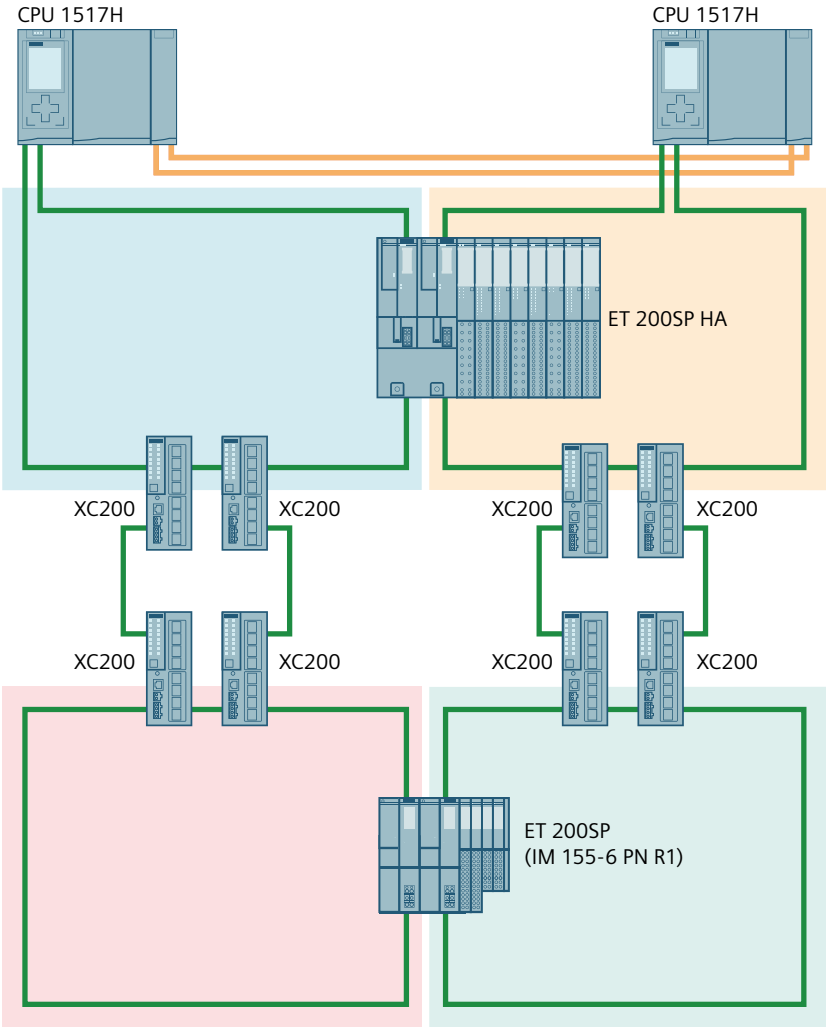

Figure 3-767 Example: S7-1500H configuration with R1 devices and switches with MRP interconnection in the PROFINET ring

Additional information

You can find all information that generally applies to MRP interconnection and thus also to redundant S7-1500R/H systems with MRP interconnection, in the section MRP interconnection (Page 201), for example, constraints, principle of operation, configuration and times.

Tool for setting the watchdog timer

For the correct setting of the watchdog timer, you can use the "S7-1500R/H AddIn (https://support.industry.siemens.com/cs/de/en/view/109769093)" which is available on the Internet and can also be used for MRP interconnections.

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SIMATIC

S7-1500 / ET 200MP / ET 200SP CM PtP - Configurations for point-to-point connections

Function Manual

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Basics of serial communication 3

Configuring / parameter assignment 4

Programming - communication using instructions 5

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Preface

Purpose of the documentation

This documentation provides important information on configuring and commissioning the point-to-point communication modules for the S7-1500 (ET 200MP) and ET 200SP.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Proficiency with STEP 7

Scope of the documentation

This documentation is valid for all point-to-point communication modules of the S7-1500 (ET 200MP) and the ET 200SP when used with STEP 7 (TIA Portal) V12 and higher.

Conventions

The term "CPU" is used in this manual both for the CPUs of the S7-1500 as well as for interface modules of distributed I/O systems, such as the IM 155-5.

Also observe notes labeled as follows:

NOTE

The notes contain important information on the product described in the documentation, on the handling of the product or on part of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Additional support

The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.
- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.
- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.
- **Forums**

  For answers and solutions concerning automation technology.
- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (https://support.industry.siemens.com).

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com) and in the Information and Download Center (https://www.siemens.com/automation/infocenter).

Security information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions form one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on industrial cybersecurity measures, please visit (http://www.siemens.com/cybersecurity-industry).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed here (https://www.siemens.com/cert).

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Function Manuals Documentation Guide 1

1.1 Function Manuals Documentation Guide

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.3 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

See also

PRONETA Professional (https://support.industry.siemens.com/cs/ww/en/view/109781283)

Introduction 2

2.1 Overview of the communication modules

Automation systems encompass a wide range of components. These also include communications modules. A simple possibility of data exchange is provided by serial communication via point-to-point connections.

Customizing to a wide range of communication partners is possible by setting the communication parameters at a lower layer of the OSI layer model (see section Transmission security (Page 20)).

Communication through point-to-point connection with S7-1500, ET 200MP and ET 200SP takes place exclusively by means of communications modules (CM) with serial interfaces.

SIMATIC S7 offers a number of modules that provide the physical interface and fundamental protocol mechanisms for this application use.

- RS232: An interface that can coordinate the communication between the partners through additional accompanying signals.
- RS422/RS485: An interface that allows longer lines through the use of differential voltages as transmission technology and also enables structures with more than 2 devices through a bus structure (RS485).

Instructions that carry out the coordination between the CPU and CM are available to transfer data from the CPU to the respective modules. They inform the user program about a successful transmission or the receipt of new data. In systems without a SIMATIC CPU, users must program the function of these instructions themselves (https://support.industry.siemens.com/cs/ww/en/view/59062563).

The function and use of the PtP communications modules is described in this function manual.

Overview of components and article numbers

Tabular overview of communications modules and their application suitability

Communications module	S7-1500	ET 200MP	ET 200SP	Article number
CM PtP RS232 BA [1]	X	X	-	6ES7540-1AD01-0AA0
CM PtP RS422/485 BA	X	X	-	6ES7540-1AB01-0AA0
CM PtP RS232 HF [2]	X	X	-	6ES7541-1AD01-0AB0
CM PtP RS422/485 HF	X	X	-	6ES7541-1AB01-0AB0
CM PtP (ET 200SP)	-	-	X	6ES7137-6AA01-0BA0

[1] BA = Basic

[2] HF = High Feature

NOTE

CM PtP (ET 200SP) with IM 155-6 MF HF

With the IM 155-6 MF HF interface module (6ES7155-6MU00-0CN0), it is possible to use different fieldbus protocols other than PROFIBUS/PROFINET. In this case, the instruction library PtP Communication cannot be used. Note the information in the programming manual CM PtP in operation without SIMATIC system instructions (https://support.industry.siemens.com/cs/ww/en/view/59062563). See also the Equipment Manual for the interface module as a download on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109773210). The LMf library MultiFieldBus enables the connection of ET 200SP IM155-6 MF to SIMATIC S7-1500 based on the Modbus/TCP protocol, see more information at (https://support.industry.siemens.com/cs/us/en/view/109803984).

Overview of components and interfaces

Tabular overview of communications modules and their functions.

Communications module	Interface	Protocols					Connection technology		Diagnostics via Event-TracePtP
		Free-port	3964(R)	Modbus master	Modbus slave	USS mas-ter	D-sub 9-pin	D-sub 15-pin	Firmware version
CM PtP RS232 BA	RS232	X	X	-	-	X	X	-	V2.0 and higher
CM PtP RS422/485 BA	RS422	X	X	-	-	X	-	X	V2.0 and higher
	RS485	X	-	-	-	X	-	X	V2.0 and higher
CM PtP RS232 HF	RS232	X	X	X	X	X	X	-	V2.0 and higher

1 BaseUnit with terminals instead of D-sub; assignment dependent on the transmission physics

2 The CM PtP communications module can also be used for multipoint connection in RS422 mode

Communications module	Interface	Protocols					Connection technology		Diagnostics via Event-TracePtP
CM PtP RS422/485 HF	RS422	X	X	X	X	X	-	X	V2.0 and higher
	RS485	X	-	X	X	X	-	X	V2.0 and higher
CM PtP (ET 200SP)	RS232	X	X	X	X	X	ET 200SP BaseUnit [1]		-
	RS422 [2]	X	X	X	X	X			
	RS485	X	-	X	X	X			

1 BaseUnit with terminals instead of D-sub; assignment dependent on the transmission physics

2 The CM PtP communications module can also be used for multipoint connection in RS422 mode

Overview of components and data transmission rates

The communications modules can send and receive data with different data transmission rates. The table below shows the assignment to the individual communications modules.

Communications module	Data transmission rate in bps											
	300	600	1200	2400	4800	9600	19200	38400	57600	76800	115200	250000[1)]
CM PtP RS232 BA	X	X	X	X	X	X	X	-	-	-	-	-
CM PtP RS422/485 BA	X	X	X	X	X	X	X	-	-	-	-	-
CM PtP RS232 HF	X	X	X	X	X	X	X	X	X	X	X	-
CM PtP RS422/485 HF	X	X	X	X	X	X	X	X	X	X	X	X
CM PtP (ET 200SP)	X	X	X	X	X	X	X	X	X	X	X	X

1) Especially for using the DMX512 protocol with RS485

Overview of components and receive buffer size

Each communications module has a buffer to cache received frames. The table below shows the assignment of the maximum size of an individual frame as well as the size of the memory for the individual communications modules.

Module	Receive buffer size KB	Max. frame length KB	Bufferable frames
CM PtP RS232 BA	2	1	255
CM PtP RS422/485 BA	2	1	255
CM PtP RS232 HF	8	4	255
CM PtP RS422/485 HF	8	4	255
CM PtP (ET 200SP)	4	2	255

Accompanying signals and data flow control

- Software data flow control with XON/XOFF

  The Freeport protocol supports data flow control with XON/XOFF via the RS232 and RS422 interfaces.
- Hardware data flow control with RTS/CTS

  The Freeport protocol supports data flow control with RTS/CTS via the RS232 interface.
- Automatic operation of accompanying signals

  The RS232 accompanying signals can be controlled with the Freeport, Modbus master and Modbus slave protocols by means of the RS232 interface. (Only available if hardware data flow control is activated.)

Protocols of the communications modules

You may set up a communication connection with different protocols, depending on the communications modules used:

- Freeport: Transmission of ASCII character strings without specified protocol format
- 3964(R): Communication between programmable logic controllers (master/master communication)
- Modbus RTU: Communication between programmable logic controllers (master/slave communication). The communications module can be the master as well as the slave.
- USS: Communication between a programmable logic controller and a drive (master/slave communication). Communication is tailored to the drive technology requirements. The communications module can only be master.

2.2 Overview of the processing steps

Point-to-point connection

The system provides various networking options for the exchange of data between two or more communication partners. The simplest form of data interchange is via a point-to-point connection between two communication partners.

The communications module (CM) forms the interface between a programmable logic controller and one or more communication partners. Data is sent in serial mode via point-to-point connection with the communications module.

Configuring / parameter assignment

Configuring the communications module includes the arrangement of the communications module in the device configuration of STEP 7 (TIA Portal) as well as the settings of the specific protocol parameters in the properties dialog of the communications module (static configuration).

Programming

Programming includes the program-specific connection of the communications module to the corresponding CPU by means of the user program. You program the communications module with STEP 7 (TIA Portal).

Communication between CPU, communications module and a communication partner takes place through instructions (Page 68). A number of instructions are available for the S7-1500 and S7-1200 automation systems. You can use these instructions to initiate and control communication in the user program as well as influence the configuration for runtime (dynamic configuration).

For more information, please refer to Overview of instructions (Page 17) and the STEP 7 (TIA Portal) online help.

2.3 Overview of instructions

Data communication

You define the type of data exchange using the "Performance optimized for many short telegrams" parameter of the module in the hardware configuration. It is recommended to use the performance optimization option as long as the maximum length for incoming/outgoing telegrams is not exceeded.

There are two types of data exchange between CPU and communications module:

- Asynchronous data exchange

  The point-to-point instructions communicate with the communications module asynchronously (to the application cycle) by reading or writing data sets. Data transmission takes place over several application cycles. The maximum telegram length in accordance with the technical specifications of the module applies.

- Synchronous data exchange (Performance optimization option (Page 38))

  The point-to-point instructions communicate with the communications module synchronously with the application cycle via the IO data of the communications module.

  The maximum length for incoming telegrams is 24 bytes and for outgoing telegrams 30 bytes. By using data synchronously with the application cycle, the response time is optimized, especially when you use multiple CM PtPs in parallel.

NOTE

The performance optimization option is available with the PtP Communication instruction library as of V4.0.

Overview of the instructions

Communication between the CPU, the communications module and a communication partner takes place by means of special instructions and protocols that support the corresponding communications modules.

The instructions in the PtP Communication instruction library process the data exchange between the CPU and the communications module. They must be called once or cyclically

from the user program. The instructions automatically detect whether the performance optimization option is active and adapt the method for the data exchange.

The instructions are part of STEP 7 (TIA Portal). The instructions are available in the "Instructions" task card under Communication > Communication processor. They apply to all listed communications modules if they support the required function.

Point-to-point instruction	Meaning
Send_P2P (Page 84)	To send data to a communication partner.
Receive_P2P (Page 88)	To receive data from a communication partner.
Receive_Reset (Page 90)	To clear the receive buffer of the communications module.
Port_Config (Page 74)	Dynamically assigning the basic interface parameters.
Send_Config (Page 76)	Send parameter assignment; dynamically assigning serial send parameters of a port.
Receive_Config (Page 78)	Receive parameter assignment; dynamically assigning serial receive parameters of a port.
P3964_Config (Page 83)	Protocol configuration; Dynamically configuring the parameters of procedure 3964(R).
Signal_Get (Page 92)	Reading RS232 accompanying signals.
Signal_Set (Page 93)	Setting RS232 accompanying signals.
Get_Features (Page 95)	Reading the extended functions supported by the communications module.
Set_Features (Page 96)	Activating the extended functions supported by the communications module.

USS instruction	Meaning
USS_Port_Scan (Page 142)	Communication via the USS network.
USS_Drive_Control (Page 145)	Exchanging data with the drive.
USS_Read_Param (Page 149)	Reading parameters from the drive.
USS_Write_Param (Page 151)	Changing parameters in the drive.

MODBUS instruction	Meaning
Modbus_Master (Page 111)	Communicating as Modbus master via the PtP port.
Modbus_Slave (Page 118)	Communicating as Modbus slave via the PtP port.
Modbus_Comm_Load (Page 107)	Configuring the port of the communications module for Modbus RTU.

Basics of serial communication 3

3.1 Serial data transmission

During serial data transmission, the individual bits of a character of information to be transmitted are sent successively in a defined sequence.

Bidirectional data traffic - operating mode

In the context of bidirectional data traffic, we distinguish between two operating modes for the communication module:

- Half-duplex operation

  The data is exchanged between the communication partners in both directions alternately. In half-duplex operation one communication partner is sending and the other communication partner is receiving at the same time. In the process one line is alternately used for sending or receiving.

- Full-duplex operation

  The data is exchanged between one or more communication partners in both directions simultaneously, which means you can send and receive data at the same time. This process requires one line for sending and one line for receiving.

Data transmission

The so-called time base synchronism (a fixed timing code used in the transmission of a fixed character string) is only upheld during transmission of a character. Each character to be sent is preceded by a synchronization impulse, also called start bit. The length of the start-bit transmission determines the clock pulse. The end of character transmission is formed by one or two stop bits.

Declarations

In addition to start and stop bits, additional declarations must be made between the sending and receiving partners before serial transmission can take place. These include:

- Data transmission rate
- Frame start and end criteria (e.g., character delay time)
- Parity
- Number of data bits (7 or 8 bits/characters)
- Number of stop bits (1 or 2)

3.2 Transmission security

Transmission security plays an important role in the transmission of data and in the selection of the transmission procedure. Generally speaking, the more layers of the reference model are applied, the higher the transmission security.

Classification of existing protocols

The figure below illustrates how the protocols of the communication module fit into the reference model.

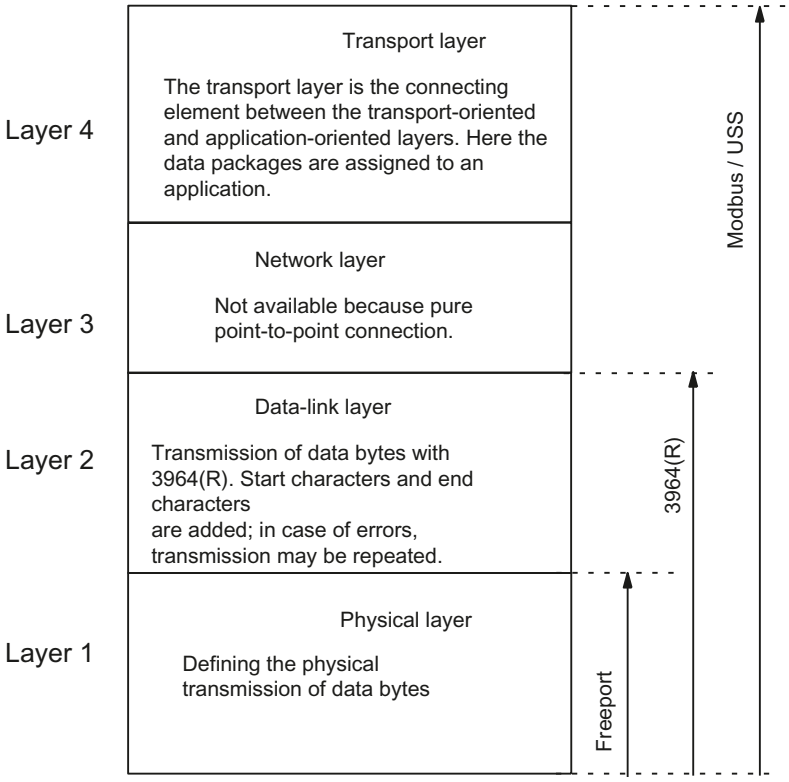

Figure 3-768 Classification of the existing protocols of the communication module in the reference model

Transmission security with Freeport

Transmission security when using Freeport:

- When data is sent with Freeport, there are no data security measures other than the use of a parity bit. This means data transmission with Freeport is very efficient, but data security is not guaranteed. A certain degree of data security can be achieved through parameter assignment of the frame start and frame end conditions.
- Using the parity bit ensures that the inversion of a bit in a character to be sent can be recognized. If two or more bits of a character are inverted, however, there is no guarantee that these errors are still detected.

- To increase transmission security, you can, for example, implement a checksum, a frame length specification, or configurable end conditions. These measures must be implemented by the user.
- A further increase in data security can be achieved by means of acknowledgment frames in response to send or receive frames. This is the case with high-grade protocols for data communication (ISO 7-layer reference model).

Transmission security with 3964(R)

The parity bit is used to increase data security; depending on the configuration, it completes the number of data bits to be transmitted to form an even or odd number.

Using the parity bit ensures that the inversion of a bit in a character to be sent can be recognized. If two or more bits of a character are inverted, however, these errors can no longer be reliably detected.

If parity is set to "none", no parity bit is transmitted. This setup reduces transmission security.

Two different procedures for data transmission can be used, either with or without a block check character:

- Data transmission without block check character: **3964**

  Transmission security is achieved by means of a specified frame structure, frame breakdown, and frame repetitions.
- Data transmission with block check character: **3964R**

  The high degree of transmission security is achieved by means of a specified frame structure and breakdown, frame repetitions, as well as inclusion of a block check character (BCC).

In this manual, the term 3964(R) is used when descriptions and notes refer to both data transmission modes.

Transmission integrity for Modbus and USS

The parity bit is used to increase transmission security; depending on the configuration, it completes the number of data bits to be transmitted to form an even or odd number.

Using the parity bit ensures that the inversion of a bit in a character to be sent can be recognized. If two or more bits of a character are inverted, however, this error can no longer be clearly detected.

If parity is set to "none", no parity bit is transmitted. This setup reduces transmission security.

The cyclic redundancy check (CRC) is additionally used with Modbus. With this method additional redundancy in the form of a so-called CRC value is added for each data block of the user data before data transmission. This is a check value calculated by using a specific procedure that can be used to detect any errors that may occur during transmission.

A BCC (block check character) is additionally used with USS. The block check character is formed during the receipt and is compared with the received BCC after the entire frame has been read in. If these two characters do not match, the frame is not evaluated. When a character is incorrectly transmitted, an error is reliably detected. When an even number of characters is incorrectly transmitted, an error can no longer be reliably detected.

3.3 RS232 mode

The following communications modules support RS232 mode:

- CM PtP RS232 BA
- CM PtP RS232 HF
- CM PtP (ET 200SP)

In RS232 mode, data is sent via two lines. A separate line is available for the send direction and the receive direction. Simultaneous sending and receiving is possible (full duplex).

RS232 signals

In addition to the TXD, RXD and GND signals, the communications module provides additional RS232 signals when using RS232 hardware:

TXD	Output	Transmitted data; Interface is transmitting
RXD	Input	Received data; Interface is receiving
GND		Shared ground reference (ground); isolated
DCD	Input	Data carrier detect; Carrier signal when connecting a modem. The communication partner signals that it recognizes incoming data.
DTR	Output	Data terminal ready; DTR set to "ON": Communications module switched on, ready for operation DTR set to "OFF": Communications module not switched on, not ready for operation
DSR	Input	Data set ready; DSR set to "ON": Communication partner signals readiness for operation DSR set to "OFF": Communication partner not switched on, not ready for operation
RTS	Output	Request to send; RTS set to "ON": Communications module ready to send; signals to the communication partner that there is data ready to send RTS set to "OFF": Communications module not ready to send
CTS	Input	Clear to send; Communication partner can receive data from the communications module (response to RTS = ON of the communications module) CTS set to "ON": Signals readiness to receive to the communication partner CTS set to "OFF": Signals "Not ready to receive" to the communication partner
RI	Input	Incoming call for connecting a modem (ring indicator)

After power on of the communications module, the output signals are in the OFF state (inactive).

You configure the operation of the DTR/DSR and RTS/CTS control signals in the user interface of the communications module.

The RS232 signals cannot be influenced in case of:

- configured data flow control "Hardware RTS always switched"
  (corresponds to automatic operation of the accompanying signals)
- configured data flow control "Hardware RTS always ON"
  (corresponds to hardware flow control with RTS/CTS)
- configured data flow control "Hardware RTS always ON, ignore DTR/DSR"

For more information, refer to chapter Handshake procedure (Page 32).

Connecting cables

The following standard connecting cables of various lengths are available for connecting to a communication partner which also has a 9-pin D-sub pin connector:

Article number	6ES7902-1AB00-0AA0	6ES7902-1AC00-0AA0	6ES7902-1AD00-0AA0
Product type designation	S7 connecting cable RS232		
Cable length	5 m	10 m	15 m

The following table shows the pin assignment of the 9-pin D-sub pin connector of the CM PtP RS232 BA/HF.

Pin connector	Pin	Designation	Input/ output	Required/optional for self-fabrication
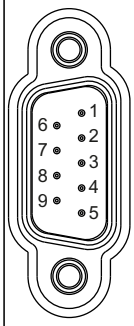	1	DCD	Input	Optional
	2	RXD	Input	Required
	3	TXD	Output	Required
	4	DTR	Output	Optional
	5	GND	—	Required
	6	DSR	Input	Optional
	7	RTS	Output	Optional
	8	CTS	Input	Optional
	9	RI	Input	Optional
Front view				

The cable or the connector of the listed connecting cables are not available for order as separate items. If you fabricate your own connecting cables you must remember that unconnected inputs at the communication partner may have to be connected to open-circuit potential.

Note that you may only use shielded connector enclosures. A large surface area of the cable shield must be in contact with the connector enclosure on both ends.

CAUTION

Never connect cable shield with GND

Never connect the cable shield with the GND as this could destroy the interfaces. GND must always be connected on both sides (pin 5), otherwise the interface modules could also be destroyed.

The figure below illustrates the cable for a point-to-point connection between a communications module and a communication partner.

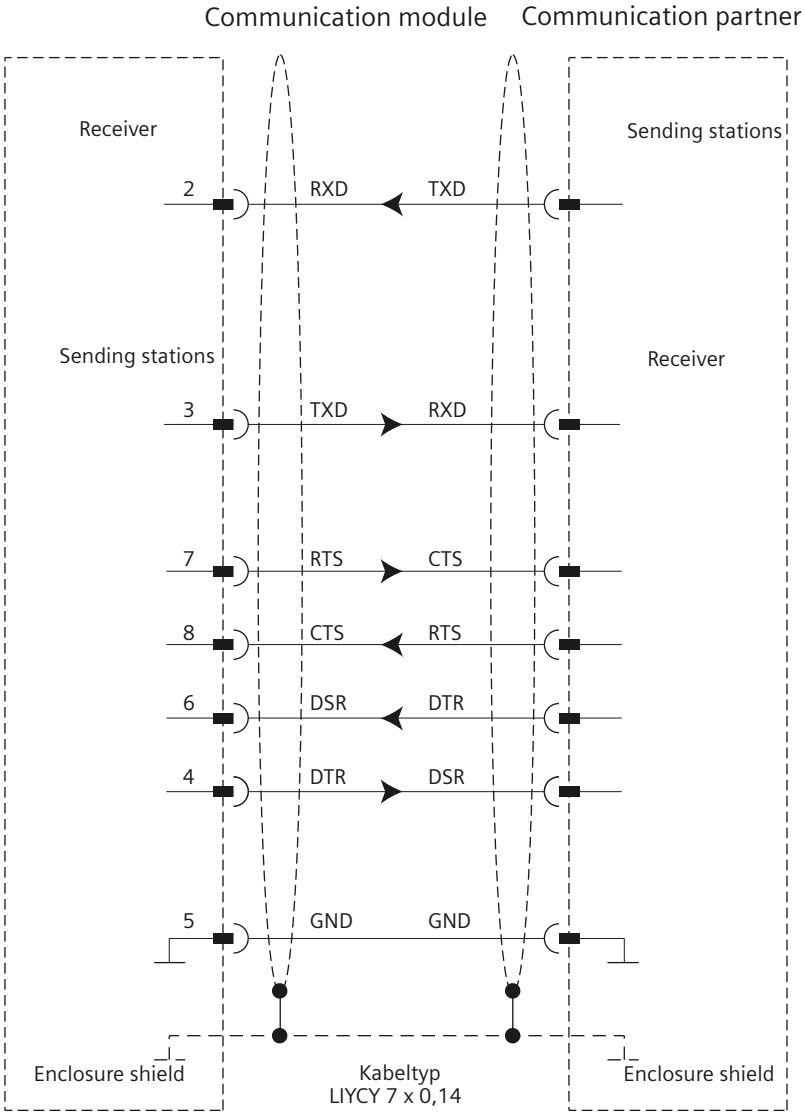

BaseUnit

In the following table, you can find the pin assignment of the BaseUnit of the CM PtP (ET 200SP).

BaseUnit	Pin	Designation	Input/output
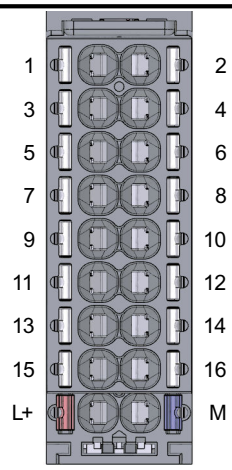	1	TXD	Output
	2	RXD	Input
	3	RTS	Output
	4	CTS	Input
	5	DTR	Output
	6	DSR	Input
	7	DCD	Input
	8	RI	Input
	9	GND	---
	10		
Front view			

CAUTION

Never connect cable shield with GND

Never connect the cable shield with the GND as this could destroy the interfaces. GND must always be connected on both sides (pin 5), otherwise the interface modules could also be destroyed.

3.4 RS422 mode

The following communications modules support RS422 mode:

- CM PtP RS422/485 BA
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

In RS422 mode, data is transmitted via two line pairs (four-wire mode). A separate line pair is available for the send direction and the receive direction. Simultaneous sending and receiving is possible (full duplex).

The data can be exchanged simultaneously between two or more communication partners. In RS422 multipoint mode, only one slave may send data at any given time.

Interface operating modes

The following table is a summary of the interface operating modes for the various communications modules and protocols.

The communications module can be used in the following topologies in RS422 mode:

- Link between two nodes: Point-to-point connection
- Link between several nodes: Multipoint connection
  (only available with CM PtP (ET 200SP))

Operating mode	Description
Full duplex (RS422) four-wire mode (point-to-point connection)	Both devices have the same priority in this operating mode.
Full duplex (RS422) four-wire mode (multipoint master)	The communications module can be used as multipoint master.
Full duplex (RS422) four-wire mode (multipoint slave)	The communications module can be used as multipoint slave.

The following applies for a multipoint master/slave topology in RS422 mode:

- The sender of the master is interconnected with the receivers of all slaves.
- The senders of the slaves are interconnected with the master's receiver.
- Only the receiver of the master and the receiver of one slave have a default setting. All other slaves operate without default settings.

RS422 signals

The following signals are present on the communications module when using the RS422 hardware:

T (A) -	Output	Transmitted data
T (B) +	Output	Transmitted data
R (A) -	Input	Received data
R (B) +	Input	Received data
GND		Common ground reference (ground); floating

Connecting cables

The following standard connecting cables of various lengths are available for connecting to a communication partner which also has a 15-pin D-sub socket:

Article number	6ES7902-3AB00-0AA0	6ES7902-3AC00-0AA0	6ES7902-3AG00-0AA0
Product type designation	S7 connecting cable RS422		
Cable length	5 m	10 m	50 m

The following table shows the pin assignment of the 15-pin D-sub socket of the CM PtP RS232 BA/HF.

Socket	Pin	Designation	Input/output
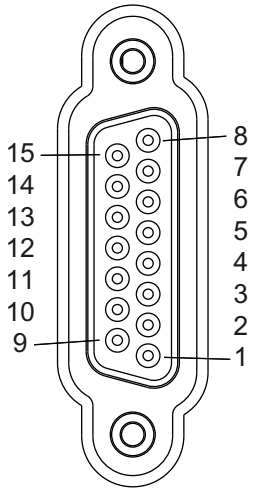	1	-	-
	2	T (A) -	Output
	3	-	-
	4	R (A) -	Input
	5	-	-
	6	-	-
	7	-	-
	8	GND	-
	9	T (B) +	Output
	10	-	-
	11	R (B) +	Input
	12	-	-
	13	-	-
	14	-	-
	15	-	-
Front view			

The cable or the connector of the listed connecting cables are not available for order as separate items. If you fabricate your own connecting cables you must remember that unconnected inputs at the communication partner may have to be connected to open-circuit potential.

Note that you may only use shielded connector enclosures. A large surface area of the cable shield must be in contact with the connector enclosure on both ends.

CAUTION

Never connect cable shield with GND

Never connect the cable shield with the GND as this could destroy the interfaces. GND must always be connected on both ends (pin 8), otherwise the interface modules could be destroyed.

The figure below illustrates the cable for a point-to-point connection between a communications module and a communication partner.

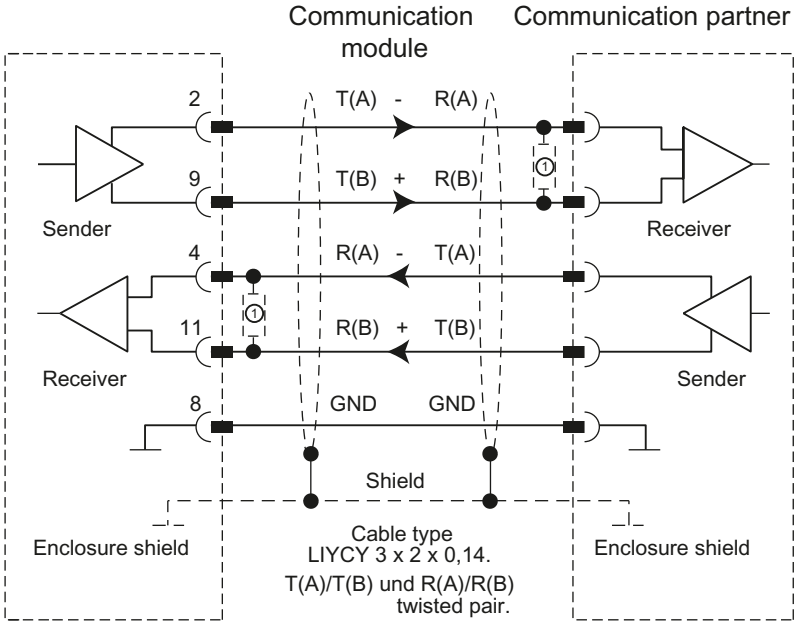

① For cable lengths longer than 50 m, you need to solder a terminating resistor of approx. 330 Ω at the receiver end to ensure interference-free data traffic.

BaseUnit

In the following table, you can find the pin assignment of the BaseUnit of the CM PtP (ET 200SP).

BaseUnit	Pin	Designation	Input/output
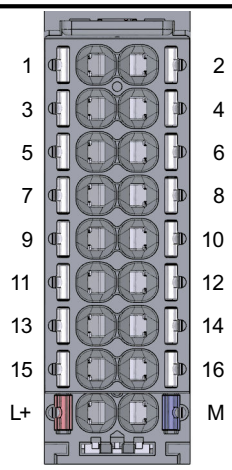	11	T (A) -	Output
	12	R (A) - T(A)/R(A)	Input Input/output
	13	T (B) +	Output
	14	R (B) + T(B)/R(B)	Input Input/output
	15	GND	---
	16		
Front view			

CAUTION

Never connect cable shield with GND

Never connect the cable shield with the GND as this could destroy the interfaces. GND must always be connected on both sides (pin 5), otherwise the interface modules could also be destroyed.

3.5 RS485 mode

The following communications modules support RS485 mode:

- CM PtP RS422/485 BA
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

In RS485 mode, data is transmitted via one line pair (two-wire operation). The line pair is available alternately for the send and receive directions. It is possible to either send or receive (half duplex). On completion of a send operation, operation is immediately switched to receive mode (ready to receive). Send mode is reset again as soon as a new send job is received.

Interface operating modes

The following table is a summary of the interface operating modes for the various communications modules and protocols.

Operating mode	Description
Half duplex (RS485) two-wire operation	Operating mode for point-to-point connection or multipoint connection (multipoint) in two-wire operation. The communications module can be the master as well as the slave.

If you operate the Freeport in RS485 mode (half duplex, two-wire operation), you must make provisions in the user program to ensure that only one device sends data at any given time. If more than one device sends data at the same time, the frames are corrupted.

Modbus automatically ensures that only one device is sending.

Changeover times for RS485 communications module in half duplex mode

A maximum time of 0.1 ms is set for the changeover between sending and receiving.

RS485 signals

The following signals are present on the communications module when using the RS485 hardware:

R (A)/T (A) -	Input/output	Received/transmitted data
R (B)/T (B) +	Input/output	Received/transmitted data
GND		Common ground reference (ground); floating

Connecting cables

The table below shows the pin assignment of the 15-pin D-sub socket of the respective communications module.

Socket	Pin	Designation	Input/output
	1	-	-
	2	-	-
	3	-	-
	4	R (A)/T (A) -	Input/output
	5	-	-
	6	-	-
	7	-	-
	8	GND	-
	9	-	-
	10	-	-

Socket	Pin	Designation	Input/output
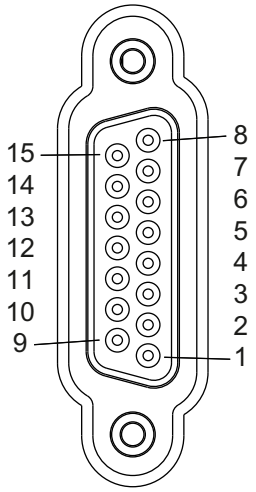	11	R (B)/T (B) +	Input/output
	12	-	-
	13	-	-
	14	-	-
	15	-	-
Front view			

When fabricating the connecting cables, you need to remember that unconnected inputs at the communication partner may have to be connected to open-circuit potential.

Note that you may only use shielded connector enclosures. A large surface area of the cable shield must be in contact with the connector enclosure on both ends.

⚠ CAUTION

Never connect cable shield with GND

Never connect the cable shield with the GND as this could destroy the interfaces. GND must always be connected on both ends (pin 8), otherwise the interface modules could be destroyed.

The figure below illustrates the cable for a point-to-point connection between a communications module and a communication partner.

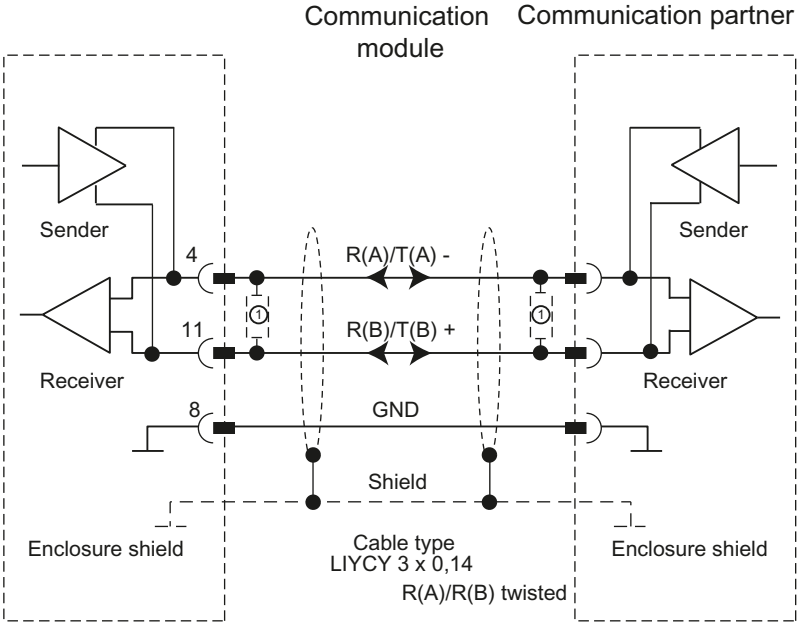

① For cable lengths longer than 50 m, you need to solder a terminating resistor of approx. 330 Ω at the receiver end to ensure interference-free data traffic.

3.6 Handshake procedure

Introduction

Handshaking controls the data flow between two communication partners. The use of the handshaking method prevents data loss during transmission if the devices are operating at different speeds.

We can basically distinguish between the following methods:

Table 3-973 Overview of methods and interfaces

Method	RS232	RS422	RS485
Software data flow control XON/XOFF	X	X	-
Hardware data flow control (RTS/CTS)	X	-	-
Automatic operation of accompanying signals	X	-	-

Software data flow control

Software data flow control is implemented as follows on the communications module:

- **XON/XOFF**
  - As soon as the communications module has been set to the "XON/XOFF" operating mode by means of parameter assignment, it sends the XON character, thereby allowing the communication partner to send data.
  - When the configured maximum number of telegrams or 16 characters is reached before the receive buffer overflows, the communications module sends the character XOFF and thus requests the communication partner to interrupt the transmission. If the communication partner nonetheless continues to send data, an error message is generated if the receive buffer overflows. Data received in the last frame is discarded.
  - As soon as a frame has been fetched by the CPU and the receive buffer is ready to receive data again, the communications module sends the XON character.
  - If the communications module receives the XOFF character during sending, it cancels the current send operation until it receives a XON again from its communication partner. If no XON is received within a specific configurable time, send operation is canceled and a corresponding error message is output.

NOTE

You can configure the characters for XON and XOFF (any ASCII character).

During parameter assignment of the XON/XOFF software data flow control, user data may not contain any of the configured XON or XOFF characters.

Hardware data flow control

NOTE

The DTR/DSR signals do not have to be wired for "Hardware RTS always ON, ignore DTR/DSR" parameter assignment.

If "Hardware RTS always ON" is configured, it is imperative that you fully wire the interface signals used. Make sure that the local RTS (out) is connected with the CTS (in) of the communication partner and the local CTS is connected with the RTS of the communication partner. Accordingly, the local DTR must be connected with the DSR of the communication partner and the local DSR with the DTR of the communication partner.

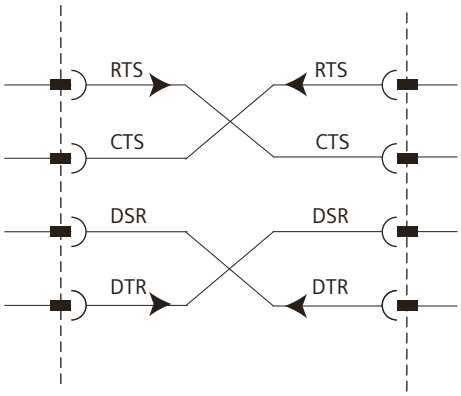

Figure 3-769 Wiring of the interface signals

- **Hardware RTS always ON, ignore DTR/DSR**
  - As soon as the communications module has been set to an operating mode with "Hardware RTS always ON" through parameter assignment, it outputs the RTS = ON signal to the communication partner to indicate its ready state.
  - RTS is set to OFF as soon as the configured maximum number of frames or 16 characters before buffer overflow is reached.
    If the communication partner nonetheless continues to send data, an error message is generated on overflow of the receive buffer. Data received in the last frame is discarded.
  - RTS is reset to ON as soon as the frame has been fetched by the CPU and the receive buffer is ready to receive data again.
  - If CTS switches to OFF during the send operation, the communications module interrupts the send operation until CTS is reset to ON. If CTS is not reset to ON within a specific configurable time, the send operation is canceled and a corresponding error message is output.
- **Hardware RTS always ON**

  The "Hardware RTS always ON" mode corresponds to the "Hardware RTS always ON, ignore DTR/DSR" mode. However, you also need to wire DTR and DSR.
  - As soon as the communications module has been set to an operating mode with "Hardware RTS always ON" through parameter assignment, it sets DTR = ON and RTS = ON to signal its general ready state to the communication partner.
  - RTS is set to OFF as soon as the configured maximum number of frames or 16 characters before buffer overflow is reached.
    If the communication partner nonetheless continues to send data, an error message is generated on overflow of the receive buffer. Data received in the last frame is discarded.
  - RTS is reset to ON as soon as the frame has been fetched by the CPU and the receive buffer is ready to receive data again.
  - If CTS switches to OFF during the send operation, the communications module interrupts the send operation until CTS is reset to ON. If CTS is not reset to ON within a specific configurable time, the send operation is canceled and a corresponding error message is output.
  - A switch from DSR = ON to DSR = OFF cancels an active send job and triggers an error message.

Automatic operation of accompanying signals

- **Hardware RTS always switched**

  "Hardware RTS always switched" is implemented as follows on the communications module:

  – As soon as the communications module is set to the operating mode with "Hardware RTS always switched" through parameter assignment, it sets the line RTS to OFF and DTR to ON (communications module ready for operation).

    It is not possible to send frames until the DSR line is set to ON. No data is sent via the RS232C interface as long as DSR is set to OFF. A send job is canceled and a corresponding error message is generated.

  – When a send job is pending, RTS is set to ON and the configured RTS ON delay starts. On expiration of the data output time, the system checks whether the communication partner has set CTS to ON. If so, the data is sent via the RS232 interface.

  – If the CTS line is not set to ON within the RTS ON delay, or if CTS changes to OFF during transmission, the send job is aborted and an error message is generated.

  – Once the data has been sent and the configured clear RTS OFF delay has elapsed, the RTS line is set to OFF. The system does not wait for CTS to change to OFF.

  – It is always possible to receive data via the RS232 interface. There will be no reaction if there is a danger of the receive buffer of the communications module overflowing.

  – A switch from DSR = ON to DSR = OFF cancels an active send job and triggers an error message.

  NOTE

  Set the "RTS ON delay" in such a way that the communication partner is able to enter the ready to receive state before the time elapses.

  Set the "RTS OFF delay" in such a way that the communication partner is able to receive the last characters of the frame completely before RTS is set to OFF and the send request is canceled.

  NOTE

  When automatic operation of the RS232 signals is configured, RTS and DTR cannot be controlled by means of the corresponding instruction!

Time diagram

The figure below shows the chronological sequence of a send job with configured data flow control "Hardware RTS always switched":

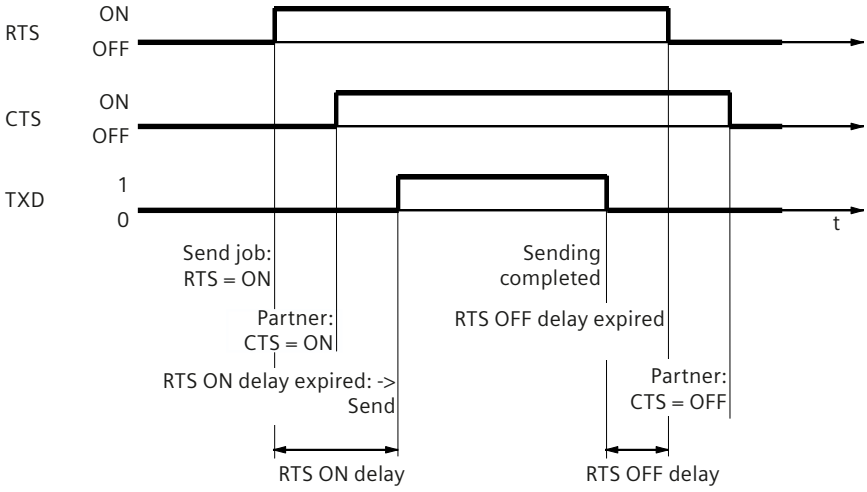

Figure 3-770 Time diagram for Hardware RTS always switched

More information

NOTE

Operation of DTR/DSR or RTS/CTS is accepted by the communications module with the following settings:

- Hardware RTS always ON, ignore DTR/DSR
- Hardware RTS always ON
- Hardware RTS always switched

Configuring / parameter assignment 4

4.1 Configuring / parameter assignment of a communication module

The following sections contain explanations on the following protocols and their parameters:

- Communication using Freeport (Page 38)
- Communication using 3964(R) (Page 46)
- Communication through Modbus RTU (Page 51)
- Communication using USS (Page 58)

This information is required to carry out the parameter assignment and subsequently programming of the communication in accordance with the used protocol.

Configuration and parameter assignment are carried out in the device view of STEP 7 (TIA Portal) and in the properties dialog of the communications module. Some configurations can also be changed during runtime by means of the corresponding "Config" instructions (Port_Config, Send_Config, Receive_Config, P3964_Config).

NOTE

GSD file for PROFIBUS DP

Information about restrictions when using the GSD file for PROFIBUS DP can be found in the respective equipment manual in the Parameter Settings section.

Procedure for setting up point-to-point communication

The procedure does not depend on the communications module used.

1. In the device view of the STEP 7 (TIA Portal) hardware editor configure an S7-1500 structure with CPU and communications module.
2. You assign the parameters of the communications module interface (protocol, protocol parameters, addresses) in the "General" area of the "Properties" tab.

4.2 Special features for the use of the option for performance optimization

From firmware version V2.0 of the communications module, the option for performance optimization is available. This option is suitable if you are exclusively sending and receiving short frames with several communications modules.

The following overview shows the key differences between not using and using the option:

Without performance optimization option	With performance optimization option
Limiting the telegram length depending on the communications module to 1, 2, or 4 KB	Limiting the telegram length to 24 bytes for receive frames and 30 bytes for send frames. Longer frames are rejected.
Transfer of a telegram requires several application cycles of the CPU. The number of cycles increases with the number of communications modules that communicate via data record.	Transmission of a frame requires an application cycle of the CPU and several communications modules can be served in parallel (reaction time optimized, timing behavior improved).
Allocation of an address range of 8 bytes of input data and 0 bytes of output data	Allocation of an address range of 32 bytes of input data and 32 bytes of output data
Available from firmware version V1.0 of the communications module	Available from firmware version V2.0 of the communications modules
Configuration and parameter assignment in the device view of STEP 7 (TIA Portal) and in the Properties dialog of the communications module. The option for performance optimization cannot be changed with "Config" instructions (Port_Config, Send_Config,Receive_Config, P3964_Config).	
Available as of version V1.0 of the instruction libraries PtP Communication, USS Communication and MODBUS (RTU)	Available as of version V4.0 of the instruction library PtP Communication and V5.0 of the instruction libraries USS Communication and MODBUS (RTU)

NOTE

Modbus RTU

In communication via Modbus RTU with the performance optimization option activated, there are restrictions on the quantity structure of the transferred data (Page 56).

4.3 Communication using Freeport

4.3.1 Procedure for establishing a serial connection with Freeport

Requirements

- The hardware is set up and there is an electrical connection to the link partner.
- The project has been created in STEP 7 (TIA Portal) and the CPU has been inserted into the hardware configuration.

Procedure - Hardware configuration

1. Insert the CM PtP communication module into the hardware configuration.
2. Set the communication parameters according to the link partner:

   For example, transmission speed, character frame, frame start and frame end

   These parameters are transferred to the CM PtP communication module every time the CPU is started.

Procedure - Programming

1. Create the data structure that is to include the data to be transferred.

Sending data

1. Insert the instructions from the PtP Communication library: Send_P2P for sending data
2. Interconnect the input and output parameters of the instruction, e.g.:
   - HWID from the system tags at the PORT input
   - Data structure with the data to be sent at the BUFFER input

   Note: During operation, each positive edge at the REQ input will send the specified data area once. The block must be called until DONE indicates that the data was transferred to the module.

   In case of an error, setting ERROR once and displaying the corresponding information in STATUS indicates that the data was not transferred.

Receiving data:

1. Insert the instructions from the PtP Communication library: Receive_P2P for sending data
2. Interconnect the input and output parameters of the instruction, e.g.:
   - HWID from the system tags at the PORT input
   - Data structure for storage of received data at the BUFFER input

   Note: A high level at the NDR output during operation indicates that new data was received and stored in the specified data area. The block must be called until NDR=TRUE. The received data can then be analyzed and the RECEIVE_P2P can be called again.

Optional additions

- Instructions that end in _Config can be used optionally to change the parameters of the hardware configuration during operation of the user program. The changes are not saved in the hardware configuration. They are overwritten at the next restart.
- The instructions Signal_Set and Signal_Get can be used to control the RS232 accompanying signals individually if automatic operation is not a suitable option.

4.3.2 Data transmission with Freeport

Introduction

Freeport is a freely programmable frame-based protocol that is also known as ASCII protocol.

The Freeport protocol controls data transmission by means of a point-to-point connection between the communication module and a communication partner. The Freeport protocol contains the physical layer (Layer 1).

The Freeport protocol supports sending and receiving of messages with any structure (all characters from 00H through FFH (for character frames with 8 data bits) or from 00H through 7FH (for character frames with 7 data bits)).

The frame start and end criteria must be configured both for the send and the receive direction. The start and end criteria can be configured differently.

Instructions are available for communication with a communication partner (see Overview of PtP programming).

4.3.3 Sending data with Freeport

Specifying settings for sending

To send a message, the partner must be informed of the start and end of the message. These settings can be permanently set in the hardware configuration or can be adjusted during runtime by using the instruction Send_Config. You can select one of the following options or also combine them:

- Send break before frame start

  You can specify that an additional Break is sent at the beginning of each message transmission on expiration of the RTS ON delay time.
  The duration of the "Break" is specified in bit times.

  Compliance with the send break can be deactivated if other mechanisms are used for synchronization.

- Send idle line

  You can specify that an additional "Idle Line" signal is output at the start of each message transmission.
  The duration of the "Idle Line" is specified in bit times.

  Compliance with the send break can be deactivated if other mechanisms are used for synchronization.

- RTS ON delay

  You can configure the time that has to expire after the RTS (Request to send) before the actual data transmission starts (RS232 only).

- RTS OFF delay

  You can configure the time that has to expire after transmission has been completed before the RTS signal is deactivated (RS232 only).

- Send up to and including the end delimiter

  You can configure the number of end delimiters (1 or 2) and their value.

  All data up to the end delimiter(s) is sent, independent of the selected frame length. The end delimiter must be included in the data to be sent. Data is sent only up to and including the delimiter, even if the specified data length is longer.

- Number of appended characters

  Input of the number of appended characters. Sending takes place up to the configured length. The end delimiter(s) is/are appended automatically. Depending on the number of end delimiters, one to five characters more than the number specified at the instruction are sent to the partner.

NOTE

If you combine "Send break before frame start", "Send idle line" and "RTS ON delay", these are processed in the order "RTS ON delay", "Send break before frame start" and "Send idle line".

4.3.4 Receiving data with Freeport

Specifying the message start

For data transmission with Freeport, you can choose between several different start criteria. The start criterion defines when a frame starts. Once a criterion that indicates the start of the message is met, the data stream is scanned for message end criteria. Here you select the settings that correspond to the properties of the sending communication partner.

Two different methods are available for detecting the message start:

- **Start on any character**

  Any character can be used to define the start of the message (default).

  This means that the first character sent at the start of communication, or after the frame end has been detected, will be identified as the first character of a message.

- **Start on special condition**

  The start of the message is detected based on the following specified conditions.

  – **After detection of a line break**

    The frame start is not accepted unless a break has been received beforehand, in other words, it is compulsory for the partner to send a break before sending a frame.

  – **After detection of an idle line**

    The frame start is not accepted until the configured idle line duration has expired. This procedure requires a minimum interval between two frames.

  – **After receipt of a start character**

    The frame start is detected when the configured start character is identified.

  – **After detection of one or several start sequences**

    The frame start is detected when the configured string with a length of up to five characters is identified. You can configure up to 4 start sequences. The start sequences that are up to 5 characters long can also contain "don't care characters".

Example:

Table 3-974 Configured start conditions

Start condition	1st character	2nd character	3rd character	4th character	5th character
1	0x68	xx	xx	0x68	xx
2	0x10	0xaa	xx	xx	xx
3	0xdc	0xaa	xx	xx	xx
4	0xe5	xx	xx	xx	xx
:					

The following message has been received: 68 10 aa 68 bb 10 aa 16

The evaluation of the start criteria begins with the receipt of the first character 0x68.
The 2nd and 3rd characters are free.
When the 4th character (second 0x68) is received, the first start condition is met and further evaluation of the message begins.

Specifying the message end

You can choose from several different end criteria for data transmission using the Freeport protocol. The end criterion defines the point at which a frame has been received completely.

Configurable end criteria are:

- **Recognize message end by message timeout**
- **Recognize message end by response timeout**
- **After character delay time elapses (default)**
- **After receipt of a fixed frame length**
- **After receipt of a maximum number of characters**
- **Read message length from message**
- **After receipt of an end sequence**

Message timeout

When data is received, the end of frame is detected on expiration of the configured time for transferring a frame. Time measurement starts after the start criterion has been met.

Response timeout

The response time is used to monitor the response behavior of the communication partner. If a valid frame start is not recognized after the completion of a send job, the send job is acknowledged with a corresponding message.

The actual end criterion has to be configured additionally.

Expiration of character delay time

When data is received, the frame end is detected when the configured maximum time between successive characters is exceeded (character delay time). The value is specified in bit times.

In this case, the character delay time must be set in such a way as to ensure that it expires between two consecutive frames. However, it should be of sufficient length to exclude incorrect identification of the end of the frame whenever the communication partner performs a transmission pause within a frame.

NOTE

For higher data transfer speeds, a value of at least 100 bit times is recommended.

Fixed frame length

When data is received, the end of the frame is identified after the configured frame length has been reached.

An error message is output and the frame is discarded if the character delay time expires (if activated) before the fixed frame length has been reached.

Please note the following if the frame length of the received characters does not match the fixed configured frame length:

- All characters received after the fixed configured frame length has been reached will be discarded until a new start criterion is detected.
- An error message is output and the frame is discarded if another (activated) end criterion is met before the fixed frame length has been reached.

Maximum number of characters

When receiving data, the end of the frame is recognized after the declared number of characters have arrived.

This setting can be combined with the "Character delay time" settings. The frame received is also assessed as free of error if another end condition occurs, regardless of whether the maximum number of characters has been reached.

Please note the following if the frame length of the received characters does not match the configured maximum frame length:

- All characters received after the configured maximum number of characters has been reached will be discarded until a new start criterion (e.g. "Idle Line") is detected.
- If a different (activated) end criterion is met before the configured maximum number of characters has been reached, this "frame part" is assessed as a valid frame and the partner waits for a new start criterion. All characters received prior to fulfillment of a new start criterion are discarded.

NOTE

If no further end criterion is activated, the fixed frame length and maximum number of characters will respond in the same way.

Message length in the message

When data is received, the frame end is detected when the frame length sent with the received frame has been reached.

The following parameters define the characters to be used for evaluation of the message length:

- **Offset of length field in message**

  In the message, the value defines the position of the character that is to be used to determine the message length.

  You can set values from 0 to 4095 characters, depending on the buffer size.
- **Size of length field**

  This value specifies the number of characters as of the first evaluation position to be used to determine the message length.

  You can set values of 1, 2 and 4 characters.
- **Number of characters not counted in length specification**

  Number of characters appended to the frame without counting towards the frame length. This value defines the number of bytes at the end of the frame which should not be included in the evaluation of the message length.

  You can set values from 0 to 255 characters.

Example:

Parameter assignments for "Message length in the message"

Offset of length field in message:	3rd byte ("2" has to be configured as offset)
Size of length field:	1 byte
Number of characters not counted in length specification:	3 bytes

Message					Number of characters not counted in length specification		
Start character	**Address**	**Length field**			**Checksum**	**End delimiter**	
Byte 1	Byte 2	Byte 3	Byte ...	Byte X	Byte X+1	Byte X+2	Byte X+3

End sequence

When data is received, the end of the frame is identified when the configured end sequence (max. 5 characters) is received. The end sequence which is up to 5 characters long can also contain "don't care characters". The received data is applied by the CPU, including the end sequence.

If you are working with the end sequence, transmission is not code-transparent and you must exclude the presence of end code in the user data.

NOTE

Frame end sequence

If there is only one end delimiter, the entry **must** take place in the 5th line.

If there are two end delimiters, the entries **must** take place in the 4th and 5th line (no gaps).

The same applies to the use of additional characters.

4.3.5 Code transparency

Code transparency

Code-transparent means that any character combinations can occur in the user data without the end criterion being recognized.

The code transparency of the procedure depends on the selection of the configured end criterion and flow control:

- With specified end sequence or using XON/XOFF flow control
  - Not code-transparent
- End criterion character delay time, fixed frame length, maximum frame length, message timeout, or response timeout and message length in the message
  - Code-transparent

4.3.6 Receive buffer

Receive buffer of the module

The communications modules have a receive buffer that stores the received frames temporarily until they are transmitted to the CPU. The receive buffer is implemented as a ring buffer, which means the frames are transmitted to the CPU in the order in which they were received until the receive buffer is full. If additional frames are received once the buffer is full, the oldest frame is overwritten. If "Prevent overwriting" was configured, a corresponding

message is generated when the receive buffer is full. All further frames are rejected until the receive buffer is ready to receive new ones.

During the parameter assignment, you can specify whether the receive buffer should be deleted during startup. You can also specify the range of values (1 to 255) for the number of buffered receive frames.

Depending on the communications module used, the receive buffer of the module comprises up to 8 kBytes (see section Introduction (Page 13)). The frame has a maximum length of 4 KB. This means that each communications module is capable of buffering at least two frames.

If you always want to transfer the last frame received to the CPU, you must set the value "1" for the number of buffered frames and deactivate overwrite protection.

NOTE

If the cyclical call of Receive_P2P is suspended for a period of time, calling Receive_P2P again may result in an old telegram from the module being received first and only then the latest telegram from the CPU. At the time of interruption, the old frame had already been transmitted from the receive buffer of the communications module and prepared for transmission to the CPU.

4.3.7 Communication via DMX512

You can use the ET 200SP CM PtP (from firmware version V1.0.5) communication module for communication via DMX512 (Digital Multiplex). For communication via DMX512, the use of the performance optimization option is also possible, provided you use the max. value 29_D as the highest address.

You can find more information on setting up a DMX512 connection in the FAQ with the entry ID 109778975 (https://support.industry.siemens.com/cs/ww/en/view/109778975) in Siemens Industry Online Support.

4.4 Communication using 3964(R)

4.4.1 Procedure for establishing a serial connection with 3964(R)

Requirements

- The hardware is set up and there is an electrical connection to the link partner.
- The project has been created in STEP 7 (TIA Portal) and the CPU has been inserted into the hardware configuration.

Procedure - Hardware configuration

1. Insert the CM PtP communication module into the hardware configuration.
2. Set the communication parameters according to the link partner:

   For example, transmission speed, character frame, frame start and frame end

   These parameters are transferred to the CM PtP communication module every time the CPU is started.

Procedure - Programming

1. Create the data structure that is to include the data to be transferred.

Sending data:

1. Insert the instructions from the PtP Communication library: Send_P2P for sending data
2. Interconnect the input and output parameters of the instruction, e.g.:
   - HWID from the system tags at the PORT input
   - Data structure with the data to be sent at the BUFFER input

   Note: During operation, each positive edge at the REQ input will send the specified data area once. The block must be called until DONE indicates that the data was transferred to the module.

   In case of an error, setting ERROR once and displaying the corresponding information in STATUS indicates that the data was not transferred.

Receiving data:

1. Insert the instructions from the PtP Communication library: Receive_P2P for sending data
2. Interconnect the input and output parameters of the instruction, e.g.:
   - HWID from the system tags at the PORT input
   - Data structure for storage of received data at the BUFFER input

   Note: A high level at the NDR output during operation indicates that new data was received and stored in the specified data area. The block must be called until NDR=TRUE. The received data can then be analyzed and the RECEIVE_P2P can be called again.

Optional additions

- Instructions that end in _Config can be used optionally to change the parameters of the hardware configuration during operation of the user program. The changes are not saved in the hardware configuration. They are overwritten at the next restart.
- The instructions Signal_Set and Signal_Get can be used to control the RS232 accompanying signals individually if automatic operation is not a suitable option.

4.4.2 Data transmission with 3964(R) procedure

Introduction

The 3964(R) procedure controls point-to-point data exchange between the communication module and a communication partner and contains both the physical layer (layer 1) and the link layer (layer 2).

Instructions are available for communication with a communication partner (see Overview of PtP programming).

4.4.3 Control characters

Introduction

During data transmission, procedure 3964 (R) adds control characters to the raw data (data link layer). The communication partner can use these control characters to check whether it has received all data completely and without errors.

Control characters of the 3964(R) procedure

The 3964(R) procedure evaluates the following control characters:

STX	Start of Text	Beginning of the character string to be transmitted	02H
DLE	Data Link Escape	Data transmission changeover	10H
ETX	End of Text	End of the character string to be transmitted	03H
NAK	Negative Acknowledge	Negative acknowledgment	15H
BCC	Block Check Character (only with 3964R)	Block check character	

BCC is formed and monitored automatically in the communications module. The block check character is not transmitted as frame content to the CPU.

NOTE

If the DLE character is transmitted as an information character within a frame, it is sent twice (DLE duplication) to distinguish it from the DLE control character during connection establishment and termination. The receiver reverses the DLE duplication.

Priority

With the 3964(R) procedure, one communication partner must be assigned a higher and the other a lower priority. If both partners start to establish a connection at the same time, the partner having lower priority will cancel its send job.

4.4.4 Block check character

Block check character

With the 3964R transfer protocol, data security is enhanced by sending an additional block check character (BCC = Block Check Character).

The block check character is the even longitudinal parity (EXOR logic operation of all data bytes) of a sent or received block. Its calculation begins with the first byte of user data (first byte of the frame) after the connection establishment, and ends after the DLE ETX character at connection termination.

NOTE

With DLE duplication, the DLE character is included twice in the BCC calculation.

4.4.5 Sending data with 3964(R)

Connection establishment for sending

The 3964(R) procedure sends the STX control character to set up the connection. If the communication partner responds with the DLE character before the acknowledgment delay time expires, the procedure switches to send mode.

If the communication partner answers with NAK or any other character (except for DLE or STX), or the acknowledgment delay time expires without a response, the procedure tries to set up the connection again. After the configured number of unsuccessful setup attempts, the procedure cancels the connection setup and sends the NAK character to the communication partner. The communication module outputs a corresponding error message.

Sending data

If the connection is successfully established, the user data contained in the output buffer of the communication module is sent to the communication partner with the selected transmission parameters (a DLE recognized in the user data is doubled during the send job). The communication partner monitors the time intervals between the incoming characters. The interval between two characters must not exceed the character delay time. Monitoring of the character delay time starts immediately after the connection has been established.

If the communication partner sends the NAK character during an active send operation, the procedure cancels the block and repeats it as described above, beginning with connection establishment. If a different character is sent, the procedure first waits for the character delay time to expire and then sends the NAK character to set the communication partner to idle state. Then, the procedure restarts sending with the connection setup STX.

Connection termination during sending

Once the contents of the buffer have been sent, the procedure appends the DLE and ETX characters and (only with 3964R) the block checksum BCC as the end identifier, and then waits for an acknowledgment character. If the communication partner sends the DLE characters within the acknowledgment delay time, the data block has been received without errors. If the communication partner responds with NAK, any other character (except DLE), or with a corrupted character, or if the acknowledgment delay time expires without a response, the procedure restarts sending with the connection setup STX.

After the configured number of attempts to send, the procedure stops the process and sends an NAK to the communication partner. The communication module outputs a corresponding error message.

4.4.6 Receiving data with 3964(R)

Connection setup for receiving

In idle state, when there is no send job to be processed, the procedure waits for the communication partner to set up the connection.

A wait time is started (wait time = acknowledgment delay time - 10 ms, however, maximum of 400 ms) if no free receive buffer is available during the connection setup with STX. An error message is generated if no free receive buffer is available on expiration of this time. The procedure sends the NAK character and returns to the idle state. Otherwise, the procedure sends a DLE and receives the data as described above.

The acknowledgment delay time should be set to the same value at both communication partners.

If the procedure receives any character (except for STX or NAK) while in idle state, it waits for the character delay time (CDT) to expire and then sends the NAK character. The communication module outputs a corresponding error message.

Receiving data

After a successful connection establishment, the incoming receive characters are saved to the receive buffer. If two consecutive DLE characters are received, only one of these is saved to the receive buffer.

After connection has been established and after each receive character, the procedure waits for the next character during the character delay time. If this period expires before another character is received, an NAK is sent to the communication partner. The communication module outputs a corresponding error message. A retry is then expected.

If transmission errors occur during receiving (frame errors, parity errors, etc.), the procedure continues to receive data until the connection is terminated and then sends an NAK to the communication partner. A retry is then expected. If the block still cannot be received without errors after the specified number of transfer attempts, or if the communication partner does not start the retry within a block wait time of 4 seconds, the procedure cancels the receive operation. The communication module reports the first corrupted transfer and the final cancelation.

Connection setup for receiving

If the 3964 procedure detects a DLE ETX string, it terminates the receive operation and confirms a successfully received block by sending a DLE to the communication partner. In the case of a receive error, an NAK is sent to the communication partner. A retry is then expected.

The 3964R procedure terminates the receive operation after having detected the DLE ETX BCC string. It compares the received block check character BCC with the internally calculated longitudinal parity. If the BCC is correct and no other receive errors have occurred, the 3964R procedure sends a DLE and returns to the idle state. The communication module informs the control system that new receive data is available.

If the BCC is faulty or a different receive error occurs, an NAK is sent to the communication partner. A retry is then expected.

4.5 Communication through Modbus RTU

4.5.1 Procedure for establishing a serial connection with Modbus RTU

Requirements

- The hardware is set up and there is an electrical connection to the link partner.
- The project has been created in STEP 7 (TIA Portal) and the CPU has been inserted into the hardware configuration.

Procedure - Hardware configuration

1. Insert the CM PtP communications module into the hardware configuration.
2. Select the Freeport/Modbus protocol.

   Note: With Modbus RTU, most communication parameters are set using the Modbus_Comm_Load instruction during CPU start.
3. Based on the telegram length, decide whether you want to activate the "Performance optimized for many short frames" parameter.

Procedure - Programming

1. Create the data structure that is to include the data to be transferred.
2. Integrate the Modbus_Comm_Load instruction into the cyclic sequence for parameter assignment of the communications module.
3. Interconnect the HWID from the system tags at the PORT input.
4. Call the instruction until successful execution is displayed at the DONE output. Do not call the instruction again thereafter unless you want to change the communication parameters.

Operation as Modbus master:

1. Insert the Modbus_Master instruction from the MODBUS (RTU) library:
2. Interconnect the data structure with the data to be sent at the DATA_PTR input.
3. Interconnect the instance DB of the Modbus_Master instruction at the MB_DB input of the Modbus_Comm_Load.

   Note: During operation, each positive edge at the REQ input will process the specified job once. The block must be called until DONE indicates that the data was transferred to the module.

   In case of an error, setting ERROR once and displaying the corresponding information in STATUS indicates that the data was not transferred.

Operation as Modbus slave:

1. Insert the Modbus_Slave instruction from the MODBUS (RTU) library**.**
2. Interconnect the data structure with the Modbus hold registers.
3. Enter the Modbus slave address at the MB_ADDR input.
4. Interconnect the instance DB of the Modbus_Slave instruction at the MB_DB input of the Modbus_Comm_Load.

   Note: A high level at the NDR output during operation indicates that new data was received and stored in the specified data area.

4.5.2 Overview of modbus communication

Modbus RTU communication

Modbus RTU (Remote Terminal Unit) is a standard protocol for communication in the network and uses the electrical RS232 or RS422/485 connection for serial data transmission between Modbus devices in the network.

Modbus RTU uses a master/slave network in which the entire communication is triggered by only one master device while the slaves can only respond to the request of the master. The master sends a request to a slave address and only this slave address responds to the command (exception: broadcast frames to slave address 0 which are not acknowledged by the slaves).

The procedure used is a code-transparent, asynchronous half-duplex procedure. Data transmission is carried out without handshake.

Position in the system environment

The following Modbus description relates to the use of the following communications modules:

- CM PtP RS232 HF
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

Function of the coupling

With the corresponding communications modules and the related instructions, you can establish a communication connection between a remote Modbus control system and a SIMATIC S7.

The MODBUS protocol in RTU format is used for the transmission.

Function codes 01, 02, 03, 04, 05, 06, 08, 15 and 16 are used for communication between a communications module operated as a Modbus slave and a master system (see Function Codes (Page 56)).

If a SIMATIC S7 communications module is operated as a Modbus master, function codes 11 and 12 are also available.

SIMATIC S7 as a Modbus slave

The master has the initiative for transmission, the communications module works as a slave.

Frame traffic from slave to slave is not possible.

The instruction Modbus_Slave makes the data available on a SIMATIC data area in accordance with the mapping specification or stores them.

SIMATIC S7 as a Modbus master

As master, the communications module initiates transmission and, after outputting a request frame, it waits for the configured response monitoring time for a response frame from the slave. If the slave does not respond, the master repeats the request in accordance with the configuration before it outputs an error message.

frame structure

The data exchange "Master-Slave" and/or "Slave-Master" begins with the **slave address**, followed by the **function code**. The data is then transferred. The structure of the data field depends on the function code used. The CRC check is transmitted at the end of the frame.

ADDRESS	FUNCTION	DATA	CRC-CHECK
Byte/Word	Byte	n byte	2 byte

ADDRESS — Modbus slave address

- Standard address: 1 to 247 (bytes)
- Extended station address: 1 to 65535 (word)

FUNCTION — Modbus Function Codes (Page 56)

DATA — frame data: Management and net data depending on the function code

CRC-CHECK — frame checksum

Slave address

The slave address can be range from 1 to 247 (byte) or 1 to 65535 (word). The address is used to address a defined slave on the bus.

Broadcast Message

The master uses slave address 0 to address all slaves on the bus.

Broadcast messages are only permitted in conjunction with writing Function codes 05, 06, 15 and 16.

A broadcast message is not followed by a response frame from the slave.

Data Field DATA

The data field DATA is used to transfer the function code-specific data such as:

- Bytecount, Coil_Startaddress, Register_Startaddress; Number_of_Coils, Number_of_Registers, ...

  For details, see "Function Codes (Page 56)".

CRC-Check

The end of the frame is identified by means of the CRC 16 checksum consisting of 2 bytes. It is calculated by the following polynominal: $x^{16} + x^{15} + x^2 + 1$.

The low byte is transmitted first, followed by the high byte.

End of frame

The end of frame is recognized when no transmission takes place during the time period required for the transmission of three and a half characters (3.5 times character delay time) (see Modbus Protocol Reference Guide).

This end of frame TIME_OUT therefore depends on the data transmission rate and is indicated in bit times (35 bit times are fix coded internally; further bit times can be configured in addition at the instruction).

The Modbus frame received from the connection partner is evaluated and formally checked after the end of frame TIME_OUT is received.

Exception responses

If an error is detected in the request frame from the master – for example, register address illegal – the slave sets the highest value bit in the function code of the response frame.

This step is followed by transmission of a byte exception code that describes the cause of the error.

A detailed description of the meaning of the above-mentioned parameters is available in the "GOULD MODICON Modbus Protocol" (not part of this documentation).

Exception code frame

The exception code frame from the slave has the following form:

- for example, slave address 5, function code 5, exception code 2

Response frame from the device EXCEPTION_CODE_xx:

05H	Slave address
85H	Function code
02H	Exception code (1...7)
xxH	CRC checksum "Low"
xxH	CRC checksum "High"

On receipt of an exception code frame by the driver, the current job is completed with error.

The following error codes are defined in accordance with the Modbus specification:

Error code	Meaning in accordance with Modbus specification	Cause - Short Description *
1	Illegal function	Illegal function code
2	Illegal data address	Slave has illegal data address
3	Illegal data value	Slave has illegal data value
4	Failure in associated device	Slave has internal error
5	Acknowledge	Function is carried out
6	Busy, Rejected message	Slave is not ready to receive
7	Negative acknowledgement	The function cannot be carried out.
* Check slave for further details.		

RS232 mode

The following communications modules support RS232 mode:

- CM PtP RS232 HF
- CM PtP (ET 200SP)

For more information on RS232 mode, see the chapter RS232 mode (Page 22).

For information on hardware data flow control and on automatic operation of the accompanying signals, refer to the Handshake procedure (Page 32) chapter.

RS422/485 mode

The following communications modules support RS422/485 mode:

- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

For more information on RS422/485 mode, see the chapters RS422 mode (Page 25) and RS485 mode (Page 29).

FAQ

For more information, see the following FAQs in the Siemens Industry Online Support:

- Entry ID 68202723 (https://support.industry.siemens.com/cs/ww/en/view/68202723): Master-slave communication via a CM PtP using the Modbus RTU protocol
- Entry ID 58386780 (https://support.industry.siemens.com/cs/ww/en/view/58386780): Which hardware and software components do you need to implement communication between SIMATIC S7 stations and third-party devices using the MODBUS RTU protocol?

4.5.3 Function Codes

Function codes used without performance optimization option

The function code defines the meaning of the frame. It also defines the structure of a frame.

The following function codes are supported by the communications module:

Function code	Function in accordance with MODBUS specification	Range
01	Read Coil Status	1 to 2000 bit/request
02	Read Input Status	1 to 2000 bit/request
03	Read Holding Registers	1 to 124/125 word/request (124 with extended station address)
04	Read Input Registers	1 to 124/125 word/request (124 with extended station address)
05	Force Single Coil	1 bit/request
06	Preset Single Register	1 word/request
08 *	Loop Back Test	Read slave status or reset event counter in the slave
11 *	Fetch Communications Event Counter (only master)	—
15	Force Multiple Coils	1 to 1968 bits/request
16	Preset Multiple Registers	1 to 123 word/request

* Diagnostics information for slave communication

Modbus function code 00 sends a broadcast message to all slaves (without slave response).

Function codes used with performance optimization option

With the option for performance optimization (Page 38) activated, there are the following restrictions to the configuration limits of the transferred data:

Function code	Function in accordance with MODBUS specification	CM PtP is Modbus master	CM PtP is Modbus slave
01	Read Coil Status	1 to 168/160 bits/request (160 with extended station address)	1 to 216/208 bits/request (208 with extended station address)
02	Read Input Status	1 to 168/160 bits/request (160 with extended station address)	1 to 216/208 bits/request (208 with extended station address)
03	Read Holding Registers	1 to 10 word/request	1 to 13 word/request
04	Read Input Registers	1 to 10 word/request	1 to 13 word/request
05	Force Single Coil	1 bit/request	1 bit/request
06	Preset Single Register	1 word/request	1 word/request
15	Force Multiple Coils	1 to 184/176 bits/request (176 with extended station address)	1 to 136/128 bits/request (128 with extended station address)
16	Preset Multiple Registers	1 to 11 word/request	1 to 8 word/request

Modbus function code 00 sends a broadcast message to all slaves (without slave response).

Assignment of the Modbus addresses to the SIMATIC addresses

The table below shows the assignment of the Modbus addresses to the SIMATIC addresses.

Modbus				S7-1500	
FC [1]	Function	Declaration	Address area	Declaration	CPU address
01	Read bits	Output	1 - 9999	Process image of outputs	A0.0 - A1249.6
02	Read bits	Input	10001 - 19999	Process image of inputs	E0.0 - E1249.6
03 [2]	Read words	Holding Register	40001 - 49999 or 400001 - 465535	DW0 - DW19998 or DW0 - DW131068	The M address area depends on the CPU
04	Read words	Input	30001 - 39999	Process image of inputs	EW0 - EW19996
05 [2]	Write bits	Output	1 - 9999	Process image of outputs	A0.0 - A1248.7
06	Write words	Holding Register	40001 - 49999 or 400001 - 465535	DW0 - DW19998 or DW0 - DW131068	The M address area depends on the CPU
15	Write bits	Output	1 - 9999	Process image of outputs	Q0.0 - Q1249.6
16 [2]	Write words	Holding Register	40001 - 49999 or 400001 - 465535	DW0 - DW19998 or DW0 - DW131068	The M address area depends on the CPU

1) FC = function code

2) The value of the HR_Start_Offset determines whether data areas or bit memory address areas can be addressed with the FCs 03, 05 and 16 in the SIMATIC CPU.

4.6 Communication using USS

4.6.1 Procedure for establishing a serial connection with USS

Requirements

- The hardware is set up and there is an electrical connection to the link partner.
- The project has been created in STEP 7 (TIA Portal) and the CPU has been inserted into the hardware configuration.

Procedure - Hardware configuration

1. Insert the CM PtP communication module into the hardware configuration.
2. Select the Freeport protocol and set the communication parameters.

   Note: The USS functionality is implemented by the instructions.
3. Based on the telegram length, decide whether you want to activate the "Performance optimized for many short frames" parameter.

Procedure - Programming

1. Insert the USS_Port_Scan instruction from the USS Communication library.
2. Interconnect the HWID from the system tags at the PORT input.
3. Insert the USS_Drive_Control instruction from the USS Communication library.
4. Interconnect the USS_DB data structure in the instance DB of the USS_Drive_Control instruction to the USS_DB input of the USS_Port_Scan instruction. The data structure contains the data to be transferred for all drives.
5. Insert an additional call of the USS_Drive_Control instruction for each additional axis that is to be connected via the USS interface.

   Use the same instance DB each time. The distinction takes place with the help of the USS address that you specify at the DRIVE input of the USS_Drive_Control instruction. This means you have access to the control and feedback data at the parameters of the respective call for each drive.

4.6.2 Overview of USS communication

Position in the system environment

The following USS description refers to the use of the corresponding communication modules.

- CM PtP RS232 BA
- CM PtP RS422/485 BA
- CM PtP RS232 HF
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

Introduction

The USS® protocol (Universal Serial Interface Protocol) is a basic serial data transmission protocol designed to meet the requirements of drive technology.

The USS protocol defines an access method based on the master-slave principle for communication via a serial bus. One master and up to 16 drives (slaves) can be connected to the bus. The individual drives are selected by the master using an address character in the frame. A drive can never send anything without first being initiated by the master. Therefore, direct data transmission between individual drives is not possible. Communication functions in half-duplex mode. The master function cannot be transferred.

Drive technology requires specific response times for the control tasks and therefore strict cyclical frame traffic:

The master continuously sends frames (job frames) to the drives and expects a response frame from each addressed drive.

A drive must send a response frame if

- it has a received a frame without errors and
- it was addressed in this frame.

A drive may not send if these conditions are not met or the drive was addressed in the broadcast.

The connection with the respective drives exists for the master once it receives a response frame from the drive after a specified processing time (response delay time).

frame structure

Each frame begins with a start character (STX), followed by the length specification (LGE) and the address byte (ADR). The data field comes after that. The frame ends with the block check character (BCC). The frame length includes the user data (quantity n), the address byte (ADR) and the data verification character (BCC).

STX	LGE	ADR	1	2	...	N	BCC

For single-word (16-bit) data, the high byte is sent first followed by the low byte. Correspondingly, with double-word data the high word is sent first, followed by the low word. The length of a frame is specified in bytes.

Data encryption

The data is encrypted as follows:

- STX: 1 byte, start of text, 02H
- LGE: 1 byte, contains the frame length as a binary number
- ADR: 1 byte, contains the slave address and frame type in binary code
- Data fields: One byte each, content depending on job
- BCC: 1 byte, block check character

Data transmission procedure

The master ensures cyclic data transmission in frames. The master addresses all slave devices one after another with a job frame. The nodes addressed respond with a response frame. In accordance with the master-slave procedure, the slave must send the response frame to the master after it has received the job frame. Only then can the master address the next slave.

Data field in the frame

The data field is divided into two areas: the parameter area (PKW) and the process data area (PZD).

STX	LGE	ADR	Parameter (PKW)	Process data (PZD)	BCC

- **Parameter area** (PKW)

  The PKW area handles parameter transmission between two communication partners (e.g., controller and drive). This involves, for example, reading and writing parameter values and reading parameter descriptions and the associated text. The PKW interface generally contains jobs for operation and display, maintenance and diagnostics.

- **Process data area** (PZD)

  The PZD area consists of signals that are required for automation:

  – Control words and setpoints from the master to the slave

  – Status words and actual values from the slave to the master

  The contents of the parameter area and process data area are defined by the slave drives.

  For additional information on this, refer to the drive documentation.

4.6.3 Overview of functions

Transmission sequence

The instructions process the data transmission cyclically with up to 16 drive slaves. Only one job is active for each drive at any one time.

Performance features:

- Creation of data storage areas for communication, depending on the bus configuration
- Execution and monitoring of PKW jobs
- Monitoring of the complete system and troubleshooting
- Communication with the CPU
- Access to the drive functions
- Reading the drive parameters
- Writing the drive parameters

Programming - communication using instructions 5

5.1 Overview of point-to-point programming

Data exchange using Freeport or 3964(R) communication

You must provide the transmitted data in data blocks in the user program of the associated CPU. A receive buffer is available in the communications module for the receive data. A corresponding data block is set up in the data block.

In the CPU user program, the following instructions transfer data between CPU and communications module:

- Send_P2P
- Receive_P2P

The receive buffer can be deleted with the instruction Receive_Reset.

Dynamic configuration by means of the user program

As an alternative to or in addition to the parameter assignment of the communications module interface described in section Configuring / parameter assignment of a communication module (Page 37), it may be advisable in certain application areas to set up the communication dynamically, i.e., program-controlled by a specific application.

All parameter assignments carried out in the properties dialog of the communications module can also be changed during runtime using one of the following instructions:

- Port_Config
- Send_Config
- Receive_Config
- P3964_Config

Program calls for point-to-point communication - sequence

The figure below shows the function of the point-to-point instructions for communication between the user program and communication partner.

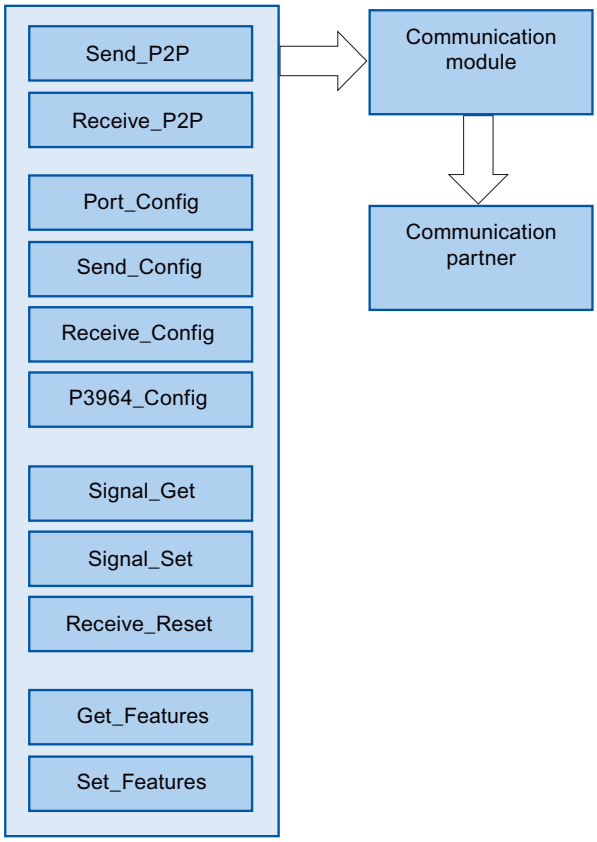

PtP instructions

Application	Instruction	Description
Data exchange between CPU, communications module and communication partner (communication)	Send_P2P (Page 84)	The instruction Send_P2P (send point-to-point data) can be used to send data to the communication partner. Call up the instruction Send_P2P to send data using the Freeport protocol. You have to call the instruction cyclically until you receive a corresponding acknowledgement at the output parameters of the instruction. Note: During parameter assignment of the XON/XOFF data flow control, user data may not contain any of the configured XON or XOFF characters. Default settings are DC1 = 11H for XON and DC3 = 13H for XOFF.
	Receive_P2P (Page 88)	The instruction Receive_P2P (receive point-to-point data) can be used to pick up the messages received in the communications module from a communication partner. Call the Receive_P2P instruction cyclically to receive data using the Freeport protocol. The instruction indicates at the NDR parameter if new received data is available. To signal the start and end of a message transmission, you need to define criteria in the Freeport protocol which identify the start and end of the message.

Application	Instruction	Description
Deletion of the receive buffer	Receive_Reset (Page 90)	The instruction Receive_Reset (delete receive buffer) allows you to clear the receive buffer of the communications module.
Dynamic parameter assignment of the interface or the protocol (optional)	Port_Config (Page 74)	You can use the Port_Config instruction (port configuration) to configure basic interface parameters, such as the data transmission rate, parity and data flow control dynamically through your user program.
	Send_Config (Page 76)	With the instruction Send_Config(send configuration) you can configure serial send parameters, such as RTS ON delay / RTS OFF delay, dynamically for a point-to-point communications interface.
	Receive_Config (Page 78)	The instruction Receive_Config (receive parameter assignment) allows you to dynamically assign serial receive parameters to a communications module. This instruction parameterizes the conditions that characterize the start and end of a received message.
	P3964_Config (Page 83)	The instruction P3964_Config(configure protocol) can be used to dynamically configure protocol parameters of the procedure 3964(R), such as character delay time, priority and block check using your program.
Operation of RS232 accompanying signals	Signal_Get (Page 92)	With the Signal_Get instruction (get RS232 signals) you can read the current states of the RS232 signals.
	Signal_Set (Page 93)	With the Signal_Set instruction (get RS232 signals), you can set the states of the RS232 signals DTR and RTS.
Enable Modbus CRC support and diagnostic interrupt	Get_Features (Page 95)	You can use the instruction Get_Features(get extended functions) to get information on the Modbus support and on generating diagnostic alarms.
	Set_Features (Page 96)	With the Set_Features instruction (set extended functions), if supported by the module, the generation of diagnostic interrupts can be activated.

Procedure for setting up Freeport or 3964(R) communication

Requirement: The configuration and parameter assignment of a CPU and a communications module in the device view and in the properties dialog of the communications module are complete.

1. In the project navigation for the CPU select the folder "Program blocks" and open the Main (OB1) in the folder by double-clicking it. The program editor opens.
2. From the "Instructions" task card, "Communication" area select the instructions Send_P2P and Receive_P2P and drag-and-drop them into a network of the Main (OB1).
3. Configure the instructions in accordance with your specifications.
4. Download the hardware configuration and the user program to the CPU.

5.2 Overview of Modbus programming

Program calls for Modbus communication - sequence

The figure below shows the function of the Modbus instructions for communication between user program and Modbus device. (The instructions Send_P2P, Receive_P2P and the Config instructions are used downstream).

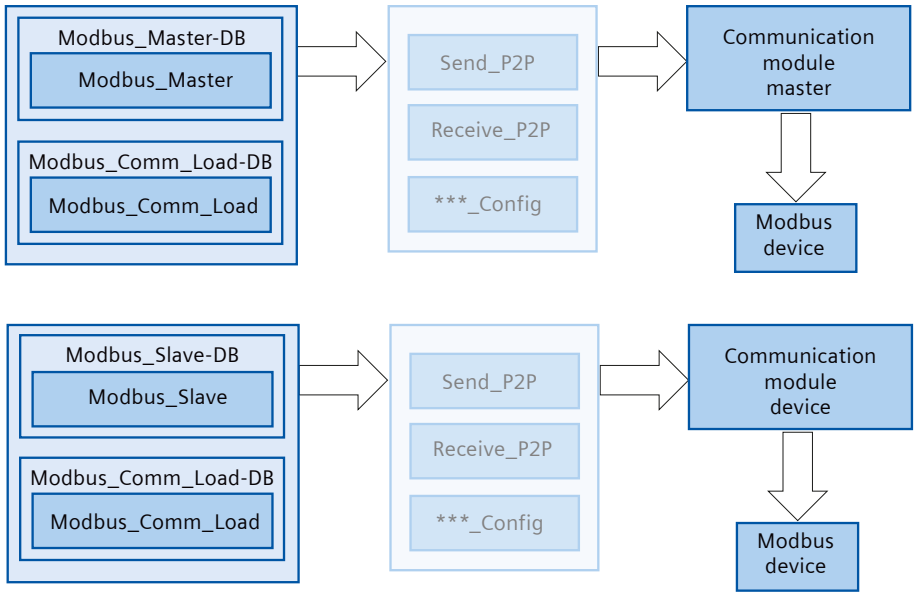

Modbus instructions

Application	Instruction	Description
Data exchange between user program and Modbus device (communication)	Modbus_Master (Page 111)	The Modbus_Master instruction allows you to communicate as Modbus master by means of the PtP port. The CPU can be used as Modbus RTU master device with the Modbus_Master instruction for communication with one or several Modbus slave devices.
	Modbus_Slave (Page 118)	The instruction Modbus_Slave allows you to communicate as Modbus slave by means of the PtP port. The CPU can be used as Modbus RTU slave device with the Modbus_Slave instruction for communication with one Modbus master device.
Parameter assignment of the interface and the protocol (mandatory)	Modbus_Comm_Load (Page 107)	The instruction Modbus_Comm_Load allows you to configure the port of the communication module for Modbus RTU. You have to run Modbus_Comm_Load to set up PtP port parameters, such as data transmission rate, parity and flow control. Once you have configured the interface for the Modbus RTU protocol, it can only be used by the instruction Modbus_Master or the instruction Modbus_Slave .

NOTE

Alternative use of Modbus_Slave and Modbus_Master

A communication module can be operated either as master or as slave.

Procedure for setting up Modbus communication

Requirement: The configuration and parameter assignment of a CPU and a communication module in the device view and in the properties dialog of the communication module are complete.

1. In the project navigation for the CPU select the folder "Program blocks" and open the Main (OB1) in the folder by double-clicking it. The program editor opens.
2. From the "Instructions" task card, "Communication" area select the instructions for Modbus communication in accordance with your task and drag-and-drop them into a network of the Main (OB1):
   - The instruction Modbus_Comm_Load configures the port of the communication module for Modbus communication.

     The Modbus_Comm_Load must be called in Main (OB1) until DONE (or ERROR) is reported.
   - The instruction Modbus_Master is used for the Modbus master functionality.
   - The instruction Modbus_Slave is used for the Modbus slave functionality.
3. Configure the instructions in accordance with your specifications.
4. Download the hardware configuration and the user program to the CPU.

5.3 Overview of USS programming

Program calls for USS communication - sequence

The figure below shows the function of the USS instructions for communication between user program and USS drive. (The instructions Send_P2P, Receive_P2P and the Config instruction are required downstream).

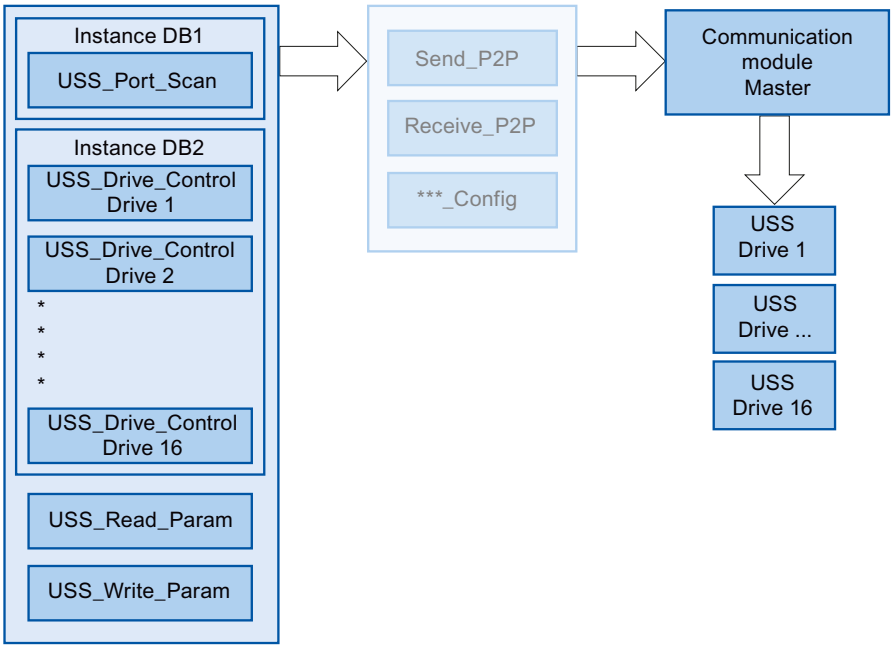

USS instructions

Application	Instruction	Description
Data communication between CPU, communications module and USS drive	USS_Port_Scan (Page 142)	The USS_Port_Scan instruction allows you to communicate via a communications module with up to 16 drives using a USS network (must be called cyclically). The instruction USS_Port_Scan controls the communication between CPU and the drives by means of the PtP communication port. A communication with the drive is processed every time you call this function. The instruction USS_Port_Scan is required once: Since most drives have a configurable internal function that monitors the integrity of communications based on a timeout, you should call the USS_Port_Scan instruction from a time-controlled OB.
Exchange data with USS drive	USS_Drive_Control (Page 145)	The USS_Drive_Control instruction allows you to prepare the send data for a drive and to display the received data. The inputs and outputs of the instruction correspond to the states and operating functions of the drive. The USS_Drive_Control instruction must be called once for each drive. For all calls of the USS_Drive_Control instruction to a USS network, only a common instance DB of the USS_Port_Scan is required. Interconnect all calls of the instructions USS_Drive_Control for a USS network with the same instance DB. The USS_Drive_Control instruction should be called from the cyclic Main (OB1) of the main program.
Read or modify parameters in USS drive	USS_Read_Param (Page 149)	The USS_Read_Param instruction allows you to read parameters from the drive. You use the USS_Read_Param instruction to read the operating parameters of the drive that controls the internal drive functions. The USS_Read_Param instruction should be called from the cyclic Main (OB1) of the main program.
	USS_Write_Param (Page 151)	The USS_Write_Param instruction allows you to change parameters in the drive. The USS_Write_Param instruction should be called from the cyclic main (OB1) of the main program.

Procedure for setting up USS communication

Requirement: The configuration and parameter assignment of a CPU and a communications module in the device view and in the properties dialog of the communications module are complete.

1. In the project tree for the CPU, select the "Program blocks" folder and open the desired time-controlled OB by double-clicking it. The program editor opens.
2. From the "Instructions" task card, "Communication" area select the instruction USS_Port_Scan and drag-and-drop it into a network of a time-controlled OB.

   The instruction USS_Port_Scan allows you to communicate by means of the USS network.
3. In the project navigation for the CPU select the folder "Program blocks" and open the Main (OB1) in the folder by double-clicking it. The program editor opens.

4. From the "Instructions" task card, "Communication" area select the instructions for USS communication in accordance with your task and drag-and-drop them into a network of the Main (OB1):
   - The instruction USS_Drive_Control is used for data exchange with the drive.
   - The instruction USS_Read_Param is used for reading parameters from the drive.
   - The instruction USS_Write_Param is used for changing parameters in the drive.
5. Configure the instructions in accordance with your specifications.
6. Download the hardware configuration and the user program to the CPU.

5.4 Instructions

5.4.1 Point-to-point

5.4.1.1 Overview of Freeport communication

STEP 7 offers extended instructions that can be used for Freeport communication with a protocol specified in the user program. These instructions can be divided into two categories:

- Configuration instructions
- Communication instructions

Data communication

You define the type of data exchange using the "Performance optimized for many short telegrams" parameter of the module in the hardware configuration. It is recommended to use the performance optimization option as long as the maximum length for incoming/outgoing telegrams is not exceeded.

There are two types of data exchange between CPU and communications module:

- Asynchronous data exchange

  The Freeport instructions communicate with the communications module asynchronously (to the application cycle) by reading or writing data sets. Data transmission takes place over several application cycles. The maximum telegram length in accordance with the technical specifications of the module applies.

- Synchronous data exchange (Performance optimization option (Page 38))

  The Freeport instructions communicate with the communications module synchronously with the application cycle via the IO data of the communications module.

  The maximum length for incoming telegrams is 24 bytes and for outgoing telegrams 30 bytes. By using data synchronously with the application cycle, the response time is optimized, especially when you use multiple CM PtPs in parallel.

NOTE

The performance optimization option is available with the PtP Communication instruction library as of V4.0.

Configuration instructions

Before the user program can start the Freeport communication, the communications interface and the parameters for sending and receiving of data must be configured.

The interface configuration and the data configuration can be set for each CM in the device configuration or with the following instructions of your user program:

- Port_Config (Page 74)
- Send_Config (Page 76)
- Receive_Config (Page 78)
- P3964_Config (Page 83)

NOTICE

Device configuration <-> Configuration instructions

The device configuration parameters are transferred to the CM upon each Power On of the CPU (return of voltage).

The parameters of the configuration instructions are transferred to the CM as defined in your user program.

The parameters of the device configuration are not synchronized with the parameters of the configuration instructions, which means the parameters of the configuration instructions are not applied to the CPU device configuration.
With your user program, you determine the parameters that apply in the CM and when they apply.

Communication instructions

The user program uses the instructions for Freeport communication to send data to and receive data from the communications interfaces. The CMs send data to and receive data from the communication stations.

- Send_P2P (Page 84)
- Receive_P2P (Page 88)

NOTE

Data consistency

- If the data to be sent is transmitted consistently, it cannot be changed after the positive edge at the REQ parameter until DONE has been set by the Send_P2P instruction.
- If the receive data is to be read consistently, it may only be evaluated in the cycle in which NDR = TRUE.

The receive buffer can be reset with additional instructions and special RS232 signals can be queried and set.

- Receive_Reset (Page 90)
- Signal_Get (Page 92)
- Signal_Set (Page 93)

The following instructions let you read or write extended functions, as long as these are supported by the module.

- Get_Features (Page 95)
- Set_Features (Page 96)

All Freeport instructions work asynchronously. The instructions must therefore be called until the DONE or NDR output parameter indicates that the execution is complete.

The user program can determine the send and receive status with the help of the query architecture. Send_P2P and Receive_P2P can be run at the same time. The communications modules buffer the send and receive data as required until a module-specific maximum buffer size has been reached.

NOTE

Resolution of bit times

The number of bit times is specified with the configured data transmission rate for different parameters. Specifying the parameter in bit times makes it independent of the data transmission rate. All parameters with unit of bit times can be specified with a maximum number of 65535.

5.4.1.2 Using the instructions

The Freeport instructions must be called cyclically to query received data or the end of transmission for a send process.

Depending on the amount of data and whether the performance optimization option is activated, data transmission can take place over several calls (application cycles).
If the job was executed with DONE = TRUE or NDR = TRUE, the job was executed without errors.

NOTE

Backing up STATUS

The DONE, NDR, ERROR and STATUS parameters are only available for one block cycle. To display the STATUS, you should therefore copy it to a free data area.

Master

Typical sequence for a master:

1. The Send_P2P instruction triggers transmission to the CM.
   Data transmission is initiated by a positive edge at the REQ input.
2. The Send_P2P instruction is executed in subsequent cycles to query the status of the transmission process.
3. When the Send_P2P instruction signals that transmission is complete at the DONE output, the user code can prepare the receipt of the answer.
4. The Receive_P2P instruction is run repeatedly to query an answer. If the CM has acquired response data, the Receive_P2P instruction copies the response to the CPU and signals that new data has been received at the NDR output.
5. The user program can process the response.
6. Back to step 1 and repetition of the sequence.

Slave

Typical sequence for a slave:

1. The user program runs the Receive_P2P instruction in each cycle.
2. If the CM has received a request, the Receive_P2P signals that new data is available at the NDR output and the request is copied to the CPU.
3. The user program processes the request and creates a response.
4. The response is returned to the master with the Send_P2P instruction.
5. The Send_P2P instruction must be run repeatedly to ensure that the send process is actually taking place.
6. Back to step 1 and repetition of the sequence.

The slave must ensure that Receive_P2P is called up often enough so that a transmission can be received by the master before it cancels the process due to a timeout while waiting for the response. To do so, the user program Receive_P2P can be called from within a cycle OB

whose cycle time is sufficiently short so that the master can receive a transmission before the timeout setting expires.

5.4.1.3 General parameters for Freeport operations

Table 3-975 General input parameters of the Freeport instructions

Parameter	Description
REQ	Data transmission is initiated by a positive edge at the REQ input. Another edge at REQ may only be generated after the command has been completed (DONE or ERROR). Data transmission can take several calls (program cycles), depending on the data volume. When you add a Freeport instruction to your program, STEP 7 prompts you to specify the instance DB (or to have STEP 7 create a corresponding instance DB). Use a unique DB for each PtP instruction call.
PORT	A port address is assigned during configuration of the communications module. The PORT parameter communicates assignment to a specific communications module to the instruction. You can select a symbolic name for the standard port after the configuration. The assigned CM port value is the "Hardware ID" property of the device configuration with S7-1200/1500 and the "Input address" with S7-300/400. The symbolic port name is assigned in the symbol table.

The output parameters DONE, NDR, ERROR and STATUS of the Freeport instructions indicate the execution status of the Freeport functions.

Table 3-976 Output parameters DONE, NDR, ERROR and STATUS

Parameter	Data type	Standard	Description
DONE	Bool	FALSE	Set to TRUE for one cycle to indicate that the last request was completed with errors; otherwise FALSE.
UNIVERSAL [1]	Bool	FALSE	Type of data communication between the CPU and the CM specified via PORT: FALSE: Performance optimization option (synchronous) (Page 38) • Receive frames max. 24 bytes • Send frames max. 30 bytes TRUE: Universal (asynchronous) • Limiting the frame length depending on the CM to 1, 2, or 4 KB
NDR	Bool	FALSE	Set to TRUE for one cycle to indicate that new data has been received; otherwise FALSE.
ERROR	Bool	FALSE	Set to TRUE for one cycle to indicate that the last request was completed with errors; the corresponding error code can be found in STATUS; otherwise FALSE.
STATUS	Word	16#0000 or 16#7000	Result status: • If the DONE or NDR bit is set, STATUS is set to 0/16#7000 or to a specific status code. • If the ERROR bit is set, STATUS displays an error code. • If none of the bits listed above is set, the instruction can return status results that describe the current status of the function. The value in STATUS is valid until you call this instruction again (with one and the same port address).

[1] Available as of Library version V4.0

Table 3-977 In/out parameter COM_RST

Parameter	Data type	Standard	Description
COM_RST	Bool	FALSE	Initialization of the instruction The instruction is initialized with TRUE. COM_RST is then set back to FALSE. Note: COM_RST must be set to TRUE when the CPU starts and can no longer be triggered afterwards. COM_RST is reset by the instruction following initialization of the instance DB.

NOTE

Please note that the parameters DONE, NDR, ERROR and STATUS are only set for one cycle.

Table 3-978 Shared error codes

Error code	Description
16#0000	No error
16#7000	Function not active
16#7001	Initial call after request started.
16#7002	Subsequent call after request started.
16#8x3A	Invalid pointer in parameter x

Table 3-979 Shared error classes of the STATUS parameter

Description of the class	Error classes	Description
Port configuration	16#81Ax	For the description of frequent errors in the interface configuration
Send configuration	16#81Bx	For the description of errors in the send configuration
Receive configuration	16#81Cx	For the description of errors in the receive configuration
Sending	16#81Dx	For the description of runtime errors during sending
Receiving	16#81Ex	For the description of runtime errors during receiving
RS232 accompanying signals	16#81Fx	For the description of errors in connection with signal processing

5.4.1.4 Port_Config: Configure PtP communication port

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Port_Config instruction (port configuration) allows you to change parameters such as the data transmission rate in runtime using your program. The data pending in the CM is deleted with the execution of Port_Config.

Configuration changes of Port_Config are saved on the CM and not in the CPU. When the voltage returns, the CM is configured with the data saved in the device configuration.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the transmission of data to the CM upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communications module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • for S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems, the input address assigned in the hardware configuration is assigned to the PORT parameter.
PROTOCOL	IN	UInt	Word	0	Protocol • 0 = Freeport protocol • 1 = Protocol 3964(R)
BAUD	IN	UInt	Word	6	Data transmission rate of the port: • 1 = 300 bps • 2 = 600 bps • 3 = 1200 bps • 4 = 2400 bps • 5 = 4800 bps • 6 = 9600 bps • 7 = 19200 bps • 8 = 38400 bps

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
					• 9 = 57600 bps • 10 = 76800 bps • 11 = 115200 bps • 12 = 250000 bits/s
PARITY	IN	UInt	Word	1	Parity of the port: • 1 = no parity • 2 = even parity • 3 = odd parity • 4 = mark parity • 5 = space parity • 6 = any
DATABITS	IN	UInt	Word	1	Bits per character: • 1 = 8 data bits • 2 = 7 data bits
STOPBITS	IN	UInt	Word	1	Stop bits: • 1 = 1 stop bit • 2 = 2 stop bits
FLOWCTRL	IN	UInt	Word	1	Flow control: • 1 = no flow control • 2 = XON/XOFF • 3 = Hardware RTS always ON • 4 = Hardware RTS switched • 5 = Hardware RTS always ON, ignore DTR/DSR
XONCHAR	IN	Char		16#0011	Specifies the character that serves as XON character. It is typically a DC1 character (11H). This parameter is only evaluated when software flow control is active.
XOFFCHAR	IN	Char		16#0013	Specifies the character that serves as XOFF character. It is typically a DC3 character (13H). This parameter is only evaluated when software flow control is active.
WAITIME	IN	UInt	Word	2000	Specifies how long to wait for an XON character after receipt of an XOFF character or how long to wait for a CTS = ON signal after CTS = OFF (0 to 65535 ms). This parameter is only evaluated when flow control is active.
MODE	IN	USInt	Byte	0	Operating mode Valid operating modes are: • 0 = Full duplex (RS232) • 1 = Full duplex (RS422) four-wire mode (point-to-point) • 2 = Full duplex (RS 422) four-wire mode (multipoint master; CM PtP (ET 200SP)) • 3 = Full duplex (RS 422) four-wire mode (multipoint slave; CM PtP (ET 200SP)) • 4 = Half duplex (RS485) two-wire mode [1]

[1] Required setting for the use of PROFIBUS cables with CM 1241 for RS485

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
LINE_PRE	IN	USInt	Byte	0	Receive line initial state Valid initial states are: • 0 = "No" initial state [1)] • 1 = signal R(A)=5 V, signal R(B)=0 V (break detection): Break detection is possible with this initial state. Can only be selected with: "Full duplex (RS422) four-wire mode (point-to-point connection)" and "Full duplex (RS422) four-wire mode (multipoint slave)". • 2 = signal R(A)=0 V, signal R(B)=5 V: This default setting corresponds to the idle state (no active send operation). No break detection is possible with this initial state.
BRK_DET	IN	USInt	Byte	0	Break detection The following settings are permitted: • 0 = break detection deactivated • 1 = break detection activated
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

1) Required setting for the use of PROFIBUS cables with CM 1241 for RS485

More information about the general parameters is available at "General parameters for Freeport operations (Page 72)".

5.4.1.5 Send_Config: Configure PtP sender

NOTE

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Send_Config instruction (send configuration) allows you to change send parameters in runtime using your program (conditions that identify the start and the end of the data to be sent). Any data pending in a CM is deleted when Send_Config is executed.

Configuration changes of Send_Config are saved on the CM and not in the CPU. The parameters saved in the device configuration are restored once the voltage returns to the CPU or the communications module.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Activates the configuration change upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communications module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • for S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems, the input address assigned in the hardware configuration is assigned to the PORT parameter.
RTSONDLY	IN	UInt	Word	0	Number of milliseconds to wait after activation of RTS before a transmission of send data is started. This parameter is only valid if the hardware flow control is active. The valid range is 0 to 65535 ms. The value 0 deactivates the function.
RTSOFFDLY	IN	UInt	Word	0	Number of milliseconds to wait after transmission of send data before RTS is deactivated: This parameter is only valid if the hardware flow control is active. The valid range is 0 to 65535 ms. The value 0 deactivates the function.
BREAK	IN	UInt	Word	0	This parameter specifies that a BREAK is to be sent at the start of each frame for the specified number of bit times. The maximum is 65535 bit times. The value 0 deactivates the function.
IDLELINE	IN	UInt	Word	0	This parameter specifies that the line is to remain in idle for the specified number of bit times prior to the start of each frame. The maximum is 65535 bit times. The value 0 deactivates the function.
USR_END	IN	STRING[2]		0	Input of end delimiters. No more than 2 end delimiters can be configured. It is sent including the end-of-text character(s).
APP_END	IN	STRING[5]		0	Input of characters to be appended. You can append up to 5 characters.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

More information about the general parameters is available at "General parameters for Freeport operations (Page 72)".

5.4.1.6 Receive_Config: Configure PtP recipient

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Receive_Config instruction (receive configuration) allows you to change receive parameters in runtime using your program. This instruction configures the conditions that mark the start and the end of received data. Any data pending in a CM is deleted when Receive_Config is executed.

Configuration changes of Receive_Config are saved **non-retentive** on the CM. The parameters saved in the device configuration are restored once the voltage returns to the CPU or the communications module. The Receive_Config instruction therefore must be called again from the user program when the voltage returns to the CPU or to the communications module in order to overwrite the parameters stored in the device configuration.

Parameter

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Activates the configuration change upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communications module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • for S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems, the input address assigned in the hardware configuration is assigned to the PORT parameter.
RECEIVE_CONDITIONS	IN	Variant	Any	-	The data structure of Receive_Conditions specifies the start and end conditions used to identify the start and end of a frame.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

More information about the general parameters is available at "General parameters for Freeport operations (Page 72)".

Start conditions for the Receive_P2P instruction

The Receive_P2P instruction uses the configuration specified in the device configuration or by the Receive_Config instruction to determine the start and end of Freeport communication frames. The start of the frame is defined by the start conditions. The start of the frame can be determined with one or several start conditions.
If Break as well as Idle Line is activated, Break must be met first and then Idle Line as well. After that, one of the other conditions (start character or start sequence) is sufficient to start data transmission.
The start condition "Any character" cannot be combined with other start conditions.

Data type structure of the Receive_Conditions parameter, part 1 (start conditions)

Table 3-980 Structure of Receive_Conditions for start conditions

Parameter	Declaration	Data type	Default	Description
START.STARTCOND	IN	Word	16#0002	Specifying the start condition • 01H - detection of the start character • 02H - Any character • 04H - detection of a line break • 08H - detection of an idle line • 10H - detection of start sequence 1 • 20H - detection of start sequence 2 • 40H - detection of start sequence 3 • 80H - detection of start sequence 4 The start conditions can be combined by adding the values together.
START.IDLETIME	IN	Word	16#0028	The number of bit times required in the idle state for a new frame start to be detected (default value: W#16#28). Only in connection with the condition "Detection of an idle line". 0 to FFFF
START.STARTCHAR	IN	Byte	16#0002	The start character for the condition "Start character". (default value: B#16#2)

Parameter	Declaration	Data type	Default	Description
START.SEQ[1].CTL	IN	Byte	0	Start sequence 1, deactivate/activate comparison for each character: (default value: B#16#0) These are the activation bits for each character of the start character string. • 01H - character 1 • 02H - character 2 • 04H - character 3 • 08H - character 4 • 10H - character 5 When a bit is deactivated for a specific character, this means that each character in this position in the character string represents a valid start character string (e.g. 1FH = all 5 characters interpreted).
START.SEQ[1].STR[1] .. START.SEQ[1].STR.[5]	IN	Char[5]	0	Start sequence 1, start character (5 characters)
START.SEQ[2].CTL	IN	Byte	0	Start sequence 2, deactivate/activate comparison for each character. Default value: B#16#0)
START.SEQ[2].STR[1] .. START.SEQ[2].STR.[5]	IN	Char[5]	0	Start sequence 2, start character (5 characters)
START.SEQ[3].CTL	IN	Byte	0	Start sequence 3, deactivate/activate comparison for each character. Default value: B#16#0
START.SEQ[3].STR[1] .. START.SEQ[3].STR.[5]	IN	Char[5]	0	Start sequence 3, start character (5 characters)
START.SEQ[4].CTL	IN	Byte	0	Start sequence 4, deactivate/activate comparison for each character. Default value: B#16#0
START.SEQ[4].STR[1] .. START.SEQ[4].STR.[5]	IN	Char[5]	0	Start sequence 4, start character (5 characters)

Example

Have a look at the following received data in hexadecimal coding: "**68** 10 aa **68** bb 10 aa 16". The configured start character strings are available in the following table. Start character strings are evaluated once the first character 68H has been successfully received. After the fourth character has been successfully received (the second 68H), start condition 1 has been met. Once the start conditions have been met, the evaluation of the end conditions starts.

Processing of the start character string can be canceled due to different errors in parity, framing or time intervals between characters. These errors prevent receipt of the data because the start condition has not been met (an error message is output).

Table 3-981 Start conditions

Start condition	First character	First character +1	First character +2	First character +3	First character +4
1	**68**H	xx	xx	**68**H	xx
2	10H	aaH	xx	xx	xx
3	dcH	aaH	xx	xx	xx
4	e5H	xx	xx	xx	xx

End conditions for the Receive_P2P instruction

The end of a frame is defined by the first occurrence of one or more configured end conditions.

You can configure the end conditions either in the properties of the communications interface in the device configuration, or with the Receive_Config instruction. The receive parameters (start and end conditions) are reset to the settings in the device configuration each time the voltage returns to the CPU or the communications module. When the STEP 7 user program executes Receive_Config, the settings are set to the parameters of Receive_Config .

Data type structure of the Receive_Conditions parameter, part 2 (end conditions)

Table 3-982 Structure of Receive_Conditions for end conditions

Parameter	Declaration	Data type	Default	Description
END.ENDCOND	IN	Word	0	This parameter specifies the condition for the frame end: • 01H - response timeout • 02H - message timeout • 04H - character delay time • 08H - maximum frame length • 10H - read message length from message (N+LEN+M) • 20H - end sequence • 40H - fixed frame length
END.FIXLEN	IN	Word	1	Fixed frame length: Only used if the end condition "Fixed frame length" has been selected. 1 to 4000 bytes (up to 4 KB depending on the module)
END.MAXLEN	IN	Word	1	Maximum frame length: Only used if the end condition "Maximum frame length" has been selected. 1 to 4000 bytes (up to 4 KB depending on the module)
END.N	IN	Word	0	Byte position of the length field in the frame. Only used with end condition N+LEN+M. 1 to 4000 bytes (up to 4 KB depending on the module)
END.LENGTHSIZE	IN	Word	0	Size of the length field (1, 2, or 4 bytes). Only used with end condition N+LEN+M.

Parameter	Declaration	Data type	Default	Description
END.LENGTHM	IN	Word	0	Number of characters after the length field that are not included in the value of the length field. This entry is only used with end condition N+LEN+M. 0 to 255 bytes
END.RCVTIME	IN	Word	200	Specify the wait time for the first received character after a frame has been sent. The receive instruction is terminated with an error message if a character is not received within the specified time. This information is used only with the condition "Response timeout". (0 to 65535 ms). Note: This parameter cannot be used as sole end criterion but only in connection with at least one other end condition.
END.MSGTIME	IN	Word	200	Specify how long to wait for receipt of the complete frame after receipt of the first character. This parameter is used only if the condition "Message timeout" is selected. (0 to 65535 ms)
END.CHARGAP	IN	Word	12	Enter the maximum number of bit times between characters. If the number of bit times between characters exceeds the specified value, the end condition has been met. This information is used only with the condition "Character delay time". (0 to 65535 bit times) Note: For higher data transfer speeds, a value of at least 100 bit times is recommended.
END.SEQ.CTL	IN	Byte	0	End delimiter sequence 1, deactivate/activate comparison for each character: These are the activation bits for each character of the end character string. Character 1 is bit 0, character 2 is bit 1, ..., character 5 is bit 4. If a bit is deactivated for a specific character, this means that each character represents a congruence at this position of the character string. **Note:** Note the sequence when checking characters: If *one* end delimiter is to be used, the entry must be made in character 5 (END.SEQ.STR[5]) and only this character must be activated in END.SEQ.CTL. If *two* end delimiters are to be used, the entry must be made in END.SEQ.STR[5] and END.SEQ.STR[4] and only these characters must be activated in END.SEQ.CTL. The same applies to the use of additional characters.
END.SEQ.STR[1] .. END.SEQ.STR[5]	IN	Char[5]	0	End delimiter string 1, start character (5 characters)

Table 3-983 General parameters of the Receive_P2P instruction

Parameter	Declaration	Data type	Default	Description
GENERAL. MBUF_SIZE	IN	Byte	255	Input number of frames that are to be buffered in the receive buffer of the CM. If no other conditions are active that influence the reaction of the receive buffer (prevent timeout, data flow control), additional frames are discarded once the limit has been reached. (1 to 255 frames)
GENERAL. OW_PROT	IN	Byte	0	Activates the no overwriting function of the buffered frame if the CM receives a new frame and the receive buffer of the CM was not yet read. This step prevents already buffered received frames from being lost. • 0 - not activated • 1 - activated

Parameter	Declaration	Data type	Default	Description
GENERAL. CLR_MBUF	IN	Byte	0	Activates deletion of the receive buffer during CPU startup. The receive buffer is automatically deleted when the CPU switches from STOP to RUN. The receive buffer only contains frames received after CPU startup. • 0 - not activated • 1 - activated

5.4.1.7 P3964_Config: Configuring the 3964(R) protocol

NOTE

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The P3964_Config instruction (protocol configuration) allows you to change protocol parameters for 3964(R), such as character delay time, priority and block check, in runtime using your program.

Configuration changes of P3964_Config are saved on the CM and not in the CPU. The parameters saved in the device configuration are restored once the voltage returns to the CPU or the communications module.

Parameter

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the instruction upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communications module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • for S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems, the input address assigned in the hardware configuration is assigned to the PORT parameter.
BCC	IN	USInt	Byte	1	Activates/deactivates the use of the block check • 0 = without block check • 1 = with block check

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
Priority	IN	USInt	Byte	1	Selection of the priority • 0 = low priority • 1 = high priority
CharacterDelay-Time	IN	UInt	Word	16#00DC	Setting the character delay time (depending on the set data transmission rate) (default value: 220 ms) 1 ms to 65535 ms
AcknDelayTime	IN	UInt	Word	16#07D0	Setting the acknowledgment delay time (depending on the set data transmission rate) (default value: 2000 ms) 1 ms to 65535 ms
BuildupAttempts	IN	USInt	Byte	16#0006	Setting the number of connection attempts (default value: 6 connection attempts) 1 to 255
RepetitionAt-tempts	IN	USInt	Byte	16#0006	Setting the number of transmission attempts (default value: 6 connection attempts) 1 to 255
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

More information about the general parameters is available at "General parameters for Freeport operations (Page 72)".

5.4.1.8 Send_P2P: Sending data

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Send_P2P instruction (send point-to-point data) starts the transmission of data and transmits the contents of the assigned buffer to the communications module. The CPU program is still being executed while the CM sends the data with the data transmission rate. Only one send instruction per communications module may be pending at any time. The CM signals an error if a second Send_P2P instruction is executed while the CM is already sending a frame.

Parameter

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the transmission of data to the CM upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communications module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • for S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems, the input address assigned in the hardware configuration is assigned to the PORT parameter.
BUFFER	IN	Variant	Any	0	This parameter points to the memory area of the send buffer. **Notes:** • Boolean data and Boolean fields are not supported. • If the send buffer is in the optimized memory area, the maximum permitted length of the sent data is 1024 bytes. Exception: Arrays of Byte, Word or DWord are supported up to a length of 4096 bytes. • If the send buffer is a String or WString, the content of the string is transferred without the current and maximum length. More information under "Using the BUFFER and LENGTH parameters for communication operations (Page 87)"
LENGTH	IN	UInt	Word	0	Length in bytes of the data to be transferred. The memory area addressed in the BUFFER parameter is completely transmitted with LENGTH = 0. More information under "Using the BUFFER and LENGTH parameters for communication operations (Page 87)"
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Send_P2P instruction The instruction is initialized with 1. The instruction then resets COM_RST to 0. Note: The parameter is only available for S7-300/400 instructions.

[1] Available as of Library version V4.0

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
UNIVERSAL [1]	OUT	Bool	---	FALSE	Type of data communication between the CPU and the CM specified via PORT: FALSE: Performance optimization option (synchronous) (Page 38) • Receive frames max. 24 bytes • Send frames max. 30 bytes TRUE: Universal (asynchronous) • Limiting the frame length depending on the CM to 1, 2, or 4 KB
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

[1] Available as of Library version V4.0

More information about the general parameters is available at "General parameters for Freeport operations (Page 72)".

Parameter

The DONE and ERROR outputs are in FALSE status when a send instruction is being processed. At the end of the send instruction, one of the DONE or ERROR outputs is set to TRUE for one cycle to signal the status of the send instruction. The error code at the STATUS output can be evaluated when the status of ERROR is TRUE.

The instruction outputs the status 16#7001 when the communications interface accepts the send data. Subsequent executions of Send_P2P output the value 16#7002 if the CM is still sending. At the end of the send instruction, the CM outputs the status 16#0000 for the send instruction (if no error has occurred). Subsequent executions of Send_P2P with REQ = 0 output the status 16#7000 (free).

The diagram below shows the relationship between the output values and REQ. It is based on the assumption that the instruction is called cyclically to check the status of the send process (indicated by the STATUS values).

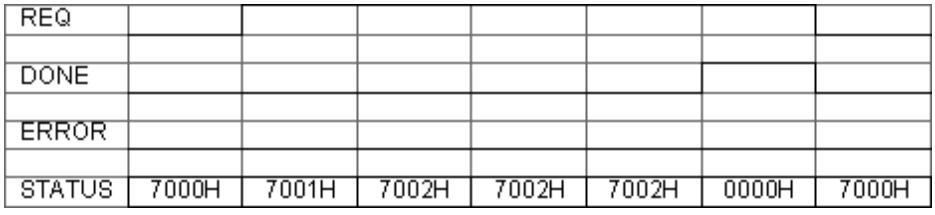

The figure below shows how the DONE and STATUS parameters are only valid for one cycle if a pulse is pending at the REQ line (for one cycle) to trigger the send instruction.

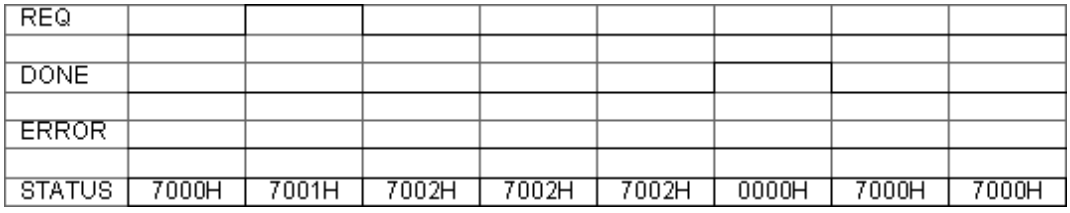

The figure below shows the relationship of the DONE, ERROR and STATUS parameters in case of an error.

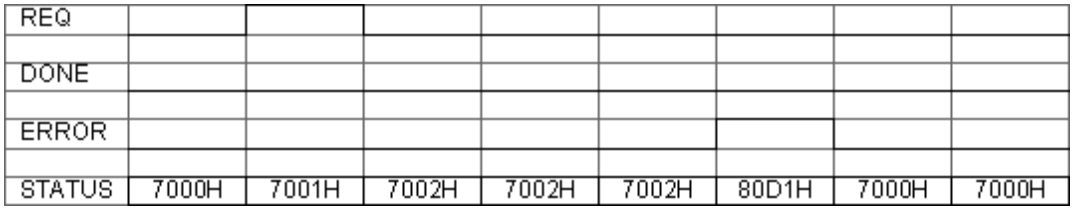

The DONE, ERROR and STATUS values are only valid until Send_P2P is executed again with the same instance DB.

5.4.1.9 Using the BUFFER and LENGTH parameters for communication operations

Interaction of BUFFER and LENGTH parameters for Send_P2P

The minimum data size sent by the Send_P2P instruction is one byte.

The BUFFER parameter specifies the size of the data to be sent if a "0" is passed at the LENGTH parameter during call. The specification of a tag is sufficient for this.

You cannot use the data type Bool or arrays of the Bool type for the BUFFER parameter. If large amounts of data are being transferred we recommend the mapping to the array or structure data types.

Table 3-984 BUFFER parameter

BUFFER	Description
Elementary data type	When sending: The LENGTH value must include the byte size of this data type. Example: For a Word value, the LENGTH must be two. For a DWord value or Real value, the LENGTH must be four.
Structure	If the option for performance optimization is not activated: • For optimized memory: The maximum permissible length of the BUFFER is 1024 Byte; otherwise 4 KB are permitted depending on the module. • When transmitting, the following applies: The LENGTH value can include a byte size smaller than the complete byte length of the structure; in this case, only the first LENGTH bytes of the structure from BUFFER are sent. If the option for performance optimization is activated: • The maximum permitted length of the BUFFER is 30 bytes.

BUFFER	Description
Array	For optimized memory: If the array data type is not equal to Byte, Word or DWord, the maximum permitted buffer length is 1024 bytes. Depending on the data structure, up to 4 KB can be transmitted if the memory is not optimized, independent of the data structure. For sending: The LENGTH value can include a byte size smaller than the complete byte length of the array, whereby, this byte size is a multiple of the byte size of the data element. Example: The LENGTH parameter of an array of the Word type must be a multiple of two and a multiple of four for an array of the Real type. If BUFFER includes an array with 15 DWord elements (a total of 60 bytes), for example, and you specify LENGTH = 20, the first five DWord elements from the array are transmitted. If LENGTH is not specified or has the value 0, the entire array is transmitted.
String	The LENGTH parameter includes the number or characters to be sent. Only the characters of the String are transmitted. The bytes with the maximum and actual length of the String are not sent.

Table 3-985 LENGTH parameter

LENGTH	Description
= 0	The complete content of the memory area specified by BUFFER is transferred. If BUFFER points to a string, the entire content of the string is transferred, without the bytes with the maximum and actual length.
> 0	The content up to the configured length of the memory area specified by BUFFER is transferred.

5.4.1.10 Receive_P2P: Receiving data

NOTE

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Receive_P2P instruction (receive data using point-to-point communication) checks the frames received in the CM. If a frame is available, it is transmitted from the CM to the CPU. A receive error is indicated at the STATUS parameter.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
PORT	IN	PORT (UInt)	Word	0	Specifies the communications module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • for S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems, the input address assigned in the hardware configuration is assigned to the PORT parameter.
BUFFER	IN	Variant	Any	0	This parameter points to the start address of the receive buffer. This buffer must be large enough to receive the maximum frame length. **Note:** • Boolean data or Boolean fields are not supported. • If the receive buffer is in the optimized memory area, the maximum permitted length of the received data is 1024 bytes. Exception: Arrays of Byte, Word or DWord are supported up to a length of 4096 bytes. • If the receive buffer is a String or WString, the received data is written to the content of the string and the current length of the string is set accordingly. More information under "Using the BUFFER and LENGTH parameters for communication operations (Page 87)"
UNIVERSAL [1]	OUT	Bool	---	FALSE	Type of data communication between the CPU and the CM specified via PORT: FALSE: Performance optimization option (synchronous) (Page 38) • Receive frames max. 24 bytes • Send frames max. 30 bytes TRUE: Universal (asynchronous) • Limiting the frame length depending on the CM to 1, 2, or 4 KB
NDR	OUT	Bool		FALSE	TRUE for one cycle if new data is available and the instruction has been completed without errors.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.

[1] Available as of library version V4.0

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
ERROR	OUT	Bool		FALSE	TRUE for one cycle once the instruction has been completed with an error.
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))
LENGTH	OUT	UInt	Word	0	Length of the frame received in bytes More information under "Using the BUFFER and LENGTH parameters for communication operations (Page 87)".

1) Available as of library version V4.0

More information about the general parameters is available at "General parameters for Freeport operations (Page 72)".

The error code at the STATUS output can be evaluated if the status of ERROR is TRUE. The STATUS value provides the reason for terminating the receive operation in the CM.
This is usually a positive value which indicates that the receive operation has been successful and the frame criterion that has been detected.
If the STATUS value is negative (the most significant bit of the hexadecimal value is set), the receive operation was terminated due to an error condition, such as a parity, framing or overflow error.

Each communications module can buffer a module-specific number for frames. If several frames are available in the CM, the Receive_P2P instruction outputs the oldest available frame (FIFO).

5.4.1.11 Receive_Reset: Clear receive buffer

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Receive_Reset instruction (reset receiver) clears the receive buffer in the CM.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the transmission of data to the CM upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communications module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • for S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems, the input address assigned in the hardware configuration is assigned to the PORT parameter.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
DONE	OUT	Bool		FALSE	TRUE for one cycle means that the last request was completed without errors.
ERROR	OUT	Bool		FALSE	TRUE means that the last request was completed with errors. If this output is TRUE, the STATUS output contains the corresponding error codes.
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

More information about the general parameters is available at "General parameters for Freeport operations (Page 72)".

5.4.1.12 Signal_Get: Read status

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Signal_Get instruction (get RS232 signals) reads the current states of the RS232 accompanying signals and displays them at the corresponding instruction outputs.

NOTE
Restriction
- This instruction can only be used with CMs RS232 BA and RS232 HF.
- If RS232C is set for the operating mode, this instruction can also be used with CM PtP (ET200SP).

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the transmission of data to the CM upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communications module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • for S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems, the input address assigned in the hardware configuration is assigned to the PORT parameter.
NDR	OUT	Bool		FALSE	TRUE for one cycle if the RS232 accompanying signals have been read and the instruction has been completed without errors.
ERROR	OUT	Bool		FALSE	TRUE for one cycle once the instruction has been completed with an error
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))
DTR	OUT	Bool		FALSE	Data device ready, module ready (output)
DSR	OUT	Bool		FALSE	Data device ready, communication station ready (input)

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
RTS	OUT	Bool		FALSE	Send request, module ready to send (output)
CTS	OUT	Bool		FALSE	Ready to send, communication station can receive data (input)
DCD	OUT	Bool		FALSE	Data carrier signal detected, signal level received
RING	OUT	Bool		FALSE	Call display, signaling incoming call

More information about the general parameters is available at "General parameters for Freeport operations (Page 72)".

5.4.1.13 Signal_Set: Set accompanying signals

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Signal_Set instruction (set RS232 signals) allows you to set the RS232 communication signals.

NOTE
Restrictions
- This instruction can only be used with CMs RS232 BA and RS232 HF.
- If RS232C is set for the operating mode, this instruction can also be used with CM PtP (ET200SP).

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the instruction upon a positive edge of this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communications module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • for S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems, the input address assigned in the hardware configuration is assigned to the PORT parameter.
SIGNAL	IN	Byte		0	Selection of the signal to be set (more than one possible): • 01H = RTS • 02H = DTR • 04H = DSR (for interface type DCE only)
RTS	IN	Bool		FALSE	Send request, module ready to send Set this value at the output (TRUE or FALSE), default value: FALSE
DTR	IN	Bool		FALSE	Data terminal ready, module ready Set this value at the output (TRUE or FALSE), default value: FALSE
DSR	IN	Bool		FALSE	Data terminal ready (for DCE interface type only), not used.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

More information about the general parameters is available at "General parameters for Freeport operations (Page 72)".

5.4.1.14 Get_Features: Get extended functions

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

If supported by the module, you can use the Get_Features instruction (get extended functions) to get information on the ability of the module to support CRC and to generate diagnostic messages.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the instruction upon a positive edge of this input.
PORT	IN	PORT	Word	0	Specifies the communications module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • for S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems, the input address assigned in the hardware configuration is assigned to the PORT parameter.
NDR	OUT	Bool		FALSE	TRUE for one cycle if new data is available and the instruction has been completed without errors
MODBUS_CRC	OUT	Bool		FALSE	Modbus CRC support
DIAG_ALARM	OUT	Bool		FALSE	Generation of diagnostic messages
SUPPLY_VOLT	OUT	Bool		FALSE	Diagnostics for missing supply voltage L+ is available
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
ERROR	OUT	Bool		FALSE	TRUE for one cycle once the instruction has been completed with an error
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

More information about the general parameters is available at "General parameters for Freeport operations (Page 72)".

5.4.1.15 Set_Features: Set extended functions

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

If supported by the module, you can use the Set_Features instruction (select extended functions) to activate CRC support and the generation of diagnostic messages.

Parameters

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	The instruction to set extended functions is started upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	Specifies the communications module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • for S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems, the input address assigned in the hardware configuration is assigned to the PORT parameter.
EN_MODBUS_CRC	IN	Bool		FALSE	Activate Modbus CRC support
EN_DIAG_ALARM	IN	Bool		FALSE	Activate generation of diagnostic messages
EN_SUPPLY_VOLT	IN	Bool		FALSE	Enable diagnostics for missing supply voltage L+ Note: This diagnostics is not supported by S7-1500 / ET 200MP communications modules. This also applies if the parameter can be set in combination with e.g. MODBUS_CRC.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.

Parameter	Declaration	Data type		Default	Description
		S7-1200/1500	S7-300/400/WinAC		
DONE	OUT	Bool		FALSE	TRUE for one execution once the last request is completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle once the instruction has been completed with an error
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 97))

More information about the general parameters is available at "General parameters for Freeport operations (Page 72)".

5.4.1.16 Error messages

Overview of PtP error messages

The error messages are provided at the STATUS output of an instruction and can be evaluated there or processed in the user program.

Error code	Description	Solution
16#0000	No error	-
RECEIVE status and error codes		
16#0094	frame end identified based on the "Receipt of fixed/maximum frame length"	-
16#0095	frame end identified based on "Message timeout"	-
16#0096	frame end identified based on expiration of the "Character delay time"	-
16#0097	The frame was aborted because the maximum response time was reached.	-
16#0098	frame end identified based on the fulfillment of the "Read message length from message" conditions	-
16#0099	frame end identified based on the receipt of the "End sequence"	-
SEND status and error codes		
16#7000	Block idle	-
16#7001	Initial call for a new frame: Data transmission initiated	-
16#7002	Interim call: Data transmission running	-
16#8085	Invalid length	Select a suitable frame length. • UNIVERSAL = 1 (data communication via data sets): Depending on the module, permissible are: 1 to 1024/2048/4096 bytes • UNIVERSAL = 0 (data communication via IO data; Performance optimized for many short frames (Page 38)): Maximum length is 30 bytes (Send_P2P instruction).

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Solution
16#8087	The number of characters received by the CM PTP module exceeds the supported number when UNIVERSAL = 0 (performance optimization option).	Select a suitable frame length or use UNIVERSAL = 1 (data communication via data sets). If UNIVERSAL = 0 (performance optimization option (Page 38)), the maximum length is 24 bytes (Receive_P2P instruction).
16#8088	The specified length exceeds the range set in the receive buffer. Note: When the data type STRING has been specified at the BUFFER parameter, this error code also appears if the current string is shorter than the length specified at the LENGTH parameter.	Change the range in the receive buffer or select a frame length which corresponds to the range set in the receive buffer. Depending on the module, permissible are: 1 to 1024/2048/4096 bytes
16#8090	Configuration error: Odd number of bytes for WString	Select an even number of bytes.
16#8091	Datasets 48, 49, and 50 are not supported when UNIVERSAL = 0 (performance optimization option).	Deactivate the "Performance optimized for many short frames" parameter. or Access the receive and transmit data via the IO data. or Use at least version V4.0 of the instruction library PtP Communication.
RECEIVE status and error codes		
16#7001	Initial call for a new frame: Data transmission initiated	-
16#7002	Interim call: Data transmission running	-
16#8088	The number of characters received exceeds the number specified at the BUFFER parameter.	Select a suitable frame length. Depending on the module, permissible are: 1 to 1024/2048/4096 bytes
16#8090	Configuration error: Odd number of bytes for WString	Select an even number of bytes.
Error message codes of the special functions		
16#818F	Incorrect parameter number setting (with USS only)	Select a suitable parameter number (PARAM). The following are permissible: 0 to 2047
16#8190	Incorrect setting of the CRC calculation	Select a suitable value for the CRC calculation. The following are valid: deactivated or activated. Check whether the module addressed supports CRC calculation.
16#8191	Incorrect setting of the diagnostic error interrupt	Select a suitable value for "Diagnostics interrupt". The following are valid: Diagnostics interrupt deactivated or diagnostic interrupt activated. Check whether the module addressed supports the generation of diagnostic interrupts.
16#8193	The module does not support supply voltage diagnostics L+.	Select a suitable value for "Diagnostics interrupt". The following are valid: Diagnostics interrupt deactivated or diagnostic interrupt activated. Check whether the module addressed supports the generation of diagnostic interrupts.
Error message codes of the "Port configuration"		
16#81A0	The module does not support this protocol.	Select a valid protocol for the module (PROTOCOL).
16#81A1	The module does not support this data transmission rate.	Select a valid data transmission rate for the module (BAUD).

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Solution
16#81A2	The module does not support this parity setting.	Select a suitable value for "Parity" (PARITY). The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
16#81A3	The module does not support this number of data bits.	Select a suitable value for "Number of data bits" (DATABITS). The following are valid: • 7 (2) • 8 (1)
16#81A4	The module does not support this number of stop bits.	Select a suitable value for "Number of stop bits" (STOPBITS). The following are valid: • 1 (1) • 2 (2)
16#81A5	The module does not support this type of data flow control.	Select a valid data flow control for the module (FLOWCTRL).
16#81A7	Invalid value for XON or XOFF	Select suitable values for XON (XONCHAR) and XOFF (XOFFCHAR). Valid range of values: 0 to 127
16#81AA	Invalid operating mode	Valid operating modes are: • Full duplex (RS232) (0) • Full duplex (RS422) four-wire mode (point-to-point) (1) • Full duplex (RS422) four-wire mode (multipoint master) (2)/ (CM PtP (ET 200SP)) • Full duplex (RS422) four-wire mode (multipoint slave) (3)/ (CM PtP (ET 200SP)) • Half duplex (RS485) two-wire operation. (4)
16#81AB	Invalid receive line initial state	Valid initial states are: • "No" default setting (0) • Signal R(A)=5 V, signal R(B)=0 V (break detection) (1): Can only be selected with: "Full duplex (RS422) four-wire mode (point-to-point connection)" and "Full duplex (RS422) four-wire mode (multipoint slave)". • Signal R(A)=0 V, signal R(B)=5 V (2): This default setting corresponds to the idle state (no active send operation).
16#81AC	Invalid value for "Break detection"	Select a suitable value for "Break detection". The following are valid: • Break detection deactivated (0) • Break detection activated (1).
16#81AF	The module does not support this protocol.	Select a valid protocol for the module.

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Solution
Error codes of the "Send configuration"		
16#81B5	More than two end delimiters or end sequence > 5 characters	Select suitable values for "End delimiter" and "End sequence". The following are valid: • deactivated (0), • 1 (1) or 2 (2) end delimiters or • deactivated (0), • 1 (1) up to 5 (5) characters for the end sequence.
16#81B6	Send configuration rejected because the 3964(R) protocol was selected	Make sure that no send configuration is transmitted if the 3964(R) protocol is set.
Error codes of the "Receive configuration"		
16#81C0	Invalid start condition	Select a suitable start condition. The following are valid: • Send break before frame start • Send Idle Line.
16#81C1	Invalid end condition or no end condition selected	Select a suitable end condition (see Sending data with Freeport (Page 40)).
16#81C3	Invalid value for "Maximum message length"	Select a suitable value for "Maximum message length" (MAXLEN). Valid range of values (depending on the module): 1 to 1024/2048/4096 (bytes)
16#81C4	Invalid value for "Offset of the length specification in the message"	Select a suitable value for "Offset of the length specification in the message". Valid range of values (depending on the module): 1 to 1024/2048/4096 (bytes)
16#81C5	Invalid value for "Size of length field"	Select a suitable value for "Size of length field" (LENGTHSIZE). Valid range of values in bytes: • 1 (1) • 2 (2) • 4 (4)
16#81C6	Invalid value for "Number of characters not counted in length specification"	Select a suitable value for "Number of characters not counted in length specification" (LENGTHM). Valid range of values: 0 to 255 (bytes)
16#81C7	The total of "Offset in the message + size of length field + number of characters not counted" is greater than the maximum frame length	Select a suitable value for "Offset in message", "Size of length field" and "Number of characters not counted". Valid range of values: • Offset in the message (depending on the module): 0 ... 1024/2048/4096 (bytes) • Size of length field: 1, 2, or 4 (bytes) • Number of characters not counted: 0 to 255 (bytes)
16#81C8	Invalid value for "Response timeout"	Select a suitable value for "Response timeout". Valid range of values: 1 to 65535 (ms)
16#81C9	Invalid value for "Character delay time"	Select a suitable value for "Character delay time". Valid range of values: 1 to 65535 (bit times)

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Solution
16#81CB	frame end sequence is activated, but no character is activated for the check	Activate one or several characters for the check.
16#81CC	frame start sequence is activated, but no character is activated for the check	Activate one or several characters for the check.
16#81CD	Invalid value for "Prevent overwriting"	Select a suitable value for "Prevent overwriting". The following are valid: • Prevent overwriting is deactivated (0) or • Prevent overwriting is activated (1)
16#81CE	Invalid value for "Clear receive buffer on startup"	Select a suitable value for "Clear receive buffer on startup". The following are valid: • Clear receive buffer on startup is deactivated (0) • Clear receive buffer on startup is activated (1)
SEND status and error codes		
16#81D0	Receiving send request during runtime of a send command	Make sure that you do not receive an additional send request during runtime of a send command.
16#81D1	The wait time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or change the parameters, if necessary.
16#81D2	"Hardware RTS always ON": Send job canceled due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ON for the entire duration of transmission.
16#81D3	Send buffer overflow / send frame too long	Select a shorter frame length. The following are valid (depending on the module): 1 to 1024/2048/4096 (bytes)
16#81D5	Transmission canceled due to parameter changes, detected wire break, or CPU in STOP	Check the parameter assignment, wire break, and CPU status.
16#81D6	Transmission canceled because end identifier was not received	Check the parameter assignment of the end delimiters and the frame of the communication partner.
16#81D7	Communication error between the user program and module	Check the communication (e.g., matching the sequence number).
16#81D8	Transmission attempt rejected because module is not configured	Configure the module.
16#81DF	The module has reset the interface to the FB for one of the following reasons: • Module was restarted • Module parameters were reassigned • CPU STOP	—
Error codes of the receive configuration		
16#81E0	Frame aborted: Receive buffer overflow/received frame too large	Increase the call rate for the receive function in the user program or configure communication with data flow control.
16#81E1	Frame aborted: Parity error	Check the connection line of the communication partners, or verify that the same data transmission rate, parity and stop bit number are configured for both devices.

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Solution
16#81E2	Frame aborted: Character frame error	Check the settings for start bit, data bits, parity bit, data transmission rate, and stop bit(s). More information on the error code is available in the FAQ with entry ID 109815286 on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109815286).
16#81E3	Frame aborted: Character overflow error	Firmware error: Please contact Customer Support.
16#81E4	Frame aborted: The total length of "Offset in the message + size of length field + number of characters not counted" is greater than the receive buffer	Select a suitable value for offset in message, size of length field, and number of characters not counted.
16#81E5	Frame aborted: Break	Break in receive line to partner. Reconnect or switch on partner.
16#81E6	Maximum number of "Buffered received frames" exceeded	In the user program call the instruction more often or configure a communication with data flow control or increase the number of buffered frames.
16#81E7	Synchronization error module and Receive_P2P	Make sure that different instances of the Receive_P2P do not access the same module.
16#81E8	Frame aborted: The character delay time has expired before the message end criterion was detected	Partner device faulty or too slow. Check this, if required, using an interface tester that is interconnected in the transmission line.
16#81E9	Modbus CRC error (only communications modules which support Modbus)	Checksum error of the Modbus frame. Check the communication partner.
16#81EA	Modbus frame too short (only communications modules which support Modbus)	Minimum length of Modbus frame not met. Check the communication partner.
16#81EB	Frame aborted: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1 to 1024/2048/4096 (bytes) Check the parameters for end of frame detection.
Error codes V24 accompanying signals		
16#81F0	The module does not support V24 accompanying signals	You have tried to set accompanying signals for a module that does not support V24 accompanying signals. Make sure that this is an RS232 module or that RS232 mode (ET 200SP) is set.
16#81F1	No operation of the V24 accompanying signals	The V24 accompanying signals cannot be operated manually if hardware data flow control is active.
16#81F2	The DSR signal cannot be set because the module has the type DTE.	Check the configured type of the module. The module type must be DCE (data communication equipment).
16#81F3	The DTR signal cannot be set because the module has the type DCE.	Check the configured type of the module. The module type must be DTE (data terminal equipment).
16#81F4	Block header error (e.g. incorrect block type or incorrect block length)	Check the instance DB and the block header.

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Solution
Error codes of the receive configuration		
16#8201 [1]	Receive_Conditions is a pointer to an invalid data type	Enter a pointer to one of the following data types: DB, BOOL, BYTE, CHAR, WORD, INT, DWORD, DINT, REAL, DATE, TIME_OF_DAY, TIME, S5TIME, DATE_AND_TIME, STRING
16#8225	Receive_Conditions points to an optimized memory area greater than 1 kB or Receive_Conditions points to an optimized memory area and the receive length is greater than the area addressed by Receive_Conditions.	Enter a pointer to an area with a maximum length of: • Optimized memory area: 1 KB • Non-optimized memory area: 4 KB Note: If the pointer points to an optimized memory area, do not send more than 1 KB.
16#8229 [1]	Receive_Conditions is a pointer to BOOL with a number of bits not equal to n * 8	If you are using a pointer to BOOL, the number of bits must be a multiple of 8.
Error codes, general		
16#8280	Negative acknowledgment when reading module	You can find more detailed information on error causes in the RDREC.STATUS static parameters and in the description of the SFB RDREC. • Check the input at the PORT parameter • Set the COM_RST parameter before the 1st call. More information on the error code is available in the FAQ with entry ID 109815286 on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109815286).
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter You can find more detailed information on error causes in the WRREC.STATUS static parameters and in the description of the SFB WRREC. More information on the error code is available in the FAQ with entry ID 109815286 on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109815286).
16#8282	Module not available	Check the input at the PORT parameter and ensure that the module can be reached.
Error codes of the receive configuration		
16#82C1	Invalid value for "Buffered received frames".	Select a suitable value for "Buffered received frames". Valid range of values: 1 to 255
16#82C2	Receive configuration rejected because the 3964(R) protocol was selected	Make sure that no receive configuration is sent if the 3964(R) protocol is set.
16#8301 [1]	Receive_Conditions is a pointer to an invalid data type	Select a valid data type. The following are valid: DB, BOOL, BYTE, CHAR, WORD, INT, DWORD, DINT, REAL, DATE, TIME_OF_DAY, TIME, S5TIME, DATE_AND_TIME, STRING
16#8322	Range length error when reading a parameter	Check the input at the Receive_Conditions parameter
16#8324	Range error when reading a parameter	Check the input at the Receive_Conditions parameter
16#8328	Setting error when reading a parameter	Check the input at the Receive_Conditions parameter

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Solution
SEND status and error codes		
16#8328 [1]	BUFFER is a pointer to BOOL with a number of bits not equal to n * 8	If you are using a pointer to BOOL, the number of bits must be a multiple of 8.
Error codes of the receive configuration		
16#8332	Invalid data block at the Receive_Conditions parameter	Check the input at the Receive_Conditions parameter
16#833A	The designation of the data block at the Receive_Conditions parameter refers to a data block which is not loaded.	Check the input at the Receive_Conditions parameter
16#8351	Invalid data type	Check the input at the Receive_Conditions parameter
16#8352 [1]	Receive_Conditions does not point to a data block	Check the pointer to Receive_Conditions
16#8353 [1]	Receive_Conditions does not point to a structure of the type Receive_Conditions	Check the pointer to Receive_Conditions
Error codes 3964(R) protocol		
16#8380	Parameter assignment error: Invalid value for "Character delay time".	Select a suitable value for "Character delay time" (CharacterDelayTime). Valid range of values: 1 ... 65535 (ms)
16#8381	Parameter assignment error: Invalid value for "Response timeout".	Select a suitable value for "Response timeout" (AcknDelayTime). Valid range of values: 1 ... 65535 (ms)
16#8382	Parameter assignment error: Invalid value for "Priority".	Select a suitable value for "Priority" (Priority). The following are valid: • High (1) • Low (0)
16#8383	Parameter assignment error: Invalid value for "Block check"	Select a suitable value for "Block check" (BCC). The following are valid: • With block check (1) • Without block check (0)
16#8384	Parameter assignment error: Invalid value for "Connection attempts".	Select a suitable value for "Connection attempts" (BuildupAttempts). Valid range of values: 1 to 255
16#8385	Parameter assignment error: Invalid value for "Transmission attempts".	Select a suitable value for "Transmission attempts" (RepetitionAttempts). Valid range of values: 1 to 255
16#8386	Runtime error: Number of connection attempts exceeded	Check the interface cable and the transmission parameters. Also check whether the receive function is configured correctly at the partner device.
16#8387	Runtime error: Number of transmission attempts exceeded	Check the interface cable, the transmission parameters and the configuration of the communication partner.
16#8388	Runtime error: Error at the "Block check character" The internally calculated value of the block check character does not correspond to the block check character received by the partner at the connection end.	Check if the connection is seriously disrupted; in this case you may also occasionally see error codes. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Solution
16#8389	Runtime error: Invalid character received while waiting for free receive buffer	The send request of the communication partner (STX, 02H) is only answered with DLE when the receive buffer is empty. No additional character may be received before (except STX again). Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
16#838A	Runtime error: Logical error during receiving. After DLE was received, a further random character (other than DLE or ETX) was received.	Check if the partner always duplicates the DLE in the frame header and data string or the connection is terminated with DLE ETX. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
16#838B	Runtime error: Character delay time exceeded	Partner device too slow or faulty. Verify by using an interface test device that is switched into the transmission line, if necessary.
16#838C	Runtime error: Wait time for free receive buffer has started	In the user program call the instruction more often or configure a communication with data flow control.
16#838D	Runtime error: frame repetition does not start within 4 s after NAK	Check the communication partner. A received frame that is possibly corrupted must be repeated by the partner within 4 seconds.
16#838E	Runtime error: In idle mode, one or several characters (other than NAK or STX) were received.	Check for proper function of the partner device, possibly using an interface test device that is switched into the transmission line.
16#838F	Runtime error: Initialization conflict - Both partners have set high priority	Set the "Low" priority at one of the partners
16#8391	Parameter assignment error: 3964 configuration data rejected because Freeport is set	If the Freeport protocol is set, make sure that no 3964 parameter assignment data is sent.
Error codes, general		
16#8FFF	The module is not ready temporarily due to a reset.	Repeat the request.

[1] Only with instructions for S7-300/400 CPUs

5.4.2 MODBUS (RTU)

5.4.2.1 Dependencies between library versions

Use the "MODBUS (RTU)" and "Point-to-point" instruction libraries only in one of the following combinations of versions:

"MODBUS (RTU)" library version	"Point-to-point" library version
V1.1	V1.1
V2.1	V2.4
V3.1	V2.4
V4.4	V3.2
V5.0	V4.0
V5.1	V4.1

5.4.2.2 Overview of the Modbus RTU communication

Modbus RTU communication

Modbus RTU (Remote Terminal Unit) is a standard protocol for communication in the network and uses the RS232 or RS422/485 connection for serial data transmission between Modbus devices in the network.

Modbus RTU uses a master/slave network in which the entire communication is triggered by only one master device while the slaves can only respond to the request of the master. The master sends a request to a slave address and only the slave with this slave address responds to the command.

Exception: Modbus slave address 0 sends a broadcast frame to all slaves (without slave response).

Modbus function codes

- A CPU that is operated as a Modbus RTU master can read and write data and I/O states in a Modbus RTU slave connected by means of a communication connection.
- A CPU operated as a Modbus RTU slave allows a Modbus RTU master connected over a communication connection to read and write data and I/O states in its own CPU.

Table 3-986 Functions for reading data: Reading distributed I/O and program data

Modbus function code	Functions for reading data from the slave (server) - standard addressing
01	Read output bits: 1 to 2000/1992[1)] bits per request
02	Read input bits: 1 to 2000/1992[1)] bits per request
03	Read hold register: 1 to 125/124[1)] words per request
04	Read input words: 1 to 125/124[1)] words per request

1) for extended addressing

Table 3-987 Functions for writing data: Changing distributed I/O and program data

Modbus function code	Functions for writing of data in the slave (server) - standard addressing
05	Write one output bit: 1 bit per request
06	Write one hold register: 1 word per request
15	Write one or several output bits: 1 to 1960 bits per request
16	Write one or several hold registers: 1 to 122 words per request

- The Modbus function codes 08 and 11 offer diagnostic options for communication with the slave device.
- Modbus slave address 0 sends a broadcast frame to all slaves (without slave response; for function codes 5, 6, 15, 16).

Table 3-988 Station addresses in the Modbus network

Station		Address
RTU station	Standard station address	1 to 247 and 0 for broadcast
	Extended station address	1 to 65535 and 0 for broadcast

Modbus memory addresses

The number of Modbus memory addresses (input/output addresses) that is actually available depends on the CPU version and the available work memory.

Modbus RTU instructions in your program

- Modbus_Comm_Load: You need to run Modbus_Comm_Load to set up PtP parameters such as data transmission rate, parity and data flow control. Once you have configured the communication module for the Modbus RTU protocol, it can only be used by the Modbus_Master instruction or the Modbus_Slave instruction.
- Modbus_Master: The CPU can be used as Modbus RTU master device with the Modbus master instruction for communication with one or more Modbus slave devices.
- Modbus_Slave: The CPU can be used as Modbus RTU slave device with the Modbus slave instruction for communication with a Modbus master device.

5.4.2.3 Modbus_Comm_Load: Configure communication module for Modbus

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Modbus_Comm_Load instruction configures a communications module for communication by means of the Modbus RTU protocol. An instance data block is automatically assigned when you add the Modbus_Comm_Load instruction in your program.

Configuration changes of Modbus_Comm_Load are saved on the CM and not in the CPU. With voltage recovery and pulling/plugging, the CM is configured with the data saved in the device configuration. The Modbus_Comm_Load instruction must be called in these scenarios.

Parameters

Parameter	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the instruction upon a positive edge of this input.
PORT	IN	Port	Word	0	Specifies the communications module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • for S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems, the input address assigned in the hardware configuration is assigned to the PORT parameter.
BAUD	IN	UDInt	DInt	9600	Selection of the data transmission rate Valid values are: 300, 600, 1200, 2400, 4800, 9600, 19200, 38400 , 57600, 76800, 115200 bps. For the module with the article number 6ES7541-1AB01-0AB0, the value 250000 bps is also permitted.
PARITY	IN	UInt	Word	0	Selection of parity: • 0 – None • 1 – Odd • 2 – Even
FLOW_CTRL	IN	UInt	Word	0	Selection of flow control: • 0 – (default) no flow control • 1 – Hardware flow control with RTS always ON (not with RS422/485 CMs) • 2 – Hardware flow control with RTS switched (not with RS422/485 CMs)
RTS_ON_DLY	IN	UInt	Word	0	Selection RTS ON delay: • 0 – No delay from "RTS active" until the first character of the frame is sent. • 1 to 65535 – Delay in milliseconds from "RTS active" until the first character of the frame is sent (not with RS422/485 CMs). RTS delays must be used independent of the selection FLOW_CTRL.
RTS_OFF_DLY	IN	UInt	Word	0	Selection RTS OFF delay: • 0 – No delay after transmission of last character until "RTS inactive" • 1 to 65535 – Delay in milliseconds after transmission of last character until "RTS inactive" (not with RS422/485 ports). RTS delays must be used independent of the selection FLOW_CTRL.

Parameter	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
RESP_TO	IN	UInt	Word	1000	Response timeout: 5 ms to 65535 ms - Time in milliseconds that Modbus_Master waits for a response from the slave. If the slave does not respond within this period, Modbus_Master repeats the request or terminates the request with an error if the specified number of repetitions (see below, RETRIES parameter) has been sent.
MB_DB	IN/OUT	MB_BASE		-	A reference to the instance data block of the Modbus_Master or Modbus_Slave instructions. The MB_DB parameter must be connected with the (static and therefore not visible in the instruction) MB_DB parameter of the Modbus_Master or Modbus_Slave instruction.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Modbus_Comm_Load instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE. Note: The parameter is only available for S7-300/400 instructions.
DONE	OUT	Bool		FALSE	The DONE bit is TRUE for one cycle after the last request has been completed without errors.
ERROR	OUT	Bool		FALSE	The ERROR bit is TRUE for one cycle after the last request has been completed with errors. The error code in the STATUS parameter is only valid in the cycle in which ERROR = TRUE.
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 132))

Modbus_Comm_Load is executed to configure a port for the Modbus RTU protocol. Once you have configured the port for the Modbus RTU protocol, it can only be used by the Modbus_Master or Modbus_Slave instructions.

You have to run Modbus_Comm_Load for the configuration of each communication port that is to be used for Modbus communication. You must assign a unique Modbus_Comm_Load instance DB to each port that you use. Only run Modbus_Comm_Load again if you need to change communication parameters, such as data transmission rate or parity, or in case the network has returned.

For example, an instance data block is assigned to the instruction if you add Modbus_Master or Modbus_Slave to your program. You need to connect the MB_DB parameter of the Modbus_Comm_Load instruction to the MB_DB parameter of the Modbus_Master or Modbus_Slave instruction.

Modbus_Comm_Load data block tags

The table below shows the public static tags in the instance DB of Modbus_Comm_Load that you can use in your program.

Table 3-989 Static tags in the instance DB

Tag	Data type		Stand-ard	Description
	S7-1200/1500	S7-300/400/WinAC		
ICHAR_GAP	Word		0	Maximum character delay time between characters. This parameter is specified in milliseconds and increases the anticipated period between the received characters. The corresponding number of bit times for this parameter is added to the Modbus default value of 35 bit times (3.5 character times).
RETRIES	Word		2	Number of retries that the master executes before the error code 0x80C8 for "No response" is returned.
EN_SUPPLY_VOLT	Bool		0	Enable diagnostics for missing supply voltage L+
MODE	USInt	Byte	0	Operating mode Valid operating modes are: • 0 = Full duplex (RS232) • 1 = Full duplex (RS422) four-wire mode (point-to-point) • 2 = Full duplex (RS 422) four-wire mode (multipoint master, CM PtP (ET 200SP)) • 3 = Full duplex (RS 422) four-wire mode (multipoint slave, CM PtP (ET 200SP)) • 4 = Half duplex (RS485) two-wire mode [1)]
LINE_PRE	USInt	Byte	0	Receive line initial state Valid initial states are: • 0 = "No" initial state [1)] • 1 = signal R(A)=5 V, signal R(B)=0 V (break detection): Break detection is possible with this initial state. Can only be selected with: "Full duplex (RS422) four-wire mode (point-to-point connection)" and "Full duplex (RS422) four-wire mode (multipoint slave)". • 2 = signal R(A)=0 V, signal R(B)=5 V: This default setting corresponds to the idle state (no active send operation). No break detection is possible with this initial state.
BRK_DET	USInt	Byte	0	Break detection The following are valid: • 0 = break detection deactivated • 1 = break detection activated
EN_DIAG_ALARM	Bool		0	Activate diagnostics interrupt: • 0 - not activated • 1 - activated
STOP_BITS	USINT	Byte	1	Number of stop bits; • 1 = 1 stop bit, • 2 = 2 stop bits, • 0, 3 to 255 = reserved

[1)] Required setting for the use of PROFIBUS cables with CM 1241 for RS485

Instruction versions

Version 3.1 is functionally identical to version 3.0 and its version number was only incremented due to internal measures.

5.4.2.4 Modbus_Master: Communicate as Modbus master

NOTE

Use with CM1241

The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

The Modbus_Master instruction communicates as Modbus master via a port configured by the Modbus_Comm_Load instruction. An instance data block is automatically assigned when you add the Modbus_Master instruction in your program. The MB_DB parameter of the Modbus_Comm_Load instruction must be connected to the (static) MB_DB parameter of the Modbus_Master instruction.

NOTE

You cannot activate retentivity (Retain) for an instance DB of the Modbus_Master instruction.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	FALSE = no request TRUE = request to send data to the Modbus slave
MB_ADDR	IN	UInt	Word	-	Modbus RTU station address: Standard addressing range (1 to 247 as well as 0 for Broadcast) Extended addressing range (1 to 65535 as well as 0 for Broadcast) The value 0 is reserved for the broadcast of a telegram to all Modbus slaves. Only the Modbus function codes 05, 06, 15 and 16 are supported for the broadcast.
MODE	IN	USInt	Byte	0	Mode selection: Specifies the type of request (read, write or diagnostics). More information is available in the table of Modbus functions below.
DATA_ADDR	IN	UDInt	DWord	0	Start address in the slave: Specifies the start address of the data that is accessed in the Modbus slave. The valid addresses are listed in the table of Modbus functions below.

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
DATA_LEN	IN	UInt	Word	0	Data length: Specifies the number of bits or words this instruction is to access. The valid lengths are listed in the table of Modbus functions below.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Modbus_Master instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE. Note: The parameter is only available for S7-300/400 instructions.
DATA_PTR	IN/OUT	Variant	Any	-	Data pointer: Points to the flag or DB address for the data to be written or read. As of instruction version V3.0: The parameter may point to an optimized memory area. In the optimized memory area, a single element or an array is permitted with the following data types: Bool, Byte, Char, Word, Int, DWord, DInt, Real, USInt, UInt, UDInt, SInt, WChar. Every other data type results in error message 16#818C.
DONE	OUT	Bool		FALSE	The DONE bit is TRUE for one cycle after the last request has been completed without errors.
BUSY	OUT	Bool		-	• FALSE – no command active for Modbus_Master • TRUE – command for Modbus_Master in progress
ERROR	OUT	Bool		FALSE	The ERROR bit is TRUE for one cycle after the last request has been completed with errors. The error code in the STATUS parameter is only valid in the cycle in which ERROR = TRUE.
STATUS	OUT	Word		0	Error code (see Error messages (Page 132))

Tags in the data block of the Modbus master

The table below shows the public static variables in the instance DB of Modbus_Master that you can use in your program.

Table 3-990 Static variables in the instance DB

Tag	Data type	Standard	Description
Blocked_Proc_Timeout	Real	3.0	Duration (in seconds) for which to wait for a blocked Modbus master instance before this instance is removed as ACTIVE. This may happen, for example, if a master request was output and the program then stops to call the master function before it has completely finished the request. The time value must be greater than 0 and less than 55 seconds to avoid an error to occur. See also "Rules for communication by the Modbus-Master" and "Calling the Modbus_Master instruction with different parameter settings".

1) The PtP communication modules respond as defined in the Modbus specification. To retain a response as with CP 341, CP 441-2 and ET 200SP 1SI for Modbus, use the "Compatibility_Mode" parameter.

Tag	Data type	Standard	Description
Extended_Addressing	Bool	FALSE	Configures the slave station address as single or double byte. • FALSE = One-byte address; 0 to 247 • TRUE = Two-byte address (corresponds to extended addressing); 0 to 65535
Compatibility_Mode [1]	Bool	FALSE	Compatibility mode with CP 341 and CP 441-2 and ET 200S 1SI with driver for Modbus RTU and with ET 200S 1SI for Modbus. The default value is 0. • FALSE = as per Modbus specification, not compatible • TRUE = compatible – For FC1 and FC2: The data read from the received frame is written word for word to the addressed CPU memory and exchanged byte by byte. If the number of bits to be transmitted is not a multiple of 16, the bits which are not relevant are set to null in the last word. – For FC15: The words to be transmitted are read word by word from the addressed memory and written byte by byte to the send frame. If the number of bits to be transmitted is not a multiple of 8, the bits in the last byte which are not relevant are read unchanged from the addressed memory and entered in the send frame.
MB_DB	MB_BASE	-	The MB_DB parameter of the Modbus_Comm_Load instruction must be connected to this MB_DB parameter of the Modbus_Master instruction.

[1] The PtP communication modules respond as defined in the Modbus specification. To retain a response as with CP 341, CP 441-2 and ET 200SP 1SI for Modbus, use the "Compatibility_Mode" parameter.

You program can write values to the Blocked_Proc_Timeout and Extended_Addressing variables to control the Modbus master operations.

Rules for communication by the Modbus-Master

- Modbus_Comm_Load must be run to configure a port so that the Modbus_Master instruction can communicate with this port.
- A port which is to be used as Modbus master must not be used by Modbus_Slave . You can use one or several instances of Modbus_Master [1] with this port. But all versions of the Modbus_Master must use the same instance DB for the port.
- The Modbus instructions do not use communication alarm events to control the communication process. Your program must query the Modbus_Master instruction for completed commands (DONE, ERROR).
- We recommend to call all executions of Modbus_Master for a specific port from a program cycle OB. Modbus master instructions can only be executed in one program cycle or in one cyclical/time-controlled processing level. They may not be processed in different processing levels. The priority interruption of a Modbus master instruction by another Modbus master instruction in a processing level with higher priority results in improper operation. Modbus master instructions may mot be processed in startup, diagnostic or time error levels.

[1] "Instance of Modbus master" here means a call of the Modbus_Master instruction with the same interconnection to a Modbus_Comm_Load instruction and the same setting for the MB_ADDR, MODE, DATA_ADDR and DATA_LEN parameters.

Example

Modbus_Master is called with MODE=0 and DATA_ADDR=10

This job is now active until it is completed with DONE=1 or ERROR=1 or until the time monitoring configured at the Blocked_Proc_Timeout parameter has expired. If a new command is started after the watchdog time expires and before the previous command has been completed, the previous command is aborted without an error message.

If, while this command is running, the instruction is now called a second time with the same instance data but different MODE and DATA_ADDR parameter settings, this second call is terminated with ERROR=1 and STATUS=8200.

Calling the Modbus_Master instruction with different parameter settings

If multiple calls of the Modbus_Master instruction with different settings for MB_ADDR, MODE, DATA_ADDR or DATA_LEN are placed in your program, you must ensure that only one of these calls is active at any given time. Otherwise, the error message 16#8200 is output (interface is busy with an ongoing request).

If a call cannot be processed in full, the watchdog is activated by the Blocked_Proc_Timeout parameter and terminates the ongoing command.

REQ parameter

FALSE = no request; TRUE = request to send data to the Modbus slave

Enable the requested transmission. This transmits the contents of the buffer to the point-to-point communication interface.

You use the DATA_ADDR and MODE parameters to select the Modbus function code.

DATA_ADDR (Modbus start address in the slave): Specifies the start address of the data that is accessed in the Modbus slave.

The Modbus_Master instruction uses the MODE input instead of a function code input. The combination of MODE and DATA_ADDR specifies the function code that is used in the actual Modbus frame. The table below shows how the MODE parameter, the Modbus function code and the Modbus address range in DATA_ADDR are related.

Table 3-991 Modbus functions

MODE	DATA_ADDR (Modbus address)			DATA_LEN (data length)			Modbus function code	Operation and data		
0				Bits per request			01	Read output bits:		
	1	to	9999	1	to	2000/1992 [1]		0	to	9998
0				Bits per request			02	Read input bits:		
	10001	to	19999	1	to	2000/1992 [1]		0	to	9998
0				Words per request			03	Read hold register:		
	40001	to	49999	1	to	125/124 [1]		0	to	9998
	400001	to	465535	1	to	125/124 [1]		0	to	65534
0				Words per request			04	Read input words:		
	30001	to	39999	1	to	125/124 [1]		0	to	9998
1				Bits per request			05	Write one output bit:		
	1	to	9999	1				0	to	9998
1				1 word per request			06	Write one hold register:		
	40001	to	49999	1				0	to	9998
	400001	to	465535	1				0	to	65524
1				Bits per request			15	Write multiple output bits:		
	1	to	9999	2	to	1968/1960 [1]		0	to	9998
1				Words per request			16	Write multiple hold registers:		
	40001	to	49999	2	to	123/122		0	to	9998
	400001	to	465534	2	to	123/122 [1]		0	to	65534
2 [2]				Bits per request			15	Write one or several output bits:		
	1	to	9999	1	to	1968/1960 [1]		0	to	9998
2 [2]				Words per request			16	Write one or several hold registers:		
	40001	to	49999	1	to	123		0	to	9998
	400001	to	465535	1	to	122 [1]		0	to	65534

[1] In extended addressing, see the Extended_Adressing parameter, the maximum data length is shorter by 1 byte or 1 word depending on the data type of the function.

[2] MODE 2 allows you to write one or more output bits and one or more holding registers using the Modbus functions 15 and 16.
MODE 1 uses the Modbus functions 5 and 6 to write 1 output bit and 1 holding register, and Modbus functions 15 and 16 to write multiple output bits and multiple holding registers.

[3] The following applies to S7-300/400/WinAC: Is not supported.

MODE	DATA_ADDR (Modbus address)			DATA_LEN (data length)			Modbus function code	Operation and data		
11	Both DATA_ADDR and DATA_LEN operands of the Modbus_Master are ignored with this function.						11	Read status word and event counter of the slave communication. The status word indicates busy (0 – not busy, 0xFFFF - busy). The event counter is incremented for each successful processing of a frame.		
80				1 word per request			08	Check slave status with data diagnostic code 0x0000 (loopback test – slave returns an echo of the request)		
	-			1				-		
81				1 word per request			08	Reset slave event counter using data diagnostic code 0x000A		
	-			1				-		
104 [3]				Words per request			04	Read input words		
	0	to	65535	1	to	125/124 [1]		0	to	65535
3 to 10, 12 to 79, 82 to 103, 105 to 255	-			-				Reserved		

[1] In extended addressing, see the Extended_Adressing parameter, the maximum data length is shorter by 1 byte or 1 word depending on the data type of the function.

[2] MODE 2 allows you to write one or more output bits and one or more holding registers using the Modbus functions 15 and 16.
MODE 1 uses the Modbus functions 5 and 6 to write 1 output bit and 1 holding register, and Modbus functions 15 and 16 to write multiple output bits and multiple holding registers.

[3] The following applies to S7-300/400/WinAC: Is not supported.

DATA_PTR parameter

The DATA_PTR parameter points to the DB or bit memory address in which reading or writing is performed. If you use a data block, you must create a global data block that provides the data memory for read and write processes on Modbus slaves.

NOTE

S7-1200/1500 - The data block addressed using DATA_PTR must support direct addressing

The data block must permit direct (absolute) and symbolic addressing.

NOTE
Using function code 5
Function code 5 is used to set or delete individual bits.
When a bit is set, the value "16#FF00" must be specified in the first word of the addressed DB or bit memory area via DATA_PTR.

- With S7-1200, the value "16#0100" can also be specified to set a bit.
- To reset a bit, the value "16#0000" must be specified in the first word of the DB or bit memory area addressed via DATA_PTR.

All other values are rejected with ERROR = TRUE and STATUS = 16#8384.

Data block structures for the DATA_PTR parameter

- These data types are valid for reading words of the Modbus address range (DATA_PTR) 30001 to 39999, 40001 to 49999 and 400001 to 465535 as well as for writing words to the Modbus address range (DATA_PTR parameter) 40001 to 49999 and 400001 to 465535.
  - Standard array of data types WORD, UINT or INT
  - Named structure of the WORD, UINT or INT type in which each element has a unique name and a 16-bit data type.
  - Named complex structure in which each element has a unique name and a 16-bit or 32-bit data type.
- For reading and writing bits for the Modbus address range (DATA_PTR parameter) 00001 to 09999 and for reading bits from 10001 to 19999.
  - Standard field from Boolean data types.
  - Named Boolean structure from clearly named Boolean variables.
- To reduce the risk of data corruption, it is recommended that each Modbus_Master instruction has its own separate memory area.
- It is not necessary for the data areas for DATA_PTR to be located in the same global data block. You can create a data block with several areas for Modbus read processes, a data block for Modbus write processes or a data block for each slave station.

Instruction versions

Version 3.0 is functionally identical to version 2.4 and its version number was only incremented due to internal measures.

5.4.2.5 Modbus_Slave

Modbus_Slave: Communicate as Modbus slave

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

Description

Your program can use the Modbus_Slave instruction to communicate as a Modbus slave by using a CM (RS422/485 or RS232). STEP 7 automatically creates an instance DB when you add the instruction. The MB_DB parameter of the Modbus_Comm_Load instruction must be connected to the (static) MB_DB parameter of the Modbus_Slave instruction.

NOTE
You cannot activate retentivity (Retain) for an instance DB of the Modbus_Slave instruction.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
MB_ADDR	IN	UInt	Word	-	Standard address of the Modbus slave: Standard addressing range (1 to 247) Extended addressing range (0 to 65535) Note: 0 is the broadcast address
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Modbus_Slave instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE. Note: The parameter is only available for S7-300/400 instructions.
MB_HOLD_REG	IN/OUT	Variant	Any	-	Pointer to the Modbus hold register DB: The Modbus hold register may be the memory area of the flags or a data block. As of instruction version V4.0: The parameter must point to a memory area that has a length of at least 16 bits. A shorter length results in error message 16#8187. This applies to single elements, arrays, STRUCTs and UDTs. For example, a Single Bool or an array consisting of less than 16 Boolean elements results in the error message. If the length is not a multiple of 16 bits, the remaining bits at the end of the memory area cannot be read or written by the Modbus_Slave instruction. The parameter may point to an optimized memory area. In the optimized memory area, a single element or an array is

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
					permitted with the following data types: Bool, Byte, Char, Word, Int, DWord, DInt, Real, USInt, UInt, UDInt, SInt, WChar. Every other data type results in error message 16#818C.
NDR	OUT	Bool		FALSE	New data available: • FALSE – No new data • TRUE – Indicates that new data was written by the Modbus master The NDR bit is TRUE for one cycle after the last request has been completed without errors.
DR	OUT	Bool		FALSE	Read data: • FALSE – No data read • TRUE – Indicates that the instruction has stored the data received by the Modbus master in the target area. The DR bit is TRUE for one cycle after the last request has been completed without errors.
ERROR	OUT	Bool		FALSE	The ERROR bit is TRUE for one cycle after the last request has been completed with errors. If the execution was terminated with an error, the error code in the STATUS parameter is only valid in the cycle in which ERROR = TRUE.
STATUS	OUT	Word		0	Error code (see Error messages (Page 132))

The function codes of the Modbus communication (1, 2, 4, 5 and 15) can read and write bits and words directly in the process image input and in the process image output of the CPU. The MB_HOLD_REG parameter must be defined as data type greater than one byte for these function codes. The table below shows the sample assignment of Modbus addresses to the process image in the CPU.

Table 3-992 Assignment of Modbus addresses to the process image

Modbus functions						S7-1200			
Code	Function	Data area	Address area			Data area	CPU address		
01	Read bits	Output	0	to	8191	Process image output	O0.0	to	O1023.7
02	Read bits	Input	0	to	8191	Process image input	I0.0	to	I1023.7
04	Read words	Input	0	to	511	Process image input	IW0	to	IW1022
05	Write bit	Output	0	to	8191	Process image output	O0.0	to	O1023.7
15	Write bits	Output	0	to	8191	Process image output	O0.0	to	O1023.7

Table 3-993 Assignment of Modbus addresses to the process image

Modbus functions						S7-1500 / S7-300 / S7-400			
Function code	Function	Data area	Address area			Data area	CPU address		
01	Read bits	Output	0	to	9998	Process image output	O0.0	to	A1249.6
02	Read bits	Input	0	to	9998	Process image input	I0.0	to	I1249.6
04	Read words	Input	0	to	9998	Process image input	IW0	to	IW19996
05	Write bit	Output	0	to	9998	Process image output	O0.0	to	A1249.6
15	Write bits	Output	0	to	9998	Process image output	O0.0	to	A1249.6

NOTE

The available address area may be smaller, depending on the memory configuration of the CPU.

The function codes of the Modbus communication (3, 6, 16) use a Modbus hold register which is an address area in the memory area of the flags or a data block. The type of holding register is specified by the MB_HOLD_REG parameter of the Modbus_Slave instruction.

NOTE

S7-1200/1500 - type of the MB_HOLD_REG data block

The data block with Modbus hold register must permit direct (absolute) and symbolic addressing.

Table 3-994 Diagnostic functions

Modbus diagnostic functions of the S7-1200 Modbus_Slave		
Function codes	**Subfunction**	**Description**
08	0000H	Output request data of echo test: The Modbus_Slave instruction returns the echo of a received data word to the Modbus master.
08	000AH	Clear communication event counter: The Modbus_Slave instruction clears the communication event counter used for Modbus function 11.
11		Call communication event counter: The Modbus_Slave instruction uses an internal communication event counter to detect the number of successful Modbus read and Modbus write requests that are sent to the Modbus slave. The counter is not incremented for function 8, function 11 and broadcast requests. It is also not incremented for requests that result in communication errors (for example, parity or CRC errors).

The Modbus_Slave instruction supports broadcast write requests from Modbus masters as long as the requests include access to valid addresses. Modbus_Slave generates error code 16#8188 for function codes that are not supported by the broadcast function.

Variables of the Modbus slave in instruction version V3.0

This table below shows the public static variables in the instance data block of Modbus_Slave that you can use in your program.

Table 3-995 Variables of the Modbus slave

Tag	Data type	Standard	Description
HR_Start_Offset	Word	0	Specifies the start address of the Modbus hold register (default = 0)
QB_Start	Word	0	Start address of the valid writable addressing range of the outputs (byte 0 to 65535) Note: The variable is not available for S7-300, S7-400 and WinAC.
QB_Count	Word	0xFFFF	Number of output bytes that can be written by the Modbus master. Note: The variable is not available for S7-300, S7-400 and WinAC.

Tag	Data type	Standard	Description
Extended_Addressing	Bool	FALSE	Extended addressing, configures slave addressing as single or double byte (FALSE = single byte address, TRUE = double byte address)
Request_Count	Word	0	The number of all requests received by this slave
Slave_Message_Count	Word	0	The number of requests received for this specific slave
Bad_CRC_Count	Word	0	The number of received requests that have a CRC error
Broadcast_Count	Word	0	The number of received broadcast requests
Exception_Count	Word	0	Modbus-specific errors that are acknowledged with an exception to the master
Success_Count	Word	0	The number of received requests without protocol errors for this specific slave
MB_DB	MB_BASE	-	The MB_DB parameter of the Modbus_Comm_Load instruction must be connected to this MB_DB parameter of the Modbus_Master instruction.

You program can write values to the HR_Start_Offset and Extended_Addressing tags and control the Modbus slave operations. The other variables can be read to monitor the Modbus status.

Rules for Modbus slave communication

- Modbus_Comm_Load must be run to configure a port so that the Modbus_Slave instruction can communicate by means of this port.
- If a port is to respond as slave to a Modbus master, this port may not be programmed with the Modbus_Master instruction.
- Only one instance of Modbus_Slave can be used with a specific port; otherwise you may encounter unexpected behavior.
- The Modbus instructions do not use communication alarm events to control the communication process. Your program must control the communication process by querying the Modbus_Slave instruction for completed send and receive processes.
- The Modbus_Slave instruction must be executed regularly with a frequency that allows a timely response to incoming requests of a Modbus master. We recommend executing Modbus_Slave in each cycle from a program cycle OB. Modbus_Slave can be executed from a cyclic interrupt OB but we do not recommend it, because excessive time delays in the interrupt program can temporarily block the execution of other interrupt programs.

Time control of the Modbus signal

Modbus_Slave must be executed regularly to receive each request of the Modbus master and respond accordingly. The frequency with which Modbus_Slave is executed depends on the timeout value specified for the response by the Modbus master. This can be seen in the figure below.

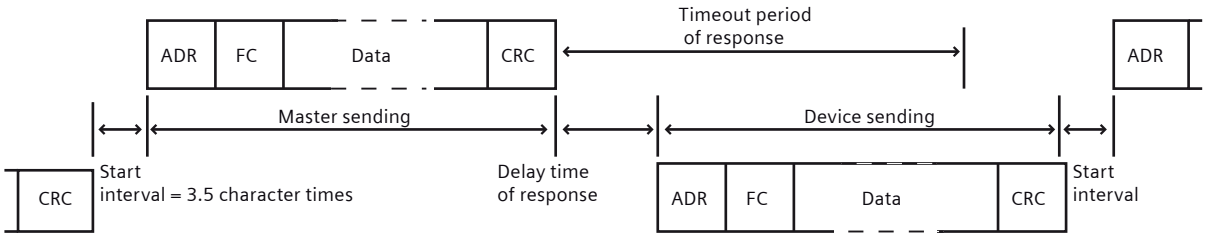

The timeout period of the (RESP_TO) response is the duration that a Modbus master waits for the beginning of an answer from a Modbus slave. This period is not defined by the Modbus protocol, but by a parameter of the Modbus_Comm_Load instruction. As both receiving and sending a frame requires multiple calls of the Modbus_Slave instruction (at least three), you should execute Modbus_Slave at least twelve times during the timeout period for the response of the Modbus master so that the Modbus slave receives and sends data twice as many times as specified by the timeout period.

HR_Start_Offset

The Modbus holding register addresses start at 40001 or 400001. These addresses correspond to the start address of the holding register in the target system memory. But you can configure the HR_Start_Offset variable to configure a start address different than 40001 or 400001 for the Modbus hold register.

The address 0 in the received frame correspond to the start address of the hold register in the target system memory. Use the HR_Start_Offset variable to configure a start address other than 0 for the Modbus hold register.

You can, for example, configure a hold register with start at MW100 and a length of 100 words. With HR_Start_Offset = 20, the address 20 in the received frame corresponds to the start address of the holding register in the target memory (MW100). Each address in the received frame below 20 and above 119 results in an addressing error.

Table 3-996 Example for addressing the Modbus hold register when DATA_PTR is a pointer to MW100 with a length of 100 words

HR_Start_Offset	Address	Minimum	Maximum
0	Modbus address (word)	0	99
	S7-1500 address	MW100	MW298
20	Modbus address (word)	20	119
	S7-1500 address	MW100	MW298

HR_Start_Offset is a word value which specifies the start address of the Modbus hold register and is saved in the Modbus_Slave instance data block. You select this public static variable by means of the parameter drop-down list once you have added Modbus_Slave in your program.

If you have added Modbus_Slave to an LAD network, for example, you can go to a previous network and assign the value HR_Start_Offset using the move command. The value must be assigned prior to execution of Modbus_Slave.

Enter Modbus slave tag using the standard DB name:

1. Position the cursor in the OUT1 parameter field and enter the character m.
2. Select the required instance DB of the Modbus_Slave instruction from the drop-down list.
3. Position the cursor to the right of the DB name (after the quotation mark) and enter a point.
4. Select "Modbus_Slave_DB.HR_Start_Offset" in the drop-down list.

Instruction versions

Version 4.0 is functionally identical to version 3.0 and its version number was only incremented due to internal measures.

Access to data areas in DBs instead of direct access to MODBUS addresses as of version V4.0

As of instruction version V4.0 of Modbus_Slave and as of firmware versions V2.5 (S7-1500 CPUs) or V4.2 (S7-1200 CPUs), you can access data areas in DBs instead of directly accessing process images and holding registers. In doing so, the attribute "Optimized block access" must be disabled for the DB and it must not be located solely in the load memory.

If a MODBUS request arrives and you have not defined a data area for the MODBUS data type of the corresponding function code, the request is treated as in the previous instruction versions, i.e. process images and holding registers are accessed directly.

If you have defined a data area for the MODBUS data type of the function code, however, the Modbus_Slave instruction reads from this data area or writes to it. Whether it reads or writes depends on the job type.

One individual MODBUS request can only ever be read from or written to one data area. If, for example, you want to read holding registers that extend over multiple data areas, you therefore require multiple MODBUS requests.

Rules for defining data areas

You can define up to eight data areas in different DBs; each DB must only contain one data area. An individual MODBUS request can only ever read from precisely one data area or write to precisely one data area. Each data area corresponds to one MODBUS address area. The data areas are defined in the static variable Data_Area_Array of the instance DB; Data_Area_Array is a field consisting of eight elements.

If you want to use less than eight data areas, the required data areas must be located one behind the other without any gaps. The first blank entry in the data areas ends the data area search during processing. If, for example, you have defined the field elements 1, 2, 4 and 5, only field elements 1 and 2 will be recognized as field element 3 is empty.

The Data_Area_Array field consists of 8 elements: Data_Area_Array[1] to Data_Area_Array[8]

Each field element Data_Area_Array[x], 1 <= x <= 8, is a UDT of the type MB_DataArea and is structured as follows:

Parameter	Data type	Meaning
data_type	UInt	Identifier for the MODBUS data type that is mapped to this data area: • 0: Identifier for an empty field element or an unused data area. In this case, the values of db, start and length are irrelevant. • 1: Process image output (used with function codes 1, 5 and 15) • 2: Process image input (used with function code 2) • 3: Holding register (used with function codes 3, 6 and 16) • 4: Input register (used with function code 4) Note: If you have defined a data area for a MODBUS data type, the instruction MB_SERVER can no longer access this MODBUS data type directly. If the address of a MODBUS request for such a data type does not correspond to a defined data area, a value of W#16#8383 is returned in STATUS.
db	UInt	Number of the data block to which the MODBUS register or bits subsequently defined are mapped. The DB number must be unique in the data areas. The same DB number must not be defined in multiple data areas. The DB must have standard access and must not be located solely in the load memory. Data areas also start with the byte address 0 of the DB. Permitted values: 1 to 60999
start	UInt	First MODBUS address that is mapped to the data block starting from address 0.0. Permitted values: 0 to 65535
length	UInt	Number of bits (for the values 1 and 2 of data_type) or number of registers (for the values 3 and 4 of data_type). The MODBUS address areas of one and the same MODBUS data type must not overlap. Permitted values: 1 to 65535

Examples of the definition of data areas

- First example: data_type = 3, db = 1, start = 10, length = 6

  The holding registers (data_type = 3) are mapped in data block 1 (db = 1). The Modbus address 10 (start = 10) is located at data word 0. The last valid Modbus address 15 (length = 6) is located at data word 5.

- Second example: data_type = 2, db = 15, start = 1700, length = 112

  The inputs (data_type = 2) are mapped in data block 15 (db = 15). The Modbus address 1700 (start = 1700) is located at data word 0. The last valid Modbus address 1811 (length = 112) is located at data word 111.

Restriction of read access to process images as of version V4.0

Restriction of read access to process images

As of instruction version V4.0 of Modbus_Slave, you can define one area each in the process image of the inputs and in the process image of the outputs to which remote MODBUS devices have read access. Read access by remote MODBUS devices to addresses outside these process image areas is then no longer possible.

NOTE

Restriction of write access to process images

The option for restricting write access to the process image of the outputs to a specific area is available as of instruction version V3.0.

Definition of read areas in the process images

Read areas in the process images are defined in the following static tags of the instance DB:

- QB_Read_Start: Address of the first byte in the process image output that can be read by a remote MODBUS device (applies to function code 1)
- QB_Read_Count: Number of bytes in the process image output that can be read by a remote MODBUS device (applies to function code 1)
- IB_Read_Start: Address of the first byte in the process image input that can be read by a remote MODBUS device (applies to function codes 2 and 4)
- IB_Read_Count: Number of bytes in the process image input that can be read by a remote MODBUS device (applies to function codes 2 and 4)

Static tags in the instance DB for defining write and read areas in the process images

The following table describes the static variables listed above in the instance DB of the Modbus_Slave instruction that you use to define the read areas in the process images.

For the sake of completeness, the static variables with which you define the write areas in the process images (QB_Start and QB_Count) as of version V3.0 are also specified.

Tag	Data type	Start value
QB_Start	UInt	0
QB_Count	UInt	65535
QB_Read_Start	UInt	0
QB_Read_Count	UInt	65535
IB_Read_Start	UInt	0
IB_Read_Count	UInt	65535

5.4.2.6 Frame structure

Extended_Addressing

You access the Extended_Addressing variable as described for the HR_Start_Offset reference, except that the Extended_Addressing variable is a Boolean value.

You can configure a single byte (Modbus standard) or two bytes (Extended_Adressing = TRUE) with Extended_Adressing = FALSE for addressing the Modbus slave. Extended addressing is used to address more than 247 devices in a single network. With Extended_Adressing = TRUE you can address up to 65535 addresses. The following example shows a Modbus frame.

Table 3-997 Slave address with one byte (Byte 0)

	Byte 0	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	
Request	Slave address	Function code	Start address		Data		
Valid response	Slave address	Function code	Length	Data...			
Error message	Slave address	0xxx	Exception code				

Table 3-998 Slave address with two bytes (Byte 0 and Byte 1)

	Byte 0	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**
Request	Slave address		Function code	Start address		Data	
Valid response	Slave address		Function code	Length	Data...		
Error message	Slave address		0xxx	Exception code			

Frame description

Data traffic between master and slave / slave and master starts with the slave address, following by the function code. The data is then transferred. The structure of the data field depends on the function code used. The checksum (CRC) is transmitted at the end of the frame.

Function codes with performance optimization

With the option for performance optimization activated, there are restrictions to the configuration limits of the transferred data. More information on the restrictions can be found in the section Function codes (Page 56).

Function code 1 - This function allows individual output bits to be read

Table 3-999 FC 1 - Read output bits

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 1	Start address		Number of outputs	
Valid response	Slave address	Function code 1	Length [1)]	Output data [3)]		
Error message	Slave address	0x81	Exception code [2)]	---		

1) Length: If there is a remainder when the number of outputs is divided by 8, the number of bytes must be increased by 1.

2) E code: 01 or 02 or 03 or 04

3) The output data can contain multiple bytes

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 1	Start address		Number of outputs	
Valid response	Slave address		Function code 1	Length [1]	Output data		
Error message	Slave address		0x81	Exception code [2]	---		

1 Length: If there is a remainder when the number of outputs is divided by 8, the number of bytes must be increased by 1.

2 E code: 01 or 02 or 03 or 04

3 The output data can comprise multiple bytes

Function code 2 - This function allows individual input bits to be read

Table 3-1000 FC 2 - Read input bits

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 2	Start address		Number of inputs	
Valid response	Slave address	Function code 2	Length [1]	Input data		
Error message	Slave address	0x82	Exception code [2]	---		

1 Length: If there is a remainder when the number of inputs is divided by 8, the number of bytes must be increased by 1.

2 E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 2	Start address		Number of inputs	
Valid response	Slave address		Function code 2	Length [1]	Input data		
Error message	Slave address		0x82	Exception code [2]	---		

1 Length: If there is a remainder when the number of inputs is divided by 8, the number of bytes must be increased by 1.

2 E code: 01 or 02 or 03 or 04

Function code 3 - This function allows individual registers to be read

Table 3-1001 FC 3 - Read hold register

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 3	Start address		Number of registers	
Valid response	Slave address	Function code 3	Length [1]	Register data		
Error message	Slave address	0x83	Exception code [2]	---		

[1] Length: Number of bytes

[2] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 3	Start address		Number of registers	
Valid response	Slave address		Function code 3	Length [1]	Register data		
Error message	Slave address		0x83	Exception code [2]	---		

[1] Length: Number of bytes

[2] E code: 01 or 02 or 03 or 04

Function code 4 - This function allows individual registers to be read

Table 3-1002 FC 4 - Read input words

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 4	Start address		Number of input words	
Valid response	Slave address	Function code 4	Length [1]	Input data		
Error message	Slave address	0x84	Exception code [2]	---		

[1] Length: 2 * number of input words

[2] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 4	Start address		Number of input words	
Valid response	Slave address		Function code 4	Length [1]	Input data		
Error message	Slave address		0x84	Exception code [2]	---		

[1] Length: 2 * number of input words

[2] E code: 01 or 02 or 03 or 04

Function code 5 - This function can set or delete individual bits

Table 3-1003 FC 5 - Write an output bit

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 5	Start address		Value	
Valid response	Slave address	Function code 5	Length	Value		
Error message	Slave address	0x85	Exception code [1]	---		

[1] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 5	Start address		Value	
Valid response	Slave address		Function code 5	Length	Value		
Error message	Slave address		0x85	Exception code [1]	---		

[1] E code: 01 or 02 or 03 or 04

Function code 6 - This function allows individual registers to be written

Table 3-1004 FC 6 - Write hold register

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 6	Address		Register	
Valid response	Slave address	Function code 6	Address		Register	
Error message	Slave address	0x86	Exception code [1]	---		

[1] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 6	Address		Register	
Valid response	Slave address		Function code 6	Address		Register	
Error message	Slave address		0x86	Exception code [1]	---		

[1] E code: 01 or 02 or 03 or 04

Function code 8 - This function is used to check the communication connection

Table 3-1005 FC 8 - Slave status

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 8	Diagnostic code		Test value	
Valid response	Slave address	Function code 8	Diagnostic code		Test value	
Error message	Slave address	0x88	Exception code [1]	---		

[1] E code: 01 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 8	Diagnostic code		Test value	
Valid response	Slave address		Function code 8	Diagnostic code		Test value	
Error message	Slave address		0x88	Exception code [1]	---		

[1] E code: 01 or 03 or 04

Function code 11 - This function can read 2 bytes of "Status word" and 2 bytes of "Event counter"

Table 3-1006 FC 11 - Event counter for slave communication

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 11	---			
Valid response	Slave address	Function code 11	Status		Event counter	
Error message	Slave address	0x8B	Exception code [1]	---		

[1] E code: 01 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 11	---			
Valid response	Slave address		Function code 11	Status		Event counter	
Error message	Slave address		0x8B	Exception code [1]	---		

[1] E code: 01 or 04

Function code 15 - This function allows multiple bits to be written

Table 3-1007 FC 15 - Write one/multiple output bits

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte n
Query	Slave address	Function code 15	Start address		Number of output words		Byte counter [1]	Value	
Valid response	Slave address	Function code 15	Start address		Number of output words		---		
Error message	Slave address	0x8F	Exception code [2]	---					

[1] Byte counter: If there is a remainder when the number of bytes is divided by 8, the number of bytes must be increased by 1.

[2] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte n
Query	Slave address		Function code 15	Start address		Number of output words		Byte counter [1]	Value	
Valid response	Slave address		Function code 15	Start address		Number of output words		---		
Error message	Slave address		0x8F	Exception code [2]		---				

[1] Byte counter: If there is a remainder when the number of bytes is divided by 8, the number of bytes must be increased by 1.

[2] E code: 01 or 02 or 03 or 04

Function code 16 - This function allows individual or multiple registers to be written

Table 3-1008 FC 16 - Write one/multiple hold registers

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte n
Query	Slave address	Function code 16	Start address		Number of registers		Byte counter [1]	Value	
Valid response	Slave address	Function code 16	Start address		Number of registers		---		
Error message	Slave address	0x90	Exception code [2]	---					

[1] Byte counter: Number of registers * 2

[2] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte n
Query	Slave address		Function code 16	Start address		Number of registers		Byte counter [1]	Value	
Valid response	Slave address		Function code 16	Start address		Number of registers		---		
Error message	Slave address		0x90	Exception code [2]		---				

[1] Byte counter: Number of registers * 2

[2] E code: 01 or 02 or 03 or 04

5.4.2.7 Error messages

Overview of the Modbus error messages

Error code	Description	Solution
16#0000	No error	-
Configuration error of the interface - Modbus_Comm_Load		
16#8181	The module does not support this data transmission rate.	Select a valid data transmission rate for the module at the BAUD parameter.
16#8182	The module does not support this parity setting.	Select a suitable value for "Parity" at the PARITY parameter. The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
16#8183	The module does not support this type of data flow control.	Select a valid data flow control for the module at the FLOW_CTRL parameter.
16#8184	Invalid value for "Response timeout".	Select a suitable value for "Response timeout" at the RESP_TO parameter. Valid range of values: 1 to 65535 (ms)
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the Send_Config.RDREC.STATUS or Receive_Config.RDREC.STATUS static parameters or RDREC.STATUS and in the description of the SFB RDREC. More information on the error code is available in the FAQ with entry ID 109815286 on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109815286).
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the Send_Config.WRREC.STATUS or Receive_Config.WRREC.STATUS static parameters or WRREC.STATUS and in the description of the SFB WRREC. More information on the error code is available in the FAQ with entry ID 109815286 on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109815286).
16#8282	Module not available	Check the input at the PORT parameter and ensure that the module can be reached.

1) Only with instructions for S7-300/400 CPUs

Error code	Description	Solution
Configuration error - Modbus_Slave		
16#8186	Invalid slave address	Select a suitable slave address at the MB_ADDR parameter. The following are valid: 1-247 at standard address area; 1-65535 at extended address area (0 is reserved for Broadcast)
16#8187	Invalid value at MB_HOLD_REG parameter	Select a suitable value for the hold register at the MB_HOLD_REG parameter.
16#8188	Invalid operating mode or broadcast (MB_ADDR = 0) and MODE parameter ≠ 1	Select the value 1 for MODE in Broadcast mode or select a different operating mode.
16#818C	The pointer to a MB_HOLD_REG area must be a data block or a bit memory address area.	Select a suitable value for the pointer to the MB_HOLD_REG area.
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC. More information on the error code is available in the FAQ with entry ID 109815286 on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109815286).
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.WRREC.STATUS or Receive_P2P.WRREC.STATUS, and in the description of the SFB WRREC. More information on the error code is available in the FAQ with entry ID 109815286 on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109815286).
16#8389	Invalid data area definition: • Illegal value of data_type • DB number not permitted or not available: – Invalid value of db – DB number does not exist – DB number is already being used by another data area – DB with optimized access – DB is not in work memory • Illegal valid for length • Overlapping of MODBUS address areas that belong to the same MODBUS data type	Check the definition of the data areas. See section Access to data areas in DBs instead of direct access to MODBUS addresses as of version V4.0 (Page 123)
16#8452 [1]	MB_HOLD_REG is not a pointer to a DB or a bit memory area	Check the MB_HOLD_REG pointer
16#8453 [1]	MB_HOLD_REG is not a pointer of type BOOL or WORD	Check the MB_HOLD_REG pointer

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Solution
16#8454 [1]	The area addressed by MB_HOLD_REG is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the MB_HOLD_REG pointer
16#8455 [1]	MB_HOLD_REG points to a write-protected DB	Check the MB_HOLD_REG pointer
16#8456 [1]	Error during instruction execution. The cause of the error is shown in the STATUS parameter.	Determine the value of the SFCSTATUS parameter. Check what this means in the description for SFC51, STATUS parameter.
Configuration error - Modbus_Master		
16#8180	Invalid value for MB_DB parameter	The value configured for MB_DB (instance data DB) at the Modbus_Comm_Load instruction is not valid. Check the interconnection of the Modbus_Comm_Load instruction and its error messages.
16#8186	Invalid station address	Select a suitable station address at the MB_ADDR parameter. The following are valid: 1-247 at standard address area; 1-65535 at extended address area (0 is reserved for Broadcast)
16#8188	Invalid operating mode or broadcast (MB_ADDR = 0) and MODE parameter ≠ 1	Select the value 1 for MODE in Broadcast mode or select a different operating mode.
16#8189	Invalid data address	Select a suitable value for the data address at the DATA_ADDR parameter. See description Modbus_Master (Page 111) in the Info system
16#818A	Invalid length	Select a suitable data length at the DATA_LEN parameter. See description Modbus_Master (Page 111) in the Info system
16#818B	Invalid value for DATA_PTR	Select a suitable value for the data pointer at the DATA_PTR parameter (M or DB address). See description Modbus_Master (Page 111) in the Info system
16#818C	Interconnection error of the DATA_PTR parameter	Check the interconnection of the instruction.
16#818D	The area addressed by DATA_PTR is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the DATA_PTR pointer
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC. More information on the error code is available in the FAQ with entry ID 109815286 on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109815286).

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Solution
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.WRREC.STATUS or Receive_P2P.WRREC.STATUS or Receive_Reset and in the description of the SFB WRREC. More information on the error code is available in the FAQ with entry ID 109815286 on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109815286).
Communication errors - Modbus_Master and Modbus_Slave		
16#80D1	The wait time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or change the parameters, if necessary.
16#80D2	"Hardware RTS always ON": Send job canceled due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ON for the entire duration of transmission.
16#80E0	Frame aborted: Send buffer overflow / send frame too long	In the user program call the instruction more often or configure a communication with data flow control.
16#80E1	Frame aborted: Parity error	Check the connection line of the communication partners, or verify that the same data transmission rate, parity and stop bit number are configured for both devices.
16#80E2	Frame aborted: Character frame error	Check the settings for start bit, data bits, parity bit, data transmission rate, and stop bit(s).
16#80E3	Frame aborted: Character overflow error	Check the number of data in the frame of the communication partner.
16#80E4	Frame aborted: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1-1024/2048/4096 (bytes)
Communication error - Modbus_Master		
16#80C8	The slave does not respond within the set time	Check the data transmission rate, parity and wiring of the slave.
16#80C9	The slave does not respond within the time set by Blocked_Proc_Timeout.	Check the setting for Blocked_Proc_Timeout. Check if the module has been configured with the Modbus_Comm_Load instruction. The module may possibly need to be reconfigured using Modbus_Comm_Load after a pull/plug or after voltage recovery.
16#8200	The interface is busy with an ongoing request.	Repeat the command later. Make sure that there are no commands still running before you start a new one.
Protocol error - Modbus_Slave (only communications modules that support Modbus)		
16#8380	CRC error	Checksum error of the Modbus frame. Check the communication partner.
16#8381	The function code is not supported or is not supported for broadcast.	Check the communication partner and make sure that a valid function code is sent.

1) Only with instructions for S7-300/400 CPUs

Error code	Description	Solution
16#8382	Invalid length information in the request frame	Select a suitable data length at the DATA_LEN parameter.
16#8383	Invalid data address in the request frame	Select a suitable value for the data address at the DATA_ADDR parameter.
16#8384	Invalid data value error in the request frame	Check the data value in the request frame of the Modbus master
16#8385	The diagnostic value is not supported by the Modbus slave (function code 08)	The Modbus slave only supports the diagnostic values 16#0000 and 16#000A.
Protocol error - Modbus_Master (only communications modules that support Modbus)		
16#8380	CRC error	Checksum error of the Modbus frame. Check the communication partner.
16#8381	Response frame from Modbus slave with the following error message: The function code is not supported.	Check the communication partner and make sure that a valid function code is sent.
16#8382	Response frame from Modbus slave with the following error message: Invalid length	Select a suitable data length.
16#8383	Response frame from Modbus slave with the following error message: Invalid data address in the request frame	Select a suitable value for the data address at the DATA_ADDR parameter.
16#8384	Response frame from Modbus slave with the following error message: Data value error	Check the request frame to the Modbus slave.
16#8385	Response frame from Modbus slave with the following error message: The diagnostic value is not supported by the Modbus slave	The Modbus slave only supports the diagnostic values 16#0000 and 16#000A.
16#8386	The returned function code does not match the requested function code.	Check the response frame and the addressing of the slave.
16#8387	A slave that was not requested answers	Check the response frame of the device. Check the address settings of the slave.
16#8388	Error in the response of the slave to a write request.	Check the response frame of the slave.
16#8828 [1)]	DATA_PTR points to a bit address that is not equal to n * 8	Check the DATA_PTR pointer
16#8852 [1)]	DATA_PTR is not a pointer to a DB or a bit memory area	Check the DATA_PTR pointer
16#8853 [1)]	DATA_PTR is not a pointer of type BOOL or WORD	Check the DATA_PTR pointer
16#8855 [1)]	DATA_PTR points to a write-protected DB	Check the DATA_PTR pointer
16#8856 [1)]	Error during call of SFC51	Call the Modbus_Master instruction again
Error - Modbus_Slave (only communications modules that support Modbus)		
16#8428 [1)]	MB_HOLD_REG points to a bit address that is not equal to n * 8	Check the MB_HOLD_REG pointer
16#8452 [1)]	MB_HOLD_REG is not a pointer to a DB or a bit memory area	Check the MB_HOLD_REG pointer
16#8453 [1)]	MB_HOLD_REG is not a pointer of type BOOL or WORD	Check the MB_HOLD_REG pointer
16#8454 [1)]	The area addressed by MB_HOLD_REG is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the MB_HOLD_REG pointer
16#8455 [1)]	MB_HOLD_REG points to a write-protected DB	Check the MB_HOLD_REG pointer

[1)] Only with instructions for S7-300/400 CPUs

Error code	Description	Solution
16#8456 [1]	Error during call of SFC51	Call the Modbus_Slave instruction again
Error codes, general		
16#8FFF	The module is not ready temporarily due to a reset.	Repeat the request.

[1] Only with instructions for S7-300/400 CPUs

5.4.3 USS

5.4.3.1 Dependencies between library versions

Use the "USS" and "Point-to-point" instruction libraries only in one of the following combinations of versions:

"USS" library version	"Point-to-point" library version
V1.3	V1.1
V2.4	V2.4
V3.1	V2.4
V4.3	V3.2
V5.0	V4.0
V5.1	V4.1

5.4.3.2 Overview of USS communication

USS communication

The USS instructions control the operation of drives which support the protocol of the universal serial interface (USS). You can communicate with several drives by means of RS485 connections and the USS instructions with the PtP communication modules. Each RS 485 port can typically operate up to 16 drives. Some communication modules can even operate up to 31 drives.

The USS protocol uses a master-slave network for communication via a serial bus. The master uses an address parameter to send data to a selected slave. A slave cannot send without having first received a send request. Communication between individual slaves is not possible. USS communication takes place in half-duplex mode. The figure below shows a network diagram for a sample application with 16 drives.

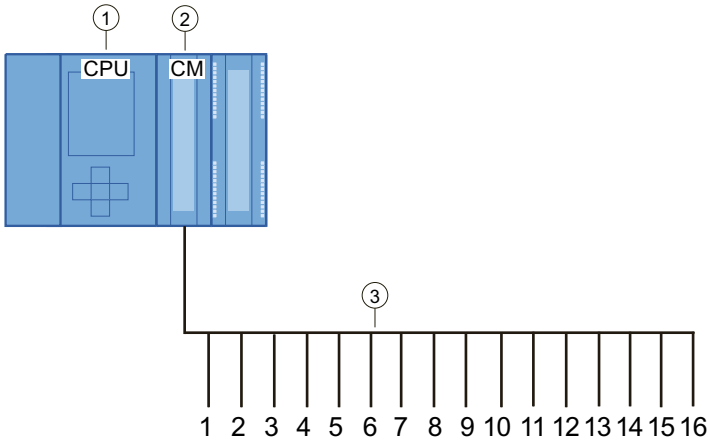

① CPU

② CM

③ USS drives in a USS network

Figure 3-771 Wiring example with S7-1500 communication module

NOTE

Communicating with a drive via RS232

You can basically also use CM PtP RS232 BA and CM PtP RS232 HF for communication with a drive. However, only **one** drive can be connected to an RS232 port.

Communicating with a drive via RS422

You can basically also use the RS422 interface of the CM PtP RS422/485 BA and CM PtP RS422/485 HF for communication with a drive. However, only **one** drive can be connected to an RS422 port.

USS instructions in your program

- USS_Port_Scan: The instruction USS_Port_Scan allows you to communicate via a communication module with up to 16 drives using a USS network (must be called cyclically).

  There is only one USS_Port_Scan instruction per PtP communication port in the program, and it controls transmission to all drives.

- USS_Drive_Control: The instruction USS_Drive_Control allows you to prepare the send data from USS_Port_Scan for a drive and display its receive data.

  USS_Drive_Control configures the data to be sent and evaluates the data received in a previous request from USS_Port_Scan.

- USS_Read_Param: The instruction USS_Read_Param allows you to read parameters from a drive.
- USS_Write_Param: The instruction USS_Write_Param allows you to change parameters in a drive.

5.4.3.3 Requirements for using the USS protocol

The four USS instructions use 2 FBs and 2 FCs to support the USS protocol. For each USS network, one instance data block (DB) is used for USS_Port_Scan and one instance data block for all calls of USS_Drive_Conrol.

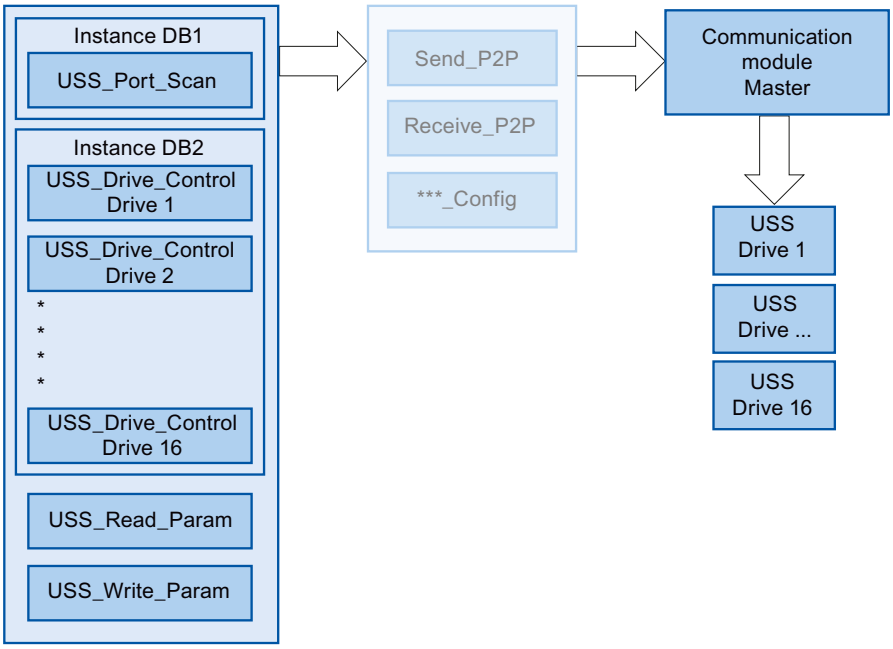

Figure 3-772 USS program sequence

All drives (max. 16) that are connected to one RS485 port are part of the same USS network. All drives that are connected to another RS485 port are part of a different USS network. Each USS network is managed using a unique instance data block for all USS_Drive_Control instructions and one further instance data block for the USS_Port_Scan instruction. All instructions that are part of a USS network must share this instance data block for USS_Drive_Conrol. The USS_Port_Scan, USS_Read_Param and USS_Write_Param instructions have the USS_DB parameter for this function. This parameter must be connected to the (static) USS_DB parameter of the instance DB of the USS_Drive_Control instruction.

- The instructions USS_Drive_Control and USS_Port_Scan are function blocks (FB). If you add the USS_Drive_Control or USS_Port_Scan instruction to the programming editor, you are prompted to assign a DB for this FB in the "Call options" dialog. If it is the first USS_Drive_Control instruction in this program for this USS network, you can apply the DB standard assignment (or change the name, if necessary) and the new DB is created for you. If, however, it is not the first USS_Drive_Control instruction for this drive, you need to select the DB which has already been assigned to this USS network from the drop-down list in the "Call options" dialog.

- The USS_Write_Param and USS_Read_Param instructions are functions (FCs). No DB is assigned when you add these FCs in the editor. If you add these FCs or the USS_Port_Scan instruction in the editor, you need to assign the USS_DB parameter of the corresponding USS_Drive_Control instance DB to the USS_DB input of these instructions. Double-click the parameter field and click the symbol to display the available DBs. Enter a period "." and select the USS_DB parameter from the drop-down list.
- The USS_Port_Scan function controls communication between the CPU and the drives via the point-to-point RS485 communication port. A communication with the drive is processed every time you call this function. Your program must call this function fast enough so that the drives do not signal a timeout. To ensure a constant time response for frame communication, you should call this instruction in a cyclic interrupt OB.
- The USS_Drive_Control instruction gives your program access to a specified drive in the USS network. Its inputs and outputs correspond to the states and operating functions of the drive. If there are 16 drives in your network, you must call USS_Drive_Control at least 16 times in your program, i.e. once for each drive.

  You should only call the USS_Drive_Control instruction from a cyclic OB.
- The operating parameters of the drive are read and written with the USS_Read_Param and USS_Write_Param functions. These parameters control the internal operation of the drive. See the drive manual for a definition of these parameters. Your program may include any number of these functions, but only one read or write request may be active for a drive at any particular time. You may only call the USS_Read_Param and USS_Write_Param functions from the cycle OB of a main program.

NOTICE

USS instruction calls

Only ever call USS_Drive_Control, USS_Read_Param or USS_Write_Param from a cycle OB of the main program. The USS_Port_Scan instruction function can be called from any OB, but it is usually called from a cyclic interrupt OB.

Do not use the USS_Drive_Control, USS_Read_Param or USS_Write_Param instruction in an OB with a higher priority than the corresponding USS_Port_Scan instruction. For example, do not add USS_Port_Scan to the main program or USS_Read_Param to a cyclic interrupt OB. You may encounter unexpected errors if the execution of USS_Port_Scan is interrupted by another instruction.

NOTE

Parameter ID value

You need to configure the use of 4 PIV words (ParameterIDValue) for the drives.

Calculating time for communication with the drive

Communication with the drive takes place asynchronously to the cycle of the CPU. The CPU usually runs through several cycles before communication with a drive is complete.

To ensure that the watchdog set for the drive is not triggered, the send frames must be sent to the drive within the watchdog time. You must allow for the number of any retries which may be needed to complete the transaction if communication errors occur. By default, up to 2 retries are made for each transaction with the USS protocol.
The maximum time interval between two send frames is calculated as follows:

N * (5 * cycle time + frame runtime + timeout of the receive frame max.) * (number of transmission attempts)

N	Number of drives in this network
Factor 5	5 cycles are typically needed for sending and receiving frames.
Cycle time	Max. cycle time of the cyclic interrupt OB in which the USS_Port_Scan instruction is called.
Frame runtime	Frame time = (number of characters per frame) * (11 Bit per character) / (data transmission rate in Bit/s)
Number of transmission attempts	Number of retries + 1
Timeout of the receive frame	RCVTIME (if no response is received from the drive)
Timeout of the receive frame max.	RCVTIME + MSGTIME (if an incomplete answer is received shortly before the expiration of RCVTIME and monitoring of MSGTIME has expired **or** if a response is still being processed at the expiration of RCVTIME, the timeout is extended by the MSGTIME)

The following times apply for "Received frame timeout" (ms):

Bit/s	**115200**	**57600**	**38400**	**19200**	**9600**	**4800**	**2400**	**1200**
Receive_Conditions.END. RCVTIME	25	29	33	56	72	100	100	100
Receive_Conditions.END. MSGTIME	25	29	33	56	72	124	240	460

Timeout of the receive frame max. = (Receive_Conditions.END.RCVTIME (0.072 s) + Receive_Conditions.END.MSGTIME (0.072 s))

Example:

5 drives
Data transmission rate = 9600 bps
28 characters per frame
Cycle time = 0.020 s
Number of retries = 2

Time interval = 5 * ((5*0.02) + ((1*28*11)/9600) + 0.072 + 0.072) * (2+1) = 4.14 (seconds)

The time monitoring of the drive must be set to about 4 seconds in this case.

NOTE

Option for performance optimization

When the performance optimization option is activated, the maximum time interval between two send telegrams is determined by the OB cycle (Send_P2P and Receive_P2P), the telegram length and the baud rate are decisive.

5.4.3.4 USS_Port_Scan / USS_Port_Scan_31: Communication by means of a USS network

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

NOTE
Using the USS_Port_Scan_31 instruction
It is only possible to use the USS_Port_Scan_31 instruction on an S7-1500 CPU.

Description

The USS_Port_Scan instruction processes the communication by means of a USS network for max. 16 drives.

The USS_Port_Scan_31 instruction processes the communication by means of a USS network for max. 31 drives.

STEP 7 automatically creates the instance DB when you add the instruction.

Parameters

Parameter	Declaration	Data type		Standard	Description
		S7-1200/1-500	S7-300/40-0/ WinAC		
PORT	IN	Port	Word	0	Specifies the communications module which is used for the communication: • For S7-1500/S7-1200: "HW identifier" from the device configuration. The symbolic port name is assigned in the "System constants" tab of the PLC tag table and can be applied from there. • for S7-300/S7-400: "Input address" from the device configuration. In the S7-300/400/WinAC systems, the input address assigned in the hardware configuration is assigned to the PORT parameter.
BAUD	IN	DInt		9600	Data transmission rate for USS communication The following are valid: • 1200 bps • 2400 bps • 4800 bps • 9600 bps • 19200 bps • 38400 bps • 57600 bps • 115200 bps

Parameter	Declaration	Data type		Standard	Description
		S7-1200/1-500	S7-300/400/WinAC		
USS_DB	INOUT	USS_BASE		–	The USS_DB parameter must be connected to the (static) USS_DB parameter of the instance DB which is generated and initialized when you add a USS_Drive_Control / USS_Drive_Control_31 instruction to your program.
COM_RST	INOUT	---	Bool	FALSE	Initialization of the USS_Port_Scan / USS_Port_Scan_31 instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE. Note: The parameter is only available for S7-300/400 instructions.
ERROR	OUT	Bool		FALSE	If TRUE, this output indicates that an error has occurred and that the STATUS output is valid. You may need to check the value of the static tag USS_DB. w_USSExtendedError in the instance DB of the USS_Drive_Control / USS_Drive_Control_31 instruction.
STATUS	OUT	Word		0	Error code (see Error messages (Page 156)).

There is only one USS_Port_Scan / USS_Port_Scan_31 instruction per PtP communication port in the program and each call of this instruction controls a transmission to or from all drives in this network. All USS functions assigned to one USS network and one PtP communication port must use the same instance DB.

Your program must execute the USS_Port_Scan / USS_Port_Scan_31 instruction often enough to prevent a timeout in the drive (see Requirements for using the USS protocol (Page 139) "Calculating time for communication with the drive").

The USS_Port_Scan / USS_Port_Scan_31 instruction is usually called from a cyclic interrupt OB to prevent drive timeouts and to make the last USS data updates available for calls of USS_Drive_Control / USS_Drive_Control_31 .

USS_Port_Scan / USS_Port_Scan_31 data block tags

The table below shows the public static tags in the instance DB of USS_Port_Scan / USS_Port_Scan_31 that you can use in your program.

Table 3-1009 Static tags in the instance DB

Tag	Data type	Standard	Description
MODE	USInt	4	Operating mode Valid operating modes are: • 0 = Full duplex (RS232) • 1 = Full duplex (RS422) four-wire mode (point-to-point) • 2 = Full duplex (RS 422) four-wire mode (multipoint master; CM PtP (ET 200SP)) • 3 = Full duplex (RS 422) four-wire mode (multipoint slave; CM PtP (ET 200SP)) • 4 = Half duplex (RS485) two-wire mode [1]

[1] Required setting for the use of PROFIBUS cables with CM 1241 for RS485

Tag	Data type	Standard	Description
LINE_PRE	USInt	2	Receive line initial state Valid initial states are: • 0 = "No" initial state [1)] • 1 = signal R(A)=5 V, signal R(B)=0 V (break detection): Break detection is possible with this initial state. Can only be selected with: "Full duplex (RS422) four-wire mode (point-to-point connection)" and "Full duplex (RS422) four-wire mode (multipoint slave)". • 2 = signal R(A)=0 V, signal R(B)=5 V: This default setting corresponds to the idle state (no active send operation). No break detection is possible with this initial state.
BRK_DET	USInt	0	Activate diagnostics interrupt: • 0 - not activated • 1 - activated
RETRIES_MAX	SInt/Byte	2	Number of retries when communication errors occur. You can use this parameter to set the number of send retries for a request frame if the response frame is not received within the set time.
EN_DIAG_ALARM	Bool	0	Activate diagnostics interrupt: • 0 - not activated • 1 - activated
EN_SUPPLY_VOLT	Bool	0	Enable diagnostics for missing supply voltage L+ • 0 - not activated • 1 - activated

1) Required setting for the use of PROFIBUS cables with CM 1241 for RS485

Version 2.5 is functionally identical to version 2.4 and its version number was only incremented due to internal measures.

Instruction versions

USS_Port_Scan:

Version 2.5 is functionally identical to version 2.4 and its version number was only incremented due to internal measures.

USS_Port_Scan_31:

Version 1.2 is functionally identical to version 1.1 and its version number was only incremented due to internal measures.

5.4.3.5 USS_Drive_Control / USS_Drive_Control_31: Preparing and displaying data for the drive

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

NOTE
Using the USS_Drive_Control_31 instruction
It is only possible to use the USS_Drive_Control_31 instruction on an S7-1500 CPU.

Description

The USS_Drive_Control instruction prepares send data for max. 16 drives and evaluates the response data of the drives.

The USS_Drive_Control_31 instruction prepares send data for max. 31 drives and evaluates the response data of the drives.

You need to use a separate instance of the instruction for each drive, and all USS functions assigned to one USS network and one PtP communication port must use the same instance DB. You must enter the DB name when you add the first USS_Drive_Control / USS_Drive_Control_31 instruction. You then refer to this DB that was created when the first instruction was added.

STEP 7 automatically creates the DB when you add the instruction.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/4-00/ WinAC		
RUN	IN	Bool		FALSE	Start bit of the drive: If this parameter is TRUE, this input allows you to operate the drive with the preset speed. If RUN changes to FALSE during operation of the drive, the motor coasts to a standstill. This behavior differs from disconnection of the power supply (OFF2) and braking of the motor (OFF3).
OFF2	IN	Bool		FALSE	"Coast to standstill" bit: If this parameter is FALSE, this bit causes the drive to coast to a standstill without braking.
OFF3	IN	Bool		FALSE	Fast stop bit: If this parameter is FALSE, this bit causes a fast stop by braking the drive.
F_ACK	IN	Bool		FALSE	Error acknowledgment bit: This bit resets the error bit of a drive. The bit is set after clearing the error and the drive detects this way that the previous error no longer has to be reported.

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/4-00/ WinAC		
DIR	IN	Bool		FALSE	Direction control of the drive: This bit is set if the drive is to run forward (if SPEED_SP is positive; see table "Interaction of SPEED_SP and DIR parameters").
DRIVE	IN	USInt	Byte	1	Address of the drive: This input is the address of the USS drive. The valid range is between drive 1 and drive 16.
PZD_LEN	IN	USInt	Byte	2	Word length: This is the number of PZD data words. Valid values are 2, 4, 6 or 8 words.
SPEED_SP	IN	Real		0.0	Speed setpoint: This is the speed of the drive as a percentage of the configured frequency. A positive value means that the drive runs forward (if DIR is true). The valid range is 200.00 to -200.00.
CTRL3	IN	Word		0	Control word 3: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL4	IN	Word		0	Control word 4: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL5	IN	Word		0	Control word 5: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL6	IN	Word		0	Control word 6: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL7	IN	Word		0	Control word 7: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL8	IN	Word		0	Control word 8: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the USS_Drive_Control / USS_Drive_Control_31 instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE. Note: The parameter is only available for S7-300/400 instructions.
NDR	OUT	Bool		FALSE	New data available: If this parameter is TRUE, the bit signals that data of a new communication request is available at the output.
ERROR	OUT	Bool		FALSE	Error occurred: If TRUE, this indicates that an error has occurred and that the STATUS output is valid. All other outputs are set to zero in the event of an error. Communication errors are only signaled at the ERROR and STATUS outputs of the USS_Port_Scan / USS_Port_Scan_31 instruction.
STATUS	OUT	Word		0	Error code (see Error messages (Page 156)).
RUN_EN	OUT	Bool		FALSE	Operation enabled: This bit signals if the drive is running.

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/4-00/ WinAC		
D_DIR	OUT	Bool		FALSE	Drive direction: This bit signals if the drive is running forward. • FALSE – forward • TRUE – backward
INHIBIT	OUT	Bool		FALSE	Drive blocked: This bit signals the status of the block bit for the drive. • FALSE – not blocked • TRUE – blocked
FAULT	OUT	Bool		FALSE	Drive error: This bit signals that an error occurred in the drive. You must remedy the fault and set the F_ACK bit to clear this bit.
SPEED	OUT	Real		0.0	Actual value drive speed (scaled value of STATUS 2 of the drive): This is the speed of the drive as a percentage of the configured speed.
STATUS1	OUT	Word		0	STATUS 1 of the drive This value includes fixed status bits of a drive.
STATUS3	OUT	Word		0	STATUS 3 of the drive This value includes a user-definable status word of the drive.
STATUS4	OUT	Word		0	STATUS 4 of the drive This value includes a user-definable status word of the drive.
STATUS5	OUT	Word		0	STATUS 5 of the drive This value includes a user-definable status word of the drive.
STATUS6	OUT	Word		0	STATUS 6 of the drive This value includes a user-definable status word of the drive.
STATUS7	OUT	Word		0	STATUS 7 of the drive This value includes a user-definable status word of the drive.
STATUS8	OUT	Word		0	STATUS 8 of the drive This value includes a user-definable status word of the drive.

When the initial execution of USS_Drive_Control / USS_Drive_Control_31 takes place, the drive specified by the USS address (DRIVE parameter) is initialized in the instance DB. After initialization, subsequent USS_Port_Scan / USS_Port_Scan_31 instructions can start communication with the drive from this drive number.

If you change the drive number, you must first place the CPU in STOP and then back in RUN to initialize the instance DB. The input parameters are configured in the USS send buffer and any outputs are read from a "previous" valid response buffer. USS_Drive_Control / USS_Drive_Control_31 only configures the data to be sent and evaluates data received in a previous request.

You can control the drive's direction of rotation by using the D_IR input (Bool) or the sign (positive or negative) at the SPEED_SP input (Real). The table below explains how these inputs work together to determine the direction of rotation of the drive, provided the motor rotates forward.

Table 3-1010 Interaction of SPEED_SP and DIR parameters

SPEED_SP	DIR	Direction of rotation of the drive
Value > 0	0	Backward
Value > 0	1	Forward
Value < 0	0	Forward
Value < 0	1	Backward

USS_Drive_Control / USS_Drive_Control_31 data block tags

The table below shows the public static tags in the instance DB of USS_Drive_Control / USS_Drive_Control_31 that you can use in your program.

Table 3-1011 Static tags in the instance DB

Tag	Data type	Standard	Description
USS_DB. w_USSExtendedEr-ror	Word	16#0	USS Drive Extended Error Code - drive-specific value The meaning of the error message depends on which instruction reported an error **first** (ERROR = TRUE). The following cases are distinguished: • USS_Write_Param / USS_Write_Param_31: You can find the meaning of the error code in the description of the drive. • USS_Read_Param / USS_Read_Param_31: You can find the meaning of the error code in the description of the drive. • USS_Port_Scan / USS_Port_Scan_31: Number of the drive affected by the error message.

Instruction versions

USS_Drive_Control:

Version 2.0 is functionally identical to version 1.2 and its version number was only incremented due to internal measures.

USS_Drive_Control_31:

Version 2.0 is functionally identical to version 1.0 and its version number was only incremented due to internal measures.

5.4.3.6 USS_Read_Param / USS_Read_Param_31: Read data from drive

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

NOTE
Using the USS_Read_Param_31 instruction
It is only possible to use the USS_Read_Param_31 instruction on an S7-1500 CPU.

Description

The USS_Read_Param instruction reads a parameter from one of max. 16 drives.

The USS_Read_Param_31 instruction reads a parameter from one of max. 31 drives.

All USS functions assigned to one USS network and one PtP communication port must use the instance data block of the USS_Drive_Control / USS_Drive_Control_31 instruction. USS_Read_Param / USS_Read_Param_31 must be called from a cycle OB of the main program.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		–	A positive edge at REQ creates a new read request.
DRIVE	IN	USInt	Byte	–	Address of the drive: DRIVE is the address of the USS drive. The valid range is between drive 1 and drive 16.
PARAM	IN	UInt		–	Parameter number: PARAM specifies the drive parameter to write. The range for this parameter is between 0 and 2047. With some drives, the most significant byte of the INDEX parameter can be used to access parameter values greater than 2047. Additional information on access to an extended range is available in your drive manual.
INDEX	IN	UInt		–	Parameter index: INDEX specifies the drive parameter index to which to write. It is a 16-bit value in which the least significant bit is the actual index value with a range of (0 to 255). The drive can also use the most significant byte, which is drive-specific. Additional information is available in your drive manual.

[1] The DONE bit indicates that valid data was read out of the referenced motor drive and transmitted to the CPU. It does not indicate that the instruction is cabable of immediately read an additional parameter. An empty read request must be sent to the motor drive and acknowledged by the instruction before the parameter channel is freed up for use by the respective drive. The immediate call of USS_Read_Param / USS_Read_Param_31 or USS_Write_Param / USS_Write_Param_31 for the specific motor drive results in error 16#818A.

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
USS_DB	INOUT	USS_BASE		–	The USS_DB parameter must be connected to the (static) USS_DB parameter of the instance DB which is generated and initialized when you add a USS_Drive_Control / USS_Drive_Control_31 instruction to your program.
DONE[1]	OUT	Bool		FALSE	If this parameter is TRUE, the previously requested value of the read parameter is available at the VALUE output. This bit is set when the USS_Drive_Control / USS_Drive_Control_31 instruction recognizes the read response of the drive. This bit is reset the next time USS_Read_Param / USS_Read_Param_31 is called.
ERROR	OUT	Bool		FALSE	ERROR = TRUE: An error has occurred and the STATUS output is valid. All other outputs are set to zero in the event of an error. Communication errors are only signaled at the ERROR and STATUS outputs of the USS_Port_Scan / USS_Port_Scan_31 instruction. You may need to check the value of the static tag USS_DB. w_USSExtendedError in the instance DB of the USS_Drive_Control / USS_Drive_Control_31 instruction.
STATUS	OUT	UInt		0	Error code (see Error messages (Page 156)).
VALUE	OUT	Variant (Word, Int, UInt, DWord, DInt, UDInt, Real)	Any (Word, Int, DWord, DInt, Real)	–	This is the value of the parameter that was read and is only valid if the DONE bit is true.

[1] The DONE bit indicates that valid data was read out of the referenced motor drive and transmitted to the CPU. It does not indicate that the instruction is cabable of immediately read an additional parameter. An empty read request must be sent to the motor drive and acknowledged by the instruction before the parameter channel is freed up for use by the respective drive. The immediate call of USS_Read_Param / USS_Read_Param_31 or USS_Write_Param / USS_Write_Param_31 for the specific motor drive results in error 16#818A.

Instruction versions

USS_Read_Param:

Version 1.5 is functionally identical to version 1.4 and its version number was only incremented due to internal measures.

USS_Read_Param_31:

Version 1.1 is functionally identical to version 1.0 and its version number was only incremented due to internal measures.

5.4.3.7 USS_Write_Param / USS_Write_Param_31: Change data in drive

NOTE
Use with CM1241
The use of this instruction with a CM1241 is only possible from firmware version V2.1 of the module.

NOTE
Using the USS_Write_Param_31 instruction
It is only possible to use the USS_Write_Param_31 instruction on an S7-1500 CPU.

NOTE
For EEPROM write instructions (EEPROM in a USS drive):
Keep the number of EEPROM write operations to a minimum in order to maximize the EEPROM service life.

Description

The USS_Write_Param instruction changes a parameter in one of max. 16 drives.

The USS_Write_Param_31 instruction changes a parameter in one of max. 31 drives.

All USS functions assigned to one USS network and one PtP communication port must use the instance data block of the USS_Drive_Control / USS_Drive_Control_31.

USS_Write_Param / USS_Write_Param_31 must be called from the cycle OB of a main program.

Parameters

Table 3-1012 Data types for the parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
REQ	IN	Bool		–	A positive edge at REQ creates a new write request.
DRIVE	IN	USInt	Byte	–	Address of the drive: DRIVE is the address of the USS drive. The valid range is between drive 1 and drive 16.

[1] The DONE bit indicates that valid data was read out of the referenced motor drive and transmitted to the CPU. It does not indicate that the USS library is able to read out an additional parameter immediately. An empty write request must be sent to the motor drive and acknowledged by the instruction before the parameter channel is freed up for use by the respective drive. The immediate call of USS_Read_Param / USS_Read_Param_31 or USS_Write_Param / USS_Write_Param_31 FC for the specific motor drive results in error 0x818A.

Parameters	Declaration	Data type		Standard	Description
		S7-1200/1500	S7-300/400/WinAC		
PARAM	IN	UInt		–	Parameter number: PARAM specifies the drive parameter to write. The range for this parameter is between 0 and 2047. With some drives, the most significant byte of the INDEX parameter can be used to access parameter values greater than 2047. Additional information on access to an extended range is available in your drive manual.
INDEX	IN	UInt		–	Parameter index: INDEX specifies the drive parameter index to which to write. It is a 16-bit value in which the least significant bit is the actual index value with a range of (0 to 255). The drive can also use the most significant byte, which is drive-specific. Additional information is available in your drive manual.
EEPROM	IN	Bool		–	Save in EEPROM of the drive: If TRUE, the transaction of a parameter for writing to the drive is saved in the EEPROM of the drive. If FALSE, the written value is saved only temporarily and is lost the next time you switch on the drive.
VALUE	IN	Variant (Word, Int, UInt, DWord, DInt, UDInt, Real)	Any (Word, Int, DWord, DInt, Real)	–	Value of the parameter in which you want to write. It must be valid with a positive edge of REQ.
USS_DB	INOUT	USS_BASE		–	The USS_DB parameter must be connected to the (static) USS_DB parameter of the instance DB which is generated and initialized when you add a USS_Drive_Control / USS_Drive_Control_31 instruction to your program.
DONE[1]	OUT	Bool		FALSE	If TRUE, the VALUE input is written to the drive. This bit is set when the USS_Drive_Control / USS_Drive_Control_31 instruction recognizes the write response of the drive. This bit is reset the next time USS_Write_Param / USS_Write_Param_31 is called.
ERROR	OUT	Bool		FALSE	If TRUE, an error has occurred and the STATUS output is valid. All other outputs are set to zero in the event of an error. Communication errors are only signaled at the ERROR and STATUS outputs of the USS_Port_Scan / USS_Port_Scan_31 instruction. You may need to check the value of the static tag USS_DB.w_USSExtendedError in the instance DB of the USS_Drive_Control / USS_Drive_Control_31 instruction.
STATUS	OUT	UInt		0	Error code (see Error messages (Page 156)).

[1] The DONE bit indicates that valid data was read out of the referenced motor drive and transmitted to the CPU. It does not indicate that the USS library is able to read out an additional parameter immediately. An empty write request must be sent to the motor drive and acknowledged by the instruction before the parameter channel is freed up for use by the respective drive. The immediate call of USS_Read_Param / USS_Read_Param_31 or USS_Write_Param / USS_Write_Param_31 FC for the specific motor drive results in error 0x818A.

Instruction versions

USS_Write_Param:

Version 1.6 is functionally identical to version 1.5 and its version number was only incremented due to internal measures.

USS_Write_Param_31:

Version 1.1 is functionally identical to version 1.0 and its version number was only incremented due to internal measures.

5.4.3.8 General information on drive setup

Requirements for the drive setup

- You need to configure the use of 4 PIV words (**P**arameter**I**D**V**alue) for the drives.
- The drives can be configured for 2, 4, 6 or 8 PZD words (**P**ro**c**ess **d**ata area).
- The number of PZD words in the drive must correspond to the PZD_LEN input of the USS_Drive_Control instruction of the drive.
- Make sure that the data transmission rate of all drives corresponds to the BAUD input of the USS_Port_Scan instruction.
- Make sure that the drive is set up for USS communication.
- Make sure that it is specified in the drive that the frequency setpoint is provided by the USS interface.
- Make sure that the drive address is specified (areas: 1-16).
  This address must correspond to the DRIVE input at the USS_Drive_Control block of the drive.
- Make sure that the RS485 network is terminated correctly.

Connection and setup of SINAMICS V20 drive

An application example for operation of a SINAMICS V20 at an S7-1200 is available on the Internet. (http://support.automation.siemens.com/WW/view/en/63696870)

Connecting the SINAMICS V20 drive

Connection example of a SIEMENS G120(C) drive to a USS network. Connection examples for other drives are available in the manual of the respective drive.

The connection of a SINAMICS G120(C) drive to the USS network takes place via plug-in connection. The connection is short-circuit proof and isolated.

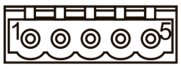

1 0 V reference potential
2 RS485N, receiving and sending (-)
3 RS485N, receiving and sending (+)
4 Cable shield
5 Not used

Figure 3-773 USS connection

NOTICE
Different reference voltages If you connect devices that do not have the same reference voltage, you may create unwanted currents in the connection cable. These unwanted currents may cause communication errors or damages in the devices. Make sure that all devices you connect with a communication cable either have the same reference conductor in the circuit or are electrically disconnected to prevent the occurrence of unwanted currents. Make sure that the shield is connected to the ground or pin 1 of the bus connector on the drive. Make sure that wiring terminal 2 (GND) of the G120(C) is connected to the ground.

If the RS485 master (e.g., S7-1200 CPU with CM1241 communication module) is connected by means of a PROFIBUS connector, wire the bus cables as follows:

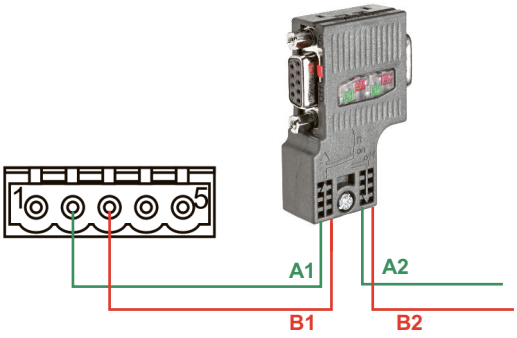

Figure 3-774 Connection of communication module

If the RS485 master is a terminating station in the network or a point-to-point connection, you must use terminals A1 and B1 (not A2 and B2) of the PROFIBUS connector, as these terminals provide termination settings (for example, with the DP plug connector 6ES7972-0BB52-0XA0).

If the G120(C) is configured as terminating station in the network, you must set the switch for the bus terminating resistor to "ON".

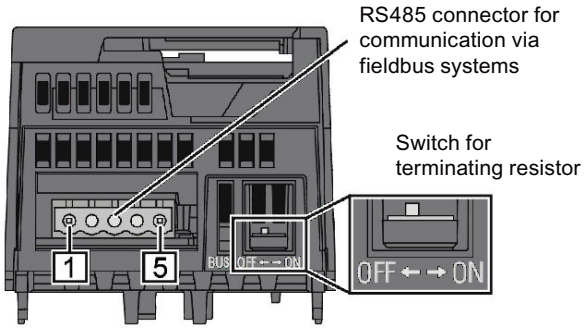

Figure 3-775 Connection of terminating stations

Setup of a G120(C) drive

Before you connect a drive to the S7-1500 or ET 200SP, make sure that the drive has the following system parameters.

Step	Instruction	Operating Instructions	
		G120 [1]	G120C [2]
1	Perform a basic commissioning of the drive with the Operator Panel BOP-2. The converter offers different defaults (macros) for its inputs and outputs and the fieldbus interface. In the ninth step of the basic commissioning (MAC PAR p15), select macro 21 for USS communication. This determines the default for the following parameters: • Data transmission rate (p2020): 38400 bps • Number of PZD (p2022): 2 • Number of PIV (p2023): variable Note: You can also conduct basic commissioning with the STARTER commissioning software or with SINAMICS Startdrive.	Chapter 4.4.3	Chapter 6.4.1
2	Specify the USS address of the converter with the address switch on the control unit of the G120 or on the G120(C). • Valid address range: 1 ... 30 Note: Yon can also set the USS address with the parameter p2021 or with STARTER or SINAMICS Startdrive.	Chapter 6.2.2.1	Chapter 8.4.2.1
	With the following steps you are accessing the parameters directly with the BOP-2 by entering their numbers and modifying their values.	Chapter 4.4.2	Chapter 6.4.2
3	Adapt the following communication-related converter parameters of your application: • Data transmission rate (p2020), of ≠ 38400 bps (Make sure that setting is identical with the BAUD parameter of the USS_Port_Scan communication instruction.) • Number of PZD (p2022), if ≠ 2 (Make sure that the setting is identical with the PZD_LEN parameter of the USS_Drive_Control communication instruction.)	Chapter 6.2.2.2	Chapter 8.4.2.1

Step	Instruction	Operating Instructions	
		G120 [1]	G120C [2]
	• Number of PIV (p2023) = 4 (Change the value set to "variable" (127) with macro 21 by default to "4" (required by instructions USS_Read_Param and USS_Write_Param.) • Fieldbus SS monitoring time [ms] (p2040)		
4	Specify the source for the speed setpoint. • n_set Eval (p1000[0]) = 6 (The speed setpoint is provided by the USS bus.)		
5	Set the reference value for speed and frequency. • n_reference f_reference (p2000) = (6,00 min^{-1} to 210000,00 min^{-1}) (all relative speeds or frequencies refer to this reference value. The reference value corresponds to 100% or 4000_{hex} (word) or 4000 0000_{hex} (double word). The following applies: $f_{reference_value}$ (in Hz) = $n_{reference_value}$ (in ((min^{-1}) / 60) x number of pole pairs))		
6	Transfer the parameters to the non-volatile memory. • Save par (p0971) = 1		

1) G120 (http://support.automation.siemens.com/WW/view/en/62089662)

2) G120(C) (http://support.automation.siemens.com/WW/view/en/61462568)

5.4.3.9 Error messages

Overview of USS error messages

Error code	Description	Remedy
16#0000	No error	-
16#8180	Length error in response of drive	Check the response frame of the drive.
16#8181	Data type error	Check the parameter VALUE.
	Parameter number error	Permissible value range of the parameter PARAM: 0 to 2047
16#8182	Data type error: "Double word" or "Real" may not be returned for the "Word" request.	Check the response frame of the drive.
16#8183	Data type error: "Word" may not be returned for the "Double word" or "Real" request.	Check the response frame of the drive.
16#8184	Checksum error in response of drive	Check the drive and the communication connection.
16#8185	Addressing error	Valid drive address range: 1 to 16
16#8186	Setpoint error	Valid setpoint range: -200% to +200%
16#8187	Incorrect drive number returned	Check the response frame of the drive.
16#8188	Invalid PZD length	Permitted PZD lengths: 2, 4, 6, 8 words
16#8189	The module does not support this data transmission rate.	Select a valid data transmission rate for the module.
16#818A	A different request for this drive is currently active.	Repeat the parameter read or write command later.
16#818B	The drive does not respond.	Check the drive.

1) Only with instructions for S7-300/400 CPUs

Error code	Description	Remedy
16#818C	The drive responds with an error message to a parameter request.	Check the response frame of the drive. Check the parameter request. Check if the instructions USS_Read_Param, USS_Write_Param or USS_Port_Scan have reported an error. If they have, check the value of the static tag USS_DB. w_USSExtendedError of the USS_Drive_Control instruction.
16#818D	The drive responds with an access error message to a parameter request.	Check the response frame of the drive. Check the parameter request.
16#818E	The drive was not initialized.	Check the user program and make sure that the USS_Drive_Control instruction is called for this drive.
16#8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Port_Config.RDREC.STATUS, Send_Config.RDREC.STATUS , Receive_Config.RDREC.STATUS , Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
16#8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Port_Config.WRREC.STATUS, Send_Config.WRREC.STATUS , Receive_Config.WRREC.STATUS , Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB WRREC.
Error codes, general		
16#8FFF	The module is not ready temporarily due to a reset.	Repeat the request.

1) Only with instructions for S7-300/400 CPUs

Startup and Diagnostics 6

6.1 Startup characteristics

Operating mode transitions

After the communication module starts up, all data between the CPU and the communication module is exchanged by means of instructions.

CPU STOP	During a running data transmission communication module - CPU, both a send and a receive job is aborted. Frames will continue to be received. However, information about this is forwarded to the CPU only after a STOP-RUN transition, provided it has been configured that the receive buffer is not cleared.
CPU RUN	Send and receive operation is ensured in the RUN state of the CPU. With a corresponding configuration in the properties dialog of the communication module, you can automatically clear the receive buffer on the communication module during CPU startup.

From the view of the communication module, there are no further operating states/operating state transitions.

6.2 Diagnostic functions

The diagnostic functions of the communications module allow errors that have occurred to be located quickly. The following diagnostic options are available to you:

Diagnostics by means of the display elements of the communications module	The indicators provide information on the operating mode or the possible error states of the communications module. The indicators provide an initial overview of any internal or external errors and interface-specific errors. For more information refer to the device manual of the corresponding communications module.
Diagnostics via the STATUS output of the instructions	Instructions have a STATUS output for error diagnostics; it provides information about communication errors between the communications module and the CPU. You can evaluate the STATUS parameter (Page 97) in the user program (the parameter is present for exactly one cycle).
Diagnostic error interrupt	The communications module can trigger a diagnostic error interrupt on the CPU assigned to it. The communications module makes diagnostic information available. The analysis of this information is made via the user program or by reading the CPU diagnostics buffer.
Diagnostics via the EventTracePtP data record (Page 159)	With the EventTracePtP data record, you can record and read out the last 1000 communication events and the parameter assignment of the communications module.

6.3 Diagnostic interrupts

The diagnostics are displayed as plain text in STEP 7 (TIA Portal) in the online and diagnostics view. You can evaluate the error codes with the user program.

The following diagnostics can be signaled:

- Error (9_H)
- Parameter assignment error (10_H)
- Wire break (S7-1500/ET 200MP: 109_H; ET 200SP: 6_H)

6.4 Diagnostics via EventTracePtP data record

You can record the last 1000 communication events and the parameter assignment of the communications module in a ring buffer (circulating memory) in the module. If necessary, you can read out and evaluate the recorded data, such as received and transmitted data or errors. This function is controlled via the EventTracePtP data record (data record 62).

You can use event diagnostics with the following communications modules as of firmware version V2.0:

- ET 200MP CM PtP RS232 BA
- ET 200MP CM PtP RS232 HF
- ET 200MP CM PtP RS422/485 BA
- ET 200MP CM PtP RS422/485 HF
- ET 200SP CM PtP (available soon)

Recording events and data

During event diagnostics, the module records the following events and data:

- Start the module
- Parameter assignment of the module:
  - Port configuration
  - Send configuration
  - Receive configuration
  - RS232 accompanying signal configuration
  - 3964 Protocol configuration
  - Diagnostic interrupt configuration
  - Error codes
- Received data
- Transmitted data
- RS232 accompanying signals
- Telegram start and end condition

- Transmit and receive errors detected
- Data exchange with the CPU

Reading options

You can read the recorded event diagnostics in the following ways:

- Support of programming and commissioning:
  MFCT is installed on the PC/PG. If required, a copy of the read data can be created. MFCT can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109773881).
- Analysis of sporadic errors:
  When the error occurs, the LPTP_GetEventTrace function block automatically stores a copy of the read data on the memory card of the CPU. The copy can be analyzed in more detail at a later stage. Information on the function module can be found in the FAQ with the entry ID 109973142 (https://support.industry.siemens.com/cs/ww/en/view/109973142).

  NOTE

  The function block LPTP_GetEventTrace should already be included in the user program so that it can be activated, for example, online, when required.

- Use with a system from other manufacturers: With the information in the section you can also use event diagnostics with a system from other manufacturers.

See also

Data record EventTracePtP (Page 161)

Data record EventTracePtP

A

A.1 Use and structure of EventTracePtP (data record 62)

With the EventTracePtP data record, you can activate and read out the recording of the last 1000 communication events and the parameter assignment of the respective communications module. The recording is carried out in a ring buffer (circulating memory). The control commands are sent to the module via the data record 62 (e.g. with the WRREC instruction) or status and event diagnostics data are read from the module (e.g. with the RDREC instruction).

Structure of data record 62 (EventTracePtP): Write

The following table shows the structure when writing the data record 62.

Table 3-1013 Write data record 62

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...7	**PtpVersionHeader:** Length of the data record							
0...1	Block type: $003E_H$							
2...3	Block length: 0006_H							
4	Highbyte block version: 01_H							
5	Lowbyte block version: 00_H							
6...7	Reserved[1]							
8	**EventTrace_Control:** Control EventTracePtP							
	Reserved[1]						Mode:	Event diagnostics:
							0_B: Logging Mode[3]	0_B: Deactivate[2]
							1_B: Reading Mode[4]	1_B: Activate (default)
9	Reserved[1]							

1 Reserved bits must be set to 0.

2 No additional events are recorded. The corresponding buffer in the module is deleted.

3 New events are recorded.

4 The recording of new events is interrupted.

Structure of data record 62 (EventTracePtP): Read

The following table shows the structure when reading the data record 62.

Table 3-1014 Read data record 62

Bit → / Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0...5	**EventTrace_ReadRecordHeader**							
0...1	EventTrace_DataReadAddress: Start address of EventTrace_Data							
2...3	EventTrace_DataTotalSize: Length of EventTrace_Data							
4	EventTrace_Status: Status information of event diagnostics							
	Reserved[1]				Reading Mode completed:	Reading Mode started:	Mode status:	Event diagnostics status:
					0_B: No	0_B: No	0_B: Logging Mode	0_B: Deactivated
					1_B: Yes	1_B: Yes	1_B: Reading Mode	1_B: Activated (default)
5	Reserved[1]							
6 ... 5 +n*6	**EventTrace_Data:** Data from parameter assignment and event diagnostics (events 1... n)							

[1] Reserved bits are set to 0.

Setup EventTrace_Data

The following table shows the structure of EventTrace_Data.

Byte ↓	Meaning
0...7	**PtpVersionHeader:** Length of the data record
0...1	Reserved (do not evaluate this value)
2...3	Reserved (do not evaluate this value)
4	Highbyte block version
5	Lowbyte block version
6...7	Reserved[1]
8...15	**General_Info**
8	Version of the firmware: Letter (CHAR)
9	Version of the firmware: Major (BYTE)
10	Version of the firmware: Minor (BYTE)
11	Version of the firmware: Patch (BYTE)

[1] Reserved bits are set to 0.

Byte ↓	Meaning
12...15	Module ID
16...43	**Port_Config_Str:** Data record 57 (port configuration: 0039_H)
44...75	**Send_Config_Str:** Data record 59 (transmission configuration: $003B_H$)
76...143	**Receive_Config_Str:** Data record 60 (receive configuration: $003C_H$)
144...159	**P3964_Config_Str:** Data record 61 (3964 protocol configuration: $003D_H$)
160...171	**Set_Features_Str:** Data record 58 (activate special function: $003A_H$)
172...183	**Signal_Set:** Data record 53 (set RS232 accompanying signals: 0035_H)
184...203	**PtP RD_ESTAT:** Data record 55 (read error codes: 0037_H)
204...205	**Number_Trace_Events:** Number n of events
206... 205+n*6	**EventTraceEntry[n]:** Entries for n events (n times 6 bytes)
206...211	EventTraceEntry[1]: Entry for event 1
206...209	EventTraceEntry[1]: UDINT: TimeStamp: Event time stamp with resolution 1 µs, 32-bit counter
210	EventTraceEntry[1]: EventType: Event number (see table below)
211	EventTraceEntry[1]: EventInfoByte: Details of the event (see table below)
212...217	EventTraceEntry[2]: Entry for event 2
...	...

[1] Reserved bits are set to 0.

NOTE

Data sets 53 to 61

The structure of data sets 53 to 61 can be found in the "CM PtP in operation without SIMATIC system instructions" manual on the Internet (https://support.industry.siemens.com/cs/ww/en/view/59062563).

Event-Type	EventInfoByte	Meaning
Configuration event:		
0	1	Startup of the module
1	• 0: Module was reconfigured • 1: Configuration deleted	New configuration was received
2	• 57_D: Port_Config • 58_D: Set_Features • 59_D: Send_Config • 60_D: Receive_Config • 61_D: P3964_Config	New parameterization was received
Receive event:		
50	0...FF_H	New received valid byte of received data
51	0...FF_H	Newly received byte of received data, with parity error
52	0...FF_H	Newly received byte of received data, with character frame error
53	0...FF_H	The newly received byte of received data could not be read (Overrun). Therefore, entry of the last received byte that could be read.
54	0...FF_H	Reception interrupted. Therefore, the last received byte that could be read.
55	• 1_H: START_CHAR (start with start character) • 2_H: START_ANY_CHAR (start with any character) • 4_H: START_LINE_BREAK (start after line break) • 8_H: START_IDLE_LINE (start after idle line) • 10_H: START_SEQ1 (start with initial sequence 1) • 20_H: START_SEQ2 (start with initial sequence 2) • 40_H: START_SEQ3 (start with initial sequence 3) • 80_H: START_SEQ4 (start with initial sequence 4)	Telegram start detected
56	• 94_H: RX_COMPLETE_LENGTH (telegram end due to length) • 95_H: RX_COMPLETE_MESSAGE_TO (telegram end due to message timeout) • 96_H: RX_COMPLETE_INTERCHAR_TO (telegram end due to expiration of character delay time) • 97_H: RX_COMPLETE_RESPONSE_TO (telegram end due to response timeout)	Telegram end detected

Event-Type	EventInfoByte	Meaning
	• 98_H: RX_COMPLETE_CALC_LENGTH (telegram end due to message length read from message) • 99_H: RX_COMPLETE_END_SEQUENCE (telegram end due to end sequence) • $E0_H$: RX_COMPLETE_BUFFER_FULL (receive buffer full) • $E1_H$: RX_COMPLETE_PARITY (message error due to parity error) • $E2_H$: RX_COMPLETE_FRAMING (message error due to framing error) • $E3_H$: RX_COMPLETE_OVERRUN (message error due to internal overrun) • $E4_H$: RX_COMPLETE_CALC_LENGTH_ERROR (message error due to error when reading message length from message) • $E5_H$: RX_COMPLETE_BREAK_DETECT (wire break message error detected) • $E8_H$: RX_FIXLENGTH_TIMEOUT_ERROR (message error due to timeout error with fixed telegram length) • EB_H: RX_MAX_MSG_SIZE_EXCEEDED (message error due to max. message length exceeded)	
57	0...FF_H	XOFF character received
58	0...FF_H	XON character received
59	• 0: CTS = OFF • 1: CTS = ON	CTS changed
60	• 0: DSR = OFF • 1: DSR = ON	DSR changed
61		Receive buffer full
62		Telegram length exceeded
63	0...FF_H	Receive buffer overflow: Oldest message overwritten
64		CRC error
Send data event:		
100	0...FF_H	A byte was sent
101	• 00_H: Due to other reason • 01_H: Due to DSR • 02_H: Due to CTS • 03_H: due to DTR • 04_H: Due to RTS • 05_H: Due to XOFF	Unable to send a new byte of transmitted data...
102	0...FF_H	XOFF character sent
103	0...FF_H	XON character sent
104	• 0: RTS = OFF • 1: RTS = ON	RTS changed

Event-Type	EventInfoByte	Meaning
105	• 0: DTR = OFF • 1: DTR = ON	DTR changed
106	• $D1_H$: WAIT_TIMEOUT (wait time for CTS exceeded) • $D2_H$: DSR_INACTIVE (DSR inactive because DTR was retracted) • $D5_H$: CANCELED (CPU stop or wire break)	Sending interrupted
107		Sending a telegram started
108		Sending a telegram completed
109	Low-byte telegram length	Transfer a new send telegram from user program to module
CPU communications event:		
149	• 00_H: No error • $A2_H$: Module error • $B0_H$: Invalid index • $B1_H$: Incorrect data record length • $B5_H$: Invalid state • $E1_H$: Invalid parameter	RDREC was executed for data record 49 (e.g. by the S7-1500 instruction Receive_P2P)
150	• 00_H: No error • $A2_H$: Module error • $B0_H$: Invalid index • $B1_H$: Incorrect data record length • $B5_H$: Invalid state • $E1_H$: Invalid parameter	RDREC was executed for data record 50 (e.g. by the S7-1500 instruction Receive_P2P)
151	• 00_H: No error • $B0_H$: Invalid index • $B1_H$: Incorrect data record length • $B5_H$: Invalid state • $E1_H$: Invalid parameter	WRREC was executed for data record 48 (e.g. by the Send_P2P instruction)
152	• 00_H: No error • $B1_H$: Incorrect data record length • $E1_H$: Invalid parameter	WRREC was executed for data record 62
153	• 00_H: No error • $B1_H$: Incorrect data record length • $E1_H$: Invalid parameter	WRREC was executed for data record 53
154	• 00_H: No error • $B1_H$: Incorrect data record length • $B5_H$: Invalid state • $E1_H$: Invalid parameter	WRREC was executed for data record 54 (e.g. by the Receive_Reset instruction)
155	0: New telegram entered in input data	When performance optimization option is selected: Changed input data
156	0: New telegram received by CPU	When performance optimization option is selected: Changed initial data

Event-Type	EventInfoByte	Meaning
Other event:		
200		Recording of new events has started or continues after an interruption
201		Mode changed to "Reading Mode"
202		Mode changed to "Logging Mode"
205		Overflow of the time stamp counter
206		Internal receive buffer deleted
207	Number of bytes (low-byte)	Receive telegram prepared for CPU
208	• 0: Wire break fixed • 1: Wire break present	Internal wire break signal
209	• 0: Wire break fixed • 1: Wire break present	Wire break diagnostics (send)
210	• 0: Parameterization error fixed • 1: Parameterization error present	Parameterization error diagnostics (send)

Event diagnostics

By default, event diagnostics is activated in the EventTracePtP data record.

You control the following two modes via EventTracePtP:

Logging Mode	New events and data are recorded in the module.
Reading Mode	The events and data are read from the module. The recording of new events and data is interrupted.

The procedure for both modes is described below.

Activate event diagnostics (Logging Mode)

To activate event diagnostics with data record 62, follow these steps:

1. Set the "Event diagnostics" bit to 1.
2. Set the "Mode" bit to 0.
3. Send the data record to the module.
   "Logging Mode" is activated. New events are saved.

Read event diagnostics (Reading Mode)

To read out the consistent data from the event diagnostics with data record 62, follow these steps:

1. Set the "Event diagnostics" bit to 1.
2. Set the "Mode" bit to 1.

3. Send the data record to the module.
   "Reading Mode" is activated. The recording of new events is not possible during this time.
4. Read the data record from address 0 (EventTrace_DataReadAddress) from the module.
   Due to the data volume of up to 6212 bytes (EventTrace_DataTotalSize), several read cycles may be necessary.
   – Check that the "Event diagnostics status" and "Mode status" bits are set to 1.
   – Check the "Reading Mode Started" (EventTrace_DataReadAddress = 0) or "Reading Mode Ended" bits.
     When the "Reading Mode Ended" bit is set to 0, additional read cycles with the data record are necessary.
5. Add the new data from EventTrace_Data to a corresponding location in your buffer, which must have the minimum size of EventTrace_DataTotalSize.
6. Repeat reading the data record and saving the data until the "Reading Mode completed" bit is set to 1 or the EventTrace_DataTotalSize value is reached.
   The parameter assignment and event diagnostics data are then completely read out.

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S7-1500 / ET 200MP / ET 200SP CM PtP in operation without SIMATIC system instructions

Programming and Operating Manual

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Preface

Purpose of the documentation

You have two general options to use point-to-point communication modules:

Use of the communication modules with	Procedure
SIMATIC S7 CPU and Step 7 (TIA Portal) or Step 7 configuration software	Use the available specific instructions (http://support.automation.siemens.com/WW/view/en/59057093).
Third-party CPU and configuration software	You must implement the functionality according to the documentation in the configuration software of the third-party manufacturer.

Requirements

To use point-to-point communication modules with third-party CPU and configuration software, the CPU must support communication via data records and have a suitable fieldbus controller. Information is available in the system manuals ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) and S7-1500, ET 200MP automation system (https://support.industry.siemens.com/cs/ww/en/view/59191792).

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers

Validity of the documentation

This documentation is valid for the following point-to-point communication modules:

- CM PtP RS232 BA (6ES7540-1AD0x-0AA0) (https://support.industry.siemens.com/cs/ww/en/view/59057152) communication module
- CM PtP RS422/485 BA (6ES7540-1AB0x-0AA0) (https://support.industry.siemens.com/cs/ww/it/view/59057390) communication module
- CM PtP RS232 HF (6ES7541-1AD0x-0AB0) (https://support.industry.siemens.com/cs/ww/en/view/59057160) communication module

- CM PtP RS422/485 HF (6ES7541-1AB0x-0AB0) (https://support.industry.siemens.com/cs/ww/en/view/59061372) communication module
- CM PtP (6ES7137-6AA0x-0BA0) (https://support.industry.siemens.com/cs/ww/en/view/59061378) communication module

Conventions

Please also observe notes labeled as follows:

NOTE

The notes contain important information on the product described in the documentation, on the handling of the product or on part of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal company and dispose of the equipment according to the applicable regulations in your country.

Additional assistance

The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).

Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.
- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.
- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.
- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (https://support.industry.siemens.com).

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com) and in the Information and Download Center (https://www.siemens.com/automation/infocenter).

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions form one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial security measures that may be implemented, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Security RSS Feed under (http://www.siemens.com/industrialsecurity).

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Documentation guide

1

The documentation for the SIMATIC S7-1500 automation system, the CPUs 1513/1516pro-2 PN based on SIMATIC S7-1500, and the distributed I/O systems SIMATIC ET 200MP, ET 200SP and ET 200AL is divided into three areas.
This division allows you easier access to the specific information you require.

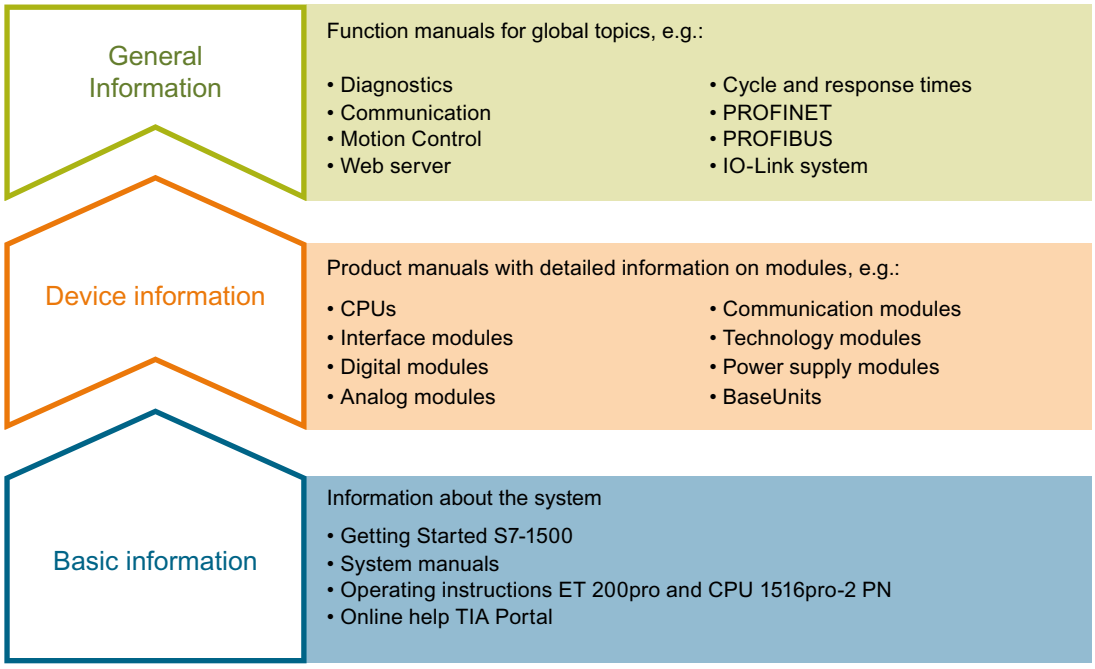

Basic information

System manuals and Getting Started manuals describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL systems. Use the corresponding operating instructions for the CPUs 1513/1516pro-2 PN. The STEP 7 online help supports you in the configuration and programming.

Device information

Product manuals contain a compact description of the module-specific information, such as properties, terminal diagrams, characteristics and technical specifications.

General information

The function manuals contain detailed descriptions on general topics such as diagnostics, communication, Motion Control, Web server, OPC UA.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Changes and additions to the manuals are documented in product information sheets.

You will find the product information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/us/en/view/68052815)
- ET 200SP (https://support.industry.siemens.com/cs/us/en/view/73021864)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)

"mySupport"

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

In "mySupport", you can save filters, favorites and tags, request CAx data and compile your personal library in the Documentation area. In addition, your data is already filled out in support requests and you can get an overview of your current requests at any time.

You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (https://support.industry.siemens.com/My/ww/en).

"mySupport" - Documentation

With "mySupport", your personal workspace, you make the best out of your Industry Online Support.

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You must register once to use the full functionality of "mySupport".

You can find "mySupport" on the Internet (http://support.industry.siemens.com/My/ww/en/documentation).

"mySupport" - CAx data

In the CAx data area of "mySupport", you can access the latest product data for your CAx or CAe system.

You configure your own download package with a few clicks.

In doing so you can select:

- Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files
- Manuals, characteristics, operating manuals, certificates
- Product master data

You can find "mySupport" - CAx data on the Internet (http://support.industry.siemens.com/my/ww/en/CAxOnline).

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You will find the application examples on the Internet (https://support.industry.siemens.com/sc/ww/en/sc/2054).

TIA Selection Tool

With the TIA Selection Tool, you can select, configure and order devices for Totally Integrated Automation (TIA).
This tool is the successor of the SIMATIC Selection Tool and combines the known configurators for automation technology into one tool.
With the TIA Selection Tool, you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet (http://w3.siemens.com/mcms/topics/en/simatic/tia-selection-tool).

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities simultaneously on various SIMATIC S7 stations as a bulk operation independent of TIA Portal.

The SIMATIC Automation Tool provides a multitude of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Address assignment (IP, subnet, gateway) and station name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization by means of LED flashing
- Reading out of CPU error information
- Reading of the CPU diagnostics buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet (https://support.industry.siemens.com/cs/ww/en/view/98161300).

PRONETA

SIEMENS PRONETA (PROFINET network analysis) allows you to analyze the plant network during commissioning. PRONETA features two core functions:

- The topology overview automatically scans the PROFINET and all connected components.
- The IO check is a fast test of the wiring and the module configuration of a plant.

You can find SIEMENS PRONETA on the Internet (https://support.industry.siemens.com/cs/ww/en/view/67460624).

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://www.siemens.com/sinetplan).

Overview

2

Overview of components and article numbers

Tabular overview of communication modules.

Communication module	Article number
CM PtP RS232 BA	6ES7540-1AD0x-0AA0
CM PtP RS422/485 BA	6ES7540-1AB0x-0AA0
CM PtP RS232 HF	6ES7541-1AD0x-0AB0
CM PtP RS422/485 HF	6ES7541-1AB0x-0AB0
CM PtP (ET 200SP)	6ES7137-6AA0x-0BA0

Overview of components and interfaces

Tabular overview of communication modules and their functions.

Communication module	Interface	Protocols		Connection of the communication cable	
		Freeport	3964(R)	D-Sub 9-pin	D-Sub 15-pin
CM PtP RS232 BA	RS232	X	X	X	-
CM PtP RS422/485 BA	RS422	X	X	-	X
	RS485	X	-	-	X
CM PtP RS232 HF	RS232	X	X	X	-
CM PtP RS422/485 HF	RS422	X	X	-	X
	RS485	X	-	-	X
CM PtP (ET 200SP)	RS232	X	X	ET 200SP BaseUnit with 18 terminals[1]	
	RS422	X	X		
	RS485	X	-		

[1] ET 200SP BaseUnit instead of sub D; same for all; pin assignment depending on physical transmission properties

Overview of components and data transmission rates

Communication module	Data transmission rate in bps											
	300	600	1200	2400	4800	9600	19200	38400	57600	76800	115200	250000[1]
CM PtP RS232 BA	X	X	X	X	X	X	X	-	-	-	-	-
CM PtP RS422/485 BA	X	X	X	X	X	X	X	-	-	-	-	-
CM PtP RS232 HF	X	X	X	X	X	X	X	X	X	X	X	-
CM PtP RS422/485 HF	X	X	X	X	X	X	X	X	X	X	X	-
CM PtP (ET 200SP)	X	X	X	X	X	X	X	X	X	X	X	X

[1] Especially for using the DMX512 protocol with RS485 (Page 35)

Overview of components and receive buffer size

Module	Receive buffer size in KB	Max. frame length in KB	Bufferable frames
CM PtP RS232 BA	2	1	255
CM PtP RS422/485 BA	2	1	255
CM PtP RS232 HF	8	4	255
CM PtP RS422/485 HF	8	4	255
CM PtP (ET 200SP)	4	2	255

Secondary signals and data flow control

- Software data flow control with XON/XOFF

  The Freeport protocol supports data flow control with XON/XOFF via the RS232 and RS422 interfaces.
- Hardware data flow control with RTS/CTS

  The Freeport protocol supports data flow control with RTS/CTS via the RS232 interface.
- Automatic operation of secondary signals

  The Freeport protocol supports operation of the RS232 secondary signals by means of the RS232 interface. Only available when hardware data flow control is activated.

Application options for the communication modules

You may set up a communication connection with different partners, depending on the communication modules used:

- Freeport: Transmission of ASCII character strings without specified protocol format
- 3964(R): Communication between automation systems (master/master communication)

GSD file

Engineering must be provided with information regarding functionality and parameters of the communication modules for the higher-level application.

The properties of the point-to-point communication modules are defined in a GSD file (Generic Station Description) that is defined based on the GSD schema (ISO 15745: GSD for PROFIBUS and GSDML for PROFINET IEC 61804: EDDL IEC 62453: FDT/DTM). The Engineering System must provide a suitable interpreter that makes the data of the file available to the system.

The GSD file contains:

- Device and identification data
- Parameter assignment data
- Diagnostics data

For parameter assignment of the communication modules, the GSD file must be installed/imported in the Engineering System.

ET 200MP

The respective GSD file for the ET 200MP distributed I/O system is available for download on the Internet:

- GSD file PROFINET IO (https://support.industry.siemens.com/cs/ww/en/view/68189683)
- GSD file PROFIBUS DP (https://support.industry.siemens.com/cs/ww/en/view/80206700)

ET 200SP

The respective GSD file for the ET 200SP distributed I/O system is available for download on the Internet:

- GSD file PROFINET IO (http://support.automation.siemens.com/WW/view/en/57138621)
- GSD file PROFIBUS DP (http://support.automation.siemens.com/WW/view/en/73016883)

Parameter assignment in the application when using a GSD file for PROFIBUS slaves

Important parameters are missing in the GSD file for PROFIBUS slaves. The parameter assignment of the communication module must therefore be performed from the user program using the following data records:

Freeport communication:

- Port configuration record - data record 57 (Page 40) (Port_Config)
- Send configuration record - data record 59 (Page 42) (Send_Config)
- Receive configuration record - data record 60 (Page 43) (Receive_Config)
- Activate special function - data record 58 (Page 49) (Set_Features)

3964 communication:

- Port configuration record - data record 57 (Page 40) (Port_Config)
- 3964 protocol configuration - data record 61 (Page 47) (P3964_Config)
- Activate special function - data record 58 (Page 49) (Set_Features)

NOTE

Activate special function - data record 58 (Page 49) must always be called as the last data record.

NOTE

To use the communication module, the CPU must support communication by means of data records.

For a SIMATIC S7 CPU and Step 7 (TIA Portal) / Step 7, the parameter assignment can be performed with the instructions given in parentheses. You can find more information on configuring with GSD file in the FAQ with the entry ID 109487470 (https://support.industry.siemens.com/cs/ww/en/view/109487470) in Siemens Industry Online Support.

Basic information

3

3.1 Serial transmission of a character

Introduction

Different networking options are available for the exchange of data between two or more communication partners. The PtP connection between two communication partners is the simplest means of information exchange.

Point-to-point connection

In point-to-point connection, the communication module forms the interface between an automation system and a communication partner. Data is sent in serial mode via PtP connection with the communication module.

Serial data transmission

During serial data transmission, the individual bits of a character of information to be transferred are sent successively in a defined sequence.

Bidirectional data traffic - operating mode

In the context of bidirectional data traffic, we distinguish between two operating modes for the communication module:

- Half duplex mode

  The data is transferred between one or several communication partners in both directions alternately. Half duplex mode means that data is either sent or received at a given point in time.

- Full duplex mode

  The data is exchanged simultaneously between one or several communication partners, i.e. it is possible to send and receive data simultaneously at a given point in time.

Data transmission

The so-called time base synchronism (fixed time base for transmission of a fixed character string) is only upheld during transmission of a character. Each character to be sent is preceded by a synchronization pulse, which is also known as start bit. The length of the start bit transmission determines the clock cycle. The end of character transmission is formed by one or two stop bits.

Handshakes

In addition to the start and stop bits, both communication partners need further handshake procedures for serial data transmission. These include:

- Data transmission rate
- Character and acknowledgment delay time
- Parity
- Number of data bits (7 or 8 bits/characters)
- Number of stop bits (1 or 2)

3.2 Transmission security

Transmission security plays an important role in the transmission of data and in the selection of the transmission procedure. Generally speaking, the more layers of the ISO/OSI reference model are applied, the higher the transmission security.

Classification of existing protocols

The figure below illustrates how the protocols of the communication module fit into the reference model.

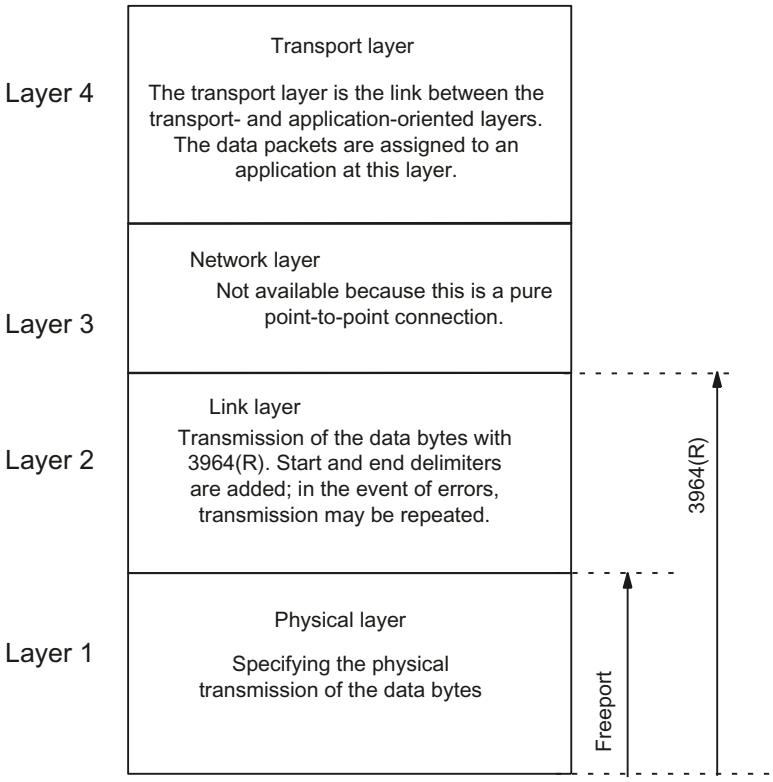

Figure 3-776 Classification of the existing protocols of the communication module in the ISO/OSI reference model

Transmission security with Freeport

Data security when using Freeport:

- Despite the efficiency of data transmission with the Freeport protocol, it is not possible to ensure secure data transmission with Freeport because no data security measures other than the use of a parity bit (can also be disabled, depending on the character frame setting) are applied. A certain degree of data security can be achieved through parameter assignment of the frame start and frame end conditions.
- The parity bit ensures that the inversion of a bit in a character to be sent can be recognized. If two or more bits of a character are inverted, this error can no longer be detected.
- To increase transmission security, you can, for example, implement a checksum, a frame length specification, or configurable end conditions. These measures must be implemented by the user.
- A further increase in data security can be achieved by means of acknowledgment message frames in response to send or receive message frames. This is the case with high-grade protocols for data communication (ISO 7-layer reference model).

Transmission security with 3964(R)

Two different procedures for data transmission can be used, either with or without a block check character:

- Data transmission without block check character: **3964**

  Transmission security is achieved by means of a specified frame structure, frame breakdown, and frame repetitions.
- Data transmission with block check character: **3964R**

  The high degree of transmission security is achieved by means of a specified frame structure and breakdown, frame repetitions, as well as inclusion of a block check character (BCC). The hamming distance in 3964R mode is 3.

The hamming distance represents a measure for data transmission security.

In this manual, the term 3964(R) is used when descriptions and notes refer to both data transmission modes.

Basic communication mechanisms 4

4.1 Data exchange types

Data communication

Two types of data exchange between the CPU and the communication module are possible with the communication modules, depending on whether you are using the Performance option:

Acyclic data exchange (Universal)	**Cyclic data exchange (with performance optimization)**
The CPU communicates with the communication module asynchronously by reading or writing data records (Page 19).	The CPU communicates with the communication module synchronously with the application cycle via the net data of the communication module (Page 21).
Limiting the telegram length depending on the communication module to 1, 2, or 4 KB	Limiting the telegram length to 24 bytes for receive frames and 30 bytes for send frames. Longer frames are rejected.
Transmitting a frame requires several cycles of the CPU. The number of cycles increases with the number of communication modules that communicate via data record.	Transmission of a frame requires an application cycle of the CPU and several communication modules can be served in parallel (reaction time optimized, timing behavior improved).
Allocation of an address range of 8 bytes of input data and 0 bytes of output data	Allocation of an address range of 32 bytes of input data and 32 bytes of output data
Available from firmware version V1.0 of the communication module	Available from firmware version V2.0 of the communication modules
Configuration and parameter assignment with GSD file. The option for performance optimization cannot be changed with the configuration data records 57 to 61.	

Example

In this example, 18 communication modules are used in distributed operation, but the measured values are received by one digital scale each. The scales send their measured values cyclically at such a high speed that the update time of the measured values in the CPU is limited by the communication speed between CPU and communication module.

The following comparison shows the difference of the update time depending on whether performance optimization is used:

	Number of communication modules read in parallel by the CPU	Update time (interval between two value updates in the CPU) per communication module
Without Performance option	1	Approx. 30 ms
	18	Approx. 250 ms
With Performance option	1	Approx. 20 ms[1]
	18	Approx. 20 ms[1]

[1] Depending on the application, faster update times are also possible; for example, for sensors that only send short frames cyclically.

4.2 Communication using data record (Universal)

Write/read data record

NOTE
Reading and writing data records
For information about the functions for reading/writing data records, refer to the documentation of your controller.

The "Write data record" function can be used to configure the devices by means of configuration data records. The "Write data record" function also transmits the send data to the devices. Accordingly, "Read data record" can be used to read diagnostics data and receive data from the devices.

Overview of data records

Configuration data records are available for the following tasks:

- Freeport communication
  Configuration of the communication module for data transmission using the open Freeport frame
  - Port configuration record - data record 57 (Page 40)
  - Activate special function - data record 58 (Page 49)
  - Send configuration record - data record 59 (Page 42)
  - Receive configuration record - data record 60 (Page 43)

- 3964 communication
  Configuration of the communication module for data transmission with 3964(R) protocol
  - Port configuration record - data record 57 (Page 40)
  - 3964 protocol configuration - data record 61 (Page 47)
- Special functions - Activation
  Activating or verifying the active state of diagnostic interrupts.
  - Activate special function - data record 58 (Page 49)

The following data records are available for operating the communication modules:

- Query error status
  Acknowledgment of the communication module in response to the writing of a configuration data record
  - Read error status - data record 55 (Page 50)
- Send data
  Transmitting send data to the communication module and querying transmission acknowledgment in the user data
  - Send data - data record 48 (Page 52)
  - Request acknowledgment - Input data (Page 53)
- Receive data
  Display of a receive frame in the net data
  - Data received - data record 49/50 (Page 59)
  - Query: New receive frame - Input data (Page 60)
- Delete receive buffer
  Deleting the receive buffer of the communication module
  - Clear receive buffer - data record 54 (Page 65)
- RS232 secondary signals
  Manipulation of the RS232 secondary signals of the communication module and reading the RS232 secondary signals in the net data
  - Set RS232 secondary signals - data record 53 (Page 66)
  - Read RS232 secondary signals - Input data (Page 67)

Sending

Sending data via data records is described in the section Sending data using data record (Page 51).

Receiving

Receiving data via data records is described in the section Receiving data using data record (Page 58).

4.3 Communication via user data (Performance option)

From firmware version V2.0 of the communication module, the option for performance optimization is available. This option is suitable if you are exclusively sending and receiving short frames. Unlike in communication via data records (Universal), the number of communication modules in a project does not affect the update time.

In this case, sending and receiving of user data takes place via the net data (cyclic IO data of the automation system) of the communication module. Communication via data records is used for configuration and diagnostics.

Sending

Sending data via net data is described in the section Sending data via output data (Page 55).

Receiving

Receiving data via net data is described in the section Receiving data via input data (Page 62).

Data transmission with Freeport 5

Introduction

Freeport is a freely programmable, frame-based protocol. Freeport enables users to map almost all protocols available in the market in applications.

The Freeport driver controls data transmission via point-to-point connection between the communication module and a communication partner. The Freeport driver contains the physical layer (layer 1).

The Freeport driver supports sending and receiving of messages with any structure (all characters from 00_H through FF_H (for character frames with 8 data bits) or from 00_H through $7F_H$ (for character frames with 7 data bits).

The frame start and end criteria must be configured both for the send and the receive direction. The structure of the send frames may differ from that of the receive frames.

5.1 Sending data with Freeport

Sending data

NOTE

During parameter assignment of the XON/XOFF data flow control, user data may not contain any of the configured XON or XOFF characters. The default settings are DC1 = 11_H for XON and DC3 = 13_H for XOFF.

Specifying settings for sending

To send a message, the partner must be informed of the start and end of the message (see Send configuration record - data record 59 (Page 42)). You can select one of the following options:

- Send the Break signal at the start of the message

  You can specify that an additional Break is sent at the beginning of each message transmission on expiration of the RTS ON delay time.
  The duration of the "Break" signal is specified in bit times (refer to Send configuration record - data record 59 (Page 42) bytes 12 and 13).

  Compliance with the send break can be deactivated if other mechanisms are used for synchronization.

- Send Idle Line

  You can specify that at the beginning of each message transmission the send line is held in Idle state for a specific time.
  The duration of the "Idle Line" is specified in bit times (refer to Send configuration record - data record 59 (Page 42) bytes 14 and 15).

  Compliance with the send break can be deactivated if other mechanisms are used for synchronization.

- RTS ON delay

  You can configure the time that has to expire after the RTS (Request to send) before the actual data transmission starts (see Send configuration record - data record 59 (Page 42) bytes 8 and 9).

- RTS OFF delay

  You can configure the time that has to expire after transmission has been completed before the RTS signal is deactivated (see Send configuration record - data record 59 (Page 42) bytes 10 and 11).

- Sending including the end delimiter

  You can configure the number of end delimiters (1 or 2) and their value.

  All data up to the end delimiter(s) is sent, independent of the selected frame length. The end delimiter must be included in the data to be sent. Data is sent only up to and including the end delimiter, even if the data length specified is longer (refer to Send configuration record - data record 59 (Page 42) bytes 18 and 21).

- Number of appended characters

  Input of the number of appended characters. All data transferred to the communication module will be sent. The end delimiter(s) is/are appended automatically. Depending on the number of end delimiters, one to five characters more than the specified number are sent to the partner (refer to Send configuration record - data record 59 (Page 42) bytes 22 and 28).

NOTE

If you do not configure either the "End delimiter" (0) or the "Number of appended characters" (0), all data transferred to the communication module is sent to the partner in a transparent operation.

5.2 Receiving data with Freeport

Introduction

You need to specify message start and end criteria in the Freeport driver to enable detection of a message in the incoming data flow.

NOTE

The start and end criteria described below can be combined as required. Such combinations may lead to unwanted results if the start and end criteria influence or even exclude each other.

Specifying the message start

For data transmission with Freeport, you can choose between several different start criteria. The start criterion defines when a frame starts. Once a criterion that indicates the start of the message is met, the data stream is scanned for message end criteria. (See Receive configuration record - data record 60 (Page 43) byte 9)

Two different methods are available for detecting the message start:

- **Start on any character**
- **Start on special condition**

Start on any character

- **Start on any character**

  Any character can be used to define the start of the message (default).

  This means that the first character sent at the start of communication, or after the frame end has been detected, will be identified as the first character of a message. (refer to Receive configuration record - data record 60 (Page 43) byte 12)

Start on special condition

The start of the message is detected based on the following specified conditions:

- **After detection of a line break**

  The frame start is not accepted unless a break has been received beforehand, in other words, it is compulsory for the partner to send a break before sending a frame.

- **After detection of an idle line**

  The frame start is not accepted until the configured idle line duration has expired. This procedure requires a minimum interval between two frames. (See Receive configuration record - data record 60 (Page 43) bytes 10 and 11)

- **After receipt of a start character**

  The frame start is detected when the configured start character is identified. (See Receive configuration record - data record 60 (Page 43) byte 12)

- **After detection of one or several start sequences**

  The frame start is detected when the configured string with a length of up to five characters is identified. You can configure up to 4 start sequences. (See Receive configuration record - data record 60 (Page 43) bytes 13 to 37)

Specifying the message end

You can choose from several different end criteria for data transmission using the Freeport driver. The end criterion defines the point at which a message frame has been received completely. (See Receive configuration record - data record 60 (Page 43) byte 39)

Configurable end criteria are:

- **Recognize message end by message timeout**
- **Recognize message end by response timeout**
- **After character delay time elapses (default)**
- **After receipt of a fixed frame length**
- **After receipt of a maximum number of characters**
- **Read message length from message**
- **After receipt of an end sequence**

Message timeout

When data is received, the end of frame is detected on expiration of the configured time for transferring a frame. Time measurement starts after the start criterion has been met. (See Receive configuration record - data record 60 (Page 43) bytes 52 and 53)

An error message is output and the frame is discarded if a message end condition is met before the fixed frame length has been reached.

Response timeout

When data is received, the end of frame is detected on expiration of the configured time between the end of the send operation and the receipt of a frame start. (refer to Receive configuration record - data record 60 (Page 43) bytes 50 and 51)

An error message is output and the frame is discarded if a message end condition is met before the fixed frame length has been reached.

Expiration of character delay time

When data is received, the frame end is detected when the configured maximum time (bit times) between successive characters is exceeded (character delay time). (See Receive configuration record - data record 60 (Page 43) bytes 54 and 55)

In this case, the character delay time must be set in such a way as to ensure that it expires between two consecutive frames. However, it should be of sufficient length to exclude incorrect identification of the end of the frame whenever the communication partner performs a transmission pause within a frame.

Fixed frame length

When data is received, the end of the frame is identified after the configured frame length has been reached. (See Receive configuration record - data record 60 (Page 43) bytes 40 and 41)

An error message is output and the frame is discarded if the character delay time expires (if activated) before the fixed frame length has been reached.

Please note the following if the frame length of the received characters does not match the fixed configured frame length:

- All characters received after the configured maximum number of characters has been reached will be discarded until a new start criterion (e.g. "Idle Line") is detected.
- Receiving is terminated if the character delay time (if activated) expires before the fixed configured frame length has been reached. An error message is generated and the message frame fragment is discarded.
- If a different (activated) end criterion is met before the fixed configured frame length has been reached, this frame part is assessed as a valid frame and the partner waits for a new start criterion. All characters received prior to fulfillment of a new start criterion are discarded.

Maximum number of characters

When receiving data, the end of the message frame is recognized after the declared number of characters have arrived. (See Receive configuration record - data record 60 (Page 43) bytes 42 and 43)

This setting can be combined with the "Character delay time" settings. The frame received is also assessed as free of error if another end condition occurs, regardless of whether the maximum number of characters has been reached.

Please note the following if the frame length of the received characters does not match the configured maximum frame length:

- All characters received after the configured maximum number of characters has been reached will be discarded until a new start criterion (e.g. "Idle Line") is detected.
- If a different (activated) end criterion is met before the configured maximum number of characters has been reached, this frame part is assessed as a valid frame and the partner waits for a new start criterion. All characters received prior to fulfillment of a new start criterion are discarded.

NOTE

If no further end criterion is activated, the fixed frame length and maximum number of characters will respond in the same way.

Message length in the message

The length of the receive frame is also sent. When data is received, the frame end is identified after the frame length also sent has been reached. If "After character delay time elapses" is activated as an additional end criterion, receiving may be terminated prematurely. An error message is generated and the message frame fragment is discarded.

The following parameters define the characters to be used for evaluation of the message length:

- **Offset of the length field in the message**

  In the message, the value defines the position of the character that is to be used to determine the message length.

  You can set values from 1 to 4096 characters, depending on the buffer size.

  (See Receive configuration record - data record 60 (Page 43) bytes 44 to 45)

- **Size of the length field**

  This value specifies the number of characters as of the first evaluation position to be used to determine the message length.

  You can set values of 0, 1, 2 and 4 characters.

  (See Receive configuration record - data record 60 (Page 43) bytes 46 to 47)

- **Number of characters not counted in length specification**

  Number of characters appended to the frame without counting towards the frame length. This value defines the number of bytes at the end of the frame which should not be included in the evaluation of the message length.

  You can set values from 0 to 255 characters.

  (See Receive configuration record - data record 60 (Page 43) bytes 48 to 49)

End sequence

When data is received, the end of the frame is identified when the configured end sequence (max. 5 characters) is received. The received data is transferred to the CPU including the end sequence. (See Receive configuration record - data record 60 (Page 43) bytes 56 to 61)

If you are working with the end sequence, transmission is not code-transparent and you must exclude the presence of end code in the user data.

5.3 Code transparency

Code transparency

Code transparency means that user data can contain any character combinations, without recognition of the end criterion.

The code transparency of the protocol depends on the selection of the parameterized end criterion and flow control:

- With up to five end delimiters or using XON/XOFF flow control
  - Not code-transparent
- End criterion character delay time, fixed frame length, maximum frame length, message timeout, or response timeout and message length in the message
  - Code-transparent

5.4 Receive buffer

Receive buffer of the module

The receive buffer of the module may have a size of up to 8 KB, depending on the communication module used (see chapter Overview (Page 11)). The maximum frame length always equals half the length of the receive buffer. This means that each communication module is capable of buffering at least two frames.

During parameter assignment, you can specify whether to clear the receive buffer at startup and whether to prevent overwriting of data in the receive buffer. You can also specify the range of values (1 to 255) for the number of buffered receive frames. (See Receive configuration record - data record 60 (Page 43) bytes 62 to 64)

The receive buffer on the communication module is organized as FIFO:

- If several frames are entered in the receive buffer of the communication module, the communication module always sends the oldest frame to the CPU.
- If you always want to transfer the last frame received to the CPU, you must set the value "1" for the number of buffered frames and deactivate overwrite protection.

NOTE

If continuous reading of the receive data in the user program is interrupted for a certain time and the receive data is then requested again, the communication module will possibly transmit an older frame before the CPU receives the most recent one. At the time of interruption, the old frame had already been transferred from the receive buffer of the communication module and prepared for transmission to the CPU.

5.5 RS232 mode

The following communication modules support RS232 mode:

- CM PtP RS232 BA
- CM PtP RS232 HF
- CM PtP (ET 200SP)

In RS232 mode, data is sent via two lines. A separate line is available for the send direction and the receive direction. Simultaneous sending and receiving is possible (full duplex).

RS232 secondary signals

In addition to the TXD (transmit data), RXD (receive data) and GND signals, the communication module provides the following RS232 secondary signals when using RS232 hardware:

DCD	(input)	Data Carrier detect; Data carrier signal detected
DTR	(output)	Data terminal ready; Module ready for operation
DSR	(input)	Data set ready; Communication partner ready for operation
RTS	(output)	Request to send; Module is ready to send
CTS	(input)	Clear to send; Communication partner can receive data from the module (response to RTS = ON of the communication module)
RI	(input)	Ring Indicator; Ring indicator

After power on of the communication module, the output signals are in the OFF state (inactive).

You can parameterize the operation of the DTR/DSR and RTS/CTS control signals in the configuration data record of the module (Port configuration record - data record 57 (Page 40)).

The RS232 secondary signals cannot be manipulated by data record communication (Set RS232 secondary signals - data record 53 (Page 66)) in case of:

- parameterized data flow control "Hardware RTS always ON"

  (corresponds to automatic operation of the secondary signals)
- parameterized data flow control "Hardware RTS always ON"

  (corresponds to hardware flow control with RTS/CTS)
- parameterized data flow control "Hardware RTS always ON, ignore DTR/DSR "

An error message is generated if an attempt is made to manipulate RS232 secondary signals by means of data record communication.

For more information, refer to chapter Handshaking (Page 32).

5.6 RS422 mode

The following communication modules support RS422 mode:

- CM PtP RS422/485 BA
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

In RS422 mode, data is transmitted via two line pairs (four-wire mode). A separate line pair is available for the send direction and the receive direction. Simultaneous sending and receiving is possible (full duplex).

The data can be exchanged simultaneously between one or several communication partners. In RS422 multipoint mode, only one multipoint slave may send data at any given time.

Interface operating modes

The following table is a summary of the interface operating modes for the various communication modules and protocols.

The communication module can be used in the following topologies in RS422 mode:

- Link between two nodes: Point-to-point connection
- Link between several nodes: Multipoint coupling
  (only available with CM PtP (ET 200SP))

Operating mode	Description
Full duplex (RS 422) four-wire mode (point-to-point connection)	Both devices have the same priority in this operating mode.
Full duplex (RS422) four-wire mode (multipoint master)	The communication module can be used as multipoint master.
Full duplex (RS 422) four-wire mode (multipoint slave)	The communication module can be used as multipoint slave.

In the case of a multipoint master/slave topology in the RS422 mode:

- The master's sender is connected to the receivers of all slaves.
- The slaves' senders are connected to the master's receiver.
- The receiver of the master and the receiver of one slave are assigned default settings of the receive line (refer to chapter Port configuration record - data record 57 (Page 40) byte 25). All other slaves operate without default settings.

5.7 RS485 mode

The following communication modules support RS485 mode:

- CM PtP RS422/485 BA
- CM PtP RS422/485 HF
- CM PtP (ET 200SP)

In RS485 mode, data is transferred via one line pair (two-wire mode). The line pair is available alternately for the send and receive directions. It is possible to either send or receive (half duplex). On completion of a send operation, operation is immediately switched to receive mode (ready to receive). Send mode is reset again as soon as a new send job is received.

RS485 mode

The following table is a summary of the interface operating modes for the various communication modules and protocols.

Operating mode	Description
Half duplex (RS485) two-wire mode	Operating mode for point-to-point connection or multipoint connection (multipoint) in two-wire mode. The communication module can be the master as well as the slave.

When you operate the Freeport driver in RS485 mode (half duplex, two-wire mode), you must make provisions in the user program to ensure that only one device sends data at any given time. If more than one device sends data at the same time, the frame is corrupted.

Changeover times for RS485 communication module in half duplex mode

A maximum time of 0.1 ms is set for the changeover between sending and receiving.

5.8 Handshaking

Introduction

Handshaking controls the data flow between two communication partners. The use of the handshaking method prevents data loss during transmission if the devices are operating at different speeds.

We can basically distinguish between the following methods:

Table 3-1015 Overview of methods and interfaces

Method	RS232	RS422	RS485
Software data flow control XON/XOFF	X	X	-
Hardware data flow control (RTS/CTS)	X	-	-
Automatic operation of secondary signals	X	-	-

Software data flow control

Software data flow control is implemented as follows on the communication module:

- **XON/XOFF**
  - As soon as the communication module has been set to the "XON/XOFF" operating mode by means of parameter assignment, it sends the XON character, thereby allowing the communication partner to send data.
  - On reaching the configured maximum number of frames or 16 characters ahead of receive buffer overflow, the communication module sends the XOFF character, thereby requesting that the communication partner stop sending. If the communication partner nonetheless continues to send data, an error message is generated if the receive buffer overflows. Data received in the last frame is discarded.
  - As soon as a frame has been fetched by the CPU and the receive buffer is ready to receive data again, the communication module sends the XON character.
  - If the communication module receives the XOFF character during sending, it cancels the current send operation until it receives a XON again from its communication partner. If no XON is received within a specific configurable time, send operation is canceled and a corresponding error message is output.

NOTE

You can configure the characters for XON and XOFF (any ASCII character).

During parameter assignment of the XON/XOFF software data flow control, user data may not contain any of the configured XON or XOFF characters.

Hardware data flow control

NOTE

The DTR/DSR signals do not have to be wired for "Hardware RTS always ON, ignore DTR/DSR" parameter assignment.

If "Hardware RTS always ON" is configured, it is imperative that you fully wire the interface signals used. Make sure that the local RTS (out) is connected with the CTS (in) of the communication partner and the local CTS is connected with the RTS of the communication partner. Accordingly, the local DTR must be connected with the DSR of the communication partner and the local DSR with the DTR of the communication partner.

- **Hardware RTS always ON, ignore DTR/DSR**
  - As soon as the communication module has been set to an operating mode with "Hardware RTS always ON" through parameter assignment, it outputs the RTS = ON signal to the communication partner to indicate its ready state.
  - RTS is set to OFF as soon as the configured maximum number of frames or 16 characters before buffer overflow is reached.
    If the communication partner nonetheless continues to send data, an error message is generated on overflow of the receive buffer. Data received in the last frame is discarded.
  - RTS is reset to ON as soon as the frame has been fetched by the CPU and the receive buffer is ready to receive data again.
  - If CTS switches to OFF during the send operation, the communication module interrupts the send operation until CTS is reset to ON. If CTS is not reset to ON within a specific configurable time, the send operation is canceled and a corresponding error message is output.
- **Hardware RTS always ON**

  The "Hardware RTS always ON" mode corresponds to the "Hardware RTS always ON, ignore DTR/DSR" mode. However, you also need to wire DTR and DSR.
  - As soon as the communication module has been set set to an operating mode with "Hardware RTS always ON" through parameter assignment, it sets DTR = ON and RTS = ON to signal its general ready state to the communication partner.
  - RTS is set to OFF as soon as the configured maximum number of frames or 16 characters before buffer overflow is reached.
    If the communication partner nonetheless continues to send data, an error message is generated on overflow of the receive buffer. Data received in the last frame is discarded.
  - RTS is reset to ON as soon as the frame has been fetched by the CPU and the receive buffer is ready to receive data again.
  - If CTS switches to OFF during the send operation, the communication module interrupts the send operation until CTS is reset to ON. If CTS is not reset to ON within a specific configurable time, the send operation is canceled and a corresponding error message is output.
  - A switch from DSR = ON to DSR = OFF cancels an active send job and triggers an error message.

Automatic operation of secondary signals

- **Hardware RTS always switched**

  "Hardware RTS always switched" is implemented as follows on the communication module:

  – As soon as the communication module is set to the operating mode with "Hardware RTS always switched" through parameter assignment, it sets the line RTS to OFF and DTR to ON (communication module ready for operation).

    It is not possible to send frames until the DSR line is set to ON. No data is sent via the RS232C interface as long as DSR is set to OFF. A send job is canceled and a corresponding error message is generated.

  – If a send job is pending, RTS is set to ON and the configured data output wait time starts. On expiration of the data output time, the system checks whether the communication partner has set CTS to ON. If so, the data is sent via the RS232 interface.

  – If the CTS line is not set to ON within the data output time, or changes to OFF during the send operation, the send job is aborted and an error message generated.

  – Once the data has been sent and the configured clear RTS time has elapsed, the RTS line is set to OFF. The system does not wait for CTS to change to OFF.

  – It is always possible to receive data via the RS232 interface. There will be no reaction if there is a danger of the receive buffer of the communication module overflowing.

  – A switch from DSR = ON to DSR = OFF cancels an active send job and triggers an error message.

  NOTE

  Set the "data output wait time" in such a way that the communication partner is able to enter the ready to receive state before the time elapses.

  Set the "Clear RTS time" in such a way that the communication partner is able to receive the last characters of the frame completely before RTS is set to OFF and the send request is canceled.

Additional information

For information on the settings, refer to chapter Port configuration record - data record 57 (Page 47).

NOTE

Operation of DTR/DSR or RTS/CTS is accepted by the communication module with the following settings. Operation by means of Set RS232 secondary signals - data record 53 (Page 66) is impossible (any attempt made will trigger an error message):

- Hardware RTS always ON, ignore DTR/DSR
- Hardware RTS always ON
- Hardware RTS always switched

5.9 Communication via DMX512

You can use the ET 200SP CM PtP (from firmware version V1.0.5) communication module for communication via DMX512 (Digital Multiplex). For communication via DMX512, the use of the performance optimization option (Page 21) is also possible, provided you use the max. value 29_D as the highest address.

You can find more information on setting up a DMX512 connection in the FAQ with the entry ID 109778975 (https://support.industry.siemens.com/cs/ww/en/view/109778975) in Siemens Industry Online Support.

Data transmission with 3964(R) 6

6.1 Data transmission with 3964(R) protocol

Introduction

The 3964(R) protocol controls PtP data exchange between the communication module and a communication partner. The 3964(R) protocol contains both the physical layer (layer 1) and the link layer (layer 2).

6.2 Control characters

Introduction

During data transmission, the 3964(R) protocol adds control characters to the information data (link layer). The communication partner can use these control characters to check whether it has received all data completely and without errors.

Control characters of the 3964(R) protocol

The 3964(R) protocol evaluates the following control characters:

- **STX** Start of Text; start of the string to be sent
- **DLE** Data Link Escape
- **ETX** End of Text; end of the string to be sent
- **BCC** Block Check Character (only with 3964R)
- **NAK** Negative Acknowledge; negative response

NOTE

If the DLE character is transferred as an information character, it is sent twice during connection setup and shutdown (DLE duplication) in order to distinguish it from the DLE control character. The receiver reverses the DLE duplication.

Priority

For operation with 3964(R) protocol, one communication partner must be assigned a higher priority and one communication partner a lower priority. If both partners simultaneously start the connection setup, the partner having lower priority will postpone its send job.

6.3 Block checksum

Block checksum

With the 3964R transfer protocol, data security is enhanced by sending an additional block check character (BCC = Block Check Character).

The block checksum represents the even longitudinal parity (EXOR logic operation of all data bytes) of a sent or received block. Its calculation begins with the first byte of user data (first byte of the frame) after the connection establishment, and ends after the DLE ETX character at connection termination.

NOTE

With DLE duplication, the DLE character is included twice in the BCC calculation.

6.4 Sending data with 3964(R)

Connection setup for sending

The 3964(R) protocol sends the STX control character to set up the connection. The transition to send mode is initiated when the communication partner responds with the DLE character before the ACK delay time has expired.

The protocol retries to connect if the communication partner responds with NAK or any other character (except DLE or STX), or if inactivity triggers an acknowledgment timeout. After the parameterized number of unsuccessful retries to connect, the connection setup is canceled and the NAK character is transmitted to the communication partner. The communication module outputs a corresponding error message.

Sending data

On successful connection setup, the user data from the output buffer of the communication module and the selected transmission parameters are sent to the communication partner. The partner monitors the time intervals between incoming characters. The interval between two characters must not exceed the character delay time. Monitoring of the character delay time starts immediately after the connection was set up.

If the communication partner transmits an NAK while a transmission is busy, the block transmission is aborted and repeated as shown above starting with the connection setup. If any other character is received, a wait time for expiration of the character delay time is triggered and an NAK is then transmitted to set the communication partner to idle state. Transmission is then restarted with STX connection setup.

Connection shutdown during transmission

After the buffer content has been transmitted, the routine inserts the DLE, ETX characters, appends the BCC block checksum (only for 3964R) and waits for an ACK character. If the communication partner sends the DLE characters within the acknowledgment delay time, the data block has been received without errors. If the communication partner responds with NAK, or any other character (except DLE), or with a corrupt character, or if the acknowledgment delay time expires without response, the routine restarts transmission with STX connection setup.

After the parameterized number of retries to connect, the routine is aborted and NAK is transmitted to the communication partner. The communication module outputs a corresponding error message.

6.5 Receiving data with 3964(R)

Connection setup for receiving

While in idle state and not processing a send job, the module waits for the communication partner to set up the connection.

A wait time is started (wait time = acknowledgment delay time - 10 ms, however, maximum of 400 ms) if no free receive buffer is available during the connection setup with STX. An error message is generated if no free receive buffer is available on expiration of this time. An NAK is transmitted and initiates the transition to idle state. Otherwise, the DLE character is transmitted and the data is received as described above.

The acknowledgment delay time should be set to the same value at both communication partners.

If any character (except for STX or NAK) is received in idle state, the routine waits for expiration of the character delay time (CDT) and then transmits the NAK character. The communication module outputs a corresponding error message.

Receiving data

After successful connection setup, the incoming receive characters are saved to the receive buffer. If two consecutive DLE characters are received, only one of these is saved to the receive buffer.

After connection setup and after each receive character, the routine waits for the next character within the character delay time. If this period expires before another character is received, an NAK is sent to the communication partner. The communication module outputs a corresponding error message. A retry is then expected.

If transfer errors occur during receiving (lost character, frame error, parity error, etc.), the procedure continues to receive data until the connection is terminated and then sends an NAK to the communication partner. A retry is then expected. Receiving is aborted if the block cannot be received without errors after the specified number of transmission retries, or if the communication partner fails to retry transmission within a block delay time of 4 seconds. The communication module reports the first corrupted transfer and the final cancelation.

Connection setup for receiving

Once the DLE ETX string is detected, receiving is terminated and DLE is transmitted to the communication partner for a block that was received without error. In the case of a receive error, an NAK is sent to the communication partner. A retry is then expected.

Receiving is stopped once the DLE ETX BCC string is detected. The BCC is compared with the internally generated longitudinal parity. DLE is transmitted (return to idle state) if the BCC is correct and no other receive error is pending. If the BCC is faulty or a different receive error occurs, an NAK is sent to the communication partner. A retry is then expected.

Configuration data records 7

7.1 Freeport communication

The following three configuration data records must be sent to the communication module for Freeport communication.

7.1.1 Port configuration record - data record 57

NOTE

Parameter assignment error

If the communication module detects a parameter assignment error when writing the data record 57, the data record is rejected with error status $80E1_H$.

The corresponding cause of error can be read by means of data record "Read Error Status - data record 55" (error codes of the port configuration).

Port configuration: PORT_CFG (Write Record 0039_H)								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: 0039_H – PORT_CFG							
1								
2	Block length: 0018_H							
3								
4	Block version high byte: 01_H							
5	Block version low byte: 00_H							
6	Reserved[1]							
7								
°	Protocol:							
8	0000_H – Freeport protocol 0001_H – 3964 protocol 0002_H through $FFFF_H$ – Reserved							
9								
°	Data transmission rate:							
10	0000_H - Reserved				0007_H - 19.2 kbit/s			

1 Reserved bits must be set to 0.

2 Available as of firmware version V1.0.5 of the communication module and only for RS485 mode

Port configuration: PORT_CFG (Write Record 0039_H)			
11	0001_H - 300 bit/s 0002_H - 600 bit/s 0003_H - 1.2 kbit/s 0004_H - 2.4 kbit/s 0005_H - 4.8 kbit/s 0006_H - 9.6 kbit/s	0008_H - 38.4 kbit/s 0009_H - 57.6 kbit/s $000A_H$ - 76.8 kbit/s $000B_H$ - 115.2 kbit/s $000C_H$ – 250 kbit/s[2] $000D_H$ through $FFFF_H$ – Reserved	
°	Parity:		
12 **13**	0000_H - Reserved 0001_H - None 0002_H - Even 0003_H - Odd 0004_H - Mark (set parity bit to 1) 0005_H - Space (set parity bit to 0) 0006_H - Any (The parity is not checked during receiving. The parity is always set to "0" during sending.) 0007_H through $FFFF_H$ - Reserved		
°	Data bits:		
14 **15**	0000_H - Reserved 0001_H - 8 data bits per character 0002_H - 7 data bits per character 0003_H through $FFFF_H$ - Reserved		
°	Stop bits:		
16 **17**	0000_H - Reserved 0001_H - 1 stop bit 0002_H - 2 stop bits 0003_H through $FFFF_H$ - Reserved		
°	Data flow control:		
18 **19**	RS232 settings: 0000_H - Reserved 0001_H - None 0002_H - XON/XOFF 0003_H - Hardware RTS always ON, DSR required 0004_H - Hardware RTS always switched, DSR required 0005_H - Hardware RTS always ON, ignore DTR/DSR 0006_H through $FFFF_H$ - Reserved	RS485 settings: 0000_H - Reserved 0001_H - None 0002_H through $FFFF_H$ - Reserved	RS422 settings: 0000_H - Reserved 0001_H - None 0002_H - XON/XOFF 0003_H through $FFFF_H$ - Reserved
20	XON: 00_H through FF_H - XON character		
21	XOFF: 00_H through FF_H - XOFF character		
22 **23**	Wait for XON after XOFF in ms: (0000_H through $FFFF_H$)		
24	Operating mode:		
	00_H - RS232 01_H - RS422 full duplex four-wire mode (point-to-point) 02_H - RS422 full duplex (RS422) four-wire mode (multipoint master) (CM PtP (ET 200SP)) 03_H - Full duplex (RS422) four-wire mode (multipoint slave) (CM PtP (ET 200SP)) 04_H - Half duplex (RS485) two-wire operation 05_H through FF_H - Reserved		

1 Reserved bits must be set to 0.

2 Available as of firmware version V1.0.5 of the communication module and only for RS485 mode

Port configuration: PORT_CFG (Write Record 0039_H)	
25	Receive line default:
	00_H - "No" default setting 01_H -Signal R(A)=5 V, signal R(B)=0 V (break detection): Break detection is possible with this default setting. Can only be selected with: "Full duplex (RS 422) four-wire mode (point-to-point connection)" and "Full duplex (RS 422) four-wire mode (multipoint slave)". 02_H - Signal R(A)=0 V, Signal R(B)=5 V: This default corresponds to the idle state (no active send operation). No break detection is possible with this default setting. 03_H through FF_H - Reserved
26	Break detection:
	00_H - Break detection deactivated 01_H - Break detection activated 02_H through FF_H - Reserved
27	Reserved[1]

1 Reserved bits must be set to 0.

2 Available as of firmware version V1.0.5 of the communication module and only for RS485 mode

7.1.2 Send configuration record - data record 59

NOTE

Parameter assignment error

If the communication module detects a parameter assignment error when writing the data record 59, the data record is rejected with error status $80E1_H$.

The corresponding cause of error can be read by means of data record "Read Error Status - data record 55" (error codes of the send configuration).

Send configuration: SEND_CFG (Write Record $003B_H$)								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type $003B_H$ – SEND_CFG							
1								
2	Block length: $001C_H$							
3								
4	Block version high byte: 01_H							
5	Block version low byte: 00_H							
6	Reserved[1]							
7								
8	RTS ON delay in ms: (0000_H through $FFFF_H$) (not available for RS422/485 modules)							
9								
10	RTS OFF delay in ms: (0000_H through $FFFF_H$) (not available for RS422/485 modules)							
11								
12	Break duration in bit times: (0000_H through $FFFF_H$)							

1 Reserved bits must be set to 0.

Send configuration: SEND_CFG (Write Record $003B_H$)	
13	Break duration in bit times: (0000_H through $FFFF_H$)
14	Idle Line duration in bit times: (0000_H through $FFFF_H$)
15	
16	Reserved[1]
17	
°	Number of end delimiters: USR_END
18	02_H
19	Number of end delimiters (0, 1 or 2)
20	First end delimiter (for number of end delimiters = 1 or 2)
21	Second end delimiter (for number of end delimiters = 2)
°	Number of appended characters: APP_END
22	05_H
23	Number of appended characters (0, 1, 2, 3, 4 or 5)
24	First appended character (for number of appended characters = 1, 2, 3, 4 or 5)
25	Second appended character (for number of appended characters = 2, 3, 4 or 5)
26	Third appended character (for number of appended characters = 3, 4 or 5)
27	Fourth appended character (for number of appended characters = 4 or 5)
28	Fifth appended character (for number of appended characters = 5)
29	Reserved[1]
30	
31	

[1] Reserved bits must be set to 0.

7.1.3 Receive configuration record - data record 60

NOTE

Parameter assignment error

If the communication module detects a parameter assignment error when writing the data record 60, the data record is rejected with error status $80E1_H$.

The corresponding cause of error can be read by means of data record "Read Error Status - data record 55" (error codes of the receive configuration).

NOTE

End sequence #1 character check (bytes 56 to 61) - Note sequence

If **one** end delimiter is to be used, the entry **must** be made in "Character #5" (byte 61) and only this character must be activated in "Character #5" (byte 56).

If **two** end delimiters are to be used, the entry **must** be made in "Character #5" (byte 61) and in "Character #4" (byte 60) and only these characters must be activated in "Character #5" and "Character #4" (byte 56).

The same applies to the use of additional characters.

Receive configuration: RCV_CFG (Write Record $003C_H$)								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: $003C_H$ – RCV_CFG							
1								
2	Block length: 0040_H							
3								
4	Block version high byte: 01_H							
5	Block version low byte: 00_H							
6	Reserved[1]							
7								
°	Start conditions:							
8	Reserved[1]							
9	Sequence #4[2]	Sequence #3[2]	Sequence #2[2]	Sequence #1[2]	Idle Line[2]	Break detection[2]	Any character[2]	Start character[2]
10	Idle Line duration in bit times: 0000_H through $FFFF_H$							
11								
12	Start characters: 00_H through FF_H							
°	Frame start sequence #1 character check							
13	Reserved[1]			Character #5[2]	Character #4[2]	Character #3[2]	Character #2[2]	Character #1[2]
14	Character #1: 00_H through FF_H							
15	Character #2: 00_H through FF_H							
16	Character #3: 00_H through FF_H							
17	Character #4: 00_H through FF_H							
18	Character #5: 00_H through FF_H							
°	Frame start sequence #2 character check							
19	Reserved[1]			Character #5[2]	Character #4[2]	Character #3[2]	Character #2[2]	Character #1[2]
20	Character #1: 00_H through FF_H							
21	Character #2: 00_H through FF_H							

1 Reserved bits must be set to 0.

2 You enable the respective parameter by setting the associated bit to 1.

3 Buffer size depends on the communication module used.

Receive configuration: RCV_CFG (Write Record $003C_H$)								
22	Character #3: 00_H through FF_H							
23	Character #4: 00_H through FF_H							
24	Character #5: 00_H through FF_H							
°	Frame start sequence #3 character check							
25	Reserved[1]			Character #5[2]	Character #4[2]	Character #3[2]	Character #2[2]	Character #1[2]
26	Character #1: 00_H through FF_H							
27	Character #2: 00_H through FF_H							
28	Character #3: 00_H through FF_H							
29	Character #4: 00_H through FF_H							
30	Character #5: 00_H through FF_H							
°	Frame start sequence #4 character check							
31	Reserved[1]			Character #5[2]	Character #4[2]	Character #3[2]	Character #2[2]	Character #1[2]
32	Character #1: 00_H through FF_H							
33	Character #2: 00_H through FF_H							
34	Character #3: 00_H through FF_H							
35	Character #4: 00_H through FF_H							
36	Character #5: 00_H through FF_H							
37	Reserved[1]							
°	End conditions:							
38	Reserved[1]							
39	Reserved[1]	Fixed frame length[2]	Sequence #1[2]	Read length[2]	Maximum frame length	Character delay time[2]	Message timeout[2]	Response timeout[2]
40	Fixed frame length: 0001_H through $0xxx_H$[3]							
41								
42	Maximum frame length: 0001_H through $0xxx_H$[3]							
43								
44	Offset of the length field in the message: 0000_H through $0xxx_H$[3]							
45								
46	Size of the length field: 01_H, 02_H, 04_H - all other values are not permitted							
47								
48	Number of characters not counted in length specification: 00_H through FF_H							
49								
50	Response timeout in ms: 0000_H through $FFFF_H$							
51								
52	Message timeout in ms: 0000_H through $FFFF_H$							
53								

1 Reserved bits must be set to 0.

2 You enable the respective parameter by setting the associated bit to 1.

3 Buffer size depends on the communication module used.

Receive configuration: RCV_CFG (Write Record $003C_H$)						
54	Character delay time in bit times: 0000_H through $FFFF_H$					
55						
°	End sequence #1 character check					
56	Reserved[1]	Character #5[2]	Character #4[2]	Character #3[2]	Character #2[2]	Character #1[2]
57	Character #1: 00_H through FF_H					
58	Character #2: 00_H through FF_H					
59	Character #3: 00_H through FF_H					
60	Character #4: 00_H through FF_H					
61	Character #5: 00_H through FF_H					
62	Maximum number of buffered received frames:					
	00_H - Reserved 01_H through FF_H - 1 through 255					
63	Prevent overwriting:					
	00_H - Deactivated (on receive buffer overflow, a new message overwrites the oldest message)01H - Activated (on receive buffer overflow, the new message is discarded) 02_H through FF_H - Reserved					
64	Clear receive buffer at startup:					
	00_H - Deactivated 01_H - Activated 02_H through FF_H - Reserved					
65	Reserved[1]					
66						
67						

1 Reserved bits must be set to 0.

2 You enable the respective parameter by setting the associated bit to 1.

3 Buffer size depends on the communication module used.

7.2 3964 communication

The following two configuration data records must be transferred to the communication module for 3964 communication:

7.2.1 Port configuration record - data record 57

NOTE

The "Port configuration record" is described in chapter Port configuration record - data record 57 (Page 40).

7.2.2 3964 protocol configuration - data record 61

NOTE

Parameter assignment error

If the communication module detects a parameter assignment error when writing the data record 61, the data record is rejected with error status $80E1_H$.

The corresponding cause of error can be read by means of data record "Read Error Status - data record 55" (error codes of the 3964 protocol).

3964 protocol configuration: P3964 (Write Record $003D_H$)								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: $003D_H$ – P3964							
1								
2	Block length: $000C_H$							
3								
4	Block version high byte: 01_H							
5	Block version low byte: 00_H							
6	Reserved[1]							
7								
8	3964(R) - With block check:							
	00_H - Deactivated 01_H - Activated 02_H through FF_H - Reserved							
9	3964(R) priority:							
	00_H - Low priority 01_H - High priority 02_H through FF_H - Reserved							
°	3964(R) character delay time:							

[1] Reserved bits must be set to 0.

3964 protocol configuration: P3964 (Write Record $003D_H$)	
10	0000_H through 0013_H - Reserved 0014_H through $FFFF_H$ - 20 to 65535 ms Default: $00DC_H$ - 220 ms
11	
°	3964(R) acknowledgment delay time:
12	0000_H through 0013_H - Reserved 0014_H through $FFFF_H$ - 20 to 65535 ms Default: $07D0_H$ - 2000 ms
13	
14	3964(R) connection attempts:
	00_H - Reserved 01_H through FF_H - 1 to 255 connection attempts Default: 06_H - 6 connection attempts
15	3964(R) transmission attempts:
	00_H - Reserved 01_H through FF_H - 1 to 255 transmission attempts Default: 06_H - 6 transmission attempts

[1] Reserved bits must be set to 0.

7.3 Activate special function - data record 58

The following data record can be used to activate diagnostic interrupts (write) and check whether diagnostic interrupts are activated (read).

NOTE

Parameter assignment error

If the communication module detects a parameter assignment error when writing the data record 58, the data record is rejected with error status $80E1_H$.

The corresponding cause of error can be read by means of data record "Read Error Status - data record 55" (error codes of the special functions).

Activate special function: PtP SET_FTRS (Write Record 003AH)								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: $003A_H$ – SET_FTRS							
1								
2	Block length: 0008_H							
3								
4	Block version high byte: 01_H							
5	Block version low byte: 00_H							
6	Reserved[1]							
7								
8								
9	Diagnostics interrupt:							
	00_H - Deactivated 01_H - Activated 02_H through FF_H - Reserved							
10	Reserved[1]							
11								

[1] Reserved bits must be set to 0.

Error status

8

The following data record contains the acknowledgment of the communication module to the writing a configuration data record.

8.1 Read error status - data record 55

Read Error Status: PtP RD_ESTAT (Read Record 0037_H)								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: 0037_H – RD_ESTAT							
1								
2	Block length: 0010_H							
3								
4	Block version high byte: 01_H							
5	Block version low byte: 00							
6	Reserved[1]							
7								
8	Error codes of the special functions							
9								
10	Error codes of the port configuration							
11								
12	Error codes of the send configuration							
13								
14	Error codes of the receive configuration							
15								
16	Error codes of the RS32 secondary signals							
17								
18	Error codes of the 3964 protocol							
19								

[1] Reserved bits must be set to 0.

A list of all error codes is available in chapter Error messages (Page 68).

Sending data

9

9.1 Sending data using data record

9.1.1 Flow chart for sending using data record

Users can send data based on the sequence outlined below. Management data and send data is transmitted to the communication module by means of a special data record. The communication module provides the acknowledgment in the input data.

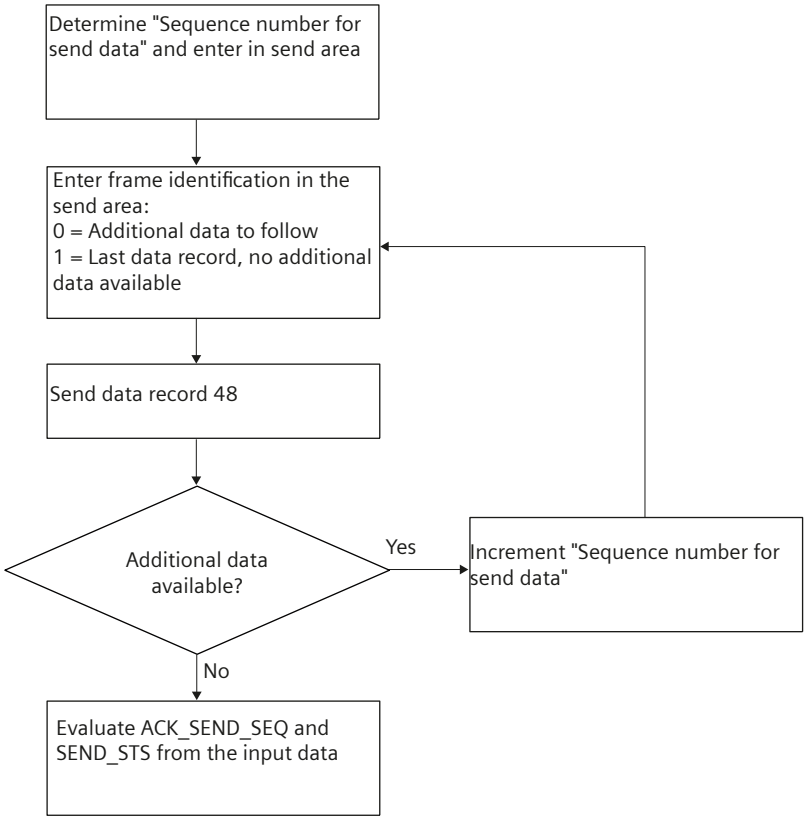

9.1.2 Send data - data record 48

The following data record is used to write send data to the communication module:

Sending data: SEND_PTP Record (Write Record 0030_H)								
Byte ↓	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
0	Sequence number for send data (1 to 255)							
1	Frame end identifier (0 or 1)							
2	Data to transmit byte 0							
: :	: :							

Sequence number for send data

The sequence number for send data identifies a new send frame or a new data record of a frame. The acknowledgment by the module in the input data (Page 53) must be read as first sequence number and incremented by the count of one. For the first data record, the sequence number therefore starts with 1 after a STOP-RUN transition of the CPU. It is then incremented by one for each data record with new content.

The value "0" may not be used as sequence number for send data. as it serves to detect the start of the module. The maximum value 255 is therefore followed by 1.

Frame end identifier

The frame end identifier serves to identify the last data record belonging to a frame.

- 0 means: At least one more data record follows for the current frame.
- 1 means: This data record is the last one for the current frame.

Data to transmit

The data must be stored in the data record as of "Data to transmit byte 0". The size and therefore the number of data records for transmitting a frame is defined by the transmission medium:

- PROFINET: 1, 2, or 4 KB, depending on the communication module
- PROFIBUS: 240 bytes

If the length of the data to transmit is not a multiple of the data record length, the length of the last data record corresponds to the length of the remaining data to transmit.

Acknowledgment from module

The module writes the sequence number received in the data record as acknowledgment to the net data (Page 53).

For the last data record belonging to a frame,the acknowledgment is not written until the module has sent the frame.

This acknowledgment (ACK_SEND_SEQ) must therefore be evaluated along with SEND_STS after the last data record was written.

Startup characteristics

During startup, the module writes to the input data "ACK_SEND_SEQ = 0" (Page 53).

A busy job must be aborted when ACK_SEND_SEQ = 0.

9.1.3 Request acknowledgment - Input data

The acknowledgment is entered by the communication module in ACK_SEND_SEQ in the input data. The input data has the following structure:

Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	: :	MODE[1]	: :					
1	ACK_SEND_SEQ							
2	SEND_STS							
3								
4	: :							
5								
6								
7								

[1] This bit is used for the plausibility check:
0_B: Universal
1_B: Performance option

Before sending a new frame, the feedback of the communication module must be received in the input data.

When the following feedback is received in the input data, the last send frame was sent without errors and the module is ready to accept the next frame:

- ACK_SEND_SEQ = Last "sequence number for send data"
- SEND_STS = 0

When SEND_STS ≠ 0, the last send frame was not sent without errors. In this case, you can find the meaning of the SEND_STS value in the section Error messages (Page 68).

Reaction of the module to an unexpected sequence number

The module rejects a data record with an unexpected sequence number for send data when writing the data record and returns the error message $80B8_H$. In SEND_STS, the value $81D7_H$ can be found in the input data. In this case, active communication must be canceled and transmission with the first data record (Page 52) must be repeated.

The send request is discarded, the incorrect sequence number is applied (if it is not 0) and incremented from this value.

9.1.4 Example

A frame with a length of 500 bytes is to be transmitted. The data record has a length of 240 bytes.

- First data record, length of 240 bytes:

  "Sequence number for send data" = 1

  "Frame end identifier" = 0

  238 bytes user data
- Second data record, length of 240 bytes:

  "Sequence number for send data" = 2

  "Frame end identifier" = 0

  238 bytes user data
- Third data record, length of 26 bytes

  "Sequence number for send data" = 3

  "Frame end identifier" = 1

  24 bytes user data
- Wait for feedback from the communication module; see Request acknowledgment - Input data (Page 53).

Afterwards, a frame with a length of 100 bytes is to be transmitted.

- First = last data record, length of 102 bytes:

  "Sequence number for send data" = 4

  "Frame end identifier" = 1

  100 bytes user data
- Wait for feedback from the communication module; see Request acknowledgment - Input data (Page 53).

9.2 Sending data via output data

9.2.1 Flow chart for sending using output data

Users can send data based on the sequence outlined below. Management data and send data is transmitted to the communication module using output data. The communication module provides the acknowledgment in the input data.

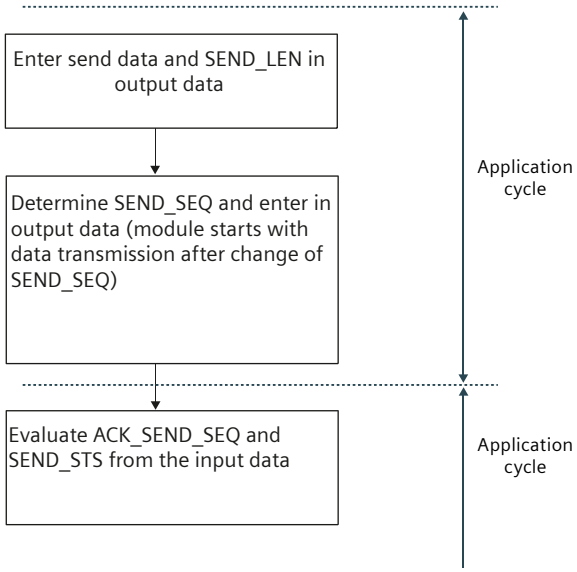

9.2.2 Output data when using the Performance option

When using the Performance option, the send data is written to the communication module via the output data.

Output data

The following table shows the assignment of the output data:

Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	SEND_SEQ							
1	ACK_RCV_ RECORD	SEND_LEN						
2	Data to transmit byte 0							
3	Data to transmit byte 1							
: :	: :							
30	Data to transmit byte 28							
31	Data to transmit byte 29							

SEND_SEQ

SEND_SEQ is the sequence number for send data and identifies a new send frame. In case of a change of SEND_SEQ, the communication module adopts the SEND_LEN value and the data to be transmitted and starts with the serial data transmission.

The SEND_SEQ value for the first send job after a STOP-RUN transition of the CPU is "1". For each additional send frame, the acknowledgment (Page 56) in the input data must be read and this value must then be incremented for SEND_SEQ by the count of one.

The value "0" may not be used. As it serves to detect the STOP-RUN transition of the CPU. The maximum value 255 is therefore followed by 1.

ACK_RCV_RECORD

After receiving a new sequence number for receive data (RCV_SEQ), the ACK_RCV_RECORD bit must be toggled in the output data to acknowledge receipt of the data. Afterwards, the communication module can once again send new input data.

SEND_LEN

SEND_LEN specifies the length of the data to be transmitted (1 to 30 bytes).

Data to transmit

The data to be transmitted contains the send frame whose length is limited to 30 bytes. The data must be stored as of "Data to transmit byte 0".

Acknowledgment from module

The module writes the received sequence number to ACK_SEND_SEQ in the input data (Page 56) as acknowledgment and confirmation that it is ready to accept the next send frame.

9.2.3 Request acknowledgment - Input data

The acknowledgment is entered by the communication module in ACK_SEND_SEQ in the input data. The input data has the following structure:

Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	: :	MODE[1]				: :		
1	ACK_SEND_SEQ							

[1] This bit is used for the plausibility check:
0_B: Universal
1_B: Performance option

Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
2	SEND_STS							
3								
4	: :							

[1] This bit is used for the plausibility check:
0_B: Universal
1_B: Performance option

Before sending a new frame, the feedback of the communication module (acknowledgment) must be received in the input data.

When the following feedback is received, the last send frame was sent without errors and the module is ready to accept the next frame:

- ACK_SEND_SEQ = Last sequence number for SEND_SEQ
- SEND_STS = 0

When SEND_STS ≠ 0, the last send frame was not sent without errors. In this case, you can find the meaning of the SEND_STS value in the section Error messages (Page 68).

Reaction of the module to an early send job

If you do not wait for the send acknowledgment, the module writes the value $81D0_H$ in SEND_STS as long as the current send job is active. The communication module initially postpones the new send job and continues with it as soon as the current send job is completed.

Reaction of the module to an unexpected sequence number

The module rejects an unexpected sequence number for send data. In SEND_STS, the value $81D7_H$ can be found.

The send request is discarded, the incorrect sequence number is applied (if it is not 0) and incremented from this value.

Receiving data

10

10.1 Receiving data using data record

10.1.1 Flow chart for receiving using data record

Users can receive data based on the sequence outlined below. The communication module signals the availability of new received data in the input data. The communication module provides management and receive data in a special data record.

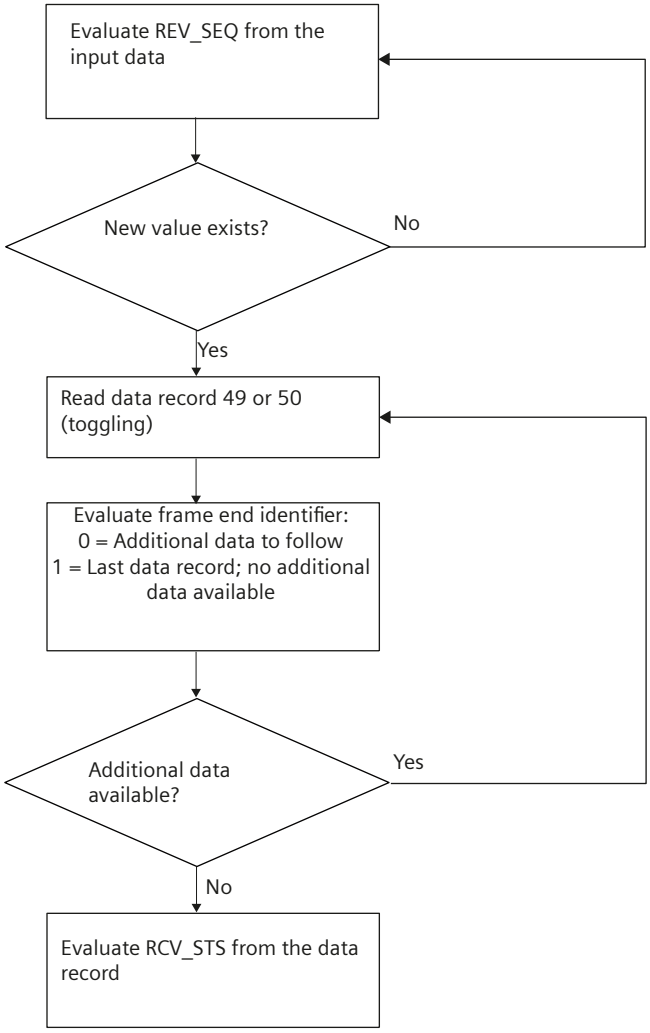

10.1.2 Data received - data record 49/50

A new value for RCV_SEQ in the input data (Page 60) indicates a new frame is ready for reading in the communication module.

The following data records are used to read receive data from the communication module:

Receiving data: RCV_PTP Record (Read Record 0031H/0032H)								
Byte ↓	**Bit 7**	**Bit 6**	**Bit 5**	**Bit 4**	**Bit 3**	**Bit 2**	**Bit 1**	**Bit 0**
0	Sequence number for this data record (1 to 255)							
1	Frame end identifier (0 or 1)							
2	RCV_STS							
3								
4	Receive data byte 0							
: :	: :							

Change of the data record number when receiving data

After startup of the communication module, reading of the frame content must start with the data record number 31_H. You must then toggle the data record number with each read process.

Sequence number of this data record

The "Sequence number of this data record" is equal to RCV_SEQ for the first data record of a frame in the input data (Page 60) that were displayed by the new frame. This value is incremented by the count of one for each data record read subsequently. An overflow to 2 is triggered at 255. The values 0 and 1 have a special significance.

Frame end identifier

The frame end identifier is equal to 1 for the last data record that has to be read for this frame, while it is 0 for all other data records.

The size of the last data record that belongs to a frame is determined by the frame length and limited accordingly by the communication module.

RCV_STS

RCV_STS displays the result of the data reception.

- $009x_H$: Frame received without error
- $8xxx_H$: Frame received with error

See chapter Error messages (Page 68).

10.1.3 Query: New receive frame - Input data

Sequence number for receive data

A new received frame is indicated by a sequence number for receive data in byte 4 of the input data.

Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	: :	MODE[1]	: :					
1	: :							
2								
3								
4	RCV_SEQ							
5	: :							
6	RCV_STS							
7								

1 This bit is used for the plausibility check:
0_B: Universal
1_B: Performance option

RCV_SEQ

RCV_SEQ contains the sequence number of the first data record of the frame currently being received by the module.

The values 0 and 1 have special meanings:

RCV_SEQ = 0:

- The communication module has performed a restart after power on and that no frame has been received yet.

RCV_SEQ = 1:

- This is the first frame after power on of the communication module. Reading of the frame content must start with the data record number 31_H.

A busy job must be aborted in both cases.

RCV_STS

In RCV_STS, you can read status information and an error number in case of an error (Page 68).

10.1.4 Example

A frame with a length of 500 bytes was received. The data record has a length of 240 bytes

- In the user data, the frame is indicated by "Sequence number for RCV" = 1.
- You read the data record 0031_H which includes:

  "Sequence number of this data record" = 1

  "Frame end identifier" = 0

  "RCV status or error code" = $009x_H$ [1)]

  It contains 236 bytes of user data.
- You read the second data record 0032_H which includes:

  "Sequence number of this data record" = 2

  "Frame end identifier" = 0

  "RCV status or error code" = $009x_H$ [1)]

  It contains 236 bytes of user data.
- You read the third data record 0031_H which includes:

  "Sequence number of this data record" = 3

  "Frame end identifier" = 1

  "RCV status or error code" = $009x_H$ [1)]

  It contains 28 bytes of user data. The communication module has limited the data record length to 32 bytes.

  This completes reading of the first frame from the CM.

A frame with a length of 100 bytes was received subsequently.

The sequence number for RCV changes from 1 to 4 in the user data.

- You read the data record 0032_H which includes:

  "Sequence number of this data record" = 4

  "Frame end identifier" = 1

  "RCV status or error code" = $009x_H$ [1)]

  The data record contains 100 bytes of user data and the communication module has limited the data record length to 104 bytes.

1) 0x009x Frame received without error

   0x8xxx Frame received with error

   (see error codes in chapter Query: New receive frame - Input data (Page 60))

10.2 Receiving data via input data

10.2.1 Flow chart for receiving via input data

Users can receive data based on the sequence outlined below. The communication module provides management and receive data in the input data.

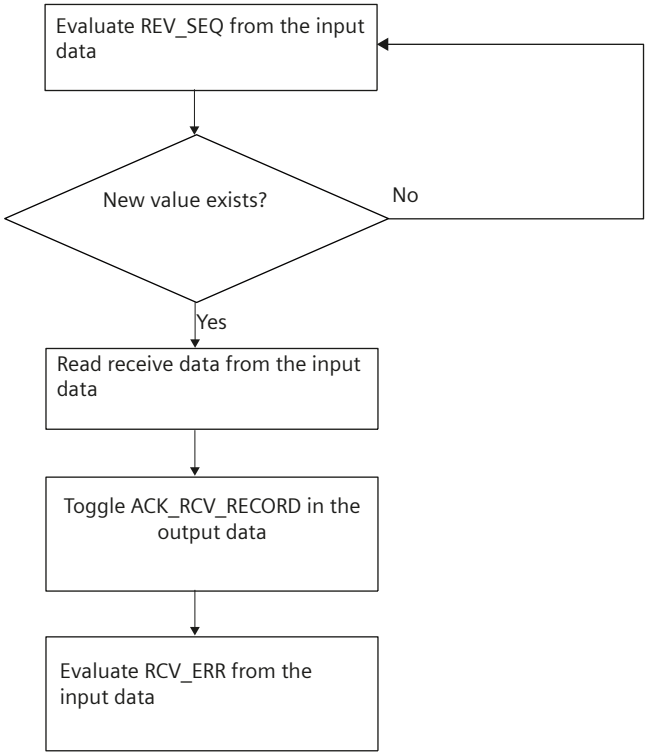

10.2.2 Input data when using the Performance option

When using the Performance option, the receive data is read from the communication module via the input data.

Input data

The following table shows the assignment of the input data:

Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	SGN_STAT	MODE	Ring_ Status	DCD_ Status	CTS_ Status	RTS_ Status	DSR_ Status	DTR_ Status
1	ACK_SEND_SEQ							
2	SEND_STS							
3								
4	RCV_SEQ							
5	RCV_ Record	RCV_LEN						

Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
6	RCV_STS							
7								
8	Receive data byte 0							
9	Receive data byte 1							
: :	: :							
30	Receive data byte 22							
31	Receive data byte 23							

SGN_STAT

This bit indicates whether RS232 secondary signals (Page 67) are available in the current operating mode of the communication module.

MODE

This bit is used for the plausibility check of the data exchange type:

MODE = 0: Universal (data communication via data record)

MODE = 1: Performance option (data communication via net data)

ACK_SEND_SEQ

The module acknowledges an executed send job by writing the associated sequence number in ACK_SEND_SEQ.

The module thus confirms that it is ready to execute the next send job.

RCV_SEQ

RCV_SEQ contains the sequence number of the frame currently shown in the input data and received by the module. This value is incremented by the count of one for each frame read subsequently. An overflow to 2 is triggered at 255.

The values 0 and 1 have special meanings:

RCV_SEQ = 0:

- The communication module has performed a restart after power on and that no frame has been received yet.

  or

- The receive buffer was cleared.

RCV_SEQ = 1:

- This is the first frame after power on of the communication module.

  or

- This is the first frame after clearing the receive buffer.

Acknowledge receipt of data

When a new frame with a new sequence number RCV_SEQ was received by the module, the receive data is read out. The ACK_RCV_RECORD bit must then be toggled in the output data to acknowledge receipt of the data. Afterwards, the communication module can write a new frame to the input data again.

RCV_RECORD

RCV_RECORD returns the value that was last received by the communication module in the ACK_RCV_RECORD bit in the output data.

RCV_LEN

RCV_LEN contains the length of the received data (1 to 24 bytes).

SEND_STS

In SEND_STS, you can read status information and an error number in case of an error (Page 68).

RCV_STS

RCV_STS displays the result of the data reception.

- $009x_H$: Frame received without error
- $8xxx_H$: Frame received with error

See chapter Error messages (Page 68).

Clear receive buffer

11

11.1 Clear receive buffer - data record 54

The receive buffer of the communication module is cleared by writing the following data record.

Delete receive buffer: PtP RCV_RST (Write Record 0036_H)								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: 0036_H – RCV_RST							
1								
2	Block length: 0008_H							
3								
4	Block version high byte: 01_H							
5	Block version low byte: 00_H							
6	Reserved[1]							
7								
8	0	0	0	0	0	0	0	1
9	Reserved[1]							
10								
11								

[1] Reserved bits must be set to 0.

MODE = Universal:

The communication module does not acknowledge the reset of its receive buffer.

MODE = Performance option:

Clearing of the receive buffer is signaled back with RCV_SEQ = 0.

RS232 signals

12

12.1 Set RS232 secondary signals - data record 53

The RS232 secondary signals of the communication module are manipulated by writing to the following data record, provided the communication module supports this action in the current mode.

NOTE

Parameter assignment error

If the communication module detects a parameter assignment error when writing the data record 53, the data record is rejected with error status $80E1_H$.

The corresponding cause of error can be read by means of data record "Read Error Status - data record 55" (error codes of the RS232 secondary signals).

Set RS232 accompanying signals: PtP SGN_SET (Write Record 0035_H)								
Bit->	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Byte								
0	Block type: 0035_H - SGN_SET							
1								
2	Block length: 0008_H							
3								
4	Block version high byte: 01_H							
5	Block version low byte: 00_H							
6	Reserved[1]							
7								
8	Reserved[1]					Set_DSR_ State	Set_DTR_ State	Set_RTS_ State
9	Reserved[1]					DSR_State[2]	DTR_State	RTS_State
10	Reserved[1]							
11								

1 Reserved bits must be set to 0.

2 Only available with interface type DCE

Note:
Set_xxx_State = 0: the status of the specified control bit is not changed.
Set_xxx_State = 1: the status of the specified control bit must be set to the value that was specified by xxx_State.

For information on reading the acknowledgment to the writing of this data record, refer to chapter "Error status (Page 50)".

12.2 Read RS232 secondary signals - Input data

The RS232 secondary signals of the communication module can be read in the input data.

Byte ↓	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	SGN_STAT	Mode	Ring_ Status	DCD_ Status	CTS_ Status	RTS_ Status	DSR_ Status	DTR_ Status
: :	: :							

SGN_STAT

This bit indicates whether RS232 secondary signals are available in the current operating mode of the communication module:

- SGN_STAT = 0: RS232 secondary signals not available
- SGN_STAT = 1: RS232 secondary signals available

Ring_Status

This bit indicates the status of the RS232 secondary signal RI (ring indicator).

DCD_Status

This bit indicates the status of the RS232 secondary signal DCD (data carrier signal detected).

CTS_Status

This bit indicates the status of the RS232 secondary signal CTS (send permission).

RTS_Status

This bit indicates the status of the RS232 secondary signal RTS (send request).

DSR_Status

This bit indicates the status of the RS232 secondary signal DSR (ready state of the communication partner).

DTR_Status

This bit indicates the status of the RS232 secondary signal DTR (ready state of the communication module).

Error messages 13

Overview of the status and error messages

Code	Description	Remedy
0000_H	No error	-
RECEIVE status and error codes		
0094_H	Frame end identified based on the "Receipt of fixed/maximum frame length"	-
0095_H	Frame end identified based on "Message timeout"	-
0096_H	Frame end identified based on expiration of the "Character delay time"	-
0097_H	No response frame was received within the parameterized maximum response time.	-
0098_H	Frame end identified based on the fulfillment of the "Read message length from message" conditions	-
0099_H	Frame end identified based on the receipt of the "End sequence"	-
SEND status and error codes		
7001_H	Initial call for a new frame: Data record transmission initiated	-
7002_H	Interim call: Data record transmission in process	-
8085_H	Invalid length specification	Select a suitable frame length. • Communication using data record: Depending on the module, the following are permissible: 1 ... 1024/2048/4096 bytes • Communication using net data: Maximum length is 30 bytes.
8087_H	The number of characters received by the module exceeds the number supported for performance optimization.	Select a suitable frame length or use communication via data record. For performance optimization, the maximum length is 24 bytes.
Error codes of the special functions		
8190_H	Incorrect setting of the CRC calculation	Select a suitable value for CRC calculation. The following are valid: deactivated or activated. Check whether the module addressed supports CRC calculation.
8191_H	Incorrect setting of the diagnostic interrupt	Select a suitable value for "Diagnostic interrupt". The following are valid: Diagnostic interrupt deactivated (0) or diagnostic interrupt activated (1).
Error codes of the "Port configuration"		
$81A0_H$	The module does not support this protocol.	Select a valid protocol for the module.
$81A1_H$	The module does not support this data transmission rate.	Select a valid data transmission rate for the module.

Code	Description	Remedy
$81A2_H$	The module does not support this parity setting.	Select a suitable value for "Parity". The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
$81A3_H$	The module does not support this number of data bits.	Select a suitable value for "Number of data bits". The following are valid: • 7 (2) • 8 (1)
$81A4_H$	The module does not support this number of stop bits.	Select a suitable value for "Number of stop bits". The following are valid: • 1 (1) • 2 (2)
$81A5_H$	The module does not support this type of data flow control.	Select a valid data flow control for the module.
$81A7_H$	Invalid value for XON or XOFF	Select suitable values for XON and XOFF. Valid range of values: 0...7F. XON must not be equal to XOFF.
$81A8_H$	Error in frame header	Check the data/values in the frame header.
$81AA_H$	Invalid operating mode	Valid operating modes are: • Full duplex (RS232) (0) • Full duplex (RS422) four-wire mode (point-to-point) (1) • Full duplex (RS422) four-wire mode (multipoint master) (2) / (CM PtP (ET 200SP)) • Full duplex (RS422) four-wire mode (multipoint slave) (3) / (CM PtP (ET 200SP)) • Half duplex (RS485) two-wire mode (4)
$81AB_H$	Invalid default setting of the receive line	Valid default settings are: • "No" default setting (0) • Signal R(A)=5 V, signal R(B)=0 V (break detection) (1): Can only be selected with: "Full duplex (RS422) four-wire mode (point-to-point connection)" and "Full duplex (RS422) four-wire mode (multipoint slave)". • Signal R(A)=0 V, signal R(B)=5 V (2): This default corresponds to the idle state (no active send operation). No break detection is possible with this default setting.
$81AC_H$	Invalid value for "Break detection"	Select a suitable value for "Break detection". The following are valid: • "0" (break detection deactivated) • "1" (break detection activated)
$81AF_H$	The module does not support this protocol.	Select a valid protocol for the module.

Code	Description	Remedy
Error codes of the "Send configuration"		
$81B5_H$	More than two end delimiters or End sequence > 5 characters	Select suitable values for "End delimiter" and "End sequence". The following are valid: • deactivated (0), • 1 (1) or 2 (2) end delimiters or • deactivated (0), • 1 (1) up to 5 (5) characters for the end sequence.
$81B6_H$	Send configuration rejected because the 3964(R) protocol was selected	Verify that no send configuration is transmitted if the 3964R) protocol is set.
Error codes of the "Receive configuration"		
$81C0_H$	Invalid start condition	Select a suitable start condition. The following are valid: • Send break before frame start • Send Idle Line.
$81C1_H$	Invalid end condition or no end condition selected	Select a suitable end condition.
$81C3_H$	Invalid value for "Maximum message length"	Select a suitable value for "Maximum message length". Valid range of values (depending on the module): 1-1024/2048/4096 (Byte)
$81C4_H$	Invalid value for "Offset of the length specification in the message"	Select a suitable value for "Offset of the length specification in the message". Valid range of values (depending on the module): 1-1024/2048/4096 (Byte)
$81C5_H$	Invalid value for "Size of length field"	Select a suitable value for "Size of length field". Valid range of values in bytes: • 1 (1) • 2 (2) • 4 (4)
$81C6_H$	Invalid value for "Number of characters not counted in length specification"	Select a suitable value for "Number of characters not counted in length specification". Valid range of values: 0 to 255 (bytes)
$81C7_H$	The total of "Offset in the message + size of the length field + number of character not counted" is greater than the maximum frame length	Select a suitable value for "Offset in message", "Size of the length field" and "Number of characters not counted". Valid range of values: • Offset in the message (depending on the module): 0-1022/2046/4094 (Byte) • Size of the length field: 1, 2, or 4 (bytes) • Number of characters not counted: 0-255 (bytes)
$81C8_H$	Invalid value for "Response timeout"	Select a suitable value for "Response timeout". Valid range of values: 1-65535 (ms)
$81C9_H$	Invalid value for "Character delay time"	Select a suitable value for "Character delay time". Valid range of values: 1-65535 (bit times)
$81CB_H$	Frame end sequence is activated, but no character is activated for the check	Activate one or several characters for the check.
$81CC_H$	Frame start sequence is activated, but no character is activated for the check	Activate one or several characters for the check.

Code	Description	Remedy
$81CD_H$	Invalid value for "Prevent overwriting"	Select a suitable value for "Prevent overwriting". The following are valid: • Prevent overwriting is deactivated (0) or • Prevent overwriting is activated (1)
$81CE_H$	Invalid value for "Clear receive buffer at startup"	Select a suitable value for "Clear receive buffer at startup". The following are valid: • Clear receive buffer at startup is deactivated (0) • Clear receive buffer at startup is activated (1)
SEND status and error codes		
$81D0_H$	Receiving send requests during runtime of a send job	Make sure that you do not receive send requests during runtime of a send job.
$81D1_H$	The waiting time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or, if necessary, change the parameter assignment.
$81D2_H$	"Hardware RTS always ON": Send command aborted due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ONfor the entire duration of transmission.
$81D3_H$	Send buffer overflow / send frame too long	Select a shorter frame length. The following are valid (depending on the module): 1-1024/2048/4096 (Byte)
$81D5_H$	Transmission aborted due to parameter changes, detected wire break, or because CPU in STOP	Check the parameter assignment, for wire break, and the CPU status.
$81D6_H$	Transmission canceled because end identifier was not received	Check the parameter assignment of the end delimiters and the frame of the communication partner.
$81D7_H$	Communication error between the user program and module	Check communication (e.g. consistency of the sequence number).
$81D8_H$	Transmission attempt rejected because module is not configured	Configure the module.
$81DF_H$	The module has reset the interface for one of the following reasons: • Module was restarted • Module parameters were reassigned • CPU STOP	–
Error codes when receiving messages		
$81E0_H$	Frame canceled: Receive buffer overflow / send frame too long	Increase the call rate for the receive function in the user program or configure communication with data flow control.
$81E1_H$	Frame canceled: Parity error	Check the connection line of the communication partners, or verify that both devices are configured for the same data transmission rate, parity and stop bit number.
$81E2_H$	Frame canceled: Character frame error	Check the settings for the start bit, data bits, parity bit, data transmission rate, and stop bit(s).
$81E3_H$	Frame canceled: Character overflow error	Firmware error: Contact Customer Support.

Code	Description	Remedy
$81E4_H$	Frame canceled: The total length of "Offset in the message + size of the length field + number of character not counted" is greater than the receive buffer	Select a suitable value for Offset in message, Size of the length field, and Number of characters not counted.
$81E5_H$	Frame canceled: Break	Receive line to partner is interrupted. Reconnect or switch on partner.
$81E6_H$	Maximum number of "Buffered receive frames" exceeded	In the user program, increase the call rate of the instruction, or parameterize communication with data flow control, or increase the number of buffered frames.
$81E8_H$	Frame canceled: The character delay time has expired before the message and criterion was detected	Partner device faulty or too slow. Check this, if required, using an interface tester that is interconnected in the transmission line.
$81EB_H$	Frame canceled: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1-1024/2048/4096 (Byte) Check the parameters of the frame end detection.
Error codes of RS232 secondary signals		
$81F0_H$	The module does not support RS232 secondary signals	You have made an attempt to set up secondary signals on a module that does not support RS232 secondary signals. Verify that this is an RS232 module or that RS232 mode (ET 200SP) is set.
$81F1_H$	No operation of RS232 secondary signals	RS232 secondary signals cannot be manipulated manually as long as hardware data flow is active.
Error codes of the receive configuration		
$82C1_H$	Invalid value for "Buffered receive frames".	Select a suitable value for "Buffered receive frames". Valid range of values: 1-255
$82C2_H$	Receive configuration rejected because the 3964(R) protocol was selected	Verify that no receive configuration is transmitted if the 3964(R) protocol is set.
3964(R) protocol error codes		
8380_H	Parameter assignment error: Invalid value for "Character delay time".	Select a suitable value for "Character delay time". Valid range of values: 1-65535 (ms)
8381_H	Parameter assignment error: Invalid value for "Response timeout".	Select a suitable value for "Response timeout". Valid range of values: 1-65535 (ms)
8382_H	Parameter assignment error: Invalid value for "Priority".	Select a suitable value for "Priority". The following are valid: • High (1) • Low (0)
8383_H	Parameter assignment error: Invalid value for "Block check"	Select a suitable value for "Block check". The following are valid: • with block check (1) • without block check (0)
8384_H	Parameter assignment error: Invalid value for "Connection attempts".	Select a suitable value for "Connection attempts". Valid range of values: 1-255
8385_H	Parameter assignment error: Invalid value for "Transmission attempts".	Select a suitable value for "Transmission attempts". Valid range of values: 1-255

Code	Description	Remedy
8386_H	Runtime error: Number of connection attempts exceeded	Check the interface cable and the transmission parameters. Also check whether the receive function is configured correctly at the partner device.
8387_H	Runtime error: Number of transmission attempts exceeded	Check the interface cable, the transmission parameters and the configuration of the communication partner.
8388_H	Runtime error: Error at the "Block check character" The internally calculated value of the block check character does not correspond to the block check character received by the partner at the connection end.	Check whether the connection is seriously disrupted; in this case you may also occasionally see error codes. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
8389_H	Runtime error: Invalid character received while waiting for free receive buffer	The send request of the communication partner (STX, 02H) is not answered with DLE until the receive buffer has been cleared. No additional character may be received before it has been cleared (except STX again). Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
$838A_H$	Runtime error: Logical error during receiving. Another character (other than DLE, ETX) was received after receipt of DLE.	Check whether the partner DLE in the frame header and in the data string is always in duplicate or the connection is released with DLE ETX. Check for proper function of the partner device, possibly using an interface test device that is switched into the transmission line.
$838B_H$	Runtime error: Character delay time exceeded	Partner device too slow or faulty. Check for proper function of the partner device, possibly using an interface test device that is switched into the transmission line.
$838C_H$	Runtime error: Wait time for free receive buffer has started	Increase the call rate of the instruction in the user program, or parameterize communication with data flow control.
$838D_H$	Runtime error: Frame repetition does not start within 4 s after NAK	Check the communication partner. A received frame that is possibly corrupted must be repeated by the partner within 4 seconds.
$838E_H$	Runtime error: One or several characters (except NAK and STX) were received in idle mode.	Verify the proper function of the partner device, for example, by means an interface tester that is interconnected in the transmission line.
$838F_H$	Runtime error: Initialization conflict - Both partners have set high priority	Set the "Low" priority at one of the partners
8390_H	Parameter assignment error: Error in frame header	Check the data/values in the frame header.
8391_H	Parameter assignment error: 3964 Parameter data record rejected because Freeport is set	Verify that no 3964 parameter data is transmitted if the Freeport protocol is set.

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ET 200MP / ET 200SP PtP Communication Instructions Used with Distributed I/O of an S7-300/400

Programming Manual

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Preface

Purpose of the documentation

This documentation provides important information on programming the point-to-point communication modules of the ET 200MP and ET 200SP in an S7-300/400 system with the instructions developed for TIA-Portal V12 (distributed use).

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Proficiency with STEP 7

Validity of the documentation

This documentation is valid for the following point-to-point communication modules

- CM PtP RS232 BA (6ES7540-1AD00-0AA0) communication module
- CM PtP RS422/485 BA (6ES7540-1AB00-0AA0) communication module
- CM PtP RS232 HF (6ES7541-1AD00-0AB0) communication module
- CM PtP RS422/485 HF (6ES7541-1AB00-0AB0) communication module
- CM PtP (6ES7137-6AA00-0BA0) communication module

Conventions

The term "CPU" is used in this manual to refer to both the CPUs of the S7-300/400 and the interface modules of the distributed I/O system.

Please also observe notes labeled as follows:

NOTE

The notes contain important information on the product described in the documentation, on the handling of the product or on part of the documentation to which particular attention should be paid.

Recycling and disposal

The products can be recycled due to their low pollutant content. For environmentally compliant recycling and disposal of your old device, please contact a company certified for the disposal of electronic waste.

Additional assistance

- Information about the Technical support (http://www.siemens.com/automation/support-request) available can be found in the appendix to this documentation.
- The range of technical documentation for the individual SIMATIC products and systems can be found on the SIMATIC Portal (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available in the Catalog (http://mall.automation.siemens.com).

Note on IT security

Siemens offers IT security mechanisms for its automation and drive product portfolio in order to support the safe operation of the plant/machine. We recommend that you inform yourself regularly on the IT security developments regarding your products. You can find information on this on the Internet (http://support.automation.siemens.com).

You can register for a product-specific newsletter here.

For the safe operation of a plant/machine, however, it is also necessary to integrate the automation components into an overall IT security concept for the entire plant/machine, which corresponds to the state-of-the-art IT technology. You can find information on this on the Internet (http://www.siemens.com/industrialsecurity).

Products used from other manufacturers should also be taken into account here.

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Documentation guide

1

Introduction

This modular documentation of the SIMATIC products covers diverse topics concerning your automation system.

The complete documentation for the S7-300/400, ET 200MP/SP systems consists of the relevant operating instructions, manuals and product information.

Overview of documentation on the topic of point-to-point communication

The table below includes additional documentation which amends this description.

Subject	Documentation	Important contents
System	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293) System manual ET 200MP distributed I/O system (http://support.automation.siemens.com/WW/view/en/59193214)	• Application planning • Installing • Connecting • Addressing • Commissioning • Maintenance
Communication	Function manual Communication (http://support.automation.siemens.com/WW/view/en/59192925)	• Basics of serial communication • Data transmission functions • Diagnostic functions
	Device manual CM PtP RS232 BA communication module (http://support.automation.siemens.com/WW/view/en/59057152) Device manual CM PtP RS232 HF communication module (http://support.automation.siemens.com/WW/view/en/59057160) Device manual CM PtP RS422/485 BA communication module (http://support.automation.siemens.com/WW/view/en59057390) Device manual CM PtP RS422/485 HF communication module (http://support.automation.siemens.com/WW/view/59061372) Device manual CM PtP communication module (http://support.automation.siemens.com/WW/view/en/59061378)	• Product overview • Connecting • Assigning parameters • Programming • Diagnostics

Subject	Documentation	Important contents
System diagnostics	Function manual System diagnostics (http://support.automation.siemens.com/WW/view/en/59192926)	For S7-1500, ET 200MP, ET 200SP: • Diagnostic evaluation Hardware/software
Setup	Function manual EMC/EMI compatible installation of control systems (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection

SIMATIC Manuals

The latest manuals of SIMATIC products are available on the Internet (http://www.siemens.com/automation/service&support) and can be downloaded free of charge.

Introduction 2

2.1 Convention

TIA Portal terminology

NOTE

TIA Portal terminology is used in this documentation.

- Instruction
  For the description of the blocks for Freeport/3964(R), Modbus and USS, this means that the differentiation between FB and SFB and between FC and SFC familiar to you from the S7-300/400 environment is no longer relevant and reference is now made only to instructions.
  All instructions are no longer dependent on the CPU used, but rather can be used both for S7-300/S7-400 (distributed in an ET 200MP/SP) and for S7-1500 (central and distributed).
- Communication module
  For the description of the devices, this means that the term "communication processor" familiar to you from the S7-300/400 environment is replaced by "communication module".

2.2 Overview of instructions

NOTE

Use of the instructions

In order to be able to use the instructions described below in an S7-300/400 environment (distributed in an ET 200MP/SP), you need to have integrated the required library in your STEP 7 (SIMATIC Manager) via a HSP (Hardware Support Package).

The following libraries are available:

- Freeport: PtP Communication, PtP_Comm
- Modbus (RTU): MODBUS (RTU), MODBUS_(RTU)
- USS: USS Communication, USS_Comm

Overview of the instructions

The communication protocols are implemented on the communication module. The protocol is used to adapt the interface of the communication module to the interface of the communication partner.

Communication between the CPU, the communication module and a communication partner takes place by means of special instructions and protocols that support the corresponding communication modules.

The instructions form the software interface between the CPU and the communication module. They must be called cyclically from the user program. Data transmission takes place across several cycles.

Table 3-1016 Instructions for Freeport

Instruction	Meaning
Port_Config (Page 15)	The instruction Port_Config allows you to dynamically assign basic interface parameters.
Send_Config (Page 17)	The instruction Send_Config (send configuration) allows you to dynamically assign send parameters of a port.
Receive_Config (Page 19)	The instruction Receive_Config (receive configuration) allows you to dynamically assign receive parameters of a port.
P3964_Config (Page 23)	The instruction P3964_Config (protocol configuration) allows you to dynamically configure the parameters of the 3964(R) procedure.
Send_P2P (Page 24)	The instruction Send_P2P allows you to send data to a communication partner.
Receive_P2P (Page 27)	The instruction Recveive_P2P allows you to receive data from a communication partner.
Receive_Reset (Page 28)	The instruction Receive_Reset allows you to clear the receive buffer of the communication module.
Signal_Get (Page 29)	The instruction Signal_Get allows you to read the RS232 accompanying signals.
Signal_Set (Page 30)	The instruction Signal_Set allows you to set the RS232 accompanying signals.
Get_Features (Page 31)	The instruction Get_Features allows you to read the extended functions supported by the communication module.
Set_Features (Page 32)	The instruction Set_Features allows you to activate the extended functions supported by the communication module.

Table 3-1017 Instructions for USS

Instruction	Meaning
USS_Port_Scan (Page 57)	The instruction USS_Port_Scan allows you to communicate by means of the USS network.
USS_Drive_Control (Page 58)	The instruction USS_Drive_Control allows you to swap data with the drive.
USS_Read_Param (Page 61)	The instruction USS_Read_Param allows you to read parameters from the drive.
USS_Write_Param (Page 63)	The instruction USS_Write_Param allows you to change parameters in the drive.

Table 3-1018 Instructions for Modbus

Instruction	Meaning
Modbus_Comm_Load (Page 34)	The instruction Modbus_Comm_Load allows you to configure the port of the communication module for Modbus RTU. .
Modbus_Master (Page 37)	The instruction Modbus_Master allows you to communicate as Modbus master by means of the PtP port.
Modbus_Slave (Page 43)	The instruction Modbus_Slave allows you to communicate as Modbus slave by means of the PtP port.

Programming - communication using instructions 3

3.1 Point-to-point

3.1.1 Overview of Freeport communication

STEP 7 offers extended instructions that can be used for Freeport communication with a protocol specified in the user program. These instructions can be divided into two categories:

- Configuration instructions
- Communication instructions

NOTE

CPU capacity

The Freeport instructions communicate with the communication modules by reading or writing data records.
When using the instructions, you should therefore check the capacity of the CPU for reading and writing data records.
If several instructions need to read or write data records simultaneously on a CPU, the user program may need to create a time offset between the calls of each instruction.

Configuration instructions

Before the user program can start the Freeport communication, the communication interface and the parameters for sending and receiving of data must be configured.

The interface configuration and the data configuration can be set for each CM in the device configuration or with the following instructions of your user program:

- Port_Config (Page 15)
- Send_Config (Page 17)
- Receive_Config (Page 19)
- P3964_Config (Page 23)

NOTICE

Device configuration <-> Configuration instructions

The device configuration parameters are transferred to the CM upon each Power On of the CPU (return of voltage).

The parameters of the configuration instructions are transferred to the CM as defined in your user program.

The parameters of the device configuration are not synchronized with the parameters of the configuration instructions, which means the parameters of the configuration instructions are not applied to the CPU device configuration.
With your user program, you determine the parameters that apply in the CM and when they apply.

Communication instructions

The user program uses the instructions for Freeport communication to send data to and receive data from the communication interfaces. The CMs send data to and receive data from the communication stations.

- Send_P2P (Page 24)
- Receive_P2P (Page 27)

NOTE

Data consistency

- If the data to be sent is transmitted consistently, it cannot be changed after the positive edge at the REQ parameter until DONE has been set by the Send_P2P instruction.
- If the receive data is to be read consistently, it may only be evaluated in the cycle in which NDR = TRUE.

The receive buffer can be reset with additional instructions and special RS232 signals can be queried and set.

- Receive_Reset (Page 28)
- Signal_Get (Page 29)
- Signal_Set (Page 30)

The following instructions let you read or write extended functions, as long as these are supported by the module.

- Get_Features (Page 31)
- Set_Features (Page 32)

All Freeport instructions work asynchronously. The instructions must therefore be called until the DONE output parameter indicates that execution is complete.

The user program can determine the send and receive status with the help of the query architecture. Send_P2P and Receive_P2P can be run at the same time. The communication modules buffer the send and receive data as required until a module-specific maximum buffer size has been reached.

NOTE

Resolution of bit times

The number of bit times is specified with the configured data transmission rate for different parameters. Specifying the parameter in bit times makes it independent of the data transmission rate. All parameters with unit of bit times can be specified with a maximum number of 65535.

3.1.2 Using the instructions

The Freeport instructions must be called cyclically to query received data or the end of transmission for a send process.

Depending on the data volume, data transmission may take place over several calls (program cycles).
If a command is completed with DONE = TRUE or NDR = TRUE, it has been executed without errors.

NOTE

Backing up STATUS

The DONE, NDR, ERROR and STATUS parameters are only available for one block cycle. To display the STATUS, you should therefore copy it to a free data area.

Master

Typical sequence for a master:

1. The Send_P2P instruction triggers transmission to the CM.
   Data transmission is initiated by a positive edge at the REQ input.
2. The Send_P2P instruction is executed in subsequent cycles to query the status of the transmission process.
3. When the Send_P2P instruction signals that transmission is complete at the DONE output, the user code can prepare the receipt of the answer.

4. The Receive_P2P instruction is run repeatedly to query an answer. If the CM has acquired response data, the Receive_P2P instruction copies the response to the CPU and signals that new data has been received at the NDR output.
5. The user program can process the response.
6. Back to step 1 and repetition of the sequence.

Slave

Typical sequence for a slave:

1. The user program runs the Receive_P2P instruction in each cycle.
2. If the CM has received a request, the Receive_P2P signals that new data is available at the NDR output and the request is copied to the CPU.
3. The user program processes the request and creates a response.
4. The response is returned to the master with the Send_P2P instruction.
5. The Send_P2P instruction must be run repeatedly to ensure that the send process is actually taking place.
6. Back to step 1 and repetition of the sequence.

The slave must ensure that Receive_P2P is called up often enough so that a transmission can be received by the master before it cancels the process due to a timeout while waiting for the response. To do so, the user program Receive_P2P can be called from within a cycle OB whose cycle time is sufficiently short so that the master can receive a transmission before the timeout setting expires. If the OB cycle time is set so that two runs can take place during the timeout setting of the master, the user program can receive all transmissions without any losses.

3.1.3 General parameters for Freeport operations

Table 3-1019 General input parameters of the Freeport instructions

Parameters	Description
REQ	Data transmission is initiated by a positive edge at the REQ input. Another edge at REQ may only be created after the command has been completed (DONE or ERROR). Data transmission can take several calls (program cycles), depending on the data volume. When you add a Freeport instruction to your program, STEP 7 prompts you to specify the instance DB (or to have STEP 7 create a corresponding instance DB). Use a unique DB for each PtP instruction call.
PORT	A port address is assigned during configuration of the communication module. The PORT parameter communicates assignment to a specific communication module to the instruction. You can select a symbolic name for the standard port after the configuration. The assigned CM port value is the "Hardware ID" property of the device configuration with S7-1500 and the "Input address" with S7-300/400. The symbolic port name is assigned in the symbol table.

The output parameters DONE, NDR, ERROR and STATUS of the Freeport instructions indicate the execution status of the Freeport functions.

Table 3-1020 Output parameters DONE, NDR, ERROR and STATUS

Parameters	Data type	Standard	Description
DONE	Bool	FALSE	Set to TRUE for one cycle to indicate that the last request was completed with errors; otherwise FALSE.
NDR	Bool	FALSE	Set to TRUE for one cycle to indicate that new data has been received; otherwise FALSE.
ERROR	Bool	FALSE	Set to TRUE for one cycle to indicate that the last request was completed with errors; the corresponding error code can be found in STATUS; otherwise FALSE.
STATUS	Word	0 or 0x7000	Result status: • If the bit DONE or NDR is set, STATUS is set to 0/0x700 or to a specific error code. • If the bit ERROR is set, STATUS displays an error code. • If none of the bits listed above is set, the instruction can return status results that describe the current status of the function. The value in STATUS is valid until you call this instruction again (with one and the same port address).

Table 3-1021 COM_RST in/out parameter

Parameters	Data type	Standard	Description
COM_RST	Bool	FALSE	Initialization of the instruction You initialize the instruction with TRUE. COM_RST is then reset to FALSE. Note: You must set COM_RST to TRUE during startup and should not subsequently change the parameter (that is, do not assign a value when you call the instruction). COM_RST is reset by the instruction following initialization of the instance DB.

NOTE

Please note that the parameters DONE, NDR, ERROR and STATUS are only set for one cycle.

Table 3-1022 Shared error codes

Error code	Description
0x0000	No error
0x7000	Function not active
0x7001	Initial call after request started.
0x7002	Subsequent call after request started.
0x8x3A	Invalid pointer in parameter x

Table 3-1023 Shared error classes of the STATUS parameter

Description of the class	Error classes	Description
Port configuration	0x81Ax	For the description of frequent errors in the interface configuration
Send configuration	0x81Bx	For the description of errors in the send configuration
Receive configuration	0x81Cx	For the description of errors in the receive configuration

Description of the class	Error classes	Description
Sending	0x81Dx	For the description of runtime errors during sending
Receiving	0x81Ex	For the description of runtime errors during receiving
RS232 accompanying signals	0x81Fx	For the description of errors in connection with signal processing

3.1.4 Port_Config: Configure PtP communication port

Description

The Port_Config instruction (port configuration) allows you to change parameters such as the data transmission rate in runtime using your program. The data pending in the CM is deleted with the execution of Port_Config.

Configuration changes of Port_Config are saved on the CM and not in the CPU. When the voltage returns, the CM is configured with the data saved in the device configuration.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/40-0/ WinAC		
REQ	IN	Bool		FALSE	Starts the transmission of data to the CM upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	The CM port value can be found in the "Hardware ID" property of the device configuration (S7-1500) (input address; S7-300/400) once you have configured the CM. The symbolic port name is assigned in the "System constants" tab of the PLC tag table. In S7-300/400/WinAC systems, the input address assigned in HWCN must be assigned to the CM port.
PROTOCOL	IN	UInt	Word	0	Protocol • 0 = Freeport protocol • 1 = Protocol 3964(R)
BAUD	IN	UInt	Word	6	Data transmission rate of the port: • 1 = 300 Bit/s • 2 = 600 Bit/s • 3 = 1200 Bit/s • 4 = 2400 Bit/s • 5 = 4800 Bit/s • 6 = 9600 Bit/s • 7 = 19200 Bit/s • 8 = 38400 Bit/s • 9 = 57600 Bit/s • 10 = 76800 Bit/s • 11 = 115200 Bit/s

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/ WinAC		
PARITY	IN	UInt	Word	1	Parity of the port: • 1 = no parity • 2 = even parity • 3 = odd parity • 4 = mark parity • 5 = space parity • 6 = any
DATABITS	IN	UInt	Word	1	Bits per character: • 1 = 8 data bits • 2 = 7 data bits
STOPBITS	IN	UInt	Word	1	Stop bits: • 1 = 1 stop bit • 2 = 2 stop bits
FLOWCTRL	IN	UInt	Word	1	Flow control: • 1 = no flow control • 2 = XON/XOFF • 3 = Hardware RTS always ON • 4 = Hardware RTS switched • 5 = Hardware RTS always ON, ignore DTR/DSR
XONCHAR	IN	Char		11H	Specifies the character that serves as XON character. It is typically a DC1 character (11H). This parameter is only evaluated when software flow control is active.
XOFFCHAR	IN	Char		13H	Specifies the character that serves as XOFF character. It is typically a DC3 character (13H). This parameter is only evaluated when software flow control is active.
WAITIME	IN	UInt	Word	2000	Specifies how long to wait for an XOFF character after receipt of an XON character or how long to wait for a CTS = ON signal after CTS = OFF (0 to 65535 ms). This parameter is only evaluated when flow control is active.
MODE	IN	USInt	Byte	0	Operating mode Valid operating modes are: • 0 = Full duplex (RS232) • 1 = Full duplex (RS422) four-wire operation (point-to-point) • 2 = Full duplex (RS 422) four-wire mode (multipoint master; CM PtP (ET 200SP)) • 3 = Full duplex (RS 422) four-wire mode (multipoint slave; CM PtP (ET 200SP)) • 4 = Half duplex (RS485) two-wire mode

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/40-0/ WinAC		
LINE_PRE	IN	USInt	Byte	0	Receive line initial state Valid initial states are: • 0 = "no" initial state • 1 = signal R(A)=5 V, signal R(B)=0 V (break detection): Break detection is possible with this initial state. Can only be selected with: "Full duplex (RS422) four-wire operation (point-to-point connection)" and "Full duplex (RS422) four-wire operation (multipoint slave)". • 2 = signal R(A)=0 V, signal R(B)=5 V: This default setting corresponds to the idle state (no active send operation). No break detection is possible with this initial state.
CABLE_BRK	IN	USInt	Byte	0	Break detection The following settings are valid: • 0 = break detection deactivated • 1 = break detection activated
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Port_Config instruction The instruction is initialized with 1. The instruction then resets COM_RST to 0.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 68))

3.1.5 Send_Config: Configure PtP sender

Description

The Send_Config instruction (send configuration) allows you to change send parameters in runtime using your program (conditions that identify the start and the end of the data to be sent). Any data pending in a CM is deleted when Send_Config is executed.

Configuration changes of Send_Config are saved on the CM and not in the CPU. The parameters saved in the device configuration are restored once the voltage returns to the CPU or the communication module.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/ WinAC		
REQ	IN	Bool		FALSE	Activates the configuration change upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	The CM port value can be found in the "Hardware ID" property of the device configuration (S7-1500) (input address; S7-300/400) once you have configured the CM. The symbolic port name is assigned in the "System constants" tab of the PLC tag table. In S7-300/400/WinAC systems, the input address assigned in HWCN must be assigned to the CM port.
RTSONDLY	IN	UInt	Word	0	Number of milliseconds to wait after activation of RTS before a transmission of send data is started. This parameter is only valid if the hardware flow control is active. The valid range is 0 to 65535 ms. The value 0 deactivates the function.
RTSOFFDLY	IN	UInt	Word	0	Number of milliseconds to wait after transmission of send data before RTS is deactivated: This parameter is only valid if the hardware flow control is active. The valid range is 0 to 65535 ms. The value 0 deactivates the function.
BREAK	IN	UInt	Word	0	This parameter specifies that a BREAK is to be sent at the start of each frame for the specified number of bit times. The maximum is 65535 bit times. The value 0 deactivates the function.
IDLELINE	IN	UInt	Word	0	This parameter specifies that the line is to remain in idle for the specified number of bit times prior to the start of each frame. The maximum is 65535 bit times. The value 0 deactivates the function.
USR_END	IN	STRING[2]		0	Input of end delimiters. No more than 2 end delimiters can be configured. All data including the end delimiter(s) is sent, independent of the configured frame length.
APP_END	IN	STRING[5]		0	Input of characters to be appended. You can append up to 5 characters.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Send_Config instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 68))

3.1.6 Receive_Config: Configure PtP recipient

Description

The Receive_Config instruction (receive configuration) allows you to change receive parameters in runtime using your program. This instruction configures the conditions that mark the start and the end of received data. Any data pending in a CM is deleted when Receive_Config is executed.

Configuration changes of Port_Config are saved on the CM and not in the CPU. The parameters saved in the device configuration are restored once the voltage returns to the CPU or the communication module.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Activates the configuration change upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	The CM port value can be found in the "Hardware ID" property of the device configuration (S7-1500) (input address; S7-300/400) once you have configured the CM. The symbolic port name is assigned in the "System constants" tab of the PLC tag table. In S7-300/400/WinAC systems, the input address assigned in HWCN must be assigned to the CM port.
Receive_Conditions	IN	Variant	Any	-	The data structure of Receive_Conditions specifies the start and end conditions used to identify the start and end of a frame.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Receive_Config instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 68))

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Start conditions for the Receive_P2P instruction

The Receive_P2P instruction uses the configuration specified in the device configuration or by the Receive_Config instruction to determine the start and end of Freeport communication frames. The start of the frame is defined by the start conditions. The start of the frame can be determined with one or several start conditions.
If Break as well as Idle Line is activated, Break must be met first and then Idle Line as well. After that, one of the other conditions (start character or start sequence) is sufficient to start data transmission.

The start condition "Random character" cannot be combined with other start conditions.

Data type structure of the Receive_Conditions parameter, part 1 (start conditions)

Table 3-1024 Structure of Receive_Conditions for start conditions

Parameters	Declaration	Data type	Standard	Description
START. STARTCOND	IN	Word	02H	Specifying the start condition • 01H - detection of the start character • 02H - Any character • 04H - detection of a line break • 08H - detection of an idle line • 10H - detection of start sequence 1 • 20H - detection of start sequence 2 • 40H - detection of start sequence 3 • 80H - detection of start sequence 4 The start conditions can be combined by adding the values together.
START.IDLETIME	IN	Word	28H	The number of bit times required in the idle state for a new frame start to be detected (default value: W#16#28). Only in connection with the condition "Detection of an idle line". 0 to FFFF
START. STARTCHAR	IN	Byte	02H	The start character for the condition "Start character". (default value: B#16#2)
START.SEQ[1].CTL	IN	Byte	0	Start sequence 1, deactivate/activate comparison for each character: (default value: B#16#0) These are the activation bits for each character of the start character string. • 01H - character 1 • 02H - character 2 • 04H - character 3 • 08H - character 4 • 10H - character 5 When a bit is deactivated for a specific character, this means that each character in this position in the character string represents a valid start character string (e.g. 1FH = all 5 characters interpreted).
START.SEQ[1].STR [1] .. START.SEQ[1]. STR.[5]	IN	Char[5]	0	Start sequence 1, start character (5 characters).
START.SEQ[2].CTL	IN	Byte	0	Start sequence 2, deactivate/activate comparison for each character. Default value: B#16#0)
START.SEQ[2].STR [1] .. START.SEQ[2]. STR.[5]	IN	Char[5]	0	Start sequence 2, start character (5 characters).
START.SEQ[3].CTL	IN	Byte	0	Start sequence 3, deactivate/activate comparison for each character. Default value: B#16#0

Parameters	Declaration	Data type	Standard	Description
START.SEQ[3].STR[1] .. START.SEQ[3]. STR.[5]	IN	Char[5]	0	Start sequence 3, start character (5 characters).
START.SEQ[4].CTL	IN	Byte	0	Start sequence 4, deactivate/activate comparison for each character. Default value: B#16#0
START.SEQ[4].STR[1] .. START.SEQ[4]. STR.[5]	IN	Char[5]	0	Start sequence 4, start character (5 characters),

Example

Have a look at the following received data in hexadecimal coding: "**68** 10 aa **68** bb 10 aa 16". The configured start character strings are available in the following table. Start character strings are evaluated once the first character 68H has been successfully received. After the fourth character has been successfully received (the second 68H), start condition 1 has been met. Once the start conditions have been met, the evaluation of the end conditions starts.

Processing of the start character string can be canceled due to different errors in parity, framing or time intervals between characters. These errors prevent receipt of the data because the start condition has not been met (an error message is output).

Table 3-1025 Start conditions

Start condition	First character	First character +1	First character +2	First character +3	First character +4
1	**68**H	xx	xx	**68**H	xx
2	10H	aaH	xx	xx	xx
3	dcH	aaH	xx	xx	xx
4	e5H	xx	xx	xx	xx

End conditions for the Receive_P2P instruction

The end of a frame is defined by the first occurrence of one or more configured end conditions.

You can configure the end conditions either in the properties of the communication interface in the device configuration, or with the Receive_Config instruction. The receive parameters (start and end conditions) are reset to the settings in the device configuration each time the voltage returns to the CPU or the communication module. When the STEP 7 user program executes Receive_Config, the settings are set to the parameters of Receive_Config .

Data type structure of the Receive_Conditions parameter, part 2 (end conditions)

Table 3-1026 Structure of Receive_Conditions for end conditions

Parameters	Declaration	Data type	Standard	Description
END.ENDCOND	IN	Word	0	This parameter specifies the condition for the frame end: • 01H - response timeout • 02H - message timeout • 04H - character delay time • 08H - maximum frame length • 10H - read message length from message (N+LEN+M) • 20H - end sequence • 40H - fixed frame length
END.FIXLEN	IN	Word	1	Fixed frame length: Only used if the end condition "Fixed length" has been selected. 1 to 4000 bytes (up to 4 KB depending on the module)
END.MAXLEN	IN	Word	1	Maximum frame length: Only used if the end condition "Maximum length" has been selected. 1 to 4000 bytes (up to 4 KB depending on the module)
END.N	IN	Word	0	Byte position of the length field in the frame. Only used with end condition N+LEN+M. 1 to 4000 bytes (up to 4 KB depending on the module)
END.LENGTHSIZE	IN	Word	0	Size of the length field (1, 2, or 4 bytes). Only used with end condition N+LEN+M.
END.LENGTHM	IN	Word	0	Number of characters after the length field that are not included in the value of the length field. This entry is only used with end condition N+LEN+M. 0 to 255 bytes
END.RCVTIME	IN	Word	200	Specify the wait time for the first received character after a frame has been sent. The receive instruction is terminated with an error message if a character is not received within the specified time. This information is used only with the condition "Response timeout". (0 to 65535 ms). Note: This parameter cannot be used as sole end criterion but only in connection with at least one other end condition.
END.MSGTIME	IN	Word	200	Specify how long to wait for receipt of the complete frame after receipt of the first character. This parameter is used only if the condition "Message timeout" is selected. (0 to 65535 ms)
END.CHARGAP	IN	Word	12	Enter the maximum number of bit times between characters. If the number of bit times between characters exceeds the specified value, the end condition has been met. This information is used only with the condition "Character delay time". (0 to 65535 bit times)
END.SEQ.CTL	IN	Byte	0	Character sequence 1, deactivate/activate comparison for each character: These are the activation bits for each character of the end character string. Character 1 is bit 0, character 2 is bit 1, ..., character 5 is bit 4. If a bit is deactivated for a specific character, this means that each character represents a congruence at this position of the character string.
END.SEQ.STR[1] .. END.SEQ.STR[5]	IN	Char[5]	0	Character string 1, start character (5 characters)

Table 3-1027 General parameters of the Receive_P2P instruction

Parameters	Declaration	Data type	Standard	Description
GENERAL. MBUF_SIZE	IN	Byte	255	Input number of frames that are to be buffered in the receive buffer of the CM. If no other conditions are active that influence the reaction of the receive buffer (prevent timeout, data flow control), additional frames are discarded once the limit has been reached. (1 to 255 frames)
GENERAL. OW_PROT	IN	Byte	0	Activates the no overwriting function of the buffered frame if the CM receives a new frame and the receive buffer of the CM was not yet read. This step prevents already buffered received frames from being lost. • 0 - not activated • 1 - activated
GENERAL. CLR_MBUF	IN	Byte	0	Activates deletion of the receive buffer during CPU startup. The receive buffer is automatically deleted when the CPU switches from STOP to RUN. The receive buffer only contains frames received after CPU startup. • 0 - not activated • 1 - activated

3.1.7 P3964_Config: Configuring the 3964(R) protocol

Description

The P3964_Config instruction (protocol configuration) allows you to change protocol parameters for 3964(R), such as character delay time, priority and block check, in runtime using your program.

Configuration changes of P3964_Config are saved on the CM and not in the CPU. The parameters saved in the device configuration are restored once the voltage returns to the CPU or the communication module.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the instruction upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	The CM port value can be found in the "Hardware ID" property of the device configuration (S7-1500) (input address; S7-300/400) once you have configured the CM. The symbolic port name is assigned in the "System constants" tab of the PLC tag table. In S7-300/400/WinAC systems, the input address assigned in HWCN must be assigned to the CM port.
BCC	IN	SInt	Byte	1	Activates/deactivates the use of the block check • 0 = without block check • 1 = with block check

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
Priority	IN	SInt	Byte	1	Selection of the priority • 0 = low priority • 1 = high priority
CharacterDelay-Time	IN	UInt	Word	DCH	Setting the character delay time (depending on the set data transmission rate) (default value: 220 ms) 1 ms to 65535 ms
AcknDelayTime	IN	UInt	Word	7D0H	Setting the acknowledgment delay time (depending on the set data transmission rate) (default value: 2000 ms) 1 ms to 65535 ms
BuildupAttempts	IN	SInt	Byte	6H	Setting the number of connection attempts (default value: 6 connection attempts) 1 to 255
RepetitionAt-tempts	IN	SInt	Byte	6H	Setting the number of transmission attempts (default value: 6 connection attempts) 1 to 255
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the P3964_Config instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 68))

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3.1.8 Send_P2P: Sending data

Description

The Send_P2P instruction (send point-to-point data) starts the transmission of data and transmits the contents of the assigned buffer to the communication module. The CPU program is still being executed while the CM sends the data with the data transmission rate. Only one send instruction per communication module may be pending at any time. The CM signals an error if a second Send_P2P instruction is executed while the CM is already sending a frame.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the transmission of data to the CM upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	The CM port value can be found in the "Hardware ID" property of the device configuration (S7-1500) (input address; S7-300/400) once you have configured the CM. The symbolic port name is assigned in the "System constants" tab of the PLC tag table. In S7-300/400/WinAC systems, the input address assigned in HWCN must be assigned to the CM port.
BUFFER	IN	Variant	Any	0	This parameter points to the start address of the send buffer. **Note:** Boolean data and Boolean fields are not supported.
LENGTH	IN	UInt	Word	0	Length in bytes of the data to be transferred
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Send_P2P instruction The instruction is initialized with 1. The instruction then resets COM_RST to 0.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 68))

Parameters

The DONE and ERROR outputs are in FALSE status when a send instruction is being processed. At the end of the send instruction, one of the DONE or ERROR outputs is set to TRUE for one cycle to signal the status of the send instruction. The error code at the STATUS output can be evaluated when the status of ERROR is TRUE.

The instruction outputs the status 16#7001 when the communication interface accepts the send data. Subsequent executions of Send_P2P output the value 16#7002 if the CM is still sending. At the end of the send instruction, the CM outputs the status 16#0000 for the send instruction (if no error has occurred). Subsequent executions of Send_P2P with REQ = 0 output the status 16#7000 (free).

The diagram below shows the relationship between the output values and REQ. It is based on the assumption that the instruction is called cyclically to check the status of the send process (indicated by the STATUS values).

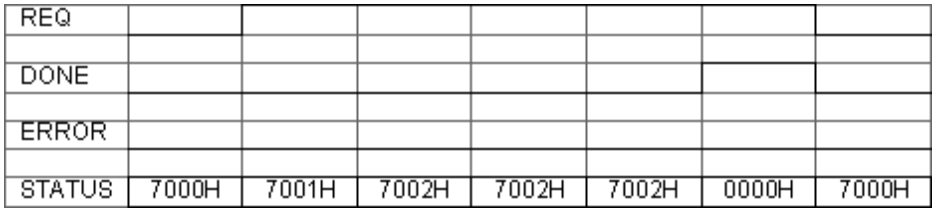

The figure below shows how the DONE and STATUS parameters are only valid for one cycle if a pulse is pending at the REQ line (for one cycle) to trigger the send instruction.

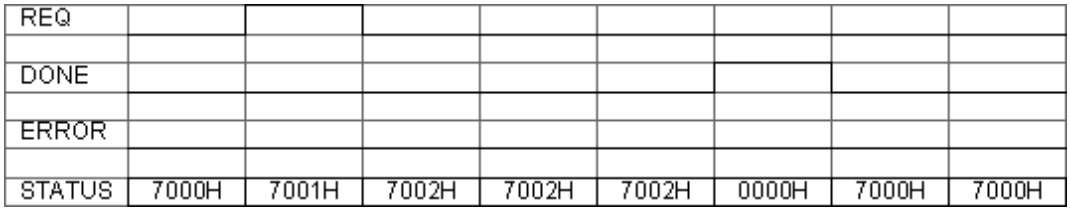

The figure below shows the relationship of the DONE, ERROR and STATUS parameters in case of an error.

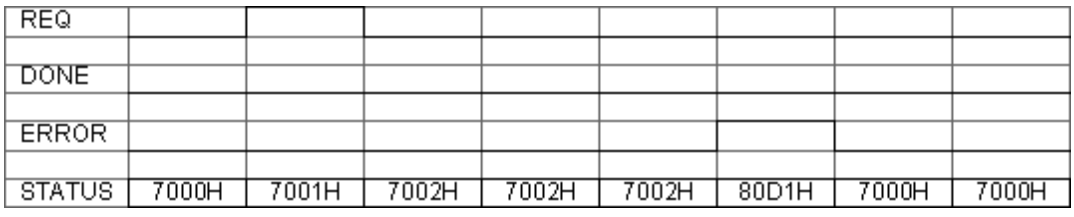

The DONE, ERROR and STATUS values are only valid until Send_P2P is executed again with the same instance DB.

3.1.9 Using LENGTH and BUFFER parameters in communication operations

Interaction of LENGTH and BUFFER parameters for Send_P2P

The minimum data size sent by the Send_P2P instruction is one byte. The BUFFER parameter specifies the size of the data to be sent if a "0" is passed at the LENGTH parameter during call. You cannot use the data type Bool or arrays of the Bool type for the BUFFER parameter.

Table 3-1028 LENGTH parameter

LENGTH	Description
> 0	Transfers the configured number of bytes.
= 0	Transfers the entire contents of the send buffer addressed with BUFFER. If BUFFER points to a string, the entire string contents are transferred except for the bytes with the maximum and actual length.

Table 3-1029 BUFFER parameter

BUFFER	Description
Elementary data type	When sending: The LENGTH value must include the byte size of this data type. Example: For a Word value, the LENGTH must be two. For a DWord value or Real value, the LENGTH must be four.
Structure	For optimized memory: The maximum permitted length of the BUFFER is 1024 Byte; otherwise 4 KB are permitted depending on the module. For sending: The LENGTH value can include a byte size smaller than the complete byte length of the structure; in this case, only the first LENGTH bytes of the structure from BUFFER are sent.
Array	For optimized memory: If the array data type is not equal to Byte, Word or DWord, the maximum permitted buffer length is 1024 Byte. Depending on the module, up to 4 KB can be transmitted if the memory is not optimized, independent of the data structure. For sending: The LENGTH value can include a byte size smaller than the complete byte length of the array, whereby, this byte size is a multiple of the byte size of the data element. Example: The LENGTH parameter of an array of the Word type must be a multiple of two and a multiple of four for an array of the Real type. If LENGTH is specified, the number of array elements is transmitted. If BUFFER includes an array with 15 DWord elements (a total of 60 Bytes), for example, and you specify LENGTH = 20, the first five DWord elements from the array are transmitted.
String	The LENGTH parameter includes the number or characters to be sent. Only the characters of the String are transmitted. The bytes with the maximum and actual length of the String are not sent.

3.1.10 Receive_P2P: Receiving data

Description

The Receive_P2P instruction (receive data using point-to-point communication) checks the frames received in the CM. If a frame is available, it is transmitted from the CM to the CPU. A receive error is indicated at the STATUS parameter.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
PORT	IN	PORT (UInt)	Word	0	The CM port value can be found in the "Hardware ID" property of the device configuration (S7-1500) (input address; S7-300/400) once you have configured the CM. The symbolic port name is assigned in the "System constants" tab of the PLC tag table. In S7-300/400/WinAC systems, the input address assigned in HWCN must be assigned to the CM port.
BUFFER	IN	Variant	Any	0	This parameter points to the start address of the receive buffer. This buffer must be large enough to receive the maximum frame length. **Note:** Boolean data or Boolean fields are not supported.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Receive_P2P instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
LENGTH	OUT	UInt	Word	0	Length of the frame received in bytes
NDR	OUT	Bool		FALSE	TRUE for one cycle if new data is available and the instruction has been completed without errors.
ERROR	OUT	Bool		FALSE	TRUE for one cycle once the instruction has been completed with an error.
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 68))

The error code at the STATUS output can be evaluated if the status of ERROR is TRUE. The STATUS value provides the reason for terminating the receive operation in the CM.
This is usually a positive value which indicates that the receive operation has been successful and the frame criterion that has been detected.
If the STATUS value is negative (the most significant bit of the hexadecimal value is set), the receive operation was terminated due to an error condition, such as a parity, framing or overflow error.

Each communication module can buffer a module-specific number for frames. If several frames are available in the CM, the Receive_P2P instruction outputs the oldest available frame (FIFO).

3.1.11 Receive_Reset: Clear receive buffer

Description

The Receive_Reset instruction (reset receiver) clears the receive buffer in the CM.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the transmission of data to the CM upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	The CM port value can be found in the "Hardware ID" property of the device configuration (S7-1500) (input address; S7-300/400) once you have configured the CM. The symbolic port name is assigned in the "System constants" tab of the PLC tag table. In S7-300/400/WinAC systems, the input address assigned in HWCN must be assigned to the CM port.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Receive_Reset instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
DONE	OUT	Bool		FALSE	TRUE for one cycle means that the last request was completed without errors.
ERROR	OUT	Bool		FALSE	TRUE means that the last request was completed with errors. If this output is TRUE, the STATUS output contains the corresponding error codes.
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 68))

3.1.12 Signal_Get: Read status

Description

The Signal_Get instruction (get RS232 signals) reads the current states of the RS232 accompanying signals and displays them at the corresponding instruction outputs.

NOTE
Restriction
This function can only be used with CMs RS232 BA and RS232 HF.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the transmission of data to the CM upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	The CM port value can be found in the "Hardware ID" property of the device configuration (S7-1500) (input address; S7-300/400) once you have configured the CM. The symbolic port name is assigned in the "System constants" tab of the PLC tag table. In S7-300/400/WinAC systems, the input address assigned in HWCN must be assigned to the CM port.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Signal_Get instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
NDR	OUT	Bool		FALSE	TRUE for one cycle if the RS232 accompanying signals have been read and the instruction has been completed without errors.
ERROR	OUT	Bool		FALSE	TRUE for one cycle once the instruction has been completed with an error
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 68))
DTR	OUT	Bool		FALSE	Data device ready, module ready (output)

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
DSR	OUT	Bool		FALSE	Data device ready, communication station ready (input)
RTS	OUT	Bool		FALSE	Send request, module ready to send (output)
CTS	OUT	Bool		FALSE	Ready to send, communication station can receive data (input)
DCD	OUT	Bool		FALSE	Data carrier signal detected, signal level received
RING	OUT	Bool		FALSE	Call display, signaling incoming call

3.1.13 Signal_Set: Set accompanying signals

Description

The Signal_Set instruction (set RS232 signals) allows you to set the RS232 communication signals.

This function is only valid for RS232 CM.

NOTE
Restrictions
This function can only be used with CMs RS232 BA and RS232 HF.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the instruction upon a positive edge of this input.
PORT	IN	PORT (UInt)	Word	0	The CM port value can be found in the "Hardware ID" property of the device configuration (S7-1500) (input address; S7-300/400) once you have configured the CM. The symbolic port name is assigned in the "System constants" tab of the PLC tag table. In S7-300/400/WinAC systems, the input address assigned in HWCN must be assigned to the CM port.
SIGNAL	IN	Byte		0	Selection of the signal to be set (more than one possible): • 01H = RTS • 02H = DTR • 04H = DSR (for interface type DCE only)
RTS	IN	Bool		FALSE	Send request, module ready to send Set this value at the output (TRUE or FALSE), default value: FALSE

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
DTR	IN	Bool		FALSE	Data terminal ready, module ready Set this value at the output (TRUE or FALSE), default value: FALSE
DSR	IN	Bool		FALSE	Data terminal ready (for DCE interface type only), not used.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Signal_Set instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
DONE	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle after the last request has been completed with errors
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 68))

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3.1.14 Get_Features: Get extended functions

Description

If supported by the module, you can use the Get_Features instruction (get extended functions) to get information on the ability of the module to support CRC and to generate diagnostic messages.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the instruction upon a positive edge of this input.
PORT	IN	PORT (UInt)	Word	0	The CM port value can be found in the "Hardware ID" property of the device configuration (S7-1500) (input address; S7-300/400) once you have configured the CM. The symbolic port name is assigned in the "System constants" tab of the PLC tag table. In S7-300/400/WinAC systems, the input address assigned in HWCN must be assigned to the CM port.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Get_Features instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
NDR	OUT	Bool		FALSE	TRUE for one cycle if new data is available and the instruction has been completed without errors
MODBUS_CRC	OUT	Bool		FALSE	Modbus CRC support

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
DIAG_ALARM	OUT	Bool		FALSE	Generation of diagnostic messages
ERROR	OUT	Bool		FALSE	TRUE for one cycle once the instruction has been completed with an error
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 68))

3.1.15 Set_Features: Set extended functions

Description

If supported by the module, you can use the Set_Features instruction (select extended functions) to activate CRC support and the generation of diagnostic messages.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	The instruction to set extended functions is started upon a positive edge at this input.
PORT	IN	PORT (UInt)	Word	0	The CM port value can be found in the "Hardware ID" property of the device configuration (S7-1500) (input address; S7-300/400) once you have configured the CM. The symbolic port name is assigned in the "System constants" tab of the PLC tag table. In S7-300/400/WinAC systems, the input address assigned in HWCN must be assigned to the CM port.
EN_MODBUS_CRC	IN	Bool		FALSE	Activate Modbus CRC support
EN_DIAG_ALARM	IN	Bool		FALSE	Activate generation of diagnostic messages
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Set_Features instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
DONE	OUT	Bool		FALSE	TRUE for one execution once the last request is completed without errors
ERROR	OUT	Bool		FALSE	TRUE for one cycle once the instruction has been completed with an error
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 68))

3.2 Modbus

3.2.1 Overview of the Modbus RTU communication

Modbus RTU communication

Modbus RTU (Remote Terminal Unit) is a standard protocol for communication in the network and uses the RS232 or RS422/485 connection for serial data transmission between Modbus devices in the network.

Modbus RTU uses a master/slave network in which all communication is triggered by a single master device while the slaves can only respond to the request of the master. The master sends a request to a slave address and only the slave with this slave address responds to the command.

Exception: Modbus slave address 0 sends a broadcast frame to all slaves (without slave response).

Modbus function codes

- A CPU that is operated as a Modbus RTU master can read and write data and I/O states in a Modbus RTU slave connected by means of a communication connection.
- A CPU operated as a Modbus RTU slave allows a Modbus RTU master connected over a communication connection to read and write data and I/O states in its own CPU.

Table 3-1030 Functions for reading data: Reading distributed I/O and program data

Modbus function code	Functions for reading the slave (server) - standard addressing
01	Read output bits: 1 to 1992 bits per request
02	Read input bits: 1 to 1992 bits per request
03	Read holding register: 1 to 124 words per request
04	Read input words: 1 to 124 words per request

Table 3-1031 Functions for writing data: Changing distributed I/O and program data

Modbus function code	Functions for writing in the slave (server) - standard addressing
05	Write one output bit: 1 bit per request
06	Write one holding register: 1 word per request
15	Write one or several output bits: 1 to1960 bits per request
16	Write one or several holding registers: 1 to 122 words per request

- The Modbus function codes 08 and 11 offer diagnostic information for communication of the slave device.
- Modbus slave address 0 sends a broadcast frame to all slaves (without slave response; for function codes 5, 6, 15, 16).

Table 3-1032 Station addresses in the Modbus network

Station		Address
RTU station	Standard station address	1 to 247 and 0 for broadcast
	Extended station address	1 to 65535 and 0 for broadcast

Modbus memory addresses

The number of Modbus memory addresses that is actually available depends on the CPU version and the available work memory.

Modbus RTU instructions in your program

- Modbus_Comm_Load: You need to run Modbus_Comm_Load to set up PtP parameters such as data transmission rate, parity and data flow control. Once you have configured the communication module for the Modbus RTU protocol, it can only be used by the Modbus_Master instruction or the Modbus_Slave instruction.
- Modbus_Master: The CPU can be used as Modbus RTU master device with the Modbus master instruction for communication with one or more Modbus slave devices.
- Modbus_Slave: The CPU can be used as Modbus RTU slave device with the Modbus slave instruction for communication with one Modbus master device.

3.2.2 Modbus_Comm_Load: Configure communication module for Modbus

Description

The Modbus_Comm_Load instruction configures a communication module for communication by means of the Modbus RTU protocol. An instance data block is automatically assigned when you add the Modbus_Comm_Load instruction in your program.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
REQ	IN	Bool		FALSE	Starts the instruction upon a positive edge of this input.
PORT	IN	Port	Laddr	0	The CM port value can be found in the "Hardware ID" property of the device configuration (S7-1500) (input address; S7-300/400) once you have configured the CM. The symbolic port name is assigned in the "System constants" tab of the PLC tag table. In S7-300/400/WinAC systems, the input address assigned in HWCN must be assigned to the CM port.

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
BAUD	IN	UDInt	DWord	6	Selection of the data transmission rate: 1 = 300, 2 = 600, 3 = 1200, 4 = 2400, 5 = 4800, 6 = 9600, 7 = 19200, 8 = 38400, 9 = 57600, 10 = 76800, 11 = 115200 bit/s.
PARITY	IN	UInt	Word	1	Selection of parity: • 0 – None • 1 – Odd • 2 – Even
FLOW_CTRL	IN	UInt	Word	0	Selection of flow control: • 0 – (default) no flow control • 1 – Hardware flow control with RTS always ON (not with RS422/485 CMs) • 2 – Hardware flow control with RTS switched (not with RS422/485 CMs)
RTS_ON_DLY	IN	UInt	Word	0	Selection RTS ON delay: • 0 – No delay from "RTS active" until the first character of the frame is sent. • 1 to 65535 – Delay in milliseconds from "RTS active" until the first character of the frame is sent (not with RS422/485 CMs). RTS delays must be used independent of the selection FLOW_CTRL.
RTS_OFF_DLY	IN	UInt	Word	0	Selection RTS OFF delay: • 0 – No delay after transmission of last character until "RTS inactive" • 1 to 65535 – Delay in milliseconds after transmission of last character until "RTS inactive" (not with RS422/485 ports). RTS delays must be used independent of the selection FLOW_CTRL.
RESP_TO	IN	UInt	Word	1000	Response timeout: 5 ms to 65535 ms - Time in milliseconds that Modbus_Master waits for a response from the slave. If the slave does not respond within this period, Modbus_Master repeats the request or terminates the request with an error if the specified number of repetitions (see below, RETRIES parameter) has been sent.
MB_DB	IN/OUT	MB_BASE		-	A reference to the instance data block of the Modbus_Master or Modbus_Slave instructions. The MB_DB parameter must be connected with the (static and therefore not visible in the instruction) MB_DB parameter of the Modbus_Master or Modbus_Slave instruction.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Modbus_Comm_Load instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
DONE	OUT	Bool		FALSE	The DONE bit is TRUE for one cycle after the last request has been completed without errors.
ERROR	OUT	Bool		FALSE	The ERROR bit is TRUE for one cycle after the last request has been completed with errors. The error code in the STATUS parameter is only valid in the cycle in which ERROR = TRUE.
STATUS	OUT	Word		16#7000	Error code (see Error messages (Page 68))

Modbus_Comm_Load is executed to configure a port for the Modbus RTU protocol. Once you have configured the port for the Modbus RTU protocol, it can only be used by the Modbus_Master or Modbus_Slave instructions.

You have to run Modbus_Comm_Load for the configuration of each communication port that is to be used for Modbus communication. You must assign a unique Modbus_Comm_Load instance DB to each port that you use. Only run Modbus_Comm_Load again if you need to change communication parameters, such as data transmission rate or parity, or in case the network has returned.

For example, an instance data block is assigned to the instruction if you add Modbus_Master or Modbus_Slave to your program. You need to connect the MB_DB parameter of the Modbus_Comm_Load instruction to the MB_DB parameter of the Modbus_Master or Modbus_Slave instruction.

Modbus_Comm_Load data block variables

The table below shows the public static tags in the instance DB of Modbus_Comm_Load that you can use in your program.

Table 3-1033 Static tags in the instance DB

Tag	Data type	Standard	Description
ICHAR_GAP	Word	0	Maximum character delay time between characters. This parameter is specified in milliseconds and increases the anticipated period between the received characters. The corresponding number of bit times for this parameter is added to the Modbus default value of 35 bit times (3.5 character times).
RETRIES	Word	2	Number of retries that the master executes before the error code 0x80C8 for "No response" is returned.
EN_DIAG_ALARM	Word	0	Activate diagnostics interrupt: • 0 - not activated • 1 - activated
MODE	USInt	0	Operating mode Valid operating modes are: • 0 = Full duplex (RS232) • 1 = Full duplex (RS422) four-wire operation (point-to-point) • 2 = Full duplex (RS 422) four-wire mode (multipoint master, CM PtP (ET 200SP)) • 3 = Full duplex (RS 422) four-wire mode (multipoint slave, CM PtP (ET 200SP)) • 4 = Half duplex (RS485) two-wire mode

Tag	Data type	Standard	Description
LINE_PRE	USInt	0	Receive line initial state Valid initial states are: • 0 = "no" initial state • 1 = signal R(A)=5 V, signal R(B)=0 V (break detection): Break detection is possible with this initial state. Can only be selected with: "Full duplex (RS422) four-wire operation (point-to-point connection)" and "Full duplex (RS422) four-wire operation (multipoint slave)". • 2 = signal R(A)=0 V, signal R(B)=5 V: This default setting corresponds to the idle state (no active send operation). No break detection is possible with this initial state.
CABLE_BRK	USInt	0	Break detection The following are valid: • 0 = break detection deactivated • 1 = break detection activated

3.2.3 Modbus_Master: Communicate as Modbus master

Description

The Modbus_Master instruction communicates as Modbus master via a port configured by the Modbus_Comm_Load instruction. An instance data block is automatically assigned when you add the Modbus_Master instruction in your program. The MB_DB parameter of the Modbus_Comm_Load instruction must be connected to the (static) MB_DB parameter of the Modbus_Master instruction.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/ WinAC		
REQ	IN	Bool		FALSE	FALSE = no request TRUE = request to send data to the Modbus slave
MB_ADDR	IN	UInt	Word	-	Modbus RTU station address: Standard addressing range (1 to 247 as well as 0 for Broadcast) Extended addressing range (1 to 65535 as well as 0 for Broadcast) The value 0 is reserved for the broadcast of a frame to all Modbus slaves. Only the Modbus function codes 05, 06, 15 and 16 are supported for the broadcast.
MODE	IN	USInt	Byte	0	Mode selection: Specifies the type of request (read, write or diagnostics). Additional information is available in the table of Modbus functions below.
DATA_ADDR	IN	UDInt	DWord	0	Start address in the slave: Specifies the start address of the data that is accessed in the Modbus slave. The valid addresses are listed in the table of Modbus functions below.

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/40-0/ WinAC		
DATA_LEN	IN	UInt	Word	0	Data length: Specifies the number of bits or words this instruction is to access. The valid lengths are listed in the table of Modbus functions below.
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Modbus_Master instruction You initialize the instruction with TRUE. The instruction then resets COM_RST to FALSE.
DATA_PTR	IN/OUT	Variant	Any	-	Data pointer: Points to the flag or DB address for the data to be written or read.
DONE	OUT	Bool		FALSE	The DONE bit is TRUE for one cycle after the last request has been completed without errors.
BUSY	OUT	Bool		-	• FALSE – no command active for Modbus_Master • TRUE – command for Modbus_Master in progress
ERROR	OUT	Bool		FALSE	The ERROR bit is TRUE for one cycle after the last request has been completed with errors. The error code in the STATUS parameter is only valid in the cycle in which ERROR = TRUE.
STATUS	OUT	Word		0	Error code (see Error messages (Page 68))

Tags in the data block of the Modbus master

The table below shows the public static tags in the instance DB of Modbus_Master that you can use in your program.

Table 3-1034 Static tags in the instance DB

Tag	Data type	Standard	Description
Blocked_Proc_Timeout	Real	0.5	Duration (in seconds) for which to wait for a blocked Modbus master instance before this instance is removed as ACTIVE. This may happen, for example, if a master request was output and the program then stops to call the master function before it has completely finished the request. The time value must be greater than 0 and less than 55 seconds to avoid an error to occur. See also "Rules for communication by the Modbus-Master" and "Calling theModbus_Master instruction with different parameter settings".
Extended_Addressing	Bool	FALSE	Configures the slave station address as single or double byte. • FALSE = One-byte address; 0 to 247 • TRUE = Two-byte address (corresponds to extended addressing); 0 to 65535

1) The PtP communication modules respond as defined in the Modbus specification. To retain a response as with CP 341, CP 441-2 and ET 200SP 1SI for Modbus, use the "Compatibility_Mode" parameter.

Tag	Data type	Standard	Description
Compatibility_Mode [1]	Bool	FALSE	Compatibility mode with CP 341 and CP 441-2 with driver for Modbus RTU and with ET 200SP 1SI for Modbus. The default value is 0. • FALSE = as per Modbus specification, not compatible • TRUE = compatible – For FC1 and FC2: The data read from the received frame is written word for word to the addressed CPU memory and exchanged byte by byte. If the number of bits to be transmitted is not a multiple of 16, the bits which are not relevant are set to null in the last word. – For FC15: The words to be transmitted are read word by word from the addressed memory and written byte by byte to the send frame. If the number of bits to be transmitted is not a multiple of 8, the bits in the last byte which are not relevant are read unchanged from the addressed memory and entered in the send frame.
MB_DB	MB_BASE	-	The MB_DB parameter of the Modbus_Comm_Load instruction must be connected to this MB_DB parameter of the Modbus_Master instruction.

[1] The PtP communication modules respond as defined in the Modbus specification. To retain a response as with CP 341, CP 441-2 and ET 200SP 1SI for Modbus, use the "Compatibility_Mode" parameter.

You program can write values to the Blocked_Proc_Timeout and Extended_Addressing variables to control the Modbus master operations.

Rules for communication by the Modbus-Master

- Modbus_Comm_Load must be run to configure a port so that the Modbus_Master instruction can communicate with this port.
- A port which is to be used as Modbus master must not be used by Modbus _Slave . You can use one or several instances of Modbus_Master [1] with this port. But all versions of the Modbus_Master must use the same instance DB for the port.
- The Modbus instructions do not use communication alarm events to control the communication process. Your program must query the Modbus_Master instruction for completed commands (DONE, ERROR).
- We recommend to call all executions of Modbus_Master for a specific port from a program cycle OB. Modbus master instructions can only be executed in one program cycle or in one cyclical/time-controlled processing level. They may not be processed in different processing levels. The priority interruption of a Modbus master instruction by another Modbus master instruction in a processing level with higher priority results in improper operation. Modbus master instructions may mot be processed in startup, diagnostic or time error levels.

[1] "Instance of Modbus master" here means a call of the Modbus_Master instruction with the same interconnection to a Modbus_Comm_Load instruction and the same setting for the MB_ADDR, MODE, DATA_ADDR and DATA_LEN parameters.

Example

Modbus_Master is called with MODE=0 and DATA_ADDR=10

This job is now active until it is completed with DONE=1 or ERROR=1 or until the time monitoring configured at the Blocked_Proc_Timeout parameter has expired. If a new command is started after the watchdog time expires and before the previous command has been completed, the previous command is aborted without an error message.

If, while this command is running, the instruction is now called a second time with the same instance data but different MODE and DATA_ADDR parameter settings, this second call is terminated with ERROR=1 and STATUS=8200.

Calling the Modbus_Master instruction with different parameter settings

If multiple calls of the Modbus_Master instruction with different settings for MB_ADDR, MODE, DATA_ADDR or DATA_LEN are placed in your program, you must ensure that only one of these calls is active at any given time. Otherwise, the error message 0x8200 is output (interface is busy with an ongoing request).

If a call cannot be processed in full, the watchdog is activated by the Blocked_Proc_Timeout parameter and terminates the ongoing command.

REQ parameter

FALSE = no request; TRUE = request to send data to the Modbus slave

Enable requested transmission at a positive edge of this enable input. This transmits the contents of the buffer to the point-to-point communication interface.

You use the DATA_ADDR and MODE parameters to select the Modbus function code.

DATA_ADDR (Modbus start address in the slave): Specifies the start address of the data that is accessed in the Modbus slave.

The Modbus_Master instruction uses the MODE input instead of a function code input. The combination of MODE and DATA_ADDR specifies the function code that is used in the actual Modbus frame. The table below shows how the MODE parameter, the Modbus function code and the Modbus address range in DATA_ADDR are related.

Table 3-1035 Modbus functions

MODE	DATA_ADDR (Modbus address)			DATA_LEN (data length)			Modbus function code	Operation and data		
0				Bits per request			01	Read output bits:		
	1	to	9999	1	to	2000/1992 [1]		0	to	9998
0				Bits per request			02	Read input bits:		
	10001	to	19999	1	to	2000/1992 [1]		0	to	9998
0				Words per request			03	Read hold register:		

[1] In extended addressing, see the Extended_Adressing parameter, the maximum data length is shorter by 1 byte or 1 word depending on the data type of the function.

[2] MODE 2 allows you to write one or more output bits and one or more hhold registers using the Modbus functions 15 and 16.
MODE 1 uses the Modbus functions 5 and 6 to write 1 output bit and 1 hold register, and Modbus functions 15 and 16 to write multiple output bits and multiple hold registers.

MODE	DATA_ADDR (Modbus address)			DATA_LEN (data length)			Modbus function code	Operation and data		
0	40001	to	49999	1	to	125/124 [1]	03	0	to	9998
	400001	to	465535	1	to	125/124 [1]		0	to	65534
0				Words per request			04	Read input words:		
	30001	to	39999	1	to	125/124 [1]		0	to	9998
1				Bits per request			05	Write one output bit:		
	1	to	9999	1				0	to	9998
1				1 word per request			06	Write one hold register:		
	40001	to	49999	1				0	to	9998
	400001	to	465535	1				0	to	65524
1				Bits per request			15	Write multiple output bits:		
	1	to	9999	2	to	1968/1960 [1]		0	to	9998
1				Words per request			16	Write multiple hold registers:		
	40001	to	49999	2	to	123/122		0	to	9998
	400001	to	465534	2	to	123/122 [1]		0	to	65534
2 [2]				Bits per request			15	Write one or several output bits:		
	1	to	9999	2	to	1968/1960 [1]		0	to	9998
2 [2]				Words per request			16	Write one or several hold registers:		
	40001	to	49999	1	to	123		0	to	9998
	400001	to	465535	1	to	122 [1]		0	to	65534
11	Both DATA_ADDR and DATA_LEN operands of the Modbus_Master are ignored with this function.						11	Read status word and event counter of the slave communication. The status word indicates busy (0 – not busy, 0xFFFF - busy). The event counter is incremented for each successful processing of a frame.		
80				1 word per request			08	Check slave status with data diagnostic code 0x0000 (loopback test – slave returns an echo of the request)		
	-			1				-		

[1] In extended addressing, see the Extended_Adressing parameter, the maximum data length is shorter by 1 byte or 1 word depending on the data type of the function.

[2] MODE 2 allows you to write one or more output bits and one or more hhold registers using the Modbus functions 15 and 16.
MODE 1 uses the Modbus functions 5 and 6 to write 1 output bit and 1 hold register, and Modbus functions 15 and 16 to write multiple output bits and multiple hold registers.

MODE	DATA_ADDR (Modbus address)			DATA_LEN (data length)			Modbus function code	Operation and data		
81				1 word per request			08	Reset slave event counter using data diagnostic code 0x000A		
	-			1				-		
3 to 10, 12 to 79, 82 to 255	-			-				Reserved		

[1] In extended addressing, see the Extended_Adressing parameter, the maximum data length is shorter by 1 byte or 1 word depending on the data type of the function.

[2] MODE 2 allows you to write one or more output bits and one or more hhold registers using the Modbus functions 15 and 16.
MODE 1 uses the Modbus functions 5 and 6 to write 1 output bit and 1 hold register, and Modbus functions 15 and 16 to write multiple output bits and multiple hold registers.

DATA_PTR parameter

The DATA_PTR parameter points to the DB or bit memory address in which reading or writing is performed. If you use a data block, you must create a global data block that provides the data memory for read and write processes on Modbus slaves.

NOTE
S7-1500 - The data block addressed using DATA_PTR must support direct addressing
The data block must permit direct (absolute) and symbolic addressing.

Data block structures for the DATA_PTR parameter

- These data types are valid for **reading words** of Modbus addresses (DATA_PTR) 30001 to 39999, 40001 to 49999 and 400001 to 465535 as well as for **writing words** to Modbus addresses (DATA_PTR parameter) 40001 to 49999 and 400001 to 465535.
  - Standard array of data types WORD, UINT or INT
  - Named structure of the WORD, UINT or INT type in which each element has a unique name and a 16-bit data type.
  - Named complex structure in which each element has a unique name and a 16-bit or 32-bit data type.
- For **reading** and writing bits for the Modbus addresses (DATA_PTR parameter) 00001 to 09999 and for reading of bits from 10001 to 19999.
  - Standard field from Boolean data types.
  - Named Boolean structure from uniquely named Boolean variables.

- It is not essential, but nevertheless advisable, to allocate each Modbus_Master instruction its own separate memory area. The reason for this is that data destruction is far more likely if multiple Modbus_Master instructions are reading and writing in the same memory area.
- It is not necessary for the data areas for DATA_PTR to be located in the same global data block. You can create a data block with several areas for Modbus read processes, a data block for Modbus write processes or a data block for each slave station.

See also

Modbus_Slave: Communicate as Modbus slave (Page 43)

3.2.4 Modbus_Slave: Communicate as Modbus slave

Description

Your program can use the Modbus_Slave instruction to communicate as a Modbus slave by using a CM (RS422/485 or RS232). STEP 7 automatically creates an instance DB when you add the instruction. The MB_DB parameter of the Modbus_Comm_Load instruction must be connected to the (static) MB_DB parameter of the Modbus_Slave instruction.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/ WinAC		
MB_ADDR	IN	UInt	Word	-	Standard address of the Modbus slave: Standard addressing range (1 to 247) Extended addressing range (0 to 65535) Note: 0 is the broadcast address
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the Modbus_Slave instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
MB_HOLD_REG	IN/OUT	Variant	Any	-	Pointer to the Modbus hold register DB: The Modbus hold register may be the memory area of the flags or a data block.
NDR	OUT	Bool		FALSE	New data available: • FALSE – No new data • TRUE – Indicates that new data was written by the Modbus master The NDR bit is TRUE for one cycle after the last request has been completed without errors.
DR	OUT	Bool		FALSE	Read data: • FALSE – No data read • TRUE – Indicates that the instruction has stored the data received by the Modbus master in the target area. The DR bit is TRUE for one cycle after the last request has been completed without errors.

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/ WinAC		
ERROR	OUT	Bool		FALSE	The ERROR bit is TRUE for one cycle after the last request has been completed with errors. If the execution was terminated with an error, the error code in the STATUS parameter is only valid in the cycle in which ERROR = TRUE.
STATUS	OUT	Word		0	Error code (see Error messages (Page 68))

The function codes of the Modbus communication (1, 2, 4, 5 and 15) can read and write bits and words directly in the process image of the inputs and in the process image of the outputs of the CPU. The MB_HOLD_REG parameter must be defined as data type greater than one byte for these function codes. The table below shows the sample assignment of Modbus addresses to the process image in the CPU.

Table 3-1036 Assignment of Modbus addresses to the process image

Modbus functions						S7-1500 / S7-300 / S7-400			
Code	Function	Data area	Address area			Data area	CPU address		
01	Read bits	Output	0	to	9998	Process image of outputs	Q0.0	to	Q1248.6
02	Read bits	Input	0	to	9998	Process image of inputs	I0.0	to	I1248.6
04	Read words	Input	0	to	9998	Process image of inputs	IW0	to	IW19996
05	Write bit	Output	0	to	9998	Process image of outputs	Q0.0	to	Q1248.6
15	Write bits	Output	0	to	9998	Process image of outputs	Q0.0	to	Q1248.6

NOTE

The available address area may be smaller, depending on the memory configuration of the CPU.

The function codes of the Modbus communication (3, 6, 16) use a Modbus hold register which is an address area in the memory area of the flags or a data block. The type of hold register is specified by the MB_HOLD_REG parameter of the Modbus_Slave instruction.

NOTE

S7-1500 - Type of MB_HOLD_REG data block

The data block with Modbus hold register must permit direct (absolute) and symbolic addressing.

Variables of the Modbus slave

This table below shows the public static tags in the instance data block of Modbus_Slave that you can use in your program.

Table 3-1037 Variables of the Modbus slave

Tag	Data type	Standard	Description
HR_Start_Offset	Word	0	Specifies the start address of the Modbus hold register (default = 0)
Extended_Addressing	Bool	FALSE	Extended addressing, configures slave addressing as single or double byte (FALSE = single byte address, TRUE = double byte address)
Request_Count	Word	0	The number of all requests received by this slave
Slave_Message_Count	Word	0	The number of requests received for this specific slave
Bad_CRC_Count	Word	0	The number of received requests that have a CRC error
Broadcast_Count	Word	0	The number of received broadcast requests
Exception_Count	Word	0	Modbus-specific errors that are acknowledged with an exception to the master
Success_Count	Word	0	The number of received requests without protocol errors for this specific slave
MB_DB	MB_BASE	-	The MB_DB parameter of the Modbus_Comm_Load instruction must be connected to this MB_DB parameter of the Modbus_Master instruction.

You program can write values to the HR_Start_Offset and Extended_Addressing variables and control the Modbus slave operations. The other variables can be read to monitor the Modbus status.

Rules for Modbus slave communication

- Modbus_Comm_Load must be run to configure a port so that the Modbus_Slave instruction can communicate by means of this port.
- If a port is to respond as slave to a Modbus master, this port may not be programmed with the Modbus_Master instruction.
- Only one instance of Modbus_Slave can be used with a specific port; otherwise you may encounter unexpected behavior.
- The Modbus instructions do not use communication alarm events to control the communication process. Your program must control the communication process by querying the Modbus_Slave instruction for completed send and receive processes.
- The Modbus_Slave instruction must be executed regularly with a frequency that allows a timely response to incoming requests of a Modbus master. We recommend executing Modbus_Slave in each cycle from a program cycle OB. Modbus_Slave can be executed from a cyclic interrupt OB but we do not recommend it, because excessive time delays in the interrupt program can temporarily block the execution of other interrupt programs.

Time control of the Modbus signal

Modbus_Slave must be executed regularly to receive each request of the Modbus master and respond accordingly. The frequency with which Modbus_Slave is executed depends on the timeout value specified for the response by the Modbus master. This can be seen in the figure below.

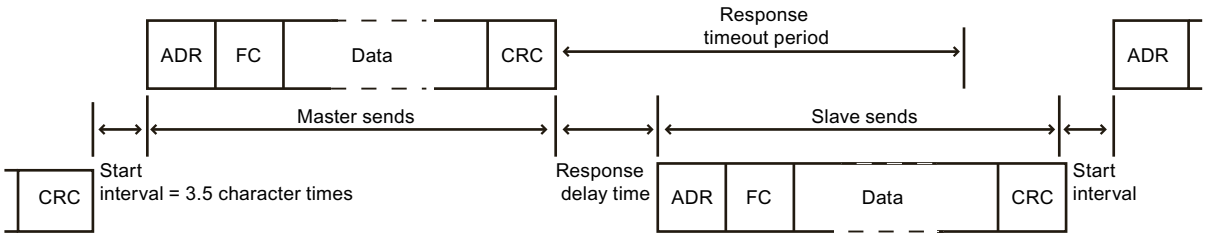

The timeout period of the (RESP_TO) response is the duration that a Modbus master waits for the beginning of an answer from a Modbus slave. This period is not defined by the Modbus protocol, but by a parameter of the Modbus_Comm_Load instruction. As both receiving and sending a frame requires multiple calls of the Modbus_Slave instruction (at least three), you should execute Modbus_Slave at least twelve times during the timeout period for the response of the Modbus master so that the Modbus slave receives and sends data twice as many times as specified by the timeout period.

HR_Start_Offset

The addresses of the Modbus hold register start with 40001 or 400001; these addresses correspond to the start address of the hold register in the target system memory. But you can configure the HR_Start_Offset tag to configure a start address different than 40001 or 400001 for the Modbus hold register.

You can, for example, configure a hold register with start at MW100 and a length of 100 words. With an offset of 20, you can enter a hold register start address of 40021 instead of 40001. Each address below 40021 and above 400119 results in an addressing error.

Table 3-1038 Example for addressing the Modbus hold register when DATA_PTR is a pointer to MW100

HR_Start_Offset	Address	Minimum	Maximum
0	Modbus address (word)	40001	40099
	S7-1500 address	MW100	MW298
20	Modbus address (word)	40021	40119
	S7-1500 address	MW100	MW298

HR_Start_Offset is a word value which specifies the start address of the Modbus hold register and is saved in the Modbus_Slave instance data block. You select this public static tag by means of the parameter drop-down list once you have added Modbus_Slave in your program.

If you have added Modbus_Slave to an LAD network, for example, you can go to a previous network and assign the value HR_Start_Offset using the move command. The value must be assigned prior to execution of Modbus_Slave.

Enter Modbus slave tag using the standard DB name:

1. Position the cursor in the OUT1 parameter field and enter the character m.
2. Select the required instance DB of the Modbus_Slave instruction from the drop-down list.
3. Position the cursor to the right of the DB name (after the quotation mark) and enter a point.
4. Select "Modbus_Slave_DB.HR_Start_Offset" in the drop-down list.

3.2.5 Frame structure

Extended_Addressing

You access the Extended_Addressing tag as described for the HR_Start_Offset reference, except that the Extended_Addressing tag is a Boolean value.

You can configure a single byte (Modbus standard) or a double byte for addressing the Modbus slave. Extended addressing is used to address more than 247 devices in a single network. If you decide to use extended addressing, you can address up to 65535 addresses. The following example shows a Modbus frame.

Table 3-1039 Slave address with one byte (Byte 0)

	Byte 0	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	
Request	Slave address	Function code	Start address		Data		
Valid response	Slave address	Function code	Length	Data...			
Error message	Slave address	0xxx	Exception code				

Table 3-1040 Slave address with two bytes (Byte 0 and Byte 1)

	Byte 0	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**
Request	Slave address		Function code	Start address		Data	
Valid response	Slave address		Function code	Length	Data...		
Error message	Slave address		0xxx	Exception code			

Frame description

Data traffic between master and slave / slave and master starts with the slave address, following by the function code. The data is then transferred. The structure of the data field depends on the function code used. The checksum (CRC) is transmitted at the end of the frame.

Function code 1 - This function allows individual output bits to be read

Table 3-1041 FC 1 - Read output bits

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 1	Start address		Number of outputs	
Valid response	Slave address	Function code 1	Length [1]	Output data [3)]		
Error message	Slave address	0x81	Exception code [2]	---		

1 Length: If there is a remainder when the number of outputs is divided by 8, the number of bytes must be increased by 1.

2 E code: 01 or 02 or 03 or 04

3 The output data can comprise multiple bytes

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 1	Start address		Number of outputs	
Valid response	Slave address		Function code 1	Length [1]	Output data		
Error message	Slave address		0x81	Exception code [2]	---		

1 Length: If there is a remainder when the number of outputs is divided by 8, the number of bytes must be increased by 1.

2 E code: 01 or 02 or 03 or 04

3 The output data can comprise multiple bytes

Function code 2 - This function allows individual input bits to be read

Table 3-1042 FC 2 - Read input bits

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 2	Start address		Number of inputs	
Valid response	Slave address	Function code 2	Length [1]	Input data		
Error message	Slave address	0x82	Exception code [2]	---		

1 Length: If there is a remainder when the number of inputs is divided by 8, the number of bytes must be increased by 1.

2 E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 2	Start address		Number of inputs	
Valid response	Slave address		Function code 2	Length [1]	Input data		
Error message	Slave address		0x82	Exception code [2]	---		

1 Length: If there is a remainder when the number of inputs is divided by 8, the number of bytes must be increased by 1.

2 E code: 01 or 02 or 03 or 04

Function code 3 - This function allows individual registers to be read

Table 3-1043 FC 3 - Read hold register

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 3	Start address		Number of registers	
Valid response	Slave address	Function code 3	Length [1]	Register data		
Error message	Slave address	0x83	Exception code [2]	---		

[1] Length: Number of bytes

[2] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 3	Start address		Number of registers	
Valid response	Slave address		Function code 3	Length [1]	Register data		
Error message	Slave address		0x83	Exception code [2]	---		

[1] Length: Number of bytes

[2] E code: 01 or 02 or 03 or 04

Function code 4 - This function allows individual registers to be read

Table 3-1044 FC 4 - Read input words

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 4	Start address		Number of input words	
Valid response	Slave address	Function code 4	Length [1]	Input data		
Error message	Slave address	0x84	Exception code [2]	---		

[1] Length: 2 * number of input words

[2] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 4	Start address		Number of input words	
Valid response	Slave address		Function code 4	Length [1]	Input data		
Error message	Slave address		0x84	Exception code [2]	---		

[1] Length: 2 * number of input words

[2] E code: 01 or 02 or 03 or 04

Function code 5 - This function can set or delete individual bits

Table 3-1045 FC 5 - Write an output bit

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 5	Start address		Value	
Valid response	Slave address	Function code 5	Length	Value		
Error message	Slave address	0x85	Exception code [1]	---		

[1] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 5	Start address		Value	
Valid response	Slave address		Function code 5	Length	Value		
Error message	Slave address		0x85	Exception code [1]	---		

[1] E code: 01 or 02 or 03 or 04

Function code 6 - This function allows individual registers to be written

Table 3-1046 FC 6 - Write hold register

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 6	Address		Tabs	
Valid response	Slave address	Function code 6	Address		Tabs	
Error message	Slave address	0x86	Exception code [1]	---		

[1] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 6	Address		Tabs	
Valid response	Slave address		Function code 6	Address		Tabs	
Error message	Slave address		0x86	Exception code [1]	---		

[1] E code: 01 or 02 or 03 or 04

Function code 8 - This function is used to check the communication connection

Table 3-1047 FC 8 - Slave status

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 8	Diagnostic code		Test value	
Valid response	Slave address	Function code 8	Diagnostic code		Test value	
Error message	Slave address	0x88	Exception code [1]	---		

[1] E code: 01 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 8	Diagnostic code		Test value	
Valid response	Slave address		Function code 8	Diagnostic code		Test value	
Error message	Slave address		0x88	Exception code [1]	---		

[1] E code: 01 or 03 or 04

Function code 11 - This function can read 2 bytes of "Status word" and 2 bytes of "Event counter"

Table 3-1048 FC 11 - Event counter for slave communication

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Query	Slave address	Function code 11	---			
Valid response	Slave address	Function code 11	State		Event counter	
Error message	Slave address	0x8B	Exception code [1]	---		

[1] E code: 01 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6
Query	Slave address		Function code 11	---			
Valid response	Slave address		Function code 11	State		Event counter	
Error message	Slave address		0x8B	Exception code [1]	---		

[1] E code: 01 or 04

Function code 15 - This function allows multiple bits to be written

Table 3-1049 FC 15 - Write one/multiple output bits

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte n
Query	Slave address	Function code 15	Start address		Number of output words		Byte counter [1]	Value	
Valid response	Slave address	Function code 15	Start address		Number of output words		---		
Error message	Slave address	0x8F	Exception code [2]	---					

[1] Byte counter: If there is a remainder when the number of bytes is divided by 8, the number of bytes must be increased by 1.

[2] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte n
Query	Slave address		Function code 15	Start address		Number of output words		Byte counter [1]	Value	
Valid response	Slave address		Function code 15	Start address		Number of output words		---		
Error message	Slave address		0x8F	Exception code [2]		---				

[1] Byte counter: If there is a remainder when the number of bytes is divided by 8, the number of bytes must be increased by 1.

[2] E code: 01 or 02 or 03 or 04

Function code 16 - This function allows individual or multiple registers to be written

Table 3-1050 FC 16 - Write one/multiple hold registers

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte n
Query	Slave address	Function code 16	Start address		Number of registers		Byte counter [1]	Value	
Valid response	Slave address	Function code 16	Start address		Number of registers		---		
Error message	Slave address	0x90	Exception code [2]	---					

[1] Byte counter: Number of registers * 2

[2] E code: 01 or 02 or 03 or 04

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte n
Query	Slave address		Function code 16	Start address		Number of registers		Byte counter [1]	Value	
Valid response	Slave address		Function code 16	Start address		Number of registers		---		
Error message	Slave address		0x90	Exception code [2]		---				

[1] Byte counter: Number of registers * 2

[2] E code: 01 or 02 or 03 or 04

3.3 USS

3.3.1 Overview of USS communication

USS communication

The USS instructions control the operation of drives which support the protocol of the universal serial interface (USS). You can communicate with several drives by means of RS485 connections and the USS instructions with the PtP communication modules. Each RS485 port can operate up to 16 drives.

The USS protocol uses a master-slave network for communication via a serial bus. The master uses an address parameter to send data to a selected slave. A slave cannot send without having first received a send request. Communication between individual slaves is not possible. USS communication takes place in half-duplex mode. The figure below shows a network diagram for a sample application with 16 drives.

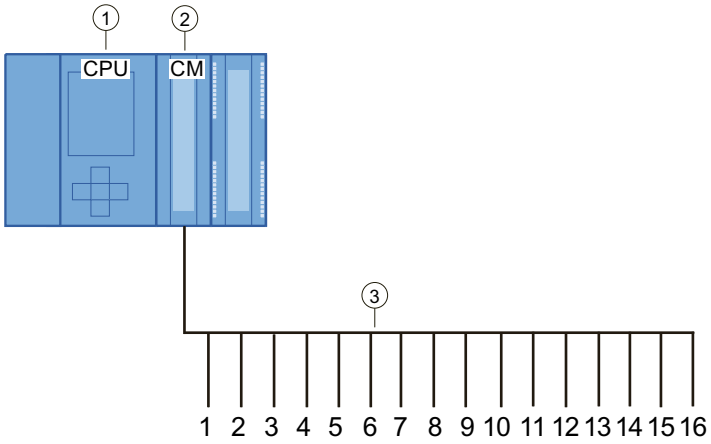

① CPU

② CM

③ USS drives in a USS network

Figure 3-777 Wiring example with S7-1500 communication module

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NOTE

Communicating with a drive via RS232

You can basically also use CM PtP RS232 BA and CM PtP RS232 HF for communication with a drive. However, only **one** drive can be connected to an RS232 port.

Communicating with a drive via RS422

You can basically also use the RS422 interface of the CM PtP RS422/485 BA and CM PtP RS422/485 HF for communication with a drive. However, only **one** drive can be connected to an RS422 port.

USS instructions in your program

- USS_Port_Scan: The instruction USS_Port_Scan allows you to communicate via a communication module with up to 16 drives using a USS network (must be called cyclically).

  There is only one USS_Port_Scan instruction per PtP communication port in the program, and it controls transmission to all drives.
- USS_Drive_Control: The instruction USS_Drive_Control allows you to prepare the send data from USS_Port_Scan for a drive and display its receive data.

  USS_Drive_Control configures the data to be sent and evaluates the data received in a previous request from USS_Port_Scan.
- USS_Read_Param: The instruction USS_Read_Param allows you to read parameters from a drive.
- USS_Write_Param: The instruction USS_Write_Param allows you to change parameters in a drive.

3.3.2 Requirements for using the USS protocol

The four USS instructions use 2 FBs and 2 FCs to support the USS protocol. For each USS network, one instance data block (DB) is used for USS_Port_Scan and one instance data block for all calls of USS_Drive_Conrol.

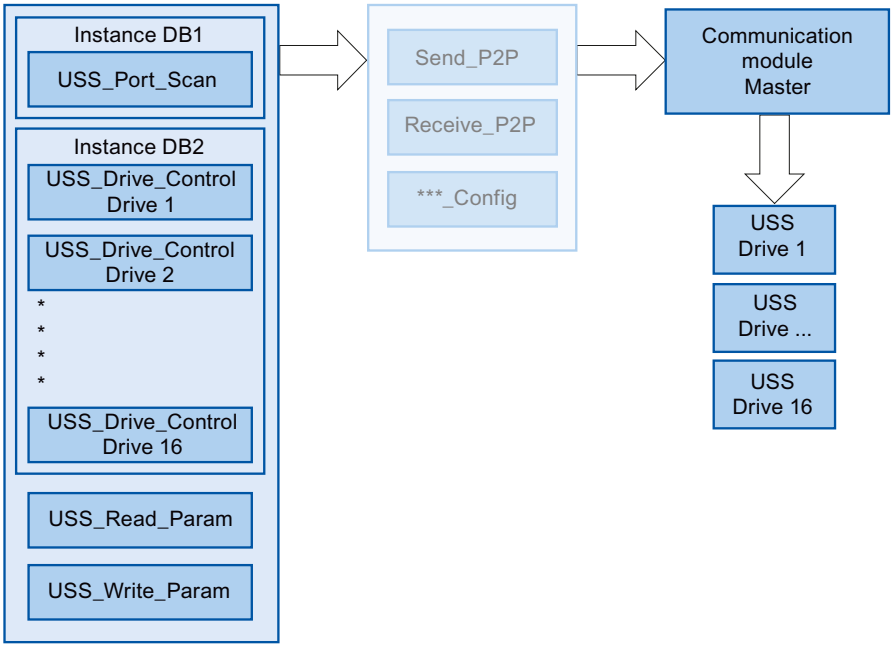

Figure 3-778 USS program sequence

All drives (max. 16) that are connected to one RS485 port are part of the same USS network. All drives that are connected to another RS485 port are part of a different USS network. Each USS network is managed using a unique instance data block for all USS_Drive_Control instructions and one further instance data block for the USS_Port_Scan instruction. All instructions that are part of a USS network must share this instance data block for USS_Drive_Conrol. The USS_Port_Scan, USS_Read_Param and USS_Write_Param instructions

have the USS_DB parameter for this function. This parameter must be connected to the (static) USS_DB parameter of the instance DB of the USS_Drive_Control instruction.

- The instructions USS_Drive_Control and USS_Port_Scan are function blocks (FB). If you add the USS_Drive_Control or USS_Port_Scan instruction to the programming editor, you are prompted to assign a DB for this FB in the "Call options" dialog. If it is the first USS_Drive_Control instruction in this program for this USS network, you can apply the DB standard assignment (or change the name, if necessary) and the new DB is created for you. If, however, it is not the first USS_Drive_Control instruction for this drive, you need to select the DB which has already been assigned to this USS network from the drop-down list in the "Call options" dialog.
- The USS_Port_Scan and USS_Read_Param instructions are functions (FCs). No DB is assigned when you add these FCs in the editor. If you add these FCs or the USS_Port_Scan instruction in the editor, you need to assign the USS_DB parameter of the corresponding USS_Drive_Control instance DB to the USS_DB input of these instructions. Double-click the parameter field and click the symbol to display the available DBs. Enter a period "." and select the USS_DB parameter from the drop-down list.
- The USS_Port_Scan function controls communication between the CPU and the drives via the point-to-point RS485 communication port. A communication with the drive is processed every time you call this function. Your program must call this function fast enough so that the drives do not signal a timeout. To ensure a constant time response for frame communication, you should call this instruction in a cyclic interrupt OB.
- The USS_Drive_Control instruction gives your program access to a specified drive in the USS network. Its inputs and outputs correspond to the states and operating functions of the drive. If there are 16 drives in your network, you must call USS_Drive_Control at least 16 times in your program, i.e. once for each drive.

  You should only call the USS_Drive_Control instruction from a cyclic OB.
- The operating parameters of the drive are read and written with the USS_Read_Param and USS_Write_Param functions. These parameters control the internal operation of the drive. See the drive manual for a definition of these parameters. Your program may include any number of these functions, but only one read or write request may be active for a drive at any particular time. You may only call the USS_Read_Param and USS_Write_Param functions from the cycle OB of a main program.

NOTICE
USS instruction calls Only ever call USS_Drive_Control, USS_Read_Param or USS_Write_Param from a cycle OB of the main program. The USS_Port_Scan instruction function can be called from any OB, but it is usually called from a cyclic interrupt OB. Do not use the USS_Drive_Control, USS_Read_Param or USS_Write_Param instruction in an OB with a higher priority than the corresponding USS_Port_Scan instruction. For example, do not add USS_Port_Scan to the main program or USS_Read_Param to a cyclic interrupt OB. You may encounter unexpected errors if the execution of USS_Port_Scan is interrupted by another instruction.

Calculating time for communication with the drive

Communication with the drive takes place asynchronously to the cycle of the CPU. The CPU usually runs through several cycles before communication with a drive is complete.

To ensure that the watchdog set for the drive is not triggered, the send frames must be sent to the drive within the watchdog time. You must allow for the number of any retries which may be needed to complete the transaction if communication errors occur. By default, up to 2 retries are made for each transaction with the USS protocol.
The time interval between two send frames is calculated as follows:

(N * 5 * cycle time + 2 * frame runtime) * number of retries + (received frame timeout) * (number of retries - 1)

N	Number of drives in this network
Factor 5	5 cycles are needed for sending and receiving frames.
Cycle time	Max. cycle time of the cyclic interrupt OB in which the USS_Port_Scan instruction is called.
2 * frame time	Once each for sending and receiving
Frame runtime	Frame time = (number of characters per frame) * (11 Bit per character) / (data transmission rate in Bit/s)
Number of retries	3

The following times apply for "Received frame timeout" (ms)

Bit/s	115200	57600	38400	19200	9600	4800	2400	1200
Receive_Conditions.END. RCVTIME	25	29	33	56	72	100	100	100
Receive_Conditions.END. MSGTIME	25	29	33	56	72	124	240	460

Example:
5 drives
data transmission rate = 9600 Bit/s
28 characters per frame
cycle time = 0.020 sec
time interval = (5 * 5 * 0.02 sec + 2 * 28 * 11 / 1200 sec) * 3 = 1.69 sec
The time monitoring of the drive must be set to approx. 2 seconds in this case.

3.3.3 USS_Port_Scan: Communication by means of a USS network

Description

The USS_Port_Scan instruction processes the communication by means of a USS network. STEP 7 automatically creates the instance DB when you add the instruction.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/ WinAC		
PORT	IN	Port	Word	0	The CM port value can be found in the "Hardware ID" property of the device configuration (S7-1500) (input address; S7-300/400) once you have configured the CM. The symbolic port name is assigned in the "System constants" tab of the PLC tag table. In S7-300/400/WinAC systems, the input address assigned in HWCN must be assigned to the CM port.
BAUD	IN	DInt		9600	Data transmission rate for USS communication The following are valid: • 1200 Bit/s • 2400 Bit/s • 4800 Bit/s • 9600 Bit/s • 19200 Bit/s • 38400 Bit/s • 57600 Bit/s • 115200 Bit/s
USS_DB	INOUT	USS_BASE		–	The USS_DB parameter must be connected to the (static) USS_DB parameter of the instance DB which is generated and initialized when you add a USS_Drive_Control instruction to your program.
COM_RST	INOUT	---	Bool	FALSE	Initialization of the USS_Port_Scan instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
ERROR	OUT	Bool		FALSE	If TRUE, this output indicates that an error has occurred and that the STATUS output is valid.
STATUS	OUT	Word		0	Error code (see Error messages (Page 68)).

There is only one USS_Port_Scan instruction per PtP communication port in the program and each call of this instruction controls a transmission to or from all drives in this network. All USS functions assigned to one USS network and one PtP communication port must use the same instance DB.

Your program must execute the USS_Port_Scan instruction often enough to prevent a timeout in the drive (see Requirements for using the USS protocol (Page 54) "Calculating time for communication with the drive").

The USS_Port_Scan instruction is usually called from a cyclic interrupt OB to prevent drive timeouts and to have the last USS data updates available for calls of USS_Drive_Control .

USS_Port_Scan data block tags

The table below shows the public static tags in the instance DB of USS_Port_Scan that you can use in your program.

Table 3-1051 Static tags in the instance DB

Tag	Data type	Standard	Description
MODE	USInt	4	Operating mode Valid operating modes are: • 0 = Full duplex (RS232) • 1 = Full duplex (RS422) four-wire operation (point-to-point) • 2 = Full duplex (RS 422) four-wire mode (multipoint master; CM PtP (ET 200SP)) • 3 = Full duplex (RS 422) four-wire mode (multipoint slave; CM PtP (ET 200SP)) • 4 = Half duplex (RS485) two-wire mode
LINE_PRE	USInt	2	Receive line initial state Valid initial states are: • 0 = "no" initial state • 1 = signal R(A)=5 V, signal R(B)=0 V (break detection): Break detection is possible with this initial state. Can only be selected with: "Full duplex (RS422) four-wire operation (point-to-point connection)" and "Full duplex (RS422) four-wire operation (multipoint slave)". • 2 = signal R(A)=0 V, signal R(B)=5 V: This default setting corresponds to the idle state (no active send operation). No break detection is possible with this initial state.
RETRIES_MAX	SInt/Byte	2	Number of retries when communication errors occur. You can use this parameter to set the number of send retries for a request frame if the response frame is not received within the set time.

3.3.4 USS_Drive_Control: Preparing and displaying data for the drive

Description

The instruction USS_Drive_Control prepares send data for the drive and evaluates the drive response data. You need to use a separate instance of the instruction for each drive, and all USS functions assigned to one USS network and one PtP communication port must use the same instance DB. You must enter the DB name when you add the first USS_Drive_Control instruction. You then refer to this DB that was created when the first instruction was added.

STEP 7 automatically creates the DB when you add the instruction.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/4-00/ WinAC		
RUN	IN	Bool		FALSE	Start bit of the drive: If this parameter is TRUE, this input allows you to operate the drive with the preset speed. If RUN changes to FALSE during operation of the drive, the motor coasts to a standstill. This behavior differs from disconnection of the power supply (OFF2) and braking of the motor (OFF3).
OFF2	IN	Bool		FALSE	"Coast to standstill" bit: If this parameter is FALSE, this bit causes the drive to coast to a standstill without braking.
OFF3	IN	Bool		FALSE	Fast stop bit: If this parameter is FALSE, this bit causes a fast stop by braking the drive.
F_ACK	IN	Bool		FALSE	Error acknowledgment bit: This bit resets the error bit of a drive. The bit is set after clearing the error and the drive detects this way that the previous error no longer has to be reported.
DIR	IN	Bool		FALSE	Direction control of the drive: This bit is set if the drive is to run forward (if SPEED_SP is positive; see table "Interaction of SPEED_SP and DIR parameters").
DRIVE	IN	USInt	Byte	1	Address of the drive: This input is the address of the USS drive. The valid range is between drive 1 and drive 16.
PZD_LEN	IN	USInt	Byte	2	Word length: This is the number of PZD data words. Valid values are 2, 4, 6 or 8 words.
SPEED_SP	IN	Real		0.0	Speed setpoint: This is the speed of the drive as a percentage of the configured frequency. A positive value means that the drive runs forward (if DIR is true). The valid range is 200.00 to -200.00.
CTRL3	IN	Word		0	Control word 3: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL4	IN	Word		0	Control word 4: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL5	IN	Word		0	Control word 5: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL6	IN	Word		0	Control word 6: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL7	IN	Word		0	Control word 7: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).
CTRL8	IN	Word		0	Control word 8: Value that is written to a user-defined parameter of the drive. You have to configure it in the drive (optional parameter).

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/4-00/ WinAC		
COM_RST	IN/OUT	---	Bool	FALSE	Initialization of the USS_Drive_Control instruction The instruction is initialized with TRUE. The instruction then resets COM_RST to FALSE.
NDR	OUT	Bool		FALSE	New data available: If this parameter is TRUE, the bit signals that data of a new communication request is available at the output.
ERROR	OUT	Bool		FALSE	Error occurred: If TRUE, this indicates that an error has occurred and that the STATUS output is valid. All other outputs are set to zero in the event of an error. Communication errors are only signaled at the ERROR and STATUS outputs of the USS_Port_Scan instruction.
STATUS	OUT	Word		0	Error code (see Error messages (Page 68)).
RUN_EN	OUT	Bool		FALSE	Operation enabled: This bit signals if the drive is running.
D_DIR	OUT	Bool		FALSE	Drive direction: This bit signals if the drive is running forward. • FALSE – forward • TRUE – backward
INHIBIT	OUT	Bool		FALSE	Drive blocked: This bit signals the status of the block bit for the drive. • FALSE – not blocked • TRUE – blocked
FAULT	OUT	Bool		FALSE	Drive error: This bit signals that an error occurred in the drive. You must remedy the fault and set the F_ACK bit to clear this bit.
SPEED	OUT	Real		0.0	Actual value drive speed (scaled value of STATUS 2 of the drive): This is the speed of the drive as a percentage of the configured speed.
STATUS1	OUT	Word		0	STATUS 1 of the drive This value includes fixed status bits of a drive.
STATUS3	OUT	Word		0	STATUS 3 of the drive This value includes a user-definable status word of the drive.
STATUS4	OUT	Word		0	STATUS 4 of the drive This value includes a user-definable status word of the drive.
STATUS5	OUT	Word		0	STATUS 5 of the drive This value includes a user-definable status word of the drive.
STATUS6	OUT	Word		0	STATUS 6 of the drive This value includes a user-definable status word of the drive.
STATUS7	OUT	Word		0	STATUS 7 of the drive This value includes a user-definable status word of the drive.
STATUS8	OUT	Word		0	STATUS 8 of the drive This value includes a user-definable status word of the drive.

When the initial execution of USS_Drive_Control takes place, the drive specified by the USS address (DRIVE parameter) is initialized in the instance DB. After initialization, subsequent USS_Port_Scan instructions can start communication with the drive from this drive number.

If you change the drive number, you must first place the CPU in STOP and then back in RUN to initialize the instance DB. The input parameters are configured in the USS send buffer and any outputs are read from a "previous" valid response buffer. USS_Drive_Control only configures the data to be sent and evaluates data received in a previous request.

You can control the drive's direction of rotation by using the D_IR input (Bool) or the sign (positive or negative) at the SPEED_SP input (Real). The table below explains how these inputs work together to determine the direction of rotation of the drive, provided the motor rotates forward.

Table 3-1052 Interaction of SPEED_SP and DIR parameters

SPEED_SP	DIR	Direction of rotation of the drive
Value > 0	0	Backward
Value > 0	1	Forward
Value < 0	0	Forward
Value < 0	1	Backward

3.3.5 USS_Read_Param: Read data from drive

Description

The USS_Read_Param instruction reads a parameter from a drive. All USS functions assigned to one USS network and one PtP communication port must use the instance data block of the USS_Drive_Control instruction. USS_Read_Param must be called from a cycle OB of the main program.

Parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/ WinAC		
REQ	IN	Bool		–	A positive edge at REQ creates a new read request.
DRIVE	IN	USInt	Byte	–	Address of the drive: DRIVE is the address of the USS drive. The valid range is between drive 1 and drive 16.
PARAM	IN	UInt		–	Parameter number: PARAM specifies the drive parameter to write. The range for this parameter is located between 0 and 2047; for some drives the most significant byte of the INDEX parameter can access parameter values greater than 2047. Additional information on access to an extended range is available in your drive manual.

[1] The DONE bit indicates that valid data was read out of the referenced motor drive and transmitted to the CPU. It does not indicate that the instruction is cabable of immediately read an additional parameter. An empty read request must be sent to the motor drive and acknowledged by the instruction before the parameter channel is freed up for use by the respective drive. The immediate call of USS_Read_Param or USS_Write_Param for the specific motor drive results in error 0x818A.

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/ WinAC		
INDEX	IN	UInt		–	Parameter index: INDEX specifies the drive parameter index to which to write. It is a 16-bit value in which the least significant bit is the actual index value with a range of (0 to 255). The drive can also use the most significant byte, which is drive-specific. Additional information is available in your drive manual.
USS_DB	INOUT	USS_BASE		–	The USS_DB parameter must be connected to the (static) USS_DB parameter of the instance DB which is generated and initialized when you add a USS_Drive_Control instruction to your program.
DONE[1]	OUT	Bool		FALSE	If this parameter is TRUE, the previously requested value of the read parameter is available at the VALUE output. This bit is set when the USS_Drive_Control instruction recognizes the read response of the drive. This bit is reset the next time USS_Read_Param is called.
ERROR	OUT	Bool		FALSE	ERROR = TRUE: An error has occurred and the STATUS output is valid. All other outputs are set to zero in the event of an error. Communication errors are only signaled at the ERROR and STATUS outputs of the USS_Port_Scan instruction.
STATUS	OUT	Word		0	Error code (see Error messages (Page 68)).
VALUE	OUT	Variant (Word, Int, UInt, DWord, DInt, UDInt, Real)	Any (Word, Int, UInt, DWord, DInt, UDInt, Real)	–	This is the value of the parameter that was read and is only valid if the DONE bit is true.

[1] The DONE bit indicates that valid data was read out of the referenced motor drive and transmitted to the CPU. It does not indicate that the instruction is cabable of immediately read an additional parameter. An empty read request must be sent to the motor drive and acknowledged by the instruction before the parameter channel is freed up for use by the respective drive. The immediate call of USS_Read_Param or USS_Write_Param for the specific motor drive results in error 0x818A.

3.3.6 USS_Write_Param: Change data in drive

NOTE

For EEPROM write instructions (EEPROM in a USS drive):

Keep the number of EEPROM write operations to a minimum in order to maximize the EEPROM service life.

Description

The USS_Write_Param instruction changes a parameter in the drive. All USS functions assigned to one USS network and one PtP communication port must use the instance data block of the USS_Drive_Control.

USS_Write_Param must be called from the cycle OB of a main program.

Parameters

Table 3-1053 Data types for the parameters

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/WinAC		
REQ	IN	Bool		–	A positive edge at REQ creates a new write request.
DRIVE	IN	USInt	Byte	–	Address of the drive: DRIVE is the address of the USS drive. The valid range is between drive 1 and drive 16.
PARAM	IN	UInt		–	Parameter number: PARAM specifies the drive parameter to write. The range for this parameter is located between 0 and 2047; for some drives the most significant byte of the INDEX parameter can access parameter values greater than 2047. Additional information on access to an extended range is available in your drive manual.
INDEX	IN	UInt		–	Parameter index: INDEX specifies the drive parameter index to which to write. It is a 16-bit value in which the least significant bit is the actual index value with a range of (0 to 255). The drive can also use the most significant byte, which is drive-specific. Additional information is available in your drive manual.
EEPROM	IN	Bool		–	Save in EEPROM of the drive: If TRUE, the transaction of a parameter for writing to the drive is saved in the EEPROM of the drive. If FALSE, the written value is saved only temporarily and is lost the next time you switch on the drive.

[1] The DONE bit indicates that valid data was read out of the referenced motor drive and transmitted to the CPU. It does not indicate that the USS library is able to read out an additional parameter immediately. An empty write request must be sent to the motor drive and acknowledged by the instruction before the parameter channel is freed up for use by the respective drive. The immediate call of USS_Read_Param or USS_Write_Param FC for the specific motor drive results in error 0x818A.

Parameters	Declaration	Data type		Standard	Description
		S7-1500	S7-300/400/ WinAC		
VALUE	IN	Variant (Word, Int, UInt, DWord, DInt, UDInt, Real)	Any (Word, Int, UInt, DWord, DInt, UDInt, Real)	–	Value of the parameter in which you want to write. It must be valid with a positive edge of REQ.
USS_DB	INOUT	USS_BASE		–	The USS_DB parameter must be connected to the (static) USS_DB parameter of the instance DB which is generated and initialized when you add a USS_Drive_Control instruction to your program.
DONE[1]	OUT	Bool		FALSE	If TRUE, the VALUE input is written to the drive. This bit is set when the USS_Drive_Control d instruction recognizes the write response of the drive. This bit is reset the next time USS_Write_Paramis called.
ERROR	OUT	Bool		FALSE	If TRUE, an error has occurred and the STATUS output is valid. All other outputs are set to zero in the event of an error. Communication errors are only signaled at the ERROR and STATUS outputs of the USS_Port_Scan instruction.
STATUS	OUT	Word		0	Error code (see Error messages (Page 68)).

[1] The DONE bit indicates that valid data was read out of the referenced motor drive and transmitted to the CPU. It does not indicate that the USS library is able to read out an additional parameter immediately. An empty write request must be sent to the motor drive and acknowledged by the instruction before the parameter channel is freed up for use by the respective drive. The immediate call of USS_Read_Param or USS_Write_Param FC for the specific motor drive results in error 0x818A.

3.3.7 General information on drive setup

General requirements for drive setup

- You need to configure the use of 4 PIV words (**P**arameter**I**D**V**alue) for the drives.
- The drives can be configured for 2, 4, 6 or 8 PZD words (**p**ro**c**ess **d**ata area).
- The number of PZD words in the drive must correspond to the PZD_LEN input of the USS_Drive_Control instruction of the drive.
- The data transmission rate of all drives must correspond to the BAUD input of the USS_Port_Scan instruction.
- The drive must be set up for remote control.
- USS must be specified for the frequency setpoint at the COM connection of the drive.
- 1 to 16 must be specified for the drive address. This address must correspond to the DRIVE input at the USS_Drive_Control block of the drive.
- The use of the polarity of the drive setpoint must be set up for direction control of the drive.
- The RS485 network must be properly terminated.

Connecting a MicroMaster drive

The information on SIEMENS MicroMaster drives is used as an example. The setup instructions for other drives are included in the drive manual.

If you want to connect a Series 4 MicroMaster drive (MM4), insert the ends of the RS485 cable into the two screwless pressure clamps for USS operation. You can connect the S7-1500 and ET 200SP with the conventional PROFIBUS cable and the plug connectors to the MicroMaster drive.

NOTICE
If you connect devices that do not have the same reference voltage, you may create unwanted currents in the connection cable. These unwanted currents may cause communication errors or damages in the devices. Make sure that all devices you connect with a communication cable either have the same reference conductor in the circuit or are electrically disconnected to prevent the occurrence of unwanted currents. The shielding must be connected to the ground or pin 1 of the 9-pin plug connector. The wiring terminal 2 0V of the MicroMaster drive should be connected to the ground.

Insert the two wires at the other end of the RS485 cable into the terminal block of the MM4 drive. To create a cable connection at the MM4 drive, remove the drive cover(s) to gain access to the terminal blocks. The MM4 drive System Manual includes a detailed description on how to remove the cover(s) on your specific drive.

The connections on the terminal block are numbered consecutively. On the S7-1500 or ET 200SP end, use a PROFIBUS connection plug and connect terminal A of the cable to terminal 15 of the drive (with an MM420) or to terminal 30 of the drive (with an MM440). Connect terminal B (P) A (N) of the connector to terminal 14 (for an MM420) or to terminal 29 (for an MM440).

If the S7-1500 or ET 200SP is a terminating station in the network or a point-to-point connection, you must use terminals A1 and B1 (not A2 and B2) of the plug connector, as these terminals provide termination settings (for example, with the DP plug connector 6ES7972-0BA40-0X40).

NOTICE
Fitting the drive covers Make sure that you install the drive covers carefully once again before you connect the power supply of the device.

If the drive is configured as terminating station in the network, the terminating resistors must be connected with the corresponding terminals. This figure shows examples for the connections of the MM4 drive for termination.

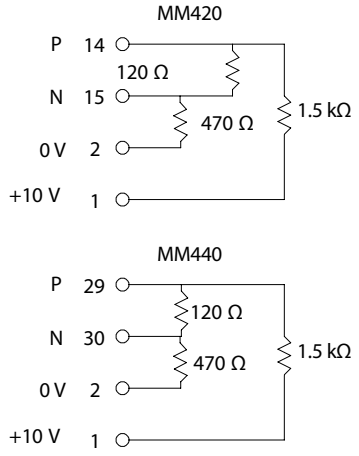

Setup of the MM4 drive

Before you connect a drive to the S7-1500 or ET 200SP, make sure that the drive has the following system parameters. Use the drive keyboard to set the parameters:

1.	Reset the drive to the factory settings (optional).	P0010 = 30 P0970 = 1
	If you skip step 1, make sure that these parameters are set to the specified values:	USS PZD length = P2012 index 0 = (2, 4, 6 or 8) USS PKW length = P2013 index 0 = 4
2.	Activate the read/write access for all parameters (expert mode).	P0003 = 3
3.	Check the motor settings of your drive. The settings depend on the respective motor. You must set parameter P010 to 1 before you can set parameters P304, P305, P307, P310 and P311 (fast commissioning mode). Once you have set the parameters, set parameter P010 to 0. Parameters P304, P305, P307, P310 and P311 can only be changed in fast commissioning mode.	P0304 = rated motor voltage (V) P0305 = rated motor current (A) P0307 = rated motor power (W) P0310 = rated motor frequency (Hz) P0311 = rated motor speed
4.	Set the local/remote mode.	P0700 Index 0 = 5
5.	Set the frequency setpoint of the COM connection to USS.	P1000 Index 0 = 5
6.	Acceleration time (optional) Time in seconds that the motor needs to accelerate to maximum frequency.	P1120 = (0 to 650.00)
7.	Ramp-down time (optional) Time in seconds that the motor needs to decelerate to a complete stop.	P1121 = (0 to 650.00)
8.	Set the reference frequency of the serial connection:	P2000 = (1 to 650 Hz)
9.	Set the USS normalization:	P2009 Index 0 = 0

10.	Set the bps for the RS-485 serial interface:	P2010 Index 0 = 4 (2400 Bit/s) 5 (4800 Bit/s) 6 (9600 Bit/s) 7 (19200 Bit/s) 8 (38400 Bit/s) 9 (57600 Bit/s) 12 (115200 Bit/s)
11.	Enter the slave address. Each drive (up to 31) can be operated by means of the bus.	P2011 Index 0 = (0 to 31)
12.	Specify the timeout value for the serial connection. This is the maximum permitted interval between two incoming data frames. This function turns off the inverter in case of a communication failure. The time measurement starts once a valid frame has been received. If no additional data frame is received during the specified time, the inverter turns off and displays error code F0070. If you set the value to zero, the control is turned off.	P2014 Index 0 = (0 to 65535 ms) 0 = timeout deactivated
13.	Transmit the data from RAM to EEPROM:	P0971 = 1 (start transmission). Save the changes to the parameter settings in EEPROM.

Error messages

4

Overview of error messages - PtP

The error messages are provided at the STATUS output of an instruction and can be evaluated there or processed in the user program.

Error code	Description	Remedy
0x0000	No error	-
RECEIVE status and error codes		
0x0094	frame end identified based on the "Receipt of fixed/maximum frame length"	-
0x0095	frame end identified based on "Message timeout"	-
0x0096	frame end identified based on expiration of the "Character delay time"	-
0x0097	The frame was aborted because the maximum response time was reached.	-
0x0098	frame end identified based on the fulfillment of the "Read message length from message" conditions	-
0x0099	frame end identified based on the receipt of the "End sequence"	-
SEND status and error codes		
0x7000	Block idle	-
0x7001	Initial call for a new frame: Data transmission initiated	-
0x7002	Interim call: Data transmission running	-
0x8085	Invalid length	Select a suitable frame length. The following are valid (depending on the module): 1-1024/2048/4096 (Byte)
0x8088	The specified length exceeds the range set in the receive buffer. Note: If the data type STRING has been specified at the BUFFER parameter, this error code also appears if the current string is shorter than the length specified at the LENGTH parameter.	Change the range in the receive buffer or select a frame length which corresponds to the range set in the receive buffer. The following are valid (depending on the module): 1-1024/2048/4096 (Byte)
RECEIVE status and error codes		
0x8088	The number of characters received exceeds the number specified at the BUFFER parameter.	Select a suitable frame length. The following are valid (depending on the module): 1-1024/2048/4096 (Byte)
Error message codes of the special functions		
0x818F	Incorrect parameter number setting (with USS only)	Select a suitable parameter number (PARAM). The following numbers are valid: 0-2047

1) Only with instructions for S7-300/400 CPUs

Error code	Description	Remedy
0x8190	Incorrect setting of the CRC calculation	Select a suitable value for the CRC calculation. The following are valid: deactivated or activated. Check whether the module addressed supports CRC calculation.
0x8191	Incorrect setting of the diagnostic error interrupt	Select a suitable value for "Diagnostic error interrupt". The following are valid: Diagnostic error interrupt deactivated or diagnostic error interrupt activated. Check whether the module addressed supports the generation of diagnostic interrupts.
Error message codes of the "Port configuration"		
0x81A0	The module does not support this protocol.	Select a valid protocol for the module (PROTOCOL).
0x81A1	The module does not support this data transmission rate.	Select a valid data transmission rate for the module (BAUD).
0x81A2	The module does not support this parity setting.	Select a suitable value for "Parity" (PARITY). The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
0x81A3	The module does not support this number of data bits.	Select a suitable value for "Number of data bits" (DATABITS). The following are valid: • 7 (2) • 8 (1)
0x81A4	The module does not support this number of stop bits.	Select a suitable value for "Number of stop bits" (STOPBITS). The following are valid: • 1 (1) • 2 (2)
0x81A5	The module does not support this type of data flow control.	Select a valid data flow control for the module (FLOWCTRL).
0x81A7	Invalid value for XON or XOFF	Select suitable values for XON (XONCHAR) and XOFF (XOFFCHAR). Valid range of values: 0...255
0x81AA	Invalid operating mode	Valid operating modes are: • Full duplex (RS232) (0) • Full duplex (RS422) four-wire mode (point-to-point) (1) / (CM PtP (ET 200SP)) • Full duplex (RS422) four-wire mode (multipoint master) (2)/ (CM PtP (ET 200SP)) • Full duplex (RS 422) four-wire mode (multipoint slave) (3) • Half duplex (RS485) two-wire mode. (4)

1) Only with instructions for S7-300/400 CPUs

Error code	Description	Remedy
0x81AB	Invalid receive line initial state	Valid initial states are: • "No" default setting (0) • Signal R(A)=5 V, signal R(B)=0 V (break detection) (1): Can only be selected with: "Full duplex (RS422) four-wire operation (point-to-point connection)" and "Full duplex (RS422) four-wire operation (multipoint slave)". • Signal R(A)=0 V, signal R(B)=5 V (2): This default setting corresponds to the idle state (no active send operation).
0x81AC	Invalid value for "Break detection"	Select a suitable value for "Break detection". The following are valid: • Break detection deactivated (0) • Break detection activated (1).
0x81AF	The module does not support this protocol.	Select a valid protocol for the module.
Error codes of the "Send configuration"		
0x81B5	More than two end delimiters or end sequence > 5 characters	Select suitable values for "End delimiter" and "End sequence". The following are valid: • deactivated (0), • 1 (1) or 2 (2) end delimiters or • deactivated (0), • 1 (1) up to 5 (5) characters for the end sequence.
0x81B6	Send configuration rejected because the 3964(R) protocol was selected	Make sure that no send configuration is transmitted if the 3964(R) protocol is set.
Error codes of the "Receive configuration"		
0x81C0	Invalid start condition	Select a suitable start condition. The following are valid: • Send break before frame start • Send Idle Line.
0x81C1	Invalid end condition or no end condition selected	Select a suitable end condition (see Receiving data with Freeport).
0x81C3	Invalid value for "Maximum message length"	Select a suitable value for "Maximum message length" (MAXLEN). Valid range of values (depending on the module): 1-1024/2048/4096 (Byte)
0x81C4	Invalid value for "Offset of the length specification in the message"	Select a suitable value for "Offset of the length specification in the message". Valid range of values (depending on the module): 1-1024/2048/4096 (Byte)
0x81C5	Invalid value for "Size of length field"	Select a suitable value for "Size of length field" (LENGTHSIZE). Valid range of values in bytes: • 1 (1) • 2 (2) • 4 (4)

1) Only with instructions for S7-300/400 CPUs

Error code	Description	Remedy
0x81C6	Invalid value for "Number of characters not counted in length specification"	Select a suitable value for "Number of characters not counted in length specification" (LENGTHM). Valid range of values: 0 to 255 (bytes)
0x81C7	The total of "Offset in the message + size of length field + number of characters not counted" is greater than the maximum frame length	Select a suitable value for "Offset in message", "Size of length field" and "Number of characters not counted". Valid range of values: • Offset in the message (depending on the module): 0-1024/2048/4096 (Byte) • Size of length field: 1, 2, or 4 (bytes) • Number of characters not counted: 0 to 255 (bytes)
0x81C8	Invalid value for "Response timeout"	Select a suitable value for "Response timeout". Valid range of values: 1-65535 (ms)
0x81C9	Invalid value for "Character delay time"	Select a suitable value for "Character delay time". Valid range of values: 1 to 65535 (bit times)
0x81CB	frame end sequence is activated, but no character is activated for the check	Activate one or several characters for the check.
0x81CC	frame start sequence is activated, but no character is activated for the check	Activate one or several characters for the check.
0x81CD	Invalid value for "Prevent overwriting"	Select a suitable value for "Prevent overwriting". The following are valid: • Prevent overwriting is deactivated (0) or • Prevent overwriting is activated (1)
0x81CE	Invalid value for "Clear receive buffer on startup"	Select a suitable value for "Clear receive buffer on startup". The following are valid: • Clear receive buffer at startup is deactivated (0) • Clear receive buffer at startup is activated (1)
SEND status and error codes		
0x81D0	Receiving send request during runtime of a send command	Make sure that you do not receive an additional send request during runtime of a send command.
0x81D1	The waiting time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or change the parameters, if necessary.
0x81D2	"Hardware RTS always ON": Send job canceled due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ON for the entire duration of transmission.
0x81D3	Send buffer overflow / send frame too long	Select a shorter frame length. The following are valid (depending on the module): 1 to 1024/2048/4096 (bytes)
0x81D5	Transmission canceled due to parameter changes, detected wire break, or CPU in STOP	Check the parameter assignment, wire break, and CPU status.
0x81D6	Transmission canceled because end identifier was not received	Check the parameter assignment of the end characters and the frame of the communication partner.
0x81D7	Communication error between the user program and module	Check the communication (e.g., matching the sequence number).
0x81D8	Transmission attempt rejected because module is not configured	Configure the module.

1) Only with instructions for S7-300/400 CPUs

Error code	Description	Remedy
Error codes of the receive configuration		
0x81E0	Frame aborted: Send buffer overflow / send frame too long	Increase the call rate for the receive function in the user program or configure communication with data flow control.
0x81E1	Frame aborted: Parity error	Check the connection line of the communication partners, or verify that both devices are configured for the same data transmission rate, parity and stop bit number.
0x81E2	Frame aborted: Character frame error	Check the settings for start bit, data bits, parity bit, data transmission rate, and stop bit(s).
0x81E3	Frame aborted: Character overflow error	Firmware error: Please contact Customer Support.
0x81E4	Frame aborted: The total length of "Offset in the message + size of the length field + number of characters not counted" is greater than the receive buffer	Select a suitable value for offset in message, size of the length field, and number of characters not counted.
0x81E5	Frame aborted: Break	Receive line to partner is interrupted. Reconnect or switch on partner.
0x81E6	Maximum number of "Buffered received frames" exceeded	In the user program call the instruction more often or configure a communication with data flow control or increase the number of buffered frames.
0x81E8	Frame aborted: The character delay time has expired before the message end criterion was detected	Partner device faulty or too slow. Check this, if required, using an interface tester that is interconnected in the transmission line.
0x81E9	Modbus CRC error (only communication modules which support Modbus)	Checksum error of the Modbus frame. Check the communication partner.
0x81EA	Modbus frame too short (only communication modules which support Modbus)	Minimum length of Modbus frame not met. Check the communication partner.
0x81EB	Frame aborted: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1-1024/2048/4096 (Byte) Check the parameters for end of frame detection.
Error codes V24 accompanying signals		
0x81F0	The module does not support V24 accompanying signals	You have tried to set accompanying signals for a module that does not support V24 accompanying signals. Make sure that this is an RS232 module or that RS232 mode (ET 200SP) is set.
0x81F1	No operation of the V24 accompanying signals	The V24 accompanying signals cannot be operated manually if hardware data flow control is active.
Error codes of the receive configuration		
0x8201 [1]	BUFFER is a pointer to an invalid data type	Enter a pointer to one of the following data types: DB, BOOL, BYTE, CHAR, WORD, INT, DWORD, DINT, REAL, DATE, TIME_OF_DAY, TIME, S5TIME, DATE_AND_TIME, STRING

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Remedy
0x8225	BUFFER points to an optimized memory area greater than 1 KB or BUFFER points to an optimized memory area and the receive length is greater than the area addressed by BUFFER.	Enter a pointer to an area with a maximum length of: • Optimized memory area: 1 kByte • Non-optimized area: 4 kByte Note: If the pointer points to an optimized memory area, do not send more than 1 kByte.
0x8229 [1]	BUFFER is a pointer to BOOL with a number of bits not equal to n * 8	If you are using a pointer to BOOL, the number of bits must be a multiple of 8.
Error codes, general		
0x8280	Negative acknowledgment when reading module	Check the input at the PORT parameter You can find more detailed information on error causes in theRDREC.STATUS static parameters and in the description of the SFB RDREC.
0x8281	Negative acknowledgment when writing module	Check the input at the PORT parameter You can find more detailed information on error causes in the WRREC.STATUS static parameters and in the description of the SFB WRREC.
0x8282	Module not available	Check the input at the PORT parameter and ensure that the module can be reached.
Error codes of the receive configuration		
0x82C1	Invalid value for "Buffered received frames".	Select a suitable value for "Buffered received frames". Valid range of values: 1-255
0x82C2	Receive configuration rejected because the 3964(R) protocol was selected	Make sure that no receive configuration is sent if the 3964(R) protocol is set.
0x8301 [1]	BUFFER is a pointer to an invalid data type	Select a valid data type. The following are valid: DB, BOOL, BYTE, CHAR, WORD, INT, DWORD, DINT, REAL, DATE, TIME_OF_DAY, TIME, S5TIME, DATE_AND_TIME, STRING
0x8322	Range length error when reading a parameter	Check the input at the BUFFER parameter
0x8324	Range error when reading a parameter	Check the input at the BUFFER parameter
0x8328	Setting error when reading a parameter	Check the input at the BUFFER parameter
Error codes of the send configuration		
0x8328 [1]	BUFFER is a pointer to BOOL with a number of bits not equal to n * 8	If you are using a pointer to BOOL, the number of bits must be a multiple of 8.
Error codes of the receive configuration		
0x8332	Invalid data block at the Receive_Conditions parameter	Check the input at the Receive_Conditions parameter
0x833A	The designation of the data block at the BUFFER parameter refers to a data block that is not loaded.	Check the input at the BUFFER parameter
0x8351	Invalid data type	Check the input at the BUFFER parameter
0x8352 [1]	Receive_Conditions does not point to a data block	Check the pointer to Receive_Conditions
0x8353 [1]	Receive_Conditions does not point to a structure of the type Receive_Conditions	Check the pointer to Receive_Conditions

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Remedy
Error codes 3964(R) protocol		
0x8380	Parameter assignment error: Invalid value for "Character delay time".	Select a suitable value for "Character delay time" (CharacterDelayTime). Valid range of values: 1 to 65535 (ms)
0x8381	Parameter assignment error: Invalid value for "Response timeout".	Select a suitable value for "Response timeout" (AcknDelayTime). Valid range of values: 1 to 65535 (ms)
0x8382	Parameter assignment error: Invalid value for "Priority".	Select a suitable value for "Priority" (Priority). The following are valid: • High (1) • Low (0)
0x8383	Parameter assignment error: Invalid value for "Block check"	Select a suitable value for "Block check" (BCC). The following are valid: • With block check (1) • Without block check (0)
0x8384	Parameter assignment error: Invalid value for "Connection attempts".	Select a suitable value for "Connection attempts" (BuildupAttempts). Valid range of values: 1-255
0x8385	Parameter assignment error: Invalid value for "Transmission attempts".	Select a suitable value for "Transmission attempts" (RepetitionAttempts). Valid range of values: 1-255
0x8386	Runtime error: Number of connection attempts exceeded	Check the interface cable and the transmission parameters. Also check whether the receive function is configured correctly at the partner device.
0x8387	Runtime error: Number of transmission attempts exceeded	Check the interface cable, the transmission parameters and the configuration of the communication partner.
0x8388	Runtime error: Error at the "Block check character" The internally calculated value of the block check character does not correspond to the block check character received by the partner at the connection end.	Check whether the connection is seriously disrupted; in this case you may also occasionally see error codes. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
0x8389	Runtime error: Invalid character received while waiting for free receive buffer	The send request of the communication partner (STX, 02H) is only answered with DLE when the receive buffer is empty. No additional character may be received before (except STX again). Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
0x838A	Runtime error: Logical error during receiving. After DLE was received, a further random character (other than DLE or ETX) was received.	Check if partner DLE in frame header and in data string is always in duplicate or the connection is released with DLE ETX. Check for proper function at the partner device, possibly by using an interface test device that is switched into the transmission line.
0x838B	Runtime error: Character delay time exceeded	Partner device too slow or faulty. Verify by using an interface test device that is switched into the transmission line, if necessary.

1) Only with instructions for S7-300/400 CPUs

Error code	Description	Remedy
0x838C	Runtime error: Wait time for free receive buffer has started	In the user program call the instruction more often or configure a communication with data flow control.
0x838D	Runtime error: frame repetition does not start within 4 s after NAK	Check the communication partner. A received frame that is possibly corrupted must be repeated by the partner within 4 seconds.
0x838E	Runtime error: In idle mode, one or several characters (other than NAK or STX) were received.	Check for proper function of the partner device, possibly using an interface test device that is switched into the transmission line.
0x838F	Runtime error: Initialization conflict - Both partners have set high priority	Set the "Low" priority at one of the partners
0x8391	Parameter assignment error: 3964 configuration data rejected because Freeport is set	If the Freeport protocol is set, make sure that no 3964 parameter assignment data is sent.

1) Only with instructions for S7-300/400 CPUs

Overview of error messages - Modbus

Error code	Description	Remedy
0x0000	No error	-
Configuration error of the interface - Modbus_Comm_Load		
0x8181	The module does not support this data transmission rate.	Select a valid data transmission rate for the module at the BAUD parameter.
0x8182	The module does not support this parity setting.	Select a suitable value for "Parity" at the PARITY parameter. The following are valid: • None (1) • Even (2) • Odd (3) • Mark (4) • Space (5) • Any (6)
0x8183	The module does not support this type of data flow control.	Select a valid data flow control for the module at the FLOW_CTRL parameter.
0x8184	Invalid value for "Response timeout".	Select a suitable value for "Response timeout" at the RESP_TO parameter. Valid range of values: 1 to 65535 (ms)
0x8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the Send_Config.RDREC.STATUS or Receive_Config.RDREC.STATUS static parameters or RDREC.STATUS and in the description of the SFB RDREC.
0x8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the Send_Config.WRREC.STATUS or Receive_Config.WRREC.STATUS static parameters or WRREC.STATUS and in the description of the SFB WRREC.

1) Only with instructions for S7-300/400 CPUs

Error code	Description	Remedy
0x8282	Module not available	Check the input at the PORT parameter and ensure that the module can be reached.
Configuration error - Modbus_Slave		
0x8186	Invalid slave address	Select a suitable slave address at the MB_ADDR parameter. The following are valid: 1-247 at standard address area; 1-65535 at extended address area (0 is reserved for Broadcast)
0x8187	Invalid value at MB_HOLD_REG parameter	Select a suitable value for the hold register at the MB_HOLD_REG parameter.
0x8188	Invalid operating mode or broadcast (MB_ADDR = 0) and MODE parameter ≠ 1	Select the value 1 for MODE in Broadcast mode or select a different operating mode.
0x818C	The pointer to a MB_HOLD_REG area must be a data block or a bit memory address area.	Select a suitable value for the pointer to the MB_HOLD_REG area.
0x8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
0x8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.WRREC.STATUS or Receive_P2P.WRREC.STATUS, and in the description of the SFB WRREC.
0x8452 [1)]	MB_HOLD_REG is not a pointer to a DB or a bit memory area	Check the MB_HOLD_REG pointer
0x8453 [1)]	MB_HOLD_REG is not a pointer of type BOOL or WORD	Check the MB_HOLD_REG pointer
0x8454 [1)]	The area addressed by MB_HOLD_REG is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the MB_HOLD_REG pointer
0x8455 [1)]	MB_HOLD_REG points to a write-protected DB	Check the MB_HOLD_REG pointer
0x8456 [1)]	Error during instruction execution. The cause of the error is shown in the STATUS parameter.	Determine the value of the SFCSTATUS parameter. Check what this means in the description for SFC51, STATUS parameter.
Configuration error - Modbus_Master		
0x8180	Invalid value for MB_DB parameter	The value configured for MB_DB (instance data DB) at the Modbus_Comm_Load instruction is not valid. Check the interconnection of the Modbus_Comm_Load instruction and its error messages.
0x8186	Invalid station address	Select a suitable station address at the MB_ADDR parameter. The following are valid: 1-247 at standard address area; 1-65535 at extended address area (0 is reserved for Broadcast)

[1)] Only with instructions for S7-300/400 CPUs

Error code	Description	Remedy
0x8188	Invalid operating mode or broadcast (MB_ADDR = 0) and MODE parameter ≠ 1	Select the value 1 for MODE in the Broadcast operating mode or select a different operating mode.
0x8189	Invalid data address	Select a suitable value for the data address at the DATA_ADDR parameter. See description Modbus_Master (Page 37) in the Info system
0x818A	Invalid length	Select a suitable data length at the DATA_LEN parameter. See description Modbus_Master (Page 37) in the Info system
0x818B	Invalid value for DATA_PTR	Select a suitable value for the data pointer at the DATA_PTR parameter (M or DB address). See description Modbus_Master (Page 37) in the Info system
0x818C	Interconnection error of the DATA_PTR parameter	Check the interconnection of the instruction.
0x818D	The area addressed by DATA_PTR is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the DATA_PTR pointer
0x8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
0x8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Send_P2P.WRREC.STATUS or Receive_P2P.WRREC.STATUS or Receive_Reset and in the description of the SFB WRREC.
Communication errors - Modbus_Master and Modbus_Slave		
0x80 D1	The waiting time for XON or CTS = ON has expired.	The communication partner has a fault, is too slow or is offline. Check the communication partner or change the parameters, if necessary.
0x80D2	"Hardware RTS always ON": Send job canceled due to change from DSR = ON to OFF	Check the communication partner. Make sure that DSR is ON for the entire duration of transmission.
0x80E0	Frame aborted: Send buffer overflow / send frame too long	In the user program call the instruction more often or configure a communication with data flow control.
0x80E1	Frame aborted: Parity error	Check the connection line of the communication partners, or verify that both devices are configured for the same data transmission rate, parity and stop bit number.
0x80E2	Frame aborted: Character frame error	Check the settings for start bit, data bits, parity bit, data transmission rate, and stop bit(s).
0x80E3	Frame aborted: Character overflow error	Check the number of data in the frame of the communication partner.

1) Only with instructions for S7-300/400 CPUs

Error code	Description	Remedy
0x80E4	Frame aborted: Maximum frame length reached	Select a shorter frame length at the communication partner. The following are valid (depending on the module): 1 to 1024/2048/4096 (bytes)
Communication error - Modbus_Master		
0x80C8	The slave does not respond within the set time	Check the data transmission rate, parity and wiring of the slave.
0x8200	The interface is busy with an ongoing request.	Repeat the command later. Make sure that there are no commands still running before you start a new one.
Protocol error - Modbus_Slave (only communication modules that support Modbus)		
0x8380	CRC error	Checksum error of the Modbus frame. Check the communication partner.
0x8381	The function code is not supported or is not supported for broadcast.	Check the communication partner and make sure that a valid function code is sent.
0x8382	Invalid length information in the request frame	Select a suitable data length at the DATA_LEN parameter.
0x8383	Invalid data address in the request frame	Select a suitable value for the data address at the DATA_ADDR parameter.
0x8384	Invalid data value error in the request frame	Check the data value in the request frame of the Modbus master
0x8385	The diagnostic value is not supported by the Modbus slave (function code 08)	The Modbus slave only supports the diagnostic values 0x0000 and 0x000A.
Protocol error - Modbus_Master (only communication modules that support Modbus)		
0x8380	CRC error	Checksum error of the Modbus frame. Check the communication partner.
0x8381	Response frame from Modbus Slave with the following error message: The function code is not supported.	Check the communication partner and make sure that a valid function code is sent.
0x8382	Response frame from Modbus Slave with the following error message: Invalid length	Select a suitable data length.
0x8383	Response frame from Modbus Slave with the following error message: Invalid data address in the request frame	Select a suitable value for the data address at the DATA_ADDR parameter.
0x8384	Response frame from Modbus Slave with the following error message: Data value error	Check the request frame to the Modbus slave.
0x8385	Response frame from Modbus Slave with the following error message: The diagnostic value is not supported by the Modbus slave	Modbus slaves only support the diagnostic values 0x0000 and 0x000A.
0x8386	The returned function code does not match the requested function code.	Check the response frame and the addressing of the slave.
0x8387	A slave that was not requested answers	Check the response frame of the slave. Check the address settings of the slave.
0x8388	Error in the response of the slave to a write request.	Check the response frame of the slave.
0x8828 [1]	DATA_PTR points to a bit address that is not equal to n * 8	Check the DATA_PTR pointer

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Remedy
0x8852 [1]	DATA_PTR is not a pointer to a DB or a bit memory area	Check the DATA_PTR pointer
0x8853 [1]	DATA_PTR is not a pointer of type BOOL or WORD	Check the DATA_PTR pointer
0x8855 [1]	DATA_PTR points to a write-protected DB	Check the DATA_PTR pointer
0x8856 [1]	Error during call of SFC51	Call the Modbus_Master instruction again
Error - Modbus_Slave (only communication modules that support Modbus)		
0x8428 [1]	MB_HOLD_REG points to a bit address that is not equal to n * 8	Check the MB_HOLD_REG pointer
0x8452 [1]	MB_HOLD_REG is not a pointer to a DB or a bit memory area	Check the MB_HOLD_REG pointer
0x8453 [1]	MB_HOLD_REG is not a pointer of type BOOL or WORD	Check the MB_HOLD_REG pointer
0x8454 [1]	The area addressed by MB_HOLD_REG is longer than the DB, or the area addressed is too small for the number of data bytes to be read or written.	Check the MB_HOLD_REG pointer
0x8455 [1]	MB_HOLD_REG points to a write-protected DB	Check the MB_HOLD_REG pointer
0x8456 [1]	Error during call of SFC51	Call the Modbus_Slave instruction again

[1] Only with instructions for S7-300/400 CPUs

Overview of error messages - USS

Error code	Description	Remedy
0x0000	No error	-
0x8180	Length error in response of drive	Check the response frame of the drive.
0x8181	Data type error	Select a suitable data type. The following are valid: • Real • Word • Double word
0x8182	Data type error: "Double word" or "Real" may not be returned for the "Word" request.	Check the response frame of the drive.
0x8183	Data type error: "Word" may not be returned for the "Double word" or "Real" request.	Check the response frame of the drive.
0x8184	Checksum error in response of drive	Check the drive and the communication connection.
0x8185	Addressing error	Valid drive address range: 1 to 16
0x8186	Setpoint error	Valid setpoint range: -200 % to +200 %
0x8187	Incorrect drive number returned	Check the response frame of the drive.
0x8188	Invalid PZD length	Permitted PZD lengths: 2, 4, 6, 8 words
0x8189	The module does not support this data transmission rate.	Select a valid data transmission rate for the module.
0x818A	A different request for this drive is currently active.	Repeat the parameter read or write command later.
0x818B	The drive does not respond.	Check the drive.

[1] Only with instructions for S7-300/400 CPUs

Error code	Description	Remedy
0x818C	The drive responds with an error message to a parameter request.	Check the response frame of the drive. Check the parameter request.
0x818D	The drive responds with an access error message to a parameter request.	Check the response frame of the drive. Check the parameter request.
0x818E	The drive was not initialized.	Check the user program and make sure that the USS_Drive_Control instruction is called for this drive.
0x8280	Negative acknowledgment when reading module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Port_Config.RDREC.STATUS, Send_Config.RDREC.STATUS , Receive_Config.RDREC.STATUS , Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB RDREC.
0x8281	Negative acknowledgment when writing module	Check the input at the PORT parameter. You can find more detailed information on error causes in the static parameters Port_Config.WRREC.STATUS, Send_Config.WRREC.STATUS , Receive_Config.WRREC.STATUS , Send_P2P.RDREC.STATUS or Receive_P2P.RDREC.STATUS, and in the description of the SFB WRREC.

1) Only with instructions for S7-300/400 CPUs

Service & Support

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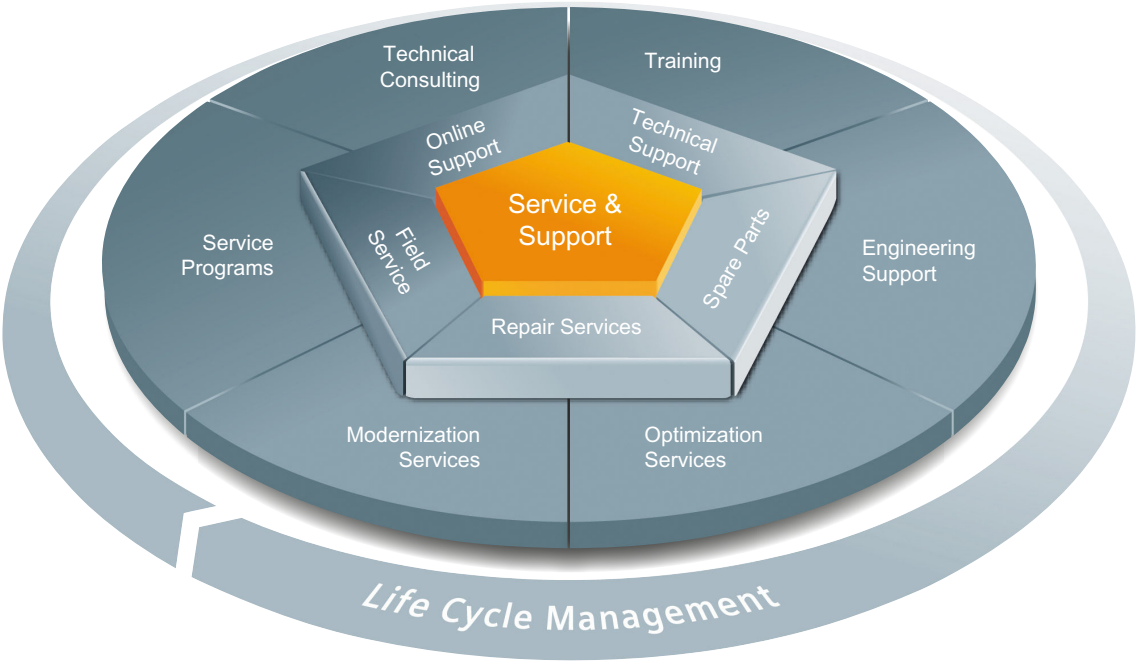

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SIMATIC

MultiFieldbus

Function Manual

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Preface

Purpose of the documentation

This function manual provides an overview and a detailed description of the individual MultiFieldbus functions. The function manual supplements the description of the system manuals and product manuals of the MultiFieldbus devices (MF devices).

This function manual includes all the information you need to configure and commission the above-mentioned devices on other fieldbuses (EtherNet/IP and Modbus TCP).

Basic knowledge required

The following knowledge is required in order to understand the manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Knowledge of
  - PROFINET
  - EtherNet/IP
  - Modbus TCP

Scope of the documentation

This documentation is the basic documentation for MF devices from Siemens. The product documentation is based on the content of this Function Manual.

Conventions

Also observe notes labeled as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product, or on the section of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal service and dispose of the equipment according to the applicable regulations in your country.

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial security concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

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Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customers' exposure to cyber threats.

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Documentation guide

1

Documentation

Various MultiFieldbus devices are available from Siemens. Each of these MultiFieldbus devices has a separate documentation. The MultiFieldbus devices are embedded in systems, e.g. ET 200SP. The documentation for the system consists of the respective system manual, function manuals and manuals.

MultiFielbus devices from Siemens

Detailed information on the MultiFieldbus devices can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109779189).

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- ET 200SP (https://support.automation.siemens.com/WW/view/en/84133942)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

System overview 2

2.1 System overview

Properties

The following properties are available. You can find out which features the MF Device supports in the respective system and equipment manuals.

- Connection to various fieldbuses as
  - PROFINET IO device
  - EtherNet/IP adapter
  - Modbus TCP server
- MF Shared Device (Page 99)
- All fieldbuses can be operated over the same Ethernet cable.
- Integrated 2-port switch

If you use the EtherNet/IP or Modbus TCP fieldbus protocol, one application relation (AR) is used for each fieldbus protocol.

2.2 MultiFieldbus engineering

MultiFieldbus Configuration Tool (MFCT)

You can create the configuration and parameter assignment of the MultiFieldbus Devices with MFCT. You download the configuration and parameter assignment to the MF Device with MFCT. The configuration and parameter assignment are stored retentively in the MF Device. For structured access to the I/O data with EtherNet/IP, you can export a UDT file (file extension *.l5x).

MFCT is available for download (https://support.industry.siemens.com/cs/ww/en/view/109773881) on the Internet.

NOTE

For commissioning with MFCT, the MF Device must be connected via an Ethernet connection with **100 Mbps full duplex**.

NOTE

Only one instance of MFCT or PRONETA may be active in a network.

If PRONETA and MFCT are simultaneously active in the network, you must deactivate cyclic scanning in PRONETA.

Installation requirements for MFCT

You also need to install the following software for MFCT:

- Microsoft .NET Framework 4.6.1 (Offline Installer) (https://www.microsoft.com/en-US/download/confirmation.aspx?id=49982)
- WinPcap from directory "Misc"
- Microsoft C++ Redistributable:
  - For x86 systems (https://aka.ms/vs/15/release/vc_redist.x86.exe)
  - For x64 systems (https://aka.ms/vs/15/release/vc_redist.x64.exe)

Electronic Data Sheet (EDS)

For integration in EtherNet/IP configuration systems, a generic EDS file according to CIP specification Vol.1 is available for download (https://support.industry.siemens.com/cs/ww/en/ps/27993).

See also

Import EDS station description (Page 28)

Configuring with MFCT (Page 12)

2.3 Detect active fieldbus

For exclusive operation on a fieldbus (not MF Shared Device) you can recognize the active fieldbus by the number of green LEDs on the MF Device.

This requires that there are no errors and that the MF Device is in cyclic data exchange with a controller.

Active fieldbus:	RN/NS	ER/MS	MT/IO
PROFINET	■ Green	□ Off	□ Off
Modbus TCP	■ Green	■ Green	□ Off
EtherNet/IP	■ Green	■ Green	■ Green

EtherNet/IP

3

3.1 EtherNet/IP functions

3.1.1 EtherNet/IP

MultiFieldbus supports the following EtherNet/IP functions:

- I/O communication with scanner
- Configuring from the user program
- Read diagnostics (interrupts are not supported)
- Normative CIP objects
- Resetting interface module to factory setting
- Diagnostics bit in data status of cyclic I/O data per submodule

3.2 Integration in the automation system

3.2.1 Overview

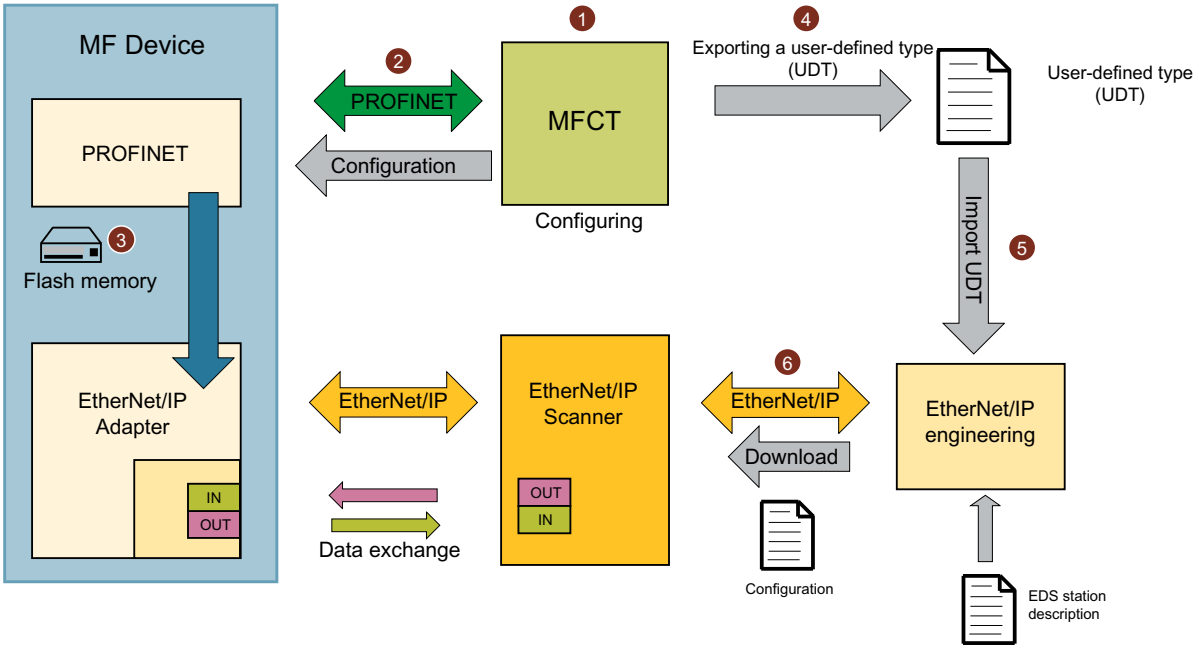

In the MultiFieldbus Configuration Tool (MFCT), you configure the MF device and assign an IP address and a device name to the MF device ①. You then download the configuration to the MF device with PROFINET IO mechanisms ②. The configuration is saved on the MF device ③.

You generate and export the I/O data mapping of the MF device as user-defined type (UDT) as I5x file for EtherNet/IP in MFCT ④. You then import the I5x file to your engineering system ⑤. Download the project to the EtherNet/IP scanner with the engineering system ⑥.

Import the generic EDS station description to your engineering system once.

Procedure

For commissioning, follow these steps:

1. Scan the network in MFCT and assign an IP address for the MF device.
2. Configure the MF device.
3. Select EtherNet/IP as fieldbus for the Ethernet interface.
4. Load the MultiFieldbus project to the MF device.
5. Export the I/O data mapping of the MF device as user-defined type (UDT) from MFCT.
6. Import the user-defined type (UDT) to your EtherNet/IP engineering system.
7. Configure the interface module in the EtherNet/IP engineering system.
8. Download the project to the EtherNet/IP scanner.
9. (Optional) Configure the modules from inside the user program.

NOTE

For MF devices, there might be modules displayed in engineering systems starting with slot 1000.
These merely reflect the retentively stored project in the MF device consisting of configuration and parameter assignment.

3.2.2 Configuring with MFCT

3.2.2.1 Requirements

Information on which MFCT version is required for which MF Device can be found in the Equipment Manual of the MF Device.

You can find version information for MFCT on the "About" tab.

3.2.2.2 Settings

In the "Settings" tab, you can specify basic properties of the MultiFieldbus Configuration Tool:

- Select the user interface language.
- Select the network adapter.

You can also update the GSD file used.

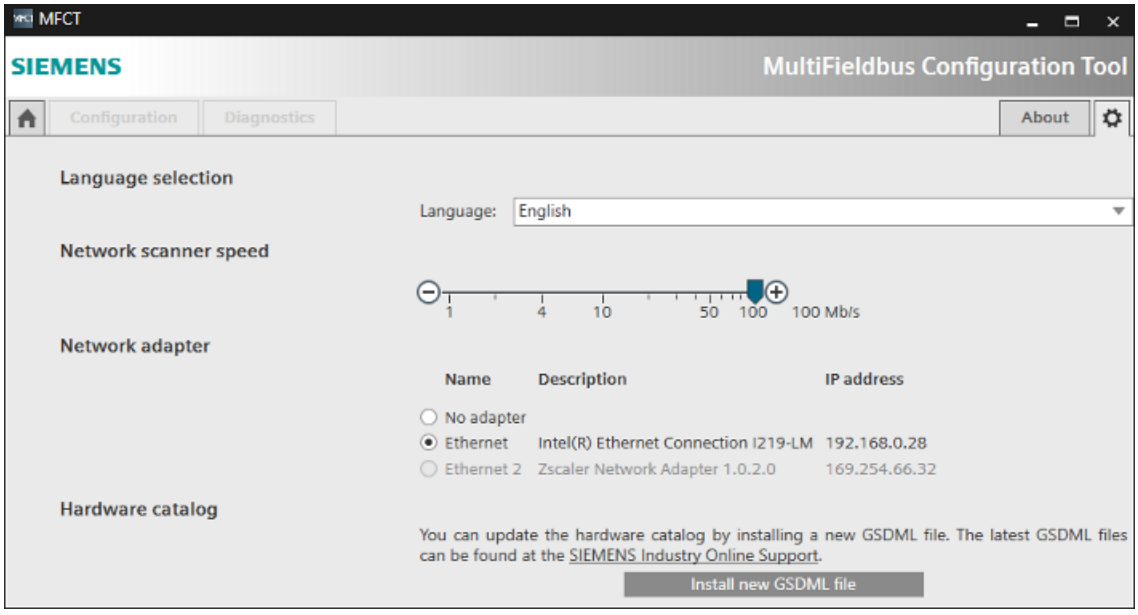

Language selection

Under "Language selection", select the user interface language for the MFCT.

Network scanner speed

Under "Network scanner speed", select the speed of the network scanner.

Network adapter

Under "Network adapter", select the interface you want to use to connect to MF devices.

Hardware catalog

In the "Hardware catalog" section, you can update the GSD module description in the MFCT using the "Install new GSDML file" button.

To do this, proceed as follows:

1. Click the link in the text.
2. Download the zipped GSD file and save it locally.
3. Unzip the GSD file.
4. Click "Install new GSDML file" and select the unzipped GSD file.

3.2.2.3 Assigning network parameters

In the "Home" tab, you can assign the network parameters for MF devices under "Assign parameters":

1. Click the "Start scan" button to find MF devices via the preset network interface.
2. Select an MF device.

   (You can make the LEDs of the MF device flash for identification with "Flash LED".)
3. Enter a device name, valid IP address and the subnet mask.
4. If you use a gateway, you can enable the "Use router for gateway" option and enter the router address.
5. Click "Assign network parameters".

The network parameters are assigned.

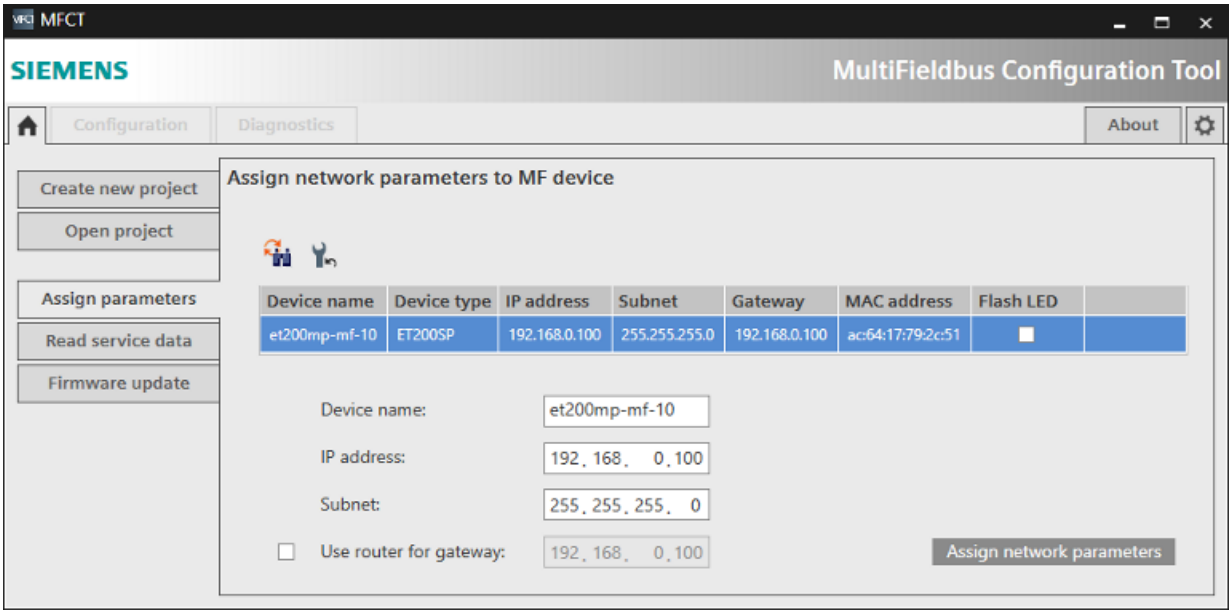

3.2.2.4 Resetting the MF device

In the "Home" tab, you can reset the MF device to the factory settings under "Accessible MF devices":

1. Click the "Start scan" button to find MF devices via the preset network interface.
2. Select an MF device.
3. Click "Reset network parameters".

The network parameters and the MultiFieldbus project are deleted.

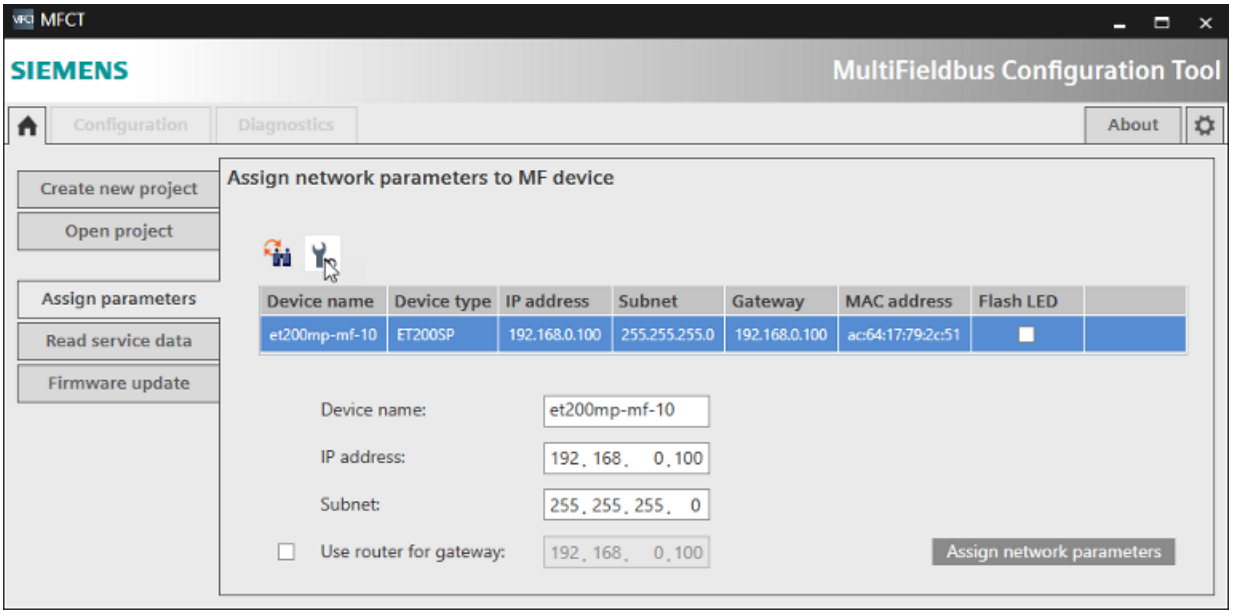

3.2.2.5 Creating new MultiFieldbus project in MFCT

You can create a new MultiFieldbus project in the "Home" tab:

1. Select "Create new project" and enter a name and a path for the new MultiFieldbus project.

   Optionally, you can describe the project in more detail by entering the author and comments.
2. Click "Create project".

The MultiFieldbus project is created as a file with the extension ".mfp1". The MFCT then goes to the next step in the "Configuration" tab.

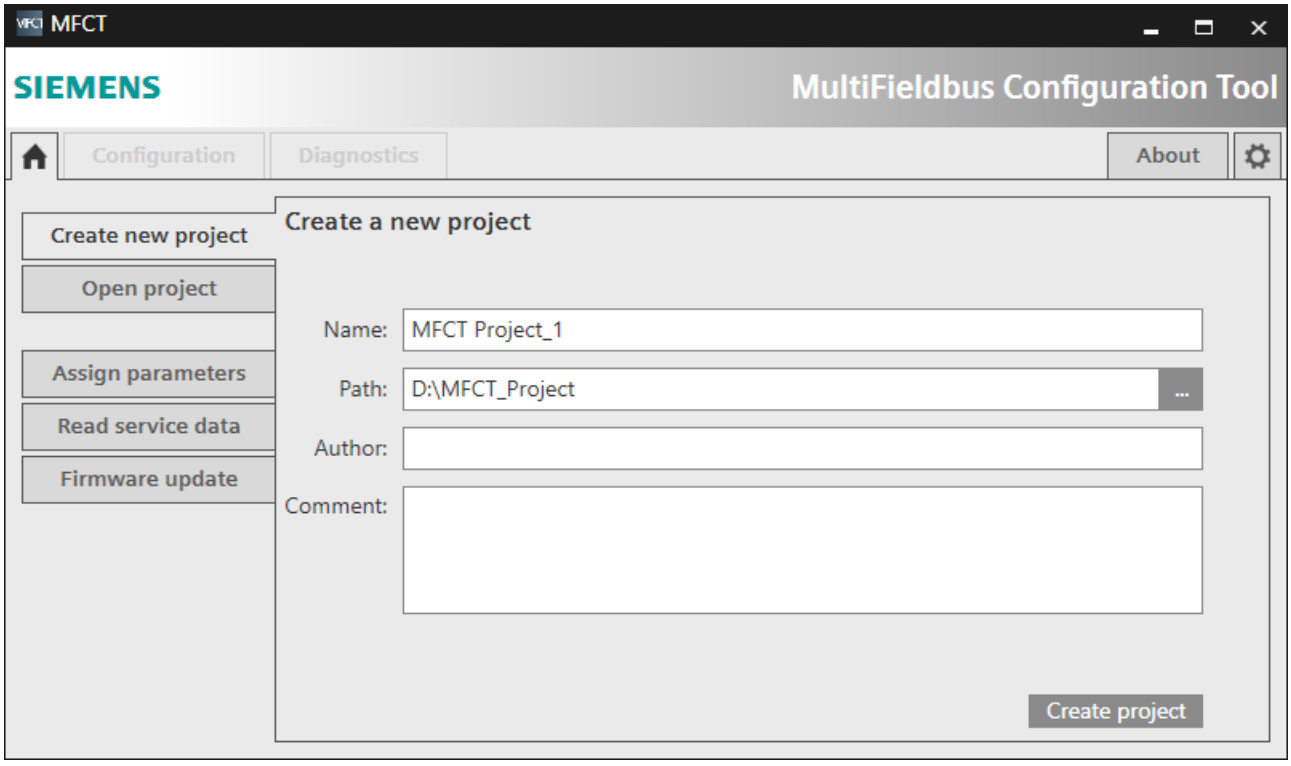

3.2.2.6 Open MultiFieldbus project in MFCT

You can open an existing MultiFieldbus project in the "Home" tab:

1. Select "Open project".
   - Under "Recently Used Projects", you can select a recently edited project and read it in directly by double-clicking it or using the "Open" button.
   - Alternatively, you can use the "Browse" button to open a project file.

The project is opened and the MFCT switches to the "Configuration" tab.

NOTE

The "Delete" button allows you to delete an existing project from the "Recently Used Projects" list. The project file itself is not deleted by this action.

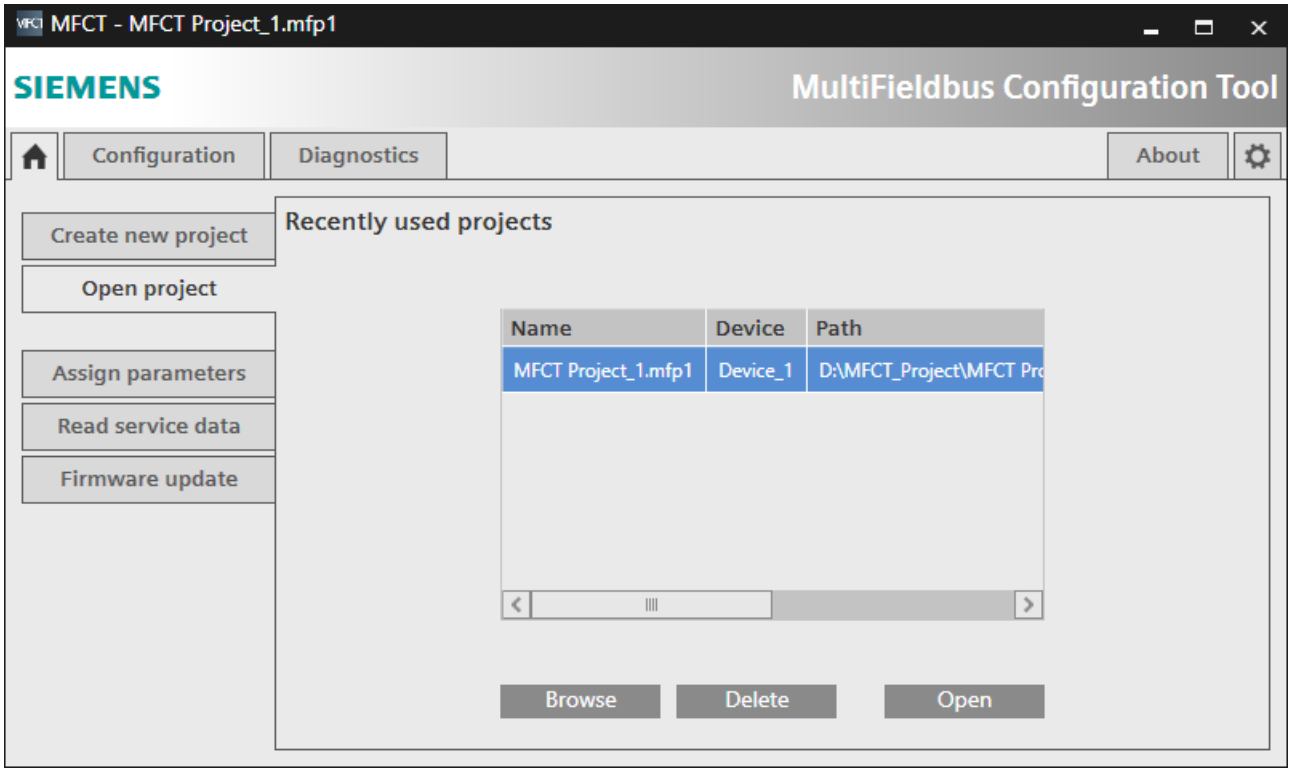

3.2.2.7 Selecting a station

You can create the configuration of the MF device in two ways:

- From the catalog if the real MF station is not available.
- From the network if the MF station is available online.

Selecting MF device from the catalog

1. Select the "Catalogue" option under "Select MF device from".
2. Under "Select MF device", select the desired MF device, e.g. ET 200SP.
3. Assign a name for the MF device under "Device name".
4. Select the desired interface module under "Short designation".
5. Click on the "Create Selected MF Device" button.

The MFCT automatically goes to the next step, "Configure Station".

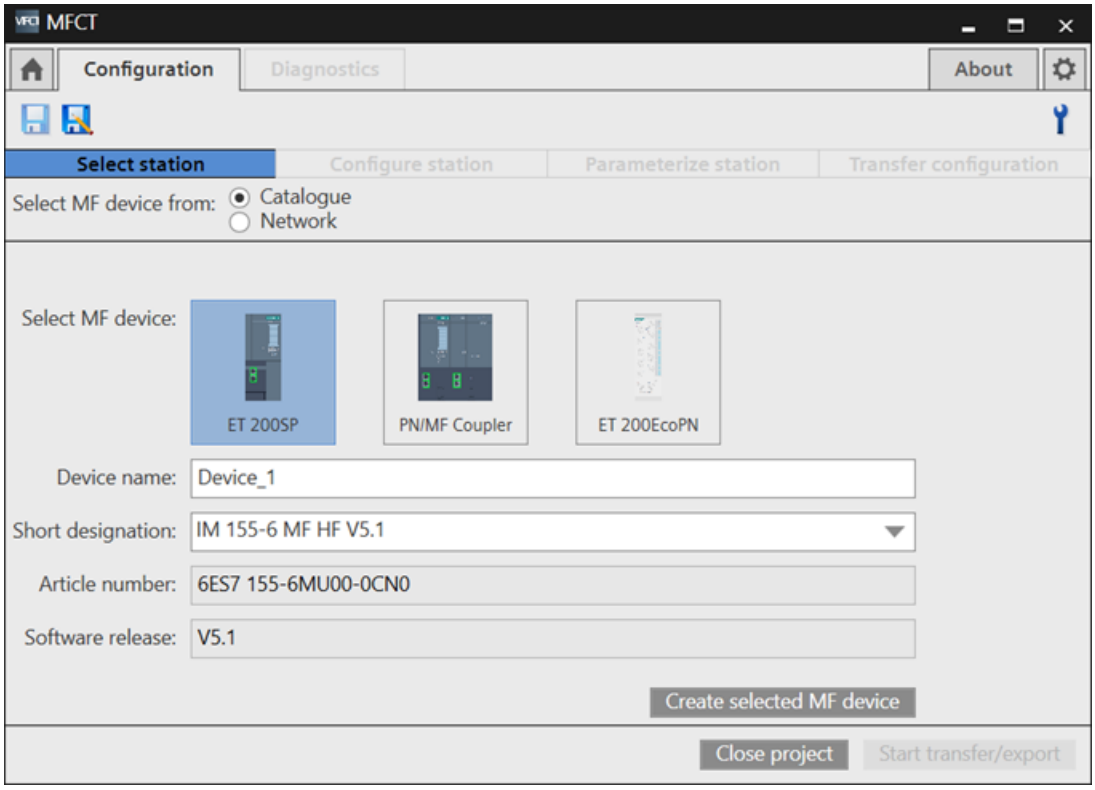

Selecting MF device from the network and loading the configuration

1. Ensure that the network interface selected in the "Settings" tab is connected to the desired MF device.
2. Select the "Network" option under "Select MF device from".
3. Click "Start scan".
4. Select the desired MF device from the list. Devices without MultiFieldbus support cannot be selected and are grayed out.
5. Click "Create new project".

The current configuration is read out from the MF device and added to the MultiFieldbus project. MFCT then goes to the next step "Configure Station" for review and editing.

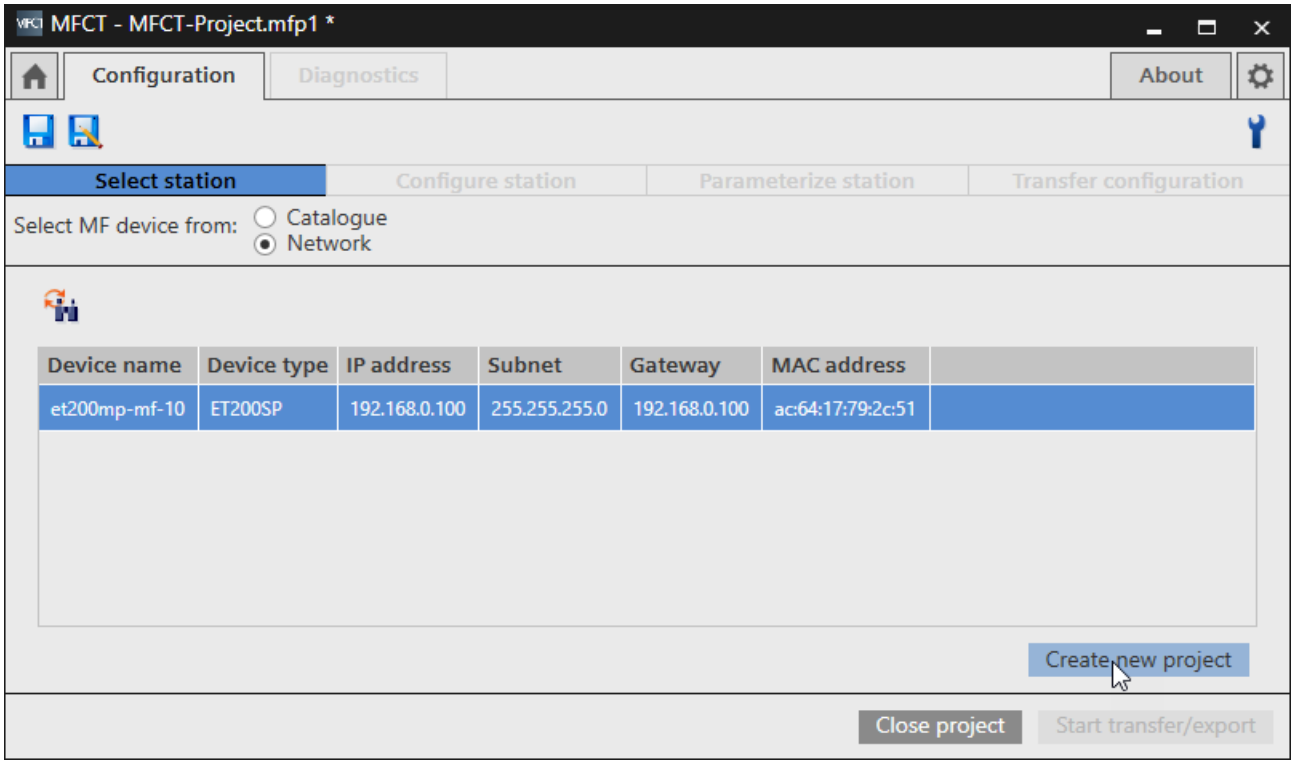

3.2.2.8 Configuring modules of a station

Under "Configure Station", assemble the station with modules and submodules from the hardware catalog based on the GSDML.

The composition of the station is shown as a list on the left, sorted in ascending slot order. The modules and submodules of the hardware catalog based on the installed GSDML are shown on the right.

Additional information on the selected module and potential application at the fieldbuses is shown below the hardware catalog in the "Details" area.

A tooltip above the MF device displays the amount of I/O data available and the amount currently used.

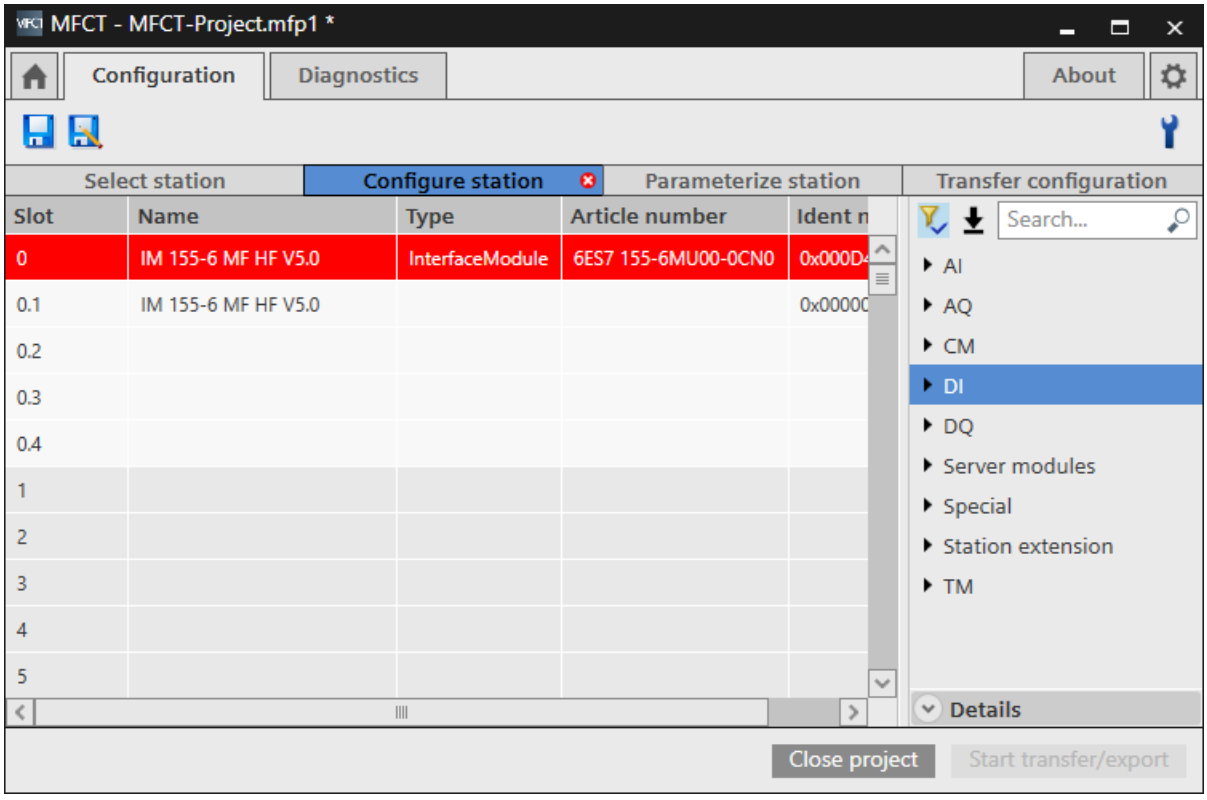

Filter function

You use the filter function to restrict the hardware catalog depending on the fieldbus and the category.

To activate the filter function, follow these steps:

1. Expand the list with the filter criteria.

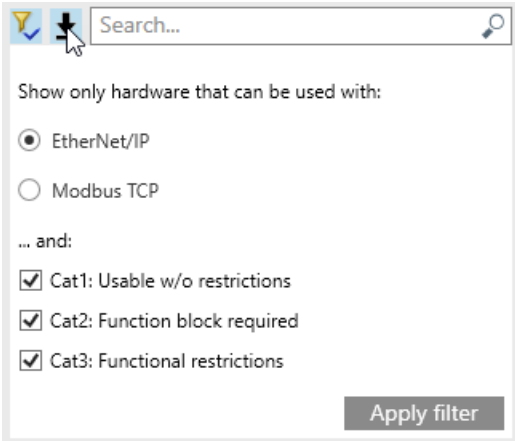

2. Select the desired fieldbus.

3. Select the desired categories.
4. Activate the filter function using the "Apply filter" button.

To deactivate the filter function, follow these steps:

1. Click the filter icon.

Selecting modules

1. Select the module in the desired version and operating mode from the catalog for each slot and drag it onto the slot.

NOTE

The possible slots for the selected module are highlighted in green.

2. Finally, add a server module.

NOTE

The MF device is highlighted in red until you have added the server module.

Selecting submodules

1. Select one of the available submodules from the drop-down list of the module in the hardware catalog.

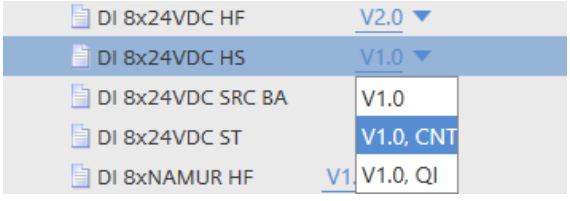

2. Select the submodule and drag it onto a slot.

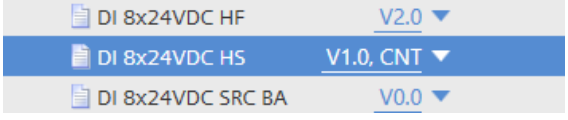

NOTE

The possible submodule slots are highlighted in green.

Deleting modules/submodules

1. Select the module/submodule to be deleted.
2. Click "Delete" in the shortcut menu.

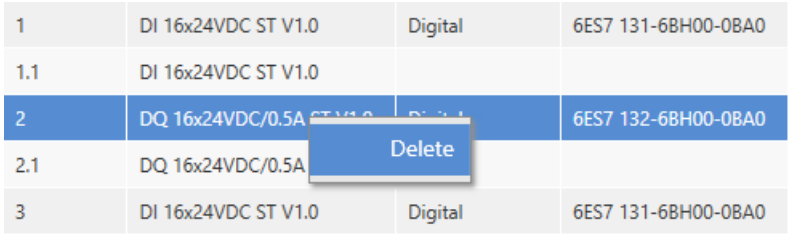

3.2.2.9 Configuring IO modules of a station

Under "Configure Station", assemble the station with IO modules from the hardware catalog based on the GSDML.

The composition of the station is shown as a list on the left, sorted in ascending slot order. The IO modules of the hardware catalog based on the installed GSDML are shown on the right.

Additional information on the selected IO module is shown below the hardware catalog in the "Details" area.

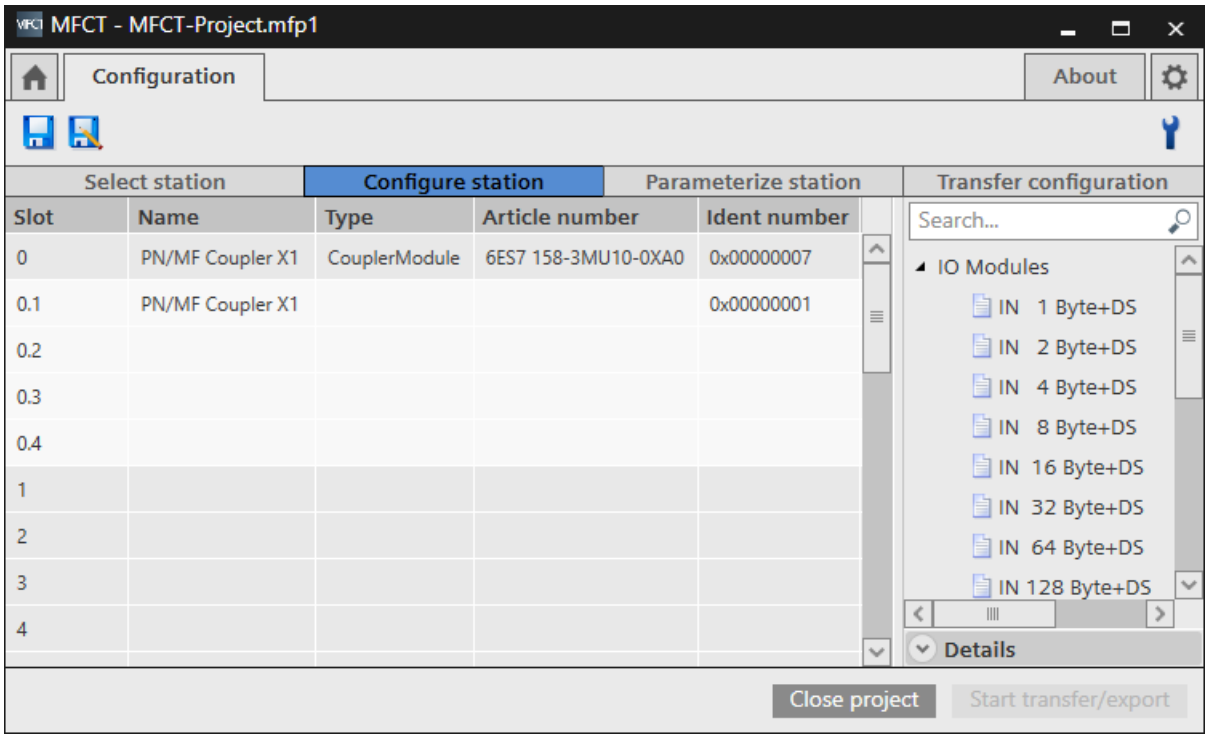

Selecting IO modules

1. Select the IO module from the hardware catalog for each slot and drag it onto the slot.

NOTE

The possible slots for the selected IO module are highlighted in green.

Deleting IO modules

1. Select the IO module to be deleted.
2. Click "Delete" in the shortcut menu.

1	OUT 64 Byte	Output		0x04400000
1.1	OUT 64 Byte			0x00000001
2	IN 64 Byte+DS	Input		0x00000440
2.1	IN 64 Byte+DS	Delete		0x00000001
3	OUT 1 Byte	Output		0x04010000

Example

Assuming that you want to read 128 bytes and write 64 bytes on network side X1 from network side X2, you need to configure the following for network side X1 in MFCT:

1	OUT 64 Byte	Output		0x04400000
1.1	OUT 64 Byte			0x00000001
2	IN 128 Byte+DS	Input		0x00000480
2.1	IN 128 Byte+DS			0x00000001

Information on how to configure network side X2 with STEP 7 (TIA Portal) with GSD file is available in the "PN/MF Coupler (https://support.industry.siemens.com/cs/ww/en/view/109781406)" hardware installation and operating manual.

3.2.2.10 Parameter assignment of the station

Under "Assign Station Parameters", set the parameters of the previously configured station.

The composition of the station is shown as a list on the left, sorted in ascending slot order. The parameters for the MF device and the modules/submodules are shown on the right.

For MF devices that support the "MF Shared Device" function, you can configure various fieldbuses for the MF device and for each module.

A tooltip above the MF device displays the amount of I/O data available and the amount currently used.

Procedure

1. Select the MF device on slot 0.
2. If the MF device supports the "MF Shared Device" function and you want to configure different fieldbuses for the MF device and the modules, activate the "MF Shared Device" parameter on the right under "Multi fieldbus parameters".

Multi fieldbus features	
Parameter	**Value**
MF Shared Device	☑

3. Select the desired fieldbus for the MF device under "Multi fieldbus connection".
4. Use the "I/O data alignment" parameter to select a supported format, "Byte" or "Word" for I/O data mapping (Page 29).
5. Under "MultiFieldbus modbus TCP", you can set for each modbus TCP connection separately the hold time for the connection and the time for "Hold time after connection reset" from 1 to 30,000 ms.

   This parameter is not relevant for EtherNet/IP.
6. Assign parameters for the remaining modules and submodules by selecting the slot and setting the parameter values on the right side.
7. When you have activated the "MF Shared Device" parameter, you can select a fieldbus for each module under "MultiFieldbus connection".

NOTE

Observe restrictions in the manuals of the MF device used.

Slot	Name	Type	Article number	Fieldbus connection
0	IM 155-6 MF HF V5.2	InterfaceModule	6ES7 155-6MU00-0CN0	PROFINET
0.1	IM 155-6 MF HF V5.2			
0.1				
0.2				
0.3				
1	DI 16x24VDC ST V0.0	Digital	6ES7 131-6BH01-0BA0	EtherNet/IP #0 (0x301, 0x300)
2	DQ 16x24VDC/0.5A BA V0.0	Digital	6ES7 132-6BH00-0AA0	ModbusTCP #0 (0x000, 0x2D0)
3	F-AI 4xU 0..10V HF, XP	FAnalog	6ES7 136-6AB00-0CA1	PROFINET
4	F-DQ 8x24VDC/0.5A PP HF, BP	FDigital	6ES7 136-6DC00-0CA0	PROFINET
5	Server module V1.2 (0 bytes)	ServerModule	6ES7 193-6PA00-0AA0	PROFINET

NOTE

A parameterization error can be displayed during reconfiguration of PROFINET to EtherNet/IP or Modbus TCP in connection with changing the BusAdapter type. You can only remedy the parameterization error with a reset to factory settings (Page 15) and reconfiguration with MFCT.

3.2.2.11 Transfer the configuration

The "Transfer configuration" area offers you the following options:

- Transfer the project to the MF device
- Export the configuration for use in other engineering tools.

Transferring the project to the MF device

To transfer the MF project to the MF device, follow these steps:

1. Select the "Transfer the project to the MF device" check box.
2. Click the "Start scan" button to search via the preset network interface for MF devices for the project download. Devices without MultiFeldbus support cannot be selected and are grayed out.
3. Select an MF device and start the download to the MF device using the "Start transfer/export" button.

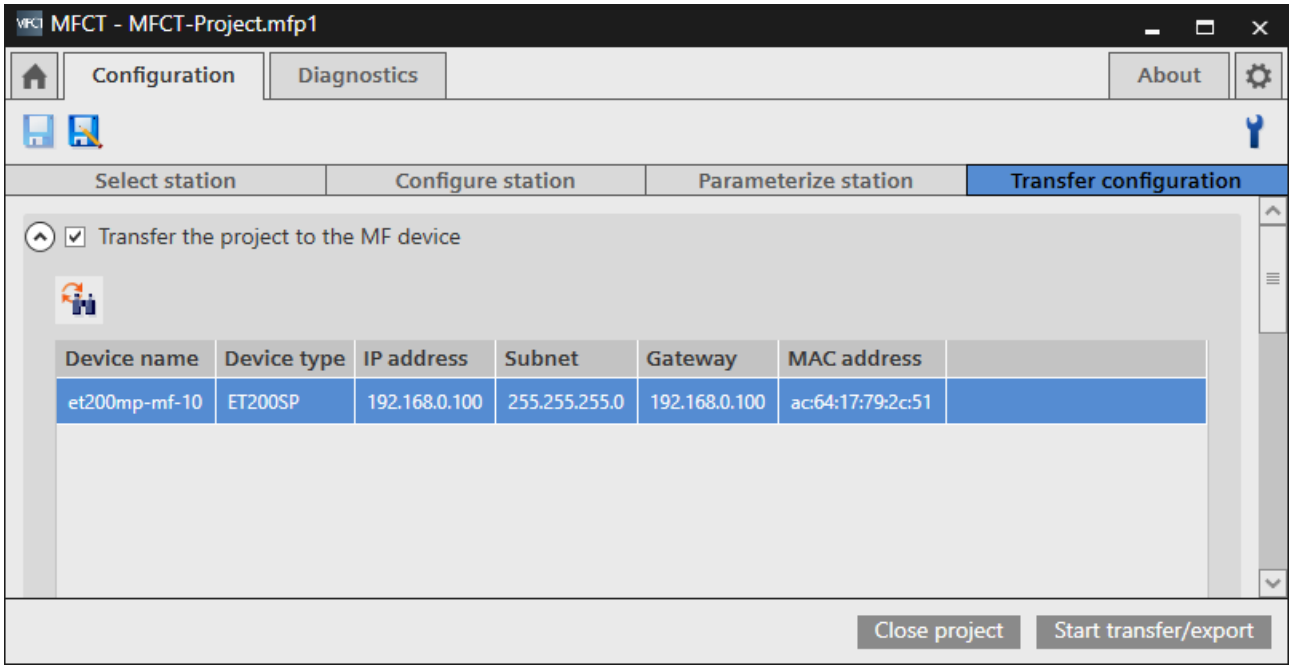

Fault rectification of the timeout on transfer to the MF device

- Check the accessibility of the MF device via the network interface selected in MFCT.
- Disconnect the connection of the MF device to PROFINET IO controllers.
- If you have selected the "Use router for gateway" option in the network parameters, check the network parameters of the device.

Export of configuration

1. Select the "Export configuration for use in other engineering tools" check box.
2. Assign a name and a path for the export
3. Select the file formats to be exported:
   - MultiFieldbus Configuration Tool (MFCT) project
   - User Defined Data Type (UDT) (as l5x file)
   - Comma Separated Values (CSV)
   - Electronic Data Sheet (EDS)
4. Start the export using the "Start transfer/export" button.

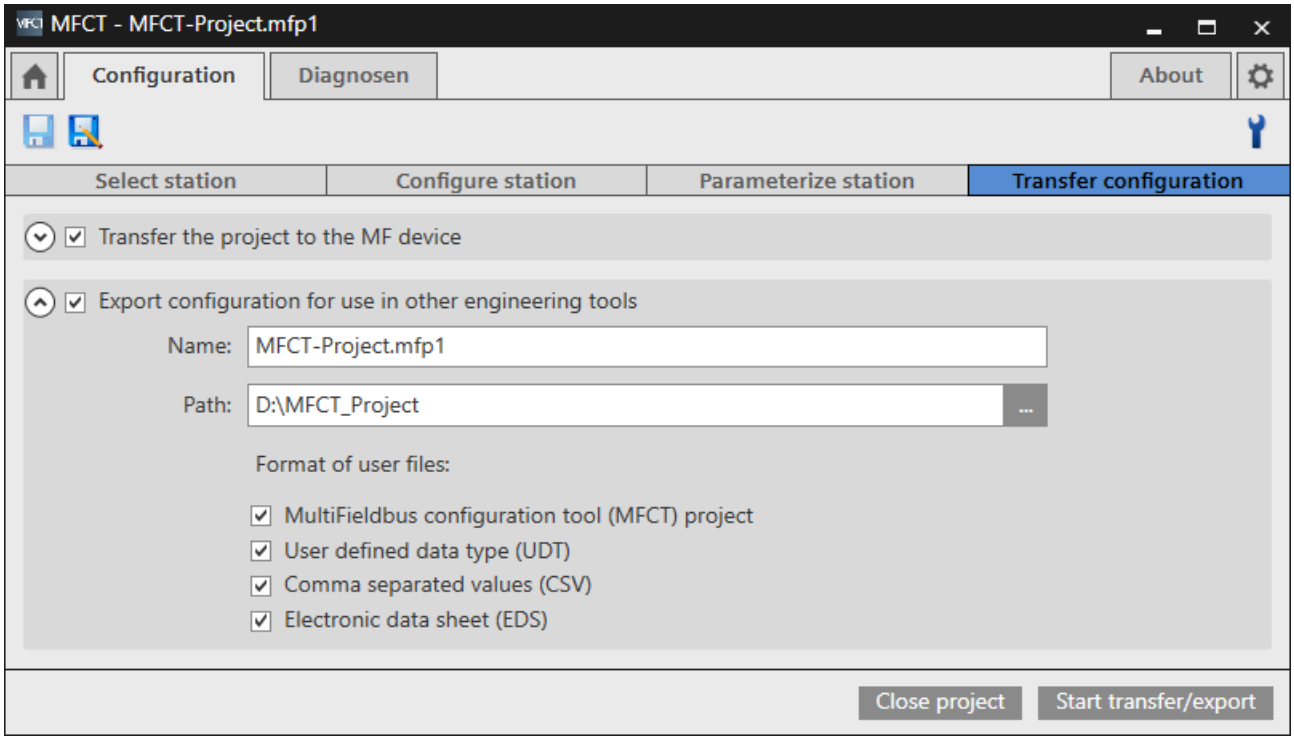

Transfer/export status

The progress and result of the file export and project download are each displayed. The fieldbus activated in the MF device as well as any differences between the configured and real hardware are also displayed.

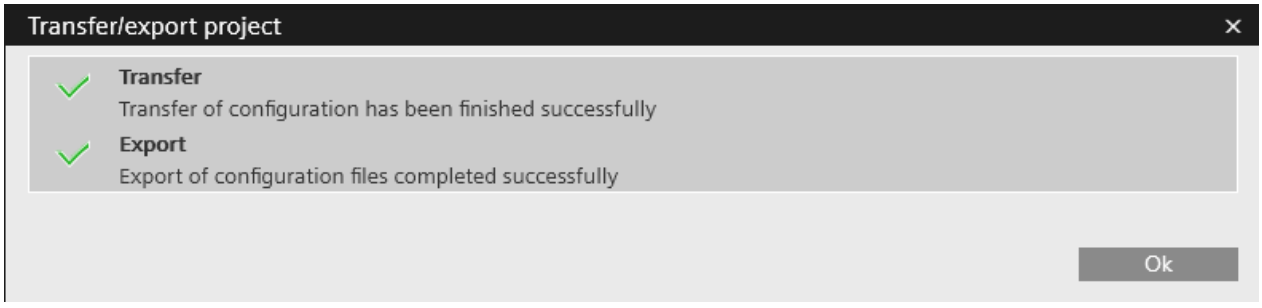

3.2.2.12 Sending user feedback

You have the option of sending us feedback on MFCT in the "About" tab:

1. Click on the "Send feedback" button.
   MFCT collects diagnostics data and attaches it to the open email.
2. Enter your feedback on MFCT in the email.
3. Send the email.

3.2.3 Configuration in the engineering system

3.2.3.1 Import EDS station description

To import the EDS station description into the engineering system, proceed as described in the documentation of the engineering system.

If the EDS station description cannot be imported, configure a generic EtherNet/IP module (Page 36).

3.2.3.2 Importing a user-defined type (UDT)

To import the user-defined type (UDT) as an l5x file into the engineering system, proceed as described in the documentation of the engineering system.

3.2.3.3 Configuring the MF device

To configure the MF device, follow these steps:

1. Create a new module under "Ethernet" with the "New module" shortcut menu.
2. Select the module type from the catalog and click "Create".
3. Assign a name and IP address under "General".
4. Click "Change" and adjust the input and output sizes to the station configuration.

NOTE

Because there are engineering systems that can only manage one EDS station description per device type, the maximum possible input and output sizes for the device type are modeled in the EDS station description.

For the specific station configuration, you can reduce the input and output sizes of a device instance to the byte length described in the User Defined Type (UDT) in order to optimize the bandwidth needed in the network.

Some MF devices support advanced IP settings. These settings are only possible before the implied communication with the controller. With this setting, the gateway IP address does not have to match the IP address of the MF device.

The following figure shows an example of the setting options.

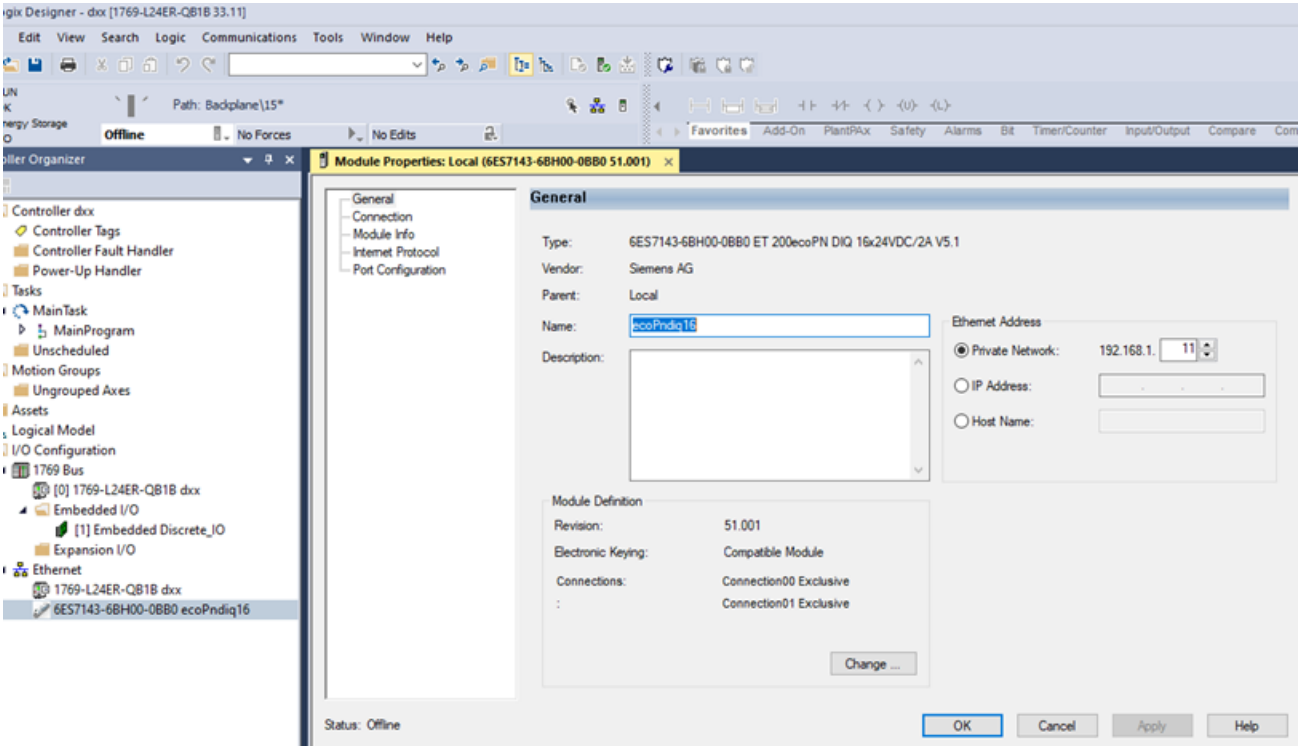

Figure 3-779 Possible IP settings

3.2.3.4 I/O data mapping

I/O data mapping

During parameter assignment of the MF Device (Page 23), you can choose between two formats for the I/O data mapping:

- With the "Byte" format, the input or output data of the modules of an I/O connection are lined up by increasing slot address (Slot.Subslot).
- With the "Word" format, the input or output data of the modules of an I/O connection are lined up by increasing slot address (Slot.Subslot). If the submodule has an odd data length, a fill byte (content 0x00) is inserted after the submodule. This aligns the following data status bytes (IDS, ODS) to word limits. A padding byte (content 0x00) is also inserted after the data status byte (IDS, ODS). Subsequent submodules will then also start at an even byte offset.

The image of the outputs contains only the output data (with padding bytes if necessary), while the input image also supplies additional status bytes together with the input data (with padding bytes if necessary).

An Output Data Status Byte (ODS) is available for each output submodule in the image of the inputs.

There is an Input Data Status Byte (IDS) for each input submodule that follows the respective input data of the submodule in the input image.

Submodules with a data length of 0 for input and output data are treated as input submodules. Only an Input Data Status Byte (IDS) is entered in the input image.

NOTE

You can find the I/O data mapping for your configuration in the exported CSV file (Page 25).

NOTE

For information about data mapping, see the system and equipment manuals.

I/O data status

The following table shows the coding of the status bytes for IDS and ODS:

Field	Bit number	Bit mask	Default	Bit value = '0'	Bit value = '1'
IOValid	7	0x80	0	I/O data invalid	I/O data valid*
Problem	6	0x40	0	Initial status	Module problem: • Module not plugged • Incorrect module plugged • Module with incorrect parameter assignment • I/O data temporarily invalid after station startup
NoCoupling	5	0x20	0	Initial status	No I/O data from coupling partner (MSO Local or PN/MF Coupler)
Reserved	4...2	0x1E	000	-	
ProcessEvent	1	0x02	0	No process event	Process event available
Diagnosis	0	0x01	0	No diagnostics	Diagnostics available

* With the PN/MF Coupler, output data is always displayed as valid (ODS = 0x80).

NOTE

The following applies to the PN/MF coupler:

The input data of the data record modules are always valid (IDS = 0x80) and their content indicates the availability of the data record coupling.

If the PROFINET communication of coupled modules fails on the X2 interface, EtherNet/IP input data is reset to zero and the IDS data status is set to invalid.

NOTE

For MSI and MSO submodules, the IDS.Diagnosis bit is 0. Comparable to the diagnostic interrupt of PROFINET, the diagnostics for MSI and MSO are only signaled in the IDS.Diagnosis bit for the default submodule (subslot = 1).

3.2.3.5 Examples of I/O data mapping for coupler

Example of I/O data mapping for I/O data alignment Byte

Configuration example

The example uses the following IO modules:

Slot	Module/IO module
0	PN/MF Coupler X1
1	OUT 2 Byte
2	IN 1 Byte+DS
3	OUT 2 Byte
4	OUT 1 Byte
5	IN 2 Byte+DS
6	PROFIsafe IN/OUT 6 Byte / 12 Byte

Input buffer

The following table shows the input buffer for the example configuration for the I/O data alignment Byte:

Slot	Name*	Data type	Byte offset	Description
0	Slot0_1_Id_0_IDS	Byte	0	Input Data State for the PN/MF Coupler
2	Slot2_1_Id_0_Inputs	Byte	1	IN 1 Byte+DS
	Slot2_1_Id_1_IDS	Byte	2	Input Data State for IN 1 Byte+DS
5	Slot5_1_Id_0_Inputs	Byte	3	IN 2 Byte+DS
	Slot5_1_Id_1_Inputs	Byte	4	
	Slot5_1_Id_2_IDS	Byte	5	Input Data State for IN 2 Byte+DS
6	Slot6_1_Id_0_Inputs	Byte	7	PROFIsafe IN/OUT 6 Byte / 12 Byte
	Slot6_1_Id_1_Inputs	Byte	8	
	Slot6_1_Id_2_Inputs	Byte	9	
	Slot6_1_Id_3_Inputs	Byte	10	
	Slot6_1_Id_4_Inputs	Byte	11	
	Slot6_1_Id_5_Inputs	Byte	12	
	Slot6_1_Id_6_IDS	Byte	13	Input Data State for PROFIsafe IN/OUT 6 Byte / 12 Byte
1	Slot1_1_Id_0_ODS	Byte	14	Output Data State for OUT 2 Byte
3	Slot3_1_Id_0_ODS	Byte	15	Output Data State for OUT 2 Byte
4	Slot4_1_Id_0_ODS	Byte	16	Output Data State for OUT 1 Byte
6	Slot6_1_Id_0_ODS	Byte	17	Output Data State for PROFIsafe IN/OUT 6 Byte / 12 Byte

The sum of the input data is 18 bytes.

Output buffer

The following table shows the output buffer for the example configuration for the I/O data alignment Byte:

Slot	Name*	Data type	Byte offset	Description
1	Slot1_1_Id_0_Outputs	Byte	0	OUT 2 Byte
	Slot1_1_Id_1_Outputs	Byte	1	
3	Slot3_1_Id_0_Outputs	Byte	2	OUT 2 Byte
	Slot3_1_Id_1_Outputs	Byte	3	
4	Slot4_1_Id_0_Outputs	Byte	4	OUT 1 Byte
	Slot6_1_Id_0_Outputs	Byte	5	PROFIsafe IN/OUT 6 Byte / 12 Byte
	Slot6_1_Id_1_Outputs	Byte	6	
	Slot6_1_Id_2_Outputs	Byte	7	
	Slot6_1_Id_3_Outputs	Byte	8	
	Slot6_1_Id_4_Outputs	Byte	9	
	Slot6_1_Id_5_Outputs	Byte	10	
	Slot6_1_Id_6_Outputs	Byte	11	
	Slot6_1_Id_7_Outputs	Byte	12	
	Slot6_1_Id_8_Outputs	Byte	13	
	Slot6_1_Id_9_Outputs	Byte	14	
	Slot6_1_Id_10_Outputs	Byte	15	
	Slot6_1_Id_11_Outputs	Byte	16	
-	-	Byte	17	Reserved

* The name is formed according to the following scheme: Slot<Slot#>_<Subslot#>_Id_<Id#>_<DataItem-TextId>

The sum of the output data is 18 bytes.

Example of I/O data mapping for I/O data alignment Word

Configuration example

The example uses the following IO modules:

Slot	Module/IO module
0	PN/MF Coupler X1
1	OUT 2 Byte
2	IN 1 Byte+DS
3	OUT 2 Byte
4	OUT 1 Byte
5	IN 2 Byte+DS
6	PROFIsafe IN/OUT 6 Byte / 12 Byte

Input buffer

The following table shows the input buffer for the example configuration for the I/O data alignment Word:

Slot	Name*	Data type	Byte off-set	Description
0	Slot0_1_Id_0_IDS	Byte	0	Input Data State for the PN/MF Coupler
	Slot0_1_Id_1_Padding	Byte	1	*Padding byte*
2	Slot2_1_Id_0_Inputs	Byte	2	IN 1 Byte+DS
	Slot2_1_Id_1_Padding	Byte	3	*Padding byte*
	Slot2_1_Id_2_IDS	Byte	4	Input Data State for IN 1 Byte+DS
	Slot2_1_Id_3_Padding	Byte	5	*Padding byte*
5	Slot5_1_Id_0_Inputs	Byte	6	IN 2 Byte+DS
	Slot5_1_Id_1_Inputs	Byte	7	
	Slot5_1_Id_2_IDS	Byte	8	Input Data State for IN 2 Byte+DS
	Slot5_1_Id_3_Padding	Byte	9	*Padding byte*
6	Slot6_1_Id_0_Inputs	Byte	10	PROFIsafe IN/OUT 6 Byte / 12 Byte
	Slot6_1_Id_1_Inputs	Byte	11	
	Slot6_1_Id_2_Inputs	Byte	12	
	Slot6_1_Id_3_Inputs	Byte	13	
	Slot6_1_Id_4_Inputs	Byte	14	
	Slot6_1_Id_5_Inputs	Byte	15	
	Slot6_1_Id_6_IDS	Byte	16	Input Data State for PROFIsafe IN/OUT 6 Byte / 12 Byte
	Slot6_1_Id_7_Padding	Byte	17	*Padding byte*
1	Slot1_1_Id_0_ODS	Byte	18	Output Data State for OUT 2 Byte
	Slot1_1_Id_1_Padding	Byte	19	*Padding byte*
3	Slot3_1_Id_0_ODS	Byte	20	Output Data State for OUT 2 Byte
	Slot3_1_Id_1_Padding	Byte	21	*Padding byte*
4	Slot4_1_Id_0_ODS	Byte	22	Output Data State for OUT 1 Byte
	Slot4_1_Id_1_Padding	Byte	23	*Padding byte*
6	Slot6_1_Id_8_ODS	Byte	24	Output Data State for PROFIsafe IN/OUT 6 Byte / 12 Byte
	Slot6_1_Id_9_Padding	Byte	25	*Padding byte*

The sum of the input data is 26 bytes.

Output buffer

The following table shows the output buffer for the example configuration for the I/O data alignment Word:

Slot	Name*	Data type	Byte off-set	Description
1	Slot1_1_Id_0_Outputs	Byte	0	OUT 2 Byte
	Slot1_1_Id_1_Outputs	Byte	1	
3	Slot3_1_Id_0_Outputs	Byte	2	OUT 2 Byte
	Slot3_1_Id_1_Outputs	Byte	3	
4	Slot4_1_Id_0_Outputs	Byte	4	OUT 1 Byte
	Slot4_1_Id_1_Padding	Byte	5	*Padding byte*
6	Slot6_1_Id_0_Outputs	Byte	6	PROFIsafe IN/OUT 6 Byte / 12 Byte
	Slot6_1_Id_1_Outputs	Byte	7	
	Slot6_1_Id_2_Outputs	Byte	8	
	Slot6_1_Id_3_Outputs	Byte	9	
	Slot6_1_Id_4_Outputs	Byte	10	
	Slot6_1_Id_5_Outputs	Byte	11	
	Slot6_1_Id_6_Outputs	Byte	12	
	Slot6_1_Id_7_Outputs	Byte	13	
	Slot6_1_Id_8_Outputs	Byte	14	
	Slot6_1_Id_9_Outputs	Byte	15	
	Slot6_1_Id_10_Outputs	Byte	16	
	Slot6_1_Id_11_Outputs	Byte	17	

* The name is formed according to the following scheme: Slot<Slot#>_<Subslot#>_Id_<Id#>_<DataItem-TextId>

The sum of the output data is 18 bytes.

3.2.3.6 Configuring the module from the user program

Module-specific data records can be read/written as explicit messages from the user program.

You can find information on the structure of the data records, for example, in the manual for the respective module.

Message Type	CIP Generic
Service Code	0x32 = ReadRecord 0x33 = WriteRecord
Class	0x66 (param object)
Instance ID	Slot/subslot is coded in the instance ID: Slot number x 256 + Subslot number (access to subslots of the interface module [1, 0x8000, 0x8001, 0x8002] with subslot number [1...4])

Instance Attribute	Record index (see table below)
Source	Param Object Request (length and parameter data record) (Page 60)
Destination	Param Object Response (length and parameter data record) (Page 60)

Table 3-1054 Record index

Record type		Record index range	Access via CIP Message
User-specific records		0x0000...0x7FFF	Read/write
Normative PROFINET records		0x8000...0xAFF0	Read-only
	I&M1...3	0xAFF1...0xAFF3	Read/write
		0xAFF4...0xFFFF	Read-only

Example

The following example shows how you read 6 bytes from slot 3 with parameter data record 128.

Table 3-1055 CIP Request:

Field	Value	Description
Message Type	CIP Generic	
Service Code	0x32	Read Record
Class	0x66	Param Object
Instance ID	0x301	Slot 3 and Subslot 1
Instance Attribute	128	Record Index
Source Length	4	CIP Request Length
Source Element	0x00, 0x00, 0x00, 0x06	Record Request Length

Table 3-1056 CIP Response:

Field	Value	Description
Destination Element	0x00, 0x00, 0x00, 0x06	Record Response Length
	0x01, 0x02, 0x03, 0x04, 0x05, 0x06	Record Response Data

Example

The following example shows how you read 4 bytes from slot 0 with parameter data record 128.

Table 3-1057 CIP Request:

Field	Value	Description
Message Type	CIP Generic	
Service Code	0x32	Read Record
Class	0x66	Param Object

Field	Value	Description
Instance ID	0x0001	Slot 0 and Subslot 1
Instance Attribute	128	Record Index
Source Length	4	CIP Request Length
Source Element	0x00, 0x00, 0x00, 0x04	Record Request Length

Table 3-1058 CIP Response:

Field	Value	Description
Destination Element	0x00, 0x00, 0x00, 0x04	Record Response Length
	0x01, 0x02, 0x03, 0x04	Record Response Data

3.2.3.7 Configuration as generic EtherNet/IP module

You can use the following parameters to create the interface module in your engineering system as a generic EtherNet/IP module without an EDS station description.

The lengths of the assemblies can be taken from the User Defined Type (UDT) or CSV file exported with MFCT.

Table 3-1059 Connection Path Settings - Example for EtherNet/IP Connection #0

☑ Configuration Assembly	Consuming Assembly (O-->T)	Producing Assembly (T-->O)
Class ID 16#4	Class ID 16#4	Class ID 16#4
Instance ID 16#307	Instance ID 16#300	Instance ID 16#301
Attribute ID 16#3	Attribute ID 16#3	Attribute ID 16#3

Table 3-1060 Generic Parameters

Connection Name	Generic connection
Transport Type	Exclusive Owner
Connection Path	20 04 25 00 07 03 2D 00 00 03 2D 00 01 03
Timeout Muliplier	4

Table 3-1061 Connection Parameters

Scanner to Target (Output)		Target to Scanner (Input)	
O-->T Size (Bytes)	246	T-->O Size (Bytes)	500
RPI (ms)	10	RPI (ms)	10
Trigger Type	Cyclic	Trigger Type	Cyclic
Inhibit Time (ms)	0	Inhibit Time (ms)	0
Config#1 Size (Bytes)	0	Fallback Mode	Go to zero <default>
Config#2 Size (Bytes)	0		

Scanner to Target (Output)		Target to Scanner (Input)	
Connection Type	Point to Point	Connection Type	Point to Point
Fixed/Variable	Fixed	Fixed/Variable	Fixed
Transfer Format	32 bit Run/Idle	Transfer Format	pure Data

3.3 Diagnostics

3.3.1 Reading diagnostics via CIP EtherNet/IP

You can read out diagnostics information of MF devices or modules via the CIP Param Object.

To do this, call the Param Object (Page 60) with the RecIndex 0x800C Read (ReadRecord (0x32)).

The diagnostics responds with the following structure:

DiagnosisData

Field		Size	Description
BlockHeader			
	BlockType	Unsigned16	0x0010 = DiagnosisData
	BlockLength	Unsigned16	
	BlockVersionHigh	Unsigned8	0x01
	BlockVersionLow	Unsigned8	0x01
API		Unsigned32	0x00000000
SlotNumber		Unsigned16	
SubslotNumber		Unsigned16	
ChannelNumber		Unsigned16	0x8000 = Whole submodule
ChannelProperties		Unsigned16	
<ChannelDiagnosis> or <ExtChannelDiagnosis>			

ChannelDiagnosis

Field	Size	Description
UserStructureIdentifier	Unsigned16	0x8000 = ChannelDiagnosis
ChannelDiagnosisData		

Field		Size	Description
<Channel>	ChannelNumber	Unsigned16	0x0000 – 0x7FFF: Manufacturer-specific 0x8000: Submodule (only one coding should be used for ChannelProperties.Direction.) 0x8001 – 0xFFFF: Reserved
<Channel>	ChannelProperties	Unsigned16	See the "ChannelProperties" table below
<Channel>	ChannelErrorType	Unsigned16	The error code for the MF device can be found in the section "Channel diagnostics" of the manuals. The error code for I/O modules can be found in the "Error code" column in section "Diagnostics alarms" of the manuals.

ExtChannelDiagnosis

Field		Size	Description
UserStructureIdentifier		Unsigned16	0x8002 = ExtChannelDiagnosis
ExtChannelDiagnosisData			
<Channel>	ChannelNumber	Unsigned16	0x0000 – 0x7FFF: Manufacturer-specific 0x8000: Submodule (only one coding should be used for ChannelProperties.Direction.) 0x8001 – 0xFFFF: Reserved
<Channel>	ChannelProperties	Unsigned16	See the "ChannelProperties" table below
<Channel>	ChannelErrorType	Unsigned16	The error code for the MF device can be found in the section "Channel diagnostics" of the manuals. The error code for I/O modules can be found in the "Error code" column in section "Diagnostics alarms" of the manuals.
<Channel>	ExtChannelErrorType	Unsigned16	
<Channel>	ExtChannelAddValue	Unsigned32	

ChannelProperties

Bits	Field	Description
0...7	ChannelProperties.Type	0x00: If ChannelNumber == 0x8000 0x01: The data length of the channel is 1 bit. 0x02: The data length of the channel is 2 bits. 0x03: The data length of the channel is 4 bits. 0x04: The data length of the channel is 8 bits. 0x05: The data length of the channel is 16 bits. 0x06: The data length of the channel is 32 bits. 0x07: The data length of the channel is 64 bits. 0x08 - 0xFF: Reserved
8	ChannelProperties.Accumulative	1 = Group diagnostics of more than one channel 0 = Other

Bits	Field	Description
9...10	ChannelProperties.Maintenance	0x00: Error 0x01: Maintenance required 0x02: Maintenance demanded 0x03: QualifiedChannelQualifier (indicates that the severity is coded in the field QualifiedChannelQualifier.)
11...12	ChannelProperties.Specifier	0x00: All following outgoing 0x01: Incoming 0x02: Outgoing 0x03: Outgoing, but other still present
13...15	ChannelProperties.Direction	0x00: Manufacturer-specific 0x01: Input 0x02: Output 0x03: Input/output 0x04 - 0x07: Reserved

3.3.2 Reading diagnostics with MFCT

In the "Diagnostics" tab, you can read information of selected MF devices:

- The project configuration
- The online plugged modules
- Diagnostics from the diagnostic buffer

Follow these steps:

1. Click the "Start scan" button to find accessible MF devices via the preset network interface.
2. Select an MF device under "Select online device".

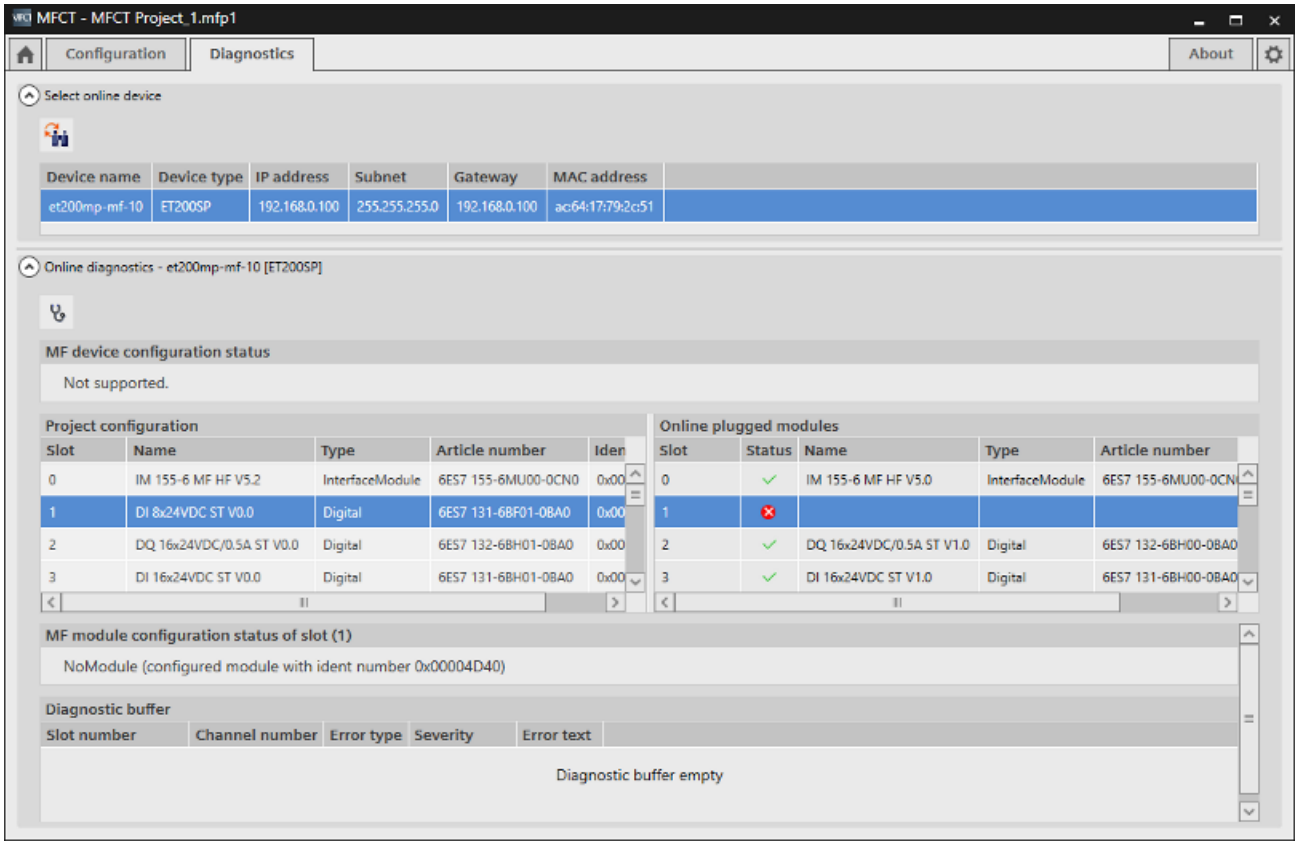

You can update the display under "Online plugged modules" with the "Update online status" button.

Project configuration

Under "Project configuration", you will receive information on the configuration of the selected MF device loaded in MFCT.

Online plugged modules

Under "Online plugged modules", you will receive information on the selected MF device, if it is accessible online.

MF module configuration status

Under "MF module configuration status", you can see whether an online plugged module matches the module in the MultiFieldbus project.

Diagnostic buffer

Under "Diagnostic buffer", you can see the content of the diagnostic buffer.

3.3.3 Reading hardware interrupt via CIP EtherNet/IP

Hardware interrupts are reported on EtherNet/IP via the IDS data status via service 34 of the CIP class 66. Service 34 processes the following tasks via acyclic data requests:

- Reading of interrupt information
- Sending of acknowledgements

Notification of hardware interrupts

Field	Bit number	Bit mask	Default	Bit value = '0'	Bit value = '1'
ProcessEvent	1	0x02	0	No process event	Process event available

Reading RALM via the GetAlarmInformation service

Retrieve interrupt information	
Service code	0x34
Class	0x66
Example	Instance index
Attribute	Event (0x0002 = PRAL)
Source data	ReadRequestData
Length of the source	4 bytes
Target data	ReadResponseData

Identifying User Structure Identifier (USI)

Use the following service to determine the USI in use.

Service	Data type	Command	Description
GetAlarmInformation (0x34)	Array of UINT8	**Call:** ReadRequestData [0..3]	Requested length (Big Endian)
		Response: ReadResponseData [0..3] ReadResponseData [4..ReadLength+3]	Length of the data sent Record read data for byte array

Data record response for USI 0x0001

The following table explains the data record response structure for USI 0x0001 with a length of 4 bytes.

Bits	Field	Description
16 ... 31	User Structure Identifier (USI)	0x0001
0 ... 1	Event	Event that triggered the hardware interrupt: 0x1: Rising edge 0x2 Falling edge
8 ... 11	Channel	Triggering channel 0x0 ... 0xF

Data record response for USI 0x8320

The following table explains the data record response structure for USI 0x8320 with a length of 14 bytes.

Bits	Field	Description
2 bytes	User Structure Identifier (USI)	0x8320
2 bytes	ChannelNumber	0x8000 (entire submodule)
2 bytes	PRAL_ChannelProperties	Value: 0x0000 Accumulative: 0x00 (individual) Direction: 0x00 (manufacturer-specific)
2 bytes	PRAL_Reason	0x9500 for event code: 0x0000 ... 0x7FFF 0x9501 for event code: 0x8000 ... 0xFFFF
2 bytes	PRAL_ExtReason	0x0001 ... 0x7FFF (event code)
4 bytes	PRAL_ReasonAddValue	0x0000 0000

3.3.4 PULL/PLUG event EtherNet/IP

The PULL/PLUG event is only supported by the MultiFieldbus IO-Link master.

With a correctly connected and parameterized submodule, the MF IO-Link master makes the configuration and parameterization available to the submodule.

PULL/PLUG event for EtherNet/IP

The PULL interrupt and PLUG interrupt is communicated to the controller by the data status.

PULL interrupt:

The PULL interrupt is triggered when a parameterized module is pulled. The PULL interrupt is triggered via the problem bit and the diagnostic bit in the data status.

PLUG interrupt:

The PLUG interrupt is triggered if the parameterization in the MF IO-Link master is not identical to the plugged module. The PLUG interrupt is triggered via the problem bit and the diagnostic bit in the data status.

Reset:
If the submodule meets the following properties, the interrupt is reset:

- Correctly connected
- Correctly configured
- Ready for cyclic communication

The following table shows the coding of the status bytes for IDS and ODS:

Field	Bit number	Bit mask	Default	Bit value = '0'	Bit value = '1'
Problem	6	0x40	0	Initial status	Module problem: • Module not plugged • Incorrect module plugged • Module with incorrect parameter assignment
Diagnosis	0	0x01	0	No diagnostics	Diagnostics available

3.3.5 Reading service data

In the "Home" tab, you can read out and store the service data provided by an MF device under "Read service data":

1. Click the "Start scan" button to find MF devices via the preset network interface.
2. Select an MF device.

   (You can make the LEDs of the MF device flash for identification with "Flash LED".)
3. Select the path to the location where you want to save the service data under "Service data output path".
4. Click the "Start" button.

The service data is saved under the selected path.

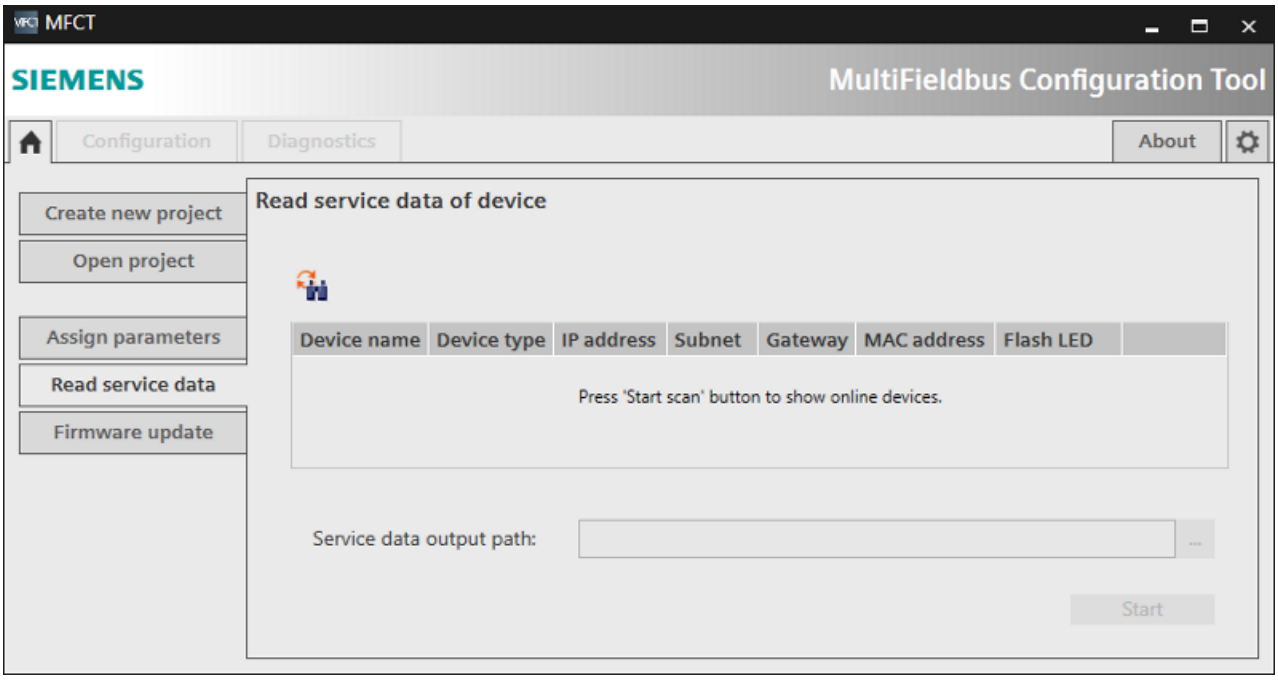

3.4 Supported CIP objects for EtherNet/IP

3.4.1 Identity Object

The following information applies to the Identity Object.

Class code	0x01
Class attributes	1, 2, 3
Class services	0x01, 0x05, 0x0E
Instance attributes	1, 2, 3, 4, 5, 6, 7
Instance services	0x01, 0x05, 0x0E
Number of instances	1

Attributes of instance 1 for the Identity Object

Attribute ID	Access rule	Designation	Data type	Data value
1	Retrieve	Vendor	UINT	0x04E3
2	Retrieve	Device type	UINT	0x000C

Attribute ID	Access rule	Designation	Data type	Data value
3	Retrieve	Product code	UINT	You can find the data value in the technical specifications of the MF device under "Device ID according to ODVA (ProductCode)".
4	Retrieve	Revision Major revision Minor revision	Structure of: USINT USINT	Depending on the firmware Vx.y.z • Major = x*10+y • Minor = z
5	Retrieve	Status	WORD	Defined in the definition table below Device_Status
6	Retrieve	Serial number	UDINT	Last 4 bytes of the MAC address
7	Retrieve	Product label Character string length ASCII character string	Structure of: USINT STRING	The data value is product-specific.

Device_Status definitions for the Identity Object

Bit(s)	Called	Definition	
0	Owned by	TRUE indicates that the device (or an object in the device) has an owner. 0 = No Exclusive Owner IO connection established 1 = At least one Exclusive Owner IO connection established	
1	-	Reserved	
2	Configured	TRUE indicates that the use of this device was configured so that it executes something other than the "Out-of-Box" standard. This does not include configuration of the communication. 0 = No valid MultiFieldbus project saved in the MF device (MF device in status < online) 1 = Active MultiFieldbus project saved in the MF device (MF device in status >= online) (Without a valid MultiFieldbus project with EtherNet/IP modules, the MultiFieldbus driver is offline and the CIP object cannot be accessed. This results in a timeout error.)	
3	-	Reserved	
4 to 7	Extended device status	**Bits 4 to 7**	**Description of the extended device status**
		0 0 0 0	Self-test or unknown.
		0 0 0 1	Ongoing firmware update.
		0 0 1 0	At least one faulty I/O connection. • I/O connection timed out? • I/O module missing? • I/O module IOxS bad?
		0 0 1 1	No I/O connections established.
		0 1 0 0	Non-volatile configuration faulty. • Multi-fieldbus project damaged? • ModuleDiffBlock?
		0 1 0 1	Severe error – either bit 10 or bit 11 is TRUE (1).
		0 1 1 0	At least one I/O connection is in RUN operating state.
		0 1 1 1	At least one I/O connection established, all in idle.
		1 0 0 0	Reserved

Bit(s)	Called	Definition	
4 to 7	Extended device status	1 0 0 1	Reserved
		1 0 1 0 to 1 1 1 1	Manufacturer/product-specific.
8	Minor, correctable error	TRUE indicates that the device has detected an internal problem which it considers to be correctable. The problem prevents the device from entering one of the faulty states. See the note below regarding the behavior.	
9	Minor uncorrectable error	TRUE indicates that the device has detected an internal problem which it considers to be uncorrectable. The problem prevents the device from entering one of the faulty states. See the note below regarding the behavior.	
10	Severe, correctable error	TRUE indicates that the device has detected an internal problem which has put the device in the "Severe, correctable error" state. See the note below regarding the behavior.	
11	Severe uncorrectable error	TRUE indicates that the device has detected an internal problem which has put the device in the "Severe, uncorrectable error" state. See the note below regarding the behavior.	
12 to 15	-	Reserved	

NOTE

Response after an error

A device cannot communicate in the "Severe uncorrectable error" state. This means it might also not be able to signal a severe uncorrectable error. A reset service is not processed. The only option to remedy a severe, uncorrectable error is to turn the power supply off and then on again.

General services for the Identity Object

Service code	Implemented for		Service designation
	Class	Instance	
0x01	Yes	Yes	Get_Attributes_All
0x05	Yes	Yes	Reset
0x0E	Yes	Yes	Get_Attribute_Single

3.4.2 Assembly Object

The following information applies to the Assembly object.

Class code 0x04

Class attributes 1, 2, 3

Class services 0x0E

Instance attributes 1, 2, 3

Instance services 0x0E, 0x10

Number of instances 4

Class attributes for the Assembly object

Attribute ID	Access rule	Description	Data type	Default value
1	Retrieve	Revision of this object	UINT	0x0002
2	Retrieve	Maximum permissible instance	UINT	0x0069
3	Retrieve	Number of instances	UINT	0x0004

Instance attributes for the Assembly object:

Output Assembly/Connection Point

Attribute ID	Access rule	Description	Data type	Default value
3	Set	Output data	ARRAY of BYTE	---

Input Assembly/Connection Point

Attribute ID	Access rule	Description	Data type	Default value
3	Retrieve	Input data	ARRAY of BYTE	---

Config Assembly/Connection Point

Attribute ID	Access rule	Description	Data type	Default value
3	Retrieve	Reserved for future use	ARRAY of BYTE	Zero

Instance attributes for the Assembly object:

Attribute ID 3

ConnectionIndex	Output Assembly /Connection Point	Input Assembly /Connection Point	Config Assembly /Connection Point
0	Instance 768 (0x300)	Instance 769 (0x301)	Instance 775 (0x307)
1	Instance 776 (0x308)	Instance 777 (0x309)	Instance 783 (0x30F)

General services for the Assembly object

Service code	Available service		Service designation	Description
	Class	Instance		
0x0E	Yes	Yes	Get_Attribute_Single	Returns contents of all relevant attributes
0x10	No	Yes	Set_Attribute_Single	Changes an attribute value

3.4.3 Connection Manager Object

The following information applies to the Connection Manager object.

Class code 0x06
Class attributes 1, 2, 3
Class services 0x01, 0x0E
Instance attributes 1, 2, 3, 4, 5, 6, 7, 8
Instance services 0x01, 0x0E
Number of instances 1

Attributes of instance 1 for the Connection Manager object

Attribute ID	Required in case of implementation	Access rule	NV	Designation	Data type	Description
1	Optional	Set [1]	V	Open Requests	UINT	Number of received Forward Open service requests.
2	Optional	Set [1]	V	Open Format Rejects	UINT	Number of Forward Open service requests that were rejected due to an incorrect format.
3	Optional	Set [1]	V	Open Resource Rejects	UINT	Number of Forward Open service requests that were rejected due to insufficient resources.
4	Optional	Set [1]	V	Open Other Rejects	UINT	Number of Forward Open service requests that were not rejected due to an incorrect format or a lack of resources.
5	Optional	Set [1]	V	Close Requests	UINT	Number of received Forward Close service requests.

[1] A device can reject a Set request for this attribute with the General Status Code 0x09 (Invalid attribute value) if the sent attribute value is not zero.

Attribute ID	Required in case of implement-ation	Access rule	NV	Designation	Data type	Description
6	Optional	Set [1]	V	Close Format Requests	UINT	Number of Forward Close service requests that were rejected due to an incorrect format.
7	Optional	Set [1]	V	Close Other Requests	UINT	Number of Forward Close service requests that were not rejected due to an incorrect format.
8	Optional	Set [1]	V	Close Timeout	UINT	Total number of connection timeouts that occurred in connections controlled by this Connection Manager.

[1] A device can reject a Set request for this attribute with the General Status Code 0x09 (Invalid attribute value) if the sent attribute value is not zero.

General services for the Connection Manager object

Service code	Implemented for		Service designation
	Class	Instance	
0x01	Yes	Yes	Get_Attributes_All
0x0E	Yes	Yes	Set_Attribute_Single

3.4.4 TCP/IP Interface Object

The TCP/IP interface object offers you access to status information and configuration of the TCP/IP network interface.

Class code 0xF5

Class attributes 1, 2, 3

Class services 0x1, 0xE

Instance attributes 1, 2, 3, 4, 5, 6, 13

Instance services 0x1, 0xE, 0x10

Number of instances 1

Class attributes for the TCP/IP interface object

Attribute ID	Access rule	Description	Data type	Default value
1	Retrieve	Revision	UINT	0x0004
2	Retrieve	Maximum permitted number of instances	UINT	0x0001
3	Retrieve	Number of instances	UINT	0x0001

Instance attributes for the TCP/IP interface object

Attribute ID	Access rule	Description	Data type	Default value	Value semantics
1	Retrieve	Interface status (status)	DWORD	0x00000002	See table below: "Table for "interface status", attribute 1"
2	Retrieve	Interface capability bit memory (configurability)	DWORD	0x00000010	Bit 0: BOOTP client (0 = No) Bit 1: DNS client (0 = No) Bit 2: DHCP client (0 = No) Bit 3: DHCP-DNS update (0 = Device cannot send its host name in the DHCP request) Bit 4: Configuration adjustable (0 = Interface configuration is not adjustable, see attributes 3 and 5) Bit 5: Configurable hardware (1 = IP address of the interface configuration can be called using the hardware settings (e.g. push wheel, thumbwheel, flash memory, etc.)) Bit 6: A change of the interface configuration requires a reset (false): 1 = A restart of the device is required for the change of the attribute of the interface configuration to take effect. 0 = the change of the attribute of the interface configuration takes effect immediately. Bit 7: AcdCapable: 0 = The device is not ACD-capable Bit 8...31: Reserved
3	Retrieve	Interface control bit memory (configuration control)	DWORD	0x00000000	Bit 0 to 3: Starting configuration (0 = As saved in flash memory, 1 = Via BOOTP, 2 = Via DHCP, 3 to 15 = Reserved) Bit 4: Enable DNS (False)
4	Retrieve	Path to the physical link object	STRUCT from:		Identifies the object that is associated with the underlying physical communication object.
		Path size	UINT	0x0002	Number of 16-bit words in the path.
		Logical segments that identify the physical link	Increased EPATH	Class: = 0xF6 Instance = 1	Path address of the internal port of the embedded switch.
5	Retrieve	Interface configuration	STRUCT from:		Contains parameters that are required for operation as TCP/IP node. To prevent an incomplete or incompatible configuration, the parameters cannot be set individually. Users must first "retrieve" this attribute, change the desired parameters, and then "set" the attribute.
		IP address	UDINT	IP address of the device	The value 0 indicates that no IP address was configured. Otherwise, a valid address of class A, B or C must be set but not the loopback address (127.0.0.1).
		Network mask	UDINT	Network mask of the device	The value 0 indicates that no network mask address was configured.
		Gateway address	UDINT	Standard gateway address	The value 0 indicates that no IP address was configured. Otherwise, a valid address of class A, B or C must be set but not the loopback address (127.0.0.1).
		Primary name server	UDINT	0x00000000	The value 0 indicates that no name server address was configured. Otherwise, a valid A, B or C address must be set.
		Secondary name server	UDINT	0x00000000	The value 0 indicates that no secondary name server address was configured. Otherwise, a valid A, B or C address must be set.

Attribute ID	Access rule	Description	Data type	Default value	Value semantics
5	Retrieve	Domain name	STRING	0x0000 (length = 0, empty CHARACTER STRING)	ASCII characters. Maximum permissible length is 48 characters. Must be increased to an even number of characters (increase is not included in length). The length 0 indicates that no domain name is configured.
6	Set	Host name	STRING	Not supported (length zero)	ASCII characters. The maximum permissible length is 64 characters. Increased to an even number of characters (increase is not included in length). The length 0 indicates that no host name is configured.
13	Set	Encapsulation idle time	UINT	120	0 = disabled 1 to 3600 = timeout in seconds

Table for "Interface status", attribute 1

Bit(s):	Called:	Definition	
0 to 3	Interface configuration status	Displays the status of the interface configuration attribute.	0 = The interface configuration attribute was not configured 1 = The interface configuration attribute contains a valid configuration obtained from BOOTP, DHCP or non-volatile memory. 2 = The interface configuration attribute contains a valid configuration obtained from hardware settings (e.g. push wheel, thumbwheel, flash memory, etc.) 3 to 15 = Reserved for future use
4	Mcast requested	Specifies a requested configuration change in the TTL value and/or in the McastConfig attributes. This bit is set when either the TTL value or the McastConfig attribute is set and deleted later as soon as the device starts.	
5	Interface Configuration Pending	Shows a pending configuration change in the Configuration-Attribute interface. The bit turns 1 (TRUE) when the Configuration-Attribute interface is set; the device needs a reset for the configuration change to become effective (as shown in the Configuration-Attribute interface). The reason for the Interface Config Pending bit is to permit the client software to know that the IP configuration has changed but only becomes active after a device reset.	
6	AcdStatus	Indicates that an IP address conflict was detected by ACD. The bit is set to 0 (FALSE) by default during startup. When ACD is supported and activated, the bit is set to 1 (TRUE) whenever an address conflict as defined in [ConflictDetected] transition in Figure F-1.1 ACD Behavior of Volume 2 EtherNet/IP Adaptation of CIP, Appendix was detected.	
7	AcdFault	Indicates that an IP address conflict was detected by ACD or the defense failed, and the current interface configuration can not be used due to a conflict. The bit turns 1 (TRUE) if an address conflict was detected and the interface is in the ACD status Notification & FaultAction or AcquireNewIpv4Parameters, as defined in Annex F. In other cases, the bit turns 0 (FALSE). Note that if the bit is set, the CIP port can not be used. However, the bit offers a way for devices with several ports to find out whether the port has an ACD error and therefore can not be used.	
8	IANA Port Admin Change Pending	Shows a pending configuration change in the IANA Port Admin attribute. The bit is set when the device needs a reset for the configuration change to become effective (as shown in the Admin Capability element of the IANA Port Admin attribute).	

Bit(s):	Called:	Definition
9	IANA Protocol Admin Change Pending	Shows a pending configuration change in the IANA Protocol Admin attribute. The bit is set when the device needs a reset for the configuration change to become effective (as shown in the Admin Capability element of the IANA Protocol Admin attribute).
10 to 31	Reserved	Reserved for future use and set to zero.

General services for the TCP/IP interface object

Service code	Available service		Service designation	Description
	Class	Instance		
0x01	Yes	Yes	Get_Attribute_All	Returns contents of all attributes
0x0E	Yes	Yes	Get_Attribute_Single	Returns contents of all relevant attributes
0x10	No	Yes	Set_Attribute_Single	Changes an attribute value

3.4.5 EtherNet Link Object

The EtherNet Link object saves link-specific counters and status information for a IEEE 802.3 communication interface. MF devices have an embedded two-port switch and an instance of the EtherNet Link object for the internally accessible interface.

Values set in instance 1 attribute 6 are valid for both ports.

Class code -

Class attributes 1, 2, 3

Class services 0x1, 0xE, 0x10

Instance attributes 1, 2, 3, 4, 5, 6, 7, 8, 10, 11

Instance services 0x1, 0xE, 0x10

Number of instances 2

Class attributes for the EtherNet Link Object

Attribute ID	Access rule	Designation	Description	Data type	Value semantics
1	Retrieve	Revision	Revision of this object	UINT	1 = The minimum value ≥ 2 = When the instance attribute 6 is implemented 3 = The maximum value
2	Retrieve	Max. instance	Maximum instance number of an object that was currently created on this class level of the device.	UINT	The greatest instance number of a created object on this class hierarchy level.
3	Retrieve	Number of instances	Number of object instances that were currently created on this class level of the device.	UINT	The number of object instances on this class hierarchy level.

Attributes of instance 1 for the EtherNet Link Object

Attribute ID	Access rule	Designation	Description	Data type	Value semantics
1	Retrieve	Interface speed	Currently applied interface speed	UDINT	Speed in Mbps (10, 100, etc.). Default = 100
2	Retrieve	Interface bit memory	Interface status bit memory	DWORD	Bitmap of interface bit memory. See table below, "Interface bit memory attribute".
3	Retrieve	Physical address	MAC layer address	ARRAY of 6 USINTs	MAC layer address in the format "XX-XX-XX-XX-XX-XX."
4	Retrieve	Interface counter	Important for receiving packets	STRUCT from:	See section "Interface counter" below.
5	Retrieve	Media counter	Media-specific counters	STRUCT from:	See "Media counter" section below.
6	Set	Interface control	Configuration for physical interface	STRUCT from:	See the following section, "Interface control".
		Control bits	Interface control bits	WORD	See the following section, "Interface control"
		Forced interface speed	Speed at which the interface is supposed to work	UINT	Speed in Mbps (10, 100, etc.). When the autonegotiation bit is 0, the forced interface speed bits show the speed at which the interface is to operate.
7	Retrieve	Interface type	Interface type: Twisted pair, fiber, internal, etc.	USINT	2 = Twisted pair 3 = Optical fiber
8	Retrieve	Interface status	Current status of the interface: in operation, disabled, etc.	USINT	0 = Unknown 1 = Enabled and ready for sending (default) 2 = Disabled 3 = Testing
10	Retrieve	Interface name	Human-readable identifier	SHORT_STRING	"Siemens, SIMATIC S7, Ethernet Port, X1 P1 R" "Siemens, SIMATIC S7, Ethernet Port, X1 P2 R"
11	Retrieve	Interface capability	Shows the capabilities of the interface	STRUCT from:	----
		Function bits	Interface capabilities except speed/duplex	DWORD	Bitmap
		Speed/duplex options	Shows speed/duplex pairs supported by the interface control attribute	STRUCT from:	----
			Speed/duplex array counter	USINT	Number of elements

Attribute ID	Access rule	Designation	Description	Data type	Value semantics
11	Retrieve	Speed/duplex options	Speed/duplex array	ARRAY of STRUCT from:	----
			Interface speed	USINT	The semantics are the same as for the forced interface speed in the interface control attribute: Speed in Mbps.
			Interface duplex mode	USINT	0 = Half-duplex 1 = Full duplex 2 to 255 = Reserved

Interface bit memory attribute

Bit(s):	Called:	Definition
0	Link status	Specifies whether the IEEE 802.3 communication interface is connected to an active network: 0 = Inactive link. 1 = Active link. Specification of the link status depends on the implementation.
1	Half duplex / full duplex	Indicates the currently used duplex mode: 0 = Interface runs at half duplex. 1 = Interface runs at full duplex. Note that the value of the half duplex / full duplex is undefined when the link status bit memory is 0.
2 to 4	Negotiation status	Specifies the status of the link autonegotiation: 0 = Ongoing autonegotiation. 1 = Autonegotiation and speed measurement failed. Use of default values for speed and duplex. 2 = Autonegotiation failed, but speed was measured. Duplex was faulty. 3 = Speed and duplex negotiated successfully. 4 = Autonegotiation not attempted. Forced speed and duplex.
5	Manual setting requires reset.	0 = Interface can automatically activate changes to link parameters (autonegotiate, duplex mode, interface speed). 1 = Device requires that a reset service is output at its Identity object so that the changes will become effective.
6	Local hardware fault	0 = Interface does not detect a local hardware fault. 1 = Local hardware fault detected.
7 to 31	Reserved	Set to 0.

Interface counter (STRUCT from):

Designation	Data type	Attribute description
In Octets	UDINT	Octets received at the interface
In Ucast Packets	UDINT	Unicast packets received at the interface
In NUcast Packets	UDINT	Non-Unicast packets received at the interface

Designation	Data type	Attribute description
In Discards	UDINT	Incoming packets received at interface but discarded
In Errors	UDINT	Incoming packets containing errors (excluded In Discards)
In Unknown Protos	UDINT	Incoming packets with unknown protocol
Out Octets	UDINT	Octets transmitted by the interface
Out Ucast Packets	UDINT	Unicast packets transmitted by the interface
Out NUcast Packets	UDINT	Non-Unicast packets transmitted by the interface
Out Discards	UDINT	Outgoing packets discarded
Out Errors	UDINT	Outgoing packets containing errors

Media counter (STRUCT from):

Designation	Data type	Attribute description
Alignment Errors	UDINT	Frames received that not only include complete octets
FCS Errors	UDINT	Frames received that do not pass the FCS test
Single Collisions	UDINT	Successfully transmitted frames with exactly one collision
Multiple Collisions	UDINT	Successfully transmitted frames with more than one collision
SQE Test Errors	UDINT	Number of error messages generated by SQE test
Deferred Transmission	UDINT	Frames whose transmission is delayed due to medium overload
Late Collisions	UDINT	Number of cases in which a collision is detected later than after transmission of 512 bits of the packet
Excessive Collisions	UDINT	Frames whose transmission fails due to a very high number of collisions
MAC transmission error	UDINT	Frames whose transmission failed due to an internal transmission error in the MAC sublayer
Carrier Sense Errors	UDINT	Number of carrier tests that failed or were not executed during transmission of a frame
Frame Too Long	UDINT	Frames received that exceed the permissible maximum size
MAC receive error	UDINT	Frames whose receipt at an interface failed due to an internal transmission error in the MAC sublayer

Interface control attribute

The interface control attribute is a structure that consists of bits of the forced interface speed and control bits.

When the autonegotiate bit is 0, the bit of the forced interface speed specifies the speed at which the interface is operating. The speed is given in megabits per second; the interface speed for an Ethernet with 10 Mbps, for example. Interfaces that do not support the required speed, show 0x09 (invalid attribute value). When autonegotiation is enabled, the attempt to set the forced interface speed results in the response 0x0C (object status conflict).

Control bits work as follows:

Bit(s)	Called:	Definition
0	Autonegotiate	0 = 802.3 Link autonegotiation is disabled. 1 = Autonegotiation is enabled. When autonegotiation is disabled, the device uses the settings made by the bits of the forced duplex mode and the forced interface speed.
1	Forced duplex mode	When the autonegotiate bit is 0, the bit of the forced duplex mode specifies whether the interface operates in full duplex or half duplex mode. 0 = Half-duplex 1 = Full duplex Interfaces that do not support the required duplex mode, show 0x09 (invalid attribute value). When autonegotiation is enabled, the attempt to set the bits of the forced duplex mode results in the response 0x0C (object status conflict).

Interface capability

The interface capability attribute displays the number of interface capabilities. The attribute is a structure with two main elements: Function bits and speed/duplex options

Bit(s)	Called:	Definition
0	Manual setting requires reset	Indicates whether a device requires a reset to apply changes of the interface control attribute (#6). 0 = Indicates that changes made to the interface control attribute (#6) will become effective without resetting the device. The bit takes on this value when the interface control attribute (#6) is not implemented. 1 = Indicates that changes made to the interface control attribute (#6) are not applied automatically but will only become effective by resetting the device. Note: This bit is repeated in the interface bit memory attribute (#2) to ensure backward compatibility with earlier object revisions.
1	Autonegotiate	0 = Indicates that the interface does not support link autonegotiation. 1 = Indicates that the interface supports link autonegotiation.
2	Auto-MDIX	0 = Indicates that the interface does not support automatic MDIX mode. 1 = Indicates that the interface supports MDIX mode.
3	Speed/duplex manual	0 = Indicates that the interface does not support manual setting of speed/duplex. The interface control attribute (#6) is not supported. 1 = Indicates that the interface supports manual setting of speed/duplex via the interface control attribute (#6).
4 to 31	Reserved	Set to 0

General services for the EtherNet Link object

Service code	Required in implementation		Service designation	Description
	Class	Instance		
0x01	Optional	Optional	Get_Attribute_All	Returns contents of all attributes.
0x0E	Conditional	Required	Get_Attribute_Single	Returns contents of all relevant attributes.
0x10	Not applicable	Conditional	Set_Attribute_Single	Changes a single attribute.

3.4.6 LLDP Management Object

The object contains management information for LLDP and should be present when LLDP is implemented on the device. Only one instance of the LLDP management object should be implemented.

Referring to ODVA Specification Rel.1911 / Volume 2 (1.25) / 5-15 LLDP Management Object.

Class code 0x109

Instance attributes 1, 2, 3, 4, 5

Number of instances 1

Attributes of instance 1 for the LLDP Management Object

Attribute ID	Access rule	Designation	Description	Data type	Value semantics
1	Setting required	LLDP Enable		STRUCT from:	
		LLDP Enable Array Length	The number of elements in the LLDP Enable Array. Matches the Max Ethernet Link Object Instance Number. This value, divided by 8 and the remainder rounded, specifies the length (in bytes) of the LLDP Enable Array of this structure.	UINT	Class attribute 2 of the Ethernet Link Object (0xF6)
		LLDP Enable Array	Enables the generation of LLDP frames globally or per port and the processing of received LLDP frames globally.	ARRAY from BOOL	Bit number: 0: Enable globally 1-N: Corresponds to the instance number of each port of Ethernet Link Max Instance, N = value of Ethernet Link Max Instance class attribute 2 For every bit: 0 = LLDP deactivated, **1 = LLDP activated (default)** If Enable globally (bit 0) = 0, then the other bits must be ignored and the received LLDP frames are ignored. The values of the elements corresponding to non-existing Ethernet link instances must be set to 0 or are ignored.
2	Setting required	msgTxInterval	From 802.1AB-2016. The interval in seconds after which the LLDP frames were sent from the device	UINT	0-4 = Reserved, 5-32768 = Message Transmission Interval for LLDP frames, 32769-65535 = Reserved **Recommended default setting is** 30. **Default value = 5** (Only acceptable value to be additionally compliant with the PNIO standard.).

Attribute ID	Access rule	Designation	Description	Data type	Value semantics
3	Retrieval required	msgTxHold	From 802.1AB-2016. A factor of msgTxInterval to determine the value of TTL TLV that was sent by the neighboring device	USINT	0 = Reserved, 1-100 = Message Transmission Multiplier for LLDP frames, 101-255 = Reserved **Recommended default setting is 4**.
4	Retrieval required	LLDP Datastore	An indication of the query method that is supported by the service's LLDP database (see Section 9-8.5)	WORD	Bit: **0 = LLDP Data Table Object (Default)** 1 = SNMP 2 = NETCONF YANG 3 = RESTCONF YANG 4-15 = Reserved
5	Retrieval required	Last Change	The number of seconds since the last time an entry in the local LLDP database (without TTL) has changed.	UDINT	Seconds since last change

3.4.7 LLDP Data Table Object

The object contains information about received LLDP frames and should be present when LLDP is implemented on the device and SNMP LLDP MIB has not been implemented.

Referring to ODVA Specification Rel.1911 / Volume 2 (1.25) / 5-16 LLDP Data Table Object.

Class code 0x10A

Class attributes 2, 3

Instance attributes 1, 2, 3, 4, 5, 6, 7, 8, 9

Number of instances 2

Attributes for the LLDP Data Table Object

Attribute ID	Access rule	Designation	Description	Data type	Value semantics
1	Retrieval required	Ethernet Link Instance Number	The local instance number of the Ethernet Link Object that corresponds to the physical Ethernet port of the received instance that makes up the LLDP frame, if available.	UINT	0 = Unknown 1-65535 = Ethernet Link Object (0xF6) instance number
2	Retrieval required	MAC address	The neighboring MAC address received from the CIP MAC address, Chassis ID, or Port ID TLV.	ETH_MAC-_ADDR	The MAC address is set with the first occurrence of a MAC ID in the following list: 1. The CIP MAC address (TLV type = 127, subtype = 2) 2. The Chassis ID (TLV type = 1) only if subtype = 2 3. The Port ID (TLV Type = 2) only if subtype = 3 4. All zero

Attribute ID	Access rule	Designation	Description	Data type	Value semantics
3	Retrieval required	Interface Label	The neighboring Interface Label received from the CIP Interface Label, Chassis ID, or Port ID TLV	Short_String	The Interface Label will be a maximum of 64 characters long. It is set with the first occurrence of an Interface Label which is contained in the following list: 1. The CIP Interface Label (TLV type = 127, subtype = 1) 2. The Chassis ID (TLV type = 1) only if subtype = 6 3. The Port ID (TLV type = 2) only if subtype = 5 4. One zero string
4	Retrieval required	Time to Live	Number of seconds for which the neighborhood information is considered valid.	UINT	(TLV type = 3) 0 = Reserved, 1-65535 = Time To Live (in seconds) Note: A received TTL TLV value = 0 means that the table entry should be removed according to IEEE 802.1AB-2016.
5	Retrieval required	System Capabilities TLV		STRUCT from:	(TLV type = 7) See section 5-16.3.3.1
		System Capabilities	The capabilities that the neighboring device supports based on the currently loaded firmware.	WORD	
		Enabled Capabilities	The capabilities currently activated on the neighboring device.	WORD	
6	Retrieval required	IPv4 Management Addresses	The IPv4 management addresses of the neighboring device.	Struct from:	A list of IPv4-encoded management addresses, as defined by one or more received management addresses TLVs (TLV type = 8). Without non-IPv4 management addresses
		Management Address Count	Number of implemented management addresses	USINT	0-255 = Number of received Management Address TLVs from its neighbor.
		Management Address	IPv4 management addresses of neighboring devices	ARRAY from UDINT	The IP address must be assigned a valid Class A, B or C address and must not consist of just zeros or be the loopback address (127.0.0.1).
7	Retrieval required	CIP Identification	The CIP Identification TLV of the neighboring device, if available.	STRUCT from:	Set by CIP Identification TLV (TLV type = 127, subtype = 01), if available, otherwise 0.
		Vendor ID		UINT	See Volume 1, Appendix C-1.4.2, format 5 for details and semantics
		Device Type		UINT	
		Product Code		UINT	
		Major Revision		BYTE	
		Minor Revision		UINT	
		CIP Serial Number		UDINT	

Attribute ID	Access rule	Designation	Description	Data type	Value semantics
8	Retrieval required	Additional Ethernet Capabilities	A TLV for Ethernet preemption support from the neighboring device	STRUCT from:	Set by Additional Ethernet Capabilities TLV (TLV type = 127, subtype 7), if available, otherwise 0 See IEEE 802.3-2018 79.3 for more information.
		Preemption Support		BOOL	0 = Not supported 1 = Supported
		Preemption Status		BOOL	0 = Not released 1 = Released
		Preemption Active		BOOL	0 = Not active 1 = Active
		Additional Fragment Size		USINT	0 = 64 octets 1 = 128 octets 2 = 192 octets 3 = 256 octets 4-255 = Reserved
9	Retrieval required	Last Change	The number of seconds since the last time an attribute in this instance has changed.	UDINT	Seconds since last change

3.4.8 Param Object

You can transfer PROFINET data records by accessing the Param Object.

The following information applies to the Param Object of the MF device.

Class code 0x66

Class attributes 1

Class services -

Instance attributes -

Instance services -

Number of instances 256

Class attributes for the Param Object

Attribute ID	Access rule	Description	Data type	Default value
1	Retrieve	Revision of this object	UINT32	

Attributes of instance 1 for the Param Object

Attribute	Service Code	Element	Data type	Data value
Index of the PROFINET data record	ReadRecord (0x32)	**Source:** Read length **Source Length:** 4	UINT32	**Call:** Read length[0..3] = Length of the requested data record to be read. (Big Endian) The maximum read length is 3992 bytes.
		Destination: Read buffer	UINT32 Array of UINT8	**Response:** Read buffer[0..3] = Length of the returned data record (response length in big-endian) Read buffer[4..ResponseLength+3] = Read data record as an array of bytes
	WriteRecord (0x33)	**Destination:** Write buffer	UINT32 Array of UINT8	**Call:** Write buffer[0..3] = Length of the data to be written to the data record (*Write length* in big-endian) Write buffer[4..write length+3] = Data of the data record to be written as an array of bytes The maximum write length is 3984 bytes. **Response:** No user data returned.
	GetAlarmInformation (0x34)	**Source:** Read length **Source Length:** 4	UINIT32	**Call:** Read length[0..3] = Length of the requested data record to be read. (Big Endian) The maximum read length is 3992 bytes.
		Destination: Read buffer	UINT32 Array of UINT8	**Response:** Read buffer[0..3] = Length of the returned data record (response length in big-endian) Read buffer[4..ResponseLength+3] = Read data record as an array of bytes

Answer-Record-Mapping

PROFINET ErrorCode1		**EtherNet/IP CIP Status**	
Success:			
0x00	Successful Operation	0x00	Success
Application error:			
0xA0	Read Error	0x1F	Vendor specific error
0xA1	Write Error	0x1F	Vendor specific error
0xA2	Module Failure	0x1F	Vendor specific error
0xA7	Busy	0x1E	Embedded service error
0xA8	Version Conflict	0x1F	Vendor specific error
0xA9	Feature Not Supported	0x14	Attribute not supported
Access error:			
0xB0	Invalid Index	0x09	Invalid attribute value
0xB1	Write Length Error	0x15	Too much data

PROFINET ErrorCode1		EtherNet/IP CIP Status	
0xB2	Invalid Slot/Subslot	0x05	Class/Instance unknown
0xB3	Type Conflict	0x0E	Attribute not settable
0xB4	Invalid Area/API	0x16	Object does not exist
0xB5	State Conflict	0x10	Device state conflict
0xB6	Access Denied	0x0F	Privilege violation
0xB7	Invalid Range	0x20	Invalid parameter
0xB8	Invalid Parameter	0x20	Invalid parameter
0xB9	Invalid Type	0x29	Member not settable
Resources error:			
0xC0	Read Constrain Conflict	0x2C	Attribute not gettable
0xC1	Write Constrain Conflict	0x0E	Attribute not settable
0xC2	Resource Busy	0x0C	Object state conflict
0xC3	Resource Unavailable	0x02	Resource unavailable
S7+ module application error:			
0xE0	Invalid Record Struct	0x24	Message Format Error
0xE1	Invalid User Param	0x03	Invalid parameter value
ELSE response error:			
		0x1F	Vendor specific error

When not enough data is provided for the Record Message Source Element, the device always returns CIP Status error 0x06 (Partial Transfer).

Modbus TCP

4

4.1 Modbus TCP functions

4.1.1 Modbus TCP

MultiFieldbus supports the following Modbus TCP functions:

- I/O communication with Modbus client
- Free user registers (e.g. for coordination of the redundancy)
- Device status register
- Config status tab
- Diagnostics bit in data status of cyclic I/O data per submodule (interrupts are not supported)
- Data record interface

4.2 Integration in the automation system

4.2.1 Overview

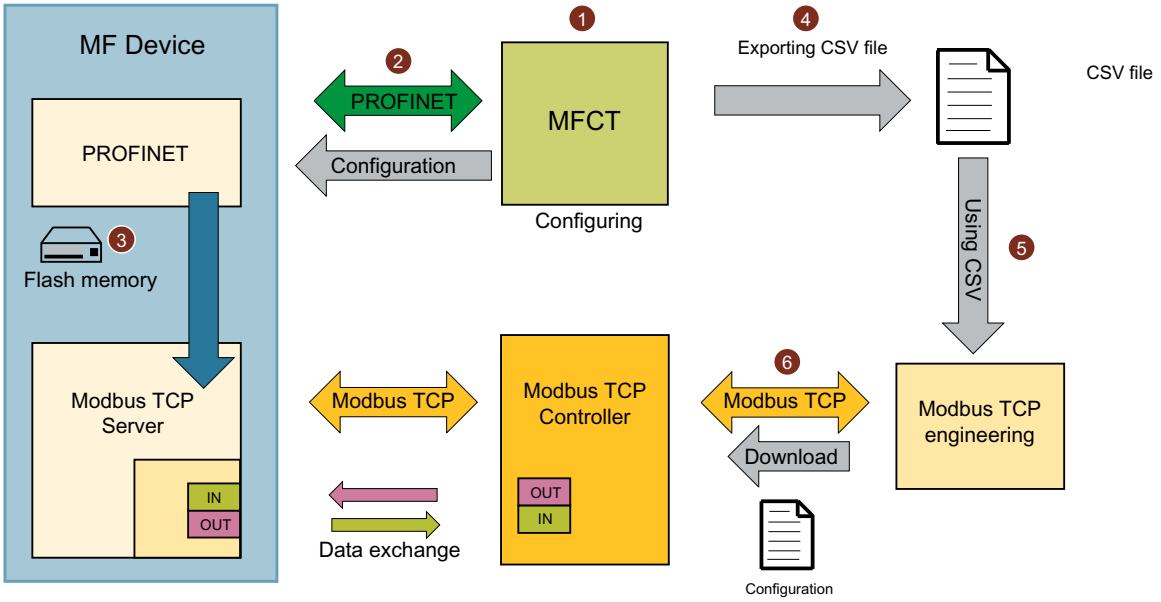

In the MultiFieldbus Configuration Tool (MFCT), you configure the MF device and assign an IP address and a device name to the MF device ①. You then download the configuration to the MF device with PROFINET IO mechanisms ②. The configuration is saved on the MF device ③.

You generate and export the I/O data mapping of the MF device as CSV file for Modbus TCP in MFCT ④. You then use the CSV file to implement I/O access in your Modbus TCP application ⑤. Download the project to the Modbus TCP controller with the engineering system ⑥.

Procedure

For commissioning, follow these steps:

1. Scan the network in MFCT and assign an IP address for the MF device.
2. Configure the MF device.
3. Select Modbus TCP as fieldbus for the Ethernet interface.
4. Load the MultiFieldbus project to the MF device.
5. Exporting a CSV file from MFCT.
6. Use the CSV file to implement your Modbus TCP application.
7. Configure the interface module in the Modbus TCP engineering system.
8. Download the project to the Modbus TCP controller.
9. (Optional) Configure the modules from inside the user program.

NOTE

For MF devices, there might be modules displayed in engineering systems starting with slot 1000.
These merely reflect the retentively stored project in the MF device consisting of configuration and parameter assignment.

4.2.2 Configuring with MFCT

4.2.2.1 Requirements

Information on which MFCT version is required for which MF Device can be found in the Equipment Manual of the MF Device.

You can find version information for MFCT on the "About" tab.

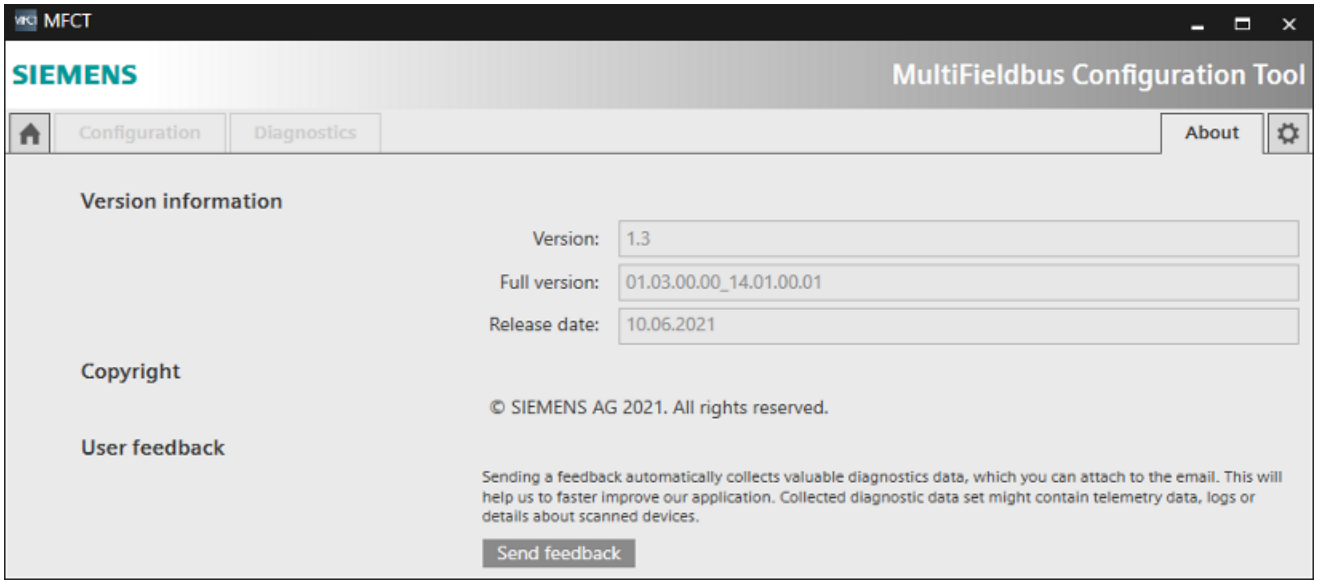

4.2.2.2 Settings

In the "Settings" tab, you can specify basic properties of the MultiFieldbus Configuration Tool:

- Select the user interface language.
- Select the network adapter.

You can also update the GSD file used.

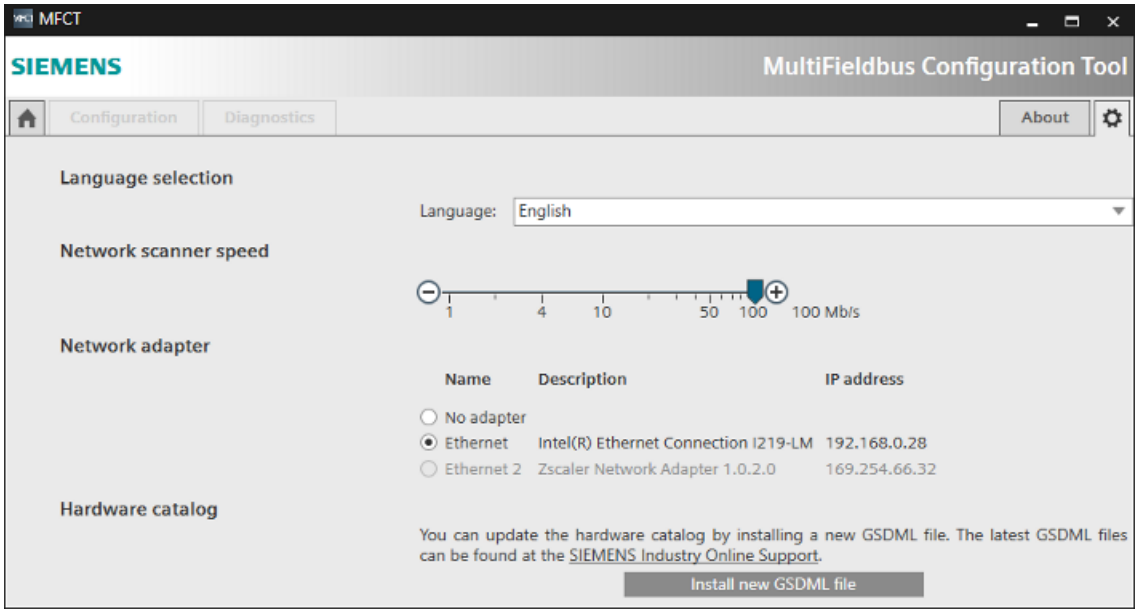

Language selection

Under "Language selection", select the user interface language for the MFCT.

Network scanner speed

Under "Network scanner speed", select the speed of the network scanner.

Network adapter

Under "Network adapter", select the interface you want to use to connect to MF devices.

Hardware catalog

In the "Hardware catalog" section, you can update the GSD module description in the MFCT using the "Install new GSDML file" button.

To do this, proceed as follows:

1. Click the link in the text.
2. Download the zipped GSD file and save it locally.
3. Unzip the GSD file.
4. Click "Install new GSDML file" and select the unzipped GSD file.

4.2.2.3 Assigning network parameters

In the "Home" tab, you can assign the network parameters for MF devices under "Assign parameters":

1. Click the "Start scan" button to find MF devices via the preset network interface.
2. Select an MF device.

   (You can make the LEDs of the MF device flash for identification with "Flash LED".)
3. Enter a device name, valid IP address and the subnet mask.
4. If you use a gateway, you can enable the "Use router for gateway" option and enter the router address.
5. Click "Assign network parameters".

The network parameters are assigned.

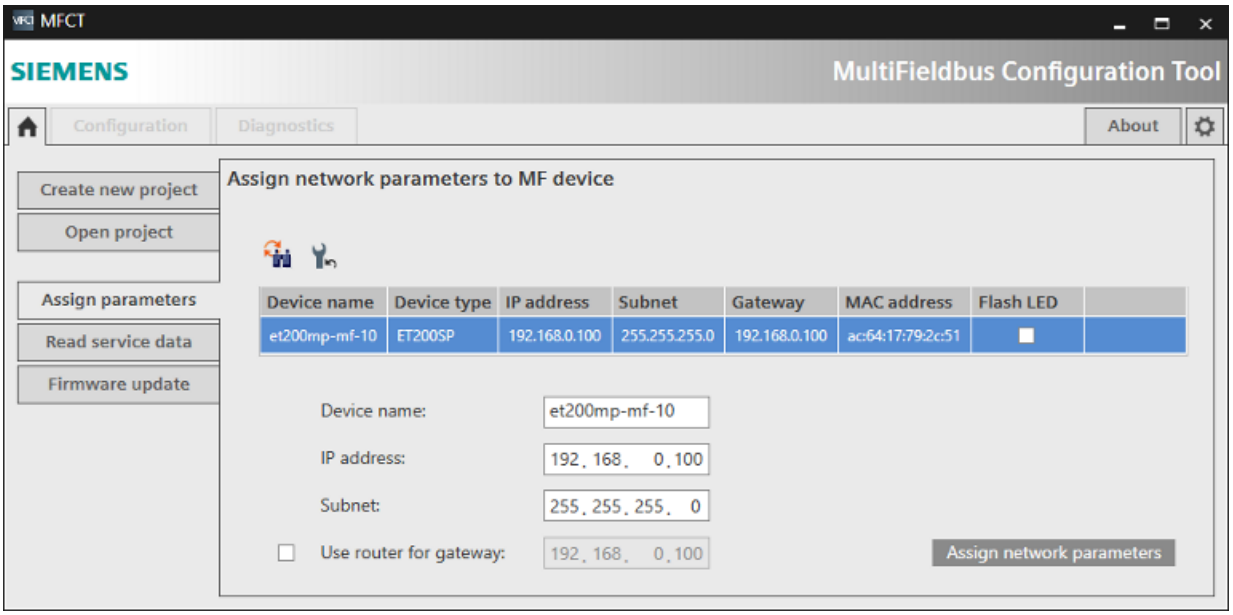

4.2.2.4 Resetting the MF device

In the "Home" tab, you can reset the MF device to the factory settings under "Accessible MF devices":

1. Click the "Start scan" button to find MF devices via the preset network interface.
2. Select an MF device.
3. Click "Reset network parameters".

The network parameters and the MultiFieldbus project are deleted.

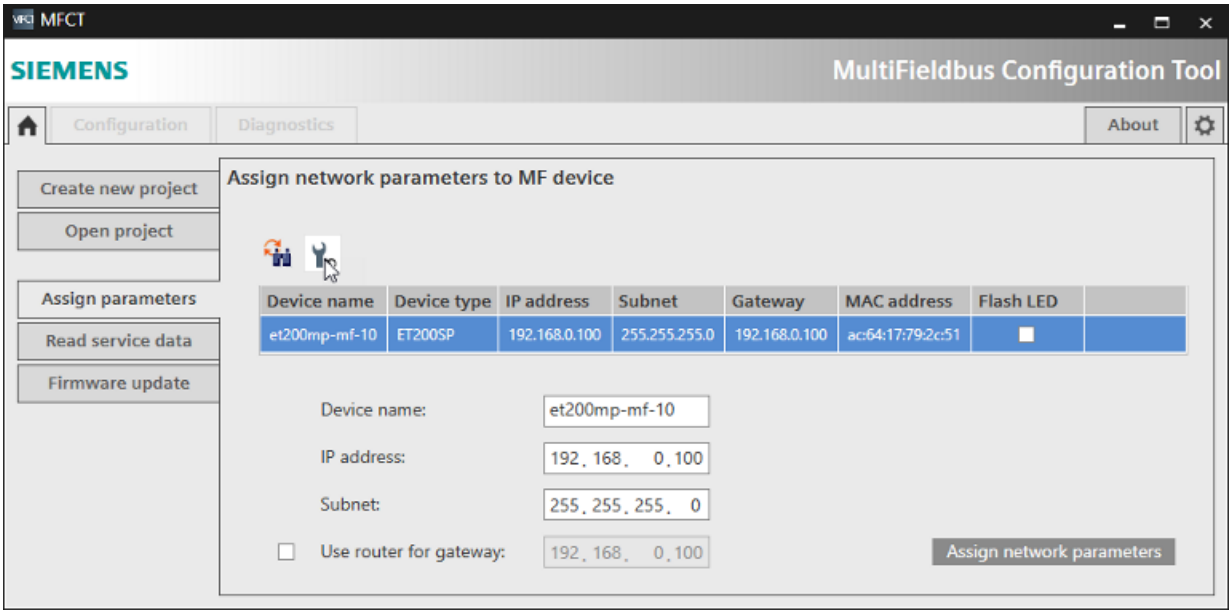

4.2.2.5 Creating new MultiFieldbus project in MFCT

You can create a new MultiFieldbus project in the "Home" tab:

1. Select "Create new project" and enter a name and a path for the new MultiFieldbus project.

   Optionally, you can describe the project in more detail by entering the author and comments.
2. Click "Create project".

The MultiFieldbus project is created as a file with the extension ".mfp1". The MFCT then goes to the next step in the "Configuration" tab.

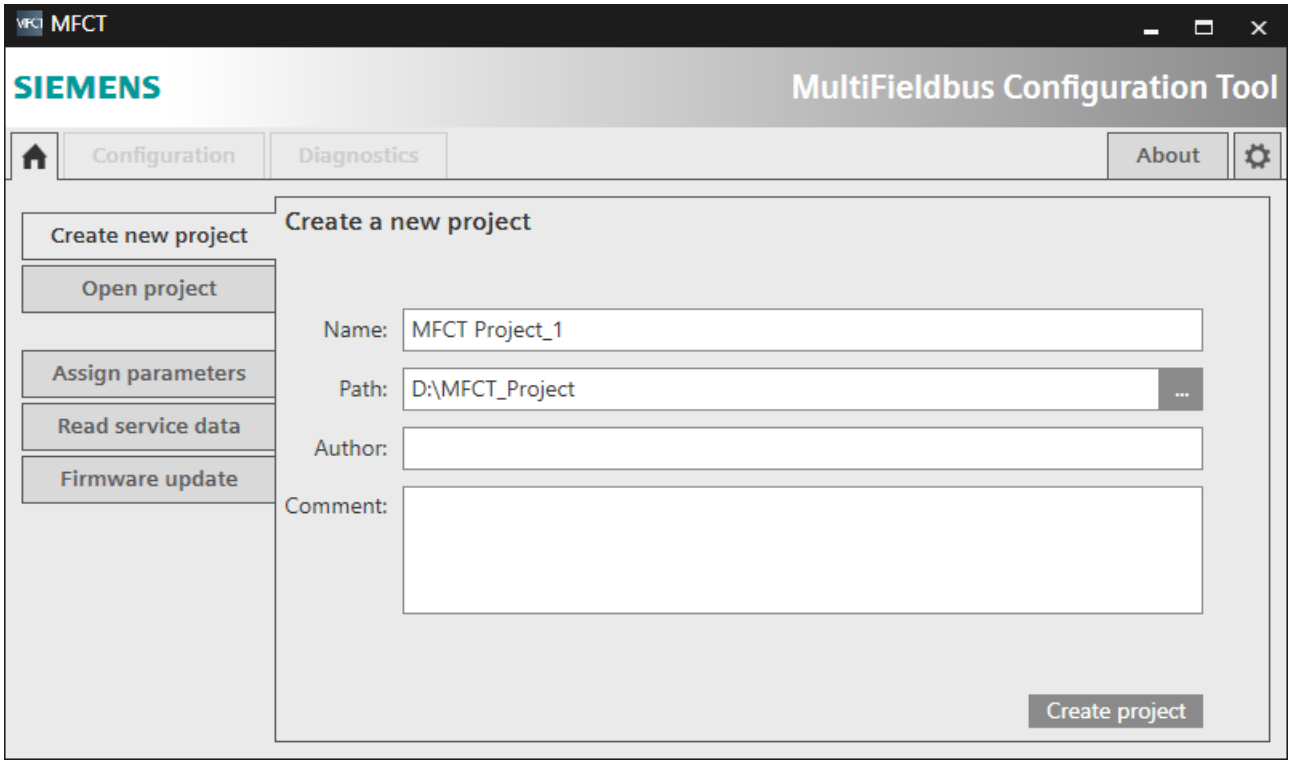

4.2.2.6 Open MultiFieldbus project in MFCT

You can open an existing MultiFieldbus project in the "Home" tab:

1. Select "Open project".
   - Under "Recently Used Projects", you can select a recently edited project and read it in directly by double-clicking it or using the "Open" button.
   - Alternatively, you can use the "Browse" button to open a project file.

The project is opened and the MFCT switches to the "Configuration" tab.

NOTE

The "Delete" button allows you to delete an existing project from the "Recently Used Projects" list. The project file itself is not deleted by this action.

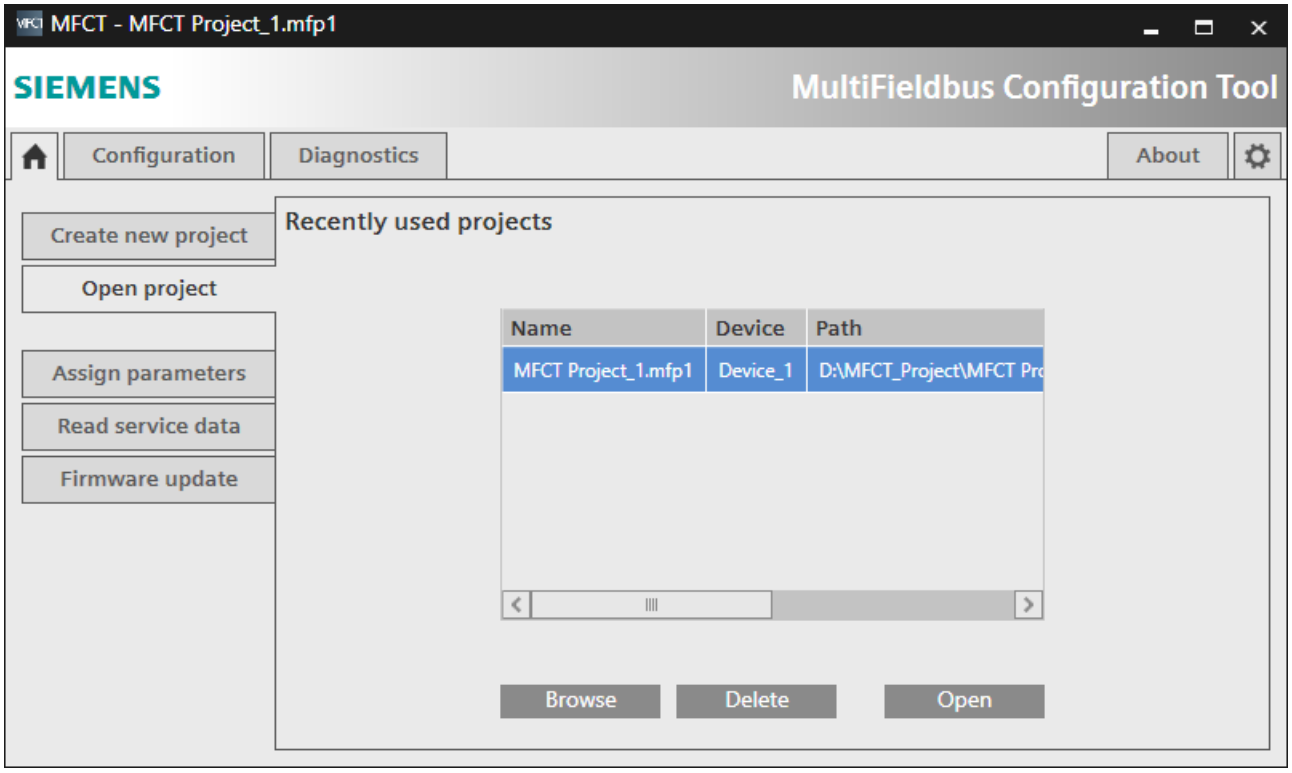

4.2.2.7 Selecting a station

You can create the configuration of the MF device in two ways:

- From the catalog if the real MF station is not available.
- From the network if the MF station is available online.

Selecting MF device from the catalog

1. Select the "Catalogue" option under "Select MF device from".
2. Under "Select MF device", select the desired MF device, e.g. ET 200SP.
3. Assign a name for the MF device under "Device name".
4. Select the desired interface module under "Short designation".
5. Click on the "Create Selected MF Device" button.

The MFCT automatically goes to the next step, "Configure Station".

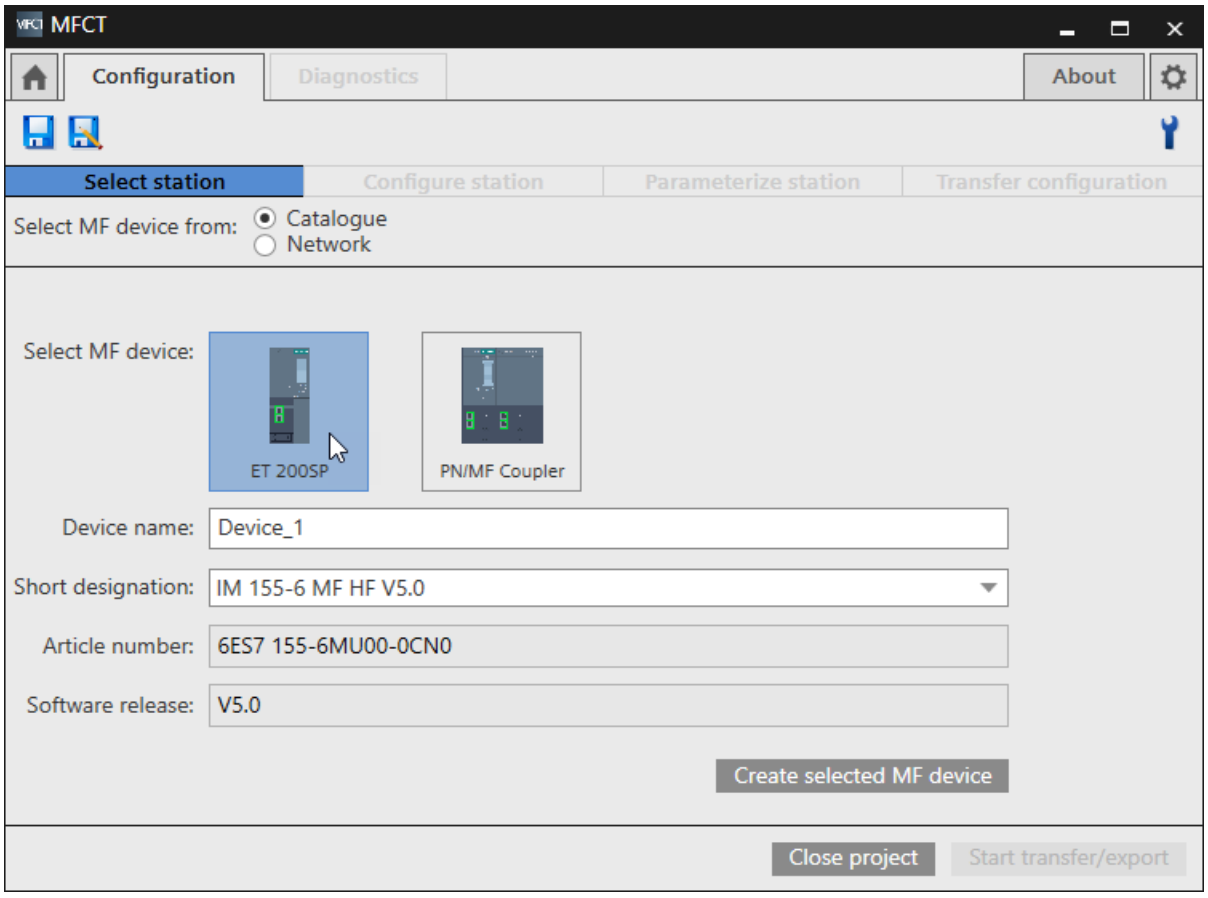

Selecting MF device from the network and loading the configuration

1. Ensure that the network interface selected in the "Settings" tab is connected to the desired MF device.
2. Select the "Network" option under "Select MF device from".
3. Click "Start scan".
4. Select the desired MF device from the list. Devices without MultiFieldbus support cannot be selected and are grayed out.
5. Click "Create new project".

The current configuration is read out from the MF device and added to the MultiFieldbus project. MFCT then goes to the next step "Configure Station" for review and editing.

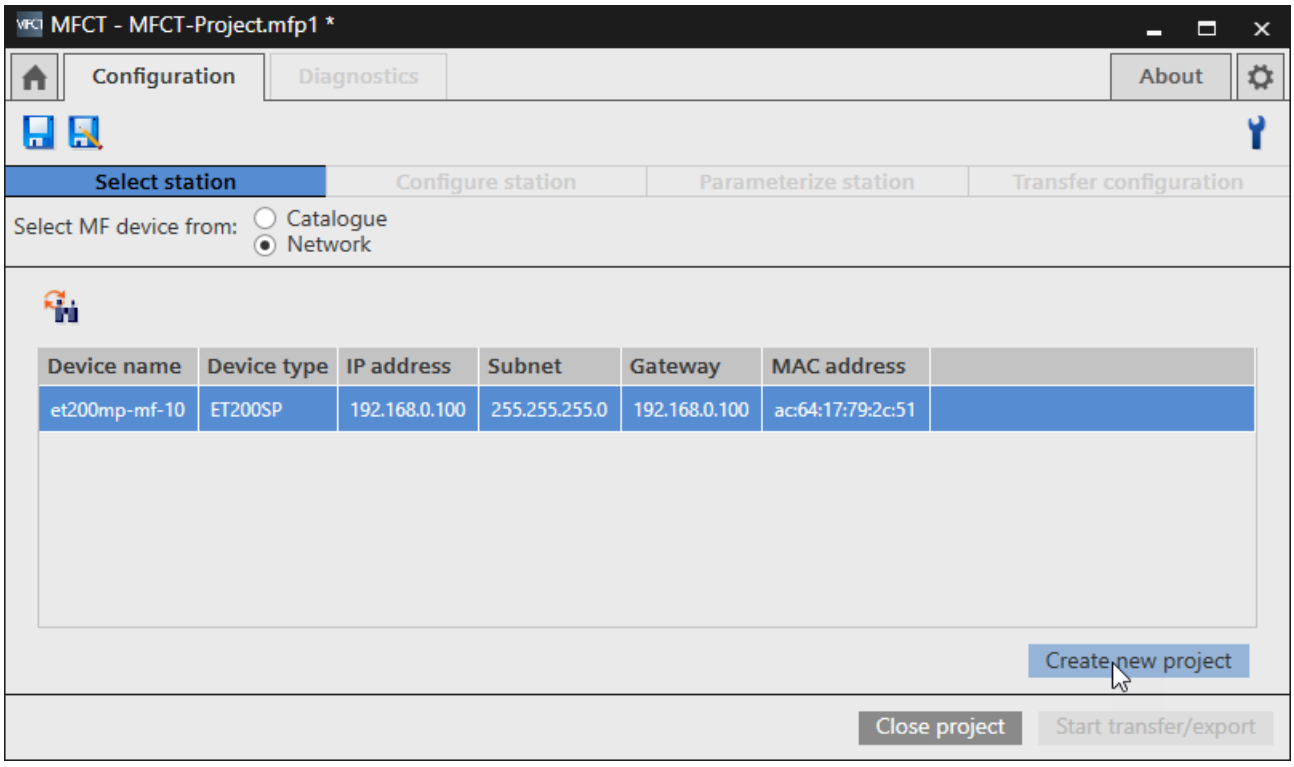

4.2.2.8 Configuring a station

Under "Configure Station", assemble the station with modules and submodules from the hardware catalog based on the GSDML.

The composition of the station is shown as a list on the left, sorted in ascending slot order. The modules and submodules of the hardware catalog based on the installed GSDML are shown on the right.

Additional information on the selected module and potential application at the fieldbuses is shown below the hardware catalog in the "Details" area.

A tooltip above the MF device displays the amount of I/O data available and the amount currently used.

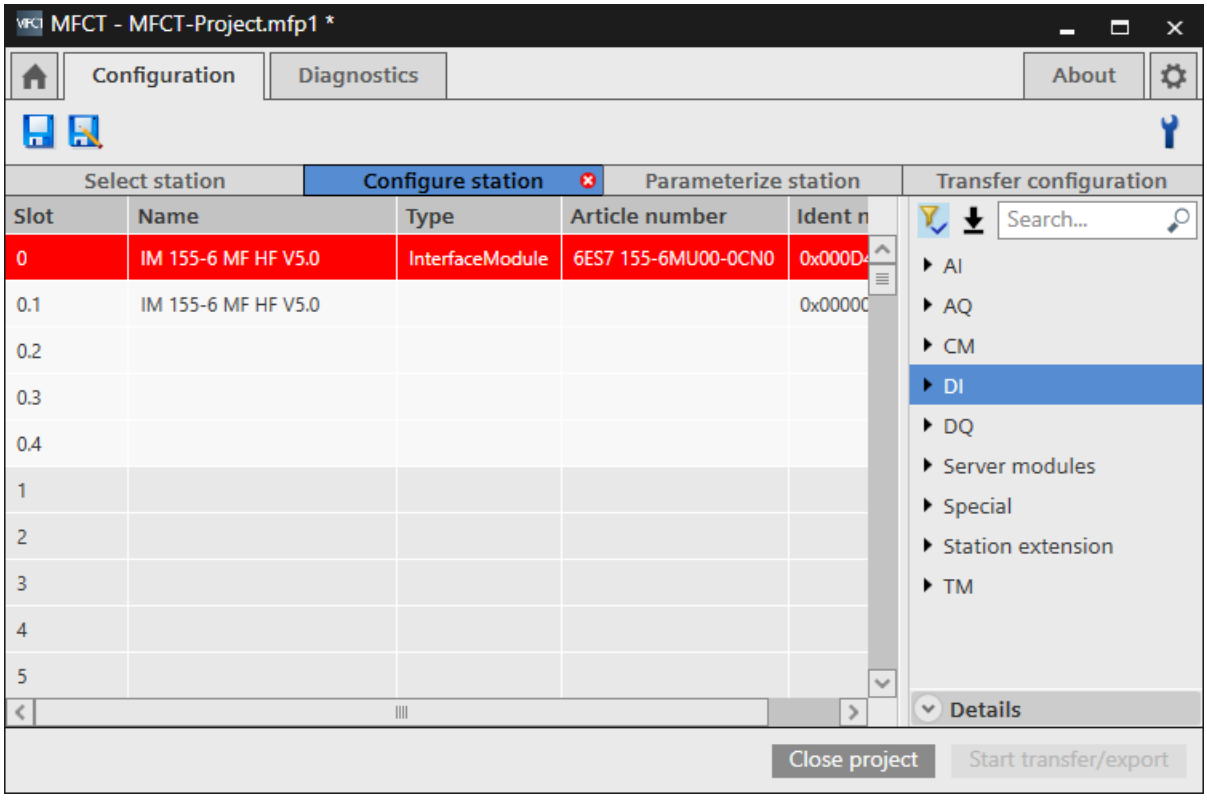

Filter function

You use the filter function to restrict the hardware catalog depending on the fieldbus and the category.

To activate the filter function, follow these steps:

1. Expand the list with the filter criteria.

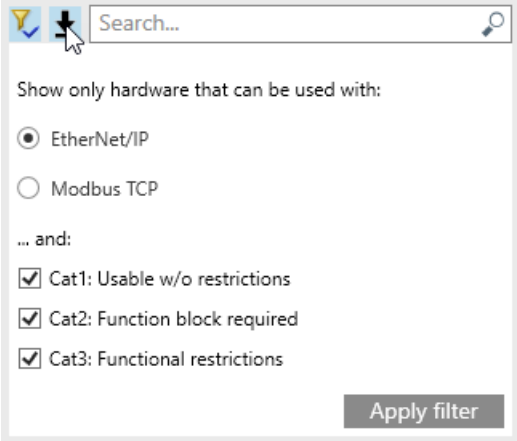

2. Select the desired fieldbus.

3. Select the desired categories.
4. Activate the filter function using the "Apply filter" button.

To deactivate the filter function, follow these steps:

1. Click the filter icon.

Selecting modules

1. Select the module in the desired version and operating mode from the catalog for each slot and drag it onto the slot.

NOTE

The possible slots for the selected module are highlighted in green.

2. Finally, add a server module.

NOTE

The MF device is highlighted in red until you have added the server module.

Selecting submodules

1. Select one of the available submodules from the drop-down list of the module in the hardware catalog.

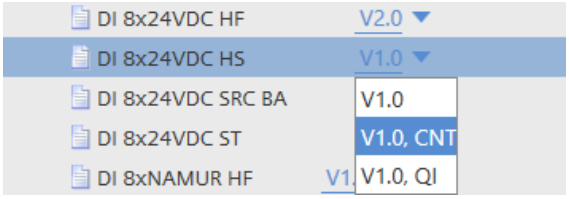

2. Select the submodule and drag it onto a slot.

NOTE

The possible submodule slots are highlighted in green.

Deleting modules/submodules

1. Select the module/submodule to be deleted.
2. Click "Delete" in the shortcut menu.

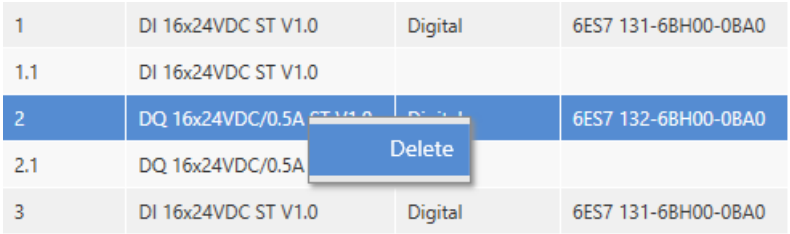

4.2.2.9 Parameter assignment of the station

Under "Assign Station Parameters", set the parameters of the previously configured station.

The composition of the station is shown as a list on the left, sorted in ascending slot order. The parameters for the MF device and the modules/submodules are shown on the right.

For MF devices that support the "MF Shared Device" function, you can configure various fieldbuses for the MF device and for each module.

A tooltip above the MF device displays the amount of I/O data available and the amount currently used.

Procedure

1. Select the MF device on slot 0.
2. If the MF device supports the "MF Shared Device" function and you want to configure different fieldbuses for the MF device and the modules, activate the "MF Shared Device" parameter on the right under "Multi fieldbus parameters".

3. Select the desired fieldbus for the MF device under "Multi fieldbus connection".
4. Use the "I/O data alignment" parameter to select "Byte" or "Word" for I/O data mapping (Page 84).
5. Under "MultiFeldbus Modbus TCP", you can set for each Modbus TCP connection separately the hold time for the connection and the time for "Hold time after connection reset" from 1 to 30,000 ms.

   This parameter is not relevant for EtherNet/IP.
6. Assign parameters for the remaining modules and submodules by selecting the slot and setting the parameter values on the right side.
7. When you have activated the "MF Shared Device" parameter, you can select a fieldbus for each module under "MultiFieldbus connection".

Slot	Name	Type	Article number	Fieldbus connection
0	IM 155-6 MF HF V5.2	InterfaceModule	6ES7 155-6MU00-0CN0	PROFINET
0.1	IM 155-6 MF HF V5.2			
0.1				
0.2				
0.3				
1	DI 16x24VDC ST V0.0	Digital	6ES7 131-6BH01-0BA0	EtherNet/IP #0 (0x301, 0x300)
2	DQ 16x24VDC/0.5A BA V0.0	Digital	6ES7 132-6BH00-0AA0	ModbusTCP #0 (0x000, 0x2D0)
3	F-AI 4xU 0..10V HF, XP	FAnalog	6ES7 136-6AB00-0CA1	PROFINET
4	F-DQ 8x24VDC/0.5A PP HF, BP	FDigital	6ES7 136-6DC00-0CA0	PROFINET
5	Server module V1.2 (0 bytes)	ServerModule	6ES7 193-6PA00-0AA0	PROFINET

NOTE

A parameterization error can be displayed during reconfiguration of PROFINET to EtherNet/IP or Modbus TCP in connection with changing the BusAdapter type. You can only remedy the parameterization error with a reset to factory settings (Page 68) and reconfiguration with MFCT.

4.2.2.10 Transfer the configuration

The "Transfer configuration" area offers you the following options:

- Transfer the project to the MF device
- Export the configuration for use in other engineering tools.

Transferring the project to the MF device

To transfer the MF project to the MF device, follow these steps:

1. Select the "Transfer the project to the MF device" check box.
2. Click the "Start scan" button to search via the preset network interface for MF devices for the project download. Devices without MultiFeldbus support cannot be selected and are grayed out.
3. Select an MF device and start the download to the MF device using the "Start transfer/export" button.

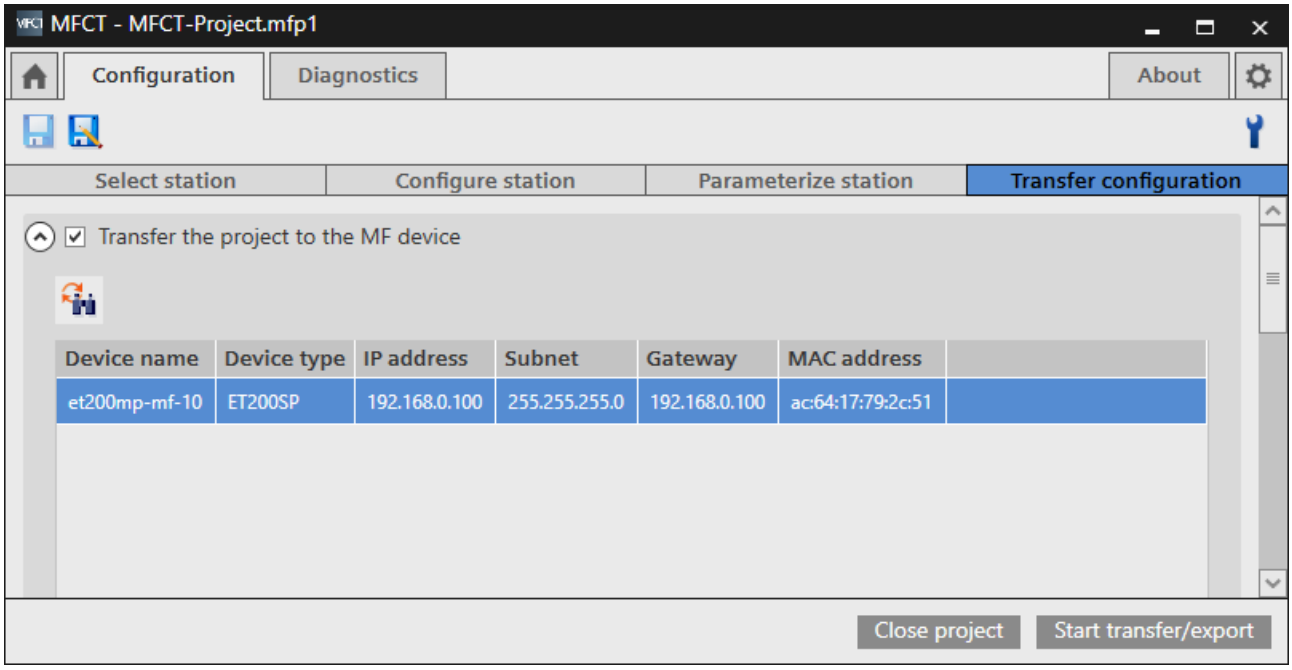

Fault rectification of the timeout on transfer to the MF device

- Check the accessibility of the MF device via the network interface selected in MFCT.
- Disconnect the connection of the MF device to PROFINET IO controllers.
- If you have selected the "Use router for gateway" option in the network parameters, check the network parameters of the device.

Export of configuration

1. Select the "Export configuration for use in other engineering tools" check box.
2. Assign a name and a path for the export
3. Select the file formats to be exported:
   - MultiFieldbus Configuration Tool (MFCT) project
   - User Defined Data Type (UDT) (as l5x file)
   - Comma Separated Values (CSV)
   - Electronic Data Sheet (EDS)
4. Start the export using the "Start transfer/export" button.

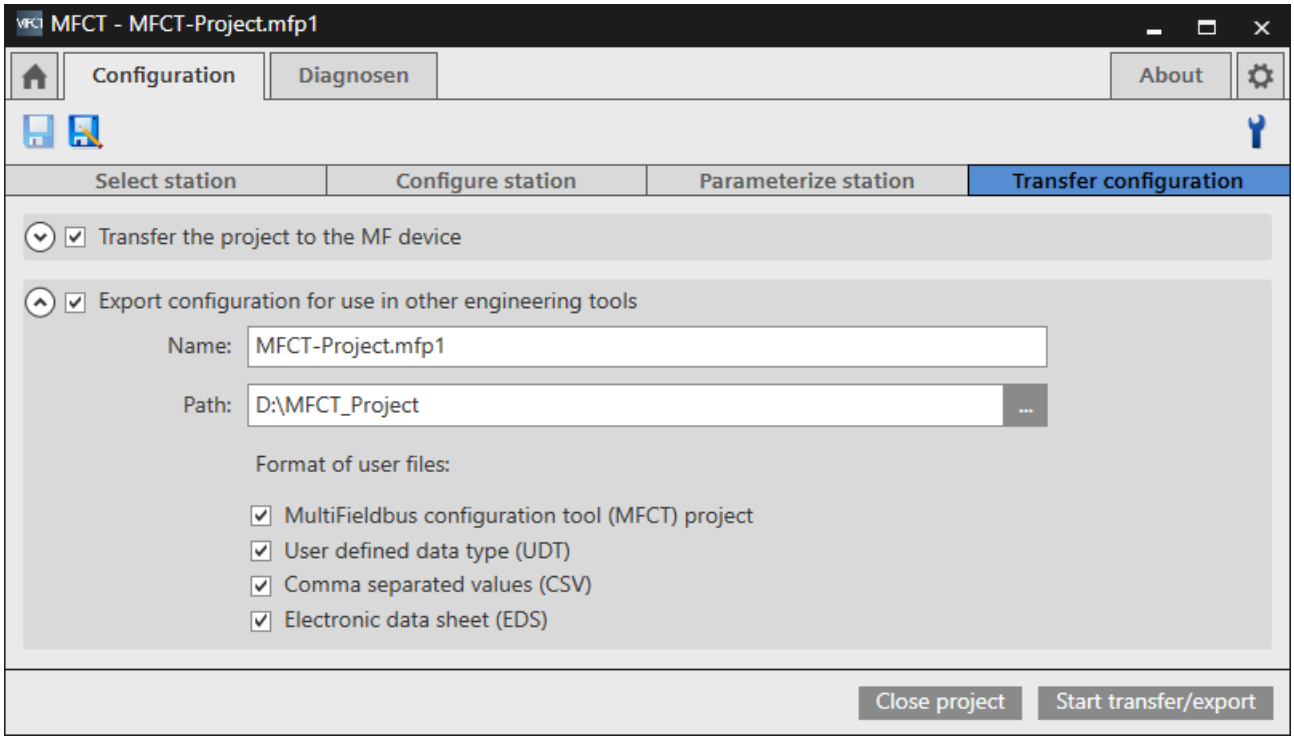

Transfer/export status

The progress and result of the file export and project download are each displayed. The fieldbus activated in the MF device as well as any differences between the configured and real hardware are also displayed.

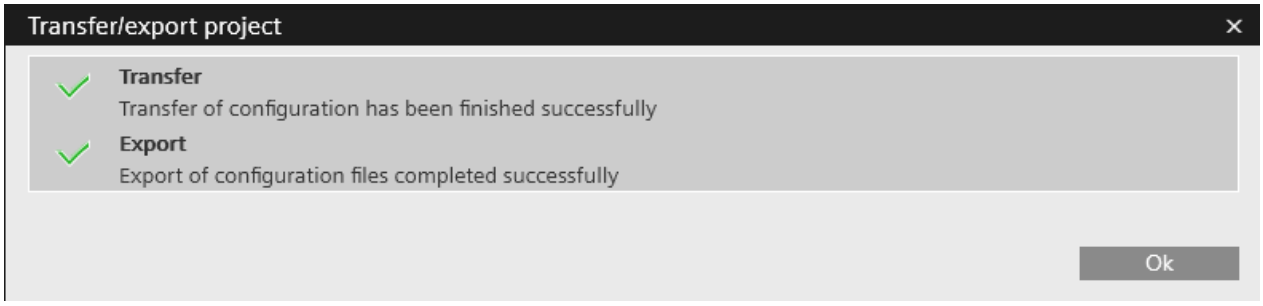

4.2.2.11 Sending user feedback

You have the option of sending us feedback on MFCT in the "About" tab:

1. Click on the "Send feedback" button.
   MFCT collects diagnostics data and attaches it to the open email.
2. Enter your feedback on MFCT in the email.
3. Send the email.

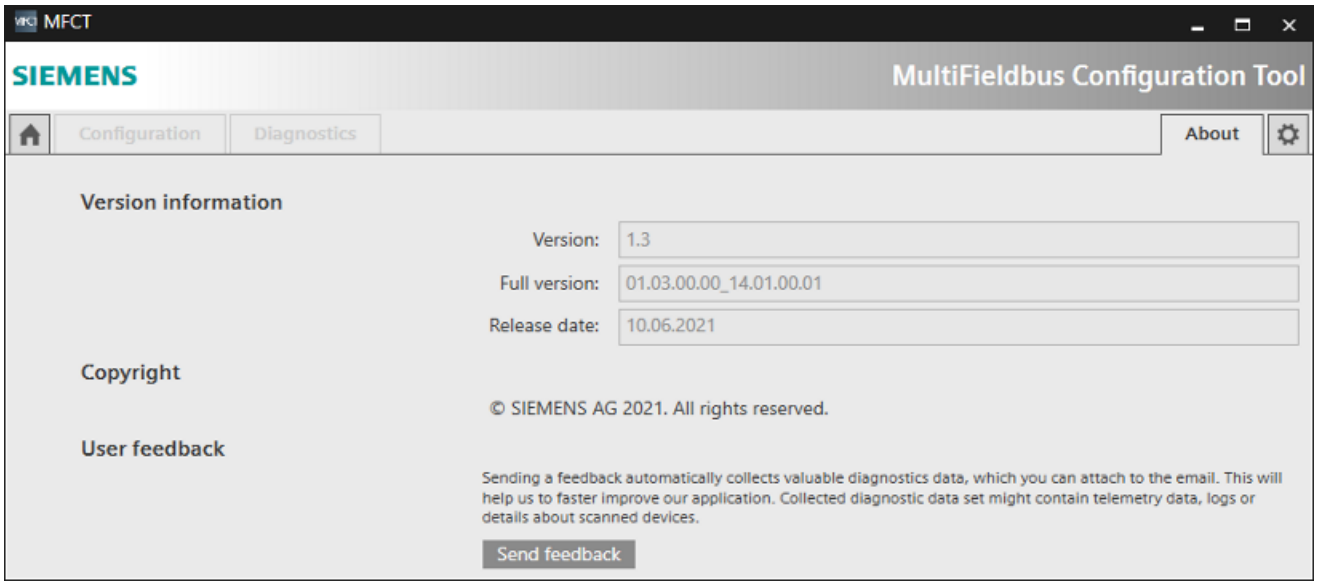

4.2.3 Configuration in the engineering system

4.2.3.1 Services

The following Modbus TCP services are supported:

- Read Holding Registers (code = 3)
- Write Multiple Registers (code = 16)

4.2.3.2 Register addresses

Overview of the Modbus TCP registers

Consistent access to register:

- Function Code 3:

  Read inputs via 2 parallel connections of a controller: Up to 2 x 125 registers at 16 bits = 2 to 500 bytes
- Function Code 16:

  Write outputs via a controller: 1 to 123 registers at 16 bit = 2 to 246 bytes

Partial writing of the output data or reading of the input data within the configured total length is possible.

The table below shows the overview of the available Modbus TCP registers:

Register area	Address [Hex]	Address [Decimal]	RegLayoutVersion
I/O data of the connection	0x0000 - 0x59FF	0 - 23039	≥ V1.0
Module status	0x6000 - 0x69E3	24576 - 27107	≥ V1.1

Register area	Address [Hex]	Address [Decimal]	RegLayoutVersion
Data record	0xD000 - 0xD0FA	53248 - 53498	≥ V1.1
Volatile registers	0xFE00 - 0xFE7C	65024 - 65148	≥ V1.0
Deviceinfo	0xFF00 - 0xFF08	65280 - 65288	≥ V1.0

Input/output data of the connection

The following table shows the valid ranges for register addresses:

Connection ID	Input data (with FC3)		Output data (with FC16)	
	Register addresses [Hex]	Register addresses [Decimal]	Register addresses [Hex]	Register addresses [Decimal]
0	0x0000 - 0x00F9	0 - 249	0x02D0 - 0x034A	720 - 842
1	0x05A0 - 0x0699	1440 - 1689	0x0870 - 0x08EA	2160 - 2282
2	0x0B40 - 0x0C39	2880 - 3129	0x0E10 - 0x0E8A	3600 - 3722
3	0x10E0 - 0x11D9	4320 - 4569	0x13B0 - 0x142A	5040 - 5162
4	0x1680 - 0x1779	5760 - 6009	0x1950 - 0x19CA	6480 - 6602
5	0x1C20 - 0x1D19	7200 - 7449	0x1EF0 - 0x1F6A	7920 - 8042
6	0x21C0 - 0x22B9	8640 - 8889	0x2490 - 0x250A	9360 - 9482
7	0x2760 - 0x2859	10080 - 10329	0x2A30 - 0x2AAA	10800 - 10922
8	0x2D00 - 0x2DF9	11520 - 11769	0x2FD0 - 0x304A	12240 - 12362
9	0x32A0 - 0x3399	12960 - 13209	0x3570 - 0x35EA	13680 - 13802

Bit-by-bit access to cyclic I/O data

The input and output functions work for one connection in the same bit address area.

You can access up to 500 bytes of input data and 246 bytes of output data with 16 connections.

Simultaneous bit-by-bit access with the function codes 1, 2, 5, 15 and register access with the function codes 3, 16 are possible.

Connection		Function codes (FC)	
ID	**Bit address**	**Access to input data**	**Access to output data**
0	0x0000 – 0x0FFF	Max. 500 bytes per connection FC2 (read individual input)	Max. 246 bytes per connection FC1 (read coil) FC5 (write individual coil) FC15 (write multiple coils)
1	0x1000 – 0x1FFF		
2	0x2000 – 0x2FFF		
...	...		
8	0x8000 – 0x8FFF		
9	0x9000 – 0x9FFF		

NOTE

Bit access takes place for input and output data in the same address area within a connection.

Module status area

This area contains detailed information on modules and submodules that were configured for Modbus TCP. The area contains submodule-specific status information for up to 281 submodules.

A summary of the complete configuration is available in the *DeviceStatus* field of the Device-Info area. *RealModuleIdent* and *RealSubmoduleIdent* return 0 if a submodule is not plugged and *SubmoduleState* shows "No submodule".

Table 3-1062 Module status area (big-endian, read-only access)

Register	Block	Field	Size	Description
0x6000 (24576)	Block Header	VersionHigh	Unsigned8	0x01 Major revision module status
		VersionLow	Unsigned8	0x00 Minor revision module status
0x6001 (24577)		BlockLength	Unsigned16	Number of subsequent elements for the module status area as Word
0x6002 (24578)	Submod #0	Slot	Unsigned8	Slot number of the module
		Subslot	Unsigned8	Subslot number of the submodule
0x6003 (24579)		ExpectedModuleIdent	Unsigned16	High Word expected ModuleIdentNumber
0x6004 (24580)			Unsigned16	Low Word expected ModuleIdentNumber
0x6005 (24581)		ExpectedSubmod-uleIdent	Unsigned16	High Word expected SubmodIdentNumber

Register	Block	Field	Size	Description
0x6006 (24582)	Submod #0	ExpectedSubmod-uleIdent	Unsigned16	Low Word expected SubmodIdentNumber
0x6007 (24583)		RealModuleIdent	Unsigned16	High Word actual ModuleIdentNumber
0x6008 (24584)			Unsigned16	Low Word actual ModuleIdentNumber
0x6009 (24585)		RealSubmoduleIdent	Unsigned16	High Word actual SubmoduleIdentNumber
0x600A (24586)			Unsigned16	Low Word actual SubmoduleIdentNumber
0x600B (24587)		SubmoduleState	Unsigned16	Bits 3..0: Configuration status 0 = OK 1 = Substitute submodule 2 = Wrong submodule 3 = No submodule 4..15 = Reserved Bit 4 = Error diagnostics Bit 5 = Maintenance diagnostics Bits 15..6: Reserved (0)
...	...			
0x69DA (27098) - 0x69E3 (27107)	Submod #280			

Volatile register area

This area provides 123 multi-purpose registers with read/write access for customized use.

The registers can be controlled by any Modbus TCP connection. The content of the volatile registers is stored non-retentively in the RAM of the MF device. The content is set to 0 when the device is switched off and on again.

Table 3-1063 Volatile register area (big-endian, read/write access)

Register	Field	Size	Default	Description
0xFE00 (65024)	VersionHigh	Unsigned8	0x01	Major revision of the volatile registers (Read access)
	VersionLow	Unsigned8	0x00	Minor revision of the volatile registers (Read access)
0xFE01 (65025)	BlockLength	Unsigned16	0x007B	Number of volatile registers (Read access)
0xFE02 (65026)	VolatileReg0	Unsigned16	0x0000	
...	...			
0xFE7C (65148)	VolatileReg122	Unsigned16	0x0000	

Device-Info Area

This register area provides read access to revision and status information.

The following table shows the register addresses:

Table 3-1064 Device-Info area (big-endian, read-only access)

Register	Field	Size	Default	Description
0xFF00 (65280)	VersionHigh	Unsigned8	0x01	Major revision of the Deviceinfo
	VersionLow	Unsigned8	0x01	Minor revision of the Deviceinfo
0xFF01 (65281)	BlockLength	Unsigned16	0x0008	Number of subsequent elements for the Deviceinfo area in Word
0xFF02 (65282)	RegLayoutVersionHigh	Unsigned8	0x01	Major revision of the layout of the Modbus TCP register
	RegLayoutVersionLow	Unsigned8	0x01	Minor revision of the layout of the Modbus TCP register
0xFF03 (65283)	IOLayoutVersionHigh	Unsigned8	0x01	Major revision of the layout of the I/O data area
	IOLayoutVersionLow	Unsigned8	0x00	Minor revision of the layout of the I/O data area
0xFF04 (65284)	FirmwareVersionMajor	Unsigned8	-	Depending on firmware revision Vx.y.z Major = x*10+y / Minor = z
	FirmwareVersionMinor	Unsigned8	-	
0xFF05 (65285)	ProductCode	Unsigned16	-	You can find the data value in the technical specifications of the MF device under "Device ID according to ODVA (ProductCode)".
0xFF06 (65286)	SerialNumber	Unsigned8	-	Last 4 bytes of the MAC address of the MF device
		Unsigned8	-	
0xFF07 (65287)		Unsigned8	-	
		Unsigned8	-	
0xFF08 (65288)	DeviceStatus	Unsigned16	0x0000	Bits: 0 = Configured (MultiFieldbus project with Modbus TCP modules) 1 = Connected to a Modbus TCP client 2 = Diagnostics error 3 = Maintenance diagnostics 4 = Configuration error (no module or wrong module)
0xFF09 (65289)	RecordAreaVersion-High	Unsigned8	0x01	Revision Major from *Record Register Area*
	RecordAreaVersionLow	Unsigned8	0x00	Revision Minor from *Record Register Area*

4.2.3.3 Behavior of the inputs and outputs

The following section describes how the inputs and outputs of modules behave during the use of Modbus TCP.

- Outputs return substitute values after:
  - POWER ON, if a retentive project download is present
  - Change of the configuration/parameter assignment via MFCT download
  - Interruption of the Ethernet connection longer than the Modbus hold time
  - STOP of the Modbus TCP controller
  - Register access to the output area in a cycle greater than the Modbus hold time
- Outputs return "0":
  - For POWER ON if no project download is present
  - For unwritten output registers after POWER ON or after substitute value output initiated by any write access to the output register area
  - For unwritten I/O registers
- Outputs return the last written values:
  - For output registers other than those addressed in the write access
- Outputs return current values:
  - At a write access to the affected output registers
- Inputs deliver values depending on the module status for configuration, parameter assignment and error modes
  - At a read access to the affected input registers

NOTE

If you have only configured inputs, read these within the configured Modbus hold time to prevent the LED display for timeout.

If you have configured outputs, write these within the configured Modbus hold time to prevent the LED display for timeout and receive the device status = 1 (Connected).

4.2.3.4 I/O data mapping

I/O data mapping

During parameter assignment of the MF Device (Page 75), you can choose between two formats for the I/O data alignment:

- With the "Byte" format, the input or output data of the modules of an I/O connection are lined up by increasing slot address (Slot.Subslot).

- With the "Word" format, the input or output data of the modules of an I/O connection are lined up by increasing slot address (Slot.Subslot). If the submodule has an odd-numbered data length (e.g. data length of 1 for a DI 8 HF module), a padding byte (content 0x00) is inserted after the submodule. This aligns the following data status bytes (IDS, ODS) to word limits. A padding byte (content 0x00) is also inserted after the data status byte (IDS, ODS). Subsequent submodules will then also start at an even byte offset.

The image of the outputs contains only the output data (with padding bytes if necessary), while the input image also supplies additional status bytes together with the input data (with padding bytes if necessary).

An Output Data Status Byte (ODS) is available for each output submodule in the image of the inputs.

There is an Input Data Status Byte (IDS) for each input submodule that follows the respective input data of the submodule in the input image.

Submodules with a data length of 0 for input and output data are treated as input submodules. Only an Input Data Status Byte (IDS) is entered in the input image.

NOTE

You can find the I/O data mapping for your configuration in the exported CSV file (Page 76).

NOTE

For information about data mapping, see the system and equipment manuals.

I/O data status

The following table shows the coding of the status bytes for IDS and ODS:

Field	Bit number	Bit mask	Default	Bit value = '0'	Bit value = '1'
IOValid	7	0x80	0	I/O data invalid	I/O data valid
Problem	6	0x40	0	Initial status	Module problem: • Module not plugged • Incorrect module plugged • Module with incorrect parameter assignment
NoCoupling	5	0x20	0	Initial status	No I/O data from coupling partner (MSO Local)
Reserved	4...2	0x1E	000	-	
ProcessEvent	1	0x02	0	No process event	Process event available
Diagnosis	0	0x01	0	No diagnostics	Diagnostics available

4.2.3.5 Data record interface

Overview

Via this Modbus TCP interface, you can access configured modules in the form of PROFINET data records for reading and writing.

Examples for this are

- Write/read I&M data
- Read diagnostic data
- Write parameter data records
- Read measured value data records

Information on parameter data records, measured value data records and diagnostics can be found in the device manuals of the modules used.

Access to the register areas of the data record interface is exclusively provided via the services Write Multiple Registers (Code=16) and Read Holding Registers (Code=3).

Modbus TCP limits the data that can be consistently transferred to 246 bytes Write (123 registers) and 246 bytes Read (123 registers). Larger data records are provided in an internal intermediate buffer and are read or written via Modbus TCP through multiple record requests. It can be used to transfer PROFINET data records with a maximum length of 4096 bytes.

The data record interface and the protocol are described below.

User interface

Table 3-1065 Register area for data records

Connec-tion	Block		Register address	Access
#0	Record Register Area0	0xD000 - 0xD0FA		
		Record request	0xD000 - 0xD006	Read/write
		Record response	0xD040 - 0xD042	Read only
		Record Data	0xD080 - 0xD0FA	Read/write
#1	Record Register Area1	0xD100 - 0xD1FA		
...				
#9	Record Register Area9	0xD900 - 0xD9FA		

Table 3-1066 Record request (big-endian, read/write access)

Register Offset	Block	Field	Size	Description
0x0000	Record Header	Slot	Unsigned16	
0x0001		Subslot	Unsigned16	
0x0002		Record Index	Unsigned16	
0x0003		Record Length	Unsigned16	Length of the PROFINET data record in bytes
0x0004	Request Header	Request Offset	Unsigned16	Offset within the PROFINET data record in bytes
0x0005		Request Length	Unsigned16	Number of bytes requested for the *Record Data* register, in the data record starting at *Read Request Offset*. > 246 returns the Modbus TCP error "Illegal Data Value (3)".

Register Offset	Block	Field	Size	Description
0x0006	Request Trigger	Request Control		**0x0000 Execute read:** Fetch new internal data record (record header & request header are evaluated) **0x0001 Resume read:** Returns another data packet of a previously internally requested data record. (Returns the Modbus TCP error "Illegal Data Value (3)", if the content of the *Record Header* has changed since the last execution.) **0x0002 Prepare write:** Fill internal write buffer, but without executing the write request of the data record internally. **0x0003 Execute write:** Fill internal write buffer and execute internal writing of the data record. (Returns the Modbus TCP error "Illegal Data Value (3)", if the content of the *Record Header* has changed since the last execution.) **0x0004 – 0xFFFF:** Reserved (Returns the Modbus TCP error "Illegal Data Value (3)")

Table 3-1067 Record response (big-endian, read-only access)

Register Offset	Block	Field	Size	Description
0x0040		Status	Unsigned16	**0x0000:** Done / OK (request was successfully executed.) **0x0001:** Busy (access to the data record interface not allowed.) **0x0002:** Waiting (for **"Execute write"**) **0x0003:** Processing (internal request of the data record is executed) **0x8000-0x80FF:** Error (request failed with the PROFINET data record error response [2])(= 0x8000 + "PROFINET ErrorCode1" column in Param Object/Response-Record-Mapping (Page 60)) **0xFF00:** *Request Length* invalid (> 246 returns the Modbus TCP error "Illegal Data Value (3)") **0xFF01:** *Record Length* invalid (if == 0) **0xFF02:** Request header invalid (if *Request Offset* + *Request Length* > *Record Length*)
0x0041		Processed Length	Unsigned16	Processed length of the PROFINET data record in bytes **Read:** Length of the read PROFINET data record. **Write:** Record length of the executed write job = Record Length (Zero in case of an error)
0x0042		Response Length	Unsigned16	**Read:** Number of valid bytes available in *Record Data*. **Write:** Number of bytes taken from *Record Data*. (Zero in case of an error)

Table 3-1068 Record content (big-endian, read/write access)

Register Offset	Block	Field	Size	Description
0x0080-0x00FA	Record	Data [123]	Unsigned16	PROFINET data record content (246 bytes) (Read: Contains the number of valid bytes returned with *Response Length*. Remaining bytes have the value 0.)

Read data record

Proceed as follows to read a PROFINET data record:

1. Write *Record Header* and *Request Header* in the *Record Request* register structure.

   It is important that you first write all information into the *Record Request* register structure before you write the *Request Control* register.

2. Write 0x0000 in *Request Control* to trigger the reading of the PROFINET data record. Write *Request Control* only once until reading is complete.
3. Read the *Record Response* structure and poll *Status* to detect the completion of the internal read request for the PROFINET data record.
4. You can use *Status* == 0x0000 (OK) to read the *Record Data* registers with the contents of the PROFINET data record.
5. If *Processed Length* > *Response Length*, further data of the PROFINET data record are available for reading.

   In this case, continue with step 1. Set *Request Offset* = *Request Offset + Response Length* and *Request Control* = 0x0001 to request further data of the PROFINET data record from the internal *PROFINET Record Data Buffer*.

Write data record

Proceed as follows to write a PROFINET data record:

1. Write the first 123 registers (246 bytes) of the PROFINET data record to the *Record Data* registers. If the data record > 246 bytes; otherwise less, depending to the data record.
2. Write *Record Header* and *Request Header* in the *Record Request* register structure.

   It is important that you first write all information into the *Record Request* register structure before you write the *Request Control* register.

3. For a data record >= 246 0x0002, write in *Request Control* to write the first 123 registers (246 bytes) to an internal write buffer. Otherwise, continue with step 6.
4. Wait until writing is complete. To do so, evaluate *Response Length*. When *Response Length* is equal to the number of the first 123 registers (246 bytes), writing is complete.
5. Write the next register of the PROFINET data record to the *Record Data* registers. Write the number of previously written registers (246 bytes) to *Request Offset*.
6. Write 0x0003 in *Request Control* to write the next registers to the internal write buffer and execute the data record task.

   Do not change the address information for previous access.

7. Wait until writing is complete. To do so, evaluate *Response Length*. When *Response Length* is equal to the number of the next written registers, writing is complete.
8. Read the *Record Response* structure and poll *Response Status*.
   - If *Response Status* == 0x0000, the internal write operation for the PROFINET data record has been successfully completed. You can use *Processed Length* and *Response Length* to evaluate the resulting length information.
   - With *Response Status* == 0x0002 the write request of the current data block is completed and *Record Data* was filled into the *PROFINET Record Data Buffer*.

   To write another data block, continue with step 1.

If the PROFINET data record is only up to 123 registers (246 bytes) long, skip steps 3 to 5.

Example: Read I&M0 data

To read I&M0 data from an interface module with Modbus TCP connection #0, proceed as follows:

1. Check the revision of the Modbus TCP data record interface.

Read 0xFF09 (Record Area Version)	=> 0x0100 (1.0)

Check if you have implemented the correct address scheme (e.g. 0x0100 = V1.0)

2. Prepare request to read the data record.

Write 0xD000 (Slot) = 0x0000	IM slot = 0 in connection #0 of 0xD000
Write 0xD001 (Subslot) = 0x0001	IM subslot = 1
Write 0xD002 (Record Index) = 0xAFF0	I&M0
Write 0xD003 (Record Length) = 0x003C	Read 60 bytes from I&M0 data record
Write 0xD004 (Request Offset) = 0x0000	Request data from offset 0 from I&M0 data record
Write 0xD005 (Request Length) = 0x003C	Request 60 bytes of data from the I&M0 data record

3. Execute the read request.

Write 0xD006 (Request Control) = 0x0000	Starts the internal retrieval of data from the I&M0 record.

4. Wait until the read request is completed.

Read 0xD040 (Status)	Poll status <> 0x0001= Busy or 0x0003 = Processing

5. Evaluate the result of the reading.

When status <> 0x0000 (OK), evaluate the error code.	→ 0x80xx = Normative PROFINET error response code → 0xFFxx = Request parameter error
Read 0xD041 (Processed Length) => 0x003C	60 bytes is the total length of the I&M0 record
Read 0xD042 (Response Length) => 0x003C	60 bytes were returned from the current read request

6. Read the data of the I&M0 record.

Read 0xD080 - 0xD09E (Record Data [0-29])	Read 60 bytes of data of the I&M0 data record

Example: Write I&M1 data

To write I&M1 data to a module with Modbus TCP connection #1, proceed as follows:

1. Check the revision of the Modbus TCP data record interface.

Read 0xFF09 (Record Area Version)	=> 0x0100 (1.0)

Check if you have implemented the correct address scheme (e.g. 0x0100 = V1.0)

2. Fill the data for the PROFINET data record.

Write 0xD180 - 0xD19E (Record Data [0-29])	Write 60 bytes of data of the I&M1 data record

3. Prepare the request to write the record.

Write 0xD100 (Slot) = 0x0002	Slot = 2 in connection #1 of 0xD100
Write 0xD101 (Subslot) = 0x0001	Subslot = 1
Write 0xD102 (Record Index) = 0xAFF1	I&M1
Write 0xD103 (Record Length) = 0x003C	60 bytes total length for the I&M1 data record
Write 0xD104 (Request Offset) = 0x0000	Request to fill the data of offset 0 from the I&M1 data record to
Write 0xD105 (Request Length) = 0x003C	Request to write 60 bytes of data into the I&M1 data record

4. Execute the read request.

Write 0xD106 (Request Control) = 0x0003	Starts the internal retrieval of data from the I&M1 data record.

5. Wait until the write request is completed.

Read 0xD140 (Status)	Poll status <> 0x0001= Busy or 0x0003 = Processing

6. Evaluate the result of the writing.

When status <> 0x0000 (OK), evaluate the error code.	→ 0x80xx = Normative PROFINET error response code → 0xFFxx = Request parameter error
Read 0xD141 (Processed Length) => 0x003C	60 bytes is the total length of the I&M1 record
Read 0xD142 (Response Length) => 0x003C	60 bytes written with the current write request

Example: Read diagnostics (multiple data packets)

To read diagnostic data (0x800C) from a module with Modbus TCP connection #0, proceed as follows:

1. Check the revision of the Modbus TCP data record interface.

Read 0xFF09 (Record Area Version)	=> 0x0100 (1.0)

Check if you have implemented the correct address scheme (e.g. 0x0100 = V1.0).

2. Prepare request to read the first data packet of the diagnostic data record.

Write 0xD000 (Slot) = 0x0002	Slot=2 in connection #0 of 0xD000
Write 0xD001 (Subslot) = 0x0001	Subslot=1
Write 0xD002 (Record Index) = 0x800C	Diagnostics data
Write 0xD003 (Record Length) = 0x1000	Read 4096 bytes data of the diagnostic data record
Write 0xD004 (Request Offset) = 0x0000	Request data from offset 0 of the diagnostic data record
Write 0xD005 (Request Length) = 0x00F6	Request a data packet with the first 246 bytes of the diagnostic data record.
Write 0xD006 (Request Control) = **0x0000**	Starts the internal fetch of the data package from the diagnostic data record.

3. Wait until the read request is completed and evaluate the result.

Read 0xD040 (Status)	Poll status <> 0x0001= Busy or 0x0003 = Processing
When status <> 0x0000 (OK), evaluate the error code.	→ 0x80xx = Normative PROFINET error response code → 0xFFxx = Request parameter error
Read 0xD041 (Processed Length) => 0x0190	For example, 400 bytes is the total length of the diagnostic data record
Read 0xD042 (Response Length) => 0x00F6	246 bytes were returned by the first read request

4. Read first data packet of the diagnostic data record.

Read 0xD080 - 0xD0FA (Record Data [0-122])	Read 246 bytes of data [0-245] of the diagnostic data record

5. Prepare request to read the second data packet of the diagnostic data record.

Write 0xD004 (Request Offset) = 0x00F6	Request data of offset 246 of the diagnostic data record
Write 0xD005 (Request Length) = 0x009A	Request a data packet with the remaining 154 bytes of the diagnostic data record.
Write 0xD006 (Request Control) = **0x0001**	Provides the previously requested data.

6. Wait until the second read request is completed and evaluate the result.

Read 0xD040 (Status)	Poll status <> 0x0001= Busy or 0x0003 = Processing
When status <> 0x0000 (OK), evaluate the error code.	→ 0x80xx = Normative PROFINET error response code → 0xFFxx = Request parameter error
Read 0xD041 (Processed Length) => 0x0190	400 bytes is the total length of the diagnostic data record
Read 0xD042 (Response Length) => 0x009A	154 bytes were returned by the second read request

7. Read second data packet of the diagnostic data record.

Read 0xD080 - 0xD0CA (Record Data [0-76])	Read 154 bytes of data [246-399] of the diagnostic data record

Example: Write parameter data record (multiple data packets)

To write a parameter data record to an AI Energy Meter module with Modbus TCP connection #0, proceed as follows:

1. Check the revision of the Modbus TCP data record interface.

Read 0xFF09 (Record Area Version)	=> 0x0100 (1.0)

Check if you have implemented the correct address scheme (e.g. 0x0100 = V1.0)

2. Fill the first data packet for the parameter data record.

Write 0xD080 - 0xD0FA (Record Data [0-122])	Write 246 bytes of the parameter data record

3. Prepare the request to write the first data packet of the parameter data record.

Write 0xD000 (Slot) = 0x0004	Slot=4 in connection #0 of 0xD100
Write 0xD001 (Subslot) = 0x0001	Subslot=1
Write 0xD002 (Record Index) = 0x0087	Parameter data record
Write 0xD003 (Record Length) = 0x0130	Write 304 bytes data of the parameter data record
Write 0xD004 (Request Offset) = 0x0000	Request to fill the data of offset 0 of the parameter data record
Write 0xD005 (Request Length) = 0x00F6	Request to write the first data packet with 246 bytes of data into the parameter data record.
Write 0xD006 (Request Control) = **0x0002**	Starts the internal writing of the data packet into the diagnostic data record.

4. Wait until the write request is completed and evaluate the result.

Read 0xD040 (Status)	Poll status <> 0x0001= Busy or 0x0003 = Processing
When status <> 0x0000 (OK), evaluate the error code.	→ 0x80xx = Normative PROFINET error response code → 0xFFxx = Request parameter error
Read 0xD041 (Processed Length) => 0x0000	Internal writing of the data packet not yet executed.
Read 0xD042 (Response Length) => 0x00F6	246 bytes were written internally by the first write request.

5. Fill the second data packet for the parameter data record.

Write 0xD080 - 0xD0BA (Record Data [0-28])	Write 58 bytes of the parameter data record [246-303].

6. Prepare request to write the second data packet of the parameter data record.

Write 0xD004 (Request Offset) = 0x00F6	Prepare request to fill the second data packet starting at offset 246 of the parameter data record
Write 0xD005 (Request Length) = 0x003A	Request to write the second data packet with 58 bytes of data into the parameter data record.
Write 0xD006 (Request Control) = **0x0003**	Starts the internal writing of the data packet into the diagnostic data record.

7. Wait until the write request for the second data packet is completed and evaluate the result.

Read 0xD040 (Status)	Poll status <> 0x0001= Busy or 0x0003 = Processing
When status <> 0x0000 (OK), evaluate the error code.	→ 0x80xx = Normative PROFINET error response code → 0xFFxx = Request parameter error
Read 0xD041 (Processed Length) => 0x0130	304 bytes is the total length of the parameter data record.
Read 0xD042 (Response Length) => 0x003A	58 bytes were written internally by the second write request.

4.3 Diagnostics

4.3.1 Reading diagnostics with MFCT

In the "Diagnostics" tab, you can read information of selected MF devices:

- The project configuration
- The online plugged modules
- Diagnostics from the diagnostic buffer

Follow these steps:

1. Click the "Start scan" button to find accessible MF devices via the preset network interface.
2. Select an MF device under "Select online device".

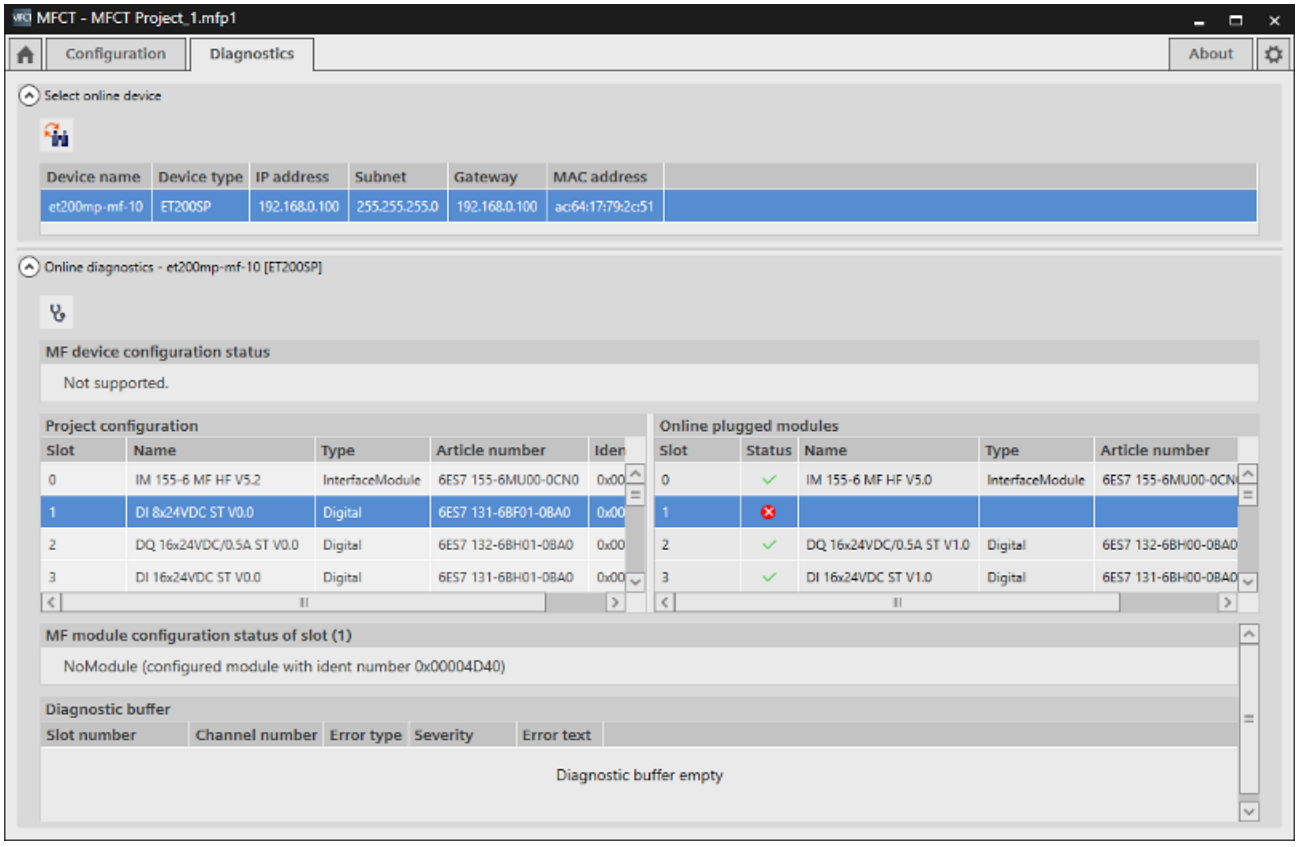

You can update the display under "Online plugged modules" with the "Update online status" button.

Project configuration

Under "Project configuration", you will receive information on the configuration of the selected MF device loaded in MFCT.

Online plugged modules

Under "Online plugged modules", you will receive information on the selected MF device, if it is accessible online.

MF module configuration status

Under "MF module configuration status", you can see whether an online plugged module matches the module in the MultiFieldbus project.

Diagnostic buffer

Under "Diagnostic buffer", you can see the content of the diagnostic buffer.

4.3.2 Reading hardware interrupts via event interface

Hardware interrupts are reported on Modbus TCP via the IDS data status and event information. The IDS data status and event information processes the following tasks via acyclic data requests:

- Reading of interrupt information
- Sending of acknowledgements

Notification of hardware interrupts

Field	Bit number	Bit mask	Default	Bit value = '0'	Bit value = '1'
ProcessEvent	1	0x02	0	No process event	Process event available

Reading RALM via the GetAlarmInformation service

A confirmation is made by reading RALM via the GetAlarmInformation service of the event interface. The resulting event data corresponds to the PRAL event information in the table.

Event information (PRAL)			Big Endian	Read access
Byte offset	**Field**	**Size**	**Default**	**Description**
0x0000	VersionHigh	Unsigned8	0x01	Main event of event interface (PRAL)
	VersionLow	Unsigned8	0x00	Sub-event of event interface (PRAL)
0x0002	EventType	Unsigned16	0x0002	PRAL
0x0004	Sequence-Counter	Unsigned16	0x0000	Increases with each event
0x0006	BlockLength	Unsigned16		Number of bytes for the following section
0x0008	USI	Unsigned16		Event structure type
0x000A ... 0x00F5	EventData	Byte [236]		

Data record response for USI 0x0001

The following table explains the data record response structure for USI 0x0001 with a length of 4 bytes.

Bits	Field	Description
16 ... 31	User Structure Identifier (USI)	0x0001
0 ... 1	Event	Event that triggered the hardware interrupt: 0x1: Rising edge 0x2 Falling edge
8 ... 11	Channel	Triggering channel 0x0 ... 0xF

Data record response for USI 0x8320

The following table explains the data record response structure for USI 0x8320 with a length of 14 bytes.

Bits	Field	Description
2 bytes	User Structure Identifier (USI)	0x8320
2 bytes	ChannelNumber	0x8000 (entire submodule)
2 bytes	PRAL_ChannelProperties	Value: 0x0000 Accumulative: 0x00 (individual) Direction: 0x00 (manufacturer-specific)
2 bytes	PRAL_Reason	0x9500 for event code: 0x0000 ... 0x7FFF 0x9501 for event code: 0x8000 ... 0xFFFF
2 bytes	PRAL_ExtReason	0x0001 ... 0x7FFF (event code)
4 bytes	PRAL_ReasonAddValue	0x0000 0000

4.3.3 PULL/PLUG event modbus TCP

The PULL/PLUG event is only supported by the MultiFieldbus IO-Link master.

With a correctly connected and parameterized submodule, the MF IO-Link master makes the configuration and parameterization available to the submodule.

PULL/PLUG event for modbus TCP

The PULL interrupt and PLUG interrupt is communicated to the controller by the data status.

PULL interrupt:
The PULL interrupt is triggered when a parameterized module is pulled. The PULL interrupt is triggered via the problem bit and the diagnostic bit in the data status.

PLUG interrupt:
The PLUG interrupt is triggered if the parameterization in the MF IO-Link master is not identical to the plugged module. The PLUG interrupt is triggered via the problem bit and the diagnostic bit in the data status.

Reset:
If the submodule meets the following properties, the interrupt is reset:

- Correctly connected
- Correctly configured
- Ready for cyclic communication

The following table shows the coding of the status bytes for IDS and ODS:

Field	Bit number	Bit mask	Default	Bit value = '0'	Bit value = '1'
Problem	6	0x40	0	Initial status	Module problem: • Module not plugged • Incorrect module plugged • Module with incorrect parameter assignment

4.3.4 Reading service data

In the "Home" tab, you can read out and store the service data provided by an MF device under "Read service data":

1. Click the "Start scan" button to find MF devices via the preset network interface.
2. Select an MF device.

   (You can make the LEDs of the MF device flash for identification with "Flash LED".)
3. Select the path to the location where you want to save the service data under "Service data output path".
4. Click the "Start" button.

The service data is saved under the selected path.

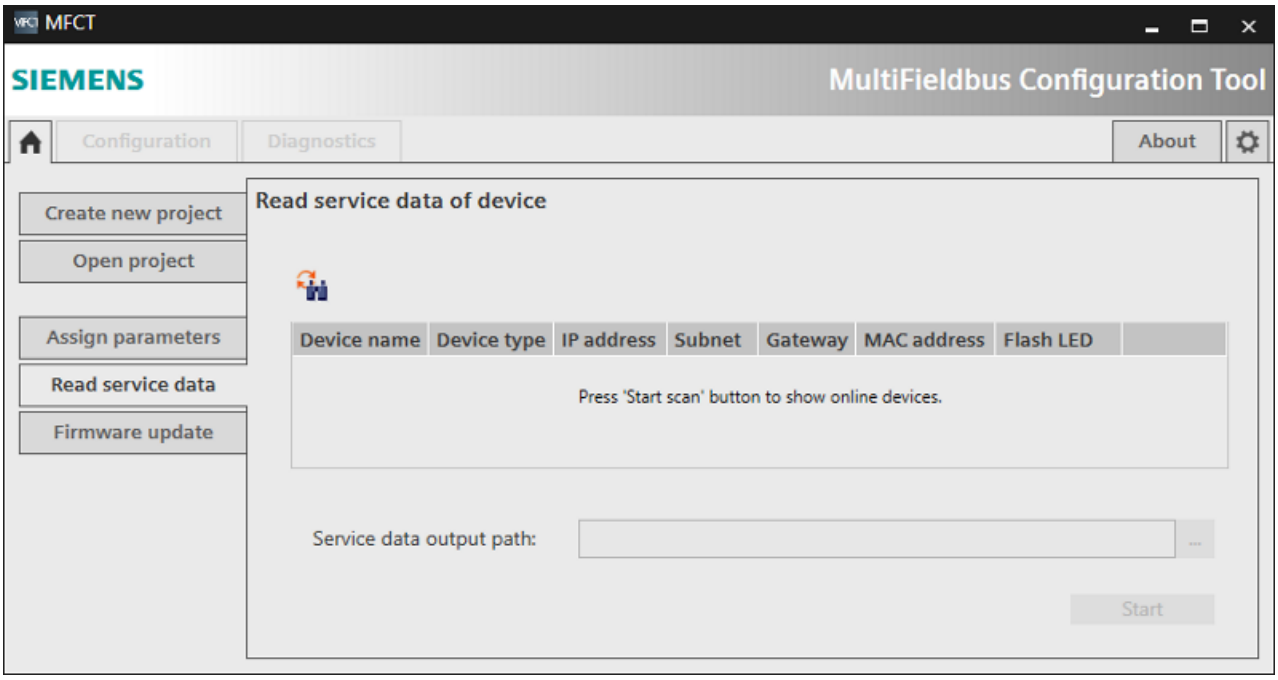

MF Shared Device

5

The "MF Shared Device" function lets you use various fieldbuses in a station. You select the fieldbus you want to use for each module in MFCT.

The System Manual or Equipment Manual of the MF device used describes how many connections and fieldbuses are supported at the same time.

This gives you the option to use, for example, F-modules that communicate via PROFIsafe with an F-CPU in a station. You configure and program the F-modules and the F-CPU in the TIA Portal with STEP 7 Safety.

For information on the maximum amount of I/O data, refer to the Device Manuals of the MF devices that support the MF Shared Device function.

The download size contains the I/O data of all EtherNet/IP and Modbus TCP connections as well as additional bytes for controlling the download.

NOTE

To avoid temporarily exceeding the I/O quantity structure, you must proceed as follows for a reconfiguration that results in changed I/O lengths:

1. Reduce the amount of I/O data in one configuration and download it to the MF device/CPU.
2. Increase the amount of I/O data in another configuration and download it to the MF device/CPU.

Multiple Modbus TCP connections

Several TCP connections (sockets) to the same *register area* for I/O data (e.g. for fieldbus connection ModbusTCP #0) can be established from a Modbus TCP controller to extend the area of the register addresses for input/output addresses.

The *register area* for I/O data of different fieldbus connections (e.g. ModbusTCP #0 and ModbusTCP #1) cannot be accessed within a TCP connection (socket).

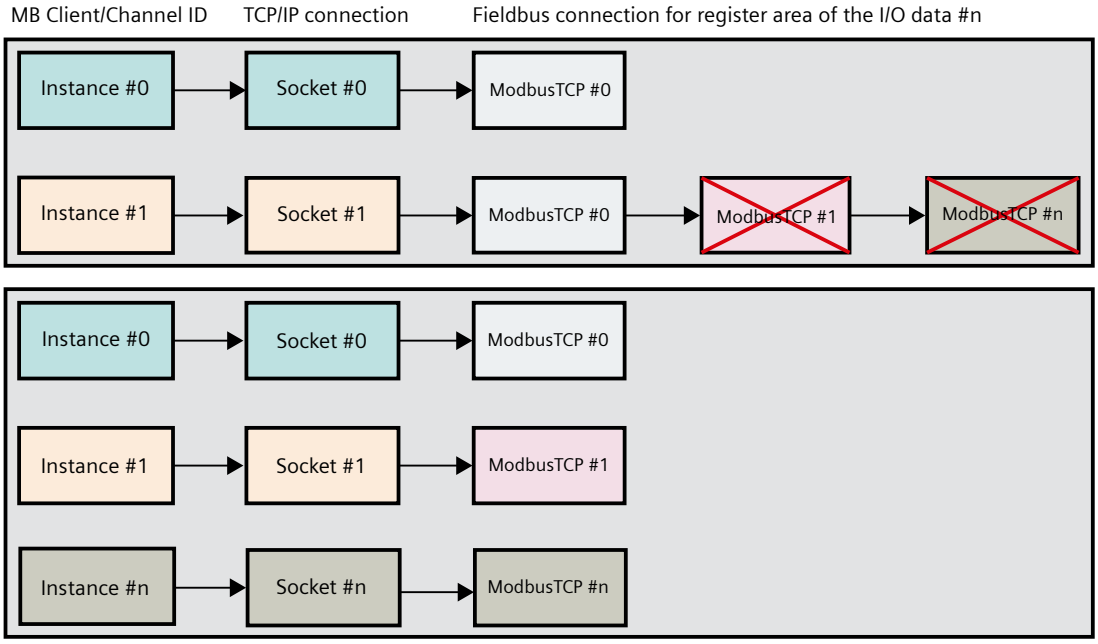

Figure 3-780 Example of multiple Modbus TCP connections

5.1 Configuration

Introduction

You parameterize modules you want to use with EtherNet/IP (Page 23) and Modbus TCP (Page 75) in MFCT.

Modules that are to be operated with PROFINET must be configured separately in the TIA Portal. You can find more information in the TIA Portal help.

Requirements

- MFCT V1.3 and higher
- A MultiFieldbus project is created in MFCT
- When PROFINET is to be used for MF Shared Device mode, a project must be created in the TIA Portal.

Configuring in MFCT

1. Configure the modules in MFCT.
2. In MFCT, enable the "MF Shared Device" function for the MF Device.

   In this way, you can select the fieldbus at each submodule separately.
3. Parameterize modules that you want to use with EtherNet/IP (Page 12) and Modbus TCP (Page 65). Select "PROFINET" for modules that you configure separately in the TIA Portal.
4. Parameterize the desired fieldbus and the controller connection for the modules under "Fieldbus connection".
5. Transfer the MultiFieldbus project to the MF Device.

NOTE

In case of high utilization of the MF Device or too little network bandwidth, the services of the fieldbus selected on the interface module are prioritized. Services of other fieldbuses may be delayed or fail in heavy load scenarios.

Configuring in the TIA Portal

1. Configure the MF Device in the TIA Portal.
2. Configure all modules in the TIA Portal.
3. In the TIA Portal, configure the modules you want to use with PROFINET.
4. In the TIA Portal, configure the modules that use EtherNet/IP or Modbus TCP in the properties of the interface module under "Shared Device" with the IO Controller deselected.
5. Configure the correct potential groups in the TIA Portal.

NOTE

Shared device conflicts between PROFINET and EtherNet/IP or Modbus TCP can be solved by:

- POWER OFF/POWER ON or
- Disconnection of active PROFINET connections to the MF Device, download of the MultiFieldbus project again and re-establishment of PROFINET connections.

NOTE

You can prevent shared device conflicts by first deregistering modules on the old fieldbus and then registering them on the new fieldbus.

Example:

1. Deselect the CPU for the module in TIA Portal.
2. Download the hardware configuration to the CPU,
3. Select EtherNet/IP as the fieldbus for the module in MFCT.
4. Download to the MF Device with MFCT.

5.2 Example

The following example shows you the configuration with one connection each via PROFINET (PROFIsafe), EtherNet/IP and Modbus TCP. The connection via PROFINET (PROFIsafe) is supposed to have the highest priority.

Configuring in MFCT

In this example, the DI module is to be addressed via Modbus TCP and the DQ module via EtherNet/IP. To do so, enable the "MF Shared Device" function in the parameters of the interface module.

Multi fieldbus features	
Parameter	**Value**
MF Shared Device	☑

Next, you can select the fieldbuses and the controller connection in the module parameters.

Slot	Name	Type	Article number	Fieldbus connection
0	IM 155-6 MF HF V5.2	InterfaceModule	6ES7 155-6MU00-0CN0	PROFINET
0.1	IM 155-6 MF HF V5.2			
0.2				
0.3				
0.4				
1	DI 16x24VDC ST V0.0	Digital	6ES7 131-6BH01-0BA0	EtherNet/IP #0 (0x301, 0x300)
2	DQ 16x24VDC/0.5A BA V0.0	Digital	6ES7 132-6BH00-0AA0	ModbusTCP #0 (0x000, 0x2D0)
3	F-DI 8x24VDC HF, BP	FDigital	6ES7 136-6BA00-0CA0	PROFINET
4	F-DQ 8x24VDC/0.5A PP HF, BP	FDigital	6ES7 136-6DC00-0CA0	PROFINET
5	Server module V1.2 (0 bytes)	ServerModule	6ES7 193-6PA00-0AA0	PROFINET

Configuring in the TIA Portal

In this example, the two F-modules are to be used by an F-CPU via PROFINET (PROFIsafe).

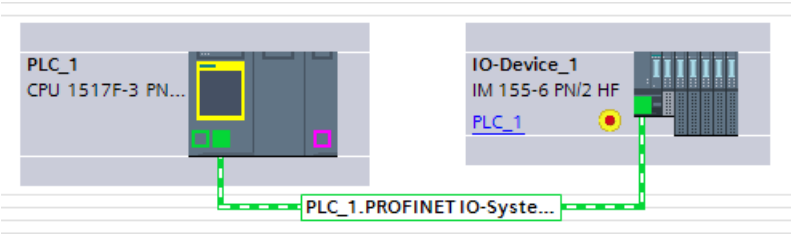

Configure the interface module IM 155-6 PN HF and the (F) modules in the TIA Portal.

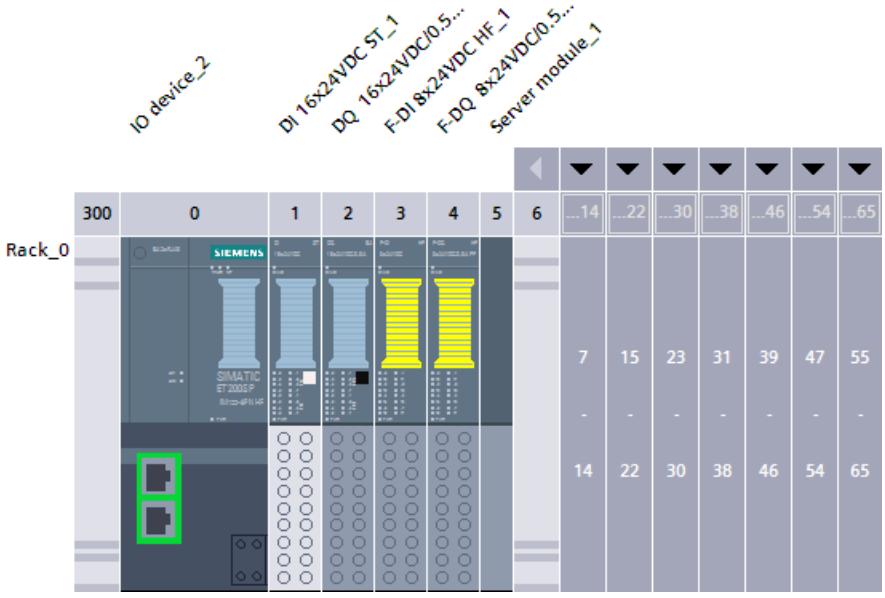

In the settings of the interface module, disable access by the IO controllers to the modules, which you access with EtherNet/IP and Modbus TCP.

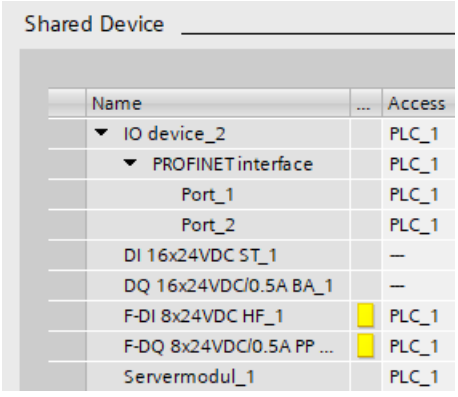

Firmware update with MFCT

6

For a firmware update, you can load the new firmware and update the loaded firmware at different times.

This means you can download the firmware during operation to multiple MF devices and modules. The MF devices and modules continue their operation uninterrupted. You can then activate the update of the new firmware with MFCT during a planned maintenance break.

By performing the time-consuming loading during operation, you reduce the downtimes of your plant.

You can also use the option "Automatically activate firmware after download" to select whether you want to update the firmware after the download.

6.1 Settings

You can set the speed of the network scanner in the settings.

The default setting is 100 Mbps.

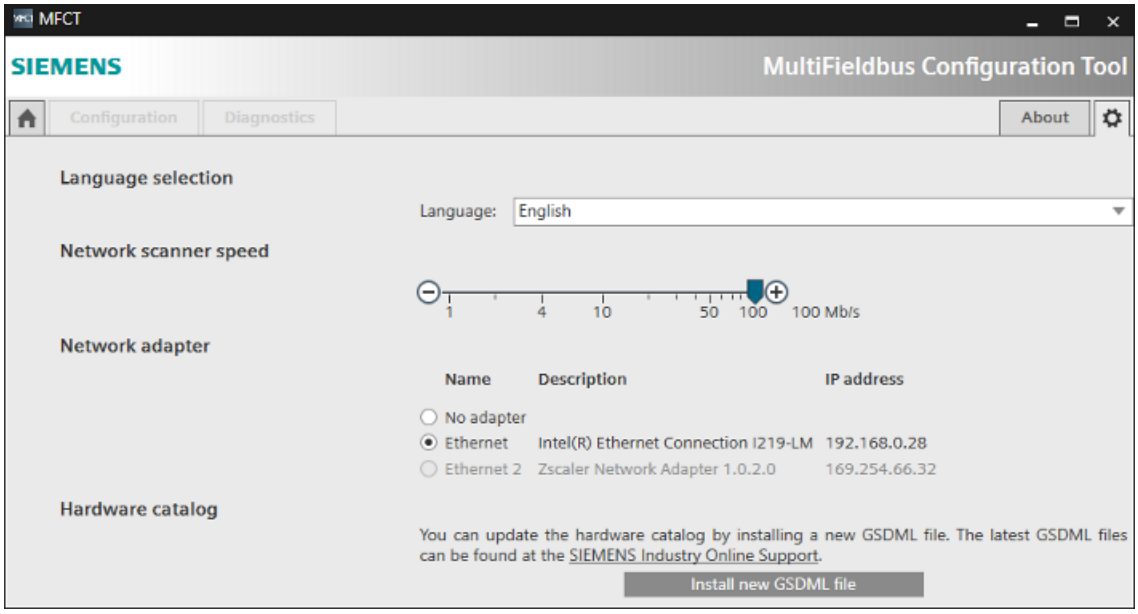

In the case of networks with high network load we recommend reducing the speed of the network scanner before the firmware update.

A firmware update of more than 20 devices results in a network load of approx. 3 Mbps.

6.2 Updating the firmware

Requirements

NOTE

We recommend that you do not connect directly to the MF device that you want to update. The activation of the new firmware can lead to a loss of the scanned MF devices due to a brief interruption of the network connection at the network adapter.

Procedure

You can update the firmware of MF devices and modules in the "Home" tab under "Firmware update":

1. Click the "Start scan" button to find MF devices via the preset network interface.

   All MF devices and lower-level modules whose firmware you can update are displayed.

2. Select the firmware files (*.upd) for the update:

   – You can select the appropriate firmware file for each MF device with "Select firmware file".

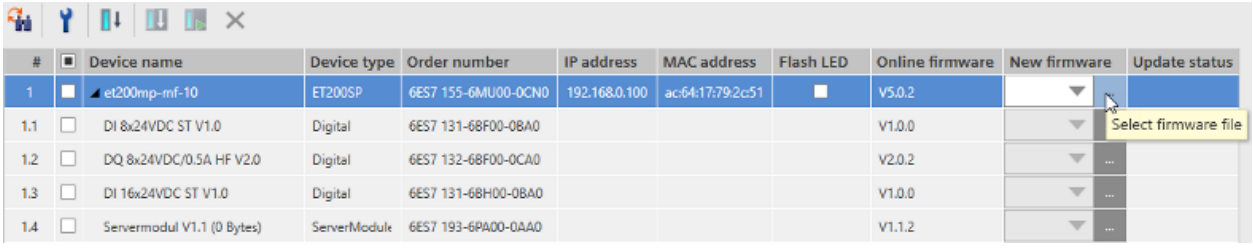

#	Device name	Device type	Order number	IP address	MAC address	Flash LED	Online firmware	New firmware	Update status
1	et200mp-mf-10	ET200SP	6ES7 155-6MU00-0CN0	192.168.0.100	ac:64:17:79:2c:51		V5.0.2		
1.1	DI 8x24VDC ST V1.0	Digital	6ES7 131-6BF00-0BA0				V1.0.0		
1.2	DQ 8x24VDC/0.5A HF V2.0	Digital	6ES7 132-6BF00-0CA0				V2.0.2		
1.3	DI 16x24VDC ST V1.0	Digital	6ES7 131-6BH00-0BA0				V1.0.0		
1.4	Servermodul V1.1 (0 Bytes)	ServerModule	6ES7 193-6PA00-0AA0				V1.1.2		

   If you are using a STEP 7 FW update file (recommended), select the file header.upd.

   – You can select a directory with "Firmware update settings".

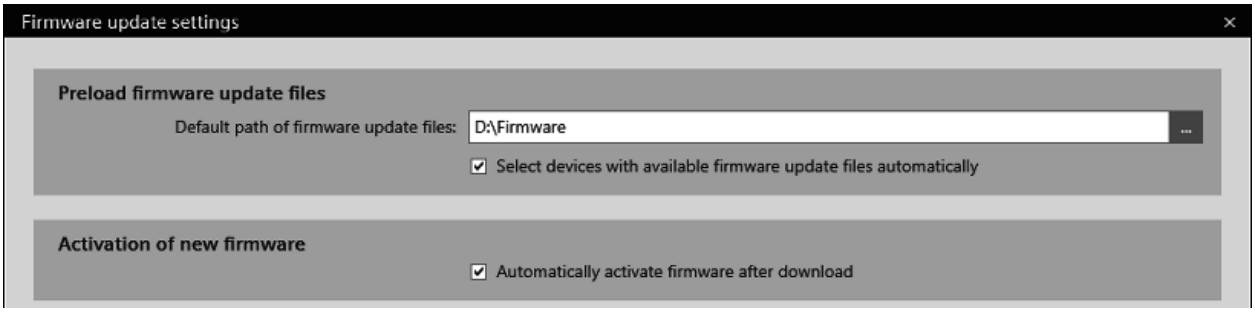

When you activate the option "Automatically activate firmware after download", the firmware is automatically activated after the download.

NOTE

Select a directory which contains subdirectories with firmware files.

If large directories, entire hard disks (for example C:\) or directories are selected on network drives, the corresponding access can take very long or MFCT can no longer react.

Then, click "OK".

The latest suitable firmware file is automatically selected for the scanned MF devices.

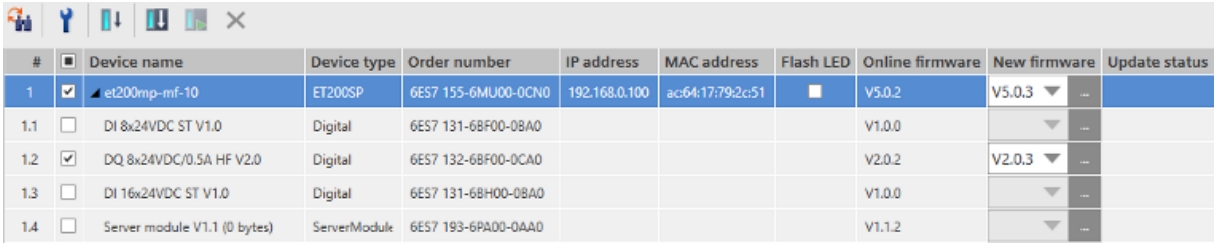

#		Device name	Device type	Order number	IP address	MAC address	Flash LED	Online firmware	New firmware	Update status
1	☑	et200mp-mf-10	ET200SP	6ES7 155-6MU00-0CN0	192.168.0.100	ac:64:17:79:2c:51	☐	V5.0.2	V5.0.3	
1.1	☐	DI 8x24VDC ST V1.0	Digital	6ES7 131-6BF00-0BA0				V1.0.0		
1.2	☑	DQ 8x24VDC/0.5A HF V2.0	Digital	6ES7 132-6BF00-0CA0				V2.0.2	V2.0.3	
1.3	☐	DI 16x24VDC ST V1.0	Digital	6ES7 131-6BH00-0BA0				V1.0.0		
1.4	☐	Server module V1.1 (0 bytes)	ServerModule	6ES7 193-6PA00-0AA0				V1.1.2		

3. Select the MF devices and modules whose firmware is to be downloaded. All MF devices and modules are selected by default.
4. Start the download of the firmware files to the selected MF devices and modules with "Update firmware".

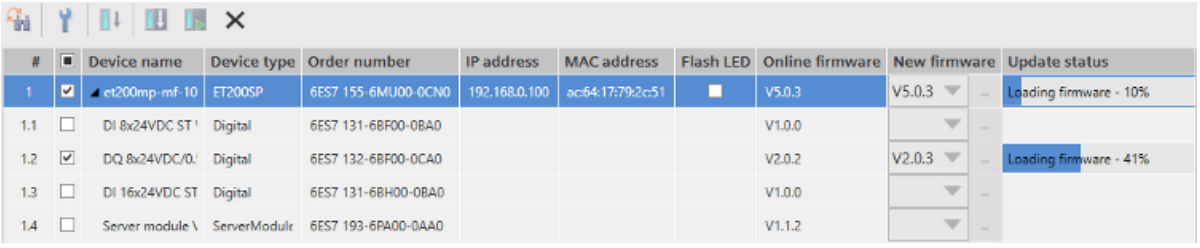

#		Device name	Device type	Order number	IP address	MAC address	Flash LED	Online firmware	New firmware	Update status
1	☑	et200mp-mf-10	ET200SP	6ES7 155-6MU00-0CN0	192.168.0.100	ac:64:17:79:2c:51	☐	V5.0.3	V5.0.3	Loading firmware - 10%
1.1	☐	DI 8x24VDC ST	Digital	6ES7 131-6BF00-0BA0				V1.0.0		
1.2	☑	DQ 8x24VDC/0.	Digital	6ES7 132-6BF00-0CA0				V2.0.2	V2.0.3	Loading firmware - 41%
1.3	☐	DI 16x24VDC ST	Digital	6ES7 131-6BH00-0BA0				V1.0.0		
1.4	☐	Server module \	ServerModule	6ES7 193-6PA00-0AA0				V1.1.2		

You can cancel the download at any time with the "Cancel" button.

NOTE

If you cancel the download of the firmware in the "Initialization" or "Waiting" phase, it takes a few minutes until the MF devices are ready again and you can restart the download.

5. Activate the downloaded firmware as described under "Activating the firmware (Page 108)".

NOTE

The number of MF devices and modules that can be loaded simultaneously is not restricted.

From experience, a simultaneous download to 60 MF devices with firmware <V3.3.0 takes approximately one hour.

6.3 Updating firmware in multiple subnets

To update the firmware in multiple subnets, follow these steps:

1. Open the settings for the firmware update in the "Home" tab under "Firmware update".
2. Under "Scan options", select "Subnet scan".
3. For each subnet enter the IP address, the subnet mask and the gateway address, and add the subnet to the list with "Add".
4. Exit the dialog with "Ok".
5. Proceed as described under "Updating the firmware (Page 105)".

NOTE

Assign a static IP address, the address for the gateway and a device name for each MF Device.

Comments

We recommend activating the "Use router" option for CPUs in the project in the TIA Portal.

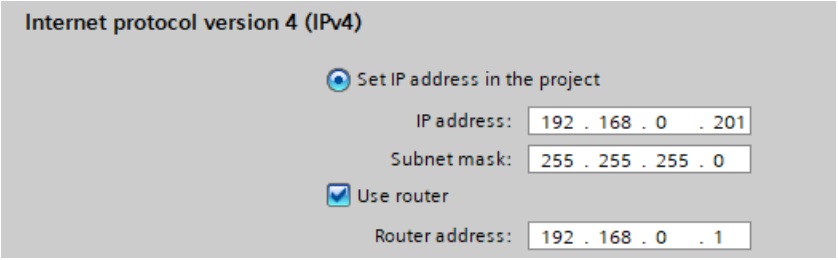

When the router is connected to interface X1 of the CPU and the rest of the topology in which, for example, the ET 200SP is located is connected to interface X2, activate the option "Enable IPv4 forwarding for interfaces of this PLC" for the CPU in the TIA Portal.

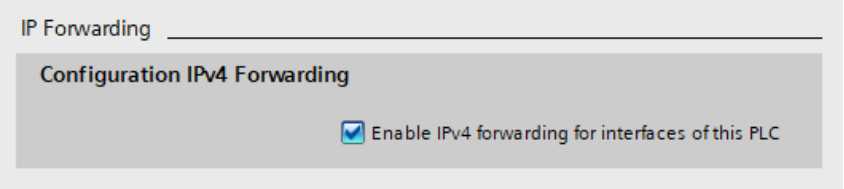

Example of multiple subnets

The figure below shows an example of a topology with multiple subnets.

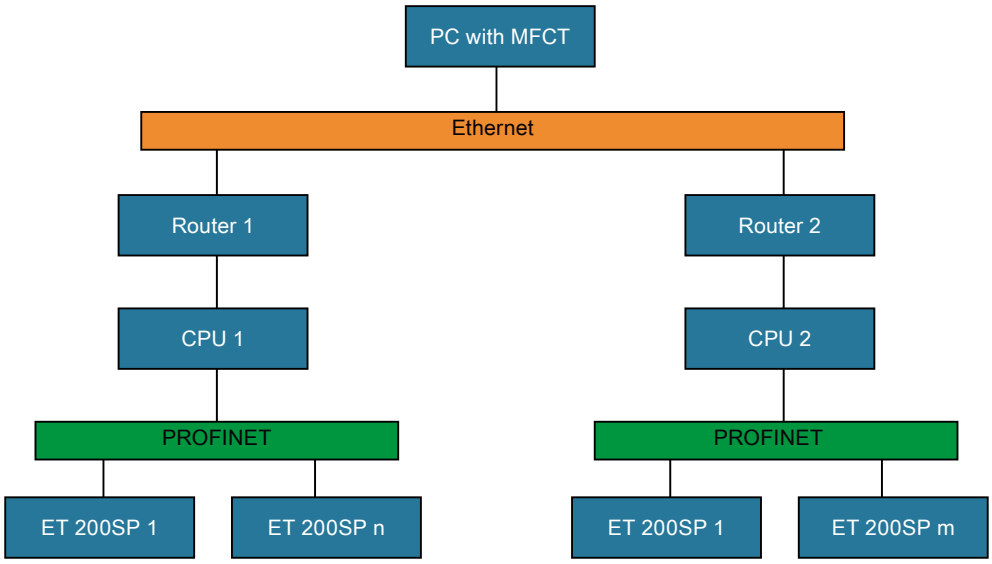

6.4 Activating the firmware

The new firmware is not active yet once the firmware update has been successfully performed. You can activate the firmware later on the MF device or module.

Requirements

We recommend setting the CPU to STOP.

Procedure

You can recognize MF devices and modules with updated firmware that has not been activated yet in the device table by scanning again.

Proceed as follows to activate the firmware:

1. Select the MF devices or modules whose firmware you want to activate.
2. Click the "Activate firmware" button.

The firmware of the selected MF devices or modules is activated one after the other.

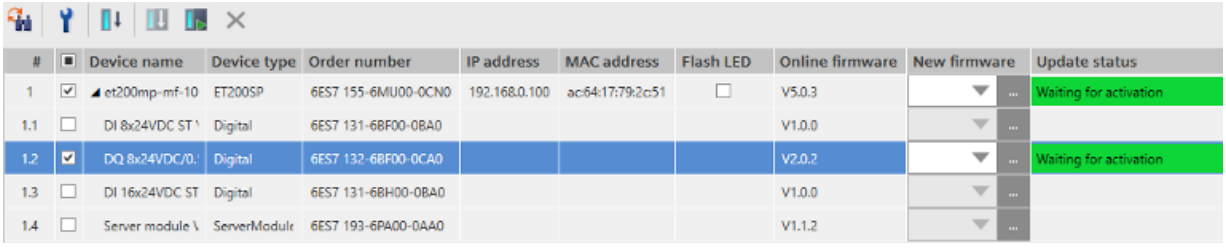

#		Device name	Device type	Order number	IP address	MAC address	Flash LED	Online firmware	New firmware	Update status
1	☑	et200mp-mf-10	ET200SP	6ES7 155-6MU00-0CN0	192.168.0.100	ac:64:17:79:2c:51	☐	V5.0.3		Waiting for activation
1.1	☐	DI 8x24VDC ST	Digital	6ES7 131-6BF00-0BA0				V1.0.0		
1.2	☑	DQ 8x24VDC/0.	Digital	6ES7 132-6BF00-0CA0				V2.0.2		Waiting for activation
1.3	☐	DI 16x24VDC ST	Digital	6ES7 131-6BH00-0BA0				V1.0.0		
1.4	☐	Server module	ServerModule	6ES7 193-6PA00-0AA0				V1.1.2		

If activation fails, scan the network again.

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MultiFieldbus Configuration Tool (MFCT)

Configuration Manual

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Introduction 1

Purpose of this documentation

This documentation provides important information on the following topics:

- Description of the MultiFieldbus Configuration Tool (MFCT)
- Configuring and commissioning MultiFieldbus devices on fieldbuses, for example, EtherNet/IP and Modbus TCP.

The configuration manual supplements the description of the system manuals and equipment manuals of the MultiFieldbus devices.

Basic knowledge required

The following knowledge is required to understand the document:

- General knowledge of automation engineering
- Knowledge of the SIMATIC industrial automation system
- Knowledge of the use of Microsoft Windows computers
- Knowledge of PROFINET, EtherNet/IP, Modbus TCP

Scope of this documentation

This documentation is the basic documentation for the MFCT. The product documentation is based on the content of this Configuration Manual.

Conventions

The MultiFieldbus Configuration Tool is referred to in this documentation as MFCT.

This documentation contains illustrations of the MFCT user interface. The illustrations may differ in detail from the current version of the MFCT.

You should also pay particular attention to notes such as the one shown below:

NOTE

A note contains important information on the product, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Open Source Software

Open Source Software is used in the MFCT. The open-source software is provided free of charge. Siemens AG is liable for the product described, including the Open Source Software contained in it, pursuant to the conditions applicable to the product. Any and all liability is excluded:

- For use of the Open Source Software beyond the program sequence intended for the product by Siemens
- For defects caused by changes to the software

For legal reasons, Siemens AG is obliged to publish the original text of the license conditions and copyright notices from the third-party software contained in this product.
You can find the corresponding file with the above-mentioned information in the SiePortal in the section Information on third-party products, license conditions and OSS sources (https://support.industry.siemens.com/cs/ww/en/view/109773881).

1.1 Reference documents

The following list contains additional documentation that supplements this Configuration Manual:

Topic	Link to the documentation
MultiFieldbus topic page	MultiFieldbus - an overview of the most important documents and links (https://support.industry.siemens.com/cs/us/en/view/109779189)
MultiFieldbus Configuration Tool (MFCT) topic page	MultiFieldbus Configuration Tool (MFCT) (https://support.industry.siemens.com/cs/us/en/view/109773881)
SIMATIC MultiFieldbus	SIMATIC MultiFieldbus Function Manual (https://support.industry.siemens.com/cs/us/en/view/109773209)
Communications module DALI	Equipment manual SIMATIC ET 200SP ET 200SP communications module CM 1xDALI (https://support.industry.siemens.com/cs/us/en/view/109769428)
Technology module TM FAST	TM FAST Equipment Manual (https://support.industry.siemens.com/cs/us/en/view/109816087)
SIWAREX WP321	Operating instructions SIWAREX WP321 (https://support.industry.siemens.com/cs/us/en/view/109770838)
CM PtP module	CM PtP - Configurations for point-to-point connections Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59057093)
SIMATIC ET 200SP Distributed I/O System	SIMATIC ET 200SP System Manual (https://support.industry.siemens.com/cs/us/en/view/58649293)

Topic	Link to the documentation
SIMATIC S7-1500/ET 200MP Automation System	SIMATIC S7-1500/ET 200MP System Manual (https://support.industry.siemens.com/cs/us/en/view/59191792)
SIMATIC ET 200AL Distributed I/O System	SIMATIC ET 200AL System Manual (https://support.industry.siemens.com/cs/us/en/view/89254965)
SIMATIC ET 200clean	SIMATIC ET 200clean System Manual (https://support.industry.siemens.com/cs/ww/en/view/109822889)
SIMATIC ET 200eco PN Distributed I/O System	SIMATIC ET 200eco PN System Manual (https://support.industry.siemens.com/cs/us/en/view/109778292)
SIMATIC Bus links PN/MF Coupler	Installation and Operating Manual PN/MF Coupler (https://support.industry.siemens.com/cs/us/en/view/109781406)

Safety instructions 2

2.1 General security instructions

Read the security-related information provided in the corresponding system manual.

You can find cybersecurity-related information in the section Industrial cybersecurity (Page 9).

Industrial cybersecurity 3

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

Refer to the relevant system manual of the devices used for general information and measures regarding industrial cybersecurity.

This section provides an overview of security-related information for the MultiFieldbus Configuration Tool (MFCT).

3.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

3.2 Basic information on industrial cybersecurity

3.2.1 Definition of industrial cybersecurity

Industrial cybersecurity is generally understood to mean all measures to protect against the following threats:

- Loss of confidentiality due to unauthorized access to data
- Loss of integrity due to manipulation of data
- Loss of availability (e.g. due to the destruction of data or denial of service (DoS))

3.2.2 Objectives of industrial cybersecurity

The objectives of industrial cybersecurity are:

- Ensuring trouble-free operation of industrial systems and production processes
- Preventing threats to people and production from cybersecurity attacks
- Protection of industrial plants against espionage and manipulation
- Protection of industrial automation systems and components against unauthorized access and data loss
- Provision of a practical and cost-effective concept for securing existing systems and devices without their own security functions
- Use of existing, open and proven industrial cybersecurity standards
- Compliance with legal requirements

An optimized and adapted security concept applies to automation and drive technology. The security measures must not impede or endanger production.

3.3 Operational application environment and security measures

3.3.1 Intended use

The MFCT is a PC-based Microsoft Windows software for commissioning and configuring MultiFieldbus devices (MF devices). MFCT uses PROFINET communication for this. You can find information on communication protocols and the port numbers used for Ethernet communication in the Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925) function manual.

The software may be used only for the specific task in accordance with the relevant documentation, in particular its warning notices and security information.

Operational reliability and intended use

An MF device supports the following Ethernet-based protocols:

- PROFINET I/O (PN)
- EtherNet/IP (EIP)
- Modbus TCP (MTCP)

Communication between MFCT and an MF device does not cross network boundaries (e.g. to the customer network or the Internet).

Exception: If the IP forwarding option is enabled on devices within the system, data is forwarded to connected subnets or a configured router.

Area of application

You can use the MFCT to configure MF devices, e.g. for the following typical use cases:

- Mechanical engineering
- Tunnel applications
- Energy management

3.3.2 Requirements for the operational environment and security measures

Siemens recommends the following security measures:

- Threat and risk assessment (as part of security management)
- Network security concepts
  - Network segmentation
  - Asset and network management
  - Network protection
  - Remote access
  - Microsoft Windows access and protection mechanisms
- System protection
  - Consideration of security aspects in the selection of systems and components
  - Minimal assignment of rights for user management
- Access control concepts (utilizing access control systems)
  - Physical protection
  - Physical corporate security
  - Physical product security

Threat and risk assessment

Vulnerabilities and risks are identified, and countermeasures are proposed to ensure the security of the system, networks, and data.

Network security concepts

You can find information on network security in the whitepaper "Industrial Network Security Architecture", available at the Download Center (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security/downloads.html) on the Industrial cybersecurity (https://www.siemens.com/us/en/company/topic-areas/cybersecurity/industrial-security.html) website.

System protection

System protection depends heavily on the endangerment potential of the system operating entity and its infrastructure. The following measures provide extra protection against unauthorized access from external sources and through the network:

- Definition of security-specific guidelines and processes
- Consideration of security aspects in the selection of systems and components. This also relates to external service providers, commissioning and remote maintenance.
- Minimal assignment of rights for user management

Access control concepts

Physical protection

In addition to closing off and/or monitoring entire production facilities, it may be necessary to physically secure cabinets or even individual components such as circuit breakers.

Physical corporate security

You can ensure the physical corporate security by taking the following measures:

- Closed off and monitored company premises
- Access control, locks/card readers, and/or security personnel
- Accompaniment of non-employees by company personnel
- Employees are trained on and embrace security processes within the company

Physical production security

You can ensure physical production security by taking the following measures, including:

- Separate access control for critical areas, such as production zones.
- Installation of critical components in lockable cabinets/control rooms with monitoring and alarm capabilities. The cabinets/control rooms must be secured with a cylinder lock. Do not use simple locks, such as universal, triangular/square, or double-bit locks.
- Radio field planning to limit WLAN coverage areas, preventing them from extending beyond defined zones (e.g. factory floor).
- Guidelines that prohibit the use of external data storage media (such as USB flash drives) and IT devices (such as laptops) classified as unsecure on systems.

3.4 Security features of the MFCT

The MFCT does not require a setup program for installation. The application is downloaded as a zip file from the Internet and installed on the local drive by simply extracting the zip folder. The installation is now complete.

To check the integrity of the downloaded zip file, compare the checksum of the zip file to the checksum in SiePortal.

The "Standard user" role is sufficient for installing and using the MFCT in Microsoft Windows.

The MultiFieldbus Configuration Tool (MFCT) performs the following security checks itself:

- Checks the data integrity of the MFCT and the plug-ins
- Checks the files added by the user, e.g:
  - GSDML
  - GSDX
  - Project file
- Checks the preset security configuration
- Checks the signatures of the following file types:
  - exe file
  - dll files
  - gsdx containers

More information

You can find information on installing the MFCT in the section Installation (Page 24).

You can read how to compare the checksums in the following Internet article (https://support.industry.siemens.com/cs/ww/en/view/109483101).

3.5 Secure operation of the MFCT

This section describes measures recommended by Siemens to protect the MFCT and the connected devices against manipulation and unauthorized access.

Guidelines for secure operation

The following guidelines apply to the secure operation of the MFCT:

- Only use the original version that you have downloaded from the Internet. You can find the MFCT on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109773881).
  You can find information on installing the MFCT in the section Installation (Page 24).
- Do not mix files from different versions.
- Check regularly whether there are new versions of the MFCT available for download.
- Always use the latest version of the MFCT.
  You can find information on checking for updates in the section Update the MFCT installation (Page 24).

Dependencies on other software components

You can find the requirements for using the MFCT in the section System requirements (Page 21).

3.5.1 Security update notification

Setting up notification of security updates

To receive notifications about security updates, proceed as follows:

1. Register with mySiePortal (https://sieportal.siemens.com/en-ww/home/).
2. Enter the keyword "Security" in the search engine.
3. Choose the "Search in Knowledge base" option.
4. Select your product or product group in the "Product tree" filter menu, e.g. "Automation technology > Automation systems > SIMATIC industrial automation systems > IO systems".
5. Select the "Other types" option from the filter menu for "Type," and then choose "Download" and "Product note".
6. Select the document with which you want to create notifications.

   If you would like to be informed about changes to the MultiFieldbus Configuration Tool (MFCT), for example, select the entry "MultiFieldbus Configuration Tool (MFCT)".
7. Select "Add to my favorites" using the 3 dots on the right.
8. In the following dialog, select the name and storage location for the favorite. Activate the "Notify me" option for notifications.
   Then click the "+ Add to my favorites" button.

Result: You will be notified by email each time the document is changed.

Under "mySiePortal > Lists & notifications > My notifications", you can display your notifications and delete them if necessary.

3.5.2 Hardening measures

System hardening, also simply referred to as hardening, is the secure configuration of products or systems. The aim is to close security gaps and take various measures to reduce the attack surfaces for cyberattacks.

To minimize the attack surface for a cyber attack, only activate required plug-ins in the MFCT.

3.5.3 Access control

To control access to your system, set up logical protection in addition to physical protection. For example, use the Microsoft Windows access and protection mechanisms.

To be able to install and use MFCT on the PC, the "Standard user" user role is sufficient in Microsoft Windows.

3.5.4 Notifications about security vulnerabilities (Siemens Security Advisories)

A vulnerability is a security vulnerability in information security. It can pose a threat as it provides intruders with the opportunity to access system resources and manipulate or steal data. Many vulnerabilities allow availability to be impaired.

Siemens ProductCERT

If Siemens identifies or fixes security gaps (Vulnerabilities) in the products, this will be published in the Security Advisories.

You can find the documents for SIMATIC on the following Siemens AG Web page: Siemens ProductCERT and Siemens CERT (https://new.siemens.com/global/en/products/services/cert.html?s=SIMATIC#SecurityPublications)

"SIMATIC" is preset in the "Search Security Advisories" search field. You can also enter other product names or other terms in the search field and search for them.

On this page, you can also find all the required information on how to deal with vulnerabilities:

- Contact persons for matters related to vulnerabilities
- Options for automated notifications regarding vulnerabilities
- Notifications are also possible in CSAF format
- Option to subscribe to RSS feeds and newsletters
- List of all current vulnerabilities and detailed information such as:
  - Description
  - Classification according to Common Vulnerability Scoring System (CVSS)
  - Measures
  - Availability
  - Etc.

Set up Security feeds (https://www.siemens.com/cert) to receive notifications about security-related topics.

If you suspect or have discovered a vulnerability in a Siemens product, please inform us immediately. To do this, press the "Contact" button on the CERT Services page (https://www.siemens.com/cert) and follow the instructions.

3.5.5 Data backup

Secure your configuration and parameter settings so that you can quickly restore this data if needed. Do not use the MFCT file folder for data backup. Otherwise, this will delete your backed-up data when you switch to a newer version.

3.5.6 Secure uninstallation

If you want to remove the MFCT from your PC, delete the folder in which the MFCT is stored. Also delete any additional files created in your folders, e.g. configuration and parameter settings.

Since only one zip file was extracted to install the MFCT, no further step is required to uninstall it.

Description

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4.1 Area of application of the MFCT

The MFCT is a PC-based software for simple commissioning of MultiFieldbus devices on higher-level controllers within fieldbuses.

Main areas of application of the MFCT

The main area of application of the MFCT is in the following functions:

- Configuration of a MultiFieldbus device
- Bulk firmware update of ET 200 devices

Ethernet protocols supported by MultiFieldbus

The MultiFieldbus supports the following Ethernet protocols:

- PROFINET
- EtherNet/IP
- Modbus TCP

Additional plug-ins

You can also supplement the MFCT with the following plug-ins:

- DALI (Page 55)
  You use this plug-in to configure DALI devices.
- TM FAST (Page 78)
  You use this plug-in to create application update files for TM FAST modules or to load an application into a TM FAST module.
- SIWAREX (Page 82)
  You can use this plug-in to configure SIWAREX modules.
- PtP Event Trace (Page 88)
  You use this plug-in to do the following:
  - Read out event traces from a PtP module
  - Analyze serial communication
  - Display the current configuration of a PtP module

You can find more information on the plug-ins in the Plug-ins (Page 31) section.

4.2 Conditions for operating the MFCT

The following conditions should be met for the operation of the MFCT:

- **Commissioning:** The MF device must be connected via an Ethernet connection with 100 Mbps full duplex.
- **Network:** Only one instance of MFCT or PRONETA may be active per network.

NOTE

If PRONETA and MFCT are simultaneously active in the network, you must deactivate cyclic scanning in PRONETA.

- **Fieldbus:** MFCT can only be operated on the fieldbus, not from the system network via a CPU.

4.3 Operation with multiple subnets

In the general settings of the MFCT, select which devices you would like to scan. You can find information on the individual settings in the section General settings (Page 28).

Depending on the settings selected in the MFCT, the devices must be configured accordingly in the TIA Portal. Otherwise, the MFCT cannot establish a connection to the desired devices.

The figure below shows an example of a topology with multiple subnets. The PC with installed MFCT is in a different subnet than the MF devices.

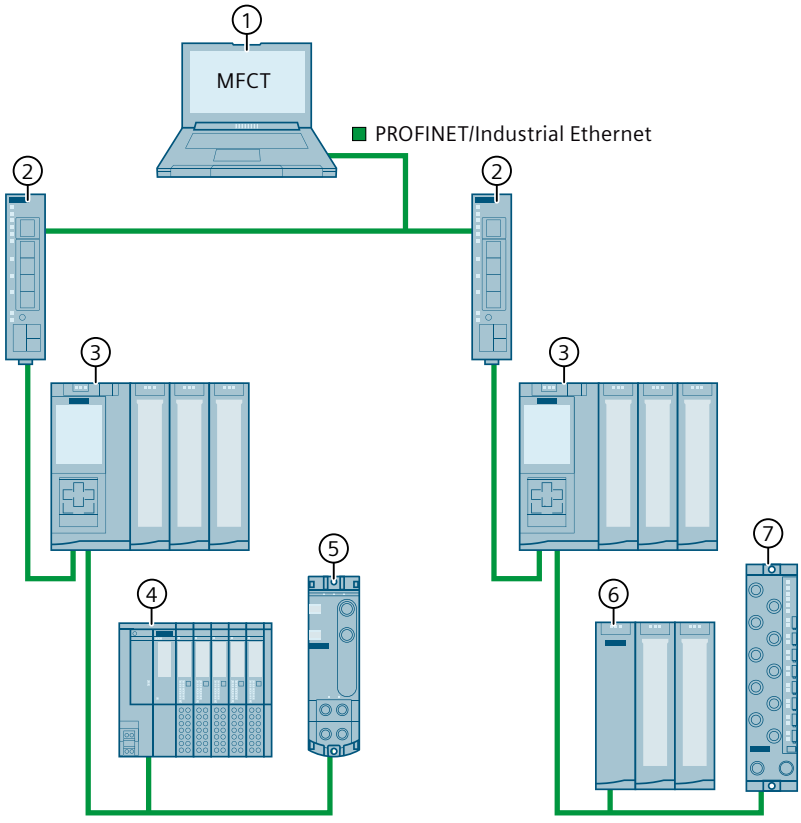

① PC with MFCT installed
② Router, e.g. SCALANCE S615
③ CPU, e.g. CPU1515-2 PN
④ MF device ET 200SP IM 155-6 MF HF
⑤ MF device ET 200AL IM 157-1 MF
⑥ MF device ET 200MP IM 155-5 MF HF
⑦ MF device ET 200eco PN

4.3.1 Recommended settings for operating the MFCT

Settings when using routers

Routers have the task of connecting IP subnets. If the MFCT is to search for MF devices in other subnets, the MFCT is first forwarded to the router. To be able to reach the devices in the other subnet, you need to enter the address of the router for each desired device.

The IP address of a device in the subnet and the IP address of the router may only be different in the places where the subnet mask contains "0".

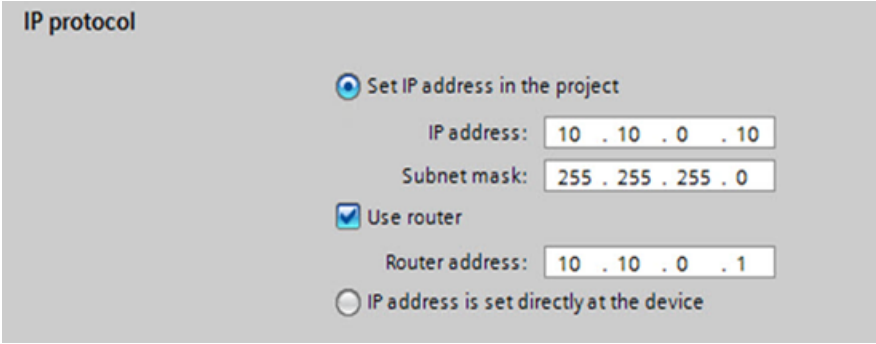

Settings for the IPv4 forwarding configuration

If the router is connected to interface X1 of the CPU and the rest of the topology is connected to interface X2, select the "Enable IPv4 forwarding for interfaces of this PLC" check box in the TIA Portal for the CPU.

More information

You can more find information on the setting options in the TIA Portal online help, for example.

Software installation 5

In the following sections, you can find all the software information required for trouble-free operation of the MFCT.

More information

You can find more information on MFCT and the current system requirements on the Internet (https://support.industry.siemens.com/cs/us/en/view/109773881).

5.1 System requirements

5.1.1 Operating systems

To operate the MFCT, you need Microsoft Windows. Install one of the following operating systems to operate the MFCT. The installation of Microsoft .NET Framework 4.8 must be supported.

NOTE

The ability of MFCT to run on all other operating systems is not ensured. The use of any other operating system is at your own risk.

- Microsoft Windows 10 (32/64-bit)
  - Microsoft Windows 10 Home
  - Microsoft Windows 10 Pro
  - Microsoft Windows 10 Enterprise
  - Microsoft Windows 10 (IoT) Enterprise 2016 LTSB
  - Microsoft Windows 10 (IoT) Enterprise 2019 LTSC (for IPC/PG)
  - Microsoft Windows 10 Enterprise 2021 LTSC
- Microsoft Windows 11 (32/64-bit)
  - Microsoft Windows 11 Home
  - Microsoft Windows 11 Pro
  - Microsoft Windows 11 Enterprise
- Microsoft Windows Server (32/64-bit)
  - Microsoft Windows Server 2016
  - Microsoft Windows Server 2019
  - Microsoft Windows Server 2022

NOTE
Security patches from Microsoft
To ensure secure operation, make sure that the security patches from Microsoft are installed promptly.

5.1.2 Additional software components

To use the MFCT, also install the following software:

- Microsoft .NET Framework 4.8

  Use the Offline installer (https://support.microsoft.com/de-de/topic/microsoft-net-framework-4-8-offline-installer-f%C3%BCr-windows-9d23f658-3b97-68ab-d013-aa3c3e7495e0) to install it.
- The npcap-x.xx-oem.exe file from the folder "MFCT_xx.xx.xx.xx_xx.xx > Npcap > Misc"
  You can find the "Misc" folder in the unzipped folder of the MFCT.

Optional software installations:

- PG/PC Interface from the "Misc" folder
- Microsoft Visual C++ Redistributable Package (x86)

5.1.3 Security programs

To protect the software from unwanted manipulation, use the following security programs.

NOTE

Promptly perform updates available security programs.

Overview of virus scanners

The following virus scanners have been tested for compatibility with the systems:

- Trend Micro OfficeScan V12.0.6040 Service Pack 1
- Avira Security V1.1.86.3
- Trend Micro Apex One V14.0.12902

You can run these antivirus programs in the default setting.

Encryption software: BitLocker

BitLocker is a Windows security feature that protects your data by encrypting your drives. This encryption ensures that anyone attempting to access a data storage medium offline cannot read any of its contents.

5.1.4 Virtualization platforms

You have the option of operating the MFCT in a virtual machine (VM)

Use the following virtualization software:

- VMware vSphere Hypervisor ESXi ≥ 6.5
- VMware Workstation ≥ 15.5.0
- VMware Workstation Player ≥ 15.5.0
- Microsoft Hyper-V Server ≥ 2016

NOTE

Hardware certified by the manufacturer is recommended for the use of the following virtualization software:

- VMware vSphere Hypervisor ESXi
- Microsoft Hyper-V Server

Guest operating systems for virtualization software

Use the following guest operating systems within the selected virtualization software:

- Microsoft Windows 10 Pro (32/64-bit)
- Microsoft Windows 11 Pro (32/64-bit)

There could be restrictions with the online functions.

NOTE

The plant operator must ensure that sufficient system resources are provided for the guest operating systems.

5.2 Installation

The MFCT is provided as a portable application. To install the MFCT, proceed as follows:

1. Download (https://support.industry.siemens.com/cs/us/en/view/109773881) the MFCT as a zip file from the Internet.
2. To check the integrity of the downloaded zip file, compare the checksum of the zip file to the checksum in SiePortal.

   You can find instructions for comparing the checksums in the following FAQ on the online support page (https://support.industry.siemens.com/cs/ww/en/view/109483101).
3. If both checksums match, extract the downloaded zip file to a local drive on your PC.

Result: You have completed the installation. The MFCT is installed on your PC. Start the MFCT by double-clicking the "MFCT.exe" file in the extracted folder.

5.3 Update the MFCT installation

Always use the latest version of the MFCT.

To check whether a new version is available, proceed as follows:

1. Open the MFCT.
2. Open the "About" tab.
   You can find information about the installed version in the "Version information" area.
3. Click the "Check for updates" button.
   The MFCT checks whether a new version is available in SiePortal.

Result: You are notified if a new version is available. Otherwise, the MFCT indicates below the release date that your installation is up-to-date.

Optionally, you can select the "Check on startup" check box to have the MCFT automatically check for updates on each startup of the application.

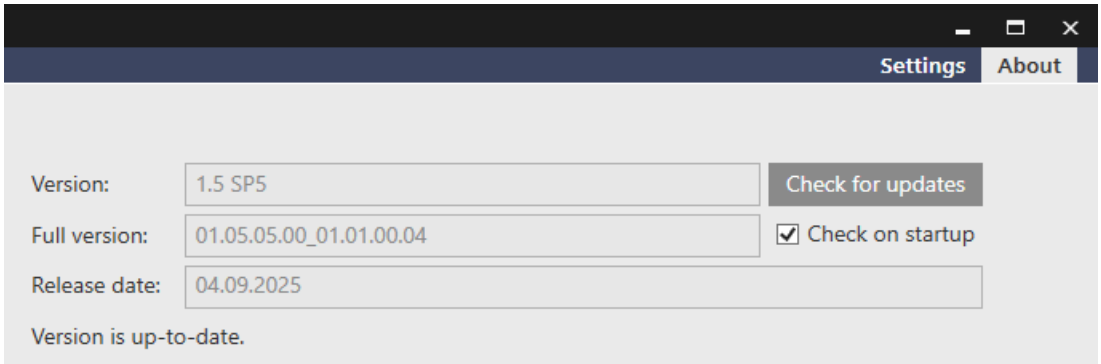

More information

You can find more information on the "About" tab in the section Information on the "About" tab (Page 26).

Functions

6

6.1 Information on the "About" tab

After opening the MFCT, you can find the "About" tab on the right. You can find the following information there:

- Version information
- Copyright
- User feedback

The figure below shows the contents of the "About" tab.

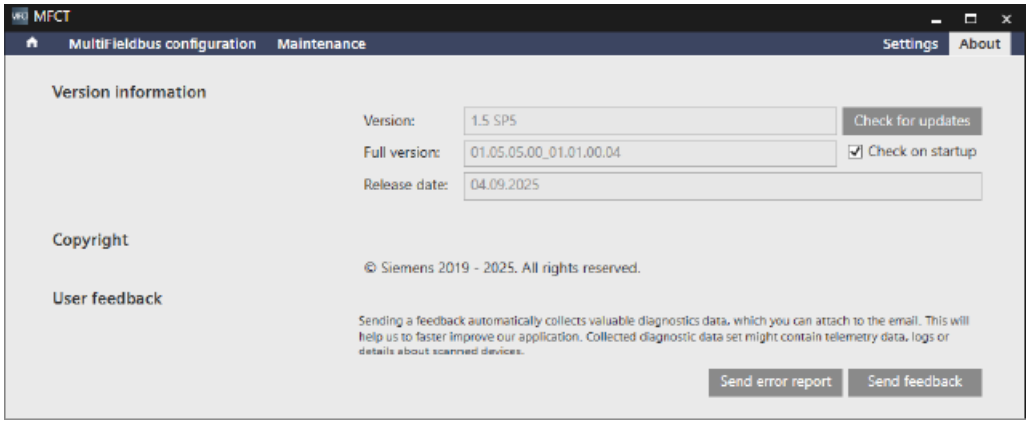

More information

You can learn more about version information and updates in section Update the MFCT installation (Page 24).

6.1.1 Version information

To obtain information about your installed version of the MFCT, click the "About" tab. The "Version information" area shows the following

- Version
- Full version
- Release date
- Check for updates

  You can find information on checking for updates in the section Update the MFCT installation (Page 24).

NOTE

Version of the MFCT required for operation

To ensure problem-free operation of the MFCT with an MF device, the MFCT requires at least the version required by the MF device. You can find this version in the equipment manual of the MF device used.

6.1.2 User feedback

To send error reports and feedback, click the "About" tab. The "User feedback" area offers the following options:

- Send error report:
  You can send information on collected diagnostic data.
- Send feedback:
  You can make suggestions and proposals for using the tool.

Sending an error report

To send an error report with information on collected diagnostic data, proceed as follows:

1. Select the "About" tab.
2. Click the "Send error report" button in the "User feedback" area.
   The MFCT collects diagnostic data and stores it in the MFCT installation folder under "Logs".
   The MFCT also opens a new email. The corresponding recipient is already specified in this email and the collected diagnostic data is attached as a zip file.
3. Enter additional information on the error description in the email.
4. Send the email.

Sending feedback

To make suggestions and proposals for handling the tool, proceed as follows:

1. Select the "About" tab.
2. Click the "Send feedback" button in the "User feedback" area.
   The MFCT opens a new email. The corresponding recipient is already specified in this email.
3. Enter your suggestions and proposals in the email.
4. Send the email.

6.2 Overview of the "Settings"

After opening the MFCT, you can find the "Settings" on the start page as an application. In an opened MFCT application, you can find the "Settings" on the right as a separate tab next to the "About" tab.

In the "Settings" tab, you have the option of configuring the basic settings of the MFCT in the following areas:

- General settings (Page 28)
- Catalog (Page 30)
- Plug-ins (Page 31)

6.2.1 General settings

The following figure shows the configuration options in the "General settings" tab:

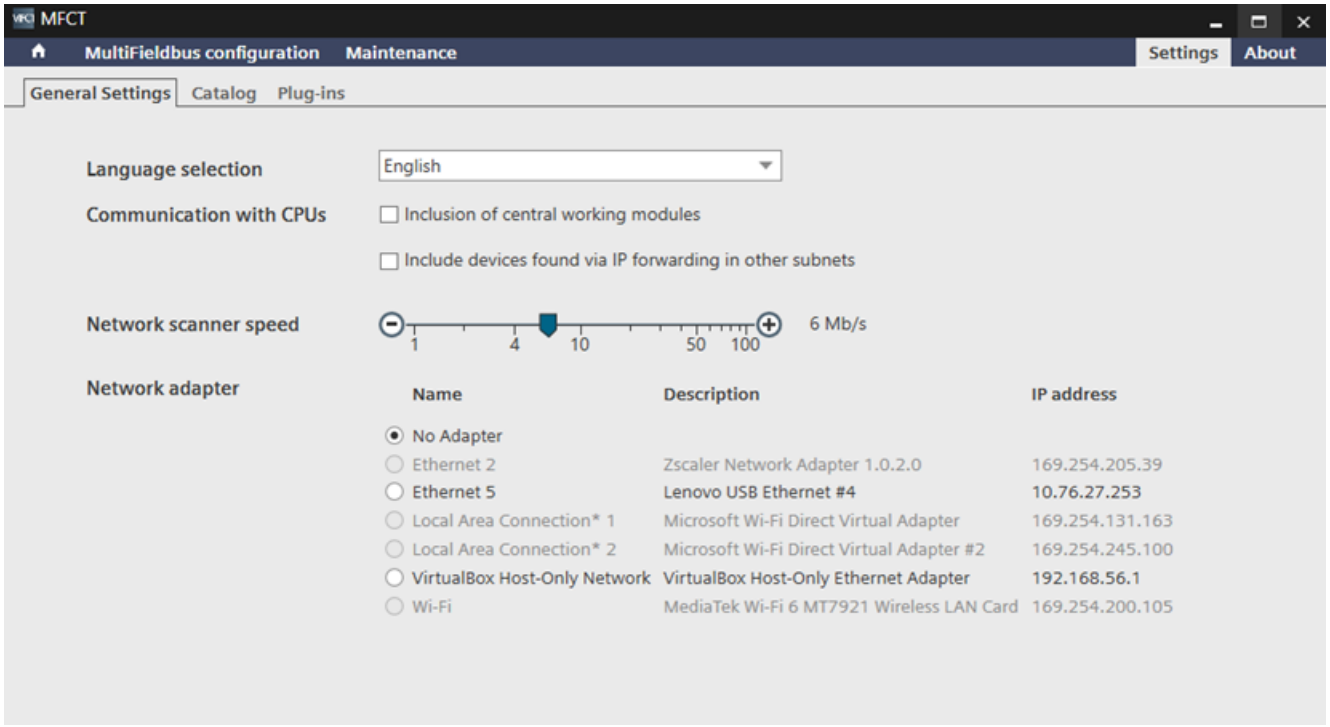

Language selection

In the "Language selection" area, select the desired language for the user interface from the selection list. The currently supported languages are German and English.

Communication with CPUs

In the "Communication with CPUs" area, select the range in which the network scan should detect modules.

- "Inclusion of centrally working modules" check box:
  The network scan detects centrally plugged modules on a CPU.
- "Include devices found via IP forwarding in other subnets" check box:
  The network scan also detects devices in other subnets.

Network scanner speed

In the "Network scanner speed" area, select the speed at which the network is scanned.

The default setting is 6 Mbps. The highest speed that can be set is 100 Mbps.

In networks with high network load, reduce the speed of the network scanner, for example, before a firmware update. A firmware update of more than 20 devices results in a network load of approx. 3 Mbps.

Network adapter

In the "Network adapter" area, you can see all available network adapters on your PC with the configured settings.

- The activated network adapters of your PC are black and can be selected.
- The deactivated network adapters of your PC are displayed grayed out.

The MFCT can only establish a connection to the devices if a network adapter is selected.

6.2.2 Catalog

The following figure shows an example of the contents of the "Catalog" tab:

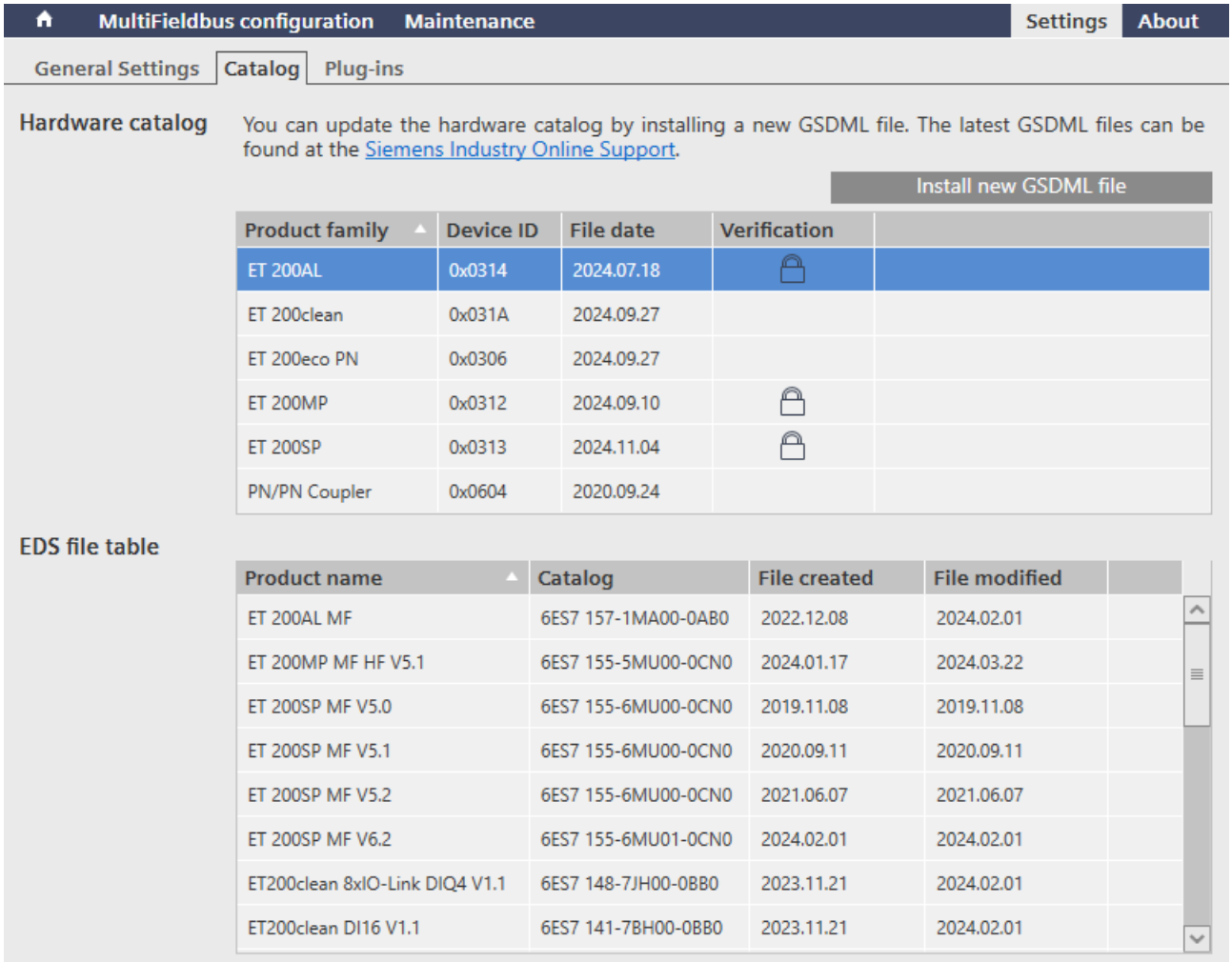

Product family	Device ID	File date	Verification
ET 200AL	0x0314	2024.07.18	
ET 200clean	0x031A	2024.09.27	
ET 200eco PN	0x0306	2024.09.27	
ET 200MP	0x0312	2024.09.10	
ET 200SP	0x0313	2024.11.04	
PN/PN Coupler	0x0604	2020.09.24	

Product name	Catalog	File created	File modified
ET 200AL MF	6ES7 157-1MA00-0AB0	2022.12.08	2024.02.01
ET 200MP MF HF V5.1	6ES7 155-5MU00-0CN0	2024.01.17	2024.03.22
ET 200SP MF V5.0	6ES7 155-6MU00-0CN0	2019.11.08	2019.11.08
ET 200SP MF V5.1	6ES7 155-6MU00-0CN0	2020.09.11	2020.09.11
ET 200SP MF V5.2	6ES7 155-6MU00-0CN0	2021.06.07	2021.06.07
ET 200SP MF V6.2	6ES7 155-6MU01-0CN0	2024.02.01	2024.02.01
ET200clean 8xIO-Link DIQ4 V1.1	6ES7 148-7JH00-0BB0	2023.11.21	2024.02.01
ET200clean DI16 V1.1	6ES7 141-7BH00-0BB0	2023.11.21	2024.02.01

Hardware catalog

You can find the currently installed GSDML files in the "Hardware catalog" area.

If the "Verification" column displays a padlock symbol, then this device originates from a GSDX-container for which the signature has been successfully verified.

To install additional GSDML files or update the GSDML files used, click the "Install new GSDML file" button.

You can find the GSDML/GSDX files used and additionally installed in the folder "MFCT_xx.xx.xx.xx_xx.xx > GSD"

EDS file table

In the "EDS file table" area, you can find the EDS files used in the MFCT.

An EDS file (Electronic Data Sheet) is an ASCII text file that contains all the relevant information of a user application. The files are used by configuration tools and controllers, for example, to integrate and configure sensors or field bus components in networks.

You can only create and configure EDS files with the MFCT (generic EDS file).

You can find the used and additionally generated EDS files in the folder "<MFCT_xx.xx.xx.xx_xx.xx > EDS".

To transfer your configuration from the MFCT project to your MF device, you need to extract the EDS file. You can find information on extracting the EDS file in the section Transfer the configuration (Page 50).

NOTE

For integration in EtherNet/IP configuration systems, use a generic EDS file according to CIP specification Vol. 1.

More information

You can find an overview of the most important documents and links to MultiFieldbus in the following Internet article (https://support.industry.siemens.com/cs/ww/en/view/109779189).

6.2.3 Plug-ins

Plug-ins supplement the MFCT with additional functions not originally supported in the main application.

On startup, the MFCT checks whether all activated plug-ins match the installed MFCT version. If a plug-in from a previous MFCT version is found, it is disabled by the MFCT.
If you want to continue working with a previous version of a plug-in, you can re-enable the plug-in on the "Plug-ins" tab. The warning is no longer displayed on the next start-up.
The MFCT displays the following warning on the start page:

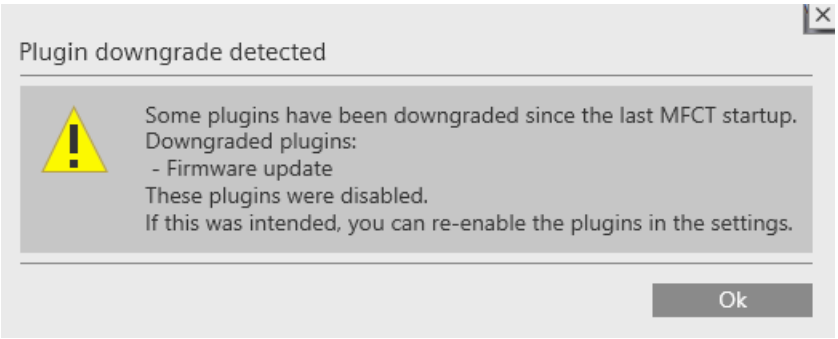

In the "Plug-ins" tab, you can install, activate/deactivate and uninstall the plug-ins. The figure below shows the contents of the "Plug-ins" tab.

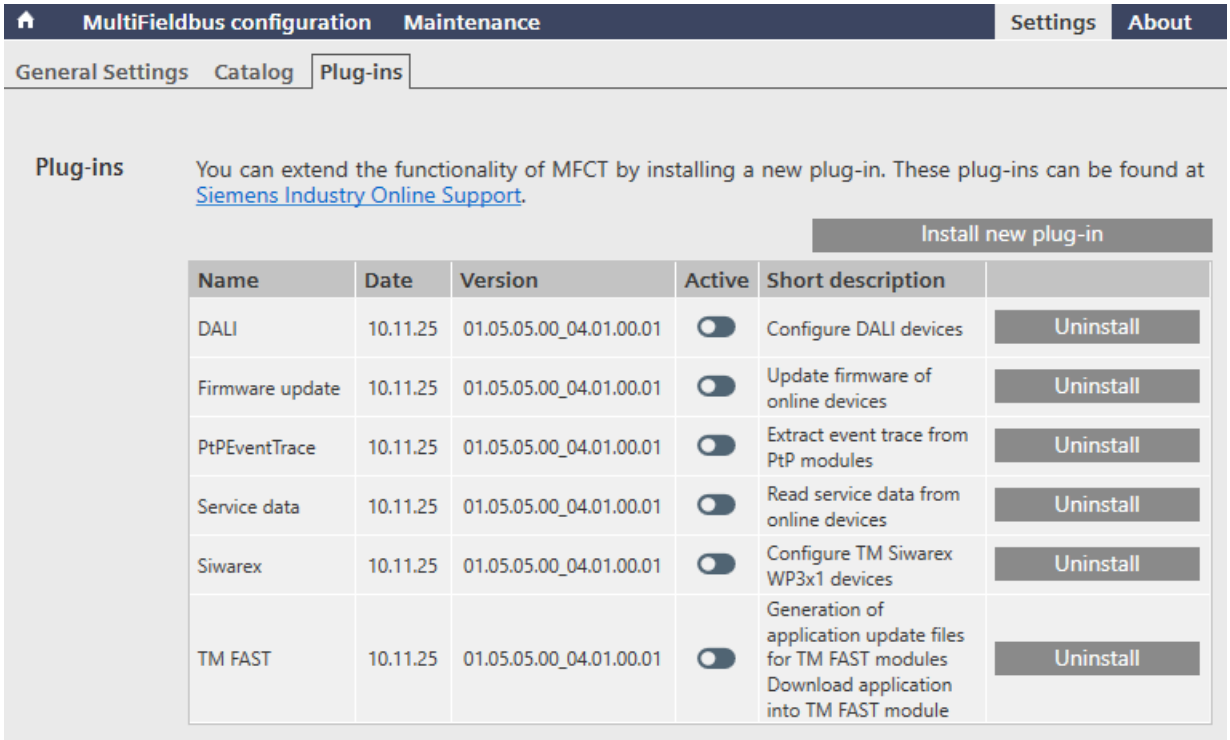

Installing

To install a new plug-in, click the "Install new plug-in" button.

"Active" column

You have the following options in the "Active" column:

- Activate available plug-ins: To activate the plug-in for the desired function, drag the slider to the right.
- Deactivate available plug-ins: The default setting is generally deactivated. To deactivate an activated plug-in, drag the slider to the left. The deactivation only takes effect when you restart the MFCT.

Uninstalling

To uninstall a plug-in, click the "Uninstall" button.

NOTE

Uninstalled plug-ins

If you uninstall a plug-in, the plug-in is completely removed and is no longer available to the MFCT.

If you need the uninstalled plug-in again, download the plug-in from the Siemens Industry Online Support page and reinstall the plug-in using the "Install new plug-in" button.

MultiFieldbus configuration 7

You have the following options in the "MultiFieldbus configuration" application:

- Configure the basic settings for your MFCT project.
- Configure and assign parameters to the required MF devices for your MFCT project.
- Perform diagnostics on MF devices that can be accessed online.

After opening the MFCT, you can find the "MultiFieldbus configuration" as an application on the start page. In an application of the MFCT that is already open, you can find the MultiFieldbus configuration as a tab in the area of the button for the start screen.

7.1 Creating new MultiFieldbus project in MFCT

To create a new project in the MFCT, proceed as follows:

1. Select the "MultiFieldbus configuration" application.
2. Select the "Projects" tab.
3. Click "Create new project".
4. Assign a name for your project, e.g. MFCT Project_1.
5. Select the storage location for your MFCT project next to "Path".
6. Optionally, you can describe the project with author and comments.
7. Click "Create project".

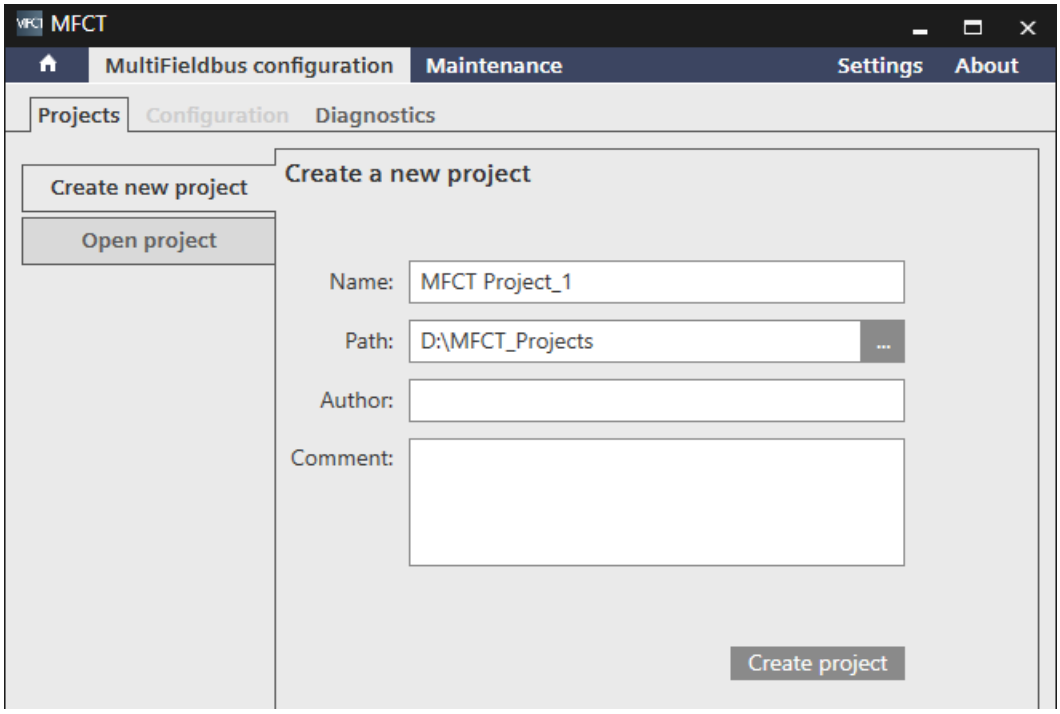

Result: MFCT creates the project under the selected path and switches to the "Configuration" (Page 36) tab for the next processing step.

7.2 Open MultiFieldbus project in MFCT

To open an existing MFCT project, proceed as follows:

1. Select the "MultiFieldbus configuration" application.
2. Select the "Projects" tab.
3. Click the "Open project" button.
   The "Recently used projects" area shows a list of the most recently used MFCT projects.
4. Select one of the following options:
   – If the list contains the desired project, click the desired project.
     To open the project, click the "Open" button or double-click the project.
   – If the list does not show the desired project, click the "Browse" button.
     Navigate to the desired project in the file explorer and select the file MFP1file.
     To open the project, click the "Open" button.

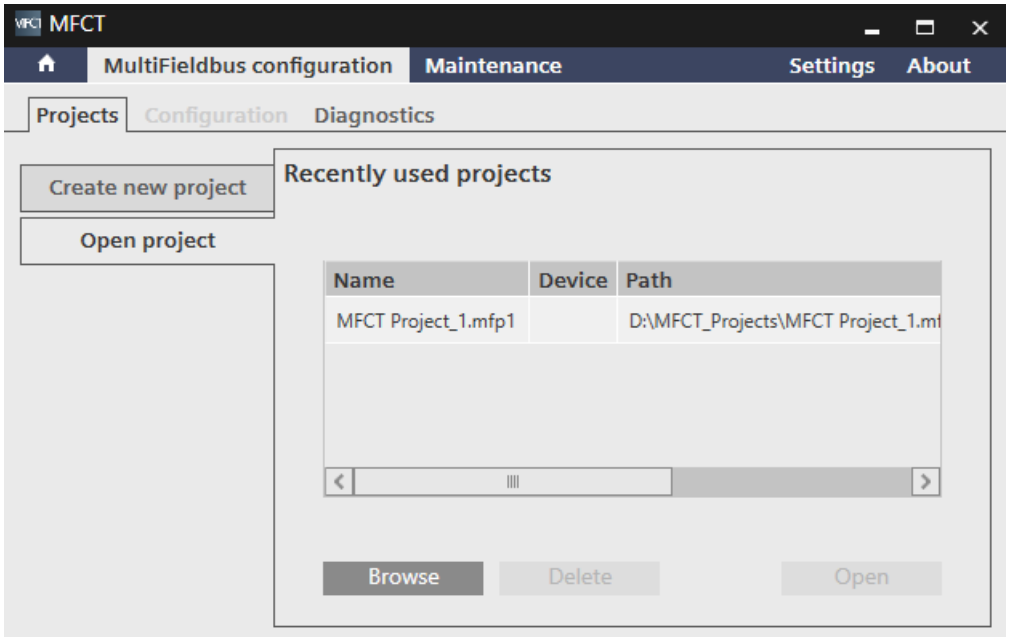

Result: MFCT opens the selected project and switches to the "Configuration" (Page 36) tab for the next processing step.

NOTE

You can use the "Delete" button to delete selected entries from the "Recently Used Projects" list. The project file itself is not deleted by this action.

7.3 Selecting a station

In the "MultiFieldbus configuration" application, you configure the devices for your project in the "Configuration" tab. To add devices to your project, you have the following options in the "Select station" area:

- Catalog:
  If the real MF device is not available or you want to configure an MF device offline.
- Network:
  If the real MF device is available online and you want to load this configuration into the MFCT project.
- Project:
  If you want to transfer MF devices from another project to this project.

In the following sections, you can read the respective procedure for adding MF devices to your project.

Add an MF device from the catalog

To add an MF device from the catalog to your project, proceed as follows:

1. In the "Devices" area, select the "Add new device" entry.
   The MFCT creates a new device. The "Project configuration / Parameterization" area shows the other options for station selection under "Select station".
2. Select the "Catalog" option.
3. Select the product family, e.g. ET 200SP.
4. Assign a name for the MF device, e.g. Device_1.
5. Select the desired MF device from the "Short designation" selection menu.
   The "Article number" and "Software version" fields show the corresponding data.

6. Click the "Create selected MF device" button.

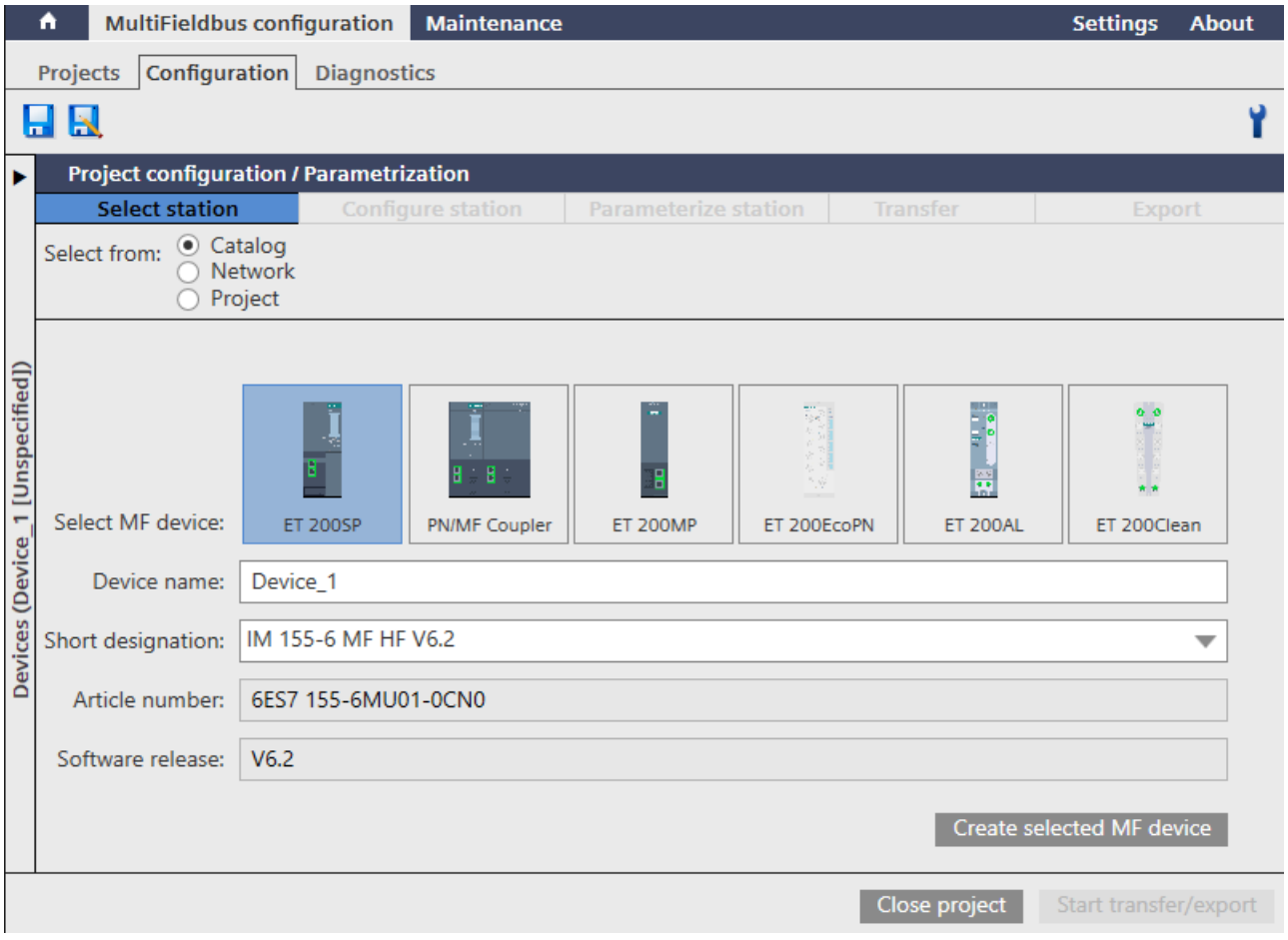

Result: MFCT adds the device to the project and automatically switches to the next step "Configure station" (Page 40).

Add an MF device from the network

Requirement: The selected network adapter can access the desired MF device.

To add an MF device that can be accessed online to your project, proceed as follows:

1. In the "Devices" area, select the "Add new device" entry.
   The MFCT creates a new device. The "Project configuration / Parameterization" area shows the other options for station selection under "Select station".
2. Select the "Network" option.
3. Click the "Start scan" button.
   The MFCT searches for devices that are accessible online and displays the results in the "Accessible devices" table. Devices without MultiFieldbus support are grayed out and cannot be selected.

4. If the "Accessible devices" table does not show any results, click the "Scan settings" button .
   MFCT opens the "Scan settings (Page 94)" window to configure the settings.
5. Optional: Use the incremental search function to locate the desired MF devices. The search starts immediately after you enter the first character. The search query is refined with each additional character. The results are dynamically adapted according to your entry.

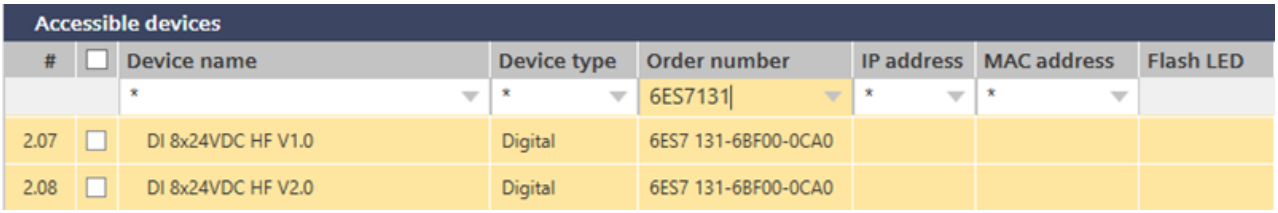

6. Select the desired MF device in the "Accessible devices" table.
7. Click "Create selected MF device".

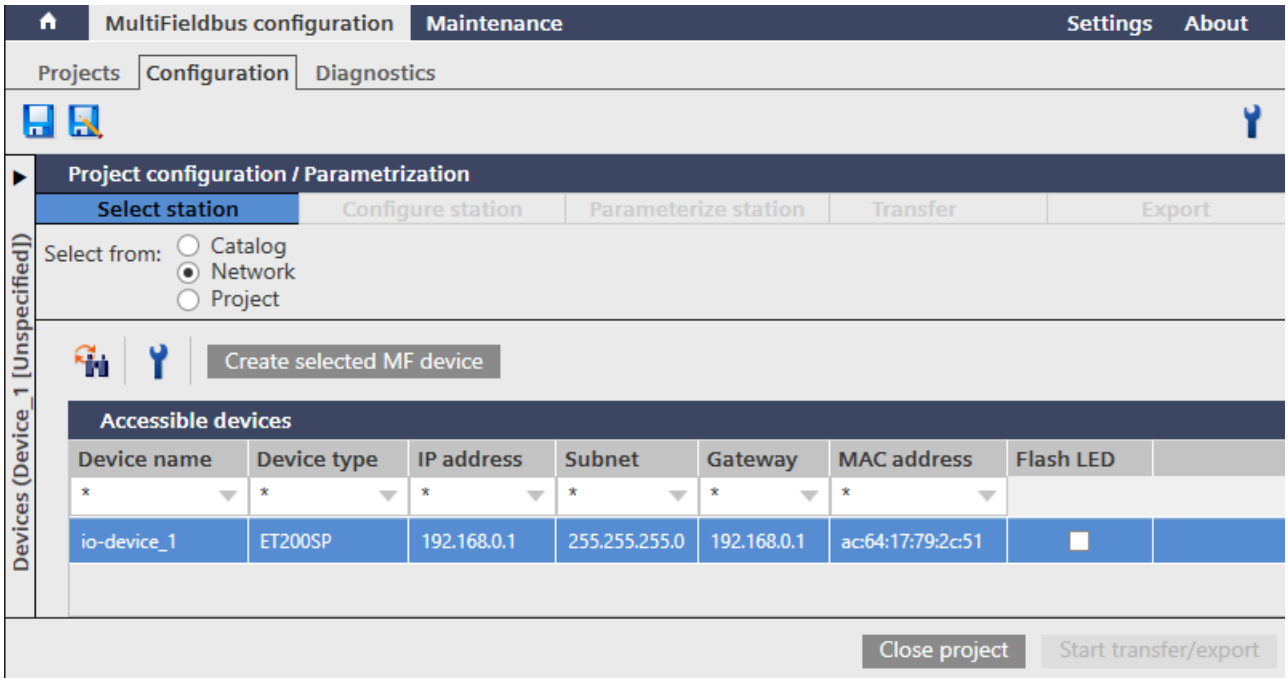

Result: MFCT reads the configuration from the MF device, transfers the configuration to the MF device added in your project and automatically switches to the next step "Configure station (Page 40)".

Add an MF device from a project

To add an MF device from another project to your project, proceed as follows:

1. In the "Devices" area, select the "Add new device" entry.
   The MFCT creates a new device. The "Project configuration / Parameterization" area shows the other options for station selection under "Select station".
2. Select the "Project" option.
   The MFCT displays a list of the most recently used MFCT projects.
3. Select one of the following options:
   – If the list contains the desired project, click the desired project.
     To open the project, click the "Open" button or double-click the project.
   – If the list does not show the desired project, click the "Browse" button.
     Navigate to the desired project in the file explorer and select the file MFP1file.
     To open the project, click the "Open" button.

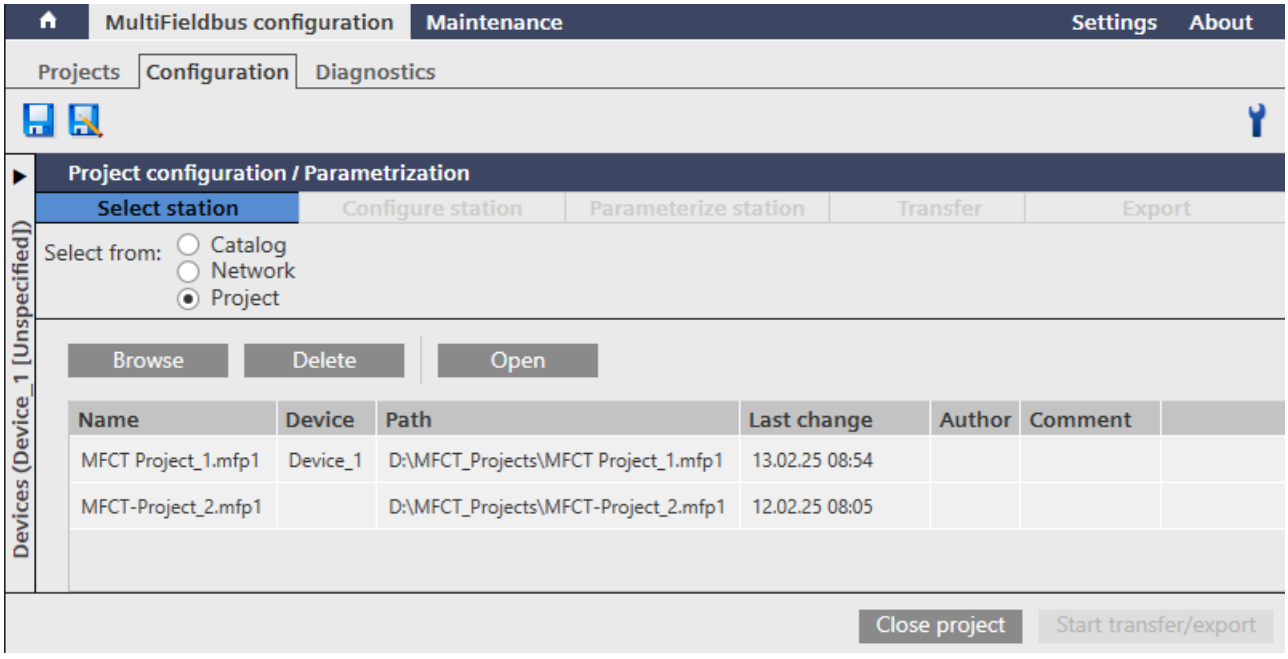

Result: MFCT loads all MF devices from the selected project into your project and automatically switches to the next step "Configure station" (Page 40).

NOTE

You can use the "Delete" button to delete selected entries from the "Recently Used Projects" list. The project file itself is not deleted by this action.

7.4 Configuring a station

After you have selected your required MF devices in the "Select station" area, configure your MF devices with all the required modules in the "Configure station" area.

A tooltip above the MF device displays the amount of I/O data available and the amount currently used.

The following figure shows the "Configure station" area in the "Configuration" tab:

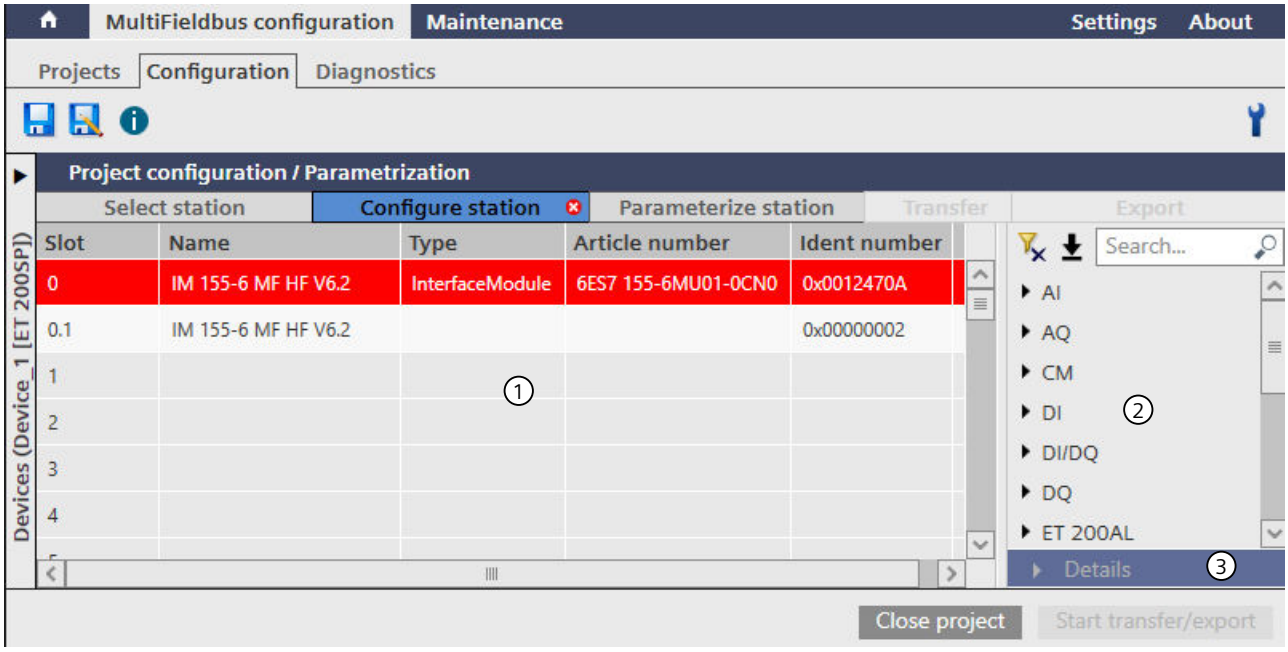

① Station setup

This area shows the structure of the MF device as a list, sorted by slots in ascending order. Incorrect configurations are displayed in red. In this example, a server module has not yet been added for the IM 155-6 MF HF interface module.

② Hardware catalog

The hardware catalog shows the modules that, based on the installed GSDML files, you can use for your MF device.

③ Details

If you select a module in the hardware catalog, you can display information on the selected module and its use on fieldbuses in the "Details" area. To open the detailed view for a module from the hardware catalog, double-click the "Details" entry.

Filter function via modules of the hardware catalog

You can use the filter function to restrict the hardware catalog depending on the fieldbus and the category.

To activate the filter function, proceed as follows:

1. Open the list with the filter criteria.

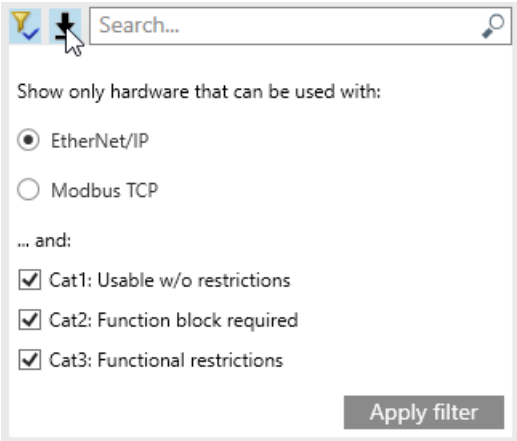

2. Select the desired fieldbus.
3. Select the desired categories.
4. Activate the filter function using the "Apply filter" button.

Result: The hardware catalog only shows modules that match the filter criteria.

To disable the filter function, click the filter symbol.

Add modules

To add modules from the hardware catalog to your MF device, proceed as follows:

1. Navigate to the required module in the hardware catalog.
2. Select the required module version, e.g. V1.0.
3. Drag-and-drop the module to the desired slot in the station setup.
   The possible slots for the selected module are highlighted in green on the MFCT.
4. Repeat steps 1 and 2 to add further modules from the hardware catalog to your MF device.

Result: You have added the desired modules to your MF device. The corresponding submodules are automatically added for each module.

Delete modules

To delete modules on the MF device, proceed as follows:

1. Select the module to be deleted in the list view.
2. Right-click the module to be deleted.
3. Select "Delete" in the context menu.

1	DI 16x24VDC ST V1.0	Digital	6ES7 131-6BH00-0BA0
1.1	DI 16x24VDC ST V1.0		
2	DQ 16x24VDC/0.5A		6ES7 132-6BH00-0BA0
2.1	DQ 16x24VDC/0.5A		
3	DI 16x24VDC ST V1.0	Digital	6ES7 131-6BH00-0BA0

Delete

Result: You have deleted the module.

Example configuration for a PN/MF-Coupler

The following figure shows an example of the configuration of the network page X1 of a PN/MF coupler.

1	OUT 64 Byte	Output		0x04400000
1.1	OUT 64 Byte			0x00000001
2	IN 128 Byte+DS	Input		0x00000480
2.1	IN 128 Byte+DS			0x00000001

In this example 64 bytes are written to the network page X2 and 128 bytes are read from the network page X2.

You can find information on how to use the network page X2 with STEP 7 (TIA Portal) with GSD file in the "PN/MF Coupler (https://support.industry.siemens.com/cs/ww/en/view/109781406)" installation and operating manual.

7.5 Parameterizing the station

After you have configured your MF devices with all the required modules in the "Configure station" area, configure the modules of the station in the "Parameterize station" area.

A tooltip above the MF device displays the amount of I/O data available and the amount currently used.

The following figure shows the "Parameterize station" area in the "Configuration" tab:

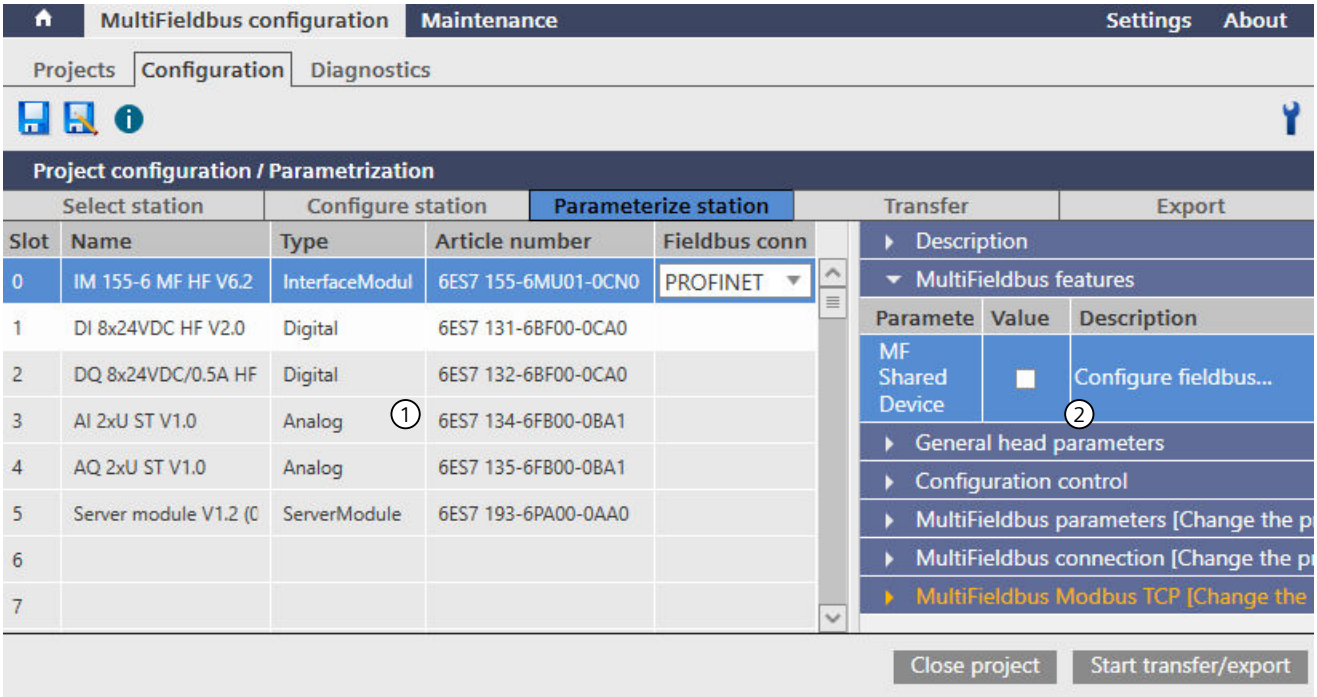

① Station setup

This area shows the structure of the MF device as a list, sorted by slots in ascending order. In this example, the IM 155-6 MF HF interface module was configured with digital and analog modules.

② Configure the parameters of the modules

This area shows the configurable parameters for the selected module in the list view ①.

You can find information on the MultiFieldbus properties in the respective equipment manual for the module. You can find an overview in the section Reference documents (Page 6).

Procedure - Configure different fieldbuses

If an MF device supports the "MF Shared Device" function, you can configure different fieldbuses for all modules. To configure different fieldbuses for the modules of the MF device, proceed as follows:

1. In the list, select the interface module in slot 0.
   The MFCT shows the configurable parameters for the selected module.
2. Open the "MultiFieldbus properties" selection menu.
3. Activate the "MF Shared Device" option.
   The MFCT displays a selection menu next to each module in the "Fieldbus connection" column. The configured fieldbus connection of the interface module is adopted in the basic settings, e.g. PROFINET.
4. Select the fieldbus connections for the modules in the selection menus.

Project configuration / Parametrization

Select station		Configure station		Parameterize station
Slot	**Name**	**Type**	**Article number**	**Fieldbus connection**
0	IM 155-6 MF HF V6.2	InterfaceModule	6ES7 155-6MU01-0CN0	PROFINET
1	DI 8x24VDC HF V2.0	Digital	6ES7 131-6BF00-0CA0	ModbusTCP #0 (0x000, 0x2D0)
2	DQ 8x24VDC/0.5A HF V2.0	Digital	6ES7 132-6BF00-0CA0	EtherNet/IP #0 (0x301, 0x300)
3	AI 2xU ST V1.0	Analog	6ES7 134-6FB00-0BA1	PROFINET
4	AQ 2xU ST V1.0	Analog	6ES7 135-6FB00-0BA1	PROFINET
5	Server module V1.2 (0 bytes)	ServerModule	6ES7 193-6PA00-0AA0	PROFINET
6				

Result: You have configured different fieldbuses for the modules.

Procedure - Configure the Modbus TCP fieldbus connections

Optionally, you can configure the hold times for all Modbus TCP field bus connections as follows:

1. In the list, select the interface module in slot 0.
   The MFCT shows the configurable parameters for the selected module.
2. Edit the following values for the desired Modbus TCP fieldbus connections in the "MultiFieldbus Modbus TCP" selection menu:
   - Connection hold time:
     The default setting is 5 000 ms. You can edit the value in a range from 1 to 30 000 ms.
   - Reset hold connection:
     The default setting is 0 ms. You can edit the value in a range from 1 to 30 000 ms.

Result: You have configured the hold times for the desired Modbus TCP field bus connections.

More information

If you change the configuration from PROFINET to EtherNet/IP or Modbus TCP, a parameterization error may occur in connection with the change of BusAdapter type. You can only remedy the parameterization error with a reset to factory settings (Page 94) and reconfiguration with MFCT.

You can find information on restrictions in the equipment manuals of the MF devices used.

7.5.1 Parameterizing the I/O data alignment

In MFCT you generate and export the I/O data alignment for modules with a fieldbus connection over EtherNet/IP. The MFCT exports the generated data as a user-defined data type (User Defined Type, UDT) in an I5x file. In addition, the MFCT generates a CSV file in which byte addresses are assigned to the slots and modules.

For further processing, the user must find the required values in the UDT and insert them into a tag in the user program. Only in this way can the values be arranged in the required order. The larger the UDT is, the greater the effort will be to find the required values in the UDT.

As of MFCT version V1.5 SP5, you can configure flexible I/O data alignment for EtherNet/IP. You can configure the order of the required I/O data already in the MFCT. The MFCT generates the UDT according to your configuration. This enables you to find the required values in the UDT more quickly and avoid having to make extensive modifications in the user program of the higher-level IO controller.

The next sections provide information on the configuration options.

Selecting flexible I/O data alignment for EtherNet/IP

You can find the configuration options for the I/O data alignment in the module parameters of the interface module under "Parameterize station > MultiFieldbus parameters > I/O data alignment". You can choose between the following standard values in the "I/O data alignment" selection menu:

- Byte (default)
- Word

To select the flexible I/O data alignment for EtherNet/IP, proceed as follows:

1. Select the desired interface module in the "Parameterize station" area.
2. Select a fieldbus connection over EtherNet/IP.
3. Navigate in the right window to the "MultiFieldbus parameters > I/O data alignment" area.

4. Select "Flexibel" in the drop-down menu next to "I/O data alignment".
   An additional line "I/O data alignment configuration" appears below the drop-down menu.

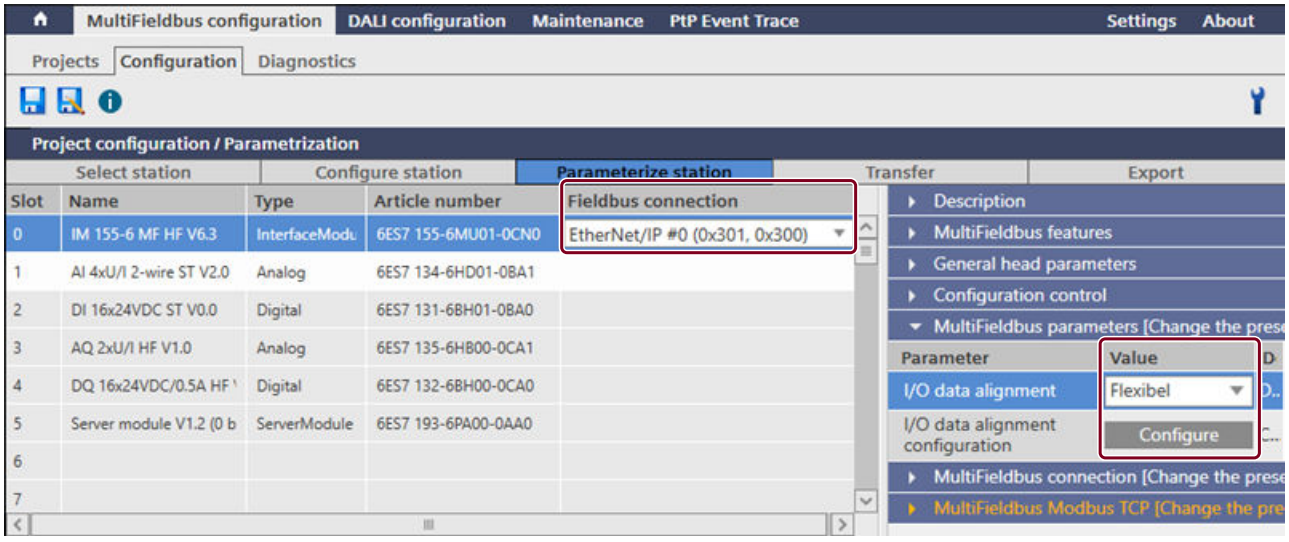

Result: You have selected a fieldbus connection over EtherNet/IP and the flexible I/O data alignment.

If you click the "Configure" button, the MFCT opens the editor for configuring the I/O data alignment.

Editor for configuring the I/O data alignment

In the "I/O data alignment configuration" editor, you configure the order of the inputs and outputs for the UDT. The next sections provide information on the various areas.

The figure below shows the "I/O data alignment configuration" editor.

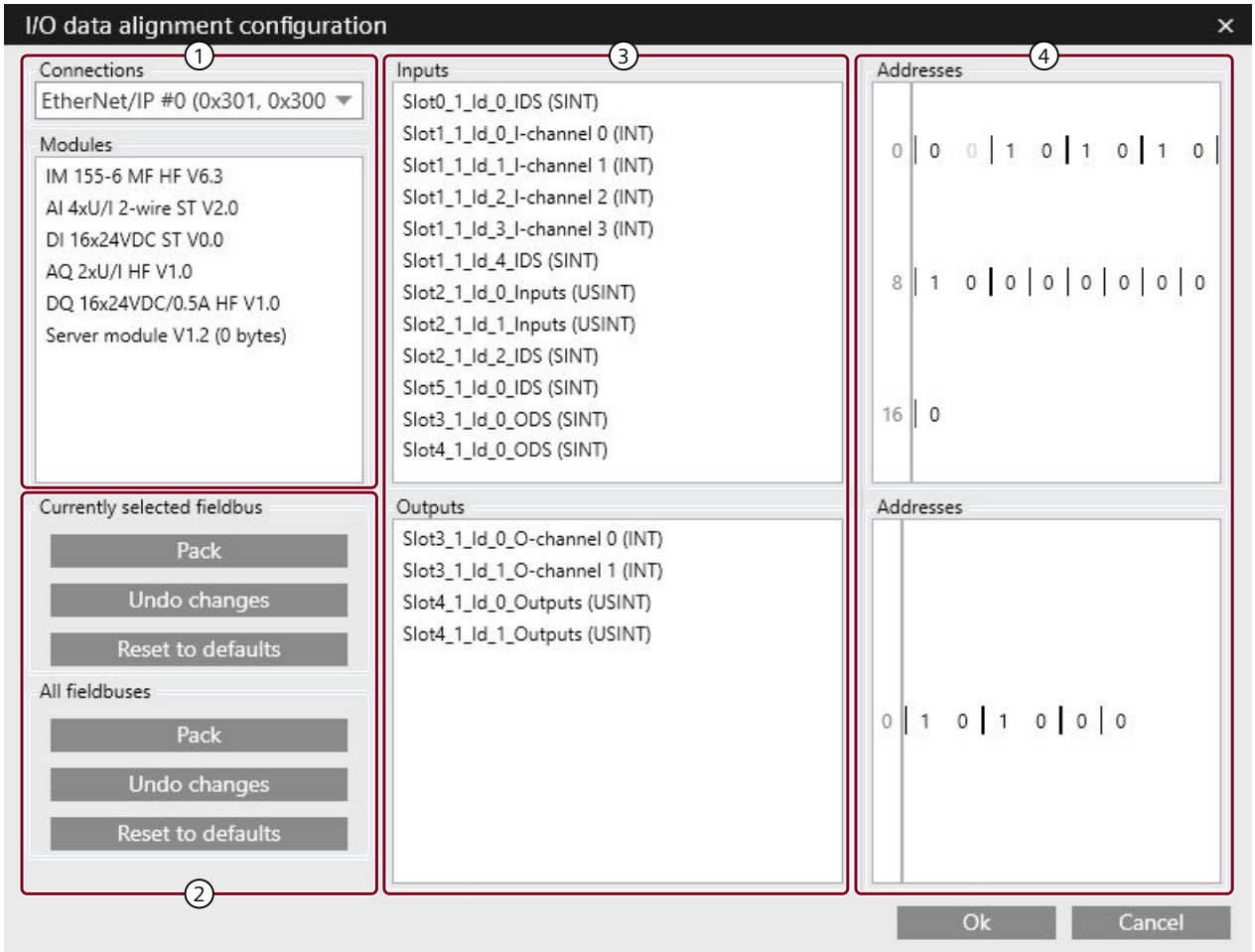

① Connections and Modules

In the drop-down menu in the "Connections" area, you select the connection for which you want to configure the order of the input and output data.

In the "Modules" area, you see the modules for which the selected connection has been configured. If you select an input module, for example, then the associated data is highlighted in color in the "Inputs" and "Addresses" areas, as shown in the following figure.

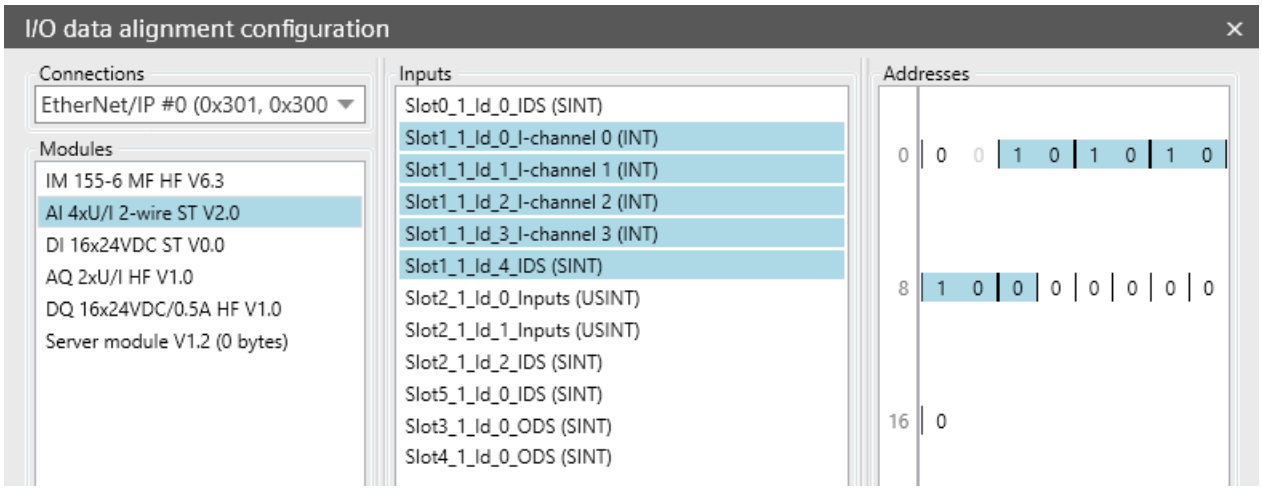

② Buttons for configuration and reset

The following buttons provide configuration options that you can apply to the selected fieldbus or all fieldbuses:

- Pack:
  Arranges the data by size, starting with the largest elements. This removes padding bytes and reduces the size of the UDT.
- Undo changes:
  Resets changes.
- Reset to defaults:
  Resets the configuration to the default configuration.

③ Inputs and outputs

The "Inputs" and "Outputs" areas show all available input and output data of the selected connection.

If you select an entry in the "Inputs" or "Outputs" area, other entries belonging to the module are shown in gray.
The "Modules" and "Addresses" areas behave as follows:

- Modules:
  The module to which the selected entry belongs is highlighted in color.
- Addresses:
  The addresses belonging to the selected entry are highlighted in color. Other addresses that belong to the module are shown in gray.

④ Addresses of inputs and outputs

The "Addresses" areas show the respective address ranges of the selected input and output data. If you select an address range, this address range is highlighted in color. Other address ranges that belong to the module are shown in gray.

If you select an address range of input data, for example, then the "Modules" and "Inputs" areas behave as follows:

- Modules:
  The module to which the selected address range belongs is highlighted in color.
- Inputs:
  The entry to which the selected address range belongs is highlighted in color. Other entries that belong to the module are shown in gray.

Changing the order of input and output data

You configure the order of the input and output data for the UDT in the "Inputs" and "Outputs" areas.

To change the order of the entries, proceed as follows:

1. Left-click on the desired entry in the "Inputs" or "Outputs" area and hold down the left mouse button.
2. Drag the entry to the desired position.
   You can only move input data within the "Inputs" area. You can only move output data within the "Outputs" area.
3. Release the left mouse button.
4. Repeat steps 1 through 3 for other entries that you want to move.

Result: You have configured the order of the input and output data. The "Addresses" areas next to the "Inputs" and "Outputs" areas are automatically adjusted to reflect the changed order.

Click the "OK" button to apply the changes. The MFCT closes the "I/O data alignment configuration" editor.

7.6 Transfer the configuration

Once you have configured your station with the modules in the "Parameterize station" area, the following options are available to you:

- Transfer configuration:
  You load the configuration into the MF device that can be accessed online.
- Export configuration:
  You export the configuration for use in other engineering tools. You can learn how to export the configuration in the section Exporting the configuration (Page 52).

Transfer the configuration to the MF device

To transfer the configured and parameterized station to the MF device, proceed as follows:

1. Select the "Transfer" function in the "Configuration" tab.
   The MFCT displays the configured devices as a list.
2. In the list, select the device that you want to transfer to the MF device that is accessible online.
3. In the "Assign device online" column, click the button next to the "<Select device>" entry.
   The MFCT opens another "Accessible devices" window.
4. In the "Accessible devices" window, click the"Start scan" button .
   The MFCT shows the accessible devices for the download as a list. Devices without MultiFieldbus support cannot be selected and are shown grayed out.
5. Select an MF device from the list.
6. Click the "Assign device" button.
   The MFCT closes the "Accessible devices" window. You can see the selected device in the "Assign device online" column.

7. Click the "Start transfer of configuration" button.
   The MFCT loads the configuration into the selected MF device. You can see the progress and status in the "Download status" column.

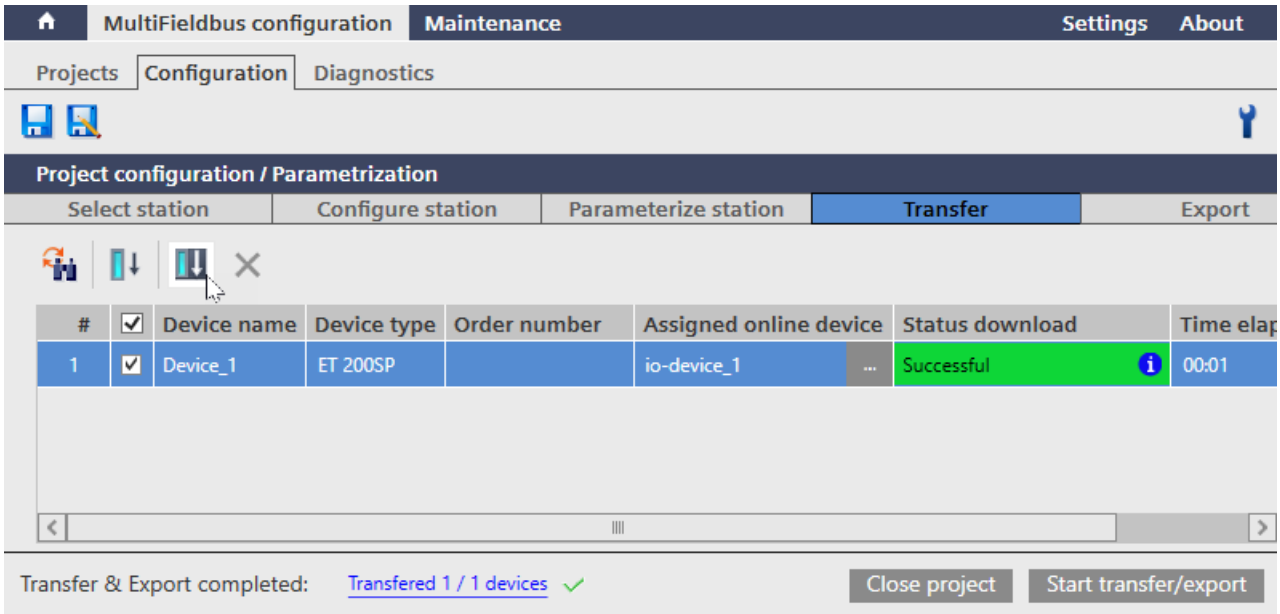

Result: You have transferred your configuration to the MF device.

NOTE

Transferring and exporting configuration

If you click the "Start transfer of configuration" button, the configuration is transferred to the MF device.

If you click the "Start transfer/export" button, the configuration is transferred to the MF device and also exported.

Troubleshooting - Timeout during transfer to the MF device

If the transfer of the configuration to the MF device exceeds a defined time window, the MFCT shows the error as a timeout under "Download status". To correct the error, you have the following options, for example:

- Check the network accessibility of the MF device via the network adapter selected in MFCT.
- Disconnect the connection of the MF device to PROFINET I/O controllers.
- If you have selected the option "Use router for gateway" in the network parameters, check the network parameters of the device.

7.7 Exporting the configuration

Once you have configured your station with the modules in the "Parameterize station" area, the following options are available to you:

- Export configuration:
  You export the configuration for use in other engineering tools.
- Transfer configuration:
  You load the configuration into the MF device that can be accessed online. You can learn how to export the configuration in the section Transfer the configuration (Page 50).

Exporting the configuration

To export the configured and parameterized station, proceed as follows:

1. Select the "Export" function in the "Configuration" tab.
   The MFCT displays the configured devices as a list.
2. Select the device you want to export from the list.
3. Next to "Path", select the storage location for the data to be exported.
4. Select the files to be exported in the "Format of user file" area.
5. Click the "Start configuration export" button.
   The MFCT exports the configuration to the selected storage location.

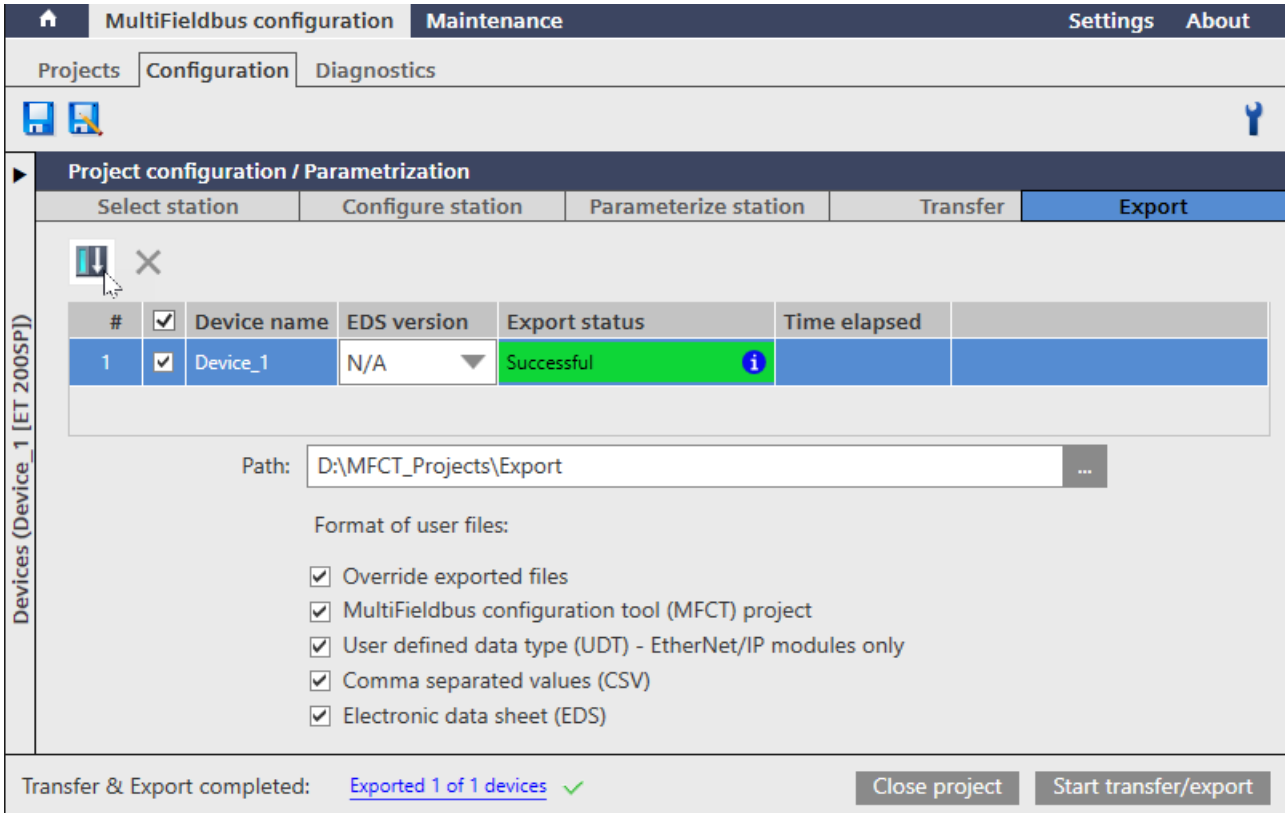

Result: You have exported your configuration to the selected storage location.

NOTE

Transferring and exporting configuration

If you click the "Start configuration export" button, the configuration is exported to the selected storage location.

If you click the "Start transfer/export" button, the configuration is transferred to the MF device and also exported.

7.8 Reading diagnostics

In the "MultiFieldbus configuration" application, you can perform diagnostics on the MF devices that can be accessed online in the "Diagnostics" tab.

The following figure shows the contents of the "Diagnostics" tab:

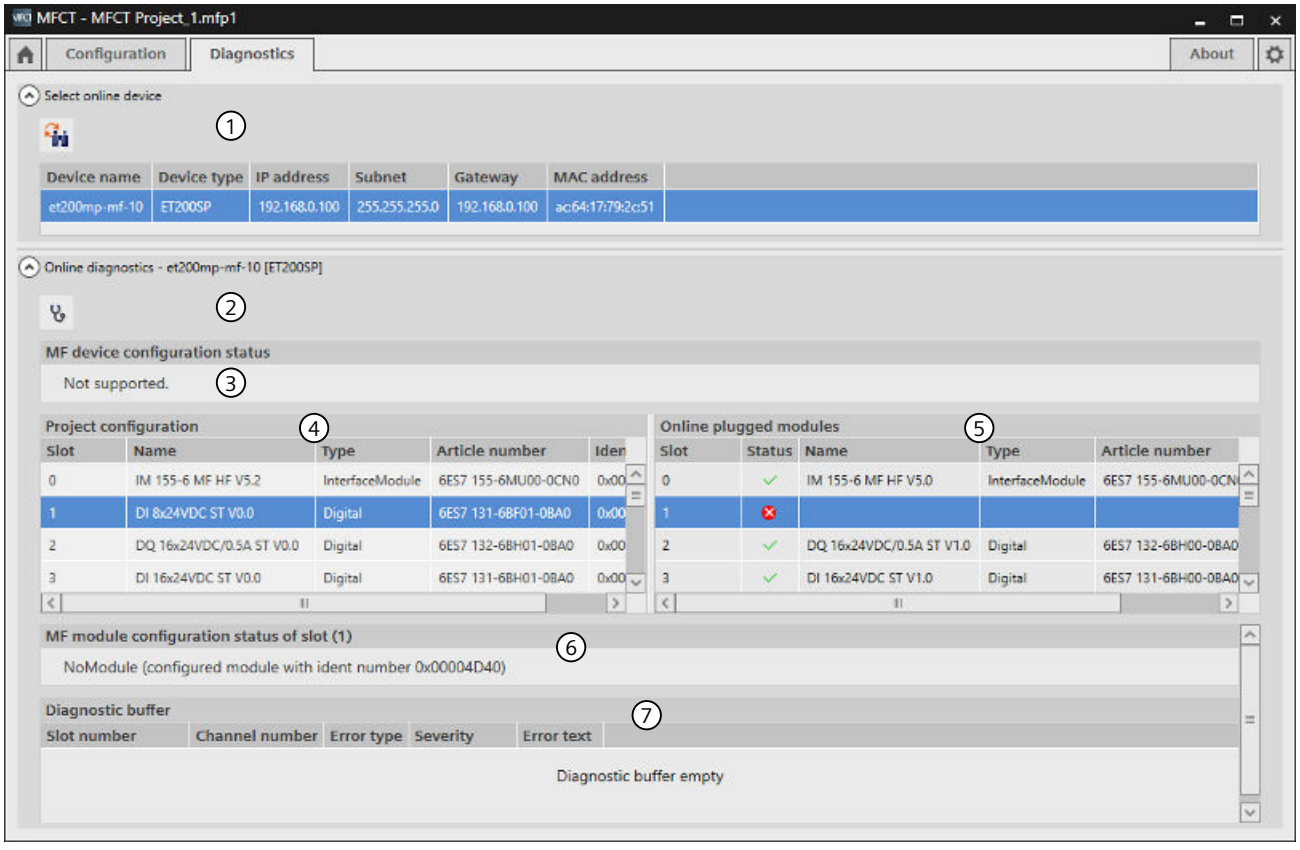

① Selecting an online device

Use the "Start scan" button to search for the MF devices that are accessible via the preset network interface.
The MFCT shows the devices that are accessible online, from which you can select an MF device.

② Online diagnostics

Use the "Update online status" button to update the display under "Online plugged modules" ⑤.

③ MF module configuration status

The status of the configuration is displayed in the "MF module configuration status" area.

④ Project configuration

In the "Project configuration" area, you can find information on the loaded configuration of the selected MF device.

⑤ Online plugged modules

You can find information on the selected MF device in the "Online plugged modules" area. This requires that the
MF device is accessible online.

⑥ MF module configuration status of slot (x)

The "MF module configuration status of slot (x)" area shows you whether a module plugged in online matches the module in the MF project.

⑦ Diagnostic buffer

Under "Diagnostic buffer", you can see the content of the diagnostic buffer.

DALI configuration

8

The "DALI configuration" application is available as a plug-in in the MFCT. To use the "DALI configuration" application, activate the plug-in.

Once you have activated the plug-in, you can find the DALI configuration on the start page as an application. In an opened application, you can find the DALI configuration as a tab in the area of the button for the start screen.

You search the connected network for devices with DALI modules in the "DALI configuration" application. You can address, parameterize and control devices connected to the DALI modules.

As of MFCT version V1.5 SP4, you can also use expert mode without an online connection to MF devices and create or save frames.

More information

You can learn how to activate a plug-in in section Plug-ins (Page 31).

You can learn how to configure frames in expert mode in section Expert mode (Page 70).

8.1 Selecting station with DALI module

You scan for ET 200 stations in which DALI modules are integrated on the "Device selection" tab.

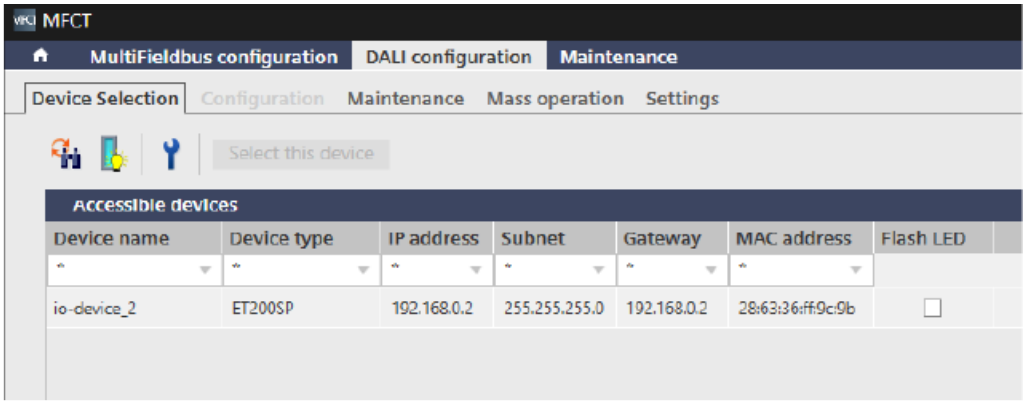

Procedure

To select an accessible device, proceed as follows:

1. Click the "Start scan" button to search for accessible CPUs and ET 200SP interface modules.
2. Click the button to filter by CPUs and interface modules with an inserted DALI module.
3. Select the desired station from the list.
4. Select the station for the configuration by clicking the button Select this device or double-clicking the station.

Result: MFCT selects the desired station and opens the "Configuration" tab.

8.2 Selecting and configuring a DALI module

You select the DALI modules present in the ET 200 station and configure the connected DALI devices on the "Configuration" tab.

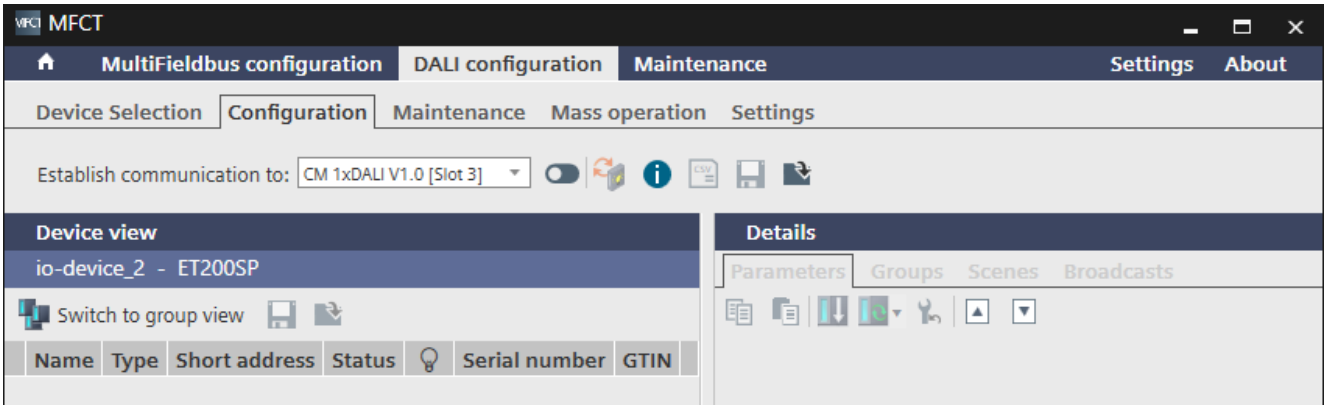

Procedure

To select and configure your DALI module, proceed as follows:

1. Select the DALI module you want to connect to in the drop-down menu .
2. Click the toggle switch "Establish communication" to establish the connection to the DALI module.
3. Beforehand, select only the required parameters in the settings (Page 76), e.g. assign short addresses automatically. The more parameters you select, the longer the scanning process will take.

   NOTE

   If you have selected the "Assign short addresses automatically" parameter, the unaddressed DALI devices are automatically assigned short addresses during scanning.

4. The button calls the communication status, i.e. whether you are connected to the module. When the connection is set up, start the search for the DALI devices connected to the module.

5. Click the "Start scan" button . Depending on the number of bus nodes, the process can take several minutes.

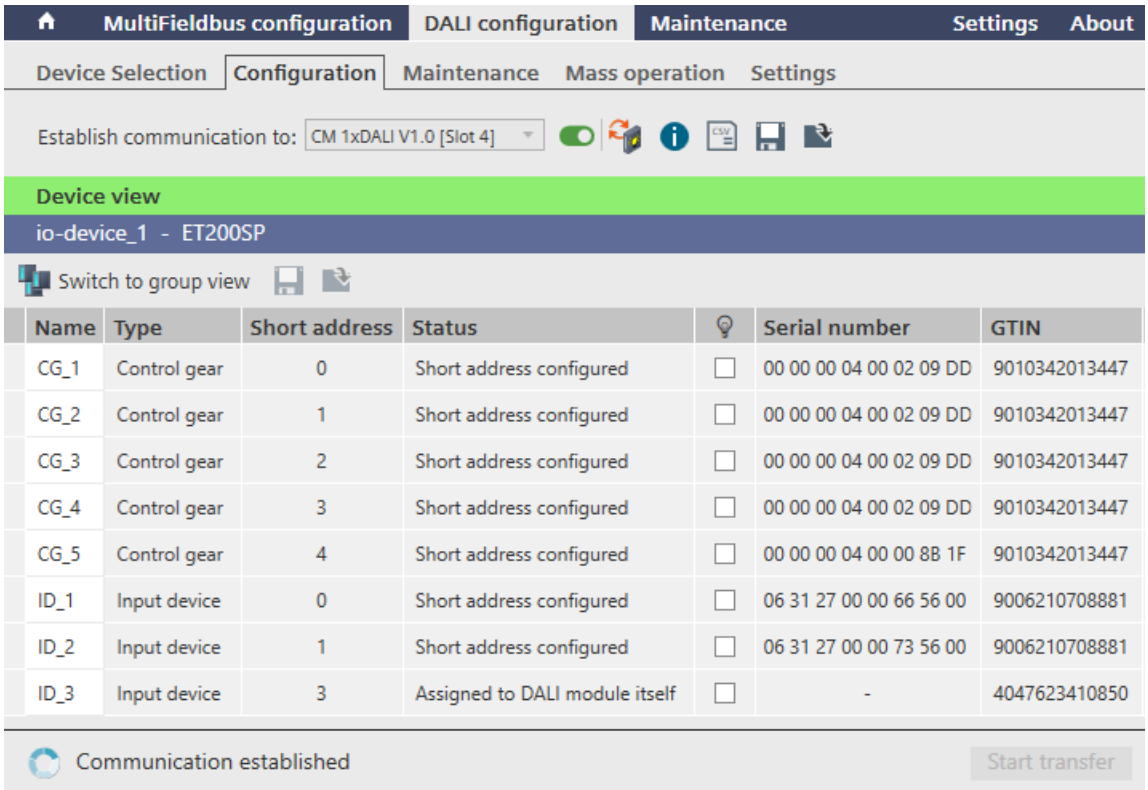

Name	Type	Short address	Status		Serial number	GTIN
CG_1	Control gear	0	Short address configured	☐	00 00 00 04 00 02 09 DD	9010342013447
CG_2	Control gear	1	Short address configured	☐	00 00 00 04 00 02 09 DD	9010342013447
CG_3	Control gear	2	Short address configured	☐	00 00 00 04 00 02 09 DD	9010342013447
CG_4	Control gear	3	Short address configured	☐	00 00 00 04 00 02 09 DD	9010342013447
CG_5	Control gear	4	Short address configured	☐	00 00 00 04 00 00 8B 1F	9010342013447
ID_1	Input device	0	Short address configured	☐	06 31 27 00 00 66 56 00	9006210708881
ID_2	Input device	1	Short address configured	☐	06 31 27 00 00 73 56 00	9006210708881
ID_3	Input device	3	Assigned to DALI module itself	☐	-	4047623410850

Result: You have read out the serial numbers and the GTIN code (Global Trade Item Number) of the connected DALI devices. For the detected DALI devices, you have the following options:

- Identify individual DALI devices using the column with the light bulb icon .
  To do so, select the check box in the row of the desired DALI device. As a result, an identification command is set on the DALI bus. Information on how a DALI device responds to this identification command can be found in the DALI device's manual.
- Change short addresses or device parameters
- Assign the DALI devices to groups

The following options are available:

- Optionally, you can export the currently displayed configuration of the devices as a *.csv file. To do this, click the "CSV" button . This allows you to document the existing configuration.
- You save and open projects with the "Save" and "Open" buttons . You can only open a saved project when there is an active connection to the CM DALI module.
- The "Status" column in the device view displays information about the bus nodes.

Information about the short addresses

DALI input devices and control gear have separate address ranges for short addresses. If a short address is assigned more than once within an address range, there is an address conflict. In this case, the "Status" column displays the corresponding text message.

For each DALI module, you may only assign each short address once to a DALI device or control gear connected to it. If a short address has been assigned more than once, you must reset the DALI devices involved. The next subsection explains how to reset DALI devices.

Details view

In the "Details > Parameters tab" area, you have additional options for configuring your devices.

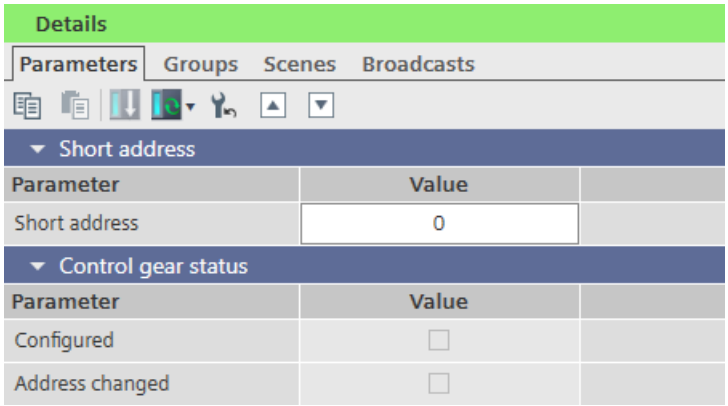

- To copy the configuration of one device and insert it into another device, use the button .
- To apply the modified parameters to the DALI device, click the button .
- In the "Details > Parameters tab" area, you can use the button to refresh the parameters of an individual device. The remaining bus nodes are not scanned again.
- To reset and/or delete a device, click the button .

  To reset only the short address of the selected device, select the "Reset the short address of the selected physical device" check box.

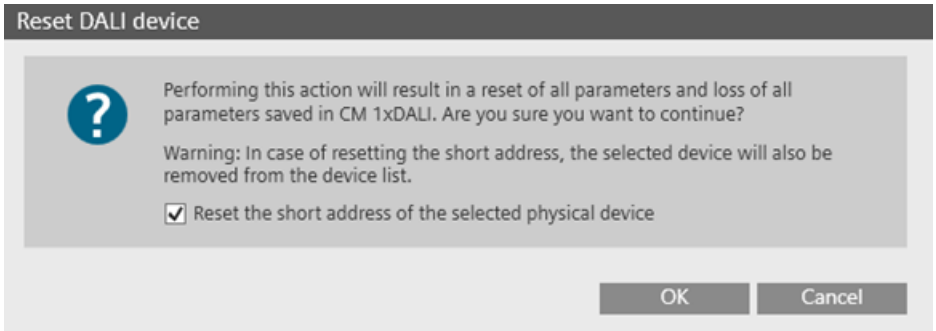

8.3 Making color settings

In the "Details > Parameters tab" area, click the button to open the color picker. Select the desired color or color temperature there. The parameter fields show the appropriate values for the selected color and color temperature based on the selection.

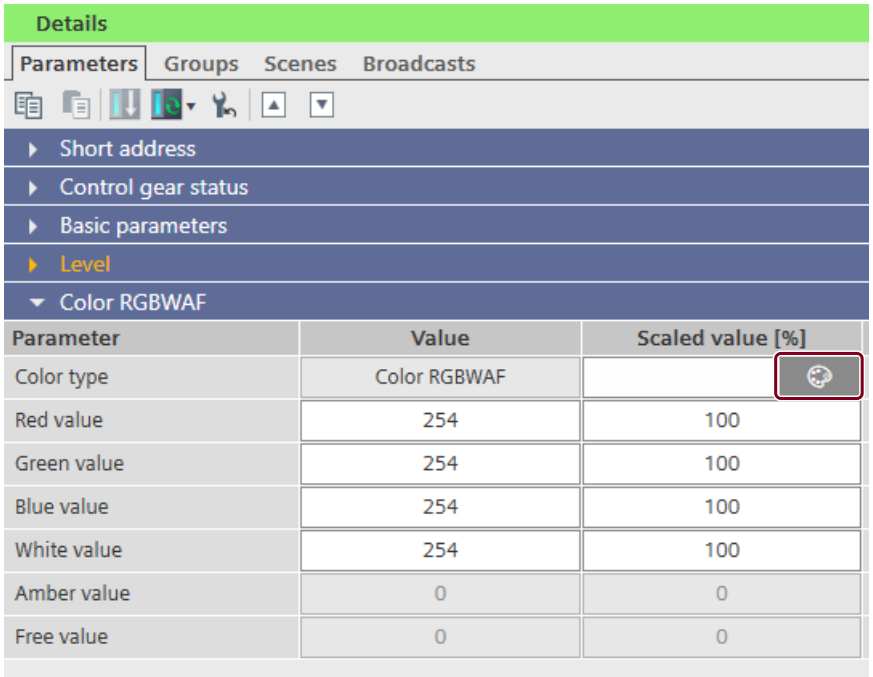

Setting the color

Depending on the control gear used, different colors are supported. The MFCT supports you in selecting a suitable color in various ways:

- Button: Select a suitable color by clicking on or in the color areas.
- Direct input:
  - Color value X/Y: X and Y coordinates for all colors
  - Color value RGBWAF: 6 values for up to 6 color components: Red, green, blue, white, amber and one free color

The following picture shows an example of a possible color selection:

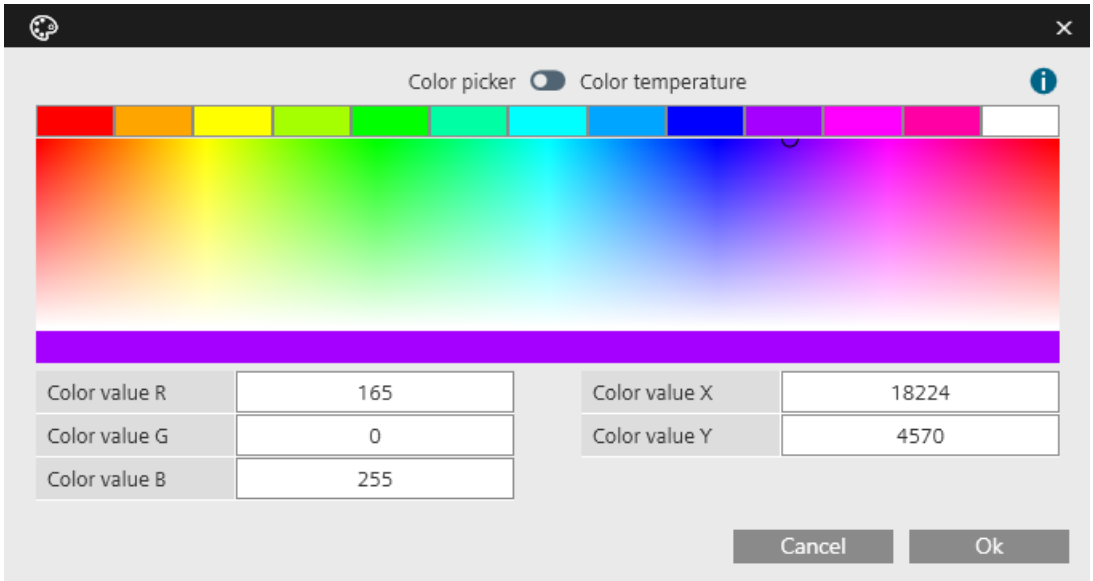

Setting the color temperature

The MFCT supports you in selecting a suitable color temperature in various ways:

- Buttons: Select a suitable value, e.g. "3500K", by clicking on the buttons.
- Direct input: Assign a value between 2000 K for warm white and 8000 K for cool white in the field next to "Color temperature (K)".

The color temperature is specified in Kelvin (K). The following figure shows an example of a color temperature of 3 500 K:

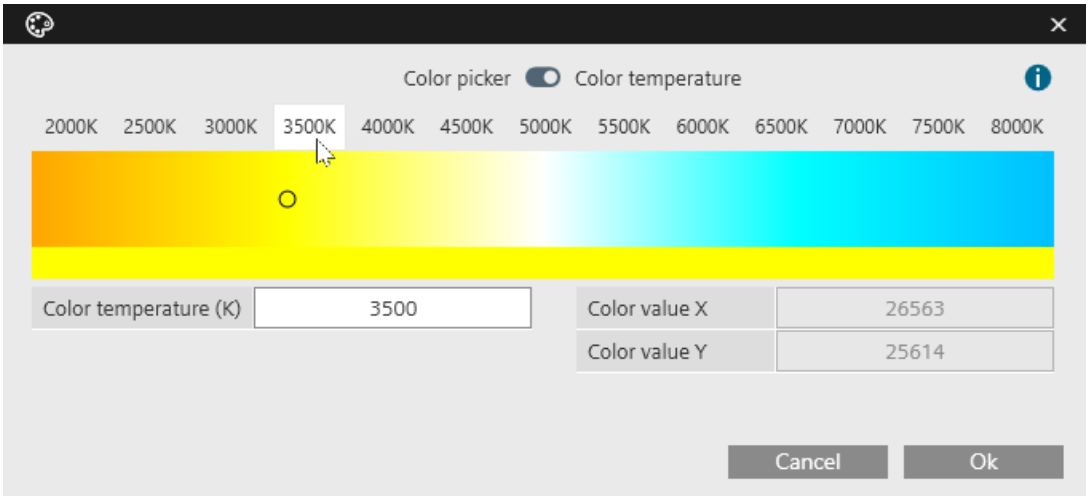

8.4 Device types

The DALI devices can be subdivided into two device types: control gear and input devices. There are different setting options for the two device types.

You can find more information in the SIMATIC ET 200SP Communication Module CM 1xDALI ST equipment manual (https://support.industry.siemens.com/cs/us/en/view/109769428).

8.4.1 Control gear

8.4.1.1 Device view

You have the following options for the control gear in the device view in the "Details" area:

- Read out and transfer parameters
- Manage groups
- Edit scenes
- Send broadcasts

Parameters that have been changed but not yet transferred are highlighted in yellow.

Read out and transfer parameters

You can display, change or transfer the parameters of a DALI device on the "Parameters" tab. For example, to change the short address of a DALI device, proceed as follows:

1. Select a device in the device view.
2. Change the value of the short address in the "Details > Parameters tab" area. The field with the changed value is highlighted in yellow.
3. Click the button Start transfer to transfer the changed parameters.

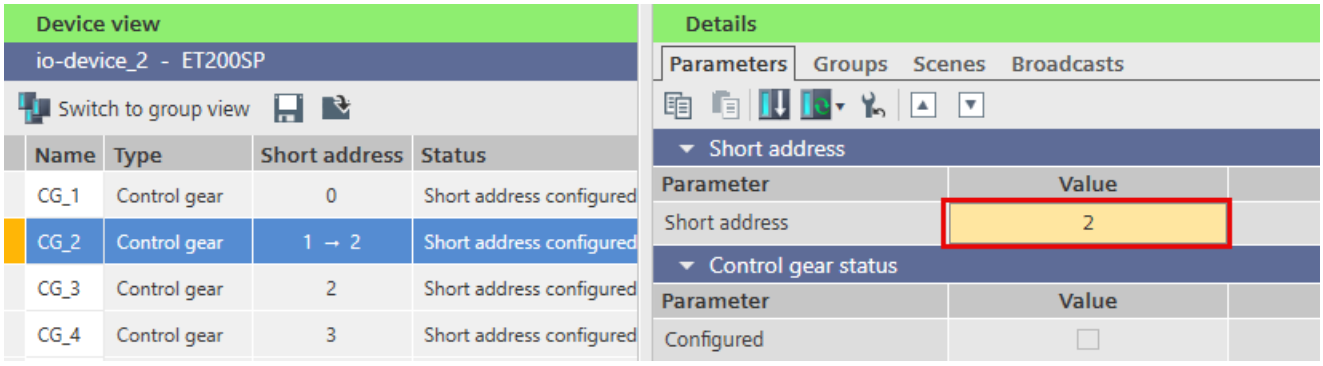

Result: The parameters have been successfully transferred and the result is displayed accordingly.

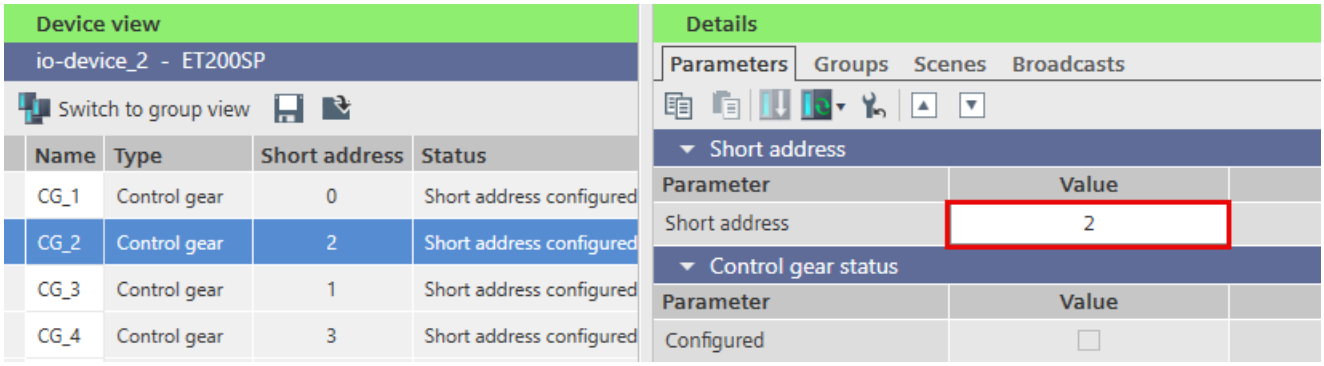

NOTE

Replacing existing addresses

f the newly assigned address already exists within the address range, the addresses are replaced as follows:
The DALI device that is currently assigned this address receives the address of the device to which the new address was assigned.

Manage groups

Multiple devices can be configured and addressed simultaneously with the help of groups. To assign the devices to different groups, proceed as follows:

1. Select a device in the device view.
2. Switch to the "Details > Groups tab" area.
3. In the "Member" column, select the groups to which you want to add the selected device. In the figure below, the selected device was added as a member of groups 0 and 1.

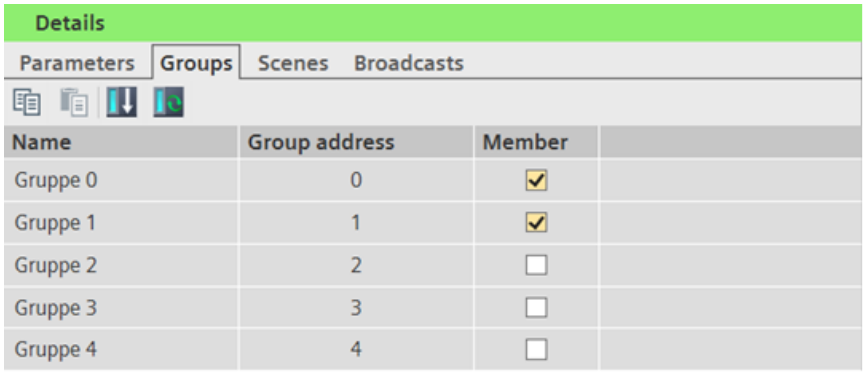

4. Click the button Start transfer to transfer the selected changes.

Edit scenes

Scenes are predefined value settings stored in the device and can be activated via a control command.

To edit the scene of a device, proceed as follows:

1. Select a device in the device view.
2. Switch to the "Details > Scenes tab" area.
3. To open the context menu, right-click in the "Scenes" area.
4. Select "Add scene".

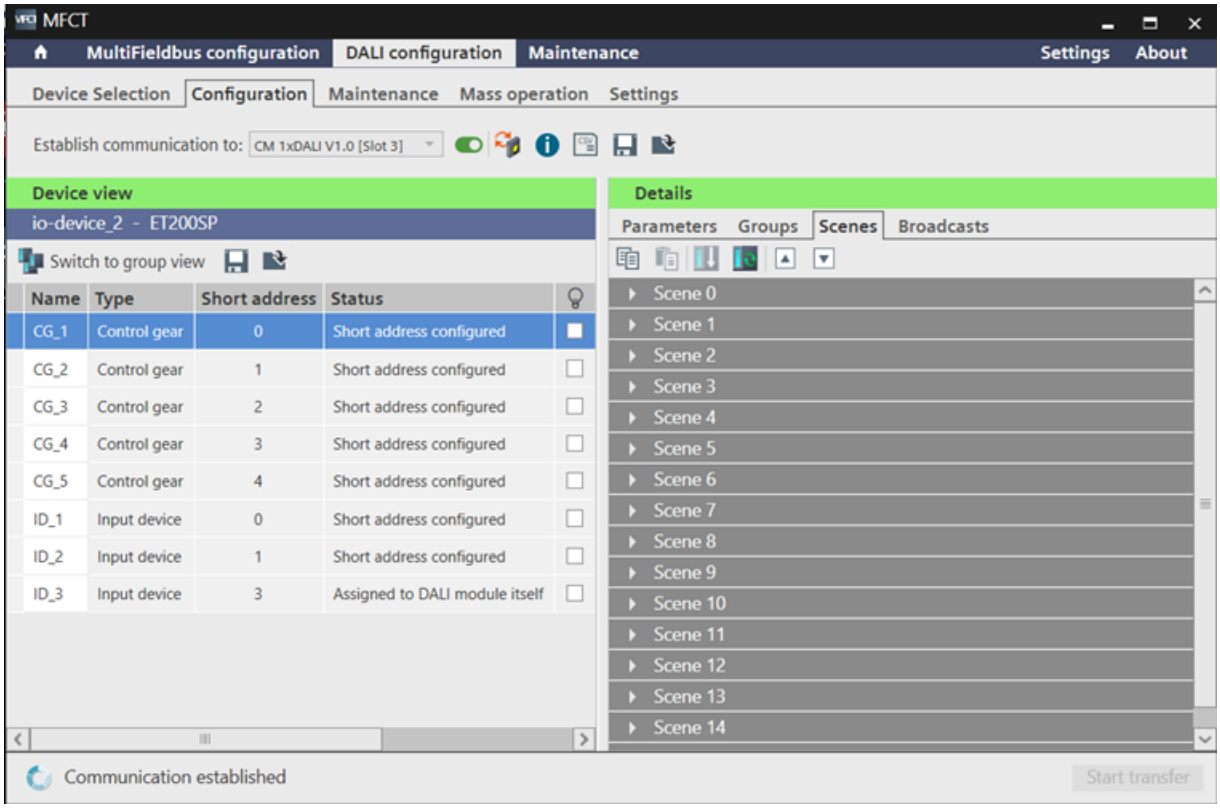

The context menu offers the following additional options

- Rename scenes
- Add all scenes
- Remove all scenes

5. For a scene stored in the device, you have the following options:
   - Activate scene
   - Remove scene

6. Optionally, you can specify the target value of the scene for the selected device.
   To do this, enter a value between 0 and 255 in the "Value" field. Depending on the type of DALI device used, you can also specify a color value for the scene.

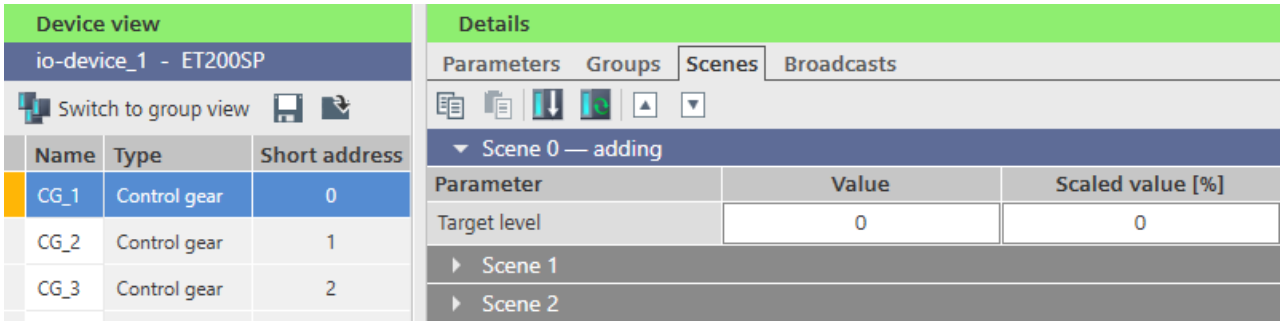

7. Click the button Start transfer to transfer the changed parameters.

Result: The parameters have been successfully transferred and the result is displayed accordingly.

Send broadcasts

To broadcast to all DALI devices, proceed as follows:

1. Select a device in the device view.
2. Switch to the area "Details > Broadcasts tab".
3. For example, change the target level in the "Value" area.
   The figure below shows an example of setting the brightness of all DALI devices on the bus to 47%:

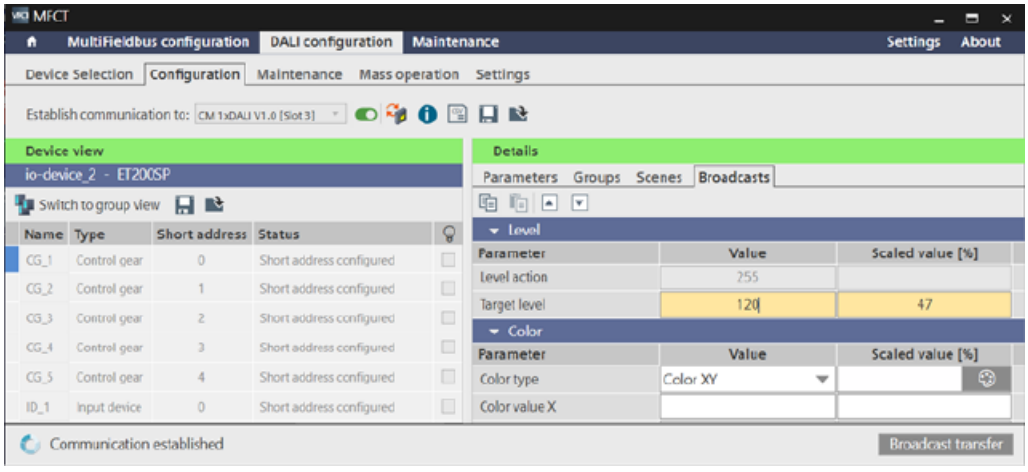

4. Click the button "Broadcast transfer" to transfer the changed parameters.

Result: The parameters have been successfully transferred and the result is displayed accordingly.

8.4.1.2 Group view

To switch to the group view, click the "Switch to group view" button .

You have the following options for the control gear in the group view in the "Details" area:

- Transfer parameters to groups
- Manage group members

Parameters that have been changed but not yet transferred are highlighted in yellow.

Transfer parameters

You can send commands to all members of a group in the "Details > Parameters tab" area.

1. Select a group in the group view.
2. Enter the required values in the "Parameters" tab.
3. Click the button Start transfer to transfer the selected changes.

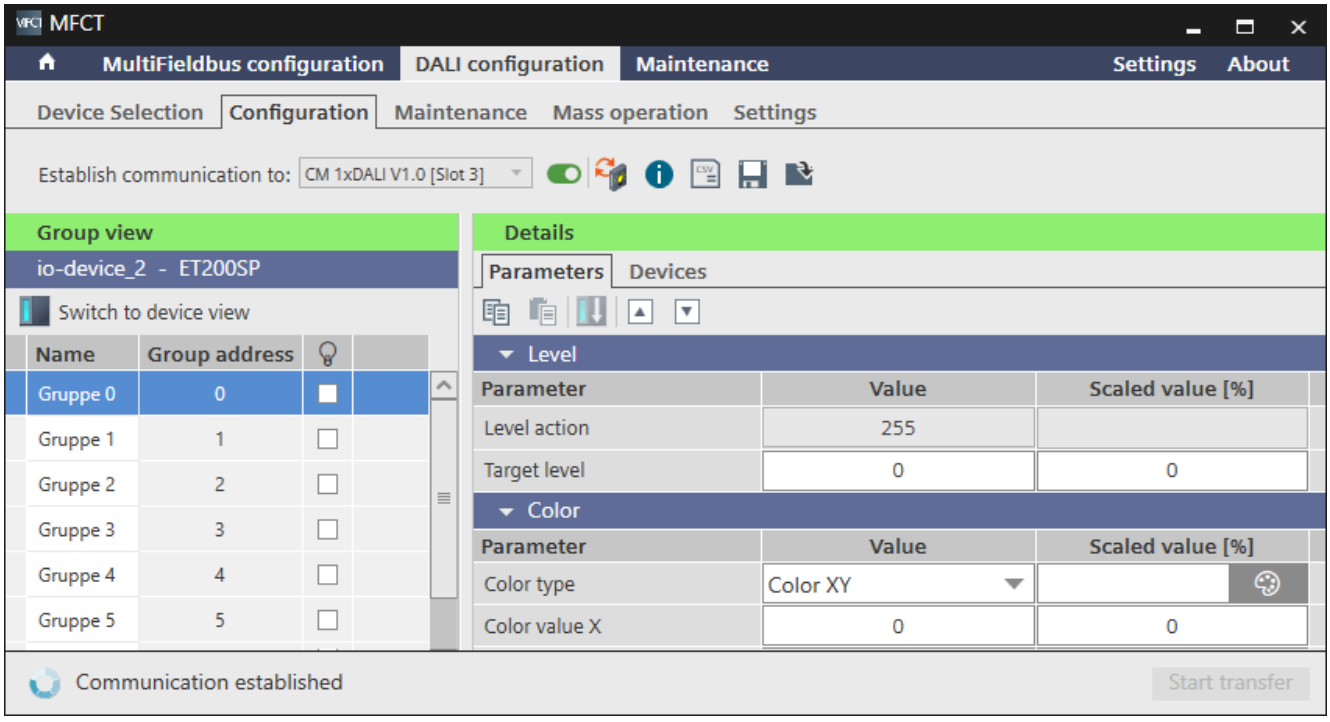

Manage group members

You have the following options in the "Details > Devices tab" area:

- Identify the individual group members. To do this, select the check box in column with the light bulb icon .
- Display, add and delete group members

For example, to add devices to a group. proceed as follows:

1. Click the desired group in the group view.
2. In the "Member" column on the "Devices" tab, select the check boxes of the devices you want to add to the group.
3. Click the button Start transfer to transfer the changed parameters.

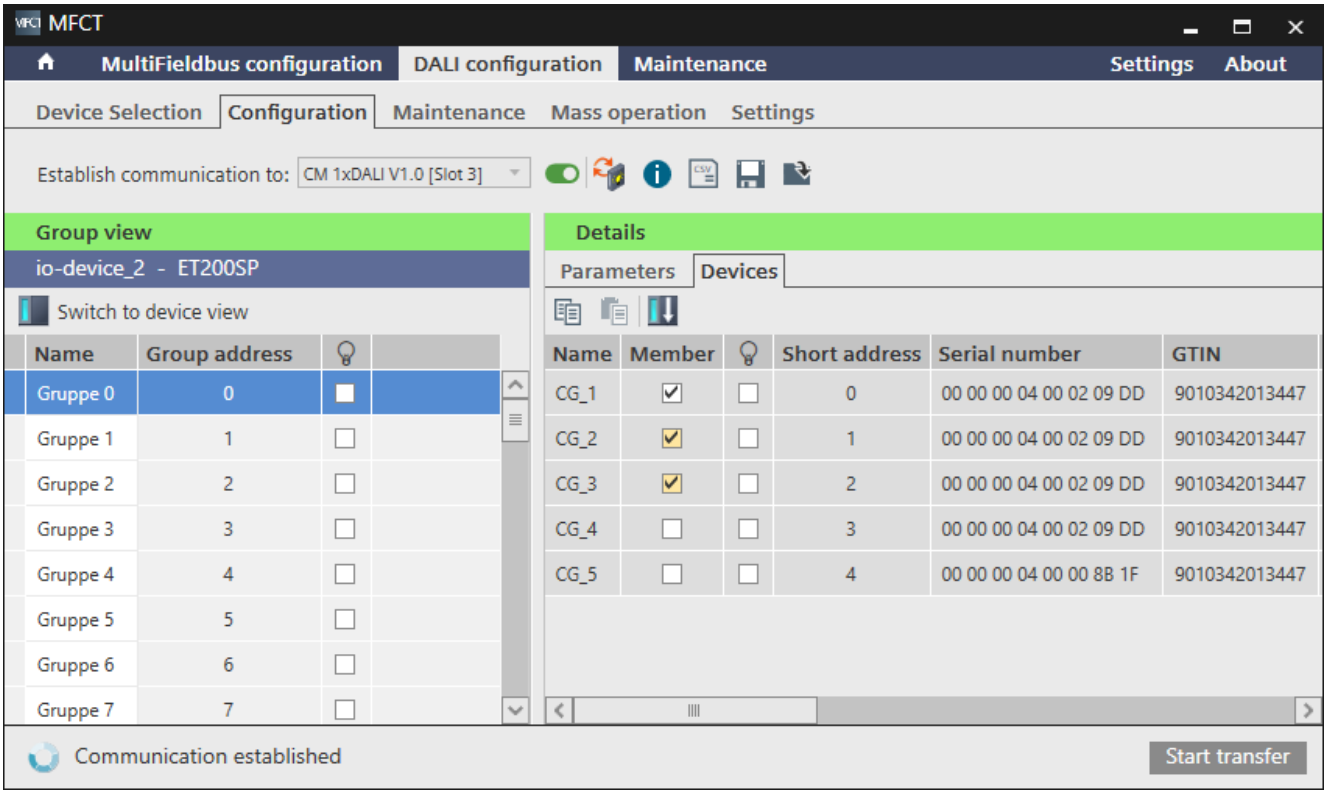

Result: The parameters have been successfully transferred and the result is displayed accordingly.

If you want to check the result, select the check box of the corresponding group under the light bulb icon in the "Group view" section. This identifies all group members at once.

8.4.2 Input devices

DALI input devices can contain multiple instances under a single short address. The "Details" area shows a separate set of parameters for each instance. You can read out and transfer parameters.

Parameters that have been changed but not yet transferred are highlighted in yellow.

Read out and transfer parameters

The parameters available depend on the instance type. The image below shows an example of the parameters of the "Push button" instance type.

You have the following options for the sensor instances in the "Parameters" tab:

- Activate
- Display
- Change
- Transfer

For example, to activate an instance, proceed as follows:

1. Select a device in the device view.
2. In the "Details > Parameters tab" section, open the desired instance, e.g., "Instance 0 Parameters (push button)".
3. Select the "Instance active" check box. The field with the changed value is highlighted in yellow.
4. Click the button Start transfer to transfer the changes.

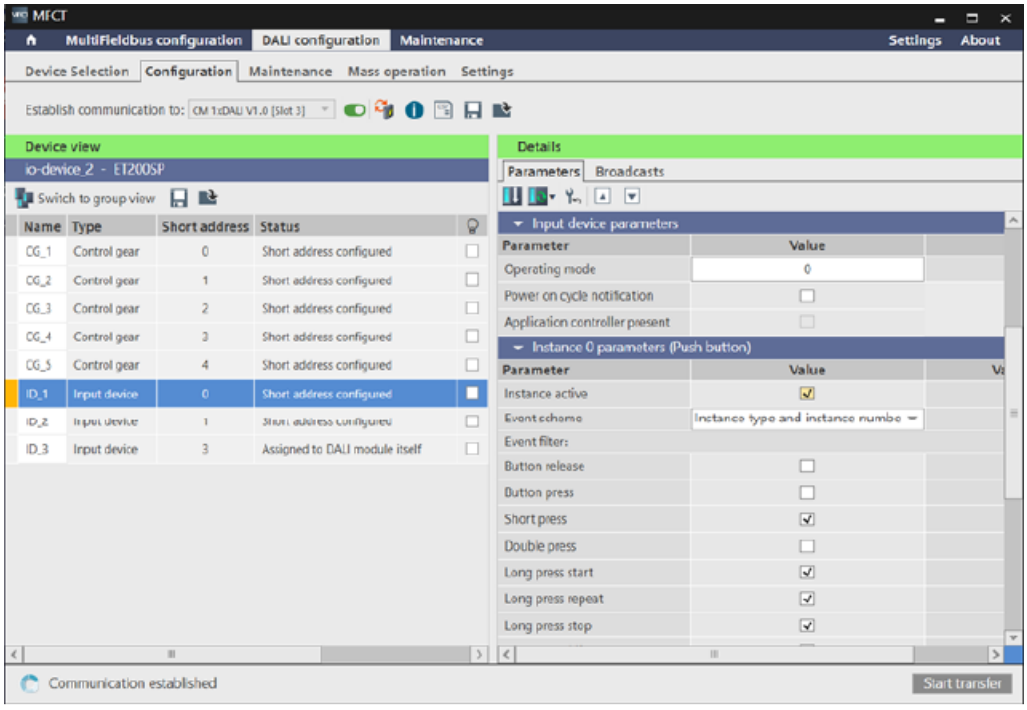

Result: The changed parameters have been transferred to the selected input device.

If you want to verify the messages of the input devices, click the "Communication status" button . You then see the frames received from the CM 1xDALI module. This enables pushbutton events, for example, to be verified.

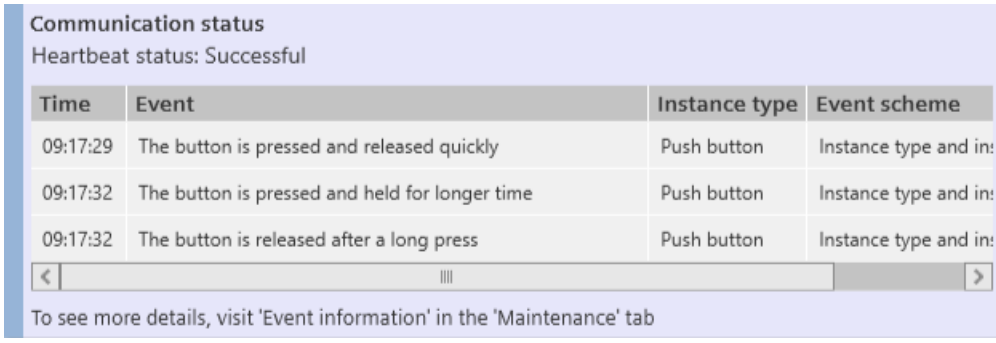

NOTE

Avoid simultaneous access attempts

An active DALI CTRL block accesses a DALI module in the user program of a CPU. At the same time, you want to access a DALI module with the MFCT. If the CPU is already communicating with the DALI module, the event is not displayed by the MFCT. The reason for this is that only the communication partner that first communicates with the DALI module after the message occurs receives the data. Either the CPU or the MFCT.

8.5 Maintenance

You can implement and process various commands with the DALI module on the "Maintenance" tab.

The sections below provide information on the following:

- Event information (Page 69)
- Running light identification (Page 69)
- Expert mode (Page 70)

8.5.1 Event information

Input devices compliant with the DALI-2 standard can actively report events on the DALI bus. These events are received by the CM 1xDALI and can be recorded by the control unit or the MFCT.

You control the function with the Start/Stop commands ▶ ■. You clear the window by clicking the button 🗑.

The following figure shows an example of received events on the DALI bus.

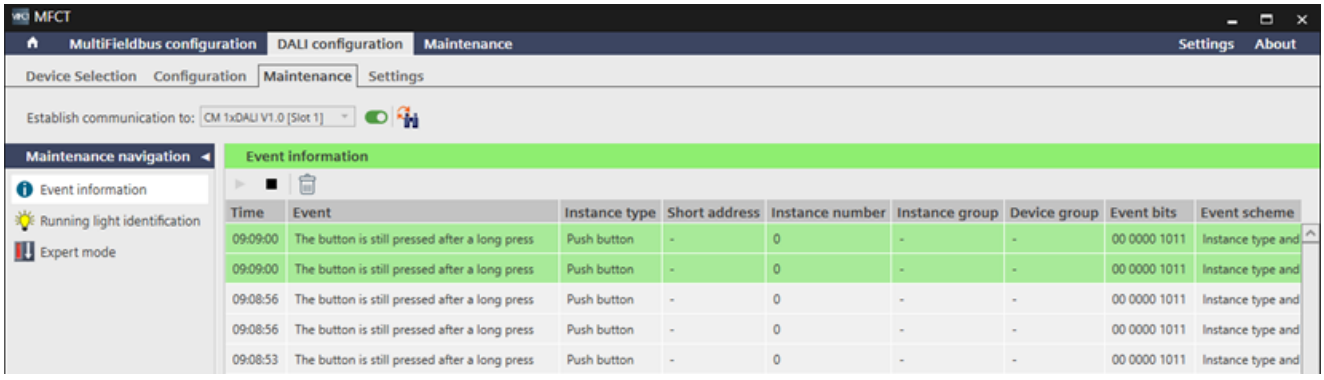

NOTE

Avoid simultaneous access attempts

An active DALI CTRL block accesses a DALI module in the user program of a CPU. At the same time, you want to access a DALI module with the MFCT. If the CPU is already communicating with the DALI module, the event is not displayed by the MFCT. The reason for this is that only the communication partner that first communicates with the DALI module after the message occurs receives the data. Either the CPU or the MFCT.

8.5.2 Running light identification

With the running light identification, you start a running light to identify the individual devices. For this purpose, the dimming values of the individual lights are set to 0 and then switched on one after another. After the running light function, the lights are returned to their original dimming value.
This makes it easy to check the arrangement of the short addresses once commissioning is complete. You can also monitor the progress of the running light identification in the list of existing short addresses.

You control the function using the Start, Pause and Stop buttons ▶ ❚❚ ■.

You configure the duration and speed of the identification, for example, on the "Settings" tab. You can find more information in section Settings (Page 76).

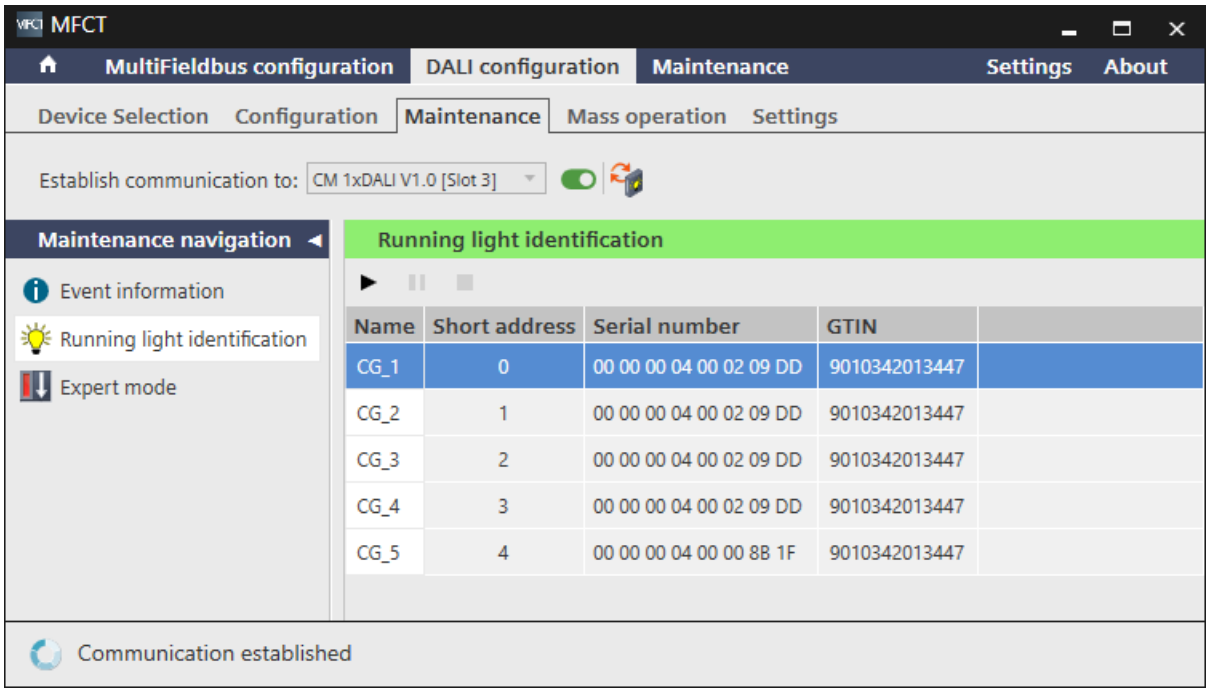

8.5.3 Expert mode

Expert mode is a function in the "Maintenance" area of the DALI configuration and offers options, such as:

- Direct access to the DALI bus with free single frames
- Creation and sending of specific frame sequences

Requirement

For MFCT versions up to V1.5 SP3: You must be connected online to the DALI module.
As of MFCT version V1.5 SP4: You can also use expert mode without a connected DALI module and create or save frames.

Procedure - Creating and sending command data

To create and send a sequence of frames with command data in expert mode, proceed as follows:

1. Use the "Plus" and "Recycle bin" buttons to add entries or remove all entries.
   Use the "Save" and "Open" buttons to load a preconfigured sequence of frames or to save the sequence you created.
2. In the first table column, select which frames you want to send to the DALI bus.
3. In the selection menu, select the bit length in each entry to be sent.
4. Edit the command data in each frame to be sent.

5. Optional:
   - To send the command twice, select the "Send twice" option.
     Some configuration commands for DALI require repetition of the frame for successful execution.
   - To wait for the response from a device connected to the DALI bus, select the "Wait for response" option.
     A received response is shown in the corresponding row in the "Response" column.
   - Enter a meaningful name in the "Name" column and a note for the entries in the "Note" column.
6. Click the "Download" button .
   The transfer to the DALI bus starts and the created list is processed.

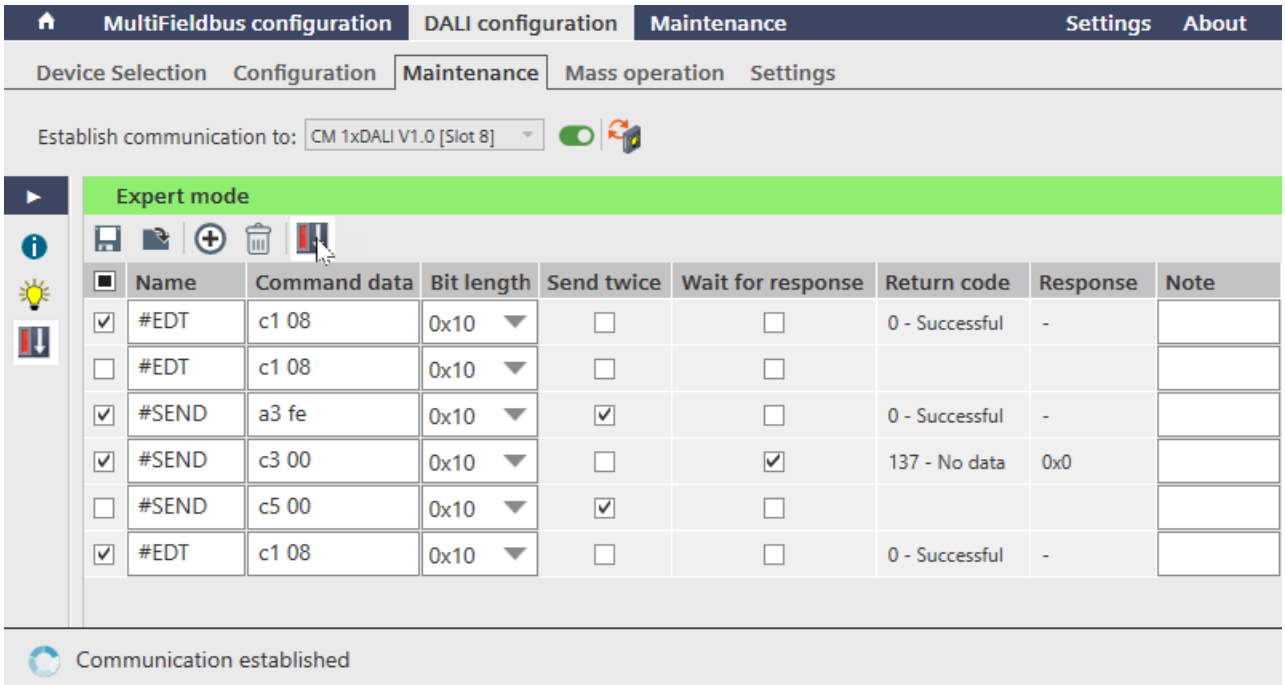

Result: You have configured the command data and transferred it to the DALI bus. The columns "Return code" and "Response" show the results of each row.

NOTE

Avoid simultaneous access attempts

An active DALI CTRL block accesses a DALI module in the user program of a CPU. At the same time, you want to access a DALI module with the MFCT. If the CPU is already communicating with the DALI module, the event is not displayed by the MFCT. The reason for this is that only the communication partner that first communicates with the DALI module after the message occurs receives the data. Either the CPU or the MFCT.

More information

You will find additional information on how to construct the command frames in the IEC 62386 standard and in the DALI device's manual.

8.6 Mass operation

As of MFCT version V1.5 SP4, the "DALI configuration" application includes the mass operation function. The mass operation feature allows you to edit multiple DALI devices across several DALI modules at the same time. The individual DALI modules may also be distributed across different ET 200SP stations.

In the mass operation, you search the network for devices that are accessible online and then select the desired DALI modules. This MFCT scans the selected DALI modules and automatically assigns short addresses to the connected devices. You can change the automatically assigned short addresses in the results list as required and reassign them to the connected devices of all DALI modules.

You can also export and save the results list locally as a CSV file. In the CSV file, you can assign pre-defined short addresses to the DALI devices based on the serial numbers or assign the DALI devices to a group. When editing the CSV file, you do not need a connection to the DALI modules.
If you are connected to the DALI modules, you can load the edited CSV file in the MFCT and load the changes into all the desired DALI devices.

You can find the mass operation as a tab in the "DALI configuration" application.

Procedure - Starting the mass scan

To start the mass scan for online-accessible DALI modules, proceed as follows:

1. Select the "Settings" tab in the "DALI configuration" application.
   The MFCT shows the settings for the DALI scan.
2. Select only the settings required for the DALI scan in order to keep the duration of the scan to a minimum.
   You can find information in section Settings (Page 76).
3. Select the "Mass operation" tab in the "DALI configuration" application.
4. Click the "Start scan" button .
   The MFCT shows the online-accessible devices as a list under "Accessible devices".
5. Select the desired DALI modules for the mass operation from the list.

6. Click the "Start mass scan" button .
   The MFCT scans the selected DALI modules and automatically assigns short addresses to the connected DALI devices. The "DALI status" column shows the progress for the respective DALI module.

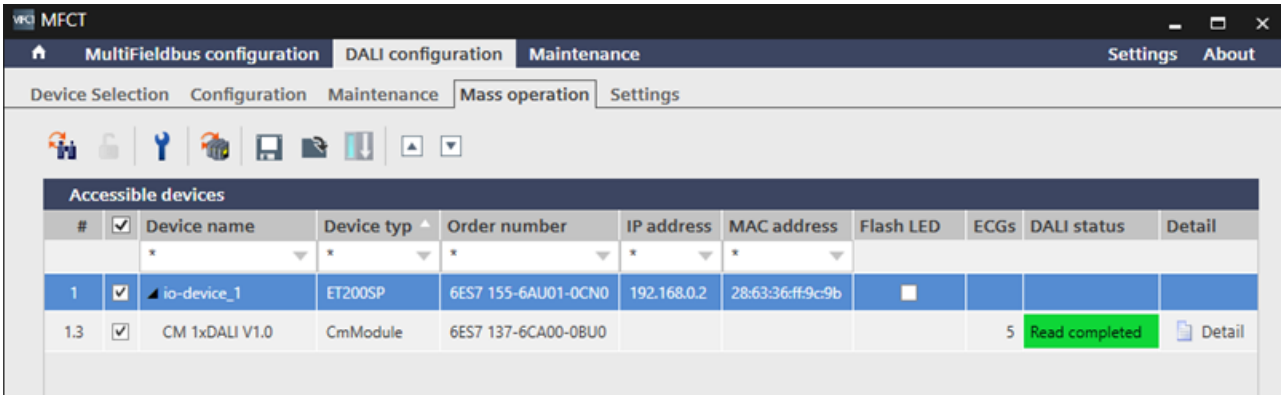

Result: You have scanned the desired DALI modules. The "DALI status" column shows the progress as "Read completed" next to the modules. In the "Detail" column, you can find a list of the results of all DALI modules and the connected DALI devices for further processing.

Procedure - Configuring short addresses online

Requirements:

- You have scanned the desired DALI modules.
- The "Detail" column shows a list of the results of the mass scan.

To configure the automatically assigned short addresses online, proceed as follows:

1. Click the list in the "Detail" column.
   The MFCT opens the list in a new window. The list shows the automatically assigned short address next to each serial number of the DALI device.
   – If you also want to read out the GTIN code, you must first enable the corresponding option in the Settings (Page 76).
2. Assign the desired short address to the devices in the "New short address" column.

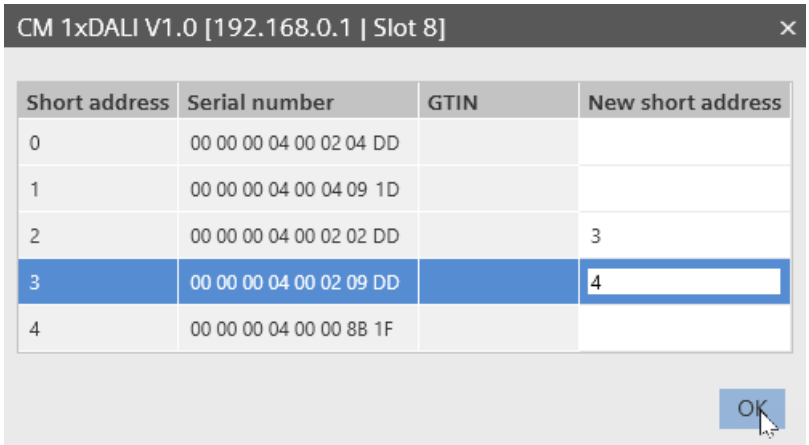

3. Click the "OK" button.
   The MFCT closes the list and shows in the "DALI status" column that parameters have been changed.
4. Click the "Load changed parameters into the devices" button.
   The MFCT automatically loads the newly assigned short addresses into the DALI devices.

Result: You have changed the automatically assigned short addresses and loaded them into the DALI devices.

Procedure - Saving results list locally and configuring offline

Requirements:

- You have scanned the desired DALI modules.
- The "Detail" column shows a list of the results of the mass scan.

To save the results list locally, proceed as follows:

1. Click the "Save" button.
   The MFCT opens the "Save as" window.
2. Select the storage location for the file in Explorer.
3. Assign a name for the file.
4. Select the file type CSV.
5. Click "Save".

Intermediate result: You have saved the results list locally as a CSV file.

To configure the short addresses offline, proceed as follows:

1. Open the CSV file.
   The CSV file shows all the information about the DALI modules and the DALI devices connected to them.
2. Assign a new short address to the devices in the "New short address" column.
3. Save the changes to the CSV file.

Result: You have configured the short addresses offline in the CSV file.

Procedure - Loading results list as CSV file

Requirements:

- You have saved the results list locally on your PC as a CSV file and configured the short addresses.
- The MFCT is open and shows the "Mass operation" function in the "DALI configuration" application.

To upload the CSV file with the changes, proceed as follows:

1. Click the "Open" button.
   The MFCT opens the "Open" window.
2. Select the CSV file to be opened.
3. Click the "Open" button.
   The MFCT closes the "Open" window and loads the results list.

Intermediate result: You have loaded a results list as a CSV file.
Optionally, you can open the configuration again in the "Data" column and change the short addresses in the "New short address" column. If you have changed short addresses and close the list, the MFCT shows in the "DALI status" column that parameters have been changed.

To load the changed short addresses into the DALI devices, proceed as follows:

1. Click the "Load changed parameters into the devices" button.
   The MFCT automatically loads the newly assigned short addresses into the DALI devices.

Result: You have loaded the changed short addresses into the DALI devices.

8.7 Settings

You can make various modifications to the following on the "Settings" tab:

- Basic configuration of the DALI scan
- Configuration of the running light for identification
- Parallel processing for the mass operation

Basic configuration of the DALI scan

Select the entry "DALI scan settings" in the "Settings navigation" column.

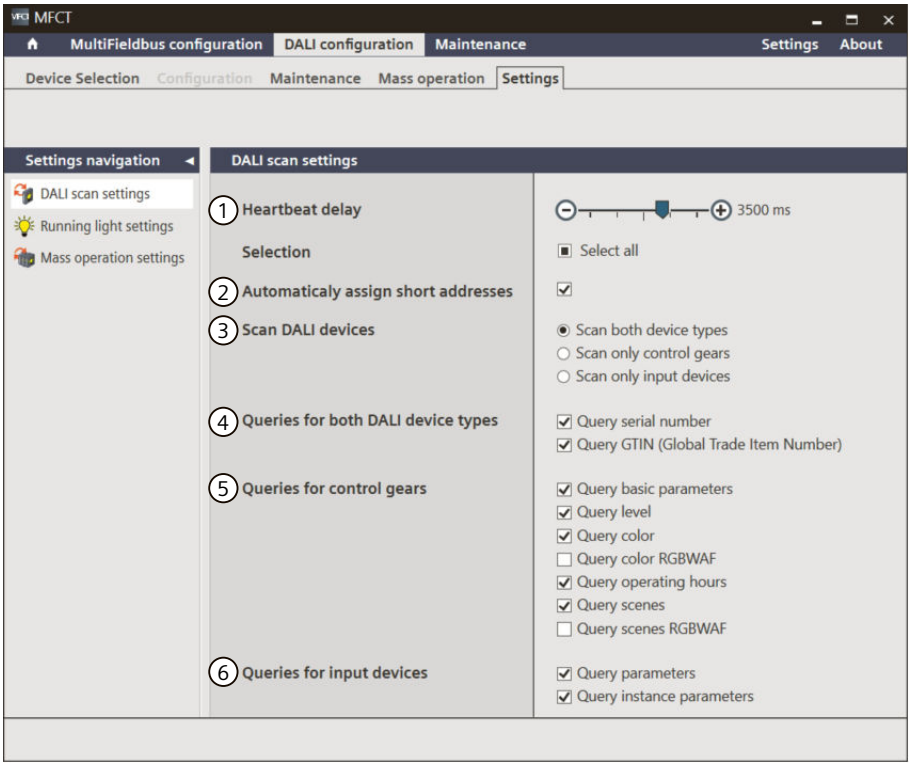

①	Heartbeat delay	Setting for the maximum time between two DALI frames to maintain communication.
②	Automatically assign short addresses	Specifies whether unaddressed devices on the DALI bus are automatically assigned an address.
③	Scan DALI devices	Specifies whether the MFCT should scan for control gear, input devices or all types on the bus.
④	Queries for both DALI device types	Specifies whether the GTIN code (Global Trade Item Number) and/or serial number should be queried for each device.
⑤	Queries for control gear	Specifies the parameters to be read out from the control gear.
⑥	Queries for input devices	Specifies the parameters queried for the input devices.

NOTE

A multiple selection is possible for items 4 to 6.
The more parameters that are queried, the longer the scan will take.

Configuration of the running light for identification

Select the entry "Running light settings" in the "Settings navigation" column.

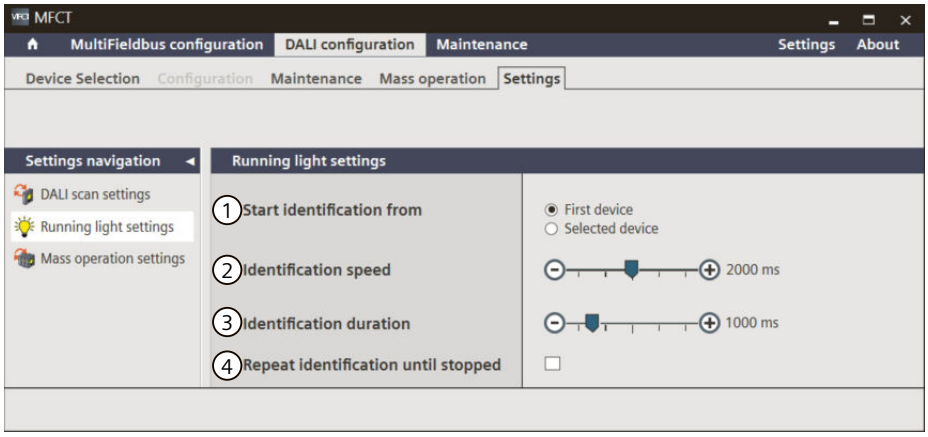

①	Start identification from	Specifies where the identification should start: • Selected device • Lowest address on the bus
②	Identification speed	Changeover time from one connected lamp to the next.
③	Identification duration	How long each controlled lamp should be lit.
④	Repeat identification until stopped	Activates the identification in an endless loop until manually stopped.

Parallel processing for the mass operation

Select the entry "Mass operation settings" in the "Settings navigation" column. You can activate parallel processing for devices and/or modules.

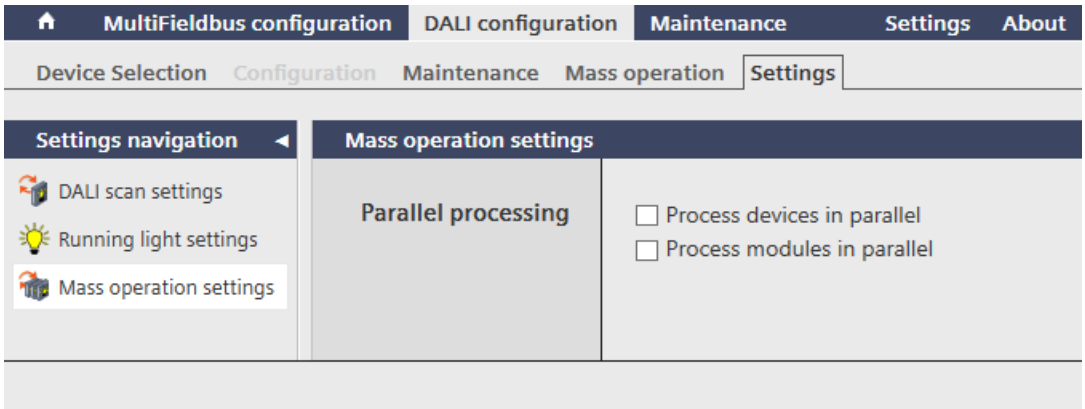

TM FAST 9

The TM FAST application is available as a plug-in in the MFCT. To use the TM FAST application, activate the plug-in.

Once you have activated the plug-in, you can find the TM FAST on the start page as an application. In an opened application, you can find the TM FAST as a tab in the area of the button for the start screen.

You can generate the following in the TM FAST application:

- A UPD file (**Upd**ate file)
- A DB file (**D**ata**b**lock file)

In this case, you use the UPD file to load the TM FAST application. You perform loading using the MFCT or the TIA Portal.

You use the DB file in STEP 7 (TIA Portal) to write the user logic from the user program of the CPU to a TM FAST module.

More information

You can learn how to activate a plug-in in section Plug-ins (Page 31).

You can get detailed information on the TM FAST module in the technology module TM FAST equipment manual (https://support.industry.siemens.com/cs/us/en/view/109816087).

You can find an application example for handling DB files in the following Internet entry (https://support.industry.siemens.com/cs/ww/en/view/109823442). This application example shows how to load and activate a TM FAST application from a SIMATIC CPU to the TM FAST module. This enables you to replace a module without additional tools such as TIA Portal or the MFCT.

9.1 Generating UPD and DB files

To generate UPD or DB files with the TM FAST application, proceed as follows:

1. Generate the Raw Binary File *.rbf and the VHD file *.vhd from the development environment for programming the FPGA application logic (Quartus® Prime Software).
2. Select the path to your RBF file in the "Quartus RBF programming file" field.
3. Select the path to your VHD file in the "IP configuration VHD file" field.
4. Select the folder in which the generated files are to be stored in the "Output directory" field.
5. After successful creation of the UPD and DB files, the following dialog is displayed as confirmation.

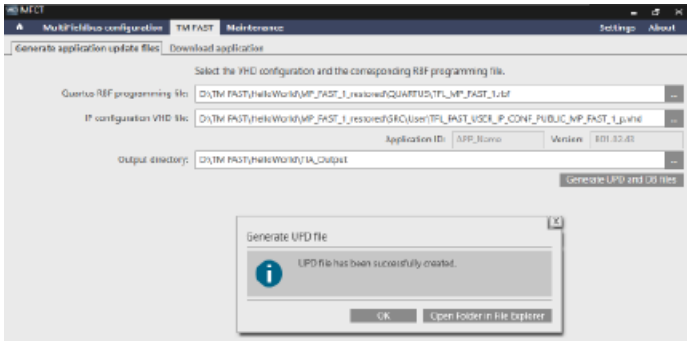

The result is that you will find the following files in the selected output directory:

- 6ES7 554-1AA00-0AB0 APP_Name_UserLogic_B01.02.43.upd
- APP_Name.db

You need the UPD file to load the user program created in Quartus® Prime using the MFCT or the TIA Portal.

More information

The DB file can be imported into STEP 7 (TIA Portal) as an external source and interconnected with the function block "CheckUserlogicdata". More information can be found in the following Internet entry (https://support.industry.siemens.com/cs/us/en/view/109817062).

9.2 Download UPD files

Transferring UPD file to a TM FAST module

You can transfer the UPD file to a TM FAST module on the tab "Download application > Device view area". To do so, proceed as follows:

1. Click the "Start scan" button to display all accessible devices of the preset network interface.

   NOTE

   To find all modules in the central configuration, select the "Inclusion of central working modules" check box under "Communication with CPUs" in the general settings.

   You can find more information in section General settings (Page 28).

2. Click the button to sort by devices with TM FAST modules.

3. In the "New application ID/logic version" column, select the TM FAST user logic (*.upd) for the update.
4. Click the button to start the download.

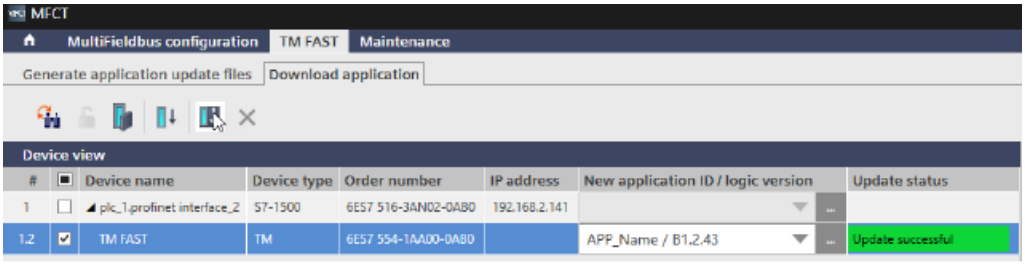

Result: You have started the download of the UPD file. You can see the progress of the update in the "Update status" column.

Loading and activating the application

In the "Module details" area, you see that the new TM FAST user logic has been loaded into the flash memory:

- Application ID: "APP_Name"
- User logic version: "B1.2.43".

To load the application into the FPGA and activate it, proceed as follows:

1. Select the command "Load TM FAST application from flash memory to FPGA" in the "ControlREC command" area.
2. Click the "Send command" button.

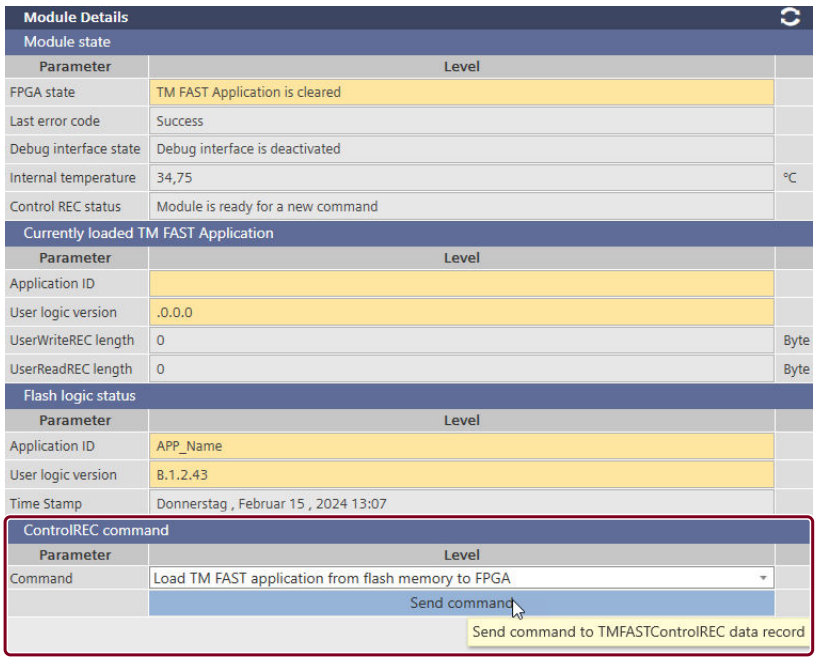

3. Select the command "Activate TM FAST application in FPGA" in the "ControlREC command" area.

4. Click the "Send command" button.

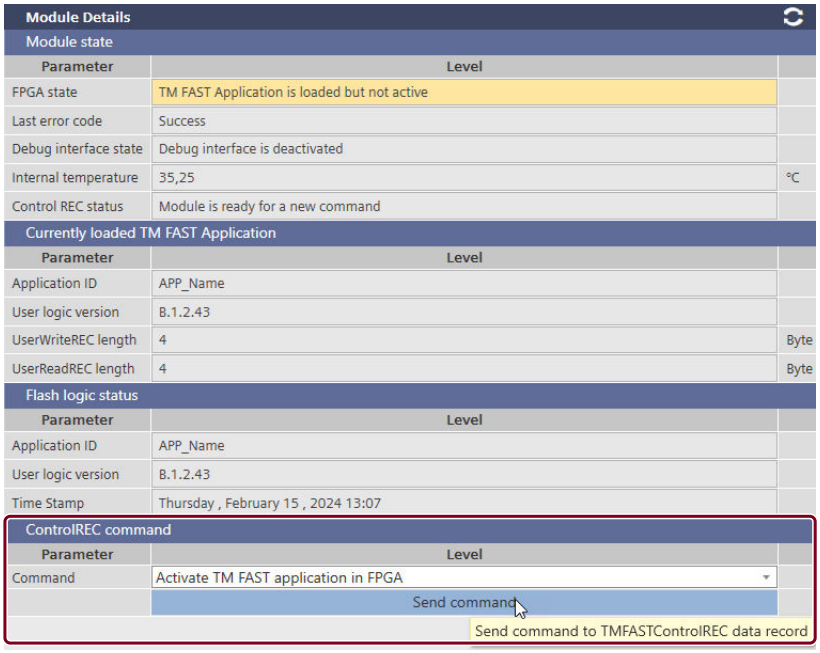

Upon successful activation, you will get the following message:

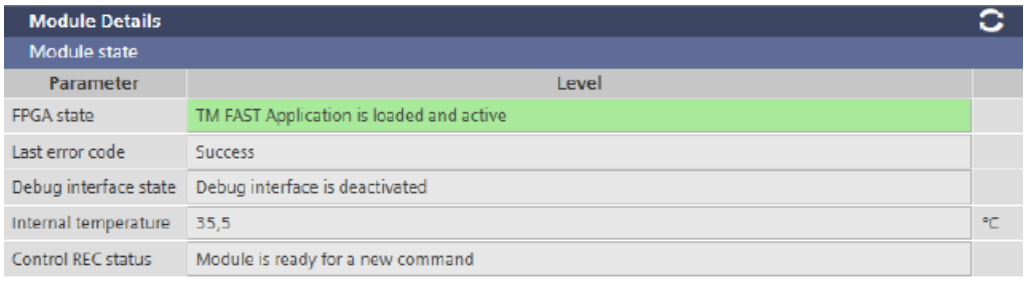

5. Enable the following parameters in the hardware configuration of the module:
   - Load TM FAST application during startup
   - Always activate TM FAST application

Result: You have loaded the application to FPGA and activated it. The application starts up automatically after a restart.

SIWAREX 10

The "SIWAREX" application is available as a plug-in in the MFCT. To use the "SIWAREX" application, activate the plug-in.

Once you have activated the plug-in, you can find SIWAREX on the start page as an application. In an opened application, you can find SIWAREX as a tab in the area of the button for the start screen.

You search the connected network for TM SIWAREX WP3x1 modules in the "SIWAREX" application. You have the following options for the found modules:

- Edit parameters
- Read, write or monitor data records

You can learn how to activate a plug-in in section Plug-ins (Page 31).

10.1 Scanning for SIWAREX assemblies

You scan for devices with connected SIWAREX modules on the "Device selection" tab. To do so, proceed as follows:

1. Click the "Start scan" button to search for accessible devices.

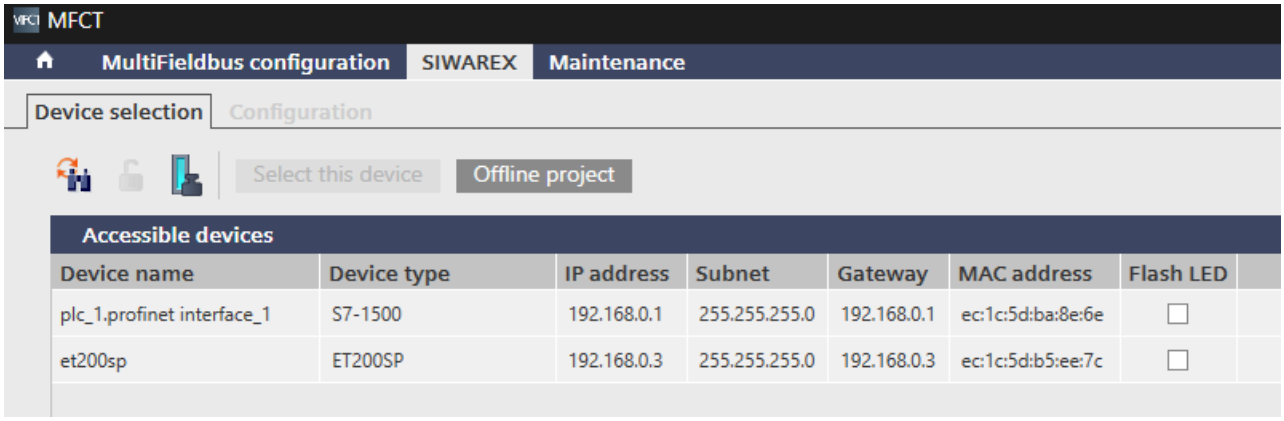

2. Optional: Click the "Set filter" button to show only the devices with connected SIWAREX WP3x1 modules.
3. Select the desired device in the selection list.
   If the ET 200SP station has multiple SIWAREX modules but you only want to select one of them, click its check box.

Result: You have scanned the network and selected the desired device. When you click the button Select this device, the station view opens.

Editing data offline

If you want to open and read backup files without an online connection, click the button Offline project. You can also prepare and store the parameters offline and transfer them to the modules later.

10.2 Setting up communication in the station view

You establish the communication with the SIWAREX module on the "Configuration" tab.

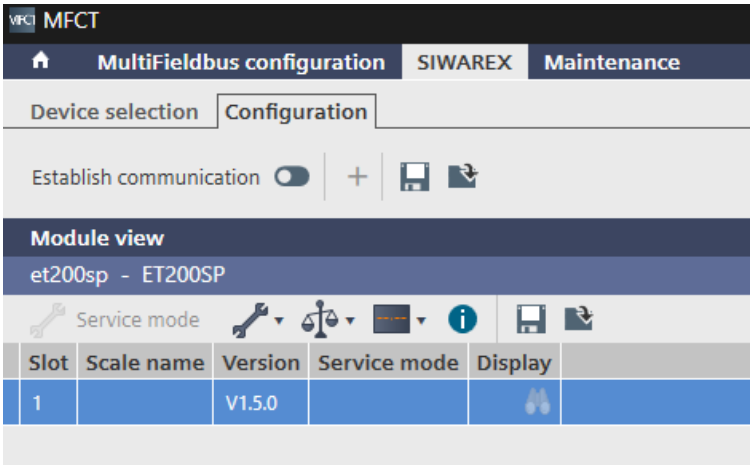

To establish the communication between the MFCT and the SIWAREX module, click the button Establish communication in the station view.

Result: The module view displays a list of all WP3x1 modules in the station.

10.3 Working in the station view

You can make different configurations on the "Configuration" tab. The figure below shows an example of the two areas "Module view" and "Details". You can find a detailed explanation of the icons in the following table.

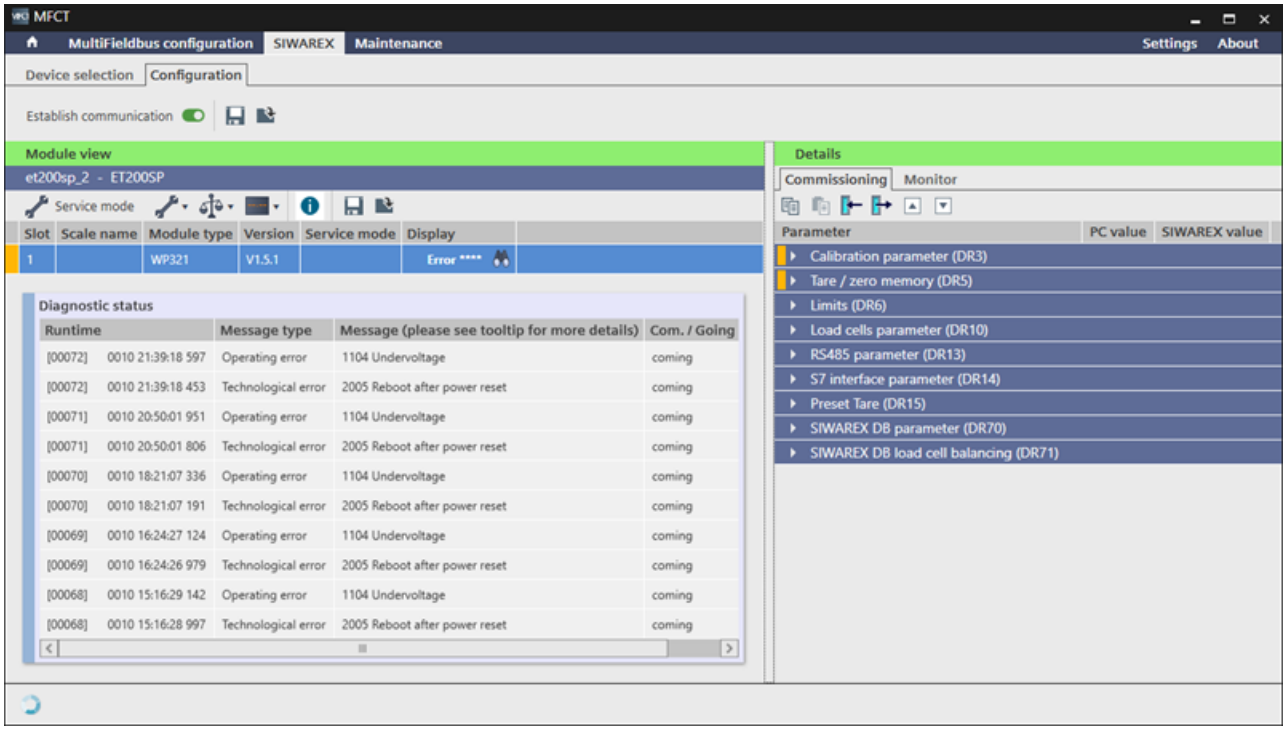

"Module view" area

	"Configuration" area: Create backup of the currently selected module. "Module view" area: Open/store configurations within the station.
Service mode	Activate/deactivate service mode.
	Execute service commands
	Execute scale commands
	Execute display commands
	Show diagnostics status Click the button to open the error buffer of the module.

Area "Details > Commissioning tab"

	Send data records from the MFCT to the module. You can only click the button if the PC values and the SIWAREX values are different from each other.
	Read in data records from the module to the MFCT.
	Open pop-up window with a strongly magnified weight display.

You see the error buffer of the module in the "Diagnostic status" display.

Diagnostic status

Runtime		Message type	Message (please see tooltip for more details)	Com. / Going
[00072]	0010 21:39:18 597	Operating error	1104 Undervoltage	coming
[00072]	0010 21:39:18 453	Technological error	2005 Reboot after power reset	coming
[00071]	0010 20:50:01 951	Operating error	1104 Undervoltage	coming
[00071]	0010 20:50:01 806	Technological error	2005 Reboot after power reset	coming
[00070]	0010 18:21:07 336	Operating error	1104 Undervoltage	coming
[00070]	0010 18:21:07 191	Technological error	2005 Reboot after power reset	coming
[00069]	0010 16:24:27 124	Operating error	1104 Undervoltage	coming
[00069]	0010 16:24:26 979	Technological error	2005 Reboot after power reset	coming
[00068]	0010 15:16:29 142	Operating error	1104 Undervoltage	coming
[00068]	0010 15:16:28 997	Technological error	2005 Reboot after power reset	coming

More information

You can find more information on the commands and parameters in the respective equipment manuals.

- TM SIWAREX WP321 (https://support.industry.siemens.com/cs/ww/en/view/109770838)
- TM SIWAREX WP341 (https://support.industry.siemens.com/cs/ww/en/view/109813264)
- TM SIWAREX WP351 (https://support.industry.siemens.com/cs/ww/en/view/109825886)

10.4 Commissioning and monitoring

Commissioning

In the "Details > Commissioning tab" area, you can view the module's data records and edit their parameters.

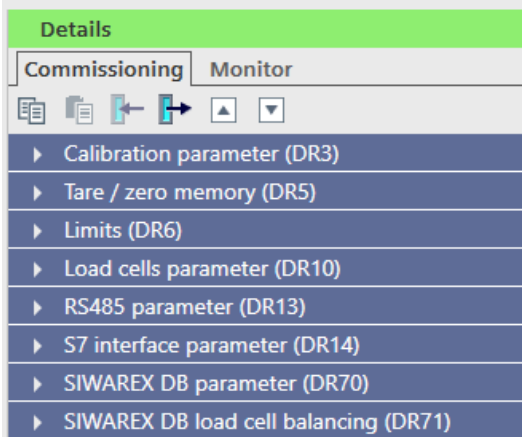

To change, for example, the adjustment parameters in data record 3 (DR3) of the SIWAREX WP321 module, proceed as follows:

1. Click the button to read all data records from the WP321 module into the MFCT.
2. Change the desired parameters.
   Parameters that have been changed but not yet transferred are highlighted in yellow.

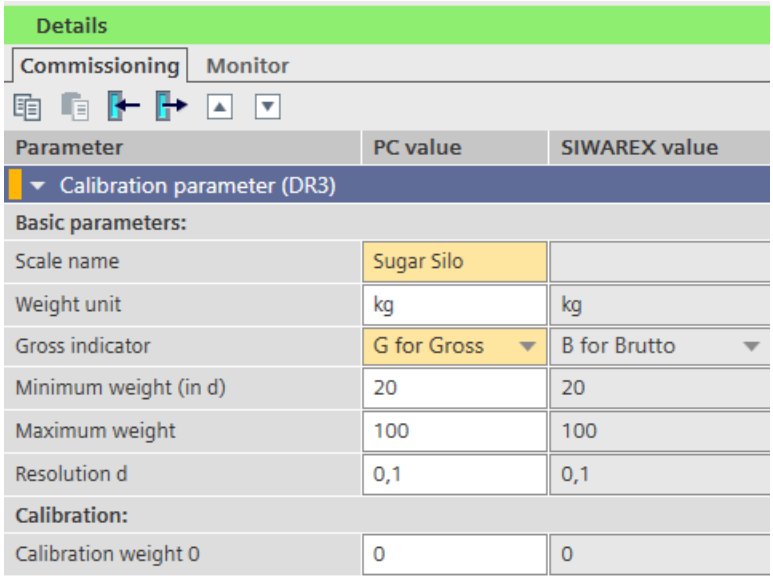

3. Click the button to write all data records from the MFCT to the WP321 module.

Result: The changed parameters have been transferred to the WP321 module.

You can expand or collapse all parameters by clicking the button .

A right-click in the "Parameters" area opens a context menu with further options for managing data records.

Monitoring

You can read-access and monitor all process data on the "Monitor" tab.

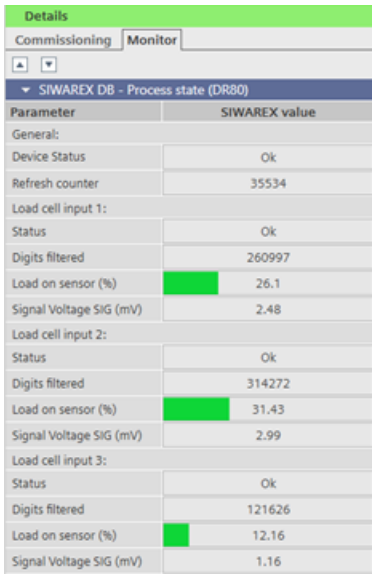

Parameter	SIWAREX value
General:	
Device Status	Ok
Refresh counter	35534
Load cell input 1:	
Status	Ok
Digits filtered	260997
Load on sensor (%)	26.1
Signal Voltage SIG (mV)	2.48
Load cell input 2:	
Status	Ok
Digits filtered	314272
Load on sensor (%)	31.43
Signal Voltage SIG (mV)	2.99
Load cell input 3:	
Status	Ok
Digits filtered	121626
Load on sensor (%)	12.16
Signal Voltage SIG (mV)	1.16

PtP Event Trace

11

The PTP Event Trace application is available as a plug-in in the MFCT. To use the "PtP Event Trace" application, activate the plug-in.

Once you have activated the plug-in, you can find PtP Event Trace on the start page as an application. In an opened application, you can find PtP Event Trace as a tab in the area of the button for the start screen.

You have the following options with the PtP Event Trace plug-in in combination with a SIMATIC CM PtP module:

- Read Event Traces
- Analyze serial communication
- Display the current configuration

More information

You can learn how to activate a plug-in in the section Plug-ins (Page 31).

You can find more information on the CM PtP module in the CM PtP (https://support.industry.siemens.com/cs/ww/en/view/109793681) equipment manual.

You can find more information on the configuration in the CM PtP - Configurations for point-to-point connections (https://support.industry.siemens.com/cs/ww/en/view/59057093) Function Manual.

11.1 Selecting a station with CM PtP module

You scan for stations with integrated CM PtP modules and can read out the traces of the modules on the "Device view" tab.

This offers you the following options:

- Analyze serial communication data
- Display the configuration of the serial interface

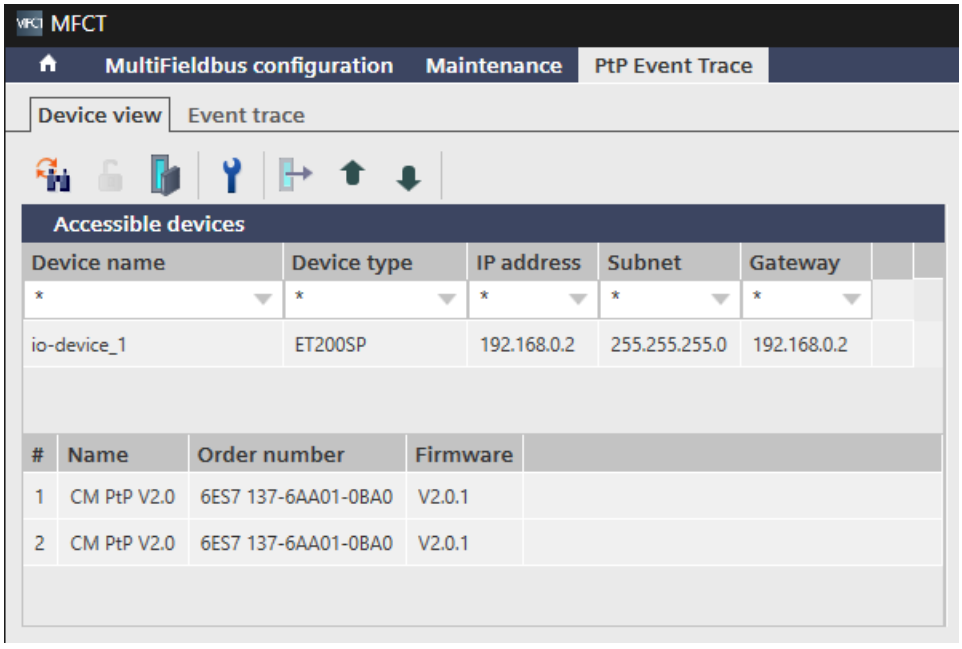

Procedure

To read out the trace from a CM PtP module, proceed as follows:

1. Click the "Start scan" button to scan for accessible devices.
2. Click the button to display only the devices with a CM PtP module.
3. To read out the trace from a CM PtP module:
   - Select the station
   - Select the CM PtP module
   - Click the button .

Result: The "Module details" tab shows the parameters of the CM PtP module.

Module details		
Identification & Maintenance		
Parameter	Value	
Order number	6ES7 137-6AA01-0BA0	
Serial number	S C-T7A10N7P2025	
Firmware version	V2.0.1	
Plant designation		
Location identifier		
Installation date		
Additional information		
Slot	1	
Port configuration		
Parameter	Value	
Specification of the operating mode	RS232C	
Receive line initial state	Keine	
Protocol	Freeport/Modbus	
Modbus CRC active	False	
Transmission rate	9600	bits/s

Importing/exporting trace files

To export a trace file, proceed as follows:

1. Read the trace of the selected module.
2. Click the "Export trace file" button .
3. Save the file in a location of your choice.

Result: You have saved the file in *.json format.

To import a trace file, proceed as follows:

1. Click the "Import trace file" button .
2. Select the desired file in *.json format.

Result: The "Module details" tab shows the saved parameters.

11.2 Analyzing a trace

The "PtP Event Trace" tab shows a table with the trace data.

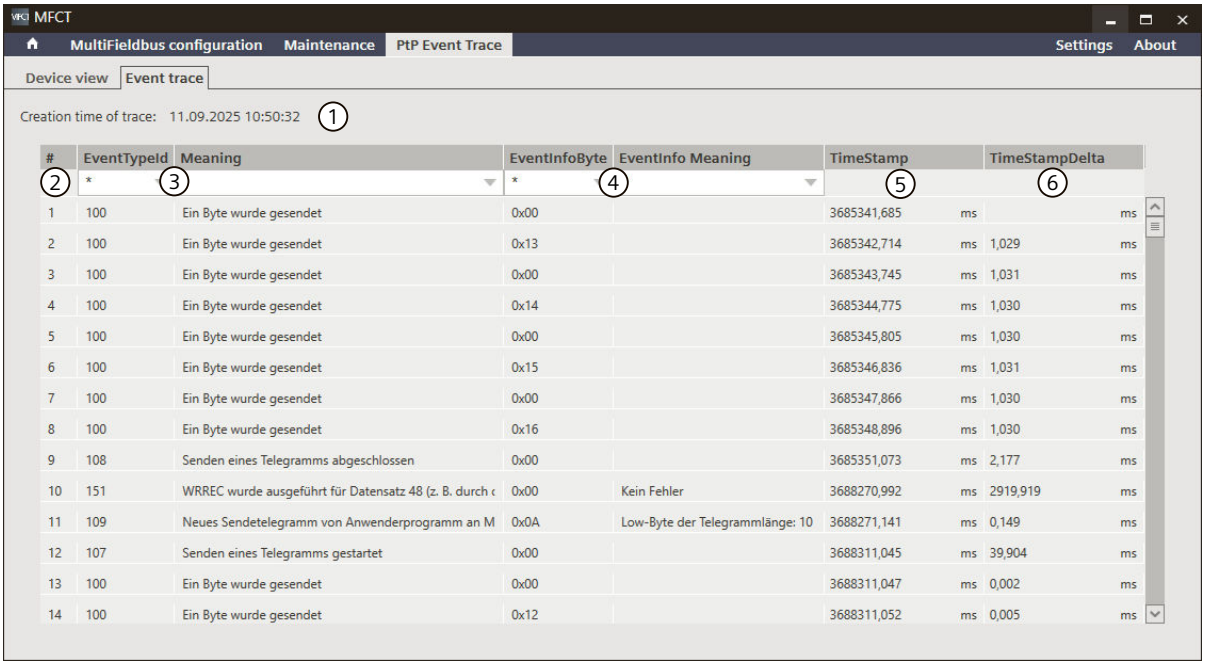

#	EventTypeId	Meaning	EventInfoByte	EventInfo Meaning	TimeStamp	TimeStampDelta
1	100	Ein Byte wurde gesendet	0x00		3685341,685 ms	ms
2	100	Ein Byte wurde gesendet	0x13		3685342,714 ms	1,029 ms
3	100	Ein Byte wurde gesendet	0x00		3685343,745 ms	1,031 ms
4	100	Ein Byte wurde gesendet	0x14		3685344,775 ms	1,030 ms
5	100	Ein Byte wurde gesendet	0x00		3685345,805 ms	1,030 ms
6	100	Ein Byte wurde gesendet	0x15		3685346,836 ms	1,031 ms
7	100	Ein Byte wurde gesendet	0x00		3685347,866 ms	1,030 ms
8	100	Ein Byte wurde gesendet	0x16		3685348,896 ms	1,030 ms
9	108	Senden eines Telegramms abgeschlossen	0x00		3685351,073 ms	2,177 ms
10	151	WRREC wurde ausgeführt für Datensatz 48 (z. B. durch (	0x00	Kein Fehler	3688270,992 ms	2919,919 ms
11	109	Neues Sendetelegramm von Anwenderprogramm an M	0x0A	Low-Byte der Telegrammlänge: 10	3688271,141 ms	0,149 ms
12	107	Senden eines Telegramms gestartet	0x00		3688311,045 ms	39,904 ms
13	100	Ein Byte wurde gesendet	0x00		3688311,047 ms	0,002 ms
14	100	Ein Byte wurde gesendet	0x12		3688311,052 ms	0,005 ms

①	Creation time of the trace	Creation time with the date and time of the CPU.
②	#	Consecutive numbering of the entries.
③	EventType and meaning	Type of event as a decimal number (EventType) and text (meaning).
④	EventInfoByte and EventInfo meaning	Additional event information as a hexadecimal number (EventInfoByte) and text (EventInfo meaning).
⑤	Time stamp	Relative time stamp of the event in milliseconds, for time analysis between the individual events.
⑥	Time stamp delta	Time difference between two consecutive events. If the table has been filtered, the time difference from the previous event is displayed.

More information

A complete list of all possible events can be found in the "CM PtP - Configurations for point-to-point connections" Function Manual (https://support.industry.siemens.com/cs/ww/en/view/59057093).

Maintenance

12

You have the following options in the "Maintenance" tab:

- Assign parameters (Page 94)
- Read service data (Page 95)
- Firmware update (Page 95)

After opening the MFCT, you can find "Maintenance" on the start page as an application. In an opened MFCT application, you can find "Maintenance" as a separate tab.

12.1 "Assign parameters" tab

You have the following options in the "Assign parameters" tab:

- Assign network parameters (Page 94)
- Resetting to factory settings (Page 94)
- Defining scan settings (Page 94)

Procedure for displaying all accessible online devices

To display all accessible online devices, proceed as follows:

1. Click "Start scan" .

   The following figure shows the contents of the "Assign parameters" tab:

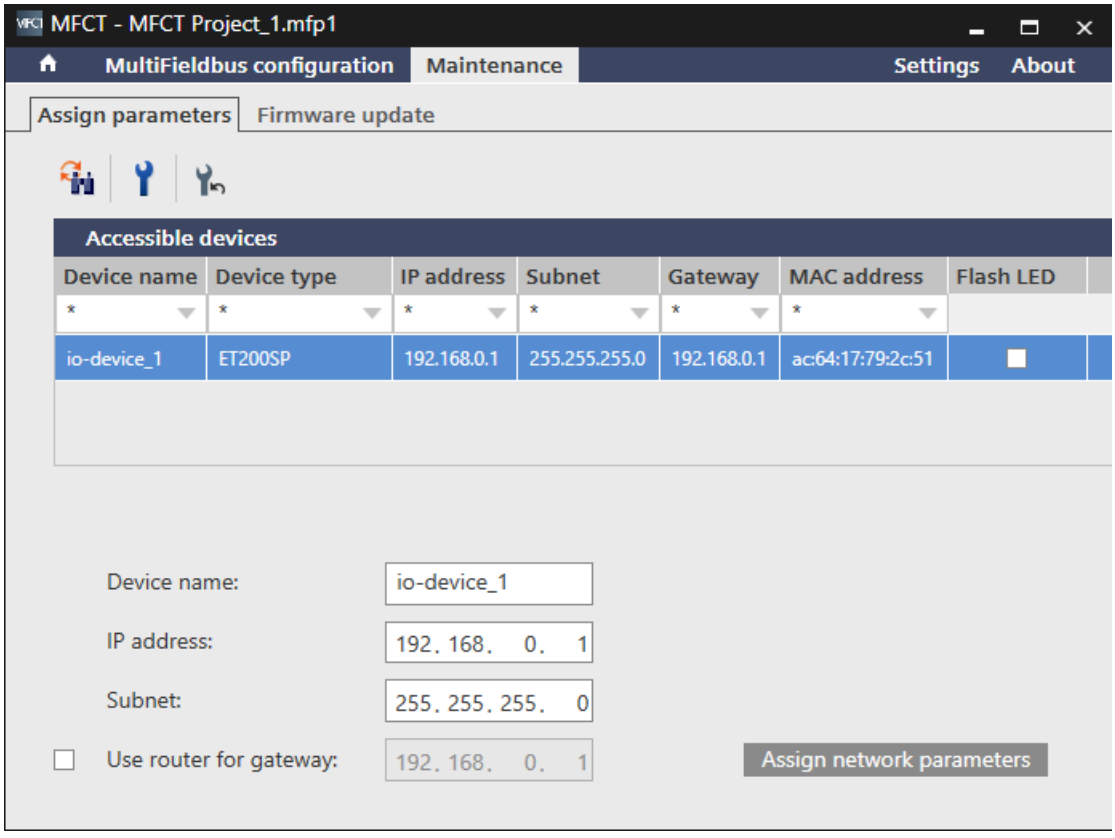

2. Select the desired device.
3. To more easily locate the selected device, you have the option of making the LEDs of the device flash. To do so, select the check box in the "Flash LED" column.

You have found your desired device and can now carry out the steps described below.

12.1.1 Assigning network parameters

Requirement: You have opened the view with your selected device.

To assign the network parameters for MF devices, proceed as follows:

1. In the lower area, you can find the device name, the IP address and the subnet in which the selected device is located. If necessary, change this information.
2. If you are using a gateway, select the "Use router for gateway" check box.
3. Enter the address of the router.
4. To complete the entries, click the "Assign network parameters" button.

You will receive a message that the assignment of the network parameters was successful.

12.1.2 Resetting to factory settings

Requirement: You have opened the view with your selected device.

To reset a device to factory settings, click the "Reset network parameters" button .

After a positive answer to the confirmation prompt, the network parameters are reset to the factory settings.

12.1.3 Defining scan settings

To define the scan settings, proceed as follows:

1. Click the "Scan settings" button .
2. In the "Scan range" selection menu, select the area you want to scan:
   - All devices
   - Devices in the IP address range
   - Devices with specific IP address
   - Use the grid filter for network scans
3. Use the "Communication with CPUs" check boxes to select the following options:
   - Inclusion of centrally working modules
   - Include devices found via IP forwarding in other subnets
4. Confirm the selection with the "OK" button.

You have made and completed the settings for the scan.

12.2 "Read service data" tab

Requirement

The ET 200 station supports this function.

Procedure

To read out and save provided service data, proceed as follows:

1. Click "Start scan" .
2. Select the desired device.
3. To locate the selected device, you have the option of making the LEDs of the device flash. To do so, select the check box in the "Flash LED" column.
4. Enter the path under which you want to save the service data in the "Service data output path" text box at the bottom.
5. Click the "Start" button.

You will receive a message that the reading of the service data has been successfully completed.

12.3 "Firmware update" tab

The firmware update allows you to load or activate new firmware in multiple devices in parallel during operation. The devices continue to run without interruption.

You have the following options in the "Firmware update" tab:

- Settings for firmware update (Page 96)
- Update firmware (Page 100)
- Activate firmware (Page 103)

Procedure to display all accessible online devices

To display all accessible online devices, proceed as follows:

1. Click the "Start scan" button .
   The following figure shows a section of the contents of the "Firmware update" tab:

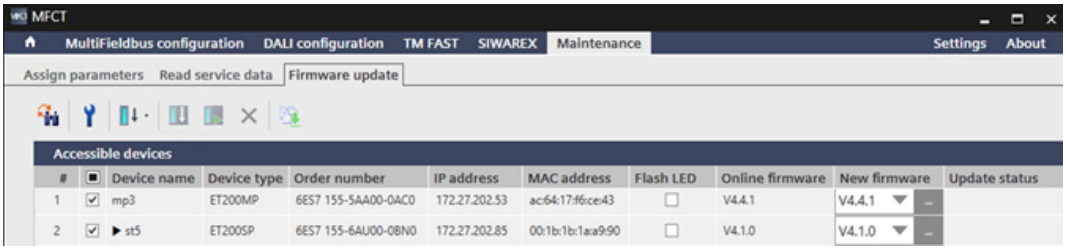

You have found your devices and can now carry out the steps described below.

12.3.1 Settings for firmware update

To make the settings for the firmware update, proceed as follows:

1. Click .
   The following figure shows the contents of the "Firmware update settings" window:

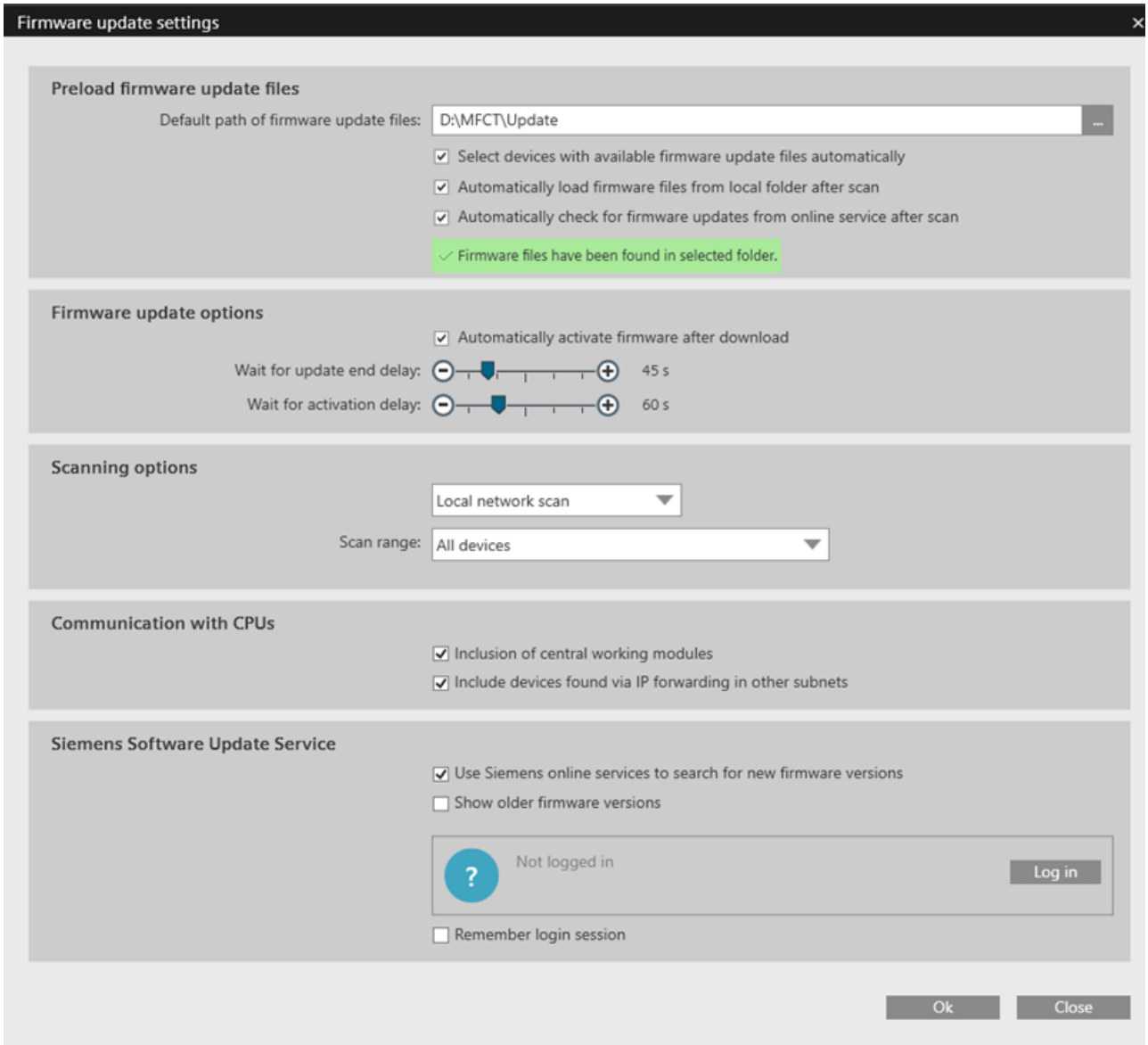

In the "Firmware update settings" window that opens, you can now make the settings explained below.

Preload the firmware update file

In the "Preload firmware update file" area, you can find the "Default path of firmware update file" text box. Here, you specify the storage path for the firmware update file.

When the "Select devices with available firmware update files automatically" check box is selected, all devices in the network for which the following criteria are met are automatically identified:

- a suitable firmware update file is available, and
- an update is possible or required, e.g. because the current firmware is out of date.

With the following options, you determine which firmware files the MFCT should display during updates:

- After the scan, automatically load firmware files from the local directory:
  The MFCT displays the locally stored firmware files in the selection menu during updates.
- After the scan, automatically check for firmware updates from the online service:
  The MFCT displays the firmware files provided by the Siemens Software Update Service in the selection menu during updates.
  This option is only available if the "Use Siemens online services to search for new firmware versions" option is enabled in the "Siemens Software Update Service" area.

Firmware update options

To activate the new firmware **directly after loading**, select the "Automatically activate firmware after download" check box. This option must be enabled in order for the two options below it to take effect.

- "Wait for update end delay": Specifies the delay time between the sending of the update file and the confirmation by the module that it received it.
  This prevents an unwanted cancellation of the download to the device.
- "Wait for activation delay": After the successful download, the MFCT waits the set amount of time before activating the firmware and restarting the device.

You can find information on the delay times in the respective equipment manual of the module. The times must be adjusted to the module with the longest delay time.

Scanning options

In the "Scanning options" area, you can determine whether the scan if to be run locally or whether subnets are also to be included.

You can find the further procedure in the section Set scanning options (Page 99).

Communication with CPUs

In the "Communication with CPUs" area, select the range in which the network scan should detect modules.

- "Inclusion of centrally working modules" check box:
  The network scan detects centrally plugged modules on a CPU.
- "Include devices found via IP forwarding in other subnets" check box:
  The network scan also detects devices in other subnets.

Siemens Software Update Service

If this section is not shown, this service is currently unavailable.

The Siemens Software Update Service is an automated service that ensures that your SIMATIC software is always up to date.

To use the service, you must register with the Siemens Software Update Service. After successfully registering, click the "Log in" button to connect your MFCT to the Siemens Software Update Service.

Select the "Use Siemens online services to search for new firmware versions" check box to allow the MFCT to search for available firmware files using the Siemens Software Update Service.

If you select the "Show older firmware versions" option, the Siemens Software Update Service will also display previous firmware files for the modules.

Select the "Remember login session" option to save your login credentials. If you are already logged in and you enable the option, you will be logged out of the Siemens Software Update Service and will need to log in again once.

12.3.1.1 Setting scanning options

To set the scan options, proceed as follows:

1. In the "Scan options" drop-down list, select the area you want to scan:
   - Local network scan: update the firmware in the local network
   - Subnet scan: update the firmware in multiple subnets

     The following figure shows an example of the three subnets found:

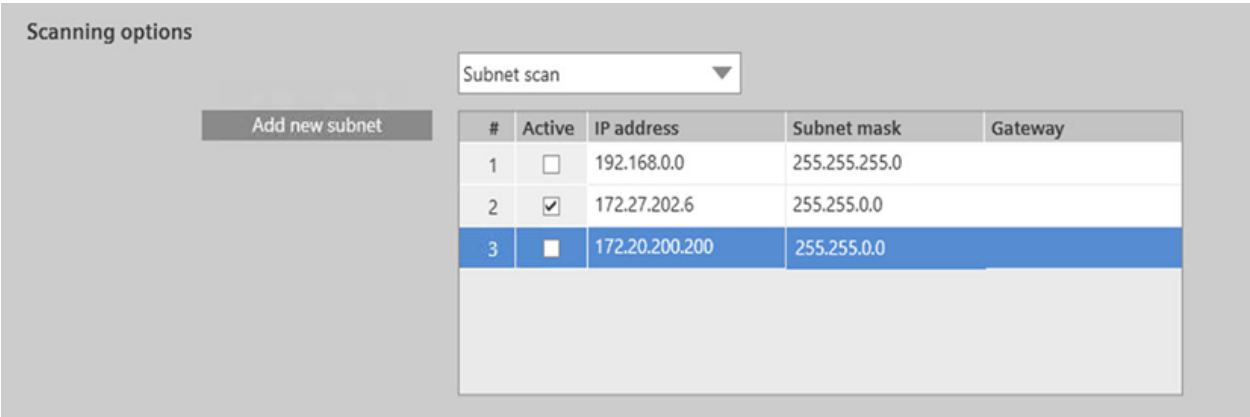

2. Enter the following details for each subnet:
   - IP address
   - Subnet mask
   - Address for the gateway
3. To create a new subnet and add it to the list, click the "Add new subnet" button.
4. To complete the entries, click the "OK" button.

You have made and completed the settings for the scan options.

12.3.2 Updating firmware

NOTE

We recommend that you do not connect directly with the device which you want to update. The activation of the new firmware can lead to a loss of the scanned devices due to a brief interruption of the network connection at the network adapter.

Procedure - Checking for updates

To check whether firmware updates are available for your devices, proceed as follows:

1. Click "Start scan" .
   All devices are displayed.
2. Optional: Use the incremental search function to locate the desired MF devices and modules. The search starts immediately after you enter the first character. The search query is refined with each additional character. The results are dynamically adapted according to your entry.

Accessible devices

#		Device name	Device type	Order number	IP address	MAC address	Flash LED	Online firmware	New firmware
		*	*	6ES7131	*	*		*	
2.07	☐	DI 8x24VDC HF V1.0	Digital	6ES7 131-6BF00-0CA0				V1.0.0	
2.08	☐	DI 8x24VDC HF V2.0	Digital	6ES7 131-6BF00-0CA0				V2.0.3	

3. Click the "Check for updates" button.
   The MFCT opens the selection menu with the available options for searching for firmware updates.
4. Select one of the following options in the shortcut menu:
   - Check for all updates:
     The MFCT searches online and locally for firmware updates.
   - Check for online updates:
     The MFCT searches the Siemens Software Update Service for firmware updates.
   - Check for local updates:
     The MFCT searches locally for firmware updates in the path you selected in the firmware update settings.

NOTE

Separation of the plant network and the Internet

To search online for firmware updates, your PG/PC must have an Internet connection. If it is not possible to connect to both the plant network and the Internet at the same time, proceed as follows:

1. After the scanning process, disconnect the plant network from your PG/PC.
2. Connect to the Internet.

Result: You have started the check for current firmware files.
The MFCT searches for available firmware updates based on your selection. The following subsections explain how to select firmware updates and load them onto the devices.

Procedure – Selecting and downloading the firmware file

Once the MFCT has finished checking for firmware updates, proceed as follows:

1. Navigate to the "New firmware" column.
2. In the selection menu, choose which firmware file you want to use for each device. Firmware files that are available online are indicated by the Internet icon V2.0.3 in the MFCT.

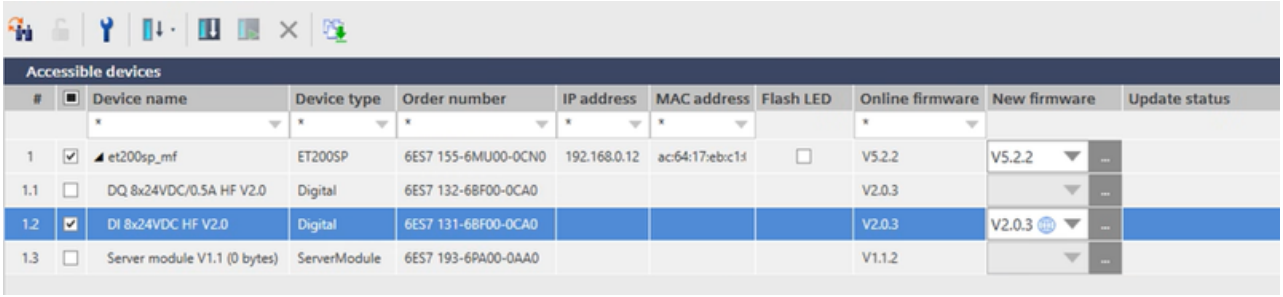

Intermediate result: You have selected the desired firmware file for all the required devices.

If you want to use firmware files that are available online but you are not connected to your plant network, click the "Download all online firmware" button. The MFCT downloads the selected firmware files and saves them in the path you specified in the firmware update settings. The "Update status" column shows the current progress.

The downloaded firmware files are then displayed in the device selection menus just like locally stored firmware files.

Procedure - Loading firmware to the devices

To load the firmware on the devices, proceed as follows:

1. Optional: Reconnect your plant network to the PG/PC where the firmware updates are stored.
2. Set the appropriate firmware file for each device.

   Recommendation: If you are using a STEP 7 firmware update file, select the file: header.upd.

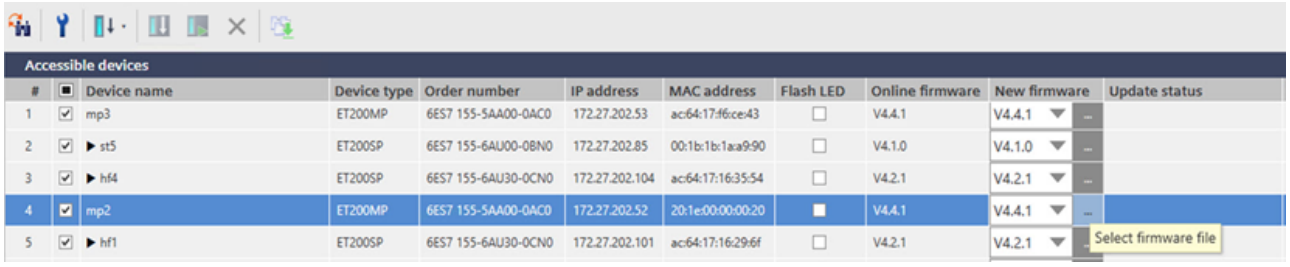

#		Device name	Device type	Order number	IP address	MAC address	Flash LED	Online firmware	New firmware	Update status
1	☑	mp3	ET200MP	6ES7 155-5AA00-0AC0	172.27.202.53	ac:64:17:f6:ce:43	☐	V4.4.1	V4.4.1	
2	☑	▶ st5	ET200SP	6ES7 155-6AU00-0BN0	172.27.202.85	00:1b:1b:1aa9:90	☐	V4.1.0	V4.1.0	
3	☑	▶ hf4	ET200SP	6ES7 155-6AU30-0CN0	172.27.202.104	ac:64:17:16:35:54	☐	V4.2.1	V4.2.1	
4	☑	mp2	ET200MP	6ES7 155-5AA00-0AC0	172.27.202.52	20:1e:00:00:00:20	■	V4.4.1	V4.4.1	
5	☑	▶ hf1	ET200SP	6ES7 155-6AU30-0CN0	172.27.202.101	ac:64:17:16:29:6f	☐	V4.2.1	V4.2.1	

NOTE

Select a directory, which contains subdirectories with firmware files.

If you select large directories, entire hard disks (for example C:\) or directories on network drives, the corresponding access can take very long or MFCT can no longer react.

3. Select the devices to be updated.

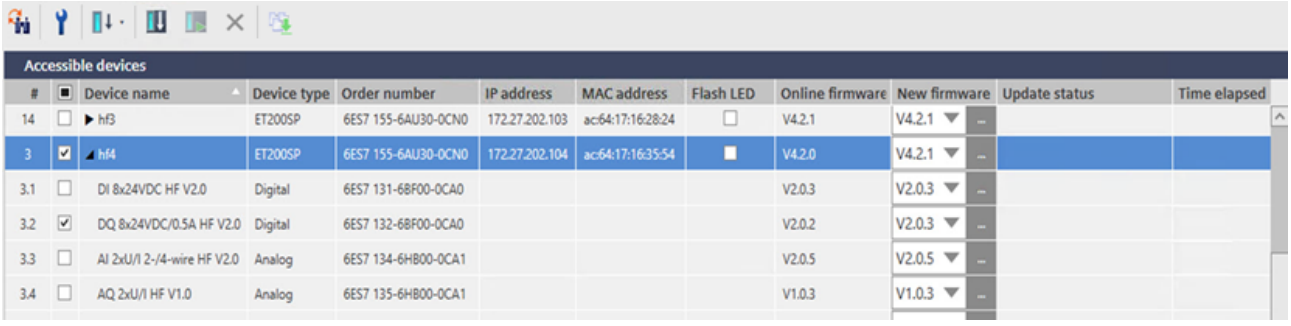

#		Device name	Device type	Order number	IP address	MAC address	Flash LED	Online firmware	New firmware	Update status	Time elapsed
14	☐	▶ hf3	ET200SP	6ES7 155-6AU30-0CN0	172.27.202.103	ac:64:17:16:28:24	☐	V4.2.1	V4.2.1		
3	☑	◢ hf4	ET200SP	6ES7 155-6AU30-0CN0	172.27.202.104	ac:64:17:16:35:54	■	V4.2.0	V4.2.1		
3.1	☐	DI 8x24VDC HF V2.0	Digital	6ES7 131-6BF00-0CA0				V2.0.3	V2.0.3		
3.2	☑	DQ 8x24VDC/0.5A HF V2.0	Digital	6ES7 132-6BF00-0CA0				V2.0.2	V2.0.3		
3.3	☐	AI 2xU/I 2-/4-wire HF V2.0	Analog	6ES7 134-6HB00-0CA1				V2.0.5	V2.0.5		
3.4	☐	AQ 2xU/I HF V1.0	Analog	6ES7 135-6HB00-0CA1				V1.0.3	V1.0.3		

4. To start the firmware update for the selected devices, click the "Update firmware" button .
   The update can be canceled at any time using the "Cancel" button .

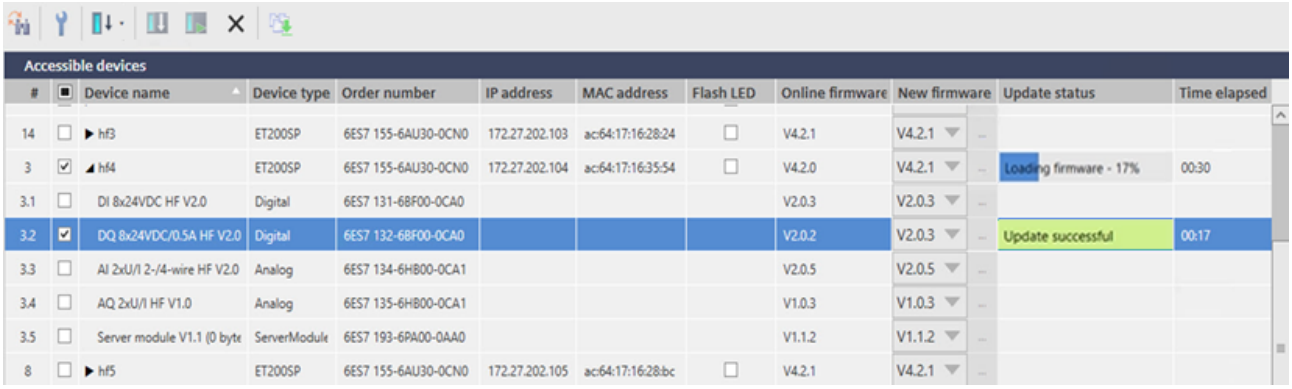

NOTE

If you cancel the update of the firmware in the "Initialization" or "Waiting" phase, it takes some minutes until the MF devices are ready again and you can restart the update.

12.3.3 Activating the firmware

The new firmware is not active yet once the firmware update has been successfully performed. You can activate the firmware on the device later.

Procedure

To activate the firmware, proceed as follows:

1. Click the "Start scan" button . You can recognize devices with updated firmware that has not been activated yet in the device table by scanning again.
2. Select the devices whose firmware you want to activate.

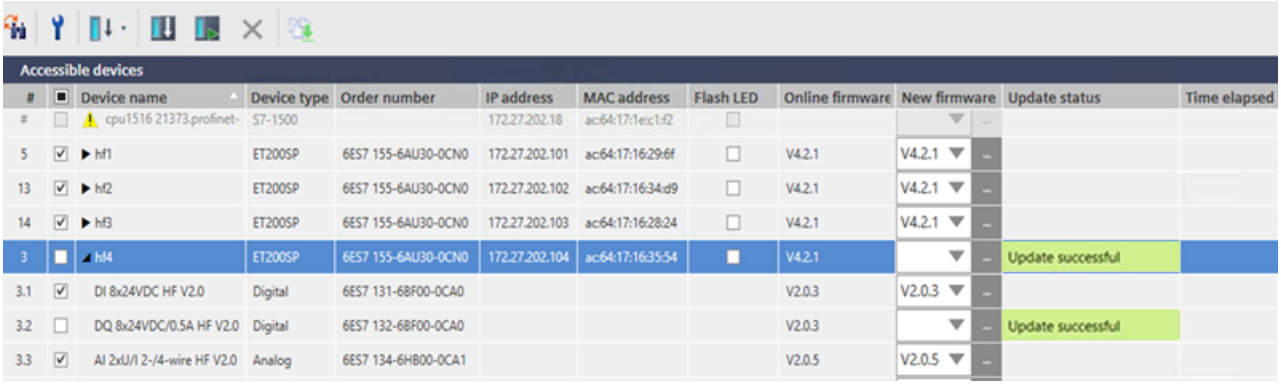

3. Click the "Activate firmware" button . This activates the firmware of the selected devices one after the other.
4. If activation fails, scan the network again.

Once activation is complete, all selected devices should have the latest firmware version.

SIEMENS

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SIMATIC

IO-Link system

Function Manual

05/2024
A5E31637677-AB

Introduction

Purpose of the documentation

This function manual provides a general overview of the IO-Link communication system.

It shows the interaction of the various components of an IO-Link system and will help you improve your general understanding of IO-Link.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Proficiency with STEP 7

Scope of the documentation

This documentation is the basic documentation for IO-Link systems at Siemens. The product documentation is based on this documentation.

Conventions

In this documentation, "STEP 7" is used as a synonym for all versions of the configuration and programming software "STEP 7 (TIA Portal)".

Please also observe notes marked as follows:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Additional support

- Information about Technical Support is available in section Siemens Industry Online Support (Page 4).
- The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (https://support.automation.siemens.com/WW/view/en/58649293).
- Information about the online catalog and online order system is available in section SiePortal (Page 4).

Guide

Documentation

Various IO-Link products are available from Siemens. Each of these products has a separate documentation. The IO-Link products are embedded in systems, e.g. ET 200SP. The documentation for the system consists of the respective system manual, function manuals and manuals. In addition, the STEP 7 online help and the Port Configuration Tool S7-PCT online help assist you in configuring and programming your automation system with IO-Link.

IO-Link components from Siemens

Siemens offers a wide range of products and support for IO-Link:

- Master
- Device, I/O modules
- Device, industrial switchgear
- Device, RFID systems (RFID = radio-frequency identification)
- Device, process instrumentation
- Device, signaling columns
- Device, power supplies
- Port Configuration Tool - S7-PCT (https://support.industry.siemens.com/cs/ww/en/view/32469496)
- IO-Link library (https://support.industry.siemens.com/cs/ww/en/view/82981502) with the blocks "LIOLink_Master" and "LIOLink_Device"
- Overview of the topic IO-Link (http://www.siemens.com/io-link)
- IT connection of IO-Link devices via OPC UA with the Field Data Enabler PN

Additional information on the products can be found on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109737170).

Additional documentation for IO-Link

You can find a free download of the latest documentation on the IO-Link products on the Internet (https://support.industry.siemens.com/cs/CN/en/ps/15818/man).

Siemens Industry Online Support

You can find current information on the following topics quickly and easily here:

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.
- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.
- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.
- **Forums**

  For answers and solutions concerning automation technology.
- **mySupport**

  Your personal working area in Industry Online Support for messages, support queries, and configurable documents.

This information is provided by the Siemens Industry Online Support in the Internet (http://www.siemens.com/automation/service&support).

SiePortal

SiePortal is the catalog and ordering system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

Open-source software

Open-source software is used in the firmware of the SIMATIC Drive Controller. The open-source software is provided free of charge. We are liable for the product described, including the open-source software contained in it, pursuant to the conditions applicable to the product. Siemens accepts no liability for the use of the open-source software over and above the program sequence intended for our product, or for any faults caused by modifications to the software.

For legal reasons, we are obliged to publish the original text of the license conditions and copyright notices.

You will find these on the Internet with the firmware downloads

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System overview

1

Introduction

A continuous communication down to the lowest field level ensures enhanced use of the functions and performance capability of sensors and actuators. Enhanced use of sensors and actuators allows you to operate your machines and plants more productively.

No data other than the actual process value can be exchanged via the standard interfaces (digital, analog) used at the sensor/actuator level. Sensors and actuators with integrated intelligence are now used for increasingly complex functions and require a communication interface tailored to these requirements.

Definition

IO-Link is an innovative, point-to-point communication interface for the sensor/actuator area that is specified in IEC 61131-9.

IO-Link consists of the following system components:

- IO-Link master
- IO-Link device and device-specific description files (IODD)
- Unshielded 3-wire or 5-wire standard cable
- Engineering tool for configuring and assigning parameters of IO-Link

1.1 Advantages of IO-Link

The IO-Link system offers significant advantages as digital interface when connecting sensors/actuators:

- Open standard in accordance with IEC 61131-9
  - Devices can be integrated in the same way in all conventional fieldbus systems and automation systems
- Tool supported parameter setting and central data management
  - Fast configuration and commissioning
  - Simple creation of current plant documentation even for sensors/actuators
- Single, uniform wiring and far fewer different interfaces at the sensors/actors
  - Standardized, uniform interface for sensors and actuators independent of their complexity (switching, measuring, multi-channel, binary, mixed signals, etc.)
  - Reduction in the variety of types and inventory
  - Fast commissioning
  - Any combination of IO-Link devices and sensors/actuators without IO-Link at IO-Link master

- Continuous communication between sensors/actuators and the CPU
  - Access to all process data, diagnostic data and device information
  - Access to device-specific data, such as energy data
  - Remote diagnostics can be performed
- Continuous diagnostic information down to sensor/actuator level
  - Reduction in troubleshooting effort
  - Minimizing risk of failure
  - Preventive maintenance and optimization of service and maintenance planning
- Dynamic change of sensor/actuators parameters by the controller or the operator at the HMI
  - Reduction in downtimes during product change
  - Increased variability of the machine
- Automatic reassignment of parameters when devices are replaced during operation
  - Minimization of downtimes
  - Device replacement by untrained personnel without additional aids
  - Avoidance of incorrect settings
- Integrated device identification
  - Identification of the installed devices
  - Ensure quality of result in production and manufacturing when replacing the device

1.2 Overview of IO-Link system

Components

A Siemens IO-Link system consists of the following components:

- IO-Link master
- IO-Link device, for example:
  - Sensors/actuators
  - RFID readers
  - I/O modules
  - Signaling columns
  - ...
- Unshielded 3-wire or 5-wire standard cables
- Engineering tool for configuring and assigning parameters of IO-Link
- IT connection via OPC UA

Example plant with IO-Link

The figure below shows an example of plant architecture with IO-Link.

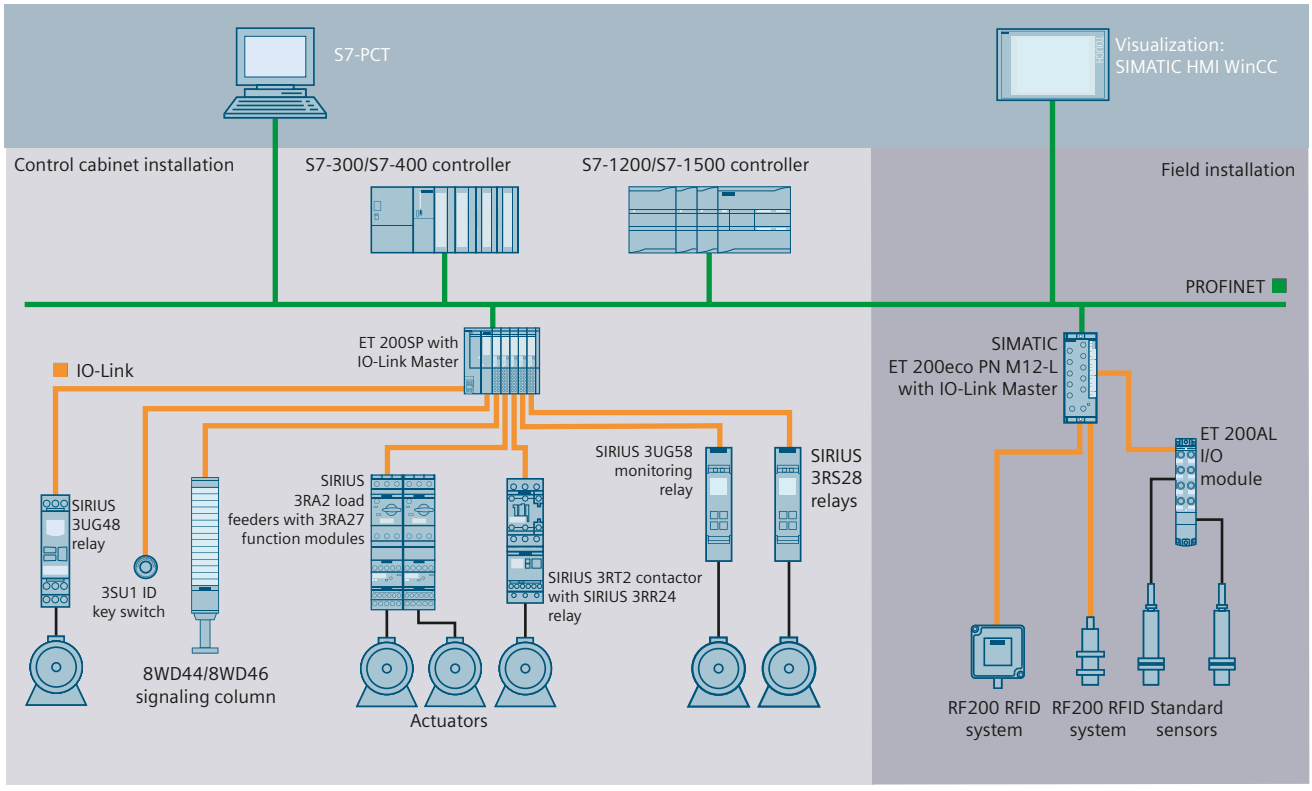

Figure 3-781 Plant architecture with IO-Link

The IO-Link master establishes the connection between the IO-Link devices and the automation system. If the IO-Link master is a component of the I/O system, it is installed either in the control cabinet or directly in the field as remote I/O in degree of protection IP65/67/69K. The IO-Link master communicates by means of various fieldbuses or product-specific backplane buses. An IO-Link master can have multiple IO-Link ports (channels). An IO-Link device can be connected (point-to-point communication) to each port.

Engineering

The IO-Link system is engineered parallel to the overall automation system and can be embedded in it and intermeshed with it.

1.3 IO-Link interface

Introduction

The IO-Link is a serial, bidirectional point-to-point connection for signal transmission and power distribution under any network, fieldbus or backplane bus.

Connection system in IP65/67/69K

M12 connectors and other connectors are defined for the connection system in IP65/67/69K; sensors have a 4-pin connector, actuators a 5-pin connector. IO-Link masters are always equipped with a 5-pin M12 socket.

The pin assignment according to IEC 60974-5-2 is specified as follows:

- Pin 1: 24 V
- Pin 3: 0 V
- Pin 4: Switching and communication cable (C/Q)

In addition to IO Link communication, these three pins also implement the power supply of the device.
Detailed information about the power supply can be found in the documentation of the utilized IO-Link master.

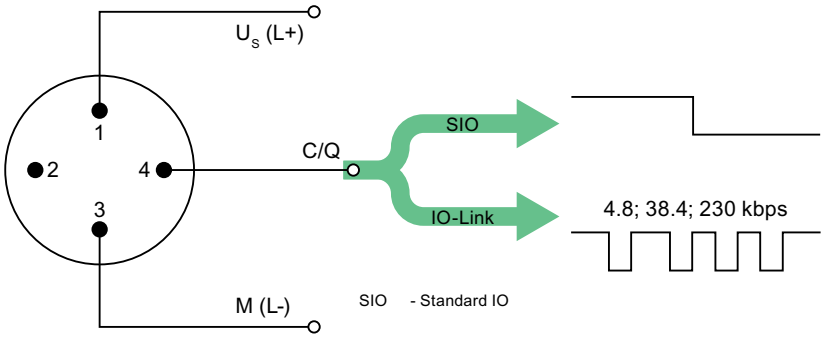

Pin	Signal	Definition	Standard
1	U_S (L+)	24 V	IEC 61131-2
2	-	not defined	-
3	M (L-)	0 V	IEC 61131-2
4	Q	Switching signal DI, DQ (SIO)	IEC 61131-2
4	C	"coded switching signal" (IO-Link)	IEC 61131-9

Figure 3-782 Pin assignment IO-Link device

Port types in IP65/67/69K

Two types of ports are distinguished in the specifications for IO-Link masters:

- Port Class A (Type A)
  With this type, the functions of pins 2 and 5 are not assigned. The manufacturer defines this function. Generally, an additional digital channel is assigned to pin 2.

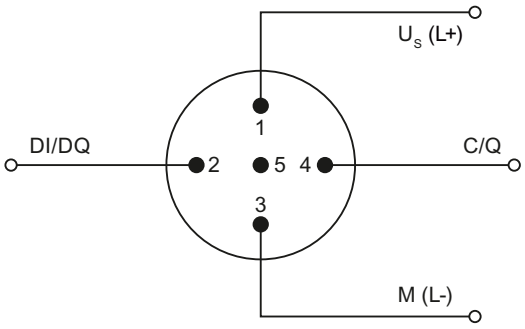

Figure 3-783 Pin assignment Port Class A

- Port Class B (Type B)
  This type offers an additional supply voltage and is suitable for the connection of devices that have an increased power requirement. In this case an additional (galvanically isolated) supply voltage is made available by pins 2 and 5. A 5-wire standard cable is required to use this additional supply voltage.

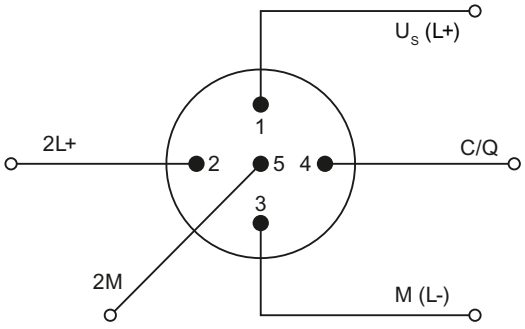

Figure 3-784 Pin assignment Port Class B

Connecting cables

The devices are connected to the master with unshielded 3-wire or 5-wire standard cables with a maximum length of 20 m. Standard cables can be used to wire the sensors. No shielding or compliance with specific regulations is necessary for the installation of the cables.

1.4 IO-Link protocol

Operating modes

The IO-Link port of the master can be operated in the following modes:

- IO-Link:
  The port is located in the IO-Link communication.
- DI:
  The port behaves like a digital input.
- DQ:
  The port behaves like a digital output.
- Disabled:
  The port is disabled.

Transmission rate

In the IO-Link specification V1.1, three data transmission rates (baud rates) are specified for the IO-Link operating mode:

- COM 1 = 4.8 kBaud
- COM 2 = 38.4 kBaud
- COM 3 = 230.4 kBaud (optional according to Specification V1.0)

The IO-Link device only supports one of the defined data transmission rates. The IO-Link master to Specification V1.1 supports all data transmission rates and adjusts automatically to the data transmission rated supported by the device.

Response time of the IO-Link system

The response time of the IO-Link system provides information about the frequency and speed of the data transmission between device and master. The response time depends on various factors.

A value for the minimum cycle time of the device is stored in the device description file IODD of the device (Page 15). This value indicates in which time intervals the master may address the device. The value has a big influence on the response time. The master also has an internal processing time that is factored into the calculation of the response time.

Devices with different minimum cycle time can be configured on a master. The response time for these devices differs accordingly. In other words, the response time for various devices connected to a master can vary greatly.

When you configure the master you can specify a fixed cycle time in addition to the device-specific minimum cycle time stored in the IODD. The master then addresses the device according to this specification.

The typical response time for a device thus results from the effective cycle time of the device and the typical internal processing time of the master.

Transmission performance

IO-Link is a very robust communication system. This communication system operates with a 24V level. If transmissions fail, the frame is repeated two more times. The IO-Link master only detects a break in communication after the failure of the second repeat attempt and reports this to the higher-level CPU.

Data types

Four data types are available:

- Process data → Cyclic data
- PQI → Cyclic data
- Device data → Acyclic data
- Events → Acyclic data

Process data

The process data of the devices is transferred cyclically in a data frame with the process data size being determined by the device. Process data from 0 to 32 bytes is possible per device (input and output, respectively).

Port Qualifier Information (PQI)

Each port has a Port Qualifier Information (PQI). This PQI provides information on the device status of the port and IO-Link (value status). The PQI is transmitted cyclically with the process data.

Device data

Device data can be parameters, identification data or diagnostic information. The data is exchanged cyclically and at the request of the IO-Link master. Device data can be written to the device and also read from the device.

Events

When an event occurs, the device signals to the master that an event is present. The master then reads the event. Events can be error messages (for example, short-circuit) and warning/maintenance data (for example, dirt, overheating).

Error messages are transferred from the device to the CPU or the HMI by the IO-Link master.

The IO-Link master can also transfer events and states. Such events are, for example, wire break, break in communication or overload.

Device parameters or events are transmitted independently of the cyclic transmission of process data. The transmissions do not influence or impair each other.

Startup of the IO system

If the port of the master is set to IO-Link mode, the IO-Link master attempts to communicate with the connected IO-Link device. For this purpose the IO-Link master sends a defined signal and waits for the reply of the IO-Link device.

The IO-Link master first attempts a communication with the highest defined data transmission rate. If this transmission attempt fails the IO-Link master attempts a communication with the lowest data transmission rate. The device always supports only one defined data transmission rate.

If the master receives a reply, communication starts. First they exchange communication parameters. If necessary the parameters stored in the system are transferred to the device.

Then the cyclic data exchange of process data and value status starts.

1.5 Device profiles

Introduction

Device profiles are defined for IO-Link to standardize access of the CPU user program to the devices.

Data structure, data contents and basic functionality are defined in the device profiles. A standard user view and an identical program access is thus achieved for a number of different devices that have the same device profile.

IO-Link profiles

The device profile "Smart Sensor Profile" is currently defined for IO-Link. This profile is especially suited for measurement sensors. In other words, measured values are transmitted in addition to switching points.

For the Smart Sensor Profile, the TIA Portal library for IO-Link ("LIOLink") contains function blocks (FBs) for "Adjustable Switching Sensors" (FB LIOLink_AdjSwitchingSensor), for "Multiple Adjusting Switching Sensors" (type 2, FB LIOLink_MultAdjSwitchingSensor), "Digital Measuring Sensors" (type 3) and "Digital Measuring Switching Sensors" (type 4) (both in LIOLink_MeasuredDataChannel FB).

The "Common Profile" profile is used for the manufacturer-independent reading of identification and diagnostics data from the devices and enables the writing of application-specific tags - it is supported by the FB LIOLink_IdentAndDiag.

In addition, the switchgear (for example, contactors) support the LVSG (Low Voltage Switchgear) profile defined in IEC 61915-2.

1.6 IODD and Port Configuration Tool - S7-PCT

Device description IODD

An electronic device description, the IODD file (IO Device Description) is available for each device. The IODD provides a wealth of information for system integration:

- Communication properties
- Device parameters with value range and default value
- Identification, process and diagnostic data
- Device data
- Text description
- Image of the device
- Manufacturer logo

The structure of the IODD is identical for all devices from all manufacturers. The structure of the IODD is always represented in the identical manner by the IO-Link Configuration Tool of the master manufacturer (for Siemens, S7-PCT). This ensures that the handling is the same for all IO-Link devices regardless of the manufacturer.

Two different IODD versions are available for devices that support both V1.0 and V1.1 functionality.

IODDfinder

The IODDfinder is a cross-vendor, central IO-Link database.
This database provides you with the latest IODDs of the device manufacturers and offers an information and download platform.
The IODDfinder is available on the Internet (https://ioddfinder.io-link.com).

As of version V3.5 SP3 update 2, S7-PCT can automatically access the IODD database and download missing IODDs, see SIOS (https://support.industry.siemens.com/cs/ww/en/view/32469496) under "What's New in PCT Version V3.5 SP3 update 2".

IO-Link configuration tool

Configuration tools are required to configure the entire IO-Link system. The IO-Link configuration tools of the master manufacturers are able to read IODDs.

The main tasks of the IO-Link configuration tool include:

- Assigning the devices to the ports of the master
- Address assignment of ports within the address area of the master
- Assigning parameters for the IO-Link device

Diagnostics can also be carried out on the connected devices.

This means the IO-Link configuration tool supports the transparent representation of the IO-Link system down to field level.

Siemens provides S7-PCT for engineering of the IO-Link system.

S7-PCT with IODD of a device

The following figure shows a section from S7-PCT with IODD of a device and the device information contained therein.

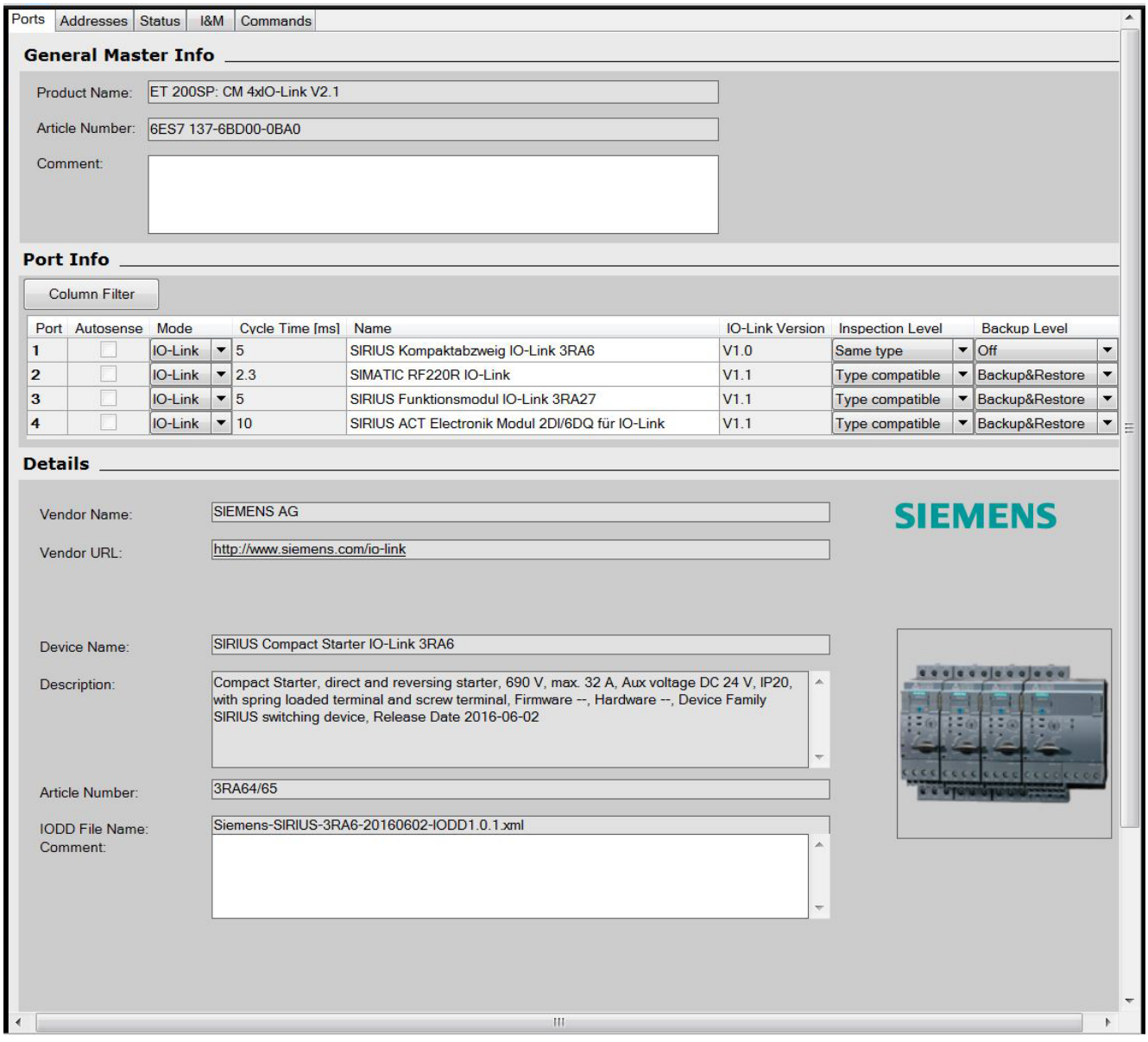

Figure 3-785 S7-PCT with IODD of a device and the device information contained therein

1.7 Differences between IO-Link specifications V1.0 and V1.1

Specification

The technical definition of the IO-Link system is described in a specification of the IO-Link consortium. The first step was the creation of specification version 1.0. The further development and added functions of the IO-Link system led to version 1.1.

The main enhancements of version 1.1 are:

- Data backup for device replacement during operation (Backup&Restore)
- Data transmission rate 230.4 kBaud is mandatory for the IO-Link master

Combination of IO-Link devices

Note the following when combining IO-Link devices:

- Only IO-Link devices that comply with V1.0 can be operated on the IO-Link master to V1.0.
- IO-Link devices that comply with V1.0 and V1.1 can be operated on the IO-Link master to V1.1.
- Data backup and a data transmission rate of 230.4 kBaud of the IO-Link master after V1.1 can only be used when these functions are also supported by the IO-Link device and the IO-Link master (optionally as of V1.0).
- IO-Link master after V1.0 only optionally supports 230.4 kBaud. If IO-Link master V1.0 does not support 230.4 kBaud, then communication with an IO-Link device with 230.4 kBaud is not possible.

Integration into the automation system 2

2.1 Configuration of the IO-Link system

Introduction

An IO-Link system is configured in several steps. In the first step, the master is integrated in the automation system and configured. In the second step, the IO-Link devices are configured.

Integration in the automation system

When using a SIMATIC S7 CPU, use the engineering tool STEP 7, V5.x or STEP 7 (TIA Portal) for configuration.
The IO-Link system is represented by the IO-Link master in the configuration of the automation system or the fieldbus and integrated with STEP 7 or a GSD file.
The IO-Link master itself can be a field bus node (e.g. ET 200eco PN IO-Link master) or a part of the modular IO system that is connected to the field bus (e.g. ET 200SP IO-Link master). In both cases, the number of ports, the address range and the module properties are described in STEP 7 or in the GSD file.

Example configuration in STEP 7 (TIA Portal)

The figure below shows a PROFINET configuration with integrated PROFINET devices ET 200SP and ET 200eco PN with IO-Link masters.

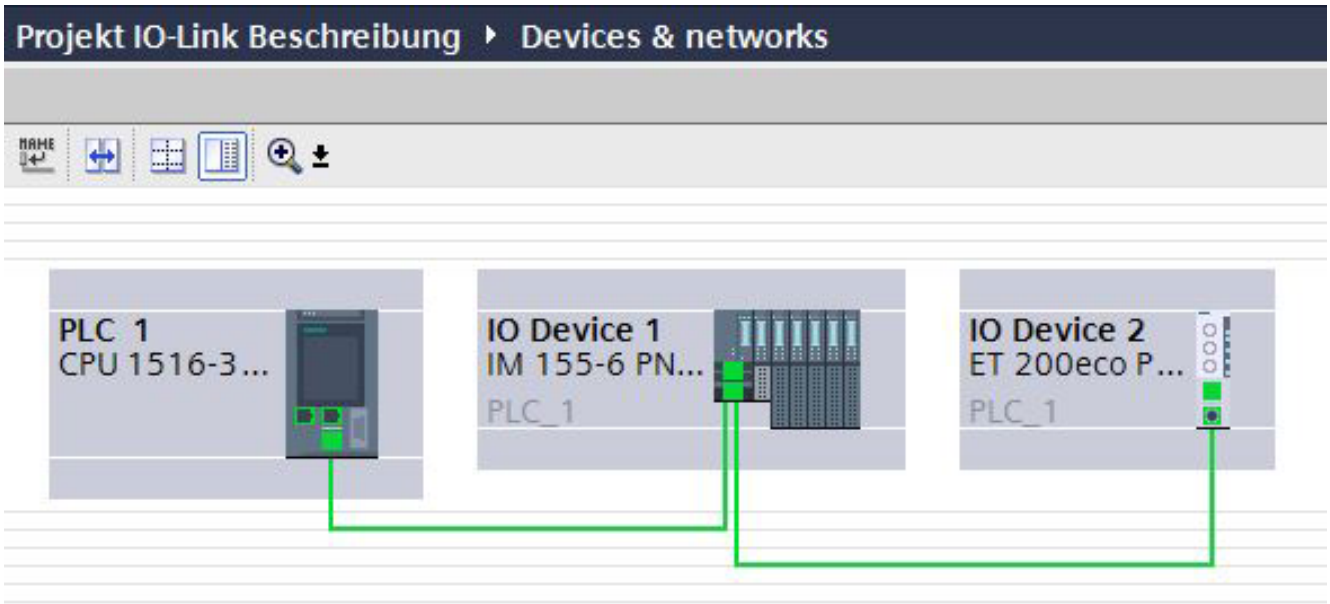

Figure 3-786 Configuration of a PROFINET network with lower-level IO-Link masters

In the device view of the PROFINET device, you can:

- Parameterize the ports
- Specify the input and output address ranges of IO-Link for exchange of cyclic data (process values).

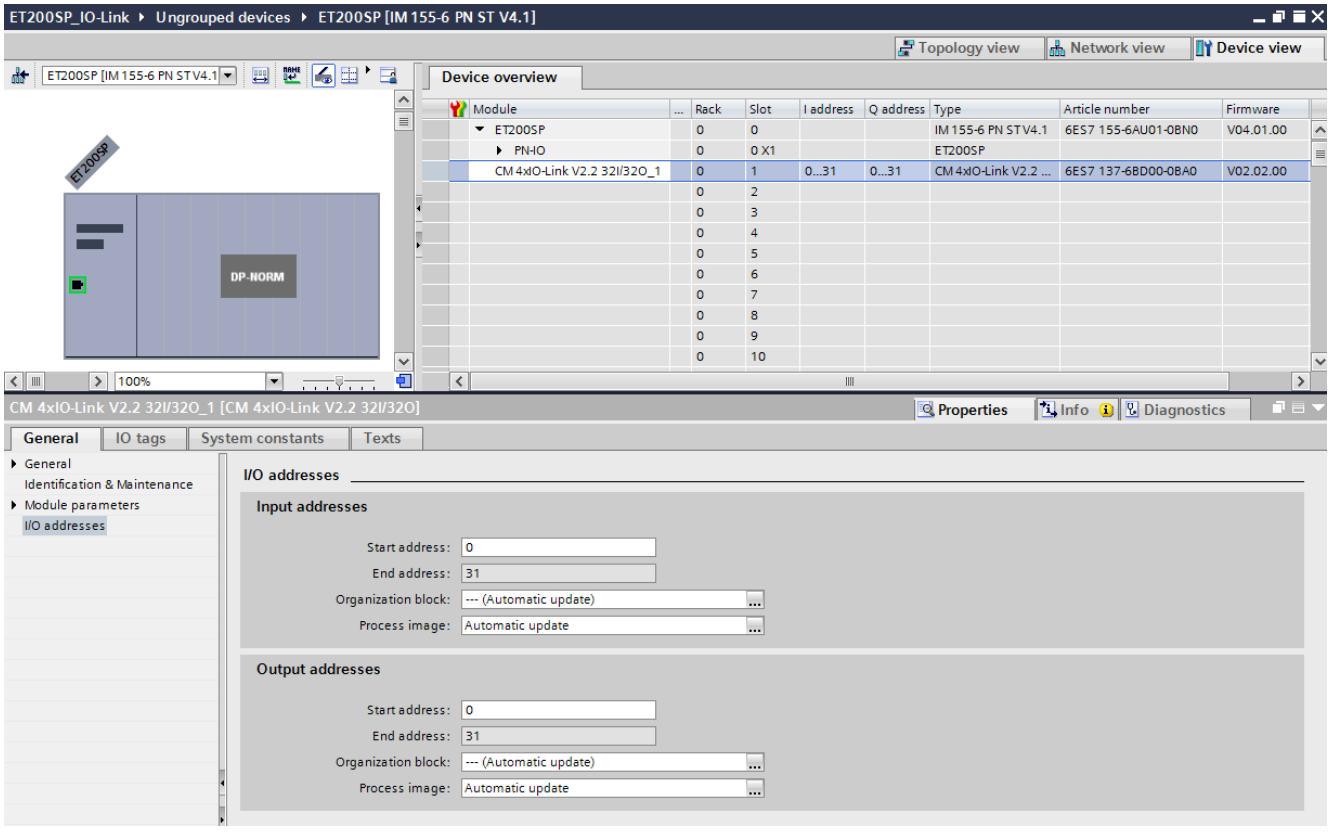

Figure 3-787 Device view with setting of the IO-Link address range

In addition, you can set in the module properties of the IO-Link master how the IO-Link system is to be configured and parameterized.
In doing so, you can select whether or not you also want to work with the S7-PCT configuration tool.

NOTE

IO data length

To ensure smooth operation, select an IO data length during configuration of the IO-Link master that corresponds at least to the IO data length of all connected IO-Link devices. If necessary, the IO-Link master offers the option of configuring the IO data length for each individual port. In this case, the IO data length must at least correspond to the IO data length of the connected IO-Link device.

2.1.1 Configuration with S7-PCT

Introduction

The following sections describe how you configure your IO-Link master with the S7-Port Configuration Tool (S7-PCT).

You need S7-PCT to display the system architecture completely and transparently all the way to the IO-Link device and to configure and parameterize the IO-Link system in detail.

With S7-PCT you can easily configure the IO-Link devices with the help of the IODD (IO-Link Device Description) supplied by the device manufacturer.
In the S7-PCT online view you can display the diagnostics states and process values of the IO-Link devices in detail.

Configuration with S7-PCT

When you have selected the option "Configuration with S7-PCT", you are also making the settings of the IO-Link master ports with S7-PCT. See Figure 3-5 (Page 23).
These settings include:

- Specification of the address range for each port
- Behavior when replacing an IO-Link device
- Setting the identification data for checking the connected IO-Link device type

Start S7-PCT from HW Config in STEP 7.
S7-PCT shows you all Siemens IO-Link masters you have configured in your automation system.
After selecting an IO-Link master, you can assign its IO-Link ports to the desired IO-Link devices.
To do so, select the corresponding IO-Link devices (or their IODDs) from the device catalog and drag them to the port of the IO-Link master.

Example configuration in S7-PCT

The following figure shows the configuration of an IO-Link master in S7-PCT.

This S7-PCT view shows you a wide variety of information:

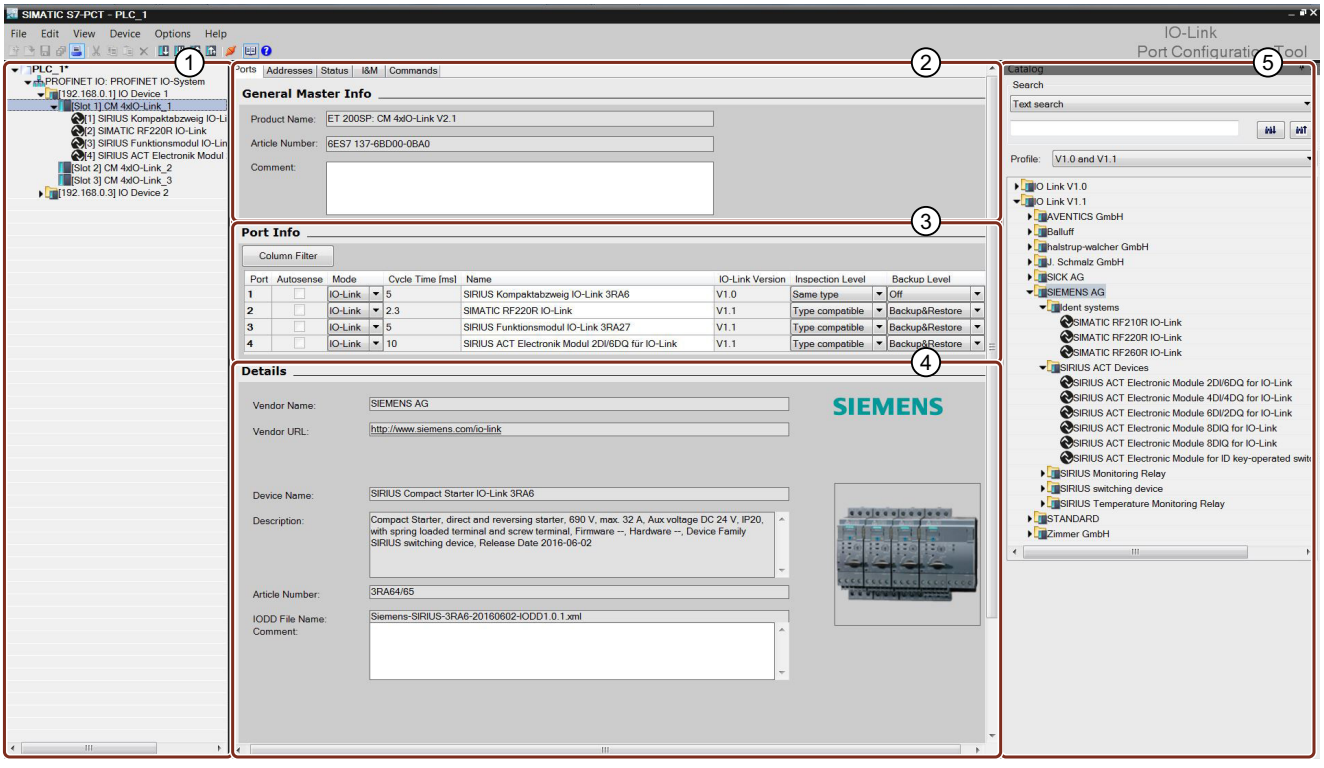

① Higher-level field bus and overview or structure of the lower-level IO-Link master

② Detailed information on the selected IO-Link master

③ Current configuration of the IO-Link ports of the selected IO-Link master

④ Detailed information on the selected IO-Link device

⑤ Device catalog with the IODDS of the IO-Link devices from different manufacturers

Figure 3-788 Configuration of an IO-Link master in S7-PCT

Address range of the ports

In addition to the assignment of the IO-Link devices to the IO-Link master ports, the default address ranges of the ports can be changed. The IO-Link master transfers the process values that it receives from the IO-Link device in these address ranges and makes the process values available to the higher-level automation system.

To set the address range, select the "Addresses" tab.

Setting device parameters

Specific parameter settings are required to adjust the device to the respective application task. The possible parameters and set values are contained in the IODD of each device. You set the device parameters directly in S7-PCT.

After selecting the corresponding device in the project tree (left tree), set the device parameters in the "Parameters" tab.

The figure below shows you an example of the parameter assignment of an IO-Link device:

Identification | Parameters | Monitoring | Diagnostics | Connection

Column Filter

Parameter	Value	Icon	Unit	Status	Help
Parameters					
Parameter Data					
System command					
Device Reset	Device Reset				
Restore Factory Setting	Restore Factory Setting				
Device access locks					
Parameter (write) Access	Locked			changed	
Data Storage	Unlocked				
Operating system functions					
index131 - Group diagnostics	enabled				enable/disable automatic signaling to PLC
index131 - Group error diagnostics	enabled				enable/disable automatic signaling of error messages to PLC
index131 - Local threshold change	enabled				enable/disable local threshold changing via buttons
index131 - Local parameter change	enabled				enable/disable local parameter changing via buttons
index131 - Local reset	enabled				enable/disable local reset via buttons
index131 - Retentive error memory	disabled				enable/disable remanent saving of error messages in the event of a power fa...
index131 - Analog value coding	Tmax [°C] (5)				choose the analog value trasmitted cyclically in the process image
Temperature monitoring					
index131 - Temperature monitoring mode	Range monitoring			changed	set the value of temperature monitoring mode
index131 - Temperature unit	°C				choose the temperature unit for display and monitoring (°C or °F)
index131 - ON-delay time (at Power ON)	enabled				enable/disable starting of delay time at Power-ON
index131 - ON-delay time (at manual reset)	enabled				enable/disable starting of delay time at manual reset of the device
index131 - ON-delay time	0.0		s		set the value of ON-delay time
index131 - Tripping delay time (if the temperat...	0.0		s		set the value of tripping delay time (temperature overshoot or undershoot)
index131 - Temperature sensor type	PT100				choose the type of the connected temperature sensor(s)
index131 - Hysteresis	3			changed	set the value of hysteresis for automatic reset after overshoot or undershoot
index131 - Relay switching response	Closed-circuit principle (NC)				choose the circuit principle of relay switching
Thresholds					
index131 - Threshold ϑ1	30			changed	set temperature threshold 1 for tripping (overshoot or undershoot depends o...
index131 - Threshold ϑ2	20			changed	set temperature threshold 2 for tripping (overshoot or undershoot depends o...
index131 - Warning threshold for ϑ1	28			changed	set temperature warning threshold 1 (overshoot or undershoot depends on ...
index131 - Warning threshold for ϑ2	22			changed	set temperature warning threshold 2 (overshoot or undershoot depends on ...

Figure 3-789 Setting the parameter values of the IO-Link device

Starting from the displayed defaults, you can edit and save the values in the defined value range.

The configuration of the IO-Link system and the parameters of the devices are available to the IO-Link system and the entire automation project. You have the option of saving and printing the configuration and the parameters.

It is not possible to change parameters in online mode.

2.1.2 Configuration without S7-PCT

Introduction

The following sections describe how you configure your IO-Link master without the S7-Port Configuration Tool (S7-PCT).

Your options for configuration of the IO-Link system without S7-PCT are limited.
You can configure the port of the IO-Link master using STEP 7 or the GSD file, but you cannot set any parameters of the lower-level IO-Link devices.

Configuration without S7-PCT

You can activate the following parameters in STEP 7 or the GSD file during port configuration:

- Port Qualifier Information (PQI):
  provides information on the status, such as process data of the IO-Link port; is transmitted with the input data of the IO-Link device.
- Operating mode
  - IO-Link Autostart:
    The IO-Link master accepts each connected IO-Link device and starts it automatically.
  - IO-Link Manual:
    The IO-Link master only accepts IO-Link devices that match the Vendor ID and Device ID set below.
    The connected IO-Link device is started automatically after a successful Vendor ID and Device ID check.
  - DI:
    The port is operating as a standard digital input.
  - DQ:
    The port is operating as a standard digital output.
  - Disabled:
    The port is disabled.
- Input Data Length:
  Process data length of the input data
- Output Data Length:
  Process data length of the output data
- Vendor ID
  ID number of the device manufacturer. You can find the Vendor ID on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109748852).
- Device ID
  ID number of the device. You can find the Device ID on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109748852).
- The IODD - and thus Device and Vendor ID - can be loaded into the TIA project as a .zip file (as of TIAP V17)
- Inspection level for data backup:
  - Identical type (V1.0) without Backup&Restore
  - Type-compatible (V1.1) without Backup&Restore
  - Type-compatible (V1.1) with Backup&Restore
  - Type-compatible (V1.1) with Restore

The figure below shows you an example of the settings of a port configuration in STEP 7 or with GSD file:

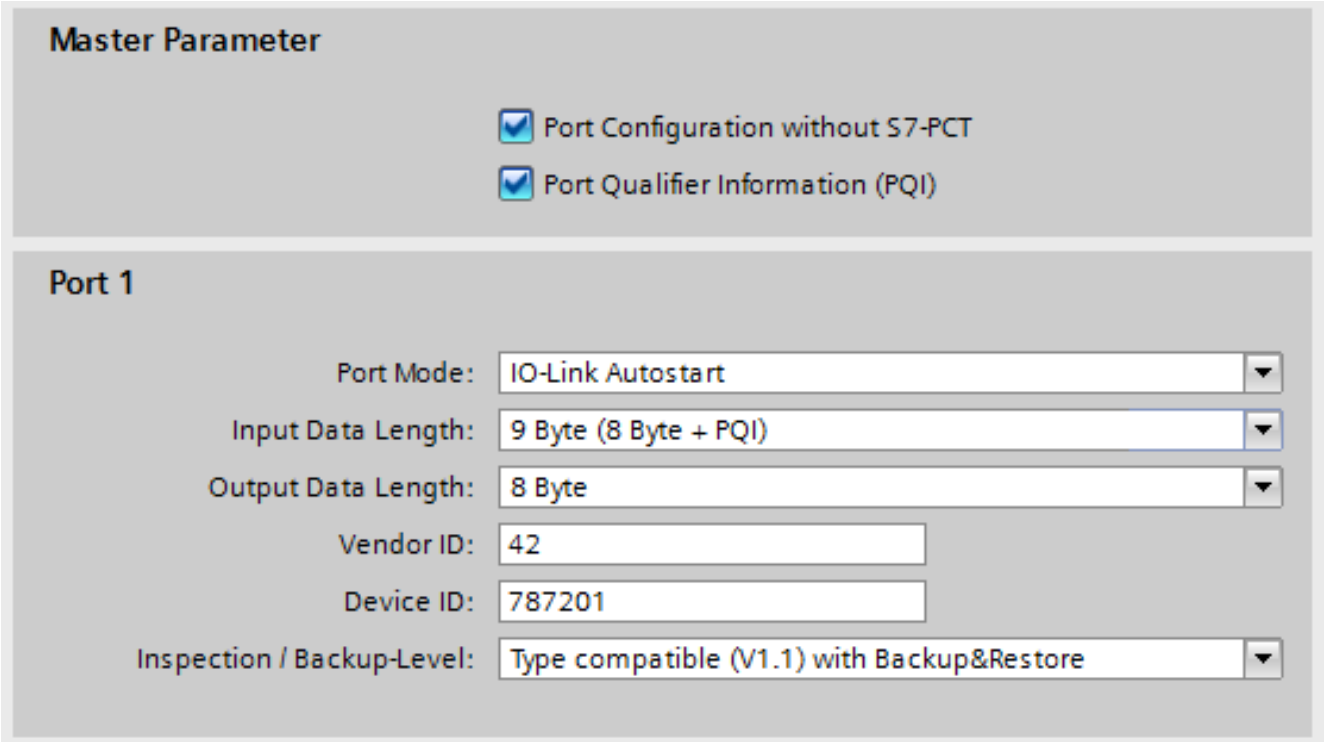

Figure 3-790 Settings of the port configuration in STEP 7 or with GSD file

2.1.3 Comparison of the configuration options

The following table provides an overview of the available options for configuration with and without S7-PCT:

Requirement	Configuration with S7-PCT	Configuration without S7-PCT	
		IO-Link Autostart	IO-Link Manual
Use of the IO-Link device description IODD	Yes	No	No
Setting the length of input and output data (per port)	Automatic	Manual	Manual
Assignment of the Vendor ID and Device ID	Automatic	-	Manual (see FAQ (https://support.industry.siemens.com/cs/ww/en/view/1097488-52))
Behavior during IO-Link device replacement	Programmable	-	Programmable
Adjustable IO-Link cycle time	Yes	No	No
Adjustable IO-Link device parameters	Yes	No	No

Requirement	Configuration with S7-PCT	Configuration without S7-PCT	
		IO-Link Autostart	IO-Link Manual
Display of the IO-Link process data structure	Yes	No	No
Monitoring of IO-Link process data	Yes	No	No
Display of IO-Link device diagnostics messages	Yes	No	No

2.2 Data access of the automation system and the HMI device

Cyclic data exchange

To exchange cyclic process data between an IO-Link device and a CPU, the IO-Link data is assigned by the IO-Link master to the previously set address ranges. The user program of the CPU accesses and processes the process values by using these addresses. The cyclic data from the CPU to the IO-Link device (for example, IO-Link actuator) takes place in reverse order.

Acyclic data exchange

Acyclic data, such as device parameters or events, is exchanged by means of a fixed index and subindex area. The CPU accesses the data using system mechanisms (for example, for online functions such as reading the status). You can use the index and subindex area to access specific device information (for example, to re-assign parameters of the device or master during operation).

Function blocks "LIOLink_Master" and "LIOLink_Device"

The programming of the CPU user program is another task in addition to the configuration and parameterization of the IO-Link system and its integration into the overall automation system.

For acyclic data exchange, you can use the function blocks "LIOLink_Master" and "LIOLink_Device" for controllers of the S7-300, S7-400, S7-1200 and S7-1500 product lines.

The function block "LIOLink_Master" reads all relevant functions and access to the IO-Link master, the function block "LIOLink_Device" reads all access to the IO-Link devices.
With the "LIOLink_Master" function block, you can save (Backup) and retrieve (Restore) the device parameters and settings of an IO-Link master via the S7 program (master replacement without engineering tool). A typical application is the replacement of the IO-Link master.

NOTE

Function blocks "LIOLink_Master" and "LIOLink_Device"

The function blocks "LIOLink_Master" and "LIOLink_Device" replace the functions of the previously available block "IOL_CALL".

Reference

The IO-Link block library with a description of the integration is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/82981502).

You can find an application example of using the block library with HMI devices on the Internet (https://support.industry.siemens.com/cs/ww/en/view/90529409).

2.3 Changing and saving device parameters during plant operation

Changing device parameters

You can adjust the device parameters during operation.
The changed parameters will become effective on the device in the process and are retentively saved in the device.

The parameters can be adapted during operation with:

- the engineering tool used (e.g. during plant commissioning)
- the CPU user program (program-controlled)
- HMI (through plant operator during batch change, process optimization)
- Locally through operation on the device (local operating unit on the device)

Saving device parameters (backup)

You can also automatically save the parameters set in the device during commissioning or changed during operation of the plant in the IO-Link master.
This data backup takes place depending on the set behavior of the IO-Link master ports.
You can set the following data backup levels:

- None
  No data backup in the IO-Link master.
- Backup&Restore
  Every time the device parameters are changed, the changed data is automatically saved in the IO-Link master (see section "Triggering a backup").
- Restore
  No automatic data backup in the IO-Link master.

IO-Link Version	Inspection Level	Backup Level
V1.0	No check	Off
V1.1	Type compatible	Backup&Restore
V1.1	Type compatible	Backup&Restore
V1.1	Type compatible	Backup&Restore

Figure 3-791 Overview of data backup level in S7-PCT

NOTE

IO-Link Specification V1.0

IO-Link master and devices to IO-Link specification V1.0 do not offer this function; a data backup cannot be set (Data backup: None).

Note that the behavior of the IO-Link master and the IO-Link devices during device replacement depends directly on the set data backup level.
You can find additional information on this dependency in the section Replacing a master or device during operation (Page 29).

NOTE

We strongly recommend resetting an IO-Link device to the factory settings before performing a restore by the IO-Link master. This prevents a permanently stored backup prompt of the device from accidentally overwriting the restore parameters.

Triggering a backup

Requirements

- You have set the correct data backup level.
- The IO-Link master and the IO-Link devices you are using support this function (IO-Link Specification V1.1).

Procedure

There are several ways to trigger a backup:

- In the engineering tool:
  After you have downloaded the engineering settings to the device, the IO-Link device immediately triggers a backup.
- In the CPU user program:
  IO-Link device parameters can be changed successively by the user program.
  A backup is only triggered by a system command. The system command must be triggered by the user program after the parameter changes.
  You can implement the parameter changes and the system command for triggering the backup with function blocks of the CPU.
- Using the HMI:
  You proceed as with triggering by the user program.
  The plant operator then triggers the necessary system command on the HMI device.
- Locally by operating the IO-Link device:
  After confirming the input on the IO-Link device, the IO-Link device initiates the backup.

2.4 Replacing a master or device during operation

Replacing a device

Replacing a device during operation is a scenario that occurs again and again and has to be completed without longer plant downtimes. Replace a device quickly and avoid incorrect settings. Devices can also be replaced by operators without special knowledge and aids.

When you use the backup function of the master, the master automatically supplies the saved parameters to the new device during device replacement.
You have the following setting options for device replacement:

- Backup&Restore
  You have set the master port to Backup&Restore. The new device behaves as the replaced device because the master has saved the last parameter change with the backup function.
- Restore
  You have set the master port to Restore. The new device applies the parameter settings that were saved in the master at the time of the last backup.
  If you have made parameter changes since the last backup, these are not saved in the master and are not available to the new device.
  The behavior of the new device can deviate from the behavior of the replaced device. This may be useful if you want to make short-term plant optimizations but do not want to save them in the plant backup.

NOTE

Field calibration of sensors

When you are using sensors that must be adapted to specific rated conditions on site (field calibration), you must repeat this calibration after replacing the device.
The backup does not include the data of the field calibration. After repeating the field calibration, the new device works just like the replaced device.

Replacing a master

Replacing a master during operation is a rather rare scenario. Here, too, longer plant downtimes are to be avoided. Replace a device quickly and avoid incorrect settings. Devices can also be replaced by operators without special knowledge and aids.

The "Toolchanger" function enables the deliberate replacement of devices without error messages (e.g. when replacing tools with IO-Link functionality).

You can save the configuration and parameter data of the master and the devices connected to the master in the CPU and download this information to the new master after the replacement.
When using an S7-CPU, you can use function blocks for this purpose.
You can find additional information on function blocks in the section Data access of the automation system and the HMI device (Page 26).

SIEMENS

SIMATIC

S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro, ET 200eco PN Analog value processing

Function Manual

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Representation of analog values 3

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Preface

Purpose of the documentation

This documentation covers general topics applicable to all products.

In addition to introductory information about analog value processing, this manual covers the following topics:

- Wiring transducers to analog inputs
- Wiring actuators/loads to analog outputs
- Compensating for reference junction temperatures
- Calibrating analog modules
- Diagnostics options of an analog module
- High-speed analog modules

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of analog value processing (analog technology)
- Knowledge of the industrial automation system SIMATIC
- Knowledge about how to use STEP 7 (TIA Portal)

Scope of the documentation

This manual is considered the basic documentation for all analog input and analog output modules of the S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro and ET 200eco PN product series.

Changes compared to previous version

Changes / enhancements described in this manual, compared to the previous version (version 12/2013):

- Extension of the scope of validity to the distributed I/O system ET 200AL

Conventions

STEP 7: In this documentation, "STEP 7" is used as a synonym for "STEP 7 as of V12 (TIA Portal)" and subsequent versions of the configuration and programming software. This documentation includes images of the products it describes. The products supplied may differ slightly from these images.

Please observe notes labeled as follows:

NOTE

Notes contain important information on a point in the documentation of particular importance.

Additional support

Additional information on SIMATIC products is available on the Internet. The associated documentation is also available on the Internet.

- The portfolio of technical documentation for SIMATIC products and systems can be accessed on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers diverse topics concerning your automation system.

The complete documentation for the S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200pro and ET 200eco PN systems consists of the respective system manuals, function manuals and product manuals.

Overview of additional documents related to analog value processing

The following table lists further references that supplement this description of analog value processing.

Table 3-1069 References for analog value processing

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Connecting • Commissioning
	System manual ET 200SP distributed I/O system (http://support.automation.siemens.com/WW/view/en/58649293)	
	System Manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
	System manual Distributed I/O System ET 200AL (http://support.automation.siemens.com/WW/view/en/89254965)	
	Operating instructions ET 200pro Distributed I/O System (http://support.automation.siemens.com/WW/view/en/21210852)	
	Operating instructions ET 200eco PN Distributed I/O System (http://support.automation.siemens.com/WW/view/en/29999018)	
Configuring interference-free controllers	Function manual Configuring Interference-Free Controllers (http://support.automation.siemens.com/WW/view/en/59193566)	• Basics • Electromagnetic compatibility • Lightning protection
Analog module	Product manual of the respective analog module	• Connecting • Parameters • Technical specifications • Parameter data record • Tables of analog values

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

What you should know about analog technology 2

2.1 Overview

Introduction

This chapter is intended to familiarize you with the essential parameters of analog input modules and analog output modules based on the fundamentals of analog technology. The descriptions and examples provided on the following pages serve as a reference to the manuals for the respective analog module and are intended to facilitate the handling of these manuals.

Analog and binary signals

Binary signals can assume only 2 signal states: signal state 1 (voltage present) and signal state 0 (no voltage present). In control engineering, it is frequently necessary to read, process and output analog signals in addition to binary signals. In contrast to binary signals, analog signals take on any number of values within a specific range. Possible analog variables include:

- Temperature
- Pressure
- Speed
- Fill level
- pH value

Transducers

Controllers are only capable of processing analog values in the form of bit patterns. For this purpose, transducers which can be connected to the analog module measure physical variables such as pressure or temperature. The analog input module reads this analog value in the form of current, voltage or resistance. To enable the CPU to process the current or voltage measured, an integrated analog-to-digital converter in the analog input module converts the value into a 16-bit integer value. Depending on the type of measurement, you can use the following transducers:

- Voltage transducers
- Current transducers
  - 2-wire transducers
  - 4-wire transducers
- Resistance transducers
  - 4-wire connection
  - 3-wire connection
  - 2-wire connection
- Thermocouples

Additional information on wiring various types of transducers to analog inputs can be found in Wiring transducers (Page 56).

Example

Speed is acquired using a transducer which converts the speed range of 0 to 1500 rpm to a voltage range of 1 to 5 V. At a measured speed of 865 rpm, the transducer outputs a value of 3.3 V.

The resulting voltage value is calculated as follows:

$$U = \frac{5\ V - 1\ V}{1500\ \frac{U}{min}} * 865\ \frac{U}{min} + 1\ V = 3.3\ V$$

The graph below illustrates voltage acquisition:

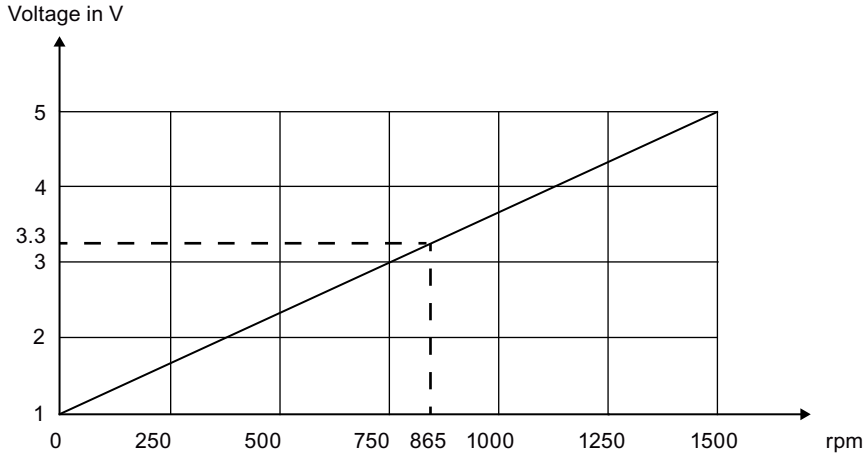

Figure 3-792 Speed measurement

Analog-to-digital conversion

A CPU processes information exclusively in digital format. The analog value is therefore converted into a bit pattern. Conversion is done using an integrated ADC (analog-to-digital converter) in the analog input module. For the CPU, this conversion always returns a 16-bit word for SIMATIC products. The ADC used digitalizes the analog signal and approximates its value with a stepped curve. Resolution and conversion speed are the most important ADC parameters.

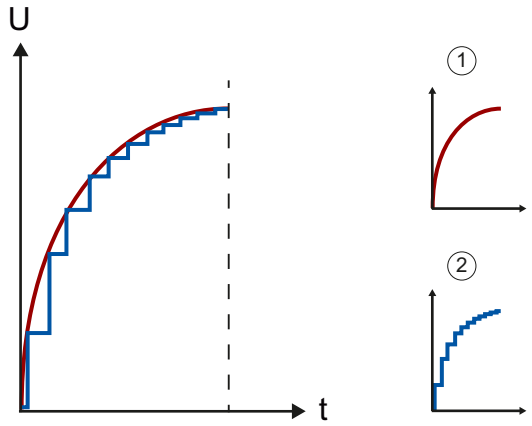

① Analog value

② Digital value

Figure 3-793 Approximation of an analog graph with low- and high-resolution stepped curves

Digital-to-analog conversion

Once the CPU has processed the digital signal, an integrated DAC (digital-to-analog converter) in the analog output module converts the output signal to an analog current or voltage value. The resulting value of the output signal corresponds to the output value used to control the analog actuators. Such actuators include, for example, small servo drives or proportional valves. You will find more information on wiring actuators in Wiring loads/actuators (Page 87).

Important parameters of analog modules

Alongside the type and range of measurement, the precision, resolution and conversion time are the main points to consider when selecting an analog module. For some applications such as systems which cover a large area, common mode or channel isolation are also important. The parameters listed here are examined in more detail in the following pages.

Processing analog signals

The following figure demonstrates analog signal processing in a PLC.

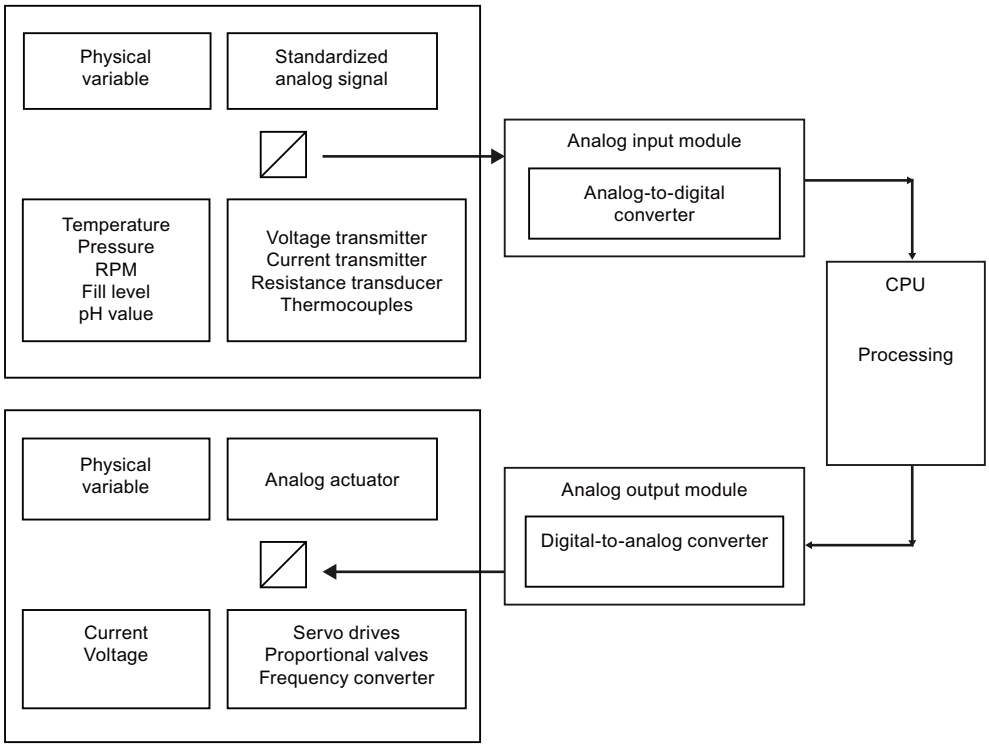

Figure 3-794 Analog value processing

2.2 Precision/resolution

The resolution of an analog module depends on the converter and its external circuitry. An approximation of the analog signal to be acquired/output is returned by a stepped curve. The resolution determines the number of increments of the analog value along this stepped curve. A higher module resolution reduces the length of increments and adds precision to the digitization of the analog signal.

Approximation of an analog value

The figures below show the approximation of an analog value by means of a stepped curve. A low resolution only returns a rough approximation of the actual curve (left figure), while the approximation is more precise at higher resolutions (right figure).

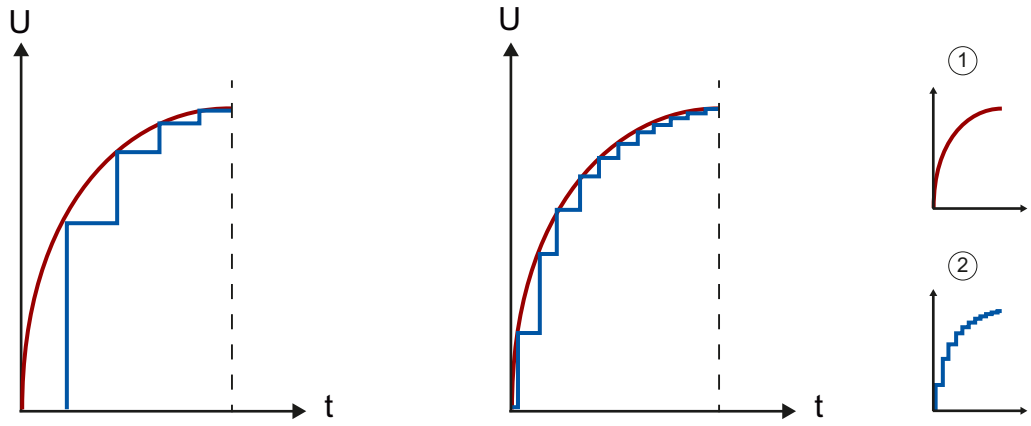

① Analog value

② Digital value

Figure 3-795 Approximation of an analog curve with a stepped curve

Visualization of the measuring range at a resolution of 13 bits and 16 bits

The unipolar measured value from a module having a resolution of 13 bits (= 12 bits + S) is segmented into a total of 2^{12} = 4096 increments. The smallest increment in a measuring range of 0 to10 V is 10 V/4096, equal to 2.4 mV.

A module with16-bit (= 15 bits + S) resolution thus provides an increment of 0.3 mV. If the resolution increases by one bit, the number of increments doubles and the width of an increment halves.

If the resolution increases from 13 bits to 16 bits, the number of increments increases eightfold from 4096 to 32768. With a resolution of 13 bits, the smallest value that can be displayed is therefore 2.4 mV. By contrast, this value is approximately 0.3 mV at a resolution of 16 bits.

Measuring ranges

For the display of the measuring range, SIMATIC S7 distinguishes between the rated range, the overrange and underrange, and the overflow or underflow. This distinction allows you to recognize whether the measured value is actually in the measuring range determined in the technical specifications. The overflow and underflow ranges are reserved for error detection.

At a resolution of 16 bits the theoretically possible 32768 increments are distributed across a voltage range of 11.852 V, which means that only 27648 increments are actually available for the resolution of a measuring range of 10 V. The minimum value which can be represented is therefore 0.3617 mV (see table).

Table 3-1070 Example of resolution for the 0 to 10 V measuring range of a SIMATIC S7 module

Value (increments)	**Voltage measuring range**	
Decimal	**0 to 10 V**	**Range**
32767	11.852 V	Overflow
32512		
32511	11.759 V	Overrange
27649		
27648	10.0 V	Rated range
20736	7.5 V	
1	361.7 µV	
0	0 V	
not relevant for this example as negative values are not possible		Underrange
		Underflow

The digitized visualization of the input ranges, separated into bipolar and unipolar input ranges, is shown in the section Visualization of the input ranges (Page 53). The digitized visualization of the output ranges, separated into bipolar and unipolar output ranges, is shown in the section Visualization of the output ranges (Page 54). You will find a summary of all measuring ranges which you can use with your analog module in the corresponding device manual.

Over and underrange

It may happen for control processes with high signal jumps that the settling curve of the signal briefly leaves the rated range until it reaches the setpoint. The over and underrange ensures that no error is reported while the signal is not in the rated range. If the signal exceeds the over or underrange, however, and reaches the overflow or underflow range, the error state "Overflow" or "Underflow" is diagnosed. This means the over or underrange correspond to a tolerance range between the rated range and the overflow or underflow. Additional information on the settling time is available in the section Settling and response times of analog output modules (Page 44).

The figure below shows the rated range, the overrange and overflow of a unipolar measuring range. The signal leaves the rated range briefly during the settling phase.

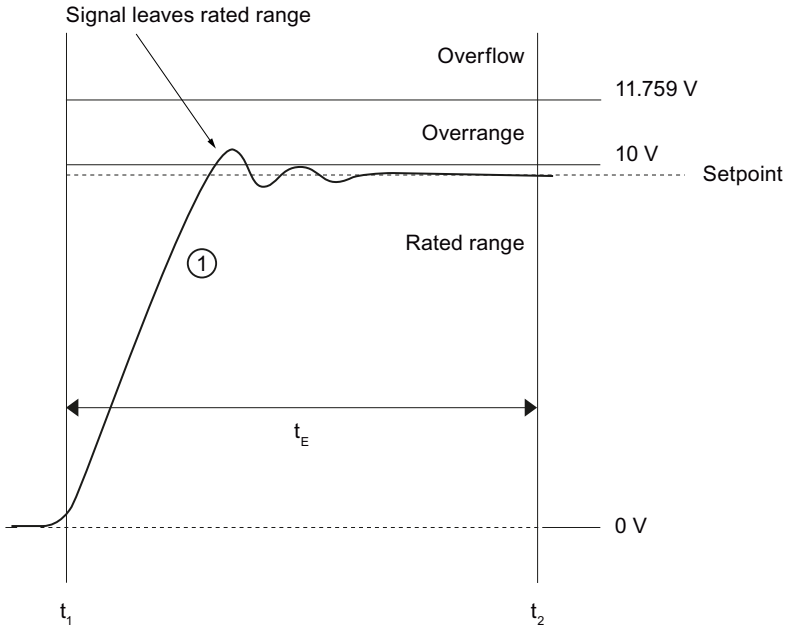

① Analog output signal

t_E Settling time of the signal to the setpoint

t_1 Module ends conversion at the terminal of the analog output channel and outputs the signal

t_2 Signal has settled and the specified analog output value has been reached

Analog module precision

The precision of an analog module is specified as a percentage value or absolute value, for example, in K or °C. This characterizes the total error of measured value acquisition. The basic error limit at 25 °C, as well as the operational limit, are specified in accordance with international standard IEC 61131, which also forms the basis for European Standard EN 61131. For more information on the operational/basic error limits, refer to the Operational and basic error limits (Page 21) section.

Relation between resolution and precision

A certain resolution must be given to reach a specific precision (operational error).

Example

Measuring error as a result of digitization at a resolution of 8 bits and 14 bits

An analog module has a measuring range of 0 V to 10 V. A resolution of 8 bits represents a total of 256 values. This is equivalent to a minimum possible voltage step of 39 mV or 0.4% of the measuring range end value. A resolution of 14 bits represents a total of 16384 values. This is equivalent to a minimum possible voltage step of 0.61 mV or 0.006% of the measuring range end value.

The percentages derived in this way also represent the theoretical best-case values for the operational limit. With a resolution of 8 bits and a measuring range of 0 to 10 V, it is therefore impossible to achieve a precision of more than 0.4 %. In practical life, this value would be clearly worse, depending on the implemented circuitry.

Calculating the maximum measuring error

The maximum measuring error of a 0 to 10 V analog module with an operational limit of ±0.5 % across the entire temperature range is calculated as follows:

10 V x 0.5/100 = 50 mV

This means the maximum measuring error is approximately ±50 mV. This also means that each analog voltage input is subject to a distortion of ±50 mV across the entire input range. A voltage of 3.5 V that is to be measured can therefore be visualized by any value between 3.45 V and 3.55 V.

For more information on the operational/basic error limits, refer to the Operational and basic error limits (Page 21) section.

2.3 Scaling analog values

Scaling

It is often necessary to calculate the actual process value rather than increments (e.g., 10 V = 27648 increments) for further processing of digitalized analog values. The conversion of a value range (e.g., -27648 to +27648 increments) to the original physical quantity (e.g., 0 to 500 liters) is referred to as scaling.

Scaling blocks

STEP 7 offers the suitable program block for scaling of analog values. The SCALE block is included in the STEP 7 scope of delivery and permits input of a high and low limit (e.g., 0 to 500 liters).

Example

In the example below the fill level of a tank with a capacity of 500 liters is to be measured. The transducer used measures a voltage of -10 V with an empty tank and a voltage of +10 V with a full tank. The analog module converts the voltage range from -10 V to +10 V into the value range -27648 to +27648 and converts this range into the original quantity of 0 to 500 liters with the SCALE program block.

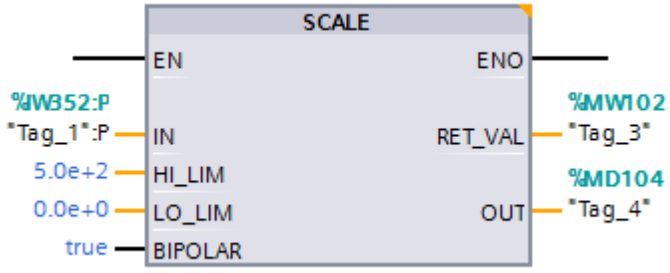

Figure 3-796 Scaling in the SCALE program block

The analog value at input **IN** is read directly by the module or is transferred by a data interface in INT format. The input **LO_LIM** is used to determine the low limit (0 liters) and **HI_LIM** to determine the high limit (500 liters) of the physical quantity. The output **OUT** outputs the scaled value (physical quantity) as floating-point number (LO_LIM <= OUT <= HI_LIM). You can assign parameters via the input **BIPOLAR** to specify if only positive or only negative values are to be converted. If the parameter receives an operand with the state '0', there is a unipolar scaling. An operand with the state '1' results in a bipolar scaling. The output **RET_VAL** outputs an error code in case of an error (e.g., overflow) and the value '0' in case of an error-free execution.

Additional information on the SCALE block can be found in the STEP 7 online help.

Unipolar and bipolar measuring ranges

The measurement of the fill level in our example took place within a bipolar measuring range. In addition to the positive voltage the transducer also provides negative voltage. Because the tank volume is mapped to the range from -27648 to +27648 increments, the measurement of the fill level takes place with twice the resolution (Δ) as in the unipolar measuring range.

NOTE

Transducers

The prerequisite for a measurement within a bipolar measuring range is that the used transducer supports bipolar measuring ranges.

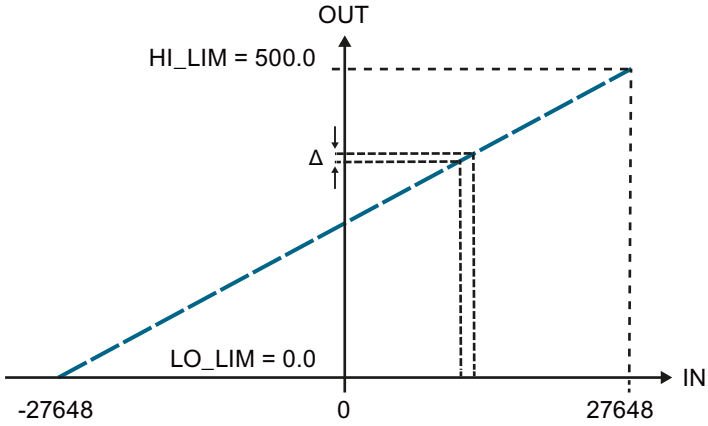

Figure 3-797 Bipolar measuring range

The measurement of the fill level in the bipolar measuring range takes place with twice the resolution (Δ) as in the unipolar measuring range.

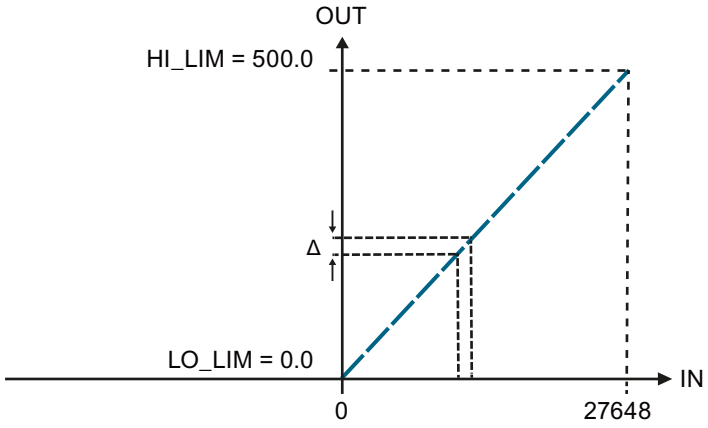

Figure 3-798 Unipolar measuring range

2.4 Unscaling analog values

Unscaling

The output of scaled analog values often requires conversion of the analog value calculated by the user program into the value range of the analog output module. This conversion is referred to as unscaling.

Unscaling blocks

STEP 7 offers the suitable program block for unscaling of analog values. The UNSCALE block is included in the STEP 7 scope of delivery and permits the input of a high and low limit that defines the range of the program value.

Example

An analog value from 0.0 to 100.0% calculated by the user program is to be converted with the UNSCALE block to the value range -27648 to +27648. When the unscaled value is output to an analog output module, this module addresses an analog actuator (e.g., modulating valve). The actuator is to be addressed at a program value of 0% with the minimum value (-10 V or -20 mA) and at 100% with the maximum value (+10 V or +20 mA).

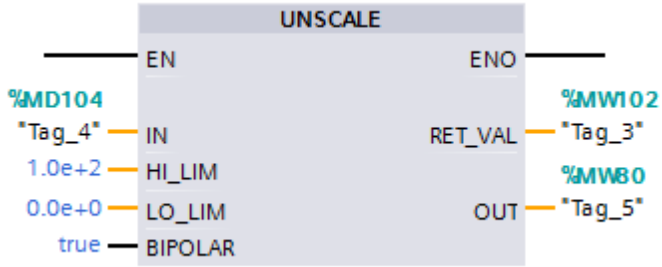

Figure 3-799 Unscaling in the UNSCALE program block

The value calculated by the program must be transferred in the REAL format (**IN**). You use the input **LO_LIM** to determine the low limit (0.0%), and **HI_LIM** to determine the high limit (100.0%) within which the program value moves. The unscaled value is output in INT format at the **OUT** output. You can assign parameters via the input **BIPOLAR** to specify if only positive or only negative values are to be converted. If the parameter receives an operand with the state '0', there is a unipolar scaling. An operand with the state '1' results in a bipolar scaling. The output **RET_VAL** outputs an error code in case of an error and the value '0' in case of an error-free execution.

Additional information on the UNSCALE block can be found in the STEP 7 online help.

Unipolar and bipolar measuring ranges

The figure below shows the scaling for an actuator that is to be addressed at a program value of 0% with the minimum value 0 (0 V or 0 mA) and at 100% (+27648) with the maximum value (10 V or 20 mA).

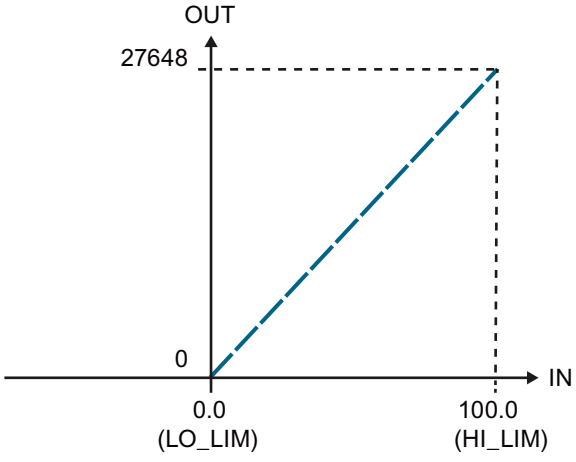

Figure 3-800 Unipolar measuring range

The figure below shows the scaling for an actuator that is to be addressed at a program value of 0% (-27648) with the minimum value 0 (-10 V or -20 mA) and at 100% (+27648) with the maximum value (+10 V or +20 mA).

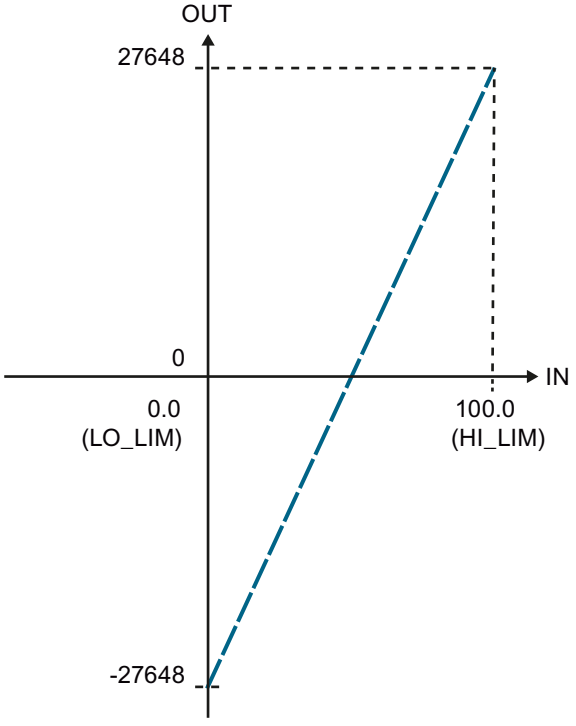

Figure 3-801 Bipolar measuring range

2.5 Linearity errors

Definition

Linearity denotes the deviation of the actual A/D or D/A conversion from the ideal lines within a specified measuring range. The linearity error therefore represents the deviation of the real transmission function from the ideal straight line. The error is given in the technical data as a percentage of the rated range of the analog module.

The figure below shows the linearity error of an ADC, magnified for better visibility.

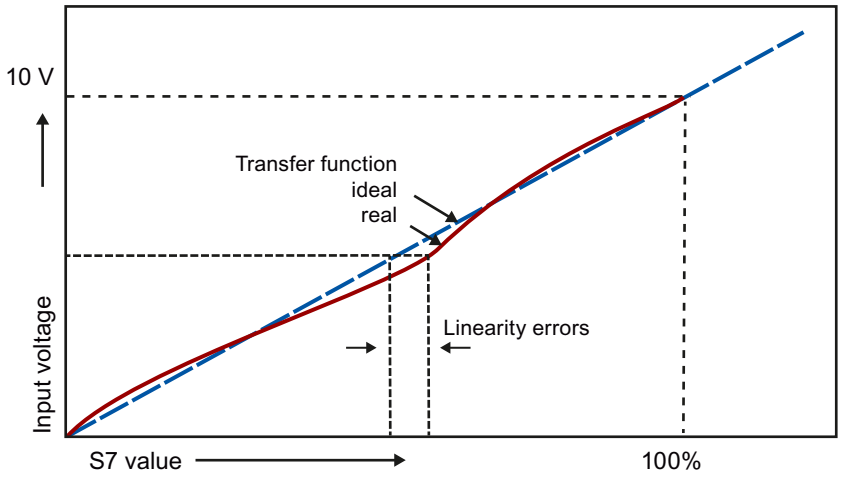

Figure 3-802 Linearity errors

Example

An error of ±1 mV is returned at an input range of ±10 V and a linearity error of ±0.01%. The error is calculated as follows: 10 V · 0.01 % = 1 mV

The linearity error information given in the technical specifications is taken into account in the operational limit. You will find a detailed description of the operational limit in Operational and basic error limits (Page 21).

2.6 Repeat accuracy

Definition

The repeat accuracy is the maximum deviation in measured/output value for the same input signal or output value after another value has been created or output. Other parameters, e.g. the Temperature parameter, remain unchanged. The repeat accuracy refers to the rated range of the module and applies in a steady temperature state.

Measured value variance

The repeat accuracy provides information on the variance of individual measurements. The smaller the variance, the greater the repeat accuracy. The repeat accuracy is therefore one of the most important properties of measuring devices. In the technical data, the repeat accuracy is given as a percentage of the input or output range at 25°C in the steady state.

Example

The specified repeat accuracy for an analog input module as a percentage of the measuring range end value is ±0.02 %. This corresponds to a repeat accuracy of 2 mV for any value within the measuring range of ±10 V. If you change the measured value from 10 V to -10 V, for example, and then measure with 10 V again, the measured value deviation may not exceed ±2 mV.

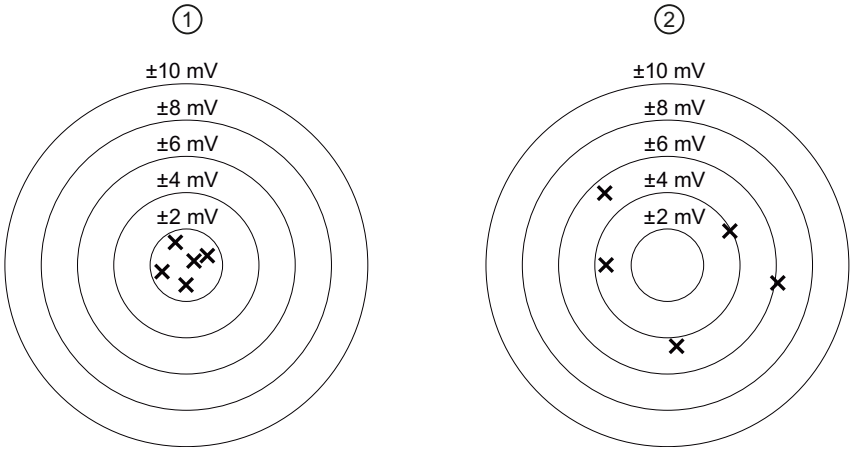

① Good repeat accuracy

② Poor repeat accuracy

Figure 3-803 Repeat accuracy of measured values output

2.7 Operational and basic error limits

Introduction

The following section shows you how to determine the operational or basic error limits and thus the measurement error or output error with the help of the technical specification. The worst-case configuration ensures that the module will not exceed the specified value within the valid operational range.

The precision of analog input or output modules is only part of the precision of the entire measurement section. A measurement section usually consists of transducer, transmitter, transmission line as well as input / output module.

Operational limit

The operational limit is the entire measurement or output error rate of the analog module in the rated range in temperature-settled state within the approved temperature range.

Basic error limit

The basic error limit is the entire measurement or output error rate in the rated range at an ambient temperature of 25 °C and temperature-settled state.

The basic error limit of the module is more or less a theoretical value, because a constant ambient temperature of 25 °C is rarely maintained in plants. For this reason, the operational limit always takes priority in terms of the practical selection and assessment of a module.

NOTE

The operational limit and basic error limit percentages listed in the technical specifications always relate to the **maximum possible** I/O value (the measuring range end value) in the rated range of the module.

The following image shows an example of operational and basic error limits in comparison with the ideal curve.

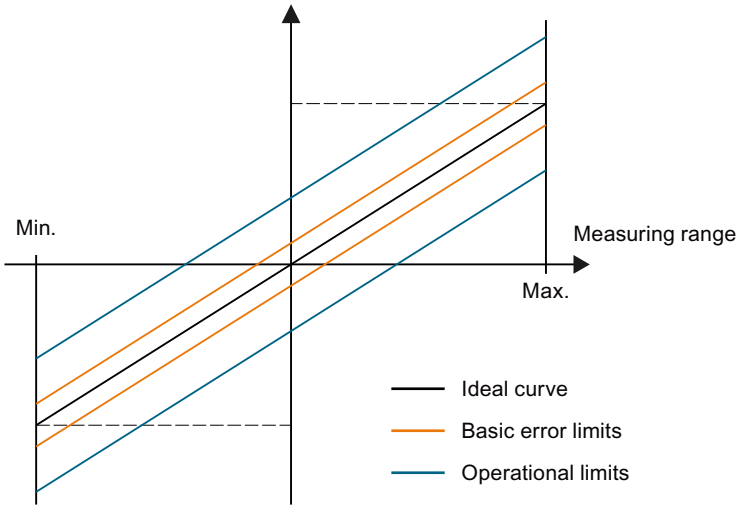

Figure 3-804 Operational and basic error limits

Example of output error calculation

An analog output module is used for voltage output in a range of 0 to 10 V. The module is operating at an ambient temperature of 30 °C, which means that the operational limit applies. Technical specifications of the module:

- Operational limit for the voltage output: ±0.1 %

The result is an output error of approximately ±10 mV (±0.1 % of 10 V) across the rated range of the module.

For example, the output value may range from 2.49 V to 2.51 V at an actual voltage of 2.50 V.

NOTE

Bipolar measuring ranges

The calculation also applies to bipolar measuring ranges.

An error of ±10 mV is also returned at an input range of ±10 V and a linearity error of ±0.1%.

2.8 Temperature error

Introduction

Analog modules are exposed to operational conditions that have an impact on their precision and on the measurement results they return. Temperature errors develop, for example, if the operating temperature of the module deviates from the ambient temperature of 25 °C. These temperature errors within the approved temperature range are taken into account in the operational limit.

Definition

The temperature error identifies the maximum drift of measuring/output values caused by fluctuation of the ambient temperature at the analog module. The maximum drift can occur at any ambient temperature. The temperature error is specified depending on the module used in percent per degree Celsius and/or percent per Kelvin, e.g. ±0.005%/K, and relates to the measuring range end value of the analog module.

Operational limits of compensation

The temperature error of the reference junction temperature compensation function only occurs with thermocouple measurements. The temperature error of compensation is added to the actual temperature error if "Internal reference junction" operating mode is selected. The temperature error of compensation is defined in the technical specifications as a percentage of the physical rated range of the analog module or as an absolute value in °C.

NOTE

Calculating the error in thermocouple measurements

Add the error of a thermocouple measurement to the error of the compensation measurement to determine the total error of a thermocouple measurement. These errors are defined in the respective manual.

Example

In this example, the total error of the temperature measurement is determined with the help of a type K thermocouple. The type K thermocouple takes measurements at a temperature range from -270 °C to +1372 °C.

The technical specifications state an operational limit of >-200 °C ±2.4 K for the type K thermocouple. The temperature error of compensation amounts to ±6 °C. The total temperature error is measured as follows at a temperature of >-200 °C:

Operational error (±2.4 K) + temperature error of compensation (±6 °C) = ±8.4 °C.

2.9 Interference frequency suppression

Definition

The interference frequency suppression function is applied to analog input modules to suppress the noise caused by the frequency of the AC voltage supply used.

The frequency of the AC voltage supply is likely to have a negative effect particularly on the values returned by measurements in the low voltage range and on thermocouples.

Parameter assignment

The line frequency at which the system is operated can be set by means of module parameters, for example, in STEP 7.

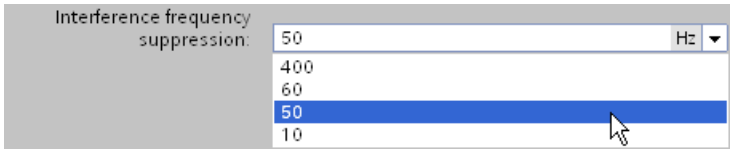

Figure 3-805 Interference frequency suppression

The conversion time changes depending on the set interference frequency suppression. The data sheets of the respective module define this dependency.

Please note the following when selecting interference frequency suppression:

The higher the frequency setting, the shorter the conversion time.

NOTE

Line frequency

Always select the interference frequency based on the line frequency used. Mismatch errors must be expected if a frequency that deviates from this line frequency is set, for example, to reduce the conversion time. In this case, the specified technical data and, in particular, precision are possibly outside the specified range.

Smoothing

By smoothing analog values, you achieve an additional improvement for the suppression of interference frequencies. For more information on the smoothing of analog values, refer to the section Smoothing (Page 46).

Line frequencies used

The line frequency is the frequency used in an electricity network for AC supply. It is measured in hertz and indicates the number of oscillations per second in a periodic signal. A line frequency of 50 Hz, for example, means 50 oscillations per second.

Europe, Australia and most countries in Asia and Africa use a line frequency of 50 Hz. North and Central America and most countries in South America have electricity networks with a line frequency of 60 Hz.

Frequencies of 400 Hz are most commonly used in on-board networks for airplanes, in the aerospace sector and for military applications. One reason for this is that engines with a line frequency of 400 Hz can usually be made smaller and lighter. As, however, it is not economic to transport such high frequencies over large distances, 400 Hz applications are usually subject to significant spatial limits.

A frequency of 16 2/3 Hz is used for the traction power supply in Germany, Austria and Switzerland. Some modules of the SIMATIC S7 product range also support the interference frequency suppression of this line frequency. The configurable interference frequency suppression in these cases is 16.6 Hz.

2.10 Common mode interference (UCM)

Definition

Common mode interference denotes interference voltages and currents in the lines connecting electrical devices and system components. They affect both the positive and negative line with the same phase angle and amplitude. The interference signal needs an additional current path to affect the utility signal. This current path is usually provided by common reference potential, e.g. earth or ground connection, of the utility signal and interference source.

Common mode interference in analog modules

Common mode interference occurs in analog input and output modules if their reference potential is different from the reference potential of the connected sensor or actuator.

Common mode interference is most likely to occur when analog modules are operated with grounded sensors. The size of the overall system means that voltage differences may develop between machine components with grounded sensors and the analog module reference. These voltage differences affect both the positive and negative signal path equally, which is why they are termed common mode interference.

In operation with non-grounded sensors, the occurrence of common mode interference is not as obvious as in grounded operation. Nevertheless, capacitive or inductive coupling can also create voltage differences in such cases which have the effect of common mode interference. Depending on the conditions in grounded and non-grounded operation, common mode voltage can occur as direct or as alternating voltage.

Example

The following figure of an analog module with two inputs (Ch_1/Ch_2) shows the coupled interference voltages at the inputs (U_{CM1}/U_{CM2}) as well as an interference voltage coupled between these inputs (U_{CM3}). Common mode rejection indicates the extent to which these interference signals can be suppressed. It is calculated using the following equation:
CMR [dB] = 20 · log (U_{CM} / U_a)

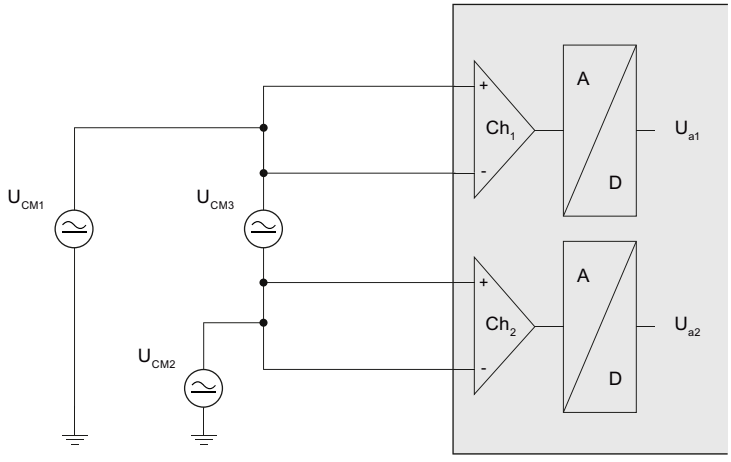

Figure 3-806 Common mode voltage coupled between two inputs

If there is common-mode voltage (U_{CM}), the equation is solved for U_a to calculate the measuring error (U_a):

$$U_a = U_{CM} * 10^{-\frac{CMR}{20}}$$

NOTE

The common mode rejection (CMR) is detailed in "Common mode interference" in the technical data of the device manual for your analog module.

2.11 Series mode interference (USM)

Definition

Series mode interference is interference voltages and currents affecting the connection lines in opposite directions. They have opposite polarity in the positive and negative directions. Series mode interference currents cause a voltage drop at the input impedance that has the effect of an interference voltage.

Causes

Series mode interference is caused by capacitive or inductive coupling. Inductive coupling generates a magnetic flow that is radiated between adjacent current-carrying conductors. This induces an interference voltage in the conductor. Galvanic coupling is given where different circuits influence each other due to common conductor sections, e.g. common ground connection.

The diagram below shows series mode interference as a voltage source (U_{SM}) connected in series to the actual measuring signal (U_M). The index "SM" stands for "Series Mode". Series Mode rejection indicates the extent to which these interference signals are suppressed. It is calculated using the following equation: SMR [dB] = 20 · log (U_{SM} / U_a)

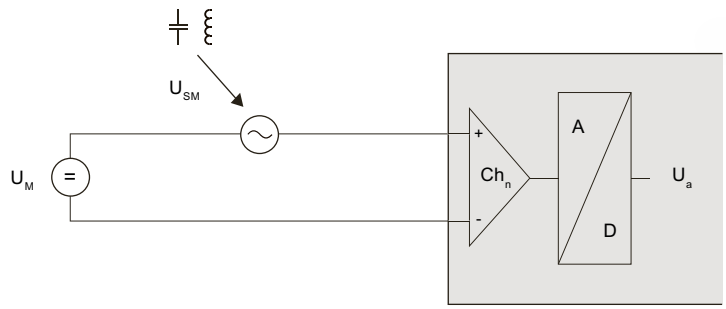

Figure 3-807 Capacitive or inductive interference coupling to the signal cable

The voltage (U_a) measurement error is calculated by solving the equation for U_a.

$$U_a = U_{SM} * 10^{-\frac{SMR}{20}}$$

The following equation shows the calculation of current (I_a) measuring errors using a current input.

$$I_a = \frac{U_{SM}}{R_{ein}} * 10^{-\frac{SMR}{20}}$$

NOTE

The series mode rejection (SMR) is detailed in "Series mode interference" in the technical data of the device manual for your analog module. The level of input resistance (R_{ein}) is also specified in the technical data.

2.12 Interference voltage suppression

Definition

Interference voltage suppression gives the factor by which the interference signal is suppressed in measurement value acquisition. Higher values reduce the effect of interference on the measurement signal. The technical data differentiates between "Common mode interference" and "Series mode interference". Interference voltage suppression is specified in decibels.

Example

The diagram below shows the measuring error for interference voltages in volts and interference voltage suppression of 0 to 120 dB.

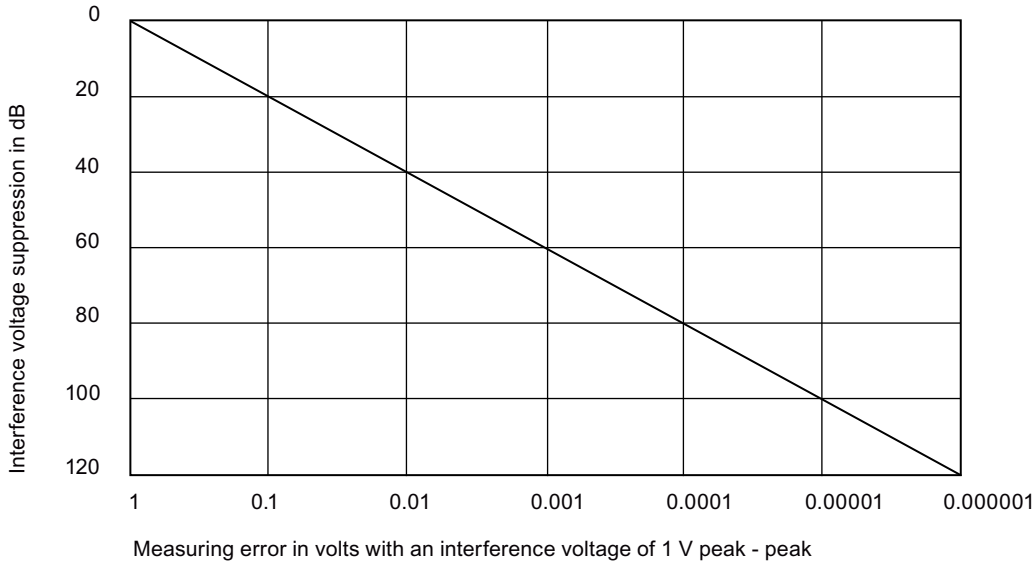

Figure 3-808 Interference voltage suppression

With an interference voltage suppression of 40 dB and an interference voltage of 1 V, the measured value is only distorted by 0.01 V.

NOTE

Interference-free design

Disturbance variables can be substantially reduced by means of appropriate grounding and shielding to increase interference immunity of the configuration. You will find a detailed description of how to avoid interference in the Configuring interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) function manual.

Common mode rejection

The table below sets out the possible common mode rejection specifications in the technical data of an analog input module:

Interference voltage suppression for f = n x (f1 ± 1 %), (f1 = interference frequency), n = 1, 2, ...	
Common mode interference	> 100 dB
Common mode voltage, max.	10 V

If the interference frequency is configured as 50 Hz, the specified interference voltage suppression for common mode interference will only apply for the frequencies 50 Hz ±1 %, 100 Hz ±1 %, 150 Hz ±1 %, etc. Immunity is lower for all other frequencies. Interferences caused by the line voltage distort the measured utility signal in the ratio of 100,000 : 1. An interference voltage amplitude of 1 V, for example, will affect the utility signal by 10 µV.

The Common Mode voltage (U_{CM}) defines the maximum permitted deviation of the potential between two channels and between one channel and analog ground. The interference voltage suppression defined in the technical specifications must not be exceeded. If the maximum common mode voltage specified, for example, 10 V, is exceeded, the analog signal is processed incorrectly. Depending on the module used, this error may be diagnosed and an error message output. The maximum common mode voltage may be exceeded as a result of varying input or overly long lines.

Series mode rejection

The table below sets out the possible series mode rejection specifications in the technical data of an analog module:

Interference voltage suppression for f = n x (f1 ± 1 %), (f1 = interference frequency), n = 1, 2, ...	
Series mode interference	> 60 dB

If the interference frequency is configured as 50 Hz, the specified interference voltage suppression for series mode interference will only apply for the frequencies 50 Hz ±1 %, 100 Hz ±1 %, 150 Hz ±1 %, etc. Immunity is lower for all other frequencies. Overall, interference caused by the line voltage distorts the utility signal measured by 1000 : 1. For example, an interference voltage amplitude of 1 V will affect the utility signal by 1 mV.

2.13 Crosstalk between channels

Origin of the term

The term crosstalk/XT was originally used in the field of telecommunication to denote unwanted coupling of voice signals between two cable conductors of different subscribers.

Definition

Crosstalk between signal channels denotes the interactive influence between two independent channels as a result of leakage currents and capacitive or inductive coupling. Crosstalk between the channels changes the signal by the value of the amplitude of the crosstalk signal.

Causes

Technically, it is not feasible to totally isolate the module channels from environmental conditions. This means that it is always possible for leakage currents or disturbance coupling having an interactive effect.

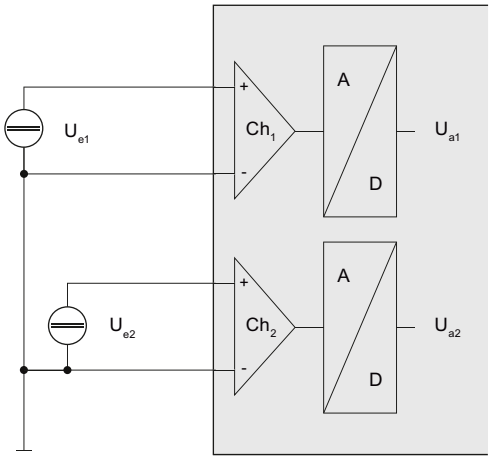

Figure 3-809 Crosstalk between two channels

The diagram shows the effects of crosstalk for the user with two channels (Ch_1/Ch_2) of an analog module. The crosstalk value is the factor by which the utility signal at a second channel U_{a2} is affected by the signal at the first channel U_{e1}. The measuring error (U_{a1}) can be calculated using the following equation:

$$U_{a1} = U_{e2} * 10^{\frac{XT\,[dB]}{20}}$$

Example of crosstalk attenuation

The "crosstalk between inputs" value in the technical specifications is defined as a value of >-100 dB at a measuring range of -10 V to +10 V on channel 1 of an eight-channel analog input module. The voltage at the input has an amplitude of 10 V. What is the error caused by crosstalk at channel 0 (measuring range ±10 V) and channel 2 (measuring range ±80 mV)?

100 dB are equal to a factor of 100,000. The measured values at channels 0 and 2 to 7 are therefore affected by 10 V / 100,000 = 100 µV. This distortion is added to or subtracted from the pending measuring signal and its effect depends on the selected measuring range.

- Channel 0: 100 µV / 10 V = 0.001 %
- Channel 2: 100 µV / 80 mV = 0.125 %

A voltage of 10 V set at channel 1 distorts the measured value at channel 0 by 0.001% and the measured value at channel 2 by 0.125%. The measuring error resulting from crosstalk in this example is therefore 0.001 % or 0.125 %. The basic error limit already includes the error generated as a result of crosstalk between the channels.

Calculating measuring error

You calculate the measurement error at channel 1 in this example based on a change in the measurement voltage of 10 V at channel 2. The crosstalk (XT [dB]) value is defined in the technical specifications in the manual of the analog module that you are using.

$$\text{Measured value error channel 1 [in V]} = \text{measured value change at channel 2 [in V]} * 10^{\frac{XT\,[dB]}{20}}$$

$$\text{Measured value error channel 1 [in V]} = 10\ V * 10^{\frac{-80\ dB}{20}} = 0.001\ V$$

A change in the measurement voltage of 10 V at channel 2 causes a measurement deviation of 0.001 V at channel 1.

2.14 Diagnostics

Diagnostics for analog modules

SIMATIC analog modules can diagnose errors. A number of different types of diagnostics are available for analog modules in STEP 7. Please note that the parameter assignment options vary depending on the analog module and product family used. More detailed information on the types of diagnostics can be found in the device manual for your analog input or analog output module.

Proceed as follows to select the diagnostics types of the analog module used:

1. Open STEP 7.
2. Select the analog module in the Device view.
3. Select the "Properties" tab.
4. Select the inputs or the required channel of the analog module in the Inspector window.

Table 3-1071 Overview of diagnosable errors

Type of diagnostics	Analog input module	Analog output module
Wire break	✓	✓
No supply voltage L+	✓	✓
Overflow	✓	✓
Underflow	✓	✓
Common mode error	✓	-
Short-circuit	✓	✓
Overload	-	✓
Reference junction	✓	-

Diagnostics of the analog module are carried out while the system is in operation, on the basis of the current output variables such as current or voltage. If the output current or output voltage is no longer sufficient, the module will not be able to run reliable diagnostics. The limits within which diagnostics are possible are specified in the technical data for each module.

The module reports the diagnosed state to the CPU using a diagnostics error interrupt. If several diagnostics are pending at the same time, the diagnostics with the highest priority is reported to the CPU first. Diagnostics are output on LED displays on the affected module, on the CPU display, on the Web server or on an HMI device.

The configurable diagnostics types depend on the respective selected measuring type or output type. The following tables shows the relationship between the diagnostics types, measuring types or output types of an analog input module or analog output module.

Diagnostics Analog input modules

Table 3-1072 **Diagnostics types of an analog input module to be configured depending on the measurement type "Voltage"**

	No supply voltage L+	Wire break (1 to 5 V)	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	✓	-	-
ET 200MP	✓	✓	✓	✓	✓	-	-
ET 200SP	✓	-	✓	✓	-	-	✓
ET 200AL	-	✓	✓	✓	-	-	✓
ET 200eco PN	✓	✓	✓	✓	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	✓

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 3-1073 **Diagnostics types of an analog input module to be configured depending on the measurement type "**Current (4-wire transducer)**"**

	No supply voltage L+	Wire break (4 to 20 mA)	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	✓	-	-
ET 200MP	✓	✓	✓	✓	✓	-	-
ET 200SP	✓	✓	✓	✓	-	-	✓**
ET 200AL	-	✓	✓	✓	-	-	✓**
ET 200eco PN	✓	✓	✓	✓	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	✓

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

** Diagnostics for encoder supply only

Table 3-1074 **Diagnostics types of an analog input module to be configured depending on the measurement type "**Current (2-wire transducer)**"**

	No supply voltage L+	Wire break (4 to 20 mA)	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	✓	-	-
ET 200MP	✓	✓	✓	✓	✓	-	-
ET 200SP	✓	✓	✓	-	-	-	✓**

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

** Diagnostics for encoder supply only

	No supply voltage L+	Wire break (4 to 20 mA)	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
ET 200AL	-	✓	✓	✓	-	-	✓**
ET 200eco PN	✓	✓	✓	✓	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	✓

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

** Diagnostics for encoder supply only

Table 3-1075 **Configurable diagnostics types of an analog input module depending on the measurement type "**Resistor (4-wire connection)**"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	-	-	-
ET 200MP	✓	✓	✓	✓	-	-	-
ET 200SP	✓	✓	✓	✓	-	-	-
ET 200eco PN	✓	✓	✓	-	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 3-1076 **Configurable diagnostics types of an analog input module depending on the measurement type "**Resistor (3-wire connection)**"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	-	-	-
ET 200MP	✓	✓	✓	✓	-	-	-
ET 200SP	✓	✓	✓	✓	-	-	-
ET 200AL	-	✓	✓	-	-	-	-
ET 200eco PN	✓	✓	✓	-	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 3-1077 **Configurable diagnostics types of an analog input module depending on the measurement type "**Resistor (2-wire connection)**"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	-	-	✓	-	-	-
ET 200MP	✓	-	-	✓	-	-	-
ET 200SP	✓	✓	✓	✓	-	-	-
ET 200AL	-	✓	✓	-	-	-	-
ET 200eco PN	✓	✓	✓	-	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 3-1078 **Configurable diagnostics types of an analog input module depending on the measurement type "**Thermal resistor (4-wire connection)**"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	-	-	-
ET 200MP	✓	✓	✓	✓	-	-	-
ET 200SP	✓	✓	✓	✓	-	-	-
ET 200eco PN	✓	✓	✓	✓	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 3-1079 **Configurable diagnostics types of an analog input module depending on the measurement type "**Thermal resistor (3-wire connection)**"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	-	-	-
ET 200MP	✓	✓	✓	✓	-	-	-
ET 200SP	✓	✓	✓	✓	-	-	-
ET 200AL	-	✓	✓	✓	-	-	-
ET 200eco PN	✓	✓	✓	✓	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 3-1080 **Configurable diagnostics types of an analog input module depending on the measurement type "**Thermal resistor (2-wire connection)**"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	-	-	-	✓	-	-	-
ET 200MP	-	-	-	✓	-	-	-
ET 200SP	✓	✓	✓	✓	-	-	-
ET 200AL	-	✓	✓	✓	-	-	-
ET 200eco PN	✓	✓	✓	✓	-	-	-
ET 200pro	-	✓	✓*	✓*	-	-	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Table 3-1081 **Diagnostics types of an analog input module to be configured depending on the measurement type "**Thermocouple**"**

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
S7-1500	✓	✓	✓	✓	✓	✓	-
ET 200MP	✓	✓	✓	✓	✓	✓	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

	No supply voltage L+	Wire break	Overflow	Underflow	Common mode error	Reference junction	Short-circuit
ET 200SP	✓	✓	✓	✓	-	✓	-
ET 200eco PN	✓	-	✓	✓	-	✓	-
ET 200pro	-	-	✓*	✓*	-	✓	-

* For ET 200pro, the parameters "Overflow" and "Underflow" are combined to the parameter "Overflow/Underflow"

Diagnostics for analog output modules

Table 3-1082 **Diagnostics types of an analog output module to be configured depending on the measurement type "Voltage"**

	No supply voltage L+	Wire break	Overflow	Underflow	Short-circuit	Overload
S7-1500	✓	-	✓	✓	✓	-
ET 200MP	✓	-	✓	✓	✓	-
ET 200SP	✓	-	✓	✓	✓	-
ET 200eco PN	✓	-	-	-	✓	✓
ET 200pro	-	-	-	-	✓	-

Table 3-1083 **Diagnostics types of an analog output module to be configured depending on the measurement type "Current"**

	No supply voltage L+	Wire break	Overflow	Underflow	Short-circuit	Overload
S7-1500	✓	✓	✓	✓	-	-
ET 200MP	✓	✓	✓	✓	-	-
ET 200SP	✓	✓	✓	✓	-	-
ET 200eco PN	✓	✓	-	-	-	✓
ET 200pro	-	✓	-	-	-	-

NOTE

Measuring ranges

Note that the diagnostics types that can be parameterized depend on the selected measurement/output type as well as on the respective measuring range.

NOTE

Minimum output values

Certain errors such as wire break and short circuit cannot be diagnosed below a given current or voltage value. Diagnostics are only possible again once the output returns to above this minimum value.

No supply voltage L+

You can diagnose a missing or low supply voltage L+ at the analog module by activating the "No supply voltage L+" checkbox. If the supply voltage is missing or too low, the status and error display on the analog module will provide the relevant information. The entry in the diagnostics buffer also makes this information available to the CPU.

If there is no supply voltage, no other types of diagnostics available are possible either.

Wire break

The term wire break denotes a failure state that is triggered by the interruption of a usually closed electrical circuit.

Wire break in analog input modules

The "Wire break" diagnostics function facilitates the detection of errors during system operation. In STEP 7 you define the module properties by setting various parameters. Depending on the module used, you may, for example, be able to set a current limit parameter at which a wire break is to be reported.

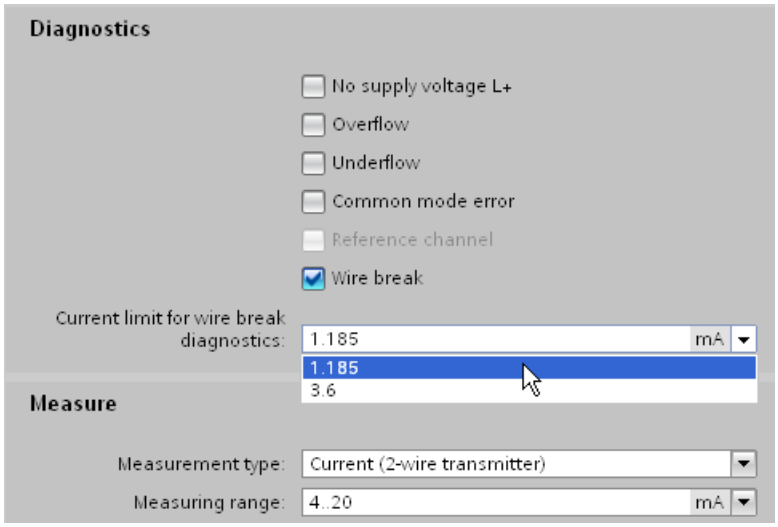

Figure 3-810 Configuring the wire break current limit for an analog input module in STEP 7

Usually, the live zero technique is deployed to detect wire breaks. The start of the measuring range for the standard live zero signal of 4 to 20 mA is assigned the 4 mA signal value. A wire break between the input and sensor can therefore be detected based on the missing current flow. Instead of a current signal, you may also use a voltage signal from 1 to 5 V to detect a wire break. The "Wire break" diagnostics function can therefore only be configured for a range of 4 to 20 mA or 1 to 5 V.

For "Resistor", "Thermal resistor" and "Thermocouple" measurements, a current is impressed into the line. If a wire break occurs, the flow of current is interrupted and the analog module therefore detects the wire break.

Wire break in analog output modules

The analog signal output is used for wire break detection. Reliable wire break diagnostics is not possible if the voltage is too low. In this case, the diagnostics function is deactivated without triggering a change of the diagnostics status.

The current limit up to which the module will diagnose wire break can be found in the technical data for the module.

Overflow/underflow

The resolution of the measuring range of an analog input module distinguishes between the rated range, the overrange or underrange, and the overflow or underflow. The following table assign the number of increments into which the measured signal is divided to the various voltage measuring ranges.

Table 3-1084 Voltage measuring range ±10 V of an analog input module

Value (increments)	Voltage measuring range	Range
Decimal	**±10 V**	
32767	> 11.759 V	Overflow
32511	11.759 V	Overrange
27649		
27648	10.0 V	Rated range
0	0 V	
-27648	-10 V	
-27649		Underrange
-32512	-11.759 V	
-32768	< -11.759 V	Underflow

As of a decimal value of 32512, the value acquired is beyond the overrange and is no longer valid. If this is the case, the error status "Overflow" is diagnosed. The overrange is a tolerance range before overflow is reached.

As of a decimal value of -32513, the value acquired is below the configured measuring range and is no longer valid. If this is the case, the error status "Underflow" is diagnosed. The underrange is the equivalent of the overrange, but for negative values.

An "Overflow" or "Underflow" diagnostics may be caused, for example, by a wire break, an incorrect measuring range or incorrect wiring.

NOTE

Accuracy

The accuracy specified in the technical data of the relevant module is only guaranteed within the rated range.

Common mode error

Activating the "Common mode" checkbox diagnoses a violation of the maximum potential difference U_{CM}. A violation of the permitted potential difference U_{CM} has occurred, for example, between the reference point of the measuring inputs and the analog ground M_{ANA} .

Possible causes:

- Wiring error
- Environments with EMC disturbance
- Incorrectly grounded transducers
- Long line lengths
- Sensor not connected
- 2-wire transducer connected to M_{ANA}

NOTE

With 4-wire transducers, a current meter connected in series will result in too great a drop in voltage.

Potential differences U_{CM} beyond the valid limits may lead to measurement errors and malfunctions. If you want to ensure that the maximum value is not exceeded, interconnect the measuring inputs and analog ground M_{ANA} with an equipotential bonding cable. More detailed information can be found in Wiring transducers.

Short-circuit

Activating the "Short circuit" checkbox activates short-circuit diagnostics for an analog channel. The diagnostics function is triggered by channel overload.

Possible causes:

- Wiring error (e.g. short circuit between conductors at the connections or in the cable)
- Use of faulty or incorrect actuators (e.g. internal short circuit or low input resistance as a result of actuator failure)

The analog signal output is used for short circuit detection. If the voltage is too low, reliable short-circuit diagnostics are not possible. In this case, the diagnostics function is deactivated without triggering a change of the diagnostics status. The voltage limit up to which the module will diagnose a short circuit can be found in the technical data for the module.

SIMATIC modules have a special protective circuit to prevent short circuit. The short circuit current is limited internally in the module. The level of short circuit current is specified in the technical data of your analog module.

NOTE

Overload

Please note that overload exposes the modules are exposed to a greater thermal load. This can affect the output channels. You should therefore avoid continuously running analog output modules in overload.

Reference junction

This type of diagnostics can only be selected for analog input modules for "Thermocouple" measuring. Selecting the "Reference junction" check box diagnoses an error on the reference channel for compensating the reference junction temperature.

The temperature at the reference junction of a thermocouple is measured at the reference channel of the module using an external thermal resistor (RTD). If an error occurs, for example as a result of a wire break, the temperature measured at the reference junction of the thermocouple will no longer be compensated. The reference temperature may then be outside the valid range.

Additional information on connecting thermocouples and thermal resistors and on how they operate can be found in Thermocouples and Wiring transducers.

Overload

Activating the "Overload" checkbox activates the diagnostics of the thermal monitoring of the output level. The "Overload" diagnostics is triggered when the maximum temperature is exceeded at the output and is detected channel by channel.

The maximum temperature may be exceeded for the following reasons:

- Ambient temperature is too high
- Output is being operated outside the specification

NOTE

Overload

Please note that overload exposes the modules to a high thermal load. This can affect the output channels. You should therefore avoid continuously running analog output modules in overload.

2.15 Value status

Value status

In case of a faulty analog value, the analog module outputs the error values 0x7FFF (error value for overflow and all other error states) or 0x8000 (error value for underflow) for the affected channel. The user program is now able to detect and evaluate a channel error. The user also has the option to evaluate the system diagnostics event-driven by means of diagnostics alarms.

In addition to the error values 0x7FFF or 0x8000 and the configured diagnostic types, analog input and output modules provide diagnostics information by means of the Process image input (PII). It is referred to as Value status and transferred synchronously with the user data. The value status (Quality Information = QI) provides a statement regarding the validity of the input signal. A distinction is made between the quality level "Good" (signal valid = 1) and "Bad" (signal invalid = 0).

NOTE

For analog input modules, the use of the value status is an alternative to the evaluation of the channels by the error values 0x7FFF or 0x8000. Compared to the error values, the binary evaluation of the value status (0 or 1) in the user program is simpler and more clearly arranged.

For analog output modules, the value status informs you as to whether the written value can be output by the respective channel. Using the value status you can respond to this information without having to evaluate the diagnostics of the module in the first place.

Example

Enabling the value status of an analog input module

To enable the value status of an analog input module, follow these steps:

- Select the required analog module in STEP 7.
- Select "AI configuration" in the "Properties" tab of the analog module.
- Click the "Value status" button.

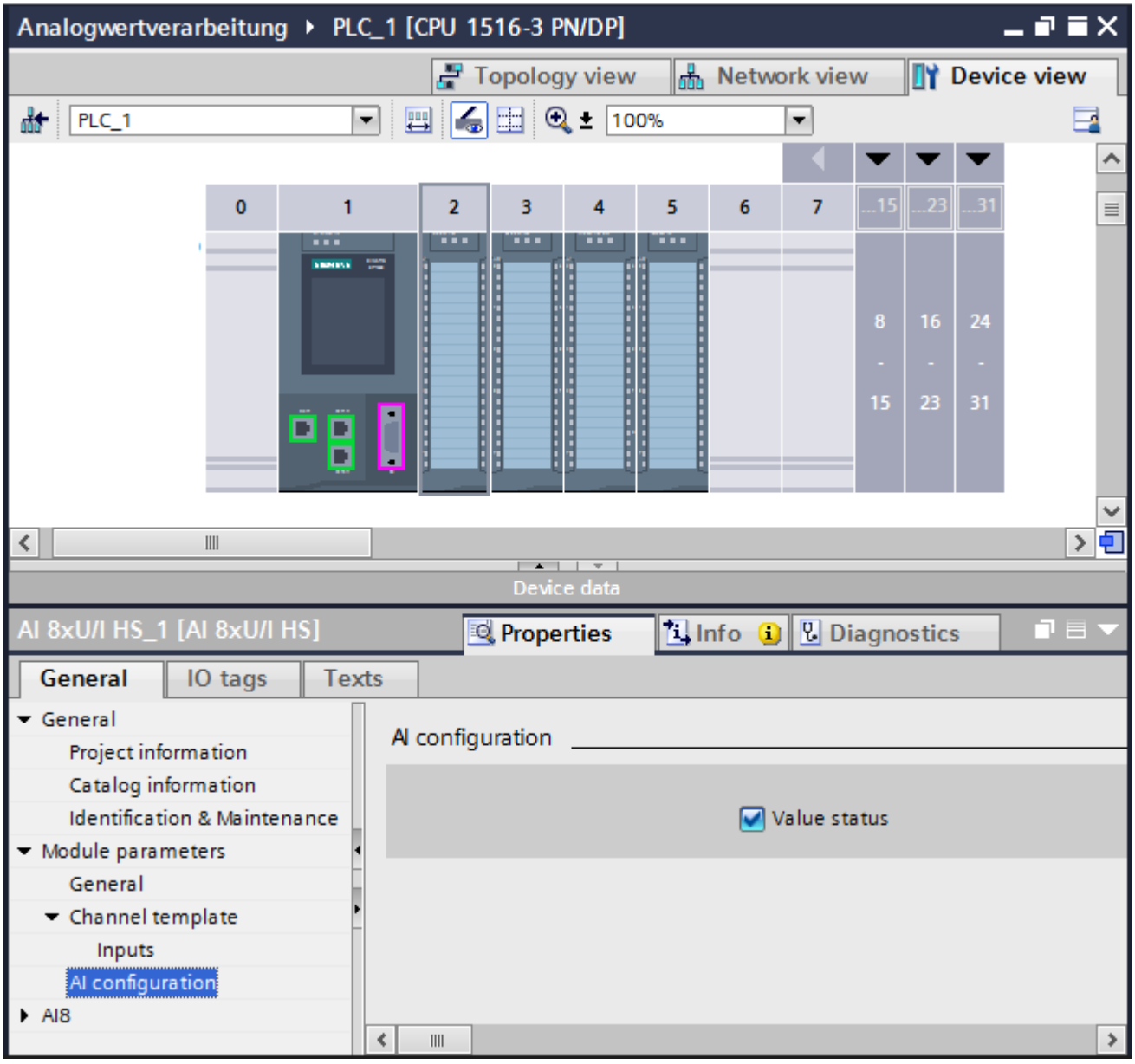

Figure 3-811 Enabling the value status in STEP 7

An additional byte is occupied in the input address space of the respective module when you enable the value status. Each bit in this byte is assigned to a channel and provides information on, for example, whether the output value specified by the user program is actually queued at the module terminal (0= value is invalid; 1= value is valid).

Error occurrence

If a wire break occurs at an analog input module, for example, the current signal state is entered in the process image and the value status of the signal is set to "invalid". To trigger an indicator light in case of an error, for example, evaluate the value status in the user program.

Diagnostics alarms and value status

If you configure analog modules in a third-party product with the help of a GSD file and the diagnostics alarms are not evaluated event-driven, it is best to use the value status.

NOTE

The Value status represents a group diagnostics which only gives the user a Good or Bad information. The Value status is not suitable for a more specific identification of the cause of the error (e.g., wire break, short circuit in the encoder cable or load voltage failure).

2.16 Conversion time of an analog module

Basic conversion time and conversion time of an analog input channel

The basic conversion time is the minimum time required by one single channel to convert analog values. The actual conversion time comprises both the basic conversion time and, depending on the analog input module used:

- Processing time for measuring resistance
- Processing time for wire break monitoring
- Processing time for overflow/underflow monitoring
- Processing time for checking common mode errors

Example

This example shows channel 6 of an analog input module for resistance measurement in the range of 6000 Ω, a configured integration time of 20 ms, and activated wire break monitoring.

The conversion time of the channel is derived from the total of the following measurement variables:

Measurement variable	Time in ms
Basic conversion time	27
Processing time for RTD/resistance (6000 Ω)	4
Processing time for wire break monitoring in the RTD/resistance and thermocouple areas	9
Conversion time of the channel	**40**

Conversion time of the analog output channels

The conversion time of an output channel starts with the transfer of the digital value from the internal memory of the module and ends with the digital-to-analog conversion.

The conversion time does not include the settling time for the analog signal at the module terminal. Detailed information on the settling time can be found in Settling and response times of analog output modules (Page 44).

NOTE

Relationship between diagnostics and conversion time

While some diagnostics run parallel to the conversion and do not extend the conversion time, other diagnostics types can lead to an extension of the conversion time, as demonstrated in the example above.

Conversion time for high-speed analog modules

High-Speed analog modules (HS modules) are designed for faster processing of signals. HS modules offer fewer diagnostics and measurement types than standard modules (ST modules). You can find more information on HS modules in the section High-Speed analog modules (Page 96).

2.17 Cycle time of an analog module

Definition

The cycle time of an analog module represents the time that the module needs to process all channels used. The cycle time depends on the form of measured value acquisition used, e.g. multiplex or parallel measured value acquisition.

Sequential measured value processing

This procedure processes the analog channels in the module one after another (sequentially). For analog inputs, the values are connected to a converter, for example using a multiplexer, and sequentially converted.

The cycle time of the analog module is derived from the total conversion time of all activated analog channels of the module. STEP 7 provides the option of deactivating unused analog channels. to reduce the cycle time.

The figure below gives an overview of the factors that determine the cycle time of an n-channel analog module.

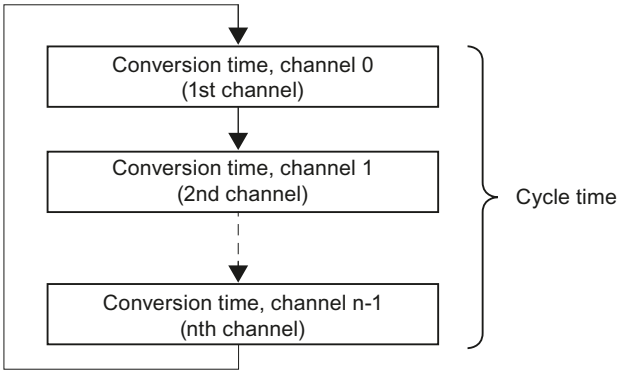

Figure 3-812 Cycle time of an analog module with multiplex conversion

Parallel measured value acquisition

This procedure processes the analog channels of a module at the same time (in parallel) rather than one after another. In parallel measured value processing, the cycle time of the module is usually constant and does not depend on the number of channels used. The goal of parallel measured value acquisition as it is applied by high-speed analog modules, for example, is a shorter cycle time. You can find more information on HS modules in the section High-Speed analog modules (Page 96).

2.18 Settling and response times of analog output modules

Settling and response times provide information on the delay of the output of a specified analog output variable and its availability to the process.

Response time

The response time for a new output value is defined as the time between the input of a digital output value to the internal memory of the module and the value to be output at the analog output being reached (with a residual error of 1 %).

The response time (t_A) is the sum of application time (t_X), conversion time (t_W) and settling time (t_E):

$t_A = t_X + t_W + t_E$

Settling and response times of analog output modules

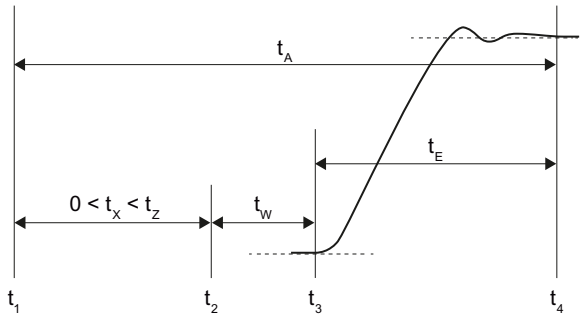

t_A	Response time
t_X	Application time
t_Z	Module cycle time
t_W	Conversion time
t_E	Settling time
t_1	New digital output value is available in the internal memory of the module
t_2	Module activates the digital output value and starts conversion
t_3	Module ends conversion at the terminal of the analog output channel and outputs the analog signal
t_4	Signal has settled and the specified analog output value has been reached (residual error 1 %)

Figure 3-813 Settling and response time of an output channel

Application time

The CPU/IM (interface module) writes new output values to the internal memory of the analog output module. The time required for this is not determined by the CPU/IM. These output values are converted asynchronously to their entry in buffer memory. The worst-case application time (t_X) may be equal to the cycle time (t_Z). This situation develops if the CPU writes a new value to the internal memory of the module immediately after the transfer of the value for conversion. This new value will not be processed until the next conversion.

The figure below shows acyclic access of the analog output module to output values from the internal memory in non-isochronous mode. You can find more information on isochronous mode in the paragraph on isochronous mode of the section High-Speed analog modules (Page 96).

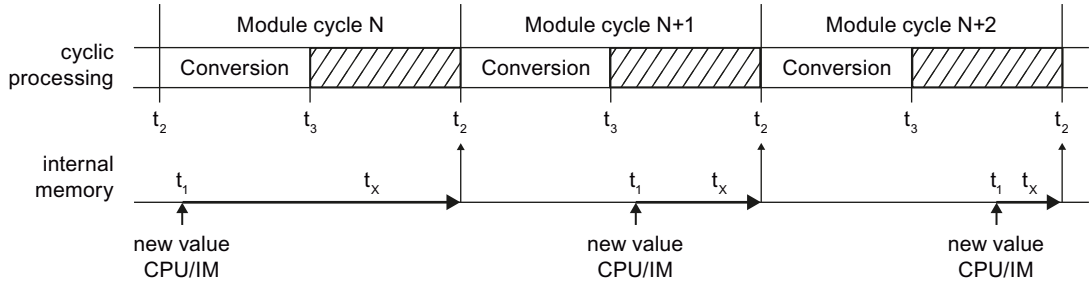

t_X Application time

t_1 New digital output value is available in the internal memory of the module

t_2 Module activates the digital output value and starts conversion

t_3 Module ends conversion at the terminal of the analog output channel and outputs the analog signal

Figure 3-814 Application of the output values

Conversion time

The conversion time of an output channel starts with the transfer of the digital value from the internal memory of the module (t_2) and ends with the digital-to-analog conversion (t_3).

Settling time

The settling time starts when the analog signal is output to the module (t_3) terminals and ends when the output value (t_4) is reached. The output value is reached as soon as the output signal has settled at its final value, taking into account a residual error of 1%.

The settling time depends on the type of output for the module, and on the connected load. The load for the analog output consists of connecting line and connected actuator. When the output is "Current", the settling time increases with high ohmic resistance. Inductive loads cause subsequent fluctuation in the output value. When the output is "Voltage", the capacitive load causes subsequent fluctuation.

2.19 Smoothing

Using the smoothing functions

Most analog input modules allow you to configure smoothing for the measuring signal in STEP 7. Smoothing analog values reduces the effect of interference signals. Smoothing is useful with slow changes in measured values, for example in temperature measurements.

Smoothing principle

The measured values are smoothed by means of filtering. The module forms mean values from a specified number of converted (digitalized) analog values. Smoothing should not be confused with the integration of measured values over a defined period of time. It is therefore not possible to smooth measured signals to filter out a specific interference frequency. However, this smoothing returns more "stable" data values because it suppresses peaks which overlay the measured signal.

4 (none, weak, medium, strong) or more levels of smoothing can be configured by the user depending on the module used. The level determines the number of analog values from which the mean value is generated. The greater the smoothing factor, the better the filtering.

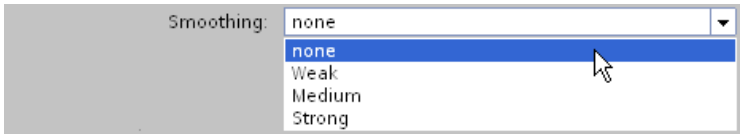

Figure 3-815 Selecting the smoothing level in STEP 7

Smoothing method

A smoothing algorithm is applied to a configurable number of measured values (e.g. 4, 8, 32) in line with the moving average. Each new measured value is factored in, and the oldest measured value then ignored. This mechanism suppresses interference peaks which overlay the measured signal. Utility signal jumps only become evident in the data after some time (see examples below).

The modules of the various product ranges use different smoothing algorithms. Smoothing is either linear or exponential. The differences are apparent particularly with strong smoothing and lead to a faster or slower rate of rise depending on the product used.

For information on whether or not a specific module supports customization of the smoothing function, please refer to the manual of the analog input module.

Example 1: Linear smoothing

The diagram below shows the number of module cycles (k) it takes for each smoothing level setting for the smoothed analog value to reach approximately 100 % after a step response. This specification is valid for all signal changes at the analog input.

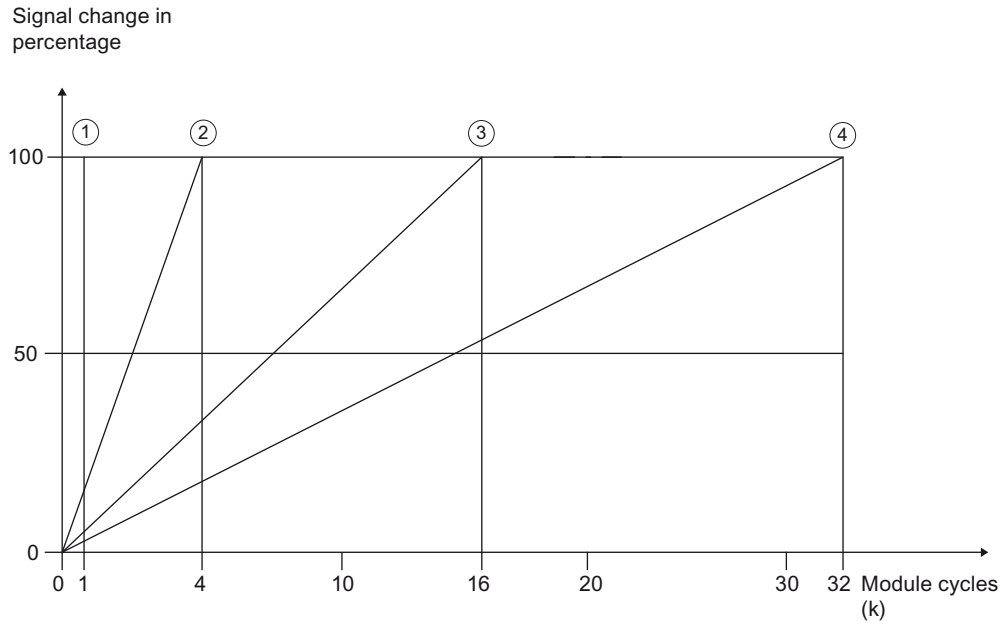

① No smoothing (k = 1)

② Weak smoothing (k = 4)

③ Medium smoothing (k = 16)

④ Strong smoothing (k = 32)

Figure 3-816 Linear smoothing with four smoothing levels

Example 2: Exponential smoothing

The diagram below shows the step response of the smoothing factor for different numbers of module cycles.

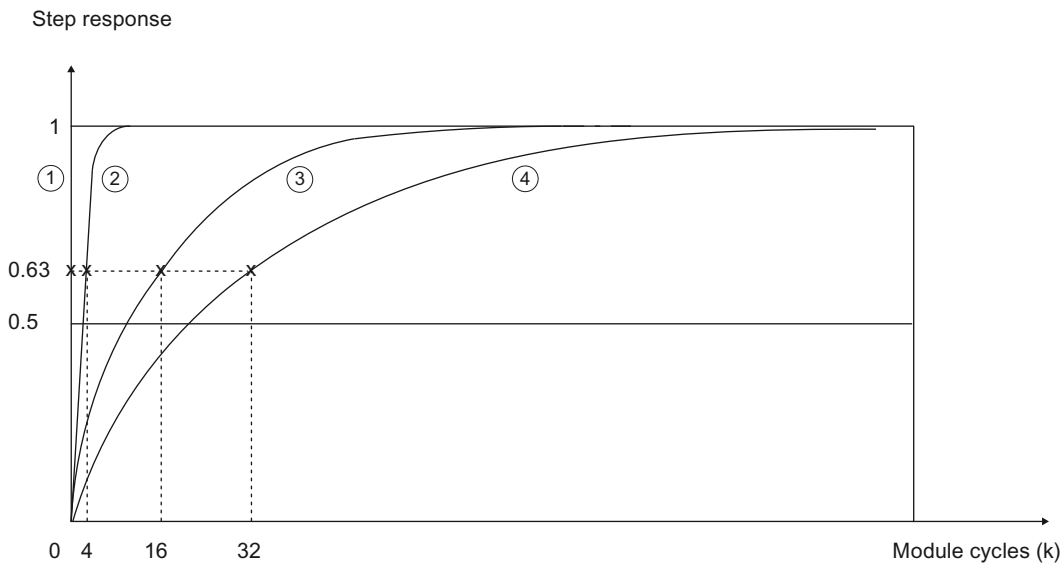

① No smoothing (k = 1)

② Weak smoothing (k = 4)

③ Medium smoothing (k = 16)

④ Strong smoothing (k = 32)

Figure 3-817 Exponential smoothing with four smoothing levels

2.20 Burden with 2-wire transducers

2-wire transducers

2-wire transducers are current transducers which convert the process variable into a current signal of between 4 and 20 mA. Two connection lines supply the transducer with an output current of at least 4 mA. Additional information on connecting 2-wire transducers to analog input modules can be found in the section Wiring current transducers (Page 61).

Burden

The burden indicates how great the external resistance in a current loop may be. If the external resistance is greater than the specified burden, the 2-wire transducer supply voltage is too low. The burden consists of the resistance of the transducer and all other resistances connected to the current loop.

The maximum admissible burden of the transducer, e.g. 820 Ω, is specified in the technical data of the analog module.

Example 1: Connecting a transducer to the electrical circuit

In accordance with the technical data of the 2-wire transducer used, it requires a supply voltage (U_{min}) of at least 8.5 V. Using Ohm's Law, you can calculate the resistance of the transducer used (R_{2DMU}) for a current of 20 mA.

$$R_{2DMU} = \frac{U_{min}}{I} = \frac{8.5\ V}{0.020\ A} = 425\ \Omega$$

With a supply voltage of at least 8.5 V, the transducer has a resistance of 425 Ω. The resistance is less than 820 Ω. You can therefore connect the transducer to the analog input module (AI) without exceeding the maximum burden.

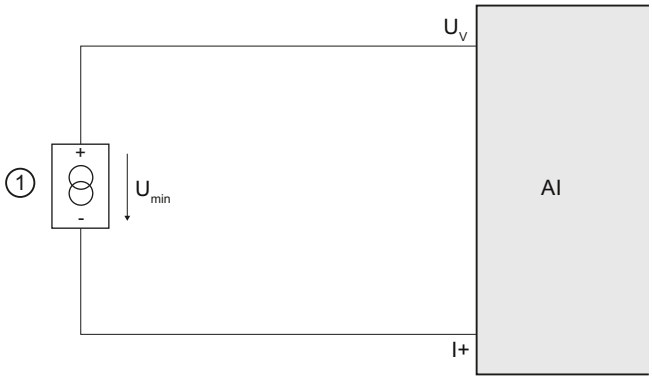

① 2-wire transducers

U_V Terminal for feed voltage at the channel

I+ Terminal for current input

U_{min} Voltage drop at 2-wire transducer

Figure 3-818 Connecting a transducer to the electrical circuit

Example 2: Connecting a transducer and other devices

If multiple measuring devices are connected in series, the sum of all connected resistances may not exceed the value of the maximum burden.

If you have connected a 2-wire transducer to a supply voltage of 8.5 V, you will need to allow for the resistance of the measuring device connected ②.

Maximum transducer burden:	820 Ω
Transducer resistance upon a voltage drop of 8.5 V:	425 Ω
Maximum resistance of additional devices connected:	395 Ω

The resistance of the measuring instrument may therefore not exceed 395 Ω.

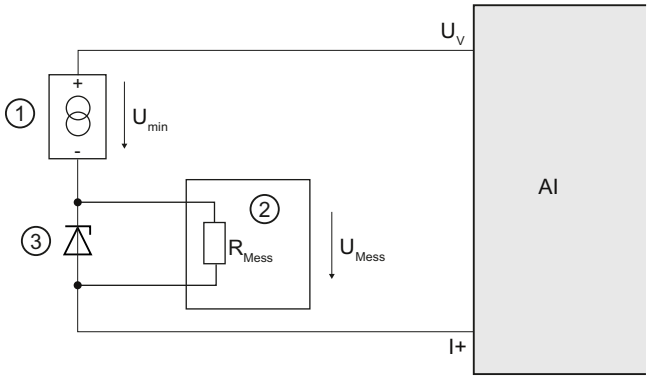

① 2-wire transducers
② Digital multimeter
③ Zener diode
U_V Terminal for feed voltage at the channel
I+ Terminal for current input
U_{min} Voltage drop at 2-wire transducer
R_{Mess} Resistance at measuring instrument
U_{Mess} Voltage drop at the measuring instrument

Figure 3-819 Connecting a transducer and other devices to the circuit

Calculating admissible voltage drop

The maximum additional resistance in the current loop may not exceed 395 Ω at a maximum current of 20 mA. You can calculate the voltage drop at the connected measuring instrument (U_{Mess}) as follows using Ohm's Law:

$U_{Mess} = R_{Mess} * I = 395\ \Omega * 0.020\ A = 7.9\ V$

The voltage drop at the measuring instrument should therefore not exceed 7.9 V.

Representation of analog values 3

3.1 Overview

Conversion of analog values

The CPU only processes analog values in digitalized format.

Analog input modules convert the analog signal into a digital value for further processing by the CPU.

Analog output modules convert the digital output value from the CPU into an analog signal.

Analog value representation at 16-bit resolution

The digitized analog value is the same for all I/O values at the same rated range. The analog values are represented as fixed point numbers in twos complement. This leads to the following conditions:

Table 3-1085 Representation of analog values

Resolution	**Analog value**															
Bit number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Significance of the bits	S	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Sign

The sign (S) of the analog value is always set in bit 15:

- "0" → +
- "1" → -

Resolution less than 16 bits

The analog value is left-aligned in the memory of analog modules with a resolution of less than 16 bits. The unused least significant digits are padded with "0" values.

This reduces the number of measured values that can be represented. Modules occupy a range of values of between+32767 and -32768 regardless of the resolution. The scaling between two successive values depends on the resolution of the module.

Example

The following example shows how the least significant digits are padded with "0" values:

- The module with 16-bit resolution is capable of incrementing the values in steps of one unit ($2^0 = 1$).
- The module with 13-bit resolution is capable of incrementing the values in steps of 8 units ($2^3 = 8$).

Table 3-1086 Example: Bit pattern of a 16-bit and 13-bit analog value

Resolution	Analog value															
Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
16-bit	S	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
13-bit	S	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	0	0	0

S = sign

NOTE

For information on the resolution supported by each analog module, please refer to the technical data for the relevant module.

3.2 Representation of input ranges

The tables below set out the digitalized representation of the input ranges by bipolar and unipolar input ranges. The resolution is 16 bits.

Please see the device manuals for each analog input module for assignment of the values to the specific measured values in each measuring range.

Table 3-1087 Bipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Over range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	-100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Under range
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32768	<-117.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

Table 3-1088 Unipolar input ranges

Dec. value	Measured value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32767	>117.589	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Overflow
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Over range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	Under range
-4864	-17.593	1	1	1	0	1	1	0	1	0	0	0	0	0	0	0	0	
-32768	<-17.593	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Underflow

3.3 Representation of output ranges

The tables below set out the digitalized representation of the output ranges by bipolar and unipolar range. The resolution is 16 bits.

Please see the device manuals for each analog output module for assignment of the values to the specific output values in each measuring range.

Table 3-1089 Bipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Maximum output value*
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Over range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
-1	-0.003617	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
-27648	-100.000	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	
-27649	100.004	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	Under range
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
-32512	-117.593	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Minimum output value**

* When values > 32511 are specified, the output value is limited to 117.589 % or 0 % (0.0 V / 0.0 mA), depending on the module used.

** When values < -32512 are specified, the output value is limited to -117.593 % or 0 % (0.0 V / 0.0 mA), depending on the module used.

Table 3-1090 Unipolar output ranges

Dec. value	Output value in %	Data word																Range
		2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
32511	117.589	0	1	1	1	1	1	1	1	x	x	x	x	x	x	x	x	Maximum output value*
32511	117.589	0	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	Over range
27649	100.004	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	
27648	100.000	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	Rated range
1	0.003617	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
0	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Minimum output value**

* When values > 32511 are specified, the output value is limited to 117.589 % or 0 % (0.0 V / 0.0 mA), depending on the module used.

** When values < 0 are specified, the output value is limited to 0% (0.0 V / 0.0 mA).

Connecting transducers 4

4.1 Overview

Introduction

This chapter describes the basic procedure for wiring transducers to analog inputs. Information on specific wiring options is available in the manual of each module.

For more information, e.g. on cable routing and shielding or potential equalization, etc., refer to the function manual for Configuring interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566).

Transducers that can be wired to analog inputs

You can wire the following transducers to the analog input modules, depending on the type of measurement:

- Voltage transducers
- Current transducers
  - 2-wire transducers
  - 4-wire transducers
- Resistance transducers
  - 4-wire connection
  - 3-wire connection
  - 2-wire connection
- Thermocouples

Isolated transducers and non-isolated transducers

Transducers are available in various models:

- Isolated transducers are **not connected** locally to the ground potential. Floating operation is possible.
- Non-isolated transducers are **connected** locally to the ground potential.

  Non-isolated transducer connections are connected to the conductive enclosure.

  Note: All non-isolated transducers must have a galvanic connection to each other and be locally connected to the ground potential.

Abbreviations used in the figures

Key to the abbreviations in the figures below:

AI	Analog input module
M	Ground connection
L+	Supply voltage connection
M_n+/M_n-	Measuring input, channel n
I_{Cn}+/I_{Cn}-	Current output to thermal resistor (RTD) channel n
U_n+/U_n-	Voltage input channel n
I_n+/I_n-	Current input channel n
COMP+/COMP-	Compensation input
I_{Comp}+/I_{Comp}-	Current output for compensation
U_V	Feed voltage at channel (the connection can be used for 2-wire transducer (2DMU) or with ET 200eco PN and ET 200pro for 2/4-wire transducer).
U_{CM}	Potential difference between the reference points of the measuring inputs / the analog ground M_{ANA}
U_{ISO}	Potential difference between the reference points of the measuring inputs and the central ground
M_{ANA}	Reference point of the analog ground

Lines for analog signals

Always use shielded twisted-pair cables to wire the analog signals. This improves immunity.

4.2 Wiring analog inputs with MANA connection

The reference potentials of the measuring inputs and the central ground are electrically isolated in analog input modules with M_{ANA} connection.

Limited potential difference U_{ISO} (insulation voltage)

Always verify that the admissible potential difference U_{ISO} between the reference point of the analog ground M_{ANA} and the central ground is not exceeded.

Potential difference U_{ISO} may be caused by: Maximum line lengths exceeded.

If you want to ensure that the permitted value U_{ISO} is not exceeded, install an equipotential bonding cable between the terminal M_{ANA} and the central grounding point.

Limited potential difference U_{CM} (common mode)

Always verify that the admissible potential difference U_{CM} between the reference point of the measuring inputs and the analog groundM_{ANA} is not exceeded.

Potential differences U_{CM} may be caused by:

- Environments with EMC disturbance
- Use of grounded transducers
- Use of long cable lengths

Measuring errors / malfunctions can occur if the admissible potential difference U_{CM} is exceeded.

Some modules can detect an invalid potential difference U_{CM} and report this error with an entry in the diagnostics buffer of the CPU.

If you want to ensure that the maximum value U_{CM} is not exceeded, interconnect the reference points of the measuring inputs and the analog ground M_{ANA} with an equipotential bonding cable.

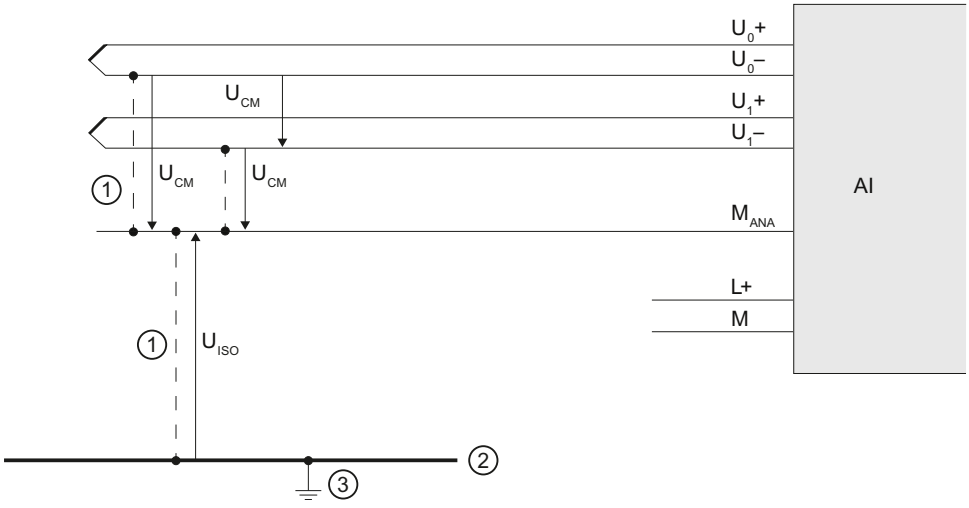

① Equipotential bonding cable

② Grounding bus cable

③ Central ground

Figure 3-820 Example: Reference potential for analog input modules with M_{ANA} connection

4.3 Wiring analog inputs without MANA connection

The reference potentials of the measuring inputs and the central ground are electrically isolated from each other in analog input modules without an M_{ANA} connection.

Limited potential difference U_{ISO} (insulation voltage)

Always verify that the maximum potential difference U_{ISO} between the reference points of the measuring inputs and central ground is not exceeded.

Potential difference U_{ISO} may be caused by: Maximum line lengths exceeded.

If you want to ensure that the permitted value U_{ISO} is not exceeded, install an equipotential bonding cable between the reference points of the measuring inputs and the central grounding point.

Limited potential difference U_{CM} (common mode)

Always ensure that the permitted potential difference U_{CM} between the reference points of the measuring inputs is not exceeded.

Potential differences U_{CM} may be caused by:

- Environments with EMC disturbance
- Use of grounded transducers
- Use of long cable lengths

Measuring errors / malfunctions can occur if the admissible potential difference U_{CM} is exceeded.

Some modules can detect an invalid potential difference U_{CM} and report this error with an entry in the diagnostics buffer of the CPU.

If you want to ensure that the permitted value U_{CM} is not exceeded, install equipotential bonding cables between the reference points of the measuring inputs or, with the ET 200eco PN and ET 200pro, between the reference points of the measuring inputs and ground.

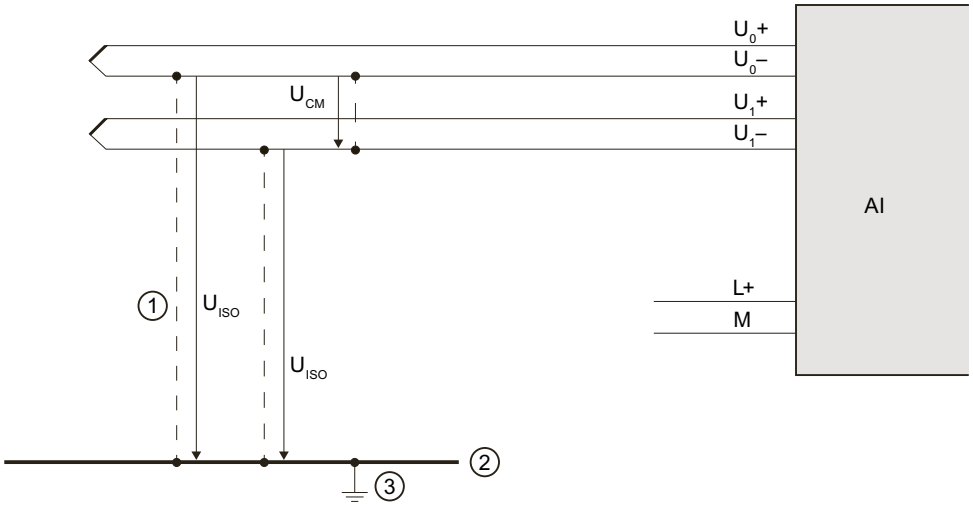

① Equipotential bonding cable (not for 2-wire and resistance transducers)

② Grounding bus cable

③ Central ground

Figure 3-821 Example: Reference potential for analog input modules without M_{ANA} connection

4.4 Wiring voltage transducers

The figure below shows how to connect voltage transducers. If you want to ensure that the permitted value U_{CM} is not exceeded, install equipotential bonding cables to connect the reference points of the measuring inputs to the analog ground M_{ANA}, or with ET 200eco PN and ET 200pro the reference points of the measuring inputs to the ground.

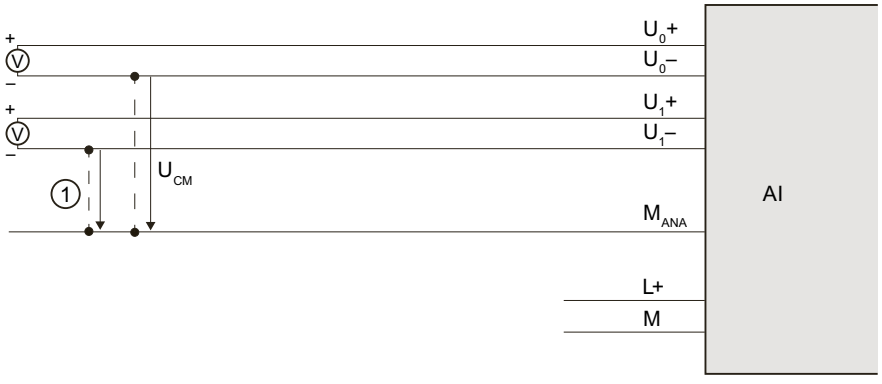

① Equipotential bonding cable (only relevant to modules with M_{ANA} connection)

Figure 3-822 Example: Wiring voltage transducers to an analog input module

4.5 Wiring current transducers

Current transducers are available as 2-wire transducers and 4-wire transducers. Below are a number of ways to supply current transducers with voltage.

Wiring 2-wire transducers with power supply from the module

The 2-wire transducer converts the process variable into a current. The 2-wire transducer is wired to the short circuit-proof supply voltage at the terminals of the analog input module. The transducer is therefore frequently also called a "passive transducer". Its simple wiring means that the 2-wire transducer is frequently used in industrial environments. If you use this type of connection, you will need to set the "Current (**2-wire transducer**)" measurement type in STEP 7.

NOTE

2-wire transducers must be electrically isolated.

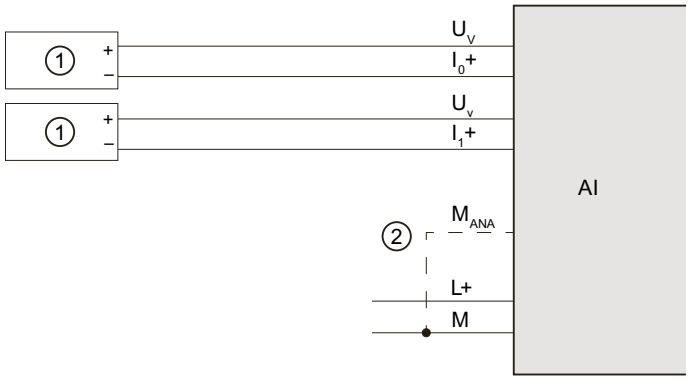

① 2-wire transducers (2WT)

② Equipotential bonding cable (only relevant to modules with M_{ANA} connection)

Figure 3-823 Example: Wiring 2-wire transducers to an analog input module

Wiring 2-wire transducers to an analog input for 4-wire transducers

The figure below shows an alternative to the above connection: supplying the 2-wire transducer from supply line L+ of the module. If you use this type of connection, you will need to set the "Current (**4-wire transducer**)" measurement type in STEP 7.

In this type of connection, galvanic isolation between the supply voltage L+ and the analog circuit will be removed.

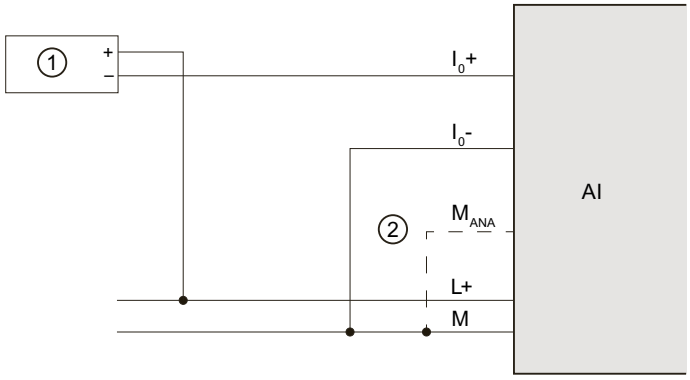

① 2-wire transducers (2WT)

② Equipotential bonding cable (only relevant to modules with M_{ANA} connection)

Figure 3-824 Example: Wiring 2-wire transducers to an analog input for 4-wire transducers

Wiring and connecting 4-wire transducers

4-wire transducers provide terminals for connecting a separate supply voltage. They are powered with an external supply and are frequently called "active transducers". If you use this type of connection, you will need to set the "Current (**4-wire transducer**)" measurement type in STEP 7.

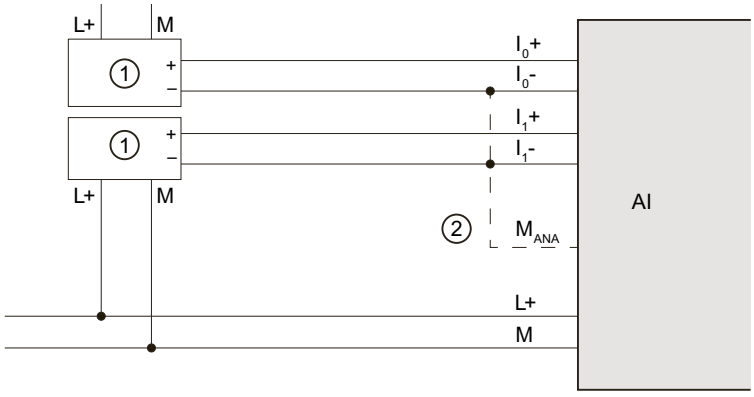

① 4-wire transducers (4WT)

② Equipotential bonding cable (only relevant to modules with M_{ANA} connection)

Figure 3-825 Example: Wiring 4-wire transducers to an analog input module

4.6 Wiring thermal resistors and resistors

The module provides a constant current at terminals I_C+ and I_C- for resistance measurements. The constant current is fed to the resistance to be measured where it is measured as voltage drop. It is important to wire the connected constant current cables directly to the thermal resistor/resistor.

Measurements with 4-wire or 3-wire connection compensate for line resistance and therefore achieve greater accuracy compared to measurements with 2-wire connection.

Measurements with two-wire connection always acquire line resistance in addition to the actual resistance; you must therefore allow for a significant loss of precision in the measuring results.

The figures below give some connection examples.

4-wire connection of a thermal resistor

The voltage at the thermal resistor is acquired using high-impedance measurement via the M_0+ and M_0- terminals. Make sure the wiring is correctly poled (I_{C0}+ and M_0+, and I_{C0}- and M_0- at the thermal resistor).

Always wire the **I_{C0}+ and M_0+** lines, and the **I_{C0}- and M_0-** lines directly to the thermal resistor.

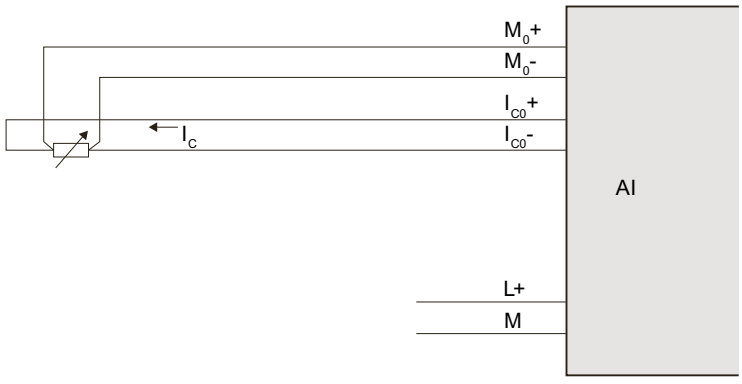

Figure 3-826 Example: 4-wire connection of thermal resistor to an analog input module

3-wire connection of a thermal resistor

Depending on the module, for a 3-wire connection to modules with 4 terminals (per channel), you may need to insert a bridge between **M_0- and I_{C0}-** (see figure below) or between **M_0+ and I_{C0}+**. Always wire the **I_{C0}+** and **M_0+** lines directly to the thermal resistor. Use cable with wires with identical cross-section.

For ET 200AL, ET 200eco PN and ET 200pro, no bridge is required as all necessary connections are implemented internally.

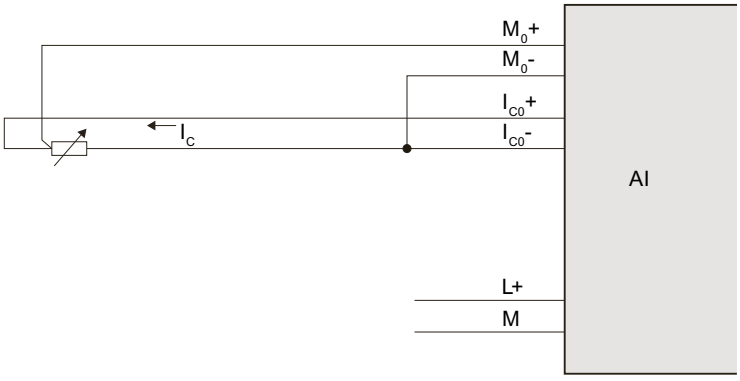

Figure 3-827 Example: 3-wire connection of thermal resistor to an analog input module

2-wire connection of a thermal resistor

When installing a 2-wire device on modules with 4 terminals (per channel), you will need to insert bridges at the module between **M_0+ and I_{C0}+** and between **M_0- and I_{C0}-** as shown in the figure below. The line resistance is measured, but not compensated. As a result of physical limitations, this measurement type is less accurate than measurement with 3-wire or 4-wire connections. The wiring for this type of measurement is, however, simple as the bridges required can be wired in the plug, saving line.

For ET 200AL, ET 200eco PN and ET 200pro, no bridge is required as all necessary connections are implemented internally.

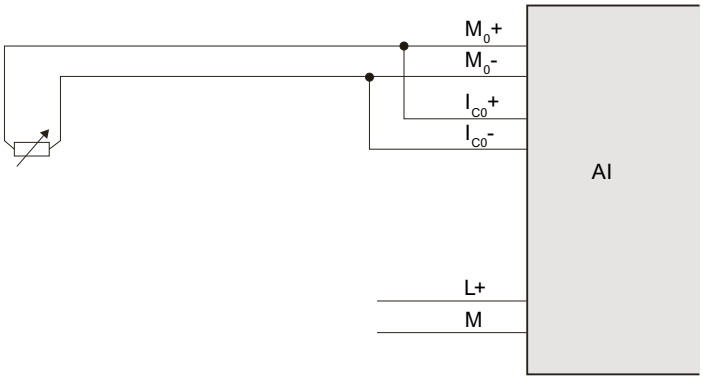

Figure 3-828 Example: 2-wire connection of thermal resistor to an analog input module

4.7 Wiring thermocouples

Introduction

Thermocouples are generally supplied ready-to-use. Protective casing prevents the thermocouples from being destroyed by mechanical force, for example.

Compensating lines

The compensating lines belonging to the respective thermocouples are identified by a special color code, because only the compensating line that is made of the material matching the thermocouple may be used. The standardized compensating lines are specified in DIN EN 60584. Observe the maximum temperatures in the manufacturer's specifications.

Thermocouple connection options

There are various different ways to wire thermocouples to an analog input module:

- Directly ①.
- Using compensating lines ②.
- With a compensating line to the reference junction, connected with a supply line, e.g. copper ③.

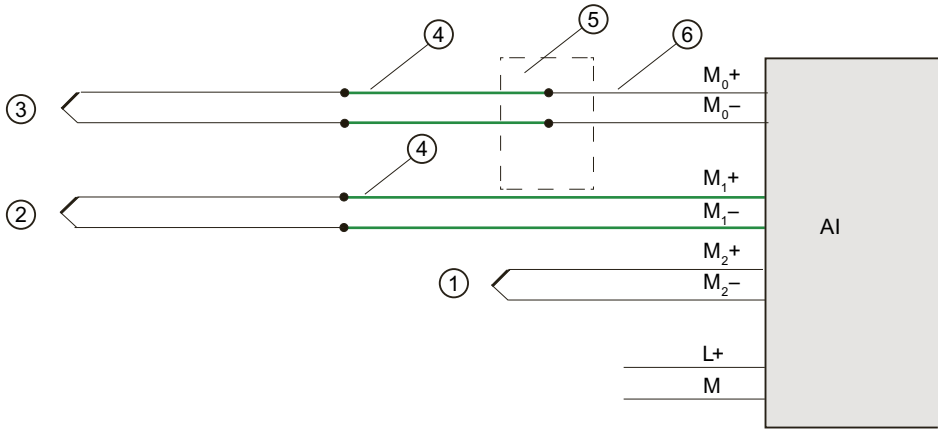

① Thermocouple without compensating line
② Thermocouple with compensating line
③ Thermocouple with compensating line and supply line
④ Compensating line (same material as thermocouple)
⑤ External reference junction
⑥ Copper supply cable, for example

Figure 3-829 Example: Wiring thermocouples to an analog input module

Further information

Further information, such as the selection of thermocouples and how they operate, can be found in the section Thermocouples (Page 67).

Thermocouples

5

5.1 Selecting thermocouples

Introduction

Thermocouples are electrical devices for precise temperature measurement. They consist of two different metals connected at one point. Temperature affecting this point generates a voltage difference from which the temperature can be calculated.

Thermocouples can measure a wide range of temperatures and come in extremely robust models. They are therefore frequently used in industrial applications. Below are some of the criteria to consider when selecting the right thermocouple:

- Temperature range
- Atmospheric conditions
- Price

Grounded thermocouples

In grounded thermocouples, a conductive thermocouple wire is attached to the inside of the sensor housing. This results in good heat transfer from the sensor housing to the thermocouple measuring tip.

Non-grounded thermocouples

In non-grounded thermocouples, the thermocouple is not connected to the sensor housing. The response time following temperature changes is longer than with grounded thermocouples. The measuring point is galvanically isolated.

Type and temperature range

The different thermocouple types are derived from different material compositions.

NOTE

Due to physical conditions, thermocouples are extremely inaccurate outside the specified temperature range. Only use thermocouple in the temperature range specified by the manufacturer.

The following table lists the types and material compositions, as well as the temperature measuring range of different thermocouples:

Type	Material composition	Temperature range
B	PtRh-PtRh	250 to 1820 °C
C	W-Re	0 to 2315 °C
E	NiCr-CuNi	-270 to 1000 °C
J	Fe-CuNi	-210 to 1200 °C
K	NiCr-Ni	-270 to 1372 °C
L	Fe-CuNi	-200 to 900 °C
N	NiCrSi-NiSi	-270 to 1300 °C
R	PtRh-Pt (Pt 13%)	- 50 to 1769 °C
S	PtRh-Pt (Pt 10%)	-50 to 1769 °C
T	Cu-CuNi	-270 to 400 °C
U	Cu-CuNi	-200 to 600 °C
TXK/XKL	NiCr-CuCr	-200 to 800 °C

5.2 Structure and operating principle of thermocouples

Thermocouple structure

A thermocouple consists of a pair of thermal sensors and the respective installation and wiring elements. Two wires made of different metals/alloys are welded together at their ends (hot end). The welding point forms the so-called measuring point, while the free ends of the thermocouple form the reference junction.

The free ends are interconnected with the evaluation device (e.g. analog input module) via insulated wires or cables.

The different thermocouple types, e.g. K/J/N, are derived from different material composition; the same measuring principle is applied to all thermocouples, independent on their type.

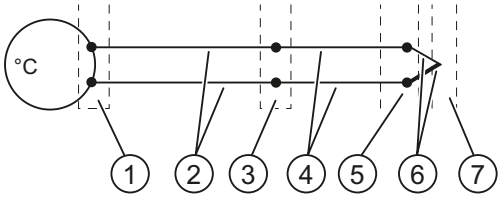

① Thermal voltage acquisition point
② Copper supply cable, for example
③ Reference junction
④ Compensating line (same material as thermocouple)
⑤ Connection point
⑥ Thermocouple with positive and negative thermal elements
⑦ Measurement point

Figure 3-830 Thermocouple

Operating principle of thermocouples

Temperature differences between the measuring point and the free ends of the pair of thermal sensors (connection point) generate a thermal voltage at the reference junction. The value of the thermal voltage is determined by the temperature difference between the measuring point and the free ends, as well as by the material composition of the pair of thermal sensors.

Thermocouples always acquire a differential temperature, which means that the temperature at their free ends (reference junction) must be known to determine the temperature at the measuring point.

The thermocouple can be extended with compensating lines from the connection point. This allows the reference junction to be located at a specific point, for example, where the temperature can be kept constant or the temperature sensor is easy to install. The compensating lines and thermocouple wires are made of the same material. Copper cables are used to connect the reference junction to the module.

NOTE

Always observe the polarity, as incorrect wiring will result in unacceptable measuring errors.

5.3 Compensation for the reference junction temperature

5.3.1 Overview

Introduction

You have several options for measuring the reference junction temperature in order to obtain a correct temperature value as a function of the temperature difference between the reference junction and the measuring point.

You have various compensation options to suit requirements at the location of the reference junction.

The compensation options supported by the analog module used are specified in the manual of the respective module.

Options of compensating for the reference junction temperature

Table 3-1091 Compensation options: Explanation and use case

Compensation options	Explanation	Use case / special feature
Internal reference junction	**Function principle** With this type of compensation, the temperature of the reference junction is measured using an integrated sensor in the analog module. **Procedure** Connect the thermocouple to the I/O module directly, or with compensating lines; see chapter Compensation with internal reference junction (Page 72).	• For the connection, use compensating lines that match the thermocouple material. • If the reference junction temperature and the module temperature are identical in your system, you may also use lines made from a different material. • Advantages: – Inexpensive – No external reference junction required – No additional wiring required
Reference channel of the module	**Properties** With this type of compensation, the reference junction temperature is determined using an external thermal resistor (RTD). **Procedure** Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module. Wire the thermal resistor (RTD) to the reference channel of the module. The thermal resistor (RTD) must be positioned in the area of the reference junction; see chapter Compensation with reference channel of the module (Page 74).	• They acquire the temperature directly at the reference junction. • The measured temperatures of all channels that you have configured for this compensation type will be corrected automatically by the temperature value of the reference junction. • Advantages: – More precise compared to compensation with internal reference junction; however, you need to install and wire an additional thermal resistor.

Compensation options	Explanation	Use case / special feature
Reference channel of group 0	**Properties** With the "TC" (thermocouple...) setting, the channel acts as receiver for the reference junction temperature of group 0. The associated transmitter of group 0 is set up to for the RTD channel. **Procedure** Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module. Wire the thermal resistor (RTD) to the configured reference channel for group 0 of the module. The thermal resistor (RTD) must be positioned in the area of the reference junction; see chapter Compensation, reference channel of Group 0 (Page 75).	• They acquire the temperature directly at the reference junction. • The measured temperatures of all channels that you have configured for this compensation type will be corrected automatically by the temperature value of the reference junction (transmitter).
Fixed reference temperature	**Properties** With this type of compensation, the reference junction temperature is stored in the module as fixed value. **Procedure** Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module. Depending on the module, you can enter a fixed reference junction temperature in the configuration data (e.g. 20 °C), or use the fixed reference junction temperature of the module (0 °C); see chapter Compensation with fixed reference temperature (Page 77).	• You keep the reference junction temperature constant and know the temperature value. • To ensure high precision, you must ensure that the temperature remains constant (this can be complicated, depending on the application).
Dynamic reference temperature	**Properties** With this type of compensation, the reference junction temperature is determined using a module. Transfer this temperature value to other modules in the user program by means of a data record. **Procedure** Wire the thermal resistor (RTD) for the reference junction to any channel. The reference junction temperature is transferred with a function block by means of data records from the CPU or IM to the module, see section Compensation by means of dynamic reference temperature (Page 80).	• You are using multiple modules at the reference junction and can therefore compensate for all channels using a common temperature value. • You only need a thermal resistor (RTD) or a thermocouple to measure the temperature value.
No/external compensation	**Properties** With this type of compensation, the reference junction temperature is measured outside the analog input module. You can, for example, connect a compensating box to the thermocouple for this purpose. **Procedure** Connect the compensating box with the connection module of the analog input module with copper cables, see section "None" or external compensation (Page 82).	• The temperature of the reference junction for this type of compensation is specified as 0 °C. This can be achieved by using a compensating box. A separate compensating box is required for each thermocouple. • Thermocouples of type B do not require a compensating box.

Compensation options	Explanation	Use case / special feature
RTD (0)	**Properties** This compensation is based on a measurement of the resistance value of a Pt1000 at the clamping unit of a compensation connector or of an external resistance value Pt1000. **Procedure** Additional information about the connection options with and without compensation connector is available in the section Type of compensation RTD (0) (Page 84).	• The reference junction temperature is determined with resistance value of the Pt1000. • All channels of the analog input module that you select for this type of compensation receive the same reference junction temperature.

5.3.2 Compensation with internal reference junction

Function principle

The reference junction for compensation via internal reference junction is at the terminals of the analog input module. Wire the thermocouples or compensating lines directly to the module inputs. The internal temperature sensor acquires the module temperature and returns a compensating voltage.

Note that compensation via internal reference junction will not always reach the precision of external compensation!

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermocouple" value as "Measurement type".

6. As "Reference junction", select the value "Internal reference junction".

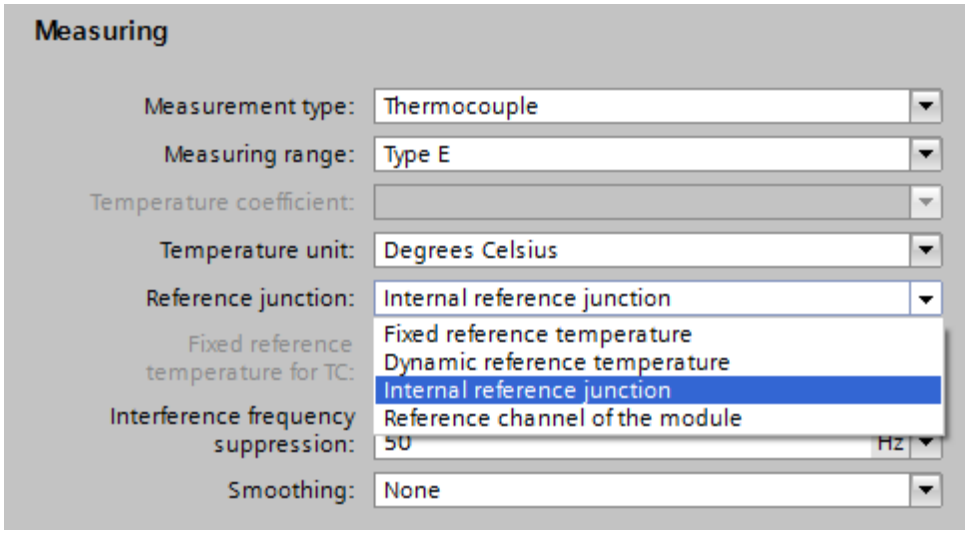

Figure 3-831 Internal reference junction

Wiring thermocouples

Wire the thermocouples directly or indirectly via compensating lines to the module inputs.

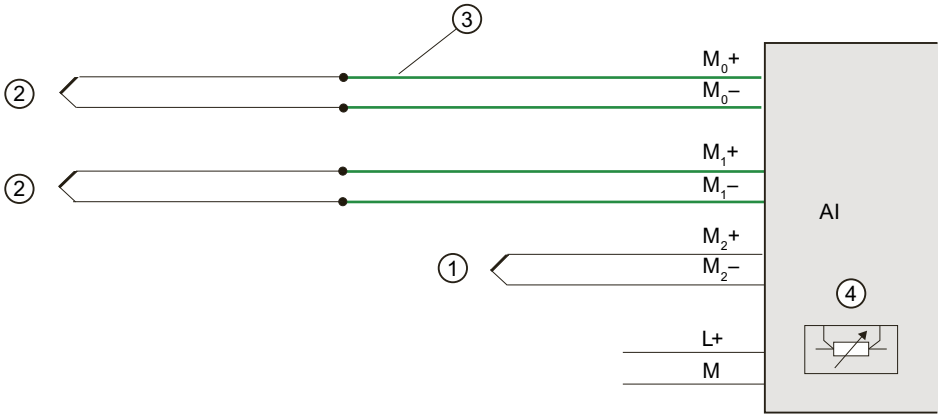

① Thermocouple without compensating line
② Thermocouple with compensating line
③ Compensating line (same material as thermocouple)
④ Internal reference junction

Figure 3-832 Example: Wiring thermocouples for compensation via internal reference junction

5.3.3 Compensation with reference channel of the module

Function principle

With this type of compensation, the reference junction temperature is determined using an external thermal resistor (RTD). Certain modules provide an internal reference channel.

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermocouple" value as "Measurement type".
6. As "Reference junction", select the value "Reference channel of the module"".

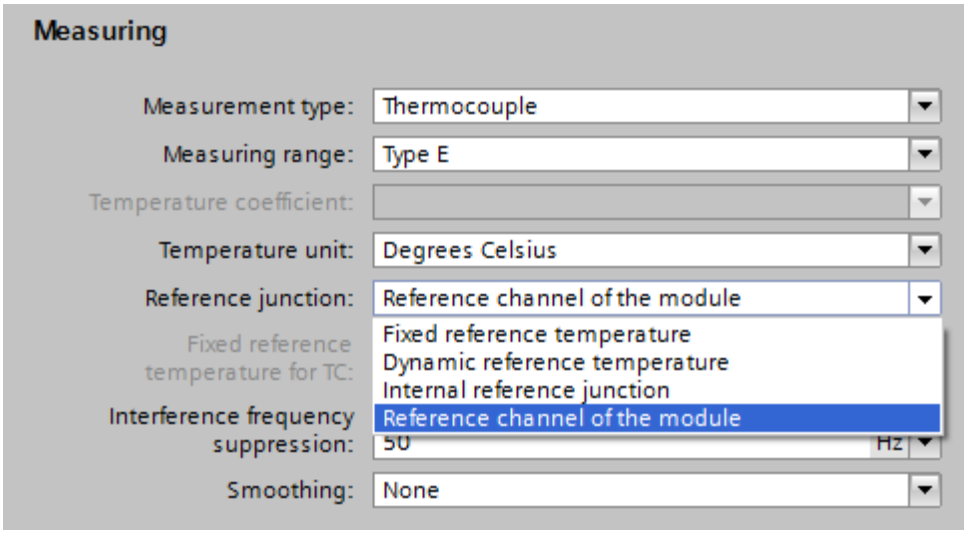

Figure 3-833 Reference channel of the module

Wiring thermocouples and thermal resistors

Connect the thermocouple to the supply lines directly at the reference junction, or indirectly using compensating lines. Wire the supply lines to the corresponding terminals of the module.

You may use cables made of any material to wire the thermal resistor to the module terminals.

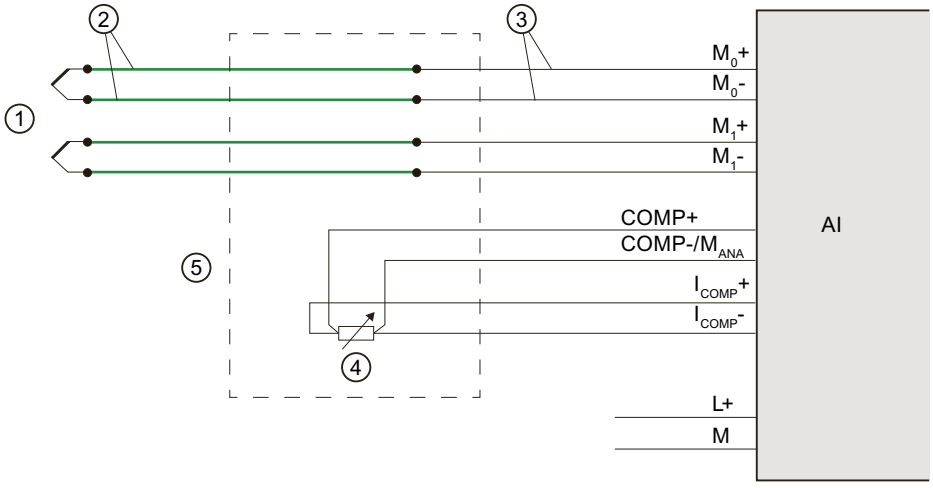

① Thermocouple

② Compensating line (same material as thermocouple)

③ Copper supply cable, for example

④ Thermal resistor (RTD)

⑤ Reference junction

Figure 3-834 Example: Wiring thermocouples/thermal resistors for compensation by means of reference channel of the module

5.3.4 Compensation, reference channel of Group 0

Function principle

For this compensation, a module channel with a connected thermal resistor (RTD) acts as "Reference temperature transmitter". Other channels (reference temperature receivers) with connected thermocouples can be compensated using this reference temperature. The measured temperatures of all channels (receivers) that you have configured for this compensation type will be compensated automatically by the temperature value of the reference junction (transmitter).

The reference junction temperature is determined by means of an external thermal resistor (RTD).

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the area "Inputs/measurement".
5. For the channel of the relevant module, specify as transmitter:
   As "Measurement type" select, for example, "Thermal resistor (4-wire connection)".
   As "Reference junction", select the value "Reference channel of group 0".

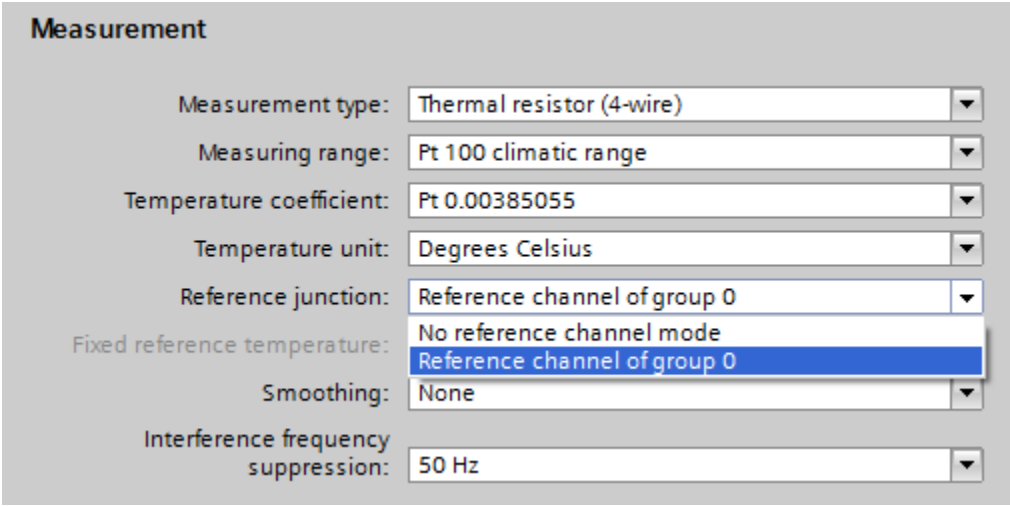

Figure 3-835 Transmitter: Reference channel of group 0

6. For the channels you specify as receivers:
   Select the "Thermocouple" value as "Measurement type".
   As "Reference junction", select the value "Reference channel of group 0".

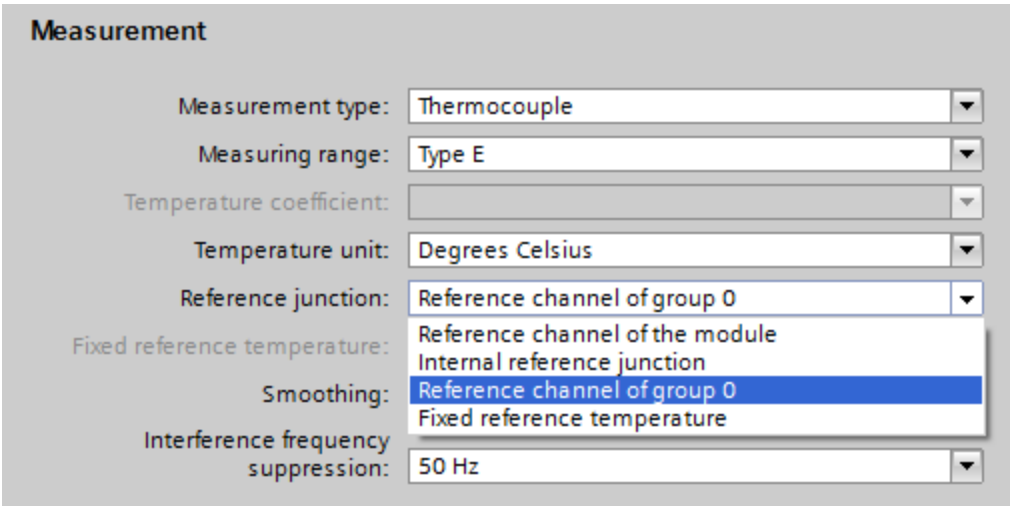

Figure 3-836 Receivers: Reference channel of group 0

Connecting thermocouples and thermal resistors

The example below shows:

- An analog module with thermal resistor as reference temperature transmitter and
- Two analog modules with thermocouple as reference temperature receivers.

Connect the thermocouples to the supply lines at the reference junction, either directly or with compensating lines. Wire the supply lines to the corresponding terminals of the module.

You may use cables made of any material to wire the thermal resistor to the module terminals.

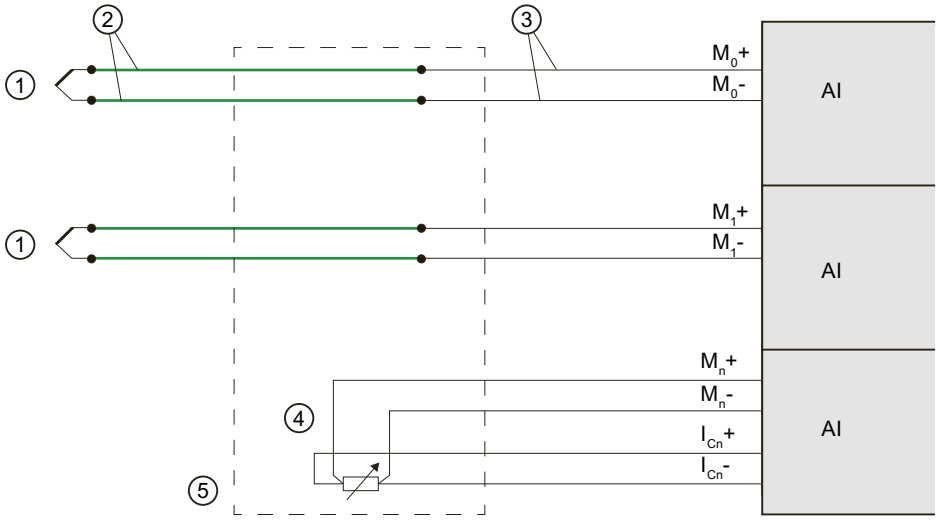

① Thermocouple
② Compensating line (same material as thermocouple)
③ Copper supply cable, for example
④ Thermal resistor (RTD)
⑤ Reference junction

Figure 3-837 Example: Connecting thermocouples/thermal resistors for group 0 compensation

5.3.5 Compensation with fixed reference temperature

Function principle

With this type of compensation, the reference junction temperature is stored in the module as fixed value.

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. Select the required analog module in the Device view.
3. Select the "General" tab in the Inspector window of the selected module.

4. Select the "Inputs/Measuring" area.
5. Select the "Thermocouple" value as "Measurement type".
6. As "Reference junction", select the value "Fixed reference temperature".
7. Specify the temperature of the reference junction in the "Fixed reference temperature" area, for example, 20 °C.

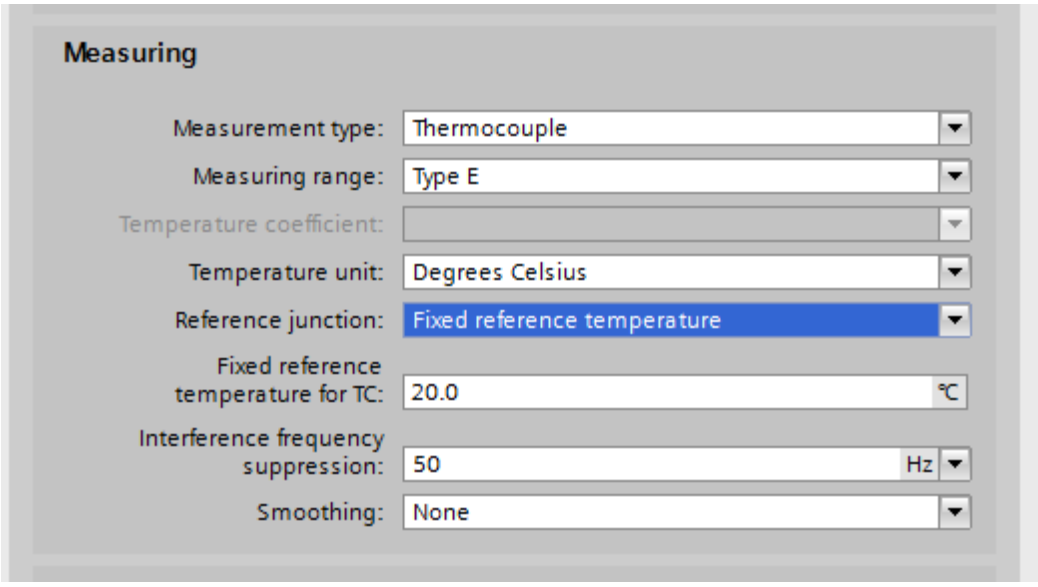

Figure 3-838 Fixed reference temperature

Temperature condition with "Fixed reference temperature" setting

The figure below shows the connection options for thermocouples provided the temperature of the module is kept at a fixed reference temperature (20 °C), for example by installing it in an air-conditioned switch cabinet. The reference junction is in the module.

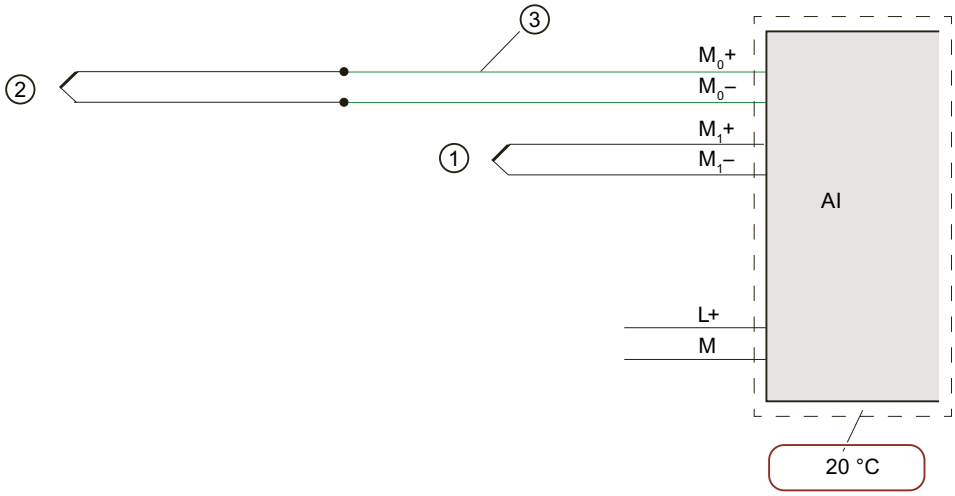

① Thermocouple without compensating line

② Thermocouple via compensating line

③ Compensating line (same material as thermocouple)

Figure 3-839 Example 1: Connecting a thermocouple to an analog module for compensation with "fixed reference temperature"

The figure below shows the connection options for thermocouples provided the temperature of the reference junction (outside the module) is kept at a fixed reference temperature (20 °C).

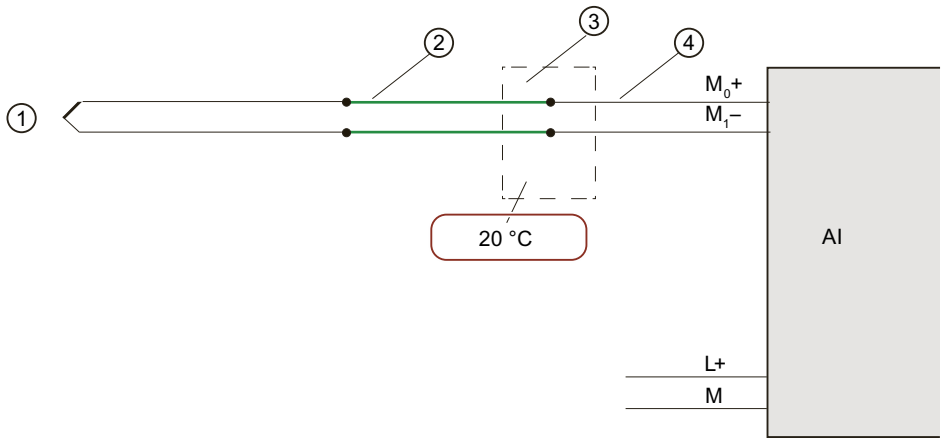

① Thermocouple with compensating line and supply line

② Compensating line (same material as thermocouple)

③ Reference junction

④ Copper supply cable, for example

Figure 3-840 Example 2: Connecting a thermocouple to an analog module for compensation with "fixed reference temperature"

5.3.6 Compensation by means of dynamic reference temperature

Function principle

This compensation type allows you to handle the reference junction temperature for temperature compensation in the user program. You can derive the temperature value from any other module of the station. The reference junction temperature is transferred via data records using the instruction **WRREC** (SFB 53).

The structure of the data records is detailed in the device manual for each module.

Requirement

STEP 7 project with the following contents:

- User program with WRREC (SFB 53) instruction for transferring the data records with reference temperature
- Analog module for acquisition of the process temperature using thermocouple (TC)
- Analog module for measuring the process temperature using thermal resistor (RTD)

Analog module for acquisition of the process temperature using thermocouple (TC)

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermocouple" value as "Measurement type".
6. As "Reference junction", select the value "Dynamic reference temperature".

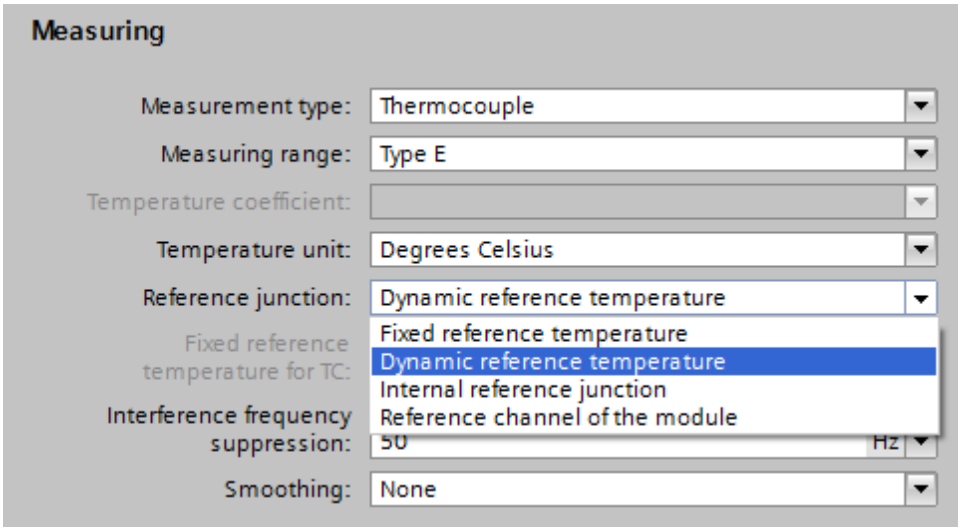

Figure 3-841 Dynamic reference temperature

Analog module for measuring the process temperature using thermal resistor (RTD)

Configuration steps:

1. Open the project in STEP 7.
2. In the device view, select the required analog module and the corresponding channel.
3. Select the "General" tab in the Inspector window of the selected module.
4. Select the "Inputs/Measuring" area.
5. Select the "Thermal resistor (4-wire connection)" value as "Measurement type".

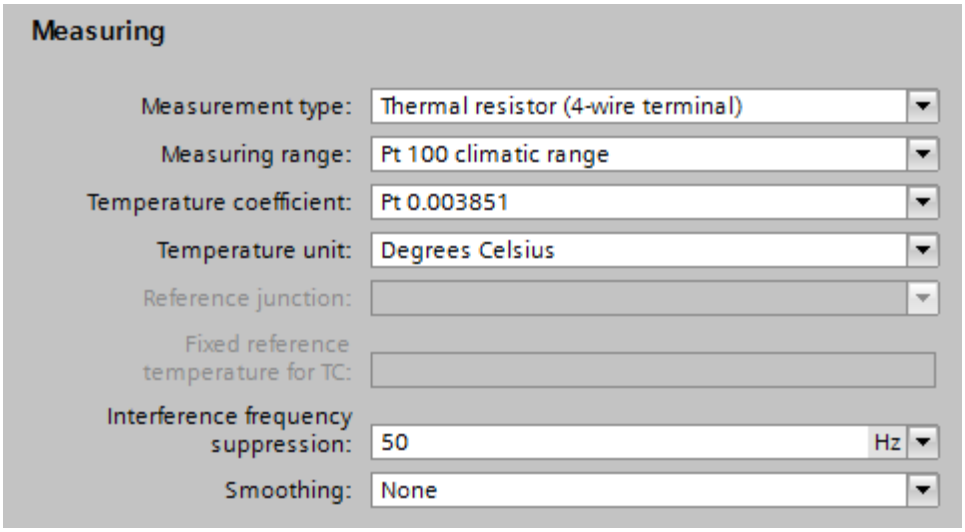

Figure 3-842 Settings for thermal resistor (RTD) type of measurement

Connecting thermocouples and thermal resistors

Connect the thermocouples, for example, to the module inputs using supply lines for temperature compensation with dynamic reference temperature. In this case, the temperature is acquired at the reference junction by means of a thermal resistor (RTD). This reference junction temperature determined in this way is transferred to the analog module with thermocouple via data records with the WRREC instruction.

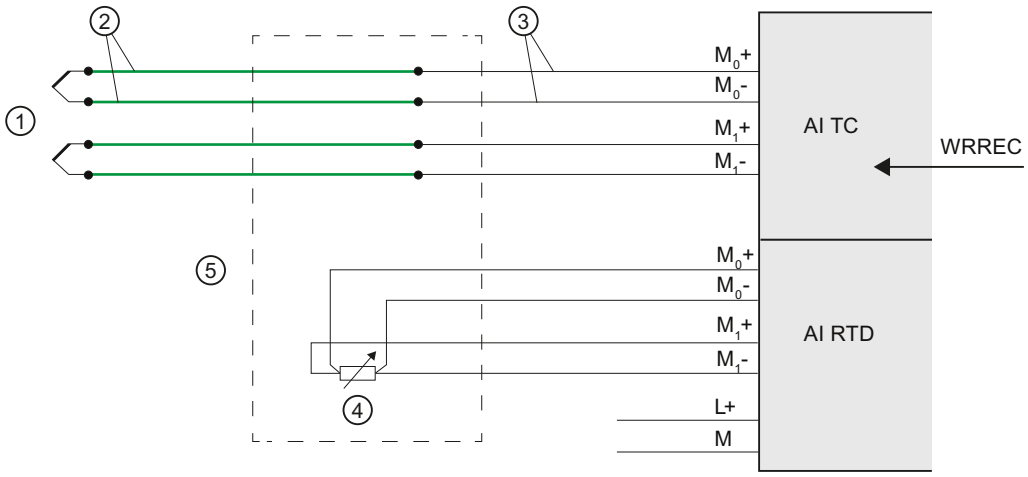

① Thermocouple

② Compensating line (same material as thermocouple)

③ Copper supply cable, for example

④ Thermal resistor (RTD)

⑤ Reference junction

Figure 3-843 Example: Connecting thermocouples/thermal resistors for compensation by means of dynamic reference temperature

5.3.7 "None" or external compensation

Function principle

The reference junction temperature of the thermocouples is measured outside the analog input module, e.g., by means of a compensating box on the thermocouple. The temperature of the reference junction for this type of compensation is specified as 0° C.

The compensating box includes a bridge circuit that is calibrated for a specific reference junction temperature (compensation temperature). The connectors for the ends of the compensating line of the thermocouple form the reference junction. If the actual comparison temperature deviates from the compensation temperature, the temperature-dependent bridge resistor changes. A positive or negative compensation voltage is generated and added to the thermal voltage.

NOTE

Thermocouples of type B do not require a compensating box.

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. Select the required analog module in the Device view.
3. Select the "Inputs" tab in the Inspector window of the selected module and the respective channel.
4. Select the "Thermocouple" value as "Measurement type" in the "Measuring" area.
5. As "Reference junction", select the value "None" or "External compensation" depending on the used module.

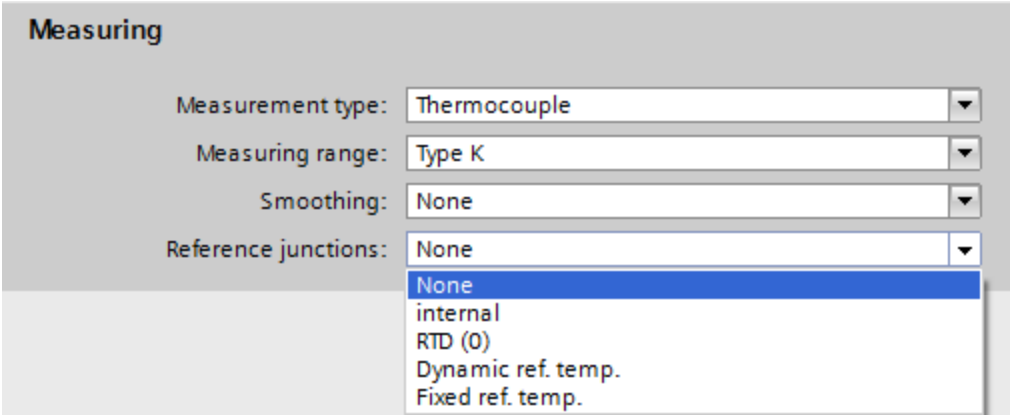

Figure 3-844 No reference junction

Connection of the compensating box

The compensating box is looped into the supply lines of an individual thermocouple. The compensating box must be supplied isolated. The power supply unit must have a sufficient noise filter, e.g., by means of a grounded shielding winding.

Each channel can use its own thermocouple type supported by the analog module regardless of the other channels. A separate compensating box is required for each channel.

Connection example "None" or external compensation

Connect the compensating box with the connection module of the analog input module using copper cables.

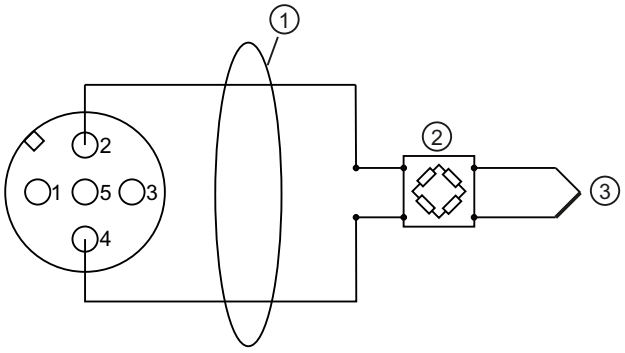

① Copper cables

② Compensating box (per channel), for example; thermocouple type B does not require a compensating box

③ Thermocouple

Figure 3-845 Connection example "No" compensation as reference junction

5.3.8 Compensation type RTD (0)

Function principle

The reference junction temperature is determined by means of the resistance value of a Pt 1000 at the clamping unit of the M12 compensation connector. The resistance measurement is only permitted at the X1 circular socket (channel 0). All of the module's channels with this type of compensation receive the same reference junction temperature.

Procedure

Configuration steps:

1. Open the project in STEP 7.
2. Select the required analog module in the Device view.
3. Select the "Inputs" tab in the Inspector window of the selected module.
4. Select the "Thermocouple" value as "Measurement type" in the "Measuring" area.

5. As "Reference junction", select the value "RTD (0)".

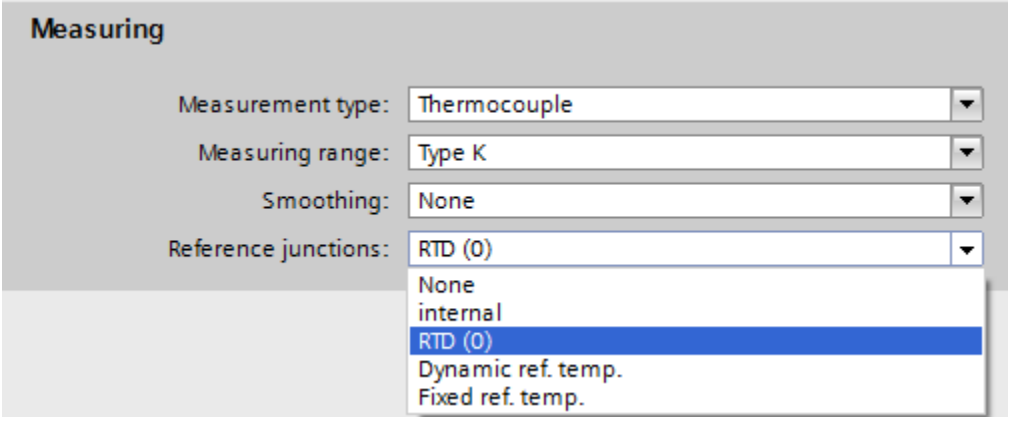

Figure 3-846 Compensation type RTD (0)

Connection example

Connection with M12 compensation connector

Connect the thermocouple to the M12 compensation connector directly or with compensating lines. Install the M12 compensation connector to the X1 circular socket (channel 0) of the CM IO 4 x M12 at the 4 AI TC High Feature.

Connection without M12 compensation connector

To measure the referent junction temperature, connect an external Pt1000 (with α = 003851) to terminals 1 and 3 using copper cables. The thermal resistor Pt1000 must be positioned in the area of the reference junction. Connect the thermocouples to terminals 2 and 4 from the reference junction with copper cables.

Connecting additional thermocouples

You can connect additional thermocouples to the circular sockets X2 to X4 on the CM IO 4 x M12 of the 4 AI TC High Feature. The temperature of reference junction collected by measuring the resistance value at the X1 circular socket applies to all channels of the module that you have selected for this type of compensation.

The figure below shows a connection example "RTD (0)" as reference junction with M12 compensation connector and integrated thermal resistor Pt1000:

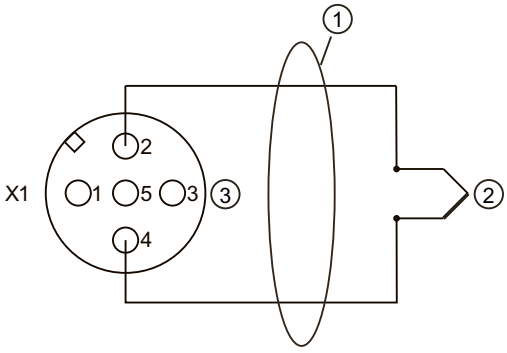

① Direct connection of the thermocouple or with compensating lines

② Thermocouple

③ M12 compensation connector (terminals 1 and 3 with internal Pt1000) only at X1 circular socket. The comparison value of the M12 compensation connector at circular socket X1 also applies to thermocouples at X2, X3 and X4.

Figure 3-847 Connection example "RTD (0)" as reference junction in the M12 compensation connector

The figure below shows a connection example "RTD (0)" as reference junction with external thermal resistor Pt1000:

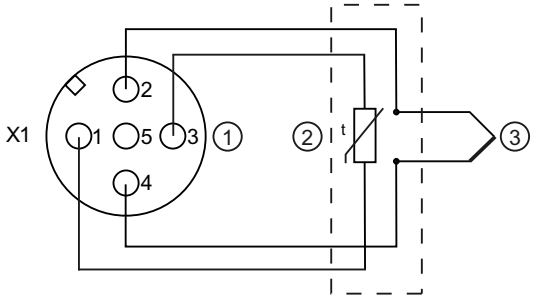

① M12 connector only at X1 circular socket

② External Pt1000 (α = 0.003851) in the area of the reference junction with copper cables at terminals 1 and 3. The comparison value of the external Pt1000 at circular socket X1 also applies to thermocouples at X2, X3 and X4.

③ Thermocouple

Figure 3-848 Connection example "RTD (0)" as reference junction with external Pt1000

Wiring loads/actuators

6

6.1 Overview

Introduction

This chapter describes the basic procedure for wiring loads/actuators to analog outputs. Information on specific wiring options is available in the manual of each module.

For detailed information on cable routing and shielding, potential equalization, etc. please refer to the function manual Configuring interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566).

Abbreviations used in the figures

Key to the abbreviations in the figures below:

AQ	Analog output module
M	Ground connection
L+	Supply voltage connection
S_n+/S_n-	Sense line channel n
QV_n+/QV_n-	Voltage output channel n
QI_n+/QI_n-	Current output channel n
M_{ANA}	Reference point of the analog ground
U_{ISO}	Insulation voltage

Lines for analog signals

Always use shielded twisted-pair cables to wire the analog signals. This improves immunity.

6.2 Wiring loads/actuators

Reference potential for analog output modules with M_{ANA} connection

Analog output modules have no galvanic connection between the reference point of the analog ground M_{ANA} and the central ground.

Always verify that the admissible potential difference U_{ISO} between the reference point of the analog ground M_{ANA} and the central ground is not exceeded.

Potential difference U_{ISO} may be caused by: Maximum line lengths exceeded.

If you want to ensure the maximum value U_{ISO} is not exceeded, wire terminal M_{ANA} and the central ground with an equipotential bonding cable.

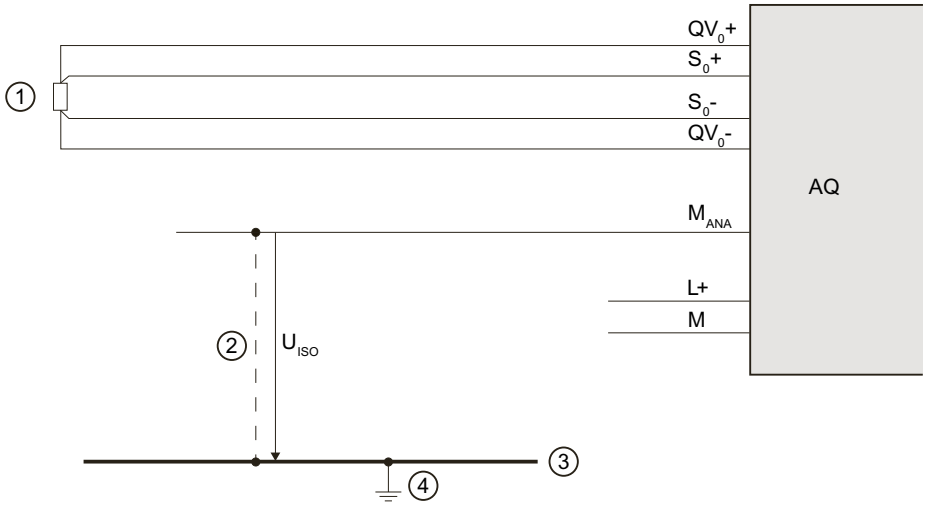

① Load on the voltage output
② Equipotential bonding cable
③ Grounding bus cable
④ Central ground

Figure 3-849 Example: Reference potential for an analog output module with M_{ANA} connection

Reference potential for analog output modules without M_{ANA} connection

Analog output modules have no galvanic connection between the reference potential of the analog output circuits and central ground.

Always verify that the maximum potential difference U_{ISO} between the reference points of the analog output circuits and the central ground is not exceeded.

Potential difference U_{ISO} may be caused by: Maximum line lengths exceeded.

f you want to ensure the maximum value U_{ISO} is not exceeded, interconnect each analog output circuit with the central ground using an equipotential bonding cable.

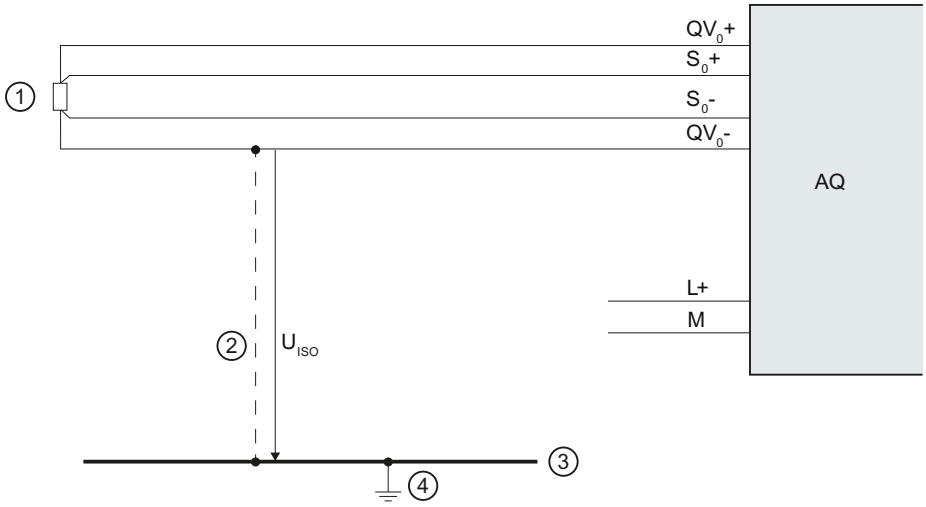

① Load on the voltage output
② Equipotential bonding cable
③ Grounding bus cable
④ Central ground

Figure 3-850 Example: Reference potential for an analog output module without M_{ANA} connection

Supported functions 7

7.1 Calibrating analog modules

7.1.1 Overview

Calibration

A calibration checks the process values measured by the analog input module and the process values output by the analog output module, determines the deviation from the actual values and compensates for any measurement and output errors.

Calibrating analog modules

The SIMATIC analog modules were calibrated before being shipped and have excellent long-term stability; calibration is therefore not required during runtime.

But certain regulations and directives, for example from the Food and Drug Administration (FDA), require regular calibration for all components in a measuring circuit. These components include analog input and output modules.

A calibration makes sense especially for plants in which sensors detect and process relatively small voltages or currents. The calibration compensates for influences on the measuring result by cables and/or temperature.

The calibration collects the new values and saves them retentively on the module. But the calibration values determined prior to delivery at the plant are not lost. You can return to these original calibration values at any time.

NOTE

The calibration saves the calibration values of each channel for the specific measuring range retentively on the module, which means the values apply to the same measuring range in which the user calibration took place.

If you reconfigure a channel with effective user calibration values to another type of measuring mode, the calibration values saved at the plant for this channel and for this measuring range will become effective.

But the user calibration values are not deleted. They are not overwritten until there is a new user calibration of the channel. If you set the original measuring range for this channel once again without new user calibration, the previously determined user calibration values will become effective.

The respective manual will include information whether or not your analog module supports the "Calibration" functionality.

Scope of functions

The "Calibration" group offers the following functions:

- Specifying the current calibration of all channels
- Calibrating a channel
- Canceling a running calibration
- Resetting the calibration of a channel to the factory settings

7.1.2 Calibrating analog modules

Manual calibration

The following requirements must be met to start manual calibration:

- An online connection exists between STEP 7, the respective CPU and the analog module to be calibrated.
- You have opened the "Online & Diagnostics" view for the selected analog module from the shortcut menu of the project and you are now in the "Functions > Calibration" area.
- The configuration reflects the actual structure of the station.
- No calibration process is busy on the module (if you want to launch calibration).
- A 24 V load voltage must be present at each module for the calibration.
- The last step was successfully completed (if you want to continue or conclude calibration).

Procedure

The basic mask for calibration opens once you start the "Calibration" function. The module reads the following general information data and calibration values after each new selection of a channel:

- **Calibration:** Indicates whether or not the currently effective calibration values are factory calibration values or user calibration values.
- **Measurement type:** Information about the selected measurement type
- **Measuring range:** Currently configured measuring range of the selected channel
- **Gain:** Currently effective gain correction of the analog-digital converter
- **Offset:** Currently effective offset correction of the analog-digital converter

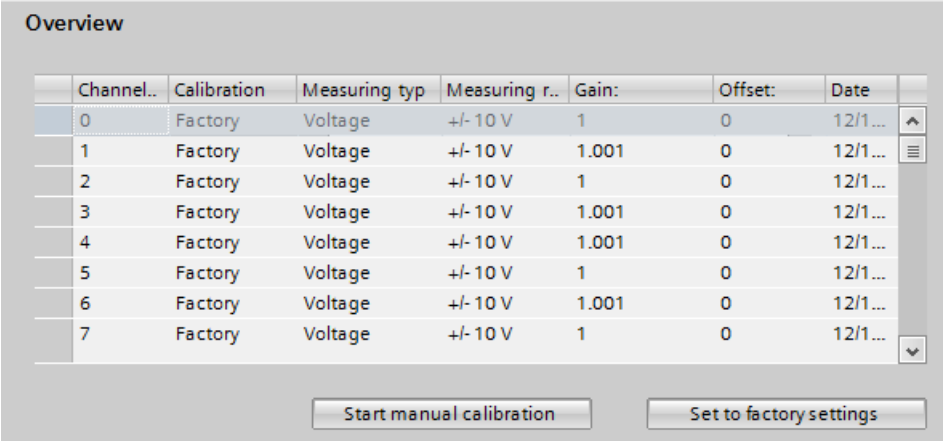

Channel..	Calibration	Measuring typ	Measuring r..	Gain:	Offset:	Date
0	Factory	Voltage	+/- 10 V	1	0	12/1...
1	Factory	Voltage	+/- 10 V	1.001	0	12/1...
2	Factory	Voltage	+/- 10 V	1	0	12/1...
3	Factory	Voltage	+/- 10 V	1.001	0	12/1...
4	Factory	Voltage	+/- 10 V	1.001	0	12/1...
5	Factory	Voltage	+/- 10 V	1	0	12/1...
6	Factory	Voltage	+/- 10 V	1.001	0	12/1...
7	Factory	Voltage	+/- 10 V	1	0	12/1...

Figure 3-851 Calibration table

To start the calibration, follow these steps:

1. Select the line associated with the channel to be calibrated in the overview table.
2. Click the "Start manual calibration" button.
3. Now go through the steps in the "Manual calibration" section.
4. Follow the instructions in the "Command" field.
5. Click ""Next".

The required calibration values of the selected channel according to the measuring range configured for this channel are specified once again during the user calibration.

NOTE

The calibration can take place in RUN mode as well as STOP mode of the CPU. If the CPU is in RUN, the calibration value that was last collected prior to the start of the calibration is supplied for the duration of the calibration.

The module channel to be calibrated cannot process any new process values during the user calibration. All analog input values of the module are set to 0x7FFF ("Invalid analog value") until the end of the calibration. When the value status is enabled, the value status of the signal is set to "invalid" for the duration of the calibration.

You must provide a voltage and/or temperature during a user calibration. To do so, use the corresponding external wiring and an external voltage/temperature transducer. The field "Command" includes numbers of pins to which you can connect the calibration stimulus. The first pin number identifies the positive connector, the second pin number the negative connector. The accuracy of the calibration depends on the accuracy of the provided voltage/temperature.

NOTE

To ensure that the module retains the specified measuring accuracy after the user calibration, the provided voltage/temperature must be twice as accurate as specified for the module. Inaccurate voltages or temperature result in a faulty calibration.

The figure below shows an example of channel calibration with "Voltage" measurement, measuring range "+/- 10 V".

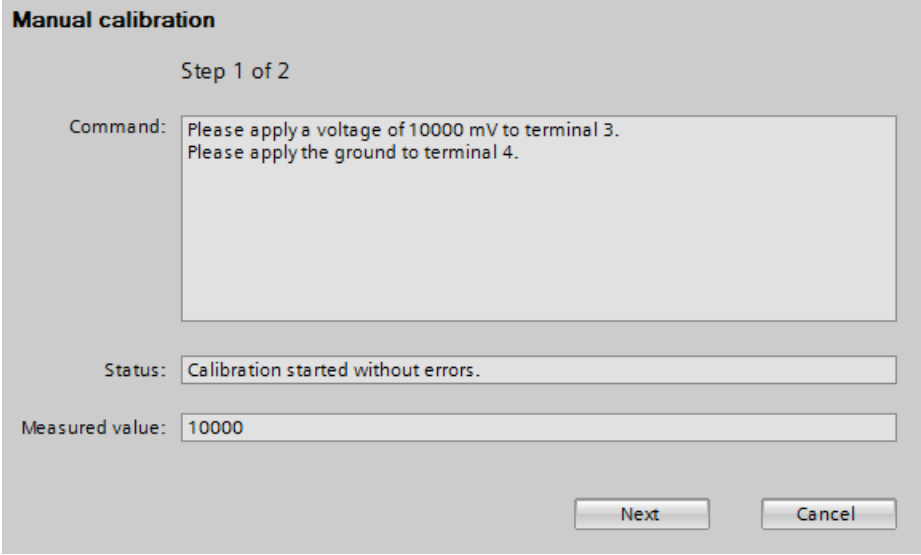

Figure 3-852 Manual calibration

- **Command:** The field "Command" indicates which actions the user has to execute during the current calibration step. Here you execute the specified actions and confirm them with the "Next" button. The module now executes all actions required for the current calibration step. If the calibration step was error-free, the next calibration step takes place. The instructions in the "Command" field are to be performed additively. For example, after you have applied the voltage/ground to the terminals 3/4, these connections must remain in place during the execution of the next calibration step.
- **Status:** Depending on the set type of measurement, several calibration steps are required for calibration of a channel. The field "Status" indicates whether or not the last calibration step included errors. If an error occurs during processing of a calibration step, the error is displayed here and calibration of the channel is aborted. All calibration values recorded up to this point are deleted. The calibration values that were in effect prior to the start of the user calibration are effective once again.

NOTE

Calibrators

If the "Wire break" diagnostics is activated for analog input modules, a test current is applied to the line for the measuring types "Resistance", "Thermistor" and "Thermocouple". This applied test current can result in inaccurate measured values in some calibrators. The wire break monitoring is therefore automatically disabled in some analog modules during the calibration.

To avoid the risk of inaccurate measured values, we recommend you disable the "Wire break" diagnostics during the calibration of analog input modules.

Result

Calibration sets new settings for the channel.

Error occurrence

If an error occurs during the calibration, the module cancels the calibration. All calibration values recorded up to this point are lost. The channel to be calibrated will then have the same settings as before the start of calibration.

7.1.3 Canceling a calibration

Requirement

- You have opened the "Online & Diagnostics" view for the selected analog module from the shortcut menu of the project and you are now in the "Functions > Calibration" area.
- The associated CPU is online.
- A calibration is currently running on the analog module.

Procedure

Click the "Cancel" button to cancel an ongoing calibration.

Result

The active calibration is canceled. The channel to be calibrated will then have the same settings as before the start of calibration.

7.1.4 Resetting analog modules to factory settings

Requirement

- You have opened the "Online & Diagnostics" view for the selected analog module from the shortcut menu of the project and you are now in the "Functions > Calibration" area.
- The associated CPU is online.

Procedure

Proceed as follows to reset the channel of an analog module to factory settings:

1. In the overview table, select the line of the channel to be calibrated.
2. Click the "Set to factory settings" button.

Result

The factory settings of the channel are restored.

NOTE

When you reset the current channel to the factory settings, the original calibration values that were saved in the delivery state of the module become effective once again. Any existing user calibration values of this channel are lost. You cannot restore these user calibration values.

High-speed analog modules 8

8.1 Basics

High-Speed analog modules (HS) are available for users with high demands regarding performance and speed. The main characteristics of these HS analog modules compared to Standard analog modules (ST) is their shorter cycle times. To achieve this goal, the input and output modules are equipped with components with extremely short throughput and conversion times. In addition, the entire architecture of the modules is designed for faster signal processing.

HS analog modules convert the output of measured values and output values at the same time. Each channel within the module has its own A/D or D/A converter. This means the cycle time is basically the conversion time and independent of the number of activated channels. This is true for analog input modules as well as analog output modules. This means HS modules can be used in fast isochronous mode.

Apart from isochronous mode, the HS analog modules also provide benefits in non-isochronous (free-running) mode. Due to the fast processing of the process signals, HS analog modules are able to detect changes in the process values more quickly and to respond to these events with the appropriate program blocks (for example, hardware interrupt or cyclic interrupt organization blocks). Additional information on the various organizational blocks can be found in the STEP 7 online help.

Isochronous mode

Isochronous mode refers to synchronous coupling:

- Of signal acquisition and output via the distributed I/O
- Of signal transmission via PROFIBUS or PROFINET
- Of program processing with the constant bus cycle time of PROFIBUS or PROFINET.

The result is a system that acquires its input signals in constant time intervals, processes them and outputs the output signals. Isochronous mode guarantees reproducible and defined process reaction times as well as equidistant and synchronous signal processing with distributed I/O.

The bus system and the I/O modules work synchronously with configured isochronous mode. The transmitted input and output data are linked to an "isochronous task" in the CPU. As a result, the data of a cycle are always consistent. All data of a process image belong together logically and in time. Jitter in the user program caused by the acquisition of outdated values is therefore almost impossible.

Even fast processes can be perfectly controlled by the exact timing reproducibility of all processes. Isochronous mode thus contributes to high control quality and hence to greater manufacturing precision. While possible fluctuations of the process reaction times are drastically reduced. The time-assured processing can be utilized to improve machine cycle times. Shorter cycle times increase the processing speed and help to lower production costs.

Send clocks

When you configure isochronous mode, the input and output data is synchronized within a send clock (cycle). The data of the input modules is acquired in cycle n and simultaneously transferred to the IM. The data is available in cycle n+1 in the CPU and can be processed. The CPU copies the data to the IM in the next cycle n+2. The output modules then output the data simultaneously in the same send clock. The acquisition – processing – output therefore takes place in three cycles. You can find more information on the configuration of isochronous mode in the STEP 7 online help.

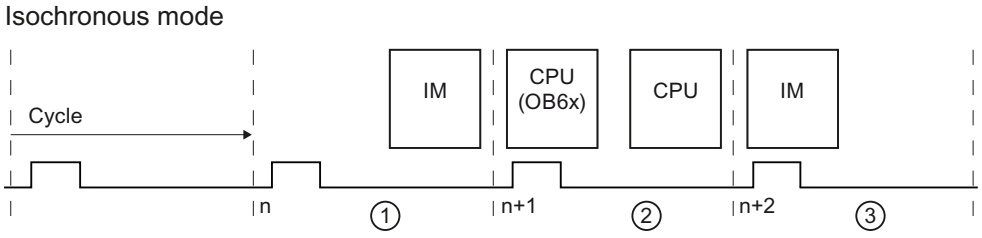

① Measured values of the input modules are acquired and copied to the IM

② Measured values are processed and output values determined

③ Output values are copied to the IM and output by output modules

Figure 3-853 3-cycle model

Oversampling

The use of the oversampling function in analog input or analog output modules requires an isochronous configuration.

With analog input modules, the set send clock is divided into time-equidistant sub-cycles. The send clocks can be subdivided into 2 to 16 sub-cycles. Each sub-cycle reads in a measured value. The read-in measured values of a data cycle are copied to the IM in the next send clock and are then available to the processing CPU one send clock later.

With analog output modules, the set send clock is also divided into time-equidistant sub-cycles. The send clocks can be subdivided into 2 to 16 sub-cycles. Each sub-cycle returns an output value. The output values are copied to the IM by the CPU within the same send clock and are written to the process one send clock later.

The read-in and output values are transmitted in the user data of the analog module. This way, the address space of the module is extended from 2 bytes of user data per channel to 16 x 2 bytes of user data per channel. If you subdivide the send clock into less than 16 sub-cycles, the unused addresses are assigned the error value 0x7FFF during input. For output, the values of the unused addresses are ignored.

Because the sub-cycles have to be within a send clock, oversampling needs an additional send clock to copy the data to the IM, unlike the 3-cycle model of isochronous mode. The result is a 5-cycle model.

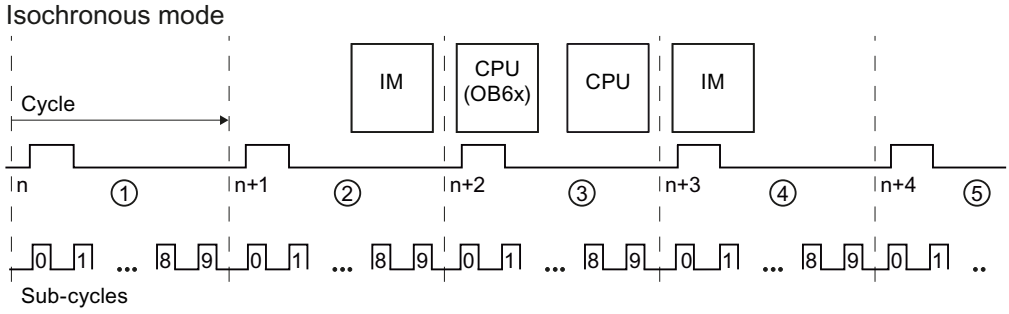

① Send clock is divided into sub-cycles which record the measured value

② Measured values are copied to the IM

③ Measured values are processed and output values determined

④ Output values are copied by the CPU to the IM

⑤ Output values are written to the process

Figure 3-854 5-cycle model

Due to the configured modules, the send clock of an IO device has a minimum possible update time, which means the time interval within which an IO device/IO controller of the PROFINET IO system is supplied with new data. Modules with oversampling functionality, however, offer the option of further reducing the update time for their channels without having to shorten the send clock for the entire S7 station at the same time. The subdivision of the send clock into time-equidistant sub-cycles therefore enables an even faster signal processing speed.

Example

In practice, the use of oversampling makes sense when the isochronous system works with only one specific specific send clock (for example, 1 ms) due to the modules used and when faster sampling of the process values is required. By using oversampling and a subdivision of the send clock into 4 sub-cycles, for example, you can sample the process values in intervals of 250 µs.

Configuring oversampling

Enable the option "Isochronous mode" in the IO device used and set the corresponding parameters ("Send clock", etc.). You define the number of sub-cycles in the relevant distributed analog module with the "Sampling rate" parameter for analog input modules and the "Output rate" parameter for analog output modules. If, for example, you configure a "Sampling rate" of 4 "Values/cycle" for a "Send clock" of 1 ms, the send clock is subdivided into 4 sub-cycles and the process values are sampled in intervals of 250 µs.

Cycle time of an analog input module

If you have configured the system property "Isochronous mode" for HS modules, all analog input modules are synchronized to a shared time within the send clock (cycle) ①. The cycle time is made up of the following time intervals: $t_Z = t_1 + t_2 + t_3 + t_4$

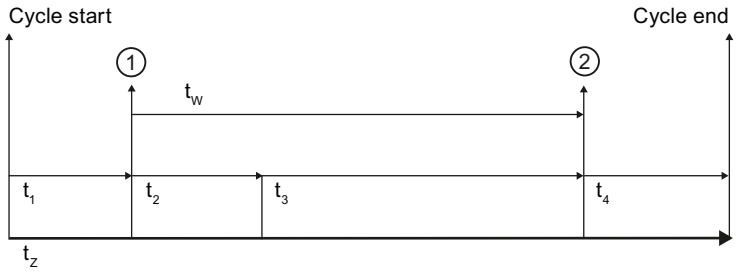

① Synchronization time for all analog input modules in isochronous mode and simultaneously time of the converted input signal at the terminal in this cycle

② Digitalized input signal is transferred to the backplane bus

t_Z Cycle time

t_1 Time between cycle start and synchronization

t_2 Hardware-related runtime up to the analog-digital converter

t_3 Processing time of digitalized input data in the module

t_4 Transfer time of the backplane bus

t_W Conversion time of the module

Figure 3-855 Cycle time of the analog input module

Cycle time of an analog output module

The synchronization time for analog output modules refers to the output of the digital-analog converter ②. Because the impedance of the connected actuator including connection cable is unknown in output modules but has a significant impact on the signal run time, the settling time cannot be added as a fixed value. The respective manuals of the output modules specify the typical load settling times as reference point. But in practice, a measurement with an oscilloscope is required for a precise measurement of the settling time. The settling time may exceed the actual end of the cycle due to very short cycle times and very high capacitive loads. The cycle time is made up of the following time intervals: $t_Z = t_1 + t_2 + t_3$

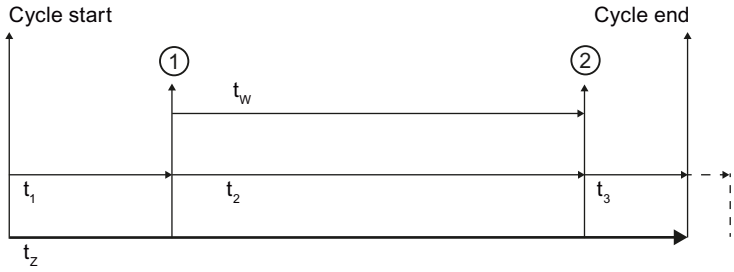

① Output data is available in digital form in the module

② Synchronization time for all analog output modules in isochronous mode and simultaneously output time of data in the digital-analog converter

t_Z Cycle time

t_1 Transfer time of the backplane bus

t_2 Processing time of data in the module until output at digital-analog converter

t_3 Settling time of hardware until setpoint of output value

t_W Conversion time of the module

Figure 3-856 Cycle time of the analog output module

Typical applications

In principle, isochronous mode is worthwhile whenever measured values must be acquired synchronously, movements must be coordinated, and process reactions must be defined and executed at the same time. There are thus numerous areas in which isochronous mode can be used.

Typical applications include, for example, the acquisition of binary signals for quality assurance at specific times and positions. But hydraulic applications with position and pressure control can benefit as well from the equidistant and isochronous data transmission.

The following example shows the use of isochronous mode within the production process of camshafts. Precise measurements must be made at several measuring points for quality assurance.

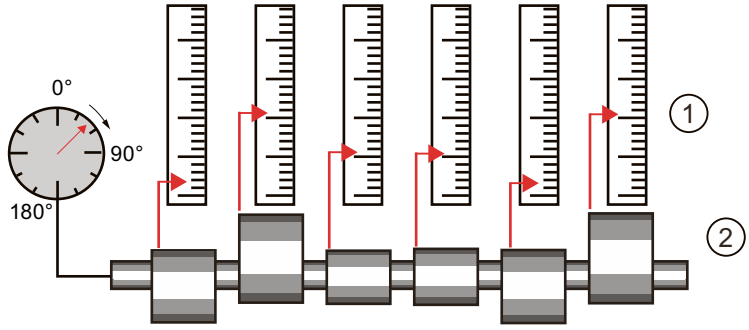

① Measured values
② Camshaft

Figure 3-857 Measuring of camshafts

By using the system property "isochronous mode" and the associated simultaneous measured value acquisition, measurement can be performed continuously. The time required for measurement is reduced. Resultant workflow:

- Continuous machining of the camshaft
- During the continuous turning, measure the positions and cam excursion synchronously
- Process the next cam shaft

All camshaft positions and the corresponding measured values are measured synchronously within a single rotation of the camshaft. This increases machine output and maintains or enhances precision of the measurement.

8.2 ST modules vs HS modules

This section gives you an overview of other important distinctions between standard and high-speed analog modules. The specified numerical values are examples of selected modules. Keep in mind that the information can vary from module to module. The exact information of specific used analog module is available in the corresponding manual.

Conversion method

Instantaneous value conversion

Instantaneous value conversion if often used to convert analog signal into digital information in HS modules. In this type of conversion a very short sample is taken from the measured signal and converted into digital data. This digital information therefore represents an instantaneous value of the measured signal. Instantaneous value conversion is used to acquire fast changes of process values, such as in the area of motion control. The quickly changing physical quantities in this case must be acquired and processed quickly in cooperation with suitable transducers. Input areas are primarily voltage, current and resistance, the latter especially for position potentiometers.

Because the measured signal is converted within a short time, there is a risk of incorrect measurements in case of faulty signals. The analog inputs working with the instantaneous value conversion method cannot detect if the sampled signal value is the target signal or an

overlaying disturbing pulse. They always convert the "instantaneously" detected value. This means the pending measurement task should be carefully examined with regard to time constraints.

Integrating conversion

ST modules usually work according to the integrating conversion principle. The integrating conversion involves the sampling of a measured signal across a specified time period (integration time). Although this method is slower than instantaneous value conversion, it returns a conversion with higher immunity to interference. When you select the time interval for the conversion so that it corresponds to one or several periods of the surrounding network frequency, the omnipresent interference that is possibly also overlaying the signal is basically suppressed. SIMATIC modules give you the option to set the network frequency at which the plant is operated by means of parameter assignment. The resolution and conversion times may change depending on the interference frequency suppression that is set. The technical specifications of the respective module define these dependencies.

Analog inputs with integrating methods can be used universally. Even though the cabling must also be carefully designed with these analog inputs, the requirements are much less than those for analog inputs with instantaneous value conversion due to their slower signal acquisition that is basically immune to interference.

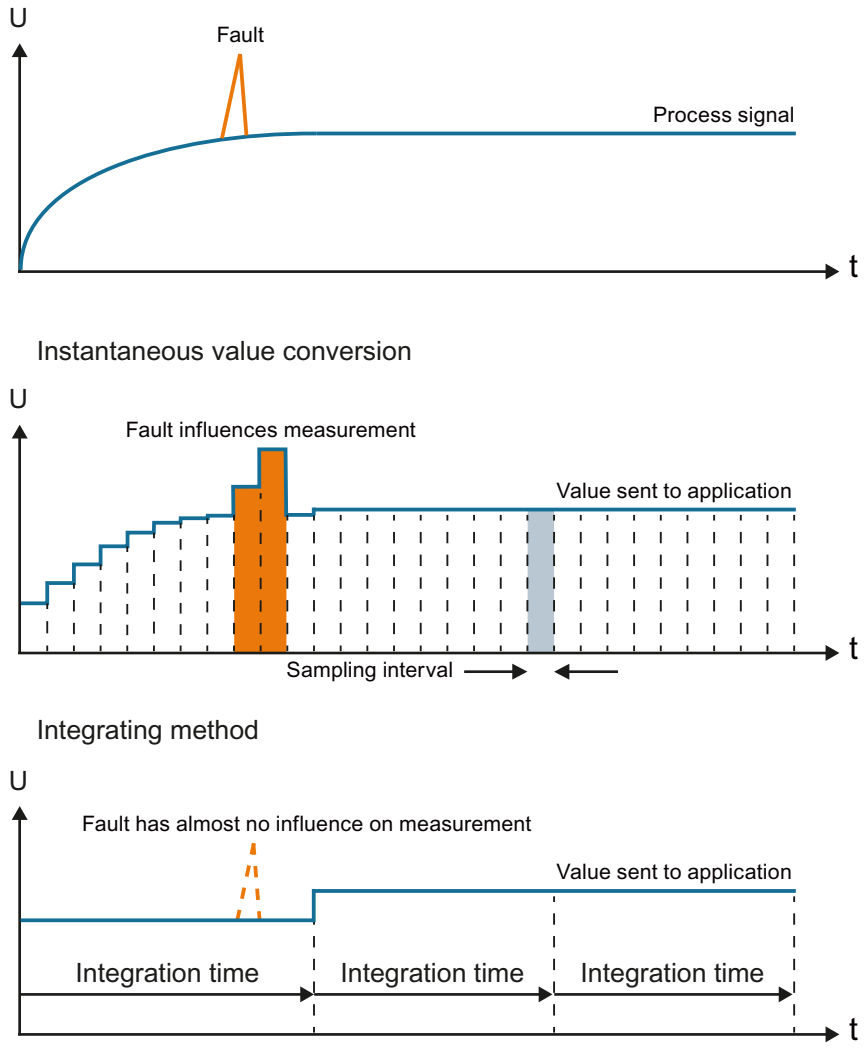

Figure 3-858 While an interference directly influences the value that is supplied to the application with instantaneous value encryption, its influence is negligible for the integrating method.

Electromagnetic compatibility

The entire architecture of HS modules is designed for fast processing of the signals. An interference-free design is therefore critical when using HS modules.

The following rules apply to the wiring of HS modules with sensors and actuators:

- Keep the cables as short as possible
- Use shielded and twisted pair cables
- Low-impedance connection of the cable shield at the respective shield supports
- Short cable loop between shield support and terminal connection

NOTE

Interference-free design

Make sure that you pay close attention to the notes listed in the function manual Configuring interference-free controllers (http://support.automation.siemens.com/WW/view/en/59193566) when using HS modules.

Effect of load on the settling time

The settling times to the setpoint achieved with analog output modules depend on the applied load, among other things. To take advantage of the faster conversion times, only small loads (e.g., max. 47 nF) are permitted in HS modules as specified in the technical specifications.

The type of load has an effect on the form of settling to the setpoint when using output modules. Capacitive loads reduce the rise time due to the charging process and can cause the output signal to overshoot. Inductive loads result in a delayed current increase due to remagnetization and therefore also a shorter rise time. The figure below shows the output signal with no/small ①, medium ② and high ③ capacitive load.

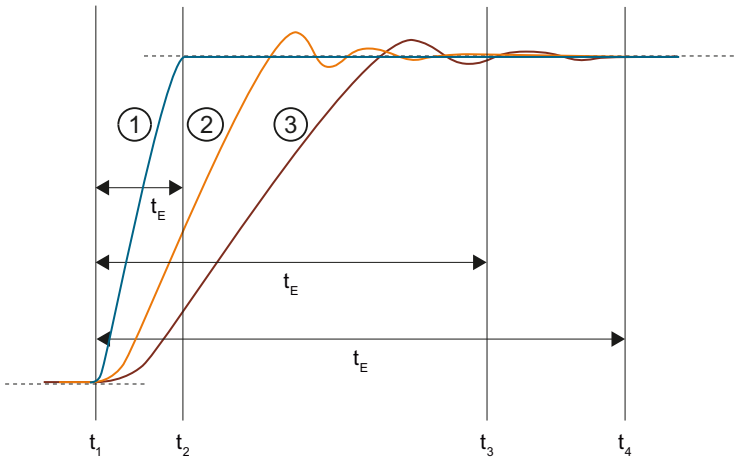

① Reference curve of a signal with no/small load capacity

② Signal with a load capacity of 47 nF

③ Signal with a load capacity of 100 nF

t_E Settling time

t_1 Module ends conversion at the terminal of the analog output channel and outputs the analog signal

t_2 Signal ① has settled and the specified analog output value has been reached (residual error 1 %)

t_3 Signal ② has settled and the specified analog output value has been reached (residual error 1 %)

t_4 Signal ③ has settled and the specified analog output value has been reached (residual error 1 %)

Figure 3-859 Effect of different loads on the settling time

Effect of the cable length on the settling time

Long cables between signal source and module are a target for interferences. You should therefore keep the cables as short as possible especially for HS modules. Cables have a capacitive and inductive component and therefore have an effect on the settling behavior of the signal.

The example below shows the jump of the output voltage of an HS output module with small, medium and long cable length. The overshoot of the input signal increases with the length of the cable and therefore the time until it reaches the setpoint.

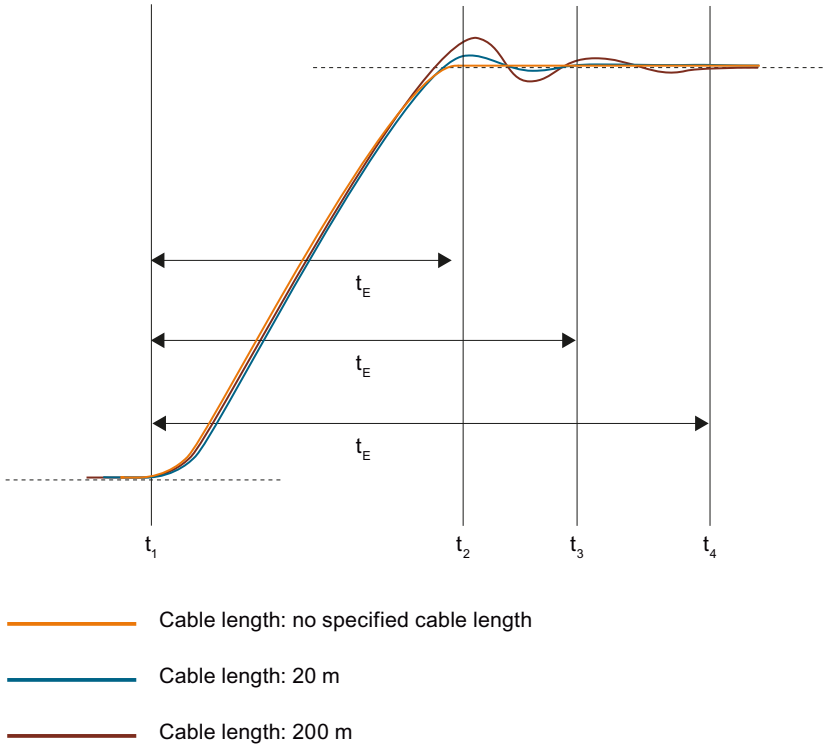

t_E Settling time

t_1 Module ends conversion at the terminal of the analog output channel and outputs the analog signal

t_2 The signal running through a cable with short length has settled and the specified analog output value has been reached (residual error 1 %)

t_3 The signal running through a 20 m cable has settled and the specified analog output value has been reached (residual error 1 %)

t_4 The signal running through a 200 m cable has settled and the specified analog output value has been reached (residual error 1 %)

Figure 3-860 Effect of different cable lengths on the settling time

Effect of the value jump on the settling time

The figure below shows the effect of the height of the value jump between different output values on the settling time for analog output modules. The dotted line indicates the time when the signal has reached the setpoint. The higher the value jump, the later the signal reaches the setpoint.

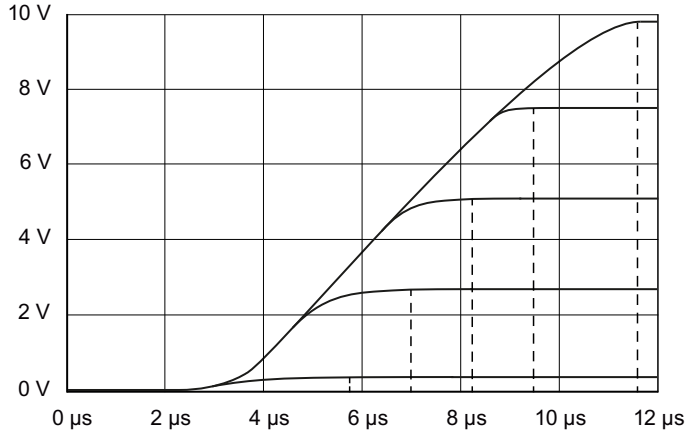

Figure 3-861 Settling time of five different analog signals with different value jumps

SIEMENS

SIMATIC

S7-1500, ET 200MP, ET 200SP, ET 200AL
Designing interference-free controllers

Function Manual

Documentation guide 1

Basic information on electromagnetic compatibility 2

Interference-free cable routing 3

Cable shielding 4

Equipotential bonding 5

Special measures for interference-free operation 6

Lightning protection and overvoltage protection 7

06/2014

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Preface

Purpose of the documentation

This documentation will support you in installing and commissioning programmable controllers.

Correct configuration is essential for fault-free operation of programmable controllers.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge of VDE (German Association for Electrical, Electronic and Information Technologies) and EC regulations
- Knowledge of the rules for installing controllers and switchgear

Conventions

You should also pay particular attention to notes such as the one shown below:

NOTE

A note contains important information on the product described in the documentation, on the handling of the product or on the section of the documentation to which particular attention should be paid.

Scope of the documentation

This documentation is valid for all products of the product series SIMATIC S7-1500, ET 200MP, ET 200SP and ET 200AL.

The product series SIMATIC S7-1500, ET 200MP and ET 200SP are approved for IP20 degree of protection, i.e. the modules of these product series must be installed in a control cabinet.

The SIMATIC ET 200AL product series is approved for IP65/IP67 degree of protection, i.e. the modules need **not** be installed in a control cabinet.

Changes compared to previous version

Changes / enhancements described in this manual, compared to the previous version (version 01/2013):

- Extension of the scope of validity to the distributed I/O system ET 200AL
- Supplement to the section Connection of the cable shielding for ET 200AL
- Components for lightning protection potential equalization amended

Additional support

Additional information on SIMATIC products is available on the Internet. The associated documentation is also available on the Internet.

- The range of technical documentation for the individual SIMATIC products and automation systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).
- The online catalog and the ordering system are available on the Internet (http://mall.automation.siemens.com).

Security information

Siemens provides products and solutions with industrial security functions that support the secure operation of plants, solutions, machines, equipment and/or networks. They are important components in a holistic industrial security concept. With this in mind, Siemens' products and solutions undergo continuous development. Siemens recommends strongly that you regularly check for product updates.

For the secure operation of Siemens products and solutions, it is necessary to take suitable preventive action (e.g. cell protection concept) and integrate each component into a holistic, state-of-the-art industrial security concept. Third-party products that may be in use should also be considered. You can find more information about industrial security on the Internet (http://www.siemens.com/industrialsecurity).

To stay informed about product updates as they occur, sign up for a product-specific newsletter. You can find more information on the Internet (http://support.automation.siemens.com).

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Documentation guide

1

Introduction

The documentation of the SIMATIC products has a modular structure and covers diverse topics concerning your automation system.

The complete documentation for the S7-1500, ET 200SP, ET 200MP and ET 200AL systems consists of the respective system manuals, function manuals and product manuals.

The STEP 7 information system (online help) also supports you when configuring and programming your automation system.

Overview of documentation on the subject of designing interference-free controllers

The following table lists additional documentation which supplements this description of designing interference-free controllers.

Table 3-1092 Documentation on the subject of designing interference-free controllers

Topic	Documentation	Most important contents
System description	System manual S7-1500 Automation System (http://support.automation.siemens.com/WW/view/en/59191792)	• Application planning • Installation • Wiring • Commissioning
	System manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293)	
	System Manual ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214)	
	System manual Distributed I/O System ET 200AL (http://support.automation.siemens.com/WW/view/en/89254965)	

SIMATIC manuals

All current manuals for SIMATIC products are available for download free of charge from the Internet (http://www.siemens.com/automation/service&support).

Basic information on electromagnetic compatibility 2

2.1 Overview of possible interference

Introduction

SIMATIC products and their components have been developed for use in industrial environment and meet the legal EMC requirements (EMC - Electromagnetic Compatibility). However, you still need to conduct an EMC assessment before installing your controller in order to identify possible sources of interference and to include these in your considerations.

Electromagnetic compatibility

Electromagnetic compatibility describes the ability of an electrical device to function properly in its particular electromagnetic environment. Neither the environment itself nor the electrical device are influenced in an unacceptable manner.

Possible interference

Electromagnetic interference can influence an automation system in various ways. The most significant interferences and their causes are as follows:

- Electromagnetic fields having a direct influence on the system
- Interference coupling caused by bus signals (for example, PROFINET)
- Interference influencing the system via the process wiring
- Interference which reaches the system via the power supply and/or protective ground

The figure below shows the likely paths of electromagnetic interference.

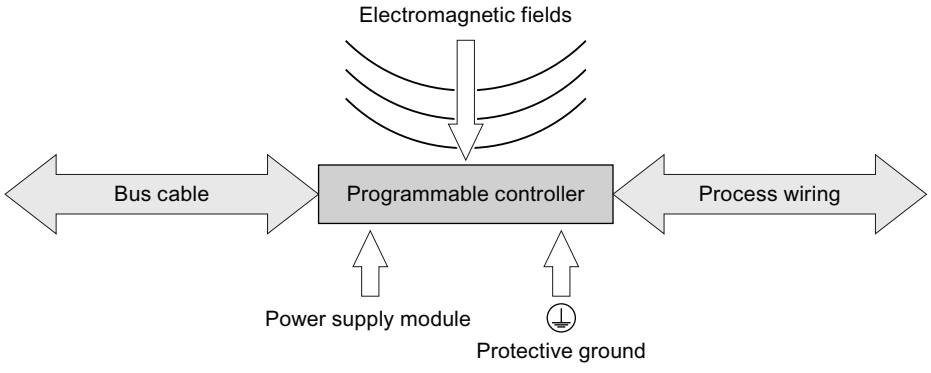

Figure 3-862 Electromagnetic interference

2.2 Coupling mechanisms

Depending on the emitting medium and the distance between the source of interference and the device, interference can reach the automation system via four different coupling mechanisms.

The following table shows possible causes and typical sources of interference for the various coupling mechanisms:

Table 3-1093 Coupling mechanisms

Coupling mechanism	Cause	Typical sources of interference
Galvanic coupling	Two electric circuits share the same cable	• Clocked devices (influence on the network due to converters and third-party power supply units) • Starting motors • Potential differences on component enclosures with shared power supply
Capacitive coupling	Potential difference between conductors	• Interference coupling due to parallel routing of signal cables • Static discharge of the operator
Inductive coupling	Mutual influencing of current-carrying conductor loops. The magnetic fields caused by the current flow induce interference voltages.	• Transformers, motors, electrical welding equipment • Power supply cables routed in parallel • Cables whose currents are switched • High-frequency signal cables • Unwired coils
Radiation coupling	Effect of an electromagnetic wave on a cable configuration. This wave induces currents and voltages.	• Neighboring transmitters (for example, walkie-talkies) • Spark gaps (spark plugs, collectors of electrical motors, welding devices)

Interference-free cable routing 3

This chapter describes the EMC-compatible classification of cables and cable routing for bus, data, signal and supply lines.

3.1 Classifying cables into cable categories

Classify the cables into cable categories according to their sensitivity to interference coupling and interference emission. The further away from one another cables of different cable categories are installed, the lower the mutual influence by capacitive and inductive coupling.

The following table shows the cable categories into which you can classify your cables accordingly.

Table 3-1094 Cable categories

Category A	• Signal lines to I/O modules • Bus and data lines (for example, PROFIBUS, PROFINET) • Lines to HMI devices • Supply lines for extra-low voltages (< 24V DC or < 60V AC)
Category B	• Supply lines with safe electrical isolation (SELV) • Supply voltages < 400 V
Category C	• Supply voltages > 400 V

The following table shows the minimum clearance you must maintain when installing cables.

Table 3-1095 Combination of cable categories

	Category A	Category B	Category C
Category A	• In common bundles or cable channels	• In separate bundles or cable channels (no minimum clearance necessary)	• Inside cabinets in separate bundles or cable channels • Outside cabinets, but inside buildings, on separate cable racks with at least 10 cm clearance
Category B	• In separate bundles or cable channels (no minimum clearance necessary)	• In common bundles or cable channels	
Category C	• Inside cabinets in separate bundles or cable channels • Outside cabinets, but inside buildings, on separate cable racks with at least 10 cm clearance		• In common bundles or cable channels

If you install different cable categories in the same cable channel, use metallic cable channels with metallic partition.

The following figure show a schematic view of a cable channel with partition.

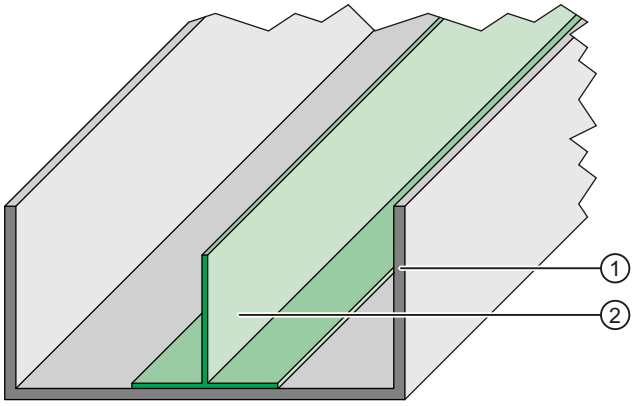

① Metallic cable channel

② Metallic partition

Figure 3-863 Cable channel with partition

3.2 Cable routing inside cabinets in buildings

Rule

Observe the following rules for proper cable routing inside of control cabinets:

- If a crossing of cables is unavoidable, then cross the cables at an angle of 90°, if possible, in order to keep interference from electrical fields as low as possible.
- Do not route cables coming into the cabinet from outside parallel to the shield supports.

3.3 Cable routing outside cabinets and inside buildings

Rule

Observe the following rules for proper cable routing outside control cabinets and inside buildings:

- Read the information in section Assigning cables to cable categories (Page 8).
- If you route the cables in metallic cable channels, you can rearrange the cable channels next to each other.
- Connect metallically conductive cable racks to the potential equalization of the building.
- If a crossing of cables is unavoidable, then cross the cables at an angle of 90°, if possible, in order to keep interference from electrical fields as low as possible.

3.4 Cable routing outside buildings

If possible, lay the cables outside buildings on metallic cable holders. Connect the cable holder joints galvanically to each other and ground the cable holders.

Rule

Observe the following rules when laying cables outside of buildings:

- Use metallic auxiliary terminal boxes to connect cables coming from outside at the junction to cables inside the building. Ground these boxes.
- If a crossing of cables is unavoidable, then cross the cables at an angle of 90°, if possible, in order to keep interference from electrical fields as low as possible.
- Integrate bus cables installed outside of buildings into your lightning and overvoltage concept.

Lightning protection

When you lay cables for SIMATIC devices outside of buildings, you have to take internal and external lightning protection measures.

Reference

For additional information about lightning protection, refer to chapter Lightning protection and overvoltage protection (Page 23).

3.5 Underground cable routing

Rule

Observe the following rules for underground cable routing:

- Lay the cable at least 60 cm below the ground surface.
- Install equipotential bonding approximately 20 cm above the cable. You can use a zinc-plated ground strip, for example. The ground strips also serve as protection against lightning strikes.
- Protect the cable against mechanical damage by, for example, using a plastic pipe and/or a cable warning tape in the ground, approximately 40 cm above the cable.
- Separate the various cable categories in the ground using cable channels, for example.

The following figure shows the arrangement of cable warning tape, equipotential bonding and a cable.

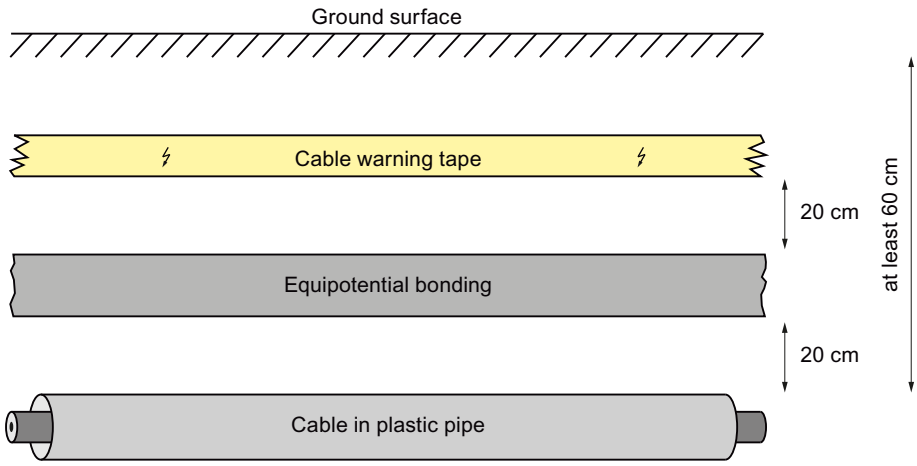

Figure 3-864 Arrangement underground

Lightning protection

When you lay cables for SIMATIC devices outside of buildings, you have to take internal and external lightning protection measures.

Reference

For additional information about lightning protection, refer to chapter Lightning protection and overvoltage protection (Page 23).

3.6 Bending radii and tensile strength of cables

Tensile strain

A high strain on the cables due to tensile forces leads to conductor material flow. The tensile forces thus cause a change in the structure of the material and lower the conductor cross-section. This decrease of the conductor cross-section leads, in turn, to a heating of the conductor and premature wear of the conductor insulation.

Use the supplied cable ties to relieve the terminal points on the plugs for the I/O modules of the product series SIMATIC S7-1500 and SIMATIC ET 200MP.

Bending radius

If you select too small bending radii when laying cables, this will cause the materials to stretch and compress and changes the mechanical structure of the cables. The electrical properties are impaired as a result.

Pay particular attention to the bending radii of fiber-optic cables. If the bending radii are too small, the optical properties of the fiber-optic cable are adversely affected. Reliable transmission is no longer guaranteed.

Cable shielding

4

Shielding is a measure to attenuate (dampen) magnetic, electrical or electromagnetic interference fields.

Interference currents on cable shields are diverted from the shield connection to ground. To avoid interference as a result of these currents, it is imperative to provide a low-impedance connection to the protective conductor.

Rules

Ideally, you should use cables equipped with a protective braided shield. The shield's contacting must be more than 80% at the contact point. Avoid tensile and compression strain on cables with a foil shield. This type of strain can damage the foil shield very slightly at the fastening point. The result is a reduced shielding effect.

Shield connection with grounding at both ends

Always connect the cable shields to the ground at both ends. Low and high frequency interference can be reduced only by connecting both ends of the shield to the ground.

NOTE

Laying an additional equipotential bonding cable

Whenever potential differences develop between the grounding points, an equalizing current flows on a shielding that is connected at both ends. In this case, lay an additional equipotential bonding cable. You can find more information on this topic in the chapter Equipotential bonding (Page 20).

Shield connection with capacitive grounding at one end

If you do not have the option of installing equipotential bonding (in plants covering a large area, for example), connect capacitive grounding to one end of your shield. In this case, only high-frequency interference will be reduced.

The following figure shows the capacitive grounding of a cable shield. The values indicated in the figure are indicative and will differ from system to system. The capacity diverts the high-frequency interference. This capacity provides high-impedance protection for the power frequency (50 or 60 Hz), thus preventing equalizing currents via the shield. A parallel switched high-impedance resistance prevents the capacity from loading a direct current.

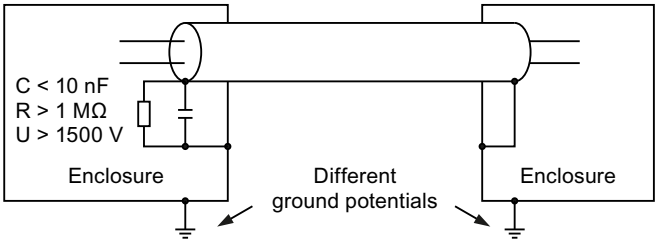

Figure 3-865 Capacitive grounding of the shield

4.1 Connecting the cable shielding for S7-1500 and ET 200MP

A special shield design has been developed for the automation system S7-1500 and the distributed I/O system ET 200MP for the shield connection of the signal lines. The connection element for the cable shield consists of a shield clamp and a shield terminal.

If the front connector is located in the module, the interference currents which occur are diverted by the connection element to the ground via the module and mounting rail.

The shield clamp is a pluggable mount for the analog and technology modules. The shield clamp allows the low-impedance application of cable shields with minimum installation times.

The following figure shows a front connector with mounted shield clamp and associated shield terminal.

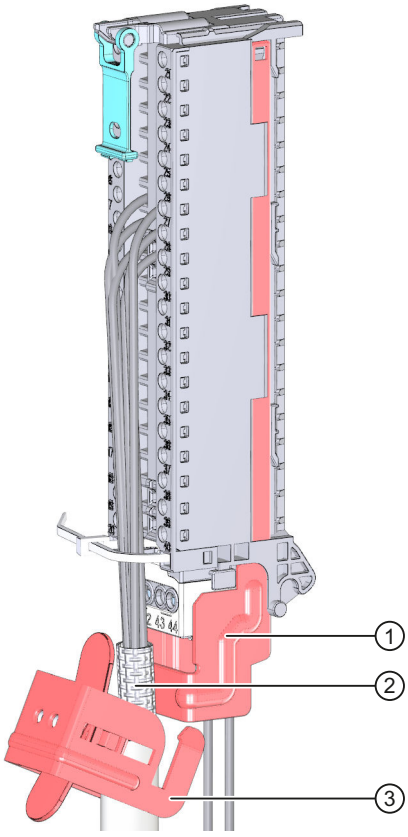

① Shield clamp

② Stripped cable shield

③ Shield terminal

Figure 3-866 Shield clamp and shield terminal on front connector

The shield clamp is inserted from below onto the front connector until the shield clamp latches audibly. The shield terminal is fastened to the shield clamp.

Additional information

For additional information on installing the shield clamp and shield terminal, refer to the "Connecting front connectors" chapter in the S7-1500 automation system (http://support.automation.siemens.com/WW/view/en/59191792) or ET 200MP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/59193214) system manuals.

4.2 Connecting the cable shielding for ET 200SP

A special shield design has been developed for the shield connection of the signal lines of the ET 200SP distributed I/O system. The connection element for the cable shield consists of a shield terminal.

If the front connector is located in the module, the interference currents that occur are diverted by the connection element via BaseUnit and mounting rail to the ground.

The shield terminal is plugged into a mount of the BaseUnit. The shield terminal allows the low-impedance application of cable shields with minimum installation times. There is no need for the otherwise standard connection of the cable shield at the cabinet entry.

The following figure shows a BaseUnit with shield terminal and shield support.

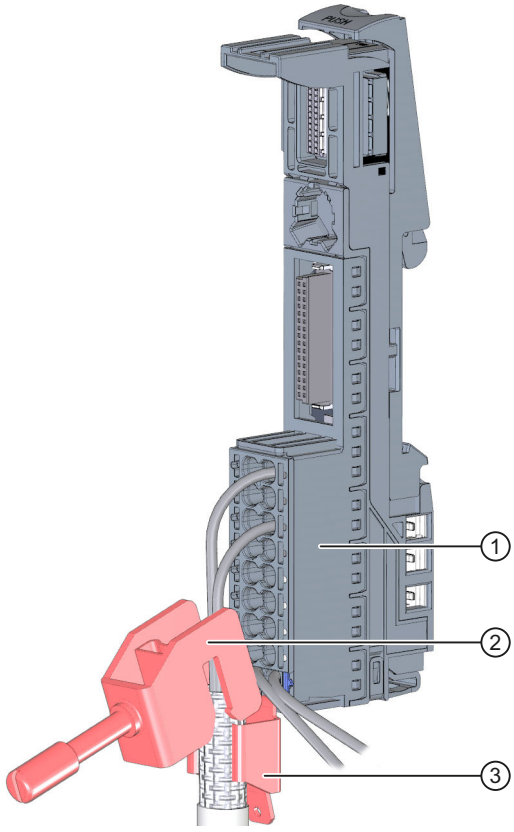

① BaseUnit of ET 200SP

② Shield terminal

③ Shield support with flat plug for terminal sockets

Figure 3-867 BaseUnit with shield terminal

Additional information

For more information on mounting the shield terminal, refer to the "Connecting cable shields" chapter of the system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293).

4.3 Connecting the cable shielding for ET 200AL

Each module of the ET 200AL distributed I/O system features a functional ground connection.

Use only shielded cables for connection of analog signals, PROFINET and PROFIBUS signals and for the ET-Connection. If you have screwed the plug in correctly, the interference currents that occur are diverted to the metal parts and functional ground.

If you attach an ET 200AL module to a **conductive**, grounded base, the lower mounting bolt establishes a conductive connection to the earth potential.

If you attach an ET 200AL module to a **non-conductive** base, connect the lower mounting bolt to the ground wire at the same time.

The following figure shows how to connect the functional ground via a ground wire, using the IM 157-1 PN interface module as an example.

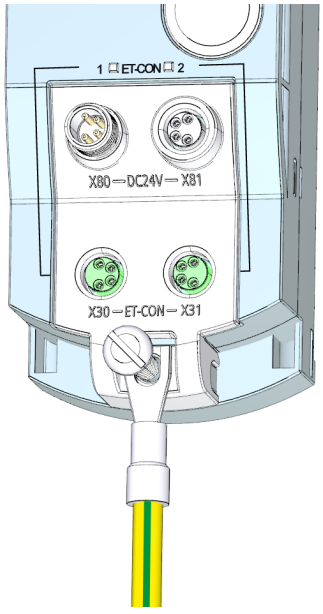

Figure 3-868 Connect functional ground via a ground wire

Additional information

You can find more information on installing ET 200AL modules in the Installing Modules section of the system manual Distributed I/O System ET 200AL (http://support.automation.siemens.com/WW/view/en/89254965).

4.4 Connecting the cable shield for bus cables

In the S7-1500, ET 200MP and ET 200SP systems, the cable shields of PROFIBUS and PROFINET cables are connected to the existing bus connection elements. Cable shield and shield support are thus galvanically connected to each other. If the connector is plugged into the module, the coupled interferences are diverted via the module carrier to the ground. There is no need for the otherwise standard connection of the shield at the cabinet entry.

The following figure shows examples of the shield connection for various bus connection elements.

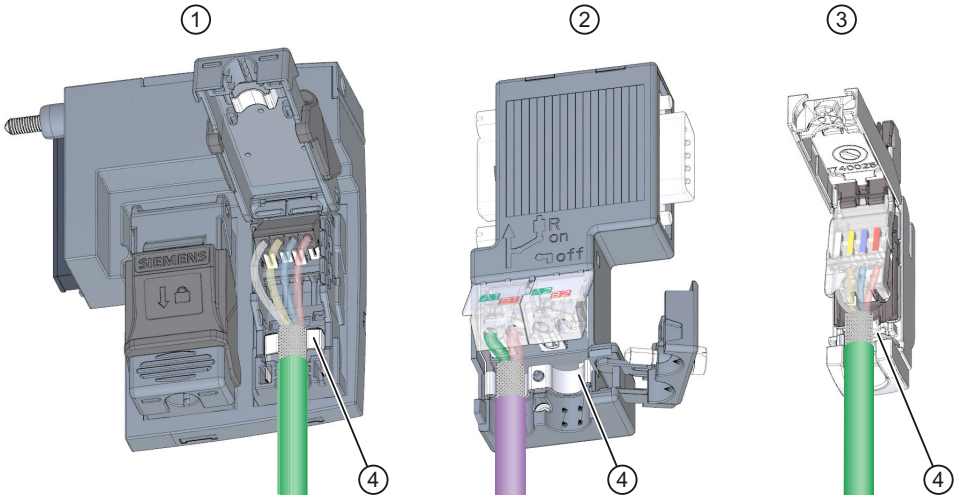

① BusAdapter BA 2xRJ45 for ET 200SP

② PROFIBUSconnector, 9-pin D-Sub

③ PROFINETconnector RJ45

④ Shield support of respective connector

Figure 3-869 Shield connection for bus connection elements

Reference

For more information on installing the connectors, refer to the "Connecting PROFINET IO BusAdapter BA 2xRJ45 to the interface module" chapter of the system manual ET 200SP Distributed I/O System (http://support.automation.siemens.com/WW/view/en/58649293) and to the supplied product information.

4.5 Connecting the cable shield for other components

The following procedures for connecting the shield to devices that do not have any special shield terminals have proven themselves in practice.

Rule

Note the following points when handling the shield:

- Always use metal clamps to mount the protective braided shields of the cables. The clamps must cover a large area of the shield and provide appropriate contact force.
- Attach the shield to a shielding bus directly after the point where the cable enters the cabinet. If you route the shield further to the module, do not connect the shield again in front of the module, as this would create ground loops.

The following figure shows standard types of shield fastening.

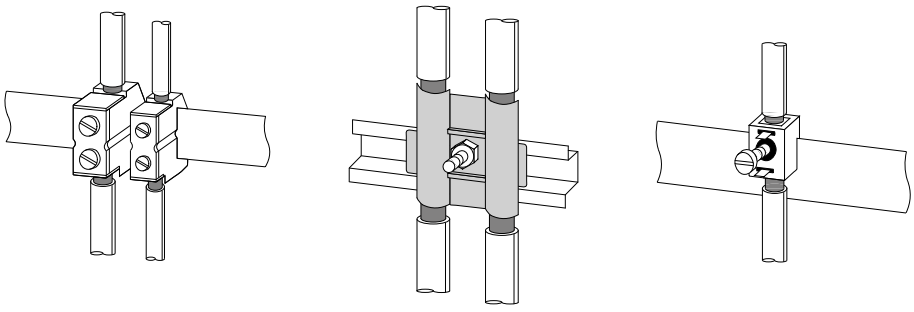

Figure 3-870 Cable shielding

Equipotential bonding

5

Definition according to DIN VDE 0100

Equipotential bonding is an electrical connection which brings the bodies of electrical equipment and external conductive parts to the same, or nearly the same, potential.

Equipotential bonding is divided into:

- Main equipotential bonding
- Additional local equipotential bonding

Both versions of equipotential bonding are of great importance not only for protection against electric shock, but also for EMC.

Main equipotential bonding

Main equipotential bonding is required by DIN VDE 0100 Part 410 as a protective measure and is mandatory, regardless of other measures for protection against direct and indirect contact.

Additional local equipotential bonding

Additional local equipotential bonding is required if:

- Unfavorable grounding conditions exist between plant parts due to different conductivity of the soil (for example, sandy or stony ground)
- Cables bridge a large distance
- Electrical energy is fed in from various power supplies (for example, in the case of multiple substations)
- Considerable electrical power is used (for example, welding robots, large drives)

Measures

In such cases, an additional equipotential bonding cable between the individual potentials can solve the problem. The equipotential bonding cable must also be able to divert large currents and carry lightning stroke current. The following equipotential bonding systems have proven themselves in practice:

- 16 mm^2 for copper equipotential bonding cables up to 200 m long
- 25 mm^2 for copper equipotential bonding cables over 200 m long

To prevent ground loops, equipotential bonding cables are installed in parallel and, whenever possible, near to the signal/bus cable. This allows the area between the two cables to be kept as small as possible.

The following figure shows a schematic view of the installation of an equipotential bonding cable.

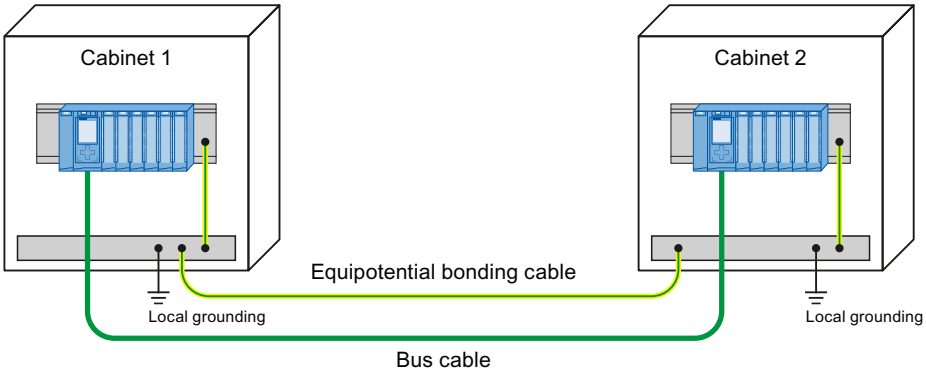

Figure 3-871 Installation of equipotential bonding cables

Rule

Note the following issues regarding equipotential bonding:

- The lower the impedance of an equipotential bonding cable, the more effective is equipotential bonding. The impedance of the additionally installed equipotential bonding cable should not exceed 10% of the shield impedance.
- Connect the equipotential bonding cables to a large area of the grounding system.
- Protect the connection points against corrosion.
- Avoid ground loops.
- Install the equipotential bonding cables in such a way as to minimize the areas enclosed between the equipotential bonding cables and signal lines.

Special measures for interference-free operation 6

Connecting inductances to quenching elements

Ideally, the inductances (for example, contactor or relay coils) controlled by SIMATIC do not require any wiring to external quenching elements. The required quenching elements are already integrated into the modules.

If the SIMATIC output circuit can also be switched off by built-in contacts (such as relay contacts for EMERGENCY OFF), the module's integrated quenching elements are no longer effective. In this case, the inductances must be wired to quenching elements.

Wire inductances to freewheeling diodes, varistors or RC elements, for example.

Table 3-1096 Wiring inductances

Wiring DC-operated inductances		Wiring AC-operated inductances	
with diode	with Z diode	with varistor	with RC element
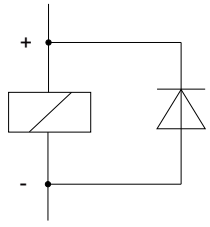	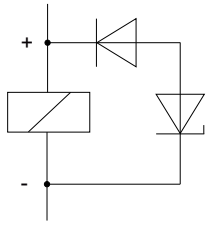	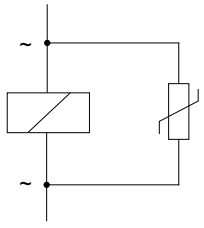	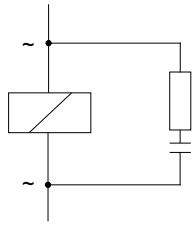

Programming devices

Provide a socket in each cabinet for the supply of the programming devices. The sockets are supplied from the distribution board to which the protective conductor for the cabinet is also connected.

Observe the following points during the installation of the socket in the control cabinet:

- Include the grounding of the socket in your consideration of the equipotential bonding.
- The common star point of the two ground potentials (cabinet and socket) must be close to the two end points.
- An equipotential bonding cable is not permitted as communication cable between programming device and controller.

Lightning protection and overvoltage protection 7

7.1 What is lightning and overvoltage protection?

Introduction

The term "Lightning and overvoltage protection" covers both the concept and system for the protection of structural systems (such as buildings or electrical equipment). This concept also includes the protection of people and animals.

Overvoltages are most frequently caused by lightning strikes.

Lightning protection system

The lightning protection system is the complete system used to reduce physical damage to a structural system as a result of direct lightning strikes and overvoltages. The lightning protection system is divided into external and internal lightning protection.

External lightning protection

External lightning protection is part of the lightning protection system and comprises an interception device, an arrester and a grounding system. In the event of a lightning strike, the external lightning protection serves to divert the lightning current safely to the ground. This measure most frequently prevents fire damage.

Internal lightning protection

Internal lightning protection is part of the lightning protection system and comprises lightning protection equipotential bonding and/or electrical isolation with respect to the external lightning protection. In the event of a lightning strike, the internal lightning protection reduces the damage caused by overvoltages resulting from the lightning.

Even at larger distances of up to 1.5 km, lightning strikes can sometimes still cause damage. You obtain effective lightning protection by expanding the external lightning protection into an overall protection system. This system includes equipotential bonding and surge protection devices.

7.2 Lightning protection zone concept

Introduction

Each building requires a coordinated protection zone concept. The grading of the protection is of key importance for this. Sufficient protection can only be guaranteed if this grading requirement is satisfied.

The lightning protection zone concept described in the standards IEC 62305-4 and DIN EN 62305-4 is used for this purpose. The lightning protection zone concept groups devices and areas that have the same risk potential and can be wired to arresters of the same type.

Use overvoltage protection devices at the transitions of the lightning protection zones based on the requirements. Install the overvoltage protection devices at an appropriate location such as the main or sub-distribution board.

Principle of the lightning protection zone concept

The principle behind the lightning protection zone concept is the division of the areas to be protected from overvoltages, for example buildings, into lightning protection zones based on EMC considerations.

Schematic diagram of the lightning protection zone concept

The following is a schematic diagram of the lightning protection zone concept in a physical structure.

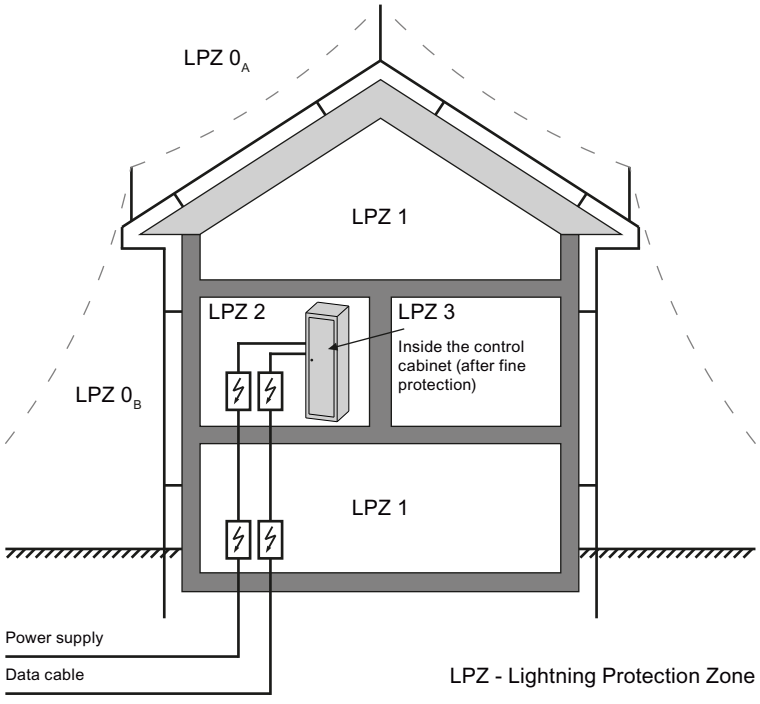

Figure 3-872 Division of a structural system into lightning protection zones

Division of lightning protection zones

The various lightning protection zones (LPZ - Lightning Protection Zone) are limited spatially as follows and not necessarily by physical boundaries, such as walls or floors.

The following table explains the division into various lightning protection zones.

Table 3-1097 External and internal lightning protection zones

Lightning protection zones	
External lightning protection zones:	
LPZ 0_A	• Risk from direct lightning strikes • Risk from the full electromagnetic field of the lightning
LPZ 0_B	• Protected against direct lightning strike • Risk from the full electromagnetic field of the lightning
Internal lightning protection zones:	
LPZ 1	• Protected against direct lightning strike • Attenuated electromagnetic field of the lightning
LPZ 2	• Protected against direct lightning strike • Reduced leakage currents and electromagnetic fields compared to LPZ 1 • Protected terminal devices
LPZ 3	• Protected against direct lightning strike • Protected area inside the terminal device • Local equipotential bonding

Effects of the lightning strike

Direct lightning strikes occur in the lightning protection zone LPZ 0_A. Effects of the lightning strike are high-energy lightning currents and strong electromagnetic fields. These effects are reduced from one lightning protection zone to the next through suitable lightning current or overvoltage arrester/shielding measures.

Frequent damage caused by lightning strikes includes:

- Injury to people and animals, which may in worst cases lead to death
- Damage to buildings
- Fire caused by strong heat development of a lightning strike

Overvoltages

Electromagnetic fields of the lightning channel can be reduced with appropriate shielding measures. Overvoltages due to inductions can be reduced to a safe level starting in lightning protection zone LPZ 0_B with overvoltage arresters.

7.3 Rules and components for the transitions between lightning protection zones

Introduction

This chapter provides you with information on the rules for transitions between lightning protection zones. Measures must be taken to reduce the surge current load and the magnetic fields at the transitions between the lightning protection zones.

Each zone-penetrating metallic/electrical system is incorporated into the equipotential bonding at the zone transition.

The metallic systems include channels, structural parts, and pipes (for water, gas, and heat, for example).

Electrical systems include power and IT cables and wires (for example, power cables and bus cables).

Transitions between lightning protection zones

Overvoltage protection must be provided at the transitions between lightning protection zones (LPZ - Lightning Protection Zone) in accordance with DIN EN 62305. The protection levels are defined at the transitions and implemented by means of overvoltage protection devices (SPD - Surge Protective Device).

- SPD Type 1 - Coarse protection for the transition from LPZ 0 to LPZ 1
- SPD Type 2 - Medium protection for the transition from LPZ 1 to LPZ 2
- SPD Type 3 - Fine protection for the transition from LPZ 2 to LPZ 3

The following figure illustrates the lightning protection zones and the type classes from the supply line to the consumer.

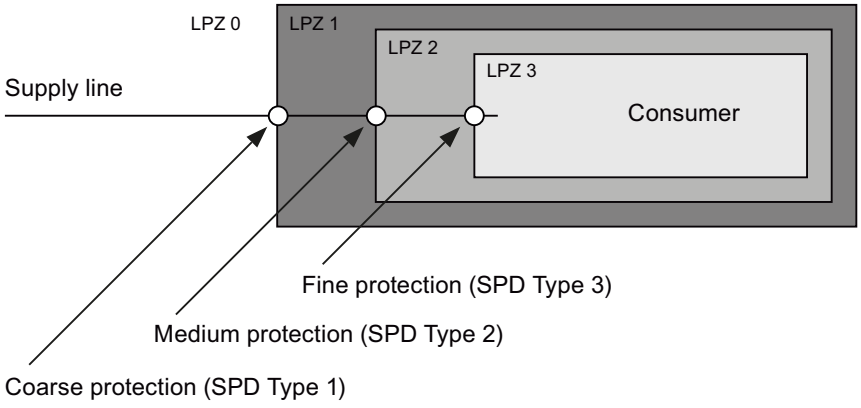

Figure 3-873 Lightning protection zone transitions

Rule for transition from lightning protection zone 0_A to 1

Lightning protection equipotential bonding is required at the transition from lightning protection zone 0_A to 1. The following applies to the transition at the interface of lightning protection zone 0_A to 1:

- Use of lightning arresters prevents introduction of partial lightning currents into structural systems
- Creation of local equipotential bonding at the transition of lightning protection zones, with incorporation of metallic supply systems (for example, pipes, air ducts, cable channels or cable ducts)

Components for lightning protection equipotential bonding from lightning protection zone 0_A to 1

The following table shows components for lightning protection equipotential bonding from lightning protection zone 0_A to 1.

Table 3-1098 Components for transition from lightning protection zone 0_A to 1

Seq. no.	Cables for ...	Connection at the 0_A interface to 1 with:	
		S7-1500/ET 200MP/ET 200SP/ET 200AL	**Article number**
1	Three-phase TN-C system	DEHNventil® DV M TNC 255	951 300
		DEHNventil® DV M TNC 255 FM *	951 305 *
2	Three-phase TN-S system	DEHNventil® DV M TNS 255	951 400
		DEHNventil® DV M TNS 255 FM *	951 405 *
3	Three-phase TT system	DEHNventil® DV M TT 255	951 310
		DEHNventil® DV M TT 255 FM *	951 315 *
4	AC TN-S system	DEHNventil® DV M TN 255	951 200
		DEHNventil® DV M TN 255 FM *	951 205 *
5	AC TT system	DEHNventil® DV M TT 2P 255	951 110
		DEHNventil® DV M TT 2P 255 FM *	951 115 *
6	Supply U_N = 24 V DC	BLITZDUCTOR® XT, base section BXT BAS	920 300
		BLITZDUCTOR® XT, module BXT ML2 B 180 (I_L = 1.2 A) (2-wire)	920 211
7	Supply U_N = 24 V DC	DEHNbloc® M, DB M 1 150	961 110
		DEHNbloc® M, DB M 1 150 FM * (2 pieces required)	961 115 *
8	Bus cable MPI RS 485, RS 232 (V.24)	BLITZDUCTOR® XT, base section BXT BAS	920 300
		BLITZDUCTOR® XT, module BXT ML2 B 180 (2-wire)	920 211
9	Inputs/outputs of digital modules U_N = 24 V DC	BLITZDUCTOR® XT, base section BXT BAS	920 300
		BLITZDUCTOR® XT, module BXT ML4 B 180 (I_L = 1.2 A) (4-wire)	920 310
10	Inputs/outputs of	DEHNbloc® M, DB M 1 255	961 120

Seq. no.	Cables for ...	Connection at the 0_A interface to 1 with:	
		S7-1500/ET 200MP/ET 200SP/ET 200AL	**Article number**
10	digital modules U_N = 230 V AC	DEHNbloc® M, DB M 1 255 * (2 pieces required)	961 125 *
11	Inputs/outputs of analog modules (e.g., 4-20 mA, 1-10 V)	BLITZDUCTOR® XT, base section BXT BAS	920 300
		BLITZDUCTOR® XT, module (I_L = 1.2 A) (4-wire)	920 310
* Version with remote indication contact Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (http://www.dehn.de) **Components can be ordered directly from:** DEHN+SÖHNE GMBH+CO.KG. Hans-Dehn-Straße 1 D-92318 Neumarkt			

Rule for the transition from lightning protection zone 0_B to 1, 1 to 2, or 2 to 3

The transition from lightning protection zone 0_B to 1, 1 to 2, or 2 to 3 prevents strong electromagnetic coupling and serves as overvoltage protection. The following applies to the transition at the interface from lightning protection zone 0_B to 1, 1 to 2, or 2 to 3:

- Use of power cables with surge current-carrying cable shields or twisted-pair IT cables
- Laying cables and lines
  - In continuous, surge current-carrying metal pipes that are grounded at both ends
  - In reinforced concrete channels capable of carrying surge current with grounding at both ends
  - On closed metal cable racks that are grounded at the beginning and end
- Use of fiber-optic cables without a metal shield if such a transmission is intended
- Creation of local equipotential bonding at the transition of lightning protection zones, with incorporation of metallic supply systems (for example, pipes, air ducts, cable channels or cable ducts)

Additional measures

If the actions listed above cannot be implemented, protection by means of overvoltage arresters must be provided. The following sections contain tables with overvoltage arresters that are very suitable for protecting the plant.

Components for lightning protection equipotential bonding from lightning protection zone 0_B to 1 and 1 to 2

The following table shows components for lightning protection equipotential bonding from lightning protection zone 0_B to 1 and 1 to 2.

Table 3-1099 Components for transition from lightning protection zone 0_B to 1 and 1 to 2

Seq. no.	Cables for ...	Connection at the 0_B interface to 1 with:	
		S7-1500/ET 200MP/ET 200SP/ET 200AL	**Article number**
1	Three-phase TN-C system	DEHNguard® DG M TNC 275	952 300
		DEHNguard® DG M TNC 275 FM *	952 305 *
2	Three-phase TN-S system	DEHNguard® DG M TNS 275	952 400
		DEHNguard® DG M TNS 275 FM *	952 405 *
3	Three-phase TT system	DEHNguard® DG M TT 275	952 310
		DEHNguard® DG M TT 275 FM *	952 315 *
4	AC TN-S system	DEHNguard® DG M TN 275	952 200
		DEHNguard® DG M TN 275 FM *	952 205 *
5	AC TT system	DEHNguard® DG M TT 2P 275	952 110
		DEHNguard® DG M TT 2P 275 FM *	952 115 *
6	Supply U_N = 24 V DC	BLITZDUCTOR® VT, BVT AVD 24	918422
7	Bus cable MPI/DP RS 485	BLITZDUCTOR® XT, base section BXT BAS	920 300
		BLITZDUCTOR® XT, module BXT ML2 BD HFS 5	920 271
8	Bus cable RS 232 (V.24)	BLITZDUCTOR® XT, base section BXT BAS	920 300
		BLITZDUCTOR® XT, module BXT ML2 BE S 12	920 222
9	Industrial Ethernet	DEHNpatch® DPA M CLE RJ45B 48	929 121
10	Inputs of digital modules U_N = 24 V DC	DEHNconnect® RK, DCO RK E 60 (I_L = 0.5 A)	919 990
11	Outputs of digital modules U_N = 24 V DC	DEHNconnect® RK, DCO RK D 5 24 (I_L = 10.0 A)	919 986
12	Inputs/outputs of digital modules U_N = 230 V AC	DEHNguard® DG S 275	952 070
		DEHNguard® DG S 275 FM *	952 090 *
		N-PE arrester in the TT system	
		DEHNgap® C S, DGP C S	952 030
		DEHNgap® C S, DGP C S FM *	952 035 *
13	Inputs/outputs of analog modules (e.g., 4-20 mA, 1-10 V)	DEHNconnect® RK, DCO RK E 60 (I_L = 0.5 A)	919 990
14	Inputs/outputs of the fail-safe modules (24 V DC)	DEHNconnect® RK, DCO RK D 5 24	919 986

Seq. no.	Cables for ...	Connection at the 0_B interface to 1 with:	
		S7-1500/ET 200MP/ET 200SP/ET 200AL	**Article number**

* Version with remote indication contact
Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (http://www.dehn.de)
Components can be ordered directly from:
DEHN+SÖHNE GMBH+CO.KG.
Hans-Dehn-Straße 1
D-92318 Neumarkt

Components for lightning protection equipotential bonding from lightning protection zone 2 to 3

The following table shows components for lightning protection equipotential bonding from lightning protection zone 2 to 3 that you can use for S7-1500/ET 200MP and ET 200SP.

Table 3-1100 Components for transition from lightning protection zone 2 to 3 (for S7-1500/ET 200MP and ET 200SP)

Seq. no.	Cables for ...	Connection at the interface 2 to 3 with:			
		S7-1500/ET 200MP	**Article number**	**ET 200SP**	**Article number**
1	Three-phase TN-S, TT system	DEHNrail® DR M 4P 255	953 400	DEHNguard® DG M TNS 275	952 400
				DEHNguard® DG MOD 275	952 010
		DEHNrail® DR M 4P 255 FM * (I_L = 25.0 A)	953 405 *	DEHNguard® DG M TT 275	952 310
				DEHNguard® DG MOD 275	952 010
				DEHNguard® DG MOD NPE	952 050
2	AC TN-S, TT system	DEHNrail® DR M 2P 255	953 200	DEHNguard® DG M TN 275	952 200
				DEHNguard® DG MOD 275	952 010
		DEHNrail® DR M 2P 255 FM * (I_L = 25.0 A)	953 205 *	DEHNguard® DG M TT 2P 275	952 110
				DEHNguard® DG MOD 275	952 010
				DEHNguard® DG MOD NPE	952 050
3	Supply U_N = 24 V DC	BLITZDUCTOR® VT, BVT AVD 24	918 422	BLITZDUCTOR® VT, BVT AVD 24 ® VT	918 422
4	Bus cable MPI/DP RS 485	BLITZDUCTOR® XT, base section BXT BAS	920 300	---	---
		BLITZDUCTOR® XT, module BXT ML2 BD HFS 5	920 271	---	---

Seq. no.	Cables for ...	Connection at the interface 2 to 3 with:			
		S7-1500/ET 200MP	**Article number**	**ET 200SP**	**Article number**
5	Bus cable RS 232 (V.24)	BLITZDUCTOR® XT, base section BXT BAS	920 300	---	---
		BLITZDUCTOR® XT, module BXT ML2 BE S 12	920 222	---	---
6	Industrial Ethernet	DEHNpatch® DPA M CLE RJ45B 48	929 121	---	---
7	Inputs of digital modules U_N = 24 V DC	DEHNconnect® RK, DCO RK E60 (I_L = 0.5 A)	919 990	BLITZDUCTOR® XT, BXT ML4 BD 24 (I_L < 1 A)	920 344
				BLITZDUCTOR® XT, base section BXT BAS (I_L < 1 A)	920 300
8	Outputs of digital modules U_N = 24 V DC	DEHNconnect® RK, DCO RK D 5 24 (I_L = 10.0 A)	919 986	BLITZDUCTOR® XT, BXT ML4 BD 24 (I_L < 1 A)	920 344
				BLITZDUCTOR® XT, base section BXT BAS (I_L < 1 A)	920 300
				DEHNconnect® SD2, DCO SD2 E 48 (I_L < 10 A)	917 989
9	Inputs/outputs of digital modules U_N = 230 V AC	DEHNguard® DG S 275	952 070	DEHNguard® DG S 275	952 070
				DEHNguard® DG MOD 275	952 010
		DEHNguard® DG S 275 FM *	952 090 *	---	---
		N-PE arrester in the TT system			
		DEHNgap® C S, DGP C S	952 030	---	---
		DEHNgap® C S, DGP C S FM *	952 035 *	---	---
10	Inputs/outputs of analog modules (e.g., 4-20 mA, 1-10 V)	DEHNconnect® RK, DCO RK E 60 (I_L = 0.5 A)	919 990	BLITZDUCTOR® XT, BXT ML4 BD 24 (I_L < 1 A)	920 344
				BLITZDUCTOR® XT, base section BXT BAS (I_L < 1 A)	920 300
11	Inputs/outputs of the fail-safe modules (24 V DC)	---	---	DEHNconnect® RK, DCO RK D 5 24	919 986
				DEHNconnect® RK, DCO RK E 60	919 990

* Version with remote indication contact
Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (http://www.dehn.de)
Components can be ordered directly from:
DEHN+SÖHNE GMBH+CO.KG.

Seq. no.	Cables for ...	Connection at the interface 2 to 3 with:			
		S7-1500/ET 200MP	Article number	ET 200SP	Article number
Hans-Dehn-Straße 1 D-92318 Neumarkt					

The following table shows components for lightning protection equipotential bonding from lightning protection zone 2 to 3 that you can use for ET 200AL.

Table 3-1101 Components for transition from lightning protection zone 2 to 3 (for ET 200AL)

Seq. no.	Cables for ...	Connection at the interface 2 to 3 with:	
		ET 200AL	Article number
1	Supply U_N = 24 V DC	BLITZDUCTOR® VT, BVT AVD 24 ® VT	918 422
Components of the series BLITZDUCTOR® XT can be remotely monitored with the appropriate accessories. Additional information is available on the Internet (http://www.dehn.de) **Components can be ordered directly from:** DEHN+SÖHNE GMBH+CO.KG. Hans-Dehn-Straße 1 D-92318 Neumarkt			

SIEMENS

SIMATIC

S7-1500
S7-1500/S7-1500T Motion Control
Overview V10.0 as of STEP 7 V21

Function Manual

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S7-1500/S7-1500T Motion Control

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Introduction 1

Purpose of the documentation

This documentation provides important information that you need to configure and commission the integrated Motion Control functionality of the S7-1500 Automation systems.

Required basic knowledge

In order to understand this documentation, the following knowledge is required:

- General knowledge in the field of automation
- General knowledge in the field of drive engineering and motion control

Validity of the documentation

This documentation is valid for the S7-1500 product range.

Conventions

- The path specifications in the project tree assume that the "Technology objects" folder is open in the subtree of the CPU. The "Technology object" placeholder represents the name of the technology object.

  Example: "Technology object > Configuration > Basic parameters".
- The <TO> placeholder represents the name set in tags for the respective technology object.

  Example: <TO>.Actor.Type
- This documentation contains pictures of the devices described. The pictures may differ in minor details from the devices supplied.

You should also observe the notes that are marked as follows:

NOTE

A note contains important information about the product described in the documentation, about the handling of the product, and about sections in this documentation demanding your particular attention.

Industry Mall

The Industry Mall is the catalog and ordering system of Siemens Aktiengesellschaft for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

1.1 S7-1500 Motion Control Documentation Guide

Product information

Please also note the supplementary information on the Motion Control documentation:

- Product information on the S7-1500/1500T Motion Control documentation
  https://support.industry.siemens.com/cs/ww/en/view/109794046
  (https://support.industry.siemens.com/cs/ww/en/view/109794046)

Documentation

The documentation of the Motion Control functions is divided into the following documents:

- S7-1500/S7-1500T Motion Control Overview
  https://support.industry.siemens.com/cs/en/view/109990070
  (https://support.industry.siemens.com/cs/ww/en/view/109990070)

  This document describes the innovations in the technology versions, how to upgrade the technology version, functions that are used for all technology objects, and the operational sequence of Motion Control applications.
- S7-1500/S7-1500T Motion Control alarms and error IDs
  https://support.industry.siemens.com/cs/ww/en/view/109990076
  (https://support.industry.siemens.com/cs/ww/en/view/109990076)

  This document describes the technology alarms of the technology objects and the error identifications of the Motion Control instructions.
- S7-1500/S7-1500T Axis functions
  https://support.industry.siemens.com/cs/en/view/109990072
  (https://support.industry.siemens.com/cs/ww/en/view/109990072)

  This document describes the drive and encoder connection and functions for single-axis movements.
- S7-1500/S7-1500T Synchronous operation functions
  https://support.industry.siemens.com/cs/ww/en/view/109990074
  (https://support.industry.siemens.com/cs/ww/en/view/109990074)

  This document describes gearing, velocity synchronous operation and camming as well as cross-PLC synchronous operation.

- S7-1500/S7-1500T Measuring input and output cam functions
  https://support.industry.siemens.com/cs/ww/en/view/109990075
  (https://support.industry.siemens.com/cs/ww/en/view/109990075)
  This document describes the detection of the actual position via a measuring input and the output of switching signals via output cam or cam track.
- S7-1500T kinematics functions
  https://support.industry.siemens.com/cs/ww/en/view/109990073
  (https://support.industry.siemens.com/cs/ww/en/view/109990073)
  This document describes the control of kinematics with up to 6 interpolating axes.
- S7-1500T Interpreter functions
  https://support.industry.siemens.com/cs/ww/en/view/109990077
  (https://support.industry.siemens.com/cs/ww/en/view/109990077)
  This documentation describes the control of technology objects via an Interpreter program.

See also

Topic page "SIMATIC Technology - Motion Control: Overview and Important Links"
https://support.industry.siemens.com/cs/ww/en/view/109751049
(https://support.industry.siemens.com/cs/ww/en/view/109751049)

1.2 Function Manuals documentation guide

1.2.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.2.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.2.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
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CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 General safety instructions

The safety instructions can be found in section "Safety instructions" in the System Manual "SIMATIC S7-1500, ET 200MP Automation System" (https://support.industry.siemens.com/cs/ww/en/view/59191792) document.

Cybersecurity-relevant information can be found in the Industrial Cybersecurity section.

2.2 Warnings in this document

You can find explanations of the warnings used in this document in the "Legal information" section.

Industrial cybersecurity 3

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

3.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Overview of functions

4

4.1 Areas of application of S7-1500 Motion Control

Machines and production lines must increasingly be adapted to different formats, sizes, product types and production processes. S7-1500 Motion Control offers a precise, dynamic and easy-to-implement solution for open- and closed-loop control of electrically driven machine axes.

Drives with PROFIdrive capability, drives with analog setpoint interface and stepper motors are controlled by means of standardized Motion Control instructions in accordance with PLCopen. The axis control panel and comprehensive online and diagnostic functions support easy commissioning and optimization of drives. S7-1500 Motion Control is fully integrated into the system diagnostics of the S7-1500 CPU.

The S7-1500 CPU Interpreter runs motion jobs for kinematics and single axes serially. You write the motion jobs for the Interpreter in Interpreter programs that you can load into the Interpreter.

Supported CPUs

The following CPUs support the Motion Control functions:

- Advanced Controller S7-1500(F)/S7-1500T(F)
- Distributed Controller S7-1500SP (F)/S7-1500SP T(F)
- Software Controller S7-1507S (F), S7-1508S (F)/S7-1508S T(F)
- Open Controller S7-1515SP PC2 (F)/S7-1515SP PC2 T(F) up to FW 31.1
- Open Controller S7-1515SP PC3 (F) as of FW 40.0
- Open Controller S7-1515SP PC3 T(F) as of FW 40.1
- Drive Controller S7-150xD TF up to FW 3.1

The S7-1500T Technology CPUs offer extended functions. The fail-safe S7-1500(T)F CPUs enable you to use safety functions additionally.

Motion tasks and functions

S7-1500 Motion Control supports the following functions:

Motion task/Function	S7-1500	S7-1500T
Moving S7-1500 Motion Control enables, for example, continuous motions in roller, belt, chain and other conveyors.		
Speed-controlled continuous motions	✓	✓
Connection of drives		
Torque limiting		

Motion task/Function	S7-1500	S7-1500T
Positioning S7-1500 Motion Control enables precise, cyclic positioning for motion tasks calling for dynamic response and precision.		
Precise absolute and relative positioning (closed-loop position control)	✓	✓
High dynamic response		
Traversing range limits through HW and SW limit switches		
Backlash compensation		
Linear and rotation axes		
Switchover of active encoder	-	✓
Direct specification of motion setpoints		
Processing For continuous processing steps demanding accurate speed, torque and position, S7-1500 Motion Control enables operation of production machines with coordinated axis motions, e.g. flying saw, presses and winder applications.		
Gearing without specification of the synchronous position	✓	✓
Gearing with specification of the synchronous position	-	✓
Velocity gearing		
Camming		
Cross-PLC synchronous operation		
Handling S7-1500 Motion Control enables precise and efficient handling control with up to four mechanically-coupled axes, e.g. for palletizing and pick and place applications. The additional Motion Control package "S7-1500T Motion Control KinPlus" enables operation of up to six mechanically coupled axes.		
Calibration of coordinate systems and zones	-	✓
Moving a kinematics in a linear manner		
Moving a kinematics in a circular manner		
Moving a kinematics with a synchronous "point-to-point" motion		
Conveyor tracking		
Zone monitoring		

4.2 Functions in STEP 7

TIA Portal

The TIA Portal supports you in the planning and commissioning of Motion Control functionality:

- Integrating and configuring the hardware
- Creating and configuring the technology objects
- Creating the user program
- Downloading to the CPU
- Commissioning the axes
- Optimizing the drives
- Testing and diagnostics

You use the TIA Portal to configure the hardware, the technology objects as well as your user program. You download the program you created to the CPU. You test your user program and diagnose the hardware with the online and diagnostic functions of the TIA Portal. Automatic data adaptation prevents configuration errors and input errors between components.

If the online and offline data of the technology object are identical, you can activate online mode for older TIA Portal projects and use the online functions.

4.3 Principle of operation of S7-1500 Motion Control

You create a project, configure technology objects, and download the configuration to the CPU with the TIA Portal. The Motion Control functionality is processed in the CPU. You control the technology objects by using the Motion Control instructions in your user program. The TIA Portal provides additional functions for commissioning, optimization and diagnostics.

The following figure provides a schematic representation of the user interfaces and the integration of Motion Control into the S7-1500 CPU. The concepts are then briefly explained:

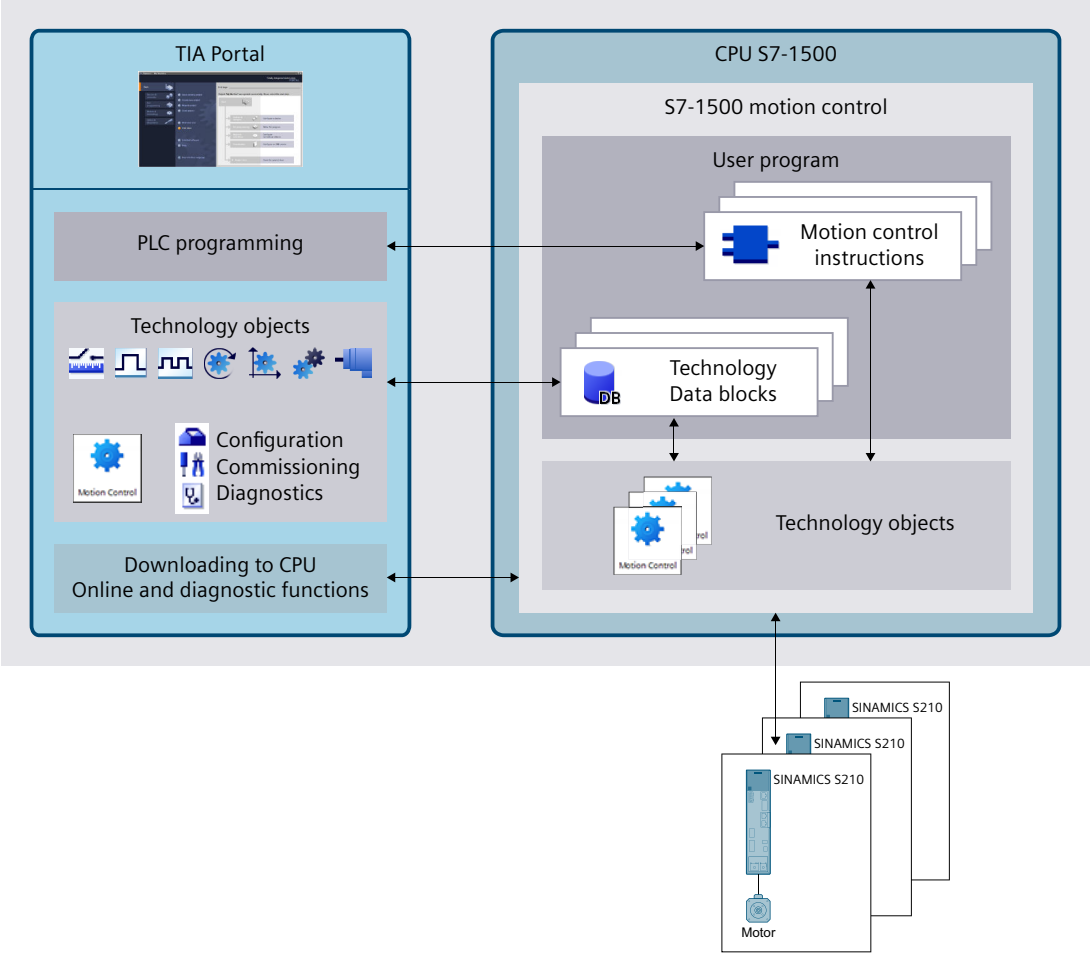

Technology objects

Technology objects represent real objects in the controller, such as an axis. The configuration data of the technology objects mirrors the properties of the real object. You call the functions of the technology objects by means of Motion Control instructions in your user program. These functions are executed in the Motion Control organization blocks (Page 104) independently of the user program. The technology objects perform open- and closed-loop control of the motions of the real objects and report back status information, such as the current position.

Technology object data block

You configure the properties of real objects using the technology objects. The configuration data of the technology objects is stored in a technology object data block (Page 116). The technology object data block contains all configuration data, setpoint and actual values and status information of the technology object. The TIA Portal automatically creates the technology object data block when the technology object is created. You perform read and write access to the data of the technology object data block from your user program.

Motion Control instructions

With the Motion Control instructions you perform the desired functionality in the technology objects. The Motion Control instructions are available in the TIA Portal under "Instructions > Technology > Motion Control". The instructions can be called at all execution levels.

The Motion Control instructions conform to PLCopen (version 2.0).

User program

The Motion Control instructions and the technology object data block represent the programming interfaces for the technology objects. You use Motion Control instructions to transfer Motion Control jobs for the technology objects in your user program. The technology objects process the jobs in the Motion Control organization blocks, which are called independent of the user program, and report back the current status to the Motion Control instruction. Each time the Motion Control instruction is called, the current status of the current job is displayed at the output parameters of the Motion Control instruction. You access status information of the technology object and change specific configuration parameters during runtime using the technology data block.

4.4 Description of technology objects

The S7-1500 and S7-1500T CPUs support the following technology objects:

Technology object		Description	S7-1500	S7-1500T
	Speed axis	The speed axis technology object ("TO_SpeedAxis") is used to specify the speed for a drive. The technology object calculates speed setpoints taking into account the preset dynamic settings and outputs them to the drive. You program the motion of the axis with Motion Control instructions. All motions of the speed axis take place as speed-controlled motions.	✓	✓
	Positioning axis	The positioning axis technology object ("TO_PositioningAxis") is used to position a drive with closed-loop position control. The technology object calculates position setpoints taking into account the preset dynamic settings and outputs corresponding speed setpoints to the drive. You issue positioning jobs to the axis with Motion Control instructions in your user program.	✓	✓

Technology object		Description	S7-1500	S7-1500T
	Synchronous axis	The synchronous axis technology object ("TO_SynchronousAxis") includes all functions of the positioning axis technology object. The synchronous axis can also be interconnected with a leading value so that it, as the following axis, follows the position change of a leading axis during synchronous operation.	✓	✓
	External encoder	The external encoder technology object ("TO_ExternalEncoder") detects a position and makes this available to the controller. The detected position can be evaluated in the user program.	✓	✓
	Measuring input	The measuring input technology object ("TO_MeasuringInput") is used for quick, accurate and event-dependent detection of the actual position of an axis or external encoder when a signal change occurs at the measuring input.	✓	✓
	Output cam	The output cam technology object ("TO_OutputCam") generates switching signals depending on the position of an axis or external encoder. You can evaluate the switching signals in the user program or feed them to digital outputs.	✓	✓
	Cam track	The cam track technology object ("TO_CamTrack") generates a switching signal sequence depending on the position of an axis or external encoder. A cam track can consist of up to 32 individual output cams. The switch signals are output as a track, which you can evaluate in the user program or connect to digital outputs.	✓	✓
10k 600 6k	Cam	The cam technology object ("TO_Cam", "TO_Cam_10k", "TO_Cam_600Seg", "TO_Cam_6kSeg") describes the dependency of an output variable on an input variable in a unit-neutral manner. The cam defines a transfer function f(x) that is used to couple the leading and following axes during camming. The transfer function f(x) is defined using data points and/or segments. Missing function ranges are interpolated. The cam can also be used for the positioning job with time-based position profile at the axis. The cam technology object of the type "TO_Cam" can contain up to 1000 points and 50 segments. The cam technology object of the type "TO_Cam_10k" can contain up to 10,000 points and 50 segments. The cam technology object of the type "TO_Cam_600Seg" can contain up to 50 points and 600 segments. The cam technology object of the type "TO_Cam_6kSeg" can contain up to 50 points and 6 000 segments.	-	✓
	Leading axis proxy	In the case of a cross-PLC synchronous operation, the leading axis proxy technology object ("TO_LeadingAxisProxy") represents the leading axis for the local synchronous operation within a CPU. The leading axis proxy evaluates the leading value telegram and provides the external leading value for the local following axes.	-	✓
	Kinematics	The kinematics technology object ("TO_Kinematics") is used to interconnect individual axes to a kinematics. The technology object calculates motion setpoints for the tool center point (TCP) of a kinematics taking into account the preset dynamic settings.	-	✓

Technology object		Description	S7-1500	S7-1500T
	Interpreter	The technology object Interpreter ("TO_Interpreter") processes the instructions from Interpreter programs and issues motion commands to technology objects.	-	✓
	Interpreter program	The Interpreter program technology object ("TO_InterpreterProgramm") includes an editor for programming and testing Interpreter programs.. Interpreter programs from the "Interpreter program" technology object can be loaded into the Interpreter.	-	✓
	Interpreter mapping	The technology object Interpreter Mapping ("TO_InterpreterMapping") defines which technology objects and PLC tags an Interpreter program can access.	-	✓

You can find more in-depth information on the individual technology objects and their possible applications in the Motion Control documentation (Page 7).

4.5 HW Configuration

Drives and encoders

Drives ensure the motion of the axis. They are integrated in the hardware configuration.

When you execute a Motion Control job in your user program, the technology object takes over the control of the drive and the reading in of values of encoders.

Drives and encoders with PROFIdrive capability are connected by means of PROFIdrive telegrams. The following connections are possible:

- PROFINET IO
- PROFIBUS DP
- Technology module (TM)
- SINAMICS Integrated (SIMATIC Drive Controller)

Drives with analog setpoint interfaces are connected using an analog output (AQ) and an optional enable signal. Analog inputs and outputs are made available by means of corresponding I/O modules.

A drive is also called an actuator, and an encoder is also called a sensor.

The following figure shows an example configuration in which all components are connected to the CPU by means of PROFINET IO:

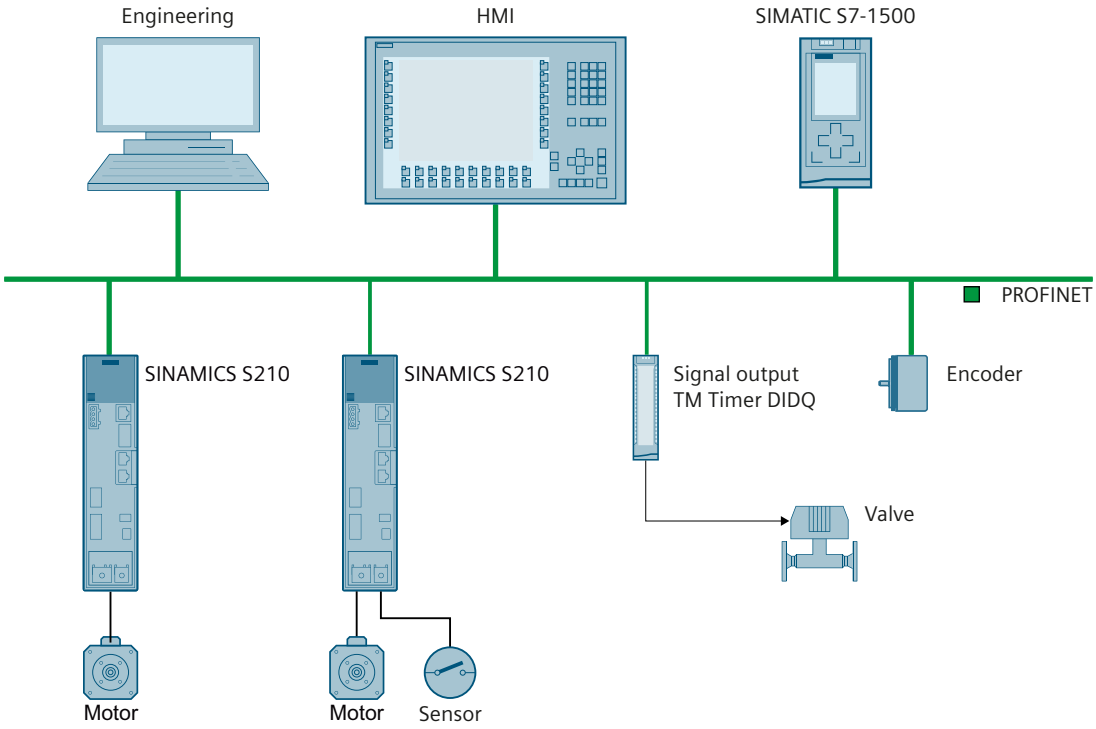

4.6 Configuration limits

The technology objects occupy memory in the CPU's RAM. The internal memory requirements of the technology objects are mapped by the Motion Control and Extended Motion Control resources. Each CPU offers a defined set of these resources. You can find the total resources available in the technical specifications of the utilized CPU.

A cam technology object occupies additional memory space in the load memory and work memory of the CPU.

For an overview of the consumption of the Motion Control, Extended Motion Control resources, and the memory of a CPU, see "Program information > Memory utilization" in the project tree.

Motion Control resources

The following table shows how many Motion Control resources a technology object requires on an S7-1500 or S7-1500T CPU:

Technology object	Motion Control resources used
Speed axis	40
Positioning axis	80
Synchronous axis	160
External encoder	80
Measuring input	40
Output cam	20
Cam track	160

Extended Motion Control resources (S7-1500T)

The following table shows how many Extended Motion Control resources a technology object requires on an S7-1500T CPU:

Technology object	Extended Motion Control resources used
Leading axis proxy	3
Cam of the type "TO_Cam"	2
Cam of the type "TO_Cam_10k"	20
Cam of the type "TO_Cam_600Seg"	2
Cam of the type "TO_Cam_6kSeg"	20
Kinematics	30
Interpreter	60
Interpreter program	0
Interpreter mapping	0

Application cycle

As the number of technology objects used increases, the computing time needed by CPU to process the technology objects increases. The Motion Control application cycle can be adapted according to the number of technology objects used.

Selecting the S7-1500 with the TIA Selection Tool

To identify the right SIMATIC S7-1500 CPU for your Motion Control application, use the TIA Selection Tool (https://support.industry.siemens.com/cs/ww/en/view/109767888).

The TIA Selection Tool takes into account the following criteria when selecting the CPU:

- Used technology, e.g. Kinematics
- Configuration limits of the technology objects
- Cycle time
- Safety functions

New features

5

5.1 New features V10.0

5.1.1 New general functions V10.0

Hardware

The CPUs with 2 IRT interfaces can be configured as I-devices with IRT in isochronous mode.

PC-based PLCs

The following new Open Controllers support Motion Control and offer improved properties:

- Open Controller S7-1515SP PC3 (F) as of FW 40.0
- Open Controller S7-1515SP PC3 T/TF as of FW 40.1

The S7-1508S T/TF Software Controllers offer improved properties as of FW 40.1.

The table shows the improved properties:

Property	S7-1515SP PC3[1)]	S7-1515SP PC3 T/TF[1)]	S7-1508S T/TF[1)]
Code work memory	4.5 MB	4.5 MB	20 MB
Data work memory	10 MB	10 MB	200 MB
Motion Control resources	6,000	6,000	50,000
Extended Motion Control resources	-	300	2,000
Minimum cycle time MC_Servo	500 µs	500 µs	250 µs

1) Applies for all CPU variants as of start of delivery

Process response

The "Improve system performance" function for motion jobs enables the application cycle for CPUs with multi-core processors to be shortened. In the process, the editing of the isochronous organization blocks MC_Servo and MC_Interpolator is divided between the cores.

Diagnostics

The event recording adds the recording of the status changes to Motion Control jobs as well as coming and going program and technology alarms to the signal recording with the trace.

Online mode for projects from previous TIA Portal versions

You can activate online mode for projects that were created in earlier versions of the TIA Portal. Online mode enables access to online functions such as the axis control panel.

Requirement

- The online and offline data of the technology object are identical.

Access via Web server

With the new system web page "Diagnostics > Motion Control", you can access the diagnostics data of the individual technology objects, such as status bits and error bits.

With the "Data block accessible via web server" attribute, you can specify in the properties of a technology object data block the accessibility via the system web page "Motion Control".

5.1.2 New axis functions V10.0

Technology version V10.0 contains the following new features.

Default values for the permissible following error

The following default values for the permissible following error have been updated for the rotary axis:

- <TO>.FollowingError.MinValue: 30°
- <TO>.FollowingError.MaxValue: 360°

Encoder connection via separate drive object encoder from Startdrive

- As of TIA Portal V21, you can interconnect a separate drive object encoder (DO ENCODER) on S120 with telegram 81 or 83 to the positioning axis, synchronous axis and external encoder technology objects.

Superimposed motion specification via "MotionIn" (S7-1500T)

- The motion setpoints of a superimposing axis are specified to the axis in the application cycle in addition to the basic motion. You can call the "MC_MotionInSuperimposedAxes" instruction in every cyclic organization block. The possible superimposing axes can be interconnected in the configuration of the synchronous axis or positioning axis technology object.

Use cam as time-based position profile (S7-1500T)

- With the Motion Control instruction "MC_PositionProfile", you start a relative or absolute positioning job with time-based position profile through which the profile of a cam can be traversed on the positioning axis or the synchronous axis. Specify the time-based position profile via the cam technology object.

5.1.3 New synchronous operation functions V10.0

Technology version V10.0 contains the following new features:

Actual value extrapolation (S7-1500T)

- The leading value velocity can be differentiated from the extrapolated leading value position ("<TO>.Extrapolation.Settings.ExtrapolatedVelocityMode" = 2).
- When the effective extrapolation time amounts to zero and the extrapolation is omitted, the position and velocity filters remain active.

Camming (S7-1500T)

- Use the Motion Control instruction "MC_SetCamRangeScaling" to scale a cam range. Up to two scaling ranges are possible. Range scaling can also be used during synchronous camming. An active range scaling is displayed in the online view of the cam diagnostics. In addition, range scaling can be simulated offline in the configuration of the cam.

Cross-PLC synchronous operation (S7-1500T)

- The leading axis proxy supports different leading value telegram versions. Observe the compatibility of the technology versions.
- If multiple PROFINET interfaces of a CPU support the "PROFINET with IRT" functionality, you can operate the CPU as an isochronous I-device. The PROFINET interface configured as an I-device is used for isochronous data exchange with the higher-level IO Controller, through which you can realize cross-PLC synchronous operation. The other PROFINET interface can synchronize with the I-device interface and operate connected IO devices isochronously.

5.1.4 New kinematics functions V10.0

Technology version V10.0 contains the following new features:

Kinematics control panel

- The traversing velocity can only be set with active master control via "Adjust > Velocity" in the kinematics control panel, but not via <TO>.Override.Velocity in the user program.

S7-1500T Motion Control KinPlus

- The Motion Control package "S7-1500T Motion Control KinPlus" V10.0 supports the technology versions V9.0 and V10.0 also on the CPU 1516T/TF-3 PN and CPU 1517T/TF-3 PN with CPU firmware version V4.1.
- The configuration of the kinematics type "6-axis articulated arm with central wrist" has been extended by the parameter length L6. This supports kinematics with horizontal offset of the central wrist in relation to the A1 axis.
- The predefined kinematics types have been expanded to include the "6-axis articulated arm with offset wrist" kinematics type.

5.1.5 New Interpreter functions V10.0

Technology version V10.0 contains the following new Interpreter functions:

Extensions of the Interpreter mapping

Mapping complex data types for describing position data is supported, e.g. TO_Struct_Ipr_Frame.

Mapping of arrays is supported.

Changing the values of tag in "Debug" program mode

In "Debug" program mode, you can display the value of a tag and change the value at the breakpoints, e.g. for test purposes.

Conversion rules for explicit data type conversion LREAL_TO_DINT or LREAL_TO_UDINT

The conversion of floating-point numbers into DINT/UDINT values now provides a defined result, even when values outside of the valid range or invalid floating-point numbers are entered. Previously, the result of the conversion was undefined in such cases.

5.2 New features V9.0

5.2.1 New general functions V9.0

Hardware

The following new CPUs have PROFINET IRT functionality on interfaces X1 and X2:

- 1517(F)-3 PN
- 1518(F)-3 PN
- 1516T/TF-3 PN
- 1517T/TF-3 PN
- 1518T/TF-3 PN

Improved properties

With firmware version V4.0, the following CPUs offer a bit operation time of 6 ns and a word operation time of 7 ns and thus improved performance:

- 1511C-1PN/1511-1 PN/1511F-1 PN
- 1512C-1 PN
- 1513-1 PN/1513F-1 PN
- 1510SP-1 PN/1510SP F-1 PN
- 1512SP-1 PN/1512SP F-1 PN

With firmware version V4.0, the technology CPUs offer the following improved properties:

Property	1511T/TF-1 PN	1516T/TF-3PN	1517T/TF- 3 PN	1518T/TF-3 PN
Code work memory	450 kB	3 MB	6 MB	18 MB
Data work memory	1.5 MB	25 MB	50 MB	150 MB
Motion Control resources	1,120	12,800	20,480	30,720
Extended Motion Control resources	90	540	720	1,560
Bit operations	6 ns	1.2 ns	0.6 ns	0.3 ns
Word operations	7 ns	2.6 ns	1.3 ns	0.8 ns
Minimum cycle time MC_Servo	250 µs	250 µs	250 µs	125 µs

5.2.2 New axis functions V9.0

Technology version V9.0 contains the following new features:

Stopping the basic motion and the superimposed motion

- The Motion Control instruction "MC_Halt" has been extended to include the input parameter "Mode".

  You stop both the basic motion and the superimposed motion with the parameter "Mode" = 0, while "Mode" = 1 only stops the basic motion.

Change stop reaction directly during "Remove enable" alarm response

- With the Motion Control instruction "MC_WriteParameter", you change the parameter for the stop reaction "Actor.RemoveEnableReaction" directly during runtime.

Defining the motion transition

- The Motion Control instructions "MC_MoveAbsolute" or "MC_MoveRelative" have been expanded by the input parameter "BufferMode" and the output parameter "Active".

  With a "MC_MoveAbsolute" or "MC_MoveRelative" job, you can define a motion transition as of V9.0.

5.2.3 New synchronous operation functions V9.0

Technology version V9.0 contains the following new features:

Gearing

- The current gear ratio of an active "MC_GearIn" job is shown on the synchronous axis in the "<TO>.StatusSynchronizedMotion.ActualRatioNumerator" and "<TO>.StatusSynchronizedMotion.ActualRatioDenominator" tags.

Gearing (S7-1500T)

- The current gear ratio of an active "MC_GearInPos" job is shown on the synchronous axis in the "<TO>.StatusSynchronizedMotion.ActualRatioNumerator" and "<TO>.StatusSynchronizedMotion.ActualRatioDenominator" tags.
- The Motion Control instruction "MC_GearInPos" has been extended with the following synchronization modes:
  - Subsequent synchronization using leading value distance starting from current leading value position with calculated synchronous position of the following axis
  - Subsequent synchronization using leading value distance with calculated synchronous position of the following axis
- A reverse tolerance of the leading value during synchronization with "MC_GearInPos" and desynchronization with "MC_GearOut" is definable.

Velocity gearing (S7-1500T)

- The current gear ratio at an active "MC_GearInVelocity" job is shown on the synchronous axis in the "<TO>.StatusSynchronizedMotion.ActualRatioNumerator" and "<TO>.StatusSynchronizedMotion.ActualRatioDenominator" tags.

Camming (S7-1500T)

- The transfer function f(x) of the new cam technology object of the type "TO_Cam_600Seg" can comprise up to 600 segments and up to 50 interpolation points.
- The transfer function f(x) of the new cam technology object of the type "TO_Cam_6kSeg" can comprise up to 6 000 segments and up to 50 interpolation points.
- The Motion Control instruction "MC_CamIn" has been extended to include the synchronization profile "SyncProfileReference" = 7. With this setting, you can directly set a following axis synchronously at a specified leading value position.
- A reverse tolerance of the leading value during synchronization with "MC_CamIn" and desynchronization with "MC_CamOut" is definable.

- The third derivative of the following value (jerk) can be read out using the "ThirdDerivative" parameter with the "MC_GetCamFollowingValue" and "MC_GetCamFollowingValueCyclic" Motion Control instructions. In addition, the instructions are each expanded by the "ApplicationMode" parameter to specify the read mode.
- After the interpolation of a cam, the "<TO>.StatusCam.StartFollowingValue" and "<TO>.StatusCam.EndFollowingValue" parameters contain the following values associated with the start value and end value of the definition range.

Cross-PLC synchronous operation (S7-1500T)

- The communication via a PN/PN coupler is possible.
- Interconnection across multiple projects is possible. The CPUs can be configured in various projects.
- To analyze a cross-PLC synchronous operation in various projects with the trace, you can use the "GetPNWorkingClock" instruction.
- A leading value can be provided via up to 32 transfer areas. The array of the tag "<TO>.CrossPlcSynchronousOperation.Interface[1..32]" has been expanded from [1..8] to [1..32].

5.2.4 New kinematics functions V9.0

Technology version V9.0 contains the following new features:

Kinematics control panel

- You can activate keyboard control for jogging and jogging to target position. With keyboard control, you can operate the sliders to jog the axes, joints or kinematics. For jogging and jogging to target position in JCS and MCS, you can also select an axis or joint using the keyboard control.
- For jogging and jogging to target position in JCS and MCS, select an axis or joint. Only the slider for the selected axis or joint is displayed at a time.
- Depending on the set kinematics type set, you can jog the kinematics in 2 different modes. You can jog kinematics types without orientation in "Cartesian" mode. You can also jog kinematics types with orientation in "Orientation" mode.
- For kinematics as of technology version V9.0, you can adapt the velocity as a percentage in the kinematics control panel, also in "Individual axis: Homing" mode.

Display of effective dynamic limits

- The new "<TO>.StatusPath.DynamicLimit" tag shows you which dynamic limits affect the dynamic response of the active motion.

Dynamic reserve object coordinate systems

- You can define the dynamic reserve individually for each object coordinate system. The array of the tag "<TO>.Conveyor.DynamicReserve[1..3].<tag name>" was extended from [1..1] to [1..3].

Radius kinematics types Delta picker 3D, Delta picker 3D with orientation and Delta picker 3D with two orientations A, B

- For the Delta picker 3D, Delta picker 3D with orientation and Delta picker 3D with 2 orientations A, B kinematics types, you can define a negative value for the Distance D1 (radius of the upper connecting plate, "Parameter[1]").

5.2.5 New Interpreter functions V9.0

Technology version V9.0 includes the following new Interpreter functions:

"Debug" program mode

In "Debug" program mode, test the execution of the Interpreter program.

Logical expressions in "waitEvent()"

The MCL instruction "waitEvent()" supports logical expressions as event.

System constant "NULL_POS"

You can use the system constant "NULL_POS" in the MCL instructions "circAbs()" and "circRel()" for the mandatory end position "pos".

5.3 New features V8.0

5.3.1 New general functions V8.0

Hardware

The following CPUs with an *03-0AB0 article number are available with a new hardware release:

- 1511C
- 1512C

These CPUs offer the following improved properties with firmware version V3.1:

- The work memory has been increased.
- Motion Control resources have been increased to 1120.
- The Motion Control performance has been increased by at least 25%.

The following CPUs with an *03-0AB0 article number are available with a new hardware release:

- 1513pro(F)
- 1516pro(F)

These CPUs offer the following improved properties with firmware version V3.1:

- The work memory has been increased.
- The Motion Control performance has been increased by at least 25%.

With firmware version V31.1, the 1508S T/TF software controllers offer the following improved property:

- Motion Control resources have been increased to 26,800.

With firmware version V30.1, the 1505SP T/TF software controllers offer the following improved property:

- Motion Control resources have been increased to 5,120.

Technology objects

- You can organize technology objects in groups.
- The user interface no longer supports technology objects of Technology versions V1.0 and V2.0. You cannot create new technology objects of these versions. You also cannot change back to these technology objects after upgrading them. Existing technology objects of these versions in the project can continue to be used.

Programming

- You can use organization blocks for Motion Control in software units. For this, the names of the organization blocks must adhere to the naming conventions according to IEC 61131-3. The "-" character is replaced by "_". The new names are independent of the firmware used and the technology version.

  Example: The previous name "MC-Servo" has been renamed to "MC_Servo".
- Name values for software units are available. Named values are values that have a unique and understandable name assigned to them. Named values can be referenced in the program and increase the readability and maintainability. The concept of the named value data types is comparable with the concept of the enumerations in accordance with IEC 61131-3.

5.3.2 New axis functions V8.0

Technology version V8.0 contains the following new features:

Axis control panel

- Setting of the absolute encoder
  - The axis control panel provides the new operating modes Absolute Encoder Calibration Absolute and Absolute Encoder Calibration Relative.
- Display and adjustment of velocity override
  - The axis control panel includes 2 new control elements for adjusting the velocity override. A slider, which must be continuously actuated during the axis movements, replaces the control elements for starting and stopping.

Axis control via Interpreter

You can control the speed axis, positioning axis and synchronous axis technology objects via an Interpreter program.

Measuring gearbox for positioning axis and synchronous axis technology objects

- A measuring gearbox is available for encoders of the positioning axis and synchronous axis technology objects. For both technology object types, up to 4 encoders can be configured and are expanded with a measuring gearbox.

Torque precontrol

- For the position controller of the S7-1500 CPU, you can configure torque precontrol.

Dynamic filter with sliding window demand

- For the dynamic filter the new mode "Sliding window demand filter" is available.

Standstill signal on external encoder

- The standstill signal is available with external encoder.

Virtual axis

- The position and velocity setpoints of a virtual axis are directly adopted as actual values with an application cycle delay. The feedback loop and the drive model are not simulated.

Alarm response

- Three stop modes of the drive can be configured for the alarm response "Remove enable".

5.3.3 New measuring input and output cam functions V8.0

Technology version V8.0 contains the following new features:

Cyclic measuring with central measuring input

- Cyclical measuring with the central measuring input via telegram 39x is supported.

Measuring via "Monitor measuring input"

- When measuring via "Monitor measuring input", the measuring input captures the measured signal from an interconnected measuring input with configured measuring input.

5.3.4 New synchronous operation functions V8.0

Technology version V8.0 contains the following new features:

Camming (S7-1500T)

- With the Motion Control instruction "MC_GetCamFollowingValueCyclic", you can cyclically read the following value that is defined for a leading value from a cam. In this process, you can specify scaling and offset of the cam without altering the cam technology object. Job processing is done synchronously so that the result is output directly.
- The Motion Control instruction "MC_GetCamLeadingValue" has been extended with parameters for specifying the offset and scaling of the cam, without altering the cam technology object.
  - MasterOffset
  - SlaveOffset
  - MasterScaling
  - SlaveScaling

  In addition, you can define an approach direction for the sought leading value with the "ApproachDirection" parameter.
- The Motion Control instruction "MC_GetCamFollowingValue" has been extended with parameters for specifying the offset and scaling of the cam, without altering the cam technology object.
  - MasterOffset
  - SlaveOffset
  - MasterScaling
  - SlaveScaling

5.3.5 New kinematics functions V8.0

Technology version V8.0 contains the following new features:

- You can control a kinematics technology object via an Interpreter program.

  You can find information on the Interpreter programs in the documentation "S7-1500 Interpreter functions".
- Improved blending behavior during conveyor tracking

  Blending is possible for the following motions:
  - From a motion in the tracked OCS to a motion job that desynchronizes the TCP
  - From a motion job that synchronizes the TCP with the tracked OCS to the subsequent motion job in the tracked OCS
  - To blend the intermediate point in the WCS during a movement from one tracked OCS to another tracked OCS, you can also only issue the synchronization job during desynchronization "TrackingState" = 4.
- You can enable dynamic adaptation (for motion jobs) in all phases of conveyor tracking.
- The new tag structure "<TO>.StatusInterpreterMotion <tag name>" contains status information on motion jobs controlled by a technology object Interpreter.
- The array of the tag "<TO>.StatusTool.Frame[1..3].<tag name>" was extended from [1..1] to [1..3]:

S7-1500T Motion Control KinPlus

- The "MC_InverseKinematicsTransformation" Motion Control instruction has been extended to include the "TurnJoint" parameter for the specification of the target joint position ranges.

5.3.6 Interpreter functions V8.0

Technology version V8.0 contains the following Interpreter functions:

Technology objects

The following technology objects are available:

- Interpreter technology object
- Interpreter program technology object
- Interpreter mapping technology object

Programming

MCL

- The programming language Motion Control Language (MCL) is supported. In MCL, you can program sequential motion jobs for kinematics and axes.
- The Interpreter program technology object includes a programming editor for creating and editing MCL programs.

User program

The following Motion Control instructions are available to control the Interpreter technology object in the user program:

- MC_LoadProgram: Load/unload the Interpreter program
- MC_RunProgram: Start execution of the Interpreter program
- MC_StopProgram: Stop execution of the Interpreter program

5.4 New features V7.0

5.4.1 New general functions V7.0

Technology version V7.0 contains the following new features:

Hardware

- The following new CPUs are available:
  - 1514SP/SP F
  - 1514SP T/TF
  - 1508S T/TF
- The following CPUs with an *03-0AB0 article number are available with a new hardware release:
  - 1510SP
  - 1511, 1511F/T/TF
  - 1512SP
  - 1513, 1513F
  - 1515, 1515F/T/TF
  - 1516, 1516F

These CPUs offer the following improved properties with firmware version V3.0:

– The work memory has been increased.
– Motion control resources have been increased:

CPU	Motion Control resources
1510SP 1511, 1511F/T/TF 1512SP 1513, 1513F	1120

– The extended Motion Control resources of the technology CPUs have been increased:

CPU	Extended Motion Control Resources
1511T/TF	90

– The Motion Control performance of the technology CPUs has been increased by at least 25%.

- The CPUs 1516T/TF offer the following improved properties with firmware version V3.0:
  – The code work memory has been expanded to 3 MB. The data work memory has been expanded to 7.5 MB.
  – The CPU performance and the work memory have been increased according to the new hardware release of the CPU 1516 (standard).
- The CPU 1504D TF offers the following improved properties with firmware version V3.0:
  – The code work memory has been expanded to 4 MB. The data work memory has been expanded to 6 MB.
  – Motion Control resources have been increased to 3200.
  – Extended Motion Control resources have been increased to 160.
- The CPU 1507D TF offers the following improved properties with firmware version V3.0:
  – The code work memory has been expanded to 15 MB. The data work memory has been expanded to 40 MB.

Programming

- Temporary references to technology objects in combination with "DB_ANY".

  You can assign a tag of data type "DB_ANY" of a type-specific reference to a technology object during runtime. If the tag contains a matching technology object type, then the reference becomes valid. After checking the validity, you can use the reference to access technology object data or Motion Control instructions. A conversion function depending on the technology object type is no longer required.

  Parameter transfer for function blocks (Page 126)

5.4.2 New axis functions V7.0

Technology version V7.0 contains the following new features:

Drive and encoder connection

- When connecting a drive via a data block, you can configure the communication times T_i, T_o, and T_{DC} for calculating the following error.

Motion control and dynamic limits

- The "MC_MotionInSuperimposed" instruction is available. With this instruction you can assign the axis cyclic applicative motion setpoints for additional distance, velocity and acceleration in addition to the basic motion.
- The "MC_HaltSuperimposed" instruction is available. This instruction decelerates a superimposed motion on the axis generated with the instructions "MC_MoveSuperimposed", "MC_MotionInSuperimposed", or "MC_HaltSuperimposed" to zero velocity.

Traversing range limitation

- Extension SW limit switch:
  - You can additionally configure "Stop at SW limit switch with programmable dynamics".
  - When overtraveling the SW limit switches, emergency stop and retention of the axis enable is possible.
- Extension HW limit switch:
  - When configuring the positioning axis and synchronous axis, the HW limit switches can be configured as "traversable" as before, and now as "non-traversable".
  - When approaching a HW limit switch that cannot be overtraveled, you can configure the alarm response.

Homing

- The "MC_SaveAbsoluteEncoderData" instruction is available. Use this instruction to save the absolute adjustment data for CPU device replacement on the SIMATIC Memory Card.
- With the "MC_Home" instruction, the new incremental encoder adjustment homing type "MC_Home.Mode" = 13 is available. The axis does not perform a compensating motion and the offset of the position is not applied at all encoders of the axis. This makes it easier to readjust individual encoders.
- Active and passive homing of absolute encoders with "MC_Home" is available.
- The homing status of the "<TO>.StatusSensor[1..4].Adjusted" encoders is displayed.
- The S7-1500T CPU supports absolute adjustment/incremental adjustment of non-operational encoders. This means that the respective encoder no longer has to be enabled for homing.

Configuring a control loop

- For axes in a synchronous system, the dynamic filter enables dynamic adaptation of axes with higher dynamic responses to the axis with the lowest dynamic response.

Position monitoring

- The parameter assignment of the additional delay time for following error calculation when the dynamic filter is active is available.

"MC_Power.StopMode" = 3

- The "MC_Power" instruction supports "StopMode" = 3 (coast down).

5.4.3 New synchronous operation functions V7.0

Technology version V7.0 contains the following new features:

Velocity gearing (S7-1500T)

- The "MC_GearInVelocity" instruction is available. With an "MC_GearInVelocity" job, you can start velocity gearing between a leading axis and a following axis.
- Continuous changing of the gear ratio during operation is possible. While that is happening, the following axis remains in the status "Synchronous".

Camming (S7-1500T)

- The "MC_CamIn" instruction has been expanded to include the synchronization profile "SyncProfileReference" = 6. With this setting, the following axis synchronizes in advance over a pre-definable leading value path, starting from the current leading value position. The cam is offset accordingly in the master value range.
- For interpolating the cam technology object, you can improve the system performance using the properties of MC-Interpolator [OB92]. This is possible with the modular S7-1500T(F) CPUs and the SIMATIC Drive Controller as of firmware version V3.0.

5.4.4 New kinematics functions V7.0

Technology version V7.0 contains the following new features:

- For motion preparation of the kinematics technology object, you can improve the system performance using the properties of MC-LookAhead [OB97]. This is possible with the modular S7-1500T(F) CPUs and the SIMATIC Drive Controller as of firmware version V3.0.

  NOTE
  Upgrade
  If you are using user-defined kinematics, disable the system performance improvement after upgrading to technology version V7.0.
  Note the information provided in the section "Upgrading to technology version V7.0" (Page 60).

- You configure mechanical axis couplings in the "Interconnections" configuration window.
- In the new "Joints" configuration window, you configure the joints of the kinematics types with more than four kinematics axes.
- Kinematics control panel:
  - You can now execute the functions of the kinematics control panel with new sliders. You can use the new sliders to finely adjust velocities of motions.
  - 3D visualization provides visual support for commissioning the kinematics technology object.
  - In the JCS, you can jog each kinematics joint individually forward, backward or to a set target position.
  - You can find the dynamics settings for commissioning in the Inspector window under "Properties".
  - The status bits in the "Control panel status" diagnostics window show you whether all kinematics axes are switched on and homed and whether there are errors on the kinematics or the kinematics axes. You can also show additional diagnostics windows via the toolbar.
  - Error messages for commissioning via the kinematics control panel are displayed in a yellow banner above the toolbar.
- Kinematics trace:
  - You can record a maximum of 64 signals in a kinematics trace.
  - You can show or hide the TCP orientation as trace in the kinematics trace.
- The "MC_MoveDirectAbsolute" and "MC_MoveDirectRelative" Motion Control instructions have been extended by the "TurnJoint" parameter.
- The "MC_KinematicsTransformation" and "MC_InverseKinematicsTransformation" Motion Control instructions have been extended by the "AxesCoordSystem" parameter.
- The arrays of the following instruction parameters have been extended from [1..4] to [1..6]:
  - MC_MoveLinearAbsolute.Position
  - MC_MoveLinearRelative.Distance
  - MC_MoveCircularAbsolute.EndPoint

- MC_MoveCircularRelative.EndPoint
- MC_MoveDirectAbsolute.Position
- MC_MoveDirectRelative.Distance
- MC_KinematicsTransformation.AxesPosition
- MC_KinematicsTransformation.AxesVelocity
- MC_KinematicsTransformation.AxesAcceleration
- MC_InverseKinematicsTransformation.Position
- MC_InverseKinematicsTransformation.Velocity
- MC_InverseKinematicsTransformation.Acceleration

NOTE
Upgrade
When upgrading to technology version V7.0, you must adapt the user program.
Note the information provided in the section "Upgrading to technology version V7.0" (Page 60).

- The tag structure of the following tags has been extended by the coordinates B and C:
  - <TO>.Tcp
  - <TO>.KcsFrame
  - <TO>.OcsFrame
  - <TO>.Tool
  - <TO>.TcpInWcs
  - <TO>.TcpInOcs
  - <TO>.StatusOcsFrame[1..3]
  - <TO>.FlangeInKcs
  - <TO>.StatusTool
  - <TO>.StatusConveyor[1..3]
  - <TO>.StatusWorkspaceZone[1..10]

S7-1500T Motion Control KinPlus

- You can use the "S7-1500T Motion Control KinPlus" Motion Control package to configure and commission predefined kinematics types with more than four kinematics axes.
- The following kinematics types are available:
  - Cartesian portal 3D with 2 orientations A, B
  - 6-axis articulated arm with central hand
  - Delta picker 3D with 2 orientations A, B
  - User defined kinematics 3D with 3 orientations

- Joints:
  - The joint coordinate system (JCS) is available.
  - The tag "<TO>.Joint" contains the configuration of the joints for kinematics types with more than four interpolating kinematics axes.
  - The tag "<TO>.JointData" contains the setpoints of the kinematics motion for the joints.
- The tag "<TO>.AxisCoupling" contains the configuration of the mechanical axis coupling for kinematics types with more than four interpolating kinematics axes.

5.5 Innovations V6.0

The technology version V6.0 contains the following new features:

General functions

- All diagnostics information is available through the web server.
- You can use the security settings to restrict access to the technology objects.
- A restart of the technology objects kinematics, output cam, cam track and measuring input no longer cancels an active job with "ErrorID" = 16#8001 but with "ErrorID" = 16#800D instead.
- Technology object data connection via data block: As of TIA Portal V17, you can connect the tag structures of the data type "PD_TELx" that are defined in arrays (Array [0..x] of "PD_TELx"), PLC data types or structures within a data block. This function is available for technology objects as of technology version V3.0 and higher.

Axis functions

- A backlash compensation can be configured for the positioning axis and synchronous axis technology objects.
- A linear axis can be configured with linear motor for the positioning axis and synchronous axis technology objects.
- The actual velocity can be calculated from the actual speed NIST_B from the drive telegram for the positioning axis, synchronous axis and external encoder technology objects.
- The "<TO>.PositionMonitoring.MinDwellTime" tag of the positioning axis and synchronous axis technology objects has the start value 0.01 s as default setting.
- Axis control panel: The "Deceleration" element in the "Control" area has the default 100% of the configured value in "Technology objects > Configuration > Extended parameters > Limits > Dynamics limits".

Synchronous operation functions

Gearing (S7-1500T):

- The "MC_PhasingAbsolute" and "MC_PhasingRelative" instructions have been expanded by additional parameters. You can traverse the leading value offset of following axis from a defined or from the current leading value position.
- In gearing, a following value offset is possible via an "MC_OffsetAbsolute" - or "MC_OffsetRelative" job. You can traverse the following value offset of following axis from a defined leading value position or from the current leading value position.
- With a "MC_GearOut" job, you can desynchronize a gearing.

Camming (S7-1500T):

- In contrast to the cam technology object of type "TO_Cam", the transfer function f(x) of the new cam technology object of type "TO_Cam_10k" can comprise up to 10,000 interpolation points.
- A diagnostics area is available for the cam technology object via project tree.
- The "MC_CamIn" instruction has been expanded to include the synchronization profile "SyncProfileReference" = 5. With this setting you can rescale the active cam or replace a new cam at the end of the active cam.
- In camming, a leading value offset is possible via a "MC_PhasingAbsolute" or "MC_PhasingRelative" job. You can traverse the leading value offset of following axis from a defined or from the current leading value position.
- In camming, a following value offset is possible via an "MC_OffsetAbsolute" job or "MC_OffsetRelative" job. You can traverse the following value offset of following axis from a defined leading value position or from the current position. .
- With a "MC_CopyCamData" job, you can copy calculated cam elements to a cam. You can also overwrite any existing cam elements in this step. Copying of cam elements is also possible during active camming.
- With a "MC_CamOut" job you can desynchronize a camming.

Cross-PLC synchronous operation (S7-1500T):

- A cross-PLC synchronous operation between technology objects is possible with different technology versions ≥ V5.0 on CPUs with different firmware versions ≥ V2.8.
- You can provide a cross-PLC leading value over up to eight different transfer areas.

Kinematics functions (S7-1500T)

- In the "Calibration" configuration window can calibrate workspace zones in online and offline mode.
- With a "MC_KinematicsMotionSimulation" job, you can simulate the motion of a kinematics with interconnected axes that are not enabled and exit simulation mode.
- You can configure the maximum smoothing distance in the configuration menu "Technology object > Configuration > Extended parameters> Job sequence" or directly via the "<TO>.Transition.FactorBlendingLength" tag. You can move the kinematics with smoothing distances > 50% of the shorter distance.

- In the "Technology object > Configuration > Extended parameters > Dynamics" configuration menu, you can define the default values for the dynamic responses for synchronous "point-to-point" motions.
- In the kinematics control panel, the dynamic adaptation is effective in "Jog to target position" mode and the dynamic limits of the kinematics axes are taken into account. The "dynamic adaptation without segmentation of the path" is always used.
- The tag "<TO>.StatusWord.InSimulation" indicates the simulation mode of a kinematics.
- The "<TO>.AxesData" tag structure shows the axis data from the kinematics motion.
- The "<TO>.StatusPath.AccumulatedPathLength" tag shows the sum of the distance already traveled.
- The "<TO>.StatusPath.TotalPathLength" tag shows the sum of the total distance (distance already traveled and calculated distance).
- The tag "<TO>.StatusMotionQueue.NumberOfPreparedCommands" shows the number of prepared commands in the job sequence.

5.6 Innovations V5.0

Technology version V5.0 contains the following new features:

General functions

- The values for position, velocity and angle can be configured with higher resolution.
- In the central operation of the technological modules, the clock synchronization is supported via the active backplane bus.
- The organization block MC-PreInterpolator [OB68] enables iposynchronous processing of motion control instructions.
- The default value of the CPU communication load for the following CPUs was reduced from 50% to 20%:
  - S7-1505SP T/TF
  - S7-1511T/TF
  - S7-1515T/TF
  - S7-1516T/TF
- The default values of the bus clocks are:
  - 4 ms for CPUs 1511T/TF and 1515T/TF
  - 2 ms for CPU 1516T/TF
  - 1 ms for CPU 1517T/TF

Axis functions

- In the axis control panel, the dynamic values are retained until the axis control panel is closed.
- With a "MC_Stop" job, you can stop an axis and prevent new jobs.
- With a "MC_Home" job, set positions can be set absolutely or relatively.
- With a "MC_Reset" job, alarms in the drive can be acknowledged without a pending error at the technology object.
- Selected bits in control word 1 and control word 2 can be controlled with a "MC_SetAxisSTW" job.
- With a "MC_WriteParameter" job, hardware limit switches can be enabled and disabled.
- The "<TO>.VelocitySetpoint" tag indicates the active velocity setpoint.
- The tag "<TO>.ModuloCycle" indicates the number of modulo cycles of the setpoint.
- The tag "<TO>.ActualModuloCycle" indicates the number of modulo cycles of the actual value.

Measuring input and output cam functions (S7-1500T)

- The X142 interface of the SIMATIC Drive Controller is supported.

Synchronous operation functions (S7-1500T)

- With a cross-PLC synchronous operation, a synchronous operation is possible between axes which are located on different CPUs within a project.
- A cross-PLC synchronous operation can be configured using the leading axis proxy technology object.
- The actual value extrapolation has been extended.
- With a "MC_LeadingValueAdditive" job, an additive leading value can be specified for the following axis cyclically to a master value.
- With a "MC_GearInPos" job, a subsequent synchronization via leading value distance is possible for gearing.
- With a "MC_CamIn" job, a subsequent synchronization via leading value distance is possible for camming.
- During synchronization, the tag "<TO>.StatusSynchronizedMotion.StatusWord" indicates that the dynamic limits have been exceeded.
- The tag "<TO>.StatusSynchronizedMotion.WaitingFunctionState" indicates a pending synchronous operation.

Kinematics functions (S7-1500T)

- You can configure the predefined kinematics type "SCARA 2D with orientation".
- A model of the kinematics with the configured zones is displayed in the "Diagnostics" window.
- It is possible to calibrate object coordinate systems offline and online using the "Calibration" window.
- The movement preparation of the kinematics technology object is calculated in the MC-LookAhead [OB97] organization block.
- A kinematics with a synchronous "point-to-point" motion can be traversed absolutely with a "MC_MoveDirectAbsolute" job.
- A kinematics with a synchronous "point-to-point" motion can be traversed relatively with a "MC_MoveDirectRelative" job.
- With a "MC_KinematicsTransformation" job, a forward transformation can be calculated.
- With a "MC_InverseKinematicsTransformation" job, an inverse transformation can be calculated.
- With a "MC_TrackConveyorBelt" job, conveyor tracking is possible.

5.7 Innovations V4.0

Technology version V4.0 contains the following new features:

Axis functions

- Exchange of torque data with the drive in the technological units of the technology object.
  - Additive setpoint torque
  - Current actual torque
  - Permissible torque range
- Extension of the data structure of the positioning axis and synchronous axis for using the kinematics technology object
- Use of optimized data blocks (drive/encoder connection)
- Motion specification via "MotionIn" instructions (S7-1500T)

Synchronous operation functions (S7-1500T)

- Direct synchronous setting with "MC_CamIn" V4.0 (S7-1500T)

Kinematics functions (S7-1500T)

- You can use the following kinematics with the kinematics technology object:
  - Cartesian portals
  - Roller picker
  - SCARA
  - Articulated arm
  - Delta picker
  - Cylindrical robots
  - Tripod
  - User-defined kinematics
- You can record the motions of the kinematics in the kinematics trace.
- With the kinematics control panel you can move the kinematics during the commissioning.
- The status of the motion, errors and warnings are displayed in the diagnostics.

5.8 Innovations V3.0

Technology version V3.0 contains the following new features:

General functions

- Technology CPU S7-1500T

Axis functions

- Force/torque limiting
- Fixed stop detection
- Axis type virtual axis
- MC-PreServo [OB67] and MC-PostServo [OB95]
- Using multiple encoders (S7-1500T)

Synchronous operation functions (S7-1500T)

- Cam technology object (S7-1500T)
- Gearing with "MC_GearInPos" (S7-1500T)
- Camming with "MC_CamIn" (S7-1500T)

Measuring input and output cam functions

- Technology object measuring input
- Output cam technology object
- Cam track technology object

Using versions 6

6.1 Overview of versions

With S7-1500 Motion Control, the version of the technology also defines the version of the technology objects and of the Motion Control instructions. Only one technology version can be operated on a CPU. The overview shown below includes S7-1500 and S7-1500T.

An overview of technology versions V1.0 and V2.0 is available here (Page 63).

CPU firmware version and technology version

The following table shows which technology version is available as of which firmware version of the CPU.

CPU firmware version[1]	V10.0	V9.0	V8.0	V7.0	V6.0	V5.0	V4.0	V3.0
V4.1[4]	✓	✓	✓	✓	-	-	-	-
V4.0[4]	-	✓	✓	✓	-	-	-	-
V3.1[2][3]	-	-	✓	✓	✓	✓	✓	✓
V3.0[2][3]	-	-	-	✓	✓	✓	✓	✓
V2.9[2]	-	-	-	-	✓	✓	✓	✓
V2.8	-	-	-	-	-	✓	✓	✓
V2.5, V2.6	-	-	-	-	-	-	✓	✓
V2.0, V2.1	-	-	-	-	-	-	-	✓

1) The following applies analogously to the CPU firmware of the software controller: V3.0 ≙ V30.0, V3.1 ≙ 30.1, V4.0 ≙ V40.0, ...

2) The CPUs 1518T-4 PN/DP and 1518TF-4 PN/DP only support technology versions as of V6.0.

3) The CPUs with article number *03-0AB0 support technology versions as of V7.0.

4) The following CPUs support the technology versions as of V9.0: S7-1500 CPUs with article number *10-0AB0 (with the exception of SIMATIC Drive Controller); Software Controller as of firmware version V40.0; Open Controller S7-1515SP PC3

Technology objects of a technology version

The following table shows as of which technology version a technology object is available.

Technology object	V10.0	V9.0	V8.0	V7.0	V6.0	V5.0	V4.0	V3.0
Speed axis	✓	✓	✓	✓	✓	✓	✓	✓
Positioning axis	✓	✓	✓	✓	✓	✓	✓	✓
External encoder	✓	✓	✓	✓	✓	✓	✓	✓
Synchronous axis	✓	✓	✓	✓	✓	✓	✓	✓
Measuring input	✓	✓	✓	✓	✓	✓	✓	✓
Output cam	✓	✓	✓	✓	✓	✓	✓	✓

Technology object	V10.0	V9.0	V8.0	V7.0	V6.0	V5.0	V4.0	V3.0
Cam track	✓	✓	✓	✓	✓	✓	✓	✓
"TO_Cam" cam (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	✓
"TO_Cam_10k" cam (S7-1500T)	✓	✓	✓	✓	✓	-	-	-
"TO_Cam_600Seg" cam (S7-1500T)	✓	✓	-	-	-	-	-	-
"TO_Cam_6kSeg" cam (S7-1500T)	✓	✓	-	-	-	-	-	-
Leading axis proxy (S7-1500T)	✓	✓	✓	✓	✓	✓	-	-
Kinematics (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-
Interpreter (S7-1500T)	✓	✓	✓	-	-	-	-	-
Interpreter program (S7-1500T)	✓	✓	✓	-	-	-	-	-
Interpreter mapping (S7-1500T)	✓	✓	✓	-	-	-	-	-

S7-1500 Motion Control instructions

The following table shows from which technology version a Motion Control instruction is available.

Instructions	V10.0	V9.0	V8.0	V7.0	V6.0	V5.0	V4.0	V3.0
MC_Power	✓	✓	✓	✓[1)]	✓	✓	✓	✓
MC_Reset	✓	✓	✓[1)]	✓	✓	✓[1)]	✓	✓
MC_Home	✓	✓	✓	✓[1)]	✓	✓[1)]	✓	✓
MC_Halt	✓	✓[1)]	✓	✓	✓	✓	✓[1)]	✓[1)]
MC_HaltSuperimposed	✓	✓	✓	✓	-	-	-	-
MC_MoveAbsolute	✓	✓[1)]	✓	✓	✓	✓	✓[1)]	✓[1)]
MC_MoveRelative	✓	✓[1)]	✓	✓	✓	✓	✓[1)]	✓
MC_PositionProfile (S7-1500T)	✓	-	-	-	-	-	-	-
MC_MoveVelocity	✓	✓	✓	✓	✓	✓	✓[1)]	✓
MC_MoveJog	✓	✓	✓	✓	✓	✓	✓[1)]	✓
MC_MoveSuperimposed	✓	✓	✓	✓	✓	✓	✓[1)]	✓
MC_SetSensor (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	✓
MC_Stop	✓	✓	✓	✓	✓	✓	-	-
MC_SetAxisSTW	✓	✓	✓	✓	✓	✓	-	-
MC_WriteParameter	✓	✓[1)]	✓	✓[1)]	✓	✓	-	-

1) Instruction revised in the version

2) Can only be used as of firmware version V2.8.2

Instructions	V10.0	V9.0	V8.0	V7.0	V6.0	V5.0	V4.0	V3.0
MC_SaveAbsoluteEncoder-Data	✓	✓	✓	✓	-	-	-	-
MC_MeasuringInput	✓	✓	✓	✓	✓	✓	✓	✓
MC_MeasuringInputCyclic	✓	✓	✓	✓	✓	✓	✓	✓
MC_AbortMeasuringInput	✓	✓	✓	✓	✓	✓	✓	✓
MC_OutputCam	✓	✓	✓	✓	✓	✓	✓	✓
MC_CamTrack	✓	✓	✓	✓	✓	✓	✓	✓
MC_GearIn	✓	✓	✓	✓	✓	✓	✓	✓[1]
MC_GearInPos (S7-1500T)	✓	✓[1]	✓	✓	✓	✓[1]	✓	✓
MC_GearInVelocity (S7-1500T)	✓	✓	✓	✓	-	-	-	-
MC_PhasingRelative (S7-1500T)	✓	✓	✓	✓	✓[1]	✓	✓	✓
MC_PhasingAbsolute (S7-1500T)	✓	✓	✓	✓	✓[1]	✓	✓	✓
MC_OffsetRelative (S7-1500T)	✓	✓	✓	✓	✓	-	-	-
MC_OffsetAbsolute (S7-1500T)	✓	✓	✓	✓	✓	-	-	-
MC_CamIn (S7-1500T)	✓	✓[1]	✓	✓[1]	✓[1]	✓[1]	✓[1]	✓
MC_SynchronizedMotion-Simulation (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	✓
MC_GearOut (S7-1500T)	✓	✓	✓	✓	✓	-	-	-
MC_CamOut (S7-1500T)	✓	✓	✓	✓	✓	-	-	-
MC_LeadingValueAdditive (S7-1500T)	✓	✓	✓	✓	✓	✓	-	-
MC_InterpolateCam (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	✓
MC_GetCamLeadingValue (S7-1500T)	✓	✓	✓[1]	✓	✓	✓	✓	✓
MC_GetCamFollowing-Value (S7-1500T)	✓	✓[1]	✓[1]	✓	✓	✓	✓	✓
MC_GetCamFollowing-ValueCyclic (S7-1500T)	✓	✓[1]	✓	-	-	-	-	-
MC_CopyCamData (S7-1500T)	✓	✓	✓	✓	✓	-	-	-
MC_SetCamRangeScaling (S7-1500T)	✓	-	-	-	-	-	-	-
MC_MotionInVelocity (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-
MC_MotionInPosition (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-

1) Instruction revised in the version

2) Can only be used as of firmware version V2.8.2

Instructions	V10.0	V9.0	V8.0	V7.0	V6.0	V5.0	V4.0	V3.0
MC_MotionInSuper-imposed (S7-1500T)	✓	✓	✓	✓	-	-	-	-
MC_MotionInSuper-imposedAxes (S7-1500T)	✓	-	-	-	-	-	-	-
MC_TorqueAdditive	✓	✓	✓	✓	✓	✓	✓	-
MC_TorqueRange	✓	✓	✓	✓	✓	✓	✓	-
MC_TorqueLimiting	✓	✓	✓	✓	✓	✓	✓	✓
MC_GroupInterrupt (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-
MC_GroupContinue (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-
MC_GroupStop (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-
MC_MoveLinearAbsolute (S7-1500T)	✓	✓	✓	✓[1]	✓	✓	✓	-
MC_MoveLinearRelative (S7-1500T)	✓	✓	✓	✓[1]	✓	✓	✓	-
MC_MoveCircularAbsolute (S7-1500T)	✓	✓	✓	✓[1]	✓	✓	✓	-
MC_MoveCircularRelative (S7-1500T)	✓	✓	✓	✓[1]	✓	✓	✓	-
MC_MoveDirectAbsolute (S7-1500T)	✓	✓	✓	✓[1]	✓	✓	-	-
MC_MoveDirectRelative (S7-1500T)	✓	✓	✓	✓[1]	✓	✓	-	-
MC_TrackConveyorBelt (S7-1500T)	✓	✓	✓[1]	✓	✓	✓[2]	-	-
MC_KinematicsMotion-Simulation (S7-1500T)	✓	✓	✓	✓	✓	-	-	-
MC_DefineWorkspaceZone (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-
MC_DefineKinematicsZone (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-
MC_SetWorkspaceZone-Active (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-
MC_SetWorkspaceZone-Inactive (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-
MC_SetKinematicsZone-Active (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-
MC_SetKinematicsZone-Inactive (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-
MC_DefineTool (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-

1) Instruction revised in the version

2) Can only be used as of firmware version V2.8.2

Instructions	V10.0	V9.0	V8.0	V7.0	V6.0	V5.0	V4.0	V3.0
MC_SetTool (S7-1500T)	✓	✓	✓	✓	✓	✓	✓	-
MC_SetOcsFrame (S7-1500T)	✓	✓	✓	✓[1]	✓	✓	✓	-
MC_KinematicsTransform-ation (S7-1500T)	✓	✓	✓	✓[1]	✓	✓	-	-
MC_InverseKinematics-Transformation (S7-1500T)	✓	✓	✓	✓[1]	✓	✓	-	-
MC_LoadProgram (S7-1500T)	✓	✓	✓	-	-	-	-	-
MC_RunProgram (S7-1500T)	✓	✓	✓	-	-	-	-	-
MC_StopProgram (S7-1500T)	✓	✓	✓	-	-	-	-	-

1) Instruction revised in the version

2) Can only be used as of firmware version V2.8.2

6.2 Replacing devices

You can replace an S7-1500 for an S7-1500T of the same design and vice versa. The behavior with respect to functions and the existing configuration is different depending on what is being replaced.

- S7-1500 ⇒ S7-1500T

  The functions of the S7-1500 are expanded to include additional parameters for the extended functions of the S7-1500T. The additional parameters are preassigned with default values and must be configured appropriately.

- S7-1500T ⇒ S7-1500
  - Extended functions are only supported by an S7-1500T and are no longer available after a replacement with S7-1500.
  - Unsupported function blocks are marked.
  - Unsupported technology objects are displayed in an error message after compilation and must be deleted.

6.3 Upgrade technology version

To use all the advantages of a new technology version, you need to change the technology version of existing projects for a CPU.

There are two ways of changing the technology version of a CPU:

- Changing the version of the Motion Control instructions
- Adding a technology object with an alternative version

The version of a technology object or a Motion Control instruction is indicated in the properties of the technology object in the "General > Information" tab, "Version" field.

The technology objects and Motion Control instructions are only converted to the selected version of the technology during compilation.

Changing the version of the motion control instructions

Requirement: The firmware of the CPU supports the required technology version.

To change the version of the motion control instructions, proceed as follows:

1. Open the program editor (e.g. by opening the OB1).
2. In the "Instructions" task card, select the higher technology version in the "Technology > Motion control" folder.

   The invalid technology objects and Motion Control instructions are highlighted in red after the CPU is replaced.
3. Save and compile the project.

   The version of the technology objects and Motion Control instructions is changed to the appropriate higher technology version during the project compile.

   Pay attention to any error information that is displayed during compilation. Deal with the causes of the errors indicated.
4. Check the configuration of the technology objects.
5. Take into consideration the notes on upgrading to a technology version, including those on the skipped versions.

Result: You have upgraded the technology version of the CPU.

6.4 Upgrade to technology version V10.0

Permissible following error - changes to the default values

As of technology version V10.0, the following default values for the permissible following error for the rotary axis have been updated:

- <TO>.FollowingError.MinValue: 30°
- <TO>.FollowingError.MaxValue: 360°

You handle compatibility between versions as follows:

- After upgrading to technology version V10.0, the existing default values or the configured values remain unchanged.
- When changing to an older technology version, the values set in V10.0 are retained.

Configuration of the "6-axis articulated arm with central wrist" kinematics type

As of technology version V10.0, the configuration of the kinematics type "6-axis articulated arm with central wrist" has been extended by the parameter Length L6 (<TO>.Kinematics.Parameter[7]).

After upgrading to technology version V10.0, the length L6 has the default value (0.0).

When upgrading to a technology version <V10.0, the configured Length L6 value is not considered.

Actual value extrapolation in synchronous operation

If the effective extrapolation time is zero, the actual value extrapolation is omitted.

Up to technology version V9.0, the positioning filter and the velocity filter are inactive in this case.

As of technology version V10.0, the filtered actual values are evaluated with the hysteresis and used as the leading value.

Cross-PLC synchronous operation

Note the compatible leading value telegram versions for cross-PLC synchronous operation.

Leading value telegram version 2

If you upgrade the technology version V8.0 to the technology version V10.0, the leading value telegram version 2 is used automatically.

To make the leading value of the leading value telegram version 1 available, proceed as follows:

1. Open the "Technology object > Configuration > Leading value settings" configuration window of the leading axis.
2. To show rows 2 to 32 in the table in the "Provision of leading value" area, select the "Show all transfer areas" check box.
3. To use the leading value telegram version 1, clear the check box of the corresponding transfer area in the "Leading value telegram V2" table column.

   The leading value telegram version depends on the technology version of the receiver.

6.5 Upgrading to technology version V9.0

Dynamic reserve for dynamics changes during conveyor tracking

After the upgrade to technology version V9.0, the default or configured dynamic reserve (<TO>.Conveyor.DynamicReserve[1..1]) is applied as dynamic reserve for the object coordinate systems 1 to 3 (<TO>.Conveyor.DynamicReserve[1..3]). If you are using conveyor tracking, check and configure a sufficient dynamic reserve for all object coordinate systems.

On a change from technology version V9.0 to technology version V8.0, the settings for the dynamic reserve of OCS2 and OCS3 (<TO>.Conveyor.DynamicReserve[2, 3]) are lost. The default or configured dynamic reserve of OCS1 (<TO>.Conveyor.DynamicReserve[1]) is effective for all three object coordinate systems in technology version V8.0.

Cross-PLC synchronous operation

Note the compatible firmware and technology versions for cross-PLC synchronous operation.

6.6 Upgrading to technology version V8.0

Blending behavior during conveyor tracking

After upgrading to technology version 8.0, blending is possible for the following motions:

- In a motion job that desynchronizes the TCP from the tracked OCS
- From a motion job that synchronizes the TCP with the tracked OCS to the subsequent motion job in the tracked OCS

To maintain compatibility with technology version ≤ V7.0, parameterize the motion transition on the following job with "BufferMode" = 1. The current motion job is then not blended.

If you want to blend the current motion job, parameterize the motion transition on the following job with "BufferMode" = 2 or 5 and parameterize the blending distance "TransitionParameter[1]".

Dynamic adaptation during conveyor tracking

Activate the Dynamic adaptation during the conveyor tracking by setting the value for "DynamicAdaption" to "1" or "2" on the motion job. Alternatively, configure the default setting on the technology object by setting the "<TO>.DynamicDefaults.DynamicAdaption" tag to "1" or "2" and specifying the value "-1" on the motion job.

Also configure the dynamic range reserve (<TO>.Conveyor.DynamicReserve).

Newly designed mode of the virtual axis

In technology version V8.0, the behavior of the virtual axis has been changed. The behavior of a virtual axis is no longer identical to the behavior of an axis in simulation. The setpoints are directly adopted as actual values with an application cycle delay. Further configurations do not affect the calculation of the actual values.

To maintain compatibility with virtual axes of technology versions ≤ V7.0 for an axis, switch the axis to simulation (<TO>.Simulation.Mode = 1) and deactivate the virtual axis (<TO>.VirtualAxis.Mode = 0).

Organization blocks for Motion Control in software units

When upgrading existing TIA projects, the names of the organization blocks for Motion Control are retained. To use the organization blocks in software units, you must change the names manually according to the IEC 61131-3 naming convention.

6.7 Upgrading to technology version V7.0

Extend default Motion Control instructions for kinematics movements and transformation information

Extend the ARRAY [1..4] OF LREAL to ARRAY [1..6] OF LREAL for target coordinates at the Motion Control instructions for kinematics movements and for the default at the Motion Control instructions for transformation information. The parameters have been extended at the instructions for programming kinematics with more than four kinematics axes. As the same instructions are used for programming kinematics with up to four kinematics axes, you must extend the array. To program kinematics with up to four kinematics axes, parameterize array elements 5 and 6 with "0.0".

The following parameters of the instructions have been extended to six elements:

Instruction	Parameters	Technology version	
		≤ V6.0	V7.0
MC_MoveLinearAbsolute	Position	ARRAY [1..4] OF LREAL	ARRAY [1..6] OF LREAL
MC_MoveLinearRelative	Distance		
MC_MoveCircularAbsolute	EndPoint		
MC_MoveCircularRelative	EndPoint		
MC_MoveDirectAbsolute	Position		
MC_MoveDirectRelative	Distance		
MC_KinematicsTransformation	AxesPosition		
	AxesVelocity		
	AxesAcceleration		
MC_InverseKinematicsTransformation	Position		
	Velocity		
	Acceleration		

Upgrading data types with user-defined transformation

When upgrading to technology version V7.0, the "TO_Struct_TransformationAxisData_V1" and "TO_Struct_TransformationCartesianData_V1" data types are automatically upgraded in the "TransformationParameter" system data block.

Manually update the following data types to V2 at all points of use in the project:

Technology version	
≤ V6.0	**V7.0**
TO_Struct_TransformationAxisData_V1	TO_Struct_TransformationAxisData_V2
TO_Struct_TransformationCartesianData_V1	TO_Struct_TransformationCartesianData_V2
REF_TO TO_Struct_TransformationParameter_V1	REF_TO TO_Struct_TransformationParameter_V2

Disabling system performance improvement for user-defined kinematics

When the technology version is upgraded to V7.0, system performance improvement for motion preparation of the kinematics technology object is enabled.

If you are using user-defined kinematics, clear the "Improve system performance" check box in the MC-LookAhead [OB97] properties under "General > Multi-core processor".

6.8 Upgrade to technology version V3.0 to V6.0

Upgrading to technology version V6.0

Using "DB_ANY" data type with the cam technology object

On motion control instructions from technology version V6.0, direct assignment of the "DB_ANY" data type at the "Cam" parameter results in an access error. Due to this access error, the CPU changes to the "STOP" state.

Use a data type conversion function for the cam technology object of the type "TO_Cam" or "TO_Cam_10k". A description of the procedure can be found in the section "Parameter transfer for function blocks (Page 126)".

Upgrading to technology version V5.0

Version-dependent organization block "MC-LookAhead [OB97]"

If you switch from technology version V4.0 to ≥ V5.0, an "MC-LookAhead [OB97]" organization block (OB) is automatically created.

When switching from technology version V4.0 to ≥ V5.0, you still have the same options as with a technology version V4.0.

If you use multiple kinematics, only one "MC-LookAhead [OB97]" OB is used for all kinematics used. In the "MC-LookAhead [OB97]" OB, the motion formatting of the kinematics technology object is calculated.

Upgrading to technology version V4.0

Version-based UDT names

The following table shows the version-based UDT names for the control words and status words of the SIEMENS telegrams 10x:

UDT name < V4.0	UDT name ≥ V4.0	WORD data type
PD_STW1	PD_STW1_611Umode	Control word 1 (STW1)
PD_STW2	PD_STW2_611Umode	Control word 2 (STW2)
PD_ZSW1	PD_ZSW1_611Umode	Status word 1 (ZSW1)
PD_ZSW2	PD_ZSW2_611Umode	Status word 2 (ZSW2)

If you switch from technology version < V4.0 to ≥ V4.0 or vice versa, an error occurs during the compilation. You have to adapt the UDT names manually.

Upgrading to technology version V3.0

Tags of the technology object

Starting from technology version V3.0, all input and output addresses are specified using data type "VREF". This results in the following changes to the tags of the technical object:

Tag of technology object	Changes starting from V3.0
<TO>.Actor.Interface.AddressIn	Data type: VREF
<TO>.Actor.Interface.AddressOut	Data type: VREF
<TO>.Sensor[1..4].Interface.AddressIn	Data type: VREF
<TO>.Sensor[1..4].Interface.AddressOut	Data type: VREF
<TO>.Actor.Interface.EnableDriveOutputAddress	Data type: VREF
<TO>.Actor.Interface.EnableDriveOutputBitNumber	Tag eliminated
<TO>.Actor.Interface.DriveReadyInputAddress	Data type: VREF
<TO>.Actor.Interface.DriveReadyInputBitNumber	Tag eliminated
<TO>.Sensor[1..4].ActiveHoming.DigitalInputAddress	Data type: VREF
<TO>.Sensor[1..4].ActiveHoming.DigitalInputBitNumber	Tag eliminated
<TO>.Sensor[1..4].PassiveHoming.DigitalInputAddress	Data type: VREF
<TO>.Sensor[1..4].PassiveHoming.DigitalInputBitNumber	Tag eliminated
<TO>.PositionLimits_HW.MinInputAddress	Data type: VREF
<TO>.PositionLimits_HW.MinInputBitNumber	Tag eliminated
<TO>.PositionLimits_HW.MaxInputAddress	Data type: VREF
<TO>.PositionLimits_HW.MaxInputBitNumber	Tag eliminated

6.9 Technology versions V1.0 and V2.0

CPU FW and technology versions V1.0 and V2.0

The following table shows which version of the technology is available as of which FW version of CPU.

CPU FW	V2.0	V1.0
V1.6 or higher	✓	-
V1.5	-	✓
V1.1	-	✓
V1.0	-	✓

When changing to a CPU ≥ V1.6, you must change the technology version accordingly. Card replacement from a CPU < V1.6 to a ≥ CPU V1.6 is supported. In the TIA Portal, you can use a CPU ≥ 1.6 only to work on projects with a correspondingly higher technology version.

Technology objects in the technology versions V1.0 and V2.0

The user interface no longer supports technology objects of Technology versions V1.0 and V2.0. You cannot create new technology objects of these versions. You also cannot change back to these technology objects after upgrading them. Existing technology objects of these versions in the project can continue to be used.

The following table shows as of which technology version a technology object is available.

Technology object	V2.0	V1.0
Speed axis	✓	✓
Positioning axis	✓	✓
External encoder	✓	✓
Synchronous axis	✓	-

S7-1500 Motion control instructions in the technology versions V1.0 and V2.0

The following table shows from which technology version a Motion Control instruction is available.

Instructions	V2.0	V1.0
MC_Power	✓	✓
MC_Reset	✓	✓
MC_Home	✓[1]	✓
MC_Halt	✓	✓
MC_MoveAbsolute	✓	✓
MC_MoveRelative	✓	✓

1) Instruction revised in the version

Instructions	V2.0	V1.0
MC_MoveVelocity	✓	✓
MC_MoveJog	✓	✓
MC_MoveSuperimposed	✓	-
MC_GearIn	✓	-

1) Instruction revised in the version

Innovations V2.0

Technology Version V2.0 contains the following new features:

- Standardization of the "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control
- Simulation mode
- Support of safety functions of the drive

Upgrading to Technology version V2.0

Parameter "Mode" of the Motion Control instruction "MC_Home"

The "MC_Home.Mode" parameter for S7-1200 Motion Control and S7-1500 Motion Control has been standardized within the framework of technology version V2.0. This results in a new assignment of the parameter values for the "MC_Home.Mode" parameter.

The table below shows a comparison of the "MC_Home.Mode" parameter for technology V1.0 and ≥ V2.0:

MC_Home.HomingMode V1.0	Parameter value	MC_Home.Mode ≥ V2.0
Direct homing (absolute)	0	Direct homing (absolute)
Direct homing (relative)	1	Direct homing (relative)
Passive homing	2	Passive homing (without reset)
Passive homing (with configured home position)	3	Active homing
Active homing	4	Reserved
Active homing (with configured home position)	5	Active homing (with configured home position)
Absolute encoder adjustment (relative)	6	Absolute encoder adjustment (relative)
Absolute encoder adjustment (absolute)	7	Absolute encoder adjustment (absolute)
Passive homing (without reset)	8	Passive homing
Abort passive homing	9	Abort passive homing
-	10	Passive homing (with configured home position)

You can find additional information about the "MC_Home.Mode" parameter in the description of the Motion Control instruction "MC_Home".

Resetting the "Mode" parameter of the Motion Control instruction "MC_Home"

When you upgrade the technology version from V1.0 to ≥ V2.0, the "MC_Home.HomingMode" parameter (V1.0) is then renamed to "MC_Home.Mode" (≥ V2.0). The assignment of the parameter values is changed as well.

To reset the "MC_Home.Mode" parameter (V2.0), follow these steps:

1. To change the technology version, follow the instructions given above.

   When compiling the project, the "MC_Home.HomingMode"parameter (V1.0) is renamed to "MC_Home.Mode" (≥ V2.0):

   – The assignment of the parameter values is changed.

     You can find additional information about the "MC_Home.Mode" parameter in the description of the Motion Control instruction "MC_Home".

   – The value configured at the "MC_Home.HomingMode" parameter (V1.0) is lost. As a note on renaming, the following text is entered as the parameter value in the "MC_Home.Mode" parameter (≥ V2.0).

     "The interface has changed. You can find additional information in the description of the Motion Control instruction MC_Home".

   – There is a message in the "Info > Compile" tab in the Inspector window stating that the operand has the wrong data type.

2. Change the value of the "MC_Home.Mode" parameter (≥ V2.0) in your user program according to the new assignment.

3. Save and compile the project.

Configuring 7

7.1 Basics on the configuration of technology objects

7.1.1 Add technology object

The following describes how to add a technology object in the project tree.

Requirements

- A project with a CPU S7-1500/S7-1500T is created.
- The CPU supports the required technology object.
- For a lower-level technology object, the higher-level technology object must have been created.

Procedure

To add a technology object, follow these steps:

1. Open the CPU's folder in the project navigator.
2. Open the "Technology Objects" folder.
3. Double-click "Add new object".

   The "Add new object" dialog opens.
4. Select the required technology object. You can infer the function of the technology object from the displayed description.
5. If you add output cams, cam tracks, measuring inputs to a technology object, select the higher-level technology object in the "Axis or external encoder that is to be assigned".
6. In the "Name" input field, adapt the name to your requirements.
7. To change the suggested data block number, select the "Manual" option.
8. To add your own information about the technology object, click "Additional information".
9. To open the configuration after adding the technology object, select the "Add new and open" check box.
10. When adding a "Interpreter" technology object, you can select a "Select kinematics" technology object from the drop-down list under "Kinematics (optional)". Upon addition, the Interpreter technology object is assigned to the selected "Kinematics" technology object.
11. To add the technology object, click "OK".

Result

The new technology object was created and created in the "Technology objects" folder in the project tree.

If the "MC_Servo" and "MC_Interpolator" organization blocks were not yet present, they were added.

When adding the "Kinematics" or "Interpreter" technology objects, the "MC_LookAhead" organization block is also added.

7.1.2 Copy technology object

You can copy a technology object in the following ways:

- Copying a technology object within a CPU
- Copying a technology object from a CPU S7-1500 to a CPU S7-1500T

  Additional parameters for the extended functions are preset with default values. You must configure them appropriately.
- Copying a technology object from a CPU S7-1500T to a CPU S7-1500

  Additional parameters, which are not supported by the CPU S7-1500, are reset to the default values.
- Copying a Kinematics technology object with an assigned Interpreter technology object
  - When you copy a Kinematics technology object with an assigned Interpreter technology object, the link to the Interpreter technology object is also copied. Note that an interpreter technology object can be assigned to only one kinematics technology object. In one of the Kinematics technology objects, remove the assignment to the Interpreter technology object.
  - When you copy a Kinematics technology object with an assigned Interpreter technology object to a different S7-1500T CPU, the link to the Interpreter technology object is also copied. If there is a technology object with the same name, Interpreter, in the other CPU, the link points to it. Otherwise, the link is without a target.

When you copy a technology object that has lower-level technology objects such as output cams, cam tracks or measuring inputs, the lower-level technology object are also copied.

The following describes how to copy a technology object within a CPU. The procedure also applies accordingly to the other copying methods mentioned.

Requirement

- You have created an technology object in the project.

Procedure

To copy a technology object, follow these steps:

1. Open the CPU's folder in the project navigator.
2. Open the "Technology Objects" folder.
3. If necessary, open the higher-level technology object.

4. Select the technology object to be copied.
5. To also copy the technology objects connected to a technology object, such as axes on a Kinematics technology object, select them as well. To select multiple axes, press and hold down the <Ctrl> key.
6. Select "Copy" in the shortcut menu.
7. Select the "Technology objects" folder or the higher-level technology object.
8. Select "Paste" in the shortcut menu.

Result

The selected technology object, including lower-level technology objects, has been copied and created in the "Technology objects" folder of the project tree.

7.1.3 Delete technology object

You can delete technology objects in the project tree.

When you delete a technology object that has lower-level technology objects such as output cams, cam tracks or measuring inputs, the lower-level technology object are also deleted.

Requirement

- You have created an technology object in the project.

Procedure

To delete a technology object, follow these steps:

1. Open the CPU's folder in the project navigator.
2. Open the "Technology objects" folder.
3. If necessary, open the higher-level technology object.
4. Select the technology object to be deleted.
5. Select the "Delete" command in the shortcut menu.

   The "Confirm delete" dialog is opened.
6. To delete the technology object, click "Yes".

Result

The selected technology object has been deleted.

Lower-level technology objects of the deleted technology object are deleted.

Technology objects connected with the technology object remain intact after deletion, for example, linked axes to the Kinematics technology object.

Links to a technology object remain as links without a target after deletion of the technology object.

7.1.4 Group technology objects

You can create subfolders (groups) within the "Technology objects" folder. You use these subfolders to structure your technology objects. Only the technology objects in the subfolders are relevant to the process, not the folders themselves. Groups of technology objects behave in the same way as groups of program blocks.

When copying or deleting a group, all technology objects contained in it are copied or deleted.

The online/offline comparison only shows differences at the technology object, but not that the technology objects are in different groups.

7.1.5 Working with the configuration editor

You configure the properties of a technology object in the configuration window. To open the configuration window of the technology object in the project view, follow these steps:

1. Open the device "Technology objects" group in the project navigator.
2. Select the technology object and double-click on "Configuration".

The configuration is divided into categories which depend on the object type, for example, basic parameters, hardware interface, extended parameters.

Configuration editor icons

Icons in the area navigation of the configuration show additional details about the status of the configuration:

Symbol	Description
	The configuration contains default values and is complete. The configuration contains only default values. With these default values you can use the technology object without additional changes.
	The configuration contains user-defined or automatically adapted values and is complete. All input fields of the configuration contain valid values and at least one preset value has been changed.
	The configuration is incomplete or incorrect. At least one input field or drop-down list contains an invalid value. The corresponding field or the drop-down list is displayed on a red background. Click the field shows you the roll-out error message that indicates the cause of error.

7.1.6 Toolbar of the configuration

The following functions are available in the toolbar of the function view:

Symbol	Function	Explanation
	Show online values	Displays the current values read back from the CPU.
	Couples the function view and parameter view for the objects selected in the navigation	Enables the targeted toggling between the parameter view and function-based view.
	Collapse/expand all nodes and objects	Collapses or expands all nodes and objects of the navigation or the data structure in the currently active view.
	Collapse/expand the nodes below the marked node	Collapses or expands the marked nodes and objects of the navigation or the data structure in the currently active view.

7.2 Compare values

If an online connection to the CPU is available, the "Monitor all" function appears in the configuration of the technology object.

The "Monitor all" function provides the following options:

- Comparison of configured start values of the project with the start values in the CPU and the actual values
- Direct editing of actual values and the start values of the project
- Immediate detection and display of input errors with suggested corrections
- Backup of actual values in the project
- Transfer of start values of the project to the CPU as actual values

NOTE

Differences between online and offline values

By adding or deleting technology objects that have a connection to other technology objects, such as cams, cam tracks, measuring inputs or synchronous axes, differences can occur when online and offline values are compared. These differences can be eliminated by re-compiling the project and then uploading it to the CPU.

Icons and operator controls

If there is an online connection to the CPU, the actual values are displayed at the parameters.

In addition to the actual values of the parameters, the following symbols appear:

Symbol	Description
	Start value in CPU matches the configured start value in project
	Start value in CPU does not match the configured start value in project

Symbol	Description
	Software difference in lower-level component: The online and offline versions differ in at least one lower-level software component.
	The comparison of the Start value in CPU with the configured start value in project cannot be performed.
	Comparison of the online and offline values is not advisable.
	Use this button to show the start value of the CPU and the start value of the project for the respective parameter.

You can change the start value of the CPU directly and then download it to the CPU. With directly changeable parameters, the actual value can also be changed and the change is transferred immediately to the CPU.

7.3 Working with the parameter view

The Parameter view provides you with a general overview of all relevant parameters of a technology object. You obtain an overview of the parameter settings and can easily change them in offline and online mode.

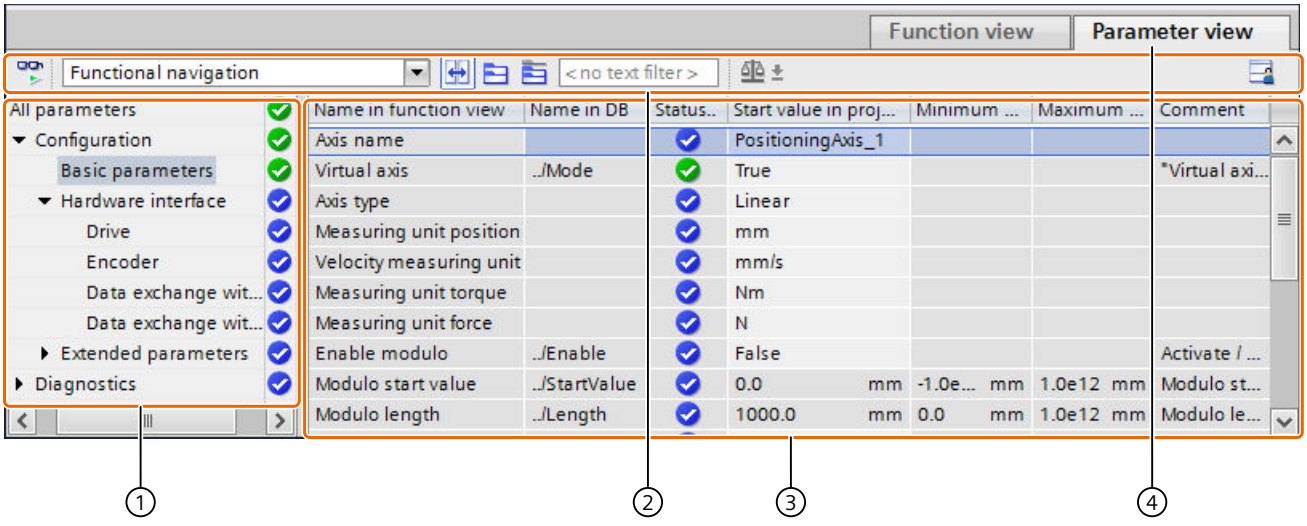

① Navigation (Page 73)

② Toolbar (Page 72)

③ Parameter table (Page 74)

④ "Parameter view" tab

Function scope

The following functions are available for analyzing the parameters of the technology objects and for enabling targeted monitoring and modification.

Display functions:

- Display of parameter values in offline and online mode
- Display of status information of the parameters
- Display of value deviations and option for direct correction

- Display of configuration errors
- Display of value changes as a result of parameter dependencies
- Display of all memory values of a parameter: Start value PLC, Start value in project, Monitor value
- Display of the parameter comparison of the memory values of a parameter

Operator control functions:

- Navigation for quickly changing between the parameters and parameter structures
- Text filter for faster searches for particular parameters
- Sorting function for customizing the order of parameters and parameter groups to requirements
- Memory function for backing up structural settings of the Parameter view
- Monitoring and modifying of parameter values online
- Saving a snapshot of parameter values of the CPU in order to capture momentary situations and to respond to them
- Applying a snapshot of parameter values as start values
- Download of modified start values to the CPU
- Comparison functions for comparing parameter values with one another

7.3.1 Structure of the parameter view

7.3.1.1 Toolbar of the parameter view

The following functions can be selected in the toolbar of the parameter view.

Symbol	Function	Explanation
	Monitor all	Starts monitoring of the visible tags in the active table.
Functional navigation	Select navigation structure	Toggle between function-based navigation and the view of the data structure of the technology data block.
	Couples the function view and parameter view for the objects selected in the navigation	Enables the targeted toggling between the parameter view and function-based view.
	Collapse/expand all nodes and objects	Collapses or expands all nodes and objects of the navigation or the data structure in the currently active view.
	Collapse/expand the nodes below the marked nodes	Collapses or expands the marked nodes and objects of the navigation or the data structure in the currently active view.

Symbol	Function	Explanation
<Select filter>	Text filter...	After entry of a character string: Display of all parameters containing the entered string in one of the currently visible columns.
	Selection of compare values	Selection of parameter values that are to be compared with one another in online mode (Start value in project, Start value PLC) Only in online mode.
	Save window settings	Saves your display settings for the Parameter view (e.g. selected navigation structure, activated table columns, etc.)

7.3.1.2 Navigation

Within the "Parameter view" tab, the following alternative navigation structures can be selected.

Navigation		Explanation
Functional navigation	All parameters Configuration Basic parameters Hardware interface Drive Encoder	In the functional navigation, the structure of the parameters is based on the structure in the configuration window ("Function view" tab), commissioning window and diagnostics window.
Data structure	Velocity Acceleration ActualSpeed VelocitySetpoint Actor Type	In the "Data structure" navigation, the structure of the parameters is based on the structure of the technology data block.

You can use the "Select navigation structure" drop-down list to toggle the navigation structure.

7.3.1.3 Parameter table

The table below shows the meaning of the individual columns of the parameter table. You can show or hide the columns as required.

Column	Explanation	Offline	Online
Name in function view	Name of the parameter in the function view. The display field is empty for parameters that are not configured via the technology object.	✓	✓
Name in DB	Name of the parameter in the technology data block. If the parameter is part of a structure or UDT, the prefix "../" is added. The display field is empty for parameters that are not contained in the technology data block.	✓	✓
Full name in DB	Complete path of the parameter in the instance data block. The display field is empty for parameters that are not contained in the technology data block.	✓	✓
Status of configuration	Display of the completeness of the configuration using status symbols.	✓	-
Compare result	Result of the "Compare values" function. This column is displayed when there is an online connection.	-	✓
Start value in project	Configured start value in project. Error indication if entered values have a syntax or process-related error.	✓	✓
Default value	Value that is pre-assigned to the parameter. The display field is empty for parameters that are not contained in the technology data block.	✓	✓
Start value PLC	Start value in the CPU. This column is displayed when there is an online connection.	-	✓
Monitor value	Current value in the CPU. This column is displayed when there is an online connection.	-	✓
Modify value	Value that is to be used to change the monitor value. This column is displayed when there is an online connection.	-	✓
Minimum value	Minimum process-related value of the parameter. If the minimum value is dependent on other parameters, it is defined: • Offline: by the start value in the project. • Online: by the monitor values.	✓	✓
Maximum value	Maximum process-related value of the parameter. If the maximum value is dependent on other parameters, it is defined: • Offline: by the start value in the project. • Online: by the monitor values.	✓	✓
Setpoint	Designates the parameter as a setpoint. These parameters can be initialized online.	✓	✓
Data type	Data type of the parameter. The display field is empty for parameters that are not contained in the technology data block.	✓	✓

✓ This function is visible in offline/online mode.

- This function is not visible in offline/online mode.

Column	Explanation	Offline	Online
Retain	Designates the value as a retentive value. The values of retentive parameters are retained even after the voltage supply is switched off.	✓	✓
Accessible from HMI	Indicates whether the HMI can access this parameter during runtime.	✓	✓
Visible in HMI	Indicates whether the parameter is visible in the selection list of the HMI by default.	✓	✓
Comment	Brief description of the parameter.	✓	✓

✓ This function is visible in offline/online mode.

- This function is not visible in offline/online mode.

7.3.2 Opening the parameter view

Requirement

The technology object was added in the project navigator.

Procedure

1. Open the "Technology objects" folder in the project tree.
2. Open the technology object in the project tree.
3. Double-click the "Configuration" object.
4. Select the "Parameter view" tab in the top right corner.

Result

The Parameter view opens. Each displayed parameter is represented by one row in the parameter table.

The displayable parameter properties (table columns) vary depending on whether you are working with the Parameter view in offline or online mode.

In addition, you can selectively display and hide individual table columns.

7.3.3 Working with the parameter view

The following table provides an overview of the functions of the Parameter view in online and offline mode described below:

Function/action	Offline	Online
Filtering the parameter table (Page 76)	✓	✓
Sorting the parameter table (Page 77)	✓	✓

✓ This function is possible in offline operation/online operation.

- This function is not possible in offline/online mode.

Function/action	Offline	Online
Indicating errors (Page 77)	✓	✓
Editing start values in the project (Page 78)	✓	✓
Monitoring values online in the parameter view (Page 79)	-	✓
Modifying values (Page 80)	-	✓
Comparing values (Page 81)	-	✓

✓ This function is possible in offline operation/online operation.

- This function is not possible in offline/online mode.

7.3.3.1 Filtering the parameter table

You can filter the parameters in the parameter table in the following ways:

- With the text filter
- With the subgroups of the navigation

Both filter methods can be used simultaneously.

With the text filter

The text filter can only be use on texts in displayed parameter lines and displayed columns.

To work with the text filter, follow these steps:

1. To filter a desired character string, enter it in the "Text filter..." input box.

   The parameter table displays only the parameters containing the character string.

To reset text filtering, the following options are available:

- Select another parameter group in the navigation.
- Switch between data navigation and functional navigation, or vice versa.

With the subgroups of the navigation

To filter the navigation with the subgroups, follow these steps:

1. Click the desired parameter group in the navigation, e.g., "Static".

   The parameter table now only shows the "static" parameters. You can select further subgroups for some groups of the navigation.
2. If all parameters are to be shown again, click "All parameters" in the navigation.

7.3.3.2 Sorting the parameter table

The values of the parameters are arranged in rows. The parameter table can be sorted by any displayed column.

- In columns containing numerical values, sorting is based on the magnitude of the numerical value.
- In text columns, sorting is alphabetical.

Sort column-by-column

1. Position the cursor in the header cell of the desired column.

   The background of this cell turns blue.
2. Click the column header.

Result

The entire parameter table is sorted by the selected column. A triangle with tip facing up appears in the column header.

Clicking the column header again changes the sorting as follows:

Symbol	Description
▲	Parameter table is sorted in ascending order.
▼	Parameter table is sorted in descending order.
No symbol	The sorting is removed again. The parameter table shows the default display.

The "../" prefix in the "Name in DB" column is ignored when sorting.

7.3.3.3 Indicating errors

Error display

Parameter assignment errors that result in compilation errors (e.g. limit violation) are indicated in the Parameter view.

Every time a value is entered in the Parameter view, a check is made for process-related and syntax errors and displayed with the following indicators:

- Red error symbol in the "Status of configuration" (offline mode) or "Compare result" (online mode, depending on the selected comparison type) columns
- Table field with red background

  If you click the bad field, a roll-out error message appears with information of the permissible value range or the required syntax (format)

Compilation error

From the error message of the compiler, you can directly open the Parameter view (functional navigation) containing the parameter causing the error in situations where the parameter is not displayed in the configuration window.

7.3.3.4 Editing start values in the project

With the Parameter view, you can edit the start values in the project in offline mode and online mode.

- You make value changes in the "Project start value" column of the parameter table.
- In the "Status of configuration" column of the parameter table, the progress of the configuration is indicated by the familiar status symbols from the configuration window of the technology object.

Boundary conditions

- If other parameters depend on the parameter whose start value was changed, the start value of the dependent parameters are also adapted.
- If a parameter of a technology object is not editable, it is also not editable in the parameter view. The ability to edit a parameter can also depend on the values of other parameters.

Defining new start values

To define start values for parameters in the Parameter view, follow these steps:

1. Open the Parameter view of the technology object.
2. Enter the desired start values in the "Project start value" column. The value must match the data type of the parameter and must not exceed the value range of the parameter. The limits of the value range can be seen in the "Maximum value" and "Minimum value" columns.

The "Status of configuration" column indicates the progress of the configuration with colored symbols.

Following adaptation of the start values and downloading of the technology object to the CPU, the parameters take the defined value at startup if they are not declared as retentive ("Retain" column).

Error display

When a start value is input, a check is made for process-related and syntax errors and the result is indicated.

Bad start values are indicated by:

- Red error symbol in the "Status of configuration" (offline mode) or "Compare result" (online mode, depending on the selected comparison type) columns

and/or

- Red background in the "Project start value" field
  If you click on the faulty field: a roll-out error message appears with information of the permissible value range or the necessary syntax (format)

Correcting bad start values

1. Correct bad start values using information from the roll-out error message.

   Red error symbol, red field background, and roll-out error message are no longer displayed.

The project cannot be successfully compiled unless the start values are error-free.

7.3.3.5 Monitoring values online in the parameter view

You can monitor the values currently taken by the parameters of the technology object in the CPU (Actual values) directly in the Parameter view.

Requirements

- There is an online connection.
- The technology object is downloaded to the CPU.
- The Parameter view of the technology object is open.

Procedure

As soon as the Parameter view is online, the following columns are additionally displayed:

- Compare result
- PLC start value
- Actual value

The "Actual value" column shows the current parameter values on the CPU.

Display

All columns that are only available online are displayed in color as follows:

Color	Description
	The values are modifiable.
	These values cannot be changed.

See also

Parameter table (Page 74)

7.3.3.6 Modifying values

With the Parameter view, you can modify values of the technology object in the CPU. You can assign values to a parameter once (control value) and modify them immediately. The modify request is executed as quickly as possible without reference to any particular point in the user program.

DANGER

Danger when modifying

Changing the parameter values while the plant is operating may result in severe damage to property and personal injury in the event of malfunctions or program errors.

Make sure that dangerous states cannot occur before you use the "Modify" function.

Requirements

- There is an online connection.
- The technology object is downloaded to the CPU.
- The Parameter view of the technology object is open.
- The parameter is modifiable. (Associated field in the "Actual value" column has a corresponding background color).

Procedure

To modify values immediately, follow these steps:

1. Enter the desired control value in the "Actual value" column of the parameter table.

   The parameter is modified once and immediately with the specified value.

Error display

When a control value is input, a check is made immediately for process-related and syntax errors and the result is indicated.

You can recognize incorrect control values as follows:

- The field "Actual value" is displayed with red background color.
- If you click in the incorrect field, a roll-out error message appears with information on the permissible value range or the necessary syntax.

Bad control values

- Control values with process-related errors can be transmitted.
- Control values with syntax errors cannot be transmitted.

7.3.3.7 Comparing values

You can use comparison functions to compare the following memory values of a parameter:

- Start value in project
- Start value PLC
- Actual value in PLC

Requirements

- There is an online connection.
- The technology object is downloaded to the CPU.
- The Parameter view of the technology object is open.

Procedure

To compare the start values on the various target systems, follow these steps:

1. In the icon , click on the arrow "Select comparison values".

   A selection list containing the comparison options opens:

   – Start value in project / Start value in PLC (default setting)
   – Start value in project / Actual value in PLC
   – Start value in PLC / Actual value in PLC

2. Select the desired comparison option.

   The selected comparison option is carried out immediately:

   – Symbols are used in the "Compare result" column to indicate the result of the comparison of the selected columns.

Symbol in "Compare result" column

Symbol	Meaning
	The compare values are equal and error-free.
	The compare values are not equal and error-free.
	At least one of the two compare values has a process-related or syntax error.
	The comparison cannot be performed. At least one of the two comparison values is not available (e.g. snapshot).

Symbol in the navigation

The symbols are shown in the same way in the navigation if the compare result applies to at least one of the parameters below the displayed navigation structure.

7.4 Configuring technological modules and onboard I/O for Motion Control

Use with Motion Control

You can use technology functions of technology modules and the onboard I/Os of the CPUs listed below with Motion Control technology objects. To use the technology functions for Motion Control, specific parameters of the I/O configuration and parameters of the configuration of the technology object must be configured accordingly. Which parameters are relevant for the function is described below. You can set additional parameters that are not listed here. The description of the parameters is found in the documentation of the respective technology module or the respective CPU.

The following technology modules support Motion Control functionalities:

S7-1500/ET 200MP	ET 200 SP	Possible applications
TM Count 2x24V (Page 84) [1]	TM Count 1x24V (Page 84) [1]	• Position detection for homing with zero mark via PROFIdrive telegram • Position detection with measuring input
TM PosInput 2 (Page 86) [1]	TM PosInput 1 (Page 86) [1]	• Position detection for homing with zero mark via PROFIdrive telegram • Position detection with measuring input
TM Timer DIDQ 16x24V (Page 88) [2]	TM Timer DIDQ 10x24V (Page 88) [2]	• Output of output cam and cam track for time-controlled switching [2] • Time-based position detection via measuring input (time stamp recording) [2]
–	TM Pulse 2x24V (Page 90) [1]	• Drive connection using PWM (pulse width modulation)
TM PTO 4 (Page 93) [3]	TM PTO 2x24V (Page 91) [3]	• Drive connection via PTO (Pulse Train Output) • Position detection with measuring input via PROFIdrive telegram [2] • Position detection for homing with zero mark via PROFIdrive telegram

[1] Automatic data exchange for encoder values is supported

[2] Isochronous mode required

[3] Automatic data exchange for drive and encoder values is supported

The following CPUs support Motion Control functionalities through their onboard I/O:

CPU	Possible applications
CPU 1511C-1 PN/CPU 1512C-1 PN (Page 95) [1]	• Drive connection via PTO (Pulse Train Output) • Drive connection using PWM (pulse width modulation) • Encoder connection via HSC (High-speed counter) • Position detection with measuring input via PROFIdrive telegram [2]
SIMATIC Drive Controller (Page 101)	• Output of output cam and cam track for time-controlled switching [2] • Time-based position detection via measuring input (time stamp recording) [2]

[1] Automatic data exchange for drive and encoder values is supported

[2] Isochronous mode required

Isochronous mode

Isochronous mode is required for use with a measuring input, output cam or cam track.

Technology modules can be used centrally or distributed in the system. Isochronous mode is supported in central operation as well as distributed operation with suitable PROFINET interface modules.

The onboard technology I/Os (X142) of the SIMATIC Drive Controller support clock synchronization.

Automatic data exchange for drive and/or encoder values

By selecting the check box for automatic data exchange, the drive and encoder parameters are automatically applied in the CPU.

Alternatively, you can manually match, by drive and encoder type, the parameters described and identified in the following table.

The following types are available for automatic data exchange:

- **Offline**

  Select the check box if you want to transfer the offline values of the drive or encoder to the configuration of the technology object in the project.

- **Online**

  Select the check box if you want to transfer the effective values online in the drive or encoder to the CPU during runtime. The drive and encoder parameters are transferred from the bus after the (re)initialization of the technology object and (re)start of the drive, encoder or the CPU.

7.4.1 TM Count 1x24V/TM Count 2x24V

For use with Motion Control, the following parameters must be configured:

Configuration	
Technology module **TM Count 1x24V/TM Count 2x24V**	**Technology object** **Axis and external encoder**
TM Count 1x24V/TM Count 2x24V > Channel 0/1 > Operating mode	–
Select "Position detection for Motion Control technology object" operating mode	
TM Count 1x24V/TM Count 2x24V > Channel 0/1 > Module parameters	**Hardware interface > Encoder**
–	Select "Encoder" data connection and the channel configured for Motion Control on the technology module as encoder
Signal type • Incremental encoder	Select encoder type corresponding to configuration for technology module • Incremental [1]
–	**Axis: Hardware interface > Data exchange with encoder** **External encoder: Hardware interface > Data exchange**
	Telegram "Standard telegram 83" is automatically selected after the selection of the encoder.
	Clear the check box "Automatic data exchange for encoder values (online)"
	Select the check box "Automatic data exchange for encoder values (offline)" If the check box is cleared, you can manually match the parameters described and identified in this table.
	Select rotary or linear measuring system type [1]
Signal evaluation • Single • Double • Quadruple	Select fine resolution corresponding to configuration on the technology module [1] • 0 = Single • 1 = Double • 2 = Quadruple
• Rotary type: Enter increments per revolution • Linear type: Configuration not relevant	• Rotary type: Enter increments per revolution corresponding to configuration at technology module (1:1) [1] • Linear type: Enter distance between increments [1]
–	**Axis: Hardware interface > Data exchange with the drive**
• Rotary type: Enter reference speed corresponding to configuration for technology object (1:1) • Linear type: Configuration not relevant	Enter reference speed

[1] Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration for technology module/technology object is required for these parameters

Configuration	
Technology module **TM Count 1x24V/TM Count 2x24V**	**Technology object** **Axis and external encoder**
–	**Homing**
Select the homing signal for homing mark 0: • Signal N of the incremental encoder • DI0	Use the homing mode "Use zero mark via PROFIdrive telegram". **TM Count 1x24V as of V2.0** The states of the digital inputs are displayed in the operating mode "Position detection for Motion Control technology object" in the process image. The following bits are used for this purpose: • STS_DI0 (Status of DI0): ZSW2_ENC.Reserved_Bit11 • STS_DI1 (Status of DI1): ZSW2_ENC.Reserved_Bit10 • STS_DI2 (Status of DI2): ZSW2_ENC.Reserved_Bit8 To select one of the digital inputs use, for example, a PLC tag of the data type "PD_TEL83_IN" with the input start address of the desired channel of the module. The status word "ZSW2_ENC" and the named bits can be found within the created tag structure.
TM Count 2x24V > I/O addresses	–
The organization block ("MC_Servo") and the process image ("PIP OB Servo") are selected automatically for the input and output addresses by selecting the channel in the encoder configuration at the technology object.	
Process image: PIP OB servo	

1) Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration for technology module/technology object is required for these parameters

Additional configuration for use with the technology object measuring input

Configuration	
Technology module **TM Count 1x24V/TM Count 2x24V**	**Technology object** **Measuring input**
TM Count 1x24V/TM Count 2x24V > Channel 0/1 > Operating mode	**Hardware interface > Measuring input**
Select "Position detection for Motion Control technology object" operating mode	Measuring using PROFIdrive telegram (drive or external encoder)
TM Count 1x24V/TM Count 2x24V > Channel 0/1 > Module parameters You set the parameters for the encoder signals of the channel under "Module parameters" in the operating mode "Position input for Motion Control". The parameters must be set depending on the encoder used.	In the "Number of the measuring input" selection box, select "1" (measuring input 1).

7.4.2 TM PosInput 1/TM PosInput 2

For use with Motion Control, the following parameters must be configured:

Configuration	
Technology module **TM PosInput 1 / TM PosInput 2**	**Technology object** **Axis and external encoder**
TM PosInput 1/2 > Channel 0/1 > Operating mode	–
Select "Position detection for Motion Control technology object" mode	
TM PosInput 1/2 > Channel 0/1 > Module parameters You set the parameters for the encoder signals of the channel under "Module parameters" in the "Position input for Motion Control" mode. The parameters must be set depending on the encoder used. The configuration of the encoder is required for use with an SSI absolute encoder. Information on the configuration is available in the documentation for the respective technology module.	**Hardware interface > Encoder**
–	Select "Encoder" data connection and the channel activated and configured as encoder on the technology module
Signal type • Incremental encoder • Absolute encoder	Select encoder type corresponding to configuration for technology module: • Incremental [1)] • Absolute/Cyclic absolute
–	**Axis: Hardware interface > Data exchange with encoder** **External encoder: Hardware interface > Data exchange**
	Telegram "Standard telegram 83" is automatically selected after the selection of the encoder.
	Clear the check box "Automatic data exchange for encoder values (online)"
	Select the check box "Automatic data exchange for encoder values (offline)" If the check box is cleared, you can manually match the parameters described and identified in this table.
	Select rotary or linear measuring system type [1)]
Signal evaluation • Single • Double • Quadruple	Select fine resolution corresponding to configuration on the technology module [1)] • Incremental encoder: – 0 = Single – 1 = Double – 2 = Quadruple • Absolute encoder: – 0 = Single

1) Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration for technology module/technology object is required for these parameters

Configuration	
Technology module **TM PosInput 1 / TM PosInput 2**	**Technology object** **Axis and external encoder**
• Rotary type: Enter increments per revolution • Linear type: Configuration not relevant	• Rotary type: Enter increments per revolution corresponding to configuration at technology module (1:1) [1)] • Linear type: Enter distance between increments [1)]
–	**Axis: Hardware interface > Data exchange with the drive**
• Rotary type: Enter reference speed corresponding to configuration for technology object (1:1) • Linear type: Configuration not relevant	Enter reference speed
–	**Homing**
Select the homing signal for homing mark 0: • Signal N of the incremental encoder • DI0	Use the homing mode "Use zero mark via PROFIdrive telegram".
TM PosInput 1/2 > I/O addresses	–
The organization block ("MC_Servo") and the process image ("PIP OB Servo") are selected automatically for the input and output addresses by selecting the channel in the encoder configuration at the technology object.	

[1)] Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration for technology module/technology object is required for these parameters

Additional configuration for use with the technology object measuring input

Configuration	
Technology module **TM PosInput 1 / TM PosInput 2**	**Technology object** **Measuring input**
TM PosInput 1/2 > Channel 0/1 > Operating mode	**Hardware interface > Measuring input**
Select operating mode "Position detection for Motion Control technology object"	Measuring using PROFIdrive telegram (drive or external encoder)
TM PosInput 1/2 > Channel 0/1 > Module parameters You set the parameters for the encoder signals of the channel under "Module parameters" in the operating mode "Position input for Motion Control". The parameters must be set depending on the encoder used. The configuration of the encoder is required for use with an SSI absolute encoder. Please note the following information in this regard. Information on the configuration is available in the documentation for the respective technology module.	In the "Number of the measuring input" selection box, select "1" (measuring input 1).

NOTE

When a single-turn absolute encoder is used and two edges are to be measured ("MC_MeasuringInput.Mode" = 2, 3 or 4), the distance between the measured edges of the Measurement input must be < 1 encoder revolution. Otherwise, use a multi-turn absolute encoder.

7.4.3 TM Timer DIDQ 10x24V/TM Timer DIDQ 16x24V

The TM Timer DIDQ 16x24V technology module can be operated centrally on an S7-1500 CPU or distributed on distributed I/O.

The TM Timer DIDQ 10x24V technology module can be operated centrally on an ET200SP CPU or distributed on a distributed I/O.

If you use the technology module centrally or distributed with a measuring input, an output cam or a cam track, isochronous mode is mandatory.

NOTICE

Inaccurate time synchronization

When the technology module TM Timer DIDQ with the measuring input, output cam, or cam track technology object is used at the same time as the "TIO_Sync" function, the time synchronization of the technology module becomes inaccurate.

Do not use the "TIO_Sync" function if you are using the technology module TM Timer DIDQ with the measuring input, output cam, or cam track technology object.

For use with Motion Control, the following parameters must be configured:

Use with output cam/cam track technology object

Configuration	
Technology module **TM Timer DIDQ 10x24V/TM Timer DIDQ 16x24V**	**Technology object** **Output cam / Cam track**
Basic parameters	–
Select desired number of outputs under channel configuration (ET 200MP TM Timer DIDQ 16x24V only)	
Channel parameters	**Hardware interface > Output cam output/output cam track**
–	Activate output
	Output via Timer DQ
Select "Timer DQ" mode for the respective output	Select output cam output
I/O addresses	–
Select "Isochronous mode"	
The organization block ("MC_Servo") and the process image ("PIP OB Servo") are updated automatically for the input and output addresses by selecting the channel in the output configuration at the technology object.	

"–" No configuration for technology module/technology object is required for these parameters

Use with technology object measuring input

Configuration	
Technology module **TM Timer DIDQ 10x24V/TM Timer DIDQ 16x24V**	**Technology object** **Measuring input**
Basic parameters	–
Select desired number of inputs under channel configuration	
Channel parameters	**Hardware interface > Measuring input**
Configuration of DI group: Use inputs individually	–
Select "Timer DI" mode for the respective input	Select measuring via timer DI
–	Select measuring input
Select application-dependent input delay	–
I/O addresses	
Select "Isochronous mode"	
The organization block ("MC_Servo") and the process image ("PIP OB Servo") are updated automatically for the input and output addresses by selecting the channel in the input configuration at the technology object.	

"–" No configuration for technology module/technology object is required for these parameters

7.4.4 TM Pulse 2x24V

For use with Motion Control, the parameters described below must each be configured:

Drive connection using PWM (pulse width modulation)

Configuration	
TM Pulse 2x24V	**Technology object**
	Axis
TM Pulse 2x24V > Channel configuration	–
Select if you want to use 1 or 2 channels.	
TM Pulse 2x24V > Channel > Operating mode	
Select "Pulse width modulation PWM" or "PWM with DC motor" operating mode	
TM Pulse 2x24V > Channel > Parameters	**Hardware interface > Drive**
Select "S7 analog output" output format	Select analog drive connection For the selection of the analog output, create a PLC tag of the "Int" type with corresponding address. The offset for the PLC tag to the start address is 2. To activate the output of the PWM signal, set the following two bits of the control interface of the PWM channel in the user program: • SW_ENABLE (= Bit 0 in Byte 9) • TM_CTRL_DQ (= Bit 1 in Byte 9) The offset for byte 9 to the start address of the PWM channel is 9.
TM Pulse 2x24V > Channel > I/O addresses	–
Select the organization block "MC_Servo" for the input and output addresses. The "TPA OB Servo" process image is selected automatically for the input and output addresses by selecting the organization block.	

"–" No configuration for technology object is required for these parameters

7.4.5 TM PTO 2x24V

For use with Motion Control, the following parameters must be configured.

Configuration	
Technology module TM PTO 2x24V	**Technology object**
	Axis
TM PTO 2 > Channel 0...1 > Operating mode	–
Select signal type: • PTO (pulse (P) and direction (D)) • PTO (count up (A) and count down (B)) • PTO (A, B phase-shifted) • PTO (A, B phase-shifted - quadruple)	
Configure the pulse pause for direction reversal	
–	**Hardware interface > Drive**
	Select drive type "PROFIdrive" and "Drive" data connection Select the channel at the technology module as drive
	Hardware interface > Encoder
	Select encoder type "PROFIdrive" and data connection Select the simulated encoder of the PTO 2 channel as encoder
TM PTO 2 > Channel 0...1 > Diagnostic interrupts	-
When the "Enable diagnostic interrupts" check box is selected, diagnostic interrupts are activated if: • No supply voltage • Errors occur at digital outputs The detected error is displayed for the respective channel with feedback bit "Fault_Present" and "Sensor_Error".	
TM PTO 2 > Channel 0...1 > Axis parameters	**Data exchange with the drive**
–	Telegram "Standard telegram 1" is automatically selected after selection of the drive
	Clear check box "Automatic data exchange for drive values (online)"
	Select check box "Automatic data exchange for drive values (offline)" If the check box is cleared, you can manually match the parameters described and identified in this table.
Enter reference speed corresponding to configuration for technology object (1:1)	Enter reference speed of the drive [1]
Enter maximum speed corresponding to configuration for technology object (1:1)	Enter maximum speed of the drive [1] If the maximum speed is exceeded, technology alarm 102 is triggered and displayed.
–	**Data exchange with encoder**
	Telegram "Standard telegram 81" is automatically selected after selection of the encoder

[1] Parameters are automatically applied when "Automatic data exchange for drive values (offline)" is selected

[2] Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration required for these parameters at the technology module/technology object

Configuration	
Technology module TM PTO 2x24V	**Technology object**
	Axis
–	Clear the check box "Automatic data exchange for encoder values (online)"
	Select the check box "Automatic data exchange for encoder values (offline)" If the check box is cleared, you can manually match the parameters described and identified in this table.
	Select rotary measuring system type [2]
Enter increments per revolution	Enter increments per revolution corresponding to configuration at technology module (1:1) [2]
-	Enter fine resolution [2] • 0 = Single
Configure stop behavior • Quick stop time • Ramp stop time	–
TM PTO 2 > Channel 0...1 > Hardware inputs/outputs	–
If you want to use a hardware output to enable the drive, select the "Use ED as drive enable" check box.	No setting required at the technology object. The output is automatically controlled by the "MC_Power".
	Homing
For the hardware input (DI0), select the "Use RS as reference switch" check box.	Use the homing mode "Use zero mark via PROFIdrive telegram".
Select the edge of the hardware input for triggering the reference output cam function.	
	"Measuring input > Configuration > Hardware interface" technology object
When using a measuring input, select the "Use MI as measuring input" check box.	Select the measuring input type "Measuring via PROFIdrive telegram (drive or external encoder)". Select the measuring input "1" under hardware connection.
When using Drive ready, select the "Use Rdy as ready signal" check box.	No setting required at the technology object. When the input is used, "MC_Power" waits until the input signal is present before it sets the drive enable.
Configuring input delay	–
TM PTO 2 > Channel 0...1 > Sign-of-life error	
Configure tolerated number of sign-of-life errors	
TM PTO 2 > I/O addresses	
The organization block ("MC_Servo") and the process image ("PIP OB Servo") are selected automatically for the input and output addresses by selecting the PTO channel at the technology object.	

[1] Parameters are automatically applied when "Automatic data exchange for drive values (offline)" is selected

[2] Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration required for these parameters at the technology module/technology object

7.4.6 TM PTO 4

For use with Motion Control, the following parameters must be configured.

Configuration	
Technology module TM PTO 4	**Technology object**
	Axis
TM PTO 4 > Channel configuration	–
Configure the number of channels (1 to 4) you want to use.	
TM PTO 4 > Channel 0...3 > Operating mode	
Select signal type: • PTO (pulse (P) and direction (D)) • PTO (count up (A) and count down (B)) • PTO (A, B phase-shifted) • PTO (A, B phase-shifted - quadruple)	
Select signal interface: • RS422, symmetrical/TTL (5V), asymmetrical • 24V asymmetric	
Configure the interpulse pause for direction reversal.	
–	**Hardware interface > Drive**
	Select drive type "PROFIdrive" and "Drive" data connection. Select the pulse output configured at the technology module as drive.
	Hardware interface > Encoder
	The encoder of the actuator telegram (simulated encoder) is automatically selected. Alternatively, an existing encoder interface can be selected.
TM PTO 4 > Channel 0...3 > Diagnostic interrupts	-
When the "Enable diagnostic interrupts" check box is selected, diagnostic interrupts are activated if: • No supply voltage • Errors occur at digital outputs The detected error is displayed for the respective channel with feedback bit "Fault_Present" and "Sensor_Error".	
TM PTO 4 > Channel 0...3 > Axis parameters	**Data exchange with the drive**
–	Telegram "Standard telegram 3" is automatically selected after the selection of the drive.
	Clear check box "Automatic data exchange for drive values (online)"
	Select check box "Automatic data exchange for drive values (offline)" If the check box is cleared, you can manually match the parameters described and identified in this table.
Enter reference speed corresponding to configuration for technology object (1:1)	Enter reference speed of the drive [1]

[1] Parameters are automatically applied when "Automatic data exchange for drive values (offline)" is selected

[2] Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration required for these parameters at the technology module/technology object

Configuration	
Technology module TM PTO 4	**Technology object**
	Axis
Enter maximum speed corresponding to configuration for technology object (1:1)	Enter maximum speed of the drive [1] If the maximum speed is exceeded, technology alarm 102 is triggered and displayed.
–	**Data exchange with encoder**
	Telegram "Standard telegram 83" is automatically selected after the selection of the encoder.
	Clear the check box "Automatic data exchange for encoder values (online)"
	Select the check box "Automatic data exchange for encoder values (offline)" If the check box is cleared, you can manually match the parameters described and identified in this table.
	Select rotary measuring system type [2]
Enter increments per revolution	Enter increments per revolution corresponding to configuration at technology module (1:1) [2]
-	Enter fine resolution [2] • 0 = Single
Configure stop behavior • Quick stop time • Ramp stop time	–
TM PTO 4 > Channel 0...3 > Hardware inputs/outputs	–
If you want to use a hardware output to enable the drive, select the "Use drive enable" check box. Next select one of the two hardware outputs DQ0 or DIQ2.	No setting required at the technology object. The output is automatically controlled by the "MC_Power".
	Homing
Activate the hardware input (DI0) for the reference output cam.	Use the homing mode "Use zero mark via PROFIdrive telegram".
Select the edge of the hardware input for triggering the reference output cam function.	
When using a measuring input, select the "Use DI1 check box as measuring input".	**"Measuring input > Configuration > Hardware interface" technology object**
	Select the measuring input type "Measuring via PROFIdrive telegram (drive or external encoder)". Select the measuring input "1" under hardware connection.
Select the "Use "drive ready"" check box. In the ""Drive ready" input", select the hardware input that is to be used to display whether the drive is ready.	No setting required at the technology object. When the input is used, "MC_Power" waits until the input signal is present before it sets the drive enable.
Configuring input delay	–
TM PTO 4 > Channel 0...3 > Sign-of-life error	

[1] Parameters are automatically applied when "Automatic data exchange for drive values (offline)" is selected

[2] Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration required for these parameters at the technology module/technology object

Configuration	
Technology module TM PTO 4	**Technology object**
	Axis
Configure tolerated number of sign-of-life errors	–
TM PTO 4 > I/O addresses	
The organization block ("MC_Servo") and the process image ("PIP OB Servo") are selected automatically for the input and output addresses by selecting the PTO channel at the technology object.	

1) Parameters are automatically applied when "Automatic data exchange for drive values (offline)" is selected

2) Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration required for these parameters at the technology module/technology object

7.4.7 CPU 1511C-1 PN/CPU 1512C-1 PN (onboard I/O devices)

For use with Motion Control, the parameters described below must be configured.

Drive connection via PTO (Pulse Train Output)

Configuration	
CPU 1511C-1 PN/CPU 1512C-1 PN	**Technology object**
	Axis
Pulse generators (PTO/PWM) > PTO1...4/PWM1...4 > General	–
To activate a channel for PTO mode, select one of the following operating modes: • PTO (pulse (A) and direction (B)) • PTO (count up (A), count down (B)) • PTO (A,B phase shifted) • PTO (A,B phase shifted, quadruple)	
–	**Hardware interface > Drive**
	Select drive type "PROFIdrive" and "Drive" data connection. Select the pulse generator of the CPU configured for PTO mode as drive.
	Hardware interface > Encoder
	The encoder of the actuator telegram (simulated encoder) is automatically selected. Alternatively, an existing encoder interface can be selected.
Pulse generators (PTO/PWM) > PTO1...4/PWM1...4 > Axis parameters	**Hardware interface > Data exchange with the drive**
–	Telegram "Standard telegram 3" is automatically selected after the selection of the drive.

1) Parameters are automatically applied when "Automatic data exchange for drive values (offline)" is selected

2) Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration for CPU/technology object is required for these parameters

Configuration	
CPU 1511C-1 PN/CPU 1512C-1 PN	**Technology object**
	Axis
–	Clear check box "Automatic data exchange for drive values (online)"
	Select check box "Automatic data exchange for drive values (offline)" If the check box is cleared, you can manually match the parameters described and identified in this table.
Enter reference speed corresponding to configuration for technology object (1:1)	Enter reference speed of the drive [1]
Enter reference speed corresponding to configuration for technology object (1:1)	Enter maximum speed of the drive [1] If the maximum speed is exceeded, technology alarm 102 is triggered and displayed.
–	**Hardware interface > Data exchange with encoder**
	Telegram "Standard telegram 3" is automatically selected after the selection of the encoder.
	Clear the check box "Automatic data exchange for encoder values (online)"
	Select the check box "Automatic data exchange for encoder values (offline)" If the check box is cleared, you can manually match the parameters described and identified in this table.
	Select rotary measuring system type [2]
Enter increments per revolution	Enter increments per revolution corresponding to configuration for CPU (1:1) [2]
The fine resolution has the fixed value "0 bit" (= single) and cannot be changed.	Enter the fine resolution corresponding to the configuration on the CPU [2] Bits in incr. actual value (G1_XIST1): 0 (= single)
Pulse generators (PTO/PWM) > PTO1...4/PWM1...4 > Hardware inputs/outputs	**Homing**
Select the hardware input for the reference switch In addition, configure the input delay for the selected hardware input. You configure the input delay in the device configuration at the corresponding DI channel (DI 16/DQ 16 > Inputs > Channel > Input parameters > Input delay).	Use the homing mode "Use zero mark via PROFIdrive telegram" for drive connection via PTO.
Select the edge of the hardware input for triggering the reference output cam function.	
When using a measuring input, select the hardware input of the measuring input. The following table includes the configuration description.	–

[1] Parameters are automatically applied when "Automatic data exchange for drive values (offline)" is selected

[2] Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration for CPU/technology object is required for these parameters

Configuration	
CPU 1511C-1 PN/CPU 1512C-1 PN	**Technology object**
	Axis
Select the hardware input that is used to display whether the drive is ready. In addition, configure the input delay for the selected hardware input. You configure the input delay in the device configuration at the corresponding DI channel (DI 16/DQ 16 > Inputs > Channel > Input parameters > Input delay).	–
With selected "PTO (pulse (A) and direction (B))" mode, the hardware output for the PTO signal A ("Pulse output (A)") is automatically selected through the device configuration and cannot be changed. For PTO signal B ("Direction output (B)") select one of the hardware outputs offered in the selection box. The hardware outputs for the PTO signals are selected through the device configuration for the following operating modes and cannot be changed: • PTO (count up (A), count down (B)) • PTO (A,B phase shifted) • PTO (A,B phase shifted, quadruple)	
Pulse generators (PTO/PWM) > PTO1...4/PWM1...4 > I/O addresses	
The organization block ("MC_Servo") and the process image ("PIP OB Servo") are selected automatically for the input and output addresses by selecting the PTO channel at the technology object.	

1) Parameters are automatically applied when "Automatic data exchange for drive values (offline)" is selected

2) Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration for CPU/technology object is required for these parameters

Additional configuration for use with the technology object measuring input

Configuration	
Technology module CPU 1511C-1 PN/CPU 1512C-1 PN	**Technology object**
	Measuring input
Pulse generators (PTO/PWM) > PTO1...4/PWM1...4 > Hardware inputs/outputs	**Hardware interface > Measuring input**
Select the hardware input of the measuring input. In addition, configure the input delay for the selected hardware input. You configure the input delay in the device configuration at the corresponding DI channel (DI 16/DQ 16 > Inputs > Channel > Input parameters > Input delay).	Measuring using PROFIdrive telegram (drive or external encoder)
	In the "Number of the measuring input" selection box, select "1" (measuring input 1).

Drive connection using PWM (pulse width modulation)

Note that only travel in the positive direction is possible with a drive connection using the integrated PWM function of the compact CPU.

Configuration	
CPU 1511C-1 PN/CPU 1512C-1 PN	**Technology object**
	Speed axis
Pulse generators (PTO/PWM) > PTO1...4/PWM1...4 > General	–
Select "Pulse width modulation PWM" mode	
Pulse generators (PTO/PWM) > PTO1...4/PWM1...4 > Hardware inputs/outputs	
Select the hardware output to be used for pulse output.	
Select whether the set hardware output is to work as a fast push-pull switch or as P switch.	
Pulse generators (PTO/PWM) > PTO1...4/PWM1...4 > Parameters	**Hardware interface > Drive**
Select "S7 analog output" output format	Select analog drive connection For the selection of the analog output, create a PLC tag of the "Int" type with corresponding address. The offset for the PLC tag of the control interface of the PWM channel is 2. To activate the output of the PWM signal, set the following two bits of the control interface of the PWM channel in the user program: • SW_ENABLE (= bit 0 in byte 9) • TM_CTRL_DQ (= Bit 1 in Byte 9) The offset for byte 9 to the start address of the PWM channel is 9.
Select minimum pulse width of 0 µs	–
Select required period duration (e.g. 100 µs)	
Pulse generators (PTO/PWM) > PTO1...4/PWM1...4 > I/O addresses	
Select the organization block "MC_Servo" for the input and output addresses. The "TPA OB Servo" process image is selected automatically for the input and output addresses by selecting the organization block.	

"–" No configuration for technology object is required for these parameters

Encoder connection via HSC (High Speed Counter)

Configuration		
CPU 1511C-1 PN/CPU 1512C-1 PN	**Technology object**	
	Axis	**External encoder**
High-speed counter (HSC) > HSC 1...6 > General > Enable	–	–
Enable high-speed counter		
High-speed counter (HSC) > HSC 1...6 > Basic parameters > Operating mode		
Select "Position input for Motion Control" mode		
High-speed counter (HSC) > HSC 1...6 > Basic parameters > Module parameters	**Hardware interface > Encoder**	**Hardware interface > Encoder**
–	Select "Encoder" data connection and the high-speed counter activated and configured as encoder on the CPU	Select "Encoder" data connection and the high-speed counter activated and configured as encoder on the CPU
Signal type • Incremental encoder	Select encoder type according to the device configuration of the CPU [1)] • Incremental	Select encoder type according to the device configuration of the CPU [1)] • Incremental
–	**Hardware interface > Data exchange with encoder**	**Hardware interface > Data exchange**
	Telegram "Standard telegram 83" is automatically selected after the selection of the encoder.	Telegram "Standard telegram 83" is automatically selected after the selection of the encoder.
	Clear the check box "Automatic data exchange for encoder values (online)"	Clear the check box "Automatic data exchange for encoder values (online)"
	Select the check box "Automatic data exchange for encoder values (offline)" If the check box is cleared, you can manually match the parameters described and identified in this table.	Select the check box "Automatic data exchange for encoder values (offline)" If the check box is cleared, you can manually match the parameters described and identified in this table.
	Select rotary measuring system type [1)]	Select rotary measuring system type [1)]
Signal evaluation • Single • Double • Quadruple	Enter fine resolution according to the configured signal evaluation set for the high-speed counter (HSC) [1)] • 0 = Single • 1 = Double • 2 = Quadruple	Enter fine resolution according to the configured signal evaluation set for the high-speed counter (HSC) [1)] • 0 = Single • 1 = Double • 2 = Quadruple
Enter increments per revolution	Enter increments per revolution corresponding to device configuration for CPU (1:1) [1)]	Enter increments per revolution corresponding to device configuration for CPU (1:1) [1)]
–	**Hardware interface > Data exchange with the drive**	–
Enter reference speed corresponding to configuration for technology object (1:1)	Enter reference speed	

[1)] Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration for CPU/technology object is required for these parameters

Configuration		
CPU 1511C-1 PN/CPU 1512C-1 PN	**Technology object**	
	Axis	**External encoder**
–	**Homing**	**Homing**
Select the homing signal for homing mark 0: • Signal N of the incremental encoder • DI0 (can be set with the hardware inputs/outputs) In addition, configure the input delay for the selected hardware input. You configure the input delay in the device configuration at the corresponding DI channel (DI 16/DQ 16 > Inputs > Channel > Input parameters > Input delay).	Use the homing mode "Use zero mark via PROFIdrive telegram".	Use the homing mode "Use zero mark via PROFIdrive telegram".
High-speed counter (HSC) > HSC 1...6 > I/O addresses	–	–
The organization block ("MC_Servo") and the process image ("PIP OB Servo") are selected automatically for the input and output addresses by selecting the HSC channel at the technology object.		

1) Parameters are automatically applied when "Automatic data exchange for encoder values (offline)" is selected

"–" No configuration for CPU/technology object is required for these parameters

Additional configuration for use with the technology object measuring input

Configuration	
Technology module CPU 1511C-1 PN/CPU 1512C-1 PN	**Technology object**
	Measuring input
High-speed counter (HSC) > HSC 1...6 > Hardware inputs/outputs	**Hardware interface > Measuring input**
Select the hardware input of the measuring input. In addition, configure the input delay for the selected hardware input. You configure the input delay in the device configuration at the corresponding DI channel (DI 16/DQ 16 > Inputs > Channel > Input parameters > Input delay).	Measuring using PROFIdrive telegram (drive or external encoder)
	In the "Number of the measuring input" selection box, select "1" (measuring input 1).

7.4.8 SIMATIC Drive Controller (onboard I/O)

You can use the inputs and outputs of interface X142 of a SIMATIC Drive Controller as measuring input for the measuring input technology object, as well as for the output cam/cam track technology object.

Isochronous mode is required for use with a measuring input, output cam or cam track.

For use with Motion Control, the following parameters must be configured:

Use with output cam/cam track technology object

Configuration	
SIMATIC Drive Controller	**Technology object**
	Output cam / Cam track
Channel parameters > Channel 0 to 7	**Hardware interface > Output cam output/output cam track**
–	Activate output
	Output via Timer DQ
Select desired channel and select operating mode "Timer DQ".	Select output cam output
I/O addresses	–
Select "Isochronous mode"	
The organization block ("MC_Servo") and the process image ("PIP OB Servo") are updated automatically for the input and output addresses by selecting the channel in the output configuration at the technology object.	

"–" No configuration at the SIMATIC Drive Controller/technology object is required for these parameters

Use with measuring input technology object

Configuration	
SIMATIC Drive Controller	**Technology object**
	Measuring input
Channel parameters > Channel 0 to 7	**Hardware interface > Measuring input**
–	Select measuring via timer DI
Select desired channel and select operating mode "Timer DI"	Select measuring input
I/O addresses	–
Select "Isochronous mode"	
The organization block ("MC_Servo") and the process image ("PIP OB Servo") are updated automatically for the input and output addresses by selecting the channel in the input configuration at the technology object.	

"–" No configuration at the SIMATIC Drive Controller/technology object is required for these parameters

7.5 Motion Control configurations on CPUs with two IRT interfaces

On CPUs that have two interfaces with IRT functionality, you can operate two different PROFINET subnetworks with IRT.

You can operate technology objects on the two interfaces X1 and X2 as follows:

- Coupled with synchronized send clock
- Synchronized with synchronized send clock
- Independent of each other

Coupled with synchronized send clock

In order to operate time-dependent Motion Control technology objects at both interfaces in an isochronous manner on the MC_Servo, the interfaces are coupled with a compensating send clock.

Possible applications:

- Synchronous operations of the axes (TO_SynchronousAxis), with the drives connected to both IRT interfaces. Up to 64 IRT devices per interface are possible.
- Operation of technology objects that require a time level and whose devices are distributed across both interfaces. Example: A measuring input, which detects positions with respect to a technology object axis, is connected to interface X2. The drive to the same technology object axis is connected to interface X1.

Required settings:

- To synchronize the send clock, a PROFINET interface is set to "Based on the send clock of the PROFINET interface [X[1..2]]".
- No reduction ratio is set between PROFINET send clocks.

NOTE

Using an interface as an I-device with IRT in isochronous mode

An interface can be operated as I-device with IRT in isochronous mode. This allows you to realize cross-PLC synchronous operation with the higher-level I/O controller.

If you configure an interface as an I-device with IRT in isochronous mode, this interface cannot be an IO controller for IO devices with IRT. IO devices with RT are possible.

Synchronized with synchronized send clock

To operate devices on a fast isochronous OB clock (OB6x) and Motion Control technology objects on the slower MC_Servo clock (OB91), the interfaces are coupled to each other with compensating send clocks with reduction ratio.

Possible applications:

- Control of valves on an ET 200SP distributed I/O system at rapid intervals on X1 interface and synchronous operation of axes. The drives of the axes are connected to interface X2.
- Synchronous operation of axes (TO_SynchronousAxis) and rapid data acquisition from sensors, such as camera or probe: The drives are connected to interface X1. The sensors are connected to interface X2.

Required settings:

- To synchronize the send clock, a PROFINET interface is set to "Based on the send clock of the PROFINET interface [X[1..2]]".
- A reduction ratio is set between PROFINET send clocks.
- The slower interface is assigned to the MC_Servo and thus to the synchronous axes.
- The faster interface is assigned to an OB6x.
- The priority of the OB6x must be set higher than the priority of the MC_Servo.

Notes

Devices whose technology objects are directly related to each other in time must be connected to the same interface, e.g. the drive and the associated measuring input of the axis.

Take the priority of OBs into account when exchanging data. Data that is updated in MC_Servo and processed in OB6x is delayed due to the higher set priority of the OB6x.

The fast interface allows you to operate positioning axes in RT mode, e.g. via F-TM Servo modules.

Independent of each other

To operate devices on both interfaces without time dependencies, the interfaces are independent of each other and have their own local send clocks.

Possible applications:

- Positioning or synchronous operation of axes and control of digital outputs: The drives are connected to interface X1. The digital outputs are connected to interface X2.
- Positioning or synchronous operation of axes (technology objects) on interface X1 and speed control (RT) of axes on interface X2.

Required settings:

- Both PROFINET interfaces have the "Local send clock".
- IRT devices that are assigned to technology objects must be connected to the interface associated with the MC_Servo.

More information

Additional information on synchronizing the send clock of the PROFINET interfaces is described in the PROFINET (https://support.industry.siemens.com/cs/ww/en/view/49948856) function manual.

Programming 8

User program

The "Programming" section contains general information on supplying and evaluating the Motion Control instructions and on the technology data block.

You can use Motion Control instructions in the user program to assign jobs to the technology object. You define the job using the input parameters of the Motion Control instructions. You can track the current job status using the job parameters if you use a separate instance for each Motion Control instruction per technology object.

In a typical programming, you can use one or more instances for each Motion Control instruction for each technology object.

The use of a separate instance per technology object is always necessary for Motion Control instructions without parameter "DONE" and for the Motion Control instruction "MC_MoveJog".

Only one instance per technology object may be active in the program flow for the Motion Control instruction "MC_Power". Disable the technology object with the same instance you used to enable the technology object, otherwise an error with error ID 16#800C will occur.

The technology data block is available to you as an additional interface to the technology object.

Interpreter programs

You can find information on the Interpreter program in the documentation S7-1500 Interpreter functions (Page 7)

8.1 Process response

8.1.1 Organization blocks for Motion Control

When you create a technology object, organization blocks MC_Servo and MC_Interpolator are automatically created for processing the technology objects. The organization block MC_LookAhead is also created for the kinematics technology object as of technology version 5.0. The technology objects are processed in the motion control application cycle. The application cycle consists of required and optional organization blocks (OBs).

In the user program, call the appropriate Motion Control instruction and start a Motion Control job for a technology object. In the organization block Main, call the user program cyclically.

Optionally, programmable motion control OBs are available, which you must insert manually. These organization blocks take into account special requirements with regard to time-critical events or the time sequence of function calls. This makes it possible, for example, to start motions immediately in the event of time-critical events.

The following table shows the organization blocks for motion control:

Organization block	Description	Priority[1)]
MC_PreServo [OB67] (optional)	For example: Preparation of the telegram contents from the drive system. Called immediately before the MC_Servo.	Corresponds to MC_Servo
MC_Servo [OB91] (know-how-protected)	Calculation of the position controller System performance, no user program possible.	17 to 26 Default 26
MC_PostServo [OB95] (optional)	For example: Preparation of the setpoints for the drive system. Called immediately after the MC_Servo.	Corresponds to MC_Servo
MC_Transformation [OB98] (optional)	Programming of the transformation of Cartesian coordinates and axis-specific setpoints for user-defined kinematics	17 to 25 Default 25
MC_PreInterpolator [OB68] (optional)	For example: MotionIn instructions, and instructions for measuring inputs, output cams and cam tracks The MC_PreInterpolator is required for iposynchronous processing of Motion Control instructions. Called immediately before the MC_Interpolator.	Corresponds to MC_Interpolator
MC_Interpolator [OB92] (know-how-protected)	Evaluation of the Motion Control instructions, generation of setpoints and monitoring functionality System performance, no user program possible.	16 to 25 Default 24
MC_LookAhead [OB97] (know-how-protected)	Calculation of the motion processing of the kinematics technology object Applies only to a technology object kinematics V5.0 or higher. System performance, no user program possible.	15 to 16 Default 15

1) 26 corresponds to highest priority.

The clock ratio of the two organization blocks MC_Servo and MC_Interpolator to each other is always 1:1. You can scale the ratio of the bus clock to the application cycle.

You can set the application cycle and the priority of the organization blocks according to your requirements for control quality and system load.

You can check the runtime of the respective organization block (except MC_LookAhead) with the instruction "RT_INFO". The current application cycle (in µs) of the organization blocks MC_PreServo, MC_PostServo and MC_PreInterpolator can be read using the start information.

Application cycle

In the properties of the organization block MC_Servo, you can set the application cycle in which the organization blocks for MC_Servo, MC_Interpolator and their optional OBs are called:

- **Synchronous to the bus (recommended setting for optimum control quality)**

  The application cycle is synchronous to the selected source of the send clock and the corresponding reduction ratio. The following clock sources are available for selection:

  – PROFINET IO
  – PROFIBUS DP
  – Local bus system (as of firmware version ≥ 2.6)
  – PROFIdrive system for SINAMICS Integrated of SIMATIC Drive Controller

A bus system that is connected to the CPU via a communications processor/communication module (CP/CM) cannot be used synchronously.

- **Cyclic**

  The application cycle is called at the specified time interval. Processing is asynchronous to the bus clock/send clock.

Ways to influence the process response

The system load is primarily determined by the quantity structure (number of technology objects), the communication load and the user program. The processing time in the application cycle increases with the number of technology objects (MC_Servo). Simultaneous starting of Motion Control instructions results in additional processing times in the application cycle (MC_Interpolator and MC_LookAhead) at short notice. Optional motion control OBs additionally affect the processing time of the application cycle.

You define the available processing time using the set application cycle. The time available at the end of the application cycle is used for processing the low-priority OBs with the other user program.

The cycle time of the Main can increase significantly due to longer processing times in the application cycle.

System overloads are indicated by timeouts or overflows (Page 108) of Main, MC_Servo and MC_Interpolator.

You have the following options for influencing the system load and the processing times of the user program:

- Adjusting the application cycle:
  - Adjusting the send clock of the bus system
  - Reduce clock
- Adjusting the percentage cycle load of the MC_LookAhead (adjustment range 1% to 40%, default setting 20%)
- Adjusting the percentage communication load of the CPU
- To relieve the load on MC_Interpolator and MC_LookAhead, avoid simultaneous starting of Motion Control instructions
- "Improve system performance" for the interpolation of the cam in the MC_Interpolator and "Improve system performance" for the motion processing of the kinematics technology object in the MC_LookAhead (S7-1500T as of FW V3.0)

  If both the options are activated, a cam interpolation can interrupt the motion preparation of the kinematics technology object.
- Improving system performance (Page 114) for motion jobs in the MC_Interpolator

If necessary, use one or more options to optimize the system and the process response.

Reduction ratio

You can reduce the application cycle of the MC_Servo relative to the send clock of the selected isochronous bus system. You can set an integer multiple of the send clock as the factor. A maximum cycle time of 32 ms is possible for the application cycle.

Note the following settings when you call an isochronous mode interrupt OB (OB6x) and the MC_Servo.

- Call both organization blocks with the same source of the send clock (same bus system).
- Use the same application cycle both organization blocks (in ms).

Priority

You can configure the priority of the organization blocks as needed in their properties under "General > Properties > Priority".

When setting the priorities, make sure that the MC_Servo is always set before the MC_PreInterpolator and the MC_Interpolator. The priority of MC_Servo must be at least one level higher than the priority of MC_Interpolator. The priority of the MC_LookAhead must be higher than the priority of cyclic interrupts.

See also

Connecting a PROFIdrive drive via data block (Page %getreference)

8.1.2 Process image partition "OB Servo PIP"

The process image partition "PIP OB Servo" is made available in isochronous mode for Motion Control when MC_Servo is called. All drives and encoders used by Motion Control are assigned to this process image partition.

Because the organization blocks MC_PreServo and MC_PostServo are called automatically by the MC_Servo, the process image partition is also available automatically. If you use a MC_PreServo, the data is read in when the MC_PreServo starts. If you use a MC_PostServo, the data is output after the MC_PostServo.

Additionally, you should assign all I/O modules used by Motion Control to this process image partition (e.g. hardware limit switches). The assignment results in chronologically synchronous processing with the technology object.

The input process image partition is also updated in STOP mode.

Process image partition in the user program

As of firmware version V1.5, you can access the process image partition "OB Servo PIP" in your user program. This makes it possible to evaluate the process image partition using the trace function.

Process image partition in watch/force table

Access to data of the process image partition "PIP OB Servo" via watch and force tables is not possible.

8.1.3 Operational Sequence and Timeouts

When processing the Motion Control functionality, the Motion Control organization blocks MC_Servo and MC_Interpolator, including the optional organization blocks, are called and processed in each application cycle. Your user program is processed during the remaining time until the next application cycle.

For error-free program execution, keep to the following rules:

- In each application cycle, MC_Servo must be started and executed completely.
- In each application cycle, the relevant MC_Interpolator must at least be started.
- For drives connected via PROFINET, the MC_PreServo, the MC_Servo, and the MC_PostServo must be completely processed in the first PROFINET cycle.

Example

The figure below illustrates the time sequence of the cyclic user program and the application cycle:

- The upper section shows the processing of the Main without interruption of the application cycle by Motion Control OBs with higher priority.
- The central section shows the processing of Main with interruption Motion control OBs with higher priority are executed in the application cycle.

  The Main is interrupted in the cycle of the application cycle. The cycle time of the user program becomes correspondingly longer.
- The lower section shows a detailed view of the error-free process response of the individual organization blocks.

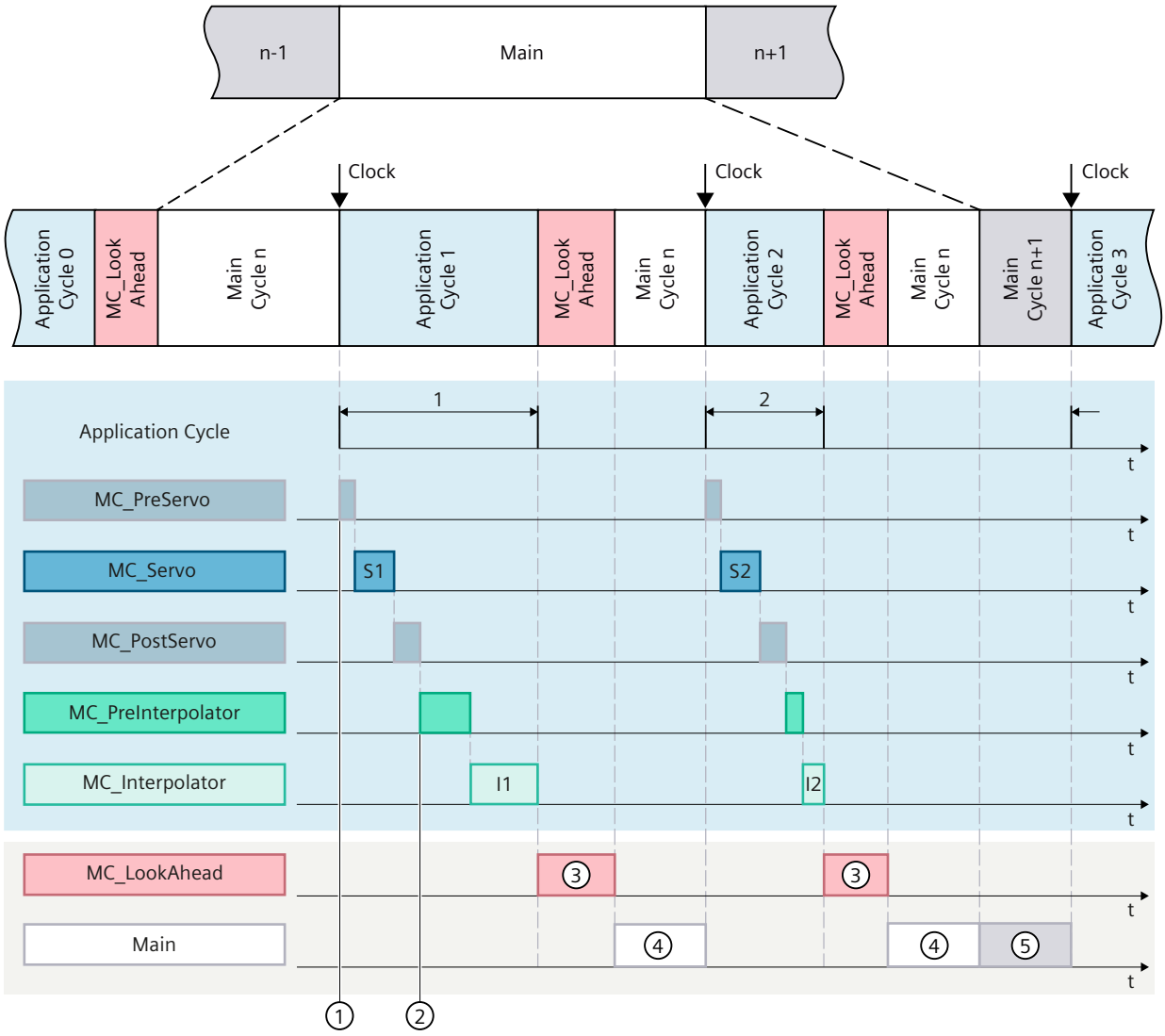

① "TPA OB Servo" input process image partition

② "TPA OB Servo" output process image partition

③ MC_LookAhead cycle

④ Main cycle n

⑤ Main cycle n+1

The Motion Control OBs and the Main are processed one after the other in application cycle 1. The process image partition "PIP OB Servo" ① is read before processing the MC_PreServo. The MC_Servo is displayed as "S1" in the first application cycle. After the processing of the MC_PostServo, the process image partition "PIP OB Servo" ② is updated.

The MC_PreInterpolator and the MC_Interpolator are then processed. The MC_Interpolator is displayed as "I1" in the first application cycle. Its processing time varies according to the evaluation of the motion control instructions as well as the monitoring and setpoint generation for all technology objects configured on the CPU for motion control.

Number ③ represents the processing of the MC_LookAhead . The processing of the MC_LookAhead is interrupted in the first application cycle and continued in the second application cycle.

The Main ④ is further processed only after all Motion Control OBs have been processed.

In the second application cycle, the processing time for the MC_Interpolator "I2" and MC_LookAhead cycle ③ is shorter than in the first application cycle. The MC_LookAhead ③ is processed further in the second application cycle. The Main cycle n ④ is finished before the third application cycle. The Main cycle n+1 ⑤ is already processed in the time still remaining until the third application cycle. This means that parts of two Main cycles can be processed between two application cycles.

Overflows

Overflows can occur if the configured application cycle is not adhered to, for example because additional technology objects or programs are added in the MC_PreServo or MC_PostServo. The application cycle must be adapted in this case. The MC_Servo must be completed before the next send clock, irrespective of the permissible duration of the application cycle.

If the processing time of the MC_Servo (including MC_PreServo and/or MC_PostServo, if available) exceeds the duration of a send clock, the message "Overflow" is displayed in the diagnostic buffer of CPU. The controller no longer runs isochronously.

If the processing time exceeds the duration of an application cycle, the CPU switches to STOP operating state.

The following figure shows the process response in the case of overflow of MC_Servo in the application cycle and in the send clock with a reduction ratio of 2:

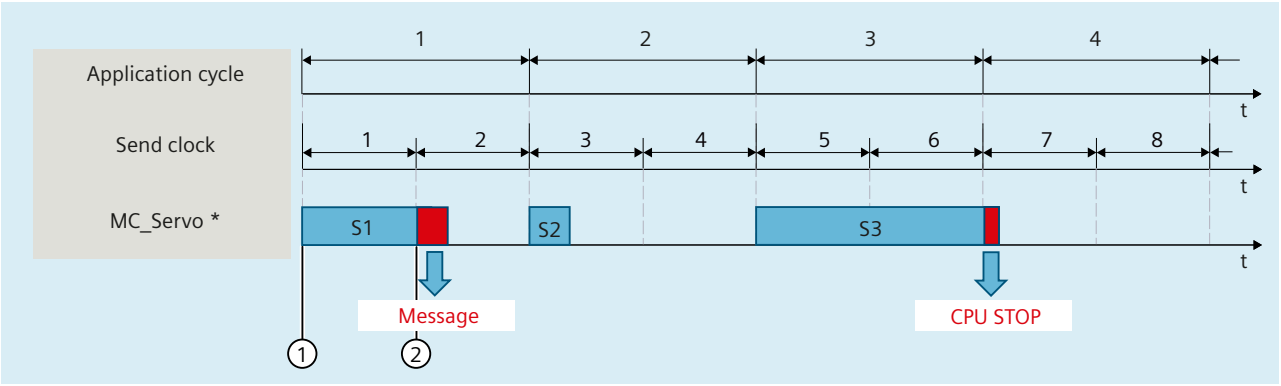

① Start of the processing of MC_Servo

② Overflow (message)

* Including MC_PreServo and/or MC_PostServo, if present

The execution of an MC_Interpolator may only be interrupted by an MC_Servo call. If more interruptions occur, the CPU switches to STOP mode.

The following figure shows the process response when an MC_Interpolator is interrupted over two time slices:

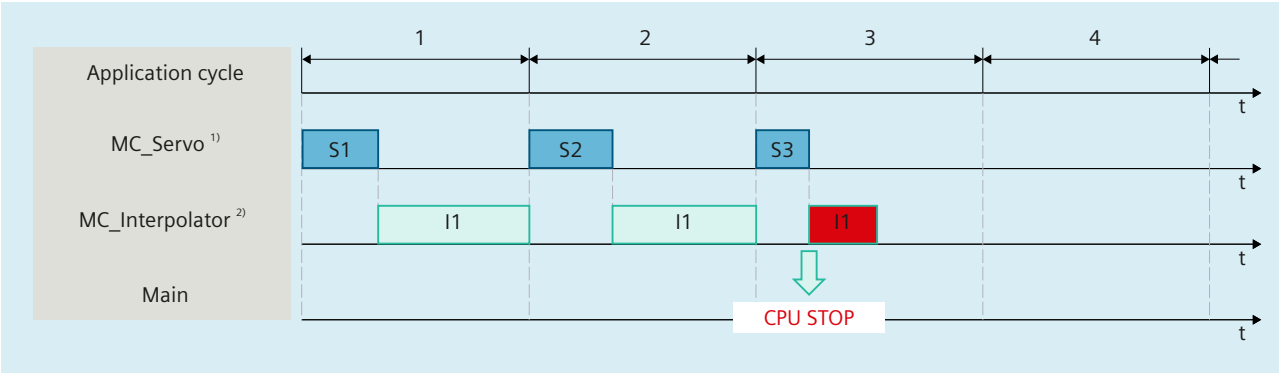

1) Including MC_PreServo and/or MC_PostServo, if present

2) Including MC_PreInterpolator, if present

The CPU tolerates a maximum of three consecutive MC_Interpolator overflows. If more overflows occur, the CPU switches to STOP mode.

The following figure shows the process response if there are four consecutive individual overflows of MC_Interpolator:

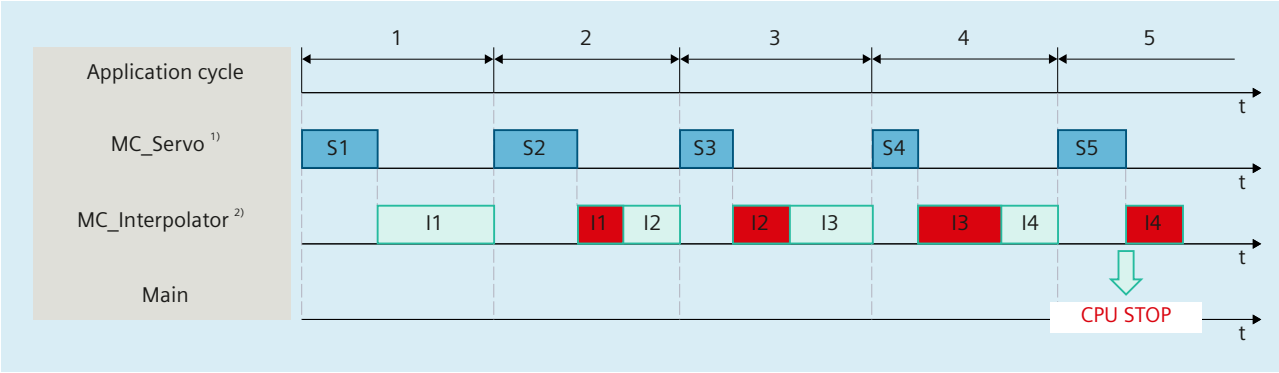

1) Including MC_PreServo and/or MC_PostServo, if present

2) Including MC_PreInterpolator, if present

8.1.4 Operating modes

This section examines the behavior of the Motion Control in the respective operating modes and in the transitions between operating modes. A general description of the operating modes can be found in the S7-1500 System Manual

Operating modes and transitions

The CPU has the following operating modes:

- STOP
- STARTUP
- RUN
- HOLD

The following figure shows the operating modes and the operating mode transitions:

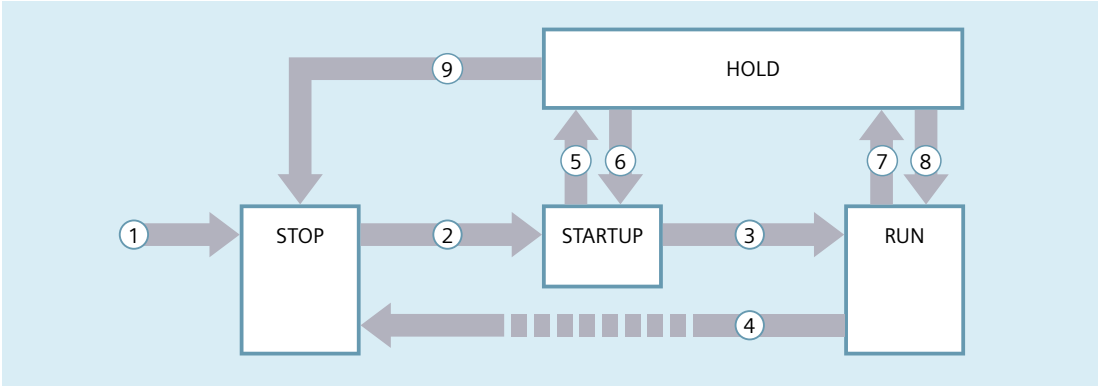

Operating mode transitions

The following table shows the behavior of the Motion Control in the transitions between the operating modes:

No.	Operating mode transition	Behavior
①	POWER ON → STOP	The CPU performs a restart of the technology objects. The technology objects are reinitialized with the values from the load memory.
②	STOP → STARTUP	Not relevant for Motion Control.
③	STARTUP → RUN	The process outputs are enabled.
④	RUN → STOP	When the CPU changes from RUN mode to STOP mode, all technology objects are disabled in accordance with the alarm response "remove enable". Active Motion Control jobs are aborted. If restart-relevant data has been changed for technology objects in RUN, the CPU performs a restart of the corresponding technology objects.
⑤	STARTUP → HOLD	Breakpoint in the start-up routine reached.
⑥	HOLD → STARTUP	Not possible when using technology objects

No.	Operating mode transition	Behavior
⑦	RUN → HOLD	Breakpoint reached
⑧	HOLD → RUN	Not possible when using technology objects
⑨	HOLD → STOP	By operation of switch/display or by setting to STOP from programming device.

STOP mode

In STOP mode the user program is not processed and all process outputs are disabled. Thus no Motion Control jobs are executed.

The technology data blocks are updated.

STARTUP mode

Before the CPU starts processing of the cyclical user program, the startup OBs are processed one time.

In STARTUP mode, the process outputs are disabled. Motion Control jobs are rejected.

The technology data blocks are updated.

RUN mode

The user program is processed in RUN mode.

In RUN mode, the programmed Motion Control jobs are cyclically called and processed.

The technology data blocks are updated.

HOLD operating state

Working with breakpoints is not supported when technology objects are used. An overflow of the MC_Servo hereby occurs. This leads to an immediate switch to STOP mode.

In HOLD operating state, events are not initiated and the user program is not executed.

The outputs in the HOLD operating state behave as parameterized. Outputs either supply a configured substitute value or keep the last value output and bring the controlled process to a safe operating state.

When you reach a breakpoint, the CPU executes an implicit restart of the technology object. Homing the technology once again.

8.1.5 Improving system performance for motion jobs

In the case of complex applications, the processing time in the application cycle increases as the number of technology objects increases.

The "Improve system performance" function for motion jobs enables the application cycle for CPUs with multi-core processors to be shortened. In the process, the editing of the isochronous organization blocks MC_Servo and MC_Interpolator is divided between the cores.

The image below shows the process behavior with and without the "Improve system performance" function. The function is not active in the upper part of the image. In the lower part of the image, the function is activated. The processing of the organization blocks MC_Servo and MC_Interpolator is divided between the cores C1 and C2. The processing time in the application cycle is reduced. More processing time is therefore available for the main program.

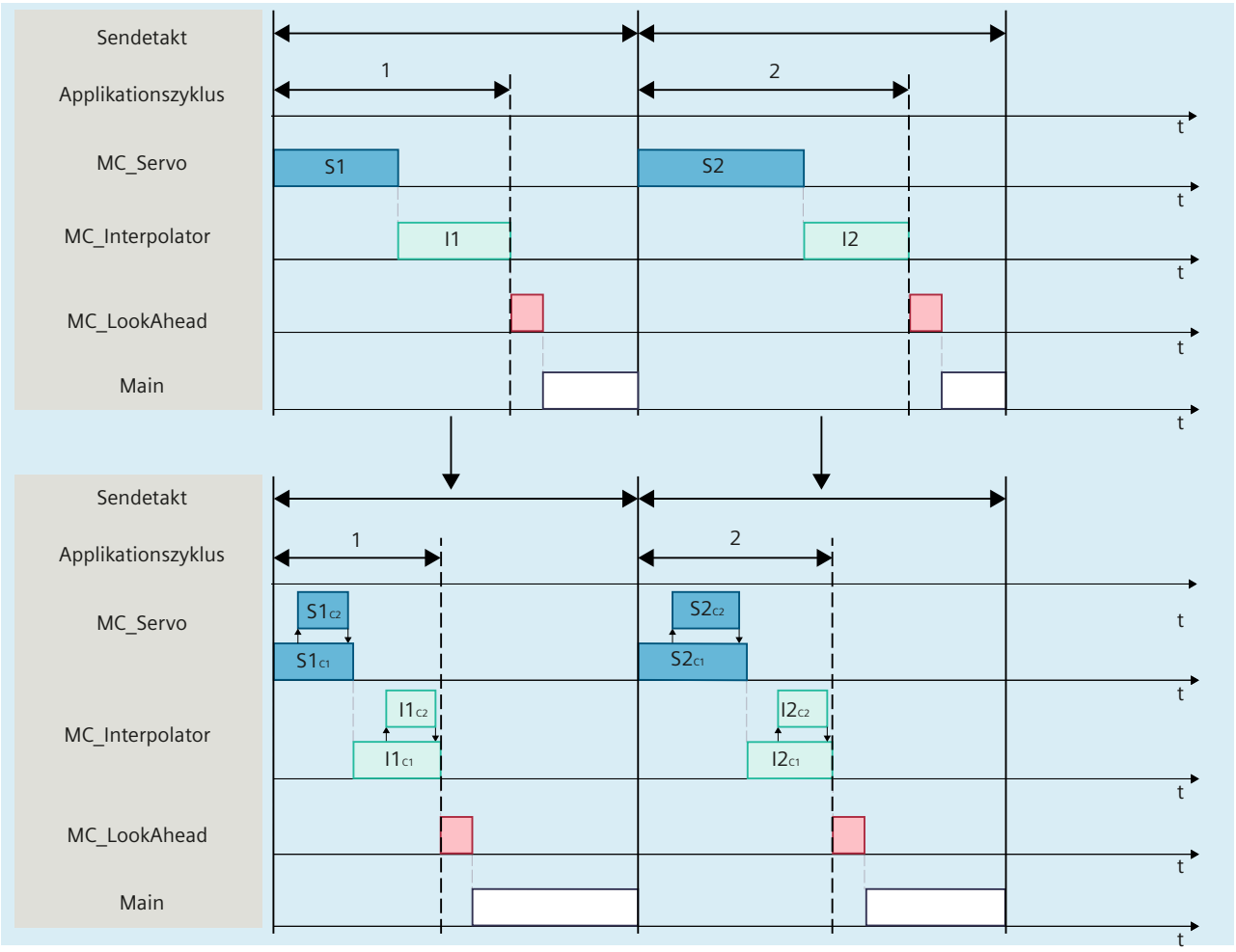

With the "Improve system performance" function, you can reduce the processing time for the application cycle by up to 30%. The actual time savings depend primarily on the following factors:

- CPU used

  The function is especially suitable for high-performance CPUs.
- Motion Control share

  The higher the Motion Control share in the user program, the greater the time savings.
- Number of technology objects

  The more technology objects you are using, the greater the time savings.

  With a small number of technology objects, the effect is negligible. The processing time could even increase due to the distribution workload between the cores.

Requirements

- Technology CPUs with multi-core processor as of firmware version V4.1
- Organization block MC_Interpolator is created
- Version of the Motion Control instructions as of V10.0

Activating "Improve system performance"

Proceed as follows to activate the function:

1. In the project tree, navigate in the CPU to "Program blocks".
2. Select the "MC_Interpolator".
3. Open the "Properties" in the context menu.
4. Select the "Improve system performance" check box under "General > Multi-core processor > Motion jobs".
5. Set the CPU to "STOP" mode, if necessary.
6. Load the changes onto the CPU.

Result: The "Improve system performance" function for motion jobs is activated and effective at the organization blocks MC_Interpolator and MC_Servo.

Checking the effects

Use the following possibilities to determine the exact time savings of the function:

- Measuring of the processing times of the organization blocks MC_Servo and MC_Interpolator with the instruction "RT_Info"
- Reading out the application cycle time via the start information of the organization blocks

8.2 Technology data block

The properties of real objects (e.g. axes) are configured by means of the technology objects and saved in a technology data block. The technology data block contains all configuration data, setpoint and actual values, and status information of the technology object. The TIA Portal automatically creates the technology data block when the technology object is created. You access the data of the technology data block (read/write access) with your user program.

You can find a list and description at the tags of the corresponding technology object.

8.2.1 Evaluating the technology data block

Access to data in the technology data block occurs in accordance with the access to standard data blocks. Only tags with elementary data types can be accessed in the technology data block. Access to a complete data structure (e.g. STRUCT, ARRAY) is not possible.

Reading values from the technology data block

In your user program you can read actual values (e.g. current position) and status information, or detect error messages in the technology object. When you program a query in your user program (e.g. current velocity), the value is directly read from the technology object.

Reading values from the technology data block takes longer than for other data blocks. If you use these tags several times in a single cycle of your user program, it is recommended to copy the tag values to local tags, and use the local tags in your program.

Writing values to the technology data block

The configuration of the technology object in the TIA Portal is used to write the corresponding data to the technology data block. After they have been loaded into the CPU, these data are stored in the CPU on the SIMATIC Memory Card (load memory).

In the following cases, it may be necessary for the user program to write values to the technology data block:

- Adaptation of the configuration of the technology object (e.g. dynamic limits, software limit switches)
- Use of overrides
- Adaptation of position control (e.g. "Kv" parameter)

Behavior of the CPU when invalid values are written

If you write an invalid value into a tag during runtime, the CPU behaves as follows:

- LREAL data type

  The tag is set to the limit value without a note.
- All other data types

  The tag is not changed.

- Exceptions are:
  - <TO_PositioningAxis>.Sensor[1..4].Parameter.Backlash.DirectionAbsoluteHoming
  - <TO_SynchronousAxis>.Sensor[1..4].Parameter.Backlash.DirectionAbsoluteHoming
  - <TO_SynchronousAxis>.SynchronizedMotion.LeadingValueToleranceDirection
  - <TO_CamBase>.InterpolationSettings.InterpolationMode
  - <TO_CamBase>.InterpolationSettings.BoundaryConditions

  With these tags, the CPU switches to STOP mode.

Effectiveness of changes

Changes to values in the technology data block by the user program can take effect at various points in time. The respective properties of the individual tags are described in the tags of the corresponding technology object:

Effectiveness of changes	Description	
Direct (DIR)	You write changes using direct assignments. The changes are applied only at the start of the next MC_Servo. The changes are retained until the next POWER OFF of the CPU or restart of the technology object.	
	LREAL (e.g. <TO>.Override.Velocity)	The technology object performs a range check on the written value, and immediately starts using the new value. If range limits are violated when writing, the technology object automatically corrects the values. If the value is below the range, then the value is set to the low limit of the range; if the range is exceeded, then the value is set to the high limit of the range.
	DINT/BOOL (e.g. <TO>.PositionLimits_SW.Active)	Changes are only permitted in the defined value range. Value changes outside the value range are not applied. If you enter invalid values, the programming error OB (OB 121) is started.
When Motion Control instruction is called (CAL) (e.g. <TO>.Sensor[1..4].ActiveHoming.HomePositionOffset)	You write changes using direct assignments. The changes are applied at the start of the next MC_Servo after the call of the corresponding Motion Control instruction in the user program. The changes are retained until the next POWER OFF of the CPU or restart of the technology object.	
Restart (RES) (e.g. <TO>.Homing.AutoReversal)	Since restart-relevant tags have dependencies on other tags, value changes cannot be applied at any arbitrary time. The changes are only used after reinitialization (restart) of the technology object. During a restart the technology object is reinitialized with the data in load memory. You therefore write changes to the start value in the load memory with the extended instruction "WRIT_DBL" (write to data block in load memory). You trigger the restart in your user program using the Motion Control instruction "MC_Reset" with parameter "Restart" = TRUE. Additional information regarding the restart can be found in the section Restarting technology objects (Page 140).	
Read only (RON) (e.g. <TO>.Position)	The tag cannot and must not be changed during runtime of the user program.	

NOTE

Save changes with "WRIT_DBL"

Changes to tags immediately in effect are lost on POWER OFF of the CPU, or restart of the technology object.

If changes in the technology data block should also be retained after POWER OFF of the CPU, or restart of the technology object, you must write the changes to the start value in the load memory with the extended instruction "WRIT_DBL".

NOTE

Using the "READ_DBL" and "WRIT_DBL" data block functions

The "READ_DBL" and "WRIT_DBL" data block functions may only be used on individual tags in conjunction with the tags of the technology object. The "READ_DBL" and "WRIT_DBL" data block functions must not be applied to data structures of the technology object.

Isochronous evaluation of data

If you want to process data of the technology data block in isochronous mode from a Motion Control application cycle, there is the option of evaluating this data in the MC_PreServo /MC_PostServo as of technology version V3.0. As of technology version V5.0, you also have the option of evaluating this in MC_PreInterpolator.

8.2.2 Evaluate StatusWord, ErrorWord and WarningWord

To be able to symbolically use individual status and error information from the "StatusWord", "ErrorWord" and "WarningWord" data double words, you can evaluate them as described below. For consistent evaluation, you should avoid using bit addressing to access these data double words in the technology data block. Access to an individual bit in the technology data block only lasts as long as the access to the entire data word.

When required, copy the required data double word to a tag of a data structure and query the individual bits of the tag.

The allocation of the individual bits in the data double words can be found in the description of the tags of the corresponding technology object.

Requirements

The technology object has been created.

Procedure

To evaluate the individual bits in the data word "StatusWord", follow these steps:

1. Crate a global data structure. Name the data structure, e.g. as "Status".
2. Create a double word (DWORD) in the data structure "Status". Name the double word, e.g. as "Temp".

3. Create 32 Boolean tags in the "Status" data structure. You can obtain a clearer overview by giving the individual Boolean tags identical names as the bits in the technology DB (e.g. name the fifth Boolean tag "HomingDone").
4. If needed, copy the tag "<TO>.StatusWord" from the technology data block to the double word "Temp" in your data structure.
5. Copy the individual bits of double word "Temp" to the corresponding Boolean tags with bit accesses.
6. Use the Boolean tags to query the status bits.

Evaluate the data words "ErrorWord" and "WarningWord" as specified in steps 1 to 6.

Example

The following example shows how you can read out and save the fifth bit "HomingDone" of the data word "StatusWord":

SCL	Explanation
`#Status.Temp := "TO".StatusWord;`	`//Copy status word`
`#Status.HomingDone := #Status.Temp.%X5;`	`//Copy individual bits per bit access`

STL	Explanation
`L "TO".StatusWord`	`//Copy status word`
`T #Status.Temp`	
`U #Status.Temp.%X5`	`//Copy individual bits per bit access`
`= #Status.HomingDone`	

8.2.3 Change restart-relevant data

In order to change restart-relevant data in the technology data block, write to the starting values of the tags in load memory using the extended instruction "WRIT_DBL". In order for the changes to be applied, a restart of the technology object must be performed.

You can see from the description of the tag of the corresponding technology object whether value changes of a tag are restart-relevant.

Requirement

The technology object has been created.

Procedure

To change restart-relevant data, proceed as follows:

1. Create a data block and fill it with the restart-relevant values, that you want to change in the technology data block. In doing so, the data types must match the tags to be changed.
2. Write the values from your data block to the starting values of the tags of the technology data block in load memory, using the extended instruction "WRIT_DBL".

   If restart-relevant data were changed, this will be indicated in the "<TO>.StatusWord.X3 (OnlineStartValuesChanged)" tag of the technology object.
3. Perform a restart of the technology object using the Motion Control instruction "MC_Reset" with parameter "Restart" = TRUE.

After the restart of the technology object, the new value is transferred into the technology data block in work memory, and is effective.

Changing multiple variables with the "WRIT_DBL" instruction

The tag "<TO>.StatusWord.X3 (OnlineStartValuesChanged)" indicates that the value of a tag has been changed.

If you change several variables with "WRIT_DBL", you cannot use "<TO>.StatusWord.X3 (OnlineStartValuesChanged)" to determine which tags have already been written.

To capture the relevant value changes of several variables, build your user program with "WRIT_DBL" similar to the following programming example in a sequencer:

SCL programming example

```
//*******
#FB_STATE_LIMITS_MAX_JERK: //write limits max jerk
#tempRetVal := WRIT_DBL (REQ := TRUE,
SRCBLK := #statDynamicLimits.MaxJerk,
BUSY => #statBusyWriting,
DSTBLK => #axis.DynamicLimits.MaxJerk);
IF #statBusyWriting THEN
; //wait until writing completed
ELSIF #tempRetVal = 16#0 AND NOT #statBusyWriting
THEN //done without error
//go to next state:
//restart technology object, if all data are
//written to load memory
//Alternatively: Write more variables in
//the next state via WRIT_DBL and
//execute restart later
#statFBState := #FB_STATE_RESTART_TO;
ELSE //error Write DBL
//go to error state
#statStatus := INT_TO_WORD (#tempRetVal);
END_IF;
//*******
```

```
#FB_STATE_RESTART_TO: //Restart TO
#instFBReset (Axis := #axis,
Execute := TRUE,
Restart := TRUE);
```

8.3 Motion Control instructions

8.3.1 Motion Control instruction parameters

The individual Motion Control instructions are described in detail in the section "S7-1500 Motion Control V7".

When creating your user program, take the following explanations of the Motion Control instruction parameters into account.

Reference to the technology object

The technology object is specified for the Motion Control instruction as follows:

- **Parameter "Axis"**

  The "Axis" input parameter of a Motion Control instruction contains a reference to the technology object that is to execute the corresponding job.

  The corresponding technology object is also referenced in the following parameters:

  – Parameter "Master"
  – Parameter "Slave"
  – Parameter "Cam"
  – Parameter "MeasuringInput"
  – Parameter "OutputCam"
  – Parameter "CamTrack"
  – Parameter "AxesGroup"
  – Parameter "TimePosition"

  As of technology version V3.0, the reference to the technology object can be specified, also in limited manner, via the data type "DB_ANY".

  As of firmware version V3.0, you can temporarily home the technology object with "DB_ANY".

  For more information on programming with "DB_ANY", refer to the section "Parameter transfer for function blocks (Page 126)".

Job start and transfer of input parameters of a Motion Control instruction

For the start of jobs and the transfer of modified parameter values, a distinction is made between the following Motion Control instructions:

- **Motion Control instructions with "Execute" parameter**

  With a positive edge at the "Execute" parameter, the job is started and the existing values for the input parameters are transferred.

  Subsequently changed parameter values are not transferred until the next job start.

  Resetting the "Execute" parameter does not end the job, but it does affect the display duration of the job status. As long as "Execute" is set to "TRUE", the output parameters will be updated. If "Execute" is reset before the completion of a job, the parameters "Done", "Error" and "CommandAborted" are correspondingly set for only one call cycle.

- **Motion Control instructions with "Enable" parameter**

  The job is started by setting the "Enable" parameter.

  As long as "Enable" = TRUE, the job remains active and changed parameter values will be transferred each time the instruction is called in the user program.

  The job is ended by resetting the "Enable" parameter.

  The input parameters "JogForward" and "JogBackward" of the Motion Control instruction "MC_MoveJog" correspond in their behavior to the "Enable" parameter.

Job status

The following output parameters indicate the status of the job execution:

- **Motion Control instructions with "Done" parameter**

  The normal completion of a job is indicated with parameter "Done" = TRUE.

- **Motion Control instructions without "Done" parameter**

  The achievement of the job objective is indicated by other parameters (e.g. "Status", "InVelocity"). For more information, refer to the "Tracking running jobs (Page 131)" section.

- **Parameter "Busy"**

  As long as a job is in progress, the "Busy" parameter shows the value "TRUE". If a job was ended or canceled, "Busy" shows the value "FALSE".

- **Parameter "Active"**

  If a job is active in Motion Control, the parameter "Active" shows the value "TRUE". As long as a job is in the job sequence, "Active" shows the value "FALSE".

- **Parameter "CommandAborted"**

  If a job was canceled by another job, the "CommandAborted" parameter shows the value "TRUE".

- **Parameter "Error"**

  If a Motion Control instruction error occurs, the "Error" parameter shows the value "TRUE". The "ErrorID" parameter indicates the cause of the error.

As long as the "Execute" or "Enable" parameter is set to "TRUE", the output parameters will be updated. Otherwise, the parameters "Done", "Error" and "CommandAborted" are correspondingly set for only one cycle.

Cancelation of running jobs

An active Motion Control job is canceled by the start of a new Motion Control job. In the process, the current dynamic setpoints (acceleration, deceleration, jerk, velocity) are set to the values of the overriding job.

Example of parameter behavior

The behavior of the parameters of Motion Control instructions is shown in the following chart using the example of two "MC_MoveAbsolute" jobs.

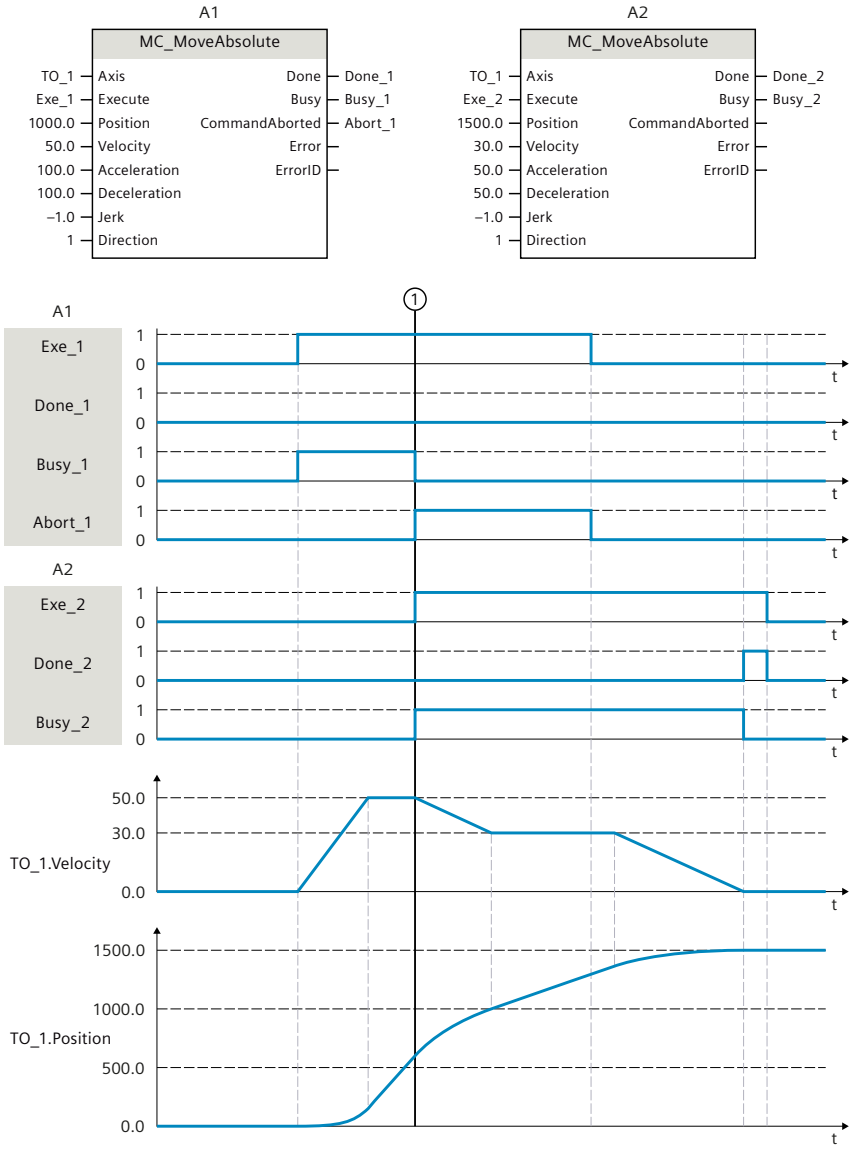

Using "Exe_1", an "MC_MoveAbsolute" job (A1) with target position 1000.0 is initiated. "Busy_1" is set to "TRUE". The axis is accelerated to the specified velocity and moved to the target position (see TO_1.Velocity and TO_1.Position). Before the target position is reached, the job is overridden at time ① by another "MC_MoveAbsolute" job (A2). The termination is signaled via "Abort_1", and "Busy_1" is set to "FALSE". The axis is braked to the velocity specified in A2 and moved to the new target position 1500.0. When the axis reaches the target position, this is signaled via "Done_2".

Non-position-controlled operation

The position control of the axis can be deactivated with the following parameters:

- MC_Power.StartMode = 0
- MC_MoveVelocity.PositionControlled = FALSE
- MC_MoveJog.PositionControlled = FALSE

For more information, refer to the section "Non-position-controlled operation" of the "S7-1500/S7-1500T Axis functions" (Page 7) documentation.

8.3.2 Add Motion Control instructions

You add Motion Control instructions to a program block in the same way as other instructions. You control all available functions of the technology object using the Motion Control instructions. The instructions can be called at all execution levels.

Requirements

The technology object was created.

Procedure

To add Motion Control instructions in your user program, proceed as follows:

1. Double click your program block in the project tree (the program block must be called in the cyclical program).

   The program block is opened in the programming editor, and the available instructions are displayed.
2. In the "Instructions" task card, open the "Technology > Motion Control" folder.
3. Using drag-and-drop, move the Motion Control instruction, e.g. "MC_Power", to the desired segment of the program block.

   The "Call options" dialog opens.
4. In the dialog, specify a name and a number for the instance data block of the Motion Control instruction.

5. Click "OK".

   The Motion Control instruction "MC_Power" is inserted into the network.

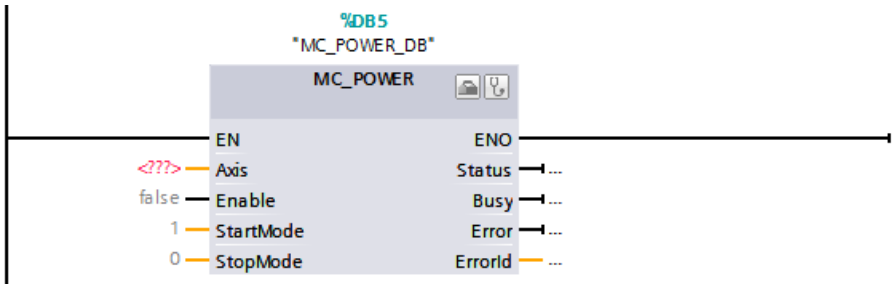

   The instance data block is automatically created under "Program Blocks > System Blocks > Program Resources".

6. Input parameters without a default value (e.g. "Axis"), must be assigned. Select the technology object in the project tree and move the technology object onto <...> at the "Axis" parameter using drag-and-drop.

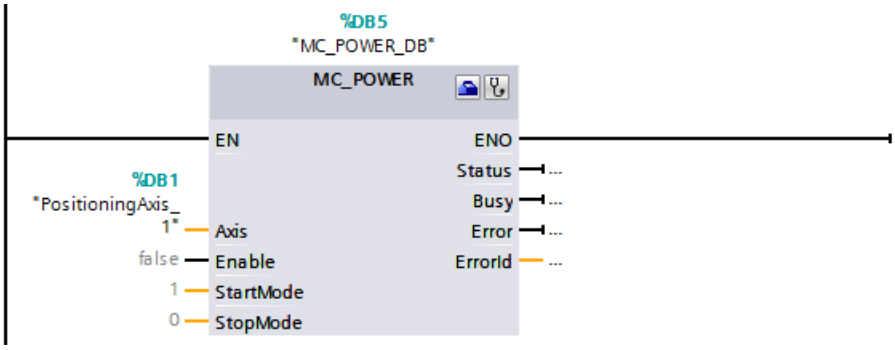

   Once the technology object is specified in the "Axis" parameter, the following buttons are available to you:

	To open the configuration of the technology object, click on the toolbox icon.
	To open the diagnostics of the technology object, click on the stethoscope icon.

7. Add additional Motion Control instructions in accordance with steps 3 through 6.

NOTE

Multi-instance DBs

If you use multi-instances of the Motion Control instructions "MC_Power" or "MC_TorqueLimiting", create the multi-instances in a separate instance data block. This allows you to download program blocks from other sections of your user program without switching off the axes, including in "RUN" mode.

See also

Tracking active jobs (Page 131)

8.3.3 Parameter transfer for function blocks

If you want to reuse a function block with Motion Control instructions for different technology objects, create an input parameter of the data type of the respective technology object in the block interface of the calling function block. You assign the data type in the block interface with a direct input. The parameter is then transferred as reference to the technology object to the "Axis" parameter of the Motion Control instructions. The data types of technology objects correspond to the structure of the associated technology data block.

In contrast to standard data types, the data types for technology objects are always passed on as pointers to the function block (Call by reference). This remains true if you declare the data types of the technology objects in "Input" area of the block interface. Write access to function blocks always leads directly to modification of the referenced technology object.

Example 1: Tag transfer with specific data type

By specifying the data type, you can address the tags of the technology object in the function block (<parameters of the block interface>.<tag of the technology object>). The data types for the reference to the technology objects are available in the section "appendix (Page 141)".

The following table shows the declaration of the tags used:

Tag	Declaration	Data type	Description
axis	Input	TO_PositioningAxis	Reference to the technology object
on	Input	BOOL	Signal to enable the axis
actPosition	Output	LReal	Query of the actual position from the technology data block
instMC_POWER	Static	MC_POWER	Multi-instance of the Motion Control instruction "MC_Power"

The following SCL program shows the tag transfer with a specific data type:

SCL	Explanation
`#instMC_POWER(Axis := #axis, Enable := #on);`	`//Call of the Motion Control instruction "MC_Power" with enable of the axis`
`#actPosition := #axis.ActualPosition;`	`//Query of the actual position from the technology data block`

Example 2: Tag transfer with "DB_ANY" for axes

A more flexible option for the transferring technology objects to blocks is provided by the data type "DB_ANY" in combination with references to technology objects. These references can be assigned during runtime.

You can store all types of technology objects in a "DB_ANY" data type ARRAY. An ARRAY of the data type "DB_ANY" can thus represent a list of axes, for example. This allows technology objects to be handled more flexibly in a user program.

This example shows how to enable and disable different axis types with one function block. The technology objects are homed temporarily.

The following technology objects are used:

Number	Data type	Name
1	TO_SpeedAxis	SpeedAxis_1
1	TO_PositioningAxis	PositioningAxis_1
1	TO_SynchronousAxis	SynchronousAxis_1

To enable and disable all three axes with one function block, follow these steps:

1. Add a global data block, in the example "AxesDB".
2. Define the one constant as the last index of the array, e.g. LAST_INDEX_AXES. The constant has the value 2 in this example because 3 axes are used and the array starts at 0.
3. Add an "AxesDB" to the created "Array[0.. LAST_INDEX_AXES] of DB_ANY" data block:

Tag	Declaration	Data type
axes	Static	Array[0.. LAST_INDEX_AXES] of DB_ANY

   The unique assignment of the technology objects to the elements of the array must be carried out once in the user program, for example, when the CPU is started in OB100 (Startup).
4. Assign the created technology objects to the elements of the array from the data block in OB100 (Startup).

   The following SCL program shows the tag transfer with "DB_ANY":

   ```
   //assign technology objects to ARRAY of DB_ANY
   "Data".axes[0] := "SpeedAxis_1";
   "Data".axes[1] := "PositioningAxis_1";
   "Data".axes[2] := "SynchronousAxis_1";
   ```
5. Create a function block, in the example "EnableAxes".
6. Declare the tags as follows:

Tag	Declaration	Data type	Description
enableAxes	Input	BOOL	Enable/disable all axes
axisEnabled	Output	ARRAY [0.. LAST_INDEX_AXES] of BOOL	Status axis enable
axis	InOut	ARRAY[0.. LAST_INDEX_AXES] of DB_ANY	List of the axes
instMC_Power	Static	ARRAY [0.. LAST_INDEX_AXES] of MC_POWER	Array of multi-instances of the MC_POWER
tempRefSpeedAxis	Temp	REF_TO TO_SpeedAxis	Temporary reference of the technology object type TO_SpeedAxis
tempAxesCounter	Temp	Dint	Counter tag for axes

   In the program code, reference the three axis types to the temporary reference of the TO_SpeedAxis technology object. Since the TO_SpeedAxis is part of the TO_PositioningAxis and the TO_SynchronousAxis, it is possible to reference all three axes.

7. Program the "EnableAxis" FB as follows.

```
//enable all axes
FOR #tempAxesCounter := 0  TO LAST_INDEX_AXES DO
    //build temporary reference
    #tempRefSpeedAxis ?= #axes[#tempAxesCounter];
    //check valid reference
    IF #tempRefSpeedAxis <> NULL THEN
        //call multi instance
        #instMC_Power[#tempAxesCounter](Axis :=
#tempRefSpeedAxis^,
                                        Enable := #enableAxes);
        //set output states, if axis is enabled
        #axisEnabled[#tempAxesCounter] :=
#tempRefSpeedAxis^.StatusWord.%X0;
    ELSE
        ; //implement error handling in case of NULL
END_IF;
END_FOR;
```

Example 3: Tag transfer with "DB_ANY" for cams

This example shows how to temporarily reference the different technology object types for cams for cam interpolation. You can also implement the switching of cams during camming with temporary references.

The following technology objects are used:

Number	Data type	Name
2	TO_Cam	TO_Cam_1, TO_Cam_2
2	TO_Cam_10k	TO_Cam_3_10k_1, TO_Cam_4_10k

1. Proceed as in the first five steps of example 2. Cams are used instead of axes.
2. Declare the tags of the "InterpolateCams" function block as follows:

Tag	Declaration	Data type	Description
executeCamInter-polation	Input	BOOL	Start cam interpolation
selectedCamIndex	Input	USInt	Cam index
done	Output	BOOL	Cam was interpolated
busy	Output	BOOL	Cam is being interpolated
error	Output	BOOL	Error on the block
cams	InOut	ARRAY[0.. LAST_INDEX_CAMS] of DB_ANY	List of cams

Tag	Declaration	Data type	Description
instInterpolateCam	Static	MC_INTERPOLATECAM	Multi-instance of the MC_INTERPOLATECAM
tempRefCam	Temp	REF_TO TO_CamBase	Temporary reference of the technology object type TO_CamBase
tempAxesCounter	Temp	Dint	Counter tag for axes

In the program code, you home the cams to the temporary reference of the TO_CamBase technology object. A reference is possible because the TO_CamBase is a component of the TO_Cam and the TO_Cam_10k.

You can use the "selectedCam" input to access the index of the array and thus select the cam that is to be interpolated. Start the cam interpolation via the "executeCamming" input.

3. Program the FB "InterpolateCams" as follows.

```
//execute cam interpolation for TO_Cam and TO_Cam_10k
#tempRef_Cam ?= #cams[#selectedCamIndex];
//check valid reference
IF #tempRefCam <> NULL THEN
   //call multi instance for cam interpolation
   #instInterpolateCam(Cam := #tempRefCam^,
                       Execute := #executeCamInterpolation,
                       Done => #done,
                       Busy => #busy,
                       Error => #error);
ELSE
   // implement error handling here,
   // DB_ANY does not have a type TO_Cam or TO_Cam_10k
   #busy := FALSE;
   #done := FALSE;
   #error := TRUE;
END_IF;
```

More information

You can find an FAQ on flexible programming with the "DB_ANY" data type in combination with references on technology objects on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109822593).

8.4 Starting Motion Control jobs

Motion Control jobs are started by setting the "Execute" or "Enable" parameter of the Motion Control instruction. The call of the Motion Control instructions for a technology object should occur in an execution level.

When executing Motion Control jobs, you should also take note of the status of the technology object.

Starting Motion Control jobs should be performed in the following steps:

1. Query the status of the technology object.
2. Initiate new job for the technology object.
3. Check job status.

These steps are explained using the example of a job for absolute positioning.

1. Query the status of the technology object

Make sure that the technology object is in the appropriate status to perform the desired job:

- **Has the technology object been released?**

  To execute motion jobs, the technology object must be enabled.

  Enabling is performed using the Motion Control instruction "MC_Power".

  The "MC_Power.Status" parameter (<TO>.StatusWord.X0 (Enable)) must show the value "TRUE".

- **Is a technology alarm pending?**

  To perform motion commands, no technology alarms or alarm responses may be pending. The "<TO>.ErrorDetail.Number" and "<TO>.ErrorDetail.Reaction" tags of the technology object must show the value zero. After resolving the error, acknowledge any pending alarms using the Motion Control instruction "MC_Reset".

  You can find a list of the technology alarms and alarm responses in the "Technology alarms" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation (Page 7).

- **Has the technology object been homed?**

  In order to perform a job for absolute positioning, the positioning axis/synchronous axis technology object must be homed. The referencing occurs via the Motion Control instruction "MC_Home". The "<TO>.StatusWord.X5 (HomingDone)" tag of the technology object must show the value "TRUE".

2. Initiate new job for the technology object

At the "Position" parameter of a Motion Control instruction, e.g. "MC_MoveAbsolute", specify the position to which the axis should be moved. Start the job with a positive edge at the "Execute" parameter.

3. Check job status

Parameter "Done" of the Motion Control instruction indicates successful completion of a job (target reached, in this case).

If an error is detected, the "Error" parameter of the Motion Control instruction is set to "TRUE", and the job is rejected.

You can program an error handling routine for the Motion Control job. For this purpose, evaluate the error indicated in the "Error" parameter. The cause of the error is indicated in the ErrorID parameter. After resolving the cause of the error, restart the job.

If "Error" = TRUE and "ErrorID" = 16#8001 is indicated during job execution, a technology alarm has occurred.

You can find a list of the ErrorIDs in the "Error IDs on Motion Control instructions" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation (Page 7)".

More information

An option for evaluating the individual status-, error- and warning bits find can be found in section "Evaluate StatusWord, ErrorWord and WarningWord (Page 118)".

8.5 Tracking active jobs

The current status of the job processing is made available via the output parameters of the Motion Control instruction. These parameters are updated with each call of the Motion Control instruction.

A distinction is made between the following groups when follow-up jobs:

- Motion Control instructions with "Done" parameter (Page 131)
- Motion Control instructions without "Done" parameter (Page 135)

8.5.1 Motion Control instructions with "Done" parameter

Jobs of Motion Control instructions with the "Done" parameter are started with a positive edge at the "Execute" parameter. If the job was completed without errors or interruption by another job (e.g. "MC_MoveAbsolute": Target position reached), the "Done" parameter shows the value "TRUE". The CPU processes the Motion Control instructions and the technology object in different execution levels. The status bits on the Motion Control statements, such as the "Done" parameter, are updated with a delay.

In positioning instructions, the parameter "Done" is delayed by the set minimum dwell time (<TO>.PositioningMonitoring.MinDwellTime).

The behavior of the parameters is shown below by way of example for various situations.

Complete execution of the job

If the Motion Control job has been completely executed all the way to the end, this is indicated with parameter "Done" = "TRUE". The signal state of the "Execute" parameter influences the display duration for the "Done" parameter:

You set "Execute" **after completion** of the job to "FALSE".	You set "Execute" **during processing** of the job to "FALSE".
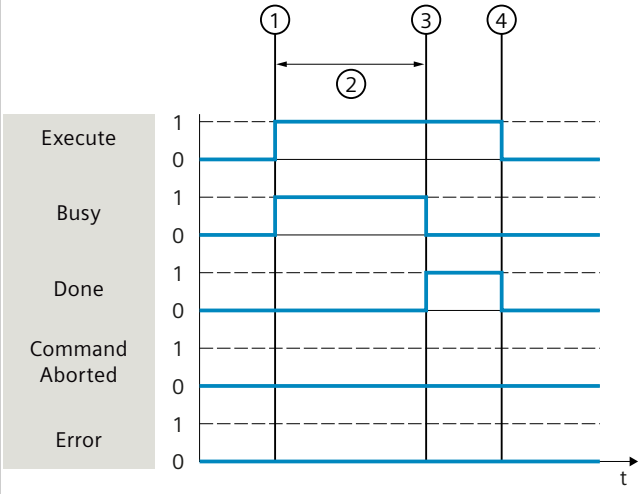	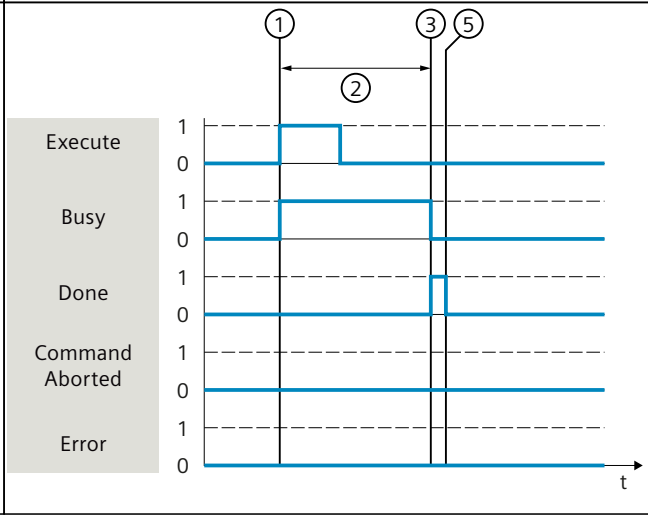

1	The job is started with a positive edge at the "Execute" parameter. Depending on the programming, "Execute" can be reset to the value "FALSE" during the job or the value "TRUE" can be retained until after completion of the job.
2	While the job is being executed, the "Busy" parameter shows the value "TRUE".
3	At the completion of the job (for example, with Motion Control instruction "MC_MoveAbsolute": Target position reached), the "Busy" parameter changes to "FALSE" and the "Done" parameter to "TRUE".
4	As long as the "Execute" parameter retains the value "TRUE" after completion of the job, the "Done" parameter also retains the value "TRUE".
5	If the "Execute" parameter was already set to "FALSE" before completion of the job, the "Done" parameter shows the value "TRUE" for only one execution cycle.

Job abort

If the Motion Control job is canceled during processing by another job, this is indicated in the "CommandAborted" parameter with the value "TRUE". The signal state of the "Execute" parameter influences the display duration for the "CommandAborted" parameter:

You set "Execute" **after** the job is aborted to "FALSE".	You set "Execute" **before** the job is aborted to "FALSE".
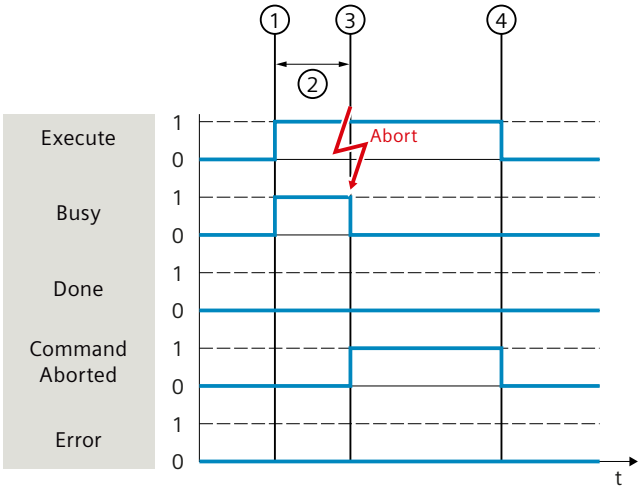	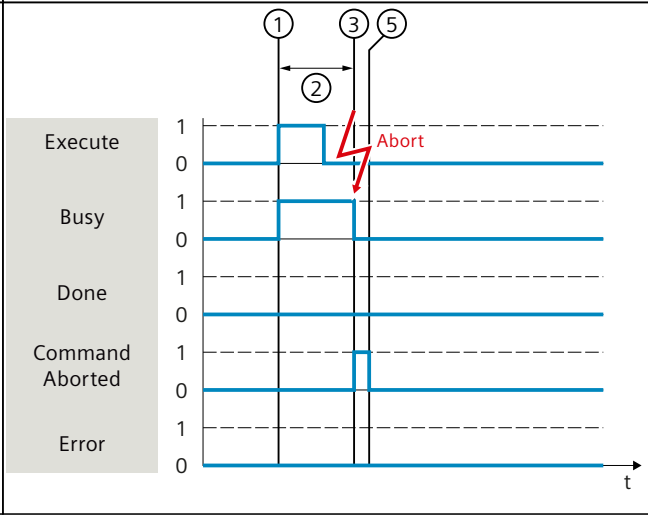

①	The job is started with a positive edge at the "Execute" parameter. Depending on the programming, "Execute" can be reset to the value "FALSE" during the job or the value "TRUE" can be retained until after completion of the job.
②	While the job is being executed, the parameter "Busy" shows the value "TRUE".
③	During job execution, the job is aborted by another Motion Control job. When the job is aborted, the "Busy" parameter changes to "FALSE" and "CommandAborted" changes to "TRUE".
④	As long as the "Execute" parameter retains the value "TRUE" after completion of the job, the "CommandAborted" parameter also retains the value "TRUE".
⑤	If the "Execute" parameter was already set to "FALSE" before the job is aborted, the "CommandAborted" parameter shows the value "TRUE" for only one execution cycle.

Error during job execution

If an error occurs during execution of the Motion Control job, this is indicated with parameter "Error" = "TRUE". The signal state of the "Execute" parameter influences the display duration for the "Error" parameter:

You set "Execute" **after** the occurrence of the error to "FALSE".	You set "Execute" **before** the occurrence of the error to "FALSE".
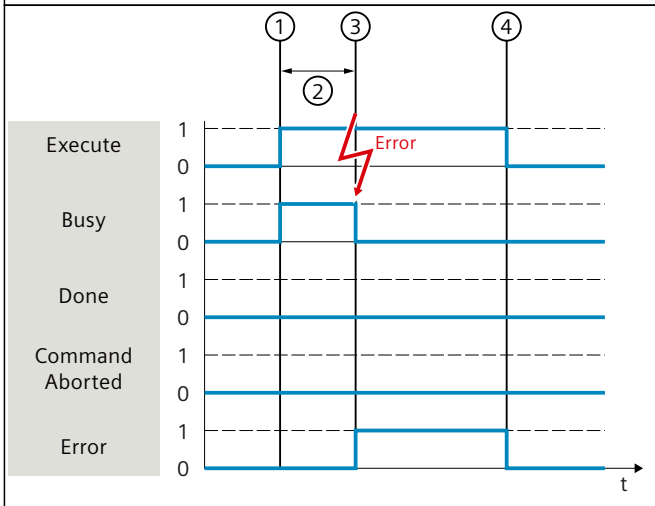	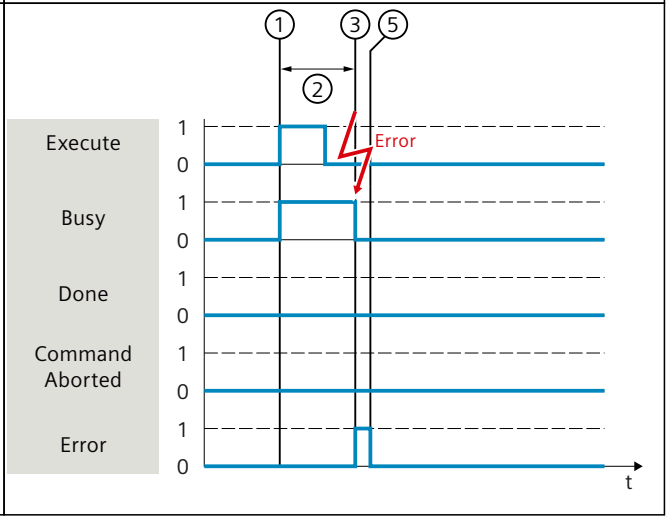

①	The job is started with a positive edge at the "Execute" parameter. Depending on the programming, "Execute" can be reset to the value "FALSE" during the job or the value "TRUE" can be retained until after completion of the job.
②	While the job is being executed, the "Busy" parameter shows the value "TRUE".
③	An error occurs during the execution of the job. When the error occurs, the "Busy" parameter changes to "FALSE" and the "Error" parameter to "TRUE".
④	As long as the "Execute" parameter retains the value "TRUE" after the occurrence of the error, the "Error" parameter also retains the value "TRUE".
⑤	If the "Execute" parameter was already set to "FALSE" before the occurrence of the error, the "Error" parameter shows the value "TRUE" for only one execution cycle.

Motion Control instructions

You can find more information on the Motion Control instructions of the Kinematics technology object in the "S7-1500T Kinematics functions" documentation (Page 7).

8.5.2 Motion Control instructions without "Done" parameter

Motion control instructions without the "Done" parameter use a special parameter to indicate that the job objective (e.g. "InVelocity", "InGear") has been achieved. The target state or motion is held until the job is aborted or an error occurs.

The following Motion Control instructions have a special parameter for indicating the job status:

Motion Control instruction	Parameter	S7-1500	S7-1500T
MC_Power	Status	✓	✓
MC_MoveVelocity	InVelocity	✓	✓
MC_MoveJog	InVelocity	✓	✓
MC_GearIn	InGear	✓	✓
MC_GearInPos	InSync	-	✓
MC_GearInVelocity	InSync	-	✓
MC_CamIn	InSync	-	✓
MC_SynchronizedMotionSimulation	InSimulation	-	✓
MC_TorqueLimiting	InClamping and InLimitation	✓	✓

The following Motion Control instructions do not have any special parameter for indicating the job status. Feedback is provided via the following tags:

Motion Control instruction	Parameter	Description
MC_MeasuringInputCyclic	Busy	The execution of a measuring job is indicated with parameter "Busy" = "TRUE". Completed measuring events are indicated in the corresponding event counters "<TO>.MeasuredValues.MeasuredValue1Counter" and "<TO>.MeasuredValues.MeasuredValue2Counter" of the technology data block.
MC_OutputCam	Busy	The execution of a job is indicated with parameter "Busy" = "TRUE". The CamOutput tag in the associated technology data block indicates the switching state of the output cam.
MC_CamTrack	Busy	The execution of a job is indicated with parameter "Busy" = "TRUE". The TrackOutput tag in the associated technology data block indicates the switching state of the cam track.
MC_LeadingValueAdditive	Busy	The execution of a job is indicated with parameter "Busy" = "TRUE".
MC_MotionInVelocity	Busy	The execution of a job is indicated with parameter "Busy" = "TRUE".
MC_MotionInPosition	Busy	The execution of a job is indicated with parameter "Busy" = "TRUE".

Motion Control instruction	Parameter	Description
MC_MotionInSuperimposed	Busy	The execution of a job is indicated with parameter "Busy" = "TRUE".
MC_KinematicsTransformation	Busy	The execution of a job is indicated with parameter "Busy" = "TRUE".
MC_InverseKinematicsTransformation	Busy	The execution of a job is indicated with parameter "Busy" = "TRUE".

The behavior of the parameter is shown for various situations using the Motion Control instruction "MC_MoveVelocity" as an example:

Example "MC_MoveVelocity"

An "MC_MoveVelocity" job is started with a positive edge at the "Execute" parameter. The job objective is fulfilled when the assigned velocity is reached and the axis travels at constant velocity. When the assigned velocity is reached and maintained, this is indicated in the "InVelocity" parameter with the value "TRUE".

The motion of the axis can, for example, be stopped with an "MC_Halt" job.

The assigned velocity is reached and maintained

Reaching of the assigned velocity is indicated with parameter "InVelocity" = "TRUE". The "Execute" parameter has no effect on the display duration for the "InVelocity" parameter.

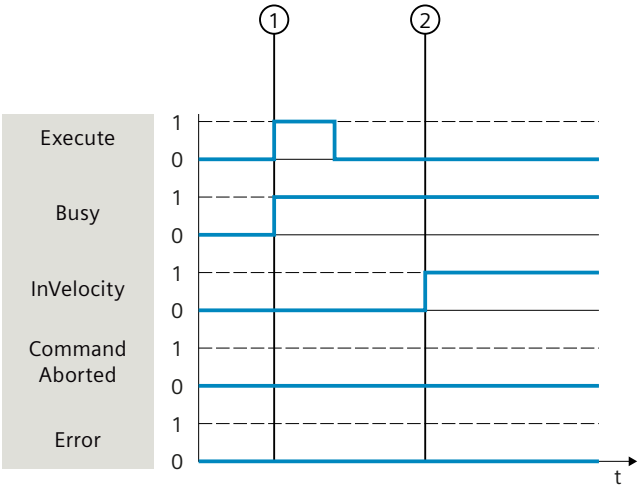

1	The job is started with a positive edge at the "Execute" parameter. Depending on the programming, "Execute" can be reset to the "FALSE" value before or after the parameterized velocity has been reached. While the job is being executed, the parameter "Busy" shows the value "TRUE".
2	When the assigned velocity is reached, the "InVelocity" parameter changes to "TRUE". The "Busy" and "InVelocity" parameters retain the value "TRUE" until another motion control job overrides the "MC_MoveVelocity" job.

The job is aborted before the assigned velocity is reached

If the motion control job is canceled by another job before the assigned velocity is reached, this is indicated with parameter "CommandAborted" = "TRUE". The signal state of the "Execute" parameter influences the display duration for the "CommandAborted" parameter.

You set "Execute" **after** the job is aborted to "FALSE".	You set "Execute" **before** the job is aborted to "FALSE".
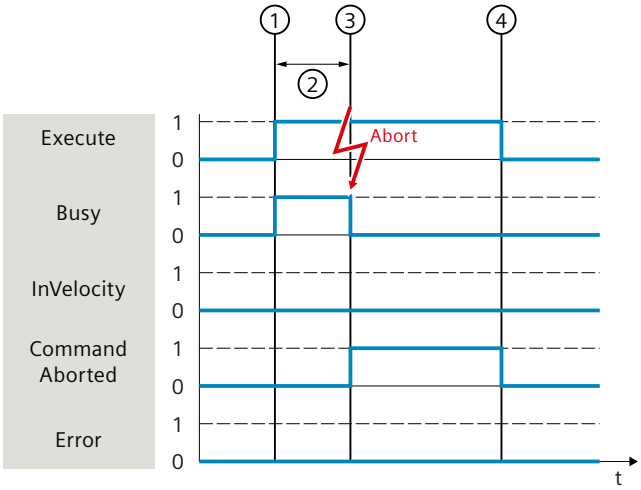	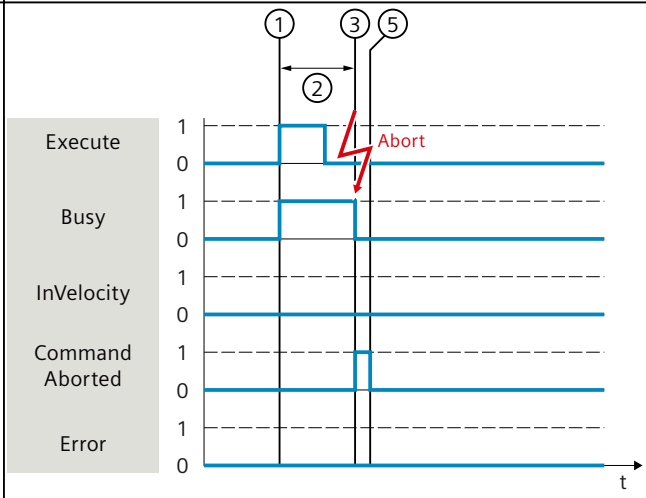

①	The job is started with a positive edge at the "Execute" parameter. Depending on the programming, "Execute" can be reset to the value "FALSE" during the job or the value "TRUE" can be retained until after the job is aborted.
②	While the job is being executed, the "Busy" parameter shows the value "TRUE".
③	During job execution, the job is aborted by another Motion Control job. When the job is aborted, the "Busy" parameter changes to "FALSE" and "CommandAborted" changes to "TRUE".
④	As long as the "Execute" parameter retains the value "TRUE" after completion of the job, the "CommandAborted" parameter also retains the value "TRUE".
⑤	If the "Execute" parameter was already set to "FALSE" before the job is aborted, the "CommandAborted" parameter shows the value "TRUE" for only one execution cycle.

An error has occurred prior to reaching the assigned velocity

If an error occurs during execution of the motion control job before the assigned velocity has been reached, this is indicated with parameter "Error" = "TRUE". The signal state of the "Execute" parameter influences the display duration for the "Error" parameter.

You set "Execute" **after** the occurrence of the error to "FALSE".	You set "Execute" **before** the occurrence of the error to "FALSE".
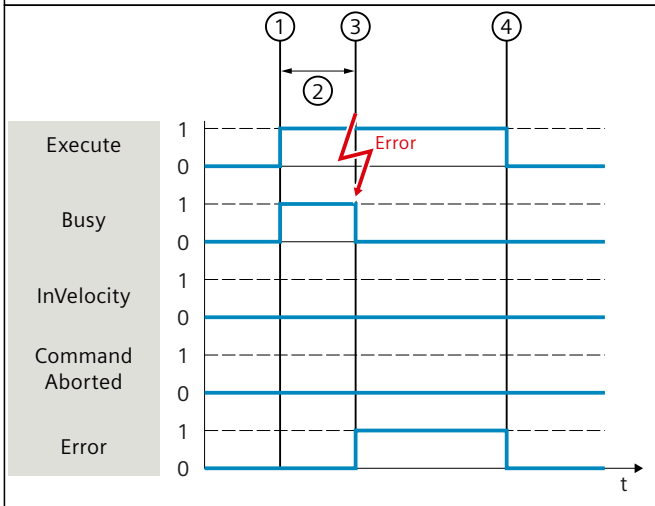	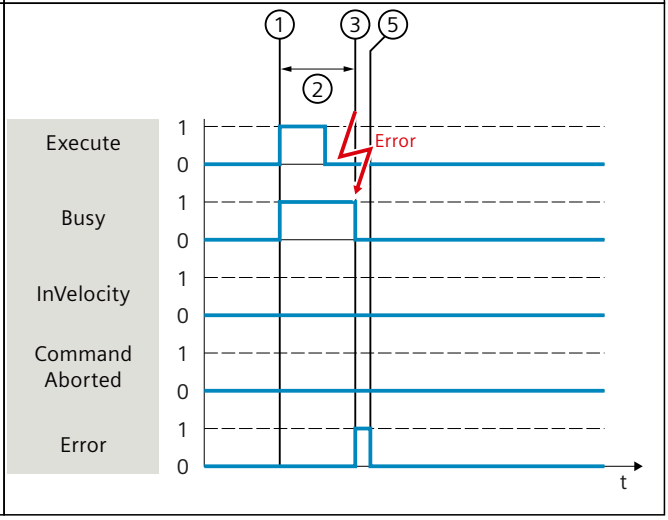

1	The job is started with a positive edge at the "Execute" parameter. Depending on the programming, "Execute" can be reset to the value "FALSE" during the job or the value "TRUE" can be retained until after the error has occurred.
2	While the job is being executed, the "Busy" parameter shows the value "TRUE".
3	An error occurs during the execution of the job. When the error occurs, the "Busy" parameter changes to "FALSE", and the "Error" parameter to "TRUE".
4	As long as the "Execute" parameter retains the value "TRUE" after completion of the job, the "Error" parameter also retains the value "TRUE".
5	If the "Execute" parameter was already set to "FALSE" before the job is aborted, the "Error" parameter shows the value "TRUE" for only one execution cycle.

Motion Control instructions

You can find more information on the Motion Control instructions of the Kinematics technology object in the "S7-1500T Kinematics functions" documentation (Page 7).

8.6 Ending Motion Control jobs

When a job is ended, a distinction is made between error-free completion of the job and a motion cancelation.

Completion of job

The completion of a Motion Control job is indicated as described in the "Tracking running jobs (Page 131)" section.

Job termination

The termination and the substitution behavior are described in the section "Substitution behavior of Motion Control jobs". Special waiting jobs can be canceled with an "MC_Power" job.

Motion cancelation

If a motion must be canceled, you can perform the following measures:

- Execute "MC_Halt" or "MC_Stop"

  To cancel a motion and stop the axis, you can use an "MC_Halt" or "MC_Stop" job.
- Execute "MC_GroupStop" (S7-1500T)

  With the Motion Control instruction "MC_GroupStop", you stop and abort an active motion on the kinematics technology object.
- Disable "MC_Power"

  In an emergency, you can stop the axis via an emergency stop ramp. To do this, set the "Enable" parameter of the "MC_Power" job to "FALSE". The axis is decelerated according to the selected "StopMode" and all jobs of the technology object are canceled.
- Execute "MC_GearOut" or "MC_CamOut" (S7-1500T)

  To terminate gearing, you can desynchronize the following axis with a "MC_GearOut" job.

  To end camming, you can desynchronize the following axis with an "MC_CamOut" job.
- Execute "MC_StopProgram" (S7-1500T)

  To stop a motion controlled by the Interpreter technology object, stop the execution of the Interpreter program with an "MC_StopProgram" job.

Measuring job cancelation

With an "MC_AbortMeasuringInput" job you can cancel an active one-time or cyclic measuring job.

Cancellation of an active output cam/cam track

- "MC_OutputCam"

  With "MC_OutputCam.Enable" = FALSE you can disable an output cam.
- "MC_CamTrack"

  With "MC_CamTrack.Enable" = FALSE you can disable an active cam track.

8.7 Restart of technology objects

After the CPU is switched on, or after technology objects are downloaded into the CPU, the system automatically initializes the technology objects with the start values from the technology data block. If restart-relevant changes are detected during a reload into the CPU, a restart of the technology object is automatically performed.

If restart-relevant data have been changed in RUN mode by the user program, then the technology object must be reinitialized by the user in order for the changes to be used. At a RUN → STOP transition, the CPU automatically performs a restart of technology objects with restart-relevant changes.

If changes in the technology data block should also be retained after the restart of the technology object, then you must write the changes to the start value in load memory using the extended instruction "WRIT_DBL".

Restart required

If a restart of the technology object is required, this is indicated at "Technology object > Diagnostics > Status and error bits > Axis status or Encoder status > Online start value changed", as well as in the tag "<TO>.StatusWord.X3 (OnlineStartValuesChanged)" of the technology object.

Restarting a technology object

A restart of the technology object is triggered by the user by means of the "MC_Reset" Motion Control instruction, with parameter "Restart" = TRUE.

During a restart, all configuration data of the technology object are loaded from load memory into work memory. In the process, the actual values in the technology data block are overwritten.

Note the following during a restart of the technology object:

- A restart resets the "Homed" status of a technology object with incremental actual values ("<TO>.StatusWord.X5 (HomingDone)").
- While a restart is being performed, the technology object cannot perform any jobs. An active restart will be indicated under "Technology object > Diagnostics > Status and error bits > Axis status or Encoder status > Restart active", and in the "<TO>.StatusWord.X2 (RestartActive)" tag of the technology object.
- Motion Control jobs are rejected during a restart with the "Error" = TRUE and "ErrorID" = 16#800D parameters (job not executable, because a restart is active).

- Active Motion Control jobs to the technology objects output cam, cam track, measuring input and kinematics are canceled by a restart with "ErrorID" = 16#800D.
- While a restart is being executed, you cannot access the technology data block.

See also

Change restart-relevant data (Page 119)

8.8 Data types

Data types for the use of technology

The table below contains the data types for reference to the respective technology object:

Data type	Description
TO_Object[1) 2)]	Basis of technology objects
TO_Axis[1)]	Basis of axes
TO_SpeedAxis[1)]	Speed axis
TO_PositioningAxis[1)]	Positioning axis
TO_SynchronousAxis[1)]	Synchronous axis
TO_ExternalEncoder[1)]	External encoder
TO_OutputCam	Output cam
TO_CamTrack	Cam track
TO_MeasuringInput	Measuring input
TO_CamBase[2)]	Basic information on cams (S7-1500T)
TO_Cam[2)]	Cam (S7-1500T)
TO_Cam_10k[2)]	
TO_Cam_600Seg[2)]	
TO_Cam_6kSeg[2)]	
TO_Kinematics	Kinematics (S7-1500T)
TO_LeadingAxisProxy[1)]	Leading axis proxy (S7-1500T)
TO_Interpreter	Interpreter (S7-1500T)
TO_InterpreterProgram	Interpreter program (S7-1500T)
TO_InterpreterMapping	Interpreter mapping (S7-1500T)
PD_TELx	Telegram no. "x"
DX_TEL_SyncOp	Leading value telegram
PD_STW1_611Umode	Control word 1 (STW1)
PD_STW2_611Umode	Control word 2 (STW2)
PD_ZSW1_611Umode	Status word 1 (ZSW1)
PD_ZSW2_611Umode	Status word 2 (ZSW2)

[1) 2)] Cascading technology objects

Cascading technology objects

The structure of the technology objects is structured as follows:

- "TO_Object" is the basis of all technology objects and a component of the "TO_Axis" and "TO_CamBase".
- "TO_Axis" is part of "TO_SpeedAxis", "TO_ExternalEncoder" and "TO_LeadingAxisProxy".
- "TO_SpeedAxis" is part of "TO_PositioningAxis".
- "TO_PositioningAxis" is part of "TO_SynchronousAxis".
- "TO_CamBase" is part of "TO_Cam", "TO_Cam_10k", "TO_Cam_600Seg" and "TO_Cam_6kSeg".

Downloading to CPU 9

When downloading to the CPU S7-1500, it is always verified that the project files are consistent online and offline after the download. The data of the technology objects is stored in technology data blocks. The conditions for downloading blocks thus apply when downloading new or modified technology objects.

Downloading in "RUN" mode

When downloading in "RUN" mode of the CPU, a check is made to determine whether a download without restart of the technology object is possible. If restart-relevant configuration values were changed, then a restart of the technology object is automatically performed after the load into the CPU.

Loading a technology object is only possible if the technology object is disabled.

Downloading a function block with multi-instances of Motion Control instructions "MC_Power" is only possible under the following preconditions:

- "MC_Power.Enable" = FALSE
- "MC_Power.Status" = FALSE
- "<TO>.StatusWord.X0" = FALSE

Downloading a function block with multi-instances of Motion Control instructions "MC_TorqueLimiting" is only possible under the following preconditions:

- "MC_TorqueLimiting.Enable" = FALSE
- "MC_TorqueLimiting.Busy" = FALSE
- "<TO>.StatusWord.X26" = FALSE

The following changes **cannot** be downloaded to the CPU in "RUN" mode:

- Changes to the cycle clocks of MC_Servo
- Changes to the hardware interface of the technology object in "Technology object > Configuration > Hardware interface"

NOTE

Multi-instance DBs

If you use multi-instances of the Motion Control instructions "MC_Power" or "MC_TorqueLimiting", create the multi-instances in a separate instance data block. This allows you to download program blocks from other sections of your user program without switching off the axes, including in "RUN" mode.

Diagnostics 10

The description of Motion Control diagnostics is limited to the diagnostics view of the technology objects in TIA Portal, the technology alarms and the error IDs on Motion Control instructions.

"Debug" program mode is available for testing the execution of your Interpreter program.

The following descriptions can be found in the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation (Page 7):

- Diagnostics concept
- Technology alarms
- Error IDs in Motion Control instructions

A comprehensive description of the system diagnostics of the S7-1500 CPU can be found in the "Diagnostics" function manual (https://support.industry.siemens.com/cs/ww/en/view/59192926).

10.1 Recording and diagnostics of events with the trace

The event recording adds the recording of status changes to Motion Control jobs as well as coming and going program and technology alarms to the signal recording with the trace.

The event recording can be used in S7-1500 CPUs as of FW 4.0 and technology version V9.0 and is activated in the trace configuration.

The recorded events are displayed for recordings and measurements in the time diagram in the "Events" tab.

NOTE

The recorded events are only loaded after the trace recording has been finished. The loading process is aborted if you close the trace during this loading process. As soon as you open the trace again, the loading process restarts.

You save, export and import the recording as a measurement just like a trace without event recording.

With these recording and measurements you can, for example, analyze the correct sequence and programming in complex Motion Control applications. For this purpose, the TIA Portal as of V21 offers comprehensive filter possibilities and detailed information on each event.

10.1.1 Representation of the event recording in the time diagram

Display in the TIA Portal

The event data is loaded after the recording is finished and listed in the "Event" tab. With the task card "Event filter", you have multiple filter possibilities available for the recorded events.

> **⚠ CAUTION**
>
> **Inconsistencies in the projects with active event recording**
>
> If there are inconsistencies in the projects (online/offline), the event data may not be displayed correctly.
>
> Make sure you are using the correct projects and that the projects (online/offline) are consistent.

You can find more information on setting the view of the curve diagram in the "Trace and logic analyzer function" (https://support.industry.siemens.com/cs/us/en/view/64897128) manual, section "Set the view of the curve diagram".

The following figure shows the relevant areas in the work area of a completed trace recording with active event recording:

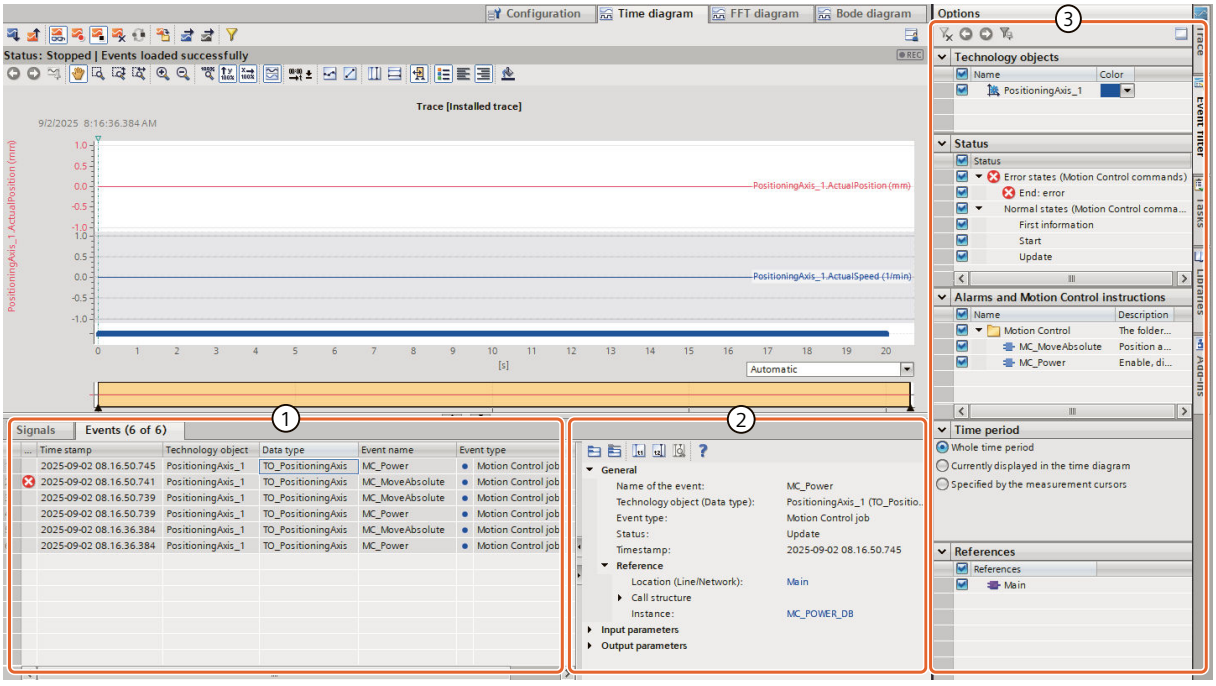

① "Events" tab

② Details view

③ "Event filter" task card

"Events" tab

The "Events" tab lists the following for each recorded event:

- The time stamp
- The affected technology object
- The data type of the technology object
- The technology object group
- The name of the event
  - Name of the instruction for the Motion Control job event type
  - Alarm number for the technology alarm event type
  - User-defined name for the program alarm event type
- The event type
- The status of the event
- The reference to the block in which the Motion Control instruction is called
- Instance of the instruction that is called

Additional data is available on each event in the "Details view". The data differs depending on the event type.

Via a context menu of an event, you can place the measurement cursor and optimize the scaling of the time diagram on the basis of the position of the measurement cursor.

Details view of the Motion Control jobs

The most important data from the "Events" tab is shown in the "General" node for each event.

The "Reference" entry shows the block in which the instruction is called, the call structure and the instance of the instruction which is called.

The "Input parameter" entry shows the input values of the instruction at the time of the event. The "Output parameter" entry shows the output values of the instruction at the time of the event.

The following figure shows the representation of the details view on a Motion Control job:

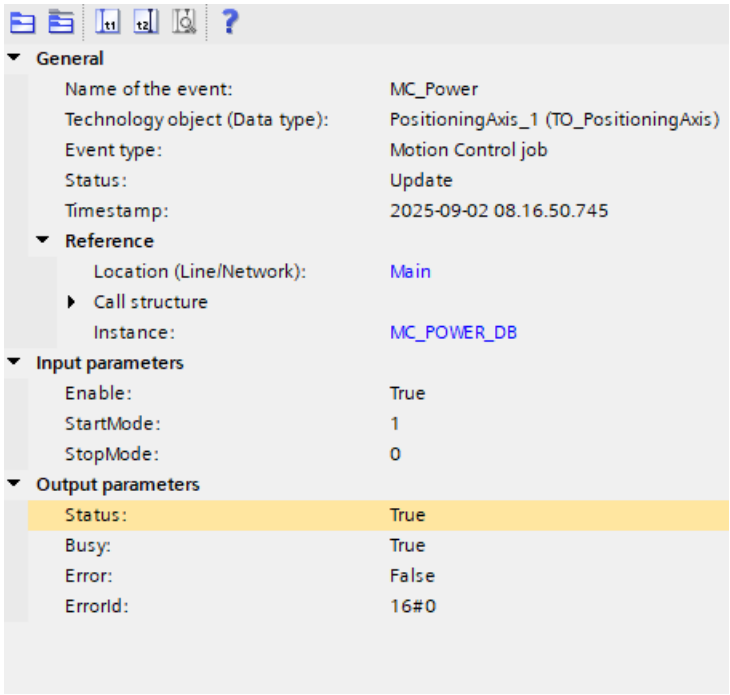

Details view for alarms

All associated alarms are displayed in the details view of alarms.

The following figure shows the display of the details view for a technology alarm:

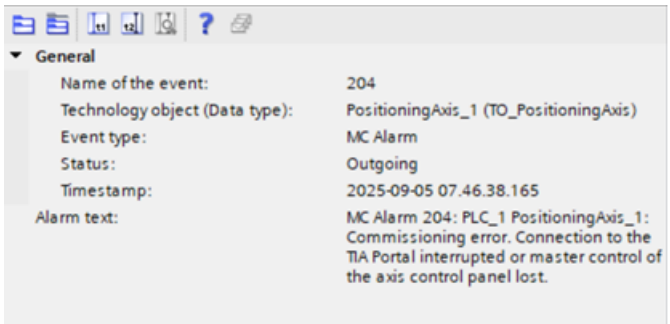

"Event filter" task card

The "Event filter" task card offers the possibility to filter the recorded data by different criteria. The filter criteria are independent of each other.

The filter criteria are divided among the following palettes:

- Technology objects
- Status
- Alarms and Motion Control jobs
- Time range
- Reference

The following figure shows the display of the "Event filter" task card:

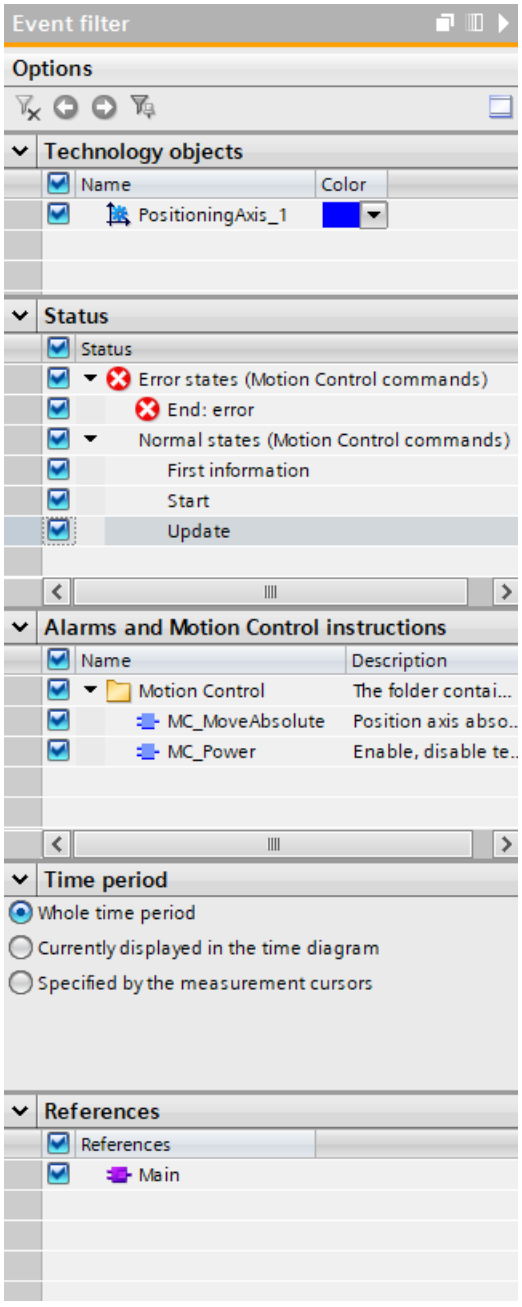

In each palette, you can find all objects which have resulted in an event in this recording.

To hide events in the "Events" tab, clear the respective check box.

10.1.2 Recordable events

Recordable events at Motion Control jobs

The following tables show which status changes of Motion Control jobs are recorded as an event:

Status	Description
First information	First call of the instruction This event is recorded after the instruction is called for the first time within the recording.
Start	Instruction has started This event is detected on a rising edge at the "Enable" or "Execute" parameter.
Update	Value change at the input or output parameters This event is recorded when the input or output parameters change after the instruction has been started. Some output parameters may change with each call (e.g. "RemainingDistance"). A new event is recorded for each value change.
Change	Value change at the input parameters This event is recorded when the input parameters change without leading to an "Update" event (for example, without any effect on the technological process).
End	Instruction was finished successfully This event is detected on a rising edge at the "Done" output parameter or on a falling edge at the "Enable" input parameter.
End: aborted	Instruction aborted This event is detected on a rising edge at the "CommandAborted" output parameter.
First information: Error	Instruction errors These events are detected on a rising edge at the "Error" output parameter. The value of the output parameter "ErrorId" is saved together with the event data.
Start: Error	
Change: Error	
End: Error	

Recordable events at program and technology alarms

The following table shows which status changes of program and technology alarms are recorded as an event:

Status	Description
Incoming	Alarm came
Outgoing	Alarm went

10.1.3 Guide to using the event recording

1. Activating event recording in the trace configuration (Page 151)
2. Performing trace recording
3. Filtering events (Page 151)
4. Displaying details of a recorded event (Page 152)
5. Navigating to the call of a Motion Control job (Page 153)

10.1.4 Activating event recording in the trace configuration

Requirement

- A Motion Control technology object as of Version V9.0 is created in the CPU.
- A trace configuration is created in the CPU.
- The "Configuration" tab is opened in the work area.
- The "Measurement in device (memory card)" function is deactivated.

NOTE

- Only one trace recording with active event recording can be located in a CPU. If a further recording with event recording is activated, you have to confirm the deactivation of the first trace via the dialog box. Alternatively, you have to deactivate the "Event recording" function in the second trace.
- Delete the non-required trace configuration with activated event recording on the PLC so that other diagnostic tools are not influenced.

Procedure

Proceed as follows to activate the function:

1. Navigate to "Configuration → Event recording".
2. Select the "Record events from technology objects" check box.

Result

The events of technology objects and alarms are additionally recorded during the trace recording for the selected signals.

After the recording is finished, the recorded data is loaded and listed in the "Events" tab.

The loading process requires some time.

10.1.5 Filtering events

If you activate a filter, it is signaled in the associated palette by the symbol.

The following description shows as an example the application of the filters for an event of the "MC_MoveAbsolute" instruction with an error status in a specific time range:

1. Open the "Event filter" task card.
2. Expand the "Alarms and Motion Control instructions" palette and leave only the check box for the MC_MoveAbsolute instruction selected.
3. Expand the "Status" palette and leave only the check box for "Error states (Motion Control commands)" selected.

4. Expand the "Time range" palette and select the matching option:
   – "Currently displayed in the time diagram"

   When selecting this filter option, you have to set the time range manually in the time diagram.

   The list in the "Events" tab is updated accordingly and only events which were recorded at the "MC_MoveAbsolute" instruction with the "Error" status in the time range that is currently displayed in the time diagram become visible. In the case of a further change of the displayed time range (e.g. through scaling or shifting), the list with the events updates accordingly.

   – "Specified by the measurement cursors"

   This filter option is only active when the vertical measurement cursor is set.

   You can set the vertical measurement cursor from the "Events" tab to specify the area by means of an event (e.g. MC_Power with status "First information"). You set the measurement cursor in the context menu of the selected event with the command "Set vertical measurement cursor t1 on this event" or "Set vertical measurement cursor t2 on this event". You can use the toolbar of the time diagram to set the measurement cursor. You can find more information on the use of the measurement cursor in the "Trace and logic analyzer function" manual, section "Use measurement cursor".

If you want to save the filter settings, click the icon "Save filter settings as standard" in the toolbar. When the recording is opened again, these settings are restored as the default view.

10.1.6 Displaying details of a recorded event

To display the detailed information on an event, follow these steps:

1. Select a recorded event in the "Events" tab.
2. In the toolbar of the detail view, click the icon to expand or collapse the nodes in the detailed view. If necessary, click the icon to only expand or collapse the nodes located below a selected node.

   The detailed information is displayed above the selected event. Differences compared to the corresponding previously recorded events are highlighted in color.
3. To receive more information and help on the selected event, click the icon "Help".

   The TIA Portal information system is opened with the relevant topic.

10.1.7 Navigating to the call of a Motion Control job

To be directed to the position where the Motion Control job was called, follow these steps:

1. Select a recorded event in the "Events" tab.
2. In the details view, click on the "Reference" node.

   The node is expanded.
3. To be forwarded to a specific point in the program code or network at which the Motion Control job was called, click on the link in the "Location (line/network)" line.

   Or:

   To be forwarded to a specific point within the call structure of a Motion Control job, click on the corresponding link in the "Call structure" line.

   The same procedure applies for the navigation to the associated data block.

NOTE

Analysis of further TIA Portal projects

The links to the event points are only available if the program or call structure is identical to the original project in which the events are recorded.

SIEMENS

SIMATIC

S7-1500
S7-1500/S7-1500T Axis functions
V10.0 as of STEP 7 V21

Function Manual

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Appendix A

S7-1500/S7-1500T Motion Control

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Introduction 1

Purpose of the documentation

This documentation provides important information that you need to configure and commission the integrated Motion Control functionality of the S7-1500 Automation systems.

Required basic knowledge

In order to understand this documentation, the following knowledge is required:

- General knowledge in the field of automation
- General knowledge in the field of drive engineering and motion control

Validity of the documentation

This documentation is valid for the S7-1500 product range.

Conventions

- The path specifications in the project tree assume that the "Technology objects" folder is open in the subtree of the CPU. The "Technology object" placeholder represents the name of the technology object.

  Example: "Technology object > Configuration > Basic parameters".
- The <TO> placeholder represents the name set in tags for the respective technology object.

  Example: <TO>.Actor.Type
- This documentation contains pictures of the devices described. The pictures may differ in minor details from the devices supplied.

You should also observe the notes that are marked as follows:

NOTE

A note contains important information about the product described in the documentation, about the handling of the product, and about sections in this documentation demanding your particular attention.

Industry Mall

The Industry Mall is the catalog and ordering system of Siemens Aktiengesellschaft for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

1.1 S7-1500 Motion Control Documentation Guide

Product information

Please also note the supplementary information on the Motion Control documentation:

- Product information on the S7-1500/1500T Motion Control documentation
  https://support.industry.siemens.com/cs/ww/en/view/109794046
  (https://support.industry.siemens.com/cs/ww/en/view/109794046)

Documentation

The documentation of the Motion Control functions is divided into the following documents:

- S7-1500/S7-1500T Motion Control Overview
  https://support.industry.siemens.com/cs/en/view/109990070
  (https://support.industry.siemens.com/cs/ww/en/view/109990070)

  This document describes the innovations in the technology versions, how to upgrade the technology version, functions that are used for all technology objects, and the operational sequence of Motion Control applications.
- S7-1500/S7-1500T Motion Control alarms and error IDs
  https://support.industry.siemens.com/cs/ww/en/view/109990076
  (https://support.industry.siemens.com/cs/ww/en/view/109990076)

  This document describes the technology alarms of the technology objects and the error identifications of the Motion Control instructions.
- S7-1500/S7-1500T Axis functions
  https://support.industry.siemens.com/cs/en/view/109990072
  (https://support.industry.siemens.com/cs/ww/en/view/109990072)

  This document describes the drive and encoder connection and functions for single-axis movements.
- S7-1500/S7-1500T Synchronous operation functions
  https://support.industry.siemens.com/cs/ww/en/view/109990074
  (https://support.industry.siemens.com/cs/ww/en/view/109990074)

  This document describes gearing, velocity synchronous operation and camming as well as cross-PLC synchronous operation.

- S7-1500/S7-1500T Measuring input and output cam functions
  https://support.industry.siemens.com/cs/ww/en/view/109990075
  (https://support.industry.siemens.com/cs/ww/en/view/109990075)
  This document describes the detection of the actual position via a measuring input and the output of switching signals via output cam or cam track.
- S7-1500T kinematics functions
  https://support.industry.siemens.com/cs/ww/en/view/109990073
  (https://support.industry.siemens.com/cs/ww/en/view/109990073)
  This document describes the control of kinematics with up to 6 interpolating axes.
- S7-1500T Interpreter functions
  https://support.industry.siemens.com/cs/ww/en/view/109990077
  (https://support.industry.siemens.com/cs/ww/en/view/109990077)
  This documentation describes the control of technology objects via an Interpreter program.

See also

Topic page "SIMATIC Technology - Motion Control: Overview and Important Links"
https://support.industry.siemens.com/cs/ww/en/view/109751049
(https://support.industry.siemens.com/cs/ww/en/view/109751049)

1.2 Function Manuals documentation guide

1.2.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.2.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.2.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 General safety instructions

The safety instructions can be found in section "Safety instructions" in the System Manual "SIMATIC S7-1500, ET 200MP Automation System" (https://support.industry.siemens.com/cs/ww/en/view/59191792) document.

Cybersecurity-relevant information can be found in the Industrial Cybersecurity section.

2.2 Warnings in this document

You can find explanations of the warnings used in this document in the "Legal information" section.

Industrial cybersecurity 3

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

3.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

New features V10.0

4

4.1 New axis functions V10.0

Technology version V10.0 contains the following new features.

Default values for the permissible following error

The following default values for the permissible following error have been updated for the rotary axis:

- <TO>.FollowingError.MinValue: 30°
- <TO>.FollowingError.MaxValue: 360°

Encoder connection via separate drive object encoder from Startdrive

- As of TIA Portal V21, you can interconnect a separate drive object encoder (DO ENCODER) on S120 with telegram 81 or 83 to the positioning axis, synchronous axis and external encoder technology objects.

Superimposed motion specification via "MotionIn" (S7-1500T)

- The motion setpoints of a superimposing axis are specified to the axis in the application cycle in addition to the basic motion. You can call the "MC_MotionInSuperimposedAxes (Page 364)" instruction in every cyclic organization block. The possible superimposing axes can be interconnected in the configuration of the synchronous axis or positioning axis technology object.

Use cam as time-based position profile (S7-1500T)

- With the Motion Control instruction "MC_PositionProfile (Page 312)", you start a relative or absolute positioning job with time-based position profile through which the profile of a cam can be traversed on the positioning axis or the synchronous axis. Specify the time-based position profile via the cam technology object.

Overview of functions

5

5.1 Speed axis technology object

The speed axis technology object calculates speed setpoints, taking into account the dynamic settings, and outputs them to the drive. All motions of the speed axis take place as speed-controlled motions. An existing load gear is taken into account on the system side.

You can find an overview of the supported instructions of the speed axis technology object in the section "Motion Control instructions for axis control (Page 30)".

A drive is assigned to each speed axis, e.g. via a PROFIdrive telegram.

The speed is specified in revolutions per unit of time.

The following figure shows the basic principle of operation of the speed axis technology object:

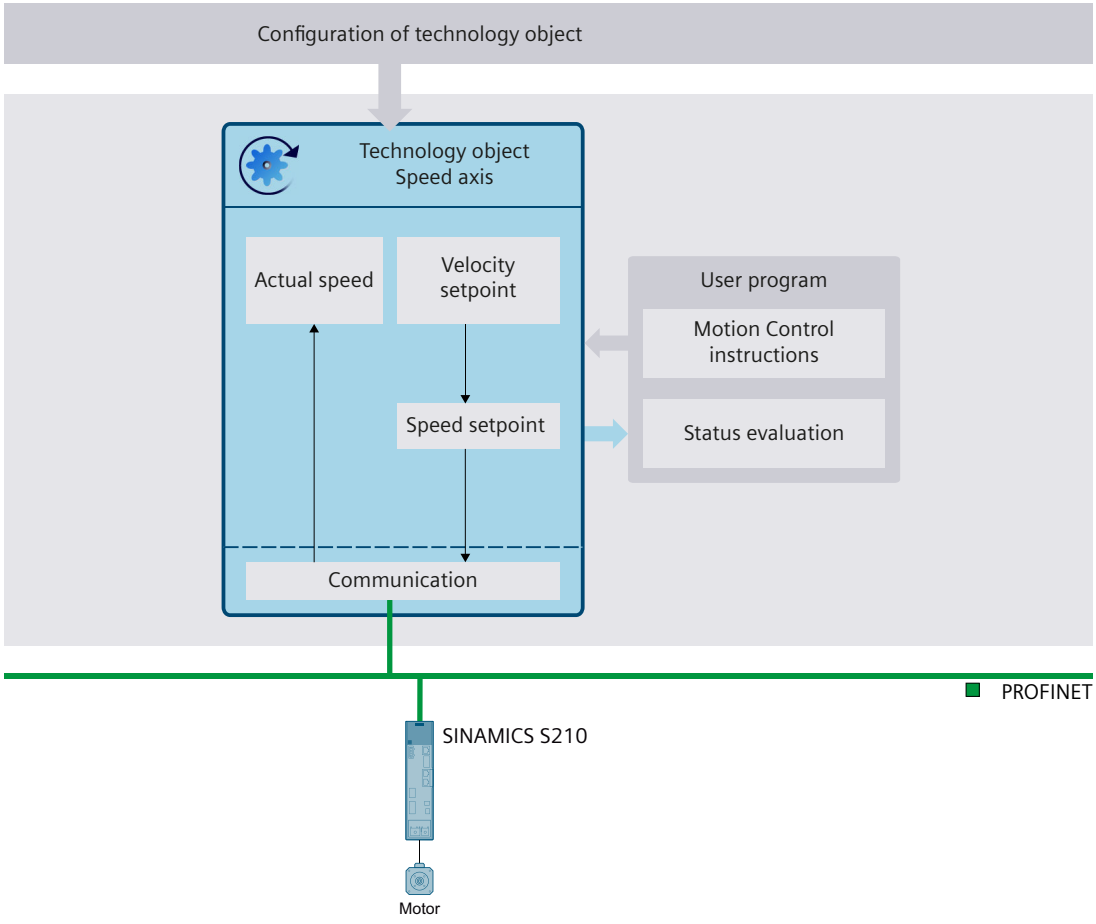

Configuration

The following configurations are available in the speed axis technology object:

- Basic parameters
  - Units of measure (Page 34)
  - Virtual axis (Page 39)
  - Axis in simulation (Page 43)
- Hardware interface
  - Connecting PROFIdrive drives (Page 57)
  - Transfer drive parameters automatically (Page 71)
  - Connecting stepper motors (Page 72)
  - Connecting drives with analog setpoint interface (Page 73)
  - Connecting force/torque data via SIEMENS additional telegram 750 (Page 74)
- Mechanics
  - Configuring the mechanics of the speed axis (Page 87)
  - Configuring the load gear (Page 97)
- Dynamic default (Page 115)
- Emergency stop (Page 123)
- Configuring the alarm responses (Page 159)
- Limits
  - Dynamic limits (Page 117)
  - Torque limits (Page 124)

5.2 Positioning axis technology object

The positioning axis technology object calculates position setpoints, taking into account the encoder settings, and outputs corresponding speed setpoints to the drive. In position-controlled mode, all movements of the positioning axis take place as position-controlled movements. For absolute positioning, the physical position must be known to the positioning axis technology object.

You can find an overview of the supported instructions of the positioning axis technology object in the section "Motion Control - Instructions for axis control (Page 30)".

Each positioning axis is assigned a drive, e.g. via a PROFIdrive telegram, and an encoder, via a PROFIdrive telegram.

The relationship between the encoder values and a defined position is established by the parameter assignment of the mechanical properties and encoder settings and by a homing operation. The technology object can also perform movements without a position relationship, and relative position movements, even without being in a homed status.

Depending on the design of the mechanics, a positioning axis can be configured as a linear or rotary axis.

The figure below shows the basic principle of operation of the positioning axis technology object:

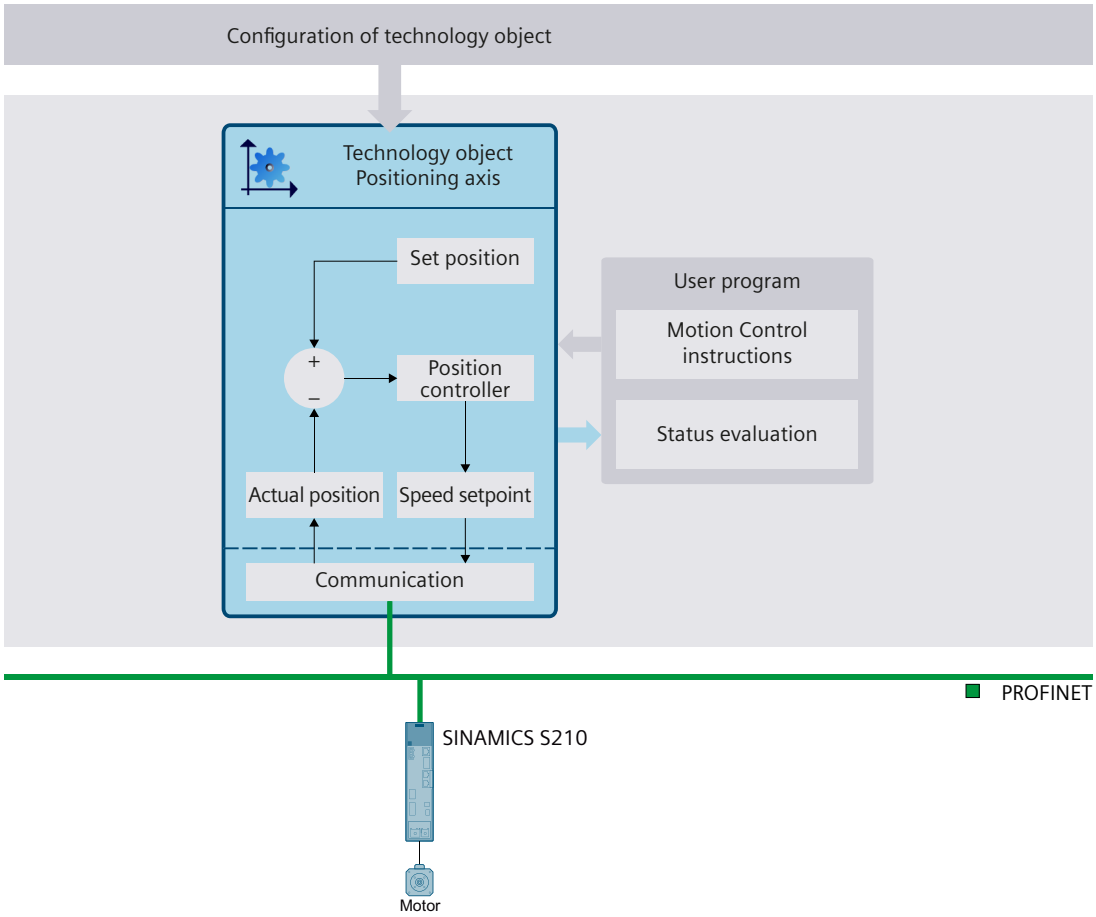

Configuration

The following configurations are available in the positioning axis technology object:

- Basic parameters
  - Axis or encoder type (Page 33)
  - Units of measure (Page 34)
  - Modulo setting (Page 37)
  - Virtual axis (Page 39)
  - Axis in simulation (Page 43)
- Hardware interface
  - Connecting PROFIdrive drives (Page 57)
  - Connecting encoders via PROFIdrive (Page 63)
  - Transferring drive and encoder parameters automatically (Page 71)
  - Connecting stepper motors (Page 72)

  - Connecting drives with analog setpoint interface (Page 73)
  - Connecting force/torque data via SIEMENS additional telegram 750 (Page 74)
- Mechanics
  - Configuring drive and encoder direction for positioning axis/synchronous axis (Page 96)
  - Configuring the load gear (Page 97)
  - Configuring the encoder gear (Page 98)
  - Configuring the leadscrew pitch (Page 98)
  - Configuring inertia values (Page 105)
  - Backlash compensation (Page 100)
- Dynamic default (Page 115)
- Emergency stop (Page 123)
- Configuring the alarm responses (Page 159)
- Limits
  - Position limits (Page 172)
  - Dynamic limits (Page 117)
  - Torque limits (Page 124)
  - Fixed stop detection (Page 127)
- Homing
  - Active homing (Page 195)
  - Passive homing (Page 205)
- Position monitoring functions
  - Positioning monitoring (Page 222)
  - Following error (Page 223)
  - Standstill signal (Page 225)
- Control loop
  - Configuring position controller in the PLC (Page 233)
  - Configuring position controller for drives with DSC (Page 232)
  - Configuring a dynamic filter (Page 236)
  - Switching the position control off and on (Page 242)
- Superimposing axes (Page 251)

The following configurations of the positioning axis technology object are specific to synchronous operation:

- Leading value settings
  - Configuring provision of the leading value
  - Configuring the delay time
- Actual value extrapolation

You can find a description of the configuration parameters in the "S7-1500/S7-1500T synchronous operation functions" documentation.

5.3 Synchronous axis technology object

The synchronous axis technology object includes all functions of the positioning axis technology object.

A synchronous axis can also follow the motions of a leading axis. The synchronous operation relationship between the leading and following axes is specified by a synchronous operation function.

You can find an overview of the supported instructions of the synchronous axis technology object in the section "Motion control instructions for axis control (Page 30)".

The figure below shows the basic principle of operation of the synchronous axis technology object:

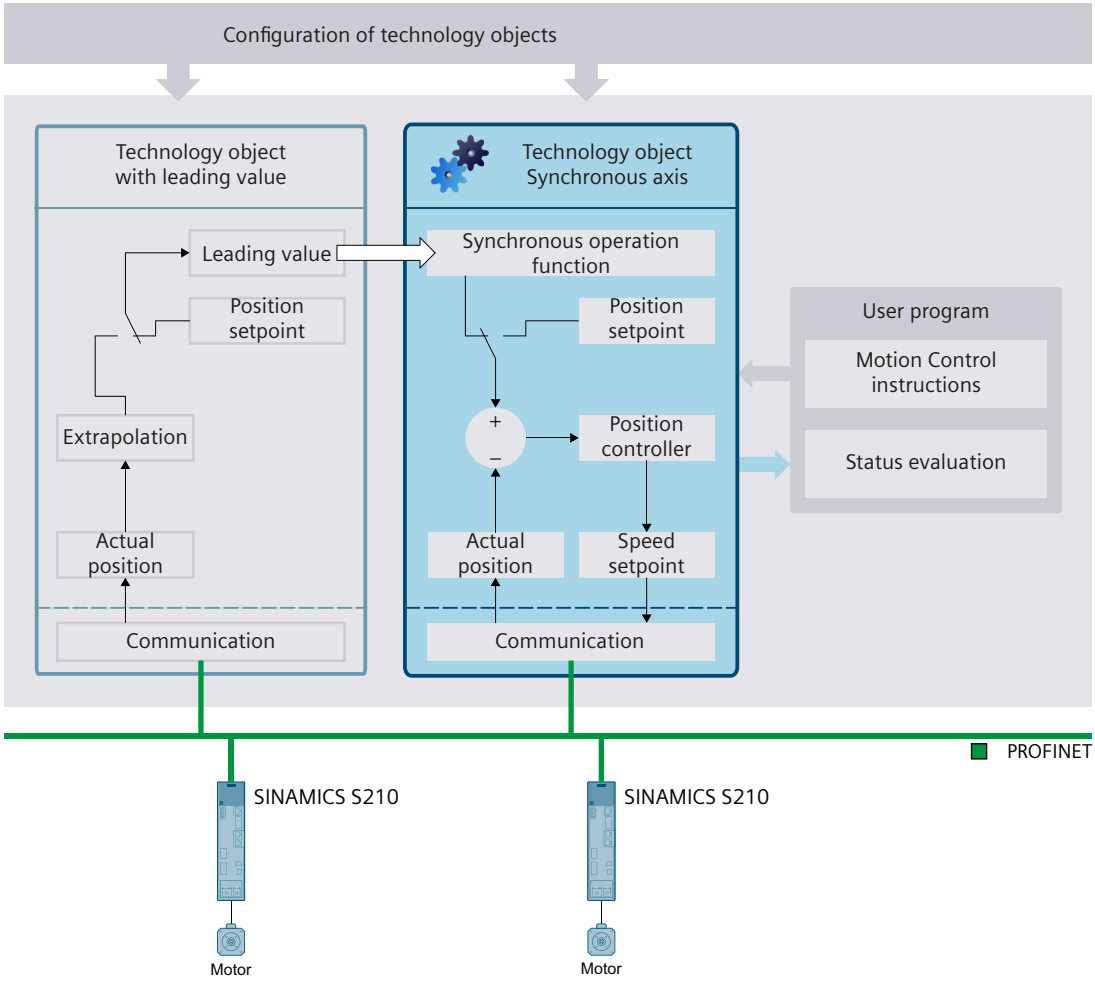

Configuration

The following non-isochronous specific configurations correspond to the positioning axis technology object:

- Basic parameters
  - Axis or encoder type (Page 33)
  - Units of measure (Page 34)
  - Modulo setting (Page 37)
  - Virtual axis (Page 39)
  - Axis in simulation (Page 43)
- Hardware interface
  - Connecting PROFIdrive drives (Page 57)
  - Connecting encoders via PROFIdrive (Page 63)
  - Transferring drive and encoder parameters automatically (Page 71)
  - Connecting stepper motors (Page 72)
  - Connecting drives with analog setpoint interface (Page 73)
  - Connecting force/torque data via SIEMENS additional telegram 750 (Page 74)
- Mechanics
  - Configuring drive and encoder direction for positioning axis/synchronous axis (Page 96)
  - Configuring the load gear (Page 97)
  - Configuring the encoder gear (Page 98)
  - Configuring the leadscrew pitch (Page 98)
  - Configuring inertia values (Page 105)
  - Configuring backlash compensation (Page 100)
- Dynamic default (Page 115)
- Emergency stop (Page 123)
- Configuring the alarm responses (Page 159)
- Limits
  - Position limits (Page 172)
  - Dynamic limits (Page 117)
  - Torque limits (Page 124)
  - Fixed stop detection (Page 127)
- Homing
  - Active homing (Page 195)
  - Passive homing (Page 205)

- Position monitoring functions
  - Positioning monitoring (Page 222)
  - Following error (Page 223)
  - Standstill signal (Page 225)
- Control loop
  - Configuring position controller in the PLC (Page 233)
  - Configuring position controller for drives with DSC (Page 232)
  - Configuring a dynamic filter (Page 236)
  - Switching the position control off and on (Page 242)
- Superimposing axes (Page 251)

You can find a description of the configuration parameters in the "S7-1500/S7-1500T Axis functions" documentation.

The following configurations of the synchronous axis technology object are specific to synchronous operation:

- Leading value interconnections
- Leading value settings
  - Configuring provision of the leading value
  - Configuring the delay time
- Actual value extrapolation
- Configuring the reverse tolerance of the leading value

You can find a description of the configuration parameters in the "S7-1500/S7-1500T synchronous operation functions" documentation.

5.4 External encoder technology object

The external encoder technology object detects a position and makes this available to the controller.

The actual position detected by the external encoder can be used for the following functions, for example:

- Measured value acquisition by a measuring input
- Position-dependent generation of switching signals and switching signal sequences by output cam and cam track with actual value reference.
- As a leading value of a synchronous axis (S7-1500T)

The relationship between the encoder values and a defined position is established by the parameter assignment of the mechanical properties and encoder settings and by a homing operation.

You can find an overview of the supported instructions of the positioning axis technology object in the section "Motion Control - Instructions for axis control (Page 30)".

The following figure shows the basic principle of operation of the external encoder technology object:

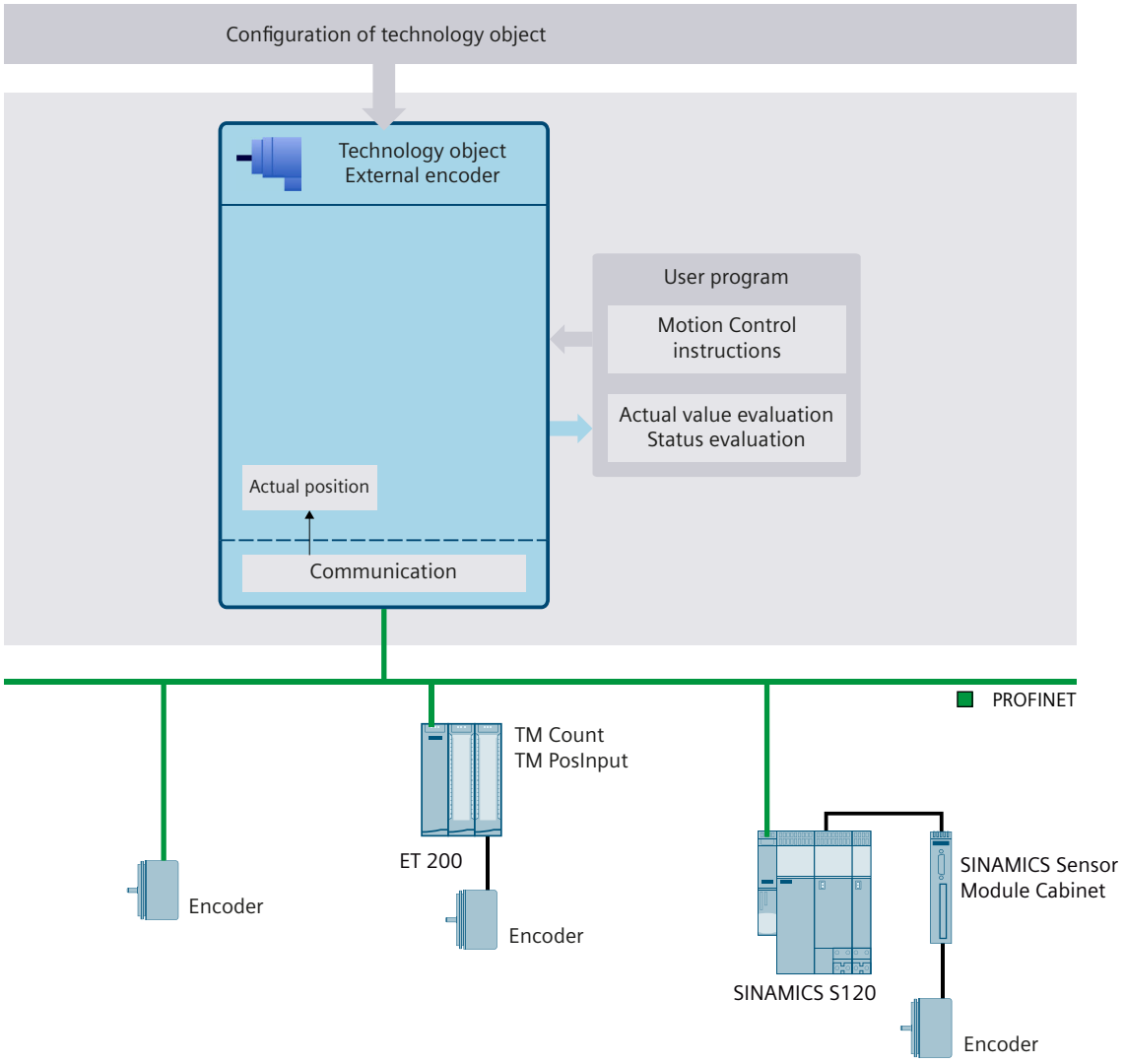

Configuration

The following configurations are available in the technology object external encoder:

- Basic parameters
  - Configure the type of an external encoder (Page 34)
  - Units of measure (Page 34)
  - Modulo setting (Page 37)
- Hardware interface
  - Connecting encoders via PROFIdrive (Page 63)

- Mechanics
  - Configuring the mechanics of the external encoder (Page 94)
  - Configuring the load gear (Page 97)
  - Configuring the leadscrew pitch (Page 98)
- Homing
  - Passive homing (Page 205)
- Standstill
  - Standstill (Page 225)

The following configurations of the external encoder technology object are specific to synchronous operation:

- Leading value settings
  - Configuring provision of the leading value
  - Configuring the delay time
- Actual value extrapolation

You can find a description of the configuration parameters in the "S7-1500/S7-1500T synchronous operation functions" documentation.

5.5 Motion control instructions for axis control

You can execute the functions of the speed axis, positioning axis, synchronous axis and external encoder technology objects using motion control instructions in your user program or using the TIA Portal (under "Technology object > Commissioning").

The following table shows the motion control instructions that are supported by the technology objects:

Motion Control instruction	Validity		Technology object		
	S7-1500	S7-1500T	Speed axis (Page 22)	Positioning axis (Page 23) Synchronous axis (Page 26)	External encoder (Page 28)
"MC_Power" Enable, disable technology object	✓	✓	✓	✓	-
"MC_Reset" Acknowledge alarms, restart technology object	✓	✓	✓	✓	✓
"MC_Home" Home technology object, set home position	✓	✓	-	✓	✓
"MC_Halt" Pause axis	✓	✓	✓	✓	-
"MC_MoveAbsolute" Position axis absolutely	✓	✓	-	✓	-
"MC_MoveRelative" Position axis relatively	✓	✓	-	✓	-

Motion Control instruction	Validity		Technology object		
	S7-1500	S7-1500T	Speed axis (Page 22)	Positioning axis (Page 23) Synchronous axis (Page 26)	External encoder (Page 28)
"MC_PositionProfile" Move axis via a time-based position profile	-	✓	-	✓	-
"MC_MoveVelocity" Move axes with velocity/speed setpoint	✓	✓	✓	✓	-
"MC_MoveJog" Move axis in jog mode	✓	✓	✓	✓	-
"MC_MoveSuperimposed" Position axis superimposing	✓	✓	-	✓	-
"MC_HaltSuperimposed" Pause superimposed motions on the axis	✓	✓	-	✓	-
"MC_SetSensor" Switch alternative encoder to operative encoder	-	✓	-	✓	-
"MC_Stop" Stop axis and prevent new motion jobs	✓	✓	✓	✓	-
"MC_SetAxisSTW" Control bits of control word 1 and control word 2	✓	✓	✓	✓	-
"MC_WriteParameter" Write parameter	✓	✓	✓	✓	✓
"MC_SaveAbsoluteEncoderData" Save absolute adjustment for device replacement	✓	✓	-	✓	✓
"MC_MotionInVelocity" Specify motion setpoints	-	✓	✓	✓	-
"MC_MotionInPosition" Specify motion setpoints	-	✓	-	✓	-
"MC_MotionInSuperimposed" Specify superimposed motion setpoints	-	✓	-	✓	-
"MC_MotionInSuperimposedAxes" Specify superimposed motion setpoints from another axis	-	✓	-	✓	-
"MC_TorqueAdditive" Specify additive torque	✓	✓	✓	✓	-
"MC_TorqueRange" Set high and low torque limit	✓	✓	✓	✓	-
"MC_TorqueLimiting" Activate/deactivate force/torque limiting / fixed stop detection	✓	✓	✓	✓	-

5.6 Extended functions of the technology CPU

In addition to the functionality of the S7-1500 CPU, the S7-1500T CPU provides additional functions:

Additional functions	Description	
Multiple encoders for positioning axis/synchronous axis (Page 67)	Up to four encoders can be connected to a positioning axis/synchronous axis. The encoders can be switched over during operation. Only one encoder at a time is active for closed loop position control.	
"MotionIn" function (Page 244)	"MC_MotionInVelocity", "MC_MotionInPosition", "MC_MotionInSuperimposed"	With the Motion Control instructions, you can specify cyclically applicable calculated motion setpoints as the basic motion for the axis. No velocity profile is calculated for this, the values are directly active at the technology object.
	"MC_MotionInSuperimposedAxes"	The motion setpoints of a superimposing axis are specified to the axis in the application cycle in addition to the basic motion. You can call the instruction in every cyclic organization block. The possible superimposing axes can be interconnected in the configuration of the synchronous axis or positioning axis technology object.
Use cam as time-based position profile (Page 142)	With the "MC_PositionProfile" Motion Control instruction, you start a relative or absolute positioning job with time-based position profile on the positioning axis or the synchronous axis. Specify the time-based position profile via the cam technology object.	

5.7 Functions in STEP 7

The following table shows the functions supported by technology objects in STEP 7:

Functions in the TIA Portal	Technology object		
	Speed axis (Page 22)	**Positioning axis** (Page 23) **Synchronous axis** (Page 26)	**External encoder** (Page 28)
"Axis control panel" Move and home axes using the TIA Portal	✓	✓	-
"Optimization" Optimization of closed loop position control	-	✓	-

Axis functions

6

6.1 Configuring basic parameters

6.1.1 Configure axis type

Axes can be configured with different axis types:

- Speed axes are always rotary axes.
- You configure positioning axes and synchronous axes either as rotary or linear axes, depending on the mechanics.

Configure axis type

In the "Axis type" area, select the type that matches the mechanics for your axis.

- **Linear axis**

  You can configure the linear axis either with a standard motor or with a linear motor.

  For linear axes, the position of the axis is specified as a linear measure, e.g. millimeters (mm).

  – Linear axis with standard motor

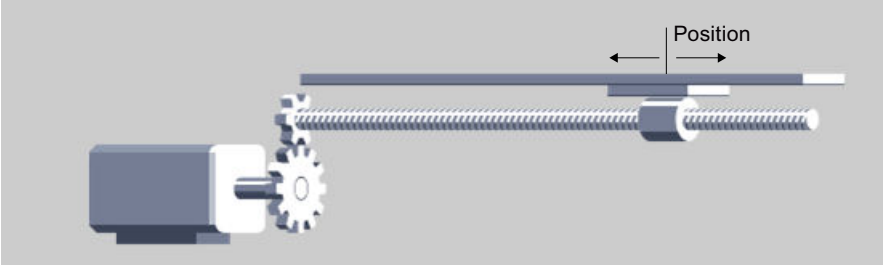

  – Linear axis with linear motor

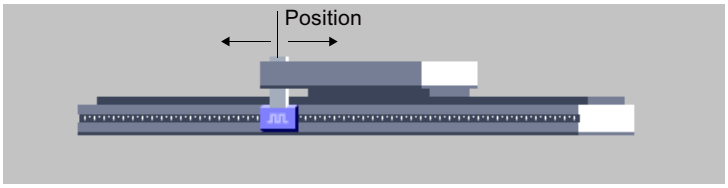

- **Rotary axis**

  The rotary axis is always configured with a standard motor.

  For rotary axes, the position of the axis is specified as an angular measure, e.g. degrees (°).

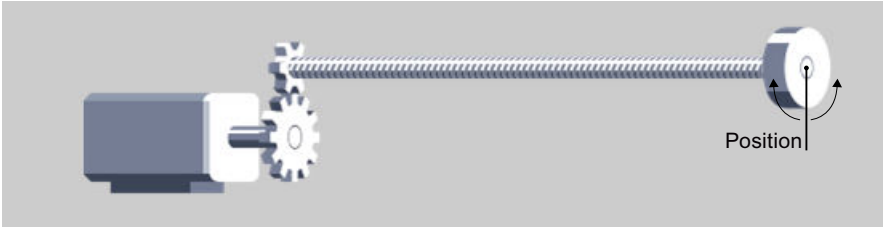

  Note the following if you apply the drive values automatically from the Startdrive.

  If the drive in the Startdrive is configured as a linear motor, you have to adapt the configuration of the axis type. Change the axis type to "Linear" or attach a standard motor as drive.

  Connecting PROFIdrive drives (Page 57)

  Transferring drive and encoder parameters automatically (Page 71)

6.1.2 Configure the type of an external encoder

For the "External encoder" technology object, you can configure whether the encoder accepts linear or rotary motions.

Select the appropriate type for your encoder in the "External encoder type" area.

- Linear
- Rotary

6.1.3 Units of measure

Select the units of measure available for the technology object from the drop-down lists.

Setting or changing the measurement units affects the display of the parameter values and the user program:

- Display of parameter values in the technology data block
- Assignment of parameters in the user program
- Input and display of the position and velocity in the TIA Portal
- Setpoint settings by leading axes in synchronous operation

All information and displays correspond to the selected unit of measure.

When measurement units are changed, the values of individual parameters in the technology object may lie outside the minimum value or maximum value due to the LREAL format. Adapt the values or change the measurement units back.

The set units are displayed in the "<TO>.Units" tag structure of the technology object. The tag structure is described under the tags of the respective technology object.

Speed

The supported measurement units for speed (revolutions per time unit) are 1/s, 1/min and 1/h.

Position and velocity

The table below shows the supported measurement units for position and velocity:

Position	Velocity
nm, µm, mm, m, km	mm/s, mm/min, mm/h, m/s, m/min, m/h, km/min, km/h
in, ft, mi	in/s, in/min, ft/s, ft/min, mi/h
°, rad	°/s, °/min, rad/s, rad/min

Regardless of the selected unit of measure and the selected resolution, the usable accuracy is 1 µm.

Position values with higher resolution

If you select the check box "Use position values with higher resolution" in the configuration of the positioning axis, synchronous axis, external encoder and kinematics technology objects, six decimal places are available in the selected unit, instead of the standard three. Due to the LREAL format, the representable position and angle range in [mm] and [°] is limited to +/-1.0E09.

Values smaller than 1 µm are set to 1 µm internally.

The maximums of the following values are reduced by a factor of 1000 for position values with a higher resolution:

- Displayable position range
- Displayable angular range
- Mechanical gear ratio
- Numerical traversing range limit with regard to long-term stability (Page 187)
- Dynamic values for velocity, acceleration and deceleration

Acceleration and jerk

The units of measurement for acceleration and jerk are derived from the configured unit of measurement for velocity:

Velocity	Acceleration	Jerk
m/s	m/s^2	mm/s^3
mm/s	mm/s^2	mm/s^3
mm/min	mm/s^2	mm/s^3
m/min	m/s^2	mm/s^3
km/min	m/s^2	mm/s^3

Velocity	Acceleration	Jerk
mm/h	mm/s^2	mm/s^3
m/h	m/s^2	mm/s^3
km/h	m/s^2	mm/s^3
in/s	in/s^2	in/s^3
ft/s	ft/s^2	ft/s^3
in/min	in/s^2	in/s^3
ft/min	ft/s^2	ft/s^3
miles/h	ft/s^2	ft/s^3
1/s	1/s^2	1/s^3
1/min	1/s^2	1/s^3
1/h	1/s^2	1/s^3

Leadscrew pitch

The unit of measurement for the leadscrew pitch results from the configured unit of measurement for the position.

Position	Leadscrew pitch
m	mm/rot
mm	mm/rot
km	m/rot
µm	µm/rot
nm	nm/rot
in	in/rot
ft	in/rot
miles	in/rot

Force and torque

The table below shows the supported measurement units for force and torque:

Force	Torque
N, kN	Nm, kNm
lbf, ozf, pdl	lbf in, lbf ft, ozf in, ozf ft, pdl in, pdl ft

Mass and moment of inertia

The table below shows the supported measurement units for mass and moment of inertia.

Mass	Moment of inertia
mg, g, kg, t	kgm^2
lb	$lbft^2$

Time

The measurement unit for time is permanently specified for the following technology objects:

Technology object	Time
Speed axis, positioning/synchronous axis, external encoder	s
Output cam, cam track, measuring input	ms

6.1.4 Modulo setting

For the positioning axis, synchronous axis and external encoder technology objects, the "Modulo" setting can be activated.

When an axis moves in only one direction, the position value continually increases. To limit the position value to a recurring reference system, you can activate the "Modulo" setting. The long-term accuracy (Page 187) can also be adhered to with modular axes up to the maximum travel time.

When the "Modulo" setting is activated, the position value of the technology object is mapped onto a recurring modulo range. The modulo range is defined by the start value and the length.

For example, to limit the position value of a rotary axis to a full rotation, the modulo range can be defined with start value = 0° and length = 360°. As a result, the position value is mapped onto the modulo range 0° to 359.999°.

The modulo cycle counters for the position setpoint and the actual position on the positioning axis, synchronous axis and external encoder technology objects indicate the number of modulo revolutions.

Modulo cycle counter

If the "Modulo" setting is activated, the modulo cycle counter is activated for the positioning axis, synchronous axis and external encoder technology objects. The modulo cycle counter is displayed at the technology object for the position setpoint and the actual position. The modulo cycle counter counts the modulo revolutions and thus the number of modulo runs at the technology object.

The tag <TO>.ModuloCycle indicates the number of modulo cycles of the setpoint.

The tag <TO>.ActualModuloCycle indicates the number of modulo cycles of the actual value.

The counter values of the modulo cycles change during switch on, restart and homing.

The following applies to an incremental encoder:

Action	Description
Switching on the CPU	The modulo cycle counter is set to 0.
Reset with "Restart" = TRUE	The modulo cycle counter is set to 0.
Active and passive homing with "Mode" = 2, 3, 5, 8, 10	• If the home position is in the range "Modulo start value ≤ Home position ≤ (Modulo Start value + Modulo length / 2)", the modulo cycle counter is set to 0. • If the home position is in the range "(Modulo start value + Modulo length / 2) < Home position < (Modulo start value + Modulo length)" the modulo cycle is set to -1.
Direct homing absolute with "Mode" = 0, 11	The modulo value is the shortest distance between the current and new position. Depending of the distance, the modulo cycle counter can remain the same, increase by 1 or decrease by 1.
Direct homing absolute with "Mode"= 1, 12	
Incremental encoder adjustment with "Mode" = 13	

The following applies to an absolute encoder:

Action	Description
Switching on the CPU	The modulo cycle counter changes according to the determined modulo length from the absolute value of the encoder and the absolute value offset of an absolute value encoder adjustment, if an absolute value encoder adjustment has taken place.
Reset with "Restart" = TRUE	The modulo cycle counter remains unchanged.
Absolute encoder adjustment with "Mode" = 7	The modulo cycle counter is set to 0.
Absolute encoder adjustment with "Mode" = 6	The modulo value is the shortest distance between the current and new position. Depending of the distance, the modulo cycle counter can remain the same, increase by 1 or decrease by 1.
Direct homing absolute with "Mode" = 0, 11	
Direct homing absolute with "Mode"= 1, 12	

Enable and configure modulo

Select the "Enable modulo" check box if you want to use a recurring system of units for the axis (e.g. 0° to 360° for an axis of the "rotary" axis type).

- **Modulo start value**

  In this field, define the position at which the modulo range should begin (e.g. 0° for an axis of the "rotary" axis type).

- **Modulo length**

  In this field, define the length of the modulo range (e.g. 360° for an axis of the "rotary" axis type).

6.1.5 Virtual axis

S7-1500 Motion Control offers the possibility to configure an axis as a virtual axis. The setpoints are only processed within the controller. A real drive is never controlled in this situation. If the axis is later intended to be operated with a real drive and a real encoder, then use the "Axis in simulation" function.

A virtual axis, for example, is often used as a virtual leading axis in order to generate the setpoints for several real following axes in synchronous operation.

The "Virtual axis" configuration can only be changed by a new download to the CPU in STOP mode (<TO>.VirtualAxis.Mode).

If you have configured an absolute encoder at the virtual axis, you must home the virtual axis after switching on the CPU.

NOTE

The configured alarm response "Remove enable" is not output to the drive.

The following diagram illustrates the differences between a real axis, an axis in simulation, and a virtual axis.

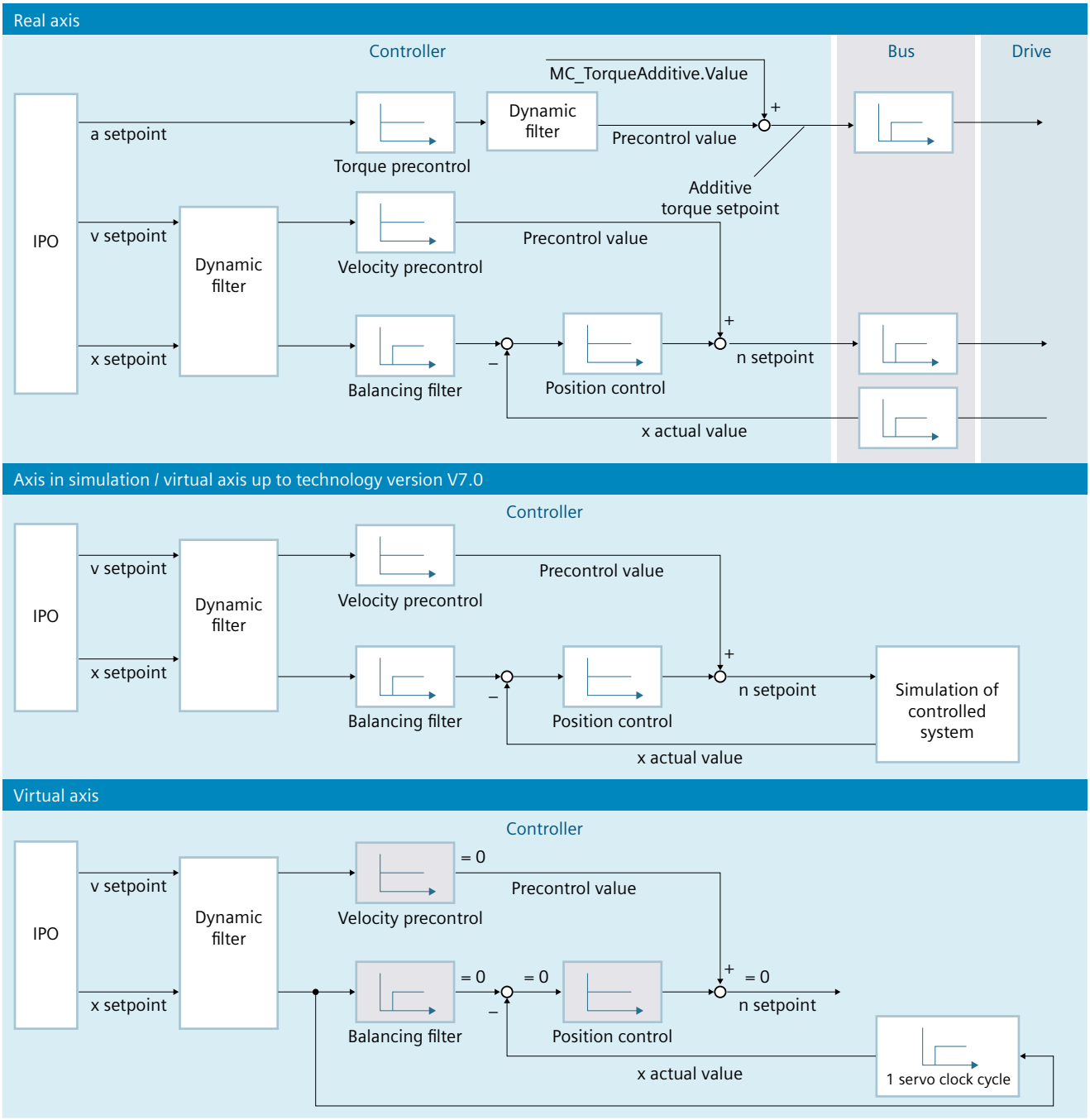

Virtual axis technology version ≤ V7.0

The behavior of a virtual axis is identical to the behavior of an axis in simulation (Page 43). The actual values are generated via the control loop and a simplified drive model.

Virtual axis technology version ≥ V8.0

The position and velocity setpoints are directly adopted as actual values with an application cycle delay. The feedback loop and the drive model are not simulated. The dynamic filter is effective.

NOTE

To maintain compatibility with virtual axes of technology versions ≤ V7.0 for an axis:

1. Interconnect the axis in simulation (<TO>.Simulation.Mode" = 1).
2. Disable the virtual axis (<TO>.VirtualAxisMode = 0)

The following table shows the differences in the behavior of tags for the virtual axis up to technology version V7.0:

Tag	Description
<TO>.ActualPosition	Apply the position setpoint ("Positon") after one servo clock cycle
<TO>.StatusSensor.Position	Apply the position setpoint ("Positon") after one servo clock cycle
<TO>.ActualVelocity	Apply the speed setpoint ("Velocity") after one servo clock cycle
<TO>.StatusSensor.Velocity	Apply the speed setpoint ("Velocity") after one servo clock cycle
<TO>.ActualAcceleration	Apply the acceleration setpoint ("Accelaration") after one servo clock cycle
<TO>.ActualSpeed	0.0
<TO>.VelocitySetpoint	0.0
<TO>.StatusServo.ControlDifference	0.0
<TO>.StatusServo.BallancedPosition	0.0
<TO>.StatusSensor.Adjusted	1

Behavior during operation of the virtual axis

A virtual axis does not output setpoints to the drive and does not read any actual values of the encoder.

Hardware limit switches and home position switches have no effect.

The technology objects measuring input (with signal detection via TM Timer DIDQ or SINAMICS measurement sensing input), output cam and cam track can also be used for virtual axes.

The following table shows the Motion Control instructions with adapted behavior with virtual axes:

Motion Control instruction	Characteristics in simulation mode
MC_Power	The axis is enabled immediately without waiting for feedback from the drive.
MC_Home	Homing jobs are executed immediately without simulated axis motion.
MC_TorqueLimiting	The specified torque is not output to the drive.

Possible applications

- As the leading axis for synchronous applications with real following axes.
- Applicable for software tests

6.1.6 Actual value calculation with the virtual axis

The position and velocity setpoints are directly adopted as actual values with an application cycle delay. The feedback loop and the drive model are not simulated. The dynamic filter is active.

The configuration of the control loop, including velocity and torque precontrol, is not taking effect.

Note that the trace recording is delayed as follows, depending on the configured time of recording:

Displayed tag in the trace	Setpoint position "<TO>.Position"
Encoder position "<TO>.StatusSensor.Position"	Recording point "MC_Servo": 1 servo clock cycle Recording point "MC_Interpolator": 2 servo clock cycles
Actual position "<TO>.ActualPosition"	Recording point "MC_Servo": 2 servo clock cycles Recording point "MC_Interpolator": 2 servo clock cycles

Actual value calculation after switching on the CPU

For the encoder type "Absolute" or "Cyclic Absolute," the actual position of the axis is calculated from the following values:

- Fixed simulated incremental actual value of the encoder of 240 increments.
- Configured increments per revolution
- Stored encode offset "<TO>.StatusSensor.AbsEncoderOffset"
- Mechanical configuration

Example of the rotary positioning axis:

- All gear ratios = 1
- Increments per revolution = 2048
- Encoder offset = 137.812°

  The actual position after power-on = (240/2048)° + 137.812° = 180°

6.1.7 Axis in simulation

S7-1500 Motion Control offers the option to move real axes in simulation mode. Speed, positioning and synchronous axes can thus be simulated without a connected drive and encoder in the CPU.

When the simulation mode is activated, the drive and encoder connection does not need to be configured in the axis configuration, for example, if the drive configuration is not yet available at this time. The "Simulation" configuration can be changed during runtime of the user program (<TO>.Simulation.Mode). A valid drive and encoder connection is required when exiting the simulation.

To use a technology object in simulation mode or with SIMATIC S7 PLCSIM, you need to use encoder 1 for closed loop position control of the axis.

NOTE

The configured alarm response "Remove enable" is not output to the drive.

Characteristics in simulation mode

An axis in simulation does not output setpoints to the drive and does not read any actual values of the encoder. The actual values are formed with a time delay from the setpoints.

Hardware limit switches and home position switches have no effect.

The technology objects measuring input (with signal detection via TM Timer DIDQ or SINAMICS measuring input), output cam and cam track can also be used for axes in simulation.

The following table shows the Motion Control instructions with adapted behavior in simulation mode:

Motion Control instruction	Characteristics in simulation mode
MC_Power	The axis is enabled immediately without waiting for feedback from the drive.
MC_Home	Homing jobs are executed immediately without simulated axis motion.
MC_TorqueLimiting	The specified torque is not output to the drive.

Possible applications

- For example, an axis is simulated for programming the machine application and assigned to the configured hardware later for commissioning.
- During commissioning, for example, not all hardware components are available.
- No axis motions should take place during commissioning.

6.1.8 Actual value calculation for the axis in simulation

The actual value of an axis in simulation is formed from the setpoint taking time delays into account.

You calculate the time delay from actual value to the setpoint (T_t) as follows:

Calculation	
With precontrol	$T_t = T_{ipo} + T_{servo} + T_{vtc} + T_{addPtc}$
Without precontrol, without DSC	$T_t = T_{ipo} + 1/Kv + T_{addPtc}$
Without precontrol, with DSC for one axis in simulation	$T_t = T_{ipo} + T_{servo} + 1/Kv + T_{addPtc}$

T_t Time delay from the actual value to the setpoint

T_{ipo} Cycle time of the MC_Interpolator

T_{servo} Cycle time of the MC_Servo

T_{vtc} Speed control loop substitute time (T_{vtc} from "<TO>.DynamicAxisModel.VelocityTimeConstant")

T_{addPtc} Additive position control loop equivalent time (T_{addPtc} from "<TO>.DynamicAxisModel.AdditionalPositionTimeConstant")

kV Gain factor (Kv from "<TO>.PositionControl.Kv")

Actual value calculation after switching on the CPU

For the encoder type "Absolute" or "Cyclic Absolute," the actual position of the axis is calculated from the following values:

- Fixed simulated incremental actual value of the encoder of 240 increments.
- Configured increments per revolution
- Stored encode offset "<TO>.StatusSensor.AbsEncoderOffset"
- Mechanical configuration

Example of the rotary positioning axis:

- All gear ratios = 1
- Increments per revolution = 2048
- Encoder offset = 137.812°

  The actual position after power-on = (240/2048)° + 137.812° = 180°

6.2 Drive and encoder connection

Number of drives and encoders per technology object

The following table shows the number of drives and encoders for the various technology objects.

Technology object	Number of drives (actuators)	Number of encoders (sensors)
Speed axis	1	0
Positioning axis, synchronous axis	1	1 (S7-1500) 1 to 4 (S7-1500T)
External encoder	0	1

Supported drive types

You can connect the following drives:

- Drive with an analog setpoint interface
- Drives with PROFIdrive telegram (PROFINET IO or PROFIBUS DP), e.g.
  - SINAMICS
  - SIMATIC MICRO-DRIVE
  - Technology modules
  - Drives from other manufacturers

Encoder connection options

The following connection options are available for an encoder:

- Connection to the drive
- Encoder on the technology module, e.g. TM Count 1x24V
- PROFIdrive encoder directly on the PROFIBUS DP/PROFINET IO

The actual encoder value is transmitted exclusively via PROFIdrive telegram.

Drive configuration process

Complete the following steps to add and configure a drive.

- Adding a drive unit (Page 47)
  - SINAMICS Startdrive
  - GSD file
  - SIMATIC technology module
- Configuration of the PROFIdrive telegram for PROFIdrive drives (Page 53)

- Configure communication between drive and CPU in the device configuration
  - Configure PROFINET IO network (Page 48)
  - Configure PROFIBUS DP network (Page 51)
- Configure data exchange between technology object and PROFIdrive drive
  - Connect PROFIdrive drive directly (Page 57)
  - Connect PROFIdrive drive via data block (Page 58)
  - Configure drive parameters manually (Page 62)
  - Transfer drive parameters automatically (Page 71)
- Configure data exchange between technology object and drive with analog setpoint interface (Page 73)
- Connect stepper motors (Page 72)

If you want to use a torque pre-control, change the torque limits in the drive from the user program, or evaluate the current actual torque value, you have to connect the additional telegram 750 to the technology object.

- Connecting force/torque data via SIEMENS additional telegram 750 (Page 74)

Encoder configuration process

Add the encoder in the device configuration.

- Add encoder in the device configuration
  - PROFINET-IO encoder
  - Profibus-DP encoder
  - Technology module

Configuring the data exchange between technology object and encoder.

- Connect ProfiDrive encoder directly (Page 63)
- Connect PROFIdrive encoder via data block (Page 64)
- Transfer encoder parameters automatically (Page 71)
- Configure encoder parameters manually (Page 66)

Configure the encoder type (Page 64).

6.2.1 Adding and configuring drives

Siemens offers numerous drive systems for various applications.

Depending on the drive, the parameter assignment and implementation in the TIA Portal are different. The application examples provide step-by-step descriptions of how to add and configure the drives.

Using Startdrive

If you use a SINAMICS drive with Startdrive, you can find additional information in the hardware catalog in the "Drives & Starter" folder. For more information on connecting via Startdrive, refer to:

- Getting Started SINAMICS S120 in Startdrive:
  Getting Started SINAMICS S120
  (https://support.industry.siemens.com/cs/ww/en/view/109781584)
- Application example "Configuring an S120 with Startdrive":
  Application example SINAMICS S120
  (https://support.industry.siemens.com/cs/ww/en/view/109743270)
- Application example "Configuring an S210 with Startdrive":
  Application example SINAMICS S210
  (https://support.industry.siemens.com/cs/ww/en/view/109750431)

Using the GSD file

You can add and configure the SINAMICS S210 using a GSD file.

Application example SINAMICS S210
(https://support.industry.siemens.com/cs/ww/en/view/109750431)

Using SINAMICS V90 PN

To add and configure a SINAMICS V90 PN drive in the TIA Portal, you need the Hardware Support Package HSP 0185 (SINAMICS V90 PN).

- Getting Started SINAMICS V90 PN on S7-1500 motion control:
  Getting Started SINAMICS V90 PN
  (https://support.industry.siemens.com/cs/ww/en/view/109739497)
- Configuring SINAMICS V90 PN with web server:
  Application example SINAMICS V90 PN
  (https://support.industry.siemens.com/cs/ww/en/view/109739053)

Using SIMATIC MICRO-DRIVE PDC

To add and configure a SIMATIC MICRO-DRIVE PDC in the TIA Portal, you need the Hardware Support Package HSP 198.

Application example SIMATIC MICRO-DRIVE PDC
(https://support.industry.siemens.com/cs/ww/us/view/109770395)

Using ET 200SP F - TM ServoDrive

To add and configure a ET 200SP F-TM ServoDrive in the TIA Portal, you need the Hardware Support Package HSP 0311.

Application example ET 200SP F - TM ServoDrive (https://support.industry.siemens.com/cs/ww/en/view/109780201)

6.2.1.1 Adding and configuring a PROFINET IO drive

Adding and configuring a PROFINET IO drive is described below with the example of a SINAMICS S120 drive. Adding and configuring other PROFINET IO drives may differ from the description in certain respects.

Requirements

- The SIMATIC S7-1500 device is created in the project.
- The desired drive can be selected in the hardware catalog.

If the drive is not available in the hardware catalog, you must install the drive in the "Options" menu as a device description file (GSD).

Adding a drive and telegram in the device configuration

1. Open the device configuration and change to the network view.
2. In the hardware catalog, open the folder "Additional field devices > PROFINET IO > Drives > Siemens Aktiengesellschaft > SINAMICS".
3. Select the desired drive with the desired version, then drag it to the network view.
4. Assign the drive to the PROFINET interface of the CPU.
5. Open the drive in the device view.
6. Drag a drive object (DO) and a telegram from the hardware catalog and drop it onto a slot of the device overview of the drive.
7. Make sure that the order of the telegrams in the device configuration and in the drive parameter assignment are the same.

   Depending on the version of the SINAMICS S120 drive, select "DO with telegram X", or "DO Servo" and a "Telegram X" for the telegram.

   For more information on suitable telegrams, refer to the section "Configuring PROFIdrive telegrams (Page 53)".

   Repeat step 6 if you want to add another drive and another standard telegram.

Interconnect the port of the CPU with the port of the drive

1. Select the topology view of the device configuration.
2. Interconnect the port of the drive with the port of the CPU as in the real setup.
   To plan your PROFINET topology, please note the PROFINET installation guideline of the PROFIBUS user organization (https://www.profibus.com).

Activating isochronous mode of the drive in the device configuration

PROFINET drives can always be operated in isochronous mode or clock synchronized mode. Isochronous mode, however, increases the quality of the closed loop position control of the drive and is therefore recommended for drives such as SINAMICS S120.

To control the drive in isochronous mode, follow these steps:

1. Open the device view of the drive.
2. In the properties window, select the tab "PROFINET interface [X150] > Advanced options > Isochronous mode".
3. Select the "Isochronous mode" check box in this tab.

   In the detailed overview, the check box for the telegram must also be selected for isochronous mode.

Configure the CPU as the sync master and set isochronous mode

1. Select the device view of the CPU.
2. In the Properties window, select the tab "PROFINET interface [X1] > Advanced options > Real-time settings > Synchronization".
3. Select "Sync master" from the "Synchronization role" drop-down list.
4. Click the "Domain settings" button.
5. Open the "Domain Management > Sync Domains" tab and set the desired "Send clock" (isochronous clock).

Configure drive as sync device

1. Select the device view of the drive unit.
2. In the properties dialog, select the tab "PROFINET interface [X150] > Advanced options > Real-time settings > Synchronization".
3. Select "IRT" as the RT class.

Select drive in the configuration of the technology object

1. Add a new technology object axis, or open the configuration of an existing axis.
2. Open the configuration "Hardware interface > Drive".
3. Select from the "PROFIdrive" entry in the "Drive type" drop-down list.
4. Select the drive object of the PROFINET drive from the "Drive" list.

Checking/configuring the properties of the MC_Servo

1. Open the "Program blocks" folder in the project navigator.
2. Select the "MC_Servo" organization block.
3. Select the "Properties" command in the shortcut menu.
4. Select the "Cycle time" entry in the area navigation.
5. The option "Synchronous to the bus" must be selected in the dialog box.
6. An "PROFINET IO system" must be selected in the "Source of the send clock" drop-down list.
7. The application cycle of "MC_Servo" must correspond to the send clock of the bus or be reduced by an integral factor relative to the send clock of the bus.

Result

The PROFINET IO drive is configured in such a way that it can be controlled in isochronous mode in the PROFINET IO network.

The properties of the SINAMICS drive must be configured according to the configuration of the axis with the STARTER software or SINAMICS Startdrive.

Check the clock synchronization at the drive.

If the configuration sequence described above is not adhered to during configuration of the axis, and drive-specific errors occur when the project is compiled, the setting for isochronous mode on the drive must be checked.

1. Open the device view of the drive.
2. Select standard telegram in the device overview.
3. Select the properties dialog "General > I/O Addresses".
4. The following settings apply for the input and output addresses:
   - "Isochronous mode" is enabled.
   - "MC_Servo" must be selected for the "Organization block".
   - "PIP OB Servo" must be selected for the "Process image".

6.2.1.2 Adding and configuring a PROFIBUS DP drive

Adding and configuring a PROFIBUS drive is described below with the example of a SINAMICS S120 drive. Adding and configuring other PROFIBUS drives may differ from the description in certain respects.

Requirements

- The SIMATIC S7-1500 device is created in the project.
- The desired drive can be selected in the hardware catalog.

If the drive is not available in the hardware catalog, you must install the drive in the "Options" menu as a device description file (GSD).

Adding a drive and telegram in the device configuration

1. Open the device configuration and change to the network view.
2. In the hardware catalog, open the folder "Additional field devices > PROFIBUS DP > Drives > Siemens Aktiengesellschaft > SINAMICS".
3. Select the folder of the desired drive with the desired version, then drag the drive object to the network view.
4. Assign the drive to the PROFIBUS interface of the CPU.
5. Open the drive in the device view.
6. Drag-and-drop a telegram from the hardware catalog onto a slot in the device overview of the drive.

For more information on suitable telegrams, refer to the section "Configuring PROFIdrive telegrams (Page 53)".

If you want to add another drive and another telegram to the device overview, use the "Axis disconnector" in the hardware catalog.

Activating isochronous mode of the drive in the device configuration

PROFIBUS drives can be operated in cyclic mode or isochronous mode. Isochronous mode, however, increases the quality of the position control of the drive.

If you want to control the drive in isochronous mode, follow these steps:

1. Open the device view of the drive.
2. In the properties dialog, select the tab "General > Isochronous Mode".
3. Select the "Synchronize DP slave to constant DP bus cycle time" check box.

Setting isochronous mode

1. Select the network view.
2. Select the DP master system.
3. In the properties dialog, select the tab "General > Constant bus cycle time".
4. Select the desired "Constant DP bus cycle times".

Select drive in the configuration of the technology object

1. Add a new technology object axis, or open the configuration of an existing axis.
2. Open the configuration "Hardware interface > Drive".
3. Select from the "PROFIdrive" entry in the "Drive type" drop-down list.
4. Select the telegram of the PROFIBUS drive from the "Drive" list.

Result

The technology object is connected to the drive and the "MC-Servo" organization block can be checked/configured.

The telegram of the configured drive is assigned to the "PIP OB Servo" process image.

Checking/configuring the properties of the MC_Servo

1. Open the "Program blocks" folder in the project navigator.
2. Select the "MC_Servo" organization block.
3. Select the "Properties" command in the shortcut menu.

   The "MC_Servo" dialog opens.
4. Select the "Synchronous to the bus" option under "General > Cycle time".
5. In the "Distributed I/O" drop-down list, select a "PROFIBUS DP-System".

   The application cycle of "MC_Servo" must correspond to the send clock of the bus or be reduced by an integral factor relative to the send clock of the bus.

You can select a drive connected to the CPU via a communications processor/communications module (CP/CM) in the configuration of the technology object. You cannot select the DP master system of the CP/CM as the source clock for MC_Servo.

Result

The PROFIBUS DP drive is configured in such a way that it can be controlled in isochronous mode in the PROFIBUS network.

The properties of the SINAMICS drive must be configured according to the configuration of the axis with the STARTER software or SINAMICS Startdrive.

Checking isochronous mode on the drive

If the configuration sequence described above is not adhered to during configuration of the axis, and drive-specific error occurs when the project is compiled, isochronous mode can be checked on the drive.

1. Open the device view of the drive.
2. Select the entry of the telegram in the device overview.
3. Select the properties dialog "General > I/O Addresses".
4. The following settings apply for the input and output addresses:
   – "MC_Servo" must be selected for the "Organization block".
   – "PIP OB Servo" must be selected for the "Process image".

6.2.2 Configuring PROFIdrive telegrams

PROFIdrive

PROFIdrive is the standardized drive technology profile for connecting drives and encoders via PROFIBUS DP and PROFINET IO. Drives that support the PROFIdrive profile are connected according to the PROFIdrive standard.

The current PROFIdrive specification is available at the page of the PROFIBUS user organization under "Download" > "Profiles":

https://www.profibus.com (https://www.profibus.com)

Communication between the controller and drive/encoder is performed using various PROFIdrive telegrams. Each of the telegrams has a standardized structure. You can select the appropriate telegram according to the application. Control words and status words as well as setpoints and actual values are transmitted in the PROFIdrive telegrams.

The PROFIdrive profile likewise supports the "Dynamic Servo Control" (DSC) control concept. DSC uses rapid closed loop position control in the drive. This can be used to solve highly dynamic Motion Control tasks.

PROFIdrive telegrams

PROFIdrive telegrams are used to transfer setpoints and actual values, control and status words and other parameters between the controller and drive/encoder.

When a PROFIdrive telegram is used for connection, the drives and encoders are handled and switched on in accordance with the PROFIdrive profile.

The following table shows the possible PROFIdrive telegrams for various technology objects.

Technology object	Possible PROFIdrive telegrams
Speed axis	• 1, 2 • 3, 4, 5, 6, 102, 103, 105, 106 (Actual encoder value is not evaluated)
Positioning axis/synchronous axis	
Setpoint and actual encoder value in one drive telegram	3, 4, 5, 6, 102, 103, 105, 106

Technology object	Possible PROFIdrive telegrams
Setpoint and actual encoder value separately	
Setpoint in drive telegram	1, 2, 3, 4, 5, 6, 102, 103, 105, 106
Actual value from telegram	81, 83
External encoder	81, 83
Measuring input (Measuring via SINAMICS (central probe))	391, 392, 393
Measuring input at axis module	Corresponds to measuring via PROFIdrive

Telegram types

The following table shows the supported PROFIdrive telegram types for the assignment of drives and encoders:

Telegram	Brief description
Standard telegrams	
1[1)]	• Control word STW1[5)], status word ZSW1 • Speed setpoint 16 bit (NSET), actual speed value 16 bit (NACT)
2	• Controls word STW1[5)] and STW2[5)], status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT)
3	• Controls word STW1[5)] and STW2[5)], status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2)
4	• Controls word STW1[5)] and STW2[5)], status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) • Actual encoder value 2 (G2_XIST1, G2_XIST2)
5	• Controls word STW1[5)] and STW2[5)], status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) (motor encoder) • Dynamic Servo Control (DSC)[2)] – Speed precontrol value – Position difference (XERR) – Kv factor gain position control (KPC)

1) Isochronous mode is not possible.

2) For use of Dynamic Servo Control (DSC), the motor encoder (first encoder in the telegram) of the drive must be used as the first encoder for the technology object.

3) Can also be used for the telegrams 1, 2, 3, 4, 5, 6, 102, 103, 105, 106

4) When using SINAMICS drives (measuring using SINAMICS measuring input)

5) STW1 and STW2: Bits not used by the technology object can be controlled via the user program with the Motion Control instruction "MC_SetAxisSTW".

6) Using the SETIO or GETIO instructions may result in a sign-of-life error of the drive. Use the free telegram configuration to set bits.

Telegram	Brief description
6	• Controls word STW1[5] and STW2[5], status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) (motor encoder) • Actual encoder value 2 (G2_XIST1, G2_XIST2) • Dynamic Servo Control (DSC)[2] – Speed precontrol value – Position difference (XERR) – Kv factor gain position control (KPC)
Siemens telegrams (with torque limiting)	
102	• Controls word STW1[5] and STW2[5], status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) • Torque limiting
103	• Controls word STW1[5] and STW2[5], status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) • Actual encoder value 2 (G2_XIST1, G2_XIST2) • Torque limiting
105	• Controls word STW1[5] and STW2[5], status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) (motor encoder) • Dynamic Servo Control (DSC)[2] – Speed precontrol value – Position difference (XERR) – Kv factor gain position control (KPC) • Torque limiting
106	• Controls word STW1[5] and STW2[5], status words ZSW1 and ZSW2 • Speed setpoint 32 bit (NSET), actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2) (motor encoder) • Actual encoder value 2 (G2_XIST1, G2_XIST2) • Dynamic Servo Control (DSC)[2] – Speed precontrol value – Position difference (XERR) – Kv factor gain position control (KPC) • Torque limiting
SIEMENS additional telegrams (torque data)	
750[3]	• Additive setpoint torque • High and low torque limits • Torque actual values

1) Isochronous mode is not possible.

2) For use of Dynamic Servo Control (DSC), the motor encoder (first encoder in the telegram) of the drive must be used as the first encoder for the technology object.

3) Can also be used for the telegrams 1, 2, 3, 4, 5, 6, 102, 103, 105, 106

4) When using SINAMICS drives (measuring using SINAMICS measuring input)

5) STW1 and STW2: Bits not used by the technology object can be controlled via the user program with the Motion Control instruction "MC_SetAxisSTW".

6) Using the SETIO or GETIO instructions may result in a sign-of-life error of the drive. Use the free telegram configuration to set bits.

Telegram	Brief description
SIEMENS telegrams (measuring input) [4) 6)]	
391	• Control word CU_STW1, status word CU_ZSW1 • Measuring input control word (MT_STW), measuring input status word (MT_ZSW) • Measuring input time stamp of negative (MT1...2_ZS_F) or positive edges (MT1...2_ZS_S) • Digital output 16 bit, digital input 16 bit
392	• Control word CU_STW1, status word CU_ZSW1 • Measuring input control word (MT_STW), measuring input status word (MT_ZSW) • Measuring input time stamp of negative (MT1...6_ZS_F) or positive edges (MT1...6_ZS_S) • Digital output 16 bit, digital input 16 bit
393	• Control word CU_STW1, status word CU_ZSW1 • Measuring input control word (MT_STW), measuring input status word (MT_ZSW) • Measuring input time stamp of negative (MT1...8_ZS_F) or positive edges (MT1...8_ZS_S) • Digital output 16 bit, digital input 16 bit • Analog input 16 bit
Standard telegrams - encoder	
81	• Control word STW2_ENC, status word ZSW2_ENC • Actual encoder value 1 (G1_XIST1, G1_XIST2)
83	• Control word STW2_ENC, status word ZSW2_ENC • Actual speed value 32 bit (NACT) • Actual encoder value 1 (G1_XIST1, G1_XIST2)

1) Isochronous mode is not possible.

2) For use of Dynamic Servo Control (DSC), the motor encoder (first encoder in the telegram) of the drive must be used as the first encoder for the technology object.

3) Can also be used for the telegrams 1, 2, 3, 4, 5, 6, 102, 103, 105, 106

4) When using SINAMICS drives (measuring using SINAMICS measuring input)

5) STW1 and STW2: Bits not used by the technology object can be controlled via the user program with the Motion Control instruction "MC_SetAxisSTW".

6) Using the SETIO or GETIO instructions may result in a sign-of-life error of the drive. Use the free telegram configuration to set bits.

The following table shows PROFIdrive telegrams that are not supported but are modified by the MC_Servo:

Telegram	Brief description
SIEMENS telegrams	
390	Control word CU_STW1, status word CU_ZSW1
394	Control word CU_STW1, status word CU_ZSW1
395	Control word CU_STW1, status word CU_ZSW1

The exact content of the telegrams can be found in the "SINAMICS S120/S150 (https://support.industry.siemens.com/cs/ww/en/view/109827046)" list manual

6.2.3 Connecting PROFIdrive drives

6.2.3.1 Connecting PROFIdrive drive directly

In the "Drive" field, select an already configured PROFIdrive drive/slot. A suitable PROFIdrive telegram must be configured so that a drive is displayed.

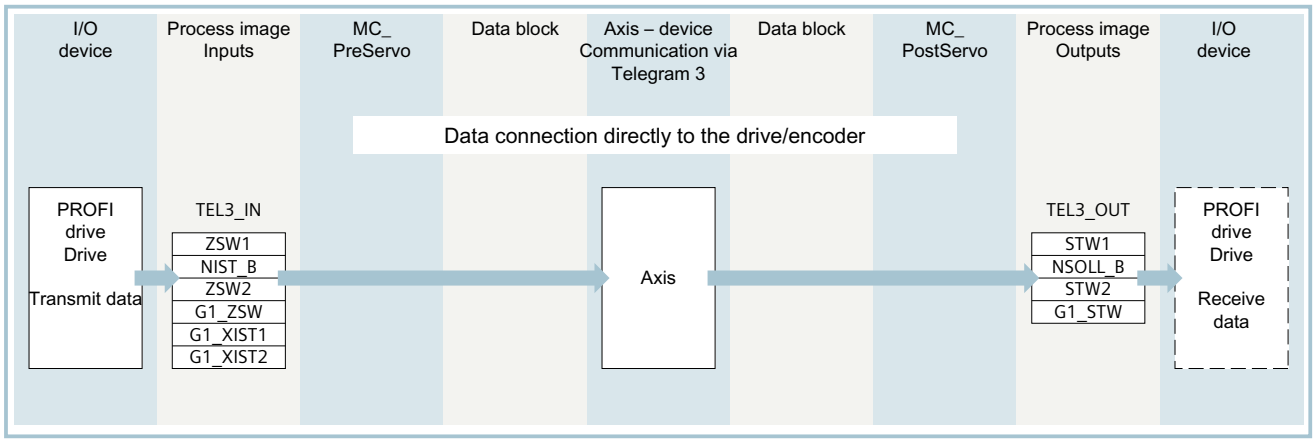

When you have selected a drive, you can use the "Device configuration" button to navigate directly to the device view of the PROFIdrive, e.g. in Startdrive. Use the "Drive configuration" button to navigate to the parameter assignment of the PROFIdrive drive in Startdrive.

NOTE

Option "Show all modules"

If a PROFIdrive drive that has already been configured is not available for selection, use the option "Show all modules" to display all reachable modules.

When you select the option "Show all modules", only the address range for each of the displayed modules is checked. If the address range of the module is large enough for the selected PROFIdrive telegram, you can select the module. For this reason, make sure that you select a PROFIdrive drive.

6.2.3.2 Connecting a PROFIdrive drive via data block

Use the connection via data block if you want to influence or evaluate telegram contents in the user program for process-specific reasons.

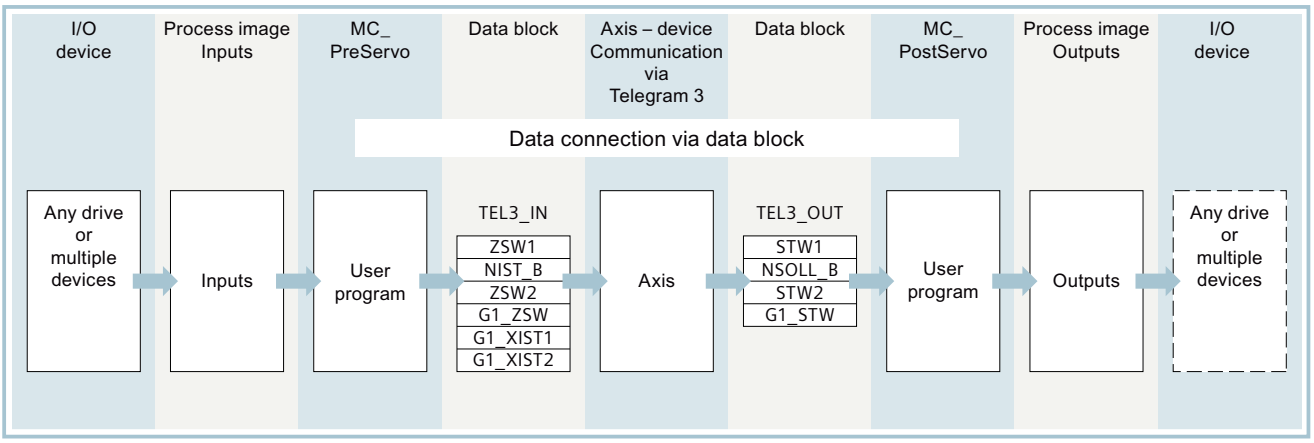

Principle of data connection via data block

Generally, at the start of closed-loop position control of the axis (by MC_Servo), the input area of the drive or encoder telegram is read.

At the end of closed loop position control, the output area of the drive or encoder telegram is written.

To influence or evaluate process-related telegram contents, a data interface can be connected via a data block before and after the position control.

- The input area of the telegram can be edited using the MC_PreServo organization block. The MC_PreServo is called before the MC_Servo.
- The output area of the telegram can be edited using the MC_PostServo organization block. The MC_PostServo is called after the MC_Servo.

The data block must be created by the user and contain a data structure of data type "PD_TELx" for the data connection. Here, "x" stands for the telegram number of the drive or encoder configured in the device configuration.

The organization blocks MC_PreServo and MC_PostServo can be programmed by the user and must be added with the command "Add new block". The connection to the I/O via telegram must be programmed in this organization block. When you use DSC, you have to edit the signs of life in the telegrams in MC_PreServo and MC_PostServo yourself according to the PROFIdrive standard.

6.2.3.3 Connect drive/encoder via data block

Creating the data block for data connection

1. Create a new data block of type "Global DB".
2. Select the data block in the project tree and select "Properties" from the shortcut menu.
3. Disable the following attributes under Attributes and accept the change with "OK":
   – "Only store in load memory"
   – "Data block write-protected in the device"
   – "Optimized block access" for technology version < V4.0
4. Open the data block in the block editor.
5. Create a new tag on "Add" in the block editor.
6. For the new tag, enter "PD_TELx" completely in the "Data type" column. The "x" stands for the telegram number. Example: "PD_TEL3" for standard telegram 3
   You have created a tag structure of the type "PD_TELx". This tag structure contains the "Input" tag structure for the input area of the telegram and the "Output" tag structure for the output area of the telegram.

NOTE

"Input" and "Output" relate to the view of the technology object. For example, the input area contains the actual values of the drive and the output area contains the setpoints for the drive.

For the data connection via a data block, "Input" and "Output" must always be in of the "PD_TELx" tag structure. Do not use standalone tag structures for "Input" and "Output", such as "PD_TEL3_IN".

The data block may contain the data structures of multiple axes and encoders and other contents.

Configuring data connection via a data block

1. Open the configuration window "Hardware interface > Drive" or "Hardware interface > Encoder".
2. Select the entry "Data block" from the "Data block" drop-down list.
3. In the "Data block" field, select the previously created data block.
   Open this data block and select the tag name defined for the drive and encoder.

NOTE

As of TIA Portal V17, you can connect tag structures of the "PD TELx" data type that are defined in arrays (Array [0..x] of "PD_TELx"), PLC data types or structures within a data block.

Programming MC_PreServo and MC_PostServo

- Edit the tag structure for the input area "Input" in the MC_PreServo.
- Edit the tag structure for the output area "Output" in the MC_PostServo.

NOTICE
Machine damage Improper manipulation of drive and encoder telegrams may result in unwanted drive motions. Check your user program for consistency in the drive and encoder connection.

An application example for the use of MC_PreServo and MC_PostServo is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109741575).

Configuration of the communication times T_i, T_o, T_{DC}

When calculating the following error, the transmission times of the setpoint to the drive and of the actual position value to the controller are deducted. The transmission times result from the following communication times:

- T_i: Time to import process values
- T_o: Time to export process values
- T_{DC}: Send clock of the PROFINET interface or PROFIBUS send clock

The following error is calculated from the delayed position setpoint by the communication times $T_i + T_o + T_{DC}$ and the cycle time of the MC_Servo T_{Servo} minus the actual position in the controller.

Unlike with direct drive or encoder connection, the communication times are not automatically adapted by the technology object with the connection via data block; by default, the communication times are preset to 0.0 s. For the correct calculation of the real following error "<TO>.StatusPositioning.FollowingError" and the system deviation at the position controller "<TO>.StatusServo.ControlDifference", you configure the communication times T_i, T_o, T_{DC} manually.

You can find a description of the communication times in the PROFINET with STEP 7 function manual on the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

Procedure

1. Read the T_i, T_o, and T_{DC} (send clock) from the device configuration of the drive or encoder. You can find the values in the menu "PROFINET interface > Advanced settings > Isochronous mode".
2. Define the read times as tags of the data type "LREAL" in a data block.

NOTE

Enter the time in seconds (s) in the data block. In the device configuration, times are entered in milliseconds (ms). A time Ti of 0.125 ms corresponds to 0.000125 s.

3. Call the "MC_WriteParameter" instruction with the following parameter assignment for "MC_WriteParameter.ParameterNumber". For the input parameter "Value", assign the defined tag for T_i with the corresponding time.

Communication time	MC_WriteParameter.ParameterNumber
T_i	1010
T_o	1011
T_{DC}	1012

4. Assign the associated technology object at the "Axis" input parameter.
5. Start the job with a positive edge at the "Execute" input parameter.

   The output parameter "Done" signals that the change has been applied.

   Bit 3 of the tag "<TO>.StatusWord" (OnlineStartValueChanged) indicates that a restart of the technology object is required to effectively apply the values.
6. Repeat steps 3. to 5. for the communication times T_o and T_{DC}.
7. To apply the change of the communication times, restart the technology object with the instruction "MC_Reset" with "Restart" = TRUE.

Result

The communication times for T_i, T_o and T_{DC} are now taken into account by the technology object when calculating the following error.

NOTE

When you connect the technology object directly to the drive, the technology object automatically adapts the communication times. Do not configure the communication times via the user program in this case.

The communication times are retained with a "RUN → STOP → RUN" transition of the CPU or in case of another restart of the technology object.

Note that the communication times are reset to 0.0 s in the following cases:

- Download of the technology object
- POWER OFF → POWER ON
- Memory reset

In this case, configure the communication times again.

6.2.3.4 Configuring drive parameters manually

If the connected drive does not allow the drive parameters to be applied automatically, configure the drive parameters manually. You can find the configured values in the manufacturer's information or in the drive commissioning tool.

Transferring drive and encoder parameters automatically (Page 71)

Standard motor

- **Reference speed**

  Configure the reference speed of the drive in accordance with the manufacturer's specifications in this field. The specification of the drive speed is a percentage of the reference speed in the range -200% to 200%.

- **Maximum speed**

  Configure the maximum speed of the drive in this field.

- **Reference torque**

  Configure the reference torque of the drive corresponding to its configuration in this field.

  The reference torque is needed for force/torque reduction, which is supported with telegram 10x.

Linear motor

- **Reference velocity**

  Configure the reference velocity of the drive in accordance with the manufacturer's specifications in this field. The specification of the drive velocity is a percentage of the reference velocity in the range -200% to 200%.

- **Maximum velocity**

  Configure the maximum velocity of the drive in this field.

- **Reference force**

  Configure the reference force of the drive corresponding to its configuration in this field.

  The reference torque is needed for force/torque reduction, which is supported with telegram 10x.

6.2.4 Connecting encoders via PROFIdrive

When using a PROFIdrive drive telegram with encoder data for the positioning axis or synchronous axis technology object, e.g. telegram 3, the encoder from the PROFIdrive telegram is automatically connected as the first encoder.

With telegram 6 or 106, the first two encoders are automatically connected (only S7-1500T).

You must connect the encoder separately to the drive in the following applications:

- Drive and encoder data in two separate PROFIdrive telegrams (drive connection via PROFIdrive telegram 1 and encoder connection via PROFIdrive telegram 81/83)
- Connection to the technology object external encoder
- Connection as a second, third or fourth encoder on the positioning axis or synchronous axis technology object (S7-1500T)
- Connection as the first encoder, instead of the automatically connected encoder from the PROFIdrive drive telegram.

More information

More information on encoder parameterization can be found in the Siemens Industry Online Support in the FAQ entry 109486133 (https://support.industry.siemens.com/cs/ww/en/view/109486133).

6.2.4.1 Connecting the encoder directly

In the "Encoder" field, select an already configured encoder or its PROFIdrive telegram.

Connection to the drive (not with analog drive connection)

The encoder is configured via the configuration of the PROFIdrive drive. The drive evaluates the encoder signals and sends them to the controller in the PROFIdrive telegram.

Encoder on technology module (TM)

Select a previously configured technology module and the channel to be used. Only technology modules set to the "Position input for Motion Control" mode are displayed for selection.

If no technology module is available for selection, change to the device configuration and add a technology module. If you have selected a technology module, you can access the configuration of the technology module using the "Device configuration" button.

You can operate the technology module centrally on an S7-1500 CPU or decentrally on a distributed I/O. During central operation in the CPU isochrone mode is possible as of firmware version 2.8.1.

You can identify the technology modules suitable for position detection for Motion Control in the documentation for the technology module and the catalog data.

With the compact CPUs (e.g. CPU 1512C-1 PN) you can use the high-speed counters (HSC) for position detection.

PROFIdrive encoder on PROFINET/PROFIBUS (PROFIdrive)

In the "PROFIdrive encoder" field, select a configured encoder on PROFINET/PROFIBUS. When you have selected an encoder, you can configure the encoder using the "Device configuration" button.

Switch to the device configuration in the network view, and add an encoder, in the event that no encoder can be selected.

NOTE

Option "Show all modules"

If a PROFIdrive that has already been configured is not available for selection, use the option "Show all modules" to display all reachable modules.

When you select the option "Show all modules", only the address range for each of the displayed modules is checked. If the address range of the module is large enough for the selected PROFIdrive telegram, you can select the module. For this reason, make sure that you select a PROFIdrive encoder.

6.2.4.2 Connect encoder via data block

If you have selected "Data block" under the data connection, select in the "Data block" field a previously created data block which contains a tag structure of the data type "PD_TELx" ("x" stands for the telegram number to be used).

The procedure is described in the section "Connecting a PROFIdrive drive via data block (Page 58)".

6.2.4.3 Configuring the encoder type

For position-controlled motion and positioning, the controller must know the actual position value.

The actual position value is provided by a PROFIdrive telegram.

The actual values are represented as incremental or absolute values in the PROFIdrive telegram. The actual values are normalized in the controller to the technological unit taking into account the configuration of the mechanics. The reference to a physical position of the axis or external encoder is established by homing.

The controller supports the following types of actual values (encoder types):

- Incremental actual value
- Absolute actual value with the setting absolute (measuring range > traversing range of the axis)
- Absolute actual value with the setting cyclic absolute (measuring range < traversing range of axis)

Configuration of the encoder type

Make the setting of the encoder type depending on the encoder used and the measuring range of the encoder. The following table contains the selection criteria.

Encoder type	Actual value type	Explanation	Selection
Incremental	The actual value in the PROFIdrive telegram is based on an incremental value.	After POWER ON, position zero is displayed. A transition of the CPU to RUN mode starts the actual value update. The actual value is then also updated in CPU STOP mode. The relationship between the technology object and the mechanical position must be re-established by means of homing.	Select this encoder type when using an incremental encoder.
Absolute	The actual value in the PROFIdrive telegram is based on an absolute value. After POWER ON, position zero is displayed. The first transition of the CPU to RUN mode starts the actual value update. The actual value is then also updated in CPU STOP mode. The supplied absolute value is assigned to the associated mechanical axis position by means of the absolute encoder adjustment. The absolute encoder adjustment must be performed once. The absolute value offset is retentively saved beyond the switching on/off of the controller.	The axis position results directly from the current actual encoder value. The traversing range must be within an encoder measuring range. This means that the zero crossing of the encoder must not be located in the traversing range. When the controller is switched on, the axis position is determined from the absolute actual encoder value.	An absolute encoder is used and the measuring range of the encoder is greater than the traversing range of the axis. If you cannot ensure that there is no encoder zero crossing in the traversing range, use the "Cyclic absolute" setting.
Cyclic absolute		The encoder supplies an absolute value within its measuring range. The controller includes the traversed measuring ranges and thus determines the correct axis position beyond the measuring range. When the controller is switched off, the traversed measuring ranges are saved in the retentive memory area of the controller. At the next power-on, the saved traversed measuring ranges are taken into account in the calculation of the actual position value.	An absolute encoder is used and the measuring range of the encoder is smaller than the traversing range of the axis. Recommended settings for absolute actual values: The "Cyclic absolute" encoder type is recommended. With this setting, the position of the zero crossing of the encoder is automatically taken into account by the technology object.

The following graphic illustrates three different encoder measurement ranges and the possible configuration of the encoder type.

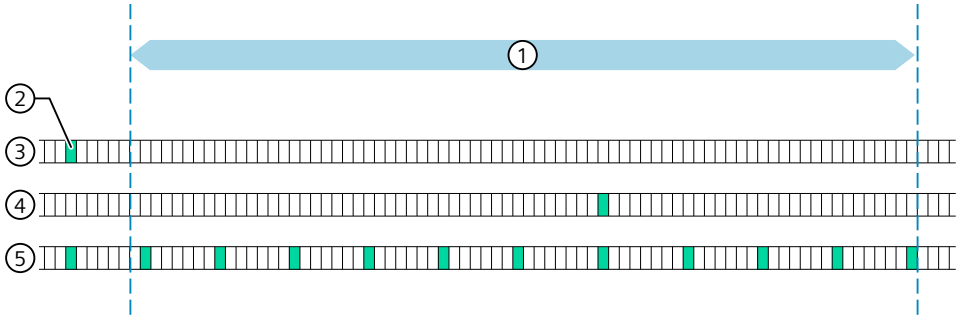

① Maximum traversing range

② Zero crossing

③ Zero crossing outside the maximum traversing range
Encoder type: "Absolute" or "Cyclically absolute"

④ Zero crossing within the maximum traversing range
Encoder type: "Cyclic absolute"

⑤ Zero crossing multiple times within the maximum traversing range
Encoder type: "Cyclic absolute"

6.2.4.4 Configuring encoder parameters manually

If the connected encoder does not allow the encoder parameters to be applied automatically, configure the encoder parameters manually. You can find the configured values in the manufacturer's information or in the drive commissioning tool.

Transferring drive and encoder parameters automatically (Page 71)

Encoder parameters for a rotary measuring system

Parameters	Drive parameters in SINAMICS	Encoder type		
		Increment-al	Absolute	Cyclic absolute
Increments per revolution	p979[2] encoder 1 p979[12] encoder 2	x	x	x
Number of revolutions	p979 [5] encoder 1 p979[15] encoder 2	-	x	x
Bits for fine resolution in the incremental actual value (Gx_XIST1)	p979[3] encoder 1 p979[13] encoder 2	x	x	x
Bits for fine resolution in the absolute actual value (Gx_XIST2)	p979[4] encoder 1 p979[14] encoder 2	-	x	x
Encoder reference speed	p2000	x	x	x

Encoder parameters for linear measuring system

Parameters	Drive parameters in SINAMICS	Encoder type		
		Increment-al	Absolute	Cyclic absolute
Distance between two increments	p979[2] encoder 1 p979[12] encoder 2	x	x	x
Bits for fine resolution in the incremental actual value (Gx_XIST1)	p979[3] encoder 1 p979[13] encoder 2	x	x	x
Bits for fine resolution in the absolute actual value (Gx_XIST2)	p979[4] encoder 1 p979[14] encoder 2	-	x	x
Encoder reference velocity	p2000	x	x	x

Evaluation of incremental actual value Gx_XIST1 with absolute encoders

In its default setting "<TO>.Sensor[1..4].Parameter.BehaviorGx_XIST1" = 1, the technology object assumes that the incremental actual value "Gx_XIST1" in the PROFIdrive telegram is supplied as an incremental counter value with a data width of 32 bits by the encoder or by the encoder module. In the "Gx_XIST1", this corresponds to a value between 0 and 4.294.967.295 (32 bits). The technology object expects overflow at these limits.

If "Gx_XIST1" is transmitted in the PROFIdrive telegram with a data width of less than 32 bits, configure "<TO>.Sensor[1..4].Parameter.BehaviorGx_XIST1" with 0. In this configuration, the technology object does not expect an incremental counter value with 32 bits, but evaluates only the data width according to the parameter assignment of the encoder at the technology object in "Gx_XIST1". The overflow in "Gx_XIST1" is also expected based on this parameter assignment. You can diagnose whether the data width of the incremental counter value is less than 32 bits with a trace of "Gx_XIST1" from the PROFIdrive telegram. If "Gx_XIST1" overflows back to 0 before it reaches 4,294,967,295, then the data width is less.

6.2.4.5 Using multiple encoders

The S7-1500T technology CPU offers the option of using up to 4 encoder or measuring systems per positioning axis and synchronous axis as the actual position for the closed loop position control

Only one encoder at a time is active for closed loop position control. You can switch between the 4 encoder or measuring systems.

However, the actual values of all configured encoders can be evaluated in the user program.

This opens up the following possible application areas, for example:

- Use of additional machine encoders (besides the motor encoder), e.g. as direct measuring systems for more accurate detection of actual positions of machining processes.
- Use of alternative encoder systems following a tool change in a flexible manufacturing process.

You configure the encoders in the axis configuration. You control the switchover of the encoders in the user program with the Motion Control instruction "MC_SetSensor".

Configuring an axis with multiple encoders

Note the following configuration windows when using multiple encoders:

- In the configuration window "Hardware interface > Encoder", configure which alternative encoders are to be used and their corresponding encoder type (incremental, absolute or cyclic absolute).
  All encoders marked as used supply continually updated actual values to the closed loop position control regardless of their use.
- In the configuration window "Hardware interface > Encoder", configure an encoder as "Encoder at power-up". This is necessary because an encoder must always be assigned to the positioning axis and synchronous axis. To use Dynamic Servo Control (DSC), you must configure the motor encoder of the drive as the first encoder on the axis. The motor encoder is always the first encoder in the telegram.
- In the configuration window "Hardware interface > Data exchange with encoder", configure additional encoder details and the telegram that is to be used to connect the encoders. The configuration must be performed for each encoder used.
  Each encoder to be used or each measuring system may differ with regard to its encoder mounting type.
- In the configuration window "Extended parameters > Mechanics", configure the encoder mounting type and any gear parameters. The configuration must be performed for each encoder used.
- The axis can be homed with any configured encoder. In the configuration window "Extended parameters > Homing", configure the parameters for active and passive homing. The configuration can be performed for each encoder used.
  When the axis is homed with an encoder, the axis is homed and retains the "homed" status following encoder switchover.

Encoder switchover in the user program

For closed loop position control of the positioning and synchronous axes, an encoder must always be active. Individual encoders may fail as long as they are not involved in closed loop position control.

With the Motion Control instruction "MC_SetSensor", you switch over the encoder for closed loop position control of the axis.

The switchover can occur during an active motion job or at a standstill. The axis does not have to be enabled.

A switchover during an active homing or restart job is not possible.

NOTE

Homing

Homing with the Motion Control instruction "MC_Home" or the axis control panel is always performed with the encoder involved in closed loop position control.

The homing status of the axis is not changed following an encoder switchover.

Simulation

When the axis is simulated, all encoders configured as "used" are simulated.

Parameters "Mode" = 2 and "Mode" = 3 of the Motion Control instruction "MC_SetSensor" can be used to prepare a switchover.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_SetSensor" to define the encoder switchover:

- With the "Sensor" parameter, you define the number of the new encoder.
- With the "Mode" parameter, you define the position adjustment between the old encoder and new encoder.
- With the "ReferenceSensor" parameter, you define the number of the reference encoder.

Position adjustment mode

Following the switchover to an alternative encoder or encoder system, you can select what happens if the actual positions of the encoders are different.

You define how to deal with the difference in the actual positions of the encoders using input parameter "Mode" of the Motion Control instruction "MC_SetSensor".

- **Switch over encoder and transfer actual position to the encoder to be switched ("Mode" = 0)**

  With this encoder switchover, step changes in the actual position are prevented. Bumpless switchover of the encoders is possible.

- **Switch over sensor without transferring the actual position ("Mode" = 1)**

  Following a switchover to an encoder without adjustment, a step change of the actual position may occur. This can be desirable if the new encoder is intended to compensate for possible mechanical influences (such as slip) in the positioning.

  The position difference is not implemented immediately but rather after a delay using time constant "<TO>.PositionControl.SmoothingTimeByChangeDifference" in order to prevent step changes in the actual position with active closed loop position control.

- **Transfer actual position ("Mode" = 2)**

  The actual position of the axis is transferred to the encoder specified in the "Sensor" parameter.

- **Transfer actual position of the reference encoder ("Mode" = 3)**

  The actual position of the "Reference encoder" ("ReferenceSensor" parameter) is transferred to the encoder specified in the "Sensor" parameter.

Switchover to an absolute encoder

When you switch the encoder to an absolute encoder and transfer the actual value ("Mode" = 2, 3), the actual value is offset against the value of the absolute encoder and the absolute value offset. At the switchover to a different encoder, this offset of the actual value is discarded. The absolute encoder again returns the absolute value + absolute value offset (<TO>.StatusSensor[1..4].AbsEncoderOffset) without the offset by the "MC_SetSensor" job.

See also

MC_SetSensor: Switch alternative encoder to operative encoder V10 (Page 338)

6.2.4.6 Calculate actual velocity from actual speed NIST_B from PROFIdrive telegram

If you use an encoder with a low resolution, configure the following calculation methods:

- For positioning axis and synchronous axis technology objects: Calculate actual velocity from actual speed "NIST_B" from telegram
- For technology object external encoder: Calculate actual velocity from actual speed "NIST_B" of encoder telegram 83

For encoders with low resolution, the calculation of the actual velocity from the actual speed "NIST_B" in the PROFIdrive telegram is more precise than the standard calculation from the change in the actual position in the servo cycle.

Encoder resolution	Recommended configuration	Explanation
High	<TO>.Sensor[1..4].ActualVelocityMode = 0	Calculation of the actual velocity from the differentiation of the actual position
Low	<TO>.Sensor[1..4].ActualVelocityMode = 1	Calculation of the actual velocity from the actual speed "NIST_B" from the PROFIdrive telegram

The calculation of the actual velocity is relevant for the following Motion Control functions:

- Actual value extrapolation for actual value coupling in synchronous operation (S7-1500T)
- Output cam with output cam reference "Actual value"
- Transition from follow-up mode to position-controlled mode
- Calculation of the emergency stop ramp
- Standstill detection

NOTE

The calculation method of the actual velocity has no influence on the position control and the motion control of the technology object.

⚠ WARNING

Use of drive telegrams with two encoders

The standard telegrams 4 and 6 and the Siemens telegram 106 support up to two encoders.

Note that the actual speed "NIST_B" is only transferred for encoder 1 in the drive telegram.

If you have connected the second encoder of the telegram for encoder 2 in the technology object and for this encoder "Calculate actual velocity from actual speed NIST_B from PROFIdrive telegram" (<TO>.Sensor.Sensor (2).ActualVelocityMode = PROFIDRIVE_NIST), then the first encoder of the telegram returns the actual speed and the second encoder of the telegram returns the actual position.

If you calculate actual velocity from actual speed "NIST_B" of encoder telegram 83, you must configure the following reference values:

- With rotary measuring system: Encoder reference speed "<TO>.Sensor[1..4].Parameter.ReferenceSpeed"
- With linear measuring system: Encoder reference velocity "<TO>.Sensor[1..4].Parameter.ReferenceVelocity"

When calculating the actual velocity from the actual speed "NIST_B" from drive telegrams, the reference value from the tag "<TO>.Actor.DriveParameter.ReferenceSpeed" or "<TO>.Actor.DriveParameter.ReferenceVelocity" is automatically used. You do not need to configure any additional reference values in "<TO>.Sensor[1..4]".

6.2.5 Transferring drive and encoder parameters automatically

Identical reference values for the drive and encoder connections must be set in the controller and in the drive and encoder for the operation.

The speed setpoint NSET and the actual speed value NACT are transferred in the PROFIdrive telegram as a percentage of the reference speed. The reference value for the speed must be set identically in the controller and in the drive.

The resolution of the actual value in the PROFIdrive telegram must likewise be set identically in the controller and in the drive and encoder modules

Automatic transfer of parameters during runtime (online)

The drive and encoder parameters can be automatically applied in the CPU for the following drives and encoders.

- SINAMICS drives
- Certified PROFINET encoder as of encoder profile 4.1

The corresponding parameters are transferred after the (re-)initialization of the technology object or (re)start of the drive and the CPU. Changes in the drive configuration are transferred after restart of the drive or technology object.

Successful transfer of the parameters can be checked in the controller with the value of the tags "<TO>.StatusDrive.AdaptionState" = 2 and "<TO>.StatusSensor[1..4].AdaptionState" = 2 of the technology object.

To automatically take data from drive parameters via acyclic communication, the technology object requires read permissions to the drive data. The PROFINET fieldbus protocol must be able to access the drive data without user authentication (login).

For SINAMICS FW V6.1 or higher, you can find information in the section "Security functions > User management and access control > Access control" of the "SINAMICS Industrial Cybersecurity" configuration manual (https://support.industry.siemens.com/cs/ww/en/view/109983025).

Automatic transfer of parameters during configuration (offline)

When you have completed the drive configuration with SINAMICS Startdrive, you can apply the drive or encoder parameters offline in the technology object. The parameters are automatically transferred to the CPU before the download.

Parameters

The settings for automatic transfer can be found in the TIA Portal under "Technology object > Configuration> Hardware interface > Data exchange with the drive/encoder".

The drive and encoder settings are made in the configuration or the respective hardware.

The drive and encoder parameters must correspond to the specifications in the device configuration.

6.2.6 Connecting stepper motors

Drives with a stepper motor interface are connected using telegram 3 and with the help of PTO (Pulse Train Output) pulse generators.

Use the following modules to control the stepper motors:

- TM PTO 2x24V / TM PTO 4
- SIMATIC MICRO-Drive F-TM StepDrive S

For functional support of stepper motor operation, quantization of the control deviation can be set.

Through the specification of a quantization, a range around the target position is defined in which no correction of the actual position is to be made. This prevents a possible oscillation of the stepper motor around the target position. Two types of quantization can be set:

- Quantization of the control deviation corresponding to the encoder resolution

  ("<TO>.PositionControl.ControlDifferenceQuantization.Mode" = 1)

  This prevents oscillation of the motor in standstill between two increment values, for example. This mode is especially helpful when using multiple encoders. With this setting, the quantization is adapted appropriately at an encoder switchover. This mode is helpful for stepper motors with encoders in which the resolution of the encoder is lower than the step size of the stepper motor.
- Direct specification of a value for quantization of the control deviation.

  ("<TO>.PositionControl.ControlDifferenceQuantization.Mode" = 2, value setting in "<TO>.PositionControl.ControlDifferenceQuantization.Value")

  This mode is helpful for stepper motors with encoders in which the resolution of the encoder is greater than the step size of the stepper motor.

6.2.7 Connecting drives with analog setpoint interface

Drives with analog setpoint interfaces are connected using an analog output and an optional enable signal. The speed setpoint is specified via an analog output signal (e.g. from -10 V to +10 V) from the CPU.

Analog output

In the "Analog output" field, select the PLC tag of the analog output via which the drive is to be controlled.

In order to be able to select an output, you first need to add an analog output module in the device configuration and define the PLC tag name for the analog output.

Activate enable output

Select the "Activate enable output" check box if the drive supports an enable.

Select the PLC tag of the digital output for the drive enable in the corresponding field. With the enable output, the speed controller in the drive is enabled, or disabled.

In order to be able to select an enable output, a digital output module must be added in the device configuration and the PLC tag name must be defined for the digital output.

NOTE

If you do not use an enable output, the drive cannot be immediately disabled on the part of the system due to error reactions or monitoring functions. A controlled stop of the drive is not guaranteed.

Enable ready input

Select the "Enable ready input" check box if the drive can signal its readiness.

Select the PLC tag of the digital input via which the drive is to signal its operational readiness to the technology object in the corresponding field. The power module is switched on and the analog speed setpoint input is enabled.

In order to be able to select a ready input, you first need to add a digital input module in the device configuration and define the PLC tag name for the digital input.

NOTE

The enable output and the ready input can be separately enabled.

The following boundary conditions apply to the activated ready input:

- The axis is only enabled ("MC_Power Status" = TRUE) when a signal is present at the ready input.
- If a signal is not present at the ready input on an enabled axis, the axis is disabled with an error.
- If the axis is disabled with the instruction "MC_Power" ("Enable" = FALSE), the axis is disabled even when a signal is present at the ready input.

Reference speed with analog setpoint interface

The reference speed of the drive is the speed with which the drive spins when there is an output of 100% at the analog output. The reference speed must be configured in the drive, and transferred into the configuration of the technology object.

The analog value that is output at 100% depends on the type of the analog output. For example, for an analog output with +/- 10 V, the value 10 V is output at 100%.

Analog outputs can be overridden by approximately 17%. This means that an analog output can be operated in the range from -117% to 117%, insofar as the drive permits this.

Reference velocity with analog setpoint interface

With a linear motor, the reference velocity is the velocity at which the drive moves with an output of 100% at the analog output. The reference velocity must be configured for the drive and transferred to the configuration of the technology object.

The analog value that is output at 100% depends on the type of the analog output. For example, for an analog output with +/- 10 V, the value 10 V is output at 100%.

Analog outputs can be overridden by approximately 17%. This means that an analog output can be operated in the range from -117% to 117%, insofar as the drive permits this.

6.2.8 Connecting force/torque data via SIEMENS additional telegram 750

With the connection of the Siemens additional telegram 750 you can use the following functions:

- Specification of an additive setpoint torque (torque precontrol) based on the acceleration of the axis
- Specification of an additive setpoint torque (torque precontrol) with "MC_TorqueAdditive"
- Setting of the upper and lower torque limit with "MC_TorqueRange"
- Readout of the actual torque value with "<DB>.StatusTorqueData.ActualTorque" or "ActualForce"

NOTE

Force data for linear motors

When using a linear motor, force data is transferred via SIEMENS additional telegram 750 instead of torque data.

Activation of the additional data in the technology object

If you want to configure the data connection of the torque data, select the "Torque data" check box in "Technology object > Configuration > Hardware interface > Drive data exchange with the drive > Additional data". If you have selected a drive with which the additional telegram 750 has been configured, the "Torque data" check box is preselected.

Data connection of the additional telegram in the technology object

If you select the entry "Additional telegram" in the "Data connection" drop-down list, you can edit the "Additional telegram" drop-down list.

- Select an additional telegram configured in the "Additional telegram" field.
- Select the "Show all modules" check box if you want to display all submodules of the connected drive. You can also find self-defined supplemental telegrams with this function.

Connect additional telegram via data block

If you select the "Data block" entry in the "Data connection" drop-down list, you can select the previously created data block which contains a tag structure of the "PD_TEL750" data type.

In the "Data block" field, select the data block which you want to use to integrate the torque data.

6.2.9 Encoder signal output via TM41

With the TM41 you can emulate the axis position (a leading value) as encoder signal output. The output angle signal behaves like the signal of an incremental encoder. This means that you can, for example, provide a leading value as an encoder signal for an external control.

The TM41 is connected to a TO Axis via standard telegram 3. The TO can be used as an axis at the Motion FBs in the user program.

In the following figure, a real servo axis operated with DSC is controlled by a virtual axis on the SIMATIC S7-1500 and an axis with signal output is controlled via a TM41 module. The position of the servo axis is output via an encoder signal at the TM41 through the synchronous operation coupling of the two following axes. The encoder signals can be evaluated by other controllers.

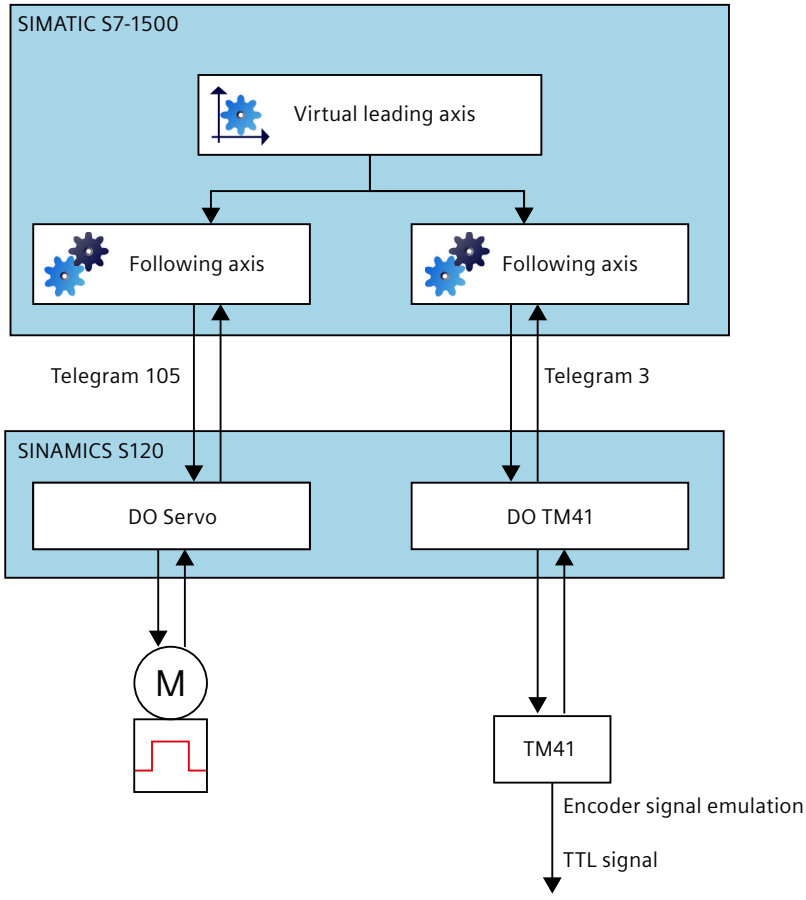

Requirements for the drive

- The TM41 can only be connected to SINAMICS S120 drives.
- The value [0] must be configured in the drive for the "Selection of operating mode" (p4400).

Restrictions

Please note the following restrictions for operation of the TM41 at the technology object.

- No active homing
- No measuring via digital drive
- Backlash compensation must be deactivated.
- Following error monitoring must be deactivated.
- Position monitoring must be deactivated.
- Standstill monitoring must be deactivated.
- Hardware limit position monitoring must be deactivated.

Necessary position controller setting

- Precontrol = 100%
- Speed control loop substitute time = 0.000

Automatic transfer of parameters

Recommendation: For the TM41, the automatic transfer of parameters should always be executed online.

Proceed as follows for automatic transfer offline:

1. Commission the TM41 online.
2. Upload the drive parameters to the TIA Portal project so that the parameters in the Startdrive project are consistent with the online parameters in the drive.

Transferring drive and encoder parameters automatically (Page 71)

6.2.10 Tags: Drive and encoder connection

The following technology object tags are relevant for the drives and encoder connections:

Drive telegram	
Tag	**Description**
<TO>.Actor.Interface.AddressIn	Input address for the PROFIdrive telegram
<TO>.Actor.Interface.AddressOut	Output address for the PROFIdrive telegram or the analog setpoint
<TO>.Actor.DriveParameter.ReferenceSpeed	Reference value (100%) for the speed setpoint (NSET) of the drive
<TO>.Actor.DriveParameter.MaxSpeed	Maximum value for the speed setpoint of the drive (NSET)
<TO>.Actor.DriveParameter.ReferenceTorque	Reference torque for the torque transferred as a percentage

Drive telegram	
Tag	**Description**
<TO>.Actor.LinearMotorDriveParameter.ReferenceVelocity	Reference value (100%) for the velocity setpoint of a liner motor
<TO>.Actor.LinearMotorDriveParameter.MaxVelocity	Maximum value for the velocity setpoint of a linear motor
<TO>.Actor.LinearMotorDriveParameter.ReferenceForce	Reference force for the force of a linear motor, which is transmitted as percentage value

Encoder telegram	
Tag	**Description**
<TO>.Sensor[1..4].Interface.AddressIn	Input address for the PROFIdrive telegram
<TO>.Sensor[1..4].Interface.AddressOut	Output address for the PROFIdrive telegram
<TO>.Sensor[1..4].System	Encoder system linear or rotary
<TO>.Sensor[1..4].Type	Encoder type, incremental, absolute or cyclic absolute
<TO>.Sensor[1..4].Parameter.Resolution	Resolution for linear encoder Space between two lines
<TO>.Sensor[1..4].Parameter.StepsPerRevolution	Steps per revolution for rotary encoder
<TO>.Sensor[1..4].Parameter.DeterminableRevolutions	Number of differentiable encoder revolutions for a multi-turn absolute encoder
<TO>.Sensor[1..4].Parameter.DistancePerRevolution	For technology objects < V8.0: Load distance per revolution of an externally mounted encoder For technology objects ≥ V8.0: Load travel per measuring wheel revolution of an externally mounted encoder
<TO>.Sensor[1..4].Parameter.ReferenceSpeed	Reference speed for the actual speed (NSET_B), which is transmitted as percentage value
<TO>.Sensor[1..4].Parameter.ReferenceVelocity	Reference velocity for the actual speed (NSET_B), which is transmitted as percentage value
<TO>.Sensor[1..4].MeasuringGear.Numerator	Encoder gear counter
<TO>.Sensor[1..4].MeasuringGear.Denominator	Encoder gear denominator

Fine resolution	
Tag	**Description**
<TO>.Sensor[1..4].Parameter.FineResolutionXist1	Number of bits for fine resolution XIST1 (cyclic actual encoder value)
<TO>.Sensor[1..4].Parameter.FineResolutionXist2	Number of bits for fine resolution XIST2 (absolute value of encoder)

Simulation mode		
Tag	**Description**	
<TO>.Simulation.Mode	Simulation mode	
	0	No simulation, normal operation
	1	Simulation mode

6.3 Safety functions in the drive

In addition to programming the motion sequences, you must also reduce the risks of the machine through safety functions to ensure machine safety. The SINAMICS drive system provides integrated safety functions, hereinafter referred to as "Safety Integrated Functions".

The "Safety Integrated Functions" of the SINAMICS drive system available can be subdivided into the following functions:

- Safe stopping process
- Safe brake control
- Safe monitoring of motion
- Safe monitoring of position

More information on the "Safety Integrated Functions" in SINAMICS drives is available in the "SINAMICS S120 Safety Integrated" function manual (https://support.industry.siemens.com/cs/ww/en/view/109781722).

Interaction between the technology object and the SINAMICS "Safety Integrated Functions"

The "Safety Integrated Functions" of the SINAMICS drive system are monitoring functions for fail-safe monitoring of the drive motion. The motion of the drives is controlled via technology objects and the programmed motion control jobs in the user program of the SIMATIC S7-1500.

When using the "Safety Integrated Functions", you must evaluate the status information of the SINAMICS "Safety Integrated Functions" and program your user program depending on this status information. You can implement an interaction between the SINAMICS "Safety Integrated Functions" and the motion control in the SIMATIC S7-1500.

The technology object does not contain any information on the states of the SINAMICS "Safety Integrated Functions". Evaluate the current status of the "Safety Integrated Functions" in the drive using one of the following options.

- "Safety Info Channel" (SIC)
- Status words of the PROFIsafe telegram (read access)

If you do not use a PROFIsafe telegram, create a telegram for the SIC.

Safety Info Channel

The "Safety Info Channel" is mapped in the telegrams 700 and 701.

Status word	Status information	Telegram 700	Telegram 701
S_ZSW1B	• Safe stopping process • Safe monitoring of motion	x	x
S_ZSW2B	Safe monitoring of position	-	x
S_ZSW3B	Status information on the brake test	-	x
S_V_LIMIT_B	• Necessary velocity setpoint limiting due to the selected SINAMICS "Safety Integrated Functions". • When selecting a "Safety Integrated Function" for safe shutdown or the "Safety Integrated Function" SDI, the necessary status word S_V_LIMIT_B takes on the value 0.	x	x

The free "LDrvSafe" library contains function blocks and a description for easy evaluation of the "Safety Info Channel" in your user program.

LDrvSafe (https://support.industry.siemens.com/cs/ww/en/view/109485794)

PROFIsafe telegram

When you control the SINAMICS "Safety Integrated Functions" via PROFIsafe, you have read access from the standard user program to the PROFIsafe status words.

With this information you can react with a Motion Control Instruction suitable for your machine when a "Safety Integrated Function" is triggered in the user program.

6.3.1 Safe stopping process

SINAMICS "Safety Integrated Functions" with drive-autonomous stop reaction

The "Safety Integrated Function" STO triggers a drive-autonomous stop reaction and the drive coasts down (OFF2). The technology object signals the technology alarm 421 (alarm response: remove enable).

The following "Safety Integrated Functions" trigger a drive-autonomous stop reaction and the drive decelerates at the OFF3 ramp.

- SS1
- SS2

The result is that the drive performs a motion that was not specified by the technology object. The technology object signals the technology alarm 550 (alarm response: follow up setpoints). Have the technology object enabled ("MC_Power.Enable" = TRUE) so that the drive-autonomous braking process is not interrupted.

Example - Pressing an emergency stop control device

Example:

After pressing the emergency stop button, all drives of the machine must be brought to a standstill as quickly as possible. Standstill drives must not accelerate unintentionally.

Solution:

To this end, the "Safety Integrated Function" SS1 is selected in the SINAMICS drive system and each selected drive is independently braked electrically until it is at standstill.

Enabling the technology object after a drive-autonomous stop reaction:

To enable the technology object again after triggering a drive-autonomous stop reaction, follow these steps:

1. Verify in the "Safety Info Channel" SIC, whether STO, SS1 or SS2 was triggered.
2. Eliminate the cause of the triggered "Safety-Integrated Function", for example, by unlocking the emergency stop button.
3. Safely acknowledge the pending safety messages in the drive.
4. Wait until STO, SS1 and SS2 are no longer active.
5. Acknowledge the technology alarms 421 and 550 with an "MC_Reset" job.

Drive-autonomous stop reaction with coupled axes

NOTICE
Machine damage caused by loss of synchronous operation coupling after drive-autonomous stop reaction For axes coupled by synchronous operation, a drive-autonomous stop reaction causes each axis to decelerate individually along its own OFF3 ramp. This means that the axes are no longer coupled after SS1 or SS2. This can damage the mechanical components or the workpiece. If permitted by the risk assessment, use the following "Safety Integrated Functions": • SS1E instead of SS1 • SS2E or SOS instead of SS2

When triggering SS1E, no drive-autonomous deceleration is started but a safe delay time is started instead. Motion control still takes place within the safe delay time from the user program of the SIMATIC S7-1500. You must set the axis group to a standstill within the delay time. To do so, stop the leading axis of the synchronous operation, for example, with an "MC_Halt" job to safely stop the entire axis group within the safe delay time. When the safe delay time expires, STO automatically takes effect.

The same behavior applies to SS2E and SOS.

6.3.2 Safe brake control

The drive-based function "Safe Brake Test" (SBT) is a diagnostic function and checks the required holding torque of a brake (operating or holding brake). After starting the brake test, the drive purposely generates a torque against the applied brake.

The brake test in combination with technology objects is usually controlled via the "Safety Control Channel".

The free "LDrvSafe" library provides you with function blocks and a description for easy control of the "Safety Control Channel" and to use the safe brake test.

LDrvSafe (https://support.industry.siemens.com/cs/ww/en/view/109485794)

6.3.3 Safe monitoring of motion

When you select the motion monitoring "Safety Integrated Functions" of the SINAMICS drive system, you must limit the speed and/or the acceleration of the axis to maintain the availability of the machine.

You have the following options to limit the velocity and the acceleration.

- Adapting the dynamic limits at the technology object
  - <TO>.DynamicLimits.Velocity
  - <TO>.DynamicLimits.Acceleration
- Limiting the dynamic parameters at the Motion Control instructions
- Limiting the velocity through the override "<TO>.Override.Velocity"

SLS

In SINAMICS, the necessary setpoint speed limiting is configured as follows:

S_V_LIMIT_B (r9733) = Selected SLS limit value (p9531) * evaluation factor (p9533

The setpoint speed limiting "S_V_LIMIT_B" is specified on the motor side in SINAMICS and calculated from the SLS limit value configured on the load side.

Parameter	Limit value	Unit
S_V_LIMIT_B (r9733)	Motor-side limit value	• Standard motor: 1/min • Linear motor: m/min
SLS limit value (p9531)	Load side limit value taking into account the mechanical parameters in SINAMICS	• Safety rotary axis: 1/min • Safety linear axis: mm/min

To recognize the necessary setpoint speed limiting after selection of SLS, evaluate the tag "S_V_LIMIT_B" from the "Safety Info Channel". "S_V_LIMIT_B" is transmitted in the SIC normalized via the parameter p2000. The parameter p2000 is saved in the tag "<TO>.Actor.DriveParameter.ReferenceSpeed" of the technology object.

To convert "S_V_LIMIT_B" into the maximum velocity setpoint (v_{max}) of the technology object, use the following formula for the following units of measurement.

- Linear axis with standard motor:

$$v_{max}\left[\frac{mm}{s}\right] = \frac{S_V_LIMIT_B}{16\#40000000} \cdot \text{<TO>.Actor.DriveParameter.ReferenceSpeed}\left[\frac{1}{min}\right] \cdot \frac{1}{60}\left[\frac{min}{s}\right] \cdot \text{<TO>.Mechanics.LeadScrew}\,[mm] \cdot \frac{\text{<TO>.LoadGear.Denominator}}{\text{<TO>.LoadGear.Numerator}}$$

- Linear axis with linear motor:

$$v_{max}\left[\frac{mm}{s}\right] = \frac{S_V_LIMIT_B}{16\#40000000} \cdot \text{<TO>.Actor.DriveParameter.ReferenceSpeed}\left[\frac{m}{min}\right] \cdot \frac{1000}{1}\left[\frac{mm}{m}\right] \cdot \frac{1}{60}\left[\frac{min}{s}\right]$$

- Rotary axis with standard motor:

$$v_{max}\left[\frac{°}{s}\right] = \frac{S_V_LIMIT_B}{16\#40000000} \cdot \text{<TO>.Actor.DriveParameter.ReferenceSpeed}\left[\frac{1}{min}\right] \cdot \frac{1}{60}\left[\frac{min}{s}\right] \cdot 360[°] \cdot \frac{\text{<TO>.LoadGear.Denominator}}{\text{<TO>.LoadGear.Numerator}}$$

Alternatively, especially when using fewer SLS levels, you can define the necessary setpoint speed limiting yourself and save it permanently in a data block. See the procedure for SLA as a reference.

Example - Opening a protective door in setup mode

Example:

The machine operator must be able to enter the danger zone of a machine after the protective door has been opened and slowly move a horizontal conveyor in it with an acknowledgment button. The actual velocity of 250 mm/s must not be exceeded in this process.

The horizontal conveyor is implemented using the following technology:

- Technology object Positioning axis as linear axis in the SIMATIC S7-1500
- Safety linear axis axes with standard motor in SINAMICS

Solution:

Select the "Safety Integrated Function" SLS with the limit value 15000 mm/min (is equivalent to 250 mm/s) in SINAMICS. If the actual velocity (intentionally or unintentionally) exceeds the limit value of 250 mm/s, a drive-autonomous, user-defined stop reaction, such as SS1, is triggered.

1. In SINAMICS, you make the following parameter assignment for the drive:
   - SLS limit value Level 1 (p9531) = 15000 mm/min = 250 mm/s
   - Evaluation factor (p9533) = 80%

   Result: The parameter assignment results in the following value for the setpoint speed limiting: 250 mm/s * 0.8 = 200 mm/s

   In this example, this means that the velocity setpoint of the horizontal conveyor is 200 mm/s before the "Safety Integrated Function" SLS Level 1 with the actual speed limit value of 250 mm/s is active.
2. Evaluate the setpoint speed limiting from "S_V_LIMIT_B" in the SIC and convert the standardized value into the velocity value with the configured unit of measurement of the technology object.

   Alternatively, especially when using fewer SLS levels, you can save the setpoint speed limiting of 200 mm/s directly in a data block.
3. Evaluate "S_ZSW1B.Bit6" from SIC (SLS selected) cyclically in the user program. If SLS is selected ("S_ZSW1B.Bit6" = TRUE), execute step 4.
4. Specify the setpoint speed limiting of 200 mm/s as dynamic limitation "<TO>.DynamicLimits.Velocity" at the technology object and limit the setpoint velocity "Velocity" at the Motion Control instructions of the technology object. Alternatively, you can also reduce the setpoint velocity via the override "<TO>.Override.Velocity".

SLA

For SLA, the necessary setpoint speed limiting is not calculated by the drive system but must be calculated by the user instead. In this case, you must calculate the necessary setpoint speed limiting yourself and save it in the SIMATIC S7-1500, for example, in a data block. When selecting SLA, you limit the acceleration to this specific value.

SDI

You can recognize a corresponding direction of rotation limitation via the signals SDI negative/SDI positive. If the axis is currently moving in the direction that is no longer permissible after the delay time has expired, you stop or change the motion direction of the axis before the drive performs a drive-autonomous stop reaction.

6.3.4 Safe monitoring of position

When you select the position monitoring "Safety Integrated Functions" of the SINAMICS drive system, you must limit the position area of the axis to maintain the availability of the machine.

To recognize the permissible position area after selecting SLP, you calculate and save it in the SIMATIC S7-1500, for example, in a data block. When selecting SLP, you limit the setpoint positions of the technology object at the Motion Control instructions to this position area.

6.3.5 Overview of safety-oriented functions

Below you will find a description of the drive response and which corresponding user reactions you have to program in the SIMATIC user program.

Function	SIC STW	SIC Bit	Drive response		Recommended reaction in the user program
Safe stopping process					
STO	S_ZSW1B	0	1	Drive switches off immediately (OFF2).	"MC_Power" can remain enabled (waiting).
			0	STO not active	None
SS1	S_ZSW1B	1	1	Drive decelerates autonomously along the OFF3 ramp and then switches off (OFF2).	"MC_Power" remains enabled until STO
			0	SS1 not active	None
SS1E	S_ZSW1B	1	1	Drive switches off after delay time has expired (OFF2).	Stop axis before delay time elapses, e.g. with "MC_Halt", and then switch off the drive with "MC_Power.Enable" = FALSE
			0	SS1E not active	None
SS2	S_ZSW1B	2	1	Drive decelerates along OFF3 ramp and then monitors the standstill.	"MC_Power" remains enabled
			0	SS2 not active	None
SS2E	S_ZSW3B	11	1	Drive monitors the standstill after a delay time has expired.	Stop axis before delay time elapses with "MC_Halt" and hold drive in control with "MC_Power.Enable" = TRUE
			0	SS2E not active	None
SOS	S_ZSW1B	3	1	Drive monitors the standstill after a delay time has expired	Stop axis before delay time elapses with "MC_Stop" and hold drive in control with "MC_Power.Enable" = TRUE
			0	SOS not active	None
Safe brake control					
SBC	-	-	Drive switches off immediately (OFF2) and safely controls the outputs for the brake.		None
SBT	S_ZSW_3	0..15	Drive is brought to a standstill and remains in control. Then, a drive-autonomous torque is generated against the applied brake.		Stop axis before selecting SBT, e.g. with "MC_Halt" and hold drive in control with "MC_Power.Enable" = TRUE

Function	SIC STW	SIC Bit	Drive response		Recommended reaction in the user program
Safe monitoring of motion					
SLS	S_ZSW1B	4	1	Drive monitors a maximum permissible velocity.	Limit the axis velocity
			0	SLS not active	None
		6	1	After expiration of a delay time, drive monitors a maximum permissible velocity.	Limit axis velocity within the delay time
			0	SLS deselected	None
SSM	-	-	Drive transfers signal to the F-CPU whether the current velocity is below a defined velocity.		Reach positive velocity of the axis within the delay time and maintain or stop axis with "MC_Halt".
SDI	S_ZSW1B	12	1	After expiration of a delay time, drive monitors the positive motion direction.	Reach positive velocity of the axis within the delay time and maintain or stop axis with "MC_Halt"
			0	SDI positive deselected	None
		13	1	After expiration of a delay time, drive monitors the negative motion direction.	Reach negative velocity of the axis within the delay time and maintain or stop axis with "MC_Halt"
			0	SDI negative deselected	None
Safe monitoring of position					
SLP	S_ZSW2B	4	1	SLP area 2 selected	None
			0	SLP area 2 selected	None
		7	1	When a delay time expires, the drive monitors compliance with a defined position area.	Maintain position area of the axis according to the selected SLP area
			0	SLP not selected or no user approval	None
SP	-	-	Drive transfers actual position to the F-CPU.		None
SCA	-	-	Drive transfers safe cam information to the F-CPU.		None

6.4 Mechanics

For the display and processing of the technology object's position, the decisive factor is whether the position is represented as a unit of length (linear axis) or a unit of angle (rotary axis).

Examples of units of length: mm, m, km

Examples of units of angle: °, rad

For the determination of the physical position from an actual encoder value, the system must know the various properties and configurations of the mechanics.

6.4.1 Configuring the mechanics of the speed axis

In the mechanics of the speed axis technology object, you configure how the load side is connected mechanically to the drive.

Configuring the mechanics of a speed axis technology object is necessary for the correct display and processing of the technology object speed.

Configure the following parameters:

- Invert drive direction
- Load gear (Page 97)

Inverting the drive direction of the speed axis

By default, the technology object controls the drive with positive speed if the axis is to be moved in the positive direction. Invert the drive direction if the axis travels in positive direction at negative speed due to the mechanical design.

To invert the drive direction of the speed axis, follow these steps:

1. In the configuration of the technology object, navigate to "Extended parameters > Mechanics".
2. Select the "Invert drive direction" check box.

6.4.2 Configuring the mechanics of the positioning axis/synchronous axis

Configuring the mechanics of an axis technology object is necessary for the correct display and processing of the technology object position. The options for configuring the mechanics depend on the following configurations:

- "Axis type" under "Basic parameters"
- "Encoder mounting type" under "Extended parameters > Mechanics > Encoder"
- "Measuring system" under "Hardware interface > Data exchange with encoder > Encoder data"

Select encoder (S7-1500T)

With an S7-1500T, you can configure the mechanics of a positioning axis/synchronous axis for up to four encoders.

Select the encoder to be configured from the drop-down list under "Settings for". You can configure the encoders independently of each other.

"Linear" axis type with "Standard motor", encoder mounting type "On motor shaft"

The encoder is connected to the motor shaft in a mechanically fixed manner. Motor and encoder form a unit.

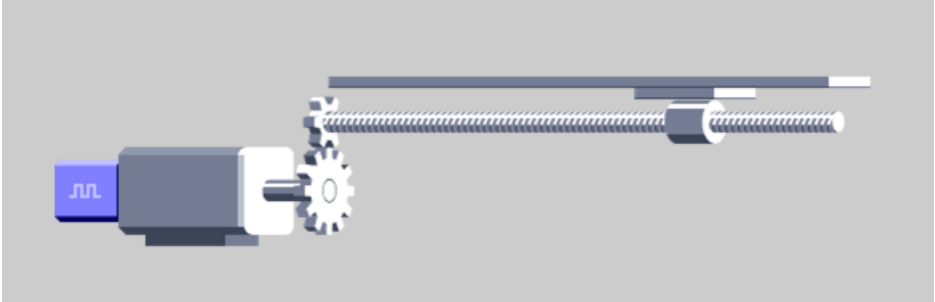

To configure the mechanics for this constellation of axis type and encoder mounting type, follow these steps:

1. Check that the axis type is configured as "Linear" and "Standard motor" under Basic parameters.
2. Under "Extended parameters > Mechanics > Encoder", select the "On motor shaft" encoder mounting type.
3. Configure the following parameters:
   - Drive and encoder direction for positioning axis/synchronous axis (Page 96)
   - Backlash compensation (Page 100)
   - Load gear (Page 97)
   - Encoder gear (Page 98)
   - Leadscrew pitch (Page 98)
   - Inertia values (Page 105)

"Linear" axis type with "Standard motor", encoder mounting type "On load side", measuring system "Rotary"

The encoder is mechanically connected to the load side of the gear.

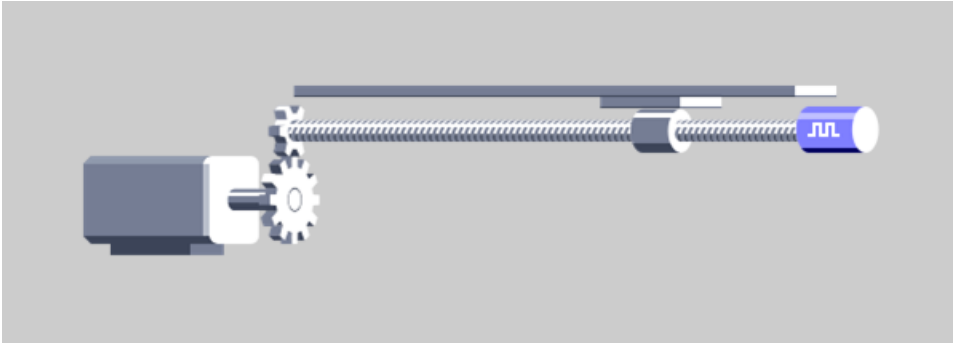

To configure the mechanics for this constellation of axis type and encoder mounting type, follow these steps:

1. Check that the axis type is configured as "Linear" and "Standard motor" under Basic parameters.
2. Under "Extended parameters > Mechanics > Encoder", select the "On load side" encoder mounting type.
3. Configure the following parameters:
   - Drive and encoder direction for positioning axis/synchronous axis (Page 96)
   - Load gear (Page 97)
   - Encoder gear (Page 98)
   - Leadscrew pitch (Page 98)
   - Inertia values (Page 105)

"Linear" axis type with "Standard motor", encoder mounting type "On load side", measuring system "Linear"

The encoder is mechanically connected to the load side of the gear.

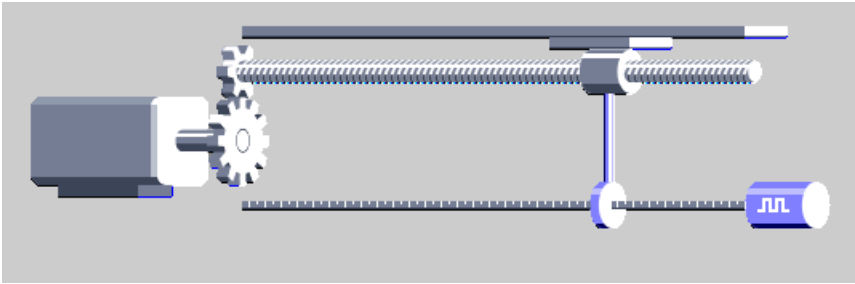

Figure 3-874 Encoder mounting type load side linear axis, measuring system linear

To configure the mechanics for this constellation of axis type and encoder mounting type, follow these steps:

1. Check that the axis type is configured as "Linear" and "Standard motor" under Basic parameters.
2. Select the measuring system "Linear" under "Extended parameters > Hardware interface > Data exchange with encoder > Encoder data".
3. Configure the following parameters:
   - Drive and encoder direction for positioning axis/synchronous axis (Page 96)
   - Load gear (Page 97)
   - Encoder gear (Page 98)
   - Leadscrew pitch (Page 98)
   - Inertia values (Page 105)

"Linear" axis type with "Standard motor", encoder mounting type "External measuring system"

An external measuring system provides the position values of the linear load motion.

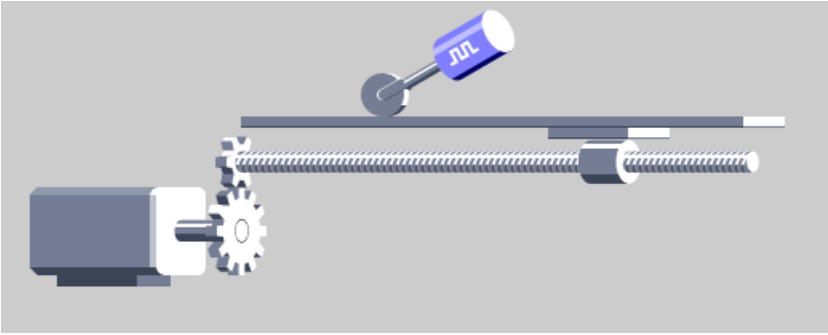

To configure the mechanics for this constellation of axis type and encoder mounting type, follow these steps:

1. Check that the axis type is configured as "Linear" and "Standard motor" under Basic parameters.
2. Under "Extended parameters > Mechanics > Encoder", select the "External measuring system" encoder mounting type.
3. Configure the linear load travel per encoder revolution under "Distance per encoder revolution".
4. Configure the following parameters:
   - Drive and encoder direction for positioning axis/synchronous axis (Page 96)
   - Load gear (Page 97)
   - Encoder gear (Page 98)
   - Leadscrew pitch (Page 98)
   - Inertia values (Page 105)

"Linear" axis type with "Linear motor", encoder mounting type "External measuring system", measuring system "Rotary"

An external measuring system provides the position values of the linear load motion.

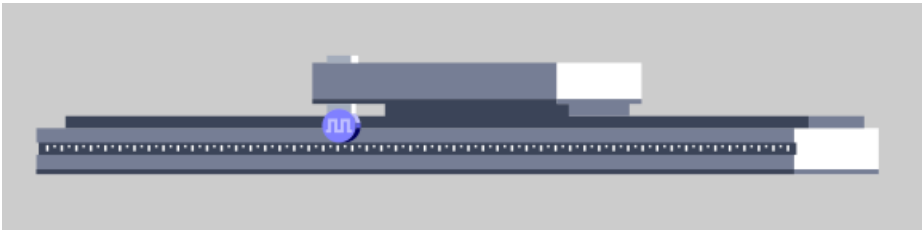

To configure the mechanics for this constellation of axis type and encoder mounting type, follow these steps:

1. Check that the axis type is configured as "Linear" and "Linear motor" under Basic parameters.

   With this constellation, "External measuring system" is automatically set permanently as encoder mounting type under "Extended parameters > Mechanics > Encoder".

2. Configure the linear load travel per encoder revolution under "Distance per encoder revolution".
3. Configure the following parameters:
   - Drive and encoder direction for positioning axis/synchronous axis (Page 96)
   - Encoder gear (Page 98)
   - Inertia values (Page 105)

"Linear" axis type with "Linear motor", encoder mounting type "On motor shaft", measuring system "Linear"

An external measuring system provides the position values of the linear load motion.

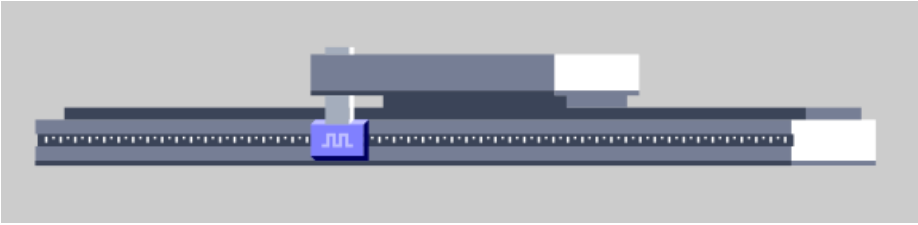

To configure the mechanics for this constellation of axis type and encoder mounting type, follow these steps:

1. Check that the axis type is configured as "Linear" and "Linear motor" under Basic parameters.

   With this constellation, "On motor shaft" is automatically set permanently as encoder mounting type under "Extended parameters > Mechanics > Encoder".

2. Configure the following parameters:
   - Drive and encoder direction for positioning axis/synchronous axis (Page 96)
   - Encoder gear (Page 98)
   - Inertia values (Page 105)

"Rotary" axis type with "Standard motor", encoder mounting type "On motor shaft"

The encoder is connected to the motor shaft in a mechanically fixed manner. Motor and encoder form a unit.

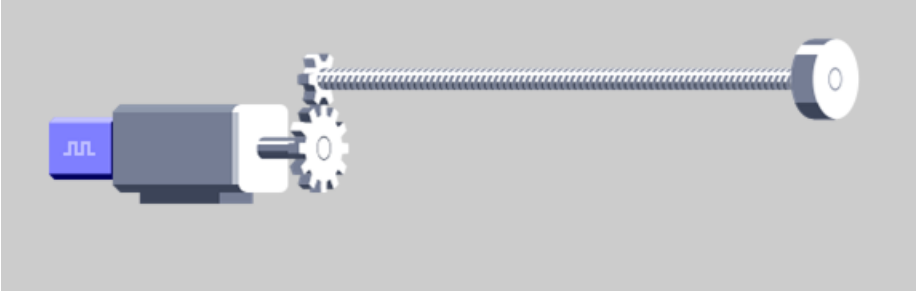

To configure the mechanics for this constellation of axis type and encoder mounting type, follow these steps:

1. Check that the axis type is configured as "Rotary" and "Standard motor" under Basic parameters.
2. Under "Extended parameters > Mechanics > Encoder", select the "On motor shaft" encoder mounting type.
3. Configure the following parameters:
   - Drive and encoder direction for positioning axis/synchronous axis (Page 96)
   - Backlash compensation (Page 100)
   - Load gear (Page 97)
   - Encoder gear (Page 98)
   - Inertia values (Page 105)

"Rotary" axis type with "Standard motor", encoder mounting type "On load side"

The encoder is mechanically connected to the load side of the gear.

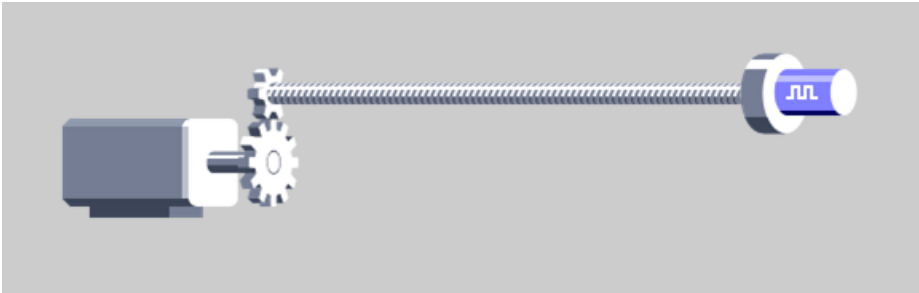

To configure the mechanics for this constellation of axis type and encoder mounting type, follow these steps:

1. Check that the axis type is configured as "Rotary" and "Standard motor" under Basic parameters.
2. Under "Extended parameters > Mechanics > Encoder", select the "On load side" encoder mounting type.
3. Configure the following parameters:
   - Drive and encoder direction for positioning axis/synchronous axis (Page 96)
   - Load gear (Page 97)
   - Encoder gear (Page 98)
   - Inertia values (Page 105)

"Rotary" axis type with "Standard motor", encoder mounting type "External measuring system"

An external measuring system provides the position values of the rotary load motion.

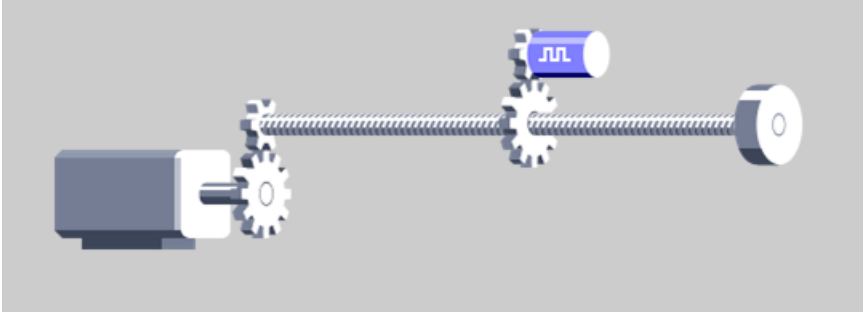

To configure the mechanics for this constellation of axis type and encoder mounting type, follow these steps:

1. Check that the axis type is configured as "Rotary" and "Standard motor" under Basic parameters.
2. Under "Extended parameters > Mechanics > Encoder", select the "External measuring system" encoder mounting type.
3. Configure the rotary load travel per encoder revolution under "Distance per encoder revolution".
4. Configure the following parameters:
   - Drive and encoder direction for positioning axis/synchronous axis (Page 96)
   - Load gear (Page 97)
   - Encoder gear (Page 98)
   - Inertia values (Page 105)

6.4.3 Configuring the mechanics of the external encoder

In the mechanics of the external encoder technology object, you configure how the external encoder is connected mechanically to an axis.

Configuring the mechanics of an external encoder technology object is necessary for the correct display and processing of the technology object position. The options for configuring the mechanics depend on the following configurations:

- "External encoder type" under "Basic parameters"
- "Measuring system" under "Hardware interface > Data exchange with encoder > Encoder data"

"Linear" type, measuring system "Rotary"

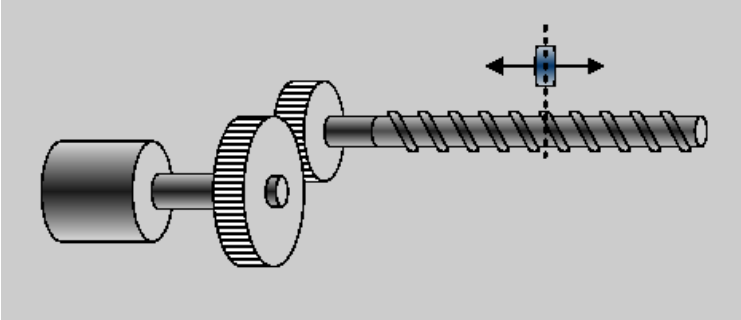

Configure the following parameters:

- Invert encoder direction
- Load gear (Page 97)
- Leadscrew pitch (Page 98)

"Linear" type, measuring system "Linear"

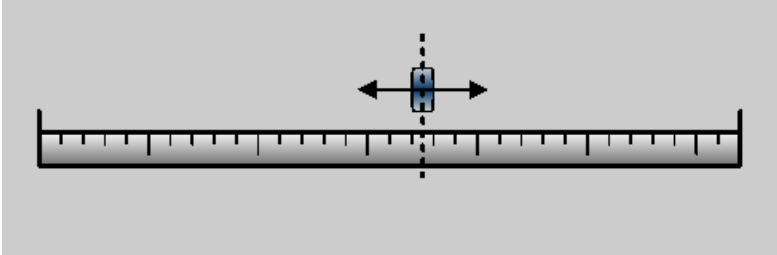

Configure the following parameters:

- Invert encoder direction

"Rotary" type

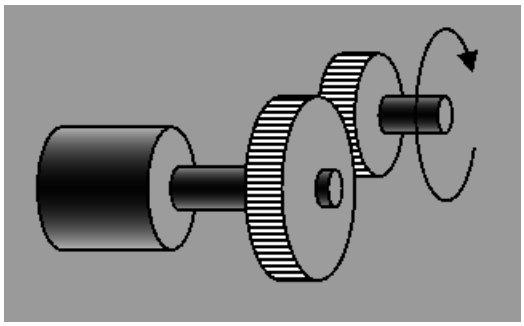

Configure the following parameters:

- Invert encoder direction
- Load gear (Page 97)

Inverting the encoder direction for external encoder

To invert the encoder direction for an external encoder, follow these steps:

1. In the configuration of the technology object, navigate to "Extended parameters > Mechanics > Encoder".
2. Select the "Invert encoder direction" check box.

Example: Inverting the encoder direction for an external encoder

In the following example, an external encoder with two different installation directions is shown. If the encoder rotates in the counter-clockwise direction or counts in the negative direction when the axis travels in the positive direction, you need to invert the encoder direction.

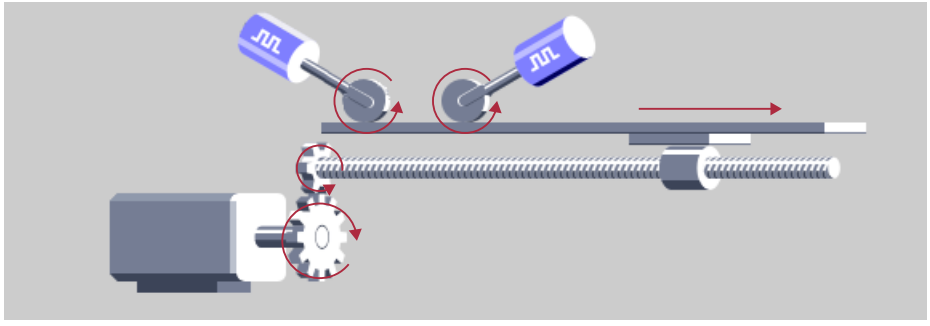

To check the direction of rotation, you can monitor the "Gx_XIst1" value from the PROFIdrive telegram in a trace.

Rotate the encoder shaft as it rotates when the axis travels in the positive direction:

- Value "Gx_XIst1" decreases: The encoder counts in the negative direction. Invert the encoder direction.
- Value "Gx_XIst1" increases: The encoder counts in the positive direction, no inversion necessary.

6.4.4 Configuring drive and encoder direction for positioning axis/synchronous axis

For the speed axis and positioning axis/synchronous axis technology objects, you can invert the drive and encoder direction.

Configuring drive and encoder direction on a positioning axis

By default, the technology object controls the drive with positive speed if the axis is to be moved in the positive direction. Invert the drive direction if the axis travels in positive direction at negative speed due to the mechanical design.

By default, an increasing actual encoder value is evaluated as positive direction of movement of the axis. Invert the encoder direction if the actual encoder value decreases when the axis travels in the positive direction.

With SINAMICS drives, the direction of the drive and the direction of the motor encoder are identical by default. If the axis travels in the positive direction at positive speeds, you do not need to invert either the drive direction or the encoder direction.

In the following figure, the drive direction, encoder direction and the real mechanical direction of movement are positive. This arrangement does not require inversion.

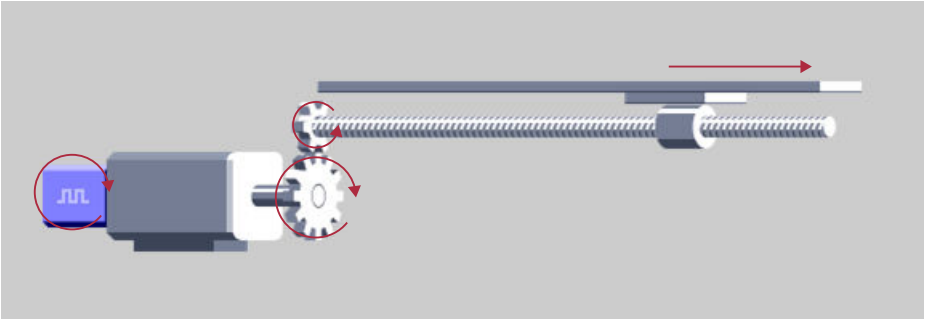

Invert the drive direction and the encoder direction if the axis travels in the mechanically negative direction with positive motor speed and increasing encoder increments.

An example of this is the linear axis in the following figure, which travels in the negative direction with positive speed.

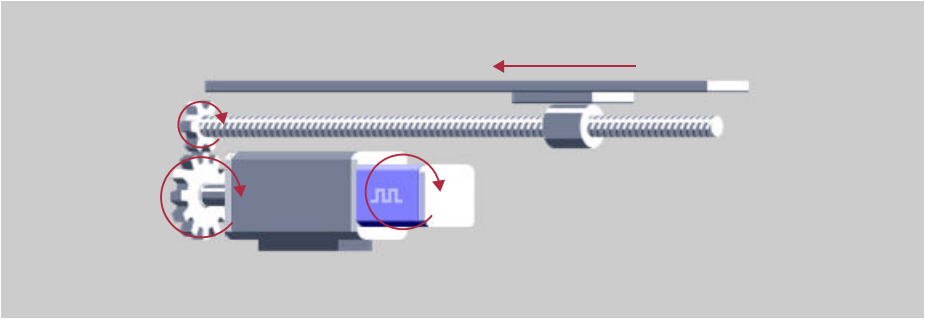

Through the inversion of the drive direction and the encoder direction, the motor travels with negative speed in the case of positively specified velocity, which results in movement in the correct direction. You also need to invert the encoder direction, because the motor encoder direction corresponds to the drive direction.

Invert drive direction

To invert the drive direction, follow these steps:

1. In the configuration of the technology object, navigate to "Extended parameters > Mechanics > Drive".
2. Select the "Invert drive direction" check box.

Invert encoder direction

To invert the encoder direction, follow these steps:

1. In the configuration of the technology object, navigate to "Extended parameters > Mechanics > Encoder".
2. Select the "Invert encoder direction" check box.

6.4.5 Configuring the load gear

If you use a load gear between motor shaft and load side, you need to configure the load gear at the technology object.

The gear ratio of the load gear is specified as the ratio between motor revolutions and load revolutions.

You can configure the load gear for the following technology objects:

- Speed axis
- Positioning axis/synchronous axis
- External encoder

Procedure

To configure the load gear, follow these steps:

1. In the configuration of the technology object, navigate to "Extended parameters > Mechanics > Drive > Load gear".
2. In the "Number of motor revolutions" configuration field, configure the integer number of motor revolutions.
3. In the "Number of load revolutions" configuration field, configure the integer number of load revolutions.

6.4.6 Configuring the encoder gear

If you use a measuring gearbox for encoders of axes, you need to configure the encoder gear at the technology object. The gear ratio of the load gear is specified as a ratio.

You can find the setting in the configuration of the technology object in the section "Extended parameters > Mechanics > Encoder > Encoder gear.

Depending on the mounting type of the encoder, you have to configure the following values:

- External measuring system:
  - In the "Number of measuring wheel revolutions" configuration field, configure the integer number of measuring wheel revolutions.
  - In the "Number of encoder revolutions" configuration field, configure the integer number of encoder revolutions.
  - In the "Distance per measuring wheel revolution" configuration field, configure the distance covered by the measuring wheel in one revolution.
- On load side:
  - In the "Number of load revolutions" configuration field, configure the integer number of load revolutions.
  - In the "Number of encoder revolutions" configuration field, configure the integer number of encoder revolutions.
- On the motor shaft:
  - In the "Number of motor revolutions" configuration field, configure the integer number of motor revolutions.
  - In the "Number of encoder revolutions" configuration field, configure the integer number of encoder revolutions.

Requirement

- Technology objects
  - Positioning axis
  - Synchronous axis
- Encoder type: Rotary

  Encoder gears are not relevant for linear encoder systems.

6.4.7 Configuring the leadscrew pitch

The leadscrew pitch indicates the distance by which the load is moved when the leadscrew makes one revolution.

You can configure the leadscrew pitch for the following technology objects:

- Positioning axis/synchronous axis
- External encoder

Example

Movement of the load [mm] = Leadscrew pitch * number of motor revolutions * (load gear denominator / load gear numerator)

Load gear denominator = 2

Load gear numerator = 1

Leadscrew pitch = 10 mm / load revolution

Motor revolutions = 50

1000 mm = 10 [mm/rot] * 50 [rot] * 2

Procedure

To configure the leadscrew pitch, follow these steps:

1. In the configuration of the technology object, navigate to "Extended parameters > Mechanics > Drive > Position parameters".
2. In the "Leadscrew pitch" configuration field, enter the leadscrew pitch in the unit of measurement of the leadscrew pitch.

6.4.8 Backlash compensation

What is the backlash?

Backlash (also called play, mechanical play) is the distance or the angle that a motor must travel through when the direction of rotation reverses until the axis actually moves in the other direction.
The backlash of an axis is made up of the backlash of the gearbox and spindle.

The following figure shows the backlash on the spindle of a linear axis.

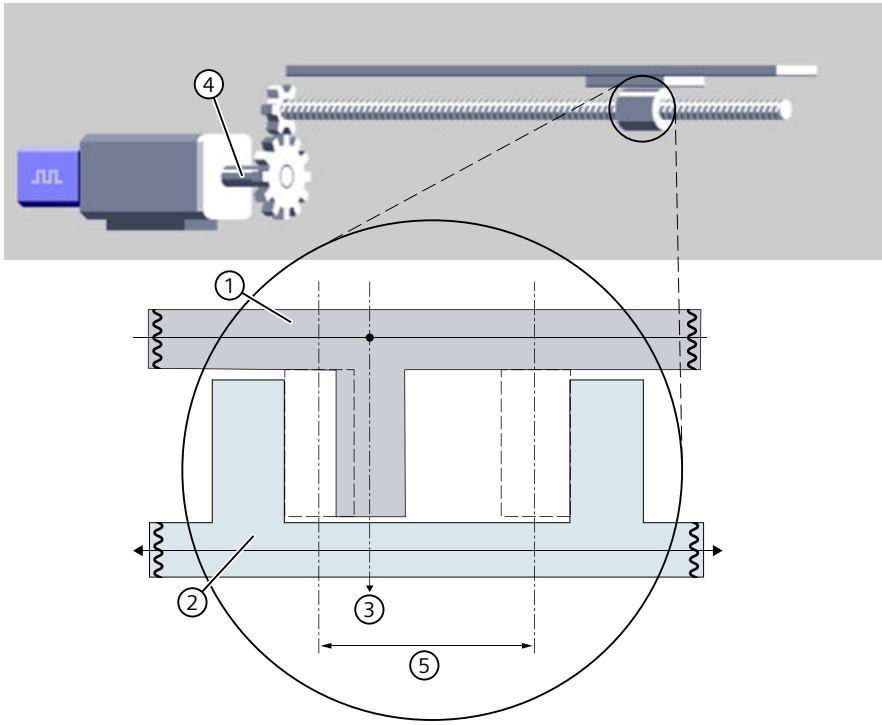

① Load side
② Drive side
③ Axis position
④ Motor position
⑤ Size of backlashes

An encoder with mounting type "on motor shaft" records the motor position. The technology object calculates the axis position from the motor position, taking the mechanics (gear unit, leadscrew pitch) into account.

If there is a backlash on the axis, then this backlash is traversed during a reversing motion at the reversal point. While the backlash is being traversed, the real mechanical position of axis does not change, but the motor position changes. Without backlash compensation, the technology object calculates a faulty axis position from the motor position, which means that the axis is not moved to the correct axis position during a reversing motion job.

Backlash compensation

If you enable backlash compensation for the motor encoder, the backlash is taken into account when calculating the axis position. The axis is always moved to the correct axis position even with a reversing motion job.

Setpoint operation

The setpoint mode is the standard mode of the axis in which motion jobs are accepted and executed.

When the direction of the position setpoint is reversed, the technology object automatically compensates for the backlash. When the motion job starts with a direction reversal, the actual position value of the technology object is adapted. The following settings are relevant for calculating the actual position value:

- Size of backlashes
- Velocity of backlash compensation

The resulting following error is compensated by the position controller and the backlash is traversed. The traversing of the backlash is therefore also dependent on the position controller gain (Kv factor).

Follow-up mode

In follow-up mode the setpoint is followed up to the actual value. Actual position and actual velocity are updated. This means that it is possible to track when the axis is moved by external influence. Motion jobs are not executed.

Backlash compensation is required in follow-up mode if an axis is moved on the load side with a direction reversal. The same compensation model is used in follow-up mode as in setpoint mode. After the direction reversal of the actual encoder value has been recognized, the actual position value of the technology object is only coupled when the complete size of backlashes has been traversed.

Requirements

- Technology objects (V6.0 or higher)
  - Positioning axis
  - Synchronous axis
- Encoder mounting type: On motor shaft

  Backlash compensation is not relevant for a load-side encoder and external measuring systems. A load-side encoder records the axis position directly. After a direction reversal, the backlash on the load-side encoder is traversed using the position control.

NOTE

Excessive velocity if the backlash is too large

Do not set the backlashes larger than as the real existing backlashes. With direction reversal, note that the actual position value is adapted according to the set velocity of backlash compensation and the size of backlashes. A higher velocity of backlash compensation shortens the compensation time. The resulting control difference is output via the position controller.

Enable backlash compensation

To activate backlash compensation for an axis, proceed as follows:

1. In the configuration of the Axis technology object, navigate to "Extended parameters"> "Mechanics".
2. Select the "Enable backlash compensation" check box.

In case of axes with multiple encoders, you must activate backlash compensation for each encoder individually.

Backlash compensation settings

In the configuration of the technology object, set the following values for backlash compensation:

- Size of backlashes
- Velocity of backlash compensation. At 0.0, the actual value is modified in a servo cycle.
- Absolute homing direction (relevant for absolute encoders)

You have the option of changing the settings for the backlash compensation directly during runtime without restarting the technology object. Change the value of the tags in the technology object "<TO>.Sensor[1..4].Backlash".

After changing the settings for backlash compensation, you have to home the axis again.

You can find more information on the tags of the technology objects in the section "Tags of the technology object data blocks (Page 393)".

Backlash compensation function chart

The function chart shows how the backlash compensation affects the movement of an axis when the direction changes.

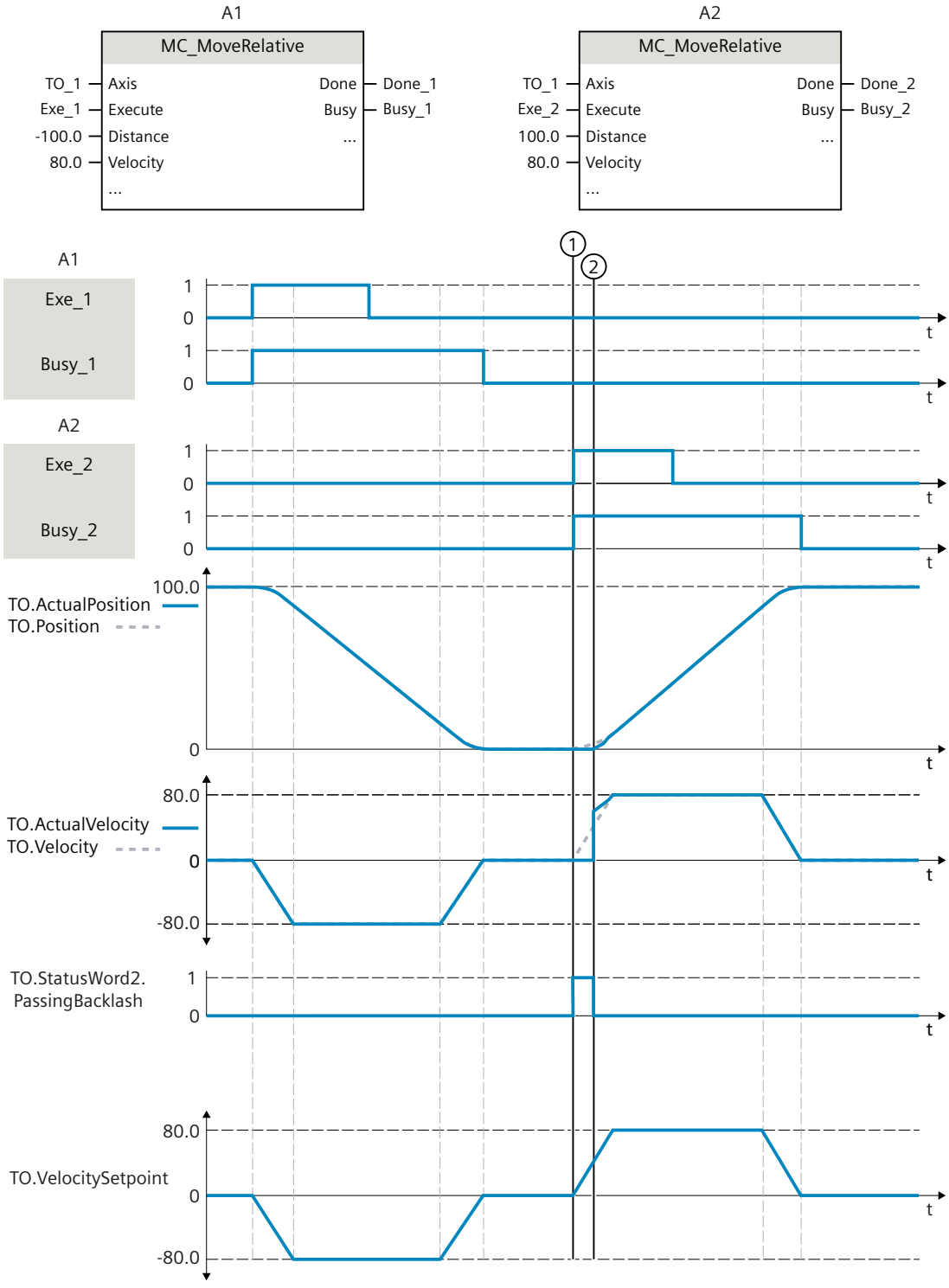

① The reversing motion job "MC_MoveRelative" is triggered. The actual motor value is modified by the backlash and the axis traverses the backlash via the position controller.

The "<TO>.StatusWord2.PassingBacklash" bit is set.

② The backlash is run through completely.

The "<TO>.StatusWord2.PassingBacklash" bit is reset.

The axis position "<TO>.ActualPosition" is adjusted to the position setpoint "<TO>.Position" via the position control.

Homing when backlash compensation is enabled

You can find more information in the section "Homing when backlash compensation is enabled (Page 218)".

Reversal of direction for non-homed axes

The backlash compensation when the direction is reversed is independent of the "Homed" status. In the first motion of the non-homed axis, the backlash compensation is not active. After the axis has completely passed through the backlash in one direction, the backlash compensation becomes active when the axis travels in the opposite direction.

What do you need to note in axes with multiple encoders?

- If the effective encoder is a load-side encoder, then the backlash is implicitly controlled via the position control.
- The position of the motor encoder is followed up accordingly during operation with the load-side encoder as an effective encoder and the backlash is taken into account.
- Switch from a load-side encoder to the motor encoder with "MC_SetSensor" with "Mode" = 0:
  - The backlash must be completely run through once in order that you can set the position of the motor encoder to the same as that of the encoder on the load side.
  - The homing status of the axis is maintained. A new homing is not required on the motor encoder.
- Switch the motor encoder to a load-side encoder with "MC_SetSensor" with "Mode" = 0:
  - The backlash must be completely run through once in order that you can match the position of the load-side encoder to the position of the motor encoder.

How large is the backlash?

The following basic options are available to determine the size of backlashes:

- Read the backlash from the data sheet, e.g. for a ball screw
- Measuring backlash

Example: Measuring the size of backlashes on a linear axis

Using a linear axis as example, the following section describes how you can determine the size of backlashes by measuring.

Requirement: Backlash compensation is not enabled.

1. Traverse the axis to an axis position A. Mark the axis position and write down the corresponding actual value from the technology object (<TO>.ActualPosition).
2. Continue to move the axis in the same direction at least around the expected size of backlashes.
3. Traverse the axis to the noted actual value from 1. or by the traveled distance from 2. Because of the backlash, the axis is now at of axis position B.
4. Measure the position difference of the axis positions Δ = A - B.

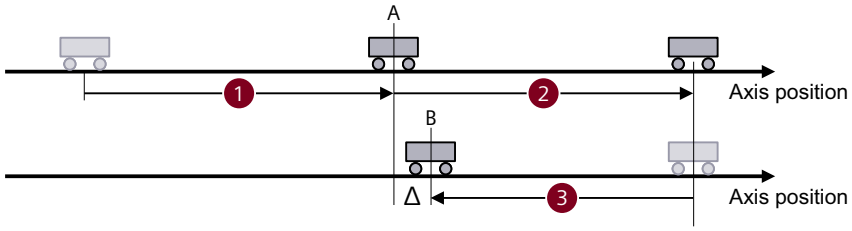

You have measured the backlash.

5. Activate backlash compensation and enter the measured size of backlashes.

6.4.9 Configure inertia values

Configure the inertia values for the axis under "Extended parameters > Mechanics > Inertia values".

The configuration of the inertia values is a requirement for calculating torque precontrol in the "Based on acceleration" mode.

You can find information on torque precontrol in the section "Configuring the torque precontrol (Page 234)".

Automatically adopt Inertia values from drive

For drives with DSC, you can transfer the inertia values for the configuration of the position controller with "Automatic transfer from drive".

You can find information on "Automatic transfer from drive" in the section "Configuring position controller for drives with DSC (Page 232)".

Moment of inertia or weight of the load

Configure the moment of inertia or weight of the load depending on the motion.

- For rotary motions Moment of inertia
- For linear motions Mass

You must configure the moment of inertia or weight of the load on the load side.

Follow these steps:

1. Define the p1498 in the drive.

   To determine the value for p1498 once, use "One Button Tuning" for the drive. You can find information on "One Button Tuning" in the function manual of the SINAMICS drive.
2. Convert the value to the load side.
3. Enter the load-side value in the configuration field.

Moment of inertia motor

Configure the moment of inertia of the standard motor.

You can adopt the value p0341 from the drive.

Mass of motor

Configure the weight of the linear motor.

You can adopt the value p0341 from the drive.

6.4.10 Tags: Mechanics

The following technology object tags are relevant for the setting of the mechanics:

Type of motion		
Tag	**Description**	
<TO>.Properties.MotionType	Indication of linear or rotary motion	
	0	Linear motion
	1	Rotary motion

Load gear	
Tag	**Description**
<TO>.LoadGear.Numerator	Load gear numerator
<TO>.LoadGear.Denominator	Load gear denominator

Leadscrew pitch	
Tag	**Description**
<TO>.Mechanics.LeadScrew	Leadscrew pitch
<TO>.Actor.Efficiency	Efficiency of leadscrew pitch

Encoder mounting type	
Tag	**Description**
<TO>.Sensor[1..4].MountingMode	Encoder mounting type
<TO>.Sensor[1..4].Parameter.DistancePerRevolution	Load distance per encoder revolution with an externally mounted encoder

Inversion	
Tag	**Description**
<TO>.Actor.InverseDirection	Setpoint inversion
<TO>.Sensor[1..4].InverseDirection	Actual value inversion

Modulo	
Tag	**Description**
<TO>.Modulo.Enable	Enable modulo
<TO>.Modulo.Length	Modulo length
<TO>.Modulo.StartValue	Modulo start value

Backlash compensation	
Tag	**Description**
<TO>.Sensor[1..4].Backlash.Enable	Enable backlash compensation
<TO>.Sensor[1..4].Backlash.Size	Size of backlashes[1)]
<TO>.Sensor[1..4].Backlash.Velocity	Velocity for traversing of backlashes At 0.0, the backlash is traversed in a servo cycle. (only with positioning axis and synchronous axis)
<TO>.Sensor[1..4].Backlash.DirectionAbsoluteHoming	Direction of movement during or before absolute encoder adjustment

1) If you enable/disable backlash compensation or change the size of backlashes during runtime, you must home the axis again.

Inertia values		
Tag	**Description**	
<TO>.Actor.LoadInertia	Depends on the motion	
	Rotary motion	Moment of inertia of the load
	Linear motion	Weight of the load
<TO>.Actor.DriveParameter.MotorInertia	Moment of inertia of the standard motor	
<TO>.Actor.LinearMotorDriveParameter.MotorMass	Mass of linear motor	

6.5 Enabling a technology object

With the Motion Control instruction "MC_Power", you can enable a technology object with the "Enable" parameter.

Before you can enable a technology object without errors with "MC_Power", all encoders and drives required for the technology object must be available. To correctly connect and configure the encoder or drive, follow the description in section Drive and encoder connection (Page 45).

Requirements for successful enabling of the technology object

- The technology object has been created ("TO_PositioningAxis", "TO_SpeedAxis", "TO_SynchronousAxis", "TO_ExternalEncoder"). You can find more information in section "Add technology object" in document "S7-1500/S7-1500T Motion Control Overview".
- The technology object has been configured correctly for your requirements.
- The readiness of the drive is a prerequisite for enabling the technology object.

  Example:

  If you are using the Siemens telegram 10x, you evaluate the bit "DriveReady" from the message word "MELDW" of the received telegram "PD_TEL10x_IN".
- The cyclic bus communication between the controller and encoder/drive has been established ("<TO>.StatusSensor[1..4].CommunicationOK" = TRUE, "<TO>.StatusDrive.CommunicationOK" = TRUE).
  - Since the CPU generally starts up faster than the connected I/O, a technology object usually cannot be enabled immediately after the CPU startup. A data transfer (online) is only possible if the communication connection between the CPU and drive exists.
  - The status of the cyclic communication between the technology object and the drive or encoder can be checked with the "CommunicationOK" tag (data type: BOOL). The status "CommunicationOK" = TRUE is a further requirement for the enabling of the technology object.

  NOTE

  - The status of the "CommunicationOK" tag shows you whether the encoder or drive is ready for cyclic communication with the technology object. If the status value is FALSE , you can find information on the cause in the diagnostic buffer. For this, however, you must have enabled the diagnostics for the related I/O devices beforehand.
  - If the technology object is enabled with the "MC_Power" instruction before the encoder interface ("CommunicationOK") receives the TRUE signal, alarm messages, e.g. "Sensor driver/actuator driver not initialized during startup", may occur depending on the configuration.

- The status of the active encoder is valid ("<TO>.StatusSensor[1..4].State" = 2).

  The optional data adaptation (Page 71) has been completed ("<TO>.StatusDrive.AdaptionState" = 2 and "<TO>.StatusSensor[1..4].AdaptionState" = 2).

  You can find more detailed information on the requirements and the library for the function block "IsAxisReady" in Siemens Industry Online Support in FAQ entry 109750297 (https://support.industry.siemens.com/cs/ww/en/view/109750297).

Programming example for control of "MC_Power"

The input parameter "Enable" of the Motion Control instruction "MC_Power" can be controlled as follows:

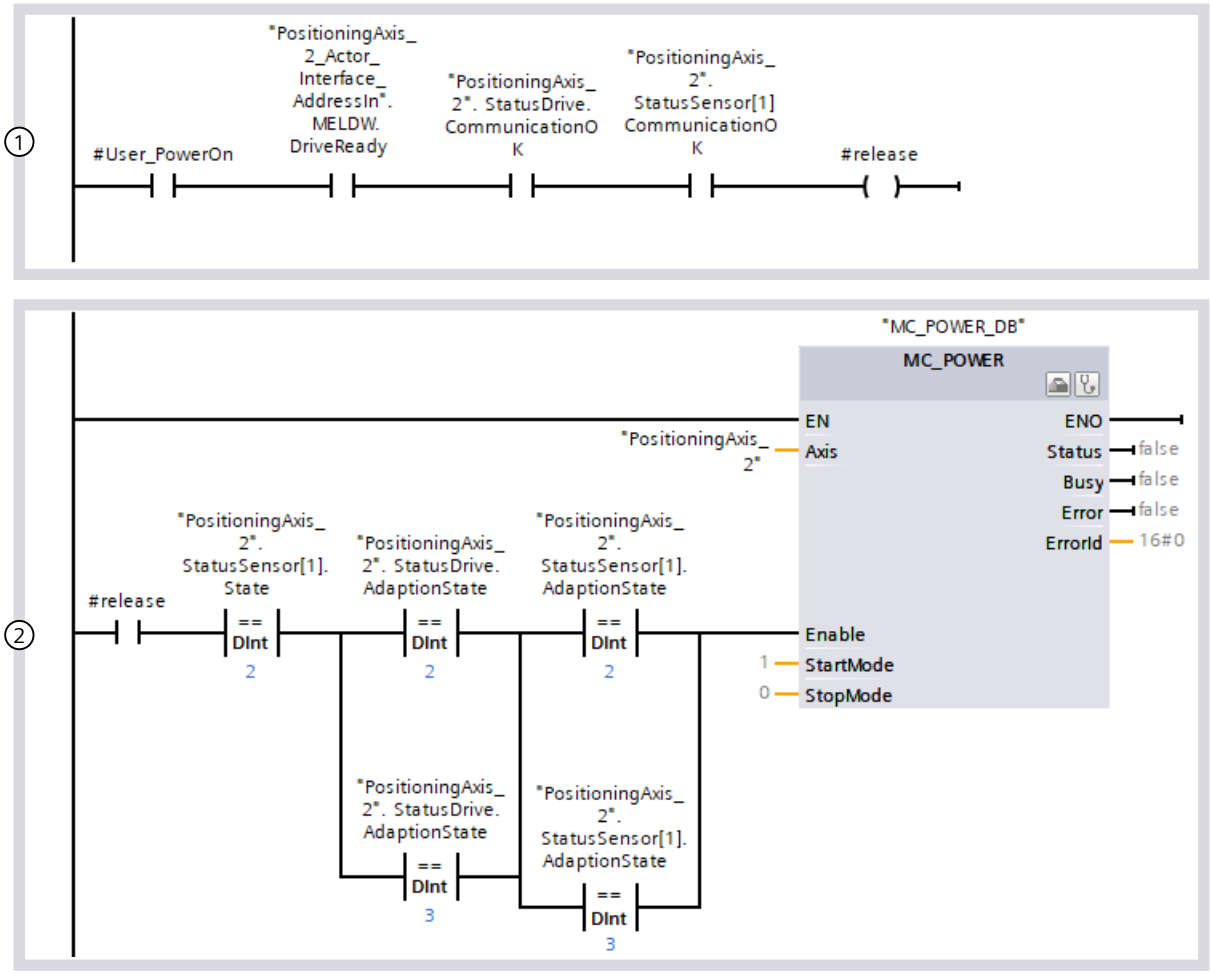

① Network 1

② Network 2

See also

Transferring drive and encoder parameters automatically (Page 71)
FAQ MC_Power (https://support.industry.siemens.com/cs/ww/en/view/109750297)

6.5.1 Enabling a technology object with the Motion Control instruction "MC_Power"

With the Motion Control instruction "MC_Power", a technology object is enabled or disabled and, if necessary, a configured drive is switched on or off.

Parameter inputs

You use the following parameters of the Motion Control instruction"MC_Power" to enable the technology object:

- By setting the "Enable" parameter = TRUE , you enable the technology object.

  As long as "Enable" = TRUE, the job remains active and the changed parameters are applied at each call of the instruction in the user program. The technology object is enabled. Setpoints are output to the drive. If the drive is not yet switched on, these are ignored by the drive. As soon as the drive is switched on, these setpoints take effect immediately.

- You use the "StartMode" parameter to enable/disable the position control of an axis. The parameter is ignored when a speed axis or an external encoder is being used.

  For position-controlled motion jobs, you set the input parameter "MC_Power.StartMode" = 1.

  For motion jobs without position control, you set the input parameter "MC_Power.StartMode" = 0.

  You can find more information on switching off the position control in section Switching the position control off and on (Page 242).

The output parameter "MC_Power.Status" must show the value TRUE . In this case, the enabled technology object accepts the motion jobs. The speed control/position control is active. The actual values of the technology object are valid.

NOTE

Technology alarm is pending/error is indicated

The execution of motion jobs requires that no technology alarms, alarm reactions or errors be pending.

You can find more detailed information on eliminating the technology alarms and the causes of errors in section "Technology alarms" or "Error IDs" of document "S7-1500/S7-1500T Motion Control alarms and error IDs".

NOTE

Automatic enable after acknowledgment of a technology alarm

If the technology object is disabled due to a technology alarm, the technology object will be enabled again automatically after the cause of the alarm has been eliminated and the alarm has been acknowledged. A precondition for this is that the "Enable" parameter retains the value "TRUE" during this process.

Behavior when technology object is enabled at a standstill

Depending on the "StartMode" parameter, the position is held ("StartMode" = 1) or the velocity setpoint zero is output ("StartMode" = 0). If the "Status" parameter shows the value "TRUE", the technology object is enabled.

Behavior when technology object is enabled while axis is in motion

When "StartMode" = 1, the position at the time of the setting of the "Enable" input takes effect as the position setpoint for the position controller. The axis is decelerated to zero and adjusted to the position setpoint as a function of the maximum deceleration configured under "Technology object > Configuration > Extended parameters > Dynamic limits". If, in so doing, monitored conditions are violated or dynamic limits are exceeded, this triggers corresponding alarm responses.

When "StartMode" = 0, the axis is decelerated to a standstill by setting the velocity setpoint zero. Monitoring functions and dynamic limits are not active in this case.

If the "Status" parameter shows the value "TRUE", the technology object is enabled.

Behavior when technology object is enabled at a standstill and encoder signal is noisy

When the "Enable" input is set, the extrapolated actual position is applied as the position setpoint. The current actual velocity and the times $T_i + T_{ipo} + T_{servo}$ are taken into account for the extrapolation.

Noisy encoder signals lead to detection of an actual velocity despite the axis being at a standstill. This detected actual velocity is greater for encoders with low resolution than for encoders with high resolution. High actual velocities result in significant step changes of the position setpoint when the axis is enabled.

To output the velocity setpoint zero when the axis is enabled and "StartMode" = 1 and avoid step changes of the position setpoint and a deceleration of the axis with maximum deceleration, follow these steps:

- Set <TO>.PositionControl.VelocityModePowerOn = 1. Monitoring functions and dynamic limits are not active in this case.

Enabling a drive

You can enable PROFIdrive drives or drives with analog setpoint interface with the Motion Control instruction "MC_Power".

Drive connection via PROFIdrive

When a drive is connected using PROFIdrive, the setpoint, enable and drive status are transmitted via the PROFIdrive telegram.

When the "Enable" parameter is set to TRUE, the technology object is enabled. The drive is enabled according to the PROFIdrive standard.

If the "<TO>.StatusDrive.InOperation" tag shows the value "TRUE", the drive is ready to execute setpoints. The "Status" parameter is set to the value "TRUE".

You can find more detailed information in section Connecting PROFIdrive drives (Page 57).

Analog drive connection

The setpoint is output via an analog output. Optionally, an enabling signal via a digital output (<TO>.Actor.Interface.EnableDriveOutput) and a readiness signal via a digital input (<TO>.Actor.Interface.DriveReadyInput) can be configured.

When the "Enable" parameter is set to TRUE, the enable output ("Enable drive output") is set.

When the drive returns the readiness signal via the ready input ("Drive ready input"), the "Status" parameter and the "<TO>.StatusDrive.InOperation" tag of the technology object are set to "TRUE", and the setpoint is switched to the analog output.

You can find more detailed information in section Connecting drives with analog setpoint interface (Page 73).

6.5.2 Tags: Enabling a technology object

The following tags are relevant for the enabling of the technology object:

Parameters for the enabling of the technology object	
Tag	**Description**
<TO>.PositionControl.VelocityMode-PowerOn	Behavior of the velocity setpoint when the axis is enabled
<TO>.Actor.Interface.EnableDriveOutput	"Enable output" for analog drives
<TO>.Actor.Interface.DriveReadyInput	"Ready input" for analog drives The drive signals its readiness to receive speed setpoints.

6.6 Acknowledging technology alarms and reinitializing the technology object

Motion jobs cannot be executed if technology alarms are pending. How the technology alarm affects the technology object is defined by the alarm response. Depending on the alarm class, either an acknowledgment (W, F) or a restart (R) is required. Technology alarms are divided into three alarm classes:

- Acknowledgeable warning (W)
- Alarm requiring acknowledgment (F)
- Fatal error (R)

You can find a list of the technology alarms with corresponding alarm responses and alarm classes in section "Overview of the technology alarms" of document "S7-1500/S7-1500T Motion Control alarms and error IDs".

You can find a detailed description of the alarm classes in section "Brief description of technology alarms" of document "S7-1500/S7-1500T Motion Control alarms and error IDs".

You can find an overview of the locations where a technology alarm is displayed and the options for acknowledging a pending technology alarm in section "Brief description of technology alarms" of document "S7-1500/S7-1500T Motion Control alarms and error IDs".

You restart the technology object in the following cases:

- After elimination of a fatal error
- At a value change of restart-relevant data

You can see from the description of the tag of the corresponding technology object whether value changes of a tag are restart-relevant.

You can find more detailed information in section "Change restart-relevant data" or "Restart of technology objects" of document "S7-1500/S7-1500T Motion Control overview".

Acknowledging technology alarms in the user program and reinitializing the technology object

With the Motion Control instruction "MC_Reset", you can start the following jobs:

- Acknowledging technology alarms (Page 113)
- Reinitializing the technology object (Page 114)

6.6.1 Acknowledging technology alarms

With the Motion Control instruction "MC_Reset" (Page 291), you acknowledge all technology alarms and warnings that can be acknowledged in the user program. With the acknowledgment, the "Error" and "Warning" bits in the technology object data block are also reset. An acknowledgment of alarms in the drive is also possible without a pending error at the technology object.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_Reset" to acknowledge the pending technology alarms:

- With the "Axis" parameter, you reference the technology object at which the acknowledgeable alarms are pending.
- With the "Execute" parameter, you start the job with a positive edge.
- By setting the "Restart" parameter = FALSE, you acknowledge the technology alarms.

Status evaluation

When the "Done" parameter shows the value "TRUE", the error has been acknowledged.

When you acknowledge multiple pending alarms, the pending alarms are displayed briefly in the "ErrorDetail.Number" tag without a new message. Check whether all alarms have been acknowledged after a restart with "MC_Reset.Done" = TRUE has been completely processed.

NOTE

Acknowledging technology alarms with "Restart" = FALSE

To acknowledge only the technology alarms, set "Restart" = FALSE. The technology object cannot be used during a restart. All technology alarms at axes and encoders are acknowledged, even if these have not been enabled or are not operative.

6.6.2 Restart of technology object

With the Motion Control instruction "MC_Reset (Page 291)", you restart a technology object after elimination of a fatal error.

When the technology object is restarted, new configuration data in the technology data block is simultaneously applied. Because restart-relevant tags (RES) are dependent on other tags, the application of value changes at any time is not possible. The changes are only applied at a reinitialization (restart) of the technology object. At a restart, the technology object is reinitialized with the data in the load memory. For this reason, you write changes to the start value in the load memory with the extended instruction "WRIT_DBL" (write to data block in load memory).

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_Reset" to perform a restart:

- With the "Axis" parameter, you reference the technology object at which a restart is required or restart-relevant changes are to be applied.
- With the "Execute" parameter, you start the job with a positive edge.
- By setting the parameter "Restart" = TRUE, you reinitialize the technology object.

Status evaluation

If the "Done" parameter shows the value "TRUE", the restart of the technology object is complete.

6.7 Motion control and dynamic limits

Motion control of the axis occurs by means of velocity profiles (Page 120). The velocity profiles are calculated in accordance with the specifications for dynamics. A velocity profile defines the behavior of the axis during approach, braking and changes in velocity. During positioning a velocity profile is calculated, that moves the axis to the target point.

The configurable emergency stop deceleration (Page 123) is triggered by the Motion Control instructions "MC_Power" and "MC_Stop" or by a technology alarm.

The jerk limit reduces the mechanical load during a change in acceleration or deceleration. The result is a "smoothed" velocity profile.

Parameterizing dynamic values in Motion Control instruction

At the Motion Control instructions, you configure the dynamic values for a motion job at the parameters "Velocity", "Acceleration", "Deceleration" or "Jerk". You make the parameter assignment for each parameter individually.

Using dynamic defaults for a motion job

To use a dynamic default for a motion job, set a value of less than 0 at the parameter (default: -1.0).

The following table shows which dynamic defaults you can use with which Motion Control instruction.

Motion Control instruction	<TO>.DynamicDefaults .Velocity	<TO>.DynamicDefaults .Acceleration	<TO>.DynamicDefaults .Deceleration	<TO>.DynamicDefaults .Jerk
MC_MoveAbsolute	✓	✓	✓	✓
MC_MoveRelative	✓	✓	✓	✓
MC_MoveVelocity	-	✓	✓	✓
MC_MoveJog	-	✓	✓	✓
MC_MoveSuperimposed	✓[1)]	✓	✓	✓
MC_Halt	-	-	✓	✓
MC_HaltSuperimposed	-	-	✓	✓
MC_Stop."Mode" = 3	-	-	✓	✓

1) At the parameter "MC_Superimposed.VelocityDiff"

Parameterizing individual dynamic values for a motion job

To use an individual dynamic value for a motion job, set a value that is greater than 0 at the parameter.

6.7.1 Configuring dynamic defaults

You can configure dynamic defaults for motion jobs for the axis technology object. You define values as dynamic defaults that can be used for motion jobs in most situations.

Configure the following dynamic defaults under "Extended parameters > Dynamic default":

- Velocity (<TO>.DynamicDefaults.Velocity)

  In the "Velocity" field, you configure the default value for the velocity of the axis.

- Acceleration (<TO>.DynamicDefaults.Acceleration)

  You configure the default value for acceleration in the "Ramp-up time" or "Acceleration" fields.

  Relationship between ramp-up time and acceleration:

$$\text{Ramp-up time} = \frac{\text{Velocity}}{\text{Acceleration}}$$

NOTE

A change in the velocity influences the acceleration value of the axis. The ramp-up time remains.

- Deceleration (<TO>.DynamicDefaults.Deceleration)

  You configure the default value for deceleration in the "Ramp-down time" or "Deceleration" fields.

  Relationship between ramp-down time and deceleration:

$$\text{Ramp-down time} = \frac{\text{Velocity}}{\text{Deceleration}}$$

  NOTE

  A change in the velocity influences the deceleration value of the axis. The ramp-down time remains.

- Jerk of the axis (<TO>.DynamicDefaults.Jerk)
  - You configure the jerk for the acceleration and deceleration ramp in the "Jerk" box. The value "0" means that jerk limiting is deactivated.
  - You configure the smoothing time for the acceleration ramp in the "Smoothing time" field.

  NOTE

  The jerk value is identical for the acceleration and deceleration ramps. The smoothing time in effect for the deceleration ramp results from the following relationships:

  - **Acceleration > Deceleration**

    A shorter smoothing time is used for the deceleration ramp compared with the acceleration ramp.
  - **Acceleration < Deceleration**

    A longer smoothing time is used for the deceleration ramp compared with the acceleration ramp.
  - **Acceleration = Deceleration**

    The smoothing times of the acceleration and deceleration ramp are equal.

  In case of a fault, the axis decelerates with the configured emergency stop deceleration. A configured jerk limit is not taken into account for this.

  Relationship between the smoothing times and the jerk:

$$\text{Smoothing time (acceleration ramp)} = \frac{\text{Acceleration}}{\text{Jerk}}$$

$$\text{Smoothing time (deceleration ramp)} = \frac{\text{Deceleration}}{\text{Jerk}}$$

  Motion jobs started in the user program are performed with the selected jerk.

The default values for acceleration and deceleration also act on the traversing motions of active homing.

6.7.2 Limiting the dynamics

Maximum values for velocity, acceleration, deceleration and jerk result from the properties of the drive and the mechanics.

Configure the following dynamic limits under "Extended parameters > Limits > Dynamic limits":

- Maximum velocity (<TO>.DynamicLimits.MaxVelocity)

  Configure the maximum permitted velocity of the axis in the "Maximum velocity" field.

  NOTE

  "MaxVelocity" or "Velocity", whichever is lower, is used for the motion control (<TO>.DynamicLimits.Velocity).

- Maximum acceleration (<TO>.DynamicLimits.MaxAcceleration)

  Configure the maximum permitted acceleration in the "Ramp-up time" or "Maximum acceleration" fields.

  Relationship between ramp-up time and maximum acceleration:

$$\text{Ramp-up time} = \frac{\text{Maximum velocity}}{\text{Maximum acceleration}}$$

  NOTE

  A change in the maximum velocity influences the acceleration value of the axis. The ramp-up time remains.

- Maximum deceleration (<TO>.DynamicLimits.MaxDeceleration)

  Configure the maximum permitted deceleration in the "Ramp-down time" or "Maximum deceleration" fields.

  Relationship between ramp-down time and maximum deceleration:

$$\text{Ramp-down time} = \frac{\text{Maximum velocity}}{\text{Maximum deceleration}}$$

  NOTE

  The "maximum deceleration" for active homing with change of direction at the hardware limit switch must be set sufficiently high to brake the axis before it reaches the mechanical endstop.

  A change in the velocity influences the deceleration value of the axis. The ramp-down time remains.

- Jerk (<TO>.DynamicLimits.MaxJerk)

  You configure the jerk for the dynamic limits in the "Smoothing time" and "Jerk" fields. The same rules apply for the configuration as for the dynamic default of the jerk.

The limits for dynamics are in effect as limits for every motion generated by means of the technology object. The dynamic limits have no effect on a following axis in synchronous operation.

6.7.3 Velocity or speed override

Use the "<TO>.Override.Velocity" tag to set a factor that corrects the velocity or rotational speed of the axis during a motion job. You can set the value between 0.0% and 200.0%. The adjustment affects both the preset dynamic value "<TO>.DynamicDefaults.Velocity" and the parameterized velocity on the motion job.

An override change takes effect immediately, and is performed with the dynamic settings in effect in the Motion Control instruction.

This tag remains ineffective during operation of the axis control panel.

See also

Interaction of dynamic defaults, override and dynamic limits (Page 118)

6.7.4 Interaction of dynamic defaults, override and dynamic limits

The following overview shows how the dynamic values for a motion job are formed from the dynamic defaults, the velocity override and the dynamic limits. The velocity override is only relevant for the velocity.

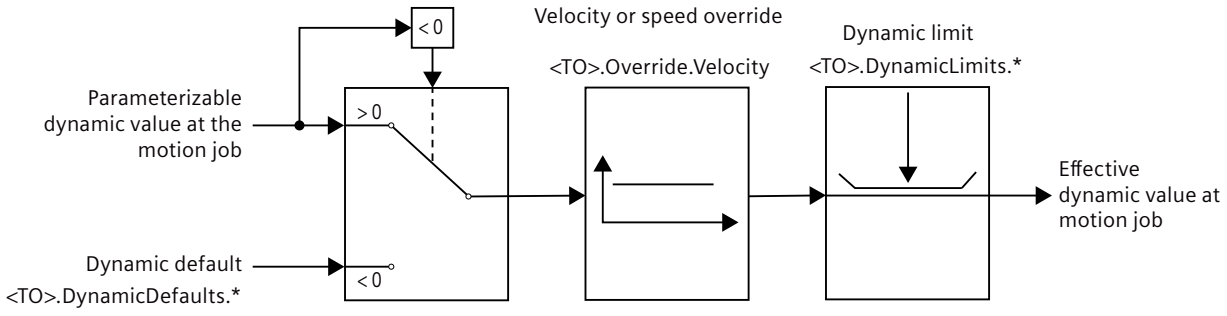

Examples

The following table shows examples of the determined dynamic value for the velocity at a job of the MC_MoveAbsolute instruction.

	Configured dynamic default <TO>.DynamicDefaults.Velocity	Parameterized value at the motion job MC_MoveAbsolute.Velocity	Override <TO>.Override.Velocity	Dynamic limit <TO>.DynamicLimits.MaxVelocity	Dynamic value at the motion job
Example 1	2000.0	-1.0	100.0	4000.0	2000.0
Example 2	2000.0	-1.0	150.0	4000.0	3000.0
Example 3	2000.0	-1.0	100.0	500.0	500.0
Example 4	2000.0	-1.0	150.0	500.0	500.0

	Configured dynamic default <TO>.DynamicDefaults .Velocity	Parameterized value at the motion job MC_MoveAbsolute.Velocity	Override <TO>.Override. Velocity	Dynamic limit <TO>.DynamicLimits.MaxVelocity	Dynamic value at the motion job
Example 5	2000.0	3000.0	100.0	4000.0	3000.0
Example 6	2000.0	6000.0	100.0	4000.0	4000.0
Example 7	2000.0	6000.0	50.0	4000.0	3000.0

6.7.5 Dynamic defaults for modulo axes

Maximum permissible velocity of the modulo axis

Note the maximum permissible velocity for modulo axes.

- Modulo axis has not been configured as a possible leading value for a synchronous axis technology object:

$$\text{Maximum permissible velocity} = \frac{\text{Modulo length}}{T_{Servo}}$$

  If the maximum permissible velocity is exceeded, alarm 412 is output and the axis is blocked.

- Modulo axis has been configured as a possible leading value for a synchronous axis technology object:

$$\text{Maximum permissible velocity} = \frac{\text{Modulo length}}{2 \cdot T_{Servo}}$$

  When the limit is active, alarm 501 is output.

6.7.6 Velocity profile

Velocity profiles with or without jerk limitation are supported for motion control of the axis.

The dynamic values for the motion are specified in the Motion Control job. Alternatively, the values of the dynamic default can be used. The defaults and the limits for velocity, acceleration, deceleration and jerk are set in the configuration.

To influence velocity, a velocity override can override the current traversing velocity.

Velocity profile without jerk limitation

The following figure shows velocity, acceleration and jerk:

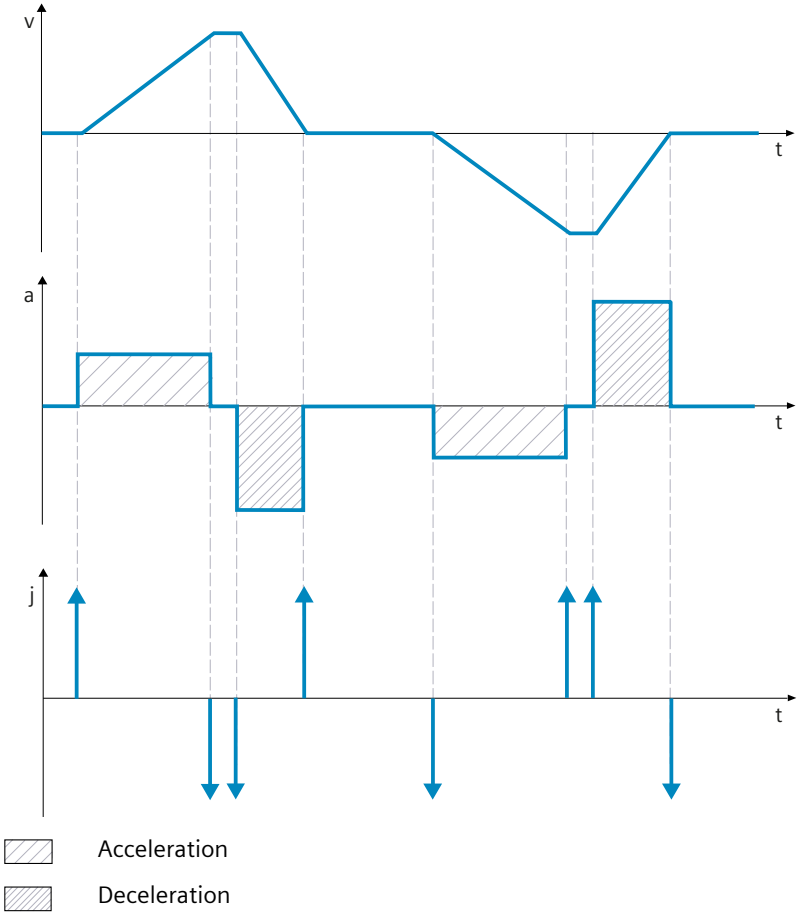

Velocity profile with jerk limitation

The following figure shows velocity, acceleration and jerk:

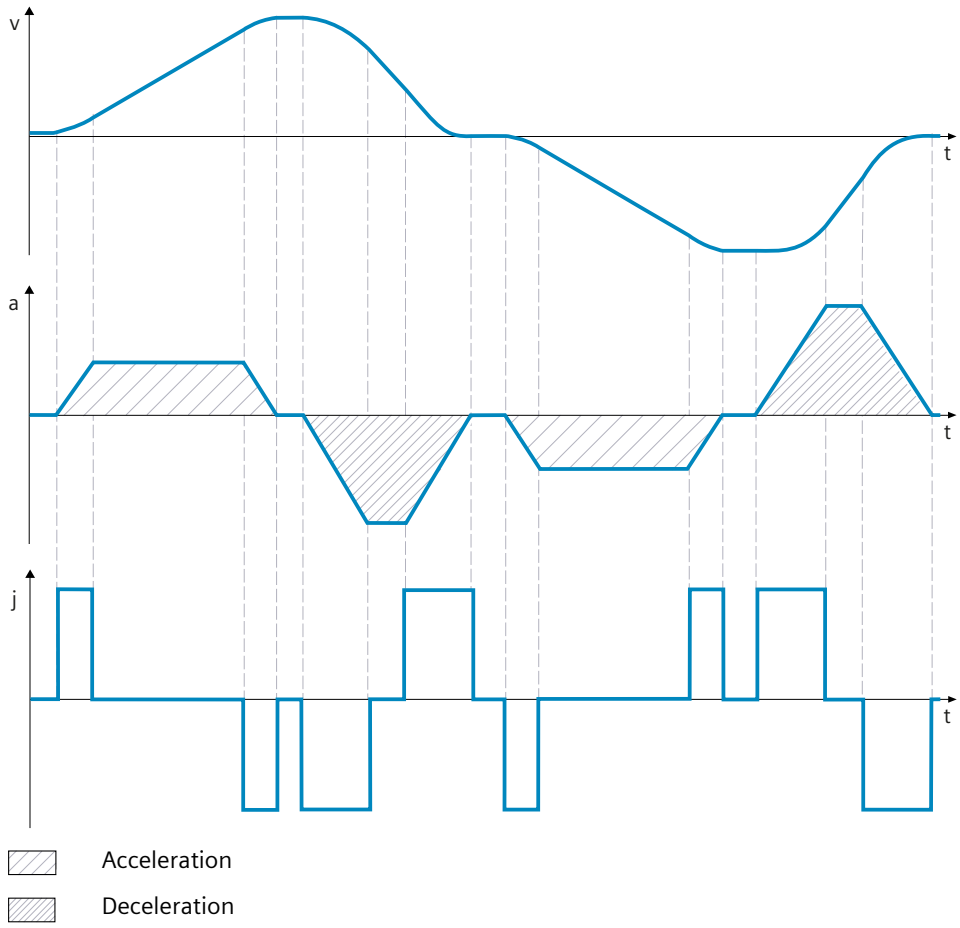

A velocity profile with jerk limitation is employed for a continuous acceleration and deceleration sequence. The jerk can be specified.

6.7.7 Override response with and without jerk limitation

When overriding the active job with a new jerk-limited motion, the current acceleration or deceleration is transferred to the new acceleration/deceleration via the jerk. For overriding motions without jerk limitation, the acceleration/deceleration of the overriding job is effective immediately.

The following figure shows velocity, acceleration and jerk:

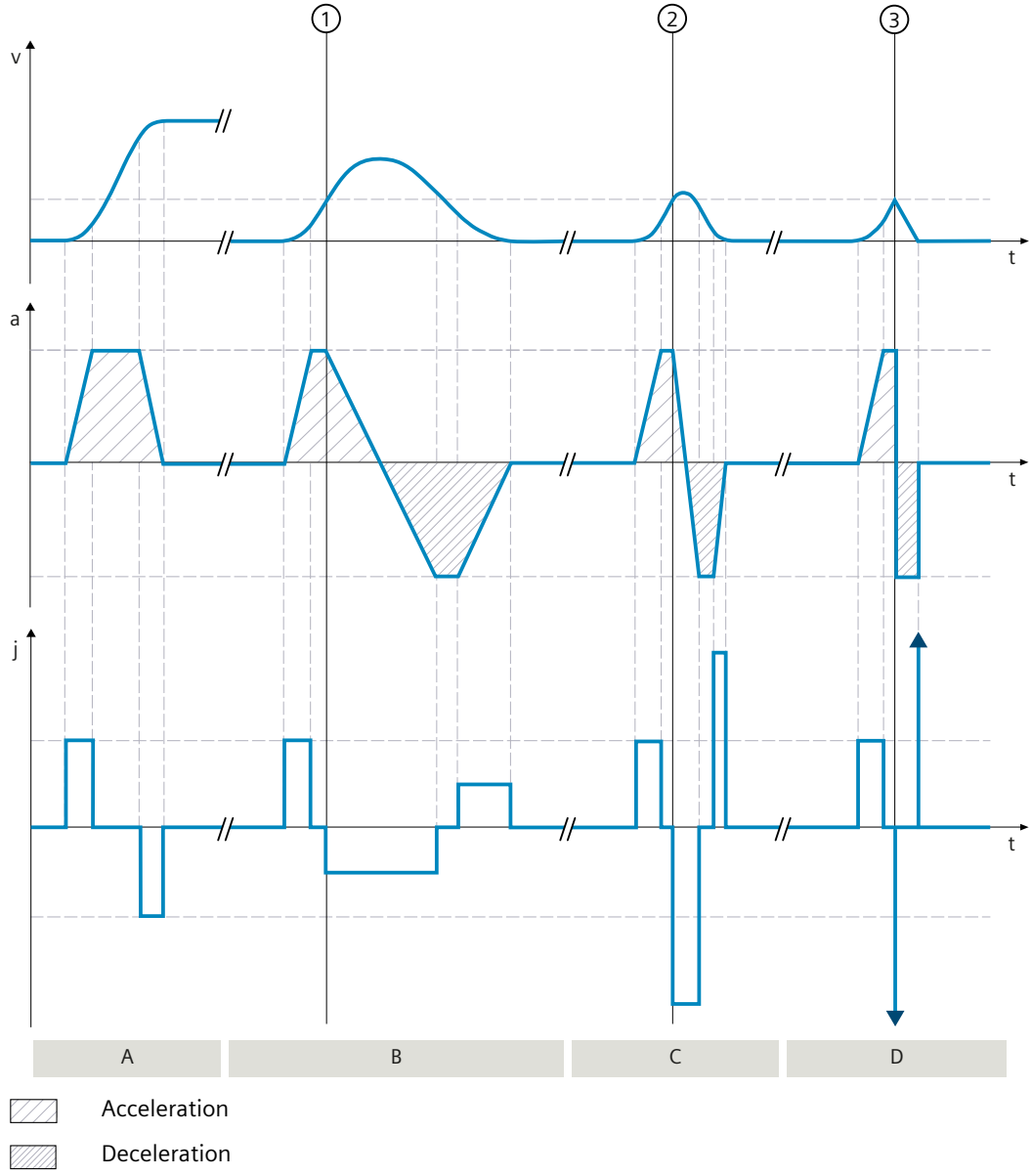

Section A

An "MC_MoveVelocity" job A1 is active.

In the following sections B, C and D, the job A1 is replaced by an additional "MC_MoveVelocity" job A2, A3 and A4 with "Velocity" = 0 in each case but with different jerk values.

Section B

At time ①, the active job A1 is overridden by a job A2 with low jerk. The acceleration is slowly transitioned via the jerk into the deceleration of the overriding job.

Section C

At time ②, the active job A1 is overridden by a job A3 with high jerk. The acceleration is quickly transitioned via the jerk into the deceleration of the overriding job.

Section D

At time ③, the active job A1 is overridden by a job A4 without jerk limitation. The deceleration of the overriding job is effective immediately.

6.7.8 Emergency stop deceleration

When stopping with the emergency stop ramp, the axis is braked from the current actual position and actual velocity to a standstill without a jerk limitation, using the configured emergency deceleration.

In the following cases the configured emergency stop deceleration is in effect:

- In case of an emergency stop ramp that has been enabled via the Motion Control instruction "MC_Power" or "MC_Stop".
- For a technology alarm with the local alarm response "Stop with emergency stop ramp".

This emergency stop deceleration can be set greater than the maximum deceleration. If the emergency stop deceleration is set lower than this, it may occur that the axis does not stop until after the limit switch in the case of "Stop at software limit switch" and the occurrence of a technology alarm with the local alarm response "Stop with emergency stop ramp".

Configuring emergency stop deceleration

Under "Extended parameters > Emergency stop", you configure the deceleration value for emergency stop in the "Emergency stop deceleration" or "Emergency stop ramp-down time" fields.

The following equation shows the relationship between emergency stop ramp-down time and emergency stop deceleration.

$$\text{Emergency stop ramp-down time} = \frac{\text{Maximum velocity}}{\text{Emergency stop deceleration}}$$

The configuration of the emergency stop deceleration is related to the configured maximum velocity of the axis. When the maximum velocity of the axis changes, then the value of the emergency stop deceleration also changes. The emergency stop ramp-down time remains unchanged.

6.7.9 Torque limits

6.7.9.1 Force/torque limiting

Adjustable force/torque limiting is available for the speed axis, positioning axis and synchronous axis technology objects. The force/torque limiting can be activated and deactivated before and during a motion job.

The following requirements are necessary to use the force/torque limit:

- The drive and the PROFIdrive telegram support the torque reduction. You can use, for example, a telegram 10x.
- The upper and lower torque limit of the drive must be set to the reference torque of the drive. The sum of all values must be equal.

  If you want to use different torque limits, use an "MC_TorqueRange" job, for example.

  You can find more information in the "Connecting force/torque data via SIEMENS additional telegram 750 (Page 74)" section.
- The reference torque set in the "Data exchange with the drive" configuration dialog of the technology object must match the reference torque of the drive. If the automatic application of drive data is enabled, the axis automatically takes the reference torque of the drive.
- No "MC_Stop" job is running.

The limit value can be configured as a default value during configuration of the axis or it can be defined in the user program using Motion Control instruction "MC_TorqueLimiting".

You can specify the limiting values in the configured measurement unit for force or torque. The measurement units are defined in the "Basic parameters" configuration window.

The following configuration options are available for force/torque limiting:

- **"Linear" axis type**
  - Torque limiting active on motor side
  - Force limit active on load side
- **"Rotary" axis type**
  - Torque limiting active on load side or motor side

The force/torque limit defined by the user in accordance with the specification in the PROFIdrive telegrams 10x are transferred internally to the drive as a percentage torque reduction.

Linear axis type

With the rotary motor, a load-side force limit you have defined is converted by the technology into a torque reduction. If the limiting relates to the load side, the gear and leadscrew parameters defined in the "Mechanics" configuration dialog are taken into consideration. If the efficiency of the gear and leadscrew is crucial, you can set them in the "<TO>.Actor.Efficiency" tag.

With the linear motor, you specify the load-side force limit directly. The efficiency is not taken into account.

Rotary axis type

The torque is reduced on the load side with the rotary axis type. The gear parameters defined in the "Mechanics" configuration window are taken into consideration. If the efficiency of the gear is crucial, you can set it in the "<TO>.Actor.Efficiency" tag.

The defined limiting values act as an absolute value and thus in the same way for positive and negative forces/torques.

Positioning and following error monitoring with active force/torque limiting

As a result of force/torque limiting, a larger setpoint-actual value difference can build up for position-controlled axes, which may cause unwanted activation of the positioning and following error monitoring.

To deactivate the monitoring of the following error and the positioning monitoring during force/torque limiting, select the "Disable position-related monitoring" option. If you want to activate the position-related monitoring, select the option "Leave position-related monitoring enabled".

Typical behavior of a positioning or synchronous axis with active force/torque limiting

With active force/torque limiting, a larger setpoint-actual value difference can build up than during motion without force/torque limit.

Given a constant setpoint, the axis makes repeated attempts to reduce the following error.

When the limiting values are increased or limiting is deactivated during active closed loop position control, the axis can accelerate briefly to reduce the following error. If the axis is switched to non-position-controlled operation, e.g. using "MC_MoveVelocity" with "PositionControlled" = FALSE, the following error is no longer in effect.

Stopping an axis with active force/torque limiting

When stopping an axis in position-controlled mode with "MC_Halt" or "MC_Stop", the set position and the velocity setpoint are applied. Torque limiting still remains active and any accumulated following error is reduced. The axis is in standstill when the actual velocity "0.0" is reached and the minimum dwell time in the standstill window has expired. The axis remains enabled.

When stopping an axis with "MC_Power" and an emergency stop ramp, the actual position value and the actual velocity are used as a basis. The axis is decelerated and brought to a standstill with the configured emergency deceleration without jerk limitation. The axis is then disabled when at a standstill.

Configuring force/torque limiting

You can configure the force/torque limit in the configuration of the positioning axis/synchronous axis technology object under "Extended parameters > Limits > Torque limiting".

Follow these steps:

1. In the "Effective" drop-down list, select whether the limit value is to be in effect "on load side" or "on motor side".

   If you have configured a linear motor, this setting has no effect.

2. Enter a default value in the specified measurement unit for "Torque limiting" or "Force limit".

   The default value is in effect when the torque limiting or force limit is specified using the Motion Control instruction "MC_TorqueLimiting", input parameter "Limit" < 0.

   Torque limiting applies to the following axis configurations:

   – Axis type is "Rotary" and limit value is in effect "On load side" or "On motor side"
   – Axis type is "Linear" and limit value is in effect "On motor side"

   Force limit applies to the following axis configuration:

   – "Standard motor", axis type "linear" and limiting value effective "on load side".

     If the efficiency of the gear and leadscrew is crucial, you can set them in the "<TO>.Actor.Efficiency" tag.

   – "Linear motor"

Required interconnections in the SINAMICS drive

Make sure that the following interconnections required for force/torque limit are set in all drive data sets in the drive:

- P1522 = P1520 = P2003 (interconnection to the reference torque)
- P1523 = P1521 = -P2003 (interconnection to the negative reference torque)
- P1544 Torque/force reduction evaluation during travel to fixed stop to 100% (default)
- P2194 Threshold value for the parameter "InLimitation" of < 100% (default 90%)

Enabling force/torque limiting with the Motion Control instruction "MC_TorqueLimiting"

With the Motion Control instruction "MC_TorqueLimiting" in the user program, you specify the limit value for force and torque for the drive.

Parameter inputs:

You use the following parameters of the Motion Control instruction "MC_TorqueLimiting" to define the force/torque limiting:

- By setting the "Mode" parameter to 0, you select the force/torque limiting.
- With the "Limit" parameter, you specify the value of the force/torque limiting (value ≥ 0.0) or use the limit value preset in the configuration (<DB>.TorqueLimiting.LimitDefaults) (value < 0.0).
- With the "Enable"parameter, you enable/disable the force/torque limiting.

See also

Fixed stop detection (Page 127)

6.7.9.2 Fixed stop detection

With the Motion Control instruction "MC_TorqueLimiting", you activate and monitor a fixed stop detection. Together with a position-controlled motion job, a "Travel to fixed stop" can be realized. The operation is also referred to as clamping. "Travel to fixed stop" can be used, for example, to move quills against the workpiece with a specified torque.

The fixed stop detection is only possible in position-controlled operation of the axis. If the drive and telegram support force/torque limiting, this is active during travel to fixed stop and for clamping.

Detection of the fixed stop using following error

If the drive is stopped by a mechanical fixed stop during a motion job, the following error is increased. When the following error configured in the configuration window "Extended parameters > Limits > Fixed stop detection" is exceeded, this is regarded as the fixed stop having been reached.

When following error monitoring is activated, the configured following error must be greater than the following error for fixed stop detection.

Clamping at the mechanical endstop

When the fixed stop is reached, the active position-controlled motion job is canceled with "CommandAborted". The setpoint is no longer changed and the following error remains constant. The closed loop position control remains active and the monitoring of the configured "Positioning tolerance" is activated The drive is in "Clamping" state.

If the drive and telegram support force/torque limiting, this continues to be active with active fixed stop detection. During clamping, the clamping force or clamping torque can be changed. The value in input parameter "Limit" of the Motion Control instruction "MC_TorqueLimiting" can be changed for this.

Monitoring of the clamping

If the actual position changes by a value greater than the configured "Positioning tolerance" during active clamping, this is regarded as the break or push-back of the fixed stop. An alarm is triggered. The axis is disabled and the drive is stopped according to its configuration.

If the position setpoint is within the configured "Positioning tolerance", the breaking away or turning back of the fixed stop cannot be detected.

The configured position tolerance must be less than the configured following error for detection of clamping.

Retracting

Retracting from the fixed stop is only possible with a position-controlled motion job in the opposite direction to the fixed stop.

The "Travel to fixed stop" or "Clamping" function is ended when the "Positioning tolerance" is left in the retraction direction.

Configuring fixed stop detection

You configure the fixed stop detection in the configuration of the Positioning axis/synchronous axis technology object under "Extended parameters > Limits > Fixed stop detection".

- For "Following error", you configure the value of the following error starting from which the fixed stop detection is to take effect.

  NOTE

  If the following error monitoring was activated in the position monitoring configuration, the "Maximum following error" configured there must be greater than the "Following error" of the fixed stop detection.

- For "Positioning tolerance", you configure the positioning tolerance that is regarded as a breaking away or turning back of the fixed stop when exceeded. To detect the breaking away or turning back of the fixed stop, the position setpoint must be located outside the positioning tolerance.

  The configured position tolerance must be less than the configured following error.

Configuring fixed stop detection with the Motion Control instruction "MC_TorqueLimiting"

With the Motion Control instruction "MC_TorqueLimiting" in the user program, you activate and monitor a fixed stop detection.

Parameter inputs:

You use the following parameters of the Motion Control instruction "MC_TorqueLimiting" to define the force/torque limiting:

- By setting the "Mode" parameter to 1, you select the fixed stop detection.
- With the "Limit" parameter, you specify the value of the force/torque limiting (value ≥ 0.0) or use the limit value preset in the configuration (<DB>.TorqueLimiting.LimitDefaults) (value < 0.0).
- With the "Enable" parameter, you enable/disable the fixed stop detection.

See also

Force/torque limiting (Page 124)

MC_TorqueLimiting: Activate/deactivate force/torque limit / fixed stop detection V10 (Page 374)

6.7.9.3 Additive setpoint torque/additive setpoint force

The Motion Control instruction "MC_TorqueAdditive" allows you to apply an additional torque/an additional force in the drive.

The additive setpoint torque is used for example in torque feedforward control or the specification of the tensile torque for winding applications.

The following requirements are necessary for setting the additive setpoint torque/additive setpoint force:

- SINAMICS drive
- SIEMENS supplementary telegram 750 for transmitting the torque data to the drive
- No "MC_Stop" job is running.

Parameter inputs

You use the following parameters of the Motion Control instruction"MC_TorqueAdditive" to specify an additive setpoint torque/force for the drive assigned to the technology object:

- With the "Enable" parameter, you enable/disable the additive setpoint torque/force.
- With the "Value" parameter, you specify the additive setpoint torque/force.

  The additive setpoint torque setting acts as a superimposed torque. An additional torque may be positive or negative. If you invert the setpoint for the technology object, the value for the additive torque is also inverted and transferred inverted to the drive. The value specified in the instruction is a technological value, not a percentage. You set the unit of measure at the axis (default values: Nm, N).

See also

MC_TorqueAdditive: Specify additive torque V10 (Page 368)

6.7.9.4 Permissible torque range/force range

The Motion Control instruction "MC_TorqueRange" allows you to set torque limits/force limits for the drive.

The motion control instruction is used, for example, for winding applications in order to prevent the tearing of the material.

The following requirements must be fulfilled to set the torque data:

- SINAMICS drive
- SIEMENS supplementary telegram 750 for transmitting the torque data to the drive
- No "MC_Stop" job is running.

If the torque limitation is activated by specifying the high and low torque limit, the following monitorings and limits are deactivated:

- Following error monitoring
- Time limits for positioning monitoring
- Time limits for standstill monitoring

NOTE

Travel to fixed stop under "MC_Torque Range"

If the axis travels to a fixed stop with specification of the torque limits/force limits with "MC_TorqueRange", the STW2.TravelToFixStop bit is not set automatically in contrast to the behavior with "MC_TorqueLimiting" in control word 2. If the bit is not set, an error occurs in the drive when the limits are reached (e.g. drive blocked).

If you move the axis under "MC_TorqueRange" to fixed stop, set the STW2.TravelToFixStop bit manually in the drive telegram, e.g. in the "MC_PostServo" organization block or with the "MC_SetAxisSTW" instruction.

Monitoring remains in effect if you have selected the option "Leave position-related monitoring enabled" under "Technology object > Configuration > Extended parameters > Limits > Torque limiting".

If, when using the SIEMENS additional telegram 750, you do not set the torque limits with Motion Control instruction "MC_TorqueRange", the following preset reference torque limits are used:

- For standard motors, the preset reference torque limits from the "<TO>.Actor.DriveParameter.ReferenceTorque" tag
- For linear motors, the preset reference torque limits from the "<TO>.Actor.LinearMotorDriveParameter.ReferenceForce" tag

Parameter inputs

You use the following parameters of the Motion Control instruction"MC_TorqueRange" to specify the upper and lower torque limit for the drive assigned to the technology object:

- With the "Enable" parameter, you enable/disable the upper and lower force/torque limit.
- With the "UpperLimit" and "LowerLimit" parameters, you specify the upper and lower force/torque limit.

  If you invert the setpoints for the technology object, the values for the high and low torque limit are also inverted and transferred inverted to the drive. The value specified in the instruction is a technological value, not a percentage. You set the unit of measure at the axis (default values: Nm, N).

If alarms occur at the technology object while "Enable" = TRUE , the force/torque limits remain in effect.

See also

MC_TorqueRange: Set high and low torque limit V10 (Page 371)

6.7.10 Superimposed motion

With the Motion Control instruction "MC_MoveSuperimposed", you start a relative positioning motion that is superimposed on a running basic motion.

With the Motion Control instruction "MC_HaltSuperimposed", you stop a superimposed motion on the axis independently of the basic motion. You can find more information on stopping superimposed motion in the section Halting a superimposed motion (Page 134).

You can superimpose the Motion Control instructions "MC_MoveSuperimposed" and "MC_HaltSuperimposed" on the following Motion Control instructions:

- Single-axis motion
  - MC_MoveAbsolute
  - MC_MoveRelative
  - MC_MoveVelocity
  - MC_MoveJog
  - MC_Halt
  - MC_PositionProfile
- Synchronous operation motion
  - MC_GearIn
  - MC_GearInPos
  - MC_GearInVelocity
  - MC_CamIn

A kinematics motion is not permitted as a basic motion. If a kinematics motion is active, the execution of an "MC_MoveSuperimposed" job is canceled with "Error" and the associated "ErrorID".

Overriding of superimposed motions

The instructions of the superimposed motions are overridden according to the behavior described in section "Override response V10: Homing and motion jobs (Page 380)". As a rule, the current dynamic responses are approximated to the new motion.

Status indicators for superimposed motions

The "<TO>.StatusWord.X23 (MoveSuperimposedCommand)" tag is set when an "MC_MoveSuperimposed" job is active.

The "<TO>.StatusWord2.X7 (HaltSuperimposedCommand)" tag is set when an "MC_HaltSuperimposed" job is active.

The "<TO>.StatusPositioning.SuperimposedDistance" tag indicates the distance traversed with the "MC_MoveSuperimposed" and "MC_HaltSuperimposed" instructions. The value is reset when the basic motion and superimposed motion have been completed or canceled.

See also

MC_MoveSuperimposed: Position axis overlapping V10 (Page 330)

MC_HaltSuperimposed: Pause superimposed motions on axis V10 (Page 334)

Stopping a technology object with "MC_Halt" (Page 168)

MC_Halt: Stop axis V10 (Page 296)

6.7.10.1 Superimposed positioning motion with "MC_MoveSuperimposed"

With the Motion Control instruction "MC_MoveSuperimposed", you start a relative positioning motion that is superimposed on a running basic motion.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_MoveSuperimposed" to define the superimposition of a relative positioning motion onto the basic motion. The basic motion is not affected by the superimposed motion:

- With the "Distance" parameter, you define the additional distance for the superimposed positioning (negative or positive).
- With the "VelocityDiff" parameter, you define the maximum velocity difference of the superimposed motion from the running motion.
- With the "Acceleration" parameter, you define the acceleration of the superimposed motion.
- With the "Deceleration" parameter, you define the deceleration of the superimposed motion.
- With the "Jerk" parameter, you define the jerk of the superimposed motion.

The dynamics of the overall motion of the axis is determined by adding the dynamic values of the basic motion and the superimposed motion.

The behavior of the overall motion depends on the type of basic motion:

- If the basic motion is a single-axis motion:
  - The maximum dynamic response of the superimposed motion is the difference between the current dynamic values of the basic motion and the dynamic limits.
  - The entire motion is limited to the configured dynamic limits.
- If the basic motion is a synchronous operation motion:
  - The synchronous operation motion of the following axis is not limited to the dynamic limits of the following axis.
  - An "MC_MoveSuperimposed" job on a leading axis in synchronous operation acts on the leading axis and thus indirectly on the following axis.
  - An "MC_MoveSuperimposed" job on a following axis in synchronous operation acts only on the following axis.

NOTICE
Machine damage due to possible setpoint jumps If superimposed motions are or were active on the following axis due to the Motion Control instructions "MC_MoveSuperimposed" or "MC_HaltSuperimposed", the following axis follows the leading axis after simulation is ended without the position offset by the superimposed motion. Setpoint jumps can occur as a result. To avoid setpoint jumps, note the following: – For superimposed motions, do not set a synchronous operation to simulation. – To move following values on the following axis, use the "MC_OffsetAbsolute" or "MC_OffsetRelative" instructions instead of the instructions for superimposed motions.

It is always the dynamics of the overall motion that is displayed in the technology data block and in the diagnostics view of the technology object in TIA Portal.

Starting a superimposed positioning motion with "MC_MoveSuperimposed"

To start a superimposed positioning motion with the Motion Control instruction "MC_MoveSuperimposed", follow these steps:

1. Specify the additional distance to be moved in the "Distance" parameter.
2. Start the "MC_MoveSuperimposed" job with a positive edge at the "Execute" parameter.

   The "MC_MoveSuperimposed" job is executed with the set dynamic responses and superimposed on the basic motion.

   The processing status of the job is displayed at the "Busy", "Done", and "Error" parameters.

See also

MC_MoveSuperimposed: Position axis overlapping V10 (Page 330)

6.7.10.2 Halting a superimposed motion

With the Motion Control instruction "MC_HaltSuperimposed", you halt the superimposed motion generated with the "MC_MoveSuperimposed" or "MC_HaltSuperimposed" instruction independently of the basic motion.

If no superimposed motion is active, then the "MC_HaltSuperimposed" job is ended immediately without effect (MC_HaltSuperimposed.Done = true; MC_HaltSuperimposed.Busy = false).

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_HaltSuperimposed" to define the dynamic behavior when the superimposed motion is halted. The Motion Control instruction "MC_HaltSuperimposed" has no effect on the basic motion of the axis:

- With the "Deceleration" parameter, you specify the deceleration of the superimposed motion when it is halted.
- With the "Jerk" parameter, you define the jerk of the superimposed motion when it is halted.
- With the "AbortAcceleration" parameter, you define the acceleration reduction during braking.

NOTE

With the Motion Control instruction "MC_Halt" (Page 296) and the parameter "Mode" = 0, you stop the basic motion and the superimposed motion. With the parameter "Mode" = 1, you only stop the basic movement.

NOTE

Setting synchronous operation with superimposing motions to simulation

If superimposing motions by the Motion Control instructions "MC_MoveSuperimposed" or "MC_HaltSuperimposed" are or were active on the following axis, do not set a synchronous operation in simulation. That is because after you end the simulation, the following axis follows the leading axis without the position shifted by the superimposing motion. This can cause a setpoint step change of the position on the following axis.

If you are using synchronous operation simulation, use the Motion Control instruction "MC_OffsetAbsolute" or "MC_OffsetRelative" to shift the following axis position.

See also

MC_HaltSuperimposed: Pause superimposed motions on axis V10 (Page 334)
Stopping a technology object with "MC_Halt" (Page 168)

6.7.11 Tags: Motion control and limits for dynamics

The following technology object tags are relevant for motion control:

Status	
Tag	**Description**
<TO>.StatusWord	Status indicator for an active motion
<TO>.StatusWord2	Status indicator for an active motion
<TO>.Position	Position setpoint
<TO>.Velocity	Velocity setpoint/speed setpoint
<TO>.VelocitySetpoint	Specified velocity setpoint/speed setpoint
<TO>.ActualPosition	Actual position
<TO>.ActualVelocity	Actual velocity
<TO>.ActualSpeed	Actual speed of the motor (only with PROFIdrive drive type)
<TO>.Acceleration	Setpoint acceleration
<TO>.ActualAcceleration	Actual acceleration
<TO>.StatusPositioning.Superimposed-Distance	Distance traversed with the instructions "MC_MoveSuperimposed" and "MC_HaltSuperimposed". The value is reset when the basic motion and the superimposed motion are completed.
<TO>.StatusSynchronizedMotion.StatusWord.X0 (MaxVelocityExceeded)	The tag is set to the value "TRUE" when the maximum velocity configured for the following axis is exceeded during synchronous operation.
<TO>.StatusSynchronizedMotion.StatusWord.X1 (MaxAccelerationExceeded)	The tag is set to the value "TRUE" when the maximum acceleration configured for the following axis is exceeded during synchronous operation.
<TO>.StatusSynchronizedMotion.StatusWord.X2 (MaxDecelerationExceeded)	The tag is set to the value "TRUE" when the maximum deceleration configured for the following axis is exceeded during synchronous operation.
<TO>.StatusWord.X23 (MoveSuperimposedCommand)	An "MC_MoveSuperimposed" job is running.
<TO>.StatusWord2.X7 (HaltSuperimposedCommand)	An "MC_HaltSuperimposed" job is running.

Override	
Tag	**Description**
<TO>.Override.Velocity	Velocity or speed override

Dynamic limit values	
Tag	**Description**
<TO>.DynamicLimits.MaxVelocity	Dynamic limitation for maximum velocity (mechanical)
<TO>.DynamicLimits.Velocity	Dynamic limitation for maximum velocity (programmable)
<TO>.DynamicLimits.MaxAcceleration	Dynamic limitation for maximum acceleration
<TO>.DynamicLimits.MaxDeceleration	Dynamic limitation for maximum deceleration
<TO>.DynamicLimits.MaxJerk	Dynamic limitation for maximum jerk

Dynamic defaults	
Tag	**Description**
<TO>.DynamicDefaults.Velocity	Default velocity
<TO>.DynamicDefaults.Acceleration	Default acceleration
<TO>.DynamicDefaults.Deceleration	Default deceleration
<TO>.DynamicDefaults.Jerk	Default jerk
<TO>.DynamicDefaults.EmergencyDeceleration	Default emergency deceleration

Torque limiting		
Tag	**Description**	
<TO>.TorqueLimiting.LimitDefaults.Torque	Limiting torque	
<TO>.TorqueLimiting.LimitDefaults.Force	Limiting force	
<TO>.TorqueLimiting.LimitBase	Torque limiting, motor or load side	
	0	Motor side
	1	Load side
<TO>.TorqueLimiting.PositionBasedMonitorings	Positioning and following error monitoring	
	0	Deactivated
	1	Enabled
<TO>.StatusTorqueData.CommandAdditiveTorqueActive	Additive setpoint torque/additive force function	
	0	Deactivated
	1	Enabled
<TO>.StatusTorqueData.CommandTorqueRangeActive	Torque limits/force limits function	
	0	Deactivated
	1	Enabled
<TO>.StatusTorqueData.ActualTorque	Actual torque of the axis (for standard motor)	
<TO>.StatusTorqueData.ActualForce	Actual force of axis (for linear motor)	

Fixed stop detection	
Tag	**Description**
<TO>.Clamping.FollowingErrorDeviation	Value of the following error starting from which the fixed stop is detected
<TO>.Clamping.PositionTolerance	Position tolerance for clamping monitoring

6.8 Axis movements

You can use Motion Control instructions for axis movements to move the axis.

You have the following options for the axis movement:

- Tracking the motion status
- Defining the dynamics of the motion
- Defining the direction of movement
- Defining the target position
- Defining the motion transition
- Starting the job

Types of movement

The following movement types are available for the axis movement:

- Moving axis with constant velocity ("MC_MoveVelocity") (Page 137)
- Moving axis to an absolute position ("MC_MoveAbsolute") (Page 140)
- Moving axis relative to the specified position ("MC_MoveRelative") (Page 140)
- Moving axis in jog mode ("MC_MoveJog") (Page 146)

See also

Configuring dynamic defaults (Page 115)
Motion control and dynamic limits (Page 114)

6.8.1 Moving axis with constant velocity

With the Motion Control instruction "MC_MoveVelocity", you move an axis with constant velocity/speed.

Parameter inputs for the dynamics of the motion and the direction of movement

You use the following parameters of the Motion Control instruction "MC_MoveVelocity (Page 321)" to define the dynamic behavior for the movement:

- With the "Velocity" parameter, you specify the velocity setpoint or speed setpoint. In contrast to "MC_MoveAbsolute" and "MC_MoveRelative", the value setting = 0.0 is allowed.
- With the "Acceleration" parameter, you define the acceleration.
- With the "Deceleration" parameter, you define the deceleration.

- With the "Jerk" parameter, you define the jerk.
- With the "Direction" parameter, you define the direction of rotation of the axis.
- With the "Current" parameter, you define the maintenance of the current velocity.

NOTE

Response to an override change

If the velocity/speed during the constant movement is affected by an override change (<TO>.Override.Velocity), the "InVelocity" parameter is reset during the acceleration or deceleration. When the newly calculated velocity/speed is reached ("Velocity" × "Override" %), "InVelocity" is set again.

Observe the information in sections Configuring dynamic defaults (Page 115) and Velocity profile (Page 120).

Behavior when velocity/speed setpoint is zero ("Velocity" = 0.0)

An "MC_MoveVelocity" job with "Velocity" = 0.0 stops the axis with the configured deceleration. When the velocity/speed setpoint zero is reached, the "InVelocity" parameter shows the value "TRUE".

Under "Technology object > Diagnostics > Status and error bits > Motion status", the motion status values "Constant velocity" and "Standstill" are indicated (<TO>.StatusWord.X12 (ConstantVelocity); <TO>.StatusWord.X7 (Standstill)).

The "InVelocity" and "Busy" parameters show the value "TRUE" until the "MC_MoveVelocity" job is overridden by another Motion Control job.

Switching a position-controlled operation on or off

During an active motion job, the axis can be operated in position-controlled mode or not in position-controlled mode.

Closed loop position control is applicable only for the positioning axis and synchronous axis.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_MoveVelocity" to define the operating mode of the axis movement:

- With the "PositionControlled" parameter, you switch the position control on or off.

Observe the information in section Switching the position control off and on (Page 242).

Position-controlled mode

As soon as the "MC_MoveVelocity" job with "PositionControlled" = TRUE takes effect, the axis is switched to position-controlled mode.

A superimposed motion, e.g. with a "MC_MoveSuperimposed" job, and the travel to fixed stop are only possible in position-controlled mode.

Not in position-controlled mode

As soon as the "MC_MoveVelocity" job with "PositionControlled" = FALSE takes effect, the axis is switched to not in position-controlled mode.

Tracking of "MC_MoveVelocity" jobs

With the Motion Control instruction "MC_MoveVelocity", you can specify the reaching of a velocity/speed setpoint. This velocity/speed is maintained until the job is canceled or an error occurs.

Status evaluation

The reaching of the velocity/speed setpoint can be tracked at the "InVelocity" parameter.

If the "InVelocity" parameter shows the value "TRUE", the velocity/speed setpoint has been reached. The axis continues moving at this constant velocity. The "InVelocity" and "Busy" parameters show the value "TRUE" until the "MC_MoveVelocity" job is overridden by another Motion Control job.

Example

An "MC_MoveVelocity" job is started with a positive edge at the "Execute" parameter. The job objective is fulfilled when the configured velocity has been reached and the axis moves with constant velocity. The reaching and maintaining of the configured velocity is indicated at the "InVelocity" parameter with the value "TRUE".

The configured velocity is reached and maintained

The reaching of the configured velocity is indicated at the "InVelocity" parameter with the value "TRUE". The "Execute" parameter has no effect on the indication duration at the "InVelocity" parameter.

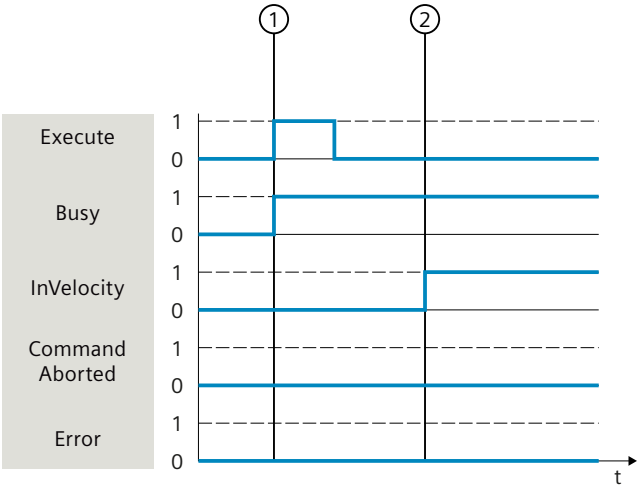

1	The job is started with a positive edge at the "Execute" parameter. Depending on the programming, "Execute" can be reset to the value "FALSE" before the configured velocity is reached or only afterward. While the job is being executed, the "Busy" parameter shows the value "TRUE".
2	When the configured velocity is reached, the "InVelocity" parameter changes to "TRUE". The "Busy" and "InVelocity" parameters continue showing the value "TRUE" until another Motion Control job overrides the "MC_MoveVelocity" job.

6.8.2 Absolute or relative positioning of an axis

The positioning is executed as a controlled, relative or absolute traversing movement by the specified distance and dynamic parameters.

With the Motion Control instruction "MC_MoveRelative (Page 307)", you move an axis relative to its actual position setpoint when execution of the job began.

With the Motion Control instruction "MC_MoveAbsolute (Page 302)", you move an axis to an absolute position.

Defining the dynamics of the motion

You can define the dynamics of the axis movement at the corresponding Motion Control instructions.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_MoveAbsolute" or "MC_MoverRelative" to define the dynamic behavior for the movement:

- With the "Velocity" parameter, you define the velocity or speed with which the axis is moved.
- With the "Acceleration" parameter, you define the acceleration.
- With the "Deceleration" parameter, you define the deceleration.
- With the "Jerk" parameter, you define the jerk.

Observe the information in sections Configuring dynamic defaults (Page 115) and Velocity profile (Page 120).

Moving axis to an absolute target position

You can define the target position, the direction of movement and the distance of the axis movement at the corresponding Motion Control instructions.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_MoveAbsolute" to define the absolute target position of the axis movement:

- With the "Position" parameter, you define the desired absolute target position.
- With the "Direction" parameter, you define the direction of movement of the axis when the modulo function is activated. You can move the axis in the positive direction (1) or negative direction (2) or on the shortest path (3).

Observe the information in sections Modulo setting (Page 37) and Dynamic defaults for modulo axes (Page 119).

Moving axis to a relative target position

You can define the distance of the axis movement at the corresponding Motion Control instruction.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_MoveRelative" to define the relative target position of the axis movement:

- With the "Distance" parameter, you define the negative or positive distance by which the axis is to move relative to its start position. The start position is the current position setpoint of the axis.

Starting the job and tracking the motion status

You start the motion job with a positive edge at the "Execute" parameter (= TRUE). You can recognize the status of a motion job from the "Busy" parameters. When the job is issued, the "Busy" parameter is set to TRUE. As soon as the target position is reached and the job is complete, the "Busy" parameter is set to FALSE and the "Done" parameter is set to TRUE.

6.8.3 Defining the motion transition

You can actively abort the active motion sequence or attach the new motion to an active motion job in the case of a motion job with the Motion Control instruction "MC_MoveAbsolute (Page 302)", "MC_MoveRelative (Page 307)" or "MC_PositionProfile (Page 312)" .

Parameter inputs

You define the transition to the already active motion with the following parameter of the Motion Control instruction "MC_MoveAbsolute", "MC_MoveRelative" or "MC_PositionProfile":

- With the "BufferMode" parameter, you define the mode of the motion transition.

Abort motion

With the parameter "BufferMode" = 0, the active motion sequence is immediately aborted and the next motion job is executed.

Append motion

With the "BufferMode" = 1 parameter, the new motion is appended to the active motion. The active motion sequence is either an absolute or relative positioning motion or an axis motion which follows a time-based position profile. While the motion sequence is active, the next motion job can be started without time being critical. The active motion sequence is completed and the axis comes to a standstill. The next motion job is then executed.

6.8.4 Moving an axis relatively or absolutely with a time-based position profile

You start an axis motion which follows a time-based position profile with the Motion Control instruction "MC_PositionProfile (Page 312)" at the positioning axis or synchronous axis technology object. You specify the time-based position profile with a cam.

The cam profile defines the time-dependent position setpoint of a positioning axis or a synchronous axis.

- The X axis shows the time value in seconds.
- The Y axis shows the position value in the respective axis unit of measure.

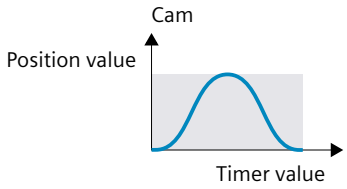

If you want to use a cam in combination with a time-based position profile, you can optionally activate the "Use cam as time-based position profile" check box in the configuration of the cam under "Profile > Effective runtime curves > General settings" in the "Settings of the leading axis" area.

The configured cam is not changed by this. The specifications for position range and time value range in the configuration of the technology object only affect the display in the graphical editor.

You can find more information on the configuration of the cam in the section "Configuration profile - Effective runtime curves" of the "S7-1500/S7-1500T Synchronous operation functions" documentation.

Requirements

- The cam is interpolated with an "MC_InterpolateCam" job.
- If you want to use a scaled cam or a range scaled cam, scale the cam via a "MC_SetCamRangeScaling" job.

Parameter inputs

You define the behavior of the axis for moving a time-based profile with the following parameters of the Motion Control instruction "MC_PositionProfile":

- With the "Axis" parameter, you define the technology object of the axis that traverses the positioning job with time-based position profile.
- With the "TimePosition" parameter, you define the cam technology object for the time-based position profile.
- With the "BufferMode" parameter, you define the transition between the currently effective motion and the time-based positioning motion. To do this, observe the information in section "Defining a motion transition (Page 141)".
- With the "StartTime" parameter, you define the start time of the time-based position profile with regard to the start time of the cam. The time value must lie within the definition of the cam.

- With the "ProfileReference" parameter, you define whether the traversing motion of the time-based position profile is relative or absolute.

  NOTE
  "Modulo" setting
  When the "Modulo (Page 37)" setting is activated in the absolute motion mode, the axis always travels the transition profile on the shortest route. Direction changes can occur in the process.

- With the "Velocity", "Acceleration", "Deceleration" and "Jerk" parameters, you specify the dynamics of the transition profile on the cam technology object.

Transition profile

A transition profile represents a defined motion profile that is used in the event of a discontinuous motion transition when an "MC_PositionProfile" job is started. It allows a continuous transition from the current motion state of the axis to the following time-based position profile.

The following cases require a transition profile:

- The position setpoint of the axis does not match with the start values of the cam profile.
- The setpoint dynamics of the axis does not match with the start values of the cam profile.

After the "MC_PositionProfile" job has started, a transition profile for the axis is calculated. The transition profile is calculated based on the following parameters:

- Specified start time of the time-based position profile "StartTime" at the Motion Control instruction
- Specified traversing motion "ProfileReference" at the Motion Control instruction
- Specified dynamics at the Motion Control instruction
- Current position and dynamics of the axis at the start time of the motion job
- Time-based position profile specified via the cam

The length of the transition profile and thus the start position of the time-based position profile results from the calculation.

Until the start position is reached, the axis is in the state "<TO>.StatusWord2.X9 (PositionProfileCommand) = TRUE" and "<TO>.StatusWord2.X10 (OnProfile) = FALSE".

As soon as the axis of the start position of the time-based position profile is reached, the active status "OnProfile" is displayed at the axis and the axis traverses in accordance with the cam profile.

If the axis is ready at the start of the "MC_PositionProfile" job to traverse the time-based position profile immediately, the "OnProfile" status is active directly.

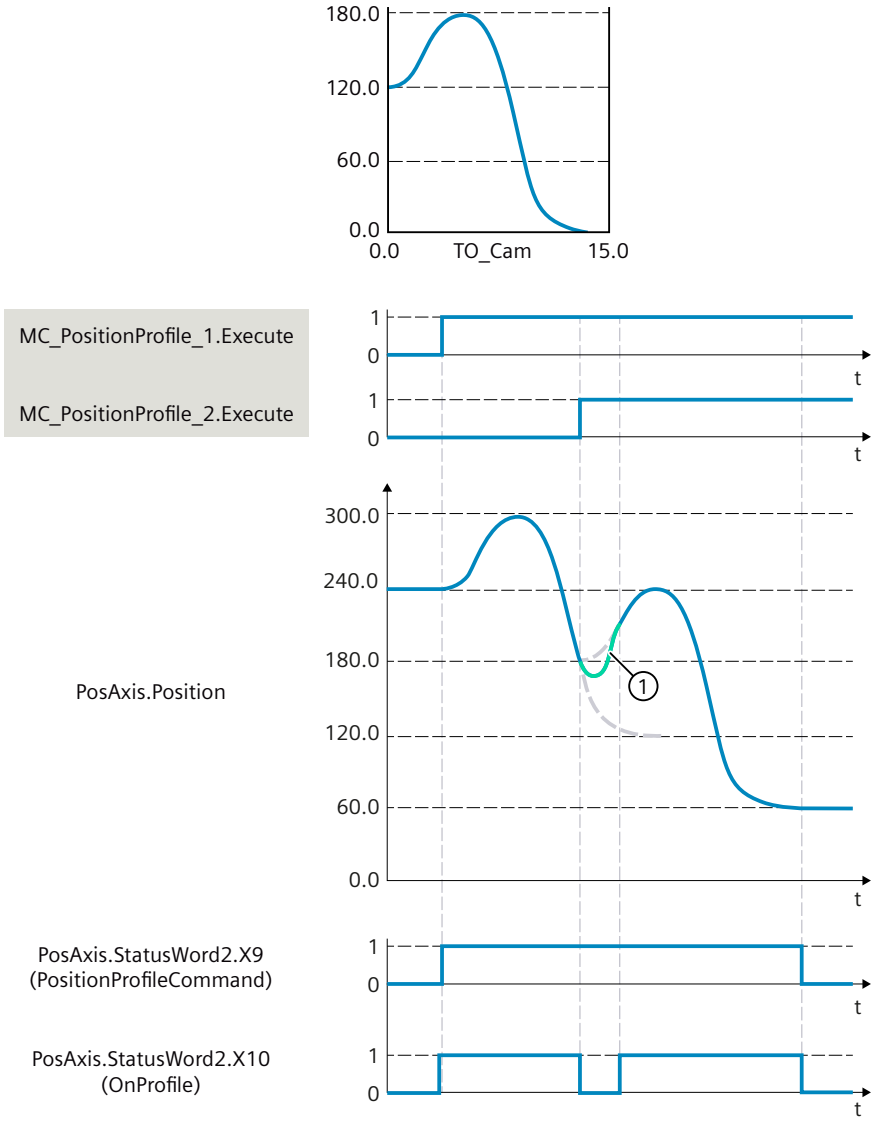

① Transition profile with defined dynamics for constant profile connection

Dynamic limits

If an "MC_PositionProfile" job at a positioning axis or a synchronous axis is active, the following dynamic limits apply:

- <TO>.DynamicLimits.MaxVelocity
- <TO>.DynamicLimits.MaxAcceleration
- <TO>.DynamicLimits.MaxDeceleration
- <TO>.DynamicLimits.MaxJerk

Dynamic limits when traversing the transition profile

If the dynamics programmed via the input parameters for the dynamics of the transition profile is greater than the maximum dynamics of the axis when the "Execute" parameter is set, the corresponding technology alarms 501, 502, or 503 are output at the positioning axis or synchronous axis.

Dynamic limits when traversing the time-based position profile

If the dynamics programmed in the technology object cam is greater than the maximum dynamics of the axis when the "Execute" parameter is set, the corresponding technology alarms 501, 502, or 503 are output at the positioning axis or synchronous axis.

In the case of a dynamics limitation, the axis is in the state "<TO>.StatusWord2.X9 (PositionProfileCommand) = TRUE" and "<TO>.StatusWord2.X10 (OnProfile) = FALSE".

Status indicators

The "<TO>.StatusWord2.X9 (PositionProfileCommand)" tag is set when an "MC_PositionProfile" job is active.

The "<TO>.StatusWord2.X10 (OnProfile)" tag is set to "TRUE", if an "MC_PositionProfile" job is active and the axis follows the setpoint values of the cam profile.

6.8.5 Jogging an axis

With the Motion Control instruction "MC_MoveJog (Page 326)", you move an axis in jog mode.

Parameter inputs for the dynamics of the motion and the direction of movement

You use the following parameters of the Motion Control instruction "MC_MoveJog" to define the dynamic behavior for the movement:

- With the "Velocity" parameter, you specify the velocity setpoint or speed setpoint. In contrast to "MC_MoveAbsolute" and "MC_MoverRelative", the value setting = 0.0 is allowed.
- With the "Acceleration" parameter, you define the acceleration.
- With the "Deceleration" parameter, you define the deceleration.
- With the "Jerk" parameter, you define the jerk.
- With the "JogForward" and "JogBackward" parameters, you define the direction of movement of the axis.

NOTE

Response to an override change

If the velocity/speed during the constant movement is affected by an override change (<TO>.Override.Velocity), the "InVelocity" parameter is reset during the acceleration or deceleration. When the newly calculated velocity is reached ("Velocity" × "Override" %), "InVelocity" is set again.

Observe the information in sections Configuring dynamic defaults (Page 115) and Velocity profile (Page 120).

Behavior when velocity/speed setpoint is zero ("Velocity" = 0.0)

An "MC_MoveJog" job with "Velocity" = 0.0 stops the axis with the configured deceleration. When the velocity/speed setpoint zero is reached, the "InVelocity" parameter shows the value "TRUE".

Under "Technology object > Diagnostics > Status and error bits > Motion status", the motion status values "Constant velocity" and "Standstill" are indicated (<TO>.StatusWord.X12 (ConstantVelocity); <TO>.StatusWord.X7 (Standstill)).

Switching a position-controlled operation on or off

During an active motion job, the axis can be operated in position-controlled mode or not in position-controlled mode.

Closed loop position control is applicable only for the positioning axis and synchronous axis.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_MoveJog" to define the operating mode of the axis movement:

- With the "PositionControlled" parameter, you switch the position control on or off.

Observe the information in section Switching the position control off and on (Page 242).

Position-controlled mode

As soon as the "MC_MoveJog" job with "PositionControlled" = TRUE takes effect, the axis is switched to position-controlled mode.

A superimposed motion, e.g. with a "MC_MoveSuperimposed" job, and the travel to fixed stop are only possible in position-controlled mode.

Not in position-controlled mode

As soon as the "MC_MoveJog" job with "PositionControlled" = FALSE takes effect, the axis is switched to not in position-controlled mode.

Tracking of "MC_MoveJog" jobs

With the Motion Control instruction "MC_MoveJog", you can specify the reaching of a velocity/speed setpoint. The setpoint velocity/speed is maintained until the job is aborted, an error occurs or the "JogForward" or "JogBackward" parameter is set to the value "FALSE".

Status evaluation

The reaching of the velocity/speed setpoint can be tracked at the "InVelocity" parameter.

If the "InVelocity" parameter shows the value "TRUE", the velocity/speed setpoint has been reached. The axis continues moving at this constant velocity. The "InVelocity" and "Busy" parameters show the value "TRUE" until the "MC_MoveJog" job is overridden by another Motion Control job or the "JogForward" or "JogBackward" parameter is set to the value "FALSE".

Example

An "MC_MoveJog" job is started by setting the "JogForward" or "JogBackward" parameter. The job objective is fulfilled when the configured velocity has been reached and the axis moves with constant velocity. The reaching and maintaining of the configured velocity is indicated at the "InVelocity" parameter with the value "TRUE".

The job is complete when the "JogForward" or "JogBackward" parameter has been set to the value "FALSE" and the axis has come to a standstill.

The configured velocity is reached and maintained

If the Motion Control job has been executed up to the point that the configured velocity is reached, this is indicated at the "InVelocity" parameter with the value "TRUE".

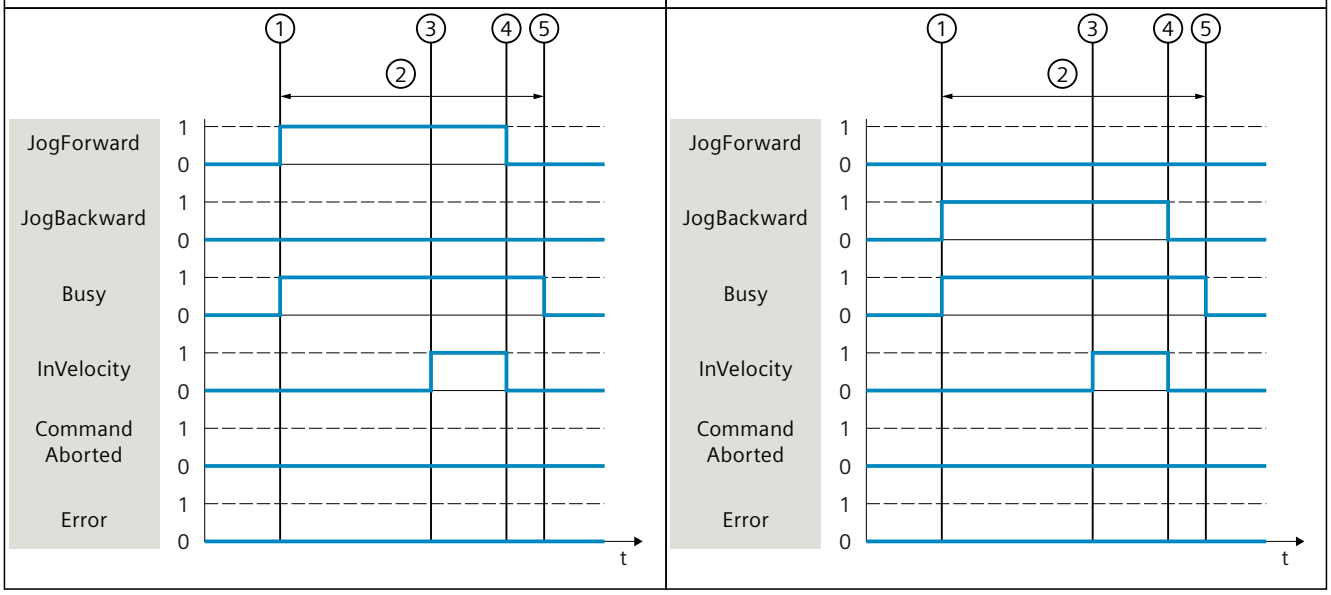

①	The job is started by setting the "JogForward" or "JogBackward" parameter.
②	While the job is being executed, the "Busy" parameter shows the value "TRUE".
③	When the configured velocity is reached, the "InVelocity" parameter changes to "TRUE".
④	When the "JogForward" or "JogBackward" parameter is reset, the movement of the axis ends. The axis decelerates. The "InVelocity" parameter changes to "FALSE".
⑤	If the axis has come to a standstill, the Motion Control job is complete and the "Busy" parameter changes to "FALSE".

6.9 Stopping motions

You can stop the technology object yourself, or the technology object is disabled with one of the following alarm responses (Page 158) when an error occurs:

- "Remove enable"
- "Stop with current dynamic values"
- "Stop with maximum dynamic values"
- "Stop with emergency stop ramp"

If a motion must be canceled, you can perform the following measures:

- Execute "MC_Halt (Page 168)" or "MC_Stop (Page 170)"

  To cancel a motion and stop the axis, you can use an "MC_Halt" or "MC_Stop" job.
- Disable "MC_Power (Page 149)"

  In an emergency, you can stop the axis via an emergency stop ramp. To do this, you set the "Enable" parameter of the "MC_Power" job to "FALSE". The axis is decelerated according to the selected "StopMode" and all jobs of the technology object are canceled.

6.9.1 Disabling the technology object

With the Motion Control instruction "MC_Power", you disable the technology object or switch off the configured drive.

All current jobs at the technology object are canceled in accordance with the configured "StopMode".

The technology object matches the setpoint to the actual value.

The following stop modes are available for selection:

- Emergency stop ("MC_Power.StopMode" = 0) (Page 150)
- Fast stop ("MC_Power.StopMode" = 1) (Page 152)
- Stop with maximum dynamic values ("MC_Power.StopMode" = 2) (Page 154)
- Coast down ("MC_Power.StopMode" = 3) (Page 156)

The configuration of the stop modes is applicable for the positioning axis, speed axis and synchronous axis.

Parameter inputs

You use the following parameters of the Motion Control instruction"MC_Power" to disable the technology object:

- With the "StopMode" parameter, you configure the braking operation.
- By setting the "Enable" parameter = FALSE, you disable the technology object. All running jobs are canceled and the technology object is brought to a standstill.

When the "Busy" and "Status" output parameters show the value "FALSE", the disabling of the technology object is complete and, if necessary, a configured drive has been switched off.

Disabling the drive

- If the drive was connected via PROFIdrive, the drive is disabled according to the PROFIdrive standard. You can find more detailed information on the connection of PROFIdrive-drives in section Connecting PROFIdrive drives (Page 57).
- If the drive was connected with an analog drive connection, the enable output is set to "FALSE" when setpoint zero is reached. You can find more detailed information on the analog drive connection in section Connecting drives with analog setpoint interface (Page 73).

See also

MC_Power V10 (Page 286)

6.9.1.1 Disabling the technology object with emergency deceleration ("StopMode" = 0)

Basics

The axis is decelerated and brought to a standstill with the configured emergency deceleration without jerk limiting. The drive is then switched off and the technology object is disabled. (<TO>.DynamicDefaults.EmergencyDeceleration)

For information on configuring the emergency deceleration, see section Emergency deceleration (Page 123).

Parameter inputs

MC_Power.Axis = <TO_SpeedAxis>, <TO_PositioningAxis>, <TO_SynchronousAxis>

MC_Power.Enable = FALSE

MC_Power.StopMode = 0

Function diagrams

The following function diagram shows the disabling of a technology object with **drive connection via PROFIdrive** and "StopMode" = 0:

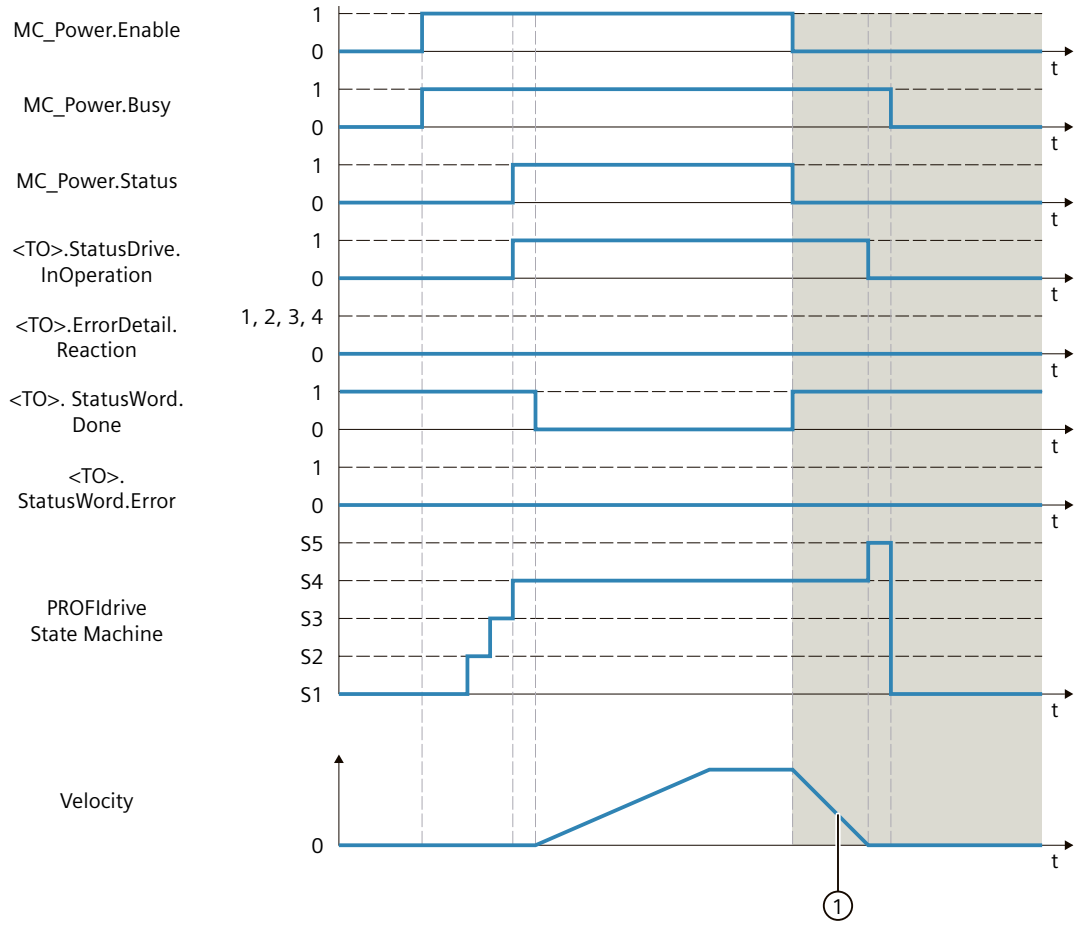

① The axis is decelerated with the configured emergency deceleration.

The following function diagram shows the disabling of a technology object with **analog drive connection** and "StopMode" = 0:

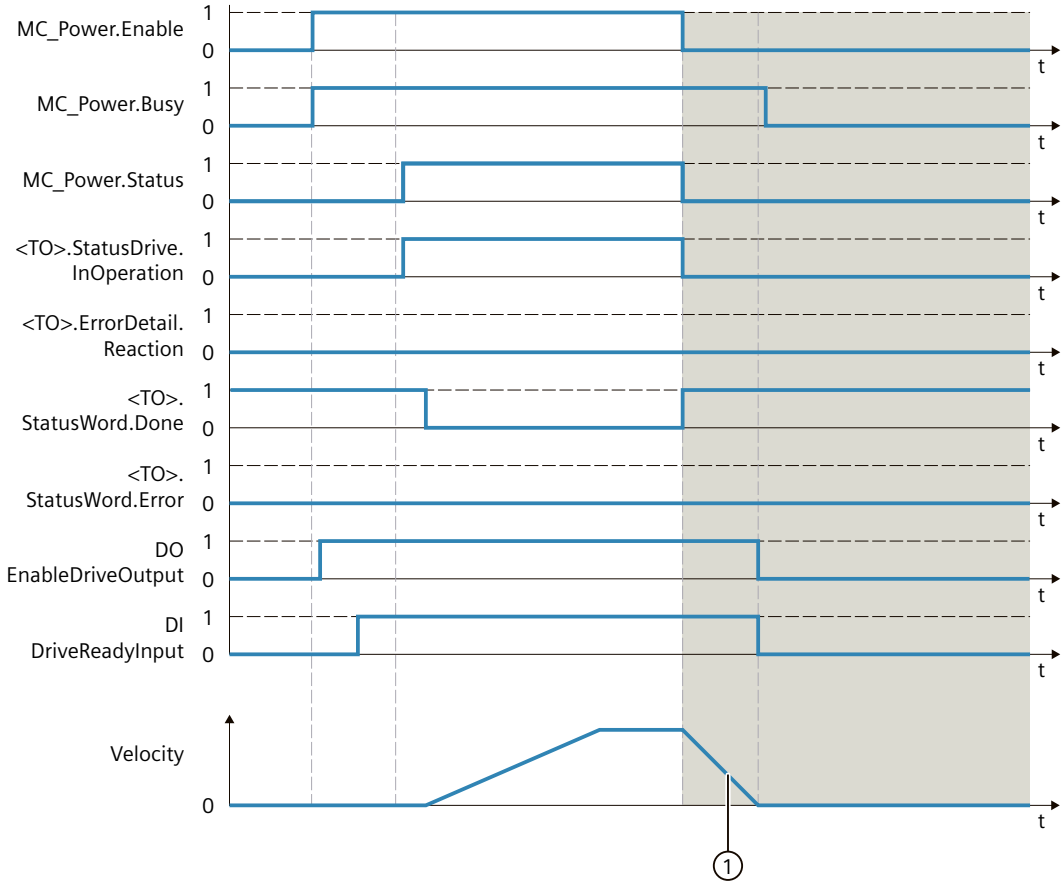

① The axis is decelerated with the configured emergency deceleration.

6.9.1.2 Disabling a technology object with fast stop ("StopMode" = 1)

Basics

The speed setpoint zero is output. The axis is decelerated and brought to a standstill according to the "p1135" parameter ("OFF3 Ramp-down time") in the drive. The drive is then switched off and the technology object is disabled. OFF1 and OFF2 are reset.

Parameter inputs

MC_Power.Axis = <TO_SpeedAxis>, <TO_PositioningAxis>, <TO_SynchronousAxis>

MC_Power.Enable = FALSE

MC_Power.StopMode =1

Function diagrams

The following function diagram shows the disabling of a technology object with **drive connection via PROFIdrive** and "StopMode" = 1:

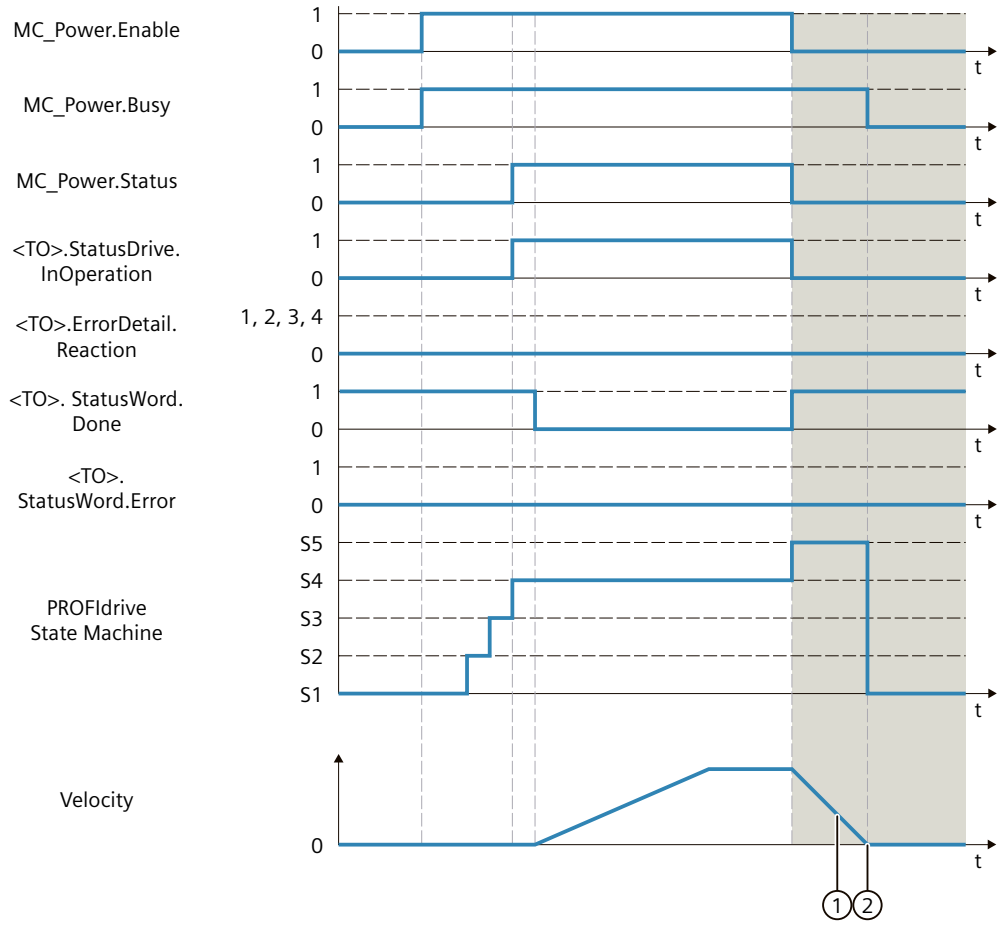

① The braking ramp is specified using the parameter "P1135" (OFF3).

② After stopping, a pulse inhibit occurs. The status changes to "Ready to start". OFF1 and OFF2 are reset.

The following function diagram shows the disabling of a technology object with **analog drive connection** and "StopMode" = 1:

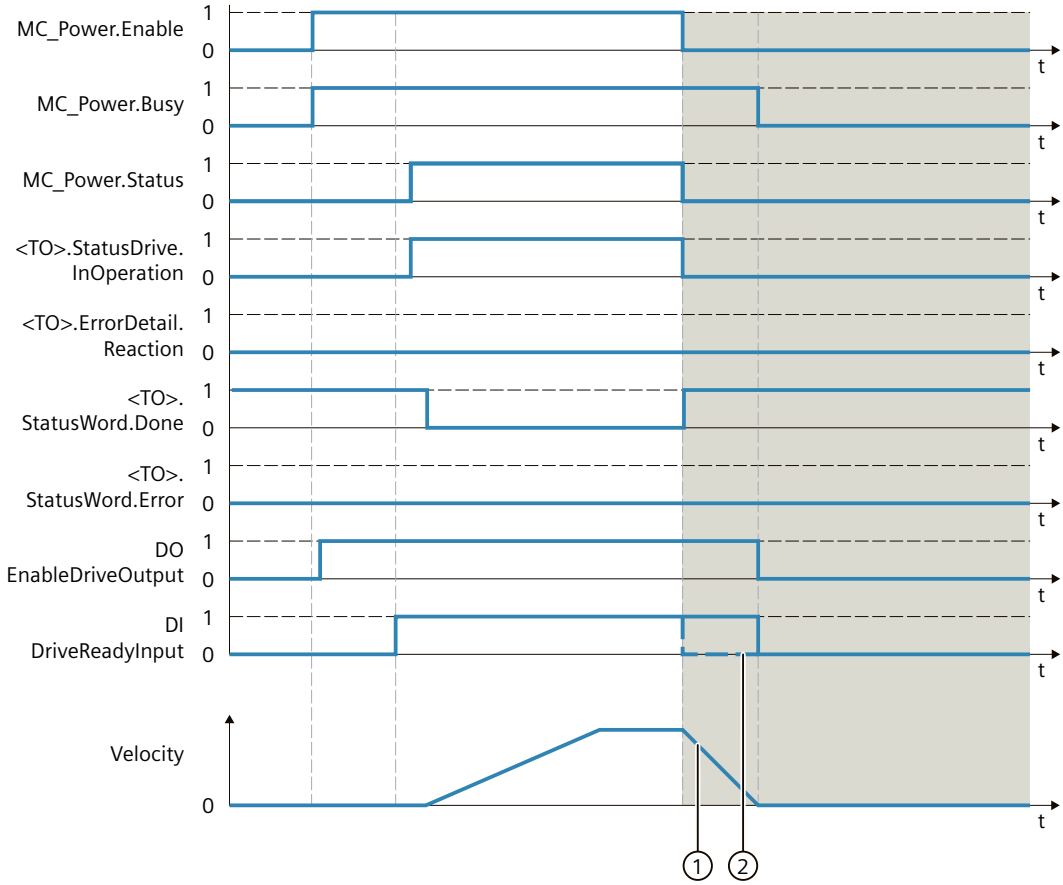

① The braking ramp depends on the configuration in the drive.

② The behavior of the ready signal of the drive "DI DriveReadyInput" is manufacturer-specific.

6.9.1.3 Disabling a technology object with maximum dynamic values ("StopMode" = 2)

Basics

The axis is decelerated and brought to a standstill with the configured maximum deceleration. In so doing, the configured maximum jerk is taken into account. The drive is then switched off and the technology object is disabled.

For information on configuring the deceleration with maximum dynamic limits, see section Limiting the dynamics (Page 117).

Parameter inputs

MC_Power.Axis = <TO_SpeedAxis>, <TO_PositioningAxis>, <TO_SynchronousAxis>

MC_Power.Enable = FALSE

MC_Power.StopMode = 2

Function diagrams

The following function diagram shows the disabling of a technology object with **drive connection via PROFIdrive** and "StopMode" = 2:

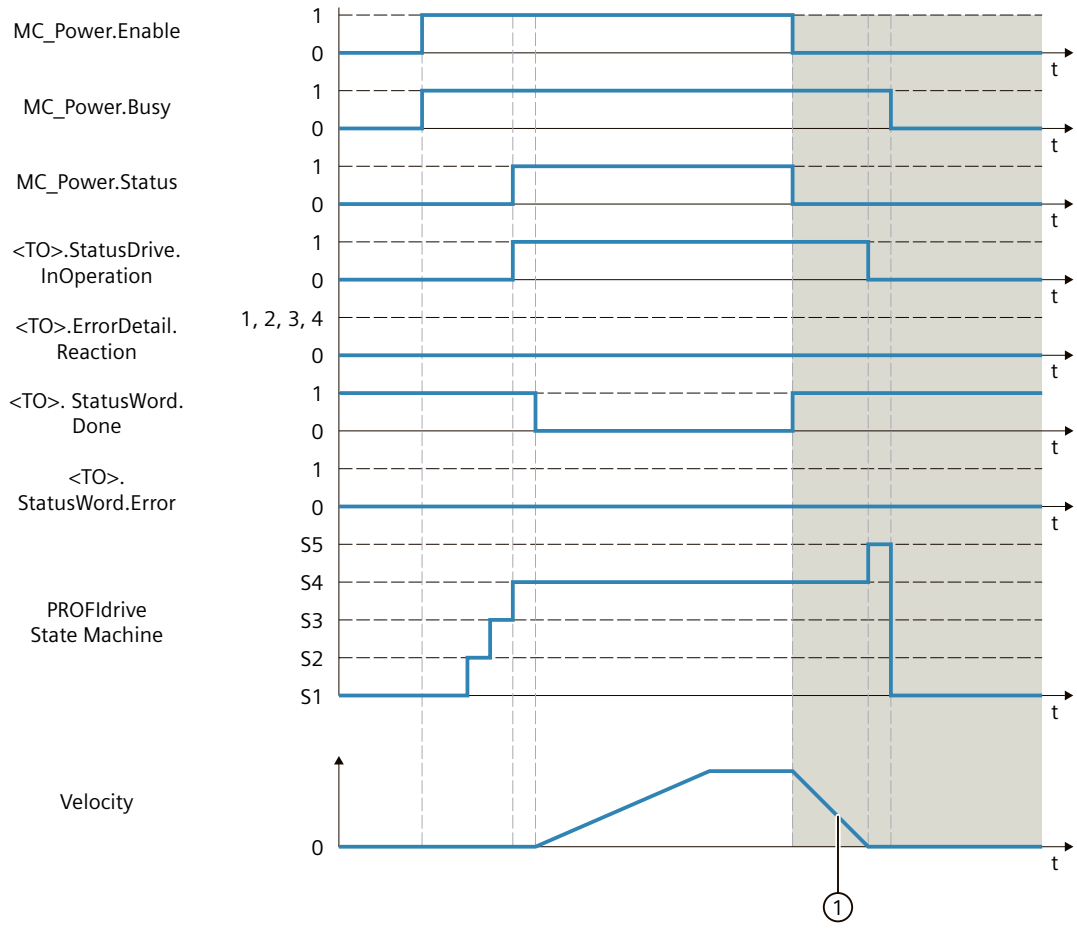

① The axis is decelerated with the configured maximum deceleration.

The following function diagram shows the disabling of a technology object with **analog drive connection** and "StopMode" = 2:

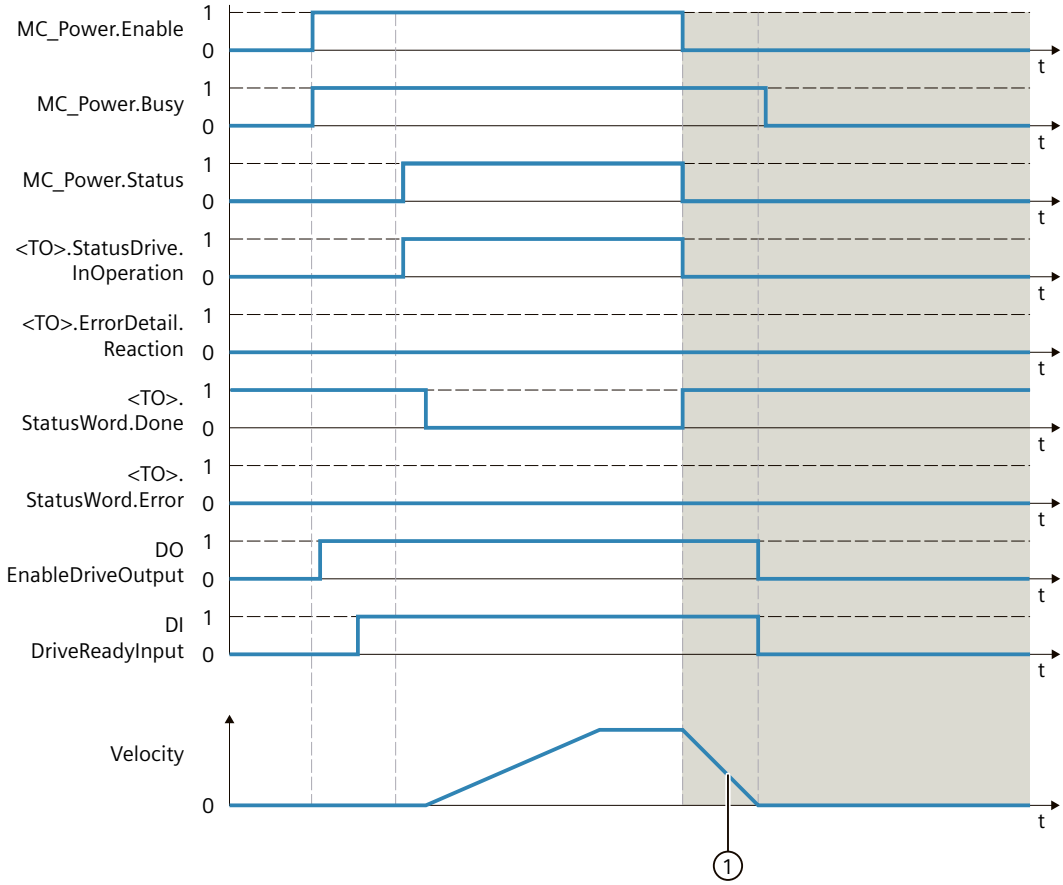

① The axis is decelerated with the configured maximum deceleration.

6.9.1.4 Disabling a technology object with coast down ("StopMode" = 3)

Basics

The drive is de-energized (pulse inhibit) and changes to the closing lockout state. The drive then coasts to a stop.

If you are using a drive with an analog setpoint interface, the enable output is disabled and the analog output signal is set to 0.0.

NOTE

Use of drives with motor holding brake

With pulse inhibit, the drive gives the command to close the motor holding brake immediately and independently of the motor speed. If you do not want the brake to close, make sure to keep the brake open with the FB "LAxisCtrl_BrakeControl". Library "LAxisCtrl (https://support.industry.siemens.com/cs/ww/en/view/109749348)".

Parameter inputs

MC_Power.Axis = <TO_SpeedAxis>, <TO_PositioningAxis>, <TO_SynchronousAxis>

MC_Power.Enable = FALSE

MC_Power.StopMode = 3

Function diagrams

The following function diagram shows the disabling of a technology object with **drive connection via PROFIdrive** and "StopMode" = 3:

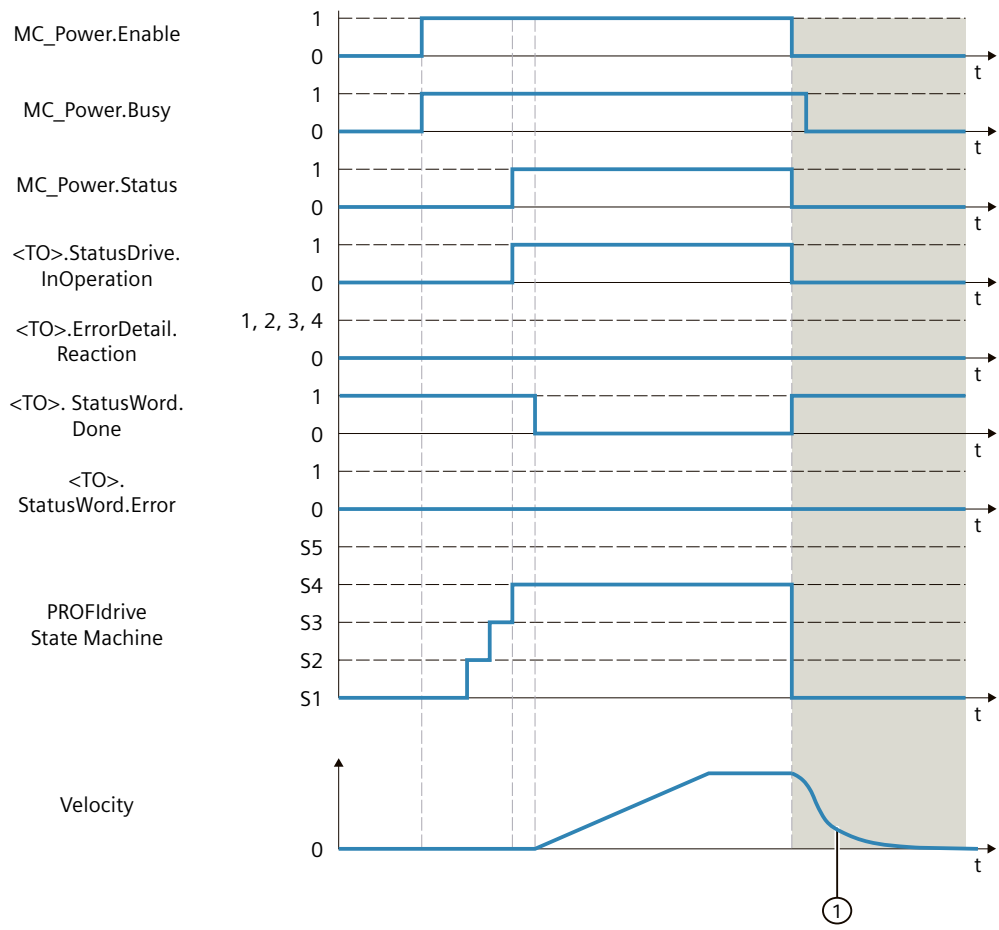

① The drive coasts to a stop. The behavior depends on the mechanical circumstances.

The following function diagram shows the disabling of a technology object with **analog drive connection** and "StopMode" = 3:

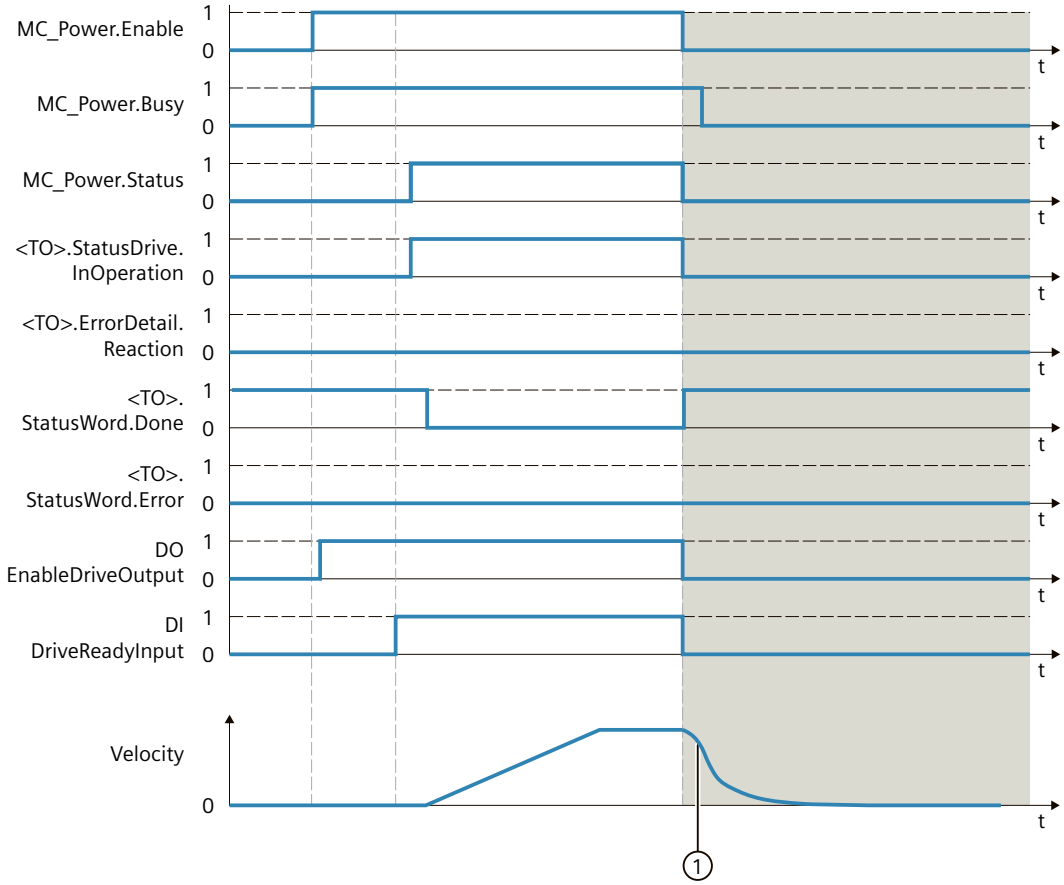

① The drive coasts to a stop. The behavior depends on the mechanical circumstances.

6.9.2 Disabling of the technology object in case of alarm responses

A technology alarm always leads to an alarm response, which describes the effect on the technology object. The alarm response is specified by the system. The technology object is disabled when any of the following alarm responses occurs:

- Alarm response "Remove enable (Page 159)" (<TO>.ErrorDetail.Reaction=4)
- Alarm response "Stop with current dynamic values (Page 165)" (<TO>.ErrorDetail.Reaction=1)
- Alarm response "Stop with maximum dynamic values (Page 165)" (<TO>.ErrorDetail.Reaction=2)
- Alarm response "Stop with emergency stop ramp (Page 165)" (<TO>.ErrorDetail.Reaction=3)

When the technology object is disabled, "MC_Power.Enable" and "MC_Power.Busy" remain set to TRUE.

The technology object is disabled in accordance with the alarm response. Since the axis is not disabled with "MC_Power.Enable" = FALSE, the selected "MC_Power.StopMode" is not relevant for the alarm response.

You can find more detailed information on technology alarms in document "S7-1500/S7-1500T Motion Control alarms and error IDs".

See also

Override behavior between alarm responses and "MC_Stop" (Page 171)

6.9.2.1 Disabling of the technology object with the alarm response "Remove enable"

When an error with the alarm response "Remove enable" occurs at the technology object, the technology object is disabled (<TO>.ErrorDetail.Reaction = 4). Running motion commands are canceled.

In the case of technology alarms with the "Remove enable" response, axes with drive connection via PROFIdrive stop according to the configured stop mode and the drive configuration.

The configuration is available for the positioning, speed, and synchronous axis. The configuration is not relevant for the virtual axis and the axis in simulation.

Overview of stop modes

- Ramp stop (OFF1) - STW1 Bit 0 = 0

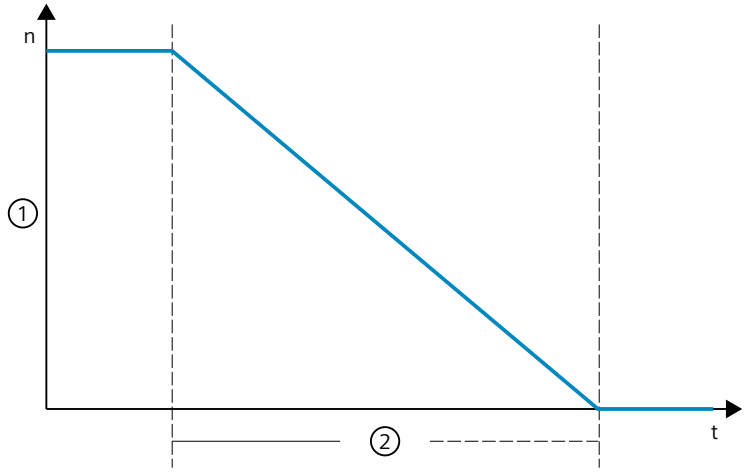

① Maximum drive speed

② OFF1 ramp-down time

– The drive moves to speed "0.0" with the deceleration configured at the drive (parameter "p1121 - Ramp-function generator ramp-down time").

– The stop process can be interrupted

– After stopping, a pulse inhibit occurs and the status changes to "Ready to start"

- Coast stop (OFF2) - STW1 Bit 1 = 0

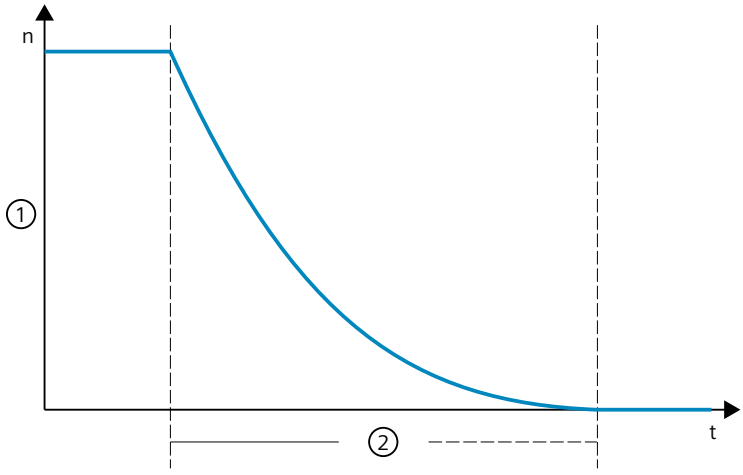

① Current speed
② Coasting down

– The drive deletes the pulses and the status changes to "closing lockout".
– The drive is switched off and coasts to a stop.
– The stop process cannot be interrupted.

- Quick stop (OFF3) - STW 1 Bit 2 = 0

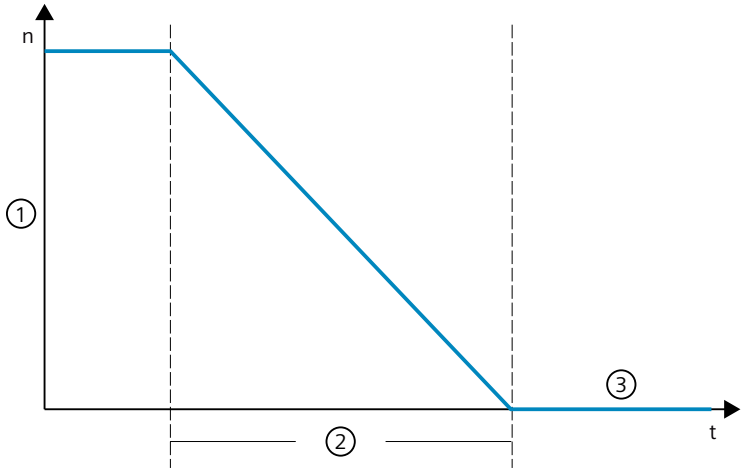

① Maximum drive speed
② OFF3 ramp-down time
③ Closing lockout (OFF1, OFF2)

– The drive moves to the stop with the deceleration configured on the drive speed "0.0" (parameter "p1135 - OFF3 ramp-down time").
– The stop process cannot be interrupted.
– After stopping, a pulse inhibit occurs and the status changes to "Closing lockout".

Configure stop mode for alarm response "Remove enable"

To set the stop mode, proceed as follows:

- Configure the stop mode in the technology object configuration under "Extended parameters > Alarm responses".
- Alternatively, write the stop mode to the load memory of the technology object in the user program (<TO>.Actor.RemoveEnableReaction) with the "WRIT_DBL" instruction. Call the Motion Control instruction "MC_Reset" and apply the change by setting the "Restart" parameter = TRUE.

The following table shows the corresponding alarm response depending on the configuration:

Configuration				
OFF3	**OFF2**	**OFF1**	**"<TO>.Actor.RemoveEnableReaction"**	**Stop mode for alarm response "Remove enable"**
1	1	1	16#7	OFF3 – Quick stop (compatible configuration for technology versions up to V7) Default setting
1	0	1	16#5	OFF3 – Quick stop
0	1	1	16#3	OFF2 – Coast stop
0	0	1	16#1	OFF1 – Ramp stop

To change the "Actor.RemoveEnableReaction" tag directly in the user program, follow these steps:

1. Define a tag for the "Remove enable" alarm response of the data type "WORD" in a data block. Name the tag, e.g. "MyRemoveEnableReaction":

Name	Data type	Start value
MyRemoveEnableReaction	WORD	16#7

2. Call the instruction "MC_WriteParameter (Page 346)":
   - Enter the value 1020 at the "ParameterNumber" input parameter.
   - Assign the "MyRemoveEnableReaction" tag to the "Value" input parameter.
   - Assign the associated technology object at the "Axis" input parameter.
3. Assign the value of the desired stop response to the tag "MyRemoveEnableReaction" (16#1, 16#3, 16#5, 16#7).
4. Start the job with a positive edge at the "Execute" input parameter.

Result

The "Done" output parameter signals that the change has been applied. The "Actor.RemoveEnableReaction" tag shows the changed value.

Procedure for enabling the axis

To enable the axis again after the alarm response, follow these steps:

1. Do not call "MC_Power" while the stop response is active. For this, evaluate "ErrorDetails.Reaction" = 4.

   If the alarm is acknowledged and "MC_Power" is called during the braking ramp, this can lead to undesirable compensating movements.

2. Acknowledge the alarm when the drive is at a standstill.

   You can use, for example, the standstill signal (Page 225) (<TO>.StatusWord.X7(Standstill)) to detect the standstill.

3. To enable the axis again, call "MC_Power" with the input "Enable" = TRUE.

Note the following if you set a value other than 16#7 (default setting) as the alarm response in "RemoveEnableReaction":

- Disabling the axis while alarm response "RemoveEnable" is active ("ErrorDetails.Reaction" = 4) with "MC_Power.Enable" = FALSE leads to AUS2 (coast-down) of the axis irrespective of the "StopMode".

Note the following if you set 16#7 (default setting) as the alarm response in "RemoveEnableReaction":

- An active AUS3 ramp cannot be interrupted until the drive reaches a standstill. The axis is disabled after reaching a standstill.

Function diagrams

The following function diagram shows the configured stop response of the drive with alarm response "Remove enable" for a drive with **drive connection via PROFIdrive**:

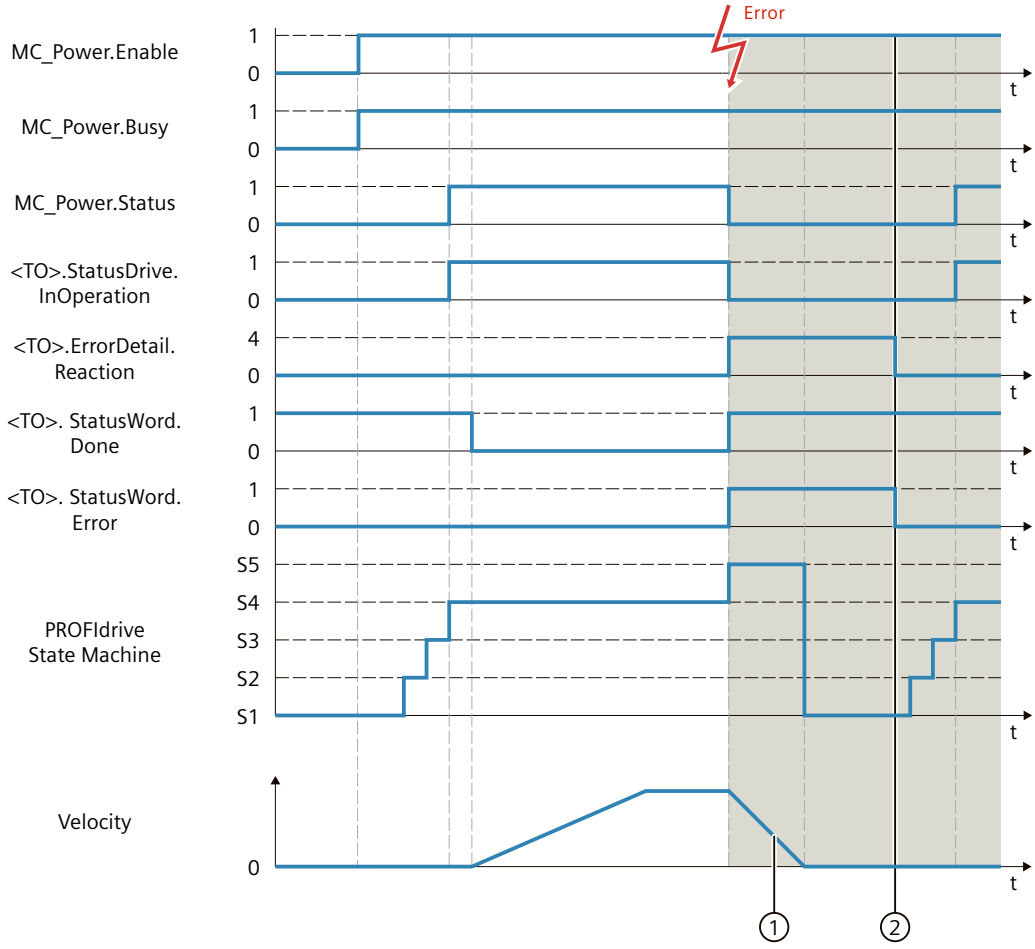

① The configured stop response of the drive (OFF1, OFF2, OFF3) determines the braking behavior. You configure the braking ramp for OFF1 and OFF3 in the drive. In this example, OFF3 is active as the stop response: "<TO>.Actor.RemoveEnableReaction" = 16#7

② The technology alarm is acknowledged at time ②.

The following function diagram shows the configured stop response of the drive with alarm response "Remove enable" for a drive with **analog drive connection:**

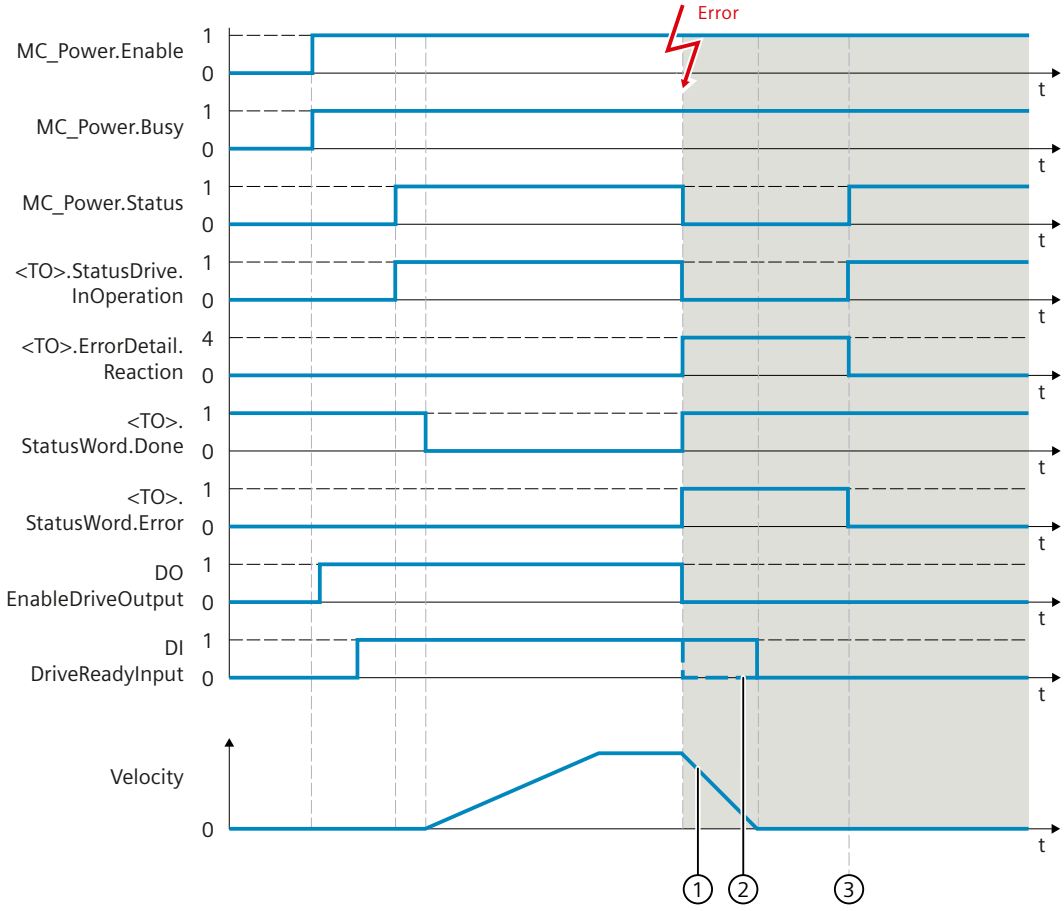

① The braking ramp depends on the configuration in the drive.

② The behavior of the ready signal of the drive "DI DriveReadyInput" is manufacturer-specific.

③ The technology alarm is acknowledged at time ③.

More information

You can find more information on PROFIdrive with using state machines as well as control and status words at Siemens Industry Online Support in the FAQ entry 109770665 (https://support.industry.siemens.com/cs/ww/en/view/109770665).

6.9.2.2 Disabling of the technology object in case of alarm responses with braking ramp

Basics

When an error with the alarm response "Stop with current dynamic values", "Stop with maximum dynamic values" or "Stop with emergency stop ramp" occurs at the technology object, the technology object is disabled (<TO>.ErrorDetail.Reaction = 1,2,3). Running motion commands are canceled.

Stop with current dynamic values

In the case of alarm response "Stop with current dynamic values" (<TO>.ErrorDetail.Reaction = 1), the axis is decelerated and brought to a standstill with the current dynamic values at the Motion Control instruction.

Stop with maximum dynamic values

In the case of alarm response "Stop with maximum dynamic values" (<TO>.ErrorDetail.Reaction = 2), the axis is decelerated and brought to a standstill with the configured maximum dynamic values.

For information on configuring the deceleration with maximum dynamic limits, see section Limiting the dynamics (Page 117).

Stop with emergency stop ramp

In the case of alarm response "Stop with emergency stop ramp" (<TO>.ErrorDetail.Reaction = 3), the axis is decelerated and brought to a standstill with the configured emergency deceleration without jerk limiting.

For a description of configuring the emergency deceleration, see section Emergency stop deceleration (Page 123).

Function diagrams

The following function diagram shows the stop response when a technology alarm occurs with braking ramp - **drive connection via PROFIdrive**:

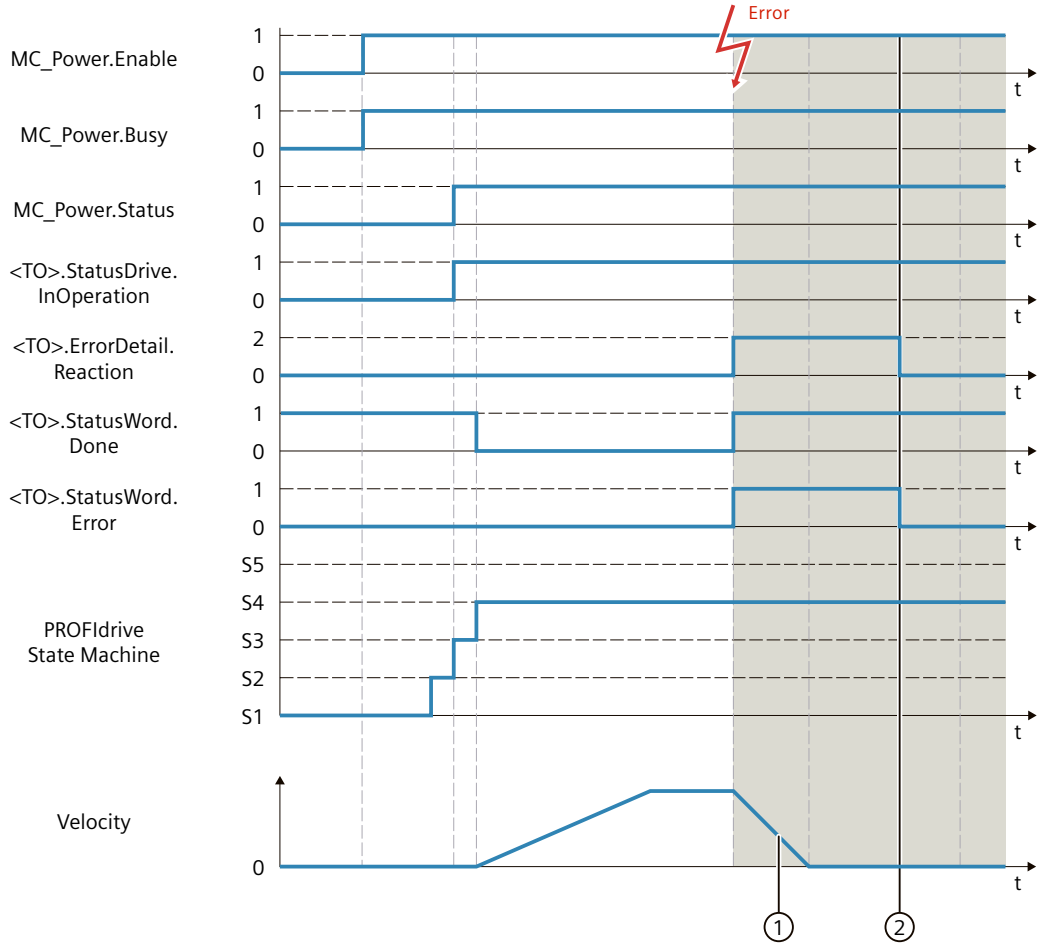

① The axis is decelerated according to the alarm response:
- Stop with current dynamic values (<TO>.ErrorDetail.Reaction = 1)
  The axis is decelerated with the current deceleration at the Motion Control instruction.
- Stop with maximum dynamic values (<TO>.ErrorDetail.Reaction = 2)
  The axis is decelerated with the configured maximum deceleration.
- Stop with emergency stop ramp (<TO>.ErrorDetail.Reaction = 3)
  The axis is decelerated with the configured emergency deceleration.

② The technology alarm is acknowledged.

The following function diagram shows the stop response when a technology alarm occurs with braking ramp - **analog drive connection**:

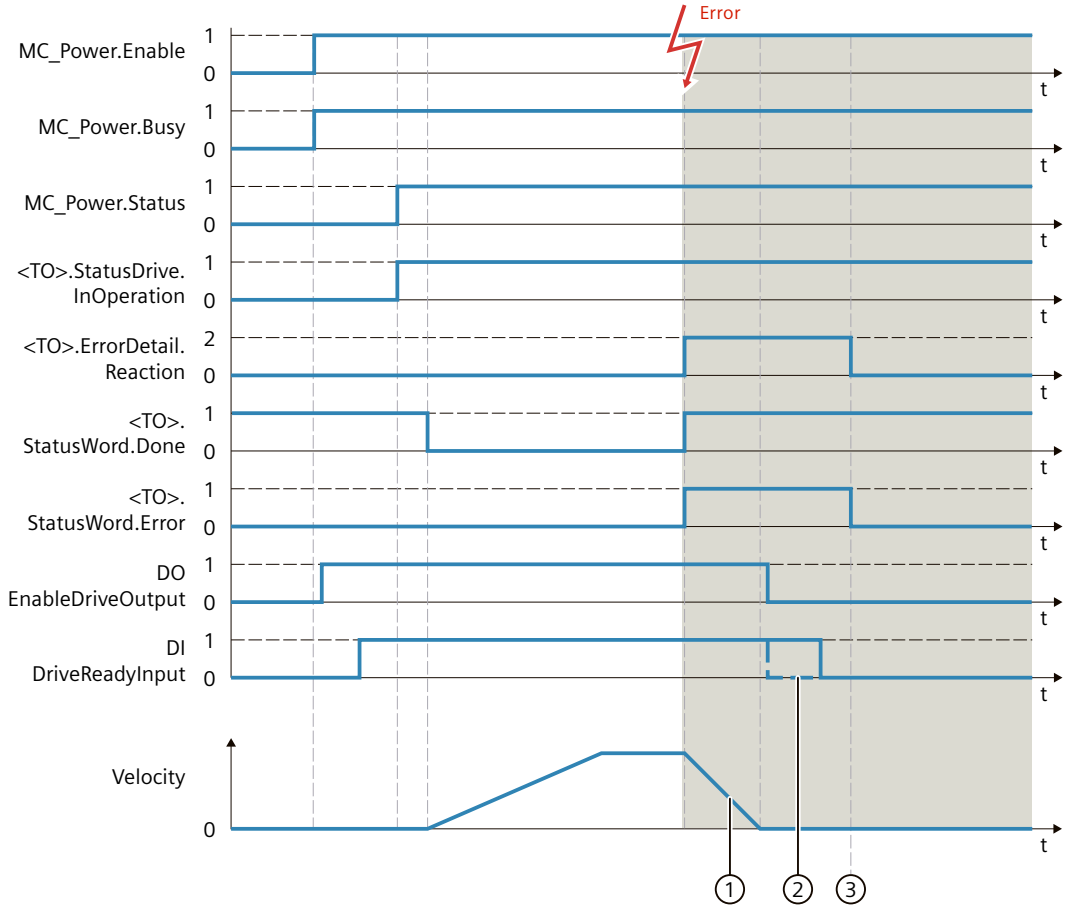

① The axis is decelerated according to the alarm response:
- Stop with current dynamic values (<TO>.ErrorDetail.Reaction = 1)
  The axis is decelerated with the current deceleration at the Motion Control instruction.
- Stop with maximum dynamic values (<TO>.ErrorDetail.Reaction = 2)
  The axis is decelerated with the configured maximum deceleration.
- Stop with emergency stop ramp (<TO>.ErrorDetail.Reaction = 3)
  The axis is decelerated with the configured emergency deceleration.

② The behavior of the ready signal of the drive "DI DriveReadyInput" is manufacturer-specific.

③ The technology alarm is acknowledged at time ③.

6.9.3 Stopping a technology object

You can cancel running motions and bring the axis to a standstill with Motion Control instruction "MC_Halt" or "MC_Stop" .

With "MC_Halt", you stop the axis, and the standstill position conforms to the settings of the dynamic values at the "Jerk" and "Decelaration" parameters.

With "MC_Stop", you stop the axis, and the standstill position conforms to the stop ramp you define with the "Mode" parameter.

Unlike with the Motion Control instruction "MC_Halt", new motion jobs for the technology object are prevented with the Motion Control instruction "MC_Stop".

6.9.3.1 Stopping a technology object with "MC_Halt"

To cancel a motion and stop the axis, you can use a Motion Control instruction "MC_Halt". New motion jobs are allowed with the "MC_Halt" job.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_Halt" to define the stopping of the technology object:

- With the "Execute" parameter, you start the job with a positive edge.
- With the "Deceleration" parameter, you define the deceleration.
- With the "Jerk" parameter, you define the jerk.
- With the "AbortAcceleration" parameter, you define the acceleration reduction during braking.
- With the "Mode" parameter, you define whether a superimposed motion, if active, is also to be stopped or not.

Stopping basic motion with superimposed/without superimposed motion

You can stop the basic motion with or without the superimposed motion as follows:

Stopping the basic motion

You stop the basic motion without affecting the superimposed motion with the "MC_Halt" Motion Control instruction and the parameter "Mode" = 1.

Stopping the basic motion and the superimposed motion

You stop both the basic motion and the superimposed motion with the "MC_Halt" Motion Control instruction and the parameter "Mode" = 0.

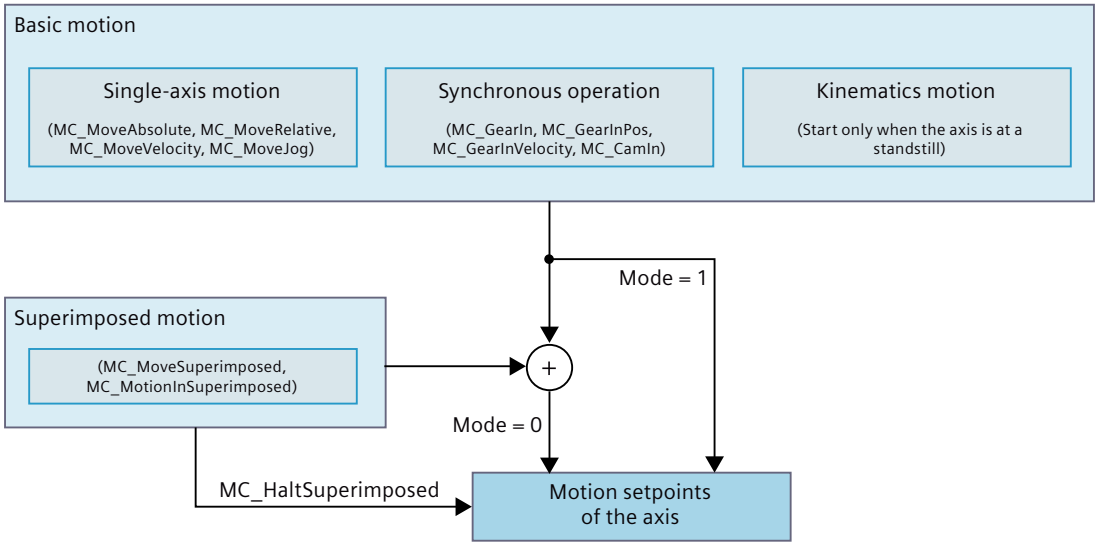

NOTE

Stopping the superimposed motion

With the "MC_HaltSuperimposed (Page 334)" Motion Control instruction, you stop a superimposed motion independently of the basic motion. The basic motion is still executed.

NOTE

Stopping an axis with active force/torque limit

To decelerate an axis with active force/torque limiting, use the Motion Control instruction "MC_Stop" with "Emergency stop" mode ("Mode" = 0).

See also

MC_Halt V10 (Page 296)

6.9.3.2 Stopping a technology object with "MC_Stop" and preventing new motion jobs

With the Motion Control instruction "MC_Stop", you stop all movements of an axis and prevent new motion jobs for the technology object. The axis decelerates to a standstill and remains switched on.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_Stop" to define the stopping of the technology object:

- With the "Execute" parameter, you start the job with a positive edge.
- With the "Deceleration" parameter, you define the deceleration.
- With the "Jerk" parameter, you define the jerk.
- With the "AbortAcceleration" parameter, you define the acceleration reduction during braking.
- With the "Mode" parameter, you define the dynamic behavior during braking.

Modes for the dynamic behavior

The standstill position is determined by the stop ramp. The following modes, which you define with the "Mode" parameter, are available for this purpose:

Decelerate technology object with emergency deceleration ("Mode" = 0)

The axis is decelerated and brought to a standstill with the configured emergency deceleration without jerk limiting. (<TO>.DynamicDefaults.EmergencyDeceleration)

For a description of configuring the emergency deceleration, see section Emergency stop deceleration (Page 123).

NOTE

Decelerating an axis with active force/torque limiting

To decelerate an axis with active force/torque limiting, use the "Emergency stop" mode ("Mode" = 0).

Decelerating a technology object with maximum dynamic values ("Mode" = 2)

The axis is decelerated and brought to a standstill with the configured maximum deceleration. In so doing, the configured maximum jerk is taken into account. (<TO>.DynamicLimits.MaxDeceleration,<TO>.DynamicLimits.MaxJerk)

For a description of configuring the deceleration with maximum dynamic limits, see section Limiting the dynamics (Page 117).

Decelerate technology object with specified dynamics ("Mode" = 3)

The axis is stopped with the specified values at the "Jerk" and "Decelaration" parameters.

Decelerating an axis with "MC_Stop"

Proceed as follows to decelerate an axis to a standstill:

1. Set the necessary values for the "Mode", "Deceleration", "Jerk" and "AbortAcceleration" parameters.
2. Start the "MC_Stop" job with a positive edge at the "Execute" parameter.

The current motion status is indicated at the "Busy", "Done" and "Error" parameters. The standstill of the axis is indicated under "Technology object > Diagnostics > Status and error bits > Motion status > Standstill" (<TO>.StatusWord.X7 (Standstill)).

As long as "Execute" = TRUE, the technology object cannot execute motion jobs.

See also

Override behavior between alarm responses and "MC_Stop" (Page 171)

MC_Stop: Stop axis and prevent new motion jobs V10 (Page 340)

6.9.4 Override behavior between alarm responses and "MC_Stop"

"MC_Stop" jobs and alarm responses with "Stop" or "Remove enable" can override each other. An alarm response or a configured stop mode with higher significance overrides.

"MC_Stop" jobs are rejected or overridden by alarm responses with higher significance with "CommandAborted" = TRUE. Unlike with other Motion Control instructions, "Error" = TRUE and "ErrorID" = 16#8001 are not output.

Alarm responses with stop can by overridden by "MC_Stop" jobs with higher significance.

The following table shows the significances of the stop mode at the "MC_Stop" job and the alarm responses:

Stop mode	MC_Stop.Mode	<TO>.ErrorDetail.Reaction	Significance
Remove enable	-	4	4
Emergency stop	0	3	3
Stop with maximum dynamic values	2	2	2
Stop with current dynamic values/stop with specified dynamics	3	2	1

Example 1

An alarm with "<TO>.ErrorDetail.Reaction" = 2 occurs. While the alarm is active, an "MC_Stop" job with "Mode" = 0 is sent.

Result: The stop with maximum dynamic values that was caused by the alarm is overridden by the emergency stop of the "MC_Stop" job. Once the axis has been decelerated to zero velocity by the emergency stop, the "MC_Stop" job outputs "Done" = TRUE.

Example 2

An MC_Stop job with Mode = 3 is active. During the active job, an alarm occurs with the alarm response "<TO>.ErrorDetail.Reaction" = 2.

Result: The stop of the "MC_Stop" job with specified dynamics is overridden by a stop with maximum dynamics caused by the alarm response. The "MC_Stop" job indicates "CommandAborted" = TRUE.

NOTE

Check the configuration of the dynamic limits and the emergency stop. Because an emergency stop has a higher significance, configure the emergency deceleration higher than or equal to the dynamic limits. In this way, you make sure that an overriding emergency stop does not reduce the dynamics of a stop with current or maximum dynamic values.

See also

Stopping a technology object with "MC_Stop" and preventing new motion jobs (Page 170)
Disabling of the technology object in case of alarm responses (Page 158)

6.9.5 Tags: Stopping motions

The following tag is relevant for stopping the technology object:

Alarm response	
Tag	**Description**
<TO>.Actor.RemoveEnableReaction	Stop modes of the drive for the alarm response "Remove enable": • OFF1 • OFF2 • OFF3

6.10 Traversing range limitation

Hardware and software limit switches limit the permissible traversing range and operating range of the positioning axis/synchronous axis. Before use, they must be enabled in the configuration or in the user program.

The following figure shows the relationship between the operating range, maximum traversing range and limit switches:

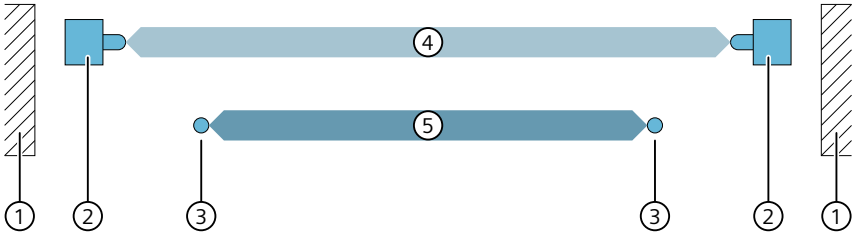

① Mechanical endstop
② Hardware limit switch (HW limit switch)
③ Software limit switch (SW limit switch)
④ Maximum traversing range
⑤ Operating range

Types of HW limit switches

The positioning axis/synchronous axis technology object supports the following types of HW limit switches.

- Switch traversable: Axis can move beyond HW limit switch. The HW limit switch is enabled when it is approached. When it is overtraveled, the HW limit switch is disabled once again.

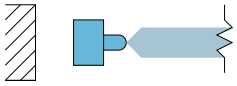

- Switch non-traversable: HW limit switch covers the entire range all the way to the mechanical endstop. The HW limit switch is enabled when it is approached and stays enabled up to the mechanical endstop.

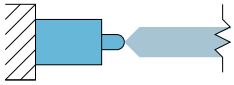

6.10.1 Behavior when approaching and retracting a HW limit switch

Hardware limit switches are limit position switches that limit the maximum permissible traversing range of the axis.

Select the mounting positions of the hardware limit switches so that there is adequate braking distance for the axis when needed. The axis should come to a standstill before a mechanical endstop.

Approaching the hardware limit switches

In the monitoring of range limitation, no distinction is made as to whether the switches are reached or crossed.

When a traversable hardware limit switch is approached, technology alarm 531 is output. The axis is disabled and stopped with the configured braking ramp.

When a non-traversable hardware limit switch is approached, technology alarm 531 is output and the configured alarm response is executed.

Using the hardware limit switches as reversing output cams during active homing

When hardware limit switches are used as reversing output cams during homing, monitoring of the hardware limit switches has no effect during active homing.

When hardware limit switches are used as reversing output cams, the axis is braked with the deceleration configured in the dynamic defaults.

When planning the distance between the hardware limit switch and mechanical endstop in the case of active homing, take into account the dynamic default of the deceleration and the approach velocity.

Direction reversal at the hardware limit switch (reversing output cam) (Page 202)

Retracting the axis with a traversable HW limit switch

In case of a traversable HW limit switch, the position of the axis when the hardware limit switch is detected is stored internally on the CPU. The status of the reached hardware limit switch is reset only after the hardware limit switch is left and the axis is once again in the maximum traversing range.

To retract the axis after it reaches the hardware limit switch and to reset the status of the hardware limit switch, follow the steps below:

1. To enable movements in the retraction direction, acknowledge the technology alarm with "MC_Reset". A restart is not required.
2. Move the axis in the retraction direction until the hardware limit switch is exited.
   - Negative HW limit switch: For retracting, move in the direction of higher position values.
   - Positive HW limit switch: For retracting, move in the direction of lower position values.

   Afterwards, the axis must be within the maximum traversing range.

   If you move the axis opposite the retraction direction before the hardware limit switch is exited, the monitoring is triggered again.

The following diagram shows the behavior of the status word when the hardware limit switch is approached and when the axis is retracted:

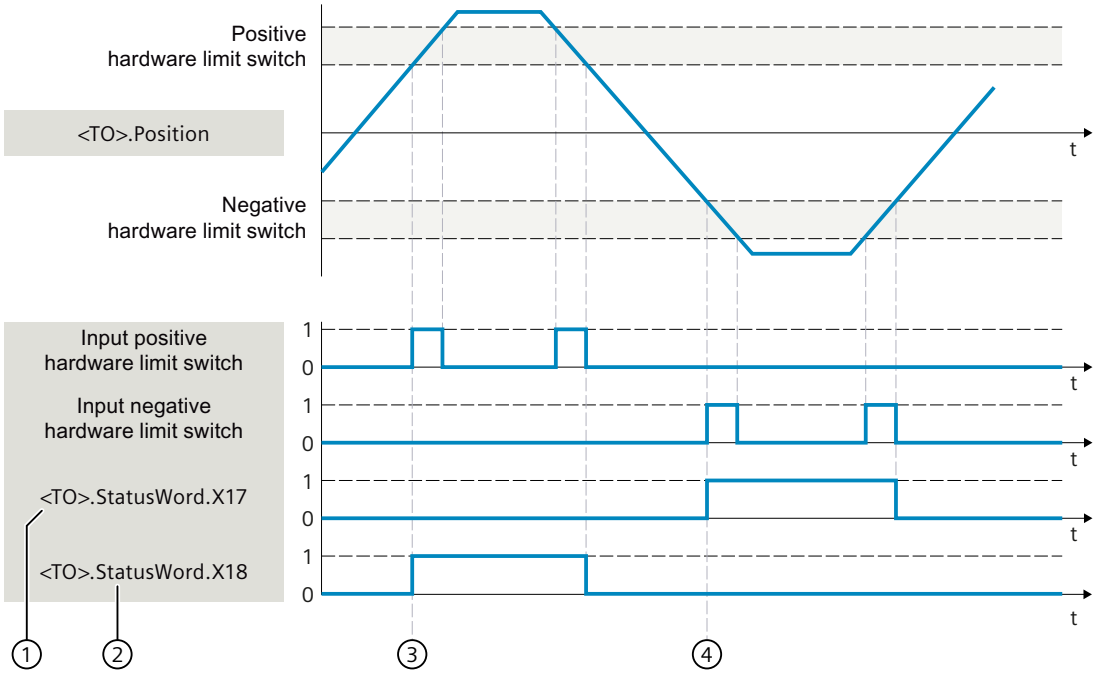

① <TO>.StatusWord.X17 (HWLimitMinActive)

- 0 Negative hardware limit switch not reached
- 1 Negative hardware limit switch reached or overtraveled

② <TO>.StatusWord.X18 (HWLimitMaxActive)

- 0 Positive hardware limit switch not reached
- 1 Positive hardware limit switch reached or overtraveled

③ The position of the axis when the **positive** hardware limit switch is detected is saved internally in the CPU. To reset the status of the hardware limit switch, the axis position must fall short of this position.

④ The position of the axis when the **negative** hardware limit switch is detected is saved internally in the CPU. To reset the status of the hardware limit switch, the axis position must go past this position.

NOTE

Retracting after technology alarm 531 with polarity-reversed HW limit switch or both HW limit switches active

To enable retraction, you can temporarily disable the hardware limit switches with Motion Control instruction "MC_WriteParameter (Page 346)" using parameter "PositionLimits_HW.Active" = FALSE.

Retracting the axis with a non-traversable HW limit switch

In case of a non-traversable HW limit switch, the position of the axis when the hardware limit switch is approached is not stored.

To retract the axis after it reaches the hardware limit switch and to reset the status of the hardware limit switch, follow the steps below:

1. To enable movements in the retraction direction, acknowledge the technology alarm with "MC_Reset". A restart is not required.
2. Move the axis in the retraction direction until the hardware limit switch is exited.
   - Negative HW limit switch: For retracting, move in the direction of higher position values.
   - Positive HW limit switch: For retracting, move in the direction of lower position values.

   The status of the approached HW limit switch is reset as soon as the configured level is no longer present at the digital input of the HW limit switch.

   If you move the axis opposite the retraction direction before the hardware limit switch is exited, the monitoring is triggered again.

The following diagram shows the behavior of the status word when the hardware limit switch is approached and when the axis is retracted:

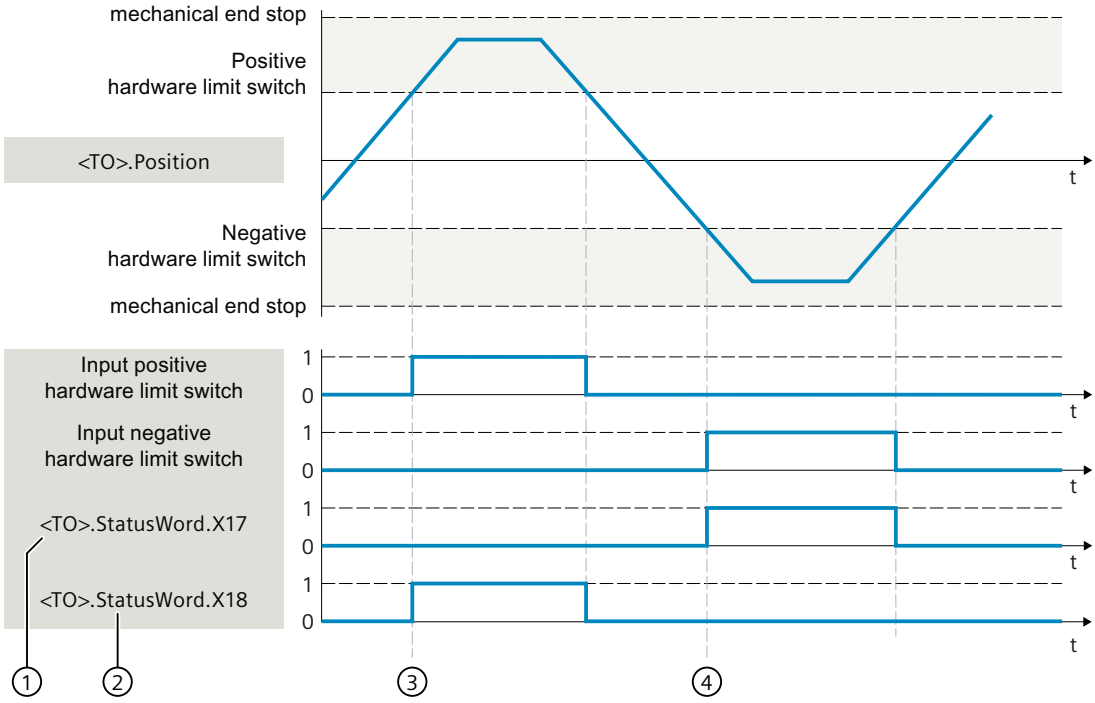

① <TO>.StatusWord.X17 (HWLimitMinActive)

- 0 Negative hardware limit switch not reached
- 1 Negative hardware limit switch reached or overtraveled

② <TO>.StatusWord.X18 (HWLimitMaxActive)

- 0 Positive hardware limit switch not reached
- 1 Positive hardware limit switch reached or overtraveled

③ When the **positive** hardware limit switch is detected, the status "<TO>.StatusWord.X18 (HWLimitMaxActive)" is set for the positive HW limit switch. The status is reset as soon as the configured level at the digital input of the HW limit switch is no longer present.

④ When the **negative** hardware limit switch is detected, the status "<TO>.StatusWord.X17 (HWLimitMinActive)" is set for the positive HW limit switch. The status is reset as soon as the configured level at the digital input of the HW limit switch is no longer present.

NOTE

Retracting after technology alarm 531 with polarity-reversed HW limit switch or both HW limit switches active

To enable retraction, you can temporarily disable the hardware limit switches with Motion Control instruction "MC_WriteParameter (Page 346)" using parameter "PositionLimits_HW.Active" = FALSE.

Deactivating the hardware limit switch

For example, to enable homing at the fixed stop, you can temporarily disable the hardware limit switches with Motion Control instruction "MC_WriteParameter (Page 346)" using parameter "PositionLimits_HW.Active" = FALSE.

See also

MC_WriteParameter: Write parameter V10 (Page 346)

Direct homing (Page 211)

6.10.2 Configuring HW limit switches

Configuring HW limit switches

To configure the HW limit switches for the positioning axis/synchronous axis technology object, follow these steps:

1. In the configuration, navigate to "Extended parameters > Limits > Position limits > HW limit switch".
2. Click on the "Enable HW limit switches" check box.

   The function of the negative and positive hardware limit switch is active.
3. Select the type of HW limit switch from the "Type of hardware limit switch" drop-down list:
   - Switch traversable
   - Switch non-traversable
4. If you have selected "Switch not traversable", configure the alarm response of technology alarm 531 at "Reaction":
   - Emergency stop and keep axis enabled: When approaching the HW limit switch, the axis brakes to a standstill with the emergency stop deceleration without jerk limitation. The axis remains enabled.
   - Disable axis: When approaching the HW limit switch, the axis is stopped with the braking ramp configured in the drive.
5. For "Input negative HW limit switch", select the PLC tag of the digital input for the negative hardware limit switch.

   To be able to select an input, a digital input module must have been added in the device configuration, and the PLC tag name for the digital input must be defined.

NOTE

Only use hardware limit switches that remain permanently switched after the approach. This switching state may only be canceled after the return to the permitted traversing range.

The digital inputs of the hardware limit switches are evaluated by default in cyclic data exchange. If the hardware limit switches are to be evaluated in the position control cycle clock of the drive, select the entry "MC_Servo" for "Organization block" and "PIP OB Servo" for "Process image" in the settings of the input module under "I/O addresses".

CAUTION

Filter times of the digital inputs

Pay attention to the filter times of the digital inputs when placing hardware limit switches.

Based on the time for one position control cycle clock and the filter time of the digital inputs, the resulting delay times must be taken into account.

The filter time is configurable in individual digital input modules in the device configuration.

The digital inputs are set to a filter time of 6.4 ms by default. If these are used as hardware limit switches, undesired decelerations may occur. If this occurs, reduce the filter time for the relevant digital inputs.

The filter time can be set under "Input filter" in the device configuration of the digital inputs.

6. For "Input positive HW limit switch", select the PLC tag of the digital input for the positive hardware limit switch.

   To be able to select an input, a digital input module must have been added in the device configuration, and the PLC tag name for the digital input must be defined.

7. In the "Level negative hardware limit switch" drop-down list, select the triggering signal level for the negative hardware limit switch.
   - High level: Input signal is "TRUE" when the hardware limit switch is approached.
   - Low level: Input signal is "FALSE" when the hardware limit switch is approached.
8. In the "Level positive hardware limit switch" drop-down list, select the triggering signal level for the positive hardware limit switch.

See also

MC_WriteParameter: Write parameter V10 (Page 346)

S7-1500 Motion Control Documentation Guide (Page %getreference)

Interconnecting inputs for HW limit switches with Boolean variables

Instead of using digital inputs, you can also use Boolean variables to control the HW limit switches. For this, create a data block with the tags without the "Optimized block access" attribute.

Specify the addresses of these Boolean variables in the technology object data block.

NOTE

Applications with a real HW limit switch

Two HW limit switches are always required for the configuration. The following is possible for applications with only one real HW limit switch: The real HW limit switch can be configured via the mask as an I/O variable and the second via the data block as a dummy.

Define a data block for switching and activating the HW limit switches

Proceed as follows to define the Boolean variables as HW limit switches:

1. Create a data block "HWLimitSwitches" without the "Optimized block access" attribute.
2. Define the following tags in the data block:

Name	Data type	Offset	Start value	Comment
UserData	DWord	0.0	16#0	Random data
HwLimitNeg	Bool	4.0	FALSE	Tag for negative HW limit switch
HwLimitPos	Bool	4.1	FALSE	Tag for positive HW limit switch
HwLimitActivate	Bool	4.2	FALSE	Tag for activation of HW limit switches

3. Use the "HwLimitPos" and "HwLimitNeg" tags in the user program to switch the HW limit switches.
4. Use the "HwLimitActivate" tag in the user program to activate the HW limit switches.

Interconnecting the addresses of the Boolean variables in the technology object

To connect the HW limit switch to the address, follow these steps:

1. Open the Parameter view of the technology object.
2. Change the navigation structure to data structure.
3. Enter the following values:

Structure	Project start value	Comment
PositionLimits_HW.		
Active	false	Hardware switches have to be deactivated for download
MinSwitchAdress.		
RID	33554433	RID for data type Boolean
AREA	132	DB memory area
DB_NUMBER	n	n = number of DB "HWLimitSwitches"
OFFSET	32	Example in DB "HWLimitSwitches": Offset Boolean variable ("HwLimitNeg") = 4.0 Offset = (4 bytes x 8 bits/byte) + 0 bits = 32 bits
MinSwitchAdress.		
RID	33554433	RID for data type Boolean
AREA	132	DB memory area
DB_NUMBER	n	n = number of DB "HWLimitSwitches"
OFFSET	33	Example in DB "HWLimitSwitches" Offset Boolean variable ("HwLimitPos") = 4.1 Offset = (4 bytes x 8 bits/byte) + 1 bit = 33 bits

Result: The addresses of the HW limit switches are configured. The hardware limit switches are deactivated.

4. Download the project to the CPU.

5. Call the "MC_WriteParameter" instruction:
   – Enter the value 1000 for activating the HW limit switches at the "ParameterNumber" input parameter.
   – Assign the "HWLimitSwitches".HwLimitActivate tag to the "Value" input parameter.
   – Assign the associated technology object at the "Axis" input parameter.
6. Assign the value TRUE to the tag "HWLimitSwitches".HwLimitActivate.
7. Start the job with a positive edge at the "Execute" input parameter. The "Done" output parameter signals that the change has been applied.

Result

The hardware limit switches with the configured DB tags are now active. (<TO>.PositionLimits_HW.Active = TRUE)

Note that after restarting the CPU, you must execute the "MC_WriteParameter" instruction again.

The changed value is retained at a "RUN → STOP → RUN" transition of the CPU.

Note that the TRUE value is reset to FALSE in the following cases:

- Restart of the technology object
- POWER OFF → POWER ON
- Memory reset

Writing addresses of the Boolean variables in the user program

To connect the HW limit switch to the address during runtime, follow these steps:

1. Create a data block with the "Optimized block access" attribute, e.g. "HWPositionLimitsAdress".
2. Define the following tags in the data block:

Name	Data type	Start value	Comment
MinSwitchAddressRid	DWord	33554433	RID for data type Boolean
MinSwitchAddressAr-ea	Byte	132	DB memory area
MinSwitchAddressDb-Number	UInt	n	n = number of DB "HWLimitSwitches"
MinSwitchAddressOff-set	UDint	32	Example in DB "HWLimitSwitches": Offset Boolean variable ("HwLimitNeg") = 4.0 Offset = (4 bytes x 8 bits/byte) + 0 bits = 32 bits
MaxSwitchAddressRid	DWord	33554433	RID for data type Boolean

Name	Data type	Start value	Comment
MaxSwitchAddressArea	Byte	132	DB memory area
MaxSwitchAddressDbNumber	UInt	n	n = number of DB "HWLimitSwitches"
MaxSwitchAddressOffset	UDint	33	Example in DB "HWLimitSwitches" Offset Boolean variable ("HwLimitPos") = 4.1 Offset = (4 bytes x 8 bits/byte) + 1 bit = 33 bits

3. Write the start values for each tag from the data block to the load memory of the "<TO>.PositionLimits_HW.MaxSwitchAddress" and "<TO>.PositionLimits_HW.MinSwitchAddress" tag with the "WRIT_DBL" instruction.

   You can find more information on changing restart-relevant data in the technology object in section "Changing restart-relevant data" of function manual "S7-1500/S7-1500T Motion Control Overview".

   Example of the tag "<TO>.PositionLimits_HW.MinSwitchAddress.RID":

   ```
   tempRetVal := WRIT_DBL
   (REQ := execute,
   SRCBLK := "HWPositionLimitsAdress".MinSwitchAddressRid,
   BUSY => busy,
   DSTBLK => <TO>.PositionLimits_HW.MinSwitchAddress.RID);
   ```

   Repeat the call of the "WRIT_DBL" instruction for the remaining 7 tags in the data block.

4. Perform a restart of the technology object.

   Result: The Boolean variable is used as the input for the HW limit switch.

5. Call the "MC_WriteParameter" instruction:
   - Enter the value 1000 for activating the HW limit switches at the "ParameterNumber" input parameter.
   - Assign the "HWLimitSwitches".HwLimitActivate tag to the "Value" input parameter.
   - Assign the associated technology object at the "Axis" input parameter.
6. Assign the value TRUE to the tag "HWLimitSwitches".HwLimitActivate.
7. Start the job with a positive edge at the "Execute" input parameter. The "Done" output parameter signals that the change has been applied.

Result

The hardware limit switches with the configured DB tags are now active. (<TO>PositionLimits_HW.Active = TRUE)

Note that after restarting the CPU, you must execute the "MC_WriteParameter" instruction again.

The changed value is retained at a "RUN → STOP → RUN" transition of the CPU.

Note that the TRUE value is reset to FALSE in the following cases:

- Restart of the technology object
- POWER OFF → POWER ON
- Memory reset

6.10.3 Behavior when reaching the SW limit switch

The operating range of the axis is limited with software limit switches. Relative to the traversing range, always position the software limit switches within the hardware limit switches. Since the positions of the software limit switches can be flexibly configured, the operating range of the axis can be individually adapted in accordance with the current velocity profile.

During motion control, cyclic checks are carried out taking into consideration the current dynamic values to ensure that the software limit switches are not exceeded. If this is the case, the current movement is interrupted and the software limit switch is approached.

When software switches are activated, an active motion comes to a stop at the position of the software limit switch. The technological object signals an error. After acknowledgment of the error, the axis can again be moved in the direction of its operating range.

Software limit switches are only in effect when there is a valid actual value after homing the technology object. The monitoring of the software limit switches is relative to the setpoint.

Approaching the software limit switches

When the software limit switch is approached, technology alarm 533 is output.

You can configure the alarm response for approaching the SW limit switches.

The technology object remains enabled.

Overrun of the software limit switches

If the software limit switches are overshot, technology alarm 534 is output.

You can configure the alarm response for crossing the SW limit switches.

Modulo function is enabled

When the modulo function is enabled, the modulo position is monitored.

The software limit switches are configured and activated in the axis configuration. The software limit switches can be activated or deactivated in the user program using the "<TO>.PositionLimits_SW.Active" tag. If the positions of both software limit switches are outside the modulo range, the monitoring has no effect. No check is made to determine whether the positions of the software limit switches are within the modulo range.

If a software limit switch is active within the valid Modulo range, the system places the second software limit switch at the corresponding Modulo boundary.

6.10.4 Retracting the SW limit switch

To retract the axis after violation of the software limit switch, follow the steps below:

1. Acknowledge the technology alarm.
2. Move the axis in the retraction direction into the permitted operating range.
   - Negative SW limit switch: For retracting, move in the direction of positive position values.
   - Positive SW limit switch: For retracting, move in the direction of negative position values.

   If the axis is outside the valid traversing range, e.g. due to homing, the current position is the effective SW limit switch. As soon as the axis has been moved back into the valid traversing range, the configured SW limit switch takes effect.

   If you overtravel the effective SW limit switch in the opposite retraction direction, technology alarm 533 or 534 is issued.

6.10.5 Configuring SW limit switches

To configure the SW limit switches for the positioning axis/synchronous axis technology object, follow these steps:

1. In the configuration, navigate to "Extended parameters > Limits > Position limits > SW limit switch".
2. Click the check box "Enable SW limit switches".
   The function of the negative and positive SW limit switch is active.

   NOTE

   Activated software limit switches act only on a homed axis.

3. For "Position of negative SW limit switch", configure the position of the SW limit switch with the smaller position value.
4. For "Position of positive SW limit switch", configure the position of the SW limit switch with the higher position value.
5. For "Reaction upon reach", configure the alarm response of the technology alarm 533.
   - Stop with maximum dynamic values: The axis stops when the SW limit switch is approached with maximum dynamic values.
   - Stop with current dynamic values: The axis stops when the SW limit switch is approached with the programmed dynamic values of the active job.

   NOTE

   If the axis approaches the software limit switch as a following axis in synchronous operation or as a kinematics axis during a kinematic movement, the axis is stopped with maximum dynamic values regardless of the selected setting.

   The technology object remains enabled.

6. For "Reaction when exceeded", configure the alarm response of the technology alarm 534:
   - Emergency stop and keep axis enabled: When the software limit switch is overtraveled, the axis brakes to a standstill with the emergency stop deceleration without jerk limitation. The axis remains enabled.
   - Disable axis: The axis is disabled when the SW limit switch is overtraveled and is braked with the braking ramp configured in the drive.

6.10.6 Tags: Traversing range limitation

Software limit switches

The following technology object tags are relevant for software limit switches:

Status indicators	
Tag	**Description**
<TO>.StatusWord.X15 (SWLimitMinActive)	Negative software limit switch is active.
<TO>.StatusWord.X16 (SWLimitMaxActive)	Positive software limit switch is active.
<TO>.ErrorWord.X8 (SWLimit)	An alarm is pending, indicating that a software limit switch has been violated.

Control bits	
Tag	**Description**
<TO>.PositionLimits_SW.Active	Enables/disables the monitoring of the software limit switches.

Position values		
Tag	**Description**	
<TO>.PositionLimits_SW.MinPosition	Position of the negative software limit switch	
<TO>.PositionLimits_SW.MaxPosition	Position of the positive software limit switch	
<TO>.PositionLimits_SW.LimitReached-Behavior	Alarm response when a software limit switch is approached with a single axis job	
	0	Stop axis with maximum dynamics
	1	Stop axis with the programmed dynamic parameters
<TO>.PositionLimits_SW.LimitExceeded-Behavior	Alarm response when overrunning a software limit switch	
	0	Disable axis
	1	Brake the axis with the configured emergency stop deceleration without any jerk limitation and bring it to a standstill.

Hardware limit switches

The following technology object tags are relevant for hardware limit switches:

Status indicators	
Tag	**Description**
<TO>.StatusWord.X17 (HWLimitMinActive)	Negative hardware limit switch is active.
<TO>.StatusWord.X18 (HWLimitMaxActive)	Positive hardware limit switch is active.
<TO>.ErrorWord.X9 (HWLimit)	An alarm is pending. A hardware limit switch was reached.

Control bits	
Tag	**Description**
<TO>.PositionLimits_HW.Active	Enables/disables the monitoring of the hardware limit switches.

Parameters		
Tag	**Description**	
<TO>.PositionLimits_HW.MinSwitchLevel	Level selection for activation of the low hardware limit switch	
	FALSE	At low level, the signal is active.
	TRUE	At high level, the signal is active.
<TO>.PositionLimits_HW.MinSwitchAddress	Address for the negative hardware limit switch	
<TO>.PositionLimits_HW.MaxSwitchLevel	Level selection for activation of the high hardware limit switch	
	FALSE	At low level, the signal is active.
	TRUE	At high level, the signal is active.
<TO>.PositionLimits_HW.MaxSwitchAddress	Address for the positive hardware limit switch	
<TO>.PositionLimits_HW.Mode	Type of HW limit switch	
	0	The HW limit switches are non-traversable.
	1	The HW limit switches are mechanically traversable.
<TO>.PositionLimits_HW.ApproachBehavior	Alarm response when approaching a HW limit switch	
	0	Disable axis
	1	Keep emergency stop and axis enable

6.10.7 Long-term accuracy

Long-term accuracy means that the technological set and actual position can always be determined uniquely.

The maximum technological position depends on the selected unit of measure and the maximum display of 9.0E12 mm. At higher resolution the maximum display is reduced to 9.0E9 mm.

The maximum travel time in which the technological position is accurate without rounding error depends on the maximum position and the velocity. The maximum travel time applies likewise to axes with and without modulo setting.

You can use the following equation to estimate when the limit of long-term accuracy is reached:

$$\text{Travel time} = \frac{\text{Maximum position}}{\text{Velocity}}$$

Example of the maximum traversing time

Maximum position = 9.0E12 mm

Velocity = 20.0 m/min = 2.0E4 mm/min

$$\text{Travel time} = \frac{9.0\text{E}12\ \text{mm}}{2.0\text{E}4\ \text{mm/min}} = 4.5\text{E}8\ \text{min} \quad \triangleq 856\ \text{years}$$

Unit of measure	Maximum travel time
nm, µm, mm, m, km, in, ft, mi, rad, °	4.5E8 min ≙ 856 years
mm[1], °[1]	4.5E5 min ≙ 0.856 years

[1] Position values with higher resolution or six decimal places. The maximum position is reduced to 9.0E9 mm and thus also the travel time.

A change in the velocity has the consequence that the traversing time changes accordingly.

Measures to maintain long-term accuracy

To reset the travel time, carry out the following measures before the maximum travel time has expired or before reaching the maximum position:

- Incremental encoder: Home the incremental encoder again.
- Absolute encoder: Perform an absolute encoder adjustment with the default of the currently known position.

See also

Units of measure (Page 34)

6.11 Homing

With homing, you create the relationship between the position in the technology object and the mechanical position. The actual position value in the technology object is assigned to a homing mark at the same time. This homing mark represents a known mechanical position.

Homing is a requirement for display of the correct position for the technology object and for absolute positioning.

Homing mode

Homing can occur by means of an independent homing motion (active homing), the detection of a homing mark during a motion initiated (passive homing) or a direct position assignment.

You select the homing mode with the "Mode (Page 295)" parameter of the "MC_Home (Page 293)" instruction.

A distinction is made between the following homing modes:

- **Active homing**

  Active homing initiates a homing movement and performs the necessary homing mark approach. When the homing mark is detected, the actual position is set to the value specified in "MC_Home". It is possible to specify a home position offset. Retraction to the home position offset occurs automatically during the home position approach.

  Active homing has an effect on the operative encoder.

  When active homing starts, current traversing movements are aborted.

  In the case of active homing with absolute encoder, if a valid absolute value offset has not yet been saved (<TO>.StatusSensor[1..4].Adjusted = 0), an absolute value offset is retentively saved beyond the switching on/off of the controller. If an absolute value offset has already been saved in the CPU (<TO>.StatusSensor[1..4].Adjusted = 1), it is retained after an active homing. To update the absolute encoder offset, perform an absolute encoder adjustment to the current position after the active homing.

  Active homing (Page 195)

- **Passive homing**

  The homing job does not perform its own homing motion. When the homing mark is detected during a motion initiated on the user side, the actual position is set to the value specified in "MC_Home".

  Passive homing has an effect on the operative encoder.

  Passive homing is also called homing on the fly.

  In the case of passive homing with absolute encoder, if a valid absolute value offset has not yet been saved (<TO>.StatusSensor[1..4].Adjusted = 0), an absolute value offset is retentively saved beyond the switching on/off of the controller. If an absolute value offset has already been saved in the CPU (<TO>.StatusSensor[1..4].Adjusted = 1), it is retained after a passive homing. To update the absolute encoder offset, perform an absolute encoder adjustment to the current position after the passive homing.

Passive homing (Page 205)

- **Direct homing**

  With the homing job, the actual position is set directly to the value specified in "MC_Home" or is offset by this value.

  Direct homing (Page 211)

- **Set position setpoint**

  The set position of the technology object is set or offset directly to the value specified in "MC_Home". The following error remains.

  Set setpoint position (Page 213)

- **Absolute encoder adjustment**

  The supplied absolute value is assigned to the associated mechanical axis position by means of the absolute encoder adjustment. You carry out the absolute encoder adjustment once. The absolute value offset is retentively saved beyond the switching on/off of the controller.

  Absolute value adjustment (Page 213)

- **Incremental encoder adjustment**

  With the homing job, the actual position is set directly to the value specified in "MC_Home".

  Incremental encoder adjustment (Page 217)

Supported encoders and technology objects

The following table shows which homing types are possible with the respective technology objects:

Homing mode	Positioning axis/synchronous axis with incremental encoder	Positioning axis/synchronous axis with absolute encoder	External encoder incremental	External encoder absolute
Active homing ("Mode" = 3, 5)	✓	✓	-	-
Passive homing ("Mode" = 2, 8, 10)	✓	✓	✓	✓
Set actual position ("Mode" = 0) Relative offset to the actual position ("Mode" = 1)	✓	✓	✓	✓

Homing mode	Positioning axis/synchronous axis with incremental encoder	Positioning axis/synchronous axis with absolute encoder	External encoder incremental	External encoder absolute
Set position setpoint (direct absolute) ("Mode" = 11) Relative offset of the position setpoint ("Mode" = 12)	✓	✓	✓	✓
Absolute encoder adjustment ("Mode" = 6, 7)	-	✓	-	✓
Incremental encoder adjustment ("Mode" = 13)	✓	-	✓	-

Start homing job

To start the homing job, activate the Motion Control instruction "MC_Home".

Homing status

The "<TO>.StatusWord.X5 (HomingDone)" tag of the technology object indicates whether the technology object axis or external encoder is homed.

The "<TO>.StatusWord.X11 (HomingCommand)" tag of the technology object indicates that a homing job is active.

The "<TO>.ErrorWord.X10 (HomingFault)" tag of the technology object indicates an error during homing.

The "<TO>.StatusSensor[1..4].Adjusted" tag indicates whether the encoder was homed with one of the following homing types:

- Active homing
- Passive homing
- Absolute encoder adjustment
- Incremental encoder adjustment

NOTE

Once the tag "<TO>.StatusSensor[1..4].Adjusted" is set for an absolute encoder, it remains set until you download new settings for the encoder.

Home the axis again when replacing the absolute encoder.

After homing with the homing types Direct homing ("Mode" = 0,1) and Setting of position setpoint ("Mode" = 11,12) is completed, the "<TO>.StatusWord.X5 (HomingDone)" tag of the axis or external encoder technology object is set, but not the "<TO>.StatusSensor[1..4].Adjusted" tag of the encoder.

See also

Homing SINAMICS drives with external zero marks (Page 218)

6.11.1 Terms for active and passive homing

Important terms

The following terms must be noted when homing:

Homing mark

A homing mark is an input signal, on whose occurrence a known mechanical position can be assigned to the actual values.

A homing mark can be:

- **Zero mark**

  The zero mark of an incremental encoder or an external zero mark is used as a homing mark.

  The zero mark is detected at the drive module or encoder module and transmitted in the PROFIdrive telegram. Perform the setting and evaluation as an encoder zero mark or external zero mark at the drive module and encoder module.

- **Edge at the digital input**

  The negative or positive edge at a digital input is used as a homing mark.

Reference output cam

If there are several zero marks in the traversing range, the reference output cam is used to select a specific zero mark before or after the reference output cam.

Homing mark position

The homing mark position is the position assigned to the homing mark.

With active homing, the homing mark position corresponds to the home position minus the home position offset.

With passive homing, the homing mark position corresponds to the home position.

Home position

At the end of the active homing motion, the axis arrives at the home position.

Home position offset

The difference between the home position and the homing mark position is the home position offset.

A home position offset only has an effect with active homing. After reaching the homing mark position, the offset is traversed at approach velocity via the Motion Control instruction "MC_Home". For axes with activated modulo setting, the home position offset is always traversed with the direction setting for the shortest path.

Direction reversal at the hardware limit switch

Hardware limit switches can be used as reversing output cams in active homing. If the homing mark was not detected or was approached from the wrong side, the motion continues in the opposite direction after the reversing output cam.

Approach velocity

With active homing, the technology object approaches the reference cam or the digital input at the approach velocity.

A home position offset is also performed at the approach velocity.

Homing velocity

With active homing, the technology object approaches the homing mark with the homing velocity.

6.11.2 Homing mode for active and passive homing

Three homing modes are available for active and passive homing of absolute encoders and incremental encoders:

- Reference output cam and zero mark via PROFIdrive telegram

  High accuracy
- Zero mark via PROFIdrive telegram

  High accuracy
- Digital input

  Low accuracy

Selection criteria

Select the homing mode based on the following criteria:

- Encoder zero mark "N" available on encoder
- Hardware support for a zero mark substitute through use of a fast digital input
- Number of encoder zero marks in the traversing range of the axis

The following figure shows the selection criteria for the homing mode:

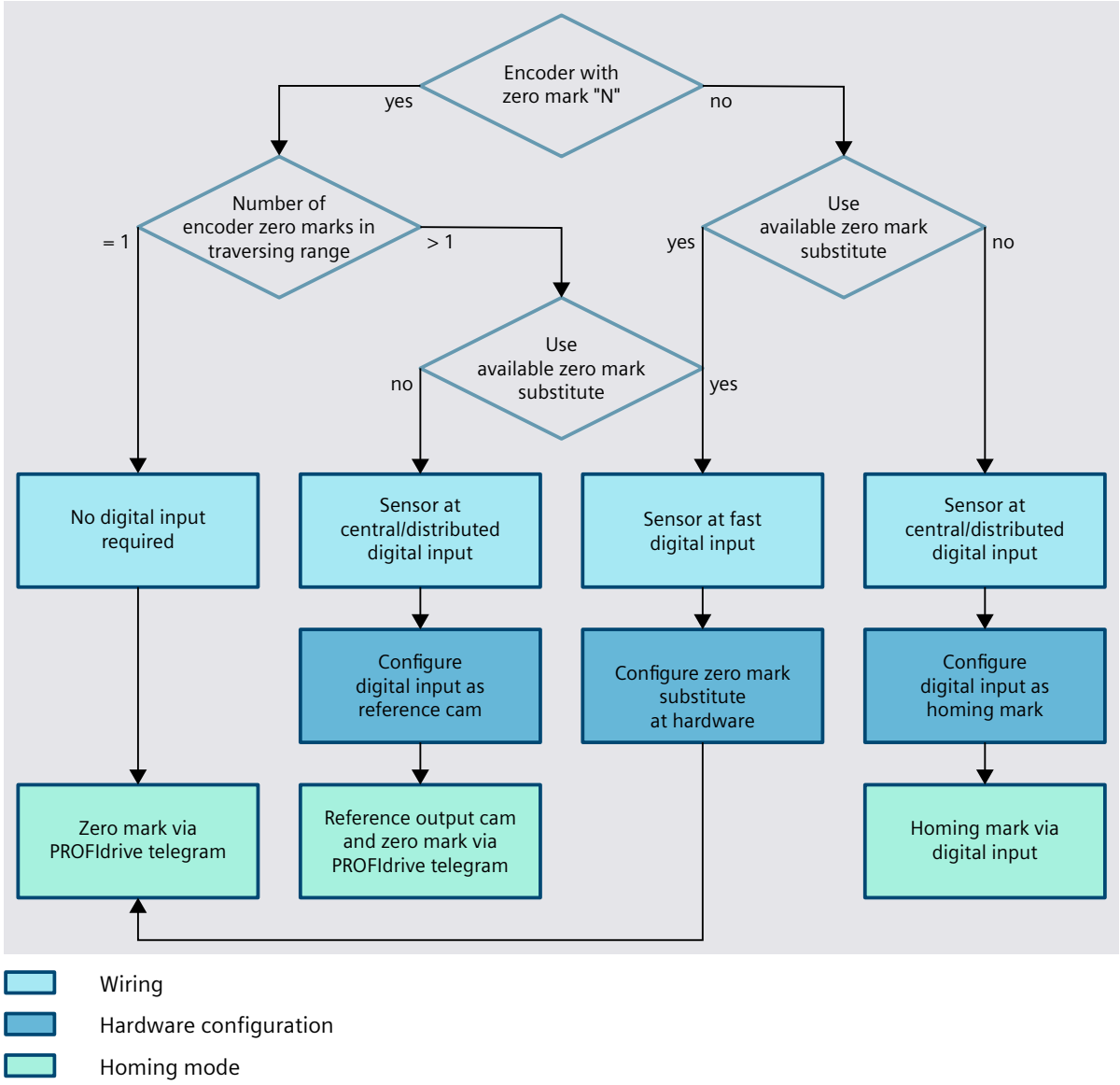

Reference output cam and zero mark via PROFIdrive telegram

If multiple encoder zero marks are in the traversing range and you want to home to one of the zero marks, use this mode

As the reference output cam, you need a digital input at the central or distributed I/O of the CPU or at the compact CPU.

The system checks the reaching of the reference output cam. After the reference output cam has been reached and exited again in the assigned homing direction, zero mark detection is activated via the PROFIdrive telegram.

When the zero mark is reached in the configured direction, the actual position of the technology object is set to the homing mark position.

Zero mark via PROFIdrive telegram

You use this homing mode in the following situations:

- The encoder has no zero mark and a zero mark substitute is available.
- The encoder has a zero mark and it is present only once in the entire traversing range of the axis.
- The encoder has multiple zero marks in the traversing range. Instead of the zero marks, a zero mark substitute will be used.

You can use a fast digital input as a zero mark substitute. The signal of this input is transferred via PROFIdrive instead of the encoder zero mark.

The following hardware components have digital inputs that you configure as a zero mark substitute.

- SINAMICS:

  Configure digital input as "External zero mark (Page 218)"
- Technology modules (e.g. TM Count, TM PosInput):

  Configure operating mode as "Position detection for technology object Motion Control"

  Configure "Signal selection for reference mark 0" as DI0
- Onboard I/O S7-151xC-1 PN

  Activate HSC

  Configure operating mode as "Position detection for technology object Motion Control"

  Configure "Signal selection for reference mark 0" as DI0

  Configure hardware input for HSC DI0 to the wired terminal

Digital input

If the encoder has no encoder zero mark in the traversing range and the hardware does not support a zero mark substitute, use this homing mode. You need a digital input at the central or distributed I/O of the CPU or at the compact CPU.

A hardware limit switch can be used as a digital input.

The system checks the state of the digital input as soon as the actual value of the axis or encoder moves in the configured homing direction. When the homing mark is reached (setting of the digital input) in the specified homing direction, the actual position of the technology object is set to the homing mark position.

The digital inputs must be placed into the process image partition "PIP OB Servo". The filter time of the digital inputs must be set smaller than the duration of the input signal at the reference point switch.

A low homing velocity increases the accuracy.

6.11.3 Active homing

6.11.3.1 Active homing with reference output cam and zero mark

The following examples show homing motions in the positive and negative directions.

Example of homing in the positive direction

The approach to the homing mark and the home position occurs in the positive direction.

The following figure shows the homing motion with the following settings:

- Active homing with reference output cam and zero mark
- Approach in the positive direction
- Homing in the positive direction
- Positive home position offset

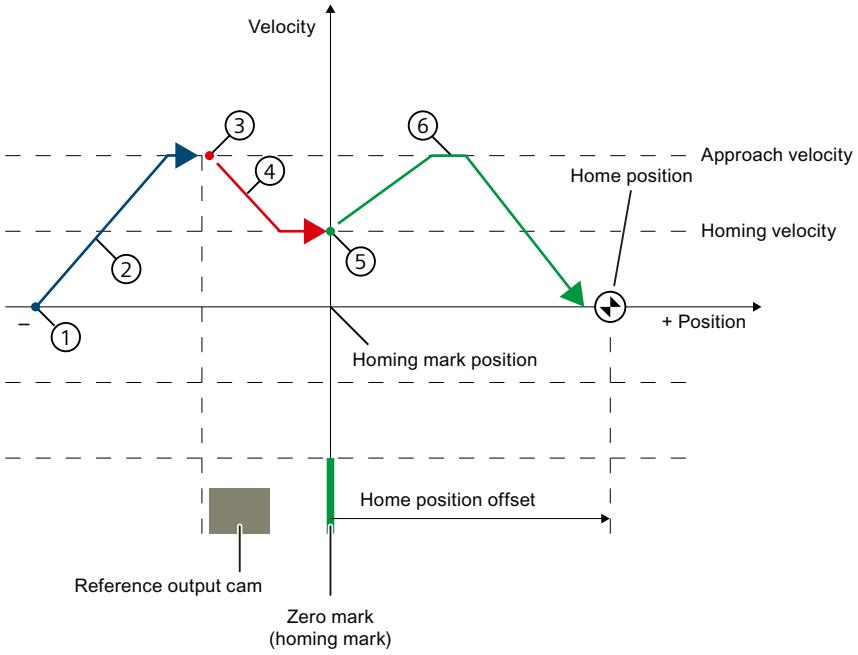

Motion sequence

① Start of active homing via the Motion Control instruction "MC_Home"

② Approach to the reference output cam in approach direction with approach velocity

③ Detection of reference output cam and activation of homing mark detection

④ Approach to the homing mark with homing velocity

⑤ Detection of the homing mark

⑥ Approach to home position with approach velocity

NOTE

If the velocity cannot be reduced to the homing velocity between detection of the reference output cam and the zero mark, homing is performed at the velocity present when the zero mark is crossed.

Example of homing in the negative direction

The approach to the homing mark occurs in the negative direction by means of a direction reversal during the homing process. The approach to home position causes another direction reversal and occurs in the positive direction.

The following figure shows the homing motion with the following settings:

- Active homing with reference output cam and zero mark
- Approach in the positive direction
- Homing in the negative direction
- Positive home position offset

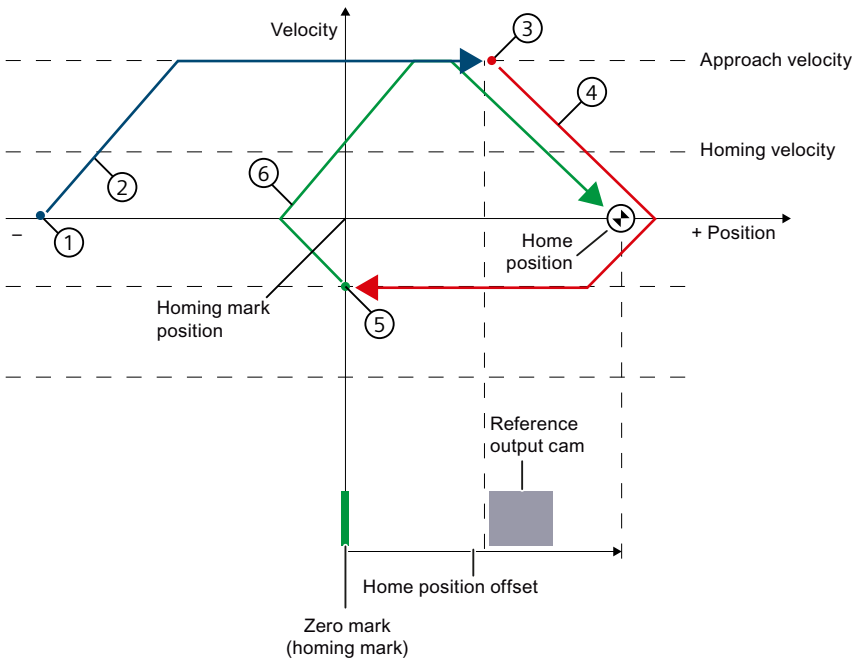

Motion sequence

① Start of active homing via the Motion Control instruction "MC_Home"

② Approach to the reference output cam in approach direction with approach velocity

③ Detection of reference output cam and activation of homing mark detection

④ Approach to the homing mark with homing velocity

⑤ Detection of the homing mark

⑥ Approach to home position with approach velocity

Requirements

- Digital input as PLC tag
- The technology object has been enabled.

Procedure

To home the technology object actively with reference output cam and zero mark, follow these steps:

1. In the project tree, in the configuration of the technology object, navigate to "Extended parameters > Homing > Active homing".
2. In the "Select the homing mode" field, select the "Use reference cam and zero mark via PROFIdrive telegram" option.
3. For "Digital input homing mark/cam", select the PLC tag of the digital input.
4. Select the appropriate signal level for the digital input under "Level selection".
5. In the "Approach direction" field, select the direction in which the reference cam is approached:
   - Positive: Approach direction in direction of positive position values
   - Negative: Approach direction in direction of negative position values
6. In the "Homing direction" field, select the direction in which the zero mark is approached for homing:
   - Positive: Homing direction in the direction of positive position values
   - Negative: Homing direction in the direction of negative position values
7. Under "Approach velocity", set the velocity with which the reference output cam is approached. Any configured home position offset is traversed at the same velocity.
8. Under "Homing velocity", set the velocity with which the zero mark is approached for homing.
9. If the home position is different from the homing mark position, enter a corresponding home position offset under "Home position offset". The axis approaches the home position at approach velocity.
10. Configure the "Home position". The home position configured here is in effect when the Motion Control instruction "MC_Home" is executed with "Mode" = 5.
11. To home the technology object with the home position configured in the technology object, call the "MC_Home" instruction with "Mode" = 5.
    - When the homing mark is recognized, the position is set to:

      Position = value in tag "<TO>.Homing.HomePosition" minus "<TO>.Sensor[1..4].ActiveHoming.HomePositionOffset"
    - The "Homed" status of the technology object is set to TRUE.
    - The axis moves to the position that is specified in the "<TO>.Homing.HomePosition" tag.
    - The "Done" parameter in "MC_Home" is set to TRUE after moving to the home position.

12. To home the technology object and specify the home position directly on the homing job, call the "MC_Home" instruction with "Mode" = 3 and "Position" = <Home position>.
    - When the homing mark is recognized, the position is set to:

      Position = value in parameter "Position" minus "<TO>.Sensor[1..4].ActiveHoming.HomePositionOffset"
    - The "Homed" status of the technology object is set to TRUE.
    - The axis moves to the position that is specified in the "Position" parameter.
    - The "Done" parameter in "MC_Home" is set to TRUE after moving to the home position.

See also

Homing SINAMICS drives with external zero marks (Page 218)

6.11.3.2 Active homing with zero mark

Example of homing motion

The following figure shows an example of the homing motion with the following settings:

- Active homing with zero mark
- Homing in the positive direction
- Positive home position offset

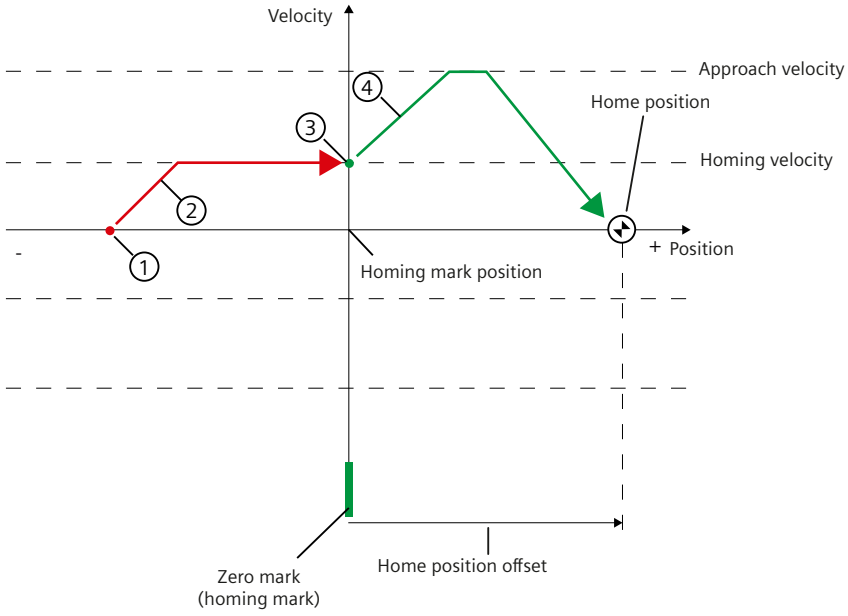

Motion sequence

① Start of active homing via the "MC_Home" Motion Control instruction

② Approach to the homing mark in the homing direction with homing velocity

③ Detection of the homing mark

④ Approach to home position with approach velocity

Requirements

- The technology object has been enabled.

Procedure

To home the technology object actively with zero mark, follow these steps:

1. In the project tree, in the configuration of the technology object, navigate to "Extended parameters > Homing > Active homing".
2. In the "Select the homing mode" field, select the "Use zero mark via PROFIdrive telegram" option.
3. In the "Approach direction" field, select the direction in which the zero mark is approached:
   - Positive: Homing direction in the direction of positive position values
   - Negative: Homing direction in direction of negative position values
4. Under "Approach velocity", set the velocity with which any set home position offset is retracted.
5. Under "Homing velocity", set the velocity with which the homing mark is approached.
6. If the home position is different from the homing mark position, enter a corresponding home position offset under "Home position offset". The axis approaches the home position at approach velocity.
7. For "Home position", configure the absolute home position coordinate of the home position. The home position configured here is in effect when the Motion Control instruction "MC_Home" is executed with "Mode" = 5.
8. To home the technology object with the home position configured in the technology object, call the "MC_Home" instruction with "Mode" = 5.
   - When the homing mark is recognized, the position is set to:

     Position = value in tag "<TO>.Homing.HomePosition" minus "<TO>.Sensor[1..4].ActiveHoming.HomePositionOffset"
   - The "Homed" status of the technology object is set to TRUE.
   - The axis moves to the position that is specified in the "<TO>.Homing.HomePosition" tag.
   - The "Done" parameter in "MC_Home" is set to TRUE after moving to the home position.
9. To home the technology object and specify the home position directly on the homing job, call the "MC_Home" instruction with "Mode" = 3 and "Position" = <Home position>.
   - When the homing mark is recognized, the position is set to:

     Position = value in parameter "Position" minus "<TO>.Sensor[1..4].ActiveHoming.HomePositionOffset"
   - The "Homed" status of the technology object is set to TRUE.
   - The axis moves to the position that is specified in the "Position" parameter.
   - The "Done" parameter in "MC_Home" is set to TRUE after moving to the home position.

See also

Homing SINAMICS drives with external zero marks (Page 218)

6.11.3.3 Active homing with digital input

Example of homing motion

The following figure shows an example of the homing motion with the following settings:

- Active homing with digital input
- Approach in the positive direction
- Homing mark on the positive side of the digital input
- Positive home position offset

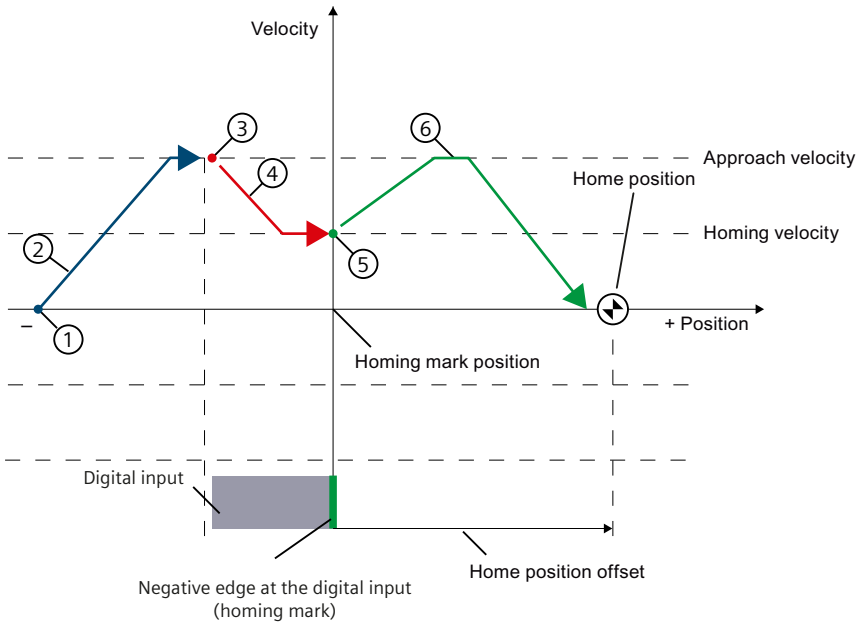

Motion sequence

① Start of active homing via the "MC_Home" Motion Control instruction

② Move on the positive edge at the digital input in the approach direction with approach velocity

③ Detection of the positive edge at the digital input

④ Approach to the homing mark in the homing direction with the homing velocity

⑤ Detection of the homing mark

⑥ Approach to home position with approach velocity

NOTE

If the velocity cannot be reduced to the homing velocity between detection of the reference output cam and the zero mark, homing is performed at the velocity present when the zero mark is crossed.

Requirements

- Digital input as PLC tag
- The technology object has been enabled.

Procedure

To home the technology object actively with a digital input, follow these steps:

1. In the project tree, in the configuration of the technology object, navigate to "Extended parameters > Homing > Active homing".
2. In the "Select the homing mode" field, select the "Use homing mark via digital input" option.
3. For "Digital input homing mark/cam", select the PLC tag of the digital input.
4. Select the appropriate signal level for the digital input under "Level selection".
5. In the "Approach direction" field, select the direction in which the digital input is approached:
   - Positive: Approach direction in direction of positive position values
   - Negative: Approach direction in direction of negative position values
6. In the "Homing direction" field, select the direction in which the homing mark of the digital input is approached for homing:
   - Positive: Homing direction in the direction of positive position values
   - Negative: Homing direction in the direction of negative position values
7. In the "Homing mark" field, select which side of the digital input is to be used as the homing mark.
   - Positive side
   - Negative side
8. Under "Approach velocity", set the velocity with which the "digital input" is approached. Any configured home position offset is traversed at the same velocity.
9. Under "Homing velocity", set the velocity with which the homing mark is approached.
10. If the home position is different from the homing mark position, enter a corresponding home position offset under "Home position offset". The axis approaches the home position at approach velocity.
11. For "Home position", configure the absolute home position coordinate of the home position. The home position configured here is in effect when the Motion Control instruction "MC_Home" is executed with "Mode" = 5.

12. To home the technology object with the home position configured in the technology object, call the "MC_Home" instruction with "Mode" = 5.
    - When the homing mark is recognized, the position is set to:

      Position = value in tag "<TO>.Homing.HomePosition" minus "<TO>.Sensor[1..4].ActiveHoming.HomePositionOffset"
    - The "Homed" status of the technology object is set to TRUE.
    - The axis moves to the position that is specified in the "<TO>.Homing.HomePosition" tag.
    - The "Done" parameter in "MC_Home" is set to TRUE after moving to the home position.
13. To home the technology object and specify the home position directly on the homing job, call the "MC_Home" instruction with "Mode" = 3 and "Position" = <Home position>.
    - When the homing mark is recognized, the position is set to:

      Position = value in parameter "Position" minus "<TO>.Sensor[1..4].ActiveHoming.HomePositionOffset"
    - The "Homed" status of the technology object is set to TRUE.
    - The axis moves to the position that is specified in the "Position" parameter.
    - The "Done" parameter in "MC_Home" is set to TRUE after moving to the home position.

6.11.3.4 Direction reversal at the hardware limit switch (reversing output cam)

During active homing, the hardware limit switch can optionally be used as a reversing output cam. If the homing mark is not detected or the motion was not in the homing direction, the motion continues in the opposite direction with the approach velocity after the reversing output cam.

When the hardware limit switch is reached, the default settings for dynamics take effect. Deceleration with the emergency deceleration does not hereby occur.

NOTICE
Avoid moving to a mechanical endstop Ensure by one of the following measures, that in a direction reversal the machine does not move to a mechanical endstop. • Keep the approach velocity low. • Increase the configured default acceleration/deceleration. • Increase the distance between the hardware limit switch and the mechanical endstop.

6.11.3.5 Active homing to a hardware limit switch

If only hardware limit switches are available on the axis and no separate digital inputs are available as homing marks, then you can home the axis to the hardware limit switches.

NOTICE
Avoid moving to a mechanical endstop Take one of the following measures to ensure that the machine does not hit a mechanical stop when homing is active with the hardware limit switch as the homing mark: • Keep the approach velocity low. • Increase the configured acceleration/deceleration. • Increase the distance between the hardware limit switch and the mechanical endstop. • Select a home position offset in direction of the traversing range of the axis against the mechanical stop.

Procedure

To use the signal of the hardware limit switch as a homing mark, follow these steps:

1. In the project tree, in the configuration of the technology object, navigate to "Extended parameters > Homing > Active homing".
2. In the "Select the homing mode" field, select the "Use homing mark via digital input" option.
3. For "Digital input homing mark/cam", select the PLC tag of the hardware limit switch, e.g. "HwLimitPos".
4. Select the appropriate signal level for the digital input under "Level selection".
5. In the "Approach direction" field, select the direction in which the digital input is approached:
   - Positive: Approach direction in direction of positive position values
   - Negative: Approach direction in direction of negative position values
6. In the "Homing direction" field, select the direction in which the homing mark of the digital input is approached for homing:
   - Positive: Homing direction in the direction of positive position values
   - Negative: Homing direction in the direction of negative position values
7. In the "Homing mark" field, select which side of the digital input is to be used as the homing mark. The following recommendation applies to hardware limit switches in order not to traverse the axis unnecessarily far in the direction of the mechanical stop.
   - Positive side of the negative hardware limit switch
   - Negative side of the positive hardware limit switch
8. Under "Approach velocity", set the velocity with which the hardware limit switch is approached. Any configured home position offset is traversed at the same velocity.
9. Under "Homing velocity", set the velocity with which the homing mark is approached.

10. If the home position is different from the homing mark position, enter a corresponding home position offset under "Home position offset". The axis approaches the home position at approach velocity. When homing to the hardware limit switch, the following settings are recommended in order to perform the approach to the home position in the direction of the traversing range or opposite the mechanical stop.
    - Negative hardware limit switch: Home position offset ≥ 0
    - Positive hardware limit switch: Home position offset ≤ 0
11. For "Home position", configure the absolute home position coordinate of the home position. The home position configured here is in effect when the Motion Control instruction "MC_Home" is executed with "Mode" = 5.
12. Disable the existing hardware limit switch with the Motion Control instruction "MC_WriteParameter".
13. To start active homing, call the "MC_Home" instruction in the user program.
    - To home the technology object with the home position configured in the technology object, call the "MC_Home" instruction with "Mode" = 5.
    - To home the technology object with the home position at the parameter "Position" home position, call the "MC_Home" instruction with "Mode" = 3.
14. Move the axis back to the working area between the hardware limit switches.
15. Activate existing hardware limit switches with the "MC_WriteParameter" Motion Control instruction.

6.11.4 Passive homing

6.11.4.1 Passive homing with reference cam and zero mark

Example of homing motion

The following figure shows an example of the homing motion with the following settings:

- Passive homing with reference output cam and zero mark
- Homing in the positive direction

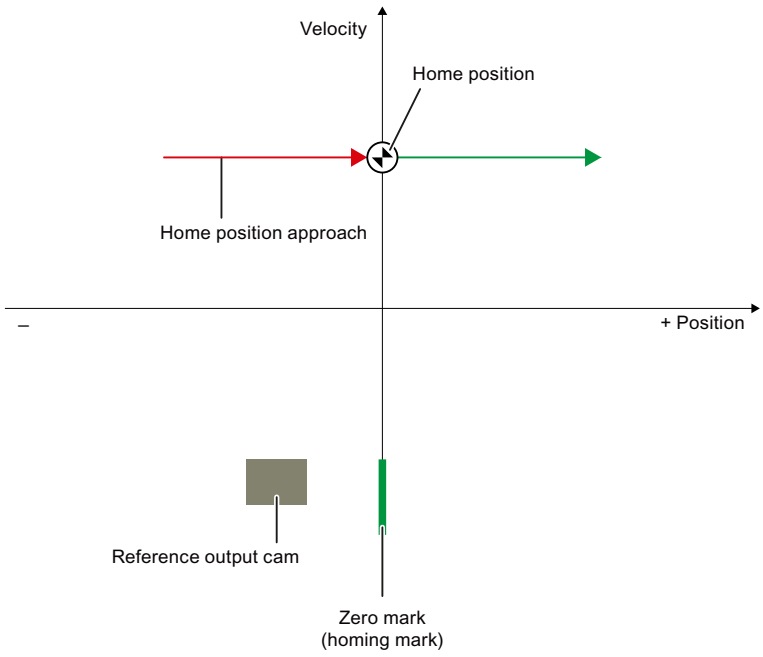

Motion sequence

① Activation of passive homing using the Motion Control instruction "MC_Home"

② Motion due to a motion job
The detection of the reference output cam and homing mark is enabled when the actual position value of the axis or encoder moves in the assigned homing direction.

③ Detection of the reference output cam

④ Exit from the reference output cam
The exit from the reference output cam activates the homing mark detection.

⑤ Detection of the homing mark

NOTE

If the motion direction changes after the exit from the reference output cam and before detection of the homing mark, the reference output cam must be detected again. The Motion Control instruction "MC_Home" remains enabled.

Requirements

- Digital input as PLC tag
- The technology object has been enabled.

Procedure

To home the technology object passively with reference output cam and zero mark, follow these steps:

1. In the project tree, in the configuration of the technology object, navigate to "Extended parameters > Homing > Passive homing".
2. In the "Select the homing mode" field, select the "Use reference cam and zero mark via PROFIdrive telegram" option.
3. For "Digital input homing mark/cam", select the PLC tag of the digital input.
4. Select the appropriate signal level for the digital input under "Level selection".
5. In the "Homing direction" field, select the direction in which the next zero mark is to be approached for homing.
   - Positive: The axis moves in the direction of positive position values.
   - Negative: The axis moves in the direction of negative position values.
   - Current: The currently effective approach direction is used for homing.
6. For "Home position", configure the absolute home position coordinate of the home position. The home position configured here is in effect when the Motion Control instruction "MC_Home" is executed with "Mode" = 10.
7. To home the technology object with the home position configured in the technology object, call the "MC_Home" instruction with "Mode" = 10.
8. To home the technology object and specify the home position directly on the homing job, call the "MC_Home" instruction with "Mode" = 8 or "Mode" = 2 (without resetting the "homed" status).
9. Traverse the axis in the configured homing direction.
   - The detection of the zero mark/homing mark is activated after the reference output cam has been traversed.
   - When the homing mark is detected, the position of the axis or encoder is set depending on the mode:

     "Mode" = 10: Position = value in tag "<TO>.Homing.HomePosition"

     "Mode" = 8 or "Mode" = 2: Position = value in parameter "Position"
   - The axis is homed as soon as the zero mark/homing mark is reached or detected.
10. To save the absolute value offset retentively for an absolute encoder, you must perform an absolute encoder adjustment (Page 213).

6.11.4.2 Passive homing with zero mark

Example of homing motion

The following figure shows an example of the homing motion with the following settings:

- Passive homing with zero mark
- Homing in the positive direction

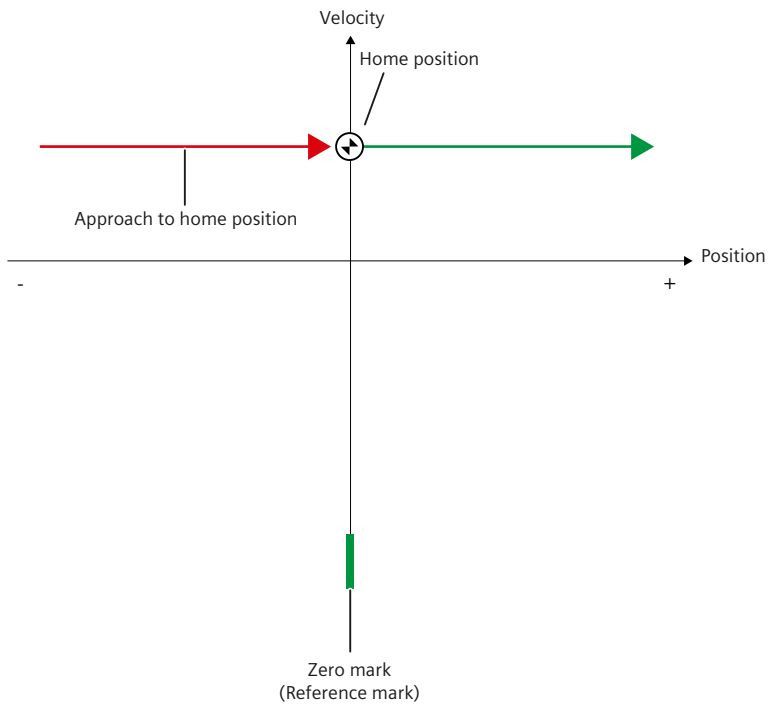

Motion sequence

① Activation of passive homing using the Motion Control instruction "MC_Home"

② Motion due to a motion job
The detection of the reference output cam and homing mark is enabled when the actual position value of the axis or encoder moves in the assigned homing direction.

③ Detection of the homing mark

Requirements

- Technology object is enabled.

Procedure

To home the technology object passively with zero mark, follow these steps:

1. In the project tree, in the configuration of the technology object, navigate to "Extended parameters > Homing > Passive homing".
2. In the "Select the homing mode" field, select the "Use zero mark via PROFIdrive telegram" option.
3. In the "Homing direction" field, select the direction in which the next zero mark is to be approached for homing.
   - Positive: The axis moves in the direction of positive position values.
   - Negative: The axis moves in the direction of negative position values.
   - Current: The currently effective approach direction is used for homing.
4. For "Home position", configure the absolute home position coordinate of the home position. The home position configured here is in effect when the Motion Control instruction "MC_Home" is executed with "Mode" = 10.
5. To home the technology object with the home position configured in the technology object, call the "MC_Home" instruction with "Mode" = 10.
6. To home the technology object and specify the home position directly on the homing job, call the "MC_Home" instruction with "Mode" = 8 or "Mode" = 2 (without resetting the "homed" status).
7. Traverse the axis in the configured homing direction.
   - The detection of the zero mark/homing mark is activated after the reference output cam has been traversed.
   - When the homing mark is detected, the position of the axis or encoder is set depending on the mode:

     "Mode" = 10: Position = value in tag "<TO>.Homing.HomePosition"

     "Mode" = 8 or "Mode" = 2: Position = value in parameter "Position"
   - The axis is homed as soon as the zero mark/homing mark is reached or detected.

6.11.4.3 Passive homing with digital input

Example of homing motion

The following figure shows an example of the homing motion with the following settings:

- Passive homing with digital input
- Homing in the positive direction
- Homing mark on the positive side of the digital input

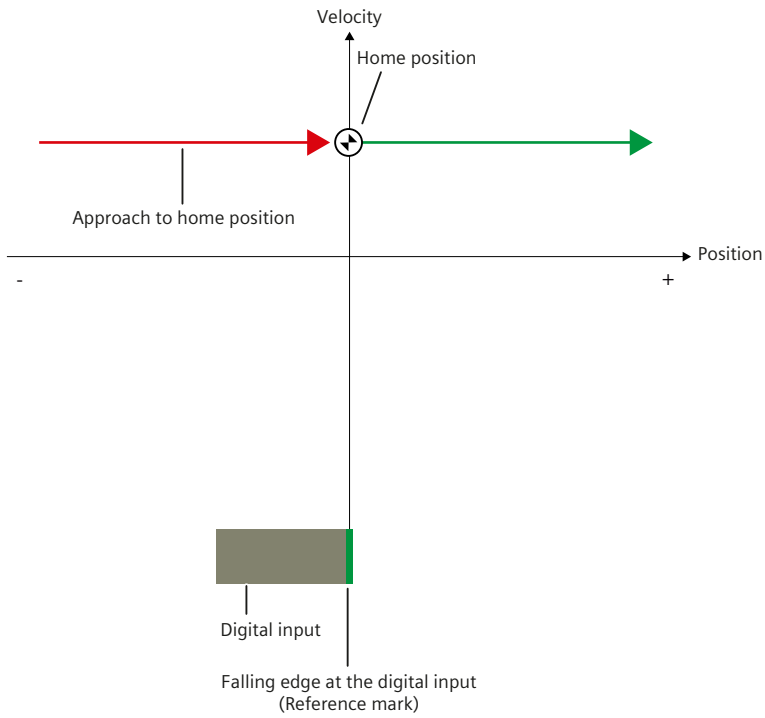

Motion sequence

① Activation of passive homing using the Motion Control instruction "MC_Home"

② Motion due to a motion job
The detection of the reference output cam and homing mark is enabled when the actual position value of the axis or encoder moves in the assigned homing direction.

③ Detection of the homing mark
In the example, the negative edge of the switch at the digital input represents the homing mark.

Requirements

- Digital input as PLC tag
- The technology object has been enabled.

Procedure

To home the technology object passively with digital input, follow these steps:

1. In the project tree, in the configuration of the technology object, navigate to "Extended parameters > Homing > Passive homing".
2. In the "Select the homing mode" field, select the "Use homing mark via digital input" option.
3. For "Digital input homing mark/cam", select the PLC tag of the digital input.
4. Select the appropriate signal level for the digital input under "Level selection".
5. In the "Homing direction" field, select the direction in which the next zero mark is to be approached for homing.
   - Positive: The axis moves in the direction of positive position values.
   - Negative: The axis moves in the direction of negative position values.
   - Current: The currently effective approach direction is used for homing.
6. In the "Homing mark" field, select which side of the digital input is to be used as the homing mark.
   - Positive side
   - Negative side
7. For "Home position", configure the absolute home position coordinate of the home position. The home position configured here is in effect when the Motion Control instruction "MC_Home" is executed with "Mode" = 10.
8. To home the technology object with the home position configured in the technology object, call the "MC_Home" instruction with "Mode" = 10.
9. To home the technology object and specify the home position directly on the homing job, call the "MC_Home" instruction with "Mode" = 8 or "Mode" = 2 (without resetting the "homed" status).
10. Traverse the axis in the configured homing direction.
    - The detection of the zero mark/homing mark is activated after the reference output cam has been traversed.
    - When the homing mark is detected, the position of the axis or encoder is set depending on the mode:

      "Mode" = 10: Position = value in tag "<TO>.Homing.HomePosition"

      "Mode" = 8 or "Mode" = 2: Position = value in parameter "Position"
    - The axis is homed as soon as the zero mark/homing mark is reached or detected.

6.11.4.4 Cancel passive homing

Requirements

- A job for passive homing with the instruction "MC_Home" ("Mode" = 2, 8, 10) was started.
- The technology object has not yet been homed.

Procedure

To cancel an active job for passive homing, follow these steps:

- Call the "MC_Home" instruction with "Mode" = 9.
  - When the active "MC_Home" job for passive homing ("Mode" = 2, 8, 10) is overridden by another "MC_Home" job with "Mode" = 9, the running job is canceled with the parameter "CommandAborted" = TRUE.
  - The overriding job with "Mode" = 9 signals successful execution with parameter "Done" = TRUE.

6.11.5 Direct homing

Depending on the configured mode, the position of the positioning axis/synchronous axis or external encoder technology objects can be absolutely or relatively set with "MC_Home".

Requirement

- The technology object is in position-controlled mode.

Procedure

Set actual position absolutely

To set the actual position absolutely, proceed as follows:

1. In the "MC_Home" Motion Control instruction, enter the absolute actual position in the "Position" parameter.
2. Call the "MC_Home" Motion Control instruction with parameter "Mode" = 0.

The position is set to the value specified in the "Position" parameter.

Set actual position relatively

To set the actual position relatively, proceed as follows:

1. In the "MC_Home" Motion Control instruction, enter the relative actual position in the "Position" parameter.
2. Call the "MC_Home" Motion Control instruction with parameter "Mode" = 1.

The position is set to the current position plus the value specified in the "Position" parameter.

Direct homing at fixed stop

For direct homing at fixed stop, all motions must be programmed in the user program. Change the configuration data directly in the user program. The fixed stop is used as homing mark.

NOTICE
Too fast manual traversing to the fixed stop Too fast a manual traversing of the axis can lead to machine damage. Move the axis manually with low speed/velocity. Configure a suitable torque limit.

To set the position at the fixed stop absolutely or relatively, proceed as follows:

1. Activate a suitable fixed stop detection with the Motion Control instruction "MC_TorqueLimiting".
2. Deactivate the existing hardware limit switch with the Motion Control instruction "MC_WriteParameter".
3. Move the axis to the fixed stop using a suitable motion job. For example, use the Motion Control instructions "MC_MoveRelative" or "MC_MoveJog".
4. After the axis has reached the fixed stop, execute a direct homing using the Motion Control instruction "MC_Home".
5. Move the axis back to the working area between the hardware limit switches.
6. Activate the hardware limit switch with the Motion Control instruction "MC_WriteParameter".
7. Deactivate the fixed stop detection using the Motion Control instruction "MC_TorqueLimiting".

NOTE

In the case of an axis with several encoders, the offset of the position at the sensors of all encoders is also applied with a position correction with the parameter "Mode" = 0. This prevents the sensors from diverging.

See also

MC_TorqueLimiting V10 (Page 374)
MC_WriteParameter V10 (Page 346)
MC_MoveJog V10 (Page 326)
MC_MoveRelative V10 (Page 307)
MC_Home V10 (Page 293)

6.11.6 Set setpoint position

You can set the position setpoint of the axis or the encoder as absolute or relative.

Requirement

- Encoder values are valid (<TO>.StatusSensor[1..4].State = 2)

Procedure

Set position setpoint absolutely

To set the position setpoint absolutely, follow these steps:

1. In the "MC_Home" Motion Control instruction, enter the absolute position setpoint in the "Position" parameter.
2. Call the "MC_Home" Motion Control instruction with parameter "Mode" = 11.

The set position of the technology object is set to the value of the "Position" parameter. The following error remains.

Set position setpoint relatively

To set the position setpoint relatively, follow these steps:

1. In the "MC_Home" Motion Control instruction, enter the relative position setpoint in the "Position" parameter.
2. Call the "MC_Home" Motion Control instruction with parameter "Mode" = 12.

The set position of the technology object is shifted by the value of the "Position" parameter. The following error remains.

6.11.7 Absolute value adjustment

In absolute encoder adjustment, Motion Control determines an absolute value offset that is retentively stored on the CPU.

You can set the actual position of the axis or the encoder as absolute or relative.

Requirements

- The technology object is in position-controlled mode.
- The actual encoder values are valid ("<TO>.Statussensor[1..4].State" = 2).
- The following applies to modulo axes: The position setpoint after resolving the modulo (number of modulo overflows + position within the modulo cycle) must be within the valid value range:
  - 9.0E9, if "Use position values with higher resolution" is activated
  - 9.0E12 if "Use position values with higher resolution" is deactivated

Absolute specification of position

To perform absolute encoder adjustment with absolute specification of position, call the Motion Control instruction "MC_Home" with the parameters "Mode" = 7 and "Position" = absolute position setpoint.

To adjust the operative encoder, enter "Sensor" = 0 at the parameter.

To adjust a non-operative encoder, enter the number of the encoder at the "Sensor" parameter. (S7-1500T)

The current position is set to the value of parameter "Position".

The absolute encoder offset is retentively saved in the "<TO>.StatusSensor[1..4].AbsEncoderOffset" tag.

Relative specification of position

To perform absolute encoder adjustment with relative specification of position, call the Motion Control instruction "MC_Home" with the parameters "Mode" = 6 and "Position" = value by which the current position is to be shifted.

To adjust the operative encoder, enter "Sensor" = 0 at the parameter.

To adjust a non-operative encoder, enter the number of the encoder at the "Sensor" parameter. (S7-1500T)

The current position is shifted by the value of parameter "Position".

The absolute encoder offset is retentively saved in the "<TO>.StatusSensor[1..4].AbsEncoderOffset" tag.

Restoring the position after switching on the CPU

Absolute actual value with setting absolute (measuring range > traversing range)

The axis position results directly from the current actual encoder value. The traversing range must be within an encoder measuring range. This means that the zero crossing of the encoder must not be located in the traversing range.

When the controller is switched on, the axis position is determined from the absolute actual encoder value.

Absolute actual value with setting cyclic absolute (measuring range < traversing range)

The encoder supplies an absolute value within its measuring range. The controller includes the traversed measuring ranges and thus determines the correct axis position beyond the measuring range.

You can find more information on the encoder type in the section "Configuring the encoder type" (Page 64).

When the controller is switched off, the traversed measuring ranges are saved in the retentive memory area of the controller.
At the next power-on, the saved traversed measuring ranges are taken into account in the calculation of the actual position value.

NOTICE
Movements of the axis while the controller is switched off can skew the actual value If the axis or the encoder is moved by more than half of the encoder measuring range while the controller is switched off, the actual value in the controller is no longer in accord with the mechanical axis position.

NOTE
Renaming the technology object
Renaming the technology object deletes a retentive absolute value offset stored in the CPU.
After renaming the technology object, you must carry out the absolute encoder adjustment again.

Resetting the absolute value offset of an encoder

To reset an absolute value offset stored retentively in the CPU, follow these steps:

1. Change the encoder type to incremental.
2. Load the technology object to the CPU.
   The retentively stored absolute value offset is deleted.
3. Change the encoder type back to absolute encoder.
4. Load the technology object to the CPU.

Specify the position of the axis again.

NOTE
Renaming the technology object
Renaming the technology object deletes a retentive absolute value offset stored in the CPU.
After renaming the technology object, you must carry out the absolute encoder adjustment again.

See also

MC_SaveAbsoluteEncoderData V10 (Page 349)

6.11.8 Save data on the SIMATIC Memory Card

With the "MC_SaveAbsoluteEncoderData" Motion Control instruction you can save the absolute encoder adjustment data on the SIMATIC Memory Card for all technology objects with "Absolute" or "Cyclic absolute" encoder type.

The data is saved on the SIMATIC Memory Card in the "UserFiles" folder as "AbsEncoderData.dat".

Requirements

You can use the data saved with "MC_SaveAbsoluteEncoderData" when replacing a device if the following requirements are met.

- Identical encoder configuration
- Identical names of technology objects
- Identical numbers of technology object data blocks

The absolute encoder adjustment is therefore saved.

NOTE

Invalid values of the absolute encoder adjustment on the CPU

If your CPU is not in factory-set state, reset it to factory settings without the "Format memory card" option.

Transferring data to a new CPU

For transferring the data from the absolute encoder adjustment to the new SIMATIC CPU, you have further steps available.

Use existing SIMATIC memory card

1. Insert the SIMATIC Memory Card with values of the absolute encoder adjustment into the new SIMATIC CPU.
2. If your CPU is not in factory-set state, reset it to factory settings without the "Format memory card" option.
3. Check the successful recovery of data in the diagnostic buffer.
4. Switch the CPU to "Run" mode.

Copy the file "AbsEncoderData.dat" to a new SIMATIC Memory Card with the card reader

1. Copy the file "AbsEncoderData.dat" to a new SIMATIC Memory Card in the folder "UserFiles".
2. Insert the SIMATIC Memory Card with values of the absolute encoder adjustment into the SIMATIC CPU.
3. If your CPU is not in factory-set state, reset it to factory settings without the "Format memory card" option.
4. Check the successful recovery of data in the diagnostic buffer.
5. Switch the CPU to "Run" mode.

Transfer the file "AbsEncoderData.dat" to a SIMATIC Memory Card in the web server

Note that the "UserFiles" folder is write-protected on the "Filebrowser" web page.

To transfer the data to a SIMATIC Memory Card in the web server, follow these steps:

1. Select the file "AbsEncoderData.dat" in the web server under User files .
2. Upload the file. The file is automatically assigned in the folder "UserFiles".
3. If your CPU is not in factory-set state, reset it to factory settings without the "Format memory card" option.
4. Check the successful recovery of data in the diagnostic buffer.
5. Switch the CPU to "Run" mode.

Result

The values of the absolute encoder adjustment are restored.

The entry "The data backup for the absolute encoder adjustment was successfully restored" is displayed in the diagnostic buffer.

The backup on the SIMATIC Memory Card is automatically renamed ("AbsEncoderData.bak") and cannot continue to be used.

Checking the restore and backing up data again

Check the correct axis positions.

To back up the data of the absolute encoder adjustment again, perform a backup of the absolute encoder data with the Motion Control instruction "MC_SaveAbsoluteEncoderData".

6.11.9 Incremental encoder adjustment

With the incremental encoder adjustment, you can set the absolute position of an incremental encoder with "Mode" = 13 at "MC_Home".

If the selected encoder is the operative encoder, the setpoint is automatically adjusted to the calibrated actual value during homing. The axis does not perform a compensating motion. After homing, the actual value of the axis is equal to the actual value of the encoder.

In the case of an axis with several encoders: In contrast to "Mode" = 0, when parameter "Mode" = 13 is set, the position offset is not applied at all encoders during a position correction. This means the actual position values can deviate between the encoders. When you switch over the encoder with "MC_SetSensor" with "Mode" = 1 (without synchronization of the actual position) and active position control, an additional difference between the two encoders acts as additional control deviation and can trigger a compensating motion.

During incremental encoder adjustment, the position of the incremental encoder is not saved retentively in the CPU. The values are lost after POWER-OFF.

Requirements

- Incremental encoder
- Technology object enabled and position-controlled or technology object disabled
- No active alarms

Procedure

To perform the incremental encoder adjustment, call the Motion Control instruction "MC_Home" with the parameters "Mode" = 13 and "Position" = absolute position setpoint.

To adjust the active encoder, set parameter "Sensor" = 0.

To adjust a non-active encoder, enter the number of the encoder at the "Sensor" parameter. (S7-1500T)

The current position is set to the value of parameter "Position".

6.11.10 Homing SINAMICS drives with external zero marks

For SINAMICS drives with external zero mark, synchronization during homing must always occur on the left side of the external zero mark's signal. That is to say, with a positive direction of travel synchronization is done on a positive edge, and with a negative direction of travel synchronization is done on a negative edge.

By inverting the signal, synchronization can also be done on the right sight of the signal of the external zero mark. The inversion can be set on the drive with SINAMICS parameter p490.

Homing to an encoder zero mark or an external zero mark is set in SINAMICS parameter p495.

6.11.11 Homing when backlash compensation is enabled

Active and passive homing "MC_Home" with "Mode" = 2, 3, 5, 8 or 10

Always move the axis in the same direction to the home position. Select either "positive" or "negative" as homing direction.

NOTE

Before reaching the homing mark, the backlash must have traversed completely in the homing direction.

Direct homing "MC_Home" with "Mode" = 0 or 1

Always move the axis in the same direction before or during direct homing. If you move the axis in another direction during direct homing, then the axis position around the backlash is invalidated.

Absolute encoder adjustment "MC_Home" with "Mode" = 6 or 7

In order that the actual encoder value can be clearly assigned to an axis position for an absolute encoder, the position of the backlash must also be taken into account when setting the absolute value offset for the absolute encoder adjustment. The position of the backlash results from the direction of travel of the axis during or before the absolute encoder adjustment. Configure the direction of travel of axis using the "Absolute homing direction" parameter. After the controller is switched on again, the axis traverses the backlash if the first traversing motion is in the opposite direction to the absolute homing direction.

If the absolute encoder adjustment has already been carried out, the axis position will only be displayed correctly after the controller has been switched off and on again if the position of the backlash at the time of switch-on corresponds to the position of the backlash in relation to the axis position when the absolute encoder offset was set. Otherwise the axis position can deviate from the axis position displayed up to a maximum of the size of the backlash. The controller records the actual encoder value at the switch-on time, but cannot infer the position of the backlash without traversing the axis. After the axis has been traversed for the first time by at least the size of backlashes, the technology object again shows the real mechanical position.

Incremental encoder adjustment "MC_Home" with "Mode" = 13

Always move the axis and the encoder to be adjusted "MC_Home.Sensor" in the same direction before or during the incremental encoder adjustment. If you move the axis in another direction during incremental encoder adjustment, then the encoder position is incorrect by the amount of the backlash.

See also

Backlash compensation (Page 100)

6.11.12 Resetting the "Homed" status

Incremental encoder

In the following cases, the "Homed" status is reset, and the technology object must be rehomed.

- Error in sensor system/encoder failure
- Starting an "MC_Home" job with "Mode" = 3, 5, 8, 10

  (As soon the homing mark has been approached, the status "Homed" is set to "TRUE".)
- Replacement of the CPU
- Replacement of the SIMATIC Memory Card
- POWER OFF
- Memory reset
- Modification of the encoder configuration
- Restart of the technology object
- Restoration of the CPU factory settings
- Transfer of a different project into the controller

When you use a new incremental encoder you need to home the incremental encoder once again.

Absolute encoder

In the following cases, the "Homed" status is reset, and the technology object must be rehomed.

- Replacement of the CPU
- Changing the encoder type to incremental encoder
- Restoration of the CPU factory settings
- Transfer of a different project into the controller

When you use a new absolute value encoder you need to home the absolute encoder once again.

Resetting the memory of the CPU or upgrading a project does not require another absolute encoder adjustment.

6.11.13 Tags: Homing

The following technology object tags are relevant for homing:

Status indicators	
Tag	**Description**
<TO>.StatusWord.X11 (HomingCommand)	Homing job running
<TO>.StatusWord.X5 (HomingDone)	Technology object homed
<TO>.ErrorWord.X10 (HomingFault)	Error occurred during homing
<TO>.StatusSensor[1..4].Adjusted	Encoder homed

NOTE

Evaluation of the bits in "StatusWord", "ErrorWord" and "WarningWord"

Note the information in section "Evaluating StatusWord, ErrorWord and WarningWord" of the "S7-1500/S7-1500T Motion Control overview" documentation.

Approach to reference output cam	
Tag	**Description**
<TO>.Homing.ApproachDirection	Start direction or approach direction for the approach to the reference output cam
<TO>.Homing.ApproachVelocity	Velocity for the approach to the reference output cam

Approach to the homing mark	
Tag	**Description**
<TO>.Sensor[1..4].ActiveHoming.Direction	Homing direction
<TO>.Homing.ReferencingVelocity	Velocity for the approach to the homing mark

Approach to home position	
Tag	**Description**
<TO>.Homing.ApproachVelocity	Velocity for the move to homing point

Positions	
Tag	**Description**
<TO>.Homing.AutoReversal	Reversal at the hardware limit switches
<TO>.Homing.HomePosition	Home position
<TO>.StatusSensor[1..4].AbsEncoderOffset	Calculated offset after the absolute encoder adjustment

Parameters for active homing	
Tag	**Description**
<TO>.Sensor[1..4].ActiveHoming.Mode	Homing mode
<TO>.Sensor[1..4].ActiveHoming.SideInput	Side of the digital input
<TO>.Sensor[1..4].ActiveHoming.Direction	Homing direction or approach direction
<TO>.Sensor[1..4].ActiveHoming.DigitalInputAddress	Address of digital input
<TO>.Sensor[1..4].ActiveHoming.HomePositionOffset	Offset of the homing mark from the home position

Parameters for passive homing	
Tag	**Description**
<TO>.Sensor[1..4].PassiveHoming.Mode	Homing mode
<TO>.Sensor[1..4].PassiveHoming.SideInput	Side of the digital input
<TO>.Sensor[1..4].PassiveHoming.Direction	Homing direction or approach direction
<TO>.Sensor[1..4].PassiveHoming.DigitalInputAddress	Address of digital input

6.12 Position monitoring functions

The following functions are available in the positioning axis/synchronous axis technology object for monitoring positioning and motion:

- Positioning monitoring (Page 222)

  The actual position value must reach a positioning window within a specified time, and remain in this positioning window for a minimum dwell time.

- Following error monitoring (Page 223)

  The following error is monitored based on a velocity-dependent following error limit. The permissible maximum following error depends on the velocity setpoint.

- Standstill signal (Page 225)

  When the actual velocity reaches the standstill window and remains there for the minimum dwell time, the standstill of the axis is indicated.

If monitored conditions are violated, then technology alarms are output. The technology object responds in accordance with the alarm response.

6.12.1 Positioning monitoring

Position monitoring monitors the behavior of the actual position at the end of the setpoint calculation.

As soon as the velocity setpoint reaches the value zero, the actual position value must be located in the positioning window within a tolerance time. The actual value must not exit the positioning window during the minimum dwell time.

If the actual position is reached at the end of a positioning motion within the tolerance time and remains in the positioning window for the minimum dwell time, then "<TO>.StatusWord.X6 (Done)" is set in the technology data block. After expiration of the minimum dwell time, the "Done" parameter of the corresponding Motion Control instruction is also set. This completes a motion job.

The following figure shows the chronological sequence and the positioning window:

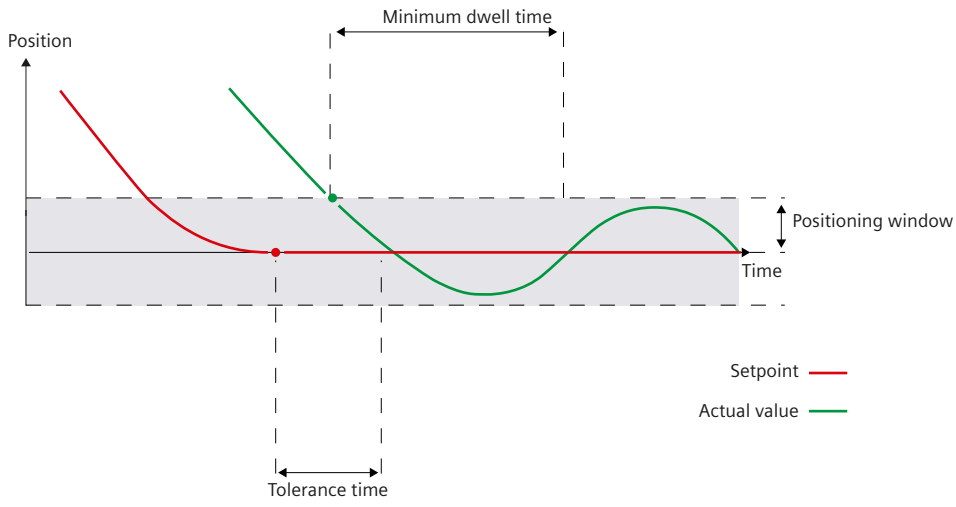

Positioning monitoring does not make any distinction between how the setpoint interpolation was completed. The end of setpoint interpolation can for example be reached as follows:

- By the setpoint reaching the target position
- By position-controlled stopping during motion by the Motion Control instruction "MC_Halt" or "MC_Stop"

Violation of positioning monitoring

In the following cases, technology alarm 541 is output by the positioning monitoring, and the technology object is disabled (alarm reaction: remove enable).

- The actual value does not reach the positioning window during the tolerance time.
- The actual value exits the positioning window during the minimum dwell time.

Configure positioning monitoring

You can find the positioning monitoring in the configuration of the positioning axis/synchronous axis under "Extended parameters > Position monitoring > Position monitoring".

Follow these steps:

1. In the "Positioning window" field, configure the size of the positioning window. If the axis is located within this window, the position is considered to be "reached".
2. In the "Tolerance time" field, configure the time within which the position value must reach the positioning window.
3. In the "Minimum dwell time" field, configure the time for which the current position value must be in the positioning window for at least the "minimum dwell time".

   Recommended setting: To avoid longer pauses, set values between 0 ms and 20 ms for dynamic positioning tasks.

6.12.2 Following error monitoring

The following error is the difference between the setpoint and actual position based on the connection of the axis at the drive. The leading behavior of the axis is contained in the following error. The size of the following error depends on the velocity. The following error also contains a portion that arises from the disturbance variables.

The following error in the positioning axis/synchronous axis technology object is monitored based on a velocity-dependent following error limit. The permissible following error depends on the velocity setpoint.

A constant permissible following error can be specified for velocities lower than an adjustable velocity low limit.

Above this low velocity limit, the permissible following error increases in proportion to the velocity setpoint. The configurable maximum permissible following error is the maximum velocity limit.

Calculation of the following error

When calculating the following error, the transmission times of the setpoint to the drive and of the actual position value to the controller are deducted. The transmission times of the setpoints from the controller to the drive and the actual position values from the drive to the controller are therefore not part of the following error. The value of the following error is thus not the same as the difference between the position setpoint available in the controller minus the existing actual position.

The following error is thus calculated from the delayed position setpoint by $T_i + T_o + T_{DC} + T_{Servo}$ minus the actual position in the controller.

The calculation of the following error is valid for the following conditions:

- Position control with and without DSC
- Configuration with and without precontrol of the position control loop
- Configuration of the drive coupling via a PROFIdrive telegram or via an analog output

Warning limit

A warning limit can be specified for the following error. The warning limit is input as a percentage value and operates relative to the current permissible following error. If the warning limit of the following error is reached, then technology alarm 522 is output. This is a warning and contains no alarm response.

Violation of the permissible following error

If the permissible following error is exceeded, then technology alarm 521 is output, and the technology object is disabled (alarm response: remove enable).

When force/torque limiting is activated, the monitoring of the permissible following error can be deactivated.

Enabling and configuring following error monitoring

You can find the following error monitoring in the configuration of the positioning axis/synchronous axis under "Extended parameters > Position monitoring > Following error".

Select the "Enable following error monitoring" check box.

To configure the following error monitoring, follow these steps:

1. In the "Following error" field, configure the permissible following error for low velocities (without dynamic adaptation of the following error) in the unit of measure for position of the axis.
2. In the "Maximum following error" field, enter the maximum permissible following error in the unit of measure for position of the axis.

3. In the "Start of dynamic adjustment" field, enter in the unit of measure for velocity of the axis the velocity from which the following error is to be adjusted dynamically. Starting from this velocity, the following error up to the maximum velocity will be adjusted to the maximum following error.
4. In the "Warning level" field, enter the percentage of the permitted following error as of which a warning is output.

   Example: The current maximum following error is 100 mm. The warning level is configured at 90%. If the current following error exceeds a value of 90 mm, the technology alarm 522 "Warning following error tolerance" is output. This is a warning and contains no alarm response.

Parameter assignment of the following error calculation with active dynamic filter

The following error is calculated from the delayed interpolated position setpoint by T_i, T_o, T_{DC} and T_{Servo} minus the current actual position value. The deceleration of the position setpoint by the dynamic filter in the technology object or through additional filters in the drive is not taken into account when calculating the following error. The calculated following error is therefore greater in reference to the position setpoint before the dynamic filter.

For correct calculation of the following error, configure an additional delay time <TO>.FollowingError.AdditionalSetpointDelayTime that delays the position setpoint when calculating the following error.

6.12.3 Standstill signal

When the actual velocity reaches the standstill window and remains there for the minimum dwell time, the standstill of the axis or the external encoder is indicated.

Configuring stationary state detection

You can find the stationary state detection of the positioning axis / synchronous axis in the configuration under "Extended parameters > Position monitoring > Standstill signal".

You can find the stationary state detection of the external encoder in the configuration under "Extended parameters > Standstill signal".

Follow these steps:

1. In the "Standstill window" field, configure the size of the standstill window in the measurement unit for the axis velocity.

   To avoid repeated toggling of the "<TO>.Statusword.X7 (Standstill)" bit, a hysteresis acts internally when the standstill window is exited. To exit the standstill window again, the actual velocity must be slightly higher than what is configured for "Standstill window".
2. In the "Minimum dwell time in standstill window" field, configure the duration in seconds for which the velocity of the axis must remain in the standstill window for stationary state detection.

6.12.4 Tags: Position monitoring functions

Standstill signal

The following technology object tags are relevant for position monitoring and for the standstill signal:

Status indicators	
Tag	**Description**
<TO>.StatusWord.X7 (Standstill)	Set to the value "TRUE" when the actual velocity reaches the standstill window and does not exit it within the minimum dwell time. The standstill signal is not present at the speed axis.
<TO>.StatusWord.X6 (Done)	**Positioning axis/synchronous axis** Set to the value "TRUE" when the actual velocity value reaches the positioning window within the tolerance time and remains in the window for the minimum dwell time.
	Speed axis Set to "TRUE" when the motion is complete and the speed set-point is therefore equal to zero.
<TO>.ErrorWord.X12 (PositioningFault)	A positioning error has occurred.

Positions and times	
Tag	**Description**
<TO>.PositioningMonitoring.Tolerance-Time	Maximum permissible time until positioning window is reached The time is started with the end of the setpoint interpolation.
<TO>.PositioningMonitoring.MinDwell-Time	Minimum dwell time in position window
<TO>.PositioningMonitoring.Window	Positioning window

Standstill signal	
Tag	**Description**
<TO>.StandstillSignal.VelocityThreshold	Velocity threshold for the standstill signal
<TO>.StandstillSignal.MinDwellTime	Minimum dwell time below the velocity threshold

Following error monitoring

The following technology object tags are relevant for following error monitoring:

Status indicators	
Tag	**Description**
<TO>.StatusPositioning.FollowingError	Current following error
<TO>.ErrorWord.X11 (FollowingErrorFault)	Status indication, that the following error is too large
<TO>.WarningWord.X11 (FollowingErrorWarning)	Status indication, that the following error warning limit has been reached

Control bits	
Tag	**Description**
<TO>.FollowingError.EnableMonitoring	Enable/disable following error monitoring

Timers	
Tag	**Description**
<TO>.FollowingError.AdditionalSetpoint-DelayTime	Time constant for additional deceleration of position setpoint to calculate the following error in the time unit of the axis

Limits	
Tag	**Description**
<TO>.FollowingError.MinVelocity	Lower velocity setpoint for the characteristic curve of the maximum following error
<TO>.FollowingError.MinValue	Permissible following error below the "<TO>.FollowingError.MinVelocity"
<TO>.FollowingError.MaxValue	Maximum permissible following error at maximum axis velocity
<TO>.FollowingError.WarningLevel	Warning limit as a percentage value relative to the maximum permissible following error (velocity-dependent in accordance with the characteristic curve)

6.13 Configuring a control loop

Together with the controller in the drive, the technology object forms a cascade control system. The innermost control cascade is the current control, the next cascade is the speed control. Both are located in the drive. The position controller is the outermost cascade and is in the technology object.

The position controller of the positioning axis/synchronous axis is a closed-loop P controller with or without velocity precontrol. Use the servo gain factor to set the gain of the proportional-action controller. Optionally, you can configure a torque precontrol.

When position control is enabled, encoder systems, actual value calculation, controllers and monitors are active.

If position control is inactive, encoder systems, actual value calculation and monitoring are active on the actual value side.

In follow-up mode, the setpoint tracks the actual value. Motion jobs are not executed. Actual position and actual velocity are updated. This means that tracking is possible when the axis is being moved by an external influence.

Follow-up mode is active in the following situations when position-controlled mode (Page 242) <TO>.StatusWord.%X28 = FALSE:

- For alarms with stop response <TO>.ErrorDetail.Reaction = 4, 5
- Stopping and disabling a technology object with MC_Power.StopMode = 1, 3
- Technology object is disabled <TO>.StatusWord.%X0 = FALSE

Position controller configuration

Configure the position controller of the positioning axis/synchronous axis technology object:

- Control methods
  - Position control in the drive with Dynamic Servo Control (DSC) (Page 228)
  - Position control in the PLC (Page 231)
- Where does the position controller get its values?
  - Configuring position controller in the PLC (Page 233)
  - Configuring position controller for drives with DSC (Page 232)
- Setpoint filter
  - Configuring a dynamic filter (Page 236)

Optionally, configure the torque precontrol.

- Configuring the torque precontrol (Page 234)

Optimize the position controller during commissioning.

- Optimize position controller (Page 265)

More information

For more information about axis control and controller optimization, refer to Siemens Industry Online Support in the FAQ entry 109779884 (https://support.industry.siemens.com/cs/ww/en/view/109779884).

6.13.1 Position control in the drive with Dynamic Servo Control (DSC)

In drives that support Dynamic Servo Control (DSC), you can use the position controller in the drive. If you use telegrams that support DSC, DSC, and thus the position controller in the drive, is automatically activated.

The position controller is usually executed in the drive in the cycle clock of the speed control loop. In this way, you can set higher position controller gain (Kv factor) and increase the dynamic response for reference variable sequence and disturbance variable correction for highly dynamic drives.

When used with a SINAMICS drive, DSC is the standard case, since the faster control cycle in the drive (e.g. 125 µs) leads to even better control quality.

The following figure shows the effective control structure **with** DSC and with precontrol:

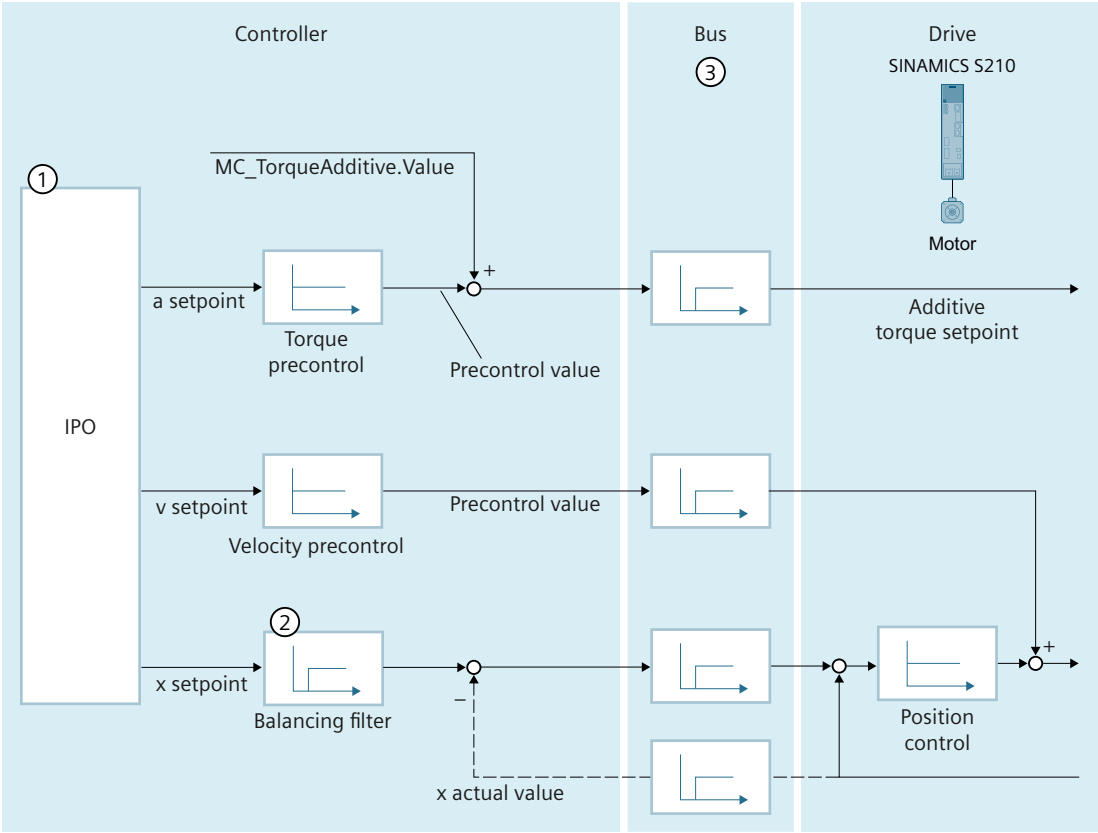

① Interpolator with motion control

② Internal consideration of speed control loop substitute time

③ Communication between controller and drive

Requirements

The following requirements must be met to use DSC:

- The motor encoder (first encoder in the telegram) of the drive is used as the first encoder for the technology object.
- One of the following PROFIdrive telegrams is configured on the drive:
  - Standard telegram 5 or 6
  - SIEMENS telegram 105 or 106

Procedure

To configure position control in the drive with DSC for a positioning axis/synchronous axis, follow these steps:

1. In the configuration of the technology object, navigate to "Extended parameters > Control loop > Dynamic Servo Control (DSC)".
2. Select the "Position control in the drive (DSC enabled)" option.
3. Apply the values from the drive.

   Configuring position controller for drives with DSC (Page 232)

Signal flow diagrams

For more information about the control structure in the form of signal flow diagrams for the positioning axis/synchronous axis technology object, refer to the appendix (Page 459).

6.13.2 Position control in the PLC

The position controller is executed in the Motion Control application cycle, for example, 4 ms in the MC_Servo.

With position control in the CPU, the drive can be connected either isochronously or non-isochronously. If the drive supports isochronous mode, you can also connect it isochronously. You can find a description on how to connect a drive isochronously in section "Adding and configuring drives (Page 47)".

The following figure shows the effective control structure in position control in the controller:

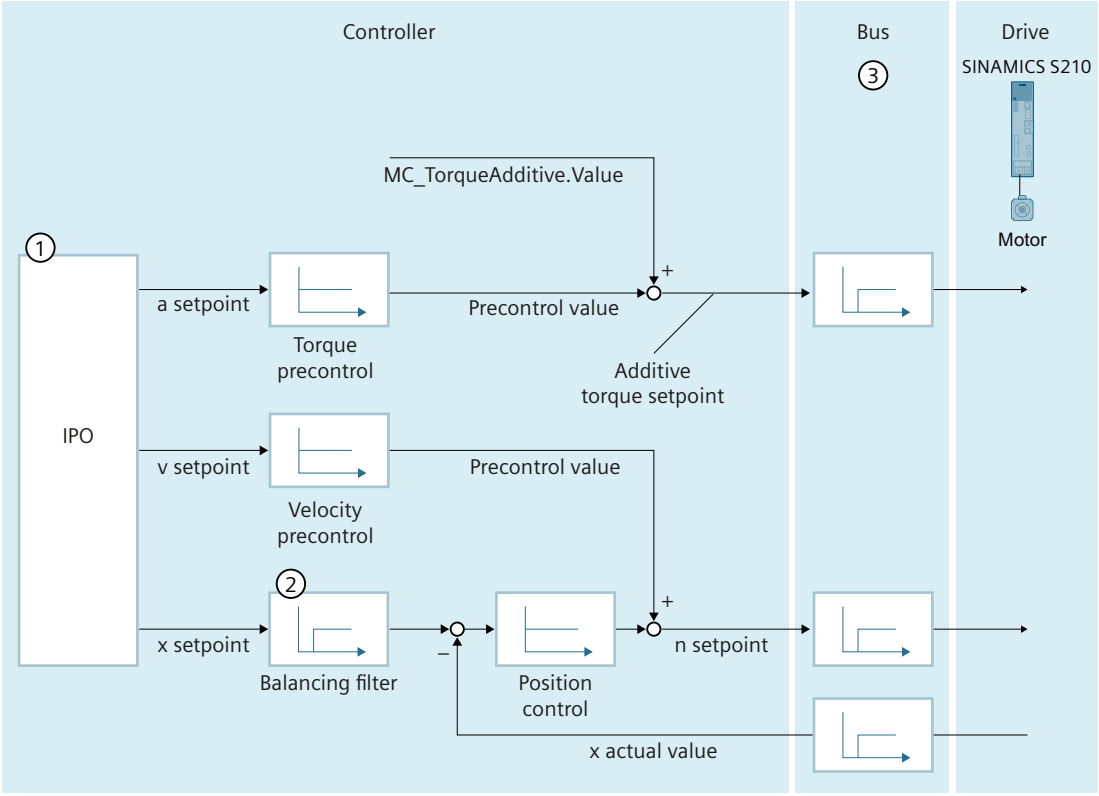

① Interpolator with motion control

② Internal consideration of the signal propagation times and the speed-control loop substitute time

③ Communication between controller and drive

Procedure

To configure position control in the CPU for a positioning axis/synchronous axis, follow these steps:

1. In the configuration of the technology object, navigate to "Extended parameters > Control loop > Dynamic Servo Control (DSC)".
2. Select the "Position control in the PLC" option.
3. Under "Position control", configure the values for precontrol, speed control loop substitute time and gain (Kv factor).

   Configuring position controller in the PLC (Page 233)

Signal flow diagrams

For more information about the control structure in the form of signal flow diagrams for the positioning axis/synchronous axis technology object, refer to the appendix (Page 459).

6.13.3 Configuring position controller for drives with DSC

You configure automatic adoption of the values for the positioning axis/synchronous axis in the configuration under "Extended parameters > Control loop > Position control".

A description of how to adapt the adopted values for the position controller to your axis is provided in section "Optimize position controller (Page 265)".

Automatic transfer from drive

If you have configured and optimized the assigned drive with SINAMICS Startdrive you can then apply the following values for the in the technology object from the drive.

- Gain (Kv factor): The technology object adopts 50% of the value from the drive.
- Speed control loop substitute time: The technology object adopts the value from the drive.
- Moment of inertia load/weight of the load
- Moment of inertia motor/weight motor
- Current control loop substitute time

Requirements:

- A drive is linked to the technology object.
- Dynamic Servo Control (DSC) is enabled.

Drive optimized

The display only applies if you have optimized the assigned drive with One Button Tuning (OBT).

- Display is green: Drive is optimized
- Display is gray: Drive is not optimized

Optimizing values on the drive

The green arrow takes you to the configuration of the drive in Startdrive. Optimize the drive there.

Taking values from the drive

When you click on this button you transfer the values from the drive to the technology object.

	SINAMICS Startdrive offline	SINAMICS Startdrive online
Monitoring off	Offline values of the drive are applied. The values are transferred as start value to the technology object.	Online values of the drive are applied. The values are transferred as start value to the technology object.
Monitoring on	Offline values of the drive are applied. The values are transferred as actual values to the technology object.	Online values of the drive are applied. The values are transferred as actual values to the technology object.

6.13.4 Configuring position controller in the PLC

You configure the values for the position controller for the positioning axis/synchronous axis in the configuration under "Extended parameters > Control loop > Position control".

The basics on configuration values are explained below.

The configuration of the torque precontrol is described in the section Configuring torque precontrol (Page 234).

A description of how to set the suitable values for the position controller to your axis during commissioning is provided in section "Optimize position controller (Page 265)".

You need to optimize the speed controller separately on the drive.

Velocity precontrol

Configure the percentage velocity precontrol in this field.

The velocity precontrol can be used to minimize the velocity-based following error during position control. As a result, faster positioning may be achieved because the reference variable acts faster.

When using the velocity precontrol, the velocity setpoint is additionally switched to the output of the position controller. You can weight this additional setpoint by a factor.

With digital drive coupling, the velocity precontrol should be at 100%.

Speed control loop substitute time

In this field, configure the speed control loop substitute time (T_{vtc}).

The speed control loop substitute time is included in the balancing filter.

The balancing filter is a simplified model of the closed speed control loop. The balancing filter is used to prevent the position controller from overriding the speed manipulated variable during the acceleration and deceleration phases. To accomplish this, the position setpoint of the position controller is delayed by the speed control loop substitute time in relation to the speed precontrol.

Note the following regarding the configuration of the speed control loop substitute time:

- If you do not use any speed precontrol (0%), the configuration of the speed control loop substitute time is not relevant.
- If you use speed precontrol (>0%) and set the speed control loop substitute time to 0.0 s (default value), the axis will overshoot. To find the right setting, optimize the position controller.

Gain (Kv factor)

In this field, you configure the gain Kv of the position control loop.

The Kv factor affects the following parameters:

- Positioning accuracy and stop control
- Uniformity of motion
- Positioning time

The better the mechanical conditions of the real axis (high stiffness), the higher the Kv factor can be configured. This reduces the following error, and a higher dynamic repsonse is achieved.

6.13.5 Configuring the torque precontrol

Torque precontrol

The torque precontrol, as part of the closed loop position control, allows for faster and more precise movement of the axis while maintaining smoother control settings.

The torque precontrol allows for a reduction of following error during acceleration and deceleration phases.

Note that the torque values of the torque precontrol of the technology object and the torque values specified by an instruction "MC_TorqueAdditive" are added. The resulting value is displayed in "<TO>.StatusTorqueData.TotalTorqueAdditive".

For a linear motor, the torque precontrol outputs force values.

When utilizing torque precontrol, you should configure jerk limitation for all motion jobs.

Requirements

- Additional telegram 750 used

  Connecting force/torque data via SIEMENS additional telegram 750 (Page 74)
- You have configured the inertia values for load and motor, either via "Automatic transfer from drive" or manually.

  Configuring position controller for drives with DSC (Page 232)

  Configure inertia values (Page 105)
- The drive is set correctly.

Boundary conditions

- When utilizing torque precontrol, you should configure jerk limitation for all motion jobs.
- Torque precontrol should not be used for a synchronous axis with actual value coupling.
- For improved control performance, it is recommended to additionally configure the dynamic filter with a moving average and a time constant of, for example, 10 ms. The optimum time constant may be different.
- The inertia load / mass load must be specified on the load side.

Torque precontrol mode

Configure the mode for the torque precontrol:

- Off

  No torque precontrol active
- Torque precontrol based on the acceleration of the axis

  The torque precontrol of the S7-1500 CPU provides torque setpoints based on the dynamic response of the axis.

  The value of the torque precontrol M_{add} depends on:

  – Acceleration setpoint

  – Inertia value of the load and motor converted to the motor side.

  – Weighting factor as a percentage

Current control loop substitute time

Configure the current control loop substitute time <TO>.DynamicAxisModel.CurrentTimeConstant for the torque precontrol.

For drives with DSC, you can automatically take over the current control loop substitute time with "Automatic transfer from drive".

Manual configuration: For SINAMICS drives, a suitable guide value for the current control loop substitute time is the current control loop sampling time of drive $T_{Current}$ (p115[0])

$T_{ctc} = T_{Current}$

Weighting factor

Configure the weighting factor in percent <TO>.TorquePreControl.Scale for the torque precontrol.

Requirements for the torque precontrol in drive

The SINAMICS S2x0 requires the following settings:

- Activate the exchange of torque data on the technology object via telegram 750.
- Check that the torque precontrol is active in the "p5271.4 = 1" drive. To do this, you must enable the advanced expert list view.
- If both of the above requirements are met, perform the one-button tuning.

The SINAMICS S120 requires the following settings:

- Activate interpolation for the additional torque between T_{DP} and $T_{current}$ (p1409.0 = 1).
- Configure the speed precontrol balancing dead time (p1428 = 2).
- Deactivate speed precontrol balancing time constant (p1429 = 0).
- Configure the speed precontrol to the value "For balancing" (p1400.10 = 1).

You can find more information on the SIMATIC TIA AddIn for quick adjustment of torque precontrol in the Siemens Industry Online Support in the FAQ entry 109955411 (https://support.industry.siemens.com/cs/document/109955411/simatic-torque-pre-control-assistant-addin?dti=0&lc=en-WW).

6.13.6 Dynamic filter

Axes that act mostly independent of one another are usually optimized independent of one another. Only in specific cases, such as in the highly dynamic interaction of a complete system, can you perform a dynamic adjustment following the actual optimization of individual axes.

The axes involved in a machine often have different mechanics. As a result, speed and position controllers of individual axes cannot be optimized identically. The axes can therefore have different dynamics.

Use the dynamic filter to adapt the dynamic response of axes to one another. The configuration of the dynamic filter is available for positioning and synchronous axes.

The dynamic filter is effective with closed loop position control with and without DSC. The dynamic filter delays the calculated position and velocity setpoints of the interpolator. Smoothing the position and velocity setpoints reduces jerk at the axis and can help minimize the generation of mechanical oscillations on the axis.

For axes in a synchronous operation with different speed control loop substitute time T_{vtc} and used precontrol, we recommend a dynamic adjustment using the dynamic filter. Thus, the real traversing movements of the leading axis and the following axes can be more precisely synchronized because the same following error occurs in the axes involved.

To execute path motions with high contour accuracy, for kinematics with different speed control loop substitute times T_{vtc} of the kinematics axes, a dynamic adaptation is required.

Configure the following error calculation with active dynamic filter

The following error is calculated from the delayed interpolated position setpoint by T_i, T_o, T_{Pn} and T_{Servo} minus the current actual position value. The deceleration of the position setpoint by the dynamic filter in the technology object or through additional filters in the drive is not taken into account when calculating the following error. This calculates a larger following error.

For correct calculation of the following error, set an additional delay time that delays the position setpoint when calculating the following error (<TO>.FollowingError.AdditionalSetpointDelayTime).

Dynamic filter - mode

You can specify the dynamic filter with the following modes:

- PT1 or PT2 filter (Page 237) (<TO>.SetPointFilter.DynamicFilter.Mode = 1)

  The dynamic filter can be configured as a parameterizable PT2 setpoint filter with the time constants T_1, T_2 and an additional parameterizable dead time T_t. Use this mode for axes in synchronous operation.

- Sliding window demand filter (Page 239) (<TO>.SetPointFilter.DynamicFilter.Mode = 2)

  The dynamic filter is used with either one or two sliding window demand filters in series. This mode is suitable for achieving high path accuracy in kinematic motions. Use this mode for axes with torque precontrol based on the acceleration of the axis (<TO>.TorquePreControl.Mode = 1)

6.13.6.1 Dynamic filter as PT1 or PT2 filter

The dynamic filter can be configured as a parameterizable PT2 setpoint filter with the time constants T_1, T_2 and an additional parameterizable dead time T_t. You use the filter to adjust axes with higher dynamic to the axis with the lowest dynamic. The dynamic filter is individually configurable for each positioning axis and synchronous axis.

The dynamic filter is disabled at an axis by default. To activate the dynamic filter with PT1 or PT2 filter on an axis, set the "PT1 or PT2 filter" mode in the configuration of the technology object under "Extended Parameters > Settings of the control loop > Dynamic Filter" ("<TO>.SetPointFilter.DynamicFilter.Mode" = 1) and configure one of the times T_1, T_2 or T_t with a value greater than 0.0.

The following table shows the effectiveness of the dynamic filter depending on the configured timers:

T_1	T_2	T_t	Active dynamic filter
0.0	0.0	0.0	Dynamic filter not active (default)
> 0.0	0.0	0.0	PT1 setpoint filter without additional dead time
0.0	> 0.0	0.0	PT1 setpoint filter without additional dead time
> 0.0	> 0.0	0.0	PT2 setpoint filter without additional dead time
0.0	0.0	> 0.0	Exact setpoint delay via dead time
> 0.0	0.0	> 0.0	PT1 setpoint filter with additional dead time
0.0	> 0.0	> 0.0	PT1 setpoint filter with additional dead time
> 0.0	> 0.0	> 0.0	PT2 setpoint filter with additional dead time

The series connection of two PT1 filters creates a PT2 filter. PT1/PT2 filters act as a low pass. This smooths the position and velocity setpoints. For the damping degree D of PT2 filter, $D \geq 1$. The PT2 filter cannot vibrate.

The damping degree D is calculated using the following equation.

$$D = \frac{T_1 + T_2}{2 \cdot \sqrt{T_1 \cdot T_2}}$$

The angular frequency ω is calculated using the following equation.

$$\omega = \frac{1}{(T_1 \cdot T_2)^{\frac{1}{2}}}$$

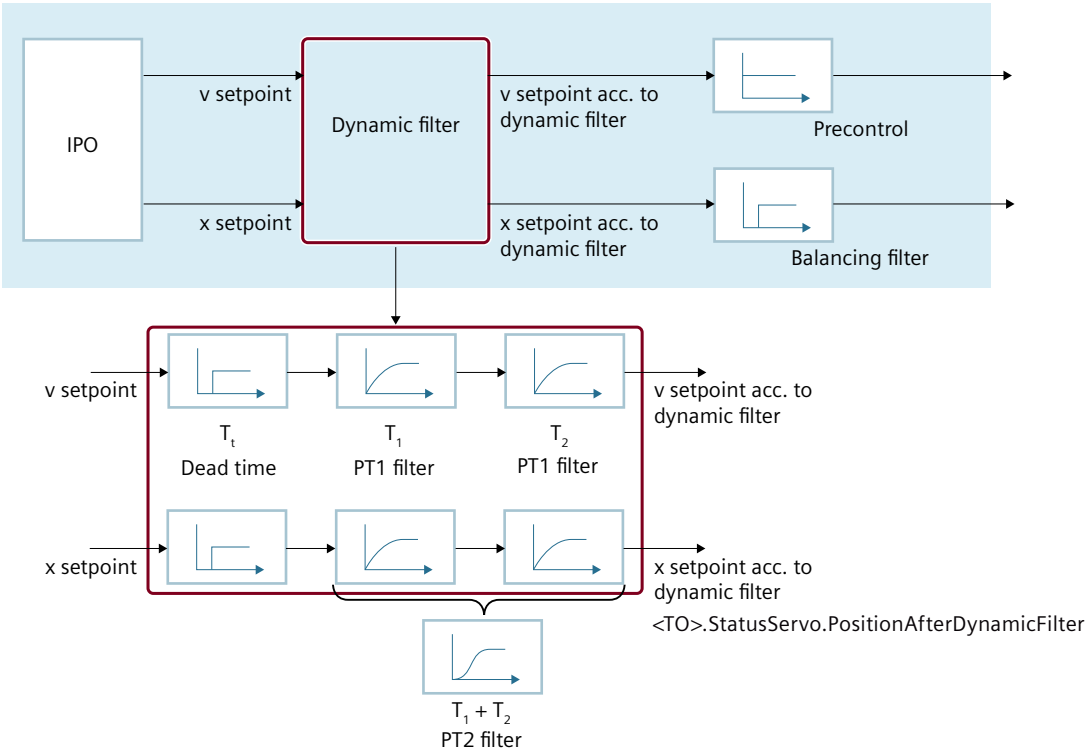

Procedure

To set the dynamic filter, proceed as follows:

1. First, optimize all axes.
2. Determine the speed control loop substitute times T_{vtc} of all axes (<TO>.DynamicAxisModel.VelocityTimeConstant)

   Example:

   Axis 1: T_{vtc} = 0.004 s

   Axis 2: T_{vtc} = 0.006 s

   Axis 1 is the more dynamic axis. The difference is 0.002 s.
3. Enable the dynamic filter in mode PT1or PT2 filter in the configuration of axis 1 under "Extended parameters > Settings of the control loop > Dynamic filter".

4. Configure the effective time constant of the dynamic filter (sum of the time constants T_1, T_2, T_t) at axis 1 to 0.002 s. Depending on the preferred filter behavior, set one of the following variants for parameter assignment of the dynamic filter. In the configuration of the technology object, you can see a graphic representation of the step response.
   - PT1: T_1 = 0.002 s
   - PT2: T_1 = 0.001 s, T_2 = 0.001 s
   - Exact setpoint delay without smoothing: T_t = 0.002 s
5. For calculating the following error on axis 1, assign the effective time constant of the dynamic filter as additional delay time of the setpoint position ("<TO>.FollowingError.AdditionalSetpointDelayTime" = 0.002 s = $T_1 + T_2 + T_t$).

   You can find more information in the section "Following error monitoring (Page 223)".

6.13.6.2 Dynamic response as sliding window demand filter

The dynamic filter can be configured as a moving average with the time constants T_1, T_2 and an additional parameterizable dead time T_t. You use the filter to adjust axes with higher dynamic to the axis with the lowest dynamic. The dynamic filter is individually configurable for each positioning axis and synchronous axis.

The dynamic filter is disabled at the axis by default. To activate the dynamic filter with one moving average filter or two moving average filters connected in series, set the "Moving average filter" mode in the configuration of the technology object under "Extended Parameters > Settings of the control loop > Dynamic Filter" ("<TO>.DynamicFilter.Mode" = 2) and configure one of the times T_1, T_2 or T_t with a value greater than 0.0. The times T_t, T_1 and T_2 are limited to 16 times the servo cycle.

The following table shows the effectiveness of the dynamic filter depending on the configured timers:

T_1	T_2	T_t	Active dynamic filter
0.0	0.0	0.0	Dynamic filter not active (default)
> 0.0	0.0	0.0	One moving average filter without additional dead time
0.0	> 0.0	0.0	One moving average filter without additional dead time
> 0.0	> 0.0	0.0	Two moving average filters in series without additional dead time
0.0	0.0	> 0.0	Exact setpoint delay via dead time
> 0.0	0.0	> 0.0	One moving average filter with additional dead time
0.0	> 0.0	> 0.0	One moving average filter with additional dead time
> 0.0	> 0.0	> 0.0	Two moving average filters with additional dead time

The time T_1 defines the time window over which the dynamic filter calculates the average of the position setpoint and the velocity setpoint. With a servo cycle time of 4 ms and T_1 of 12 ms, the dynamic filter calculates the average of the values from the last 3 servo cycles and the current value. The values in the remaining time that do not correspond to a multiple of the servo cycle are weighted in proportion to time. With a servo cycle time of 4 ms and T_1 of 13 ms, the dynamic filter calculates the average of the values from the last 4 servo cycles and the current value. The current value and the values of the last three servo cycles are fully weighted. The value from the time window of the remaining time is weighted at only one-fourth. This corresponds to the remaining time of 1 ms for a servo cycle time of 4 ms.

To reduce mechanical oscillations on an axis and to additionally adapt the dynamic response of this axis to the dynamic response of a less dynamic axis with higher speed control loop substitute time T_{vtc}, use two moving average filters in series ($T_1 > 0$, $T_2 > 0$).

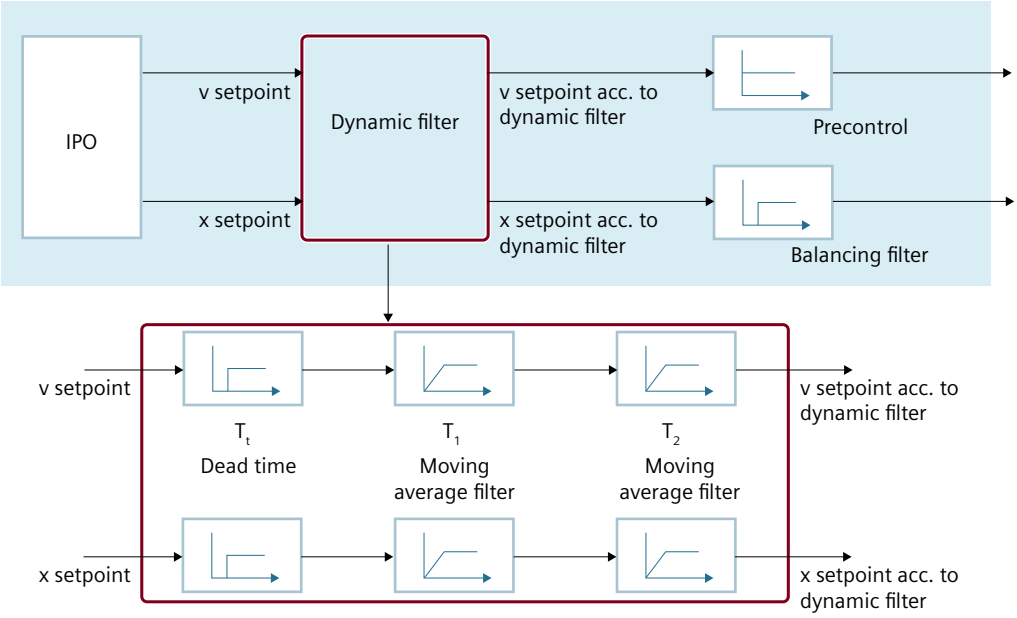

Dynamics of two coupled axes with different dynamic response

To adjust the dynamic response of two coupled axes with different dynamics, follow these steps:

1. Optimize all axes.
2. Determine the speed control loop substitute times T_{vtc} of all axes (<TO>.DynamicAxisModel.VelocityTimeConstant)

   Example:

   Axis 1: $T_{vtc} = 0.004$ s

   Axis 2: $T_{vtc} = 0.006$ s

   Axis 1 is the more dynamic axis. The difference is 0.002 s.
3. Activate the dynamic filter in "Moving average" mode in the configuration of axis 1 under "Extended parameters > Settings of the control loop > Dynamic filter" (<TO>.SetpointFilter.DynamicFilter.Mode).
4. Configure the time constant T_1 of the dynamic filter on axis 1 to 0.004 seconds. This corresponds to twice the time difference of the two speed control loop substitute times. Configure the time constants T_t and T_2 to 0.0 s.
5. For calculating the following error on axis 1, configure the effective time constant of the dynamic filter as additional delay time of the setpoint position ("<TO>.FollowingError.AdditionalSetpointDelayTime" $= 0.002\ s -= 0.5 \cdot T_1 + 0.5 \cdot T_2 +- T_t\ 0.5 \cdot 0.004\ s + 0\ s + 0\ s$).

Reduce mechanical oscillations on an axis

To reduce mechanical vibrations on an axis, follow these steps:

1. Optimize all axes.
2. Determine the dominant natural frequency of the axis using appropriate measuring methods in the time or frequency domain. For this purpose, use the measurement functions of SINAMICS or position the axis via the control panel or user program and perform a measurement of the actual values.

   Example: The determined natural frequency is 23 Hz.
3. Activate the dynamic filter in "Moving average" mode in the configuration of axis 1 under "Extended parameters > Settings of the control loop > Dynamic filter" (<TO>.SetpointFilter.DynamicFilter.Mode).
4. Configure the time constant T_1 of the dynamic filter on axis 1 to 1/23 Hz. This corresponds to 0.0435 s. Configure the time constants T_t and T_2 to 0.0 s.
5. For calculating the following error on axis 1, configure the effective time constant of the dynamic filter as additional delay time of the setpoint position ("<TO>.FollowingError.AdditionalSetpointDelayTime" = 0.02175 s = 0.5 T_1 + 0.5 T_2 + T_t = 0.5 · 0.0435 s-+ 0 s + 0 s).

Reduce mechanical oscillations on an axis and adjust dynamic response to a coupled axis

To reduce mechanical oscillations on an axis and match the dynamics to a coupled axis, follow these steps:

1. Optimize all axes.
2. Determine the natural frequency of the axis using appropriate measuring methods.

   Example: The determined natural frequency is 23 Hz.
3. Determine the speed control loop substitute times T_{vtc} (<TO>.DynamicAxisModel.VelocityTimeConstant).

   Example:

   Axis 1: T_{vtc} = 0.004 s

   Axis 2: T_{vtc} = 0.036 s

   Axis 1 is the more dynamic axis. The difference is 0.032 s.
4. Activate the dynamic filter in "Moving average" mode in the configuration of axis 1 under "Extended parameters > Settings of the control loop > Dynamic filter" (<TO>.SetpointFilter.DynamicFilter.Mode).
5. Configure the time constant T_1 of the dynamic filter on axis 1 to 1/23 Hz. This corresponds to 0.0435 s. operating distance. This dampens the mechanical vibration.
6. Calculate the time constant T_2 of the dynamic filter on axis 1. Through use of the additional time constant T_2, activate the second moving average filter and achieve an effective time constant of the dynamic filter of 0.032 s, which corresponds to the difference between the two axes: $T_2 = 2 \cdot 0.032\ s - T_1 = 0.0205\ s$

   A negative time result indicates that axis 1 with the dynamic filter is "slower" than axis 2. The determined value should be set as the filter time on axis 2.

7. For calculating the following error on axis 1, configure the effective time constant of the dynamic filter as additional delay time of the setpoint position ("<TO>.FollowingError.AdditionalSetpointDelayTime" = 0.032 s = 0.5 T_1 + 0.5 T_2 + T_t = 0.5 · 0.0435 s + 0.5 · 0.0205 s + 0 s).

6.13.7 Switching the position control off and on

The position control of an axis can be switched off and on again with the following Motion Control instructions in the non-position-controlled mode:

- MC_Power
- MC_MoveVelocity
- MC_MoveJog
- MC_MotionInVelocity

The non-position-controlled mode is indicated in the tag of the technology object "<TO>.StatusWord.X28 (NonPositionControlled)" = TRUE.

MC_Power

The axis is enabled without position control with "MC_Power.Enable" = TRUE and the parameter "StartMode" = 0. The position control remains switched off until a different Motion Control instruction changes the status of the position control.

MC_MoveVelocity and MC_MoveJog

A "MC_MoveVelocity" or "MC_MoveJog" job with "PositionControlled" = FALSE forces non-position-controlled operation.

A "MC_MoveVelocity" or "MC_MoveJog" job with "PositionControlled" = TRUE forces position-controlled operation.

The selected mode remains in effect after the job is completed.

MC_MotionInVelocity and MC_MotionInPosition

A "MC_MotionInVelocity" job with "PositionControlled" = FALSE forces non-position-controlled operation.

A "MC_MotionInVelocity" job with "PositionControlled" = TRUE forces position-controlled operation.

The selected mode remains in effect after the job is completed.

A "MC_MotionInPosition" job forces position-controlled operation.

Influence of additional Motion Control instructions

Starting the following Motion Control instructions forces position-controlled operation of the axis:

- MC_Home with "Mode" = 3, 5
- MC_MoveAbsolute
- MC_MoveRelative
- MC_MoveSuperimposed
- MC_MotionInPosition
- MC_GearIn
- MC_GearInPos (S7-1500T)
- MC_CamIn (S7-1500T)

The position control remains active after completing the corresponding jobs.

The Motion Control instructions "MC_Halt" and "MC_Stop" are executed in position-controlled and also in non-position-controlled operation. The status of the position control is not changed by "MC_Halt"/"MC_Stop".

A torque limiting activated with "MC_TorqueLimiting" is in effect even with non-position-controlled operation.

6.13.8 Tags: Closed-loop control

The following technology object tags are relevant for the control loop:

Parameters		
Tag	**Description**	
<TO>.PositionControl.Kv	Proportional gain of the closed loop position control	
<TO>.PositionControl.Kpc	Velocity precontrol of the closed loop position control [%]	
<TO>.PositionControl.EnableDSC	Enable DSC	
<TO>.DynamicAxisModel.VelocityTime-Constant	Speed control loop substitute time [s]	
<TO>.PositionControl.ControlDifference-Quantization.Mode	Type of quantification Configuration of a quantization when a drive with stepper motor interface is connected	
	0	No quantification
	1	Quantization corresponding to encoder resolution
	2	Quantization to a direct value (value input in "<TO>.PositionControl.ControlDifference-Quantization.Value")
	Configuration is performed using the parameter view (data structure).	

Parameters		
Tag	**Description**	
<TO>.PositionControl.ControlDifference-Quantization.Value	Value of quantification Configuration of a value for quantization to a direct value ("<TO>.PositionControl.ControlDifferenceQuantization.Mode" = 2) The quantization value is specified in the position unit of the axis. Configuration is performed using the parameter view (data structure).	
<TO>.TorquePreControl.Mode	Mode of torque precontrol (effect only in position-controlled mode)	
	0	Torque precontrol not in effect
	1	Torque precontrol based on the acceleration of the axis
<TO>.TorquePreControl.Scale	Weighting factor for the value of the torque precontrol [%]	
<TO>.DynamicAxisModel.CurrentTime-Constant	Current control loop substitute time in time unit of the axis	

The following technology object tags are relevant for the dynamic filter:

Parameters		
Tag	**Description**	
<TO>.SetpointFilter.DynamicFilter.Mode	Dynamic filter mode	
	0	Dynamic filter not active
	1	PT1/PT2 filter + dead time
	2	Sliding window demand + dead time
<TO>.SetpointFilter.DynamicFilter.T1	First time constant of the sliding window demand The value is internally limited to the 16-fold servo clock.	
<TO>.SetpointFilter.DynamicFilter.T2	Second time constant of the sliding window demand The value is internally limited to the 16-fold servo clock.	
<TO>.SetpointFilter.DynamicFilter.Tt	Additional dead time of the dynamic filter in the time unit of the axis The value is internally limited to the 16-fold servo clock.	
<TO>.StatusServo.PositionAfterDynamic-Filter	Position setpoint after the dynamic filter	
<TO>.FollowingError.AdditionalSetpoint-DelayTime	Time constant for additional deceleration of position setpoint to calculate the following error in the time unit of the axis	

6.14 Motion specification via "MotionIn"

The following MotionIn instructions are available:

- "MC_MotionInVelocity" (Page 350)

  Specify velocity and acceleration
- "MC_MotionInPosition" (Page 355)

  Specifying the position, velocity and acceleration

- "MC_MotionInSuperimposed" (Page 360)
  Specify superimposed motion setpoints
- "MC_MotionInSuperimposedAxes" (Page 364)
  Specify superimposed motion setpoints from another axis

WARNING

Personal injury or machine damage due to unintended axis motions

When using the motion specification via all "MotionIn" instructions, the axis can execute unintended motions.

Before operation with the "MotionIn" instructions, take the following precautionary measures:

- Ensure that the EMERGENCY OFF switch is within the reach of the operator.
- Enable the hardware limit switches.
- Enable the software limit switches.
- Ensure that following error monitoring is enabled.

Note that a following axis that is coupled to the axis is also moved.

"MC_MotionInVelocity", "MC_MotionInPosition", "MC_MotionInSuperimposed"

In contrast to Motion Control instructions such as "MC_MoveAbsolute" and "MC_MoveRelative", no motion profile is calculated by the system. Each individual setpoint of the motion profile (motion vector) must be specified with the "MotionIn" instruction in the application cycle. This allows you to calculate your own motion profile. You are responsible for the accuracy of your information.

The setpoints are typically adapted in the processing cycle of the technology object. Call the "MotionIn" instruction in the MC_PreInterpolator. The setpoints take effect directly in the next application cycle when the MC_Servo is called to calculate the position controller.

"MC_MotionInSuperimposedAxes"

The motion setpoints of a superimposing axis are specified to the axis in the application cycle in addition to the basic motion. You can call the instruction in every cyclic organization block.

Overriding with MotionIn instructions

If a Motion Control instruction is overridden by a "MotionIn" instruction, the specified setpoints take immediate effect with the current application cycle. The dynamic response results exclusively through the setpoint value specifications of the user program. It is not limited and no smooth transition takes place from the current motion state. Consider the current dynamic response of the axis when specifying the new motion vectors. Note that dynamic limits set on the technology object are not effective. Only limits set on the drive side are in effect.

"MotionIn" status indicators

The tag "<TO>.StatusMotionIn.FunctionState" = 1 indicates that an "MC_MotionInVelocity" job is active.

The tag "<TO>.StatusMotionIn.FunctionState" = 2 indicates that an "MC_MotionInPosition" job is active.

The "<TO>.StatusMotionIn.ActualSuperimposingAxis" tag shows the currently selected superimposing axis in the "MC_MotionInSuperimposedAxes" job.

The "<TO>.StatusWord.X31 (MotionInCommand)" tag is set when an "MC_MotionInVelocity" job or an "MC_MotionInPosition" job is active.

The "<TO>.StatusWord2.X6 (MotionInSuperimposedCommand)" tag is set when an "MC_MotionInSuperimposed" job is active.

The "<TO>.StatusWord2.X8 (MotionInSuperimposedAxesCommand)" tag is set when an "MC_MotionInSuperimposedAxes" job is active.

The "<TO>.StatusMotionIn.StatusWord.X0 (MaxVelocityExceeded)" tag indicates that the configured maximum velocity has been exceeded during a "MotionIn" job.

The "<TO>.StatusPositioning.SuperimposedDistance" tag indicates the distance traversed with the "MC_MoveSuperimposed", "MC_MotionInSuperimposed", "MC_MotionInSuperimposedAxes" und "MC_HaltSuperimposed" instructions. The value is reset when the basic motion and superimposed motion have been completed or canceled.

6.14.1 Specifying velocity and acceleration

Use the "MC_MotionInVelocity" (Page 350) instruction to specify the velocity and acceleration of the motion. The instruction is applicable for speed, positioning and constant axes.

NOTICE
Machine damage due to possible setpoint jumps Setpoint jumps can occur as a result of the specification of an inconsistent motion profile. To avoid setpoint jumps, note the following: • Consider the current dynamic response of the axis when specifying the new motion vectors. • Only specify motion vectors that are consistent with one another. • Note that a following axis that is coupled to the axis is also moved.

Parameter inputs

To execute the instruction, you must at least specify the velocity. Acceleration is usually only required for the substituting running motions. By default, the acceleration value is zero.

With the following parameters of the Motion Control instruction "MC_MotionInVelocity", you specify cyclically applicative calculated motion setpoints for velocity and acceleration as a basic motion for the axis.

- With the "Velocity" parameter, you specify the velocity setpoint or speed setpoint.
- With the "Acceleration" parameter, you specify the acceleration.
- With the "PositionControlled" parameter, you switch on the position-controlled mode or not in position-controlled mode.

The velocity setpoint and acceleration setpoint are in effect when the "Enable" parameter = TRUE and at least one value is specified for the "Velocity" parameter.

6.14.2 Specifying the position, velocity and acceleration

Use the "MC_MotionInPosition" (Page 355) instruction to specify the position, velocity and acceleration of the motion. This instruction is used for velocity, positioning and synchronous axes.

NOTICE
Machine damage due to possible setpoint jumps Setpoint jumps can occur as a result of the specification of an inconsistent motion profile. To avoid setpoint jumps, note the following: • Consider the current dynamic response of the axis when specifying the new motion vectors. • Only specify motion vectors that are consistent with one another. • Note that a following axis that is coupled to the axis is also moved.

Parameter inputs

To execute the instruction, you must at least specify the position and velocity. The acceleration is needed for the overriding of running motions. By default, the acceleration value is zero. The specified setpoints must be consistent with each other.

The position specification is position-controlled. If you use a velocity precontrol, the velocity specification is processed via the velocity precontrol.

With the following parameters of the Motion Control instruction "MC_MotionInPosition", you specify cyclically applicative calculated motion setpoints for position, velocity and acceleration as a basic motion for the axis:

- With the "Position" parameter, you can specify the position setpoint.
- With the "Velocity" parameter, you specify the velocity setpoint or speed setpoint. The velocity setpoint is used as the precontroller value when velocity precontrol is activated.
- With the "Acceleration" parameter, you specify the acceleration.

The position setpoint, velocity setpoint and acceleration setpoint are in effect when the "Enable" parameter = TRUE and values have been specified for at least the "Position" and "Velocity" parameters.

6.14.3 Superimposed "MotionIn" motion

A positioning or synchronous axis is moved position-controlled via a Motion Control job. With the Motion Control instructions "MC_MotionInSuperimposed" and "MC_MotionInSuperimposedAxes", you can start a motion on the axis that additionally superimposes this basic motion.

Possible basic motions

You can superimpose the following Motion Control jobs with a Motion Control job "MC_MotionInSuperimposed" or "MC_MotionInSuperimposedAxes":

- Single-axis motion
  - MC_MoveAbsolute
  - MC_MoveRelative
  - MC_MoveVelocity
  - MC_MoveJog
  - MC_Halt
  - MC_PositionProfile
- Synchronous operation motion
  - MC_GearIn
  - MC_GearInPos
  - MC_GearInVelocity
  - MC_CamIn
  - MC_CamOut
  - MC_GearOut
- "MotionIn" motion
  - MC_MotionInVelocity
  - MC_MotionInPosition

A kinematics motion is not permitted as a basic motion. If a kinematics motion is active, the execution of a "MC_MotionInSuperimposed" job or a "MC_MotionInSuperimposedAxes" job is aborted with "Error" and the associated "ErrorID".

Resulting overall motion

The behavior of the overall motion depends on the type of basic motion:

- If the basic motion is a single-axis motion:
  - The dynamic response of the superimposed motion and the dynamic response of the overall motion are not limited.
  - Only the basic motion is limited to the configured dynamic limits.
  - When the basic motion is complete, a job with "MC_MotionInSuperimposed" or with "MC_MotionInSuperimposedAxes" continues to be executed.
- If the basic motion is a synchronous operation motion:
  - The synchronous operation motion of the following axis is not limited to the dynamic limits of the following axis.
  - The dynamic response of the superimposed motion and the dynamic response of the overall motion are not limited.
  - An "MC_MotionInSuperimposed", "MC_MotionInSuperimposedAxes" job on a leading axis in synchronous operation acts on the leading axis and thus indirectly on the following axis.
  - An "MC_MotionInSuperimposed", "MC_MotionInSuperimposedAxes" job on a following axis in synchronous operation acts only on the following axis.

NOTICE

Machine damage due to possible setpoint jumps

If superimposed motions are or were active on the following axis due to the Motion Control instructions "MC_MoveSuperimposed", "MC_MotionInSuperimposed", "MC_MotionInSuperimposedAxes" or "MC_HaltSuperimposed", the following axis follows the leading axis after simulation is ended without the position offset by the superimposed motion. Setpoint jumps can occur as a result.

To avoid setpoint jumps, note the following:

- For superimposed motions, do not set a synchronous operation to simulation.
- To move following values on the following axis, use the "MC_OffsetAbsolute" or "MC_OffsetRelative" instructions instead of the instructions for superimposed motions.
- To set a synchronous operation with an active "MC_MotionInSuperimposedAxes" motion to simulation at the following axis, consider the conditions and procedure in the FAQ entry 109994585 (https://support.industry.siemens.com/cs/ww/en/view/109994585).

- The basic motion is a "MotionIn" motion:
  - The dynamic response of the superimposed motion and the dynamic response of the overall motion are not limited.
  - The dynamic response of the basic motion is not limited.
- No basic motion is active on the axis:
  - A job with "MC_MotionInSuperimposed" or with "MC_MotionInSuperimposedAxes" is also possible if no basic motion is running.

It is always the dynamics of the overall motion that is displayed in the technology data block and in the diagnostics of the axis.

The position specification is position-controlled. If you use a velocity precontrol, the velocity specification is processed via the velocity precontrol.

The additive position values for superimposing specified at the "MotionInSuperimposed" instructions are referred to as an additional distance. An additional distance is interpreted by the system as absolute value for the setpoint when the instruction is called. The current superimposing is displayed in the "<TO>.StatusPositioning.SuperimposedDistance (Page 366)" tag.

See also

Halting a superimposed motion (Page 134)

MC_MotionInSuperimposedAxes: Specify superimposed motion setpoints from another axis V10 (Page 364)

MC_MotionInSuperimposed: Specify superimposed motion setpoints V10 (Page 360)

MC_HaltSuperimposed: Pause superimposed motions on axis V10 (Page 334)

MC_Halt: Stop axis V10 (Page 296)

Stopping a technology object with "MC_Halt" (Page 168)

6.14.3.1 Specifying superimposed motion setpoints with "MC_MotionInSuperimposed"

To realize a superimposed motion, you can specify cyclically applicative motion setpoints with the "MC_MotionInSuperimposed (Page 360)" instruction. The motion setpoints are additive to the motion setpoints of the basic motion and consist of an additional distance, velocity and acceleration difference. You need to specify at least the additional distance and the velocity difference. Because no velocity profile is calculated, the specified setpoints need to be consistent with one another. The added motion setpoints take effect directly at the technology object.

If you want to specify the motion setpoints of another axis at "MC_MotionInSuperimposed", a cycle offset occurs between the basic motion and the superimposed motion. To superimpose the values of another axis without a cycle offset, use the "MC_MotionInSuperimposedAxes (Page 364)" instruction.

NOTICE
Machine damage due to possible setpoint jumps Setpoint jumps can occur as a result of the specification of an inconsistent motion profile. To avoid setpoint jumps, note the following: • Consider the current dynamic response of the axis when specifying the new motion vectors. • Only specify motion vectors that are consistent with one another. • Note that a following axis that is coupled to the axis is also moved.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_MotionInSuperimposed" to superimpose motion onto the basic motion:

- With the "Distance" parameter, you define the negative or positive additional distance of the superimposed motion.

  The sum of the additional distance and position setpoint of the basic motion corresponds to the position setpoint of the axis.
- With the "VelocityDiff" parameter, you define the velocity difference of the superimposed motion.

  The sum of the velocity difference "VelocityDiff" of the superimposed motion and setpoint velocity of the basic motion is used as precontroller value when velocity precontrol is enabled.
- With the "AccelerationDiff" parameter, you define the acceleration difference of the superimposed motion.

  The superimposed acceleration difference "AccelerationDiff" is only required for overriding the superimposed motion or the overall motion.

6.14.3.2 Specifying superimposed motion setpoints from another axis

To superimpose the basic motion of an axis with the motion of another axis, configure one or more axes whose motion setpoints can be superimposed on the basic motion.

With the "MC_MotionInSuperimposedAxes" (Page 364) instruction, you define during runtime a superimposing axis from which the motion setpoints are added to the basic motion. The motion setpoints are additive to the motion setpoints of the basic motion. Because no velocity profile is calculated, the specified setpoints need to be consistent with one another. The added motion setpoints take effect directly at the technology object.

You can use the positioning axis and synchronous axis technology objects as an axis with basic motion and as a superimposing axis. For all superimposing axes required during operation, the possibility of superimposing must be configured on the technology object for the basic motion.

NOTICE
Machine damage due to high dynamic specification The dynamic response of the overall motion at the axis is only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). Before you activate the "MC_MotionInSuperimposedAxes" instruction, you need to ensure that the dynamic response of the overall motion does not exceed the dynamic limits of the axis.

NOTICE
Machine damage due to possible setpoint jumps Setpoint jumps can occur as a result of the specification of an inconsistent motion profile. To avoid setpoint jumps, note the following before setting the "Enable" parameter to "TRUE": • The technology object of the superimposed motion during standstill is at the position setpoint that is shown at the technology object of the basic motion in the "<TO>.StatusPositioning.SuperimposedDistance" tag. • Note that a following axis that is coupled to the axis is also moved.

Configuring the possible superimposing axes

To define possible superimposing axes, follow these steps:

1. Open the "Technology object > Configuration > Extended parameters > Superimposing axes" configuration window of the synchronous axis or positioning axis technology object.
2. In the "Possible superimposing setpoint values" table column, add all technology objects that you need during operation as superimposing axes.

   You can use the technology objects added to the table as superimposing axis with the Motion Control instruction "MC_MotionInSuperimposedAxes".

Parameter inputs of the Motion Control instruction "MC_MotionInSuperimposedAxes"

You use the following parameters of the Motion Control instruction "MC_MotionInSuperimposedAxes" to superimpose motion onto the basic motion:

- With the "Axis" parameter, you define the technology object axis for the basic motion.
- With the "SuperimposingAxis" parameter, you define the technology object for the superimposed motion.
- With the ""Enable" " parameter, you start the superimposing of the motions. The motion setpoints of the technology object of the superimposed motion "SuperimposingAxis" are added to the motion setpoints of the basic motion of the "Axis" technology object.

6.14.3.3 Halting a superimposed motion

With the Motion Control instruction "MC_HaltSuperimposed", you stop a superimposed motion on the axis independently of the basic motion. You can find more detailed information on this in section "Halting a superimposed motion (Page 134)".

6.14.4 Stopping the "MotionIn" instructions

The "MotionIn" instructions can be canceled by the following means:

- Overriding them with another Motion Control instruction

  The "MotionIn" instructions are overridden according to the behavior described in the sectionOverride response of Motion Control jobs V10 (Page 380). As a rule, the current dynamic responses are approximated to the new motion.

  NOTE

  Deviating dynamic settings

  When overriding the active job with a new jerk-limited motion, the current acceleration or deceleration is transferred to the new acceleration/deceleration via the jerk. Depending on the dynamic settings, this may take several application cycles. When the new acceleration or deceleration deviates significantly from the acceleration/deceleration at the time of the override, the transition profile can result in an unexpected axis motion.

  If such transitions cannot be excluded during acceleration/deceleration, adjust the dynamic settings of your jobs. For example, add a motion that is not jerk-limited with a direct transition to the new acceleration/deceleration. As an alternative, use high jerk values.

  For "MotionIn" jobs, the specification of the acceleration is only relevant for overriding the job. When the currently active acceleration is not to be reduced via the jerk, enter the value "0.0" at the "Acceleration" parameter of the "MotionIn" job.

- Setting the parameter "Enable" to "FALSE"

  If you set the "Enable" parameter to "FALSE" at the "MC_MotionInPosition" or "MC_MotionInVelocity" Motion Control instructions, the velocity and acceleration setpoint values are immediately set to zero. The position setpoint value of the "MC_MotionInPosition" is held. If you set the "Enable" parameter to "FALSE" at the "MC_MotionInSuperimposed" or "MC_MotionInSuperimposedAxes" Motion Control instructions, the velocity and acceleration setpoint values of the superimposed motion are immediately set to zero. The additional distance already traveled is retained. Note that the dynamic limits set on the technology object are not effective. Only limits set on the drive side are in effect.

  NOTICE

  Machine damage due to possible setpoint jumps

  To avoid dynamic jumps at the technology object of the basic motion, choose one of the following alternatives before setting the "Enable" parameter to "FALSE":

  – End the motion job at the technology object of the superimposed motion.
  – Stop the superimposed motion with the "MC_HaltSuperimposed" job.

6.14.5 Tags: Motion specification with "MotionIn"

The following tags of the technology object are relevant for the motion specification with "MotionIn":

Status indicator		
Tag	**Description**	
<TO>.StatusPositioning.SuperimposedDistance	Distances traversed with the instructions "MC_MoveSuperimposed", "MC_MotionInSuperimposed", "MC_MotionInSuperimposedAxes" and "MC_HaltSuperimposed". The value is reset when the basic motion and the superimposed motion are completed or the basic motion is aborted.	
<TO>.StatusMotionIn.FunctionState	Status of the "MotionIn" function	
	0	No "MotionIn" function active
	1	"MC_MotionInVelocity" active
	2	"MC_MotionInPosition" active
<TO>.StatusMotionIn.ActualSuperimposingAxis	Currently selected superimposing axis of "MC_MotionInSuperimposedAxes" job	
<TO>.StatusMotionIn.StatusWord.X0 (MaxVelocityExceeded)	The configured maximum velocity is exceeded during a "MotionIn" motion.	
<TO>.StatusWord.X31 (MotionInCommand)	An "MC_MotionInVelocity" job or an "MC_MotionInPosition" job is active.	
<TO>.StatusWord2.X6 (MotionInSuperimposedCommand)	An "MC_MotionInSuperimposed" job is running.	
<TO>.StatusWord2.X7 (HaltSuperimposedCommand)	An "MC_HaltSuperimposed" job is running.	
<TO>.StatusWord2.X8 (MotionInSuperimposedAxesCommand)	An "MC_MotionInSuperimposedAxes" job is running.	
<TO>.ErrorWord.X16 (SuperimposingError)	Error occurred in the superimposition of the axis	

NOTE

Evaluation of the bits in "StatusWord", "ErrorWord" and "WarningWord"

Note the information in the section "Evaluating the StatusWord, ErrorWord and WarningWord" of the "S7-1500/S7-1500T Motion Control overview" documentation.

Commissioning 7

The following guidelines describe the steps that you should note when commissioning the Motion Control-specific components of your equipment.

The commissioning of other components of your automation system depends on the particular equipment configuration. Commissioning (not Motion Control) is described in the "Automation System S7-1500" (https://support.industry.siemens.com/cs/ww/en/view/59191792) system manual.

7.1 Commissioning guidelines

These guidelines serve as recommendations for commissioning equipment with Motion Control. The procedure is described using the example of a positioning axis technology object.

Requirement

- The configuration of the following components is complete:
  - CPU
  - BUS communication
  - Drives
  - Technology objects
- The user program has been created.
- The wiring of the CPU and of the associated I/O is complete.
- The commissioning and optimization of the drive is complete.

Procedure

Proceed as follows to commission the Motion Control-specific components of your equipment:

Step	Action to be performed	Supported by TIA Portal
Turn on CPU	Turn on the power supply and the CPU.	-
"Disable" position controller	Set the gain (Kv factor) of the position control loop to zero. (This setting avoids unwanted drive movements that may be caused by incorrect parameterization of the position control loop.)	"Technology object > Configuration > Extended parameters > Settings of the control loop > Control loop"
Activate precontrol	Set the precontrol to 100 %.	"Technology object > Configuration > Extended parameters > Settings of the control loop > Control loop"

Step	Action to be performed	Supported by TIA Portal
Load project into the CPU	Bring the CPU to the STOP mode. Download your project to the CPU (load hardware and software).	• "Toolbar > Stop CPU" • "Toolbar > Download to device"
Create online connection to the CPU	Select the "Receive messages" check box under "Online & Diagnostics > Online Access". Configure the interface of the TIA Portal and create an online connection with the CPU.	• Device configuration • "Online & Diagnostics > Online Access"
Disable Motion Control specific user program	In order to avoid conflicts with the axis control panel, lock the enabling of technology objects in your user program ("MC_Power.Enable" = FALSE).	• PLC programming • Motion Control instructions
Evaluating pending messages	Evaluate the message display in the inspector window. Resolve the causes of pending technology alarms. Acknowledge the technology alarms.	"Inspector window > Diagnostics > Message display"
Check hardware limit switches	Click the hardware limit switches. Check for correct message display (technology alarm 531). Acknowledge the technology alarm.	"Inspector window > Diagnostics > Message display"
Check the connection and configuration of the drive (setpoint)	Bring the CPU into the RUN mode. Open the Axis control panel and take over master control (Page 257). Perform the following steps: • Enable the technology object. ⇒ The drive must turn itself on, and where applicable release the brake. The position is held. • Move the axis in jog mode (Page 264) at low velocity in the positive direction. ⇒ The drive must move. The actual position value must increase (positive direction). • Disable (Page 271) the technology object. ⇒ The drive must turn itself off, and where applicable apply the brake.	"Technology object > Commissioning > Axis control panel"
Check the connection and configuration of the encoder (actual value)	• Check the scaling of the actual values (rotation direction, distance evaluation, and resolution of the encoder) ⇒ The change in the actual mechanical position must match the change in the actual values. In case of deviations, correct the parameters assigned for mechanics under "Technology object > Extended parameters > Mechanics". • For absolute encoders, check the absolute encoder adjustment. To do this, move the axis to the start of the traversing range and switch the system off. After the restart, check the actual encoder values for correctness. Repeat this step likewise at the traversing range end. If there are deviations, correct the following: – Settings for fine resolution under "Technology object > Data exchange with encoder" – Zero-crossing position of the encoder The position of the zero crossing can be changed by rotating the encoder in the dismantled state. With programmable encoders, the zero crossing can be adjusted by parameter assignment. The zero crossing must be outside the traversing range.	• "Technology object > Diagnostics > PROFIdrive telegram" • "Technology object > Commissioning > Axis control panel"
Specify dynamic parameters	For each traversing motion of the axis, enter the dynamic parameters (Page 261) in the axis control panel.	

Step	Action to be performed	Supported by TIA Portal
Checking the reference speed	Traverse the axis in jog mode (Page 264) at low velocity in the positive direction. ⇒ The displayed current velocity must match the velocity setpoint. If the displayed current velocity deviates significantly from the velocity setpoint, adjust the reference speed.	• "Technology object > Hardware interface > Data exchange" • "Technology object > Commissioning > Axis control panel"
Homing axis	If necessary, you can home (Page 262) the axis or set the home position.	
Optimize position controller	Use the Optimization (Page 265) commissioning function to optimize the gain (Kv) of the position control loop. For this purpose, adapt following error limits as needed.	"Technology object > Commissioning > Optimization"
Transfer the gain Kv to the project.	Enter the gain Kv that you determined by means of the optimization function in your configuration data. Load your project into the CPU.	"Technology object > Configuration > Extended parameters > Control loop"
Enable Motion Control specific user program	Unlock the enabling technology objects lock in your user program ("MC_Power.Enable" = TRUE).	• PLC programming • Motion Control instructions
Check the functioning of the user program	Check the programmed functions of your user program.	• Watch and force tables • Online and diagnostic functions
Commissioning additional technology objects	To commission additional technology objects, perform the corresponding steps again.	See above.

7.2 Take over master control and enable axis

You traverse individual axes during commissioning. A user program is not required.

With the axis control panel, you assume master control for a technology object and control the motions of the axis.

The axis control panel is located in the project tree of the speed axis, positioning axis and synchronous axis technology objects under "Technology object > Commissioning".

With optimization, you take over the master control and optimize the gain and the speed control loop substitute time of the position controller.

You optimize the positioning axis and synchronous axis technology objects under "Technology object > Commissioning".

WARNING

Unexpected axis motions

During commissioning, the axis can execute unexpected motions (e.g. due to erroneous configuration of the drive or the technology object). Any synchronized following axis is moved as well when moving a leading axis with the axis control panel or during optimization.

Therefore, perform the following precautionary measures before operation with the axis control panel or during optimization:

- Ensure that the EMERGENCY OFF switch is within the reach of the operator.
- Enable the hardware limit switches.
- Enable the software limit switches.
- Ensure that following error monitoring is enabled.
- Make sure that no following axis is coupled to the axis to be moved.

Requirement

- The project has been created and downloaded to the CPU.
- The CPU must be in the RUN mode.
- The technology object is disabled by your user program ("MC_Power.Enable" = FALSE).
- The commissioning for the technology object is not used by another instance of the TIA Portal.

Procedure

Follow these steps to control the axis:

1. To assume master control of the technology object and to set up an online connection to the CPU, click "Activate" in the "Master control" area.

   A warning message is displayed.
2. If necessary, adapt the sign of life monitoring and click "OK".
3. To enable the technology object, click the "Enable" button in the "Axis" area.

Setting the sign-of-life monitoring time

Monitoring time	Effect
Too low	Master control is frequently returned due to violation of the monitoring time and the axis stops with maximum deceleration because the communication time between the TIA Portal and CPU is longer than the configured monitoring time.
Appropriate	Monitoring time is not exceeded and the axis is stopped in time when the online connection is lost or sign of life monitoring is exceeded. Recommendation: 1000 ms to 2000 ms
Too high	Axis continues moving with the last setpoints of the axis control panel even though the connection between TIA Portal and CPU is interrupted or the communication time between TIA Portal and CPU is too long. The axis is not stopped in time because the monitoring time is still running.

Result

An online connection to the CPU is established, the axis control panel or optimization takes over master control of the technology object, and the technology object is enabled.

Behavior while the axis control panel or optimization has the master control

The axis can only be traversed with the axis control panel or the optimization. Access to the axis is blocked by another instance of the TIA Portal.

The user program has no influence on the functions of the technology object. Motion Control jobs from the user program to the technology object are rejected with error ("ErrorID" = 16#8012: Axis control panel enabled).

Changes to the axis configuration will not become effective until the master control is taken over again.

In the following situations, the axis control panel or optimization will retain the master control and the axis keeps moving:

- The axis control panel/optimization is embedded in the TIA Portal, and you switch to a different window, for example, to the trace. Use the Split editor space option to use the axis control panel and the trace at the same time.

In the following situations, the axis control panel or optimization will retain the master control but stops the axis with maximum deceleration.

- The axis control panel or optimization is replaced in the TIA Portal, and you switch to a different window within the TIA Portal, for example, to the project tree. You change to a window outside of the TIA Portal.
- The "Stop" button is hidden by another dialog window or is no longer visible due to scrolling.

In the following situations, the axis is stopped with maximum deceleration and the axis control panel/optimization returns the master control to the user program.

- The online connection to the CPU fails and the time for sign of life monitoring has elapsed. The error message "ErrorID" = 16#8013 is displayed.

  Adapt the time for the sign-of-life monitoring in the warning.
- The online connection to the CPU is impaired by a communication load that is too high. The following message is entered in the alarm display log: "Commissioning error. Sign-of-life failure between controller and TIA Portal". Adapt the time for the sign-of-life monitoring in the warning.
- A dialog box (e.g. Save as) covers the axis control panel or optimization.

7.3 Operator controls for jogging, homing and positioning

You can use the slider to execute the following functions of the axis control panel:

- Homing with the axis control panel (Page 262)
- Traversing the axis with the axis control panel (Page 264)

Jogging and homing velocity

The preset jogging and homing velocity is calculated as follows:

Jogging/homing velocity = configured velocity * slider position * "Adjust velocity" factor

Jog forward or backward

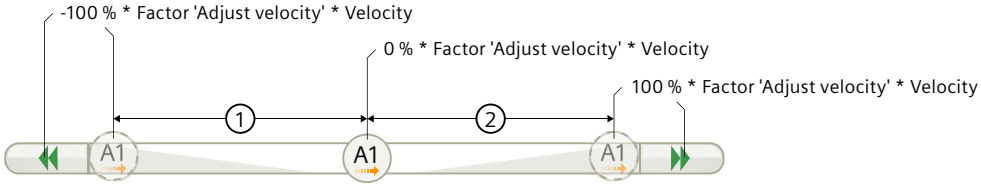

① **Backward**

- Click the slider and drag the slider to the left.
- The further you drag the slider to the left, the higher the jogging velocity.
- To jog backward at the maximum, specified jogging velocity, click the ◀◀ symbol.

② **Forward**

- Click the slider and drag the slider to the right.
- The further you drag the slider to the right, the higher the jogging velocity.
- To jog forward at the maximum preset jogging velocity, click the ▶▶ symbol.

Stop jogging

- Release the pressed mouse button. The slider automatically jumps to zero and the axis/joint is stopped with the specified deceleration.

Active homing

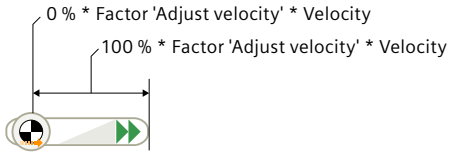

- Click the slider and drag the slider to the right. The further you drag the slider to the right, the higher the homing velocity.
- To home at the maximum preset velocity, click the ▶▶ symbol.
- The homing stops automatically with the set dynamics.

Cancel homing

- To cancel homing, release the pressed mouse button.

Positioning

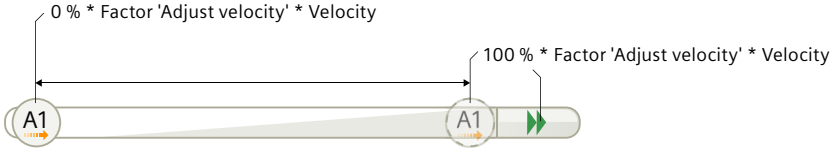

- Click the slider and drag the slider to the right. The further you drag the slider to the right, the higher the positioning speed.
- To jog to the target position at the maximum preset jog velocity, click the ▶▶ icon.
- Positioning stops automatically at the specified target position with the set dynamics.

Stop positioning

To stop positioning, release the pressed mouse button.

7.4 Specify the dynamics in the axis control panel

In the operating modes of the axis control panel, you can specify the dynamics for traversing the axis.

Configure the dynamic limits before you use the axis control panel so that the specified dynamic values from the axis control panel are limited and the default setting of the dynamic values takes place accordingly.

During the first commissioning, you should traverse the axis at low dynamics. Reduce the dynamic values to less than the default setting. Increase the dynamic values gradually when traversing of the axis meets your expectations.

Next, adapt the dynamic default and the dynamic limits in the configuration of the technology object. The dynamic values from the axis control panel are not automatically applied to the configuration of the technology object.

Default setting of the dynamics values

The default setting of the dynamic values is as follows when calling the axis control panel:

Dynamic value	Default value
Velocity/ Velocity setpoint	Velocity or speed at which the axis is traversed when "Homing" operating mode is not selected. Default setting: 10% of the configured value in "Technology objects > Configuration > Extended parameters > Limits > Dynamics limits".
Acceleration	Acceleration with which the axis is traversed. Default setting: 10% of the configured value in "Technology objects > Configuration > Extended parameters > Limits > Dynamics limits".
Deceleration	Deceleration with which the axis is traversed. Default setting: 100% of the configured value in "Technology objects > Configuration > Extended parameters > Limits > Dynamic limits".
Jerk	Jerk with which the axis is traversed. Default setting: 100% of the configured value in "Technology objects > Configuration > Extended parameters > Limits > Dynamic limits".

Adjusting the velocity

Under "Adjust velocity", you correct the configured velocity using a percentage.

Example:

- Configured velocity in the axis control panel: 100 mm/s
- Adjust velocity: 50%
- Resulting velocity specification: 50 mm/s

You can set a value with the slider or enter a value between 1% and 200% directly in the text box below.

The value set in the tag "<TO>.Override.Velocity" of the speed axis/positioning axis/synchronous axis technology object is invalid during the operation of the axis control panel.

7.5 Homing with the axis control panel

With homing, you create the relationship between the position in the technology object and the mechanical position. The actual position value in the technology object is assigned to a homing mark at the same time. This homing mark represents a known mechanical position.

The "Active homing" operating mode corresponds to active homing with "Mode" = 3. The positioning axis/synchronous axis technology object performs a homing movement according to the configuration of the active homing (Page 195).

The "Set actual position" operating mode in the axis control panel corresponds to direct homing (absolute) with "Mode" = 0.

The operating mode "Absolute encoder adjustment relative" in the axis control panel corresponds to the absolute encoder adjustment (absolute specification of position) with "MODE" = 7.

The operating mode "Absolute encoder adjustment absolute" in the axis control panel corresponds to the absolute encoder adjustment (relative specification of position) with "MODE" = 6.

For more detailed information on homing, refer to the section "Homing (Page 188)".

Actively homing the axis

Requirements

- The axis is enabled in the axis control panel.
- The parameters for active homing (Page 195) must be configured.

Procedure

1. Under "Operating mode", select "Active homing" from the drop-down list.
2. Enter the home position in the Position text box.
3. Enter the setpoints for acceleration, deceleration and jerk.
4. To start active homing, click the slider and drag the slider to the right.
5. To cancel homing, release the pressed mouse button.

Result

The axis executes the homing movement configured under "Active homing".

Setting the home position of an axis

Requirements

- The axis is enabled in the axis control panel.

Procedure

1. Under "Operating mode", select "Set actual position" from the drop-down list.
2. Enter the position to which the axis is to be homed.
3. Click the "Start" button.

Result

The entered position is set as the actual position and the status is set to "Homed".

Adjusting absolute encoder with absolute specification of position

Requirements

- The axis is enabled in the axis control panel.

Procedure

1. Under "Operating mode", select "Absolute encoder adjustment absolute" from the drop-down list.
2. In the text box "Position setpoint", enter the value by which the position is to be set.
3. Click the "Start" button.

Result

The current position is set to the value of the "Position" parameter.

Adjusting absolute encoder with relative specification of position

Requirements

- The axis is enabled in the axis control panel.

Procedure

1. Under "Operating mode", select "Absolute encoder adjustment relative" from the drop-down list.
2. In the "Offset" text box, enter the value by which the position is to be offset.
3. Click the "Start" button.

Result

The current position is shifted by the value of the "Offset" parameter.

7.6 Traversing the axis with the axis control panel

Requirement

- The axis is enabled in the axis control panel.
- The axis is homed (position axis absolutely).

Jogging the axis

In "Jog" operating mode in the axis control panel, the motion commands are made by jogging.

1. Under "Operating mode", select "Jog" from the drop-down list.
2. Specify the dynamic parameters for the traversing motion.
3. To move the axis in the positive direction, click on the arrow symbol slider and drag the slider to the right.
4. To move the axis in the negative direction, click on the arrow symbol slider and drag the slider to the left.
5. To stop the traversing motion, release the pressed mouse button.

Position axis relatively

The positioning is executed as a controlled, relative traversing motion by the specified distance and the dynamic parameters assigned under "Control".

1. In the "Operating mode" drop-down list, select the entry "Relative positioning".
2. Specify the distance by which the axis is to be moved. A negative distance can be specified; it reverses the traversing direction. If you click on the arrow symbol and drag the slider to the right, the axis travels in negative direction and vice versa.
3. Specify the dynamic parameters for the traversing motion.
4. To move the axis by the specified distance, click on the arrow symbol and drag the slider to the right. To move the axis by the specified distance in the opposite direction, click on the arrow symbol and drag the slider to the left.
5. To stop the traversing motion, release the pressed mouse button.

Position axis absolutely

The positioning is executed as a controlled, absolute traversing motion by the specified distance and the dynamic parameters assigned under "Control".

1. In the "Operating mode" drop-down list, select "Absolute positioning".
2. Enter the target position.
3. Specify the dynamic parameters for the traversing motion.
4. Axes without modulo setting: To move the axis to the specified target position, drag the slider to the right.
   Axes with Modulo setting: To move to the target position in the positive direction, drag the slider to the right. To move to the target position in the negative direction, drag the slider to the left. Position settings outside the modulo range are recalculated to the modulo range accordingly.
5. To stop the traversing motion, release the pressed mouse button.

7.7 Optimize position controller

The following section describes how to optimize the position controller of a drive with the axis control panel.

How you proceed depends on the assigned drive:

- SINAMICS drive with DSC configured with Startdrive
- SINAMICS drive with DSC configured without Startdrive
- Drive without DSC

Requirements

- The CPU must be in the RUN mode.
- The project has been created and downloaded to the CPU.
- The technology object is disabled by your user program ("MC_Power.Enable" = FALSE).
- The axis control panel for the technology object is not used by another installation of the TIA Portal.
- The axis has been enabled for commissioning.

Procedure for SINAMICS drives with DSC configured with Startdrive

To optimize the position controller, follow these steps:

1. Configure values for the distance, duration, and dynamics of a test step in the "Measurement configuration" area.
2. Click the green arrow at "Optimize values in drive".

   You go to the optimization of the drive in Startdrive.
3. Optimize the controller automatically in Startdrive using One Button Tuning (OBT).
4. Navigate back to the optimization of the axis.

   The "Drive optimized" display is green.
5. Click the "Take values from drive" button.

   The following values are taken:

   – Gain (Kv factor): The technology object takes 50% of the value from the drive (r5276).
   – Speed control loop substitute time: The technology object adopts the value from the drive (r5277).

   The online values of the drive are applied when they are connected to the drive online in SINAMICS Startdrive. The offline values of the drive are applied when they are not connected to the drive online in SINAMICS Startdrive.
6. Click the "Forward" or "Backward" button to start a test step for optimization in the positive or negative direction.

   A setpoint is output for the specified duration according to the specified distance. The axis moves by the specified distance. A trace recording of the motion (setpoint and actual values) is created automatically in the "Trace" area.
7. Evaluate the trace recording.
8. If you are not yet satisfied with the optimization result, continue to adjust the gain (KV).
9. Apply the optimized parameters in the project.

Procedure for SINAMICS drives with DSC configured without Startdrive

Requirements: You have carried out a One Button Tuning (OBT) controller optimization in the configuration of the drive. If you use an alternative method for controller optimization in drive, then proceed as with the other drives.

To optimize the position controller, follow these steps:

1. If necessary, configure values for the distance, duration, and dynamics of a test step in the "Measurement configuration" area.
2. Configure the following values as actual values in the "Optimize position controller" area:
   - Gain (Kv factor): Apply 50% of the value from the parameter "r5276" of the drive to the technology object.

     Note that: Kv(TO) = 0.5 · 16.66666 · Kv(r5276)
   - Speed control loop substitute time: Apply the value from the parameter "r5277" of the drive to the technology object.

     Note that: vtc(TO) = 0.001 · vtc(r5277)
3. Click the "Forward" or "Backward" button to start a test step for optimization in the positive or negative direction.

   A setpoint is output for the specified duration according to the specified distance. The axis moves by the specified distance. A trace recording of the motion (setpoint and actual values) is created automatically in the "Trace" area.
4. Evaluate the trace recording.
5. If you are not yet satisfied with the optimization result, continue to adjust the gain (KV).
6. Apply the optimized parameters in the project.

Procedure for other drives

You use the procedure described here for the following drives:

- SINAMICS drives with DSC that are not optimized with OBT
- SINAMICS drives without DSC
- Third-party drives

To optimize the position controller, follow these steps:

1. In the "Master control" area, click the "Activate" button to activate master control for the technology object, and to establish an online connection to the CPU.

   A warning message is displayed.
2. In the "Axis" area, click the "Enable" button to enable the technology object.
3. Configure values for the distance and dynamics of a test step in the "Measurement configuration" area. Select a sufficiently long measurement duration to record the entire measurement with the trace. If the measurement duration is too short, you will see a warning when entering the value.

4. Configure the following values as actual values in the "Optimize position controller" area:
   - Precontrol: 0.0
   - Speed control loop substitute time: 0.0
   - Gain (Kv factor): 10.0
5. Click the "Forward" or "Backward" button to start a test step for optimization in the positive or negative direction.

   To traverse the specified distance, a trapezoid velocity profile is used. The velocity profile is calculated from the specified dynamic parameters and the distance. A trace recording of the motion (setpoint and actual values) is created automatically in the "Trace" area.

   NOTE

   Check whether the current or torque limitation is active in the drive. To get a meaningful trace recording, both limitations should not be active during optimization. To check this, record the tag "<TO>.StatusTorqueData.ActualTorque" when using telegram 750 or check the limitations directly in the drive.

6. Evaluate the trace recording.
7. If required, increase in "measurement configuration" the values you use for "acceleration" and "deceleration".
8. Configure the following values as actual values in the "Optimize position controller" area:
   - Precontrol: 100.0
   - Speed control loop substitute time: 0.0
   - Gain (Kv factor): 90% of the determined value
9. Adjust the speed control loop equivalent time until no more overshoots occur.
10. Apply the optimized parameter values as start values in the project.

Evaluating trace recordings

The trace recordings are not saved. Note the following properties of the curve:

- The curve shows a brief compensation time.
- The curve does not show any motion reversal of the actual position.
- When approaching the position setpoint, no overshoot occurs.
- The curve shows a stable overall behavior (oscillation-free curve).

The following trace recording shows a curve with a long settling time:

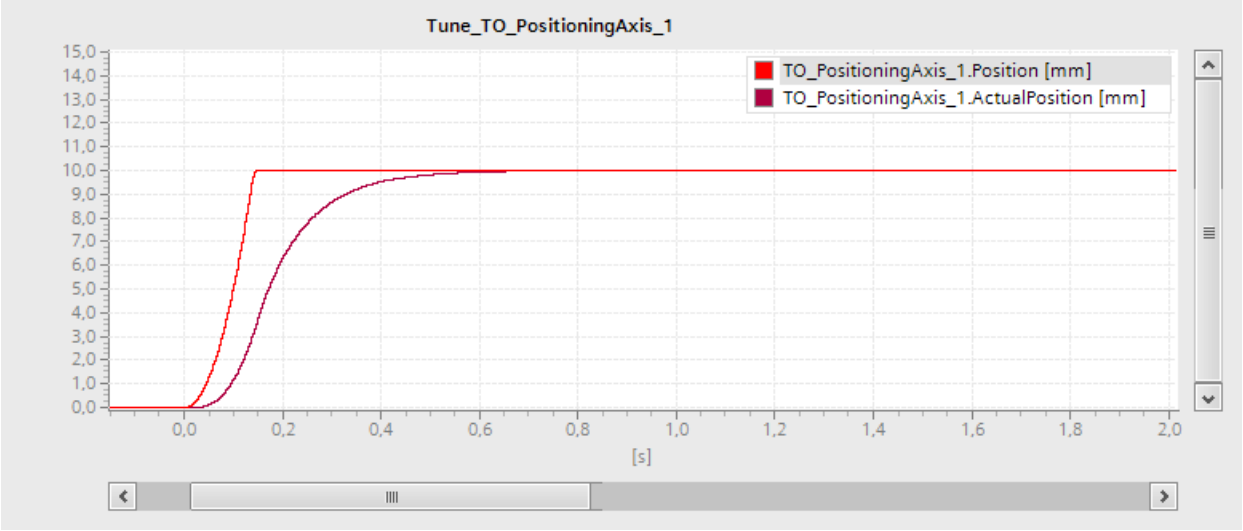

The following trace recording shows a curve with overshoot when approaching the setpoint:

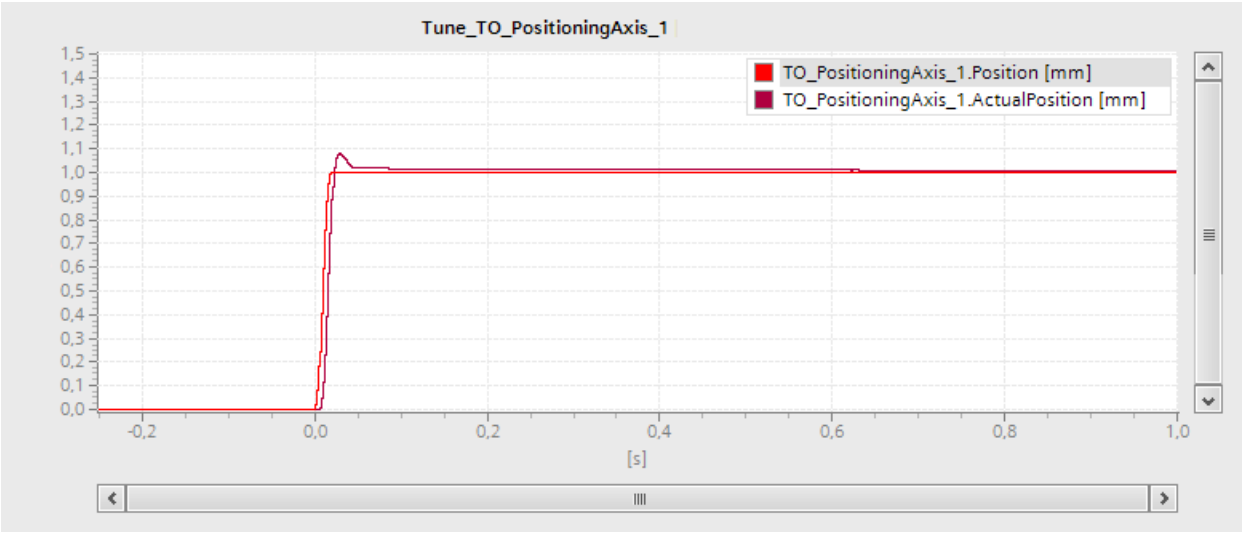

The following trace recording shows a curve in which the gain is optimal and the overall response is steady:

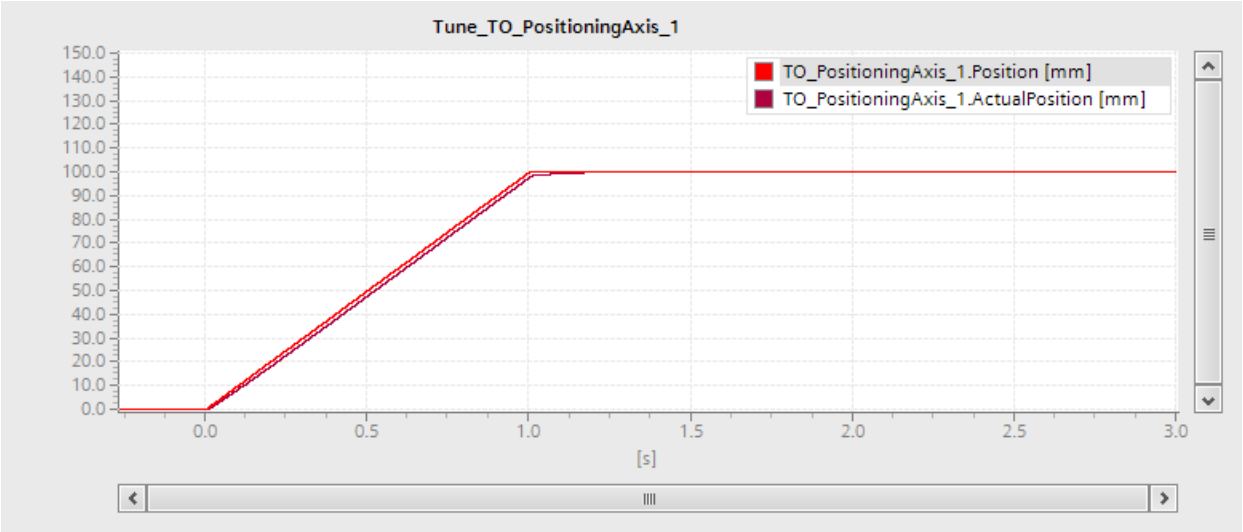

Adjust gain (Kv factor)

Proceed as follows to adapt the gain (Kv factor):

1. Increase the value with each test step, e.g. by 5%. If there is no major change in the control behavior, then select larger steps.
2. Click the "Forward" or "Backward" button to start another test step for optimization in the positive or negative direction.
3. Evaluate the trace recording.
4. Repeat steps 1 to 3 until no more overshoots occur in the trace recording.

Adjust speed control loop substitute time

With velocity precontrol, a simplified speed control loop model can be generated using the speed control loop substitute time. This prevents the velocity variable being overridden by the position controller during the acceleration and deceleration phases. To accomplish this, the position setpoint of the position controller is delayed by the amount of the speed control loop substitute time in relation to the velocity precontrol. Proceed as follows to adapt the speed control loop equivalent time:

1. Increase the value with each test step, e.g. by 1 ms.
2. On "Forward" or "Backward", perform another test step.
3. Evaluate the trace recording.
4. Repeat steps 1 to 3 until no more overshoots occur in the trace recording.

Transferring the optimized parameter values of the position controller to the project

To transfer the optimized parameter values of the position controller to your project, follow these steps:

1. Click the icon next to the field of the respective parameter.

   A list of values is displayed.
2. Enter the determined value in the "Start value project" field of the value list. The value is then transferred to the configuration of the technology object in the project.
3. In the "Axis" area, click the "Disable" button to disable the technology object.
4. In the "Master control" area, click the "Deactivate" button to return master control to your user program.
5. Load your project into the CPU.

More information

For more information about axis control and axis optimization, refer to Siemens Industry Online Support in the FAQ entry 109779884 (https://support.industry.siemens.com/cs/ww/en/view/109779884).

7.8 Disable axis and hand over master control

NOTE

No automatic transfer of the parameters to the technology object

The configured parameter values are discarded after master control is returned.

Transfer the values as needed into your configuration. You can apply the values for the gain, precontrol and speed control loop equivalent time in your configuration using the "Project start value" value.

Requirement

- The axis is enabled in the axis control panel/optimization.
- The enabled technology object accepts Motion Control jobs.
- Speed control and position control are active.
- The actual values of the technology object are valid.

Procedure

Follow these steps to disable the axis and hand over the master control using the axis control panel or optimization:

1. To disable the technology object, click the "Disable" button in the "Axis" area.
2. To return master control to your user program, click the "Deactivate" button in the "Master control" area.

Diagnostics 8

The description of Motion Control diagnostics is limited to the diagnostics view of the technology objects in TIA Portal, the technology alarms and the error IDs on Motion Control instructions.

"Debug" program mode is available for testing the execution of your Interpreter program.

The following descriptions can be found in the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation:

- Diagnostics concept
- Technology alarms
- Error IDs in Motion Control instructions

A comprehensive description of the system diagnostics of the S7-1500 CPU can be found in the "Diagnostics" function manual (https://support.industry.siemens.com/cs/ww/en/view/59192926).

8.1 Speed-controlled axis technology object

8.1.1 Status and error bits

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object. The diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables. The associated technology object tag is given in parentheses.

Axis status

The following table shows the possible axis status values:

Status	Description
Simulation active	The axis is simulated in the CPU or used as the virtual axis. Setpoints are not output to the drive.
Enabled	The technology object has been enabled. The axis can be moved with motion jobs. (<TO>.StatusWord.X0 (Enable))
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area and in the "<TO>.ErrorDetail.Number" and "<TO>.ErrorDetail.Reaction" tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is reinitialized. (<TO>.StatusWord.X2 (RestartActive))

Status	Description
Axis control panel enabled	The axis control panel is active. The axis control panel has master control over the technology object. The axis cannot be controlled from the user program. (<TO>.StatusWord.X4 (ControlPanelActive))
Drive ready	Drive is ready to execute setpoints. (<TO>.StatusDrive.InOperation)
Restart required	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))

Motion status

The following table shows the possible axis motion status values:

Status	Description
Done (no job running)	There is no active motion job at the technology object. (<TO>.StatusWord.X6 (Done))
Jog	The axis is being moved with a job for jog mode of Motion Control instruction "MC_MoveJog" or from the axis control panel. (<TO>.StatusWord.X9 (JogCommand))
Speed setpoint	The axis is traversed with a job with speed setpoint of the Motion Control instruction "MC_MoveVelocity" or using the axis control panel. (<TO>.StatusWord.X10 (VelocityCommand))
Constant speed	The axis is moved with constant speed or is stationary. (<TO>.StatusWord.X12 (ConstantVelocity))
Accelerating	Axis is being accelerated. (<TO>.StatusWord.X13 (Accelerating))
Decelerating	The axis is being decelerated. (<TO>.StatusWord.X14 (Decelerating))
Torque limit active	At least the threshold value (default 90%) of the preset force/torque limitation acts on the axis. (<TO>.StatusWord.X27 (InLimitation))
Active stop job	The axis is stopped and disabled by Motion Control instruction "MC_Stop". (<TO>.StatusWord2.X0 (StopCommand))

Warnings

The following table shows the possible warnings:

Warning	Description
Configuration	One or several configuration parameters are adjusted internally at a certain time. (<TO>.WarningWord.X1 (ConfigWarning))
Job rejected	A job cannot be executed. A Motion Control instruction cannot be executed because the necessary conditions have not been met. (<TO>.WarningWord.X3 (CommandNotAccepted))
Dynamic limitation	The dynamic values are limited to the dynamic limits. (<TO>.WarningWord.X6 (DynamicWarning))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	A configuration error has occurred. One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data was incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	An error occurred in the user program with a Motion Control instruction or its use. (<TO>.ErrorWord.X2 (UserFault))
Drive	An error occurred in the drive. (<TO>.ErrorWord.X4 (DriveFault))
Data exchange	Communication with a connected device is faulty. (<TO>.ErrorWord.X7 (CommunicationFault))
I/O	An error occurred accessing a logical address. (<TO>.ErrorWord.X13 (PeripheralError))
Job rejected	A job cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met (e.g. technology object not homed). (<TO>.ErrorWord.X3 (CommandNotAccepted))
Dynamic limitation	The dynamic values are limited to the dynamic limits. (<TO>.ErrorWord.X6 (DynamicError))

Alarm display

For more information and to acknowledge the error, go to the Inspector window by clicking on the "Alarm display" link.

More information

An option for evaluating the individual status bits can be found in the section "Evaluating StatusWord, ErrorWord and WarningWord" of the "S7-1500/S7-1500T Motion Control overview" documentation.

See also

"StatusWord" tag (speed axis) (Page 403)
"ErrorWord" tag (speed axis) (Page 405)
"WarningWord" tag (speed axis) (Page 406)

8.1.2 Motion status

You use the "Technology object > Diagnostics > Motion status" diagnostic function in the TIA Portal to monitor the motion status of the axis. The diagnostics function is available in online operation.

"Setpoints" area

The following table shows the meaning of the status data:

Status	Description
Speed setpoint	Speed setpoint of the axis (<TO>.Velocity)
Speed override	Speed setpoint correction as percentage The speed setpoint specified in Motion Control instructions or set by the axis control panel is superimposed with an override signal and corrected as a percentage. Valid speed correction values range from 0.0 % to 200.0 %. (<TO>.Override.Velocity)

"Current values" area

The following table shows the meaning of the status data:

Status[1]	Description
Speed on load side	Speed of the axis on the load side (<TO>.Velocity)
Speed on motor shaft	Actual speed of the axis at the motor shaft (<TO>.ActualSpeed)

[1] At the virtual axis, only the "Speed on load side" value is displayed (<TO>.Velocity).

"Dynamic limits" area

This area displays the limit values for the dynamic parameters.

The following table shows the meaning of the status data:

Status	Description
Speed	Configured maximum speed (<TO>.DynamicLimits.MaxVelocity)
Acceleration	Configured maximum acceleration (<TO>.DynamicLimits.MaxAcceleration)
Deceleration	Configured maximum deceleration (<TO>.DynamicLimits.MaxDeceleration)
Jerk	Configured maximum jerk (<TO>.DynamicLimits.MaxJerk)

8.1.3 PROFIdrive telegram

The "Technology object > Diagnostics > PROFIdrive telegram" diagnostics function is used in the TIA Portal to monitor the PROFIdrive telegram that the drive returns to the controller. The Diagnostics function is available in online operation.

"Drive" area

This area displays the following parameters contained in the PROFIdrive telegram from the drive to the controller:

- Status words "ZSW1" and "ZSW2"
- The speed setpoint (NSET) that was output to the drive
- The actual speed that was signaled from the drive (NACT)

8.2 Positioning axis technology object

8.2.1 Status and error bits

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object. The diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables. The associated technology object tag is given in parentheses.

Axis status

The following table shows the possible axis status values:

Status	Description
Simulation active	The axis is simulated in the CPU or used as the virtual axis. Setpoints are not output to the drive. (<TO>.StatusWord.X25 (AxisSimulation))
Enabled	The technology object has been enabled. You can move the axis with motion jobs. (<TO>.StatusWord.X0 (Enable))
Position-controlled mode	The axis is in position-controlled mode. (Inversion of <TO>.StatusWord.X28 (NonPositionControlled))
Homed	The technology object is homed. The relationship between the position in the technology object and the mechanical position was successfully created. (<TO>.StatusWord.X5 (HomingDone))
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area and in the "<TO>.ErrorDetail.Number" and "<TO>.ErrorDetail.Reaction" tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is reinitialized. (<TO>.StatusWord.X2 (RestartActive))
Axis control panel enabled	The axis control panel is active. The axis control panel has master control over the technology object. You cannot control the axis from the user program. (<TO>.StatusWord.X4 (ControlPanelActive))
Drive ready	Drive is ready to execute setpoints. (<TO>.StatusDrive.InOperation)
Encoder values valid	The actual encoder values are valid. (<TO>.StatusSensor[1].State)
Encoder values valid (S7-1500T)	The actual encoder values of encoder 1, encoder 2, encoder 3 or encoder 4 are valid. (<TO>.StatusSensor[1..4].State)
Active encoder (S7-1500T)	The encoder in effect operationally is encoder 1, encoder 2, encoder 3 or encoder 4. (<TO>.OperativeSensor)

Status	Description
Encoder homed	Encoder is homed with one of the following homing types: • Active homing • Passive homing • Absolute encoder adjustment • Incremental encoder adjustment (<TO>.StatusSensor[1].Adjusted)
Encoder homed (S7-1500T)	Encoder 1, encoder 2, encoder 3 or encoder 4 is homed with one of the following homing types: • Active homing • Passive homing • Absolute encoder adjustment • Incremental encoder adjustment (<TO>.StatusSensor[1..4].Adjusted)
Restart required	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))

Status limit switch

The following table shows the possibilities for enabling the software and hardware limit switches:

Status	Description
Negative SW limit switch approached.	The negative software limit switch has been approached. (<TO>.StatusWord.X15 (SWLimitMinActive))
Positive SW limit switch approached.	The positive software limit switch has been approached. (<TO>.StatusWord.X16 (SWLimitMaxActive))
Negative HW limit switch approached	The negative hardware limit switch has been approached or overtraveled. (<TO>.StatusWord.X17 (HWLimitMinActive))
Positive HW limit switch approached.	The positive hardware limit switch has been approached or overtraveled. (<TO>.StatusWord.X18 (HWLimitMaxActive))

Motion status

The following table shows the possible axis motion status values:

Status	Description
Done (no job running)	No job active at technology object. (<TO>.StatusWord.X6 (Done))
Homing job	The technology object executes a homing job of the Motion Control instruction "MC_Home" or from the axis control panel. (<TO>.StatusWord.X11 (HomingCommand))
Jog	The axis is being moved with a job for jog mode of Motion Control instruction "MC_MoveJog". (<TO>.StatusWord.X9 (JogCommand))

Status	Description
Velocity specification	The axis is traversed with a job with velocity specification of the Motion Control instruction "MC_MoveVelocity" or from the axis control panel. (<TO>.StatusWord.X10 (VelocityCommand))
Positioning job	The axis is traversed with a positioning job of the Motion Control instruction "MC_MoveAbsolute", "MC_MoveRelative", "MC_PositionProfile" or of the axis control panel (OR logic operation). (<TO>.StatusWord.X8 (PositioningCommand); <TO>.StatusWord2.X9 (PositionProfileCommand))
Constant velocity	The axis is moved with constant velocity or is stationary. (<TO>.StatusWord.X12 (ConstantVelocity))
Standstill	The axis is at a standstill. (<TO>.StatusWord.X7 (StandStill))
Accelerating	Axis is being accelerated. (<TO>.StatusWord.X13 (Accelerating))
Decelerating	The axis is being decelerated. (<TO>.StatusWord.X14 (Decelerating))
Torque limit active	At least the threshold value (default 90%) of the preset force/torque limitation acts on the axis. (<TO>.StatusWord.X27 (InLimitation))
Active stop job	The axis is stopped and disabled by Motion Control instruction "MC_Stop". (<TO>.StatusWord2.X0 (StopCommand))
Superimposed motion	The motion of the axis is superimposed by at least one superimposing Motion Control instruction (OR logic operation). (<TO>.StatusWord.X23 (MoveSuperimposedCommand); <TO>.StatusWord2.X6 (MotionInSuperimposedCommand); <TO>.StatusWord2.X8 (MotionInSuperimposedAxesCommand); <TO>.StatusWord2.X7 (HaltSuperimposedCommand))

Warnings

The following table shows the possible warnings:

Warning	Description
Configuration	One or more configuration parameters are being internally adapted temporarily. (<TO>.WarningWord.X1 (ConfigWarning))
Job rejected	Job cannot be executed. You cannot execute a Motion Control instruction because necessary requirements are not fulfilled. (<TO>.WarningWord.X3 (CommandNotAccepted))
Dynamic limitation	The dynamic values are limited to the dynamic limits. (<TO>.WarningWord.X6 (DynamicWarning))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	A configuration error has occurred. One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data was incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	An error occurred in the user program with a Motion Control instruction or its use. (<TO>.ErrorWord.X2 (UserFault))
Drive	An error occurred in the drive. (<TO>.ErrorWord.X4 (DriveFault))
Encoder	An error occurred in the encoder system. (<TO>.StatusSensor[1].Error)
Encoder (S7-1500T)	An error has occurred in the encoder system of encoder 1, encoder 2, encoder 3 or encoder 4. (<TO>.StatusSensor[1..4].Error)
Data exchange	Communication with a connected device is faulty. (<TO>.ErrorWord.X7 (CommunicationFault))
I/O	An error occurred accessing a logical address. (<TO>.ErrorWord.X13 (PeripheralError))
Job rejected	A job cannot be executed. You cannot execute a Motion Control instruction because necessary requirements are not fulfilled (for example, technology object not homed). (<TO>.ErrorWord.X3 (CommandNotAccepted))
Homing	An error occurred during a homing process. (<TO>.ErrorWord.X10 (HomingFault))
Positioning	The positioning axis was not positioned correctly at the end of a positioning motion. (<TO>.ErrorWord.X12 (PositioningFault))
Dynamic limitation	The dynamic values are limited to the dynamic limits. (<TO>.ErrorWord.X6 (DynamicError))
Following error	The maximum permitted following error has been exceeded. (<TO>.ErrorWord.X11 (FollowingErrorFault))
SW limit switch	A software limit switch has been reached. (<TO>.ErrorWord.X8 (SwLimit))
HW limit switch	A hardware limit switch has been reached or overtraveled. (<TO>.ErrorWord.X9 (HWLimit))
Adaptation	An error occurred during data adaption. (<TO>.ErrorWord.X15 (AdaptionError))
Superimposing	An error has occurred during the superimposing of the axis motion. The superimposing axis specified at the corresponding Motion Control instruction was not configured as a possible superimposing axis. (<TO>.ErrorWord.X16 (SuperimposingError))

Alarm display

For more information and to acknowledge the error, go to the Inspector window by clicking on the "Alarm display" link.

More information

An option for evaluating the individual status bits can be found in the section "Evaluating StatusWord, ErrorWord and WarningWord" of the "S7-1500/S7-1500T Motion Control overview" documentation.

See also

"StatusWord" tag (positioning axis) (Page 437)
"ErrorWord" tag (positioning axis) (Page 439)
"WarningWord" tag (positioning axis) (Page 441)

8.2.2 Motion status

You use the "Technology object > Diagnostics > Motion status" diagnostic function in the TIA Portal to monitor the motion status of the axis. The Diagnostics function is available in online operation.

"Setpoints" area

The following table shows the meaning of the status data:

Status	Description
Target position	Current target position of an active positioning job The target position value is only valid during execution of a positioning job. (<TO>.StatusPositioning.TargetPosition)
Position setpoint	Setpoint position of the axis (<TO>.Position)
Velocity setpoint	Velocity setpoint of the axis (<TO>.Velocity)
Velocity override	Percentage correction of the velocity specification The velocity setpoint specified in Motion Control instructions or set by the axis control panel is superimposed with an override signal and corrected as a percentage. Permissible velocity correction values are 0.0% to 200.0%. (<TO>.Override.Velocity)

"Current values" area

The following table shows the meaning of the status data:

Status	Description
Operative encoder	Operative encoder of the axis
Actual position	Actual position of the axis If the technology object is not homed, then the value is displayed relative to the position that existed when the technology object was enabled. (<TO>.ActualPosition)
Actual velocity	Actual velocity of the axis (<TO>.ActualVelocity)
Following error	Following error of the axis (<TO>.StatusPositioning.FollowingError)

"Dynamic limits" area

This area displays the limit values for the dynamic parameters.

The following table shows the meaning of the status data:

Status	Description
Velocity	Configured maximum velocity (<TO>.DynamicLimits.MaxVelocity)
Acceleration	Configured maximum acceleration (<TO>.DynamicLimits.MaxAcceleration)
Deceleration	Configured maximum deceleration (<TO>.DynamicLimits.MaxDeceleration)
Jerk	Configured maximum jerk (<TO>.DynamicLimits.MaxJerk)

8.2.3 PROFIdrive telegram

You use the "Technology object > Diagnostics > PROFIdrive telegram" diagnostic function in the TIA Portal to monitor the PROFIdrive telegrams returned by the drive and encoder. The display of the Diagnostics function is available in online operation.

"Drive" area

This area displays the following parameters contained in the PROFIdrive telegram from the drive to the controller:

- Status words "ZSW1" and "ZSW2"
- The speed setpoint (NSET) that was output to the drive
- The actual speed that was signaled from the drive (NACT)

"Encoder" area

in the areas "Encoder" for CPU S7-1500 or "Encoder 1" to "Encoder 4" for CPU S7-1500T, the following parameters from the PROFIdrive telegram are displayed by the encoder to the controller.

- Status word "Gx_ZSW"
- The actual position value "Gx_XIST1" (cyclic actual encoder value)
- The actual position value "Gx_XIST2" (absolute encoder value)

8.3 Technology object external encoder

8.3.1 Status and error bits

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object. The diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables. The associated technology object tag is given in parentheses.

Encoder status

The following table shows the possible external encoder status values:

Status	Description
Encoder enabled	The technology object has been enabled. (<TO>.StatusWord.X0 (Enable))
Homed	The technology object is homed. The relationship between the position in the technology object and the mechanical position was successfully created. (<TO>.StatusWord.X5 (HomingDone))
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area and in the "<TO>.ErrorDetail.Number" and "<TO>.ErrorDetail.Reaction" tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is being reinitialized. (<TO>.StatusWord.X2 (RestartActive))
Encoder values valid	The actual encoder values are valid. (<TO>.StatusSensor[n].State)
Encoder homed	Encoder is homed with one of the following homing types: • Active homing • Passive homing • Absolute encoder adjustment • Incremental encoder adjustment (<TO>.StatusSensor[n].Adjusted)
Restart required	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))

Motion status

The following table shows the possible states of the job execution:

Status	Description
Done (no job running)	No Motion Control job is active at the technology object (enable by "MC_Power" job excepted). (<TO>.StatusWord.X6 (Done))
Homing job	The technology object executes a homing job of the Motion Control instruction "MC_Home". (<TO>.StatusWord.X11 (HomingCommand))
Standstill	The axis is at a standstill. (<TO>.StatusWord.X7 (StandStill))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	A configuration error has occurred. One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data was incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	An error occurred in the user program with a Motion Control instruction or its use. (<TO>.ErrorWord.X2 UserFault))
Encoder	An error occurred in the encoder system. (<TO>.ErrorWord.X5 (SensorFault))
Data exchange	Missing or faulty communication. (<TO>.ErrorWord.X7 (CommunicationFault))
Adaptation	An error occurred during data adaption. (<TO>.ErrorWord.X15 (AdaptionError))

Alarm display

For more information and to acknowledge the error, go to the Inspector window by clicking on the "Alarm display" link.

More information

An option for evaluating the individual status bits can be found in the section "Evaluating StatusWord, ErrorWord and WarningWord" of the "S7-1500/S7-1500T Motion Control overview" documentation.

See also

"StatusWord" tag (external encoder) (Page 454)
"ErrorWord" tag (external encoder) (Page 455)
"WarningWord" tag (external encoder) (Page 456)

8.3.2 Motion status

You use the "Technology object > Diagnostics > Motion status" diagnostic function in the TIA Portal to monitor the actual encoder values. The diagnostics function is available in online operation.

"Current values" area

The following table shows the meaning of the status data:

Status	Description
Actual position	Actual position of the axis If the technology object is not homed, then the value is displayed relative to the position that existed when the technology object was enabled. (<TO>.ActualPosition)
Actual velocity	Actual velocity of the axis (<TO>.ActualVelocity)

8.3.3 PROFIdrive telegram

The "Technology object > Diagnostics > PROFIdrive telegram" diagnostic function is used in the TIA Portal to monitor the PROFIdrive telegram of the encoder. The display of the diagnostics function is available in technology object online mode.

"Encoder" area

This area displays the following parameters contained in the PROFIdrive telegram that the encoder returns to the controller:

- Status word "G1_ZSW"
- The actual position value "G1_XIST1" (cyclic actual encoder value)
- The actual position value "G1_XIST2" (absolute value of the encoder)

Instructions 9

9.1 MC_Power V10

9.1.1 MC_Power: Enable, disable technology object V10

Description

With the Motion Control instruction "MC_Power", a technology object is enabled or disabled and, if necessary, a configured drive is switched on or off.

The Motion Control instruction offers you the following:

- Enabling a technology object with the Motion Control instruction "MC_Power" (Page 108)
  - Enabling a technology object at a standstill (Page 110)
  - Enabling a technology object in motion (Page 110)
  - Enabling a technology object at a standstill when encoder signal is noisy (Page 110)
  - Enabling a technology object after the alarm response "Remove enable" (Page 158)
- Switching the position control off and on (Page 242)
- Enabling a drive (Page 110)
- Disabling a technology object with the Motion Control instruction "MC_Power" (Page 149)
  - Disabling a technology object with emergency deceleration (Page 150)
  - Disabling a technology object with fast stop (Page 152)
  - Disabling a technology object with maximum dynamic values (Page 154)
  - Disabling a technology object with coast down (Page 156)
- Disabling the drive (Page 149)

NOTE

Multi-instance DBs

If you use multi-instances of the MC_Power instruction, create the multi-instances in a separate function block. This allows you to download program blocks from other sections of your user program without switching off the axes, including in "RUN" mode.

Applies to

- Speed axis
- Positioning axis
- Synchronous axis
- External encoder

Requirements

- The technology object has been configured correctly.
- The readiness of the drive is assumed for enabling the technology object. When using the SIEMENS telegram 10x, you can evaluate the bit "DriveReady" from the signal word "MELDW" of the receiving telegram "PD_TEL10x_IN".
- Cyclic bus communication is established between controller and encoder ("<TO>.StatusSensor[1..4].CommunicationOK" = TRUE).
- Cyclic bus communication is established between controller and drive ("<TO>.StatusDrive.CommunicationOK" = TRUE).
- The status of the active encoder is valid ("<TO>.StatusSensor[1..4].State" = 2).
- The optional data adaptation (Page 71) has been completed ("<TO>.StatusDrive.AdaptionState" = 2 and "<TO>.StatusSensor[1..4].AdaptionState" = 2).

The requirements that must be met before a technology object can be released via "MC_Power" can be found in the Siemens Industry Online Support in the FAQ entry 109750297 (https://support.industry.siemens.com/cs/ww/en/view/109750297).

Override response

- An "MC_Power" job cannot be aborted by any other Motion Control job.
- An "MC_Power" job with parameter "Enable" = TRUE enables a technology object but does not thereby abort any other Motion Control instructions.
- Disabling the technology object (parameter "Enable" = FALSE) aborts all Motion Control jobs on the corresponding technology object in accordance with the selected "StopMode". This process cannot be canceled by the user.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_Power":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis TO_PositioningAxis TO_SynchronousAxis TO_ExternalEncoder	-	Technology object	
Enable	INPUT	BOOL	FALSE	TRUE	The technology object is enabled. (Page 110) Setpoints are output to the drive. If the drive is not yet switched on, these are ignored by the drive. As soon as the drive is switched on, these setpoints take effect immediately.
				FALSE	The technology object is disabled. (Page 149) All current jobs at the technology object are canceled in accordance with the configured "StopMode". The technology object matches the setpoint to the actual value.
StartMode	INPUT	DINT	1	Position control (Page 242)	
				0	Enable positioning axis/synchronous axis not position-controlled
				1	Enable positioning axis/synchronous axis position-controlled
				The parameter initially takes effect when the positioning axis is enabled ("Enable" changes from "FALSE" to "TRUE") and when the axis is enabled after acknowledgment of an interrupt that caused the axis to be disabled. The parameter is ignored when a speed axis or an external encoder is being used.	
StopMode	INPUT	INT	0	Not applicable to the technology object external encoder If you disable a technology object with a negative edge at parameter "Enable", the axis decelerates in accordance with the selected "StopMode".	
				0	Emergency stop (Page 150)
				1	Fast stop (Page 152)
				2	Stop with maximum dynamic values (Page 154)
				3	Coast-down (Page 156)[1]
Status	OUTPUT	BOOL	FALSE	Technology object enable status	

[1] When an AUS3 ramp is active and "RemoveEnableReaction" = 16#7, this StopMode takes effect only after the AUS3 ramp and standstill of the drive.

Parameter	Declaration	Data type	Default value	Description	
Status	OUTPUT	BOOL	FALSE	FALSE	Disabled • The technology object does not accept any Motion Control jobs. • Speed control and positioning control are not active. • The actual values of the technology object are not checked for validity.
				TRUE	Enabled • The enabled technology object accepts Motion Control jobs. • Speed control and positioning control are active. • The actual values of the technology object are valid.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred in Motion Control instruction "MC_Power". The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

[1] When an AUS3 ramp is active and "RemoveEnableReaction" = 16#7, this StopMode takes effect only after the AUS3 ramp and standstill of the drive.

See also

Transferring drive and encoder parameters automatically (Page 71)
"LAxisCtrl" library (https://support.industry.siemens.com/cs/ww/en/view/109749348)

9.1.2 MC_Power: Function chart V10

Function chart: Enabling a technology object and example of alarm response

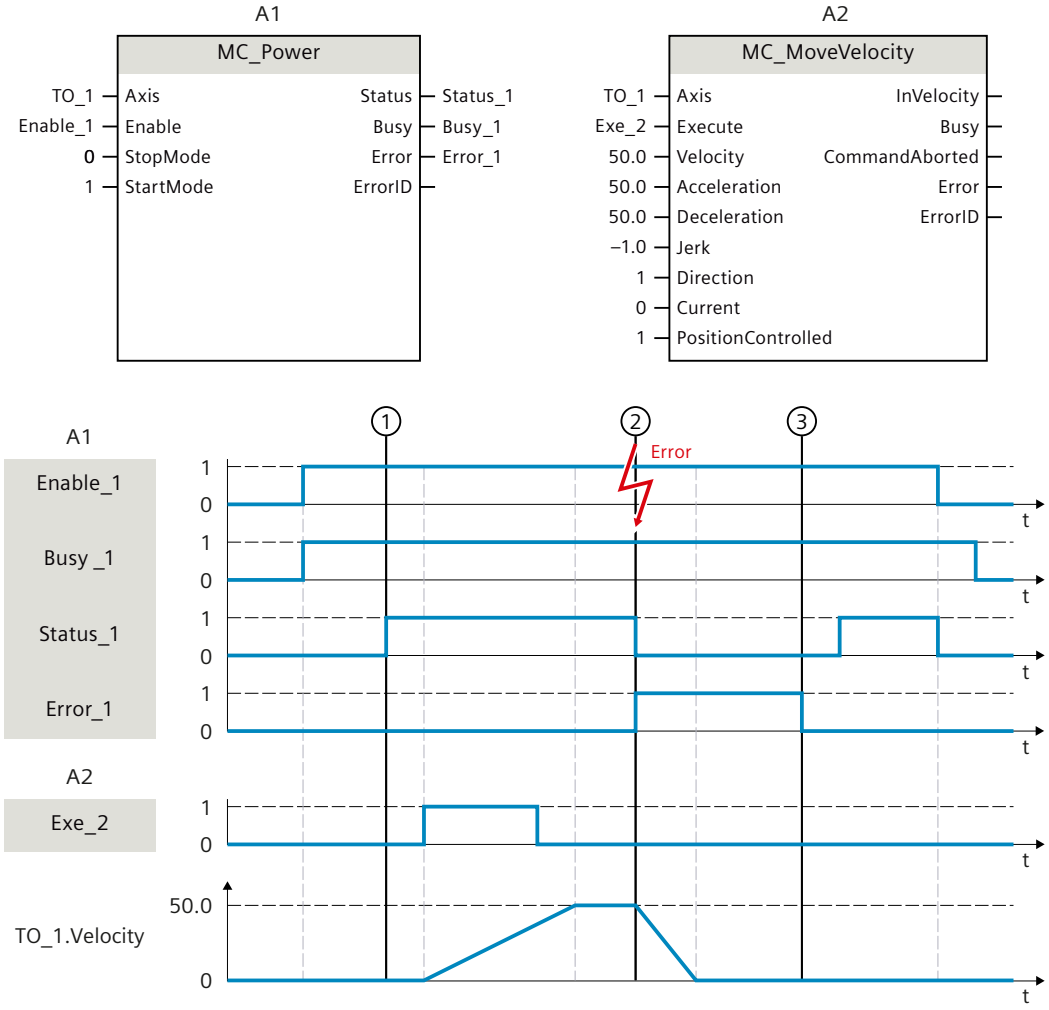

A technology object is enabled with "Enable_1" = TRUE. The successful enable can be read from "Status_1" at time ①. The axis will then move with an "MC_MoveVelocity" job (A2). The velocity profile of the axis can be read from "TO_1.Velocity".

At time ② an error occurs in the technology object, which results in the disabling of the technology object (alarm response: remove enable). The axis is decelerated to a standstill dependent on the configured alarm response "Remove enable" (Page 159). When the technology object is disabled, "Status_1" is reset. Since the axis was not disabled using "Enable_1" = FALSE, the selected "StopMode" does not apply. The cause of the error is corrected and the alarm is acknowledged at time ③.

Since "Enable_1" is still set, the technology object is enabled again. The successful enable can be read from "Status_1". Finally, the technology object is disabled with "Enable_1" = FALSE.

9.2 MC_Reset V10

9.2.1 MC_Reset: Acknowledge alarms, restart technology object V10

Description

With the Motion Control instruction "MC_Reset", you acknowledge all technology alarms that can be acknowledged in the user program. Acknowledgment also resets the "Error" and "Warning" bits in the technology object data block. An acknowledgment of alarms in the drive is also possible without a pending error at the technology object.

With "Restart" = TRUE, you start reinitialization (restart) of technology objects. Upon restart of the technology object, the new configuration data are applied in the technology object data block.

The Motion Control instruction offers you the following:

- Acknowledging technology alarms (Page 113)
- Reinitializing a technology object after a fatal error (Page 114)
- Applying restart-relevant value changes (Page 114)

Applies to

- All technology objects

Requirement

- The technology objects speed axis, positioning axis, synchronous axis and external encoder.

  For a restart, the technology object must be disabled.

  ("MC_Power.Status" = FALSE and "MC_Power.Busy" = FALSE)
- Cyclic BUS communication is established between controller and encoder ("<TO>.StatusSensor[1..4].CommunicationOK" = TRUE).
- Cyclic BUS communication is established between controller and drive ("<TO>.StatusDrive.CommunicationOK" = TRUE).
- With parameter "Restart" = TRUE: The "Debug" program mode cannot have master control over the Interpreter technology object.

Override response

- An "MC_Reset" job cannot be aborted by any other Motion Control job.
- A "MC_Reset" job with "Restart" = TRUE cancels all running Motion Control jobs.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_Reset":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis TO_PositioningAxis TO_SynchronousAxis TO_ExternalEncoder TO_LeadingAxisProxy (S7-1500T) TO_OutputCam TO_CamTrack TO_MeasuringInput TO_Cam (S7-1500T) TO_Cam_10k (S7-1500T) TO_Cam_600Seg (S7-1500T) TO_Cam_6kSeg (S7-1500T) TO_Kinematics (S7-1500T) TO_Interpreter (S7-1500T)	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Restart	INPUT	BOOL	FALSE	TRUE	Reinitialization of the technology object and acknowledgment of pending technology alarms (Page 114) The technology object is being reinitialized with the configured start values.
				FALSE	Acknowledgment of pending technology alarms (Page 113)
Done	OUTPUT	BOOL	FALSE	TRUE	Technology alarms have been acknowledged. The restart has been executed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

9.3 MC_Home V10

9.3.1 MC_Home: Home technology object, set home position V10

Description

With the Motion Control instruction "MC_Home", you create the relationship between the position in the technology object and the mechanical position. The actual position value in the technology object is assigned to a homing mark at the same time. This homing mark represents a known mechanical position.

In the case of active homing (Page 188), the default values under "Technology object > Configuration > Extended parameters > Dynamic default" are used for the dynamic values acceleration, deceleration and jerk.

The Motion Control instruction offers you the following:

- Active homing (Page 195)
- Passive homing (Page 205)
- Direct homing (Page 211)
- Setting the position setpoint (Page 213)
- Adjusting the absolute encoder (Page 213)
- Adjusting the incremental encoder (Page 217)

Applies to

- Positioning axis
- Synchronous axis
- External encoder

Requirements

- The technology object has been configured correctly.
- The actual value of the active encoder is valid (<TO>.StatusSensor[1..4].State = 2).
- "Mode" = 2, 3, 5, 8, 10
  The axis is in position-controlled mode. The axis is enabled.
- "Mode" = 0, 1, 6, 7,11,12,13

  The axis is in position-controlled mode. Enabling of the technology object is not required.

Override response

The override response for "MC_Home" jobs is described in section "Override response V10: Homing and motion jobs (Page 380)".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_Home":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_PositioningAxis TO_SynchronousAxis TO_ExternalEncoder	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Position	INPUT	LREAL	0.0	The specified value is used according to the selected "Mode".	
Mode	INPUT	INT	0	0 to 13	Homing mode (Page 295) Homing can occur by means of an independent homing motion (active homing), the detection of a homing mark during an initiated motion (passive homing) or a direct position assignment.
Sensor	INPUT	DINT	0	S7-1500: Not relevant	
				S7-1500T: Selection of the absolute encoder ("Mode" = 6, 7) or incremental encoder ("Mode" = 13) to be calibrated	
				0	Operative encoder
				1..4	Encoders 1 to 4 (S7-1500T)
ReferenceMarkPosition	OUTPUT	LREAL	0.0	Display of the position at which the technology object was homed. With active homing, the homing mark position corresponds to the home position minus home position offset. With passive homing, the homing mark position corresponds to the home position. (valid when "Done" = TRUE)	
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

More information

An option for evaluating the individual status bits can be found in the section "Evaluating StatusWord, ErrorWord and WarningWord" of the "S7-1500/S7-1500T Motion Control overview" documentation.

See also

Homing (Page 188)

9.3.2 MC_Home: "MC_Home.Mode" parameter V10

Value	Description
0	Direct homing (absolute) (Page 211) The current position of the technology object is set to the value of parameter "Position". **Note** In the case of an axis with several encoders, the offset of the position at the sensors of all encoders is also applied with a position correction with the "Mode" parameter = 0. This prevents the sensors from diverging.
1	Direct homing (relative) (Page 211) The current position of the technology object is shifted by the value of parameter "Position". **Note** In the case of an axis with several encoders, the offset of the position at the sensors of all encoders is also applied with a position correction with the "Mode" parameter = 1. This prevents the sensors from diverging.
2	Passive homing (without reset) (Page 205)[1)] Function same as "Mode" = 8 with the difference that the "homed" status is **not** reset when the function is enabled.
3	Active homing (Page 195)[1)] The positioning axis/synchronous axis technology object performs a homing movement according to the configuration. After the completion of the motion, the axis is positioned at the value of the "Position" parameter.
4	Reserved
5	Active homing ("Position" parameter invalid) (Page 195)[1)] The positioning axis/synchronous axis technology object performs a homing movement according to the configuration. After completion of the motion, the axis is positioned at the home position configured under "Technology object > Configuration > Extended parameters > Homing > Active homing". (<TO>.Homing.HomePosition)
6	Absolute encoder adjustment (relative) (Page 213) The current position is shifted by the value of parameter "Position". The calculated absolute value offset is stored retentively in the CPU. (<TO>.StatusSensor[1..4].AbsEncoderOffset)
7	Absolute encoder adjustment (absolute) (Page 213) The current position is set to the value of parameter "Position". The calculated absolute value offset is stored retentively in the CPU. (<TO>.StatusSensor[1..4].AbsEncoderOffset)
8	Passive homing (Page 205)[1)] When the homing mark is detected, the actual value is set to the value of the "Position" parameter.
9	Abort passive homing (Page 205) An active job for passive homing is aborted.

1) In the case of active/passive homing with absolute encoder, if a valid absolute value offset has not yet been saved (<TO>.StatusSensor[1..4].Adjusted = 0), an absolute value offset is retentively saved via the switching on/off of the controller. If an absolute value offset has already been saved in the CPU (<TO>.StatusSensor[1..4].Adjusted = 1), it is retained after an active/passive homing. To update the absolute encoder offset, perform an absolute encoder adjustment to the current position after the active/passive homing.

Value	Description
10	Passive homing ("Position" parameter invalid) (Page 205)[1)] When the homing mark is detected, the actual value is set to the home position configured under "Technology object > Configuration > Extended parameters > Homing > Passive homing". (<TO>.Homing.HomePosition)
11	Setting of position setpoint (absolute) (Page 213) The set position of the technology object is set to the value of the "Position" parameter. The following error remains.
12	Shift the setpoint position (relative) (Page 213) The set position of the technology object is shifted by the value of the "Position" parameter. The following error remains.
13	Incremental encoder adjustment (Page 217) The current position is set to the value of parameter "Position".

1) In the case of active/passive homing with absolute encoder, if a valid absolute value offset has not yet been saved (<TO>.StatusSensor[1..4].Adjusted = 0), an absolute value offset is retentively saved via the switching on/off of the controller. If an absolute value offset has already been saved in the CPU (<TO>.StatusSensor[1..4].Adjusted = 1), it is retained after an active/passive homing. To update the absolute encoder offset, perform an absolute encoder adjustment to the current position after the active/passive homing.

9.4 MC_Halt V10

9.4.1 MC_Halt: Stop axis V10

Description

With the Motion Control instruction "MC_Halt", you brake an axis until it comes to a standstill.

You define the dynamic behavior of the braking operation with parameters "Jerk" and "Deceleration".

The Motion Control instruction offers you the following:

- Configuring dynamic values (Page 114)
- Stopping a technology object (Page 168)
- Stopping a basic motion with or without a superimposed motion (Page 168)

Applies to

- Speed axis
- Positioning axis
- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override response for "MC_Halt" jobs is described in section "Override response V10: Homing and motion jobs (Page 380)".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_Halt":

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Deceleration	INPUT	LREAL	-1.0	Deceleration (Page 114)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk (Page 114)	
				> 0.0	Constant-acceleration velocity profile; the specified jerk is used
				= 0.0	Trapezoid velocity profile
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)
AbortAcceleration	INPUT	BOOL	FALSE	FALSE	The current acceleration at the start of the job is reduced using the configured jerk. Afterwards, the deceleration builds up.
				TRUE	The acceleration is set to 0.0 at the start of the job, and the deceleration immediately builds up.
Mode	INPUT	DINT	0	Select the motion which is to be stopped (Page 168)	
				0	The basic motion and the superimposed motion are stopped.
				1	The basic motion is stopped. The superimposed motion remains active.
Done	OUTPUT	BOOL	FALSE	TRUE	When "Mode" = 0: Velocity zero has been reached.
					When "Mode" = 1: Velocity zero of the basic motion has been reached.

Parameters	Declaration	Data type	Default value	Description	
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

More information

Information on the evaluation of the individual bits can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

See also

Configuring dynamic defaults (Page 115)

9.4.2 MC_Halt: Function chart V10

Function chart: Pausing an axis and the overriding job characteristics

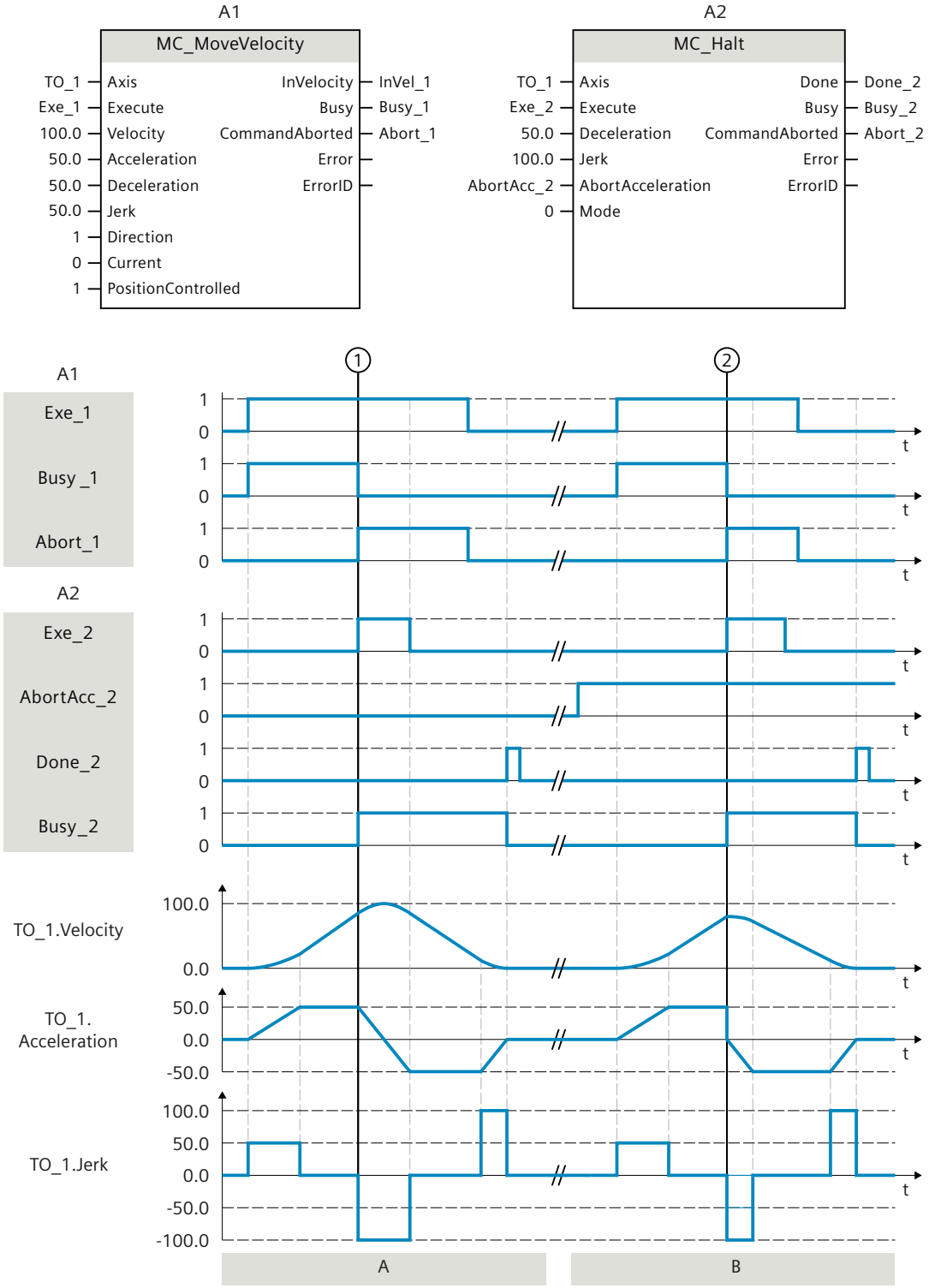

Section A

An axis is moved with an "MC_MoveVelocity" job (A1). At time ①, the "MC_MoveVelocity" job is overridden by an "MC_Halt" job (A2). The job abort is signaled via "Abort_1". With "AbortAcc_2" = FALSE, the current acceleration is reduced with the specified jerk. Afterward, the deceleration builds up and the axis is braked to a standstill. The completion of the "MC_Halt" job is reported via "Done_2".

Section B

The axis is moved with an "MC_MoveVelocity" job (A1). At time ②, the "MC_MoveVelocity" job is overridden by an "MC_Halt" job (A2). The job abort is signaled via "Abort_1". With "AbortAcc_2" = TRUE, the current acceleration is set to zero immediately and the deceleration builds up. The axis is braked to a standstill. The completion of the "MC_Halt" job is reported via "Done_2".

Function chart: Stopping basic motion with "Mode"=1

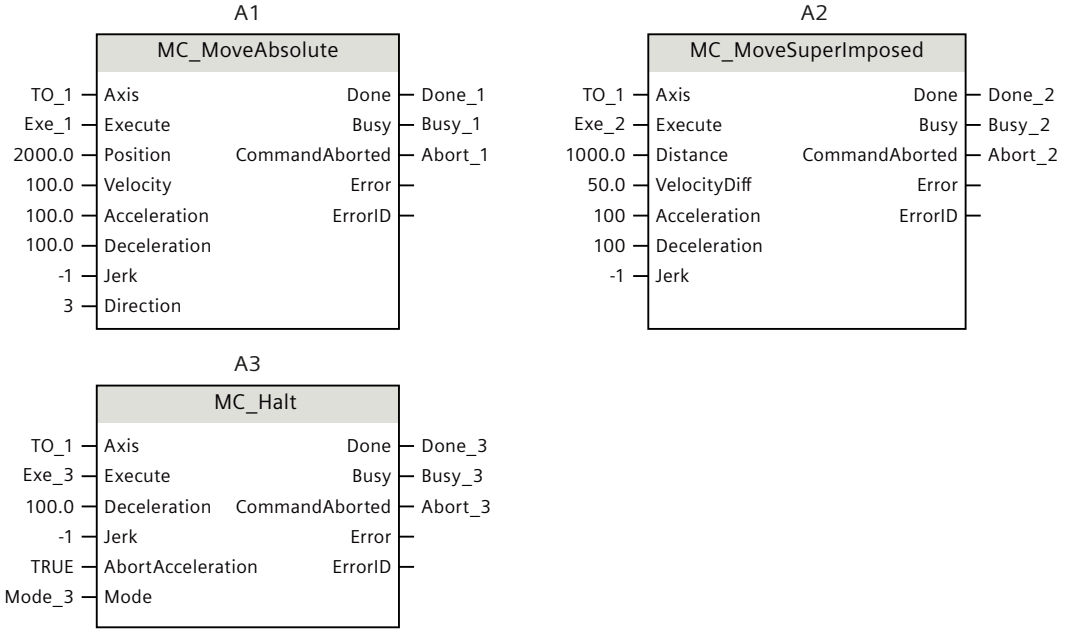

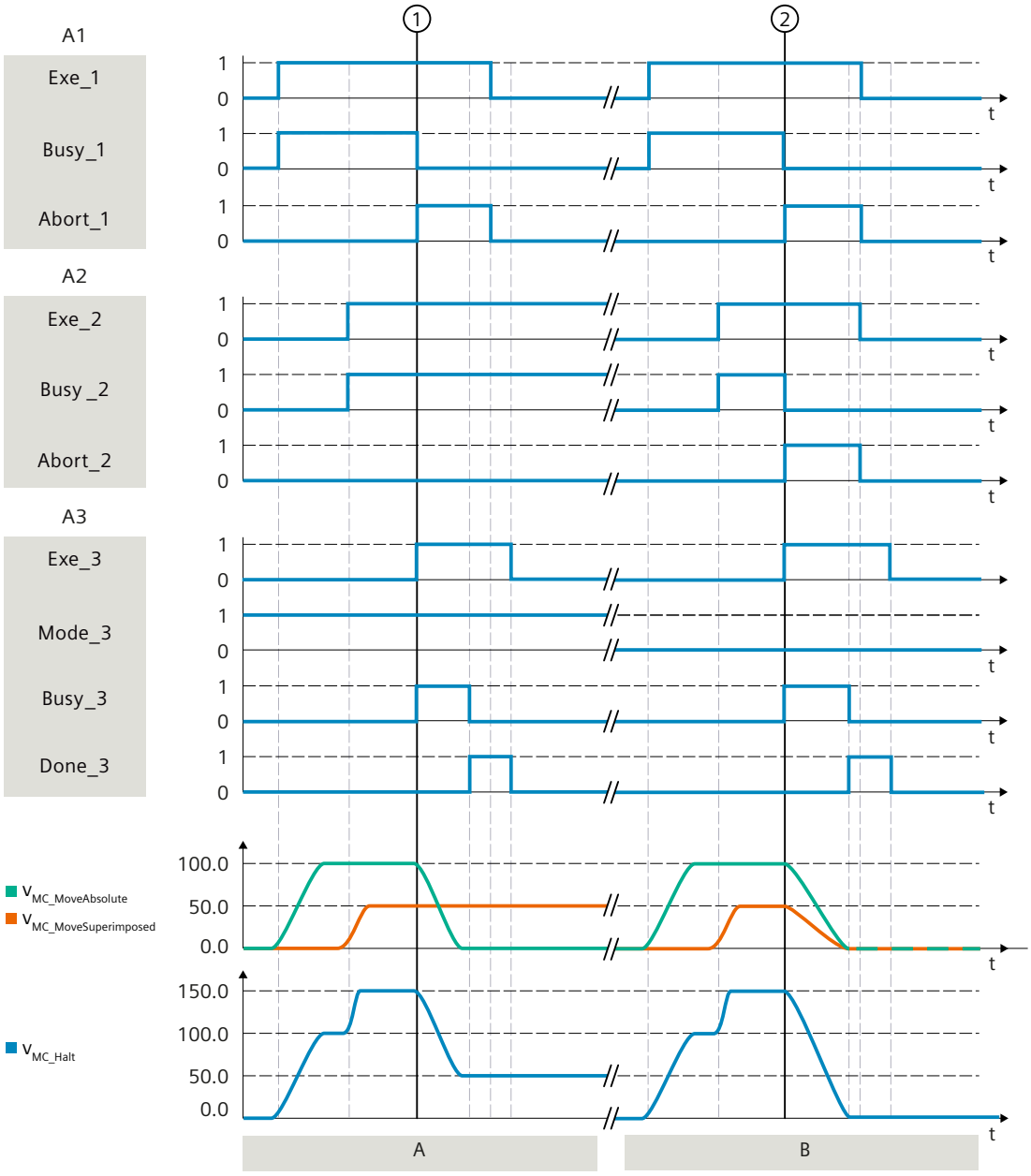

Section A

An axis is moved with an "MC_MoveAbsolute" job (A1) with setpoint velocity 100.0. An "MC_MoveSuperimposed" job (A2) is triggered via "Exe_2" with the velocity deviation 50.0 from the running basic motion. The axis is moved with the added velocities of both jobs 100.0 + 50.0 = 150.0.

At time ①, the "MC_MoveAbsolute" job (A1) is overridden by an "MC_Halt" job (A3) with "Mode_3" = 1. The basic motion is stopped. The "MC_MoveSuperimposed" job (A2) remains active. The job abort is signaled via "Abort_1". The completion of the "MC_Halt" job is reported via "Done_3".

Section B

An axis is moved with an "MC_MoveAbsolute" job (A1) with setpoint velocity 100.0. An "MC_MoveSuperimposed" job (A2) is triggered via "Exe_2" with the velocity deviation 50.0 from the running basic motion. The axis is moved with the added velocities of both jobs 100.0 + 50.0 = 150.0.

At time ②, the "MC_MoveAbsolute" job (A1) and the "MC_MoveSuperimposed" job (A2) are overridden by an "MC_Halt" job (A3) with "Mode_3" = 0. The basic motion and the superimposed motion are stopped. The job abort is signaled via "Abort_1" and "Abort_2". The completion of the "MC_Halt" job is reported via "Done_3".

9.5 MC_MoveAbsolute V10

9.5.1 MC_MoveAbsolute: Position axis absolutely V10

Description

With the Motion Control instruction "MC_MoveAbsolute", you move an axis to an absolute position.

The Motion Control instruction offers you the following:

- Defining the dynamics of the motion (Page 140)
- Defining the absolute target position (Page 140)
- Defining the motion transition (Page 141)
- Starting the job and tracking the motion status (Page 140)

Applies to

- Positioning axis
- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The technology object has been enabled.
- The technology object is homed.

Override response

The override response for "MC_MoveAbsolute" jobs is described in section "Override response V10: Homing and motion jobs (Page 380)".

NOTE

Deviating dynamic settings

When overriding the active job with a new jerk-limited motion, the current acceleration or deceleration is transferred to the new acceleration/deceleration via the jerk. Depending on the dynamic settings, this may take several application cycles. When the new acceleration or deceleration deviates significantly from the acceleration/deceleration at the time of the override, the transition profile can result in an unexpected axis motion.

If such transitions cannot be excluded during acceleration/deceleration, adjust the dynamic settings of your jobs. For example, add a motion that is not jerk-limited with a direct transition to the new acceleration/deceleration. As an alternative, use high jerk values.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MoveAbsolute":

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Position	INPUT	LREAL	0.0	Absolute target position (Page 140)	
Velocity	INPUT	LREAL	-1.0	Velocity setpoint for the positioning	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Velocity)
Acceleration	INPUT	LREAL	-1.0	Acceleration (Page 140)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration (Page 140)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted

Parameters	Declaration	Data type	Default value	Description	
Deceleration	INPUT	LREAL	-1.0	< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk (Page 140)	
				> 0.0	Constant acceleration velocity profile The specified value is used.
				= 0.0	Trapezoid velocity profile
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)
BufferMode	INPUT	DINT	0	Motion transition (Page 141)	
				0	Abort active motion
				1	Append new motion
Direction	INPUT	INT	1	Direction of movement of the axis (Page 140) This parameter is only evaluated when the modulo function is enabled. "Technology object > Configuration > Basic parameters > Enable modulo"	
				1	Positive direction
				2	Negative direction
				3	Shortest distance
Done	OUTPUT	BOOL	FALSE	TRUE	The target position has been reached. The minimum dwell time has expired (<TO>.PositioningMonitoring.MinDwellTime).
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Active	OUTPUT	BOOL	FALSE	TRUE	The setpoints are calculated. The job has control of the axis.
				FALSE	When "Busy" = TRUE: Job is waiting. (Typical: A preceding job is still active.)
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

9.5.2 MC_MoveAbsolute: Function chart V10

Function chart: Motion transition when positioning an axis absolutely

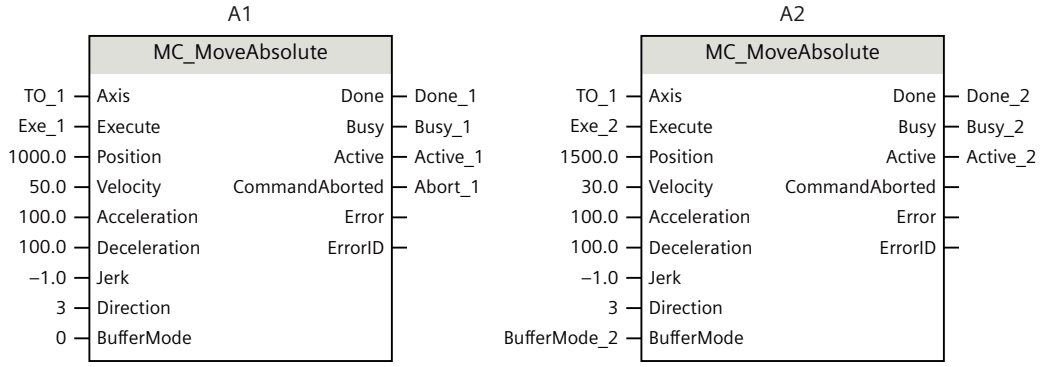

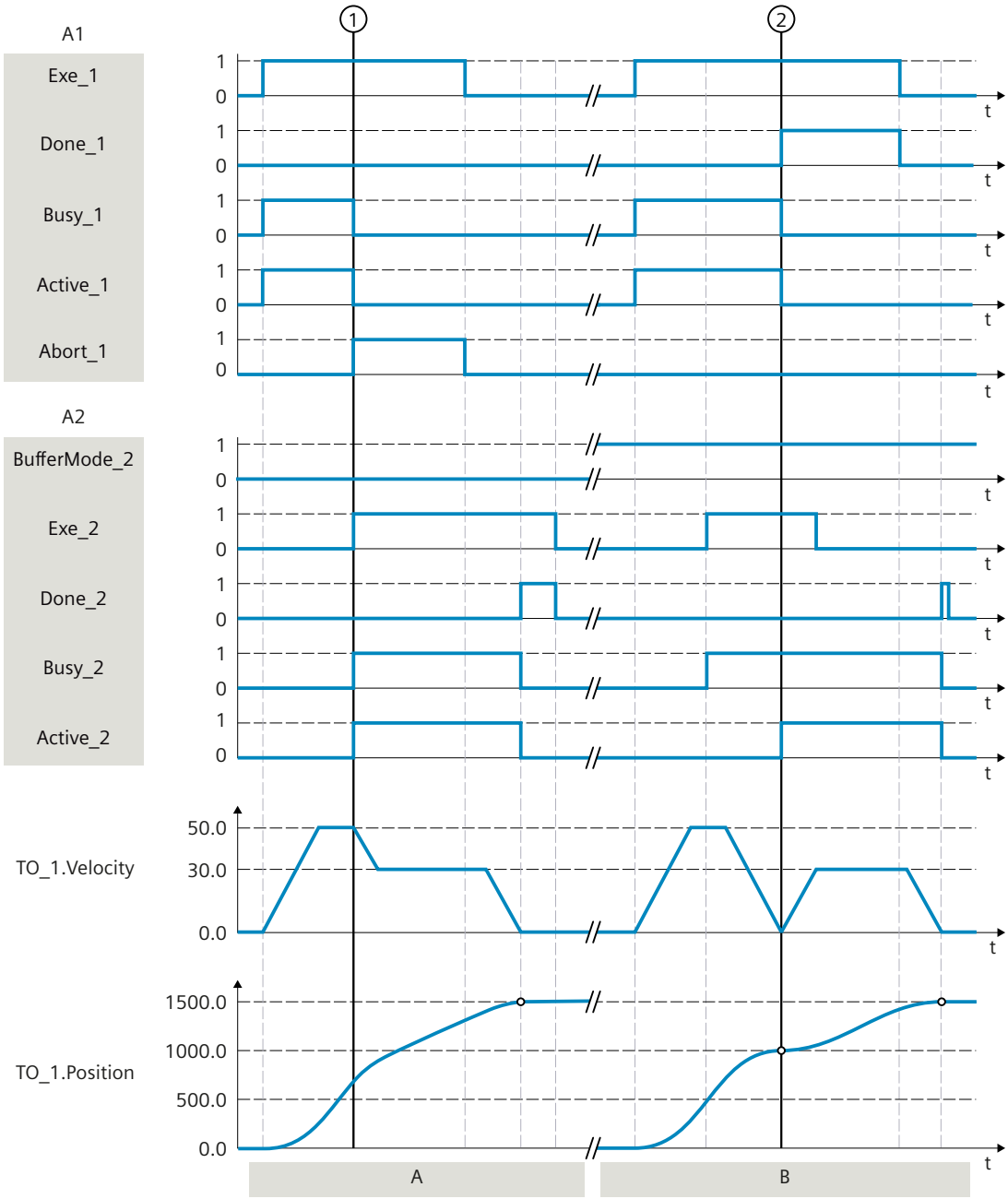

Section A

An active "MC_MoveAbsolute" job (A1) is overridden at time ① by another "MC_MoveAbsolute" job (A2). The abort is signaled via "Abort_1". The axis is braked to the changed velocity and moved to the new target position 1500.0. When the new target position is reached, this is signaled via "Done_2".

Section B

An axis is moved to absolute position 1000.0 with an "MC_MoveAbsolute" job (A1). An additional "MC_MoveAbsolute" job (A2) has been appended to the active motion sequence via "Exe_2". The active motion sequence is completed and the axis comes to a standstill. When the axis reaches the target position, this is signaled at time ② via "Done_1". At this

time ②, another "MC_MoveAbsolute" job (A2) with target position 1500.0 is started. When the axis reaches the target position 1500.0, this is signaled via "Done_2".

9.6 MC_MoveRelative V10

9.6.1 MC_MoveRelative: Position axis relatively V10

Description

With the Motion Control instruction "MC_MoveRelative", you move an axis relative to its actual position setpoint when execution of the job began.

The Motion Control instruction offers you the following:

- Defining the dynamics of the motion (Page 140)
- Defining the relative target position (Page 140)
- Defining the motion transition (Page 141)
- Starting the job and tracking the motion status (Page 140)

Applies to

- Positioning axis
- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override response for "MC_MoveRelative" jobs is described in section "Override response V10: Homing and motion jobs (Page 380)".

NOTE

Deviating dynamic settings

When overriding the active job with a new jerk-limited motion, the current acceleration or deceleration is transferred to the new acceleration/deceleration via the jerk. Depending on the dynamic settings, this may take several application cycles. When the new acceleration or deceleration deviates significantly from the acceleration/deceleration at the time of the override, the transition profile can result in an unexpected axis motion.

If such transitions cannot be excluded during acceleration/deceleration, adjust the dynamic settings of your jobs. For example, add a motion that is not jerk-limited with a direct transition to the new acceleration/deceleration. As an alternative, use high jerk values.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MoveRelative":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Distance	INPUT	LREAL	0.0	Distance for the positioning[1] (negative or positive) (Page 140)	
Velocity	INPUT	LREAL	-1.0	Velocity setpoint for the positioning (Page 140)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Velocity)
Acceleration	INPUT	LREAL	-1.0	Acceleration (Page 140)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration (Page 140)	
				> 0.0	The specified value is used.

[1] If you have set "nm" as the unit of measurement for an axis, enter a value with magnitude greater than or equal to 1000.0 at the "MC_MoveRelative.Distance" parameter. If the amount of the value of "MC_MoveRelative.Distance" is less than 1000.0, the axis will not move during a motion task.

Parameter	Declaration	Data type	Default value	Description	
Deceleration	INPUT	LREAL	-1.0	= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk (Page 140)	
				> 0.0	Constant acceleration velocity profile The specified value is used.
				= 0.0	Trapezoid velocity profile
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)
BufferMode	INPUT	DINT	0	Motion transition (Page 141)	
				0	Abort active motion
				1	Append new motion
Done	OUTPUT	BOOL	FALSE	TRUE	The target position has been reached. The minimum dwell time has expired (<TO>.PositioningMonitoring.MinDwell-Time).
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Active	OUTPUT	BOOL	FALSE	TRUE	The setpoints are calculated. The job has control of the axis.
				FALSE	When "Busy" = TRUE: Job is waiting. (Typical: A preceding job is still active.)
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

1) If you have set "nm" as the unit of measurement for an axis, enter a value with magnitude greater than or equal to 1000.0 at the "MC_MoveRelative.Distance" parameter. If the amount of the value of "MC_MoveRelative.Distance" is less than 1000.0, the axis will not move during a motion task.

9.6.2 MC_MoveRelative: Function chart V10

Function chart: Motion transition when positioning an axis relatively

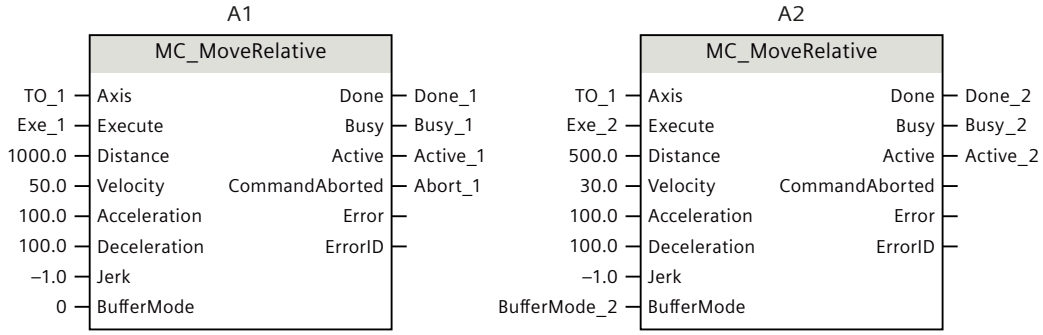

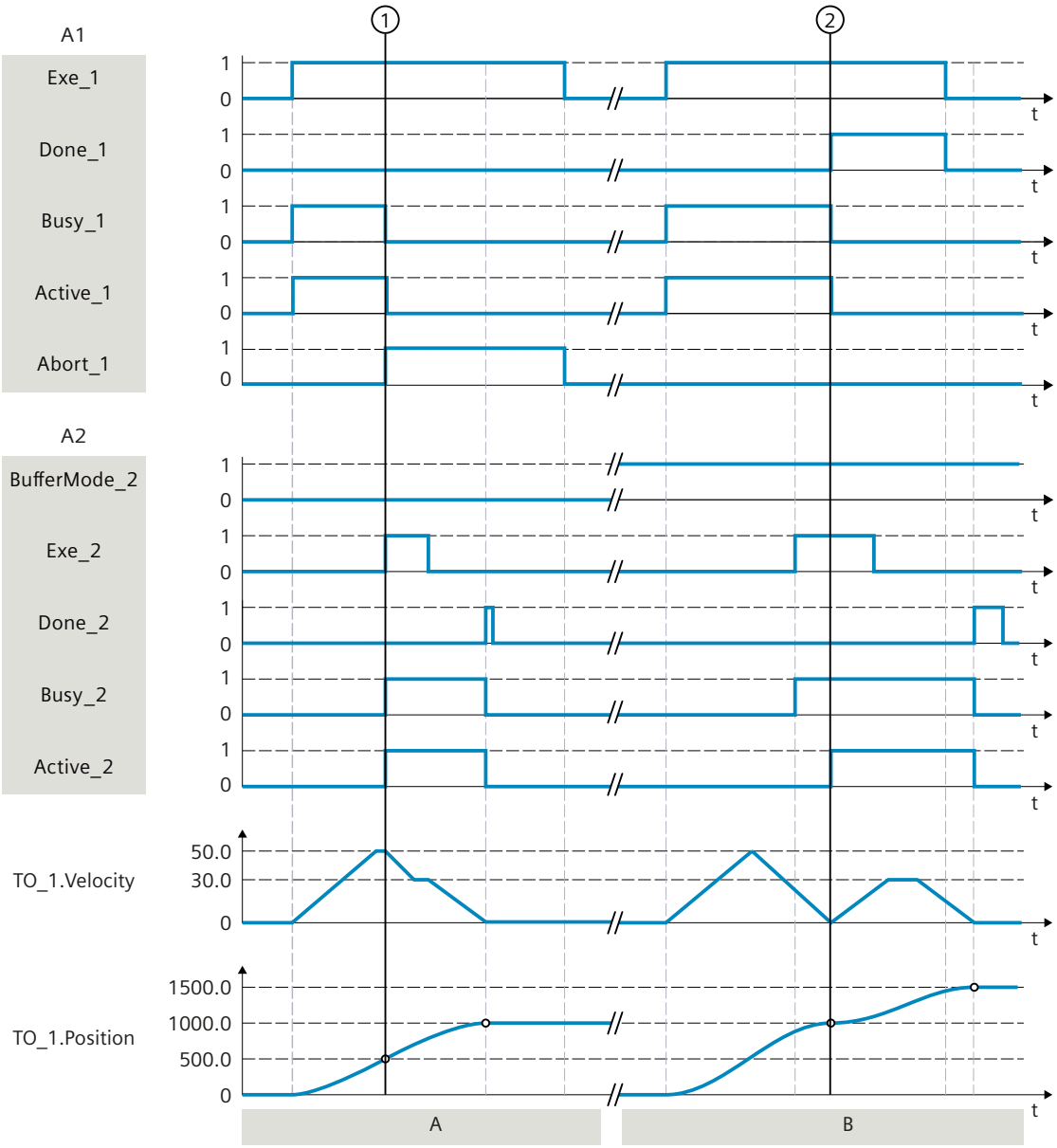

Section A

An active "MC_MoveRelative" job (A1) is overridden by another "MC_MoveRelative" job (A2). The abort is signaled at time ① via "Abort_1". The axis is then moved at the new velocity by the distance ("Distance") 500.0. When the new target position is reached, this is signaled via "Done_2".

Section B

The axis is moved by an "MC_MoveRelative" job (A1) by the distance ("Distance") 1000.0 (the start position here is 0.0). An additional "MC_MoveRelative" job (A2) has been appended to the active motion sequence via "Exe_2". The active motion sequence is completed and the axis comes to a standstill. When the axis reaches the target position, this is signaled at time ② via "Done_1". At this time ②, another "MC_MoveRelative" job (A2) with distance 500.0 is started. When the new target position is reached, this is signaled via "Done_2".

9.7 MC_PositionProfile V10

9.7.1 MC_PositionProfile: Move axis via a time-based position profile V10

Description

You start an axis motion which follows a time-based position profile preset in the cam technology object with the Motion Control instruction "MC_PositionProfile".

The axis motion is ended when the end position of the time-based position profile of the cam is reached. The axis is at a standstill.

The Motion Control instruction offers you the following:

- Defining the relative or absolute traversing motion of the time-based position profile (Page 142)
- Defining the motion transition (Page 141)
- Defining the dynamics of the transition profile (Page 142)
- Defining the start time of the time-based position profile (Page 142)

Applies to

- Positioning axis
- Synchronous axis
- Cam

Requirement

- The technology objects positioning axis/synchronous axis and cam have been configured correctly.
- The technology object of the axis is enabled.
- The cam is interpolated with "MC_InterpolateCam".
- The technology object of the axis is homed when "ProfileReference" = 1.

Override response

The override response for "MC_PositionProfile" jobs is described in section "Override response V10: Homing and motion jobs (Page 380)".

NOTE

Deviating dynamic settings

When the active job is overridden by a new jerk-limited motion, the current acceleration or deceleration is transferred to the new acceleration or deceleration via the jerk. Depending on the dynamic settings, this may take several application cycles. If the new acceleration or deceleration deviates significantly from the acceleration or deceleration at the time of the override, the transition profile can result in an unexpected axis motion.

If such transitions cannot be excluded during acceleration or deceleration, adjust the dynamic settings of your jobs. For example, add a motion that is not jerk-limited with a direct transition to the new acceleration or deceleration. As an alternative, use high jerk values.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_PositionProfile":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_PositioningAxis TO_SynchronousAxis	-	Axis technology object	
TimePosition	INPUT	TO_Cam TO_Cam_10k TO_Cam_6kSeg TO_Cam_600Seg	-	Time-based position profile of the cam technology object (Page 142)	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
BufferMode	INPUT	DINT	0	Motion transition (Page 141)	
				0	Abort active motion
				1	Append new motion
StartTime	INPUT	LREAL	0.0	Start time of the time-based position profile (Page 142) The time relates to the start time of the cam from which the motion transition of the axis to the profile begins. The value must be within the definition of the cam.	
ProfileReference	INPUT	DINT	0	Traversing motion of the time-based position profile (Page 142)	
				0	Relative
				1	Absolute
Velocity	INPUT	LREAL	-1.0	Velocity (Page 142)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted

Parameter	Declaration	Data type	Default value	Description	
Velocity	INPUT	LREAL	-1.0	< 0.0	The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Velocity)
Acceleration	INPUT	LREAL	-1.0	Acceleration (Page 142)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration (Page 142)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk (Page 142)	
				> 0.0	Constant acceleration velocity profile The specified value is used.
				= 0.0	Trapezoid velocity profile
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed. The target position has been reached. The minimum dwell time has expired (<TO>.PositioningMonitoring.MinDwell-Time).
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Active	OUTPUT	BOOL	FALSE	TRUE	The setpoints are calculated. The job has master control over the axis.
				FALSE	When "Busy" = TRUE: Job is waiting. (Typical: A preceding job is still active.)

Parameter	Declaration	Data type	Default value	Description	
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

9.7.2 MC_PositionProfile: Function chart V10

Function chart: Time-based position profile with relative positioning of an axis

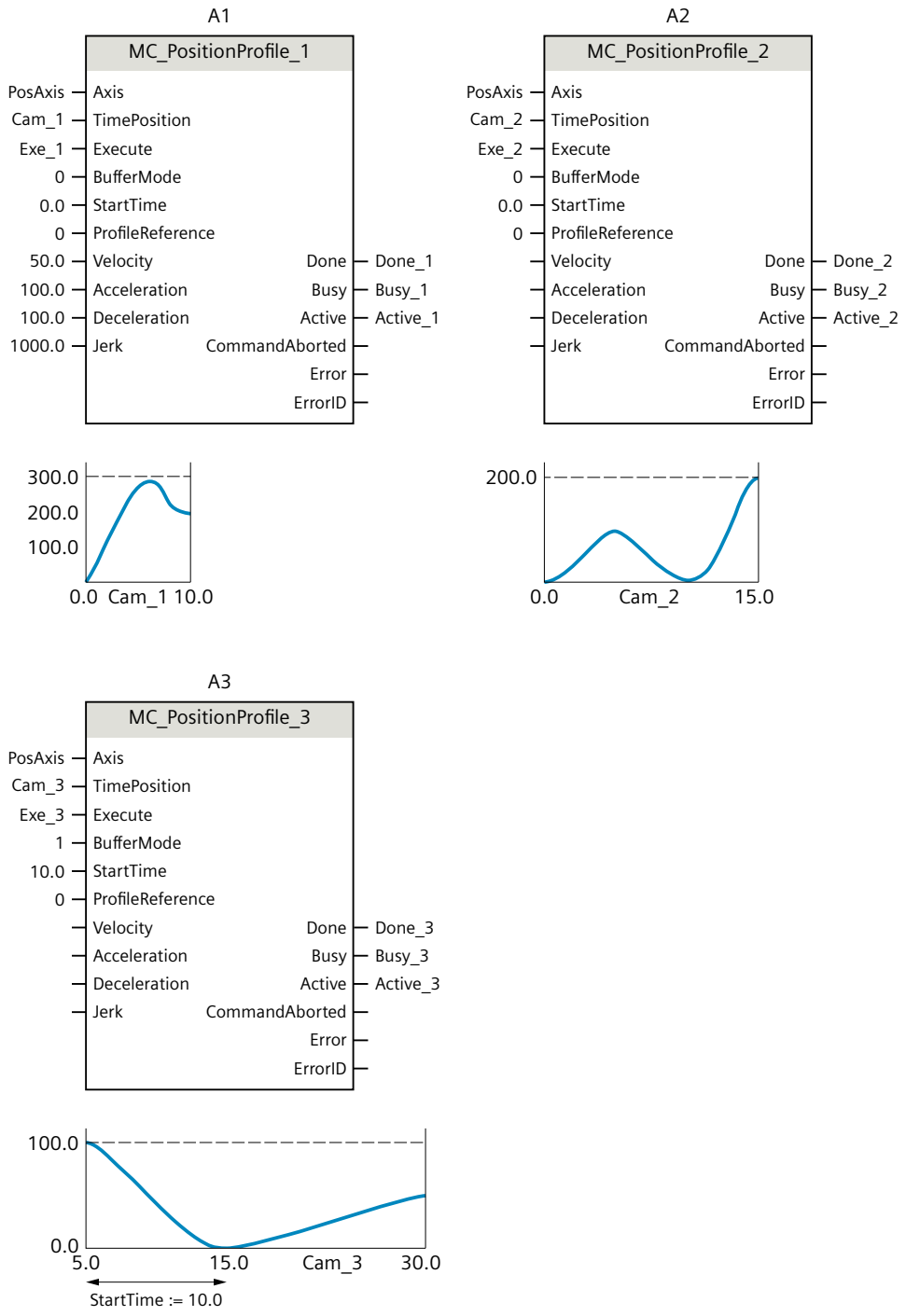

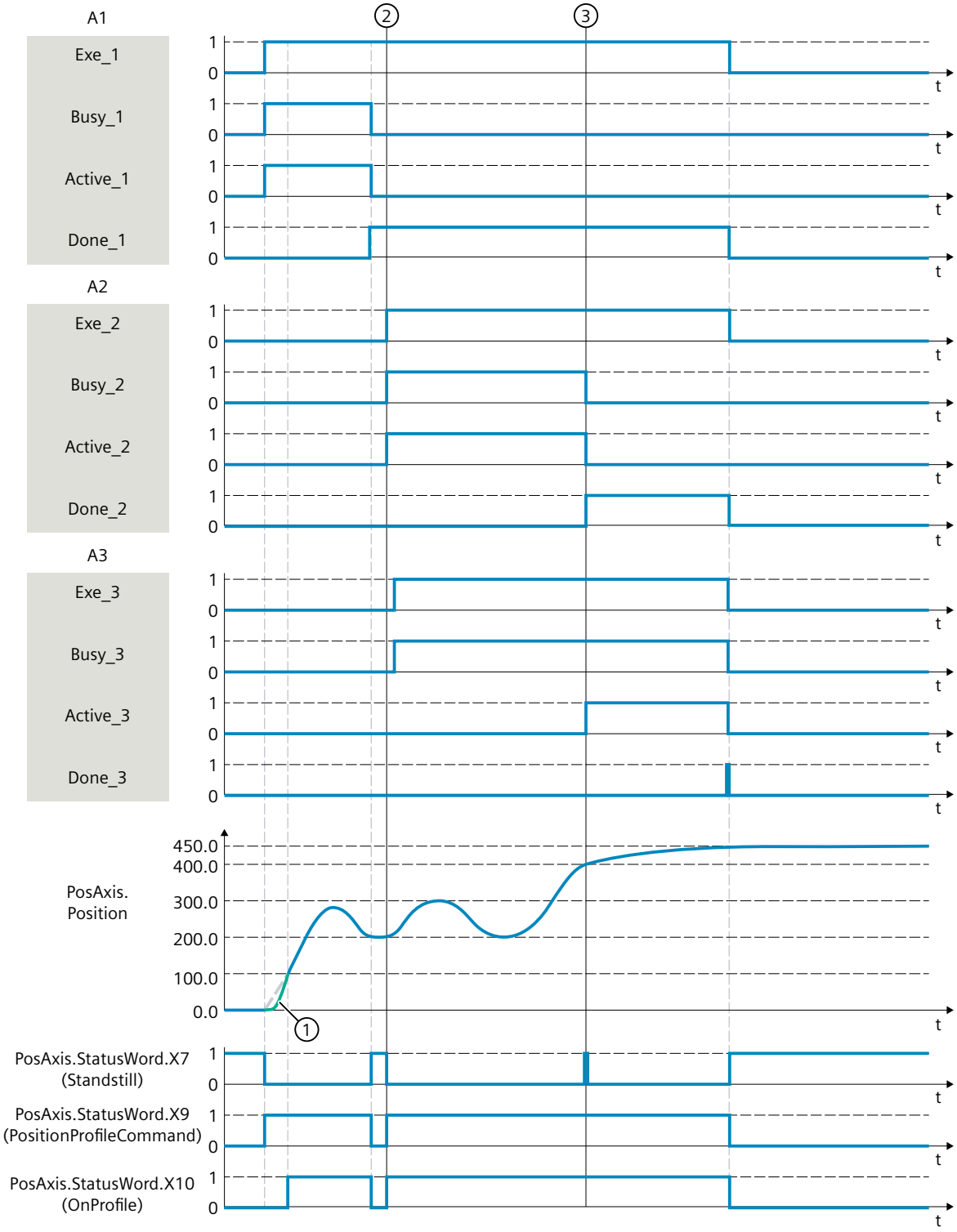

Using "Exe_1", an "MC_PositionProfile" job (A1) is initiated. In the range ①, the axis does not follow the cam "Cam_1". A transition profile ① is calculated by the system with required dynamics.

The "PosAxis.StatusWord2.X10 (OnProfile) = TRUE" tag indicates that the start position of the cam profile has been reached. The axis travels relative to its position according to the cam profile "Cam_1". The axis comes to a standstill when the end position of the time-based position profile of the cam is reached.

At the time ②, a further "MC_PositionProfile" job (A2) is initiated via "Exe_2". The axis travels immediately according to the cam profile "Cam_2".

Shortly afterwards, a further "MC_PositionProfile" job (A3) is initiated via "Exe_3". The "MC_PositionProfile" job (A3) waits until the end of the active cam "Cam_2".

At the time ③, the "MC_PositionProfile" job (A3) is appended to the running job (A2). The "MC_PositionProfile" job (A2) active motion sequence is completed and the axis comes briefly to a standstill. The job (A3) is then executed. The axis travels relative to its position according to the start time "StartTime = 10.0" of the cam "Cam_3".

Function chart: Time-based position profile with absolute positioning of an axis

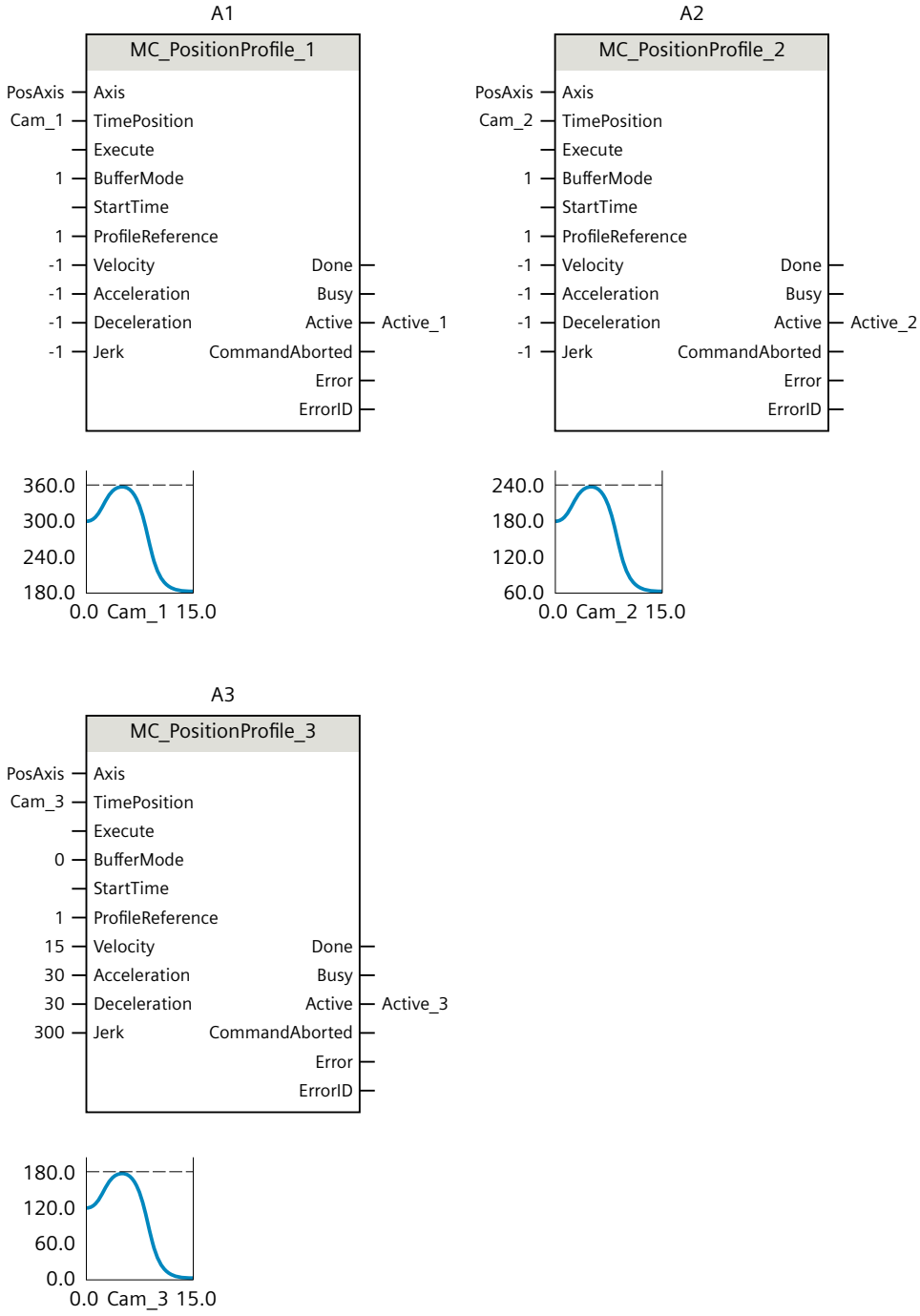

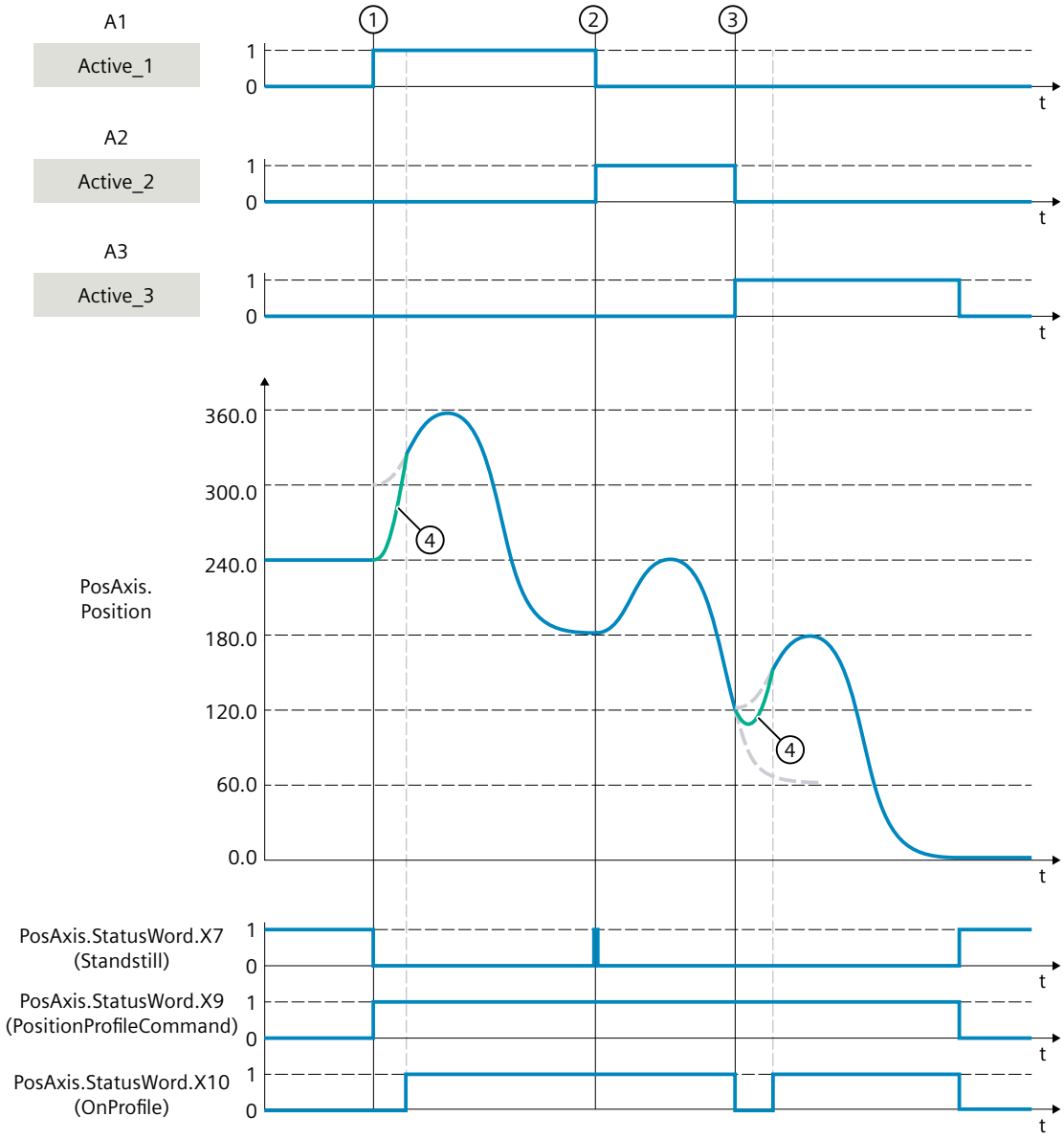

At time ①, an "MC_PositionProfile" job (A1) with absolute traversing motion is initiated. Shortly thereafter, an "MC_PositionProfile" job (A2) is transmitted. The axis does not follow the cam "Cam_1". A transition profile ④ is calculated by the system with required dynamics. The axis moves a transition profile to the absolute time-based position profile of the "MC_PositionProfile" job (A1). The "PosAxis.StatusWord2.X10 (OnProfile) = TRUE" tag indicates that the start position of the cam profile has been reached. The axis travels absolutely according to the cam profile "Cam_1". The "MC_PositionProfile" job (A2) waits until the end of the active cam "Cam_1". The axis comes to a standstill when the absolute end position of the time-based position profile of the cam (A1) is reached.

At the time ②, the "MC_PositionProfile" job (A2) is appended to the running job (A1). The axis travels immediately according to the cam profile "Cam_2" without using a transition profile.

At the time ③, the "MC_PositionProfile" job (A2) is aborted by another "MC_PositionProfile" job (A3). The axis moves a transition profile ④ to the absolute time-based position profile of the "MC_PositionProfile" job (A3). During traversing of the transition profile, the axis has the state "PosAxis.StatusWord2.X10 (OnProfile) = FALSE". After the start position of the cam profile is reached, the axis travels absolutely according to the cam profile "Cam_3". The axis comes to a standstill when the absolute end position of the time-based position profile of the cam (A3) is reached.

9.8 MC_MoveVelocity V10

9.8.1 MC_MoveVelocity: Move axis with velocity/speed setpoint V10

Description

With the Motion Control instruction "MC_MoveVelocity", you move an axis with constant velocity/speed.

The Motion Control instruction offers you the following:

- Defining the dynamics of the motion (Page 137)
- Defining the position control (Page 137)
- Starting the job and tracking the motion status (Page 137)

Applies to

- Speed axis
- Positioning axis
- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override response for "MC_MoveVelocity" jobs is described in section "Override response V10: Homing and motion jobs (Page 380)".

NOTE

Deviating dynamic settings

When overriding the active job with a new jerk-limited motion, the current acceleration or deceleration is transferred to the new acceleration/deceleration via the jerk. Depending on the dynamic settings, this may take several application cycles. When the new acceleration or deceleration deviates significantly from the acceleration/deceleration at the time of the override, the transition profile can result in an unexpected axis motion.

If such transitions cannot be excluded during acceleration/deceleration, adjust the dynamic settings of your jobs. For example, add a motion that is not jerk-limited with a direct transition to the new acceleration/deceleration. As an alternative, use high jerk values.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MoveVelocity":

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Velocity	INPUT	LREAL	100.0	Velocity setpoint/speed setpoint for the motion (Page 137) ("Velocity" = 0.0 is permitted)	
Acceleration	INPUT	LREAL	-1.0	Acceleration (Page 137)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration (Page 137)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk (Page 137)	

Parameters	Declaration	Data type	Default value	Description	
Jerk	INPUT	LREAL	-1.0	> 0.0	Constant acceleration velocity profile The specified value is used.
				= 0.0	Trapezoid velocity profile
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)
Direction	INPUT	INT	0	Direction of rotation of the axis	
				0	The sign of the velocity specified at the "Velocity" parameter defines the direction of rotation.
				1	Positive direction of rotation The value of "Velocity" is used.
				2	Negative direction of rotation The value of "Velocity" is used.
Current	INPUT	BOOL	FALSE	Maintain current velocity	
				FALSE	Disabled The values of parameters "Velocity" and "Direction" are taken into account.
				TRUE	Enabled The values at the parameters "Velocity" and "Direction" are not taken into account. The current velocity and direction at function start are retained. When the axis resumes motion at the velocity that was current at function start, the "InVelocity" parameter returns the value "TRUE".
PositionControlled	INPUT	BOOL	TRUE	FALSE	Not in position-controlled mode (Page 137)
				TRUE	Position-controlled mode (Page 137)
				The parameter applies as long as the "MC_MoveVelocity" job is being executed. After this, the setting of the following job applies. This parameter is ignored when a speed axis is used.	
InVelocity	OUTPUT	BOOL	FALSE	TRUE	The velocity setpoint/speed setpoint has been reached. A constant velocity setpoint/speed setpoint is output (Page 137).
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.

Parameters	Declaration	Data type	Default value	Description	
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

More information

An option for evaluating the individual status bits can be found in the section "Evaluating StatusWord, ErrorWord and WarningWord" of the "S7-1500/S7-1500T Motion Control overview" documentation.

9.8.2 MC_MoveVelocity: Function chart V10

Function chart: Moving an axis with velocity specification, and the response to an overriding job

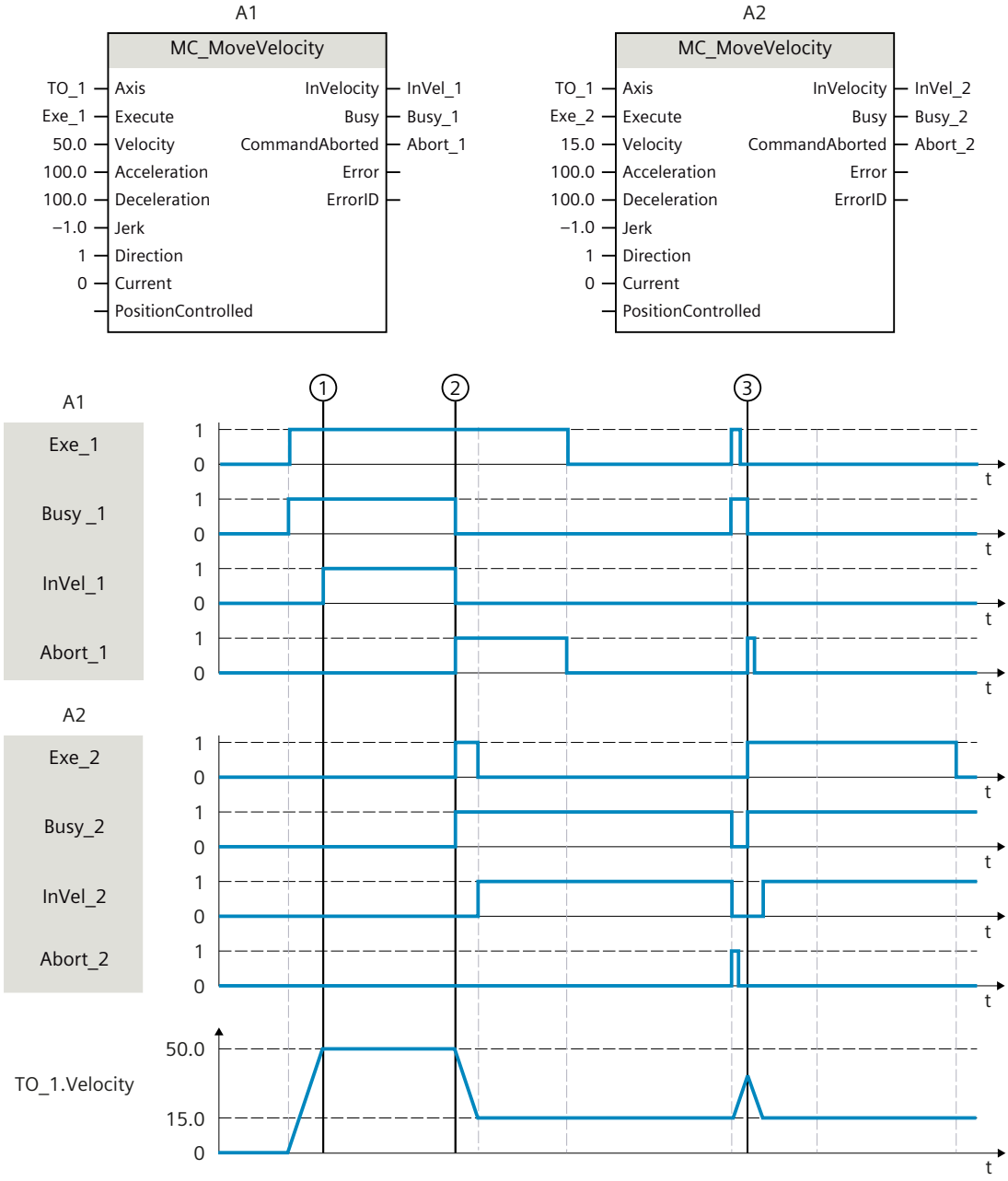

An "MC_MoveVelocity" job (A1) initiated via "Exe_1" accelerates the axis and signals at time ① via "InVel_1" that the velocity setpoint 50.0 has been reached.

At time ②, the job is overridden by another "MC_MoveVelocity" job (A2). The abort is signaled via "Abort_1". When the new velocity setpoint 15.0 is reached, this is signaled via "InVel_2". The axis then continues moving at the constant velocity 15.0.

The running "MC_MoveVelocity" job (A2) is overridden by another "MC_MoveVelocity" job (A1). The abort is signaled via "Abort_2". The axis is accelerated to the new velocity setpoint

50.0. Before the velocity setpoint is reached, the current "MC_MoveVelocity" job (A1) is overridden at time ③ by another "MC_MoveVelocity" job (A2). The abort is signaled via "Abort_1". When the new velocity setpoint 15.0 is reached, this is signaled via "InVel_2". The axis then continues moving at the constant velocity 15.0.

9.9 MC_MoveJog V10

9.9.1 MC_MoveJog: Move axis in jog mode V10

Description

With the Motion Control instruction "MC_MoveJog", you move an axis in jog mode.

The Motion Control instruction offers you the following:

- Defining the dynamics of the motion and the direction of movement (Page 146)
- Defining the position control (Page 146)
- Starting the job and tracking the motion status (Page 146)

Applies to

- Speed axis
- Positioning axis
- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override response for "MC_MoveJog" jobs is described in section "Override response V10: Homing and motion jobs (Page 380)".

NOTE

Deviating dynamic settings

When overriding the active job with a new jerk-limited motion, the current acceleration or deceleration is transferred to the new acceleration/deceleration via the jerk. Depending on the dynamic settings, this may take several application cycles. When the new acceleration or deceleration deviates significantly from the acceleration/deceleration at the time of the override, the transition profile can result in an unexpected axis motion.

If such transitions cannot be excluded during acceleration/deceleration, adjust the dynamic settings of your jobs. For example, add a motion that is not jerk-limited with a direct transition to the new acceleration/deceleration. As an alternative, use high jerk values.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MoveJog":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
JogForward	INPUT	BOOL	FALSE	TRUE	As long as the parameter is "TRUE", the axis moves in the positive direction with the velocity specified at the "Velocity" parameter. (Page 146)
JogBackward	INPUT	BOOL	FALSE	TRUE	As long as the parameter is "TRUE", the axis moves in the negative direction with the velocity specified at the "Velocity" parameter. (Page 146)
Velocity	INPUT	LREAL	100.0	Velocity setpoint/speed setpoint for the motion (Page 146)	
				≥ 0.0	The specified value is used.
				< 0.0	The absolute value of the specified value is used.
Acceleration	INPUT	LREAL	-1.0	Acceleration (Page 146)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration (Page 146)	
				> 0.0	The specified value is used.

Parameter	Declaration	Data type	Default value	Description	
Deceleration	INPUT	LREAL	-1.0	= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk (Page 146)	
				> 0.0	Constant acceleration velocity profile The specified value is used.
				= 0.0	Trapezoid velocity profile
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)
PositionControlled	INPUT	BOOL	TRUE	FALSE	Not in position-controlled mode (Page 146)
				TRUE	Position-controlled mode (Page 146)
				The parameter applies as long as the "MC_MoveJog" job is being executed. After this, the setting of the following job applies. This parameter is ignored when a speed axis is used.	
InVelocity	OUTPUT	BOOL	FALSE	TRUE	The velocity setpoint/speed setpoint has been reached. A constant velocity setpoint/speed setpoint is output.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

More information

An option for evaluating the individual status bits can be found in the section "Evaluating StatusWord, ErrorWord and WarningWord" of the "S7-1500/S7-1500T Motion Control overview" documentation.

9.9.2 MC_MoveJog: Function chart V10

Function chart: Moving an axis in jog mode

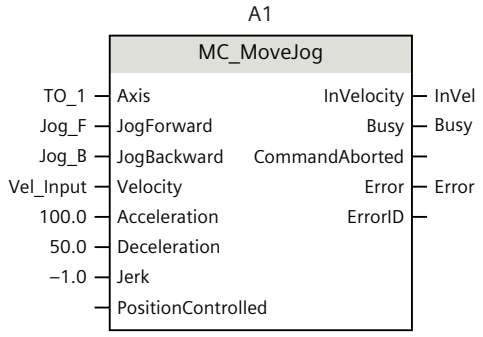

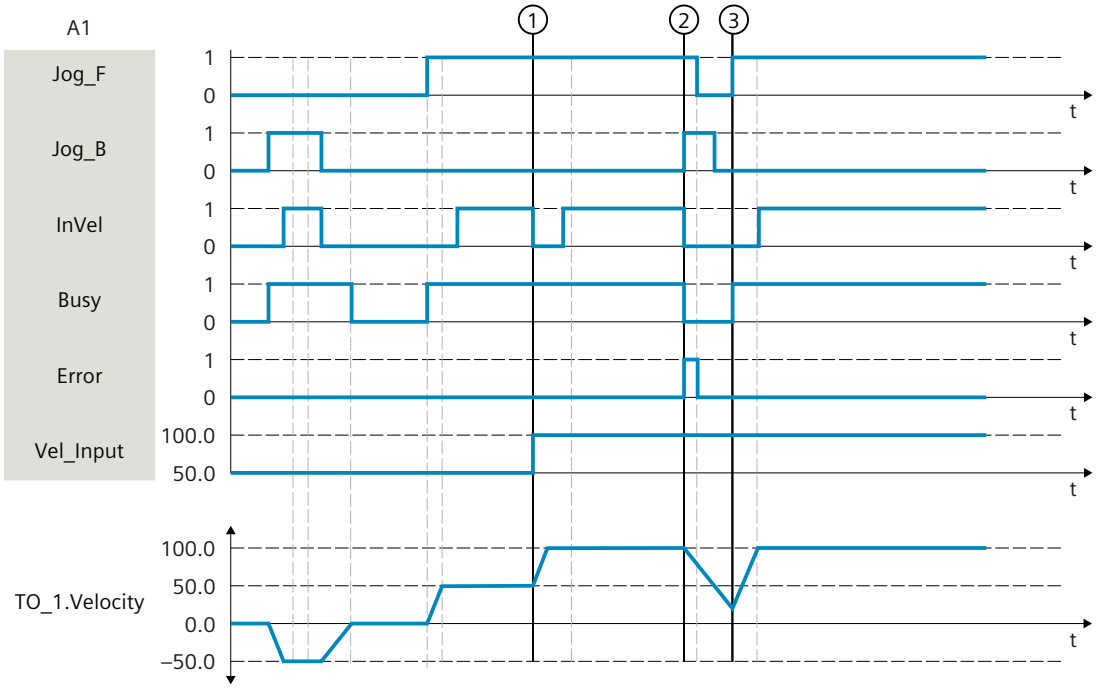

The axis is moved in the negative direction in jog mode via "Jog_B". When the velocity setpoint -50.0 is reached, this is signaled via "InVel" = TRUE. After "Jog_B" is reset, the axis is braked and brought to a standstill. Then the axis is moved in the positive direction via "Jog_F". When the velocity setpoint 50.0 is reached, this is signaled via "InVel" = TRUE.

At the time ①, if "Jog_F" is set, the velocity setpoint is changed to 100.0 by means of "Vel_Input". Alternatively, you can also change the velocity setpoint using the velocity override. "InVel" is reset. Axis is being accelerated. When the new velocity setpoint 100.0 is reached, this is signaled via "InVel" = TRUE.

If "Jog_F" is set, "Jog_B" is likewise set at time ②. If both "Jog_F" and "Jog_B" are set, then the axis is braked with the last applicable deceleration. An error is indicated via "Error", and the "ErrorID" of the error 16#8007 (incorrect direction specification) is output.

This error is resolved by resetting the two inputs "Jog_F" and "Jog_B".

During the braking ramp, "Jog_F" is set at time ③. The axis is accelerated to the last configured velocity. When the velocity setpoint 100.0 is reached, this is signaled via "InVel" = TRUE.

9.10 MC_MoveSuperimposed V10

9.10.1 MC_MoveSuperimposed: Position axis overlapping V10

Description

With the Motion Control instruction "MC_MoveSuperimposed", you can start a relative positioning motion which is superimposed on a running basic motion.

The Motion Control instruction offers you the following:

- Superimposing a relative positioning motion onto a basic motion (Page 132)
  - The basic motion is a single-axis motion (Page 132)
  - The basic motion is a synchronous operation motion (Page 132)
  - The basic motion is a MotionIn motion (Page 132)
- Starting a superimposed motion (Page 132)

Applies to

- Positioning axis
- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override response for "MC_MoveSuperimposed" jobs is described in section "Override response V10: Homing and motion jobs (Page 380)".

NOTE

Deviating dynamic settings

When overriding the active job with a new jerk-limited motion, the current acceleration or deceleration is transferred to the new acceleration/deceleration via the jerk. Depending on the dynamic settings, this may take several application cycles. When the new acceleration or deceleration deviates significantly from the acceleration/deceleration at the time of the override, the transition profile can result in an unexpected axis motion.

If such transitions cannot be excluded during acceleration/deceleration, adjust the dynamic settings of your jobs. For example, add a motion that is not jerk-limited with a direct transition to the new acceleration/deceleration. As an alternative, use high jerk values.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MoveSuperimposed":

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_PositioningAxis TO_SynchronousAxis	-	Axis technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Distance	INPUT	LREAL	0.0	Additional distance for the superimposed positioning (negative or positive) (Page 132)	
VelocityDiff	INPUT	LREAL	-1.0	Maximum velocity difference from the running motion (Page 132)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Velocity)
Acceleration	INPUT	LREAL	-1.0	Acceleration (Page 132)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration (Page 132)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted

Parameters	Declaration	Data type	Default value	Description	
Deceleration	INPUT	LREAL	-1.0	< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk (Page 132)	
				> 0.0	Constant acceleration velocity profile The specified value is used.
				= 0.0	Trapezoid velocity profile
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)
Done	OUTPUT	BOOL	FALSE	TRUE	Superimposed positioning complete
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	0	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

9.10.2 MC_MoveSuperimposed: Function chart V10

Function chart: Positioning axes overlapping

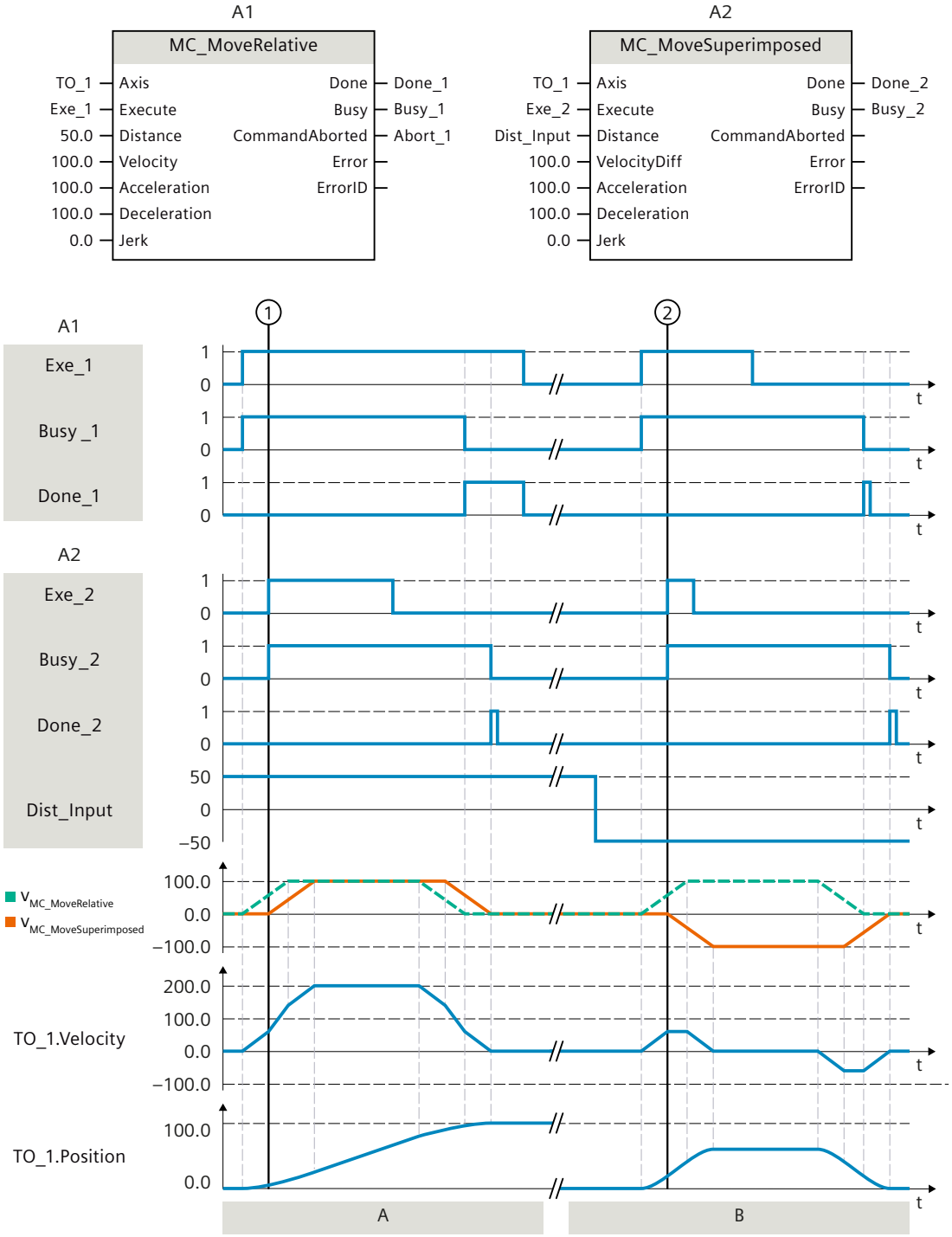

Section A

Using "Exe_1", an "MC_MoveRelative" job with a distance of 50.0 is initiated. At time ①, using "Exe_2", an "MC_MoveSuperimposed" job with a distance of 50.0 is initiated. The axis is

traversed by the distance 50.0 + 50.0 = 100.0 with the added dynamic values of both jobs. When the axis reaches the target position, this is signaled via "Done_2".

Section B

Using "Exe_1", an "MC_MoveRelative" job with a distance of 50.0 is initiated. At time ②, using "Exe_2", a "MC_MoveSuperimposed" job with a distance of -50.0 is initiated. The axis reverses and is traversed by the distance 50.0 - 50.0 = 0.0 with the added dynamic values of both jobs. When the axis reaches the target position, this is signaled via "Done_2".

9.11 MC_HaltSuperimposed V10

9.11.1 MC_HaltSuperimposed: Pause superimposed motions on axis V10

Description

With the Motion Control instruction "MC_HaltSuperimposed", you decelerate a superimposed motion on the axis generated with the "MC_MoveSuperimposed", "MC_MotionInSuperimposed", "MC_MotionInSuperimposedAxes" or "MC_HaltSuperimposed" instructions to zero velocity. This instruction has no effect on the basic motion of the axis.

The Motion Control instruction offers you the following:

- Stopping a superimposed motion (Page 134)

Applies to

- Positioning axis
- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override response for "MC_HaltSuperimposed" jobs is described in section "Override response V10: Homing and motion jobs (Page 380)".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_HaltSuperimposed":

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Deceleration	INPUT	LREAL	-1.0	Deceleration of the superimposed motion (Page 134)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk of the superimposed motion (Page 134)	
				> 0.0	Constant-acceleration velocity profile of the superimposed motion; the specified jerk is used
				= 0.0	Trapezoidal velocity profile of the superimposed motion
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)
AbortAcceleration	INPUT	BOOL	FALSE	Acceleration reduction during braking (Page 134)	
				FALSE	The current acceleration of the superimposed motion at the start of the job is reduced using the configured jerk. Afterwards, the deceleration builds up.
				TRUE	The acceleration of the superimposed motion is set to 0.0 at the start of the job; the deceleration builds up immediately.
Done	OUTPUT	BOOL	FALSE	TRUE	The execution of the job is completed. The superimposed motion is stopped.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.

Parameters	Declaration	Data type	Default value	Description	
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

9.11.2 MC_HaltSuperimposed: Function chart V10

Function chart: Pause superimposed motions on the axis

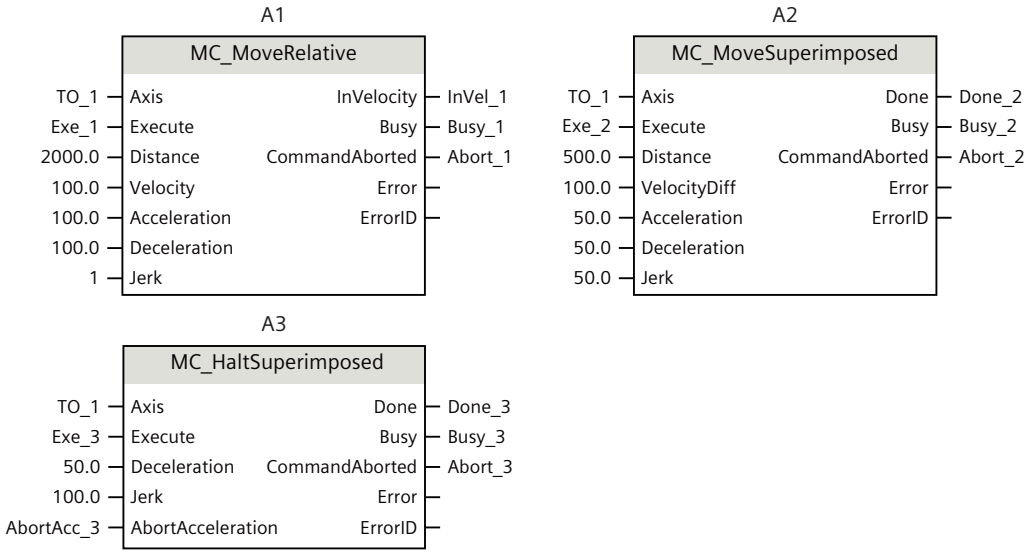

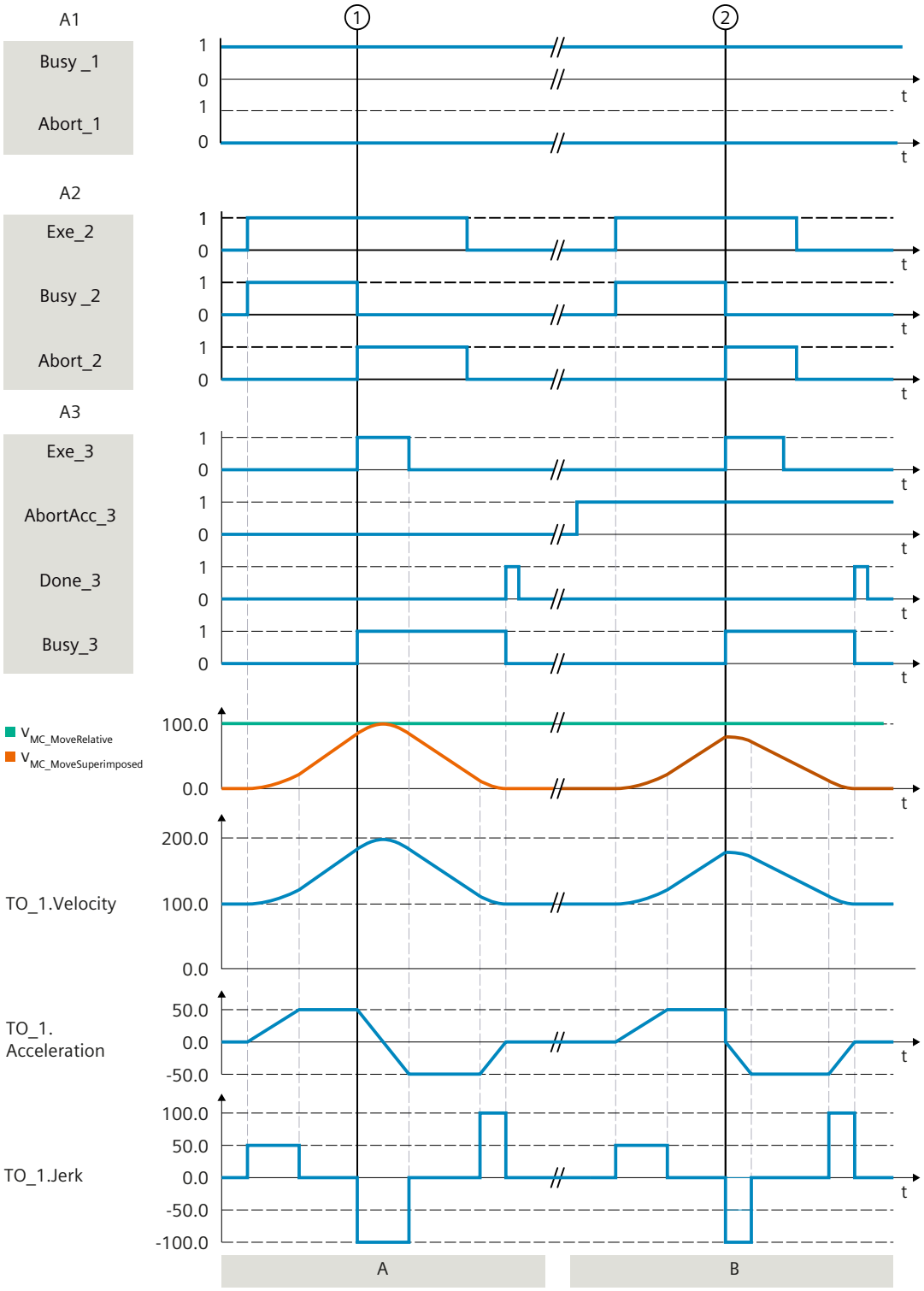

Section A

The axis is moved with an "MC_MoveRelative" job (A1) as the basic motion.

Via "Exe_2", a "MC_MoveSuperimposed" job (A2) is triggered as a superimposed motion. The <TO>.StatusWord.X23 bit is set. At time ①, the "MC_MoveSuperimposed" job is overridden by an "MC_HaltSuperimposed" job (A3). The job abort is signaled via "Abort_2". The

<TO>.StatusWord2.X7 bit is set and the <TO>.StatusWord.X23 bit is reset. With "AbortAcc_3" = FALSE, the current acceleration is reduced with the specified jerk. After that, the deceleration is built up and the superimposed motion is decelerated to velocity = 0. The completion of the "MC_HaltSuperimposed" job is reported via "Done_3". The <TO>.StatusWord2.X7 bit is reset.

Section B

The axis is moved with an "MC_MoveRelative" job (A1) as the basic motion.

Via "Exe_2", a "MC_MoveSuperimposed" job (A2) is triggered as a superimposed motion. The <TO>.StatusWord.X23 bit is set. At time ②, the "MC_MoveSuperimposed" job is overridden by an "MC_HaltSuperimposed" job (A3). The job abort is signaled via "Abort_2". The <TO>.StatusWord2.X7 bit is set and the <TO>.StatusWord.X23 bit is reset. With "AbortAcc_3" = TRUE, the current acceleration is set to zero immediately and the deceleration builds up. The superimposed motion is decelerated to velocity = 0. The completion of the "MC_HaltSuperimposed" job is reported via "Done_3". The <TO>.StatusWord2.X7 bit is reset.

9.12 MC_SetSensor V10

9.12.1 MC_SetSensor: Switch alternative encoder to operative encoder V10

Description

With the Motion Control instruction "MC_SetSensor", you switch over the encoder for closed loop position control of the axis.

The actual value of the addressed encoder can be adapted without switchover using parameter "Mode" = 2 and 3.

The Motion Control instruction offers you the following:

- Switching the encoder ("Mode" = 0, 1) (Page 67)
- Adjusting the position between the new encoder ("Sensor" parameter) and the old/active encoder ("Mode" = 0, 2) (Page 67)
- Transferring the position of the reference encoder ("ReferenceSensor" parameter) to the new encoder ("Sensor" parameter) ("Mode" = 3) (Page 67)
- Switching the encoder to an absolute encoder (Page 67)

Applies to

- Positioning axis
- Synchronous axis

Requirement

- The technology object and the alternative encoder have been configured correctly.
- No restart job and no "MC_Home" job running.

Override response

- An "MC_SetSensor" job is not aborted by any other Motion Control job.
- A new "MC_SetSensor" job does not abort any active Motion Control jobs.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_SetSensor":

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Sensor	INPUT	INT	1	Number of the new encoder (1 to 4) (Page 67)	
Mode	INPUT	DINT	0	The mode determines the position alignment between the old encoder and new encoder.	
				0	Switching the encoder and transferring the current actual position to the new encoder (Page 67)
				1	Switching the encoder without adjusting the actual position (Page 67) **Note** When closed loop position control is active, an additional difference of the two encoders acts as additional control deviation and can trigger a compensating motion.
				2	Transferring the actual value (Page 67)
				3	Transferring the actual value of the "reference encoder" (Page 67)
ReferenceSensor	INPUT	INT	1	Number of the reference encoder (see parameter "Mode" = 3) (Page 67)	
Done	OUTPUT	BOOL	FALSE	TRUE	Encoder for closed loop position control of the axis was switched over.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job has been aborted.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

9.13 MC_Stop V10

9.13.1 MC_Stop: Stop axis and prevent new motion jobs V10

Description

With the Motion Control instruction "MC_Stop", you stop all movements of an axis and prevent new motion jobs for the technology object. The axis decelerates to a standstill and remains switched on.

The Motion Control instruction offers you the following:

- Stopping a technology object (Page 170)
- Decelerating an axis with active force/torque limiting (Page 170)
- Decelerating an axis with emergency deceleration (Page 170)
- Decelerating an axis with maximum dynamic values (Page 170)
- Decelerating an axis with specified dynamics (Page 170)

Applies to

- Speed axis
- Positioning axis
- Synchronous axis

Requirements

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

- An "MC_Stop" job is not triggered by other movements.
- An "MC_Stop" job is aborted by an "MC_Power" job with "Enable" = FALSE.
- An "MC_Stop" job does not abort any synchronous operation function in simulation.
- An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

  Significance of stop responses (descending): "Mode" = 0 > "Mode" = 2 > "Mode" = 3

You can find more detailed information on the override behavior of an "MC_Stop" job in section "Override response of Motion Control jobs V10 (Page 380)" or "Override behavior between alarm responses and "MC_Stop" (Page 171)".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_Stop":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	The motion is stopped and new motion jobs are prevented.
				FALSE	Motion jobs can be executed again.
Mode	INPUT	DINT	0	Mode for dynamic behavior (Page 170)	
				0	Emergency stop (Page 170) The technology object is braked to a standstill without jerk limitation, using the emergency stop deceleration configured in "Technology object > Configuration > Extended parameters > Emergency stop". (<TO>.DynamicDefaults.EmergencyDeceleration)
				1	Not permitted
				2	Stop with maximum dynamic values (Page 170) The technology object is braked to a standstill using the maximum deceleration configured in "Technology object > Configuration > Extended parameters > Dynamics limits". In so doing, the configured maximum jerk is taken into account. (<TO>.DynamicLimits.MaxDeceleration, <TO>.DynamicLimits.MaxJerk)
				3	Stop with specified dynamics (Page 170) The technology object is stopped with the specified values at the parameters "Deceleration" and "Jerk".
Deceleration	INPUT	LREAL	-1.0	When "Mode" = 3: Deceleration for the braking ramp (Page 115)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	When "Mode" = 3: Jerk for the braking ramp (Page 115)	
				> 0.0	The specified value is used.
				= 0.0	No jerk limitation

Parameter	Declaration	Data type	Default value	Description	
Jerk	INPUT	LREAL	-1.0	< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic defaults" is used. (<TO>.DynamicDefaults.Jerk)
AbortAcceleration	INPUT	BOOL	FALSE	TRUE	Acceleration is set to 0.0. The configured deceleration is built up immediately.
				FALSE	The acceleration is reduced using the configured jerk. The configured deceleration then builds up.
Done	OUTPUT	BOOL	FALSE	TRUE	Standstill is reached.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted during execution either by "MC_Power" with "Enable" = FALSE, another "MC_Stop" job or an alarm response.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

See also

Override response V10: Homing and motion jobs (Page 380)
Emergency stop deceleration (Page 123)

9.13.2 MC_Stop: Function chart V10

Function chart: Braking an axis and the overriding job characteristics

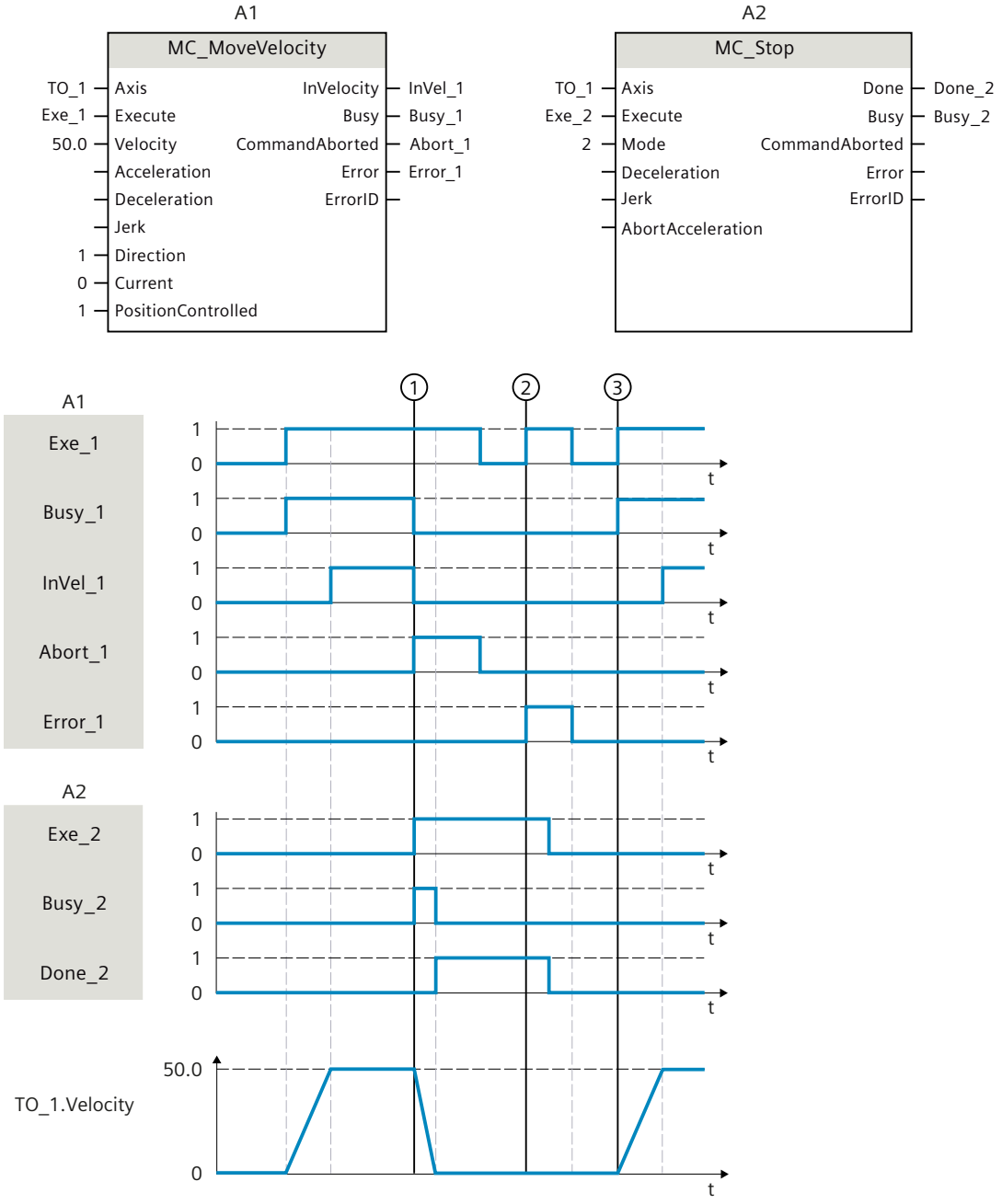

An axis is moved with an "MC_MoveVelocity" job (A1). At time ①, the "MC_MoveVelocity" job is overridden by an "MC_Stop" job (A2). The job abort is signaled via "Abort_1". Afterwards, the configured deceleration builds up and the axis is braked to a standstill. While the axis is braking, "Busy_2" = TRUE. The completion of the "MC_Stop" job is reported via "Done_2".

At time ②, with an active "MC_Stop" job (A1), an "MC_MoveVelocity" job (A2) is executed. Because the axis is disabled by an "MC_Stop" job, the "MC_MoveVelocity" job is rejected. The error is signaled by "Error_1". "Exe_2" is then reset to "FALSE".

At time ③, the axis is moved by an "MC_MoveVelocity" job (A1) with positive edge.

9.14 MC_SetAxisSTW V10

9.14.1 MC_SetAxisSTW: Control bits of control word 1 and 2 V10

Description

With the Motion Control instruction "MC_SetAxisSTW", you control selected bits in control word 1 (STW1) and control word 2 (STW2) of the PROFIdrive telegram. This provides the possibility of directly controlling bits not used by the technology object. The bits to be controlled are specified via the parameters "STW1" and "STW2". The controlled bits remain effective until an "MC_SetAxisSTW" job is reset, the technology object is restarted or the CPU transitions from "RUN" to "STOP".

The following bits can be controlled in STW1:

- 8
- 9
- 11 to 15

Bits 0 to 11 can be controlled in STW2.

The following parameters are available:

- With the "STW1BitMask" and "STW2BitMask" parameters, you define which bit is to be written.
- With the "STW1" and "STW2" parameters, you set the value of the specified bit.

For the meaning of the controllable bits, refer to the list manuals of your drive system.

Applies to

- Speed axis
- Positioning axis
- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The technology object is interconnected with a drive telegram.
- The technology object is not in simulation.
- A permissible bit masking is set.

Override response

- A new "MC_SetAxisSTW" job does not abort any active Motion Control jobs.
- An "MC_SetAxisSTW" job is aborted by another "MC_SetAxisSTW" job.
- An "MC_SetAxisSTW" job is aborted during disabling of the technology object ("MC_Power.Enable" = FALSE, "MC_Power.Busy" = TRUE).

Parameters

The following table shows the parameters of the Motion Control instruction "MC_SetAxisSTW":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
STW1	INPUT	WORD	16#0000	Set bits for STW1: Set values of the specified bits for STW1	
STW1BitMask	INPUT	WORD	16#0000	Bit masking for STW1: Select the bits to be specified. If 1, the bit is specified with this command. If 0, the bit is not specified with this command.	
STW2	INPUT	WORD	16#0000	Set bits for STW2: Set values of the specified bits for STW2	
STW2BitMask	INPUT	WORD	16#0000	Bit masking for STW2: Select the bits to be specified. If 1, the bit is specified with this command. If 0, the bit is not specified with this command.	
Done	OUTPUT	BOOL	FALSE	TRUE	The job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

See also

Override response V10: Homing and motion jobs (Page 380)
Configuring PROFIdrive telegrams (Page 53)

9.15 MC_WriteParameter V10

9.15.1 MC_WriteParameter: Write parameter V10

Description

With the Motion Control instruction "MC_WriteParameter", you can change selected parameters of the technology objects in runtime. The changes take effect directly or after a restart, depending on the corresponding parameter.

The values of restart-relevant parameters (RES) are retained at a "RUN → STOP → RUN" transition of the CPU and at another restart of the technology object.

In the following cases, however, the changed values are reset to the start value:

- Download of the technology object
- POWER OFF → POWER ON
- Memory reset

For parameters that take effect directly, the values are retained at a "RUN → STOP → RUN" transition of the CPU.

In the following cases, however, the changed values are reset to the start value:

- Restart of the technology object
- POWER OFF → POWER ON
- Memory reset

The Motion Control instruction offers you the following:

- Interconnecting the addresses of the Boolean variables in the technology object (Page 178)
- Writing addresses of the Boolean variables in the user program (Page 178)
- Configuring the communication times T_i, T_o, T_{DC} (Page 59)
- Configure stop mode for alarm response "Remove enable" (Page 159)

Applies to

- Speed axis
- Positioning axis
- Synchronous axis
- External encoder

Requirement

- The technology object has been configured correctly.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_WriteParameter": An overview of the changeable parameters ("ParameterNumber" = Index) can be found in the next table:

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis TO_PositioningAxis TO_SynchronousAxis TO_ExternalEncoder	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
ParameterNumber	INPUT	DINT	0	Index of the parameter to be changed	
Value	INPUT	Variant (BOOL, INT, DINT, UDINT, LREAL)	-	Variant pointer to the value to be written (source address)	
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred during processing. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

Modifiable parameters

The following table shows the parameters that can be changed with the Motion Control instruction "MC_WriteParameter". You select the parameters to be changed at the "ParameterNumber" input parameter using the index:

Tag	Index	Technology object	Data type	Description		Effectiveness
PositionLimits_HW.Active	1000	Positioning axis Synchronous axis	BOOL	Enabling/disabling hardware limit switch The negative and the positive hardware limit switches (Page 211) are activated or deactivated with this parameter,		Direct
				FALSE	HW limit switch deactivated	

Tag	Index	Technology object	Data type	Description		Effectiveness
PositionLimits_HW.Active	1000	Positioning axis Synchronous axis	BOOL	TRUE	HW limit switch activated	Direct
T_i	1010	Speed axis Positioning axis Synchronous axis External encoder	LREAL	Communication time T_i (read in process values) Specify the values in seconds (s).		After restart
T_o	1011	Speed axis Positioning axis Synchronous axis External encoder	LREAL	Communication time T_o (output process values) Specify the values in seconds (s).		After restart
T_{Pn}/T_{DP}	1012	Speed axis Positioning axis Synchronous axis External encoder	LREAL	PROFINET send clock or PROFIBUS send clock Specify the values in seconds (s).		After restart
Actor.RemoveEnableReaction	1020	Speed axis Positioning axis Synchronous axis	WORD	Stop reaction on "Remove enable"		Direct
				16#1	OFF1 – Ramp stop - Braking with ramp-function generator	
				16#3	OFF2 – Coast stop - Coast down	
				16#5	OFF3 – Quick stop - Quick stop	
				16#7 Default setting	OFF3 – Quick stop (compatible configuration for technology versions up to V7)	

See also

Override response V10: Homing and motion jobs (Page 380)
Direct homing (Page 211)
Configuring HW limit switches (Page 178)
Tags of the positioning axis technology object (Page 408)
Tags of the speed axis technology object (Page 394)
Tags of the technology object external encoder (Page 443)

9.16 MC_SaveAbsoluteEncoderData V10

9.16.1 MC_SaveAbsoluteEncoderData: Save absolute encoder adjustment for device replacement V10

Description

With the Motion Control instruction "MC_SaveAbsoluteEncoderData" you can save the adjustment of an absolute encoder for the device replacement.

The Motion Control instruction offers you the following:

- Saving the data of the absolute encoder adjustment on the SIMATIC Memory Card (Page 216)

Requirement

Sufficient storage space is available on the SIMATIC Memory Card.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_SaveAbsoluteEncoderData":

Parameter	Declaration	Data type	Default value	Description	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Done	OUTPUT	BOOL	FALSE	TRUE	The absolute encoder adjustment for all technology objects of the CPU with an absolute encoder is saved for device replacement.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	0	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

9.17 MotionIn

9.17.1 MC_MotionInVelocity V10

9.17.1.1 MC_MotionInVelocity: Specify motion setpoints V10

Description

With the Motion Control instruction "MC_MotionInVelocity", you specify cyclically applicable calculated motion setpoints for velocity and acceleration as a basic motion for the axis. No velocity profile is calculated for this, the values are directly active at the technology object. The dynamic limits are not effective.

The Motion Control instruction offers you the following:

- Specifying the motion profile in the application cycle (Page 244)
- Defining the dynamics of the motion (Page 246)
- Stopping the MotionIn motion (Page 253)

Applies to

- Speed axis
- Positioning axis
- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override response for "MC_MotionInVelocity" jobs is described in section "Override response V10: Homing and motion jobs (Page 380)".

NOTE

Deviating dynamic settings

When overriding the active job with a new jerk-limited motion, the current acceleration or deceleration is transferred to the new acceleration/deceleration via the jerk. Depending on the dynamic settings, this may take several application cycles. When the new acceleration or deceleration deviates significantly from the acceleration/deceleration at the time of the override, the transition profile can result in an unexpected axis motion.

If such transitions cannot be excluded during acceleration/deceleration, adjust the dynamic settings of your jobs. For example, add a motion that is not jerk-limited with a direct transition to the new acceleration/deceleration. As an alternative, use high jerk values.

For MotionIn jobs, the specification of the acceleration is only relevant for overriding the job. When the currently active acceleration is not to be slowed down via the jerk, enter the value "0.0" at the "Acceleration" parameter of the MotionIn job.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MotionInVelocity":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
Enable	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge The specified setpoints are used as long as the parameter is set to "TRUE".
				FALSE	End of the job with negative edge If the parameter is set from "TRUE" to "FALSE", the setpoints are set to 0.0.
Velocity	INPUT	LREAL	0.0	Velocity setpoint Observe the dynamic limits.	
Acceleration	INPUT	LREAL	0.0	Setpoint acceleration Observe the dynamic limits.	
PositionControlled	INPUT	BOOL	TRUE	TRUE	Position-controlled mode
				FALSE	Controlled running
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.

Parameter	Declaration	Data type	Default value	Description	
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

9.17.1.2 MC_MotionInVelocity: Function chart V10

Function chart: Specify motion setpoints

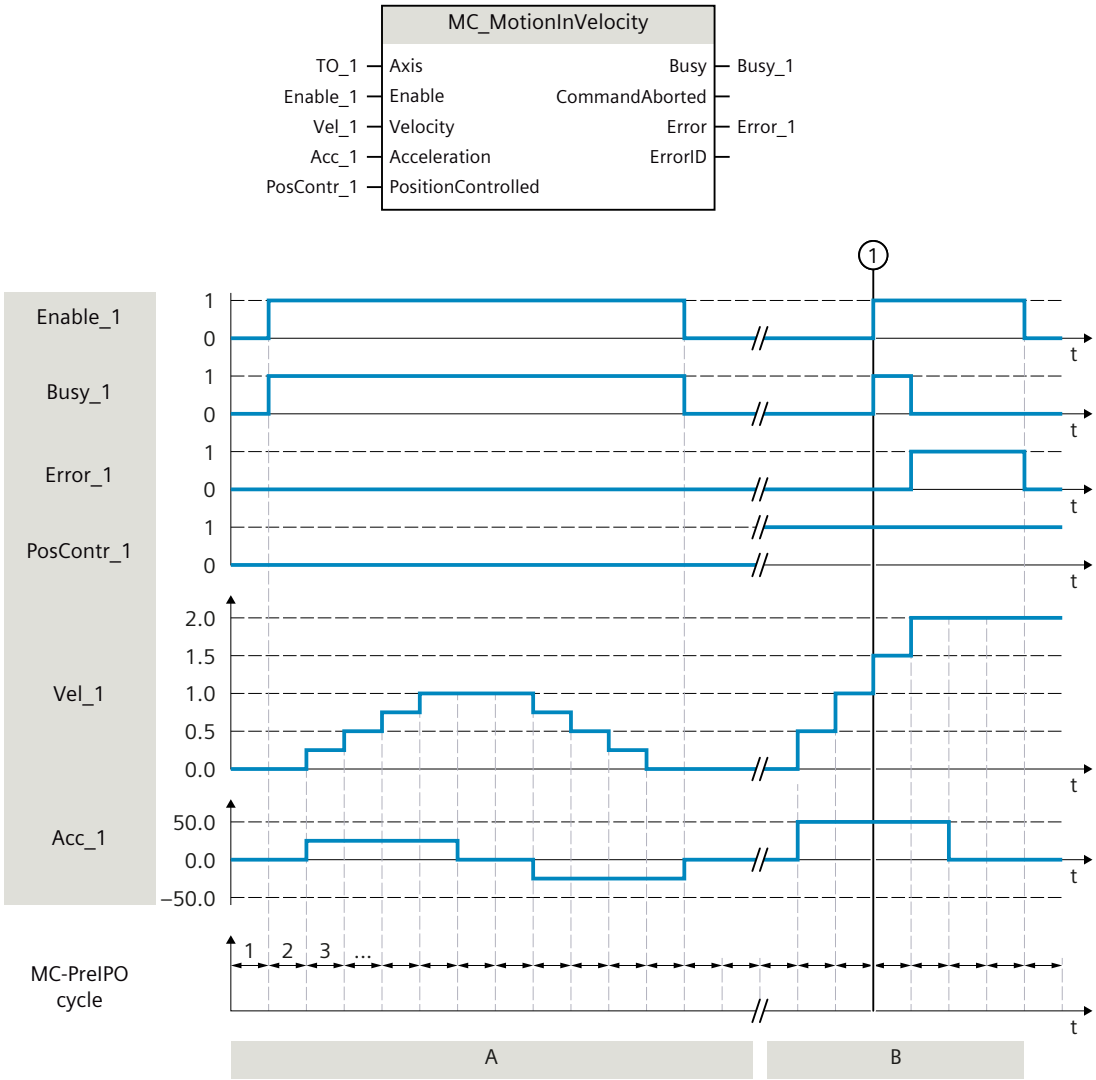

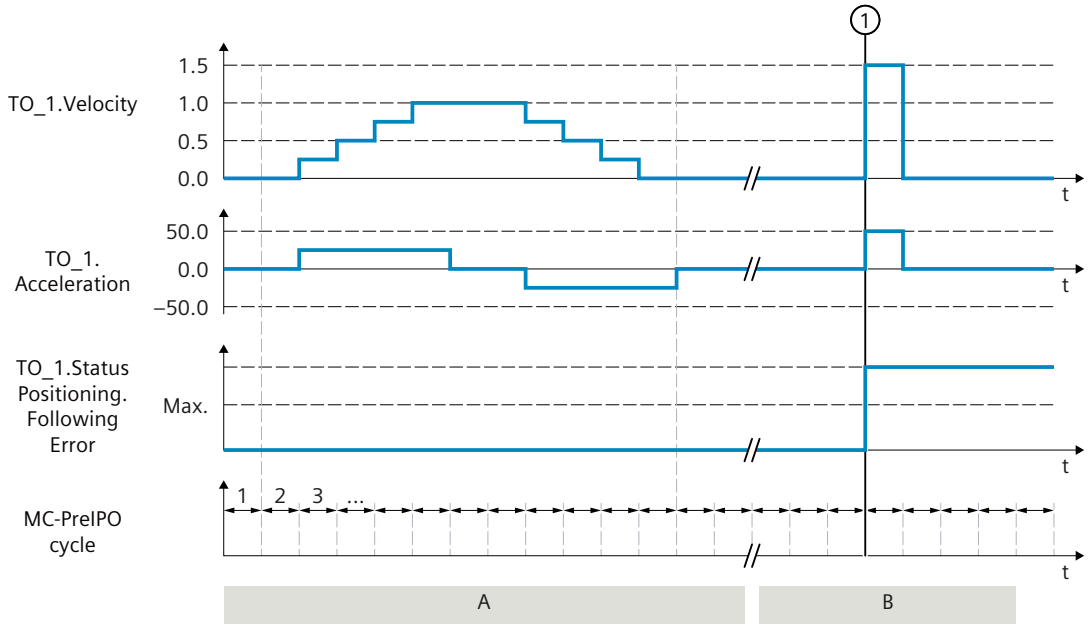

Section A

With "Enable_1 = TRUE", the technology object is specified cyclically in the MC_PreServo clock velocity "Vel_1" and acceleration "Acc_1". These specifications are applied directly as setpoint velocity "TO_1.Velocity" and setpoint acceleration "TO_1.Acceleration", without hereby calculating a velocity profile.

As the position monitoring "PosContr_1" is set to "FALSE", no following error "TO_1.StatusPositioning.FollowingError" is determined.

Section B

The velocity and acceleration specifications are not effective as long as "Enable_1" is set to "FALSE".

At time ①, "Enable_1" is set to "TRUE". As the position monitoring "PosContr_1" is set to "TRUE", a following error "TO_1.StatusPositioning.FollowingError" is determined.

The velocity specification "Vel_1" and the acceleration default "Acc_1" cause a setpoint jump which exceeds the maximum permissible following error. With active position lag monitoring, the technology alarm 521 is output, and the technology object is disabled. With deactivated following error monitoring, the setpoint jump is executed with maximum dynamic.

9.17.2 MC_MotionInPosition V10

9.17.2.1 MC_MotionInPosition: Specify motion setpoints V10

Description

With the Motion Control instruction "MC_MotionInPosition", you specify the cyclic, applicable motion setpoints for position, velocity and acceleration as basic motion for the axis. No velocity profile is calculated for this, the values are directly active at the technology object. The dynamic limits are not effective.

The Motion Control instruction offers you the following:

- Specifying the motion profile in the application cycle (Page 244)
- Defining the motion setpoints (Page 247)
- Stopping the MotionIn motion (Page 253)

Applies to

- Positioning axis
- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override response for "MC_MotionInPosition" jobs is described in section "Override response V10: Homing and motion jobs (Page 380)".

NOTE

Deviating dynamic settings

When overriding the active job with a new jerk-limited motion, the current acceleration or deceleration is transferred to the new acceleration/deceleration via the jerk. Depending on the dynamic settings, this may take several application cycles. When the new acceleration or deceleration deviates significantly from the acceleration/deceleration at the time of the override, the transition profile can result in an unexpected axis motion.

If such transitions cannot be excluded during acceleration/deceleration, adjust the dynamic settings of your jobs. For example, add a motion that is not jerk-limited with a direct transition to the new acceleration/deceleration. As an alternative, use high jerk values.

For MotionIn jobs, the specification of the acceleration is only relevant for overriding the job. When the currently active acceleration is not to be slowed down via the jerk, enter the value "0.0" at the "Acceleration" parameter of the MotionIn job.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MotionInPosition":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
Enable	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge The specified setpoints are used as long as the parameter is set to "TRUE".
				FALSE	End of the job with negative edge If the parameter is set from "TRUE" to "FALSE", the setpoints are set to 0.0. The most recently specified value remains active for the set position.
Position	INPUT	LREAL	0.0	Position setpoint	
Velocity	INPUT	LREAL	0.0	Velocity setpoint Observe the dynamic limits.	
Acceleration	INPUT	LREAL	0.0	Setpoint acceleration Observe the dynamic limits.	
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.

Parameter	Declaration	Data type	Default value	Description	
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for the parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

9.17.2.2 MC_MotionInPosition: Function chart V10

Function chart: Specify motion setpoints

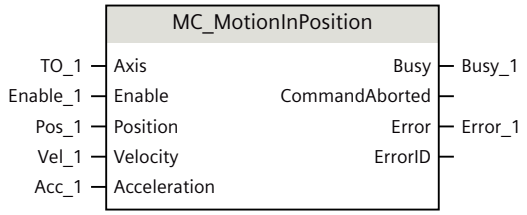

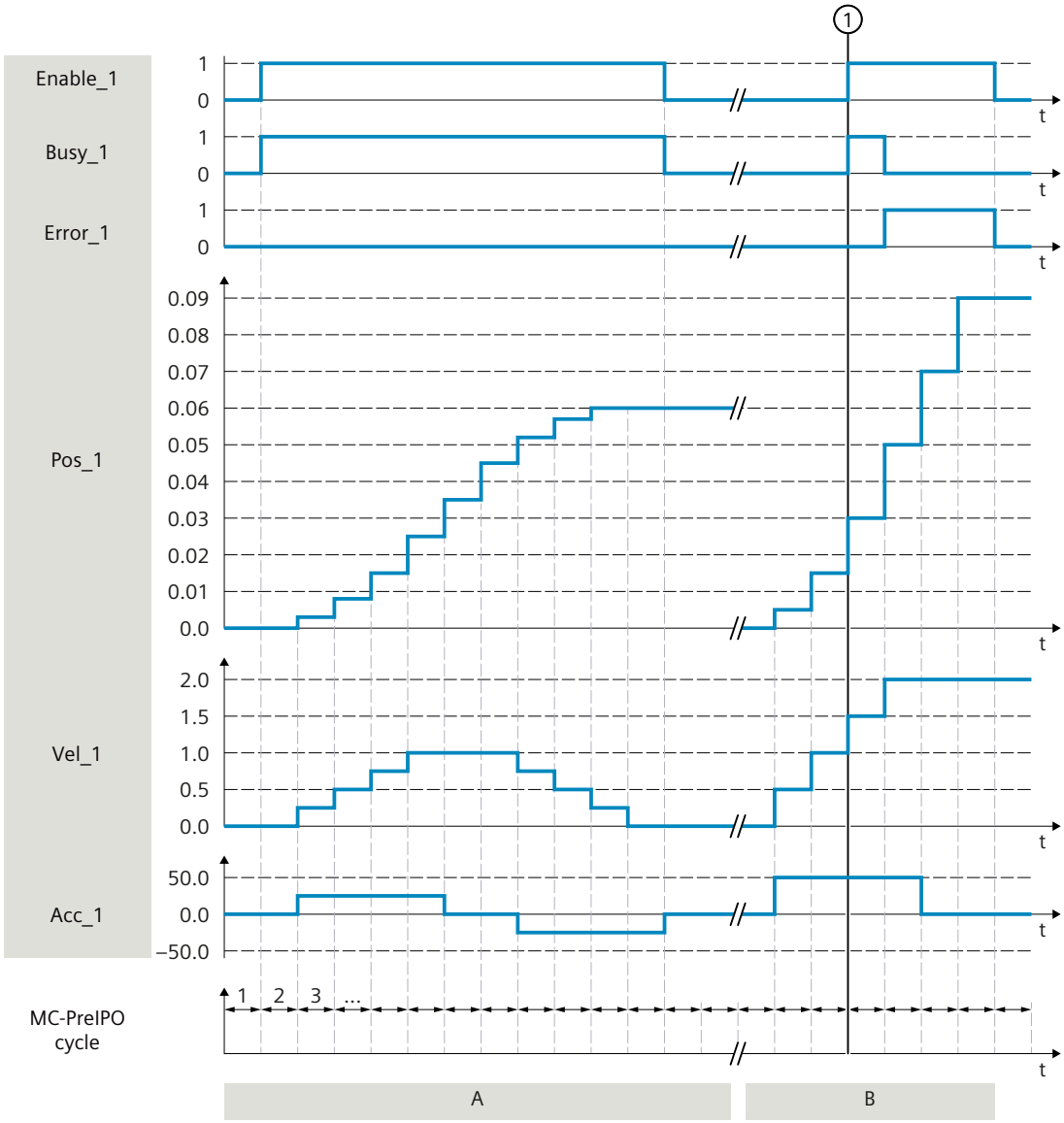

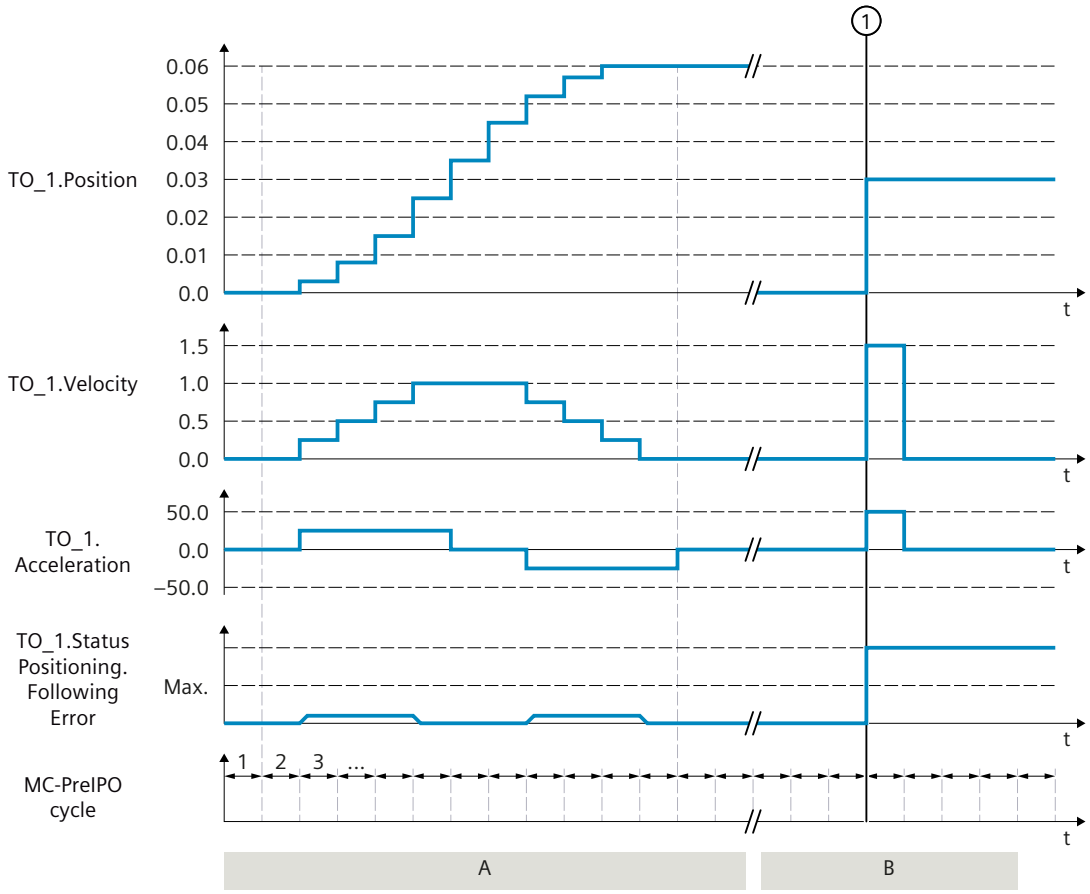

Section A

With "Enable_1 = TRUE", the technology object is specified cyclically in the MC_PreServo clock position "Pos_1", velocity "Vel_1" and acceleration "Acc_1". These specifications are applied directly as set position "TO_1.Position", setpoint velocity "TO_1.Velocity" and setpoint acceleration "TO_1.Acceleration", without hereby calculating a velocity profile.

Section B

The position, velocity and acceleration specifications are not active as long as "Enable_1" is set to "FALSE".

At time ①, "Enable_1" is set to TRUE. The default position setting "Pos_1" causes a setpoint jump which exceeds the maximum permissible following error. With active position lag monitoring, the technology alarm 521 is output, and the technology object is disabled. With deactivated following error monitoring, the setpoint jump is executed with maximum dynamic.

9.17.3 MC_MotionInSuperimposed V10

9.17.3.1 MC_MotionInSuperimposed: Specify superimposed motion setpoints V10

Description

With the Motion Control instruction "MC_MotionInSuperimposed", you specify the cyclic, applicable motion setpoints for position, velocity and acceleration in addition to the basic motion for the axis. No velocity profile is calculated for this, the values are directly active at the technology object. The dynamic limits are not effective.

The Motion Control instruction offers you the following:

- Specifying the motion profile in the application cycle (Page 244)
- Superimposed MotionIn motions (Page 248)
- Specifying superimposed motion setpoints with "MC_MotionInSuperimposed" (Page 250)
- Ending a superimposed motion (Page 253)
- Halting a superimposed motion (Page 252)

Applies to

- Positioning axis
- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The technology object has been enabled.

Override response

The override response for "MC_MotionInSuperimposed" jobs is described in section "Override response V10: Homing and motion jobs (Page 380)".

NOTE

Deviating dynamic settings

When overriding the active job with a new jerk-limited motion, the current acceleration or deceleration is transferred to the new acceleration/deceleration via the jerk. Depending on the dynamic settings, this may take several application cycles. When the new acceleration or deceleration deviates significantly from the acceleration/deceleration at the time of the override, the transition profile can result in an unexpected axis motion.

If such transitions cannot be excluded during acceleration/deceleration, adjust the dynamic settings of your jobs. For example, add a motion that is not jerk-limited with a direct transition to the new acceleration/deceleration. As an alternative, use high jerk values.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MotionInSuperimposed":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_PositioningAxis TO_SynchronousAxis	-	Axis technology object	
Enable	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge The specified setpoints are used as long as the parameter is set to "TRUE".
				FALSE	End of the job with negative edge If the parameter is set from "TRUE" to "FALSE", the setpoints are set to 0.0. The most recently specified value remains active for the set position.
Distance	INPUT	LREAL	0.0	Additional distance of the superimposed motion (negative or positive) (Page 250)	
VelocityDiff	INPUT	LREAL	0.0	Acceleration setpoint of the superimposed motion (velocity difference) (Page 250) Observe the dynamic limits of the axis.	
AccelerationDiff	INPUT	LREAL	0.0	Acceleration setpoint of the superimposed motion (acceleration difference) (Page 250)[1)] Observe the dynamic limits of the axis.	
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	0	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

1) The superimposed acceleration "AccelerationDiff" is only required for overriding the superimposed or entire motion. When braking the superimposed motion with a "MC_HaltSuperImposed" job with "AbortAcceleration" = FALSE, the specified acceleration is reduced via the jerk.

9.17.3.2 MC_MotionInSuperimposed: Function chart V10

Function chart: Specifying superimposed motion setpoints

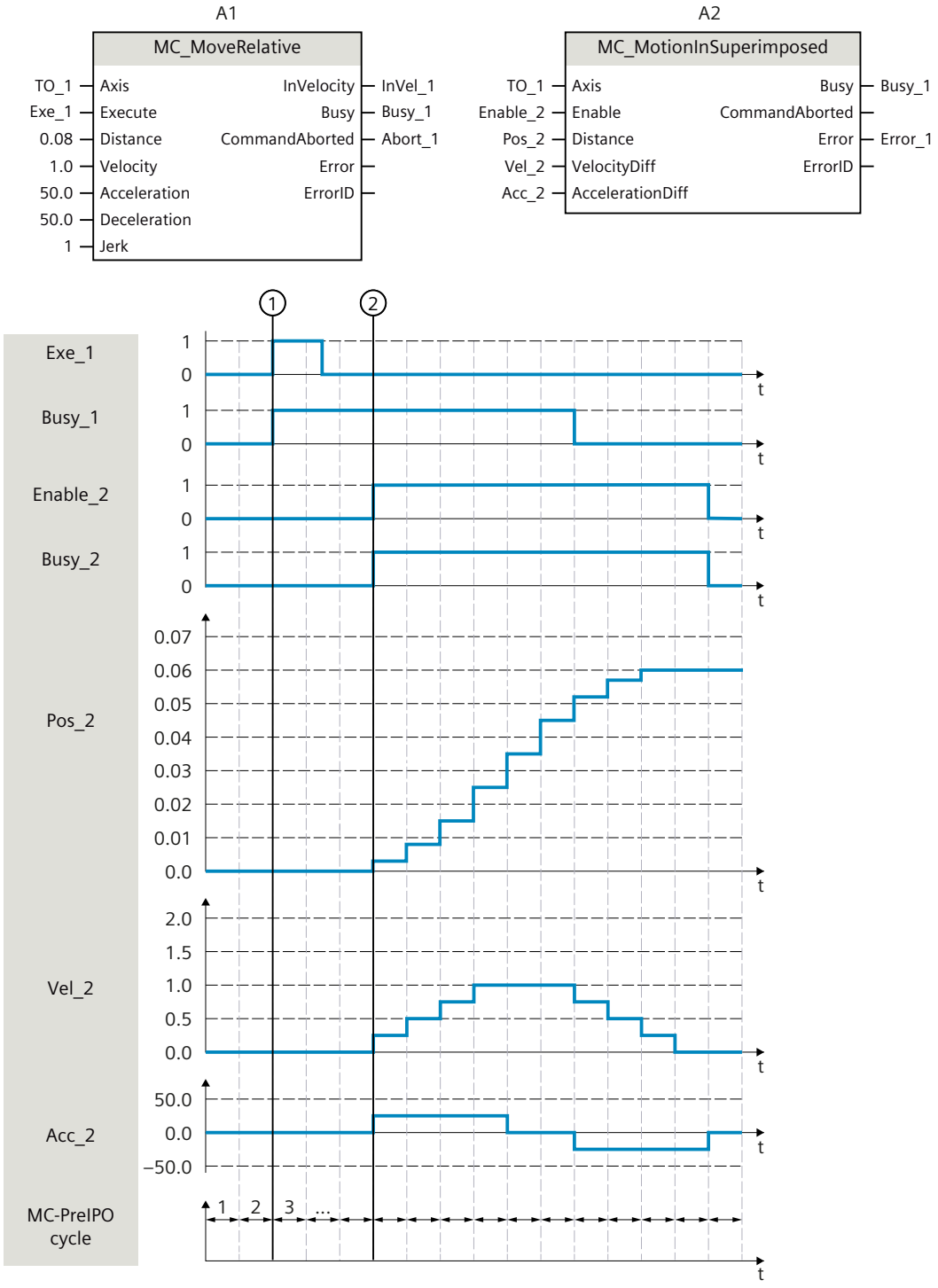

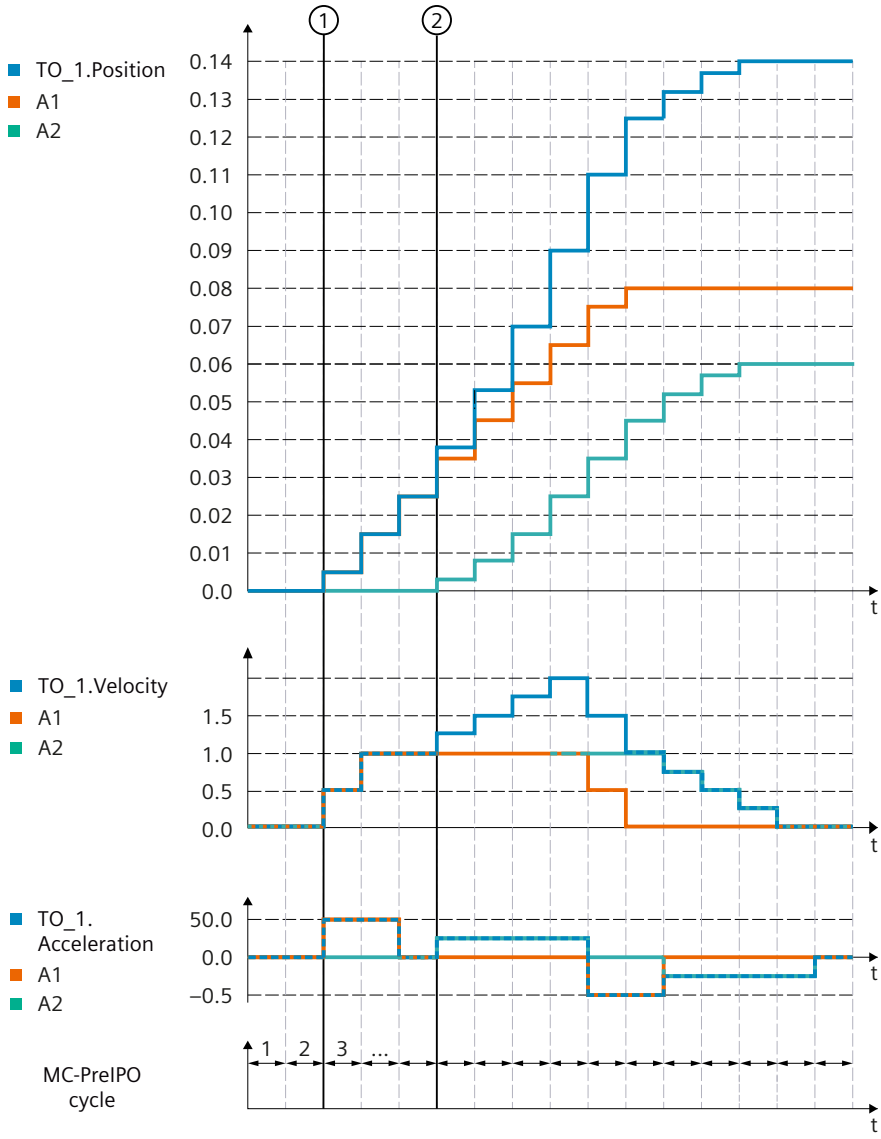

①

A "Exe_1" job is triggered via "MC_MoveRelative" with the distance 0.08 as the basic motion.

②

The "MC_MotionInSuperimposed" job is triggered. With the positive edge at "Enable_2", the setpoints "Pos_2", "Vel_2", and "Acc_2" become valid and superimpose the basic motion.

9.17.4 MC_MotionInSuperimposedAxes V10

9.17.4.1 MC_MotionInSuperimposedAxes: Specify superimposed motion setpoints from another axis V10

Description

With the Motion Control instruction "MC_MotionInSuperimposedAxes", you specify for the axis of the basic motion the superimposing axis from which the additional motion setpoint values for additional distance, velocity and acceleration are derived without cycle offset. In this case, no velocity profile is calculated. The additive values take effect directly at the technology object. The dynamic limits are not effective.

The Motion Control instruction offers you the following:

- Specifying the motion profile in the application cycle (Page 244)
- Superimposed MotionIn motions (Page 248)
- Specifying superimposed motion setpoints from another axis (Page 251)
- Ending a superimposed motion (Page 253)
- Halting a superimposed motion (Page 252)

Applies to

- Positioning axis
- Synchronous axis

Requirement

- The technology objects have been configured correctly.
- The technology objects are enabled.
- The superimposing axis "SuperimposingAxis" is configured as one of the possible superimposing axes for the superimposed axis "Axis" under "Configuration > Extended parameters > Superimposing axes".
- The technology objects are in position-controlled mode.
- No active homing job on both axes

Override response

The override response for "MC_MotionInSuperimposedAxes" jobs is described in section "Override response V10: Homing and motion jobs (Page 380)".

NOTE

Deviating dynamic settings

When overriding the active job with a new jerk-limited motion, the current acceleration or deceleration is transferred to the new acceleration/deceleration via the jerk. Depending on the dynamic settings, this may take several application cycles. When the new acceleration or deceleration deviates significantly from the acceleration/deceleration at the time of the override, the transition profile can result in an unexpected axis motion.

If such transitions cannot be excluded during acceleration/deceleration, adjust the dynamic settings of your jobs. For example, add a motion that is not jerk-limited with a direct transition to the new acceleration/deceleration. As an alternative, use high jerk values.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MotionInSuperimposedAxes":

Parameters	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_PositioningAxis TO_SynchronousAxis	-	Axis technology object for superimposing the basic motion (Page 251)	
SuperimposingAxis	INPUT	TO_PositioningAxis TO_SynchronousAxis	-	Technology object of the axis for the superimposed motion (Page 251)	
Enable	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge (Page 251) The specified setpoints are used as long as the parameter is set to "TRUE".
				FALSE	End of the job with negative edge If the parameter is set from "TRUE" to "FALSE", the setpoints are set to 0.0. The most recently specified value remains active for the set position.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

9.17.4.2 MC_MotionInSuperimposedAxes: Function chart V10

Function chart: Specify superimposed motion setpoints from another axis

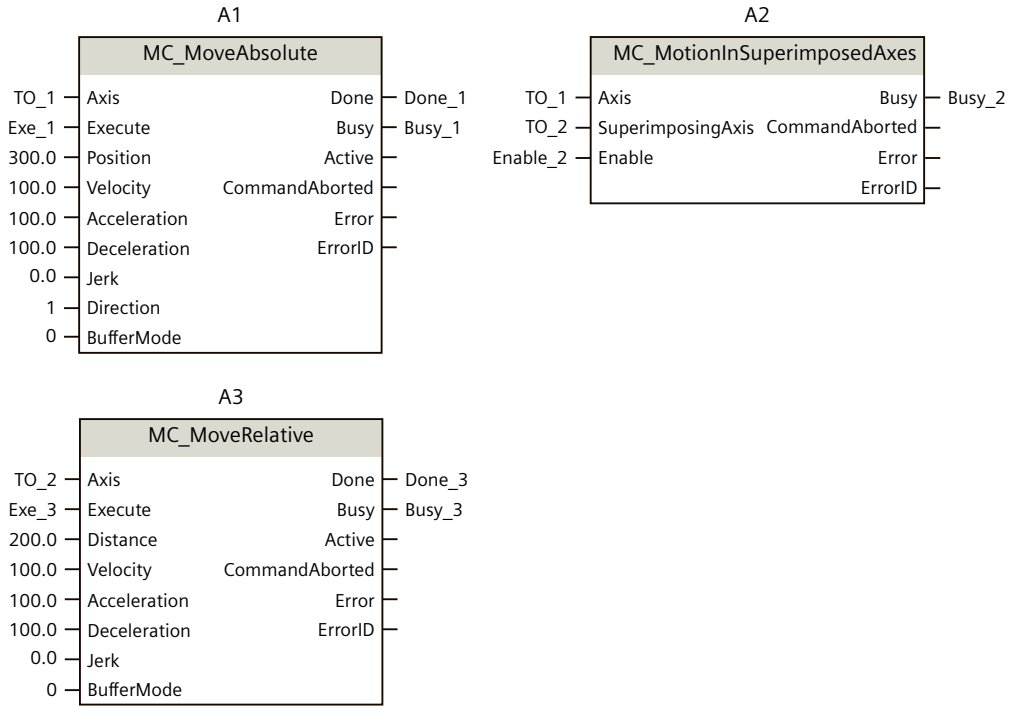

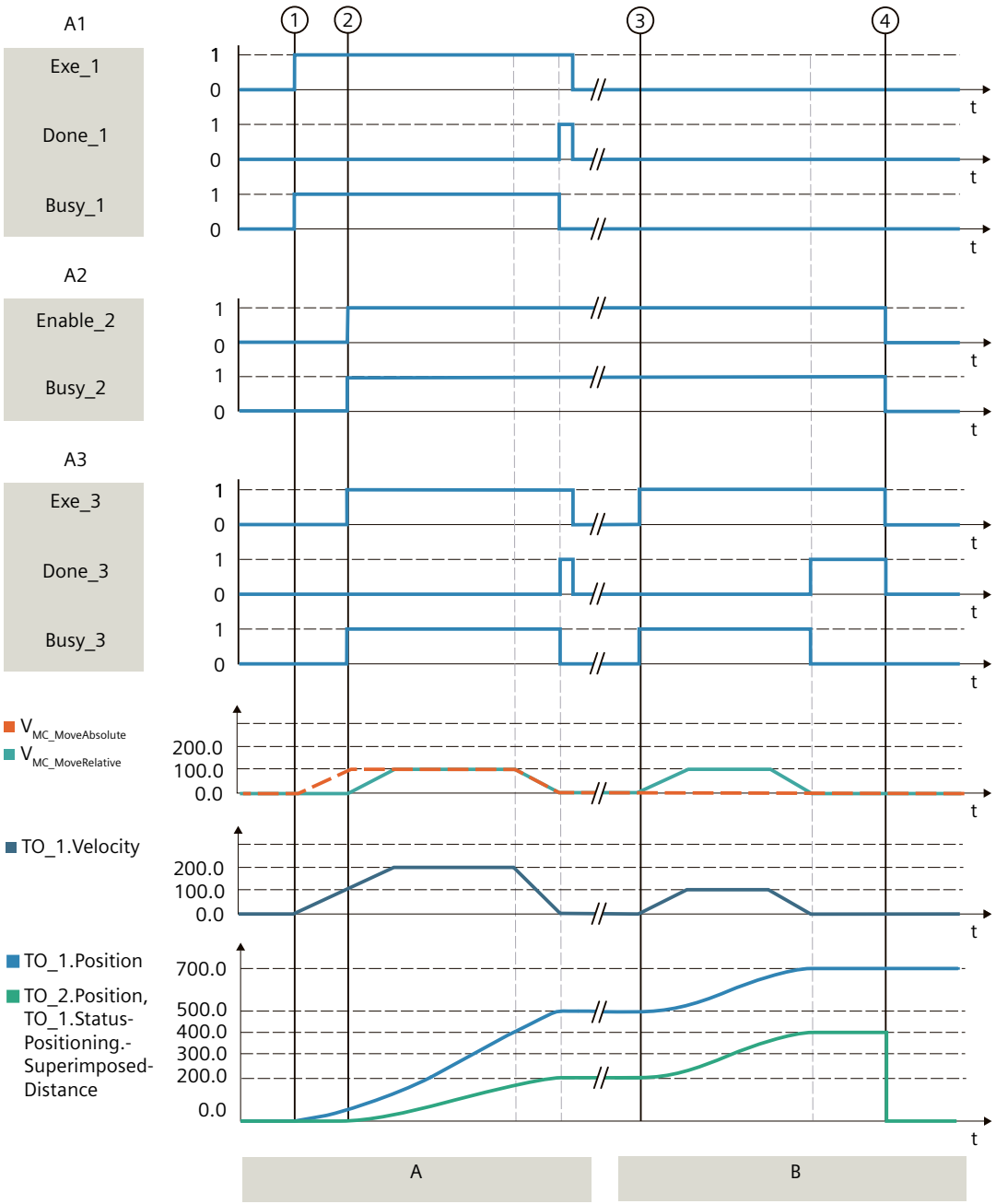

Section A

Via "Exe_1", the TO_1 axis is traversed with a "MC_MoveAbsolute" job (A1) as basic motion with the target position 300.0 and the velocity of 100.0 ①.

At time ②, "Enable_2" from the "MC_MoveSuperimposedAxes" job (A2) is used to activate that the motion of the TO_2 axis is superimposed on the motion of the TO_1 axis. Via "Exe_3", the TO_1 axis is superimposed with the relative positioning motion (A3) with a distance of 200.0 and a velocity of 100.0. The TO_1 axis is traversed with the added dynamic values of the two positioning jobs and reaches the target position 500.0. The resulting

velocity TO_1.Velocity is composed of the velocity of the absolute motion $V_{MC_MoveAbsolute}$ and the relative motion $V_{MC_MoveRelative}$.

Section B

The "MC_MoveAbsolute" job (A1) is at a standstill. The "MC_MoveSuperimposedAxes" job (A2) is active.

At time ③, a relative positioning motion (A3) without the basic movement (A1) is triggered via "Exe_3". The TO_1 axis is traversed further by the distance 200.0 with the dynamic values of the "MC_MoveRelative" job (A3) and reaches the target position 700.0. The resulting velocity TO_1.Velocity is composed of the velocity of the absolute motion $V_{MC_MoveAbsolute}$ and the relative motion $V_{MC_MoveRelative}$.

At time ④, "Enable_2" is reset by the "MC_MoveSuperimposedAxes" job (A2). The motion of the TO_2 axis no longer superimposes the motion of the TO_1 axis.

9.18 Torque data

9.18.1 MC_TorqueAdditive V10

9.18.1.1 MC_TorqueAdditive: Specify additive torque V10

Description

With the Motion Control instruction "MC_TorqueAdditive", you specify an additive torque for the drive to which the technology object is assigned. The torque data are transferred via the telegram 750.

With a linear motor, use the "MC_TorqueAdditive" instruction to specify an additive force.

The Motion Control instruction offers you the following:

- Specifying and activating an additive setpoint torque in the drive (Page 129)

If alarms occur at the technology object while "Enable" = TRUE, the force/torque limiting or fixed stop detection remains active.

Applies to

- Speed axis
- Positioning axis
- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The technology object has been enabled.
- The drive is connected via PROFIdrive telegram.
- Telegram 750 is configured.
  Telegram 750 is available for SINAMICS drives V4.9 and higher.

Override response

- An "MC_TorqueAdditive" job is not aborted by any other Motion Control job.
- A new "MC_TorqueAdditive" job does not abort any active Motion Control jobs.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_TorqueAdditive":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
Enable	INPUT	BOOL	FALSE	TRUE	The specified setpoint is used as long as the parameter is set to TRUE.
				FALSE	The additive torque transferred to the drive is zero.
Value	INPUT	LREAL	0.0	With standard motor: Additive setpoint torque With linear motor: Additive setpoint force Permissible values: -1.0E12 to 1.0E12	
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

See also

Connecting force/torque data via SIEMENS additional telegram 750 (Page 74)

9.18.1.2 MC_TorqueAdditive: Function chart V10

Function chart: Activate/deactivate additive setpoint torque

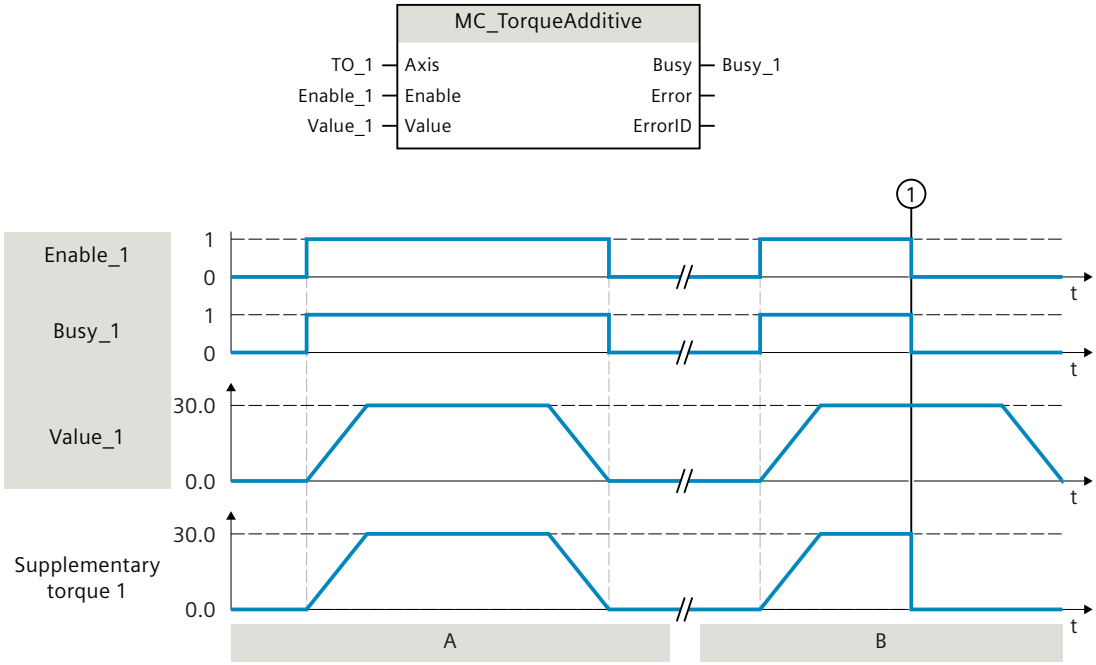

Section A

With "Enable_1" = TRUE, an additive setpoint torque "Value_1" is specified for the drive assigned to the technology object. This specification is transferred to the drive parameter "p1511" (Supplementary torque 1) using telegram 750.

Section B

With "Enable_1" = TRUE, an additive setpoint torque "Value_1" is specified for the drive assigned to the technology object. This specification is transferred to the drive parameter "p1511" (Supplementary torque 1) using telegram 750. The additive setpoint torque is first built up. At time ①, "Enable_1" is already set to "FALSE", before the additive setpoint torque is reduced again. The reduction of the torque setpoint is transmitted directly to the drive.

9.18.2 MC_TorqueRange V10

9.18.2.1 MC_TorqueRange: Set high and low torque limit V10

Description

With the Motion Control instruction "MC_TorqueRange", you can specify an upper and lower torque limit to the drive assigned to the technology object. The torque data are transferred via the telegram 750.

With a linear motor, use the "MC_TorqueRange" instruction to specify an upper and lower force limit.

The Motion Control instruction offers you the following:

- Specifying an upper and lower force/torque limit in the drive (Page 130)

If alarms occur at the technology object while "Enable" = TRUE, the force/torque limiting or fixed stop detection remains active.

Applies to

- Speed axis
- Positioning axis
- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The drive is connected via PROFIdrive telegram.
- Telegram 750 is configured.

  Telegram 750 is available for SINAMICS drives V4.9 and higher.

Override response

- An "MC_TorqueRange" job is not aborted by any other Motion Control job.
- A new "MC_TorqueRange" job does not abort any active Motion Control jobs.
- If the torque limiting is active via the "MC_TorqueLimiting" job, the "MC_TorqueRange" job is rejected with an error message and vice versa. The functions do not override one another.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_TorqueRange":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
Enable	INPUT	BOOL	FALSE	TRUE	The specified values are used as long as the TRUE parameter is set.
				FALSE	No values for the high and low torque limit are transferred to the drive.
UpperLimit	INPUT	LREAL	1.0 E12	With standard motor: Upper torque limit (in the configured unit) With linear motor: Upper force limit (in the configured unit) Permitted value range: -1.0 E12 to 1.0 E12 The value of the parameter "UpperLimit" must be greater than the value of the parameter "LowerLimit".	
LowerLimit	INPUT	LREAL	-1.0 E12	With standard motor: Lower torque limit (in the configured unit) With linear motor: Lower force limit (in the configured unit) Permitted value range: -1.0 E12 to 1.0 E12 The value of the parameter "LowerLimit" must be less than the value of the parameter "UpperLimit".	
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

See also

Connecting force/torque data via SIEMENS additional telegram 750 (Page 74)

9.18.2.2 MC_TorqueRange: Function chart V10

Function chart: Set high and low torque limits

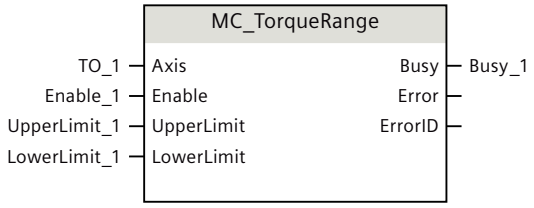

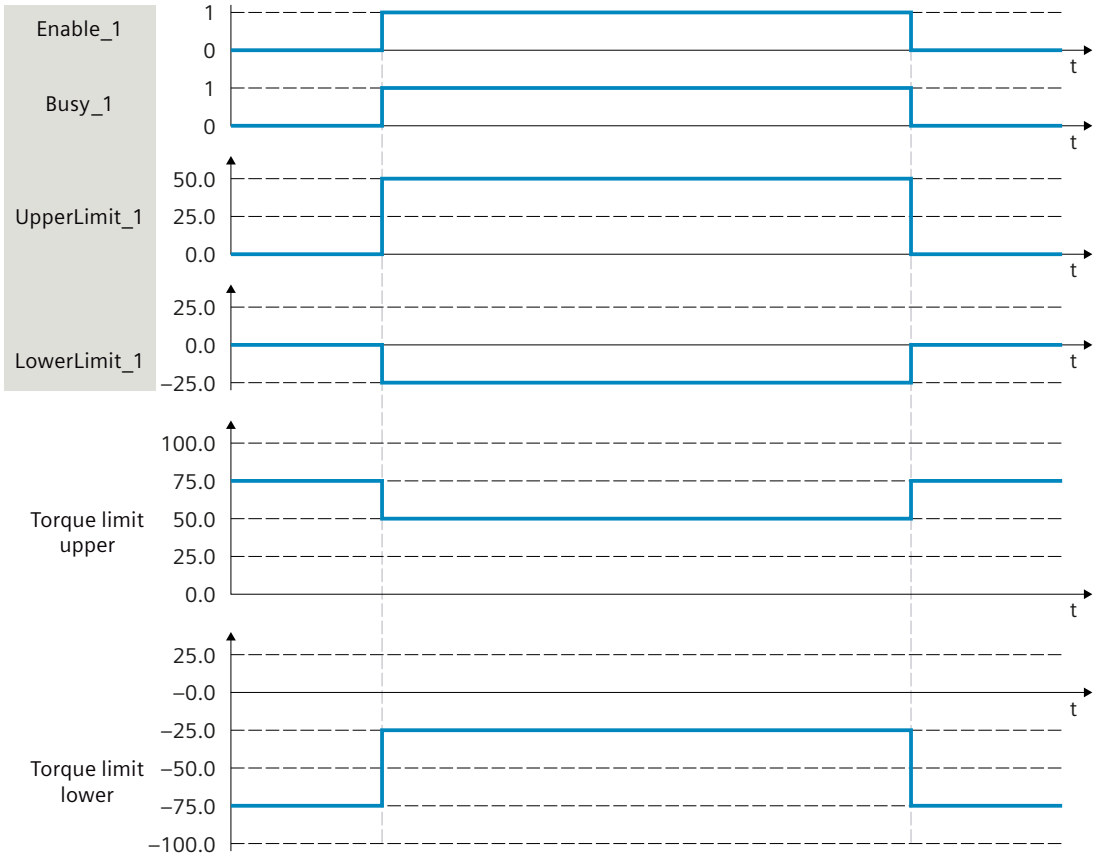

With "Enable_1" = TRUE, an upper torque limit "UpperLimit_1" and a lower torque limit "LowerLimit_1" are specified to the drive assigned to the technology object. These settings are transferred directly to the drive parameters "p1522" (Torque limit upper) and "p1523" (Torque limit lower) using telegram 750. If "Enable_1" is reset to "FALSE", the upper and lower torque limits are no longer active.

9.18.3 MC_TorqueLimiting V10

9.18.3.1 MC_TorqueLimiting: Activate/deactivate force/torque limit / fixed stop detection V10

Description

With the Motion Control instruction "MC_TorqueLimiting", you activate and assign parameters for force/torque limiting and fixed stop detection. Together with a position-controlled motion job, a "Travel to fixed stop" can be realized with the fixed stop detection. In the axis configuration, you can configure whether the force/torque limiting is to relate to the drive side or the load side.

The functions of the Motion Control instruction "MC_TorqueLimiting" can be activated and deactivated before and during a motion job.

The Motion Control instruction offers you the following:

- Specifying and activating the force/torque limiting (Page 124)
- Activating and monitoring the fixed stop detection (Page 127)

NOTE

Multi-instance DBs

If you use multi-instances of the MC_TorqueLimiting instruction, create the multi-instances in a separate function block. This allows you to download program blocks from other sections of your user program without switching off the axes, including in "RUN" mode.

In case of alarms on the technology object and "Enable" = TRUE, the force/torque limits or the fixed stop detection remain active.

Force/torque limiting applies to

- Speed axis
- Positioning axis
- Synchronous axis

Requirements for force/torque limiting

- The technology object and the reference torque of the drive have been configured correctly.
- No errors that prevent enabling are pending for the technology object (the technology object must not be enabled).
- The drive must support force/torque reduction. Only PROFIdrive drives with SIEMENS telegram 10x support force/torque limiting.

- The upper and lower torque limit of the drive must be set to the reference torque of the drive. The sum of all values must be equal.

  If you want to use different torque limits, use an "MC_TorqueRange" job, for example.

  You can find more information in the "Connecting force/torque data via SIEMENS additional telegram 750 (Page 74)" section.
- The reference torque set in the "Data exchange with the drive" configuration dialog of the technology object must match the reference torque of the drive. If the automatic application of drive data is enabled, the axis automatically takes the reference torque of the drive.

Required interconnections in the SINAMICS drive

Make sure that the following interconnections required for force/torque limit are set in all drive data sets in the drive:

- P1522 = P1520 = P2003 (interconnection to the reference torque)
- P1523 = P1521 = -P2003 (interconnection to the negative reference torque)
- P1544 Torque/force reduction evaluation during travel to fixed stop to 100% (default)
- P2194 Threshold value for the parameter "InLimitation" of < 100% (default 90%)

Fixed stop detection applies to

- Synchronous axis
- Positioning axis

Requirement for fixed stop detection

- Fixed stop detection can only be applied to position-controlled axes. For fixed stop detection, the axis must be enabled as position-controlled. Motion jobs must be executed as position-controlled.
- The technology object has been configured correctly.
- When a drive and telegram that support force/torque limiting are used, the reference torque of the drive must be correctly configured for the technology object.
- No errors that prevent enabling are pending for the technology object (the technology object must be enabled).

Override response

- An "MC_TorqueLimiting" job cannot be aborted by any other Motion Control job.
- A new "MC_TorqueLimiting" job does not abort any active Motion Control jobs.
- If the high and low torque limiting is active via the "MC_TorqueRange" job, the "MC_TorqueLimiting" job is rejected with an error message and vice versa. The functions do not override one another.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_TorqueLimiting":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SpeedAxis TO_PositioningAxis TO_SynchronousAxis	-	Technology object	
Enable	INPUT	BOOL	FALSE	TRUE	Activate function corresponding to input parameter "Mode"
Limit	INPUT	LREAL	-1.0	Value of force/torque limiting (in the configured unit)[1]	
				≥ 0.0	The value specified at the parameter is used.
				< 0.0	The value configured in the "Torque limiting" configuration window is used. Tag Torque Limit: <TO>.TorqueLimiting.LimitDefaults.Torque Tag Force Limit: <TO>.TorqueLimiting.LimitDefaults.Force
Mode	INPUT	DINT	0	0	Force/torque limiting (Page 124)[1]
				1	Fixed stop detection (Page 127)[1]
InClamping	OUTPUT	BOOL	FALSE	TRUE	"Mode" = 1: The drive is kept at the fixed stop (clamping[2]). The axis position is within the positioning tolerance.
InLimitation	OUTPUT	BOOL	FALSE	TRUE	"Mode" = 0 and 1: The drive operates at least at the threshold value (default 90%) of the torque limit/force limitation.

1) Changes to input parameters "Limit" and "Mode" are also applied at the cyclic call of the Motion Control instruction when "Enable" = TRUE.

2) If "InClamping" = TRUE, all motion and synchronization jobs are canceled.

Parameter	Declaration	Data type	Default value	Description	
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

1) Changes to input parameters "Limit" and "Mode" are also applied at the cyclic call of the Motion Control instruction when "Enable" = TRUE.

2) If "InClamping" = TRUE, all motion and synchronization jobs are canceled.

9.18.3.2 MC_TorqueLimiting: Function chart V10

Function chart: Pausing an axis when the torque limit is reached

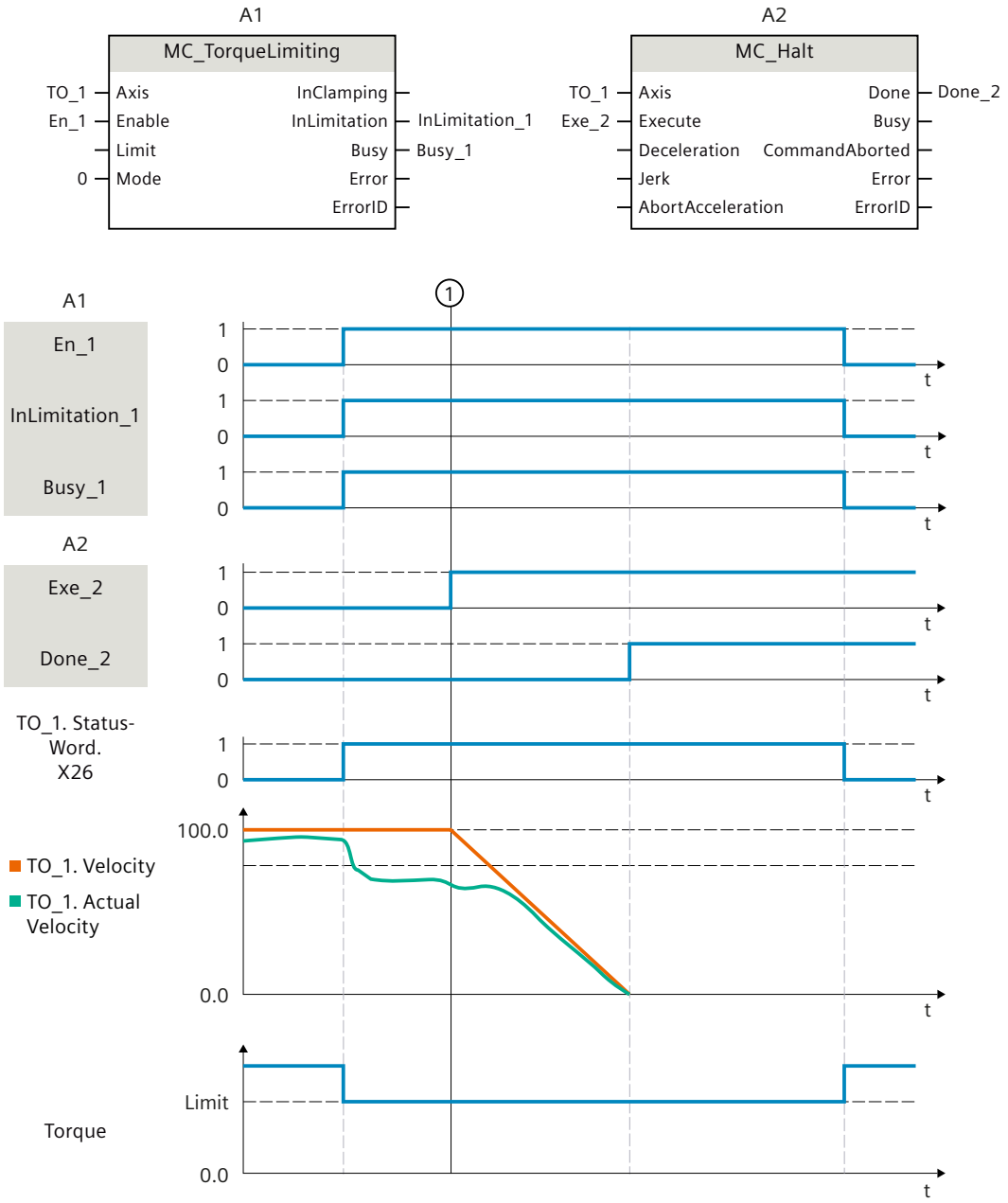

At time ①, an "MC_Halt" job (A2) is executed on an axis with active torque limiting "MC_TorqueLimiting" (A1). Torque limiting is still active ("MC_TorqueLimiting.Enable" = TRUE) and any accumulated following error is retained and will be reduced with the time.

When the actual velocity is "0.0" and the minimum dwell time in the standstill window has elapsed, the tag "MC_Halt.Done" shows = TRUE. When position monitoring is activated, reaching of the target position is also monitored.

Function chart: Torque limiting with fixed stop detection (mode = 1)

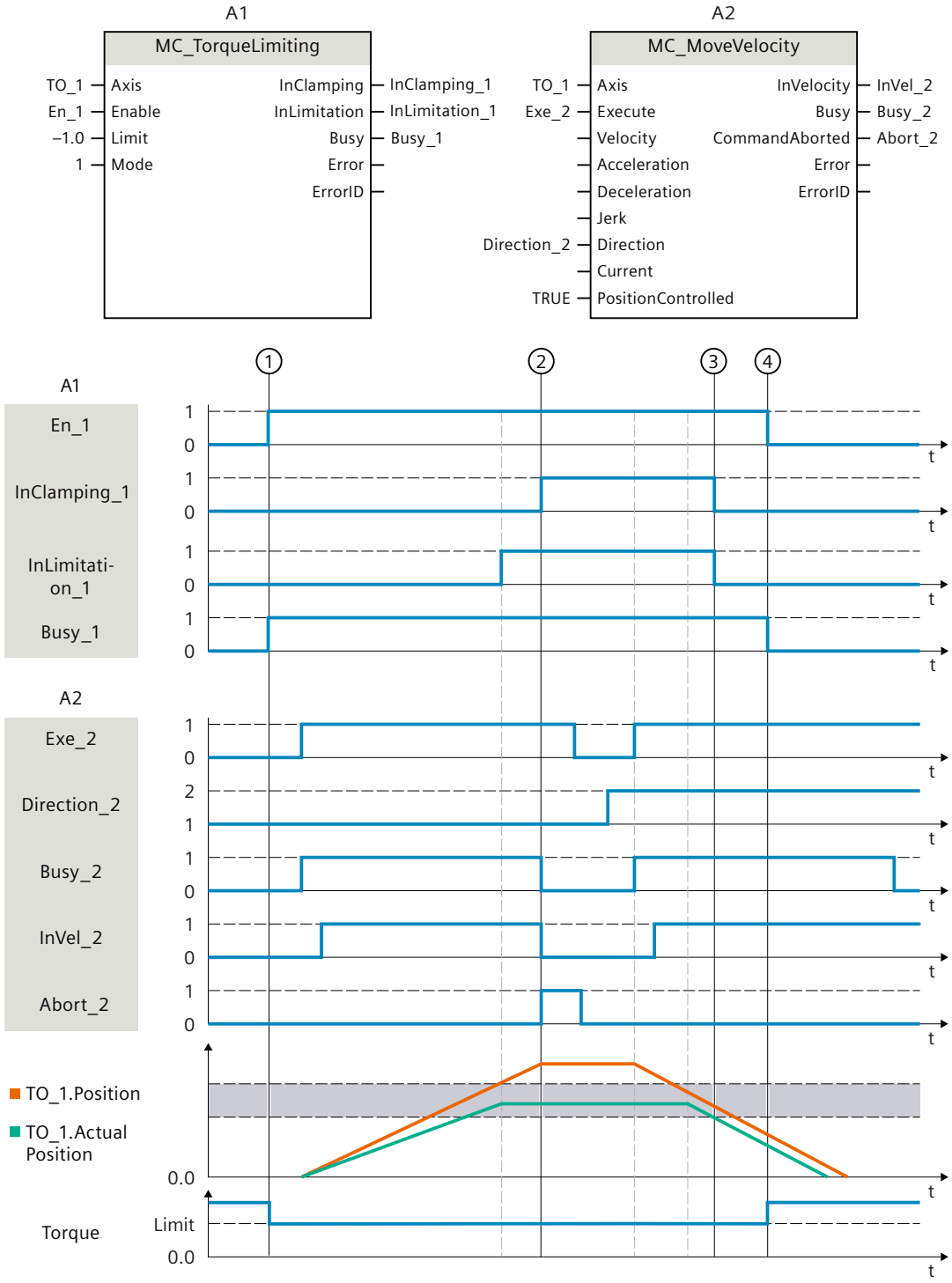

At time ①, a "MC_TorqueLimiting" job (A1) is initiated via "En_1". An "MC_MoveVelocity" job (A2) is executed on the axis with active torque limiting. The torque limiting is still active "MC_TorqueLimiting.Enable" = TRUE.

When the following error limit ② is reached, the "MC_MoveVelocity" job is aborted with "Abort" = TRUE. The drive is kept at the fixed stop (clamping). The actual position of the axis is within the positioning tolerance.

An "MC_MoveVelocity" job is once again called via the two tags "Execute" = TRUE and "Direction_2" = TRUE and the axis moves with constant velocity in the opposite direction. The clamping is hereby reduced when the positioning tolerance ③ is exited.

At time ④, the torque limiting is cancelled.

9.19 Override response of Motion Control jobs V10

9.19.1 Override response V10: Homing and motion jobs

The following table shows how a new Motion Control job affects active homing and motion jobs:

⇒ Active job ⇓ New job	MC_Home "Mode" = 2-, 8, 10	MC_Home "Mode" = 3, 5	MC_Halt "Mode" = 1 MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 0, 1 active MC_Move-Velocity MC_MoveJog	MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 1 waiting	MC_Halt "Mode" = 0	MC_Stop	MC_Move-Super-imposed MC_Motion-InSuper-imposed MC_Motion-InSuper-imposed-Axes MC_Halt-Super-imposed	MC_Motion-InVelocity MC_Motion-InPosition
MC_Home[1)] "Mode" = 3, 5	A	A	A	A	A	N	A	A
MC_Home "Mode" = 9	A	-	-	-	-	N	-	-
MC_Halt "Mode" = 1	-	A	A	A	-	N	-	A
MC_Halt "Mode" = 0	-	A	A	A	A	N	A	A

A The running job is aborted with "CommandAborted" = TRUE.

B An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) The status "Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE corresponds to a waiting synchronous operation.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) The status "Busy" = TRUE, "StartSyncOut" = FALSE corresponds to a pending desynchronization job.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) An "MC_CamIn" job with "SyncProfileReference" = 5 does not abort an "MC_[...]Superimposed" job. Running job continues to be executed.

⇒ Active job ⇓ New job	MC_Home "Mode" = 2-, 8, 10	MC_Home "Mode" = 3, 5	MC_Halt "Mode" = 1 MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 0, 1 active MC_Move-Velocity MC_MoveJog	MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 1 waiting	MC_Halt "Mode" = 0	MC_Stop	MC_Move-Super-imposed MC_Motion-InSuper-imposed MC_Motion-InSuper-imposed-Axes MC_Halt-Super-imposed	MC_Motion-InVelocity MC_Motion-InPosition
MC_MoveAbso-lute/ MC_MoveRelat-ive/ MC_PositionPro-file "BufferMode" = 0 Active **MC_MoveVelo-city MC_MoveJog MC_MotionIn-Velocity MC_MotionIn-Position**								
MC_MoveAbso-lute/ MC_Move-Relative/ MC_PositionPro-file "BufferMode" = 1 active, waiting	N	N	-/N	N	N	N	-	N

A The running job is aborted with "CommandAborted" = TRUE.

B An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) The status "Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE corresponds to a waiting synchronous operation.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) The status "Busy" = TRUE, "StartSyncOut" = FALSE corresponds to a pending desynchronization job.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) An "MC_CamIn" job with "SyncProfileReference" = 5 does not abort an "MC_[...]Superimposed" job. Running job continues to be executed.

⇒ Active job ⇓ New job	MC_Home "Mode" = 2-, 8, 10	MC_Home "Mode" = 3, 5	MC_Halt "Mode" = 1 MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 0, 1 active MC_Move-Velocity MC_MoveJog	MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 1 waiting	MC_Halt "Mode" = 0	MC_Stop	MC_Move-Super-imposed MC_Motion-InSuper-imposed MC_Motion-InSuper-imposed-Axes MC_Halt-Super-imposed	MC_Motion-InVelocity MC_Motion-InPosition
MC_MoveSuper-imposed MC_MotionIn-Superimposed MC_MotionIn-Superimposed-Axes MC_HaltSuper-Imposed	-	-	-	-	-	N	A	-
MC_Stop	A	A	A	A	A	B	A	A
MC_GearIn MC_GearInVelo-city	-	A	A	A	A	N	A	A
MC_GearInPos MC_CamIn waiting[2]	-	-	-	A	-	N	-	-
MC_GearInPos MC_CamIn active[3]	-	A	A	A	A	N	A[6]	A

A The running job is aborted with "CommandAborted" = TRUE.

B An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) The status "Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE corresponds to a waiting synchronous operation.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) The status "Busy" = TRUE, "StartSyncOut" = FALSE corresponds to a pending desynchronization job.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) An "MC_CamIn" job with "SyncProfileReference" = 5 does not abort an "MC_[...]Superimposed" job. Running job continues to be executed.

⇒ Active job ⇓ New job	MC_Home "Mode" = 2-, 8, 10	MC_Home "Mode" = 3, 5	MC_Halt "Mode" = 1 MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 0, 1 active MC_Move-Velocity MC_MoveJog	MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 1 waiting	MC_Halt "Mode" = 0	MC_Stop	MC_Move-Super-imposed MC_Motion-InSuper-imposed MC_Motion-InSuper-imposed-Axes MC_Halt-Super-imposed	MC_Motion-InVelocity MC_Motion-InPosition
MC_Leading-ValueAdditive	-	-	-	-	-	-	-	-
MC_GearOut MC_CamOut waiting[4)]	N	N	N	N	N	N	-	N
MC_GearOut MC_CamOut active[5)]	N	N	N	N	N	N	A	N

A The running job is aborted with "CommandAborted" = TRUE.

B An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) The status "Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE corresponds to a waiting synchronous operation.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) The status "Busy" = TRUE, "StartSyncOut" = FALSE corresponds to a pending desynchronization job.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) An "MC_CamIn" job with "SyncProfileReference" = 5 does not abort an "MC_[...]Superimposed" job. Running job continues to be executed.

NOTE

Override response with active fixed stop

With an active force and torque limiting with "MC_TorqueLimiting", running jobs are aborted if the drive is held at the fixed stop with "InClamping" = TRUE.

9.19.2 Override response V10: Synchronous operation jobs

The following table shows how a new Motion Control job affects the motion of the axis on active synchronous operation jobs:

⇒ **Active job** ⇓ **New job**	**MC_GearIn**	**MC_GearInVelocity**	**MC_GearInPos MC_CamIn waiting[2)]**	**MC_GearInPos MC_CamIn active[3)]**	**MC_PhasingAbsolute MC_PhasingRelative**	**MC_OffsetAbsolute MC_OffsetRelative**	**MC_LeadingValueAdditive**	**MC_GearOut MC_CamOut waiting[4)]**	**MC_GearOut MC_CamOut active[5)]**
MC_Home[1)] "Mode" = 3, 5	A	A	-	N	-	-	-	-	A
MC_Halt "Mode" = 0, 1 **MC_MoveAbsolute/ MC_MoveRelative** "BufferMode" = 0 Active **MC_PositionProfile** "BufferMode" = 0 Active **MC_MoveVelocity** **MC_MoveJog**	A	A	-	A	A	A	-	A	A

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) A waiting synchronous operation job ("Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) A pending desynchronization job ("Busy" = TRUE, "StartSyncOut" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) When the following axis is in position-controlled mode, execution of the running job is continued. When the following axis is not in position-controlled mode, the new job is rejected.

7) An "MC_GearOut" job only terminates an "MC_Gear[...]" job. Correspondingly, an "MC_CamOut" job only cancels a "MC_Cam[...]" job.

8) A job with "SyncProfileReference" = 5 aborts a pending synchronous operation. Canceling a pending synchronous operation has no influence on an active synchronous operation.

⇒ Active job ⇓ New job	MC_GearIn	MC_GearInVelocity	MC_GearInPos MC_CamIn waiting[2]	MC_GearInPos MC_CamIn active[3]	MC_PhasingAbsolute MC_PhasingRelative	MC_OffsetAbsolute MC_OffsetRelative	MC_LeadingValueAdditive	MC_GearOut MC_CamOut waiting[4]	MC_GearOut MC_CamOut active[5]
MC_MoveAbsolute/-MC_MoveRelative "BufferMode" = 1 active, waiting **MC_PositionProfile** "BufferMode" = 1 active, waiting	N	N	-	N	N	N	-	N	N
MC_MotionInVelocity MC_MotionInPosition	A	A	-	A	A	A	-	A	A
MC_MoveSuperimposed MC_MotionInSuperimposed MC_MotionInSuperimposedAxes MC_HaltSuperImposed	-	-/N[6]	-	-	-	-	-	-	-
MC_Stop	A	A	A	A	A	A	-	A	A

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) A waiting synchronous operation job ("Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) A pending desynchronization job ("Busy" = TRUE, "StartSyncOut" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) When the following axis is in position-controlled mode, execution of the running job is continued. When the following axis is not in position-controlled mode, the new job is rejected.

7) An "MC_GearOut" job only terminates an "MC_Gear[...]" job. Correspondingly, an "MC_CamOut" job only cancels a "MC_Cam[...]" job.

8) A job with "SyncProfileReference" = 5 aborts a pending synchronous operation. Canceling a pending synchronous operation has no influence on an active synchronous operation.

⇒ Active job ⇓ New job	MC_GearIn	MC_GearInVelocity	MC_GearInPos MC_CamIn waiting[2]	MC_GearInPos MC_CamIn active[3]	MC_PhasingAbsolute MC_PhasingRelative	MC_OffsetAbsolute MC_OffsetRelative	MC_LeadingValueAdditive	MC_GearOut MC_CamOut waiting[4]	MC_GearOut MC_CamOut active[5]
MC_GearIn MC_GearInVelocity	A	A	A	A	A	A	-	A	A
MC_GearInPos MC_CamIn waiting[2]	-	-	A	-	-	-	-	A	-
MC_GearInPos MC_CamIn active[3]	A	A[6]	A	A	A	A	-	A	A
MC_PhasingAbsolute MC_PhasingRelative	-	N	-	-	A	N	-	-	N
MC_OffsetAbsolute MC_OffsetRelative	-	N	-	-	N	A	-	-	N
MC_LeadingValueAdditive	-	-	-	-	-	-	A	-	-
MC_GearOut MC_CamOut waiting[4]	-	N	A[7] [8]	-	-	-	-	A[7]	N
MC_GearOut MC_CamOut active[5]	A[7]	N	A[7] [8]	A[7]	A	A	-	A[7]	N

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) A waiting synchronous operation job ("Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) A pending desynchronization job ("Busy" = TRUE, "StartSyncOut" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) When the following axis is in position-controlled mode, execution of the running job is continued. When the following axis is not in position-controlled mode, the new job is rejected.

7) An "MC_GearOut" job only terminates an "MC_Gear[...]" job. Correspondingly, an "MC_CamOut" job only cancels a "MC_Cam[...]" job.

8) A job with "SyncProfileReference" = 5 aborts a pending synchronous operation. Canceling a pending synchronous operation has no influence on an active synchronous operation.

NOTE
Override response with active fixed stop
With an active force and torque limiting with "MC_TorqueLimiting", running jobs are aborted if the drive is held at the fixed stop with "InClamping" = TRUE.

9.19.3 Override response V10: Measuring input jobs

The following table shows which new Motion Control jobs will override active measuring input jobs:

⇒ **Active job** ⇓ **New job**	**MC_MeasuringInput**	**MC_MeasuringInputCyclic**
MC_Home "Mode" = 2, 3, 5, 8, 9, 10	B	B
MC_Home "Mode" = 0, 1, 6, 7, 11, 12	-	-
MC_MeasuringInput **MC_MeasuringInputCyclic** **MC_AbortMeasuringInput**	A	A

A The running job is aborted with "CommandAborted" = TRUE.

B The running job is aborted with "ErrorID" = 16#80A3.

- No effect. Running job continues to be executed.

9.19.4 Override response V10: Kinematics motion commands

Single axis jobs are not overridden by kinematics jobs.

The following table shows how a new Motion Control job affects active kinematics motion jobs:

⇒ **Active job** ⇓ **New job**	**MC_MoveLinearAbsolute** **MC_MoveLinearRelative** **MC_MoveCircularAbsolute** **MC_MoveCircularRelative** **MC_MoveDirectAbsolute** **MC_MoveDirectRelative** **MC_TrackConveyorBelt** **MC_DefineWorkspaceZone** **MC_DefineKinematicsZone** **MC_SetWorkspaceZoneActive** **MC_SetWorkspaceZoneInactive** **MC_SetKinematicsZoneActive** **MC_SetKinematicsZoneInactive** **MC_SetOcsFrame**	**MC_GroupInterrupt**	**MC_GroupStop**
MC_Home **MC_MoveSuperimposed** **MC_GearOut** **MC_CamOut**	N	N	N
MC_Halt **MC_MoveAbsolute/** **MC_MoveRelative/** **MC_PositionProfile** "BufferMode" = 0 Active **MC_MoveVelocity** **MC_MoveJog** **MC_Stop** **MC_GearIn** **MC_GearInPos** **MC_GearInVelocity** **MC_CamIn** **MC_MotionInVelocity** **MC_MotionInPosition**	A	A	A
MC_GroupStop	A	A	N
MC_GroupInterrupt **MC_GroupContinue**	B	A	N
MC_MoveLinearAbsolute **MC_MoveLinearRelative** **MC_MoveCircularAbsolute** **MC_MoveCircularRelative** **MC_MoveDirectAbsolute** **MC_MoveDirectRelative** **MC_TrackConveyorBelt**	-	-	N

⇒ Active job ⇓ New job	MC_MoveLinearAbsolute MC_MoveLinearRelative MC_MoveCircularAbsolute MC_MoveCircularRelative MC_MoveDirectAbsolute MC_MoveDirectRelative MC_TrackConveyorBelt MC_DefineWorkspaceZone MC_DefineKinematicsZone MC_SetWorkspaceZoneActive MC_SetWorkspaceZoneInactive MC_SetKinematicsZoneActive MC_SetKinematicsZoneInactive MC_SetOcsFrame	MC_GroupInterrupt	MC_GroupStop
MC_DefineWorkspaceZone MC_DefineKinematicsZone MC_SetWorkspaceZoneActive MC_SetWorkspaceZoneInactive MC_SetKinematicsZoneActive MC_SetKinematicsZoneInactive			
MC_SetOcsFrame	C, -	-	N

A The running job is aborted with "CommandAborted" = TRUE.

B Running job is interrupted or resumed.

C Synchronization of the OCS with the conveyor belt is aborted with "MC_SetOcsFrame" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed. A new kinematics job is added to the job sequence.

9.19.5 Override response V10: Interpreter jobs

The following table shows how a new Motion Control job affects running Interpreter jobs:

⇒ Active job ⇓ New job	MC_LoadProgram	MC_RunProgram	MC_StopProgram
MC_LoadProgram	N	N	N
MC_RunProgram	-[1]	N	N
MC_StopProgram	A	A	A[2]
MC_Reset	-/N[3]	-/N[3]	-/N[3]

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) The new job is also executed.

2) A new "MC_StopProgram" job with "Mode" = 0 cancels a running "MC_StopProgram" job with "Mode" = 1 or 2. A new "MC_StopProgram" job with "Mode" = 1 aborts a current "MC_StopProgram" job with "Mode" = 2.

3) An "MC_Reset" job with "Restart" = TRUE is rejected. Running job continues to be executed.

Override response for technology objects controlled by the Interpreter

The following table shows how a new Motion Control job acts in relation to a technology object controlled by the Interpreter during the execution of an Interpreter program ("<TO>.StatusInterpreterMotion.StatusWord.X0" = TRUE (ControlledByInterpreter)):

⇓ New job	The new job will be executed.	The new job aborts the execution of the Interpreter program.
MC_Power disable/enable with technology object	✓	✓
MC_Reset with "Restart" = TRUE	✓	✓
MC_Reset with "Restart" = FALSE	✓	-
MC_Home **MC_Halt** **MC_Stop**	✓	✓
MC_MoveAbsolute **MC_MoveRelative** **MC_MoveVelocity** **MC_MoveJog**	✓	✓
MC_SetAxisSTW **MC_WriteParameter**	✓	-
MC_MoveSuperimposed **MC_MotionInSuperimposed** **MC_MotionInSuperimposedAxes** **MC_HaltSuperimposed**	-	-
MC_MotionInVelocity **MC_MotionInPosition**	✓	✓
MC_GearIn **MC_GearInPos** **MC_GearInVelocity** **MC_GearOut** **MC_CamIn** **MC_CamOut**	✓	✓[1]
MC_PhasingRelative **MC_PhasingAbsolute**	-	-
MC_LeadingValueAdditive	✓	-
MC_OffsetRelative **MC_OffsetAbsolute**	-	-
MC_TorqueAdditive **MC_TorqueRange**	✓	-
MC_TorqueLimiting	✓	-/✓[2]
MC_SynchronizedMotionSimulation	✓	-

1) When the synchronization/desynchronization starts, the execution of the Interpreter program is cancelled.

2) If a technology alarm is issued due to a fixed stop, the execution of the Interpreter program is cancelled.

⇓ New job	The new job will be executed.	The new job aborts the execution of the Interpreter program.
MC_MoveLinearAbsolute **MC_MoveLinearRelative** **MC_MoveCircularAbsolute** **MC_MoveCircularRelative** **MC_MoveDirectAbsolute** **MC_MoveDirectRelative**	-	-
MC_GroupInterrupt **MC_GroupContinue**	-	-
MC_GroupStop	✓	✓
MC_KinematicsMotionSimulation	✓	-
MC_TrackConveyorBelt	-	-
MC_DefineTool **MC_SetTool** **MC_SetOcsFrame**	-	-
MC_KinematicsTransformation **MC_InverseKinematicsTransformation**	✓	-
MC_DefineWorkspaceZone **MC_SetWorkspaceZoneActive** **MC_SetWorkspaceZoneInactive** **MC_DefineKinematicsZone** **MC_SetKinematicsZoneActive** **MC_SetKinematicsZoneInactive**	-	-

1) When the synchronization/desynchronization starts, the execution of the Interpreter program is cancelled.

2) If a technology alarm is issued due to a fixed stop, the execution of the Interpreter program is cancelled.

NOTE

MC_Power

Note that a "MC_Power" request with "Enable" = FALSE always locks the specified technology object, even if the technology object was enabled via an Interpreter program with "powerOn()".

Mixed operation of MC_Power (SCL) and powerOn() (MCL) is not permitted.

NOTE

MC_Stop

Note that when starting a motion controlled by the Interpreter no "MC_Stop" job may be active, otherwise the motion job will be aborted.

NOTE

MC_GroupStop

Note that when starting a kinematics motion controlled by the Interpreter, no "MC_GroupStop" job may be active, otherwise the motion job will be aborted.

A "MC_GroupStop" job only affects active kinematics motions or if the kinematics technology object is controlled by the Interpreter ("<TO>.StatusInterpreterMotion.StatusWord.X0" = TRUE (ControlledByInterpreter)).

See also

Override response V10: Homing and motion jobs (Page 380)
Override response V10: Synchronous operation jobs (Page 384)
Override response V10: Kinematics motion commands (Page 388)

Tags of the technology object data blocks 10

10.1 Legend

Tag	Name of the tag	
Data type	Data type of the tag	
Values	Value range of the tag - minimum value to maximum value (L - linear specification R - rotary specification) If no specific value is shown, the value range limits of the relevant data type apply or the information under "Description".	
W	Effectiveness of changes in the technology data block	
	DIR	Direct: Values are changed via direct assignment and take effect at the start of the next MC_Servo.
	CAL	At call of Motion Control instruction: Values are changed directly and take effect at the start of the next MC_Servo after the call of the corresponding Motion Control instruction in the user program.
	RES	Restart: Changes to the start value in the load memory are made using the extended instruction "WRIT_DBL" (write to DB in load memory). Changes will not take effect until after restart of the technology object.
	RON	Read only: The tag cannot and must not be changed during runtime of the user program.
Description	Description of the tag	

Access to the tags is with "<TO>.<tag name>". The placeholder <TO> represents the name of the technology object.

10.2 Tags of the speed axis technology object

10.2.1 Actual values and setpoints (speed axis)

The following tags indicate the setpoint and actual values of the technology object.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
Velocity	LREAL	-	RON	Velocity setpoint/speed setpoint
ActualSpeed	LREAL	-	RON	With analog setpoint = 0.0: Actual speed of motor in 1/min
Acceleration	LREAL	-	RON	Setpoint acceleration
VelocitySetpoint	LREAL	-1.0E12 to 1.0E12	RON	Output velocity setpoint/speed setpoint

10.2.2 "Simulation" tag (speed axis)

The tag structure "<TO>.Simulation.<tag name>" contains the configuration of the simulation mode. In simulation mode, you can simulate axes without a real drive in the CPU.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
Simulation.	TO_Struct_AxisSimulation				
Mode	UDINT	0, 1	RES[1]	Simulation mode	
				0	No simulation, normal operation
				1	Simulation mode

[1] Technology version V2.0: RON

10.2.3 "VirtualAxis" tag (speed axis)

The tag structure "<TO>.VirtualAxis.<tag name>" contains the configuration of the virtual operation of the axis. A virtual axis is often used as a virtual leading axis in order to generate the setpoints for several real following axes in synchronous operation.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
VirtualAxis.	TO_Struct_VirtualAxis				
Mode	UDINT	0, 1	RON	Virtual axis	
				0	No virtual axis
				1	Technology version ≤ V7.0: The behavior of a virtual axis is identical to the behavior of an axis in simulation. The actual values are generated via the control loop and a simplified drive model. Technology version ≥ V8.0: In technology version V8.0, the behavior of the virtual axis has been changed. The behavior of a virtual axis is no longer identical to the behavior of an axis in simulation. The position and velocity setpoints are directly adopted as actual values with an application cycle delay. The feedback loop and the drive model are not simulated. The dynamic filter is effective. To maintain compatibility with virtual axes of technology versions ≤ V7.0 for an axis: 1. Switch on the axis in simulation (<TO>.Simulation.Mode = 1). 2. Deactivate the virtual axis (<TO>.VirtualAxisMode = 0).

10.2.4 "Actor" tag (speed axis)

The tag structure "<TO>.Actor.<tag name>" contains the controller-side configuration of the drive.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
Actor.	TO_Struct_Actor				
Type	DINT	0, 1	RON	Drive connection	
				0	Analog output

[1] With the Motion Control instruction "MC_WriteParameter", you can change the "Actor.RemoveEnableReaction" parameter during runtime. The change takes effect directly.

Tag	Data type	Values	W	Description	
Type	DINT	0, 1	RON	1	PROFIdrive telegram
InverseDirection	BOOL	-	RES	Inversion of the setpoint	
				FALSE	No
				TRUE	Yes
DataAdaption	DINT	0, 1	RES	Automatic transfer of the drive values reference speed, maximum speed and reference torque in the device	
				0	No automatic transfer, manual configuration of values
				1	Automatic transfer of values configured in the drive to the configuration of the technology object
Efficiency	LREAL	0.0 to 1.0	RES	Efficiency of gear	
RemoveEnableReaction	WORD	16#0...16#7	RES[1]	Stop reaction on "Remove enable"	
				16#1	OFF1 – Ramp stop - Braking with ramp-function generator
				16#3	OFF2 – Coast stop - Coast down
				16#5	OFF3 – Quick stop - Quick stop
				16#7	OFF3 – Quick stop (compatible configuration for technology versions up to V7)
				16#0 16#2 16#4 16#6	Invalid
Interface.	TO_Struct_ActorInterface				
AddressIn	VREF	0 to 65535	RON	Input address for the PROFIdrive telegram	
AddressOut	VREF	0 to 65535	RON	Output address for the PROFIdrive telegram or the analog setpoint	
EnableDriveOutput	BOOL	-	RES	"Enable output" for analog drives	
				FALSE	Disabled
				TRUE	Enabled
EnableDriveOutput-Address	VREF	0 to 65535	RON	Address for the "Enable output" for analog setpoint	
DriveReadyInput	BOOL	-	RES	"Ready input" for analog drives The analog drive signals its readiness to receive speed set-points.	
				FALSE	Disabled
				TRUE	Enabled
DriveReadyInput-Address	VREF	0 to 65535	RON	Address for the "Enable input" for analog setpoint	
EnableTorqueData	BOOL	-	RES	Torque data	
				FALSE	Disabled
				TRUE	Enabled

[1] With the Motion Control instruction "MC_WriteParameter", you can change the "Actor.RemoveEnableReaction" parameter during runtime. The change takes effect directly.

Tag	Data type	Values	W	Description
TorqueDataAddressIn	VREF	0 to 65535	RON	Input Address of the Telegram 750
TorqueDataAddress-Out	VREF	0 to 65535	RON	Output address of the telegram 750
DriveParameter.	TO_Struct_ActorDriveParameter			
ReferenceSpeed	LREAL	0.0 to 1.0E12	RES	Reference value (100%) for the speed setpoint (N-set) of the drive The speed setpoint is transferred in the PROFIdrive telegram as a normalized value from -200% to 200% of the "ReferenceSpeed". For setpoint specification via an analog output, the analog output can be operated in the range from -117% to 117%, provided the drive permits this.
MaxSpeed	LREAL	0.0 to 1.0E12	RES	Maximum value for the speed setpoint of the drive (N-set) (PROFIdrive: MaxSpeed ≤ 2 × ReferenceSpeed Analog setpoint: MaxSpeed ≤ 1.17 × ReferenceSpeed)
ReferenceTorque	LREAL	0.0 to 1.0E12	RES	Reference torque of drive (p2003) Valid for the standard motor setting.

[1] With the Motion Control instruction "MC_WriteParameter", you can change the "Actor.RemoveEnableReaction" parameter during runtime. The change takes effect directly.

10.2.5 "TorqueLimiting" tag (speed axis)

The tag structure "<TO>.TorqueLimiting.<tag name>" contains the configuration of the torque limiting.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
TorqueLimiting.	TO_Struct_TorqueLimiting				
LimitBase	DINT	0, 1	RES	Torque limiting	
				0	Motor side
				1	Load side
PositionBasedMonitor-ings	DINT	0, 1	RES	Positioning and following error monitoring	
				0	Monitoring deactivated
				1	Monitoring activated
LimitDefaults.	TO_Struct_TorqueLimitingLimitDe-faults				
Torque	LREAL	0.0 to 1.0E12	CAL	Limiting torque	
Force	LREAL	0.0 to 1.0E12	CAL	Limiting force	

10.2.6 "LoadGear" tag (speed axis)

The tag structure "<TO>.LoadGear.<tag name>" contains the configuration of the load gear.

Tags

Legend (Page 393)

Tag	Data type	Value range	W	Description
LoadGear.	TO_Struct_LoadGear			
Numerator	UDINT	1 to 4294967295	RES	Load gear numerator
Denominator	UDINT	1 to 4294967295	RES	Load gear denominator

10.2.7 "Units" tag (speed axis)

The tag structure "<TO>.Units.<tag name>" shows the set technological units.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
Units.	TO_Struct_Units / TO_Struct_ExternalEncoder_Units				
VelocityUnit	UDINT	-	RON	Unit for velocity	
				1082	1/s
				1083	1/min
				1528	1/h
TimeUnit	UDINT	-	RON	Unit for time	
				1054	s
TorqueUnit	UDINT	-	RON	Unit for torque	
				1126	Nm
				1128	kNm
				1529	lbf in (pound-force-inch)
				1530	lbf ft
				1531	ozf in (ounce-force-inch)
				1532	ozf ft
				1533	pdl in (poundal-inch)
				1534	pdl ft
ForceUnit	UDINT	-	RON	Unit for force	
				1120	N
				1122	kN
				1094	lbf (pound-force)

Tag	Data type	Values	W	Description	
ForceUnit	UDINT	-	RON	1093	ozf (ounce-force)
				1535	pdl (poundals)
MassUnit	UDINT	-	RON	Unit for mass	
				1088	kg
				1089	g
				1090	mg
				1092	t
				1540	lb
IneritaUnit	UDINT	-	RON	Unit for moment of inertia	
				1118	kg·m²
				1541	lb·ft²

10.2.8 "DynamicLimits" tag (speed axis)

The tag structure "<TO>.DynamicLimits.<tag name>" contains the configuration of the dynamic limits. During Motion Control, no dynamic values greater than the dynamic limits are permitted. If you specify greater values in a Motion Control instruction, then motion is performed using the dynamic limits, and a warning is indicated (alarm 501 to 503 - Dynamic values are limited).

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
DynamicLimits.	TO_Struct_DynamicLimits			
MaxVelocity	LREAL	0.0 to 1.0E12	RES	Maximum permissible velocity of the axis
Velocity	LREAL	0.0 to 1.0E12	DIR	Current maximum velocity of the axis The minimum from "MaxVelocity" and "Velocity" is effective for motion control.
MaxAcceleration	LREAL	0.0 to 2.77777777777778E8	DIR	Maximum permissible acceleration of the axis
MaxDeceleration	LREAL	0.0 to 2.77777777777778E8	DIR	Maximum permissible deceleration of the axis
MaxJerk	LREAL	0.0 to 4629629.629	DIR	Maximum permissible jerk on the axis

10.2.9 "DynamicDefaults" tag (speed axis)

The tag structure "<TO>.DynamicDefaults.<tag name>" contains the configuration of the dynamic defaults. These settings will be used when you specify a dynamic value less than 0.0 in a Motion Control instruction (exceptions: "MC_MoveJog.Velocity", "MC_MoveVelocity.Velocity"). Changes to the default dynamic values will be applied at the next positive edge at the "Execute" parameter of a Motion Control instruction.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
DynamicDefaults.	TO_Struct_DynamicDefaults			
Velocity	LREAL	0.0 to 1.0E12	CAL	Default velocity
Acceleration	LREAL	0.0 to 2.77777777777778E8	CAL	Default acceleration
Deceleration	LREAL	0.0 to 2.77777777777778E8	CAL	Default deceleration
Jerk	LREAL	0.0 to 4629629.629	CAL	Default jerk
EmergencyDeceleration	LREAL	0.0 to 2.77777777777778E8	DIR	Emergency stop deceleration

10.2.10 "Override" tag (speed axis)

The tag structure "<TO>.Override.<tag name>" contains the configuration of override parameters. The override parameters are used to apply a correction percentage to default values. An override change takes effect immediately, and is performed with the dynamic settings in effect in the Motion Control instruction.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
Override.	TO_Struct_Override			
Velocity	LREAL	0.0 to 200.0%	DIR	Velocity or speed override Percentage correction of the velocity or speed

10.2.11 "StatusDrive" tag (speed axis)

The tag structure "<TO>.StatusDrive.<tag name>" indicates the status of the drive.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
StatusDrive.	TO_Struct_StatusDrive				
InOperation	BOOL	-	RON	Operation status of the drive	
				FALSE	Drive not ready Setpoints will not be executed.
				TRUE	Drive ready Setpoints can be executed.
CommunicationOK	BOOL	-	RON	Cyclic BUS communication between controller and drive	
				FALSE	Cyclic communication not established. Fault ZSW1.X3 (FaultPresent) is present. Possible causes: • The CPU is in STOP. • The drive has failed. • The "ControlRequested" bit in the status word of the drive has the value "FALSE". • The drive signals an error using the status word. • For isochronous configuration, the dynamic sign of life in the telegram has failed or is not supplied by the drive.
				TRUE	Cyclic communication OK and no fault effective
Error	BOOL	-	RON	FALSE	No drive error
				TRUE	Drive error
AdaptionState	DINT	0 to 4	RON	Status of automatic data transfer of drive parameters	
				0	"NOT_ADAPTED" Data not transferred
				1	"IN_ADAPTION" Data transfer in progress
				2	"ADAPTED" Data transfer complete
				3	"NOT_APPLICABLE" Data transfer not selected, not possible
				4	"ADAPTION_ERROR" Error during data transfer

10.2.12 "StatusTorqueData" tag (speed axis)

The tag structure "<TO>.StatusTorqueData.<tag name>" indicates the status of the torque.

Tags

Legend (Page 393)

Tag	Data type	Value range	W	Description	
StatusTorqueData.	TO_Struct_StatusTorqueData				
CommandAdditive-TorqueActive	DINT	-	RON	Additive torque setpoint function	
				0	Disabled
				1	Enabled
CommandTorqueRange-Active	DINT	-	RON	Torque range above high and low limit of the torque function	
				0	Disabled
				1	Enabled
ActualTorque	LREAL	-1.0E12 to 1.0E12	RON	Actual torque of the axis in the technological unit of the technology object for torque	

10.2.13 "StatusMotionIn" tag (speed axis)

The tag structure "<TO>.StatusMotionIn.<tag name>" indicates the motion status.

Tags

Legend (Page 393)

Tag	Data type	Value range	W	Description	
StatusMotionIn.	TO_Struct_StatusMotionIn				
FunctionState	DINT	0, 1	RON	0	No "MotionIn" function active
				1	"MotionInVelocity" function active

10.2.14 "StatusInterpreterMotion" tag (speed axis)

The tag structure "<TO>.StatusInterpreterMotion.<tag name>" contains status information on motion jobs controlled by a technology object Interpreter.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
StatusInterpreterMotion.	TO_Struct_StatusInterpreterMotion			
Interpreter	DB_ANY	0 to 65535		Controlling Interpreter technology object
StatusWord.	DWORD	-	RON	Status information

Tag			Data type	Values	W	Description
		Bit 0	-	-	-	"ControlledByInterpreter" An MCL job is processed or active or the bit is set via the MCL instruction "setControlledByInterpreter()".
		Bit 1	-	-	-	"MotionByInterpreter" An MCL motion job is in effect.
		Bit 2 to Bit 31	-	-	-	Reserved

10.2.15 "StatusWord" tag (speed axis)

The "<TO>.StatusWord" tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 0 "Enable") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend (Page 393)

Tag		Data type	Values	W	Description
StatusWord		DWORD	-	RON	Status information of the technology object
	Bit 0	-	-	-	"Enable" Enable status The technology object has been enabled.
	Bit 1	-	-	-	"Error" An error is present.
	Bit 2	-	-	-	"RestartActive" A restart is active. The technology object is reinitialized.
	Bit 3	-	-	-	"OnlineStartValuesChanged" The restart tags have been changed. For the changes to be applied, the technology object must be reinitialized.
	Bit 4	-	-	-	"ControlPanelActive" The axis control panel is active.
	Bit 5	-	-	-	Reserved
	Bit 6	-	-	-	"Done" No motion job is in progress and the axis control panel is deactivated.
	Bit 7	-	-	-	Reserved
	Bit 8	-	-	-	Reserved
	Bit 9	-	-	-	"JogCommand" An "MC_MoveJog" job is running.
	Bit 10	-	-	-	"VelocityCommand" An "MC_MoveVelocity" job is running.
	Bit 11	-	-	-	Reserved

[1] The bit is correctly displayed only when using SIEMENS telegram 10x. When using Mc_TorqueRange without SIEMENS telegram 10x, compare M_ACT with M_LIMIT_POS or M_LIMIT_NEG of telegram 750. InLimit = M_ACT * 0.9 > M_LIMIT_POS OR M_ACT * 0.9 < M_LIMIT_NEG. Evaluate the variable InLimit instead of StatusWord.%X27.

Tag	Data type	Values	W	Description
Bit 12	-	-	-	"ConstantVelocity" The velocity setpoint is reached. A constant velocity setpoint is output.
Bit 13	-	-	-	"Accelerating" An acceleration operation is active.
Bit 14	-	-	-	"Decelerating" A deceleration operation is active.
Bit 15... Bit 24	-	-	-	Reserved
Bit 25	-	-	-	"AxisSimulation" The simulation is active.
Bit 26	-	-	-	"TorqueLimitingCommand" An "MC_TorqueLimiting" job is running.
Bit 27	-	-	-	"InLimitation" The drive operates at least at the threshold value (default 90%) of the torque limit.
Bit 28... Bit 31	-	-	-	Reserved

[1] The bit is correctly displayed only when using SIEMENS telegram 10x. When using Mc_TorqueRange without SIEMENS telegram 10x, compare M_ACT with M_LIMIT_POS or M_LIMIT_NEG of telegram 750. InLimit = M_ACT * 0.9 > M_LIMIT_POS OR M_ACT * 0.9 < M_LIMIT_NEG. Evaluate the variable InLimit instead of StatusWord.%X27.

10.2.16 "StatusWord2" tag (speed axis)

The "<TO>.StatusWord2" tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 0 "StopCommand") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend (Page 393)

Tag	Data type	Value range	W	Description
StatusWord2	DWORD	-	RON	Status information of the technology object
Bit 0	BOOL	-	RON	"StopCommand" An "MC_Stop" job is running. The technology object is disabled.
Bit 1 to Bit 31	BOOL	-	RON	Reserved

10.2.17 "ErrorWord" tag (speed axis)

The "<TO>.ErrorWord" tag shows the error groups in which there is at least one technology alarm for the technology object. The tag takes technology alarms of the alarms requiring acknowledgment and serious errors alarm classes into consideration.

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

To read out the specific alarm number of the technology alarm with the highest priority associated with the technology object, evaluate the tag "<TO>.ErrorDetail.Number".

You can use the "Get_Alarm" instruction, for example, to evaluate all technology alarms pending on the technology object.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" System error
Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
Bit 4	-	-	-	"DriveFault" Error in drive
Bit 5	-	-	-	Reserved
Bit 6	-	-	-	"DynamicError" Specified dynamic values are limited to permissible values.
Bit 7	-	-	-	"CommunicationFault" Communication error Missing or faulty communication.
Bit 8... Bit 12	-	-	-	Reserved
Bit 13	-	-	-	"PeripheralError" Error accessing a logical address
Bit 14	-	-	-	Reserved
Bit 15	-	-	-	"AdaptionError" Error during data transfer
Bit 16 ... Bit 31	-	-	-	Reserved

10.2.18 "ErrorDetail" tag (speed axis)

The "<TO>.ErrorDetail" tag structure contains the alarm number and the effective local alarm response of the technology alarm pending on the technology object with the highest priority.

You can find a list of the technology alarms and alarm responses in the "Overview of the technology alarms" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.

You can use the "Get_Alarm" instruction, for example, to evaluate all technology alarms pending on the technology object.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
ErrorDetail.	TO_Struct_ErrorDetail				
Number	UDINT	-	RON	Alarm number	
Reaction	DINT	0 to 5	RON	Effective alarm response	
				0	No reaction
				1	Stop with current dynamic values
				2	Stop with maximum dynamic values
				3	Stop with emergency stop ramp
				4	Remove enable
				5	Track setpoints

10.2.19 "WarningWord" tag (speed axis)

The "<TO>.WarningWord" tag indicates pending warnings at the technology object.

Information on the evaluation of the individual bits (e.g. bit 13 "PeripheralWarning") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use

Tag	Data type	Values	W	Description
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
Bit 4	-	-	-	"DriveWarning" Warning of the drive When a warning message is pending at the drive that does not result in a TO alarm, this bit is not set. Evaluate the drive warnings directly using the status word of the drive.
Bit 5	-	-	-	Reserved
Bit 6	-	-	-	"DynamicWarning" Specified dynamic values are limited to permissible values.
Bit 7	-	-	-	"CommunicationWarning" Communication error Missing or faulty communication.
Bit 8... Bit 12	-	-	-	Reserved
Bit 13	-	-	-	"PeripheralWarning" Error accessing a logical address
Bit 14	-	-	-	Reserved
Bit 15	-	-	-	"AdaptionWarning" Error in automatic data transfer
Bit 16... Bit 31	-	-	-	Reserved

10.2.20 "ControlPanel" tag (speed axis)

The tag structure "<TO>.ControlPanel.<tag name>" contains no relevant data for you. This tag structure is internally used.

10.2.21 "InternalToTrace" tag (speed axis)

The tag structure "<TO>.InternalToTrace.<tag name>" contains no relevant data for you. This tag structure is internally used.

10.3 Tags of the positioning axis technology object

10.3.1 Actual values and setpoints (positioning axis)

The following tags indicate the setpoint and actual values of the technology object.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
Position	LREAL	-	RON	Position setpoint	
Velocity	LREAL	-	RON	Velocity setpoint/speed setpoint	
ActualPosition	LREAL	-	RON	Actual position	
ActualVelocity	LREAL	-	RON	Actual velocity	
ActualSpeed	LREAL	-	RON	For PROFIdrive drives	Actual speed of the motor
				For drives with analog setpoint interface	0.0
				For drives with linear motor	0.0
Acceleration	LREAL	-	RON	Setpoint acceleration	
ActualAcceleration	LREAL	-	RON	Actual acceleration	
OperativeSensor	UDINT	1 to 4	RON	Operative encoder	
ModuloCycle	DINT	-2147483648 to 2147483647	RON	Number of modulo cycles of the setpoint	
ActualModuloCycle	DINT	-2147483648 to 2147483647	RON	Number of modulo cycles of the actual value	
VelocitySetpoint	LREAL	-1.0E12 to 1.0E12	RON	Output velocity setpoint/speed setpoint	

10.3.2 "Simulation" tag (positioning axis)

The tag structure "<TO>.Simulation.<tag name>" contains the configuration of the simulation mode. In simulation mode, you can simulate axes without a real drive in the CPU.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
Simulation.	TO_Struct_AxisSimulation				
Mode	UDINT	0, 1	RES[1]	Simulation mode	
				0	No simulation, normal operation
				1	Simulation mode

[1] Technology version V2.0: RON

10.3.3 "VirtualAxis" tag (positioning axis)

The tag structure "<TO>.VirtualAxis.<tag name>" contains the configuration of the virtual operation of the axis. A virtual axis is often used as a virtual leading axis in order to generate the setpoints for several real following axes in synchronous operation.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
VirtualAxis.	TO_Struct_VirtualAxis				
Mode	UDINT	0, 1	RON	Virtual axis	
				0	No virtual axis
				1	Technology version ≤ V7.0: The behavior of a virtual axis is identical to the behavior of an axis in simulation. The actual values are generated via the control loop and a simplified drive model. Technology version ≥ V8.0: In technology version V8.0, the behavior of the virtual axis has been changed. The behavior of a virtual axis is no longer identical to the behavior of an axis in simulation. The position and velocity setpoints are directly adopted as actual values with an application cycle delay. The feedback loop and the drive model are not simulated. The dynamic filter is effective. To maintain compatibility with virtual axes of technology versions ≤ V7.0 for an axis: 1. Switch on the axis in simulation (<TO>.Simulation.Mode = 1). 2. Deactivate the virtual axis (<TO>.VirtualAxisMode = 0).

10.3.4 "Actor" tag (positioning axis)

The tag structure "<TO>.Actor.<tag name>" contains the controller-side configuration of the drive.

Tags

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Tag	Data type	Values	W	Description	
Actor.	TO_Struct_Actor				
Type	DINT	0, 1	RON	Drive connection	
				0	Analog output
				1	PROFIdrive telegram
InverseDirection	BOOL	-	RES	Inversion of the setpoint	
				FALSE	No
				TRUE	Yes
DataAdaption	DINT	0, 1	RES	Automatic transfer of the drive values reference speed, maximum speed and reference torque	
				0	No automatic transfer, manual configuration of values
				1	Automatic transfer of values configured in the drive to the configuration of the technology object
Efficiency	LREAL	0.0 to 1.0	RES	Efficiency of mechanics (gear and leadscrew)	
MotorType	DINT	0.1	DL	Motor type	
				0	Round-frame motor (standard motor)
				1	Linear motor
LoadInertia	LREAL	0.0 to 1.0E12	DIR	Moment of inertia or weight of the load	
RemoveEnableReaction	WORD	16#0...16#7	RES[1]	Stop reaction on "Remove enable"	
				16#1	OFF1 – Ramp stop - Braking with ramp-function generator
				16#3	OFF2 – Coast stop - Coast down
				16#5	OFF3 – Quick stop - Quick stop
				16#7	OFF3 – Quick stop (compatible configuration for technology versions up to V7)
				16#0 16#2 16#4 16#6	Invalid
Interface.	TO_Struct_ActorInterface				
AddressIn	VREF	0 to 65535	RON	Input address for the PROFIdrive telegram	
AddressOut	VREF	0 to 65535	RON	Output address for the PROFIdrive telegram or the analog setpoint	

[1] With the Motion Control instruction "MC_WriteParameter", you can change the "Actor.RemoveEnableReaction" parameter during runtime. The change takes effect directly.

Tag	Data type	Values	W	Description
EnableDriveOutput	BOOL	-	RES	"Enable output" for analog drives FALSE: Disabled TRUE: Enabled
EnableDriveOutput-Address	VREF	0 to 65535	RON	Address for the "Enable output" for analog setpoint
DriveReadyInput	BOOL	-	RES	"Ready input" for analog drives The analog drive signals its readiness to receive speed setpoints. FALSE: Disabled TRUE: Enabled
DriveReadyInput-Address	VREF	0 to 65535	RON	Address for the "Enable input" for analog setpoint
EnableTorqueData	BOOL	-	RES	Torque data FALSE: Disabled TRUE: Enabled
TorqueDataAddressIn	VREF	0 to 65535	RON	Input address of the supplemental telegram
TorqueDataAddress-Out	VREF	0 to 65535	RON	Output address of additional telegram
DriveParameter.	TO_Struct_ActorDriveParameter			Valid when "<TO>.Actor.MotorType" = 0
ReferenceSpeed	LREAL	0.0 to 1.0E12	RES	Reference value (100%) for the speed setpoint (N-set) of the drive The speed setpoint is transferred in the PROFIdrive telegram as a normalized value from -200% to 200% of the "ReferenceSpeed". For setpoint specification via an analog output, the analog output can be operated in the range from -117% to 117%, provided the drive permits this.
MaxSpeed	LREAL	0.0 to 1.0E12	RES	Maximum value for the speed setpoint of the drive (N-set) (PROFIdrive: MaxSpeed ≤ 2 × ReferenceSpeed Analog setpoint: MaxSpeed ≤ 1.17 × ReferenceSpeed)
ReferenceTorque	LREAL	0.0 to 1.0E12	RES	Reference value (100%) for the drive torque
MotorInertia	LREAL	0.0 to 1.0E12	DIR	Moment of inertia of the motor
LinearMotorDrivePara-meter.	TO_Struct_LinearMotorActorDrive-Parameter			Valid when "<TO>.Actor.MotorType" = 1
ReferenceVelocity	LREAL	0.0 to 1.0E12	RES	Reference value (100%) for the velocity setpoint (N-set) of the drive The speed setpoint is transferred in the PROFIdrive telegram as a normalized value from -200% to 200% of the "ReferenceVelocity". For setpoint specification via an analog output, the analog output can be operated in the range from -117% to 117%, provided the drive permits this.

[1] With the Motion Control instruction "MC_WriteParameter", you can change the "Actor.RemoveEnableReaction" parameter during runtime. The change takes effect directly.

Tag	Data type	Values	W	Description
MaxVelocity	LREAL	0.0 to 1.0E12	RES	Maximum value for the velocity setpoint of the drive (N-set) (PROFIdrive: MaxVelocity ≤ 2 × ReferenceVelocity Analog setpoint: MaxVelocity ≤ 1.17 × ReferenceVelocity)
ReferenceForce	LREAL	0.0 to 1.0E12	RES	Reference value (100%) for the force of the drive
MotorMass	LREAL	0.0 to 1.0E12	DIR	Mass of linear motor

[1] With the Motion Control instruction "MC_WriteParameter", you can change the "Actor.RemoveEnableReaction" parameter during runtime. The change takes effect directly.

10.3.5 "TorqueLimiting" tag (positioning axis)

The tag structure "<TO>.TorqueLimiting.<tag name>" contains the configuration of the force/torque limitation.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
TorqueLimiting.	TO_Struct_TorqueLimiting				
LimitBase	DINT	0, 1	RES	Force/torque limiting	
				0	Motor side
				1	Load side
				Setting is not relevant for linear motors.	
PositionBasedMonitor-ings	DINT	0, 1	RES	Positioning and following error monitoring	
				0	Monitoring deactivated
				1	Monitoring activated
LimitDefaults.	TO_Struct_TorqueLimitingLimitDe-faults				
Torque	LREAL	0.0 ... 1.0E12	CAL	Limiting torque	
Force	LREAL	0.0 ... 1.0E12	CAL	Limiting force	

10.3.6 "Clamping" tag (positioning axis)

The tag structure "<TO>.Clamping.<tag name>" contains the configuration of the fixed stop detection.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
Clamping.	TO_Struct_Clamping			
FollowingErrorDeviation	LREAL	0.001 to 1.0E12	DIR	Value of the following error starting from which the fixed stop is detected.
PositionTolerance	LREAL	0.001 to 1.0E12	DIR	Position tolerance for clamping monitoring

10.3.7 Sensor[1..4] tags (positioning axis)

The tag structure "<TO>.Sensor[1..4].<tag name>" contains the controller-end configuration of the encoder and the configuration of active and passive homing.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
Sensor[1..4].	ARRAY [1..4] OF TO_Struct_Sensor				
Existent	BOOL	-	RON	Displaying created encoders	
Type	DINT	0 to 2	RON	Encoder type	
				0	"INCREMENTAL" Incremental
				1	"ABSOLUTE" Absolute
				2	"CYCLIC_ABSOLUTE" Cyclic absolute
InverseDirection	BOOL	-	RES	Inversion of the actual value	
				FALSE	No
				TRUE	Yes
System	DINT	0, 1	RES	Encoder system	
				0	"LINEAR" Linear encoder
				1	"ROTATORY" Rotary encoder
MountingMode	DINT	0 to 2	RES	Mounting type of encoder	
				0	On motor shaft
				1	On load side
				2	External measuring system

Tag	Data type	Values	W	Description	
DataAdaption	DINT	0, 1	RES	Automatic transfer of the drive values reference speed, maximum speed and reference torque in the device	
				0	No automatic transfer, manual configuration of values
				1	Automatic transfer of values configured in the drive to the configuration of the technology object
ActualVelocityMode	DINT	0, 1	RES	Type of calculation for actual speed value or actual velocity value	
				0	Actual value calculation from differentiation of the position change
				1	Actual value calculation with NACT value from the PROFIdrive telegram
Interface.	TO_Struct_SensorInterface				
AddressIn	VREF	0 to 65535	RON	Input address for the PROFIdrive telegram	
AddressOut	VREF	0 to 65535	RON	Output address for the PROFIdrive telegram	
Number	UDINT	1 to 2	RON	Number of the encoder in the telegram	
Parameter.	TO_Struct_SensorParameter				
Resolution	LREAL	1.0E-12 ... 1.0E12	RES	Resolution of a linear encoder (offset between two encoder pulses)	
StepsPerRevolution	UDINT	1 to 8388608	RES	Increments per rotary encoder revolution	
FineResolutionXist1	UDINT	0 to 31	RES	Number of bits for fine resolution "Gx_XIST1" (cyclic actual encoder value)	
FineResolutionXist2	UDINT	0 to 31	RES	Number of bits for fine resolution "Gx_XIST2" (absolute value of the encoder)	
DeterminableRevolutions	UDINT	0 to 8388608	RES	Number of differentiable encoder revolutions for a multi-turn absolute encoder (For a single-turn absolute encoder = 1; for an incremental encoder = 0)	
DistancePerRevolution	LREAL	0.0 to 1.0E12	RES	For technology objects < V8.0: Load distance per revolution of an externally mounted encoder For technology objects >= V8.0: Load travel per measuring wheel revolution of an externally mounted encoder	
BehaviorGx_XIST1	DINT	0, 1	RES	Evaluation of "Gx_XIST1" bits.	
				0	Based on the bits of the encoder resolution. The incremental actual value "Gx_XIST1" is transmitted with less than 32 bits in the PROFIdrive telegram. For example: At 16 bits, the value ranges from 0 to 65,535.
				1	32-bit value of the encoder value The "Gx_XIST1" incremental actual value is transferred with 32 bits of 0 to 4,294,967,295 in the PROFIdrive telegram.
ReferenceSpeed	LREAL	0.0 to 1.0E12	RES	Reference speed for NACT in PROFIdrive telegram with rotary encoder Only relevant for "ActualVelocityMode" = 1	

Tag	Data type	Values	W	Description	
ReferenceVelocity	LREAL	0.0 to 1.0E12	RES	Reference velocity for NACT in the PROFIdrive telegram with linear encoder Only relevant for "ActualVelocityMode" = 1	
Backlash.	TO_Struct_Backlash				
Enable	BOOL	-	DIR	Enable backlash compensation	
				FALSE	Disabled
				TRUE	Enabled
				If you enable or disable backlash compensation at runtime, you must home the axis again.	
Size	LREAL	0.0 to 1.0E12	DIR	Size of backlashes	
				If you change the size of backlashes during runtime, you have to home the axis again.	
Velocity	LREAL	0.0 to 1.0E12	DIR	Velocity for traversing of backlashes	
				0.0	Motor traverses backlashes within one servo cycle.
				> 0.0	Motor traverses backlash with the specified velocity.
DirectionAbsolute-Homing	DINT	0, 1	DIR	Direction of movement during or before absolute encoder adjustment	
				0	Positive
				1	Negative
ActiveHoming.	TO_Struct_SensorActiveHoming				
Mode	DINT	0 to 2	RES	Homing mode	
				0	Use zero mark via PROFIdrive telegram
				1	Zero mark via PROFIdrive telegram and reference output cam
				2	Use homing mark via digital input
SideInput	BOOL	-	CAL	Side of the digital input for active homing	
				FALSE	Negative side
				TRUE	Positive side
Direction	DINT	0, 1	CAL	Homing direction or homing mark approach direction	
				0	Positive homing direction
				1	Negative homing direction
DigitalInputAddress	VREF	0 to 65535	RON	Address of digital input	
HomePositionOffset	LREAL	-1.0E12 ... 1.0E12	CAL	Home position offset	
SwitchLevel	BOOL	-	RES	Signal level that is present at the digital input when homing mark is approached	
				FALSE	Low level

Tag	Data type	Values	W	Description	
SwitchLevel	BOOL	-	RES	TRUE	High level
PassiveHoming.	TO_Struct_SensorPassiveHoming				
Mode	DINT	0 to 2	RES	Homing mode	
				0	Use zero mark via PROFIdrive telegram
				1	Zero mark via PROFIdrive telegram and reference output cam
				2	Use homing mark via digital input
SideInput	BOOL	-	CAL	Side of the digital input for passive homing	
				FALSE	Negative side
				TRUE	Positive side
Direction	DINT	0 to 2	CAL	Homing direction or homing mark approach direction	
				0	Positive homing direction
				1	Negative homing direction
				2	Current homing direction
DigitalInputAddress	VREF	0 to 65535	RON	Address of digital input	
SwitchLevel	BOOL	-	RES	Signal level that is present at the digital input when homing mark is approached	
				FALSE	Low level
				TRUE	High level
MeasuringGear.	TO_Struct_SensorMeasuringGear				
Numerator	UDINT	1 to 4294967295	RES	Default value 1. For “MountingMode” = Motor side (0): Specifies the counter of the gear ratio for a measuring wheel for motor-mounted encoders. Number of motor revolutions. For “MountingMode” = Load side (1): Specifies the counter of the gear ratio for a measuring gearwheel for load-mounted encoders. Number of load revolutions. For “MountingMode” = External (2): Specifies the counter of the gear ratio for a measuring gearwheel for externally mounted encoders. Number of revolutions of the measuring wheel.	
Denominator	UDINT	1 to 4294967295	RES	Specifies the denominator of the gear wheel for a measuring wheel. It depends on "MountingMode". Number of encoder revolutions.	

10.3.8 "CrossPlcSynchronousOperation" tag (positioning axis)

The tag structure "<TO>.CrossPlcSynchronousOperation.<tag name>" contains the configuration of the cross-PLC synchronous operation.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
CrossPlcSynchronousOperation.	TO_Struct_CrossPlcSynchronousOperation				
Interface[1..32].	ARRAY [1..32] of TO_Struct_CrossPlcLeadingValueInterface				
EnableLeadingValueOutput	BOOL	-	RON	Provide cross-PLC leading value	
				FALSE	No
				TRUE	Yes
AddressOut	VREF	-	RON	Output address for the leading value telegram	
TelegramVersion	WORD	1, 2	RON	Leading value telegram version	
				1	Version 1 (technology version ≤ 8.0 and ≥ 10.0)
				2	Version 2 (technology version ≥ 9.0)
LocalLeadingValueDelayTime	LREAL	0.0 to 1.0E9	RES	Delay time of leading value output to the local following axes	

10.3.9 "Extrapolation" tag (positioning axis)

The tag structure "<TO>.Extrapolation.<tag name>" contains the configuration of the actual value extrapolation.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
Extrapolation.	TO_Struct_Extrapolation			
LeadingAxisDependentTime	LREAL	-	RON	Extrapolation time component (caused by leading axis) Results from the following times: • Time of actual value acquisition for the leading axis • Interpolator cycle clock • Time of position filter of actual value extrapolation (T1 + T2)
FollowingAxisDependentTime	LREAL	0.0 to 1.0E12	DIR	Extrapolation time component (caused by following axis)

Tag	Data type	Values	W	Description	
				For a following axis with set velocity precontrol, the following times result in: • Communication cycle • Interpolator cycle clock • Speed control loop substitute time for the following axis • Output delay time of the setpoint at the following axis For a following axis without velocity precontrol, the following times result in: • Communication cycle • Interpolator cycle clock • Position control loop equivalent time (1/Kv from "<TO>.PositionControl.Kv") • Output delay time of the setpoint at the following axis	
Settings.	TO_Struct_ExtrapolationSettings				
SystemDefinedExtrapolation	DINT	0, 1	RES	Leading axis dependent time	
				0	Not effective
				1	Effective
ExtrapolatedVelocityMode	DINT	0, 1, 2	RES	Effective velocity value for the synchronization function	
				0	Filtered velocity Leading value velocity from filtered actual velocity
				1	Extrapolated velocity Leading value velocity from extrapolation
				2	Differentiated velocity Leading value velocity from differentiation of the extrapolated leading value position
PositionFilter.	TO_Struct_ExtrapolationPositionFilter				
T1	LREAL	0.0 to 1.0E12	DIR	Position filter time constant T1	
T2	LREAL	0.0 to 1.0E12	DIR	Position filter time constant T2	
VelocityFilter.	TO_Struct_ExtrapolationVelocityFilter				
T1	LREAL	0.0 to 1.0E12	DIR	Velocity filter time constant T1	
T2	LREAL	0.0 to 1.0E12	DIR	Velocity filter time constant T2	
VelocityTolerance.	TO_Struct_ExtrapolationVelocityTolerance				
Range	LREAL	0.0 to 1.0E12	DIR	Tolerance band width for velocity	
Hysteresis.	TO_Struct_ExtrapolationHysteresis				
Value	LREAL	0.0 to 1.0E12	DIR	Hysteresis of the extrapolated actual position value	

10.3.10 "LoadGear" tag (positioning axis)

The tag structure "<TO>.LoadGear.<tag name>" contains the configuration of the load gear.

Tags

Legend (Page 393)

Tag	Data type	Value range	W	Description
LoadGear.	TO_Struct_LoadGear			
Numerator	UDINT	1 to 4294967295	RES	Load gear numerator
Denominator	UDINT	1 to 4294967295	RES	Load gear denominator

10.3.11 "Properties" tag (positioning axis)

The tag structure "<TO>.Properties.<tag name>" contains the configuration of the type of axis or motion.

Tags

Legend (Page 393)

Tag	Data type	Value range	W	Description	
Properties.	TO_Struct_Properties				
MotionType	DINT	0, 1	RON	Indication of axis type or motion type	
				0	Linear axis or motion
				1	Rotary axis or motion

10.3.12 "Units" tag (positioning axis)

The tag structure "<TO>.Units.<tag name>" shows the set technological units.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
Units.	TO_Struct_Units / TO_Struct_ExternalEncoder_Units				
LengthUnit	UDINT	-	RON	Unit for position	
				1010	m
				1013	mm
				1536	mm[1)]
				1011	km

1) Position values with higher resolution or six decimal places

Tag	Data type	Values	W	Description	
LengthUnit	UDINT	-	RON	1014	µm
				1015	nm
				1019	in
				1018	ft
				1021	mi
				1004	rad
				1005	°
				1537	°[1]
VelocityUnit	UDINT	-	RON	Unit for velocity	
				1521	°/s
				1539	°/s[1]
				1522	°/min
				1086	rad/s
				1523	rad/min
				1062	mm/s
				1538	mm/s[1]
				1061	m/s
				1524	mm/min
				1525	m/min
				1526	mm/h
				1063	m/h
				1527	km/min
				1064	km/h
				1066	in/s
				1069	in/min
				1067	ft/s
				1070	ft/min
				1075	mi/h
TimeUnit	UDINT	-	RON	Unit for time	
				1054	s
TorqueUnit	UDINT	-	RON	Unit for torque	
				1126	Nm
				1128	kNm
				1529	lbf in (pound-force-inch)
				1530	lbf ft
				1531	ozf in (ounce-force-inch)
				1532	ozf ft
				1533	pdl in (poundal-inch)

[1] Position values with higher resolution or six decimal places

Tag		Data type	Values	W	Description	
	TorqueUnit	UDINT	-	RON	1534	pdl ft
	ForceUnit	UDINT	-	RON	Unit for force	
					1120	N
					1122	kN
					1094	lbf (pound-force)
					1093	ozf (ounce-force)
					1535	pdl (poundals)
	MassUnit	UDINT	-	RON	Unit for mass	
					1088	kg
					1089	g
					1090	mg
					1092	t
					1540	lb
	IneritaUnit	UDINT	-	RON	Unit for moment of inertia	
					1118	kg·m²
					1541	lb·ft²

1) Position values with higher resolution or six decimal places

See also

Units of measure (Page 34)

10.3.13 "Mechanics" tag (positioning axis)

The tag structure "<TO>.Mechanics.<tag name>" contains the configuration of the mechanics.

Tags

Legend (Page 393)

Tag		Data type	Value range	W	Description
Mechanics.		TO_Struct_Mechanics			
	LeadScrew	LREAL	1.0E-12 to 1.0E12	RES	Leadscrew pitch

10.3.14 "Modulo" tag (positioning axis)

The tag structure "<TO>.Modulo.<tag name>" contains the configuration of the modulo function.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
Modulo.	TO_Struct_Modulo				
Enable	BOOL	-	RES	FALSE	Modulo conversion disabled
				TRUE	Modulo conversion enabled
Length	LREAL	0.001 to 1.0E12	RES	Modulo length When modulo conversion is enabled, a check is made for modulo length > 0.0	
StartValue	LREAL	-1.0E12 to 1.0E-12	RES	Modulo start value	

10.3.15 "DynamicLimits" tag (positioning axis)

The tag structure "<TO>.DynamicLimits.<tag name>" contains the configuration of the dynamic limits. During Motion Control, no dynamic values greater than the dynamic limits are permitted. If you specify greater values in a Motion Control instruction, then motion is performed using the dynamic limits, and a warning is indicated (alarm 501 to 503 - Dynamic values are limited).

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
DynamicLimits.	TO_Struct_DynamicLimits			
MaxVelocity	LREAL	0.0 to 1.0E12	RES	Maximum permissible velocity of the axis
Velocity	LREAL	0.0 to 1.0E12	DIR	Current maximum velocity of the axis The minimum from "MaxVelocity" and "Velocity" is effective for motion control.
MaxAcceleration	LREAL	0.0 to 1.0E12	DIR	Maximum permissible acceleration of the axis
MaxDeceleration	LREAL	0.0 to 1.0E12	DIR	Maximum permissible deceleration of the axis
MaxJerk	LREAL	0.0 to 1.0E12	DIR	Maximum permissible jerk on the axis

10.3.16 "DynamicDefaults" tag (positioning axis)

The tag structure "<TO>.DynamicDefaults.<tag name>" contains the configuration of the dynamic defaults. These settings will be used when you specify a dynamic value less than 0.0 in a Motion Control instruction (exceptions: "MC_MoveJog.Velocity", "MC_MoveVelocity.Velocity"). Changes to the default dynamic values will be applied at the next positive edge at the "Execute" parameter of a Motion Control instruction.

Tags

Legend (Page 393)

Tag		Data type	Values	W	Description
DynamicDefaults.		TO_Struct_DynamicDefaults			
	Velocity	LREAL	0.0 to 1.0E12	CAL	Default velocity
	Acceleration	LREAL	0.0 to 1.0E12	CAL	Default acceleration
	Deceleration	LREAL	0.0 to 1.0E12	CAL	Default deceleration
	Jerk	LREAL	0.0 to 1.0E12	CAL	Default jerk
	EmergencyDecelera-tion	LREAL	0.0 to 1.0E12	DIR	Emergency stop deceleration

10.3.17 "PositionLimits_SW" tag (positioning axis)

The tag structure "<TO>.PositionLimits_SW.<tag name>" contains the configuration of position monitoring with software limit switches. Software limit switches are used to limit the operating range of a positioning axis.

Tags

Legend (Page 393)

Tag		Data type	Values	W	Description	
PositionLimits_SW.		TO_Struct_PositionLimitsSW				
	Active	BOOL	-	DIR	FALSE	Monitoring deactivated
					TRUE	Monitoring enabled
	MinPosition	LREAL	-1.0E12 to 1.0E-12	DIR	Position of negative software limit switches	
	MaxPosition	LREAL	-1.0E12 to 1.0E-12	DIR	Position of positive software limit switches ("MaxPosition" > "MinPosition")	
	LimitReachedBehavior	DINT	0 ... 1	RES	Alarm response when a software limit switch is approached with a single axis job	
					0	Stop with maximum dynamic values
					1	Stop with current dynamic values
	LimitExceededBehavior	DINT	0 ... 1	RES	Alarm response when overrunning a software limit switch	
					0	Disable axis
					1	Keep emergency stop and axis enable

10.3.18 "PositionLimits_HW" tag (positioning axis)

The tag structure "<TO>.PositionLimits_HW.<tag name>" contains the configuration of position monitoring with hardware limit switches. Hardware limit switches are used to limit the traversing range of a positioning axis.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
PositionLimits_HW.	TO_Struct_PositionLimitsHW				
Active	BOOL	-	RES[1]	FALSE	Monitoring deactivated
				TRUE	Monitoring enabled
				With "Active", both (negative and positive) hardware limit switches are activated or deactivated.	
MinSwitchLevel	BOOL	-	RES	Level for activation of the negative hardware limit switch	
				FALSE	Low level (Low active)
				TRUE	High level (high-enabled)
MinSwitchAddress	VREF	0 to 65535	RES	Address for the negative hardware limit switch	
MaxSwitchLevel	BOOL	-	RES	Level for activation of the positive hardware limit switch	
				FALSE	Low level (Low active)
				TRUE	High level (high-enabled)
MaxSwitchAddress	VREF	0 to 65535	RES	Address for the positive hardware limit switch	
Mode	DINT	0, 1	RES	Type of HW limit switch	
				0	Switch non-traversable
				1	Switch traversable
AppoachBehavior	DINT	0, 1	RES	Alarm response when approaching a HW limit switch	
				0	Disable axis
				1	Keep emergency stop and axis enabled

[1] With the Motion Control instruction "MC_WriteParameter", you can change the "PositionLimits_HW.Active" parameter at runtime. The change takes effect directly.

See also

MC_WriteParameter: Write parameter V10 (Page 346)

10.3.19 "Homing" tag (positioning axis)

The tag structure "<TO>.Homing.<tag name>" contains the configuration for homing the TO.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
Homing.	TO_Struct_Homing / TO_Struct_ExternalEncoder_Homing			
AutoReversal	BOOL	-	RES	Reversal at the hardware limit switches FALSE: No TRUE: Yes
ApproachDirection	BOOL	-	CAL	Direction of approach to the homing position switch FALSE: Positive direction TRUE: Negative direction
ApproachVelocity	LREAL	Linear: 0.0 to 10000.0 mm/s Rotary: 0.0 to 360000.0 °/s	CAL	Approach velocity Velocity during active homing at which the reference output cam and home position are approached.
ReferencingVelocity	LREAL	Linear: 0.0 to 1000.0 mm/s Rotary: 0.0 to 36000.0 °/s	CAL	Homing velocity Velocity during active homing at which the home position is approached.
HomePosition	LREAL	-1.0E12 to 1.0E12	CAL	Home position

10.3.20 "Override" tag (positioning axis)

The tag structure "<TO>.Override.<tag name>" contains the configuration of override parameters. The override parameters are used to apply a correction percentage to default values. An override change takes effect immediately, and is performed with the dynamic settings in effect in the Motion Control instruction.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
Override.	TO_Struct_Override			
Velocity	LREAL	0.0 to 200.0%	DIR	Velocity or speed override Percentage correction of the velocity or speed

10.3.21 "PositionControl" tag (positioning axis)

The tag structure "<TO>.PositionControl.<tag name>" contains the settings of position control.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
PositionControl.	TO_Struct_PositionControl			
Kv	LREAL	0.0 to 2147480.0	DIR	Proportional gain of the closed loop position control ("Kv" > 0.0)
Kpc	LREAL	0.0 to 150.0%	DIR	Velocity precontrol of the position control Recommended setting: • Isochronous drive connection via PROFIdrive: 100.0% • Non-isochronous drive connection via PROFIdrive: 0.0 to 100.0% • Analog drive connection: 0.0 to 100.0%
EnableDSC	BOOL	-	RES	Dynamic Servo Control (DSC) FALSE: DSC disabled TRUE: DSC activated DSC is only possible with one of the following PROFIdrive telegrams: • Standard telegram 5 or 6 • SIEMENS telegram 105 or 106
SmoothingTimeByChangeDifference	LREAL	0.0 to 1.0E12 s	DIR	Smoothing time for the manipulated variable for switching operations, for example: • Encoder switchover • Change in P-gain ("Kv") • Switchover to emergency stop ramp
InitialOperativeSensor	UDINT	1 to 4	RES	Active sensor after initialization of the axis (sensor number 1 to 4) This encoder is used after startup of the CPU and after a restart of the technology object. At an operating mode transition from STOP → RUN of the CPU (without restart of the technology object), the encoder that was also active before the STOP is still being used.
ControlDifferenceQuantization.	TO_Struct_PositionDifferenceQuantification			
Mode	DINT	-	RES	Type of quantification Configuration of a quantization when a drive with stepper motor interface is connected 0: No quantification 1: Quantization corresponding to encoder resolution 2: Quantization to a direct value

Tag	Data type	Values	W	Description
Mode	DINT	-	RES	(configuration is performed using the parameter view (data structure))
Value	LREAL	0.001 to 1.0E12	RES	Value of quantification Configuration of a value for quantization to a direct value ("<TO>.PositionControl.ControlDifferenceQuantization.Mode" = 2) (configuration is performed using the parameter view (data structure))
VelocityModePowerOn	DINT	0 to 1	RES	Behavior of the velocity setpoint when the axis is enabled
				0 Velocity is set to "0" with maximum dynamic values of the axis (ramp).
				1 Velocity is immediately set to "0" without ramp.

10.3.22 "TorquePreControl" tag (positioning axis)

The tag structure "<TO>.TorquePreControl.<tag name>" contains the settings of the torque precontrol.

Tags

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Tag	Data type	Values	W	Description
TorquePreControl.	TO_Struct_TorquePreControl			
Mode	DINT	0, 1	RES	Mode of torque precontrol (effect only in position-controlled mode)
				0 Torque precontrol not in effect
				1 Torque precontrol based on the acceleration of the axis
Scale	LREAL	0.0 to 150.0	DIR	Weighting factor for the value of the torque precontrol [%]

10.3.23 "SetpointFilter" tag (positioning axis)

The tag structure "<TO>.SetpointFilter.<tag name>" contains the settings of the setpoint filter.

Tags

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Tag	Data type	Values	W	Description
SetpointFilter.	TO_Struct_SetpointFilter			
DynamicFilter.	TO_Struct_DynamicFilter			
Mode	DINT	0 to 2	RES	Dynamic filter mode

1) The dead time T_t is internally limited to sixteen times the value from the application cycle of the MC_Servo. No alarm is output at higher values.

Tag	Data type	Values	W	Description	
Mode	DINT	0 to 2	RES	0	Dynamic filter not active
				1	PT1/PT2 filter + dead time
				2	Sliding window demand + dead time
T1	LREAL	0.0 to 1.0E12	DIR	First time constant of the sliding window demand The value is internally limited to the 16-fold servo clock.	
T2	LREAL	0.0 to 1.0E12	DIR	Second time constant of the sliding window demand The value is internally limited to the 16-fold servo clock.	
Tt	LREAL	0.0 to 1.0E12[1)]	DIR	Additional dead time of the dynamic filter in time unit of the axis	

1) The dead time T_t is internally limited to sixteen times the value from the application cycle of the MC_Servo. No alarm is output at higher values.

10.3.24 "DynamicAxisModel" tag (positioning axis)

The tag structure "<TO>.DynamicAxisModel.<tag name>" contains the balancing filter settings.

Tags

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Tag	Data type	Values	W	Description
DynamicAxisModel.	TO_Struct_DynamicAxisModel			
VelocityTimeConstant	LREAL	0.0 to 1.0E12	DIR	Speed control loop substitute time [s]
AdditionalPositionTime-Constant	LREAL	0.0 to 1.0E12	DIR	Additive position control loop substitute time [s]
CurrentTimeConstant	LREAL	0.0 to 1.0E12	DIR	Current control loop substitute time in time unit of the axis

10.3.25 "FollowingError" tag (positioning axis)

The tag structure "<TO>.FollowingError.<tag name>" contains the configuration of the dynamic following error monitoring.

If the permissible following error is exceeded, then technology alarm 521 is output, and the technology object is disabled (alarm reaction: remove enable).

When the warning level is reached, a warning is output (technology alarm 522).

Tags

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Tag	Data type	Values	W	Description	
FollowingError.	TO_Struct_FollowingError				
EnableMonitoring	BOOL	-	RES	FALSE	Following error monitoring deactivated
				TRUE	Following error monitoring enabled

Tag	Data type	Values	W	Description
MinValue	LREAL	Linear: 0.0 to 1.0E12 Rotary: 0.001 to 1.0E12	DIR	Permissible following error at velocities below the value of "MinVelocity"
MaxValue	LREAL	Linear: 0.0 to 1.0E12 Rotary: 0.002 to 1.0E12	DIR	Maximum permissible following error, which may be reached at the maximum velocity.
MinVelocity	LREAL	0.0 to 1.0E12	DIR	"MinValue" is permissible below this velocity and is held constant.
WarningLevel	LREAL	0.0 to 100.0	DIR	Warning level Percentage value relative to the valid maximum following error
AdditionalSetpointDelay-Time	LREAL	0.0 to 1.0E12	DIR	Time constant for additional deceleration of position set-point to calculate the following error in the time unit of the axis

10.3.26 "PositioningMonitoring" tag (positioning axis)

The tag structure "<TO>.PositioningMonitoring.<tag name>" contains the configuration of position monitoring at the end of a positioning motion.

If the actual position value at the end of a positioning motion is reached within the tolerance time and remains in the positioning window for the minimum dwell time, then "<TO>.StatusWord.X6 (Done)" is set in the technology data block. This completes a Motion Control job.

If the tolerance time is exceeded, then technology alarm 541 "Positioning monitoring" with supplemental value 1: "Target range not reached" is displayed.

If the minimum dwell time is not met, then technology alarm 541 "Positioning monitoring" with supplemental value 2: "Exit target range again" is displayed.

Tags

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Tag	Data type	Values	W	Description
PositioningMonitoring.	TO_Struct_PositionMonitoring			
ToleranceTime	LREAL	0.0 to 1.0E12	DIR	Tolerance time Maximum permitted duration from reaching of velocity setpoint zero until entrance into the positioning window
MinDwellTime	LREAL	0.0 to 1.0E12	DIR	Minimum dwell time in positioning window
Window	LREAL	0.001 to 1.0E12	DIR	Positioning window

10.3.27 "StandstillSignal" tag (positioning axis)

The tag structure "<TO>.StandstillSignal.<tag name>" contains the configuration of the standstill signal.

If the actual velocity value is below the velocity threshold, and does not exceed it during the minimum dwell time, then the standstill signal "<TO>.StatusWord.X7 (Standstill)" is set.

Tags

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Tag	Data type	Values	W	Description
StandstillSignal.	TO_Struct_StandstillSignal			Configuration for the standstill signal
VelocityThreshold	LREAL	0.0 to 1.0E12	DIR	Velocity threshold If velocity is below this threshold, the minimum dwell time begins.
MinDwellTime	LREAL	0.0 to 1.0E12	DIR	Minimum dwell time

10.3.28 "StatusPositioning" tag (positioning axis)

The tag structure "<TO>.StatusPositioning.<tag name>" indicates the status of a positioning motion.

Tags

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Tag	Data type	Values	W	Description
StatusPositioning.	TO_Struct_StatusPositioning			
Distance	LREAL	-1.0E12 ... 1.0E12	RON	Distance to target position
TargetPosition	LREAL	-1.0E12 ... 1.0E12	RON	Target position
TargetPositionModulo-Cycle	DINT	-2147483648 ... 2147483647	RON	Number of modulo cycles to target position with positioning motions
FollowingError	LREAL	-1.0E12 ... 1.0E12	RON	Current following error
SetpointExecutionTime	LREAL	0 ... 1.0E12	RON	Setpoint execution time of the axis (Results from T_{lpo}, T_{vtc} or 1/kv, T_{Send} and T_O of the axis)
SuperimposedDistance	LREAL	0 ... 1.0E12	RON	Use the instructions "MC_MoveSuperimposed", "MC_MotionInSuperimposed", "MC_MotionInSuperimposedAxes" and "MC_HaltSuperimposed" to move the distance. The value is reset when the basic motion and the superimposed motion are completed or the basic motion is aborted.

10.3.29 "StatusDrive" tag (positioning axis)

The tag structure "<TO>.StatusDrive.<tag name>" indicates the status of the drive.

Tags

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Tag	Data type	Values	W	Description	
StatusDrive.	TO_Struct_StatusDrive				
InOperation	BOOL	-	RON	Operation status of the drive	
				FALSE	Drive not ready Setpoints will not be executed.
				TRUE	Drive ready Setpoints can be executed.
CommunicationOK	BOOL	-	RON	Cyclic BUS communication between controller and drive	
				FALSE	Cyclic communication not established. Fault ZSW1.X3 (FaultPresent) is present. Possible causes: • The CPU is in STOP. • The drive has failed. • The "ControlRequested" bit in the status word of the drive has the value "FALSE". • The drive signals an error using the status word. • For isochronous configuration, the dynamic sign of life in the telegram has failed or is not supplied by the drive.
				TRUE	Cyclic communication OK and no fault effective
Error	BOOL	-	RON	FALSE	No drive error
				TRUE	Drive error
AdaptionState	DINT	0 to 4	RON	Status of automatic data transfer of drive parameters	
				0	"NOT_ADAPTED" Data not transferred
				1	"IN_ADAPTION" Data transfer in progress
				2	"ADAPTED" Data transfer complete
				3	"NOT_APPLICABLE" Data transfer not selected, not possible
				4	"ADAPTION_ERROR" Error during data transfer

10.3.30 "StatusServo" tag (positioning axis)

The tag structure "<TO>.StatusServo.<tag name>" indicates the status for the balancing filter.

Tags

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Tag	Data type	Values	W	Description
StatusServo.	TO_Struct_StatusServo			
BalancedPosition	LREAL	-	RON	Position setpoint after the balancing filter
ControlDifference	LREAL	-	RON	Control deviation
PositionAfterDynamicFilter	LREAL	-	RON	Position setpoint after the dynamic filter

10.3.31 "StatusProvidedLeadingValue" tag (positioning axis)

The tag structure "<TO>.StatusProvidedLeadingValue.<tag name>" contains the provided leading value with leading value delay of the cross-PLC synchronous operation.

Tags

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Tag	Data type	Values	W	Description
StatusProvidedLeadingValue.	TO_Struct_StatusProvidedLeadingValue			Provided leading value
DelayedLeadingValue	TO_Struct_ProvidedLeadingValue			Leading value with leading value delay
Position	LREAL	-1.0E12 to 1.0E-12	RON	Position
Velocity	LREAL	-1.0E12 to 1.0E-12	RON	Velocity
Acceleration	LREAL	-1.0E12 to 1.0E-12	RON	Acceleration

10.3.32 StatusSensor[1..4] Tags (positioning axis)

The tag structure "<TO>.StatusSensor[1..4].<tag name>" indicates the status of the measuring system.

Tags

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Tag	Data type	Values	W	Description
StatusSensor[1..4].	Array [1..4] OF TO_Struct_StatusSensor			
State	DINT	0 to 2	RON	Status of the actual encoder value

Tag	Data type	Values	W	Description	
State	DINT	0 to 2	RON	0	"NOT_VALID" Invalid
				1	"WAITING_FOR_VALID" Waiting for "Valid" status
				2	"VALID" Valid
CommunicationOK	BOOL	-	RON	Cyclic BUS communication between controller and encoder	
				FALSE	Not established
				TRUE	Established
Error	BOOL	-	RON	FALSE	No error in the measuring system
				TRUE	Error in the measuring system.
AbsEncoderOffset	LREAL	-	RON	Home position offset for value of an absolute value encoder. The value will be retentively stored in the CPU.	
Control	BOOL	-	RON	FALSE	Encoder is not active
				TRUE	Encoder is active
Position	LREAL	-	RON	Encoder position	
Velocity	LREAL	-	RON	Encoder velocity	
AdaptionState	DINT	0 to 4	RON	Status of automatic data transfer of encoder parameters	
				0	"NOT_ADAPTED" Data not transferred
				1	"IN_ADAPTION" Data transfer in progress
				2	"ADAPTED" Data transfer complete
				3	"NOT_APPLICABLE" Data transfer not selected, not possible
				4	"ADAPTION_ERROR" Error during data transfer
ModuloCycle	DINT	-2147483648 to 2147483647	RON	Number of modulo cycles	
Adjusted	DINT	0, 1	RON	Homing status of the encoder	
				0	Encoder not homed
				1	Encoder homed with one of the following homing types: • Active homing • Passive homing • Absolute encoder adjustment • Incremental encoder adjustment

10.3.33 "StatusExtrapolation" tag (positioning axis)

The tag structure "<TO>.StatusExtrapolation.<tag name>" indicates the status of the actual value extrapolation.

Tags

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Tag	Data type	Values	W	Description
StatusExtrapolation.	TO_Struct_StatusExtrapolation			
FilteredPosition	LREAL	-1.0E12 to 1.0E-12	RON	Position after position filter
FilteredVelocity	LREAL	-1.0E12 to 1.0E-12	RON	Velocity after velocity filter and tolerance band
ExtrapolatedPosition	LREAL	-1.0E12 to 1.0E-12	RON	Extrapolated position
ExtrapolatedVelocity	LREAL	-1.0E12 to 1.0E-12	RON	Extrapolated velocity

10.3.34 "StatusKinematicsMotion" tag (positioning axis)

The "<TO>.StatusKinematicsMotion" tag contains status information of the technology object with regard to usage as kinematics axis.

Information on evaluating individual bits (e.g. bit 2 "MaxDecelerationExceeded") can be found in the "Evaluating StatusWord, ErrorWord, and WarningWord" section of the "S7-1500/S7-1500T Motion Control overview" documentation.

Tag

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Tag	Data type	Values	W	Description	
StatusKinematicsMotion	DWORD	-	RON	Status information of the technology object	
Bit 0	-	-	-	"MaxVelocityExceeded"	
				0	The kinematics technology object calculated a lower velocity setpoint than the maximum velocity on the axis.
				1	The kinematics technology object calculated a higher velocity setpoint than the maximum velocity on the axis.
Bit 1	-	-	-	"MaxAccelerationExceeded"	
				0	The kinematics technology object calculated a lower setpoint acceleration calculated than the maximum acceleration of the axis.
				1	The kinematics technology object calculated a higher setpoint acceleration than the maximum acceleration of the axis.

Tag		Data type	Values	W	Description	
	Bit 2	-	-	-	"MaxDecelerationExceeded"	
					0	The kinematics technology object calculated a lower setpoint deceleration than the maximum deceleration of the axis.
					1	The kinematics technology object calculated a lower setpoint deceleration than the maximum deceleration of the axis.

10.3.35 "StatusTorqueData" tag (positioning axis)

The tag structure "<TO>.StatusTorqueData.<tag name>" shows the status of the force/torque data.

Tags

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Tag		Data type	Value range	W	Description	
StatusTorqueData.		TO_Struct_StatusTorqueData				
	CommandAdditiveT-orqueActive	DINT	0, 1	RON	Additive setpoint torque or additive setpoint force	
					0	Inactive
					1	Active
	CommandTorqueRange-Active	DINT	0, 1	RON	Force/torque limits B+, B-	
					0	Inactive
					1	Active
	ActualTorque	LREAL	-1.0E12 ... 1.0E12	RON	Actual torque of the axis	
	ActualForce	LREAL	-1.0E12 ... 1.0E12	RON	Actual force of the axis	
	TotalTorqueAdditive	LREAL	-1.0E12 ... 1.0E12	RON	Effective additional torque of the axis	
	TotalForceAdditve	LREAL	-1.0E12 ... 1.0E12	RON	Effective additional force of the axis	

10.3.36 "StatusMotionIn" tag (positioning axis)

The tag structure "<TO>.StatusMotionIn.<tag name>" indicates the status of the "MotionIn" function.

Tags

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Tag		Data type	Value range	W	Description	
StatusMotionIn.		TO_Struct_StatusMotionIn				
	FunctionState	DINT	0 to 2	RON	0	No "MotionIn" function active

Tag	Data type	Value range	W	Description	
FunctionState	DINT	0 to 2	RON	1	"MC_MotionInVelocity" active
				2	"MC_MotionInPosition" active
ActualSuperimposingAxis	DB_ANY	0 to 65535	RON	At the start of a "MC_MotionInSuperimposedAxes" job, the number of the technology data block of the currently used superimposing axis is displayed.	
				0	"MC_MotionInSuperimposedAxes" job inactive
StatusWord.	DWORD	-	RON	-	
Bit 0	Bool	-	RON	"MaxVelocityExceeded" The configured maximum velocity is exceeded during a MotionIn movement.	
Bit 1 ... Bit 31	Bool	-	RON	Reserved	

10.3.37 "StatusInterpreterMotion" tag (positioning axis)

The tag structure "<TO>.StatusInterpreterMotion.<tag name>" contains status information on motion jobs controlled by a technology object Interpreter.

Tags

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Tag	Data type	Values	W	Description
StatusInterpreterMotion.	TO_Struct_StatusInterpreterMotion			
Interpreter	DB_ANY	0 to 65535		Controlling Interpreter technology object
StatusWord.	DWORD	-	RON	Status information
Bit 0	-	-	-	"ControlledByInterpreter" An MCL job is processed or active or the bit is set via the MCL instruction "setControlledByInterpreter()".
Bit 1	-	-	-	"MotionByInterpreter" An MCL motion job is in effect.
Bit 2 to Bit 31	-	-	-	Reserved

10.3.38 "StatusWord" tag (positioning axis)

The "<TO>.StatusWord" tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 5 "HomingDone") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

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Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status information of the technology object
Bit 0	-	-	-	"Enable" Enable status The technology object has been enabled.
Bit 1	-	-	-	"Error" An error is present.
Bit 2	-	-	-	"RestartActive" A restart is active. The technology object will be reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" The restart tags have been changed. For the changes to be applied, the technology object must be reinitialized.
Bit 4	-	-	-	"ControlPanelActive" The axis control panel is active.
Bit 5	-	-	-	"HomingDone" Homing status The technology object is homed.
Bit 6	-	-	-	"Done" No motion job is in progress and the axis control panel is deactivated.
Bit 7	-	-	-	"Standstill" Standstill signal The axis is at a standstill.
Bit 8	-	-	-	"PositioningCommand" A positioning job is active ("MC_MoveRelative","MC_MoveAbsolute").
Bit 9	-	-	-	"JogCommand" An "MC_MoveJog" job is running.
Bit 10	-	-	-	"VelocityCommand" An "MC_MoveVelocity" job is running.
Bit 11	-	-	-	"HomingCommand" An "MC_Home" job is being processed.

[1] The bit is correctly displayed only when using SIEMENS telegram 10x. When using MC_TorqueRange without SIEMENS telegram 10x, compare the values from telegram 750:
<InLimit> = ActualTorque (M_ACT) * 0.9 > UpperTorqueLimit (M_LIMIT_POS) OR ActualTorque (M_ACT) * 0.9 < LowerTorqueLimit (M_LIMIT_NEG)

Tag	Data type	Values	W	Description
Bit 12	-	-	-	"ConstantVelocity" The velocity setpoint is reached. A constant velocity set-point is output.
Bit 13	-	-	-	"Accelerating" An acceleration operation is active.
Bit 14	-	-	-	"Decelerating" A deceleration operation is active.
Bit 15	-	-	-	"SWLimitMinActive" A negative software limit switch has been approached or exceeded.
Bit 16	-	-	-	"SWLimitMaxActive" A positive software limit switch has been approached or exceeded.
Bit 17	-	-	-	"HWLimitMinActive" A negative hardware limit switch has been approached or exceeded.
Bit 18	-	-	-	"HWLimitMaxActive" A positive hardware limit switch has been approached or exceeded.
Bit 19 ... Bit 22	-	-	-	Reserved
Bit 23	-	-	-	"MoveSuperimposedCommand" An "MC_MoveSuperimposed" job is running.
Bit 24	-	-	-	Reserved
Bit 25	-	-	-	"AxisSimulation" The technology object is in simulation.
Bit 26	-	-	-	"TorqueLimitingCommand" An "MC_TorqueLimiting" job is running.
Bit 27	-	-	-	"InLimitation"[1] The drive operates at least at the threshold value (default 90%) of the torque limit/force limitation.
Bit 28	-	-	-	"NonPositionControlled" The axis is not in position-controlled mode.
Bit 29	-	-	-	"KinematicsMotionCommand" The axis is used for a kinematics job.
Bit 30	-	-	-	"InClamping" The axis is clamped at a fixed stop.
Bit 31	-	-	-	"MotionInCommand" An "MC_MotionInVelocity" job or an "MC_MotionInPosition" job is active.

[1] The bit is correctly displayed only when using SIEMENS telegram 10x. When using MC_TorqueRange without SIEMENS telegram 10x, compare the values from telegram 750:
<InLimit> = ActualTorque (M_ACT) * 0.9 > UpperTorqueLimit (M_LIMIT_POS) OR ActualTorque (M_ACT) * 0.9 < LowerTorqueLimit (M_LIMIT_NEG)

10.3.39 "StatusWord2" tag (positioning axis)

The "<TO>.StatusWord2" tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 0 "StopCommand") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

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Tag	Data type	Value range	W	Description
StatusWord2	DWORD	-	RON	Status information of the technology object
Bit 0	BOOL	-	RON	"StopCommand" An "MC_Stop" job is running. The technology object is disabled.
Bit 1	BOOL	-	RON	Reserved
Bit 2	BOOL	-	RON	"PassingBacklash" The backlash is traversed. "<TO>.ActualPosition" does not hereby change.
Bit 3 ... Bit 5	BOOL	-	RON	Reserved
Bit 6	BOOL	-	RON	"MotionInSuperimposedCommand" An "MC_MotionInSuperimposed" job is running.
Bit 7	BOOL	-	RON	"HaltSuperimposedCommand" An "MC_HaltSuperimposed" job is running.
Bit 8	BOOL	-	RON	"MotionInSuperimposedAxesCommand" An "MC_MotionInSuperimposedAxes" job is running.
Bit 9	BOOL	-	RON	"PositionProfileCommand" An "MC_PositionProfile" job is running.
Bit 10	BOOL	-	RON	"OnProfile" An "MC_PositionProfile" job is running and the axis traverses the setpoint values of the time-based position profile.
Bit 11 to Bit 31	BOOL	-	RON	Reserved

10.3.40 "ErrorWord" tag (positioning axis)

The "<TO>.ErrorWord" tag shows the error groups in which there is at least one technology alarm for the technology object. The tag takes technology alarms of the alarms requiring acknowledgment and serious errors alarm classes into consideration.

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

To read out the specific alarm number of the technology alarm with the highest priority associated with the technology object, evaluate the tag "<TO>.ErrorDetail.Number".

You can use the "Get_Alarm" instruction, for example, to evaluate all technology alarms pending on the technology object.

Tags

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Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
Bit 4	-	-	-	"DriveFault" Error in drive
Bit 5	-	-	-	"SensorFault" Error in encoder system
Bit 6	-	-	-	"DynamicError" Specified dynamic values are limited to permissible values.
Bit 7	-	-	-	"CommunicationFault" Communication error Missing or faulty communication.
Bit 8	-	-	-	"SWLimit" Software limit switch reached or overtraveled.
Bit 9	-	-	-	"HWLimit" Hardware limit switch reached or overtraveled.
Bit 10	-	-	-	"HomingError" Error during homing operation The homing cannot be completed.
Bit 11	-	-	-	"FollowingErrorFault" Following error limits exceeded
Bit 12	-	-	-	"PositioningFault" Positioning error
Bit 13	-	-	-	"PeripheralError" Error accessing a logical address
Bit 14	-	-	-	Reserved

Tag		Data type	Values	W	Description
	Bit 15	-	-	-	"AdaptionError" Error in automatic data transfer
	Bit 16	-	-	-	"SuperimposingError" Error in the superimposition of the axis The superimposing axis specified in the Motion Control instruction was not configured as a possible superimposing axis.
	Bit 17 to Bit 31	-	-	-	Reserved

10.3.41 "ErrorDetail" tag (positioning axis)

The "<TO>.ErrorDetail" tag structure contains the alarm number and the effective local alarm response of the technology alarm pending on the technology object with the highest priority.

You can find a list of the technology alarms and alarm responses in the "Overview of the technology alarms" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.

You can use the "Get_Alarm" instruction, for example, to evaluate all technology alarms pending on the technology object.

Tags

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Tag		Data type	Values	W	Description	
ErrorDetail.		TO_Struct_ErrorDetail				
	Number	UDINT	-	RON	Alarm number	
	Reaction	DINT	0 to 5	RON	Effective alarm response	
					0	No reaction
					1	Stop with current dynamic values
					2	Stop with maximum dynamic values
					3	Stop with emergency stop ramp
					4	Remove enable
					5	Track setpoints

10.3.42 "WarningWord" tag (positioning axis)

The "<TO>.WarningWord" tag shows the error groups in which there is at least one technology alarm for the technology object. The tag takes technology alarms of the acknowledgeable warnings alarm class into consideration.

Information on the evaluation of the individual bits (e.g. bit 13 "PeripheralWarning") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

You can use the "Get_Alarm" instruction, for example, to evaluate all warnings pending on the technology object.

Tags

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Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
Bit 4	-	-	-	"DriveWarning" Warning of the drive When a warning message is pending at the drive that does not result in a TO alarm, this bit is not set. Evaluate the drive warnings directly using the status word of the drive.
Bit 5	-	-	-	"SensorWarning" Error in encoder system
Bit 6	-	-	-	"DynamicWarning" Specified dynamic values are limited to permissible values.
Bit 7	-	-	-	"CommunicationWarning" Communication error Missing or faulty communication.
Bit 8	-	-	-	"SWLimitMin" The negative software limit switch has been approached.
Bit 9	-	-	-	"SWLimitMax" The positive software limit switch has been approached.
Bit 10	-	-	-	"HomingWarning" Error during homing operation The homing cannot be completed.
Bit 11	-	-	-	"FollowingErrorWarning" Warning limit of following error monitoring reached/exceeded
Bit 12	-	-	-	"PositioningWarning" Positioning error
Bit 13	-	-	-	"PeripheralWarning" Error accessing a logical address
Bit 14	-	-	-	Reserved

Tag	Data type	Values	W	Description
Bit 15	-	-	-	"AdaptionWarning" Error in automatic data transfer
Bit 16	-	-	-	"SuperimposingWarning" Error in the superimposition of the axis The superimposing axis specified in the Motion Control instruction was not configured as a possible superimposing axis.
Bit 16... Bit 31	-	-	-	Reserved

10.3.43 "ControlPanel" tag (positioning axis)

The tag structure "<TO>.ControlPanel.<tag name>" contains no relevant data for you. This tag structure is internally used.

10.3.44 "InternalToTrace" tag (positioning axis)

The tag structure "<TO>.InternalToTrace.<tag name>" contains no relevant data for you. This tag structure is internally used.

10.4 Tags of the technology object external encoder

10.4.1 Actual values (external encoder)

The following tags indicate the actual values of the technology object.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
ActualPosition	LREAL	-	RON	Actual position
ActualVelocity	LREAL	-	RON	Actual velocity
ActualAcceleration	LREAL	-	RON	Actual acceleration
ActualModuloCycle	DINT	-2147483648 to 2147483647	RON	Number of modulo cycles of the actual value

10.4.2 "Sensor" tag (external encoder)

The tag structure "<TO>.Sensor.<tag name>" contains the controller-side configuration for the encoder, and the configuration for passive homing.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
Sensor.	TO_Struct_ExternalEncoder_Sensor				
Type	DINT	0 to 2	RON	Encoder type	
				0	"INCREMENTAL" Incremental
				1	"ABSOLUTE" Absolute
				2	"CYCLIC_ABSOLUTE" Cyclic absolute
InverseDirection	BOOL	-	RES	Inversion of the actual value	
				FALSE	No
				TRUE	Yes
System	DINT	0, 1	RES	Encoder system	
				0	"LINEAR" Linear encoder
				1	"ROTATORY" Rotary encoder
MountingMode	DINT	0 to 2	RES	Mounting type of encoder	
				0	On motor shaft
				1	On load side
				2	External measuring system
DataAdaption	DINT	0, 1	RES	Automatic transfer of the drive values reference speed, maximum speed and reference torque in the device	
				0	No automatic transfer, manual configuration of values
				1	Automatic transfer of values configured in the drive to the configuration of the technology object
ActualVelocityMode	DINT	0, 1	RES	Type of calculation for actual speed value or actual velocity value	
				0	Actual value calculation from differentiation of the position change
				1	Actual value calculation with NACT value from the telegram
Interface.					
AddressIn	VREF	0 to 65535	RON	Input address for the PROFIdrive telegram	
AddressOut	VREF	0 to 65535	RON	Output address for the PROFIdrive telegram	

Tag	Data type	Values	W	Description
Number	UDINT	1 to 2	RON	Number of the encoder in the telegram
Parameter.				
Resolution	LREAL	-1.0E12 ... 1.0E12	RES	Resolution of a linear encoder (offset between two encoder pulses)
StepsPerRevolution	UDINT	1 to 8388608	RES	Increments per rotary encoder revolution
FineResolutionXist1	UDINT	0 to 31	RES	Number of bits for fine resolution "Gx_XIST1" (cyclic actual encoder value)
FineResolutionXist2	UDINT	0 to 31	RES	Number of bits for fine resolution "Gx_XIST2" (absolute value of the encoder)
DeterminableRevolutions	UDINT	0 to 8388608	RES	Number of differentiable encoder revolutions for a multi-turn absolute encoder (For a single-turn absolute encoder = 1; for an incremental encoder = 0)
DistancePerRevolution	LREAL	0.0 to 1.0E12	RES	Load distance per revolution of an externally mounted encoder
BehaviorGx_XIST1	DINT	0, 1	RES	Evaluation of "Gx_XIST1" bits.
				0: Based on the bits of the encoder resolution. The incremental actual value "Gx_XIST1" is transmitted with less than 32 bits in the PROFIdrive telegram. For example: At 16 bits, the value ranges from 0 to 65,535.
				1: 32-bit value of the encoder value The "Gx_XIST1" incremental actual value is transferred with 32 bits of 0 to 4,294,967,295 in the PROFIdrive telegram.
ReferenceSpeed	LREAL	0.0 to 1.0E12	RES	Reference speed for NACT in PROFIdrive telegram with rotary encoder Only relevant for "ActualVelocityMode" = 1
ReferenceVelocity	LREAL	0.0 to 1.0E12	RES	Reference velocity for NACT in the PROFIdrive telegram with linear encoder Only relevant for "ActualVelocityMode" = 1
PassiveHoming.	TO_Struct_SensorPassiveHoming			
Mode	DINT	0 to 2	RES	Homing mode
				0: Use zero mark via PROFIdrive telegram
				1: Zero mark via PROFIdrive telegram and reference output cam
				2: Use homing mark via digital input
SideInput	BOOL	-	CAL	Side of the digital input for passive homing
				FALSE: Negative side
				TRUE: Positive side
Direction	DINT	0 to 2	CAL	Homing direction/approach direction to homing mark
				0: Positive homing direction
				1: Negative homing direction

Tag	Data type	Values	W	Description	
Direction	DINT	0 to 2	CAL	2	Current homing direction
DigitalInputAddress	VREF	0 to 65535	RON	Address of the digital input	
SwitchLevel	BOOL	-	RON	Signal level that is present at the digital input when homing mark is approached	
				FALSE	Low level
				TRUE	High level

10.4.3 "CrossPlcSynchronousOperation" tag (external encoder)

The tag structure "<TO>.CrossPlcSynchronousOperation.<tag name>" contains the configuration of the cross-PLC synchronous operation.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
CrossPlcSynchronousOperation.	TO_Struct_CrossPlcSynchronousOperation				
Interface[1..32].	ARRAY [1..32] of TO_Struct_CrossPlcLeadingValueInterface				
EnableLeadingValueOutput	BOOL	-	RON	Provide cross-PLC leading value	
				FALSE	No
				TRUE	Yes
AddressOut	VREF	-	RON	Output address for the leading value telegram	
TelegramVersion	WORD	1, 2	RON	Leading value telegram version	
				1	Version 1 (technology version ≤ 8.0 and ≥ 10.0)
				2	Version 2 (technology version ≥ 9.0)
LocalLeadingValueDelayTime	LREAL	0.0 to 1.0E9	RES	Delay time of leading value output to the local following axes	

10.4.4 "Extrapolation" tag (external encoder)

The tag structure "<TO>.Extrapolation.<tag name>" contains the configuration of the actual value extrapolation.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
Extrapolation.	TO_Struct_Extrapolation			
LeadingAxisDependent-Time	LREAL	-	RON	Extrapolation time component (caused by leading axis) Results from the following times: • Time of actual value acquisition for the leading axis • Interpolator cycle clock • Time of position filter of actual value extrapolation (T1 + T2)
FollowingAxisDepend-entTime	LREAL	0.0 to 1.0E12	DIR	Extrapolation time component (caused by following axis) For a following axis with set velocity precontrol, the following times result in: • Communication cycle • Interpolator cycle clock • Speed control loop substitute time for the following axis • Output delay time of the setpoint at the following axis For a following axis without velocity precontrol, the following times result in: • Communication cycle • Interpolator cycle clock • Position control loop equivalent time (1/Kv from "<TO>.PositionControl.Kv") • Output delay time of the setpoint at the following axis
Settings.	TO_Struct_ExtrapolationSettings			
SystemDefinedExtra-polation	DINT	0, 1	RES	Leading axis dependent time 0 Not effective 1 Effective
ExtrapolatedVelocity-Mode	DINT	0, 1, 2	RES	Effective velocity value for the synchronization function 0 Filtered velocity Leading value velocity from filtered actual velocity 1 Extrapolated velocity Leading value velocity from extrapolation 2 Differentiated velocity Leading value velocity from differentiation of the extrapolated leading value position
PositionFilter.	TO_Struct_ExtrapolationPositionFil-ter			
T1	LREAL	0.0 to 1.0E12	DIR	Position filter time constant T1
T2	LREAL	0.0 to 1.0E12	DIR	Position filter time constant T2

Tag	Data type	Values	W	Description
VelocityFilter.	TO_Struct_ExtrapolationVelocityFilter			
T1	LREAL	0.0 to 1.0E12	DIR	Velocity filter time constant T1
T2	LREAL	0.0 to 1.0E12	DIR	Velocity filter time constant T2
VelocityTolerance.	TO_Struct_ExtrapolationVelocityTolerance			
Range	LREAL	0.0 to 1.0E12	DIR	Tolerance band width for velocity
Hysteresis.	TO_Struct_ExtrapolationHysteresis			
Value	LREAL	0.0 to 1.0E12	DIR	Hysteresis of the extrapolated actual position value

10.4.5 "LoadGear" tag (external encoder)

The tag structure "<TO>.LoadGear.<tag name>" contains the configuration of the load gear.

Tags

Legend (Page 393)

Tag	Data type	Value range	W	Description
LoadGear.	TO_Struct_LoadGear			
Numerator	UDINT	1 to 4294967295	RES	Load gear numerator
Denominator	UDINT	1 to 4294967295	RES	Load gear denominator

10.4.6 "Properties" tag (external encoder)

The tag structure "<TO>.Properties.<tag name>" contains the configuration of the type of axis or motion.

Tags

Legend (Page 393)

Tag	Data type	Value range	W	Description	
Properties.	TO_Struct_Properties				
MotionType	DINT	0, 1	RON	Indication of axis type or motion type	
				0	Linear axis or motion
				1	Rotary axis or motion

10.4.7 "Units" tag (external encoder)

The tag structure "<TO>.Units.<tag name>" shows the set technological units.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
Units.	TO_Struct_Units / TO_Struct_ExternalEncoder_Units				
LengthUnit	UDINT	-	RON	Unit for position	
				1010	m
				1013	mm
				1536	mm[1]
				1011	km
				1014	µm
				1015	nm
				1019	in
				1018	ft
				1021	mi
				1004	rad
				1005	°
				1537	°[1]
VelocityUnit	UDINT	-	RON	Unit for velocity	
				1521	°/s
				1539	°/s[1]
				1522	°/min
				1086	rad/s
				1523	rad/min
				1062	mm/s
				1538	mm/s[1]
				1061	m/s
				1524	mm/min
				1525	m/min
				1526	mm/h
				1063	m/h
				1527	km/min
				1064	km/h
				1066	in/s
				1069	in/min
				1067	ft/s

[1] Position values with higher resolution or six decimal places

Tag	Data type	Values	W	Description	
VelocityUnit	UDINT	-	RON	1070	ft/min
				1075	mi/h
TimeUnit	UDINT	-	RON	Unit for time	
				1054	s

1) Position values with higher resolution or six decimal places

10.4.8 "Mechanics" tag (external encoder)

The tag structure "<TO>.Mechanics.<tag name>" contains the configuration of the mechanics.

Tags

Legend (Page 393)

Tag	Data type	Value range	W	Description
Mechanics.	TO_Struct_Mechanics			
LeadScrew	LREAL	1.0E-12 to 1.0E12	RES	Leadscrew pitch

10.4.9 "Modulo" tag (external encoder)

The tag structure "<TO>.Modulo.<tag name>" contains the configuration of the modulo function.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
Modulo.	TO_Struct_Modulo				
Enable	BOOL	-	RES	FALSE	Modulo conversion disabled
				TRUE	Modulo conversion enabled
Length	LREAL	0.001 to 1.0E12	RES	Modulo length When modulo conversion is enabled, a check is made for modulo length > 0.0	
StartValue	LREAL	-1.0E12 to 1.0E-12	RES	Modulo start value	

10.4.10 "Homing" tag (external encoder)

The tag structure "<TO>.Homing.<tag name>" contains the configuration for homing the TO.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
Homing.	TO_Struct_Homing / TO_Struct_ExternalEncoder_Homing			
HomePosition	LREAL	-1.0E12 to 1.0E12	CAL	Home position

10.4.11 "StandstillSignal" tag (external encoder)

The tag structure "<TO>.StandstillSignal.<tag name>" contains the configuration of the standstill signal.

If the actual velocity value is below the velocity threshold, and does not exceed it during the minimum dwell time, then the standstill signal "<TO>.StatusWord.X7 (Standstill)" is set.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
StandstillSignal.	TO_Struct_StandstillSignal			Configuration for the standstill signal
VelocityThreshold	LREAL	0.0 to 1.0E12	DIR	Velocity threshold If velocity is below this threshold, the minimum dwell time begins.
MinDwellTime	LREAL	0.0 to 1.0E12	DIR	Minimum dwell time

10.4.12 "StatusProvidedLeadingValue" tag (external encoder)

The tag structure "<TO>.StatusProvidedLeadingValue.<tag name>" contains the provided leading value with leading value delay of the cross-PLC synchronous operation.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
StatusProvidedLeadingValue.	TO_Struct_StatusProvidedLeadingValue			Provided leading value
DelayedLeadingValue	TO_Struct_ProvidedLeadingValue			Leading value with leading value delay
Position	LREAL	-1.0E12 to 1.0E-12	RON	Position
Velocity	LREAL	-1.0E12 to 1.0E-12	RON	Velocity
Acceleration	LREAL	-1.0E12 to 1.0E-12	RON	Acceleration

10.4.13 "StatusSensor" tag (external encoder)

The tag structure "<TO>.StatusSensor.<tag name>" indicates the status of the measuring system.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description	
StatusSensor.	TO_Struct_StatusSensor				
State	DINT	0 to 2	RON	Status of the actual encoder value	
				0	"NOT_VALID" Invalid
				1	"WAITING_FOR_VALID" Waiting for "Valid" status
				2	"VALID" Valid
CommunicationOK	BOOL	-	RON	Cyclic BUS communication between controller and encoder	
				FALSE	Not established
				TRUE	Established
Error	BOOL	-	RON	FALSE	No error in the measuring system
				TRUE	Error in the measuring system.
AbsEncoderOffset	LREAL	-	RON	Home position offset for value of an absolute value encoder. The value will be retentively stored in the CPU.	
Control	BOOL	-	RON	FALSE	Encoder is not active

Tag	Data type	Values	W	Description	
Control	BOOL	-	RON	TRUE	Encoder is active
Position	LREAL	-	RON	Encoder position	
Velocity	LREAL	-	RON	Encoder velocity	
AdaptionState	DINT	-	RON	Status of automatic data transfer of encoder parameters	
				0	"NOT_ADAPTED" Data not transferred
				1	"IN_ADAPTION" Data transfer in progress
				2	"ADAPTED" Data transfer complete
				3	"NOT_APPLICABLE" Data transfer not selected, not possible
				4	"ADAPTION_ERROR" Error during data transfer
ModuloCycle	DINT	-2147483648 to 2147483647	RON	Number of modulo cycles	
Adjusted	DINT	0 to 1	RON	Homing status of the encoder	
				0	Encoder not homed
				1	Encoder homed with one of the following homing types: • Passive homing • Absolute encoder adjustment • Incremental encoder adjustment

10.4.14 "StatusExtrapolation" tag (external encoder)

The tag structure "<TO>.StatusExtrapolation.<tag name>" indicates the status of the actual value extrapolation.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
StatusExtrapolation.	TO_Struct_StatusExtrapolation			
FilteredPosition	LREAL	-1.0E12 to 1.0E-12	RON	Position after position filter
FilteredVelocity	LREAL	-1.0E12 to 1.0E-12	RON	Velocity after velocity filter and tolerance band
ExtrapolatedPosition	LREAL	-1.0E12 to 1.0E-12	RON	Extrapolated position
ExtrapolatedVelocity	LREAL	-1.0E12 to 1.0E-12	RON	Extrapolated velocity

10.4.15 "StatusWord" tag (external encoder)

The "<TO>.StatusWord" tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 5 "HomingDone") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tag

Legend (Page 393)

Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status information of the technology object
Bit 0	-	-	-	"Enable" Enable status The technology object has been enabled.
Bit 1	-	-	-	"Error" An error is present.
Bit 2	-	-	-	"RestartActive" A restart is active. The technology object is reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" The restart tags have been changed. For the changes to be applied, the technology object must be reinitialized.
Bit 4	-	-	-	Reserved
Bit 5	-	-	-	"HomingDone" Homing status The technology object is homed.
Bit 6	-	-	-	"Done" No motion job is in progress and the axis control panel is deactivated.
Bit 7	-	-	-	"Standstill" standstill signal The external encoder is at a standstill.
Bit 8 ... Bit 10	-	-	-	Reserved
Bit 11	-	-	-	"HomingCommand" An "MC_Home" job is being processed.
Bit 12... Bit 31	-	-	-	Reserved

10.4.16 "ErrorWord" tag (external encoder)

The "<TO>.ErrorWord" tag shows the error groups in which there is at least one technology alarm for the technology object. The tag takes technology alarms of the alarms requiring acknowledgment and serious errors alarm classes into consideration.

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

To read out the specific alarm number of the technology alarm with the highest priority associated with the technology object, evaluate the tag "<TO>.ErrorDetail.Number".

You can use the "Get_Alarm" instruction, for example, to evaluate all warnings pending on the technology object.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
Bit 4	-	-	-	Reserved
Bit 5	-	-	-	"SensorFault" Error in encoder system
Bit 6	-	-	-	Reserved
Bit 7	-	-	-	"CommunicationFault" Communication error Missing or faulty communication.
Bit 8	-	-	-	Reserved
Bit 9	-	-	-	Reserved
Bit 10	-	-	-	"HomingError" Error during homing operation The homing cannot be completed.
Bit 11	-	-	-	Reserved
Bit 12	-	-	-	Reserved
Bit 13	-	-	-	"PeripheralError" Error accessing a logical address

Tag		Data type	Values	W	Description
	Bit 14	-	-	-	Reserved
	Bit 15	-	-	-	"AdaptionError" Error in automatic data transfer
	Bit 16 ... Bit 31	-	-	-	Reserved

10.4.17 "ErrorDetail" tag (external encoder)

The "<TO>.ErrorDetail.<tag name>" tag structure contains the alarm number and the effective local alarm response of the technology alarm with the highest priority pending on the technology object.

You can find a list of the technology alarms and alarm responses in the "Overview of the technology alarms" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.

You can use the "Get_Alarm" instruction, for example, to evaluate all technology alarms pending on the technology object.

Tags

Legend (Page 393)

Tag		Data type	Values	W	Description	
ErrorDetail.		TO_Struct_ErrorDetail				
	Number	UDINT	-	RON	Alarm number	
	Reaction	DINT	0, 10	RON	Effective alarm response	
					0	No reaction
					10	Remove enable

10.4.18 "WarningWord" tag (external encoder)

The "<TO>.WarningWord" tag shows the error groups in which there is at least one technology alarm for the technology object. The tag takes technology alarms of the acknowledgeable warnings alarm class into consideration.

Information on the evaluation of the individual bits (e.g. bit 13 "PeripheralWarning") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

You can use the "Get_Alarm" instruction, for example, to evaluate all warnings pending on the technology object.

Tags

Legend (Page 393)

Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
Bit 4	-	-	-	Reserved
Bit 5	-	-	-	"SensorWarning" Error in encoder system
Bit 6	-	-	-	Reserved
Bit 7	-	-	-	"CommunicationWarning" Communication error Missing or faulty communication.
Bit 8	-	-	-	Reserved
Bit 9	-	-	-	Reserved
Bit 10	-	-	-	"HomingWarning" Error during homing operation The homing cannot be completed.
Bit 11	-	-	-	Reserved
Bit 12	-	-	-	Reserved
Bit 13	-	-	-	"PeripheralWarning" Error accessing a logical address
Bit 14	-	-	-	Reserved
Bit 15	-	-	-	"AdaptionWarning" Error in automatic data transfer
Bit 16... Bit 31	-	-	-	Reserved

10.4.19 "InternalToTrace" tag (external encoder)

The tag structure "<TO>.InternalToTrace.<tag name>" contains no relevant data for you. This tag structure is internally used.

Appendix

A

A.1 Signal flow diagrams position control

Signal flow diagrams position control

Position control in the drive with DSC

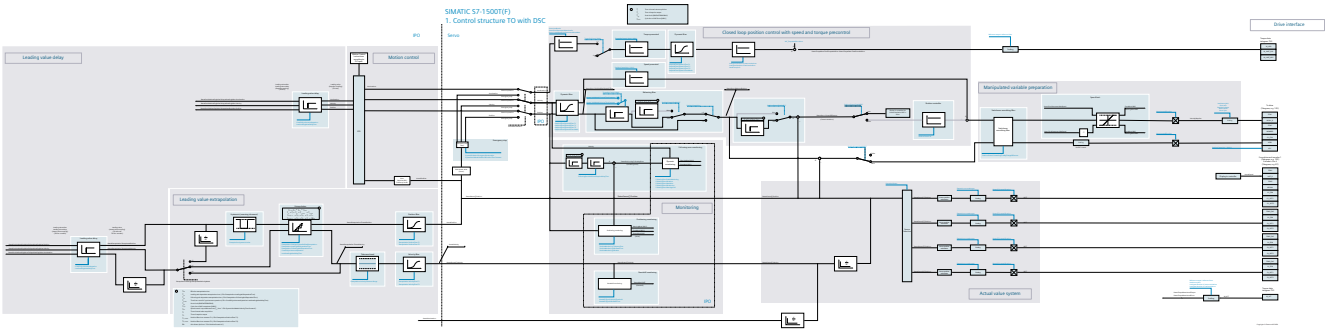

Position control in the CPU

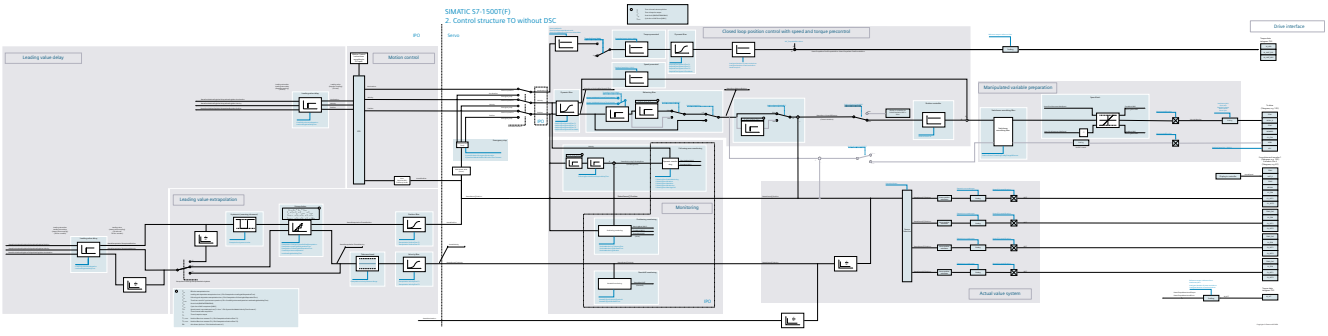

SIEMENS

SIMATIC

S7-1500
S7-1500/S7-1500T Measuring input and output cam functions V10.0 as of STEP 7 V21

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Introduction 1

Purpose of the documentation

This documentation provides important information that you need to configure and commission the integrated Motion Control functionality of the S7-1500 Automation systems.

Required basic knowledge

In order to understand this documentation, the following knowledge is required:

- General knowledge in the field of automation
- General knowledge in the field of drive engineering and motion control

Validity of the documentation

This documentation is valid for the S7-1500 product range.

Conventions

- The path specifications in the project tree assume that the "Technology objects" folder is open in the subtree of the CPU. The "Technology object" placeholder represents the name of the technology object.

  Example: "Technology object > Configuration > Basic parameters".
- The <TO> placeholder represents the name set in tags for the respective technology object.

  Example: <TO>.Actor.Type
- This documentation contains pictures of the devices described. The pictures may differ in minor details from the devices supplied.

You should also observe the notes that are marked as follows:

NOTE

A note contains important information about the product described in the documentation, about the handling of the product, and about sections in this documentation demanding your particular attention.

Industry Mall

The Industry Mall is the catalog and ordering system of Siemens Aktiengesellschaft for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

1.1 S7-1500 Motion Control Documentation Guide

Product information

Please also note the supplementary information on the Motion Control documentation:

- Product information on the S7-1500/1500T Motion Control documentation
  https://support.industry.siemens.com/cs/ww/en/view/109794046
  (https://support.industry.siemens.com/cs/ww/en/view/109794046)

Documentation

The documentation of the Motion Control functions is divided into the following documents:

- S7-1500/S7-1500T Motion Control Overview
  https://support.industry.siemens.com/cs/en/view/109990070
  (https://support.industry.siemens.com/cs/ww/en/view/109990070)

  This document describes the innovations in the technology versions, how to upgrade the technology version, functions that are used for all technology objects, and the operational sequence of Motion Control applications.
- S7-1500/S7-1500T Motion Control alarms and error IDs
  https://support.industry.siemens.com/cs/ww/en/view/109990076
  (https://support.industry.siemens.com/cs/ww/en/view/109990076)

  This document describes the technology alarms of the technology objects and the error identifications of the Motion Control instructions.
- S7-1500/S7-1500T Axis functions
  https://support.industry.siemens.com/cs/en/view/109990072
  (https://support.industry.siemens.com/cs/ww/en/view/109990072)

  This document describes the drive and encoder connection and functions for single-axis movements.
- S7-1500/S7-1500T Synchronous operation functions
  https://support.industry.siemens.com/cs/ww/en/view/109990074
  (https://support.industry.siemens.com/cs/ww/en/view/109990074)

  This document describes gearing, velocity synchronous operation and camming as well as cross-PLC synchronous operation.

- S7-1500/S7-1500T Measuring input and output cam functions
  https://support.industry.siemens.com/cs/ww/en/view/109990075
  (https://support.industry.siemens.com/cs/ww/en/view/109990075)
  This document describes the detection of the actual position via a measuring input and the output of switching signals via output cam or cam track.
- S7-1500T kinematics functions
  https://support.industry.siemens.com/cs/ww/en/view/109990073
  (https://support.industry.siemens.com/cs/ww/en/view/109990073)
  This document describes the control of kinematics with up to 6 interpolating axes.
- S7-1500T Interpreter functions
  https://support.industry.siemens.com/cs/ww/en/view/109990077
  (https://support.industry.siemens.com/cs/ww/en/view/109990077)
  This documentation describes the control of technology objects via an Interpreter program.

See also

Topic page "SIMATIC Technology - Motion Control: Overview and Important Links"
https://support.industry.siemens.com/cs/ww/en/view/109751049
(https://support.industry.siemens.com/cs/ww/en/view/109751049)

1.2 Function Manuals documentation guide

1.2.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.2.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.2.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 General safety instructions

The safety instructions can be found in section "Safety instructions" in the System Manual "SIMATIC S7-1500, ET 200MP Automation System" (https://support.industry.siemens.com/cs/ww/en/view/59191792) document.

Cybersecurity-relevant information can be found in the Industrial Cybersecurity section.

2.2 Warnings in this document

You can find explanations of the warnings used in this document in the "Legal information" section.

Industrial cybersecurity 3

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

3.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Overview of functions

4

4.1 Measuring input technology object

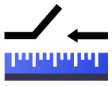

The measuring input technology object acquires the actual position of an axis or external encoder at a signal change at the measurement input.

With the measuring input technology object, you can measure once (Page 35) or cyclically (Page 36).

For position detection via measuring input, you use various technology modules and onboard I/O of CPUs which you configure as measurement input. In addition, measuring via "Monitor measuring input" provides the possibility to record measurement events of a measurement input from multiple measuring inputs at the same time.

You can find an overview of the functions of the measuring input technology object in the "Motion Control instructions (Page 23)" section.

The following figure shows the basic principle of operation of the measuring input technology object:

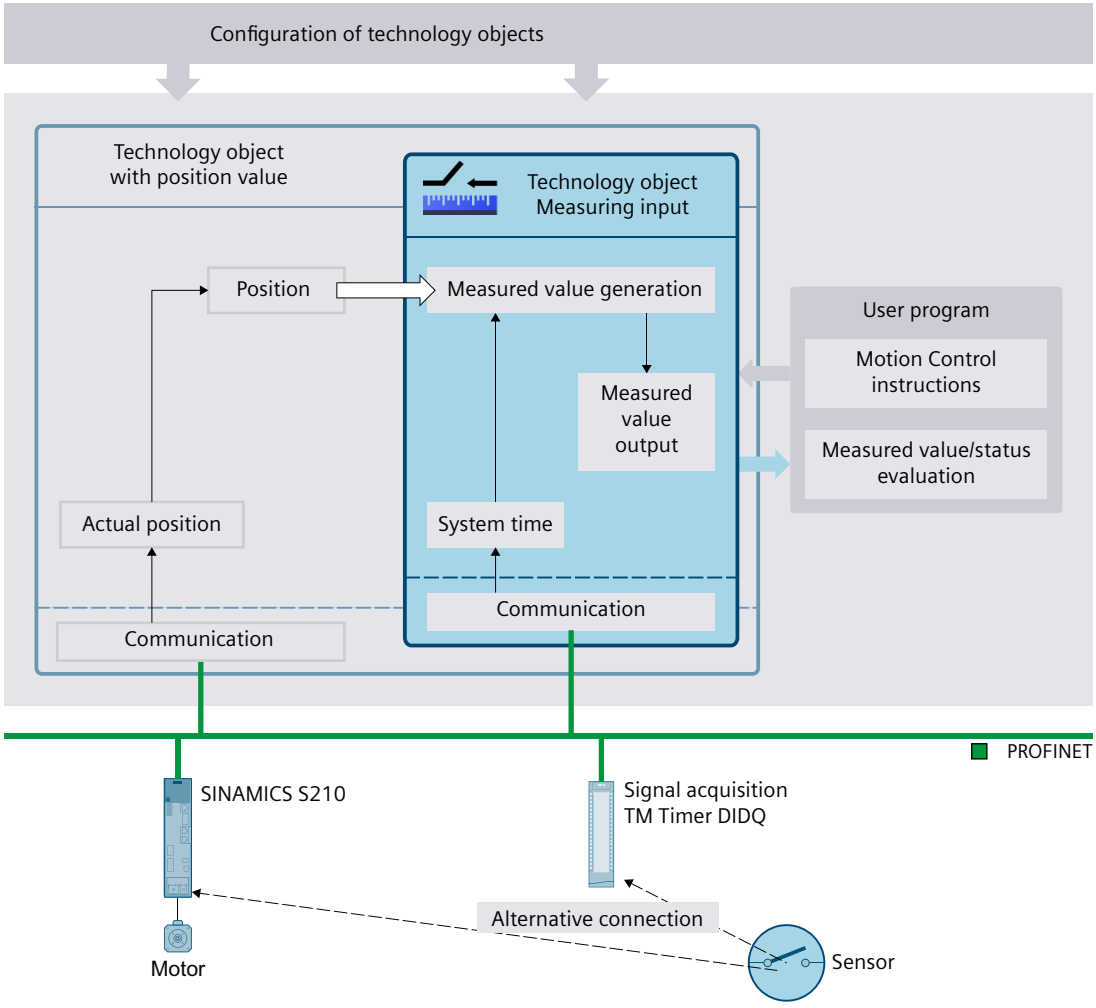

Use with SIMATIC S7-PLCSIM

The measuring input technology object cannot be used with SIMATIC S7-PLCSIM. The measuring input technology object and the measuring input jobs used in the user program can be loaded into SIMATIC S7-PLCSIM, but have no function. Measured values are not shown.

Configuration

The following configurations are available in the measuring input technology object:

- Basic parameters
  - Units of measure (Page 25)
- Hardware interface > Measurement sensing input
  - Measuring using Timer DI (Page 27)
  - Measuring via SINAMICS (central measuring probe) (Page 28)
  - Measuring using PROFIdrive telegram (Page 29)
  - Monitoring measuring input (Page 31)
- Extended parameters
  - Adjustment for activation time of the measuring range (Page 33)

See also

Overview of measurement inputs and measuring types (Page 26)

4.2 Output cam technology object

The output cam technology object generates switching signals depending on the position of an axis or external encoder. The switching states can be evaluated in the user program and fed to digital outputs.

You can find an overview of the functions of the output cam technology object in the "Motion Control instructions (Page 23)" section.

The following figure shows the basic operating principle of the output cam technology object:

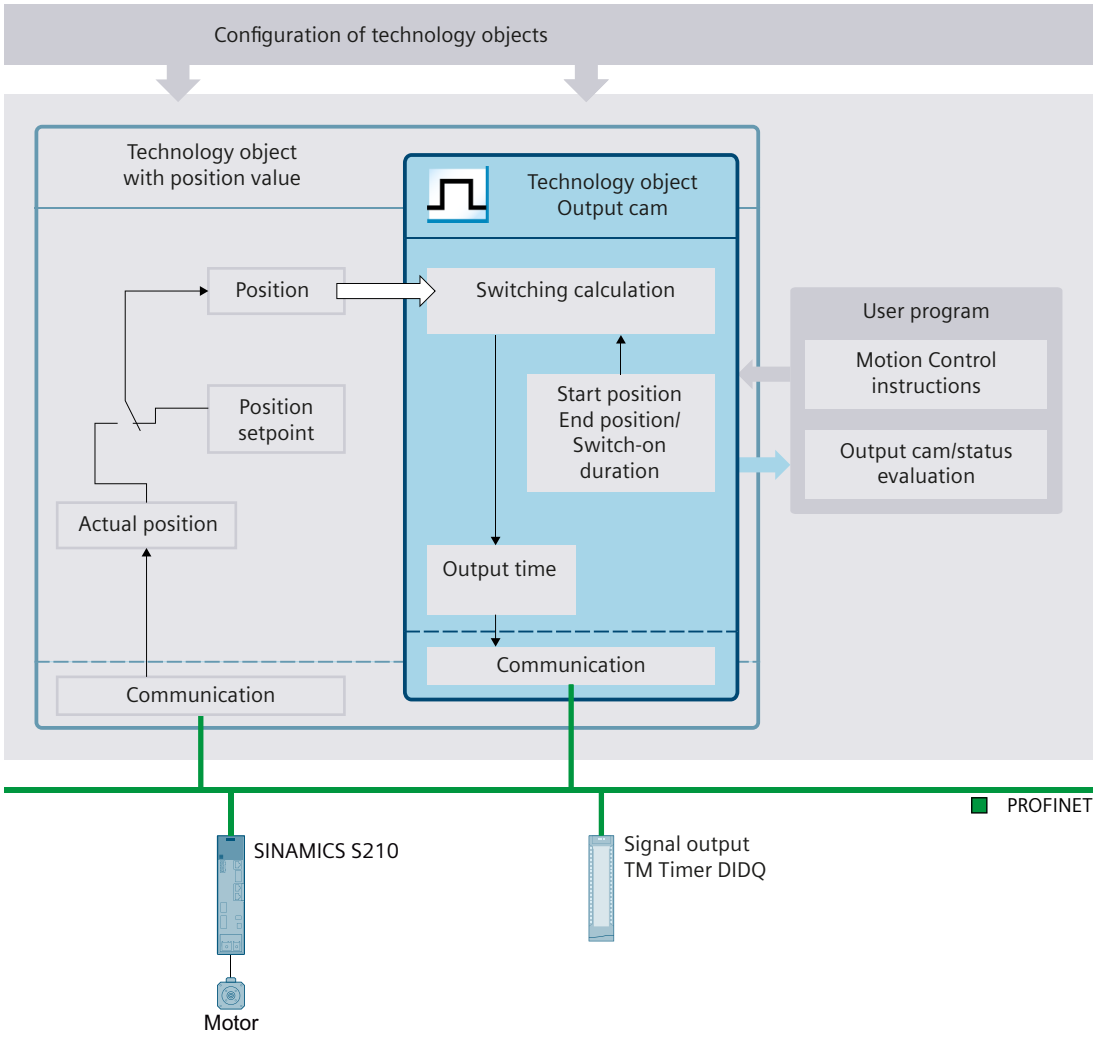

The output cam technology object supports distance output cams and time-based output cams and calculates the exact switching time. The switching signal can be output on a Timer DQ or at a digital output.

Output cam types

The following output cam types can be used:

- Distance output cam

  Distance output cams switch on between the start position and end position. Outside this range, the distance output cam is switched off.

- Time-based output cam

  Time-based output cams switch on for a defined time period when the start position is reached.

Configuration

The following configurations are available in the output cam technology object:

- Basic parameters
  - Output cam type > Distance output cam (Page 44)
  - Output cam type > Time-based output cam (Page 45)
  - Output cam reference > Position setpoint (Page 46)
  - Output cam reference > Current position (Page 46)
  - Units of measure (Page 25)
- Hardware interface
  - Output cam output > Output by Timer DQ (Page 47)
  - Output cam output > Output by digital output mode (Page 49)
- Extended parameters
  - Activation time (Page 50)
  - Hysteresis (Page 50)

4.3 Cam track technology object

The cam track technology object generates a switching signal sequence dependent on the position of an axis or external encoder. A cam track can consist of up to 32 individual output cams. The switching states can be evaluated in the user program or fed to digital outputs.

You can find an overview of the functions of the cam track technology object in the "Motion Control instructions (Page 23)" section.

The following figure shows the basic principle of operation of the cam track technology object:

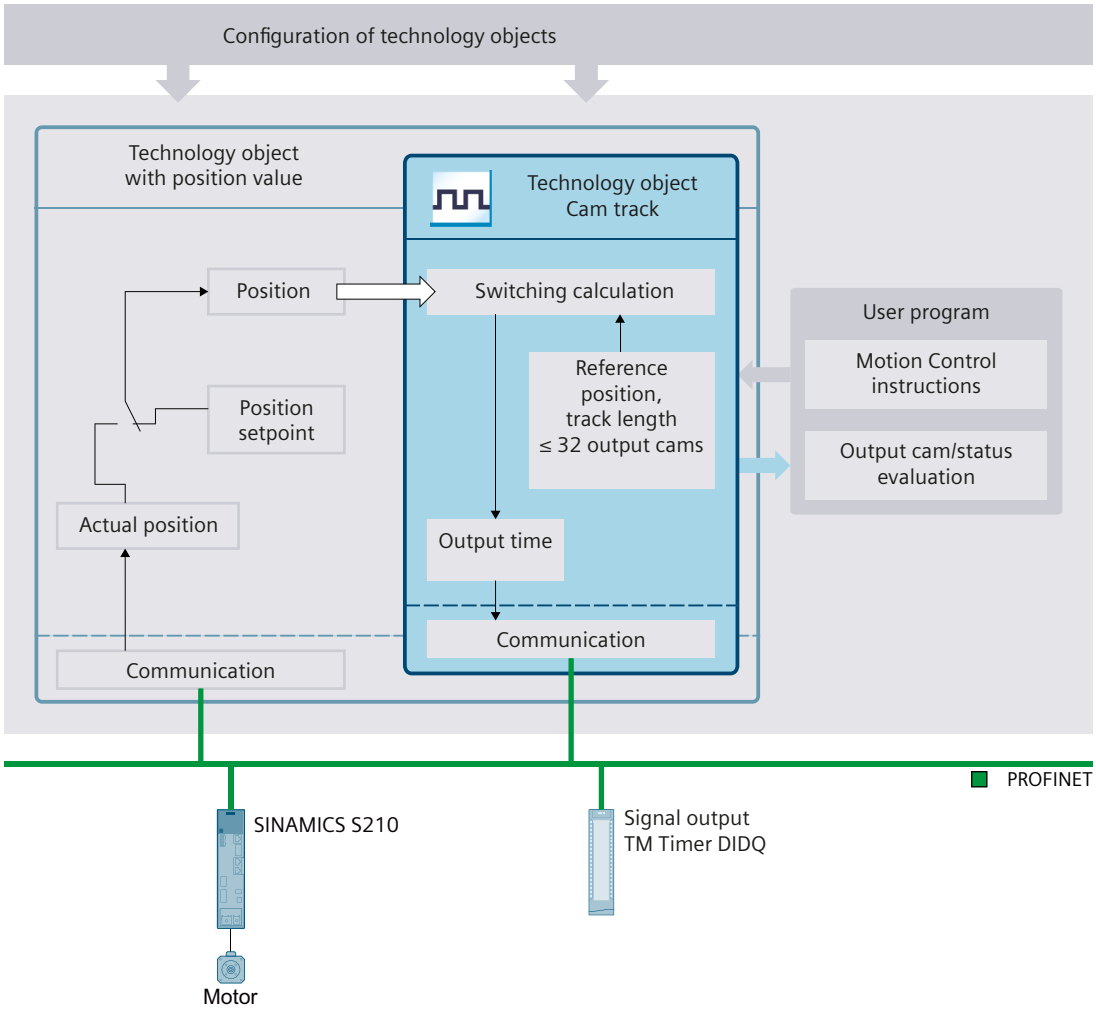

Configuration

The following configurations are available in the cam track technology object:

- Basic parameters
  - Output cam type > Distance output cam (Page 44)
  - Output cam type > Time-based output cam (Page 45)
  - Output cam reference > Position setpoint (Page 63)
  - Output cam reference > Current position (Page 63)
  - Units of measure (Page 25)
- Hardware interface
  - Output cam track > Output by Timer DQ (Page 64)
  - Output cam track > Output by digital output module (Page 64)
- Extended parameters
  - Track data > Activation time (Page 68)
  - Track data > Hysteresis (Page 65)
  - Track data > Track dimensions (Page 65)
  - Output cam data (Page 68)

4.4 Motion Control instructions

You execute the functions of the measuring input, output cam and cam track technology objects using the Motion Control instruction in your user program or using the TIA Portal (under "Technology object > Commissioning").

The following table shows the Motion Control instructions that are supported by the technology objects:

Motion Control instruction	Validity		Technology object		
	S7-1500	S7-1500T	Measuring input (Page 17)	Output cam (Page 20)	Cam track (Page 22)
"MC_Reset" Acknowledge alarms, restart technology objects	✓	✓	✓	✓	✓
"MC_MeasuringInput" Start measuring once	✓	✓	✓	-	-
"MC_MeasuringInputCyclic" Start cyclic measuring	✓	✓	✓	-	-
"MC_AbortMeasuringInput" Cancel active measuring job	✓	✓	✓	-	-
"MC_OutputCam" Activate/deactivate output cam	✓	✓	-	✓	-
"MC_CamTrack" Activate/deactivate cam track	✓	✓	-	-	✓

4.5 Functions in STEP 7

The following table shows the functions supported by technology objects in STEP 7:

Functions in the TIA Portal	Technology object		
	Measuring input (Page 17)	**Output cam** (Page 20)	**Cam track** (Page 22)
"Diagnostics" Monitor and observe status and error messages of the technology object	✓	✓	✓

Configuring the technology object 5

5.1 Assignment

The measuring input, output cam and cam track technology objects are always assigned to a higher-level technology object whose position is evaluated.

These technology objects can be:

- Positioning axis
- Synchronous axis
- External encoder

Exactly one positioning axis, synchronous axis or external encoder technology object can be assigned to a measuring input, output cam and cam track technology object.

Multiple measuring input, output cam and cam track technology objects can be assigned to a positioning axis, synchronous axis or external encoder technology object.

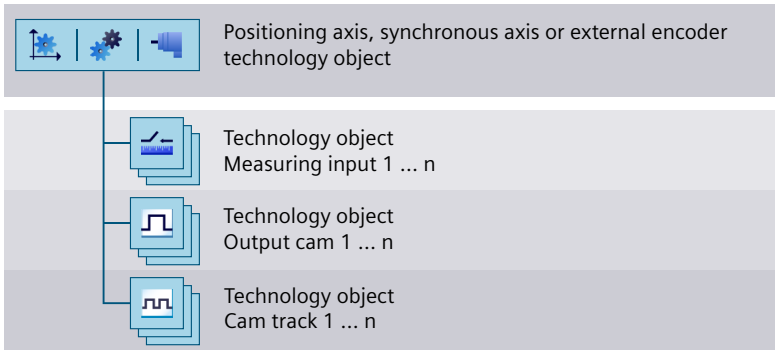

To change an existing assignment, move the measuring input, output cam or cam track technology object to the desired higher-level technology object using drag-and-drop.

You can use the icon to directly access the configuration of the higher-level technology object.

5.2 Units of measure

The position is always shown in the unit of measure and with the resolution set on the higher-level technology object.

To use six decimal places in the selected unit, select the check box "Use position values with higher resolution" in the higher-level technology object.

With a time-based output cam as the output cam type, the unit of measure for the switch-on duration and other times is also indicated. This is always ms for output cams.

Measuring input functions 6

6.1 Defining the measurement input for measured value acquisition

6.1.1 Overview of measurement inputs and measuring types

You can only operate a measurement input with a technology object measuring input.

The following table shows an overview of the possible measurement inputs and the measuring types for the different measuring input types.

Measuring input type	Possible measurement inputs	Possible measuring types
Measuring using Timer DI (Page 27) ("STANDARD")	With Timer DI: • ET 200SP or ET 200MP TM Timer DIDQ • SIMATIC Drive Controller (X142)	• "MC_MeasuringInput" (Measuring once) • "MC_MeasuringInputCyclic" (Cyclic measuring)
Measuring via SINAMICS (central measuring probe) (Page 28) ("STANDARD")	Using telegram 39x of the drive control: • SINAMICS S120 CU320-2 (X122/X132) • SINAMICS S120 CU310-2 (X121/X131) • SIMATIC Drive Controller (X122/X132)	
Measuring using PROFIdrive telegram (Page 29) ("PROFIDRIVE")	Using PROFIdrive telegram of the drive axis: • SINAMICS S210 (X130) • SINAMICS S120 CU320-2 (X122/X132) • SINAMICS S120 CU310-2 (X121/X131) • SIMATIC Drive Controller (X122/X132) • CPU 1511C-1 PN / CPU 1512C-1 PN • ET 200SP or ET 200MP • TM Count 2x24V / TM Count 1x24V • TM PosInput 2 / TM PosInput 1 • TM PTO 4 / TM PTO 2x24V	"MC_MeasuringInput" (Measuring once)
Monitor measuring input (Page 31)("MONITORING")	Measurement input via the monitored measuring input with configured measurement input for "Measuring using Timer DI" or "Measuring via SINAMICS (central measuring probe)".	• "MC_MeasuringInput" (Measuring once) • "MC_MeasuringInputCyclic" (Cyclic measuring) The measuring jobs are initiated at the measuring input with measurement input. Measuring jobs to interconnected measuring inputs that monitor the measuring input with measurement input are rejected with an error. Interconnected measuring inputs support the measuring types of the measuring input with measurement input.

6.1.2 Measuring using Timer DI

With measured value acquisition via time stamp, the time points of the signal changes are recorded precisely. The time stamps are then transferred to the controller and the associated actual positions are determined in the technology object.

Measuring using Timer DI requires isochronous mode.

Configuring technology inputs on the Timer DI

You can operate the TM Timer DIDQ technology module centrally on an S7-1500 CPU or decentrally on a distributed I/O.

WARNING

Inaccurate time synchronization

When the technology module TM Timer DIDQ with the measuring input, output cam, or cam track technology object is used at the same time as the "TIO_Sync" function, the time synchronization of the technology module becomes inaccurate.

Do not use the "TIO_Sync" function if you are using the technology module TM Timer DIDQ with the measuring input, output cam, or cam track technology object.

To configure the inputs at the TM Timer DIDQ for use with a measuring input technology object, follow these steps:

1. Under "Basic parameters > Channel configuration", select the desired number of inputs.
2. Select the use with Motion Control technology object under "Basic parameters > Module use from the user program".
3. Under "Channel parameters", configure the following parameters of the input that you want to use as measurement input:
   – "Configuration of DI group": To be able to parameterize and use the inputs independently of each other, select "Use inputs individually".
   – "Operating mode": Select the "Timer DI" operating mode.
4. Then define an application-dependent input delay for the digital input that you want to use as measurement input.
5. Then select the "Isochronous mode" check box for the input and output under "Channel parameters > I/O addresses".
6. The organization block ("MC_Servo") and the process image ("PIP OB Servo") are updated automatically for the input and output addresses by selecting the channel in the input configuration at the technology object.

You can find more information on configuring onboard I/O for Motion Control in the "Configuring technology modules and onboard I/O for Motion Control" section of the "Motion Control overview" function manual.

Interconnecting the Timer DI technology object

To configure a measuring input for measuring using Timer DI, follow these steps:

1. Select the "Measuring using Timer DI".
2. In the "Measuring input" selection box, select a configured measurement input.

   The selection box shows all channels that are configured correctly. For this purpose, you need to have configured the I/O channels as Timer DI beforehand.

6.1.3 Measuring via SINAMICS (central measuring probe)

With central measuring probes, the time points of the signal changes are recorded precisely. The time stamps are then transferred to the controller via telegram 39x and the associated actual positions are determined in the technology object.

Measurements via a central measuring probe are only possible for SINAMICS drives. The maximum usable cycle time on the bus is limited, see "Time-related boundary conditions (Page 39)".

Measurement using SINAMICS (central measuring probe) requires isochronous mode.

You can find more information on the telegrams in the "PROFIdrive telegrams configuration" section of the "S7-1500/S7-1500T Axis functions" documentation.

Configuring the central measuring probe in the drive

1. Configure the necessary central measuring probes on the drive side. For SINAMICS drives that are not configured via Startdrive, assign the inputs to the measuring inputs (p680) in the telegram without gaps and in ascending order.
2. With p728.8 to p728.15, you configure as input all DI/DQs used as measurement input on the Control Unit.
3. Use p680 of the Control Unit to specify the terminals for the central measuring probes.
4. Configure telegrams 391, 392 or 393 on the Control Unit or configure the telegrams 394 or 395 as free telegrams.

Configuring technology inputs on the SIMATIC Drive Controller

To configure the inputs of the X142 interface at SIMATIC Drive Controller for use with a measuring input technology object, follow these steps:

1. Under "DI/DQ 8x24VDC [X142] > Channel parameters", select the channel that you want to use as the measurement input.
2. Select the "Timer DI" operating mode.
3. Activate the "Isochronous mode" option under "DI/DQ 8x24VDC [X142] > I/O addresses".
4. The input and output addresses for the "MC_Servo" organization blocks and the "PIP OB Servo" process image are updated automatically when the channel is selected in the input configuration at the technology object.

You can find more information on configuring onboard I/O for Motion Control in the "Configuring technology modules and onboard I/O for Motion Control" section of the "Motion Control overview" function manual.

Interconnecting the measuring input technology object

To interconnect the measuring input technology object with the inputs, follow these steps:

1. Select the "Measuring via SINAMICS (central measuring probe)".
2. In the "Measuring input" selection box, select a configured measurement input. The selection box shows all compatible telegram types. You are shown all terminals that can potentially be used as measuring inputs.

6.1.4 Measuring using PROFIdrive telegram

With measurement using PROFIdrive telegram, the measurement input is connected to the drive device and measurement takes place directly in the drive. The position value is determined on a signal change at the measurement input. The drive or encoder module communicates the determined position value to the technology object via the PROFIdrive telegram.

With measurement using PROFIdrive telegram, only one measuring input at a time can be active on an actual value or encoder in the PROFIdrive telegram. A maximum of two measuring inputs can be configured on an actual value or encoder in the PROFIdrive telegram via PROFIdrive; see section "Automatic transfer of drive and encoder parameters" of the "S7-1500/S7-1500T Axis functions" documentation.

The drive module and the TM Count, TM PosInput and Compact CPUs technology modules are available to you for measuring using the PROFIdrive telegram.

Interconnecting the measuring input technology object

To interconnect the measuring input technology object with the inputs, follow these steps:

1. Select "Measuring using PROFIdrive telegram (drive or external encoder)" under Hardware interface in the function view.
2. Select the number of the measuring input in the selection box. The input field is preset with the value "1".

Configuring an input to a drive module as measurement input

To configure the inputs with a drive for use with a measuring input technology object, follow these steps:

Select the parameter list in the drive configuration. Use the following PROFIdrive parameters to set the digital input on the drive that is to be used for the configured communication channel.

- Measurement input for the measuring input 1 ("<TO>.Parameter.PROFIdriveProbeNumber" = 1):

  The measurement inputs are set via the p488[0], p488[1] and p488[2] parameters.
- Measurement input for the measuring input 2 ("<TO>.Parameter.PROFIdriveProbeNumber" = 2):

  The measurement inputs are set via the p489[0], p489[1] and p489[2] parameters.

[0] corresponds to encoder 1, [1] to encoder 2 and [2] to encoder 3.

If you use two encoders, select the associated DI in the drive for each encoder. Various results are then transferred to the technology object depending on the selected encoder.

Configuring an input to a TM Count technology module as measurement input

For use with a measuring input, decentralized use with isochronous mode is required.

To configure the inputs at the TM Count for use with a measuring input technology object, follow these steps:

1. Select the "Position detection for "Motion Control" technology object" operating mode for the channel that you want to use as measurement input.
2. Under "Module parameters", configure the parameters for the encoder signals of the channel, depending on the selected encoder.

You can find more information on configuring onboard I/O for Motion Control in the "Configuring technology modules and onboard I/O for Motion Control" section of the "Motion Control overview" function manual.

Configuring an input to a TM PosInput technology module as measurement input

For use with a measuring input, decentralized use with isochronous mode is required.

NOTE

Position detection with single-turn absolute encoder

When a single-turn absolute encoder is used and two edges are to be measured ("MC_MeasuringInput.Mode" = 2, 3 or 4), the distance between the measured edges of the measurement input must be < 1 encoder revolution. Otherwise, use a multi-turn absolute encoder.

To configure the inputs at the TM PosInput for use with a measuring input technology object, follow these steps:

1. Select the "Position detection for "Motion Control" technology object" operating mode for the channel that you want to use as measurement input.
2. Under "Module parameters", configure the parameters for the encoder signals of the channel, depending on the selected encoder.
3. The configuration of the encoder is required for use with an SSI absolute encoder. Information on the configuration is available in the documentation for the respective technology module.

You can find more information on configuring onboard I/O for Motion Control in the "Configuring technology modules and onboard I/O for Motion Control" section of the "Motion Control overview" function manual.

Configuring an input on a CPU 1511C-1 PN/CPU 1512C-1 PN (onboard I/O devices) as measurement input

To configure the inputs at a compact CPU for use with a measuring input technology object, follow these steps:

1. Select the hardware input of the measurement input in the device configuration.
2. Select the desired input delay at the corresponding DI channel under "Input > Channel no. > Input parameters".

You can find more information on configuring onboard I/O for Motion Control in the "Configuring technology modules and onboard I/O for Motion Control" section of the "Motion Control overview" function manual.

6.1.5 Measuring via "Monitor measuring input"

During measuring via "Monitor measuring input", the measuring event of a measurement input is captured by multiple measuring inputs at the same time. Other probes are interconnected with a probe with measuring input for this purpose.

The following figure shows the interconnection of multiple measuring inputs to a common measured signal:

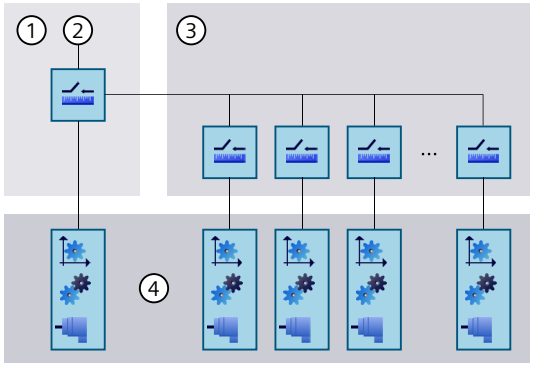

The measuring event is recorded via a measuring input with measurement input ①. "Measuring using Timer DI" or "Measuring via SINAMICS (central measuring probe)" is configured as measurement input ② at this measuring input. The measuring input with measurement input is interconnected with further measuring inputs ③ that monitor the signal acquisition of the measuring input and record the signal at the same time.

The interconnected measuring inputs ③ are each assigned to different, higher-level technology objects ④.

NOTE

Position detection via interconnected measuring inputs is only possible when the measurement input for "Measuring using Timer DI" or "Measuring via SINAMICS (central measuring probe)" is configured at the monitored measuring input.

Configuring the measuring input technology object

To interconnect a measuring input with a measuring input with measurement input, follow these steps:

1. Select "Monitor measuring input".
2. In the selection box, select a measuring input with configured measurement input "Measuring using Timer DI" or "Measuring via SINAMICS (central measuring probe)". First the higher-level technology object and then the measuring input is shown in the selection box.

Programming

Start the jobs for one-time or cyclic measuring with the instructions "MC_MeasuringInput (Page 84)" and "MC_MeasuringInputCyclic (Page 87)" on the measuring input with measurement input. The configured measuring range only applies for the measuring input with measurement input.
When the measuring job is completed, all interconnected measuring inputs automatically output the captured measured values of the actual positions (<TO>.Status = TRIGGER_OCCURRED).
Measuring jobs at interconnected measuring inputs are rejected.

The measured values of the interconnected measuring inputs are output in the data block technology object (<TO>.MeasuredValues.MeasuredValue1 / <TO>.MeasuredValues.MeasuredValue2).

6.2 Defining the correction time for the measurement time

The time of the measurement can be corrected by setting a correction time (<TO>.Parameter.CorrectionTime) for the measuring input technology object.

Define a correction time for the measured signal in the "Hardware interface" configuration window if possible delay times in the measured signal are to be compensated.

Corrections may be required for the following examples:

- Times for mechanical displacement of the measuring input
- Times for the generation of the measured signal before the measurement input
- Filter times at measurement input

The correction time is included in the calculation for all measuring input types of the measuring input technology object.

Also note the time delay when measuring on a virtual axis, see section "Virtual axis" of the "S7-1500/S7-1500T Axis functions" documentation.

6.3 Type of measurement

Parameter settings

With the "Mode" parameter of the Motion Control instructions "MC_MeasuringInput (Page 84)" or "MC_MeasuringInputCyclic (Page 87)", you determine how many and which measuring events should be recorded.

"Mode" parameter in the Motion Control instruction	"MC_MeasuringInput"	"MC_MeasuringInputCyclic"
"Mode" = 0	Measure positive edge only	Measure positive edge only
"Mode" = 1	Measure negative edge only	Measure negative edge only
"Mode" = 2	Measure the next two edges	Measure the next two edges
"Mode" = 3	Measure the next two edges starting with the positive edge	-
"Mode" = 4	Measure the next two edges starting with the negative edge	-

6.4 Defining the measuring range

A measuring job can be activated directly or restricted to a defined measuring range.

The following graphic shows an example of measuring with measuring range in "Mode" = 0 (measurement of next positive edge):

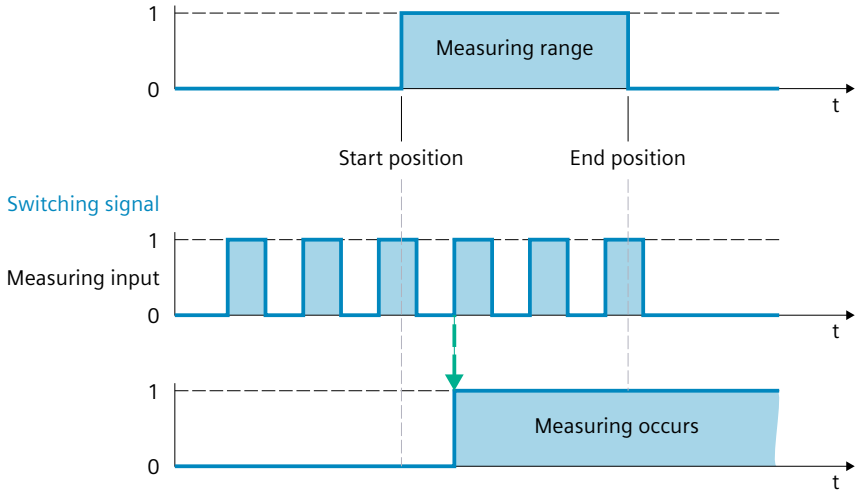

Only measured values within the measuring range are displayed for the technology object.

- If no measuring edge within the measuring range is detected during a one-time measurement, the measuring job is canceled and an alarm is triggered.
- Cyclic measuring remains active even if no measuring edge within the measuring range was detected.

Parameter settings

You activate and define a measuring range in the Motion Control instruction "MC_MeasuringInput (Page 84)" or "MC_MeasuringInputCyclic (Page 87)".

Activating a measuring range

With the parameter "MeasuringRange" = TRUE, you limit acquisition of measured values to a defined measuring range.

Defining the start and end position of the measuring range

- With the "StartPosition" parameter, you define the start position of the measuring range.
- With the "Endposition" parameter, you define the end position of the measuring range.

For axes without modulo function, it is immaterial in which order the start and end positions are specified. If the start position is greater than the end position, the two values are interchanged in the application. If the start position for an axis with modulo function is greater than the end position, the measuring range is extended from the start position past the modulo transition of the axis to the end position.

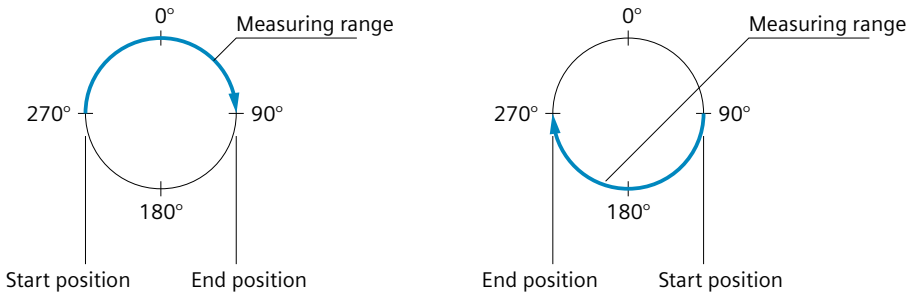

Adjusting the activation time for measuring with measuring range

The measuring function must be active at the measurement input when the start of the measuring range is reached. To compensate for the communication time for activation in the Timer DI or drive, for example, the activation of the measurement in the technology object begins earlier then the measuring range start by the amount of the activation time.

The activation time for measuring with measuring range is divided up as follows:

- The activation time allocation defined and active on the system side is indicated in the "<TO>.Parameter.MeasuringRangeActivationTime" tag.
- In addition, you can define an additional activation time with the "<TO>.Parameter.MeasuringRangeAdditionalActivationTime" tag.

To adjust the activation time defined in the system, enter an additional activation time ("<TO>.Parameter.MeasuringRangeAdditionalActivationTime") in the "Extended parameters" configuration window.

6.5 Measuring once

With one-time measurement, up to two edges can be detected with one measuring job. The associated actual positions are signaled back in the function block and in the technology data block and can be further processed in the user program.

Measuring job for measuring once

Use the Motion Control instruction "MC_MeasuringInput (Page 84)" to start a measuring job for one-time measuring.

The "<TO>.Status" tag in the technology data block changes to "WAITING_FOR_TRIGGER".

The type of measurement ("Mode") set in the Motion Control instruction specifies the edges for which the measured values are to be acquired. The technology object activates the measurement when the selected edge is detected.

- The time of the respective edge is recorded at the measurement input. From the recorded time, the associated position is determined and output, taking into consideration a correction time, if present.
- With direct position detection, the detected position value is supplied directly from the drive or encoder module to the technology object via the PROFIdrive telegram.

The measurement is then finished. The finished measuring job is indicated in the function block in "MC_MeasuringInput.DONE" = TRUE or in the technology data block in "<TO>.Status" = "TRIGGER_OCCURRED".

Depending on the defined type of measurement, the acquired values are saved in the technology data block as follows:

Configured "Mode" parameter in Motion Control instruction "MC_MeasuringInput"	**Output of Motion Control instruction "MC_MeasuringInput"**	
	"MeasuredValue1"	**"MeasuredValue2"**
Measure positive edge only "Mode" = 0	Actual position at the time of the edge	–
Measure negative edge only "Mode" = 1		
Measure the next two edges "Mode" = 2	Actual position at the time of the first edge	Actual position at the time of the second edge
Measure the next two edges starting with the positive edge "Mode" = 3	Actual position at the time of the positive edge	Actual position at the time of the negative edge
Measure the next two edges starting with the negative edge "Mode" = 4	Actual position at the time of the negative edge	Actual position at the time of the positive edge

You start measuring once again with a new Motion Control instruction "MC_MeasuringInput".

If a new job is initiated with the function block, the outputs of the function block are initialized. The technology data block is not initialized. After detecting the first valid measuring cycle, the values in the technology data block and function block are consistent with one another.

Temporal requirements for measuring jobs via "MC_MeasuringInput"

You can find information on the temporal boundary conditions in the section "Time-related boundary conditions (Page 39)".

See also

Defining the measuring range (Page 33)

6.6 Cyclic measuring

With cyclic measuring, up to two measuring events can be acquired by the system in each position control cycle of the technology object and the associated measuring positions can be displayed. The measurements are continued cyclically until they are ended per command.

The determined measured values are displayed in the function block and the technology data block and can be read by the user program.

Cyclic measuring requires the measured value to be determined using hardware support of the type "Measuring using Timer DI (Page 27)" or "Measuring via SINAMICS (central measuring probe) (Page 28)".

Measuring edges at which a measured value could not be determined are indicated in a lost edge counter in the function block and in the technology data block.

Measuring job for cyclic measuring

You start cyclic measuring with the Motion Control instruction "MC_MeasuringInputCyclic (Page 87)". The measuring job is issued to the corresponding measuring hardware.

The type of measurement in the "Mode" parameter set in the Motion Control instruction specifies the edges for which the measured values are to be acquired.

The measuring time values are then forwarded to the technology object. The technology object determines the measuring positions for the measuring times taking into consideration any specified correction times.

Depending on the defined type of measurement, the acquired values are saved in the technology data block as follows:

Configured "Mode" parameter in Motion Control instruction "MC_MeasuringInputCyclic"	Display per position control cycle			
	"MeasuredValue1"	"MeasuredValue2"	"LostEdgeCounter1"[1]	"LostEdgeCounter2"[1]
Detect positive edges only "Mode" = 0	Actual position at the time of the first positive edge	Actual position at the time of the second positive edge	Number of positive or negative edges in excess of two in the position control cycle of acquisition of "MeasuredValue1" and "MeasuredValue2". The following applies here: • If a "MeasuredValue1" and a "MeasuredValue2" are acquired, the number of acquired and lost edges indicated in "LostEdgeCounter1" and "LostEdgeCounter2" are the same. • If only one "MeasuredValue1" is acquired, the "LostEdgeCounter1" is reset to "0". The value in "LostEdgeCounter2" remains changed.	
Detect negative edges only "Mode" = 1	Actual position at the time of the first negative edge	Actual position at the time of the second negative edge		
Detect positive and negative edges "Mode" = 2	Actual position at the time of the first positive edge in the position control cycle	Actual position at the time of the first negative edge in the position control cycle	Number of edges in excess of two in the position control cycle of acquisition of "MeasuredValue1" and "MeasuredValue2". The following applies here: • If a "MeasuredValue1" and a "MeasuredValue2" are acquired, the number of acquired and lost edges indicated in "LostEdgeCounter1" and "LostEdgeCounter2" are the same. • If only one "MeasuredValue1" is acquired, the "LostEdgeCounter1" is reset to "0". The value in "LostEdgeCounter2" remains changed. • If only one "MeasuredValue2" is acquired, the "LostEdgeCounter2" is reset to "0". The value in "LostEdgeCounter1" remains changed.	

1) Applies only to cyclic measuring via Timer DI.

The technology data block tag "<TO>.Status" changes from "INACTIVE" to "WAITING_FOR_TRIGGER" and remains in this status as long as additional events are awaited.

Measured values and counters

With a positive edge at the input "MC_MeasuringInputCyclic.Execute", outputs "MeasuredValue1Counter" and "MeasuredValue2Counter" are reset to "0". As a result, new events can be tracked immediately and new measured value entries can be detected.

All measuring event occurrences of the measuring job are incremented by "1" in the corresponding event counters "<TO>.MeasuredValues.MeasuredValue1Counter" and "<TO>.MeasuredValues.MeasuredValue2Counter" of the technology data block.

The acquired measured values are continuously captured in the technology data block irrespective of individual jobs. The values are only reset to "0" at power-up or restart of the technology object.

After a completed measurement, the measured values are output in the function block. The counters of the function block are set to "0" at a new measuring job. The measured value output in the technology data block always indicates the last acquired measured value.

Lost edge counter (LEC)

Measuring using Timer DI

If more than two edges to be detected occur within one position control cycle, a measured value cannot be evaluated for the other edges to be detected. The number of lost edges is recorded in the LEC.

The lost edges that are recorded in the LEC depend on the mode set in the Motion Control instruction. For example, if only positive edges are to be measured, the LEC records only the non-measured positive edges.

A maximum of seven lost edges can be counted and displayed in the LEC.

The number of lost edges is indicated in the function block and in the technology data block in:

- "LostEdgeCounter1"

  Lost cleared edges from the position control cycle in which "MeasuredValue1" was acquired.

  ⇒ The displayed value in "LostEdgeCounter1" is updated when counter "MeasuredValueCounter1" is incremented.

- "LostEdgeCounter2"

  Lost cleared edges from the position control cycle in which "MeasuredValue2" was acquired.

  ⇒ The displayed value in "LostEdgeCounter2" is updated when counter "MeasuredValueCounter2" is incremented.

Measuring via SINAMICS (central measuring probe)

During cyclic measuring using the central measuring probe, the LEC is always 0.

Examples of measured values and counters

The following figures show examples of divergence of "MeasuredValue1Counter" and "MeasuredValue2Counter" as a result of lost edges.

Example: Measurement at positive edges (Mode = 0)

Processing cycle TO Measuring input	N	N+1	N+2	N+3	N+4	N+5	N+6	N+7	N+8	N+9	N+10
Measuring input											
MeasuredValue1Counter	...	6	7	7	8	9	9	10	11	12	13
LostEdgeCounter1	...	0	0	0	0	0	0	1	0	1	0
MeasuredValue2Counter	...	6	7	7	7	7	7	8	8	9	9
LostEdgeCounter2	...	0	0	0	0	0	0	1	1	1	1

Example: Measurement at negative edges (Mode = 1)

Processing cycle TO Measuring input	N	N+1	N+2	N+3	N+4	N+5	N+6	N+7	N+8	N+9	N+10
Measuring input											
MeasuredValue1Counter	...	6	7	8	9	10	10	11	11	12	13
LostEdgeCounter1	...	0	0	0	1	0	0	1	1	1	0
MeasuredValue2Counter	...	6	7	7	8	8	8	9	9	10	10
LostEdgeCounter2	...	0	0	0	1	1	1	1	1	1	1

Example: Measurement at positive and negative edges (Mode = 2)

Processing cycle TO Measuring input	N	N+1	N+2	N+3	N+4	N+5	N+6	N+7	N+8	N+9	N+10
Measuring input											
MeasuredValue1Counter	...	6	7	7	8	9	9	10	11	12	13
LostEdgeCounter1	...	0	2	2	0	0	0	3	0	4	0
MeasuredValue2Counter	...	6	7	8	8	9	10	11	12	13	14
LostEdgeCounter2	...	0	2	0	0	0	0	3	0	4	0

See also

Defining the measuring range (Page 33)

6.7 Cancel active measuring job

You can cancel an active measuring job with the Motion Control instruction "MC_AbortMeasuringInput (Page 91)".

If the measuring job was canceled successfully, "MC_AbortMeasuringInput.CommandAborted" = TRUE is shown at the function block.

You start another measurement with a new Motion Control instruction "MC_MeasuringInput" or "MC_MeasuringInputCyclic".

6.8 Time-related boundary conditions

Depending on the hardware used and selection of edges to be detected, different system-inherent requirements apply to the time allowed after calling the Motion Control instruction "MC_MeasuringInput" or "MC_MeasuringInputCyclic" until a measurement occurs and the results are displayed.

The following times must be distinguished here:

- Time until the measuring event can be captured
- Time until the measurement result is displayed or the measurement is finished.

The times calculated taking into account the current settings are indicated in configuration window "Extended parameters" of a measuring input.

Measuring using Timer DI

Description	Measuring once	Cyclic measuring
Time from output of a measuring job until measuring event detection becomes effective ("MeasuringRangeActivationTime")	$2 \times T_{servo}$	
Activation time for a measurement with measuring range	"MeasuringRangeActivationTime" + "MeasuringRange-AdditionalActivationTime"	
Minimum time after measuring event until measured value is available in the controller	$2 \times T_{servo} + T_{Send}$	$T_{servo} + T_{Send}$
Minimum time between two measuring events	$4 \times T_{servo} + T_{Send}$	T_{servo}

Measuring via SINAMICS (central measuring probe)

Description	Measuring once	Cyclic measuring
Time from output of a measuring job until measuring event detection becomes effective ("MeasuringRangeActivationTime")	$2 \times T_{servo}$	
Activation time for a measurement with measuring range	"MeasuringRangeActivationTime" + "MeasuringRange-AdditionalActivationTime"	
Minimum time after measuring event until measured value is available in the controller	$2 \times T_{servo}$	$T_{servo} + T_{Send}$
Minimum time between two measuring events	$4 \times T_{servo}$	$3 \times T_{servo}$

Measurement using PROFIdrive telegram (drive or external encoder)

Description	Times depending on the configuration at the Motion Control instruction "Mode" parameter in the "MC_MeasuringInput".	
Time from output of a measuring job until measuring event detection becomes effective ("MeasuringRangeActivationTime")	"Mode" 0.1, 2.3 and 4: • If T_{Send} and T_{servo} are the same: $3 \times T_{servo}$ • If T_{Send} and T_{servo} are different: $2 \times T_{servo}$	
Activation time for a measurement with measuring range	"Mode" 0, 1 or 2: "MeasuringRangeActivation-Time" + "MeasuringRangeAddition-alActivationTime" + $2 \times T_{servo}$	"Mode" 3 and 4: "MeasuringRangeActivation-Time" + "MeasuringRangeAddition-alActivationTime" + $3 \times T_{servo}$
Time from output of an "MC_MeasuringInput" job until measuring event detection becomes effective	"Mode" 0, 1, 2: "MeasuringRangeActivation-Time" + $2 \times T_{servo}$	"Mode" 3, 4: "MeasuringRangeActivation-Time" + $3 \times T_{servo}$
Time after measuring event until measured value is available in the controller	"Mode" 0, 1: $7 \times T_{servo}$	"Mode" 2, 3, 4: $13 \times T_{servo}$

Definition of tags

- T_{servo} = Call interval of the technology object in the servo cycle clock [ms]
- T_{Send} = Send clock [ms]
- "MeasuringRangeActivationTime" = See section "Measuring with measuring range (Page 33)"

NOTE

Maximum bus clock cycle

With the use of SINAMICS central measuring probes, the maximum bus clock cycle T_{Send} can be up to 8 ms.

To prevent asynchronous processing from overwriting a measured value that was just determined, a new one-time measuring job cannot be started until the active measurement has concluded. The sum of the activation time and the time until display or conclusion must be taken into account for this.

In the case of cyclic measuring, evaluation or temporary storage of the measurement results in the synchronous MC_PreInterpolator is recommended from the user perspective.

6.9 Tags: Measuring input technology object

The following technology object tags are relevant for measuring:

Status indicator		
Tag	**Description**	
<TO>.Status	Status of the measuring input function	
	0	Measurement is not active ("INACTIVE")
	1	The measuring input is waiting for a measuring event ("WAITING_FOR_TRIGGER")
	2	The measuring input has acquired one or more measured values ("TRIGGER_OCCURRED").
	3	Error during the measurement ("MEASURING_ERROR")
<TO>.InputState	Status of the measurement input	

Measurement input	
Tag	**Description**
<TO>.Parameter.MeasuringInputType	Measuring input type
<TO>.Parameter.PROFIdriveProbeNumber	Number of the measurement input to be used for a measurement via PROFIdrive telegram
<TO>.Parameter.MeasuringRangeActivationTime	System-defined activation time allocation [ms]
<TO>.Parameter.MeasuringRangeAdditionalActivationTime	Additional user-defined activation time allocation [ms]
<TO>.Parameter.CorrectionTime	User-defined correction time for the measurement result [ms]
<TO>.Interface.Address	I/O address for the digital measurement input

Measuring output	
Tag	**Description**
<TO>.MeasuredValues.MeasuredValue1	1st measured value
<TO>.MeasuredValues.MeasuredValue2	2nd measured value (when measuring two or more edges in one position control cycle)
<TO>.MeasuredValues.MeasuredValue1Counter	Count value for the first measured value
<TO>.MeasuredValues.MeasuredValue2Counter	Count value for the second measured value
<TO>.MeasuredValues.LostEdgeCounter1	Lost edges in the cycle clock of the first measured value acquisition Zero in the case of one-time measurement During cyclic measurement via SINAMICS equal to zero
<TO>.MeasuredValues.LostEdgeCounter2	Lost edges in the cycle clock of the second measured value acquisition Zero in the case of one-time measurement During cyclic measurement via SINAMICS equal to zero

StatusWord	
Tag	**Description**
<TO>.StatusWord.X0 (Control)	The technology object is in operation.
<TO>.StatusWord.X1 (Error)	An error occurred at the technology object.
<TO>.StatusWord.X2 (RestartActive)	The technology object is being reinitialized. The tags of the technology data block are not updated with active restart.
<TO>.StatusWord.X3 (OnlineStartValuesChanged)	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object.
<TO>.StatusWord.X5 (CommunicationOk)	The measuring input is synchronized with the measurement input and can be used. With the monitoring measuring input, this bit always has the value "FALSE".

ErrorWord	
Tag	**Description**
<TO>.ErrorWord.X0 (SystemFault)	A system-internal error has occurred.
<TO>.ErrorWord.X1 (ConfigFault)	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data was incorrectly modified during runtime of the user program.
<TO>.ErrorWord.X2 (UserFault)	Error in user program at a Motion Control instruction or its use
<TO>.ErrorWord.X3 (CommandNotAccepted)	Command cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
<TO>.ErrorWord.X13 (PeripheralError)	Error accessing a logical address

ErrorDetail		
Tag	**Description**	
<TO>.ErrorDetail.Number	Alarm number You can find a list of the technology alarms and alarm responses in the "Technology alarms" section in the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
<TO>.ErrorDetail.Reaction	Effective alarm response	
	0	No reaction
	6	End measuring input processing

Output cam functions

7

7.1 Defining the output cam type

Select an output cam type based on the desired switching behavior:

- Select the distance output cam (Page 44) for position-dependent switch-on/switch-off.
- Select the time-based output cam (Page 45) for position-dependent switch-on and time-dependent switch-off.

7.1.1 Configuring the distance output cam

A distance output cam switches between the start position and end position. Outside this range, the distance output cam is switched off.

Switch-on range

The switch-on range of distance output cams is defined by the start position and end position.

Start position smaller than end position

When the start position is less than the end position, the switch-on range begins with the start position and ends with the end position.

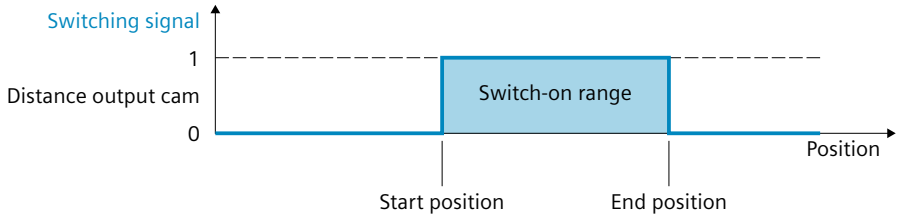

Start position greater than end position

When the start position is greater than the end position, there are two switch-on ranges as follows:

- Switch-on range beginning with the start position and ending with the positive range end (e.g. positive software limit switch, end of modulo range)
- Switch-on range beginning with the negative range end (e.g. negative software limit switch, start of modulo range) and ending with the end position

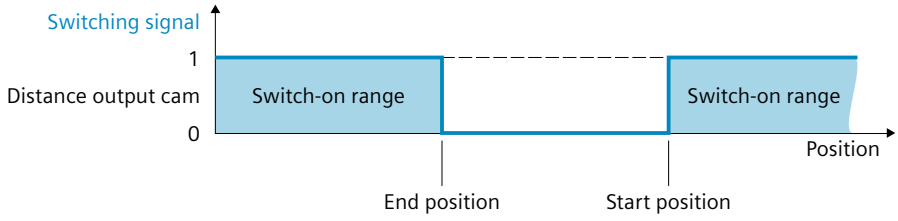

Mapping to an axis with modulo function

With active modulo function of the interconnected technology object, the start and end positions of the output cam are automatically mapped to values within the modulo range.

Example

- Modulo range = 0° to 50°
- Output cam start position = 80°
- Output cam end position = 220°

The specified start and end position of the distance output cam are outside the modulo range. The values are therefore mapped onto the modulo range. The start position is at 30° (80° mod 50° = 30°) and the end position is at 20° (220° mod 50° = 20°).

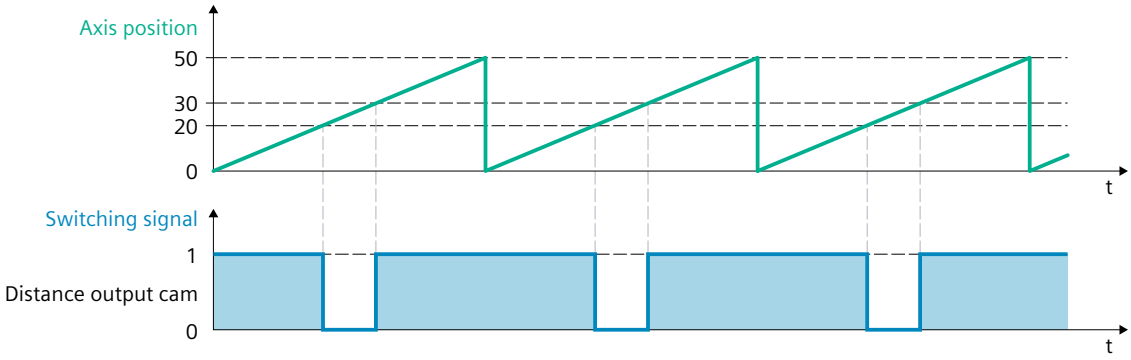

7.1.2 Configuring the time-based output cam

A time-based output cam switches on at the start position and remains set for the on-load factor.

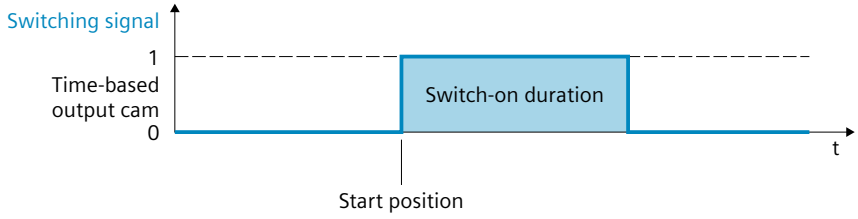

Mapping to an axis with modulo function

In the case of active modulo function of the interconnected technology object, the start position of the output cam is automatically mapped to the value within the modulo range.

Example

- Modulo range = 0° to 50°
- Output cam start positions:
  - Output cam 1 = 20°
  - Output cam 2 = 30°
  - Output cam 3 = 80°

The time-based output cam 1 switches on at 20°, the time-based output cam 2 switches on at 30°. The specified start position of time-based output cam 3 is outside the modulo range. The

value for the start position is therefore mapped onto the modulo range so that the time-based output cam 3 switches on at 30°. All three output cams remain active the set on-load factor in each case.

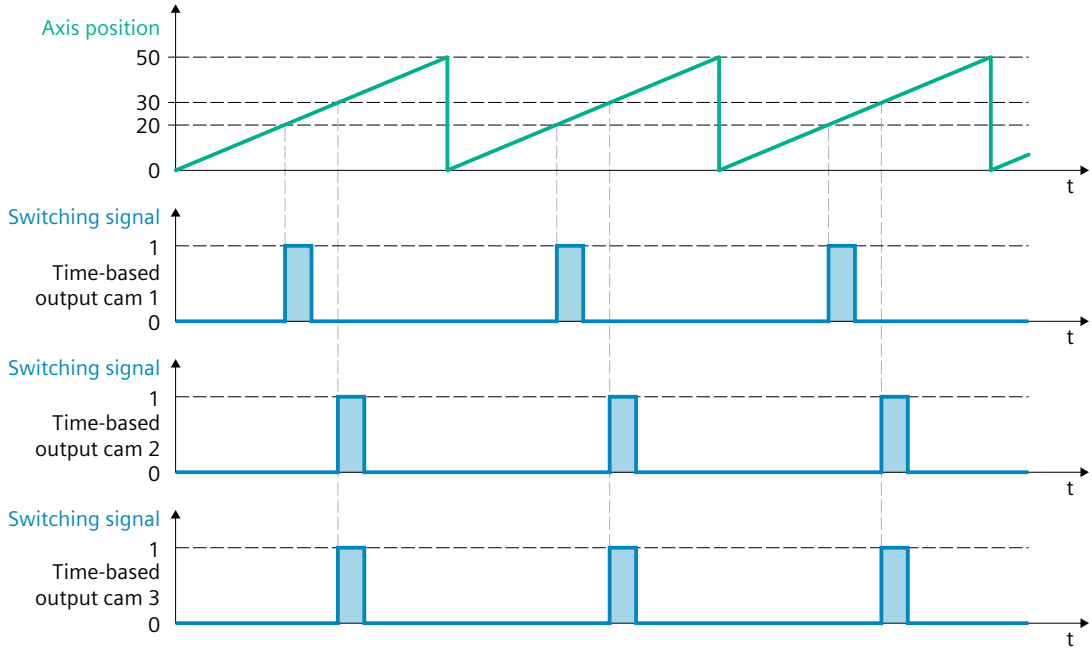

7.2 Configuring the output cam reference

You define the position reference for the switching points of the output cams in the "Basic parameters > Output cam reference" configuration window.

The switching points of the output cams can be referenced to the following positions, depending on the interconnected technology object:

- Position setpoint

  Position setpoint of the interconnected synchronous/positioning axis
- Current position

  Actual position of the interconnected synchronous/positioning axis or the position of the interconnected external encoder

Homing the interconnected technology object

A change to the position of an axis or external encoder using Motion Control instruction "MC_Home" is regarded as a sudden position change.

The following behavior is possible for a position jump:

- Distance output cams are either skipped or correspondingly output.
- Time-based output cams are skipped. A time-based output cam is switched on only when the start position is overtraveled and remains switched on for the switch-on duration.
- Switched time-based output cams are not canceled by a homing operation.

Trace recording of output cams with reference to setpoint position

The CPU calculates the output time of the output cam in such a way that the output cam is switched when the position setpoint has been transferred from the PLC to the drive.

The communication time is not considered in the trace.

7.3 Configuring the output cam output

7.3.1 Activate/deactivate output cam output

In the "Hardware interface > Output cam output" configuration window, you activate and configure the output of the generated switching signals via a digital output.

When the output is activated, you can configure the following digital outputs:

- Output by Timer DQ (Page 47)

  Digital output with high degree of accuracy and reproducibility in the microsecond range on time-based IO modules basis

- Output by a digital module (Page 49)

  Digital output with switching accuracy depending on the output cycle of the I/O used

When output is deactivated, the output cam status is not output at the hardware output. The output cam status can be used internally in the user program by evaluating the relevant "<TO>.CamOutput" tag.

7.3.2 Configuring output by Timer DQ

In the case of signal output via time stamp, the times of the signal changes are determined by the technology object. The time stamps are then transferred to the hardware of the digital output and the edges are output with high precision.

Output by Timer DQ requires isochronous mode.

With output via a Timer DQ, you select a suitable channel in the "Output" field. The selection box shows all channels that are configured as Timer DQ. For this purpose, you need to have configured the I/O channels as Timer DQ beforehand.

Timer DQs are supported by:

- ET 200MP TM Timer DIDQ 16x24V
- ET 200MP TM Timer DIDQ 24x24V
- ET 200SP TM Timer DIDQ 10x24V
- SIMATIC Drive Controller (X142)

Configuring technology outputs on the Timer DQ

You can operate the TM Timer DIDQ technology module centrally on an S7-1500 CPU or decentrally on a distributed I/O.

WARNING

Inaccurate time synchronization

When the technology module TM Timer DIDQ with the measuring input, output cam, or cam track technology object is used at the same time as the "TIO_Sync" function, the time synchronization of the technology module becomes inaccurate.

Do not use the "TIO_Sync" function if you are using the technology module TM Timer DIDQ with the measuring input, output cam, or cam track technology object.

To configure the outputs at the TM Timer DIDQ for use with an output cam or cam track technology object, follow these steps:

1. Under "Basic parameters > Channel configuration", select the desired number of outputs (only ET 200MP TM Timer DIDQ 16x24V).
2. Select the use with Motion Control technology object under "Basic parameters > Module use from the user program".
3. Select the "Timer DQ" mode for the respective output under "Channel parameters".
4. Activate the "Isochronous mode" option for the input and output under "Channel parameters > I/O addresses".
5. The organization block ("MC_Servo") and the process image ("PIP OB Servo") are updated automatically for the input and output addresses by selecting the channel in the input configuration at the technology object.

You can find more information on configuring onboard I/O for Motion Control in the "Configuring technology modules and onboard I/O for Motion Control" section of the "Motion Control overview" function manual.

Configuring technology outputs on the SIMATIC Drive Controller

To configure outputs of the X142 interface on the SIMATIC Drive Controller as an output for the output cam or cam track technology object, follow these steps:

1. Under "DI/DQ 8x24VDC [X142] > Channel parameters", select the channel that you want to use as the output.
2. Select the "Timer DQ" operating mode.
3. Activate the "Isochronous mode" option under "Channel parameters > I/O addresses".
4. The input and output addresses for the "MC_Servo" organization blocks and the "PIP OB Servo" process image are updated automatically when the channel is selected in the output configuration at the technology object.

You can find more information on configuring onboard I/O for Motion Control in the "Configuring technology modules and onboard I/O for Motion Control" section of the "Motion Control overview" function manual.

Timer DQ at the technology object

Follow these steps to configure output by Timer DQ:

1. Select the "Activate output" check box.
2. Select "Output by Timer DQ".
3. In the "Output" selection box, select a configured output cam output.

   The selection box shows all channels that are configured correctly. For this purpose, you need to have configured the I/O channels as Timer DQ beforehand.

7.3.3 Configuring output by digital module

Follow these steps to configure output by digital output module:

1. Select the "Activate output" check box.
2. Select "Output by digital output module".
3. In the "Output" selection box, select a digital output module.

   Only the digital outputs with previously defined PLC tags are displayed for selection.

7.3.4 Outputting multiple output cams to one output

You have the option to output multiple output cams to one digital output. The output of multiple output cams to one output is performed with either an AND or OR logic operation of the output cam signals to the output. The logic operation relates to the last signal to be output after the set inversion, if any.

To output multiple output cams to one output, configure the respective output cams as follows:

1. Select the "Activate output" check box
2. Select output by Timer DQ (Page 47) or a digital output module (Page 49).
3. In the "Output" selection box, select a configured output cam output.
4. Select the logical operation of the output cam signal at the output.

   All output cams that use the selected output are shown graphically.

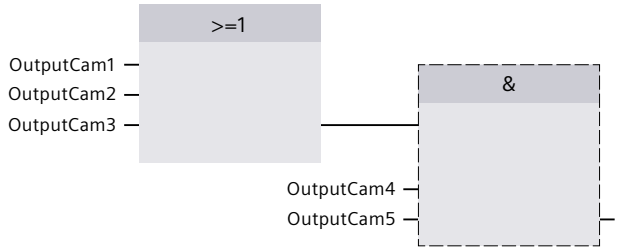

Display of the switching state

The switching state of the output cam is displayed in the associated technology data block in "<TO>.CamOutput".

7.4 Defining the activation time and deactivation time

To compensate for communication times or switching times of the output and the connected actuator, enter an activation time or deactivation time at the output cam or cam track technology object.

The activation time is specified as the lead time for the switch-on edge, and the deactivation time as the lead time for the switch-off edge.

For the timers, the following must apply:

Switch on duration > deactivation time - activation time

You define the activation time (<TO>.Parameter.OnCompensation) and the deactivation time (<TO>.Parameter.OffCompensation) in the configuration window under "Configuration > Extended parameters > Activation time".

If the output cam has been switched with consideration of the derivative-action times and the current velocity changes afterwards, the output cam will not be switched again.

Influence of the digital outputs used

- When the output cam is output via timer DQ, the communication times are automatically taken into account.
- When the output cam is output via digital output, the communication times are not automatically taken into account.

You can find more information in the sections on switching behavior of distance output cams (Page 54) or time-based output cams (Page 58).

7.5 Configuring a hysteresis

Possible variations in the actual position/position setpoint can result in unwanted switch-on and switch-off of output cams.

Minimal changes of the actual value of an axis in standstill can result in the switching on or off of an actual value output cam with preset positive or negative effective direction. Even minimal changes of the setpoints of a switched-off axis in follow-up mode can result in switch-on or switch-off of an actual value output cam with specified positive or negative effective direction. Such unwanted switching states can be prevented by configuring a hysteresis (> 0.0). The configuration of a hysteresis value (> 0.0) is recommended in particular with reference to the actual position.

The hysteresis is a position tolerance within which the position values may vary without changing the switching state of the output cam. Changes of direction detected within the hysteresis are ignored.

You define the hysteresis value in the configuration of the output cam technology object under "Configuration > Extended parameters > Hysteresis" (<TO>.Parameter.Hysteresis).

Behavior

The hysteresis is activated on a direction reversal.

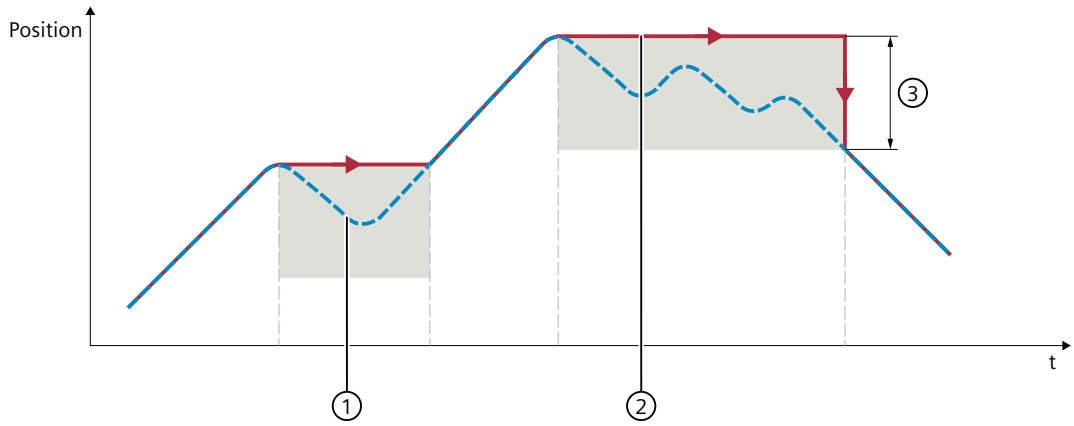

① Actual position
② Effective position
③ Hysteresis range

The hysteresis behavior depends on the output cam type:

- Distance output cam (Page 55)
- Time-based output cam (Page 59)

Hysteresis range

The maximum size of the hysteresis range in the system is:

- For an axis with modulo function, one quarter of the modulo range
- For an axis without modulo function, one quarter of the operating range

7.6 Inverted output

In the case of inverted output, the range in which the output cam output is switched on and the range in which it is switched off are swapped.

You define the operating mode with the "Mode" parameter of the Motion Control instruction "MC_OutputCam (Page 92)". With "Mode" = 2, you define the inverted output. The inverted output is active when the instruction is enabled via "Enable" = TRUE.

You can set the inverted output for both distance output cams and time-based output cams.

7.7 How distance output cams work

7.7.1 Defining the effective direction of distance output cams

You define the effective direction of the distance output cams with the "Direction" parameter of the Motion Control instruction "MC_OutputCam".

The following examples show the behavior of the distance output cams as a function of the set effective direction.

Example of "positive" effective direction ("Direction" = 1)

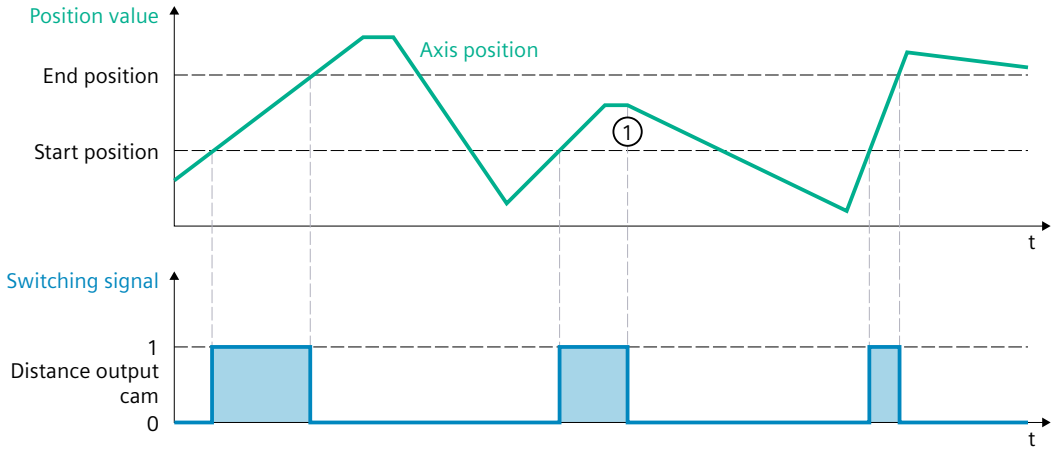

The distance output cam switches on when the switch-on range is reached in the **positive** direction. The distance output cam switches off in the event of a direction reversal 1.

If the position value is moved into the switch-on range of the distance output cam, the distance output cam switches on when there is positive motion direction of the interconnected technology object. The distance output cam remains switched off when the interconnected technology object is at a standstill.

Example of "negative" effective direction ("Direction" = 2)

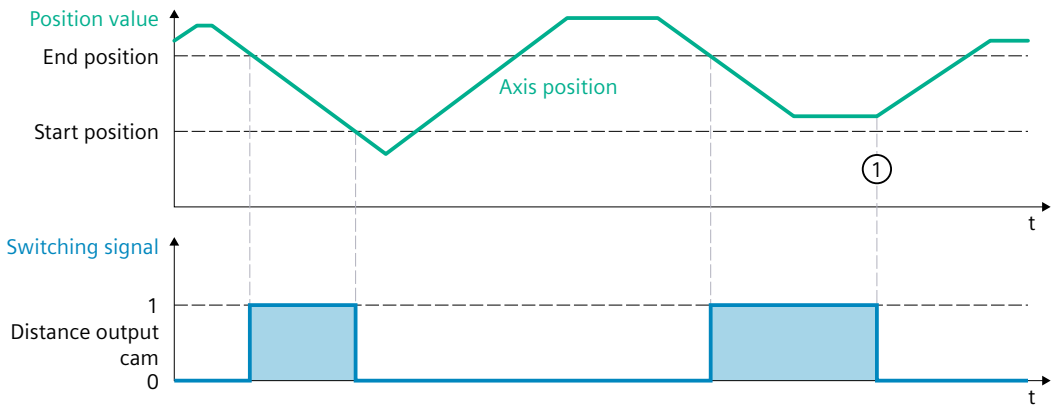

The distance output cam switches on when the switch-on range is reached in the **negative** direction. The distance output cam switches off in the event of a direction reversal ①.

If the position value is moved into the switch-on range of the distance output cam, the distance output cam switches on when there is negative motion direction of the interconnected technology object. The distance output cam remains switched off when the interconnected technology object is at a standstill.

Example of "both directions" effective direction ("Direction" = 3)

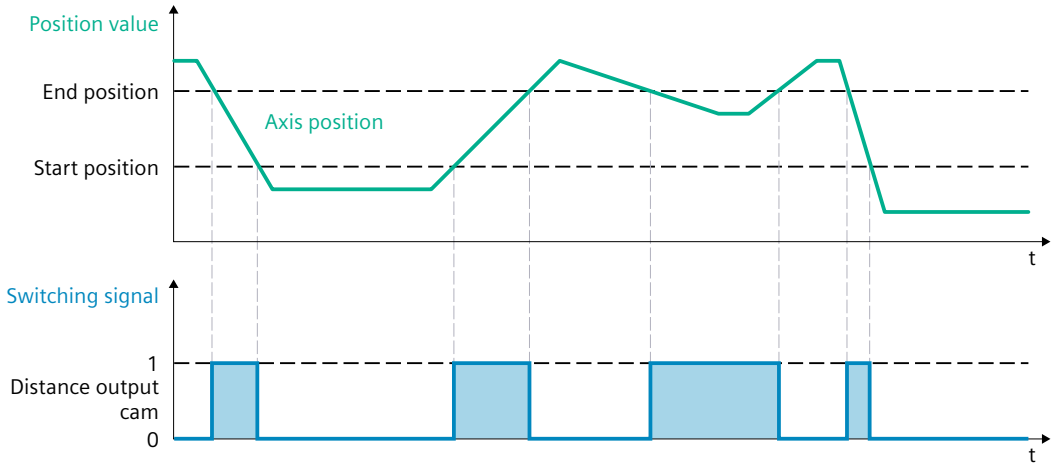

The distance output cam switches on when the position of the interconnected technology object is within the switch-on range.

If the position value of the interconnected technology object is moved into the switch-on range of the distance output cam, the distance output cam switches on even when the interconnected technology object is at a standstill.

7.7.2 Activating/deactivating the distance output cam

You use Motion Control instruction "MC_OutputCam (Page 92)" to activate the specified distance output cam.

You determine the switch-on range of a distance output cam with the following parameters of the Motion Control instruction "MC_OutputCam":

- With the "OnPosition" parameter, you define the start position of an output cam. A setpoint output cam with the setting "MC_OutputCam.OnPosition" = 0 switches at position setpoint = 0.
- With the "OffPosition" parameter, you define the end position of an output cam.

You define the operating mode of an output cam with the "Mode" parameters of the Motion Control instruction "MC_OutputCam".

- When "Mode" = 1, the output cam is not output inverted.
- When "Mode" = 2, the output cam is output inverted (Page 51).
- When "Mode" = 3, the output cam is permanently switched on while "Enable" = TRUE .

When "MC_OutputCam.Enable" = TRUE, the input parameters are always read and take effect at the next position control cycle.

When a technological alarm occurs, the output cam is processed again after error acknowledgment.

NOTE

Enabling output cams

To guarantee precise switching, an output cam must be enabled for at least two application cycles before the output cam start is reached. Otherwise, distance output cams are imprecise.

Observe the switching behavior of the distance output cams (Page 54).

The "MC_OutputCam" job is deactivated by:

- Disabling the output cam with "MC_OutputCam.Enable" = FALSE.
- Only one instance of the "MC_OutputCam" function block can be active on an output cam in the user program. A second instance of the "MC_OutputCam" function block on a currently active output cam is rejected with an error.

7.7.3 Defining the switching behavior of distance output cams

The switch-on duration for distance output cams is determined by the switching positions and the current velocity.

After activation, a distance output cam switches on in the following cases:

- The position of the interconnected technology object reaches the start or end position with the configured effective direction ("Direction").
- The position of the interconnected technology object is moved into the switch-on range of the output cam (e.g. during homing) in the configured effective direction ("Direction"). When "Direction" = 3 (both effective directions), the output cam switches on even when the interconnected technology object is at a standstill.
- The output cam is switched on permanently with Motion Control instruction "MC_OutputCam" and "Mode" = 3.

An active distance output cam switches off in the following cases:

- The position is outside the switch-on range of the output cam.
- The position value is moved outside the switch-on range of the output cam.
- Motion Control instruction "MC_OutputCam" is set to "Enable" = FALSE.
- The motion direction of the interconnected technology object is reversed and no longer agrees with the enabled effective direction.

7.7.4 Hysteresis behavior of distance output cams

The following applies within the hysteresis:

- The switching state of distance output cams is not changed.
- The motion direction is not determined again.

After the hysteresis range is exited, distance output cams are set according to the output cam settings.

The following examples show the effects of the hysteresis on the switching behavior of output cams with positive effective direction.

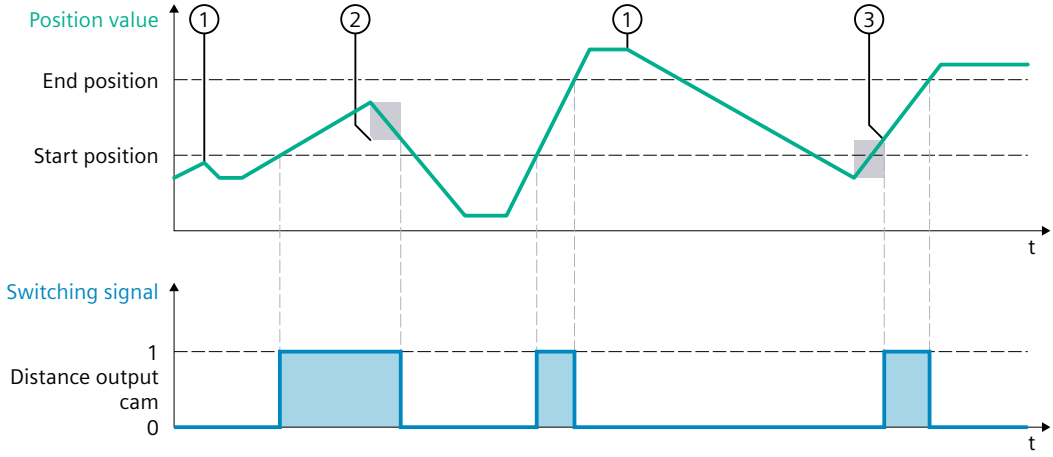

① Direction reversal without hysteresis effect

② Hysteresis in effect

③ The switch-on position of the distance output cam is influenced according to the direction reversal and hysteresis.

7.8 How time-based output cams work

7.8.1 Defining the effective direction of time-based output cams

You define the effective direction of the time-based output cams with the "Direction" parameter of the Motion Control instruction "MC_OutputCam".

The following examples show the behavior of the time-based output cams as a function of the set effective direction.

Example of "positive" effective direction ("Direction" = 1)

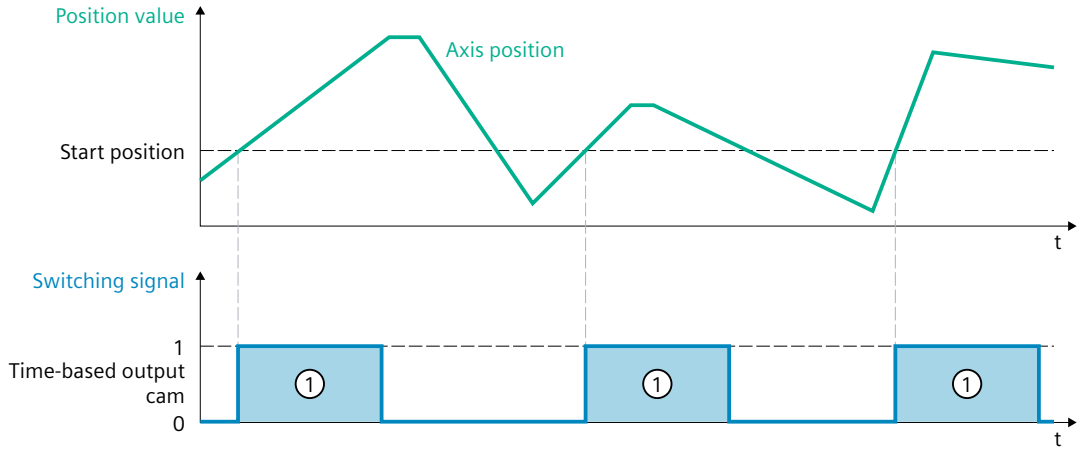

The time-based output cam switches on when the start position is reached in the **positive** direction. At a direction reversal, the time-based output cam remains switched on for the specified switch-on duration ①.

If the position value of the interconnected technology object is directly on or behind the start position of the time-based output cam during the homing motion, the time-based output cam does not switch on.

Example of "negative" effective direction ("Direction" = 2)

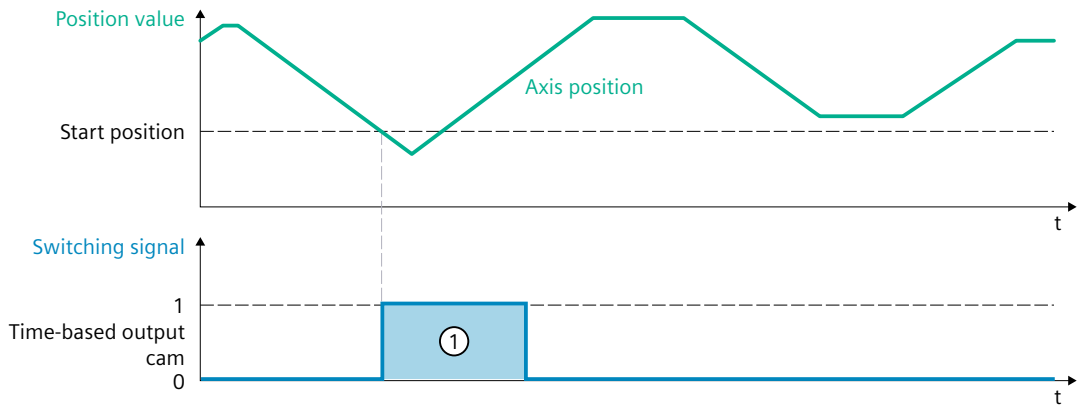

The time-based output cam switches on when the start position is reached in the **negative** direction. At a direction reversal, the time-based output cam remains switched on for the specified switch-on duration ①.

If the position value of the interconnected technology object is directly on or behind the start position of the time-based output cam during the homing motion, the time-based output cam does not switch on.

Example of "both directions" effective direction ("Direction" = 3)

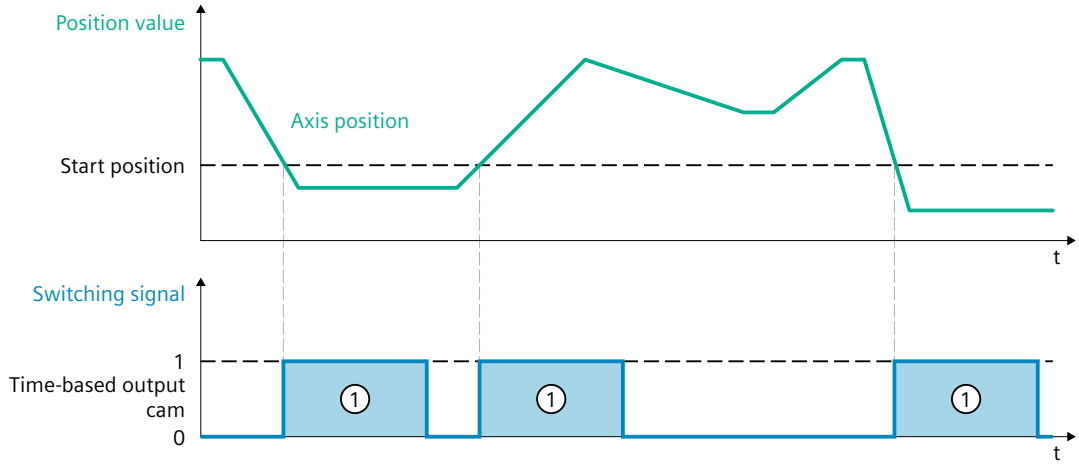

The time-based output cam switches on when the start position is reached. At a direction reversal, the time-based output cam remains switched on for the specified switch-on duration ①.

If the position value of the interconnected technology object is directly on or behind the start position of the time-based output cam during the homing motion, the time-based output cam does not switch on.

7.8.2 Activating/deactivating a time-based output cam

You use Motion Control instruction "MC_OutputCam (Page 92)" to activate the specified output cam.

You determine the switch-on range of a time-based output cam with the following parameters of the Motion Control instruction "MC_OutputCam":

- With the "OnPosition" parameter, you define the start position of an output cam. A setpoint output cam with the setting "MC_OutputCam.OnPosition" = 0 switches at position setpoint = 0.
- With the "Duration" parameter, you define the switch-on duration of an output cam.

You define the operating mode of an output cam with the "Mode" parameters of the Motion Control instruction "MC_OutputCam".

- When "Mode" = 1, the output cam is not output inverted.
- When "Mode" = 2, the output cam is output inverted (Page 51).
- When "Mode" = 3, the output cam is permanently switched on while "Enable" = TRUE.

When "MC_OutputCam.Enable" = TRUE, the input parameters are always read and take effect at the next position control cycle.

When a technological alarm occurs, the output cam is processed again after error acknowledgment.

NOTE

Enabling output cams

To guarantee precise switching, an output cam must be enabled for at least two application cycles before the output cam start is reached. Otherwise, time-based output cams are not switched on.

Observe the switching behavior of the time-based output cams (Page 58).

The "MC_OutputCam" job is deactivated by:

- Disabling the output cam with "MC_OutputCam.Enable" = FALSE.
- Only one instance of the "MC_OutputCam" function block can be active on an output cam in the user program. A second instance of the "MC_OutputCam" function block on a currently active output cam is rejected with an error.

7.8.3 Defining the switching behavior of time-based output cams

A time-based output cam switches on in the following cases:

- The start position has been reached and the motion direction of the interconnected technology object corresponds to the effective direction enabled by the instruction.

  NOTE

  – If the start position is reached again while an output cam is switched on, the switch-on duration is not re-triggered.

  – If due to the Motion Control instruction "MC_Home", the position value of the interconnected technology object is placed directly on or behind the start position of the output cam during the motion, the output cam does not switch on.

- The output cam is switched on permanently with Motion Control instruction "MC_OutputCam" and "Mode" = 3.

A time-based output cam switches off in the following cases:

- The configured switch-on duration has expired.
- Motion Control instruction "MC_OutputCam" is set to "Enable" = FALSE.

For time-based output cams, you indicate the switch-on duration at the "Duration" parameter of the "MC_OutputCam" instruction.

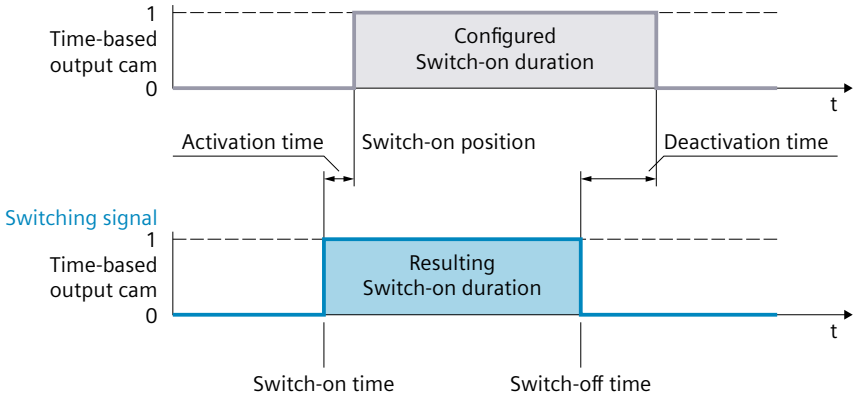

The derivative-action time dynamically shifts the switch-on and switch-off times of the time-based output cam depending on the velocity of the axis.

Example

An actuator (e.g. valve) is to open at position 200° and the derivative-action time is 0.5 s.

- With a velocity of 10°/s, the switch-on time is already at 195°.
- With a velocity of 20°/s, the switch-on time is already at 190°.

The switch-off time shifts accordingly.

7.8.4 Hysteresis behavior of time-based output cams

The following applies within the hysteresis:

- The motion direction is not determined again.
- If the start position of a time-based output cam is within the hysteresis, the time-based output cam is switched on when leaving the hysteresis with the corresponding effective direction.
- The switch-on duration of time-based output cams remains unchanged.

The following examples show the effects of the hysteresis on the switching behavior of output cams with positive effective direction.

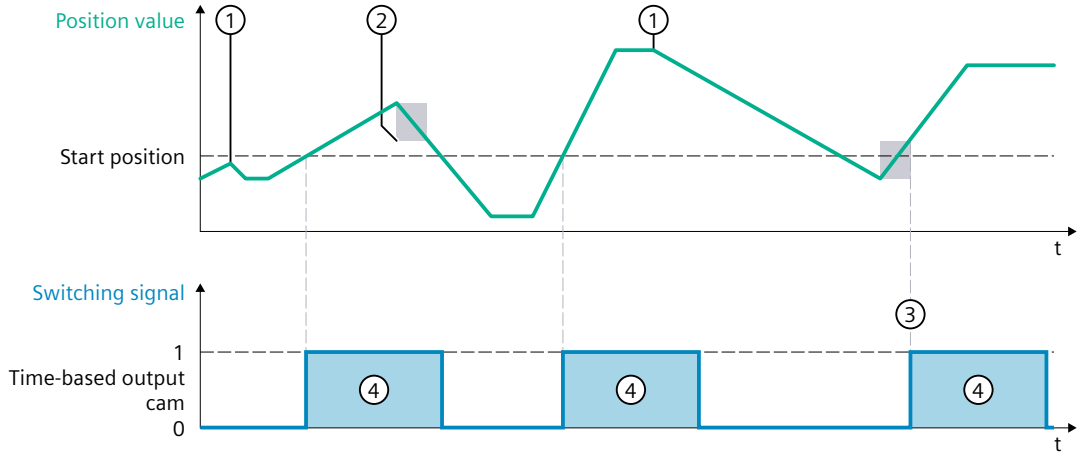

① Direction reversal without hysteresis effect

② Hysteresis in effect

③ The start position of the time-based output cam is located within the hysteresis. The time-based output cam is switched on when leaving the hysteresis with the corresponding effective direction.

④ Switch-on duration

7.9 Tags: Output cam technology object

The following technology object tags are relevant:

Status indicator	
Tag	**Description**
<TO>.CamOutput	The output cam is switched.

Parameters		
Tag	**Description**	
<TO>.Parameter.OutputCamType	Output cam type	
	0	Distance output cam
	1	Time-based output cam
<TO>.Parameter.PositionType	Position reference	
	0	Position setpoint
	1	Actual position
<TO>.Parameter.OnCompensation	Activation time (lead time for the switch-on edge)	
<TO>.Parameter.OffCompensation	Deactivation time (lead time for the switch-off edge)	
<TO>.Parameter.Hysteresis	Hysteresis value	

Interface		
Tag	**Description**	
<TO>.Interface.EnableOutput	Activation of the output cam output	
	FALSE	No output
	TRUE	Output
<TO>.Interface.Address	I/O address of the output cam	
<TO>.Interface.LogicOperation	Logical operation of the output cam signals at the output	
	0	OR logic operation
	1	AND logic operation

Units	
Tag	**Description**
<TO>.Units.LengthUnit	Unit of the length data
<TO>.Units.TimeUnit	Unit of the time data

StatusWord	
Tag	**Description**
<TO>.StatusWord.X0 (Control)	The technology object is in operation.
<TO>.StatusWord.X1 (Error)	An error occurred at the technology object.
<TO>.StatusWord.X2 (RestartActive)	The technology object is being reinitialized. The tags of the technology data block are not updated with active restart.
<TO>.StatusWord.X3 (OnlineStartValuesChanged)	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object.
<TO>.StatusWord.X4 (OutputInverted)	The output cam output is inverted.
<TO>.StatusWord.X5 (CommunicationOk)	The output cam is synchronized with the output module and available for use.

ErrorWord	
Tag	**Description**
<TO>.ErrorWord.X0 (SystemFault)	A system-internal error has occurred.
<TO>.ErrorWord.X1 (ConfigFault)	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data was incorrectly modified during runtime of the user program.
<TO>.ErrorWord.X2 (UserFault)	Error in user program at a Motion Control instruction or its use
<TO>.ErrorWord.X3 (CommandNotAccepted)	Command cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
<TO>.ErrorWord.X13 (PeripheralError)	Error accessing a logical address

ErrorDetail		
Tag	**Description**	
<TO>.ErrorDetail.Number	Alarm number You can find a list of the technology alarms and alarm responses in the "Technology alarms" section in the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
<TO>.ErrorDetail.Reaction	Effective alarm response	
	0	No reaction
	6	Output cam processing is complete.

Cam track functions

8

8.1 Configuring the cam track

A cam track consists of up to 32 individual output cams that are specified within an adjustable track length.

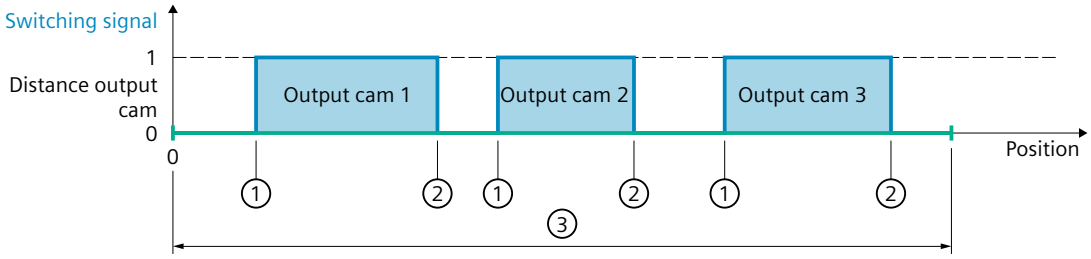

① Start position

② End position

③ Cam track length

The output cams of the cam track can be set as distance output cams or time-based output cams. Only one of the two output cam types (Page 44) can be used in a cam track.

8.2 Defining the cam track reference

You define the position reference for the switching points of the output cams of a cam track in the "Basic parameters > Output cam reference" configuration window. The switching points of the output cams of a cam track can be referenced to the following positions, depending on the interconnected technology object:

- Actual position of a synchronous axis/positioning axis
- Position setpoint of a synchronous axis/positioning axis
- Position of an external encoder

8.3 Configuring the cam track output

8.3.1 Activate/deactivate cam track output

In the "Hardware interface > Output cam track output" configuration window, you activate and configure the output of the generated switching signals via a digital output.

When the output is activated, you can configure the following digital outputs:

- Output by Timer DQ (Page 64)

  Digital output with high degree of accuracy and reproducibility in the microsecond range on time-based IO modules basis

- Output by a digital module (Page 64)

  Digital output with switching accuracy depending on the output cycle of the I/O used

When output is deactivated, the output cam status is not output at the hardware output. The output cam status can be used internally in the user program by evaluating the relevant "<TO>.TrackOutput" tag.

8.3.2 Configuring output by Timer DQ

Configuring output by Timer DQ (Page 47) corresponds to that of the output cam technology object.

A maximum of two edges via Timer DQ (positive and negative) can be output per position control cycle. If multiple switch-on edges or switch-off edges are transmitted in one position control cycle clock, the last written values in each case are valid.

8.3.3 Configuring output by digital module

Configuring output by digital module (Page 49) corresponds to that of the output cam technology object.

A maximum of one edge via digital output module (positive or negative) can be output per position control cycle. If multiple switch-on edges or switch-off edges are transmitted in one position control cycle clock, the last written values in each case are valid.

8.3.4 Masking of individual output cams of a cam track

In order for output cams to be processed, they must be configured as valid in the technology data block with "<TO>.Parameter.Cam[1..32].Existent" = TRUE.

In addition, output cams of a cam track configured as valid can be defined as valid in the user program using bit masking ("<TO>.Parameter.CamMasking"). In the default setting, all valid output cams are enabled ("<TO>.Parameter.CamMasking" = 0xFFFFFFFF).

The cam track itself is activated/deactivated using the Motion Control instruction "MC_CamTrack".

8.4 Defining cam track data

8.4.1 Time offset of output cam switching points

Switching times of the output and the connected actuator (e.g. valve) can be compensated for using the activation time or deactivation time of the cam track technology object.

The time offset of output cam switching points corresponds to the activation time or deactivation time (Page 50) for the output cam technology object.

You define the activation time (<TO>.Parameter.OnCompensation) and the deactivation time (<TO>.Parameter.OffCompensation) in the configuration window under "Configuration > Extended parameters > Track data > Activation time".

8.4.2 Configuring a hysteresis

The behavior and effect of the hysteresis setting corresponds to the hysteresis (Page 50) for the output cam technology object.

You define the hysteresis value in the configuration of the cam track technology object under "Configuration > Extended parameters > Track data > Hysteresis" (<TO>.Parameter.Hysteresis).

8.4.3 Defining the track length

You define the length of the output cam track in the configuration of the cam track technology object under "Configuration > Extended parameters > Track data > Track dimensions"

Also take into account the output cam data of the individual output cams when defining the track length. Output cams whose start position lies outside the cam track length are not included. For the output cams to become active, increase the cam track length so that at least the respective start position of an output cam is within the new track length.

Track length for an axis with modulo function

For an axis with modulo function, the modulo length of the axis is displayed in the configuration window. The track length can be less than or greater than the modulo length of the axis. In order for the cam track to be mapped without offset in the modulo range and to prevent unwanted overrides, an integer ratio of modulo length to track length, and vice versa, is required.

Example Mapping without offset

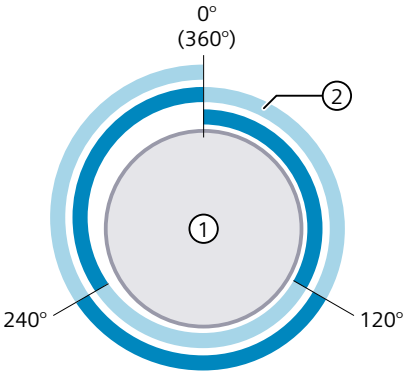

① Axis with modulo length 360°

② Cam track with track length 120°

⇒ Ratio = 360° / 120° = **3**

The cam track is output 3 times on a modulo length.

Example Mapping with offset

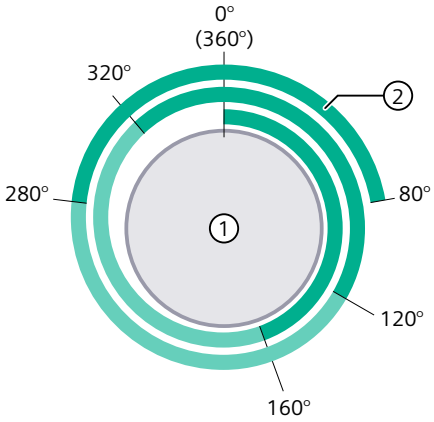

① Axis with modulo length 360°

② Cam track with track length 160°

⇒ Ratio = 360° / 160° = **2.25**

The cam track is output 2.25 times on the first modulo length and continued correspondingly in the other modulo lengths.

8.4.4 Defining the axis reference position

You define the axis reference position of the output cam track in the configuration of the cam track technology object under "Configuration > Extended parameters > Track data > Track dimensions".

As reference position, enter the position of the higher-level axis or the external encoder starting from which the output of the cam track is to occur. The start of the cam track is placed at the entered position.

You can enter a negative or positive value for the reference position. The cam track is continued in both directions of the interconnected technology object.

Example

- Axis range = -1000 mm to +1000 mm
- Desired switching points of the output cam with reference to axis position:
  - Start position = -200 mm
  - End position = -100 mm
- Cam track length = 2000 mm
- Definition of output cam on the track:
  - Start position = 800 mm
  - End position = 900 mm

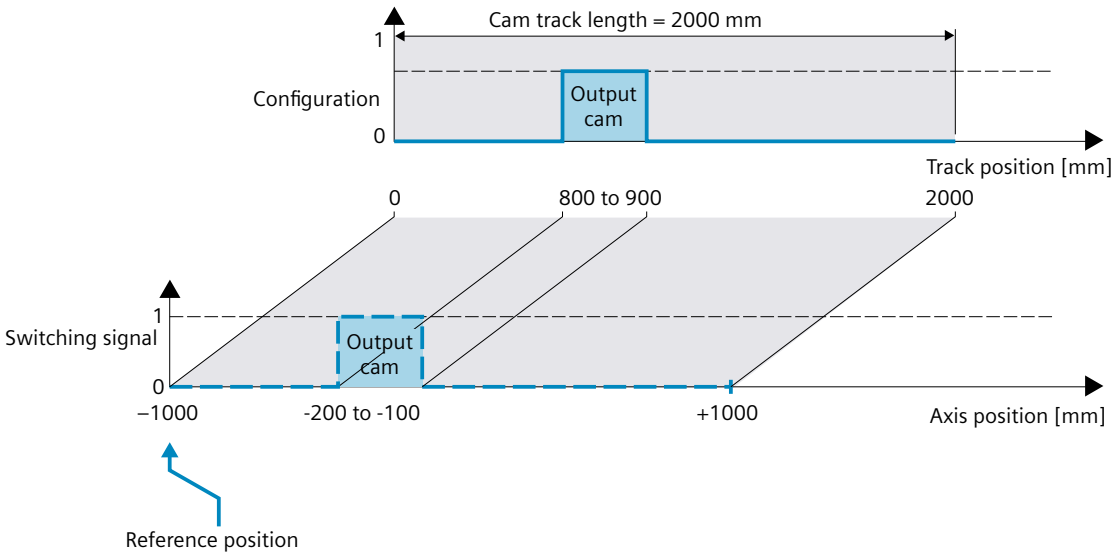

Axis reference position for an axis with modulo function

When a cam track is mapped onto an axis with modulo function, a reference position specified outside the modulo range is mapped within the modulo range.

During cyclic processing of the cam track, the continued reference position of the current cam track is displayed in the "<TO>.MatchPosition" tag. The continued reference position is independent of direction and always the position of the left boundary of the cam track. The unique detection and output of the position is only possible when the assigned technology object is in motion. The distance to the current reference position of the current cam track (<TO>.MatchPosition) is displayed in the "<TO>.TrackPosition" tag.

When the cam track is enabled by an "MC_CamTrack" job, the position of the cam track (<TO_CamTrack>.MatchPosition) is set as if the current position had been reached by a motion in the positive direction starting from the reference position (<TO_CamTrack>.ReferencePosition).

8.5 Configuring output cam data

The set output cam type is displayed.

Enter the properties for the output cams of the cam track that are to be output. You can set up to 32 individual output cams on a cam track.

The output cam positions are defined relative to the cam track. The start of the cam track is always 0.0. The output cam positions on the cam track are thus always positive.

In the configuration window under "Configuration > Basic parameters", define the individual output cams of the cam track. Depending on the set output cam type, you can define the following parameters in each case:

- **Valid**

  Only output cams set as "valid" are output and have a status display.
- **Start position**
  - The start position may not be greater than the end position for distance output cams.
  - If the start position is equal to the end position, the distance output cam does not switch.
  - The switching ranges of individual output cams are permitted to overlap.
  - Output cams whose start position lies outside the cam track length (Page 65) are not included. They become active only if the cam track length is increased so that at least the respective start position of an output cam is within the new track length.
- **End position**
  - The "End position" column is only displayed when distance output cam is set for the output cam type.
  - The end position must not be less than the start position.
- **Switch-on duration**

  The "Switch-on duration" column is only displayed when time-based output cam is set for the output cam type.

See also

Effective direction of distance output cams on a cam track (Page 71)

Effective direction of time-based output cams on a cam track (Page 72)

8.6 Activate/deactivate cam track

With the "MC_CamTrack (Page 96)" Motion Control instruction with "Enable" = TRUE, you can:

- Enable a cam track for the first time
- Change cam track data during cam track processing

The activation behavior differs when cam track data is applied. The configured cam track data (cam track data, data on the function block) is applied at different times depending on the set "Mode" parameter.

Activate a cam track for the first time

Calling the Motion Control instruction "MC_CamTrack" with "Enable" = TRUE and "Mode" = 0 or 1 activates the cam track immediately ("<TO>.Status" changes to 1) and configured cam track data takes effect immediately.

Change cam track data of an already activated cam track ("<TO>.Status" = 1)

- With the call of Motion Control instruction "MC_CamTrack" with "Enable" = TRUE and "Mode" = 0, the modified cam track data takes effect immediately.

  Previously activated distance output cams are aborted if their track signals are not still set due to the changed cam track data. Previously activated time-based output cams are always aborted.
- With the call of Motion Control instruction "MC_CamTrack" with "Enable" = TRUE and "Mode" = 1, the cam track continues to be output with the prior configuration up to the cam track end. Modified cam track data takes effect at the end of the current track cycle.

  If you change a cam track with "Mode" = 1 during runtime of the user program, keep in mind the lead time of the cam track as reserve for the first output cam. Define the first output cam position in the cam track only after the following position:

  Position of first output cam > velocity of axis x lead time of the cam track (<TO>.Parameter.OnCompensation)

  Also keep in mind the internal system time for output cam calculation, even if you set the lead time 0.0.

Changing cam track data when modulo length is not a multiple of the track length

For the switching times to be set correctly, we recommend the following procedure for changes:

- Enter changes as soon as possible after start of a new cam track
- Enter a new reference position (<TO>.Parameter.ReferencePosition) for the changed cam track. The new reference position is composed as follows depending on the direction:
  - Positive effective direction: Current reference position (<TO>.MatchPosition) + cam track length (<TO>.Parameter.CamTrackLength)
  - Negative effective direction: Current reference position (<TO>.MatchPosition) - cam track length (<TO>.Parameter.CamTrackLength)
- Output the changes of the cam track when calling the Motion Control instruction "MC_CamTrack" and "Mode" = 1.

Example

The following figure shows an example of the differences in the activation behavior.

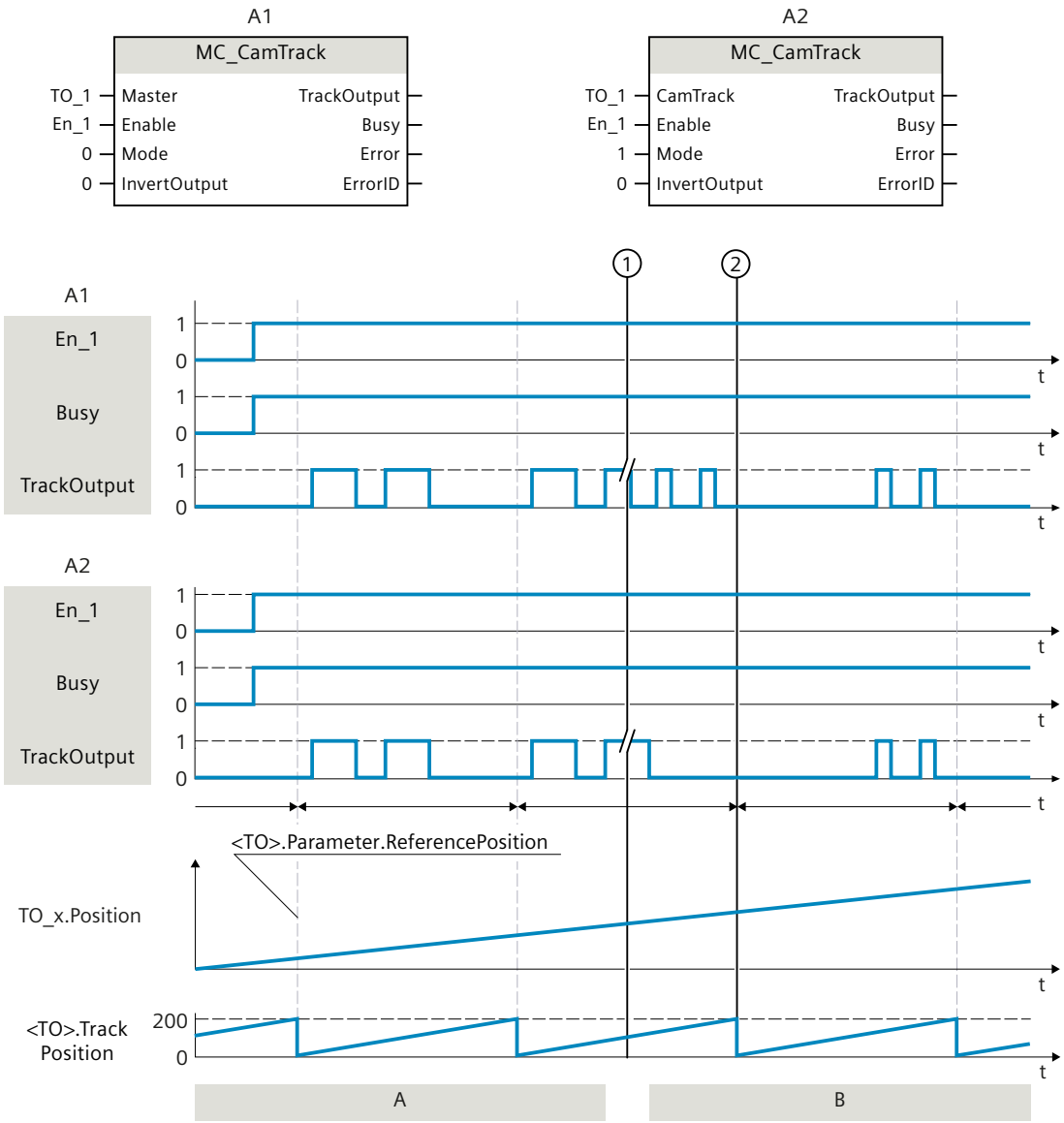

A1	A	The cam track is activated the first time with "MC_CamTrack.Enable" = TRUE and the output cams are output immediately with set "MC_CamTrack.Mode" = 0.
	B	After cam track data were changed (①), the cam track is activated by calling Motion Control instruction "MC_CamTrack" with "Enable" = TRUE and the modified data takes effect immediately (①) with set "MC_CamTrack.Mode" = 0.
A2	A	The cam track is activated the first time with "MC_CamTrack.Enable" = TRUE and the output cams are output immediately with set "MC_CamTrack.Mode" = 1.
	B	After cam track data were changed (①), the cam track is activated by calling Motion Control instruction "MC_CamTrack" with "Enable" = TRUE and the modified data takes effect at the end of the current track cycle (②) with set "MC_CamTrack.Mode" = 1.

8.7 Processing of a cam track

A cam track is processed cyclically.

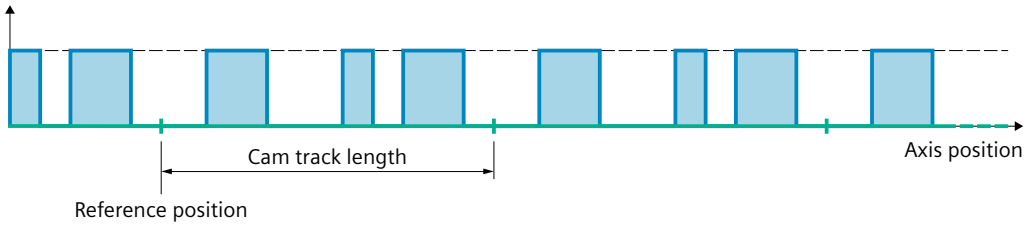

The cam track is mapped onto the position of the interconnected technology object starting from the reference position and is continued cyclically in both directions.

When the cam track is processed, the output cams with start position within the track length are taken into consideration.

If the end of a cam track is overtraveled, connected output cams behave as follows within the cam track:

- Distance output cams whose end position lies outside the cam track are switched off when the cam track is left.
- Time-based output cams remain switched on for the set switch-on duration.

8.7.1 Effective direction of distance output cams on a cam track

The cam track is always active for both directions of the position of the interconnected technology object.

Distance output cams are switched when the switch-on range is overtraveled.

The following graphic shows the execution of a cam track with distance output cam depending on the motion direction of the axis.

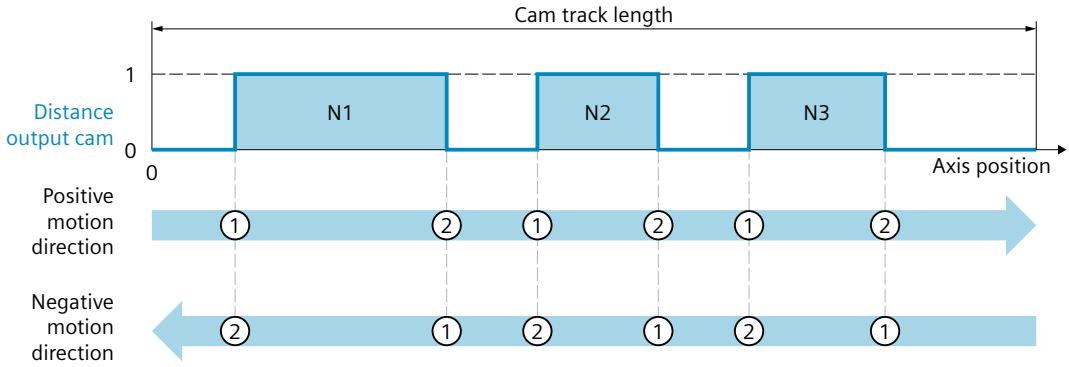

With positive motion direction, the distance output cams of the cam track are output in the order Output cam N1, Output cam N2, Output cam N3. With negative motion direction, the distance output cams of the cam track are output in the order Output cam N3, Output cam N2, Output cam N1. The distance output cams switch on at ① and switch off at ②.

8.7.2 Effective direction of time-based output cams on a cam track

The cam track is always active for both directions of the position of the interconnected technology object.

The time-based output cams are switched when the start position is overtraveled.

The following graphic shows the execution of a cam track with time-based output cam depending on the motion direction of the axis.

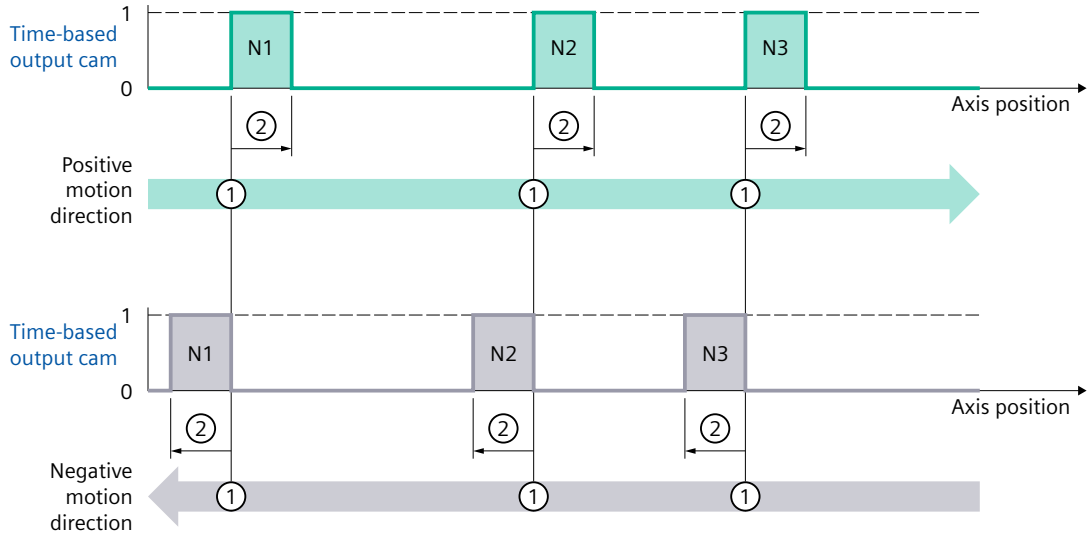

With positive motion direction, the time-based output cams of the cam track are output in the order Output cam N1, Output cam N2, Output cam N3. With negative motion direction, the time-based output cams of the cam track are output in the order Output cam N3, Output cam N2, Output cam N1. The time-based output cams switch on at ① and remain switched on for the set switch-on duration ②.

8.7.3 Homing of an axis or an encoder during cam track processing

Homing of an axis or an encoder without modulo function

A change to the position of an axis or external encoder using Motion Control instruction "MC_Home" is regarded as a sudden position change. An enabled cam track is referenced to the changed position and processed further from there.

- Homing also has an effect on the current position of the cam track (<TO>.TrackPosition). The position is formed again as quickly as possible due to the offset.
- Distance output cams are either skipped or correspondingly output.
- Time-based output cams are skipped. A time-based output cam is switched on only when the start position is overtraveled and remains switched on for the switch-on duration.
- Switched time-based output cams are not canceled by a homing operation.

Recommendation:

Disable the cam track before or during homing.

Homing of an axis or an encoder with modulo function

- Homing also has an effect on the current position of the cam track (<TO>.TrackPosition).

  The homing of the assigned technology object influences the position of the subsequently active cam track on a direction-dependent basis. This is dependent on the position difference, the difference between the new position minus the original position. If the position difference is negative, you add the modulo length (<TO_Axis/TO_ExternalEncoder>.Modulo.Length).

  If this position difference is less than or equal to half the modulo length, the new position of the cam track (<TO_CamTrack>.MatchPosition) is set as if the new position had been reached by a motion in the positive direction starting from the original position.

  If this position difference is greater than half the modulo length, the new position of the cam track (<TO_CamTrack>.MatchPosition) is set as if the new position had been reached by a motion in the negative direction starting from the original position.
- Distance output cams are either skipped or correspondingly output.
- Time-based output cams are skipped. A time-based output cam is switched on only when the start position is overtraveled and remains switched on for the switch-on duration.
- Switched time-based output cams are not canceled by a homing operation.

Recommendation:

Disable the cam track before or during homing.

8.7.4 Changing the cam track data during operation

The data of a cam track and the parameters of the Motion Control instruction "MC_CamTrack" can be changed while track processing is enabled. The active Motion Control instruction "MC_CamTrack" is not aborted. The modified parameters take effect at the next call of the Motion Control instruction "MC_CamTrack".

The following parameters can be changed during operation and are in effect after another call of Motion Control instruction "MC_CamTrack".

- Cam track data in technology data block
  - Reference position (<TO>.Parameter.ReferencePosition)
  - Track length (<TO>.Parameter.CamTrackLength)
  - Bit masking of individual output cams (<TO>.Parameter.CamMasking)
  - Activation time (<TO>.Parameter.OnCompensation)
  - Deactivation time (<TO>.Parameter.OffCompensation)
  - Hysteresis value (<TO>.Parameter.Hysteresis)
  - Output cam data (<TO>.Parameter.Cam[1..32])
- Parameters in the function block
  - Enable (MC_CamTrack.Enable)
  - Mode (MC_CamTrack.Mode)
  - Inverted output (MC_CamTrack.InvertOutput)

Note the different activation behavior (Page 68) when changing the cam track data.

8.8 Tags: Cam track technology object

The following technology object tags are relevant:

Status indicator		
Tag	**Description**	
<TO>.Status	Status of the cam track function	
	0	Inactive
	1	Active
	2	Active and waiting for next track
<TO>.TrackOutput	An output cam of cam track is switched.	
<TO>.SingleCamState	Switched on output cam (bit-masked)	
<TO>.TrackPosition	Display of the current position within the cam track The distance to the current reference position of the current cam track (<TO>.MatchPosition) is displayed.	
<TO>.MatchPosition	Reference position of the current cam track During cyclic processing of the cam track, the continued reference position of the current cam track is displayed. The unique detection and output of the position is only possible when the assigned technology object is in motion.	

Parameters		
Tag	**Description**	
<TO>.Parameter.CamTrackType	Output cam type	
	0	Distance output cam
	1	Time-based output cam
<TO>.Parameter.PositionType	Position reference	
	0	Position setpoint
	1	Actual position
<TO>.Parameter.ReferencePosition	Reference position	
<TO>.Parameter.CamTrackLength	Track length	
<TO>.Parameter.CamMasking	Bit masking of individual output cams	
<TO>.Parameter.OnCompensation	Activation time (lead time for the switch-on edge)	
<TO>.Parameter.OffCompensation	Deactivation time (lead time for the switch-off edge)	
<TO>.Parameter.Hysteresis	Hysteresis value	
<TO>.Parameter.Cam[1..32].OnPosition	Start position (distance output cams and time-based output cams)	
<TO>.Parameter.Cam[1..32].OffPosition	End position (distance output cam)	
<TO>.Parameter.Cam[1..32].Duration	Switch-on duration (time-based output cam)	
<TO>.Parameter.Cam[1..32].Existent	Validity of an output cam	
	FALSE	Output cam is not used.
	TRUE	Output cam is used.

Interface		
Tag	**Description**	
<TO>.Interface.EnableOutput	Output cam output at the bit specified under "Address"	
	FALSE	No output
	TRUE	Output
<TO>.Interface.Address	I/O address for digital output cam output	

Units	
Tag	**Description**
<TO>.Units.LengthUnit	Unit of the length data
<TO>.Units.TimeUnit	Unit of the time data

StatusWord	
Tag	**Description**
<TO>.StatusWord.X0 (Control)	The technology object is in operation.
<TO>.StatusWord.X1 (Error)	An error occurred at the technology object.
<TO>.StatusWord.X2 (RestartActive)	The technology object is being reinitialized. The tags of the technology data block are not updated with active restart.
<TO>.StatusWord.X3 (OnlineStartValuesChanged)	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object.
<TO>.StatusWord.X4 (OutputInverted)	The output cam output is inverted.
<TO>.StatusWord.X5 (CommunicationOk)	The cam track is synchronized with the output module and available for use.
<TO>.StatusWord.X6 (CamDataChanged)	The data of individual output cams has been changed but not yet taken effect with Motion Control instruction "MC_CamTrack".

ErrorWord	
Tag	**Description**
<TO>.ErrorWord.X0 (SystemFault)	A system-internal error has occurred.
<TO>.ErrorWord.X1 (ConfigFault)	Configuration error One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data was incorrectly modified during runtime of the user program.
<TO>.ErrorWord.X2 (UserFault)	Error in user program at a Motion Control instruction or its use.
<TO>.ErrorWord.X3 (CommandNotAccepted)	Command cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
<TO>.ErrorWord.X13 (PeripheralError)	Error accessing a logical address.

ErrorDetail		
Tag	**Description**	
<TO>.ErrorDetail.Number	Alarm number You can find a list of the technology alarms and alarm responses in the "Technology alarms" section in the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
<TO>.ErrorDetail.Reaction	Effective alarm response	
	0	No reaction
	5	Cam track processing is complete.

Diagnostics 9

The description of Motion Control diagnostics is limited to the diagnostics view of the technology objects in TIA Portal, the technology alarms and the error IDs on Motion Control instructions.

"Debug" program mode is available for testing the execution of your Interpreter program.

The following descriptions can be found in the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation:

- Diagnostics concept
- Technology alarms
- Error IDs in Motion Control instructions

A comprehensive description of the system diagnostics of the S7-1500 CPU can be found in the "Diagnostics" function manual (https://support.industry.siemens.com/cs/ww/en/view/59192926).

9.1 Measuring input technology object

9.1.1 Status and error bits

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object. The diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables. The associated technology object tag is given in parentheses.

Measuring input status

The following table shows the possible states of the measuring input:

Status	Description
Active	The technology object is in operation. (<TO>.StatusWord.X0 (Control))
Waiting for measuring event	The measuring input is waiting for a measuring event. The technology data block tag "<TO>.Status" has the value "1" ("WAITING_FOR_TRIGGER").
Measured value present	The measuring input has acquired one or more measured values. The technology data block tag "<TO>.Status" has the value "2" ("TRIGGER_OCCURRED").
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area and in the "<TO>.ErrorDetail.Number" and "<TO>.ErrorDetail.Reaction" tags of the technology object. (<TO>.StatusWord.X1 (Error))

Status	Description
Restart active	The technology object is being reinitialized. The tags of the technology data block are not updated with active restart. (<TO>.StatusWord.X2 (RestartActive))
Measuring input ready	The measuring input is synchronized with the measurement input and can be used. With an interconnected measuring input that monitors another measuring input with measurement input, the bit always has the value "FALSE". (<TO>.StatusWord.X5 (CommunicationOK))
Restart required	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	A configuration error has occurred. One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data was incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	An error occurred in the user program with a Motion Control instruction or its use. (<TO>.ErrorWord.X2 (UserFault))
Job rejected	A job cannot be executed. A Motion Control instruction cannot be executed because the necessary conditions have not been met (e.g. axis assigned to the measuring input is not homed). (<TO>.ErrorWord.X3 (CommandNotAccepted))
I/O	An error occurred accessing a logical address. (<TO>.ErrorWord.X13 (PeripheralError))

Alarm display

For more information and to acknowledge the error, go to the Inspector window by clicking on the "Alarm display" link.

More information

An option for evaluating the individual status bits can be found in the section "Evaluating StatusWord, ErrorWord and WarningWord" of the "S7-1500/S7-1500T Motion Control overview" documentation.

See also

"StatusWord" tag (measuring input) (Page 115)
"ErrorWord" tag (measuring input) (Page 116)
"WarningWord" tag (measuring input) (Page 117)

9.2 Output cam technology object

9.2.1 Status and error bits

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object. The diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables. The associated technology object tag is given in parentheses.

Output cam status

The following table shows the possible states of the output cam:

Status	Description
Active	The technology object is in operation. (<TO>.StatusWord.X0 (Control))
Switched	The output cam is switched. (<TO>.CamOutput)
Inverted output for output cam	The output cam output is inverted. (<TO>.StatusWord.X4 (OutputInverted))
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area and in the "<TO>.ErrorDetail.Number" and "<TO>.ErrorDetail.Reaction" tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is being reinitialized. The tags of the technology data block are not updated with active restart. (<TO>.StatusWord.X2 (RestartActive))
Output cam output ready	The output cam is synchronized with the output module and available for use. (<TO>.StatusWord.X5 (CommunicationOk))
Restart required	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	A configuration error has occurred. One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data was incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	An error occurred in the user program with a Motion Control instruction or its use. (<TO>.ErrorWord.X2 (UserFault))
Job rejected	A job cannot be executed. A Motion Control instruction cannot be executed because the necessary conditions have not been met (e.g. axis assigned to the output cam is not homed). (<TO>.ErrorWord.X3 (CommandNotAccepted))
I/O	An error occurred accessing a logical address. (<TO>.ErrorWord.X13 (PeripheralError))

Alarm display

For more information and to acknowledge the error, go to the Inspector window by clicking on the "Alarm display" link.

More information

An option for evaluating the individual status bits can be found in the section "Evaluating StatusWord, ErrorWord and WarningWord" of the "S7-1500/S7-1500T Motion Control overview" documentation.

See also

"StatusWord" tag (output cam) (Page 120)
"ErrorWord" tag (output cam) (Page 121)
"WarningWord" tag (output cam) (Page 122)

9.3 Cam track technology object

9.3.1 Status and error bits

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object. The diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables. The associated technology object tag is given in parentheses.

Cam track status

The following table shows the possible states of the cam track:

Status	Description
Active	The technology object is in operation. (<TO>.StatusWord.X0 (Control))
Switched	An output cam of cam track is switched. (<TO>.TrackOutput)
Inverted output for output cam	The output cam output is inverted. (<TO>.StatusWord.X4 (OutputInverted))
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area and in the "<TO>.ErrorDetail.Number" and "<TO>.ErrorDetail.Reaction" tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is being reinitialized. The tags of the technology data block are not updated with active restart. (<TO>.StatusWord.X2 (RestartActive))
Cam track output ready	The cam track is synchronized with the output module and available for use. (<TO>.StatusWord.X5 (CommunicationOk))
Restart required	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	A configuration error has occurred. One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data was incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))

Error	Description
User program	An error occurred in the user program with a Motion Control instruction or its use. (<TO>.ErrorWord.X2 (UserFault))
Job rejected	A job cannot be executed. A Motion Control instruction cannot be executed because the necessary conditions have not been met (e.g. axis assigned to the cam track is not homed). (<TO>.ErrorWord.X3 (CommandNotAccepted))
I/O	An error occurred accessing a logical address. (<TO>.ErrorWord.X13 (PeripheralError))

Alarm display

For more information and to acknowledge the error, go to the Inspector window by clicking on the "Alarm display" link.

More information

An option for evaluating the individual status bits can be found in the section "Evaluating StatusWord, ErrorWord and WarningWord" of the "S7-1500/S7-1500T Motion Control overview" documentation.

See also

"StatusWord" tag (cam track) (Page 126)
"ErrorWord" tag (cam track) (Page 126)
"WarningWord" tag (cam track) (Page 128)

9.3.2 Cam track status

You use the "Technology object > Diagnostics > Cam track status" diagnostics function in the TIA Portal to monitor the status of the cam track. The Diagnostics function is available in online operation.

"Validity and masking of the output cams" area

The individual output cams of a cam track are shown in this area along with the status for the following properties:

Status	Description
Valid	Validity of the individual output cams of the cam track (<TO>.Parameter.Cam[1..32].Existent)
Masked	Bit masking of the individual cams of the cam track (<TO>.Parameter.CamMasking)
Effective	Switched on output cam (bit-masked) (<TO>.SingleCamState)

"Positions" area

The following status values are displayed in this area:

Status	Description
Current position in the cam track	Position during cam track processing within a cam track cycle The distance to the current reference position of the current cam track (<TO>.MatchPosition) is displayed. (<TO>.TrackPosition)
Current cam track start	Reference position of the current cam track During cyclic processing of the cam track, the continued reference position of the current cam track is displayed. The unique detection and output of the position is only possible when the assigned technology object is in motion. (<TO>.MatchPosition)

Instructions 10

10.1 MC_MeasuringInput V10

10.1.1 MC_MeasuringInput: Start measuring once V10

Description

Use the Motion Control instruction "MC_MeasuringInput" to start a measuring job for one-time measuring.

The Motion Control instruction offers you the following:

- Type of measurement (Page 33)
- Defining the measuring range (Page 33)
- Measuring once (Page 35)

Applies to

- Measuring input

Requirement

- The technology object has been configured correctly.
- The encoder of the axis must have "VALID" status ("<TO>.StatusSensor[1..4].State" = 2). Otherwise, the measuring job is rejected in the function block with an error indication.
- The communication between the measuring input and measurement input is established ("<TO>.StatusWord.CommunicationOK" = TRUE).
- Measurement using PROFIdrive is not possible during active or passive homing.
- The measuring input is not an interconnected measuring input that monitors a measuring input with measurement input. Measuring jobs can only be started at the measuring input with measurement input.

Override response

The override response for "MC_MeasuringInput" jobs is described in section "Override response V10: Measuring input jobs".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MeasuringInput":

Parameters	Declaration	Data type	Default value	Description	
MeasuringInput	INPUT	TO_MeasuringInput	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Mode	INPUT	DINT	0	Type of measurement (Page 35)	
				0	Measurement of next positive edge
				1	Measurement of next negative edge
				2	Measurement of next two edges
				3	Measurement of two edges, beginning with the positive edge • Rising edge = "MeasuredValue1" (measured value 1) • Falling edge = "MeasuredValue2" (measured value 2)
				4	Measurement of two edges, beginning with the negative edge • Falling edge = "MeasuredValue1" • Rising edge = "MeasuredValue2"
MeasuringRange	INPUT	BOOL	FALSE	Acquisition of measured values Observe the time-related boundary conditions (Page 39).	
				FALSE	Always acquire measured values
				TRUE	Acquire measured values only within the measuring range (Page 33)
StartPosition	INPUT	LREAL	0.0	Start position of the measuring range (Page 33) For an axis or external encoder with active modulo function, position data outside the modulo range is mirrored in the modulo range.	
EndPosition	INPUT	LREAL	0.0	End position of the measuring range (Page 33) For an axis or external encoder with active modulo function, position data outside the modulo range is mirrored in the modulo range.	
Done	OUTPUT	BOOL	FALSE	TRUE	The block has been completely processed. Measured values are valid.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The measuring job has been aborted.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The cause of the error can be found in the "ErrorID" parameter.

Parameters	Declaration	Data type	Default value	Description
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.
MeasuredValue1	OUTPUT	LREAL	0.0	First measured value
MeasuredValue2	OUTPUT	LREAL	0.0	Second measured value (for measurement of two edges)

10.1.2 MC_MeasuringInput: Function chart V10

Function chart: Start measuring once

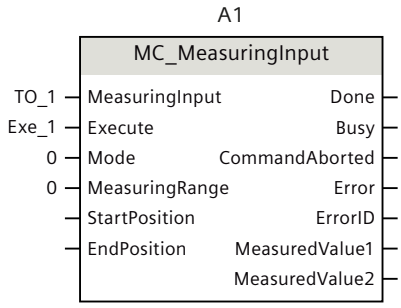

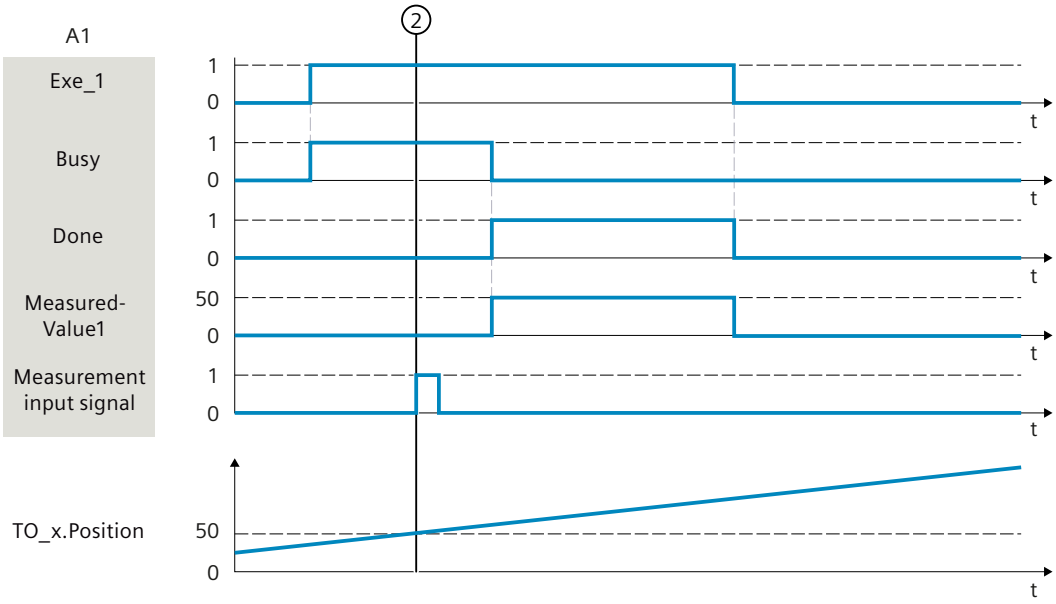

An "Execute" job with "MC_MeasuringInput" = 0 initiated using "Mode" performs a measurement of the next positive edge of the signal at the measurement input. A successfully completed measurement is signaled with "Done" = TRUE. The determined measured value at the time ① (in the example: 50) is output using "MeasuredValue1".

10.2 MC_MeasuringInputCyclic V10

10.2.1 MC_MeasuringInputCyclic: Start cyclic measuring V10

Description

You start cyclic measuring with the Motion Control instruction "MC_MeasuringInputCyclic".

The Motion Control instruction offers you the following:

- Type of measurement (Page 33)
- Defining the measuring range (Page 33)
- Cyclic measuring (Page 36)

Applies to

- Measuring input

Requirement

- The technology object has been configured correctly.
- Cyclic measuring is possible when measuring using Timer DI and when measuring via SINAMICS.
- The communication between the measuring input and measurement input is established ("<TO>.StatusWord.CommunicationOK" = TRUE).
- The encoder of the axis operationally in effect must have "VALID" status ("<TO>.StatusSensor[1..4].State" = 2). Otherwise, the measuring job is rejected in the function block with an error indication.
- The measuring input is not an interconnected measuring input that monitors a measuring input with measurement input. Measuring jobs can only be started at the measuring input with measurement input.

Override response

The override response for "MC_MeasuringInputCyclic" jobs is described in section "Override response V10: Measuring input jobs".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MeasuringInputCyclic":

Parameters	Declaration	Data type	Default value	Description	
MeasuringInput	INPUT	TO_MeasuringInput	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Mode	INPUT	DINT	0	Type of measurement (Page 36)	
				0	Measurement of positive edges
				1	Measurement of negative edges
				2	Measurement of both edges
MeasuringRange	INPUT	BOOL	FALSE	Acquisition of measured values Observe the time-related boundary conditions (Page 39).	
				FALSE	Always acquire measured values
				TRUE	Acquire measured values only within the measuring range (Page 33)
StartPosition	INPUT	LREAL	0.0	Start position of the measuring range (Page 33) For an axis or external encoder with active modulo function, position data outside the modulo range is mirrored in the modulo range.	
EndPosition	INPUT	LREAL	0.0	End position of the measuring range (Page 33) For an axis or external encoder with active modulo function, position data outside the modulo range is mirrored in the modulo range.	
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The measuring job has been aborted.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
MeasuredValue1	OUTPUT	LREAL		First measured value	
MeasuredValue2	OUTPUT	LREAL		Second measured value (when measuring multiple edges in one position control cycle)	
MeasuredValue1Counter	OUTPUT	UDINT	0	Count value for the first measured value	

Parameters	Declaration	Data type	Default value	Description
MeasuredValue2Counter	OUTPUT	UDINT	0	Count value for the second measured value
LostEdgeCounter1	OUTPUT	UDINT	0	Count value for the lost edges in the cycle clock of the first measured value acquisition During cyclic measurement via SINAMICS equal to zero
LostEdgeCounter2	OUTPUT	UDINT	0	Count value for the lost edges in the cycle clock of the second measured value acquisition During cyclic measurement via SINAMICS equal to zero

10.2.2 MC_MeasuringInputCyclic: Function chart V10

Function chart: Start cyclic measuring

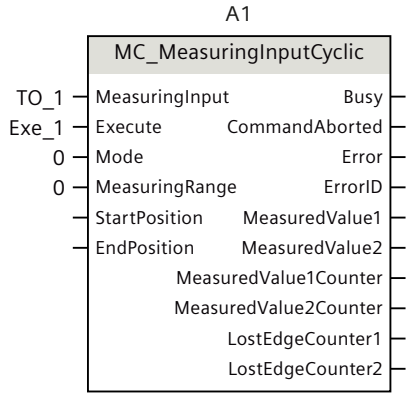

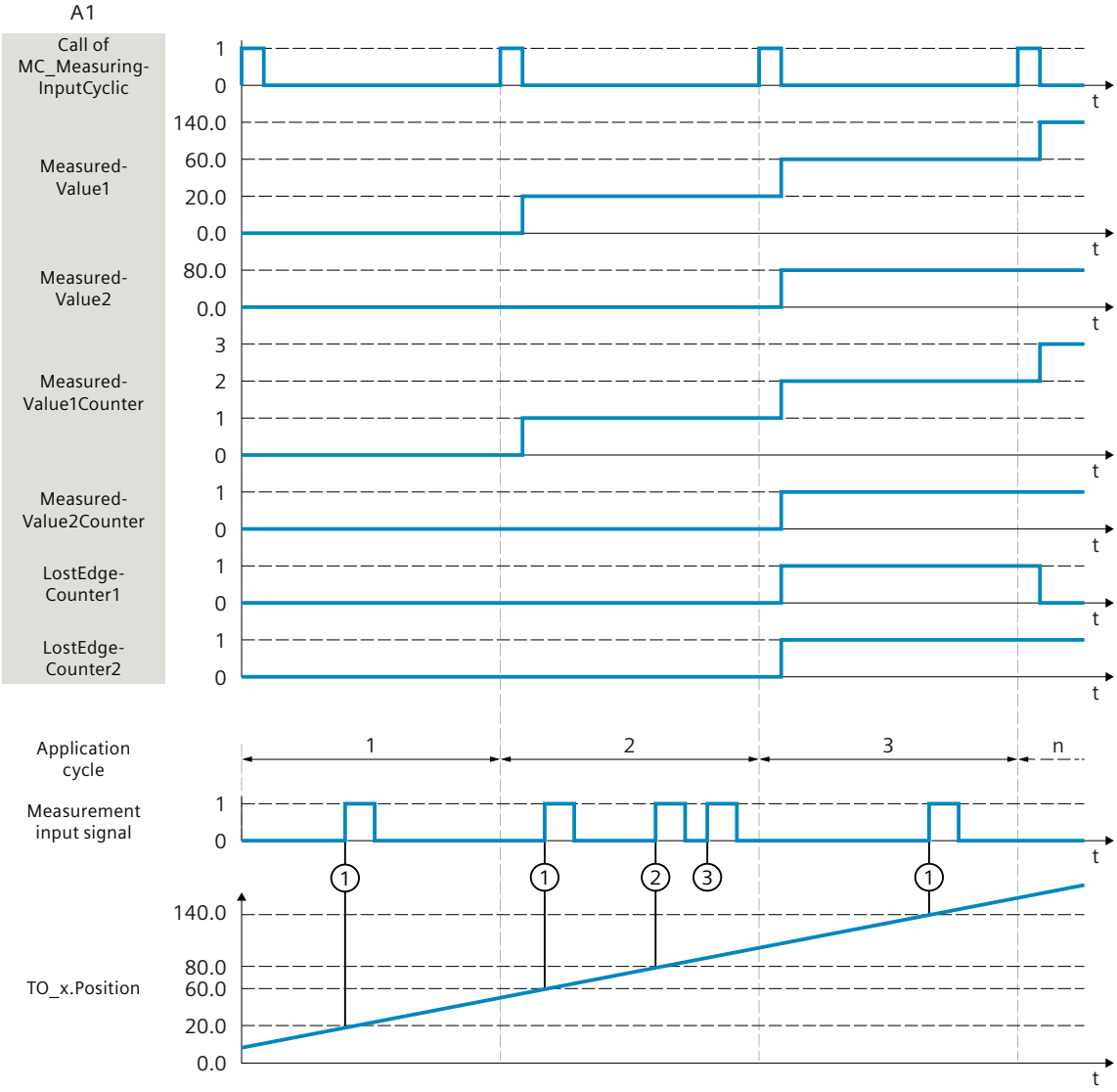

An "MC_MeasuringInputCyclic" job initiated using "Execute" (signal and start point not shown) (e.g. call in MC_PreServo) with "Mode" = 0 and without specified measuring range "MeasuringRange" = FALSE performs a measurement of the positive edges.

The actual position determined at the time of the first positive edge ① in the position control cycle is output using "MeasuredValue1", and count tag "MeasuredValue1Counter" is incremented by "1".

The actual position determined at the time of the second positive edge ② in the position control cycle is output using "MeasuredValue2", and count tag "MeasuredValue2Counter" is incremented by "1".

If additional positive edges occur in the same position control cycle ③, these are recorded in LostEdgeCounter1 and LostEdgeCounter2.

10.3 MC_AbortMeasuringInput V10

10.3.1 MC_AbortMeasuringInput: Cancel active measuring job V10

Description

With the Motion Control instruction "MC_AbortMeasuringInput", an active one-time or cyclic measuring job is aborted.

The Motion Control instruction offers you the following:

- Cancel active measuring job (Page 39)

Applies to

- Measuring input

Requirement

- The technology object has been configured correctly.

Override response

The override response for "MC_AbortMeasuringInput" jobs is described in section "Override response V10: Measuring input jobs".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_AbortMeasuringInput":

Parameters	Declaration	Data type	Default value	Description	
MeasuringInput	INPUT	TO_MeasuringInput	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Done	OUTPUT	BOOL	0	The function block has been processed. The measuring job has been deactivated.	
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.

Parameters	Declaration	Data type	Default value	Description	
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job has been aborted.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

10.4 MC_OutputCam V10

10.4.1 MC_OutputCam: Activate/deactivate output cam V10

Description

You use Motion Control instruction "MC_OutputCam" to activate the specified output cam:

The Motion Control instruction offers you the following:

- Distance output cam:
  - Defining the effective direction of distance output cams (Page 52)
  - Activating/deactivating the distance output cam (Page 53)
  - Defining the switching behavior of distance output cams (Page 54)
- Time-based output cam:
  - Defining the effective direction of time-based output cams (Page 56)
  - Activating/deactivating a time-based output cam (Page 57)
  - Defining the switching behavior of time-based output cams (Page 58)

Applies to

- Output cam

Requirement

- The technology object has been configured correctly.
- The higher-level technology object must have a valid position.
- The communication between output cam and output module is established ("<TO>.StatusWord.CommunicationOK" = TRUE).
- Setpoint output cams are not output for an axis in non-position-controlled operation.

Override response

The "MC_OutputCam" job is aborted by:

- Disabling the output cam with "MC_OutputCam.Enable" = FALSE.
- Only one instance of the "MC_OutputCam" function block can be active on an output cam in the user program. A second instance of the "MC_OutputCam" function block on a currently active output cam is rejected with an error.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_OutputCam":

Parameters	Declaration	Data type	Default value	Description	
OutputCam	INPUT	TO_OutputCam	-	Technology object	
Enable	INPUT	BOOL	FALSE	FALSE	Output cam is disabled.
				TRUE	Output cam is being processed.
OnPosition	INPUT	LREAL	0.0	With distance output cams (Page 53): Start position of the output cam [unit of measurement of the interconnected technology object]	
				With time-based output cams (Page 57): Position of the output cam [unit of measurement of the interconnected technology object]	
				For an axis or external encoder with active modulo function, position data outside the modulo range is mirrored in the modulo range.	
OffPosition	INPUT	LREAL	0.0	End position of the distance output cam (Page 53) [unit of measurement of the interconnected technology object] For an axis or external encoder with active modulo function, position data outside the modulo range is mirrored in the modulo range.	
Duration	INPUT	LREAL	0.0	Switch-on duration of the time-based output cam (Page 58)[unit of measurement: ms] The value for the switch-on duration of a time-based output cam must be greater than 0.0.	
Mode	INPUT	DINT	1	Operating mode of the output cam (distance output cam (Page 53)/time-based output cam (Page 57))	
				1	Standard Output cam functionality (output not inverted)
				2	Output cam functionality with inverted output
				3	Output cam always ON (while "Enable" = TRUE)

Parameters	Declaration	Data type	Default value	Description	
Direction	INPUT	DINT	1	Effective direction of the output cam (distance output cam (Page 52)/time-based output cam (Page 56))	
				1	Positive direction
				2	Negative direction
				3	Both directions
CamOutput	OUTPUT	BOOL	-	Status display based on last call of Motion Control instruction "MC_OutputCam"	
Busy	OUTPUT	BOOL	FALSE	TRUE	The processing of the output cam is active.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

10.4.2 MC_OutputCam: Function chart V10

Function chart: Enable output cam

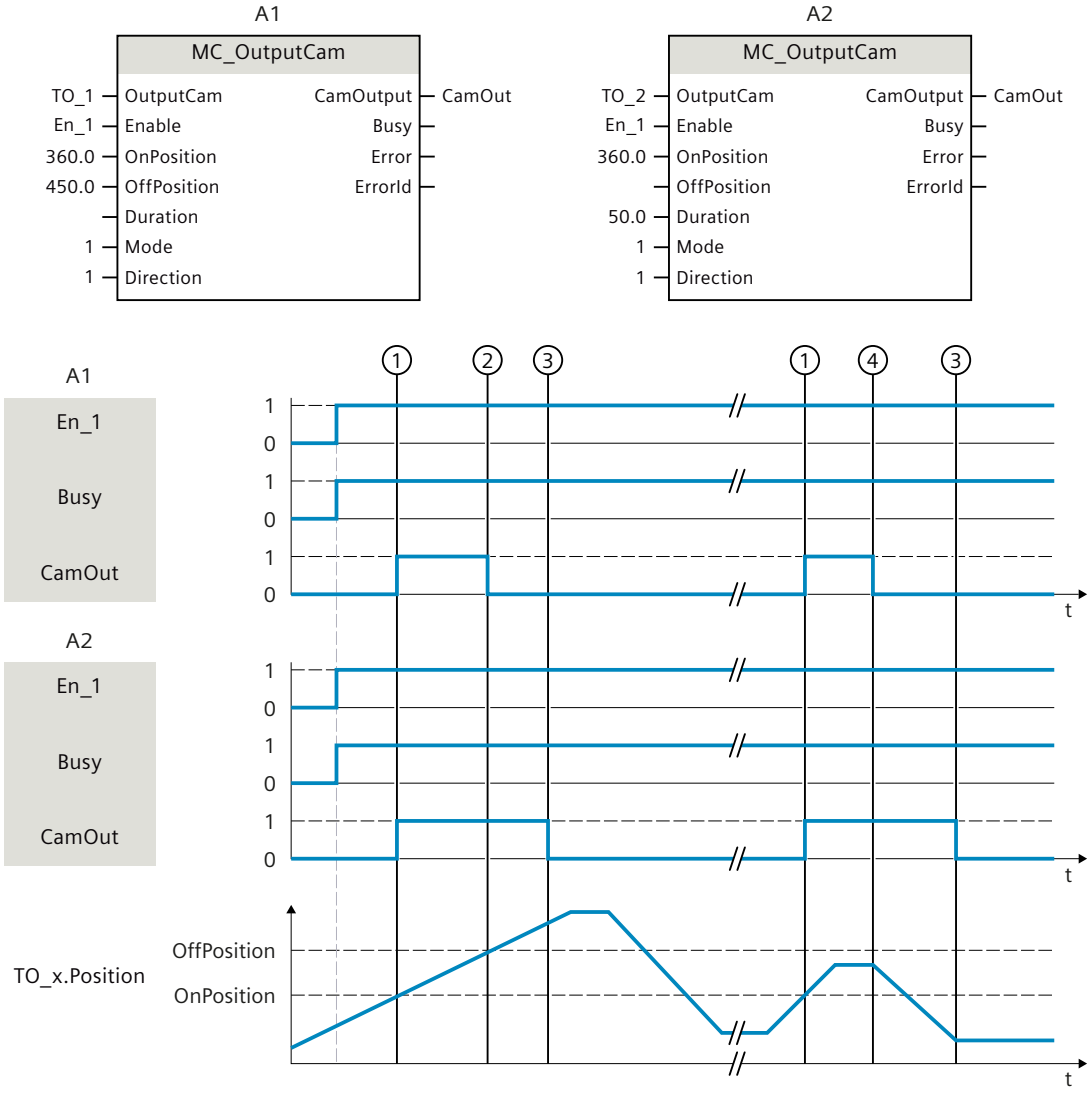

A1 Distance output cam

A2 Time-based output cam

An output cam is activated with "Enable" = TRUE. The output cam is output corresponding to the parameters.

The processing of the output cam is indicated with "Busy" = TRUE.

When activation direction "Direction" = 1 (positive) is set, the output cam behaves as follows, regardless of the output cam type setting:

- The distance output cam switches on at "OnPosition" ① and switches off again at "OffPosition" ②. At a direction reversal the output cam is switched off ④.
- The time-based output cam switches on at "OnPosition" ① and switches off again after expiration of the specified time "Duration" ③. A switched on time-based output cam remains active for the specified switch-on duration "Duration", even if overtravel of the start position occurs again in the reverse direction.

The switching state of the output cam is output using "CamOutput".

With "Enable" = FALSE, the specified output cam is disabled. "Busy" = FALSE shows that the output cam is not being processed.

10.5 MC_CamTrack V10

10.5.1 MC_CamTrack: Activate/deactivate cam track V10

Description

With the Motion Control instruction "MC_CamTrack", the processing of a cam track is enabled.

The Motion Control instruction offers you the following:

- Activation behavior (Page 68) of a cam track

Applies to

- Cam track

Requirement

- The technology object has been configured correctly.
- The higher-level technology object must have a valid position.
- The communication between output cam and output module is established ("<TO>.StatusWord.CommunicationOK" = TRUE).
- Setpoint output cams are not output for an axis in non-position-controlled operation.

Override response

- The "MC_CamTrack" job is canceled by disabling the cam track with "MC_CamTrack.Enable" = FALSE.
- Only one instance of the "MC_CamTrack" function block can be active on a cam track in the user program. A second instance of the "MC_CamTrack" function block on a currently active cam track is rejected with an error.
- The cam track is recalculated at a change of the parameters of the Motion Control instruction "MC_CamTrack" or in the technology data block. The cam track is processed in accordance with all parameter settings.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_CamTrack":

Parameters	Declaration	Data type	Default value	Description	
CamTrack	INPUT	TO_CamTrack	-	Technology object	
Enable	INPUT	BOOL	FALSE	TRUE	The cam track is processed.
				FALSE	The cam track is disabled.
Mode	INPUT	DINT	0	0	When "Enable" = TRUE: The cam track processing is activated immediately. Cam track data takes effect immediately Previously activated distance output cams are canceled if their track signal is not still set due to the changed cam track data. Previously activated time-based output cams are always aborted.
					When "Enable" = FALSE: The cam track processing is ended immediately. Distance output cams/time-based output cams are canceled immediately.
				1	When "Enable" = TRUE: The cam track processing is activated immediately/with the next track cycle: • When a cam track is activated for the first time, the cam track processing begins immediately. • If the cam track processing is already active, the current cam track is output up to the end of the track cycle. The new cam track data then takes effect.
					When "Enable" = FALSE: The cam track processing is ended at the end of the cam track
				2	When "Enable" = TRUE: The cam track output is switched on immediately and remains switched on

Parameters	Declaration	Data type	Default value	Description	
Mode	INPUT	DINT	0	2	When "Enable" = FALSE: The cam track output is switched off immediately.
InvertOutput	INPUT	BOOL	FALSE	Inverted output	
				TRUE	The track output is output inverted.
				FALSE	The track output is output non-inverted.
TrackOutput	OUTPUT	BOOL	-	Indicates the switching state of the cam track.	
Busy	OUTPUT	BOOL	FALSE	TRUE	The processing of the cam track is active.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

10.5.2 MC_CamTrack: Function chart V10

Function chart: Activate cam track

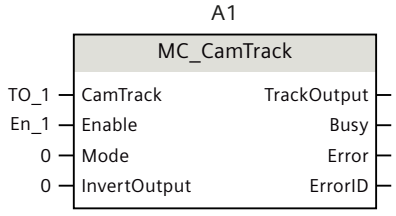

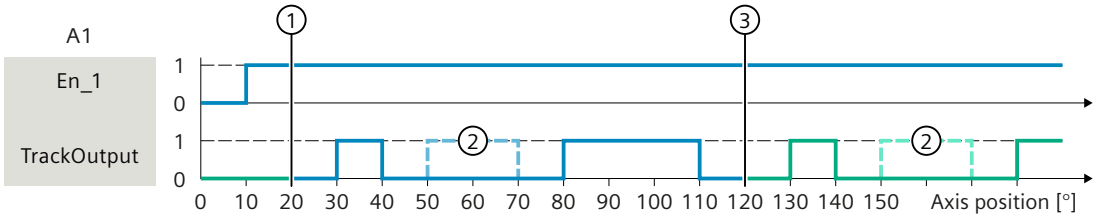

① Axis reference position

② Output cam configured as invalid

③ Start of cyclically continued cam track

A cam track is activated with "Enable" = TRUE. The cam track is output in accordance with the parameters set in the technology data block.

Tag		Value	Description
<TO>Parameter.			
	CamTrackType	0	Specified output cam type for the cam track is distance output cam

Tag		Value	Description
	ReferencePosition	20.0	Specified axis reference position for the cam track
	CamTrackLength	100.0	Specified length of the cam track
	CamTrack[1].Existent	TRUE	The first distance output cam of the cam track is specified as valid
	CamTrack[1].OnPosition	10.0	Start position for the first output cam of the cam track
	CamTrack[1].OffPosition	20.0	End position for the first output cam of the cam track
	CamTrack[2].Existent	FALSE	The second distance output cam of the cam track is specified as invalid
	CamTrack[2].OnPosition	30.0	Start position for the second output cam of the cam track
	CamTrack[2].OffPosition	50.0	End position for the second output cam of the cam track
	CamTrack[3].Existent	TRUE	The third distance output cam of the cam track is specified as valid
	CamTrack[3].OnPosition	60.0	Start position for the third output cam of the cam track
	CamTrack[3].OffPosition	90.0	End position for the third output cam of the cam track

10.6 Override response of Motion Control jobs V10

10.6.1 Override response V10: Homing and motion jobs

The following table shows how a new Motion Control job affects active homing and motion jobs:

⇒ Active job ⇓ New job	MC_Home "Mode" = 2-, 8, 10	MC_Home "Mode" = 3, 5	MC_Halt "Mode" = 1 MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 0, 1 active MC_Move-Velocity MC_MoveJog	MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 1 waiting	MC_Halt "Mode" = 0	MC_Stop	MC_Move-Super-imposed MC_Motion-InSuper-imposed MC_Motion-InSuper-imposed-Axes MC_Halt-Super-imposed	MC_Motion-InVelocity MC_Motion-InPosition
MC_Home[1)] "Mode" = 3, 5	A	A	A	A	A	N	A	A
MC_Home "Mode" = 9	A	-	-	-	-	N	-	-
MC_Halt "Mode" = 1	-	A	A	A	-	N	-	A
MC_Halt "Mode" = 0 **MC_MoveAbsolute/ MC_MoveRelative/ MC_PositionProfile** "BufferMode" = 0 Active **MC_MoveVelocity MC_MoveJog**	-	A	A	A	A	N	A	A

A The running job is aborted with "CommandAborted" = TRUE.

B An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) The status "Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE corresponds to a waiting synchronous operation.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) The status "Busy" = TRUE, "StartSyncOut" = FALSE corresponds to a pending desynchronization job.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) An "MC_CamIn" job with "SyncProfileReference" = 5 does not abort an "MC_[...]Superimposed" job. Running job continues to be executed.

⇒ Active job ⇓ New job	MC_Home "Mode" = 2-, 8, 10	MC_Home "Mode" = 3, 5	MC_Halt "Mode" = 1 MC_MoveAbsolute/ MC_MoveRelative/ MC_PositionProfile "BufferMode" = 0, 1 active MC_MoveVelocity MC_MoveJog	MC_MoveAbsolute/ MC_MoveRelative/ MC_PositionProfile "BufferMode" = 1 waiting	MC_Halt "Mode" = 0	MC_Stop	MC_MoveSuperimposed MC_MotionInSuperimposed MC_MotionInSuperimposedAxes MC_HaltSuperimposed	MC_MotionInVelocity MC_MotionInPosition
MC_MotionInVelocity MC_MotionInPosition								
MC_MoveAbsolute/ MC_MoveRelative/ MC_PositionProfile "BufferMode" = 1 active, waiting	N	N	-/N	N	N	N	-	N
MC_MoveSuperimposed MC_MotionInSuperimposed MC_MotionInSuperimposedAxes MC_HaltSuperImposed	-	-	-	-	-	N	A	-
MC_Stop	A	A	A	A	A	B	A	A
MC_GearIn MC_GearInVelocity	-	A	A	A	A	N	A	A
MC_GearInPos MC_CamIn waiting[2]	-	-	-	A	-	N	-	-
MC_GearInPos MC_CamIn active[3]	-	A	A	A	A	N	A[6]	A

A The running job is aborted with "CommandAborted" = TRUE.

B An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) The status "Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE corresponds to a waiting synchronous operation.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) The status "Busy" = TRUE, "StartSyncOut" = FALSE corresponds to a pending desynchronization job.

⇒ Active job ⇓ New job	MC_Home "Mode" = 2-, 8, 10	MC_Home "Mode" = 3, 5	MC_Halt "Mode" = 1 MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 0, 1 active MC_Move-Velocity MC_MoveJog	MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 1 waiting	MC_Halt "Mode" = 0	MC_Stop	MC_Move-Super-imposed MC_Motion-InSuper-imposed MC_Motion-InSuper-imposed-Axes MC_Halt-Super-imposed	MC_Motion-InVelocity MC_Motion-InPosition
MC_Leading-ValueAdditive	-	-	-	-	-	-	-	-
MC_GearOut MC_CamOut waiting[4)]	N	N	N	N	N	N	-	N
MC_GearOut MC_CamOut active[5)]	N	N	N	N	N	N	A	N

A The running job is aborted with "CommandAborted" = TRUE.

B An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) The status "Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE corresponds to a waiting synchronous operation.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) The status "Busy" = TRUE, "StartSyncOut" = FALSE corresponds to a pending desynchronization job.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) An "MC_CamIn" job with "SyncProfileReference" = 5 does not abort an "MC_[...]Superimposed" job. Running job continues to be executed.

NOTE

Override response with active fixed stop

With an active force and torque limiting with "MC_TorqueLimiting", running jobs are aborted if the drive is held at the fixed stop with "InClamping" = TRUE.

10.6.2 Override response V10: Synchronous operation jobs

The following table shows how a new Motion Control job affects the motion of the axis on active synchronous operation jobs:

⇒ Active job ⇓ New job	MC_GearIn	MC_GearInVelocity	MC_GearInPos MC_CamIn waiting[2]	MC_GearInPos MC_CamIn active[3]	MC_PhasingAbsolute MC_PhasingRelative	MC_OffsetAbsolute MC_OffsetRelative	MC_LeadingValueAdditive	MC_GearOut MC_CamOut waiting[4]	MC_GearOut MC_CamOut active[5]
MC_Home[1] "Mode" = 3, 5	A	A	-	N	-	-	-	-	A
MC_Halt "Mode" = 0, 1 **MC_MoveAbsolute/ MC_MoveRelative** "BufferMode" = 0 Active **MC_PositionProfile** "BufferMode" = 0 Active **MC_MoveVelocity** **MC_MoveJog**	A	A	-	A	A	A	-	A	A

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) A waiting synchronous operation job ("Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) A pending desynchronization job ("Busy" = TRUE, "StartSyncOut" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) When the following axis is in position-controlled mode, execution of the running job is continued. When the following axis is not in position-controlled mode, the new job is rejected.

7) An "MC_GearOut" job only terminates an "MC_Gear[...]" job. Correspondingly, an "MC_CamOut" job only cancels a "MC_Cam[...]" job.

8) A job with "SyncProfileReference" = 5 aborts a pending synchronous operation. Canceling a pending synchronous operation has no influence on an active synchronous operation.

⇒ Active job ⇓ New job	MC_GearIn	MC_GearInVelocity	MC_GearInPos MC_CamIn waiting[2]	MC_GearInPos MC_CamIn active[3]	MC_PhasingAbsolute MC_PhasingRelative	MC_OffsetAbsolute MC_OffsetRelative	MC_LeadingValueAdditive	MC_GearOut MC_CamOut waiting[4]	MC_GearOut MC_CamOut active[5]
MC_MoveAbsolute/-MC_MoveRelative "BufferMode" = 1 active, waiting **MC_PositionProfile** "BufferMode" = 1 active, waiting	N	N	-	N	N	N	-	N	N
MC_MotionInVelocity **MC_MotionInPosition**	A	A	-	A	A	A	-	A	A
MC_MoveSuperimposed **MC_MotionInSuperimposed** **MC_MotionInSuperimposedAxes** **MC_HaltSuperImposed**	-	-/N[6]	-	-	-	-	-	-	-
MC_Stop	A	A	A	A	A	A	-	A	A

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) A waiting synchronous operation job ("Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) A pending desynchronization job ("Busy" = TRUE, "StartSyncOut" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) When the following axis is in position-controlled mode, execution of the running job is continued. When the following axis is not in position-controlled mode, the new job is rejected.

7) An "MC_GearOut" job only terminates an "MC_Gear[...]" job. Correspondingly, an "MC_CamOut" job only cancels a "MC_Cam[...]" job.

8) A job with "SyncProfileReference" = 5 aborts a pending synchronous operation. Canceling a pending synchronous operation has no influence on an active synchronous operation.

⇒ Active job ⇓ New job	MC_GearIn	MC_GearInVelocity	MC_GearInPos MC_CamIn waiting[2]	MC_GearInPos MC_CamIn active[3]	MC_PhasingAbsolute MC_PhasingRelative	MC_OffsetAbsolute MC_OffsetRelative	MC_LeadingValueAdditive	MC_GearOut MC_CamOut waiting[4]	MC_GearOut MC_CamOut active[5]
MC_GearIn MC_GearInVelocity	A	A	A	A	A	A	-	A	A
MC_GearInPos MC_CamIn waiting[2]	-	-	A	-	-	-	-	A	-
MC_GearInPos MC_CamIn active[3]	A	A[6]	A	A	A	A	-	A	A
MC_PhasingAbsolute MC_PhasingRelative	-	N	-	-	A	N	-	-	N
MC_OffsetAbsolute MC_OffsetRelative	-	N	-	-	N	A	-	-	N
MC_LeadingValueAdditive	-	-	-	-	-	-	A	-	-
MC_GearOut MC_CamOut waiting[4]	-	N	A[7] [8]	-	-	-	-	A[7]	N
MC_GearOut MC_CamOut active[5]	A[7]	N	A[7] [8]	A[7]	A	A	-	A[7]	N

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) A waiting synchronous operation job ("Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) A pending desynchronization job ("Busy" = TRUE, "StartSyncOut" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) When the following axis is in position-controlled mode, execution of the running job is continued. When the following axis is not in position-controlled mode, the new job is rejected.

7) An "MC_GearOut" job only terminates an "MC_Gear[...]" job. Correspondingly, an "MC_CamOut" job only cancels a "MC_Cam[...]" job.

8) A job with "SyncProfileReference" = 5 aborts a pending synchronous operation. Canceling a pending synchronous operation has no influence on an active synchronous operation.

NOTE
Override response with active fixed stop
With an active force and torque limiting with "MC_TorqueLimiting", running jobs are aborted if the drive is held at the fixed stop with "InClamping" = TRUE.

10.6.3 Override response V10: Measuring input jobs

The following table shows which new Motion Control jobs will override active measuring input jobs:

⇒ **Active job** ⇓ **New job**	**MC_MeasuringInput**	**MC_MeasuringInputCyclic**
MC_Home "Mode" = 2, 3, 5, 8, 9, 10	B	B
MC_Home "Mode" = 0, 1, 6, 7, 11, 12	-	-
MC_MeasuringInput **MC_MeasuringInputCyclic** **MC_AbortMeasuringInput**	A	A

A The running job is aborted with "CommandAborted" = TRUE.

B The running job is aborted with "ErrorID" = 16#80A3.

- No effect. Running job continues to be executed.

10.6.4 Override response V10: Kinematics motion commands

Single axis jobs are not overridden by kinematics jobs.

The following table shows how a new Motion Control job affects active kinematics motion jobs:

⇒ **Active job** ⇓ **New job**	**MC_MoveLinearAbsolute** **MC_MoveLinearRelative** **MC_MoveCircularAbsolute** **MC_MoveCircularRelative** **MC_MoveDirectAbsolute** **MC_MoveDirectRelative** **MC_TrackConveyorBelt** **MC_DefineWorkspaceZone** **MC_DefineKinematicsZone** **MC_SetWorkspaceZoneActive** **MC_SetWorkspaceZoneInactive** **MC_SetKinematicsZoneActive** **MC_SetKinematicsZoneInactive** **MC_SetOcsFrame**	**MC_GroupInterrupt**	**MC_GroupStop**
MC_Home **MC_MoveSuperimposed** **MC_GearOut** **MC_CamOut**	N	N	N
MC_Halt **MC_MoveAbsolute/** **MC_MoveRelative/** **MC_PositionProfile** "BufferMode" = 0 Active **MC_MoveVelocity** **MC_MoveJog** **MC_Stop** **MC_GearIn** **MC_GearInPos** **MC_GearInVelocity** **MC_CamIn** **MC_MotionInVelocity** **MC_MotionInPosition**	A	A	A
MC_GroupStop	A	A	N
MC_GroupInterrupt **MC_GroupContinue**	B	A	N
MC_MoveLinearAbsolute **MC_MoveLinearRelative** **MC_MoveCircularAbsolute** **MC_MoveCircularRelative** **MC_MoveDirectAbsolute** **MC_MoveDirectRelative** **MC_TrackConveyorBelt**	-	-	N

⇒ Active job ⇓ New job	MC_MoveLinearAbsolute MC_MoveLinearRelative MC_MoveCircularAbsolute MC_MoveCircularRelative MC_MoveDirectAbsolute MC_MoveDirectRelative MC_TrackConveyorBelt MC_DefineWorkspaceZone MC_DefineKinematicsZone MC_SetWorkspaceZoneActive MC_SetWorkspaceZoneInactive MC_SetKinematicsZoneActive MC_SetKinematicsZoneInactive MC_SetOcsFrame	MC_GroupInterrupt	MC_GroupStop
MC_DefineWorkspaceZone MC_DefineKinematicsZone MC_SetWorkspaceZoneActive MC_SetWorkspaceZoneInactive MC_SetKinematicsZoneActive MC_SetKinematicsZoneInactive			
MC_SetOcsFrame	C, -	-	N

A The running job is aborted with "CommandAborted" = TRUE.

B Running job is interrupted or resumed.

C Synchronization of the OCS with the conveyor belt is aborted with "MC_SetOcsFrame" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed. A new kinematics job is added to the job sequence.

10.6.5 Override response V10: Interpreter jobs

The following table shows how a new Motion Control job affects running Interpreter jobs:

⇒ Active job ⇓ New job	MC_LoadProgram	MC_RunProgram	MC_StopProgram
MC_LoadProgram	N	N	N
MC_RunProgram	-[1]	N	N
MC_StopProgram	A	A	A[2]
MC_Reset	-/N[3]	-/N[3]	-/N[3]

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) The new job is also executed.

2) A new "MC_StopProgram" job with "Mode" = 0 cancels a running "MC_StopProgram" job with "Mode" = 1 or 2. A new "MC_StopProgram" job with "Mode" = 1 aborts a current "MC_StopProgram" job with "Mode" = 2.

3) An "MC_Reset" job with "Restart" = TRUE is rejected. Running job continues to be executed.

Override response for technology objects controlled by the Interpreter

The following table shows how a new Motion Control job acts in relation to a technology object controlled by the Interpreter during the execution of an Interpreter program ("<TO>.StatusInterpreterMotion.StatusWord.X0" = TRUE (ControlledByInterpreter)):

⇓ New job	The new job will be executed.	The new job aborts the execution of the Interpreter program.
MC_Power disable/enable with technology object	✓	✓
MC_Reset with "Restart" = TRUE	✓	✓
MC_Reset with "Restart" = FALSE	✓	-
MC_Home **MC_Halt** **MC_Stop**	✓	✓
MC_MoveAbsolute **MC_MoveRelative** **MC_MoveVelocity** **MC_MoveJog**	✓	✓
MC_SetAxisSTW **MC_WriteParameter**	✓	-
MC_MoveSuperimposed **MC_MotionInSuperimposed** **MC_MotionInSuperimposedAxes** **MC_HaltSuperimposed**	-	-
MC_MotionInVelocity **MC_MotionInPosition**	✓	✓
MC_GearIn **MC_GearInPos** **MC_GearInVelocity** **MC_GearOut** **MC_CamIn** **MC_CamOut**	✓	✓[1)]
MC_PhasingRelative **MC_PhasingAbsolute**	-	-
MC_LeadingValueAdditive	✓	-
MC_OffsetRelative **MC_OffsetAbsolute**	-	-
MC_TorqueAdditive **MC_TorqueRange**	✓	-
MC_TorqueLimiting	✓	-/✓[2)]
MC_SynchronizedMotionSimulation	✓	-

1) When the synchronization/desynchronization starts, the execution of the Interpreter program is cancelled.

2) If a technology alarm is issued due to a fixed stop, the execution of the Interpreter program is cancelled.

⇓ New job	The new job will be executed.	The new job aborts the execution of the Interpreter program.
MC_MoveLinearAbsolute **MC_MoveLinearRelative** **MC_MoveCircularAbsolute** **MC_MoveCircularRelative** **MC_MoveDirectAbsolute** **MC_MoveDirectRelative**	-	-
MC_GroupInterrupt **MC_GroupContinue**	-	-
MC_GroupStop	✓	✓
MC_KinematicsMotionSimulation	✓	-
MC_TrackConveyorBelt	-	-
MC_DefineTool **MC_SetTool** **MC_SetOcsFrame**	-	-
MC_KinematicsTransformation **MC_InverseKinematicsTransformation**	✓	-
MC_DefineWorkspaceZone **MC_SetWorkspaceZoneActive** **MC_SetWorkspaceZoneInactive** **MC_DefineKinematicsZone** **MC_SetKinematicsZoneActive** **MC_SetKinematicsZoneInactive**	-	-

1) When the synchronization/desynchronization starts, the execution of the Interpreter program is cancelled.

2) If a technology alarm is issued due to a fixed stop, the execution of the Interpreter program is cancelled.

NOTE

MC_Power

Note that a "MC_Power" request with "Enable" = FALSE always locks the specified technology object, even if the technology object was enabled via an Interpreter program with "powerOn()".

Mixed operation of MC_Power (SCL) and powerOn() (MCL) is not permitted.

NOTE

MC_Stop

Note that when starting a motion controlled by the Interpreter no "MC_Stop" job may be active, otherwise the motion job will be aborted.

NOTE

MC_GroupStop

Note that when starting a kinematics motion controlled by the Interpreter, no "MC_GroupStop" job may be active, otherwise the motion job will be aborted.

A "MC_GroupStop" job only affects active kinematics motions or if the kinematics technology object is controlled by the Interpreter ("<TO>.StatusInterpreterMotion.StatusWord.X0" = TRUE (ControlledByInterpreter)).

See also

Override response V10: Homing and motion jobs (Page %getreference)
Override response V10: Synchronous operation jobs (Page %getreference)
Override response V10: Kinematics motion commands (Page %getreference)

Tags of the technology object data blocks 11

11.1 Legend

Tag	Name of the tag	
Data type	Data type of the tag	
Values	Value range of the tag - minimum value to maximum value (L - linear specification R - rotary specification) If no specific value is shown, the value range limits of the relevant data type apply or the information under "Description".	
W	Effectiveness of changes in the technology data block	
	DIR	Direct: Values are changed via direct assignment and take effect at the start of the next MC_Servo.
	CAL	At call of Motion Control instruction: Values are changed directly and take effect at the start of the next MC_Servo after the call of the corresponding Motion Control instruction in the user program.
	RES	Restart: Changes to the start value in the load memory are made using the extended instruction "WRIT_DBL" (write to DB in load memory). Changes will not take effect until after restart of the technology object.
	RON	Read only: The tag cannot and must not be changed during runtime of the user program.
Description	Description of the tag	

Access to the tags is with "<TO>.<tag name>". The placeholder <TO> represents the name of the technology object.

11.2 Tags of the measuring input technology object

11.2.1 Display data (measuring input)

The "<TO>.Status" and "<TO>.InputState" tags show the status of the measuring input function and the measurement input.

Tags

Legend

Tag	Data type	Values	W	Description	
Status	DINT	-	RON	Status of the measuring input function	
				0	"INACTIVE" No measurement is active.

Tag	Data type	Values	W	Description	
Status	DINT	-	RON	1	"WAITING_FOR_TRIGGER" The measuring input is waiting for the measuring event.
				2	"TRIGGER_OCCURRED" One or more measured values have been captured.
				3	"MEASURING_ERROR" Error during the measurement
InputState	BOOL	-	RON	Status of the measurement input	
				FALSE	Measurement input inactive
				TRUE	Measurement input active

11.2.2 "Parameter" tag (measuring input)

The tag structure "<TO>.Parameter.<tag name>" contains the configuration of the basic parameters of the measuring input technology object.

Tags

Legend

Tag	Data type	Values	W	Description	
Parameter.	TO_MeasuringInput_Struct_Parameter				
MeasuringInputType	DINT	0...2	RON	Measuring input type	
				0	"STANDARD" Measurement using time stamp
				1	"PROFIDRIVE" Measuring event using PROFIdrive telegram
				2	"MONITORING" Measuring via "Monitor measuring input": Capture a measuring event of another measuring input technology object
PROFIdriveProbeNumber	UDINT	1, 2	RES	Number of the measurement input to be used for a measurement via PROFIdrive telegram	
MeasuringRangeActivationTime	LREAL	0.0 ... 1.0E12	RON	System share for activation time of measuring range	
MeasuringRangeAdditionalActivationTime	LREAL	0.0 ... 1.0E12	RES	Additional activation time when using measuring range limits [ms]	
CorrectionTime	LREAL	0.0 ... 1.0E12	RES	Correction time for the measurement result [ms]	

11.2.3 "Interface" tag (measuring input)

The tag structure "<TO>.Interface.<tag name>" contains the configuration of the input properties for the measuring input technology object.

Tags

Legend

Tag	Data type	Values	W	Description
Interface.	TO_MeasuringInput_Struct_Interface			
Address	VREF	-	RON	I/O address for the digital measurement input Not relevant for measuring via "Monitor measuring input" ("MeasuringInputType" = 2)

11.2.4 "Units" tag (measuring input)

The tag structure "<TO>.Units.<tag name>" shows the set technological units.

Tags

Legend

Tag	Data type	Values	W	Description	
Units.	TO_MeasuringInput_Struct_Units				
LengthUnit	UDINT	-	RON	Unit for position	
				1010	m
				1013	mm
				1536	mm[1)]
				1011	km
				1014	µm
				1015	nm
				1019	in
				1018	ft
				1021	mi
				1004	rad
				1005	°
				1537	°[1)]
TimeUnit	UDINT	-	RON	Unit for time	
				1056	ms

1) Position values with higher resolution or six decimal places.

11.2.5 "MeasuredValues" tag (measuring input)

The tag structure "<TO>.MeasuredValues.<tag name>" displays the measurement results.

Tags

Legend

Tag	Data type	Values	W	Description
MeasuredValues.	TO_MeasuringInput_Struct_MeasuringValues			
MeasuredValue1	LREAL	-1.0E12 ... 1.0E12	RON	First measured value
MeasuredValue2	LREAL	-1.0E12 ... 1.0E12	RON	Second measured value
MeasuredValue1Counter	UDINT	0 ... 2147483647	RON	Count value for the first measured value
MeasuredValue2Counter	UDINT	0 ... 2147483647	RON	Count value for the second measured value
LostEdgeCounter1	UDINT	0 ... 7	RON	LEC for measured value 1 (Zero in the case of one-time measurement)
LostEdgeCounter2	UDINT	0 ... 7	RON	LEC for measured value 2 (Zero in the case of one-time measurement)

11.2.6 "StatusWord" tag (measuring input)

The "<TO>.StatusWord" tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 2 "RestartActive") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status information of the technology object
Bit 0	-	-	-	"Control" The technology object is in operation.
Bit 1	-	-	-	"Error" An error is present.
Bit 2	-	-	-	"RestartActive" A restart is active. The technology object is being reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" The restart tags have been changed. For the changes to be applied, the technology object must be reinitialized.

Tag	Data type	Values	W	Description
Bit 4	-	-	-	Reserved
Bit 5	-	-	-	"CommunicationOK" The communication between the measuring input and measurement input is established. With an interconnected measuring input that monitors another measuring input with measurement input, this bit always has the value "FALSE".
Bit 6... Bit 31	-	-	-	Reserved

11.2.7 "ErrorWord" tag (measuring input)

The "<TO>.ErrorWord" tag indicates technology object errors (technology alarms).

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
Bit 4... Bit 12	-	-	-	Reserved
Bit 13	-	-	-	"PeripheralError" Error accessing a logical address
Bit 14... Bit 31	-	-	-	Reserved

11.2.8 "ErrorDetail" tag (measuring input)

The tag structure "<TO>.ErrorDetail.<tag name>" contains the alarm number and the effective local alarm response for the technology alarm that is currently pending on the technology object.

You can find a list of the technology alarms and alarm responses in the "Overview of the technology alarms" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.

Tags

Legend

Tag	Data type	Values	W	Description	
ErrorDetail.	TO_Struct_ErrorDetail				
Number	UDINT	-	RON	Alarm number	
Reaction	DINT	0, 6	RON	Effective alarm response	
				0	No reaction
				6	End measuring input processing

11.2.9 "WarningWord" tag (measuring input)

The "<TO>.WarningWord" tag indicates pending warnings at the technology object.

Information on the evaluation of the individual bits (e.g. bit 1 "ConfigWarning") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.

Tag		Data type	Values	W	Description
	Bit 4... Bit 12	-	-	-	Reserved
	Bit 13				"PeripheralWarning" Error accessing a logical address
	Bit 14... Bit 31	-	-	-	Reserved

11.3 Tags of the output cam technology object

11.3.1 Display data (output cam)

The "<TO>.CamOutput" tag indicates the switching state of the output cam.

Tags

Legend

Tag	Data type	Values	W	Description	
CamOutput	BOOL	-	RON	Switching state of output cam	
				FALSE	Not switched
				TRUE	Switched

11.3.2 "Parameter" tag (output cam)

The tag structure "<TO>.Parameter.<tag name>" contains the configuration of the basic parameters of the output cam technology object.

Tags

Legend

Tag		Data type	Values	W	Description	
Parameter.		TO_OutputCam_Struct_Parameter				
	OutputCamType	DINT	0 ... 2	RES	Output cam type	
					0	Distance output cam
					1	Time-based output cam
					2	Switching output cam
	PositionType	DINT	0, 1	RES	Position reference	
					0	Position setpoint
					1	Actual position

Tag	Data type	Values	W	Description
OnCompensation	LREAL	0.0 ... 1.0E12	DIR	Activation time Lead time for the switch-on edge
OffCompensation	LREAL	0.0 ... 1.0E12	DIR	Deactivation time Lead time for the switch-off edge
Hysteresis	LREAL	0.0 ... 1.0E12	DIR	Hysteresis value For output cams with reference to actual position, always enter a hysteresis value (> 0.0).

11.3.3 "Interface" tag (output cam)

The tag structure "<TO>.Interface.<tag name>" contains the configuration of the output properties for the output cam technology object.

Tags

Legend

Tag	Data type	Values	W	Description	
Interface.	TO_OutputCam_Struct_Interface				
EnableOutput	BOOL	-	RES	Activation of the output cam output	
				FALSE	Output is deactivated
				TRUE	Output is activated
Address	VREF	-	RON	I/O address of the output cam	
LogicOperation	DINT	0, 1	RON	Logical operation of the output cam signals at the output	
				0	OR logic operation
				1	AND logic operation

11.3.4 "Units" tag (output cam)

The tag structure "<TO>.Units.<tag name>" shows the set technological units.

Tags

Legend

Tag	Data type	Values	W	Description	
Units.	TO_OutputCam_Struct_Units				
LengthUnit	UDINT	-	RON	Unit for position	
				1010	m
				1013	mm
				1536	mm[1)]
				1011	km
				1014	µm

1) Position values with higher resolution or six decimal places.

Tag	Data type	Values	W	Description	
LengthUnit	UDINT	-	RON	1015	nm
				1019	in
				1018	ft
				1021	mi
				1004	rad
				1005	°
				1537	°[1]
TimeUnit	UDINT	-	RON	Unit for time	
				1056	ms

[1] Position values with higher resolution or six decimal places.

11.3.5 "StatusWord" tag (output cam)

The "<TO>.StatusWord" tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 2 "RestartActive") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status information of the technology object
Bit 0	-	-	-	"Control" The technology object is in operation.
Bit 1	-	-	-	"Error" An error is present.
Bit 2	-	-	-	"RestartActive" A restart is active. The technology object is being reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" The restart tags have been changed. For the changes to be applied, the technology object must be reinitialized.
Bit 4	-	-	-	"OutputInverted" The output cam output is inverted.
Bit 5	-	-	-	"CommunicationOK" The communication between output cam and output module is established.
Bit 6... Bit 31	-	-	-	Reserved

11.3.6 "ErrorWord" tag (output cam)

The "<TO>.ErrorWord" tag indicates technology object errors (technology alarms).

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
Bit 4... Bit 12	-	-	-	Reserved
Bit 13	-	-	-	"PeripheralError" Error accessing a logical address
Bit 14... Bit 31	-	-	-	Reserved

11.3.7 "ErrorDetail" tag (output cam)

The tag structure "<TO>.ErrorDetail.<tag name>" contains the alarm number and the effective local alarm response for the technology alarm that is currently pending on the technology object.

You can find a list of the technology alarms and alarm responses in the "Overview of the technology alarms" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.

Tags

Legend

Tag	Data type	Values	W	Description	
ErrorDetail.	TO_Struct_ErrorDetail				
Number	UDINT	-	RON	Alarm number	
Reaction	DINT	0, 6	RON	Effective alarm response	
				0	No reaction
				6	Output cam processing is complete.

11.3.8 "WarningWord" tag (output cam)

The "<TO>.WarningWord" tag indicates pending warnings at the technology object.

Information on the evaluation of the individual bits (e.g. bit 1 "ConfigWarning") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.

Tag	Data type	Values	W	Description
Bit 4... Bit 12	-	-	-	Reserved
Bit 13				"PeripheralWarning" Error accessing a logical address
Bit 14... Bit 31	-	-	-	Reserved

11.4 Tags of the cam track technology object

11.4.1 Display data (cam track)

The following tags indicate the status of the cam track:

Tags

Legend

Tag	Data type	Values	W	Description	
Status	DINT	0 ... 2	RON	0	"INACTIVE" Inactive
				1	"ACTIVE" Active
				2	"ACTIVE_WAITING_FOR_NEXT_CYCLE" Active and waiting for next track
TrackOutput	BOOL	-	RON	FALSE	Cam track is not output.
				TRUE	Cam track is output.
SingleCamState	DWORD	16#0 ... 16#FFFF_FFFF	RON	Switched on output cam (bit-masked)	
				0	Output cam is not switched on
				1	Output cam is switched on
TrackPosition	LREAL	-1.0E12 ... 1.0E12	RON	Display of the current position within the cam track	
MatchPosition	LREAL	-1.0E12 ... 1.0E12	RON	Reference position of the current cam track During cyclic processing of the cam track, the continued reference position of the current cam track is displayed. The unique detection and output of the position is only possible when the assigned technology object is in motion.	

11.4.2 "Parameter" tag (cam track)

The tag structure "<TO>.Parameter.<tag name>" contains the configuration of the basic parameters of the cam track technology object.

Tags

Legend

Tag	Data type	Values	W	Description	
Parameter.	TO_CamTrack_Struct_Parameter				
CamTrackType	DINT	0, 1	RES	Output cam type	
				0	Distance output cam
				1	Time-based output cam
PositionType	DINT	0, 1	RES	Position reference	
				0	Position setpoint
				1	Actual position
ReferencePosition	LREAL	-1.0E12 ... 1.0E12	DIR	Reference position	
CamTrackLength	LREAL	0.001 ... 1.0E12	DIR	Track length	
CamMasking	DWORD	16#0 ... 16#FFFF_FFFF	DIR	Bit masking of individual output cams	
OnCompensation	LREAL	0.0 ... 1.0E12	DIR	Activation time Lead time for the switch-on edge	
OffCompensation	LREAL	0.0 ... 1.0E12	DIR	Deactivation time Lead time for the switch-off edge	
Hysteresis	LREAL	0.0 ... 1.0E12	DIR	Hysteresis value For output cams with reference to actual position, always enter a hysteresis value (> 0.0).	
Cam[1..32].	ARRAY[1..32] OF TO_CamTrack_Struct_CamData				
OnPosition	LREAL	0.0 ... 1.0E12	CAL	With distance output cams and time-based output cams: Start position	
Offposition	LREAL	0.0 ... 1.0E12	CAL	With distance output cams: End position	
Duration	LREAL	0.001 ... 1.0E12	CAL	With time-based output cams: Switch-on duration	
Existent	BOOL	-	CAL	FALSE	Output cam is not used.
				TRUE	Output cam is used.

11.4.3 "Interface" tag (cam track)

The tag structure "<TO>.Interface.<tag name>" contains the configuration of the output properties for the cam track technology object.

Tags

Legend

Tag	Data type	Values	W	Description	
Interface.	TO_CamTrack_Struct_Interface				
EnableOutput	BOOL	-	RES	Output cam output at the bit specified under "<TO>.Interface.Address"	
				FALSE	No output
				TRUE	Output
Address	VREF	-	RON	I/O address for digital output cam output	

11.4.4 "Units" tag (cam track)

The tag structure "<TO>.Units.<tag name>" shows the set technological units.

Tags

Legend

Tag	Data type	Values	W	Description	
Units.	TO_CamTrack_Struct_Units				
LengthUnit	UDINT	-	RON	Unit for position	
				1010	m
				1013	mm
				1536	mm[1)]
				1011	km
				1014	µm
				1015	nm
				1019	in
				1018	ft
				1021	mi
				1004	rad
				1005	°
				1537	°[1)]
TimeUnit	UDINT	-	RON	Unit for time	
				1056	ms

1) Position values with higher resolution or six decimal places.

11.4.5 "StatusWord" tag (cam track)

The "<TO>.StatusWord" tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 2 "RestartActive") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status information of the technology object
Bit 0	-	-	-	"Control" The technology object is in operation.
Bit 1	-	-	-	"Error" An error is present.
Bit 2	-	-	-	"RestartActive" A restart is active. The technology object is being reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" The restart tags have been changed. For the changes to be applied, the technology object must be reinitialized.
Bit 4	-	-	-	"OutputInverted" The output cam output is inverted.
Bit 5	-	-	-	"CommunicationOK" The communication between cam track and output module is established.
Bit 6... Bit 31	-	-	-	Reserved

11.4.6 "ErrorWord" tag (cam track)

The "<TO>.ErrorWord" tag indicates technology object errors (technology alarms).

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.

Tag		Data type	Values	W	Description
	Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
	Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
	Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
	Bit 4... Bit 12	-	-	-	Reserved
	Bit 13	-	-	-	"PeripheralError" Error accessing a logical address
	Bit 14... Bit 31	-	-	-	Reserved

11.4.7 "ErrorDetail" tag (cam track)

The tag structure "<TO>.ErrorDetail.<tag name>" contains the alarm number and the effective local alarm response for the technology alarm that is currently pending on the technology object.

You can find a list of the technology alarms and alarm responses in the "Overview of the technology alarms" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.

Tags

Legend

Tag		Data type	Values	W	Description	
ErrorDetail.		TO_Struct_ErrorDetail				
	Number	UDINT	-	RON	Alarm number	
	Reaction	DINT	0, 6	RON	Effective alarm response	
					0	No reaction
					6	Cam track processing is complete.

11.4.8 "WarningWord" tag (cam track)

The "<TO>.WarningWord" tag indicates pending warnings at the technology object.

Information on the evaluation of the individual bits (e.g. bit 1 "ConfigWarning") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Command cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
Bit 4... Bit 12	-	-	-	Reserved
Bit 13	-	-	-	"PeripheralWarning" Error accessing a logical address
Bit 14... Bit 31	-	-	-	Reserved

SIEMENS

SIMATIC

S7-1500
S7-1500/S7-1500T synchronous operation functions V10.0 as of STEP 7 V21

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Introduction 1

Purpose of the documentation

This documentation provides important information that you need to configure and commission the integrated Motion Control functionality of the S7-1500 Automation systems.

Required basic knowledge

In order to understand this documentation, the following knowledge is required:

- General knowledge in the field of automation
- General knowledge in the field of drive engineering and motion control

Validity of the documentation

This documentation is valid for the S7-1500 product range.

Conventions

- The path specifications in the project tree assume that the "Technology objects" folder is open in the subtree of the CPU. The "Technology object" placeholder represents the name of the technology object.

  Example: "Technology object > Configuration > Basic parameters".
- The <TO> placeholder represents the name set in tags for the respective technology object.

  Example: <TO>.Actor.Type
- This documentation contains pictures of the devices described. The pictures may differ in minor details from the devices supplied.

You should also observe the notes that are marked as follows:

NOTE

A note contains important information about the product described in the documentation, about the handling of the product, and about sections in this documentation demanding your particular attention.

Industry Mall

The Industry Mall is the catalog and ordering system of Siemens Aktiengesellschaft for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

1.1 S7-1500 Motion Control Documentation Guide

Product information

Please also note the supplementary information on the Motion Control documentation:

- Product information on the S7-1500/1500T Motion Control documentation
  https://support.industry.siemens.com/cs/ww/en/view/109794046
  (https://support.industry.siemens.com/cs/ww/en/view/109794046)

Documentation

The documentation of the Motion Control functions is divided into the following documents:

- S7-1500/S7-1500T Motion Control Overview
  https://support.industry.siemens.com/cs/en/view/109990070
  (https://support.industry.siemens.com/cs/ww/en/view/109990070)

  This document describes the innovations in the technology versions, how to upgrade the technology version, functions that are used for all technology objects, and the operational sequence of Motion Control applications.
- S7-1500/S7-1500T Motion Control alarms and error IDs
  https://support.industry.siemens.com/cs/ww/en/view/109990076
  (https://support.industry.siemens.com/cs/ww/en/view/109990076)

  This document describes the technology alarms of the technology objects and the error identifications of the Motion Control instructions.
- S7-1500/S7-1500T Axis functions
  https://support.industry.siemens.com/cs/en/view/109990072
  (https://support.industry.siemens.com/cs/ww/en/view/109990072)

  This document describes the drive and encoder connection and functions for single-axis movements.
- S7-1500/S7-1500T Synchronous operation functions
  https://support.industry.siemens.com/cs/ww/en/view/109990074
  (https://support.industry.siemens.com/cs/ww/en/view/109990074)

  This document describes gearing, velocity synchronous operation and camming as well as cross-PLC synchronous operation.

- S7-1500/S7-1500T Measuring input and output cam functions
  https://support.industry.siemens.com/cs/ww/en/view/109990075
  (https://support.industry.siemens.com/cs/ww/en/view/109990075)
  This document describes the detection of the actual position via a measuring input and the output of switching signals via output cam or cam track.
- S7-1500T kinematics functions
  https://support.industry.siemens.com/cs/ww/en/view/109990073
  (https://support.industry.siemens.com/cs/ww/en/view/109990073)
  This document describes the control of kinematics with up to 6 interpolating axes.
- S7-1500T Interpreter functions
  https://support.industry.siemens.com/cs/ww/en/view/109990077
  (https://support.industry.siemens.com/cs/ww/en/view/109990077)
  This documentation describes the control of technology objects via an Interpreter program.

See also

Topic page "SIMATIC Technology - Motion Control: Overview and Important Links"
https://support.industry.siemens.com/cs/ww/en/view/109751049
(https://support.industry.siemens.com/cs/ww/en/view/109751049)

1.2 Function Manuals documentation guide

1.2.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.2.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.2.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 General safety instructions

The safety instructions can be found in section "Safety instructions" in the System Manual "SIMATIC S7-1500, ET 200MP Automation System" (https://support.industry.siemens.com/cs/ww/en/view/59191792) document.

Cybersecurity-relevant information can be found in the Industrial Cybersecurity section.

2.2 Warnings in this document

You can find explanations of the warnings used in this document in the "Legal information" section.

Industrial cybersecurity 3

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

3.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

New features V10.0

4

4.1 New synchronous operation functions V10.0

Technology version V10.0 contains the following new features:

Actual value extrapolation (S7-1500T)

- The leading value velocity can be differentiated from the extrapolated leading value position ("<TO>.Extrapolation.Settings.ExtrapolatedVelocityMode" = 2).
- When the effective extrapolation time amounts to zero and the extrapolation is omitted, the position and velocity filters remain active.

Camming (S7-1500T)

- Use the Motion Control instruction "MC_SetCamRangeScaling (Page 360)" to scale a cam range. Up to two scaling ranges are possible. Range scaling can also be used during synchronous camming. An active range scaling is displayed in the online view of the cam diagnostics. In addition, range scaling can be simulated offline in the configuration of the cam.

Cross-PLC synchronous operation (S7-1500T)

- The leading axis proxy supports different leading value telegram versions. Observe the compatibility of the technology versions. (Page 211)
- If multiple PROFINET interfaces of a CPU support the "PROFINET with IRT" functionality, you can operate the CPU as an isochronous I-device. The PROFINET interface configured as an I-device is used for isochronous data exchange with the higher-level IO Controller, through which you can realize cross-PLC synchronous operation. The other PROFINET interface can synchronize with the I-device interface and operate connected IO devices isochronously.

4.2 Upgrade to technology version V10.0

Permissible following error - changes to the default values

As of technology version V10.0, the following default values for the permissible following error for the rotary axis have been updated:

- <TO>.FollowingError.MinValue: 30°
- <TO>.FollowingError.MaxValue: 360°

You handle compatibility between versions as follows:

- After upgrading to technology version V10.0, the existing default values or the configured values remain unchanged.
- When changing to an older technology version, the values set in V10.0 are retained.

Configuration of the "6-axis articulated arm with central wrist" kinematics type

As of technology version V10.0, the configuration of the kinematics type "6-axis articulated arm with central wrist" has been extended by the parameter Length L6 (<TO>.Kinematics.Parameter[7]).

After upgrading to technology version V10.0, the length L6 has the default value (0.0).

When upgrading to a technology version <V10.0, the configured Length L6 value is not considered.

Actual value extrapolation in synchronous operation

If the effective extrapolation time is zero, the actual value extrapolation is omitted.

Up to technology version V9.0, the positioning filter and the velocity filter are inactive in this case.

As of technology version V10.0, the filtered actual values are evaluated with the hysteresis and used as the leading value.

Cross-PLC synchronous operation

Note the compatible leading value telegram versions for cross-PLC synchronous operation (Page 211).

Leading value telegram version 2

If you upgrade the technology version V8.0 to the technology version V10.0, the leading value telegram version 2 is used automatically.

To make the leading value of the leading value telegram version 1 available, proceed as follows:

1. Open the "Technology object > Configuration > Leading value settings" configuration window of the leading axis.
2. To show rows 2 to 32 in the table in the "Provision of leading value" area, select the "Show all transfer areas" check box.
3. To use the leading value telegram version 1, clear the check box of the corresponding transfer area in the "Leading value telegram V2" table column.

   The leading value telegram version depends on the technology version of the receiver.

Overview of functions

5

Synchronous operation enables a following axis to be linked to a leading axis and move synchronously with it. The synchronous operation relationship between the leading and following axes is specified by a synchronous operation function.

Gearing

During gearing (Page 49), the position of the following axis results from the position of the leading axis multiplied by the gear ratio. You specify the gear ratio as a ratio of two integers. The result is a linear synchronous operation function.

Gearing (S7-1500T)

The following axis can be synchronized in advance or synchronized subsequently via the leading value path or dynamic parameters. For this purpose, you can specify corresponding reference positions of leading and following axis that define the relation of the axes to each other.

As an alternative to the setpoint, the extrapolated actual value can be interconnected as a leading value for synchronous operation. As a result, you can use an external encoder technology object as the leading value.

In addition, the following axis can be desynchronized to a presettable stop position via the leading value path or dynamic parameters.

Velocity synchronous operation (S7-1500T)

During velocity synchronous operation (Page 94), the velocity of the following axis results from the velocity of the leading axis multiplied by the gear ratio, regardless of the position. You specify the gear ratio as a ratio of two integers either once or variably during synchronization.

Camming (S7-1500T)

During camming (Page 102), the leading axis and following axis are coupled by a synchronous operation function, which you specify using a cam technology object. The cam technology object (TO_Cam, TO_Cam_10k, TO_Cam_600Seg, TO_Cam_6kSeg) defines a function f(x) by means of interpolation points and/or segments. Gaps between the defined interpolation points and segments of the cam are closed by interpolation during runtime of the user program. The transmission behavior during camming is expressed by the cam curve.

Synchronous operation phases

A synchronous operation runs in the following phases:

- Pending synchronous operation (S7-1500T)

  The following axis waits for the starting conditions of the synchronizing motion to be fulfilled.

- Synchronization

  The following axis is synchronized to the leading value.

- Synchronous travel

  The following axis follows the position of the leading axis according to the synchronous operation function.

- End or override synchronous operation

  An active synchronous operation is overridden by motion jobs, e.g. "MC_Halt" on the following axis.

- Waiting synchronization job (S7-1500T)

  The following axis waits for the starting conditions of the desynchronization motion to be fulfilled.

- Desynchronize synchronous operation (S7-1500T)

  The following axis is desynchronized from the leading value. The following axis stops at a defined position and synchronous operation is ended.

Cross-PLC synchronous operation (S7-1500T)

Cross-PLC synchronous operation (Page 207) enables synchronous operation via multiple CPUs. You can configure leading and following axes on different CPUs. The CPUs can be configured in the same project or in various projects.

The synchronous operation function, e.g. a gearing, is executed on the CPU of the following axis. The leading axis proxy technology object (TO_LeadingAxisProxy) represents the leading axis for the local synchronous operation within a CPU. The leading axis proxy evaluates the leading value telegram and provides the leading value for the local following axes.

5.1 Synchronous axis technology object

The synchronous axis technology object includes all functions of the positioning axis technology object.

A synchronous axis can also follow the motions of a leading axis. The synchronous operation relationship between the leading and following axes is specified by a synchronous operation function.

You can find an overview of the supported instructions of the synchronous axis technology object in the section "Motion Control instructions for synchronous operation (Page 32)".

The figure below shows the basic principle of operation of the synchronous axis technology object:

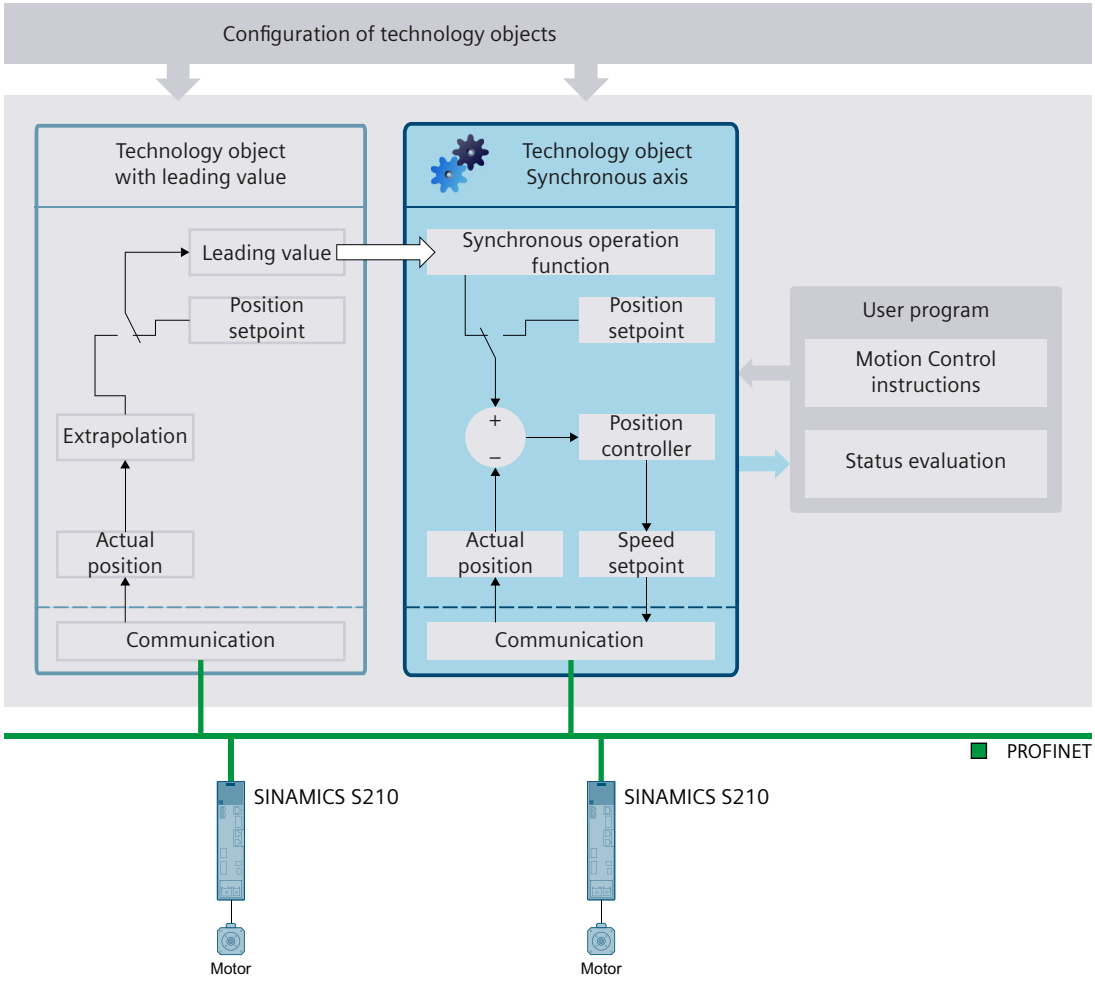

Configuration

The following non-isochronous specific configurations correspond to the positioning axis technology object:

- Basic parameters
  - Axis or encoder type
  - Units of measure
  - Modulo setting
  - Virtual axis
  - Axis in simulation
- Hardware interface
  - Connecting PROFIdrive drives
  - Connecting encoders via PROFIdrive
  - Transferring drive and encoder parameters automatically
  - Connecting stepper motors
  - Connecting drives with analog setpoint interface
  - Connecting force/torque data via SIEMENS additional telegram 750
- Mechanics
  - Configuring drive and encoder direction for positioning axis/synchronous axis
  - Configuring the load gear
  - Configuring the encoder gear
  - Configuring the leadscrew pitch
  - Configuring inertia values
  - Configuring backlash compensation
- Dynamic default
- Emergency stop
- Configuring the alarm responses
- Limits
  - Position limits
  - Dynamic limits
  - Torque limits
  - Fixed stop detection
- Homing
  - Active homing
  - Passive homing

- Position monitoring functions
  - Positioning monitoring
  - Following error
  - Standstill signal
- Control loop
  - Configuring position controller in the PLC
  - Configuring position controller for drives with DSC
  - Configuring a dynamic filter
  - Switching the position control off and on
- Superimposing axes

You can find a description of the configuration parameters in the "S7-1500/S7-1500T Axis functions" documentation.

The following configurations of the synchronous axis technology object are specific to synchronous operation:

- Leading value interconnections (Page 37)
- Leading value settings
  - Configuring provision of the leading value (Page 238)
  - Configuring the delay time (Page 245)
- Actual value extrapolation (Page 38)
- Configuring the reverse tolerance of the leading value (Page 44)

You can find a description of the configuration parameters in the "S7-1500/S7-1500T synchronous operation functions" documentation.

5.2 Cam technology object

Term definition

The following section discusses the "Cam technology object" in general. This refers to the cam technology object of the type "TO_Cam" and of the types "TO_Cam_10k", "TO_Cam_600Seg" and "TO_Cam_6kSeg". If a specific cam technology object is meant, the type is explicitly mentioned.

Cam technology object

The cam technology object defines a transfer function y = f(x). The dependency of an output value on an input value is described in this transfer function in a unit-neutral manner. A cam technology object can be used multiple times.

You define the transfer function y = f(x) in the configuration of the technology object (Page 103) using interpolation points and/or segments. Depending on the cam type, the cam technology object can contain up to the following number of interpolation points and segments:

Icon	Cam type	Interpolation points	Segments
	TO_Cam	1 000	50
10k	TO_Cam_10k	10 000	50
600	TO_Cam_600Seg	50	600
6k	TO_Cam_6kSeg	50	6 000

Ranges between interpolation points and segments are interpolated using the Motion Control instruction "MC_InterpolateCam (Page 350)". During runtime of the user program, the settings can be changed or redefined via the technology data block as described in the section "Changing the synchronous operation function of the cam online (Page 137)".

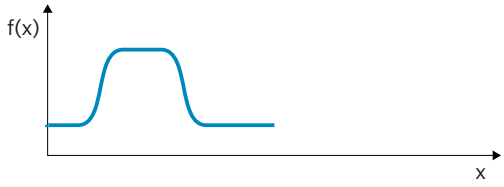

An interpolated cam can be applied as a synchronous operation function for camming (Page 102). You can find an overview of the supported instructions of the cam technology object in the section "Motion Control instructions for synchronous operation (Page 32)".

The figure below shows the basic operating principle of the cam technology object:

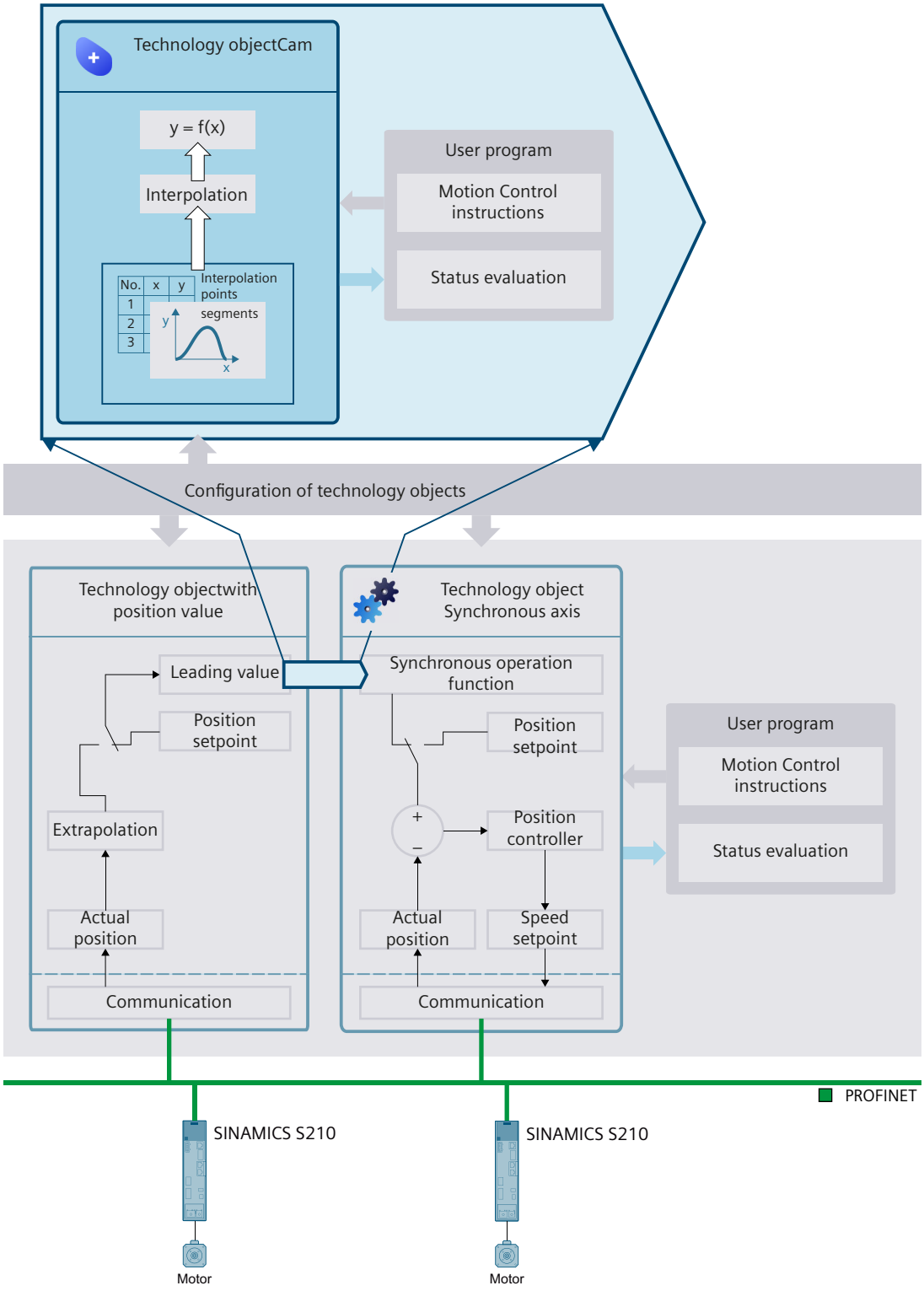

In addition, you can position a positioning axis or a synchronous axis with time-related position profile relatively or absolutely. Specify the time-based position profile via the cam technology object.

You can find more information on the topic "Time-based position profile" in the "Moving an axis relatively or absolutely with a time-based position profile" section in the "S7-1500/S7-1500T Axis functions" document.

Configuration

The following configurations are available in the cam technology object:

- Configuring the synchronous operation function of the cam (Page 103)

5.3 Leading axis proxy technology object

With cross-PLC synchronous operation, the leading axis proxy technology object represents the leading axis for local synchronous operation within a CPU. The leading axis proxy adjust the time of the leading value so that the following axes on the different CPUs are synchronous, and it provides the leading value for the local following axes.

You can find an overview of the supported instructions of the leading axis proxy technology object in the section "Motion Control instructions for synchronous operation (Page 32)".

The figure below shows the basic principle of operation of the leading axis proxy technology object:

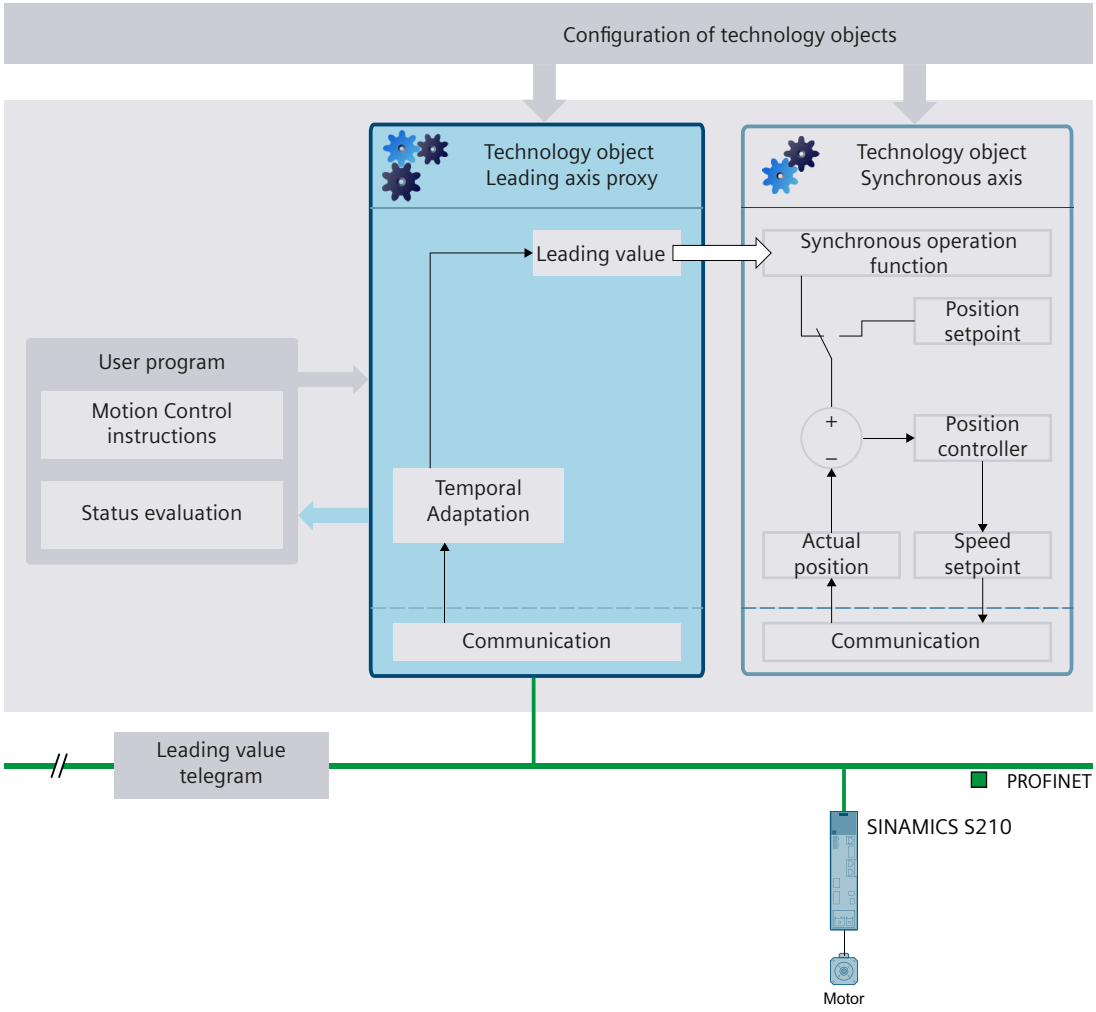

Configuration

The following configurations are available in the leading axis proxy technology object:

- Basic parameters
- Leading value settings
  - Configuring provision of the leading value (Page 238)
  - Configuring the tolerance time (Page 241)
  - Configuring the delay time (Page 245)

5.4 Motion Control instructions for synchronous operation

You execute the functions of the synchronous axis, cam and leading axis proxy technology objects using Motion Control instructions in your user program or using the TIA Portal (under "Technology object > Commissioning").

The following table shows the additional Motion Control instructions for synchronous operation that are supported by the technology objects in addition to the axis functions:

Motion Control instruction	Validity		Technology object		
	S7-1500	S7-1500T	Synchronous axis (Page 25)	Cam (Page 27)[1]	Leading axis proxy (Page 31)
"MC_Reset" Acknowledge alarms, restart technology objects	✓	✓	✓	✓	✓
"MC_GearIn" Start gearing	✓	✓	✓	-	✓
"MC_GearInPos" Start gearing with specified synchronous positions	-	✓	✓	-	✓
"MC_GearInVelocity" Start velocity synchronous operation	-	✓	✓	-	✓
"MC_PhasingRelative" Relative shift of leading value on the following axis	-	✓	✓	-	✓
"MC_PhasingAbsolute" Absolute shift of leading value on the following axis	-	✓	✓	-	✓
"MC_OffsetRelative" Relative shift of following value on the following axis.	-	✓	✓	-	-
"MC_OffsetAbsolute" Absolute shift of following value on the following axis.	-	✓	✓	-	-
"MC_CamIn" Start camming	-	✓	✓	✓	✓
"MC_SynchronizedMotionSimulation" Simulate synchronous operation	-	✓	✓	-	-

[1] Applies to the cam technology object of the type "TO_Cam", "TO_Cam_10k", "TO_Cam_600Seg" and "TO_Cam_6kSeg".

Motion Control instruction	Validity		Technology object		
	S7-1500	S7-1500T	Synchronous axis (Page 25)	Cam (Page 27)[1]	Leading axis proxy (Page 31)
"MC_LeadingValueAdditive" Specify additive leading value	-	✓	✓	-	-
"MC_GearOut" Desynchronize gearing	-	✓	✓	-	-
"MC_CamOut" Desynchronize camming	-	✓	✓	-	-
"MC_InterpolateCam" Interpolate cam	-	✓	-	✓	-
"MC_GetCamLeadingValue" Read out leading value of a cam	-	✓	-	✓	-
"MC_GetCamFollowingValue" Read out following value of a cam	-	✓	-	✓	-
"MC_GetCamFollowingValueCyclic" Cyclically read out following value of a cam	-	✓	-	✓	-
"MC_CopyCamData" Copy calculated cam elements	-	✓	-	✓	-
"MC_SetCamRangeScaling" Scaling a cam range	-	✓	-	✓	-

[1] Applies to the cam technology object of the type "TO_Cam", "TO_Cam_10k", "TO_Cam_600Seg" and "TO_Cam_6kSeg".

5.5 Mode of operation of the instructions in synchronous operation

The following graphic shows the general influence of the Motion Control instructions on the following axis in synchronous operation:

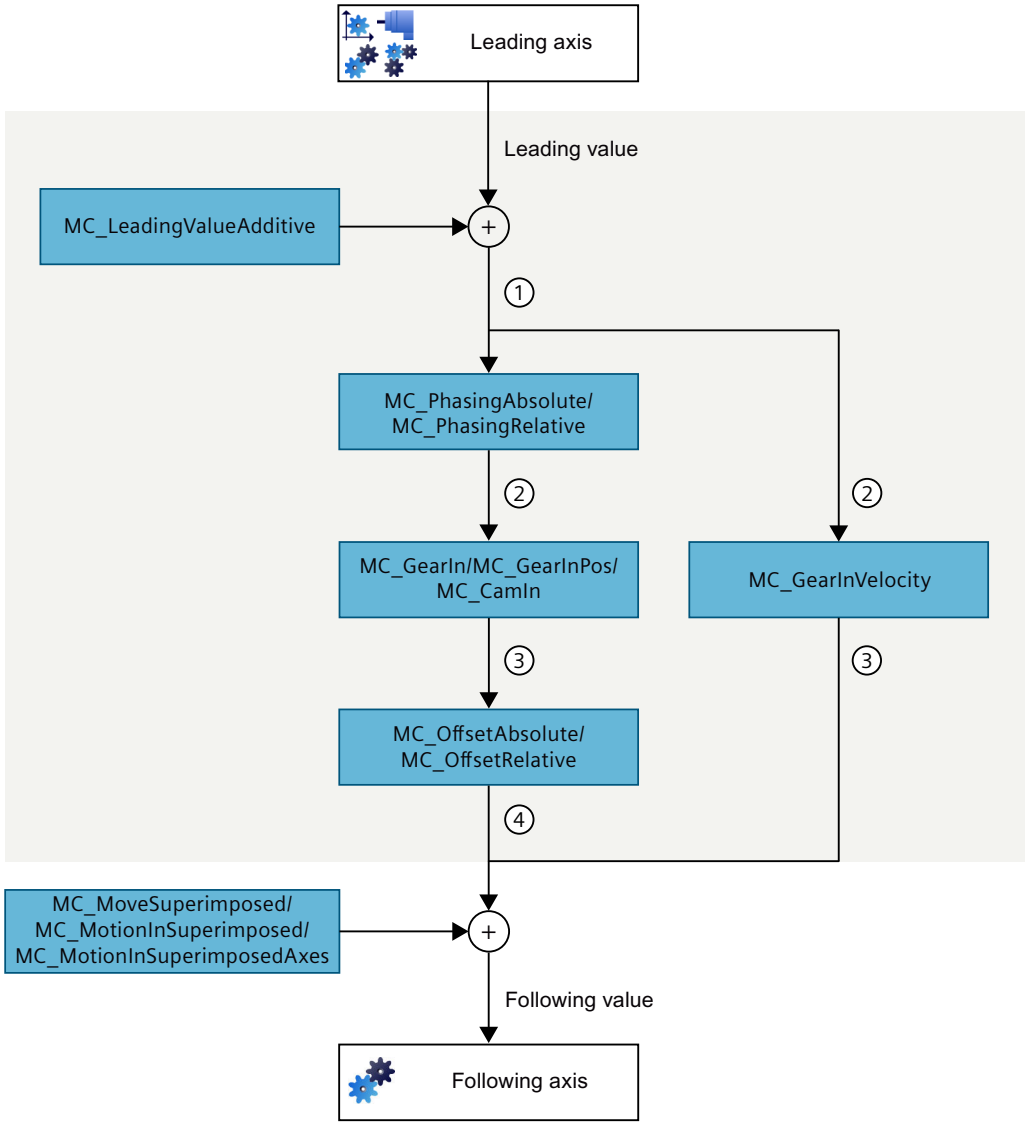

① Effective leading value
(<TO>.StatusSynchronizedMotion.EffectiveLeadingValue)

② Leading value of the synchronous operation function
(<TO>.StatusSynchronizedMotion.FunctionLeadingValue)

③ Following value of the synchronous operation function
(<TO>.StatusSynchronizedMotion.FunctionFollowingValue)

④ Following value after following value offset
(<TO>.StatusSynchronizedMotion.FunctionFollowingValue.Position + <TO>.StatusSynchronizedMotion.Offset)

Additive leading value

With an "MC_LeadingValueAdditive (Page 347)" job, you specify an additive leading value (Page 205) cyclically in addition to the active leading value of a following axis.

Leading value offset

With a "MC_PhasingAbsolute (Page 304)" or "MC_PhasingRelative (Page 297)" job you shift the effective leading value on a following axis in gearing (Page 72) or in camming (Page 183).

A simultaneous following value offset is not permitted. You can only start a new job for leading value offset once a previous job for following value offset has been completed.

Synchronous operation function

With an "MC_GearIn (Page 279)" or "MC_GearInPos (Page 283)" job, you start gearing (Page 49) between a leading axis and a following axis.

With an "MC_CamIn (Page 323)" job, you start a camming (Page 102) between a leading axis and a following axis.

With an "MC_GearInVelocity (Page 293)" job, you start velocity synchronous operation (Page 94) between a leading axis and a following axis.

Following value offset

With an "MC_OffsetAbsolute (Page 317)" or "MC_OffsetRelative (Page 311)" job, you move the following value on a following axis in gearing (Page 79) or in camming (Page 188).

A simultaneous leading value offset is not permitted. You can only start a new job for following value offset once a previous job for leading value offset has been completed.

Superimposed motion

With a "MC_MoveSuperimposed" job, you superimpose the following value with a relative positioning motion independent of the motion of the leading axis.

With a "MC_MotionInSuperimposed" job, you superimpose the subsequent value by specifying values for position, velocity and acceleration for each application cycle. The superimposed motion is independent of the motion of the leading axis.

With a "MC_MotionInSuperimposedAxes" job, you superimpose the following value with a movement of another axis. The superimposed motion is independent of the motion of the leading axis.

In velocity synchronous operation with "MC_GearInVelocity", a superimposed motion is only possible if the following axis is in position-controlled mode.

With a "MC_HaltSuperimposed" job, you stop a superimposed motion independently of the base motion.

Preparing synchronous operation 6

6.1 Creating technology objects

For synchronous operation, you need technology objects for the leading and following axes. You can also create multiple following axes for one leading axis. For a camming, you also need a cam technology object (S7-1500T).

Requirement

- You have created an S7-1500 CPU for gearing with "MC_GearIn (Page 279)".

  Note that an actual value coupling is only possible with an S7-1500T CPU.
- You have created an S7-1500T CPU for one of the following synchronous operation types:
  - Gearing with specified synchronous position with "MC_GearInPos (Page 283)"
  - Velocity synchronous operation with "MC_GearInVelocity (Page 293)"
  - Camming with "MC_CamIn (Page 323)"

Procedure

To create technology objects for synchronous operation, follow these steps:

1. As leading axis, create one of the technology objects:
   - Positioning axis
   - Synchronous axis
   - External encoder (S7-1500T)
2. As following axis, create a synchronous axis technology object.
3. Configure the configuration parameters of the leading and following axes that are not specific for synchronous operation. You can find a description of the configuration parameters in the "S7-1500/S7-1500T Axis functions" documentation.
4. For a camming, create a cam technology object (S7-1500T).

6.2 Defining leading value interconnection

6.2.1 Interconnecting the leading value

A leading value for a synchronous operation is provided by a leading axis or an external encoder (S7-1500T). The leading value is specified and coupled in the user program with the call of the corresponding Motion Control instruction for synchronous operation. The leading value is switched when you call the Motion Control instruction again, specifying a different leading axis.

The following rules apply to the master value coupling:

- A leading axis or an external encoder (S7-1500T) can output the leading value for multiple following axes.
- You can interconnect a following axis with multiple leading value-capable technology objects. The following technology objects are leading value-capable:
  - Positioning axis
  - Synchronous axis (Page 25)
  - External encoder (S7-1500T)

  The Leading axis proxy technology object is only relevant for a cross-PLC synchronous operation (Page 207) (S7-1500T).

  All interconnections required during operation must be set up during the configuration of the synchronous axis technology object.
- You can select only one leading value at a time to be coupled and evaluated during the runtime of your user program.
- The leading values and following values are coupled without conversion in the respective configured unit of measure. If, for example, a linear leading axis moves by 10 mm, a rotary following axis moves by 10° with a gear ratio of 1:1.

Procedure

To interconnect the required leading values of a following axis, follow these steps:

1. Open the "Technology object > Configuration > Leading value interconnections" configuration window of the synchronous axis.
2. In the "Possible leading values" table column, add all leading value-capable technology objects that you need during operation as leading values for the following axis.

   You can use the technology objects added to the table with the corresponding Motion Control instruction as leading values for the following axis. All configured leading value interconnections for the technology object are displayed in the cross-reference list of the technology object.
3. Select the coupling type of the leading value in the "Type of coupling" table column:
   - Setpoint coupling (Page 38)
   - Actual value coupling (Page 38) (S7-1500T)

   The "Delayed" selection is only relevant for a cross-PLC synchronous operation (Page 207) (S7-1500T).

6.2.2 Setpoint coupling

With a setpoint coupling, the setpoints of the leading axis are used as the leading value for the synchronous operation.

The setpoints of the following technology objects can be connected as leading value for the synchronous operation:

- Positioning axis
- Synchronous axis
- Leading axis proxy (S7-1500T)

6.2.3 Actual value coupling and actual value extrapolation

For applications in which setpoint coupling is not possible, e.g. when using an external encoder, or does not make sense from a technical perspective, the S7-1500T CPU also offers actual value coupling for synchronous operation. In actual value coupling, the extrapolated actual values of a technology object are used as the leading value.

The actual values of the following technology objects can be used as a leading value for the synchronous operation:

- Positioning axis
- Synchronous axis
- External encoder

Actual value extrapolation of the leading value

With an actual value coupling, delay times result from the processing of the actual values. To compensate for these delay times, the actual value is extrapolated on the leading value side. This means that the leading value is extrapolated based on previously known values.

Delay times at constant velocity or at constant acceleration or deceleration can be compensated for with the extrapolation. For technical reasons, changes of acceleration or deceleration (jerk) during extrapolation always cause a displacement of the following axis relative to the leading value.

The effective extrapolation time consists of a leading axis-dependent part, a configured following axis-dependent part and, optionally, the time from the cross-PLC synchronous operation:

- **Leading axis-dependent part**

  The leading axis-dependent part is calculated automatically and displayed at the leading axis in the "<TO>.Extrapolation.LeadingAxisDependentTime" tag of the technology object. You can disable the leading axis-dependent part using the tag "<TO>.Extrapolation.Settings.SystemDefinedExtrapolation" = 0.

- **Following axis-dependent part**

  The following axis-dependent part is calculated automatically and displayed at the following axis in the "<TO>.StatusPositioning.SetpointExecutionTime" tag of the technology object. You configure the value under "Technology object > Configuration > Extended parameters > Actual value extrapolation" (<TO>.Extrapolation.FollowingAxisDependentTime).

- **Time from the cross-PLC synchronous operation**

  For cross-PLC synchronous operation, the output delay of the leading value at the locally coupled following axes is automatically taken into account. The displayed value is equal to the leading value delay and corresponds to the delay time entered at the leading axis or at the external encoder. You configure the delay time under "Technology object > Configuration > Leading value settings" (<TO>.CrossPlcSynchronousOperation.LocalLeadingValueDelayTime).

The extrapolated actual value is evaluated with a configurable hysteresis before it is output as the leading value. The hysteresis evaluation prevents an inversion of the leading value, which may result from extrapolation of a noisy value.

If the effective extrapolation time is zero, extrapolation is omitted and the filtered actual value is evaluated directly with the hysteresis.

NOTICE
Machine damage If you change the extrapolation time during user program runtime in increments that are too large, damage to the machine may occur. Change the extrapolation time only by a small amount.

The following diagram shows the sequence of the actual value extrapolation.

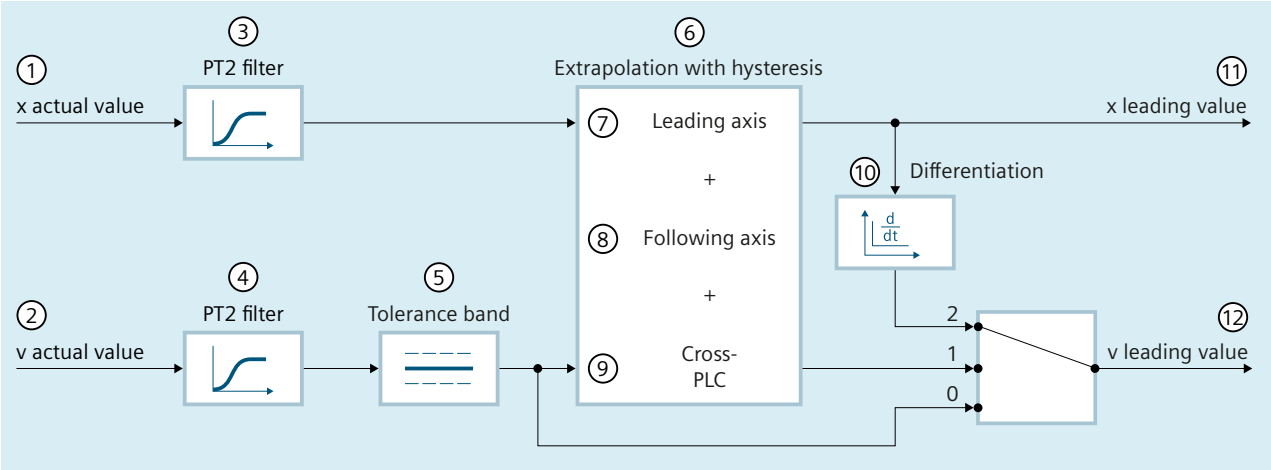

① Actual position value

② Actual velocity value

③ Position filter T1 (<TO>.Extrapolation.PositionFilter.T1) and T2 (<TO>.Extrapolation.PositionFilter.T2)

④ Velocity filters T1 (<TO>.Extrapolation.VelocityFilter.T1) and T2 (<TO>.Extrapolation.VelocityFilter.T2)

⑤ Tolerance band width for velocity (<TO>.Extrapolation.VelocityTolerance.Range)

⑥ Hysteresis value in the configured unit of length (<TO>.Extrapolation.Hysteresis.Value)

⑦ Extrapolation time component caused by the leading axis (<TO>.Extrapolation.LeadingAxisDependentTime)

⑧ Extrapolation time component caused by the following axis (<TO>.Extrapolation.FollowingAxisDependentTime)

⑨ Portion of the extrapolation time from the cross-PLC synchronous operation (<TO>.CrossPlcSynchronousOperation.LocalLeadingValueDelayTime)

⑩ Differentiation of the extrapolated leading value position

⑪ Extrapolated leading value position

⑫ Leading value velocity, depending on the switch position:
- Leading value velocity from the differentiation of the extrapolated leading value position ("<TO>.Extrapolation.Settings.ExtrapolatedVelocityMode" = 2)
- Leading value velocity from the extrapolation with hysteresis ("<TO>.Extrapolation.Settings.ExtrapolatedVelocityMode" = 1)
- Leading value velocity from the filtered actual velocity value ("<TO>.Extrapolation.Settings.ExtrapolatedVelocityMode" = 0)

Filtering the actual values

Noisy encoder signals lead to high velocity step changes, which also affect the extrapolation. These step changes can be reduced or compensated for by using suitable filter settings. The position filter is a PT2 filter. The velocity filter is a PT2 filter with configurable tolerance bandwidth.

The actual position value is blended by the actual position filter. The actual velocity value is blended by the velocity filter and further "stabilized" by the tolerance band. The filtered position value is then extrapolated taking into account the filtered velocity value.

The leading value velocity is calculated as follows, depending on the configured mode:

- The leading value velocity results from the differentiation of the extrapolated leading value position ("<TO>.Extrapolation.Settings.ExtrapolatedVelocityMode" = 2).
- The leading value velocity results from the extrapolation ("<TO>.Extrapolation.Settings.ExtrapolatedVelocityMode" = 1).
- The leading value velocity results from the filtered velocity value without extrapolation ("<TO>.Extrapolation.Settings.ExtrapolatedVelocityMode" = 0).

Recommended settings.

Set the total of the time constants T1 and T2 of the position filter significantly smaller than the time constants T1 and T2 of the velocity filter.

Tolerance band

The tolerance band acts on the filtered velocity value in the interpolation cycle. The position of the tolerance band is automatically shifted in the direction of the velocity value as soon as it changes in one direction by more than half of the tolerance band from the last output value.

A new output value is simultaneously formed with the shift of the tolerance band. This corresponds to the filtered velocity value minus half the tolerance band. As long as the velocity value remains within the tolerance band, no new output value is formed.

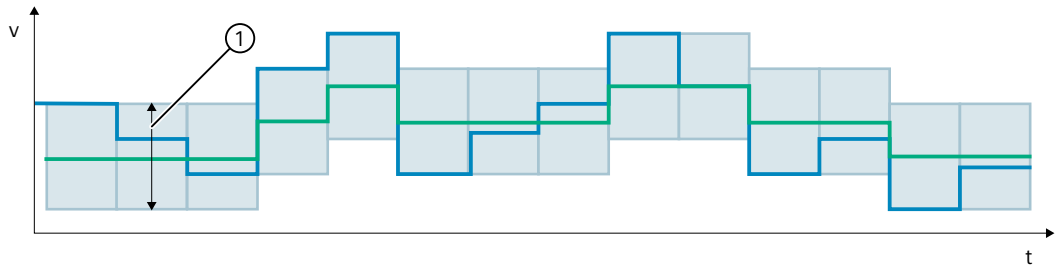

① Tolerance band

Filtered velocity before tolerance band

Filtered velocity according to tolerance band

Hysteresis

The hysteresis acts on the filtered extrapolated position value in the interpolation cycle. A change of direction only takes effect when the position value changes in the direction opposite at least by the hysteresis value. The hysteresis or reverse tolerance prevents undesired reversing of the leading value on a position reversal within the tolerance band.

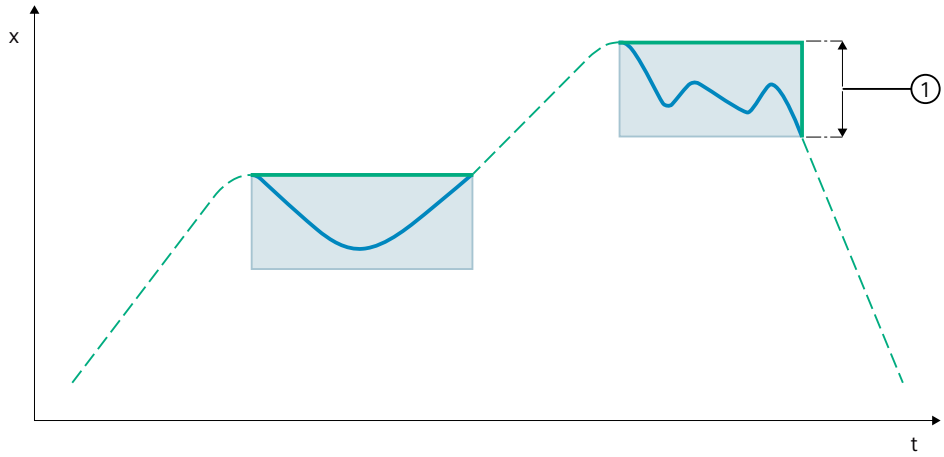

① Hysteresis or reverse tolerance

Extrapolated position before hysteresis or reverse tolerance

Extrapolated position after hysteresis or reverse tolerance

Configuring actual value extrapolation

To configure the actual value extrapolation of the leading value, follow these steps:

1. Open the "Technology object > Configuration > Extended parameters > Actual value extrapolation" configuration window of the leading axis.
2. In the "Position filter T1" and "Position filter T2" input fields, enter the time constants of the PT2 filter for smoothing the position. To activate the position filter, select the "Consider leading axis" check box.
3. In the "Hysteresis value" input field, enter a value for applying the hysteresis function to the extrapolated actual value of the position. The specification is made in the configured length unit.
4. In the "Velocity filter T1" and "Velocity filter T2" input fields, enter the time constants of the PT2 filter for smoothing the actual velocity.
5. In the "Tolerance band width" input field, enter the tolerance band width of the smoothed actual velocity. For optimized application of the tolerance band, enter the same bandwidth for the tolerance band as the width of the noise signal.
6. In the "Following axis" input field, specify the following axis proportion for the extrapolation of the leading value. The value (unchanged or offset against user-specific runtimes) from the "<TO>.StatusPositioning.SetpointExecutionTime" tag of the following axis is used as the basis.

   The leading axis-dependent extrapolation is displayed in the "Leading axis" field. The leading axis-dependent extrapolation time is calculated from the sum of the actual value

acquisition time at the leading axis, (T_i), the interpolator time (T_{Ipo}) and the sum of position filters T1 and T2:

Leading axis-dependent extrapolation time = $T_i + T_{Ipo} + T1 + T2$

The time from a cross-PLC synchronous operation is displayed in the "cross-PLC" field. The time from the cross-PLC synchronous operation corresponds to the set delay time in the configuration window "Technology object > Configuration > Leading value settings".

7. Define the speed value to be used in the "Leading value velocity" selection list:
   - To take over the leading value velocity from the filtered actual velocity value, select the "Filtered speed" entry ("<TO>.Extrapolation.Settings.ExtrapolatedVelocityMode" = 0).
   - To take over the leading value velocity from the extrapolation with hysteresis, select the "Extrapolated velocity" entry ("<TO>.Extrapolation.Settings.ExtrapolatedVelocityMode" = 1).
   - To take over the leading value velocity from the differentiation of the extrapolated leading value position, select the "Differentiated velocity" entry ("<TO>.Extrapolation.Settings.ExtrapolatedVelocityMode" = 2).
8. To take the leading axis-dependent extrapolation into account when calculating the effective extrapolation time, select the "Consider leading axis" check box. Otherwise, the leading axis-dependent extrapolation is not taken into account when calculating the effective extrapolation time and the filtered actual values are used.

   In the "Effective extrapolation time" field, the sum of the leading-axis time, the following axis- dependent time and the delay time of the cross-PLC synchronization is displayed.

A guideline to configuring the actual value extrapolation can be found in Siemens Industry Online Support in FAQ entry 109763337 (https://support.industry.siemens.com/cs/ww/en/view/109763337).

6.2.4 Tags: Actual value extrapolation

The following technology object tags are relevant for the actual value extrapolation:

Configuration		
Tag	**Description**	
<TO>.CrossPlcSynchronousOperation.LocalLeadingValueDelayTime	For cross-PLC synchronous operation: The delay time of leading value output to the local following axes	
<TO>.Extrapolation.LeadingAxisDependentTime	On the leading axis: Leading axis-dependent portion of the extrapolation time, which results from T_i, T_{Ipo}, and T_{Filter}.	
<TO>.Extrapolation.FollowingAxisDependentTime	On the leading axis: Following-axis dependent portion of the extrapolation time Enter the value from the "<TO>.StatusPositioning.SetpointExecutionTime" tag of the following axis (unchanged or compensated with user-specific times).	
<TO>.Extrapolation.Settings.SystemDefinedExtrapolation	Effectiveness of the leading axis-dependent portion of the extrapolation time (<TO>.Extrapolation.LeadingAxisDependentTime)	
	0	Not effective
	1	Effective
<TO>.Extrapolation.Settings.ExtrapolatedVelocityMode	0	"FilteredVelocity" Leading value velocity from filtered actual velocity

Configuration		
Tag	**Description**	
<TO>.Extrapolation.Settings.ExtrapolatedVelocityMode	1	"VelocityFromExtrapolation" Leading value velocity from extrapolation
	2	"VelocityByDifferentiation" Leading value velocity from differentiation of the extrapolated leading value position
<TO>.Extrapolation.PositionFilter.T1	Position filter time constant T1	
<TO>.Extrapolation.PositionFilter.T2	Position filter time constant T2	
<TO>.Extrapolation.VelocityFilter.T1	Velocity filter time constant T1	
<TO>.Extrapolation.VelocityFilter.T2	Velocity filter time constant T2	
<TO>.Extrapolation.VelocityTolerance.Range	Tolerance band width for velocity	
<TO>.Extrapolation.Hysteresis.Value	Hysteresis value (in the configured unit of length)	

Status displays	
Tag	**Description**
<TO>.StatusPositioning.SetpointExecutionTime	Setpoint execution time of the axis Results from T_{lpo}, T_{vtc} or 1/kv, T_{Send} and T_O of the axis.

6.3 Configuring the reverse tolerance of the leading value

The leading value must not reverse during the synchronization and desynchronization of the following axis. In order not to interrupt the synchronization or desynchronization when there are slight fluctuations in the leading value during an actual value coupling, for example, with an external encoder, you can define a reverse tolerance of the leading value.

The reverse tolerance is constantly based on the leading value of this following axis. Within the reverse tolerance, the leading value is unchanged from the perspective of the following axis. A reversal of the leading value within the reverse tolerance is not recognized by the following axis. If the leading value reverses before synchronization, the leading value for the following axis remains unchanged until the leading value leaves the tolerance range in the synchronization direction. Only then does the synchronization start.

Set the reverse tolerance as small as possible. Use the measured fluctuations in the actual value or the extrapolation error as a direct guide.

The reverse tolerance of the leading value is effective during synchronization and desynchronization with the following synchronization profiles:

- Synchronizing gearing with"MC_GearInPos (Page 283)"

SyncProfileReference	Synchronization profile
0	Synchronization in advance using dynamic parameters (Page 61)
1	Synchronization in advance using leading value distance (Page 63)

SyncProfileReference	Synchronization profile
3	Subsequent synchronization using leading value distance (Page 65)
4	Subsequent synchronization using leading value distance starting from current leading value position with calculated synchronous position of the following axis (Page 67)
5	Subsequent synchronization using leading value distance with calculated synchronous position of the following axis (Page 69)

- Desynchronizing gearing with"MC_GearOut (Page 338)"

SyncProfileReference	Synchronization profile
1	Desynchronization via leading value distance (Page 85)

- Synchronizing camming with "MC_CamIn (Page 323)"

SyncProfileReference	Synchronization profile
0	Synchronization in advance using dynamic parameters (Page 163)
1	Synchronization in advance using leading value distance (Page 164)
3	Subsequent synchronization using leading value distance (Page 171)
4	Subsequent synchronization using leading value distance starting from current leading value position (Page 173)
6	Synchronization in advance using leading value distance starting from current leading value position (Page 167)

- Desynchronizing camming with "MC_CamOut (Page 343)"

SyncProfileReference	Synchronization profile
1	Desynchronization via leading value distance (Page 194)

NOTE

Display of reverse-adjusted position value

The reverse-adjusted position value is not displayed in the technology object data block.

Leading value direction

Set the reverse tolerance for the positive, negative, or both directions of the leading value. The leading value direction defines the tolerated direction of the leading value to leave the tolerance range:

- Positive direction

  The reverse tolerance is effective if there is a positive leading value motion during synchronization or desynchronization.

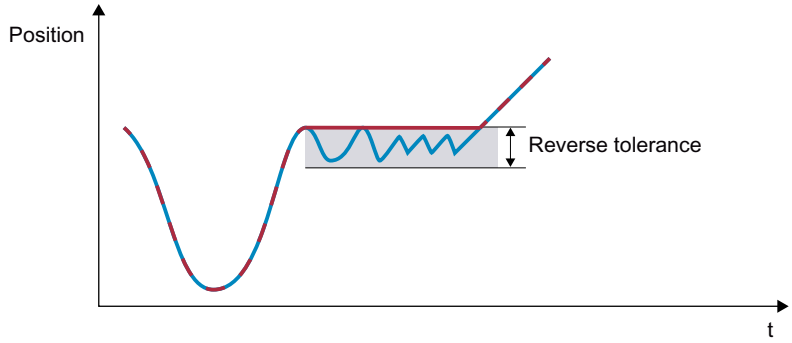

Position of the leading axis

Leading value for following axis

- Negative direction

  The reverse tolerance is effective in the event of a negative leading value motion during synchronization or desynchronization.

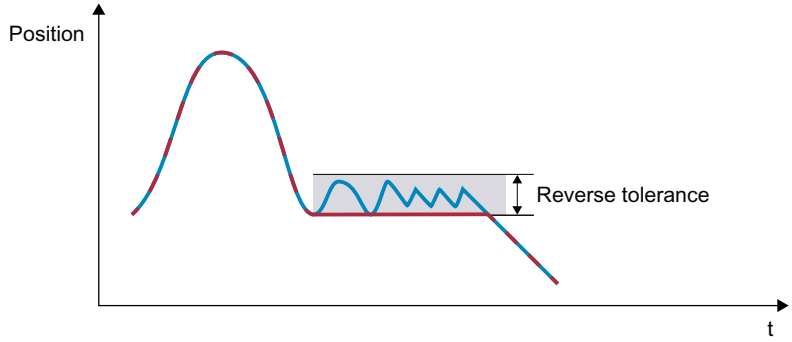

Position of the leading axis

Leading value for following axis

- Positive and negative direction

  The reverse tolerance is effective for both positive and negative leading value motion during synchronization or desynchronization.

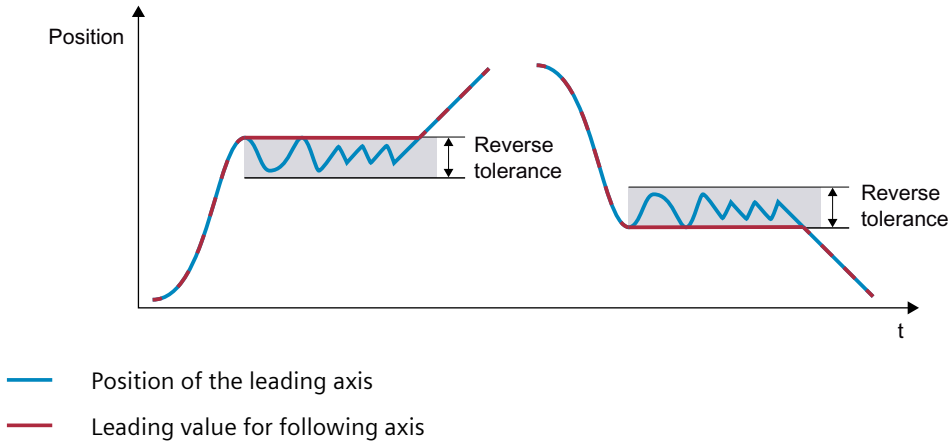

Procedure

To configure the reverse tolerance of the leading value, follow these steps:

1. Open the configuration window "Technology object > Configuration > Reverse tolerance of the leading value" of the synchronous axis technology object.
2. In the "Leading value direction" selection list, select the tolerated direction of the leading value to leave the tolerance range (<TO>.SynchronizedMotion.LeadingValueToleranceDirection).

   If synchronization and desynchronization is only allowed in one direction, configure the reverse tolerance only in that direction.
3. In the "Reverse tolerance" input box, enter the reverse tolerance of the leading value in the length unit of the axis (<TO>.SynchronizedMotion.LeadingValueReversalTolerance).

6.4 Position control in synchronous operation

Gearing or camming with setpoint coupling

A following axis is set into position-controlled operation with the start of a synchronous operation job. If the leading axis is in non-position-controlled operation at the start of the synchronous operation job, the technology alarm 603 is output and the technology object is disabled (alarm response: remove enable). Synchronization is started only after the position control has been activated and the start position of the synchronization has been reached.

NOTE

Switching the operating mode of the leading axis

If the leading axis is set to non-position-controlled operation during active synchronous operation, the setpoint of the leading axis is set to zero.

The coupling gives the setpoint of the following axis a setpoint step-change. The setpoint step-change is compensated according to the constant function. The only limiting factor is the maximum speed of the drive. A following error may occur on the following axis.

Gearing or camming with actual value coupling (S7-1500T)

A following axis is set into position-controlled operation with the start of a synchronous operation job. If the leading axis is in non-position-controlled operation at the start of the synchronous operation and the actual values are valid, the following axis is synchronized.

If the leading axis is set to the non-position-controlled mode during active synchronization, the synchronization remains active.

Velocity synchronous operation (S7-1500T)

A following axis can be operated in position-controlled or non-position-controlled mode during active synchronous operation (Page 97). You specify the operating mode of the following axis at the "MC_GearInVelocity" job.

The operating mode of the leading axis is irrelevant during an active synchronous operation.

Gearing

7

7.1 Gearing with "MC_GearIn"

With the Motion Control instruction "MC_GearIn (Page 279)", you start gearing between a leading axis and a following axis. During gearing, the position of the following axis results from the position of the leading axis multiplied by the gear ratio. You specify the gear ratio as a ratio of two integers. The result is a linear synchronous operation function.

You can start synchronous operation when the leading axis is at a standstill or when it is in motion. Synchronous travel begins after synchronization when the following axis has reached the velocity and acceleration of the leading axis, taking into account the gear ratio.

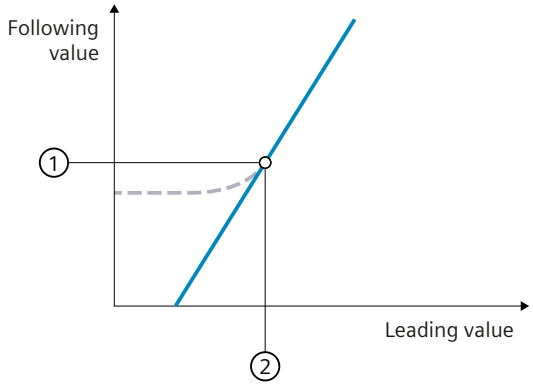

Slope of line; transmission ratio
Gear ratio = "MC_GearIn.RatioNumerator"/"MC_GearIn.RatioDenominator"

- - - Synchronization

① Synchronous position of following axis starting at which the leading and following axes move synchronously

② Synchronous position of leading axis starting at which the leading and following axes move synchronously

You have the following options for gearing with "MC_GearIn":

- Defining gear ratio (Page 50)
- Synchronizing following axis using dynamic parameters (Page 52)
- Synchronous travel in gearing (Page 53)
- Specify additive leading value with "MC_LeadingValueAdditive" (Page 205) (S7-1500T)
- Set gearing to simulation mode with "MC_SynchronizedMotionSimulation" (Page 203) (S7-1500T)
- Desynchronize following axis with "MC_GearOut" (Page 84) (S7-1500T)

Also note the dynamic limits of the following axis in gearing with "MC_GearIn" (Page 51).

7.1.1 Defining gear ratio

During gearing, the position of the following axis results from the position of the leading axis multiplied by the gear ratio. You specify the gear ratio at the Motion Control instruction "MC_GearIn (Page 279)" as the relationship between two integers (numerator/denominator). The result is a linear synchronous operation function.

Numerator of the gear ratio

With the "RatioNumerator" parameter, you define the numerator of the gear ratio. You can define the numerator of the gear ratio as positive or negative. This yields the following behavior:

- Positive gear ratio:

  The leading and following axes move in the same direction.
- Negative gear ratio:

  The following axis moves in the opposite direction of the leading axis.

The value "0" is not permitted for the numerator of the gear ratio.

Denominator of the gear ratio

With the "RatioDenominator" parameter, you define the denominator of the gear ratio. Only positive values are permitted for the denominator of the gear ratio.

Display of the gear ratio

The current gear ratio of an active "MC_GearIn" job is shown on the synchronous axis in the "<TO>.StatusSynchronizedMotion.ActualRatioNumerator" and "TO>.StatusSynchronizedMotion.ActualRatioDenominator" tags.

Example 1: Positive gear ratio

Leading axis and following axis are rotary axes and each has a traversing range from 0 ° to 360 ° with enabled "Modulo" setting.

Parameter inputs:

- "RatioNumerator" = 5
- "RatioDenominator" = 1

When the leading axis moves by 10 °, the following axis moves by 50 ° in the "Synchronous" status of the gearing.

Example 2: Negative gear ratio

Leading axis and following axis are rotary axes and each has a traversing range from 0 ° to 360 ° with enabled "Modulo" setting.

Parameter inputs:

- "RatioNumerator" = -3
- "RatioDenominator" = 1

When the leading axis moves by 10 °, the following axis moves by -30 ° in the "Synchronous" status of the gearing.

7.1.2 Dynamic limits of the following axis in gearing with "MC_GearIn"

If a synchronous axis is operated as a following axis in the gearing with the Motion Control instruction "MC_GearIn (Page 279)", the following dynamic limits apply, depending on the phase of the synchronous operation:

Synchronization

During the synchronizing phase, dynamic limits configured for the technology object apply to the following axis.

- <TO>.DynamicLimits.MaxVelocity
- <TO>.DynamicLimits.MaxAcceleration
- <TO>.DynamicLimits.MaxDeceleration
- <TO>.DynamicLimits.MaxJerk

The SW limit switches also continue to be monitored with the configured dynamic limits of the following axis.

If the programmed dynamics of the synchronization function are greater than the maximum dynamics of the following axis, the synchronization process is only completed when the resulting final velocity is lower than the maximum velocity of the following axis.

Synchronous travel

During synchronous travel, the dynamics of the following axis is limited only to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity). The dynamics of the following axis results from the synchronous operation function.

If the dynamic limits configured for the following axis are exceeded, this is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The SW limit switches continue to be monitored with the configured dynamic limits of the following axis.

If the following axis cannot follow the leading value, this results in a following error, which is monitored by the following error monitoring.

End or override synchronous operation

As soon as synchronous operation has been overridden, the dynamic limits configured for the technology object apply to the following axis again. With the start of the overriding job, the active dynamics are transitioned (smoothed) to the configured dynamic limits and the specifications for the Motion Control instruction.

Desynchronization (S7-1500T)

You can find more information on dynamic limits during desynchronization in the section "Dynamic limits of the following axis during desynchronization with "MC_GearOut" (Page 90).

7.1.3 Synchronizing following axis using dynamic parameters with "MC_GearIn"

During gearing (Page 49), synchronization establishes the relationship between the leading axis and following axis. Synchronization begins immediately after the "MC_GearIn" job starts.

Parameter inputs

You define the dynamic behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_GearIn (Page 279)":

- With the "Acceleration" parameter, you specify the acceleration of the following axis.
- With the "Deceleration" parameter, you specify the deceleration of the following axis.
- With the "Jerk" parameter, you specify the jerk of the following axis.

Observe the dynamic limits (Page 51) of the following axis during synchronization.

During synchronization

Synchronization begins after the "MC_GearIn" job starts. Active motion jobs are overridden.

The synchronization duration and distance are dependent on the following parameters:

- Dynamics of the following axis at the start time of the "MC_GearIn" job
- Dynamic settings for synchronization
- Dynamics of the leading axis

The synchronization is indicated in the "<TO>.StatusWord.X21 (Synchronizing)" tag of the following axis. The leading value must not reverse during synchronization.

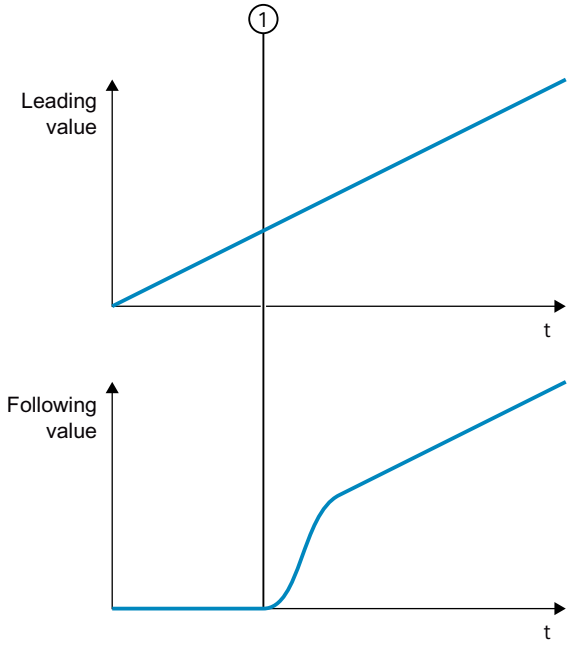

① Time when synchronization starts

If the programmed dynamic response of the synchronous operation function is greater than the maximum dynamic response of the following axis, the corresponding technology alarms 502 or 503 are output at the following axis. The speed of the following axis is also limited; however, no Technology Alarm 501 is generated. The synchronization process is only completed when the resulting final velocity is lower than the maximum velocity of the following axis (<TO>.DynamicLimits.MaxVelocity).

After synchronization

If the following axis has reached the velocity and the acceleration of the leading axis, taking into account the gear ratio, the following axis is synchronized. The following axis travels synchronously with the leading axis.

7.1.4 Synchronous travel in gearing with "MC_GearIn"

As soon as the following axis is synchronized to a leading value, the following axis follows the dynamics of the leading axis according to the gear ratio. The transmission behavior during gearing is expressed by a linear relationship between the leading value and the following value.

The following value is calculated as follows:

Position of following axis (following value) = Synchronous position of following axis + gear ratio × (Position of leading axis - Synchronous position of leading axis)

The "Synchronous" status is indicated in the Motion Control instruction "MC_GearIn (Page 279)" with the parameter "InGear" = TRUE and in the "<TO>.StatusWord.X22 (Synchronous)" tag of the technology object.

NOTE

Avoid homing the leading axis in synchronous operation

Avoid homing the leading axis during an active synchronous operation. Homing the leading axis during synchronous operation corresponds to a setpoint step-change on the following axis. The following axis compensates for the jump according to the synchronous operation function and limited only to the maximum speed of the drive.

7.2 Gearing with "MC_GearInPos"

With the Motion Control instruction "MC_GearInPos (Page 283)", you start gearing between a leading axis and a following axis. During gearing, the position of the following axis results from the position of the leading axis multiplied by the gear ratio depending on the synchronous positions. You specify the gear ratio as a ratio of two integers. The result is a linear synchronous operation function.

In contrast to the gearing with "MC_GearIn" (Page 49), for gearing with "MC_GearInPos" you also specify the synchronous positions of the leading and following axes, which define the reference of the axes to one another.

You can start synchronous operation when the leading axis is at a standstill or when it is in motion. Synchronous travel begins after synchronization when the following axis has reached the velocity and acceleration of the leading axis, taking into account the gear ratio.

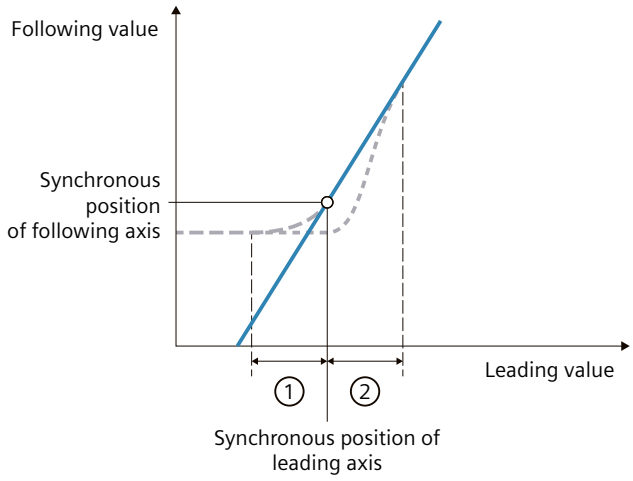

Slope of line; transmission ratio
Gear ratio = "MC_GearInPos.RatioNumerator"/"MC_GearInPos.RatioDenominator"

Synchronization in advance

Subsequent synchronization

① Leading value distance with synchronization in advance

② Leading value distance with subsequent synchronization

You have the following options for gearing with "MC_GearInPos":

- Defining gear ratio (Page 55)
- Defining direction of synchronization (Page 59)
- Defining synchronous positions and type of synchronization:
  - Synchronizing following axis in advance using dynamic parameters (Page 61)
  - Synchronizing following axis in advance using leading value distance (Page 63)
  - Subsequent synchronizing of following axis using leading value distance (Page 65)
  - Subsequent synchronization of following axis using leading axis distance starting at current leading value position with calculated synchronous position of the following axis (Page 67)
  - Subsequent synchronization of following axis using leading value distance with calculated synchronous position of the following axis (Page 69)
- Synchronous travel in gearing (Page 72)
- Specify additive leading value with "MC_LeadingValueAdditive" (Page 205)
- Offset leading value absolute or relative with "MC_PhasingAbsolute" or "MC_PhasingRelative" (Page 72)
- Absolute or relative following value offset with "MC_OffsetAbsolute" or "MC_OffsetRelative" (Page 79)
- Set gearing to simulation mode with "MC_SynchronizedMotionSimulation" (Page 203)
- Desynchronize following axis with "MC_GearOut" (Page 84)
- Cancel a pending gearing with "MC_GearOut" (Page 91)

Also note the dynamic limits of the following axis in gearing with "MC_GearInPos" (Page 56).

7.2.1 Defining gear ratio

During gearing, the position of the following axis results from the position of the leading axis multiplied by the gear ratio depending on the synchronous positions. You specify the gear ratio at the Motion Control instruction "MC_GearInPos (Page 283)" as the relationship between two integers (numerator/denominator). The result is a linear synchronous operation function.

Numerator of the gear ratio

With the "RatioNumerator" parameter, you define the numerator of the gear ratio. You can define the numerator of the gear ratio as positive or negative. This yields the following behavior:

- Positive gear ratio:

  The leading and following axes move in the same direction.
- Negative gear ratio:

  The following axis moves in the opposite direction of the leading axis.

The value "0" is not permitted for the numerator of the gear ratio.

Denominator of the gear ratio

With the "RatioDenominator" parameter, you define the denominator of the gear ratio. Only positive values are permitted for the denominator of the gear ratio.

Display of the gear ratio

The current gear ratio of an active "MC_GearInPos" job is shown on the synchronous axis in the "<TO>.StatusSynchronizedMotion.ActualRatioNumerator" and "TO>.StatusSynchronizedMotion.ActualRatioDenominator" tags.

Example 1: Positive gear ratio

Leading axis and following axis are rotary axes and each has a traversing range from 0 ° to 360 ° with enabled "Modulo" setting.

Parameter inputs:

- "RatioNumerator" = 5
- "RatioDenominator" = 1

When the leading axis moves by 10 °, the following axis moves by 50 ° in the "Synchronous" status of the gearing.

Example 2: Negative gear ratio

Leading axis and following axis are rotary axes and each has a traversing range from 0 ° to 360 ° with enabled "Modulo" setting.

Parameter inputs:

- "RatioNumerator" = -3
- "RatioDenominator" = 1

When the leading axis moves by 10 °, the following axis moves by -30 ° in the "Synchronous" status of the gearing.

7.2.2 Dynamic limits of the following axis in gearing with "MC_GearInPos"

If a synchronous axis is operated as a following axis in the gearing with the Motion Control instruction "MC_GearInPos (Page 283)", the following dynamic limits apply, depending on the phase of the synchronous operation:

Pending synchronous operation

If synchronous operation is not active, the configured dynamic limits of the following axis apply. If there is already a synchronous operation active, the descriptions in the following sections apply.

Synchronization using dynamic parameters

During synchronization using dynamic parameters, the dynamic limits configured at the technology object apply to the following axis:

- <TO>.DynamicLimits.MaxVelocity
- <TO>.DynamicLimits.MaxAcceleration
- <TO>.DynamicLimits.MaxDeceleration
- <TO>.DynamicLimits.MaxJerk

The SW limit switches also continue to be monitored with the configured dynamic limits of the following axis.

Synchronization via leading value distance and synchronous operation

When synchronizing via the leading value distance and during synchronous travel, the dynamics of the following axis are only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity). The dynamics of the following axis results from the synchronous operation function.

If the dynamic limits configured for the following axis are exceeded, this is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The SW limit switches continue to be monitored with the configured dynamic limits of the following axis.

If the following axis cannot follow the leading value, this results in a following error, which is monitored by the following error monitoring.

End or override synchronous operation

As soon as synchronous operation has been overridden, the dynamic limits configured for the technology object apply to the following axis again. With the start of the overriding job, the active dynamics are transitioned (smoothed) to the configured dynamic limits and the specifications for the Motion Control instruction.

Desynchronization

You can find more information on dynamic limits during desynchronization in the section "Dynamic limits of the following axis during desynchronization with "MC_GearOut" (Page 90).

7.2.3 Synchronizing gearing

7.2.3.1 Parameter overview for synchronizing with "MC_GearInPos"

During gearing (Page 54), synchronization establishes the relationship between the leading axis and following axis. With the parameter "SyncProfileReference" you define the type of synchronization:

SyncProfileReference	Synchronization profile
0	Synchronization in advance using dynamic parameters (Page 61)
1	Synchronization in advance using leading value distance (Page 63)
3	Subsequent synchronization using leading value distance (Page 65)
4	Subsequent synchronization using leading value distance starting from current leading value position with calculated synchronous position of the following axis (Page 67)
5	Subsequent synchronization using leading value distance with calculated synchronous position of the following axis (Page 69)

Depending on the synchronization profile, different parameters of the Motion Control instruction "MC_GearInPos (Page 283)" are relevant:

Parameters	SyncProfileReference				
	0	1	3	4	5
RatioNumerator	✓	✓	✓	✓	✓
RatioDenominator	✓	✓	✓	✓	✓
MasterSyncPosition	✓	✓	✓	-	✓
SlaveSyncPosition	✓	✓	✓	-	-
MasterStartDistance	-	✓	✓	✓	✓
Velocity	✓	-	-	-	-
Acceleration	✓	-	-	-	-
Deceleration	✓	-	-	-	-
Jerk	✓	-	-	-	-
SyncDirection	✓	✓	✓	✓	✓

7.2.3.2 Defining direction of synchronization with "MC_GearInPos"

During gearing (Page 54), synchronization establishes the relationship between the leading axis and following axis. If you have activated the "Modulo" setting for the following axis, you can define the direction of the synchronization with the "SyncDirection" parameter of the Motion Control instruction "MC_GearInPos (Page 283)".

In the examples below, the transformation ratio is 1:1.

Positive direction

With "SyncDirection" = 1, the following axis may only travel in positive direction during synchronization. In this example, the synchronous position is 360.0.

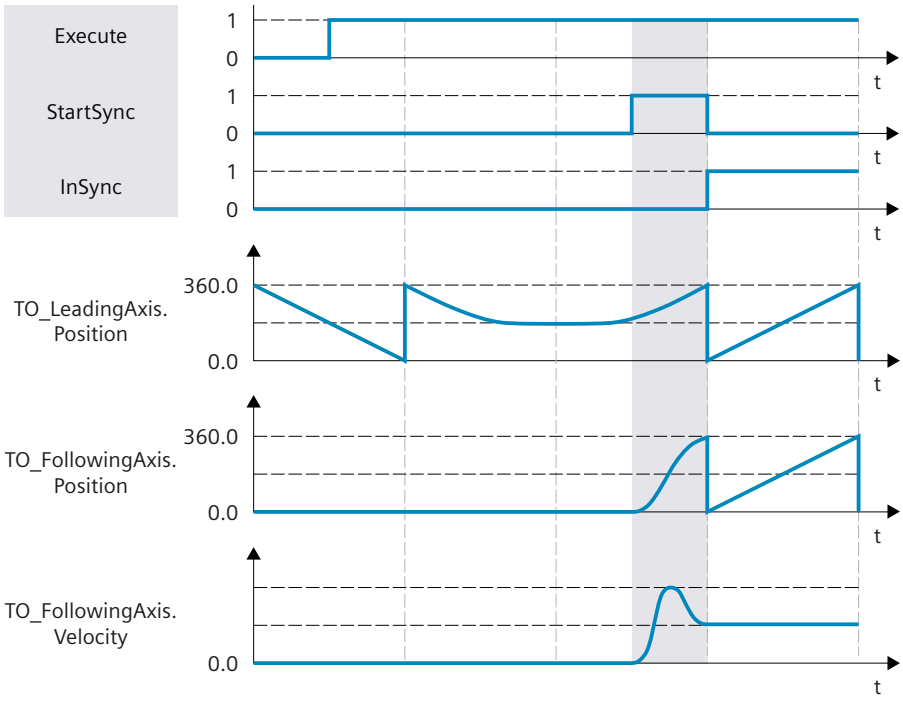

Negative direction

With "SyncDirection" = 2, the following axis may only travel in negative direction during synchronization. In this example, the synchronous position is 0.0.

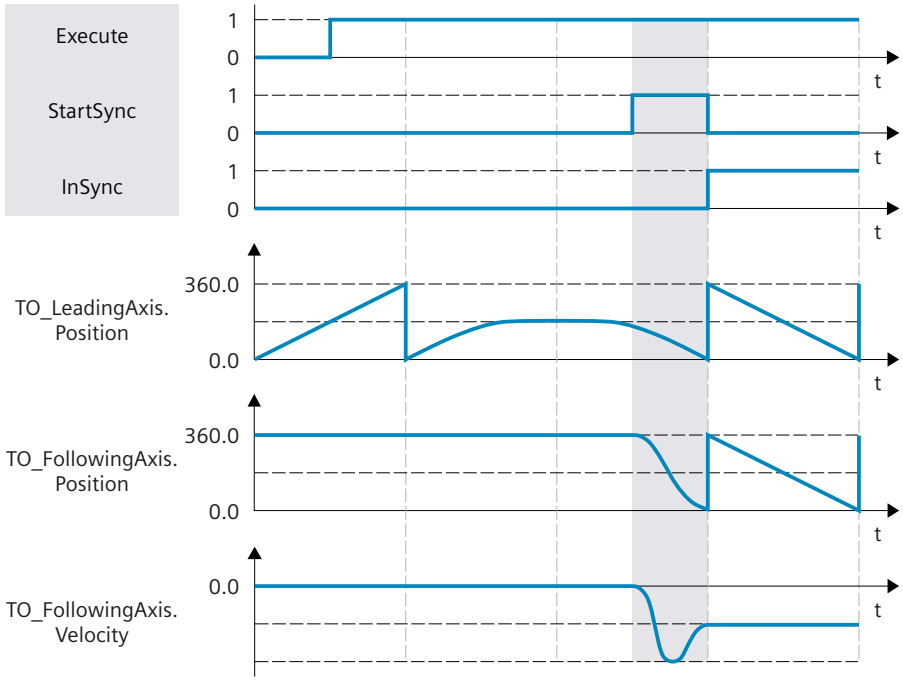

Shortest distance

With "SyncDirection" = 3, changes in direction of the following axis are permitted during synchronization. In this example, the synchronous position is 0.0.

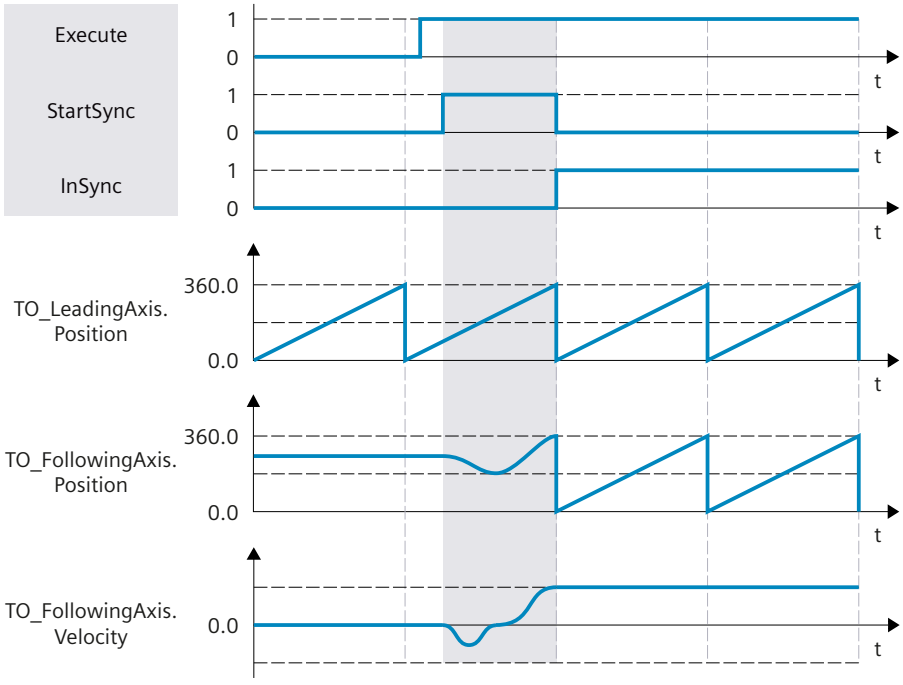

7.2.3.3 Synchronizing following axis in advance using dynamic parameters with "MC_GearInPos"

During gearing (Page 54), synchronization establishes the relationship between the leading axis and following axis. During synchronization in advance using dynamic parameters, synchronization begins in such a way that the leading and following axis are synchronous when the synchronous positions are reached.

Parameter inputs

You define the behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_GearInPos (Page 283)":

- With the parameter "SyncProfileReference" = 0, you define the type of synchronization as synchronization in advance using dynamic parameters.
- With the parameters "MasterSyncPosition" and "SlaveSyncPosition", you define the synchronous positions of the leading and following axis which determine the relationship of the axes to each other. For synchronization in advance, the synchronous position is the position starting from which the leading axis and following axis travel synchronously.
- With the parameters "Velocity", "Acceleration", "Deceleration" and "Jerk" you define the dynamics for the synchronization of the following axis.

Until synchronization

After the start of the "MC_GearInPos" job, a motion profile for the following axis is calculated continuously. The motion profile is calculated based on the following parameters:

- Specified synchronous positions of the leading and following axis at the Motion Control instruction
- Specified dynamics of the Motion Control instruction
- Current position and dynamics of the leading and following axes
- Synchronous operation function

The calculation determines the synchronization length and thus the start position of the leading axis for the synchronization.

The start position of the leading axis is derived in the following way:

Start position = Synchronous position of leading axis - Synchronization length

The status "Waiting" is displayed at the following axis until the leading value has reached the start position (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 2).

If the leading and following axes are already at their synchronous positions when the "MC_GearInPos" job is started, synchronous operation immediately has "Synchronous" status. In terms of application, you can only achieve this with a setpoint coupling by positioning the leading and following axes absolutely in the synchronous positions.

During synchronization

The following axis begins to synchronize as soon as the leading value has reached the start position. The synchronization is indicated in the Motion Control instruction "MC_GearInPos" with the parameter "StartSync" = TRUE and in the "<TO>.StatusWord.X21 (Synchronizing)" tag of the following axis.

The leading value must not reverse during synchronization. To avoid interrupting synchronization in the event of slight fluctuations in the leading value during an actual value connection, e.g. with an external encoder, you can define a reverse tolerance of the guide value (Page 44).

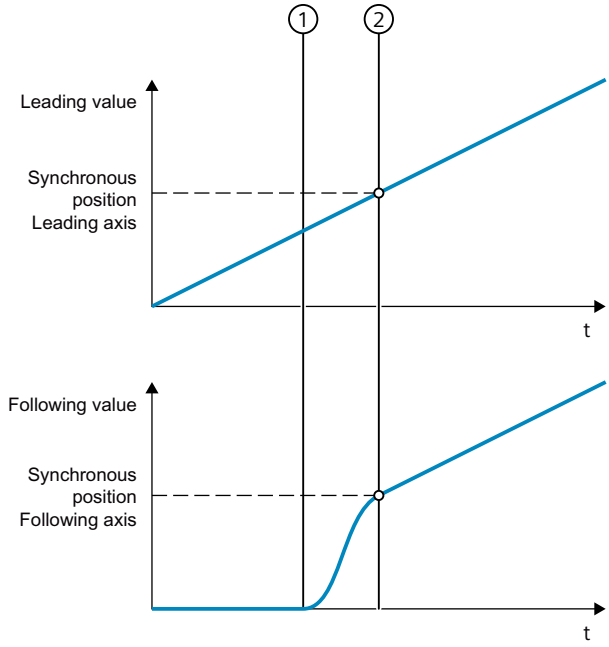

① Time when synchronization starts

② Time when synchronization is complete

The dynamics of the following axis during synchronization is obtained from the calculated motion profile and the current dynamics of the leading axis. Changes in the dynamics of the leading axis during synchronization are superimposed with the calculated motion profile in accordance with the synchronous operation function. This can have the result that the configured dynamic limits at the following axis are violated. This is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The dynamic response of the following axis is limited to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

If the programmed dynamic response of the synchronous operation function is greater than the maximum dynamic response of the following axis when the "Execute" parameter is set, the corresponding technology alarms 501, 502, or 503 are output at the following axis.

After synchronization

The following axis is synchronized as soon as the leading axis has reached the synchronous position. The following axis travels synchronously with the leading axis (Page 72).

7.2.3.4 Synchronizing following axis in advance using leading value distance with "MC_GearInPos"

During gearing (Page 54), synchronization establishes the relationship between the leading axis and following axis. During synchronization in advance using the leading value distance, synchronization begins in such a way that the leading and following axis are synchronous when the synchronous positions are reached.

Parameter inputs

You define the behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_GearInPos (Page 283)":

- With the parameter "SyncProfileReference" = 1, you define the type of synchronization as synchronization in advance using the leading value distance.
- With the parameters "MasterSyncPosition" and "SlaveSyncPosition", you define the synchronous positions of the leading and following axis which determine the relationship of the axes to each other. For synchronization in advance, the synchronous position is the position starting from which the leading axis and following axis travel synchronously.
- With the "MasterStartDistance" parameter, you specify the leading value distance (synchronization length).

Until synchronization

After the start of the "MC_GearInPos" job, a motion profile is calculated for the following axis depending on the specified leading value distance. The calculation determines the required dynamic response and thus the start position of the leading axis for the synchronization.

The start position of the leading axis is derived in the following way:

Start position = Synchronous position of leading axis - Synchronization length

The leading axis must be at least the leading value distance away from the synchronous position. The status "Waiting" is displayed at the following axis until the leading value has reached the start position (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 2).

NOTE

Dynamic jumps

If the following axis is in motion and the leading value is at standstill when the "MC_GearInPos" job is started, dynamic jumps can occur at the following axis as soon as the leading axis is set in motion and the following axis starts synchronizing.

If the leading and following axes are already at their synchronous positions when the "MC_GearInPos" job is started, synchronous operation immediately has "Synchronous" status. In terms of application, you can only achieve this with a setpoint coupling by positioning the leading and following axes absolutely in the synchronous positions.

During synchronization

The following axis begins to synchronize as soon as the leading value has reached the start position. The synchronization is indicated in the Motion Control instruction "MC_GearInPos" with the parameter "StartSync" = TRUE and in the "<TO>.StatusWord.X21 (Synchronizing)" tag of the following axis.

The leading value must not reverse during synchronization. To avoid interrupting synchronization in the event of slight fluctuations in the leading value during an actual value coupling, e.g. with an external encoder, you can define a reverse tolerance of the leading value (Page 44).

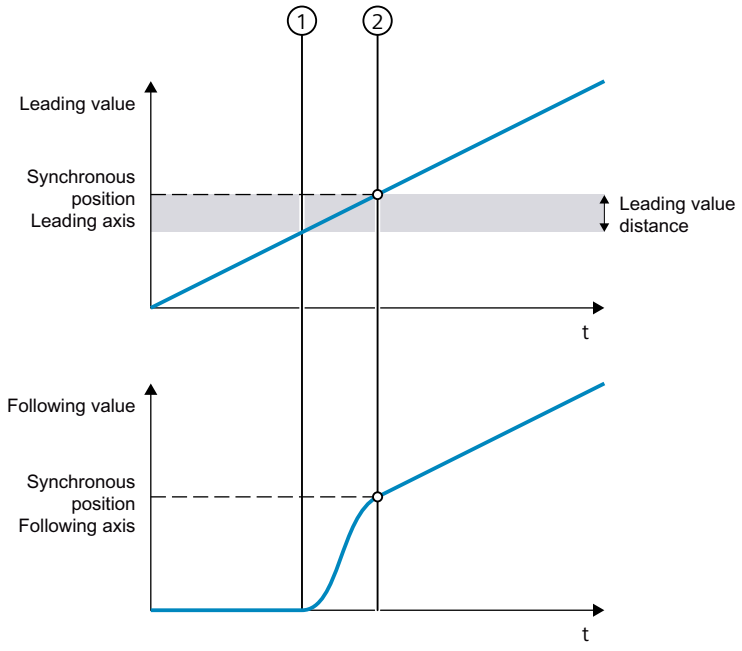

① Time when synchronization starts

② Time when synchronization is complete

The dynamics of the following axis during synchronization is obtained from the calculated motion profile and the current dynamics of the leading axis. Changes in the dynamics of the leading axis during synchronization are superimposed with the calculated motion profile in accordance with the synchronous operation function. This can have the result that the configured dynamic limits at the following axis are violated. This is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The dynamic response of the following axis is only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

After synchronization

The following axis is synchronized as soon as the leading axis has reached the synchronous position. The following axis travels synchronously with the leading axis (Page 72).

7.2.3.5 Subsequent synchronizing of following axis using leading value distance with "MC_GearInPos"

During gearing (Page 54), synchronization establishes the relationship between the leading axis and following axis. With subsequent synchronization using the leading value distance, synchronization begins as soon as the leading value has reached the synchronous position of the leading axis.

Parameter inputs

You define the behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_GearInPos (Page 283)":

- With the parameter "SyncProfileReference" = 3, you define the type of synchronization as subsequent synchronization using the leading value distance.
- With the parameters "MasterSyncPosition" and "SlaveSyncPosition", you define the synchronous positions of the leading and following axis which determine the relationship of the axes to each other. For subsequent synchronization, the synchronous position of the leading axis is the start position for synchronization. The synchronous position of the following axis is a theoretical position which is assigned to the synchronous position of the leading axis.
- With the "MasterStartDistance" parameter, you specify the leading value distance (synchronization length).

Until synchronization

After starting the "MC_GearInPos" job, a motion profile for the slave axis is calculated depending on the start position and the synchronous position of the following axis as well as on the specified leading value distance. The calculation determines the required dynamic response and the position of the leading axis as of which the leading axis and the following axis travel synchronously.

The status "Waiting" is displayed at the following axis until the leading value has reached the synchronous position of the leading axis
(<TO>.StatusSynchronizedMotion.WaitingFunctionState = 2).

NOTE

Dynamic jumps

If the following axis is in motion and the leading value is at standstill when the "MC_GearInPos" job is started, dynamic jumps can occur at the following axis as soon as the leading axis is set in motion and the following axis starts synchronizing.

If the leading and following axes are already at their synchronous positions when the "MC_GearInPos" job is started, synchronous operation immediately has "Synchronous" status. In terms of application, you can only achieve this with a setpoint coupling by positioning the leading and following axes absolutely in the synchronous positions.

During synchronization

The following axis begins to synchronize as soon as the leading value has reached the synchronous position. The synchronization is indicated in the Motion Control instruction "MC_GearInPos" with the parameter "StartSync" = TRUE and in the "<TO>.StatusWord.X21 (Synchronizing)" tag of the following axis.

The leading value must not reverse during synchronization. To avoid interrupting synchronization in the event of slight fluctuations in the leading value during an actual value coupling, e.g. with an external encoder, you can define a reverse tolerance of the leading value (Page 44).

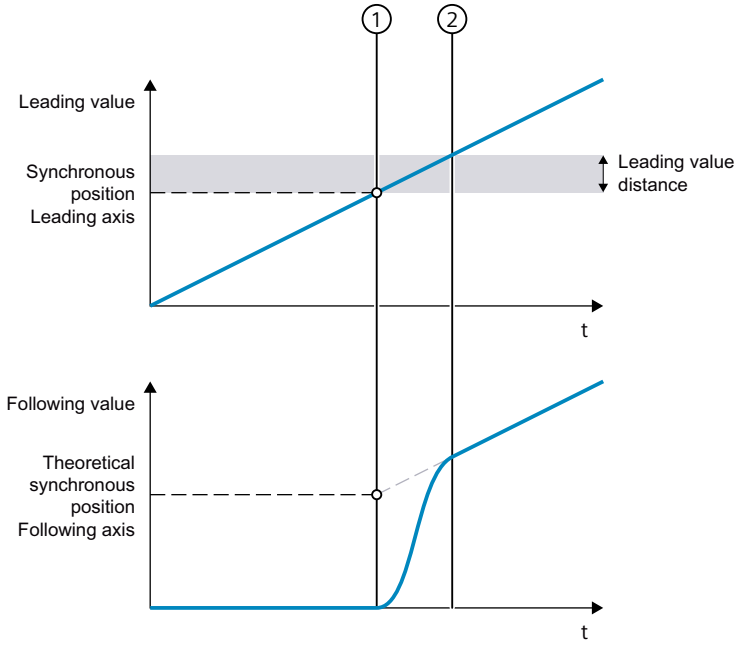

① Time when synchronization starts

② Time when synchronization is complete

The dynamics of the following axis during synchronization is obtained from the calculated motion profile and the current dynamics of the leading axis. Changes in the dynamics of the leading axis during synchronization are superimposed with the calculated motion profile in accordance with the synchronous operation function. This can have the result that the configured dynamic limits at the following axis are violated. This is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The dynamic response of the following axis is only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

After synchronization

The position of the leading axis from which the leading axis and following axis travel synchronously is derived in the following way:

Position axes synchronous = Synchronous position of leading axis + Synchronization length

As soon as the leading axis has reached this position, the following axis is synchronized. The following axis travels synchronously with the leading axis (Page 72).

7.2.3.6 Subsequent synchronization of following axis using leading axis distance starting at current leading value position with calculated synchronous position of the following axis with "MC_GearInPos"

During gearing (Page 54), synchronization establishes the relationship between the leading axis and following axis. With subsequent synchronization using the leading value distance from the current leading value position with calculated synchronous position of the following axis, synchronization begins as soon as the "MC_GearInPos" job takes effect. The leading and following axis are synchronous as soon as the leading value has passed the leading value distance. The "MC_GearInPos" Motion Control instruction calculates the synchronous position of the following axis.

Parameter inputs

You define the behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_GearInPos (Page 283)":

- With the parameter "SyncProfileReference" = 4, you define the type of synchronization as subsequent synchronization using the leading value distance from the current leading value position with calculated synchronous position of the following axis.
- With the "MasterStartDistance" parameter, you specify the leading value distance (synchronization length).

Starting the "MC_GearInPos" job

After the start of the "MC_GearInPos" job, a motion profile is calculated for the following axis depending on the specified leading value distance. The calculation determines the required dynamic response of the following axis so that the leading axis and the following axis travel synchronously at the end of the leading value distance.

NOTE

Dynamic jumps

If the following axis is in motion and the leading value is at standstill when the "MC_GearInPos" job is started, dynamic jumps can occur at the following axis.

The "Gearing with specified synchronous position" status is shown immediately at the following axis (<TO>.StatusSynchronizedMotion.FunctionState = 2).

If the leading and following axes are at standstill when the "MC_GearInPos" job is started, synchronous operation immediately has "Synchronous" status.

During synchronization

The following axis begins to synchronize as soon as the "MC_GearInPos" job takes effect and the leading axis is moving. The synchronization is indicated in the Motion Control instruction "MC_GearInPos" with the parameter "StartSync" = TRUE and in the "<TO>.StatusWord.X21 (Synchronizing)" tag of the following axis.

The leading value must not reverse during synchronization. To avoid interrupting synchronization in the event of slight fluctuations in the leading value during an actual value coupling, e.g. with an external encoder, you can define a reverse tolerance of the leading value (Page 44).

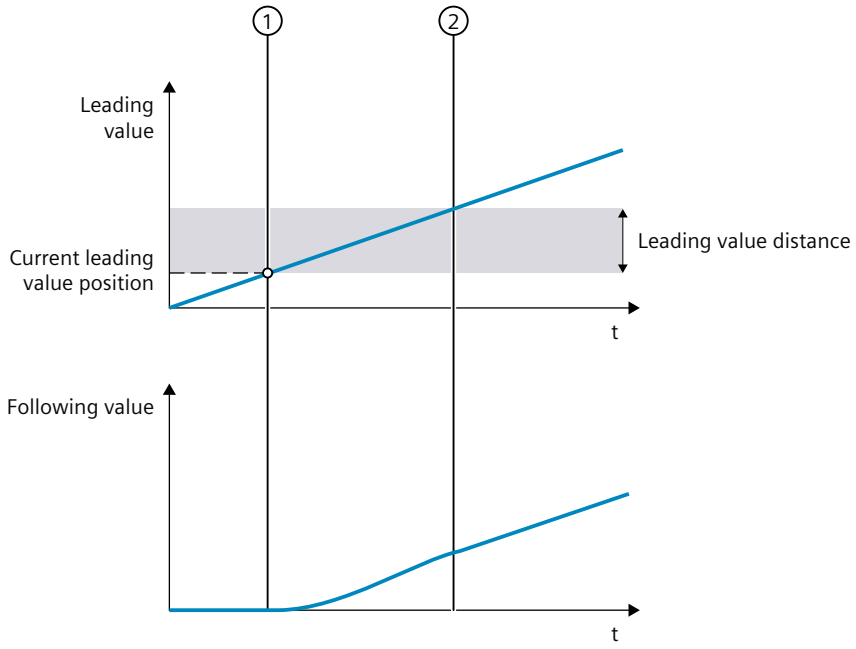

① Time when synchronization starts

② Time when synchronization is complete

If the "Modulo" setting is enabled for leading axis and following axis, the leading value distance can be several Modulo cycles long.

The dynamics of the following axis during synchronization is obtained from the calculated motion profile and the current dynamics of the leading axis. If the leading axis moves with constant velocity, the acceleration of the following axis remains constant until the "Synchronous" status. This leads to a velocity profile without jerk limitation of the following axis (trapezoidal velocity profile). If the following axis is already in motion when synchronization starts, the following axis performs a motion transition. This can lead to a non-trapezoidal speed profile.

Changes in the dynamics of the leading axis during synchronization are superimposed with the calculated motion profile in accordance with the synchronous operation function. This can have the result that the configured dynamic limits at the following axis are violated. This is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The dynamic response of the following axis is only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

After synchronization

The position of the leading axis from which the leading axis and following axis travel synchronously is derived in the following way:

Position axes synchronous = Current leading value position at job start + synchronization length

The calculated synchronous position of the following axis results from the synchronization length and the dynamic response of the leading axis.

The following axis is synchronized when the following axis has reached the velocity of the leading axis, taking into account the gear ratio. The following axis travels synchronously with the leading axis (Page 72).

7.2.3.7 Subsequent synchronization of following axis using leading value distance with calculated synchronous position of the following axis with "MC_GearInPos"

During gearing (Page 54), synchronization establishes the relationship between the leading axis and following axis. With subsequent synchronization using the leading value distance with calculated synchronous position of the following axis, synchronization begins as soon as the leading value has reached the synchronous position of the leading axis. The leading and following axis are synchronous as soon as the leading value has passed the leading value distance. The "MC_GearInPos" Motion Control instruction calculates the synchronous position of the following axis.

Parameter inputs

You define the behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_GearInPos (Page 283)":

- With the parameter "SyncProfileReference" = 5, you define the type of synchronization as subsequent synchronization using the leading value distance with calculated synchronous position of the following axis.
- With the "MasterSyncPosition" parameter, you define the synchronous position of the leading axis. For subsequent synchronization, the synchronous position of the leading axis is the start position for synchronization.
- With the "MasterStartDistance" parameter, you specify the leading value distance (synchronization length).

Until synchronization

After the start of the "MC_GearInPos" job, a motion profile for the following axis is calculated depending on the start position and the specified leading value distance. The calculation determines the required dynamic response of the following axis so that the leading axis and the following axis travel synchronously at the end of the leading value distance.

NOTE

Dynamic jumps

If the following axis is in motion and the leading value is at standstill when the "MC_GearInPos" job is started, dynamic jumps can occur at the following axis.

The status "Waiting" is displayed at the following axis until the leading value has reached the synchronous position of the leading axis (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 2).

When the leading value has reached the synchronous position of the leading axis, the "Gearing with specified synchronous position" status is shown immediately at the following axis (<TO>.StatusSynchronizedMotion.FunctionState = 2).

If the leading axis is already at its synchronous position when the "MC_GearInPos" job is started and the following axis is at standstill, synchronous operation immediately has "Synchronous" status. In terms of application, you can only achieve this with a setpoint coupling by the absolute positioning of the leading axis at the synchronous position.

During synchronization

The following axis begins to synchronize as soon as the leading value has reached the synchronous position. The synchronization is indicated in the Motion Control instruction "MC_GearInPos" with the parameter "StartSync" = TRUE and in the "<TO>.StatusWord.X21 (Synchronizing)" tag of the following axis.

The leading value must not reverse during synchronization. To avoid interrupting synchronization in the event of slight fluctuations in the leading value during an actual value coupling, e.g. with an external encoder, you can define a reverse tolerance of the leading value (Page 44).

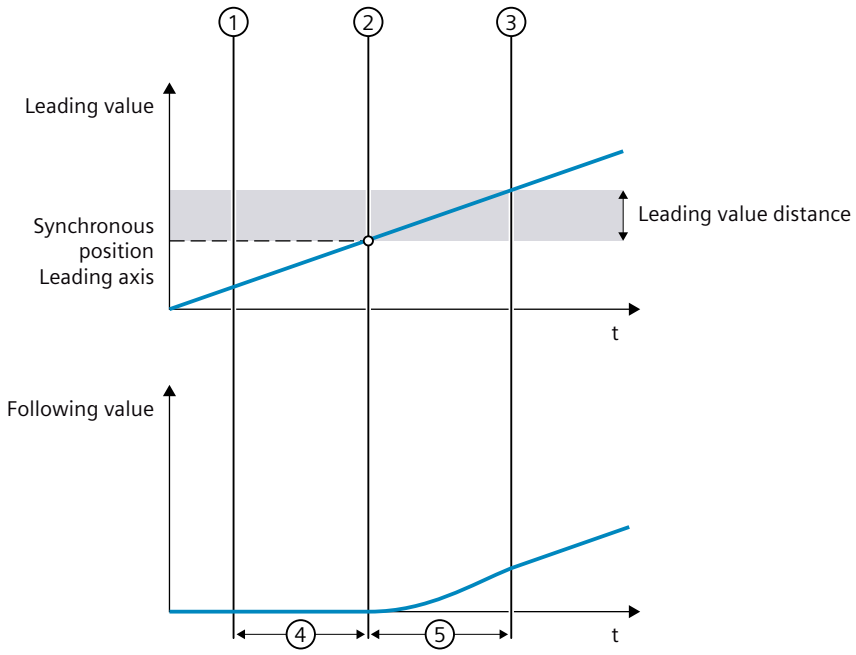

① Time at which the "MC_GearInPos" job is started

② Time when synchronization starts

③ Time when synchronization is complete

④ Duration from start of the "MC_GearInPos" job until the start of synchronization

⑤ Duration from the start of synchronization until the end of synchronization

If the "Modulo" setting is enabled for leading axis and following axis, the leading value distance can be several Modulo cycles long. The leading distance value has about three Modulo cycles in the following example:

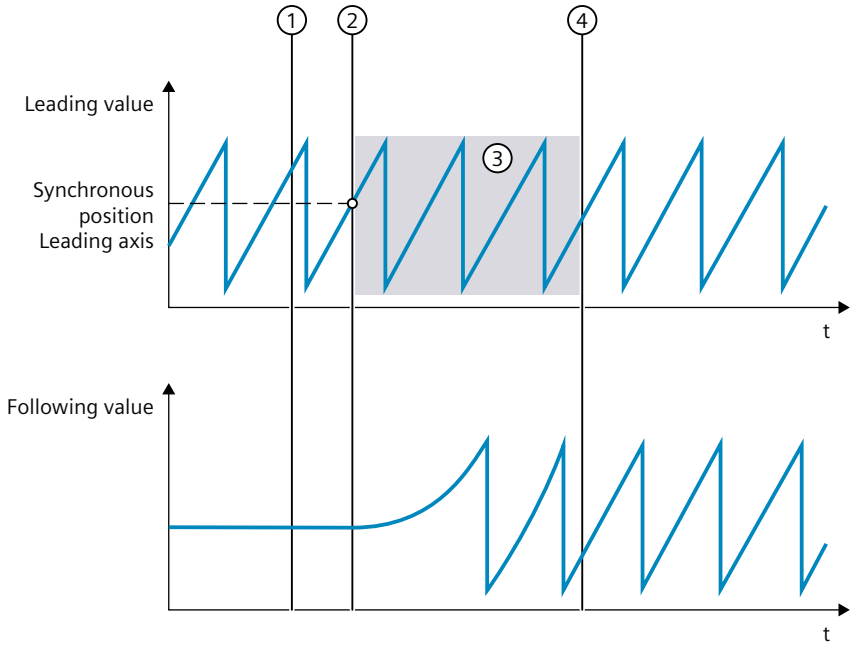

① Time at which the "MC_GearInPos" job is started

② Time when synchronization starts

③ Leading value distance

④ Time when synchronization is complete

The dynamics of the following axis during synchronization is obtained from the calculated motion profile and the current dynamics of the leading axis. If the leading axis moves with constant velocity, the acceleration of the following axis remains constant until the "Synchronous" status. This leads to a velocity profile without jerk limitation of the following axis (trapezoidal velocity profile). If the following axis is already in motion when synchronization starts, the following axis performs a motion transition. This can lead to a non-trapezoidal speed profile.

Changes in the dynamics of the leading axis during synchronization are superimposed with the calculated motion profile in accordance with the synchronous operation function. This can have the result that the configured dynamic limits at the following axis are violated. This is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The dynamic response of the following axis is only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

After synchronization

The position of the leading axis from which the leading axis and following axis travel synchronously is derived in the following way:

Position axes synchronous = Synchronous position of leading axis + Synchronization length

The calculated synchronous position of the following axis results from the synchronization length and the dynamic response of the leading axis.

The following axis is synchronized when the following axis has reached the velocity of the leading axis, taking into account the gear ratio. The following axis travels synchronously with the leading axis (Page 72).

7.2.4 Synchronous travel in gearing with "MC_GearInPos"

As soon as the following axis is synchronized to a leading value, the following axis follows the position of the leading axis according to the synchronous positions and the gear ratio. The transmission behavior during gearing is expressed by a linear relationship between the leading value and the following value.

The following value is calculated as follows:

Position of following axis (following value) = Synchronous position of following axis + gear ratio × (Position of leading axis - Synchronous position of leading axis)

The "Synchronous" status is indicated in the Motion Control instruction "MC_GearInPos (Page 283)" with the parameter "InSync" = TRUE and in the "<TO>.StatusWord.X22 (Synchronous)" tag of the technology object.

NOTE

Avoid homing the leading axis in synchronous operation

Avoid homing the leading axis during an active synchronous operation. Homing the leading axis during synchronous operation corresponds to a setpoint step-change on the following axis. The following axis compensates for the jump according to the synchronous operation function and limited only to the maximum speed of the drive.

7.2.5 Leading value offset during gearing

7.2.5.1 Leading value offset on the following axis during gearing using dynamic parameters

With a leading value offset, you offset the effective leading value on the following axis during gearing with "MC_GearIn (Page 279)" or "MC_GearInPos (Page 283)". You can move the effective leading value absolutely or relatively. The leading value of the leading value source and the position of the leading axis are not influenced by the leading value offset.

The leading value offset always refers to the effective leading value. The effective leading value is made up of the leading value of the leading value source and the additive leading value. If you do not use an additive leading value via "MC_LeadingValueAdditive (Page 347)", the effective leading value corresponds to the leading value of the leading value source. You can find an overview in the "Mode of operation of the instructions in synchronous operation (Page 34)" section. In the following, "leading value" refers to the effective leading value.

Parameter inputs

You define the behavior of the following axis during leading value offset with the following parameters of the Motion Control instruction "MC_PhasingAbsolute (Page 304)" or "MC_PhasingRelative (Page 297)":

- With the parameter "ProfileReference" = 0, you specify the type of leading value offset as offset using dynamic parameters.
- With the "PhaseShift" parameter, you specify the leading value offset on the following axis.
- With the "Velocity" parameter, you specify the additive velocity of the following axis during the leading value offset.
- With the "Acceleration" parameter, you specify the additive acceleration of the following axis during the leading value offset.
- With the "Deceleration" parameter, you specify the additive deceleration of the following axis during the leading value offset.
- With the "Jerk" parameter, you specify the additive jerk of the following axis during the leading value offset.

During the leading value offset

The leading value offset via dynamic parameters is effective immediately, regardless of the leading value position. The leading value is offset on the following axis. The dynamic values are added to the values of the synchronous operation motion. The required travel distance of the following axis to offset the leading value is calculated by the system.

During leading value offset, the speed of the following axis is limited only to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity). The configured velocity limit may be exceeded (<TO>.DynamicLimits.MaxVelocity).

Acceleration, deceleration, and jerk of the following axis are limited to the dynamic limits configured on the technology object:

- <TO>.DynamicLimits.MaxAcceleration
- <TO>.DynamicLimits.MaxDeceleration
- <TO>.DynamicLimits.MaxJerk

The leading value offset is indicated in the Motion Control instruction with the parameter "StartPhasing" = TRUE and in the "<TO>.StatusWort.X24 (PhasingCommand)" tag of the technology object. The "AbsolutePhaseShift" or "CoveredPhaseShift" parameter shows the absolute leading value portion already shifted.

After the leading value offset

As soon as the following axis has offset the leading value, the leading value offset is active on the following axis. The status is indicated in the Motion Control instruction with the parameter "Done" = TRUE and in the "<TO>.StatusSynchronizedMotion.PhaseShift" tag of the technology object.

The leading value offset only has an effect in the "Synchronous" status of the gearing. When the gearing is overridden, the leading value offset is reset to zero.

7.2.5.2 Leading value offset on the following axis during gearing using leading value distance as of current leading value position

With a leading value offset, you offset the effective leading value on the following axis during gearing with "MC_GearIn (Page 279)" or "MC_GearInPos (Page 283)". You can move the effective leading value absolutely or relatively. The leading value of the leading value source and the position of the leading axis are not influenced by the leading value offset.

The leading value offset always refers to the effective leading value. The effective leading value is made up of the leading value of the leading value source and the additive leading value. If you do not use an additive leading value via "MC_LeadingValueAdditive (Page 347)", the effective leading value corresponds to the leading value of the leading value source. You can find an overview in the "Mode of operation of the instructions in synchronous operation (Page 34)" section. In the following, "leading value" refers to the effective leading value.

Parameter inputs

You define the behavior of the following axis during leading value offset with the following parameters of the Motion Control instruction "MC_PhasingAbsolute (Page 304)" or "MC_PhasingRelative (Page 297)":

- With the parameter "ProfileReference" = 1, you specify the type of leading value offset as offset using leading value distance as of the current leading value position.
- With the "PhaseShift" parameter, you specify the leading value offset on the following axis.
- With the "PhasingDistance" parameter, you specify the leading value distance (traversing distance of the leading axis) during the leading value offset.
- With the "Direction" parameter, you specify the direction of the leading value distance in relation to the direction of motion of the leading value (Page 77).

During the leading value offset

After starting the jobs, the following axis begins with the leading value offset starting from the current position. Within the traversing distance of the leading axis, the following axis offsets the leading value at continuous velocity and acceleration. The required dynamics of the following axis to offset the leading value is calculated by the system. During leading value offset, the dynamics of the following axis is limited only to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

The leading value offset is indicated in the Motion Control instruction with the parameter "StartPhasing" = TRUE and in the "<TO>.StatusWort.X24 (PhasingCommand)" tag of the technology object. The "AbsolutePhaseShift" or "CoveredPhaseShift" parameter shows the absolute leading value portion already shifted.

The leading value must not reverse during the leading value offset on the following axis. When the leading value reverses, the "MC_PhasingAbsolute" job or "MC_PhasingRelative" job is canceled with "ErrorID" = 16#808C.

After the leading value offset

As soon as the following axis has offset the leading value, the leading value offset is active on the following axis. The status is indicated in the Motion Control instruction with the parameter "Done" = TRUE and in the "<TO>.StatusSynchronizedMotion.PhaseShift" tag of the technology object.

The leading value offset only has an effect in the "Synchronous" status of the gearing. When the gearing is overridden, the leading value offset is reset to zero.

7.2.5.3 Leading value offset on the following axis during gearing using leading value distance as of specific leading value position

With a leading value offset, you offset the effective leading value on the following axis during gearing with "MC_GearIn (Page 279)" or "MC_GearInPos (Page 283)". You can move the effective leading value absolutely or relatively. The leading value of the leading value source and the position of the leading axis are not influenced by the leading value offset.

The leading value offset always refers to the effective leading value. The effective leading value is made up of the leading value of the leading value source and the additive leading value. If you do not use an additive leading value via "MC_LeadingValueAdditive (Page 347)", the effective leading value corresponds to the leading value of the leading value source. You can find an overview in the "Mode of operation of the instructions in synchronous operation (Page 34)" section. In the following, "leading value" refers to the effective leading value.

Parameter inputs

You define the behavior of the following axis during leading value offset with the following parameters of the Motion Control instruction "MC_PhasingAbsolute (Page 304)" or "MC_PhasingRelative (Page 297)":

- With the parameter "ProfileReference" = 2, you specify the type of leading value offset as offset using leading value distance as of a specific leading value position.
- With the "PhaseShift" parameter, you specify the leading value offset on the following axis.
- With the "PhasingDistance" parameter, you specify the leading value distance (traversing distance of the leading axis) during the leading value offset.
- With the "StartPosition" parameter, you specify the leading value position from which the leading value offset starts.
- With the "Direction" parameter, you specify the direction of the leading value distance in relation to the direction of motion of the leading value (Page 77).

Until the leading value offset

After starting the job, the status "Waiting" is displayed at the following axis when the leading value is at standstill and until the leading value has reached the leading value position (<TO>.StatusWord2.X3 = TRUE (PhasingCommandWaiting)).

During the leading value offset

As soon as the leading value has reached the leading value position, the following axis begins to offset the leading value. Within the traversing distance of the leading axis, the following axis offsets the leading value at continuous velocity and acceleration. The required dynamics of the following axis to offset the leading value is calculated by the system. During leading value offset, the dynamics of the following axis is limited only to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

The leading value offset is indicated in the Motion Control instruction with the parameter "StartPhasing" = TRUE and in the "<TO>.StatusWort.X24 (PhasingCommand)" tag of the technology object. The "AbsolutePhaseShift" or "CoveredPhaseShift" parameter shows the absolute leading value portion already shifted.

The leading value must not reverse during the leading value offset on the following axis. When the leading value reverses, the "MC_PhasingAbsolute" job or "MC_PhasingRelative" job is canceled with "ErrorID" = 16#808C. The waiting job is not canceled.

After the leading value offset

As soon as the following axis has offset the leading value, the leading value offset is active on the following axis. The status is indicated in the Motion Control instruction with the parameter "Done" = TRUE and in the "<TO>.StatusSynchronizedMotion.PhaseShift" tag of the technology object.

The leading value offset only has an effect in the "Synchronous" status of the gearing. When the gearing is overridden, the leading value offset is reset to zero.

7.2.5.4 Defining the direction of the leading value distance of a leading value offset on the following axis during gearing

With a leading value offset, you offset the effective leading value on the following axis during gearing with "MC_GearIn (Page 279)" or "MC_GearInPos (Page 283)". With the "Direction" parameter of the Motion Control instruction "MC_PhasingAbsolute (Page 304)" or "MC_PhasingRelative (Page 297)", you specify the direction of the leading value distance in relation to the direction of motion of the effective leading value.

Defining leading value distance in the positive direction of motion of the effective leading value

With "Direction" = 1, the following axis only offsets the leading value when the leading axis travels in the positive direction.

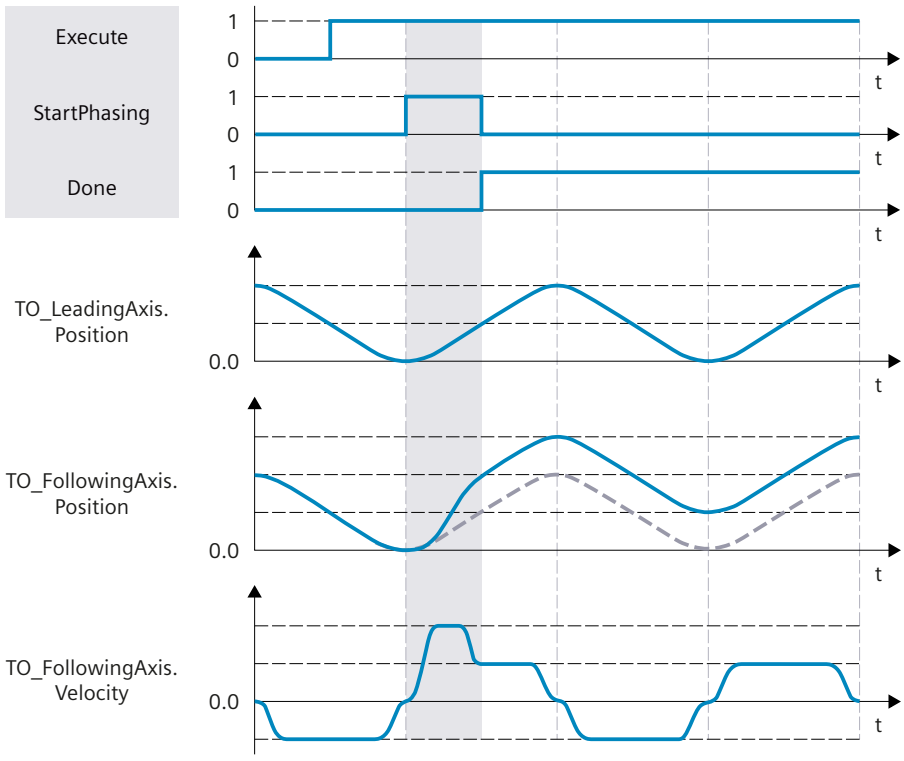

Defining leading value distance in the negative direction of motion of the effective leading value

With "Direction" = 2, the following axis only offsets the leading value when the leading axis travels in the negative direction.

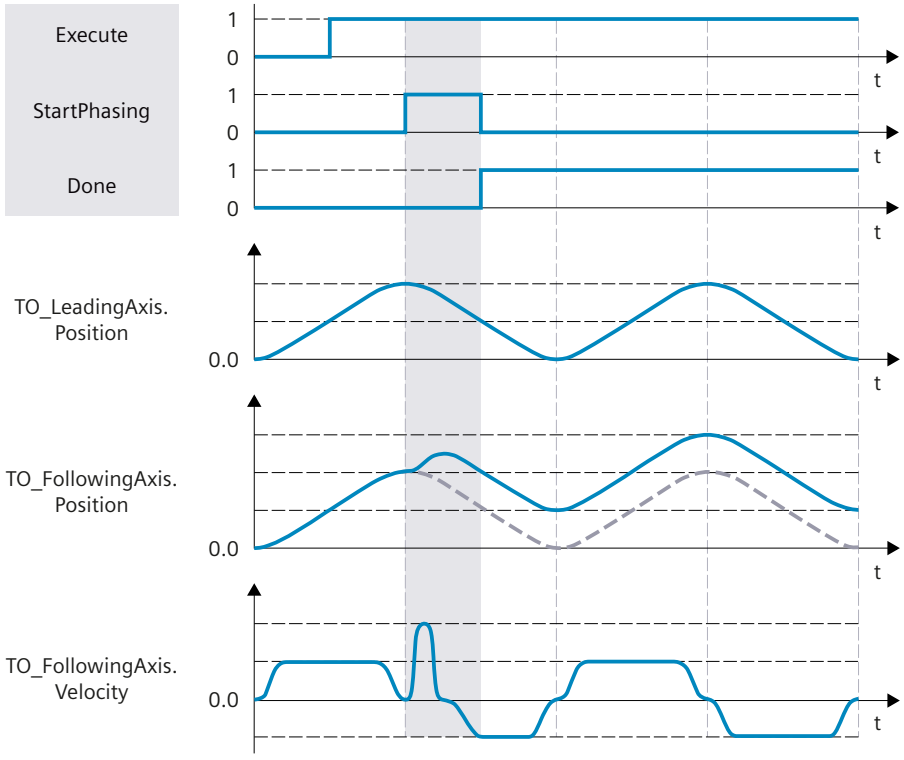

Defining leading value distance in the current direction of motion of the effective leading value

With "Direction" = 3, the following axis offsets the leading value regardless of the direction in which the leading axis is currently traveling.

7.2.5.5 Canceling a pending leading value offset in the gearing

With an "MC_PhasingAbsolute (Page 304)" or "MC_PhasingRelative (Page 297)" job with "ProfileReference" = 5, you cancel a pending "MC_PhasingAbsolute" or "MC_PhasingRelative" job. Canceling a waiting job has no effect on an active leading value offset.

7.2.6 Following value offset during gearing

7.2.6.1 Following value offset on the following axis during gearing using leading value distance as of current leading value position

With a following value offset, you offset the following value on the following axis during gearing with "MC_GearIn (Page 279)" or "MC_GearInPos (Page 283)". You can move the following value absolutely or relatively. The leading value of the leading value source and the position of the leading axis are not influenced by the following value offset.

The following value offset always refers to the effective leading value. The effective leading value is made up of the leading value of the leading value source and the additive leading value. If you do not use an additive leading value via "MC_LeadingValueAdditive (Page 347)", the effective leading value corresponds to the leading value of the leading value source. You can find an overview in the "Mode of operation of the instructions in synchronous operation (Page 34)" section. In the following, "leading value" refers to the effective leading value.

Parameter inputs

You define the behavior of the following axis during following value offset with the following parameters of the Motion Control instruction "MC_OffsetAbsolute (Page 317)" or "MC_OffsetRelative (Page 311)":

- With the parameter "ProfileReference" = 1, you specify the type of following value offset as offset using leading value distance as of the current leading value position.
- With the "Offset" parameter, you specify the following value offset on the following axis.
- With the "OffsetDistance" parameter, you specify the leading value distance (traversing distance of the leading axis) during the following value offset.
- With the "Direction" parameter, you specify the direction of the leading value distance in relation to the direction of motion of the leading value (Page 82).

During the following value offset

After starting the job, the following axis begins with the following value offset starting from the current position. Within the traversing distance of the leading axis, the following axis offsets the following value at continuous velocity and acceleration. The required dynamics of the following axis for the following value offset is calculated by the system. During following value offset, the dynamics of the following axis is limited only to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

The following value offset is indicated in the Motion Control instruction with the parameter "StartOffset" = TRUE and in the "<TO>.StatusWort2.X4 (OffsetCommand)" tag of the technology object. The "AbsoluteOffset" or "CoveredOffset" parameter shows the absolute following value portion already shifted.

The leading value must not reverse during the following value offset on the following axis. When the leading value reverses, the "MC_OffsetAbsolute" job or "MC_OffsetRelative" job is canceled with "ErrorID" = 16#808C.

After the following value offset

As soon as the following axis has offset the following value, the following value offset is active on the following axis. The status is indicated in the Motion Control instruction with the parameter "Done" = TRUE and in the "<TO>.StatusSynchronizedMotion.Offset" tag of the technology object.

The following value offset only has an effect in the "Synchronous" status of the gearing. When the gearing is overridden, the following value offset is reset to zero.

7.2.6.2 Following value offset on the following axis during gearing using leading value distance as of specific leading value position

With a following value offset, you offset the following value on the following axis during gearing with "MC_GearIn (Page 279)" or "MC_GearInPos (Page 283)". You can move the following value absolutely or relatively. The leading value of the leading value source and the position of the leading axis are not influenced by the following value offset.

The following value offset always refers to the effective leading value. The effective leading value is made up of the leading value of the leading value source and the additive leading value. If you do not use an additive leading value via "MC_LeadingValueAdditive (Page 347)", the effective leading value corresponds to the leading value of the leading value source. You can find an overview in the "Mode of operation of the instructions in synchronous operation (Page 34)" section. In the following, "leading value" refers to the effective leading value.

Parameter inputs

You define the behavior of the following axis during following value offset with the following parameters of the Motion Control instruction "MC_OffsetAbsolute (Page 317)" or "MC_OffsetRelative (Page 311)":

- With the parameter "ProfileReference" = 2, you specify the type of following value offset as offset using leading value distance as of a specific leading value position.
- With the "Offset" parameter, you specify the following value offset on the following axis.
- With the "OffsetDistance" parameter, you specify the leading value distance (traversing distance of the leading axis) during the following value offset.
- With the "StartPosition" parameter, you specify the leading value position from which the following value offset starts.
- With the "Direction" parameter, you specify the direction of the leading value distance in relation to the direction of motion of the leading value (Page 82).

Until the following value offset

After starting the job, the status "Waiting" is displayed at the following axis when the leading value is at standstill and until the leading value has reached the leading value position (<TO>.StatusWord2.X5 = TRUE (OffsetCommandWaiting)).

During the following value offset

As soon as the leading value has reached the leading value position, the following axis begins to offset the following value. Within the traversing distance of the leading axis, the following axis offsets the following value at continuous velocity and acceleration. The required dynamics of the following axis for the following value offset is calculated by the system. During following value offset, the dynamics of the following axis is limited only to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

The following value offset is indicated in the Motion Control instruction with the parameter "StartOffset" = TRUE and in the "<TO>.StatusWort2.X4 (OffsetCommand)" tag of the technology object. The "AbsoluteOffset" or "CoveredOffset" parameter shows the absolute following value portion already shifted.

The leading value must not reverse during the following value offset on the following axis. When the leading value reverses, the "MC_OffsetAbsolute" job or "MC_OffsetRelative" job is canceled with "ErrorID" = 16#808C. The waiting job is not canceled.

After the following value offset

As soon as the following axis has offset the following value, the following value offset is active on the following axis. The status is indicated in the Motion Control instruction with the parameter "Done" = TRUE and in the "<TO>.StatusSynchronizedMotion.Offset" tag of the technology object.

The following value offset only has an effect in the "Synchronous" status of the gearing. When the gearing is overridden, the following value offset is reset to zero.

7.2.6.3 Defining the direction of the leading value distance of a following value offset on the following axis during gearing

With a following value offset, you offset the following value on the following axis during gearing with "MC_GearIn (Page 279)" or "MC_GearInPos (Page 283)". With the "Direction" parameter of the Motion Control instruction "MC_OffsetAbsolute (Page 317)" or "MC_OffsetRelative (Page 311)", you specify the direction of the leading value distance in relation to the direction of motion of the effective leading value.

Defining leading value distance in the positive direction of motion of the effective leading value

With "Direction" = 1, the following axis only offsets the following value when the leading axis travels in the positive direction.

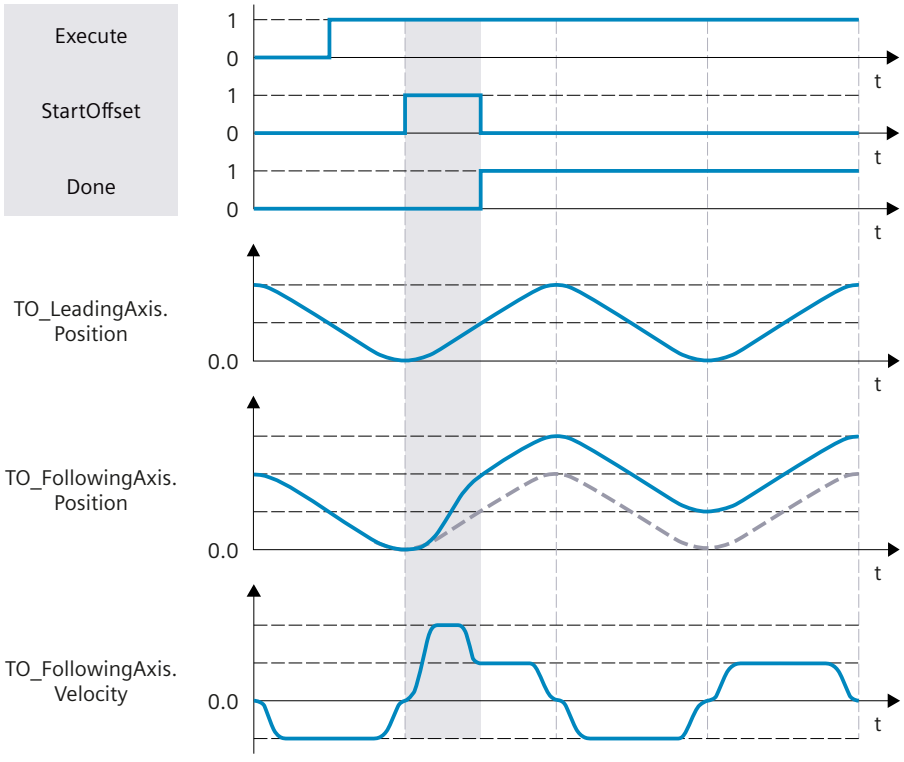

Defining leading value distance in the negative direction of motion of the effective leading value

With "Direction" = 2, the following axis only offsets the following value when the leading axis travels in the negative direction.

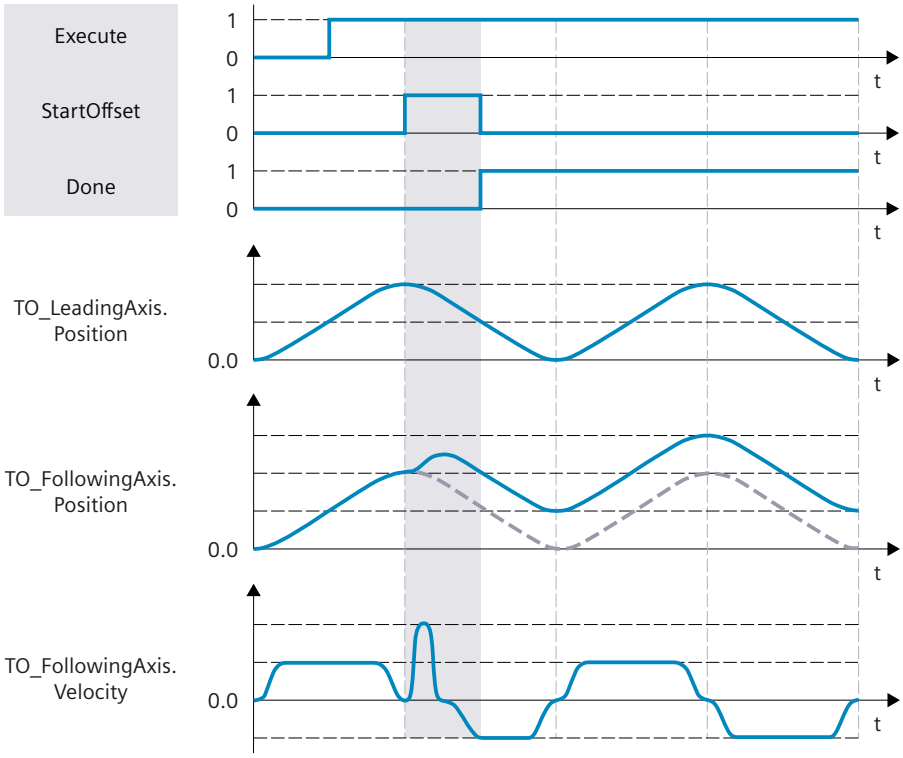

Defining leading value distance in the current direction of motion of the effective leading value

With "Direction" = 3, the following axis offsets the following value regardless of the direction in which the leading axis is currently traveling.

7.2.6.4 Canceling a pending following value offset in the gearing

With an "MC_OffsetAbsolute (Page 317)" or "MC_OffsetRelative (Page 311)" job with "ProfileReference" = 5, you cancel a pending "MC_OffsetAbsolute" or "MC_OffsetRelative" job. Canceling a pending job has no effect on an active following value offset.

7.3 Desynchronizing gearing

7.3.1 Desynchronizing following axis using dynamic parameters with "MC_GearOut"

Desynchronization ends the synchronous operation relationship between the leading and following axis and gearing is ended. For desynchronization using dynamic parameters, desynchronization begins in such a way that the following axis comes to a standstill when the stop position is reached.

With the Motion Control instruction "MC_GearOut" you can desynchronize a gearing which you have started either with a "MC_GearIn (Page 279)" job or with a "MC_GearInPos (Page 283)" job.

Parameter inputs

You define the behavior of the following axis for desynchronization with the following parameters of the Motion Control instruction "MC_GearOut (Page 338)":

- With the parameter "SyncProfileReference" = 0, you specify the type of desynchronization as desynchronization using dynamic parameters.
- With the "SlavePosition" parameter, you specify the stop positions of the following axis. The stop position of the following axis is the position at which the following axis comes to a standstill and the desynchronization is completed.
- With the "Deceleration" parameter, you specify the deceleration of the following axis.
- With the "Jerk" parameter, you specify the jerk of the following axis.
- With the "SyncOutDirection" parameter, you specify the direction of the desynchronization (Page 88).

Until desynchronization

After the start of the "MC_GearOut" job, a motion profile for the following axis is calculated continuously. The motion profile is calculated based on the following parameters:

- Specified stop position of the following axis in the Motion Control instruction
- Specified dynamics of the Motion Control instruction
- Current position and dynamics of the leading and following axes
- Synchronous operation function
- Superimposed motion of the following axis
- Additive leading value of the following axis

The distance of the following axis and thus the starting position of the following axis for desynchronization results from the calculation.

The start position of the following axis is derived in the following way:

Start position = stop position of the following axis - travel distance of the following axis

The status "Waiting" is displayed at the following axis until the following value has reached the start position (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 4).

During desynchronization

The following axis begins to desynchronize as soon as the following value has reached the start position. Desynchronization is indicated in the Motion Control instruction "MC_GearOut" with the parameter "StartSyncOut" = TRUE and in the "<TO>.StatusWord2.X1 (DesynchronizingCommand)" tag of the technology object. The synchronous operation is no longer in the "Synchronous" status. Superimposed jobs of the following axis are canceled.

The following axis moves to the stop position with the specified dynamics, independent of the leading value. The dynamic response of the following axis is limited to the dynamic limits configured on the technology object.

- <TO>.DynamicLimits.MaxVelocity
- <TO>.DynamicLimits.MaxAcceleration
- <TO>.DynamicLimits.MaxDeceleration
- <TO>.DynamicLimits.MaxJerk

During desynchronization, several modulo revolutions of both axes are generally possible.

After desynchronization

As soon as the following axis reaches the stop position, the following axis is desynchronized. The following axis is at a standstill. The status is indicated in the Motion Control instruction "MC_GearOut" with the parameter "Done" = TRUE and in the "<TO>.StatusWord.X7 (Standstill)" tag of the technology object.

See also

Configuring the reverse tolerance of the leading value (Page 44)

7.3.2 Desynchronizing following axis using leading value distance with "MC_GearOut"

Desynchronization ends the synchronous operation relationship between the leading and following axis and gearing is ended. For desynchronization using the leading value distance, desynchronization begins in such a way that the following axis comes to a standstill when the stop position is reached.

With the Motion Control instruction "MC_GearOut" you can desynchronize a gearing which you have started either with a "MC_GearIn (Page 279)" job or with a "MC_GearInPos (Page 283)" job.

Parameter inputs

You define the behavior of the following axis for desynchronization with the following parameters of the Motion Control instruction "MC_GearOut (Page 338)":

- With the parameter "SyncProfileReference" = 1, you specify the type of desynchronization as desynchronization using the leading value distance.
- With the "SlavePosition" parameter, you specify the stop positions of the following axis. The stop position of the following axis is the position at which the following axis comes to a standstill and the desynchronization is completed.

- With the "MasterStopDistance" parameter, you define the leading value distance (desynchronization length).
- With the "SyncOutDirection" parameter, you specify the direction of the desynchronization (Page 88).

Until desynchronization

After the start of the "MC_GearOut" job, a motion profile is calculated depending on the specified leading value distance. The calculation determines the required dynamics and thus the start position of the leading axis for the desynchronization.

The start position of the leading axis is derived in the following way:

Start position = leading value position when the stop position of the following axis is reached - leading value distance

The status "Waiting" is displayed at the following axis until the leading value has reached the start position (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 4).

During desynchronization

The following axis begins to desynchronize as soon as the leading value has reached the start position. Desynchronization is indicated in the Motion Control instruction "MC_GearOut" with the parameter "StartSyncOut" = TRUE and in the "<TO>.StatusWord2.X1 (DesynchronizingCommand)" tag of the technology object. The synchronous operation is no longer in the "Synchronous" status. Superimposed jobs of the following axis are canceled.

The following axis travels to the stop position depending on the leading value distance The dynamics of the following axis during desynchronization is obtained from the calculated motion profile and the current dynamics of the leading axis. The dynamic response of the following axis is thereby only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

Changes in the dynamics of the leading axis during desynchronization are superimposed with the calculated motion profile in accordance with the synchronous operation function. This can have the result that the configured dynamic limits at the following axis are violated. This is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object.

During desynchronization, several modulo revolutions of both axes are generally possible.

The leading value must not reverse during desynchronization. In order to avoid interrupting the desynchronization when there are slight fluctuations in the leading value during an actual value coupling, for example, with an external encoder, you can define a reverse tolerance of the leading value (Page 44).

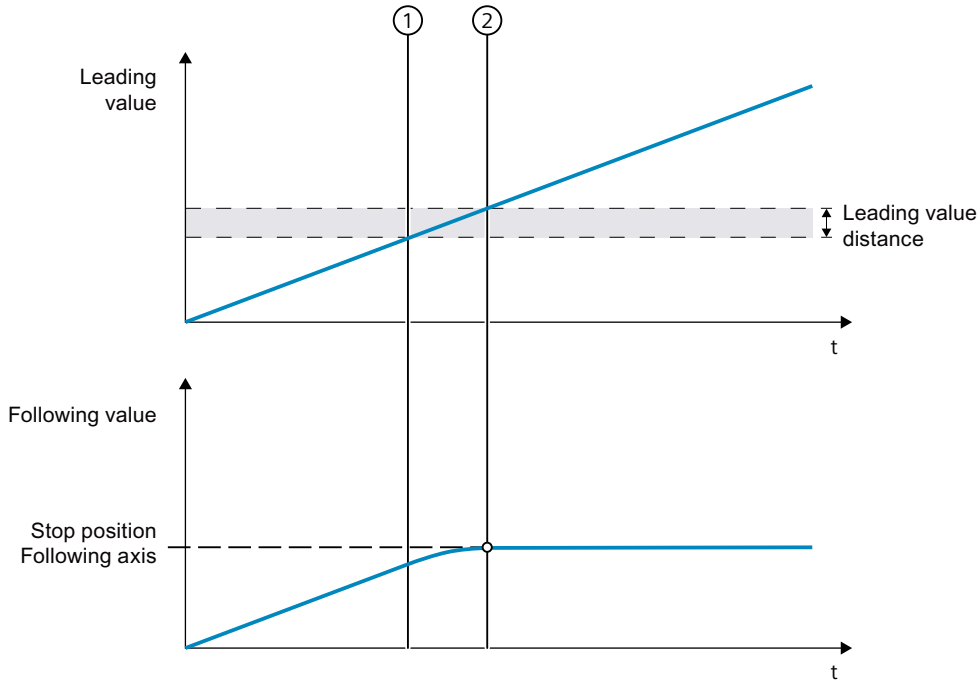

① Time when desynchronization starts

② Time when desynchronization is complete

If the leading axis stops during desynchronization, high dynamic values can occur at the following axis as soon as the leading axis starts moving again and the following axis continues moving to the specified stop position. To avoid these high dynamic values at the following axis, use desynchronization via dynamic parameters ("SyncProfileReference" = 0).

After desynchronization

As soon as the following axis reaches the stop position, the following axis is desynchronized. The following axis is at a standstill. The status is indicated in the Motion Control instruction "MC_GearOut" with the parameter "Done" = TRUE and in the "<TO>.StatusWord.X7 (Standstill)" tag of the technology object.

7.3.3 Defining direction of desynchronization with "MC_GearOut"

Desynchronization ends the synchronous operation relationship between the leading and following axis and gearing is ended. You can specify the desynchronization direction with the "SyncOutDirection" parameter of the Motion Control instruction "MC_GearOut (Page 338)".

Desynchronizing the following axis in positive traversing direction

With "SyncOutDirection" = 1, the following axis is only desynchronized when the following axis moves in the positive direction.

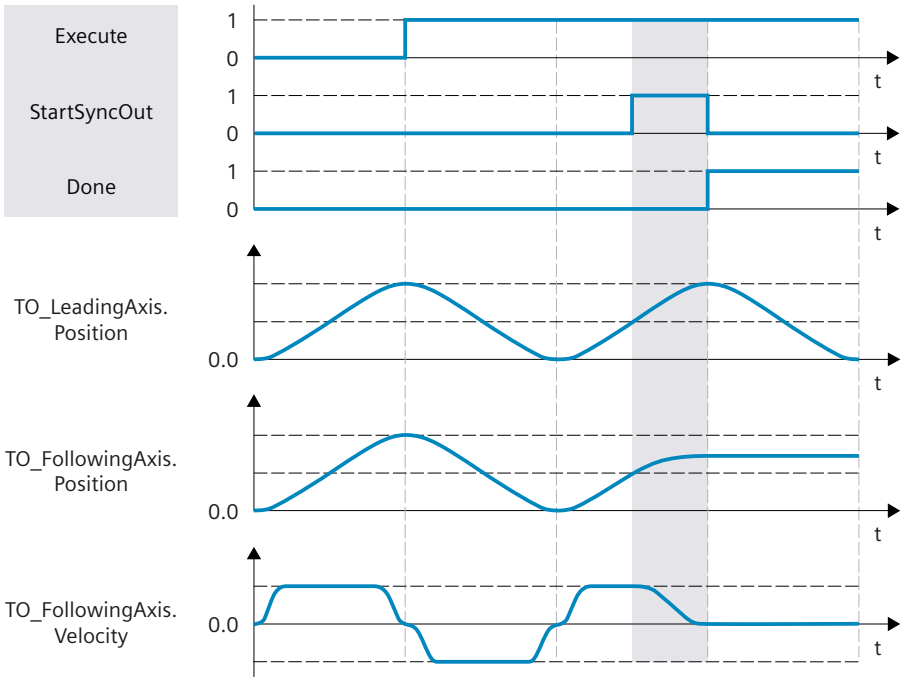

Desynchronizing the following axis in negative traversing direction

With "SyncOutDirection" = 2, the following axis is only desynchronized when the following axis moves in the negative direction.

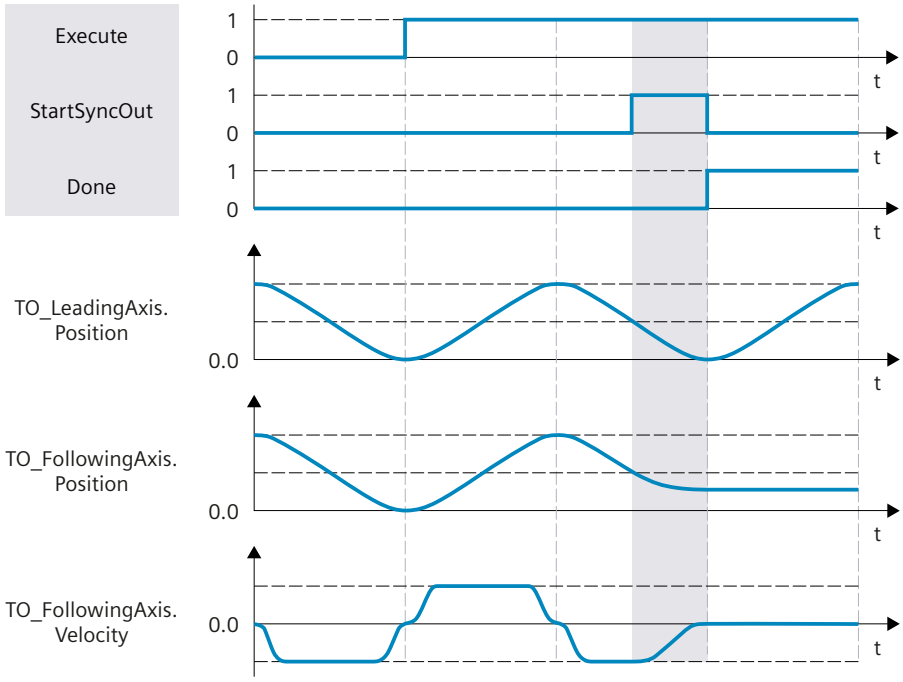

Desynchronizing the following axis in the current traversing direction

With "SyncOutDirection" = 3, the following axis is desynchronized in the direction in which the following axis is currently moving.

7.3.4 Dynamic limits of the following axis during desynchronization with "MC_GearOut"

If a synchronous axis is desynchronized as a following axis in the gearing with the Motion Control instruction "MC_GearOut (Page 338)", the following dynamic limits apply, depending on the type of the synchronous operation:

Desynchronization via dynamic parameters

During synchronization using dynamic parameters, the dynamic limits configured at the technology object apply to the following axis.

- <TO>.DynamicLimits.MaxVelocity
- <TO>.DynamicLimits.MaxAcceleration
- <TO>.DynamicLimits.MaxDeceleration
- <TO>.DynamicLimits.MaxJerk

The SW limit switches also continue to be monitored with the configured dynamic limits of the following axis.

Desynchronization using leading value distance

When desynchronizing via the leading value distance, the dynamic response of the following axis is thereby only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity). The dynamics of the following axis results from the synchronous operation function.

If the dynamic limits configured for the following axis are exceeded, this is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The SW limit switches continue to be monitored with the configured dynamic limits of the following axis.

If the following axis cannot follow the leading value, this results in a following error, which is monitored by the following error monitoring.

7.3.5 Canceling pending gearing with "MC_GearOut"

With a "MC_GearOut (Page 338)" job with "SyncProfileReference" = 5, you cancel a pending gearing. Canceling a pending gearing has no influence on an active gearing.

7.4 Tags: Gearing

The following technology object tags are relevant for gearing:

Configuration		
Tag	**Description**	
<TO>.SynchronizedMotion.LeadingValueReversalTolerance	Reverse tolerance of the leading value during synchronization with "MC_GearInPos" and desynchronization with "MC_GearOut" in length unit of the axis	
<TO>.SynchronizedMotion.LeadingValueTolerenceDirection	Tolerated leading value direction to leave the tolerance range	
	1	Positive
	2	Negative
	3	Positive and negative

Status indicators		
Tag	**Description**	
<TO>.StatusSynchronizedMotion.FunctionState	Indication of which synchronous operation function is active	
	0	No synchronous operation active
	1	Gearing ("MC_GearIn")
	2	Gearing with specified synchronous positions ("MC_GearInPos")
	3	Camming ("MC_CamIn")
	4	Desynchronization of gearing ("MC_GearOut")
	5	Desynchronization of camming ("MC_CamOut")
	6	Velocity synchronous operation ("MC_GearInVelocity")
<TO>.StatusSynchronizedMotion.WaitingFunctionState	Indication of which synchronous operation function is waiting	
	0	No synchronous operation waiting
	1	Reserved
	2	Gearing with specified synchronous positions waiting ("MC_GearInPos")
	3	Camming waiting ("MC_CamIn")
	4	Desynchronization of gearing waiting ("MC_GearOut")
	5	Desynchronization of camming waiting ("MC_CamOut")
<TO>.StatusSynchronizedMotion.ActualMaster	When a synchronous operation job is started, the number of the technology data block of the currently used leading axis is displayed.	
	0	Synchronous operation inactive
<TO>.StatusSynchronizedMotion.ActualRatioNumerator	Current counter of the gear ratio of an active "MC_GearIn", "MC_GearInPos" or "MC_GearInVelocity" job	

Status indicators	
Tag	**Description**
<TO>.StatusSynchronizedMotion.ActualRatio-Denominator	Current denominator of the gear ratio of an active "MC_GearIn", "MC_GearInPos" or "MC_GearInVelocity" job
<TO>.Position	Setpoints of the axis
<TO>.Velocity	
<TO>.Acceleration	
<TO>.StatusSynchronizedMotion.Effective-LeadingValue.Position	Effective leading value including an additive leading value with an "MC_LeadingValueAdditive" job
<TO>.StatusSynchronizedMotion.Effective-LeadingValue.Velocity	
<TO>.StatusSynchronizedMotion.Effective-LeadingValue.Acceleration	
<TO>.StatusSynchronizedMotion.PhaseShift	Current absolute leading value offset with an "MC_PhasingAbsolute" or "MC_PhasingRelative" job
<TO>.StatusSynchronizedMotion.Function-LeadingValue.Position	Leading value of the synchronous operation function after a leading value offset with an "MC_PhasingAbsolute" job or "MC_PhasingRelative" job including an additive leading value with a "MC_LeadingValueAdditive" job
<TO>.StatusSynchronizedMotion.Function-FollowingValue.Position	Following value of the synchronous operation function before a following value offset with an "MC_OffsetAbsolute" job or "MC_OffsetRelative" job
<TO>.StatusSynchronizedMotion.Function-FollowingValue.Velocity	
<TO>.StatusSynchronizedMotion.Function-FollowingValue.Acceleration	
<TO>.StatusSynchronizedMotion.Offset	Current absolute following value offset with an "MC_OffsetAbsolute" or "MC_OffsetRelative" job
<TO>.StatusSynchronizedMotion.StatusWord.X0 (MaxVelocityExceeded)	Set to the value "TRUE" when the maximum velocity configured for the following axis is exceeded during synchronous operation.
<TO>.StatusSynchronizedMotion.StatusWord.X1 (MaxAccelerationExceeded)	Set to the value "TRUE" when the maximum acceleration configured for the following axis is exceeded during synchronous operation.
<TO>.StatusSynchronizedMotion.StatusWord.X2 (MaxDecelerationExceeded)	Set to the value "TRUE" when the maximum deceleration configured for the following axis is exceeded during synchronous operation.
<TO>.StatusWord.X21 (Synchronizing)	Set to the value "TRUE" when the synchronous axis synchronizes to a leading value.
<TO>.StatusWord.X22 (Synchronous)	Set to the value "TRUE" when the synchronous axis is synchronized and moves synchronously to the leading axis.
<TO>.StatusWord2.X1 (DesynchronizingCommand)	Set to the value "TRUE" when the synchronous axis desynchronizes.
<TO>.StatusWord.X24 (PhasingCommand)	Is set to the value "TRUE" if a job for leading value offset is active ("MC_PhasingAbsolute", "MC_PhasingRelative").
<TO>.StatusWord2.X3 (PhasingCommandWaiting)	Is set to the value "TRUE" if a job for leading value offset is pending ("MC_PhasingAbsolute", "MC_PhasingRelative").

Status indicators	
Tag	**Description**
<TO>.StatusWord2.X4 (OffsetCommand)	Is set to the value "TRUE" if a job for following value offset is active ("MC_OffsetAbsolute", "MC_OffsetRelative").
<TO>.StatusWord2.X5 (OffsetCommandWaiting)	Is set to the value "TRUE" if a job for following value offset is waiting ("MC_OffsetAbsolute", "MC_OffsetRelative").
<TO>.ErrorWord.X14 (SynchronousError)	Error during synchronous operation The leading axis specified in the Motion Control instruction was not configured as a possible leading axis.

Velocity synchronous operation

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With the Motion Control instruction "MC_GearInVelocity (Page 293)" you start a velocity synchronous operation between a leading axis and a following axis. During velocity synchronous operation, the velocity of the following axis results from the velocity of the leading axis multiplied by the gear ratio, regardless of the position. You specify the gear ratio as a ratio of two integers either once or variably during synchronization. This results in a linear transformation ratio.

You can start synchronous operation when the leading axis is at a standstill or when it is in motion. Synchronous travel begins after synchronization when the following axis has reached the velocity and acceleration of the leading axis, taking into account the gear ratio.

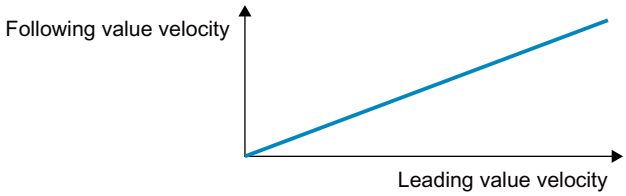

Slope of line or transmission ratio
Gear ratio = "MC_GearInVelocity.RatioNumerator"/"MC_GearInVelocity.RatioDenominator"

For velocity synchronous operation with "MC_GearInVelocity", you have the following options:

- Defining gear ratio (Page 95)
- Specify gear ratio once or dynamically (Page 96)
- Defining position control of the following axis (Page 97)
- Synchronize following axis using dynamic parameters (Page 99)
- Synchronous travel in velocity synchronous operation (Page 100)
- Specify additive leading value with "MC_LeadingValueAdditive" (Page 205)
- Set velocity synchronous operation with "MC_SynchronizedMotionSimulation" in simulation (Page 203)

Also note the Dynamic limits of the following axis in velocity synchronous operation (Page 98).

8.1 Defining gear ratio

During velocity synchronous operation, the velocity of the following axis results from the velocity of the leading axis multiplied by the gear ratio, regardless of the position. You specify the gear ratio at the Motion Control instruction "MC_GearInVelocity (Page 293)" as the relationship between two integers (numerator/denominator).

Numerator of the gear ratio

With the "RatioNumerator" parameter, you define the numerator of the gear ratio. You can define the numerator of the gear ratio as positive or negative. This yields the following behavior:

- Positive gear ratio:

  The leading and following axes move in the same direction.
- Negative gear ratio:

  The following axis moves in the opposite direction of the leading axis.

The value "0" is not permitted for the numerator of the gear ratio.

Denominator of the gear ratio

With the "RatioDenominator" parameter, you define the denominator of the gear ratio. Only positive values are permitted for the denominator of the gear ratio.

Display of the gear ratio

The current gear ratio of an active "MC_GearInVelocity" job is shown on the synchronous axis in the "<TO>.StatusSynchronizedMotion.ActualRatioNumerator" and "TO>.StatusSynchronizedMotion.ActualRatioDenominator" tags.

Example 1: Positive gear ratio

Leading axis and following axis are rotary axes.

Parameter inputs:

- "RatioNumerator" = 5
- "RatioDenominator" = 1

If the leading axis moves at 100 °/s, the following axis moves at 500 °/s in the "Synchronous" status of the velocity synchronous operation .

Example 2: Negative gear ratio

The leading axis is a linear axis. The following axis is a rotary axis.

Parameter inputs:

- "RatioNumerator" = -3
- "RatioDenominator" = 1

If the leading axis moves at 100 mm/s, the following axis moves at -300 °/s in the "Synchronous" status of the velocity synchronous operation .

8.2 Specify gear ratio once or dynamically

For a velocity synchronous operation , you can either preset the gear ratio once at the start of the job or change it continuously during an active synchronous operation.

Make sure that the dynamic limits of the following axis (Page 98) are not exceeded by the changed gear ratios.

Parameter inputs

You define the behavior with the following parameters of the Motion Control instruction "MC_GearInVelocity (Page 293)":

- You define the mode for presetting the gear ratio (Page 95) with the parameter "ContinuousUpdate" .

Specify gear ratio once

With "ContinuousUpdate" = FALSE, the gear ratio specified at the start time of the "MC_GearInVelocity" job is used as long as the job is active.

To change the gear ratio if necessary, you must start the job again with a rising edge of the parameter "Execute" = TRUE. The following axis then synchronizes again.

Specify gear ratio dynamically

With "ContinuousUpdate" = TRUE you can change the gear ratio dynamically while the "MC_GearInVelocity" job is active. Changes of the parameter values "RatioNumerator" and "RatioDenominator" are effective immediately.

That the mode for dynamic presetting of the gear ratio is active is indicated at the motion control instruction "MC_GearInVelocity" with the parameter "ContinuousUpdateActive" = TRUE.

Recommendation

You can specify only integer values as numerator ("RatioNumerator") and denominator ("RatioDenominator") of the gear ratio.

To achieve as continuous a change as possible in the gear ratio, multiply the numerator and denominator by a high factor. This increases the resolution of the gear ratio and reduces the quantization error.

Example

The gear ratio should change gradually from 1.0 to 1.1.

Parameter assignment 1:

"RatioNumerator" = 100 ... 110

"RatioDenominator" = 100 ... 100

Increasing the counter in steps of 1 increases the gear ratio by 0.01 each time.

Parameter assignment 2:

"RatioNumerator" = 1 000 000 ... 1 100 000

"RatioDenominator" = 1 000 000 ... 1 000 000

Increasing the counter in steps of 1 increases the gear ratio by 0.000001 each time.

With parameter assignment 2 you get a higher resolution and can change the gear ratio in smaller steps than with parameter assignment 1.

8.3 Defining position control of the following axis

During a velocity synchronous operation, the following axis can be operated in position-controlled or non-position-controlled mode. You specify the operating mode of the following axis independently of the operating mode of the leading axis at the motion control instruction "MC_GearInVelocity".

Parameter inputs

You define the behavior of the following axis with the following parameters of the Motion Control instruction "MC_GearInVelocity (Page 293)":

- You define the operating mode of the following axis with the parameter "PositionControlled".

Position-controlled mode

As soon as the "MC_GearInVelocity" job with "PositionControlled" = TRUE becomes effective, the following axis is switched to position-controlled operation. The configured position monitorings of the following axis are active.

Superimposed motion, e.g. with a "MC_MoveSuperimposed" job, and travel to a fixed stop is only possible in position-controlled operation.

Non-position-controlled mode

As soon as the "MC_GearInVelocity" job with "PositionControlled" = FALSE becomes effective, the following axis is switched to non-position-controlled operation. The configured position monitorings of the following axis are deactivated.

The position setpoint of the following axis is irrelevant in non-position-controlled operation. The zero position setpoint is displayed in "<TO>.Position" tag of the technology object.

8.4 Dynamic limits of the following axis in velocity synchronous operation

If a synchronous axis is operated as a following axis in velocity synchronous operation with the Motion Control instruction "MC_GearInVelocity (Page 293)", the following dynamic limits apply depending on the phase of the synchronous operation:

Synchronization

During synchronization, the velocity of the following axis is limited only to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity). The configured velocity limit may be exceeded (<TO>.DynamicLimits.MaxVelocity).

For acceleration, deceleration, and jerk of the following axis, the dynamic limits configured on the technology object apply:

- <TO>.DynamicLimits.MaxAcceleration
- <TO>.DynamicLimits.MaxDeceleration
- <TO>.DynamicLimits.MaxJerk

The SW limit switches also continue to be monitored with the configured dynamic limits of the following axis.

Synchronous travel

During synchronous travel, the dynamics of the following axis is limited only to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity). The dynamics of the following axis results from the synchronous operation function.

If the dynamic limits configured for the following axis are exceeded, this is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The SW limit switches continue to be monitored with the configured dynamic limits of the following axis.

End or override synchronous operation

As soon as synchronous operation has been overridden, the dynamic limits configured for the technology object apply to the following axis again. With the start of the overriding job, the active dynamics are transitioned (smoothed) to the configured dynamic limits and the specifications for the Motion Control instruction.

8.5 Synchronizing following axis using dynamic parameters with "MC_GearInVelocity"

During velocity synchronous operation, the synchronization establishes the relationship between the leading and following axes. Synchronization begins immediately after the "MC_GearInVelocity" job starts.

Parameter inputs

You define the dynamic behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_GearInVelocity (Page 293)":

- With the "Acceleration" parameter, you specify the acceleration of the following axis.
- With the "Deceleration" parameter, you specify the deceleration of the following axis.
- With the "Jerk" parameter, you specify the jerk of the following axis.

Observe the dynamic limits (Page 98) of the following axis during synchronization.

During synchronization

Synchronization begins after the "MC_GearInVelocity" job starts. Active motion jobs are overridden.

The synchronization duration and distance are dependent on the following parameters:

- Dynamics of the following axis at the start time of the "MC_GearInVelocity" job
- Dynamic settings for synchronization
- Preset gear ratio at the start time of the "MC_GearInVelocity" job
- Dynamics of the leading axis

The synchronization is indicated in the Motion Control instruction "MC_GearInVelocity" with the parameter "StartSync" = TRUE and in the "<TO>.StatusWord.X21 (Synchronizing)" tag of the following axis.

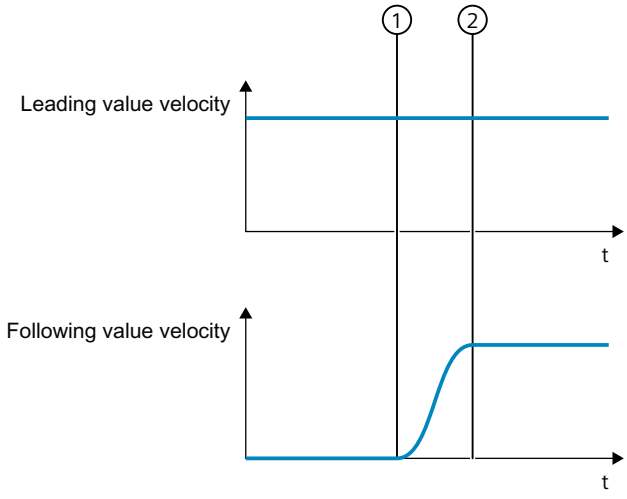

① Time when synchronization starts

② Time when synchronization is complete

The specified gear ratio at the start time of the "MC_GearInVelocity" job is used for the synchronization. If you use a variable gear ratio with "ContinuousUpdate" = TRUE, changes to the gear ratio are only taken into account after synchronization.

After synchronization

The following axis is synchronized when the following axis has reached the velocity of the leading axis, taking into account the gear ratio. The following axis travels synchronously with the leading axis.

8.6 Synchronous travel in velocity synchronous operation with "MC_GearInVelocity"

As soon as the following axis is synchronized, it follows the velocity of the leading axis depending on the specified gear ratio.

The following value velocity is obtained as follows:

Following value velocity = leading value velocity × gear ratio

The "Synchronous" status is indicated in the Motion Control instruction "MC_GearInVelocity (Page 293)" with the parameter "InSync" = TRUE and in the "<TO>.StatusWord.X22 (Synchronous)" tag of the technology object.

If the gear ratio changes when "ContinuousUpdateActive" = TRUE, the "Synchronous" status is retained.

8.7 Tags: Velocity synchronous operation

The following tags of the technology object are relevant for the velocity synchronous operation :

Status indicators		
Tag	**Description**	
<TO>.StatusSynchronizedMotion.FunctionState	Indication of which synchronous operation function is active	
	0	No synchronous operation active
	1	Gearing ("MC_GearIn")
	2	Gearing with specified synchronous positions ("MC_GearInPos")
	3	Camming ("MC_CamIn")
	4	Desynchronization of gearing ("MC_GearOut")
	5	Desynchronization of camming ("MC_CamOut")
	6	Velocity synchronous operation ("MC_GearInVelocity")
<TO>.StatusSynchronizedMotion.ActualMaster	When a synchronous operation job is started, the number of the technology data block of the currently used leading axis is displayed.	
	0	Synchronous operation inactive
<TO>.StatusSynchronizedMotion.ActualRatio-Numerator	Current counter of the gear ratio of an active "MC_GearIn", "MC_GearInPos" or "MC_GearInVelocity" job	

Status indicators	
Tag	**Description**
<TO>.StatusSynchronizedMotion.ActualRatio-Denominator	Current denominator of the gear ratio of an active "MC_GearIn", "MC_GearInPos" or "MC_GearInVelocity" job
<TO>.Position	Setpoints of the axis
<TO>.Velocity	
<TO>.Acceleration	
<TO>.StatusSynchronizedMotion.Effective-LeadingValue.Position	Effective leading value including an additive leading value with an "MC_LeadingValueAdditive" job
<TO>.StatusSynchronizedMotion.Effective-LeadingValue.Velocity	
<TO>.StatusSynchronizedMotion.Effective-LeadingValue.Acceleration	
<TO>.StatusSynchronizedMotion.Function-FollowingValue.Position	Following value of the synchronous operation function
<TO>.StatusSynchronizedMotion.Function-FollowingValue.Velocity	
<TO>.StatusSynchronizedMotion.Function-FollowingValue.Acceleration	
<TO>.StatusSynchronizedMotion.StatusWord.X0 (MaxVelocityExceeded)	Set to the value "TRUE" when the maximum velocity configured for the following axis is exceeded during synchronous operation.
<TO>.StatusSynchronizedMotion.StatusWord.X1 (MaxAccelerationExceeded)	Set to the value "TRUE" when the maximum acceleration configured for the following axis is exceeded during synchronous operation.
<TO>.StatusSynchronizedMotion.StatusWord.X2 (MaxDecelerationExceeded)	Set to the value "TRUE" when the maximum deceleration configured for the following axis is exceeded during synchronous operation.
<TO>.StatusWord.X21 (Synchronizing)	Set to the value "TRUE" when the synchronous axis synchronizes to a leading value.
<TO>.StatusWord.X22 (Synchronous)	Set to the value "TRUE" when the synchronous axis is synchronized and moves synchronously to the leading axis.
<TO>.ErrorWord.X14 (SynchronousError)	Error during synchronous operation The leading axis specified in the Motion Control instruction was not configured as a possible leading axis.

Camming

9

With the Motion Control instruction "MC_CamIn (Page 323)", you start a camming operation between a leading axis and a following axis. You specify the synchronous operation function with a cam (Page 27). To use a cam for camming, the cam must be interpolated. The utilized cam can be scaled on a job-related basis and applied shifted.

You can start synchronous operation when the leading axis is at a standstill or when it is in motion. Synchronous travel begins after synchronization of the following axis.

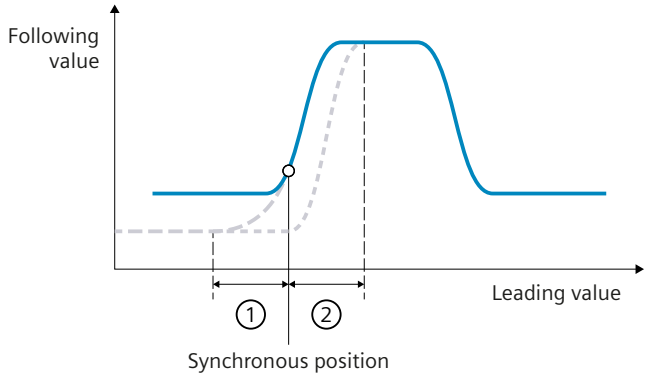

Transfer function:
Following value = f(leading value)

Synchronization in advance

Subsequent synchronization

① Leading value distance with synchronization in advance

② Leading value distance with subsequent synchronization

You have the following options for camming with "MC_CamIn":

- Defining the synchronous operation function (Page 103)
- Interpolate cam with "MC_InterpolateCam" (Page 142)
- Scaling and shifting cam (Page 150)
- Scaling a cam range with "MC_SetCamRangeScaling" (Page 153)
- Defining application mode of the cam (Page 157)
- Defining direction of synchronization (Page 161)
- Define synchronous position and type of synchronization:
  - Synchronizing following axis in advance using dynamic parameters (Page 163)
  - Synchronizing following axis in advance using leading value distance (Page 164)
  - Synchronizing the following axis in advance via the leading value path from the current leading value position (Page 167)
  - Subsequent synchronizing of following axis using leading value distance (Page 171)
  - Subsequent synchronizing of following axis using leading axis value starting at current leading value position (Page 173)

  - Directly set the following axis synchronously (Page 175)
  - Directly set the following axis synchronously at end of the cam (Page 176)
- Synchronous travel in camming (Page 179)
- Reading a leading value with "MC_GetCamLeadingValue" (Page 179)
- Reading a following value with "MC_GetCamFollowingValue" (Page 181)
- Reading a following value cyclically with "MC_GetCamFollowingValueCyclic" (Page 182)
- Specify additive leading value with "MC_LeadingValueAdditive" (Page 205)
- Offset leading value absolute or relative with "MC_PhasingAbsolute" or "MC_PhasingRelative" (Page 183)
- Absolute or relative following value offset with "MC_OffsetAbsolute" or "MC_OffsetRelative" (Page 188)
- Changing synchronous operation function during Runtime (Page 137)
- Set camming to simulation mode with "MC_SynchronizedMotionSimulation" (Page 203)
- Desynchronize following axis with "MC_CamOut" (Page 193)
- Cancel a pending camming with "MC_CamOut" (Page 200)

Also note the dynamic limits of the following axis in camming with "MC_CamIn" (Page 159).

NOTE

Using "DB_ANY" data type with the cam technology object

In Motion Control instructions with technology version ≥ V6.0, direct assignment of the "DB_ANY" data type at the "Cam" parameter leads to an access error. Due to this access error, the CPU changes to the "STOP" state.

Use a data type conversion function for the cam technology object. A description of the procedure can be found in the section "Parameter transfer for function blocks" of the "S7-1500/S7-1500T Motion Control Overview documentation".

9.1 Configuring the synchronous operation function of the cam

9.1.1 Structure and operation of the cam editor

You configure a cam technology object (Page 27) using the cam editor.

You create the cam function using a chart a table containing the elements of the curve and the properties of the elements. Transitions are calculated between the individual elements of the curve (e.g. points, lines, polynomials). The curve reflects the path-related dependency between the leading axis (leading values, abscissa in the chart) and following axis (following values, ordinate in the chart).

The cam editor offers you the following support when creating a cam:

- Optimization of the curve form
- Generation of continuous and jerk-free transitions between curve elements
- Velocity-optimized design of the cam

The figure below shows the layout of the editor:

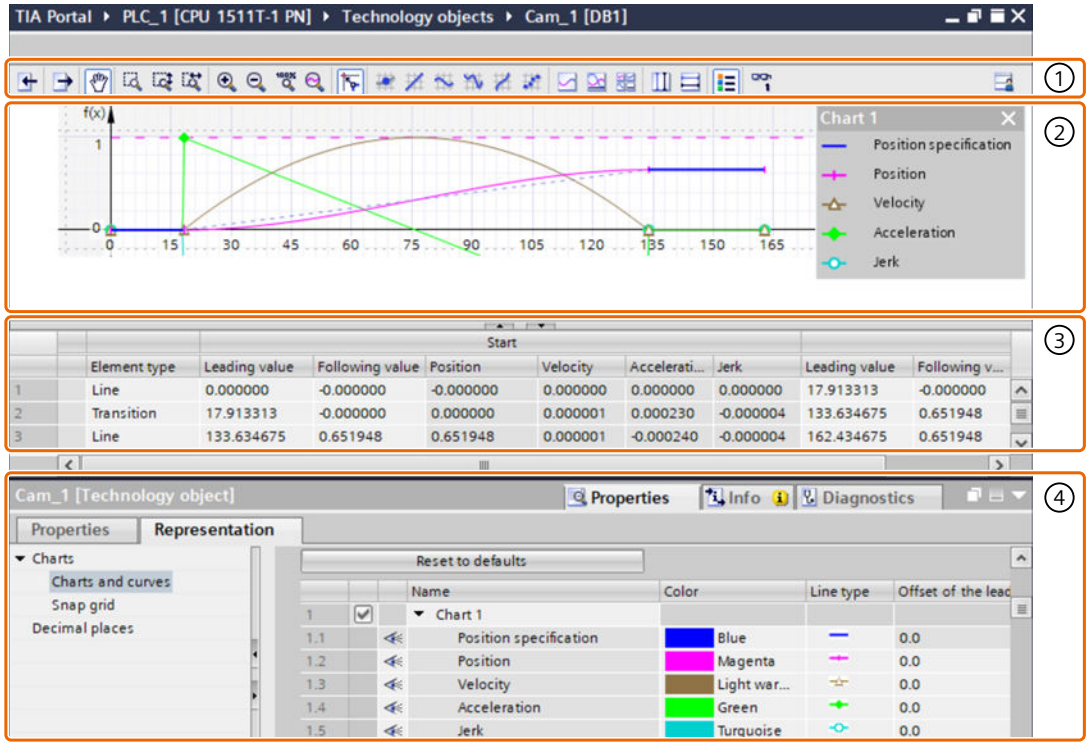

① Toolbar

② Curve diagram
The leading value range (definition range) is displayed on the abscissa (x axis).
The following value range (value range) is displayed on the ordinate (y axis).

①+② Graphical editor

③ Tabular editor

④ Inspector window (properties and display)

Toolbar

Use the toolbar to operate the graphical editor and import or export cams.

Graphical editor

In the graphical editor, you edit the elements of the curve graphically. The elements can be added, edited and deleted. Up to four charts can be created one above the other with synchronized abscissa. The setpoint curve as well as the curves for the effective position, velocity, acceleration and the jerk can be displayed in the charts.

The definition of the cam starts with the first defined interpolation point or the first segment and ends with the last interpolation point or the last segment. In contrast, the configurable display range of the leading value and the configurable value display range of the following value is used in the properties of the cam editor (Inspector window) only for display in the graphical editor.

Tabular editor

All elements of the curve are listed in the tabular editor. Existing elements can be edited or deleted. New elements can be added.

Inspector window

In the Inspector window, you configure the properties of the curve and of the selected element in the "Properties" tab. You configure the graphic view in the "Display" tab:

- Profile (e.g. leading and following value range, optimization and interpolation of the profile, number of elements used)
- Element (e.g. derivatives, polynomial coefficients, optimization of the element)
- Graphical view (e.g. line type, line color, scaling of the view)

Elements of the curve

The following table shows the elements that can be used to define the curve:

Element	Description
Point	A point assigns a following value to a leading value. Depending on the interpolation type, the curve runs through the point with these coordinates or only uses the point for orientation. The velocity, acceleration and jerk can be defined in this point using the first, second and third derivative.
Point group	A point group combines two or more points into an commonly interpolated element and allows precise interpolation between these points.
Line	A line describes a motion with constant velocity from the start point of the line to the end point. The incline of the line specifies the constant velocity.
Sine	A sine element describes a motion according to the sine function. The sine function can be adjusted with the phase angle in the start point and end point, the period length, the amplitude as well as the oscillation zero point (offset).
Polynomial	A polynomial describes a motion according to a polynomial function of the 7th degree maximum. Polynomials can be defined by entering the boundary conditions or the polynomial coefficients. Optionally, you can configure a trigonometric polynomial component.
Inverse sine (approximated)	An inverse sine describes a motion according to the arcsine function. An inverse sine is approximated using interpolation points of the arcsine function.
Transition	Transitions interpolate the range between two elements. The ranges are automatically interpolated by the controller or using a configurable optimization according to VDI Guideline 2143. Transitions are added automatically.

9.1.1.1 Structure of the graphical editor

The graphical editor is divided into the following areas:

- Toolbar
- Curve diagram

Toolbar

The toolbar at the top of the graphical editor provides you with icons for the following functions:

Symbol	Function	Description
	Importing cam from file	See section "Importing a cam (Page 136)"
	Exporting cam to file	See section "Exporting a cam (Page 135)"
	Edit elements/Move view	• Selecting and moving of individual elements • Moving the view using the drag-and-drop feature To switch from any tool to the "Edit elements/Move view" tool, press the <Esc> key.
	Activate zoom selection	Zoom into selected area
	Activate vertical zoom	Vertical zoom into selected area without horizontal scaling Alternative: <Ctrl> +drag to ordinate keeping mouse button pressed
	Activate horizontal zoom	Horizontal zoom into selected area without vertical scaling Alternative: <Ctrl> +drag to abscissa keeping mouse button pressed
	Zoom in	Enlargement of the display Alternative: <Ctrl> + mouse wheel up in curve diagram
	Zoom out	Reduction of the display Alternative: <Ctrl> + mouse wheel down in curve diagram
	Show all	Display of entire definition and value range
	Zoom into curve	Zoom to the following value range of the curve that you selected in the legend of the chart
	Activate snap grid	Alignment of inputs and element end points to the configurable snap grid and to other element end points
	Inserting a point	Adding a point to the chart
	Inserting a line	Adding a line to the chart
	Inserting a sine	Adding a sine element to the chart
	Inserting a polynomial	Adding a polynomial to the chart
	Inserting an inverse sine	Adding an inverse sine to the chart
	Insert point group	Add a point group to the chart
	View: A chart with positions	Display of one chart with the following curves of the cam opened in the editor: • Preset curve • Effective position

Symbol	Function	Description
	View: A chart with all curves	Display of one chart with the following curves of the cam opened in the editor: • Preset curve • Effective position • Effective velocity • Effective acceleration • Effective jerk
	View: Four charts with all curves	Display of four charts with the following curves of the cam opened in the editor: • Chart with setpoint curve and effective position • Chart with effective velocity • Chart with effective acceleration • Chart with effective jerk
	Vertical measuring lines	Displaying and moving of vertical measuring lines Hold down the left mouse button and drag to draw a measuring range. The vertical position of the measuring lines can be moved. The function values for the measuring line positions are displayed in the chart. The difference of the measuring lines is displayed between the measuring lines.
	Horizontal measuring lines	Displaying and moving of horizontal measuring lines Hold down the left mouse button and drag to draw a measuring range. The horizontal position of the measuring lines can be moved. The function values for the measuring line positions are displayed in the chart. The difference of the measuring lines is displayed between the measuring lines.
	Show legend	Showing or hiding of the legend in the curve diagram. To display values for a specific curve on the ordinate, click on the name of the corresponding curve in the legend.
	Read out and display online curve one time	Display of the position values of the cam read back from the CPU (orange) The cam editor reads out the cam that was already loaded into the CPU. The read out "Online curve" is displayed in the graphical editor.

Curve diagram

In the curve diagram, you enter the elements of the curve and adjust the curve by selecting and moving elements.

Chart areas outside the leading value or following value range configured in "Profile > General (Page 112)" are grayed out. Elements outside the leading or following value range are displayed with a warning ("Element is outside the definition range").

You can display various curves (position, velocity, acceleration and jerk) one above the other in up to four charts by configuring the graphical view accordingly. When multiple charts are displayed, you can adapt the graphs to match the separator lines.

You can zoom the view in manual mode using "<Ctrl> + mouse wheel" and "<Ctrl> + drag with mouse button pressed" on the abscissa or ordinate.

The editor shows messages for checking the entered curve via warning triangles . The tooltip of the waring triangle shows the message text. Configure the checking of the curve in the "Check (Page 115)" configuration window.

Display of the online curve

When you click the icon , the cam editor reads the data from the technology object data block and displays the curve in the graphical editor:

Cam status	Interpolation status	Description
Data not modified (CamDataChanged = 0)	Not interpolated (Interpolated = 0)	Only the points and segments of the cam are displayed.
	Interpolated (Interpolated = 1)	The interpolated cam is displayed.
Data modified (CamDataChanged = 1)	Not interpolated (Interpolated = 0)	Only the points and segments of the cam are displayed.
	Interpolated (Interpolated = 1)	The interpolated cam as well as changed points and segments are displayed.

9.1.1.2 Shortcut menu in the graphical editor

Use the shortcut menu in the graphical editor to call up the following functions:

Function	Description
Show all	Displaying the entire definition range and value range
Zoom into curve	Displaying the curve selected in the legend of the chart
Zoom in	Enlargement of the display
Zoom out	Reduction of the display
Open charts and curves	Opening of the "Charts and curves (Page 116)" dialog
Cut	Removing the selected elements and copying them to the clipboard
Copy	Copying of the selected elements to the clipboard
Insert	Pasting of the elements from the clipboard to the last element
Delete	Deletion of the selected elements Transitions to existing elements are also deleted.
Insert special	Open the "Insert elements (Page 129)" dialog
Group points	Combine the selected points into a group of points The entry is displayed under the following conditions: • Only points are selected in the graphic or tabular editor. • There are no other elements between the selected points.
Dissolve point group	Ungrouping the selected point group into individual points
Show/hide measuring point labels	Showing or hiding the measuring points The entry is displayed under the following conditions: • Measuring lines are displayed. • Measuring points are hidden or displayed.
Move	Open the "Move elements (Page 130)" dialog
Scale	Open the "Scale elements (Page 131)" dialog

9.1.1.3 Structure of the tabular editor

The tabular editor shows all elements of the curve, sorted by their leading values. The elements can be adjusted. New elements can be added.

The following properties are displayed in the corresponding column for each element of the curve:

Column/Property	Description
First column	Sequential number of the element
Second column	Display of calculation problems that might occur with warning triangle ⚠ The alarm text is displayed in the tooltip of the warning triangle.
Element type	• Display or change the element type • Adding elements Possible element types: • Point • Point group • Line • Sine • Polynomial • Inverse sine • Transition
Start	Parameter values at start point of the element
Leading value	Leading values at start point of the element
Following value	Following values at start point of the element
Position[1)]	Calculated effective position at start point of the element
Velocity[1)]	Calculated effective velocity at start point of the element
Acceleration[1)]	Calculated effective acceleration at start point of the element
Jerk[1)]	Calculated effective jerk at start point of the element
End	Parameter values at end point of the element
Leading value	Leading values at end point of the element
Following value	Following values at end point of the element
Position[1)]	Calculated effective position at end point of the element
Velocity[1)]	Calculated effective velocity at end point of the element
Acceleration[1)]	Calculated effective acceleration at end point of the element
Jerk[1)]	Calculated effective jerk at end point of the element
Comment	Optional comment for element.

1) Displayed according to the configuration in "Properties (Inspector window) > Graphical view > Charts and curves".

9.1.1.4 Shortcut menu in the tabular editor

Use the shortcut menu in the tabular editor to call up the following functions:

Function	Description
Insert row above	Insert a table row or element before the selected row or element If no transition exists before the element, the selected element and the adjoining elements are changed.
Insert row below	Insert a table row or element after the selected row or element If no transition exists after the element, the selected element and the adjoining elements are changed.
Cut	Removing the selected elements and copying them to the clipboard
Copy	Copying of the selected elements to the clipboard
Insert	Pasting of the elements from the clipboard to the last element
Delete	Deletion of the selected elements Transitions to existing elements are also deleted.
Insert special	Open the "Insert elements (Page 129)" dialog
Group points	Combine the selected points into a group of points The entry is displayed under the following conditions: • Only points are selected in the graphic or tabular editor. • There are no other elements between the selected points.
Dissolve point group	Ungroups the selected point group into individual points
Move	Open the "Move elements (Page 130)" dialog
Scale	Open the "Scale elements (Page 131)" dialog

9.1.1.5 Operating the cam editor

The procedure described here shows the basic operation of the cam editor. This procedure serves as a recommendation.

The basic operation can include the follow tasks:

- Adapting defaults
- Creating and adapting the curve
- Set interpolation and optimization of transitions (Page 147)

Adapting defaults

To adjust the leading and following value range of the cam profile as well as the graphical view, follow these steps:

1. In the properties (Inspector window), open the "Profile > General (Page 112)" configuration window.
2. Configure the leading value range and the following value range of the curve definition.

   The graphical view is automatically adapted to the inputs.

3. In the area navigation of the Inspector window, open the "Display (Page 112)" tab.
4. Configure the following configuration windows:
   - The display of the charts and curves
   - The grid spacing for aligning inputs in the graphical editor
   - The decimal places displayed in the cam editor.

Creating and adapting the curve

To create and adapt the curve, follow these steps:

1. Use the graphical editor and/or the tabular editor to add the elements of the cam:
   - On the toolbar, click the icon for inserting the corresponding element. Place the element at the required position in the graphical editor.
   - Use <Add> to insert the corresponding elements in the "Element type" column of the tabular editor. Adjust the position of the elements using the start and end values.

   Transitions between the elements are added automatically.
2. To edit an element, select it in the graphical or tabular editor.

   The element is highlighted in the graphical and in the tabular editor. The "Element > Parameter" configuration window is displayed in the properties (Inspector window), or in case of a transition, "Element > Characteristic".
3. The elements can be adjusted as follows:
   - Move the element or the drag handles of the element in the graphical editor.
   - Adjust the start and end values in the tabular editor.
   - Configure additional element-specific parameters in the properties (Inspector window) in the "Element > Parameter" configuration window.
   - Set the interpolation of the transitions with the properties (Inspector window).

The number of elements used is displayed in the properties (Inspector window) in the "Profile > Statistics (Page 131)" properties window.

See also

System interpolation (Page 144)
Configuring transitions (Page 142)
Configuration charts - Charts and curves (Page 116)
Interpolate cam with "MC_InterpolateCam" (Page 150)

9.1.2 Configure the profile and display of the cam

9.1.2.1 Properties and display in the inspector window

You configure further element-specific parameters in the inspector window in the following tabs:

- The parameters for the profile of the cam as well as for the elements are displayed in the "properties" tab. The corresponding parameters are displayed depending on the selected element:
  - If no element of the curve is selected, only the settings for the profile of the cam are displayed.
  - If an element of the curve is selected, the parameters of the element are additionally displayed.
- In the "Display" tab you can configure the graphic view of the charts and curves.

9.1.2.2 Configuration of profile - General

Configure the display range of the graphical editor in the "General" configuration window.

The entries for the leading and following value range only affect the display in the graphical editor. The cam is interpolated in the definition range between the following values:

- First defined interpolation point or start of the first segment of the cam (<TO>.StatusCam.StartLeadingValue)
- Last defined interpolation point or end of the last segment of the cam (<TO>.StatusCam.EndLeadingValue)

Scope of validity of the leading value

In this area, configure the scope of validity of the leading value in the graphical editor:

Parameters	Description
Start	In this field, configure the lowest permissible value for the scope of validity of the leading value.
End	In this field, configure the highest permissible value for the scope of validity of the leading value.

Following value display range

In this area, you can configure the limitation of the following value range in the graphical editor:

Parameters	Description
Minimum	In this field you configure the lowest permissible value for the following value display range.
Maximum	In this field you configure the greatest permissible value for the following value display range.

9.1.2.3 Configuration of profile - Effective runtime curves

In the configuration window "Effective Runtime curves > General settings", configure the values for the leading and following axes that are applied for the effective curve. The Runtime emulation calculates the effective curve with these applied values and displays this in the graphical editor with the applied limits.

The inputs are not downloaded into the CPU. This means the cam is interpolated without these inputs. You can use these applied values to test and visualize how the cam behaves during operation, for example, when entering a scaling at an "MC_CamIn" job.

If you use the cam for the positioning job with time-based position profile with an "MC_PositionProfile" job, you can optionally select the "Use cam as time-based position profile" check box. The configured cam is not changed by this. The specifications for position range and time value range in the configuration of the technology object only affect the display in the graphical editor. You can find a description of this function in the "Moving an axis relatively or absolutely with a time-based position profile" section in the "S7-1500/S7-1500T Axis functions" documentation.

Settings of the leading axis

Configure the calculation and display of the curve on the leading value end in this area:

Parameters	Description
Use cam as time-based position profile	Select the check box if you use the cam for the positioning job with time-based position profile. The unit of measure is automatically set to seconds. The other configuration parameters of the leading axis are grayed out. The inputs are not downloaded into the CPU. Activation is optional and is not necessary to perform the "MC_PositionProfile" job.
Copy from axis	Using the button and the "Copy leading value settings of axis" dialog, select an axis whose maximum velocity is applied as the velocity for the leading axis.
Scaling factor	Configure a leading value-side scaling factor in this field. This visualizes a scaled curve. You enter a scaling during runtime with an "MC_CamIn" job.
Unit of measure	In the selection list, select the unit of measure for the leading value. If the "Use cam as time-based position profile" check box is selected, the unit of measure is automatically set to seconds.
Unit of measure for the first derivative	In the selection list, select the unit of measure for the first derivative of the leading value.
Velocity	Configure the velocity of the leading axis applied for the Runtime emulation of the curve in this field.

Settings of the following axis

Configure the calculation and display of the curve on the following value side in this area:

Parameters	Description
Copy from axis	Using the button and the "Copy following value settings of axis" dialog, select an axis whose maximum dynamic values are applied as the limits to be checked during calculation and display of the curve.
Scaling factor	Configure a following value-side scaling factor in this field. This visualizes a scaled curve. You enter a scaling during runtime with an "MC_CamIn" job.
Unit of measure	In the selection list, select the unit of measure for the following value.
Unit of measure for the first derivative	In the selection list, select the unit of measure for the first derivative of the following value.
Maximum velocity	Configure the maximum velocity for the following axis in this field.
Maximum acceleration	Configure the maximum acceleration for the following axis in this field.
Maximum jerk	Configure the maximum jerk for the following axis in this field.

9.1.2.4 Profile configuration - Range scaling

In the "Effective Runtime curves > Range scaling" configuration window, configure the values for up to two scaling ranges that are applied for the effective curve. The Runtime emulation calculates the effective curve with these applied values and displays this in the graphical editor with the applied limits.

The inputs are not downloaded into the CPU. This means the cam is interpolated without these inputs. The applied values can be used to test and visualize how the cam behaves during operation when you scale a range with a "MC_SetCamRangeScaling (Page 360)" job. To make it easier to call up the Motion Control instruction, you can use the "Copy SCL code" button to copy the tested values as program code snippets to the clipboard.

Scaling range 1 and 2

Configure the calculation and display of the curve with the scaling ranges 1 and 2 in these areas:

Parameters	Description
Scaling mode	In the selection list, select whether the scaling range refers to the leading value range or the following value range. If you select the value "No scaling", the corresponding scaling range is not simulated.
Start point	Configure the start value of the scaling range in this field. Start point ≤ End point
End point	Configure the end value of the scaling range in this field. Start point ≤ End point
Scaling factor	Configure the scaling factor of the scaling range in this field.
Copy SCL code	Use this button to copy the configuration values as program code snippets in SCL to the clipboard.

The configured scaling ranges are indicated by markers at the edge of the graphical editor. The scaling factor is displayed in the tooltip of the area selection. If the scaling ranges overlap, the effective scaling factor is displayed.

See also

Scaling a cam range (Page 153)

9.1.2.5 Configuration of profile - Check

In the "Check" configuration window, you configure which criteria the cam editor checks when entering the curve. When you activate a check, the graphical and the tabular editor display corresponding messages via a warning triangle on the element. Use the tooltip at the warning triangle to display the message text.

NOTE

Use the checking options for the final check of the cam and enable all checks before completing the cam. If necessary, make adjustments to the cam profile.

Checking of limit violations

Configure the checks for compliance with the configured limits in this area:

Check/Element	Description
Check curve definition of the leading and following value ranges	Select this check box to have the cam editor check the curve accordingly.
Check adherence to the maximum values of the derivatives of the effective runtime curve	Select this check box to have the cam editor check the curve accordingly.

Verification of VDI suitability

Select the "Check the suitability of transitions in accordance with VDI" check box to have the cam editor check the VDI suitability of the curve.

The cam editor checks the following with this:

- Support of the transition classification of the currently selected VDI transition
- Boundary value adjustment according to VDI

Verification of continuity

In the "Required continuity" list, select which parameter the cam editor checks for continuity:

- Position
- Velocity
- Acceleration
- Jerk

If a function or a derivative is discontinuous, all higher derivatives are also discontinuous.

9.1.2.6 Configuration charts - Charts and curves

In the "Charts and curves" configuration window, configure the display of the graphical editor.

"Reset to defaults" button

Use this button to reset all settings of the view of charts and curves to the default settings.

Configuration table

Configure the display of the graphical editor in the table:

Column	Description
Show	Show or hide charts 1 to 4
Visible	Show or hide curves in the chart You can show or hide online curves already offline. The curve becomes visible when you have shown the curve, established an online connection and read out the online curve.
Name	Name of chart or curve New curves can be added. Existing curves can be removed. Curves of other cams can also be displayed. The name of the other cam is also displayed in the table and in the legend of the chart. A curve can be inserted multiple times in a chart, e.g. in order to display it with different scalings.
Color	Line color of the curve
Line type	Line type of the curve
Offset of the leading values[1)]	Movement of the curve on the abscissa
Multiplier for leading values[1)]	Scaling of abscissa
Offset of the following values[1)]	Movement of the curve on the ordinate
Multiplier for following values[1)]	Scaling of ordinate

1) Only affects the display of the curve in the chart. You specify the scaling and shifting of the cam during camming in the Motion Control instruction "MC_CamIn".

9.1.2.7 Configuration charts - Snap grid

In the "Snap grid" configuration window, you configure the grid spacing for aligning inputs to the grid in the graphical editor. When "Snap" is activated, inputs and element end points are aligned to this grid and to other element end points.

Snap grid spacing

In this area, configure the grid spacing of the snap grid:

Parameter	Description
Grid spacing leading value	Configure the grid spacing on the abscissa (leading values) in this field.
Grid spacing following value	Configure the grid spacing on the ordinate (following values) in this field.

9.1.2.8 Configuration - Decimal places

In the "Decimal places" configuration window, you configure how many decimal places are used to represent the values in the graphical and tabular editor as well as in the configuration windows. The values are rounded in the displays. The settings do not affect the calculation of the curves. The curves are calculated with higher accuracy regardless of the settings.

Displayed decimal places

In this area, configure the displayed decimal places:

Parameter	Description
Tabular editor and configuration window	In this field, configure the number of decimal places for displaying values in the tabular editor and in the configuration windows.
Graphical editor	In this field, configure the number of decimal places for displaying values in the graphical editor.

9.1.3 Inserting and configuring cam elements

9.1.3.1 Inserting and configuring a point

A point assigns a following value to a leading value. The curve runs through the point with these coordinates.

By means of the first, second and third derivatives, the velocity, acceleration and jerk can be defined in this point. The derivative are only taken into consideration during VDI-based optimization of transitions of the point to other elements.

Inserting a point

To add a point to the curve, follow these steps:

1. On the toolbar, click the icon "Insert point".
2. In Chart 1, click on the desired position.
   The point is inserted. The coordinates are displayed for the point. The tabular editor and the view of the properties (Inspector window) are updated. A transition to any element is inserted automatically.

Moving a point

To move a point in the graphical editor, follow these steps:

1. On the toolbar, click the icon "Edit elements/Move view".
2. Select the point in chart 1.
3. Use the drag-and-drop feature to move the point to the desired position.

Adapting parameters

The parameters of the point can be adjusted in the tabular editor as well as in the inspector window under "Properties > Element > Parameter".

Configure the parameters of the selected point in this area:

Parameter/Option	Description
Leading value of the point	
Leading value	In this field, configure the leading value of the point (value in the definition area).
Following values of the point	
Following value	Configure the following value of the point (value in the range of the function) in this field.
Use first derivative	By selecting the check box, you can specify the first derivative at the selected point and include it in the interpolation of the cam.
First derivative	Configure the value of the first derivative in the selected point in this field.

Parameter/Option	Description
Use second derivative	By selecting the check box, you can specify the second derivative at the selected point and include it in the interpolation of the cam.
Second derivative	Configure the value of the second derivative in the selected point in this field.
Use third derivative	By selecting the check box, you can specify the third derivative at the selected point and include it in the interpolation of the cam.
Third derivative	Configure the value of the third derivative in the selected point in this field.

The derivative are only taken into consideration during VDI-based optimization of transitions of the point to other elements.

9.1.3.2 Inserting and configuring a point group

A point group combines two or more points into a commonly interpolated element and allows precise interpolation between the points.

Insert point group

To add a point group to the curve, proceed as follows:

1. On the toolbar, click the icon "Insert point group".
2. In Chart 1, click on the desired position at which you want to insert the point group. The point group is inserted. The coordinates of the start point and the end point are displayed at the point group. The tabular editor and the view of the properties (Inspector window) are updated. If a different element already exists, a transition to the existing element is automatically inserted.

Adapt point group

To adapt a point group in the graphical editor, proceed as follows:

1. On the toolbar, click the icon "Edit elements/Move view".
2. Select the point group in chart 1.

   The point group is highlighted graphically with drag handles. The following drag handles are displayed:

   – Start point of the point group
   – End point of the point group

3. Use the drag-and-drop feature to move the handles or the whole point group to the desired position.

   If further interpolation points are configured between the start point and the end point in the point group, the cam editor handles the interpolation points as follows:

   – Definition type of the leading value "Relative to segment"

     The interpolation points are shifted relative to the start and end points.

   – Definition type of the leading value "Absolute in the profile"

     The interpolation points are not moved.

Adapting parameters

You can adjust the parameters of the point group in the graphical editor, in the tabular editor as well as in the inspector window under "Properties > Element > Parameter".

Configure the parameters of the selected point group in this area:

Parameter/Option	Description
Leading values of the point group	
Start	In this field, configure the start point of the point group in the leading value range (definition area).
End	In this field, configure the end point of the point group in the leading value area (definition area).
Interpolation points	
Definition type of the leading values	In the drop-down list, select how the leading values of the interpolation points are specified: • Relative to segment You specify the leading values of the interpolation points relative to the group of points from 0.0 to 1.0. The value 0.0 corresponds to the beginning of the point group. The value 1.0 corresponds to the end of the point group. • Absolute in the profile You specify the leading values of the interpolation points as absolute values.
Definition type of the following values	In the drop-down list, select how the following values of the interpolation points are specified: • Relative to segment You specify the following values of the interpolation points relative to the following value range of the point group from 0.0 to 1.0. The value 0.0 corresponds to the configured minimum following value of the point group. The value 1.0 corresponds to the configured maximum following value of the point group. • Absolute in the profile You specify the following values of the interpolation points as absolute values.
Minimum following value	In this field, configure the minimum following value for the point group in the following value range.
Maximum following value	In this field, configure the maximum following value of the point group in the following value range (value range).

Parameter/Option	Description
	Use this "Insert interpolation point" icon to add an interpolation point to the point group.
Interpolation points	This table shows the configured interpolation points sorted by increasing leading value. Add interpolation points using the icon. Delete interpolation points by marking a row and pressing the <Delete> key. If you delete all points except one, the element type is changed from "Point group" to "Point".
Leading value	In this field, configure the leading value of the interpolation point (value in the definition area).
Following value	In this field, configure the following value of the interpolation point (value in the value range).
Interpolation	
Interpolation type	In the drop-down list, select the interpolation type to be used for interpolating the point group: • Interpolation with cubic splines • Interpolation with Bézier splines
Approximation	
Mapping method	Select the mapping method in the drop-down list: • Point approximation • Segment approximation
Number of interpolation points	Configure the number of interpolation points for the point approximation in this field.
Maximum following value tolerance	In this field, enter the maximum permissible deviation (absolute) of the approximation from the interpolation points. If the configured value is exceeded, a warning is displayed in the graphical editor at the point group.

9.1.3.3 Inserting and configuring the line

A line describes a motion with constant velocity from the start point to the end point of the line. The incline of the line specifies the constant velocity.

Inserting a line

To add a line to the curve, follow these steps:

1. On the toolbar, click the icon "Insert line".
2. Use the drag-and-drop feature in chart 1 to draw the line from the start position to the end position.
   The straight line is inserted. The coordinates of the start point and end point are displayed for the line. The tabular editor and the view of the properties (Inspector window) are updated. A transition to any element is inserted automatically.

Moving a line

To move a line in the graphical editor, follow these steps:

1. On the toolbar, click the icon "Edit elements/Move view".
2. Select the line in chart 1.

   The line is graphically highlighted with drag handles. The following drag handles are displayed:

   – Start point of the line
   – End point of the line
3. Use the drag-and-drop feature to move the handles or the entire line to the desired position.

Adapting parameters

The parameters of the line can be adjusted in the graphical editor, in the tabular editor as well as in the inspector window under "Properties > Element > Parameter".

Configure the parameters of the selected line in this area:

Parameters	Description
Leading values of the line	
Start	Configure the start point of the line in the leading value range (definition range) in this field.
End	Configure the end point of the line in the leading value range (definition range) in this field.
Following values of the line	
Definition by	In the selection list, select the parameters to be used to define the line: • Following values at start and end • Following value at the start and incline • Incline and following value at end The corresponding parameters are displayed based on the selection.
Start	Configure the start point of the line in the following value range (value range) in this field.
End	Configure the end point of the line in the following value range (value range) in this field.
Incline	Configure the incline of the line in this field.

9.1.3.4 Inserting and configuring a sine

A sine element describes a motion according to the sine function. The sine function can be adjusted with the phase angle in the start point and end point, the period length, the amplitude as well as the oscillation zero point (offset).

Inserting a sine

To add a sine to the curve, follow these steps:

1. On the toolbar, click the icon "Insert sine".
2. In Chart 1, click on the position desired position. The mouse pointer points to the start position of the sine here.

   The sine is inserted. The coordinates of the start point and end point are displayed for the sine. The tabular editor and the view of the properties (Inspector window) are updated. A transition to any element is inserted automatically.

Adjusting a sine

To adjust a sine in the graphical editor, follow these steps:

1. On the toolbar, click the icon "Edit elements/Move view".
2. Select the sine in chart 1.

   The sine is graphically highlighted with drag handles and guide lines for the zero line and the amplitude. The following drag handles are displayed:

   – Leading value or offset at the left or right edge

     These drag handles can also be used to adjust the inclination of an inclined sine.

   – Leading value at the left or right edge
   – Phase on the left or right edge
   – Amplitude
3. Use the drag-and-drop feature to move the handles or the entire sine to the desired position.

Adapting parameters

The parameters of the sine can be adjusted in the graphical editor, in the tabular editor as well as in the inspector window under "Properties > Element > Parameter".

Configure the parameters of the selected sine element in this area:

Parameters	Description
Leading values of the sine	
Start	Configure the start point of the sine element in the leading value range (definition range) in this field.
End	Configure the end point of the sine element in the leading value range (definition range) in this field.

Parameters	Description
Trigonometric parameters	
Amplitude	Configure the amplitude of the sine element in this field.
Definition by	In the drop-down list, select how the sine element is defined: • Phase at start and at end • Phase at start and period length • Phase at start and frequency • Period length and phase at end • Frequency and phase at end The corresponding parameters are displayed based on the selection.
Phase angle at start	Configure the phase angle at the start of the sine element in this field.
Phase angle at end	Configure the phase angle at the end of the sine element in this field.
Period length	Configure the period length of the sine element in this field.
Frequency	Configure the frequency of the sine element in this field.
Extended parameters	
Segment type	Select the variant of the sine element in the drop-down list. • Sine • Inclined sine If you have configured an inclined sine, additional orientation lines are displayed in the graphical editor for the amplitude and center position. The corresponding parameters are displayed based on the selection.
Offset	Configure the oscillation midpoint of the sine element in this field.
Definition of inclination as a function of:	In the drop-down list, select how the inclined sine element is defined: • Offset at start and end • Offset at start and inclination • Inclination and offset at end The corresponding parameters are displayed based on the selection.
Offset at start	Configure the center of oscillation at the start of the sine element in this field.
Offset at end	Configure the center of oscillation at the end of the sine element in this field.
Inclination	Configure the inclination of the sine element in this field.

9.1.3.5 Inserting and configuring a polynomial

A polynomial describes a motion according to a polynomial function of the 7th degree maximum. Polynomials can be defined by entering the boundary conditions or the polynomial coefficients. Optionally, you can configure a trigonometric polynomial component.

Inserting a polynomial

To add a polynomial to the curve, follow these steps:

1. On the toolbar, click the icon "Insert polynomial".
2. In Chart 1, click on the position desired position. In so doing, the mouse pointer points to the start position of the polynomial.

   The polynomial is inserted. The coordinates of the start point and end point are displayed for the polynomial. The tabular editor and the view of the properties (Inspector window) are updated. If a different element already exists, a transition to the existing element is automatically inserted.

Adjusting a polynomial

To adjust a polynomial in the graphical editor, follow these steps:

1. On the toolbar, click the icon "Edit elements/Move view".
2. Select the polynomial in chart 1.

   The polynomial is graphically highlighted with drag handles. The following drag handles are displayed:

   – Leading value and following value on the left or right edge
   – Position of point of inflection (lambda: relative to the element or absolute in the profile)
3. Use the drag-and-drop feature to moves sizing handles or the entire polynomial to the required position.

Adapting parameters

You can adjust the parameters of the polynomial in the graphical editor, in the tabular editor as well as in the inspector window under "Properties > Element > Parameter".

Configure the parameters of the selected polynomial in this area:

Parameters	Description
Leading values of the polynomial	
Start	Configure the start point of the polynomial in the leading value range (definition range) in this field.
End	Configure the end point of the polynomial in the leading value range (definition range) in this field.

Parameters	Description
Polynomial parameters	
Definition by	In the selection list, select how the polynomial is defined: • Coefficients • Boundary values The corresponding parameters are displayed based on the selection.
Coefficients	Configure the coefficients of the 6th degree polynomial function in these fields: $P(x) = a_6x^6 + a_5x^5 + a_4x^4 + a_3x^3 + a_2x^2 + a_1x + a_0$ The coefficients are shown in scientific notation, e.g. "9.6450617283e-11".
Following value - Left boundary value	Configure the following value at the start of the polynomial in this field.
Following value - Right boundary value	Configure the following value at the end of the polynomial in this field.
Use first derivative	Select the check boxes to specify the first derivative (speed) in the left or right boundary value of the polynomial and include it in the interpolation of the cam.
First derivative - left boundary value	Configure the first derivative (velocity) for the following value at the start of the polynomial in this field.
First derivative - right boundary value	Configure the first derivative (velocity) for the following value at the end of the polynomial in this field.
Use second derivative	Select the check boxes to specify the second derivative (acceleration) in the left or right boundary value of the polynomial and include it in the interpolation of the cam.
Second derivative - left boundary value	Configure the second derivative (acceleration) for the following value at the start of the polynomial in this field.
Second derivative - right boundary value	Configure the second derivative (acceleration) for the following value at the end of the polynomial in this field.
Use third derivative	Select the check boxes to specify the third derivative (jerk) in the left or right boundary value of the polynomial and include it in the interpolation of the cam.
Third derivative - left boundary value	Configure the third derivative (jerk) for the following value at the start of the polynomial in this field.
Third derivative - right boundary value	Configure the third derivative (jerk) for the following value at the end of the polynomial in this field.
Lambda	In the selection list, select how the turning point of the polynomial is specified in the "Lambda position" field: • No lambda Do not enter any value. The position of the point of inflection is calculated automatically. • Relative to the element You specify the leading value of the turning point relative to the polynomial from 0.0 to 1.0. The value 0.0 corresponds to the beginning of the polynomial. The value 1.0 corresponds to the end of the polynomial. • Absolute in the profile You specify the leading value of the point of inflection as an absolute value.
	In this field, configure the leading value of the point of inflection for the polynomial according to the selection in the selection list.

Parameters	Description
Extended parameters	
Segment type	In the selection list, select whether or not the polynomial is to have a trigonometric component. When "Polynomial with trigonometric portion" is selected, the corresponding trigonometric parameters are displayed, as they are with sine. When a sine element is converted to a polynomial, the sine element is configured as a polynomial with trigonometric portion. The shape of the element is retained. You have the option to define the trigonometric portion of the polynomial using the following formula: $Y(x) = a_6x^6 + a_5x^5 + a_4x^4 + a_3x^3 + a_2x^2 + a_1x + a_0 + b_0\sin((b_1x) + b_2)$ $a_{0...6}$: Coefficient of order 0 to 6 of the polynomial b_0: Amplitude of the trigonometric portion b_1: Period of the trigonometric portion b_2: Phase offset of the trigonometric portion
Amplitude	Configure the amplitude of the trigonometric component in this field.
Definition by	In the selection list, select how the trigonometric component is defined: • Phase at start and at end • Phase at start and period length • Phase at start and frequency • Period length and phase at end • Frequency and phase at end The corresponding parameters are displayed based on the selection.
Phase angle at start	Configure the phase angle at the start of the trigonometric component in this field.
Phase angle at end	Configure the phase angle at the end of the trigonometric component in this field.
Period length	Configure the period length of the trigonometric component in this field.
Frequency	Configure the frequency of the trigonometric component in this field.

9.1.3.6 Inserting and configuring an inverse sine

An inverse sine describes a motion according to the arcsine function. The arcsine function is the inverse function of the sine function. An inverse sine is approximated using interpolation points of the arcsine function.

The inverse sine is defined within the definition range [-1, 1]. The inverse sine can be calculated for the entire definition range or a restricted definition range of the arcsine function.

Inserting an inverse sine

To add an inverse sine to the curve, follow these steps:

1. On the toolbar, click the icon "Insert inverse sine".
2. In Chart 1, click on the position desired position. In so doing, the mouse pointer points to the start position of the inverse sine.

   The sine is inserted. The coordinates are displayed for the point. The tabular editor and the view of the properties (Inspector window) are updated. A transition to any element is inserted automatically.

Adjusting an inverse sine

To adjust an inverse sine in the graphical editor, follow these steps:

1. On the toolbar, click the icon "Edit elements/Move view".
2. Select the inverse sine in chart 1.

   The inverse sine is graphically highlighted with drag handles. The following drag handles are displayed:

   – Start point of the inverse sine
   – End point of the inverse sine
3. Use the drag-and-drop feature to move the handles or the entire inverse sine to the desired position.

Adapting parameters

The parameters of the inverse sine can be adjusted in the graphical editor, in the tabular editor as well as in the inspector window under "Properties > Element > Parameter".

Configure the parameters of the selected inverse sine in this area:

Parameters	Description
Leading values of the inverse sine	
Start	Configure the start point of the inverse sine in the leading value range (definition range) in this field.
End	Configure the end point of the inverse sine in the leading value range (definition range) in this field.

Parameters		Description
Following values of the inverse sine		
	Minimum	Configure the minimum value of the inverse sine in the following value range (value range) in this field.
	Maximum	Configure the maximum value of the inverse sine in the following value range (value range) in this field.
Definition range		
	Not mirrored/mirrored	Select whether or not the inverse sine is to be mirrored about the abscissa.
	Start	Configure the start point in the definition range of the arcsine function that is to be used in this field.
	End	Configure the end point in the definition range of the arcsine function that is to be used in this field.
Approximation		
	Number of interpolation points	Configure the number of interpolation points for the approximation in this field.
	Maximum following value tolerance	In this field, specify the maximum permitted deviation (absolute) of the approximation from the arcsine function. If the configured value is exceeded, a warning is displayed in the graphical editor for the arcsine element.

9.1.3.7 Inserting elements from the clipboard

You can paste copied elements in both the graphical and the tabular editor. Independent of the cam type, you can also paste copied elements from other cams. Observe the maximum number of interpolation points and segments depending on the cam type (Page 27).

Insert element after the last element

To insert an element from the clipboard after the last element, follow these steps:

1. Open the shortcut menu in graphic or tabular editor.
2. Select "Insert" from the shortcut menu entry.
   The element from the clipboard is inserted after the last element.

Insert element using insert mode

To insert an element from the clipboard using a selected insert mode, follow these steps:

1. If necessary, select the elements to be overwritten.
2. Open the shortcut menu in graphic or tabular editor.
3. Select the "Insert special" entry from the shortcut menu.
   The "Insert elements" dialog opens.

4. In the "Insert mode" selection list, select the desired insert mode:

Insert mode	Description
Overwrite from the end to the left	You overwrite the selected elements with the elements from the clipboard starting from the end in the direction of smaller leading values. The end of the inserted elements then lies at the end of the selected elements. Elements that are located in the leading value range of the elements in the clipboard are overwritten or truncated.
Overwrite from the start to the right	You overwrite the selected elements with the elements from the clipboard starting from the start in the direction of bigger leading values. The start of the inserted elements then lies at the start of the selected elements. Elements that are located in the leading value range of the elements in the clipboard are overwritten or truncated.
Overwrite from the middle	Starting from the center, you overwrite the selected elements with the elements from the clipboard. The center of the inserted elements then lies at the center of the selected elements. Elements that are located in the leading value range of the elements in the clipboard are overwritten or truncated.
Scale selection to the leading value range	The elements in the clipboard are scaled to the leading value range of selected elements. The start and end of the inserted elements then lie at the start and end of the selected elements.
Apply leading values from the clipboard	The elements in the clipboard are inserted with the leading values at the start and end. Elements that are located in the leading value range of the elements in the clipboard are overwritten or truncated.

5. Click "OK".

   The element from the clipboard is inserted using the selected insert mode.

9.1.3.8 Move elements

To move an element, follow these steps:

1. In the graphical or tabular editor, open the shortcut menu of the element that is to be moved.
2. Select the "Move" shortcut menu entry.

   The "Move elements" dialog opens.
3. In the "Horizontal distance" field, enter the shift of the selection on the abscissa (x-axis).
4. In the "Vertical distance" field, enter the shift of the selection on the ordinate (y-axis).
5. Click "OK".

   The element is moved the entered distance.

9.1.3.9 Scale elements

To scale an element, follow these steps:

1. In the graphical or tabular editor, open the shortcut menu of the element that is to be scaled.
2. Select the "Scale" shortcut menu entry.

   The "Scale elements" dialog opens.
3. In the "Leading value range" field, enter the scaling length (leading value side) to which you want to scale the selection.
4. Select the direction of scaling in the "Anchor point" selection list:

Direction	Description
Links	The selection is adjusted by the left boundary point to the scaling length.
Center	The selection is adjusted by the center point to the scaling length.
Right	The selection is adjusted by the right boundary point to the scaling length.

5. Click "OK".

   The element is scaled using the selected parameter values.

9.1.3.10 Deleting elements

To delete an element in the graphical editor, follow these steps:

1. Select the element that is to be deleted.
2. Press the <Del> key.

   The element is deleted. The graphical editor and the view of the properties (Inspector window) are updated. A transition to any element present is also deleted.

9.1.3.11 Show elements used

The "Statistics" properties window shows an overview of the number of elements of the cam, as well as the minimum and maximum values of the effective curves for the slave value and the derivatives.

Used elements

In the statistics, a distinction is made between points and segments:

- Point

  A leading value / following value coordinate on the cam through which the curve runs
- Segments

  All elements and transitions calculated by a 6th degree polynomial with trigonometric part

The "Elements used" area shows the number of curve elements used:

Parameters	Description
Points	This field shows the number of used points of the cam. A cam of the type "TO_Cam" consists of a maximum of 1000 points. A cam of the type "TO_Cam_10k" consists of a maximum of 10 000 points. A cam of the type "TO_Cam_600Seg" or "TO_Cam_6kSeg" consists of a maximum of 50 points.
Segments	This field shows the number of used segments of the cam. A cam of the type "TO_Cam" or "TO_Cam_10k" consists of a maximum of 50 segments. A cam of the type "TO_Cam_600Seg" consists of a maximum of 600 segments. A cam of the type "TO_Cam_6kSeg" consists of a maximum of 6 000 segments.

The use of points and segments depends on the compilation and configuration of the elements.

If an element or a transition is defined via a point or several interpolation points, the number of specified interpolation points determines the number of points used. The following elements or transitions are calculated using interpolation points:

- "Point" element
- "Inverse sine" element
- "Point group" element with "Point approximation" mapping option
- "Double-harmonic transition" motion rule according to VDI Guideline

All other elements and transitions according to the VDI guideline are defined using 6th degree polynomials with a trigonometric component and thus count as segments in the statistics.

The following table shows the use of points and segments per element:

Element	Number of used points	Number of used segments
Point	1	0
Point at a transition with VDI-based optimization	0	0
Point group with point approximation mapping method	Number of interpolation points configured. ("Properties (Inspector window) > Element > Parameter > Approximation > Number of interpolation points") Default setting: 32	0
Point group with segment approximation mapping method	0	Number of interpolation points configured - 1
Line	0	1
Sine	0	1
Polynomial		
< of the 7th degree	0	1
of the 7th degree	0	2

Lambda = turning point of the curve

Element	Number of used points	Number of used segments
Inverse sine	Number of interpolation points configured. ("Properties (Inspector window) > Element > Parameter > Approximation > Number of interpolation points") Default setting: 32	0
Inverse sine to the right of a transition with VDI-based optimization	Number of interpolation points configured - 1	0
Transition with system interpolation	0	0
Transition with VDI-based optimization		
Motion rule		
Sine	0	1
Sine with relative Lambda ≠ 0.5	0	2
Inclined sine	0	1
Inclined sine with relative Lambda ≠ 0.5	0	2
Polynomial	0	1
Sinus with relative Lambda ≠ 0.5	0	2
Modified acceleration trapezoid		
Motion task		
Dwell-in-reverse	0	5
Reverse-in-dwell	0	5
Dwell-in-dwell	0	6
Modified sine		
Motion task		
Dwell-in-dwell	0	3
Constant velocity-in-constant velocity	0	4
Constant-velocity-in-dwell	0	4
Dwell-in-constant velocity	0	4
Sine line combination	0	3
Harmonic combination	0	3
Double-harmonic transition	Number of interpolation points configured. ("Properties (Inspector window) > Element > Parameter > Approximation > Number of interpolation points") Default setting: 32	0
Quadratic parabola	0	2

Lambda = turning point of the curve

Value ranges

This area shows the minimum and maximum values of the effective curves for the following value and the derivatives.

Boundary conditions

The following boundary conditions apply to the input and use of points and segments:

- **Points**

  With points with the same leading values, the point that you have entered last or which is listed in the tabular editor is active.

- **Segments**
  - Gaps between segments are filled with a transition segment.
  - For gaps in the leading value range of less than 1.0E-4, segment end points and segment start points are pulled together.
  - For gaps in the leading value range greater than 1.0E-4, a new transition segment is inserted.
  - For overlaps, the new segment is inserted from the start point and used completely. When the previous segment is defined in excess of the new segment, the previous segment continues to be used after the end point of the new segment.

- **Interpolation points and segments** (mixed cams)

  The segment is used when points are defined in the same range.

9.1.4 Transferring the synchronous operation function of the cam to the technology object data block

After you have configured the synchronous operation function of the cam in the cam editor, compile the cam technology object. By compiling, the configuration is transferred from the cam editor to the technology object data block of the cam. All existing values are overwritten.

Requirement

- You have defined the synchronous operation function of the cam in the cam editor or imported it.

Procedure

To transfer the synchronous operation function of the cam to the technology object data block, follow the steps below:

1. Select the can technology object in the project tree.
2. Select the "Compile > Software (only changes)" entry in the shortcut menu.

Result

The configuration of the synchronous operation function is transferred from the cam editor to the technology object data block of the cam. All existing values are overwritten.

9.1.5 Exporting cam

You can export cams using the toolbar of the cam editor.

In the cam diagnostics, you export snapshots of cams offline and online.

You can perform the following tasks via the export:

- Archive cams
- Generate cam in the cam editor from an exported snapshot of a cam generated during runtime
- Exchange cams between TIA Portal and external software tools

Export formats

The table below shows the supported export formats, their use and special features:

Format	Comment
MCD exchange format	Exchange of cams between the TIA Portal and the NX Mechatronics Concept Designer The following elements are exported in a different form, while maintaining the profile of the cam: • Polynomial of the 7th degree The format does not support 7th degree polynomials. You can define polynomials of the 7th degree using boundary values in the cam editor. If you configure all three derivatives at the right and left boundary values, which corresponds to a 7th degree polynomial. A 7th degree polynomial is mapped into two 6th degree polynomials during export. • Point group With the "Point group" element, the export depends on the mapping method. With the "Point approximation" mapping method, the interpolation points are exported and the transitions between the points are interpolated with the system interpolation. With the "Segment approximation" mapping method, the point group is exported in segments. • Inverted sine The "Inverted sine" element is exported using interpolation points.
SIMOTION SCOUT CamTool format	Exchange of cams between the TIA Portal and the SIMOTION SCOUT CamTool The same special features apply to this format as to the MCD Exchange format.
Point list	Export cams as x and y values for processing in, for example, spreadsheet or word processing programs With the point list, you export points at isochronous distances from the leading value. In addition to the following values, you also have the option to export velocity, acceleration and jerk. Select as many points as possible in order to export the cam with a high degree of accuracy.
Binary format	Exchange of cams between multiple TIA Portal projects. With the binary format you export all configuration data of the cam without restrictions. In addition, your settings for the displaying the charts, such as colors of the curves, are exported.

Procedure

To export a cam, follow these steps:

1. On the toolbar, click the icon "Export cam to file".

   The "Export cam" dialog opens.
2. Select the desired export format from the "Export as" drop-down list.
3. Select the desired delimiter:
   - When you select the "Comma" delimiter, a CSV file is created.
   - When you select the "Tabulator" delimiter, a TXT file is created.
   - This selection is not possible for the binary format.
4. If you export the cam as a point list, enter the number of points and optionally activate the curves to be exported for velocity, acceleration and jerk.

   The more points you export, the more accurately the point list maps the configured cam.
5. Enter a file name in the "File name" box.
6. Select the directory to which the file is written.
7. Click the "Export" button.

   The cam is exported to the selected directory in the specified format.

9.1.6 Importing a cam

You can import cams using the toolbar of the cam editor.

In the cam diagnostics, you import snapshots of cams.

You can perform the following tasks via the import:

- Archive cams
- Generate cam in the cam editor from an exported snapshot of a cam generated during runtime
- Exchange cams between TIA Portal and external software tools

You can import cams of different cam types as long as the respective maximum number of possible points and segments is not exceeded.

NOTICE
Machine damage Importing corrupt files (*.txt, *.csv) can result in unwanted behavior of the axes. Each time you import a cam from a file, check the integrity of the imported data.

Import formats

The following table shows the supported file formats for importing a cam:

File format	Comment
SIMOTION SCOUT CamTool format[1)]/MCD *.txt	MCD exchange format is automatically detected, imported data: • Interpolated points • Lines • Sine elements • Inverse sine elements • Polynomials • Transitions If the maximum number of possible points is reached in a pure point list, you can select whether all points are imported or whether the points are interpolated and then reduced.
SIMOTION SCOUT CamTool format[1)]/MCD *.csv	
Binary format *.bin	The binary format is used for exchanging cams between multiple TIA Portal installations.

1) Export the geometry "as polynomials" in SIMOTION SCOUT.

Procedure

To import a cam, follow these steps:

1. On the toolbar, click the icon "Import cam from file".

   The "Cam import" dialog opens.
2. Select the file type of the file to be imported.
3. From the file directory, select the file to be imported.
4. Click the "Open" button.

   The cam is imported into the cam editor and opened. All previous entries in the editor are discarded.
5. Compile the cam technology object (Page 134).

   The configuration from the cam editor is transferred to the technology object data block. All existing values are overwritten.

9.2 Changing the synchronous operation function of the cam online

You can configure the y = f(x) function of the cam using the cam editor in the configuration of the technology object (Page 103). Alternatively, for dynamic cam plate calculations, you can define or change the synchronous operation function of the cam during the runtime of the user program. The cam technology object must already be created for this.

To change the synchronous operation function of a cam online, you have the following options:

- Changing the synchronous operation function of the cam manually (Page 138)
- Copy calculated cam elements (Page 139)
- Creating the synchronous operation function of the cam with the "LCamHdl" library (Page 140)

Then, you can transfer the synchronous operation function of the cam defined online to the offline project (Page 141).

9.2.1 Changing the synchronous operation function of the cam manually

The following tags of the technology object data block (Page 415) of the cam are relevant for defining the synchronous operation function of a cam manually in runtime:

- <TO>.Point[i]
- <TO>.ValidPoint[i]
- <TO>.Segment[i]
- <TO>.ValidSegment[i]
- <TO>.InterpolationSettings

You can adapt the tags in runtime via the user program. You can use the "<TO>.ValidPoint[i]" and "<TO>.ValidSegment[i]" tags to determine which cam elements included for the interpolation. If the value is "TRUE", the element "<TO>.Point[i]" or "<TO>.Segment[i]" with the corresponding index "i" is included in the interpolation. You can determine the interpolation type (Page 150) using the "<TO>.InterpolationSettings" tag.

Requirement

- The cam technology object has been created. Configuration via the cam editor is not required.
- The project is downloaded to the CPU.
- The cam elements to be adapted should not be edited by an active copy operation of an "MC_CopyCamData (Page 358)" job.

Procedure

To manually change the synchronous operation function of a cam in runtime, follow these steps:

1. Calculate the points and segments of the cam depending on your application.
2. Define the calculated points in the technology object data block of the cam.
   ```
   <TO>.Point[i] := Point; // data type TO_Cam_Struct_PointData
   ```
3. Set the defined points to valid.
   ```
   <TO>.ValidPoint[i] := TRUE;
   ```
4. Set all undefined points to invalid.
   ```
   <TO>.ValidPoint[i] := FALSE;
   ```
5. Define the calculated segments in the technology object data block of the cam.
   ```
   <TO>.Segment[i] := Segment; // data type TO_Cam_Struct_SegmentData
   ```
6. Set the defined segments to valid.
   ```
   <TO>.ValidSegment[i] := TRUE;
   ```

7. Set all undefined segments to invalid.
```
<TO>.ValidSegment[i] := FALSE;
```
8. Make the interpolation settings of the cam.
```
<TO>.InterpolationSettings.InterpolationMode := 1;
<TO>.InterpolationSettings.BoundaryConditions := 0;
```
The values "1" and "0" are only used as examples. Adapt them as needed.
9. Interpolate the cam with a "MC_InterpolateCam (Page 350)" job.

Check the synchronous operation function of the cam

Use the cam diagnostics (Page 261) to analyze and check the generated cam. This provides you with a graphical view of the cam, a list of all valid cam elements and the interpolation type.

9.2.2 Copy calculated cam elements

You use an "MC_CopyCamData (Page 358)" job to copy calculated cam elements to a cam. You can use the same job to copy points and segments to the technology object data block of the cam.

Cam elements to be copied

Save or calculate the cam elements in a data block. Create an array for points of the "TO_Cam_Struct_PointData" type and an array for segments of the "TO_Cam_Struct_Segment-Data" type. The size of the arrays depends on the use case and is variable.

The consistency of the cam elements in the data block is your responsibility. The cam elements must not change during an active copy operation of an "MC_CopyCamData" job.

Specify the arrays for points and segments at the "ArrayOfPoints" and "ArrayOfSegments" parameters of the "MC_CopyCamData" job. Define the number of elements to be copied at the "NumberOfPoints" and "NumberOfSegments" parameters.

Use the "StartPointArray" and "StartSegmentArray" parameters to define the index of the first element to be copied in the array, respectively. Use the "StartPointCam" and "StartSegmentCam" parameters to define the respective index in the cam starting at which the elements to be copied are to be inserted.

Copy mode

Following the copy operation, the inserted cam elements are set as valid ("ValidPoint" = TRUE, "ValidSegment" = TRUE).

With copy mode "Mode" = 0, you specify that all defined elements already present in the cam are set as invalid before the copy operation ("ValidPoint" = FALSE, "ValidSegment" = FALSE). This results in only the inserted elements being valid after the copy operation. Use this copy mode to completely regenerate the cam and overwrite its previous synchronous operation function.

Use copy mode "Mode" = 1 to specify that all defined elements already present in the cam remain valid ("ValidPoint" = TRUE, "ValidSegment" = TRUE). This results in both the inserted

elements and the still existing elements not overwritten being valid after the copy operation. Use this copy mode to append cam elements to the previous synchronous operation function of the cam, or to partially overwrite the synchronous operation function of cam.

Copy operation

Copying of cam elements is possible during active cam synchronization.

An active copy operation is indicated by the "MC_CopyCamData.Busy" = TRUE parameter, in the "<TO>.StatusWord.X7 (CopyCamDataActive)" tag as well as in the status and error bits of the diagnostics of the technology object. Only one active "MC_CopyCamData" job is possible at a given time on a cam.

As soon as the cam elements have been copied and set to valid, the copy operation is complete. The status is indicated in the Motion Control instruction with the parameter "Done" = TRUE. The "<TO>.StatusWord.X4 (CamDataChanged)" tag of the technology object is set to "TRUE".

Before you can use the cam with the inserted elements, the cam must be interpolated. To do this, start an "MC_InterpolateCam" job.

9.2.3 Creating the synchronous operation function of the cam with the "LCamHdl" library

The "LCamHdl" library provides function blocks that support you in creating jerkless cams in accordance with VDI guideline 2143. The function blocks perform the required calculations of the segments for different profile types, e.g. the polynomial coefficients.

In addition, you can use the optimized "Basic" function block with a simplified user interface to define the synchronous operation function of the cam in terms of points and associated dynamic values. From this, the function block calculates the corresponding segments according to a 5th degree polynomial function.

More information

You can find additional information about the "LCamHdl" library in the Siemens Industry Online Support under entry ID 105644659 (https://support.industry.siemens.com/cs/ww/en/view/105644659).

An application example shows the creation of cams with the "LCamHdl" library and switching of two cams using the example of a press. The application example can be found in the Siemens Industry Online Support under entry ID 109749460 (https://support.industry.siemens.com/cs/ww/en/view/109749460).

9.2.4 Transferring the synchronous operation function of the cam defined online to the offline project

After you have defined or changed the synchronous operation function of the cam at runtime of the user program, you can transfer the synchronous operation function to the offline project. To do this, use the cam diagnostics.

Requirement

- You have adapted the synchronous operation function of a cam online.
- The current cam data is contained in the technology object data block.

Procedure

To transfer the adapted synchronous operation function of the cam to the offline project, follow the steps below:

1. Open the cam diagnostics.
2. Save a snapshot of the online configuration of the cam (Page 273).
3. Export the saved snapshot in binary format (Page 274).
4. Open the cam configuration.
5. Import the exported snapshot of the cam (Page 274).
6. Compile the cam technology object (Page 134).

   The configuration from the cam editor is transferred to the technology object data block of the cam. All existing values are overwritten.

   An online/offline inconsistency is displayed for the Cam technology object because the start values differ.
7. Load the Cam technology object to the CPU again.

Result

You have transferred the synchronous operation function of the cam defined online to the offline project.

9.3 Interpolating a cam

9.3.1 Configuring transitions

To use a cam in the user program, you must interpolate the cam after downloading to the CPU or after adapting the technology object data block. The interpolation closes the gaps between the defined interpolation points and segments of the cam. These missing ranges are called transitions. The interpolation type defines how the transitions are interpolated.

Configuring interpolation

You specify the interpolation type in the configuration of the technology object. You can set the interpolation separately for each transition in the cam. The following methods are possible:

- System interpolation (Page 144):

  The system interpolation is the default for interpolation of the transitions. You configure the system interpolation for all transitions in the properties (Inspector window) in the "Profile > System interpolation" configuration window.

- Interpolation according to VDI Guideline 2143 (Page 147):

  You can adapt each transition separately according to the VDI Guideline 2143. The settings in the properties (Inspector window) in the "Profile > Default optimization settings" configuration window are hereby taken into consideration.

"Characteristic" configuration window

In the "Characteristic" configuration window, you configure the parameters for optimizing the selected transition in the properties (Inspector window):

Parameters	Description
Interpolation settings of the transition	
Optimization method	Select the optimization method in the drop-down list: • System interpolation (Page 144) The CPU defines the optimization parameters automatically according to the settings of the system interpolation. • VDI-based optimization (Page 147) Adjust the optimization manually. The inputs are applied automatically according to the VDI Guideline 2143.
Motion task	The transition type is determined from the properties of the adjacent elements of the transition and displayed in this field.
Continuity at start/end	In the drop-down lists, select which parameter is continuous in the boundary points and is to be included for optimization: • Default optimization setting (setting under "Profile > Default optimization settings") • Position • Velocity (bumpless) • Acceleration (jerkless) • Jerk (jerk continuity permitted on one side only)

Parameters	Description
Optimization target	In the drop-down list, select the optimization target: • Default optimization setting (setting under "Profile > Default optimization settings") • Not specified • Velocity (Cv) • Acceleration (Ca) • Jerk (Cj) • Dynamic torque (Cmdyn)
Selection of motion rule	
Motion rule	In the drop-down list, select the motion rule according to which optimization is to occur: • Line • Quadratic parabola • Sine • Polynomial • Inclined sine • Modified acceleration trapezoid • Modified sine • Harmonic combination • Double-harmonic transition • Sine line combination The selection is automatically limited to the motion rules that can be applied according to the motion task and the selected boundary conditions. Additional parameters are displayed depending on the selected motion rule. If you have changed the motion task in such a way that the motion rule can no longer be applied, a notice is displayed. In this case, you need to select a motion rule that can be applied.
Parameter used	In the drop-down list, select the parameters to be included in the optimization: • Lambda • Maximum acceleration (Ca) • Maximum deceleration (Ca*) The selection is automatically limited to the parameters that can be applied according to the motion rule.
Lambda	In the drop-down list, select the transition point in the "Lambda position" field: • No lambda Do not enter any value. The position of the point of inflection is calculated automatically. • Relative to segment Specify the leading value of the point of inflection relative to the transition from 0.0 to 1.0. The value 0.0 corresponds to the beginning of the transition. The value 1.0 corresponds to the end of the transition. • Absolute in the profile You specify the leading value of the point of inflection as an absolute value.
Lambda position	In this field, configure the leading value of the point of inflection for the transition according to the selection in the "Lambda" drop-down list.
Maximum acceleration (Ca)	Configure the maximum acceleration (Ca) for the transition in this field.

Parameters	Description
Maximum deceleration (Ca*)	Configure the maximum deceleration (Ca*) for the transition in this field.
Approximation	
Number of interpolation points	In this field, configure the number of interpolation points for the transition.
Maximum following value tolerance	In this field, enter the maximum permitted deviation (absolute) of the approximation from the motion rule. If the configured value is exceeded, a warning is displayed in the graphical editor at the transition.
Characteristic values of the transition	The characteristic values of the transition that are relevant according to VDI 2143 are displayed in this area. The maximum value and the standardized value are displayed for the following characteristic values: • Velocity (Cv) • Acceleration (Ca) • Deceleration (Ca*) • Jerk (Cj) • Dynamic torque (Cmdyn)

9.3.2 System interpolation

With system interpolation, the transitions are interpolated according to the interpolation type and the response in the boundary points of the transition segment. The following interpolation methods are possible:

- **Linear interpolation**

  Gaps in the curve are closed with a straight line.

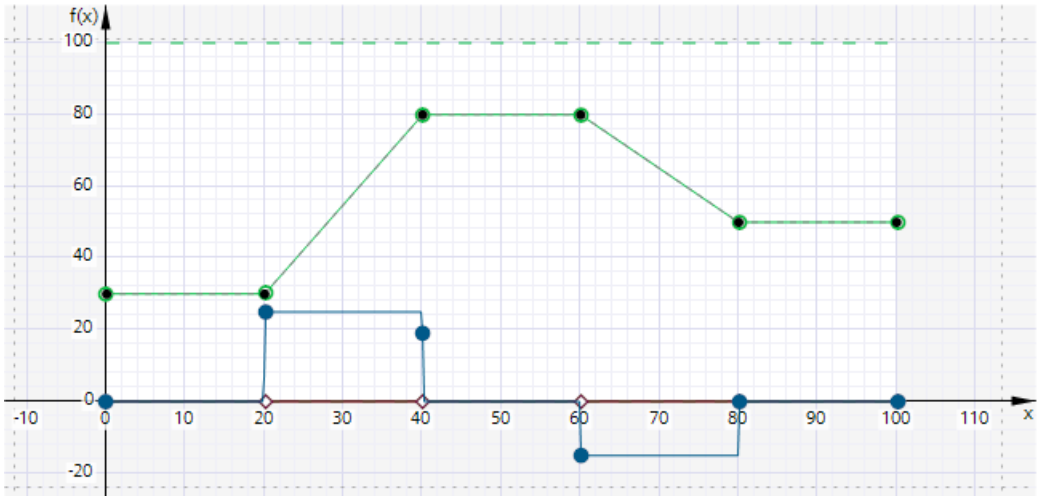

Specified position (point)
Interpolated position
Resulting velocity (scaled)
Resulting acceleration
Resulting jerk

- **Interpolation with cubic splines**

  The interpolated curve runs through the interpolation points and the segments of the curve.

  After interpolation has been completed, the value range of the following value of the cam can be greater than before interpolation.

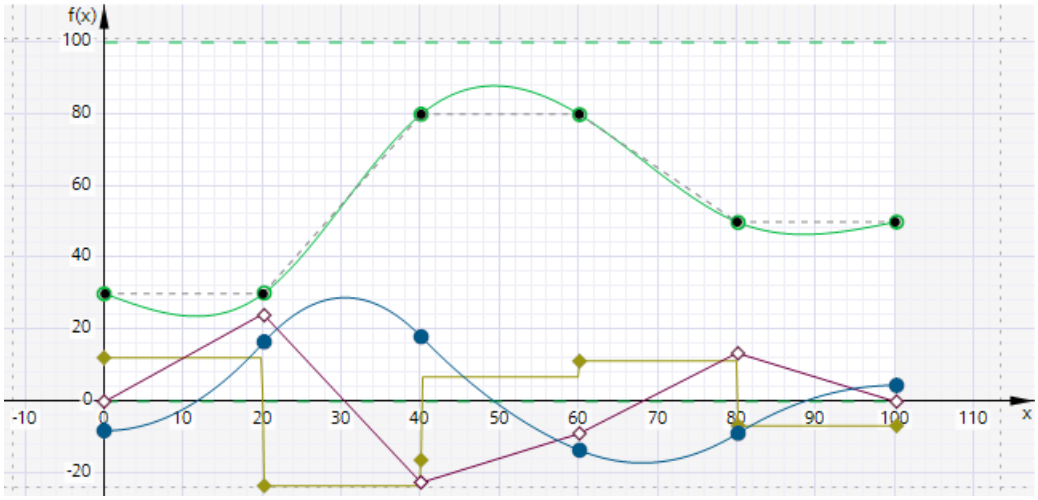

Specified position (point)
Interpolated position
Resulting velocity (scaled)
Resulting acceleration (scaled)
Resulting jerk (scaled)

- **Interpolation with Bézier splines**

  The interpolated curve runs along the interpolation points and through the segments of the curve.

  The range of the cam is not changed by interpolation.

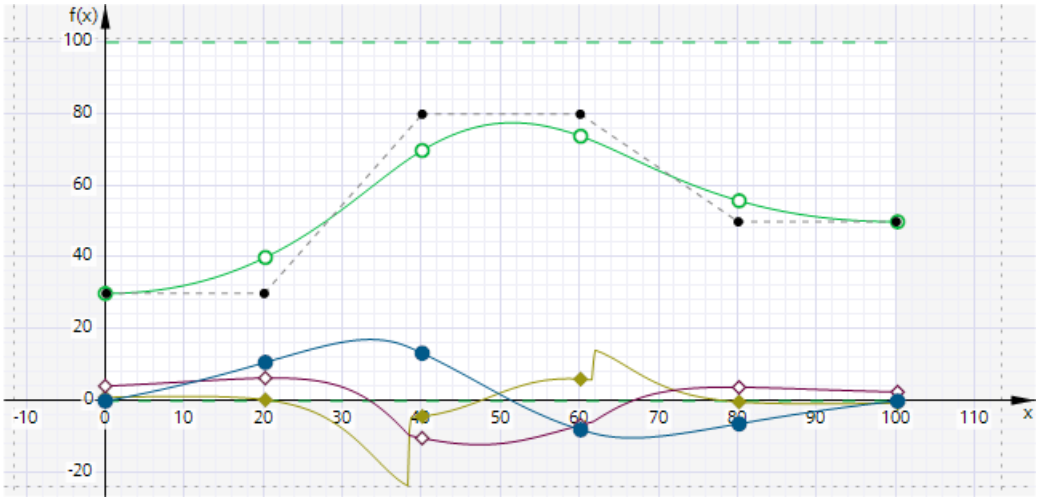

Specified position (point)
Interpolated position
Resulting velocity (scaled)
Resulting acceleration (scaled)
Resulting jerk (scaled)

NOTE

Differences in the interpolation types

Depending on the definition of the cam, high dynamic responses can result when interpolating with cubic splines, as the interpolated curve always runs through the specified points. The course of the curve for interpolation via cubic splines runs through all specified points, while the course of the curve for interpolation via Bézier splines is only based on the points and thus results in lower dynamic values.

If required, select an interpolation using Bézier splines in order to obtain a smooth, slower interpolated curve.

"System interpolation" configuration window

In the "System interpolation" configuration window, configure the interpolation of transitions according to the system specifications in the properties (Inspector window). These settings are used when the "System interpolation" optimization method is used for a transition (Page 142) (default setting).

Configure the interpolation type and the behavior of the boundary points in this area:

Parameter	Description
Interpolation type	In the drop-down list, select the interpolation type by which the transitions in the curve are interpolated: • Linear interpolation In linear interpolation, the transitions (magenta) between the cam elements (blue) are defined by a straight line. • Interpolation with cubic splines In the interpolation with cubic splines, the transitions (magenta) between the cam elements (blue) are defined so that the interpolated curve runs through all the cam elements. The acceleration (green) in the transition is linear. • Interpolation with Bézier splines In the interpolation with Bézier splines, the transitions (magenta) between the cam elements (blue) are defined so that the interpolated curve is based on specified points and the curve runs through other cam element types.
Behavior at boundary	In the drop-down list, select which behavior of the interpolation applies to a cyclic use of the cam in the boundary points: • No restrictions The areas between the elements are closed. • First derivative continuous (velocity continuous) The cam is interpolated in such a way that the first derivative (velocity) is equal at the start and end of the cam.

See also

MC_InterpolateCam: Interpolate cam V10 (Page 350)

9.3.3 Interpolation according to VDI Guideline 2143

The VDI Guideline 2143 deals with motion rules for cam gears. The aim of these motion rules is to achieve high running quality and to avoid jolts and jerks.

The VDI Guideline 2143 distinguishes between areas of usage and motion transitions:

- Areas of usage correspond to the sequences in a process, which means the inserted elements of the cam.
- Motion transitions are transitions between areas of usage that are not directly relevant to the process but must meet specific boundary conditions, for example, velocity consistency.

The following motion tasks are defined based on VDI Guideline 2143:

Motion task	Designation	Properties
Dwell	R	Velocity = 0 Acceleration = 0
Constant velocity	G	Velocity ≠ 0 Acceleration = 0
Reverse	U	Velocity = 0 Acceleration ≠ 0
Motion	B	Velocity ≠ 0 Acceleration ≠ 0

The graphic below shows an example of the motion jobs:

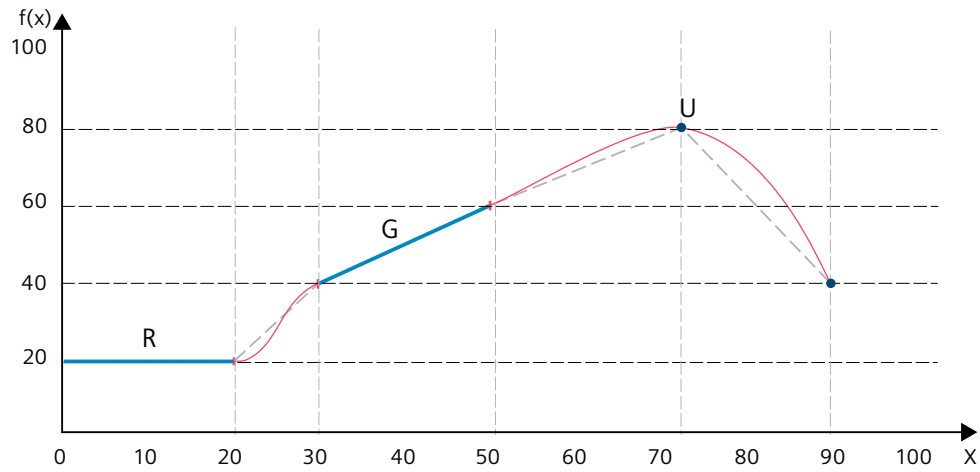

The following graphic shows the possible combinations of motion jobs:

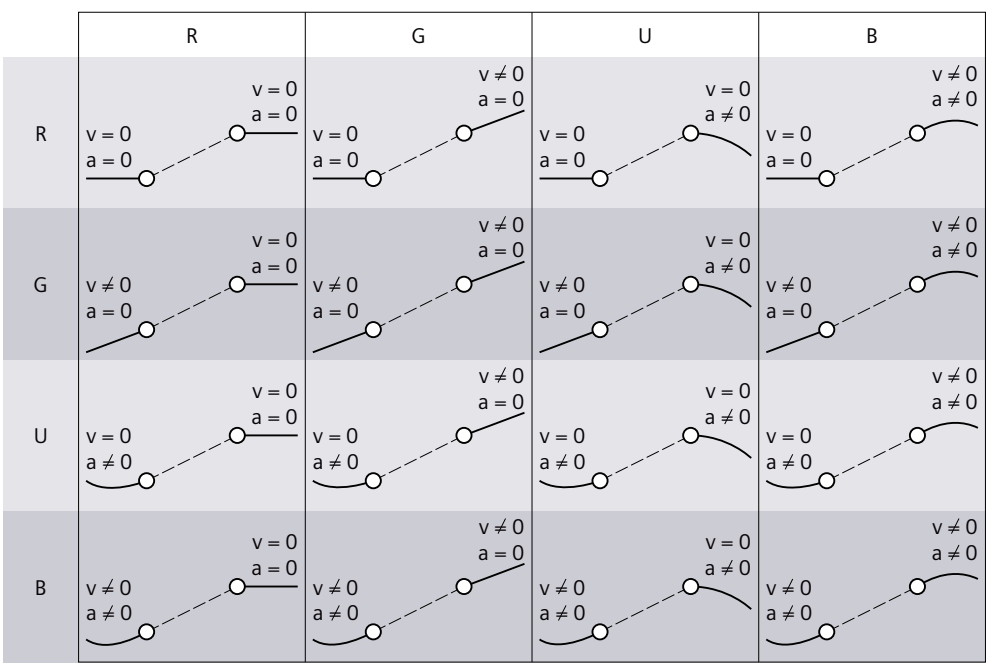

Adjust the optimization of a transition

To adapt the optimization of a transition according to the VDI Guideline 2143, follow these steps:

1. Select the transition in the graphical or tabular editor.
2. In the properties (Inspector window), open the "Element > Characteristic (Page 142)" configuration window.
3. Select the optimization method "VDI-based optimization" in the "Optimization method" drop-down list.
4. If necessary, change the default settings.

   The selection of the parameters is automatically limited to the settings that can be applied according to VDI Guideline 2143.

You interpolate the cam with the Motion Control instruction "MC_InterpolateCam (Page 350)" according to the settings for the VDI optimization. Note that, in contrast to system interpolation, the optimization of transitions according to VDI Guideline 2143 directly occupies segments in the technology object data block. This optimization type is thus not possible via "MC_InterpolateCam" during runtime.

"Default optimization settings" configuration window

You configure the default values for optimization of transitions according to VDI Guideline 2143 in the "Profile > Default optimization settings" configuration window in the properties (Inspector window). The default values are used when the "VDI-based optimization" optimization method is selected for a transition (Page 142) and when the setting "Default optimization setting" is selected for the continuity or the optimization target.

Configure the default settings for continuity requirement and optimization target in this area:

Parameter	Description
Continuity	In the drop-down list, select which parameter is continuous in the boundary points and is to be taken into consideration for optimization: • Position • Velocity • Acceleration • Jerk
Optimization target	In the drop-down list, select the optimization target according to the VDI Guideline: • Not specified • Velocity (Cv) • Acceleration (Ca) • Jerk (Cj) • Dynamic torque (Cmdyn)

9.3.4 Interpolate cam with "MC_InterpolateCam"

To use a cam in the user program, you must interpolate the cam after downloading to the CPU or after adapting the technology object data block. The interpolation closes the gaps between the defined interpolation points and segments of the cam. The interpolation type defines how missing ranges are interpolated.

NOTE

Improving system performance

To improve the system performance for interpolating the cam technology object, select the "Improve system performance" check box in the properties of MC_Interpolator under "General > Multi-core processor".

After you have configured the interpolation type (Page 142), you interpolate a cam in the user program with the Motion Control instruction "MC_InterpolateCam (Page 350)". After starting the "MC_InterpolateCam" job, the cam is interpolated in the definition range from the minimum to the maximum value in the leading value range:

- The minimum value in the leading value range is the first defined interpolation point or start of the first segment of the cam (<TO>.StatusCam.StartLeadingValue) with the associated following value (<TO>.StatusCam.StartFollowingValue).
- The maximum value in the leading value range is the last defined interpolation point or end of the last segment of the cam (<TO>.StatusCam.EndLeadingValue) with the associated following value (<TO>.StatusCam.EndFollowingValue).

As soon as the cam has been interpolated, this is indicated on the "MC_InterpolateCam" Motion Control instruction with parameter "Done" = TRUE and in the tag "<TO>.StatusWord.X5 (Interpolated)" = TRUE of the technology object. After interpolation, an explicit value in the value range is assigned to each value in the definition range.

9.4 Scaling and shifting cam

You can scale and shift the utilized cam for camming (Page 102) at the Motion Control instruction "MC_CamIn" in the leading and following value range. The configured cam is not changed by this. In contrast, the specification for leading and following value range in the configuration of the technology object only effect the display in the graphical editor.

The following diagram shows the general sequence of scaling and shifting the cam:

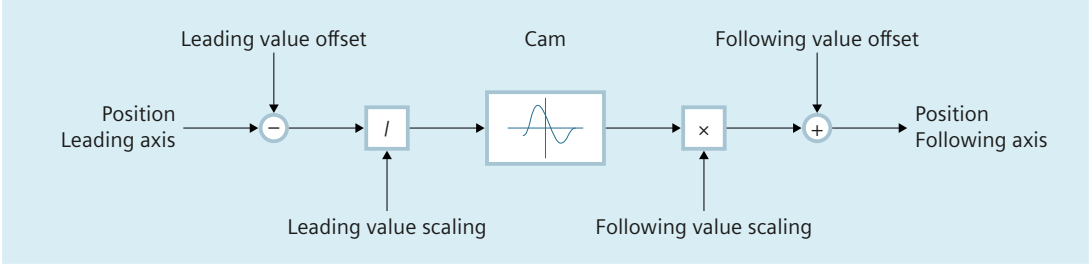

Position following axis = f[(Position leading axis - Leading value shift) / Leading value scaling] × Following value scaling + Following value shift

Parameter inputs

You define the use of the cam with the following parameters of the Motion Control instruction "MC_CamIn (Page 323)":

- With the "MasterScaling" parameter, you specify the scaling of the cam in the leading value range. The value "0.0" is invalid.
- With the "SlaveScaling" parameter, you specify the scaling of the cam in the following value range.
- You define the offset of the cam in the leading value range with the parameter "MasterOffset".
- You define the offset of the cam in the following value range with the parameter "SlaveOffset".

Scaling of the cam

The figure below shows the basic effect of scaling the cam with the parameters "MasterScaling" and "SlaveScaling":

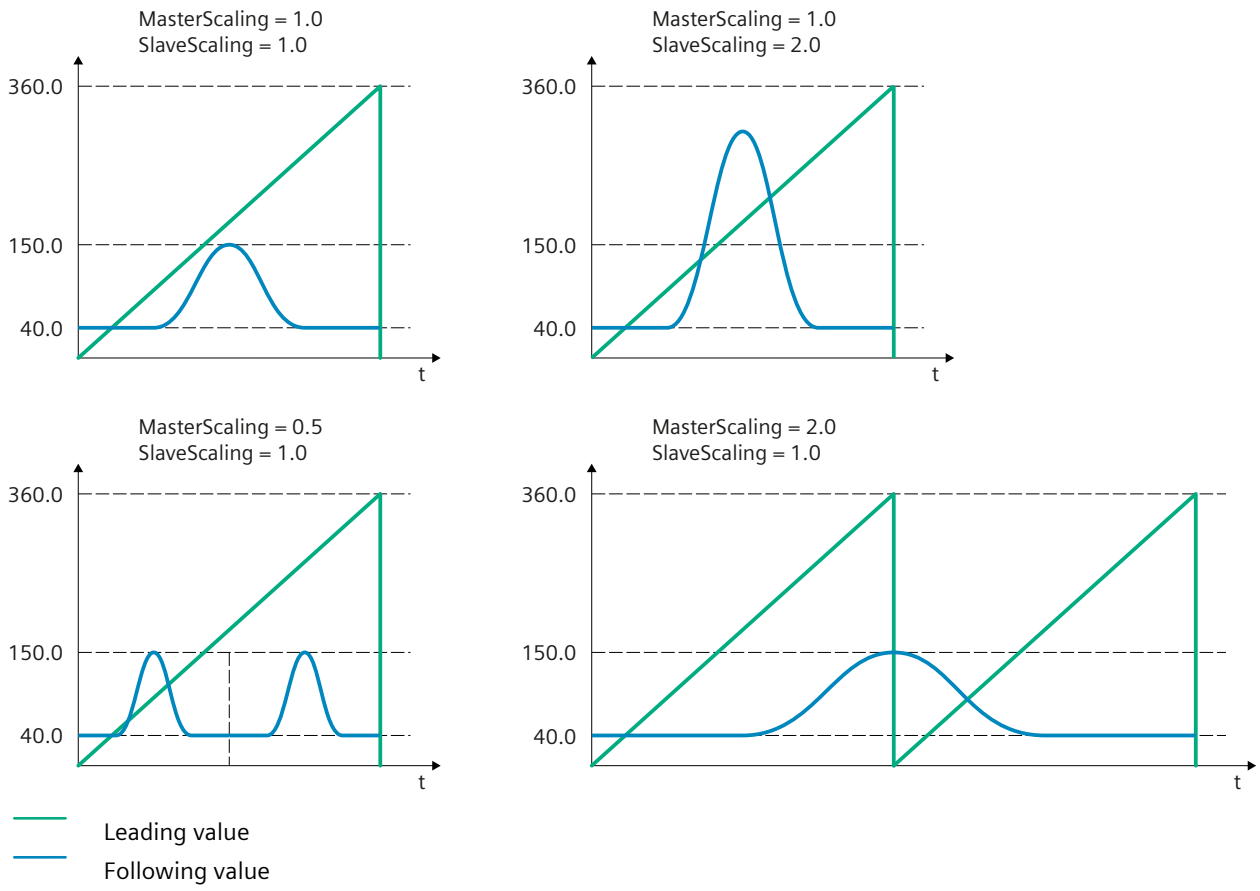

Shifting of the cam

The following figure shows the basic effect of the leading value and following value offset as well as the position of the cam with the following parameter values:

- "MasterOffset" > 0
- "SlaveOffset" > 0
- Start position of the cam > 0
- "MasterSyncPosition" > 0

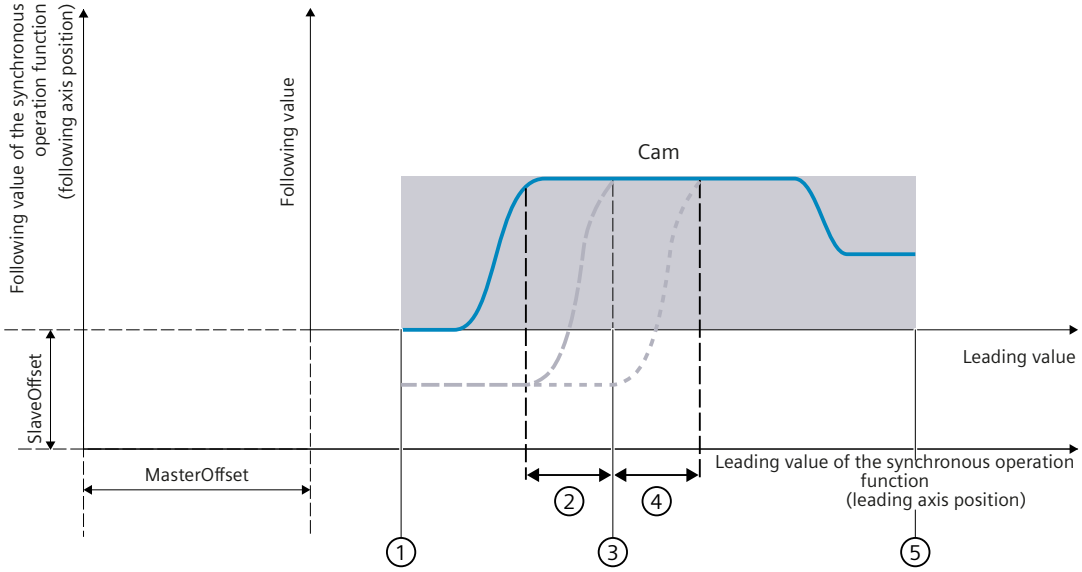

① Start position of the cam
First defined interpolation point or start of the first segment of the cam (<TO>.StatusCam.StartLeadingValue)

② Leading value distance with synchronization in advance ("MasterStartDistance")

③ Synchronous position of the leading axis relative to the starting position of the cam ("MasterSyncPosition")

④ Leading value distance with subsequent synchronization ("MasterStartDistance")

⑤ End position of the cam
Last defined interpolation point or end of the last segment of the cam (<TO>.StatusCam.EndLeadingValue)

9.5 Scaling a cam range

Use the Motion Control instruction "MC_SetCamRangeScaling" to scale a cam range. The configuration of the cam technology object is not changed.

You can use range scaling during camming. The range scaling is also in effect for the scaling of the cam by the "MC_CamIn" job.

Parameter inputs

You define the use of the cam with the following parameters of the Motion Control instruction "MC_SetCamRangeScaling (Page 360)":

- Use the "Mode" parameter to define the scaling mode.
- With the "RangeNumber" parameter, you define the number of the scaling range.
- Use the "RangeStartPoint" parameter to define the start point. The start point must be less than or equal to the end point.
- Use the "RangeEndPoint" parameter to define the end point. The end point must be greater than or equal to the start point.
- Use the "RangeScaling" parameter to define the scaling factor. Only values > 0.0 are permitted.

Scaling mode

The scaling mode defines whether the scaling range refers to the leading value range or the following value range:

- Use the "Mode" = 1 parameter to define a range scaling in the leading value range.
- Use the "Mode" = 2 parameter to define a range scaling in the following value range.

Scaling range

Use the "RangeStartPoint" and "RangeEndPoint" parameters to define the start and end of the scaling range. The scaling range always refers to the unscaled interpolated cam.

With the "RangeNumber" parameter, you define the number of the scaling range. Up to two scaling ranges are possible for one cam. The scaling ranges may overlap.

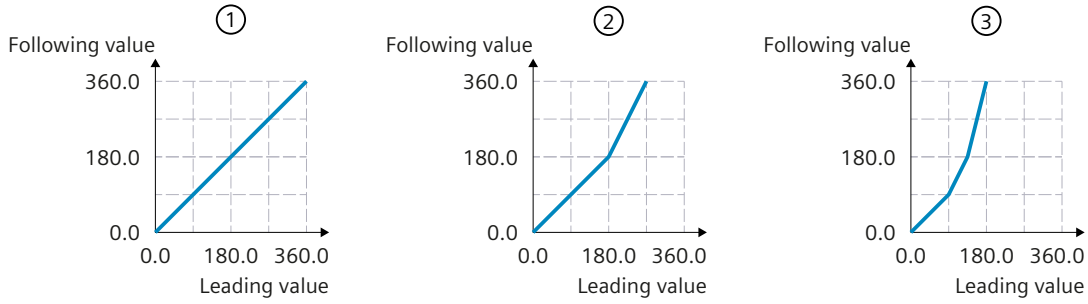

① Unscaled interpolated cam

② Scaled cam with the first range scaling in the leading value range

③ Scaled cam with the first and second range scaling in the leading value range

In the chart ②, the cam ① is scaled with a "MC_SetCamRangeScaling" job in the leading value range:

- "Mode" = 1
- "RangeNumber" = 1
- "RangeStartPoint" = 180.0
- "RangeEndPoint" = 360.0
- "RangeScaling" = 0.5

In the chart ③, the scaled cam ② is scaled again with a "MC_SetCamRangeScaling" job in the leading value range. The parameter specifications refer to the unscaled cam ①:

- "Mode" = 1
- "RangeNumber" = 2
- "RangeStartPoint" = 90.0
- "RangeEndPoint" = 360.0
- "RangeScaling" = 0.5

The two scaling ranges overlap.

NOTE

Discontinuity of the first derivative

The range scaling of an interpolated cam leads to discontinuities in the first derivative of the cam. This also applies to interpolation with cubic splines or Bézier splines.

Recommendation: Apply a range scaling within a dwell range of the cam.

Scaling range outside the definition or value range

You can also define the scaling range outside the definition or value range of the cam. If the scaling range is in a range in which the values are lower than the lowest value of the definition or value range of the cam, the range scaling also influences the definition or value range of the cam. If the scaling range is in a range in which the values are greater than the highest value of the definition or value range of the cam, the definition or value range of the cam remains unaffected.

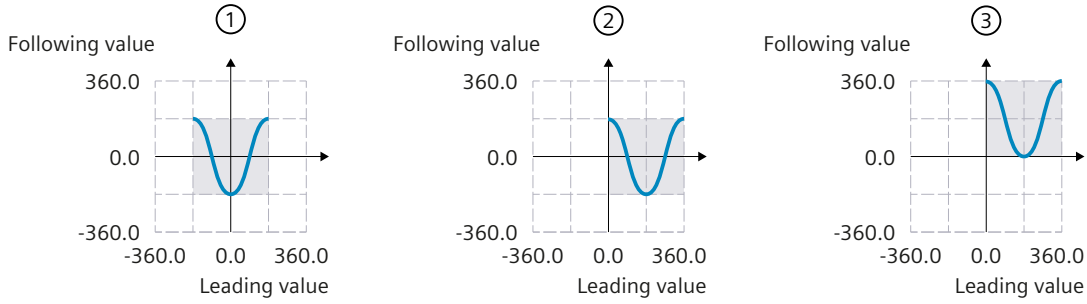

① Unscaled interpolated cam

② Scaled cam with range scaling in the leading value range

③ Scaled cam with range scaling in the leading value range and range scaling in the following value range

In the chart ②, the cam ① is scaled with a "MC_SetCamRangeScaling" job in the leading value range:

- "Mode" = 1
- "RangeNumber" = 1
- "RangeStartPoint" = -360.0
- "RangeEndPoint" = -180.0
- "RangeScaling" = 2

In the chart ③, the scaled cam ② is scaled with a "MC_SetCamRangeScaling" job in the following value range. The parameter specifications refer to the unscaled cam ①:

- "Mode" = 2
- "RangeNumber" = 2
- "RangeStartPoint" = -360.0
- "RangeEndPoint" = -180.0
- "RangeScaling" = 2

Difference to scaling with "MC_CamIn"

When scaling the entire cam with "MC_CamIn" via the parameters "MasterScaling" and "SlaveScaling", position 0.0 is the reference point for the scaling calculation.

When scaling the entire cam with "MC_SetCamRangeScaling", the reference point for the scaling calculation is the lowest value in the leading value range and in the following value range.

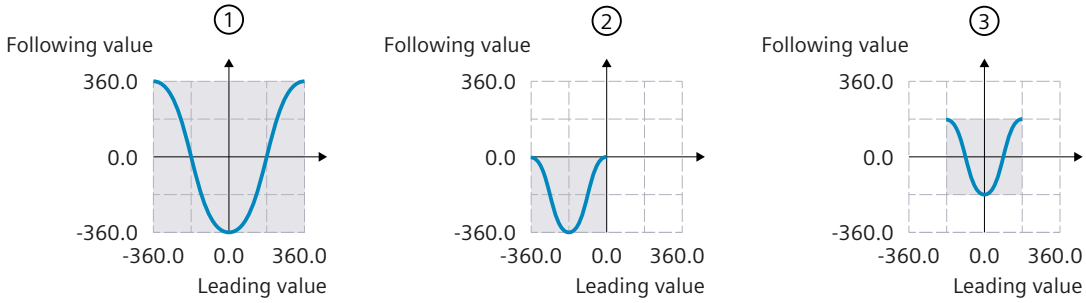

① Unscaled interpolated cam

② With "MC_SetCamRangeScaling" scaled cam

③ With "MC_CamIn" scaled cam

In the chart ②, the cam ① is scaled with two "MC_SetCamRangeScaling" jobs. In the chart ③, the cam ① is scaled with a "MC_CamIn" job. In both cases, the cam is scaled by a factor of 0.5 from -360.0 to 360.0 in the leading value range and in the following value range.

After the "MC_SetCamRangeScaling" job has started

The scaling of the cam is calculated after starting the "MC_SetCamRangeScaling" job. The scaling takes effect immediately as soon as the job is completed with "Done" = TRUE. The status is indicated with the tag "<TO>.StatusWord.X9 (CamRangeScaled)" = TRUE of the cam technology object.

NOTE

Dynamic jumps

The range scaling takes effect immediately. If camming with "MC_CamIn" is active, dynamic jumps may occur on the following axis.

Check the dynamic behavior with range scaling.

Recommendation:

- Perform range scaling in the leading value range only in a dwell range of the following axis while the following axis moves the range to be scaled so that the following axis is stationary before and after the applied range scaling.
- Do not perform range scaling in the leading value range if the range to be scaled has already been moved by the following axis in the current cam cycle.
- Do not perform range scaling in the following value range if the range to be scaled is moved from the following axis.

If the cam is interpolated again, all range scaling is reset.

9.6 Defining application mode of the cam

For camming (Page 102), you can define the application mode of the cam. The following modes are available:

- Not cyclic
- Cyclic
- Cyclic appending

A cam is defined between the start position (<TO>.StatusCam.StartLeadingValue) and end position (<TO>.StatusCam.EndLeadingValue) after the interpolation.

Parameter inputs

You define the use of the cam with the following parameters of the Motion Control instruction "MC_CamIn (Page 323)":

- With the "ApplicationMode" parameter, you define the application mode of the cam.

Not cyclic

With the "ApplicationMode" = 0 parameter, you define the application mode of the cam as "Not cyclic".

The cam is run exactly once. When the cam is run through in the positive direction, synchronous operation is ended when the end position of the cam is reached. When the cam is run through in the negative direction, synchronous operation is ended when the start position of the cam is reached.

To prevent step changes in the dynamic values, the velocity of the following axis must be zero at the start and end position of the cam.

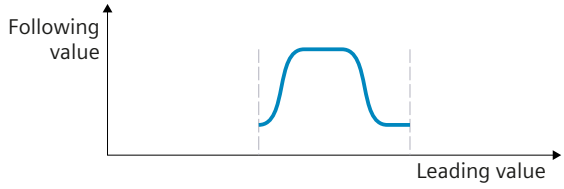

The end of the synchronous operation is reached on the setpoint side with the parameter "EndOfProfile" = TRUE of the "MC_CamIn" job. To wait with the further program processing until the following axis has reached the setpoint on the actual value side, evaluate the "<TO>.StatusWord.X6 (Done)" tag of the following axis.

If the "<TO>.StatusWord.X6 (Done)" tag is set to TRUE, the "<TO>.StatusWord.X22 (Synchronous)" tag of the technology object and the "InSync" parameter of the "MC_CamIn" job are reset to FALSE. With this, synchronous operation is ended.

You can find more information on reaching the positioning window in the section ""PositioningMonitoring" tag (synchronous axis) (Page 398)".

Cyclic

With the "ApplicationMode" = 1 parameter, you define the application mode of the cam as "Cyclical".

The cam is run cyclically. When the cam is run through in the positive direction, the cam is repeated from the start position when the end position of the cam is reached. When the cam is run through in the negative direction, the cam is repeated from the end position when the start position of the cam is reached.

To prevent step changes in the dynamic values, the start and end positions of the cam must be match, and the velocity at the start and end position must be identical. For a velocity continuous transition, use the setting "First derivative continuous (velocity continuous)" under "Properties (Inspector window) > System interpolation > Behavior at boundary" (<TO>.InterpolationSettings.BoundaryConditions = 1) for interpolation of the cam.

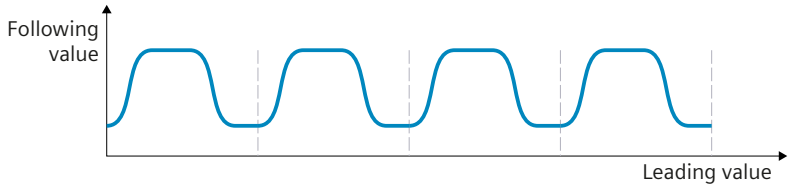

Cyclic appending

With the "ApplicationMode" = 2 parameter, you define the application mode of the cam as "Cyclic appending".

The cam is run cyclically. When the cam is run through in the positive direction, the end position of the cam is used as the start position for the next run. When the cam is run through in the negative direction, the start position of the cam is used as the start position for the next run. The position difference between the start and end position on the following value side is added up.

To prevent step changes in the dynamic values, the velocity at the start and end position must be identical. For a velocity continuous transition, use the setting "First derivative continuous (velocity continuous)" under "Properties (Inspector window) > System interpolation > Behavior at boundary" (<TO>.InterpolationSettings.BoundaryConditions = 1) for interpolation of the cam.

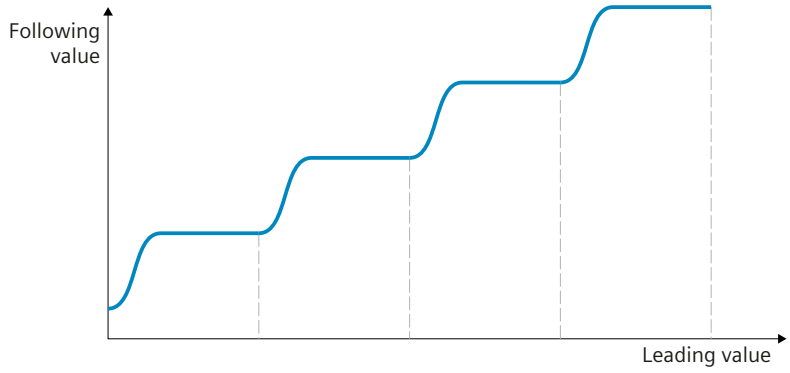

9.7 Dynamic limits of the following axis in camming

If a synchronous axis is operated as a following axis in cam synchronization with the Motion Control instruction "MC_CamIn (Page 323)" or desynchronized with the Motion Control instruction "MC_CamOut (Page 343)", the following dynamic limits apply depending on the phase of the synchronization:

Pending synchronous operation

If synchronous operation is not active, the configured dynamic limits of the following axis apply. If there is already a synchronous operation active, the descriptions in the following sections apply.

Synchronization and desynchronization via dynamic parameters

When synchronizing with "MC_CamIn" and desynchronization with "MC_CamOut" via dynamic parameters, the dynamic limits configured on the technology object apply to the following axis:

- <TO>.DynamicLimits.MaxVelocity
- <TO>.DynamicLimits.MaxAcceleration
- <TO>.DynamicLimits.MaxDeceleration
- <TO>.DynamicLimits.MaxJerk

The SW limit switches also continue to be monitored with the configured dynamic limits of the following axis.

Synchronization and desynchronization via leading value distance and synchronous operation

When synchronizing and desynchronizing via the leading value distance with "MC_CamOut" and during synchronous travel, the dynamics of the following axis are only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity). The dynamics of the following axis results from the synchronous operation function.

If the dynamic limits configured for the following axis are exceeded, this is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The SW limit switches continue to be monitored with the configured dynamic limits of the following axis.

If the following axis cannot follow the leading value, this results in a following error, which is monitored by the following error monitoring.

End or override synchronous operation

As soon as synchronous operation has been overridden, the dynamic limits configured for the technology object apply to the following axis again. With the start of the overriding job, the active dynamics are transitioned (smoothed) to the configured dynamic limits and the specifications for the Motion Control instruction.

9.8 Synchronizing camming

9.8.1 Parameter overview for synchronizing with "MC_CamIn"

During camming (Page 102), synchronization establishes the relationship between the leading axis and following axis. With the parameter "SyncProfileReference" you define the type of synchronization:

SyncProfileReference	Synchronization profile
0	Synchronization in advance using dynamic parameters (Page 163)
1	Synchronization in advance using leading value distance (Page 164)
2	Direct synchronous setting (Page 175)
3	Subsequent synchronization using leading value distance (Page 171)
4	Subsequent synchronization using leading value distance starting from current leading value position (Page 173)
5	Direct synchronous setting at the end of the cam (Page 176)
6	Synchronization in advance using leading value distance starting from current leading value position (Page 167)
7	Direct synchronous setting to specific leading value position (Page 177)

Depending on the synchronization profile, different parameters of the Motion Control instruction "MC_CamIn (Page 323)" are relevant:

Parameters	SyncProfileReference							
	0	1	2	3	4	5	6	7
MasterOffset	✓	✓	-	✓	✓	-	-	✓
SlaveOffset	✓	✓	-	✓	✓	-	✓	-
MasterScaling	✓	✓	✓	✓	✓	✓	✓	✓
SlaveScaling	✓	✓	✓	✓	✓	✓	✓	✓
MasterSyncPosition	✓	✓	✓	✓	-	✓	✓	✓
MasterStartDistance	-	✓	-	✓	✓	-	✓	-
Velocity	✓	-	-	-	-	-	-	-
Acceleration	✓	-	-	-	-	-	-	-
Deceleration	✓	-	-	-	-	-	-	-
Jerk	✓	-	-	-	-	-	-	-
ApplicationMode	✓	✓	✓	✓	✓	✓	✓	✓
SyncDirection	✓	✓	-	✓	✓	-	✓	-

9.8.2 Defining direction of synchronization with "MC_CamIn"

During camming (Page 102), synchronization establishes the relationship between the leading axis and following axis. If you have activated the "Modulo" setting for the following axis, you can define the direction of the synchronization with the "SyncDirection" parameter of the Motion Control instruction "MC_CamIn (Page 323)".

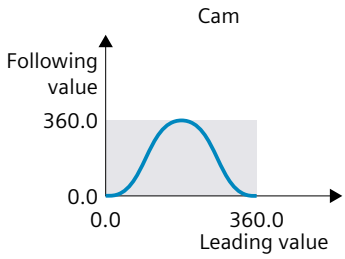

Positive direction

With "SyncDirection" = 1, the following axis may only travel in positive direction during synchronization. In this example, the synchronous position is 0.0.

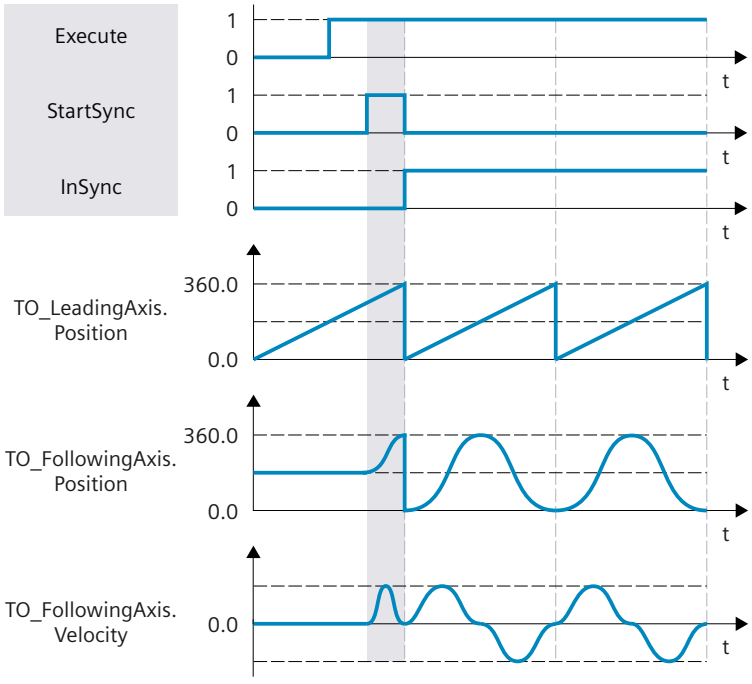

Negative direction

With "SyncDirection" = 2, the following axis may only travel in negative direction during synchronization. In this example, the synchronous position is 0.0.

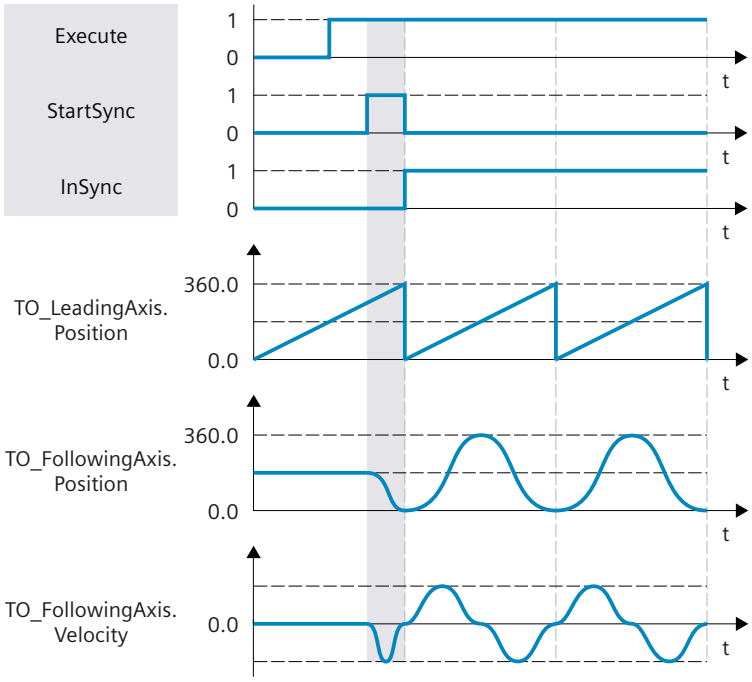

Shortest distance

With "SyncDirection" = 3, changes in direction of the following axis are permitted during synchronization. In this example, the synchronous position is 90.0.

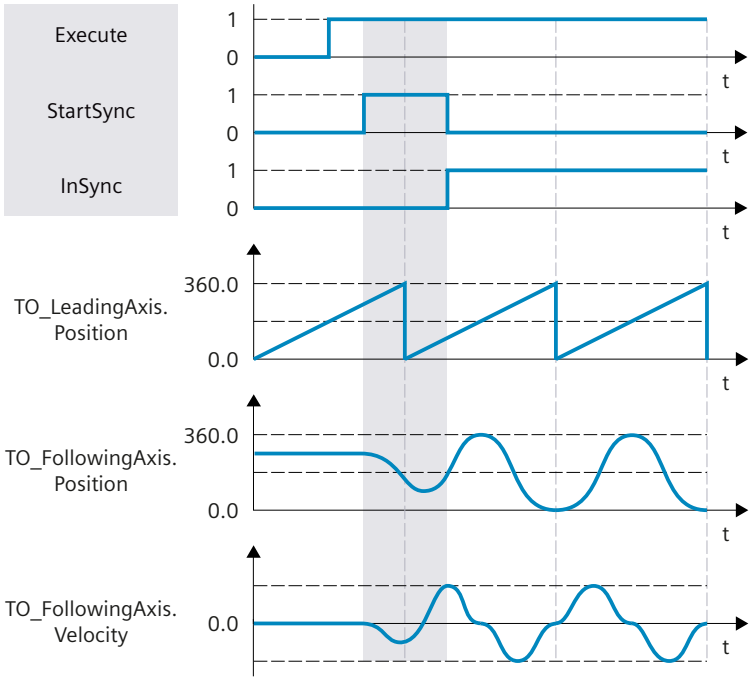

9.8.3 Synchronizing following axis in advance using dynamic parameters with "MC_CamIn"

During camming (Page 102), synchronization establishes the relationship between the leading axis and following axis. During synchronization in advance using dynamic parameters, synchronization begins in such a way that the leading and following axis are synchronous when the synchronous position is reached.

Parameter inputs

You define the behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_CamIn (Page 323)":

- With the parameter "SyncProfileReference" = 0, you define the type of synchronization as synchronization in advance using dynamic parameters.
- With the parameter "MasterSyncPosition", you define the synchronous position of the leading axis relative to the start position of the cam. The synchronous position establishes the relationship between leading value and following value. The synchronous position must be within the definition of the cam. With "MasterSyncPosition" ≠ 0.0, you move the synchronous position within the cam without changing the position of the cam. For synchronization in advance, the synchronous position is the position starting from which the leading and following axes are synchronous.
- With the parameters "Velocity", "Acceleration", "Deceleration" and "Jerk" you define the dynamics for the synchronization of the following axis.

Until synchronization

After the start of the "MC_CamIn" job, a motion profile for the following axis is calculated continuously. The motion profile is calculated based on the following parameters:

- Specified synchronous position of the Motion Control instruction
- Specified dynamics of the Motion Control instruction
- Current position and dynamics of the leading and following axes
- Synchronous operation specified via cam

The calculation determines the synchronization length and thus the start position of the leading axis for the synchronization.

The start position of the leading axis is derived in the following way:

Start position = Synchronous position of leading axis - Synchronization length

The status "Waiting" is displayed at the following axis until the leading value has reached the start position (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 3).

If the leading axis is already in its synchronous position when the "MC_CamIn" job is started, the leading axis must first cross the start position to start synchronization. If the leading and following axes are already at their synchronous positions when the "MC_CamIn" job is started, synchronous operation immediately has "Synchronous" status.

During synchronization

The following axis begins to synchronize as soon as the leading value has reached the start position. The synchronization is indicated in the Motion Control instruction "MC_CamIn" with the parameter "StartSync" = TRUE and in the "<TO>.StatusWord.X21 (Synchronizing)" tag of the following axis.

The leading value must not reverse during synchronization. To avoid interrupting synchronization in the event of slight fluctuations in the leading value during an actual value coupling, e.g. with an external encoder, you can define a reverse tolerance of the leading value (Page 44).

The dynamics of the following axis during synchronization is obtained from the calculated motion profile and the current dynamics of the leading axis. Changes in the dynamics of the leading axis during synchronization are superimposed with the calculated motion profile in accordance with the synchronous operation function. This can have the result that the configured dynamic limits at the following axis are violated. This is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The dynamic response of the following axis is limited to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

If the programmed dynamic response of the synchronous operation function is greater than the maximum dynamic response of the following axis when the "Execute" parameter is set, the corresponding technology alarms 501, 502, or 503 are output at the following axis.

After synchronization

The following axis is synchronized as soon as the leading axis has reached the synchronous position. The following axis travels synchronously with the leading axis in accordance with the cam profile (Page 179).

9.8.4 Synchronizing following axis in advance using leading value distance with "MC_CamIn"

During camming (Page 102), synchronization establishes the relationship between the leading axis and following axis. During synchronization in advance using the leading value distance, synchronization begins in such a way that the leading and following axis are synchronous when the synchronous position is reached.

Parameter inputs

You define the behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_CamIn (Page 323)":

- With the parameter "SyncProfileReference" = 1, you define the type of synchronization as synchronization in advance using the leading value distance.
- With the parameter "MasterSyncPosition", you define the synchronous position of the leading axis relative to the start position of the cam. The synchronous position establishes the relationship between leading value and following value. The synchronous position must be within the definition of the cam. With "MasterSyncPosition" ≠ 0.0, you move the synchronous position within the cam without changing the position of the cam. For

synchronization in advance, the synchronous position is the position starting from which the leading and following axes are synchronous.

- With the "MasterStartDistance" parameter, you specify the leading value distance (synchronization length).

Until synchronization

After the start of the "MC_CamIn" job, a motion profile is calculated for the following axis depending on the specified leading value distance. The calculation determines the required dynamic response and thus the start position of the leading axis for the synchronization.

The start position of the leading axis is derived in the following way:

Start position = Synchronous position of leading axis - Synchronization length

The leading axis must be at least the leading value distance away from the synchronous position. The status "Waiting" is displayed at the following axis until the leading value has reached the start position (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 3).

NOTE

Dynamic jumps

If the following axis is in motion and the leading value is at standstill when the "MC_CamIn" job is started, dynamic jumps can occur at the following axis as soon as the leading axis is set in motion and the following axis starts synchronizing.

If the leading and following axes are already at their synchronous positions when the "MC_CamIn" job is started, synchronous operation immediately has "Synchronous" status.

During synchronization

The following axis begins to synchronize as soon as the leading value has reached the start position. The synchronization is indicated in the Motion Control instruction "MC_CamIn" with the parameter "StartSync" = TRUE and in the "<TO>.StatusWord.X21 (Synchronizing)" tag of the following axis.

The leading value must not reverse during synchronization. To avoid interrupting synchronization in the event of slight fluctuations in the leading value during an actual value coupling, e.g. with an external encoder, you can define a reverse tolerance of the leading value (Page 44).

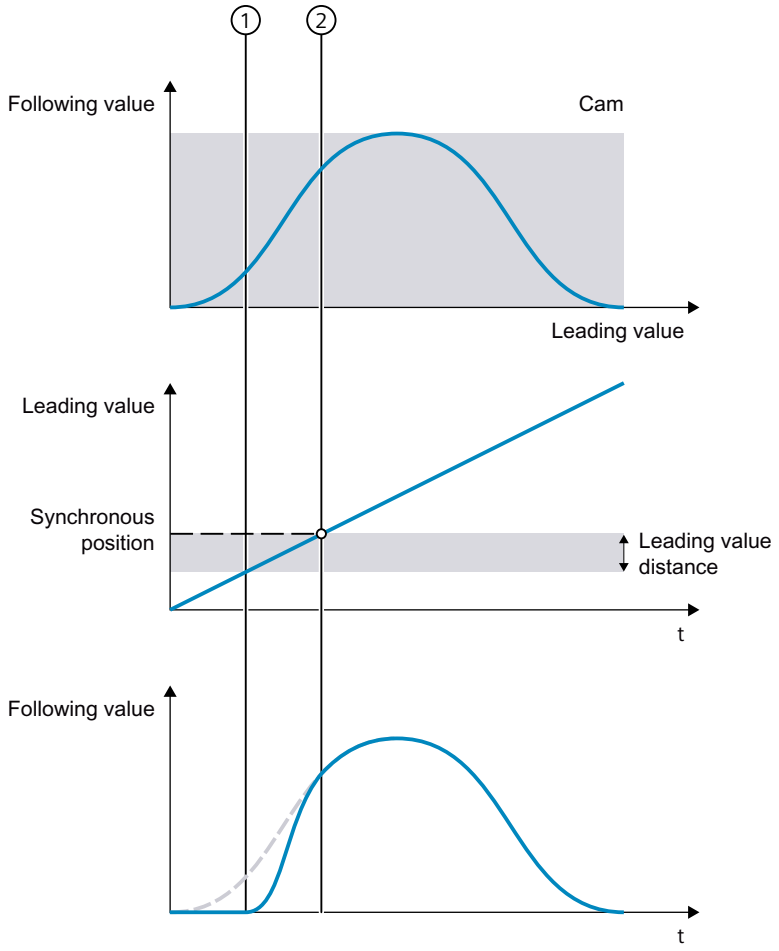

① Time when synchronization starts

② Time when synchronization is complete

The dynamics of the following axis during synchronization is obtained from the calculated motion profile and the current dynamics of the leading axis. Changes in the dynamics of the leading axis during synchronization are superimposed with the calculated motion profile in accordance with the synchronous operation function. This can have the result that the configured dynamic limits at the following axis are violated. This is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The dynamic response of the following axis is only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the

dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

After synchronization

The following axis is synchronized as soon as the leading axis has reached the synchronous position. The following axis travels synchronously with the leading axis in accordance with the cam profile (Page 179).

9.8.5 Synchronizing following axis in advance via the leading value path from the current leading value position with "MC_CamIn"

During camming (Page 102), synchronization establishes the relationship between the leading axis and following axis. For synchronization in advance, the leading value path from the current leading value position begins as soon as the "MC_CamIn" job becomes effective and the leading axis is in motion.

Parameter inputs

You define the behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_CamIn (Page 323)":

- With the parameter "SyncProfileReference" = 6, you define the type of synchronization as synchronization in advance via the leading value path from the current leading value position.
- With the parameter "MasterSyncPosition", you define the synchronous position of the leading axis relative to the start position of the cam. The synchronous position establishes the relationship between leading value and following value. The synchronous position must be within the definition of the cam. With "MasterSyncPosition" ≠ 0.0, you move the synchronous position within the cam without changing the position of the cam. For synchronization in advance, the synchronous position is the position starting from which the leading and following axes are synchronous.
- With the "MasterStartDistance" parameter, you specify the leading value distance (synchronization length).
- With the "SlaveOffset" parameter, you define the offset of the cam in the following value range (Page 150). The offset of the cam in the leading value range is calculated automatically.

After the "MC_CamIn" job has started

After the start of the "MC_CamIn" job, a motion profile is calculated for the following axis depending on the specified leading value distance. The calculation results in the required dynamics and the offset of the cam in the leading value range.

If the leading axis is at a standstill when the job starts, the status "Waiting" is displayed on the following axis (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 3) until the leading axis is set in motion.

NOTE

Dynamic jumps

If the following axis is in motion and the leading value is at standstill when the "MC_CamIn" job is started, dynamic jumps can occur at the following axis as soon as the leading axis is set in motion and the following axis starts synchronizing.

If the leading and following axes are already at their synchronous positions when the "MC_CamIn" job is started, synchronous operation immediately has "Synchronous" status.

During synchronization

The following axis begins to synchronize as soon as the "MC_CamIn" job takes effect and the leading axis is moving. The synchronization is indicated in the Motion Control instruction "MC_CamIn" with the parameter "StartSync" = TRUE and in the "<TO>.StatusWord.X21 (Synchronizing)" tag of the following axis.

The leading value must not reverse during synchronization. To avoid interrupting synchronization in the event of slight fluctuations in the leading value during an actual value coupling, e.g. with an external encoder, you can define a reverse tolerance of the leading value (Page 44).

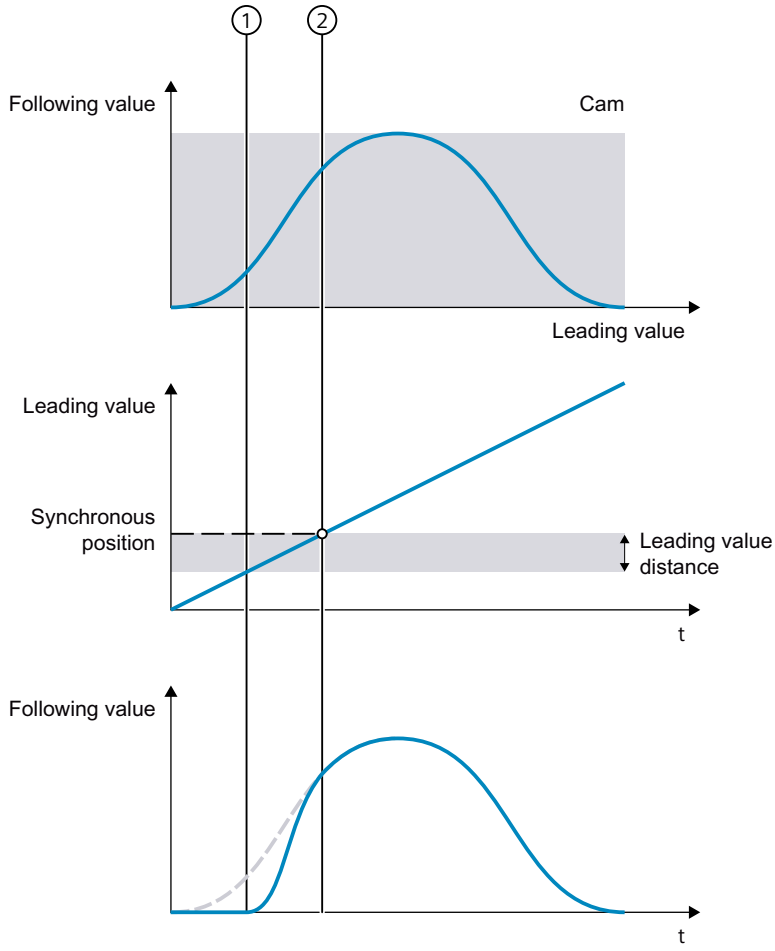

① Time at which the job becomes effective and the synchronization begins.

② Time when synchronization is complete

The dynamics of the following axis during synchronization is obtained from the calculated motion profile and the current dynamics of the leading axis. Changes in the dynamics of the leading axis during synchronization are superimposed with the calculated motion profile in accordance with the synchronous operation function. This can have the result that the configured dynamic limits at the following axis are violated. This is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The dynamic response of the following axis is only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the

dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

After synchronization

The cam is offset accordingly in the master value range. The offset results from the current leading value position and the default values of the parameters "MasterSyncPosition", "MasterStartDistance" and "SlaveOffset". The offset in the leading value range is displayed in the "<TO>.StatusSynchronizedMotion.MasterOffset" tag of the technology object.

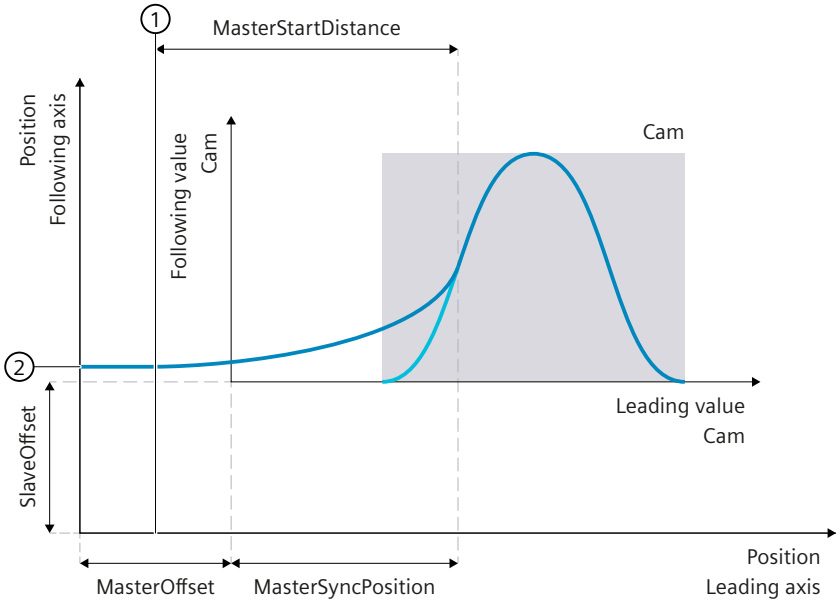

① Current leading value position

② Current following value position

The following axis is synchronized as soon as the leading axis has reached the synchronous position. The following axis travels synchronously with the leading axis in accordance with the cam profile (Page 179).

9.8.6 Subsequent synchronizing of following axis using leading value distance with "MC_CamIn"

During camming (Page 102), synchronization establishes the relationship between the leading axis and following axis. With subsequent synchronization using the leading value distance, synchronization begins as soon as the leading value has reached the synchronous position of the leading axis.

Parameter inputs

You define the behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_CamIn (Page 323)":

- With the parameter "SyncProfileReference" = 3, you define the type of synchronization as subsequent synchronization using the leading value distance.
- With the parameter "MasterSyncPosition", you define the synchronous position of the leading axis relative to the start position of the cam. The synchronous position establishes the relationship between leading value and following value. The synchronous position must be within the definition of the cam. With "MasterSyncPosition" ≠ 0.0, you move the synchronous position within the cam without changing the position of the cam. For subsequent synchronization, the synchronous position of the leading axis is the start position from which synchronization starts.
- With the "MasterStartDistance" parameter, you specify the leading value distance (synchronization length).

Until synchronization

After the start of the "MC_CamIn" job, a motion profile is calculated for the following axis depending on the specified leading value distance. The calculation determines the required dynamic response and the position of the leading axis as of which the leading axis and the following axis travel synchronously.

The status "Waiting" is displayed at the following axis until the leading value has reached the synchronous position of the leading axis (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 3).

NOTE

Dynamic jumps

If the following axis is in motion and the leading value is at standstill when the "MC_CamIn" job is started, dynamic jumps can occur at the following axis as soon as the leading axis is set in motion and the following axis starts synchronizing.

If the leading and following axes are already at their synchronous positions when the "MC_CamIn" job is started, synchronous operation immediately has "Synchronous" status.

During synchronization

The following axis begins to synchronize as soon as the leading value has reached the synchronous position. The synchronization is indicated in the Motion Control instruction "MC_CamIn" with the parameter "StartSync" = TRUE and in the "<TO>.StatusWord.X21 (Synchronizing)" tag of the following axis.

The leading value must not reverse during synchronization. To avoid interrupting synchronization in the event of slight fluctuations in the leading value during an actual value coupling, e.g. with an external encoder, you can define a reverse tolerance of the leading value (Page 44).

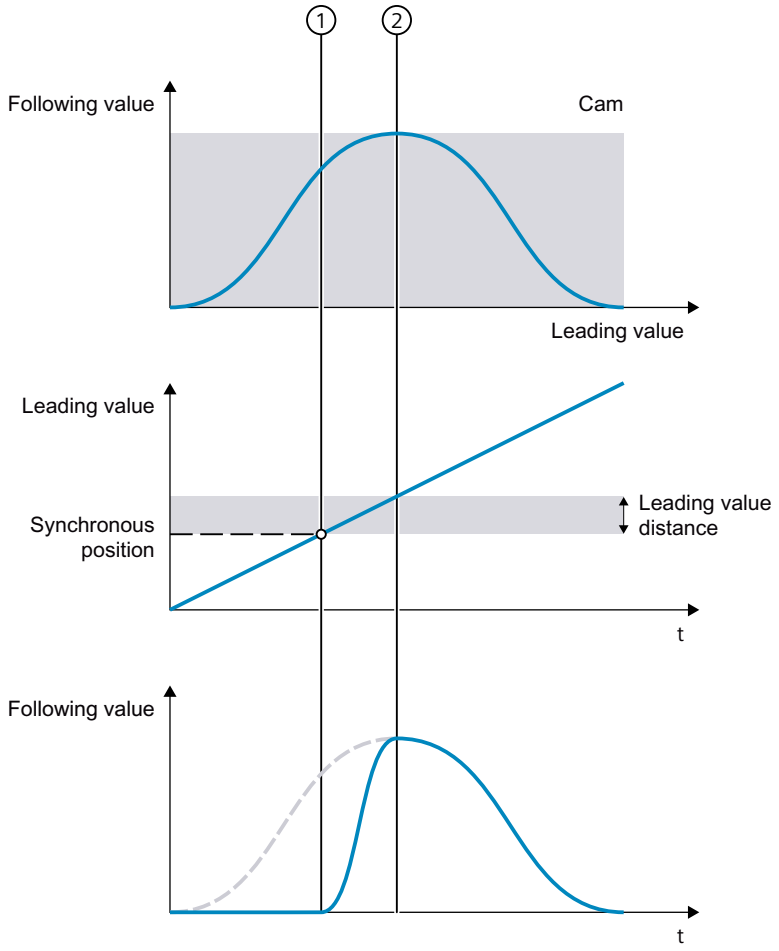

① Time when synchronization starts

② Time when synchronization is complete

The dynamics of the following axis during synchronization is obtained from the calculated motion profile and the current dynamics of the leading axis. Changes in the dynamics of the leading axis during synchronization are superimposed with the calculated motion profile in accordance with the synchronous operation function. This can have the result that the configured dynamic limits at the following axis are violated. This is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The dynamic response of the following axis is only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the

dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

After synchronization

The position of the leading axis from which the leading axis and following axis travel synchronously is derived in the following way:

Position axes synchronous = Synchronous position of leading axis + Synchronization length

As soon as the leading axis has reached this position, the following axis is synchronized. The following axis travels synchronously with the leading axis in accordance with the cam profile (Page 179).

9.8.7 Subsequent synchronizing of following axis using leading axis value starting from the current leading value position with "MC_CamIn"

During camming (Page 102), synchronization establishes the relationship between the leading axis and following axis. With subsequent synchronization using the leading value distance from the current leading value position, synchronization begins as soon as the "MC_CamIn" job takes effect and the leading axis is set in motion.

Parameter inputs

You define the behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_CamIn (Page 323)":

- With the parameter "SyncProfileReference" = 4, you define the type of synchronization as subsequent synchronization using the leading value distance from the current leading value position. The position of the leading axis must be within the definition of the cam, which may be scaled or shifted.
- With the "MasterStartDistance" parameter, you specify the leading value distance (synchronization length).

Starting the "MC_CamIn" job

After the start of the "MC_CamIn" job, a motion profile is calculated for the following axis depending on the specified leading value distance. The calculation determines the required dynamic response and the position of the leading axis as of which the leading axis and the following axis travel synchronously.

If the leading axis is at a standstill when the job starts, the status "Waiting" is displayed on the following axis (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 3) until the leading axis is set in motion.

NOTE

Dynamic jumps

If the following axis is in motion and the leading value is at standstill when the "MC_CamIn" job is started, dynamic jumps can occur at the following axis as soon as the leading axis is set in motion and the following axis starts synchronizing.

If the leading and following axes are already at their synchronous positions when the "MC_CamIn" job is started, synchronous operation immediately has "Synchronous" status.

During synchronization

The following axis begins to synchronize as soon as the "MC_CamIn" job takes effect and the leading axis is moving. The synchronization is indicated in the Motion Control instruction "MC_CamIn" with the parameter "StartSync" = TRUE and in the "<TO>.StatusWord.X21 (Synchronizing)" tag of the following axis.

The leading value must not reverse during synchronization. To avoid interrupting synchronization in the event of slight fluctuations in the leading value during an actual value coupling, e.g. with an external encoder, you can define a reverse tolerance of the leading value (Page 44).

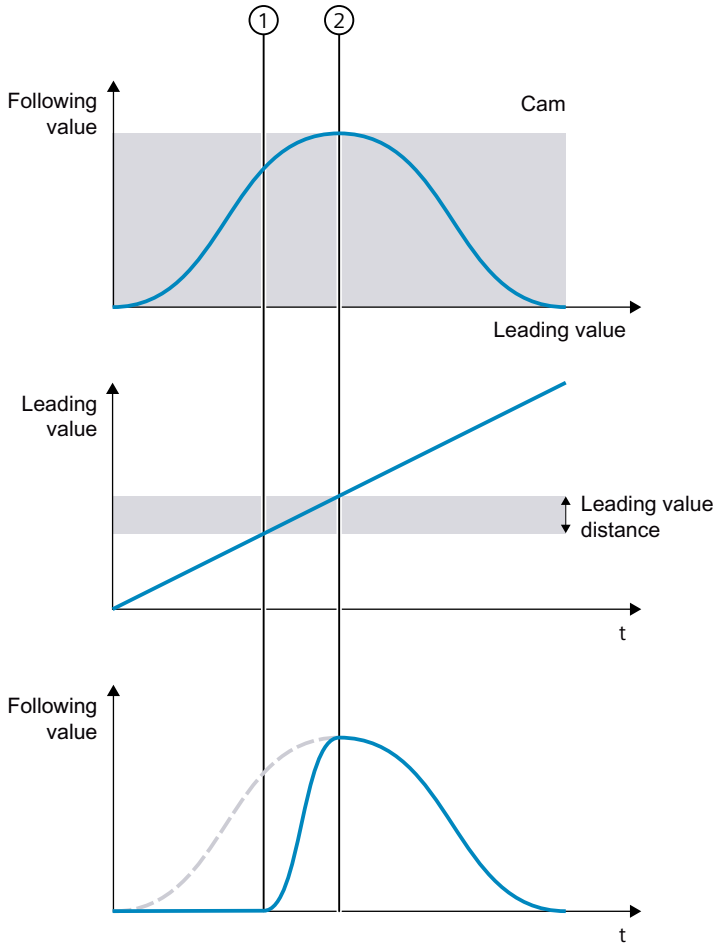

① Time at which the job becomes effective and the synchronization begins.

② Time when synchronization is complete

The dynamics of the following axis during synchronization is obtained from the calculated motion profile and the current dynamics of the leading axis. Changes in the dynamics of the leading axis during synchronization are superimposed with the calculated motion profile in accordance with the synchronous operation function. This can have the result that the

configured dynamic limits at the following axis are violated. This is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The dynamic response of the following axis is only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

After synchronization

The position of the leading axis from which the leading axis and following axis travel synchronously is derived in the following way:

Position axes synchronous = Current leading value position at job start + synchronization length

As soon as the leading axis has reached this position, the following axis is synchronized. The following axis travels synchronously with the leading axis in accordance with the cam profile (Page 179).

9.8.8 Directly set following axis synchronously with "MC_CamIn"

During camming (Page 102), synchronization establishes the relationship between the leading axis and following axis. With directly set synchronously, the leading and following axes move synchronously immediately without synchronization motion.

This type of synchronization is mainly suitable for synchronizing at a standstill.

Parameter inputs

You define the behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_CamIn (Page 323)":

- With the parameter "SyncProfileReference" = 2, you specify the type of synchronization as directly set synchronously.
- With the parameter "MasterSyncPosition", you define the synchronous position of the leading axis relative to the start position of the cam. The synchronous position must be within the definition of the cam. With directly set synchronously, the synchronous position is the position in the cam via which the relation between leading axis and following axis is established.

After the "MC_CamIn" job has started

After the "MC_CamIn" job has started, the status "Synchronous" is set directly at the current leading value position and at the current following value position.

The synchronous position specified in the cam is assigned to the position setpoint of the leading axis in the leading value range and to the position setpoint of the following axis in the following value range. The cam is offset accordingly. The current offset results from the cam and is displayed at the "<TO>.StatusSynchronizedMotion.MasterOffset" and "<TO>.StatusSynchronizedMotion.SlaveOffset" tags of the technology object.

The following axis travels synchronously with the leading axis in accordance with the cam profile (Page 179).

Additional information

For more information on direct synchronous setting, refer to the FAQ entry 109758886 (https://support.industry.siemens.com/cs/ww/en/view/109758886) in the Siemens Industry Online Support.

9.8.9 Directly set following axis synchronously at end of the cam with "MC_CamIn"

During camming (Page 102), synchronization establishes the relationship between the leading axis and following axis. With directly set synchronously at the end of the cam, you change another cam or the current cam with a new scaling at the end of the active cam. Camming must already be active for this ("MC_CamIn.InSync" = TRUE). The synchronous operation remains in "synchronous" status without a synchronous operation of the following axis.

Parameter inputs

You define the behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_CamIn (Page 323)":

- With the parameter "SyncProfileReference" = 5, you specify the type of synchronization as directly set synchronously.
- With the "MasterSyncPosition" parameter, you define the synchronous position relative to the start position of the cam. The synchronous position must be within the definition of the cam. With directly set synchronously at the end of the cam, the specified synchronous position of the cam to be changed is automatically moved to the end position of the active cam. To do this, the cam to be inserted is moved in the leading value range and in the following value range. This means that there is no setpoint jump in the following value.

NOTE

Dynamic jumps

Note that dynamic jumps on the following axis can occur in the transition between the two cams if the velocity and acceleration are discontinuous.

Dynamic jumps on the following axis

To determine dynamic jumps on the following axis, use the "MC_GetCamFollowingValue (Page 354)" instruction, for example, to check the following values for velocity and acceleration in the following positions:

- End position of the active cam (<TO>.StatusCam.EndLeadingValue)
- Synchronous position of the ("MasterSyncPosition") cam to be changed

If the parameter values "MC_GetCamFollowingValue.FirstDerivative" of both jobs match, the transition between the cams is constant in velocity. If the parameter values "MC_GetCamFollowingValue.SecondDerivative" of both jobs match, the transition between the cams is constant in acceleration.

To avoid dynamic jumps on the following axis when changing the active cam with new scaling with the start position as synchronous position, use the setting

"<TO>.InterpolationSettings.BoundaryConditions" = 1 for theinterpolation of the cam (Page 142). This gives you a steady velocity transition.

After the "MC_CamIn" job has started

The status "Waiting" is displayed at the following axis until the leading value has reached the end of the active cam or the active cam cycle ("<TO>.StatusSynchronizedMotion.WaitingFunctionState" = 3).

When reaching the end of the cam

When the end of the cam is reached ("EndOfProfile" = TRUE), the replaced cam becomes active directly at the current leading value position and at the current following value position starting from the specified synchronous position. The cam is offset accordingly. The offset is displayed in the "<TO>.StatusSynchronizedMotion.MasterOffset" and "<TO>.StatusSynchronizedMotion.SlaveOffset" tags of the technology object.

The synchronous operation remains in "synchronous" status. The following axis travels synchronously with the leading axis in accordance with the cam profile.

9.8.10 Directly set the following axis synchronously at specific leading value position with "MC_CamIn"

During camming (Page 102), synchronization establishes the relationship between the leading axis and following axis. With direct synchronous setting at specific leading value position, the leading and following axes move synchronously immediately without synchronization motion.

This type of synchronization is particularly suitable if one of the following points applies:

- The offset of the cam in the following value range should be calculated automatically. The following axis is at a standstill.
- When changing cams, the cams should be replaced in rest areas. The following axis is at a standstill.
- During cam change, the cams are defined as overlapping. The cams should be changed at the same position in the center of the overlapping areas.

Parameter inputs

You define the behavior of the following axis for synchronization with the following parameters of the Motion Control instruction "MC_CamIn (Page 323)":

- With the parameter "SyncProfileReference" = 7, you define the type of synchronization as direct synchronous setting at specific leading value position.
- With the parameter "MasterSyncPosition", you define the synchronous position of the leading axis relative to the start position of the cam. The synchronous position must be within the definition of the cam. With direct synchronous setting at specific leading value position, the synchronous position is the position in the cam via which the relation between the leading and following axis is established.
- You define the offset of the cam in the leading value range (Page 150) with the "MasterOffset" parameter. The offset of the cam in the following value range is calculated automatically.

Until the specified leading value position is reached

Until the leading value has reached the specified leading value position, the status "Waiting" is displayed on the following axis after the start of the "MC_CamIn" job ("<TO>.StatusSynchronizedMotion.WaitingFunctionState" = 3).

If the leading axis is already at its synchronous position when the "MC_CamIn" job is started, the synchronous operation immediately has "Synchronous" status.

When the specified leading value position is reached

As soon as the leading value reaches the specified leading value position, the status "synchronous" is set immediately at the current following value position. If the "MC_CamIn" job replaces already active camming without following error, the following axis remains in "synchronous" status.

NOTE

Dynamic jumps

Note that dynamic jumps on the following axis can occur in the event of discontinuity of the velocity and acceleration in the transition to the new the cam.

The synchronous position specified in the cam is assigned to the position setpoint of the leading axis in the leading value range and to the position setpoint of the following axis in the following value range. The cam is offset accordingly. The current offset results from the cam and the default value of the "MasterOffset" parameter. The offset in the following value range is displayed in the "<TO>.StatusSynchronizedMotion.SlaveOffset" tag of the technology object.

The following axis travels synchronously with the leading axis in accordance with the cam profile (Page 179).

9.9 Synchronous travel in camming with "MC_CamIn"

As soon as the following axis is synchronized to a leading value, the following axis follows the position of the leading axis according to the cam profile. The transmission behavior during camming is expressed by the cam curve.

The "Synchronous" status is indicated in the Motion Control instruction "MC_CamIn (Page 323)" with the parameter "InSync" = TRUE and in the "<TO>.StatusWord.X22 (Synchronous)" tag of the technology object.

NOTE

Avoid homing the leading axis in synchronous operation

Avoid homing the leading axis during an active synchronous operation. Homing the leading axis during synchronous operation corresponds to a setpoint step-change on the following axis. The following axis compensates for the jump according to the synchronous operation function and limited only to the maximum speed of the drive.

9.10 Reading out leading and following values during camming

9.10.1 Reading the leading value in camming

With the Motion Control instruction "MC_GetCamLeadingValue", you read the leading value that is defined for a following value from a cam.

If an area of the cam is scaled with an "MC_SetCamRangeScaling" job ("<TO>.StatusWord.X9 (CamRangeScaled)" = TRUE), the "MC_GetCamLeadingValue" job affects the scaled and interpolated cam.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_GetCamLeadingValue (Page 352)" to define the settings:

- With the parameter "FollowingValue", you define the following value for which the leading value is to be read.
- You define an approach value for the sought leading value with the parameter "ApproachLeadingValue".
- You define the approach direction for the sought leading value with the parameter "ApproachDirection".
- You define the offset of the cam in the leading value range with the MasterOffset" parameter.
- You define the offset of the cam in the following value range with the "SlaveOffset" parameter.
- You define the scaling of the cam in the leading value range with the "MasterScaling" parameter.
- You define the scaling of the cam in the following value range with the "SlaveScaling" parameter.

The cam technology object is not changed with the specification of offset and scaling of the cam. You can find more information on offset and scaling of the cam in the section "Scaling and shifting cam (Page 150)".

Approach value and approach direction

Since the same following values can be defined for different leading values, specify an approach value for the sought leading value in the "ApproachLeadingValue" parameter. If the following value is used multiple times in the cam, it can be used to limit the searched leading value. The approach value refers to the – if applicable, offset and scaled – leading values of the cam. The approach value can lie inside or outside the definition range of the cam.

In addition, you can define a search direction with the "ApproachDirection" parameter. With "ApproachDirection" = 1, the search is carried out in the positive direction from the specified approach value. With "ApproachDirection" = 2, the search is carried out in the negative direction. With "ApproachDirection" = 3, the nearest value is searched for independent of direction.

If the specified approach value "ApproachLeadingValue" already corresponds to the sought leading value, this leading value is only found with "ApproachDirection" = 3. With "ApproachDirection" = 1 or 2, the closest value in the specified search direction is found in each case.

Example

In the following example, the following value for which the leading value is to be read is defined as "FollowingValue" = 0.5. For the approach value for the sought leading value ①, "ApproachLeadingValue" = 225.0 is specified.

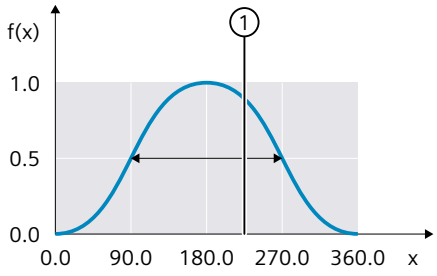

① Approach value for the sought leading value ("ApproachLeadingValue")

With "ApproachDirection" = 1, the search is carried out in the positive direction from the approach value. The read leading value is "Value" = 270.0.

With "ApproachDirection" = 2, the search is carried out in the negative direction from the approach value. The read leading value is "Value" = 90.0.

With "ApproachDirection" = 3, the nearest value is searched for from the approach value independent of direction. The read leading value is "Value" = 270.0.

After the "MC_GetCamLeadingValue" job has started

The leading value is read after the "MC_GetCamLeadingValue" job has started. As soon as the job is completed with "Done" = TRUE, the parameter "Value" contains the read leading value.

9.10.2 Reading the following value in camming

With the Motion Control instruction "MC_GetCamFollowingValue", you read the following value that is defined for a leading value from a cam.

If an area of the cam is scaled with an "MC_SetCamRangeScaling" job ("<TO>.StatusWord.X9 (CamRangeScaled)" = TRUE), the "MC_GetCamFollowingValue" job affects the scaled and interpolated cam.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_GetCamFollowingValue (Page 354)" to define the settings:

- With the "LeadingValue" parameter, you define the leading value for which the following value is to be read.
- You define the offset of the cam in the leading value range with the "MasterOffset" parameter.
- You define the offset of the cam in the following value range with the "SlaveOffset" parameter.
- You define the scaling of the cam in the leading value range with the "MasterScaling" parameter.
- You define the scaling of the cam in the following value range with the "SlaveScaling" parameter.
- With the "ApplicationMode" parameter, you define the read mode. The read mode defines which values are read out.

The cam technology object is not changed with the specification of offset and scaling of the cam. You can find more information on offset and scaling of the cam in the section "Scaling and shifting cam (Page 150)".

After the "MC_GetCamFollowingValue" job has started

The following value is read after the "MC_GetCamFollowingValue" job has started. As soon as the job is completed with "Done" = TRUE, the following parameters contain the read following value depending on the specified read mode "ApplicationMode":

- When "ApplicationMode" = 0, 1, 2, 3:

  The "Value" parameter contains the position.
- When "ApplicationMode" = 1, 2, 3:

  The "FirstDerivative" parameter contains the velocity.
- When "ApplicationMode" = 2, 3:

  The "SecondDerivative" parameter contains the acceleration.
- When "ApplicationMode" = 3:

  The "ThirdDerivative" parameter contains the jerk.

9.10.3 Reading out the following value cyclically during camming

You read the following value that has been defined for a leading value from a cam cyclically with the Motion Control instruction "MC_GetCamFollowingValueCyclic". Several "MC_GetCamFollowingValueCyclic" jobs related to the same cam are possible simultaneously.

If an area of the cam is scaled with an "MC_SetCamRangeScaling" job ("<TO>.StatusWord.X9 (CamRangeScaled)" = TRUE), the "MC_GetCamFollowingValueCyclic" job affects the scaled and interpolated cam.

Parameter inputs

You use the following parameters of the Motion Control instruction "MC_GetCamFollowingValueCyclic (Page 356)" to define the settings:

- With the "LeadingValue" parameter, you define the leading value for which the following value is to be read.
- You define the offset of the cam in the leading value range with the "MasterOffset" parameter.
- You define the offset of the cam in the following value range with the "SlaveOffset" parameter.
- You define the scaling of the cam in the leading value range with the "MasterScaling" parameter.
- You define the scaling of the cam in the following value range with the "SlaveScaling" parameter.
- With the "ApplicationMode" parameter, you define the read mode. The read mode defines which values are read out.

The cam technology object is not changed with the specification of offset and scaling of the cam. You can find more information on offset and scaling of the cam in the section "Scaling and shifting cam (Page 150)".

During the active "MC_GetCamFollowingValueCyclic" job

The following value is read cyclically as long as the parameter "Enable" = TRUE. Job processing is done synchronously so that the result is output directly. If the parameter "Valid" = TRUE, the following parameters contain the valid following value read for the leading value of the same application cycle depending on the specified read mode "ApplicationMode":

- When "ApplicationMode" = 0, 1, 2, 3:

  The "Value" parameter contains the position.
- When "ApplicationMode" = 1, 2, 3:

  The "FirstDerivative" parameter contains the velocity.
- When "ApplicationMode" = 2, 3:

  The "SecondDerivative" parameter contains the acceleration.
- When "ApplicationMode" = 3:

  The "ThirdDerivative" parameter contains the jerk.

If the leading value is outside the definition range of the cam, the parameter values for the following value are invalid ("Valid" = FALSE).

9.11 Leading value offset during camming

9.11.1 Leading value offset on the following axis during camming using leading value distance as of current leading value position

With a leading value offset, you offset the effective leading value on the following axis during camming with "MC_CamIn (Page 323)". You can move the effective leading value absolutely or relatively. The leading value of the leading value source and the position of the leading axis are not influenced by the leading value offset.

The leading value offset always refers to the effective leading value. The effective leading value is made up of the leading value of the leading value source and the additive leading value. If you do not use an additive leading value via "MC_LeadingValueAdditive (Page 347)", the effective leading value corresponds to the leading value of the leading value source. You can find an overview in the "Mode of operation of the instructions in synchronous operation (Page 34)" section. In the following, "leading value" refers to the effective leading value.

Parameter inputs

You define the behavior of the following axis during leading value offset with the following parameters of the Motion Control instruction "MC_PhasingAbsolute (Page 304)" or "MC_PhasingRelative (Page 297)":

- With the parameter "ProfileReference" = 1, you specify the type of leading value offset as offset using leading value distance as of the current leading value position.
- With the "PhaseShift" parameter, you specify the leading value offset on the following axis.
- With the "PhasingDistance" parameter, you specify the leading value distance (traversing distance of the leading axis) during the leading value offset.
- With the "Direction" parameter, you specify the direction of the leading value distance in relation to the direction of motion of the leading value (Page 185).

During the leading value offset

After starting the jobs, the following axis begins with the leading value offset starting from the current position. Within the traversing distance of the leading axis, the following axis offsets the leading value at continuous velocity and acceleration. The required dynamics of the following axis to offset the leading value is calculated by the system. During leading value offset, the dynamics of the following axis is limited only to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

The leading value offset is indicated in the Motion Control instruction with the parameter "StartPhasing" = TRUE and in the "<TO>.StatusWort.X24 (PhasingCommand)" tag of the technology object. The "AbsolutePhaseShift" or "CoveredPhaseShift" parameter shows the absolute leading value portion already shifted.

The leading value must not reverse during the leading value offset on the following axis. When the leading value reverses, the "MC_PhasingAbsolute" job or "MC_PhasingRelative" job is canceled with "ErrorID" = 16#808C.

After the leading value offset

As soon as the following axis has offset the leading value, the leading value offset is active on the following axis. The status is indicated in the Motion Control instruction with the parameter "Done" = TRUE and in the "<TO>.StatusSynchronizedMotion.PhaseShift" tag of the technology object.

The leading value offset only has an effect in the "Synchronous" status of the camming. When the camming is overridden, the leading value offset is reset to zero.

9.11.2 Leading value offset on the following axis during camming using leading value distance as of specific leading value position

With a leading value offset, you offset the effective leading value on the following axis during camming with "MC_CamIn (Page 323)". You can move the effective leading value absolutely or relatively. The leading value of the leading value source and the position of the leading axis are not influenced by the leading value offset.

The leading value offset always refers to the effective leading value. The effective leading value is made up of the leading value of the leading value source and the additive leading value. If you do not use an additive leading value via "MC_LeadingValueAdditive (Page 347)", the effective leading value corresponds to the leading value of the leading value source. You can find an overview in the "Mode of operation of the instructions in synchronous operation (Page 34)" section. In the following, "leading value" refers to the effective leading value.

Parameter inputs

You define the behavior of the following axis during leading value offset with the following parameters of the Motion Control instruction "MC_PhasingAbsolute (Page 304)" or "MC_PhasingRelative (Page 297)":

- With the parameter "ProfileReference" = 2, you specify the type of leading value offset as offset using leading value distance as of a specific leading value position.
- With the "PhaseShift" parameter, you specify the leading value offset on the following axis.
- With the "PhasingDistance" parameter, you specify the leading value distance (traversing distance of the leading axis) during the leading value offset.
- With the "StartPosition" parameter, you specify the leading value position from which the leading value offset starts.
- With the "Direction" parameter, you specify the direction of the leading value distance in relation to the direction of motion of the leading value (Page 185).

Until the leading value offset

After starting the job, the status "Waiting" is displayed at the following axis when the leading value is at standstill and until the leading value has reached the leading value position (<TO>.StatusWord2.X3 = TRUE (PhasingCommandWaiting)).

During the leading value offset

As soon as the leading value has reached the leading value position, the following axis begins to offset the leading value. Within the traversing distance of the leading axis, the following axis offsets the leading value at continuous velocity and acceleration. The required dynamics of the following axis to offset the leading value is calculated by the system. During leading value offset, the dynamics of the following axis is limited only to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

The leading value offset is indicated in the Motion Control instruction with the parameter "StartPhasing" = TRUE and in the "<TO>.StatusWort.X24 (PhasingCommand)" tag of the technology object. The "AbsolutePhaseShift" or "CoveredPhaseShift" parameter shows the absolute leading value portion already shifted.

The leading value must not reverse during the leading value offset on the following axis. When the leading value reverses, the "MC_PhasingAbsolute" job or "MC_PhasingRelative" job is canceled with "ErrorID" = 16#808C. The waiting job is not canceled.

After the leading value offset

As soon as the following axis has offset the leading value, the leading value offset is active on the following axis. The status is indicated in the Motion Control instruction with the parameter "Done" = TRUE and in the "<TO>.StatusSynchronizedMotion.PhaseShift" tag of the technology object.

The leading value offset only has an effect in the "Synchronous" status of the camming. When the camming is overridden, the leading value offset is reset to zero.

9.11.3 Defining the direction of the leading value distance of a leading value offset on the following axis during camming

With a leading value offset, you offset the effective leading value on the following axis during camming with "MC_CamIn (Page 323)". With the "Direction" parameter of the Motion Control instruction "MC_PhasingAbsolute (Page 304)" or "MC_PhasingRelative (Page 297)", you specify the direction of the leading value distance in relation to the direction of motion of the effective leading value.

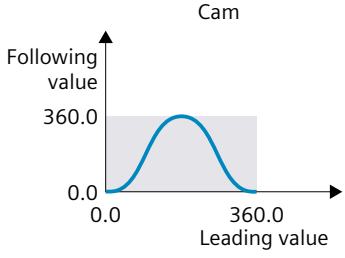

Defining leading value distance in the positive direction of motion of the effective leading value

With "Direction" = 1, the following axis only offsets the leading value when the leading axis travels in the positive direction.

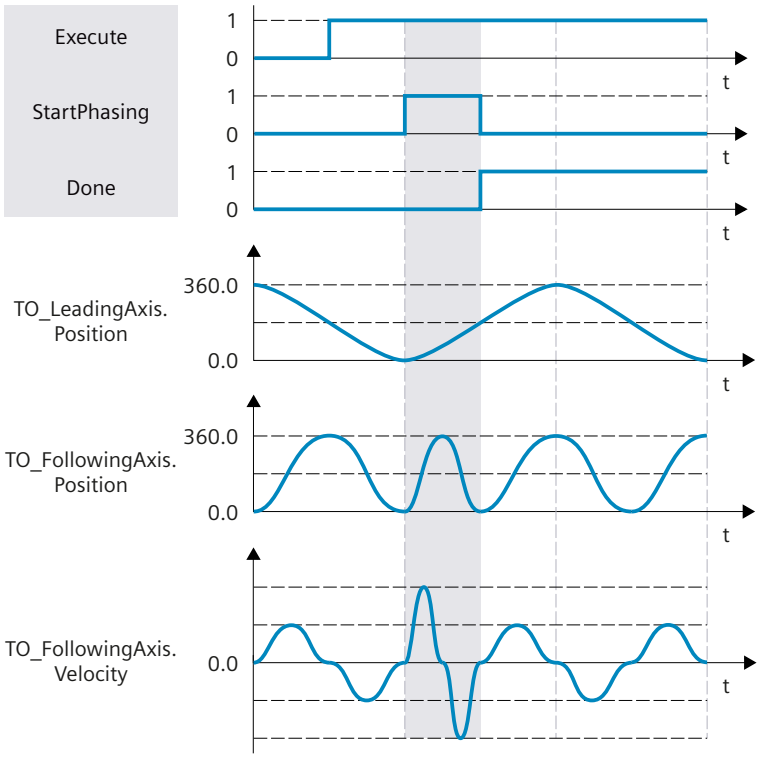

Defining leading value distance in the negative direction of motion of the effective leading value

With "Direction" = 2, the following axis only offsets the leading value when the leading axis travels in the negative direction.

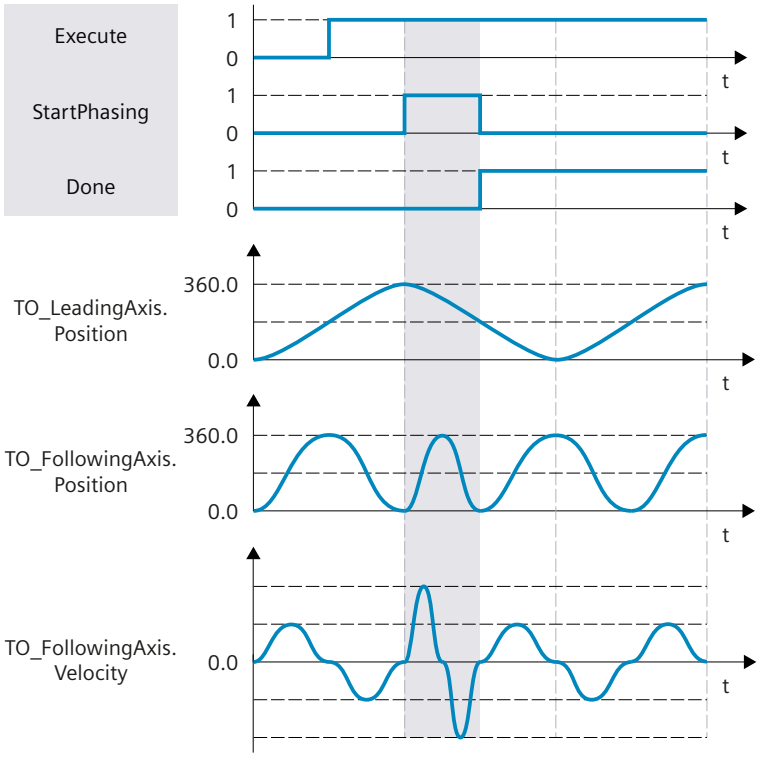

Defining leading value distance in the current direction of motion of the effective leading value

With "Direction" = 3, the following axis offsets the leading value regardless of the direction in which the leading axis is currently traveling.

9.11.4 Canceling a pending leading value offset in the camming

With an "MC_PhasingAbsolute (Page 304)" or "MC_PhasingRelative (Page 297)" job with "ProfileReference" = 5, you cancel a pending "MC_PhasingAbsolute" or "MC_PhasingRelative" job. Canceling a waiting job has no effect on an active leading value offset.

9.12 Following value offset during camming

9.12.1 Following value offset on the following axis during camming using leading value distance as of current leading value position

With a following value offset, you offset the following value on the following axis during camming with "MC_CamIn (Page 323)". You can move the following value absolutely or relatively. The leading value of the leading value source and the position of the leading axis are not influenced by the following value offset.

The following value offset always refers to the effective leading value. The effective leading value is made up of the leading value of the leading value source and the additive leading value. If you do not use an additive leading value via "MC_LeadingValueAdditive (Page 347)", the effective leading value corresponds to the leading value of the leading value source. You can find an overview in the "Mode of operation of the instructions in synchronous operation (Page 34)" section. In the following, "leading value" refers to the effective leading value.

For camming, the offset of the following value with an "MC_OffsetAbsolute" or "MC_OffsetRelative" job (<TO>.StatusSynchronizedMotion.Offset) starts at the start value "<TO>.StatusSynchronizedMotion.SlaveOffset".

Parameter inputs

You define the behavior of the following axis during following value offset with the following parameters of the Motion Control instruction "MC_OffsetAbsolute (Page 317)" or "MC_OffsetRelative (Page 311)":

- With the parameter "ProfileReference" = 1, you specify the type of following value offset as offset using leading value distance as of the current leading value position.
- With the "Offset" parameter, you specify the following value offset on the following axis.
- With the "OffsetDistance" parameter, you specify the leading value distance (traversing distance of the leading axis) during the following value offset.
- With the "Direction" parameter, you specify the direction of the leading value distance in relation to the direction of motion of the leading value (Page 191).

During the following value offset

After starting the job, the following axis begins with the following value offset starting from the current position. Within the traversing distance of the leading axis, the following axis offsets the following value at continuous velocity and acceleration. The required dynamics of the following axis for the following value offset is calculated by the system. During following value offset, the dynamics of the following axis is limited only to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

The following value offset is indicated in the Motion Control instruction with the parameter "StartOffset" = TRUE and in the "<TO>.StatusWort2.X4 (OffsetCommand)" tag of the technology object. The "AbsoluteOffset" or "CoveredOffset" parameter shows the absolute following value portion already shifted.

The leading value must not reverse during the following value offset on the following axis. When the leading value reverses, the "MC_OffsetAbsolute" job or "MC_OffsetRelative" job is canceled with "ErrorID" = 16#808C.

After the following value offset

As soon as the following axis has offset the following value, the following value offset is active on the following axis. The status is indicated in the Motion Control instruction with the parameter "Done" = TRUE and in the "<TO>.StatusSynchronizedMotion.Offset" tag of the technology object.

The following value offset only has an effect in the "Synchronous" status of the camming. When the camming is overridden, the following value offset is reset to zero.

9.12.2 Following value offset on the following axis during camming using leading value distance as of specific leading value position

With a following value offset, you offset the following value on the following axis during camming with "MC_CamIn (Page 323)". You can move the following value absolutely or relatively. The leading value of the leading value source and the position of the leading axis are not influenced by the following value offset.

The following value offset always refers to the effective leading value. The effective leading value is made up of the leading value of the leading value source and the additive leading value. If you do not use an additive leading value via "MC_LeadingValueAdditive (Page 347)", the effective leading value corresponds to the leading value of the leading value source. You can find an overview in the "Mode of operation of the instructions in synchronous operation (Page 34)" section. In the following, "leading value" refers to the effective leading value.

For camming, the offset of the following value with an "MC_OffsetAbsolute" or "MC_OffsetRelative" job (<TO>.StatusSynchronizedMotion.Offset) starts at the start value "<TO>.StatusSynchronizedMotion.SlaveOffset".

Parameter inputs

You define the behavior of the following axis during following value offset with the following parameters of the Motion Control instruction "MC_OffsetAbsolute (Page 317)" or "MC_OffsetRelative (Page 311)":

- With the parameter "ProfileReference" = 2, you specify the type of following value offset as offset using leading value distance as of a specific leading value position.
- With the "Offset" parameter, you specify the following value offset on the following axis.
- With the "OffsetDistance" parameter, you specify the leading value distance (traversing distance of the leading axis) during the following value offset.
- With the "StartPosition" parameter, you specify the leading value position from which the following value offset starts.
- With the "Direction" parameter, you specify the direction of the leading value distance in relation to the direction of motion of the leading value (Page 191).

Until the following value offset

After starting the job, the status "Waiting" is displayed at the following axis when the leading value is at standstill and until the leading value has reached the leading value position (<TO>.StatusWord2.X5 = TRUE (OffsetCommandWaiting)).

During the following value offset

As soon as the leading value has reached the leading value position, the following axis begins to offset the following value. Within the traversing distance of the leading axis, the following axis offsets the following value at continuous velocity and acceleration. The required dynamics of the following axis for the following value offset is calculated by the system. During following value offset, the dynamics of the following axis is limited only to the maximum speed of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

The following value offset is indicated in the Motion Control instruction with the parameter "StartOffset" = TRUE and in the "<TO>.StatusWort2.X4 (OffsetCommand)" tag of the technology object. The "AbsoluteOffset" or "CoveredOffset" parameter shows the absolute following value portion already shifted.

The leading value must not reverse during the following value offset on the following axis. When the leading value reverses, the "MC_OffsetAbsolute" job or "MC_OffsetRelative" job is canceled with "ErrorID" = 16#808C. The waiting job is not canceled.

After the following value offset

As soon as the following axis has offset the following value, the following value offset is active on the following axis. The status is indicated in the Motion Control instruction with the parameter "Done" = TRUE and in the "<TO>.StatusSynchronizedMotion.Offset" tag of the technology object.

The following value offset only has an effect in the "Synchronous" status of the camming. When the camming is overridden, the following value offset is reset to zero.

9.12.3 Defining the direction of the leading value distance of a following value offset on the following axis during camming

With a following value offset, you offset the following value on the following axis during camming with "MC_CamIn (Page 323)". With the "Direction" parameter of the Motion Control instruction "MC_OffsetAbsolute (Page 317)" or "MC_OffsetRelative (Page 311)", you specify the direction of the leading value distance in relation to the direction of motion of the effective leading value.

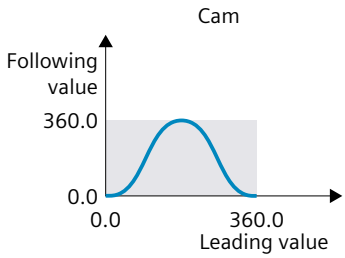

Defining leading value distance in the positive direction of motion of the effective leading value

With "Direction" = 1, the following axis only offsets the following value when the leading axis travels in the positive direction.

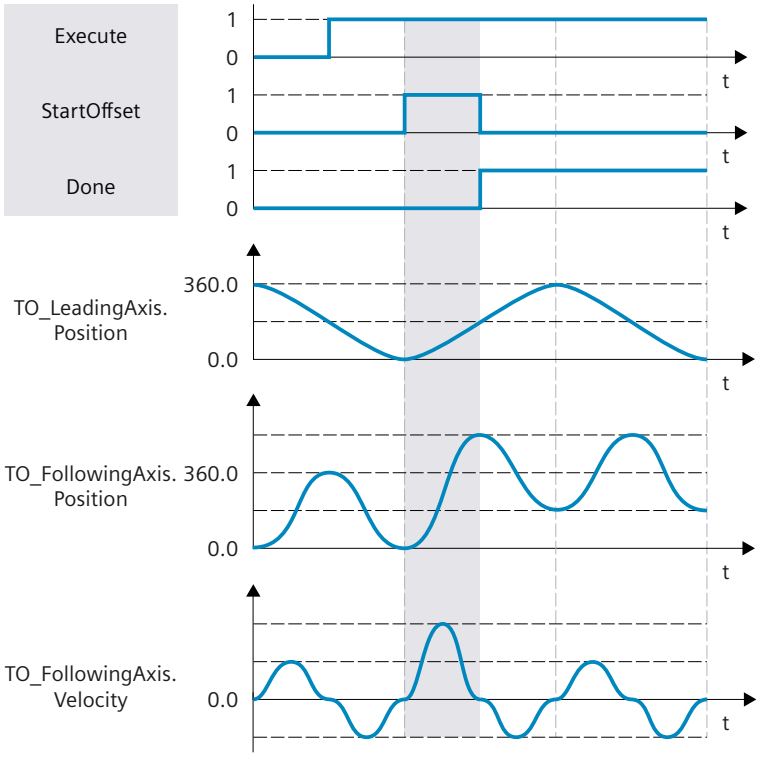

Defining leading value distance in the negative direction of motion of the effective leading value

With "Direction" = 2, the following axis only offsets the following value when the leading axis travels in the negative direction.

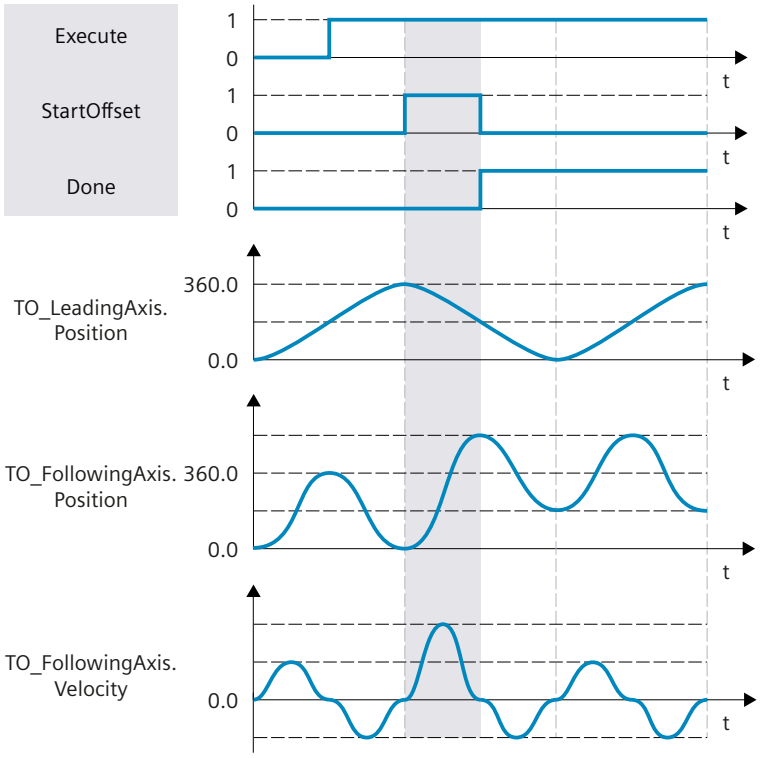

Defining leading value distance in the current direction of motion of the effective leading value

With "Direction" = 3, the following axis offsets the following value regardless of the direction in which the leading axis is currently traveling.

9.12.4 Canceling a pending following value offset in the camming

With an "MC_OffsetAbsolute (Page 317)" or "MC_OffsetRelative (Page 311)" job with "ProfileReference" = 5, you cancel a pending "MC_OffsetAbsolute" or "MC_OffsetRelative" job. Canceling a pending job has no effect on an active following value offset.

9.13 Desynchronize camming

9.13.1 Desynchronizing following axis using dynamic parameters with "MC_CamOut"

Desynchronization ends the synchronous operation relationship between the leading and following axis and camming is ended. For desynchronization using dynamic parameters, desynchronization begins in such a way that the following axis comes to a standstill when the stop position is reached.

With the Motion Control instruction "MC_CamOut" you can desynchronize a camming which you have started either with a "MC_CamIn (Page 323)" job.

Parameter inputs

You define the behavior of the following axis for desynchronization with the following parameters of the Motion Control instruction "MC_CamOut (Page 343)":

- With the parameter "SyncProfileReference" = 0, you specify the type of desynchronization as desynchronization using dynamic parameters.
- With the "SlavePosition" parameter, you specify the stop positions of the following axis. The stop position of the following axis is the position at which the following axis comes to a standstill and the desynchronization is completed.
- With the "Deceleration" parameter, you specify the deceleration of the following axis.
- With the "Jerk" parameter, you specify the jerk of the following axis.
- With the "SyncOutDirection" parameter, you specify the direction of the desynchronization (Page 197).

Until desynchronization

After the start of the "MC_CamOut" job, a motion profile for the following axis is calculated continuously. The motion profile is calculated based on the following parameters:

- Specified stop position of the following axis in the Motion Control instruction
- Specified dynamics of the Motion Control instruction
- Current position and dynamics of the leading and following axes
- Synchronous operation function
- Superimposed motion of the following axis
- Additive leading value of the following axis

The distance of the following axis and thus the starting position of the following axis for desynchronization results from the calculation.

The start position of the following axis is derived in the following way:

Start position = stop position of the following axis - travel distance of the following axis

The status "Waiting" is displayed at the following axis until the following value has reached the start position (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 5).

During desynchronization

The following axis begins to desynchronize as soon as the following value has reached the start position. Desynchronization is indicated in the Motion Control instruction "MC_CamOut" with the parameter "StartSyncOut" = TRUE and in the "<TO>.StatusWord2.X1 (DesynchronizingCommand)" tag of the technology object. The synchronous operation is no longer in the "Synchronous" status. Superimposed jobs of the following axis are canceled.

The following axis moves to the stop position with the specified dynamics, independent of the leading value. The dynamic response of the following axis is limited to the dynamic limits configured on the technology object.

- <TO>.DynamicLimits.MaxVelocity
- <TO>.DynamicLimits.MaxAcceleration
- <TO>.DynamicLimits.MaxDeceleration
- <TO>.DynamicLimits.MaxJerk

During desynchronization, several modulo revolutions of both axes are generally possible.

After desynchronization

As soon as the following axis reaches the stop position, the following axis is desynchronized. The following axis is at a standstill. The status is indicated in the Motion Control instruction "MC_CamOut" with the parameter "Done" = TRUE and in the "<TO>.StatusWord.X7 (Standstill)" tag of the technology object.

See also

Configuring the reverse tolerance of the leading value (Page 44)

9.13.2 Desynchronizing following axis using leading value distance with "MC_CamOut"

Desynchronization ends the synchronous operation relationship between the leading and following axis and camming is ended. For desynchronization using the leading value distance, desynchronization begins in such a way that the following axis comes to a standstill when the stop position is reached.

With the Motion Control instruction "MC_CamOut" you can desynchronize a camming which you have started either with a "MC_CamIn (Page 323)" job.

Parameter inputs

You define the behavior of the following axis for desynchronization with the following parameters of the Motion Control instruction "MC_CamOut (Page 343)":

- With the parameter "SyncProfileReference" = 1, you specify the type of desynchronization as desynchronization using the leading value distance.
- With the "SlavePosition" parameter, you specify the stop positions of the following axis. The stop position of the following axis is the position at which the following axis comes to a standstill and the desynchronization is completed.

- With the "MasterStopDistance" parameter, you define the leading value distance (desynchronization length).
- With the "SyncOutDirection" parameter, you specify the direction of the desynchronization (Page 197).

Until desynchronization

After the start of the "MC_CamOut" job, a motion profile is calculated depending on the specified leading value distance. The calculation determines the required dynamics and thus the start position of the leading axis for the desynchronization.

The start position of the leading axis is derived in the following way:

Start position = leading value position when the stop position of the following axis is reached - leading value distance

The status "Waiting" is displayed at the following axis until the leading value has reached the start position (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 5).

During desynchronization

The following axis begins to desynchronize as soon as the leading value has reached the start position. Desynchronization is indicated in the Motion Control instruction "MC_CamOut" with the parameter "StartSyncOut" = TRUE and in the "<TO>.StatusWord2.X1 (DesynchronizingCommand)" tag of the technology object. The synchronous operation is no longer in the "Synchronous" status. Superimposed jobs of the following axis are canceled.

The following axis travels to the stop position depending on the leading value distance. The dynamics of the following axis during desynchronization is obtained from the calculated motion profile and the current dynamics of the leading axis. The dynamic response of the following axis is thereby only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity).

Changes in the dynamics of the leading axis during desynchronization are superimposed with the calculated motion profile in accordance with the synchronous operation function. This can have the result that the configured dynamic limits at the following axis are violated. This is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object.

During desynchronization, several modulo revolutions of both axes are generally possible.

The leading value must not reverse during desynchronization. In order not to interrupt desynchronization when there are slight fluctuations in the leading value during an actual value coupling, for example, with an external encoder, you can define a reverse tolerance of the leading value (Page 44).

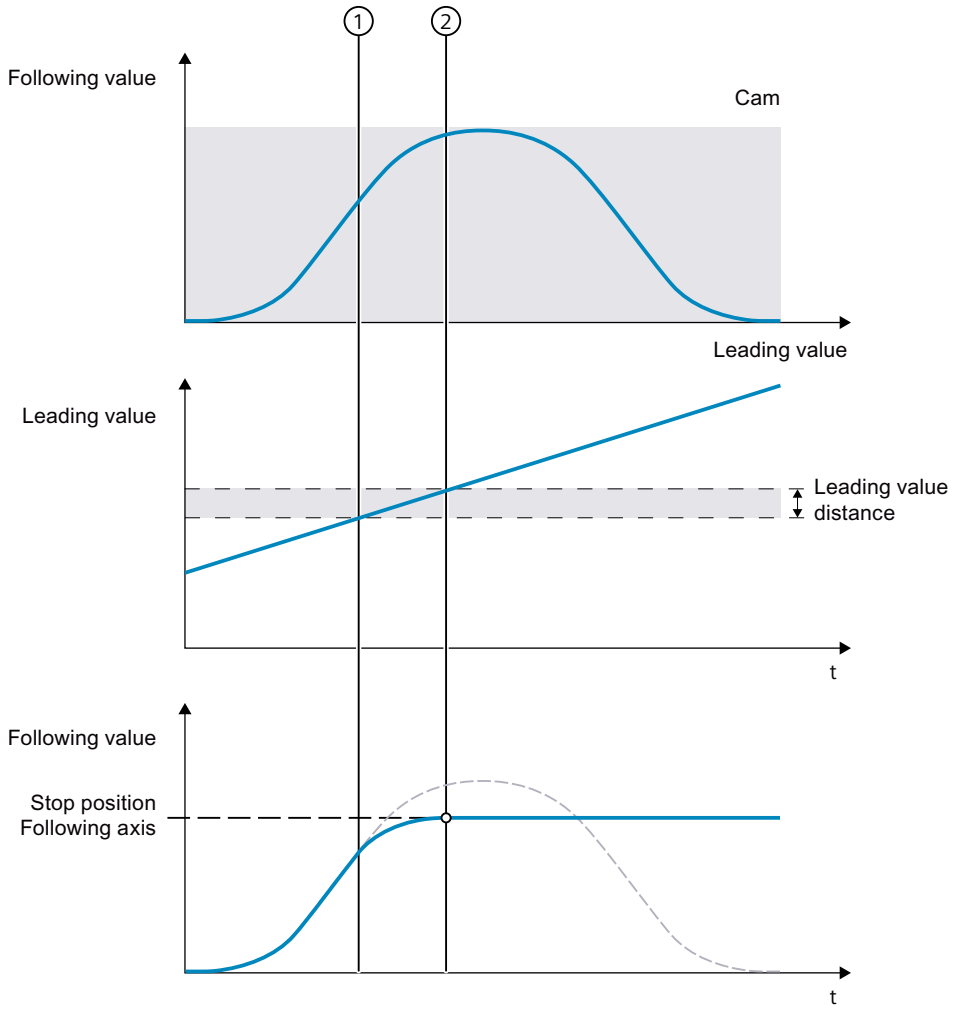

① Time when desynchronization starts

② Time when desynchronization is complete

If the leading axis stops during desynchronization, high dynamic values can occur at the following axis as soon as the leading axis starts moving again and the following axis continues moving to the specified stop position. To avoid these high dynamic values at the following axis, use desynchronization via dynamic parameters ("SyncProfileReference" = 0).

After desynchronization

As soon as the following axis reaches the stop position, the following axis is desynchronized. The following axis is at a standstill. The status is indicated in the Motion Control instruction "MC_CamOut" with the parameter "Done" = TRUE and in the "<TO>.StatusWord.X7 (Standstill)" tag of the technology object.

9.13.3 Defining direction of desynchronization with "MC_CamOut"

Desynchronization ends the synchronous operation relationship between the leading and following axis and camming is ended. You can specify the desynchronization direction with the "SyncOutDirection" parameter of the Motion Control instruction "MC_CamOut (Page 343)".

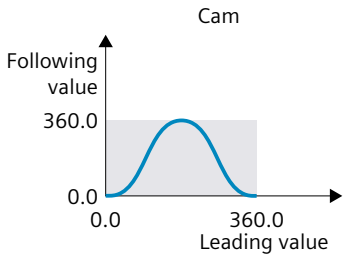

Desynchronizing the following axis in positive traversing direction

With "SyncOutDirection" = 1, the following axis is only desynchronized when the following axis moves in the positive direction.

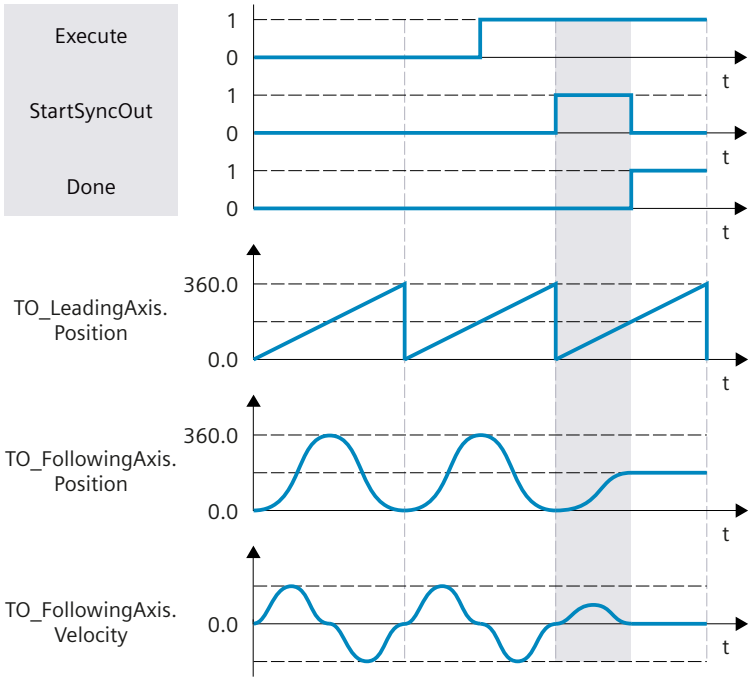

Desynchronizing the following axis in negative traversing direction

With "SyncOutDirection" = 2, the following axis is only desynchronized when the following axis moves in the negative direction.

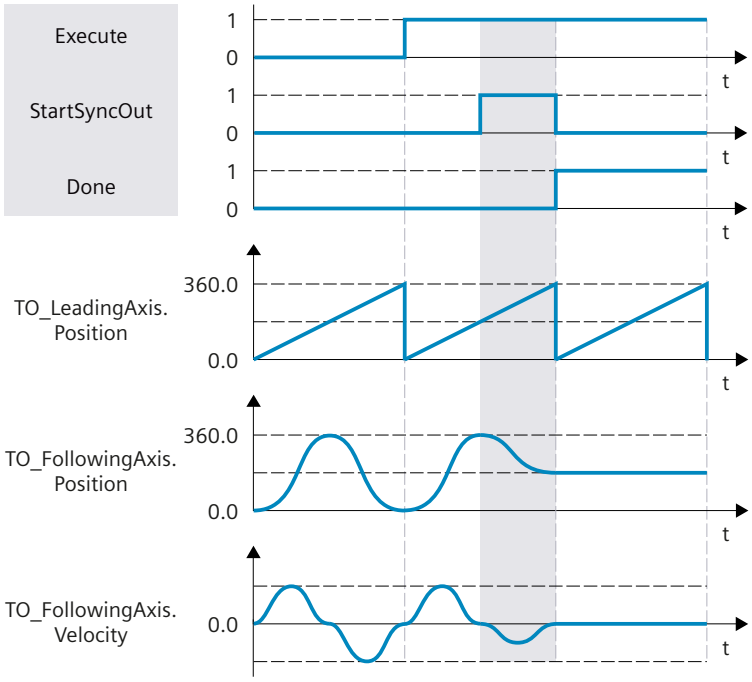

Desynchronizing the following axis in the current traversing direction

With "SyncOutDirection" = 3, the following axis is desynchronized in the direction in which the following axis is currently moving.

9.13.4 Dynamic limits of the following axis during desynchronization with "MC_CamOut"

If a synchronous axis is desynchronized as a following axis in the camming with the Motion Control instruction "MC_CamOut (Page 343)", the following dynamic limits apply, depending on the type of desynchronization:

Desynchronization via dynamic parameters

During synchronization using dynamic parameters, the dynamic limits configured at the technology object apply to the following axis.

- <TO>.DynamicLimits.MaxVelocity
- <TO>.DynamicLimits.MaxAcceleration
- <TO>.DynamicLimits.MaxDeceleration
- <TO>.DynamicLimits.MaxJerk

The SW limit switches also continue to be monitored with the configured dynamic limits of the following axis.

Desynchronization using leading value distance

When desynchronizing via the leading value distance and during synchronous travel, the dynamics of the following axis are only limited to the maximum value for the speed setpoint of the drive (<TO>.Actor.DriveParameter.MaxSpeed). With a linear motor, the dynamic response of the following axis is limited to the maximum value for the velocity setpoint of the drive (<TO>.Actor.LinearMotorDriveParameter.MaxVelocity). The dynamics of the following axis results from the synchronous operation function.

If the dynamic limits configured for the following axis are exceeded, this is indicated in the "<TO>.StatusSynchronizedMotion.StatusWord.X0 ... X2" tags of the technology object. The SW limit switches continue to be monitored with the configured dynamic limits of the following axis.

If the following axis cannot follow the leading value, this results in a following error, which is monitored by the following error monitoring.

9.13.5 Canceling pending camming with "MC_CamOut"

With a "MC_CamOut (Page 343)" job with "SyncProfileReference" = 5 you cancel a pending camming. Canceling a pending camming has no effect on an active cam camming.

9.14 Tags: Camming

The following technology object tags are relevant for camming:

Synchronous axis

Configuration		
Tag	**Description**	
<TO>.SynchronizedMotion.LeadingValueReversalTolerance	Reverse tolerance of the leading value during synchronization with "MC_CamIn" and desynchronization with "MC_CamOut" in length unit of the axis	
<TO>.SynchronizedMotion.LeadingValueTolerenceDirection	Tolerated leading value direction to leave the tolerance range	
	1	Positive
	2	Negative
	3	Positive and negative

Status displays		
Tag	**Description**	
<TO>.StatusSynchronizedMotion.FunctionState	Indication of which synchronous operation function is active	
	0	No synchronous operation active
	1	Gearing ("MC_GearIn")
	2	Gearing with specified synchronous positions ("MC_GearInPos")
	3	Camming ("MC_CamIn")
	4	Desynchronization of gearing ("MC_GearOut")
	5	Desynchronization of camming ("MC_CamOut")
	6	Velocity synchronous operation ("MC_GearInVelocity")
<TO>.StatusSynchronizedMotion.WaitingFunctionState	Indication of which synchronous operation function is waiting	
	0	No synchronous operation waiting
	1	Reserved
	2	Gearing with specified synchronous positions waiting ("MC_GearInPos")
	3	Camming waiting ("MC_CamIn")
	4	Desynchronization of gearing waiting ("MC_GearOut")
	5	Desynchronization of camming waiting ("MC_CamOut")
<TO>.StatusSynchronizedMotion.ActualMaster	When a synchronous operation job is started, the number of the technology data block of the currently used leading axis is displayed.	
	0	Synchronous operation inactive
<TO>.StatusSynchronizedMotion.ActualCam	Currently used cam for camming	

Status displays	
Tag	**Description**
<TO>.StatusSynchronizedMotion.MasterOffset	Current offset of the leading value range of the cam
<TO>.StatusSynchronizedMotion.MasterScaling	Current scaling of the leading value range of the cam
<TO>.StatusSynchronizedMotion.SlaveOffset	Current offset of the following value range of the cam
<TO>.StatusSynchronizedMotion.SlaveScaling	Current scaling of the following value range of the cam
<TO>.Position	Setpoints of the axis
<TO>.Velocity	
<TO>.Acceleration	
<TO>.StatusSynchronizedMotion.EffectiveLeadingValue.Position	Effective leading value including an additive leading value with an "MC_LeadingValueAdditive" job
<TO>.StatusSynchronizedMotion.EffectiveLeadingValue.Velocity	
<TO>.StatusSynchronizedMotion.EffectiveLeadingValue.Acceleration	
<TO>.StatusSynchronizedMotion.PhaseShift	Current absolute leading value offset with an "MC_PhasingAbsolute" or "MC_PhasingRelative" job
<TO>.StatusSynchronizedMotion.FunctionLeadingValue.Position	Leading value of the synchronous operation function after a leading value offset with an "MC_PhasingAbsolute" job or "MC_PhasingRelative" job including an additive leading value with a "MC_LeadingValueAdditive" job
<TO>.StatusSynchronizedMotion.FunctionFollowingValue.Position	Following value of the synchronous operation function before a following value offset with an "MC_OffsetAbsolute" job or "MC_OffsetRelative" job
<TO>.StatusSynchronizedMotion.FunctionFollowingValue.Velocity	
<TO>.StatusSynchronizedMotion.FunctionFollowingValue.Acceleration	
<TO>.StatusSynchronizedMotion.Offset	Current absolute following value offset with an "MC_OffsetAbsolute" or "MC_OffsetRelative" job
<TO>.StatusSynchronizedMotion.StatusWord.X0 (MaxVelocityExceeded)	Set to the value "TRUE" when the maximum velocity configured for the following axis is exceeded during synchronous operation.
<TO>.StatusSynchronizedMotion.StatusWord.X1 (MaxAccelerationExceeded)	Set to the value "TRUE" when the maximum acceleration configured for the following axis is exceeded during synchronous operation.
<TO>.StatusSynchronizedMotion.StatusWord.X2 (MaxDecelerationExceeded)	Set to the value "TRUE" when the maximum deceleration configured for the following axis is exceeded during synchronous operation.
<TO>.StatusWord.X21 (Synchronizing)	Set to the value "TRUE" when the synchronous axis synchronizes to a leading value.
<TO>.StatusWord.X22 (Synchronous)	Set to the value "TRUE" when the synchronous axis is synchronized and moves synchronously to the leading axis.
<TO>.StatusWord2.X1 (DesynchronizingCommand)	Set to the value "TRUE" when the synchronous axis desynchronizes.
<TO>.StatusWord.X24 (PhasingCommand)	Set to the value "TRUE" if a job for leading value offset is active ("MC_PhasingAbsolute", "MC_PhasingRelative").
<TO>.StatusWord2.X3 (PhasingCommandWaiting)	Set to the value "TRUE" if a job for leading value offset is pending ("MC_PhasingAbsolute", "MC_PhasingRelative").

Status displays	
Tag	**Description**
<TO>.StatusWord2.X4 (OffsetCommand)	Set to the value "TRUE" if a job for following value offset is active ("MC_OffsetAbsolute", "MC_OffsetRelative").
<TO>.StatusWord2.X5 (OffsetCommandWaiting)	Set to the value "TRUE" if a job for following value offset is waiting ("MC_OffsetAbsolute", "MC_OffsetRelative").
<TO>.ErrorWord.X14 (SynchronousError)	Error during synchronous operation The leading axis specified in the Motion Control instruction was not configured as a possible leading axis.

Cam

Status displays	
Tag	**Description**
<TO>.StatusWord.X6 (Interpolated)	Set to the value "TRUE" when the job for interpolatation of the cam has been completed ("MC_InterpolateCam").
<TO>.StatusWord.X9 (CamRangeScaled)	Set to the value "TRUE" if at least one area of the cam is scaled via a "MC_SetCamRangeScaling" job is scaled.

Other synchronous operation functions 10

10.1 Simulate synchronous operation

An active synchronous operation connection is disconnected when axis enables are removed or for motion jobs on a following axis. By simulating synchronous operation, you can keep the synchronous operation active without canceling the synchronous operation relationship. You can set an active synchronous operation with the Motion Control instruction "MC_SynchronizedMotionSimulation (Page 337)" in simulation.

The synchronous operation only acts on the following axis. Setpoint changes from the synchronous operation are no longer taken into consideration at the axis and no longer forwarded to the drive. The setpoints output to the drive continue to come from any active superimposed motions of the following axis. This also applies to single-axis jobs on the following axis, while synchronous operation is in simulation mode.

NOTICE
Machine damage due to possible setpoint jumps If superimposed motions are or were active on the following axis due to the Motion Control instructions "MC_MoveSuperimposed", "MC_MotionInSuperimposed", "MC_MotionInSuperimposedAxes" or "MC_HaltSuperimposed", the following axis follows the leading axis after simulation is ended without the position offset by the superimposed motion. Setpoint jumps can occur as a result. To avoid setpoint jumps, note the following: • For superimposed motions, do not set a synchronous operation to simulation. • To move following values on the following axis, use the "MC_OffsetAbsolute" or "MC_OffsetRelative" instructions instead of the instructions for superimposed motions. • To set a synchronous operation with an active "MC_MotionInSuperimposedAxes" motion to simulation at the following axis, consider the conditions and procedure in the FAQ entry 109994585 (https://support.industry.siemens.com/cs/ww/en/view/109994585).

Starting the simulation

Requirement

- The technology object has been configured correctly.
- The following axis is a synchronous axis.
- Synchronous operation is active on the technology object in status "Synchronous" (<TO>.StatusWord.X22 = TRUE).

Procedure

To set a synchronous operation on a following axis in simulation mode, follow these steps:

1. At the "Slave" parameter of the "MC_SynchronizedMotionSimulation" job, specify the following axis on which the synchronous operation is active.
2. Bring the leading axis to a standstill, e.g. with an "MC_Halt" job.
3. Start the simulation of the synchronous operation on the following axis with "Enable" = TRUE parameter. The leading axis must be stopped at this time.

   As soon as the synchronous operation is active, this is indicated in the Motion Control instruction by the parameter "InSimulation" = TRUE and in the "<TO>.StatusSynchronizedMotion.StatusWord.X3 (InSimulation)" tag of the technology object.

   The synchronous operation remains active during the simulation, including the motions through single axis jobs or with disabling the leading axis and/or following axis with "MC_Power.Enable" = FALSE or a "MC_Stop" job, for example by opening a protective door. The synchronous operation in "synchronous" status ("MC_GearIn.InGear" = TRUE, "MC_GearInPos.InSync" = TRUE or "MC_CamIn.InSync" = TRUE, but "<TO>.StatusWord.X22" = FALSE).

End simulation

NOTICE
Machine damage due to possible setpoint jumps If the position of the following axis at the end of the simulation differs from the position at the start of the simulation, this triggers a setpoint step-change which can lead to machine damage. Therefore, make sure that the setpoints of the following axis correspond to the setpoints from the synchronous operation relationship when simulation is ended.

Requirement

- The set position of the following axis coincides with the setpoint from the synchronous relationship.
- The technology object has been enabled ("MC_Power.Enable" = TRUE).

Procedure

To end a synchronous operation on a following axis, follow these steps:

1. End the synchronous operation with the parameter "Enable" = FALSE of the "MC_SynchronizedMotionSimulation" job.

   The setpoints of the synchronous operation are directly effective on the following axis. The following axis does not have to be synchronized again after the synchronous operation has been completed.

10.1.1 Tags: Synchronous operation is being simulated

The following tags of the technology object are relevant for simulation:

Status indicators		
Tag	**Description**	
<TO>.StatusSynchronizedMotion.StatusWord.X3 (InSimulation)	Simulation of synchronous operation on a following axis with a "MC_SynchronizedMotionSimulation" job	
	FALSE	Not simulated
	TRUE	Simulated

10.2 Specify additive leading value

To superimpose the leading value of a synchronous operation from the application, use the Motion Control instruction "MC_LeadingValueAdditive" in addition to the active leading value to cyclically specify an additive leading value on the following axis. The additive leading value consists of position, velocity and acceleration.

You can find an overview in the section "Mode of operation of the instructions in synchronous operation (Page 34)".

Parameter inputs

With the following parameters of the Motion Control instruction "MC_LeadingValueAdditive (Page 347)" you can determine the additive leading value:

- At the "Axis" parameter, specify the following axis on which the additive leading value acts.
- With the "Position" parameter, you can define the additive position value.
- With the "Velocity" parameter, you can define the additive velocity value.
- With the "Acceleration" parameter, you can define the additive acceleration value.

Start additive leading value specification

With the "Enable" parameter = TRUE of the "MC_LeadingValueAdditive" job, set the additive leading value to effective. The additive leading value becomes effective directly and without dynamic limitation on the following axis.

You can start an "MC_LeadingValueAdditive" job independently of the synchronous operation job. Only one "MC_LeadingValueAdditive" job can be active on a following axis at any time.

During the additive leading value specification

The default values for position, velocity and acceleration are valid as long as the "Busy" parameter = TRUE. Changes in the specified values are directly effective without consideration of the dynamic limits. The active additive leading value specification is displayed in of the "<TO>.StatusSynchronizedMotion.StatusWord.X4 (LeadingValueAdditiveCommand)" tag of the technology object.

The effect of a "MC_LeadingValueAdditive" job depends on the status of the synchronous operation:

Status of synchronous operation	Effect on:
Not active or pending	• Start position of synchronization • Following axis dynamic response
Synchronization	• Synchronous position • Phase position • Following axis dynamic response
Synchronous motion	• Phase position • Following axis dynamic response
Desynchronization	• Stop position of following axis • Phase position • Following axis dynamic response

With a leading value switchover, the additive leading value still remains effective.

Ending the additive leading value specification

As soon as you end the leading value specification with the parameter "Enable" = FALSE of the "MC_LeadingValueAdditive" job, the additive leading value directly becomes ineffective.

10.2.1 Tags: Additive leading value

The following technology object tags are relevant for the additive leading value:

Status indicators		
Tag	**Description**	
<TO>.StatusSynchronizedMotion.StatusWord.X4 (LeadingValueAdditiveCommand)	Additive leading value with a "MC_LeadingValueAdditive" job	
	FALSE	Additive leading value not active
	TRUE	Additive leading value active
<TO>.StatusSynchronizedMotion.EffectiveLeadingValue.Position	Effective leading value position of the synchronous operation function	
<TO>.StatusSynchronizedMotion.EffectiveLeadingValue.Velocity	Effective leading value velocity of the synchronous operation function	
<TO>.StatusSynchronizedMotion.EffectiveLeadingValue.Acceleration	Effective leading value acceleration of the synchronous operation function	

Cross-PLC synchronous operation 11

With cross-PLC synchronous operation, you realize synchronous operations between axes that are on different CPUs. All following axes of a leading value are hereby synchronous to one another with consideration of the respective synchronous operation function. All following axes receive the same leading value at the same time.

You can configure and operate the following axes on different CPUs. You can also configure the leading axis on any CPU.

The S7-1500 and S7-1500T CPUs can make the leading value available for a cross-PLC synchronous operation. You need to use an S7-1500T CPU as the CPU that receives the leading value.

Leading axis, leading axis proxy and virtual leading axis

The leading axis can be interconnected with local following axes on the same CPU to a synchronous operation. The leading axis also provides the leading value for cross-PLC synchronous operation. You can use a positioning axis, synchronous axis or external encoder technology object as the leading axis.

Recommendation: Use a virtual axis as leading axis.

On a CPU that receives the leading value, a technology object leading axis proxy reads the leading value. A following axis on the CPU can be interconnected directly to the leading axis proxy as a leading value to a synchronous operation.

Recommendation: Use an additional virtual leading axis, which you interconnect with the following axes to a synchronous operation. If, for example, the leading value of CPU 1 is not provided or fails, you can stop or move the following axes in the group via the additional virtual leading axis.

The figure below shows the operating principle based on an example with one following axis per CPU:

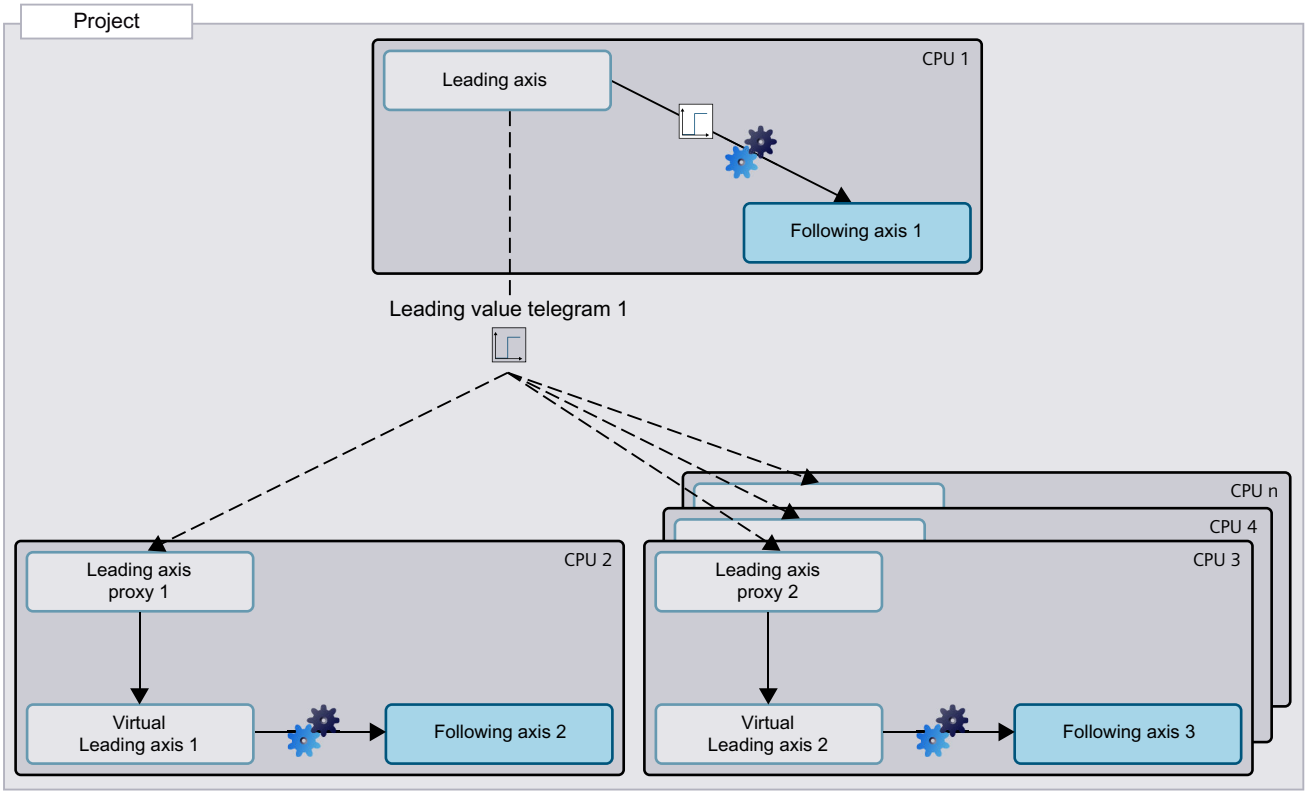

Leading value delay that can be configured at the leading axis (delay time)

Delay time caused by the processing and transfer of the leading value

Gearing (example)

The leading axis and a local following axis 1 are located on CPU 1. The leading axis and the following axis 1 are interconnected to a synchronous operation. The leading axis also makes the leading value available for cross-PLC synchronous operation.

The leading value of the CPU 1 is transferred to the CPUs 2 to n by means of a leading value telegram via PROFINET IO with IRT. On CPUs 2 to n, a leading axis proxy reads the leading value. A following axis is locally interconnected with a virtual leading axis.

All following axes 1 to n are synchronous and follow the same leading value.

Communication options

The CPUs can communicate with each other in the following ways:

- Communication via the direct data exchange (Page 213)

  If all CPUs are in the same project, use the direct data exchange.

  This is useful, for example, if the machine modules represented by the respective CPUs are always present in the machine.

- Communication via a PN/PN coupler (Page 220)

  For the communication of the CPUs via different PROFINET subnets, use a PN/PN coupler in ISO mode. ISO mode is possible as of firmware version 6.0 of the PN/PN coupler.

  The CPUs can be in the same project or in different projects:

  – If all CPUs are in the same project, you can configure a PN/PN reduction ratio, for example. This structure can also be useful for net separation.

    Note that online routing via the PN/PN coupler is not possible.

  – If the CPUs are in different projects, you can easily integrate option modules with their own CPU into the machine, for example.

    You can also connect machines from different manufacturers without having to disclose the know-how of your own project.

- Communication using isochronous I-device (Page 230)

  If multiple PROFINET interfaces of a CPU support the "PROFINET with IRT" functionality, you can operate the CPU as an isochronous I-device.

  The PROFINET interface configured as an I-device is used for isochronous data exchange with the higher-level IO Controller, through which you can realize cross-PLC synchronous operation. The other PROFINET interface can synchronize with the I-device interface and operate connected IO devices isochronously.

  The CPUs can be in the same project or in different projects:

  – If all CPUs are in the same project, you can temporarily deactivate the I-device, for example. This may be useful in order to temporarily operate a machine without a machine module equipped with a CPU.

    For more information on deactivating an I-device, refer to the "SIMATIC PROFINET with STEP 7" function manual (https://support.industry.siemens.com/cs/ww/en/view/49948856).

  – If the CPUs with the same PROFINET cycle are in different projects, you can easily integrate option modules with their own CPU into the machine or connect machines from different manufacturers, for example.

More information

For more information on the setup and diagnostics of a cross-PLC synchronous operation including sample projects, refer to the Siemens Industry Online Support FAQ entry 109770938 (https://support.industry.siemens.com/cs/ww/en/view/109770938).

More information on PROFIsafe sample configurations can be found in Siemens Industry Online Support in the FAQ entry 109740240 (https://support.industry.siemens.com/cs/ww/en/view/109740240).

11.1 Time response in cross-PLC synchronous operation

In the processing and transfer of the leading value, a delay time occurs between the generation of the leading value on the leading axis one on CPU and the provision of the leading value for the following axes at the leading axis proxy on the other CPUs. The following axes of the other CPUs receive the leading value with a time delay. The delay time depends on the route of the leading value.

To achieve synchronicity between the local following axes of the CPU of the leading axis and the following axes of other CPUs without extrapolating the leading value at the leading axis proxy, the leading value output can be delayed at the leading axis for the local following axes. The delay time can be compensated for with these configurable delay times.

Delay time

You can calculate and view the delay times in the interconnection overview (Page 242). The application cycles of the leading axis proxy and any cascading present are included in the calculation of the delay times.

Alternatively, you can manually configure the delay times on the leading axis and on the virtual following axes. In this way, you can consider additional requirements from your specific application, for example.

Depending on the set delay time, the leading value at the leading axis proxy is automatically interpolated or extrapolated. The automatic interpolation and extrapolation guarantees the synchronicity of all following axes. In the interconnection overview, an indication of whether the leading value is interpolated or extrapolated is provided for each route of a leading value (Page 244).

NOTE

Deviations in the following values

With an extrapolation, deviations in the following values can occur in the event of velocity changes.

With an interpolation, no deviations of the following values occur in the event of velocity changes.

If you increase the delay time of the leading axis in the leading value settings, this leads to a lower extrapolation time at the leading axis proxy or to a higher interpolation time of the leading value at the leading axis proxy. This reduces the deviations in the following values that arise during extrapolation in the acceleration and deceleration phases.

If the delay time at the leading axis proxy is increased, this results in a higher extrapolation time or to a lower interpolation time.

Recursive interconnection

When all axes are active, the leading axis becomes the following axis of its own leading value with a recursive interconnection. During the configuration, recursive interconnections are displayed in the interconnection overview. No delay times can be calculated for recursive interconnections.

Even if different synchronized groups are active at different times, recursive interconnections may still occur during interconnection. Recursive interconnections over multiple CPUs are not detected during runtime.

A recursive interconnection that is in effect during runtime is not permitted.

11.2 Compatible versions for synchronous operation across PLCs

Firmware and technology versions

A cross-PLC synchronous operation is possible as of firmware version V2.8 and as of technology version V5.0.

Leading value telegram and technology versions

The following table shows the possible combinations of technology versions depending on the leading value telegram version:

Technology version		Leading value telegram version
Leading value source	Recipient	
≤ V8.0	≤ V8.0	V1
	V9.0	-
	≥ V10.0	V1
V9.0	≤ V8.0	-
	V9.0	V2
	≥ V10.0	V2
≥ V10.0	≤ V8.0	V1
	V9.0	V2
	≥ V10.0	V1, V2

If the combination of the leading value telegram and technology versions is incompatible, technology alarm 901 is output on the leading axis proxy.

The leading value telegram version is indicated in the "<TO>.CrossPlcSynchronousOperation.Interfaces[1..32].TelegramVersion" tag of the technology object of the leading axis or following axis.

NOTE

Upgrade to technology version V10.0

Note the information on leading value telegram version 2 in the section "Upgrading to technology version V10.0 (Page 21)".

Reduction ratio

Cross-PLC synchronous operation between CPUs with different PROFINET send clocks requires the use of a PN/PN coupler.

Clock reduction of the subnets is supported as of technology version V9.0 and control value telegram version V2. If you use communication via a PN/PN coupler and technology objects with technology versions V5.0 to V8.0, do not use a reduction ratio of the subnets.

A reduction ratio of the application cycles of MC_Servo and MC_Interpolator to the send clock is possible.

Switching setpoint output cams/cam tracks

If you are operating cross-PLC synchronous operation with a PN/PN coupler and a reduction ratio of the send clocks, the technology objects receive the setpoints with a time offset. Nevertheless, the setpoints become effective on the drives at the same time.

You can find more information on the behavior of setpoint output cams and setpoint cam tracks in cross-PLC synchronous operation in Siemens Industry Online Support in the FAQ entry 109975409 (https://support.industry.siemens.com/cs/ww/en/view/109975409).

11.3 Preparing cross-PLC synchronous operation

For a cross-PLC synchronous operation, a leading axis proxy technology object on each additional CPU is required in addition to the technology objects for leading and following axes.

When you create a technology object, an "MC_Servo" organization block is automatically created. This is required when you set up communication via direct data exchange on each CPU.

Requirements

- You have created a CPU S7-1500 or S7-1500T for the leading axis.
- You have created one or more CPUs S7-1500T for additional following axes.

Procedure

To prepare the cross-PLC synchronous operation, follow these steps:

1. On the first CPU, create one of the following technology objects as the leading axis.
   - Positioning axis
   - Synchronous axis
   - External encoder (S7-1500T)

   Recommendation: Use a virtual axis as leading axis.
2. If necessary, create one or more synchronous axis technology objects as local following axes on the first CPU.
3. Create a leading axis proxy technology object on each additional CPU.
4. Create one or more synchronous axis technology objects as following axes on each additional CPU.

5. Configure the configuration parameters of the leading and following axes that are not specific for synchronous operation. You can find a description of the configuration parameters in the "S7-1500/S7-1500T Axis functions" documentation.
6. Set up the communication:
   – Communication via direct data exchange (Page 216)
   – Communication via PN/PN coupler (Page 223)
   – Communication using isochronous I-device (Page 233)
7. Configure the provision of leading value. (Page 238)
8. Configure the tolerance time (Page 241).
9. Set the delay times (Page 245).

11.4 Communication via direct data exchange

11.4.1 Cross-PLC synchronous operation with direct data exchange

In a cross-PLC synchronous operation, the leading value is transferred via PROFINET IO with IRT. Direct data exchange is used for the communication between the CPUs within a project. With communication by means of direct data exchange, the leading value is made available once within a project and can then by received by multiple CPUs on the same bus. Leading axis proxies that are interconnected with the same leading value can be configured on different CPUs. CPUs with a second IRT interface can be configured in multiple subnets within a project.

In addition, it is possible to make multiple leading values of different leading axes available on different CPUs via the same bus. The CPUs must be on a bus and belong to the same sync domain.

Within a subnet

The figure below shows the operating principle based on an example with two following axes on two CPUs:

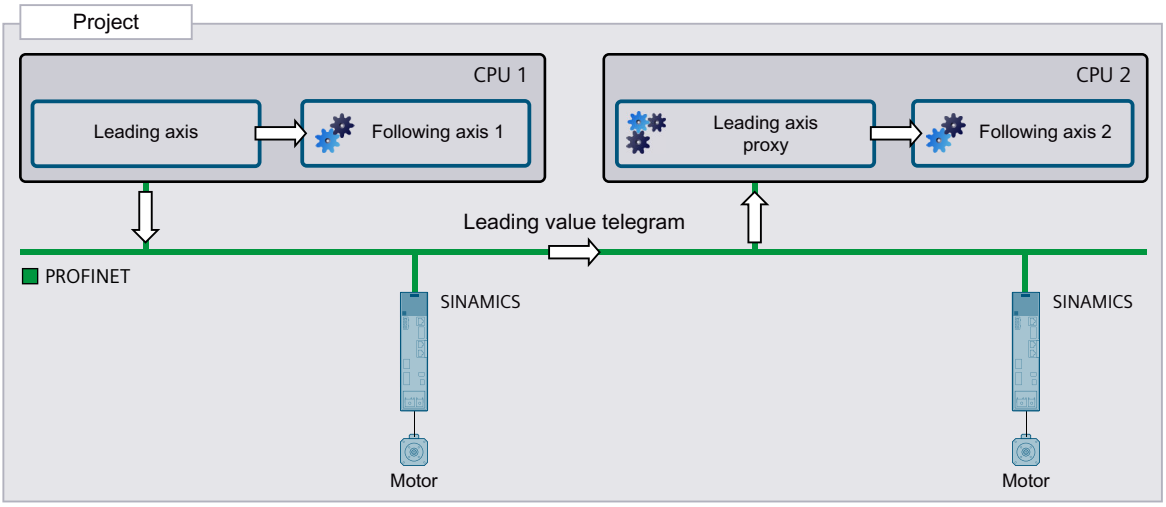

⇨ Leading value

The leading axis and a local following axis 1 are located on CPU 1. The leading axis and the following axis 1 are interconnected to a synchronous operation. The leading axis also makes the leading value available for cross-PLC synchronous operation.

The CPUs 1 and 2 are interconnected via a subnet. The leading value of CPU 1 is transferred to CPU 2 by means of a leading value telegram via PROFINET IO with IRT.

On CPU 2, a leading axis proxy reads the leading value. A following axis 2 is interconnected locally as leading value with the leading axis proxy. The following axes 1 and 2 are synchronous and follow the same leading value.

Cross-network

In order to configure a CPU cross-network within a project, an additional IRT interface to the CPU is required.

The figure below shows the operating principle based on an example with three following axes on two CPUs:

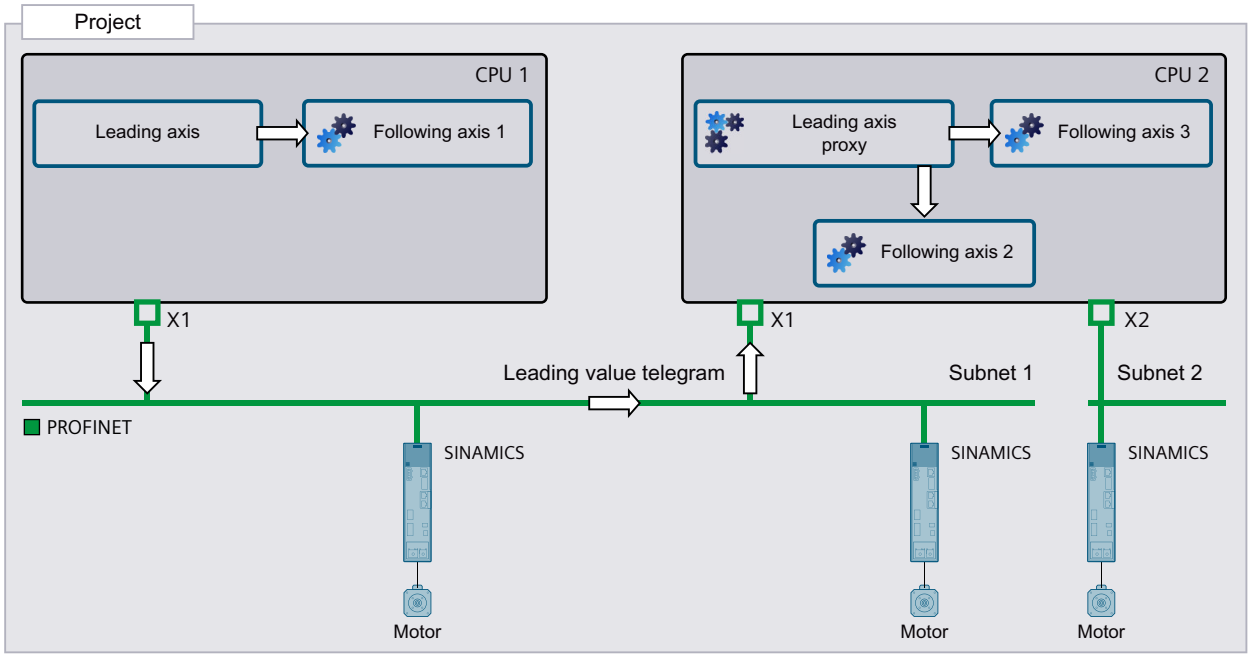

⇨ Leading value

The leading axis and a local following axis 1 are located on CPU 1. The leading axis and the following axis 1 are interconnected to a synchronous operation. The leading axis also makes the leading value available for cross-PLC synchronous operation.

The CPUs 1 and 2 are interconnected via the subnet 1. The leading value of CPU 1 is transferred to CPU 2 by means of a leading value telegram via PROFINET IO with IRT.

On CPU 2, a leading axis proxy reads the leading value. The following axes 2 and 3 are interconnected locally as leading value with the leading axis proxy. The following axis 2 provides the setpoint for a drive within subnet 1. The following axis 3 provides the setpoint for a drive within subnet 2.

Subnet 2 is interconnected via the PROFINET interface X2 of the CPU 2. The PROFINET interfaces X1 and X2 of the CPU 2 are in coupled mode. The PROFINET cycle is identical in both subnets.

The following axes 1, 2 and 3 are synchronous and follow the same leading value.

11.4.2 Setting up communication via direct data exchange

You use communication via the direct data exchange for cross-PLC synchronous operation, in which all CPUs are in the same project.

For the required communication directions between the connected CPUs, you must first set up transfer areas. You then create input and output tags which reference the relevant transfer areas. You can then select these tags for the transfer area when configuring the leading axis and the leading axis proxy.

Hereafter, the sender CPU is the CPU on which a leading axis provides a leading value. The receiver CPU is the CPU on which a leading axis proxy reads the leading value.

Requirement

- You have set up a network via PROFINET IO with IRT.
- You have connected the IRT ports of the CPUs in the network view and in the topology view.
- You have assigned the same sync domain to all CPUs.
- You have configured a CPU as sync master.
- You have configured all other CPUs as sync slaves.
- You have created at least one technology object on all CPUs.

  NOTE
  "MC_Servo" organization block
  When you create a technology object, an MC_Servo OB is created automatically.

- On all CPUs, you have configured the "Synchronous to bus" property as the cycle time for the "MC_Servo" under "General > Cycle time".

Adding communication directions

To add the communication directions, proceed as follows:

1. Open the "I/O communication" tab in the network view.
2. To create a communication direction from the sender CPU to the receiver CPU, select the sender CPU.
3. Drag-and-drop the receiver CPU into the "Drop or select the device here" field of the "Partner 2" table column of the corresponding PROFINET interface.

   The communication direction from sender CPU to receiver CPU is created.
4. Repeat steps 2 and 3 for all communication directions required between the interconnected CPUs.

NOTE
Communication direction from the receiver CPU to the sender CPU
If necessary, also set up a communication direction from the receiver CPU to the sender CPU, e.g. to transfer application-specific status information.

Configuring transfer areas

To configure the transfer areas, follow these steps:

1. In the "I/O communication" tab in the network view, select a communication direction of a selected CPU.
2. Add a transfer area in the Inspector window under "Properties > General > Direct data exchange" by entering a name.
3. Repeat steps 1 and 2 for all created configuration directions.
4. Configure the created transfer area in the Inspector window "Properties > General > Direct data exchange > <Name of transfer area>":
   - In the "Start address" fields, define the start address of the assigned logical address area of the sender and of the receiver.

     NOTE
     Multiple receiver CPUs in the same cascade (1:n relationship)
     If multiple receiver CPUs receive the same leading value of the sender CPU, select in each case for the receiver CPU the same address area for the transfer area between the sender CPU and the receiver CPU n that you defined between the sender CPU and the receiver CPU 1 under "Properties > General > Direct data exchange" in the "Partner address" table column.

   - In the "Organization block" fields, select the MC_Servo OB of the respective CPU.
   - Define a data length of 48 bytes in the "Data length [byte]" field.
5. Repeat step 4 for all created transfer areas.
6. If you use a SIMATIC Drive Controller, set the clock system of the SINAMICS Integrated:
   - Select PROFIdrive Integrated in the network view.
   - In the Inspector window, select the entry "Send clock of the PROFINET interface [X150]" under "Properties > General > Constant bus cycle time" in the "Cycle time" selection list.

Creating tags

To create the output tag of a sender CPU and the input tag of a receiver CPU, proceed as follows:

1. Open the PLC tags of a CPU via the project tree "<Name of CPU> > PLC tags > Show all tags".

   The "PLC tags" table opens.
2. Enter the name of the new tag in the "Name" column.

3. In the "Data type" column, manually enter the "DX_TEL_SyncOp" data type.

NOTE
Data type "DX_TEL_SyncOp"
If the data type "DX_TEL_SyncOp" is not available, it was deleted with the last compilation.
To restore the "DX_TEL_SyncOp" data type, add a ≥ V5.0 technology object. After you have used the data type in the "PLC tags" table, you can delete the technology object again.

4. Enter the configured start address of the transfer area in the "Address" column with the following prefix:
   – "%Q" for an output tag on the sender CPU
   – "%I" for an input tag on the receiver CPU
5. Repeat steps 1 to 4 for the respective sender and receiver CPUs of all configured transfer areas.

Result

You have set up communication via direct data exchange. During the configuration of the leading axis and the leading axis proxy, you can now select the configured tags for the transfer areas in the table column or in the "Transfer area" selection list under "Technology object > Configuration > Leading value settings".

If no technology object is created on a CPU, the MC_Servo OB is deleted when the software is compiled. To be able to check the set communication in this case, compile the hardware only.

More information

For more information on the subject of "Direct data exchange" refer to the "SIMATIC PROFINET with STEP 7" function manual (https://support.industry.siemens.com/cs/ww/en/view/49948856).

11.4.3 Cascaded interconnection with direct data exchange

The CPUs communicate with each other via the direct data exchange. With a cascaded interconnection, a following axis makes a cross-PLC leading value available to a leading axis proxy again. Use a virtual axis for this purpose. In the following figure, this is shown as a "Virtual leading axis":

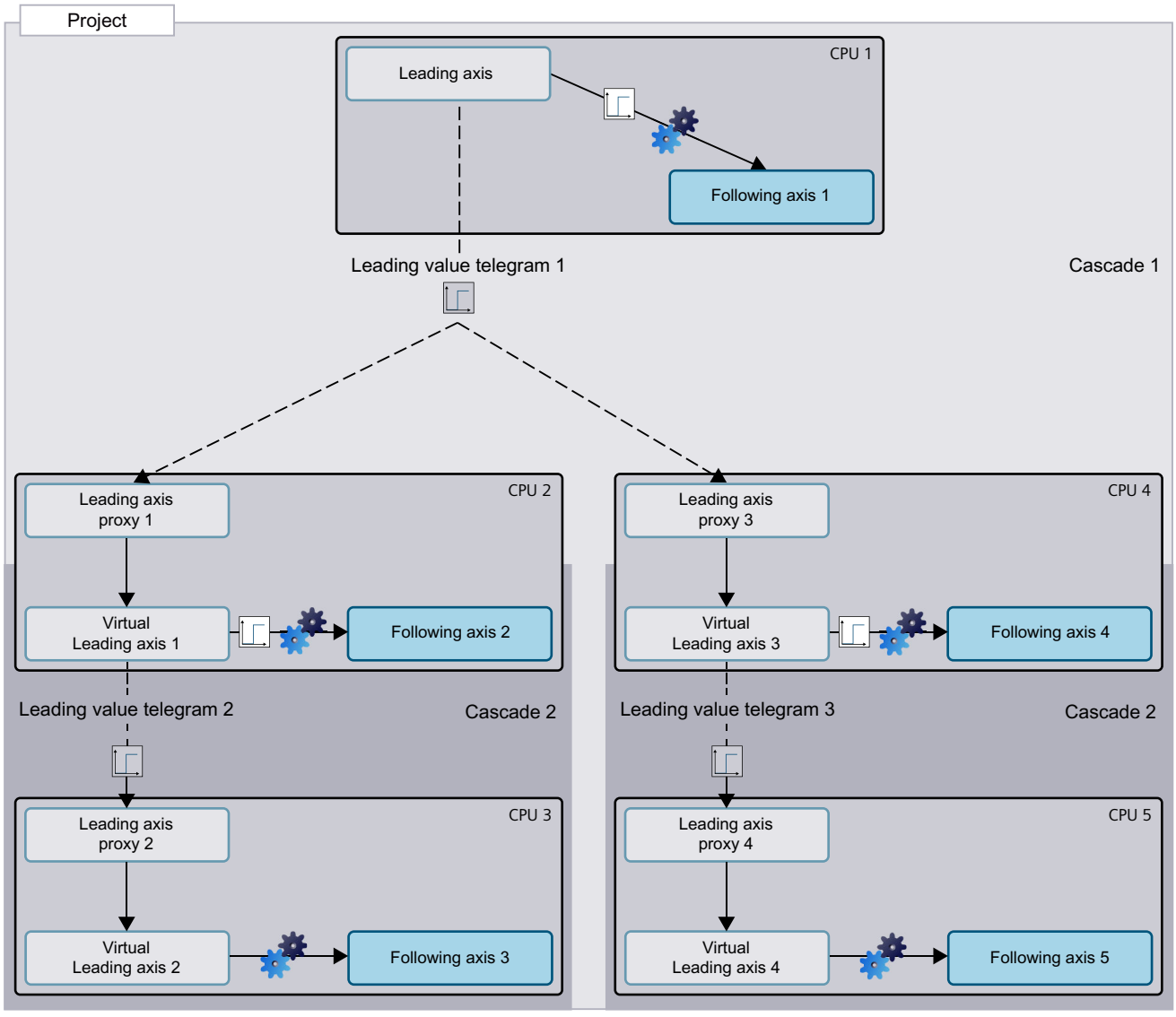

Leading value delay that can be configured at the leading axis (delay time)

Delay time caused by the processing and transfer of the leading value

Gearing (example)

The figure shows two cascades:

- The CPUs 1, 2 and 4 form the first cascade. The CPUs 2 and 4 receive the same leading value from the CPU 1 via the leading value telegram 1. The same address range is configured for transfer areas between CPUs 1 and 2 and between CPUs 1 and 4.
- The CPUs 2 and 3 as well as CPUs 4 and 5 each form a second cascade. However, CPUs 3 and 5 do not receive the same leading value. The CPU 3 receives the leading value of the CPU 2 via the leading value telegram 2. The CPU 5 receives the leading value of the CPU 4 via the leading value telegram 3. Different address ranges are therefore configured for the transfer areas between CPUs 2 and 3 and between CPUs 4 and 5.

Time response

In principle, the delay time per cascade is:

Delay time = 2 × application cycle of the CPU of the leading axis proxy

In the figure shown above, a delay time is set on the leading axis on CPU 1, which delays the leading value output to the local following axis 1. In addition, a delay time is set on each virtual leading axes 1 and 2 on CPUs 2 and 4, since CPUs 3 and 5 are present in a cascade. All following axes 1 to 5 thus receive the same leading value at the same time.

11.5 Communication via PN/PN coupler

11.5.1 Cross-PLC synchronous operation with PN/PN coupler

In a cross-PLC synchronous operation, the leading value is transferred via PROFINET IO with IRT. For communication between CPUs via different PROFINET subnets, use a PN/PN coupler in ISO mode to implement isochronous data transfer via PROFINET IO with IRT. ISO mode is possible as of firmware version 6.0 of the PN/PN coupler.

A PN/PN coupler couples two subnets together. The subnets can either be in the same project or in different projects. There can be multiple PN/PN couplers within a subnet.

With communication via multiple PN/PN couplers, the leading value is made available once and can then be received by multiple CPUs within the subnet. Leading axis proxies that are interconnected with the same leading value can be configured on different CPUs. A PN/PN coupler can only transfer a leading value from one CPU to another CPU. A transfer to multiple CPUs is not possible.

In addition, it is possible to make multiple leading values of different leading axes available on different CPUs via the same bus. The CPUs must be located in the coupled subnets and belong to the same sync domains.

Within a project

The figure below shows the operating principle based on an example with two following axes on two CPUs:

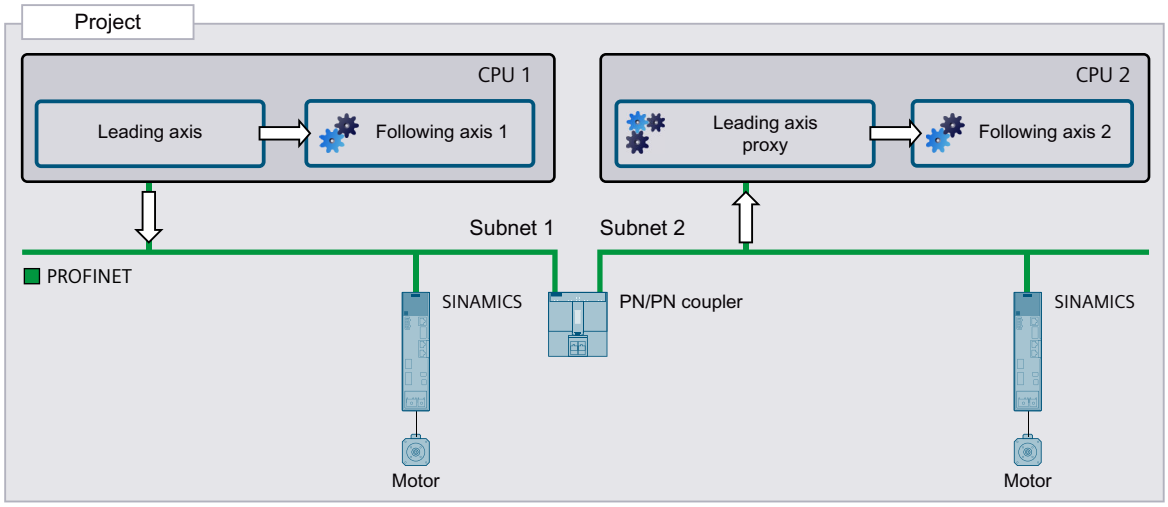

⇨ Leading value

The leading axis and a local following axis 1 are located on CPU 1. The leading axis and the following axis 1 are interconnected to a synchronous operation. The leading axis also makes the leading value available for cross-PLC synchronous operation.

The subnets 1 and 2 are interconnected via a PN/PN coupler. The leading value of CPU 1 is transferred to CPU 2 by means of a leading value telegram via PROFINET IO with IRT.

On CPU 2, a leading axis proxy reads the leading value. A following axis 2 is interconnected locally as leading value with the leading axis proxy. The following axes 1 and 2 are synchronous and follow the same leading value.

Cross-project

You can also implement cross-PLC synchronous operation cross-project. You can configure and operate the following axes on different CPUs in various projects. You can also configure the leading axis on a CPU in any project. All following axes of a leading value are hereby synchronous to one another with consideration of the respective synchronous operation function. All following axes receive the same leading value at the same time.

The figure below shows the operating principle based on an example with three following axes on three CPUs, each of which is configured in its own project:

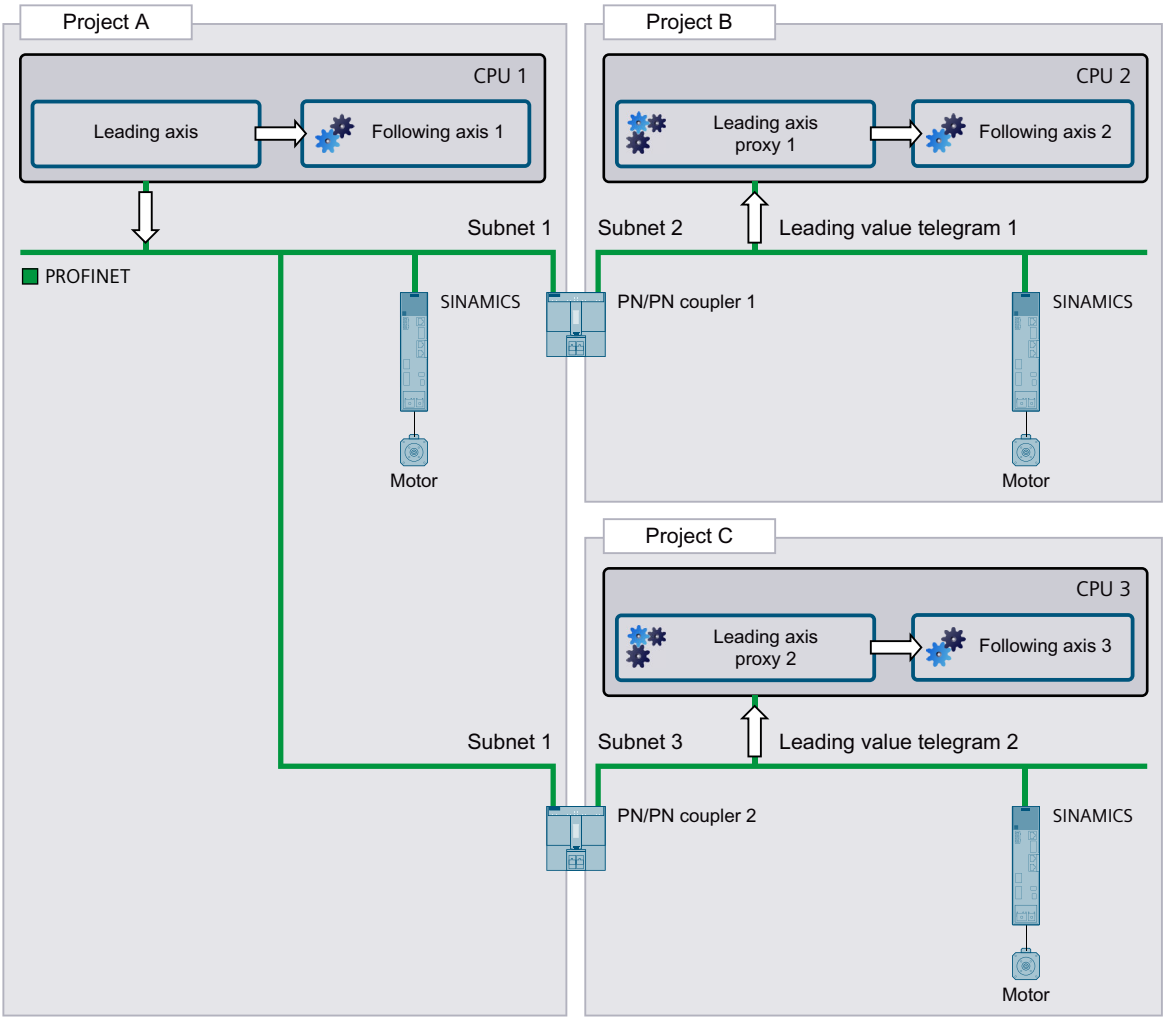

⇨ Leading value

The leading axis and a local following axis 1 are located on CPU 1 in project A. The leading axis and the following axis 1 are interconnected to a synchronous operation. The leading axis also makes the leading value available for cross-PLC synchronous operation.

The subnets 1 and 2 are interconnected via the PN/PN coupler 1. The subnets 1 and 3 are interconnected via the PN/PN coupler 2. The leading value of CPU 1 is transferred to CPUs 2 in project B and 3 in project C by leading value telegrams via PROFINET IO with IRT.

Both on CPU 2 in project B an on CPU 3 in project C, a leading axis proxy reads the leading value. The following axes 2 and 3 are locally interconnected to the respective leading axis proxy as leading value. The following axes 1, 2 and 3 are synchronous and follow the same leading value.

11.5.2 Set communication via PN/PN coupler

For the required communication directions between the connected CPUs, you must first set up transfer areas. A leading value can be provided over a maximum of 32 different transfer areas. You then create input and output tags which reference the relevant transfer areas. You can then select these tags for the transfer area when configuring the leading axis and the leading axis proxy.

When interconnecting via different projects, export one of the PROFINET interfaces of the PN/PN coupler to the other project and implement further settings there. Below, the PROFINET interface X2 is exported as an example.

Reduction ratios of 1, 2, 4, 8 and 16 are possible between projects. The send clock on the PROFINET interface X1 of the PN/PN coupler is equal to or a multiple of the send clock on the PROFINET interface X2.

Hereafter, the sender CPU in subnet 1 is the CPU on which a leading axis provides a leading value. The receiver CPU in subnet 2 is the CPU on which a leading axis proxy reads the leading value. If interconnected within the same project, both subnets 1 and 2 are in project A. If interconnected across different projects, subnet 1 is in project A and subnet 2 is in project B.

Requirement

A project

If you are running subnets 1 and 2 in the same project A, the following requirements apply:

- You have set up a network via PROFINET IO with IRT.
- You have connected the IRT ports of the CPUs in the network view and in the topology view with the IRT ports of the PN/PN coupler.
- You have assigned the same sync domain 1 to the CPU in subnet 1 and to the PROFINET interface X1 of the PN/PN coupler.
- You have assigned the same sync domain 2 to the CPU in subnet 2 and to the PROFINET interface X2 of the PN/PN coupler.
- You have configured the sender CPU as a sync master in sync domain 1.
- In sync domain 2, you have configured the PROFINET interface X2 of the PN/PN coupler as a sync master.
- You have configured the recipient CPU in subnet 2 and the PROFINET interface X1 of the PN/PN coupler as a sync slave in the corresponding sync domain.
- You have created at least one technology object on all CPUs.

NOTE

"MC_Servo" organization block

When you create a technology object, an MC_Servo OB is created automatically.

- On all CPUs, you have configured the "Synchronous to bus" property as the cycle time for the "MC_Servo" under "General > Cycle time".

Different projects

If you are running subnets 1 and 2 in different projects A and B, the following requirements apply:

- You have set up a network via PROFINET IO with IRT in both projects A and B.
- In project A, you have connected the IRT ports of the CPU in the network view and in the topology view with the IRT ports of the PROFINET interface X1 of the PN/PN coupler.
- In project A, you have assigned the same sync domain 1 to the CPU in subnet 1 and to the PROFINET interface X1 of the PN/PN coupler.
- In project B, you have assigned sync domain 2 to the CPU in subnet 2.
- In project A, you have configured the sender CPU as a sync master in the sync domain 1.
- In project A, you have configured the PROFINET interface X1 of the PN/PN coupler as a sync slave in sync domain 1.
- You have created at least one technology object on all CPUs in both projects A and B.

  NOTE

  "MC_Servo" organization block

  When you create a technology object, an MC_Servo OB is created automatically.

- In bot projects A and B, you have configured the property "Synchronous to the bus" as cycle time on all CPUs for the "MC_Servo" under "General > Cycle time".

Configuring communication directions and transfer areas

To configure the transfer areas, follow these steps:

1. In project A, in the network view, select the left coupler side with the PROFINET interface X1.
2. Configure the Ethernet connection in the Inspector window under "Properties > General > PROFINET interface [X1] > Ethernet addresses".
3. Activate the ISO mode in the Inspector window under "Properties > General > Module parameter > Operating mode".
4. Set the transfer areas in the Inspector window under "Properties > General > Module parameter > Transfer mapping". To add a new transfer area, select the value "Isochronous IN" or "Isochronous OUT" from the selection list of the "Type" column.

   The transfer area automatically has the appropriate communication direction.

   The "Isochronous control/status" transfer area is created automatically.
5. Repeat step 4 for all necessary transfer areas. You can set up to 14 transfer areas.
6. Configure the created transfer areas in the Inspector window under "Properties > General > Module parameter > Transfer mapping > Isochronous module":
   - Specify a data length in the "Length" fields. The data length of 48 bytes is preset.

     A maximum data length of 192 bytes is possible for the first two transfer areas. As of the third transfer area, the maximum possible data length is 48 bytes. In total, a maximum data length of 960 bytes for all transfer areas is possible.

- If necessary, in the "Start address" fields, define the start address of the assigned logical address area of the sender and of the receiver. Free areas are automatically preselected.
- In the "Organization block" fields, select the MC_Servo OB of the respective CPU.

7. Repeat step 6 for all created transfer areas.
8. If you use a SIMATIC Drive Controller, set the clock system of the SINAMICS Integrated:
   - Select PROFIdrive Integrated in the network view.
   - In the Inspector window, select the entry "Send clock of the PROFINET interface [X150]" under "Properties > General > Constant bus cycle time" in the "Cycle time" selection list.

Creating tags

To create the output tag of the sender CPU and the input tag of the receiver CPU, proceed as follows:

1. In project A, open the PLC tags of a CPU via the project tree "<Name of CPU> > PLC tags > Show all tags".

   The "PLC tags" table opens.
2. Enter the name of the new tag in the "Name" column.
3. In the "Data type" column, manually enter the "DX_TEL_SyncOp" data type.

   NOTE
   Data type "DX_TEL_SyncOp"
   If the data type "DX_TEL_SyncOp" is not available, it was deleted with the last compilation.
   To restore the "DX_TEL_SyncOp" data type, add a ≥ V5.0 technology object. After you have used the data type in the "PLC tags" table, you can delete the technology object again.

4. Enter the configured start address of the transfer area in the "Address" column with the following prefix:
   - "%Q" for an output tag on the sender CPU
   - "%I" for an input tag on the receiver CPU
5. Repeat steps 1 to 4 for the respective sender and receiver CPUs of all configured transfer areas.

   If you are running subnets 1 and 2 in the same project A, skip the following steps and continue reading under "Result."

Transferring the PROFINET interface X2 of the PN/PN coupler from project A to project B

This procedure is only relevant if you operate subnets 1 and 2 in different projects A and B.

To import the PROFINET interface X2 of the PN/PN coupler in project B, follow these steps:

1. In project A, in the network view, select the left coupler side with the PROFINET interface X1.
2. In the Inspector window under "Properties > General > Module parameters > Shared devices", select the "Outside the project" value for the PROFINET interface X2 in the selection list in the "Access" column.
3. Export the PROFINET interface X2 of the PN/PN coupler as a GSD file:
   - In the Inspector window under "Properties > General > Module parameter > Transfer mapping" in the "Export device description file (GSD)" area, click on the "Export" button.

     The "Export device description files (GSD)" dialog opens.
   - Select the "Export X2 (right coupler side)" option.
   - If necessary, adjust the name.

     The name is displayed in the hardware catalog after import.
   - Specify a storage location in the "Path" field.
   - Click "Export".

     The GSD file is being created.
4. Open the project B.
5. Import the GSD file of the PROFINET interface X2 of the PN/PN coupler:
   - Select the "Options > Manage general station description files (GSD)" menu.

     The "Manage device description files" dialog opens.
   - Select the storage location of the exported GSD file in the "Source path" field.
   - Select the exported GSD file in the table.
   - Click "Install".

     The GSD file is being installed. A success message then opens.
   - Click "Close".

     The hardware catalog is updated.
6. Open the network view.
7. From the hardware catalog, under "Other field devices > PROFINET IO > Gateway > Siemens Aktiengesellschaft > PN/PN coupler", drag and drop the imported PROFINET interface X2 of the PN/PN coupler in to the network view.
8. Create the tags. To do this, repeat steps 1 to 5 of the "Creating tags" procedure for project B.

Configuring PROFINET interface X2 in project B

This procedure is only relevant if you operate subnets 1 and 2 in different projects A and B.

To configure the PROFINET interface X2 of the PN/PN coupler in project B, follow these steps:

1. In project B, in the network view, select the right coupler side with the PROFINET interface X2.
2. Select subnet 2 in the Inspector window under "Properties > General > PROFINET interface [X2] > Ethernet addresses" in the "Interface connected with" area.
3. In the "Internet Protocol Version 4 (IPv4)" section, set the IP address.
4. Configure the sync domain 2:
   - Assign the sync domain 2 to the PROFINET interface X2 of the PN/PN coupler.
   - In the network view, select Sync domain 2.
   - Open the Inspector window under "Properties > General > PROFINET subnets > Domain management > Sync domains > <Sync domain 2> > Devices".
   - In the table in the "IO devices" section, select the "IRT" value for the PROFINET interface X2 of the PN/PN coupler in the "RT class" column.
   - For the PROFINET interface X2 of the PN/PN coupler, select the "Sync Master" value in the "Synchronization role" column.
   - For the recipient CPU, select the "Sync slave" value in the "Synchronization role" column.
5. In the topology view, connect the IRT ports of the CPU to the IRT ports of the PROFINET interface X2 of the PN/PN coupler.
6. Configure the transfer areas in the device view of the PN/PN coupler:
   - In the network view, select a transfer area.
   - Open the Inspector window under "Properties > General > I/O addresses".
   - Depending on the communication direction, set the start address of the incoming or outgoing address range.
   - Select the MC_Servo-OB of the corresponding CPU in the "Organization block" field.
7. Repeat step 6 for all transfer areas.

Result

You have set up the communication via the PN/PN coupler. During the configuration of the leading axis and the leading axis proxy, you can now select the configured tags for the transfer areas in the table column or in the "Transfer area" selection list under "Technology object > Configuration > Leading value settings".

If no technology object is created on a CPU, the MC_Servo OB is deleted when the software is compiled. To be able to check the set communication in this case, compile the hardware only.

More information

Via the "Isochronous control/status" transfer area, you control the isochronous mode between the PROFINET interfaces X1 and X2 of the PN/PN coupler.

If the coupled networks are not synchronized, for example because a CPU is in the "STOP" mode, a status error message is displayed if the diagnostic messages on the PN/PN coupler are enabled. The PN/PN coupler is also highlighted in red in the project tree.

You can find more information about the "PN/PN coupler" topic in the Installation and Operating Manual "SIMATIC Bus Coupler PN/PN Coupler" (https://support.industry.siemens.com/cs/ww/en/view/44319532).

11.5.3 Cascaded interconnection with PN/PN coupler

With a cascaded interconnection, a following axis makes a cross-PLC leading value available to a leading axis proxy again. Use a virtual axis for this purpose. In the following figure, this is shown as a "Virtual leading axis":

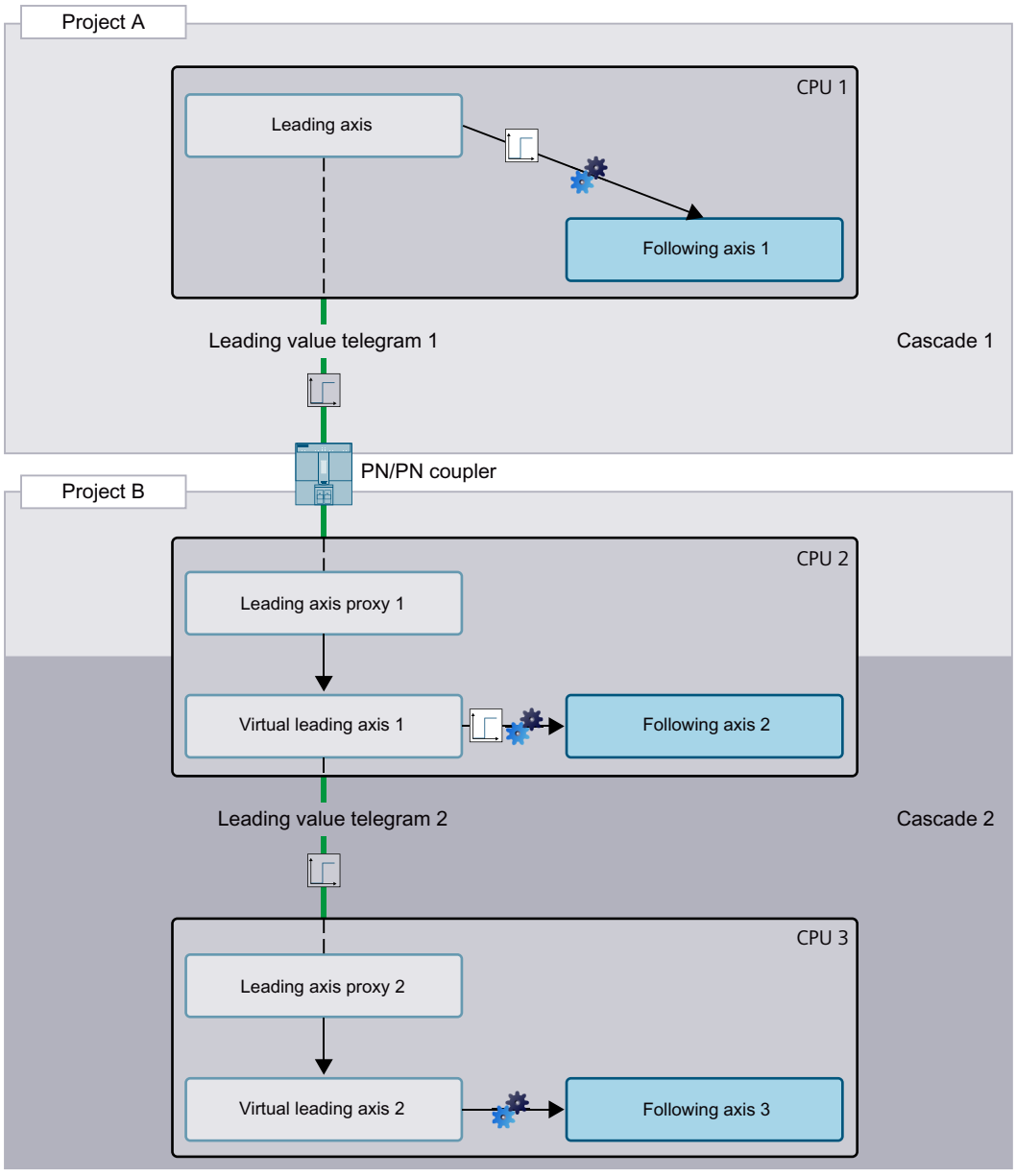

Leading value delay that can be configured at the leading axis (delay time)

Delay time caused by the processing and transfer of the leading value

Gearing (example)

The figure shows two cascades:

- The CPUs 1 and 2 in projects A and B are interconnected via a PN/PN coupler and form the first cascade.
- In Project B, CPUs 2 and 3 form the second cascade via the direct data exchange.

More than one cascade with a PN/PN coupler and multiple subnets is not permitted. Further cascades within the subnets are possible.

Time response

Regardless of whether the PN/PN coupler is interconnected within a project or cross-project, the delay time when interconnected via a PN/PN coupler is:

Delay time = 2 × application cycle of the CPU of the leading axis proxy + 2 × PROFINET cycle

In the case of a reduction ratio of the PROFINET cycle, the faster PROFINET cycle is relevant.

In the figure shown above, a delay time is set on the leading axis on CPU 1, which delays the leading value output to the local following axis 1. In addition, a delay time at the virtual leading axis 1 on CPU 2 is set, because CPU 3 is present in a cascade. All following axes 1 to 3 thus receive the same leading value at the same time.

Example

In the figure shown above, a cross-project interconnection via a PN/PN coupler (cascade 1) and an interconnection via the direct data exchange (cascade 2) are combined.

The total delay time is:

Delay time cascade 1 = 2 × application cycle of the CPU 2 + 2 × PROFINET cycle

Delay time cascade 2 = 2 × application cycle of the CPU 3

Total delay time = delay time cascade 1 + delay time cascade 2 = 2 × application cycle of the CPU 2 + 2 × PROFINET cycle + 2 × application cycle of the CPU 3

11.6 Communication using isochronous I-device

11.6.1 Cross-PLC synchronous operation with isochronous I-device

In a cross-PLC synchronous operation, the leading value is transferred via PROFINET IO with IRT in isochronous mode. For communication between CPUs, use the "I-device" functionality to implement isochronous data transfer via PROFINET IO with IRT.

An IO controller provides the leading value, which can then be received by multiple isochronous I-devices. The I-device can either be in the same project or in a different project. Leading axis proxies that are interconnected with the same leading value can be configured on different CPUs.

In addition, it is possible to make multiple leading values of different leading axes available on different CPUs via the same bus. The CPUs must be located in the same sync domains in each case.

Within a project

The figure below shows the operating principle based on an example with two following axes on two CPUs:

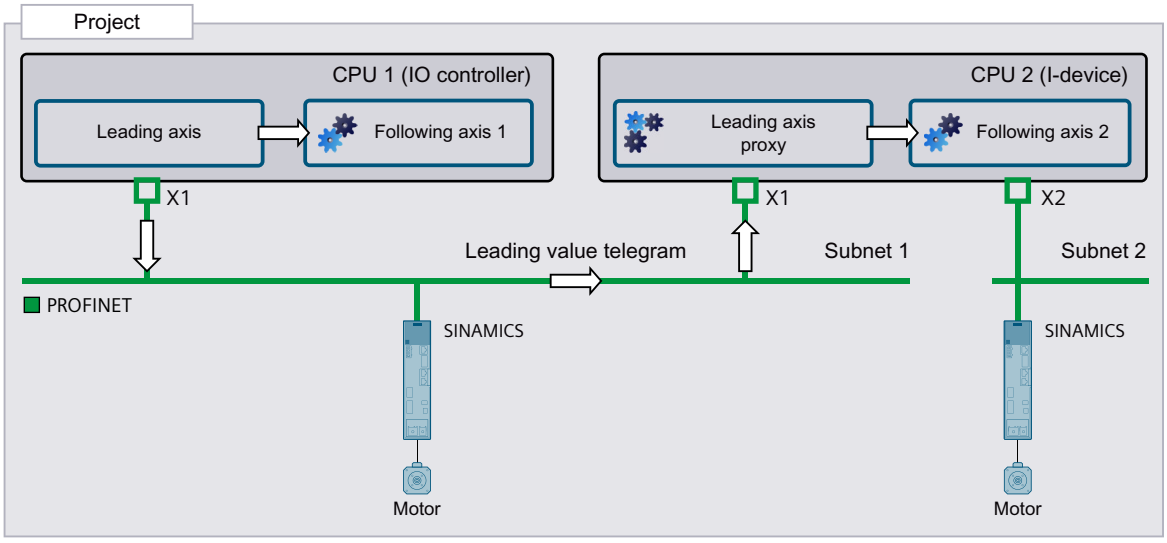

⇨ Leading value

The leading axis and a local following axis 1 are located on CPU 1. The leading axis and the following axis 1 are interconnected to a synchronous operation. The leading axis also makes the leading value available for cross-PLC synchronous operation.

CPU 2 is assigned as I-device of CPU 1 as IO controller. The leading value of CPU 1 is transferred to CPU 2 by means of a leading value telegram via PROFINET IO with IRT. The PROFINET interfaces X1 and X2 of CPU 2 are operated coupled with synchronized send clock.

On CPU 2, a leading axis proxy reads the leading value. A following axis 2 is interconnected locally as leading value with the leading axis proxy. The following axes 1 and 2 are synchronous and follow the same leading value.

Cross-project

You can also implement cross-PLC synchronous operation cross-project. You can configure and operate the following axes on different CPUs in various projects. You can also configure the leading axis on a CPU in any project. All following axes of a leading value are hereby synchronous to one another with consideration of the respective synchronous operation function. All following axes receive the same leading value at the same time.

The figure below shows the operating principle based on an example with three following axes on three CPUs, each of which is configured in its own project:

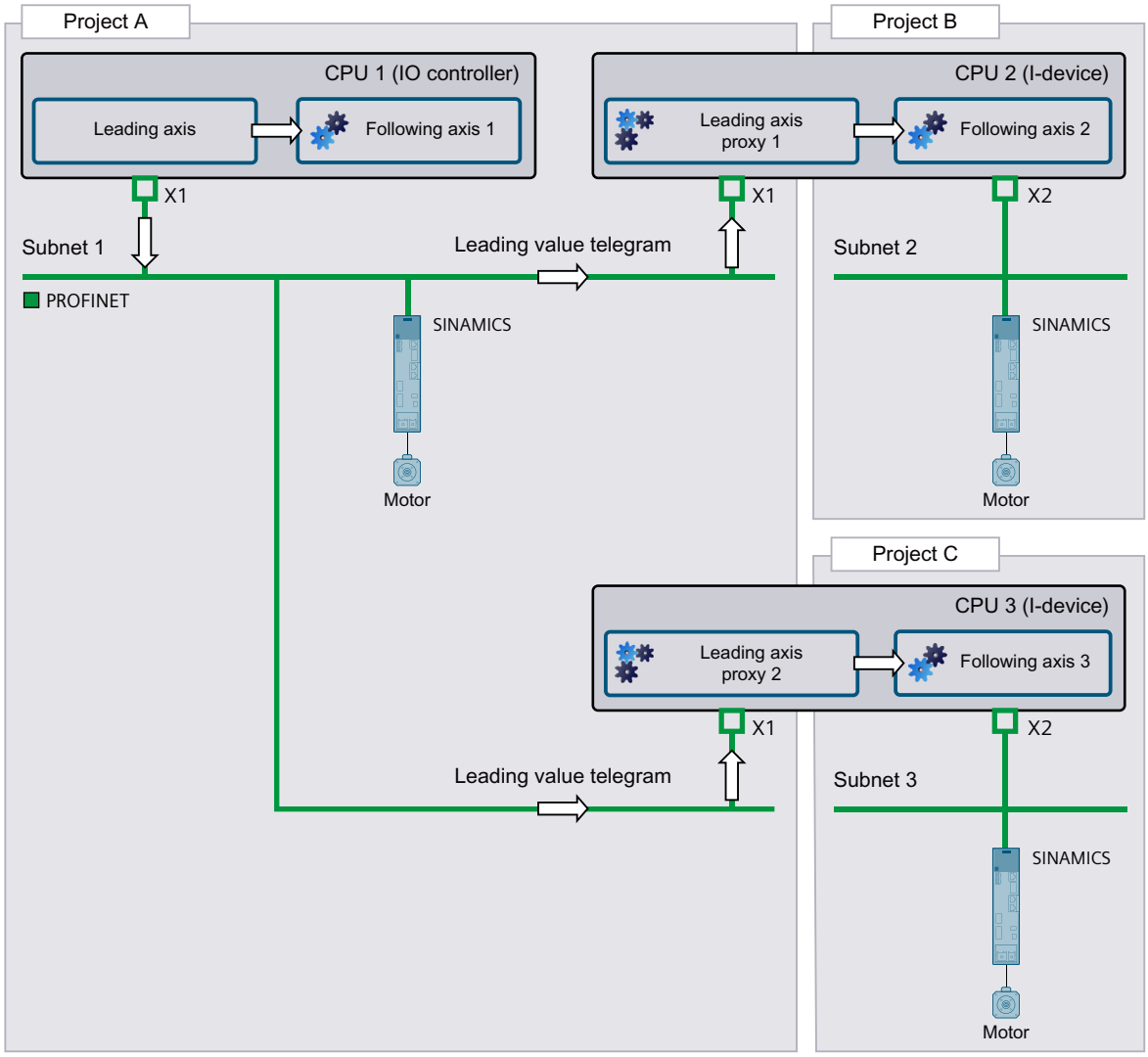

⇨ Leading value

The leading axis and a local following axis 1 are located on CPU 1 in project A. The leading axis and the following axis 1 are interconnected to a synchronous operation. The leading axis also makes the leading value available for cross-PLC synchronous operation.

CPUs 2 and 3 are assigned as I-devices of CPU 1 as IO controller. The leading value of CPU 1 is transferred to CPU 2 in project B and CPU 3 in project C by a leading value telegram via PROFINET IO with IRT. The PROFINET interfaces X1 and X2 of CPUs 2 and 3 are operated coupled with synchronized send clock.

Both on CPU 2 in project B an on CPU 3 in project C, a leading axis proxy reads the leading value. The following axes 2 and 3 are locally interconnected to the respective leading axis proxy as leading value. The following axes 1, 2 and 3 are synchronous and follow the same leading value.

11.6.2 Setting up communication using an isochronous I-device

For the required communication directions between the connected CPUs, you must first set up transfer areas. The leading value is provided via the transfer areas. You then create input and output tags which reference the relevant transfer areas. You can then select these tags for the transfer area when configuring the leading axis and the leading axis proxy.

When interconnecting via different projects, export the I-device into the project containing the IO controller and make additional settings there. Configuring I-device and IO controller in the same project is also possible.

For more information on the subject of "I-device", refer to the "SIMATIC PROFINET with STEP 7" function manual (https://support.industry.siemens.com/cs/ww/en/view/49948856).

Hereinafter, the sender CPU is the IO controller on which a leading axis provides a leading value. The sender CPU is configured in the "IO controller" project. The receiver CPU is the isochronous I-device on which a leading axis proxy reads the leading value. The receiver CPU is configured in the "I-device" project.

Requirement

- You have created the sender CPU in the "IO controller" project.
- You have created the receiver CPU in the "I-device" project.
- You have configured a PROFINET interface of the receiver CPU as I-device in the "I-device" project:
  - You have selected the "Parameter assignment of PN interface by higher-level controller" check box.
  - You have selected the "Unknown" entry in the "Higher-level IO controller" drop-down list.
- You have created at least one technology object on all CPUs in both projects "IO controller" and "I-device".

NOTE
"MC_Servo" organization block
When you create a technology object, an MC_Servo OB is created automatically.

Configuring communication directions and transfer areas

To configure transfer areas in the "I-device" project, follow these steps:

1. In the "I-device" project in the network view, select the PROFINET interface of the receiver CPU configured as I-device.
2. Select the "Isochronous mode" check box in the Inspector window under "Properties > General > Operating mode > Isochronous mode".

3. Set all required transfer areas in the Inspector window under "Properties > General > Operating mode > I-device communication":
   - To add a new transfer area, define a corresponding name in the "Transfer area" column.
   - Select the "Unknown" entry in the "Partner" column.
   - In the "Direction of transfer" column, select the corresponding communication direction via the arrow symbols. The I/O address is automatically updated with the "Q" prefix for an output tag and with the "I" prefix for an input tag.
   - Define a data length of 48 bytes in the "Length" column.
   - Select the check box in the "Isochronous mode" column.
4. Configure the created transfer areas in the Inspector window under "Properties > General > Operating mode > I-device communication > <Transfer area>":
   - If necessary, in the "Start address" fields, define the start address of the assigned logical address area of the sender and of the receiver. Free areas are automatically preselected.
   - In the "Organization block" fields, select the MC_Servo OB.
5. Repeat step 4 for all created transfer areas.

Transferring receiver CPU from "I-device" project to "IO controller" project

To transfer the receiver CPU from the "I-device" project to the "IO controller" project, follow these steps:

1. In the "I-device" project in the network view, select the PROFINET interface of the receiver CPU configured as I-device.
2. Export the PROFINET interface of the receiver CPU configured as I-device as a GSD file:
   - Compile the hardware configuration.
   - In the Inspector window under "Properties > General > Operating mode > I-device communication" in the "Export device description file (GSD)" area, click on the "Export" button.

     The "Export device description files (GSD)" dialog opens.
   - If necessary, adjust the name.

     The name is displayed in the hardware catalog after import.
   - Specify a storage location in the "Path" field.
   - Click "Export".

     The GSD file is being created.
3. In the "IO controller" project, import the GSD file of the PROFINET interface of the receiver CPU configured as I-device:
   - Select the "Options > Manage general station description files (GSD)" menu.

     The "Manage device description files" dialog opens.
   - Select the storage location of the exported GSD file in the "Source path" field.
   - Select the exported GSD file in the table.

- Click "Install".

  The GSD file is being installed. A success message then opens.
- Click "Close".

  The hardware catalog is updated.

4. In the network view, drag-and-drop the imported receiver CPU from the hardware catalog under "Other field devices > PROFINET IO > PLCs & CPs > Siemens Aktiengesellschaft" into the network view.
5. Connect the IRT ports of the CPUs with each other in the network view.
6. Connect the IRT ports of the CPUs with each other in the topology view.
7. In both projects "IO controller" and "I-device", configure the property "Synchronous to the bus" as cycle time on all CPUs for the "MC_Servo" under "General > Cycle time".
8. Configure the sync domain in the "IO controller" project:
   - Select the PROFINET network in the network view.
   - In the Inspector window, navigate to "PROFINET subnet > Domain management > Sync domains".
   - In the "Devices > IO devices" area, assign the synchronization role "Sync master" to the PROFINET interface of the sender CPU.
   - Select the RT class "IRT" for the receiver CPU.

     The synchronization role changes automatically from "Unsynchronized" to "Sync slave".
   - In the "Sync domain" area, select the same send clock that you specified in the I-device configuration.
9. Configure the receiver CPU (GSD file) in the "IO controller" project:
   - Open the device view of the receiver CPU.
   - On the right side, click the corresponding transfer area in the device overview.
   - Select the MC_Servo OB in the "Organization block" field in the Inspector window under "Properties > General > I/O addresses".
   - Select the "Isochronous mode" check box.

Creating tags

To create the output tag of the sender CPU and the input tag of the receiver CPU, proceed as follows:

1. In the "IO controller" project, open the PLC tags of the sender CPU via the project tree "<Name of CPU> > PLC tags > Show all tags".

   The "PLC tags" table opens.
2. Enter the name of the new tag in the "Name" column.

3. In the "Data type" column, manually enter the "DX_TEL_SyncOp" data type.

NOTE
Data type "DX_TEL_SyncOp"
If the data type "DX_TEL_SyncOp" is not available, it was deleted with the last compilation.
To restore the "DX_TEL_SyncOp" data type, add a ≥ V5.0 technology object. After you have used the data type in the "PLC tags" table, you can delete the technology object again.

4. Enter the configured start address of the transfer area in the "Address" column with the following prefix:
   – "%Q" for an output tag on the sender CPU
     The start addresses must match the addresses of the transfer areas of the GSD file.
   – "%I" for an input tag on the receiver CPU
     The start addresses must match the addresses of the transfer areas from the PROFINET interface of the I-device.
5. Repeat steps 1 to 4 for all configured transfer areas.
6. In the "I-device" project, repeat steps 1 to 4 for all configured transfer areas of the receiver CPU.

Result

You have set up communication using isochronous I-device. During the configuration of the leading axis and the leading axis proxy, you can now select the configured tags for the transfer areas in the table column or in the "Transfer area" selection list under "Technology object > Configuration > Leading value settings".

NOTE
Changes to the transfer areas
If you change transfer areas, you need to export the receiver CPU from the "I-device" project again and import it into the "IO controller" project.

If no technology object is created on a CPU, the MC_Servo OB is deleted when the software is compiled. To be able to check the set communication in this case, compile the hardware only.

11.6.3 Cascaded interconnection with isochronous I-device

With a cascaded interconnection, a following axis of a leading axis proxy provides a cross-PLC leading value again. Use a virtual axis for this purpose. In the following figure, this is shown as a "Virtual leading axis":

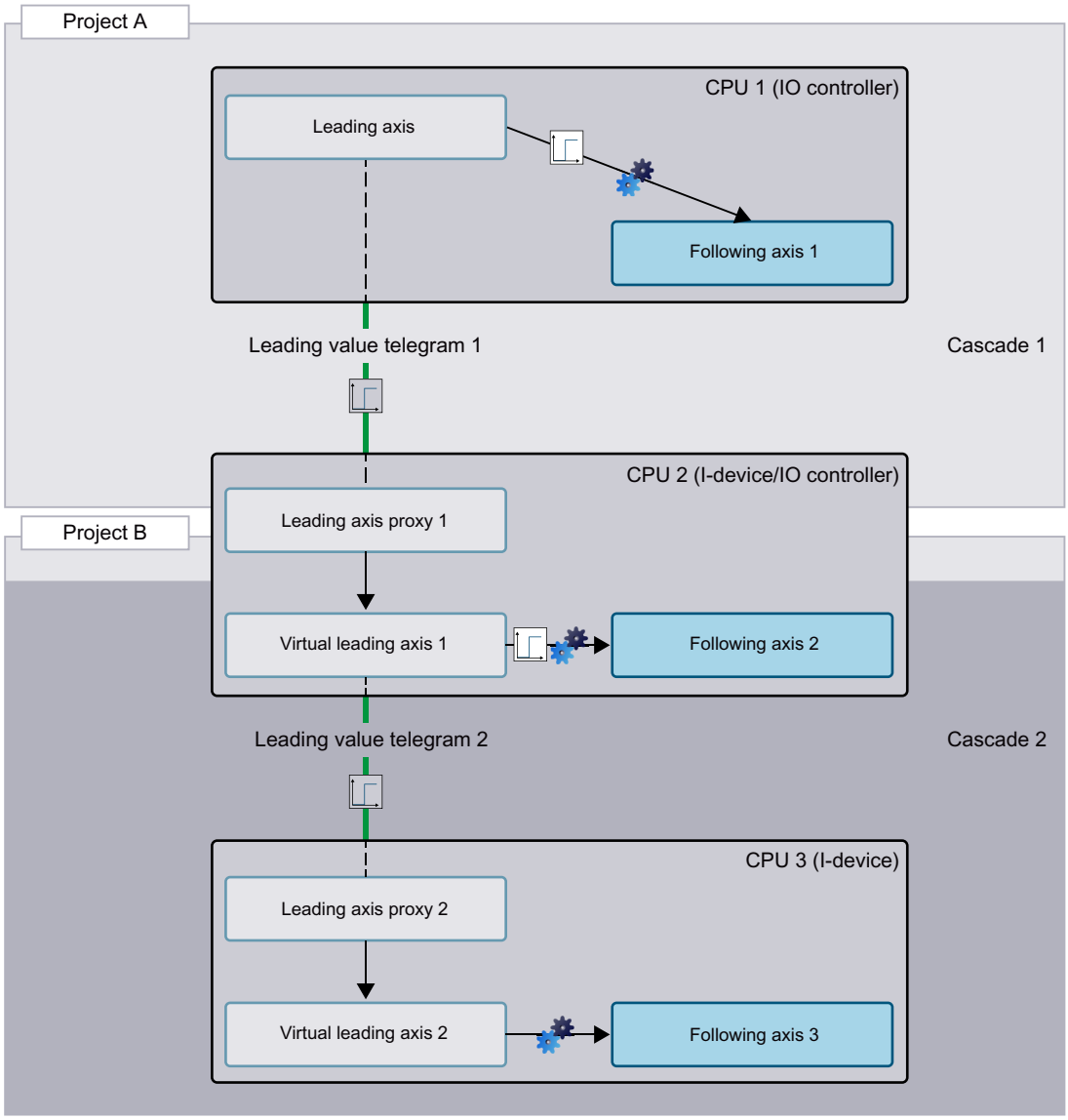

Leading value delay that can be configured at the leading axis (delay time)

Delay time caused by the processing and transfer of the leading value

Gearing (example)

The figure shows two cascades:

- CPU 1 in Project A and CPU 2 in Project B form the first cascade. CPU 2 is assigned as I-device of CPU 1 as IO controller.
- In Project B, CPUs 2 and 3 form the second cascade. CPU 3 is assigned as I-device of CPU 2 as IO controller.

Time response

Regardless of whether an isochronous I-device is interconnected within a project or across projects, the delay time when interconnected via an I-device is:

Delay time = 2 × application cycle of the CPU of the leading axis proxy

In the figure shown above, a delay time is set on the leading axis on CPU 1, which delays the leading value output to the local following axis 1. In addition, a delay time at the virtual leading axis 1 on CPU 2 is set, because CPU 3 is present in a cascade. All following axes 1 to 3 thus receive the same leading value at the same time.

You will find more information on the configuration in the section "Setting the delay times (Page 245)".

11.7 Configuring the provision of leading value and interconnecting axes

The following describes how to connect the leading value and the axes involved for a cross-PLC synchronous operation via one or more cascades.

Requirement

- You have prepared the cross-PLC synchronous operation (Page 212).
- For each additional cascade you have created a technology object synchronous axis as a virtual following axis that is used as the leading axis for the next cascade.
- The technology objects are configured correctly.
- You have set up the communication between the CPUs:
  - Via the direct data exchange (Page 216)
  - Via the PN/PN coupler (Page 223)
  - Via isochronous I-device (Page 233)

Provide cross-PLC leading value

To make the leading value of the leading axis available cross-PLC, proceed as follows:

1. Open the configuration window "Technology object > Configuration > Leading value settings" of the leading axis.
2. To show rows 2 to 32 in the table in the "Provision of leading value" area, select the "Show all transfer areas" check box.
3. In the "Provide" table column, select the check box of the corresponding transfer area.
4. In the "Transfer area" table column, select in the drop-down list the CPU output tag created for the communication.

5. To use the leading value telegram version 1, clear the check box of the corresponding transfer area in the "Leading value telegram V2" table column.

   The leading value telegram version depends on the technology version of the receiver. The leading value telegram version 2 is preset for technology objects with the technology version ≥ 10.0. You can find more information in the "Compatible versions for synchronous operation across PLCs (Page 211)" section.

Interconnect local following axes

To interconnect the local following axes on the CPU of the leading axis, follow these steps:

1. Open the configuration window "Technology object > Configuration > Leading value interconnections" of a local following axis.
2. In the "Possible leading values" table column, select the leading axis.
3. In the "Type of coupling" table column, select the entry "Delayed".
4. Repeat steps 1 to 3 for all local following axes.

Interconnecting leading axis proxies

To interconnect the leading axis proxies to other CPUs, follow these steps:

1. Open the configuration window "Technology object > Configuration > Leading value settings" of a leading axis proxy.
2. In the "Provision of leading value" area in the "Transfer area" drop-down list, select the input tag of the CPU created for the communication.
3. Repeat steps 1 and 2 for all leading axis proxies of the same cascade.

Interconnecting following axes of the other CPUs

To interconnect the following axes that are not configured on the CPU of the leading axis, proceed as follows:

1. Open the configuration window "Technology object > Configuration > Leading value interconnections" of a following axis.
2. In the "Possible leading values" table column, select the alternate leading axis of the CPU.

   In the table column "Leading value source", the leading axis is displayed which provides the leading value (<Name of the CPU>.<Name of the technology object>). The "Setpoint" entry is preset in the "Type of coupling" table column.
3. In the table column with the icon , select whether this leading value interconnection should be taken into consideration when calculating the delay time in the interconnection overview (Page 241).
4. Repeat steps 1 to 3 for all following axes of the same cascade.

Interconnecting virtual following axis as leading axis for the next cascade

To interconnect a virtual following axis that is used as leading axis for the next cascade, proceed as follows:

1. Open the configuration window "Technology object > Configuration > Leading value interconnections" of the virtual following axis.
2. In the "Possible leading values" table column, select the alternate leading axis of the CPU.

   In the table column "Leading value source", the leading axis is displayed which provides the leading value (<Name of the CPU>.<Name of the technology object>). The "Setpoint" entry is preset in the "Type of coupling" table column.
3. In the table column with the icon , select whether this leading value interconnection should be taken into consideration when calculating the delay time in the interconnection overview.
4. Switch to the configuration window "Technology object > Configuration > Leading value settings" of the virtual following axis.
5. To show rows 2 to 32 in the table in the "Provision of leading value" area, select the "Show all transfer areas" check box.
6. In the "Provide" table column, select the check box of the corresponding transfer area.
7. To use the leading value telegram version 1, clear the check box of the corresponding transfer area in the "Leading value telegram V2" table column.

   The leading value telegram version depends on the technology version of the receiver. The leading value telegram version 2 is preset for technology objects with the technology version ≥ 10.0. You can find more information in the "Compatible versions for synchronous operation across PLCs (Page 211)" section.
8. In the "Transfer area" table column, select in the drop-down list the CPU output tag created for the communication.
9. Repeat the steps in the section "Interconnecting leading axis proxies" for all leading axis proxy of the next cascade.
10. Repeat the steps in the section "Interconnecting following axes of the other CPUs" for all following axes of the next cascade.
11. Repeat steps 1 to 10 for all other cascades.

11.8 Configuring the tolerance time

If an external leading value becomes invalid during a cross-PLC synchronous operation or a communication error occurs, technology alarm 900 ("Leading values invalid") is output after a tolerance time. You can configure this tolerance time on the leading axis proxy technology object.

Procedure

To configure the tolerance time, follow these steps:

1. Open the configuration window "Technology object > Configuration > Leading value settings" of a leading axis proxy.
2. In the "Leading value monitoring" area, enter the tolerance time within which a valid leading value is expected in the "Tolerance time invalid leading value" input field.

   NOTE
   Extrapolation of the leading value
   Note that the leading value is still being extrapolated during the tolerance time and that the following axis continues to move.
   Therefore, set the tolerance time as brief as possible.

3. Repeat steps 1 and 2 for all other leading axis proxies.

11.9 Working with the interconnection overview table

11.9.1 Opening the interconnection overview

The interconnection overview contains an overview of the interconnected leading and following axes and their CPU assignment. In the interconnection overview, you also trigger the system calculation of the delay time.

Requirement

- You have created technology objects in the project for:
  - Leading axis
  - Following axis
  - Leading axis proxy
- You have interconnected the CPUs and technology objects with one another.

Procedure

To open the interconnection overview, follow these steps:

1. Select one of the following technology objects in the project navigation:
   - Positioning axis
   - Synchronous axis
   - External encoder
   - Leading axis proxy
2. Select the "Interconnection overview" command from the shortcut menu.

Result

The interconnection overview opens.

11.9.2 Interconnection overview

The interconnection overview contains an overview of the interconnected leading and following axes and their CPU assignment in tabular form.

Toolbar

The toolbar at the top of the interconnection overview provides the following functions via buttons:

Button	Description
	You update the view of the interconnection overview with this icon.
Calculate delay times	You trigger calculation of delay times with this button. The delay time is only calculated if the "Allow system calculation" check box is selected under "Leading value settings" when configuring the technology objects. You can only trigger the calculation of the delay times if the values are not current and the technology objects are not recursively connected. The delay time is calculated throughout the entire project. If the leading value for CPUs is provided in another project, you must manually transfer the delay times of the corresponding transfer areas (Page 245).

Filtering the view

You have the following options above the table to filter the view of the interconnection overview:

Field	Description
Enter text filter	In this field, enter a term by which the view should be filtered.
Show delay times	Select this check box to show the "Delay time" columns which contain the delay times.
Show local synchronous operations	Select this check box to display the local leading value interconnections in addition to the cross-PLC leading value interconnections.
Show cross-network transfer	Select this check box to additionally display the cross-network and cross-project leading value interconnections.

Interconnection overview table

The interconnection overview table contains the following information and functions:

Column		Description	
Leading value source			
	PLC	This column displays the CPU of the leading axis.	
	Leading axis	This column displays the name of the leading axis. You open the configuration of the technology object via the link.	
			If this icon is displayed in the "Leading axis" column, the interconnection is excluded from the system calculation of the delay time. In the configuration of the leading axis, the check box "Allow system calculation" is not selected under "Leading value settings".
	DT	This column displays the delay time in ms. This column is only displayed when the "Show delay times" check box is selected.	
	Leading value output	This column displays the type of the leading value output and the number of the transfer area.	
Recipient			
	PLC	This column displays the CPU of the following axis.	
	Following axis	This column displays the name of the following axis. You open the configuration of the technology object via the link.	
	Routes	When you select a row, the icon is displayed in this column. You open the "Routes" area with this icon.	
	Leading axis proxy	The name of the leading axis proxy is displayed in this column. You open the configuration of the technology object via the link.	
			If this icon is displayed in the "Leading axis proxy" column, the interconnection is excluded from the system calculation of the delay time. In the configuration of the leading axis proxy, the check box "Allow system calculation" is not selected under "Leading value settings".

Column		Description	
	DT	This column displays the delay time in ms. This column is only displayed when the "Show delay times" check box is selected.	
Cross-network transfer		These columns are only displayed when the "Show cross-network transfer" check box is selected.	
	Device	This column displays the PN/PN coupler.	
	Transfer area	This column displays the used transfer area.	
	DT	This column is only displayed when the "Show delay times" check box is selected.	
		Recipient	For a transfer area that receives the leading value from another project, the delay time is displayed in ms.
		Sender	For a transfer area that provides the leading value for recipients outside the project, enter the calculated delay time from the other project.
Interconnection			If this icon is displayed in the "Interconnection" column, the interconnection is affected by a recursion.
			If this icon is displayed in the "Interconnection" column, the interconnection is affected by a recursion, but at least one interconnection is excluded from the calculation of the delay time.
			If this icon is displayed in the "Interconnection" column, the interconnection is excluded from the system calculation of the delay time.
			With this icon, you open the configuration of the following axis.
		If the configured delay time corresponds to the calculated delay time, the icon ✔ is displayed in this column.	

In the "Leading value source cannot be clearly determined" area, interconnections are displayed where, for example, several leading axes are connected for a leading axis proxy and the leading value source is therefore not unique. The range is only displayed if there are interconnections without a unique leading value source.

11.9.3 Showing routes

The routes of the leading value of a selected following axis are shown in the interconnection overview in the area underneath the table. Within the project, the leading value is tracked backed from the following axis to the leading value source. If there are multiple routes, they are displayed next to one another. If the leading value source is outside the project, the route is only followed up to the interface that provides the leading value within the project.

Procedure

To display the existing routes of a following axis, follow these steps:

1. Select the row of the corresponding following axis in the table.
2. To show the routes, click the icon in the "Routes" column.

Result

All routes are displayed in the area below the table for the selected following axis. Routes affected by a recursion are not displayed.

It is indicated underneath a route whether the leading value is interpolated or extrapolated:

- If all cascades interpolate, "Interpolated" is displayed.
- If at least one cascade extrapolates, "Extrapolated" is displayed.

11.9.4 Setting the delay times

You can calculate and view the delay times in the interconnection overview. Alternatively, you can manually configure the delay times on the leading axis and on the virtual following axes. Depending on the set delay time, the leading value at the leading axis proxy is automatically interpolated or extrapolated.

The delay times are calculated within a project. If the leading value is provided in different projects, manually transfer the delay times from the other projects.

NOTE

Following axis on I-device

If a following axis is configured on an I-device, the delay time for this following axis cannot be calculated by the system. This applies to interconnections within a project as well as across projects.

To nevertheless be able to calculate the delay time on the leading axis, proceed as follows:

1. In this case, calculate the delay time of the following axis manually and configure this at the leading axis. To do this, follow the "Configure delay times" procedure.
2. Transfer the delay time of the following axis manually into the interconnection overview. To do this, follow the "Transfer delay times from other projects" procedure.

Requirements

- You have interconnected the CPUs and technology objects with one another.
- Except for the delay time, the technology objects are fully configured.
- You have selected the "Delayed" entry as the type of coupling in the "Technology object > Configuration > Leading value interconnections" configuration window of the local following axes so that the leading value for the local synchronous operation is delayed.

Calculating delay times

To calculate the delay times, follow these steps:

1. Open the configuration window "Technology object > Configuration > Leading value settings" of the leading axis.
2. In the "Delay time of local leading value" area, select the "Allow system calculation" check box.

3. Repeat steps 1 and 2 for all leading axis proxies and for all virtual following axes that are used as leading axis for additional cascades.
4. Open the configuration window "Technology object > Configuration > Leading value interconnections" of a non-local following axis.
5. For a leading axis proxy technology object of the table column with the symbol , select whether this leading value interconnection should be taken into account when calculating the delay time.
6. Repeat steps 4 and 5 for all other non-local following axes.
7. To open the interconnection overview, click on the link "Interconnection overview".
8. To calculate the delay times, click the "Calculate delay times" button in the interconnection overview.
9. Check the calculated delay times in the columns "DT" of the interconnection overview.
10. In the routes, check whether a leading value is interpolated or extrapolated at the leading axis proxy (<TO>.StatusExternalLeadingValue.AdjustmentTime).

Configuring delay times

To adjust the delay time and, for example, take into account additional requirements from your special application, follow these steps:

1. Open the configuration window "Technology object > Configuration > Leading value settings" of the leading axis.
2. Clear the "Allow system calculation" check box in the "Delay time of local leading value" area.
3. Enter the corresponding value in the "Delay time" input field.

   The entered delay time determines the output delay of the leading value for the local following axes (<TO>.CrossPlcSynchronousOperation.LocalLeadingValueDelayTime).
4. Repeat steps 1 to 3 for all virtual following axes that are used as the leading axis for additional cascades.
5. Open the configuration window "Technology object > Configuration > Leading value settings" of a leading axis proxy.
6. Clear the "Allow system calculation" check box in the "Delay time of local leading value" area.
7. In the "Delay time" (<TO>.Parameter.LocalLeadingValueDelayTime) input field, enter the same delay time that is set on the local virtual following axis that is used as the leading axis for an additional cascade.

   The entered delay time determines the output delay of the leading value for the local following axes (<TO>.CrossPlcSynchronousOperation.LocalLeadingValueDelayTime).
8. To open the interconnection overview, click on the link "Interconnection overview".
9. Check the delay times in the "DT" columns of the interconnection overview.
10. In the routes, check whether a leading value is interpolated or extrapolated at the leading axis proxy (<TO>.StatusExternalLeadingValue.AdjustmentTime).

Transfer delay times from other projects

This procedure is only relevant if the leading value is provided in different projects.

To transfer delay times, proceed as follows:

1. Have the delay times calculated in the project that receives the leading value.
2. Transfer the delay times of the corresponding transfer areas to the project that provides the leading value:
   - Open the interconnection overview.
   - Select the "Show delay times" option.
   - Select the "Show cross-network transfer" option.
   - In the "Cross-network transfer > VZ" column, enter the delay times for the corresponding transfer areas.
3. Have the delay times calculated in the project that provides the leading value.

11.10 Example: Analyze cross-PLC synchronous operation in various projects using the trace and instruction "GetPNWorkingClock"

In the following example, two following axes 1 and 2 are in synchronous operation. The following axes are configured on different CPUs in various projects and interconnected via a PN/PN coupler.

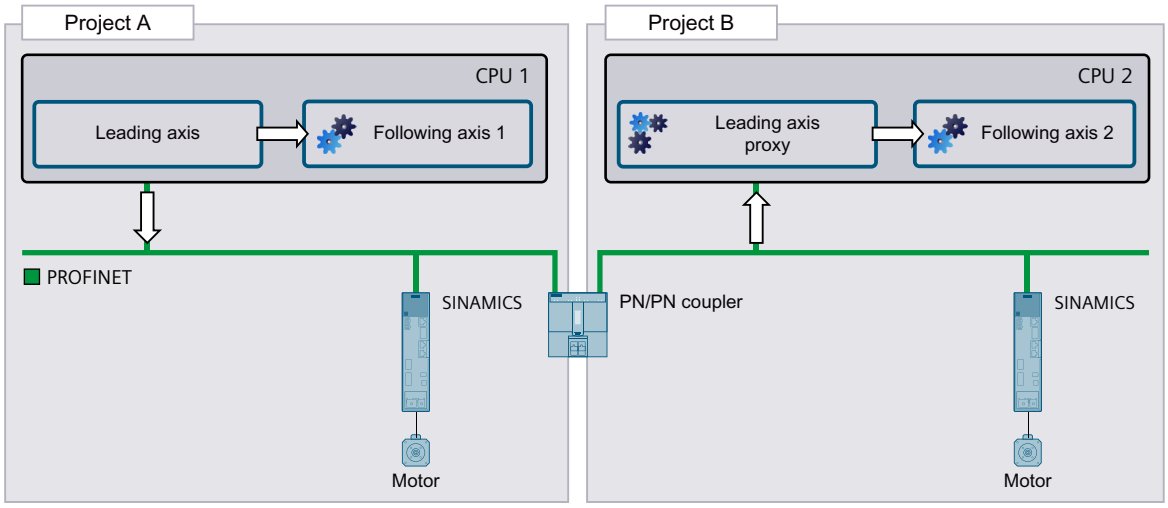

⇨ Leading value

You can use the trace to check whether the following axes are moving synchronously. Since there is no access between projects, carry out a measurement in each project. In order to be able to compare the two measurements afterwards, use the "GetPNWorkingClock" instruction, which provides the synchronization clock. The "GetPNWorkingClock" instruction is available as of firmware version V4.0.

For the instruction counters to have the same values at the same time, the measurements must run simultaneously in both CPUs. To do this, use the same trigger for both measurements, e.g. the velocity of the following axes.

Requirements

- You are using CPUs with firmware versions ≥ V4.0.
- You have two projects A and B available.
- Project A includes the following:
  - A CPU 1 with the leading axis and a local following axis 1
  - An interface of the PN/PN coupler
- Project B includes the following:
  - The second interface of the PN/PN coupler
  - A CPU 2 with a leading axis proxy and a following axis 2
- A cross-PLC synchronous operation with communication via the PN/PN coupler has been set up.
- The synchronous operation is active. The following axes 1 and 2 are in the "Synchronous" state.
- In both projects, you have programmed an instruction "GetPNWorkingClock" with "Mode" = 1. The instruction is called in MC_PreServo.

Create trace configuration in project A

To create a new trace configuration in project A, follow these steps:

1. Open project A.
2. Add a new "Trace 1" trace configuration.
3. Configure the trace 1:
   - Select the output tag of the "GetPNWorkingClock" instruction and the position of the following axis 1 as signals.
   - Set the recording time to an isochronous OB, such as the MC_Interpolator.
   - Select "Trigger on tag" as trigger mode.
   - Select the speed of the following axis 1 as the trigger tag.
   - Select the "Rising signal" event.
   - Enter a value greater than 50.0, for example.
   - Enter 100 measuring points as pretrigger (b), for example.
4. Load the trace 1 onto the CPU 1.
5. Start the trace 1.

   The trace 1 has the "Waiting for trigger" status.

Create trace configuration in project B

To create a new trace configuration in project B, follow these steps:

1. Open project B.
2. Add a new "Trace 2" trace configuration.
3. Configure the trace 2:
   - Select the output tag of the "GetPNWorkingClock" instruction and the position of the following axis 2 as signals.
   - Define the same recording conditions as for trace 1. Select the velocity of the following axis 2 as the trigger tag.
4. Load the trace 2 onto the CPU 2.
5. Start the trace 2.

   The trace 2 has the "Waiting for trigger" status.

Release trigger and merge measurements in project A

To trigger the trigger and merge the measurements in Project A, follow these steps:

1. Open project A.
2. Release the trigger. Start the traversing motion of the leading axis so that the following axes 1 and 2 each adopt a velocity of greater than 50.0.

   The recordings of the traces 1 and 2 are started in CPUs 1 and 2.
3. Add the recording of the trace 1 to the measurements.
4. Open project B.
5. Add the recording of the trace 2 to the measurements.
6. Export the measurement of the trace 2.
7. Open project A.
8. Import the measurement of the trace 2.

Create a superimposed measurement in project A

To create a superimposed measurement in project A, follow these steps:

1. Add a new superimposed measurement.
2. Add the measurements of traces 1 and 2 to the superimposed measurement.
3. Adjust the colors of the signals so that they are distinguishable.
4. Create a "workingclock" signal group with the two output tags of the "GetPNWorkingClock" instruction.

5. Create a "position" signal group with the two positions of the following axes 1 and 2.

   The signals are displayed superimposed.

Move and evaluate measurements relative to each other

Proceed as follows to move the measurements in relation to each other and evaluate them:

1. Zoom in on the time diagram of the "workingclock" signal group until the deviations of the signals are recognizable.

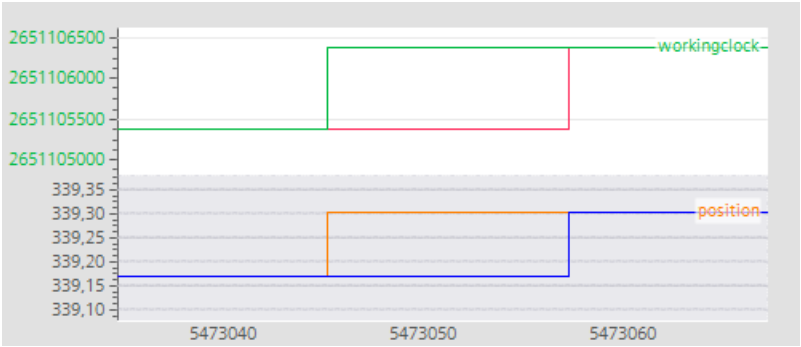

2. Measure the time delay Δt between the two signals of the "workingclock" signal group.

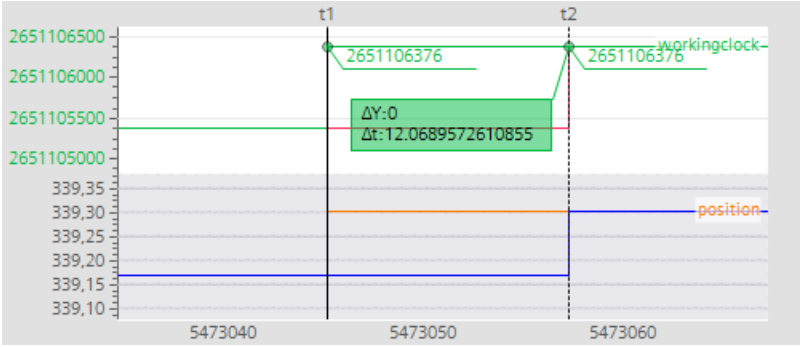

3. Move the measurements of the two projects relative to each other by using the time delay Δt as an offset.

   The signals are displayed in the time diagram without time delay.

4. You can now evaluate the signals in the time diagram of the "position" signal group.

11.11 Tags: Cross-PLC synchronous operation

Positioning axis, synchronous axis, external encoder

The following tags of the positioning axis, synchronous axis and external encoder are relevant for cross-PLC synchronous operation:

Tag	Description	
<TO>.CrossPlcSynchronousOperation.Interface[1..32].EnableLeadingValueOutput	Provide cross-PLC leading value	
	FALSE	No
	TRUE	Yes
<TO>.CrossPlcSynchronousOperation.Interface[1..32].AddressOut	Output address for the telegram of cross-PLC synchronous operation	
<TO>.CrossPlcSynchronousOperation.LocalLeadingValueDelayTime	Delay time for setpoint coupling with delayed leading value	
<TO>.StatusProvidedLeadingValue.DelayedLeadingValue.Position	Position of the provided leading value	
<TO>.StatusProvidedLeadingValue.DelayedLeadingValue.Velocity	Velocity of the provided leading value	
<TO>.StatusProvidedLeadingValue.DelayedLeadingValue.Acceleration	Acceleration of the provided leading value	

Leading axis proxy

The following leading axis proxy technology object tags are relevant for cross-PLC synchronous operation:

Tag	Description	
<TO>.Position	Position of the leading value for local synchronous operation	
<TO>.Velocity	Velocity of the leading value for local synchronous operation	
<TO>.Acceleration	Acceleration of the leading value for local synchronous operation	
<TO>.Interface.AddressIn	Input address for the telegram of the external leading value	
<TO>.Parameter.LocalLeadingValueDelayTime	Delay time of leading value output on the local following axis which, in turn, provides a leading value	
<TO>.Parameter.ToleranceTimeExternalLeadingValueInvalid	Tolerance time until a technology alarm is triggered when the external leading value becomes invalid	
<TO>.StatusExternalLeadingValue.ModuloLength	Modulo length of the external leading value	
<TO>.StatusExternalLeadingValue.ModuloStartValue	Modulo start value of the external leading value	
<TO>.StatusExternalLeadingValue.AdjustmentTime	Time by which the external leading value is adjusted	
	< 0	The external leading value is interpolated by this time.
	> 0	The external leading value is extrapolated by this time.
<TO>.StatusWord.X4 (LeadingValueValid)	Validity of the external leading value	
	FALSE	Leading value does not exist or is not valid
	TRUE	Leading value exists and is valid
<TO>.StatusWord.X5 (LeadingValueModulo)	Modulo functionality	

Tag	Description	
<TO>.StatusWord.X5 (LeadingValueModulo)	FALSE	Leading value without modulo functionality
	TRUE	Leading value with modulo functionality
<TO>.StatusWord.X6 (LeadingAxisControl)	Follow-up mode or setpoint mode	
	FALSE	Leading axis in follow-up mode
	TRUE	Leading axis in setpoint operation

Diagnostics 12

The description of Motion Control diagnostics is limited to the diagnostics view of the technology objects in TIA Portal, the technology alarms and the error IDs on Motion Control instructions.

"Debug" program mode is available for testing the execution of your Interpreter program.

The following descriptions can be found in the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation:

- Diagnostics concept
- Technology alarms
- Error IDs in Motion Control instructions

A comprehensive description of the system diagnostics of the S7-1500 CPU can be found in the "Diagnostics" function manual (https://support.industry.siemens.com/cs/ww/en/view/59192926).

12.1 Synchronous axis technology object

12.1.1 Status and error bits

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object. The diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables. The associated technology object tag is given in parentheses.

Axis status

The following table shows the possible axis status values:

Status	Description
Simulation active	The axis is simulated in the CPU or used as the virtual axis. Setpoints are not output to the drive. (<TO>.StatusWord.X25 (AxisSimulation))
Enabled	The technology object has been enabled. You can move the axis with motion jobs. (<TO>.StatusWord.X0 (Enable))
Position-controlled mode	The axis is in position-controlled mode. (Inversion of <TO>.StatusWord.X28 (NonPositionControlled))
Homed	The technology object is homed. The relationship between the position in the technology object and the mechanical position was successfully created. (<TO>.StatusWord.X5 (HomingDone))

Status	Description
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area and in the "<TO>.ErrorDetail.Number" and "<TO>.ErrorDetail.Reaction" tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is being reinitialized. (<TO>.StatusWord.X2 (RestartActive))
Axis control panel enabled	The axis control panel is active. The axis control panel has master control over the technology object. You cannot control the axis from the user program. (<TO>.StatusWord.X4 (ControlPanelActive))
Drive ready	The drive is ready to execute setpoints. (<TO>.StatusDrive.InOperation)
Encoder values valid	The actual encoder values are valid. (<TO>.StatusSensor[1].State)
Encoder values valid (S7-1500T)	The actual encoder values of encoder 1, encoder 2, encoder 3 or encoder 4 are valid. (<TO>.StatusSensor[1..4].State)
Active encoder (S7-1500T)	The encoder in effect operationally is encoder 1, encoder 2, encoder 3 or encoder 4. (<TO>.OperativeSensor)
Encoder values homed	Encoder is homed with one of the following homing types: • Active homing • Passive homing • Absolute encoder adjustment • Incremental encoder adjustment (<TO>.StatusSensor[1].Adjusted)
Encoder homed (S7-1500T)	Encoder 1, encoder 2, encoder 3 or encoder 4 is homed with one of the following homing types: • Active homing • Passive homing • Absolute encoder adjustment • Incremental encoder adjustment (<TO>.StatusSensor[1..4].Adjusted)
Restart required	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))

Status limit switch

The following table shows the possibilities for enabling the software and hardware limit switches:

Status	Description
Negative SW limit switch approached	The negative software limit switch has been approached. (<TO>.StatusWord.X15 (SWLimitMinActive))
Positive SW limit switch approached	The positive software limit switch has been approached. (<TO>.StatusWord.X16 (SWLimitMaxActive))
Negative HW limit switch approached	The negative hardware limit switch has been approached or overtraveled. (<TO>.StatusWord.X17 (HWLimitMinActive))
Positive HW limit switch approached	The positive hardware limit switch has been approached or overtraveled. (<TO>.StatusWord.X18 (HWLimitMaxActive))

Motion status

The following table shows the possible axis motion status values:

Status	Description
Done (no job running)	No job active at technology object. (<TO>.StatusWord.X6 (Done))
Homing job	The technology object executes a homing job of the Motion Control instruction "MC_Home" or from the axis control panel. (<TO>.StatusWord.X11 (HomingCommand))
Jog	The axis is being moved with a job for jog mode of Motion Control instruction "MC_MoveJog". (<TO>.StatusWord.X9 (JogCommand))
Velocity specification	The axis is traversed with a job with velocity specification of the Motion Control instruction "MC_MoveVelocity" or from the axis control panel. (<TO>.StatusWord.X10 (VelocityCommand))
Positioning job	The axis is traversed with a positioning job of the Motion Control instruction "MC_MoveAbsolute", "MC_MoveRelative", "MC_PositionProfile" or of the axis control panel (OR logic operation). (<TO>.StatusWord.X8 (PositioningCommand); <TO>.StatusWord2.X9 (PositionProfileCommand))
Constant velocity	The axis is moved with constant velocity or is stationary. (<TO>.StatusWord.X12 (ConstantVelocity))
Standstill	The axis is at a standstill. (<TO>.StatusWord.X7 (StandStill))
Accelerating	Axis is being accelerated. (<TO>.StatusWord.X13 (Accelerating))
Decelerating	The axis is being decelerated. (<TO>.StatusWord.X14 (Decelerating))

Status	Description
Torque limit active	At least the threshold value (default 90%) of the preset force/torque limitation acts on the axis. (<TO>.StatusWord.X27 (InLimitation))
Stop job active	The axis is stopped and disabled by Motion Control instruction "MC_Stop". (<TO>.StatusWord2.X0 (StopCommand))
Superimposed motion	The motion of the axis is superimposed by at least one overlapping Motion Control instruction (OR logic operation). (<TO>.StatusWord.X23 (MoveSuperimposedCommand); <TO>.StatusWord2.X6 (MotionInSuperimposedCommand); <TO>.StatusWord2.X8 (MotionInSuperimposedAxesCommand); <TO>.StatusWord2.X7 (HaltSuperimposedCommand))

Synchronous operation status

Status	Description
Synchronization	The axis is synchronized to the leading value of a leading axis. (<TO>.StatusWord.X21 (Synchronizing))
Synchronous	The axis is synchronized and moves synchronously to the leading axis. (<TO>.StatusWord.X22 (Synchronous))
Desynchronization (S7-1500T)	The axis is desynchronized from the leading value of a leading axis. (<TO>.StatusWord2.X1 (DesynchronizingCommand))
Synchronization pending (S7-1500T)	A synchronous operation is pending until the leading value reaches the start position for synchronization. (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 2 or 3)
Desynchronization pending (S7-1500T)	A desynchronization job is pending until the leading value reaches the start position for desynchronization. (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 4 or 5)
Additive leading value active (S7-1500T)	The axis receives an additive leading value with the Motion Control instruction "MC_LeadingValueAdditive". (<TO>.StatusSynchronizedMotion.StatusWord.X4 (LeadingValueAdditiveCommand))
Leading value offset (S7-1500T)	The leading value is shifted with the Motion Control instruction "MC_PhasingAbsolute" or "MC_PhasingRelative". (<TO>.StatusWord.X24 (PhasingCommand))
Leading value offset pending (S7-1500T)	A job for leading value offset is waiting. (<TO>.StatusWord2.X3 (PhasingCommandWaiting))
Following value offset (S7-1500T)	The following value is shifted with the Motion Control instruction "MC_OffsetAbsolute" or "MC_OffsetRelative". (<TO>.StatusWord2.X4 (OffsetCommand))
Following value offset is pending (S7-1500T)	A job for following value offset is waiting. (<TO>.StatusWord2.X5 (OffsetCommandWaiting))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	A configuration error has occurred. One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data was incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	An error occurred in the user program with a Motion Control instruction or its use. (<TO>.ErrorWord.X2 (UserFault))
Drive	An error occurred in the drive. (<TO>.ErrorWord.X4 (DriveFault))
Encoder	An error occurred in the encoder system. (<TO>.StatusSensor[1].Error)
Encoder (S7-1500T)	An error has occurred in the encoder system of encoder 1, encoder 2, encoder 3 or encoder 4. (<TO>.StatusSensor[1..4].Error)
Data exchange	Communication with a connected device is faulty. (<TO>.ErrorWord.X7 (CommunicationFault))
I/O	An error occurred accessing a logical address. (<TO>.ErrorWord.X13 (PeripheralError))
Job rejected	A job cannot be executed. You cannot execute a Motion Control instruction because necessary requirements are not fulfilled (for example, technology object not homed). (<TO>.ErrorWord.X3 (CommandNotAccepted))
Homing	An error occurred during a homing process. (<TO>.ErrorWord.X10 (HomingFault))
Positioning	The positioning axis was not positioned correctly at the end of a positioning motion. (<TO>.ErrorWord.X12 (PositioningFault))
Dynamic limitation	The dynamic values are limited to the dynamic limits. (<TO>.ErrorWord.X6 (DynamicError))
Following error	The maximum permitted following error has been exceeded. (<TO>.ErrorWord.X11 (FollowingErrorFault))
SW limit switch	A software limit switch has been reached. (<TO>.ErrorWord.X8 (SWLimit))
HW limit switch	A hardware limit switch has been reached or overtraveled. (<TO>.ErrorWord.X9 (HWLimit))

Error	Description
Adapt	An error occurred during data adaption. (<TO>.ErrorWord.X15 (AdaptionError))
Synchronization	An error occurred during synchronization. The leading axis specified for the corresponding Motion Control instruction was not configured as a possible leading axis. (<TO>.ErrorWord.X14 (SynchronousError))
Superimposing	An error has occurred during the superimposing of the axis motion. The superimposing axis specified at the corresponding Motion Control instruction was not configured as a possible superimposing axis. (<TO>.ErrorWord.X16 (SuperimposingError))

Warnings

The following table shows the possible warnings:

Warning	Description
Configuration	One or several configuration parameters are adjusted internally at a certain time. (<TO>.WarningWord.X1 (ConfigWarning))
Job rejected	Job cannot be executed. You cannot execute a Motion Control instruction because necessary requirements are not fulfilled. (<TO>.WarningWord.X3 (CommandNotAccepted))
Dynamic limitation	The dynamic values are limited to the dynamic limits. (<TO>.WarningWord.X6 (DynamicWarning))
Synchronization	An error occurred during synchronization. The leading axis specified for the corresponding Motion Control instruction was not configured as a possible leading axis. (<TO>.WarningWord.X14 (SynchronousWarning))

Alarm display

For more information and to acknowledge the error, go to the Inspector window by clicking on the "Alarm display" link.

More information

An option for evaluating the individual status bits can be found in the section "Evaluating StatusWord, ErrorWord and WarningWord" of the "S7-1500/S7-1500T Motion Control overview" documentation.

12.1.2 Motion status

You use the "Technology object > Diagnostics > Motion status" diagnostic function in the TIA Portal to monitor the motion status of the axis. The diagnostics function is available in online operation.

"Setpoints" area

The following table shows the meaning of the status data:

Status	Description
Target position	Current target position of an active positioning job The target position value is only valid during execution of a positioning job. (<TO>.StatusPositioning.TargetPosition)
Position setpoint	Setpoint position of the axis (<TO>.Position)
Velocity setpoint	Velocity setpoint of the axis (<TO>.Velocity)
Velocity override	Percentage correction of the velocity specification The velocity setpoint specified in Motion Control instructions or set by the axis control panel is superimposed with an override signal and corrected as a percentage. Valid velocity correction values range from 0.0 % to 200.0 %. (<TO>.Override.Velocity)

"Current values" area

The following table shows the meaning of the status data:

Status	Description
Operative encoder	Operative encoder of the axis (<TO>.OperativeSensor)
Actual position	Actual position of the axis If the technology object is not homed, then the value is displayed relative to the position that existed when the technology object was enabled. (<TO>.ActualPosition)
Actual velocity	Actual velocity of the axis (<TO>.ActualVelocity)
Following error	Following error of the axis (<TO>.StatusPositioning.FollowingError)

"Dynamic limits" area

This area displays the limit values for the dynamic parameters.

The following table shows the meaning of the status data:

Status	Description
Velocity	Configured maximum velocity (<TO>.DynamicLimits.MaxVelocity)
Acceleration	Configured maximum acceleration (<TO>.DynamicLimits.MaxAcceleration)
Deceleration	Configured maximum deceleration (<TO>.DynamicLimits.MaxDeceleration)
Jerk	Configured maximum jerk (<TO>.DynamicLimits.MaxJerk)

12.1.3 PROFIdrive telegram

The "Technology object > Diagnostics > PROFIdrive telegram" diagnostics function is used in the TIA Portal to monitor the PROFIdrive telegrams returned by the drive and encoder. The display of the Diagnostics function is available in online operation.

"Drive" area

This area displays the following parameters contained in the PROFIdrive telegram from the drive to the controller:

- Status words "ZSW1" and "ZSW2"
- The speed setpoint (NSET) that was output to the drive
- The actual speed that was signaled from the drive (NACT)

"Encoder" area

This area displays the following parameters contained in the PROFIdrive telegram from the encoder to the controller:

- Status word "Gx_ZSW"
- The actual position value "Gx_XIST1" (cyclic actual encoder value)
- The actual position value "Gx_XIST2" (absolute encoder value)

Areas "Encoder 1" to "Encoder 4" (S7-1500T)

The "Encoder 1" to "Encoder 4" areas display the following parameters from the PROFIdrive telegram of the corresponding encoder to the controller:

- Status word "Gx_ZSW"
- The actual position value "Gx_XIST1" (cyclic actual encoder value)
- The actual position value "Gx_XIST2" (absolute encoder value)

12.2 Cam technology object

12.2.1 Applications of the cam diagnostics

In the cam diagnostics you can monitor and analyze valid points and segments of a cam from the offline and online technology object data block. The values are shown in tables and graphics and correspond to the interpolated offline or online parameters of the technology object data block.

The cam diagnostics in TIA Portal interpolates the current technology object data block parameters independently. In contrast to the cam editor, the diagnostics does not depend on the interpolation in the SIMATIC S7-1500T. The interpolation always refers to the current values in the technology object data block, the so-called snapshot.

The following parameters are taken into account during interpolation.

- <TO>.Point[i]
- <TO>.Segment[i]
- <TO>.VaildPoint[i]
- <TO>.ValidSegment[i]
- <TO>.InterpolationSettings

NOTE

The term "cam" used in this chapter applies to the technology objects of the "TO_Cam" and "TO_Cam_10k" types.

Calling the diagnostics

You can call the diagnostics as follows:

- Project tree > Project> Technology objects > Cam > Diagnostics

Possible offline applications

Valid start values of the cam in the project are displayed in a list and represented graphically.

NOTE

After you have changed values in the cam editor, you must compile the cam. The cam is automatically interpolated, even without a controller or PLCSIM.

Offline, you can:

- Check the interpolation of cams
- Identify points and segments for the same leading value
- Check the calculated velocity, acceleration and jerk
- View and compare saved snapshots
- Check transitions between cams, such as the continuity when changing cams

Possible online applications

Valid start values of the cam from the project and the actual values are displayed in a list and graphically represented online.

Online you can also:

- Check the algorithms for calculating the cams in the user program, e.g. the calculation of the coefficients for segments
- Compare a curve generated during runtime with the expected curve
- Monitor status bits and error bits
- Sort points and segments according to the leading value range, even if they are not defined in ascending order according to index in the technology object data block.
- Take, save and compare snapshots. You can use the snapshots later for documentation and additional diagnostics, when you close the TIA Portal project or change the elements of the cam.

12.2.2 Structure of the diagnostics

The cam diagnostics consists of four areas:

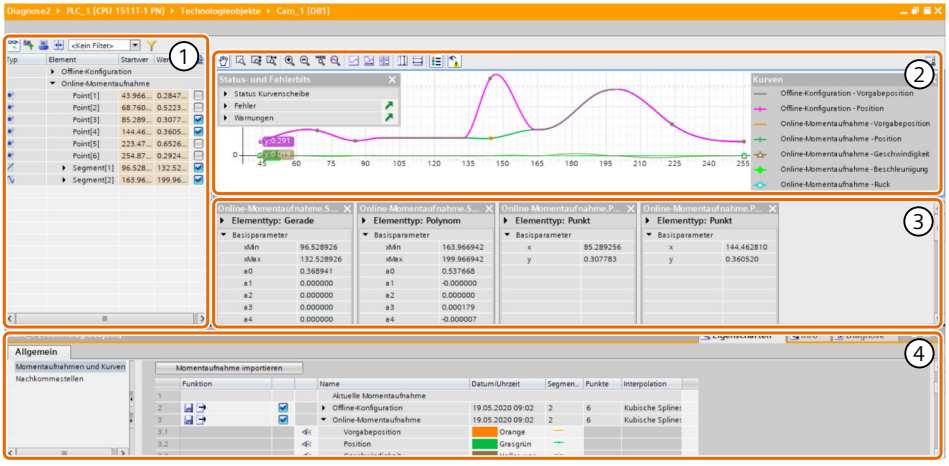

① List of valid points and segments with toolbar

② Curve diagram with toolbar

③ Element comparison

④ Inspector window

List of valid points and segments

In the list you can find all valid points and segments from the offline and online DB and the saved snapshots. Since you can display the values of the offline configuration and several snapshots, they are provided with expandable headers.

The list consists of the following columns:

Table column	Description
Type	In this column, the type of symbol is displayed with a symbol that corresponds to the symbol in the cam editor. The following element types are recognized: • Point • Line • Sine • Polynomial
Element	points or segments are shown in this column.
Start value	The x values for points and the x min. values for segments are shown in this column.
Value	The y values for points are shown in this column. When you expand the segments, the following details are shown: • x min. • x max. • a0 • a1 • a2 • a3 • a4 • a5 • a6 • sineAmplitude • sinePeriod • sinePhase
	In this column, you can select points or segments for comparison (Page 271).

Sorting

You can sort the points and segments in ascending or descending order using the "Element" and "Start value" columns.

Toolbar

The toolbar at the top of the list of valid points and segments provides the following functions via buttons:

Symbol	Function	Description
	Monitoring On/Off	Monitoring of the cam is started or ended.
	Update online curve	The online snapshot is updated.
	Print	The "Print (Page 275)" dialog will open.

Symbol	Function	Description
	Link list and graphic display for the selected objects	If coupling is enabled and an element is selected in the curve diagram, this element is automatically scrolled to in the list of valid points and segments. Note: This is only relevant if the list has so many entries that they are not all visible.
<No filter>	Select filter	You can select a defined filter.
	Defining filter	The "Define filter (Page 270)" dialog opens.

Curve diagram

Offline, online and saved snapshots are displayed in the curve diagram.
All valid data from the technology object data block are graphically displayed as a curve. In the curve diagram you can display curves that reflect the position specification, position, velocity, acceleration and jerk. You set the parameters of the displayed curves in the inspector window. You can show or hide the legend using the icon on the toolbar.

NOTE

Refresh the curve displayed in the offline view

If you change the values in the offline technology object data block, the offline snapshot is automatically reloaded. After you have changed parameters in the cam editor, you must compile the cam. The parameters are then automatically transferred to the technology object data block.

Toolbar

The toolbar at the top of the curve diagram provides the following functions via buttons:

Symbol	Function	Description
	Move view	Moving the view using the drag-and-drop feature To switch from any tool to the "Move view" tool, press the <Esc> key.
	Activate zoom selection	Zoom into selected area
	Activate vertical zoom	Vertical zoom into selected area without horizontal scaling Alternative: <Ctrl> +drag to ordinate keeping mouse button pressed
	Activate horizontal zoom	Horizontal zoom into selected area without vertical scaling Alternative: <Ctrl> +drag to abscissa keeping mouse button pressed
	Zoom in	Enlargement of the display Alternative: <Ctrl> + mouse wheel up in curve diagram

Symbol	Function	Description
	Zoom out	Reduction of the display Alternative: <Ctrl> + mouse wheel down in curve diagram
	Show all	Display of entire definition and value range
	Zoom into curve	Zoom to the following value range of the curve that you selected in the legend of the chart
	View: A chart with positions	Display of one chart with the following curves of the cam opened in the diagnostics: • Position specification • Effective position
	View: A chart with all curves	Display of one chart with the following curves of the cam opened in the diagnostics: • Position specification • Effective position • Effective velocity • Effective acceleration • Effective jerk
	View: Four charts with all curves	Display of four charts with the following curves of the cam opened in the diagnostics: • Chart with position specification and effective position • Chart with effective velocity • Chart with effective acceleration • Chart with effective jerk
	Vertical measuring lines	Displaying and moving of vertical measuring lines Hold down the left mouse button and drag to draw a measuring range. The vertical position of the measuring lines can be moved. The function values for the positions of the measuring lines are displayed in the chart. The difference is displayed between the measuring lines.
	Horizontal measuring lines	Displaying and moving of horizontal measuring lines Hold down the left mouse button and drag to draw a measuring range. The horizontal position of the measuring lines can be moved. The function values for the positions of the measuring lines are displayed in the chart. The difference is displayed between the measuring lines.
	Show legend	Showing or hiding of the legend in the curve diagram. To display values for a specific curve on the ordinate, click on the name of the corresponding curve in the legend.

Symbol	Function	Description
	Show status and error bits	Show and hide the diagnostics window "Status and error bits (Page 267)" You monitor the status of the technology object using the "Status and error bits" diagnostics window.
	Show scaling range	Showing and hiding the "Scaling range" diagnostic window Use the "Range scaling" diagnostics window to monitor the status of the scaling ranges.
	Save window settings	Saves of the display settings.

Element comparison

The element comparison is located below the curve diagram. You can select individual points and segments and thus Analyze and compare elements (Page 271):

Inspector window

In the inspector window you can manage the Manage snapshots (Page 273) in the "General" tab. You can set the decimal places separately in the list of valid points and segments and in the curve diagram.

12.2.3 Online view

Use the "Monitoring on/off" icon on the toolbar of the cam diagnostics to switch to the online view.

Online view of the list with valid points and segments

In the list with valid points and segments you can find the current online values under "Online snapshot". The start values and values of the elements are highlighted in orange.

Online view of the curve diagram

In the curve diagram you can monitor changes to the status of the online cam in the "Status and error bits (Page 267)" diagnostics window. You can show and hide the window using the icon.

Online view of the Inspector window

In the list of the current snapshots you can see the online snapshot, whose display you can manage and save under "Saved snapshots" (Page 273).

12.2.4 Status and error bits

You monitor the status of the technology object using the "Status and error bits" diagnostics window. The diagnostics function is available in online operation.

You can show and hide the diagnostics window using the icon on the toolbar. You can move the window to a desired position within the curve diagram using drag-and-drop.

The meaning of the status and error bits is described in the following tables.

Cam status

The following table shows the possible statuses of the cam:

Status	Description
In use	The cam is used. (<TO>.StatusWord.X0 (Control))
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area and in the "<TO>.ErrorDetail.Number" and "<TO>.ErrorDetail.Reaction" tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is being reinitialized. (<TO>.StatusWord.X2 (RestartActive))
Definition changed	The definition range of the cam has changed in the technology data block. (<TO>.StatusWord.X4 (CamDataChanged))
Interpolated	The cam is interpolated. (<TO>.StatusWord.X5 (Interpolated))
In interpolation	The cam is interpolated. (<TO>.StatusWord.X6 (InInterpolation))
Restart required	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))
Copy operation active	A copy operation of an "MC_CopyCamData" job is active. (<TO>.StatusWord.X7 (CopyCamDataActive))
Range scaling in calculation	The range scaling of a "MC_SetCamRangeScaling" job is calculated. (<TO>.StatusWord.X8 (SetCamRangeScalingActive))
Range scaling active	At least one range scaling is active. (<TO>.StatusWord.X9 (CamRangeScaled))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	A configuration error has occurred. One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data was incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	An error in a Motion Control instruction or during its use has occurred in the user program. (<TO>.ErrorWord.X2 (UserFault))
Job rejected	A job cannot be executed. You cannot execute a Motion Control instruction because necessary requirements are not fulfilled. (<TO>.ErrorWord.X3 (CommandNotAccepted))

You can access the alarm display via the icon.

Warnings

The following table shows the possible warnings:

Warning	Description
System	A system-internal error has occurred. (<TO>.WarningWord.X0 (SystemWarning))
Configuration	One or more configuration parameters will be temporarily adjusted internally. (<TO>.WarningWord.X1 (ConfigWarning))
User program	An error in a Motion Control instruction or during its use has occurred in the user program. (<TO>.WarningWord.X2 (UserWarning))
Job rejected	Job cannot be executed. You cannot execute a Motion Control instruction because necessary requirements are not fulfilled. (<TO>.WarningWord.X3 (CommandNotAccepted))

You can access the alarm display via the icon.

12.2.5 Range scaling

The configured scaling ranges are indicated by markers at the edge of the curve diagram. The scaling factor is displayed in the tooltip of the area selection. If the scaling ranges overlap, the effective scaling factor is displayed.

Use the "Scaling range" diagnostics window to monitor the status of the scaling ranges. The diagnostics function is available in online operation.

You can show and hide the diagnostics window using the icon on the toolbar. You can move the window to a desired position within the curve chart using drag-and-drop.

The following table describes the meaning of the parameters.

Scaling range 1 and 2

The following table shows the values for scaling ranges 1 and 2:

Parameters	Description
Scaling mode	This field shows whether the scaling range refers to the leading value range or the following value range. (<TO>.StatusRangeScaling.Range[1..2].Mode)
Start point	The start value of the scaling range is displayed in this field. (<TO>.StatusRangeScaling.Range[1..2].StartPoint)
End point	The final value of the scaling range is displayed in this field. (<TO>.StatusRangeScaling.Range[1..2].EndPoint)
Scaling factor	The scaling factor of the scaling range is displayed in this field. (<TO>.StatusRangeScaling.Range[1..2].Scaling)

12.2.6 "Definition changed" and "Interpolated" status bits

Depending on the change in the online technology object data block, the associated status bits are displayed in green.

If you change values in the online technology object data block and they do not match the interpolated values displayed in the curve diagram, the "Definition changed" status bit is displayed in green.

The following message is displayed in the upper part of the cam diagnostics:

"The online values do not correspond to the active interpolated curve. Interpolate the cam and then reload the curve in the graphic display."

Refresh graphic display

To display the current values, follow these steps:

1. Interpolate the curve.

   After the interpolation, the "Definition changed" bit is no longer set.

   The "Interpolated" bit is set.

   The note in the banner changes:

   "The curve shown is not current. Update."

2. Click on the "Refresh" icon on the toolbar or, alternatively, on the "Refresh" link in the message.

   The online snapshot is updated. You can save the online snapshots under "Saved snapshots (Page 273)".

NOTE

You can also update the diagnostics without re-interpolating the cam after making changes in the technology object data block. The last interpolated cam then remains active in the controller and during camming. The "Interpolated" bit remains set. Before interpolation, you can then analyze the interpolated cam with the new technology object data block parameters in the controller. The "Definition changed" bit then remains TRUE.

12.2.7 Filter by segments and points

To analyze the relevant elements in extensive cams, you can filter them according to the following criteria:

- Filter segments by index in the technology data block
- Filter segments by segment type
- Filter points by index in the technology data block
- Filter the displayed leading value range

Elements that do not meet the filter criteria are hidden in the list of points and segments and displayed in a lighter shade in the curve diagram than elements that meet the criteria. The filter criteria are applied to all displayed snapshots.

Defining and saving filters

To define and save a filter, follow these steps:

1. Click on the icon in the cam diagnostics toolbar.

   The "Define filter" dialog opens.
2. Set the desired filter criteria.
3. Name the filter in the drop-down list.
4. Click "OK".

   The filter is saved and applied.

Adding other filters

To add additional filters, proceed as follows:

1. Click on the icon in the cam diagnostics toolbar.

   The "Define filter" dialog opens.
2. Click the symbol .
3. Set the desired filter criteria.
4. Name the filter in the drop-down list.
5. Click "OK".

   The additional filter is saved, applied and displayed with existing filters in the drop-down list of the toolbar.

Adapting existing filters

To adjust existing filters, follow these steps:

1. Click on the icon in the cam diagnostics toolbar.
   The "Define filter" dialog opens.
2. Select the filter to be adjusted from the drop-down list.
3. Adjust the filter criteria.
4. Click "OK".
   The changes are saved and applied.

Delete filter

Proceed as follows to delete filter:

1. Click on the icon in the cam diagnostics toolbar.
   The "Define filter" dialog opens.
2. In the drop-down list, select the filter to deleted.
3. Click the symbol .
4. Click "OK".
   The filter is deleted.

Cancel filter

To cancel a filter, select the "No filter" entry in the drop-down list in the toolbar.

The filter settings are terminated.

12.2.8 Comparing elements

You can select individual points and segments from various snapshots and compare them in detail.

Select elements to compare

You can select items to compare in the following two ways:

- In the " " column, select valid points or segments.
- In the curve diagram in the shortcut menu, select the element "Show in element comparison".

Parameters in the element comparison

For each selected element, the parameters are displayed in a separate window.

NOTE

You can change the order of the window using the drag-and-drop feature.

Each window contains three expandable areas:

- Element type with mapping in the upper part

  You can expand and collapse the image of the element with the arrow next to the element type.

- Basic parameters

  The basic parameters are read out directly from the technology object data block of the cam.

  For points, the x and y values are displayed.

  The following values are displayed for segments:

  – x min.
  – x max.
  – a0
  – a1
  – a2
  – a3
  – a4
  – a5
  – a6
  – sineAmplitude
  – sinePeriod
  – sinePhase

- Extended parameters

  The extended parameters are not saved directly in the technology object data block. They are calculated by the diagnostics in the TIA Portal.

  For points, the values are displayed depending on the interpolation:

  – With linear interpolation, the velocity in the points is discontinuous. The velocity is displayed to the left (v left) and right (v right) of the point. Acceleration and jerk are not displayed.
  – With cubic interpolation, the jerk in the points is discontinuous. The jerk is displayed to the left (j left) and right (j right) of the point.
  – When interpolating with Bézier splines, the values "y", "v", "a" and "j" from the interpolation result are displayed.

The following values are displayed for segments:

- x start
- x end
- y min.
- y max.
- v start
- v end
- v min.
- v max.
- a start
- a end
- a min.
- a max.
- j start
- j end
- j min.
- j max.

NOTE

The expanding and collapsing of the individual areas and the scrolling are synchronized for all segments and points.

12.2.9 Managing snapshots

You can manage the displayed curves and snapshots in the inspector window under "Properties > General> Snapshots and curves". In the "Current snapshot" area you can see snapshots that contain valid points and segments from the technology object data block in the following order:

1. Offline configuration
2. Online configuration
3. Saved snapshot

Settings of the snapshots

You can expand the snapshots and make the following settings:

Control element/display element	Meaning
	Show and hide the respective snapshot in the curve diagram and in the list of valid points and segments
	Save the snapshot under "Saved snapshot"

Control element/display element	Meaning
	Export the snapshot (Page 274)
	Delete the saved snapshot
	Show and hide individual curves in the curve diagram and in the legend You can select the color and line shape for each curve.

The date and time of the recording, the number of segments and points and the type of interpolation are displayed for each snapshot.

You can change the name of saved snapshots.

12.2.10 Exporting and importing snapshots

You can export and import snapshots.

A list with all snapshots and the "Import snapshot" button can be found in the Inspector window > General tab > Snapshots and curves.

The following formats are supported:

- MCD exchange format
- SIMOTION SCOUT CamTool format
- Binary format

A description of the individual formats can be found in the "Exporting a cam (Page 135)" and "Importing a cam (Page 136)" sections.

Export snapshot

To export snapshots, follow these steps:

1. For the snapshot you want to export, click the icon .

   The "Export snapshot" dialog opens.
2. Select the export format and the delimiter.
   - When you select the "Comma" delimiter, the snapshot is exported as CSV file.
   - When you select the "Tabulator" delimiter, the snapshot is exported as TXT file.
3. Enter a file name.
4. Select the target directory.
5. Click the "Export" button.

NOTE

You can import into the cam configuration a snapshot exported in binary format.

Import snapshot

To import snapshots, follow these steps:

1. Click "Import snapshot".

   The "Cam import" dialog opens.
2. Select the format.
3. Select the file.
4. Click the "Open" button.

   The snapshot is displayed in the "Saved snapshots" area.
5. To display the snapshot in the list of valid points and segments and in the curve diagram, select the check box.
6. For the display in the curve diagram, select the color and line shape for the curves.

NOTE

Exports from the cam configuration can contain elements that are not supported in the cam diagnostics (see "Structure of the diagnostics (Page 262)" section). These elements are then displayed as a group of points.

12.2.11 Printing curve diagram

You have the possibility to print the displayed curves.

Procedure

To print the curves displayed in the curve diagram, follow these steps:

1. Show all curves to be printed out.
2. On the toolbar, click the icon .
3. Select the printer and the document layout.

   To preview the resulting document, click the "Preview" button.
4. Click "Press".

12.3 Leading axis proxy technology object

12.3.1 Status and error bits

You use the "Technology object > Diagnostics > Status and error bits" diagnostic function in the TIA Portal to monitor the status and error messages for the technology object. The diagnostics function is available in online operation.

The meaning of the status and error messages is described in the following tables. The associated technology object tag is given in parentheses.

Leading axis proxy status

The following table shows the possible states of the leading axis proxy:

Status	Description
In operation	The technology object is in operation. (<TO>.StatusWord.X0 (Control))
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area and in the "<TO>.ErrorDetail.Number" and "<TO>.ErrorDetail.Reaction" tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is being reinitialized. (<TO>.StatusWord.X2 (RestartActive))
Restart required	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO.>StatusWord.X3 (OnlineStartValuesChanged))
External leading value valid	The external leading value exists and is valid. (<TO>.StatusWord.X4 (LeadingValueValid))
External leading value with modulo	The external leading value has modulo functionality. (<TO>.StatusWord.X5 (LeadingValueModulo))
Leading axis in setpoint operation	The leading axis is in setpoint operation. (<TO>.StatusWord.X6 (LeadingAxisControl))

Warnings

The following table shows the possible warnings:

Warning	Description
System	A system-internal error has occurred. (<TO>.WarningWord.X0 (SystemWarning))
Configuration	One or more configuration parameters are being internally adapted temporarily. (<TO>.WarningWord.X1 (ConfigWarning))

Warning	Description
User program	An error has occurred in the user program. (<TO>.WarningWord.X2 (UserWarning))
Job rejected	Job cannot be executed. You cannot execute a Motion Control instruction because necessary requirements are not fulfilled. (<TO>.WarningWord.X3 (CommandNotAccepted))
Data exchange	An error in the communication has occurred. (<TO>.WarningWord.X7 (CommunicationWarning))

Error

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	A configuration error has occurred. One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data was incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))
User program	An error occurred in the user program at a Motion Control instruction or its use. (<TO>.ErrorWord.X2 (UserFault))
Job rejected	A job cannot be executed. You cannot execute a Motion Control instruction because necessary requirements are not fulfilled (for example, technology object not homed). (<TO>.ErrorWord.X3 (CommandNotAccepted))
Data exchange	Communication with a connected device is faulty. (<TO>.ErrorWord.X7 (CommunicationFault))

Alarm display

For additional information and to acknowledge the error, go to the Inspector window by clicking on the "Alarm display" link.

12.3.2 Motion status

You use the "Technology object > Diagnostics > Motion status" diagnostic function in the TIA Portal to monitor the leading value of the leading axis proxy. The diagnostics function is available in online operation.

Leading value for local synchronous operation

The following table shows the meaning of the status data:

Status	Description
Position	Adapted leading value for local synchronous operation (<TO>.Position)
Velocity	Leading value velocity for local synchronous operation (<TO>.Velocity)
Acceleration	Leading value acceleration for local synchronous operation (<TO>.Acceleration)

External leading value

The following table shows the meaning of the status data:

Status	Description
Modulo length	Modulo length of the external leading value (<TO>.StatusExternalLeadingValue.ModuloLength)
Modulo start value	Modulo start value of the external leading value (<TO>.StatusExternalLeadingValue.ModuloStartValue)
Adjustment time	Time by which the external leading value is adapted (<TO>.StatusExternalLeadingValue.AdjustmentTime)

Instructions 13

13.1 Synchronous motion

13.1.1 MC_GearIn V10

13.1.1.1 MC_GearIn: Start gearing V10

Description

With the Motion Control instruction "MC_GearIn", you start a gearing (Page 49) operation between a leading axis and a following axis. You can start synchronous operation when the leading axis is at a standstill or when it is in motion.

The Motion Control instruction offers you the following:

- Defining gear ratio (Page 50)
- Synchronizing following axis using dynamic parameters (Page 52)
- Synchronous travel in gearing (Page 53)

Applies to

- Synchronous axis

Requirement

- The technology objects of the leading axis and the following axis have been configured correctly.
- The leading axis is a positioning axis, a synchronous axis, an external encoder or a leading axis proxy.
- The following axis is a synchronous axis.
- The leading axis is specified as possible leading axis in the configuration of the following axis under "Technology object > Configuration > Leading value interconnections".
- The following axis is enabled.

Override response

The override response for "MC_GearIn" jobs is described in section "Override response V10: Synchronous operation jobs".

With a "MC_GearOut" job, the following axis is desynchronized, and synchronous operation is terminated (S7-1500T).

Disabling the following axis with "MC_Power.Enable" = FALSE aborts the synchronous operation in every status.

Disabling the leading axis with an "MC_Power" job, in contrast, does not abort synchronous operation. The following axis follows the leading axis even during the braking ramp and after the leading axis is enabled and traversing again.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_GearIn":

Parameters	Declaration	Data type	Default value	Description	
Master	INPUT	TO_PositioningAxis TO_SynchronousAxis TO_ExternalEncoder (S7-1500T) TO_LeadingAxisProxy (S7-1500T)	-	Leading axis technology object	
Slave	INPUT	TO_SynchronousAxis	-	Following axis technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
RatioNumerator	INPUT	DINT	1	Gear ratio numerator (Page 50) Permitted integer values: -2147483648 to 2147483647 (value 0 not permitted)	
RatioDenominator	INPUT	DINT	1	Gear ratio denominator (Page 50) Permitted integer values: 1 to 2147483647	
Acceleration	INPUT	LREAL	-1.0	Acceleration (Page 52)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration (Page 52)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Deceleration)

Parameters	Declaration	Data type	Default value	Description	
Jerk	INPUT	LREAL	-1.0	Jerk (Page 52)	
				> 0.0	Constant acceleration velocity profile The specified value is used.
				= 0.0	Trapezoid velocity profile
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Jerk)
InGear	OUTPUT	BOOL	FALSE	TRUE	Synchronous operation reached The following axis is synchronized and moves synchronously to the leading axis.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	0	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

13.1.1.2 MC_GearIn: Function chart V10

Function chart: Synchronizing and switching the leading value

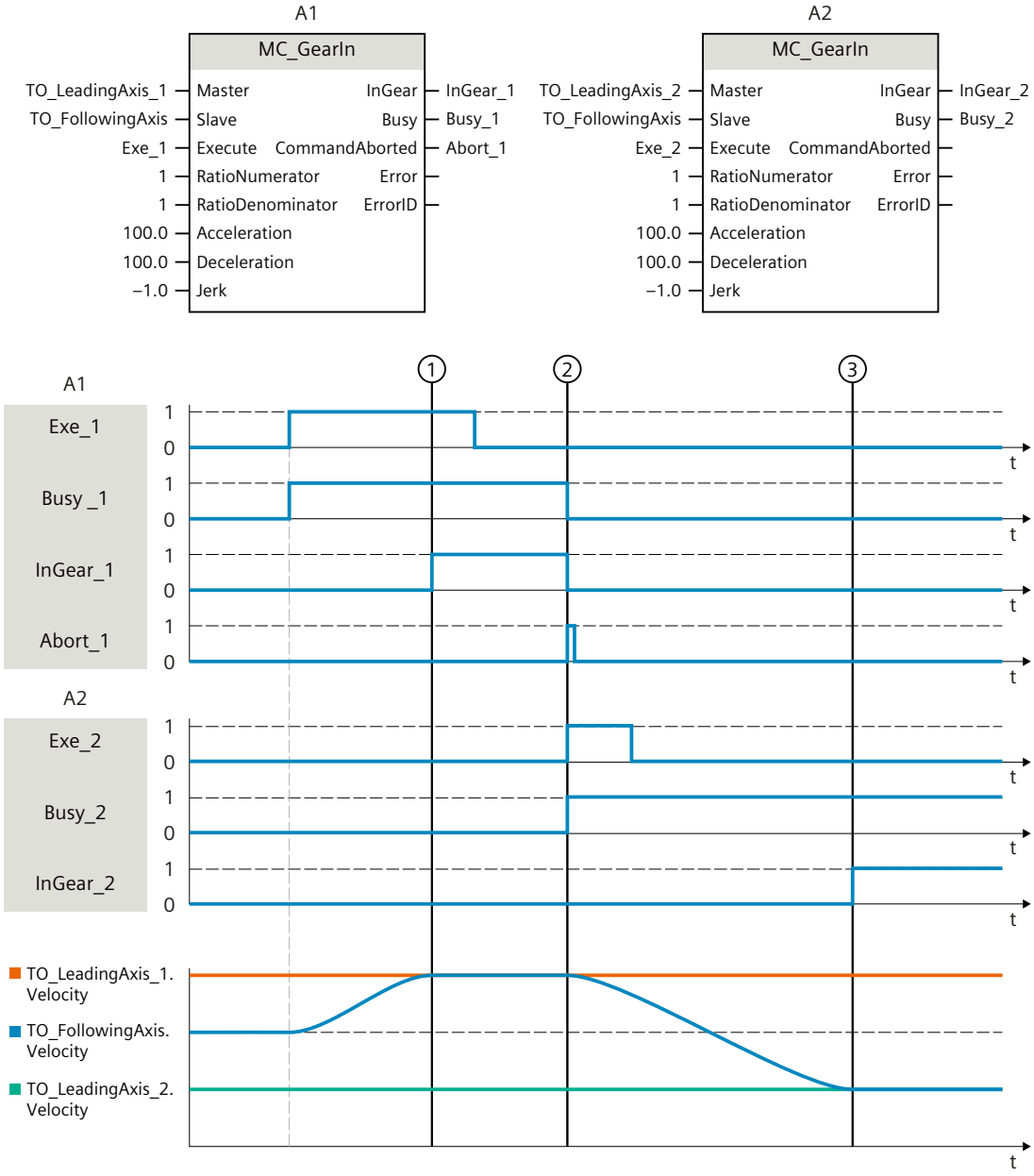

Using "Exe_1", an "MC_GearIn" job (A1) is initiated. The following axis (TO_FollowingAxis) is synchronized to the leading axis (TO_LeadingAxis_1). "InGear_1" signals at time ① that the following axis is synchronized and moves synchronously to the leading axis.

At time ②, synchronous operation is overridden by another "MC_GearIn" job (A2). The abort is signaled via "Abort_1". The following axis is synchronized to the new leading axis (TO_LeadingAxis_2). "InGear_2" signals at time ③ that the following axis is synchronized and moves synchronously to the leading axis.

13.1.2 MC_GearInPos V10

13.1.2.1 MC_GearInPos: Start gearing with specified synchronous positions V10

Description

With the Motion Control instruction "MC_GearInPos", you start gearing (Page 67) between a leading axis and a following axis. The following axis is synchronized depending on the synchronization mode and the specified synchronous positions for the leading and following axis. You can start synchronous operation when the leading axis is at a standstill or when it is in motion.

The Motion Control instruction offers you the following:

- Defining gear ratio (Page 55)
- Defining direction of synchronization (Page 59)
- Define synchronous positions and type of synchronization:
  - Synchronization in advance using dynamic parameters (Page 61)
  - Synchronization in advance using leading value distance (Page 63)
  - Subsequent synchronization using leading value distance (Page 65)
  - Subsequent synchronization using leading value distance starting from current leading value position with calculated synchronous position of the following axis (Page 67)
  - Subsequent synchronization using leading value distance with calculated synchronous position of the following axis (Page 69)
- Synchronous travel in gearing (Page 72)

Different parameters are relevant depending on the synchronization profile. You can find an overview in the "Parameter overview for synchronizing with "MC_GearInPos" (Page 58)" section.

Applies to

- Synchronous axis

Requirement

- The technology objects of the leading axis and the following axis have been configured correctly.
- The leading axis is a positioning axis, a synchronous axis, an external encoder or a leading axis proxy.
- The following axis is a synchronous axis.
- The leading axis is specified as possible leading axis in the configuration of the following axis under "Technology object > Configuration > Leading value interconnections".
- The following axis is enabled.

- The following axis is homed.
- With synchronization in advance using leading value distance, the leading axis must be at least the specified distance ("MasterStartDistance") from the synchronization position ("MasterSyncPosition") when starting the job.

Override response

The override response for "MC_GearInPos" jobs is described in section "Override response V10: Synchronous operation jobs".

With a "MC_GearOut" job, the following axis is desynchronized and synchronous operation is terminated.

Disabling the following axis with "MC_Power.Enable" = FALSE aborts the synchronous operation in every status.

Disabling the leading axis with "MC_Power", in contrast, does not abort synchronous operation. The following axis follows the leading axis even during the braking ramp and after the leading axis is enabled again.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_GearInPos":

Parameters	Declaration	Data type	Default value	Description	
Master	INPUT	TO_PositioningAxis TO_SynchronousAxis TO_ExternalEncoder TO_LeadingAxisProxy	-	Leading axis technology object	
Slave	INPUT	TO_SynchronousAxis	-	Following axis technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
RatioNumerator	INPUT	DINT	1	Gear ratio numerator (Page 55) Permitted integer values: -2147483648 to 2147483647 (value 0 not permitted)	
RatioDenominator	INPUT	DINT	1	Gear ratio denominator (Page 55) Permitted integer values: 1 to 2147483647	
MasterSyncPosition	INPUT	LREAL	0.0	Synchronous position of leading axis	
				When "SyncProfileReference" = 0, 1: Position of the leading axis from which the axes are synchronous and the synchronization is completed.	
				When "SyncProfileReference" = 3, 5: Position of the leading axis from which synchronization starts	
				When "SyncProfileReference" = 4: Not relevant	
SlaveSyncPosition	INPUT	LREAL	0.0	Synchronous position of following axis	

Parameters	Declaration	Data type	Default value	Description	
SlaveSyncPosition	INPUT	LREAL	0.0	When "SyncProfileReference" = 0, 1: Position of the following axis from which the axes are synchronous and the synchronization is completed.	
				When "SyncProfileReference" = 3: Position of the following axis, which is assigned to the synchronous position of the leading axis.	
				When "SyncProfileReference" = 4, 5: Not relevant	
SyncProfileReference	INPUT	DINT	1	Type of synchronization	
				0	Synchronization in advance using dynamic parameters (Page 61)
				1	Synchronization in advance using leading value distance (Page 63)
				2	Reserved
				3	Subsequent synchronization using leading value distance (Page 65)
				4	Subsequent synchronization using leading value distance starting from current leading value position with calculated synchronous position of the following axis (Page 67)
				5	Subsequent synchronization using leading value distance with calculated synchronous position of the following axis (Page 69)
MasterStartDistance	INPUT	LREAL	1.0	When "SyncProfileReference" = 1, 3, 4, 5: Leading value distance Distance of the leading axis during synchronization	
				> 0.0	The specified value is used.
				≤ 0.0	Not permitted
				When "SyncProfileReference" = 0: Not relevant	
Velocity	INPUT	LREAL	-1.0	When "SyncProfileReference" = 0: Velocity	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Velocity)
				When "SyncProfileReference" = 1, 3, 4, 5: Not relevant	
Acceleration	INPUT	LREAL	-1.0	When "SyncProfileReference" = 0: Acceleration	
				> 0.0	The specified value is used.

Parameters	Declaration	Data type	Default value	Description	
Acceleration	INPUT	LREAL	-1.0	= 0.0	Not permitted
				< 0.0	The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Acceleration)
				When "SyncProfileReference" = 1, 3, 4, 5: Not relevant	
Deceleration	INPUT	LREAL	-1.0	When "SyncProfileReference" = 0: Deceleration	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Deceleration)
				When "SyncProfileReference" = 1, 3, 4, 5: Not relevant	
Jerk	INPUT	LREAL	-1.0	When "SyncProfileReference" = 0: Jerk	
				> 0.0	Constant acceleration velocity profile The specified value is used.
				= 0.0	Trapezoid velocity profile
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Jerk)
				When "SyncProfileReference" = 1, 3, 4, 5: Not relevant	
SyncDirection	INPUT	DINT	3	Direction of synchronization (Page 59) (in effect for following axes with activated Modulo setting)	
				1	Positive direction The following axis may only travel in positive direction during synchronization.
				2	Negative direction The following axis may only travel in negative direction during synchronization.
				3	Shortest distance Changes in direction are permitted for the following axis during synchronization.
StartSync	OUTPUT	BOOL	FALSE	TRUE	The following axis is synchronized to the leading axis.

Parameters	Declaration	Data type	Default value	Description	
InSync	OUTPUT	BOOL	FALSE	TRUE	Synchronous operation reached The following axis is synchronized and moves synchronously to the leading axis.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	0	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

See also

Gearing with "MC_GearInPos" (Page 54)

13.1.2.2 MC_GearInPos: Function chart V10

Function chart: Synchronization in advance using dynamic parameters and leading value distance

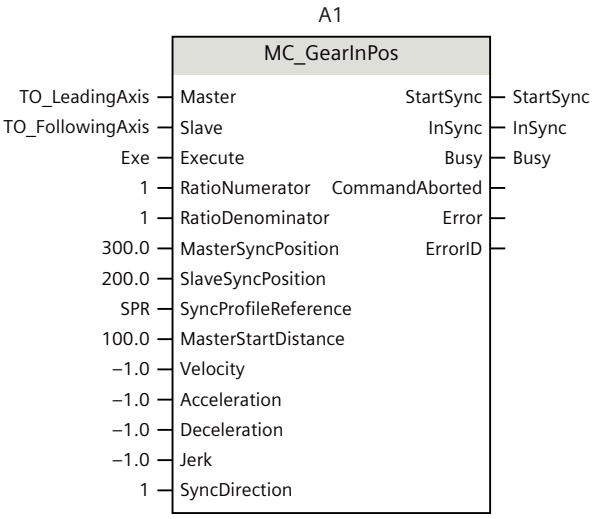

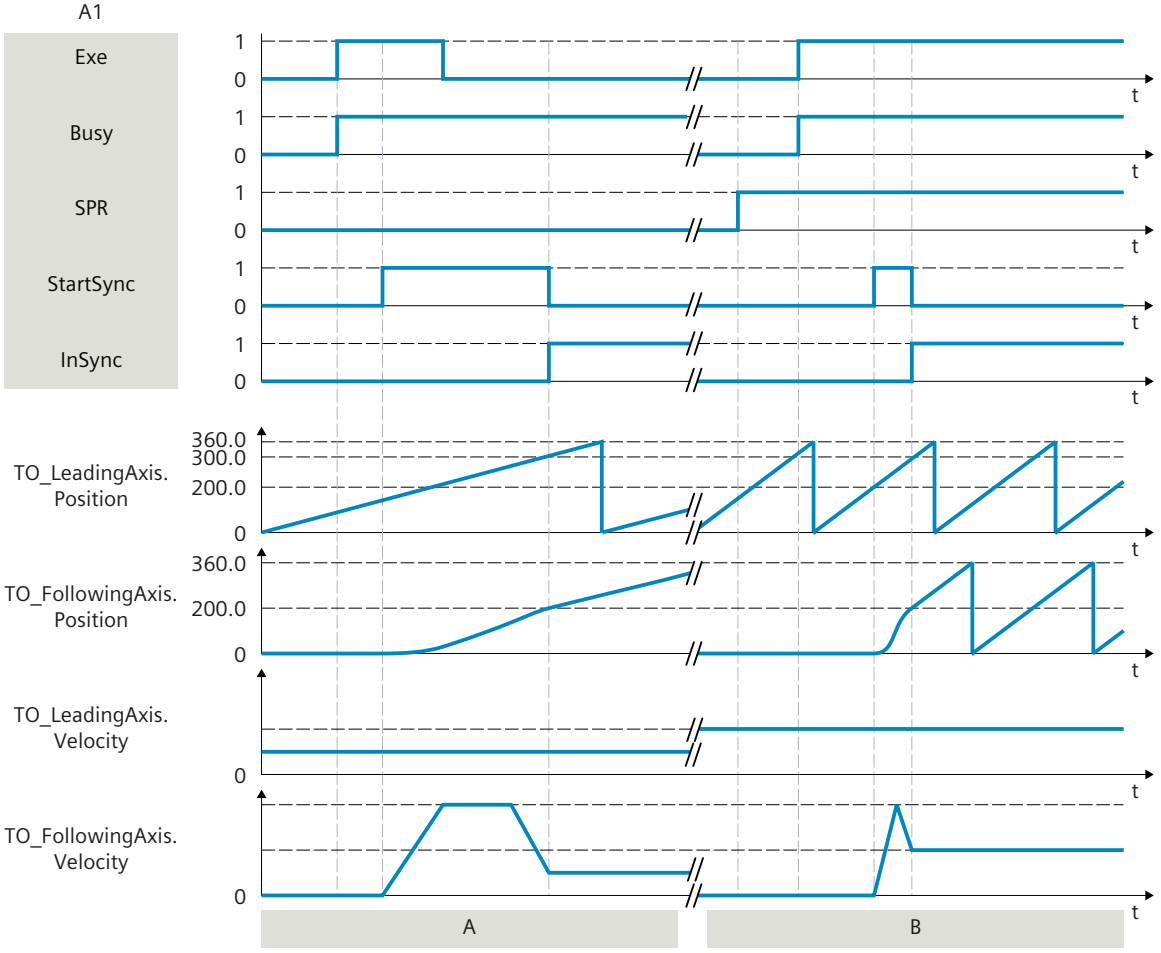

Section A

Using "Exe", an "MC_GearInPos" job (A1) is initiated. The start of the synchronization is displayed with "StartSync". The following axis (TO_FollowingAxis) is synchronized in advance to the leading axis (TO_LeadingAxis) by means of the specified dynamic parameters. The distance required for synchronization is calculated by the system. When the specified reference positions "MasterSyncPosition" and "SlaveSyncPosition" are reached, "InSync" signals that the following axis is synchronized and moving synchronously to the leading axis.

Section B

Using "Exe", an "MC_GearInPos" job (A1) is initiated. The start of the synchronization is displayed with "StartSync". The following axis (TO_FollowingAxis) is synchronized to the leading axis (TO_LeadingAxis) by means of the specified leading value distance "MasterStartDistance". The dynamic response required for synchronization is calculated by the system. When the specified reference positions "MasterSyncPosition" and "SlaveSyncPosition" are reached, "InSync" signals that the following axis is synchronized and moving synchronously to the leading axis.

Function chart: Synchronization in advance and subsequent synchronization using leading value distance

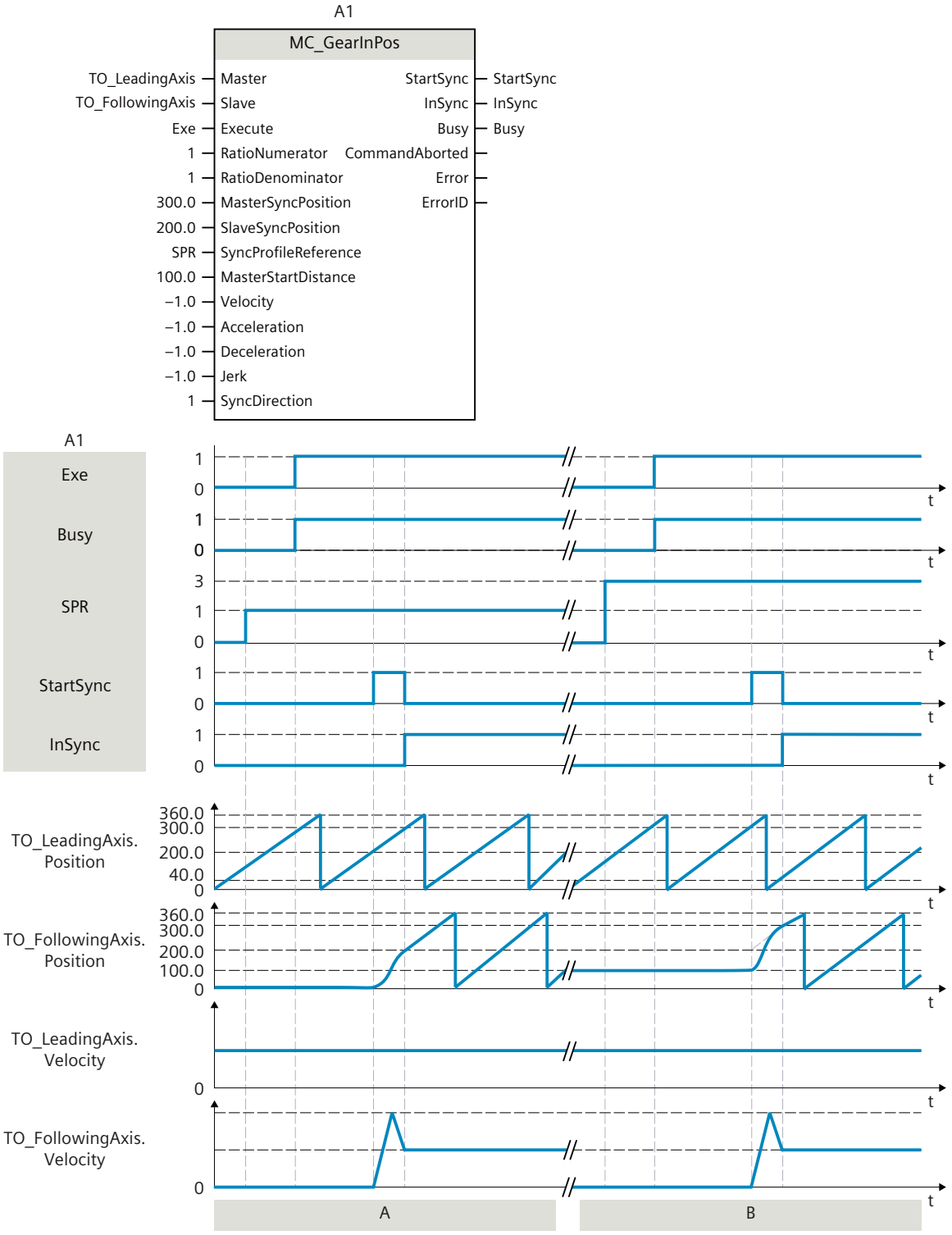

Section A

Using "Exe", an "MC_GearInPos" job (A1) is initiated. The start of the synchronization is displayed with "StartSync". The following axis (TO_FollowingAxis) is synchronized to the leading axis (TO_LeadingAxis) by means of the specified leading value distance "MasterStartDistance". The dynamic response required for synchronization is calculated by the system. When the specified reference positions "MasterSyncPosition" and "SlaveSyncPosition" are reached, "InSync" signals that the following axis is synchronized and moving synchronously to the leading axis.

Section B

Using "Exe", an "MC_GearInPos" job (A1) is initiated. When the specified reference position "MasterSyncPosition" is reached, the start of synchronization is indicated via "StartSync". The following axis (TO_FollowingAxis) is synchronized subsequently to the leading axis (TO_LeadingAxis) by means of the specified leading value distance "MasterStartDistance". The dynamic response required for synchronization is calculated by the system. "InSync" signals that the following axis is synchronized and moving synchronously to the leading axis.

Function chart: Subsequent synchronization using leading value distance starting from current or specified leading value position with calculated synchronous position of the following axis

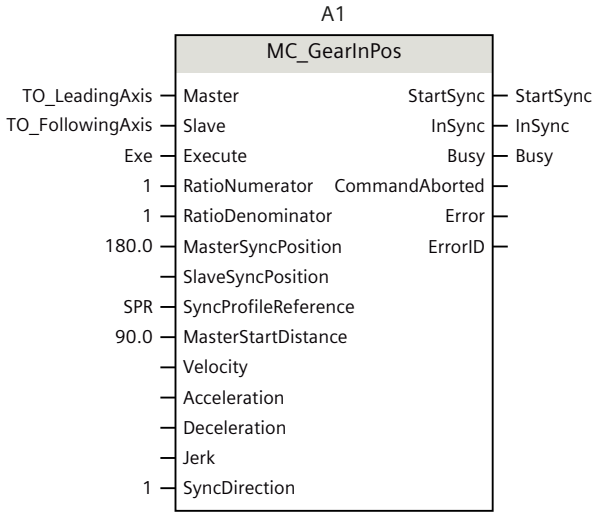

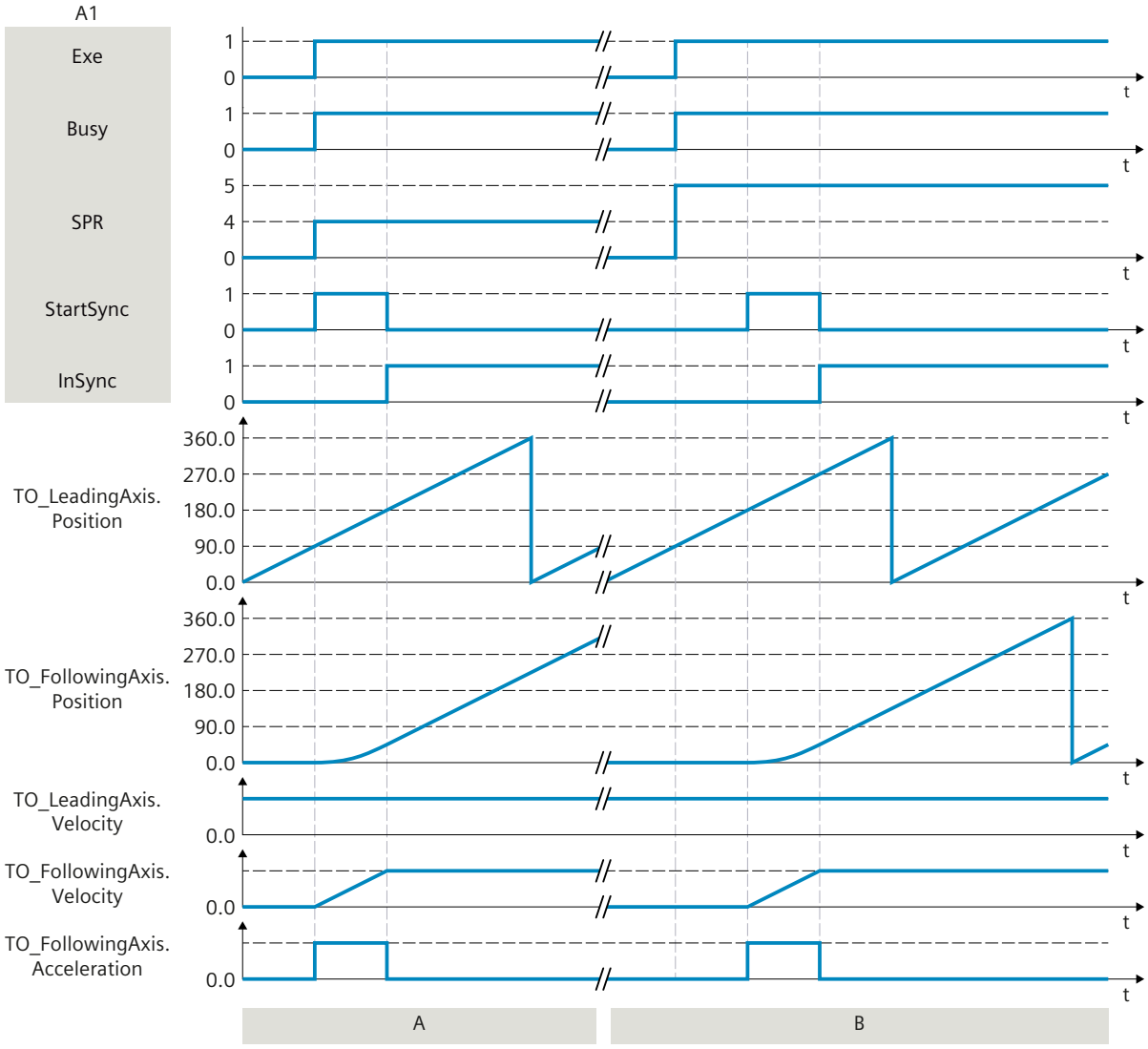

Section A

Using "Exe", an "MC_GearInPos" job (A1) is initiated. The start of the synchronization is displayed with "StartSync". The following axis (TO_FollowingAxis) is synchronized subsequently from the leading value position to the leading axis (TO_LeadingAxis) by means of the specified leading value distance "MasterStartDistance". The synchronous position of the following axis and the dynamic response required for synchronization are calculated by the system. "InSync" signals that the following axis is synchronized and moving synchronously to the leading axis at the end of the leading value distance.

Section B

Using "Exe", an "MC_GearInPos" job (A2) is initiated. When the specified reference position "MasterSyncPosition" is reached, the start of synchronization is indicated via "StartSync". The following axis (TO_FollowingAxis) is synchronized subsequently to the leading axis (TO_LeadingAxis) by means of the specified leading value distance "MasterStartDistance". The synchronous position of the following axis and the dynamic response required for synchronization are calculated by the system. "InSync" signals that the following axis is synchronized and moving synchronously to the leading axis.

13.1.3 MC_GearInVelocity V10

13.1.3.1 MC_GearInVelocity: Start velocity synchronous operation V10

Description

With the Motion Control instruction "MC_GearInVelocity", you can start velocity synchronous operation (Page 94) between a leading axis and a following axis. The following axis is synchronized to the velocity of the leading axis depending on the specified gear ratio. You can start velocity synchronous operation when the leading axis is at a standstill or when it is in motion.

The Motion Control instruction offers you the following:

- Defining gear ratio (Page 95)
- Specify gear ratio once or dynamically (Page 96)
- Defining position control of the following axis (Page 97)
- Synchronizing following axis using dynamic parameters (Page 99)
- Synchronous travel in velocity synchronous operation (Page 100)

Applies to

- Synchronous axis

Requirement

- The technology objects of the leading axis and the following axis have been configured correctly.
- The leading axis is a positioning axis, a synchronous axis, an external encoder or a leading axis proxy.
- The following axis is a synchronous axis.
- The leading axis is specified as possible leading axis in the configuration of the following axis under "Technology object > Configuration > Leading value interconnections".
- The following axis is enabled.
- The leading value is valid.

Override response

The override response for "MC_GearInVelocity" jobs is described in section "Override response V10: Synchronous operation jobs".

Disabling the following axis with "MC_Power.Enable" = FALSE aborts the synchronous operation in every status.

Disabling the leading axis with "MC_Power", in contrast, does not abort synchronous operation. The following axis follows the leading axis even during the braking ramp and after the leading axis is enabled again.

Homing jobs on the following axis are rejected in the non-position-controlled mode of the following axis. Active homing of the following axis with "MC_Home.Mode" = 3 or 5 aborts synchronous operation in every status.

Jobs for leading value or following value offset are rejected.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_GearInVelocity":

Parameter	Declaration	Data type	Default value	Description	
Master	INPUT	TO_PositioningAxis TO_SynchronousAxis TO_ExternalEncoder TO_LeadingAxisProxy	-	Leading axis technology object	
Slave	INPUT	TO_SynchronousAxis	-	Following axis technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
ContinuousUpdate	INPUT	BOOL	FALSE	Mode for specifying the gear ratio (Page 96)	
				TRUE	Specify gear ratio continuously
				FALSE	Specify gear ratio once at the start of the job with a positive edge
RatioNumerator	INPUT	DINT	1	Gear ratio numerator (Page 95) Permitted integer values: -2147483648 to 2147483647 (value 0 not permitted)	
RatioDenominator	INPUT	DINT	1	Gear ratio denominator (Page 95) Permitted integer values: 1 to 2147483647	
Acceleration	INPUT	LREAL	-1.0	Acceleration for the synchronization (Page 99)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration for the synchronization (Page 99)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted

Parameter	Declaration	Data type	Default value	Description	
Deceleration	INPUT	LREAL	-1.0	< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk for the synchronization (Page 99)	
				> 0.0	The specified value is used.
				= 0.0	No jerk limitation
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Jerk)
PositionControlled	INPUT	BOOL	FALSE	Position control of the following axis (Page 97)	
				TRUE	Position-controlled mode
				FALSE	Non-position-controlled operation
StartSync	OUTPUT	BOOL	FALSE	TRUE	The following axis is synchronized to the leading axis.
InSync	OUTPUT	BOOL	FALSE	TRUE	Synchronous operation reached The following axis is synchronized and moves synchronously to the leading axis.
ContinuousUpdateActive	OUTPUT	BOOL	FALSE	TRUE	The gear ratio is transferred continuously. Changes of the parameter values "RatioNumerator" and "RatioDenominator" are effective immediately.
				FALSE	The gear ratio is transferred once at the start of the job with a positive edge.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

13.1.3.2 MC_GearInVelocity: Function chart V10

Function chart: Synchronization and adjustment of the gear ratio

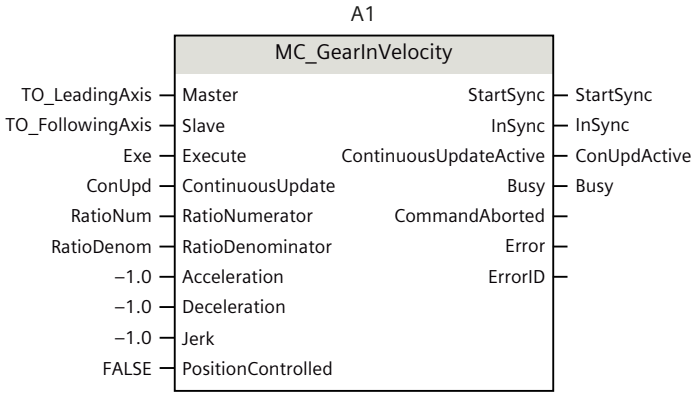

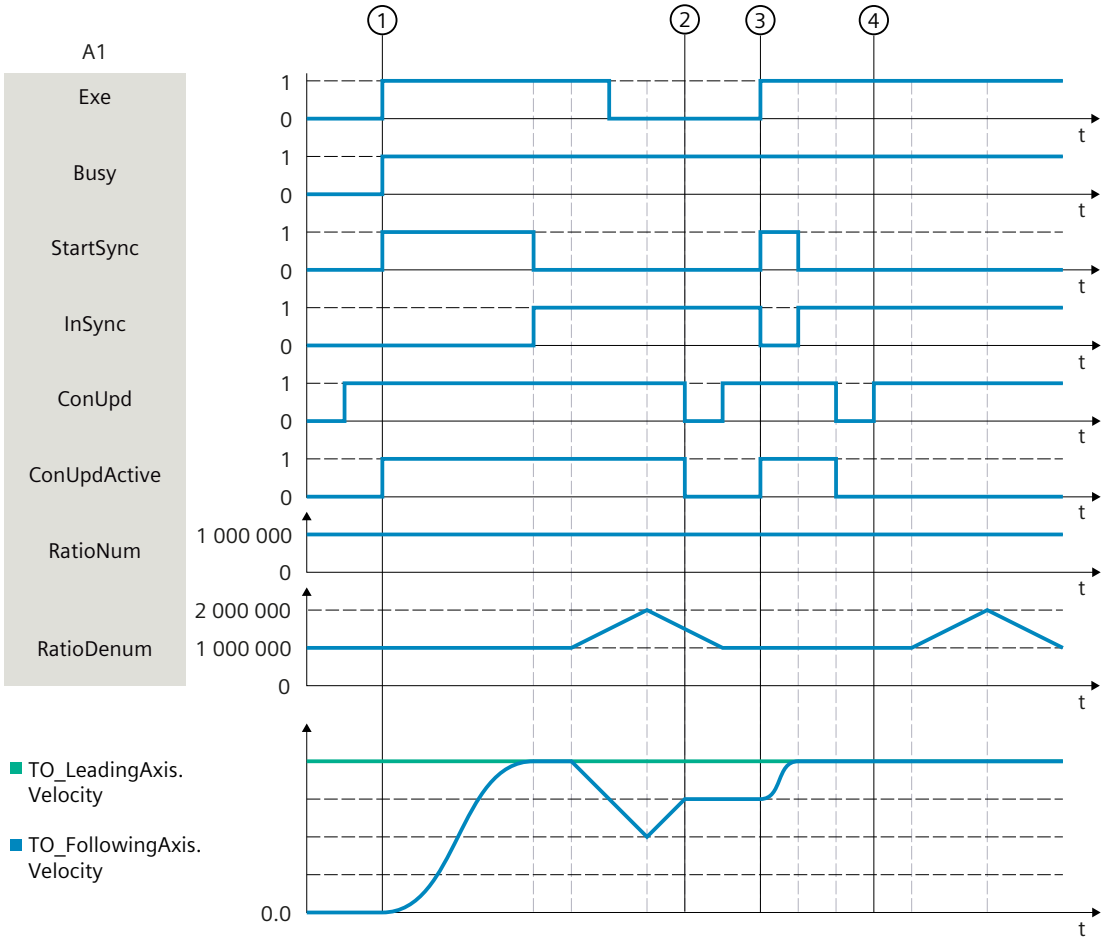

At time ①, an "MC_GearInVelocity" job (A1) with "ContinuousUpdate" = TRUE is initiated via "Exe". The start of the synchronization is displayed with "StartSync". The following axis (TO_FollowingAxis) is synchronized to the leading axis (TO_LeadingAxis) by means of the specified dynamic parameters. When reaching the velocity of the leading axis multiplied by

the specified gear ratio, "InSync" signals that the following axis is synchronized and moving synchronously to the leading axis.

The denominator of the gear ratio is changed continuously after that. Because "ContinuousUpdateActive" = TRUE, the velocity of the following axis changes immediately.

At time ②, "ContinuousUpdate" is set to FALSE. "ContinuousUpdateActive" = FALSE is displayed. The gear ratio specified last is still valid. The changes of the gear ratio are no longer effective.

"ContinuousUpdate" is once again set to TRUE. For this change to become effective, job A1 is once again triggered with "Exe" at time ③. "ContinuousUpdateActive" = TRUE is displayed. The renewed synchronization of the following axis is displayed via "StartSync".

"ContinuousUpdate" is reset to FALSE. At time ④, "ContinuousUpdate" is once again set to TRUE. Because job A1 is not triggered again via "Exe", the changes of the gear ratio are not taken into account.

13.1.4 MC_PhasingRelative V10

13.1.4.1 MC_PhasingRelative: Relative shift of leading value on the following axis V10

Description

With the Motion Control instruction "MC_PhasingRelative", you offset the effective leading value relative on a following axis. A relative leading value offset is added to an already existing leading value offset. A relative leading value offset is possible in gearing with "MC_GearIn" or "MC_GearInPos" or in camming with "MC_CamIn". The position of the leading axis is not affected. A simultaneous following value offset is not permitted.

Gearing

The Motion Control instruction offers you the following in gearing:

- Shift leading value on the following axis
  - Using dynamic parameters (Page 72)
  - Leading value offset using leading value distance starting at current leading value position (Page 74)
  - Using leading value distance starting at specific leading value position (Page 75)
- Defining the direction of the leading value distance (Page 77)
- Canceling a pending leading value offset (Page 78)

Camming

The Motion Control instruction offers you the following in camming:

- Shift leading value on the following axis
  - Leading value offset using leading value distance starting at current leading value position (Page 183)
  - Using leading value distance starting at specific leading value position (Page 184)
- Defining the direction of the leading value distance (Page 185)
- Canceling a pending leading value offset (Page 187)

Applies to

- Synchronous axis

Requirement

- The technology objects of the leading axis and the following axis have been configured correctly.
- The leading axis is a positioning axis, a synchronous axis, an external encoder or a leading axis proxy.
- The following axis is a synchronous axis.
- The leading axis is specified as possible leading axis in the configuration of the following axis in "Technology object > Configuration > Leading value interconnections".
- The following axis is enabled.
- By means of the Motion Control instruction "MC_GearIn", "MC_GearInPos" or "MC_CamIn", the following axis is synchronized to the leading axis ("MC_GearIn.InGear" = TRUE, "MC_GearInPos.InSync" = TRUE or "MC_CamIn.InSync" = TRUE).
- No "MC_OffsetAbsolute" or "MC_OffsetRelative" job is active or waiting.

Override response

The override response for "MC_PhasingRelative" jobs is described in section "Override response V10: Synchronous operation jobs".

Disabling the leading axis with "MC_Power.Enable" = FALSE does not abort the leading value offset. The following axis follows the leading axis even during the braking ramp and after the leading axis is enabled again.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_PhasingRelative":

Parameters	Declaration	Data type	Default value	Description	
Master	INPUT	TO_PositioningAxis TO_SynchronousAxis TO_ExternalEncoder TO_LeadingAxisProxy	-	Leading axis technology object	
Slave	INPUT	TO_SynchronousAxis	-	Following axis technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
PhaseShift	INPUT	LREAL	0.0	Relative leading value offset	
Velocity	INPUT	LREAL	-1.0	Velocity of the following axis during leading value offset (added to synchronous operation motion)	
				> 0.0	The specified value is used.

Parameters	Declaration	Data type	Default value	Description	
Velocity	INPUT	LREAL	-1.0	= 0.0	Not permitted
				< 0.0	The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Velocity)
Acceleration	INPUT	LREAL	-1.0	Acceleration of the following axis during leading value offset (added to synchronous operation motion)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration of the following axis during leading value offset (added to synchronous operation motion)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk of the following axis during leading value offset (added to synchronous operation motion)	
				> 0.0	Constant acceleration velocity profile The specified value is used.
				= 0.0	Trapezoid velocity profile
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Jerk)
ProfileReference	INPUT	DINT	0	Type of the leading value offset	
				0	Only with gearing: Leading value offset using dynamic parameters
				1	Leading value offset using leading value distance as of current leading value position
				2	Leading value offset using leading value distance as of leading value position "StartPosition"
				3 ... 4	Reserved

Parameters	Declaration	Data type	Default value	Description	
ProfileReference	INPUT	DINT	0	5	Cancel pending job for leading value offset
PhasingDistance	INPUT	LREAL	0.0	When "ProfileReference" = 1, 2: Leading value distance Distance of the leading axis during leading value offset	
StartPosition	INPUT	LREAL	0.0	When "ProfileReference" = 2: Leading value position as of which the leading value is offset	
Direction	INPUT	DINT	3	When "ProfileReference" = 1, 2: Direction of the leading value distance	
				1	The leading value distance is in the positive direction of motion of the leading value.
				2	The leading value distance is in the negative direction of motion of the leading value.
				3	The leading value distance is in the current direction of motion of the leading value.
Done	OUTPUT	BOOL	FALSE	TRUE	The leading value offset is finished.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	0	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
CoveredPhaseShift	OUTPUT	LREAL	0.0	Display of the absolute leading value share that has already been offset	
StartPhasing	OUTPUT	BOOL	FALSE	TRUE	The following axis offsets the effective leading value.

13.1.4.2 MC_PhasingRelative: Function chart V10

Function chart: Relative shift of the leading value in gearing

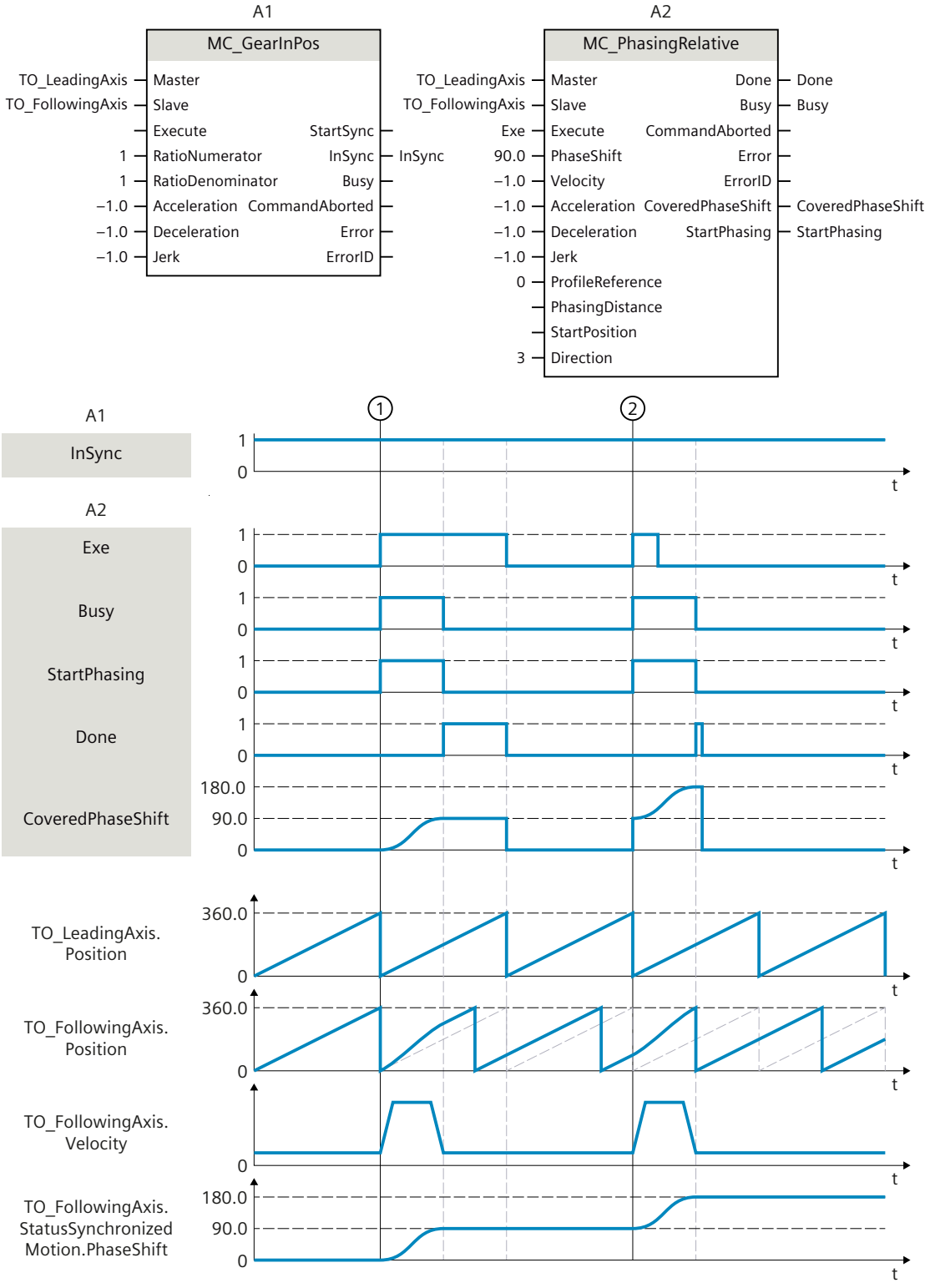

At time ①, an "MC_PhasingRelative" job (A2) is initiated with "ProfileReference" = 0 via "Exe" during an active gearing with "MC_GearInPos" (A1) . The "StartPhasing" parameter shows that the following axis traverses the leading value offset with the dynamics specified additively to the synchronous operation motion. The absolute leading value offset traversed via the job is indicated in "CoveredPhaseShift". "Done" indicates that the leading value was successfully shifted. The motion of the leading axis is not affected.

At time ② the "MC_PhasingRelative" job (A2) is initiated again via "Exe". The leading value offset via dynamic parameters is moved out again with the dynamics specified in addition to the synchronous movement. The absolute leading value offset traversed via the job is indicated in "CoveredPhaseShift". "Done" indicates that the leading value was successfully shifted.

The absolute leading value offset is indicated in the "<TO>.StatusSynchronizedMotion.PhaseShift" tag of the technology object.

Function chart: Relative shift of the leading value in camming

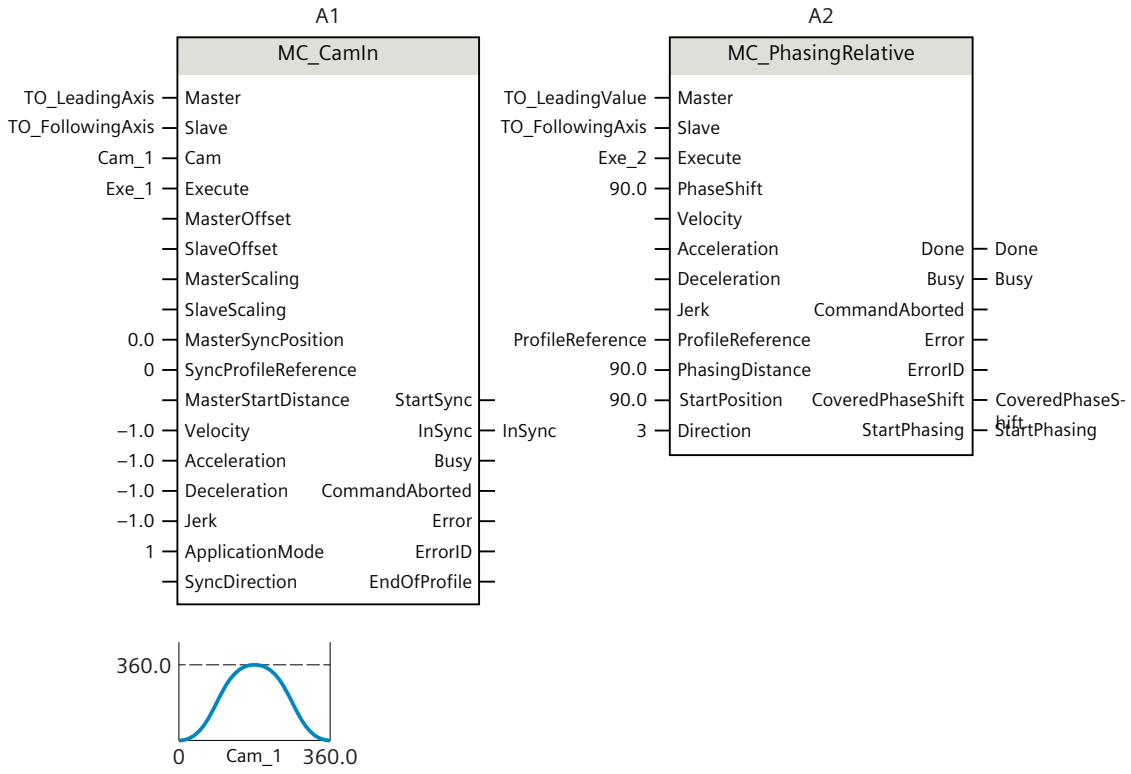

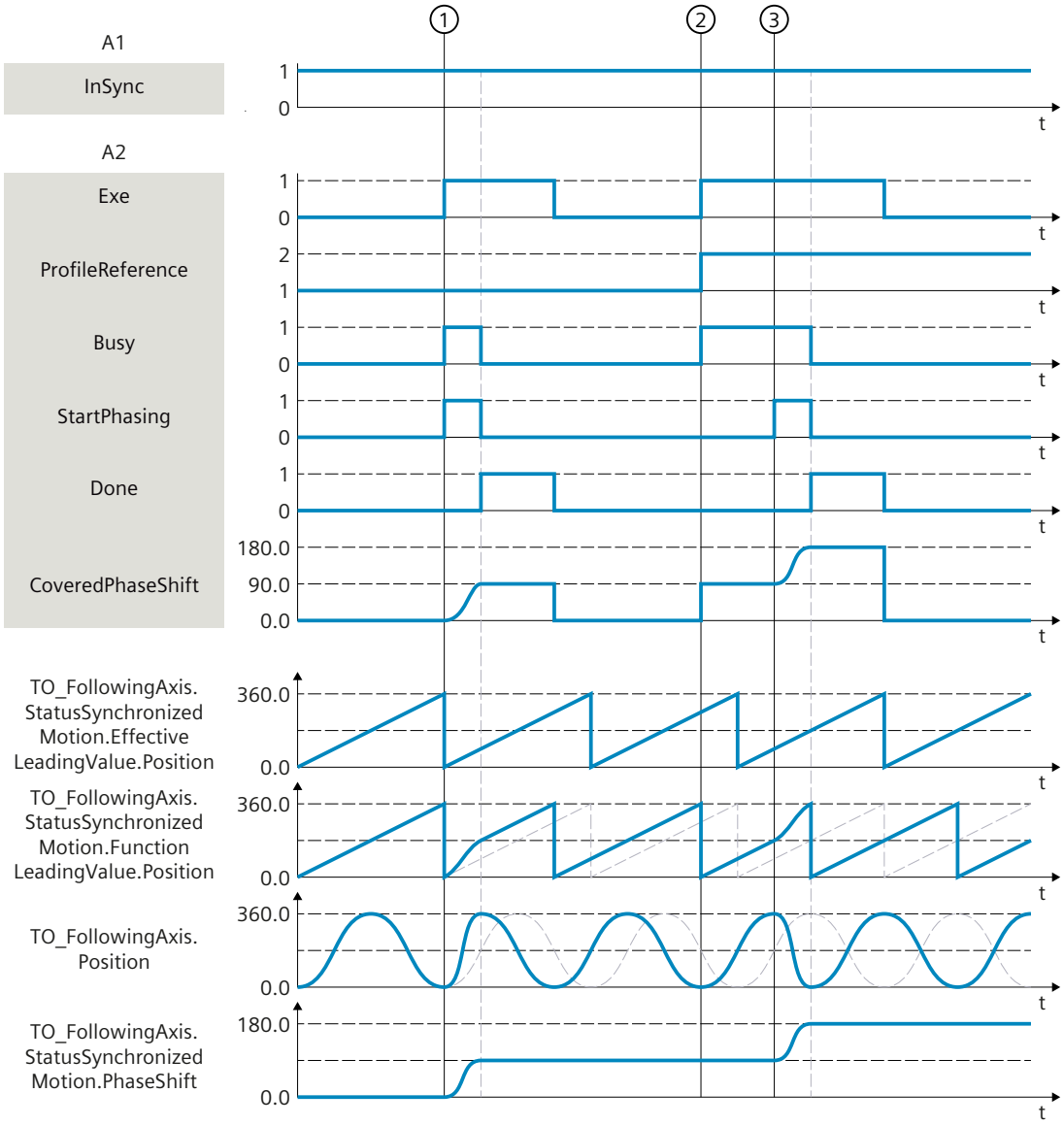

At time ①, an "MC_PhasingRelative" job (A2) is triggered with "ProfileReference" = 1 via "Exe" during an active camming with "MC_CamIn" (A1) . The "StartPhasing" parameter shows that the leading value offset traverses from the current position via the specified leading value distance. The required dynamic response is calculated by the system. The absolute leading value offset traversed via the job is indicated in "CoveredPhaseShift". "Done" indicates that the leading value was successfully shifted. The motion of the leading axis is not affected.

At time ② the "MC_PhasingRelative" job (A2) is initiated again via "Exe" with "ProfileReference" = 2. The status "Waiting" is displayed at the following axis until the leading value reaches the start position (<TO>.StatusWord2.X3 = TRUE (PhasingCommandWaiting)).

At time ③ the leading value reaches the specified start position. The "StartPhasing" parameter shows that the following axis traverses the leading value offset via the specified leading value distance. The required dynamic response is calculated by the system. The absolute leading value offset traversed via the job is indicated in "CoveredPhaseShift". "Done" indicates that the leading value was successfully shifted.

The absolute leading value offset is indicated in the "<TO>.StatusSynchronizedMotion.PhaseShift" tag of the technology object.

13.1.5 MC_PhasingAbsolute V10

13.1.5.1 MC_PhasingAbsolute: Absolute shift of leading value on the following axis V10

Description

With the Motion Control instruction "MC_PhasingAbsolute", you perform an absolute shift of the effective leading value on the following axis. An absolute leading value offset is possible in gearing with "MC_GearIn" or "MC_GearInPos" or in camming with "MC_CamIn". The position of the leading axis is not affected by this. A simultaneous following value offset is not permitted.

Gearing

The Motion Control instruction offers you the following in gearing:

- Shift leading value on the following axis
  - Using dynamic parameters (Page 72)
  - Leading value offset using leading value distance starting at current leading value position (Page 74)
  - Using leading value distance starting at specific leading value position (Page 75)
- Defining the direction of the leading value distance (Page 77)
- Canceling a pending leading value offset (Page 78)

Camming

The Motion Control instruction offers you the following in camming:

- Shift leading value on the following axis
  - Leading value offset using leading value distance starting at current leading value position (Page 183)
  - Using leading value distance starting at specific leading value position (Page 184)
- Defining the direction of the leading value distance (Page 185)
- Canceling a pending leading value offset (Page 187)

Applies to

- Synchronous axis

Requirement

- The technology objects of the leading axis and the following axis have been configured correctly.
- The leading axis is a positioning axis, a synchronous axis, an external encoder or a leading axis proxy.
- The following axis is a synchronous axis.
- The leading axis is specified as possible leading axis in the configuration of the following axis in "Technology object > Configuration > Leading value interconnections".
- The following axis is enabled.
- By means of the Motion Control instruction "MC_GearIn", "MC_GearInPos" or "MC_CamIn", the following axis is synchronized to the leading axis ("MC_GearIn.InGear" = TRUE, "MC_GearInPos.InSync" = TRUE or "MC_CamIn.InSync" = TRUE).
- No "MC_OffsetAbsolute" or "MC_OffsetRelative" job is active or waiting.

Override response

The override response for "MC_PhasingAbsolute" jobs is described in section "Override response V10: Synchronous operation jobs".

Disabling the leading axis with "MC_Power.Enable" = FALSE does not abort the leading value offset. The following axis follows the leading axis even during the braking ramp and after the leading axis is enabled again.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_PhasingAbsolute":

Parameters	Declaration	Data type	Default value	Description	
Master	INPUT	TO_PositioningAxis TO_SynchronousAxis TO_ExternalEncoder TO_LeadingAxisProxy	-	Leading axis technology object	
Slave	INPUT	TO_SynchronousAxis	-	Following axis technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
PhaseShift	INPUT	LREAL	0.0	Absolute leading value offset	
Velocity	INPUT	LREAL	-1.0	Velocity of the following axis during leading value offset (added to synchronous operation motion)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Velocity)

Parameters	Declaration	Data type	Default value	Description	
Acceleration	INPUT	LREAL	-1.0	Acceleration of the following axis during leading value offset (added to synchronous operation motion)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration of the following axis during leading value offset (added to synchronous operation motion)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk of the following axis during leading value offset (added to synchronous operation motion)	
				> 0.0	Constant acceleration velocity profile The specified value is used.
				= 0.0	Trapezoid velocity profile
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Jerk)
ProfileReference	INPUT	DINT	0	Type of the leading value offset	
				0	Only with gearing: Leading value offset using dynamic parameters
				1	Leading value offset using leading value distance as of current leading value position
				2	Leading value offset using leading value distance as of leading value position "StartPosition"
				3 ... 4	Not permitted
				5	Cancel pending job for leading value offset
PhasingDistance	INPUT	LREAL	0.0	When "ProfileReference" = 1, 2: Leading value distance Distance of the leading axis during leading value offset	

Parameters	Declaration	Data type	Default value	Description	
StartPosition	INPUT	LREAL	0.0	When "ProfileReference" = 2: Leading value position as of which the leading value is offset	
Direction	INPUT	DINT	3	When "ProfileReference" = 1, 2: Direction of the leading value distance	
				1	The leading value distance is in the positive direction of motion of the leading value.
				2	The leading value distance is in the negative direction of motion of the leading value.
				3	The leading value distance is in the current direction of motion of the leading value.
Done	OUTPUT	BOOL	FALSE	TRUE	The leading value offset is finished.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	0	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
AbsolutePhaseShift	OUTPUT	LREAL	0.0	Display of the absolute leading value share that has already been offset	
StartPhasing	OUTPUT	BOOL	FALSE	TRUE	The following axis offsets the effective leading value.

13.1.5.2 MC_PhasingAbsolute: Function chart V10

Function chart: Absolute shift of the leading value in gearing

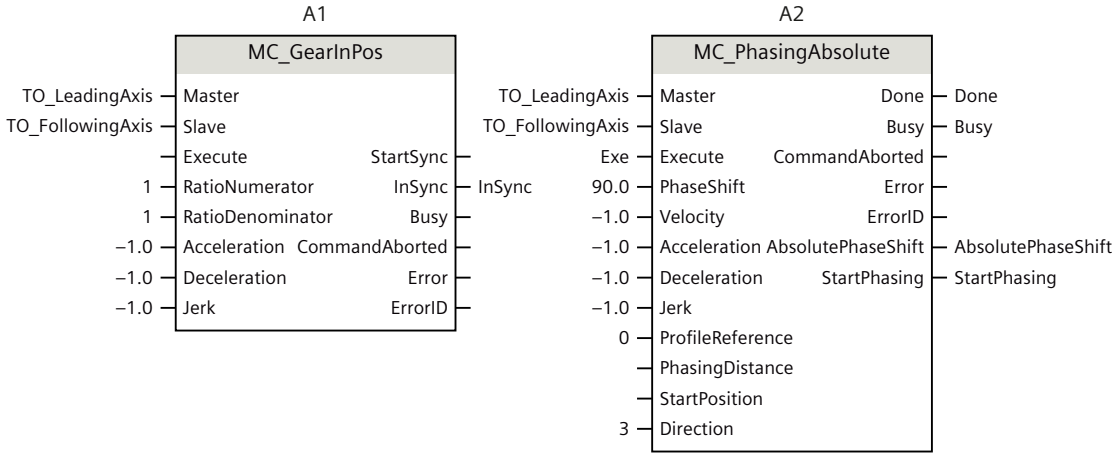

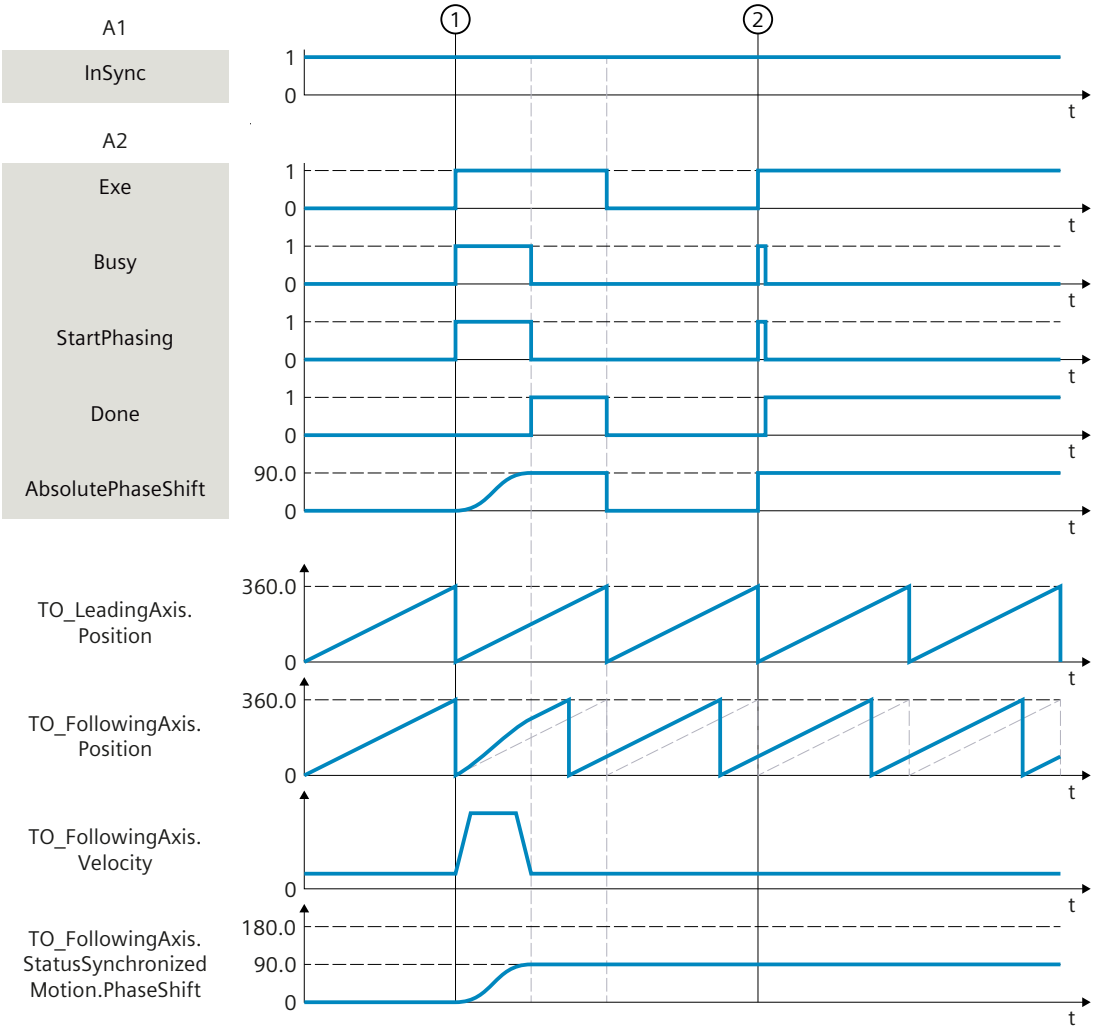

At time ①, an "MC_PhasingAbsolute" job (A2) is initiated with "ProfileReference" = 0 via "Exe" during an active gearing with "MC_GearInPos" (A1). The "StartPhasing" parameter shows that the following axis traverses the leading value offset with the dynamics specified additively to the synchronous operation motion. The absolute leading value offset traversed via the job is indicated in "AbsolutePhaseShift". "Done" indicates that the leading value was successfully shifted. The motion of the leading axis is not affected.

At time ② the "MC_PhasingAbsolute" job (A2) is initiated again via "Exe". Because the absolute leading value offset (<TO>.StatusSynchronizedMotion.PhaseShift) is already 90.0, the leading value is not shifted.

The absolute leading value offset is indicated in the "<TO>.StatusSynchronizedMotion.PhaseShift" tag of the technology object.

Function chart: Absolute shift of the leading value in camming

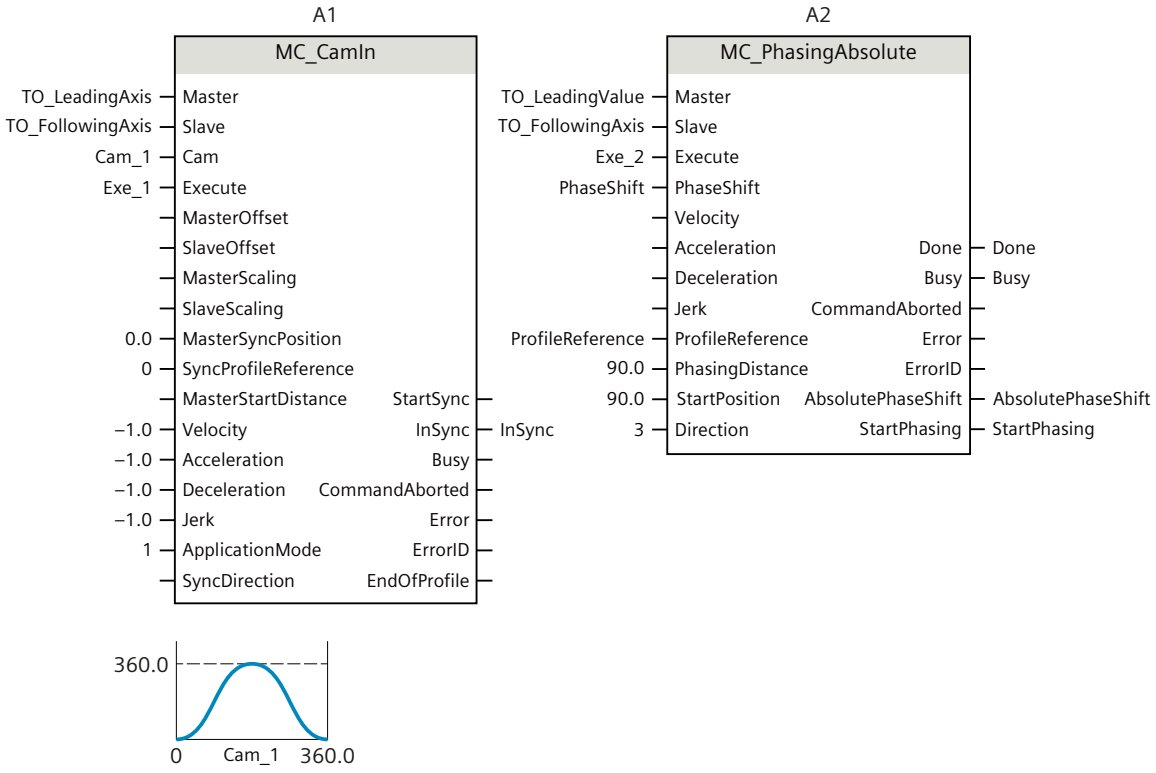

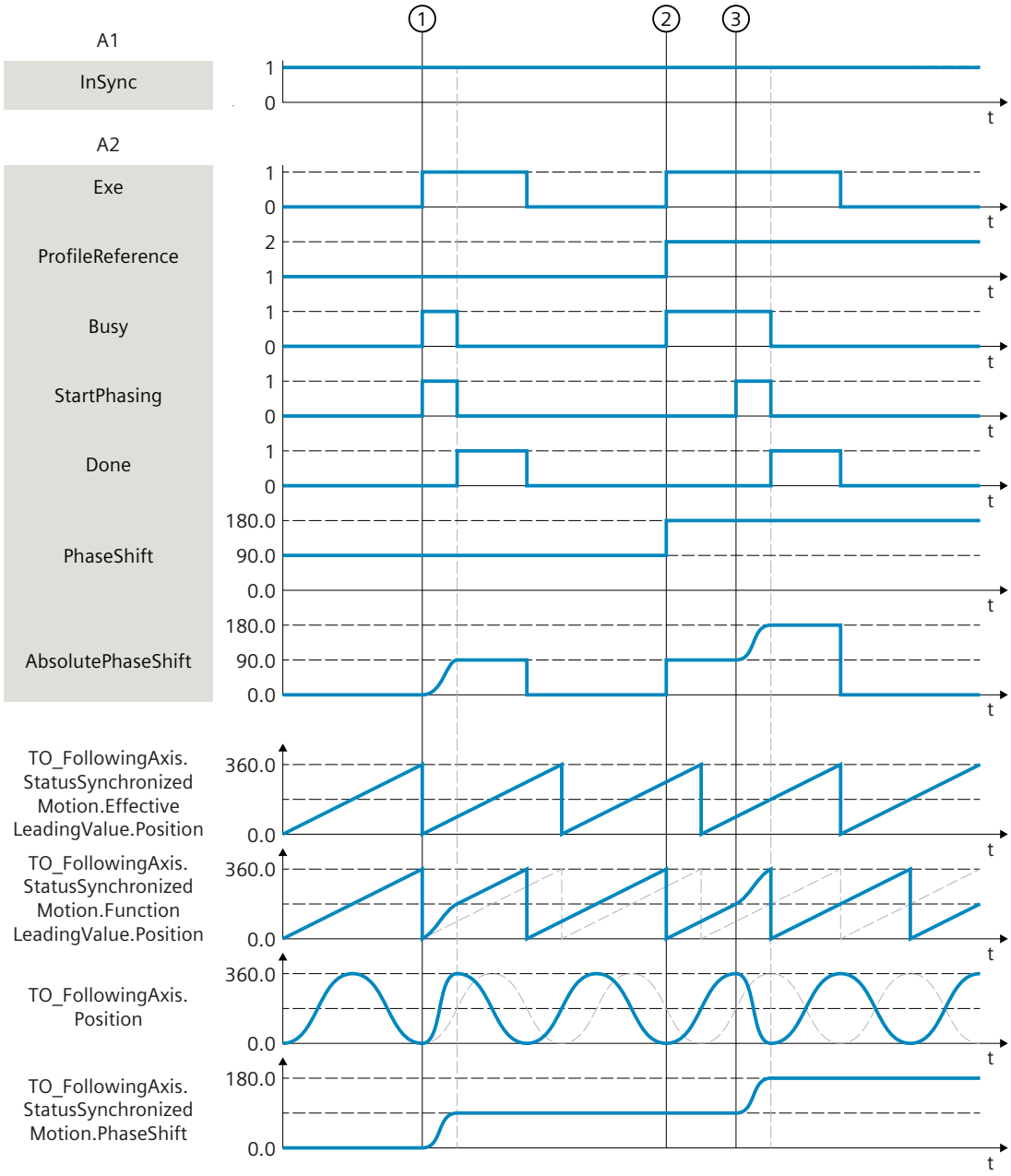

At time ①, an "MC_PhasingAbsolute" job (A2) is triggered with "ProfileReference" = 1 via "Exe" during an active camming with "MC_CamIn" (A1) . The "StartPhasing" parameter shows that the leading value offset traverses from the current position via the specified leading value distance. The required dynamic response is calculated by the system. The absolute leading value offset traversed via the job is indicated in "AbsolutePhaseShift". "Done" indicates that the leading value was successfully shifted. The motion of the leading axis is not affected.

At time ② the "MC_PhasingAbsolute" job (A2) is initiated again via "Exe" with "ProfileReference" = 2. The status "Waiting" is displayed at the following axis until the leading value reaches the start position (<TO>.StatusWord2.X3 = TRUE (PhasingCommandWaiting)).

At time ③ the leading value reaches the specified start position. The "StartPhasing" parameter shows that the following axis traverses the leading value offset via the specified

leading value distance. The required dynamic response is calculated by the system. The absolute leading value offset traversed via the job is indicated in "AbsolutePhaseShift". "Done" indicates that the leading value was successfully shifted.

The absolute leading value offset is indicated in the "<TO>.StatusSynchronizedMotion.PhaseShift" tag of the technology object.

13.1.6 MC_OffsetRelative V10

13.1.6.1 MC_OffsetRelative: Relative shift of following value on the following axis V10

Description

With the Motion Control instruction "MC_OffsetRelative", you shift the following value on a following axis relative to the existing following value offset. A relative following value offset is possible in gearing with "MC_GearIn" or "MC_GearInPos" or in camming with "MC_CamIn". The position of the leading axis is not affected by this. A simultaneous leading value offset is not permitted.

Gearing

The Motion Control instruction offers you the following in gearing:

- Shift following value on the following axis:
  - Leading value offset using leading value distance starting at current leading value position (Page 79)
  - Using leading value distance starting at specific leading value position (Page 80)
- Defining the direction of the leading value distance (Page 82)
- Canceling a pending following value offset (Page 83)

Camming

The Motion Control instruction offers you the following in camming:

- Shift following value on the following axis:
  - Leading value offset using leading value distance starting at current leading value position (Page 188)
  - Using leading value distance starting at specific leading value position (Page 189)
- Defining the direction of the leading value distance (Page 191)
- Canceling a pending following value offset (Page 192)

Applies to

- Synchronous axis

Requirements

- The technology object of following axis has been configured correctly.
- The following axis is a synchronous axis.
- The following axis is enabled.
- By means of the Motion Control instruction "MC_GearIn", "MC_GearInPos" or "MC_CamIn", the following axis is synchronized to the leading axis ("MC_GearIn.InGear" = TRUE, "MC_GearInPos.InSync" = TRUE or "MC_CamIn.InSync" = TRUE).
- No "MC_PhasingAbsolute" or "MC_PhasingRelative" job is active or waiting.

Override response

The override response for "MC_OffsetRelative" jobs is described in section "Override response V10: Synchronous operation jobs".

Parameter

The following table shows the parameters of the Motion Control instruction "MC_OffsetRelative":

Parameter	Declaration	Data type	Default value	Description	
Slave	INPUT	TO_SynchronousAxis	-	Following axis technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Offset	INPUT	LREAL	0.0	Relative following value offset	
ProfileReference	INPUT	DINT	1	Type of the following value offset	
				0	Reserved
				1	Following value offset using leading value distance as of current effective leading value position
				2	Following value offset using leading value distance as of effective leading value position "StartPosition"
				3 ... 4	Reserved
				5	Cancel pending job for following value offset
OffsetDistance	INPUT	LREAL	0.0	When "ProfileReference" = 1, 2: Leading value distance Effective leading value distance during following value offset	
StartPosition	INPUT	LREAL	0.0	When "ProfileReference" = 2: Effective leading value position as of which the following value is offset	
Direction	INPUT	DINT	3	When "ProfileReference" = 1, 2: Direction of the leading value distance	

Parameter	Declaration	Data type	Default value	Description	
Direction	INPUT	DINT	3	1	The leading value distance is in the positive direction of motion of the effective leading value.
				2	The leading value distance is in the negative direction of motion of the effective leading value.
				3	The leading value distance is in the current direction of motion of the effective leading value.
Done	OUTPUT	BOOL	FALSE	TRUE	The leading value offset is finished.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	0	Error ID for the parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
CoveredOffset	OUTPUT	LREAL	0.0	Display of the absolute following value share that has already been offset	
StartOffset	OUTPUT	BOOL	FALSE	TRUE	The following axis offsets the following value.

13.1.6.2 MC_OffsetRelative: Function chart V10

Function chart: Relative shift of the following value in gearing

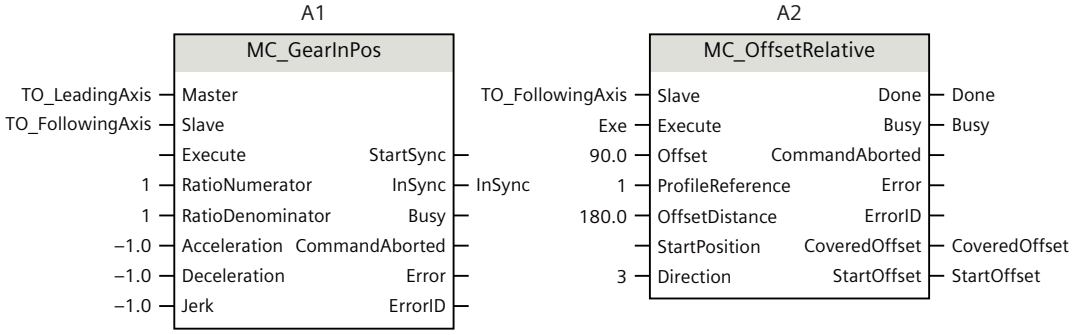

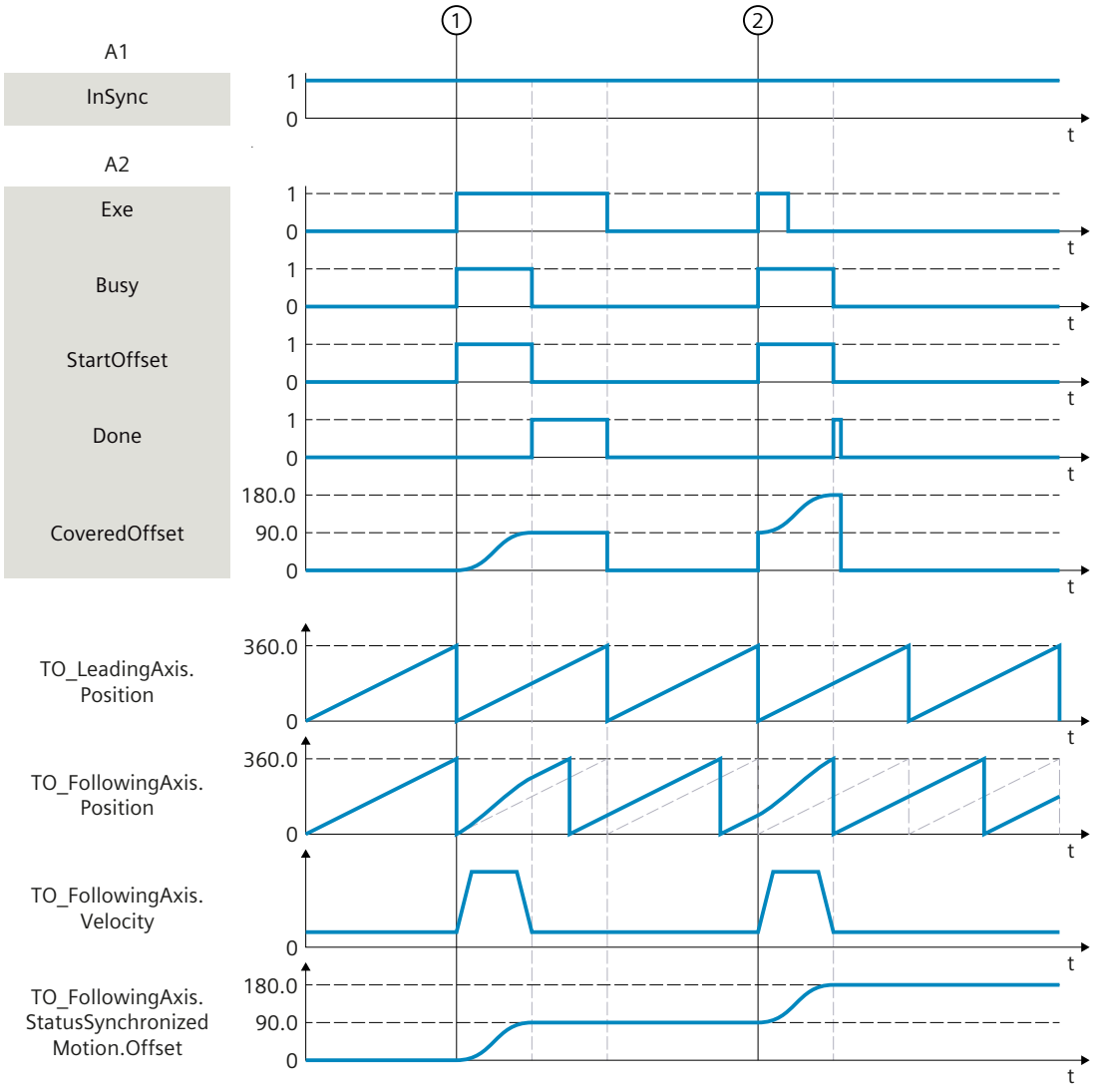

At time ①, an "MC_OffsetRelative" job (A2) is initiated with "ProfileReference" = 1 via "Exe" during an active gearing with "MC_GearInPos" (A1). The "StartOffset" parameter shows that the following axis traverses the following value offset from the current position via the specified leading value distance. The required dynamic response is calculated by the system. The absolute following value offset traversed via the job is indicated In "CoveredOffset". "Done" indicates that the following value was successfully shifted. The motion of the leading axis is not affected.

At time ② the "MC_OffsetRelative" job (A2) is initiated again via "Exe". The "StartOffset" parameter shows that the following axis traverses the following value offset via the specified leading value distance. The required dynamic response is calculated by the system. The absolute following value offset traversed via the job is indicated In "CoveredOffset". "Done" indicates that the following value was successfully shifted.

The absolute following value offset is indicated in the "<TO>.StatusSynchronizedMotion.Offset" tag of the technology object.

Function chart: Relative shift of the following value in camming

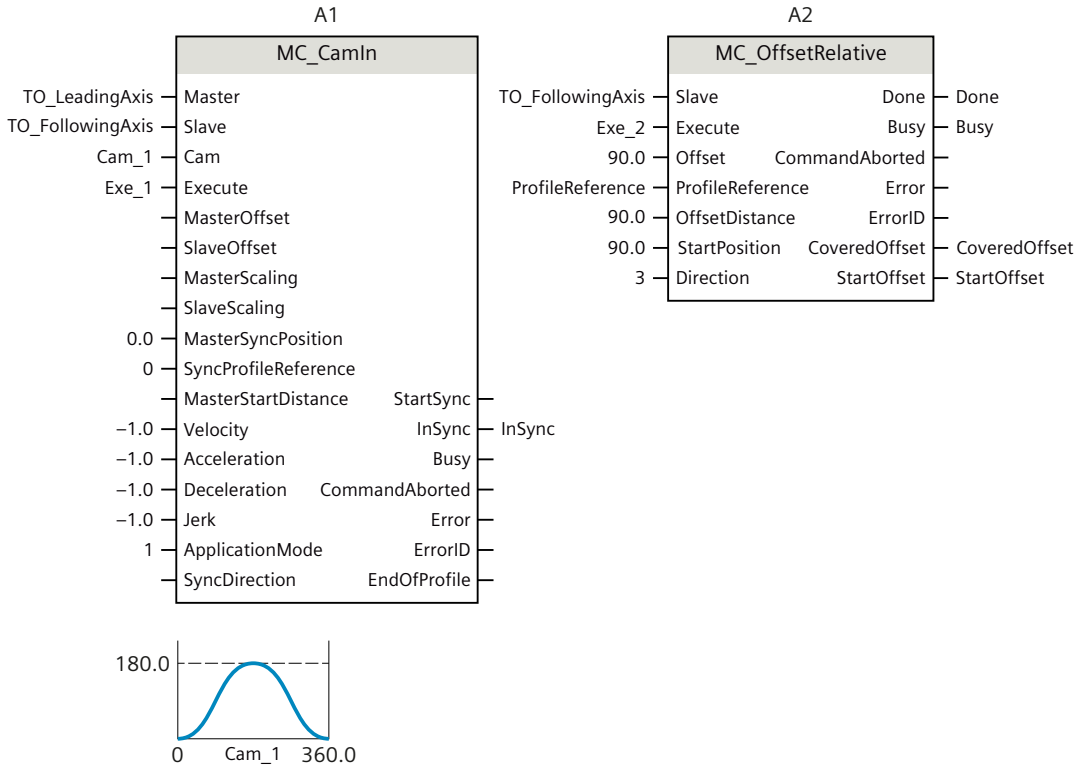

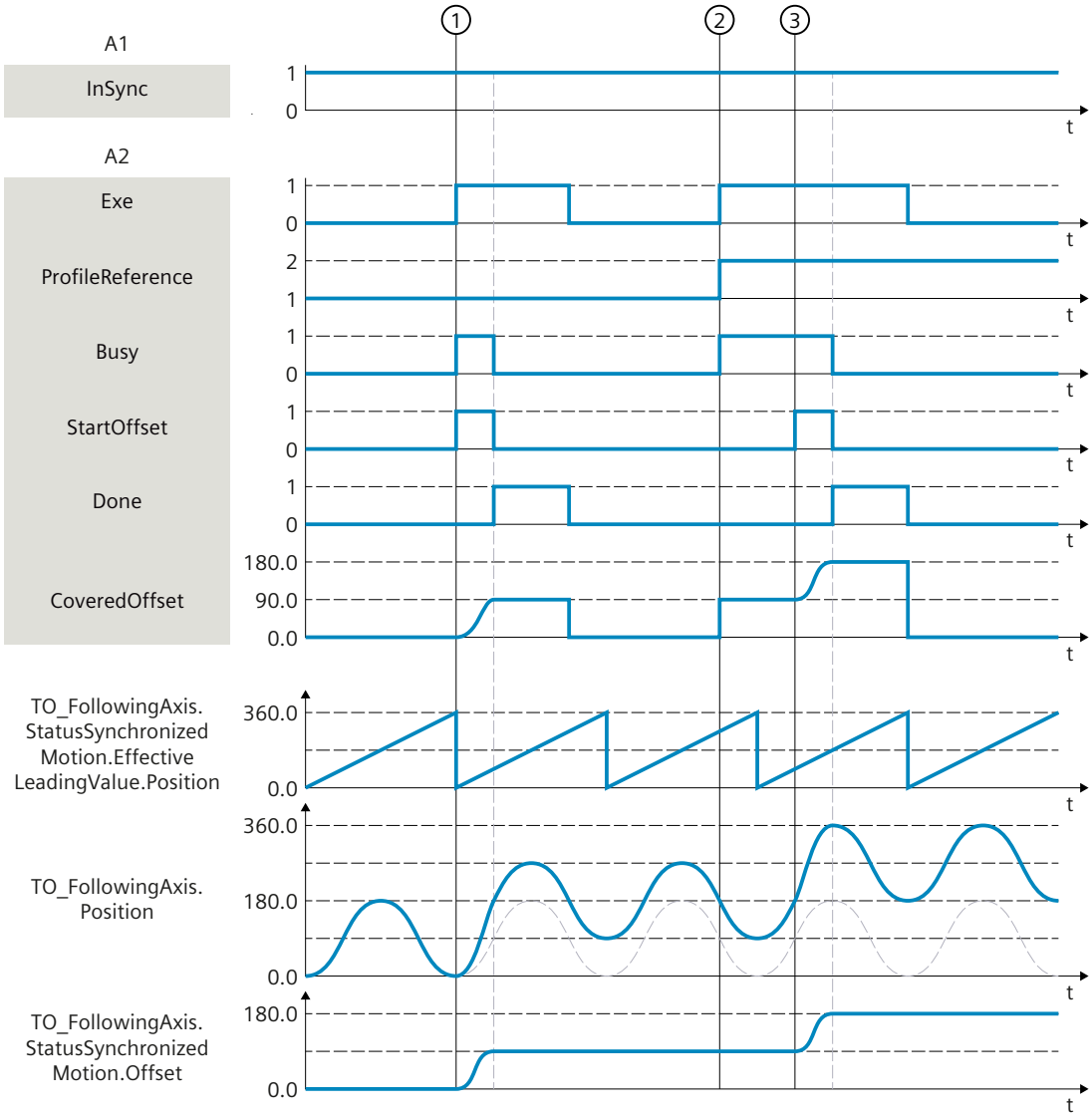

At time ①, an "MC_OffsetRelative" job (A2) is triggered with "ProfileReference" = 1 via "Exe" during an active camming with "MC_CamIn" (A1) . The "StartOffset" parameter shows that the following axis traverses the following value offset from the current position via the specified leading value distance. The required dynamic response is calculated by the system. The absolute following value offset traversed via the job is indicated In "CoveredOffset". "Done" indicates that the following value was successfully shifted. The motion of the leading axis is not affected.

At time ② the "MC_OffsetRelative" job (A2) is initiated again via "Exe" with "ProfileReference" = 2. The status "Waiting" is displayed at the following axis until the leading value reaches the start position (<TO>.StatusWord2.X5 = TRUE (OffsetCommandWaiting)).

At time ③ the leading value reaches the specified start position. The "StartOffset" parameter shows that the following axis traverses the following value offset via the specified leading value distance. The required dynamic response is calculated by the system. The absolute following value offset traversed via the job is indicated In "CoveredOffset". "Done" indicates that the leading value was successfully shifted.

The absolute following value offset is indicated in the "<TO>.StatusSynchronizedMotion.Offset" tag of the technology object.

13.1.7 MC_OffsetAbsolute V10

13.1.7.1 MC_OffsetAbsolute: Absolute shift of following value on the following axis V10

Description

With the Motion Control instruction "MC_OffsetAbsolute", you shift the following value on a following axis with an absolute offset. An absolute following value offset is possible in gearing with "MC_GearIn" or "MC_GearInPos" or in camming with "MC_CamIn". The position of the leading axis is not affected by this. A simultaneous leading value offset is not permitted.

Gearing

The Motion Control instruction offers you the following in gearing:

- Shift following value on the following axis:
  - Leading value offset using leading value distance starting at current leading value position (Page 79)
  - Using leading value distance starting at specific leading value position (Page 80)
- Defining the direction of the leading value distance (Page 82)
- Canceling a pending following value offset (Page 83)

Camming

The Motion Control instruction offers you the following in camming:

- Shift following value on the following axis:
  - Leading value offset using leading value distance starting at current leading value position (Page 188)
  - Using leading value distance starting at specific leading value position (Page 189)
- Defining the direction of the leading value distance (Page 191)
- Canceling a pending following value offset (Page 192)

Applies to

- Synchronous axis

Requirements

- The technology object of following axis has been configured correctly.
- The following axis is a synchronous axis.
- The following axis is enabled.
- By means of the Motion Control instruction "MC_GearIn", "MC_GearInPos" or "MC_CamIn", the following axis is synchronized to the leading axis ("MC_GearIn.InGear" = TRUE, "MC_GearInPos.InSync" = TRUE or "MC_CamIn.InSync" = TRUE).
- No "MC_PhasingAbsolute" or "MC_PhasingRelative" job is active or waiting.

Override response

The override response for "MC_OffsetAbsolute" jobs is described in section "Override response V10: Synchronous operation jobs".

Parameter

The following table shows the parameters of the Motion Control instruction "MC_OffsetAbsolute":

Parameter	Declaration	Data type	Default value	Description	
Slave	INPUT	TO_SynchronousAxis	-	Following axis technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Offset	INPUT	LREAL	0.0	Absolute following value offset	
ProfileReference	INPUT	DINT	1	Type of the following value offset	
				0	Reserved
				1	Following value offset using leading value distance as of current effective leading value position
				2	Following value offset using leading value distance as of effective leading value position "StartPosition"
				3 ... 4	Reserved
				5	Cancel pending job for following value offset
OffsetDistance	INPUT	LREAL	0.0	When "ProfileReference" = 1, 2: Leading value distance Effective leading value distance during following value offset	
StartPosition	INPUT	LREAL	0.0	When "ProfileReference" = 2: Effective leading value position as of which the following value is offset	
Direction	INPUT	DINT	3	When "ProfileReference" = 1, 2: Direction of the leading value distance	

Parameter	Declaration	Data type	Default value	Description	
Direction	INPUT	DINT	3	1	The leading value distance is in the positive direction of motion of the effective leading value.
				2	The leading value distance is in the negative direction of motion of the effective leading value.
				3	The leading value distance is in the current direction of motion of the effective leading value.
Done	OUTPUT	BOOL	FALSE	TRUE	The leading value offset is finished.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	0	Error ID for the parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
AbsoluteOffset	OUTPUT	LREAL	0.0	Display of the absolute following value share that has already been offset	
StartOffset	OUTPUT	BOOL	FALSE	TRUE	The following axis offsets the following value.

13.1.7.2 MC_OffsetAbsolute: Function chart V10

Function chart: Absolute shift of the following value in gearing

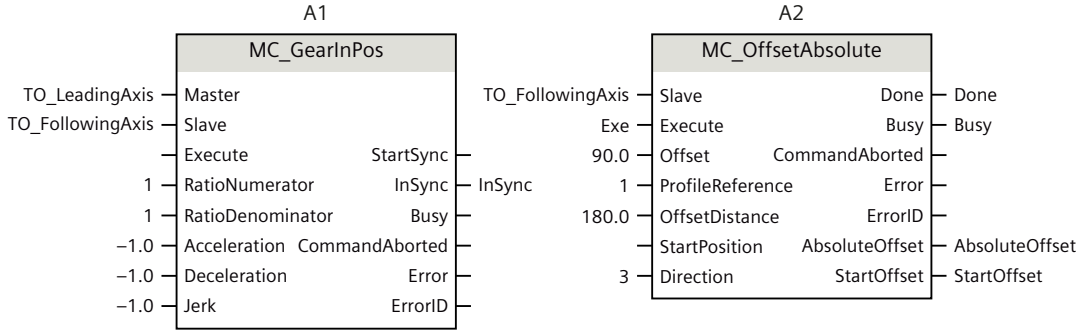

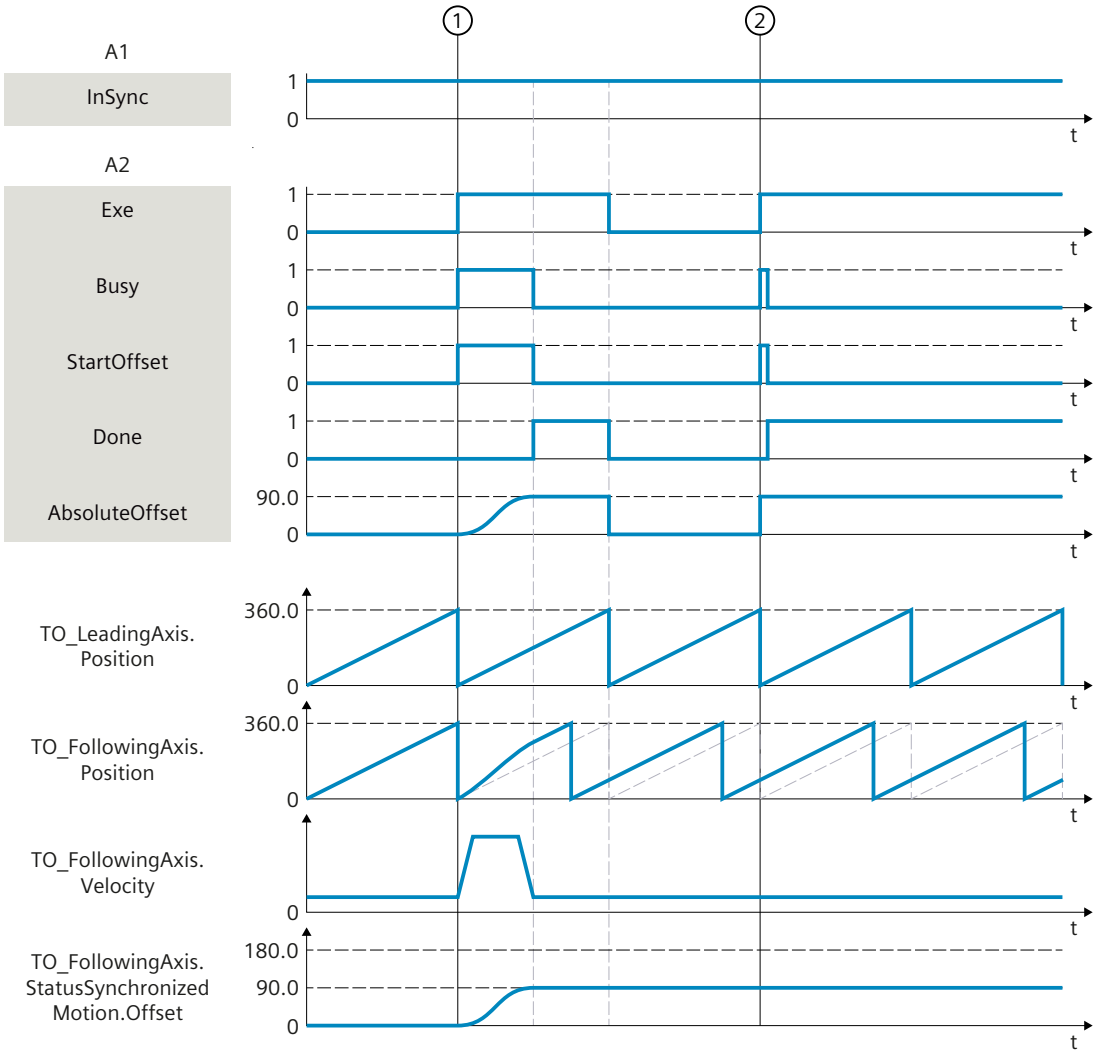

At time ①, an "MC_OffsetAbsolute" job (A2) is initiated with "ProfileReference" = 1 via "Exe" during an active gearing with "MC_GearInPos" (A1). The "StartOffset" parameter shows that the following axis traverses the following value offset from the current position via the specified leading value distance. The required dynamic response is calculated by the system. The absolute following value offset traversed via the job is indicated in "AbsoluteOffset". "Done" indicates that the following value was successfully shifted. The motion of the leading axis is not affected.

At time ② the "MC_OffsetAbsolute" job (A2) is initiated again via "Exe". Because the absolute following value offset (<TO>.StatusSynchronizedMotion.Offset) is already 90.0, the following value is not shifted.

The absolute following value offset is indicated in the "<TO>.StatusSynchronizedMotion.Offset" tag of the technology object.

Function chart: Absolute shift of the following value in camming

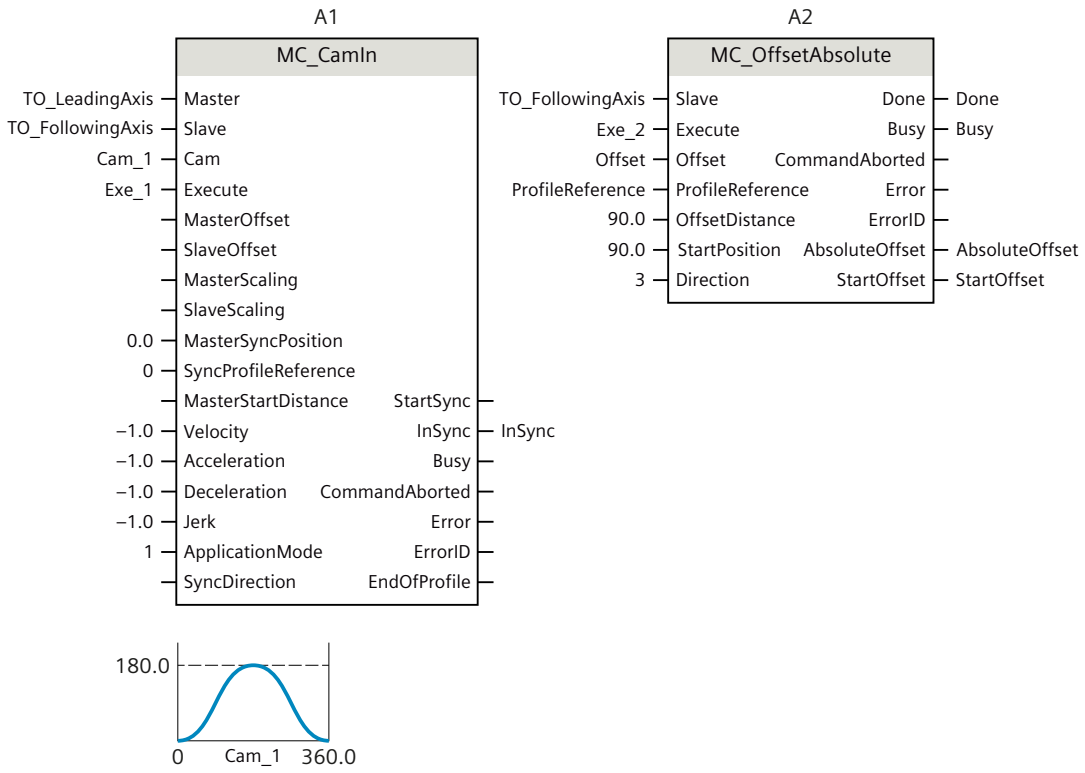

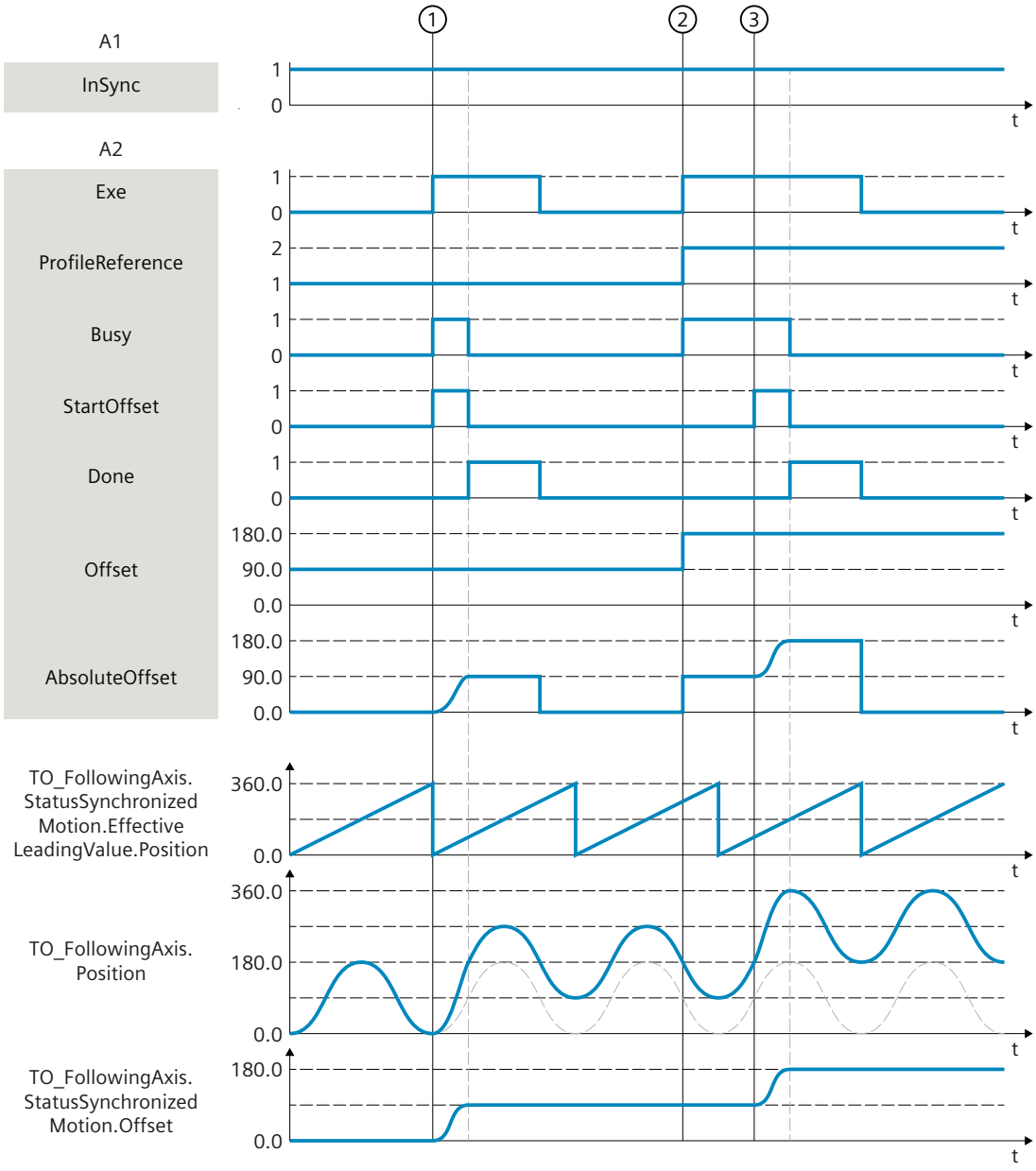

At time ①, an "MC_OffsetAbsolute" job (A2) is triggered with "ProfileReference" = 1 via "Exe" during an active camming with "MC_CamIn" (A1) . The "StartOffset" parameter shows that the following axis traverses the following value offset from the current position via the specified leading value distance. The required dynamic response is calculated by the system. The absolute following value offset traversed via the job is indicated in "AbsoluteOffset". "Done" indicates that the following value was successfully shifted. The motion of the leading axis is not affected.

At time ② the "MC_OffsetAbsolute" job (A2) is initiated again via "Exe" with "ProfileReference" = 2. The status "Waiting" is displayed at the following axis until the leading value reaches the start position (<TO>.StatusWord2.X5 = TRUE (OffsetCommandWaiting)).

At time ③ the leading value reaches the specified start position. The "StartOffset" parameter shows that the following axis traverses the following value offset via the specified leading

value distance. The required dynamic response is calculated by the system. The absolute following value offset traversed via the job is indicated in "AbsoluteOffset". "Done" indicates that the following value was successfully shifted.

The absolute following value offset is indicated in the "<TO>.StatusSynchronizedMotion.Offset" tag of the technology object.

13.1.8 MC_CamIn V10

13.1.8.1 MC_CamIn: Start camming V10

Description

With the Motion Control instruction "MC_CamIn", you start a camming (Page 102) operation between a leading axis and a following axis. The following axis is synchronized depending on the specified synchronous position of the leading axis.

The synchronous position of the leading axis and the corresponding position of the following axis from the cam represent the relationship of the two axes to one another. The synchronous position of the leading axis is determined by the following parameters:

- Start position of the cam (<TO_Cam>.StatusCam.StartLeadingValue)
- Scaling the leading values of the cam ("MasterScaling")
- Offset or location of the cam ("MasterOffset")
- Start point within the cam ("MasterSyncPosition")

The synchronous position is calculated as follows:

Synchronous position = (Start position of the cyclic cam x "MasterScaling") + "MasterOffset" + "MasterSyncPosition"

The start of movement of the following axis is defined depending on the selected synchronization mode.

The Motion Control instruction offers you the following:

- Scaling and shifting cam (Page 150)
- Defining application mode of the cam (Page 157)
- Defining direction of synchronization (Page 161)
- Define synchronous position and type of synchronization:
  - Synchronization in advance using dynamic parameters (Page 163)
  - Synchronization in advance using leading value distance (Page 164)
  - Synchronization in advance using leading value distance starting from current leading value position (Page 167)
  - Subsequent synchronization using leading value distance (Page 171)
  - Subsequent synchronization using leading value distance starting from current leading value position (Page 173)
  - Directly set the following axis synchronously (Page 175)

  - Directly set the following axis synchronously at end of the cam (Page 176)
  - Directly set the following axis synchronously at specific leading value position (Page 177)
- Synchronous travel in camming (Page 179)

Different parameters are relevant depending on the synchronization profile. You can find an overview in the "Parameter overview for synchronizing with "MC_CamIn" (Page 160)" section.

Applies to

- Cam
- Synchronous axis

Requirement

- The technology objects of the leading axis, following axis, and cam have been configured correctly.
- The leading axis is a positioning axis, a synchronous axis, an external encoder or a leading axis proxy.
- The following axis is a synchronous axis.
- The leading axis is specified as possible leading axis in the configuration of the following axis under "Technology object > Configuration > Leading value interconnections".
- The following axis is enabled.
- The following axis is homed.
- The cam is interpolated with "MC_InterpolateCam".
- With synchronization in advance using leading value distance, the leading axis must be at least the specified distance ("MasterStartDistance") from the synchronization position ("MasterSyncPosition") when starting the job.
- With direct synchronous setting at the end of the cam, camming must already be active ("InSync" = TRUE).

Override response

The override response for "MC_CamIn" jobs is described in section "Override response V10: Synchronous operation jobs".

With a "MC_CamOut" job, the following axis is desynchronized and synchronous operation is terminated.

Disabling the following axis with "MC_Power.Enable" = FALSE aborts the synchronous operation in every status.

Disabling the leading axis with "MC_Power", in contrast, does not abort synchronous operation. The following axis follows the leading axis even during the braking ramp and after the leading axis is enabled again.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_CamIn":

Parameter	Declaration	Data type	Default value	Description	
Master	INPUT	TO_PositioningAxis TO_SynchronousAxis TO_ExternalEncoder TO_LeadingAxisProxy	-	Leading axis technology object	
Slave	INPUT	TO_SynchronousAxis	-	Following axis technology object	
Cam	INPUT	TO_Cam TO_Cam_10k TO_Cam_600Seg TO_Cam_6kSeg	-	Cam technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
MasterOffset	INPUT	LREAL	0.0	When "SyncProfileReference" = 0, 1, 3, 4, 7: Offset of the leading values of the cam (Page 150) The cam technology object is not changed.	
				When "SyncProfileReference" = 2, 5, 6: Not relevant	
SlaveOffset	INPUT	LREAL	0.0	When "SyncProfileReference" = 0, 1, 3, 4, 6: Offset of the following values of the cam (Page 150) The cam technology object is not changed.	
				When "SyncProfileReference" = 2, 5, 7: Not relevant	
MasterScaling	INPUT	LREAL	1.0	Scaling of the leading values of the cam (Page 150) The cam technology object is not changed.	
				0.0	Not permitted
SlaveScaling	INPUT	LREAL	1.0	Scaling of the following values of the cam (Page 150) The cam technology object is not changed.	
MasterSyncPosition	INPUT	LREAL	0.0	Synchronous position of leading axis	
				When "SyncProfileReference" = 0, 1, 6: Position of the leading axis (relative to the start position of the cam), from which the axes are synchronous and synchronization is complete. The value must be within the definition of the cam.	
				When "SyncProfileReference" = 3: Position of the leading axis (relative to the start position of the cam) from which the synchronization begins The value must be within the definition of the cam.	
				When "SyncProfileReference" = 4: Not relevant	

Parameter	Declaration	Data type	Default value	Description	
MasterSyncPosition	INPUT	LREAL	0.0	When "SyncProfileReference" = 2, 5, 7: Position of the leading axis (relative to the start position of the cam to be changed), from which the axes are synchronous. The value must be within the definition of the cam to be changed.	
SyncProfileReference	INPUT	DINT	1	Synchronization profile	
				0	Synchronization in advance using dynamic parameters (Page 163)
				1	Synchronization in advance using leading value distance (Page 164)
				2	Direct synchronous setting (Page 175)
				3	Subsequent synchronization using leading value distance (Page 171)
				4	Subsequent synchronization using leading value distance starting from current leading value position (Page 173)
				5	Direct synchronous setting at the end of the cam (Page 176)
				6	Synchronization in advance using leading value distance starting from current leading value position (Page 167)
				7	Direct synchronous setting at specific leading value position (Page 177)
MasterStartDistance	INPUT	LREAL	0.0	When "SyncProfileReference" = 1, 3, 4, 6: Leading value distance Distance of the leading axis during the synchronization	
				> 0.0	The specified value is used.
				≤ 0.0	Not permitted
				When "SyncProfileReference" = 0, 2, 5, 7: Not relevant	
Velocity	INPUT	LREAL	-1.0	When "SyncProfileReference" = 0: Velocity	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Velocity)
				When "SyncProfileReference" = 1, 2, 3, 4, 5, 6, 7: Not relevant	
Acceleration	INPUT	LREAL	-1.0	When "SyncProfileReference" = 0: Acceleration	
				> 0.0	The specified value is used.

Parameter	Declaration	Data type	Default value	Description	
Acceleration	INPUT	LREAL	-1.0	= 0.0	Not permitted
				< 0.0	The acceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Acceleration)
				When "SyncProfileReference" = 1, 2, 3, 4, 5, 6, 7: Not relevant	
Deceleration	INPUT	LREAL	-1.0	When "SyncProfileReference" = 0: Deceleration	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Deceleration)
				When "SyncProfileReference" = 1, 2, 3, 4, 5, 6, 7: Not relevant	
Jerk	INPUT	LREAL	-1.0	When "SyncProfileReference" = 0: Jerk	
				> 0.0	Constant acceleration velocity profile The specified value is used.
				= 0.0	Trapezoid velocity profile
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Jerk)
				When "SyncProfileReference" = 1, 2, 3, 4, 5, 6, 7: Not relevant	
ApplicationMode	INPUT	DINT	0	Application of the cam (Page 157)	
				0	Once, non-cyclic
				1	Cyclic (absolute application on the following value side)
				2	Cyclic appending (continuously appending on the following value side)
SyncDirection	INPUT	DINT	3	When "SyncProfileReference" = 0, 1, 3, 4, 6: Direction of synchronization (Page 161) In effect for following axes with activated Modulo setting.	
				1	Positive direction The following axis may only travel in positive direction during synchronization.
				2	Negative direction The following axis may only travel in negative direction during synchronization.

Parameter	Declaration	Data type	Default value	Description	
SyncDirection	INPUT	DINT	3	3	Shortest distance Changes in direction are permitted for the following axis during synchronization.
				When "SyncProfileReference" = 2, 5, 7: Not relevant	
StartSync	OUTPUT	BOOL	FALSE	TRUE	The following axis is synchronized to the leading axis.
InSync	OUTPUT	BOOL	FALSE	TRUE	Synchronous operation reached The following axis is synchronized and moves synchronously to the leading axis.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
EndOfProfile	OUTPUT	BOOL	FALSE	TRUE	The end of the cam has been reached. Displayed for at least one call of "MC_CamIn" in the user program when the cam is used cyclically.

13.1.8.2 MC_CamIn: Function chart V10

Function chart: Synchronization in advance using dynamic parameters and leading value distance as well as switching of the cam

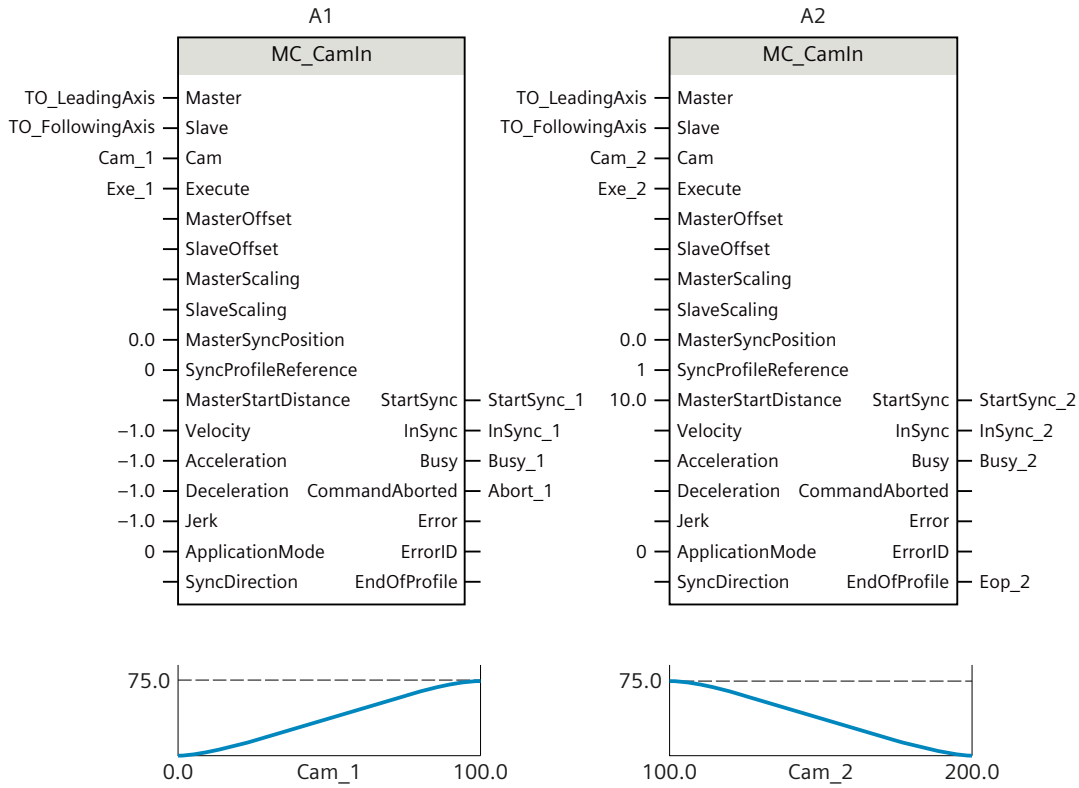

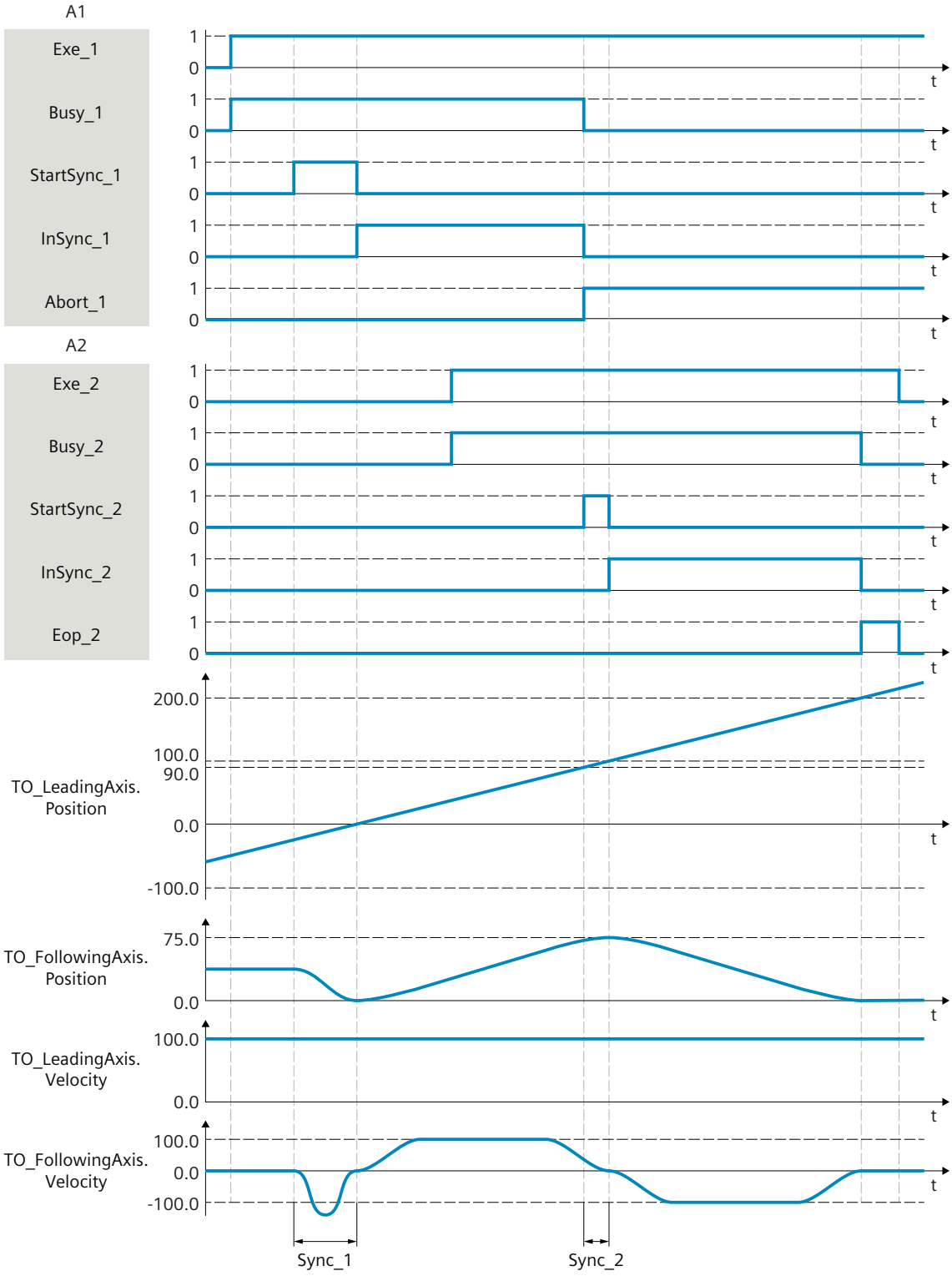

Using "Exe_1", an "MC_CamIn" job (A1) is initiated. The start of the synchronization is displayed with "StartSync_1". The following axis (TO_FollowingAxis) is synchronized in advance to the cam (Cam_1) within the range "Sync_1" by means of the specified dynamic parameters. The distance required for synchronization is calculated by the system. When the specified reference position "MasterSyncPosition" relative to the start of the cam is reached,

"InSync_1" signals that the following axis is synchronized and moves synchronously to the leading axis.

The synchronous operation is overridden by another "MC_CamIn" job (A2). The abort is signaled via "Abort_1". The start of the synchronization is displayed with "StartSync_2". The following axis is synchronized in advance to the new cam (Cam_2) within the range "Sync_2" by means of the specified leading value distance "MasterStartDistance". Within the range "Sync_2", the axis does not follow the cam "Cam_1" The dynamic response required for synchronization is calculated by the system. When the specified reference position "MasterSyncPosition" relative to the start of the cam is reached, "InSync_2" signals that the following axis is synchronized and moves synchronously to the leading axis.

Function chart: Synchronization in advance and subsequent synchronization using leading value distance and switching of the cam

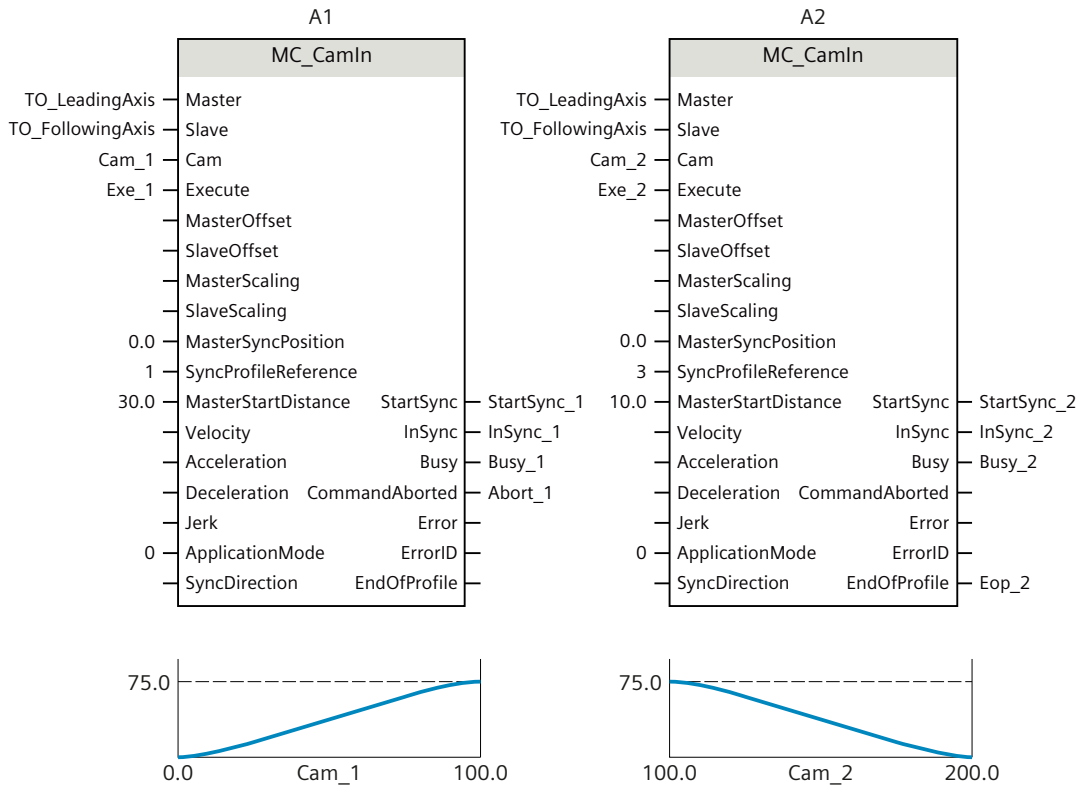

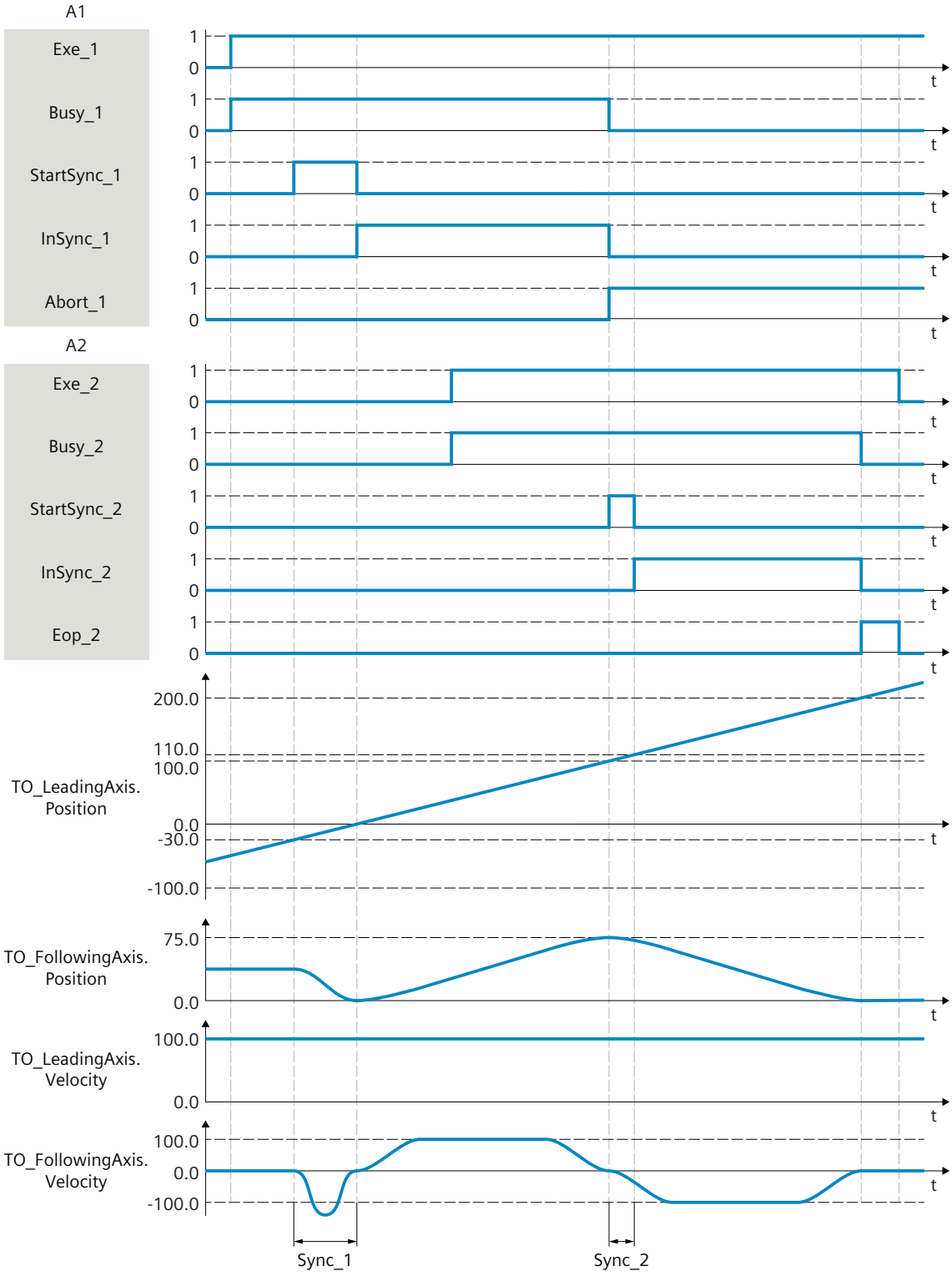

Using "Exe_1", an "MC_CamIn" job (A1) is initiated. The start of the synchronization is displayed with "StartSync_1". The following axis (TO_FollowingAxis) is synchronized in advance to the cam (Cam_1) within the range "Sync_1" by means of the specified leading value distance "MasterStartDistance". The dynamic response required for synchronization is calculated by the system. When the specified reference position "MasterSyncPosition" relative

to the start of the cam is reached, "InSync_1" signals that the following axis is synchronized and moves synchronously to the leading axis.

The synchronous operation is overridden by another "MC_CamIn" job (A2). The abort is signaled via "Abort_1". When the specified reference position "MasterSyncPosition" in relation to the start of the cam is reached, the start of synchronization is indicated via "StartSync_2". The following axis is synchronized subsequently to the new cam (Cam_2) within the range "Sync_2" by means of the specified leading value distance "MasterStartDistance". Within the range "Sync_2", the axis does not follow the cam "Cam_1" The dynamic response required for synchronization is calculated by the system. "InSync_2" signals that the following axis is synchronized and moving synchronously to the leading axis.

Function chart: Synchronization in advance and subsequent synchronization using leading value distance starting from current leading value position

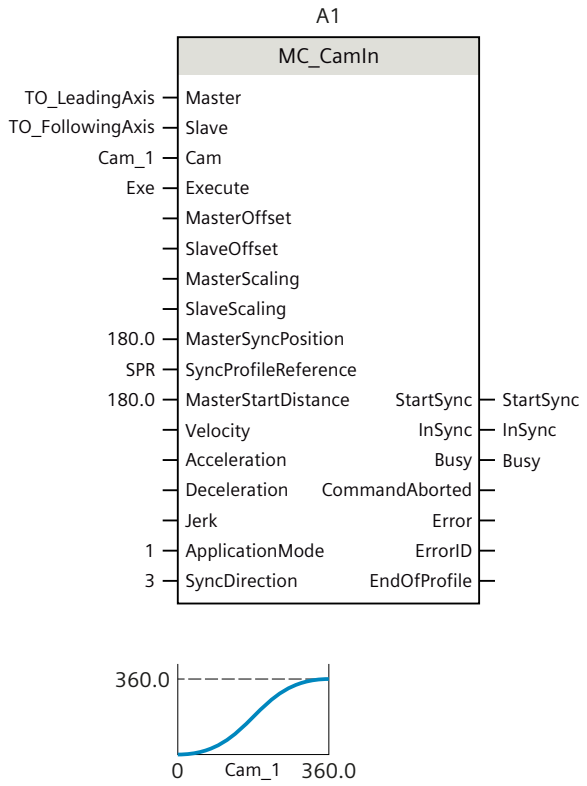

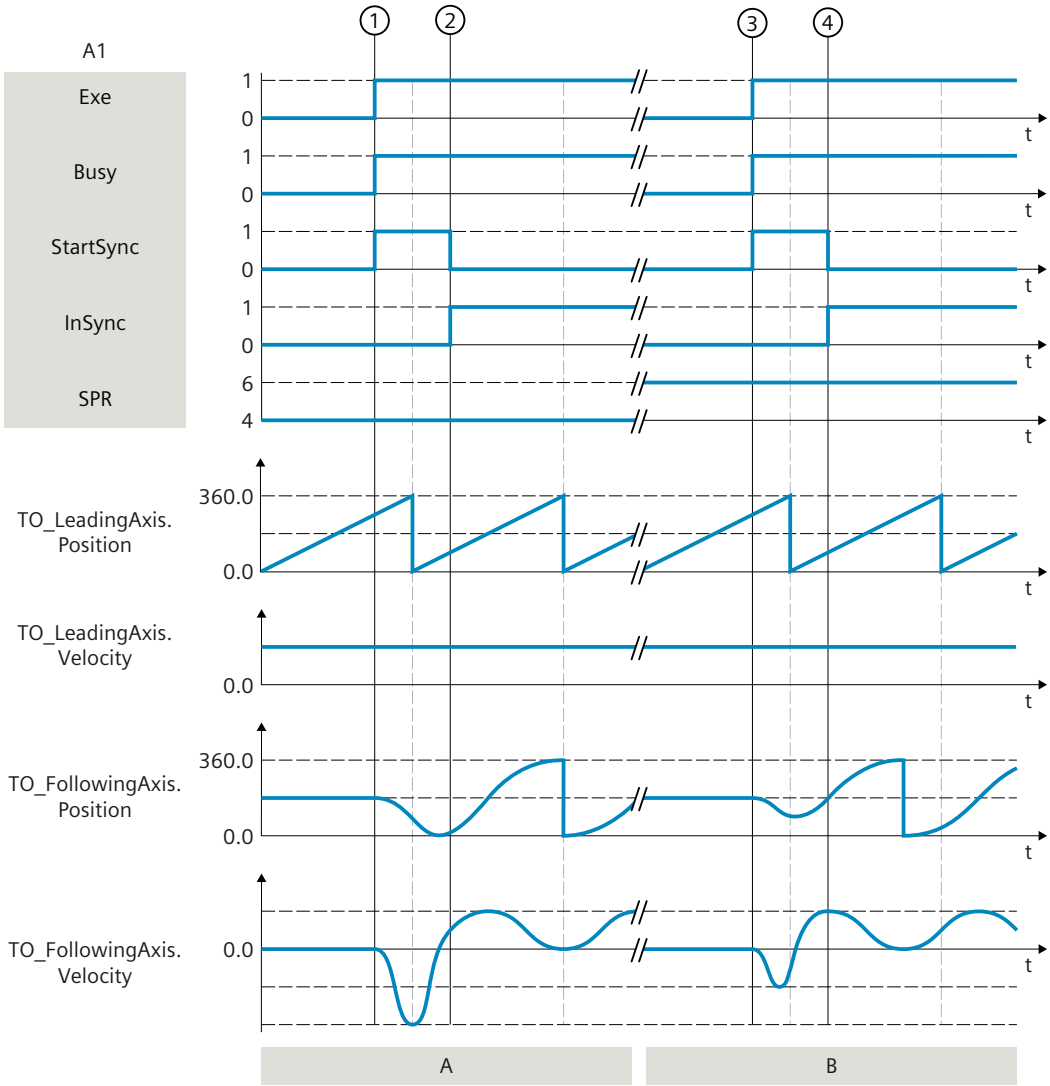

Section A

At time ①, an "MC_CamIn" job (A1) with "SyncProfileReference" = 4 is initiated via "Exe". The start of the synchronization is displayed with "StartSync". The following axis (TO_FollowingAxis) is synchronized subsequently as of the current leading value position 270° to the cam (Cam_1) by means of the specified leading value distance "MasterStartDistance" = 180°. The dynamic response required for synchronization is calculated by the system.

At time ②, "InSync" signals at the leading value position 90° that the following axis is synchronized and moves synchronously to the leading axis.

Section B

At time ③, the "MC_CamIn" job (A1) with "SyncProfileReference" = 6 is initiated via "Exe". The start of the synchronization is displayed with "StartSync". The following axis (TO_FollowingAxis) is synchronized in advance as of the current leading value position 270° to the cam (Cam_1) by means of the specified leading value distance "MasterStartDistance" = 180°. The dynamic response required for synchronization is calculated by the system.

At time ④, the following axis reaches the following value of the specified reference position "MasterSyncPosition" = 180° at the leading value position 90° in relation to the start of the cam. The cam is automatically offset by -90° in the leading value area (<TO>.StatusSynchronizedMotion.MasterOffset). "InSync" signals that the following axis is synchronized and moving synchronously to the leading axis.

Function chart: Togging and direct synchronous setting at the end of the cam

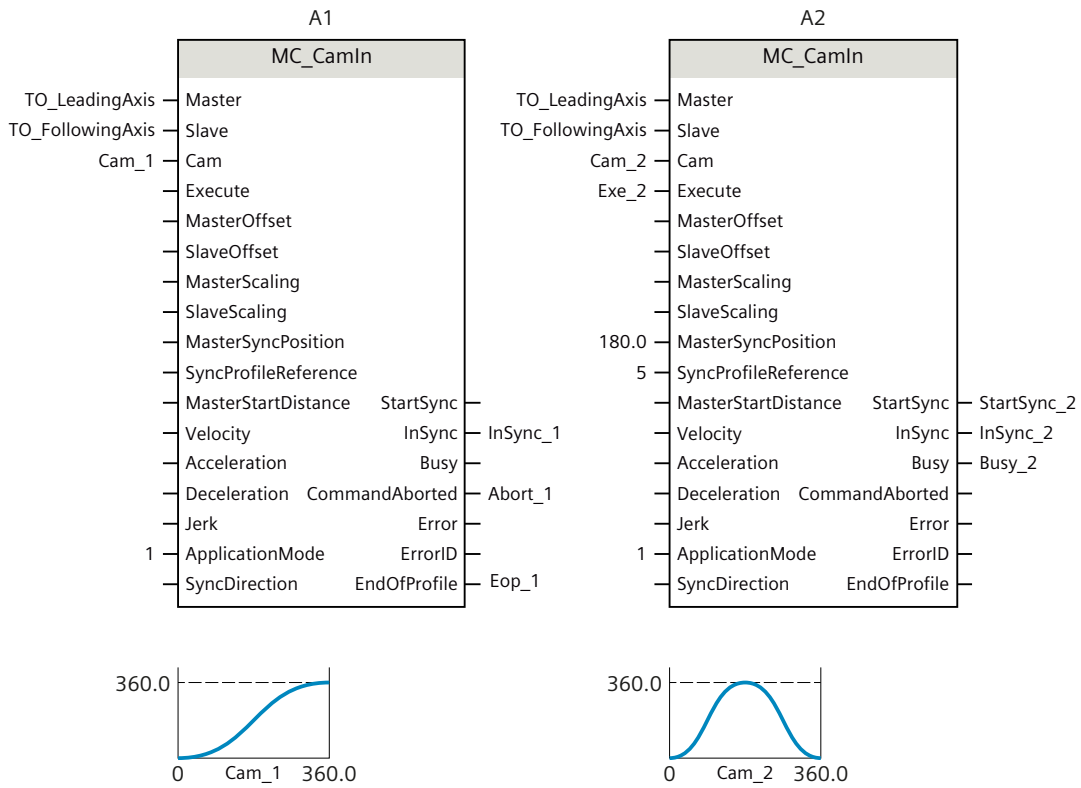

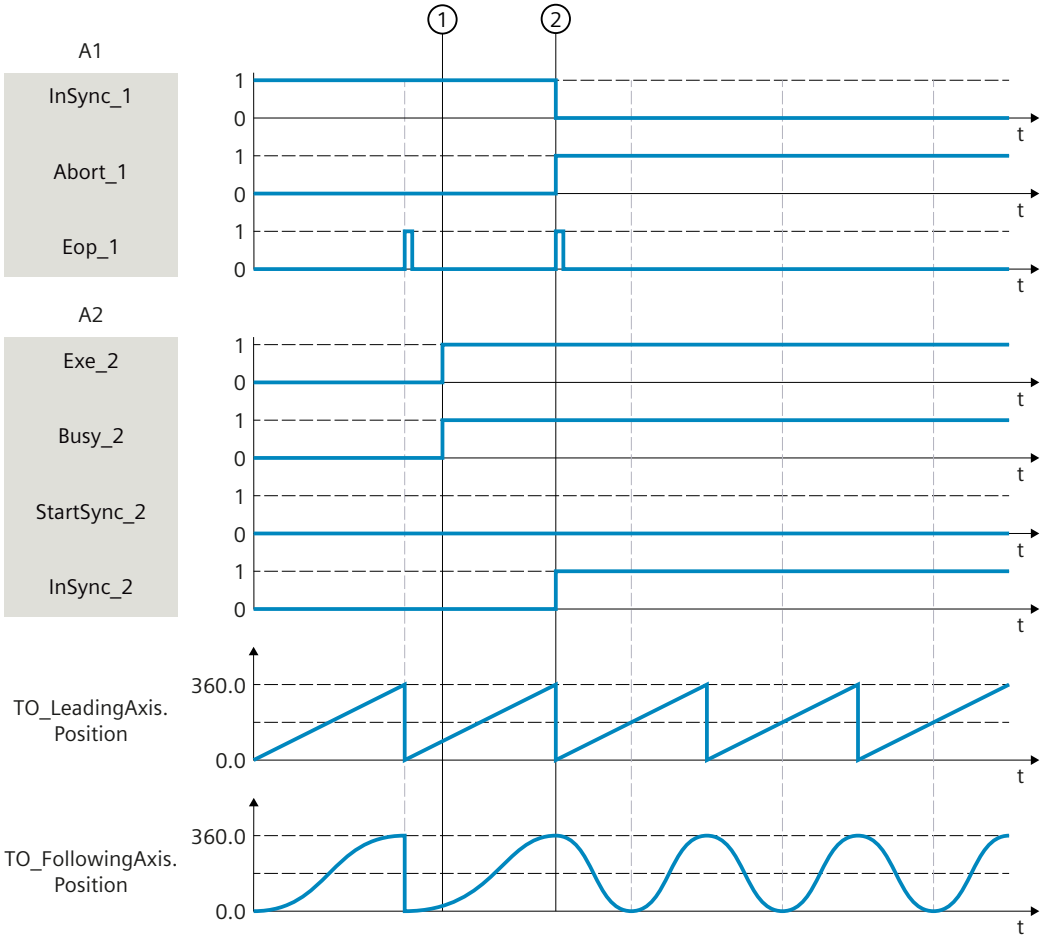

An "MC_CamIn" job (A1) is active.

At time ① another "MC_CamIn" job (A2) is initiated via "Exe_2". The status "Waiting" is displayed at the following axis until the end of the active cam "Cam_1" has been reached (<TO>.StatusSynchronizedMotion.WaitingFunctionState = 3).

At time ② the end of the cam is reached ("Eop_1"). The cam is switched over. Since no synchronization takes place, the "Synchronous" status is retained.

13.1.9 MC_SynchronizedMotionSimulation V10

13.1.9.1 MC_SynchronizedMotionSimulation: Simulate synchronous operation V10

Description

With the Motion Control instruction "MC_SynchronizedMotionSimulation", you can simulate an active synchronous operation on a following axis. This means that a synchronous operation remains active e.g. when the following axis is disabled. The following axis does not have to be synchronized again after being enabled again.

⚠ WARNING

Machine damage

If the position of the following axis at the end of the simulation differs from the position at the start of the simulation, this leads to a setpoint jump which can result in damage to the machine.

Therefore, make sure that the setpoints of the following axis correspond to the setpoints from the synchronous operation relationship when simulation is ended.

The Motion Control instruction offers you the following:

- Simulate synchronous operation (Page 203)

Applies to

- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The following axis is a synchronous axis.
- Synchronous operation is active on the technology object in status "Synchronous" (<TO>.StatusWord.X22 = TRUE).

Override response

An "MC_SynchronizedMotionSimulation" job is not aborted by any other Motion Control job. The simulated synchronous operation remains active even when the following axis is disabled with an "MC_Power" or "MC_Stop job.

A restart of the technology object stops the simulation and aborts the synchronous operation.

A new "MC_SynchronizedMotionSimulation" job does not abort any other Motion Control jobs. With "MC_SynchronizedMotionSimulation.Enable" = TRUE, synchronous operation jobs are rejected.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_SynchronizedMotionSimulation":

Parameter	Declaration	Data type	Default value	Description	
Slave	INPUT	TO_SynchronousAxis	-	Following axis technology object	
Enable	INPUT	BOOL	FALSE	TRUE	Simulation of synchronous operation is started.
				FALSE	Simulation of the synchronous operation is stopped.
InSimulation	OUTPUT	BOOL	FALSE	TRUE	The synchronous operation is in simulation.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	0	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

13.1.10 MC_GearOut V10

13.1.10.1 MC_GearOut: Desynchronize gearing V10

Description

With the Motion Control instruction "MC_GearOut" end gearing (Page 49) operation between a leading axis and a following axis. With an active gearing, the following axis is desynchronized and comes to a standstill at the specified stop position. A pending gearing is canceled.

The Motion Control instruction offers you the following:

- Defining direction of desynchronization (Page 88)
- Define the stop position of the following axis and the type of desynchronization:
  - Desynchronizing following axis using dynamic parameters (Page 84)
  - Desynchronizing following axis using leading value distance (Page 85)
- Canceling pending gearing (Page 91)

Applies to

- Synchronous axis

Requirement

- The following axis is enabled.
- Gearing with "MC_GearIn" or "MC_GearInPos" is active or pending on the following axis.
- No "MC_Stop" job is active on the following axis.

Override response

The override response for "MC_GearOut" jobs is described in section "Override response V10: Synchronous operation jobs".

An "MC_GearOut" job with "SyncProfileReference" = 5 aborts a pending "MC_GearInPos" or a pending "MC_GearOut" job.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_GearOut":

Parameter	Declaration	Data type	Default value	Description	
Slave	INPUT	TO_SynchronousAxis	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
SlavePosition	INPUT	LREAL	0.0	Stop position of following axis	
SyncProfileReference	INPUT	DINT	1	Type of desynchronization	
				0	Desynchronize using dynamic parameters (Page 84)
				1	Desynchronize using leading value distance (Page 85)
				2 ... 4	Reserved
				5	Canceling pending gearing (Page 91)
MasterStopDistance	INPUT	LREAL	0.0	When "SyncProfileReference" = 1: Leading value distance (Page 85)	
Deceleration	INPUT	LREAL	-1.0	When "SyncProfileReference" = 0: Deceleration (Page 84)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	When "SyncProfileReference" = 0: Jerk (Page 84)	
				> 0.0	The specified value is used.
				= 0.0	No jerk limitation

Parameter	Declaration	Data type	Default value	Description	
Jerk	INPUT	LREAL	-1.0	< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Jerk)
SyncOutDirection	INPUT	DINT	3	Desynchronization direction (Page 88)	
				1	Positive direction The following axis may only travel in positive direction during desynchronization.
				2	Negative direction The following axis may only travel in negative direction during desynchronization.
				3	Current direction The following axis is desynchronized in the direction in which the following axis is currently traveling.
StartSyncOut	OUTPUT	BOOL	FALSE	TRUE	The following axis is desynchronized.
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

13.1.10.2 MC_GearOut: Function chart V10

Function chart: Desynchronization using dynamic parameters and leading value distance

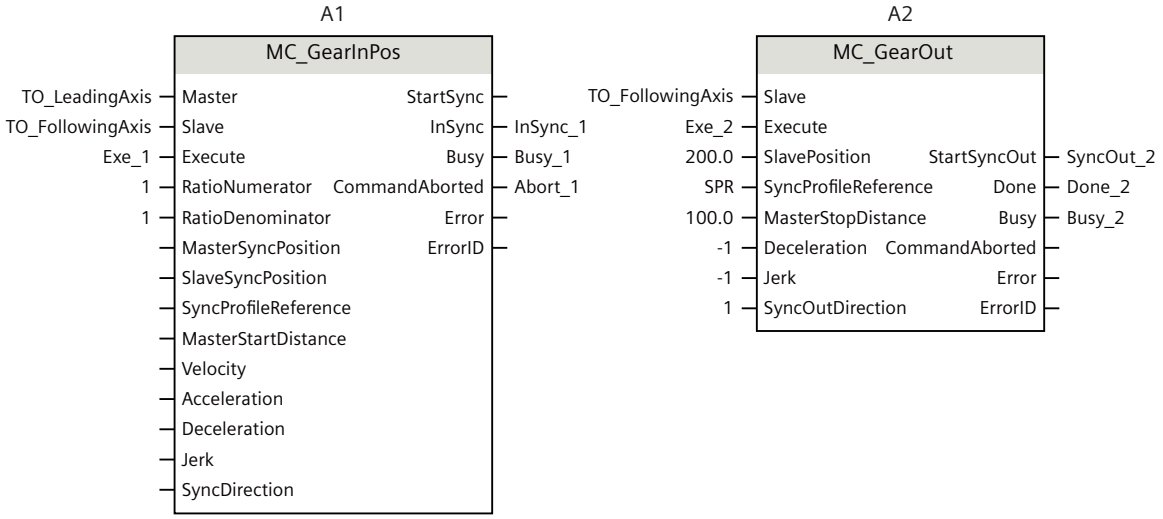

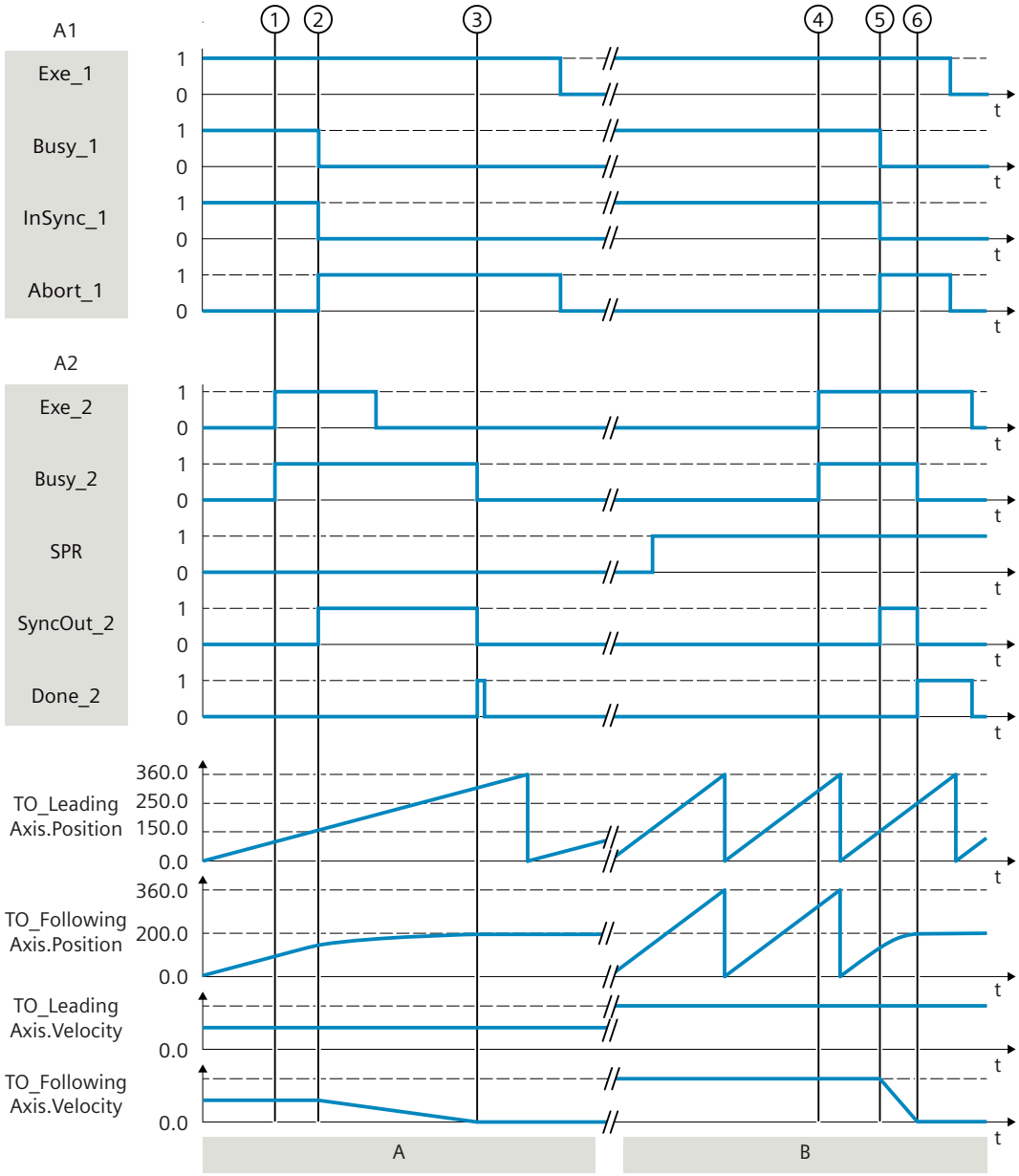

Section A

With an "MC_GearInPos" job (A1) the following axis (TO_FollowingAxis) travels synchronously to the leading axis (TO_LeadingAxis). "Synchronous" status is displayed via "InSync_1".

At time ① an "MC_GearOut" job (A2) is initiated via "Exe_2". The start of the desynchronization is displayed with "SyncOut_2" ②. The following axis is desynchronized using the specified dynamic parameters. The distance required for desynchronization is calculated by the system. When the specified stop position "SlavePosition" is reached, "Done_2" signals that the following axis is desynchronized and at standstill ③.

Section B

With an "MC_GearInPos" job (A1) the following axis travels synchronously to the leading axis. "Synchronous" status is displayed via "InSync_1".

At time ④ an "MC_GearOut" job (A2) is initiated via "Exe_2". The start of the desynchronization is displayed with "SyncOut_2" ⑤. The following axis is desynchronized using the specified leading value distance "MasterStopDistance". The dynamics required for desynchronization is calculated by the system. When the specified stop position "SlavePosition" is reached, "Done_2" signals that the following axis is desynchronized and at standstill ⑥.

13.1.11 MC_CamOut V10

13.1.11.1 MC_CamOut: Desynchronize camming V10

Description

With the Motion Control instruction "MC_CamOut" end a Camming (Page 102) operation between a leading axis and a following axis. With an active camming, the following axis is desynchronized and comes to a standstill at the specified stop position. A pending camming is canceled.

The Motion Control instruction offers you the following:

- Defining direction of desynchronization (Page 197)
- Define the stop position of the following axis and the type of desynchronization:
  - Desynchronizing following axis using dynamic parameters (Page 193)
  - Desynchronizing following axis using leading value distance (Page 194)
- Canceling pending camming (Page 200)

Applies to

- Synchronous axis

Requirement

- The following axis is enabled.
- A camming with "MC_CamIn" is active or pending on the following axis.
- No "MC_Stop" job is active on the following axis.

Override response

The override response for "MC_CamOut" jobs is described in section "Override response V10: Synchronous operation jobs".

An "MC_CamOut" job with "SyncProfileReference" = 5 aborts a pending "MC_CamIn" or a pending "MC_CamOut" job.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_CamOut":

Parameter	Declaration	Data type	Default value	Description	
Slave	INPUT	TO_SynchronousAxis	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
SlavePosition	INPUT	LREAL	0.0	Stop position of following axis	
SyncProfileReference	INPUT	DINT	1	Type of desynchronization	
				0	Desynchronize using dynamic parameters (Page 193)
				1	Desynchronize using leading value distance (Page 194)
				2 ... 4	Reserved
				5	Canceling pending camming (Page 200)
MasterStopDistance	INPUT	LREAL	0.0	When "SyncProfileReference" = 1: Leading value distance (Page 194)	
Deceleration	INPUT	LREAL	-1.0	When "SyncProfileReference" = 0: Deceleration (Page 193)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The deceleration configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Deceleration)
Jerk	INPUT	LREAL	-1.0	When "SyncProfileReference" = 0: Jerk (Page 193)	
				> 0.0	The specified value is used.
				= 0.0	No jerk limitation
				< 0.0	The jerk configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Jerk)
SyncOutDirection	INPUT	DINT	3	Desynchronization direction (Page 197)	
				1	Positive direction The following axis may only travel in positive direction during desynchronization.
				2	Negative direction The following axis may only travel in negative direction during desynchronization.
				3	Current direction The following axis is desynchronized in the direction in which the following axis is currently traveling.
StartSyncOut	OUTPUT	BOOL	FALSE	TRUE	The following axis is desynchronized.
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.

Parameter	Declaration	Data type	Default value	Description	
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

13.1.11.2 MC_CamOut: Function chart V10

Function chart: Desynchronization using leading value distance

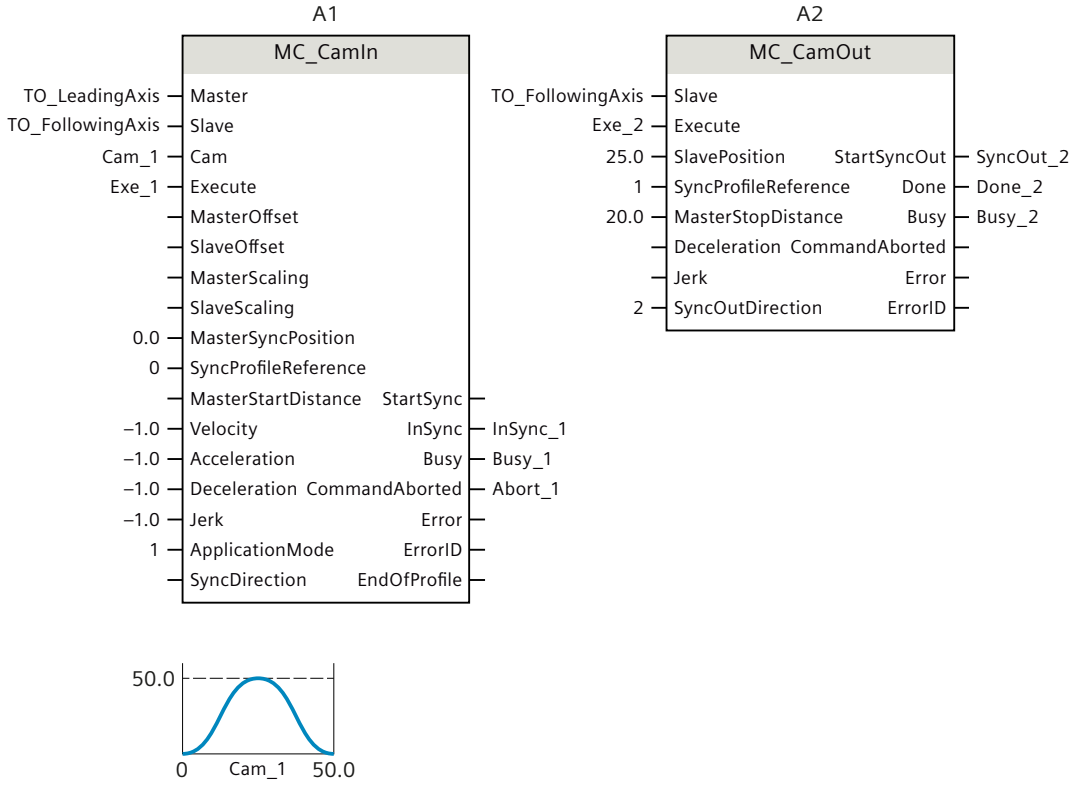

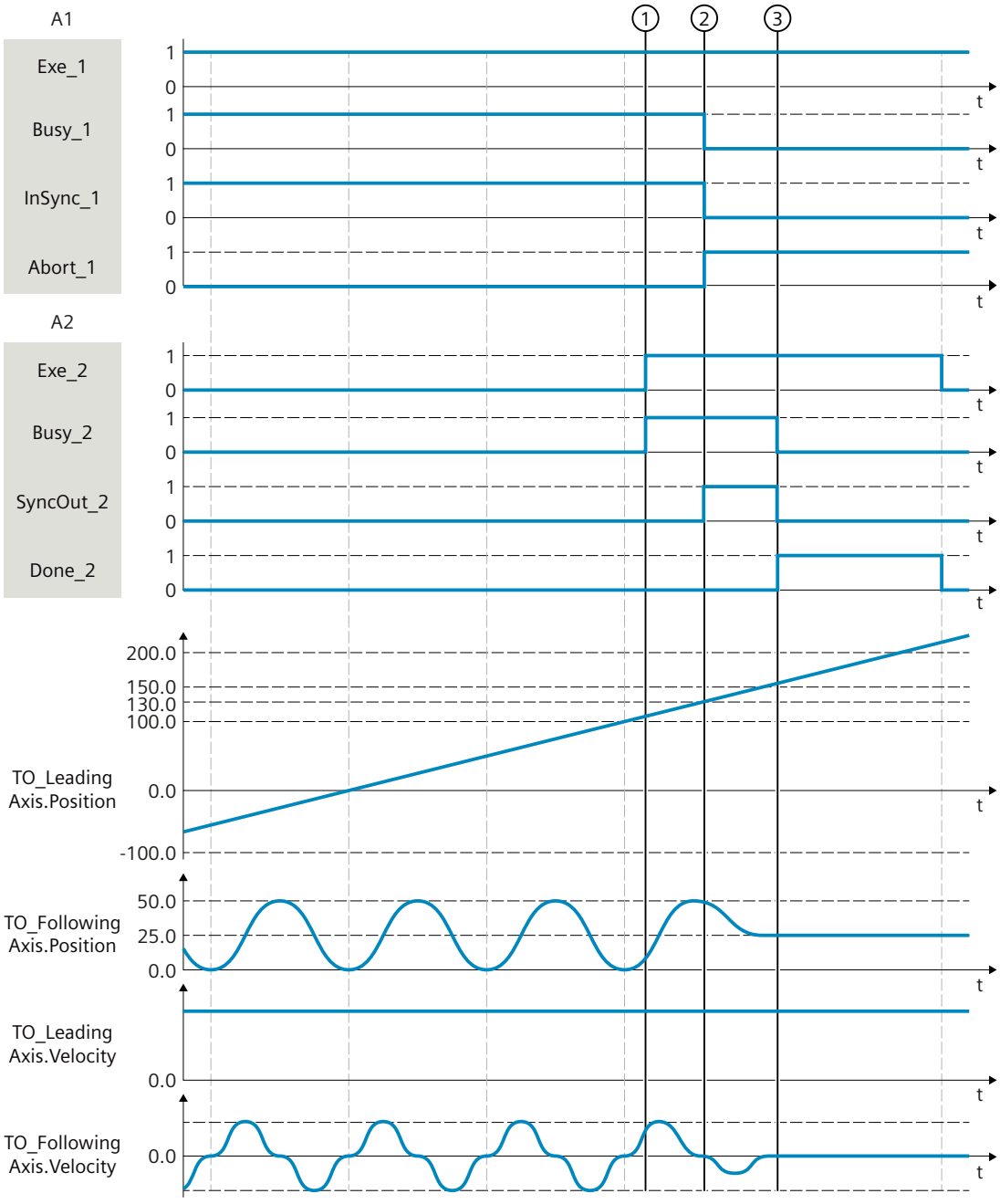

With a "MC_CamIn" job (A1) the following axis (TO_FollowingAxis) travels over a cyclically running cam (Cam_1) synchronous to the leading axis (TO_LeadingAxis). "Synchronous" status is displayed via "InSync_1".

At time ① an "MC_CamOut" job (A2) is initiated via "Exe_2". The following axis should only be desynchronized in negative direction ("SyncOutDirection" = 2). The start of the desynchronization is displayed with "SyncOut_2" ②. The following axis is desynchronized using the specified leading value distance "MasterStopDistance". The dynamics required for desynchronization is calculated by the system. When the specified stop position "SlavePosition" or the configured position window is reached, "Done_2" signals following setpoint interpolation that the following axis is desynchronized and at standstill ③.

13.1.12 MC_LeadingValueAdditive V10

13.1.12.1 MC_LeadingValueAdditive: Specify additive leading value V10

Description

With the Motion Control instruction "MC_LeadingValueAdditive", you specify an additive leading value cyclically in addition to the active leading value of a following axis. The additive leading value consists of position, velocity and acceleration. Changes to the specified values are effective immediately without consideration of the dynamic limits.

The Motion Control instruction offers you the following:

- Specify additive leading value (Page 205)

Applies to

- Synchronous axis

Requirement

- The technology object has been configured correctly.
- The technology object is enabled or is in simulation with an "MC_SynchronizedMotionSimulation" job.

Override response

The override response for "MC_LeadingValueAdditive" jobs is described in section "Override response V10: Synchronous operation jobs".

If a synchronous operation is overridden by another synchronous operation, the additive leading value remains valid.

If a synchronous operation is desynchronized, the additive leading value remains valid. Desynchronization refers to the effective leading value.

An "MC_LeadingValueAdditive" job is aborted by an "MC_Reset" job with "Restart" = TRUE.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_LeadingValueAdditive":

Parameter	Declaration	Data type	Default value	Description	
Axis	INPUT	TO_SynchronousAxis	-	Technology object on which the additive values act.	
Enable	INPUT	BOOL	FALSE	TRUE	The leading value is adapted.
				FALSE	The leading value is not adapted.

Parameter	Declaration	Data type	Default value	Description	
Position	INPUT	LREAL	0.0	Additive position value Recommendation: To avoid setpoint jumps, only change the additive position value during an active job in small steps.	
Velocity	INPUT	LREAL	0.0	Additive velocity value Observe the dynamic limits.	
Acceleration	INPUT	LREAL	0.0	Additive acceleration value Observe the dynamic limits.	
Busy	OUTPUT	BOOL	FALSE	TRUE	The additive values are valid.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

13.1.12.2 MC_LeadingValueAdditive: Function chart V10

Function chart: Specify additive leading value

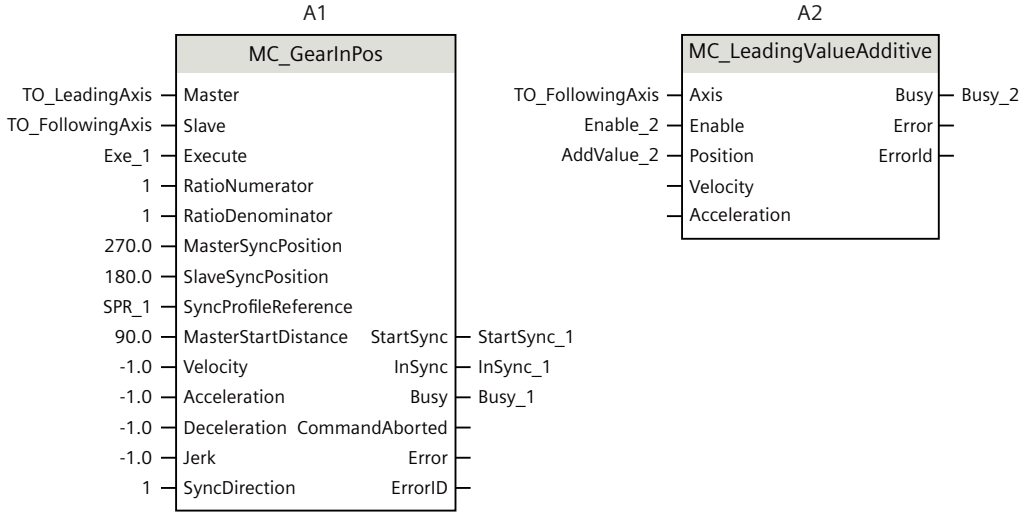

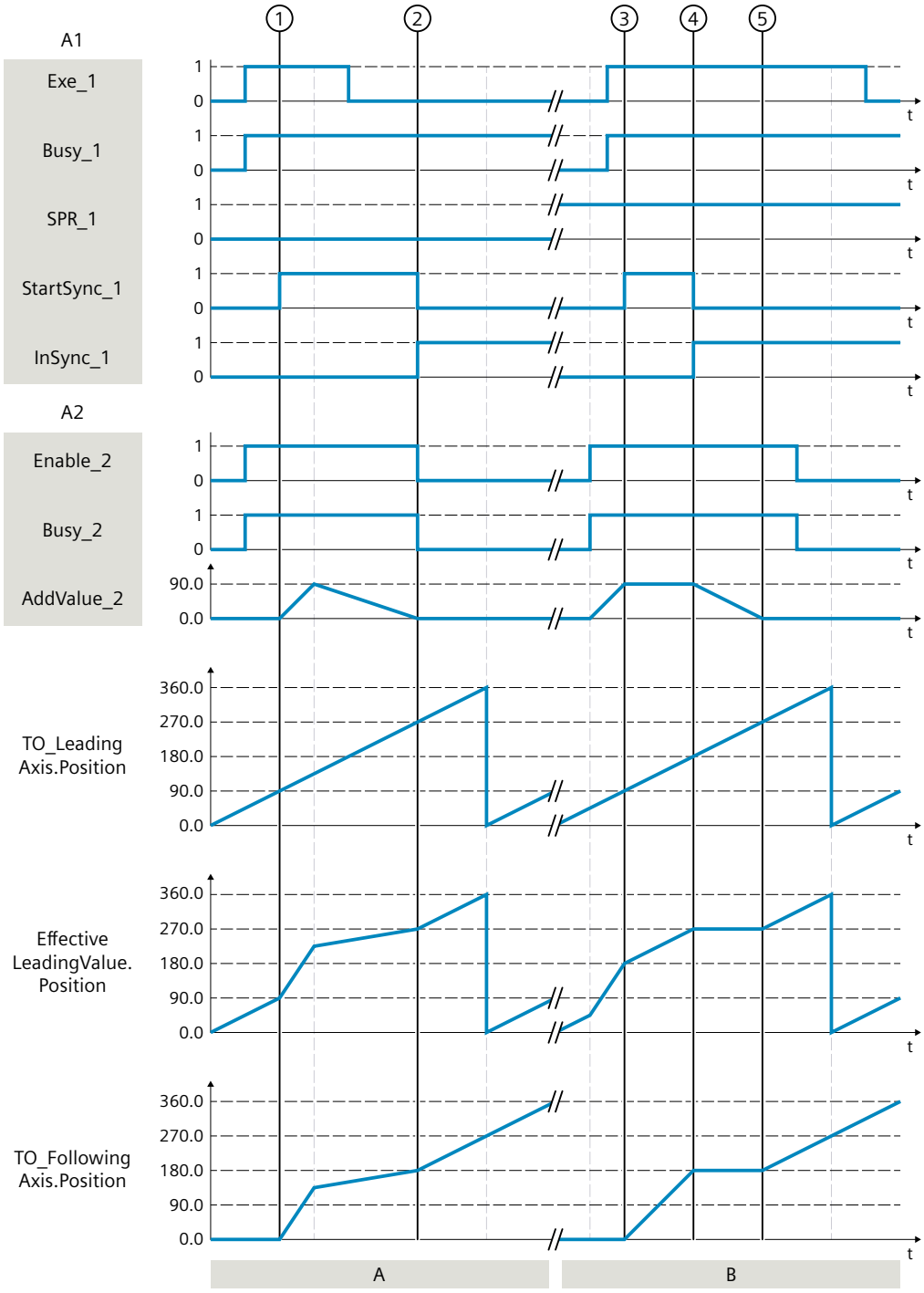

Section A

Via "Exe_1" = TRUE, a "MC_GearInPos" job (A1) is started with synchronization in advance via dynamic parameters. At the same time, a "MC_LeadingValueAdditive" job (A2) is started via "Enable_2" = TRUE. The effective leading value (EffectiveLeadingValue.Position) and the time for starting the synchronization are calculated.

At time ①, the following axis (TO_FollowingAxis) starts to synchronize with the specified dynamic parameters ("StartSync_1" = TRUE). The additive leading value (AddValue_2) is

continuously increased in the user program and added to the leading value of the following axis. The effective leading value increased in this way has an effect on the increased dynamic response of the following axis. The additive leading value is then reduced and thus the dynamic response of the following axis is also reduced.

At time ②, the additive leading value is back at "0.0" and the effective leading value is equal to the leading value of the leading axis. The following axis is synchronized to the specified synchronous position ("InSync_1" = TRUE). The A2 job is terminated with "Enable_2" = FALSE.

Section B

Via "Enable_2" = TRUE, a "MC_LeadingValueAdditive" job (A2) is started before a synchronous operation job. The user program continuously increases the additive leading value to the value "90.0". With "Exe_2" = TRUE a "MC_GearInPos" job (A1) is started with synchronization in advance via leading value distance.

At time ③, the effective leading value reaches the value "180.0". The following axis starts to synchronize ("StartSync_1" = TRUE).

At time ④, the effective leading value reaches the value "270.0". The following axis is synchronized ("InSync_1" = TRUE). At this point the leading axis has reached the value "180.0". The synchronous position of the leading axis (MasterSyncPosition) is moved by the additive leading value. Subsequently, the additive leading value is continuously reduced. While the leading value of the leading axis increases from "180.0" to "270.0", the additive leading value decreases from "90.0" to "0.0". The effective leading value remains at "270.0" and the following axis does not move.

At time ⑤, the additive leading value has reached the value "0.0" and the effective leading value is equal to the leading value of the leading axis. The shift is canceled and the motion of the following axis is continued. The A2 job is terminated with "Enable_2" = FALSE.

13.2 Cam

13.2.1 MC_InterpolateCam V10

13.2.1.1 MC_InterpolateCam: Interpolate cam V10

Description

With the Motion Control instruction "MC_InterpolateCam", you interpolate a cam. The interpolation closes the gaps between the defined interpolation points and segments of the cam.

The Motion Control instruction offers you the following:

- Interpolating a cam (Page 150)

The cam is interpolated based on the configured settings of the technology object:

- Configuring transitions (Page 142)
- System interpolation (Page 144)
- Interpolation according to VDI Guideline 2143 (Page 147)

Applies to

- Cam

Requirement

- The technology object has been configured correctly.
- The cam is not currently being used, e.g. for camming.

Override response

- An "MC_InterpolateCam" job is not aborted by any other Motion Control job.
- A new "MC_InterpolateCam" job does not abort any active Motion Control job.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_InterpolateCam":

Parameters	Declaration	Data type	Default value	Description	
Cam	INPUT	TO_Cam TO_Cam_10k TO_Cam_600Seg TO_Cam_6kSeg	-	Cam technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Done	OUTPUT	BOOL	FALSE	TRUE	The cam is interpolated.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

Interpolating a cam

To interpolate a cam with the "MC_InterpolateCam" Motion Control instruction, follow these steps:

1. Check the requirements indicated above.
2. Specify the cam to be interpolated in the "Cam" parameter.
3. Start the "MC_InterpolateCam" job with a positive edge at the "Execute" parameter.

   The cam is interpolated. When the "Done" parameter shows the value "TRUE", the interpolation is finished.

13.2.2 MC_GetCamLeadingValue V10

13.2.2.1 MC_GetCamLeadingValue: Read out leading value of a cam V10

Description

With the Motion Control instruction "MC_GetCamLeadingValue", you read the leading value that is defined for a following value from a cam.

The Motion Control instruction offers you the following:

- Reading a leading value (Page 179)
- Specifying an approach value and approach direction (Page 179)
- Specifying scaling and offset of the cam (Page 150)

Applies to

- Cam

Requirement

- The technology object has been configured correctly.
- The cam is interpolated.

Override response

- An "MC_GetCamLeadingValue" job is not aborted by any other Motion Control job.
- A new "MC_GetCamLeadingValue" job does not abort any active Motion Control job.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_GetCamLeadingValue":

Parameter	Declaration	Data type	Default value	Description	
Cam	INPUT	TO_Cam TO_Cam_10k TO_Cam_600Seg TO_Cam_6kSeg	-	Cam technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
FollowingValue	INPUT	LREAL	0.0	Following value for which the leading value is read	
ApproachLeadingValue	INPUT	LREAL	0.0	Approach value for the searched for leading value If the following value is used multiple times in the cam, it can be used to limit the searched leading value. The approach value refers to the – if applicable, offset and scaled – leading values of the cam. The approach value can lie inside or outside the scaled definition range of the cam.	
ApproachDirection	INPUT	DINT	3	Approach direction for the sought leading value	
				1	Positive direction
				2	Negative direction
				3	Nearest value
MasterOffset	INPUT	LREAL	0.0	Offset of the leading values of the cam The cam technology object is not changed.	
SlaveOffset	INPUT	LREAL	0.0	Offset of the following values of the cam The cam technology object is not changed.	
MasterScaling	INPUT	LREAL	1.0	Scaling of the leading values of the cam The cam technology object is not changed.	
				0.0	Not permitted
SlaveScaling	INPUT	LREAL	1.0	Scaling of the following values of the cam The cam technology object is not changed.	
Done	OUTPUT	BOOL	FALSE	TRUE	The leading value was read.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
Value	OUTPUT	LREAL	-	Read leading value (position) (valid when "Done" = TRUE)	

13.2.3 MC_GetCamFollowingValue V10

13.2.3.1 MC_GetCamFollowingValue: Read out following value of a cam V10

Description

With the "MC_GetCamFollowingValue" Motion Control instruction, you read the following value as well as the first, second and third derivative of the following value for a leading value from a cam depending on the specified read mode.

The Motion Control instruction offers you the following:

- Reading a following value (Page 181)
- Specifying scaling and offset of the cam (Page 150)

Applies to

- Cam

Requirement

- The technology object has been configured correctly.
- The cam is interpolated.

Override response

- An "MC_GetCamFollowingValue" job is not aborted by any other Motion Control job.
- A new "MC_GetCamFollowingValue" job does not abort any active Motion Control job.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_GetCamFollowingValue":

Parameters	Declaration	Data type	Default value	Description	
Cam	INPUT	TO_Cam TO_Cam_10k TO_Cam_600Seg TO_Cam_6kSeg	-	Cam technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
LeadingValue	INPUT	LREAL	0.0	Leading value for which the following value is read	
MasterOffset	INPUT	LREAL	0.0	Offset of the leading values of the cam The cam technology object is not changed.	

Parameters	Declaration	Data type	Default value	Description	
SlaveOffset	INPUT	LREAL	0.0	Offset of the following values of the cam The cam technology object is not changed.	
MasterScaling	INPUT	LREAL	1.0	Scaling of the leading values of the cam The cam technology object is not changed.	
				0.0	Not permitted
SlaveScaling	INPUT	LREAL	1.0	Scaling of the following values of the cam The cam technology object is not changed.	
ApplicationMode	INPUT	DINT	2	Read mode	
				0	Read out following value (position)
				1	Read out following value and first derivative (position, velocity)
				2	Read out following value, first derivative and second derivative (position, velocity, acceleration)
				3	Read out following value, first derivative, second derivative and third derivative (position, velocity, acceleration, jerk)
Done	OUTPUT	BOOL	FALSE	TRUE	The following value was read.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
Value	OUTPUT	LREAL	-	Read following value (position) (valid when "Done" = TRUE)	
FirstDerivative	OUTPUT	LREAL	-	First derivative on read out following value (velocity) (valid when "Done" = TRUE)	
SecondDerivative	OUTPUT	LREAL	-	Second derivative on read out following value (acceleration) (valid when "Done" = TRUE)	
ThirdDerivative	OUTPUT	LREAL	-	Third derivative on read following value (jerk) (valid when "Done" = TRUE)	

13.2.4 MC_GetCamFollowingValueCyclic V10

13.2.4.1 MC_GetCamFollowingValueCyclic: Cyclically read out following value of a cam V10

Description

With the "MC_GetCamFollowingValueCyclic" Motion Control instruction, you read the following value as well as the first, second and third derivative of the following value for a leading value from a cam cyclically depending on the specified read mode.

The Motion Control instruction offers you the following:

- Reading a following value cyclically (Page 182)
- Specifying scaling and offset of the cam (Page 150)

Applies to

- Cam

Requirement

- The technology object has been configured correctly.
- The cam is interpolated.

Override response

- An "MC_GetCamFollowingValueCyclic" job is not aborted by any other Motion Control job.
- A new "MC_GetCamFollowingValueCyclic" job does not abort any active Motion Control job.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_GetCamFollowingValueCyclic":

Parameters	Declaration	Data type	Default value	Description	
Cam	INPUT	TO_Cam TO_Cam_10k TO_Cam_600Seg TO_Cam_6kSeg	-	Technology object	
Enable	INPUT	BOOL	FALSE	TRUE	The following value is read out cyclically.
				FALSE	The following value is not read out.
LeadingValue	INPUT	LREAL	0.0	Leading value for which the following value is read	

Parameters	Declaration	Data type	Default value	Description	
MasterOffset	INPUT	LREAL	0.0	Offset of the leading values of the cam The cam technology object is not changed.	
SlaveOffset	INPUT	LREAL	0.0	Offset of the following values of the cam The cam technology object is not changed.	
MasterScaling	INPUT	LREAL	1.0	Scaling of the leading values of the cam The cam technology object is not changed.	
				0.0	Not permitted
SlaveScaling	INPUT	LREAL	1.0	Scaling of the following values of the cam The cam technology object is not changed.	
ApplicationMode	INPUT	DINT	2	Read mode	
				0	Read out following value (position)
				1	Read out following value and first derivative (position, velocity)
				2	Read out following value, first derivative and second derivative (position, velocity, acceleration)
				3	Read out following value, first derivative, second derivative and third derivative (position, velocity, acceleration, jerk)
Valid	OUTPUT	LREAL	FALSE	TRUE	The following value that is read out is valid.
				FALSE	The following value that is read out is invalid.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
Value	OUTPUT	LREAL	0.0	Read following value (position) (valid when "Valid" = TRUE)	
FirstDerivative	OUTPUT	LREAL	0.0	First derivative on read out following value (velocity) (valid when "Valid" = TRUE)	
SecondDerivative	OUTPUT	LREAL	0.0	Second derivative on read out following value (acceleration) (valid when "Valid" = TRUE)	
ThirdDerivative	OUTPUT	LREAL	-	Third derivative on read following value (jerk) (valid when "Valid" = TRUE)	

13.2.5 MC_CopyCamData V10

13.2.5.1 MC_CopyCamData: Copy calculated cam elements V10

Description

You use the instruction "MC_CopyCamData" to copy calculated cam elements from one array each for points and segments to the data block technology object of the cam. You use the copy mode to specify whether the existing defined cam elements remain valid or are set as invalid.

The Motion Control instruction offers you the following:

- Changing the synchronous operation function of the cam online (Page 137)
- Copy calculated cam elements (Page 139)

Applies to

- Cam

Requirement

- The technology object has been configured correctly.
- The data to be copied is available in a data block with one array each for points and segments:
  - For points: ARRAY[*] OF TO_Cam_Struct_PointData
  - For segments: ARRAY[*] OF TO_Cam_Struct_SegmentData
- The "Optimized block access" option is activated in the properties of the data block under "General > Attributes".

Override response

- An "MC_CopyCamData" job is not aborted by any other Motion Control job.
- A new "MC_CopyCamData" job does not abort any active Motion Control job.

  Cam elements can also be copied during active camming.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_CopyCamData":

Parameter	Declaration	Data type	Default value	Description	
Cam	INPUT	TO_Cam TO_Cam_10k TO_Cam_600Seg TO_Cam_6kSeg	-	Cam technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Mode	INPUT	DINT	0	Copy mode	
				0	All existing defined cam elements are set as invalid before the copying procedure. ("ValidPoint" = FALSE, "ValidSegment" = FALSE)
				1	All existing defined cam elements remain valid. ("ValidPoint" = TRUE, "ValidSegment" = TRUE)
StartPointCam	INPUT	DINT	1	Index of the start point of the points to be copied in the cam	
				Permitted values for "TO_Cam": 1 ≤ "StartPointCam" ≤ 1 000	
				Permitted values for "TO_Cam_10k": 1 ≤ "StartPointCam" ≤ 10 000	
StartSegmentCam	INPUT	DINT	1	Index of the start segment of the segments to be copied in the cam	
				Permitted values: 1 ≤ "StartSegmentCam" ≤ 50	
StartPointArray	INPUT	DINT	1	Index of the start point of the points to be copied from "ArrayOfPoints"	
				Permitted values: Low limit of "ArrayOfPoints" ≤ "StartPointArray" ≤ high limit of "ArrayOfPoints"	
StartSegmentArray	INPUT	DINT	1	Index of the start segment of the segments to be copied from "ArrayOfSegments"	
				Permitted values: Low limit of "ArrayOfSegments" ≤ "StartSegmentArray" ≤ high limit of "ArrayOfSegments"	
NumberOfPoints	INPUT	DINT	0	Number of points to be copied	
				Permitted values for "TO_Cam": "NumberOfPoints" ≤ number of points from "ArrayOfPoints" and 0 ≤ "NumberOfPoints" ≤ 1 001 - "StartPointCam"	

[1] The size of the array depends on your application.

Parameter	Declaration	Data type	Default value	Description	
NumberOfPoints	INPUT	DINT	0	Permitted values for "TO_Cam_10k": "NumberOfPoints" ≤ number of points from "ArrayOfPoints" and 0 ≤ "NumberOfPoints" ≤ 10 001 - "StartPointCam"	
NumberOfSegments	INPUT	DINT	0	Number of segments to be copied	
				Permitted values: "NumberOfSegments" ≤ number of segments in the "ArrayOfSegments" and 0 ≤ "NumberOfSegments" ≤ 51 - "StartSegmentCam"	
ArrayOfPoints	INOUT	ARRAY[*] OF TO_Cam-_Struct_PointData[1]	-	Array that contains the points to be copied	
ArrayOfSegments	INOUT	ARRAY[*] OF TO_Cam-_Struct_SegmentData[1]	-	Array that contains the segments to be copied	
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

[1] The size of the array depends on your application.

13.2.6 MC_SetCamRangeScaling V10

13.2.6.1 MC_SetCamRangeScaling: Scaling the cam range V10

Description

Use the Motion Control instruction "MC_SetCamRangeScaling" to scale a cam range. The scaling range refers to the interpolated cam. The configuration of the cam technology object is not changed.

Up to two scaling ranges are possible for one cam.

The Motion Control instruction offers you the following:

- Scaling a cam range (Page 153)

Applies to

- Cam

Requirement

- The technology object has been configured correctly.
- The cam is interpolated (<TO>.StatusWord.X5 (Interpolated) = TRUE).

Override response

- An "MC_SetCamRangeScaling" job is not aborted by any other Motion Control job.
- A new "MC_SetCamRangeScaling" job does not abort any active Motion Control job.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_SetCamRangeScaling":

Parameters	Declaration	Data type	Default value	Description	
Cam	INPUT	TO_Cam TO_Cam_10k TO_Cam_600Seg TO_Cam_6kSeg	-	Cam technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Mode	INPUT	DINT	1	Scaling mode	
				1	Range scaling in the leading value range[1)]
				2	Range scaling in the following value range[2)]
RangeNumber	INPUT	DINT	1	Number of the scaling range	
				1	Scaling range 1
				2	Scaling range 2
RangeStartPoint	INPUT	LREAL	0.0	Start point Start point ≤ End point	
RangeEndPoint	INPUT	LREAL	0.0	End point Start point ≤ End point	
RangeScaling	INPUT	LREAL	1.0	Scaling factor	
				> 0.0	The specified value is used.
				≤ 0.0	Not permitted
Done	OUTPUT	BOOL	FALSE	TRUE	The cam range is scaled.

1) If the cam is used with the Motion Control instruction "MC_PositionProfile", the range scaling refers to the time values.

2) If the cam is used with the Motion Control instruction "MC_PositionProfile", the range scaling refers to the axis values.

Parameters	Declaration	Data type	Default value	Description	
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

1) If the cam is used with the Motion Control instruction "MC_PositionProfile", the range scaling refers to the time values.

2) If the cam is used with the Motion Control instruction "MC_PositionProfile", the range scaling refers to the axis values.

13.2.6.2 MC_SetCamRangeScaling: Function chart V10

Function chart: Scaling the cam during active camming

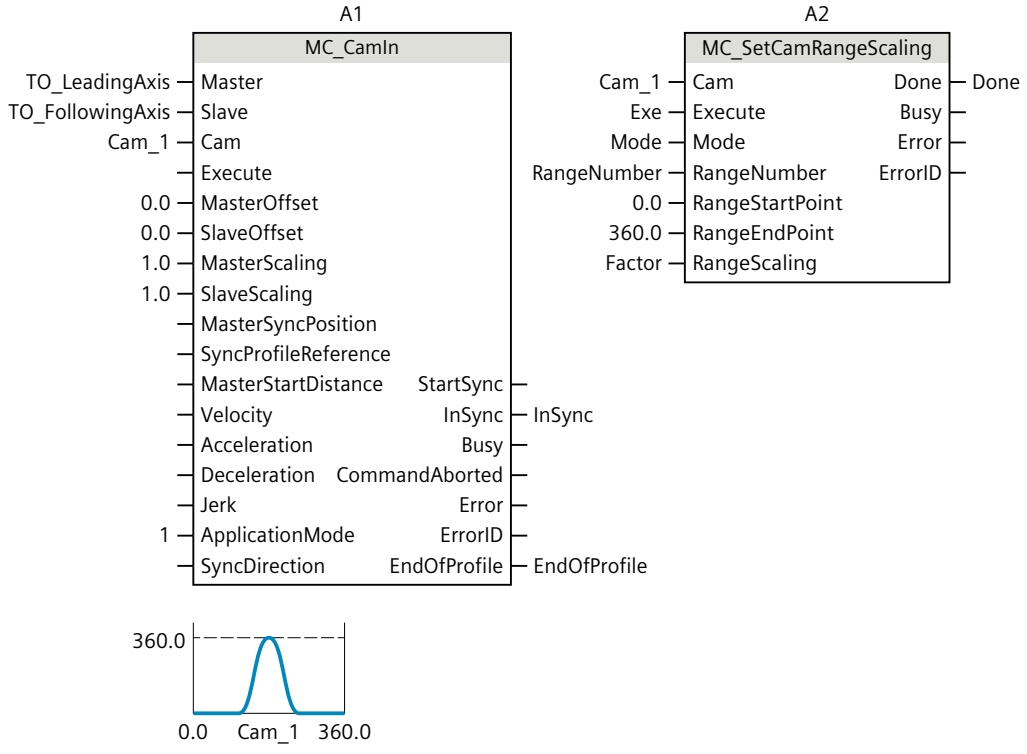

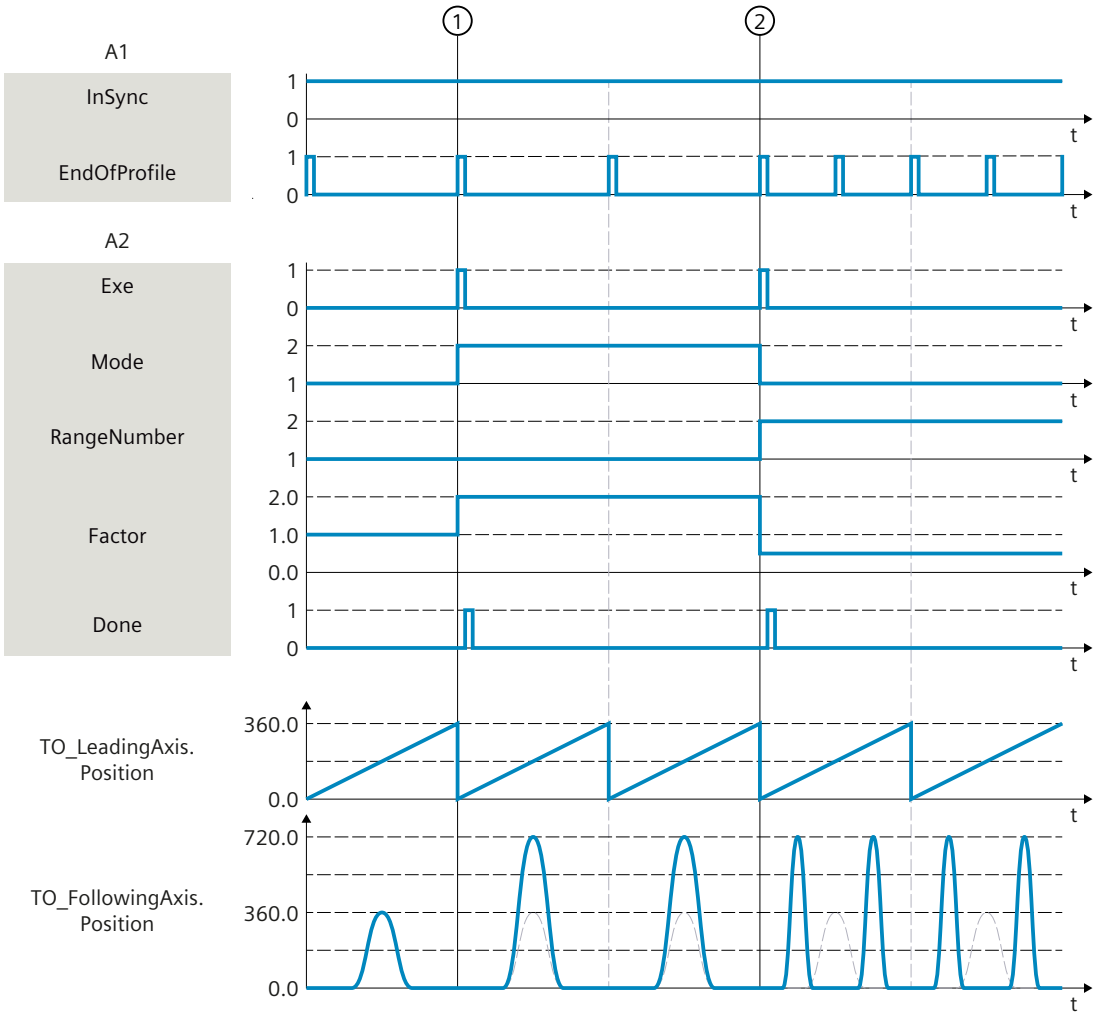

Camming with "MC_CamIn" (A1) is active ("InSync" = 1).

At time ①, "Exe" is used to initiate a "MC_SetCamRangeScaling" job (A2) with "RangeNumber" = 1. The cam is scaled in the scaling range from "RangeStartPoint" = 0.0 to "RangeEndPoint" = 360.0 by the scaling factor "Factor" = 2.0 in the following value range ("Mode" = 2). The scaling takes effect immediately.

At time ②, the "Exe" of the "MC_SetCamRangeScaling" job (A2) is initiated again with "RangeNumber" = 2. The cam is scaled in the scaling range from "RangeStartPoint" = 0.0 to "RangeEndPoint" = 360.0 by the scaling factor "Factor" = 0.5 in the leading value range ("Mode" = 1). The scaling in addition to the first scaling takes effect immediately.

13.3 Override response of Motion Control jobs V10

13.3.1 Override response V10: Homing and motion jobs

The following table shows how a new Motion Control job affects active homing and motion jobs:

⇒ Active job ⇓ New job	MC_Home "Mode" = 2-, 8, 10	MC_Home "Mode" = 3, 5	MC_Halt "Mode" = 1 MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 0, 1 active MC_Move-Velocity MC_MoveJog	MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 1 waiting	MC_Halt "Mode" = 0	MC_Stop	MC_Move-Super-imposed MC_Motion-InSuper-imposed MC_Motion-InSuper-imposed-Axes MC_Halt-Super-imposed	MC_Motion-InVelocity MC_Motion-InPosition
MC_Home[1)] "Mode" = 3, 5	A	A	A	A	A	N	A	A
MC_Home "Mode" = 9	A	-	-	-	-	N	-	-
MC_Halt "Mode" = 1	-	A	A	A	-	N	-	A
MC_Halt "Mode" = 0 **MC_MoveAbsolute/ MC_MoveRelative/ MC_PositionProfile** "BufferMode" = 0 Active **MC_MoveVelocity MC_MoveJog**	-	A	A	A	A	N	A	A

A The running job is aborted with "CommandAborted" = TRUE.

B An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) The status "Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE corresponds to a waiting synchronous operation.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) The status "Busy" = TRUE, "StartSyncOut" = FALSE corresponds to a pending desynchronization job.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) An "MC_CamIn" job with "SyncProfileReference" = 5 does not abort an "MC_[...]Superimposed" job. Running job continues to be executed.

⇒ Active job ⇓ New job	MC_Home "Mode" = 2-, 8, 10	MC_Home "Mode" = 3, 5	MC_Halt "Mode" = 1 MC_MoveAbsolute/ MC_MoveRelative/ MC_PositionProfile "BufferMode" = 0, 1 active MC_MoveVelocity MC_MoveJog	MC_MoveAbsolute/ MC_MoveRelative/ MC_PositionProfile "BufferMode" = 1 waiting	MC_Halt "Mode" = 0	MC_Stop	MC_MoveSuperimposed MC_MotionInSuperimposed MC_MotionInSuperimposedAxes MC_HaltSuperimposed	MC_MotionInVelocity MC_MotionInPosition
MC_MotionInVelocity MC_MotionInPosition								
MC_MoveAbsolute/ MC_MoveRelative/ MC_PositionProfile "BufferMode" = 1 active, waiting	N	N	-/N	N	N	N	-	N
MC_MoveSuperimposed MC_MotionInSuperimposed MC_MotionInSuperimposedAxes MC_HaltSuperImposed	-	-	-	-	-	N	A	-
MC_Stop	A	A	A	A	A	B	A	A
MC_GearIn MC_GearInVelocity	-	A	A	A	A	N	A	A
MC_GearInPos MC_CamIn waiting[2]	-	-	-	A	-	N	-	-
MC_GearInPos MC_CamIn active[3]	-	A	A	A	A	N	A[6]	A

A The running job is aborted with "CommandAborted" = TRUE.

B An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) The status "Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE corresponds to a waiting synchronous operation.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) The status "Busy" = TRUE, "StartSyncOut" = FALSE corresponds to a pending desynchronization job.

⇒ Active job ⇓ New job	MC_Home "Mode" = 2-, 8, 10	MC_Home "Mode" = 3, 5	MC_Halt "Mode" = 1 MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 0, 1 active MC_Move-Velocity MC_MoveJog	MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 1 waiting	MC_Halt "Mode" = 0	MC_Stop	MC_Move-Super-imposed MC_Motion-InSuper-imposed MC_Motion-InSuper-imposed-Axes MC_Halt-Super-imposed	MC_Motion-InVelocity MC_Motion-InPosition
MC_Leading-ValueAdditive	-	-	-	-	-	-	-	-
MC_GearOut MC_CamOut waiting[4]	N	N	N	N	N	N	-	N
MC_GearOut MC_CamOut active[5]	N	N	N	N	N	N	A	N

A The running job is aborted with "CommandAborted" = TRUE.

B An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) The status "Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE corresponds to a waiting synchronous operation.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) The status "Busy" = TRUE, "StartSyncOut" = FALSE corresponds to a pending desynchronization job.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) An "MC_CamIn" job with "SyncProfileReference" = 5 does not abort an "MC_[...]Superimposed" job. Running job continues to be executed.

NOTE

Override response with active fixed stop

With an active force and torque limiting with "MC_TorqueLimiting", running jobs are aborted if the drive is held at the fixed stop with "InClamping" = TRUE.

13.3.2 Override response V10: Synchronous operation jobs

The following table shows how a new Motion Control job affects the motion of the axis on active synchronous operation jobs:

⇒ Active job ⇓ New job	MC_GearIn	MC_GearInVelocity	MC_GearInPos MC_CamIn waiting[2]	MC_GearInPos MC_CamIn active[3]	MC_PhasingAbsolute MC_PhasingRelative	MC_OffsetAbsolute MC_OffsetRelative	MC_LeadingValueAdditive	MC_GearOut MC_CamOut waiting[4]	MC_GearOut MC_CamOut active[5]
MC_Home[1] "Mode" = 3, 5	A	A	-	N	-	-	-	-	A
MC_Halt "Mode" = 0, 1 **MC_MoveAbsolute/ MC_MoveRelative** "BufferMode" = 0 Active **MC_PositionProfile** "BufferMode" = 0 Active **MC_MoveVelocity** **MC_MoveJog**	A	A	-	A	A	A	-	A	A

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) A waiting synchronous operation job ("Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) A pending desynchronization job ("Busy" = TRUE, "StartSyncOut" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) When the following axis is in position-controlled mode, execution of the running job is continued. When the following axis is not in position-controlled mode, the new job is rejected.

7) An "MC_GearOut" job only terminates an "MC_Gear[...]" job. Correspondingly, an "MC_CamOut" job only cancels a "MC_Cam[...]" job.

8) A job with "SyncProfileReference" = 5 aborts a pending synchronous operation. Canceling a pending synchronous operation has no influence on an active synchronous operation.

⇒ Active job ⇓ New job	MC_GearIn	MC_GearInVelocity	MC_GearInPos MC_CamIn waiting[2]	MC_GearInPos MC_CamIn active[3]	MC_PhasingAbsolute MC_PhasingRelative	MC_OffsetAbsolute MC_OffsetRelative	MC_LeadingValueAdditive	MC_GearOut MC_CamOut waiting[4]	MC_GearOut MC_CamOut active[5]
MC_MoveAbsolute/-MC_MoveRelative "BufferMode" = 1 active, waiting **MC_PositionProfile** "BufferMode" = 1 active, waiting	N	N	-	N	N	N	-	N	N
MC_MotionInVelocity **MC_MotionInPosition**	A	A	-	A	A	A	-	A	A
MC_MoveSuperimposed **MC_MotionInSuperimposed** **MC_MotionInSuperimposedAxes** **MC_HaltSuperImposed**	-	-/N[6]	-	-	-	-	-	-	-
MC_Stop	A	A	A	A	A	A	-	A	A

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) A waiting synchronous operation job ("Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) A pending desynchronization job ("Busy" = TRUE, "StartSyncOut" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) When the following axis is in position-controlled mode, execution of the running job is continued. When the following axis is not in position-controlled mode, the new job is rejected.

7) An "MC_GearOut" job only terminates an "MC_Gear[...]" job. Correspondingly, an "MC_CamOut" job only cancels a "MC_Cam[...]" job.

8) A job with "SyncProfileReference" = 5 aborts a pending synchronous operation. Canceling a pending synchronous operation has no influence on an active synchronous operation.

⇒ Active job ⇓ New job	MC_GearIn	MC_GearInVelocity	MC_GearInPos MC_CamIn waiting[2]	MC_GearInPos MC_CamIn active[3]	MC_PhasingAbsolute MC_PhasingRelative	MC_OffsetAbsolute MC_OffsetRelative	MC_LeadingValueAdditive	MC_GearOut MC_CamOut waiting[4]	MC_GearOut MC_CamOut active[5]
MC_GearIn MC_GearInVelocity	A	A	A	A	A	A	-	A	A
MC_GearInPos MC_CamIn waiting[2]	-	-	A	-	-	-	-	A	-
MC_GearInPos MC_CamIn active[3]	A	A[6]	A	A	A	A	-	A	A
MC_PhasingAbsolute MC_PhasingRelative	-	N	-	-	A	N	-	-	N
MC_OffsetAbsolute MC_OffsetRelative	-	N	-	-	N	A	-	-	N
MC_LeadingValueAdditive	-	-	-	-	-	-	A	-	-
MC_GearOut MC_CamOut waiting[4]	-	N	A[7] [8]	-	-	-	-	A[7]	N
MC_GearOut MC_CamOut active[5]	A[7]	N	A[7] [8]	A[7]	A	A	-	A[7]	N

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) A waiting synchronous operation job ("Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) A pending desynchronization job ("Busy" = TRUE, "StartSyncOut" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) When the following axis is in position-controlled mode, execution of the running job is continued. When the following axis is not in position-controlled mode, the new job is rejected.

7) An "MC_GearOut" job only terminates an "MC_Gear[...]" job. Correspondingly, an "MC_CamOut" job only cancels a "MC_Cam[...]" job.

8) A job with "SyncProfileReference" = 5 aborts a pending synchronous operation. Canceling a pending synchronous operation has no influence on an active synchronous operation.

NOTE

Override response with active fixed stop

With an active force and torque limiting with "MC_TorqueLimiting", running jobs are aborted if the drive is held at the fixed stop with "InClamping" = TRUE.

13.3.3 Override response V10: Measuring input jobs

The following table shows which new Motion Control jobs will override active measuring input jobs:

⇒ **Active job** ⇓ **New job**	**MC_MeasuringInput**	**MC_MeasuringInputCyclic**
MC_Home "Mode" = 2, 3, 5, 8, 9, 10	B	B
MC_Home "Mode" = 0, 1, 6, 7, 11, 12	-	-
MC_MeasuringInput **MC_MeasuringInputCyclic** **MC_AbortMeasuringInput**	A	A

A The running job is aborted with "CommandAborted" = TRUE.

B The running job is aborted with "ErrorID" = 16#80A3.

- No effect. Running job continues to be executed.

13.3.4 Override response V10: Kinematics motion commands

Single axis jobs are not overridden by kinematics jobs.

The following table shows how a new Motion Control job affects active kinematics motion jobs:

⇒ **Active job** ⇓ **New job**	**MC_MoveLinearAbsolute** **MC_MoveLinearRelative** **MC_MoveCircularAbsolute** **MC_MoveCircularRelative** **MC_MoveDirectAbsolute** **MC_MoveDirectRelative** **MC_TrackConveyorBelt** **MC_DefineWorkspaceZone** **MC_DefineKinematicsZone** **MC_SetWorkspaceZoneActive** **MC_SetWorkspaceZoneInactive** **MC_SetKinematicsZoneActive** **MC_SetKinematicsZoneInactive** **MC_SetOcsFrame**	**MC_GroupInterrupt**	**MC_GroupStop**
MC_Home **MC_MoveSuperimposed** **MC_GearOut** **MC_CamOut**	N	N	N
MC_Halt **MC_MoveAbsolute/** **MC_MoveRelative/** **MC_PositionProfile** "BufferMode" = 0 Active **MC_MoveVelocity** **MC_MoveJog** **MC_Stop** **MC_GearIn** **MC_GearInPos** **MC_GearInVelocity** **MC_CamIn** **MC_MotionInVelocity** **MC_MotionInPosition**	A	A	A
MC_GroupStop	A	A	N
MC_GroupInterrupt **MC_GroupContinue**	B	A	N
MC_MoveLinearAbsolute **MC_MoveLinearRelative** **MC_MoveCircularAbsolute** **MC_MoveCircularRelative** **MC_MoveDirectAbsolute** **MC_MoveDirectRelative** **MC_TrackConveyorBelt**	-	-	N

⇒ Active job ⇓ New job	MC_MoveLinearAbsolute MC_MoveLinearRelative MC_MoveCircularAbsolute MC_MoveCircularRelative MC_MoveDirectAbsolute MC_MoveDirectRelative MC_TrackConveyorBelt MC_DefineWorkspaceZone MC_DefineKinematicsZone MC_SetWorkspaceZoneActive MC_SetWorkspaceZoneInactive MC_SetKinematicsZoneActive MC_SetKinematicsZoneInactive MC_SetOcsFrame	MC_GroupInterrupt	MC_GroupStop
MC_DefineWorkspaceZone MC_DefineKinematicsZone MC_SetWorkspaceZoneActive MC_SetWorkspaceZoneInactive MC_SetKinematicsZoneActive MC_SetKinematicsZoneInactive			
MC_SetOcsFrame	C, -	-	N

A The running job is aborted with "CommandAborted" = TRUE.

B Running job is interrupted or resumed.

C Synchronization of the OCS with the conveyor belt is aborted with "MC_SetOcsFrame" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed. A new kinematics job is added to the job sequence.

13.3.5 Override response V10: Interpreter jobs

The following table shows how a new Motion Control job affects running Interpreter jobs:

⇒ Active job ⇓ New job	MC_LoadProgram	MC_RunProgram	MC_StopProgram
MC_LoadProgram	N	N	N
MC_RunProgram	-[1]	N	N
MC_StopProgram	A	A	A[2]
MC_Reset	-/N[3]	-/N[3]	-/N[3]

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) The new job is also executed.

2) A new "MC_StopProgram" job with "Mode" = 0 cancels a running "MC_StopProgram" job with "Mode" = 1 or 2. A new "MC_StopProgram" job with "Mode" = 1 aborts a current "MC_StopProgram" job with "Mode" = 2.

3) An "MC_Reset" job with "Restart" = TRUE is rejected. Running job continues to be executed.

Override response for technology objects controlled by the Interpreter

The following table shows how a new Motion Control job acts in relation to a technology object controlled by the Interpreter during the execution of an Interpreter program ("<TO>.StatusInterpreterMotion.StatusWord.X0" = TRUE (ControlledByInterpreter)):

⇓ New job	The new job will be executed.	The new job aborts the execution of the Interpreter program.
MC_Power disable/enable with technology object	✓	✓
MC_Reset with "Restart" = TRUE	✓	✓
MC_Reset with "Restart" = FALSE	✓	-
MC_Home **MC_Halt** **MC_Stop**	✓	✓
MC_MoveAbsolute **MC_MoveRelative** **MC_MoveVelocity** **MC_MoveJog**	✓	✓
MC_SetAxisSTW **MC_WriteParameter**	✓	-
MC_MoveSuperimposed **MC_MotionInSuperimposed** **MC_MotionInSuperimposedAxes** **MC_HaltSuperimposed**	-	-
MC_MotionInVelocity **MC_MotionInPosition**	✓	✓
MC_GearIn **MC_GearInPos** **MC_GearInVelocity** **MC_GearOut** **MC_CamIn** **MC_CamOut**	✓	✓[1)]
MC_PhasingRelative **MC_PhasingAbsolute**	-	-
MC_LeadingValueAdditive	✓	-
MC_OffsetRelative **MC_OffsetAbsolute**	-	-
MC_TorqueAdditive **MC_TorqueRange**	✓	-
MC_TorqueLimiting	✓	-/✓[2)]
MC_SynchronizedMotionSimulation	✓	-

1) When the synchronization/desynchronization starts, the execution of the Interpreter program is cancelled.

2) If a technology alarm is issued due to a fixed stop, the execution of the Interpreter program is cancelled.

⇓ New job	The new job will be executed.	The new job aborts the execution of the Interpreter program.
MC_MoveLinearAbsolute **MC_MoveLinearRelative** **MC_MoveCircularAbsolute** **MC_MoveCircularRelative** **MC_MoveDirectAbsolute** **MC_MoveDirectRelative**	-	-
MC_GroupInterrupt **MC_GroupContinue**	-	-
MC_GroupStop	✓	✓
MC_KinematicsMotionSimulation	✓	-
MC_TrackConveyorBelt	-	-
MC_DefineTool **MC_SetTool** **MC_SetOcsFrame**	-	-
MC_KinematicsTransformation **MC_InverseKinematicsTransformation**	✓	-
MC_DefineWorkspaceZone **MC_SetWorkspaceZoneActive** **MC_SetWorkspaceZoneInactive** **MC_DefineKinematicsZone** **MC_SetKinematicsZoneActive** **MC_SetKinematicsZoneInactive**	-	-

1) When the synchronization/desynchronization starts, the execution of the Interpreter program is cancelled.

2) If a technology alarm is issued due to a fixed stop, the execution of the Interpreter program is cancelled.

NOTE

MC_Power

Note that a "MC_Power" request with "Enable" = FALSE always locks the specified technology object, even if the technology object was enabled via an Interpreter program with "powerOn()".

Mixed operation of MC_Power (SCL) and powerOn() (MCL) is not permitted.

NOTE

MC_Stop

Note that when starting a motion controlled by the Interpreter no "MC_Stop" job may be active, otherwise the motion job will be aborted.

NOTE

MC_GroupStop

Note that when starting a kinematics motion controlled by the Interpreter, no "MC_GroupStop" job may be active, otherwise the motion job will be aborted.

A "MC_GroupStop" job only affects active kinematics motions or if the kinematics technology object is controlled by the Interpreter ("<TO>.StatusInterpreterMotion.StatusWord.X0" = TRUE (ControlledByInterpreter)).

See also

Override response V10: Homing and motion jobs (Page %getreference)
Override response V10: Synchronous operation jobs (Page %getreference)
Override response V10: Kinematics motion commands (Page %getreference)

Tags of the technology object data blocks 14

14.1 Legend

Tag	Name of the tag	
Data type	Data type of the tag	
Values	Value range of the tag - minimum value to maximum value (L - linear specification R - rotary specification) If no specific value is shown, the value range limits of the relevant data type apply or the information under "Description".	
W	Effectiveness of changes in the technology data block	
	DIR	Direct: Values are changed via direct assignment and take effect at the start of the next MC_Servo.
	CAL	At call of Motion Control instruction: Values are changed directly and take effect at the start of the next MC_Servo after the call of the corresponding Motion Control instruction in the user program.
	RES	Restart: Changes to the start value in the load memory are made using the extended instruction "WRIT_DBL" (write to DB in load memory). Changes will not take effect until after restart of the technology object.
	RON	Read only: The tag cannot and must not be changed during runtime of the user program.
Description	Description of the tag	

Access to the tags is with "<TO>.<tag name>". The placeholder <TO> represents the name of the technology object.

14.2 Tags of the synchronous axis technology object

14.2.1 Actual values and setpoints (synchronous axis)

The following tags indicate the setpoint and actual values of the technology object.

Tags

Legend

Tag	Data type	Values	W	Description
Position	LREAL	-	RON	Position setpoint
Velocity	LREAL	-	RON	Setpoint velocity or speed setpoint
ActualPosition	LREAL	-	RON	Actual position
ActualVelocity	LREAL	-	RON	Actual velocity

Tag	Data type	Values	W	Description	
ActualSpeed	LREAL	-	RON	For PROFIdrive drives	Actual speed of the motor
				For drives with analog setpoint interface	0.0
				For drives with linear motor	0.0
Acceleration	LREAL	-	RON	Setpoint acceleration	
ActualAcceleration	LREAL	-	RON	Actual acceleration	
OperativeSensor	UDINT	1 ... 4	RON	Operative encoder	
ModuloCycle	DINT	-2147483648 ... 2147483647	RON	Number of modulo cycles of the setpoint	
ActualModuloCycle	DINT	-2147483648 ... 2147483647	RON	Number of modulo cycles of the actual value	
VelocitySetpoint	LREAL	-1.0E12 ... 1.0E12	RON	Output setpoint velocity or setpoint rpm	

14.2.2 "Simulation" tag (synchronous axis)

The tag structure "<TO>.Simulation.<tag name>" contains the configuration of the simulation mode. In simulation mode, you can simulate axes without a real drive in the CPU.

Tags

Legend

Tag	Data type	Values	W	Description	
Simulation.	TO_Struct_AxisSimulation				
Mode	UDINT	0, 1	RES[1)]	Simulation mode	
				0	No simulation, normal operation
				1	Simulation mode

1) Technology version V2.0: RON

14.2.3 "VirtualAxis" tag (synchronous axis)

The tag structure "<TO>.VirtualAxis.<tag name>" contains the configuration of the virtual operation of the axis. A virtual axis is often used as a virtual leading axis in order to generate the setpoints for several real following axes in synchronous operation.

Tags

Legend

Tag	Data type	Values	W	Description	
VirtualAxis.	TO_Struct_VirtualAxis				
Mode	UDINT	0, 1	RON	Virtual axis	
				0	No virtual axis

Tag	Data type	Values	W	Description	
Mode	UDINT	0, 1	RON	1	Technology version ≤ V7.0: The behavior of a virtual axis is identical to the behavior of an axis in simulation. The actual values are generated via the control loop and a simplified drive model. Technology version ≥ V8.0: In technology version V8.0, the behavior of the virtual axis has been changed. The behavior of a virtual axis is no longer identical to the behavior of an axis in simulation. The position and velocity setpoints are directly adopted as actual values with an application cycle delay. The feedback loop and the drive model are not simulated. The dynamic filter is effective. To maintain compatibility with virtual axes of technology versions ≤ V7.0 for an axis: 1. Switch on the axis in simulation (<TO>.Simulation.Mode = 1). 2. Deactivate the virtual axis (<TO>.VirtualAxisMode = 0).

14.2.4 "Actor" tag (synchronous axis)

The tag structure "<TO>.Actor.<tag name>" contains the controller-side configuration of the drive.

Tags

Legend

Tag	Data type	Values	W	Description	
Actor.	TO_Struct_Actor				
Type	DINT	0, 1	RON	Drive connection	
				0	Analog output
				1	PROFIdrive telegram
InverseDirection	BOOL	-	RES	Inversion of the setpoint	
				FALSE	No
				TRUE	Yes
DataAdaption	DINT	0, 1	RES	Automatic transfer of the drive values reference speed, maximum speed and reference torque	
				0	No automatic transfer, manual configuration of values
				1	Automatic transfer of values configured in the drive to the configuration of the technology object
Efficiency	LREAL	0.0 to 1.0	RES	Efficiency of mechanics (gear and leadscrew)	

[1] With the Motion Control instruction "MC_WriteParameter", you can change the "Actor.RemoveEnableReaction" parameter during runtime. The change takes effect directly.

Tag	Data type	Values	W	Description	
MotorType	DINT	0.1	DL	Motor type	
				0	Round-frame motor (standard motor)
				1	Linear motor
LoadInertia	LREAL	0.0 to 1.0E12	DIR	Moment of inertia or weight of the load	
RemoveEnableReaction	WORD	16#0...16#7	RES[1]	Stop reaction on "Remove enable"	
				16#1	OFF1 – Ramp stop - Braking with ramp-function generator
				16#3	OFF2 – Coast stop - Coast down
				16#5	OFF3 – Quick stop - Quick stop
				16#7	OFF3 – Quick stop (compatible configuration for technology versions up to V7)
				16#0 16#2 16#4 16#6	Invalid
Interface.	TO_Struct_ActorInterface				
AddressIn	VREF	0 to 65535	RON	Input address for the PROFIdrive telegram	
AddressOut	VREF	0 to 65535	RON	Output address for the PROFIdrive telegram or the analog setpoint	
EnableDriveOutput	BOOL	-	RES	"Enable output" for analog drives	
				FALSE	Disabled
				TRUE	Enabled
EnableDriveOutput-Address	VREF	0 to 65535	RON	Address for the "Enable output" for analog setpoint	
DriveReadyInput	BOOL	-	RES	"Ready input" for analog drives The analog drive signals its readiness to receive speed set-points.	
				FALSE	Disabled
				TRUE	Enabled
DriveReadyInput-Address	VREF	0 to 65535	RON	Address for the "Enable input" for analog setpoint	
EnableTorqueData	BOOL	-	RES	Torque data	
				FALSE	Disabled
				TRUE	Enabled
TorqueDataAddressIn	VREF	0 to 65535	RON	Input address of the supplemental telegram	
TorqueDataAddress-Out	VREF	0 to 65535	RON	Output address of additional telegram	
DriveParameter.	TO_Struct_ActorDriveParameter			Valid when "<TO>.Actor.MotorType" = 0	

[1] With the Motion Control instruction "MC_WriteParameter", you can change the "Actor.RemoveEnableReaction" parameter during runtime. The change takes effect directly.

Tag	Data type	Values	W	Description
ReferenceSpeed	LREAL	0.0 to 1.0E12	RES	Reference value (100%) for the speed setpoint (N-set) of the drive The speed setpoint is transferred in the PROFIdrive telegram as a normalized value from -200% to 200% of the "ReferenceSpeed". For setpoint specification via an analog output, the analog output can be operated in the range from -117% to 117%, provided the drive permits this.
MaxSpeed	LREAL	0.0 to 1.0E12	RES	Maximum value for the speed setpoint of the drive (N-set) (PROFIdrive: MaxSpeed ≤ 2 × ReferenceSpeed Analog setpoint: MaxSpeed ≤ 1.17 × ReferenceSpeed)
ReferenceTorque	LREAL	0.0 to 1.0E12	RES	Reference value (100%) for the drive torque
MotorInertia	LREAL	0.0 to 1.0E12	DIR	Moment of inertia of the motor
LinearMotorDrivePara-meter.	TO_Struct_LinearMotorActorDrive-Parameter			Valid when "<TO>.Actor.MotorType" = 1
ReferenceVelocity	LREAL	0.0 to 1.0E12	RES	Reference value (100%) for the velocity setpoint (N-set) of the drive The speed setpoint is transferred in the PROFIdrive telegram as a normalized value from -200% to 200% of the "ReferenceVelocity". For setpoint specification via an analog output, the analog output can be operated in the range from -117% to 117%, provided the drive permits this.
MaxVelocity	LREAL	0.0 to 1.0E12	RES	Maximum value for the velocity setpoint of the drive (N-set) (PROFIdrive: MaxVelocity ≤ 2 × ReferenceVelocity Analog setpoint: MaxVelocity ≤ 1.17 × ReferenceVelocity)
ReferenceForce	LREAL	0.0 to 1.0E12	RES	Reference value (100%) for the force of the drive
MotorMass	LREAL	0.0 to 1.0E12	DIR	Mass of linear motor

[1] With the Motion Control instruction "MC_WriteParameter", you can change the "Actor.RemoveEnableReaction" parameter during runtime. The change takes effect directly.

14.2.5 "TorqueLimiting" tag (synchronous axis)

The tag structure "<TO>.TorqueLimiting.<tag name>" contains the configuration of the force/torque limitation.

Tags

Legend

Tag	Data type	Values	W	Description	
TorqueLimiting.	TO_Struct_TorqueLimiting				
LimitBase	DINT	0, 1	RES	Force/torque limiting	
				0	Motor side
				1	Load side
				Setting is not relevant for linear motors.	

Tag	Data type	Values	W	Description	
PositionBasedMonitor-ings	DINT	0, 1	RES	Positioning and following error monitoring	
				0	Monitoring deactivated
				1	Monitoring activated
LimitDefaults.	TO_Struct_TorqueLimitingLimitDe-faults				
Torque	LREAL	0.0 ... 1.0E12	CAL	Limiting torque	
Force	LREAL	0.0 ... 1.0E12	CAL	Limiting force	

14.2.6 "Clamping" tag (synchronous axis)

The tag structure "<TO>.Clamping.<tag name>" contains the configuration of the fixed stop detection.

Tags

Legend

Tag	Data type	Values	W	Description
Clamping.	TO_Struct_Clamping			
FollowingErrorDeviation	LREAL	0.001 to 1.0E12	DIR	Value of the following error starting from which the fixed stop is detected.
PositionTolerance	LREAL	0.001 to 1.0E12	DIR	Position tolerance for clamping monitoring

14.2.7 "Sensor[1..4]" tags (synchronous axis)

The tag structure "<TO>.Sensor[1..4].<tag name>" contains the controller-end configuration of the encoder and the configuration of active and passive homing.

Tags

Legend

Tag	Data type	Values	W	Description	
Sensor[1..4].	ARRAY [1..4] OF TO_Struct_Sensor				
Existent	BOOL	-	RON	Displaying created encoders	
Type	DINT	0 to 2	RON	Encoder type	
				0	"INCREMENTAL" Incremental
				1	"ABSOLUTE" Absolute
				2	"CYCLIC_ABSOLUTE" Cyclic absolute
InverseDirection	BOOL	-	RES	Inversion of the actual value	
				FALSE	No

Tag	Data type	Values	W	Description	
InverseDirection	BOOL	-	RES	TRUE	Yes
System	DINT	0, 1	RES	Encoder system	
				0	"LINEAR" Linear encoder
				1	"ROTATORY" Rotary encoder
MountingMode	DINT	0 to 2	RES	Mounting type of encoder	
				0	On motor shaft
				1	On load side
				2	External measuring system
DataAdaption	DINT	0, 1	RES	Automatic transfer of the drive values reference speed, maximum speed and reference torque in the device	
				0	No automatic transfer, manual configuration of values
				1	Automatic transfer of values configured in the drive to the configuration of the technology object
ActualVelocityMode	DINT	0, 1	RES	Type of calculation for actual speed value or actual velocity value	
				0	Actual value calculation from differentiation of the position change
				1	Actual value calculation with NACT value from the PROFIdrive telegram
Interface.	TO_Struct_SensorInterface				
AddressIn	VREF	0 to 65535	RON	Input address for the PROFIdrive telegram	
AddressOut	VREF	0 to 65535	RON	Output address for the PROFIdrive telegram	
Number	UDINT	1 to 2	RON	Number of the encoder in the telegram	
Parameter.	TO_Struct_SensorParameter				
Resolution	LREAL	1.0E-12 ... 1.0E12	RES	Resolution of a linear encoder (offset between two encoder pulses)	
StepsPerRevolution	UDINT	1 to 8388608	RES	Increments per rotary encoder revolution	
FineResolutionXist1	UDINT	0 to 31	RES	Number of bits for fine resolution "Gx_XIST1" (cyclic actual encoder value)	
FineResolutionXist2	UDINT	0 to 31	RES	Number of bits for fine resolution "Gx_XIST2" (absolute value of the encoder)	
DeterminableRevolu-tions	UDINT	0 to 8388608	RES	Number of differentiable encoder revolutions for a multi-turn absolute encoder (For a single-turn absolute encoder = 1; for an incremental encoder = 0)	
DistancePerRevolution	LREAL	0.0 to 1.0E12	RES	For technology objects < V8.0: Load distance per revolu-tion of an externally mounted encoder For technology objects >= V8.0: Load travel per measuring wheel revolution of an externally mounted encoder	

Tag	Data type	Values	W	Description	
BehaviorGx_XIST1	DINT	0, 1	RES	Evaluation of "Gx_XIST1" bits.	
				0	Based on the bits of the encoder resolution. The incremental actual value "Gx_XIST1" is transmitted with less than 32 bits in the PROFIdrive telegram. For example: At 16 bits, the value ranges from 0 to 65,535.
				1	32-bit value of the encoder value The "Gx_XIST1" incremental actual value is transferred with 32 bits of 0 to 4,294,967,295 in the PROFIdrive telegram.
ReferenceSpeed	LREAL	0.0 to 1.0E12	RES	Reference speed for NACT in PROFIdrive telegram with rotary encoder Only relevant for "ActualVelocityMode" = 1	
ReferenceVelocity	LREAL	0.0 to 1.0E12	RES	Reference velocity for NACT in the PROFIdrive telegram with linear encoder Only relevant for "ActualVelocityMode" = 1	
Backlash.	TO_Struct_Backlash				
Enable	BOOL	-	DIR	Enable backlash compensation	
				FALSE	Disabled
				TRUE	Enabled
				If you enable or disable backlash compensation at runtime, you must home the axis again.	
Size	LREAL	0.0 to 1.0E12	DIR	Size of backlashes	
				If you change the size of backlashes during runtime, you have to home the axis again.	
Velocity	LREAL	0.0 to 1.0E12	DIR	Velocity for traversing of backlashes	
				0.0	Motor traverses backlashes within one servo cycle.
				> 0.0	Motor traverses backlash with the specified velocity.
DirectionAbsolute-Homing	DINT	0, 1	DIR	Direction of movement during or before absolute encoder adjustment	
				0	Positive
				1	Negative
ActiveHoming.	TO_Struct_SensorActiveHoming				
Mode	DINT	0 to 2	RES	Homing mode	
				0	Use zero mark via PROFIdrive telegram
				1	Zero mark via PROFIdrive telegram and reference output cam
				2	Use homing mark via digital input
SideInput	BOOL	-	CAL	Side of the digital input for active homing	
				FALSE	Negative side
				TRUE	Positive side
Direction	DINT	0, 1	CAL	Homing direction or homing mark approach direction	

Tag	Data type	Values	W	Description	
Direction	DINT	0, 1	CAL	0	Positive homing direction
				1	Negative homing direction
DigitalInputAddress	VREF	0 to 65535	RON	Address of digital input	
HomePositionOffset	LREAL	-1.0E12 ... 1.0E12	CAL	Home position offset	
SwitchLevel	BOOL	-	RES	Signal level that is present at the digital input when homing mark is approached	
				FALSE	Low level
				TRUE	High level
PassiveHoming.	TO_Struct_SensorPassiveHoming				
Mode	DINT	0 to 2	RES	Homing mode	
				0	Use zero mark via PROFIdrive telegram
				1	Zero mark via PROFIdrive telegram and reference output cam
				2	Use homing mark via digital input
SideInput	BOOL	-	CAL	Side of the digital input for passive homing	
				FALSE	Negative side
				TRUE	Positive side
Direction	DINT	0 to 2	CAL	Homing direction or homing mark approach direction	
				0	Positive homing direction
				1	Negative homing direction
				2	Current homing direction
DigitalInputAddress	VREF	0 to 65535	RON	Address of digital input	
SwitchLevel	BOOL	-	RES	Signal level that is present at the digital input when homing mark is approached	
				FALSE	Low level
				TRUE	High level
MeasuringGear.	TO_Struct_SensorMeasuringGear				
Numerator	UDINT	1 to 4294967295	RES	Default value 1. For “MountingMode” = Motor side (0): Specifies the counter of the gear ratio for a measuring wheel for motor-mounted encoders. Number of motor revolutions. For “MountingMode” = Load side (1): Specifies the counter of the gear ratio for a measuring gearwheel for load-mounted encoders. Number of load revolutions. For “MountingMode” = External (2): Specifies the counter of the gear ratio for a measuring gearwheel for externally mounted encoders. Number of revolutions of the measuring wheel.	

Tag	Data type	Values	W	Description
Denominator	UDINT	1 to 4294967295	RES	Specifies the denominator of the gear wheel for a measuring wheel. It depends on "MountingMode". Number of encoder revolutions.

14.2.8 "CrossPlcSynchronousOperation" tag (synchronous axis)

The tag structure "<TO>.CrossPlcSynchronousOperation.<tag name>" contains the configuration of the cross-PLC synchronous operation.

Tags

Legend

Tag	Data type	Values	W	Description	
CrossPlcSynchronousOperation.	TO_Struct_CrossPlcSynchronousOperation				
Interface[1..32].	ARRAY [1..32] of TO_Struct_CrossPlcLeadingValueInterface				
EnableLeadingValueOutput	BOOL	-	RON	Provide cross-PLC leading value	
				FALSE	No
				TRUE	Yes
AddressOut	VREF	-	RON	Output address for the leading value telegram	
TelegramVersion	WORD	1, 2	RON	Leading value telegram version	

Tag	Data type	Values	W	Description	
TelegramVersion	WORD	1, 2	RON	1	Version 1 (technology version ≤ 8.0 and ≥ 10.0)
				2	Version 2 (technology version ≥ 9.0)
LocalLeadingValueDelay-Time	LREAL	0.0 to 1.0E9	RES	Delay time of leading value output to the local following axes	

14.2.9 "Extrapolation" tag (synchronous axis)

The tag structure "<TO>.Extrapolation.<tag name>" contains the configuration of the actual value extrapolation.

Tags

Legend

Tag	Data type	Values	W	Description	
Extrapolation.	TO_Struct_Extrapolation				
LeadingAxisDependent-Time	LREAL	-	RON	Extrapolation time component (caused by leading axis) Results from the following times: • Time of actual value acquisition for the leading axis • Interpolator cycle clock • Time of position filter of actual value extrapolation (T1 + T2)	
FollowingAxisDepend-entTime	LREAL	0.0 to 1.0E12	DIR	Extrapolation time component (caused by following axis) For a following axis with set velocity precontrol, the following times result in: • Communication cycle • Interpolator cycle clock • Speed control loop substitute time for the following axis • Output delay time of the setpoint at the following axis For a following axis without velocity precontrol, the following times result in: • Communication cycle • Interpolator cycle clock • Position control loop equivalent time (1/Kv from "<TO>.PositionControl.Kv") • Output delay time of the setpoint at the following axis	
Settings.	TO_Struct_ExtrapolationSettings				
SystemDefinedExtra-polation	DINT	0, 1	RES	Leading axis dependent time	
				0	Not effective
				1	Effective
ExtrapolatedVelocity-Mode	DINT	0, 1, 2	RES	Effective velocity value for the synchronization function	
				0	Filtered velocity Leading value velocity from filtered actual velocity
				1	Extrapolated velocity Leading value velocity from extrapolation

Tag	Data type	Values	W	Description	
ExtrapolatedVelocity-Mode	DINT	0, 1, 2	RES	2	Differentiated velocity Leading value velocity from differentiation of the extrapolated leading value position
PositionFilter.	TO_Struct_ExtrapolationPositionFilter				
T1	LREAL	0.0 to 1.0E12	DIR	Position filter time constant T1	
T2	LREAL	0.0 to 1.0E12	DIR	Position filter time constant T2	
VelocityFilter.	TO_Struct_ExtrapolationVelocityFilter				
T1	LREAL	0.0 to 1.0E12	DIR	Velocity filter time constant T1	
T2	LREAL	0.0 to 1.0E12	DIR	Velocity filter time constant T2	
VelocityTolerance.	TO_Struct_ExtrapolationVelocityTolerance				
Range	LREAL	0.0 to 1.0E12	DIR	Tolerance band width for velocity	
Hysteresis.	TO_Struct_ExtrapolationHysteresis				
Value	LREAL	0.0 to 1.0E12	DIR	Hysteresis of the extrapolated actual position value	

14.2.10 "SynchronizedMotion" tag (synchronous axis)

The tag structure "<TO>.SynchronizedMotion.<tag name>" contains the configuration for the reverse tolerance of the leading value.

Tags

Legend

Tag	Data type	Value range	W	Description	
SynchronizedMotion.	TO_Struct_SynchronizedMotion				
LeadingValueReversalTolerance	LREAL	0.0 to 1.0E12	DIR	Reverse tolerance of the leading value during synchronization and desynchronization in length unit of the axis	
LeadingValueToleranceDirection	DINT	1 to 3	DIR	Tolerated leading value direction to leave the tolerance range	
				1	Positive
				2	Negative
				3	Positive and negative

14.2.11 "LoadGear" tag (synchronous axis)

The tag structure "<TO>.LoadGear.<tag name>" contains the configuration of the load gear.

Tags

Legend

Tag	Data type	Value range	W	Description
LoadGear.	TO_Struct_LoadGear			
Numerator	UDINT	1 to 4294967295	RES	Load gear numerator
Denominator	UDINT	1 to 4294967295	RES	Load gear denominator

14.2.12 "Properties" tag (synchronous axis)

The tag structure "<TO>.Properties.<tag name>" contains the configuration of the type of axis or motion.

Tags

Legend

Tag	Data type	Value range	W	Description	
Properties.	TO_Struct_Properties				
MotionType	DINT	0, 1	RON	Indication of axis type or motion type	
				0	Linear axis or motion
				1	Rotary axis or motion

14.2.13 "Units" tag (synchronous axis)

The tag structure "<TO>.Units.<tag name>" shows the set technological units.

Tags

Legend

Tag	Data type	Values	W	Description	
Units.	TO_Struct_Units / TO_Struct_ExternalEncoder_Units				
LengthUnit	UDINT	-	RON	Unit for position	
				1010	m
				1013	mm
				1536	mm[1)]
				1011	km

1) Position values with higher resolution or six decimal places

Tag	Data type	Values	W	Description	
LengthUnit	UDINT	-	RON	1014	µm
				1015	nm
				1019	in
				1018	ft
				1021	mi
				1004	rad
				1005	°
				1537	°[1]
VelocityUnit	UDINT	-	RON	Unit for velocity	
				1521	°/s
				1539	°/s[1]
				1522	°/min
				1086	rad/s
				1523	rad/min
				1062	mm/s
				1538	mm/s[1]
				1061	m/s
				1524	mm/min
				1525	m/min
				1526	mm/h
				1063	m/h
				1527	km/min
				1064	km/h
				1066	in/s
				1069	in/min
				1067	ft/s
				1070	ft/min
				1075	mi/h
TimeUnit	UDINT	-	RON	Unit for time	
				1054	s
TorqueUnit	UDINT	-	RON	Unit for torque	
				1126	Nm
				1128	kNm
				1529	lbf in (pound-force-inch)
				1530	lbf ft
				1531	ozf in (ounce-force-inch)
				1532	ozf ft
				1533	pdl in (poundal-inch)

[1] Position values with higher resolution or six decimal places

Tag	Data type	Values	W	Description	
TorqueUnit	UDINT	-	RON	1534	pdl ft
ForceUnit	UDINT	-	RON	Unit for force	
				1120	N
				1122	kN
				1094	lbf (pound-force)
				1093	ozf (ounce-force)
				1535	pdl (poundals)
MassUnit	UDINT	-	RON	Unit for mass	
				1088	kg
				1089	g
				1090	mg
				1092	t
				1540	lb
IneritaUnit	UDINT	-	RON	Unit for moment of inertia	
				1118	kg·m²
				1541	lb·ft²

1) Position values with higher resolution or six decimal places

See also

Units of measure (Page %getreference)

14.2.14 "Mechanics" tag (synchronous axis)

The tag structure "<TO>.Mechanics.<tag name>" contains the configuration of the mechanics.

Tags

Legend

Tag	Data type	Value range	W	Description
Mechanics.	TO_Struct_Mechanics			
LeadScrew	LREAL	1.0E-12 to 1.0E12	RES	Leadscrew pitch

14.2.15 "Modulo" tag (synchronous axis)

The tag structure "<TO>.Modulo.<tag name>" contains the configuration of the modulo function.

Tags

Legend

Tag	Data type	Values	W	Description	
Modulo.	TO_Struct_Modulo				
Enable	BOOL	-	RES	FALSE	Modulo conversion disabled
				TRUE	Modulo conversion enabled
Length	LREAL	0.001 to 1.0E12	RES	Modulo length When modulo conversion is enabled, a check is made for modulo length > 0.0	
StartValue	LREAL	-1.0E12 to 1.0E-12	RES	Modulo start value	

14.2.16 "DynamicLimits" tag (synchronous axis)

The tag structure "<TO>.DynamicLimits.<tag name>" contains the configuration of the dynamic limits. During Motion Control, no dynamic values greater than the dynamic limits are permitted. If you specify greater values in a Motion Control instruction, then motion is performed using the dynamic limits, and a warning is indicated (alarm 501 to 503 - Dynamic values are limited).

Tags

Legend

Tag	Data type	Values	W	Description
DynamicLimits.	TO_Struct_DynamicLimits			
MaxVelocity	LREAL	0.0 to 1.0E12	RES	Maximum permissible velocity of the axis
Velocity	LREAL	0.0 to 1.0E12	DIR	Current maximum velocity of the axis The minimum from "MaxVelocity" and "Velocity" is effective for motion control.
MaxAcceleration	LREAL	0.0 to 1.0E12	DIR	Maximum permissible acceleration of the axis
MaxDeceleration	LREAL	0.0 to 1.0E12	DIR	Maximum permissible deceleration of the axis
MaxJerk	LREAL	0.0 to 1.0E12	DIR	Maximum permissible jerk on the axis

14.2.17 "DynamicDefaults" tag (synchronous axis)

The tag structure "<TO>.DynamicDefaults.<tag name>" contains the configuration of the dynamic defaults. These settings will be used when you specify a dynamic value less than 0.0 in a Motion Control instruction (exceptions: "MC_MoveJog.Velocity", "MC_MoveVelocity.Velocity"). Changes to the default dynamic values will be applied at the next positive edge at the "Execute" parameter of a Motion Control instruction.

Tags

Legend

Tag	Data type	Values	W	Description
DynamicDefaults.	TO_Struct_DynamicDefaults			
Velocity	LREAL	0.0 to 1.0E12	CAL	Default velocity
Acceleration	LREAL	0.0 to 1.0E12	CAL	Default acceleration
Deceleration	LREAL	0.0 to 1.0E12	CAL	Default deceleration
Jerk	LREAL	0.0 to 1.0E12	CAL	Default jerk
EmergencyDecelera-tion	LREAL	0.0 to 1.0E12	DIR	Emergency stop deceleration

14.2.18 "PositionLimits_SW" tag (synchronous axis)

The tag structure "<TO>.PositionLimits_SW.<tag name>" contains the configuration of position monitoring with software limit switches. Software limit switches are used to limit the operating range of a synchronous axis.

Tags

Legend

Tag	Data type	Values	W	Description	
PositionLimits_SW.	TO_Struct_PositionLimitsSW				
Active	BOOL	-	DIR	FALSE	Monitoring deactivated
				TRUE	Monitoring activated
MinPosition	LREAL	-1.0E12 ... 1.0E12	DIR	Position of negative software limit switches	
MaxPosition	LREAL	-1.0E12 ... 1.0E12	DIR	Position of positive software limit switches ("MaxPosition" > "MinPosition")	
LimitReachedBehavior	DINT	0 ... 1	RES	Alarm response when a software limit switch is approached with a single axis job	
				0	Stop with maximum dynamic values
				1	Stop with current dynamic values
LimitExceededBehavior	DINT	0 ... 1	RES	Alarm response when overrunning a software limit switch	
				0	Lock axis
				1	Keep emergency stop and axis enable

14.2.19 "PositionLimits_HW" tag (synchronous axis)

The tag structure "<TO>.PositionLimits_HW.<tag name>" contains the configuration of position monitoring with hardware limit switches. Hardware limit switches are used to limit the traversing range of a synchronous axis.

Tags

Legend

Tag	Data type	Values	W	Description	
PositionLimits_HW.	TO_Struct_PositionLimitsHW				
Active	BOOL	-	RES[1]	FALSE	Monitoring deactivated
				TRUE	Monitoring activated
				With "Active", both (negative and positive) hardware limit switches are activated or deactivated.	
MinSwitchLevel	BOOL	-	RES	Level selection for activation of the negative hardware limit switch	
				FALSE	Low level (Low active)
				TRUE	High level (High active)
MinSwitchAddress	VREF	0 ... 65535	RES	Address for the negative hardware limit switch	
MaxSwitchLevel	BOOL	-	RES	Level selection for activation of the positive hardware limit switch	
				FALSE	Low level (Low active)
				TRUE	High level (High active)
MaxSwitchAddress	VREF	0 ... 65535	RES	Address for the positive hardware limit switch	
Mode	DINT	0 ... 1	RES	Type of HW limit switch	
				0	Switch non-traversable
				1	Switch traversable
AppoachBehavior	DINT	0 ... 1	RES	Alarm response when approaching a HW limit switch	
				0	Disable axis
				1	Keep emergency stop and axis enable

[1] With the Motion Control instruction "MC_WriteParameter", you can change the "PositionLimits_HW.Active" parameter at runtime. The change takes effect directly.

See also

MC_WriteParameter: Write parameter V10 (Page %getreference)

14.2.20 "Homing" tag (synchronous axis)

The tag structure "<TO>.Homing.<tag name>" contains the configuration for homing the TO.

Tags

Legend

Tag	Data type	Values	W	Description	
Homing.	TO_Struct_Homing / TO_Struct_ExternalEncoder_Homing				
AutoReversal	BOOL	-	RES	Reversal at the hardware limit switches	
				FALSE	No
				TRUE	Yes
ApproachDirection	BOOL	-	CAL	Direction of approach to the homing position switch	
				FALSE	Positive direction
				TRUE	Negative direction
ApproachVelocity	LREAL	Linear: 0.0 to 10000.0 mm/s	CAL	Approach velocity Velocity during active homing at which the reference output cam and home position are approached.	
		Rotary: 0.0 to 360000.0 °/s			
ReferencingVelocity	LREAL	Linear: 0.0 to 1000.0 mm/s	CAL	Homing velocity Velocity during active homing at which the home position is approached.	
		Rotary: 0.0 to 36000.0 °/s			
HomePosition	LREAL	-1.0E12 to 1.0E12	CAL	Home position	

14.2.21 "Override" tag (synchronous axis)

The tag structure "<TO>.Override.<tag name>" contains the configuration of override parameters. The override parameters are used to apply a correction percentage to default values. An override change takes effect immediately, and is performed with the dynamic settings in effect in the Motion Control instruction.

Tags

Legend

Tag	Data type	Values	W	Description
Override.	TO_Struct_Override			
Velocity	LREAL	0.0 to 200.0%	DIR	Velocity or speed override Percentage correction of the velocity or speed

14.2.22 "PositionControl" tag (synchronous axis)

The tag structure "<TO>.PositionControl.<tag name>" contains the settings of position control.

Tags

Legend

Tag	Data type	Values	W	Description
PositionControl.	TO_Struct_PositionControl			
Kv	LREAL	0.0 to 2147480.0	DIR	Proportional gain of the closed loop position control ("Kv" > 0.0)
Kpc	LREAL	0.0 to 150.0%	DIR	Velocity precontrol of the position control Recommended setting: • Isochronous drive connection via PROFIdrive: 100.0% • Non-isochronous drive connection via PROFIdrive: 0.0 to 100.0% • Analog drive connection: 0.0 to 100.0%
EnableDSC	BOOL	-	RES	Dynamic Servo Control (DSC) FALSE: DSC disabled TRUE: DSC activated DSC is only possible with one of the following PROFIdrive telegrams: • Standard telegram 5 or 6 • SIEMENS telegram 105 or 106
SmoothingTimeByChangeDifference	LREAL	0.0 to 1.0E12 s	DIR	Smoothing time for the manipulated variable for switching operations, for example: • Encoder switchover • Change in P-gain ("Kv") • Switchover to emergency stop ramp
InitialOperativeSensor	UDINT	1 to 4	RES	Active sensor after initialization of the axis (sensor number 1 to 4) This encoder is used after startup of the CPU and after a restart of the technology object. At an operating mode transition from STOP → RUN of the CPU (without restart of the technology object), the encoder that was also active before the STOP is still being used.
ControlDifferenceQuantization.	TO_Struct_PositionDifferenceQuantification			
Mode	DINT	-	RES	Type of quantification Configuration of a quantization when a drive with stepper motor interface is connected 0: No quantification 1: Quantization corresponding to encoder resolution 2: Quantization to a direct value

Tag	Data type	Values	W	Description
Mode	DINT	-	RES	(configuration is performed using the parameter view (data structure))
Value	LREAL	0.001 to 1.0E12	RES	Value of quantification Configuration of a value for quantization to a direct value ("<TO>.PositionControl.ControlDifferenceQuantization.Mode" = 2) (configuration is performed using the parameter view (data structure))
VelocityModePowerOn	DINT	0 to 1	RES	Behavior of the velocity setpoint when the axis is enabled
				0 Velocity is set to "0" with maximum dynamic values of the axis (ramp).
				1 Velocity is immediately set to "0" without ramp.

14.2.23 "TorquePreControl" tag (synchronous axis)

The tag structure "<TO>.TorquePreControl.<tag name>" contains the settings of the torque precontrol.

Tags

Legend

Tag	Data type	Values	W	Description
TorquePreControl.	TO_Struct_TorquePreControl			
Mode	DINT	0 ... 1	RES	Mode of torque precontrol (effect only in position-controlled mode)
				0 Torque precontrol not in effect
				1 Torque precontrol based on the acceleration of the axis
Scale	LREAL	0.0 ... 150.0	DIR	Weighting factor for the value of the torque precontrol [%]

14.2.24 "SetpointFilter" tag (synchronous axis)

The tag structure "<TO>.SetpointFilter.<tag name>" contains the settings of the setpoint filter.

Tags

Legend

Tag	Data type	Values	W	Description
SetpointFilter.	TO_Struct_SetpointFilter			
DynamicFilter.	TO_Struct_DynamicFilter			
Mode	DINT	0 to 2	RES	Dynamic filter mode

1) The dead time T_t is internally limited to sixteen times the value from the application cycle of the MC_Servo. No alarm is output at higher values.

Tag			Data type	Values	W	Description	
		Mode	DINT	0 to 2	RES	0	Dynamic filter not active
						1	PT1/PT2 filter + dead time
						2	Sliding window demand + dead time
		T1	LREAL	0.0 to 1.0E12	DIR	First time constant of the sliding window demand The value is internally limited to the 16-fold servo clock.	
		T2	LREAL	0.0 to 1.0E12	DIR	Second time constant of the sliding window demand The value is internally limited to the 16-fold servo clock.	
		Tt	LREAL	0.0 to 1.0E12[1)]	DIR	Additional dead time of the dynamic filter in time unit of the axis	

1) The dead time T_t is internally limited to sixteen times the value from the application cycle of the MC_Servo. No alarm is output at higher values.

14.2.25 "DynamicAxisModel" tag (synchronous axis)

The tag structure "<TO>.DynamicAxisModel.<tag name>" contains the balancing filter settings.

Tags

Legend

Tag		Data type	Values	W	Description
DynamicAxisModel.		TO_Struct_DynamicAxisModel			
	VelocityTimeConstant	LREAL	0.0 to 1.0E12	DIR	Speed control loop substitute time [s]
	AdditionalPositionTime-Constant	LREAL	0.0 to 1.0E12	DIR	Additive position control loop substitute time [s]
	CurrentTimeConstant	LREAL	0.0 to 1.0E12	DIR	Current control loop substitute time in time unit of the axis

14.2.26 "FollowingError" tag (synchronous axis)

The tag structure "<TO>.FollowingError.<tag name>" contains the configuration of the dynamic following error monitoring.

If the permissible following error is exceeded, then technology alarm 521 is output, and the technology object is disabled (alarm reaction: remove enable).

When the warning level is reached, a warning is output (technology alarm 522).

Tags

Legend

Tag		Data type	Values	W	Description	
FollowingError.		TO_Struct_FollowingError				
	EnableMonitoring	BOOL	-	RES	FALSE	Following error monitoring deactivated
					TRUE	Following error monitoring enabled

Tag	Data type	Values	W	Description
MinValue	LREAL	Linear: 0.0 to 1.0E12 Rotary: 0.001 to 1.0E12	DIR	Permissible following error at velocities below the value of "MinVelocity"
MaxValue	LREAL	Linear: 0.0 to 1.0E12 Rotary: 0.002 to 1.0E12	DIR	Maximum permissible following error, which may be reached at the maximum velocity.
MinVelocity	LREAL	0.0 to 1.0E12	DIR	"MinValue" is permissible below this velocity and is held constant.
WarningLevel	LREAL	0.0 to 100.0	DIR	Warning level Percentage value relative to the valid maximum following error
AdditionalSetpointDelay-Time	LREAL	0.0 to 1.0E12	DIR	Time constant for additional deceleration of position set-point to calculate the following error in the time unit of the axis

14.2.27 "PositioningMonitoring" tag (synchronous axis)

The tag structure "<TO>.PositioningMonitoring.<tag name>" contains the configuration of position monitoring at the end of a positioning motion.

If the actual position value at the end of a positioning motion is reached within the tolerance time and remains in the positioning window for the minimum dwell time, then "<TO>.StatusWord.X6 (Done)" is set in the technology data block. This completes a Motion Control job.

If the tolerance time is exceeded, then technology alarm 541 "Positioning monitoring" with supplemental value 1: "Target range not reached" is displayed.

If the minimum dwell time is not met, then technology alarm 541 "Positioning monitoring" with supplemental value 2: "Exit target range again" is displayed.

Tags

Legend

Tag	Data type	Values	W	Description
PositioningMonitoring.	TO_Struct_PositionMonitoring			
ToleranceTime	LREAL	0.0 to 1.0E12	DIR	Tolerance time Maximum permitted duration from reaching of velocity setpoint zero until entrance into the positioning window
MinDwellTime	LREAL	0.0 to 1.0E12	DIR	Minimum dwell time in positioning window
Window	LREAL	0.001 to 1.0E12	DIR	Positioning window

14.2.28 "StandstillSignal" tag (synchronous axis)

The tag structure "<TO>.StandstillSignal.<tag name>" contains the configuration of the standstill signal.

If the actual velocity value is below the velocity threshold, and does not exceed it during the minimum dwell time, then the standstill signal "<TO>.StatusWord.X7 (Standstill)" is set.

Tags

Legend

Tag	Data type	Values	W	Description
StandstillSignal.	TO_Struct_StandstillSignal			Configuration for the standstill signal
VelocityThreshold	LREAL	0.0 to 1.0E12	DIR	Velocity threshold If velocity is below this threshold, the minimum dwell time begins.
MinDwellTime	LREAL	0.0 to 1.0E12	DIR	Minimum dwell time

14.2.29 "StatusPositioning" tag (synchronous axis)

The tag structure "<TO>.StatusPositioning.<tag name>" indicates the status of a positioning motion.

Tags

Legend

Tag	Data type	Values	W	Description
StatusPositioning.	TO_Struct_StatusPositioning			
Distance	LREAL	-1.0E12 ... 1.0E12	RON	Distance to target position
TargetPosition	LREAL	-1.0E12 ... 1.0E12	RON	Target position
TargetPositionModulo-Cycle	DINT	-2147483648 ... 2147483647	RON	Number of modulo cycles to target position with positioning motions
FollowingError	LREAL	-1.0E12 ... 1.0E12	RON	Current following error
SetpointExecutionTime	LREAL	0 ... 1.0E12	RON	Setpoint execution time of the axis (Results from T_{lpo}, T_{vtc} or 1/kv, T_{Send} and T_O of the axis)
SuperimposedDistance	LREAL	0 ... 1.0E12	RON	Use the instructions "MC_MoveSuperimposed", "MC_MotionInSuperimposed", "MC_MotionInSuperimposedAxes" and "MC_HaltSuperimposed" to move the distance. The value is reset when the basic motion and the superimposed motion are completed or the basic motion is aborted.

14.2.30 "StatusDrive" tag (synchronous axis)

The tag structure "<TO>.StatusDrive.<tag name>" indicates the status of the drive.

Tags

Legend

Tag	Data type	Values	W	Description	
StatusDrive.	TO_Struct_StatusDrive				
InOperation	BOOL	-	RON	Operation status of the drive	
				FALSE	Drive not ready Setpoints will not be executed.
				TRUE	Drive ready Setpoints can be executed.
CommunicationOK	BOOL	-	RON	Cyclic BUS communication between controller and drive	
				FALSE	Cyclic communication not established. Fault ZSW1.X3 (FaultPresent) is present. Possible causes: • The CPU is in STOP. • The drive has failed. • The "ControlRequested" bit in the status word of the drive has the value "FALSE". • The drive signals an error using the status word. • For isochronous configuration, the dynamic sign of life in the telegram has failed or is not supplied by the drive.
				TRUE	Cyclic communication OK and no fault effective
Error	BOOL	-	RON	FALSE	No drive error
				TRUE	Drive error
AdaptionState	DINT	0 to 4	RON	Status of automatic data transfer of drive parameters	
				0	"NOT_ADAPTED" Data not transferred
				1	"IN_ADAPTION" Data transfer in progress
				2	"ADAPTED" Data transfer complete
				3	"NOT_APPLICABLE" Data transfer not selected, not possible
				4	"ADAPTION_ERROR" Error during data transfer

14.2.31 "StatusServo" tag (synchronous axis)

The tag structure "<TO>.StatusServo.<tag name>" indicates the status for the balancing filter.

Tags

Legend

Tag	Data type	Values	W	Description
StatusServo.	TO_Struct_StatusServo			
BalancedPosition	LREAL	-	RON	Position setpoint after the balancing filter
ControlDifference	LREAL	-	RON	Control deviation
PositionAfterDynamicFilter	LREAL	-	RON	Position setpoint after the dynamic filter

14.2.32 "StatusProvidedLeadingValue" tag (synchronous axis)

The tag structure "<TO>.StatusProvidedLeadingValue.<tag name>" contains the provided leading value with leading value delay of the cross-PLC synchronous operation.

Tags

Legend

Tag	Data type	Values	W	Description
StatusProvidedLeadingValue.	TO_Struct_StatusProvidedLeadingValue			Provided leading value
DelayedLeadingValue	TO_Struct_ProvidedLeadingValue			Leading value with leading value delay
Position	LREAL	-1.0E12 to 1.0E-12	RON	Position
Velocity	LREAL	-1.0E12 to 1.0E-12	RON	Velocity
Acceleration	LREAL	-1.0E12 to 1.0E-12	RON	Acceleration

14.2.33 "StatusSensor[1..4]" tags (synchronous axis)

The tag structure "<TO>.StatusSensor[1..4].<tag name>" indicates the status of the measuring system.

Tags

Legend

Tag	Data type	Values	W	Description
StatusSensor[1..4].	Array [1..4] OF TO_Struct_StatusSensor			
State	DINT	0 to 2	RON	Status of the actual encoder value

Tag	Data type	Values	W	Description	
State	DINT	0 to 2	RON	0	"NOT_VALID" Invalid
				1	"WAITING_FOR_VALID" Waiting for "Valid" status
				2	"VALID" Valid
CommunicationOK	BOOL	-	RON	Cyclic BUS communication between controller and encoder	
				FALSE	Not established
				TRUE	Established
Error	BOOL	-	RON	FALSE	No error in the measuring system
				TRUE	Error in the measuring system.
AbsEncoderOffset	LREAL	-	RON	Home position offset for value of an absolute value encoder. The value will be retentively stored in the CPU.	
Control	BOOL	-	RON	FALSE	Encoder is not active
				TRUE	Encoder is active
Position	LREAL	-	RON	Encoder position	
Velocity	LREAL	-	RON	Encoder velocity	
AdaptionState	DINT	0 to 4	RON	Status of automatic data transfer of encoder parameters	
				0	"NOT_ADAPTED" Data not transferred
				1	"IN_ADAPTION" Data transfer in progress
				2	"ADAPTED" Data transfer complete
				3	"NOT_APPLICABLE" Data transfer not selected, not possible
				4	"ADAPTION_ERROR" Error during data transfer
ModuloCycle	DINT	-2147483648 to 2147483647	RON	Number of modulo cycles	
Adjusted	DINT	0, 1	RON	Homing status of the encoder	
				0	Encoder not homed
				1	Encoder homed with one of the following homing types: • Active homing • Passive homing • Absolute encoder adjustment • Incremental encoder adjustment

14.2.34 "StatusExtrapolation" tag (synchronous axis)

The tag structure "<TO>.StatusExtrapolation.<tag name>" indicates the status of the actual value extrapolation.

Tags

Legend

Tag	Data type	Values	W	Description
StatusExtrapolation.	TO_Struct_StatusExtrapolation			
FilteredPosition	LREAL	-1.0E12 to 1.0E-12	RON	Position after position filter
FilteredVelocity	LREAL	-1.0E12 to 1.0E-12	RON	Velocity after velocity filter and tolerance band
ExtrapolatedPosition	LREAL	-1.0E12 to 1.0E-12	RON	Extrapolated position
ExtrapolatedVelocity	LREAL	-1.0E12 to 1.0E-12	RON	Extrapolated velocity

14.2.35 "StatusSynchronizedMotion" tag (synchronous axis)

The tag structure "<TO>.StatusSynchronizedMotion.<tag name>" indicates the status of synchronous operation.

Tags

Legend

Tag	Data type	Value range	W	Description	
StatusSynchronizedMotion.	TO_Struct_StatusSynchronizedMotion				
FunctionState	DINT	0 ... 6	RON	Indication of which synchronous operation function is active	
				0	No synchronous operation active
				1	Gearing ("MC_GearIn")
				2	Gearing with specified synchronous positions ("MC_GearInPos")
				3	Camming ("MC_CamIn")
				4	Desynchronization of gearing ("MC_GearOut")
				5	Desynchronization of camming ("MC_CamOut")
				6	Velocity synchronous operation ("MC_GearInVelocity")
WaitingFunctionState	DINT	0 ... 5	RON	Indication of which synchronous operation function is waiting	
				0	No synchronous operation waiting
				1	Reserved

Tag	Data type	Value range	W	Description	
WaitingFunctionState	DINT	0 ... 5	RON	2	Gearing with specified synchronous positions waiting ("MC_GearInPos")
				3	Camming waiting ("MC_CamIn")
				4	Desynchronization of gearing waiting ("MC_GearOut")
				5	Desynchronization of camming waiting ("MC_CamOut")
PhaseShift	LREAL	-1.0E12 ... 1.0E12	RON	Current absolute leading value offset with an "MC_PhasingAbsolute" or "MC_PhasingRelative" job.	
ActualMaster	DB_ANY	0 ... 65535	RON	When a synchronous operation job is started, the number of the technology data block of the currently used leading axis is displayed.	
				0	Synchronous operation inactive
ActualCam	DB_ANY	0 ... 65535	RON	Cam currently used for camming	
MasterOffset	LREAL	-1.0E12 ... 1.0E12	RON	Current offset of the leading value range of the cam with an "MC_CamIn" job including the leading value offset of an "MC_PhasingAbsolute" or "MC_PhasingRelative" job (<TO>.StatusSynchronizedMotion.PhaseShift)	
MasterScaling	LREAL	-1.0E12 ... 1.0E12	RON	Current scaling of the leading value range of the cam with an "MC_CamIn" job	
SlaveOffset	LREAL	-1.0E12 ... 1.0E12	RON	Current offset of the following value range of the cam with an "MC_CamIn" job	
SlaveScaling	LREAL	-1.0E12 ... 1.0E12	RON	Current scaling of the following value range of the cam with an "MC_CamIn" job	
Offset	LREAL	-1.0E12 ... 1.0E12	RON	Current absolute following value offset with an "MC_OffsetAbsolute" or "MC_OffsetRelative" job, including the following value offset of an "MC_CamIn" job (<TO>.StatusSynchronizedMotion.SlaveOffset)	
ActualRatioNumerator	DINT	-2147483648 to 2147483647	RON	Current counter of the gear ratio of an active "MC_GearIn", "MC_GearInPos" or "MC_GearInVelocity" job	
ActualRatioDenominator	DINT	1 ... 2147483647	RON	Current nominator of the gear ratio of an active "MC_GearIn", "MC_GearInPos" or "MC_GearInVelocity" job	
EffectiveLeadingValue.	TO_Struct_EffectiveLeadingValue			Effective leading value of the synchronous operation function	
Position	LREAL	-1.0E12 ... 1.0E12	RON	Position	
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity	
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration	
FunctionLeadingValue.	TO_Struct_FunctionLeadingValue			Leading value of the synchronous operation function after a leading value offset with a "MC_PhasingAbsolute" or "MC_PhasingRelative" job	
Position	LREAL	-1.0E12 ... 1.0E12	RON	Position	

Tag	Data type	Value range	W	Description
FunctionFollowingValue.	TO_Struct_FunctionFollowingValue			Following value of the synchronous operation function before a following value offset with an "MC_OffsetAbsolute" job or "MC_OffsetRelative" job
Position	LREAL	-1.0E12 ... 1.0E12	RON	Position
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration
StatusWord.	DWORD	-	RON	Status information of synchronous operation
Bit 0	BOOL	-	RON	"MaxVelocityExceeded" Configured maximum velocity is exceeded during synchronous operation.
Bit 1	BOOL	-	RON	"MaxAccelerationExceeded" Configured maximum acceleration is exceeded during synchronous operation.
Bit 2	BOOL	-	RON	"MaxDecelerationExceeded" Configured maximum deceleration is exceeded during synchronous operation.
Bit 3	BOOL	-	RON	"InSimulation" Simulation of synchronous operation
				FALSE: Not simulated
				TRUE: Simulated
Bit 4	BOOL	-	RON	"LeadingValueAdditiveCommand" Additive leading value via "MC_LeadingValueAdditive"
				FALSE: No additive leading value active
				TRUE: Additive leading value active
Bit 5 ... Bit 31	BOOL	-	RON	Reserved

14.2.36 "StatusKinematicsMotion" tag (synchronous axis)

The "<TO>.StatusKinematicsMotion" tag contains status information of the technology object with regard to usage as kinematics axis.

Information on evaluating individual bits (e.g. bit 2 "MaxDecelerationExceeded") can be found in the "Evaluating StatusWord, ErrorWord, and WarningWord" section of the "S7-1500/S7-1500T Motion Control overview" documentation.

Tag

Legend

Tag	Data type	Values	W	Description
StatusKinematicsMotion	DWORD	-	RON	Status information of the technology object
Bit 0	-	-	-	"MaxVelocityExceeded"

Tag	Data type	Values	W	Description	
Bit 0	-	-	-	0	The kinematics technology object calculated a lower velocity setpoint than the maximum velocity on the axis.
				1	The kinematics technology object calculated a higher velocity setpoint than the maximum velocity on the axis.
Bit 1	-	-	-	"MaxAccelerationExceeded"	
				0	The kinematics technology object calculated a lower setpoint acceleration calculated than the maximum acceleration of the axis.
				1	The kinematics technology object calculated a higher setpoint acceleration than the maximum acceleration of the axis.
Bit 2	-	-	-	"MaxDecelerationExceeded"	
				0	The kinematics technology object calculated a lower setpoint deceleration than the maximum deceleration of the axis.
				1	The kinematics technology object calculated a lower setpoint deceleration than the maximum deceleration of the axis.

14.2.37 "StatusTorqueData" tag (synchronous axis)

The tag structure "<TO>.StatusTorqueData.<tag name>" shows the status of the force/torque data.

Tags

Legend

Tag	Data type	Value range	W	Description	
StatusTorqueData.	TO_Struct_StatusTorqueData				
CommandAdditiveTorqueActive	DINT	0, 1	RON	Additive setpoint torque or additive setpoint force	
				0	Inactive
				1	Active
CommandTorqueRangeActive	DINT	0, 1	RON	Force/torque limits B+, B-	
				0	Inactive
				1	Active
ActualTorque	LREAL	-1.0E12 ... 1.0E12	RON	Actual torque of the axis	
ActualForce	LREAL	-1.0E12 ... 1.0E12	RON	Actual force of the axis	
TotalTorqueAdditive	LREAL	-1.0E12 ... 1.0E12	RON	Effective additional torque of the axis	
TotalForceAdditve	LREAL	-1.0E12 ... 1.0E12	RON	Effective additional force of the axis	

14.2.38 "StatusMotionIn" tag (synchronous axis)

The tag structure "<TO>.StatusMotionIn.<tag name>" indicates the status of the "MotionIn" function.

Tags

Legend

Tag	Data type	Value range	W	Description	
StatusMotionIn.	TO_Struct_StatusMotionIn				
FunctionState	DINT	0 to 2	RON	0	No "MotionIn" function active
				1	"MC_MotionInVelocity" active
				2	"MC_MotionInPosition" active
ActualSuperimposingAxis	DB_ANY	0 to 65535	RON	At the start of a "MC_MotionInSuperimposedAxes" job, the number of the technology data block of the currently used superimposing axis is displayed.	
				0	"MC_MotionInSuperimposedAxes" job inactive
StatusWord.	DWORD	-	RON	-	
Bit 0	Bool	-	RON	"MaxVelocityExceeded" The configured maximum velocity is exceeded during a MotionIn movement.	
Bit 1 ... Bit 31	Bool	-	RON	Reserved	

14.2.39 "StatusInterpreterMotion" tag (synchronous axis)

The tag structure "<TO>.StatusInterpreterMotion.<tag name>" contains status information on motion jobs controlled by a technology object Interpreter.

Tags

Legend

Tag	Data type	Values	W	Description
StatusInterpreterMotion.	TO_Struct_StatusInterpreterMotion			
Interpreter	DB_ANY	0 to 65535		Controlling Interpreter technology object
StatusWord.	DWORD	-	RON	Status information
Bit 0	-	-	-	"ControlledByInterpreter" An MCL job is processed or active or the bit is set via the MCL instruction "setControlledByInterpreter()".
Bit 1	-	-	-	"MotionByInterpreter" An MCL motion job is in effect.
Bit 2 to Bit 31	-	-	-	Reserved

14.2.40 "StatusWord" tag (synchronous axis)

The "<TO>.StatusWord" tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 5 "HomingDone") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status information of the technology object
Bit 0	-	-	-	"Enable" Enable status The technology object has been enabled.
Bit 1	-	-	-	"Error" An error is present.
Bit 2	-	-	-	"RestartActive" A restart is active. The technology object is being reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" The restart tags have been changed. For the changes to be applied, the technology object must be reinitialized.
Bit 4	-	-	-	"ControlPanelActive" The axis control panel is active.
Bit 5	-	-	-	"HomingDone" Homing status The technology object is homed.
Bit 6	-	-	-	"Done" No motion job is in progress and the axis control panel is deactivated.
Bit 7	-	-	-	"Standstill" Standstill signal The axis is at a standstill.
Bit 8	-	-	-	"PositioningCommand" A positioning job is active ("MC_MoveRelative","MC_MoveAbsolute").
Bit 9	-	-	-	"JogCommand" An "MC_MoveJog" job is running.
Bit 10	-	-	-	"VelocityCommand" An "MC_MoveVelocity" job is running.
Bit 11	-	-	-	"HomingCommand" An "MC_Home" job is being processed.

[1] The bit is correctly displayed only when using SIEMENS telegram 10x. When using MC_TorqueRange without SIEMENS telegram 10x, compare the values from telegram 750:
<InLimit> = ActualTorque (M_ACT) * 0.9 > UpperTorqueLimit (M_LIMIT_POS) OR ActualTorque (M_ACT) * 0.9 < LowerTorqueLimit (M_LIMIT_NEG)

Tag	Data type	Values	W	Description
Bit 12	-	-	-	"ConstantVelocity" The velocity setpoint is reached. A constant velocity setpoint is output.
Bit 13	-	-	-	"Accelerating" An acceleration operation is active.
Bit 14	-	-	-	"Decelerating" A deceleration operation is active.
Bit 15	-	-	-	"SWLimitMinActive" A negative software limit switch has been approached or exceeded.
Bit 16	-	-	-	"SWLimitMaxActive" A positive software limit switch has been approached or exceeded.
Bit 17	-	-	-	"HWLimitMinActive" A negative hardware limit switch has been approached or exceeded.
Bit 18	-	-	-	"HWLimitMaxActive" A positive hardware limit switch has been approached or exceeded.
Bit 19	-	-	-	Reserved
Bit 20	-	-	-	Reserved
Bit 21	-	-	-	"Synchronizing" The axis synchronizes to a leading value.
Bit 22	-	-	-	"Synchronous" The axis moves synchronously to a leading value.
Bit 23	-	-	-	"MoveSuperimposedCommand" An "MC_MoveSuperimposed" job is running.
Bit 24	-	-	-	"PhasingCommand" An "MC_PhasingAbsolute" or "MC_PhasingRelative" job for the leading value offset is active.
Bit 25	-	-	-	"AxisSimulation" The technology object is in simulation.
Bit 26	-	-	-	"TorqueLimitingCommand" An "MC_TorqueLimiting" job is running.
Bit 27	-	-	-	"InLimitation"[1] The drive operates at least at the threshold value (default setting 90%) of the force/torque limit.
Bit 28	-	-	-	"NonPositionControlled" The axis is not in position-controlled mode.

[1] The bit is correctly displayed only when using SIEMENS telegram 10x. When using MC_TorqueRange without SIEMENS telegram 10x, compare the values from telegram 750:
<InLimit> = ActualTorque (M_ACT) * 0.9 > UpperTorqueLimit (M_LIMIT_POS) OR ActualTorque (M_ACT) * 0.9 < LowerTorqueLimit (M_LIMIT_NEG)

Tag	Data type	Values	W	Description
Bit 29	-	-	-	"KinematicsMotionCommand" The axis is used for a kinematics job.
Bit 30	-	-	-	"InClamping" The axis is clamped at a fixed stop.
Bit 31	-	-	-	"MotionInCommand" An "MC_MotionInVelocity" job or an "MC_MotionInPosition" job is active.

[1] The bit is correctly displayed only when using SIEMENS telegram 10x. When using MC_TorqueRange without SIEMENS telegram 10x, compare the values from telegram 750:
<InLimit> = ActualTorque (M_ACT) * 0.9 > UpperTorqueLimit (M_LIMIT_POS) OR ActualTorque (M_ACT) * 0.9 < LowerTorqueLimit (M_LIMIT_NEG)

14.2.41 "StatusWord2" tag (synchronous axis)

The "<TO>.StatusWord2" tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 0 "StopCommand") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Value range	W	Description
StatusWord2	DWORD	-	RON	Status information of the technology object
Bit 0	BOOL	-	RON	"StopCommand" An "MC_Stop" job is running. The technology object is disabled.
Bit 1	BOOL	-	RON	"DesynchronizingCommand" An "MC_GearOut" job or "MC_CamOut" job is active. The following axis is desynchronized.
Bit 2	BOOL	-	RON	"PassingBacklash" The backlash is traversed. "<TO>.ActualPosition" does not hereby change.
Bit 3	BOOL	-	RON	"PhasingCommandWaiting" An "MC_PhasingAbsolute" or "MC_PhasingRelative" job for leading value offset is waiting.
Bit 4	BOOL	-	RON	"OffsetCommand" An "MC_OffsetAbsolute" or "MC_OffsetRelative" job for following value offset is active.
Bit 5	BOOL	-	RON	"OffsetCommandWaiting" An "MC_OffsetAbsolute" or "MC_OffsetRelative" job for following value offset is waiting.
Bit 6	BOOL	-	RON	"MotionInSuperimposedCommand" An "MC_MotionInSuperimposed" job is running.
Bit 7	BOOL	-	RON	"HaltSuperimposedCommand" An "MC_HaltSuperimposed" job is running.

Tag		Data type	Value range	W	Description
	Bit 8	BOOL	-	RON	"MotionInSuperimposedAxesCommand" An "MC_MotionInSuperimposedAxes" job is running.
	Bit 9	BOOL	-	RON	"PositionProfileCommand" An "MC_PositionProfile" job is running.
	Bit 10	BOOL	-	RON	"OnProfile" An "MC_PositionProfile" job is running and the axis traverses the setpoint values of the time-based position profile.
	Bit 11 ... Bit 31	BOOL	-	RON	Reserved

14.2.42 "ErrorWord" tag (synchronous axis)

The "<TO>.ErrorWord" tag shows the error groups in which there is at least one technology alarm for the technology object. The tag takes technology alarms of the alarms requiring acknowledgment and serious errors alarm classes into consideration.

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

You can use the "Get_Alarm" instruction, for example, to evaluate all technology alarms pending on the technology object.

Tags

Legend

Tag		Data type	Values	W	Description
ErrorWord		DWORD	-	RON	
	Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.
	Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
	Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
	Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
	Bit 4	-	-	-	"DriveFault" Error in drive
	Bit 5	-	-	-	"SensorFault" Error in encoder system
	Bit 6	-	-	-	"DynamicError" Specified dynamic values are limited to permissible values.

Tag	Data type	Values	W	Description
Bit 7	-	-	-	"CommunicationFault" Communication error Missing or faulty communication.
Bit 8	-	-	-	"SWLimit" Software limit switch reached or overtraveled.
Bit 9	-	-	-	"HWLimit" Hardware limit switch reached or overtraveled.
Bit 10	-	-	-	"HomingError" Error during homing operation The homing cannot be completed.
Bit 11	-	-	-	"FollowingErrorFault" Following error limits exceeded
Bit 12	-	-	-	"PositioningFault" Positioning error
Bit 13	-	-	-	"PeripheralError" Error accessing a logical address
Bit 14	-	-	-	"SynchronousError" Error during synchronous operation The leading axis specified in the Motion Control instruction was not configured as a possible leading axis.
Bit 15	-	-	-	"AdaptionError" Error in automatic data transfer
Bit 16	-	-	-	"SuperimposingError" Error in the superimposition of the axis The superimposing axis specified at the corresponding Motion Control instruction was not configured as a possible superimposing axis.
Bit 16 ... Bit 31	-	-	-	Reserved

14.2.43 "ErrorDetail" tag (synchronous axis)

The "<TO>.ErrorDetail" tag structure contains the alarm number and the effective local alarm response of the technology alarm pending on the technology object with the highest priority.

You can find a list of the technology alarms and alarm responses in the "Overview of the technology alarms" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.

You can use the "Get_Alarm" instruction, for example, to evaluate all technology alarms pending on the technology object.

Tags

Legend

Tag	Data type	Values	W	Description
ErrorDetail.	TO_Struct_ErrorDetail			
Number	UDINT	-	RON	Alarm number

Tag		Data type	Values	W	Description	
	Reaction	DINT	0 to 5	RON	Effective alarm response	
					0	No reaction
					1	Stop with current dynamic values
					2	Stop with maximum dynamic values
					3	Stop with emergency stop ramp
					4	Remove enable
					5	Track setpoints

14.2.44 "WarningWord" tag (synchronous axis)

The "<TO>.WarningWord" tag shows the error groups in which there is at least one technology alarm for the technology object. The tag takes technology alarms of the acknowledgeable warnings alarm class into consideration.

You can find information on evaluating the individual bits, e.g. bit 13 "PeripheralWarning", in the chapter"Evaluating StatusWord, ErrorWord and WarningWord" in the "S7-1500/S7-1500T Motion Control Overview" documentation.

You can use the "Get_Alarm" instruction, for example, to evaluate all warnings pending on the technology object.

Tags

Legend

Tag		Data type	Values	W	Description
WarningWord		DWORD	-	RON	
	Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
	Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
	Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
	Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
	Bit 4	-	-	-	"DriveWarning" Warning of the drive When a warning message is pending at the drive that does not result in a TO alarm, this bit is not set. Evaluate the drive warnings directly using the status word of the drive.
	Bit 5	-	-	-	"SensorWarning" Error in encoder system
	Bit 6	-	-	-	"DynamicWarning" Specified dynamic values are limited to permissible values.

Tag	Data type	Values	W	Description
Bit 7	-	-	-	"CommunicationWarning" Communication error Missing or faulty communication.
Bit 8	-	-	-	"SWLimitMin" The negative software limit switch has been approached.
Bit 9	-	-	-	"SWLimitMax" The positive software limit switch has been approached.
Bit 10	-	-	-	"HomingWarning" Error during homing operation The homing cannot be completed.
Bit 11	-	-	-	"FollowingErrorWarning" Warning limit of following error monitoring reached or exceeded
Bit 12	-	-	-	"PositioningWarning" Positioning error
Bit 13	-	-	-	"PeripheralWarning" Error accessing a logical address
Bit 14	-	-	-	"SynchronousWarning" Error during synchronous operation The leading axis specified in the Motion Control instruction was not configured as a possible leading axis.
Bit 15	-	-	-	"AdaptionWarning" Error in automatic data transfer
Bit 16	-	-	-	"SuperimposingWarning" Error in the superimposition of the axis The superimposing axis specified in the Motion Control instruction was not configured as a possible superimposing axis.
Bit 16... Bit 31	-	-	-	Reserved

14.2.45 "ControlPanel" tag (synchronous axis)

The tag structure "<TO>.ControlPanel.<tag name>" contains no relevant data for you. This tag structure is internally used.

14.2.46 "InternalToTrace" tag (synchronous axis)

The tag structure "<TO>.InternalToTrace.<tag name>" contains no relevant data for you. This tag structure is internally used.

14.3 Tags of the cam technology object

14.3.1 "Point[1..i]" tag (cam)

The "<TO>.Point[1..i].<tag name>" tag structure contains the defined points of the cam.

The array size depends on the type of cam:

Cam type	Array size
TO_Cam	i = 1 000
TO_Cam_10k	i = 10 000
TO_Cam_600Seg	i = 50
TO_Cam_6kSeg	

Tags

Legend

Tag		Data type	Values	W	Description
Point[1..i].		ARRAY [1..i] OF TO_Cam_Struct_PointData			
	x	LREAL	-1.0E12 ... 1.0E12	CAL	Value of the point in the definition range
	y	LREAL	-1.0E12 ... 1.0E12	CAL	Value of the point in the range of the function

14.3.2 "ValidPoint[1..i]" tag (cam)

The "<TO>.ValidPoint[1..i]" tag structure indicates the validity of the defined points of the cam.

The array size depends on the type of cam:

Cam type	Array size
TO_Cam	i = 1 000
TO_Cam_10k	i = 10 000
TO_Cam_600Seg	i = 50
TO_Cam_6kSeg	

Tags

Legend

Tag	Data type	Values	W	Description	
ValidPoint[1..i]	ARRAY [1..i] OF BOOL	-	CAL	Indicates whether the defined point is valid.	
				FALSE	Invalid
				TRUE	Valid

14.3.3 "Segment[1..i]" tag (cam)

The "<TO>.Segment[1..i].<tag name>" tag structure contains the defined segments of the cam.

The array size depends on the type of cam:

Cam type	Array size
TO_Cam	i = 50
TO_Cam_10k	
TO_Cam_600Seg	i = 600
TO_Cam_6kSeg	i = 6 000

Tags

Legend

Tag	Data type	Values	W	Description
Segment[1..i].	ARRAY [1..i] OF TO_Cam_Struct_SegmentData			
xmin	LREAL	-1.0E12 ... 1.0E12	CAL	Start coordinates of the segment
xmax	LREAL	-1.0E12 ... 1.0E12	CAL	End coordinates of the segment
a0	LREAL	-1.0E12 ... 1.0E12	CAL	Coefficient A0 for x^0 of the polynomial for the segment

Tag	Data type	Values	W	Description
a1	LREAL	-1.0E12 ... 1.0E12	CAL	Coefficient A1 for x^1 of the polynomial for the segment
a2	LREAL	-1.0E12 ... 1.0E12	CAL	Coefficient A2 for x^2 of the polynomial for the segment
a3	LREAL	-1.0E12 ... 1.0E12	CAL	Coefficient A3 for x^3 of the polynomial for the segment
a4	LREAL	-1.0E12 ... 1.0E12	CAL	Coefficient A4 for x^4 of the polynomial for the segment
a5	LREAL	-1.0E12 ... 1.0E12	CAL	Coefficient A5 for x^5 of the polynomial for the segment
a6	LREAL	-1.0E12 ... 1.0E12	CAL	Coefficient A6 for x^6 of the polynomial for the segment
sineAmplitude	LREAL	-1.0E12 ... 1.0E12	CAL	Amplitude of the sine element
sinePeriod	LREAL	-1.0E12 ... 1.0E12	CAL	Period length of the sine element [rad]
sinePhase	LREAL	-1.0E12 ... 1.0E12	CAL	Phase offset of the sine element [rad]

14.3.4 "ValidSegment[1..i]" tag (cam)

The "<TO>.ValidSegment[1..i]" tag structure indicates the validity of the defined segments of the cam.

The array size depends on the type of cam:

Cam type	Array size
TO_Cam	i = 50
TO_Cam_10k	
TO_Cam_600Seg	i = 600
TO_Cam_6kSeg	i = 6 000

Tags

Legend

Tag	Data type	Values	W	Description	
ValidSegment[1..i]	ARRAY [1..i] OF BOOL	-	CAL	Indicates whether the defined segment is valid.	
				FALSE	Invalid
				TRUE	Valid

14.3.5 "InterpolationSettings" tag (cam)

The tag structure "<TO>.InterpolationSettings.<tag name>" contains the configuration for the interpolation of the cam.

Tags

Legend

Tag	Data type	Values	W	Description	
InterpolationSettings.	TO_Cam_Struct_InterpolationSet-tings				
InterpolationMode	DINT	0 ... 2	CAL	Interpolation type	
				0	Linear
				1	Cubic splines (C splines)
				2	Bézier splines (B splines)
BoundaryConditions	DINT	0, 1	CAL	Characteristics of the boundary points	
				0	No profile start or profile end conditions
				1	First derivative equal at profile start and end

14.3.6 "StatusCam" tag (cam)

The "<TO>.StatusCam.<tag name>" tag structure indicates the status of the cam.

Tags

Legend

Tag	Data type	Values	W	Description
StatusCam.	TO_Cam_Struct_StatusCam			
StartLeadingValue	LREAL	-1.0E12 ... 1.0E12	RON	When "<TO>.StatusWord.X5 (Interpolated)" = TRUE: First defined interpolation point or start of the first seg-ment of the cam (Start value of the definition range of the cam) The value can be changed by range scaling with a "MC_SetCamRangeScaling".
EndLeadingValue	LREAL	-1.0E12 ... 1.0E12	RON	When "<TO>.StatusWord.X5 (Interpolated)" = TRUE: Last defined interpolation point or end of the last seg-ment of the cam (End value of the definition range of the cam) The value can be changed by range scaling with a "MC_SetCamRangeScaling".
StartFollowingValue	LREAL	-1.0E12 ... 1.0E12	RON	When "<TO>.StatusWord.X5 (Interpolated)" = TRUE: First defined interpolation point or start of the first seg-ment of the cam (Associated following value of the start value of the definition range of the cam) The value can be changed by range scaling with a "MC_SetCamRangeScaling".

Tag	Data type	Values	W	Description
EndFollowingValue	LREAL	-1.0E12 ... 1.0E12	RON	When "<TO>.StatusWord.X5 (Interpolated)" = TRUE: Last defined interpolation point or end of the last segment of the cam (Associated following value of the end value of the definition range of the cam) The value can be changed by range scaling with a "MC_SetCamRangeScaling".
NumberOfValidPoints	DINT	With "TO_Cam": 0 ... 1 000	RON	Number of valid points ("ValidPoint" = TRUE)
		With "TO_Cam_10k": 0 ... 10 000		
		With "TO_Cam_600Seg" or "TO_Cam_6kSeg": 0 ... 50		
NumberOfValidSegments	DINT	With "TO_Cam" or "TO_Cam_10k": 0 ... 50	RON	Number of valid segments ("ValidSegment" = TRUE)
		With "TO_Cam_600Seg": 0 ... 600		
		With "TO_Cam_6kSeg": 0 ... 6 000		

14.3.7 "StatusRangeScaling" Tag (cam)

The tag structure "<TO>.StatusRangeScaling.<tag name>" shows the status of the scaling range of the cam.

Tags

Legend

Tag	Data type	Values	W	Description	
StatusRangeScaling.	TO_Cam_Struct_StatusRangeScaling				
Range.	ARRAY [1..2] TO_Cam_Struct_Range				
Mode	DINT	1, 2	RON	Scaling mode	
				1	Range scaling in the leading value range
				2	Range scaling in the following value range
StartPoint	LREAL	-1.0E12 ... 1.0E12	RON	Start point	
EndPoint	LREAL	-1.0E12 ... 1.0E12	RON	End point	
Scaling	LREAL	-1.0E12 ... 1.0E12	RON	Scaling factor	

14.3.8 "StatusWord" tag (cam)

The "<TO>.StatusWord" tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 4 "CamDataChanged") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status information of the technology object
Bit 0	-	-	-	"Control" Use status The cam is in use.
Bit 1	-	-	-	"Error" An error is present.
Bit 2	-	-	-	"RestartActive" A restart is active. The technology object is being reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" The restart tags have been changed. For the changes to be applied, the technology object must be reinitialized.
Bit 4	-	-	-	"CamDataChanged" The definition range of the cam has changed in the technology data block.
Bit 5	-	-	-	"Interpolated" The cam is interpolated.
Bit 6	-	-	-	"InInterpolation" The cam is in interpolation.
Bit 7	-	-	-	"CopyCamDataActive" A copy operation of an "MC_CopyCamData" job is active.
Bit 8	-	-	-	"SetCamRangeScalingActive" The scaling of a range of the cam is calculated ("MC_SetCamRangeScaling.Busy" = TRUE).
Bit 9	-	-	-	"CamRangeScaled" At least one cam range is scaled via a "MC_SetCamRangeScaling" job.
Bit 10 ... Bit 31	-	-	-	Reserved

14.3.9 "ErrorWord" tag (cam)

The "<TO>.ErrorWord" tag indicates technology object errors (technology alarms).

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag		Data type	Values	W	Description
ErrorWord		DWORD	-	RON	
	Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.
	Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
	Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
	Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
	Bit 4 ... Bit 31	-	-	-	Reserved

14.3.10 "ErrorDetail" tag (cam)

The tag structure "<TO>.ErrorDetail.<tag name>" contains the alarm number and the effective local alarm response for the technology alarm that is currently pending on the technology object.

You can find a list of the technology alarms and alarm responses in the "Overview of the technology alarms" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.

Tags

Legend

Tag		Data type	Values	W	Description	
ErrorDetail.		TO_Struct_ErrorDetail				
	Number	UDINT	-	RON	Alarm number	
	Reaction	DINT	0, 9	RON	Effective alarm response	
					0	No reaction
					9	Terminate processing of the technology object

14.3.11 "WarningWord" tag (cam)

The "<TO>.WarningWord" tag indicates pending warnings at the technology object.

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
Bit 4 ... Bit 31	-	-	-	Reserved

14.4 Tags of the leading axis proxy technology object

14.4.1 Leading value (leading axis proxy)

The following tags indicate the leading value parameters of the technology object for local synchronous operation.

Tags

Legend

Tag	Data type	Values	W	Description
Position	LREAL	-	RON	Adapted leading value for local synchronous operation
Velocity	LREAL	-	RON	Leading value velocity for local synchronous operation
Acceleration	LREAL	-	RON	Leading value velocity for local synchronous operation

14.4.2 "Interface" tag (leading axis proxy)

The tag structure "<TO>.Interface.<Tag name>" contains the input address of the telegram.

Tags

Legend

Tag		Data type	Values	W	Description
Interface.		TO_Struct_LeadingAxisProxy_Interface			
	AddressIn	VRef	-	RON	Input address for the telegram of the external leading value

14.4.3 "Parameter" tag (leading axis proxy)

The tag structure "<TO>.Parameter.<tag name>" contains parameters for leading value adaptation.

Tags

Legend

Tag		Data type	Values	W	Description
Parameter.		TO_Struct_LeadingAxisProxy_Parameter			
	LocalLeadingValueDelayTime	LREAL	0.0 ... 1.0E9	DIR	Delay time of virtual local following axis which, in turn, provides a cross-PLC leading value with a cascade (<TO>.CrossPlcSynchronousOperation.LocalLeadingValueDelayTime)
	ToleranceTimeExternalLeadingValueInvalid	LREAL	0.0 ... 1.0E12	DIR	Tolerance time until a technology alarm is triggered when the external leading value becomes invalid

14.4.4 "StatusExternalLeadingValue" tag (leading axis proxy)

The tag structure "<TO>.StatusExternalLeadingValue.<Tag name>" contains the parameter values of the external leading value.

Tags

Legend

Tag		Data type	Values	W	Description
StatusExternalLeadingValue.		TO_Struct_LeadingAxisProxy_StatusData			
	ModuloLength	LREAL	0.0 ... 1.0E12	RON	Modulo length of the external leading value
	ModuloStartValue	LREAL	-1.0E12 ... 1.0E12	RON	Modulo start value of the external leading value

Tag	Data type	Values	W	Description	
AdjustmentTime	LREAL	-1.0E12 ... 1.0E12	RON	Time by which the external leading value is adjusted	
				< 0	The external leading value is interpolated by this time.
				> 0	The external leading value is extrapolated by this time.

14.4.5 "StatusWord" tag (leading axis proxy)

The "<TO>.StatusWord" tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 4 "LeadingValueValid") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
StatusWord	DWORD	-	RON	Status information of the technology object
Bit 0	-	-	-	"Control" Use status The leading axis proxy is in operation.
Bit 1	-	-	-	"Error" An error is present.
Bit 2	-	-	-	"RestartActive" A restart is active. The technology object is being reinitialized.
Bit 3	-	-	-	"OnlineStartValuesChanged" The restart tags have been changed. For the changes to be applied, the technology object must be reinitialized.
Bit 4	-	-	-	"LeadingValueValid" The leading value exists and is valid.
Bit 5	-	-	-	"LeadingValueModulo" The leading value is with modulo functionality.
Bit 6	-	-	-	"LeadingAxisControl" The leading axis is in setpoint operation.
Bit 7 ... Bit 31	-	-	-	Reserved

14.4.6 "'ErrorWord" tag (leading axis proxy)

The "<TO>.ErrorWord" tag indicates technology object errors (technology alarms).

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" System error
Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
Bit 4 ... Bit 7	-	-	-	Reserved
Bit 7	-	-	-	"CommunicationFault" Communication error Missing or faulty communication.
Bit 8 ... Bit 31	-	-	-	Reserved

14.4.7 "ErrorDetail" tag (leading axis proxy)

The tag structure "<TO>.ErrorDetail.<tag name>" contains the alarm number and the effective local alarm response for the technology alarm that is currently pending on the technology object.

You can find a list of the technology alarms and alarm responses in the "Overview of the technology alarms" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.

Tags

Legend

Tag	Data type	Values	W	Description	
ErrorDetail.	TO_Struct_ErrorDetail				
Number	UDINT	-	RON	Alarm number	
Reaction	DINT	0, 13	RON	Effective alarm response	
				0	No reaction
				13	Invalid leading value

14.4.8 "WarningWord" tag (leading axis proxy)

The "<TO>.WarningWord" tag indicates pending warnings at the technology object.

Information on the evaluation of the individual bits (e.g. bit 1 "ConfigWarning") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
WarningWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemWarning" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigWarning" Configuration error One or several configuration parameters are adjusted internally.
Bit 2	-	-	-	"UserWarning" Error in user program at a Motion Control instruction or its use
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.

Tag		Data type	Values	W	Description
	Bit 4 ... Bit 6	-	-	-	Reserved
	Bit 7	-	-	-	"CommunicationWarning" Communication error Missing or faulty communication.
	Bit 8 ... Bit 31	-	-	-	Reserved

SIEMENS

SIMATIC

S7-1500
S7-1500T Kinematics functions
V10.0 as of STEP 7 V21

Function Manual

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Introduction 1

Purpose of the documentation

This documentation provides important information that you need to configure and commission the integrated Motion Control functionality of the S7-1500 Automation systems.

Required basic knowledge

In order to understand this documentation, the following knowledge is required:

- General knowledge in the field of automation
- General knowledge in the field of drive engineering and motion control

Validity of the documentation

This documentation is valid for the S7-1500 product range.

Conventions

- The path specifications in the project tree assume that the "Technology objects" folder is open in the subtree of the CPU. The "Technology object" placeholder represents the name of the technology object.

  Example: "Technology object > Configuration > Basic parameters".
- The <TO> placeholder represents the name set in tags for the respective technology object.

  Example: <TO>.Actor.Type
- This documentation contains pictures of the devices described. The pictures may differ in minor details from the devices supplied.

You should also observe the notes that are marked as follows:

NOTE

A note contains important information about the product described in the documentation, about the handling of the product, and about sections in this documentation demanding your particular attention.

Industry Mall

The Industry Mall is the catalog and ordering system of Siemens Aktiengesellschaft for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

1.1 S7-1500 Motion Control Documentation Guide

Product information

Please also note the supplementary information on the Motion Control documentation:

- Product information on the S7-1500/1500T Motion Control documentation
  https://support.industry.siemens.com/cs/ww/en/view/109794046
  (https://support.industry.siemens.com/cs/ww/en/view/109794046)

Documentation

The documentation of the Motion Control functions is divided into the following documents:

- S7-1500/S7-1500T Motion Control Overview
  https://support.industry.siemens.com/cs/en/view/109990070
  (https://support.industry.siemens.com/cs/ww/en/view/109990070)

  This document describes the innovations in the technology versions, how to upgrade the technology version, functions that are used for all technology objects, and the operational sequence of Motion Control applications.
- S7-1500/S7-1500T Motion Control alarms and error IDs
  https://support.industry.siemens.com/cs/ww/en/view/109990076
  (https://support.industry.siemens.com/cs/ww/en/view/109990076)

  This document describes the technology alarms of the technology objects and the error identifications of the Motion Control instructions.
- S7-1500/S7-1500T Axis functions
  https://support.industry.siemens.com/cs/en/view/109990072
  (https://support.industry.siemens.com/cs/ww/en/view/109990072)

  This document describes the drive and encoder connection and functions for single-axis movements.
- S7-1500/S7-1500T Synchronous operation functions
  https://support.industry.siemens.com/cs/ww/en/view/109990074
  (https://support.industry.siemens.com/cs/ww/en/view/109990074)

  This document describes gearing, velocity synchronous operation and camming as well as cross-PLC synchronous operation.

- S7-1500/S7-1500T Measuring input and output cam functions
  https://support.industry.siemens.com/cs/ww/en/view/109990075
  (https://support.industry.siemens.com/cs/ww/en/view/109990075)
  This document describes the detection of the actual position via a measuring input and the output of switching signals via output cam or cam track.
- S7-1500T kinematics functions
  https://support.industry.siemens.com/cs/ww/en/view/109990073
  (https://support.industry.siemens.com/cs/ww/en/view/109990073)
  This document describes the control of kinematics with up to 6 interpolating axes.
- S7-1500T Interpreter functions
  https://support.industry.siemens.com/cs/ww/en/view/109990077
  (https://support.industry.siemens.com/cs/ww/en/view/109990077)
  This documentation describes the control of technology objects via an Interpreter program.

See also

Topic page "SIMATIC Technology - Motion Control: Overview and Important Links"
https://support.industry.siemens.com/cs/ww/en/view/109751049
(https://support.industry.siemens.com/cs/ww/en/view/109751049)

1.2 Function Manuals documentation guide

1.2.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.2.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.2.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 General safety instructions

The safety instructions can be found in section "Safety instructions" in the System Manual "SIMATIC S7-1500, ET 200MP Automation System" (https://support.industry.siemens.com/cs/ww/en/view/59191792) document.

Cybersecurity-relevant information can be found in the Industrial Cybersecurity section.

2.2 Warnings in this document

You can find explanations of the warnings used in this document in the "Legal information" section.

Industrial cybersecurity 3

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

3.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

New features V10.0

4

4.1 New kinematics functions V10.0

Technology version V10.0 contains the following new features:

Kinematics control panel

- The traversing velocity can only be set with active master control via "Adjust > Velocity" in the kinematics control panel, but not via <TO>.Override.Velocity in the user program.

S7-1500T Motion Control KinPlus

- The Motion Control package "S7-1500T Motion Control KinPlus" V10.0 supports the technology versions V9.0 and V10.0 also on the CPU 1516T/TF-3 PN and CPU 1517T/TF-3 PN with CPU firmware version V4.1.
- The configuration of the kinematics type "6-axis articulated arm with central wrist" has been extended by the parameter length L6. This supports kinematics with horizontal offset of the central wrist in relation to the A1 axis.
- The predefined kinematics types have been expanded to include the "6-axis articulated arm with offset wrist (Page 127)" kinematics type.

Overview of functions 5

5.1 Kinematics systems for handling tasks

Kinematics are user-programmable mechanical systems in which multiple mechanically coupled axes produce the motion of a working point. The S7-1500T technology CPUs provide functions for controlling kinematics systems, e.g. for handling tasks, with the kinematics technology object. Typical applications include:

- Pick & Place
- Installation
- Palletizing

The kinematics control panel and extensive online and diagnostic functions support straightforward commissioning of kinematics systems. The kinematics technology object is fully integrated in the system diagnostics of the S7-1500T CPU.

5.2 Kinematics technology object with up to 4 interpolating kinematics axes

The kinematics technology object calculates motion setpoints for the tool center point (TCP) of the kinematics taking into account the dynamic settings. The kinematics technology object calculates the motion setpoints for the individual axes of the kinematics and vice versa from the current values of the axes using the kinematics transformation. The kinematics technology object outputs the axis-specific motion setpoints to the interconnected positioning axes.

The kinematics technology object provides the kinematics transformation (Page 177) for the predefined kinematics types on the system level. In the case of user-defined kinematics systems, you must provide the user transformation (Page 190) in a separate program.

You create the individual axes of the kinematics in the TIA Portal as "Positioning axis" or "Synchronous axis" technology objects. When you configure the kinematics technology object, you interconnect the axes in accordance with the configured kinematics type.

You can find an overview of the functions of the kinematics technology object in the section "Motion control instructions for kinematics control (Page 24)".

The graphic below shows the basic principle of operation of the kinematics technology object with up to four interpolating kinematics axes:

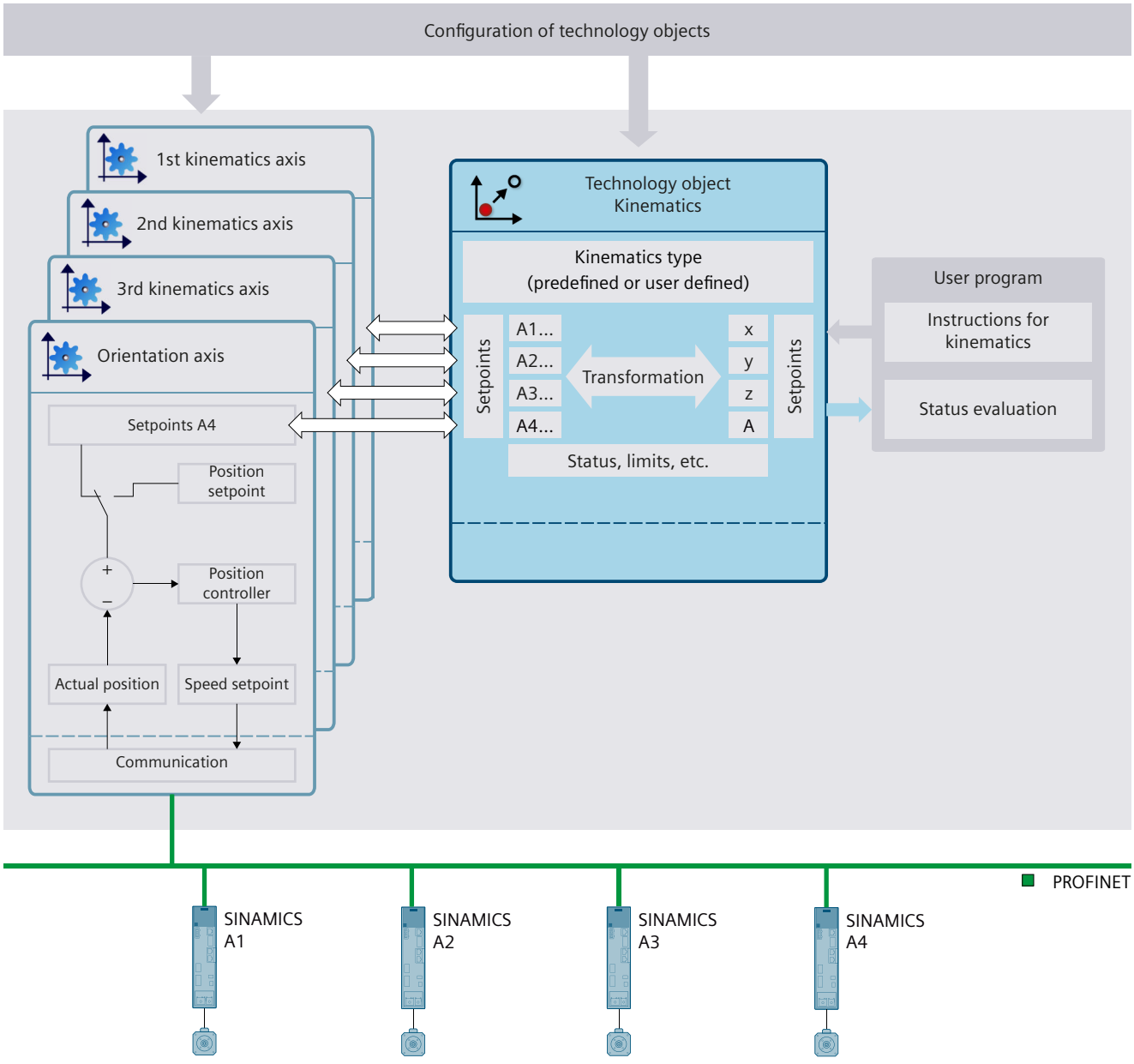

Configuration

The following configurations are available in the kinematics technology object:

- Basic parameters
  - Kinematics (Page 46)
  - Units of measure (Page 47)
- Interconnections
  - Interconnecting kinematics axes (Page 49)
  - Mechanical axis coupling (Page 51)
- Geometry (Page 58)
- Conveyor tracking (Page 288)
- Dynamics
  - Presets and limits (Page 240)
  - Dynamic adaptation (Page 244)
- Kinematics coordinate system, object coordinate systems and tools
  - Coordinate systems and frames (Page 39)
  - Kinematics types with up to four interpolating kinematics axes (Page 41)
  - Offset and rotation of the coordinate system (Page 202)
- Zones (Page 208)
- Job sequence (Page 250)

5.3 Motion control instructions for kinematics control

You execute the functions of the kinematics technology object using the Motion Control instructions in your user program or the TIA Portal (under "Technology object > Commissioning").

The following table shows the motion control instructions that are supported by the kinematics technology object:

Motion control instruction	Brief description
Kinematics motions	
"MC_GroupInterrupt"	Interrupt motion execution
"MC_GroupContinue"	Continue motion execution
"MC_GroupStop"	Stop motion
"MC_MoveLinearAbsolute"	Position kinematics with linear path motion
"MC_MoveLinearRelative"	Relative positioning of kinematics with linear path motion
"MC_MoveCircularAbsolute"	Position kinematics with circular path motion
"MC_MoveCircularRelative"	Relative positioning of kinematics with circular path motion
"MC_MoveDirectAbsolute"	Absolute movement of kinematics with synchronous "point-to-point" motion

Motion control instruction	Brief description
"MC_MoveDirectRelative"	Relative movement of kinematics with synchronous "point-to-point" motion
"MC_TrackConveyorBelt"	Start conveyor tracking
"MC_KinematicsMotionSimulation"	Start/end simulation of kinematics
Zones	
"MC_DefineWorkspaceZone"	Define workspace zone
"MC_DefineKinematicsZone"	Define kinematics zone
"MC_SetWorkspaceZoneActive"	Activate workspace zone
"MC_SetWorkspaceZoneInactive"	Deactivate workspace zone
"MC_SetKinematicsZoneActive"	Activate kinematics zone
"MC_SetKinematicsZoneInactive"	Deactivate kinematics zone
Tools	
"MC_DefineTool"	Redefine tool
"MC_SetTool"	Change active tool
Coordinate systems	
"MC_SetOcsFrame"	Redefine object coordinate systems
"MC_KinematicsTransformation"	Convert axis coordinates to Cartesian coordinates
"MC_InverseKinematicsTransformation"	Convert Cartesian coordinates to axis coordinates

5.4 Functions in STEP 7

The following table shows the functions supported by the kinematics technology object in STEP 7:

Functions in the TIA Portal	Brief description
Kinematics control panel (Page 317)	• Active homing of the kinematics axes • Jog kinematics in WCS or OCS • Jog individual kinematics axes in MCS • Jog joints in the JCS
Diagnostics (Page 339)	Monitor and observe status and error messages of the kinematics technology object
Kinematics trace (Page 347)	• 3D visualization of the current motion of the tool center point (TCP) and the object coordinate systems (OCS) • Record, play back and save kinematics motions • Exporting and importing recordings
Calibration (Page 355)	• Determine exact position of object coordinate systems • Define workspace zones • Move tool center point offline in the 3D view using the directional pad • Move real kinematics online with the kinematics control panel

5.5 Configuration limits for kinematics systems

Motion control resources

Each CPU offers a defined set of "Motion Control resources". For information on the total Motion Control resources available, refer to the technical specifications of the utilized CPU.

You can find an overview of the Motion Control resources of a CPU in the TIA Portal under "Tools > Resources".

Extended Motion Control resources (S7-1500T)

In addition to the Motion Control resources of the interconnected axes, a kinematics technology object utilizes 30 "Extended Motion Control resources". For information on the maximum number of usable kinematics systems, refer to the technical specifications of the utilized CPU.

You can find the technical specifications of the S7-15xxT CPUs in the respective manual.

Application cycle

As the number of technology objects used increases, the computing time needed by the CPU to process the technology objects increases. The Motion Control application cycle can be adapted according to the number of technology objects used.

S7-1500T Motion Control KinPlus

6

6.1 Product description "S7-1500T Motion Control KinPlus"

The Motion Control package "S7-1500T Motion Control KinPlus" enables you to control kinematics with 5 or 6 interpolating axes. These functions are not included in the firmware of a technology CPU due to export law.

Principle of operation

The Motion Control package "S7-1500T Motion Control KinPlus" contains the full Motion Control firmware with the function extensions. The Motion Control functions for kinematics with up to 4 axes and all other Motion Control functions, such as homing or synchronous operation, are also loaded from the Motion Control package "S7-1500T Motion Control KinPlus".

The Motion Control package must be copied to a SIMATIC Memory Card of the type "S7-1500T Motion Control KinPlus". The firmware with the function extensions is loaded from this card in runtime.

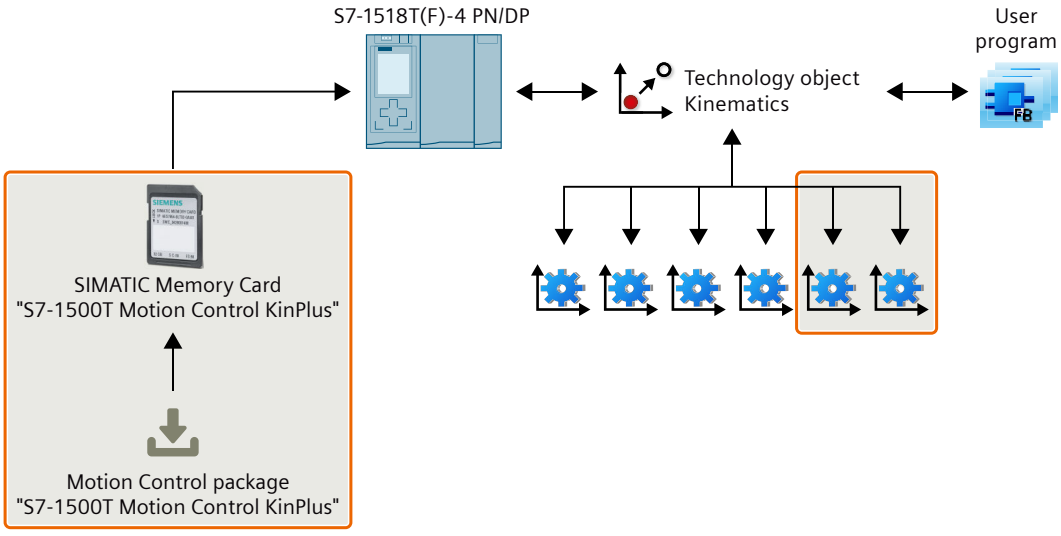

Supported kinematics types

"S7-1500T Motion Control KinPlus" extends the kinematics technology object to include the following kinematics types:

- Cartesian portal with 2 orientations A, B
- 6-axis articulated arm with central wrist
- 6-axis articulated arm with offset wrist
- Delta picker with 2 orientations A, B
- User-defined kinematics 3D with 3 orientations

Using versions

You use the "S7-1500T Motion Control KinPlus" Motion Control package depending on the CPU firmware version.

The following table shows you the CPUs with which you can use the "S7-1500T Motion Control KinPlus" Motion Control package depending on versions and which technology versions are supported.

Version Motion Control package "S7-1500T Motion Control KinPlus"	CPU firmware version	Supported CPUs	Technology version			
			V7.0	V8.0	V9.0	V10.0
V10.0	V4.1	• CPU 1516T-3 PN • CPU 1516TF-3 PN • CPU 1517T-3 PN • CPU 1517TF-3 PN • CPU 1518T-3 PN • CPU 1518TF-3 PN	-	-	✓	✓
V9.0	V4.0	• CPU 1518T-3 PN • CPU 1518TF-3 PN	-	-	✓	-
V8.0	V3.1	• CPU 1507D TF with SINAMICS S120 Integrated • CPU 1518T-4 PN/DP • CPU 1518TF-4 PN/DP	✓	✓	-	-
V7.0	V3.0	• CPU 1507D TF with SINAMICS S120 Integrated • CPU 1518T-4 PN/DP • CPU 1518TF-4 PN/DP	✓	-	-	-

Simulation with PLCSIM and PLCSIM Advanced is not supported.

Type of delivery

The SIMATIC Memory Card for "S7-1500T Motion Control KinPlus" is available with the following storage capacity:

Product	Article number
S7-1500T Motion Control KinPlus **2 GB**	6ES7 954-8LP80-0AA0
S7-1500T Motion Control KinPlus **32 GB**	6ES7 954-8LT80-0AA0

The Motion Control package "S7-1500T Motion Control KinPlus" is available as follows:

Product	Article number
S7-1500T Motion Control KinPlus package V10.0 as software download (initially only available in EU countries, planned for other countries in 2026)	6ES7 823-0KE03-1AA0
S7-1500T Motion Control KinPlus package V10.0 on USB flash drive	6ES7 823-0KU03-1AA0

NOTE

Reusing the "S7-1500T Motion Control KinPlus" Motion Control package

You need one SIMATIC Memory Card and one "S7-1500T Motion Control KinPlus" Motion Control package per CPU.
The "S7-1500T Motion Control KinPlus" Motion Control package cannot be used multiple times. It is not permissible to order it once and then duplicate it.

Important export information

Due to existing export restrictions for software, with respect to certain controller functions (more than 4 interpolating axes), the European/German export list classifies the product "S7-1500T Motion Control KinPlus" as a dual-use good with label AL=2D002 and ECCN=N.

When using "S7-1500T Motion Control KinPlus", special attention must be paid to the fact that the obligation to obtain authorization also exists when components requiring authorization are exported as part of service delivery, spare parts delivery and software upgrade/software update delivery. This applies, in particular, when the software has been exported by the machine manufacture after installation in the machine.

This can lead to severe restrictions on providing services due to the length of the official authorization process.

General information:

For certain components, an obligation exists to obtain authorization for reexport according to U.S. law. This must also be heeded. Information on the obligation to obtain authorization for delivered components can be found in the delivery documents:

Goods labeled with AL not equal to N are subject to European or German export authorization when being exported from the EU. Goods labeled with ECCN not equal to N are subject to U.S. reexport authorization.

Even without a label, or with label AL=N or ECCN=N, authorization may be required due to the final whereabouts and purpose for which the goods are to be used.

In the event of a purchase agreement, the fulfillment of the agreement on the part of Siemens is subject to there being no obstacle to fulfillment due to national or international foreign trade law or embargos and/or other sanctions.

Customers are subsequently responsible for the lawful handling.

6.2 Kinematics technology object with more than 4 interpolating kinematics axes

If a SIMATIC Memory Card with the Motion Control package "S7-1500T Motion Control KinPlus" is plugged into the CPU, the kinematics technology object calculates the motion setpoints for the tool center point for kinematics with more than 4 kinematics axes. The kinematics technology object calculates the motion setpoints for the individual axes of the kinematics and vice versa from the current values of the axis using the kinematics transformation. The dynamic specifications are included in all calculations. The kinematics technology object outputs the axis-specific motion setpoints to the interconnected positioning or synchronous axes.

For the predefined kinematics types, the kinematic transformation (Page 177) is part of the kinematics technology object. For the user-defined kinematics 3D with 3 orientations, you need to provide the kinematics transformation in a separate program.

You create the individual axes of the kinematics in the TIA Portal as "Positioning axis" or "Synchronous axis" type technology objects. When you configure the kinematics technology object, you interconnect the axes in accordance with the configured kinematics type.

The following graphic shows the basic function of the kinematics technology object when using S7-1500T Motion Control KinPlus:

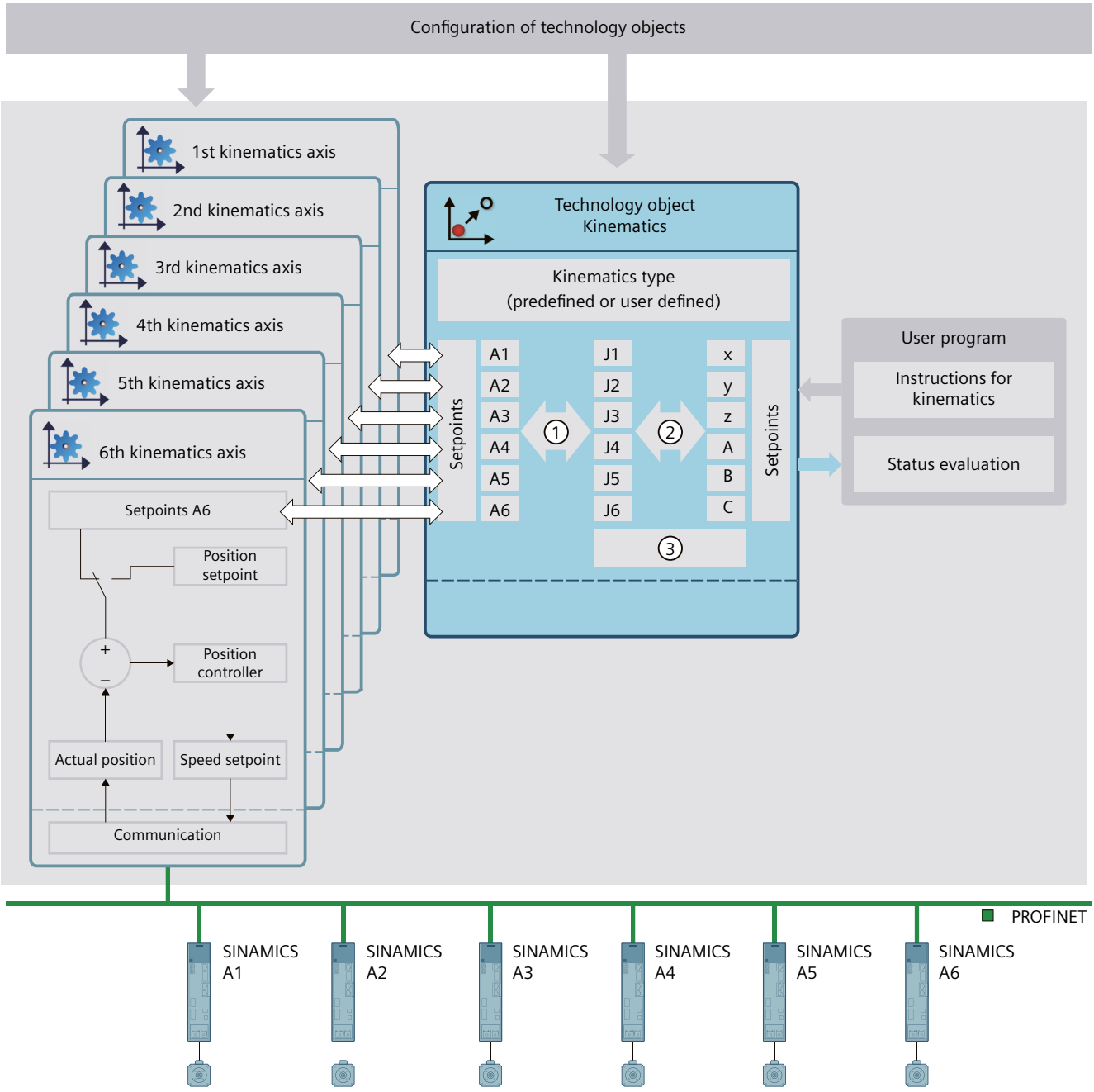

① Mechanical axis couplings

② Offsets
Inverted direction of movement
Transformation

③ Status, joint traversing range limits

For kinematics with more than 4 kinematics axes, the joint coordinate system (JCS) represents the mechanical positions of the kinematics joints, while the MCS displays the axis positions. The joint coordinates can be specified as target coordinates for sPTP motions.

Configuration

In the kinematics technology object, the following configurations are available for kinematics types with more than 4 kinematics axes:

- Basic parameters
  - Kinematics (Page 46)
  - Units of measure (Page 47)
- Interconnections
  - Interconnecting kinematics axes (Page 49)
  - Mechanical axis coupling (Page 51)
  - Joints (Page 54)
- Geometry (Page 216)
- Conveyor tracking (Page 288)
- Dynamics
  - Presets and limits (Page 243)
  - Dynamic adaptation (Page 244)
- Kinematics coordinate system, object coordinate systems and tools
  - Coordinate systems and frames (Page 39)
  - Kinematics types with more than four kinematics axes (Page 43)
  - Offset and rotation of the coordinate system (Page 202)
- Zones (Page 211)
- Job sequence (Page 250)

Motion Control instructions

All Motion Control instructions supported by the kinematics technology object can also be used for kinematics with more than 4 interpolating axes.

You can find more information under Motion control instructions for kinematics control (Page 24).

Functions in STEP 7

The following table shows the functions supported by S7-1500T Motion Control KinPlus in STEP 7:

Functions in the TIA Portal	Brief description
Kinematics control panel (Page 317)	• Active homing of the kinematics axes • Jog kinematics in WCS or OCS • Jog individual kinematics axes in MCS • Jog joints in the JCS

Functions in the TIA Portal	Brief description
Diagnostics (Page 339)	Monitor and observe status and error messages of the kinematics technology object
Kinematics trace (Page 347)	• 3D visualization of the current motion of the tool center point (TCP) and the object coordinate systems (OCS) • Record, play back and save kinematics motions • Exporting and importing recordings
Calibration (Page 355)	• Determine exact position of object coordinate systems • Define workspace zones • Move tool center point offline in the 3D view using the directional pad • Move real kinematics online with the kinematics control panel

6.3 SIMATIC Memory Card S7-1500T Motion Control KinPlus

The SIMATIC Memory Card with the Motion Control package "S7-1500T Motion Control KinPlus" is marked with "S7-1500T MC KinPlus".

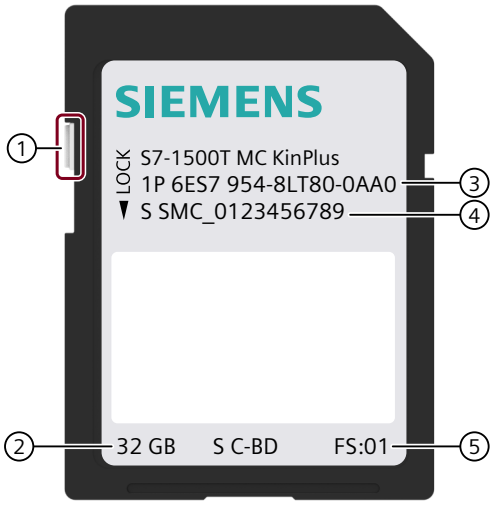

① Slider for setting write protection:
- Slider up: not write-protected
- Slider down: write-protected

② Memory size

③ Article number

④ Serial number

⑤ Production version

The card can contain the Motion Control package "S7-1500T Motion Control KinPlus" and all files that are also stored on a normal SIMATIC Memory Card. You can only use a Motion Control package "S7-1500T Motion Control KinPlus" on a SIMATIC Memory Card "S7-1500T MC KinPlus".

You can find more information about using the SIMATIC Memory Card in the function manual "Structure and Use of the CPU Memory (https://support.industry.siemens.com/cs/ww/en/view/59193101)".

Enable Motion Control package "S7-1500T Motion Control KinPlus"

The SIMATIC Memory Card "S7-1500T MC KinPlus" does not contain a Motion Control package "S7-1500T Motion Control KinPlus" in the following situations:

- The card is still unused.
- All versions have been deleted.
- The card has been formatted via the TIA Portal or the CPU display.

Requirement

You have downloaded the Motion Control package "S7-1500T Motion Control KinPlus" as a software download or have it available on a USB flash drive.

Procedure

1. Create the "\MCRC\" folder on the "SIMATIC" Memory Card "S7-1500T MC KinPlus".
2. Copy the UPD file from the Motion Control package "S7-1500T Motion Control KinPlus" into the "\MCRC\" folder ("Motion Control Runtime Component") on the SIMATIC Memory Card.

   Copy the UPD file to the SIMATIC Memory Card using a card reader or the SIMATIC web server.
3. To activate the Motion Control package on the CPU, insert the SIMATIC Memory Card into the SIMATIC CPU. After POWER OFF → POWER ON of the CPU, the firmware extension is loaded and can be used as long as the card is inserted.

Show loaded Motion Control package

To check if the firmware extension "S7-1500T Motion Control KinPlus" has been loaded successfully, check the current Motion Control package.

You can find the version and type of the loaded Motion Control package via the following options:

- Under "Online and Diagnostics > General" in the Motion Control Package Information area
- In the diagnostic buffer in the event description for the loaded version
- In the display of the CPU under Overview > Motion Control Package Information
- In the web server on the page Diagnostics > Motion Control Package Information

If the Motion Control package "S7-1500T Motion Control KinPlus" is successfully loaded, "Package name: MC KinPlus" is displayed. The version and internal version of the Motion Control package are also displayed. If "Package name: MC Base" is displayed, the Motion Control package "S7-1500T Motion Control KinPlus" is not loaded.

Upgrade the Motion Control package

To upgrade the Motion Control package, copy the new UPD file into the folder "\MCRC\". The UPD file with the highest version from the folder "\MCRC\" is always loaded during the startup of the CPU. The version of the Motion Control package is included in the file name. The newest version is always loaded if there are several versions of the Motion Control package "S7-1500T Motion Control KinPlus" on the card.

Delete data on the card

To preserve the possibility of restoring an earlier version, save the existing file on another data medium before deleting it.

To free up memory on the SIMATIC Memory Card, delete Motion Control package files with earlier versions if you have copied different versions of the Motion Control package to the card.

Format SIMATIC Memory Card

Formatting the SIMATIC Memory Card deletes the Motion Control package "S7-1500T Motion Control KinPlus".

Before formatting the SIMATIC Memory Card, save the Motion Control package file on an external data medium.

WARNING

Memory card unusable

Formatting the SIMATIC Memory Card via Windows applications makes it unusable.

Format the memory card exclusively via the TIA Portal or the display of the CPU.

NOTICE

Motion Control package "S7-1500T Motion Control KinPlus" deleted

If you select the option to format the SIMATIC Memory Card when restoring the factory settings for the module, the Motion Control package "S7-1500T Motion Control KinPlus" is deleted.

Before you restore the factory settings for the module and format the SIMATIC Memory Card, save the Motion Control package file on an external data medium.

CPU replacement

If you replace the CPU, you only have to plug the SIMATIC Memory Card "S7-1500T Motion Control KinPlus" into a new device with compatible firmware. You can find the version overview in the "Product description "S7-1500T Motion Control KinPlus" (Page 27)" section.

Mapping kinematics in the project 7

7.1 Term definition

Kinematics

Kinematics are user-programmable mechanical systems in which multiple mechanically coupled axes produce the motion of a working point.

Kinematics axes

Kinematics axes are the axes of the kinematics motion. You connect each kinematics axis with a positioning axis/synchronous axis technology object.

Wrist point

The axes A4, A5 and A6 form the central wrist with the kinematics types "6-axis articulated arm with central wrist". This means that the axes A4, A5 and A6 intersect at one point. This point is referred to as the wrist point. The axis A5 forms the wrist point with the kinematics type "6-axis articulated arm with offset wrist".

Kinematics zero point (KZP)

The coordinate origin of the kinematics coordinate system (KCS) is the KZP. You configure the geometry parameters of the kinematics starting from the KZP.

Zero point of the flange coordinate system (FZP)

The coordinate origin of the flange coordinate system (FCS) is the FZP. Starting from the FZP, you define, for example, the flange zones of the kinematics.

Tool center point (TCP)

The coordinate origin of the tool coordinate system (TCS) is the tool center point or TCP. The TCP is the operating point of the kinematics.

Degrees of freedom of kinematics

The degrees of freedom of kinematics are the dimensions in which the tool can move. 2D kinematics systems move the tool in the xz plane and thus have 2 translational degrees of freedom. 3D kinematics systems move the tool in xyz space and thus have 3 translational degrees of freedom. The optional orientation of the tool is 1 to 3 more degrees of freedom (rotations around the z, y and x axes).

Machine coordinate system (MCS)

The MCS contains the position data of the interconnected kinematics axes and thus combines up to six one-dimensional systems in one system.

Joint coordinate system (JCS)

The JCS contains the geometric positions of the kinematics joints. Joints can perform linear or rotary movements.

Job sequence

The job sequence of the kinematics technology object is the memory to which motion-related Motion Control jobs are entered as pending, waiting jobs. The job sequence allows the calculation of a velocity profile over several jobs.

AxesGroup

Kinematics-related Motion Control instructions have the input parameter "AxesGroup". Because the kinematics technology object groups the kinematics axes, you assign the kinematics technology object directly to the input parameter "AxesGroup".

Joint position space

Depending on the kinematics type, a kinematics can reach Cartesian coordinates via various joint positions. The kinematics type (Page 58) defines the possible joint positions and the positive and negative joint position spaces. The joint positioning spaces are limited by the respective transformation areas.

Joint traversing range

The joint traversing range defines the minimum and maximum traversing position of a joint.

Target joint position range

A target joint position range defines the number of revolutions of a joint.

7.2 Legend for representation of the kinematics

The following table shows the graphic elements and symbols used in the display of kinematics and coordinate systems:

Graphic element	Meaning
	Basis of kinematics
	Kinematics arm
	Kinematics deflected from zero position
	Active rotary axis
	• Passive joint • Axis guide
	Active linear axis
	Rotary axis on the tool adapter
	Swivel axis
	Tool adapter
	Tool (gripper)
	Coordinate axis set up out of the mapping plane
	Coordinate axis set up into the mapping plane
	Color x axis
	Color y axis
	Color z axis

7.3 Coordinate systems and frames

A handling task involves many objects, e.g. kinematics systems, tools, pallets and products. You describe these objects and their relative positions with coordinate systems and frames. The kinematics technology object calculates all motions for the tool center point (TCP).

Coordinate systems

The kinematics technology object uses the following right-handed Cartesian coordinate systems according to DIN 66217:

- World coordinate system (WCS)
- Kinematics coordinate system (KCS)
- Flange coordinate system (FCS)
- Tool coordinate system (TCS)
- Object coordinate systems (OCS)

The following graphic shows the relative position of the coordinate systems using a workspace example:

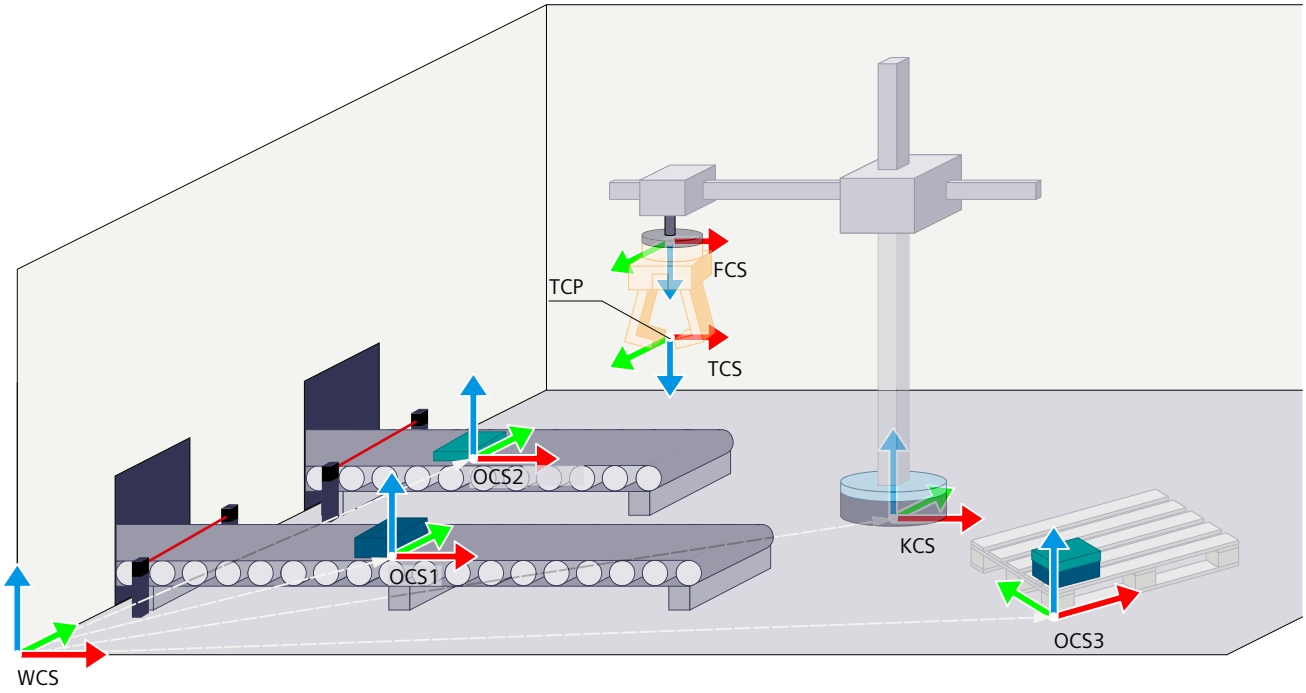

The position of the FCS and the TCS in the zero position of the kinematics is defined differently for the following kinematics types:

- Kinematics types with up to four interpolating kinematics axes (Page 41)
- Kinematics types with more than four kinematics axes (Page 43)

World coordinate system (WCS)

The WCS is the fixed coordinate system of the environment or workspace of the kinematics. The zero point of the WCS is the reference point for objects and motions on the kinematics technology object. Starting from the zero point of the WCS (e.g. corner of a workspace), you define the position of the objects using frames.

Kinematics coordinate system (KCS)

The KCS is connected to the kinematics. The position of the KCS within the kinematics is specified for each predefined kinematics type. The coordinate origin of the KCS is the kinematics zero point (KZP). You configure the geometry parameters of the kinematics starting from the KZP.

You configure the position of the KCS in the WCS using the KCS frame.

Object coordinate system (OCS)

The OCS is a user-defined coordinate system. With an OCS, for example, you define the position of a pallet in the workspace. You define the position of the OCS in the WCS with an OCS frame. You can define up to 3 OCS frames which are active at the same time.

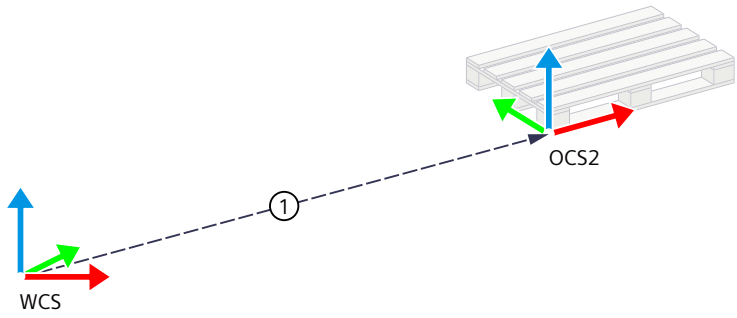

① OCS frame

Frames

Frames specify the offset and rotation of one coordinate system relative to another coordinate system.

The following table shows the frames for the kinematics technology object:

Frame	Description
KCS frame	Position of the kinematics coordinate system (KCS) in the world coordinate system (WCS)
Transformation frame	Position of the flange coordinate system (FCS) in the KCS The transformation frame results from the kinematics transformation and is displayed in the "<TO>.FlangeInKcs" tag of the technology object.
Tool frame	Position of the tool coordinate system (TCS) in the FCS
OCS1..3 frame	Position of the object coordinate systems 1 to 3 (OCS1..3) in the WCS

7.3.1 Kinematics types with up to four interpolating kinematics axes

Flange coordinate system (FCS)

The FCS is attached to the tool adapter (flange) of the kinematics. As a result, the position of the FCS changes with kinematics motions.

The position of the FCS in the zero position of the kinematics results from the configuration of the geometry parameters of the kinematics. The kinematics technology object calculates the transformation frame from the geometry parameters.

The transformation frame describes the position of the FCS in the KCS. The z axis of the FCS always points in the negative z direction of the KCS. A rotation of the FCS around z of the KCS is possible for kinematics types with orientation.

The following graphic shows the positions of the FCS, KCS and the transformation frame using the "Cylindrical robot" kinematics example:

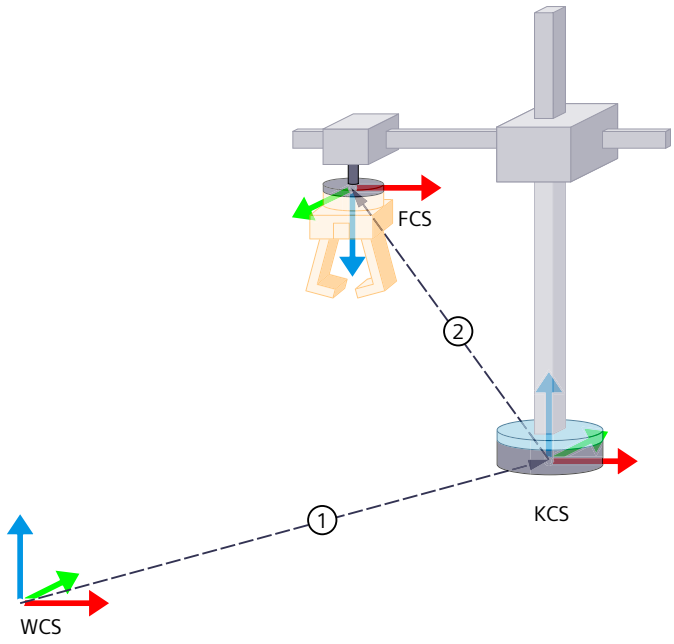

① KCS frame

② Transformation frame

Tool coordinate system (TCS) and tool center point (TCP)

The TCS is attached to the FCS and defines the tool center point (TCP) in the coordinate origin. The TCP is the operating point of the tool. The kinematics motions always refer to the TCP (with reference to WCS/OCS). You define the position of the TCS in the FCS using a tool frame.

You can define tool frames for up to three tools, of which only one tool and one tool frame is active at the same time. The procedure for the definition of tool frames is described in the section "Defining tool frames" (Page 206).

The position of the TCS is defined at the target position reached for kinematics types with up to 4 interpolating axes as follows:

- The x direction of the TCS is the same as the x direction of the target position.
- The y direction of the TCS is opposite to the y direction of the target position.
- The z direction of the TCS always points in the negative z direction of the target position.

The following graphic shows the position of the TCS and the TCP in the workspace:

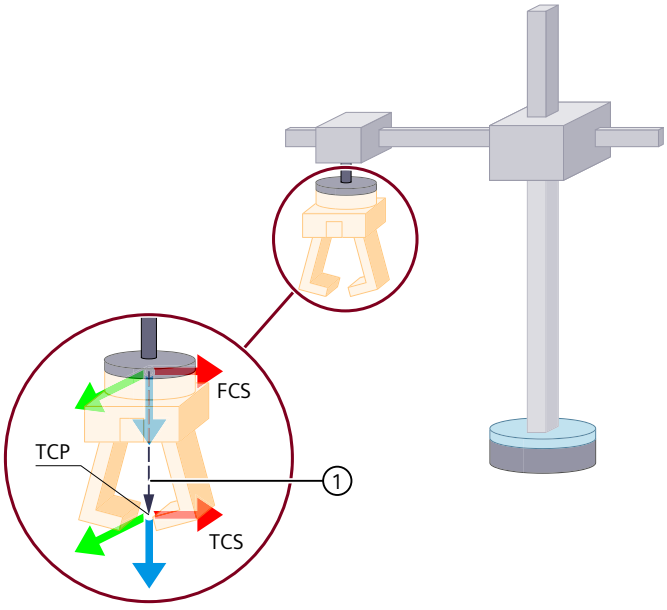

① Tool frame

The following graphic shows the position of the TCS before and after a kinematics motion:

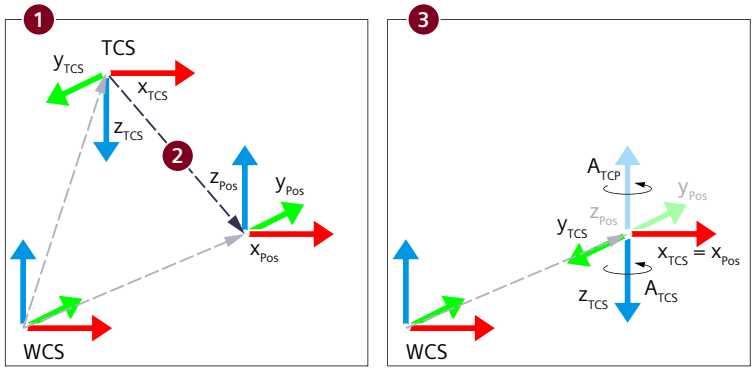

① TCS at initial position

② Kinematics motion to target position

③ TCS at the target position reached

For kinematics types with orientation, the orientation is negative relative to the TCS and positive relative to the TCP or WCS.

7.3.2 Kinematics types with more than four kinematics axes

Flange coordinate system (FCS)

The FCS is attached to the tool adapter (flange) of the kinematics. As a result, the position of the FCS changes with kinematics motions.

The position of the FCS in the zero position of the kinematics results from the configuration of the geometry parameters of the kinematics. The kinematics technology object calculates the transformation frame from the geometry parameters.

The x axis of the FCS is defined in the outward direction of the flange normal vector. This means that the x axis of the FCS is also in the direction of the tool length vector if the tool frame of the TCS is defined without rotation.

In contrast to kinematics with up to four interpolating kinematics axes, the z axis of the FCS does not always point in the negative direction of the KCS.

The following graphic shows the positions of the FCS and KCS and the transformation frame of a kinematics with five kinematics axes using the "Delta picker 3D with 2 orientations A, B" kinematics as an example:

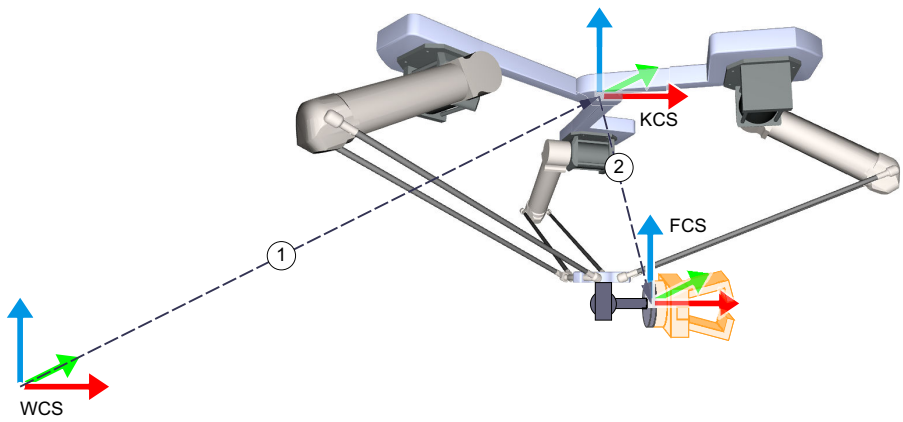

① KCS frame

② Transformation frame

The following graphic show the alignment of the FCS at other joint positions of the kinematics:

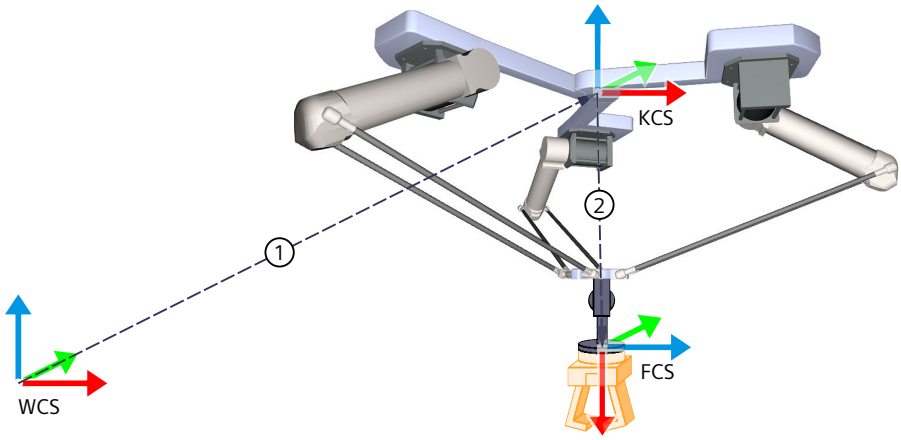

① KCS frame
② Transformation frame

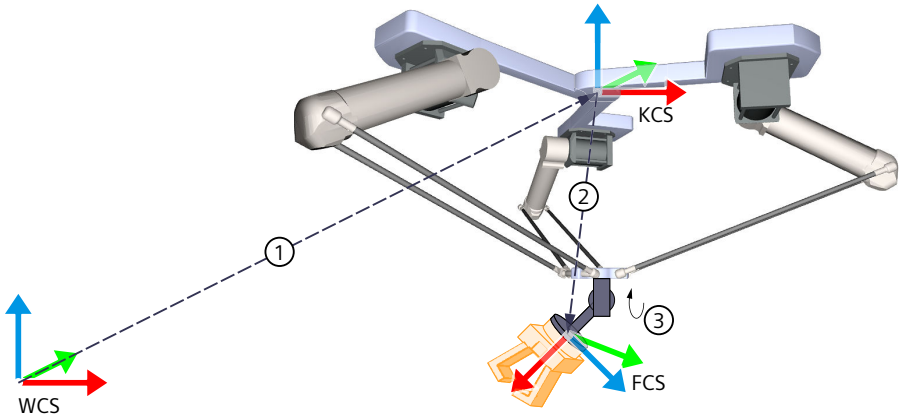

① KCS frame
② Transformation frame
③ Pivot

Tool coordinate system (TCS) and tool center point (TCP)

The TCS is attached to the FCS and defines the tool center point (TCP) in the coordinate origin. The TCP is the operating point of the tool. The kinematics motions always refer to the TCP (with reference to WCS/OCS). You define the position of the TCS in the FCS using a tool frame.

You can define tool frames for up to three tools, of which only one tool and one tool frame is active at the same time. The procedure for the definition of tool frames is described in the section "Defining tool frames" (Page 206).

The position of the TCS is defined at the target position reached for kinematics types with more than 4 interpolating axes as follows:

- The x direction of the TCS is the same as the x direction of the target position.
- The y direction of the TCS is the same as the y direction of the target position.
- The z direction of the TCS is the same as the z direction of the target position.

The following graphic shows the position of the TCS and the TCP in the workspace:

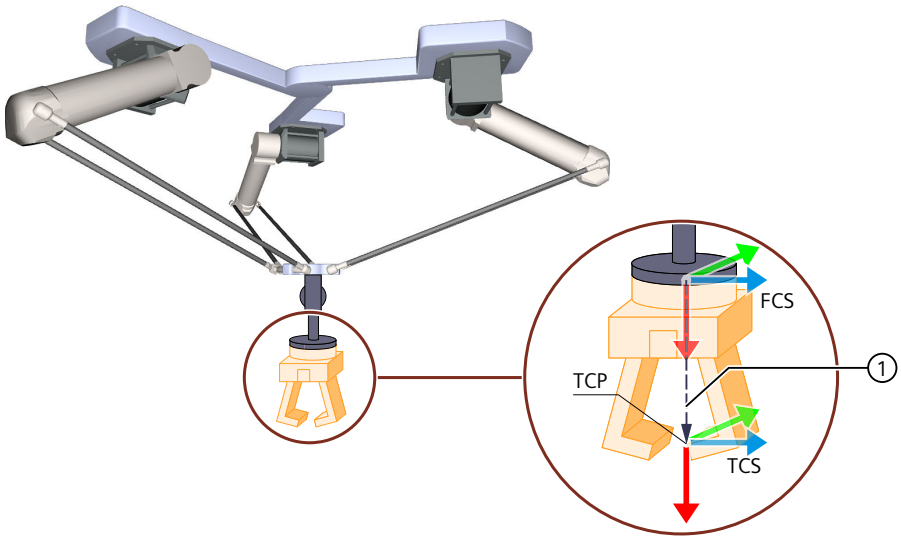

① Tool frame

The following graphic shows the position of the TCS before and after a kinematics motion:

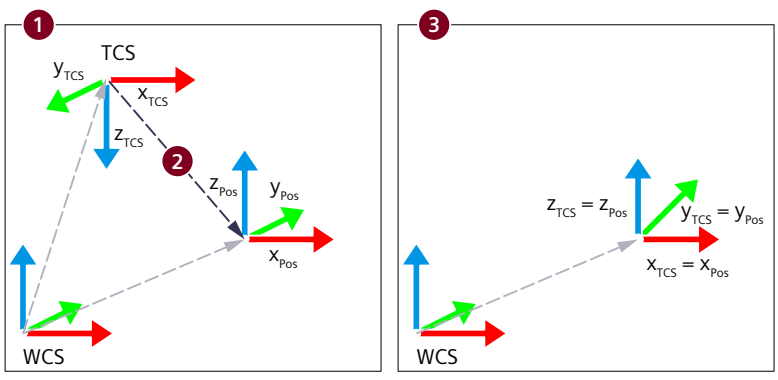

① TCS at initial position

② Kinematics motion to target position

③ TCS at the target position reached

7.4 Supported kinematics types

The type of the mechanical system and the number of the axes determine the kinematics type. The mechanically coupled axes produce the motion of the tool center point (TCP). Depending on the kinematics type, you configure the kinematics using appropriate geometry parameters.

The kinematics technology object supports the following kinematics types:

Category	Kinematics type
Predefined kinematics systems	
Cartesian portal (Page 58)	Cartesian portal 2D
	Cartesian portal 2D with orientation
	Cartesian portal 3D
	Cartesian portal 3D with orientation
	Cartesian portal 3D with 2 orientations A, B [1]
Roller picker (Page 73)	Roller picker 2D
	Roller picker 2D with orientation
	Roller picker 3D (vertical)
	Roller picker 3D with orientation (vertical)
	Roller picker 3D with orientation (horizontal)
SCARA (Page 87)	SCARA 2D with orientation
	SCARA 3D with orientation
Articulated arm (Page 96)	Articulated arm 2D
	Articulated arm 2D with orientation
	Articulated arm 3D
	Articulated arm 3D with orientation
	6-axis articulated arm with central wrist [1]
	6-axis articulated arm with offset wrist [1]
Delta picker (Page 141)	Delta picker 2D
	Delta picker 2D with orientation
	Delta picker 3D
	Delta picker 3D with orientation
	Delta picker 3D with 2 orientations A, B [1]
Cylindrical robot (Page 159)	Cylindrical robot 3D
	Cylindrical robot 3D with orientation
Tripod (Page 168)	Tripod 3D
	Tripod 3D with orientation
User-defined kinematics systems	
User-defined kinematics systems (Page 176)	User-defined 2D
	User-defined 2D with orientation A

[1] S7-1500T Motion Control KinPlus

Category	Kinematics type
User-defined kinematics systems (Page 176)	User-defined 3D
	User-defined 3D with orientation A
	User-defined 3D with 3 orientations [1]

[1] S7-1500T Motion Control KinPlus

7.5 Units of measure

Select the units of measure available for the technology object from the drop-down lists.

Setting or changing the units of measurement affects the parameter values:

- Display of parameter values in the technology data block
- Assignment of parameters in the user program
- Input and display of the position and velocity in the TIA Portal

All information and displays correspond to the selected unit of measure.

The set units are displayed in the "<TO>.Units" tag structure of the technology object. The tag structure is described in the ""Units" tag (kinematics) (Page 499)" section.

Position and velocity

The following table shows the supported units of measure for position and velocity of linear axes:

Position	Velocity
nm, µm, mm[1], m, km	mm/s[1], mm/min, mm/h, m/s, m/min, m/h, km/min, km/h
in, ft, mi	in/s, in/min, ft/s, ft/min, mi/h

[1] Six decimal places when the option box "Use position values with higher resolution" is selected.

The following table shows the supported units of measure for angle and angular velocity of rotational axes:

Angle	Angular velocity
°[1], rad	°/s[1], °/min, rad/s, rad/min

[1] Six decimal places when the option box "Use position values with higher resolution" is selected.

Acceleration

The acceleration is set accordingly as the position/s^2 (angle/s^2) unit of measure.

Jerk

The jerk is set as the position/s^3 (angle/s^3) unit of measure.

Units of measure of the axes and the kinematics technology object

The technology objects always transfer values without units of measure.

For example, if you set [mm] for an axis and [m] for the kinematics technology object, the kinematics technology object miscalculates the position values of the linear axis in [m]. If, in this example, the kinematics technology object outputs a setpoint for a one-meter motion, the axis only moves by one millimeter.

The kinematics technology object outputs linear and rotary setpoints to the interconnected axes according to the kinematics type. The kinematics technology object does not check the axis type of the interconnected axis (linear or rotary).

Configure the units of measure as follows:

- Configure the interconnected technology objects as linear or rotary axes according to the kinematics type.
- Configure the same linear/rotary units of measure for the axes interconnected according to the kinematics type as for the kinematics technology object.
- Configure the same units of measure on the interconnected axes for all linear axes and for all rotary axes.

Position values with higher resolution

If you select the "Use position values with higher resolution" check box in the configuration of the positioning axis, synchronous axis, external encoder and kinematics technology objects, six decimal places are available in the selected unit, instead of the standard three. Due to the LREAL format, the representable position and angle range in [mm] and [°] is limited to +/- 1.0E09. You can then only use the units mm, mm/s, ° and °/s. If you have previously configured other units, these will automatically be changed to the unit "mm, mm/s, ° or °/s".

The following values are reduced by a factor of 1000 for position values with a higher resolution:

- Displayable position range
- Displayable angular range
- Mechanical gear ratio
- Numerical traversing range with regard to long-term stability
- Dynamic values for velocity, acceleration and deceleration

7.6 Configuring and interconnecting kinematics axes

You can interconnect a kinematics technology object with positioning axes and synchronous axes. There must be a clear reference between the kinematics technology object and the interconnected axes. You cannot use a second kinematics technology object with already interconnected axes.

Depending on the kinematics type, you need 2 to 6 positioning axes or synchronous axes, which you interconnect with the kinematics.

Depending on the kinematics type, the following kinematics axes are relevant:

Kinematics type	Kinematics axis					
	A1	A2	A3	A4	A5 [1]	A6 [1]
2D	✓	✓	-	-	-	-
2D with orientation	✓	✓	-	✓	-	-
3D	✓	✓	✓	-	-	-
3D with orientation	✓	✓	✓	✓	-	-
3D with 2 orientations A, B [1]	✓	✓	✓	✓	✓	-
3D with 3 orientations [1]	✓	✓	✓	✓	✓	✓
6-axis articulated arm with central wrist [1]						
6-axis articulated arm with offset wrist [1]						

✓ Relevant

- Not relevant

[1] Only with S7-1500T Motion Control KinPlus

7.6.1 Configuring kinematics axes

Configure the following basic parameters of the axes depending on the kinematics used:

- Select the axis type according to the kinematics axes for the kinematics type (Page 58) used
- Set Modulo setting (Page 50) according to the kinematics type used or the interconnected kinematics axis

The following additional basic parameters are relevant for the interconnected kinematics axes:

- Axis in simulation/virtual axis (Page 50)
- Units of measure (Page 47)

7.6.1.1 Modulo setting

The kinematics technology object itself has no modulo setting. When you interconnect axes with active modulo setting to the kinematics technology object, the modulo range of the axes must cover at least the traversing range of the kinematics.

For the kinematics types with up to 4 interpolating axes, the zero position of the axis must correspond to the zero position of the kinematics axis. The Modulo range of the kinematics axes A1, A2 and A3 cannot be changed during a kinematics motion.

For the Cartesian orientations, you can specify an angle greater than 360°. A relative motion traverses this angle. An absolute motion maps this angle in the following ranges:

- A = -180° to 179.999°

The following ranges for the orientation are defined in addition for kinematics types with more than four interpolating kinematics axes:

- B = -90° to 90°
- C = -180° to 179,999°

For kinematics types with more than four interpolating kinematics axes, the "Modulo" setting should not be enabled for the axes A4, A5 and A6.

7.6.1.2 Axis in simulation/virtual axis

You can also interconnect the kinematics technology object with axes in simulation and virtual axes.

7.6.2 Interconnecting kinematics axes

Interconnect the axes of kinematics in the "Interconnections" configuration window.

Kinematics axes

In the drop-down lists, select the desired axes depending on the kinematics type (Page 58). Positioning axes and synchronous axes which are already created in the project are shown in the drop-down lists. Axes that are already interconnected are also visible in the drop-down lists but cannot be interconnected twice.

No provision is made for changing the interconnection of the axes during operation.

You directly call the configuration of the selected technology object using the button. Configure the interconnected technology objects according to the kinematics type (Page 49).

7.7 Mechanical axis coupling

7.7.1 Mechanical axis coupling for kinematics types with up to four interpolating kinematics axes.

If the position of a kinematics axis changes due to the motion of another kinematics axis, these two axes are mechanically coupled. Mechanical couplings between two kinematics axes can arise for reasons of construction. For example, if the kinematics axis A4 of the "SCARA" kinematics is coupled to the spindle of a linear axis, the orientation changes due to the motion of the linear axis.

NOTE

If you set a mechanical axis coupling for a first axis to a second axis, the setting "Modulo" must not be activated for the first axis.

The kinematics transformation compensates for the mechanical couplings with a compensation factor. You specify the mechanical couplings and respective compensation factor depending on the kinematics type during configuration of the kinematics.

You can configure the mechanical axis coupling for the following kinematics types:

- SCARA 2D with orientation (Page 87)
- SCARA 3D with orientation (Page 90)
- Articulated arm 2D (Page 96)
- Articulated arm 2D with orientation (Page 99)
- Articulated arm 3D (Page 103)
- Articulated arm 3D with orientation (Page 108)
- Cylindrical robot 3D with orientation (Page 163)

You can find additional information on the setting and the compensation factor in the description of the kinematics type used.

7.7.2 Mechanical axis coupling for kinematics types with more than four interpolating kinematics axes

Mechanical axis couplings of two axes mean that when the "<TO>.AxisCoupling.N[1].CausingAxis" axis moves by a distance or an angle, the position of another joint also changes without the coupled axis "<TO>.AxisCoupling.N[1].AffectedAxis" or the motor of the axis. The motor encoder of the coupled axis "<TO>.AxisCoupling.N[1].AffectedAxis" does not detect any change in position.

Configuring the mechanical axis coupling

If there are mechanical axis couplings, configure them in the "Interconnections" configuration window of the kinematics.

The coupling factor defines the position change of the tracked joint in relation to the position change of the moved axis.

The coupling factor <TO>.AxisCoupling.N[1..5].Factor defines the position change of the coupled axis "<TO>.AxisCoupling.N[1].AffectedAxis" in relation to the position change of the coupled axis "<TO>.AxisCoupling.N[1].CausingAxis".

The coupling factor is defined as a quotient, but the two position items do not need to be identical. The position changes are specified in a numerical value (without unit) of the position unit of the kinematics axis.

$$\text{Coupling factor} = \frac{\text{Position change coupled axis}}{\text{Position change causing axis}}$$

Example 1

When the axis A4 is moved by +90°, the joint J4 is moved by +90° and joint J5 is moved by 9° along with it, even though axis A5 does not move. This results in a coupling factor between axis A4 and axis A5 of:

$$\text{Coupling factor} = \frac{9}{90} = 0.1$$

Example 2

When the axis A4 is moved by 90°, the joint J4 is moved by 90°. The joint J5 is not affected. There is no mechanical coupling between axis A4 and axis A5.

Example 3

When the axis A4 is moved by 90°, the joint J4 is moved by 90° and joint J5 is also moved by -0.9 mm, even though axis A5 does not move. This results in a coupling factor between axis A4 and axis A5 of:

$$\text{Coupling factor} = \frac{-0.9}{90} = -0.01$$

NOTE

The coupling factor for kinematics with joint coordinate system (JCS) behaves inversely to the compensation factor of kinematics without joint coordinate system.

Determining coupling factors

You have the following options to determine the coupling factors:

- Determination based on the mechanical data of the kinematics
- Detection of the position change at the affected axis via an external measuring system with movement of the axis "<TO>.AxisCoupling.N[1..5].CausingAxis"
- Determination based on position change of the affected joint

Determination based on position change of the affected joint

Follow these steps to determine the coupling factor using the position change of the affected joint:

1. Move the affected joint into the zero position.
2. Move the coupled joint via the assigned axis by a defined distance or an angle, e.g. by 5°. The axis moves by 5° in this case when the direction of movement of the joint is not inverted.

3. Jog the axis "<TO>.AxisCoupling.N[1..5].CausingAxis" so that the coupled axis is moved again in the mechanical zero position without the motor of the affected axis moving.
4. You calculate the axis coupling factor from the moved position change of the axis "<TO>.AxisCoupling.N[1..5].CausingAxis" from step 3 and the known position change of the coupled axis "<TO>.AxisCoupling.N[1..5].AffectedAxis" (5°) from step 2.

NOTE

Traversing coupled axis with sPTP motion

For coupled axes with coupling factor ≠ 1, the traversing of joints in the JCS with an sPTP motion can result in compensation motions of the coupled axes.

NOTE

Jogging joints in the JCS

For coupled axes with coupling factor ≠ 1, the jogging of joints in the JCS can result in an unwanted position change of the coupled axes.

7.7.3 Tags: Mechanical axis coupling

For the mechanical axis coupling for kinematics types with more than four interpolating kinematics axes, the following tags of the kinematics technology object are relevant:

Tag	Description
Configuration of the mechanical axis coupling	
<TO>.AxisCoupling.N[1..5].Enable	Enabling/disabling the mechanical axis coupling
<TO>.AxisCoupling.N[1..5].CausingAxis	Coupling axis
<TO>.AxisCoupling.N[1..5].AffectedAxis	Coupled axis
<TO>.AxisCoupling.N[1..5].Factor	Coupling factor

7.8 Joints

7.8.1 Joint coordinate system (JCS)

The joint coordinate system (JCS) represents the real mechanical positions of the kinematics joints.

Functions

The JCS offers the following functions:

- Display current positions, velocities and accelerations of the joints of a kinematics
- Direct movement of the joints of a kinematics without moving mechanically coupled joints
- Traversing range limit of the joints by defining a joint traversing range (Page 56)
- Specification of the joint position ranges of a kinematics system on sPTP jobs
- Setting of zero point and counting direction of the joints

Setpoint calculation at the kinematics

The following diagram shows the kinematics transformation, the calculation of the joint coordinates (in the JCS) and the calculation of the axis coordinates (in the MCS):

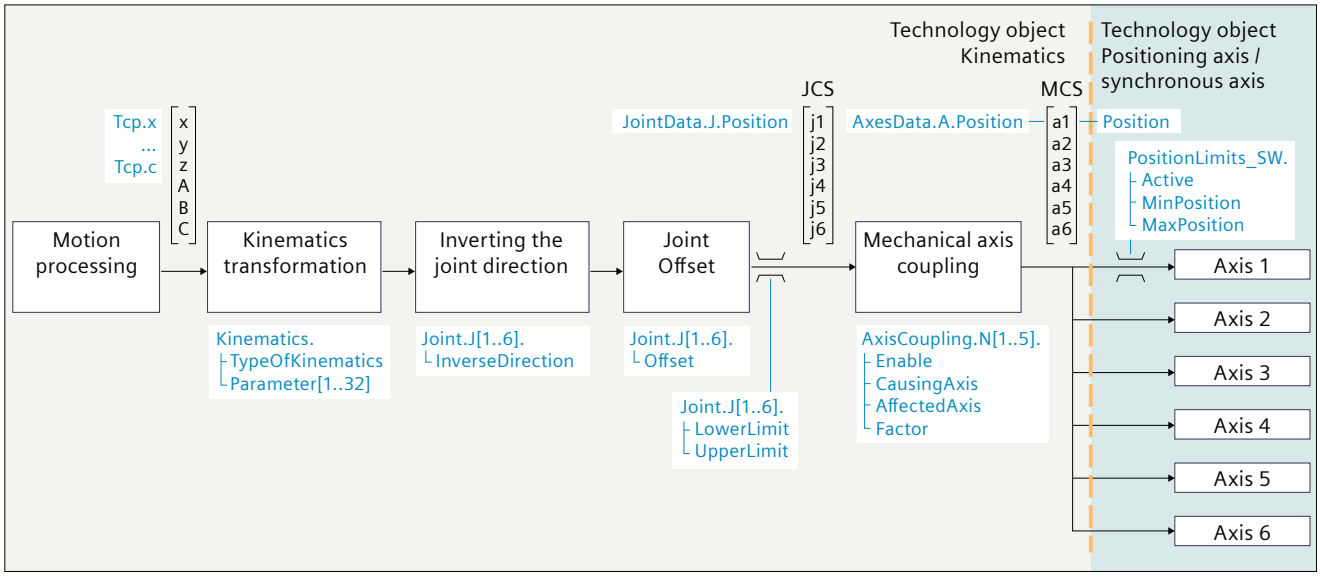

7.8.2 Configuring joints

Configure the joints of the kinematics in the "Joints" configuration window.

7.8.2.1 Inverting the joint direction

The defined directions of movement of the joints of a kinematics are described in the section "Kinematics types (Page 58)". These directions of movement are used in the kinematics transformation.

The direction of movement of the joints can be defined for different mechanics inversely to the defined directions of movement of the kinematics types.

If the direction of travel of a joint of the real kinematics is inverse to the direction of travel of the joint defined in the kinematics type from Siemens, select the check box "Direction inverted" for the joint.

The inversion of the direction of movement is calculated by the technology object after the kinematics transformation.

The following diagram shows an example of a kinematics 6-axis articulated arm with central wrist, where the inverse direction of movement is required for the joint J1:

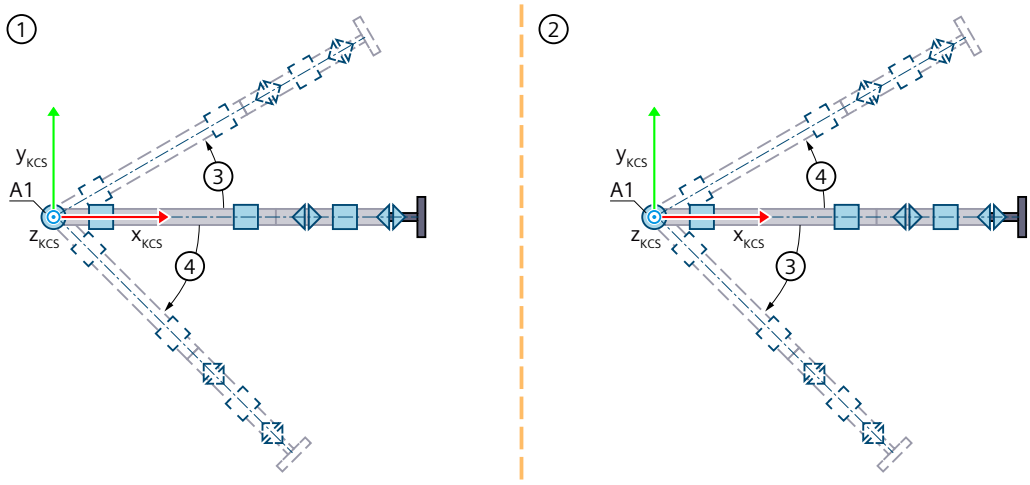

① Definition of the direction of motion on the kinematics type

② Definition of the direction of movement at the kinematics used

③ Positive direction of movement joint 1

④ Negative direction of movement joint 1

NOTE

Then check whether the direction of movement of the joint matches the direction of movement of the kinematics axis, e.g. by jogging in the MCS. If the direction of the joint and the axis direction are inverse, invert the encoder and drive direction of the kinematics axis.

7.8.2.2 Define joint traversing range

The joint traversing range defines the permitted traversing range of a kinematics joint. By defining the joint traversing range, you prevent a mechanical endstop or joint positions from being approached when these are not permitted.

In the "Joints" configuration window, define the joint traversing range by entering the lower and upper limits.

Configure the limits of the joint traversing range in such a way that the joint has a sufficient deceleration distance and comes to a standstill in the permissible traversing range.

NOTE

The software limit switches of the kinematics axes are independent of the configured joint traversing range. You can define the joint traversing range greater than, equal to or less than the axis traversing range.

7.8.2.3 Monitoring of the joint traversing range

Depending on the job, monitoring of the joint traversing range is already active when the job is issued or becomes active during the active job.

Job	Checking of the joint coordinates during the motion preparation in the MC_LookAhead	Cyclic checking of the joint coordinates during the active job
• MC_MoveLinearAbsolute • MC_MoveLinearRelative • MC_MoveCircularAbsolute • MC_MoveCircularRelative	-	✓
• MC_MoveDirectAbsolute • MC_MoveDirectRelative	✓	✓
Single axis job	-	-

Alarm response when leaving the joint position area

When a joint crosses the upper or lower limit of the joint traversing range, the 820 technology alarm is output. The kinematics motion is canceled, and the axes stop with the maximum dynamic values configured for the axes (alarm response: Stop with maximum dynamic values of the axes).

To return to the joint traversing range, move the joint via a single-axis job, e.g. with an "MC_MoveAbsolute", "MC_MoveRelative", or "MC_MoveJog" job.

7.8.2.4 Defining an offset

The offset describes the difference of the defined zero position of the joint of the kinematics type (Page 58) and the mechanical zero position of the joint at the kinematics used.

If the zero position of the mechanics axis does not match the zero position of the kinematics type, configure an offset.

Example

The joint J2 is in the mechanical zero position. This mechanical zero position deviates by 30° in positive direction of rotation from the defined zero position of the kinematics type. The defined zero position of the kinematics type used for the kinematics transformation is staggered by -30°. The offset is configured with "<TO>.Joint.J[2].Offset" = -30°.

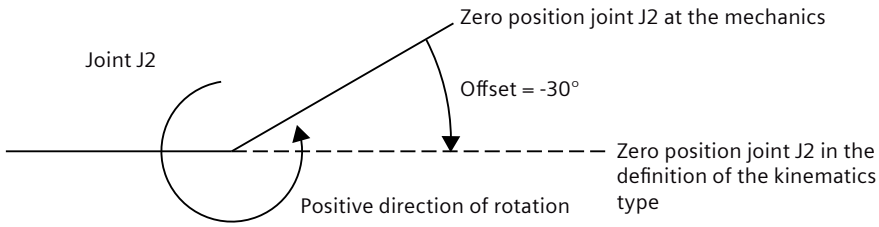

NOTE

When homing the associated kinematics axis, ensure that the mechanical zero point of the joint matches the position 0.0 of the kinematics axis.

7.8.3 Tags: Joints

When configuring the joints for kinematics types with more than four interpolating kinematics axes, the following tags of the kinematics technology object are relevant:

Tag	Description
Configuration of joints	
<TO>.Joint.J[1..6].InverseDirection	Invert direction of movement
<TO>.Joint.J[1..6].Offset	Difference between the defined zero position of the joint of the kinematics type (Page 58) and the mechanical zero position of the joint at the kinematics used
<TO>.Joint.J[1..6].LowerLimit	Lower limit of the joint traversing range
<TO>.Joint.J[1..6].UpperLimit	Upper limit of the joint traversing range
Setpoints of the kinematics motion for the joints	
<TO>.JointData.J[1..6].Acceleration	Current acceleration setpoint
<TO>.JointData.J[1..6].Position	Current position setpoint
<TO>.JointData.J[1..6].Velocity	Current velocity setpoint

7.9 Kinematics types

7.9.1 Cartesian portal

7.9.1.1 Cartesian portal 2D

The "Cartesian portal 2D" kinematics support 2 axes and 2 degrees of freedom. The following graphic shows the principal configuration and the typical working area of the kinematics:

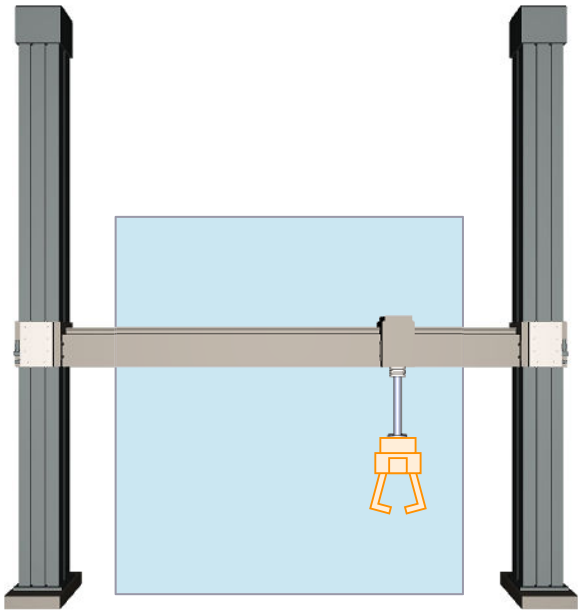

The kinematics consists of 2 orthogonal linear axes A1 and A2. The axes enclose a rectangular working range.

Coordinate systems and zero position

The graphic below shows the following in the front view:

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive deflection of the kinematics is indicated (dashed)

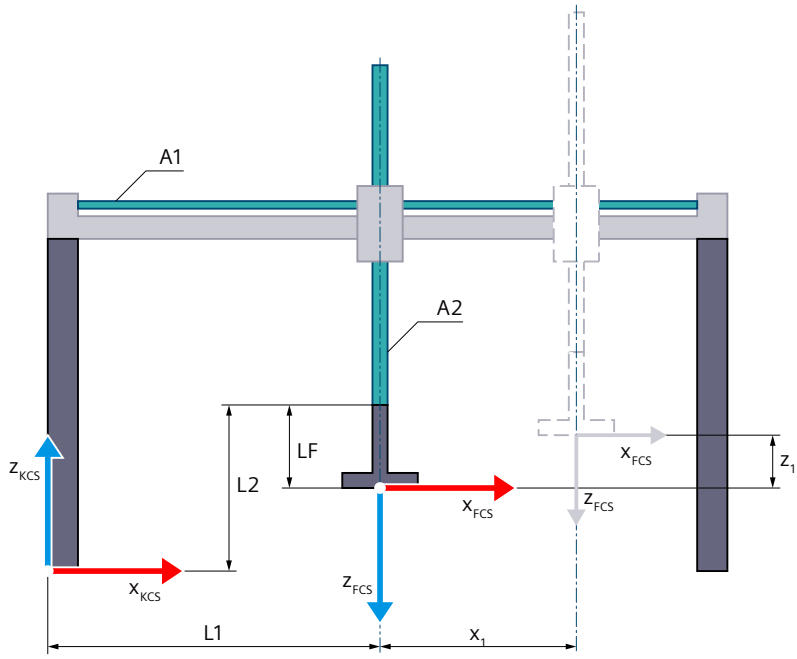

Zero position of the kinematics

L1 With axis A1 in the zero position:
Distance of the FCS to the KZP in x direction of the KCS

L2 With axis A2 in the zero position:
Distance of the FCS to the KZP and flange length LF in z direction of the KCS

LF Flange length before the FCS in the z direction of the KCS

Deflection of the kinematics

x_1 Deflection of axis A1 in the positive x direction

z_1 Deflection of axis A2 in the positive z direction

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the base of the kinematics. The flange coordinate system (FCS) is located at distance LF from the zero position of axis A2.

The position 0.0 on the respective interconnected technology object defines the zero position of axes A1 and A2. You define the position of the FCS with axes A1 and A2 in the zero position using lengths L1 and L2. You shift the FCS in the negative z direction of the KCS using length LF.

Transformation area

The kinematics transformation covers the entire traversing range (Page 178) of the axes.

Joint position space

No joint position spaces for the kinematics.

7.9.1.2 Cartesian portal 2D with orientation

The "Cartesian portal 2D with orientation" kinematics supports 3 axes and 3 degrees of freedom. The following graphic shows the principal configuration and the typical working area of the kinematics:

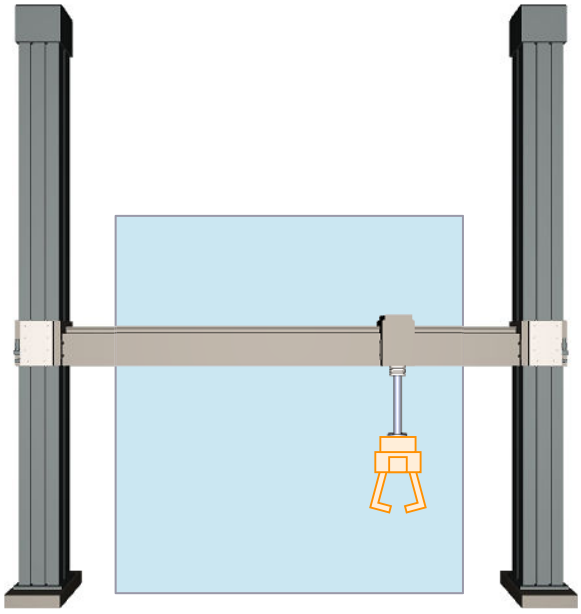

The kinematics consists of the following axes:

- 2 orthogonal linear axes A1 and A2
- 1 rotary axis A4 with rotation around z in the KCS

The linear axes enclose a rectangular working area. The kinematics axis A4 enables rotation of the tool around z in the KCS.

Coordinate systems and zero position

The graphic below shows the following in the front view:

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive deflection of the kinematics is indicated (dashed)

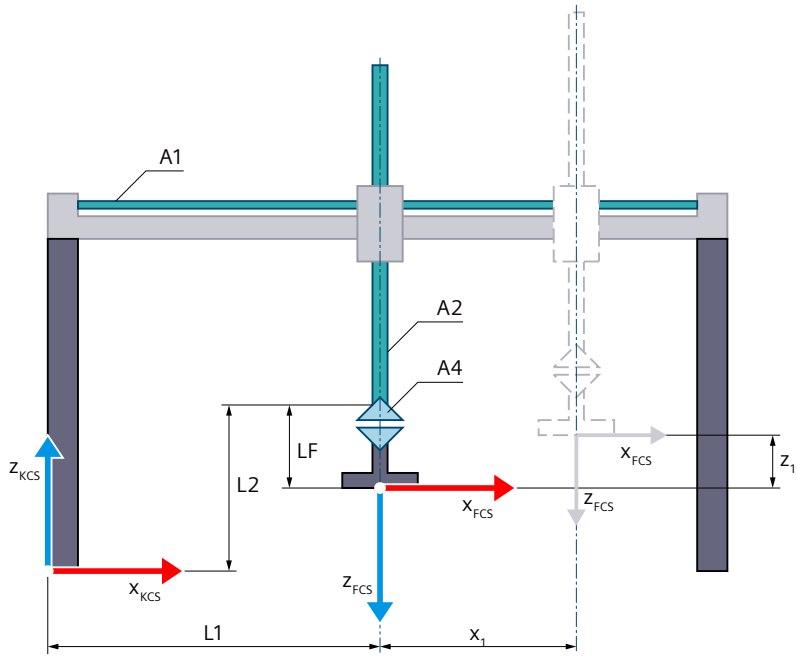

Zero position of the kinematics

L1 With axis A1 in the zero position:
Distance of the FCS to the KZP in x direction of the KCS

L2 With axis A2 in the zero position:
Distance of the FCS to the KZP and flange length LF in z direction of the KCS

LF Flange length before the FCS in the z direction of the KCS

Deflection of the kinematics

x_1 Deflection of axis A1 in the positive x direction

z_1 Deflection of axis A2 in the positive z direction

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the base of the kinematics. The flange coordinate system (FCS) is located at distance LF from the zero position of axis A2.

The position 0.0 on the respective interconnected technology object defines the zero position of axes A1 and A2. You define the position of the FCS with axes A1 and A2 in the zero position using lengths L1 and L2. You shift the FCS in the negative z direction of the KCS using length LF. In the zero position of axis A4, the x axis of the FCS points in the direction of the x axis of the KCS.

Transformation area

The kinematics transformation covers the entire traversing range (Page 178) of the axes.

Joint position space

No joint position spaces for the kinematics.

7.9.1.3 Cartesian portal 3D

The "Cartesian portal 3D" kinematics supports 3 axes and 3 degrees of freedom. The following graphic shows the principal configuration and the typical working area of the kinematics:

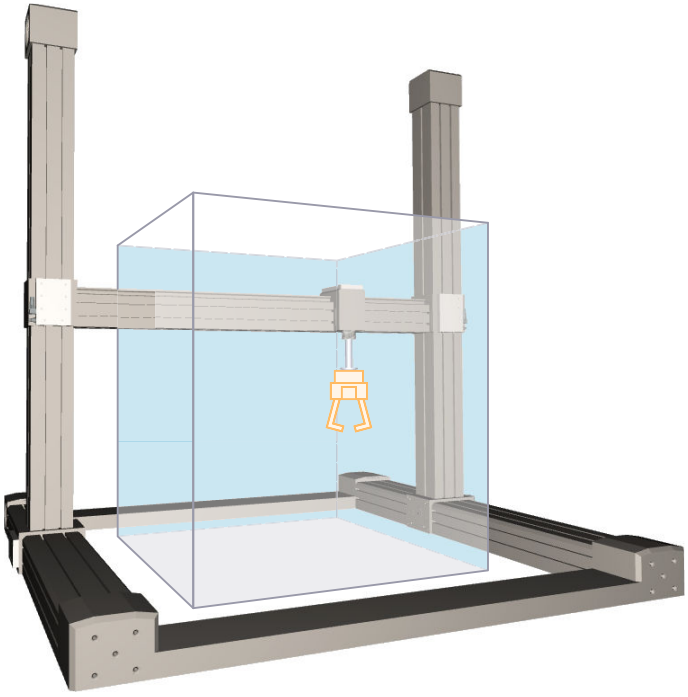

The kinematics consists of 3 orthogonal linear axes A1, A2 and A3. The linear axes enclose a rectangular working area.

Coordinate systems and zero position

The graphic below shows the following in the front view (xz plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the axes A1 and A3 is indicated (dashed)

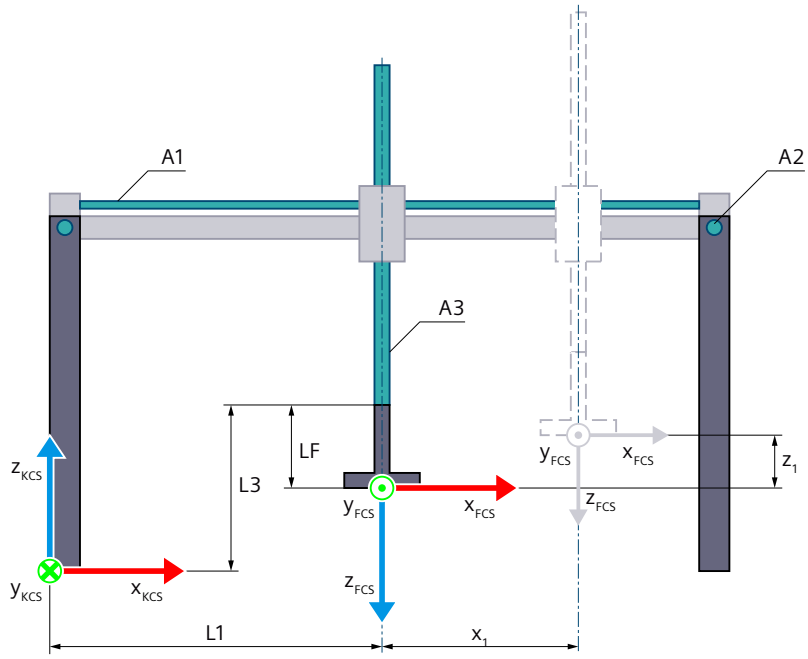

Zero position of the kinematics

L1	With axis A1 in the zero position: Distance of the FCS to the KZP in x direction of the KCS
L3	With axis A3 in the zero position: Distance of the FCS to the KZP and flange length LF in z direction of the KCS
LF	Flange length before the FCS in the z direction of the KCS

Deflection of the kinematics

x_1	Deflection of axis A1 in the positive x direction
z_1	Deflection of axis A3 in the positive z direction

Legend for representation of the kinematics (Page 38)

The graphic below shows the following in the top view (xy plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the axes A1 and A2 is indicated (dashed)

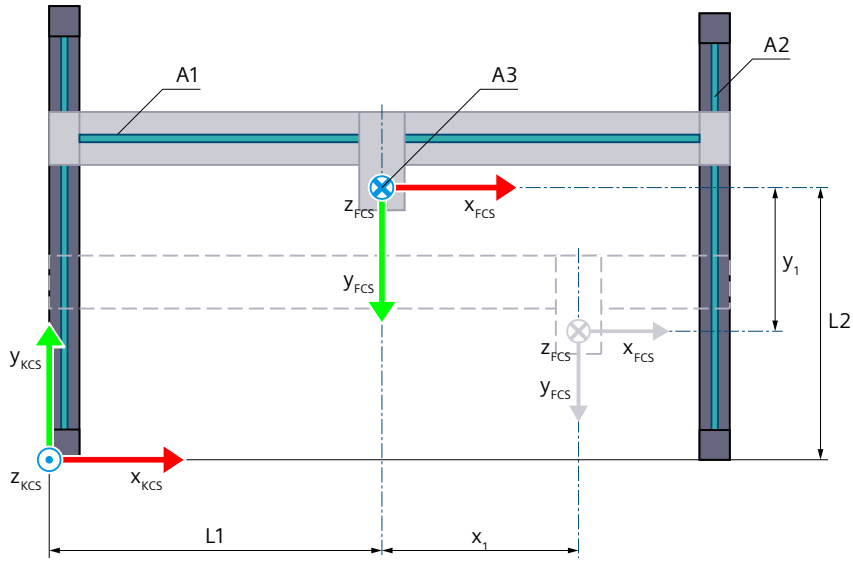

Zero position of the kinematics

L1 With axis A1 in the zero position:
Distance of the FCS to the KZP in x direction of the KCS

L2 With axis A2 in the zero position:
Distance of the FCS to the KZP in y direction of the KCS

Deflection of the kinematics

x_1 Deflection of axis A1 in the positive x direction

y_1 Deflection of axis A2 in the negative y direction

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the base of the kinematics. The flange coordinate system (FCS) is located at distance LF from the zero position of axis A2.

Position 0.0 on the respective interconnected technology object defines the zero position of axes A1, A2, and A3. You define the position of the FCS with axes A1, A2, and A3 in the zero position using lengths L1, L2 and L3. You shift the FCS in the negative z direction of the KCS using length LF.

Transformation area

The kinematics transformation covers the entire traversing range (Page 178) of the axes.

Joint position space

No joint position spaces for the kinematics.

7.9.1.4 Cartesian portal 3D with orientation

The "Cartesian portal 3D with orientation" kinematics supports 4 axes and 4 degrees of freedom. The following graphic shows the principal configuration and the typical working area of the kinematics:

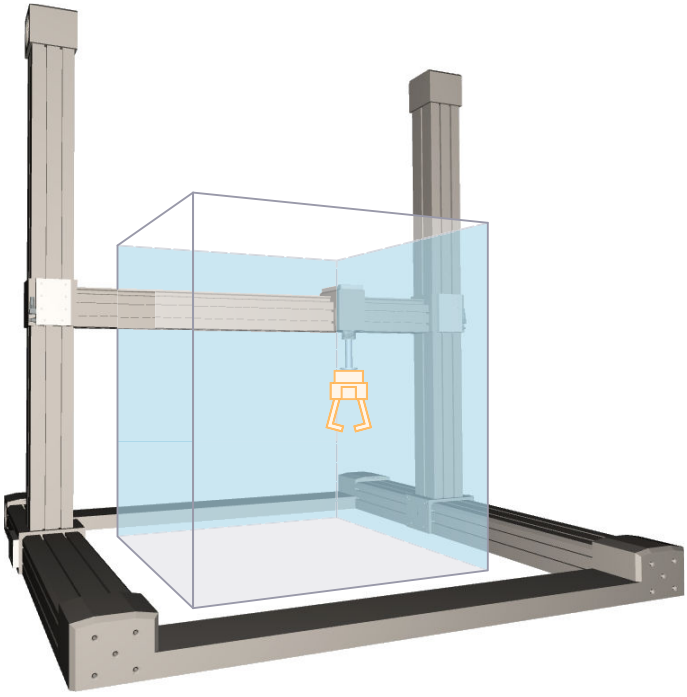

The kinematics consists of the following axes:

- 3 orthogonal linear axes A1, A2 and A3
- 1 rotary axis A4 with rotation around z in the KCS

The linear axes enclose a rectangular working area. The kinematics axis A4 enables rotation of the tool around z in the KCS.

Coordinate systems and zero position

The graphic below shows the following in the front view (xz plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the axes A1 and A3 is indicated (dashed)

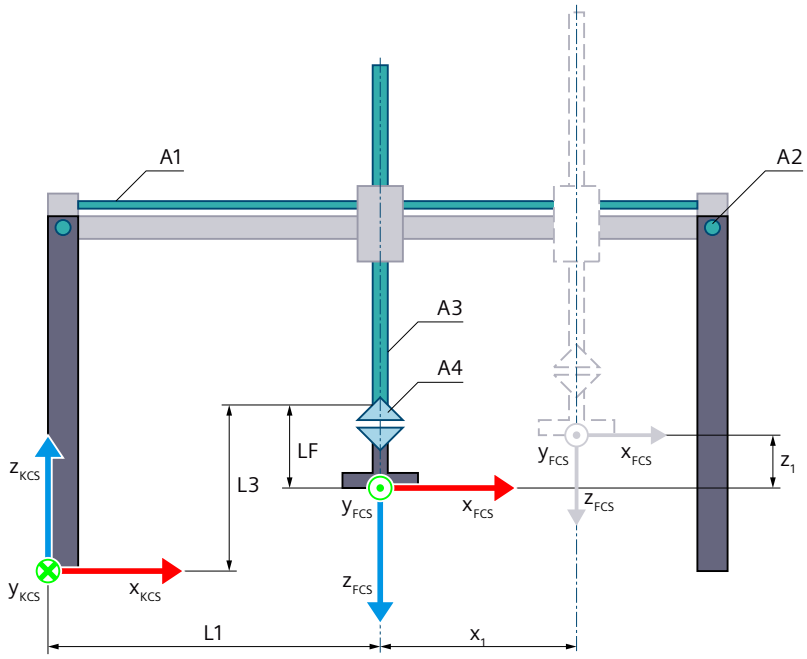

Zero position of the kinematics

L1	With axis A1 in the zero position: Distance of the FCS to the KZP in x direction of the KCS
L3	With axis A3 in the zero position: Distance of the FCS to the KZP and flange length LF in z direction of the KCS
LF	Flange length before the FCS in the z direction of the KCS

Deflection of the kinematics

x_1	Deflection of axis A1 in the positive x direction
z_1	Deflection of axis A3 in the positive z direction

Legend for representation of the kinematics (Page 38)

The graphic below shows the following in the top view (xy plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the axes A1 and A2 is indicated (dashed)

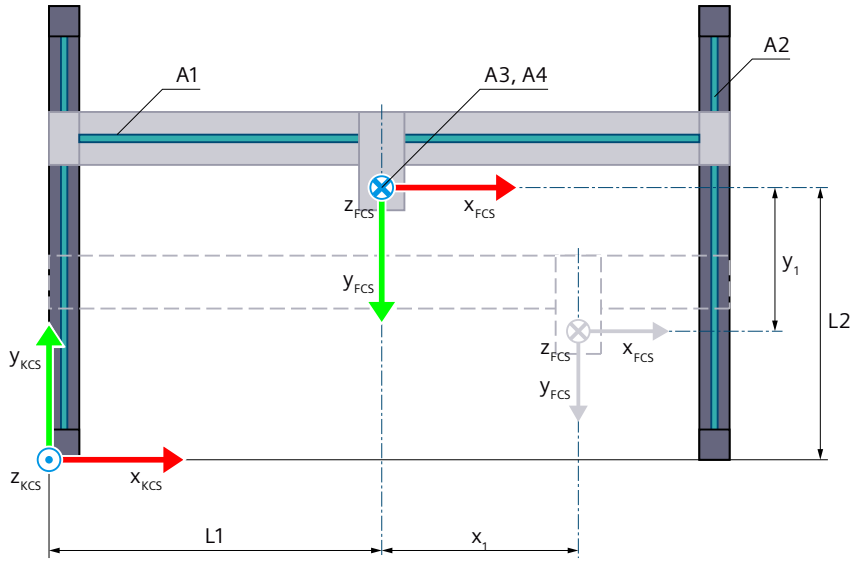

Zero position of the kinematics

L1 With axis A1 in the zero position:
Distance of the FCS to the KZP in x direction of the KCS

L2 With axis A2 in the zero position:
Distance of the FCS to the KZP in y direction of the KCS

Deflection of the kinematics

x_1 Deflection of axis A1 in the positive x direction

y_1 Deflection of axis A2 in the negative y direction

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the base of the kinematics. The flange coordinate system (FCS) is located at distance LF from the zero position of axis A2.

Position 0.0 on the respective interconnected technology object defines the zero position of axes A1, A2, and A3. You define the distances of the zero positions of the axes A1, A2 and A3 to the kinematics zero point using the lengths L1, L2 and L3. You shift the FCS in the negative z direction of the KCS using length LF. In the zero position of axis A4, the x axis of the FCS points in the direction of the x axis of the KCS.

Transformation area

The kinematics transformation covers the entire traversing range (Page 178) of the axes.

Joint position space

No joint position spaces for the kinematics.

7.9.1.5 Cartesian portal 3D with 2 orientations A, B

The "Cartesian portal 3D with 2 orientations A, B" kinematics supports 5 axes and 5 degrees of freedom. For this kinematics type, you need the Motion Control package "S7-1500T Motion Control KinPlus" (Page 27).

The following graphic shows the principal configuration and the typical working area of the kinematics:

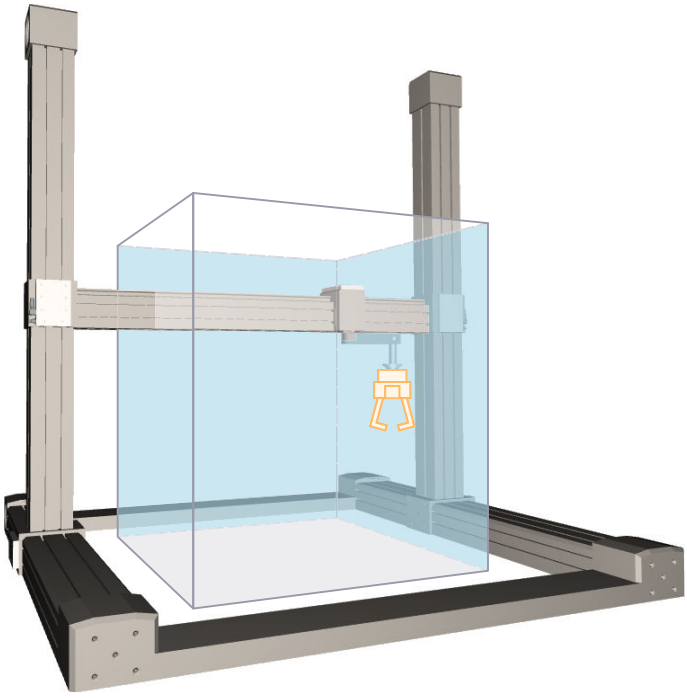

The kinematics consists of the following axes:

- 3 orthogonal linear axes A1, A2 and A3
- One rotary axis A4 rotating around the z axis of the KCS
- One rotary swivel axis A5, which rotates around the y axis of the KCS in the kinematics zero position.

The linear axes enclose a rectangular working area.

Coordinate systems and zero position

The graphic below shows the following in the front view (xz plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive deflection of axes A1 and A3 and the negative deflection of axis A5 are indicated (dashed)

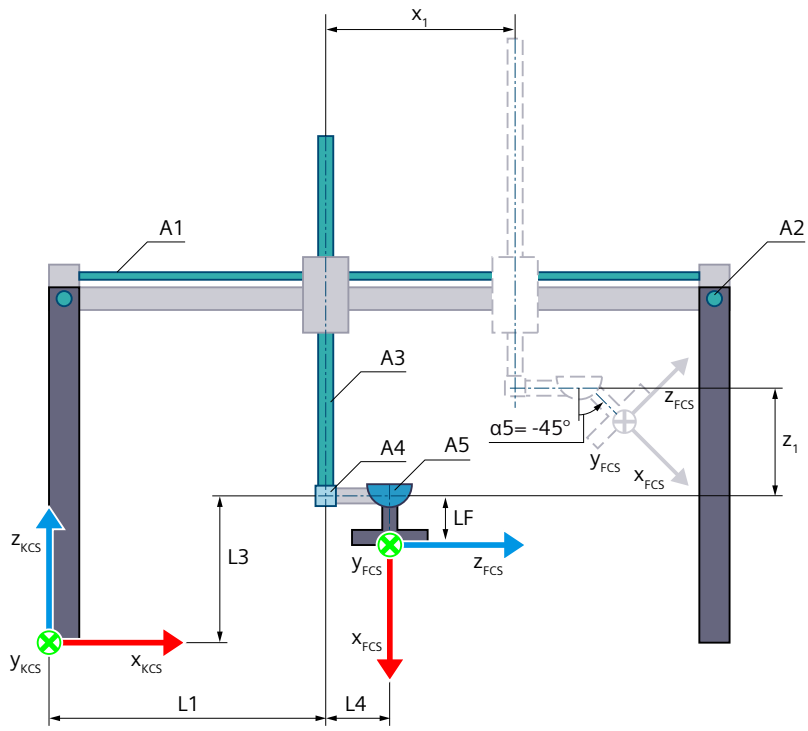

Zero position of the kinematics

L1	With axis A1 in the zero position: Distance of the zero position of axis A1 to the KZP in the x direction of the KCS
L3	With axis A3 in the zero position: Distance of the zero position of axis A3 to the KZP in the z direction of the KCS.
LF	Flange length before the FCS in the x direction of the FCS
L4	Distance of the joint points of rotational axis A4 and swivel axis A5 in the x direction of the KCS in the kinematics zero position

Deflection of the kinematics

x_1	Deflection of axis A1 in the positive x direction
z_1	Deflection of axis A3 in the positive z direction
α5	Negative deflection of swivel axis A5 when α5 = -45°

Legend for representation of the kinematics (Page 38)

The graphic below shows the following in the top view (xy plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the axes A1 and A2 is indicated (dashed)

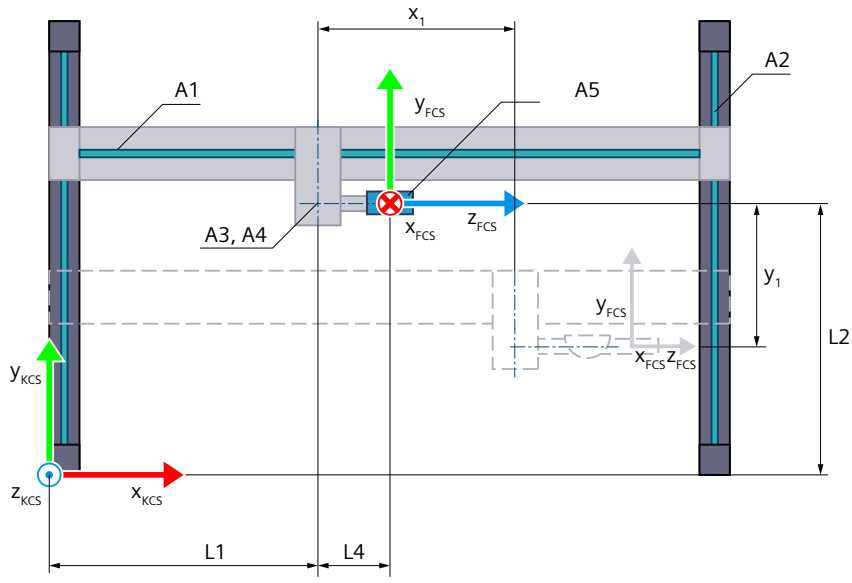

Zero position of the kinematics

L1 With axis A1 in the zero position:
Distance of axis A3/A4 to the KZP in the x direction of the KCS

L2 With axis A2 in the zero position:
Distance of the FCS to the KZP in the y direction of the KCS in the kinematics zero position. If axis A4 has been moved, the distance between KZP and FCS is no longer L2.

Deflection of the kinematics

x_1 Deflection of axis A1 in the positive x direction

y_1 Deflection of axis A2 in the negative y direction

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the base of the kinematics. The flange coordinate system (FCS) is located at a distance from axis A5 in the negative z direction of the KCS.

Position 0.0 on the respective interconnected technology object defines the zero position of axes A1, A2, and A3. You define the distances of the zero positions of axes A1, A2, and A3 to the kinematics zero point using lengths L1, L2, and L3. You can also move the zero position of axes A1, A2, and A3 and the associated joints J1, J2, and J3 with joint offsets (Page 57). You shift the FCS in the negative z direction of the KCS using length LF.

In the zero position, the FCS is aligned in the following Cartesian position:

- x = L1 + L4
- y = L2
- z = L3 - LF
- A = 0°
- B = 90°
- C = 0

In the zero position of axes A4 and A5, the x axis of the FCS points in the opposite direction of the z axis of the KCS. The y axis of the FCS points in the same direction as the y axis of the KCS. The z axis of the FCS points in the same direction as the x axis of the KCS.

Direction of travel of the joints

The following figure shows the direction of travel of the joints defined in the kinematics type.

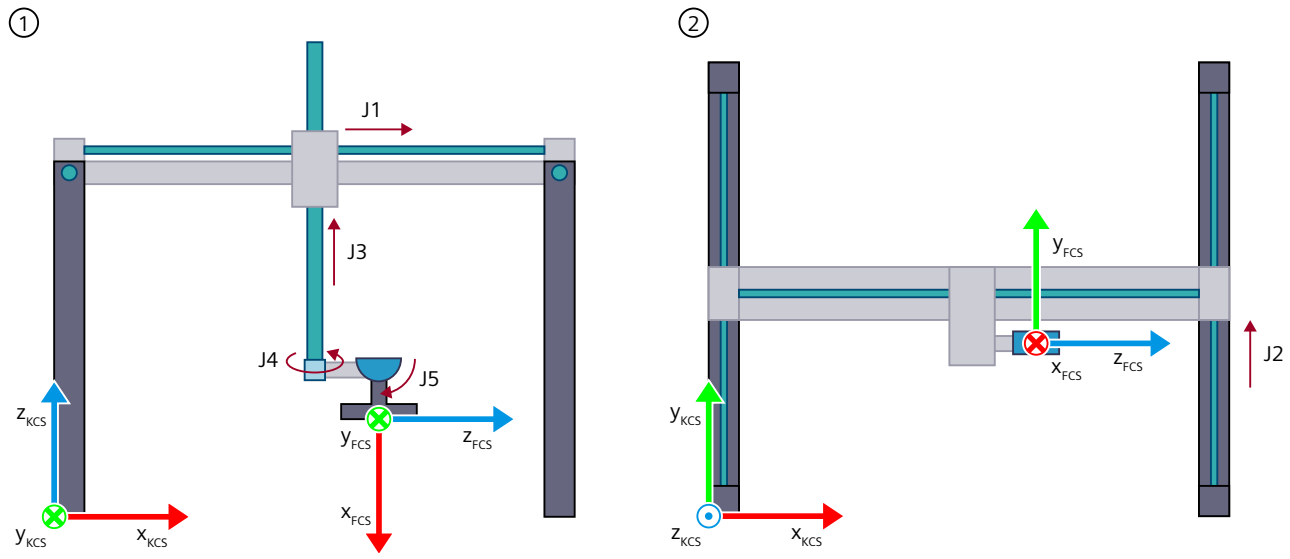

① Front view

② Top view

Positive direction of rotation of the joints

If the direction of travel of a joint of the real kinematics is inverse to the direction of travel of the joint defined in the kinematics type from Siemens, you must invert the joint direction (Page 55) in the configuration.

Transformation area

The kinematics transformation covers the entire traversing range (Page 178) of the axes.

Joint position space

No joint position spaces for the kinematics.

7.9.1.6 Tags: Cartesian portal

Cartesian portal 2D

You can define the 2D kinematics using the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	1	Cartesian portal 2D
	2	Cartesian portal 2D with orientation

Tags	Values	Description
<TO>.Kinematics.Parameter[1]	-1.0E12 to 1.0E12	Distance L1 of the zero position of axis A1 to the kinematics zero point (KZP) in the x direction of the kinematics coordinate system (KCS)
<TO>.Kinematics.Parameter[2]	-1.0E12 to 1.0E12	Distance LF of the FCS to axis A2 in the negative z direction of the KCS
<TO>.Kinematics.Parameter[3]	-1.0E12 to 1.0E12	Distance L2 of the zero position of axis A2 to the KZP in the z direction of the KCS

Cartesian portal 3D

You can define the 3D kinematics using the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	3	Cartesian portal 3D
	4	Cartesian portal 3D with orientation
	26	Cartesian portal 3D with 2 orientations A, B
<TO>.Kinematics.Parameter[1]	-1.0E12 to 1.0E12	Distance L1 of the zero position of axis A1 to the KZP in the x direction of the KCS
<TO>.Kinematics.Parameter[2]	-1.0E12 to 1.0E12	Distance L2 of the zero position of axis A2 to the KZP in the y direction of the KCS
<TO>.Kinematics.Parameter[3]	-1.0E12 to 1.0E12	• Distance LF of the FCS to axis A3 in the negative z direction of the KCS • Cartesian portal 3D with 2 orientations A, B: Distance LF of the FCS to axis A5
<TO>.Kinematics.Parameter[4]	-1.0E12 to 1.0E12	Distance L3 of the zero position of axis A3 to the KZP in the z direction of the KCS
<TO>.Kinematics.Parameter[5]	-1.0E12 to 1.0E12	Distance L4 of the joint points of rotational axis A4 and swivel axis A5 in the x direction of the KCS in the kinematics zero position[1)]

1) Only relevant for kinematics type "Cartesian portal 3D with 2 orientations A, B"

See also

Tags of the kinematics technology object (Page 469)

7.9.2 Roller picker

7.9.2.1 Roller picker 2D

The kinematics "Roller picker 2D" supports 2 axes and 2 degrees of freedom. The following graphic shows the principal configuration and the typical working area of the kinematics:

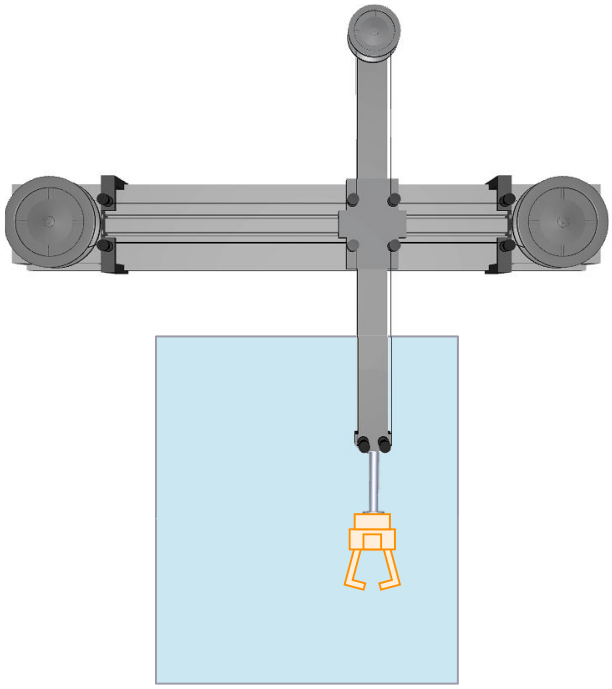

The kinematics consists of 2 rotary axes A1 and A2 and a system of guide rollers. If both axes A1 and A2 rotate with the same velocity in the same direction, the flange moves horizontally in x direction of the KCS. If both axes A1 and A2 rotate with the same velocity in opposite directions, the flange moves vertically in z direction of the KCS. The kinematics enables a rectangular working area.

Coordinate systems and zero position

The graphic below shows the following in the front view:

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The deflection of the kinematics is indicated (dashed)

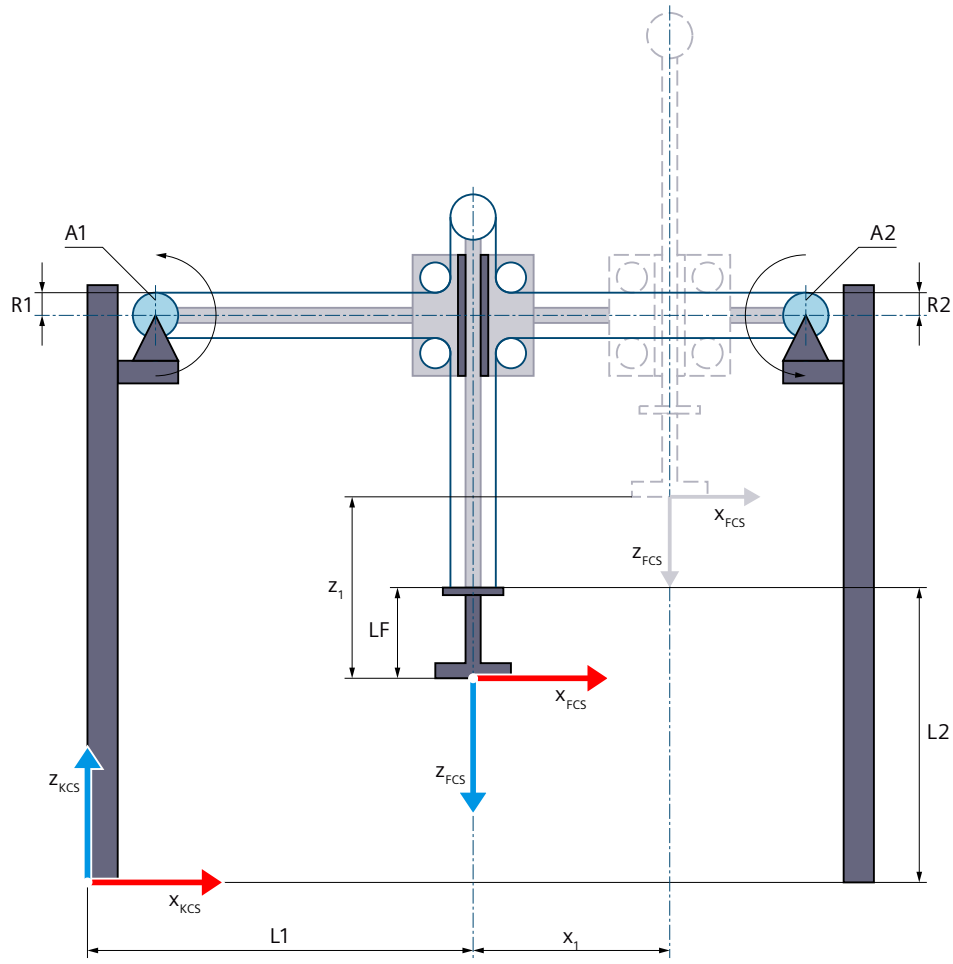

Zero position of the kinematics

L1	With axes A1 and A2 in the zero position: Distance of the FCS to the KZP in x direction of the KCS
L2	With axes A1 and A2 in the zero position: Distance of the FCS to the KZP and flange length LF in z direction of the KCS
LF	Flange length before the FCS in the z direction of the KCS
R1	Cam radius for axis A1
R2	Cam radius for axis A2

Deflection of the kinematics

x_1	Deflection of the kinematics in the positive x direction
z_1	Deflection of the kinematics in the positive z direction

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the base of the kinematics. The flange coordinate system (FCS) is located between axes A1 and A2.

The position 0.0 on the respective interconnected technology object defines the zero position of the axes A1 and A2. You define the position of the FCS with axes A1 and A2 in the zero position using lengths L1 and L2. Use the length LF to move the FCS in negative z direction of the KCS.

Transformation area

The kinematics transformation covers the entire traversing range (Page 178) of the axes.

Joint position space

No joint position spaces for the kinematics.

7.9.2.2 Roller picker 2D with orientation

The kinematics "Roller picker 2D with orientation" supports 3 axes and 3 degrees of freedom. The following graphic shows the principal configuration and the typical working area of the kinematics:

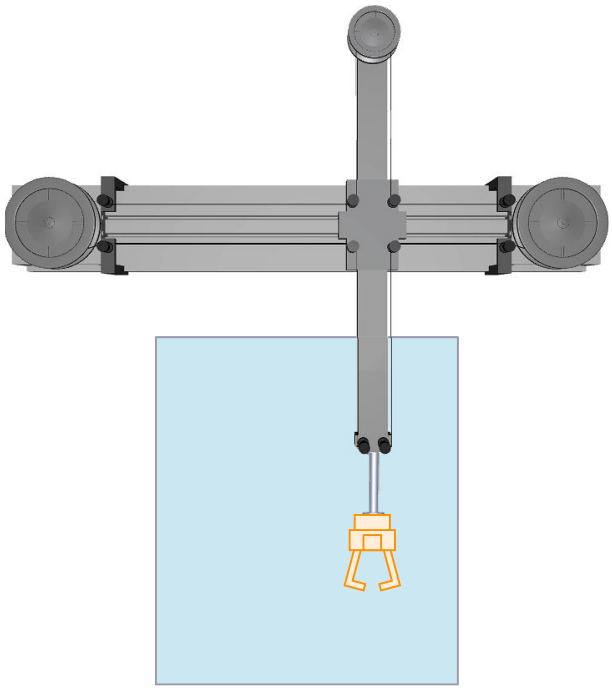

The kinematics consists of a system made up of guide rollers and the following axes:

- 2 rotary axes A1 and A2
- 1 rotary axis A4 with rotation around z in the KCS

If both axes A1 and A2 rotate with the same velocity in the same direction, the flange moves horizontally in x direction of the KCS. If both axes A1 and A2 rotate with the same velocity in opposite directions, the flange moves vertically in z direction of the KCS. The kinematics enables a rectangular working area. The kinematics axis A4 enables rotation of the tool around z in the KCS.

Coordinate systems and zero position

The graphic below shows the following in the front view:

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The deflection of the kinematics is indicated (dashed)

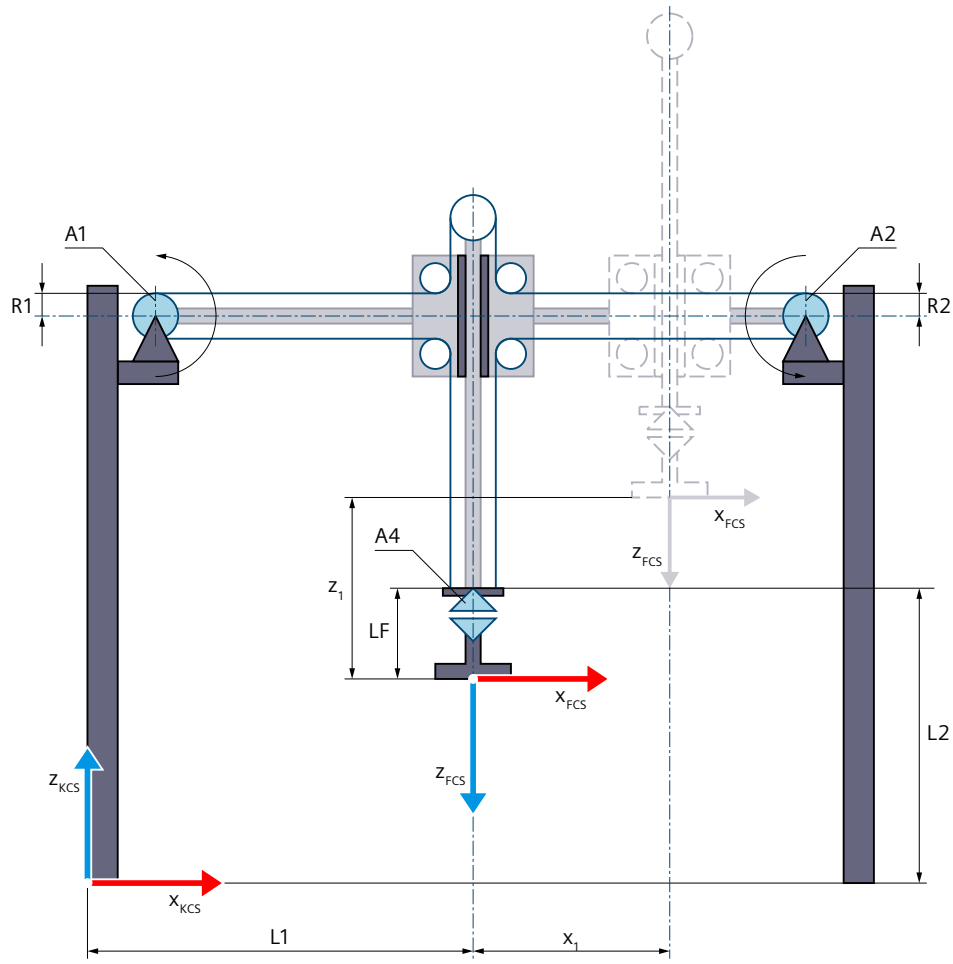

Zero position of the kinematics

L1	With axes A1 and A2 in the zero position: Distance of the FCS to the KZP in x direction of the KCS
L2	With axes A1 and A2 in the zero position: Distance of the FCS to the KZP and flange length LF in z direction of the KCS
LF	Flange length before the FCS in the z direction of the KCS
R1	Cam radius for axis A1
R2	Cam radius for axis A2

Deflection of the kinematics

x_1	Deflection of the kinematics in the positive x direction
z_1	Deflection of the kinematics in the positive z direction

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the base of the kinematics. The flange coordinate system (FCS) is located between axes A1 and A2.

The position 0.0 on the respective interconnected technology object defines the zero position of the axes A1 and A2. You define the position of the FCS with axes A1 and A2 in the zero position using lengths L1 and L2. You shift the FCS in the negative z direction of the KCS using length LF. At the zero position of axis A4, the x axis of the FCS points in the direction of the x axis of the KCS.

Transformation area

The kinematics transformation covers the entire traversing range (Page 178) of the axes.

Joint position space

No joint position spaces for the kinematics.

7.9.2.3 Roller picker 3D (vertical)

The kinematics "Roller picker 3D (vertical)" supports 3 axes and 3 degrees of freedom. The following graphic shows the principal configuration and the typical working area of the kinematics:

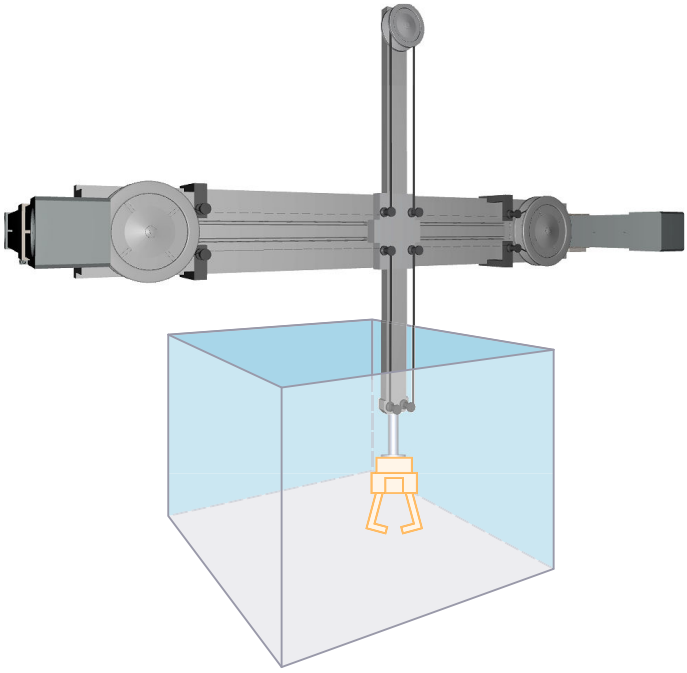

The kinematics consists of a system made up of guide rollers and the following axes:

- 2 rotary axes A1 and A2
- 1 linear axis A3 in the y direction of the KCS

If both axes A1 and A2 rotate with the same velocity in the same direction, the flange moves horizontally in x direction of the KCS. If both axes A1 and A2 rotate with the same velocity in opposite directions, the flange moves vertically in z direction of the KCS. The linear portal axis A3 moves the system of guide rollers horizontally in y direction of the KCS. The kinematics enables a cuboid working area.

Coordinate systems and zero position

The graphic below shows the following in the front view (xz plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The deflection of the kinematics is indicated (dashed)

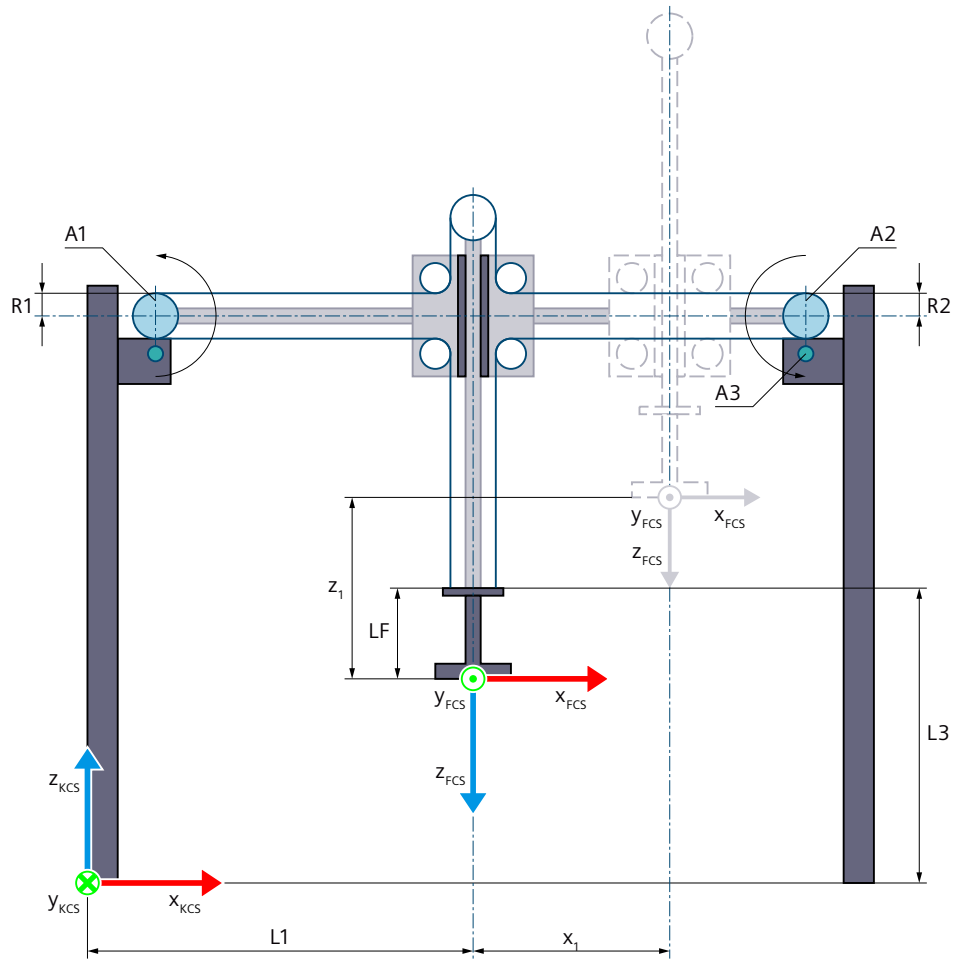

Zero position of the kinematics

L1	With axes A1 and A2 in the zero position: Distance of the FCS to the KZP in x direction of the KCS
L3	With axes A1 and A2 in the zero position: Distance of the FCS to the KZP and flange length LF in z direction of the KCS
LF	Flange length before the FCS in the z direction of the KCS
R1	Cam radius for axis A1

R2 Cam radius for axis A2

Deflection of the kinematics

x_1 Deflection of the kinematics in the positive x direction

z_1 Deflection of the kinematics in the positive z direction

Legend for representation of the kinematics (Page 38)

The graphic below shows the following in the top view (xy plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The deflection of the kinematics is indicated (dashed)

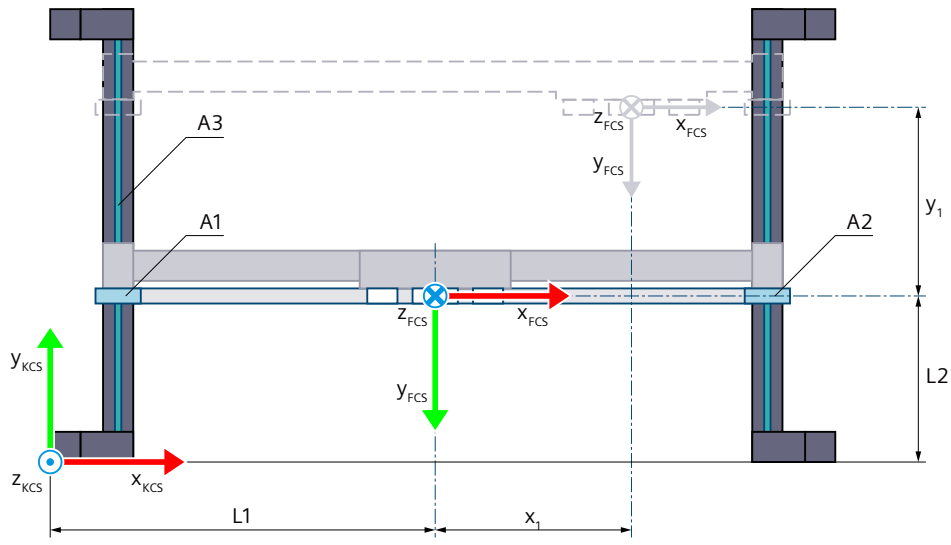

Zero position of the kinematics

L1 With axes A1 and A2 in the zero position:
Distance of the FCS to the KZP in x direction of the KCS

L2 With axis A3 in the zero position:
Distance of the FCS to the KZP in y direction of the KCS

R1 Cam radius for axis A1

R2 Cam radius for axis A2

Deflection of the kinematics

x_1 Deflection of the kinematics in the positive x direction

y_1 Deflection of the kinematics in the positive y direction

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the base of the kinematics. The flange coordinate system (FCS) is located between axes A1 and A2.

The position 0.0 on the respective interconnected technology object defines the zero position of the axes A1, A2 and A3. You define the position of the FCS for zero position of the axes A1, A2 and A3 using lengths L1, L2 and L3 . You shift the FCS in the negative z direction of the KCS using length LF.

Transformation area

The kinematics transformation covers the entire traversing range (Page 178) of the axes.

Joint position space

No joint position spaces for the kinematics.

7.9.2.4 Roller picker 3D with orientation (vertical)

The kinematics "Roller picker 3D with orientation (vertical)" supports 4 axes and 4 degrees of freedom. The following graphic shows the principal configuration and the typical working area of the kinematics:

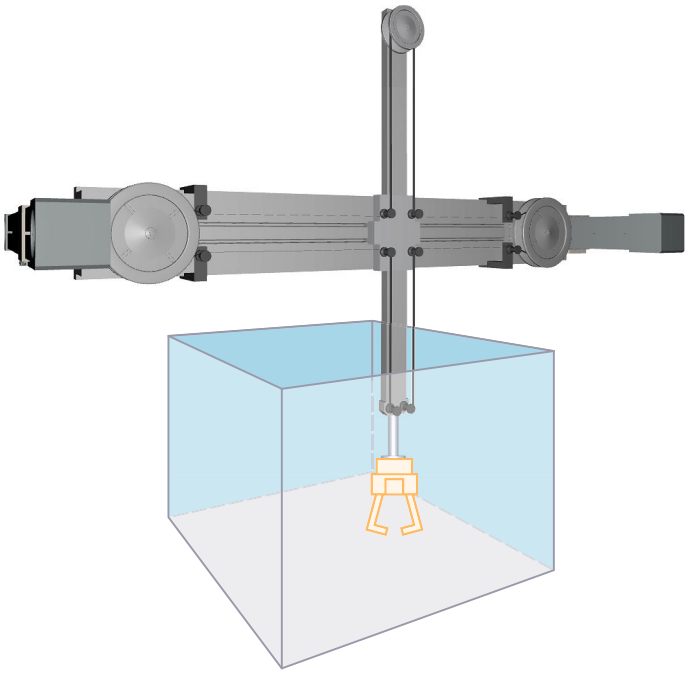

The kinematics consists of a system made up of guide rollers and the following axes:

- 2 rotary axes A1 and A2
- 1 linear axis A3 in the y direction of the KCS
- 1 rotary axis A4 with rotation around z in the KCS

If both axes A1 and A2 rotate with the same velocity in the same direction, the flange moves horizontally in x direction of the KCS. If both axes A1 and A2 rotate with the same velocity in opposite directions, the flange moves vertically in z direction of the KCS. The linear portal axis A3 moves the system of guide rollers horizontally in y direction of the KCS. The kinematics enables a cuboid working area. The kinematics axis A4 enables rotation of the tool around z in the KCS.

Coordinate systems and zero position

The graphic below shows the following in the front view (xz plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The deflection of the kinematics is indicated (dashed)

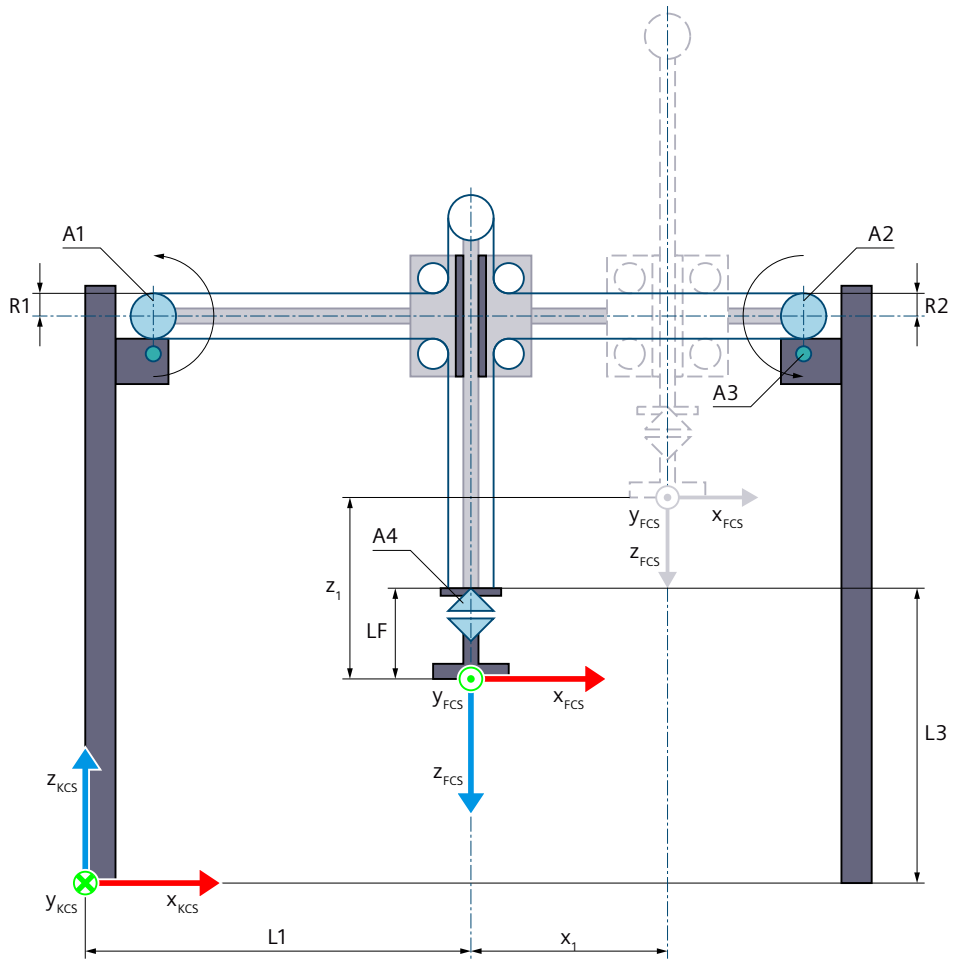

Zero position of the kinematics

L1	With axes A1 and A2 in the zero position: Distance of the FCS to the KZP in x direction of the KCS
L3	With axes A1 and A2 in the zero position: Distance of the FCS to the KZP and flange length LF in z direction of the KCS
LF	Flange length before the FCS in the z direction of the KCS
R1	Cam radius for axis A1
R2	Cam radius for axis A2

Deflection of the kinematics

x_1	Deflection of the kinematics in the positive x direction
z_1	Deflection of the kinematics in the positive z direction

Legend for representation of the kinematics (Page 38)

The graphic below shows the following in the top view (xy plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The deflection of the kinematics is indicated (dashed)

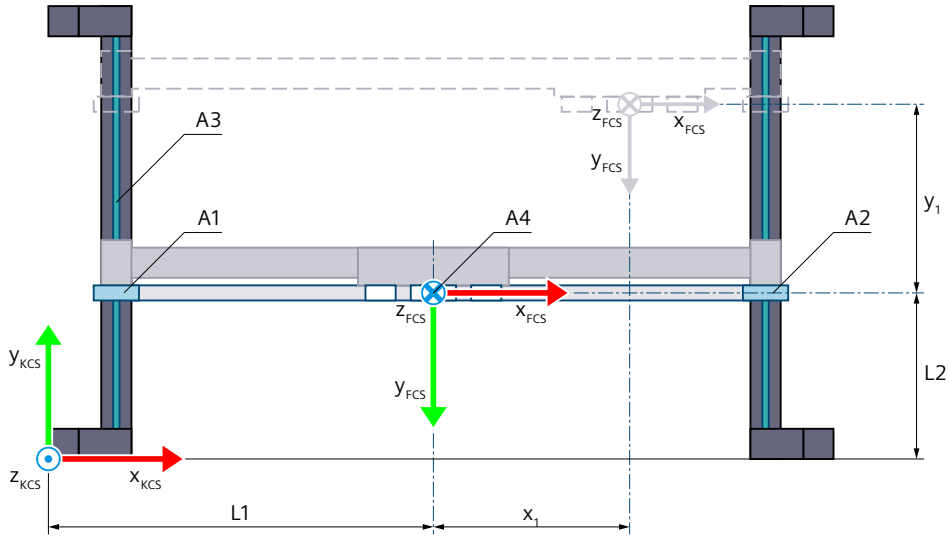

Zero position of the kinematics

L1	With axes A1 and A2 in the zero position: Distance of the FCS to the KZP in x direction of the KCS
L2	With axis A3 in the zero position: Distance of the FCS to the KZP in y direction of the KCS
R1	Cam radius for axis A1
R2	Cam radius for axis A2

Deflection of the kinematics

x_1	Deflection of the kinematics in the positive x direction
y_1	Deflection of the kinematics in the positive y direction

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the base of the kinematics. The flange coordinate system (FCS) is located between axes A1 and A2.

The position 0.0 on the respective interconnected technology object defines the zero position of the axes A1, A2 and A3. You define the distance of the zero position of axis A3 to the KZP in the y direction of the KCS using length L2.

You define the position of the FCS with axes A1 and A2 in the zero position using lengths L1 and L3. You shift the FCS in the negative z direction of the KCS using length LF. At the zero position of axis A4, the x axis of the FCS points in the direction of the x axis of the KCS.

Transformation area

The kinematics transformation covers the entire traversing range (Page 178) of the axes.

Joint position space

No joint position spaces for the kinematics.

7.9.2.5 Roller picker 3D with orientation (horizontal)

The kinematics "Roller picker 3D with orientation (horizontal)" supports 4 axes and 4 degrees of freedom. The following graphic shows the principal configuration and the typical working area of the kinematics:

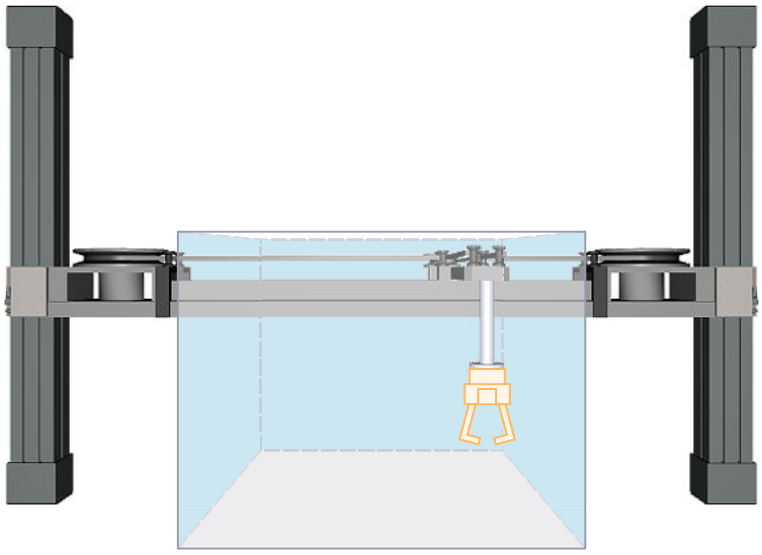

The kinematics consists of a system made up of guide rollers and the following axes:

- 2 rotary axes A1 and A2
- 1 linear axis A3 in z direction of the KCS
- 1 rotary axis A4 with rotation around z in the KCS

If both axes A1 and A2 rotate with the same velocity in the same direction, the flange moves horizontally in x direction of the KCS. If both axes A1 and A2 rotate with the same velocity in opposite directions, the flange moves horizontally in y direction of the KCS. The linear portal axis A3 moves the system of guide rollers vertically in z direction of the KCS. The kinematics enables a cuboid working area. The kinematics axis A4 enables rotation of the tool around z in the KCS.

Coordinate systems and zero position

The graphic below shows the following in the front view (xz plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The deflection of the kinematics is indicated (dashed)

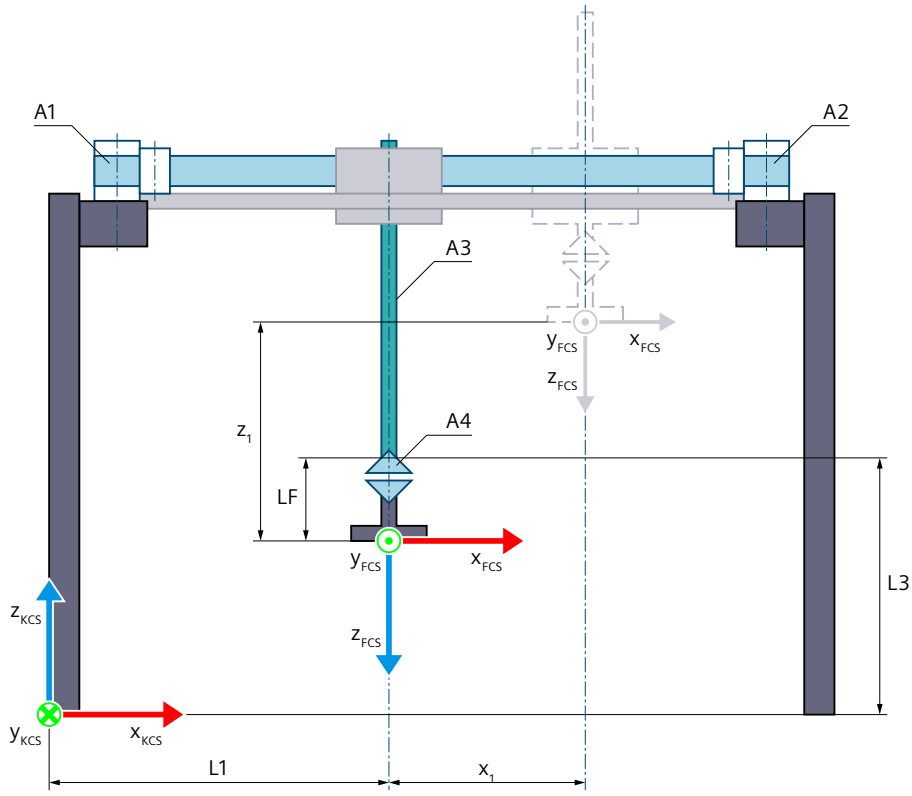

Zero position of the kinematics

L1	With axes A1 and A2 in the zero position: Distance of the FCS to the KZP in x direction of the KCS
L3	With axis A3 in the zero position: Distance of the FCS to the KZP and flange length LF in z direction of the KCS
LF	Flange length before the FCS in the z direction of the KCS
R1	Cam radius for axis A1
R2	Cam radius for axis A2

Deflection of the kinematics

x_1	Deflection of the kinematics in the positive x direction
z_1	Deflection of the kinematics in the positive z direction

Legend for representation of the kinematics (Page 38)

The graphic below shows the following in the top view (xy plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The deflection of the kinematics is indicated (dashed)

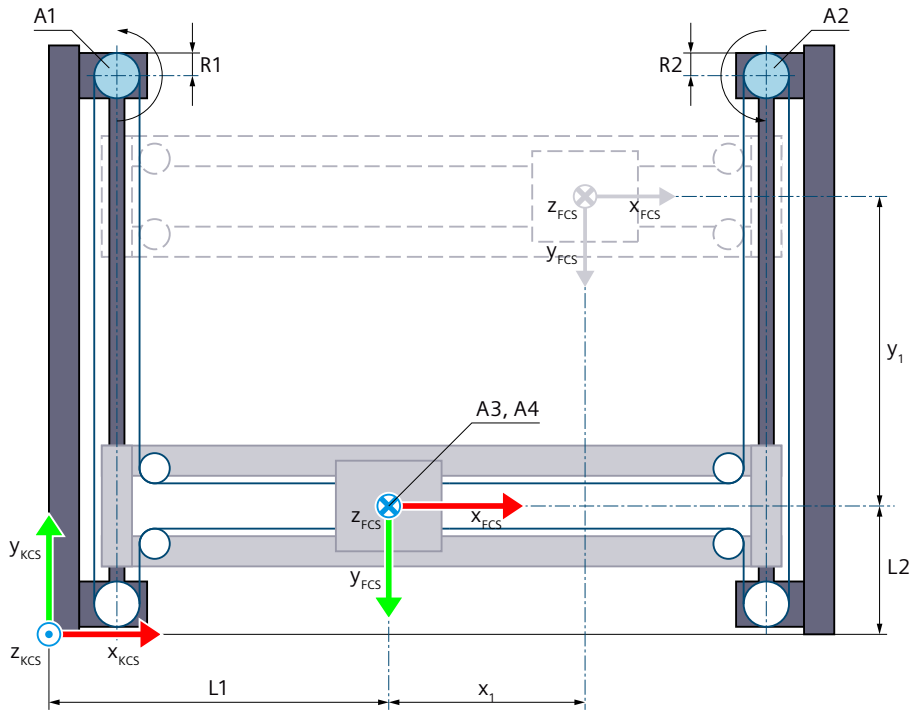

Zero position of the kinematics

L1	With axes A1 and A2 in the zero position: Distance of the FCS to the KZP in x direction of the KCS
L2	With axes A1 and A2 in the zero position: Distance of the FCS to the KZP in y direction of the KCS
R1	Cam radius for axis A1
R2	Cam radius for axis A2

Deflection of the kinematics

x_1	Deflection of the kinematics in the positive x direction
y_1	Deflection of the kinematics in the positive y direction

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the base of the kinematics. The flange coordinate system (FCS) is located between axes A1 and A2.

The position 0.0 on the respective interconnected technology object defines the zero position of the axes A1, A2 and A3. You define the distance of the zero position of axis A3 to the KZP in the y direction of the KCS using length L2.

You define the position of the FCS with axes A1 and A2 in the zero position using lengths L1 and L3. You shift the FCS in the negative z direction of the KCS using length LF. At the zero position of axis A4, the x axis of the FCS points in the direction of the x axis of the KCS.

Transformation area

The kinematics transformation covers the entire traversing range (Page 178) of the axes.

Joint position space

No joint position spaces for the kinematics.

7.9.2.6 Tags: Roller picker

Roller picker 2D

You define the 2D delta picker kinematics systems using the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	5	Roller picker 2D
	6	Roller picker 2D with orientation
<TO>.Kinematics.Parameter[1]	-1.0E12 to 1.0E12	With zero position of the axes A1 and A2: Distance L1 of the FCS to the KZP in x direction of the kinematics coordinate system (KCS)
<TO>.Kinematics.Parameter[2]	0.001 to 1.0E12	Cam radius R1 for axis 1
<TO>.Kinematics.Parameter[3]	0.001 to 1.0E12	Cam radius R2 for axis 2
<TO>.Kinematics.Parameter[4]	-1.0E12 to 1.0E12	Flange length LF before the flange coordinate system (FCS) in the negative z direction of the KCS
<TO>.Kinematics.Parameter[5]	-1.0E12 to 1.0E12	With zero position of the axes A1 and A2: Distance L2 of the FCS to the KZP in z direction of the KCS

Roller picker 3D

You define the 3D roller picker kinematics systems using the following tags of the technology object:

Tags	Values	Description	
<TO>.Kinematics.TypeOfKinematics	7	Roller picker 3D (vertical)	
	8	Roller picker 3D with orientation (vertical)	
	9	Roller picker 3D with orientation (horizontal)	
<TO>.Kinematics.Parameter[1]	-1.0E12 to 1.0E12	With zero position of the axes A1 and A2: Distance L1 of the FCS to the KZP in x direction of the KCS	
<TO>.Kinematics.Parameter[2]	0.001 to 1.0E12	Cam radius R1 for axis 1	
<TO>.Kinematics.Parameter[3]	0.001 to 1.0E12	Cam radius R2 for axis 2	
<TO>.Kinematics.Parameter[4]	-1.0E12 to 1.0E12	Flange length LF before the FCS in the negative z direction of the KCS	
<TO>.Kinematics.Parameter[5]	-1.0E12 to 1.0E12	Roller picker vertical	Distance L2 of the zero position of the axis A3 to the KZP in y direction of the KCS

Tags	Values	Description	
<TO>.Kinematics.Parameter[5]	-1.0E12 to 1.0E12	Roller picker horizontal	With zero position of the axes A1 and A2: Distance L2 of the FCS to the kinematics zero point (KZP) in y direction of the KCS
<TO>.Kinematics.Parameter[6]	-1.0E12 to 1.0E12	Roller picker vertical	With zero position of the axes A1 and A2: Distance L3 of the FCS to the KZP in z direction of the KCS
		Roller picker horizontal	Distance L3 of the zero position of the axis A3 to the KZP in z direction of the KCS

7.9.3 SCARA

7.9.3.1 SCARA 2D with orientation

The kinematics "SCARA 2D with orientation (swivel axis)" supports 3 axes and 3 degrees of freedom. The axes are configured as serial kinematics.

The following graphic shows the principal configuration and the typical working area of the kinematics:

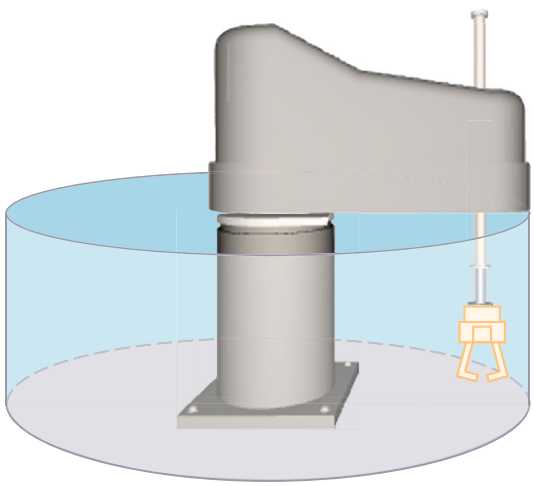

The kinematics consists of the following axes:

- 1 rotary axis A1 with rotation around the z axis of the kinematics coordinate system (KCS)
- 1 linear axis A2 in the z direction of the KCS
- 1 rotary axis A4 with rotation around z in the KCS

The kinematics consists of a base and an articulated arm for horizontal alignment which are connected by a revolute joint (axis A1). A linear stroke axis (axis A2) is fastened to the end of the articulated arm for the vertical alignment. The tool is fastened to the end of the linear axis. The kinematics axis A4 enables rotation of the tool around z in the KCS.

Coordinate systems and zero position

The graphic below shows the following in the side view (xz plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the kinematics is indicated (dashed)

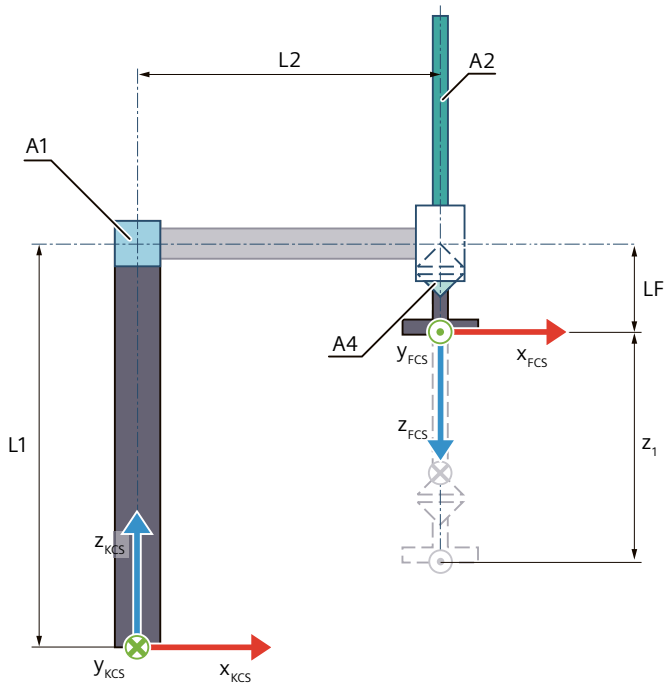

Zero position of the kinematics

L1 Distance of the axis A1 to the KZP in z direction of the KCS

L2 Distance of the axis A1 to the FCS in x direction of the KCS

LF Distance of the FCS to the axis A1 in z direction of the FCS

Deflection of the kinematics

z_1 Deflection of the axis A2 in negative direction

Legend for representation of the kinematics (Page 38)

The graphic below shows the following in the top view (xy plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the kinematics is indicated (dashed)

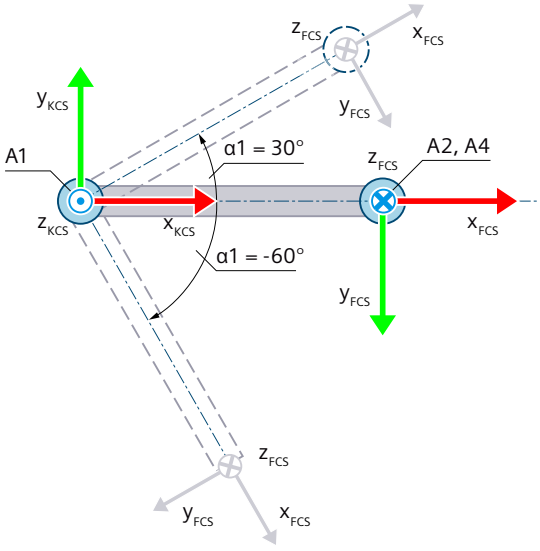

Zero position of the kinematics

Deflection of the kinematics

α1 Deflection of the axis A1 in positive direction when α1 = 30.0°
Deflection of the axis A1 in negative direction when α1 = -60.0°

Legend for representation of the kinematics (Page 38)

The KCS with the kinematics zero point (KZP) is located at the base of the kinematics. The flange coordinate system (FCS) is located at the end of the articulated arm.

The following table shows the zero position of the axes:

Axis	Zero position
A1	The articulated arm points in the x direction of the KCS.
A2	The axis A2 is at the position 0.0 of the interconnected technology object.
A4	With axis A1 in the zero position, the x axis of the FCS points in the direction of the x axis of the KCS.

Compensation of mechanical axis couplings

You can configure a mechanical axis coupling of axis A4 to axis A2 for the kinematics. The kinematics transformation compensates for the configured mechanical axis coupling. The axis coupling between axis A4 and axis A2 is implemented as a leadscrew pitch. With a compensation factor of 1.0, 360.0° on axis A4 corresponds to a distance of -1.0 mm on axis A2.

Transformation area

The kinematics transformation covers the following traversing range (Page 178) of the axes:

- Axis A1: -180.0° ≤ α1 < 180.0°
- Axis A2: No limit
- Axis A4: No limit

  An angle greater than 360° can be defined for the orientation. But coordinate A of the tool center point (TCP) is mapped in the range -180° to +180°.

You can process these kinematics only with the Motion Control instructions "MC_MoveDirectAbsolute" and "MC_MoveDirectRelative" or single-axis jobs.

Joint position space

No joint position spaces for the kinematics.

7.9.3.2 SCARA 3D with orientation

The kinematics "SCARA (Selective Compliance Assembly Robot Arm) 3D with orientation" supports 4 axes and 4 degrees of freedom. The axes are configured as serial kinematics.

The following graphic shows the principal configuration and the typical working area of the kinematics:

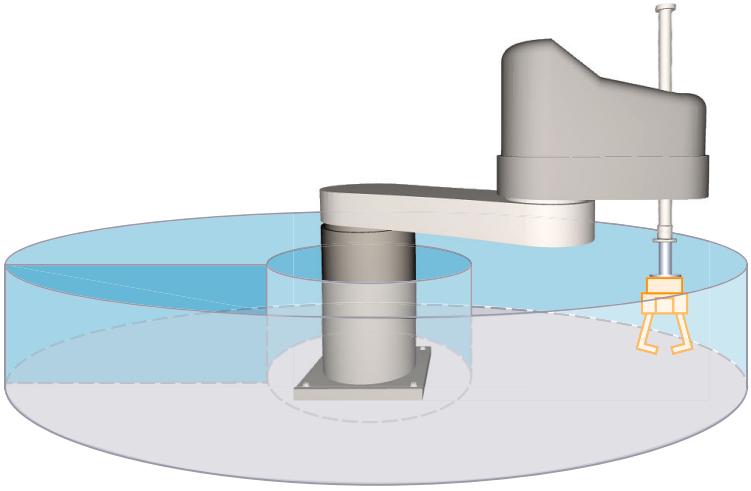

The kinematics consists of the following axes:

- 1 rotary axis A1 with rotation around the z axis of the kinematics coordinate system (KCS)
- 1 rotary axis A2 at distance L2 to A1 with rotation around z of the KCS
- 1 linear axis A3 at distance L3 to A2 with motion in z direction of the KCS
- 1 rotary axis A4 with rotation around z in the KCS

The kinematics consists of a base and two levers for horizontal alignment which are connected by revolute joints (axis A1 and A2). A linear axis (axis A3) is fastened to the end of the articulated arm for the vertical alignment. The tool is fastened to the end of the linear axis. The kinematics axis A4 enables rotation of the tool around z in the KCS.

Coordinate systems and zero position

The graphic below shows the following in the side view (xz plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics

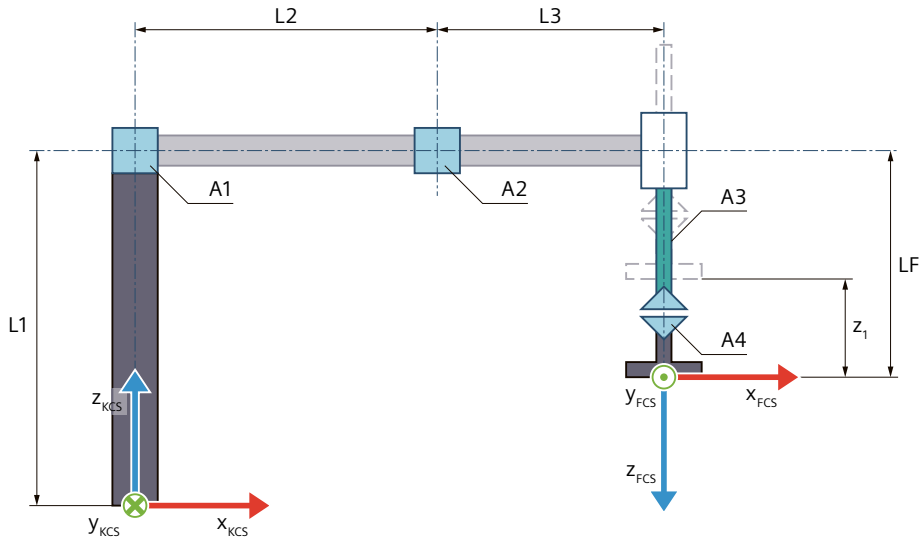

Zero position of the kinematics

L1	Distance of the axis A1 to the KZP in z direction of the KCS
L2	Distance of the axis A2 to the axis A1 in x direction of the KCS
L3	Distance of the axis A3 to the axis A2 in x direction of the KCS
LF	Distance of the FCS to the axis A2 in z direction of the FCS

Deflection of the kinematics

z_1	Deflection of the axis A3 in the positive direction

Legend for representation of the kinematics (Page 38)

The graphic below shows the following in the top view (xy plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the kinematics is indicated (dashed)

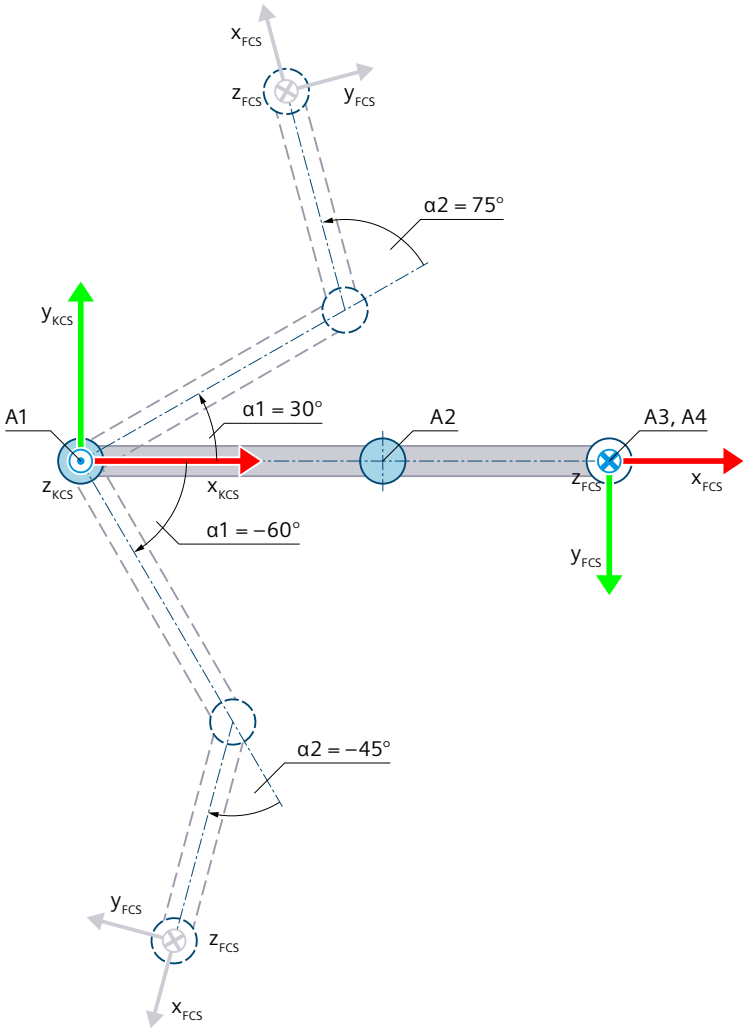

Zero position of the kinematics

Deflection of the kinematics in the positive direction when α1 = 30.0° with a positive joint position when α2 = 75.0°
Deflection of the kinematics in the negative direction when α1 = -60.0° with a negative joint position when α2 = -45.0°

α1 Deflection of the axis A1 in positive direction when α1 = 30.0°
Deflection of the axis A1 in negative direction when α1 = -60.0°

α2 The deflection of axis A2 in the positive direction when α2 = 75.0° produces a positive joint position.
The deflection of axis A2 in the negative direction when α2 = -45.0° produces a negative joint position.

Legend for representation of the kinematics (Page 38)

The KCS with the kinematics zero point (KZP) is located at the base of the kinematics. The flange coordinate system (FCS) is located at the end of the axis A3.

The following table shows the zero position of the axes:

Axis	Zero position
A1 and A2	The kinematics is elongated in the x_{KCS} direction.
A3	The FCS is located at distance L1-LF from the KCS in z direction.
A4	With axes A1 and A2 in the zero position, the x axis of the FCS points in the direction of the x axis of the KCS.

Compensation of mechanical axis couplings

You can configure the following mechanical coupled axes for the kinematics:

- Mechanical coupling of axis A1 to axis A2
- Mechanical coupling of axis A4 to axis A3

The kinematics transformation compensates for the configured mechanical axis couplings. With a compensation factor > 0.0, the kinematics transformation assumes that a positive motion of the axis A1 leads to a negative motion on the axis A2. The axis coupling between axis A4 and axis A3 is implemented as a leadscrew pitch. With a compensation factor of 1.0, 360.0° on axis A4 corresponds to a distance of -1.0 mm on axis A3.

Transformation area

The kinematics transformation covers the following traversing range (Page 178) of the axes:

- Axis A1: -180.0° ≤ α1 ≤ 180.0°
- Axis A2: -180.0° ≤ α2 ≤ 180.0°
- Axis A3: No limit
- Axis A4: No limit

  An angle greater than 360° can be defined for the orientation. But coordinate A of the tool center point (TCP) is mapped in the range -180° to +180°.

NOTE
Singularity
The kinematics has singularities (Page 183).

A singularity occurs when the zero point of the flange coordinate system (FCS) is located on the z axis of the kinematics coordinate system (KCS). Inverse transformation is not possible in this area. This position may result, e.g. in the event of suspended installation if the lengths L2 and L3 are the same size.

The graphic below shows examples of a movement in the direction of the singularity:

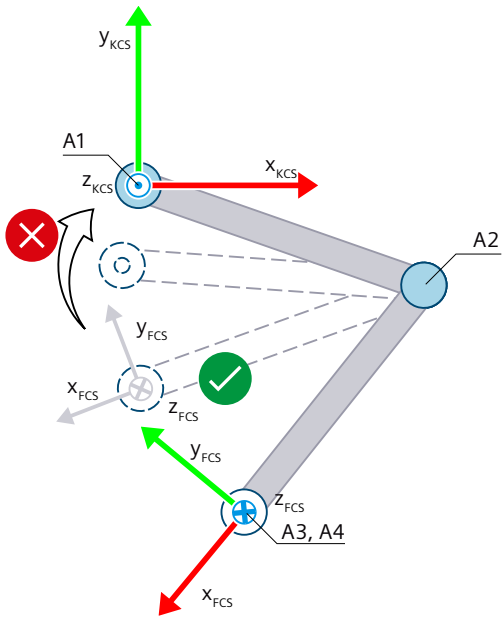

Permissible joint position

Folded position
Inner singularity at L2 = L3

Joint position space

The following table shows the possible joint position spaces of the kinematics:

Tag	Data type	Values	W	Description	
StatusKinematics.	TO_Struct_Kinematics_StatusKinematics				
Valid	BOOL	-	RON	Validity of the transformation values	
				FALSE	Invalid
				TRUE	Valid
LinkConstellation	DWORD	0 to n	RON	Joint position space	
Bit 0	-	-	-	Position axis 1	
				0	Not relevant
				1	Not relevant
Bit 1	-	-	-	Position axis 2 Angle α2 of axis A2 positive/negative taking into consideration the mechanical axis coupling	
				0	α2 positive
				1	α2 negative
Bit 2	-	-	-	Position axis 3	

Tag			Data type	Values	W	Description	
		Bit 2	-	-	-	0	Not relevant
						1	Not relevant
		Bit 3 ... 31	-	-	-	Not relevant	

7.9.3.3 Tags: SCARA

SCARA 2D

You define the SCARA 2D kinematics using the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	20	SCARA 2D with orientation
<TO>.Kinematics.Parameter[1]	-1.0E12 to 1.0E12	Distance of the axis A1 from the kinematics zero point in z direction of the kinematics coordinate system (KCS)
<TO>.Kinematics.Parameter[2]	-1.0E12 to 1.0E12	Distance L2 of the axis A2 from the axis A4 in x direction of the KCS
<TO>.Kinematics.Parameter[3]	0.001 to 1.0E12	Distance of the flange coordinate system from the axis A2 in the negative z direction of the KCS
<TO>.Kinematics.Parameter[4]	-	Mechanical axis coupling of axis A4 to A2 present/not present
	0	Not present
	1	Present
<TO>.Kinematics.Parameter[5]	-1.0E12 to 1.0E12	Compensation factor of axis A4 to axis A2

SCARA 3D

You define the SCARA 3D kinematics using the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	10	SCARA 3D with orientation
<TO>.Kinematics.Parameter[1]	-1.0E12 to 1.0E12	Distance of the axis A1 from the kinematics zero point in z direction of the kinematics coordinate system (KCS)
<TO>.Kinematics.Parameter[2]	0.001 to 1.0E12	Distance L2 of the axis A2 from the axis A1 in x direction of the KCS
<TO>.Kinematics.Parameter[3]	-	Mechanical axis coupling of axis A1 to axis A2 present/not present
	0	Not present
	1	Present
<TO>.Kinematics.Parameter[4]	-1.0E12 to 1.0E12	Compensation factor of axis A1 to axis A2
<TO>.Kinematics.Parameter[5]	0.001 to 1.0E12	Distance L3 of the axis A3 from the axis A2 in x direction of the KCS
<TO>.Kinematics.Parameter[6]	-	Mechanical axis coupling of axis A4 to axis A3 present/not present

Tags	Values	Description
<TO>.Kinematics.Parameter[6]	0	Not present
	1	Present
<TO>.Kinematics.Parameter[7]	-1.0E12 to 1.0E12	Compensation factor of axis A4 to axis A3
<TO>.Kinematics.Parameter[8]	-1.0E12 to 1.0E12	Distance of the flange coordinate system from the axis A2 in the negative z direction of the KCS

7.9.4 Articulated arm

7.9.4.1 Articulated arm 2D

The kinematics "Articulated arm 2D" supports 2 axes and 2 degrees of freedom. The axes are configured as serial kinematics with forced coupling of the flange system.

The following graphic shows the principal configuration and the typical working area of the kinematics:

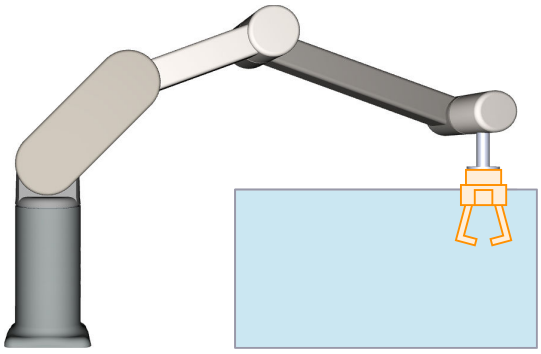

The kinematics consists of the following axes:

- 1 rotary axis A1 with the distances L1 in z direction of the KCS and L2 in x direction of the KCS to the kinematics zero point
- 1 rotary axis A2 at distance L3 to axis A1

The kinematics consists of a base and articulated arms, which are connected by revolute joints (axes A1, A2). Axes A1 and A2 move the articulated arm in the xz plane. Through a forced coupling between the axes and the flange system, the z axis of the FCS always points in the negative z direction of the KCS.

Coordinate systems and zero position

The graphic below shows the following in the side view:

- The position of the axes and of the forced coupler point
- The position of coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the kinematics is indicated (dashed)

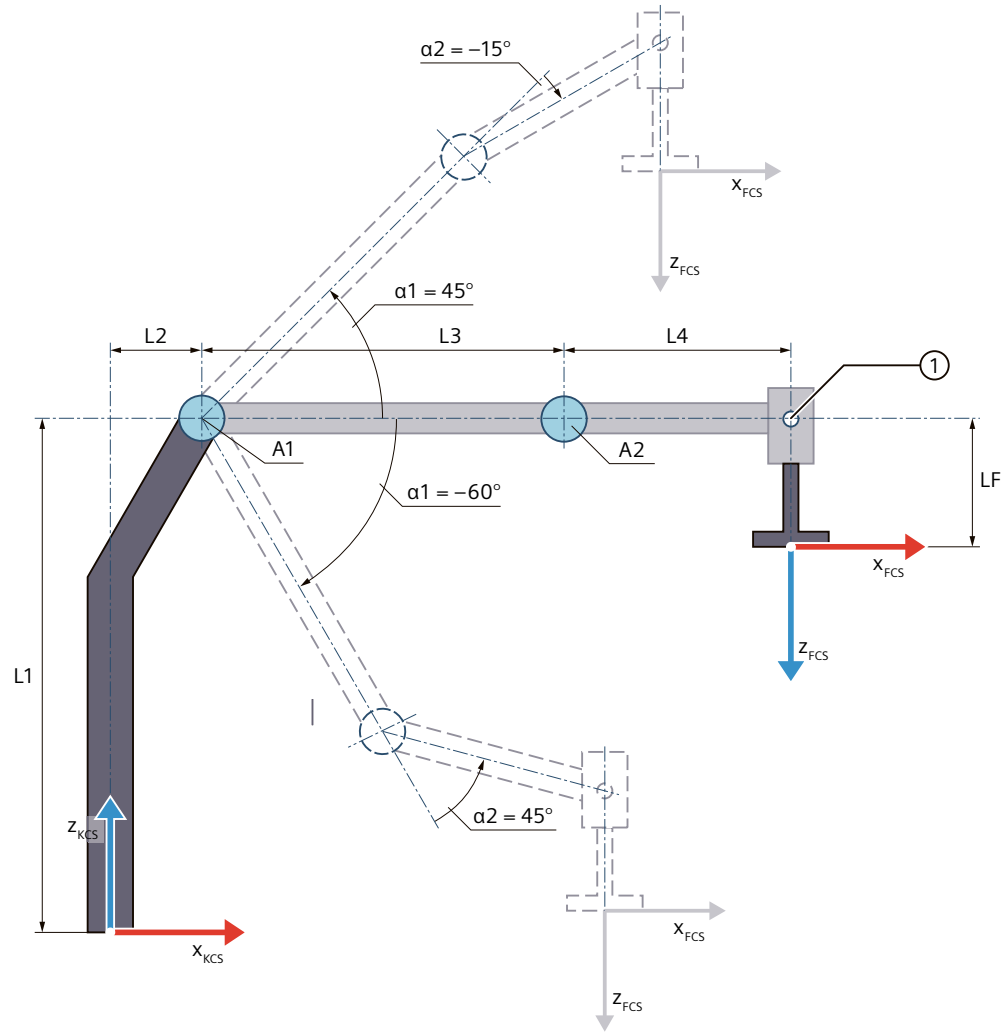

① Forced coupler point

Zero position of the kinematics

- L1 Distance of the axis A1 to the kinematics zero point (KZP) in z direction of the KCS
- L2 Distance of the axis A1 to the KZP in x direction of the KCS
- L3 Distance of the axis A2 to the axis A1 in x direction of the KCS
- L4 Distance of the forced coupler point to the axis A2 in x direction of the KCS
- LF Distance of the FCS to the forced coupler point in z direction of the FCS

Deflection of the kinematics

- α1 Positive deflection of the axis A1 when α1 = 45.0°
  Negative deflection of the axis A1 when α1 = -60.0°
- α2 The deflection of the axis A2 in the positive direction when α2 = 45.0° produces a positive joint position.
  The deflection of the axis A2 in negative direction when α2 = -15.0° produces a negative joint position.

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the base of the kinematics. You define the position of the axis A1 relative to the KZP using

lengths L1 and L2. The axis A2 is located at distance L3 in x direction of the KCS from the axis A1.

The flange coordinate system (FCS) is located at the following distances from the axis A2 and the forced coupler point:

- Distance L4 to the axis A2 in x direction of the KCS
- Distance LF to the forced coupler point in the negative z direction of the KCS

The axis A2 and the flange system are force-coupled. With the force coupling, the z axis of the FCS always points in negative z direction of the KCS. The forced coupler point is located at distance L4 in x direction of the KCS from the axis A2.

The following table shows the zero position of the axes:

Axis	Zero position
A1	Length L3 points in x direction of the KCS.
A2	At zero position of the axis A1, the length L4 points in x direction of the KCS.

Compensation of mechanical axis couplings

For the kinematics, you can configure a mechanical axis coupling of axis A1 to axis A2. The kinematics transformation compensates for the configured mechanical axis coupling. With a compensation factor > 0.0, the kinematics transformation assumes that a positive motion of the axis A1 leads to a negative motion on the axis A2.

Transformation area

The kinematics transformation covers the following traversing range (Page 178) of the axes:

- Axis A1: -180.0° ≤ α1 < 180.0°
- Axis A2: -180.0° ≤ α2 < 180.0°

NOTE
Singularity
The kinematics has outer singularities (Page 183).

Joint position space

The following table shows the possible joint position spaces of the kinematics:

Tag	Data type	Values	W	Description	
StatusKinematics.	TO_Struct_Kinematics_StatusKinematics				
Valid	BOOL	-	RON	Validity of the transformation values	
				FALSE	Invalid
				TRUE	Valid

Tag	Data type	Values	W	Description	
LinkConstellation	DWORD	0 to n	RON	Joint position space	
Bit 0	-	-	-	Position axis 1	
				0	Not relevant
				1	Not relevant
Bit 1	-	-	-	Position axis 2 Angle α2 of axis A2 positive/negative taking into consideration the mechanical axis coupling	
				0	α2 positive
				1	α2 negative
Bit 2	-	-	-	Position axis 3	
				0	Not relevant
				1	Not relevant
Bit 3 ... 31	-	-	-	Not relevant	

7.9.4.2 Articulated arm 2D with orientation

The kinematics "Articulated arm 2D with orientation" supports 3 axes and 3 degrees of freedom. The axes are configured as serial kinematics with forced coupling of the flange system.

The following graphic shows the principal configuration and the typical working area of the kinematics:

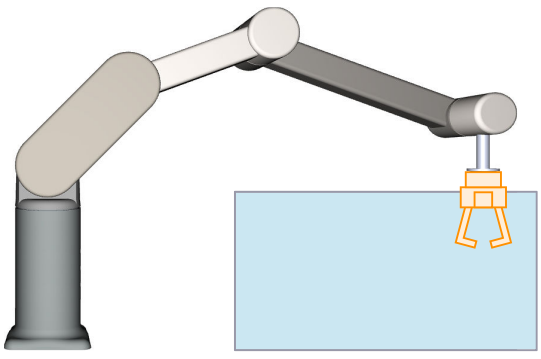

The kinematics consists of the following axes:

- 1 rotary axis A1 with the distances L1 in z direction of the KCS and L2 in x direction of the KCS to the kinematics zero point
- 1 rotary axis A2 at distance L3 to axis A1
- 1 rotary axis A4 with rotation around z in the KCS at a distance L4 in x direction of the KCS to axis A2

The kinematics consists of a base and articulated arms, which are connected by revolute joints (axes A1, A2). Axes A1 and A2 move the articulated arm in the xz plane. Through a forced coupling between the axes and the flange system, the z axis of the FCS always points in the negative z direction of the KCS. The kinematics axis A4 enables rotation of the tool around z in the KCS.

Coordinate systems and zero position

The graphic below shows the following in the side view:

- The position of the axes and of the forced coupler point
- The position of coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the kinematics is indicated (dashed)

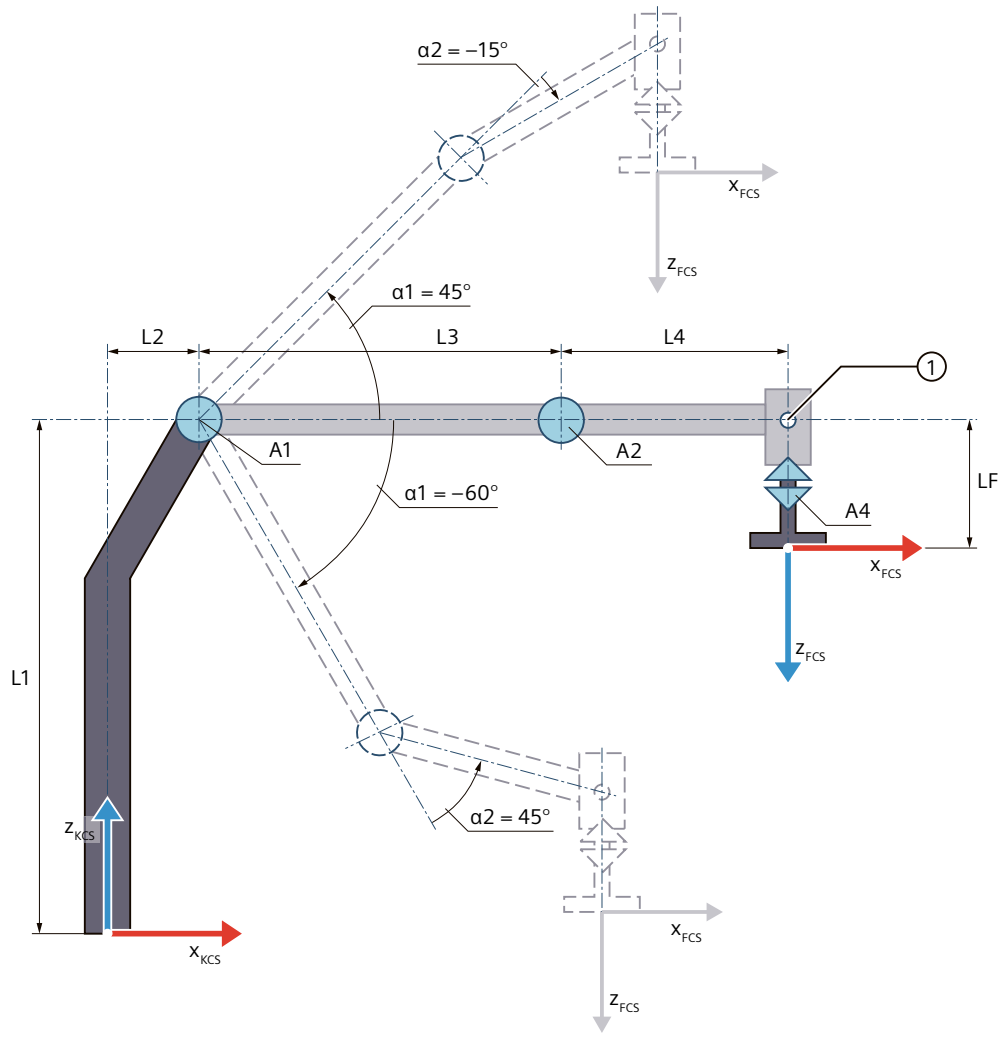

① Forced coupler point

Zero position of the kinematics

L1 Distance of the axis A1 to the kinematics zero point (KZP) in z direction of the KCS

L2 Distance of the axis A1 to the KZP in x direction of the KCS

L3 Distance of the axis A2 to the axis A1 in x direction of the KCS

L4 Distance of the forced coupler point to the axis A2 in x direction of the KCS

LF Distance of the FCS to the forced coupler point in z direction of the FCS

Deflection of the kinematics

α1 Positive deflection of the axis A1 when α1 = 45.0°
Negative deflection of the axis A1 when α1 = -60.0°

α2 The deflection of the axis A2 in the positive direction when α2 = 45.0° produces a positive joint position.
The deflection of the axis A2 in negative direction when α2 = -15.0° produces a negative joint position.

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the base of the kinematics. You define the position of the axis A1 relative to the KZP using lengths L1 and L2. The axis A2 is located at distance L3 in x direction of the KCS from the axis A1.

The flange coordinate system (FCS) is located at the following distances from the axis A2 and the forced coupler point:

- Distance L4 to the axis A2 in x direction of the KCS
- Distance LF to the forced coupler point in the negative z direction of the KCS

The axis A2 and the flange system are force-coupled. With the force coupling, the z axis of the FCS always points in negative z direction of the KCS. The forced coupler point is located at distance L4 in x direction of the KCS from the axis A2.

The following table shows the zero position of the axes:

Axis	Zero position
A1	Length L3 points in x direction of the KCS.
A2	At zero position of the axis A1, the length L4 points in x direction of the KCS.
A4	At the zero position of axis A1 and A2, the x axis of the FCS points in the direction of the x axis of the KCS.

Compensation of mechanical axis couplings

For the kinematics, you can configure a mechanical axis coupling of axis A1 to axis A2. The kinematics transformation compensates for the configured mechanical axis coupling. With a compensation factor > 0.0, the kinematics transformation assumes that a positive motion of the axis A1 leads to a negative motion on the axis A2.

Transformation area

The kinematics transformation covers the following traversing range (Page 178) of the axes:

- Axis A1: -180.0° ≤ α1 < 180.0°
- Axis A2: -180.0° ≤ α2 < 180.0°
- Axis A4: No limit

  An angle greater than 360° can be defined for the orientation. But coordinate A of the tool center point (TCP) is mapped in the range -180° to +180°.

NOTE
Singularity
The kinematics has outer singularities (Page 183).

Joint position space

The following table shows the possible joint position spaces of the kinematics:

Tag	Data type	Values	W	Description	
StatusKinematics.	TO_Struct_Kinematics_StatusKinematics				
Valid	BOOL	-	RON	Validity of the transformation values	
				FALSE	Invalid
				TRUE	Valid
LinkConstellation	DWORD	0 to n	RON	Joint position space	
Bit 0	-	-	-	Position axis 1	
				0	Not relevant
				1	Not relevant
Bit 1	-	-	-	Position axis 2 Angle α2 of axis A2 positive/negative taking into consideration the mechanical axis coupling	
				0	α2 positive
				1	α2 negative
Bit 2	-	-	-	Position axis 3	
				0	Not relevant
				1	Not relevant
Bit 3 ... 31	-	-	-	Not relevant	

7.9.4.3 Articulated arm 3D

The kinematics "Articulated arm 3D" supports 3 axes and 3 degrees of freedom. The axes are configured as serial kinematics with forced coupling of the flange system.

The following graphic shows the principal configuration and the typical working area of the kinematics:

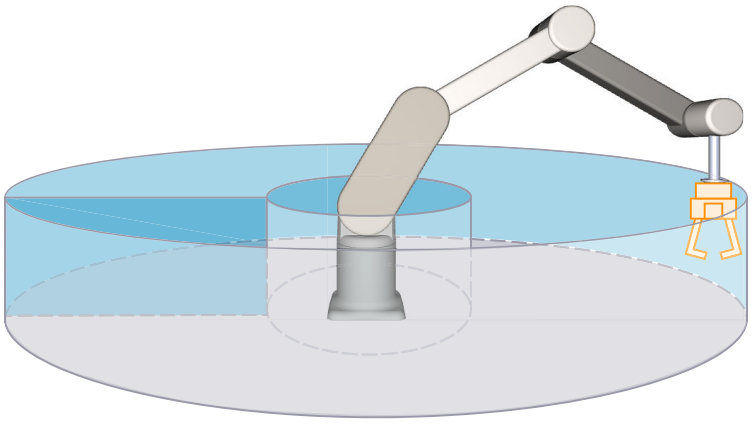

The kinematics consists of the following axes:

- 1 rotary axis A1 with rotation around the z axis of the kinematics coordinate system (KCS)
- 1 rotary axis A2 with the distances L1 in z direction of the KCS and L2 in x direction of the KCS to the kinematics zero point
- 1 rotary axis A3 at distance L3 to axis A2

The kinematics consists of a base and articulated arms, which are connected by revolute joints (axes A1, A2 and A3). Axis A1 rotates the kinematics horizontally around the base. Axes A2 and A3 move the articulated arm. The kinematics enables an approximately spherical working area. Through a forced coupling between the axes and the flange system, the z axis of the FCS always points in the negative z direction of the KCS.

Coordinate systems and zero position

The graphic below shows the following in the side view (xz plane):

- The position of the axes and of the forced coupler point
- The position of coordinate systems KCS and FCS
- The zero position of the axes
- The positive/negative deflection of the axes A2 and A3 is indicated (dashed)

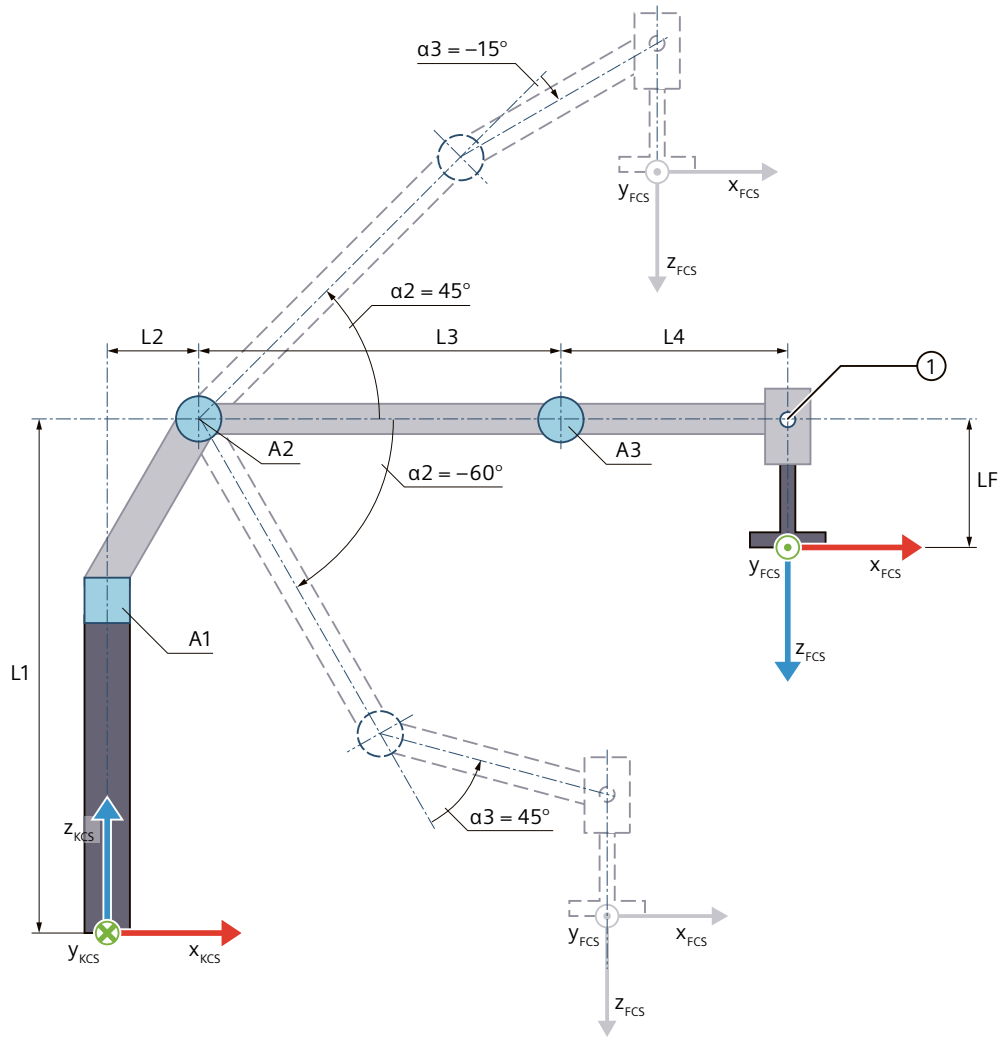

① Forced coupler point

Zero position of the kinematics

- L1 Distance of the axis A2 to the kinematics zero point (KZP) in z direction of the KCS
- L2 Distance of the axis A2 to the KZP in x direction of the KCS
- L3 Distance of the axis A3 to the axis A2 in x direction of the KCS
- L4 Distance of the forced coupler point to the axis A3 in x direction of the KCS
- LF Distance of the FCS to the forced coupler point in z direction of the FCS

Deflection of the kinematics

- α2 Positive deflection of the axis A2 when α2 = 45.0°
  Negative deflection of the axis A2 when α2 = -60.0°
- α3 The deflection of the axis A3 in positive direction when α3 = 45.0° produces a positive joint position.
  The deflection of the axis A3 in negative direction when α3 = -15.0° produces a negative joint position.

Legend for representation of the kinematics (Page 38)

The graphic below shows the following in the top view (xy plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the kinematics is indicated (dashed)

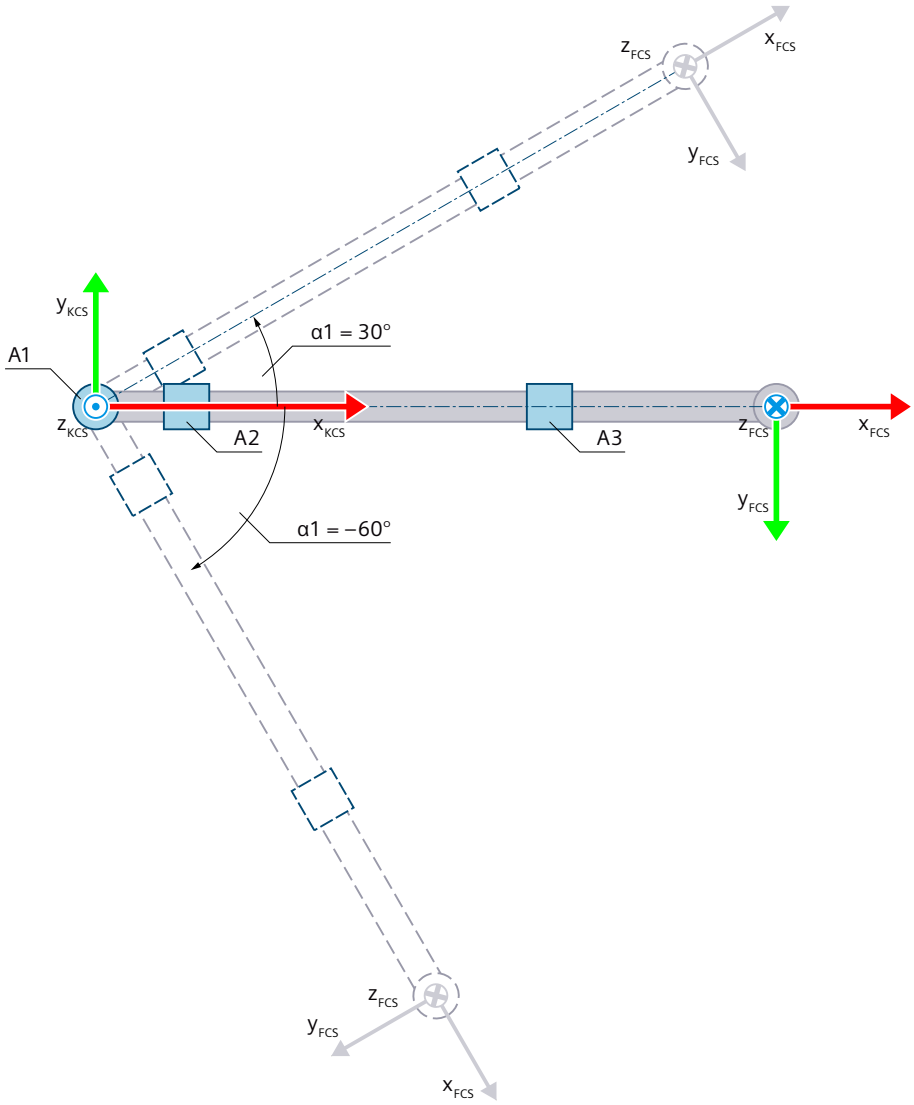

Zero position of the kinematics

Deflection of the kinematics

α1 Positive deflection of the axis A1 when α1 = 30.0°
Negative deflection of the axis A1 when α1 = -60.0°

Legend for representation of the kinematics (Page 38)

The KCS with the kinematics zero point (KZP) is located at the base of the kinematics. You define the position of the axis A2 relative to the KZP using lengths L1 and L2. The axis A3 is located at distance L3 in x direction of the KCS from the axis A2.

The flange coordinate system (FCS) is located at the following distances from the axis A3 and the forced coupler point:

- Distance L4 to the axis A3 in x direction of the KCS
- Distance LF to the forced coupler point in the negative z direction of the KCS

The axis A3 and the flange system are force-coupled. With the force coupling, the z axis of the FCS always points in negative z direction of the KCS. The forced coupler point is located at distance L4 in x direction of the KCS from the axis A3.

The following table shows the zero position of the axes:

Axis	Zero position
A1	The articulated arms of the kinematics point in the x direction of the KCS.
A2	At zero position of the axis A1, the length L3 points in x direction of the KCS.
A3	At zero position of the axes A1 and A2, the length L4 points in x direction of the KCS.

Compensation of mechanical axis couplings

You can configure a mechanical axis coupling of axis A2 to axis A3 for the kinematics. The kinematics transformation compensates for the configured mechanical axis coupling. With a compensation factor > 0.0, the kinematics transformation assumes that a positive motion of the axis A2 leads to a negative motion on the axis A3.

Transformation area

The kinematics transformation covers the following traversing range (Page 178) of the axes:

- Axis A1: $-180.0° \leq \alpha 1 < 180.0°$
- Axis A2: $-180.0° \leq \alpha 2 < 180.0°$
- Axis A3: $-180.0° \leq \alpha 3 < 180.0°$

NOTE
Singularity
The kinematics has singularities (Page 183).

A singularity occurs when the zero point of the flange coordinate system (FCS) is located on the z axis of the kinematics coordinate system (KCS). Inverse transformation is not possible in this area.

The graphic below shows examples of singularities and permissible joint positions:

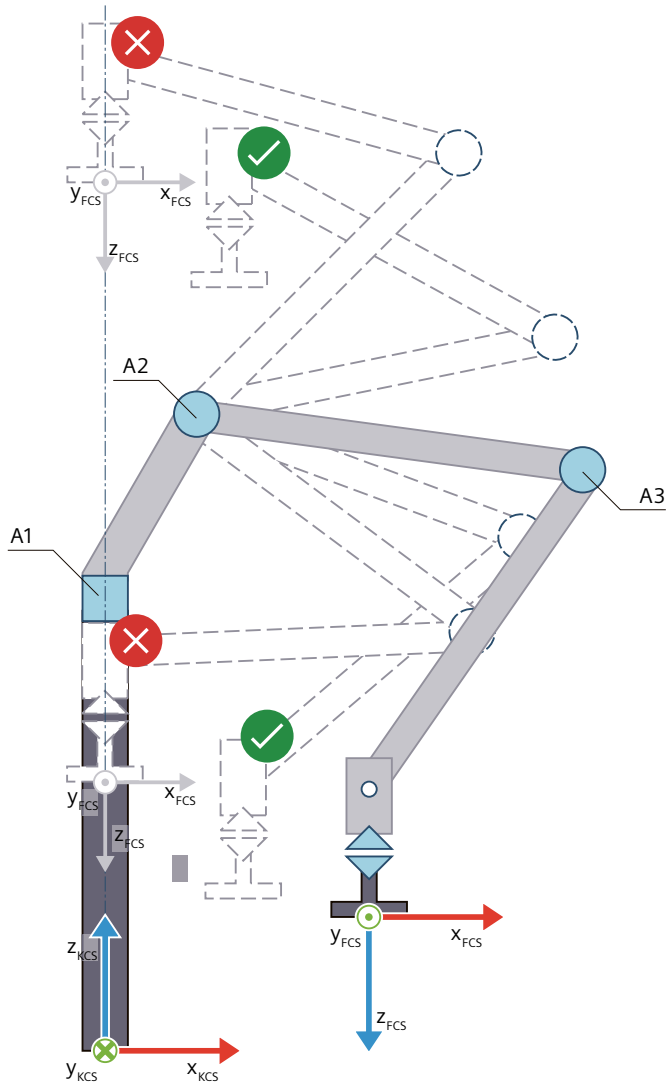

Permissible joint position

Inner singularity

Joint position space

The following table shows the possible joint position spaces of the kinematics:

Tag		Data type	Values	W	Description	
StatusKinematics.		TO_Struct_Kinematics_StatusKinematics				
	Valid	BOOL	-	RON	Validity of the transformation values	
					FALSE	Invalid
					TRUE	Valid

Tag	Data type	Values	W	Description	
LinkConstellation	DWORD	0 to n	RON	Joint position space	
Bit 0	-	-	-	Position axis 1 Angle α1 of axis A1 in the front/rear area (standard area/overhead area)	
				0	The zero point of the FCS is located in the front area (standard area) of the joint position lines for the axis A1. $\alpha 1 = \arctan(y_{FCS}/x_{FCS})$
				1	The zero point of the FCS is located in the rear area (overhead area) of the joint position lines for the axis A1. $\alpha 1 = -\arctan(y_{FCS}/x_{FCS})$
Bit 1	-	-	-	Position axis 2	
				0	Not relevant
				1	Not relevant
Bit 2	-	-	-	Position axis 3 Angle α3 of axis A3 positive/negative taking into consideration the mechanical axis coupling	
				0	α3 positive
				1	α3 negative
Bit 3 ... 31	-	-	-	Not relevant	

7.9.4.4 Articulated arm 3D with orientation

The kinematics "Articulated arm 3D with orientation" supports 4 axes and 4 degrees of freedom. The axes are configured as serial kinematics with forced coupling of the flange system.

The following graphic shows the principal configuration and the typical working area of the kinematics:

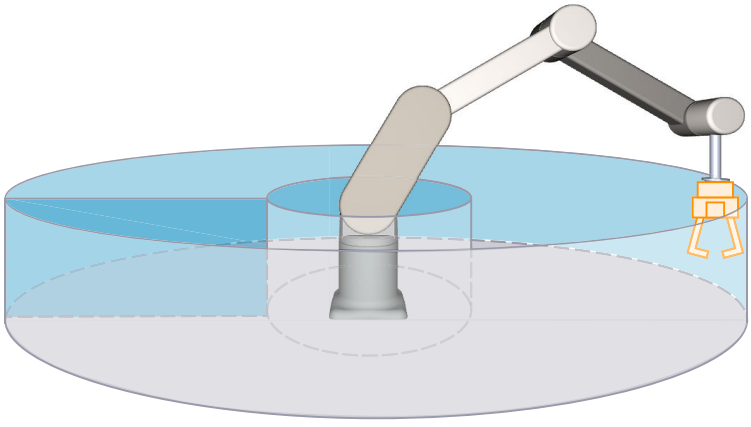

The kinematics consists of the following axes:

- 1 rotary axis A1 with rotation around the z axis of the kinematics coordinate system (KCS)
- 1 rotary axis A2 with the distances L1 in z direction of the KCS and L2 in x direction of the KCS to the kinematics zero point
- 1 rotary axis A3 at distance L3 to axis A2
- 1 rotary axis A4 with rotation around z in the KCS at a distance L4 in x direction of the KCS to axis A3

The kinematics consists of a base and articulated arms, which are connected by revolute joints (axes A1, A2 and A3). Axis A1 rotates the kinematics horizontally around the base. Axes A2 and A3 move the articulated arm. The kinematics enables an approximately spherical working area. Through a forced coupling between the axes and the flange system, the z axis of the FCS always points in the negative z direction of the KCS. The kinematics axis A4 enables rotation of the tool around z in the KCS.

Coordinate systems and zero position

The graphic below shows the following in the side view (xz plane):

- The position of the axes and of the forced coupler point
- The position of coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the kinematics is indicated (dashed)

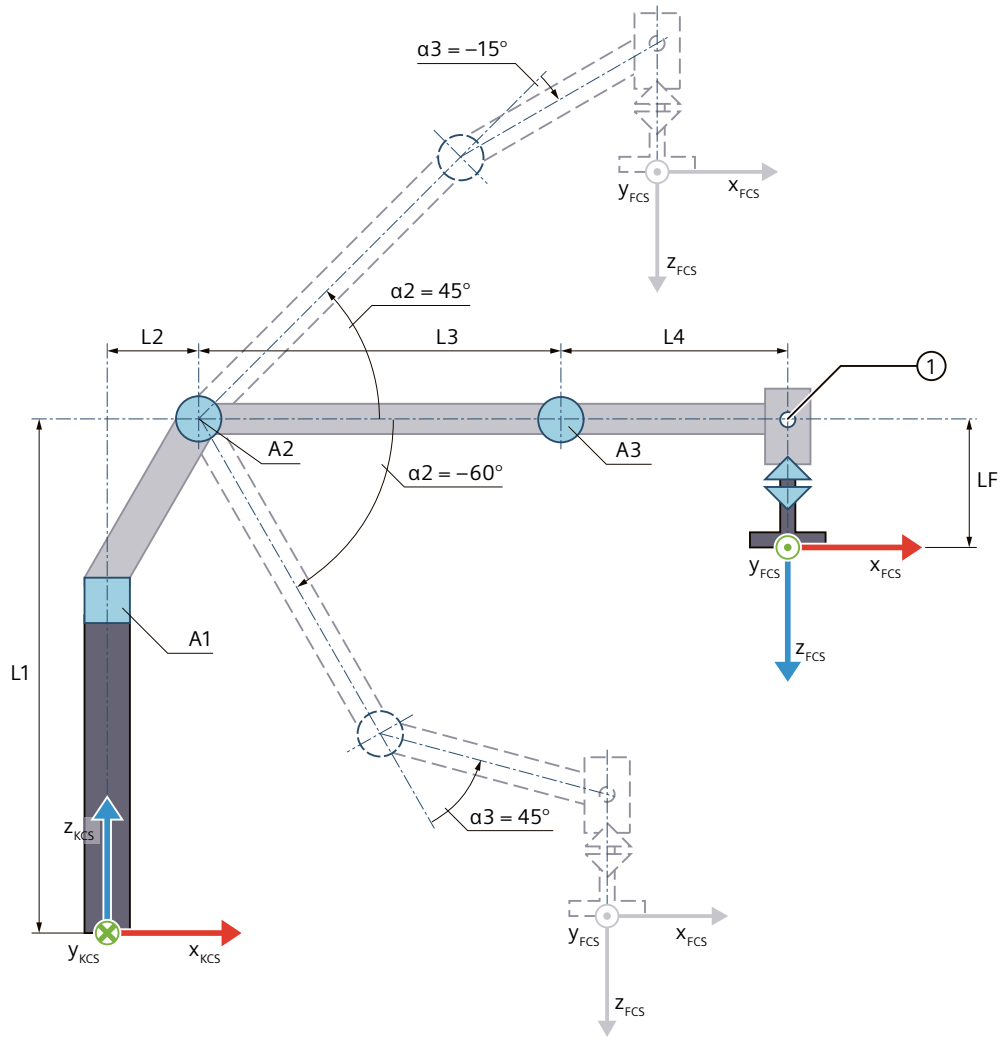

① Forced coupler point

Zero position of the kinematics

- L1 Distance of the axis A2 to the kinematics zero point (KZP) in z direction of the KCS
- L2 Distance of the axis A2 to the KZP in x direction of the KCS
- L3 Distance of the axis A3 to the axis A2 in x direction of the KCS
- L4 Distance of the forced coupler point to the axis A3 in x direction of the KCS
- LF Distance of the FCS to the forced coupler point in z direction of the FCS

Deflection of the kinematics

- α2 Positive deflection of the axis A2 when α2 = 45.0°
  Negative deflection of the axis A2 when α2 = -60.0°
- α3 The deflection of the axis A3 in positive direction when α3 = 45.0° produces a positive joint position.
  The deflection of the axis A3 in negative direction when α3 = -15.0° produces a negative joint position.

Legend for representation of the kinematics (Page 38)

The graphic below shows the following in the top view (xy plane):

- The position of the axes
- The position of coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the kinematics is indicated (dashed)

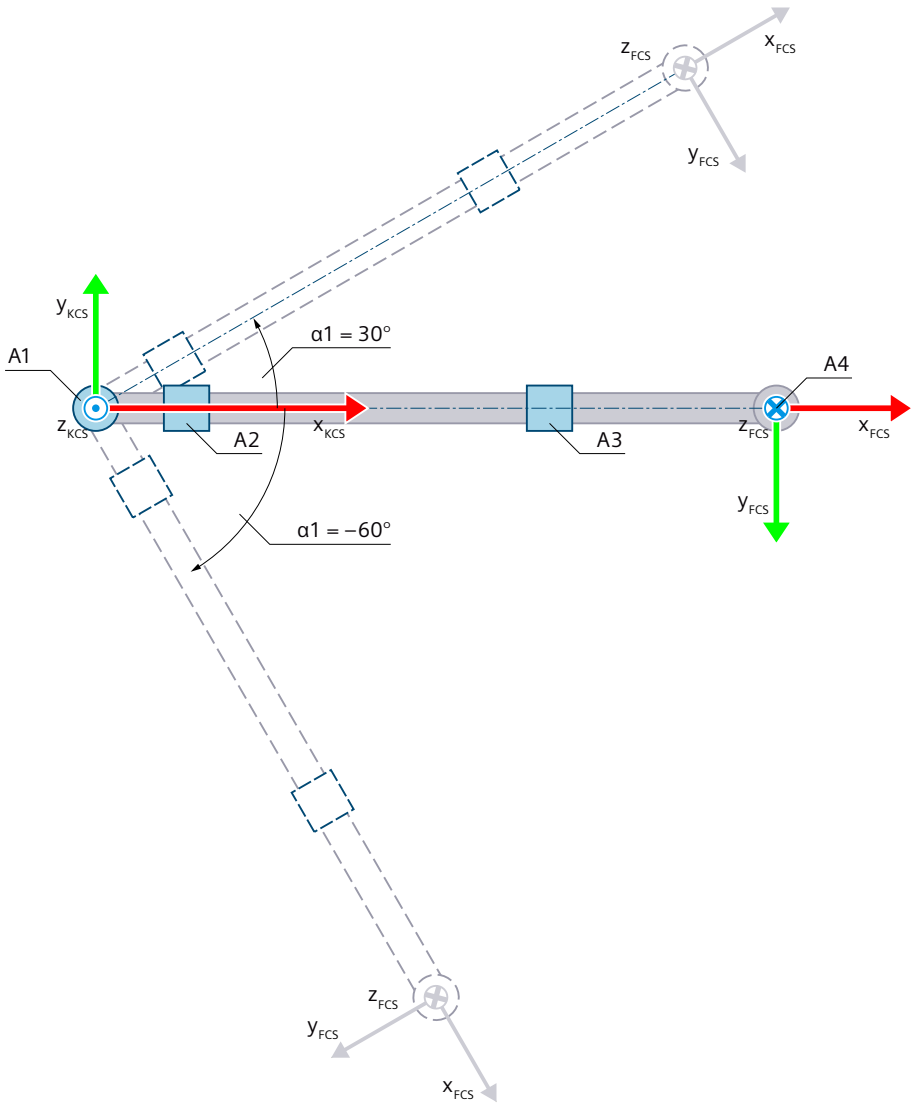

Zero position of the kinematics

Deflection of the kinematics

α1 Positive deflection of the axis A1 when α1 = 30.0°
Negative deflection of the axis A1 when α1 = -60.0°

Legend for representation of the kinematics (Page 38)

The KCS with the kinematics zero point (KZP) is located at the base of the kinematics. You define the position of the axis A2 relative to the KZP using lengths L1 and L2. The axis A3 is located at distance L3 in x direction of the KCS from the axis A2.

The flange coordinate system (FCS) is located at the following distances from the axis A3 and the forced coupler point:

- Distance L4 to the axis A3 in x direction of the KCS
- Distance LF to the forced coupler point in the negative z direction of the KCS

The axis A3 and the flange system are force-coupled. With the force coupling, the z axis of the FCS always points in negative z direction of the KCS. The forced coupler point is located at distance L4 in x direction of the KCS from the axis A3.

The following table shows the zero position of the axes:

Axis	Zero position
A1	The articulated arms of the kinematics point in the x direction of the KCS.
A2	At zero position of the axis A1, the length L3 points in x direction of the KCS.
A3	At zero position of the axes A1 and A2, the length L4 points in x direction of the KCS.
A4	At zero position of the axes A1, A2 and A3, the x axis of the FCS points in the direction of the x axis of the KCS.

Compensation of mechanical axis couplings

You can configure a mechanical axis coupling of axis A2 to axis A3 for the kinematics. The kinematics transformation compensates for the configured mechanical axis coupling. With a compensation factor > 0.0, the kinematics transformation assumes that a positive motion of the axis A2 leads to a negative motion on the axis A3.

Transformation area

The kinematics transformation covers the following traversing range (Page 178) of the axes:

- Axis A1: -180.0° ≤ α1 < 180.0°
- Axis A2: -180.0° ≤ α2 < 180.0°
- Axis A3: -180.0° ≤ α3 < 180.0°
- Axis A4: No limit

  An angle greater than 360° can be defined for the orientation. But coordinate A of the tool center point (TCP) is mapped in the range -180° to +180°.

NOTE

Singularity

The kinematics has singularities (Page 183).

A singularity occurs when the zero point of the flange coordinate system (FCS) is located on the z axis of the kinematics coordinate system (KCS). Inverse transformation is not possible in this area.

The graphic below shows examples of singularities and permissible joint positions:

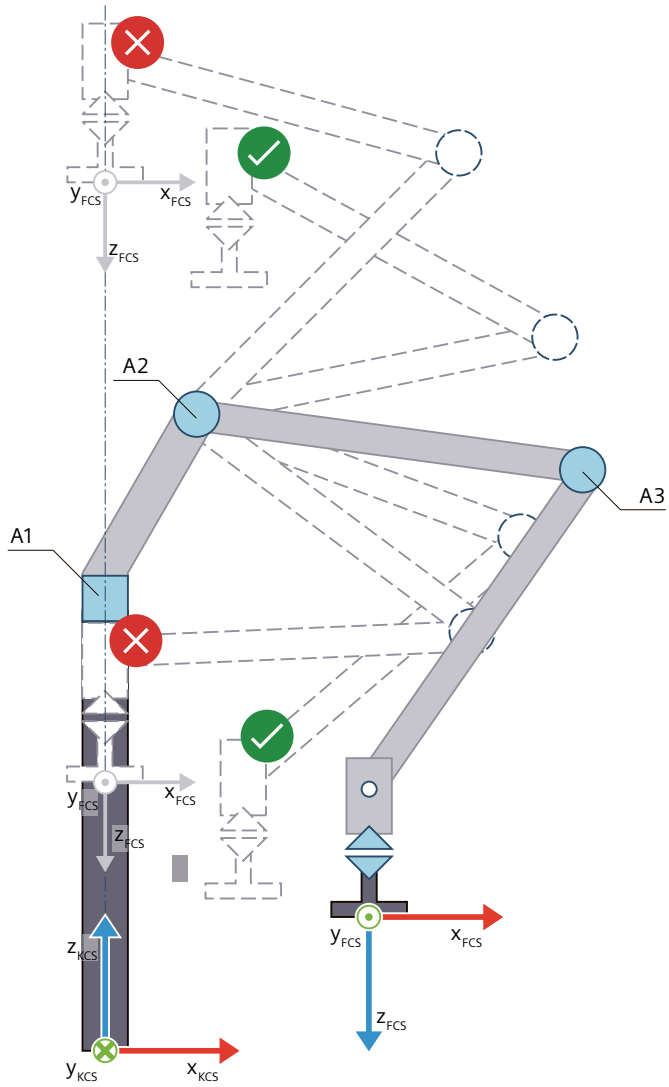

Permissible joint position

Inner singularity

Joint position space

The following table shows the possible joint position spaces of the kinematics:

Tag		Data type	Values	W	Description	
StatusKinematics.		TO_Struct_Kinematics_StatusKinematics				
	Valid	BOOL	-	RON	Validity of the transformation values	
					FALSE	Invalid
					TRUE	Valid

Tag	Data type	Values	W	Description	
LinkConstellation	DWORD	0 to n	RON	Joint position space	
Bit 0	-	-	-	Position axis 1 Angle α1 of axis A1 in the front/rear area (standard area/overhead area)	
				0	The zero point of the FCS is located in the front area (standard area) of the joint position lines for the axis A1. $\alpha 1 = \arctan(y_{FCS}/x_{FCS})$
				1	The zero point of the FCS is located in the rear area (overhead area) of the joint position lines for the axis A1. $\alpha 1 = -\arctan(y_{FCS}/x_{FCS})$
Bit 1	-	-	-	Position axis 2	
				0	Not relevant
				1	Not relevant
Bit 2	-	-	-	Position axis 3 Angle α3 of axis A3 positive/negative taking into consideration the mechanical axis coupling	
				0	α3 positive
				1	α3 negative
Bit 3 ... 31	-	-	-	Not relevant	

7.9.4.5 6-axis articulated arm with central wrist

The kinematics "6-axis articulated arm with central wrist" supports 6 axes and 6 degrees of freedom. The axes are configured as serial kinematics. For this kinematics type you need the Motion Control package "S7-1500T Motion Control KinPlus (Page 27)".

The following graphic shows the principal configuration and the typical working area of the kinematics:

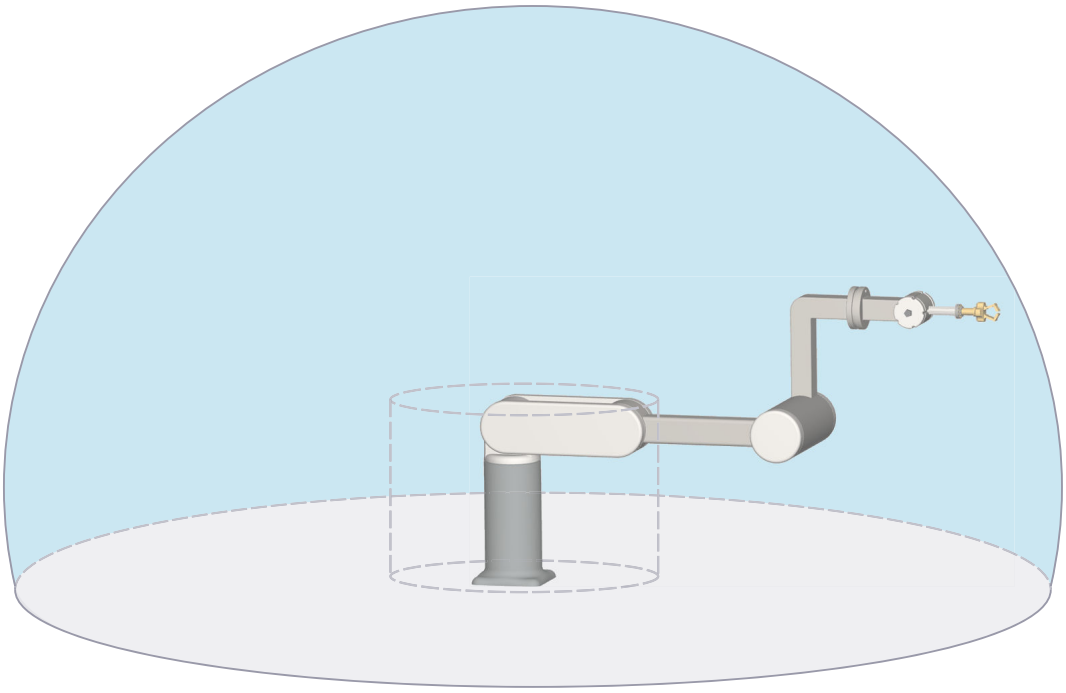

The kinematics consists of the following axes (output state):

- 1 rotary axis A1 with rotation around the z axis of the kinematics coordinate system (KCS)
- 1 rotary axis A2 with the distances L1 in z direction of the KCS and L2 in x direction of the KCS to the kinematics zero point with rotation around y
- 1 rotary axis A3 at a distance L3 in x direction of the KCS to the axis A2 with rotation around y
- 1 rotary axis A4 with the distance L5 in z direction of the KCS to the axis A5 and distance L6 in y direction to the axis A1
- 1 rotary axis A5 with the distances L4 in x direction of the KCS and L5 in z direction of the KCS to the axis A3 with rotation around y
- 1 rotary axis A6 with distance LF to axis A5 with rotation around x

The distances L1 to L6 and LF are shown in the following diagrams with the side view and the top view of the kinematics.

The kinematics consists of a base and articulated arms, which are connected by revolute joints (axes A1, A2 and A3). Axis A1 rotates the kinematics horizontally around the base. Axes A2 and A3 move the articulated arms. The kinematics enables an approximately spherical working area.

The axes A4, A5 and A6 form the central wrist. This means that the axes A4, A5 and A6 intersect at one point. This point is referred to as the wrist point.

Coordinate systems and zero position

The graphic below shows the following in the side view (xz plane):

- The position of the axes
- The position of coordinate systems KCS and FCS
- The zero position of the kinematics

NOTE
Singularity
Note that the zero position represents a singularity.

- The positive/negative deflection of the kinematics is indicated (dashed)

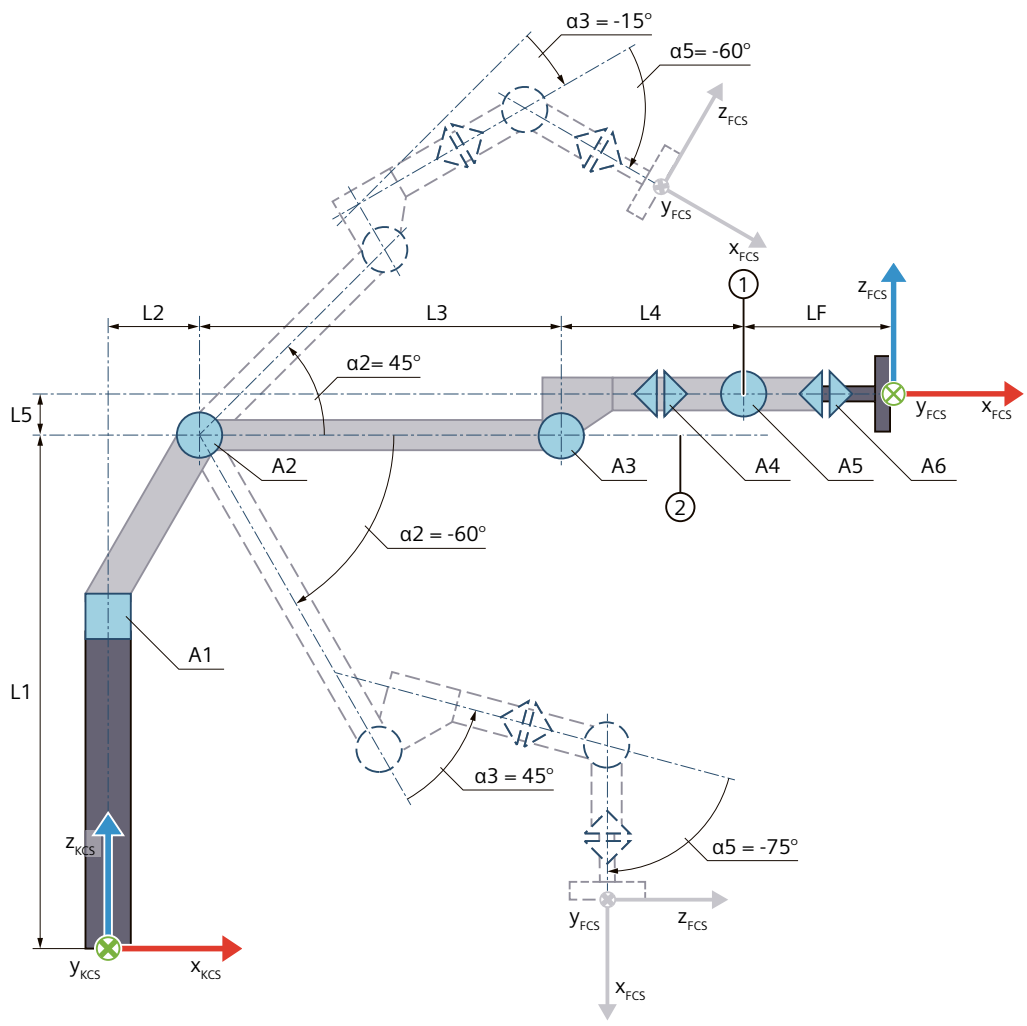

① Wrist point

② Joint position line for the joint

Zero position of the kinematics

L1 Distance of the axis A2 to the kinematics zero point (KZP) in z direction of the KCS

L2 Distance of the axis A2 to the KZP in x direction of the KCS

L3 Distance of the axis A3 to the axis A2 in x direction of the KCS

L4 Distance of the wrist point to the axis A3 in x direction of the KCS

L5 Distance of the wrist point to the axis A3 in z direction of the KCS

LF Distance of the FCS to the wrist point in x direction of the KCS

Deflection of the kinematics

α2 Positive deflection of the axis A2 when α2 = 45.0°
Negative deflection of the axis A2 when α2 = -60.0°

α3 The deflection of the axis A3 in positive direction when α3 = 45.0° produces a positive joint position.
The deflection of the axis A3 in negative direction when α3 = -15.0° produces a negative joint position.

α5 The deflection of the axis A5 in negative direction when α5 = -60.0° or α5 = -75.0°produces a negative joint position.

Legend for representation of the kinematics (Page 38)

The graphic below shows the following in the top view (xy plane):

- The position of the axes
- The position of coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the kinematics is indicated (dashed)

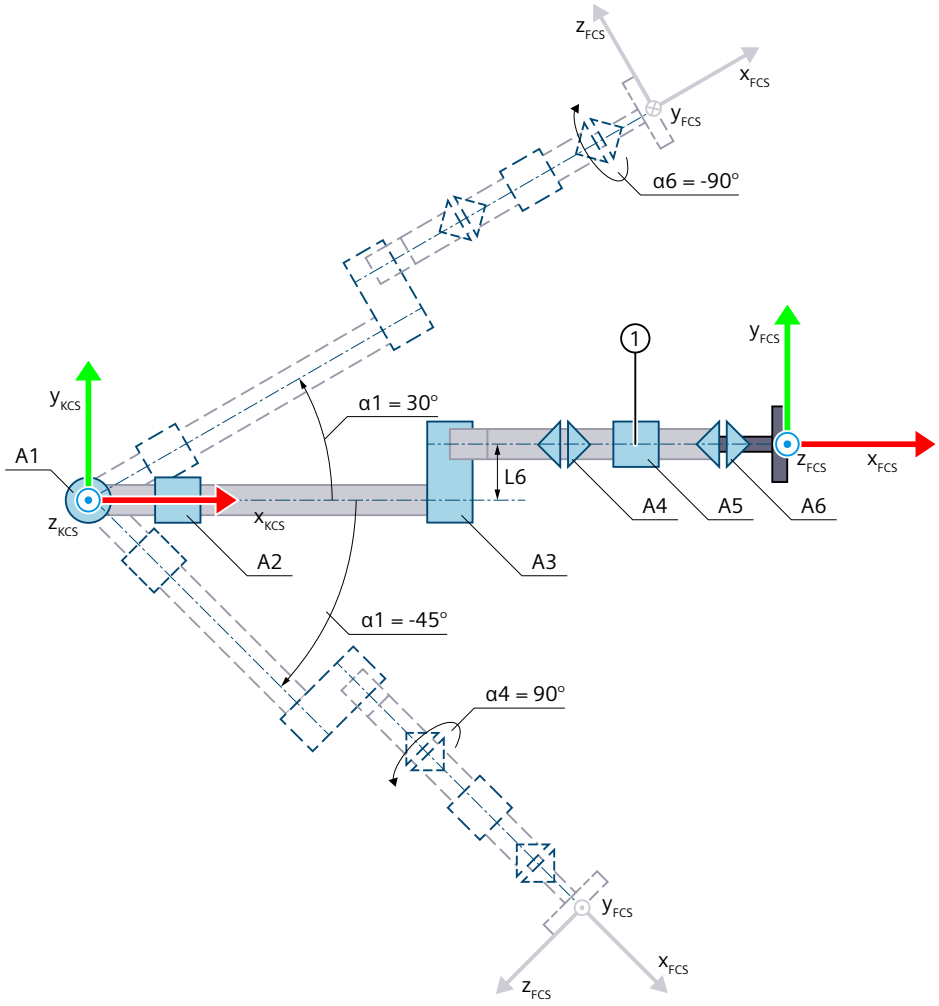

① Wrist point

Zero position of the kinematics

L6 Distance of the wrist point to the KZP in y direction of the KCS

Deflection of the kinematics

α1 Positive deflection of the axis A1 when α1 = 30.0°
Negative deflection of the axis A1 when α1 = -45.0°

α4 Positive deflection of the axis A4 when α4 = 90.0°

α6 Negative deflection of the axis A6 when α6 = -90.0°

Legend for representation of the kinematics (Page 38)

The KCS with the kinematics zero point (KZP) is located at the base of the kinematics. With zero position of the axes A1, A2, A3 and A5, the kinematics is extended in x direction of the KCS.

You can use the lengths L1 to L6 and the flange length LF to define the zero position of the flange coordinate system (FCS) at zero position of the kinematics. Since there is no forced coupling between the kinematics axes and the flange system, the coordinate axes of the FCS at the zero position of the kinematics point in the same direction as the coordinate axes of the KCS.

The following table shows the zero position of the axes:

Axis	Zero position
A1	The articulated arms of the kinematics point in the x direction of the KCS.
A2	At zero position of the axis A1, the length L3 points in x direction of the KCS.
A3	At zero position of the axes A1 and A2, the length L4 points in the x direction of the KCS and length L5 points in the z direction of the KCS.
A5	At zero position of the axes A1, A2 and A3, the length LF points in the x direction of KCS.
A4, A6	At zero position of the axes A1, A2, A3 and A5, the x, y and z axes of FCS point in the direction of the x, y and z axes of KCS.

Direction of travel of the joints

The following figure shows the direction of travel of the joints defined in the kinematics type.

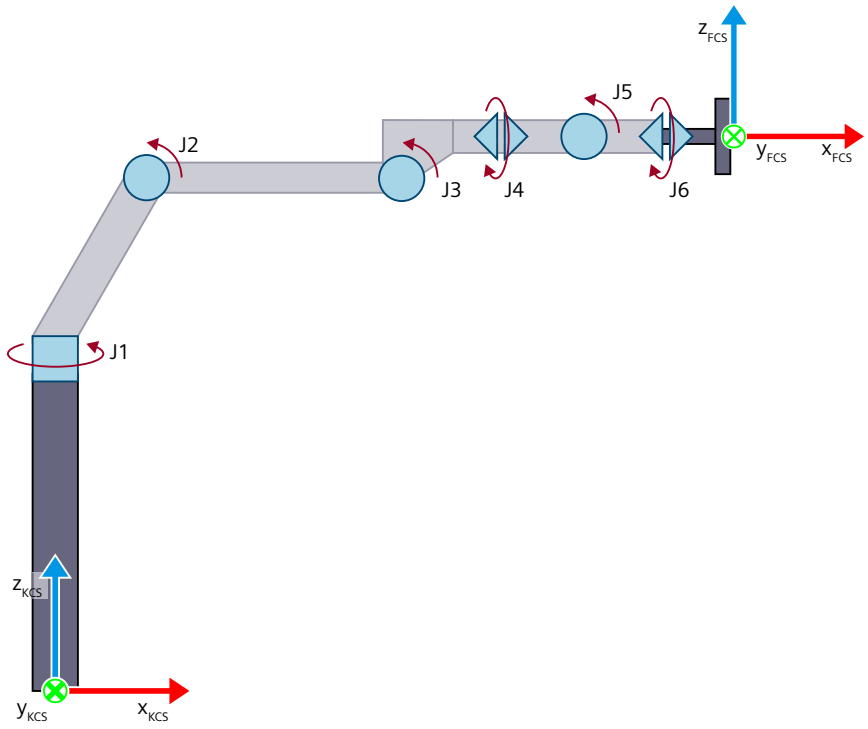

Positive direction of rotation of the joints

If the direction of travel of a joint of the real kinematics is inverse to the direction of travel of the joint defined in the kinematics type from Siemens, you must invert the joint direction (Page 55) in the configuration.

Transformation area

The kinematics transformation covers the following traversing range (Page 178) of the axes:

- Axis A[1..6]: -180.0° ≤ α[1..6] < 180.0°

To traverse outside these traversing range definitions, you can use, for example, the Motion Control instructions "MC_MoveLinearAbsolute (Page 392)" or "MC_MoveDirectAbsolute (Page 414)" and "MC_MoveDirectRelative (Page 422)" with "TurnJoint[1..6]" ≠ 1.

NOTE

Modulo functionality

Do not use the setting "Modulo" for the axes A1 to A6.

If Length L6 ≠ 0.0 is configured, an area with the wrist point is not reachable because of the horizontal offset of the central wrist.

The not reachable area corresponds to a cylinder with the radius of Length L6 and a center axis which is collinear with the z axis of the KCS.

The flange or tool can be moved within the area but not with all possible orientations.

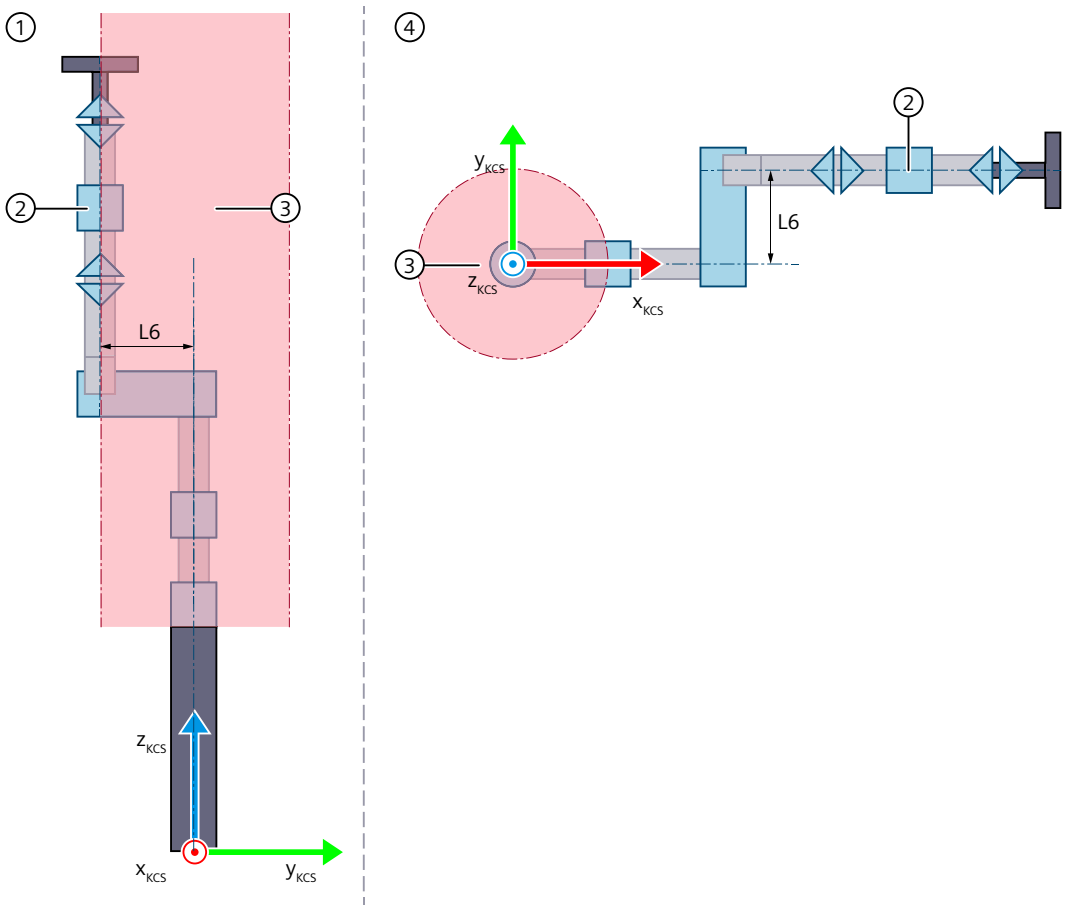

① Front view
② Wrist point
③ Not reachable area
④ Top view

The behavior is as follows for a motion job in which the wrist point moves to the non reachable area:

- **Dynamic adaptation is not activated.**

  If it is detected that the wrist point would move to the non reachable area during the kinematics motion, the job is canceled with the technology alarm 803 ("Error in the calculation of the transformation").

- **Dynamic adaptation is activated (with or without segmentation of the path)**

  If an invalid configuration is detected during motion preparation, the job is rejected with the technology alarm 802 ("Cannot calculate the geometry element").
  If no invalid configuration is detected during motion preparation, the behavior is like the behavior when traversing with deactivated dynamic adaptation.

If the kinematics travel with an sPTP motion job in WCS or OCS such that the target position results in the wrist point moving within the non reachable area, the job is rejected with the technology alarm 802 ("Cannot calculate the geometry element").

With the technology alarms 802 and 803, the corresponding function block also issues the error message with the "ErrorID" = 16#8001 ("A technology alarm (technology object error) occurred while processing the Motion Control instruction").

The behavior and effect of the wrist point moving close to the limited area is comparable to the behavior close to an outer singularity.
Avoid motions with the wrist point close to the limited area and implement suitable preventative measures. See section Singularities (Page 183).

NOTE

Singularity

The kinematics has singularities (Page 183).

Singularity is present in the following cases:

- Length L6 = 0.0
  - Axes of rotation A1 and A4 are collinear

    The axis A4 is located on the z axis of the KCS and rotates around the z axis of the KCS.
  - Axes of rotation A1 and A4 are collinear

    The axis A5 is located on the z axis of the KCS and rotates around the z axis of the KCS.
  - Axes of rotation A1 and A6 are collinear

    The axis A6 is located on the z axis of the KCS and rotates around the z axis of the KCS or the x axis of the FCS is located on the z axis of the KCS.
  - Axes of rotation A4 and A6 are collinear

    The axes A4 and A6 rotate in opposite directions around the same axis when α5 = 0.0°.
- Length L6 ≠ 0.0
  - Axes of rotation A4 and A6 are collinear

    The axes A4 and A6 rotate in opposite directions around the same axis when α5 = 0.0°.

Inverse transformation is not possible in these cases.

The graphic below shows examples of singularities and permissible joint positions:

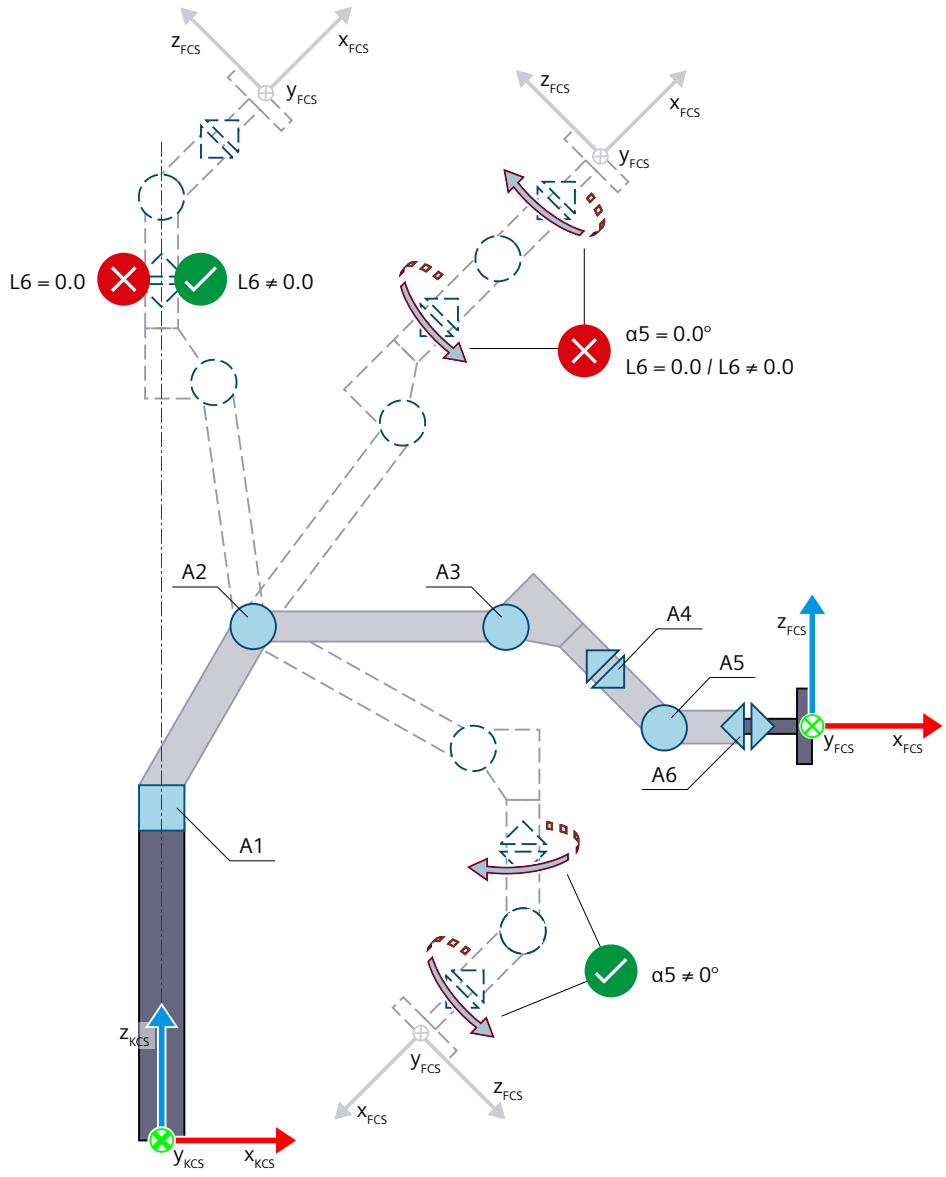

Permissible joint position

Inner singularity

Joint position space

The joint position space of the kinematics "6-axis articulated arm with central wrist" is defined by the joint positions from the kinematics transformation. The joint position space thus describes the geometric joint positions of the kinematics.

When using mechanical axis couplings, inverted joint directions or joint offsets, the joint position space is not defined by the absolute joint positions "<TO>.JointData.J[1..6].Position" or the axis positions "<TO>.AxesData.A[1..6].Position".

The following example shows the geometric joint position on joint 5:

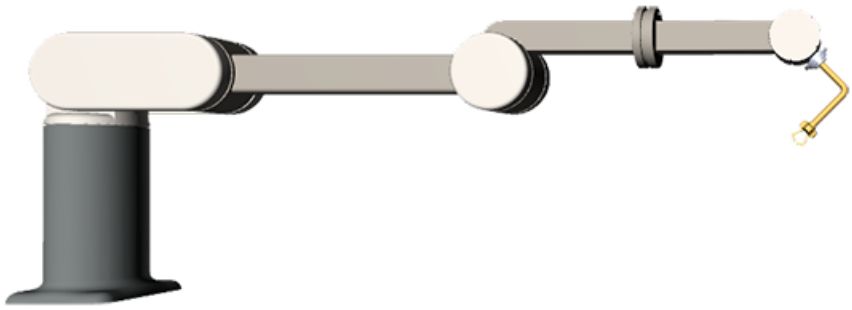

Case 1: No joint inversion and no joint offset is defined. The joint position corresponds to the geometric joint position (from the transformation), thus -45°. Bit 4 in the "<TO>StatusKinematics.LinkConstellation" tag is TRUE, because the geometric joint position is -45°.

Case 2: The inverted traversing direction is configured for joint 5. The kinematics has exactly the same geometric joint position as in Case 1. However, due to the inverted traversing direction, the joint position is +45°. Bit 4 in the "<TO>StatusKinematics.LinkConstellation" tag is thus also TRUE in this case, because the geometric joint position (from the transformation) is -45°.

Working areas

The following graphics show the overhead area ① and the standard area ②:

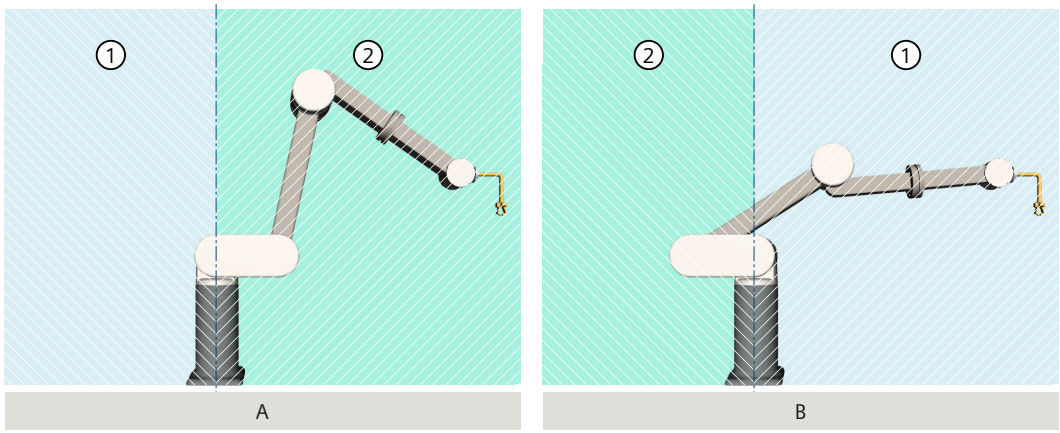

Example "A" shows the kinematics with joint J1 in the zero position. The wrist point is located in the standard area. In example "B", joint J1 is rotated by -180.0°. With the rotated joint J1, the standard area and the overhead area are also rotated.

The following table shows the possible joint position spaces of the kinematics:

Tag		Data type	Values	W	Description	
StatusKinematics.		TO_Struct_Kinematics_StatusKinematics				
	Valid	BOOL	-	RON	Validity of the transformation values	
					FALSE	Invalid

Tag	Data type	Values	W	Description	
Valid	BOOL	-	RON	TRUE	Valid
LinkConstellation	DWORD	0 ... n	RON	Joint position space	
Bit 0	-	-	-	Geometric joint position joint J1	
				0	The wrist point is located in the front area (standard area) or on the joint position lines for joint J1.
				1	The wrist point is located in the rear area (overhead area) of the joint position lines for joint J1.
Bit 1	-	-	-	Geometric joint position joint J2	
				0	Not relevant
				1	Not relevant
Bit 2	-	-	-	Geometric joint position joint J3	
				0	The wrist point is in one of the following positions: • On the joint position line for joint J3 • In the standard area (bit 0 = 0), above the joint position line for joint J3 • In the overhead area (bit 0 = 1), below the joint position line for joint J3
				1	The wrist point is in one of the following positions: • In the standard area (bit 0 = 0), below the joint position line for joint J3 • In the overhead area (bit 0 = 1), above the joint position line for joint J3
Bit 3	-	-	-	Geometric joint position joint J4	
				0	Not relevant
				1	Not relevant
Bit 4	-	-	-	Geometric joint position joint J5	
				0	α5 positive
				1	α5 negative or α5 = 0°
Bit 5	-	-	-	Geometric joint position joint J6	
				0	Not relevant
				1	Not relevant
Bit 6 ... 31	-	-	-	Not relevant	

Bits 1, 3, 5 and 6 ... 31 in the "<TO>StatusKinematics.LinkConstellation" tag are not programmable on the Motion Control instructions "MC_MoveDirectAbsolute" or "MC_MoveDirectRelative". A setting is reported as an impermissible value for the target joint position space ("ErrorID" = 16#80D2).

Examples

The following examples show various joint position spaces for the same Cartesian position of the kinematics "6-axis articulated arm with central wrist". There are no configured offsets or inversions in the example. The tool center point in the FCS is configured as follows:
x = 60 mm, y = 0 mm, z = -100 mm, A = 0°, B = 90°, C = 0°.

LinkConstellation = 16#0000_0000:

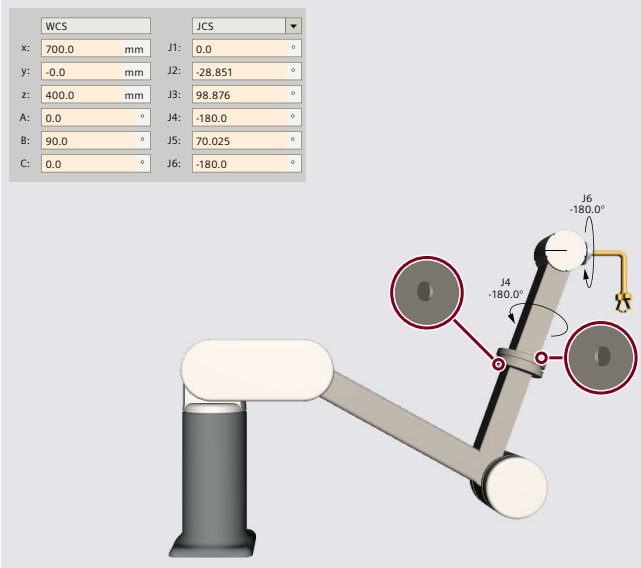

LinkConstellation = 16#0000_0001:

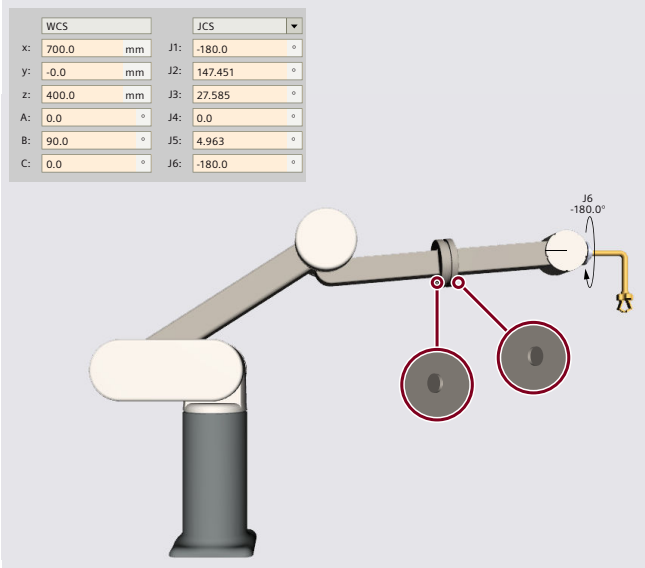

LinkConstellation = 16#0000_0004:

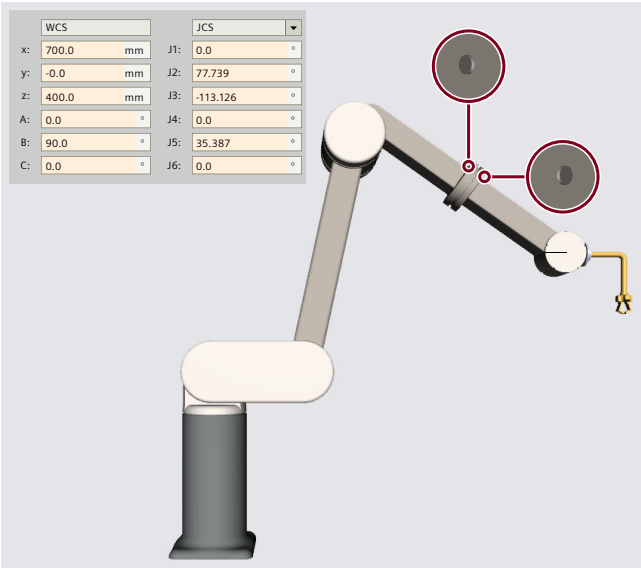

LinkConstellation = 16#0000_0005:

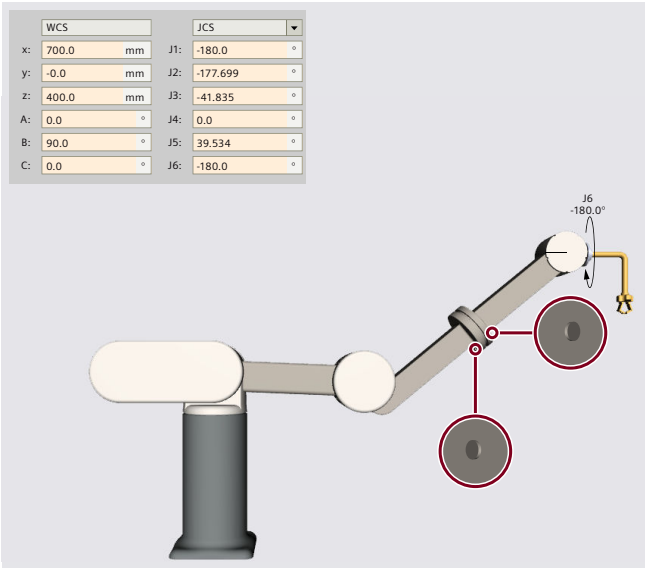

LinkConstellation = 16#0000_0010:

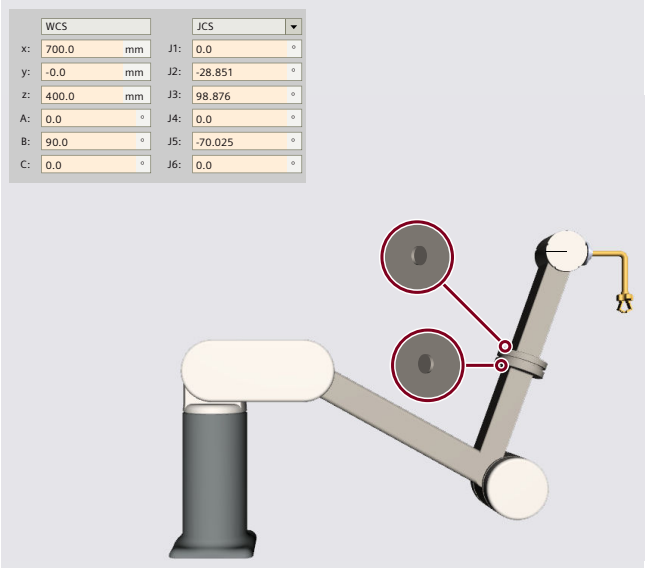

LinkConstellation = 16#0000_0011:

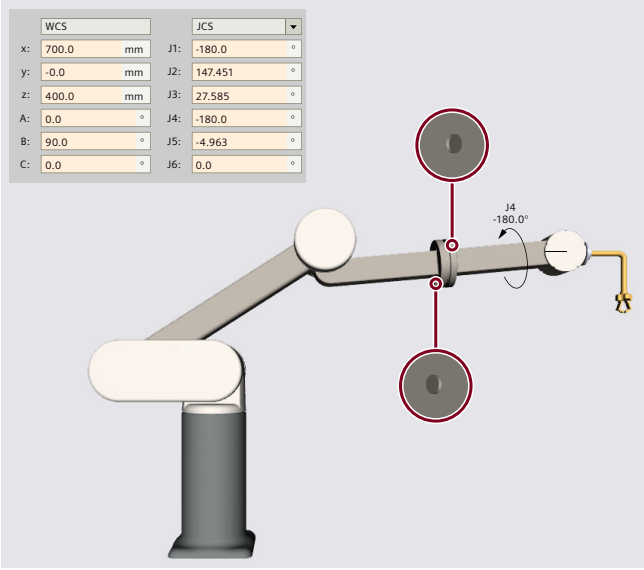

LinkConstellation = 16#0000_0014:

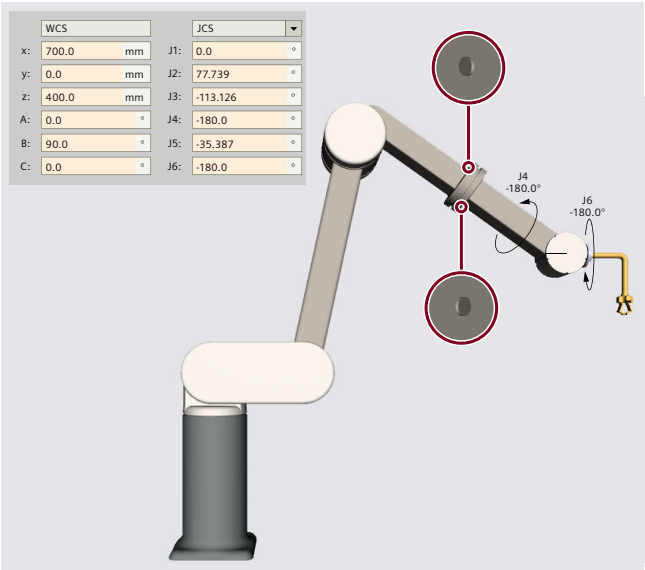

LinkConstellation = 16#0000_0015:

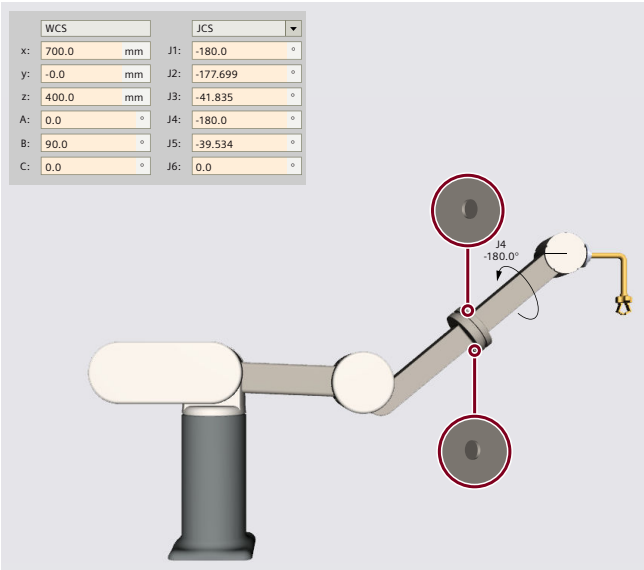

7.9.4.6 6-axis articulated arm with offset wrist

The kinematics "6-axis articulated arm with offset wrist" supports 6 axes and 6 degrees of freedom. The axes are configured as serial kinematics. For this kinematics type you need the Motion Control package "S7-1500T Motion Control KinPlus (Page 27)".

The following graphic shows the principal configuration and the typical working area of the kinematics:

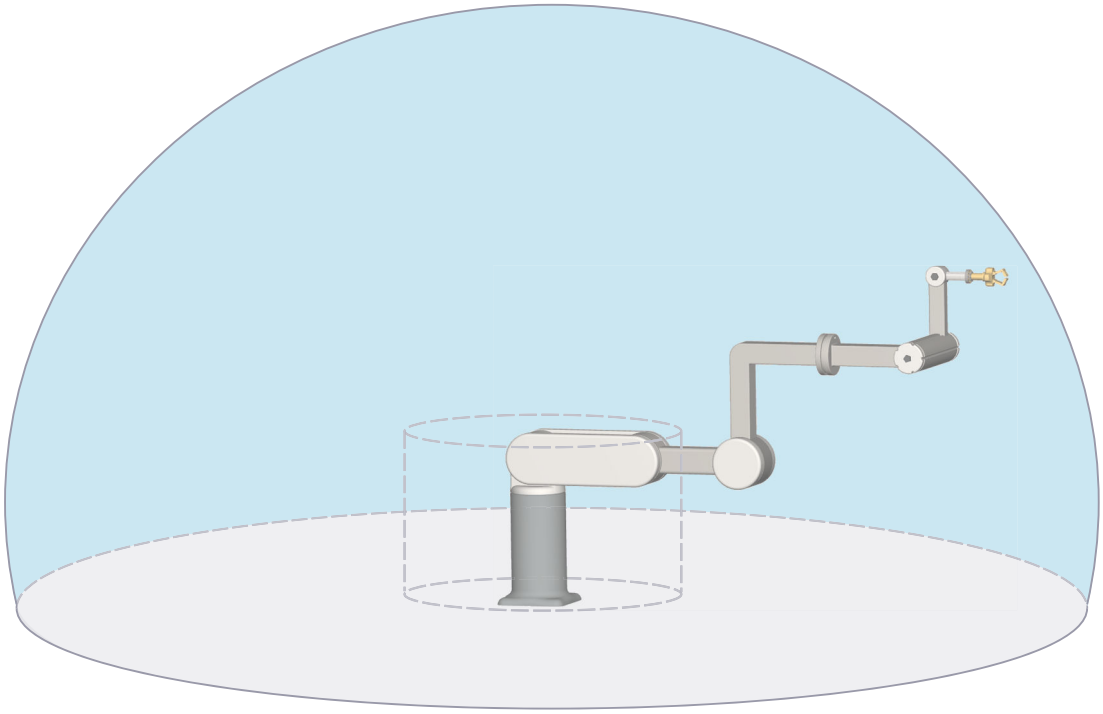

The kinematics consists of the following axes (output state):

- 1 rotary axis A1 with rotation around the z axis of the kinematics coordinate system (KCS)
- 1 rotary axis A2 with the distances L1 in z direction of the KCS and L2 in x direction of the KCS to the kinematics zero point with rotation around y
- 1 rotary axis A3 at a distance L3 to axis A2 with rotation around y
- 1 rotary axis A4 at a distance L5 in z direction of the KCS to the axis A3 with rotation around x
- 1 rotary axis A5 with the distances L4 in x direction of the KCS and L5 in z direction of the KCS to the axis A3 with rotation around y
- 1 rotary axis A6 with the distances L7 in y direction of the KCS and L8 in z direction of the KCS to the axis A5 with rotation around x

The distances L1 to L5, L7 to L8 and LF are shown in the following figures with the side view and the top view of the kinematics.

The kinematics consists of a base and articulated arms, which are connected by revolute joints (axes A1, A2 and A3). Axis A1 rotates the kinematics horizontally around the base. The axes A2, A3, A4 and A5 move the articulated arms. The kinematics enables an approximately spherical working area. The wrist point is the pivot point of axis A5.

Coordinate systems and zero position

The graphic below shows the following in the side view (xz plane):

- The position of the axes
- The position of coordinate systems KCS and FCS
- The zero position of the kinematics

NOTE
Singularity
Note that the zero position represents a singularity.

- The positive/negative deflection of the kinematics is indicated (dashed)

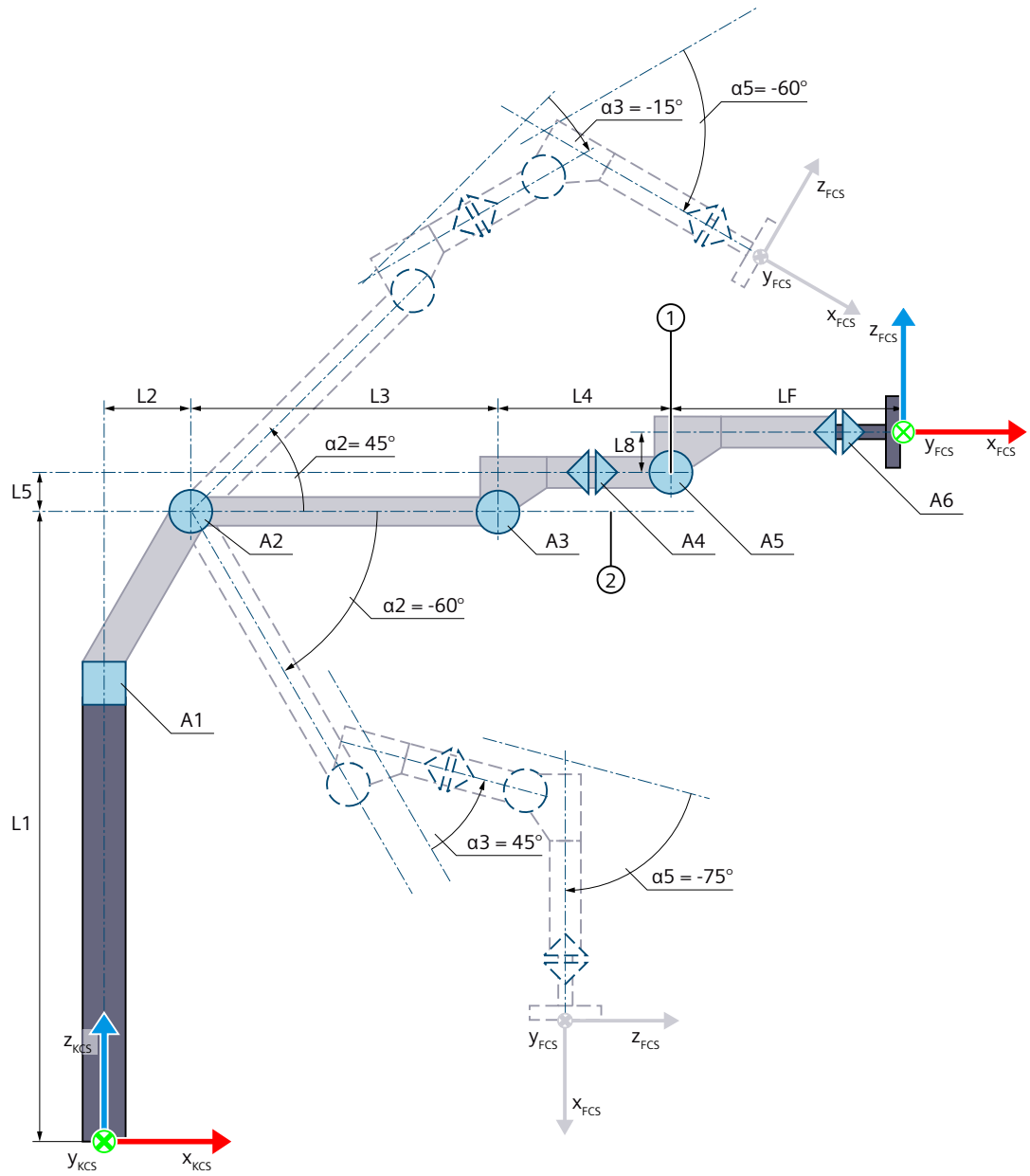

① Wrist point

② Joint position line for the joint

Zero position of the kinematics

- L1 Distance of the axis A2 to the kinematics zero point (KZP) in z direction of the KCS
- L2 Distance of the axis A2 to the KZP in x direction of the KCS
- L3 Distance of the axis A3 to the axis A2 in x direction of the KCS
- L4 Distance of the wrist point to the axis A3 in x direction of the KCS
- L5 Distance of the wrist point to the axis A3 in z direction of the KCS
- LF Distance of the FCS to the wrist point in x direction of the KCS
- L8 Distance of the axis A6 to the wrist point in z direction of the KCS

Deflection of the kinematics

α2 Positive deflection of the axis A2 when α2 = 45.0°
Negative deflection of the axis A2 when α2 = -60.0°

α3 The deflection of the axis A3 in positive direction when α3 = 45.0° produces a positive joint position.
The deflection of the axis A3 in negative direction when α3 = -15.0° produces a negative joint position.

α5 The deflection of the axis A5 in negative direction when α5 = -60.0° or α5 = -75.0°produces a negative joint position.

The graphic below shows the following in the top view (xy plane):

- The position of the axes
- The position of coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the kinematics is indicated (dashed)

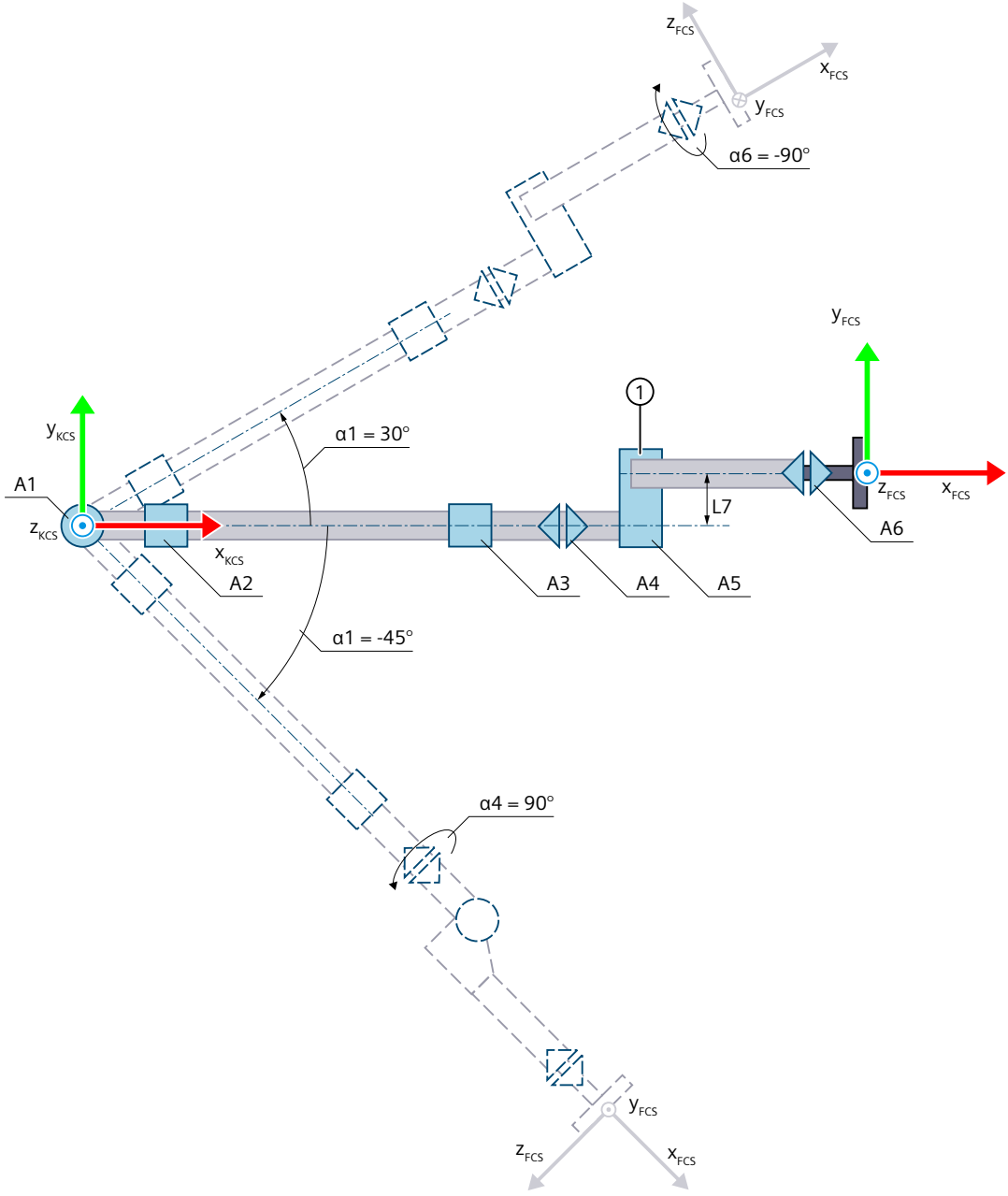

① Wrist point

Zero position of the kinematics

L7 Distance of the axis A6 to the wrist point in y direction of the KCS

Deflection of the kinematics

α1 Positive deflection of the axis A1 when α1 = 30.0°
Negative deflection of the axis A1 when α1 = -45.0°

α4 Positive deflection of the axis A4 when α4 = 90.0°

α6 Negative deflection of the axis A4 when α6 = -90.0°

The KCS with the kinematics zero point (KZP) is located at the base of the kinematics. With zero position of the axes A1, A2, A3 and A5, the kinematics is extended in x direction of the KCS.

You can use the lengths L1 to L8 and the flange length LF to define the zero position of the flange coordinate system (FCS) at zero position of the kinematics. Since there is no forced coupling between the kinematics axes and the flange system, the coordinate axes of the FCS at the zero position of the kinematics point in the same direction as the coordinate axes of the KCS.

The configuration of both lengths L7 and L8 with the value "= 0.0" is not permitted and is rejected with a technology alarm 101 on the kinematics technology object.

The following table shows the zero position of the axes:

Axis	Zero position
A1	The articulated arms of the kinematics point in the x direction of the KCS.
A2	At zero position of the axis A1, the length L3 points in x direction of the KCS.
A3	At zero position of the axes A1 and A2, the length L4 points in the x direction of the KCS and length L5 points in the z direction of the KCS.
A5	At zero position of the axes A1, A2 and A3, the length LF points in the x direction of KCS.
A4, A6	At zero position of the axes A1, A2, A3 and A5, the x, y and z axes of FCS point in the direction of the x, y and z axes of KCS.

Direction of travel of the joints

The following figure shows the direction of travel of the joints defined in the kinematics type:

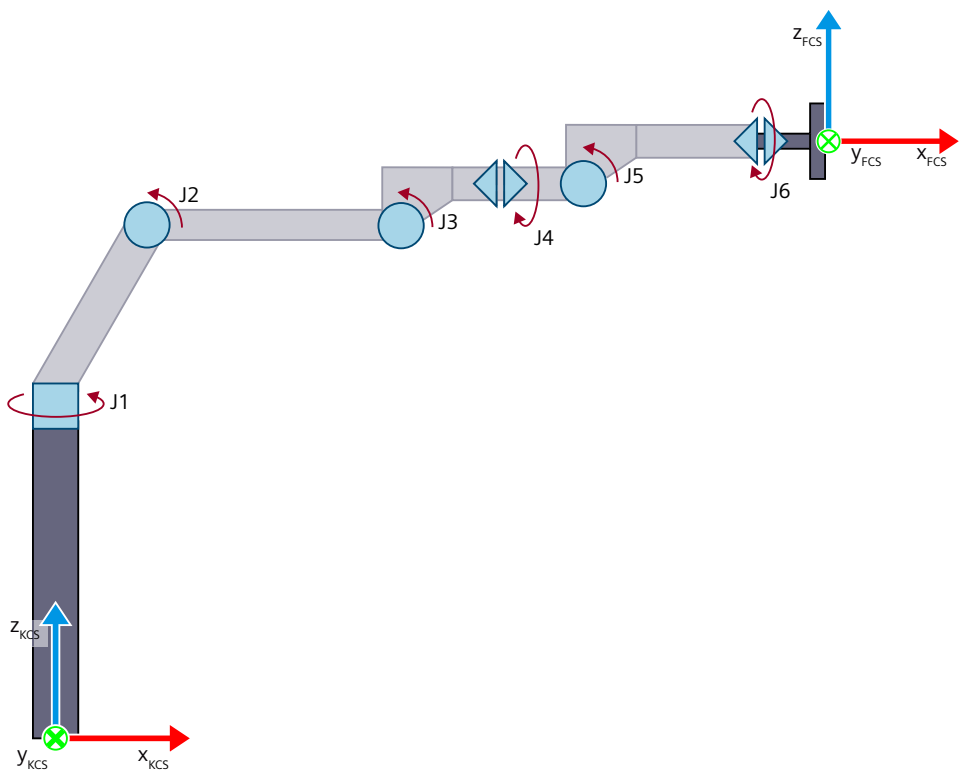

Positive direction of rotation of the joints

If the direction of travel of a joint of the real kinematics is inverse to the direction of travel of the joint defined in the kinematics type from Siemens, you must invert the joint direction (Page 55) in the configuration.

Transformation area

The kinematics transformation covers the following traversing range (Page 178) of the axes:

- Axis A[1..6]: -180.0° ≤ α[1..6] < 180.0°

To traverse outside these traversing range definitions, you can use, for example, the Motion Control instructions "MC_MoveLinearAbsolute (Page 392)" or "MC_MoveDirectAbsolute (Page 414)" and "MC_MoveDirectRelative (Page 422)" with "TurnJoint[1..6]" ≠ 1.

NOTE

Modulo functionality

Do not use the setting "Modulo" for the axes A1 to A6.

NOTE

Singularity

The kinematics has singularities (Page 183).

Singularity is present in the following cases:

- Axes of rotation A1 and A4 are collinear

  The axis A4 is located on the z axis of the KCS and rotates around the z axis of the KCS.
- Axes of rotation A1 and A5 are collinear

  The axis A5 is located on the z axis of the KCS and rotates around the z axis of the KCS.
- Axes of rotation A1 and A6 are collinear

  The axis A6 is located on the z axis of the KCS and rotates around the z axis of the KCS or the x axis of the FCS is located on the z axis of the KCS.
- Axes of rotation A4 and A6 are collinear

  The axes A4 and A6 rotate in opposite directions around the same axis when α5 = 0.0°.

Inverse transformation is not possible in these cases.

The graphic below shows examples of singularities and permissible joint positions:

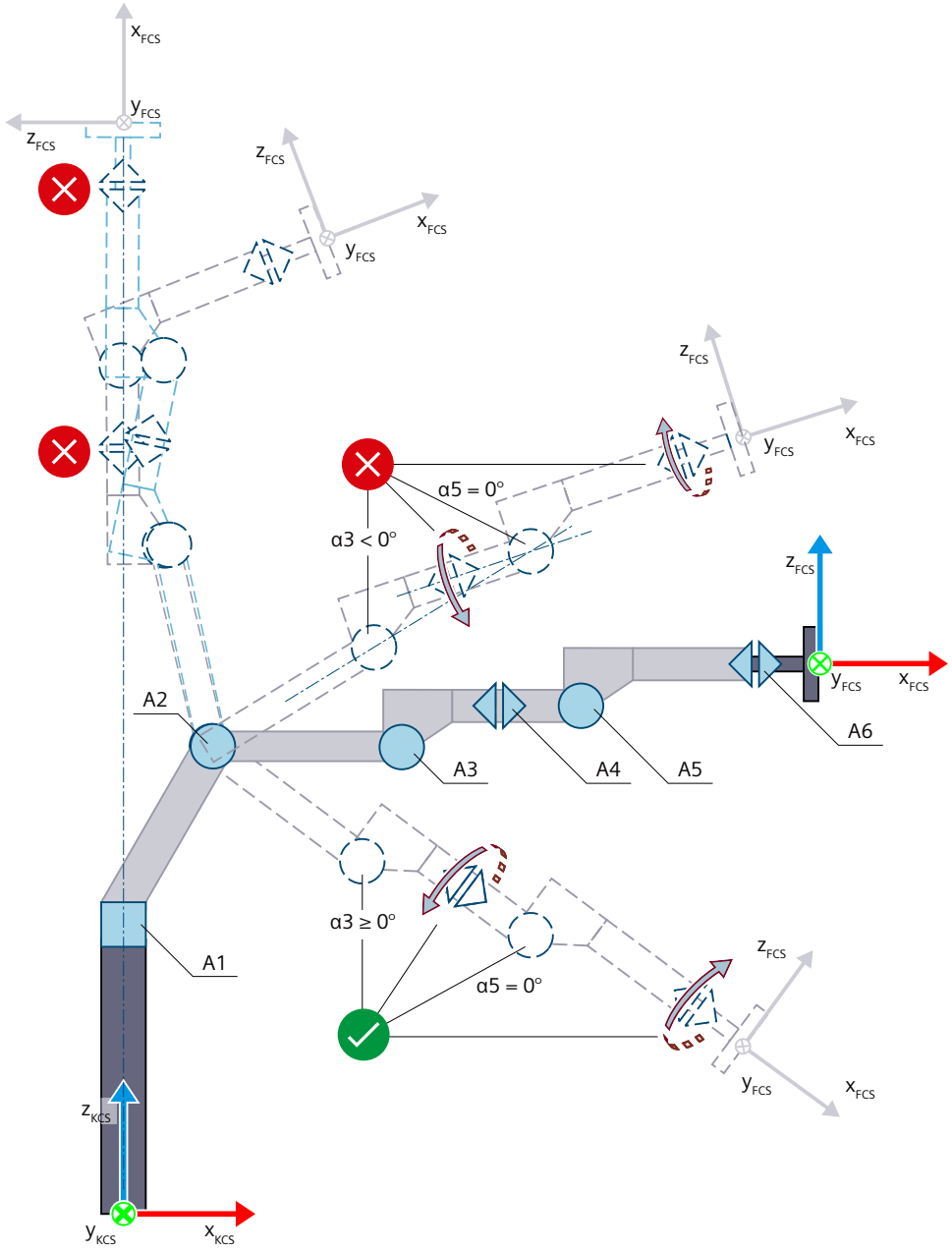

Permissible joint position

Inner singularity

Joint position space

The joint position space of the kinematics "6-axis articulated arm with offset wrist" is defined by the joint positions from the kinematics transformation. The joint position space thus describes the geometric joint positions of the kinematics.

The joint position space is not defined by the absolute joint positions "<TO>.JointData.J[1..6].Position" or the axis positions "<TO>.AxesData.A[1..6].Position" when mechanical axis couplings, inverted joint directions or joint offsets are used.

The following example shows the geometric joint position on joint 5:

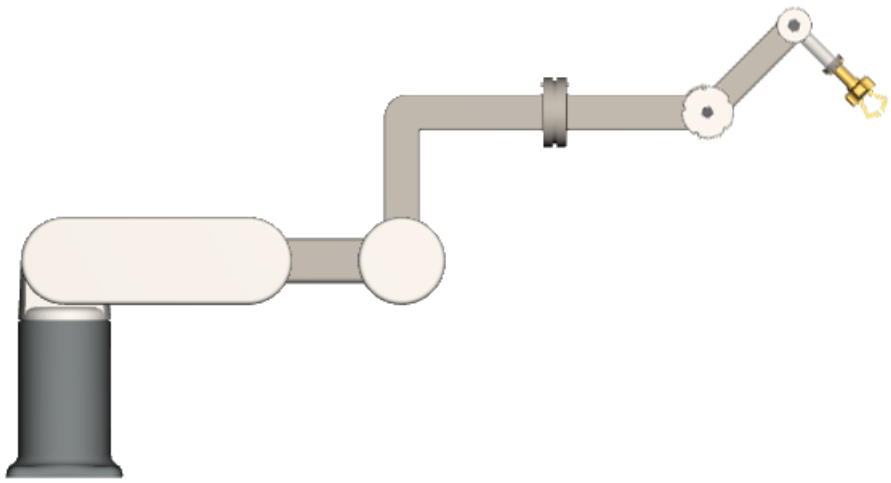

Case 1: No joint inversion and no joint offset is defined. The joint position corresponds to the geometric joint position (from the transformation), thus -45°. Bit 4 in the "<TO>StatusKinematics.LinkConstellation" tag is TRUE, because the geometric joint position is -45°.

Case 2: The inverted traversing direction is configured for joint 5. The kinematics has exactly the same geometric joint position as in Case 1. However, due to the inverted traversing direction, the joint position is +45°. Bit 4 in the "<TO>StatusKinematics.LinkConstellation" tag is thus also TRUE in this case, because the geometric joint position (from the transformation) is -45°.

Working areas

The following graphics show the overhead area and the standard area:

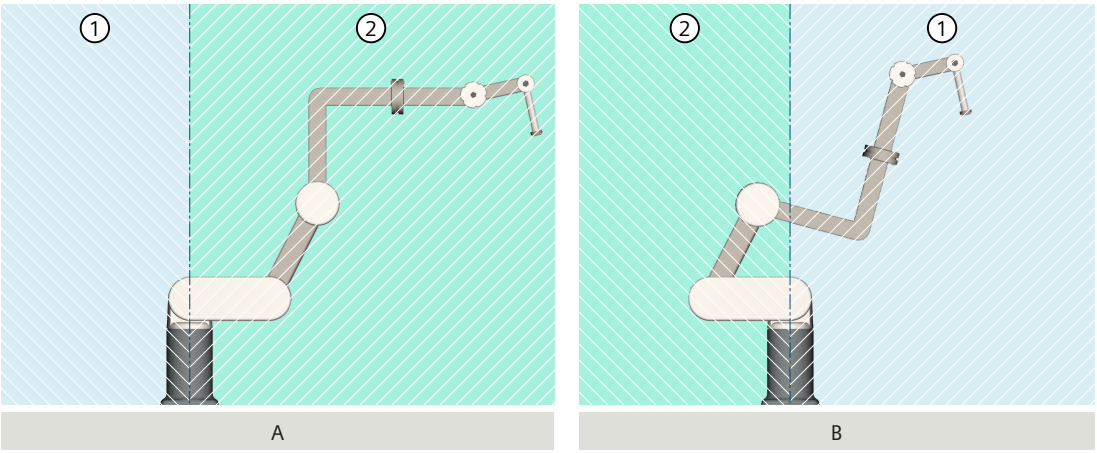

① Overhead area

② Standard area

A The kinematics with joint J1 is in the zero position. The wrist point is located in the standard area.

B Joint J1 is rotated by -180.0°. With the rotated joint J1, the standard area and the overhead area are also rotated.

The following table shows the possible joint position spaces of the kinematics:

Tag	Data type	Values	W	Description	
StatusKinematics.	TO_Struct_Kinematics_StatusKinematics				
Valid	BOOL	-	RON	Validity of the transformation values	
				FALSE	Invalid
				TRUE	Valid
LinkConstellation	DWORD	0 ... n	RON	Joint position space	
Bit 0	-	-	-	Geometric joint position joint J1	
				0	The wrist point is located in the front area (standard area) or on the joint position lines for joint J1.
				1	The wrist point is located in the rear area (overhead area) of the joint position lines for joint J1.
Bit 1	-	-	-	Geometric joint position joint J2	
				0	Not relevant
				1	Not relevant
Bit 2	-	-	-	Geometric joint position joint J3	
				0	The wrist point is in one of the following positions: • On the joint position line for joint J3 • In the standard area (bit 0 = 0), above the joint position line for joint J3 • In the overhead area (bit 0 = 1), below the joint position line for joint J3

Tag		Data type	Values	W	Description	
	Bit 2	-	-	-	1	The wrist point is in one of the following positions: • In the standard area (bit 0 = 0), below the joint position line for joint J3 • In the overhead area (bit 0 = 1), above the joint position line for joint J3
	Bit 3	-	-	-	Geometric joint position joint J4	
					0	Not relevant
					1	Not relevant
	Bit 4	-	-	-	Geometric joint position joint J5	
					0	α5 positive
					1	α5 negative or α5 = 0°
	Bit 5	-	-	-	Geometric joint position joint J6	
					0	Not relevant
					1	Not relevant
	Bit 6 ... 31	-	-	-	Not relevant	

Bits 1, 3, 5 and 6 ... 31 in the "<TO>StatusKinematics.LinkConstellation" tag are not programmable on the Motion Control instructions "MC_MoveDirectAbsolute" or "MC_MoveDirectRelative". A setting is reported as an impermissible value for the target joint position space ("ErrorID" = 16#80D2).

Examples

The following examples show various joint position spaces for the same Cartesian position of the kinematics "6-axis articulated arm with offset wrist". There are no configured offsets or inversions in the example. The tool center point in the FCS is configured as follows:
x = 50.0 mm, y = 0.0 mm, z = 0.0 mm, A = 0.0°, B = 90.0°, C = 0.0°.

LinkConstellation = 2#000000 = 0:

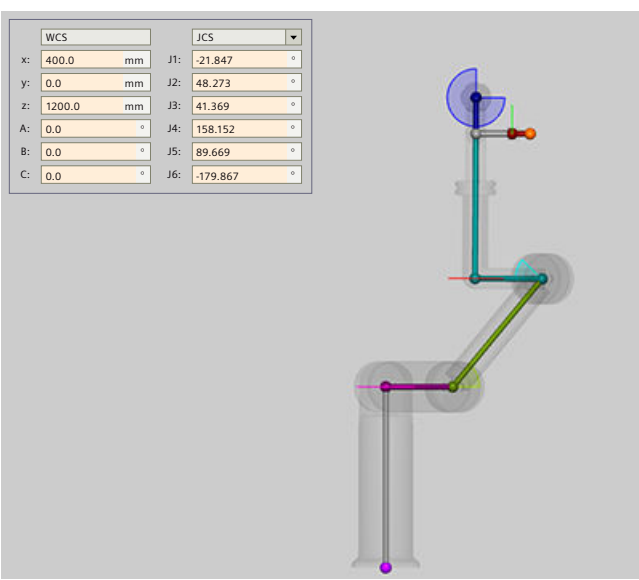

LinkConstellation = 2#000001 = 1:

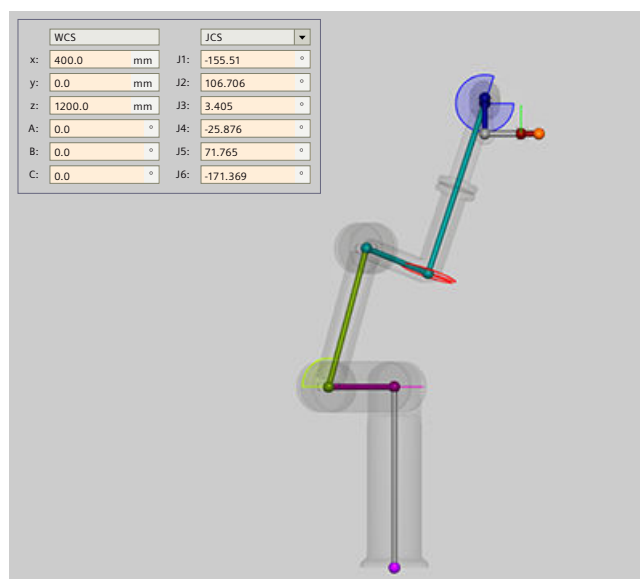

LinkConstellation = 2#000100 = 4:

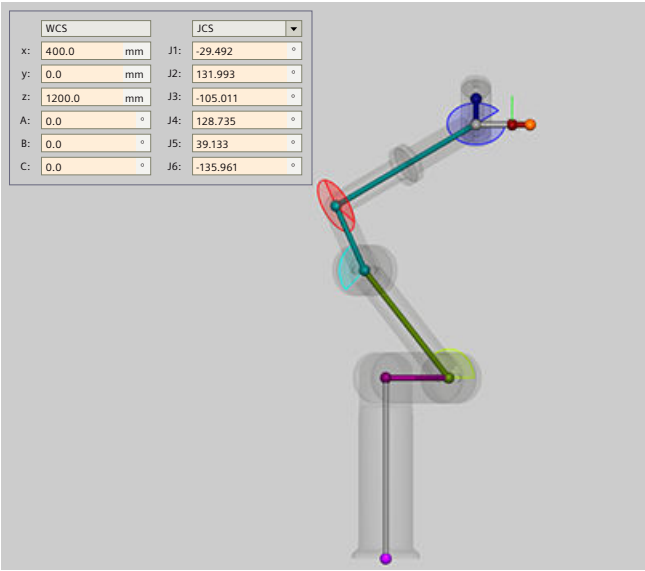

LinkConstellation = 2#000101 = 5:

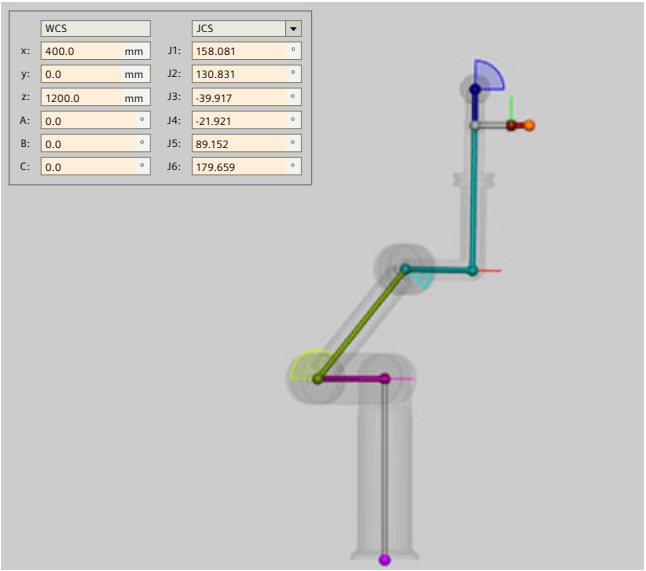

LinkConstellation = 2#010000 = 16:

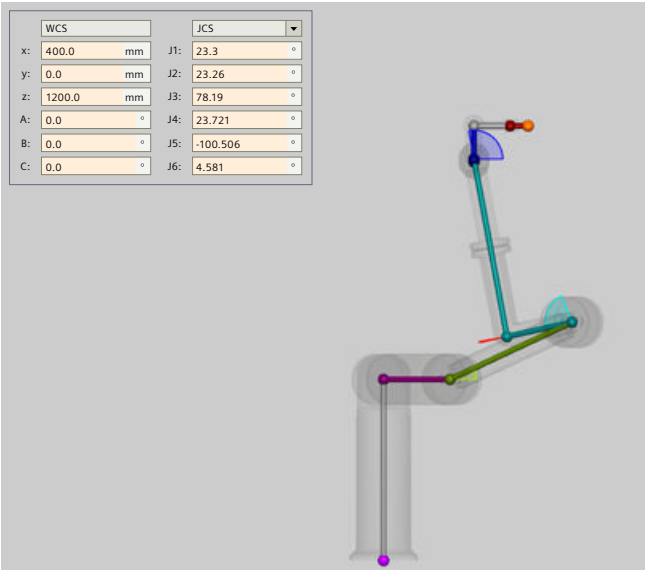

LinkConstellation = 2#010001 = 17:

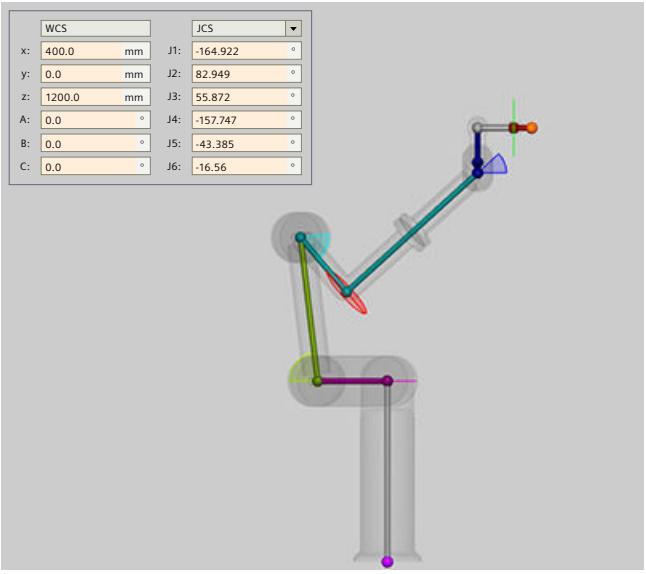

LinkConstellation = 2#010100 = 20:

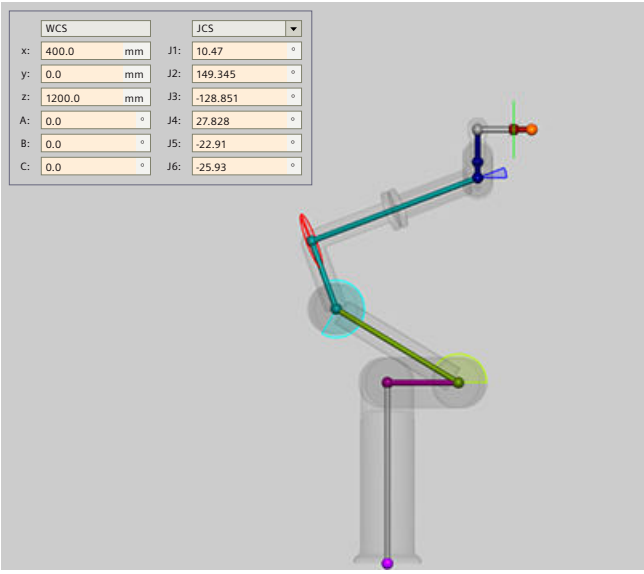

LinkConstellation = 2#010101 = 21:

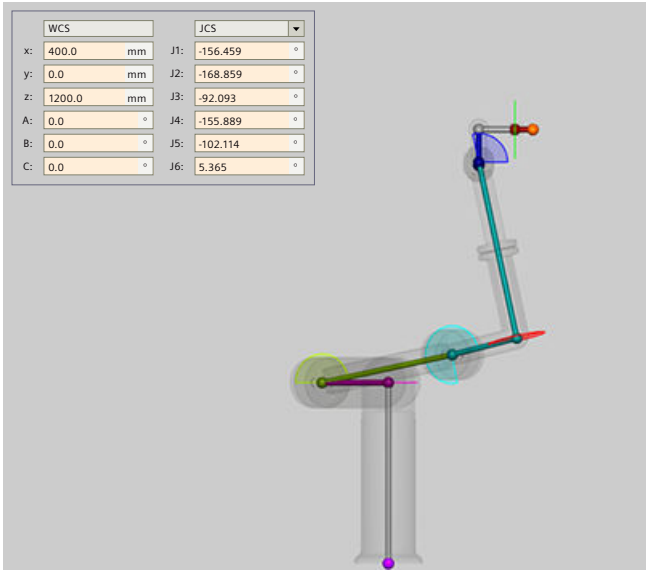

See also

6-axis articulated arm with central wrist (Page 115)

7.9.4.7 Tags: Articulated arm

Articulated arm 2D

You define the 2D articulated arm kinematics systems using the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	11	Articulated arm 2D
	12	Articulated arm 2D with orientation
<TO>.Kinematics.Parameter[1]	-1.0E12 to 1.0E12	Distance L1 of the axis A1 to the kinematics zero point in z direction of the kinematics coordinate system (KCS)
<TO>.Kinematics.Parameter[2]	-1.0E12 to 1.0E12	Distance L2 of the axis A1 to the kinematics zero point in x direction of the KCS
<TO>.Kinematics.Parameter[3]	0.001 to 1.0E12	Arm length L3 between the axes A1 and A2
<TO>.Kinematics.Parameter[4]	-	Mechanical axis coupling of axis A1 to axis A2 present/not present
	0	Not present
	1	Present
<TO>.Kinematics.Parameter[5]	-1.0E12 to 1.0E12	Compensation factor of axis A1 to axis A2
<TO>.Kinematics.Parameter[6]	0.001 to 1.0E12	Side length L4 between A2 and positive coupling point
<TO>.Kinematics.Parameter[7]	-1.0E12 to 1.0E12	Distance LF of the flange coordinate system (FCS) from the forced coupler point in the negative z direction of the KCS

Articulated arm 3D

You define the 3D articulated arm kinematics systems using the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	13	Articulated arm 3D
	14	Articulated arm 3D with orientation
<TO>.Kinematics.Parameter[1]	-1.0E12 to 1.0E12	Distance L1 of the axis A2 to the kinematics zero point in z direction of the KCS
<TO>.Kinematics.Parameter[2]	0.0 to 1.0E12	Distance L2 of the axis A2 to the kinematics zero point in x direction of the KCS
<TO>.Kinematics.Parameter[3]	0.001 to 1.0E12	Arm length L3 between the axes A2 and A3
<TO>.Kinematics.Parameter[4]	-	Mechanical axis coupling of axis A2 to A3 present/not present
	0	Not present
	1	Present
<TO>.Kinematics.Parameter[5]	-1.0E12 to 1.0E12	Compensation factor of axis A2 to axis A3
<TO>.Kinematics.Parameter[6]	0.001 to 1.0E12	Arm length L4 between the axis A3 and positive coupler point
<TO>.Kinematics.Parameter[7]	-1.0E12 to 1.0E12	Distance LF of the FCS from the forced coupler point in the negative z direction of the KCS

6-axis articulated arm with central wrist

You define the kinematics "6-axis articulated arm with central wrist" via the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	25	6-axis articulated arm with central wrist
<TO>.Kinematics.Parameter[1]	-1.0E12 to 1.0E12	Distance L1 of the axis A2 to the kinematics zero point in z direction of the KCS
<TO>.Kinematics.Parameter[2]	0.0 to 1.0E12	Distance L2 of the axis A2 to the kinematics zero point in x direction of the KCS
<TO>.Kinematics.Parameter[3]	0.001 to 1.0E12	Distance L3 of the axis A3 to the axis A2 in x direction of the KCS
<TO>.Kinematics.Parameter[4]	0.001 to 1.0E12	Distance L4 of the wrist point to the axis A3 in x direction of the KCS
<TO>.Kinematics.Parameter[5]	-1.0E12 to 1.0E12	Distance LF of the FCS to the wrist point in x direction of the KCS
<TO>.Kinematics.Parameter[6]	-1.0E12 to 1.0E12	Distance L5 of the wrist point to the axis A3 in z direction of the KCS
<TO>.Kinematics.Parameter[7]	-1.0E12 to 1.0E12	Distance L6 of the wrist point to the KZP in y direction of the KCS

6-axis articulated arm with offset wrist

You define the kinematics "6-axis articulated arm with offset wrist" via the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	28	6-axis articulated arm with offset wrist
<TO>.Kinematics.Parameter[1]	-1.0E12 to 1.0E12	Distance L1 of the axis A2 to the kinematics zero point in z direction of the KCS
<TO>.Kinematics.Parameter[2]	0.0 to 1.0E12	Distance L2 of the axis A2 to the kinematics zero point in x direction of the KCS
<TO>.Kinematics.Parameter[3]	0.001 to 1.0E12	Distance L3 of the axis A3 to the axis A2 in x direction of the KCS
<TO>.Kinematics.Parameter[4]	0.001 to 1.0E12	Distance L4 of the wrist point to the axis A3 in x direction of the KCS
<TO>.Kinematics.Parameter[5]	-1.0E12 to 1.0E12	Distance LF of the FCS to the axis A5 in x direction of the FCS
<TO>.Kinematics.Parameter[6]	-1.0E12 to 1.0E12	Distance L5 of the wrist point to the axis A3 in z direction of the KCS
<TO>.Kinematics.Parameter[7]	-1.0E12 to 1.0E12	Distance L7 of the axis A6 to the wrist point in y direction of the KCS
<TO>.Kinematics.Parameter[8]	-1.0E12 to 1.0E12	Distance L8 of the axis A6 to the wrist point in z direction of the KCS

7.9.5 Delta picker

7.9.5.1 Delta picker 2D

The kinematics "Delta picker 2D" supports 2 axes and 2 degrees of freedom. The axes are configured as parallel kinematics.

The following graphic shows the principal configuration and the typical working area of the kinematics:

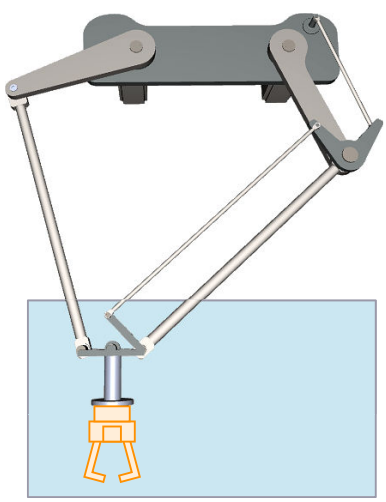

The kinematics consists of 2 rotary axes A1 and A2.

The kinematics is modeled suspended. The kinematics consists of an upper connecting plate, two upper arms, connecting rods and a lower connecting plate. The axes for moving the arms (axes A1, A2) are fastened to the upper connecting plate. The upper arms and the connecting rods connect the upper and lower connecting plates.

The tool is suspended from the lower connecting plate.

The parallelogram structures of the connecting rods keep the lower connecting plate parallel to the xy plane of the KCS.

Coordinate systems and zero position

The graphic below shows the following in the front view:

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The deflection of the kinematics is indicated (dashed)

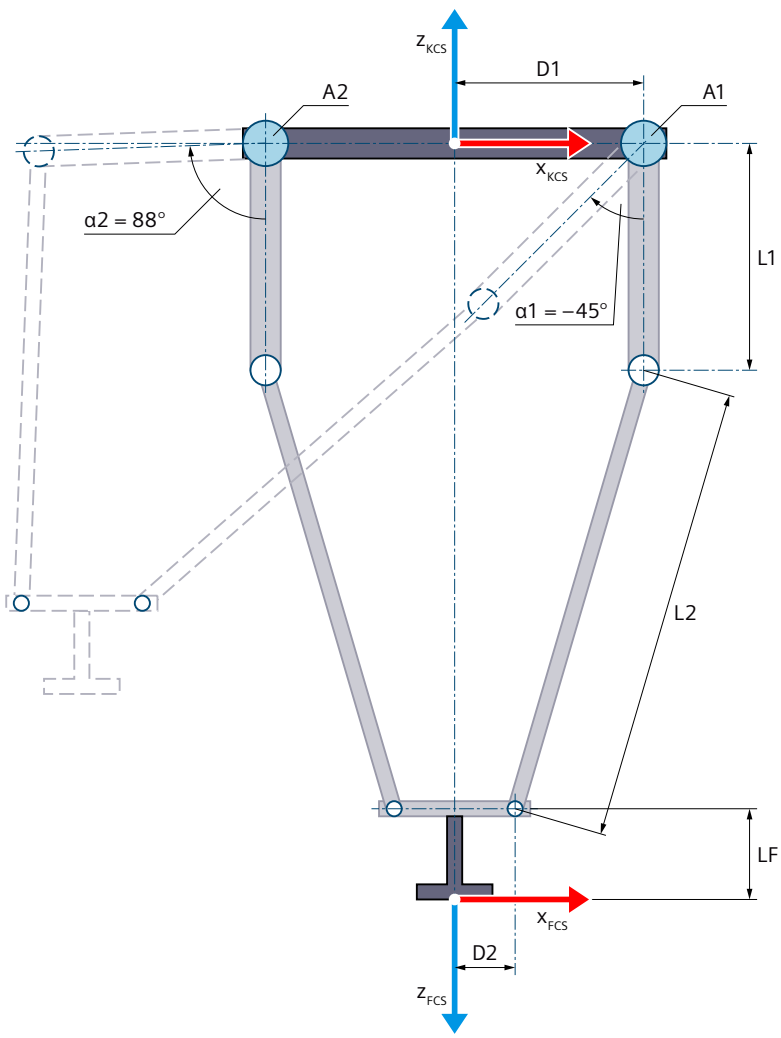

Zero position of the kinematics

D1 Distance of the axes from the center of the upper connecting plate (radius of the upper connecting plate)

D2 Distance of the hinge points of the connecting rods to the middle of the lower connecting plate (radius of the lower connecting plate)

L1 Length of the upper arms

L2 Length of the connecting rods

D1, D2, L1 and L2 are identical for the two arms of the kinematics.

LF Flange length before the FCS in the z direction of the KCS

Deflection of the kinematics
The motion of the axes in the positive direction is the outward rotation of the upper arms.

α1 Deflection of the axis A1 in the negative direction when α1 = -45.0°

α2 Deflection of the axis A2 in the positive direction when α2 = 88.0°

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the center point of the upper connecting plate. The axes A1 and A2 are at distance D1 from the common center point (kinematics zero point).

The flange coordinate system (FCS) is located on the bottom of the lower connecting plate with equal distance D2 to the hinge points of each arm. You shift the FCS in the negative z direction of the KCS using length LF.

In the zero position of the axes A1 and A2, the upper arms point in the negative z direction of the KCS.

Transformation area

Only the outwardly bent joint position (Page 157) is permitted for the arms of the kinematics. You cannot traverse the axes beyond the extended position of the arms.

NOTE
Singularity
The kinematics has outer singularities (Page 183).

7.9.5.2 Delta picker 2D with orientation

The kinematics "Delta picker 2D with orientation" supports 3 axes and 3 degrees of freedom. The axes are configured as parallel kinematics.

The following graphic shows the principal configuration and the typical working area of the kinematics:

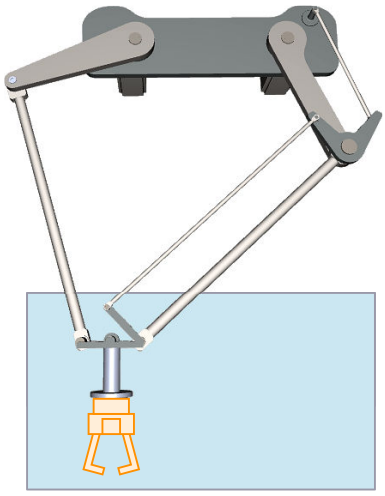

The kinematics consists of the following axes:

- 2 rotary axes A1, A2
- 1 rotary axis A4 with rotation around z in the KCS

The kinematics is modeled suspended. The kinematics consists of an upper connecting plate, two upper arms, connecting rods and a lower connecting plate. The axes for moving the arms (axes A1, A2) are fastened to the upper connecting plate. The upper arms and the connecting rods connect the upper and lower connecting plates.

The tool is suspended from the lower connecting plate.

The parallelogram structures of the connecting rods keep the lower connecting plate parallel to the xy plane of the KCS. The kinematics axis A4 enables rotation of the tool around z in the KCS.

Coordinate systems and zero position

The graphic below shows the following in the front view:

- The position of the axes and the coordinate systems KCS and FCS
- The zero positions of the axes A1 and A4
- The deflection of the kinematics is indicated (dashed)

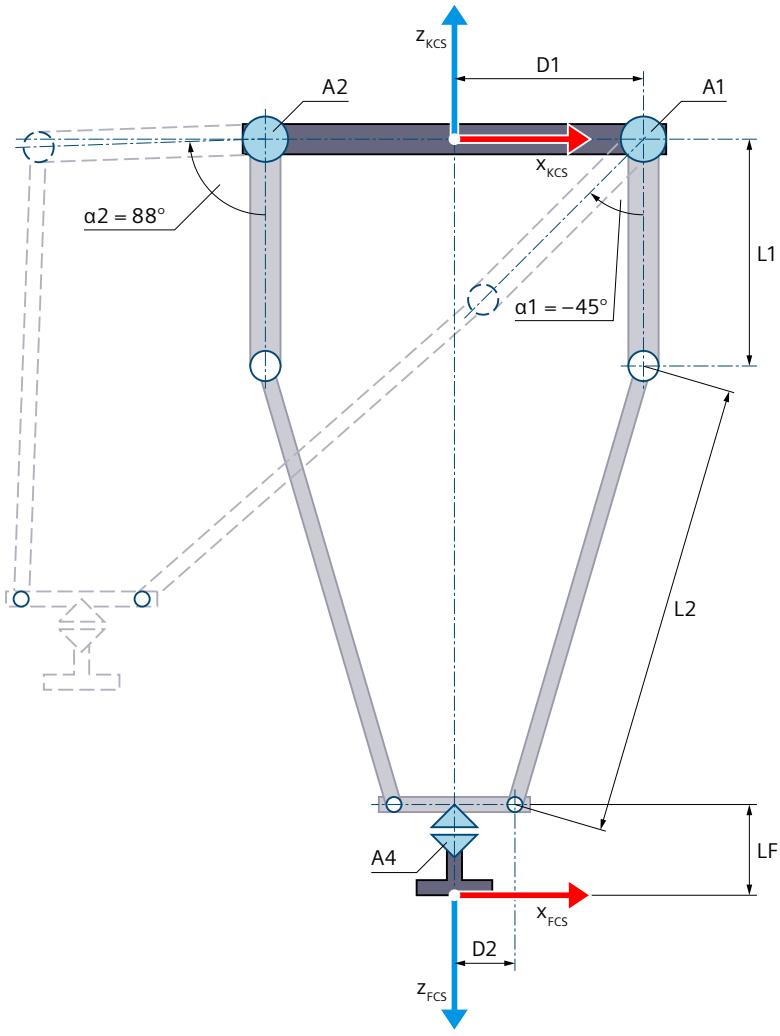

Zero position of the kinematics

D1 Distance of the axes from the center of the upper connecting plate (radius of the upper connecting plate)

D2 Distance of the joint points of the connecting rods to the middle of the lower connecting plate (radius of the lower connecting plate)

L1 Length of the upper arms

L2 Length of the connecting rods

D1, D2, L1 and L2 are identical for the two arms of the kinematics.

LF Flange length before the FCS in the z direction of the KCS

Deflection of the kinematics
The motion of the axes in the positive direction is the outward rotation of the upper arms.

α1 Deflection of the axis A1 in the negative direction when α1 = -45.0°

α2 Deflection of the axis A2 in the positive direction when α2 = 88.0°

Legend for representation of the kinematics (Page 38)

The kinematics coordinate system (KCS) with the kinematics zero point (KZP) is located at the center point of the upper connecting plate. The axes A1 and A2 are at distance D1 from the common center point (kinematics zero point).

The flange coordinate system (FCS) is located in the center point of the lower connecting plate with equal distance D2 to the joint points of each arm. You shift the FCS in the negative z direction of the KCS using length LF.

In the zero position of the axes A1 and A2, the upper arms point in the negative z direction of the KCS. At the zero position of axis A4, the x axis of the FCS points in the direction of the x axis of the KCS.

Transformation area

Only the outwardly bent joint position (Page 157) is permitted for the arms of the kinematics. You cannot traverse the axes beyond the extended position of the arms.

NOTE
Singularity
The kinematics has outer singularities (Page 183).

7.9.5.3 Delta picker 3D

The kinematics "Delta picker 3D" supports 3 axes and 3 degrees of freedom. The axes are configured as parallel kinematics.

The following graphic shows the principal configuration and the typical working area of the kinematics:

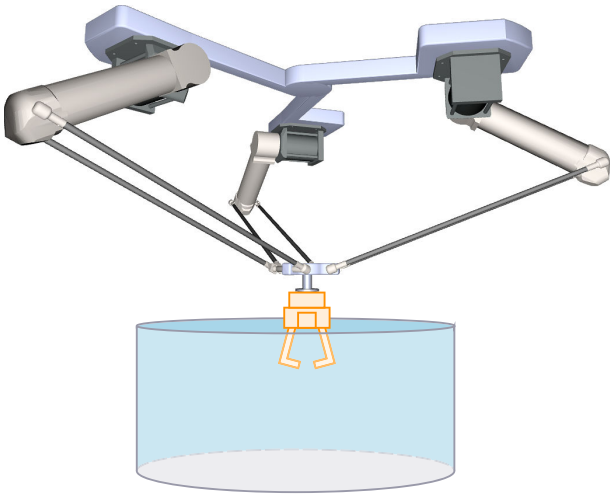

The kinematics consists of 3 rotary axes A1, A2 and A3.

The kinematics is modeled suspended. The kinematics consists of an upper connecting plate, three upper arms, connecting rods and a lower connecting plate. The axes for moving the arms (axes A1, A2 and A3) are fastened to the upper connecting plate. The upper arms and the connecting rods connect the upper and lower connecting plates.

The tool is suspended from the lower connecting plate.

The parallelogram structures of the connecting rods keep the lower connecting plate parallel to the xy plane of the KCS.

Coordinate systems and zero position

The graphic below shows the following in the top view (xy plane):

- The position of the kinematics coordinate system (KCS)
- The angles of the axes A1, A2 and A3 to one another

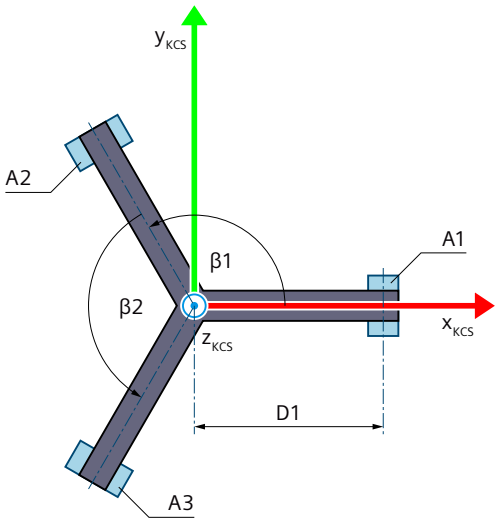

β1 Angle between the axes A1 and A2

β2 Angle between the axes A2 and A3

Legend for representation of the kinematics (Page 38)

The following graphic shows the top view of the position of the flange coordinate system (FCS) in the xy plane of the lower connecting plate:

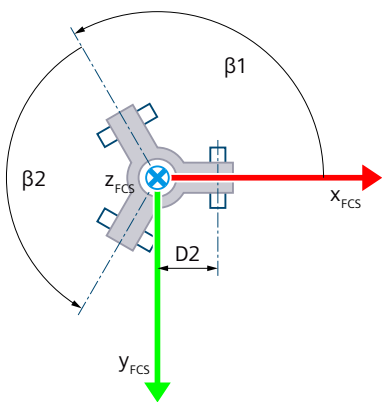

The graphic below shows the following in the front view (xz plane):

- The position of the axis A1 and the coordinate systems KCS and FCS
- The zero position of the axis A1
- The positive/negative deflection of the axis A1 is indicated (dashed)

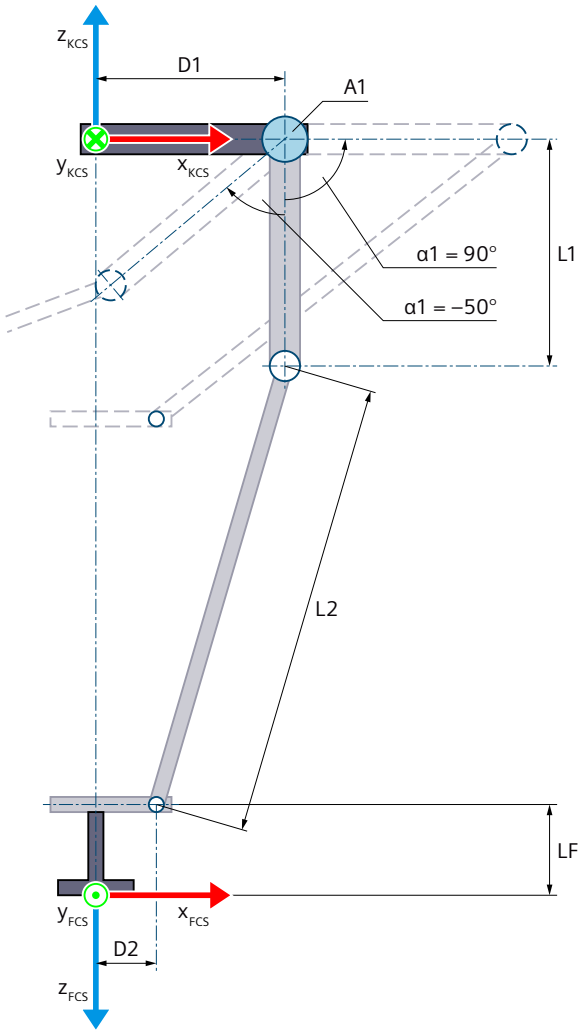

Zero position of the kinematics

D1 Distance of the axes from the center of the upper connecting plate (radius of the upper connecting plate)

D2 Distance of the hinge points of the connecting rods to the middle of the lower connecting plate (radius of the lower connecting plate)

L1 Length of the upper arms

L2 Length of the connecting rods

D1, D2, L1 and L2 are identical for the three arms of the kinematics.

LF Flange length before the FCS in the z direction of the KCS

Deflection of the kinematics
The motion of the axes in the positive direction is the outward rotation of the upper arms.

α1 Deflection of the axis A1 in negative direction when α1 = -50.0°
Deflection of the axis A1 in positive direction when α1 = 90.0°

Legend for representation of the kinematics (Page 38)

The KCS with the kinematics zero point (KZP) is located at the center point of the upper connecting plate. The axes A1, A2 and A3 are at distance D1 from the common center point (kinematics zero point).

The FCS is located in the center on the bottom of the lower connecting plate with equal distance D2 to the hinge points of each arm. You shift the FCS in the negative z direction of the KCS using length LF.

In the zero position of the axes A1, A2 and A3, the upper arms point in the negative z direction of the KCS.

Transformation area

Only the outwardly bent joint position (Page 157) is permitted for the arms of the kinematics. You cannot traverse the axes beyond the extended position of the arms.

NOTE
Singularity
The kinematics has outer singularities (Page 183).

7.9.5.4 Delta picker 3D with orientation

The kinematics "Delta picker 3D with orientation" supports 4 axes and 4 degrees of freedom. The axes are configured as parallel kinematics.

The following graphic shows the principal configuration and the typical working area of the kinematics:

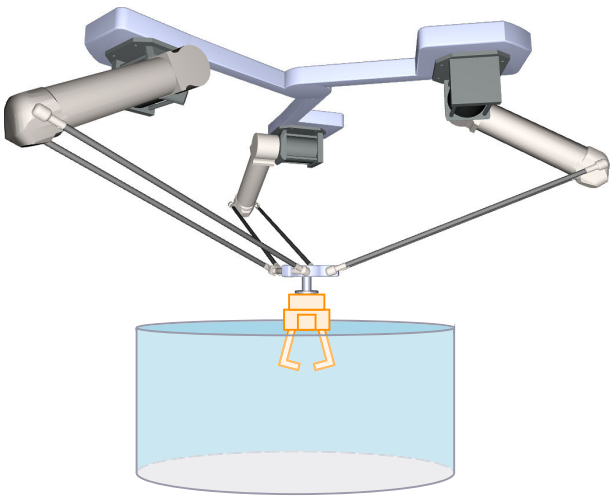

The kinematics consists of the following axes:

- 3 rotary axes A1 A2 and A3
- 1 rotary axis A4 with rotation around z in the KCS

The kinematics is modeled suspended. The kinematics consists of an upper connecting plate, three upper arms, connecting rods and a lower connecting plate. The axes for moving the arms (axes A1, A2 and A3) are fastened to the upper connecting plate. The upper arms and the connecting rods connect the upper and lower connecting plates.

The tool is attached to the lower connecting plate.

The parallelogram structures of the connecting rods keep the lower connecting plate parallel to the xy plane of the KCS. The kinematics axis A4 enables rotation of the tool around z in the KCS.

Coordinate systems and zero position

The graphic below shows the following in the top view (xy plane):

- The position of the kinematics coordinate system (KCS)
- The angles of the axes A1, A2 and A3 to one another

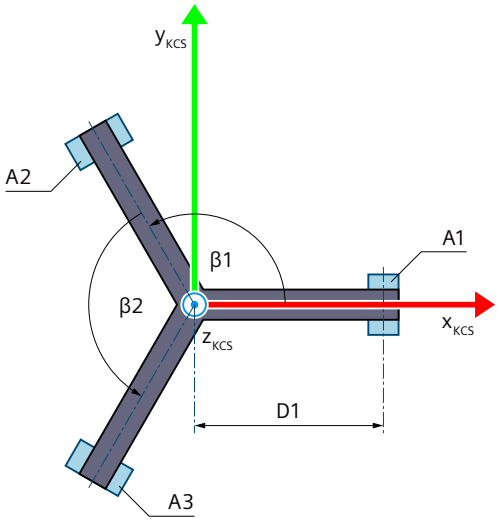

β1 Angle between the axes A1 and A2

β2 Angle between the axes A2 and A3

Legend for representation of the kinematics (Page 38)

The following graphic shows the top view of the position of the flange coordinate system (FCS) in the xy plane of the lower connecting plate:

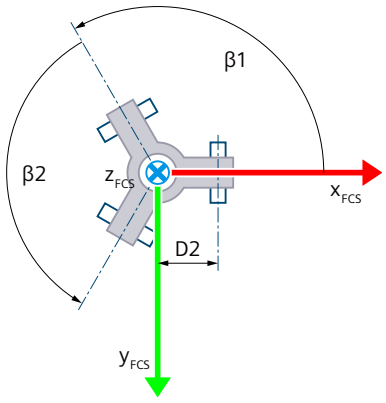

The graphic below shows the following in the front view (xz plane):

- The position of the axis A1 and the coordinate systems KCS and FCS
- The zero positions of the axes A1 and A4
- The positive/negative deflection of the axis A1 is indicated (dashed)

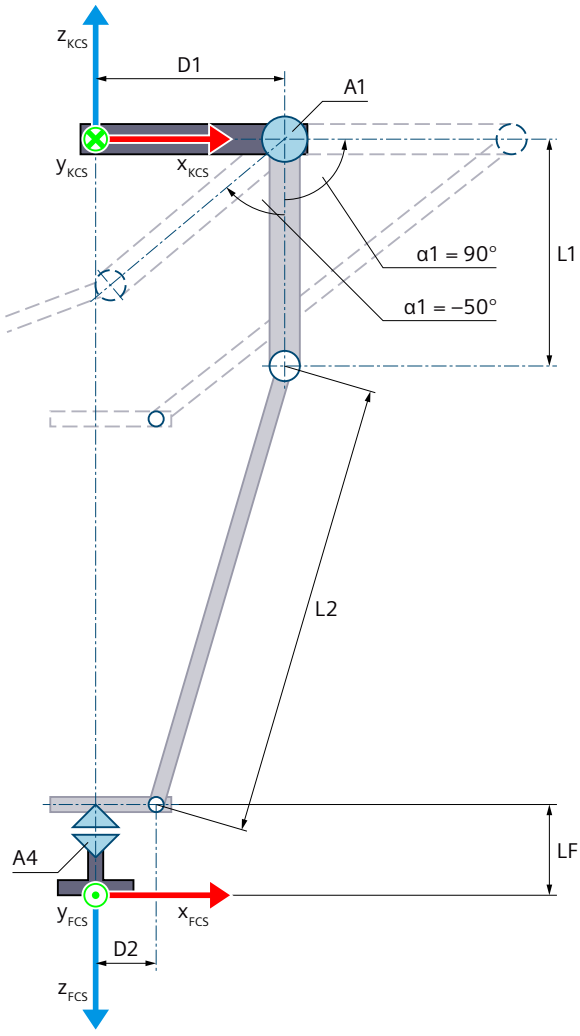

Zero position of the kinematics

D1 Distance of the axes from the center of the upper connecting plate (radius of the upper connecting plate)

D2 Distance of the joint points of the connecting rods to the middle of the lower connecting plate (radius of the lower connecting plate)

L1 Length of the upper arms

L2 Length of the connecting rods

D1, D2, L1 and L2 are identical for the three arms of the kinematics.

LF Flange length before the FCS in the z direction of the KCS

Deflection of the kinematics
The motion of the axes in the positive direction is the outward rotation of the upper arms.

α1 Deflection of the axis A1 in negative direction when α1 = -50.0°
Deflection of the axis A1 in positive direction when α1 = 90.0°

Legend for representation of the kinematics (Page 38)

The KCS with the kinematics zero point (KZP) is located at the center point of the upper connecting plate. The axes A1, A2 and A3 are at distance D1 from the common center point (kinematics zero point).

The FCS is located in the center point on the bottom of the lower connecting plate with equal distance D2 to the joint points of each arm. You shift the FCS in the negative z direction of the KCS using length LF.

In the zero position of the axes A1, A2 and A3, the upper arms point in the negative z direction of the KCS. At the zero position of axis A4, the x axis of the FCS points in the direction of the x axis of the KCS.

Transformation area

Only the outwardly bent joint position (Page 157) is permitted for the arms of the kinematics. You cannot traverse the axes beyond the extended position of the arms.

NOTE
Singularity
The kinematics has outer singularities (Page 183).

7.9.5.5 Delta picker 3D with 2 orientations A, B

The kinematics "Delta picker 3D with 2 orientations A, B" supports 5 axes and 5 degrees of freedom. The axes are configured as parallel kinematics. For this kinematics type, you need the Motion Control package "S7-1500T Motion Control KinPlus" (Page 27).

The following graphic shows the principal configuration and the typical working area of the kinematics:

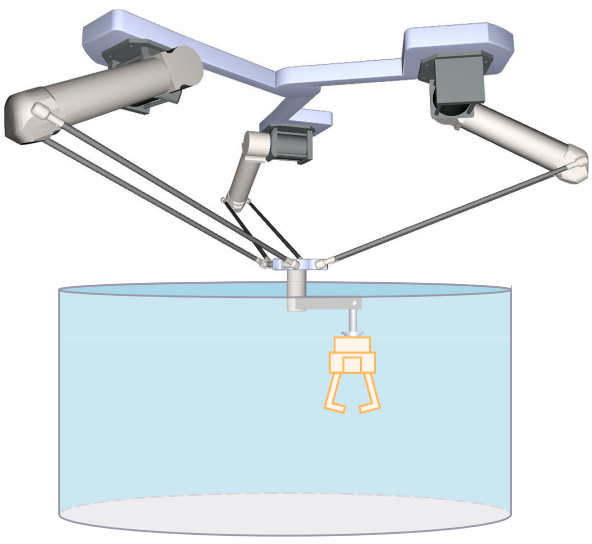

The kinematics consists of the following axes:

- 3 rotary axes A1 A2 and A3
- One rotary swivel axis A4 which rotates around the z axis of the KCS in the kinematics zero position.
- One rotary swivel axis A5, which rotates around the y axis of the KCS in the kinematics zero position.

The kinematics is modeled suspended. The kinematics consists of an upper connecting plate, three upper arms, connecting rods and a lower connecting plate. The axes for moving the arms (axes A1, A2 and A3) are fastened to the upper connecting plate. The upper arms and the connecting rods connect the upper and lower connecting plates.

The parallelogram structures of the connecting rods keep the lower connecting plate parallel to the xy plane of the KCS.

The rotary axis A4 and the swivel axis A5 are mounted on the lower connecting plate. The motors of the axes A4 and A5 can be mounted on the upper connecting plate or below the lower connecting plate. If the motors are mounted on the upper connecting plate, then the axes A4 and A5 are moved via a mechanical shaft, which is mounted between the two connecting plates.

The tool is attached to the swivel axis A5.

Coordinate systems and zero position

The graphic below shows the following in the top view (xy plane):

- The position of the kinematics coordinate system (KCS)
- The angles of the axes A1, A2 and A3 to one another

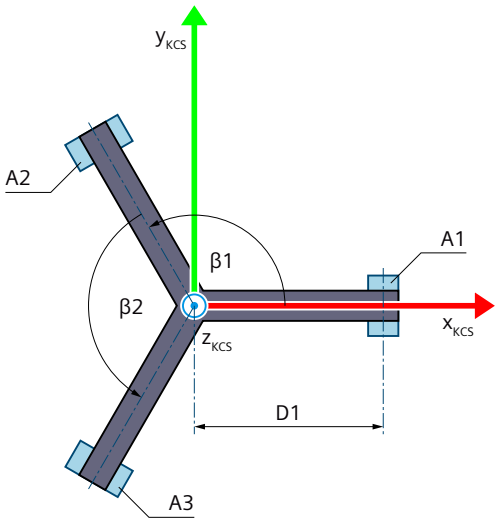

β1 Angle between the axes A1 and A2

β2 Angle between the axes A2 and A3

Legend for representation of the kinematics (Page 38)

The following graphic shows the bottom view of the position of the flange coordinate system (FCS) in the xy plane of the lower connecting plate:

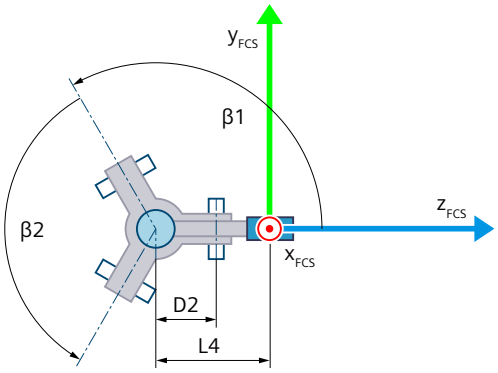

The graphic below shows the following in the front view (xz plane):

- The position of the axis A1 and the coordinate systems KCS and FCS
- The zero positions of the axes A1 and A4
- The positive/negative deflection of the axis A1 is indicated (dashed)

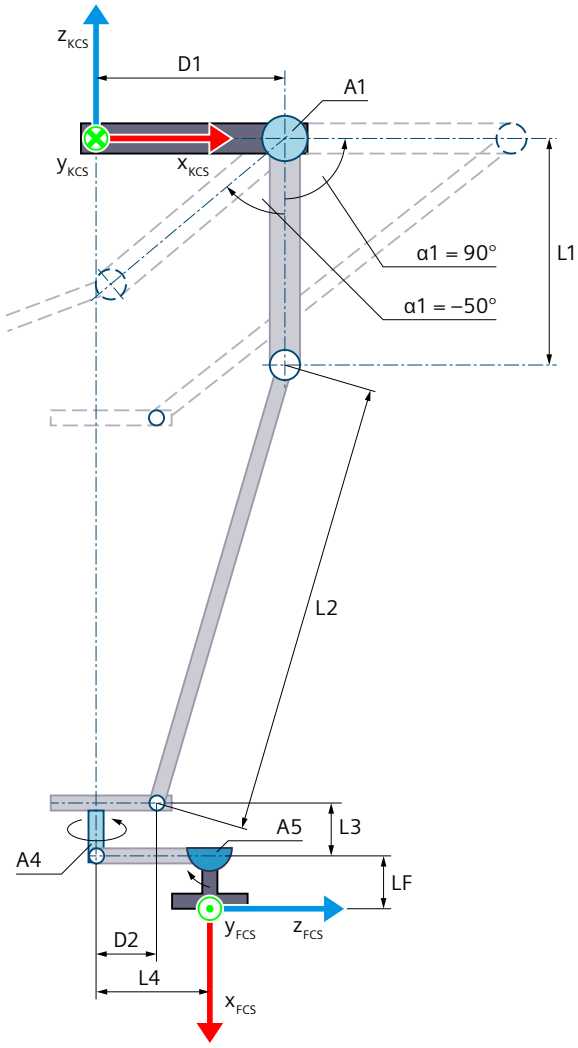

Zero position of the kinematics

D1 Distance of the axes from the center of the upper connecting plate (radius of the upper connecting plate)

D2 Distance of the joint points of the connecting rods to the middle of the lower connecting plate (radius of the lower connecting plate)

L1 Length of the upper arms

L2 Length of the connecting rods

L3 Distance of the swivel axis from the lower connecting plate in the negative z direction of the KCS

L4 Distance of the joint points of rotary axis A4 and swivel axis A5 in the x direction of the KCS
in the kinematics zero position

D1, D2, L1 and L2 are identical for the three arms of the kinematics.

LF Distance LF from the joint point of swivel axis A5 to the FCS in the negative x direction of the FCS

Deflection of the kinematics
The motion of the axes A1, A2 and A3 in positive direction is that of the rotation outward of the upper arms.

α1 Deflection of the axis A1 in negative direction when α1 = -50.0°
Deflection of the axis A1 in positive direction when α1 = 90.0°

Legend for representation of the kinematics (Page 38)

The KCS with the kinematics zero point (KZP) is located at the center point of the upper connecting plate. The axes A1, A2 and A3 are at distance D1 from the common center point (kinematics zero point).

At the zero position of the kinematics, the FCS is oriented with A = 0°, B = 90° and C = 0°.

In the zero position of the axes A1, A2 and A3, the upper arms point in the negative z direction of the KCS. At the zero position of axes A4 and A5, the x axis of the FCS points in the negative direction of the z axis of the KCS.

Direction of travel of the joints

The following figure shows the direction of travel of the joints defined in the kinematics type.

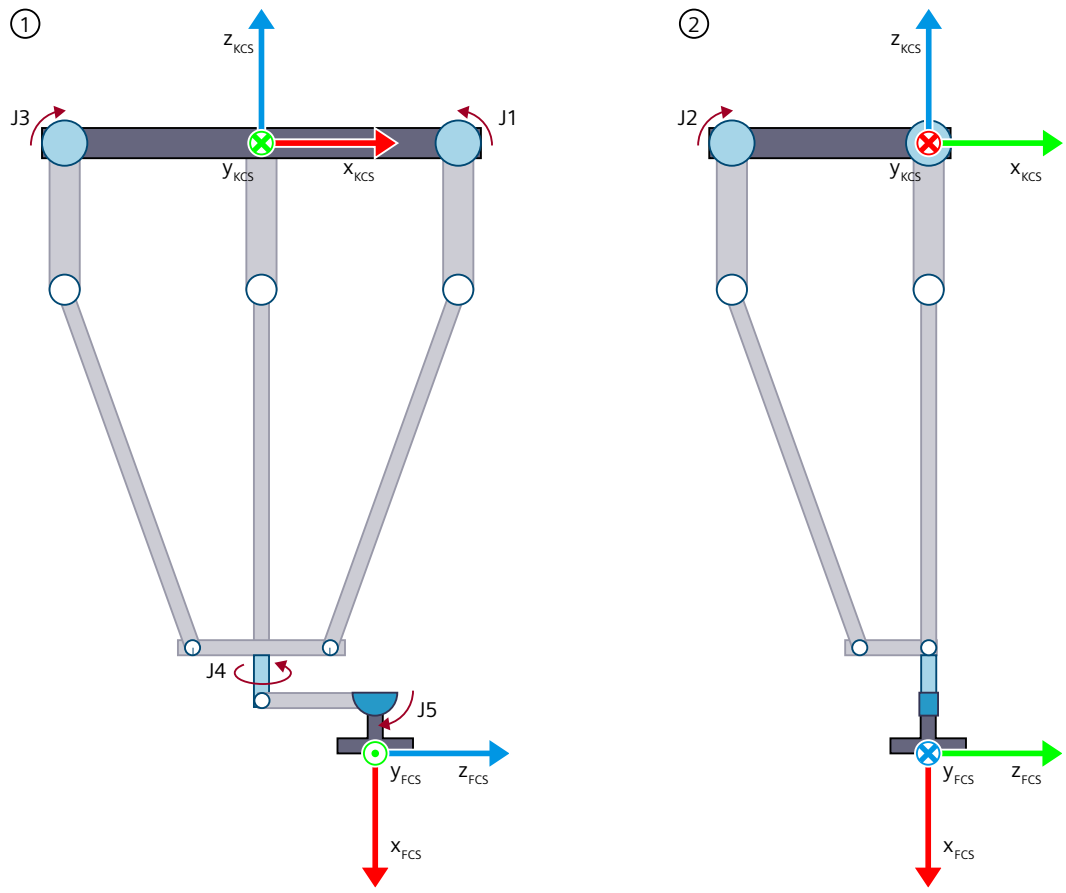

① Front view

② Side view

Positive direction of rotation of the joints

If the direction of travel of a joint of the real kinematics is inverse to the direction of travel of the joint defined in the kinematics type from Siemens, you must invert the joint direction (Page 55) in the configuration.

Transformation area

Only the outwardly bent joint position (Page 157) is permitted for the arms of the kinematics. You cannot traverse the axes beyond the extended position of the arms.

NOTE
Singularity
The kinematics has outer singularities (Page 183).

7.9.5.6 Permissible joint position for delta picker

Only the outwardly bent joint position is permitted for the arms of the delta picker kinematics. The graphic below shows examples of permissible and impermissible joint positions for the transformation:

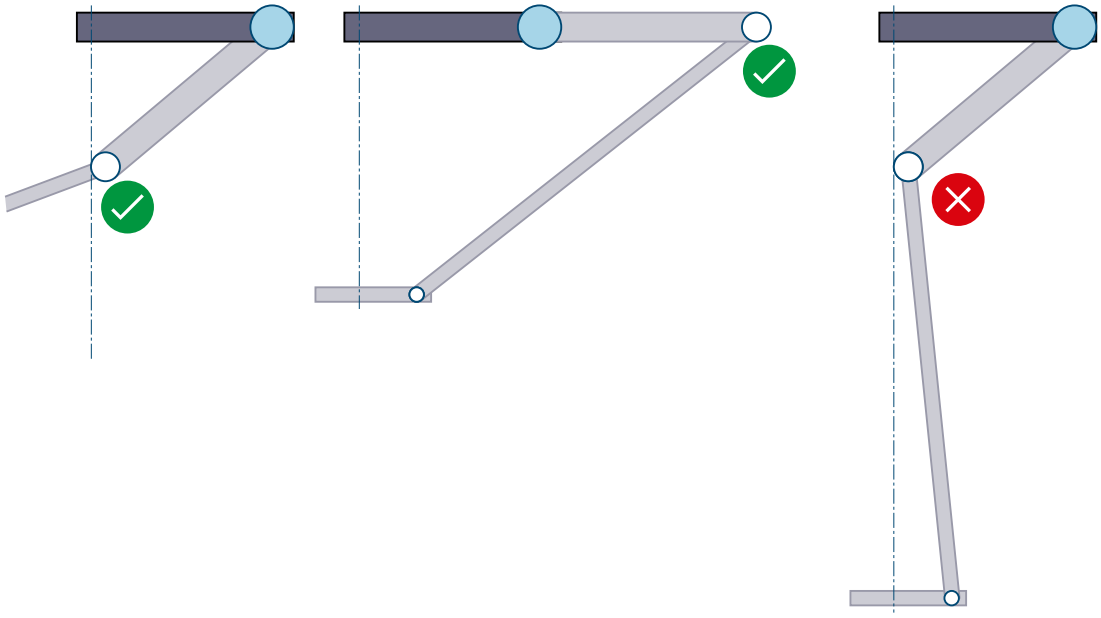

Permissible joint position

Invalid joint position for the transformation

7.9.5.7 Tags: Delta picker

Delta picker 2D

You define the 2D delta picker kinematics using the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	15	Delta picker 2D
	16	Delta picker 2D with orientation
<TO>.Kinematics.Parameter[1]	0.0 to 1.0E12	Distance D1 (radius of the upper connecting plate)
<TO>.Kinematics.Parameter[2]	0.001 to 1.0E12	Length L1 of the upper arms
<TO>.Kinematics.Parameter[3]	0.001 to 1.0E12	Length L2 of connecting rods
<TO>.Kinematics.Parameter[4]	0.0 to 1.0E12	Distance D2 (radius of the lower connecting plate)
<TO>.Kinematics.Parameter[5]	-1.0E12 to 1.0E12	Distance LF of the FCS to the lower connecting plate in the negative z direction of the KCS

Delta picker 3D

You define the 3D delta picker kinematics using the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	17	Delta picker 3D
	18	Delta picker 3D with orientation
	27	Delta picker 3D with 2 orientations A, B
<TO>.Kinematics.Parameter[1]	-1.0E12 to 1.0E12	Distance D1 (radius of the upper connecting plate)
<TO>.Kinematics.Parameter[2]	0.001 to 1.0E12	Length L1 of the upper arms
<TO>.Kinematics.Parameter[3]	0.001 to 1.0E12	Length L2 of connecting rods
<TO>.Kinematics.Parameter[4]	0.0 to 1.0E12	Distance D2 (radius of the lower connecting plate)
<TO>.Kinematics.Parameter[5]	90.001° to 179.998°	Angle β1 between the axes A1 and A2
<TO>.Kinematics.Parameter[6]	90.001° to 179.998°	Angle β2 between the axes A2 and A3
<TO>.Kinematics.Parameter[7]	-1.0E12 to 1.0E12	• Distance LF of the FCS to the lower connecting plate in the negative z direction of the KCS • Delta picker 3D with 2 orientations A, B: Distance LF from pivot point of swivel axis A5 to FCS in negative x direction of FCS
<TO>.Kinematics.Parameter[8]	0.001 to 1.0E12	Distance L3 of the swivel axis to the lower connecting plate in the negative z direction of the KCS at zero position of the kinematics [1)]
<TO>.Kinematics.Parameter[9]	0.001 to 1.0E12	Distance L4 of the hinge points of the rotary axis A4 to swivel axis A5 in x direction of the KCS at zero position of the kinematics [1)]

1) Only relevant for kinematics type "Delta picker 3D with 2 orientations A, B"

7.9.6 Cylindrical robot

7.9.6.1 Cylindrical robot 3D

The kinematics "Cylindrical robot 3D" supports 3 axes and 3 degrees of freedom. The axes are configured as serial kinematics.

The following graphic shows the principal configuration and the typical working area of the kinematics:

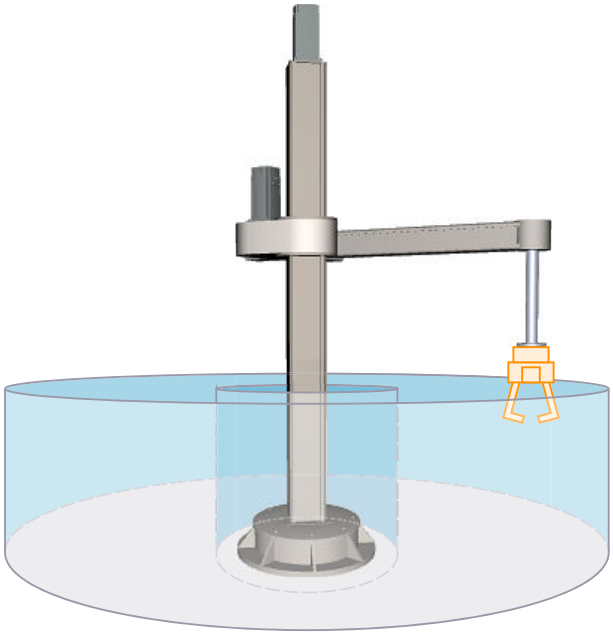

The kinematics consists of the following axes:

- 1 rotary axis A1 with rotation around the z axis of the kinematics coordinate system (KCS)
- 1 linear axis A2 in z direction of the KCS
- 1 linear axis A3 in x direction of the KCS

The kinematics consists of a base, a supporting column and a jib. Axis A1 rotates the supporting column with jib around the base. Axis A2 moves the jib vertically. Axis A3 moves the flange system horizontally on the jib. The kinematics enables a cylindrical working area.

Coordinate systems and zero position

The graphic below shows the following in the side view (xz plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero positions of the axes A1 and A2
- The deflection of the kinematics is indicated (dashed)

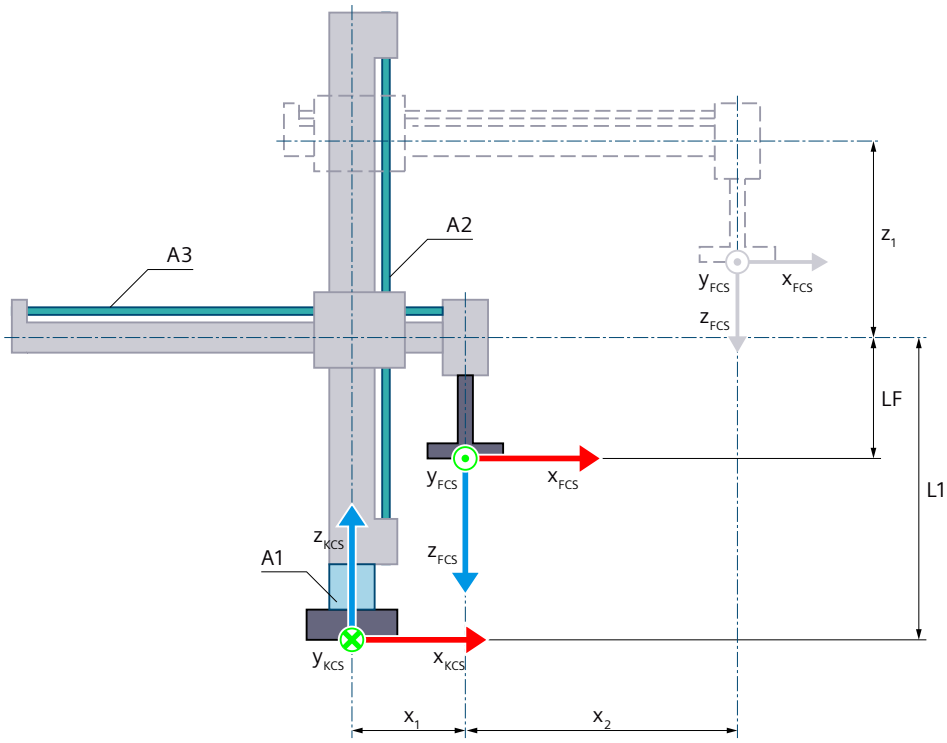

Zero position of the axes A1 and A2

L1 At zero position of the axis A2:
Distance of the FCS to the kinematics zero point (KZP) and flange length LF in z direction of the KCS

LF Flange length before the FCS in the z direction of the KCS

x_1 Positive deflection of the axis A3
At the zero position of axis A3, the z axis of the FCS is located on the z axis of the KCS. For mechanical reasons, the kinematics shown cannot approach the zero position of the axis A3.

Deflection of the kinematics

x_2 Positive deflection of the axis A3

z_1 Positive deflection of the axis A2

Legend for representation of the kinematics (Page 38)

The graphic below shows the following in the top view (xy plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the kinematics is indicated (dashed)

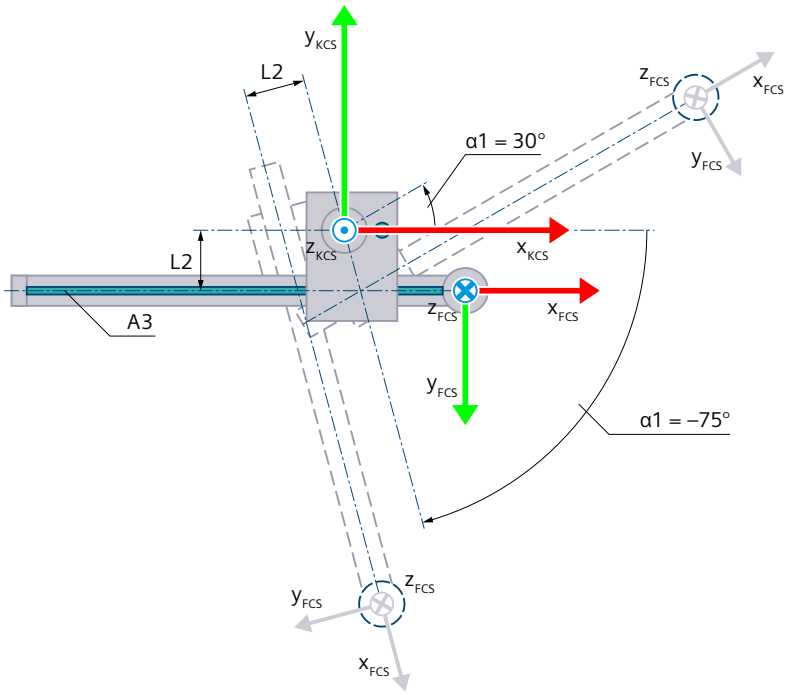

Zero position of the kinematics

L2 Distance of the axis A3 from the KZP in y direction of the KCS (negative value here)

Deflection of the kinematics

α1 Positive deflection of the axis A1 when α1 = 30°
Negative deflection of the axis A1 when α1 = -75°

Legend for representation of the kinematics (Page 38)

The KCS with the kinematics zero point (KZP) is located at the base of the kinematics. You define the distance of the zero position of axis A2 in z direction of the KCS from the KZP using length L1. You define the distance of the axis A3 from the KZP in y direction of the KCS using length L2.

The flange coordinate system (FCS) is located on the axis A3, shifted by the length LF in negative z direction of the KCS.

The following table shows the zero position of the axes:

Axis	Zero position
A1	The jib with the axis A3 points in x_{KCS} direction.
A2	The axis A2 is at the position 0.0 of the interconnected technology object.
A3	The axis A3 is at the position 0.0 of the interconnected technology object.

Transformation area

The kinematics transformation covers the following traversing range (Page 178) of the axes:

- Axis A1: -180.0° ≤ α1 < 180.0°
- Axis A2: No limit
- Axis A3: No limit

NOTE
Singularity
The kinematics has singularity (Page 183).

A singularity occurs when the zero point of the flange coordinate system (FCS) is located on the z axis of the kinematics coordinate system (KCS). Inverse transformation is not possible in this area. This position may result, e.g. if the length L2 is 0.0 due to the design.

The graphic below shows examples of permissible and impermissible joint positions for the transformation:

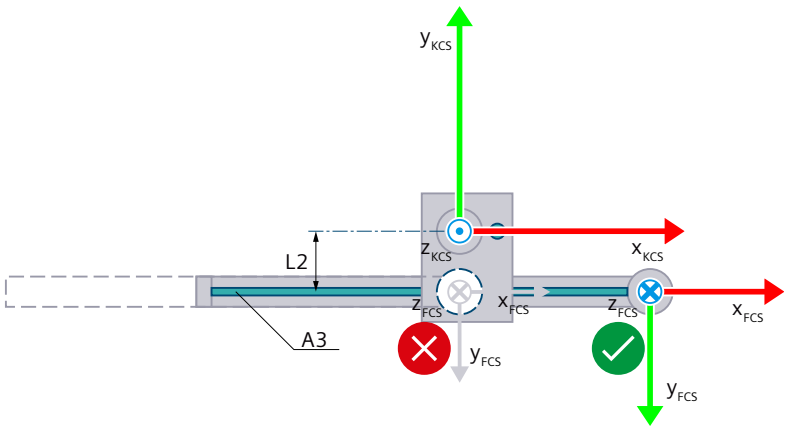

Permissible joint position

Singularity at L2 = 0.0

Joint position space

The following table shows the possible joint position spaces of the kinematics:

Tag	Data type	Values	W	Description	
StatusKinematics.	TO_Struct_Kinematics_StatusKinematics				
Valid	BOOL	-	RON	Validity of the transformation values	
				FALSE	Invalid
				TRUE	Valid
LinkConstellation	DWORD	0 to n	RON	Joint position space	
Bit 0	-	-	-	Position axis 1	
				0	Not relevant

Tag			Data type	Values	W	Description	
		Bit 0	-	-	-	1	Not relevant
		Bit 1	-	-	-	Position axis 2	
						0	Not relevant
						1	Not relevant
		Bit 2	-	-	-	Angle α3 of axis A3 positive/negative taking into consideration the mechanical axis coupling	
						0	α3 positive
						1	α3 negative
		Bit 3 ... 31	-	-	-	Not relevant	

7.9.6.2 Cylindrical robot 3D with orientation

The kinematics "Cylindrical robot 3D with orientation" supports 4 axes and 4 degrees of freedom. The axes are configured as serial kinematics.

The following graphic shows the principal configuration and the typical working area of the kinematics:

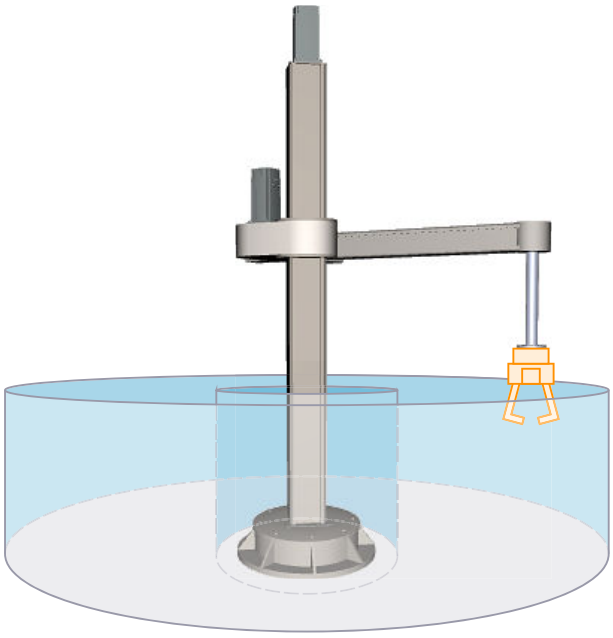

The kinematics consists of the following axes:

- 1 rotary axis A1 with rotation around the z axis of the kinematics coordinate system (KCS)
- 1 linear axis A2 in z direction of the KCS
- 1 linear axis A3 in x direction of the KCS
- 1 rotary axis A4 with rotation around z in the KCS

The kinematics consists of a base, a supporting column and a jib. Axis A1 rotates the supporting column with jib around the base. Axis A2 moves the jib vertically. Axis A3 moves the flange system horizontally on the jib. The kinematics enables a cylindrical working area. The kinematics axis A4 enables rotation of the tool around z in the KCS.

Coordinate systems and zero position

The graphic below shows the following in the side view (xz plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero positions of the axes A1 and A2
- The deflection of the kinematics is indicated (dashed)

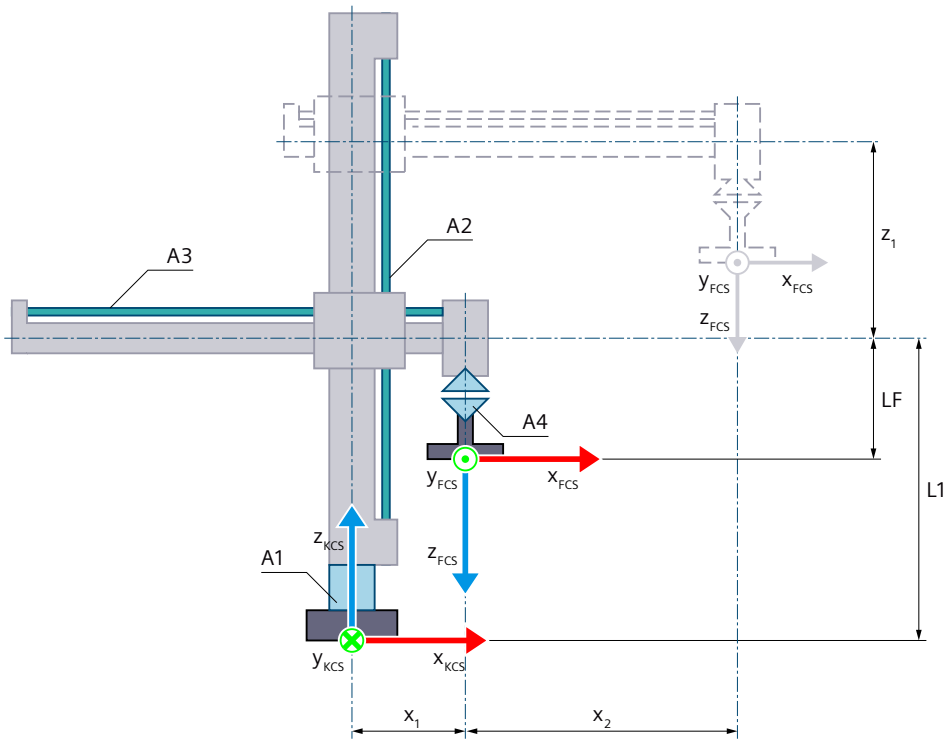

Zero position of the kinematics

L1 With axis A2 in the zero position:
Distance of the FCS to the kinematics zero point (KZP) and flange length LF in z direction of the KCS

LF Flange length before the FCS in the z direction of the KCS

x_1 Positive deflection of the axis A3
At the zero position of axis A3, the z axis of the FCS is located on the z axis of the KCS. For mechanical reasons, the kinematics shown cannot approach the zero position of the axis A3.

Deflection of the kinematics

x_2 Positive deflection of the axis A3

z_1 Positive deflection of the axis A2

Legend for representation of the kinematics (Page 38)

The graphic below shows the following in the top view (xy plane):

- The position of the axes and the coordinate systems KCS and FCS
- The zero position of the kinematics
- The positive/negative deflection of the kinematics is indicated (dashed)

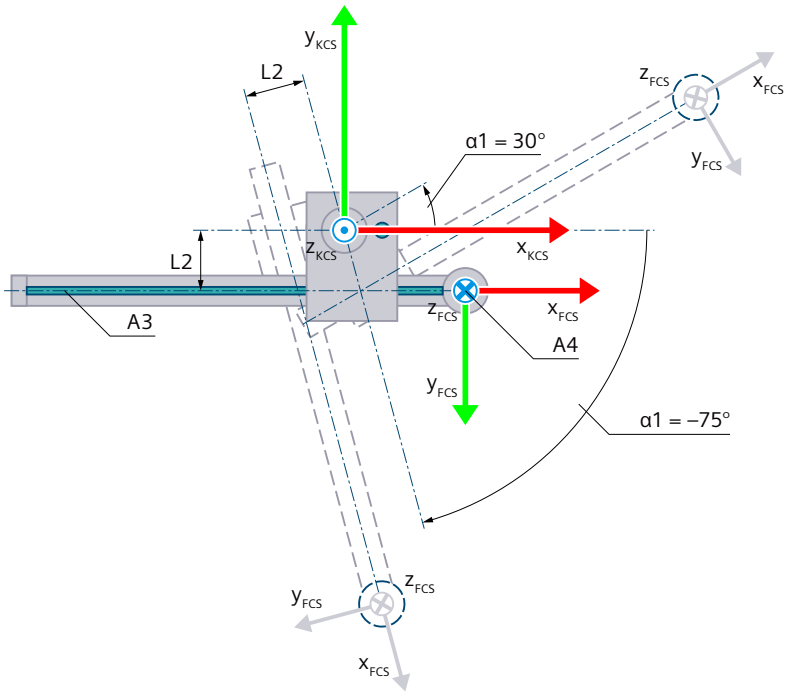

Zero position of the kinematics

L2 Distance of the axis A3 to the KZP in y direction of the KCS (negative value in this case)

Deflection of the kinematics

α1 Positive deflection of the axis A1 when α1 = 30°
Negative deflection of the axis A1 when α1 = -75°

Legend for representation of the kinematics (Page 38)

The KCS with the kinematics zero point (KZP) is located at the base of the kinematics. You define the distance of the zero position of axis A2 in z direction of the KCS from the KZP using length L1. You define the distance of the axis A3 from the KZP in y direction of the KCS using length L2.

The flange coordinate system (FCS) is located on the axis A3, shifted by the length LF in negative z direction of the KCS.

The following table shows the zero position of the axes:

Axis	Zero position
A1	The jib with the axis A3 points in x_{KCS} direction.
A2	The axis A2 is at the position 0.0 of the interconnected technology object.
A3	The axis A3 is at the position 0.0 of the interconnected technology object.
A4	With axis A1 in the zero position, the x axis of the FCS points in the direction of the x axis of the KCS.

Compensation of mechanical axis couplings

You can configure a mechanical axis coupling of axis A4 to axis A2 for the kinematics. The kinematics transformation compensates for the configured mechanical axis coupling. The axis coupling between axis A4 and axis A2 is implemented as a leadscrew pitch. With a compensation factor of 1.0, 360.0° on axis A4 corresponds to a distance of -1.0 mm on axis A2.

Transformation area

The kinematics transformation covers the following traversing range (Page 178) of the axes:

- Axis A1: -180.0° ≤ α1 < 180.0°
- Axis A2: No limit
- Axis A3: No limit
- Axis A4: No limit

  An angle greater than 360° can be defined for the orientation. But coordinate A of the tool center point (TCP) is mapped in the range -180° to +180°.

NOTE
Singularity
The kinematics has singularity (Page 183).

A singularity occurs when the zero point of the flange coordinate system (FCS) is located on the z axis of the kinematics coordinate system (KCS). Inverse transformation is not possible in this area. This position may result, e.g. if the length L2 is 0.0 due to the design.

The graphic below shows examples of permissible and impermissible joint positions for the transformation:

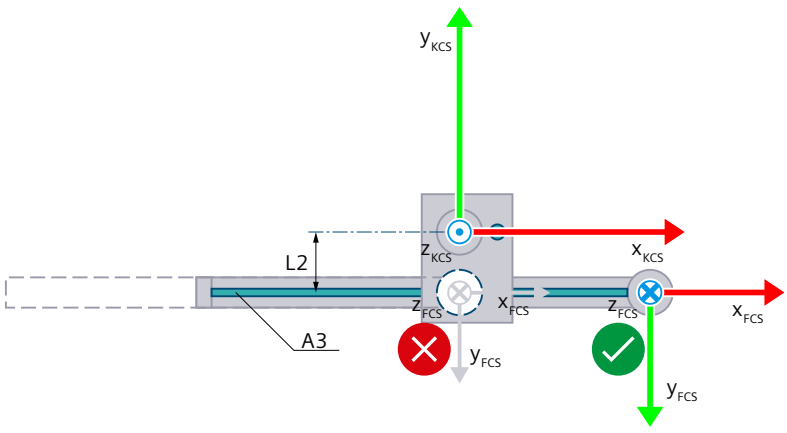

Permissible joint position

Singularity at L2 = 0.0

Joint position space

The following table shows the possible joint position spaces of the kinematics:

Tag	Data type	Values	W	Description	
StatusKinematics.	TO_Struct_Kinematics_StatusKinematics				
Valid	BOOL	-	RON	Validity of the transformation values	
				FALSE	Invalid
				TRUE	Valid
LinkConstellation	DWORD	0 to n	RON	Joint position space	
Bit 0	-	-	-	Position axis 1	
				0	Not relevant
				1	Not relevant
Bit 1	-	-	-	Position axis 2	
				0	Not relevant
				1	Not relevant
Bit 2	-	-	-	Angle α3 of axis A3 positive/negative taking into consideration the mechanical axis coupling	
				0	α3 positive
				1	α3 negative
Bit 3 ... 31	-	-	-	Not relevant	

7.9.6.3 Tags: Cylindrical robot

Cylindrical robot 3D

You define the "Cylindrical robot 3D" kinematics using the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	21	Cylindrical robot 3D
<TO>.Kinematics.Parameter[1]	-1.0E12 to 1.0E12	Distance L1 of the zero position of the axis A2 to the kinematics zero point in z direction of the kinematics coordinate system (KCS)
<TO>.Kinematics.Parameter[2]	-1.0E12 to 1.0E12	Distance L2 between the axes A2 and A3 in y direction of the KCS
<TO>.Kinematics.Parameter[3]	-1.0E12 to 1.0E12	Distance of the flange coordinate system from the axis A3 in the negative z direction of the KCS

Cylindrical robot 3D with orientation

You define the "Cylindrical robot 3D with orientation" kinematics using the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	22	Cylindrical robot 3D with orientation
<TO>.Kinematics.Parameter[1]	-1.0E12 to 1.0E12	Distance L1 of the zero position of the axis A2 to the kinematics zero point in z direction of the KCS
<TO>.Kinematics.Parameter[2]	-1.0E12 to 1.0E12	Distance L2 between the axes A2 and A3 in y direction of the KCS
<TO>.Kinematics.Parameter[3]	-1.0E12 to 1.0E12	Distance of the flange coordinate system from the axis A3 in the negative z direction of the KCS
<TO>.Kinematics.Parameter[4]	-	Mechanical axis coupling of axis A4 to A2 present/not present
	0	Not present
	1	Present
<TO>.Kinematics.Parameter[5]	-1.0E12 to 1.0E12	Compensation factor of axis A4 to axis A2

7.9.7 Tripod

7.9.7.1 Tripod 3D

The kinematics "Tripod 3D" supports 3 axes and 3 degrees of freedom. The axes are configured as parallel kinematics.

The following graphic shows the principal configuration and the typical working area of the kinematics:

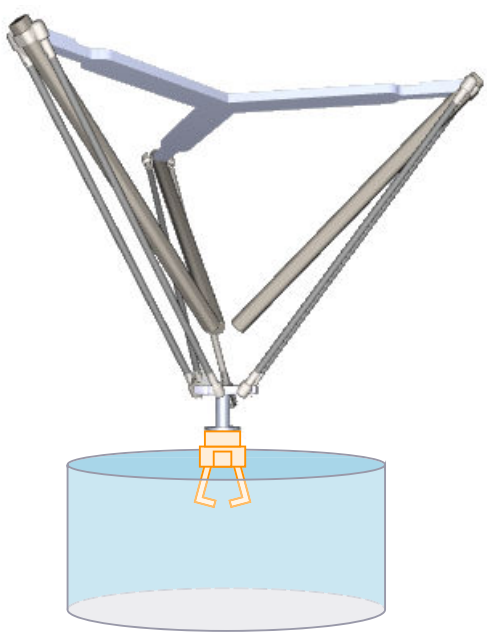

The kinematics consists of 3 linear axes A1, A2 and A3.

The kinematics is modeled suspended and consists of an upper connecting plate, 3 arms and a lower connecting plate. The axes for the motion of the arms consist of rails with sliding carriages. The rails with the sliding carriages are fastened to the upper connecting plate. Connecting rods connect the sliding carriages to the lower connecting plate. The tool is suspended from the lower connecting plate. The parallelogram structures of the connecting rods keep the lower connecting plate parallel to the xy plane of the KCS.

Coordinate systems and zero position

The graphic below shows the following in the top view (xy plane):

- The position of the kinematics coordinate system (KCS)
- The angles of the axes A1, A2 and A3 to one another

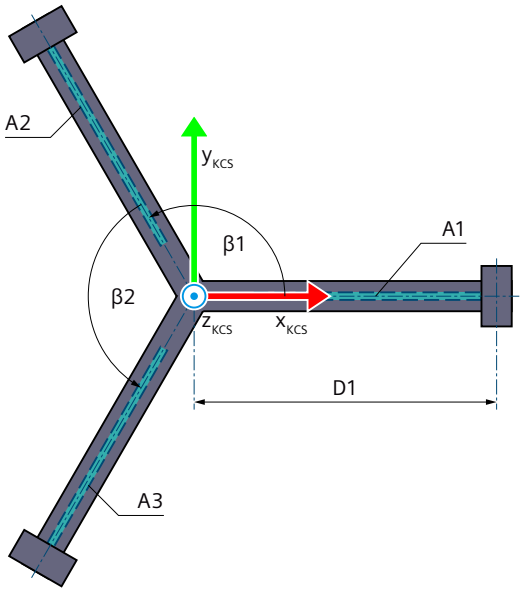

β1 Angle between the axes A1 and A2

β2 Angle between the axes A2 and A3

Legend for representation of the kinematics (Page 38)

The following graphic shows the top view of the position of the flange coordinate system (FCS) in the xy plane of the lower connecting plate:

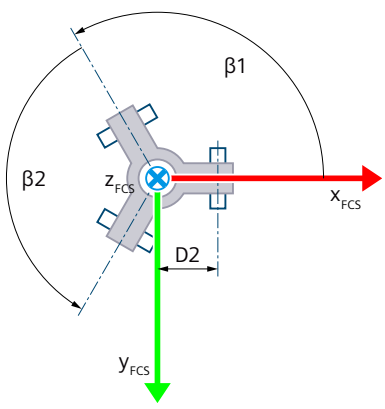

The graphic below shows the following in the front view (xz plane):

- The position of the axis A1 and the coordinate systems KCS and FCS
- The zero position of the axis A1
- The positive deflection of the axis A1 is indicated (dashed)

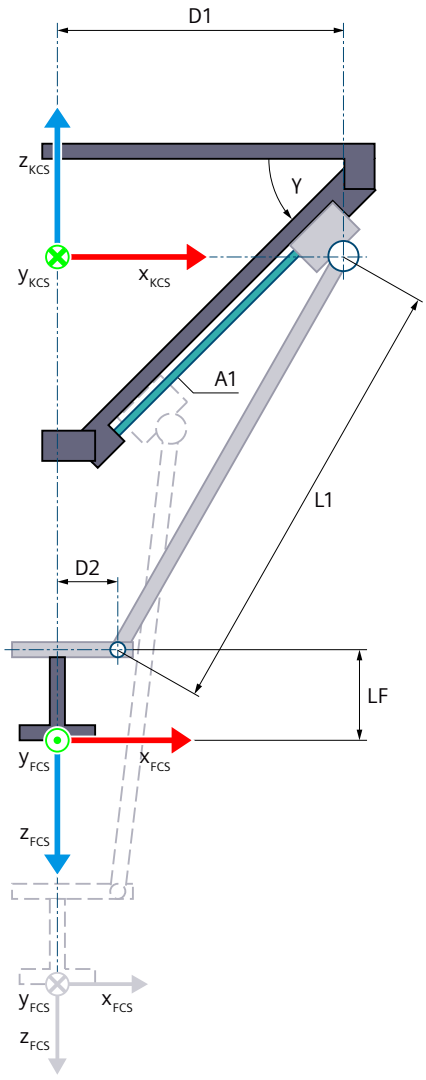

Zero position of the kinematics

D1	Distance of the upper hinge points of the connecting rods to the center of the upper connecting plate
D2	Distance of the lower hinge points of the connecting rods to the center of the lower connecting plate
L1	Length of the connecting rods
LF	Flange length before the FCS in the z direction of the KCS
γ	Angle between the upper connecting plate (xy plane of the KCS) and the rail of the axis A1 ($0.0° \leq \gamma < 90.0°$)

D1, D2, L1 and γ are identical for the three arms of the kinematics.

Deflection of the kinematics with deflection of the axis A1 in positive direction

Legend for representation of the kinematics (Page 38)

The KCS with the kinematics zero point (KZP) is located at the center point of the upper connecting plate. The kinematics zero point is centered relative to the zero positions of the axes A1, A2 and A3.

The FCS is located in the center point of the lower connecting plate with identical distance D2 to the joint points of each connecting rod. You shift the FCS in the negative z direction of the KCS using length LF.

At the zero position, axes A1, A2 and A3 are in the xy plane of the KCS.

Transformation area

The kinematics transformation covers the following traversing range (Page 178) of the axes:

- Axes A1, A2 and A3: 0.0 ≤ Travel distance

NOTE
Singularity
The kinematics has outer singularities (Page 183).

Joint position space

No joint position spaces for the kinematics.

7.9.7.2 Tripod 3D with orientation

The kinematics "Tripod 3D with orientation" supports 4 axes and 4 degrees of freedom. The axes are configured as parallel kinematics.

The following graphic shows the principal configuration and the typical working area of the kinematics:

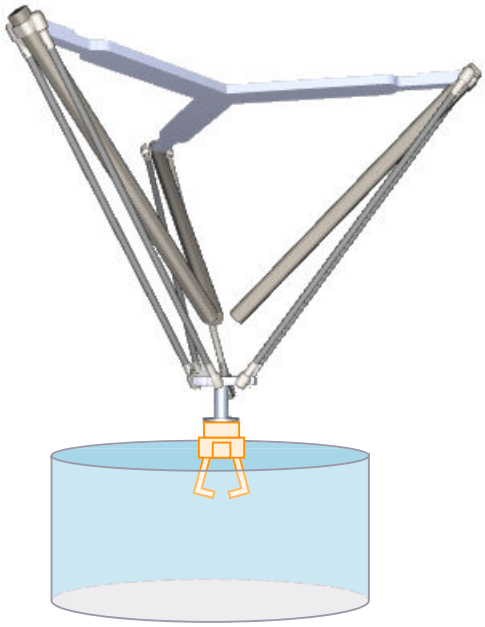

The kinematics consists of the following axes:

- 3 linear axes A1, A2 and A3
- 1 rotary axis A4 with rotation around z in the KCS

The kinematics is modeled suspended and consists of an upper connecting plate, 3 arms and a lower connecting plate. The axes for the motion of the arms consist of rails with sliding carriages. The rails with the sliding carriages are fastened to the upper connecting plate. Connecting rods connect the sliding carriages to the lower connecting plate. The tool is suspended from the lower connecting plate. The parallelogram structures of the connecting rods keep the lower connecting plate parallel to the xy plane of the KCS. The kinematics axis A4 enables rotation of the tool around z in the KCS.

Coordinate systems and zero position

The graphic below shows the following in the top view (xy plane):

- The position of the kinematics coordinate system (KCS)
- The angles of the axes A1, A2 and A3 to one another

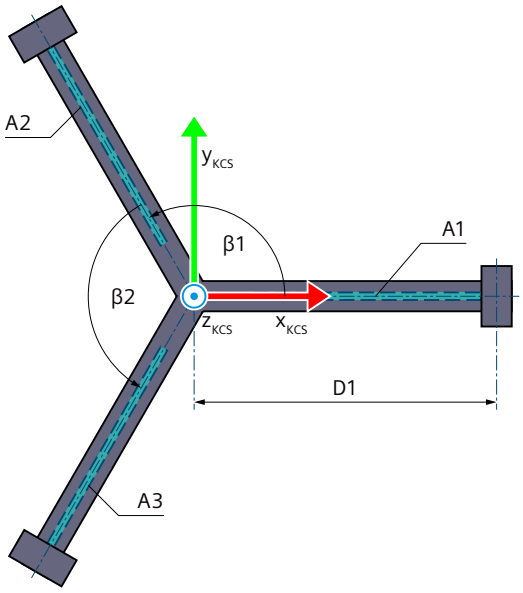

β1 Angle between the axes A1 and A2

β2 Angle between the axes A2 and A3

Legend for representation of the kinematics (Page 38)

The following graphic shows the top view of the position of the flange coordinate system (FCS) in the xy plane of the lower connecting plate:

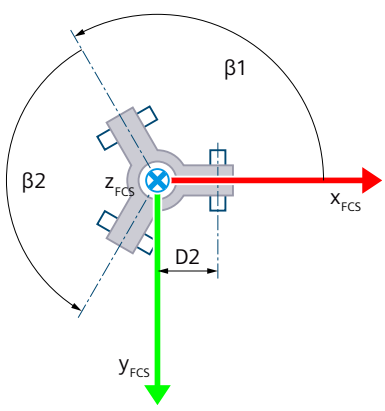

The graphic below shows the following in the side view:

- The position of the axis A1 and the coordinate systems KCS and FCS
- The zero position of the axis A1
- The positive deflection of the axis A1 is indicated (dashed)

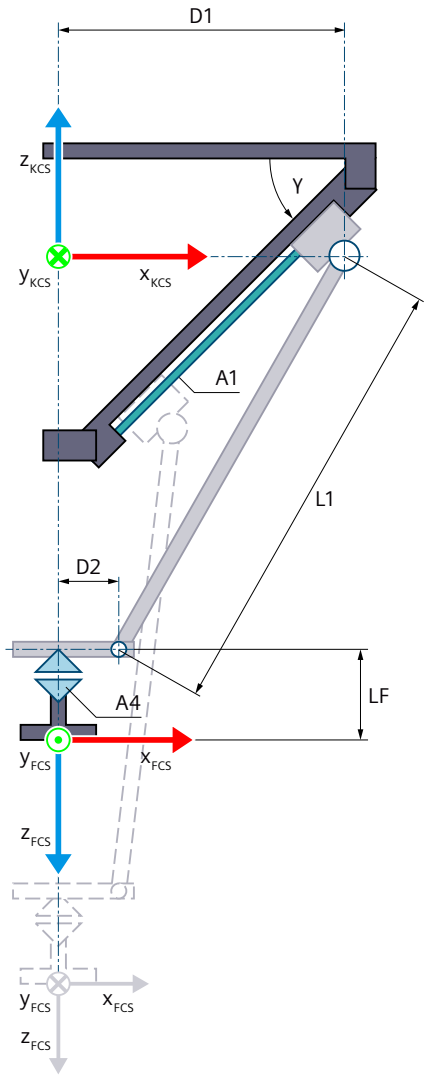

Zero position of the kinematics

D1	Distance of the upper joint points of the connecting rods to the center of the upper connecting plate
D2	Distance of the lower joint points of the connecting rods to the center of the lower connecting plate
L1	Length of the connecting rods
LF	Flange length before the FCS in the z direction of the KCS
γ	Angle between the upper connecting plate (xy plane of the KCS) and the rail of the axis A1 ($0.0° \leq \gamma < 90.0°$)

D1, D2, L1 and γ are identical for the three arms of the kinematics.

Deflection of the kinematics with deflection of the axis A1 in positive direction

Legend for representation of the kinematics (Page 38)

The KCS with the kinematics zero point (KZP) is located at the center point of the upper connecting plate. The kinematics zero point is centered relative to the zero positions of the axes A1, A2 and A3.

The FCS is located in the center point of the lower connecting plate with identical distance D2 to the joint points of each connecting rod. You shift the FCS in the negative z direction of the KCS using length LF.

At the zero position, axes A1, A2 and A3 are in the xy plane of the KCS. At the zero position of axis A4, the x axis of the FCS points in the direction of the x axis of the KCS.

Transformation area

The kinematics transformation covers the following traversing range (Page 178) of the axes:

- Axes A1, A2 and A3: 0.0 ≤ Travel distance
- Axis A4: No limit

  An angle greater than 360° can be defined for the orientation. But coordinate A of the tool center point (TCP) is mapped in the range -180° to +180°.

NOTE
Singularity
The kinematics has outer singularities (Page 183).

Joint position space

No joint position spaces for the kinematics.

7.9.7.3 Tags: Tripod

You define the tripod kinematics using the following tags of the technology object:

Tags	Values	Description
<TO>.Kinematics.TypeOfKinematics	23	Tripod 3D
	24	Tripod 3D with orientation
<TO>.Kinematics.Parameter[1]	0.0 to 1.0E12	Distance D1 (radius of the upper connecting plate)
<TO>.Kinematics.Parameter[2]	0.001 to 1.0E12	Length L1 of connecting rods
<TO>.Kinematics.Parameter[3]	0.0° to 89.999°	Angle γ between the linear axes and the x-y plane of the kinematics coordinate system
<TO>.Kinematics.Parameter[4]	0.0 to 1.0E12	Distance D2 (radius of the lower connecting plate)
<TO>.Kinematics.Parameter[5]	90.001° to 179.998°	Angle β1 between the axes A1 and A2
<TO>.Kinematics.Parameter[6]	90.001° to 179.998°	Angle β2 between the axes A2 and A3
<TO>.Kinematics.Parameter[7]	-1.0E12 to 1.0E12	Distance of the flange coordinate system from the lower connecting plate in the negative z direction of the kinematics coordinate system

7.9.8 User-defined kinematics systems

You can configure user-defined kinematics systems with corresponding axis interconnections:

- User-defined 2D
- User-defined 2D with orientation A
- User-defined 3D
- User-defined 3D with orientation A
- User-defined 3D with 3 orientations

The configuration supports you in a user-defined kinematics as follows:

- You interconnect the kinematics axes under "Technology object > Configuration > Interconnections".
- You define the transformation parameters under "Technology object > Configuration > Geometry". Up to 32 tags for defining the geometry of your kinematics are available on the system level.

Transformation area

The kinematics transformation covers the following traversing range of the axes:

- Axis A[4..6]: -180.0° ≤ α[4..6] < 180.0°

User transformation

You have to program the user transformation of the Cartesian positions and the axis positions and axis dynamics. Predefined interfaces are available on the system level. The function of the user transformation is different for kinematics with and without JCS:

- User transformation without JCS (Page 190)
- User transformation with JCS (Page 192)

7.9.8.1 Tags: User-defined kinematics systems

You configure the user-defined kinematics systems using the following tags of the technology object:

Tag	Values	Description
<TO>.Kinematics.TypeOfKinematics	31	User-defined 2D
	32	User-defined 2D with orientation A
	33	User-defined 3D
	34	User-defined 3D with orientation A
	36	User-defined 3D with 3 orientations
<TO>.Kinematics.Parameter[1..32]	-	Up to 32 user-specific parameters

7.10 Kinematics transformation

The kinematics transformation is the conversion between the Cartesian coordinates of the kinematics motion and the setpoints for the individual kinematics axes:

- Forward transformation

  Calculation of the Cartesian coordinates from the axis positions of the kinematics axes
- Inverse transformation

  Calculation of the axis positions of the kinematics axes from the Cartesian coordinates

The kinematics transformation converts the position values and the dynamic values (velocity, acceleration).

The kinematics technology object provides the kinematics transformation for the predefined kinematics types on the system level. In the case of user-defined kinematics systems, you must calculate the user transformation (Page 190) in its own program.

7.10.1 Transformation for predefined kinematics systems

7.10.1.1 Reference points

The kinematics transformation uses the following reference points:

- Kinematics zero point (KZP)
- Zero positions of the kinematics axes
- Tool center point (TCP)

The positive direction of the axes for the kinematics transformation is dependent on the kinematics type (Page 58). Configure the positive direction on the positioning axis/synchronous axis technology object corresponding to the positive direction of the axis in the kinematics.

Zero positions of the kinematics axes

The position 0.0 on the positioning axis/synchronous axis technology object defines the zero position of the kinematics axis. Reference the axes in such a way that the axes indicate the position 0.0 in the zero position of the kinematics. The zero position of the kinematics depends on the kinematics type (Page 58).

7.10.1.2 Traversing range and transformation area

The transformation area is the area of the axis positions that the kinematics transformation covers. The kinematics type defines the transformation area for the individual kinematics axes. You will find information on the transformation area in the description of the individual kinematics systems (Page 58).

The hardware and software limit switches of an axis define the maximum traversing range and the working area. The working area of a kinematics axis can be greater than or less than the transformation area depending on the axis configuration:

- Working area > Transformation area

  When a kinematics axis exits the transformation area during a kinematics motion, the kinematics technology object outputs the technology alarm 803. The kinematics motion is aborted and the axes stop with the maximum dynamic values configured for the axes (alarm reaction: Stop with maximum dynamic values of the axes).

- Working area ≤ Transformation area

  When a kinematics axis runs into the software limit switch, the positioning axis/synchronous axis technology object outputs the technology alarm 533. The axis stops with the maximum dynamic values configured for the axis (alarm reaction: Stop with maximum dynamic values). When the axis is stopped, the kinematics technology object outputs the technology alarm 801. The kinematics motion is aborted and the axes stop with the maximum dynamic values configured for the axes (alarm reaction: Stop with maximum dynamic values of the axes).

The following graphic shows the relationship between the working area of the axis and the transformation area:

① Mechanical end stop

② Hardware limit switch for positioning axis/synchronous axis technology object

③ Software limit switch for positioning axis/synchronous axis technology object

④ Maximum traversing range of the axis

⑤ Working area of the axis

⑥ Transformation area
(here working area > transformation area)

7.10.1.3 Joint position spaces (kinematics-dependent)

Depending on the kinematics type, a kinematics can reach Cartesian coordinates via various joint positions. The kinematics type (Page 58) defines the possible joint positions and the positive and negative joint position spaces. The joint position spaces are limited by the respective transformation areas. In addition, with the "Delta picker" kinematics type there are further limitations due to invalid joint positions and singularities (Page 183) with the kinematics types "articulated arm", "SCARA 3D" and "cylindrical robot". Also note the resulting constructional limitations due to the installation location of the kinematics.

The kinematics technology object indicates the current joint position in the "<TO>.StatusKinematics.LinkConstellation" tag.

The kinematics system cannot exit the joint position space during a linear or circular motion. You can change the joint position space using single-axis motions and synchronous "point-to-point" motion (sPTP motion).

Example: Kinematics type "SCARA 3D"

A "SCARA 3D" kinematics is to relocate an object from one pallet to another pallet. Due to a wall, the kinematics system cannot reach the second pallet without the axis A2 changing the joint position space.

The figure below shows the kinematics in the top view (xy plane):

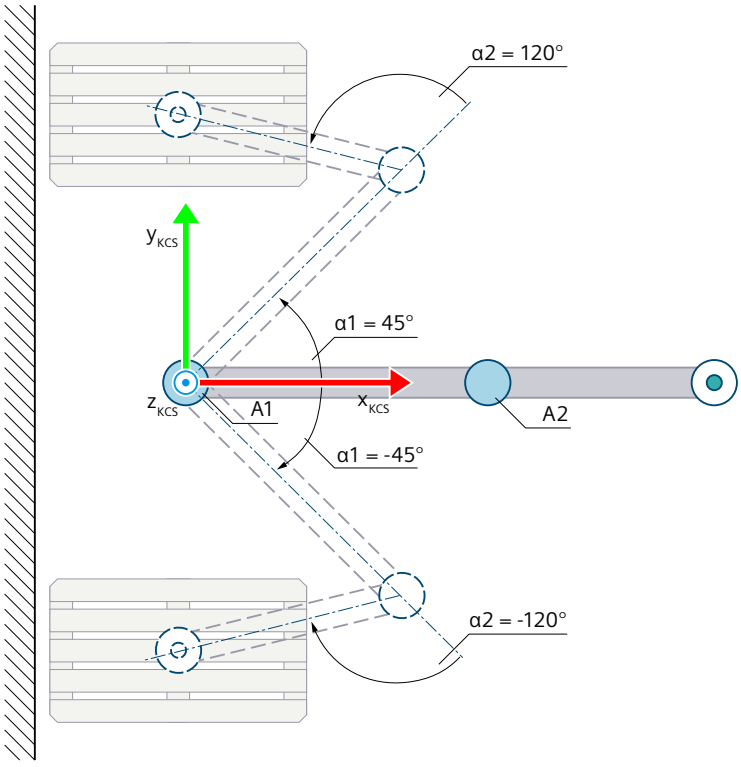

Zero position of the kinematics

Deflection of the kinematics in the positive direction when α1 = 45.0° with positive joint position when α2 = 120.0°
Deflection of the kinematics in the negative direction when α1 = -45.0° with negative joint position when α2 = -120.0°

α1 Deflection of the axis A1 in positive direction when α1 = 45.0°
Deflection of the axis A1 in the negative direction when α1 = -45.0°

α2 The deflection of the axis A2 in the positive direction when α2 = 120.0° produces a positive joint position.
The deflection of the axis A2 in negative direction when α2 = -120.0° produces a negative joint position.

Legend for representation of the kinematics (Page 38)

Example: "Articulated arm 3D" kinematics type

A kinematics "Articulated arm 3D" should move one object from one storage location to another. The kinematics cannot reach the second storage location because of the ceiling without axis A3 changing the joint position space.

The figure below shows the kinematics in the side view (xz plane):

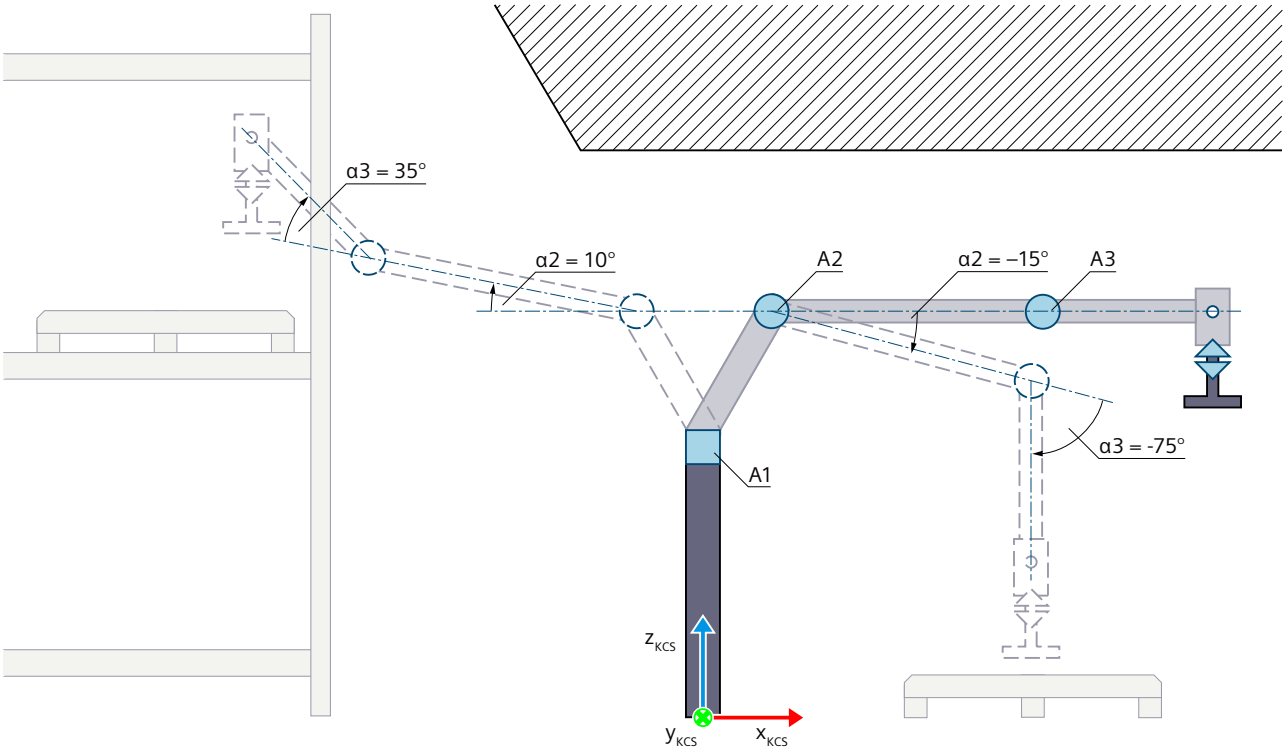

Zero position of the kinematics

Deflection of the kinematics in the positive direction when α2 = 10.0° with positive joint position when α3 = 35.0°
Deflection of the kinematics in the negative direction when α2 = -15.0° with negative joint position when α3 = -75.0°

α2 Deflection of the axis A2 in the positive direction when α2 = 10.0°
Deflection of the axis A2 in negative direction when α2 = -15.0°

α3 The deflection of the axis A3 in positive direction when α3 = 35.0° produces a positive joint position.
The deflection of the axis A3 in negative direction when α3 = -75.0° produces a negative joint position.

Legend for representation of the kinematics (Page 38)

Example: Kinematics type "cylindrical robot"

A kinematics "Cylindrical robot" should move an object from one storage location to another. The kinematics cannot reach the second storage location without axis A3 changing the joint position space.

The figure below shows the kinematics in the top view (xy plane):

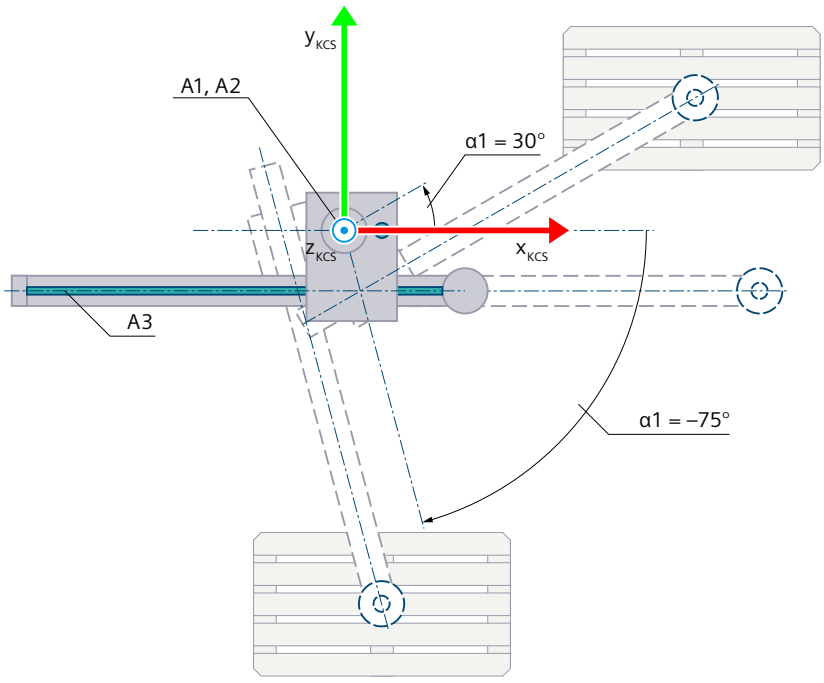

Zero position of the kinematics

Deflection of the kinematics in positive direction when α1 = 30.0°
Deflection of the kinematics in the negative direction when α1 = -75.0°

α1 Deflection of the axis A1 in positive direction when α1 = 30.0°
Deflection of the axis A1 in the negative direction when α1 = -75.0°

Legend for representation of the kinematics (Page 38)

7.10.1.4 Singularities

Depending on the kinematics type, inverse transformation Cartesian coordinates are possible, which cannot be clearly converted into axis positions of the kinematics axes. The Cartesian coordinates at which this behavior occurs are referred to as singularities.

Inner singularities

The inner singularity occurs when the zero point of the flange coordinate system (FCS) is located on the z axis of the kinematics coordinate system (KCS). The following kinematics have inner singularities:

- Articulated arm 3D
- Articulated arm 3D with orientation
- 6-axis articulated arm with central wrist
- 6-axis articulated arm with offset wrist
- SCARA 3D with orientation
- Cylindrical robot 3D
- Cylindrical robot 3D with orientation

Inner singularity using the articulated arm 3D as an example

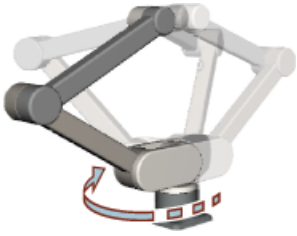

In the vicinity of the inner singularity, a path motion without dynamic adaptation will result in an overrun of the dynamics of the kinematics axis A1 and the kinematics axis A4. This causes the entire kinematics to rotate with an overrun of the dynamics.

Outer singularities

An outer singularity occurs when one or more arms of the kinematics are completely extended or folded. The following kinematics have outer singularities:

- Articulated arm 2D
- Articulated arm 2D with orientation
- Articulated arm 3D
- Articulated arm 3D with orientation
- 6-axis articulated arm with central wrist
- 6-axis articulated arm with offset wrist
- SCARA 3D with orientation
- Delta picker 2D

- Delta picker 2D with orientation
- Delta picker 3D
- Delta picker 3D with orientation
- Delta picker 3D with 2 orientations A, B
- Tripod 3D
- Tripod 3D with orientation

In the vicinity of these singularities a path motion without dynamic adaptation will result in an overrun of the dynamics at the kinematics axes, which can result in oscillations of the entire kinematics as well as excessive forces being applied.

Extended position using the articulated arm 3D as an example

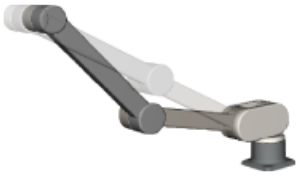

The articulated arm is fully extended and the flange is at the external limit of the maximum possible working range.

Folded position using the articulated arm 3D as an example

The articulated arm is completely folded.

Behavior in the vicinity of a singularity

In the vicinity of a singularity a path motion without dynamic adaptation results in overruns of the dynamics. This means one or more kinematics axes can move at very high speed and accelerate or decelerate with excessive force. The size of the area in which this behavior occurs depends on the kinematics used.

⚠ WARNING

Overrun of the dynamics in the vicinity of a singularity

An overrun of the dynamics in the vicinity of a singularity can result in the following damage:

- Personal injury, for example, caused by products or machine parts coming loose
- Machine damages, for example, through overload of the mechanical components

Take into account the preventive measures described in this section to prevent this behavior.

A path motion through a singularity is not possible. The technology alarm 803 "Error during calculation of the transformation" is output (alarm response: Stop with maximum dynamic values of the axes).

The kinematics system reduces the overruns of the dynamics caused by setpoints to the maximum dynamics of the axis. The reduction of the overruns of the dynamics can result in an unpredictable axis motion.

When the dynamic limits of the kinematics axes are exceeded, this is displayed at the affected kinematics axis with the tag "<TO>.StatusKinematicsMotion" and the technology alarm 511 "Dynamic limit is violated by the kinematics motion" is triggered. The technology alarm 511 does not trigger an alarm response and the kinematics motion is not stopped.

Affected kinematics motions

An overrun of the dynamics in the vicinity of a singularity only occurs for path motions without dynamic adaptation.

An overrun of the dynamics due to a singularity does not occur for the following motions:

- Synchronous point-to-point motion
- Motions in the MCS through the kinematics control panel

Dynamic adaptation in the vicinity of singularities

With movement in the vicinity of singularities with dynamic adaptation without segmentation of the path, dynamics can be significantly limited over the entire motion. Therefore, with motions in the vicinity of singularities, use the dynamic adaptation with segmentation of the path.

Preventive measures to prevent the behavior

By applying the following preventive measures, you can avoid a path motion without dynamic adaptation in the vicinity of a singularity:

1. Avoid the use of conveyor tracking in the vicinity of a singularity. When conveyor tracking is active, singularities are not handled despite active dynamic adaptation (Page 244).
2. Activate Dynamic adaptation (Page 244) for linear or circular motions that are not part of the phases of conveyor tracking.
3. To limit the working area of the kinematics, use zone monitoring or software limit switches at the kinematics axes.
4. Control with the kinematics control panel
   - Move the kinematics in the MCS.
   - In the WCS or OCS, avoid the "Jog" mode.

     The dynamic adaptation is not active in the kinematics control panel. The dynamic limits of the kinematics axes are not taken into account during a kinematics motion with the kinematics control panel.

– Up to technology version V5.0 of the kinematics technology object: In the WCS or OCS, avoid using the "Jog to target position" mode.

  The dynamic adaptation is not active in the kinematics control panel. The dynamic limits of the kinematics axes are not taken into account during a kinematics motion with the kinematics control panel.

– As of technology version V5.0 and higher: Move the kinematics to the "Jog to target position" mode in the WCS or OCS using the kinematics control panel.

  "Dynamic adaptation without segmentation of the path" is permanently active in the "Jog to target position" mode, and the dynamic limits of the kinematics axes are taken into account.

Determining the area with overrun of the dynamics for articulated arm 3D

To empirically determine the area in which overruns of the dynamics occur due to a singularity, use the following functions:

- Kinematics diagnostics
- Kinematics control panel
- Trace
- Virtual or simulated axes

WARNING

Deliberately traveling into the singularity

The following damage may occur due to overruns of the dynamics in the vicinity of a singularity:

- Personal injury, for example, caused by products or machine parts coming loose
- Machine damages, for example, through overload of the mechanical components

Do **not** determine the areas with overrun in the dynamics by moving the actual kinematics.

You **must** configure all kinematics axes as "virtual axis" or "axis in simulation".

Requirements

- All kinematics axes are configured as virtual or simulated axes. The kinematics are interconnected.
- The geometry of the kinematics is configured to match the real kinematics.
- The dynamics for kinematics and all kinematics axes are configured.
- The permitted dynamics are known from the application.
- The tool center point is located at the origin of the FCS.

Determining the distance to the inner singularity

1. Configure a Trace with the following signals:
   - <TOKinematics>.A[1..6].Velocity
   - <TOKinematics>.A[1..6].Acceleration
   - <TOKinematics>.FlangeInKcs.x.Position
   - <TOKinematics>.FlangeInKcs.y.Position
   - <TOKinematics>.FlangeInKcs.z.Position
2. Open the diagnostics of the kinematics and arrange it next to the kinematics control panel.
3. Set the kinematics control panel as follows:
   - Operating mode: Jog
   - Coordinate system: WCS
   - Path velocity: Maximum required path velocity for the process
4. Make sure that all kinematics axes are configured as virtual axes or axes in simulation.
5. Jog the kinematics to a position from which the inner singularity could be reached.
6. Jog the kinematics backward a little (e.g. 1 mm) in y direction so that you can jog slightly past the singularity.
7. Jog the kinematics with maximum path velocity in x direction past the inner singularity and record the signals in the Trace.

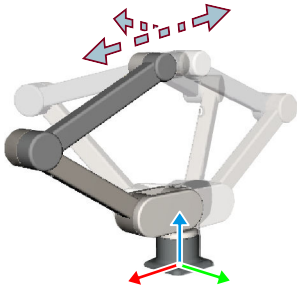

Jog forward and backward in x direction

Jog backward in y direction

8. Gradually increase the distance in y direction to the inner singularity. Repeat step 7.

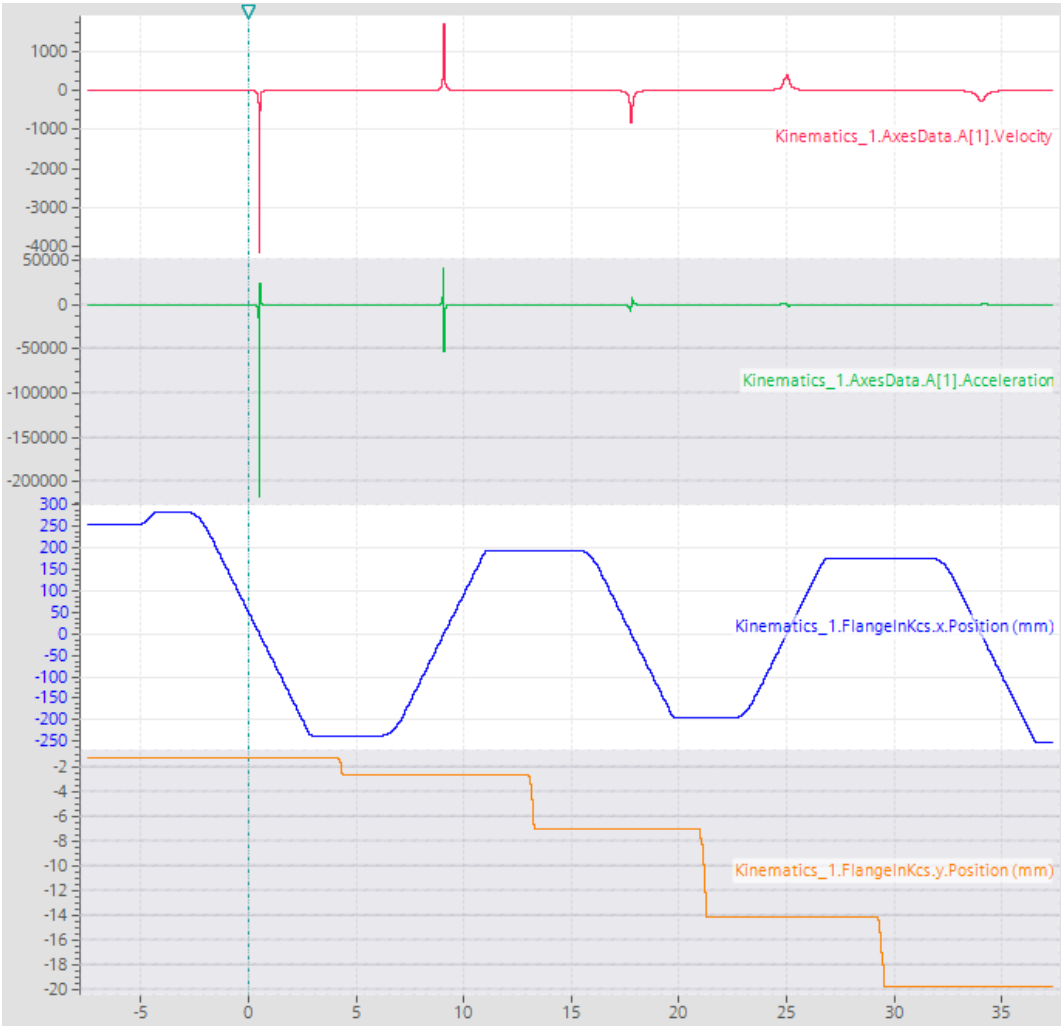

The recorded Trace shows the dynamics of the axis A1 at different distances of the FCS to the inner singularity.

9. Determine the distance on the y-axis at which the dynamics of the kinematics axis A1 is permissible for your process.

   This distance corresponds to the radius of a cylinder around the z axis of the KCS in which overruns of the dynamics occur and the flange must not be moved.

NOTE

Validity of the determined distance

The determined distance only applies to a kinematics with the configured geometry and dynamics.

NOTE

Valid tool

Configure the tool once again so that the tool matches your application.

Limiting the working area with zone monitoring

The Cartesian space that must be excluded from the working area results from the determined distance.

You can find a description of the zone monitoring in section "Zone monitoring (Page 208)".

1. Define a cylindrical blocked zone or signal zone around the z axis of the KCS:
   - Length z: Entire working area of the kinematics
   - Radius: Determined distance
   - x: Position of the KZP in x direction of the WCS
   - y: Position of the KZP in y direction of the WCS

Signal zone	Blocked zone
Useful in case of a major shift of the TCP from the origin of the FCS in x or y direction and when using conveyor tracking	Useful in case of a minor shift of the TCP from the origin of the FCS in x or y direction Not very useful when using conveyor tracking
Individually programmed stop reaction when: – Flange zone violates signal zone – Signal zone violated by TCP	Automatic stop reaction when: – Flange zone violates blocked zone – Blocked zone violated by TCP

2. Define a spherical flange zone:
   - Radius: Distance required for the stop reaction
   - CS: FCS
   - x: 0.0
   - y: 0.0
   - z: 0.0

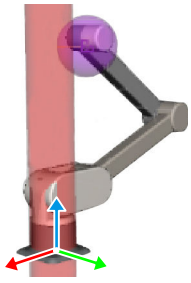

3. When you are using a signal zone, program a stop reaction for the kinematics and any other axes, if necessary.

NOTE

Extended position and folded position

You can also use this procedure to determine the area of the overruns of the dynamics in extended and folded positions and then limit the working area of the kinematics with zones.

7.10.2 Transformation for user-defined kinematics systems

7.10.2.1 User transformation without JCS

Unlike for predefined kinematics types, you must calculate the transformation for user-defined kinematics systems in your own program. Like for predefined kinematics types, the kinematics technology object performs the following tasks:

- Processing of Motion Control instructions
- Monitoring functions
- Communication with the interconnected axes

You program the user transformation of the Cartesian coordinates and the axis-specific setpoints in the MC_Transformation organization block. This programming includes the transformation of the positions and the dynamic values (velocity, acceleration). You freely define the parameters of a user-defined kinematics system in the tags of the kinematics technology object "<TO>.Kinematics.Parameter[1..32]" or under "Technology object > Configuration > Geometry".

When you add the MC_Transformation in the TIA Portal, the system data block "TransformationParameter" is automatically created under "Program blocks > System blocks > Program resources". In the properties of the organization block under "General > Transformation", the MC_Transformation indicates the number of the system data block "TransformationParameter". You write and read the axis-specific data or the Cartesian data of the kinematics to be transformed in the system data block "TransformationParameter".

With the technology version V5.0, longer runtimes of the MC_Interpolator arise during user transformation. With longer runtimes of the MC_Interpolator, the runtimes of the organization blocks with lower priority are extended.

NOTE

Disable system performance improvement

If you are using user-defined kinematics, clear the "Improve system performance" check box in the MC_LookAhead properties under "General > Multi-core processor".

Programming

The graphic below shows the interfaces and the interaction of system performance and user transformation:

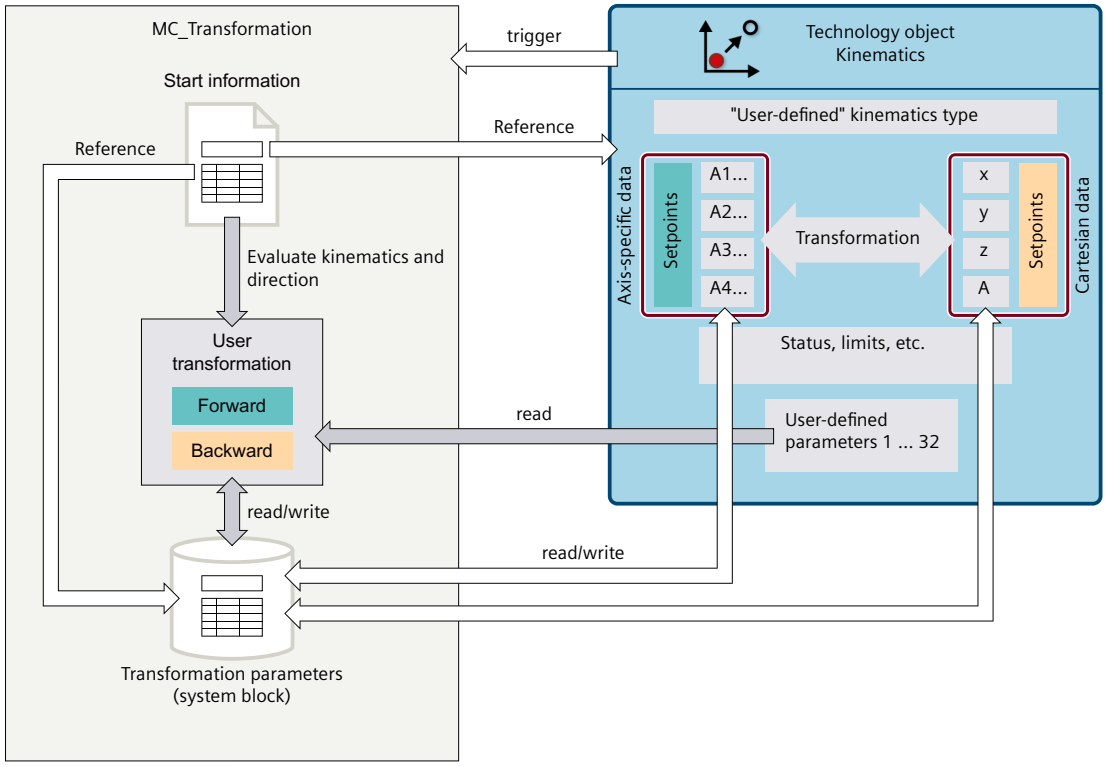

Processing by user program

System performance

The kinematics technology object automatically calls the MC_Transformation. The MC_Transformation contains the following start information:

- Kinematics technology object that calls the MC_Transformation
- Required direction of the transformation (forward or inverse transformation)
- Processing context of the transformation (current motion or motion planning)
- Pointer to the system data block "TransformationParameter" (VARIANT)

You evaluate this status information in your user program. In MC_Transformation, you program the algorithms for the calculation of the axis-specific data or the Cartesian data of all user-defined kinematics systems. You read the kinematics parameters needed for this from the tags of the "<TO>.Kinematics.Parameter[1..32]" technology object. You write the result of the calculation to the "TransformationParameter" interface.

The transformation parameters are then applied automatically to the kinematics technology object and processed further. The kinematics technology object outputs the setpoints to the kinematics axes.

You can configure and apply the user-defined transformation with multiple kinematics technology objects on a PLC. To differentiate in MC_Transformation between the different kinematics technology objects, use the input "KinematicsObject".

7.10.2.2 User transformation with JCS

Unlike for predefined kinematics types, you must calculate the transformation for user-defined kinematics systems in your own program. Like for predefined kinematics types, the kinematics technology object performs the following tasks:

- Processing of Motion Control instructions
- Monitoring functions
- Communication with the interconnected axes

You program the user transformation of the Cartesian coordinates and the joint-specific setpoints in the MC_Transformation organization block without considering inversions and offsets. If the joint directions of movement or the joint zero positions of the kinematics used do not correspond to the programmed user transformation, there are two ways to adapt them:

1. Retain the user transformation. Invert the affected joint directions of movement and joint zero positions in the "Joints" configuration window of the kinematics technology object. In this case, the joint-specific parameters "AxisData" in the system data block "Transformation" are not equal to the joint coordinates ("JointData"). The technology object performs this calculation automatically through the configured offsets and inversions.
2. Change the programmed user transformation in such a way that the calculated joint-specific setpoints from the transformation correspond to the joint coordinate system of the kinematics. In this case, the "AxisData" parameters in the "Transformation" system data block are equal to the joint coordinates ("JointData"). It is not necessary to configure the joint offset.

This programming includes the transformation of the positions and the dynamic values (velocity, acceleration). You freely define the parameters of a user-defined kinematics system in the tags of the kinematics technology object "<TO>.Kinematics.Parameter[1..32]" or under "Technology object > Configuration > Geometry".

When you add the MC_Transformation in the TIA Portal, the system data block "TransformationParameter" is automatically created under "Program blocks > System blocks > Program resources". In the properties of the organization block under "General > Transformation", the MC_Transformation indicates the number of the system data block "TransformationParameter". You write and read the joint-specific data or the Cartesian data of the kinematics to be transformed in the system data block "TransformationParameter".

With the technology version V5.0, longer runtimes of the MC_Interpolator arise during user transformation. With longer runtimes of the MC_Interpolator, the runtimes of the organization blocks with lower priority are extended.

NOTE

Disable system performance improvement

If you are using user-defined kinematics, clear the "Improve system performance" check box in the MC_LookAhead properties under "General > Multi-core processor".

Programming

The graphic below shows the interfaces and the interaction of system performance and user transformation in a kinematics with used JCS:

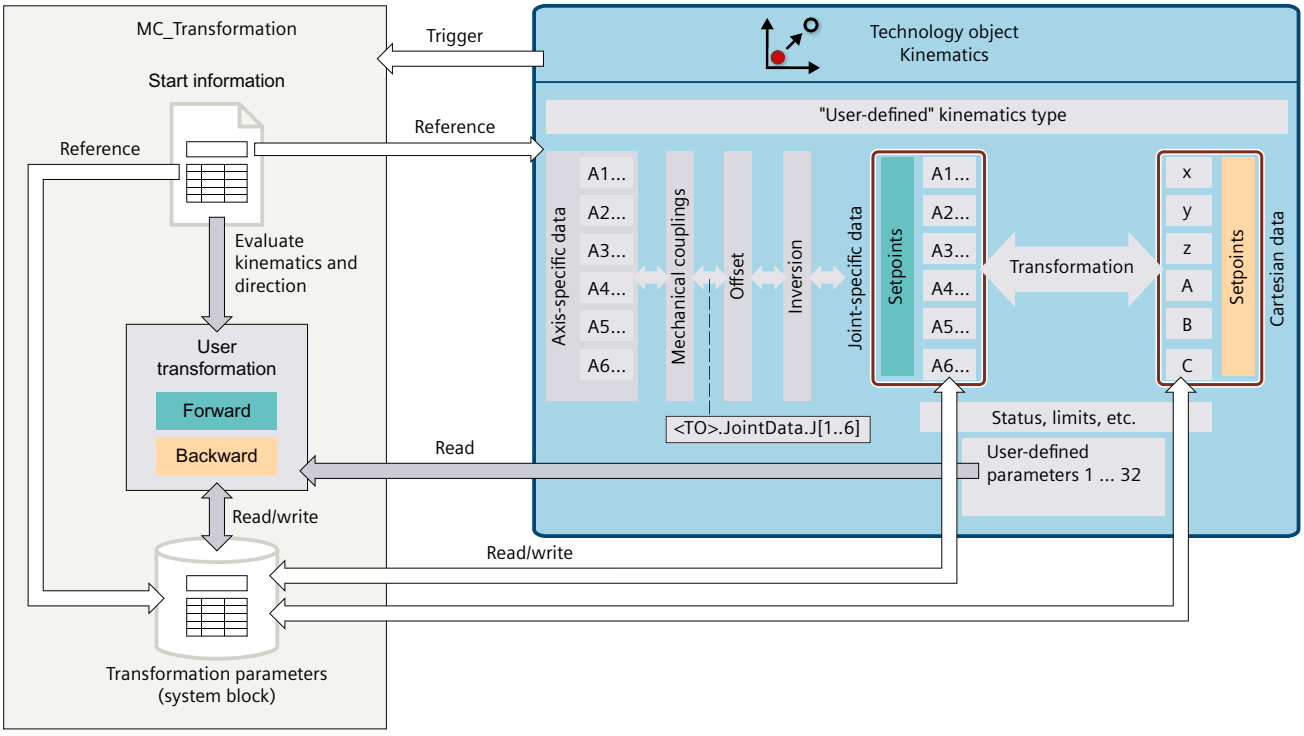

The kinematics technology object automatically calls the MC_Transformation. The MC_Transformation contains the following start information:

- Kinematics technology object that calls the MC_Transformation
- Required direction of the transformation (forward or inverse transformation)
- Processing context of the transformation (current motion or motion planning)
- Pointer to the system data block "TransformationParameter" (VARIANT)

You evaluate this status information in your user program. In MC_Transformation, you program the algorithms for the calculation of the axis-specific data or the Cartesian data of all user-defined kinematics systems. You read the kinematics parameters needed for this from the tags of the "<TO>.Kinematics.Parameter[1..32]" technology object. You write the result of the calculation to the "TransformationParameter" interface.

The transformation parameters are then applied automatically to the kinematics technology object and processed further. The kinematics technology object outputs the setpoints to the kinematics axes.

You can configure and apply the user-defined transformation with multiple kinematics technology objects on a PLC. To differentiate in MC_Transformation between the different kinematics technology objects, use the input "KinematicsObject".

NOTE
Inverse transformation
In the inverse transformation, only the basic joint range "TurnJoint" = 0 needs to be programmed. The technology object automatically calculates the sPTP motions for the joint position ranges outside of the basic joint range "TurnJoint" ≠ 0.

7.10.2.3 MC_Transformation [OB98]

Reference declaration for system data block "TransformationParameter"

You must specify a reference to the data type for the system data block "TransformationParameter" in the MC_Transformation. For this purpose, you specify a tag with the following data type in the "Temp" area of the block interface:

"REF_TO TO_Struct_TransformationParameter_V2"

To enable access to the system data block "TransformationParameter", assign the data type "TO_Struct_TransformationParameter_V2" using the following casting command:

```
#P ?= #TransformationParameters;
```

The declaration is described in a program example (Page 197).

Block call

The MC_Transformation is called in the Motion Control application cycle according to the configured priority. When the MC_Transformation is called, the kinematics technology object assigns its parameters:

Parameter	Declaration	Data type	Default value	Description	
KinematicsObject	INPUT	DB_ANY	-	Kinematics technology object for which the MC_Transformation calculates the transformation when called.	
ExecutionContext	INPUT	DINT	-	Processing context of the MC_Transformation OB	
				0	MOTION_EXECUTION Calculation of the axis setpoints in the motion execution in the MC_Interpolator. The calculated values are necessary for the current motion control.
				1	NON_MOTION_EXECUTION The transformation is necessary for the motion planning (currently no motion).
TransformationType	INPUT	DINT	-	Calculation called for	

Parameter	Declaration	Data type	Default value	Description	
TransformationType	INPUT	DINT	-	0	Forward transformation Calculation of the Cartesian parameters from the axis positions
				1	Inverse transformation Calculation of the axis-specific parameters from the Cartesian parameters
TransformationParameters	InOut	VARIANT	-	Pointer to the system data block "TransformationParameter"	
FunctionResult	OUTPUT	DINT	-	Return value of the MC_Transformation to the kinematics technology object	
				0	Calculation performed and parameters output
				≠ 0	Error during calculation (user-defined) If an error occurs during the calculation, the kinematics technology object stops the motion. The kinematics technology object outputs a technology alarm with the error ID as an accompany value and deletes the job sequence. The value can be greater than or less than zero.

Priority

You configure the priority of the MC_Transformation in the properties of the organization block under "General > Attributes > Priority". For the priority you can set values from 17 to 25 (default setting 25):

- The priority of MC_Transformation must be at least one level lower than the priority of MC_Servo.
- The priority of MC_Transformation must be at least one level higher than the priority of MC_Interpolator.

Tags of the system data block "TransformationParameter"

The following table shows the tags in the system data block "TransformationParameter":

NOTE

If JCS is used, the "AxisData" tags are to be interpreted as joint-specific setpoints.

Tag	Data type	Description	
AxisData.	STRUCT_ Transformation AxisData_V2	JCS not used: Axis-specific parameters	JCS used: Joint-specific parameters without consideration of inversions and offsets
a1Position	LREAL	Position setpoint of the axis A1	Position setpoint of the joint J1
a1Velocity	LREAL	Velocity setpoint of the axis A1	Velocity setpoint of the joint J1
a1Acceleration	LREAL	Acceleration setpoint of the axis A1	Acceleration setpoint of the joint J1
a2Position	LREAL	Position setpoint of the axis A2	Position setpoint of the joint J2

Tag	Data type	Description	
a2Velocity	LREAL	Velocity setpoint of the axis A2	Velocity setpoint of the joint J2
a2Acceleration	LREAL	Acceleration setpoint of the axis A2	Acceleration setpoint of the joint J2
a3Position	LREAL	Position setpoint of the axis A3	Position setpoint of the joint J3
a3Velocity	LREAL	Velocity setpoint of the axis A3	Velocity setpoint of the joint J3
a3Acceleration	LREAL	Acceleration setpoint of the axis A3	Acceleration setpoint of the joint J3
a4Position	LREAL	Position setpoint of the axis A4	Position setpoint of the joint J4
a4Velocity	LREAL	Velocity setpoint of the axis A4	Velocity setpoint of the joint J4
a4Acceleration	LREAL	Acceleration setpoint of the axis A4	Acceleration setpoint of the joint J4
a5Position	LREAL	Position setpoint of the axis A5	Position setpoint of the joint J5
a5Velocity	LREAL	Velocity setpoint of the axis A5	Velocity setpoint of the joint J5
a5Acceleration	LREAL	Acceleration setpoint of the axis A5	Acceleration setpoint of the joint J5
a6Position	LREAL	Position setpoint of the axis A6	Position setpoint of the joint J6
a6Velocity	LREAL	Velocity setpoint of the axis A6	Velocity setpoint of the joint J6
a6Acceleration	LREAL	Acceleration setpoint of the axis A6	Acceleration setpoint of the joint J6
CartesianData	STRUCT_ Transformation CartesianData _V2	Cartesian parameters and joint position space	
xPosition	LREAL	x position	
xVelocity	LREAL	x velocity	
xAcceleration	LREAL	x acceleration	
yPosition	LREAL	y position	
yVelocity	LREAL	y velocity	
yAcceleration	LREAL	y acceleration	
zPosition	LREAL	z position	
zVelocity	LREAL	z velocity	
zAcceleration	LREAL	z acceleration	
aPosition	LREAL	A-position (orientation)	
aVelocity	LREAL	A velocity (orientation)	
aAcceleration	LREAL	A acceleration (orientation)	
bPosition	LREAL	B position (orientation)	
bVelocity	LREAL	B velocity (orientation)	
bAcceleration	LREAL	B acceleration (orientation)	
cPosition	LREAL	C position (orientation)	
cVelocity	LREAL	C velocity (orientation)	
cAcceleration	LREAL	C acceleration (orientation)	
LinkConstellation	DWORD	Joint position space	

7.10.2.4 Program example for a user-defined kinematics systems

An example of user transformation in the MC_Transformation (Page 194) of a 2D kinematics with the name "KinematicsUserDefined2D" is described below. For these kinematics, two transformation parameters were defined under "Technology object > Configuration > Geometry".

The interaction of system performance and user transformation is displayed in the figure in section "User transformation without JCS (Page 190)".

The following table shows the declaration of the tags used:

Tag	Declaration	Data type	Description	
KinematicsObject	Input	DB_ANY	Reference to the technology object	
TransformationType	Input	DInt	Transformation direction	
			0	Forward transformation
			1	Inverse transformation
FunctionResult	Output	DInt	Transformation result	
			0	Successful
			< 0	Error
TransformationParameters	InOut	Variant	Reference to the system data block "TransformationParameter" in the MC_Transformation	
P	Temp	REF_TO TO_Struct_TransformationParameter_V2	Temporary tag for the casting command	
GearRatioA1	Temp	LReal	Temporary tag for read the defined transformation parameters	
GearRatioA2	Temp	LReal	Temporary tag for read the defined transformation parameters	
InvalidCast	Constant	DInt	Return value for an unsuccessful casting command	

The program example is structured as follows:

- Casting command for access to the system data block "TransformationParameter"
- Evaluation of the technology object
- Read the defined transformation parameters
- Evaluation of the transformation direction
- Calculation of the Cartesian coordinates from the axis positions of the kinematics axes (forward transformation)
- Calculation of the axis positions of the kinematics axes from the Cartesian coordinates (backward transformation)

First, the example program is explained step by step. The program code is summarized in the section "Program example".

Casting command for access to the system data block "TransformationParameter"

The casting command enables access the transformation parameters defined in the configuration.

The variant pointer is passed on to the temporary tag using the casting command.

```
#P ?= #TransformationParameters;
```

It is then tested whether the casting command was successful. This means that the specified InOut tag "TransformationParameters" has the expected structure of type "TO_Struct_TransformationParameter_V1".

If the casting command was not successful, the calculation is canceled and the tag "FunctionResult" gets the value "InvalidCast".

```
IF #P = NULL THEN
    #FunctionResult := #InvalidCast;
    RETURN;
END_IF;
```

Evaluation of the technology object

An IF query is used to evaluate whether the user-defined kinematics requires the transformation defined below.

```
IF #KinematicsObject = "KinematicsUserDefined2D" THEN
```

Read the defined transformation parameters

First, the transformation parameters defined in the configuration are read out. Two gears ratios were defined in this example.

```
    #GearRatioA1 := "KinematicsUserDefined2D".Kinematics.Parameter[1];
    #GearRatioA2 := "KinematicsUserDefined2D".Kinematics.Parameter[2];
```

Evaluation of the transformation direction

The transformation direction is evaluated in the next step. If the tag "TransformationType" has the value "0", the forward transformation is calculated. If the tag has the value "1", the backward transformation is calculated.

```
    IF #TransformationType = 0 THEN
```

Calculation of the Cartesian coordinates from the axis positions of the kinematics axes (forward transformation)

In the forward transformation, Cartesian data (position, velocity and acceleration) are calculated from the axis data. The forward transformation is first calculated in x direction and then in z direction.

```
#P^.CartesianData.xPosition := #P^.AxisData.a1Position * #GearRatioA1;
#P^.CartesianData.xVelocity := #P^.AxisData.a1Velocity * #GearRatioA1;
#P^.CartesianData.xAcceleration := #P^.AxisData.a1Acceleration * #GearRatioA1;

#P^.CartesianData.zPosition := #P^.AxisData.a2Position * #GearRatioA2;
#P^.CartesianData.zVelocity := #P^.AxisData.a2Velocity * #GearRatioA2;
#P^.CartesianData.zAcceleration := #P^.AxisData.a2Acceleration * #GearRatioA2;
```

The specification of the joint position space is not required in this example. The corresponding tag is set to zero.

```
#P^.CartesianData.LinkConstellation := 16#0000;
```

If the transformation is successful, the tag "FunctionResult" receives the value "0".

```
#FunctionResult := 0;
```

Calculation of the axis positions of the kinematics axes from the Cartesian coordinates (backward transformation)

In the backward transformation, axis data (position, velocity and acceleration) are calculated from the Cartesian data. The backward transformation is first calculated for axis A1 and then for axis A2.

```
    ELSIF #TransformationType = 1 THEN

        #P^.AxisData.a1Position := #P^.CartesianData.xPosition / #GearRatioA1;
        #P^.AxisData.a1Velocity := #P^.CartesianData.xVelocity / #GearRatioA1;
        #P^.AxisData.a1Acceleration := #P^.CartesianData.xAcceleration / #GearRatioA1;

        #P^.AxisData.a2Position := #P^.CartesianData.zPosition / #GearRatioA2;
        #P^.AxisData.a2Velocity := #P^.CartesianData.zVelocity / #GearRatioA2;
        #P^.AxisData.a2Acceleration := #P^.CartesianData.zAcceleration / #GearRatioA2;
```

If the transformation is successful, the tag "FunctionResult" receives the value "0".

```
        #FunctionResult := 0;

    END_IF;
END_IF;
```

Program example

The program example is summarized with Commentary in the following section:

SCL

```
//Cast of the variant "TransformationParameters" to the referenced datatype
//"TO_Struct_TransformationParameter_V2".
//This has to be done in order to access the variant pointer, which references
//the "TransformationParameters" where the "AxisData" and "CartesianData" for
//the calculation of user transformation are stored.
#P ?= #TransformationParameters;
```

SCL

```
//Check if cast of "TransformationParameters" was successfull. Otherwise abort calculation.
IF #P = NULL THEN
    #FunctionResult := #InvalidCast;
    RETURN;
END_IF;

//Check if "KinematicsUserDefined2D" needs transformation.
IF #KinematicsObject = "KinematicsUserDefined2D" THEN

    //Read the user defined cartesian parameters.
    #GearRatioA1 := "KinematicsUserDefined2D".Kinematics.Parameter[1];
    #GearRatioA2 := "KinematicsUserDefined2D".Kinematics.Parameter[2];

    //Calculate the forward transformation "AxisData" -> "CartesianData".
    //The system fills the "AxisData" of "TransformationParameters" with values.
    //To calculate the "CartesianData" evaluate "AxisData".
    IF #TransformationType = 0 THEN

        //Calculate the position, velocity and acceleration component for the x-vector.
        #P^.CartesianData.xPosition := #P^.AxisData.a1Position * #GearRatioA1;
        #P^.CartesianData.xVelocity := #P^.AxisData.a1Velocity * #GearRatioA1;
        #P^.CartesianData.xAcceleration := #P^.AxisData.a1Acceleration * #GearRatioA1;

        //Calculate the position, velocity and acceleration component for the z-vector.
        #P^.CartesianData.zPosition := #P^.AxisData.a2Position * #GearRatioA2;
        #P^.CartesianData.zVelocity := #P^.AxisData.a2Velocity * #GearRatioA2;
        #P^.CartesianData.zAcceleration := #P^.AxisData.a2Acceleration * #GearRatioA2;

        //Link constellation can be set to 0 here, hence it is not needed.
        #P^.CartesianData.LinkConstellation := 16#0000;

        //Transformation was successfull.
        #FunctionResult := 0;

    //Calculate the backward transformation "CartesianData" -> "AxisData".
    //The system fills the "CartesianData" of "TransformationParameters" with values.
    //To calculate the "AxisData" evaluate "CartesianData".
    ELSIF #TransformationType = 1 THEN

        //Calculate the position, velocity and acceleration component for the first axis.
        #P^.AxisData.a1Position := #P^.CartesianData.xPosition / #GearRatioA1;
        #P^.AxisData.a1Velocity := #P^.CartesianData.xVelocity / #GearRatioA1;
        #P^.AxisData.a1Acceleration := #P^.CartesianData.xAcceleration / #GearRatioA1;

        //Calculate the position, velocity and acceleration component for the second axis.
        #P^.AxisData.a2Position := #P^.CartesianData.zPosition / #GearRatioA2;
        #P^.AxisData.a2Velocity := #P^.CartesianData.zVelocity / #GearRatioA2;
        #P^.AxisData.a2Acceleration := #P^.CartesianData.zAcceleration / #GearRatioA2;

        //Transformation was successfull.
        #FunctionResult := 0;

    END_IF;
END_IF;
```

Check the validity of the transformation/cartesian values

Check the "<TO>.StatusKinematics.Valid" bit cyclically, e.g. in the MC_PostServo. If "<TO>.StatusKinematics.Valid" shows the value "FALSE", then the Cartesian values are invalid. In this case, initiate a stop action, for example, with the Motion Control instruction "MC_GroupStop".

Check the setpoint specification of the Cartesian values and the programmed user transformation.

7.10.3 Tags: Kinematics transformation

The following tags of the kinematics technology object are relevant for the kinematics transformation:

Tag	Description	
Status values		
<TO>.StatusKinematics.Valid	TRUE	Transformation/Cartesian values valid
	FALSE	Transformation/Cartesian values invalid
<TO>.StatusKinematics.LinkConstellation	Joint position space	
<TO>.FlangeInKcs	Current transformation frame (with dynamics, setpoint reference)	

Kinematics functions 8

8.1 Offset and rotation of the coordinate system

You can define the following frames in the configuration for a technology object kinematics:

Frame	Description
KCS frame	Position of the kinematics coordinate system (KCS) in the world coordinate system (WCS)
OCS1..3 frame	Position of the object coordinate systems 1 to 3 (OCS1..3) in the WCS
Tool frame	Position of the tool coordinate system (TCS) in the FCS

The position of the frames is determined by the offset and the rotation in the reference coordinate system.

Offset

You use the shift to define the position of the zero point of a coordinate system or a zone within the reference coordinate system. You specify the offset in Cartesian coordinates.

The following table shows the definition of the offset:

Value in the frame	Description
x	Shift in the x direction in the reference coordinate system
y	Shift in the y direction in the reference coordinate system
z	Shift in the z direction in the reference coordinate system

Rotation

You use the rotation to define the orientation of a coordinate system or a zone within the reference coordinate system. The rotation is made up of three successive individual rotations around the axes of the coordinate system which you define using three Euler angles. The individual rotations depend on each other.

The following graphic shows the three successive rotations using a cuboid zone as an example:

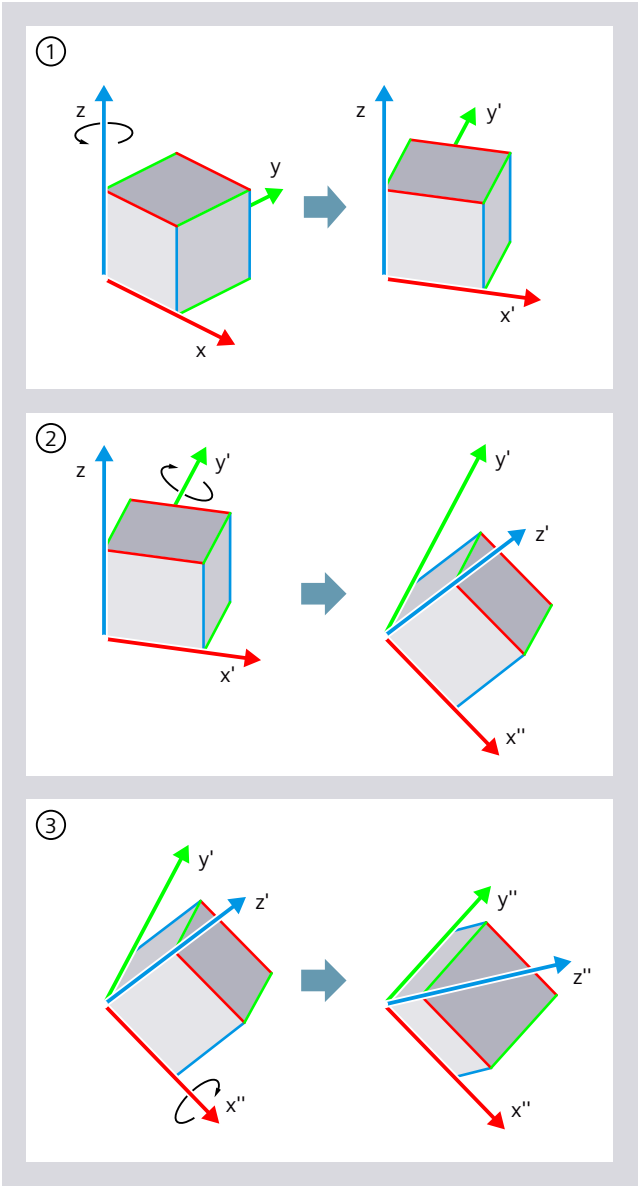

① Rotation A

② Rotation B

③ Rotation C

The following table shows the definition of the rotations:

Rotation	Description
Rotation A	Euler angle of the first rotation A positive angle corresponds to a clockwise rotation around the z axis of the coordinate system. The coordinate system rotated once consists of the axes x', y' and z.
Rotation B	Euler angle of the second rotation A positive angle corresponds to a clockwise rotation around the rotated y' axis. The coordinate system rotated twice consists of the axes x'', y' and z'.
Rotation C	Euler angle of the third rotation A positive angle corresponds to a clockwise rotation around the rotated x'' axis. The coordinate system rotated three times consists of the axes x'', y'' and z''. The x'', y'' and z'' axes correspond to the x, y and z axes of the rotated coordinate system or of the rotated zone.

8.1.1 Define KCS/OCS frame

You have the following options to define KCS and OCS frames:

- Offline, you define the KCS/OCS frames in the following configuration windows:
  - You define the position of the KCS in the WCS in the "Extended parameters > Kinematics coordinate system" configuration window.
  - You define the position of the OCS in the WCS in the "Extended parameters > Object coordinate system" configuration window.
- Use the "MC_SetOcsFrame (Page 448)" Motion Control instruction to define the position of an OCS in the WCS during runtime.

Configurable coordinates and value ranges

Since the kinematics types support different numbers of degrees of freedom, enter only the values that are relevant and permissible for your kinematics type.

The following table shows you the values that you can specify during configuration (✓) and their valid value ranges.

Kinematics type	KCS/OCS frame					
	Offset			Rotation		
	x	y	z	A	B	C
2D	✓	0.0	✓	0.0	✓ -180.0° to 179.999°	0.0
2D with orientation	✓	0.0 [1]	✓	0.0[2]	0.0	0.0

[1] For the kinematics type "SCARA 2D", an offset in the y direction is permissible.

[2] For the kinematics type "SCARA 2D", a rotation around A is permissible.

Value = 0.0: Offset/rotation not permitted or not relevant

Kinematics type	KCS/OCS frame					
	Offset			Rotation		
	x	y	z	A	B	C
3D	✓	✓	✓	✓ -180.0° to 179.999°	✓ -90.0° to 90.0°	✓ -180.0° to 179.999°
3D with orientation	✓	✓	✓	✓ -180.0° to 179.999°	0.0	0.0
3D with 2 orientations A, B	✓	✓	✓	✓ -180.0° to 179.999°	0.0	0.0
3D with 3 orientations **6-axis articulated arm with central wrist, 6-axis articulated arm with offset wrist**	✓	✓	✓	✓ -180.0° to 179.999°	✓ -90.0° to 90.0°	✓ -180.0° to 179.999°

1) For the kinematics type "SCARA 2D", an offset in the y direction is permissible.

2) For the kinematics type "SCARA 2D", a rotation around A is permissible.

Value = 0.0: Offset/rotation not permitted or not relevant

Defining the KCS frame offline

To define the KCS frame, enter the offset and rotation of the kinematics zero point in the WCS in the "Kinematics coordinate system" configuration window.

Defining the OCS frame offline

You configure the OCS frames as follows in the "Extended parameters > Object coordinate systems" configuration window:

1. Select the OCS to be defined in the "Object coordinate system (OCS)" drop-down list. You can define up to three object coordinate systems.
2. To define an OCS frame, enter the values for the offset and rotation.
3. The status of the configuration is shown via the following symbols for each OCS:
   - OCS frame is not defined. (default value)
   - Configuration is valid.
   - Configuration is incomplete or incorrect.

Calibrate OCS

Calibration (Page 355) enables you to determine the exact position of an OCS in the WCS in online or offline mode or check the defined position of an OCS.

Define OCS frames with Motion Control instructions

In an "MC_SetOcsFrame (Page 448)" Motion Control instruction, you define an OCS frame with the following parameters:

- Enter the value for offset and rotation of the OCS in the WCS in the "Frame" parameter.
- Enter the object coordinate system OCS1, OCS2 or OCS3 in the "OcsNumber" parameter.

8.1.2 Define tool frames

You have the following options to define tool frames:

- You can define the tool frames for up to three tools offline in the "Extended parameters > Tools" configuration window.
- You define the tool frame for Tool 1 with the "MC_DefineTool (Page 445)" Motion Control instruction during runtime.

Configurable coordinates and value ranges

Since the kinematics types support different numbers of degrees of freedom, define only the values that are relevant and permissible for your kinematics type.

The following table shows you the values that you can specify during configuration (✓) and their valid value ranges.

Kinematics type	Tool frame					
	Offset			Rotation		
	x	y	z	A	B	C
2D	✓	0.0	✓	0.0	0.0	0.0
2D with orientation	0.0	0.0	✓	✓ -180.0° to 179.999°	0.0	0.0
3D	✓	✓	✓	0.0	0.0	0.0
3D with orientation	✓	✓	✓	✓ -180.0° to 179.999°	0.0	0.0
3D with 2 orientations A, B	✓	✓	✓	0.0	✓ -180.0° to 179.999°	0.0
3D with 3 orientations	✓	✓	✓	✓ -180.0° to 179.999°	✓ -90.0° to 90.0°	✓ -180.0° to 179.999°
6-axis articulated arm with central wrist, 6-axis articulated arm with offset wrist						

Value = 0.0: Offset/rotation not permitted

Defining tool frames offline

You configure the tool frames as follows in the "Extended parameters > Tools" configuration window:

1. Select the tool to be defined in the "Tool" drop-down list. You can define up to three tools.
2. To define a frame, enter the values for the offset and rotation.
3. The status of the configuration is shown via the following symbols for each tool:
   - Tool frame is not defined. (default value)
   - Configuration is valid.
   - Configuration is incomplete or incorrect.

Define tool frame with Motion Control instructions

Enter the values for offset and rotation of the tool frame for Tool 1 in the "Frame" parameter in an "MC_DefineTool (Page 445)" Motion Control instruction.

Example

Tool frame with a kinematics "Delta picker 3D with 2 orientations A, B"

The following example shows a possible definition of the tool frame with a kinematics "Delta picker 3D with 2 orientations A, B". The tool is rotated by B = -90° in relation to the FCS and is shifted in direction x and z.

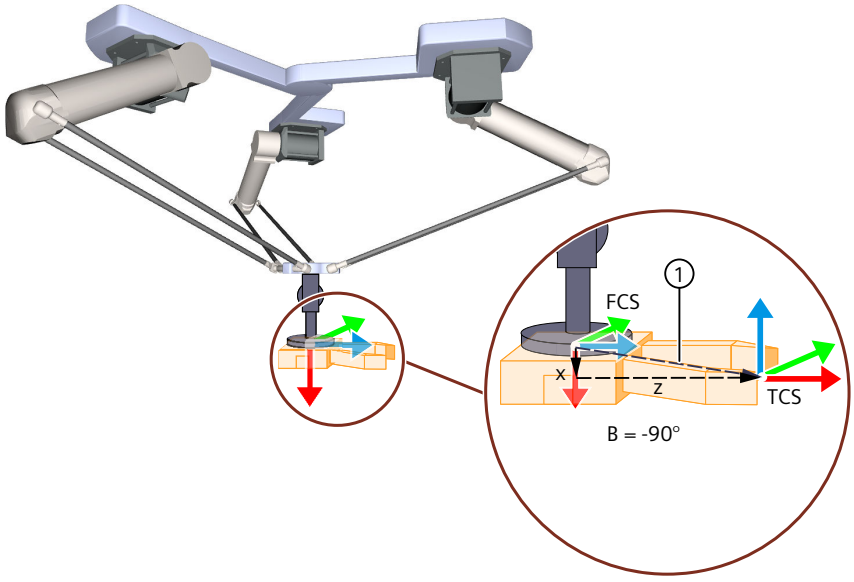

① Tool frame

8.1.3 Tags: Coordinate systems and frames

The following tags of the kinematics technology object are relevant for coordinate systems and frames:

Tag	Description
Configuration	
<TO>.KcsFrame	KCS frame x, y, z, A, B, C
<TO>.OcsFrame[1..3]	OCS frame x, y, z, A, B, C
<TO>.Tool[1..3]	Tool frame x, y, z, A, B, C
Status values	
<TO>.Tcp	Position of the tool center point (TCP), TCP frame in the world coordinate system (WCS). x, y, z, A, B, C
<TO>.TcpInWcs	Parameter for tool center point in the world coordinate system x, y, z, A, B, C
<TO>.TcpInOcs[1..3]	Parameter for the tool center point (TCP) in the Object Coordinate Systems 1 to 3 (OCS) x, y, z, A, B, C
<TO>.FlangeInKcs	Parameter for the flange coordinate system (FCS) in the kinematics coordinate system (KCS) x, y, z, A, B, C
<TO>.StatusOcsFrame[1..3]	Display of the OCS frames x, y, z, A, B, C

8.2 Zone monitoring

The zone monitoring has the following purposes:

- Protection from collisions with mechanical installations
- Triggering of process-related actions (signal zones)

⚠ WARNING

Inappropriate use of zone monitoring

Zone monitoring is not suitable for preventing personal injury.

1. Implement suitable protective measures to prevent personal injury, e.g. protective fences or safety doors.
2. Use safety functions for safe monitoring of the kinematics, for example, with SIMATIC Safe Kinematics.

Zones

Zones are geometric bodies you can use to describe and subdivide the workspace of a kinematics system. You can configure the following zones on the kinematics technology object:

- **Workspace zones**

  Workspace zones describe the environment of a kinematics system. You can configure the following zone types as workspace zones for the kinematics technology object:

  – Work zone

    With work zones, you limit the possible travel space of the kinematics or define several possible work areas.

  – Signal zone

    Signal zones are areas within the traversing space of the kinematics. Signal zones indicate the following:

    • Kinematics zone is entering the signal zones

    • Kinematics zone is located in the signal zone

  – Blocked zone

    Blocked zones are areas within the traversing space of the kinematics in which a kinematics zone must not enter (e.g. control cabinet, protective wall).

- **Kinematics zones**

  Kinematics zones envelope the end point of a kinematics system (flange or tool).

  Kinematics zones are related to the working point/flange of a kinematics and move with the kinematics. The zone monitoring checks the kinematics zones for penetration with workspace zones. With kinematics zones, you expand the monitored area beyond the tool center point (TCP). The tool center point (TCP) is permanently defined as the first kinematics zone (<TO>.KinematicsZone[1]) and always activated.

  You can configure the following zone types as kinematics zones for the kinematics technology object:

  – Tool zone

    Tool zones envelope the tool or parts of the tool.

  – Flange zone

    Flange zones envelope the flange or parts of the flange.

The following example shows how the zone types of a kinematics are used:

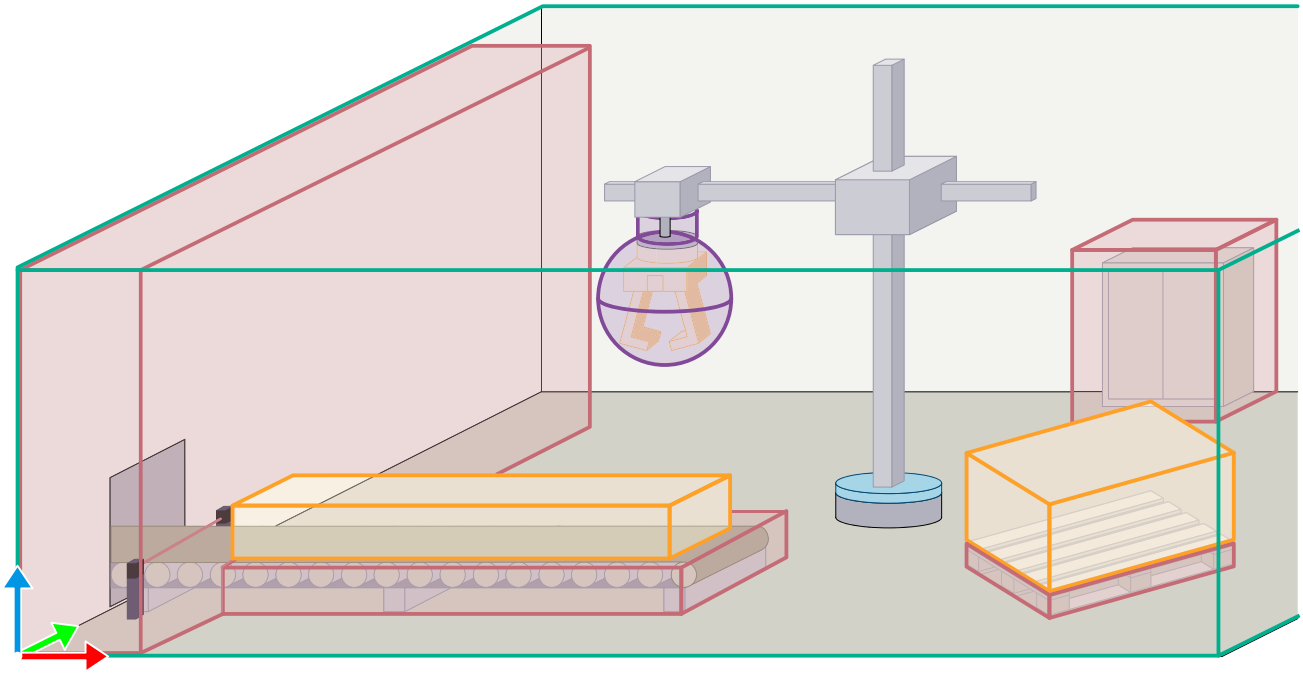

Workspace zones

- Work zone
- Signal zone
- Blocked zone

Kinematics zones

- Flange zone and tool zone

See also

Zones status (Page 342)
Tags: Zone monitoring (Page 223)
Defining workspace zones (Page 211)
Defining kinematics zones (Page 212)
SIMATIC Safe Kinematics (https://support.industry.siemens.com/cs/ww/en/view/109983768)

8.2.1 Defining zones

8.2.1.1 Structure of the "Zones" configuration window

The "Zones" configuration window is divided into the following areas:

- Graphic view

  The workspace zones or the kinematics zones, which you define in the tabular editor, are displayed in the graphic view. You operate the 3D visualization via the toolbar. For more information about operating the toolbar and the graphic display, refer to the section "3D visualization (Page 310)".
- Tabular editor of the workspace zones

  You configure the workspace zones (Page 211)here.
- Tabular editor of the kinematics zones
- You configure the kinematics zones (Page 212)here.

Online view

When you click on the symbol, values of the workspace zones and the kinematics zones at the current point in time are read back from the CPU. When you click the icon in the "Number" column, two additional rows are displayed. The additional rows contain the following values:

- Start values of the CPU
- Start values in project

  You can edit these values. If you want to apply the change, load the changes from the project into the device.

8.2.1.2 Defining workspace zones

You have the following options to define workspace zones:

- You can define workspace zones offline in the "Extended parameters > Zones > Workspace zones (Page 211)" configuration window.
- Via the Calibration (Page 355), you can define workspace zones in online and offline mode.
- With the "MC_DefineWorkspaceZone" (Page 435) Motion Control instruction, you define workspace zones during runtime.

Parameter inputs

You define the following parameters for a workspace zone:

- Defining a zone number for a zone (Page 214)
- Defining the zone type for a workspace zone (Page 214)
- Defining a reference coordinate system for a zone (Page 215)
- Defining the zone geometry (Page 216)

- Defining the offset and rotation in the reference coordinate system (Page 219)
- Activating zone monitoring (Page 219)

8.2.1.3 Defining kinematics zones

You have the following options to define kinematics zones:

- You can define kinematics zones offline in the "Extended parameters > Zones > Workspace zones (Page 211)" configuration window.
- With the "MC_DefineKinematicsZone" (Page 437) Motion Control instruction, you define kinematics zones during runtime.

Parameter inputs

You define the following parameters for a kinematics zone:

- Defining a zone number for a zone (Page 214)
- Defining the zone geometry (Page 216)
- Defining a reference coordinate system for a zone (Page 215)
- Defining the offset and rotation in the reference coordinate system (Page 219)
- Activating zone monitoring (Page 219)

Tool changeover

If you wish to define and use more than one tool, check whether the dimensions of a tool zone are suitable for all tools and envelop them. Otherwise, create a separate zone for each of the tools dimensioned differently.

Example of tool zone

You define tool zones in the tool coordinate system (TCS). The following graphic shows a spherical tool zone:

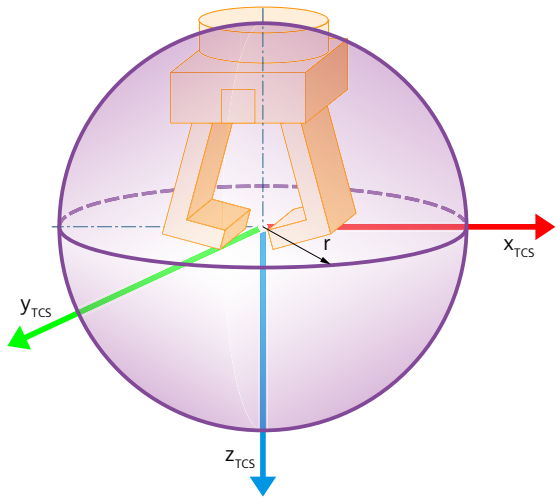

Example of flange zone

You define flange zones in the flange coordinate system (FCS). The following graphic shows a cylindrical flange zone:

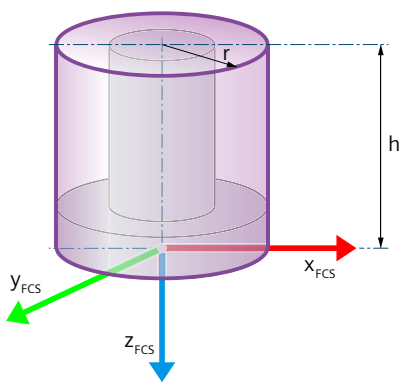

In this example, a shift by the height of the flange zone in negative z direction of the FCS has been defined.

8.2.1.4 Defining a zone number for a zone

You can define the following number of zones:

- Up to 10 workspace zones
- Up to 9 kinematics zones

Zone number in the tabular editor

If you define a zone in the kinematics configuration window under "Extended parameters > Zones > Workspace zones" or "Extended parameters > Zones > Kinematics zones", the zone number is specified by the respective line in which you define a zone.

Motion Control instructions

Specify the zone number in the "ZoneNumber" parameter in an "MC_DefineWorkspaceZone" or "MC_DefineKinematicsZone" Motion Control instruction.

8.2.1.5 Defining the zone type for a workspace zone

You can define the following zone types:

- **Work zone**

  You can specify several work zones.

  Only one work zone can be activated at a given time. If no work zone is activated, the entire traversing space of the kinematics is regarded as the work area.

  Kinematics zones must be located within work zones.
- **Signal zone**

  You can specify several signal zones. Multiple signal zones can be activated at the same time.

  Signal zones can be located outside the work zone to some extent.
- **Blocked zone**

  You can specify several blocked zones. Multiple blocked zones can be activated at the same time.

  Blocked zones can be located outside the work zone to some extent.

Selecting a zone type

Select the zone type in the "Zone type" column.

Motion Control instruction

Specify the zone type in the "ZoneType" parameter in an "MC_DefineWorkspaceZone" Motion Control instruction.

8.2.1.6 Defining a reference coordinate system for a zone

Workspace zone

You can select the following reference coordinate systems for a workspace zone:

- WCS (world coordinate system)
- OCS1 (object coordinate system 1)
- OCS2 (object coordinate system 2)
- OCS3 (object coordinate system 3)

If you create the zone in an OCS, the zone moves together with the OCS.

Kinematics zone

You can select the following reference coordinate systems for a kinematics zone:

- If you select TCS, the zone envelops the tool or parts of it and moves with the tool (TCP).
- If you select FCS, the zone envelops the flange or parts of it and moves with the flange.

Selecting a reference coordinate system

You select the reference coordinate system in the "KS" column.

Motion Control instructions

Specify the reference coordinate system in the "ReferenceSystem" parameter in an "MC_DefineWorkspaceZone" or "MC_DefineKinematicsZone" Motion Control instruction.

8.2.1.7 Defining the zone geometry

You can configure zones with the following geometric bodies:

- Sphere
- Cuboid
- Cylinder

Sphere

You define a sphere starting from the zero point using the radius:

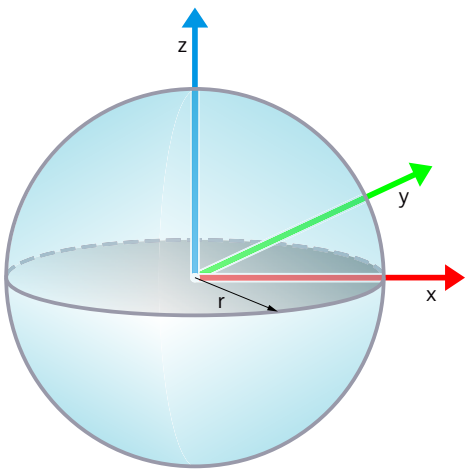

r Radius of the sphere

Configuring a sphere

1. Select the icon in the "Geometry" column.
2. Enter the radius in the "Radius" column.

Motion Control instructions

In the Motion Control instructions "MC_DefineWorkspaceZone" and "MC_DefineKinematicsZone", specify the zone geometry in these parameters:

Parameter	Value
GeometryType	1
GeometryParameter[1]	Radius of the sphere

Cuboid

You define a cuboid starting from the zero point using the edge lengths in x, y and z direction:

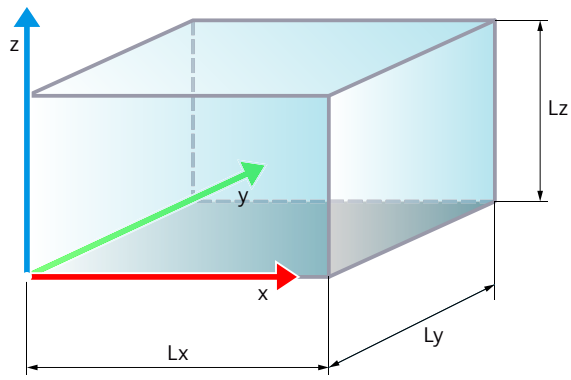

Lx Edge length in x direction of the zone coordinate system

Ly Edge length in y direction of the zone coordinate system

Lz Edge length in z direction of the zone coordinate system

Configuring a sphere

1. Select the icon in the "Geometry" column.
2. Enter the edge lengths in the following columns:
   - In the "Length x" column, edge length in x direction of the zone coordinate system
   - In the "Length y" column, edge length in y direction of the zone coordinate system
   - In the "Length z" column, edge length in z direction of the zone coordinate system

Motion Control instructions

In the Motion Control instructions "MC_DefineWorkspaceZone" and "MC_DefineKinematicsZone", specify the zone geometry in these parameters:

Parameter	Value
GeometryType	0
GeometryParameter[1]	Edge length in x direction of the zone coordinate system
GeometryParameter[2]	Edge length in y direction of the zone coordinate system
GeometryParameter[3]	Edge length in z direction of the zone coordinate system

Cylinder

You define a cylinder starting from the zero point using the radius of the base and the cylinder height:

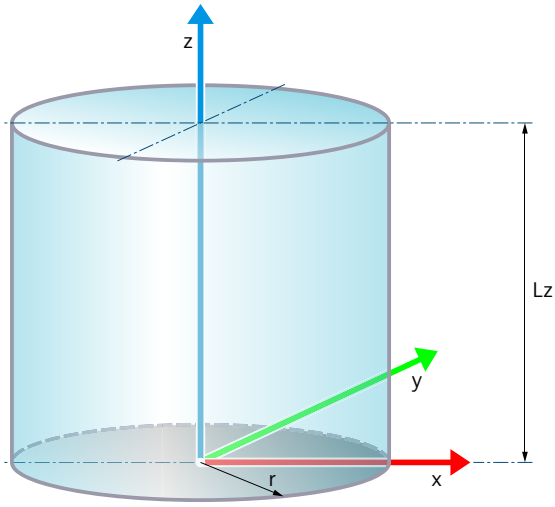

r Radius of the base of the cylinder

Lz Height of the cylinder

Configuring a cylinder

1. Select the icon in the "Geometry" column.
2. Enter the height of the cylinder in the "Length z" column.
3. Enter the radius of the base in the "Radius" column.

Motion Control instructions

In the Motion Control instructions "MC_DefineWorkspaceZone" and "MC_DefineKinematicsZone", specify the zone geometry in these parameters:

Parameter	Value
GeometryType	2
GeometryParameter[1]	Radius of the base of the cylinder
GeometryParameter[2]	Height of the cylinder

8.2.1.8 Defining the offset and rotation in the reference coordinate system

Define the offset and rotation of the geometric body starting from the zero point of the reference coordinate system as follows:

1. Define the offset of the zone by entering the following values:
   - x: Offset of the zone in the x direction
   - y: Offset of the zone in the y direction
   - z: Offset of the zone in the z direction

   In the kinematics zones, the offset of the zone to the zero point of the TCS or FCS remains constant.
2. Define the rotation of the zone by entering the following values:

   (Not relevant for a spherical zone)
   - A: Enter a value between -180.0° and 179.999° for the rotation of the zone around the z axis.
   - B: Enter a value between -90.0° and 90.0° for the rotation of the zone around the y axis.
   - C: Enter a value between -180.0° and 179.999° for the rotation of the zone around the x axis.

Enter offset and rotation

You enter the offset and rotation of the zone in the columns for the coordinates x, y, z, A, B and C.

Motion Control instructions

Specify the offset and rotation of the zone in the "Frame" parameter in an "MC_DefineWorkspaceZone" or "MC_DefineKinematicsZone" Motion Control instruction.

8.2.1.9 Activating zone monitoring

You activate zone monitoring (Page 208) for a defined zone by setting the status of the zone.

You have the following options for setting the status of a zone:

- You can set the status of a zone to active offline in the "Extended parameters > Zones" configuration window in the tabular editor.
- You activate a zone during runtime with the following Motion Control instructions:
  - MC_SetWorkspaceZoneActive: Activate workspace zone V10 (Page 438)
  - MC_SetKinematicsZoneActive: Activate kinematics zone V10 (Page 442)

Note the following when activating zone monitoring for work zones:

- Only one work zone can be active at a given time.
- If no work zone is activated, the entire traversing space of the kinematics is regarded as the work area.

Setting a zone to active offline

In the "Status" column, select whether the zone should be active or inactive after loading into the device.

Activating a defined zone with a Motion Control instruction

With the "ZoneNumber" parameter, you specify the number of the zone to be activated.

Before you issue an "MC_SetWorkspaceZoneActive" or "MC_SetKinematicsZoneActive" job, make sure that the zone specified at the "ZoneNumber" parameter is already defined and that the following conditions are therefore met:

- For an "MC_SetWorkspaceZoneActive" job
  - The "MC_DefineWorkspaceZone" job is complete ("Done" = TRUE).
  - The "StatusWorkspaceZone[1..10].Valid" tag is set to TRUE.
- For an "MC_SetKinematicsZoneActive" job
  - The "MC_DefineKinematicsZone" job is complete ("Done" = TRUE).
  - The "StatusKinematicsZone[2..10].Valid" tag is set to TRUE.

Otherwise, the job is rejected with "ErrorID" = 16#80C7.

After the start of the "MC_SetWorkspaceZoneActive" or "MC_SetKinematicsZoneActive" job with "Execute" = TRUE, the job is added to the job sequence (Page 250) and is thus effective for subsequent motion jobs.

When the job is complete ("Done" = TRUE), the tag of the data block technology object shows the status of the active zone as follows:

- Workspace zones: "<TO>.StatusWorkspaceZone[1..10].Active" = TRUE
- Kinematics zones: "<TO>.StatusKinematicsZone[2..10].Active" = TRUE

8.2.1.10 Deactivating zone monitoring

You deactivate zone monitoring (Page 208) for a defined zone by setting the status of the zone to inactive.

You have the following options for setting the status of a zone:

- You can set the status of a zone to inactive offline in the "Extended parameters > Zones" configuration window in the tabular editor.
- You set one or more zones to inactive during runtime with the following Motion Control instructions:
  - MC_SetWorkspaceZoneInactive: Deactivate workspace zone V10 (Page 440)
  - MC_SetKinematicsZoneInactive: Deactivate kinematics zone V10 (Page 443)

Setting a zone to inactive offline

In the "Status" column, select whether the zone should be active or inactive after loading into the device.

Deactivating one or more active zones with a Motion Control instruction

Deactivating an active zone

If you want to set a zone to inactive, enter the number of the zone at the "ZoneNumber" parameter.

In the "MC_SetWorkspaceZoneInactive" or "MC_SetKinematicsZoneInactive" Motion Control instruction, you choose in the "Mode" parameter with "0" that only the zone specified in the "ZoneNumber" parameter is deactivated.

Deactivating multiple active zones

If you want to set multiple active zones to inactive, enter the zones at the "Mode" parameter.

- You select the zones as follows in the "MC_SetWorkspaceZoneInactive" Motion Control instruction:
  - "Mode" = "1": All workspace zones
  - "Mode" = "2": All blocked zones
  - "Mode" = "3": All signal zones
  - "Mode" = "4": All work zones
- In the "MC_SetKinematicsZoneInactive" Motion Control instruction, you choose in the "Mode" parameter with "1" that all active kinematics zones should be set to inactive.

After the start of the "MC_SetWorkspaceZoneInactive" or "MC_SetKinematicsZoneInactive" job with "Execute" = TRUE, the job is added to the job sequence (Page 250) and is thus effective for subsequent motion jobs.

When the job is complete ("Done" = TRUE), the tag of the data block technology object shows the status of the inactive zones as follows:

- Workspace zones: "<TO>.StatusWorkspaceZone[1..10].Active" = FALSE
- Kinematics zones: "<TO>.StatusKinematicsZone[2..10].Active" = FALSE

8.2.2 Zone violation

The zone monitoring checks all activated workspace zones (work zones, signal zones, blocked zones) for collision with all activated kinematics zones (flange zones, tool zones, TCP). The zone monitoring monitors the zones for all motions of the kinematics system:

- Kinematics motions via the user program or kinematics control panel
- Single axis motions via the user program or axis control panel

The status of the zone monitoring is indicated in the diagnostics (Page 342) and in the tags (Page 223) of the kinematics technology object.

If the zone monitoring detects a zone violation by a kinematics motion, the following reactions occur:

Zone violation	Reaction	Description
Exiting the work zone	Alarm with stop	The kinematics technology object outputs technology alarm 806 (alarm response: Stop without leaving the path). The kinematics motion is stopped. The kinematics leaves the zone by the length of the deceleration distance at a minimum.
Entering a signal zone	Alarm without stop	The kinematics technology object outputs a technology alarm 807 (no alarm response). The kinematics motion will be continued.
Entering a blocked zone	Alarm with stop	The kinematics technology object outputs a technology alarm 806 (alarm response: Stop without leaving the path). The kinematics motion is stopped. The kinematics violates the zone by the length of the brake path at a minimum. All jobs in the job sequence are canceled.

The kinematics technology object outputs a technology alarm following zone violations by single axis motions. The positioning axis/synchronous axis technology object does not output a technology alarm. The single axis motion is not aborted. You can abort the single axis motion in the application.

In addition to the zones of the kinematics technology object, you can limit the travel space of the kinematics as follows:

- Software limit switches at the axes
- Joint traversing ranges

8.2.3 Retracting after a zone violation

Once you have acknowledged the technology alarm on the kinematics technology object, you can move the kinematics system again.

NOTICE

Zone monitoring for violated zone deactivated after acknowledgment

After you have acknowledged the technology alarm on the kinematics technology object, the zone monitoring is deactivated for the violated zone until the kinematics exits the violated blocked zone / signal zone or enters the violated work zone again. You can move the kinematics in all directions including again into the violated blocked zone / signal zone or from the work zone.

Take into consideration the travel direction when retracting the kinematics.

Monitor retraction in the application. The zone monitoring status is still displayed in the data block technology object.

After the kinematics has exited the violated blocked zone / signal zone again or entered the violated work zone again, zone monitoring is activated again for this zone. A new technology alarm is therefore triggered when the zone is violated again.

8.2.4 Tags: Zone monitoring

The following tags of the kinematics technology object are relevant for the zone monitoring:

Tag	Description
Zone configuration	
<TO>.WorkspaceZone[1..10]	Configuration of the workspace zones
<TO>.KinematicsZone[2..10]	Configuration of the kinematics zones The <TO>.KinematicsZone[1] zone is the tool center point (TCP) and is always activated.
Status values	
<TO>.StatusWorkspaceZone[1..10]	Status of the workspace zones
<TO>.StatusKinematicsZone[2..10]	Status of the kinematics zones
<TO>.StatusZoneMonitoring.WorkingZones	Display of violated work zones Bit numbers 0 to 9 correspond to the configured zone numbers.
<TO>.StatusZoneMonitoring.BlockedZones	Display of violated blocked zones Bit numbers 0 to 9 correspond to the configured zone numbers.
<TO>.StatusZoneMonitoring.SignalizingZones	Display of approached signal zones Bit numbers 0 to 9 correspond to the configured zone numbers.
<TO>.StatusZoneMonitoring.KinematicsZones	Display of kinematics zones that violate workspace zones Bit number 0 indicates the monitoring status of the TCP. Bit numbers 1 to 9 correspond to the configured zone numbers.

8.3 Overview of kinematics motions

With kinematics motions, you move the kinematics through the three-dimensional space and rotate the kinematics with up to three orientations. Plan the kinematics motion in advance. Take into consideration the following:

- Reachable points of the kinematics
- Zones
- Transformation areas
- Joint position spaces
- Joint traversing ranges
- Software limit switches of axes

Motion types

The following motion types are available:

- Linear motion (Page 258)

  You can move the kinematics linearly to a defined target position with a linear motion.
- Circular motion (Page 265)

  You can move the kinematics using a defined circular path with a circular motion.

- sPTP motion (Page 278)

  With a synchronous "point-to-point" motion (sPTP motion), you can move a kinematics time- and motion-optimized, bypass singularities or change joint position spaces. The kinematics does not follow a specified path. The single-axis motions, which move the kinematics axes synchronously, are calculated from the start and target positions.
- Conveyor tracking (Page 288)

  With conveyor tracking, the kinematics can follow an object on a moving conveyor belt.
- Orientation motion

  The orientation motion is the motion of the Cartesian orientation and is performed at the same time as the path motion. When the circular motion stops, the orientation motion also stops.

Blending types

The following differences apply to blending between path and orientation motions:

- **From a path motion to an orientation motion**

  Blending does not take place on transition from a path motion to an orientation motion.
- **Between orientation motions (without path motion)**

  If there is no path motion, blending takes place between the orientation motions. The blending distance is evaluated in the unit of measure for rotary axes.

If blending takes place between two motions, where there is both path motion and orientation motions, the path motion takes precedence in relation to the blending.

The following differences apply between the blending types:

- **Between linear/circular motions**

  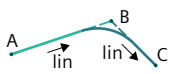

  Both motions are blended in a geometrically exact manner. The blending area is described by a 5th degree polynomial curve.
- **Between a linear/circular motion and an sPTP motion and vice versa**

  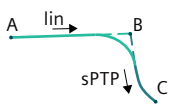

  Blending takes place with an sPTP motion in the blending area. The path is not geometrically defined.
- **Between sPTP motions**

  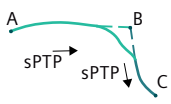

  Both motions are executed approximately. The blending area is described by a fifth degree polynomial segment.

Reference coordinate system

The target position and the target orientation you specify for a kinematics motion can relate to different coordinate systems, e.g. the world coordinate system (WCS) or an object coordinate system (OCS).

8.3.1 Introduction to the programming of the kinematics motions

You can use Motion Control instructions in the user program to transmit jobs to the technology object. You can find an overview of the Motion Control instructions for the kinematics technology object in the section "Motion control instructions for kinematics control (Page 24)".

You configure the job with the input parameters of the Motion Control instructions. The current job status is indicated in the output parameters.

Because the kinematics technology object groups the kinematics axes, you assign the kinematics technology object directly to the input parameter "AxesGroup".

You cannot enable the kinematics technology object itself using an "MC_Power" job or home it using an "MC_Home" job. For kinematics motions, the interconnected axes must be enabled ("MC_Power.Enable" = TRUE).

You can acknowledge errors of the kinematics technology object with an "MC_Reset" job or by restarting the technology object.

⚠ WARNING

Unexpected axis motions

The kinematics can perform unexpected motions due to the incorrect configuration of the technology objects or parameter assignment of the motion control jobs.

This can cause the following damages:

- Personal injury, for example, caused by products or machine parts coming loose
- Machine damages, for example, through overload of the mechanical components or collision between kinematics and machine components

Before you start the user program, implement the following preventive measures:

1. Check the correct configuration of all technology objects that are used for the motion sequence of the kinematics.
2. Check the correct parameter assignment of the motion control instructions.
3. Protect the configuration and user program against unauthorized access.

WARNING

Overrun of the dynamics through singularities

Overruns of the dynamics in the vicinity of a singularity (Page 183) can result in the following damages:

- Personal injury, for example, caused by products or machine parts coming loose
- Machine damages, for example, through overload of the mechanical components

To prevent overruns of the dynamics in the vicinity of a singularity, implement the following preventive measures:

1. Avoid path motions without dynamic adaptation in the vicinity of a singularity.
2. Use blocked zones or software limit switches for kinematics motions in the vicinity of a singularity.
3. Avoid the use of conveyor tracking in the vicinity of a singularity. Singularities are not handled when conveyor tracking is active.
4. Programming motions that are not part of the phases of conveyor tracking:
   - For linear or circular motions, activate the dynamic adaptation (Page 243).
   - Use synchronous "point-to-point" motions (Page 278).

8.3.2 Define target position

You define the target position in a Motion Control instruction for a kinematics motion depending on the kinematics type.

Define offset and rotation

Enter the values according to the following specifications:

Kinematics type	Target position					
	Offset			Rotation		
	x	y	z	A	B	C
2D	✓	0.0	✓	0.0	0.0	0.0
2D with orientation	✓	0.0	✓	✓ -180.0° to 179.999°	0.0	0.0
3D	✓	✓	✓	0.0	0.0	0.0
3D with orientation	✓	✓	✓	✓ -180.0° to 179.999°	0.0	0.0

✓ Value for offset/rotation configurable

Value = 0.0: Offset/rotation not permitted

Kinematics type	Target position					
	Offset			Rotation		
	x	y	z	A	B	C
3D with 2 orientations A, B	✓	✓	✓	✓ -180.0° to 179.999°	✓ -90.0° to 90.0°	✓ 0.0 / -180.0°
3D with 3 orientations	✓	✓	✓	✓ -180.0° to 179.999°	✓ -90.0° to 90.0°	✓ -180.0° to 179.999°
6-axis articulated arm with central wrist, 6-axis articulated arm with offset wrist						

✓ Value for offset/rotation configurable

Value = 0.0: Offset/rotation not permitted

Examples

The following examples of a kinematics type with more than 4 interpolating kinematics axes show 4 different positions of the TCP at the target position reached. The target positions are configured in each case with the same shift, but with different rotation.

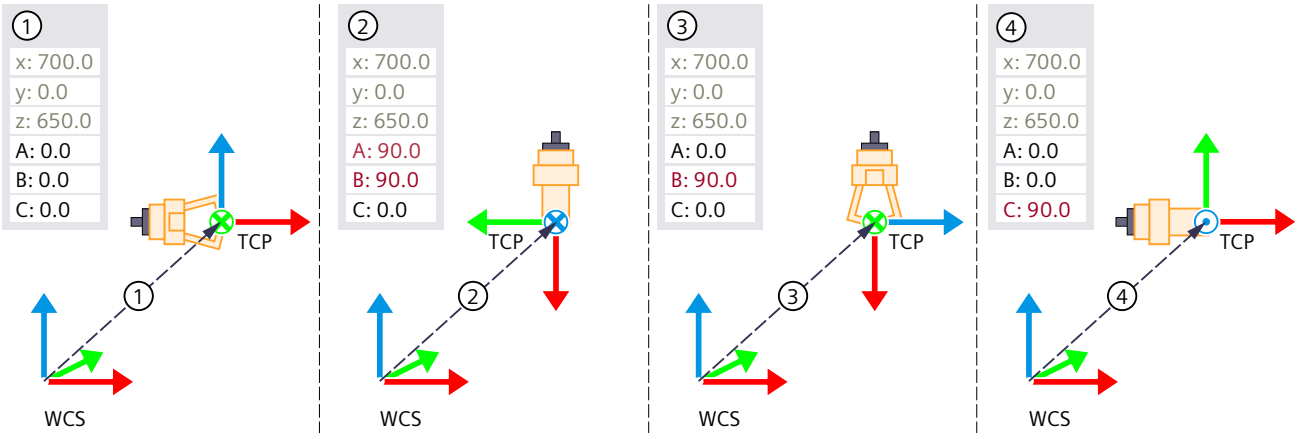

① ... ④ Position in the WCS

Orientation in path motion jobs for 3D kinematics with 2 orientations

You can move a 3D kinematics with 2 orientations to a Cartesian position with a differently configured orientation. The following figures show the kinematics with different joint positions at the same target position with different orientation of the TCP. The effective direction of the tool in x direction of the TCP is the same in both cases. However, due to the rotation C, the tool is rotated -180° around the x axis of the TCP.

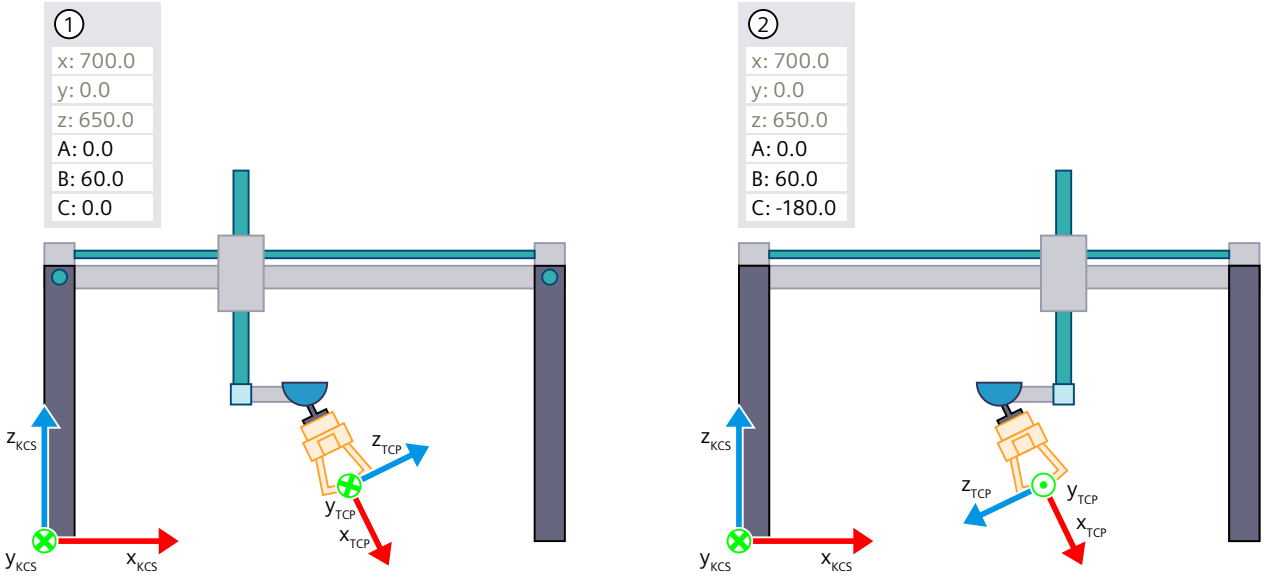

The following figure shows the orientation motion B in which joint J5 is moved beyond 0° and joint J4 is stationary. Since values greater than 90° for orientation B are not permitted, configure the Cartesian orientations as follows in order to move beyond the vertical position without rotating joint J4:

- A: By -180° (from 0° to -180° or also, e.g. from 20° to -160°)
- B: 90° when position of the TCP is vertical, decreasing to 0°
- C: -180°

Abrupt changes in orientations A and C do not lead to abrupt position changes on the joints or kinematics axes.

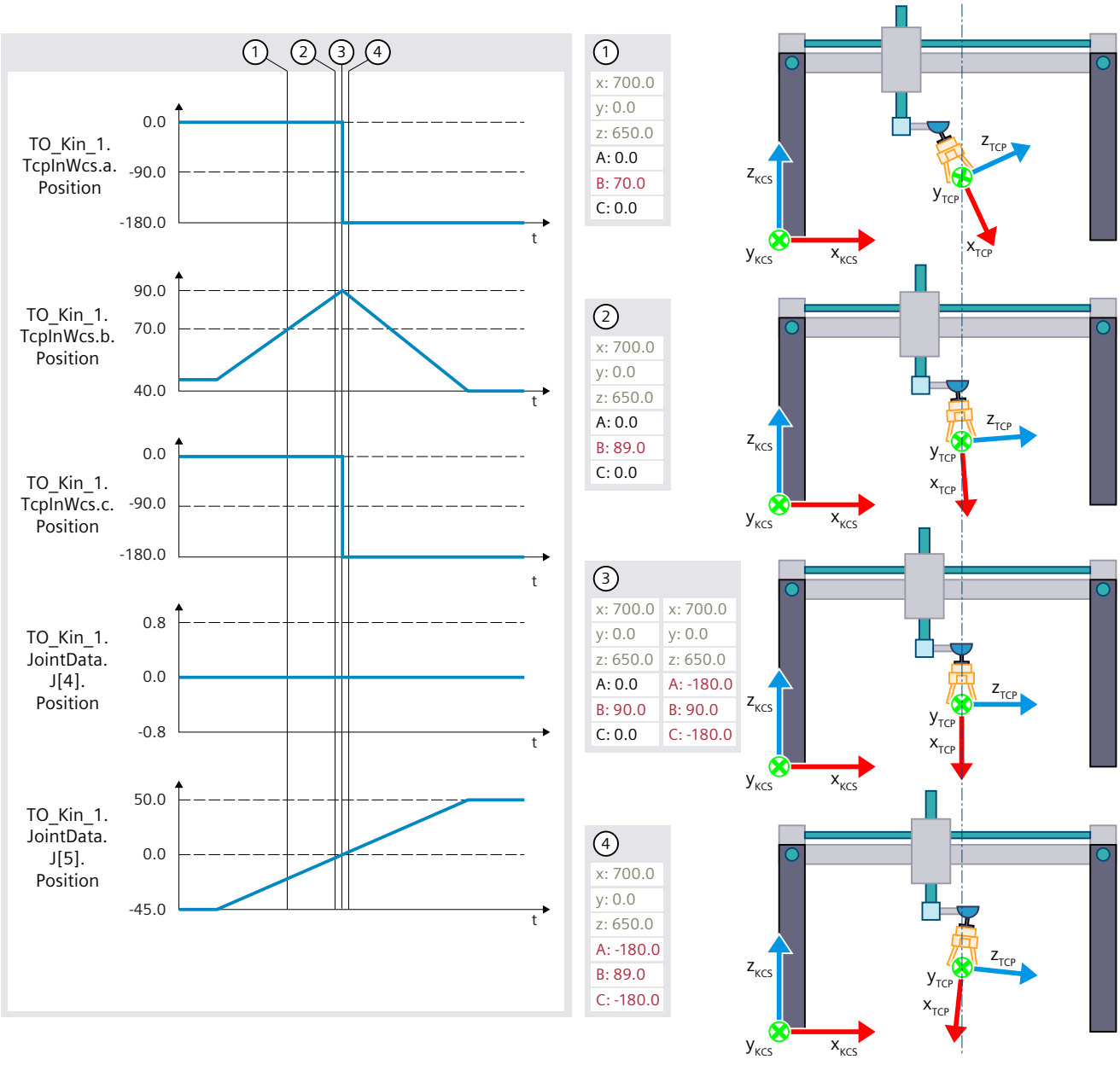

8.3.3 Motion status and remaining distance

You can obtain the status and the remaining distance of a motion job from the parameters of the corresponding Motion Control instruction.

Status of a motion job

You can identify the status of a motion job based on the "Busy" and "Active" parameters. When the job is transmitted, the "Busy" parameter is set to TRUE and the job is added to the job sequence. As long as the job is still in the job sequence, the "Active" parameter is set to FALSE. As soon as the job is active in the motion control, the "Active" parameter is set to TRUE. If the motion job is completed, the parameters "Busy" and "Active"are set to FALSE and the parameter "Done" to TRUE.

All inactive jobs in the job sequence are recalculated if another motion job is added to the job sequence. The current job is also included in the new calculation so that the current job can be blended with the next job.

Remaining distance of a motion job

You can obtain the remaining distance of a motion job from the "RemainingDistance" parameter. If the motion is not being blended, the "RemainingDistance" parameter contains the distance to the target position on the path. If the active motion is being blended with the next motion, the "RemainingDistance" parameter contains the distance to the beginning of the blending segment on the path. If only the Cartesian orientation of the TCP is changed in a motion task, but the TCP is at the Cartesian coordinates x, y, z, then the "RemainingDistance" parameter has the value "-1.0".

With an sPTP motion job, the execution progress is displayed with the "ExecutionTimeStatus" parameter instead of the remaining path. The parameter value starts at "0.0" and increases incrementally in the course of job execution until the job is completed at "1.0".

Distance of linear and circular motion jobs

The status tag "<TO>.StatusPath.AccumulatedPathLength" contains the distance already covered by the TCP of all completed motion jobs and the current motion job.

The status tag "<TO>.StatusPath.TotalPathLength" contains the total path length of the TCP for all jobs in the job sequence.

The total path length is the sum of:

- Distance of all completed motion jobs
- Distance travelled of the active motion job
- Remaining distance of the motion job
- Calculated distance of all jobs in the job sequence

Distances based on the following motion jobs are not taken into account:

- Synchronous "point-to-point" motions (sPTP motion)

  Exception: Blending segment between path motion and sPTP motion
- Active conveyor tracking
- Pure orientation motions

If there are no jobs in the job sequence and the last motion job is completed, then "AccumulatedPathLength" and "TotalPathLength" are equal.

Resetting distances

To reset the tags "AccumulatedPathLength" and "TotalPathLength" to zero in the user program, use one of the following instructions:

- Call "MC_Reset" with "Restart = TRUE" for the kinematics.
- Call "MC_GroupStop" for the kinematics.

The two tags are automatically reset during the following actions.

- Operating state changes from STOP to RUN
- Startup after POWER ON of the CPU

Calculate remaining distance of all jobs of the job sequence

To determine the remaining distance of all jobs in the job sequence, subtract "AccumulatedPathLength" from "TotalPathLength".

Remaining distance of the job sequence = "TotalPathLength" - "AccumulatedPathLength"

Example: Three linear motion jobs with smoothing

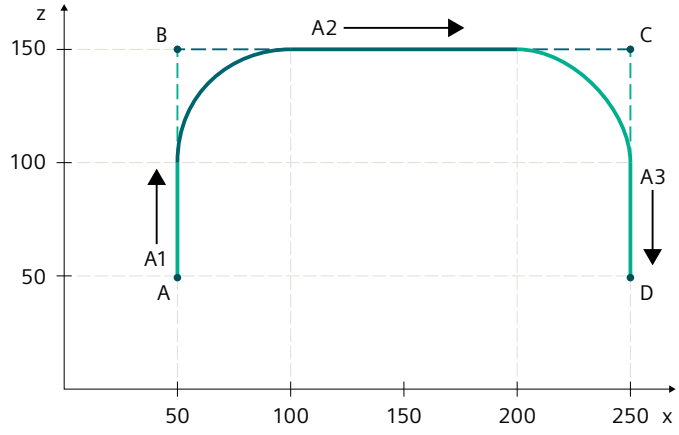

The starting point is point A. From point A, three linear path jobs are sent to points B, C and D. Blending is carried out in the second and third jobs. The path length is 0 mm at the beginning of the example. To simplify this, a 2D kinematics without orientation motion is used.

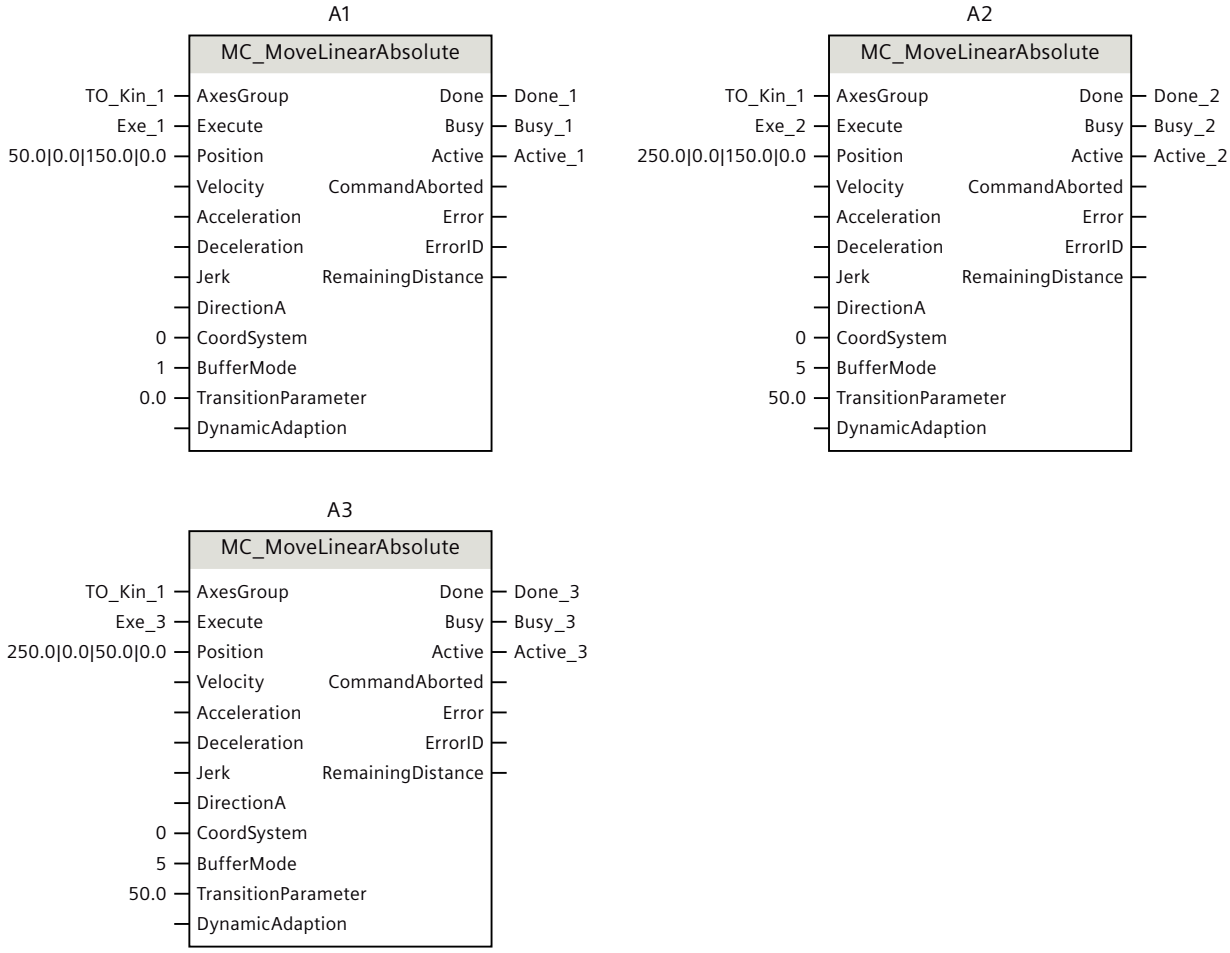

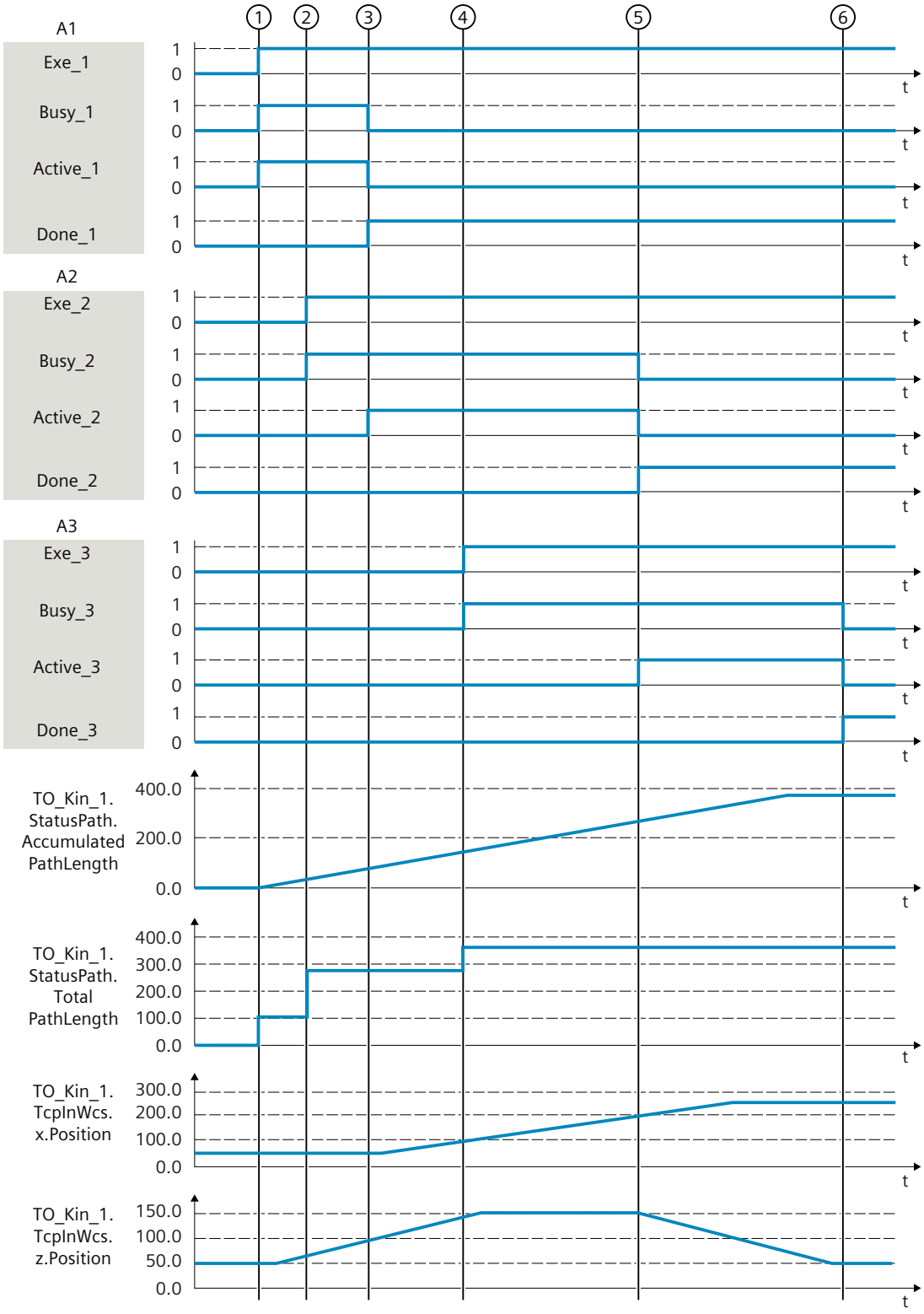

At time ①, the first linear motion job is started from point A to point B. The tag "AccumulatedPathLength" is 0.0 mm at the time ① because the kinematics is not yet

moving. "TotalPathLength" outputs the distance 100.0 mm between point A and point B. After the TCP moves, the "AccumulatedPathLength" tag shows the distance already moved.

When the second linear motion job is issued at time ②, the distance to point B is added, taking into account the smoothing, and displayed in "TotalPathLength". The total path length is now 281.8 mm. The second linear motion job becomes active at time ③.

At time ④, the third linear motion job is sent to point D. The total path length of 363.5 mm between point A and point D is now displayed in "TotalPathLength" . The third linear motion job becomes active at time ⑤.

At the time ⑥, the TCP reaches point D and all motion jobs are completed. The "AccumulatedPathLength" corresponds to the "TotalPathLength", as no more motion jobs are processed in the job sequence.

8.3.4 Interrupting, continuing and stopping kinematics motions

You can interrupt and continue active kinematics motions or stop them and thus also cancel queued motion jobs.

Suspend kinematics motions

With the Motion Control instruction "MC_GroupInterrupt (Page 384)", you interrupt the execution of the motion on a kinematics technology object.

With the "Mode" parameter, you specify the dynamic behavior. The kinematics can be stopped either with the dynamic response of the motion job to be interrupted ("Mode" = 0) or with the maximum dynamic response of the kinematics motion ("Mode" = 1). When dynamic adaptation is activated, the dynamics of the motion can also be reduced so that the dynamic limits of the axes are not exceeded.

The current path is not exited when the kinematics is stopped. If the kinematics is already at a standstill, the motion control is also interrupted for subsequent motion jobs. New motion jobs are then arranged as pending jobs in the job sequence.

The kinematics technology object is in "Interrupted" status (<TO>.StatusWord.X17).

The interrupted kinematics motion can be resumed with a "MC_GroupContinue (Page 385)" job.

Resuming interrupted kinematics motions

With the Motion Control instruction "MC_GroupContinue (Page 385)", you continue a kinematics motion that was previously interrupted with an "MC_GroupInterrupt" job. The kinematics motion can be continued if the kinematics has come to a standstill following the "MC_GroupInterrupt" job. The "MC_GroupContinue" job only has an effect if the kinematics technology object is in "Interrupted" status (<TO>.StatusWord.X17).

Stop kinematics motions

With the Motion Control instruction "MC_GroupStop (Page 389)", you stop the Motion Control of the kinematics technology object.

With the "Mode" parameter, you specify the dynamic behavior. The kinematics can be stopped either with the dynamic response of the motion job to be stopped ("Mode" = 0) or with the maximum dynamic response of the kinematics motion ("Mode" = 1). When dynamic adaptation is activated, the dynamics of the motion can also be reduced so that the dynamic limits of the axes are not exceeded.

During stopping, both the active motion job and all queued jobs in the job sequence are canceled and the job sequence is emptied. If the kinematics motion was already interrupted with an "MC_GroupInterrupt" job, this job is also canceled. As long as the "Execute" parameter is set to TRUE, the following kinematics jobs are rejected ("ErrorID" = 16#80CD).

The current path is not exited when the kinematics is stopped.

8.3.5 Interaction of kinematics motions and single axis motions

Kinematics motions are only possible if no single axis motions are active on the kinematics axes. Single axis motions have an overriding effect on kinematics motions. The motion of the corresponding axis is overridden by the single-axis motion and the job sequence is cleared. The other kinematics axes stop with the maximum dynamics. Exception: The kinematics is in simulation (Page 307).

The following functions are permitted during an active kinematics motion:

- Torque reduction on the axes/Travel to fixed stop ("MC_TorqueLimiting")

  When the fixed stop is reached, the kinematics motion is aborted.
- Setting of an additive torque ("MC_TorqueAdditive")
- Setting of the upper and lower torque limit ("MC_TorqueRange")
- Sensor switchover ("MC_SetSensor")

The following functions are rejected during an active kinematics motion:

- Overlaid motion on the axes ("MC_MoveSuperimposed")
- Homing of the axes ("MC_Home")

8.3.6 Tags: Kinematics motions

The following technology object tags are relevant for motion control:

Tag	Description
Status values	
<TO>.StatusWord	Status indicator for an active motion
<TO>.Tcp	Target coordinates x, y, z, A, B, C of the kinematics motion in the world coordinate system
<TO>.StatusPath.CoordSystem	Coordinate system of the active motion job

1) With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

2) Not relevant with sPTP motion

3) Not relevant with orientation motion

Tag	Description		
<TO>.StatusPath.CoordSystem	0	World coordinate system	
	1, 2, 3	Object coordinate system 1, 2, 3	
	100	Machine coordinate system	
	101	Joint coordinate system[1]	
<TO>.StatusPath.Velocity	Current path velocity (setpoint reference)		
<TO>.StatusPath.Acceleration	Current path acceleration (setpoint reference)		
<TO>.StatusPath.OrientationVelocity	Resulting orientation velocity		
<TO>.StatusPath.DynamicAdaption	Dynamic adaptation		
	0	No dynamic adaptation	
	1	Dynamic adaptation with segmentation of the path	
	2	Dynamic adaptation without segmentation of the path	
<TO>.StatusPath.TotalPathLength	Total path length of linear and circular path motions Sum of: • Distance of all completed motion jobs • Distance travelled of the active motion job • Remaining distance of the motion job • Calculated distance of all jobs in the job sequence		
<TO>.StatusPath.AccumulatedPathLength	Accumulated path length of linear and circular path motions Sum of: • Distance of all completed motion jobs • Distance travelled of the active motion job		
<TO>.StatusPath.DynamicLimit	Dynamic limits affecting the running motion job		
	Bit 0	"LIMIT_ORIENTATION" Dynamic limits of the orientation motion [2]	
		TRUE	The dynamic response of the current motion is limited by the dynamic limits of the orientation motion.
		FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the orientation motion.
	Bit 1	"LIMIT_PATH" Dynamic limits of the kinematics motion [2]	
		TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics motion.
		FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics motion.
	Bit 16	"LIMIT_AXIS_A1" Dynamic limits of the kinematics axis A1 [3]	

[1] With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

[2] Not relevant with sPTP motion

[3] Not relevant with orientation motion

Tag	Description		
<TO>.StatusPath.DynamicLimit	Bit 16	TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics axis A1.
		FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics axis A1.
			Dynamic adaptation is not activated. [2]
	Bit 17	"LIMIT_AXIS_A2" Dynamic limits of the kinematics axis A2 [3]	
		TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics axis A2.
		FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics axis A2.
			Dynamic adaptation is not activated. [2]
	Bit 18	"LIMIT_AXIS_A3" Dynamic limits of the kinematics axis A3 [3]	
		TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics axis A3.
		FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics axis A3.
			Dynamic adaptation is not activated. [2]
	Bit 19	"LIMIT_AXIS_A4" Dynamic limits of the kinematics axis A4 [3]	
		TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics axis A4.
		FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics axis A4.
			Dynamic adaptation is not activated. [2]
	Bit 20	"LIMIT_AXIS_A5" Dynamic limits of the kinematics axis A5 [3]	
		TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics axis A5.
		FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics axis A5.
			Dynamic adaptation is not activated. [2]

[1] With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

[2] Not relevant with sPTP motion

[3] Not relevant with orientation motion

Tag	Description		
<TO>.StatusPath.DynamicLimit	Bit 21	"LIMIT_AXIS_A6" Dynamic limits of the kinematics axis A6 [3]	
		TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics axis A6.
		FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics axis A6.
			Dynamic adaptation is not activated. [2]
<TO>.StatusMotionQueue.NumberOfCommands	Number of jobs in the job sequence		
Override			
<TO>.Override.Velocity	Velocity override		
Dynamic limits			
<TO>.DynamicLimits.Path.Velocity	Dynamic limitation for the maximum velocity of the path		
<TO>.DynamicLimits.Path.Acceleration	Dynamic limitation for the maximum acceleration of the path		
<TO>.DynamicLimits.Path.Deceleration	Dynamic limitation for the maximum deceleration of the path		
<TO>.DynamicLimits.Path.Jerk	Dynamic limitation for the maximum jerk of the path		
<TO>.DynamicLimits.Orientation.Velocity	Dynamic limitation for the maximum velocity of the Cartesian orientation		
<TO>.DynamicLimits.Orientation.Acceleration	Dynamic limitation for the maximum acceleration of the Cartesian orientation		
<TO>.DynamicLimits.Orientation.Deceleration	Dynamic limitation for the maximum deceleration of the Cartesian orientation		
<TO>.DynamicLimits.Orientation.Jerk	Dynamic limitation for the maximum jerk of the Cartesian orientation		
Dynamic defaults			
<TO>.DynamicDefaults.Path.Velocity	Default setting of the velocity of the path		
<TO>.DynamicDefaults.Path.Acceleration	Default setting of the acceleration of the path		
<TO>.DynamicDefaults.Path.Deceleration	Default setting of the deceleration of the path		
<TO>.DynamicDefaults.Path.Jerk	Default setting of the jerk of the path		
<TO>.DynamicDefaults.Orientation.Velocity	Default setting of the velocity of the Cartesian orientation		
<TO>.DynamicDefaults.Orientation.Acceleration	Default setting of the acceleration of the Cartesian orientation		
<TO>.DynamicDefaults.Orientation.Deceleration	Default setting of the deceleration of the Cartesian orientation		
<TO>.DynamicDefaults.Orientation.Jerk	Default setting of the jerk of the Cartesian orientation		
<TO>.DynamicDefaults.DynamicAdaption	Default setting of the dynamic adaptation		
	0	No dynamic adaptation	
	1	Dynamic adaptation with segmentation of the path	
	2	Dynamic adaptation without segmentation of the path	
<TO>.DynamicDefaults.MoveDirect.VelocityFactor	Factor for the velocity of the axis motions in relation to the respective maximum velocity of the axes with sPTP motion.		

1) With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

2) Not relevant with sPTP motion

3) Not relevant with orientation motion

Tag	Description	
<TO>.DynamicDefaults.MoveDirect.Acceleration-Factor	Factor for the acceleration of the axis motions in relation to the respective maximum acceleration of the axes with sPTP motion.	
<TO>.DynamicDefaults.MoveDirect.Deceleration-Factor	Factor for the deceleration of the axis motions in relation to the respective maximum deceleration of the axes with sPTP motion.	
<TO>.DynamicDefaults.MoveDirect.JerkFactor	Factor for the jerk of the axis motions in relation to the respective maximum jerk of the axes with sPTP motion.	
Rounding clearance		
<TO>.Transition.FactorBlendingLength	Factor of the maximum rounding distance in percent [%] The configuration takes place in "Technology object > Configuration > Extended parameters > Job sequence". Change the factor in the user program before sending the motion jobs to the job sequence so that the change is effective.	
	0.0	No blending possible
	50.0	Default value
	100.0	Blending possible with complete segment length or motion length

1) With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

2) Not relevant with sPTP motion

3) Not relevant with orientation motion

8.4 Motion dynamics

8.4.1 Dynamic settings and dynamic limits

Interaction

The following overview shows how the dynamic value for a motion job is formed from the dynamic settings and the dynamic limits.

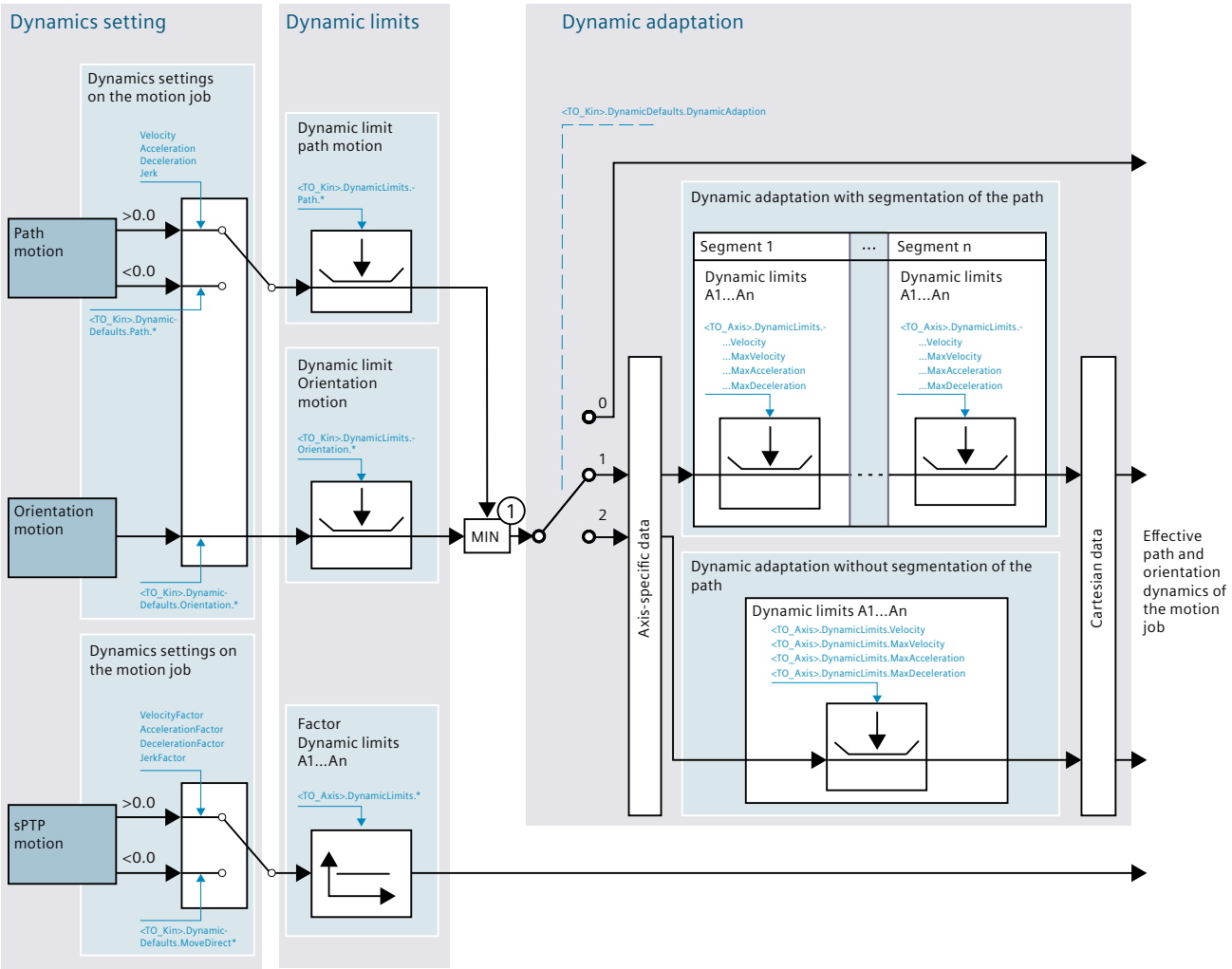

① When a motion dynamic that affects both the path motion and the orientation motion is specified, only one of the two motions can have precedence. The other one is automatically adapted to the slower dynamic. If the orientation dynamic is slower than the path dynamic, for example, the path dynamic is reduced accordingly. This means that it may not be possible for the originally specified dynamic to be reached under certain circumstances.

Dynamic limits of the kinematics

The configured dynamic limits of the kinematics configured under "Technology object > Configuration > Extended parameters > Dynamics" are taken into account during the motion execution. The dynamics of a motion can be restricted so that the dynamic limits of the kinematics are not exceeded. When you change the dynamic limits of the kinematics, the changes take effect immediately for the kinematics motion and orientation motion. The dynamic limits of the kinematics take effect independent of the dynamic adaptation (Page 244).

Dynamic limits of the kinematics axes

When a motion job is transmitted, the dynamic limits of the kinematics axes configured under "Technology object > Configuration > Extended parameters > Limits > Dynamic limits" are only taken into account when dynamic adaptation (Page 244) is active. The dynamics of the motion can be restricted so that the dynamic limits of the kinematics axes are not exceeded.

Guidelines for defining dynamic settings

The following steps are recommended to optimize the motion dynamics:

- Configure and optimize the drive according to specifications.
- Define the torque and speed limit of the drive according to the drive train consisting of motor, gears and mechanical system.
- Avoid sharp curves in the path geometry by using the largest possible blending radii.
- Define dynamic limits at the kinematics axes.
- Define dynamic limits at the kinematics.
- Specify the dynamic response at the motion job.
- Use the dynamic adaptation.

8.4.2 Considering dynamics in path planning

To optimize the dynamics in motion control, consider the following factors in path planning:

- Sharp curves in the path geometry can lead to higher axis acceleration values and thus to higher motor torques. Therefore, if possible, avoid small radii in the path execution.
- It may not be possible to fully utilize the dynamic capability in small geometrical path segments (small traversing distance). Therefore, avoid small segments.
- Where suitable, use sPTP motions.

8.4.3 Defining dynamic limits at the kinematics axes

NOTE

Violations of dynamic limits of the kinematics axes

Despite active dynamic adaptation, there may be slight overruns of the dynamic limits of the kinematics axes.

To avoid violations, set the dynamics at the kinematics axes about 5% lower than their permitted limit.

Configure the following dynamic limits at the positioning axis/synchronous axis technology object:

- Define the limit for the velocity according to the maximum speed of the drive:
  - <TO_Axis>.DynamicLimits.Velocity

    Value can be changed in the user program and is effective immediately.
  - <TO_Axis>.DynamicLimits.MaxVelocity

    Value can only be changed after technology object is restarted.

  The lower of the two values is the effective value.
- Set the acceleration and deceleration limit according to the maximum torque of the drive train:
  - <TO_Axis>.DynamicLimits.MaxAcceleration
  - <TO_Axis>.DynamicLimits.MaxDeceleration

  If in doubt, start with low values. Measurements of the motor torque occurring during motion can help you to find a suitable setting.

The configured jerk only takes effect with single axis motions and is not considered in the dynamic adaptation.

For the configured limits to be considered in the velocity profile, enable dynamic adaptation at the kinematics technology object.

When you change the dynamic limits of the kinematics axes during an active motion, the changed values only take effect during the next preparation of a motion job.

You can find a description of the configuration parameters for the positioning axis and synchronous axis technology objects in the "S7-1500/S7-1500T Axis functions" documentation.

8.4.4 Defining dynamic limits at the kinematics technology object

For the kinematics technology object, define the following dynamic settings in the "Dynamics" configuration window:

- Default values for the dynamics and the dynamic limits of the path motion and of the orientation motion
- Default values for the dynamics of the sPTP motion
- Dynamic adaptation

8.4.5 Configuring dynamics for the kinematics and the orientation motion

Configuring dynamic defaults for the translational motion (path motion)

You can define the dynamic values for a path motion at the corresponding Motion Control instruction or under "Technology object > Configuration > Extended parameters > Dynamics".

NOTE

If you change the dynamic defaults during an active motion, the changed values take effect only in the next motion job.

Procedure

1. Select the entry "Kinematics motion" in the "Settings for" drop-down list.
2. Enter the default values of the dynamics in the "Velocity", "Acceleration", "Deceleration" and "Jerk" fields.
3. To activate the default settings, set the dynamic value at the Motion Control instructions to less than zero.
4. Define the default values of the dynamic limits in the "Maximum velocity", "Maximum acceleration", "Maximum deceleration" and "Maximum jerk" fields.
5. Enable the dynamic adaptation (Page 244).

Configuring dynamic defaults for the orientation motion

You can define the dynamic values for an orientation motion exclusively under "Technology object > Configuration > Extended parameters > Dynamics".

NOTE

If you change the dynamic defaults during an active motion, the changed values take effect only in the next motion job.

Procedure

1. Select the entry "Orientation motion" in the "Settings for" drop-down list.
2. Enter the default values of the dynamics in the "Velocity", "Acceleration", "Deceleration" and "Jerk" fields.
3. Define the default values of the dynamic limits in the "Maximum velocity", "Maximum acceleration", "Maximum deceleration" and "Maximum jerk" fields.
4. Enable the dynamic adaptation (Page 244).

8.4.6 Configuring dynamics for the sPTP motion

You can define the dynamic values for an sPTP motion at the corresponding Motion Control instruction or under "Technology object > Configuration > Extended parameters > Dynamics".

You specify the default settings of the dynamics of the synchronous "point-to-point" motion using factors. These factors each relate in percentage terms to the maximum values of velocity, acceleration, deceleration and jerk that you have configured for the individual axes under "Technology object > Configuration > Extended parameters > Limits> Dynamic limits".

Configuring dynamic defaults for the sPTP motion

NOTE

If you change the dynamic defaults during an active motion, the changed values take effect only in the next motion job.

Procedure

1. Select the entry "sPTP motion" in the "Settings for" drop-down list.
2. Enter the default values of the dynamics in the "Velocity factor", "Acceleration factor", "Deceleration factor" and "Jerk factor" fields.
3. To activate the default settings, set the dynamic factors at the Motion Control instructions "MC_MoveDirectRelative" or "MC_MoveDirectAbsolute" to less than zero.

8.4.7 Dynamic adaptation

When dynamic adaptation is activated, a velocity profile is calculated for the motion of the kinematics. In addition to the dynamic default values and dynamic limits for path motions and the dynamic default values for orientation motions, the velocity profile also considers the maximum velocity, maximum acceleration and maximum deceleration of the kinematics axes.

The "<TO>.StatusPath.DynamicAdaption" tag displays the status of the dynamic adaptation.

NOTE

Dynamic adaptation in the user program

Dynamic adaptation is only active if it is activated in the user program.

WARNING

Dynamic adaptation in "Jog" mode

The dynamic adaptation is not active in the kinematics control panel. The dynamic limits of the kinematics axes are not taken into account during a kinematics motion with the kinematics control panel.

In the vicinity of a singularity (Page 183), a path motion without dynamic adaptation mostly results in overruns of the dynamics. This means one or more kinematics axes can move at very high speed and accelerate or decelerate with excessive force.

This can cause the following damages:

- Personal injury, for example, caused by products or machine parts coming loose
- Machine damage, for example, through overload of the mechanical components

To prevent dynamic overruns in the vicinity of singularities in "Jog" mode, take the following protective measures:

- In the WCS or OCS, avoid the "Jog" mode.
- Make sure that the dynamic settings in the kinematics control panel do not violate the dynamic limits of the kinematics axes or process.

NOTE

Dynamic adaptation in "Jog to target position" mode

In the kinematics control panel, the dynamic adaptation is only effective as of technology V6.0 and the dynamic limits of the kinematic axes are taken into account. "Dynamic adaptation without segmentation of the path" is always used.

NOTE

Violations of dynamic limits of the kinematics axes

Despite active dynamic adaptation, there may be slight overruns of the dynamic limits of the kinematics axes.

To avoid violations, set the dynamics at the kinematics axes about 5% lower than their permitted limit.

The graphic below shows an example of the velocity curve without and with dynamic adaptation.

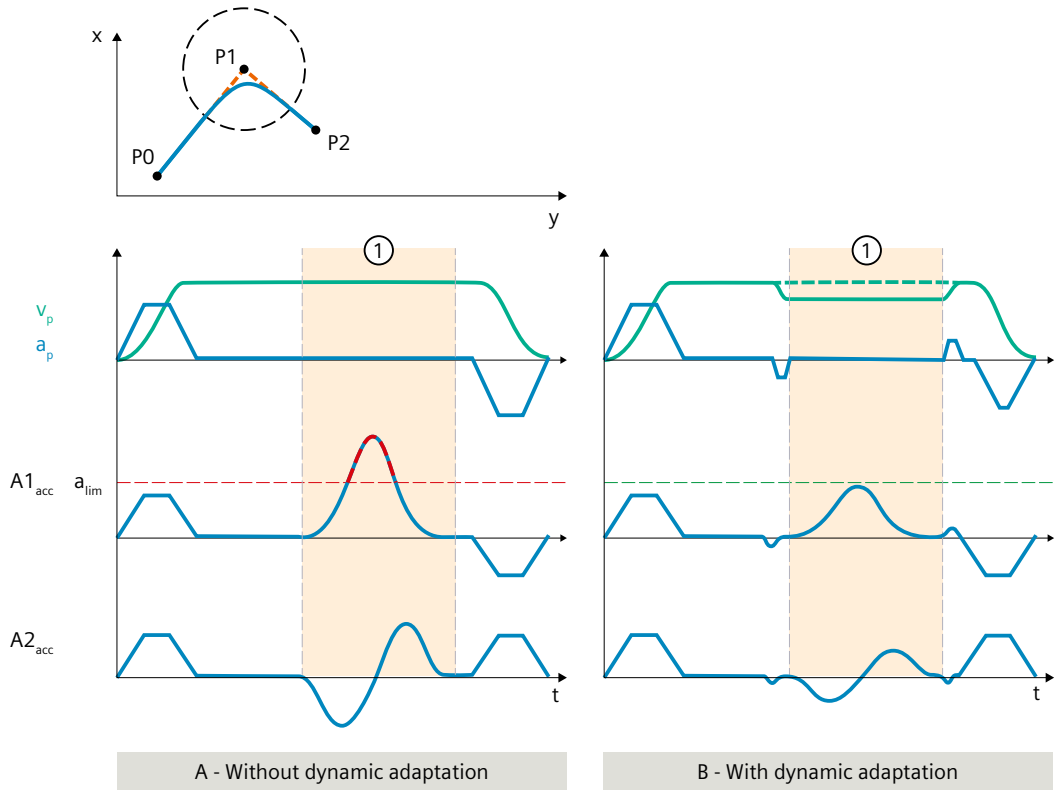

A **Velocity curve without dynamic adaptation**
The combination of path curves and path velocity causes a limit violation of the maximum acceleration of kinematics axis A1 in the blending area ① at P1.

B **Velocity curve with dynamic adaptation**
With dynamic adaptation, the velocity and acceleration/deceleration curves of the kinematics axes remain within the defined limits. The path velocity v_p is reduced in the transition area ① at point P1. The accelerations $A1_{acc}$ and $A2_{acc}$ are smoothed and optimized in the area of the transition at point P1 so that the acceleration limit is not violated.

Defining the default setting for the dynamic adaptation

You set the dynamic adaptation under "Kinematics technology object > Configuration > Extended parameters > Dynamics".

Select the default for the dynamic adaptation in the drop-down list:

- **Do not limit (<TO>.DynamicDefaults.DynamicAdaption" = 0)**

  The dynamic limits of the axes are not taken into consideration. Only dynamic limits for the path and orientation motion apply.

  If the axis limits are violated, the technology alarm 511 occurs.

- **Limit with segmentation of the path (<TO>.DynamicDefaults.DynamicAdaption" = 1)**

  The path of a motion job is divided into individual equidistant segments. For each of these segments, the velocity profile is calculated taking into consideration the dynamic limits of the kinematics axes which apply for individual sections of the motion. The dynamic response is therefore adapted for individual sections of a motion and is thus more granular than the "Limit without segmentation of the path" mode.

  Dynamic adaptation in the "Limit with segmentation of the path" mode requires a higher computing time than in the "Limit without segmentation of the path" mode. The total time for the motion job may be shorter under certain circumstances in "Limit with segmentation of the path" mode.

- **Limit without segmentation of the path (<TO>.DynamicDefaults.DynamicAdaption" = 2)**

  The velocity profile is calculated with consideration of dynamic limits of the kinematics axes. The minimum possible velocity of a motion segment is used for the entire segment.

8.4.8 Preparing dynamics at the motion job

You can specify dynamic values for a motion job in a Motion Control instruction or use the dynamics configured at the kinematics technology object. If you do not specify any dynamic values for motion jobs (default value "-1.0"), the dynamic defaults configured under "Technology object > Configuration > Extended parameters > Dynamics" are used for the path motion.

Define the dynamics in the Motion Control instruction in a granular manner, if required, or use the default settings defined at the kinematics technology object.

Defining limits in a granular manner

Start with low values or gradually increase the limit values until the optimization is complete.

First define the limit for the velocity, then for acceleration/deceleration and finally for the jerk. If necessary, increase the limits in the same order.

If there are no particular requirements relating to the motion dynamics, the limits defined at the kinematics technology object under "Technology object > Configuration > Dynamics" can be used instead.

8.4.9 Display of currently effective dynamic limits

The "<TO>.StatusPath.DynamicLimit" status tag shows you whether and which dynamic limits affect the dynamic response of the running kinematics motion. In this way, you can adapt dynamic limits in a targeted manner and optimize the dynamic response of the kinematics motion.

If dynamic limits are in effect, the respective bits of the "<TO>.StatusPath.DynamicLimit" status tag are set to TRUE for the duration of the motion job, regardless of whether dynamic limits are reached.

The calculation of motion profiles takes place in multiple, consecutive steps. First, the configured dynamic limits are evaluated. If required, the dynamic curve is then smoothed by filter algorithms. Individual bits of the "<TO>.StatusPath.DynamicLimit" tag may be set by the evaluation which takes place at the start of the calculation, even though a trace of the

resulting motion signals (velocity, acceleration, etc.) would not show any limiting behavior and the signals would be below the respective limit.

If the motion profile does not meet the specified criteria and the motion is not performed in the specified time, for example, it is advisable to check the motion profile. To do this, localize the dynamic limits that affect the dynamics of the running kinematics motion. You can localize the effective dynamic limits by evaluating the bits of "<TO>.StatusPath.DynamicLimit".

If the kinematics motion is interrupted by an "MC_GroupInterrupt" Motion Control instruction or stopped by an "MC_GroupStop" Motion Control instruction, the bits of the "<TO>.StatusPath.DynamicLimit" status tag are set to FALSE.

If the kinematics motion is resumed by an "MC_GroupContinue" Motion Control instruction, the bits of the "<TO>.StatusPath.DynamicLimit" status tag are set to the previous status.

Dynamic limits of the kinematics

The following bits of the "<TO>.StatusPath.DynamicLimit" status tag are set to TRUE if the dynamic response of the current kinematics motion is limited by the dynamic limits configured on the kinematics:

- Bit 0: Dynamic limits for the orientation motion
- Bit 1: Dynamic limits for the kinematics motion

The following dynamic limits configured on the kinematics technology object are taken into consideration:

- <TO>.DynamicLimits.Path.Velocity
- <TO>.DynamicLimits.Path.Acceleration
- <TO>.DynamicLimits.Path.Deceleration
- <TO>.DynamicLimits.Path.Jerk
- <TO>.DynamicLimits.Orientation.Velocity
- <TO>.DynamicLimits.Orientation.Acceleration
- <TO>.DynamicLimits.Orientation.Deceleration
- <TO>.DynamicLimits.Orientation.Jerk

Bits 0 and 1 of the "<TO>.StatusPath.DynamicLimit" status tag are always set to FALSE during sPTP motions.

Dynamic limits of the kinematics axes

The following bits of the "<TO>.StatusPath.DynamicLimit" status tag are set to TRUE if the dynamic response of the current kinematics motion is limited by the dynamic limits configured on the kinematics axes:

- Bit 16: Dynamic limits of the axis A1
- Bit 17: Dynamic limits of the axis A2
- Bit 18: Dynamic limits of the axis A3
- Bit 19: Dynamic limits of the axis A4
- Bit 20: Dynamic limits of the axis A5
- Bit 21: Dynamic limits of the axis A6

When dynamic adaptation is deactivated, the dynamic limits of the kinematics axes are not considered in linear and circular motions, which is why the bits are set to FALSE.

The following dynamic limits configured on the kinematics axes are taken into consideration:

- <TO>.DynamicLimits.MaxVelocity
- <TO>.DynamicLimits.MaxAcceleration
- <TO>.DynamicLimits.MaxDeceleration
- <TO>.DynamicLimits.MaxJerk

  (Only taken into consideration with sPtP motions. "<TO>.DynamicLimits.MaxJerk" is not taken into consideration with linear and circular motions with active dynamic adaptation.)

8.4.10 Override

With the velocity override, you can adjust the programmed velocity of a kinematics. You define the velocity override in the "<TO>.Override.Velocity" tag in the technology object data block.

Depending on the kinematics motion, you define the value for the velocity override within the following value ranges:

- Enter a value between 0% and 200% for a path motion.
- Enter a value between 0% and 100% for an sPTP motion.

The velocity override acts on the velocity of the tool center point (TCP) along the path. A changed velocity override takes effect immediately for the kinematics motion.

The setpoint velocity of the motion is the velocity specified for the Motion Control instruction multiplied by the percentage value of the velocity override.

The axis-specific velocity override values do not take effect for kinematics motions.

With active master control, the override from the user program has no effect on the velocity when traversing with the kinematics control panel. To adjust the velocity for traversing with the kinematics control panel, define a percentage correction of the velocity in the kinematics control panel under "Adjust (Page 331)".

NOTICE
Deviating jog velocity due to velocity override with technology versions <V10.0 If the velocity override is changed by the user program while the kinematics control panel is active, undesired deviations in the jog velocity can occur. With active master control, both settings on velocity override take effect in jog mode of the kinematics. The value set under "Adapt" with the "Velocity" slider as well as the value configured in the "<TO>.Override.Velocity" tag have a multiplicative effect on the final velocity in jog mode. For example, the following settings result in a final velocity of 25 mm/s: • Jog velocity = 100 mm/s • "<TO>.Override.Velocity" is set cyclically to 50% in OB1. • The "Velocity" slider is set to 50%. The resulting final velocity is calculated as follows: 100 mm/s × 0.5 × 0.5 = 25 mm/s. To avoid undesired deviations in the resulting final velocity, make sure that both parameters are set correctly and the velocity override with active master control is not changed by the user program. With a query of the kinematics control panel status (<TO>.StatusWord.X4 (ControlPanelActive)) when the "<TO>.Override.Velocity" tag is written, you can prevent writing of the tag with an active kinematics control panel.

8.5 Motion preparation using multiple jobs

8.5.1 Job sequence

Motion-relevant jobs are entered in the job sequence of the kinematics technology object.

The following jobs enter the job sequence:

Job	Brief description
Kinematics motions	
MC_MoveLinearAbsolute (Page 392)	Position kinematics with linear path motion
MC_MoveLinearRelative (Page 397)	Relative positioning of kinematics with linear path motion
MC_MoveCircularAbsolute (Page 402)	Position kinematics with circular path motion
MC_MoveCircularRelative (Page 408)	Relative positioning of kinematics with circular path motion
MC_MoveDirectAbsolute (Page 414)	Absolute movement of kinematics with synchronous "point-to-point" motion
MC_MoveDirectRelative (Page 422)	Relative movement of kinematics with synchronous "point-to-point" motion

Job	Brief description
Zones	
MC_DefineWorkspaceZone (Page 435)	Define workspace zone
MC_DefineKinematicsZone (Page 437)	Define kinematics zone
MC_SetWorkspaceZoneActive (Page 438)	Activate workspace zone
MC_SetWorkspaceZoneInactive (Page 440)	Deactivate workspace zone
MC_SetKinematicsZoneActive (Page 442)	Activate kinematics zone
MC_SetKinematicsZoneInactive (Page 443)	Deactivate kinematics zone
Coordinate systems	
MC_SetOcsFrame (Page 448)	Redefine object coordinate systems

Define maximum number of jobs

By default, the job sequence can contain up to five jobs. You can change the maximum number of jobs in the configuration window "Technology object > Configuration > Extended parameters > Job sequence". The job sequence can contain a maximum of ten jobs.

NOTE
Multiple jobs in the job sequence
The more jobs contained in the job sequence, the longer it takes to calculate the motion jobs.

Processing of jobs in the job sequence

The jobs are processed in the same order in which they were entered in the job sequence. The order of the jobs cannot be changed subsequently. If another motion job is added to the job sequence, all jobs in the job sequence will be recalculated. The kinematics motion jobs do not cancel each other.

The job sequence allows the calculation of a velocity profile over several jobs. The number of motion jobs to be considered depends on the type of motion jobs, e. g. sPTP motion, linear motion, circular motion, conveyor tracking. The current job is also included in the new calculation so that the current job can be blended as far as possible with the next job.

Status of the job sequence

The two tags for the status of the job sequence can be used to check whether the calculation of the jobs in the job sequence has been completed and whether the corresponding programmed motion jobs are being blended. If the number of prepared commands in the job sequence ("<TO>StatusMotionQueue.NumberOfPreparedCommands") matches the number of jobs in the job sequence ("<TO>.StatusMotionQueue.NumberOfCommands"), then the preparation of the motion is complete.

Interrupting and resuming job execution

You can also interrupt execution of the jobs with a "MC_GroupInterrupt" job, fill the job sequence and then continue execution with an "MC_GroupContinue" job. The behavior of the motion processing at the "MC_GroupContinue" differs as follows:

- If a "MC_GroupInterrupt" job is transmitted before the start of the motion, the kinematics motion jobs transmitted between the "MC_GroupInterrupt" and the "MC_GroupContinue" job are prepared. If the number of prepared commands in the job sequence ("<TO>StatusMotionQueue.NumberOfPreparedCommands") matches the number of jobs in the job sequence ("<TO>.StatusMotionQueue.NumberOfCommands"), then the preparation of the motion is complete. As soon as the motion preparation is completed, the "MC_GroupContinue" job immediately releases the motion execution without renewed preparation.
- If an active kinematics motion is stopped with a "MC_GroupInterrupt" job and continued with a "MC_GroupContinue" job, the kinematics motions in the job sequence are prepared again with the "MC_GroupContinue" job.

See also

Interrupting, continuing and stopping kinematics motions (Page 234)

"MotionQueue" tag (kinematics) (Page 478)

8.5.2 Blending kinematics motions with maximum rounding clearance

Multiple motions can be appended to one another, in which case the kinematics comes to a standstill between the individual motions. To achieve an uninterrupted Motion Control without standstill between the individual motion jobs, the individual motions can be blended and thus connected via geometric transitions.

You can configure the maximum rounding clearance of the kinematics motions from 0% to 100% of the distance. You can specify and move blending distances greater than half of the shorter path length.

Determine maximum rounding clearance

The maximum rounding clearance is determined depending on the following values:

- L0: Rounding clearance of the previous motion job
- L1: Path length of the first job to the rounding point.
- L2: Path length of the second job to the rounding point

The maximum rounding clearance is the smallest of the following values:

- L1 - L0
- "<TO>.Transition.FactorBlendingLength" / 100 * L1
- "<TO>.Transition.FactorBlendingLength" / 100 * L2

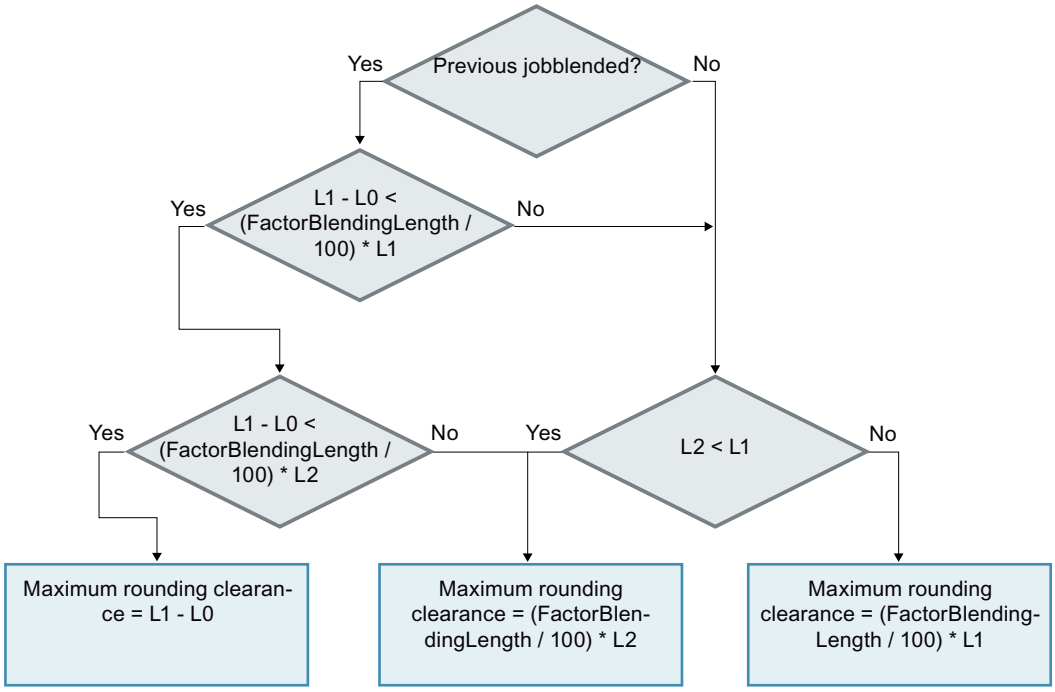

Example: Equal distances between the points

The distances between points A and B and points B and C are the same length. The kinematics is at a standstill.

<TO>.Transition.FactorBlendingLength	Maximum rounding clearance ①		Description
100.0	L1	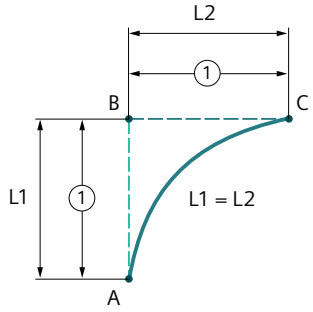	The entire motion can be blended. The maximum rounding clearance corresponds to the distance between points A and B or B and C.
50.0	L1 * 0.5	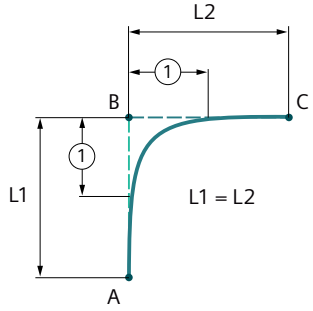	The maximum rounding clearance is reduced to half the distance between points A and B.

Example: Different distances between the points

The distances between points A and B and points B and C are different in length. The distance between points A and B is less than the distance between points B and C. The kinematics is in standstill.

<TO>.Transition.FactorBlendingLength	Maximum rounding clearance ①		Description
100.0	L1	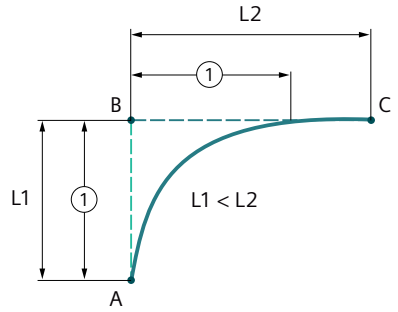	The maximum rounding clearance corresponds to the distance L1, as this is the shorter distance.
50.0	L1 * 0.5	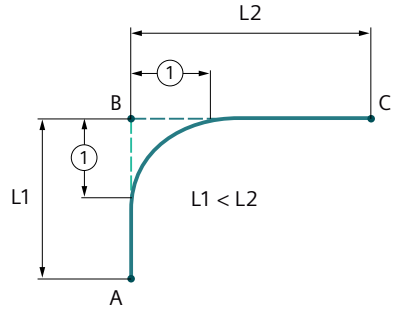	The maximum rounding clearance is calculated with half of L1, because L1 is the shorter distance.

Example: Previous job blended

The example builds on the previous example. A linear motion to point D should be traversed. Point C should not be approached directly. The motion to point D should be done with maximum rounding clearance to point C. The previous motion job to point C is blended with rounding clearance L0.

<TO>.Transition.FactorBlendingLength	Maximum rounding clearance ①		Description
100.0	L1 - L0	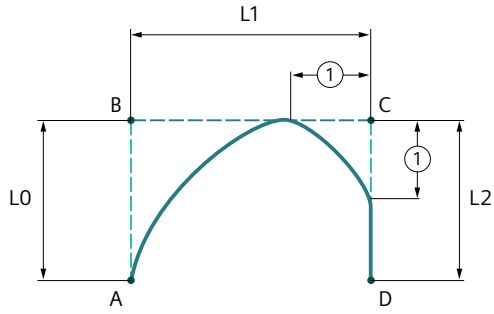	The maximum rounding clearance corresponds to the distance L1 minus the rounding clearance from the previous motion. That is the shortest distance.

<TO>.Transition.FactorBlendingLength	Maximum rounding clearance ①		Description
50.0	L2 * 0.5	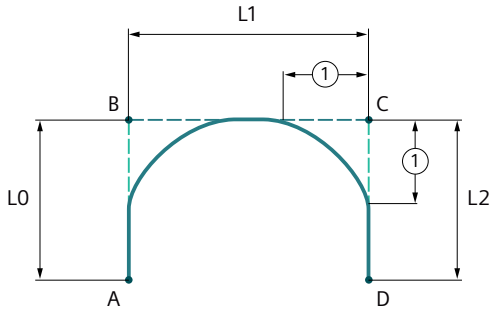	Half of L2 is the shortest distance and therefore the maximum rounding clearance. The rounding clearance of the previous motion is lower by a factor of 50% and does not reduce the maximum rounding clearance of the following motion as much as it does at 100%.

Configure maximum rounding clearance

Up to technology version V5.0, the maximum rounding clearance is limited to 50% of the shorter distance. From technology version V6.0, you can configure the maximum rounding clearance. The default is 50% and therefore compatible with the technology versions < V6.0.

The factor [%] is configured in the configuration window "Technology object > Configuration > Extended parameters > Job sequence" or using the tag "<TO>.Transition.FactorBlendingLength" of the kinematics technology object. Change the factor in the user program before sending the motion jobs to the job sequence so that the change is effective.

The maximum rounding clearance is used when the value of the "TransitionParameter[1]" parameter is < 0.0 or the specified value exceeds the maximum rounding clearance. The rounding clearance is limited to the maximum rounding clearance when the value of the "TransitionParameter[1]" is > 0. If you have parameterized a smaller positive rounding clearance at the Motion Control instruction than the maximum rounding clearance, then the configured rounding clearance "TransitionParameter[1]" is effective.

The following table shows three possible configuration examples and their effect on the calculation of the maximum rounding clearance:

Configuration example "<TO>.Transition.FactorBlendingLength"	Effect
0.0	The rounding clearance is always zero. Blending is not possible with any motion.
50.0	The maximum rounding clearance is calculated from half of the shorter distance between the two motions.
100.0	The maximum rounding clearance is calculated from the shorter distance of the two motions and the rounding clearance of the previous motion. You have the option of moving the kinematics with the maximum possible rounding clearances.

8.5.3 Dynamic behavior when motions are appended/blended

You define the dynamic behavior for the transition of kinematics motions with the "BufferMode" and "DynamicAdaption" parameters.

Multiple motions can be appended to one another, in which case the kinematics comes to a standstill between the individual motions ("BufferMode" = 1). To achieve an uninterrupted motion, the individual motions can be blended with a blending segment. The consecutive motions can be blended at the lower velocity ("BufferMode" = 2) or at the higher velocity ("BufferMode" = 5).

Dynamic adaptation

With active dynamic adaptation with segmentation of the path ("DynamicAdaption" =1), the path of a motion job is divided into individual segments. For each of these segments, the velocity profile is calculated with consideration of the applicable limits. The dynamic response of the path is thus adapted for individual segments of a motion job. As a result, a higher traversing velocity can be reached section by section, thus reducing the traversing time of the motion.

With active dynamic adaptation without segmentation of the path ("DynamicAdaption"=2), the velocity profile is calculated taking into account the limitations that apply to the entire motion job.

Dynamic adaptation in the "Limit with segmentation of the path" mode requires a considerably higher computing time than in the "Limit without segmentation of the path" mode.

When dynamic adaptation is activated, a velocity profile for the motion of the kinematics is calculated, which takes into account both the dynamic specifications or dynamic presettings and dynamic limits of the kinematic motion as well as the maximum velocity, maximum acceleration and maximum deceleration of the kinematics axes. In addition, the dynamic presets and dynamic limits for velocity, acceleration and deceleration of the orientation motion are taken into account.

8.5.4 Preliminary motion preparation

With technology version V5.0, the calculation of the motion preparation has changed. The motion preparation is calculated in the organization block (OB) MC_LookAhead and no longer in MC_Interpolator.

The jobs from the job sequence are prepared in advance with MC_LookAhead. The dynamic values for path motions and orientation motions are transferred to the job sequence. The dynamic values are only active when the job is executed.

For the motion processing, the current path motion job and the following path motion jobs (for sPTP-motions only the next motion job) must be taken into account so that the blending of path motions is possible. Path motions are first processed in MC_LookAhead and then take effect in MC_Interpolator. Motions with blending require a longer lead time and a longer reaction time.

You can change the velocity override during a path motion, which immediately changes the dynamics of the path motion.

In MC_Interpolator, less time is needed for motion preparation and you can set a shorter application cycle of MC_Servo.

The description of the organization blocks MC_Interpolator and MC_LookAhead can be found in the "Organization blocks for Motion Control" section of the "S7-1500/S7-1500T Motion Control overview" documentation.

8.5.5 Setting the motion preparation

The motion preparation is influenced by various factors.

To increase the available computing time of the MC_LookAhead, adjust the following settings:

- Application cycle:
  - Set a bigger application cycle.
  - Set a longer PN send clock.
- Increase the maximum cycle load for MC_LookAhead in the properties of the organization block under "General > Multi-core processor". You can set values from 1% to 40% (default setting 20%) for the maximum cycle load.
- If you are not using user-defined kinematics, select the "Improve system performance" check box in the properties of MC_LookAhead under "General > Multi-core processor".
- Set the higher priority 16 for the MC_LookAhead.
- Reduce the percentage communication load in the CPU properties.
- If necessary for interpolation of cyclic cams, clear the "Improve system performance" check box in the properties of MC_Interpolator under "General > Multi-core processor".

You have the following options for reducing the calculation time of the motion preparation:

- Use dynamic adaptation without segmentation of the path instead of dynamic adaptation with segmentation of the path.
- Reduce the maximum number of jobs in the job sequence.

The following measures are possible during programming of the jobs:

- So that blending of a currently active job with a newly issued subsequent job is possible, sufficient computing time must be available for preparation of the subsequent job. You can increase the available computing time using the following measures:
  - Select the smallest possible rounding clearance. Since the rounding clearance shortens the currently active job, there is less time for calculation of the subsequent job.
  - Reduce the traversing velocity.
  - Use jobs with the longest possible traversing length.
- If no motion job is active and the job sequence is empty, you can interrupt the processing of the jobs with an "MC_GroupInterrupt" job and fill the job sequence. Then continue the processing with an "MC_GroupContinue" job as soon as the motion preparation is complete. As a result, the number of prepared commands (<TO>.StatusMotionQueue.NumberOfPreparedCommands) corresponds to the number of queued jobs (<TO>.StatusMotionQueue.NumberOfCommands) in the job sequence.

8.6 Moving a kinematics in a linear manner

You can move the kinematics linearly to a defined target position with a linear motion. With the Motion Control instruction "MC_MoveLinearAbsolute (Page 392)", you move a kinematics with a linear motion to an absolute position. With the Motion Control instruction "MC_MoveLinearRelative (Page 397)", you move a kinematics with a linear path relative to the position which was present at the start of the job processing.

You have the following options for the linear motion:

- Define target position (Page 258)
- Define dynamic response (Page 259)
- Define motion transition (Page 261)
- Start job (Page 263)
- Show motion status and remaining distance (Page 230)

8.6.1 Defining the target position of the linear motion

With the Motion Control instruction "MC_MoveLinearAbsolute", you move a kinematics with a linear motion to an absolute position. With the Motion Control instruction "MC_MoveLinearRelative", you move a kinematics with a linear path relative to the position which was present at the start of the job processing.

Parameter inputs

Absolute target position

You define the absolute target position of the linear motion with the following parameters of the Motion Control instruction "MC_MoveLinearAbsolute (Page 392)":

- With the "CoordSystem" parameter, you define the reference system for the target coordinates.
- With the "Position[1..4]" parameters, you define the x, y, z and A coordinates of the target position.
- With up to 4 interpolating kinematics axes:
  - With the "DirectionA" parameter, you define the direction of movement of the Cartesian orientation A.
- With more than 4 interpolating kinematics axes:
  - With the "Position[5..6]" parameters, you define the B and C coordinates of the target position.

NOTE

Orientation motion

The target orientation is always approached by the shortest distance. If the target orientation can be reached via two paths of equal length, motion is in the positive direction.

Relative target position

You define the relative target position of the linear motion with the following parameters of the Motion Control instruction "MC_MoveLinearRelative (Page 397)":

- With the "CoordSystem" parameter, you define the reference system for the target coordinates.
- With the "Distance[1..4]" parameters, you define the x, y, z and A coordinates of the target position.
- With more than 4 interpolating kinematics axes:
  - With the "Distance[5..6]" parameters, you define the B and C coordinates of the target position.

NOTE

Orientation motion

The target orientation is always approached by the shortest distance. If the target orientation can be reached via two paths of equal length, motion is in the positive direction.

8.6.2 Defining the dynamic response of the linear motion

You can define the dynamic response of the linear path motion at the corresponding Motion Control instruction. You can only define the dynamic response of the orientation motion in the configuration of the kinematics technology object.

Parameter inputs

You define the dynamics of the linear motion with the following parameters of the Motion Control instruction "MC_MoveLinearAbsolute (Page 392)" or "MC_MoveLinearRelative (Page 397)":

- With the "Velocity" parameter, you define the velocity.
- With the "Acceleration" parameter, you define the acceleration.
- With the "Deceleration" parameter, you define the deceleration.
- With the "Jerk" parameter, you define the jerk.
- With the "DynamicAdaption" parameter, you specify the dynamic adaptation of the path motion.

With the following configuration parameters under "Technology object > Configuration > Extended parameters > Dynamics", you define the dynamic response of the orientation motion:

- Select the entry "Orientation motion" in the "Settings for" drop-down list.
- Define the velocity (<TO>.DynamicDefaults.Orientation.Velocity) in the field "Velocity".
- Define the acceleration (<TO>.DynamicDefaults.Orientation.Acceleration) in the field "Acceleration".
- Define the deceleration (<TO>.DynamicDefaults.Orientation.Deceleration) in the field "Deceleration".
- Define the jerk (<TO>.DynamicDefaults.Orientation.Jerk) in the field "Jerk".

Dynamic adaptation

The dynamic adaptation limits the path dynamics to the axis dynamics. When dynamic adaptation is activated, a velocity profile for the motion of the kinematics is calculated, which takes into account not only the dynamic specifications or dynamic defaults and the dynamic limits of the kinematic motion, but also the maximum velocity, maximum acceleration and maximum deceleration of the kinematics axes. In addition, the dynamic defaults and the dynamic limits for velocity, acceleration and deceleration of the orientation motion are taken into account.

Use the configured default

With the "DynamicAdaption" < 0 parameter, the configured default is used. You configure the default value in the field "Limit path dynamics to axis dynamics" under "Technology object > Configuration > Extended parameters > Dynamics" of the kinematics technology object (<TO>.DynamicDefaults.DynamicAdaption).

Do not limit path dynamics to axis dynamics

With the "DynamicAdaption" = 0 parameter, no dynamic adaptation is used for the linear motion.

Limit path dynamics to axis dynamics with segmentation of the path

With the "DynamicAdaption" = 1 parameter, the dynamic adaptation is used for the linear motion. The path of the linear motion is divided into individual segments. For each of these segments, the velocity profile is calculated with consideration of the applicable limits. The dynamic response of the path is thus adapted for individual segments of the linear motion. As a result, a higher traversing velocity is reached section by section and the traversing time of the linear motion is reduced.

Note that dynamic adaptation with segmentation of the path requires a considerably higher computing time than dynamic adaptation without segmentation of the path.

Limit path dynamics to axis dynamics without segmentation of the path

With the "DynamicAdaption" = 2 parameter, the dynamic adaptation is used for the linear motion. The velocity profile is calculated for the entire linear motion. The limitations which apply to the entire motion job are taken into consideration.

8.6.3 Defining the transition of linear motion

Multiple motions can be appended to one another, in which case the kinematics comes to a standstill between the individual motions. To achieve an uninterrupted Motion Control without standstill between the individual motion jobs, the individual motions can be blended with geometric transitions. You define the corresponding parameters at the new motion job (A2), into which the previous job (A1) is to be blended.

In the following examples, the various motion transitions are explained using an active linear motion (A1) and a subsequent linear motion (A2).

Parameter inputs

You define the transition to the active motion with the following parameters of the Motion Control instruction "MC_MoveLinearAbsolute (Page 392)" or "MC_MoveLinearRelative (Page 397)":

- With the "BufferMode" parameter, you define the mode of the motion transition.
- With the "TransitionParameter[1]" parameter, you define the rounding clearance.

Appending motion

With the "BufferMode" = 1 parameter, the linear motion is appended to the active motion. The active motion sequence (A1) is completed and the kinematics comes to a standstill. The linear motion (A2) is then executed.

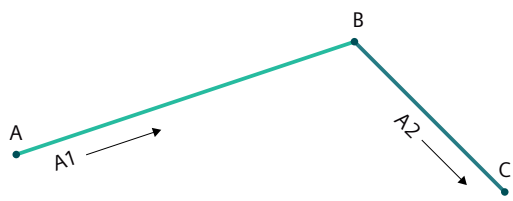

In this case, the parameter "TransitionParameter[1]" is not relevant.

Blending motion

With the "BufferMode" = 2 parameter, the active motion is blended with the linear motion and the lower velocity of both jobs is used.

With the "BufferMode" = 5 parameter, the active motion is blended with the linear motion and the higher velocity of both jobs is used.

Rounding clearance d > 0.0

With the "TransitionParameter[1]" > 0.0 parameter, the active motion (A1) is blended with the linear motion (A2) as soon as the specified rounding clearance to the target position of the active motion is reached.

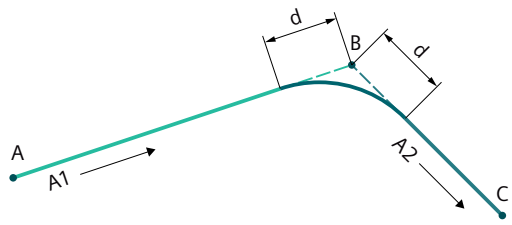

Rounding clearance d = 0.0

With the "TransitionParameter[1]" = 0.0 parameter, the linear motion is appended to the active motion as with "BufferMode" = 1. The active motion sequence (A1) is completed and the kinematics comes to a standstill. The linear motion (A2) is then executed.

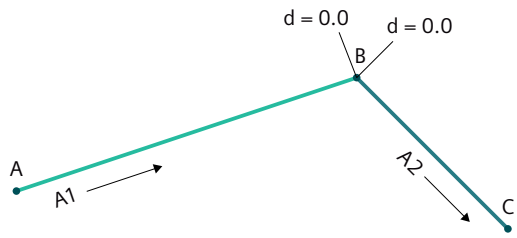

Rounding clearance d < 0.0

With the "TransitionParameter[1]" < 0.0 parameter, the active motion (A1) is blended with the linear motion (A2) as soon as the maximum rounding clearance to the target position of the active motion is reached.

You configure the factor of the maximum rounding clearance under "Technology object > Configuration > Extended parameters > Job sequence" (<TO>.Transition.FactorBlendingLength). In the following example, the maximum blending distance is limited to 50% of the shorter distance.

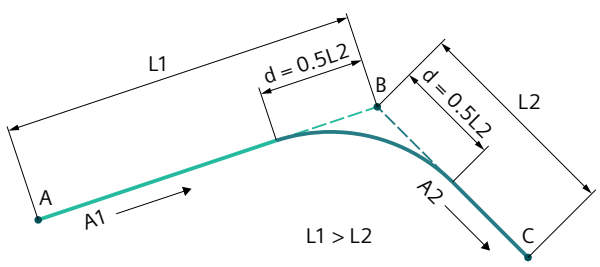

Blending between orientation motions

If the two orientation motions do not contain any translational motion, the blending distance is evaluated in the unit of measure for rotary axes.

8.6.4 Starting a linear motion job

After the start of the linear motion job with "Execute" = TRUE, the job is added to the job sequence (Page 250). The processing status is indicated in the Motion Control instruction "MC_MoveLinearAbsolute (Page 392)" or. "MC_MoveLinearRelative (Page 397)" with the parameter "Busy" = TRUE. If the job is active, this is indicated with the parameter "Active" = TRUE and in the "<TO>.StatusWord.X8 (LinearCommand)" tag of the technology object.

As soon as the target position is reached or the linear motion is blended to the next motion, the job is completed. The status is indicated with the parameter "Done" = TRUE.

You can find more information in the section "Motion status and remaining distance (Page 230)".

8.6.5 Tags: Linear motion

The following technology object tags are relevant for motion control:

Tag	Description	
Status values		
<TO>.StatusWord	Status indicator for an active motion	
<TO>.StatusWord.X8 (LinearCommand)	The value "TRUE" is set if a job for linear motion is active ("MC_MoveLinearAbsolute", "MC_MoveLinearRelative").	
<TO>.Tcp	Target coordinates x, y, z, A, B, C of the kinematics motion in the world coordinate system	
<TO>.StatusPath.CoordSystem	Coordinate system of the active motion job	
	0	World coordinate system
	1, 2, 3	Object coordinate system 1, 2, 3
	100	Machine coordinate system
	101	Joint coordinate system[1)]
<TO>.StatusPath.Velocity	Current path velocity (setpoint reference)	
<TO>.StatusPath.Acceleration	Current path acceleration (setpoint reference)	
<TO>.StatusPath.OrientationVelocity	Resulting orientation velocity	
<TO>.StatusPath.DynamicAdaption	Dynamic adaptation	
	0	No dynamic adaptation
	1	Dynamic adaptation with segmentation of the path
	2	Dynamic adaptation without segmentation of the path
<TO>.StatusPath.TotalPathLength	Total path length of linear and circular path motions Sum of: • Distance of all completed motion jobs • Distance travelled of the active motion job • Remaining distance of the motion job • Calculated distance of all jobs in the job sequence	

1) With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

Tag	Description	
<TO>.StatusPath.AccumulatedPathLength	Accumulated path length of linear and circular path motions Sum of: • Distance of all completed motion jobs • Distance travelled of the active motion job	
<TO>.StatusMotionQueue.NumberOfCommands	Number of jobs in the job sequence	
Override		
<TO>.Override.Velocity	Velocity override	
Dynamic limits		
<TO>.DynamicLimits.Path.Velocity	Dynamic limitation for the maximum velocity of the path	
<TO>.DynamicLimits.Path.Acceleration	Dynamic limitation for the maximum acceleration of the path	
<TO>.DynamicLimits.Path.Deceleration	Dynamic limitation for the maximum deceleration of the path	
<TO>.DynamicLimits.Path.Jerk	Dynamic limitation for the maximum jerk of the path	
<TO>.DynamicLimits.Orientation.Velocity	Dynamic limitation for the maximum velocity of the Cartesian orientation	
<TO>.DynamicLimits.Orientation.Acceleration	Dynamic limitation for the maximum acceleration of the Cartesian orientation	
<TO>.DynamicLimits.Orientation.Deceleration	Dynamic limitation for the maximum deceleration of the Cartesian orientation	
<TO>.DynamicLimits.Orientation.Jerk	Dynamic limitation for the maximum jerk of the Cartesian orientation	
Dynamic defaults		
<TO>.DynamicDefaults.Path.Velocity	Default setting of the velocity of the path	
<TO>.DynamicDefaults.Path.Acceleration	Default setting of the acceleration of the path	
<TO>.DynamicDefaults.Path.Deceleration	Default setting of the deceleration of the path	
<TO>.DynamicDefaults.Path.Jerk	Default setting of the jerk of the path	
<TO>.DynamicDefaults.Orientation.Velocity	Default setting of the velocity of the Cartesian orientation	
<TO>.DynamicDefaults.Orientation.Acceleration	Default setting of the acceleration of the Cartesian orientation	
<TO>.DynamicDefaults.Orientation.Deceleration	Default setting of the deceleration of the Cartesian orientation	
<TO>.DynamicDefaults.Orientation.Jerk	Default setting of the jerk of the Cartesian orientation	
<TO>.DynamicDefaults.DynamicAdaption	Default setting of the dynamic adaptation	
	0	No dynamic adaptation
	1	Dynamic adaptation with segmentation of the path
	2	Dynamic adaptation without segmentation of the path
Rounding clearance		
<TO>.Transition.FactorBlendingLength	Factor of the maximum rounding clearance in percent [%] The configuration takes place in "Technology object > Configuration > Extended parameters > Job sequence". Change the factor in the user program before sending the motion jobs to the job sequence so that the change is effective.	

1) With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

Tag	Description	
<TO>.Transition.FactorBlendingLength	0.0	No blending possible
	50.0	Default value
	100.0	Blending possible with complete segment length or motion length

1) With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

8.7 Moving a kinematics in a circular manner

You can move the kinematics using a defined circular path with a circular motion. With the Motion Control instruction "MC_MoveCircularAbsolute (Page 402)", you move a kinematics with a circular motion to an absolute position. With the Motion Control instruction "MC_MoveCircularRelative (Page 408)", you move a kinematics with a circular motion relative to the position which was present at the start of the job processing.

You have the following options for the circular motion:

- Define circular path:
  - Define circular path via intermediate point and target position (Page 265)
  - Define circular path via center point and angle (Page 267)
  - Define circular path via radius and target position (Page 269)
- Define dynamic response (Page 272)
- Define motion transition (Page 273)
- Start job (Page 276)
- Show motion status and remaining distance (Page 230)

8.7.1 Defining the circular path of the circular motion

8.7.1.1 Defining the circular path via intermediate point and target position

With the Motion Control instruction "MC_MoveCircularAbsolute", you move a kinematics with a circular motion to an absolute position. With the Motion Control instruction "MC_MoveCircularRelative", you move a kinematics with a circular motion relative to the position which was present at the start of the job processing.

Specify an intermediate point on the circular path and the target position for the definition of the circular path. The circular path is calculated via the start position, the intermediate point and the target position. The kinematics can only traverse circular paths less than 360°.

With this mode of circular path definition, the kinematics can move in three-dimensional space:

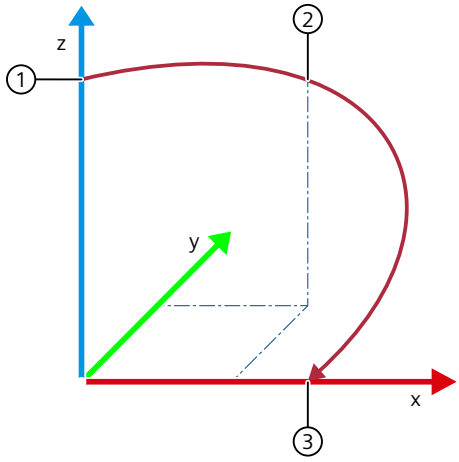

① Start position

② Intermediate point ("AuxPoint")

③ Target position ("EndPoint")

When defining the intermediate point and target position, ensure that the information is consistent.

Parameter inputs

You define the circular path of the circular motion with the following parameters of the Motion Control instruction "MC_MoveCircularAbsolute (Page 402)" or "MC_MoveCircularRelative (Page 408)":

- With the "CircMode" parameter, you define the mode of the circular path definition. With "CircMode" = 0, you define the circular path via an intermediate point and the target position.
- With the "CoordSystem" parameter, you define the reference coordinate system.
- With the "AuxPoint[1..3]" parameters, you define the x, y and z coordinates of the intermediate point of the circular path in the reference coordinate system.
- With the parameter "EndPoint[1..4]", you define the x, y, z and A coordinates of the target position in the reference coordinate system.
- With up to 4 interpolating kinematics axes:
  - With the "DirectionA" parameter, you define the direction of movement of the Cartesian orientation A (only with "MC_MoveCircularAbsolute").

- With more than 4 interpolating kinematics axes:
  - With the parameter "EndPoint[5..6]", you define the B and C coordinates of the target position in the reference coordinate system.

NOTE
Orientation motion
The target orientation is always approached by the shortest distance. If the target orientation can be reached via two paths of equal length, motion is in the positive direction.

8.7.1.2 Defining the circular path via center point and angle

With the Motion Control instruction "MC_MoveCircularAbsolute", you move a kinematics with a circular motion to an absolute position. With the Motion Control instruction "MC_MoveCircularRelative", you move a kinematics with a circular motion relative to the position which was present at the start of the job processing.

Specify the intermediate point of the circular path and the angle for the definition of the circular path. Also define the main plane and the orientation of the circular path. The circular path and the target position are calculated via the defaults .

With this mode of circular path definition, the kinematics can also move circular paths with more than 360° in a main plane.

When defining the circle center and angle, ensure that the information is consistent.

Parameter inputs

You define the circular path of the circular motion with the following parameters of the Motion Control instruction "MC_MoveCircularAbsolute (Page 402)" or "MC_MoveCircularRelative (Page 408)":

- With the "CircMode" parameter, you define the mode of the circular path definition. With "CircMode" = 1, you define the circular path via the circle center and an angle in a main plane.
- With the "CoordSystem" parameter, you define the reference coordinate system.
- With the "AuxPoint[1..3]" parameters, you define the x, y and z coordinates of the center point of the circular path in the reference coordinate system.
- With the "EndPoint[4]" parameter, you define the A coordinates of the target position in the reference coordinate system.
- With up to 4 interpolating kinematics axes:
  - With the "DirectionA" parameter, you define the direction of movement of the Cartesian orientation A (only with "MC_MoveCircularAbsolute").

- With more than 4 interpolating kinematics axes:
  - With the parameter "EndPoint[5..6]", you define the B and C coordinates of the target position in the reference coordinate system.

NOTE
Orientation motion
The target orientation is always approached by the shortest distance. If the target orientation can be reached via two paths of equal length, motion is in the positive direction.

- With the "Arc" parameter, you define the angle of the circular path in the main plane.
- With the "CirclePlane" parameter, you define the main plane of the circular path in the reference coordinate system.
- With the "PathChoice" parameter, you define the orientation of the circular path in the reference coordinate system.

Main plane of the circular path

With the "CirclePlane" parameter, you define on which main plane of the reference coordinate system the circular path is to move:

- With the "CirclePlane" = 0 parameter, you define the xz plane of the reference coordinate system as the main plane.
- With the "CirclePlane" = 1 parameter, you define the yz plane of the reference coordinate system as the main plane.
- With the "CirclePlane" = 2 parameter, you define the xy plane of the reference coordinate system as the main plane.

Orientation of the circular path

There are two possible circular paths in the specified main plane. With the "PathChoice" parameter, you specify the direction in which the circular path should move:

- Use the positive direction of rotation with the "PathChoice" = 0 parameter.
- Use the negative direction of rotation using the "PathChoice" = 1 parameter.

In the following example, the xz plane is defined as the main plane:

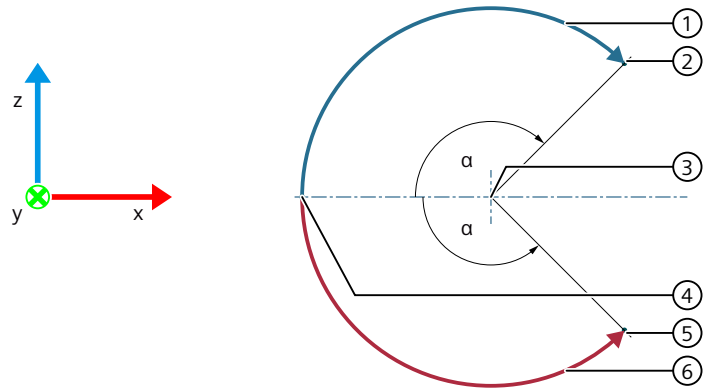

① Positive direction of rotation ("PathChoice" = 0)
② Target position of positive direction of rotation
③ Circle center
④ Start position
⑤ Target position of negative direction of rotation
⑥ Negative direction of rotation ("PathChoice" = 1)
α Angle α = 135°

The figure below shows the direction of rotation depending on the main planes:

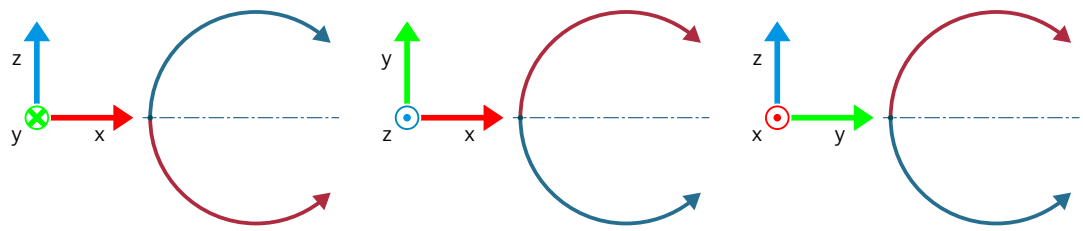

Positive direction of rotation

Negative direction of rotation

8.7.1.3 Define circular path via radius and target position

With the Motion Control instruction "MC_MoveCircularAbsolute", you move a kinematics with a circular motion to an absolute position. With the Motion Control instruction "MC_MoveCircularRelative", you move a kinematics with a circular motion relative to the position which was present at the start of the job processing.

Specify the radius of the circular path and the target position for each definition of the circular path. Also define the main plane and the orientation of the circular path. The circular path is calculated via the defaults.

With this mode of circular path definition, the kinematics can only move circular paths less than 360° in a main plane.

When defining the radius and target position, ensure that the information is consistent.

Parameter inputs

You define the circular path of the circular motion with the following parameters of the Motion Control instruction "MC_MoveCircularAbsolute (Page 402)" or "MC_MoveCircularRelative (Page 408)":

- With the "CircMode" parameter, you define the mode of the circular path definition. With "CircMode" = 2, you define the circular path via the circle radius and the target position in a main plane.
- With the "CoordSystem" parameter, you define the reference coordinate system.
- With the parameter "EndPoint[1..4]", you define the x, y, z and A coordinates of the target position in the reference coordinate system.
- With up to 4 interpolating kinematics axes:
  - With the "DirectionA" parameter, you define the direction of movement of the Cartesian orientation A (only with "MC_MoveCircularAbsolute").
- With more than 4 interpolating kinematics axes:
  - With the parameter "EndPoint[5..6]", you define the B and C coordinates of the target position in the reference coordinate system.

NOTE

Orientation motion

The target orientation is always approached by the shortest distance. If the target orientation can be reached via two paths of equal length, motion is in the positive direction.

- With the "Radius" parameter, you define the radius of the circular path in the main plane.
- With the "CirclePlane" parameter, you define the main plane of the circular path in the reference coordinate system.
- With the "PathChoice" parameter, you define the orientation of the circular path in the reference coordinate system.

Main plane of the circular path

With the "CirclePlane" parameter, you define on which main plane of the reference coordinate system the circular path is to move:

- With the "CirclePlane" = 0 parameter, you define the xz plane of the reference coordinate system as the main plane.
- With the "CirclePlane" = 1 parameter, you define the yz plane of the reference coordinate system as the main plane.
- With the "CirclePlane" = 2 parameter, you define the xy plane of the reference coordinate system as the main plane.

Orientation of the circular path

Depending on the radius, up to four possible circular paths can occur in the specified main plane. With the "PathChoice" parameter, you specify how the circular path should move:

- Use the shorter positive circle segment with the "PathChoice" = 0 parameter.
- Use the shorter negative circle segment using the "PathChoice" = 1 parameter.
- Use the longer positive circle segment with the "PathChoice" = 2 parameter.
- Use the longer negative circle segment with the "PathChoice" = 3 parameter.

In the following example, the xz plane is defined as the main plane:

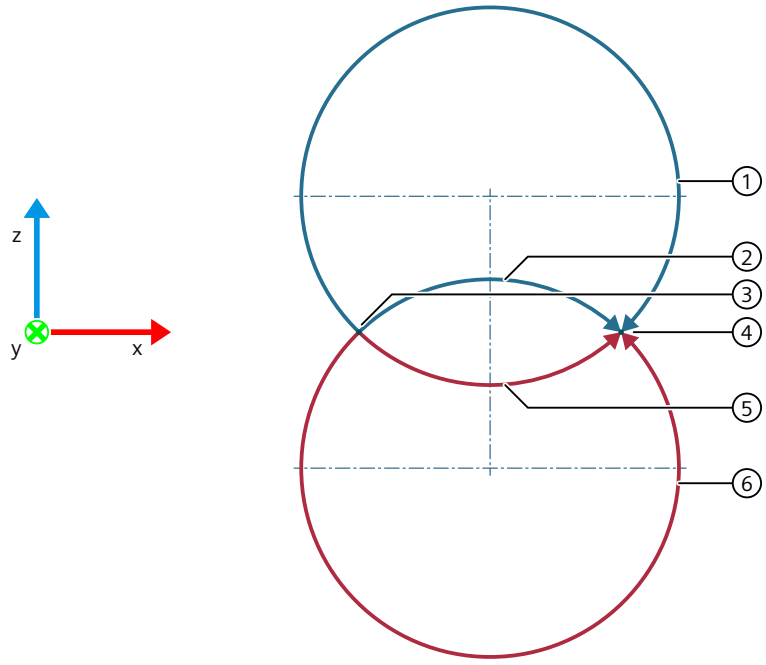

① Longer positive circle segment ("PathChoice" = 2)
② Shorter positive circle segment ("PathChoice" = 0)
③ Start position
④ Target position
⑤ Shorter negative circle segment ("PathChoice" = 1)
⑥ Longer negative circle segment ("PathChoice" = 3)

The following figure shows the positive and negative circle segments depending on the main planes:

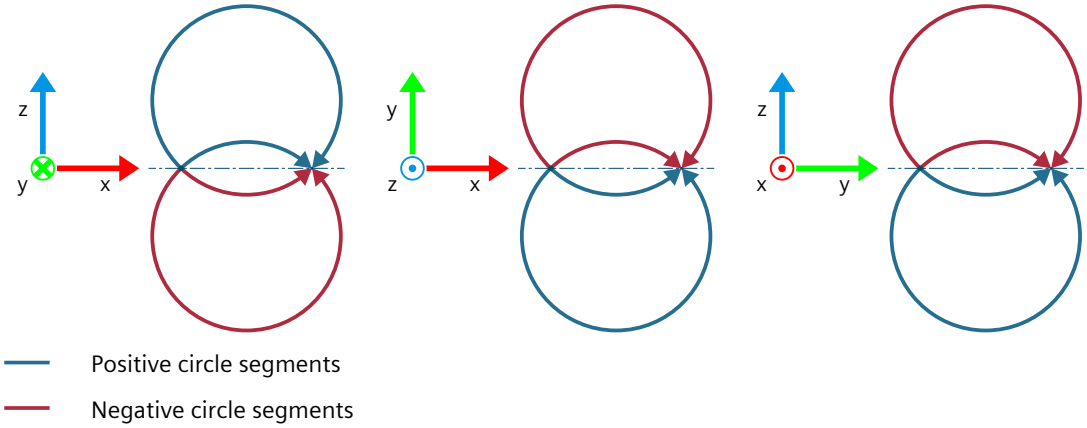

8.7.2 Define the dynamic response of the circular motion

You can define the dynamic response of the circular path motion at the corresponding Motion Control instruction. You can only define the dynamic response of the orientation motion in the configuration of the kinematics technology object.

Parameter inputs

You define the dynamics of the circular motion with the following parameters of the Motion Control instruction "MC_MoveCircularAbsolute (Page 402)" or "MC_MoveCircularRelative (Page 408)":

- With the "Velocity" parameter, you specify the velocity of the path motion.
- With the "Acceleration" parameter, you specify the acceleration of the path motion.
- With the "Deceleration" parameter, you specify the deceleration of the path motion.
- With the "Jerk" parameter, you specify the jerk of the path motion.
- With the "DynamicAdaption" parameter, you specify the dynamic adaptation of the path motion.

With the following configuration parameters under "Technology object > Configuration > Extended parameters > Dynamics", you define the dynamic response of the orientation motion:

- Select the entry "Orientation motion" in the "Settings for" drop-down list.
- Define the velocity of the orientation motion (<TO>.DynamicDefaults.Orientation.Velocity) in the field "Velocity".
- Define the acceleration of the orientation motion (<TO>.DynamicDefaults.Orientation.Acceleration) in the field "Acceleration".
- Define the deceleration of the orientation motion (<TO>.DynamicDefaults.Orientation.Deceleration) in the field "Deceleration".
- Define the jerk of the orientation motion (<TO>.DynamicDefaults.Orientation.Jerk) in the field "Jerk".

Dynamic adaptation

The dynamic adaptation limits the path dynamics to the axis dynamics. When dynamic adaptation is activated, a velocity profile for the motion of the kinematics is calculated, which takes into account not only the dynamic specifications or dynamic defaults and the dynamic limits of the kinematic motion, but also the maximum velocity, maximum acceleration and maximum deceleration of the kinematics axes. In addition, the dynamic defaults and the dynamic limits for velocity, acceleration and deceleration of the orientation motion are taken into account.

Use the configured default

With the "DynamicAdaption" < 0 parameter, the configured default is used. You configure the default value in the field "Limit path dynamics to axis dynamics" under "Technology object > Configuration > Extended parameters > Dynamics" of the kinematics technology object (<TO>.DynamicDefaults.DynamicAdaption).

Do not limit path dynamics to axis dynamics

With the "DynamicAdaption" = 0 parameter, no dynamic adaptation is used for the circular motion.

Limit path dynamics to axis dynamics with segmentation of the path

With the "DynamicAdaption" = 1 parameter, the dynamic adaptation is used for the circular motion. The path of the circular motion is divided into individual segments. For each of these segments, the velocity profile is calculated with consideration of the applicable limits. The dynamic response of the path is thus adapted for individual segments of the circular motion. As a result, a higher traversing velocity is reached section by section and the traversing time of the circular motion is reduced.

Note that dynamic adaptation with segmentation of the path requires a considerably higher computing time than dynamic adaptation without segmentation of the path.

Limit path dynamics to axis dynamics without segmentation of the path

With the "DynamicAdaption" = 2 parameter, the dynamic adaptation is used for the circular motion. The velocity profile is calculated for the entire circular motion. The limitations which apply to the entire motion job are taken into consideration.

8.7.3 Define the transition of circular motion

Multiple motions can be appended to one another, in which case the kinematics comes to a standstill between the individual motions. To achieve an uninterrupted Motion Control without standstill between the individual motion jobs, the individual motions can be blended with geometric transitions. You define the corresponding parameters at the new motion job (A2), into which the previous job (A1) is to be blended.

In the following examples, the various motion transitions are explained using an active linear motion (A1) and a subsequent circular motion (A2).

Parameter inputs

You define the transition to the active motion with the following parameters of the Motion Control instruction "MC_MoveCircularAbsolute (Page 402)" or "MC_MoveCircularRelative (Page 408)":

- With the "BufferMode" parameter, you define the mode of the motion transition.
- With the "TransitionParameter[1]" parameter, you define the rounding clearance.

Appending motion

With the "BufferMode" = 1 parameter, the circular motion is appended to the active motion. The active motion sequence (A1) is completed and the kinematics comes to a standstill. The circular motion (A2) is then executed.

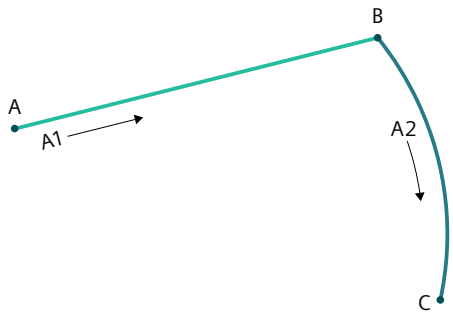

In this case, the parameter "TransitionParameter[1]" is not relevant.

Blending motion

With the "BufferMode" = 2 parameter, the active motion is blended with the circular motion and the lower velocity of both jobs is used.

With the "BufferMode" = 5 parameter, the active motion is blended with the circular motion and the higher velocity of both jobs is used.

Rounding clearance d > 0.0

With the "TransitionParameter[1]" > 0.0 parameter, the active motion (A1) is blended with the circular motion (A2) as soon as the specified rounding clearance to the target position of the active motion is reached.

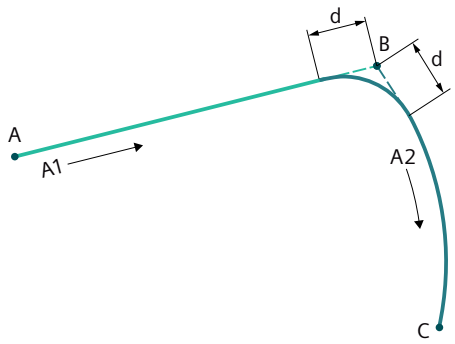

Rounding clearance d = 0.0

With the "TransitionParameter[1]" = 0.0 parameter the circular motion is appended to the active motion as with "BufferMode" = 1. The active motion sequence (A1) is completed and the kinematics comes to a standstill. The circular motion (A2) is then executed.

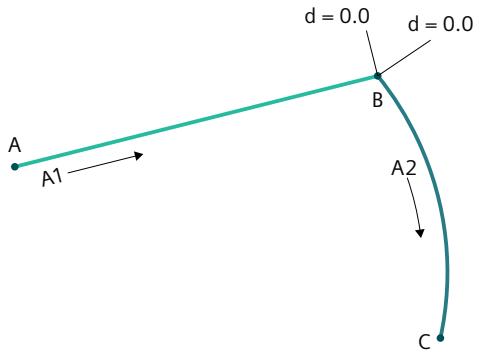

Rounding clearance d < 0.0

With the "TransitionParameter[1]" < 0.0 parameter, the active motion (A1) is blended with the circular motion (A2) as soon as the maximum rounding clearance to the target position of the active motion is reached.

You configure the factor of the maximum rounding clearance under "Technology object > Configuration > Extended parameters > Job sequence" (<TO>.Transition.FactorBlendingLength). In the following example, the maximum blending distance is limited to 50% of the shorter distance.

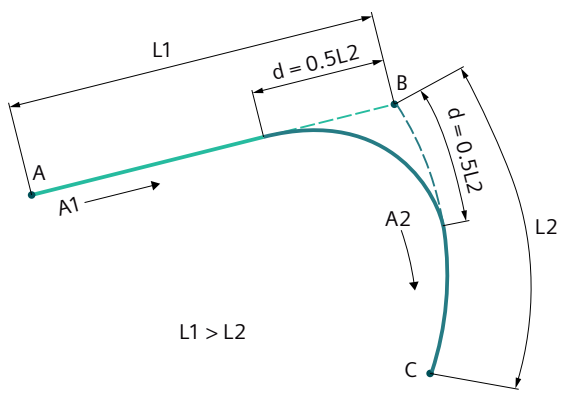

Blending between orientation motions

If the two orientation motions do not contain any translational motion, the blending distance is evaluated in the unit of measure for rotary axes.

8.7.4 Starting a circular motion job

After the start of the circular motion job with "Execute" = TRUE, the job is added to the job sequence (Page 250). The processing status is indicated in the Motion Control instruction "MC_MoveCircularAbsolute (Page 402)" or. "MC_MoveCircularRelative (Page 408)" with the parameter "Busy" = TRUE. If the job is active, this is indicated with the parameter "Active" = TRUE and in the "<TO>.StatusWord.X9 (CircularCommand)" tag of the technology object.

As soon as the target position is reached or the circular motion is blended to the next motion, the job is completed. The status is indicated with the parameter "Done" = TRUE.

You can find more information in the section "Motion status and remaining distance (Page 230)".

8.7.5 Tags: Circular motion

The following technology object tags are relevant for motion control:

Tag	Description	
Status values		
<TO>.StatusWord	Status indicator for an active motion	
<TO>.StatusWord.X9 (CircularCommand)	The value "TRUE" is set if a job for circular motion is active ("MC_MoveCircularAbsolute", "MC_MoveCircularRelative").	
<TO>.Tcp	Target coordinates x, y, z, A, B, C of the kinematics motion in the world coordinate system	
<TO>.StatusPath.CoordSystem	Coordinate system of the active motion job	
	0	World coordinate system
	1, 2, 3	Object coordinate system 1, 2, 3
	100	Machine coordinate system
	101	Joint coordinate system[1)]
<TO>.StatusPath.Velocity	Current path velocity (setpoint reference)	
<TO>.StatusPath.Acceleration	Current path acceleration (setpoint reference)	
<TO>.StatusPath.OrientationVelocity	Resulting orientation velocity	
<TO>.StatusPath.DynamicAdaption	Dynamic adaptation	
	0	No dynamic adaptation
	1	Dynamic adaptation with segmentation of the path
	2	Dynamic adaptation without segmentation of the path
<TO>.StatusPath.TotalPathLength	Total path length of linear and circular path motions Sum of: • Distance of all completed motion jobs • Distance travelled of the active motion job • Remaining distance of the motion job • Calculated distance of all jobs in the job sequence	

1) With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

Tag	Description	
<TO>.StatusPath.AccumulatedPathLength	Accumulated path length of linear and circular path motions Sum of: • Distance of all completed motion jobs • Distance travelled of the active motion job	
<TO>.StatusMotionQueue.NumberOfCommands	Number of jobs in the job sequence	
Override		
<TO>.Override.Velocity	Velocity override	
Dynamic limits		
<TO>.DynamicLimits.Path.Velocity	Dynamic limitation for the maximum velocity of the path	
<TO>.DynamicLimits.Path.Acceleration	Dynamic limitation for the maximum acceleration of the path	
<TO>.DynamicLimits.Path.Deceleration	Dynamic limitation for the maximum deceleration of the path	
<TO>.DynamicLimits.Path.Jerk	Dynamic limitation for the maximum jerk of the path	
<TO>.DynamicLimits.Orientation.Velocity	Dynamic limitation for the maximum velocity of the Cartesian orientation	
<TO>.DynamicLimits.Orientation.Acceleration	Dynamic limitation for the maximum acceleration of the Cartesian orientation	
<TO>.DynamicLimits.Orientation.Deceleration	Dynamic limitation for the maximum deceleration of the Cartesian orientation	
<TO>.DynamicLimits.Orientation.Jerk	Dynamic limitation for the maximum jerk of the Cartesian orientation	
Dynamic defaults		
<TO>.DynamicDefaults.Path.Velocity	Default setting of the velocity of the path	
<TO>.DynamicDefaults.Path.Acceleration	Default setting of the acceleration of the path	
<TO>.DynamicDefaults.Path.Deceleration	Default setting of the deceleration of the path	
<TO>.DynamicDefaults.Path.Jerk	Default setting of the jerk of the path	
<TO>.DynamicDefaults.Orientation.Velocity	Default setting of the velocity of the Cartesian orientation	
<TO>.DynamicDefaults.Orientation.Acceleration	Default setting of the acceleration of the Cartesian orientation	
<TO>.DynamicDefaults.Orientation.Deceleration	Default setting of the deceleration of the Cartesian orientation	
<TO>.DynamicDefaults.Orientation.Jerk	Default setting of the jerk of the Cartesian orientation	
<TO>.DynamicDefaults.DynamicAdaption	Default setting of the dynamic adaptation	
	0	No dynamic adaptation
	1	Dynamic adaptation with segmentation of the path
	2	Dynamic adaptation without segmentation of the path
Rounding clearance		
<TO>.Transition.FactorBlendingLength	Factor of the maximum rounding clearance in percent [%] The configuration takes place in "Technology object > Configuration > Extended parameters > Job sequence". Change the factor in the user program before sending the motion jobs to the job sequence so that the change is effective.	

1) With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

Tag	Description	
<TO>.Transition.FactorBlendingLength	0.0	No blending possible
	50.0	Default value
	100.0	Blending possible with complete segment length or motion length

1) With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

8.8 Moving a kinematics with a synchronous "point-to-point" motion

With a synchronous "point-to-point" motion (sPTP motion), you can move a kinematics time- and motion-optimized, bypass singularities (Page 183) or change joint position spaces. The kinematics does not follow a specified path. The single-axis motions, which move the kinematics axes synchronously, are calculated from the start and target positions. All kinematics axes move simultaneously and reach the corresponding target position at the same time. The kinematics axis with the longest travel time determines the travel time of the sPTP motion and therefore the travel time of all other kinematics axes. The movement path of the tool center point (TCP) results from the motions and dynamics of the individual axes.

Blending between sPTP motions and path motions results in the reduction of the travel time of a sequence of motion jobs, e.g.:

- Record product with a defined path motion
- Move product with sPTP motion as quickly as possible
- Place product with a defined path motion

With the Motion Control instruction "MC_MoveDirectAbsolute (Page 414)", you move a kinematics with an sPTP motion to an absolute position. With the Motion Control instruction "MC_MoveDirectRelative (Page 422)", you move a kinematics with an sPTP motion relative to the position which was present at the start of the job processing.

NOTE

Traversing coupled axis with sPTP motion

For coupled axes with coupling factor ≠ 1, the traversing of joints in the JCS with an sPTP motion can result in compensation motions of the coupled axes.

You have the following options for the sPTP motion:

- Define target position:
  - Define axis target positions (Page 279)
  - Define joint target positions (Page 280)
  - Define Cartesian coordinates (Page 281)
- Define dynamic factors (Page 283)
- Define motion transition (Page 284)
- Start job and show execution progress (Page 286)

8.8.1 Defining the target position of the sPTP motion

8.8.1.1 Defining the axis target position of the sPTP motion

With the Motion Control instruction "MC_MoveDirectAbsolute", you move a kinematics with a synchronous "point-to-point" motion (sPTP motion) to an absolute position. With the Motion Control instruction "MC_MoveDirectRelative", you move a kinematics with an sPTP motion relative to the position which was present at the start of the job processing.

Enter axis-related target positions in the machine coordinate system (MCS). The single-axis motions are calculated from the start and target positions of the axes. The kinematics moves all single-axis motions synchronously. All kinematics axes move simultaneously and reach the given target positions at the same time. The kinematics axis with the longest travel time determines the travel time of the sPTP motion and therefore the travel time of all other kinematics axes.

Parameter inputs

Absolute target positions

You define the absolute target position of the axes with the following parameters of the Motion Control instruction "MC_MoveDirectAbsolute (Page 414)":

- With the "CoordSystem" = 100 parameter, you define the MCS as the reference coordinate system.
- With the "Position[1..4]" parameters, you define the absolute target joint positions of the axes A1 to A4.
- With more than 4 interpolating kinematics axes:
  - With the "Position[5..6]" parameters, you define the absolute target joint positions of the axes A5 and A6.

Relative target positions

You define the relative target position of the axes with the following parameters of the Motion Control instruction "MC_MoveDirectRelative (Page 422)":

- With the "CoordSystem" = 100 parameter, you define the MCS as the reference coordinate system.
- With the "Distance[1..4]" parameters, you define the relative target joint positions of the axes A1 to A4.
- With more than 4 interpolating kinematics axes:
  - With the "Distance[5..6]" parameters, you define the relative target joint positions of the axes A5 and A6.

8.8.1.2 Define joint target positions of the sPTP motion

With the Motion Control instruction "MC_MoveDirectAbsolute", you move a kinematics with a synchronous "point-to-point" motion (sPTP motion) to an absolute position. With the Motion Control instruction "MC_MoveDirectRelative", you move a kinematics with an sPTP motion relative to the position which was present at the start of the job processing.

Enter target positions in the joint coordinate system (JCS). The single-axis motions are calculated from the start and target positions of the joints. The kinematics moves all single-axis motions synchronously. All kinematics axes move simultaneously and reach the given target positions at the same time. The kinematics axis with the longest travel time determines the travel time of the sPTP motion and therefore the travel time of all other kinematics axes.

With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

Parameter inputs

Absolute target positions

You define the absolute target position of the joints with the following parameters of the Motion Control instruction "MC_MoveDirectAbsolute (Page 414)":

- With the "CoordSystem" = 101 parameter, you define the JCS as the reference coordinate system.
- With the "Position[1..4]" parameters, you define the absolute target positions of joints J1 to J4.
- With more than 4 interpolating kinematics axes:
  - With the "Position[5..6]" parameters. you define the absolute target positions of joints J5 and J6.

Relative target positions

You define the relative target positions of the joints with the following parameters of the Motion Control instruction "MC_MoveDirectRelative (Page 422)":

- With the "CoordSystem" = 101 parameter, you define the JCS as the reference coordinate system.
- With the "Distance[1..4]" parameters, you define the relative target positions of joints J1 to J4.
- With more than 4 interpolating kinematics axes:
  - With the "Distance[5..6]" parameters, you define the relative target positions of joints J5 and J6.

8.8.1.3 Defining the Cartesian target coordinates of the sPTP motion

With the Motion Control instruction "MC_MoveDirectAbsolute", you move a kinematics with a synchronous "point-to-point" motion (sPTP motion) to an absolute position. With the Motion Control instruction "MC_MoveDirectRelative", you move a kinematics with an sPTP motion relative to the position which was present at the start of the job processing.

You define the Cartesian target coordinates in the world coordinate system (WCS) or an object coordinate system (OCS). The single-axis motions are calculated from the start and target coordinates. The kinematics moves all single-axis motions synchronously. All kinematics axes move simultaneously and reach their target positions at the same time. The kinematics axis with the longest travel time determines the travel time of the sPTP motion and therefore the travel time of all other kinematics axes.

Parameter inputs

Absolute Cartesian coordinates

You define the absolute Cartesian target coordinates of the sPTP motion with the following parameters of the Motion Control instruction "MC_MoveDirectAbsolute (Page 414)":

- With the "CoordSystem" = 0, 1, 2 or 3 parameter, you define the WCS, OCS1, OCS2 or OCS3 as the reference coordinate system.
- With the "Position[1..4]" parameters, you define the absolute Cartesian target coordinates x, y, z and A.
- With the "LinkConstellation" parameter, you define the target joint position space.
- With up to 4 interpolating kinematics axes:
  - With the "PositionMode" parameter, you define for the kinematics types with orientation A whether the value of the parameter "Position[4]" is to be interpreted as absolute or relative for the axis A4. This is only possible if you have enabled Modulo functionality for the axis A4.
  - If "PositionMode" = 1, you define the direction of movement of the Cartesian orientation A with the "DirectionA" parameter. This is only possible if you have enabled Modulo functionality for the axis A4.
- With more than 4 interpolating kinematics axes:
  - With the "Position[5..6]" parameters, you define the absolute Cartesian target coordinates B and C.
  - With the parameter "TurnJoint[1..6]", you define the target joint position ranges of the joints J1 to J6.

Relative Cartesian coordinates

You define the relative Cartesian target coordinates of the sPTP motion with the following parameters of the Motion Control instruction "MC_MoveDirectRelative (Page 422)":

- With the "CoordSystem" = 0, 1, 2 or 3 parameter, you define the WCS, OCS1, OCS2 or OCS3 as the reference coordinate system.
- With the "Distance[1..4]" parameters, you define the relative Cartesian target coordinates x, y, z and A.

- With the "LinkConstellation" parameter, you define the target joint position space.
- With more than 4 interpolating kinematics axes:
  - With the "Distance[5..6]" parameters, you define the relative target coordinates B and C.
  - With the parameter "TurnJoint[1..6]", you define the target joint position ranges of the joints J1 to J6.

Joint position range

With more than 4 interpolating kinematics axes, you can define the target joint position ranges of the joints J1 to J6. You determine the joint position range of the joint J[i] at the target position with the "TurnJoint[i]" parameter. The parameter values are defined as follows:

Value	Description
m (m < 0)	-180° + m · 360° ≤ Position < 180° + m · 360°
-2	-900 ≤ position < -540
-1	-540 ≤ position < -180
0	Shortest distance
1	-180 ≤ position < 180
2	180 ≤ position < 540
3	540 ≤ position < 900
n (n > 0)	-180° + (n - 1) · 360° ≤ Position < 180° + (n - 1) · 360°

The parameterized values for the joint position ranges are absolute for the Motion Control instructions "MC_MoveDirectAbsolute" and "MC_MoveDirectRelative".

The current position setpoints of the joints J1 to J6 are indicated in the tags "<TO>.JointData.J[1..6].Position" of the technology object. You can derive the current joint position areas from the current position setpoints.

Example

The current position of a joint J[i] is 0°. The joint J[i] is therefore located in joint position range 1.

With the specification "Position[i]" = 90.0 and "TurnJoint[i]" = 2, the joint J[i] will not only rotate by 90°, but by 450° in order to reach the specified target joint position range 2.

With the specification "Position[i]" = 0.0 and "TurnJoint[i]" = 2, the joint J[i] will rotate by 360° in order to reach the center of the specified target joint position range 2.

8.8.2 Defining the dynamics factors of the sPTP motion

The dynamic response of the synchronous "point-to-point" motion (sPTP motion) is determined via dynamics factors. The factors relate to the configured maximum dynamic values of the kinematics axes. You configure the maximum dynamic values in "Technology objects > Configuration > Extended parameters > Limits > Dynamics limits" of the technology objects of the interconnected axes.

The single-axis motions, which move the kinematics axes synchronously, are calculated from the start and target positions. All kinematics axes move simultaneously and reach the corresponding target position at the same time. The kinematics axis with the longest travel time determines the travel time of the sPTP motion and therefore the travel time of all other kinematics axes. For the motion profile calculation, the dynamic values of the individual kinematics axes are adapted to the kinematics axis with the longest movement time.

Parameter inputs

You define the dynamics of the sPTP motion with the following parameters of the Motion Control instruction "MC_MoveDirectAbsolute (Page 414)" or "MC_MoveDirectRelative (Page 422)":

- With the "VelocityFactor" parameter, you define the velocity factor of the sPTP motion.
- With the "AccelerationFactor" parameter, you define the acceleration factor of the sPTP motion.
- With the "DecelerationFactor" parameter, you define the deceleration factor of the sPTP motion.
- With the "JerkFactor" parameter, you define the jerk factor of the sPTP motion.

Configure default settings

Proceed as follows to configure the defaults for the dynamics factors of the sPTP motion:

1. Open the "Technology object > Configuration > Extended parameters > Dynamics" configuration window of the kinematics technology object.
2. Select the entry "sPTP motion" in the "Settings for" drop-down list.
3. Enter the default for the velocity factor in the field "Velocity factor" (<TO>.DynamicDefaults.MoveDirect.VelocityFactor).
4. Enter the default for the acceleration factor in the field "Acceleration factor" (<TO>.DynamicDefaults.MoveDirect.AccelerationFactor).
5. Enter the default for the deceleration factor in the field "Deceleration factor" (<TO>.DynamicDefaults.MoveDirect.DecelerationFactor).
6. Enter the default for the jerk factor in the field "Jerk factor" (<TO>.DynamicDefaults.MoveDirect.JerkFactor).

8.8.3 Defining the transition of the sPTP motion

Multiple motions can be appended to one another, in which case the kinematics comes to a standstill between the individual motions. To achieve an uninterrupted Motion Control without standstill between the individual motion jobs, the individual motions can be blended with geometric transitions. You define the corresponding parameters at the new motion job (A2), into which the previous job (A1) is to be blended.

In the following examples, the various motion transitions are explained using an active linear motion (A1) and a subsequent sPTP motion (A2). The sPTP motion is shown as an example. The motion of the kinematics results from the joint position of the individual axes and the dynamics of the motion job.

Parameter inputs

You define the transition to the active motion with the following parameters of the Motion Control instruction "MC_MoveDirectAbsolute (Page 414)" or "MC_MoveDirectRelative (Page 422)":

- With the "BufferMode" parameter, you define the mode of the motion transition.
- With the "TransitionParameter[1]" parameter, you define the rounding clearance.

Append motion

With the "BufferMode" = 1 parameter, the sPTP motion is appended to the active motion. The active motion sequence (A1) is completed and the kinematics comes to a standstill. The sPTP motion (A2) is then executed.

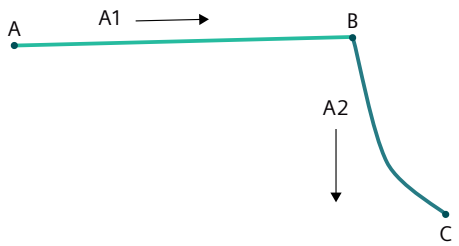

In this case, the parameter "TransitionParameter[1]" is not relevant.

Blending motion

Blending between sPTP motions

With parameter "BufferMode" = 2, the active sPTP motion is blended with the subsequent sPTP motion. When blending two sPTP motions, the lower velocity of the two jobs is used.

With parameter "BufferMode" = 5, the active sPTP motion is blended with the subsequent sPTP motion. When blending two sPTP motions, the higher velocity of the two jobs is used.

To enable continuous blending between two sPTP motions, observe the following:

- Set a sufficiently large rounding clearance.
- Set the dynamic factors for the acceleration and jerk of the sPTP motion as high as possible.
- Set the dynamic response of the two sPTP motions similarly.

Blending between path motions and sPTP motions

When blending path motions and sPTP motions, the velocity of the blending segment is independent of the parameter value "BufferMode" = 2 or 5. The dynamic limits of the axes are not exceeded in the blending area.

To enable a continuous blending between path motions and sPTP motions, observe the following:

- Set a sufficiently large rounding clearance.
- Avoid small curvature radii in the resulting contour of the TCP.
- Set the dynamic response of the path motion and the sPTP motion similarly.
- Set the dynamic adaptation for the path motion.
- Set the dynamics factors of the sPTP motion to smaller than 1.0.
- Set the acceleration and the jerk of the path motion as high as possible.

Define blending distance

Rounding clearance d > 0.0

With the "TransitionParameter[1]" > 0.0 parameter, the active motion (A1) is blended with the sPTP motion (A2) as soon as the specified rounding clearance to the target position of the active motion is reached.

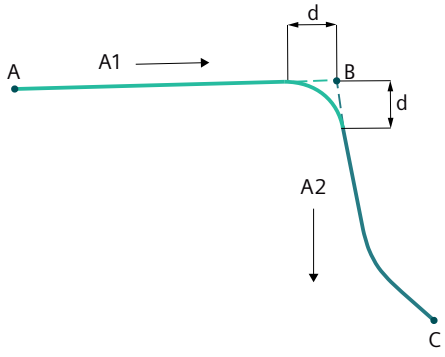

Rounding clearance d = 0.0

With the "TransitionParameter[1]" = 0.0 parameter, the sPTP motion is appended to the active motion as with "BufferMode" = 1. The active motion sequence (A1) is completed and the kinematics comes to a standstill. The sPTP motion (A2) is then executed.

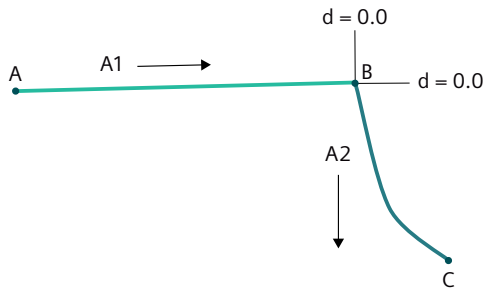

Rounding clearance d < 0.0

With the "TransitionParameter[1]" < 0.0 parameter, the active motion (A1) is blended with the sPTP motion (A2) as soon as the maximum rounding clearance to the target position of the active motion is reached.

You configure the factor of the maximum rounding clearance under "Technology object > Configuration > Extended parameters > Job sequence" (<TO>.Transition.FactorBlendingLength). In the following example, the maximum rounding clearance is limited to 50% of the shorter distance.

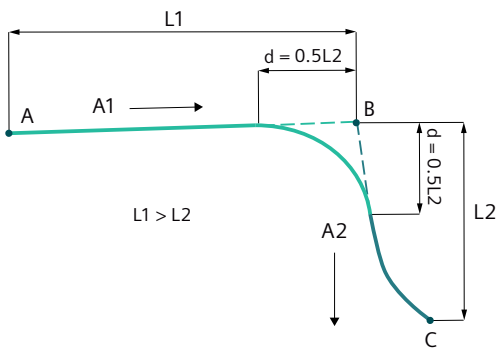

Blending between orientation motions

The behavior is independent of whether the orientation motion is with or without a path motion.

8.8.4 Starting the sPTP motion job

After the start of the synchronous "point-to-point" job (sPTP motion) with "Execute" = TRUE, the job is added to the job sequence (Page 250). The processing status is indicated in the Motion Control instruction "MC_MoveDirectAbsolute (Page 414)" or. "MC_MoveDirectRelative (Page 422)" with the parameter "Busy" = TRUE. If the job is active, this is indicated with the parameter "Active" = TRUE and in the "<TO>.StatusWord.X11 (DirectCommand)" tag of the technology object.

The progress of execution is displayed using the "ExecutionTimeStatus" parameter. The parameter value starts at 0.0 and increases incrementally in the course of job execution.

As soon as the target position is reached or the sPTP motion is blended to the next motion, the job is completed. The status is indicated with the parameter "Done" = TRUE and "ExecutionTimeStatus" = 1.0 .

8.8.5 Tags: sPTP motion

The following technology object tags are relevant for motion control:

Tag	Description	
Status values		
<TO>.StatusWord	Status indicator for an active motion	
<TO>.StatusWord.X11 (DirectCommand)	The value "TRUE" is set if a job for sPTP motion is active ("MC_MoveDirectAbsolute", "MC_MoveDirectRelative").	
<TO>.Tcp	Target coordinates x, y, z, A, B, C of the kinematics motion in the world coordinate system	
<TO>.AxesData.A[1..6]	Current setpoints of the kinematics motion for the kinematics axes A1 to A6	
<TO>.JointData.J[1..6]	Current setpoints of the kinematics motion for the joints J1 to J6	
<TO>.StatusPath.CoordSystem	Coordinate system of the active motion job	
	0	World coordinate system
	1, 2, 3	Object coordinate system 1, 2, 3
	100	Machine coordinate system
	101	Joint coordinate system[1)]
<TO>.StatusMotionQueue.NumberOfCommands	Number of jobs in the job sequence	
Override		
<TO>.Override.Velocity	Velocity override	
Dynamic defaults		
<TO>.DynamicDefaults.MoveDirect.VelocityFactor	Factor for the velocity of the axis motions in relation to the respective maximum velocity of the axes with sPTP motion.	
<TO>.DynamicDefaults.MoveDirect.Acceleration-Factor	Factor for the acceleration of the axis motions in relation to the respective maximum acceleration of the axes with sPTP motion.	
<TO>.DynamicDefaults.MoveDirect.Deceleration-Factor	Factor for the deceleration of the axis motions in relation to the respective maximum deceleration of the axes with sPTP motion.	
<TO>.DynamicDefaults.MoveDirect.JerkFactor	Factor for the jerk of the axis motions in relation to the respective maximum jerk of the axes with sPTP motion.	
Rounding clearance		
<TO>.Transition.FactorBlendingLength	Factor of the maximum rounding distance in percent [%] The configuration takes place in "Technology object > Configuration > Extended parameters > Job sequence". Change the factor in the user program before sending the motion jobs to the job sequence so that the change is effective.	

1) With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

Tag	Description	
<TO>.Transition.FactorBlendingLength	0.0	No blending possible
	50.0	Default value
	100.0	Blending possible with complete segment length or motion length

1) With up to 4 interpolating kinematics axes, the joint coordinate system is identical to the machine coordinate system.

8.9 Conveyor Tracking

With conveyor tracking, the kinematics can follow an object on a moving conveyor belt. The conveyor belt is represented by a leading-value-capable technology object. Leading-value-capable technology objects are:

- Positioning axis
- Synchronous axis
- External encoder
- Leading axis proxy

WARNING

Overrun of the dynamics in the vicinity of a singularity

In the vicinity of a singularity (Page 183) a path motion without dynamic adaptation mostly results in overruns of the dynamics. This means one or more kinematics axes can move at very high speed and accelerate or decelerate with excessive force.

This can cause the following damages:

- Personal injury, for example, caused by products or machine parts coming loose
- Machine damage, for example, through overload of the mechanical components

Activate the dynamic adaptation by setting the value for "DynamicAdaption" to "1" or "2" on the motion job. Also parameterize the dynamic reserve (<TO>.Conveyor.DynamicReserve[1..3]).

A typical motion sequence runs in 5 phases.

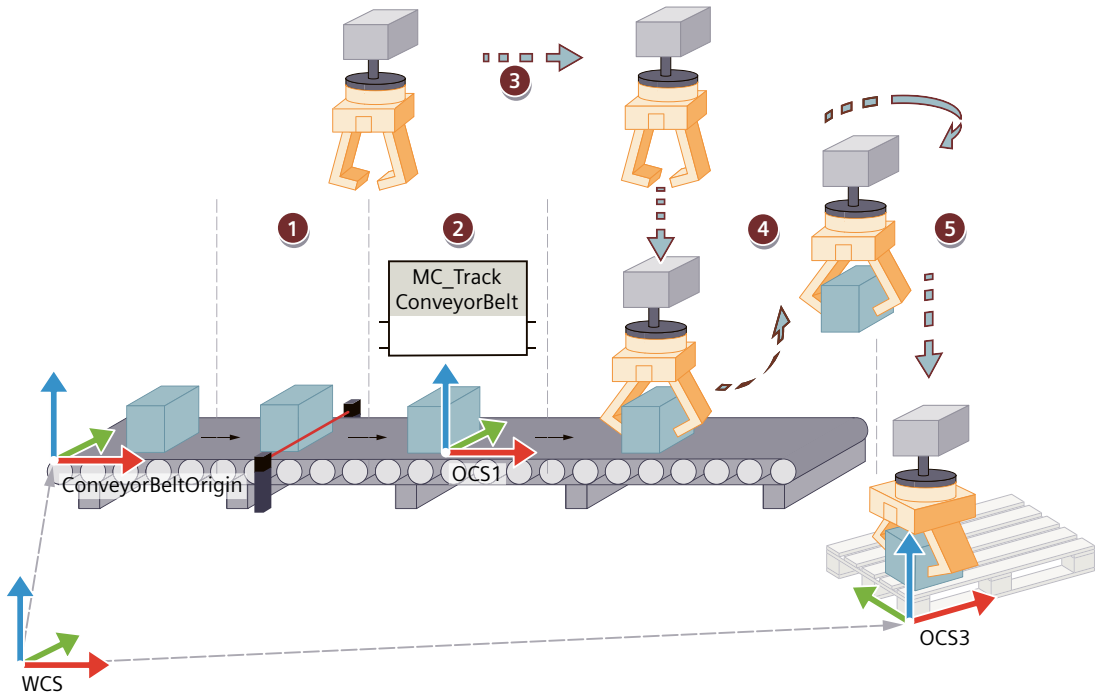

Phase 1: Detect the object position on the conveyor belt

Phase 2: Assign OCS to the object position

Phase 3: Synchronize TCP to tracked OCS

Phase 4: Move TCP within the tracked OCS

Phase 5: Desynchronize TCP from the OCS

The current status of conveyor tracking is displayed in the tag structure "<TO>.StatusConveyor[1..3].TrackingState". "StatusConveyor[1]" refers to OCS1.

8.9.1 Configuring and starting conveyor tracking

Configure and start the conveyor tracking function as follows:

- In the "Conveyor tracking" configuration window, interconnect the leading values and configure the type of coupling for conveyor tracking.
- Use the "MC_TrackConveyorBelt (Page 429)" Motion Control instruction to start the configured conveyor tracking.

Configure leading values for the conveyor tracking

Configure the coupling coefficients in the "Conveyor tracking" configuration window as follows:

1. In the table column "Possible technology objects", add all leading-value-capable technology objects that you need in the instruction as leading-value-capable values for conveyor tracking.

   An object coordinate system can only be coupled with a leading-value-capable technology object whose technology object is defined in this table.
2. In the "Type of coupling" column, select how the leading value of the leading value-capable technology object is to be coupled:
   - Via a setpoint
   - Via an actual value

     With external encoders, only the selection of the actual value is available.
   - Via a delayed setpoint/actual value

Assigning tracked OCS and defining reference position

You define the following parameters for conveyor tracking in the "MC_TrackConveyorBelt" Motion Control instruction:

- **Assigning a leading value-capable technology object**

  An OCS is assigned to a leading value-capable technology object representing the conveyor belt with the "ConveyorBelt" parameter.
- **Defining a frame for OCS reference position on the conveyor**

  The frame "ConveyorBeltOrigin" is used to define the original position of the conveyor belt in relation to the WCS.

  The x direction of the "ConveyorBeltOrigin" must be aligned in the direction of the conveyor belt.

  When defining frames, note the restrictions described in the "Define KCS/OCS frame (Page 204)" section.
- **Tracking position of the OCS**

  You define the tracking position of the OCS in relation to the OCS reference position in the "InitialObjectPosition" parameter.

  "InitialObjectPosition.x" contains the differential value to the belt position to determine the tracked position of the OCS in relation to the OCS reference position.

  The "InitialObjectPosition" is calculated as follows:

"InitialObjectPosition" = Detected position of the conveyor belt at the time of object detection - Distance of the measuring position from the "ConveyorBeltOrigin" in x direction

If the frame "ConveyorBeltOrigin" is exactly at the acquisition position of the object, then the "BeltPosition" corresponds to the "InitialObjectPosition".

- **Select tracked OCS**

  With the "CoordSystem" parameter, you define the number of the tracked OCS.

8.9.2 Phases of conveyor tracking

Phase 1: Detect the object position on the conveyor belt

The "ConveyorBeltOrigin" frame is defined in the example on the left side of the conveyor belt. However, the "ConveyorBeltOrigin" frame can be set so that it does not coincide with the zero point of the conveyor belt. The frame "ConveyorBeltOrigin" is assigned to the Motion Control instruction "MC_TrackConveyorBelt".

When an object reaches a defined position, the current position of the conveyor belt is recorded, e.g. using a measuring input function with a light barrier or with a camera. The "BeltPosition" tag shows the position of the leading-value-capable technology object. In the example, "BeltPosition" is 2000 mm at acquisition time t0. The distance between the measuring position and "ConveyorBeltOrigin" is 500 mm.

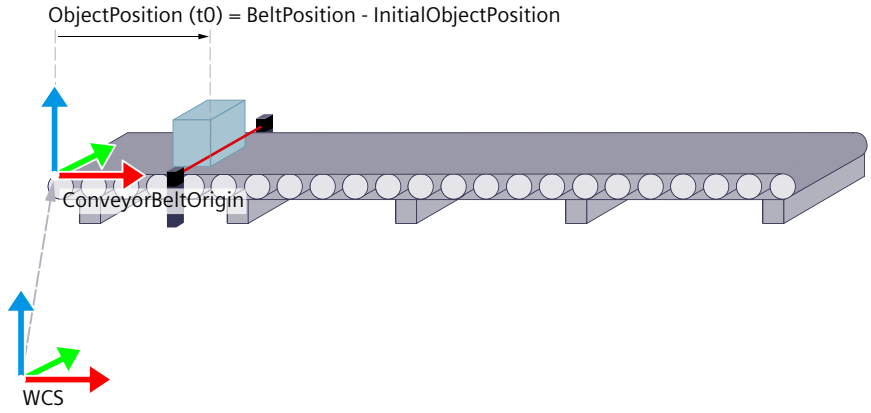

After the conveyor position has been acquired, you must enter the "InitialObjectPosition" at the Motion Control instruction "MC_TrackConveyorBelt".

The relative offset of the object to the ConveyorBeltOrigin in x direction is calculated from the difference between the "BeltPosition" and the "InitialObjectPosition".

At the time of acquisition, the "BeltPosition" is 2000 mm and the "InitialObjectPosition" is 1500 mm. This results in a relative offset of 500 mm. The offset of the tracked OCS in x direction to the reference position "ConveyorBeltOrigin" is displayed in the "ObjectPosition".

No OCS is yet coupled in this phase "TrackingState" is "0". The description of the tag and an overview of the behavior of the tag can be found in section "Behavior of the "TrackingState" tag (Page 295)".

Phase 2: OCS is assigned to the object position

With a Motion Control instruction "MC_TrackConveyorBelt", the OCS1 is assigned to the acquired object position ("ObjectPosition") at time t1. The OCS is then tracked with the object in x direction.

"TrackingState" changes from "0" to "1".

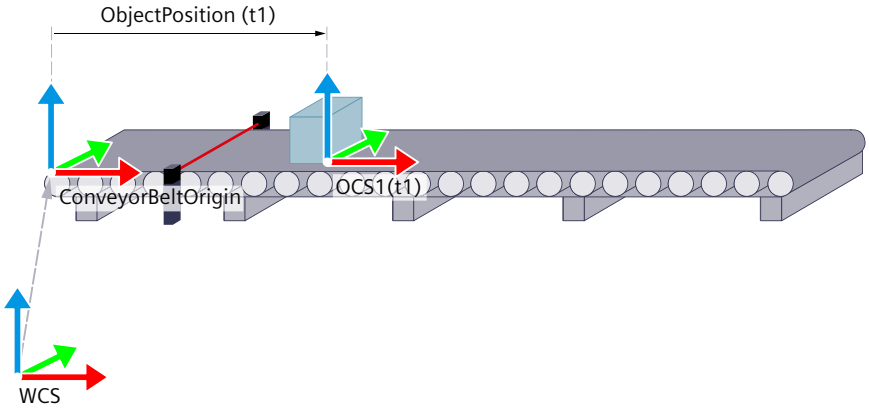

At time t1 the "BeltPosition" is 2400 mm. This calculates the "ObjectPosition" from the example as follows:

"ObjectPosition" = 2400 mm - 1500 mm = 900 mm.

When the conveyor belt moves, the "BeltPosition" and the "ObjectPosition" rise at the same time. The "InitialObjectPosition" is constant. The OCS is moved further in x direction.

At time t2, the conveyor belt has moved the object further in x direction of the OCS and the OCS1 continues to be tracked. The OCS frame moves with the leading value that the conveyor belt specifies.

At time t2 the "BeltPosition" is 2500 mm. This means that the "ObjectPosition" is 1000 mm.

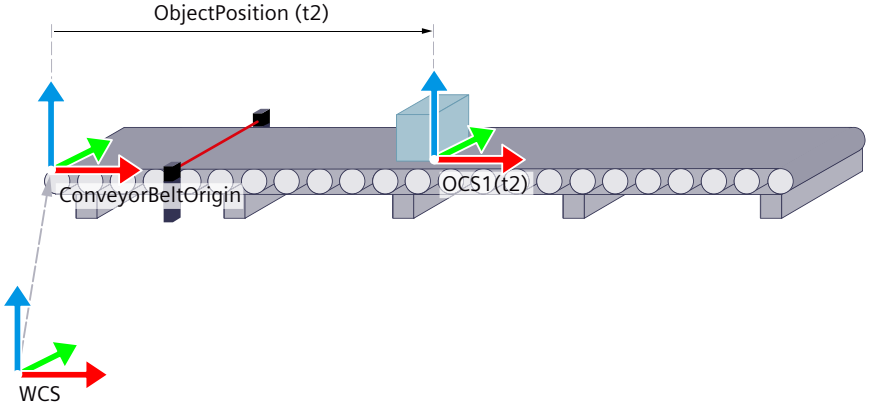

Phase 3: Synchronize TCP to tracked OCS

With the first motion job in the tracked OCS, the TCP is synchronized to the motion of the OCS. Use the Motion Control instruction "MC_MoveLinearAbsolute" or "MC_MoveCircularAbsolute" for the first motion job. You specify the target position in absolute coordinates in the tracked OCS.

"TrackingState" changes with the start of the job from "1" to "2".

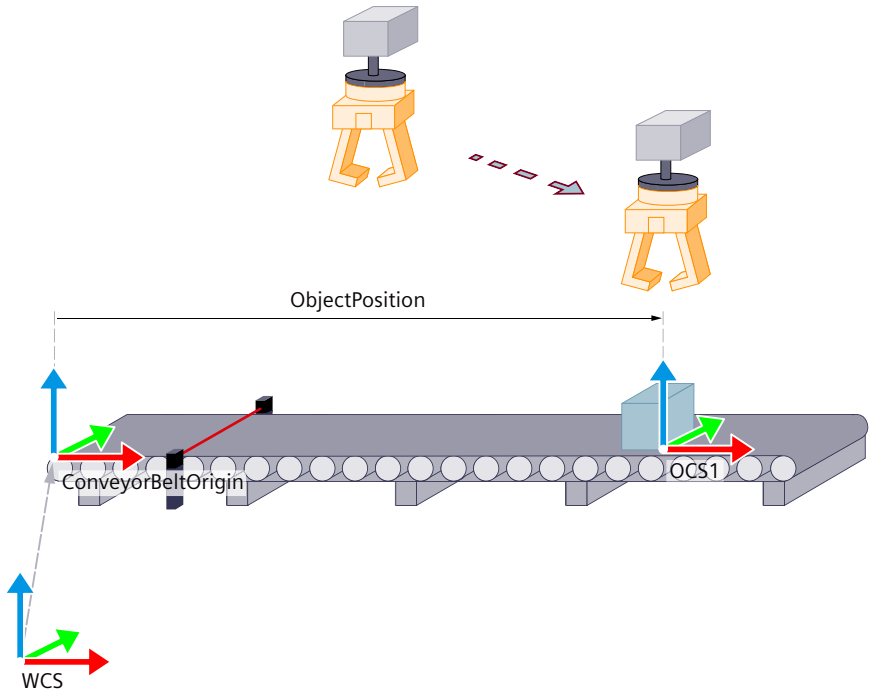

As soon as the target position is reached, "TrackingState" changes from "2" to "3" and the motion job is completed. The TCP now follows the object on the conveyor belt. If blended into the next motion job, the first motion job in the tracked OCS is already completed ("Done" = TRUE) before "TrackingState" changes to "3".

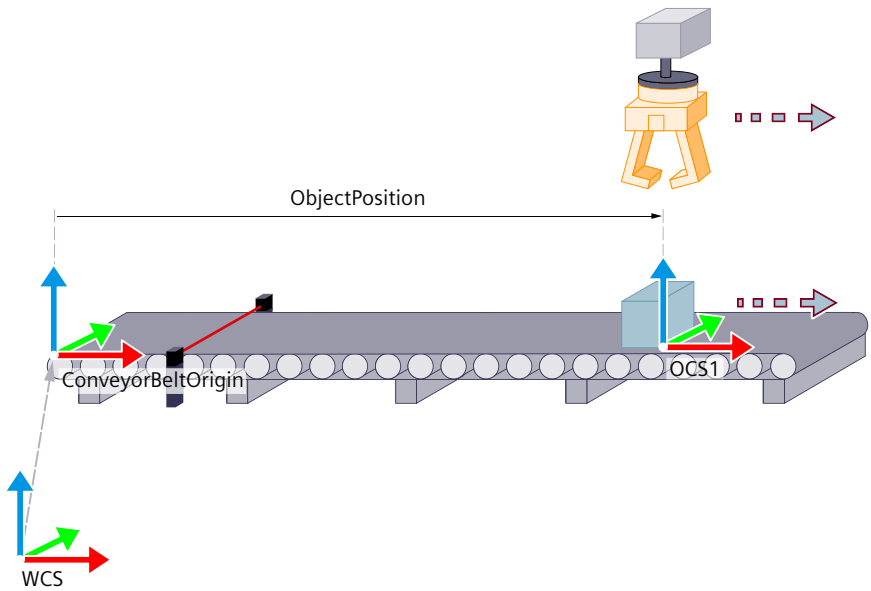

Phase 4: Move TCP within the OCS

In phase 4 you move the kinematics within the OCS, e.g. to grab or process the object. In phase 4, the TCP always follows the tracked OCS.

Select one of the following Motion Control instructions:

- "MC_MoveLinearAbsolute"
- "MC_MoveLinearRelative"
- "MC_MoveCircularAbsolute"
- "MC_MoveCircularRelative"

"TrackingState" remains at "3".

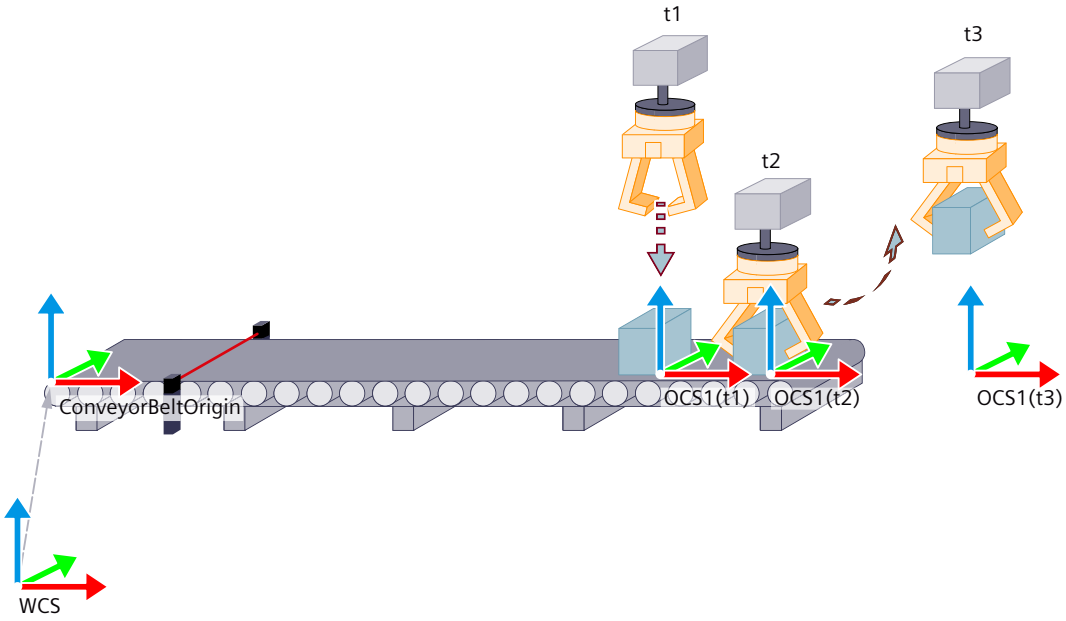

The figure shows three kinematics motions at different times.

- **t1:** The TCP is moved with the instruction "MC_MoveLinearAbsolute" in the tracked OCS1 downward in z direction toward the object.
- **t2:** The object is gripped. The TCP continues to move with the tracked OCS1.
- **t3:** The TCP is moved upwards in z direction with the instruction "MC_MoveLinearAbsolute" in the tracked OCS1, in order to lift the object from the conveyor belt. The TCP continues to be tracked with the OCS1.

Phase 5: Desynchronize TCP from the OCS

With a Motion Control instruction "MC_MoveLinearAbsolute" or "MC_MoveCircularAbsolute" in the WCS or a non-tracked OCS, the TCP is desynchronized from the OCS and no longer follows the motion of the conveyor belt.

"TrackingState" changes with the start of the job from "3" to "4".

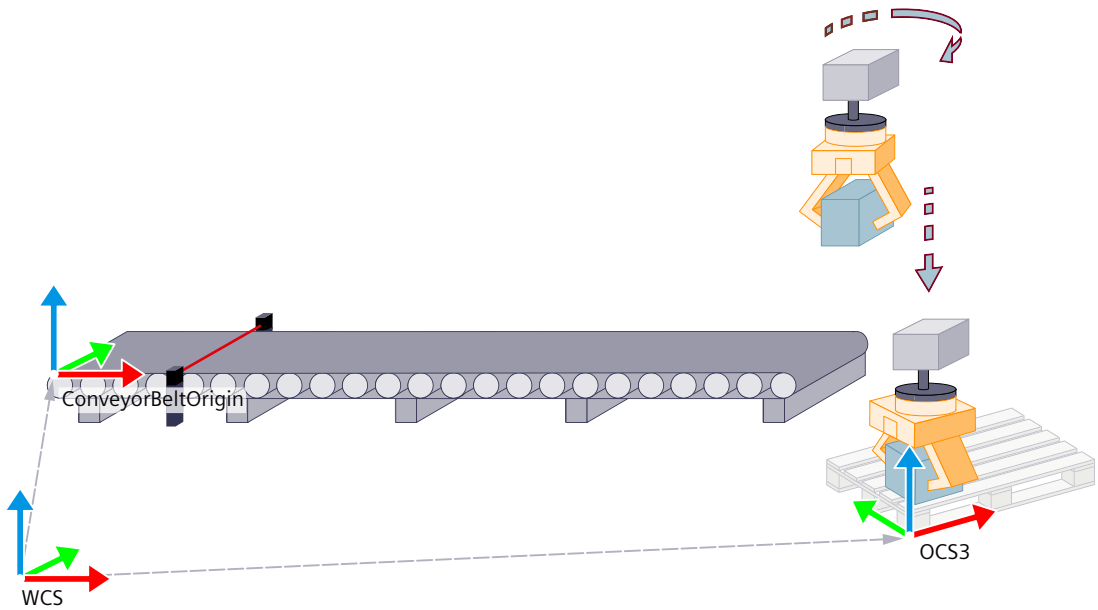

"TrackingState" changes with the end of the job from "4" to "0". The OCS is not tracked with the object position anymore.

See also

Define KCS/OCS frame (Page 204)

8.9.3 Behavior of the "TrackingState" tag

The tag "<TO>.StatusConveyor[1..3].TrackingState" indicates the status of conveyor tracking.

Tag	Description	
<TO>.StatusConveyor[1..3].TrackingState	Conveyor tracking status	
	0	OCS not assigned The OCS is not assigned to a leading-value-capable technology object.
	1	OCS assigned The Motion Control instruction "MC_TrackConveyorBelt" is finished and the OCS is assigned to a leading-value-capable technology object. The first path motion job in the tracked OCS can be sent.
	2	TCP synchronizes to OCS The OCS is assigned to a leading-value-capable technology object. The first path motion job in the tracked OCS is active.
	3	TCP follows OCS The OCS is assigned to a leading-value-capable technology object. The first path motion job in the tracked OCS is completed. The kinematics has reached the position programmed in the path motion job. The kinematics follows the motion of the OCS.

Tag	Description	
<TO>.StatusConveyor[1-..3].TrackingState	4	TCP desynchronizes from OCS The motion of the kinematics in the tracked OCS is ended by a motion job in the WCS or a non-tracked OCS. When the motion job is completed, the "TrackingState" changes to 0 and the OCS is not tracked with the object position anymore.

The following overview shows how the value of "TrackingState" changes when a Motion Control instruction is issued:

Phase	Motion Control instruction	Status of the instruction	"TrackingState"
1	Position acquisition, for example "MC_MeasuringInput"		0
2	"MC_TrackConveyorBelt"	Done = False	0
		Done = False → True	0 → 1
3	• "MC_MoveLinearAbsolute" • "MC_MoveCircularAbsolute" Reference system: Currently tracked OCS	Active = False, Done = False	1
		Active = False → True, Done = False	1 → 2
		Active = True → False, Done = False → True	2 → 3
4	• "MC_MoveLinearAbsolute" • "MC_MoveLinearRelative" • "MC_MoveCircularAbsolute" • "MC_MoveCircularRelative" Reference system: Currently tracked OCS	Active = False, Done = False	3
		Active = False → True, Done = False	3
		Active = True → False, Done = False → True	3
5	• "MC_MoveLinearAbsolute" • "MC_MoveCircularAbsolute" Reference system: WCS or non-tracked OCS	Active = False, Done = False	3
		Active = False → True, Done = False	3 → 4
		Active = True → False, Done = False → True	4 → 0

Possible jobs to define the OCS depending on "TrackingState".

Motion Control instruction	"TrackingState"	Result with active job
"MC_SetOcsFrame"	0, 4	The OCS is redefined.
	1, 2, 3	• The OCS is not redefined. • The OCS is no longer tracked with the conveyor belt. • All kinematics motions are stopped. Please note the following information in this regard.
"MC_TrackConveyorBelt"	0, 1, 4	The OCS is tracked with the defined conveyor belt.
	2, 3	• The OCS is no longer tracked with the conveyor belt. • All kinematics motions are stopped. Please note the following information in this regard.

NOTICE

Product and machine damage

If the motion of the kinematics with an OCS is not yet finished and the OCS is stopped while the conveyor is running, this leads to an interruption of motion of the kinematics.

Close the coupled motion of the kinematics using the OCS or stop the conveyor belt.

8.9.4 Motion between two tracked OCS

For many tasks it is necessary to place motion jobs orders in two tracked OCS.

Example of a pick-and-place task

A product is to be picked up by conveyor belt 1 and placed in a packaging on conveyor belt 2. The object position on conveyor belt 1 is assigned to OCS1, the object position on conveyor belt 2 is assigned to OCS2. The motion between the conveyor belts takes place via an intermediate point in the WCS.

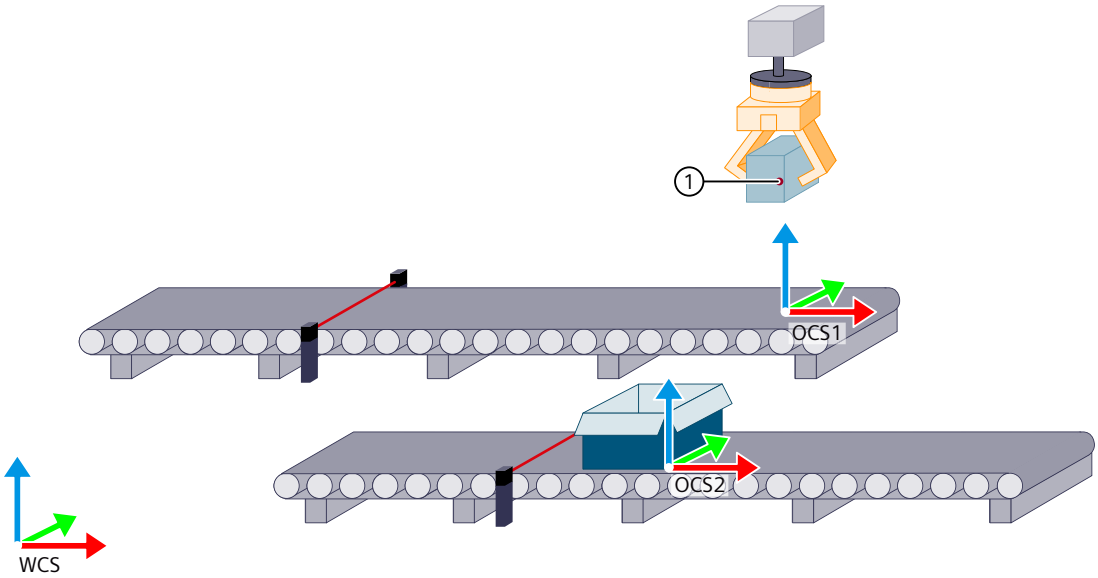

① Intermediate point in the WCS

NOTE

To approach the OCS2 more quickly, smooth the intermediate point in the WCS.

Initial situation: The "TrackingState" of OCS1 is "3". The product has already been gripped and the TCP of the kinematics follows the OCS1.

Program the following Motion Control instructions to move the kinematics from the tracked OCS1 into the tracked OCS2.

1. To assign the OCS2 to the acquired object position, transmit a "MC_TrackConveyorBelt" job.
2. Transmit a "MC_MoveLinearAbsolute" job to an intermediate point in the WCS.
3. Transmit a "MC_MoveLinearAbsolute" job in the tracked OCS2 above the position for the storage.

   The kinematics follows the OCS2.
4. To store the object, transmit a motion job in the OCS2.

8.9.5 Dynamics in the phases of the conveyor tracking

During synchronization or desynchronization, the dynamics of the kinematics results from the dynamics of the motion job and the dynamics required for synchronization or desynchronization. While traveling in the OCS, the dynamics results from the dynamics of the motion job and the dynamics of the conveyor belt.

The dynamics of the kinematics are additionally increased by a synchronization or desynchronization on conveyors with changing conveyor velocity. Execute the synchronization or desynchronization at a conveyor velocity that is as constant as possible.

The path length of the motion job for synchronization or desynchronization influences the dynamics of the kinematics. To reduce the dynamics of the kinematics during synchronization or desynchronization at a constant conveyor speed, increase the length of the path available for synchronization or desynchronization.

8.9.5.1 Dynamic adaptation during conveyor tracking

Use dynamic adaptation at any stage of conveyor tracking. Activate the dynamic adaptation on all motion jobs and parameterize a sufficient dynamic reserve to avoid exceeding the dynamic limits of the kinematics and the kinematics axes.

⚠ WARNING

Exceeding the dynamic limits despite active dynamic adaptation

The following factors can cause the dynamic limits to be exceeded despite activated dynamic adaptation:

- Changing conveyor velocity
- Synchronizing to the tracked OCS with short distance
- Change the range of kinematics motion during conveyor tracking

Exceeding the dynamic limits can cause the following damage:

- Personal injury, for example, caused by products or machine parts coming loose
- Machine damage, for example, through overload of the mechanical components

To avoid exceeding the dynamic limits, take the following measures:

- Parameterize a sufficient dynamic reserve.

  Note that despite parameterized dynamic reserve, the dynamic limits can be exceeded, e.g. by changing conveyor dynamics or short distances when synchronizing or desynchronizing.
- Execute the synchronization or desynchronization at the same conveyor velocity.
- Increase the length of the distance available for synchronization or desynchronization.

Mode of operation

The following overview shows which parameters influence the dynamics at the time of motion preparation and during motion execution in the tracked OCS.

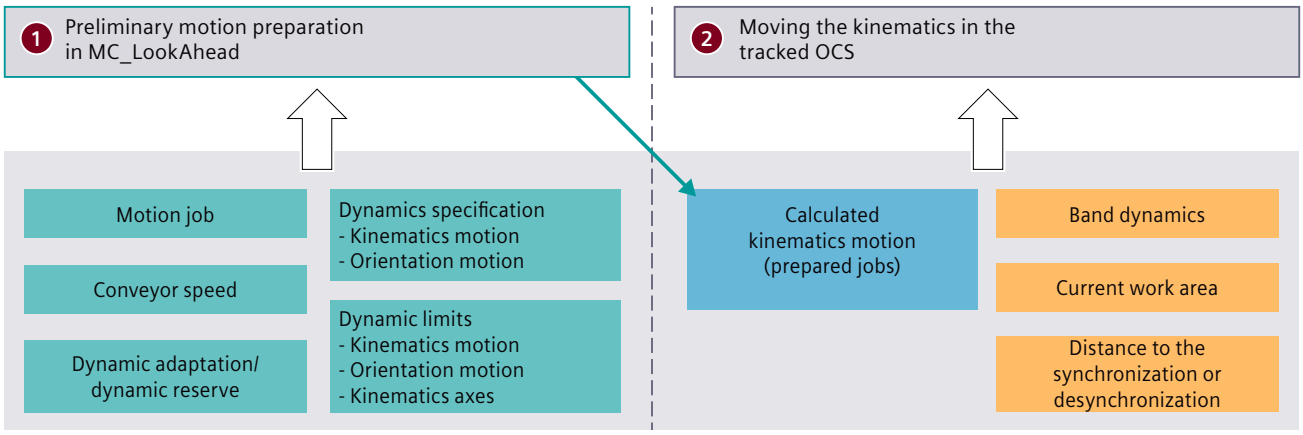

The path motion of the kinematics is calculated in advance in the MC_LookAhead organization block. The following parameters are taken into account at the time of motion preparation ①:

- Dynamics specification on the motion job
- Velocity of the conveyor belt
- Dynamic limits of the Kinematics motion "<TO>.DynamicLimits.Path"
- Dynamic limits of the orientation motion "<TO>.DynamicLimits.Orientation"
- Dynamic limits of the kinematics axes "<TO>.DynamicLimits"

The dynamic limits take into account velocity, acceleration and deceleration. The maximum permissible jerk is not taken into account.

The following changes, which occur during motion in the tracked OCS ② and which were not taken into account at the time of motion preparation, affect the dynamics of the kinematics and the kinematics axes:

Changes	Effect
Changing conveyor dynamics	If the conveyor dynamics change after the motion preparation time, the dynamics of the kinematics motion in the x direction of the tracked OCS also changes.
Change in the range of kinematics motion	Due to the motion of the tracked OCS, the kinematics motion takes place in a different area than for motion preparation. Due to the changed area, the dynamics of individual kinematics axes can be higher than at the time of motion preparation.

Depending on the path length of the motion job and the conveyor dynamics, a dynamic is superimposed to or from the tracked OCS during synchronization or desynchronization.

Enable dynamic adaptation

Activate the Dynamic adaptation (Page 244) by setting the value for "DynamicAdaption" to "1" or "2" on the motion job. Alternatively, configure the default setting on the technology object by setting the "<TO>.DynamicDefaults.DynamicAdaption" variable to "1" or "2" and specifying the value "-1" on the motion job.

8.9.5.2 Dynamic reserve

To maintain the dynamic limits of the kinematics and the kinematics axes when changing the conveyor dynamic response and the working range, use the dynamic reserve "<TO>.Conveyor.DynamicReserve[1..3]". You can configure the dynamic reserve for the object coordinate systems 1 to 3.

NOTE

Dynamic reserve after switching between technology versions V8.0 and V9.0

Up to technology version V8.0 of the kinematics technology object, you can define a value for the dynamic reserve. After the upgrade to technology version V9.0, the default or configured dynamic reserve (<TO>.Conveyor.DynamicReserve[1..1]) is applied as dynamic reserve for the object coordinate systems 1 to 3 (<TO>.Conveyor.DynamicReserve[1..3]). If you are using conveyor tracking, check and configure a sufficient dynamic reserve for all object coordinate systems.

On a change from technology version V9.0 to technology version V8.0, the settings for the dynamic reserve of OCS2 and OCS3 (<TO>.Conveyor.DynamicReserve[2, 3]) are lost. The default or configured dynamic reserve of OCS1 (<TO>.Conveyor.DynamicReserve[1]) is effective for all three object coordinate systems in technology version V8.0.

In order not to exceed the dynamic limits in case of dynamic changes, the motion preparation in x direction of the tracked OCS is calculated with reduced dynamic limits of the kinematics motion, the orientation motion and the kinematics axes. The dynamic limits are reduced by the dynamic reserve during motion preparation. This means that the dynamic reserve is available for dynamic changes during motion, e.g. when the speed of the conveyor is increased.

Parameterize the dynamic reserve according to the expected dynamics change. For strongly fluctuating conveyor dynamics, parameterize a higher dynamic reserve. At constant conveyor velocity, you can parameterize a low dynamic reserve.

① Reduced dynamic limit for motion preparation

② Dynamic reserve for dynamics changes

③ Dynamic limit

Example

The following example shows the dynamic behavior on a "TO_Kin_1" kinematics of the type "Cartesian Portal 3D" (without orientation) with different scenarios.

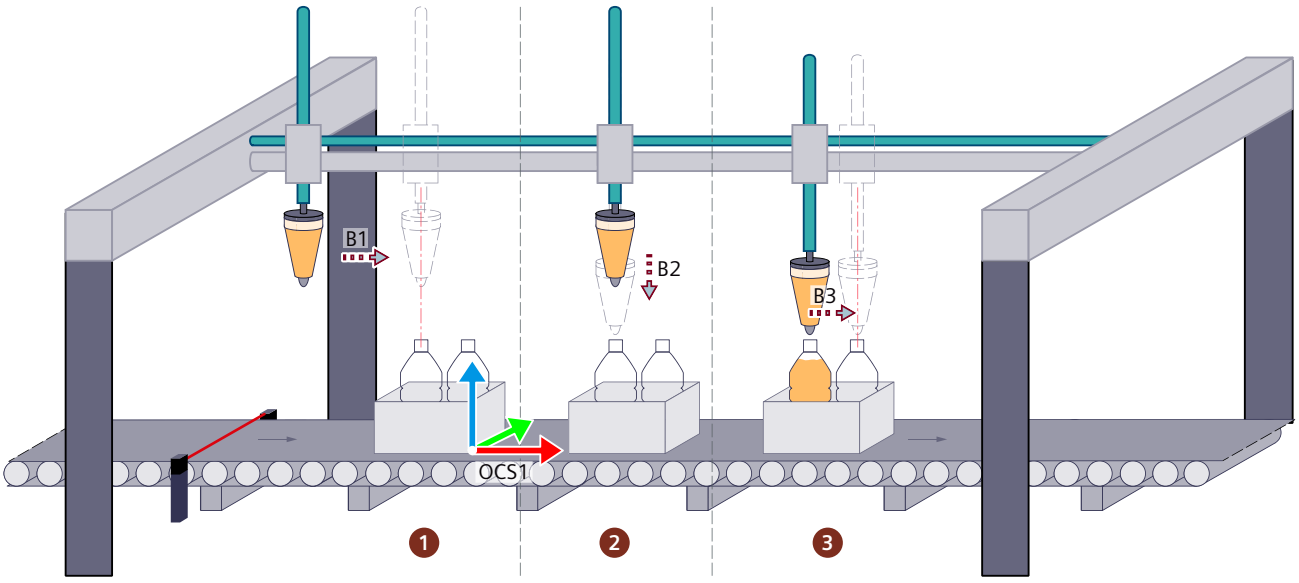

The kinematics axis A1 is aligned along the conveyor belt and thus travels in the x direction of the tracked OCS. In the example, the velocity of axis A1 and thus the path velocity in the x direction of the tracked OCS is limited by the dynamic adaptation. The dynamic reserve for OCS1 ("<TO>.Conveyor.DynamicReserve[1]") is parameterized with 30% (default setting).

The conveyor travels at a constant velocity of 20.0 mm/s. The OCS1 is tracked with the already recorded product with an "MC_TrackConveyorBelt" instruction.

Before the kinematics synchronizes to the first OCS, 3 linear motion jobs are transmitted.

- B1: Synchronization of the kinematics in x direction of the tracked OCS
- B2: Motion in z direction within the tracked OCS
- B3: Motion in the x direction within the tracked OCS to the next product.

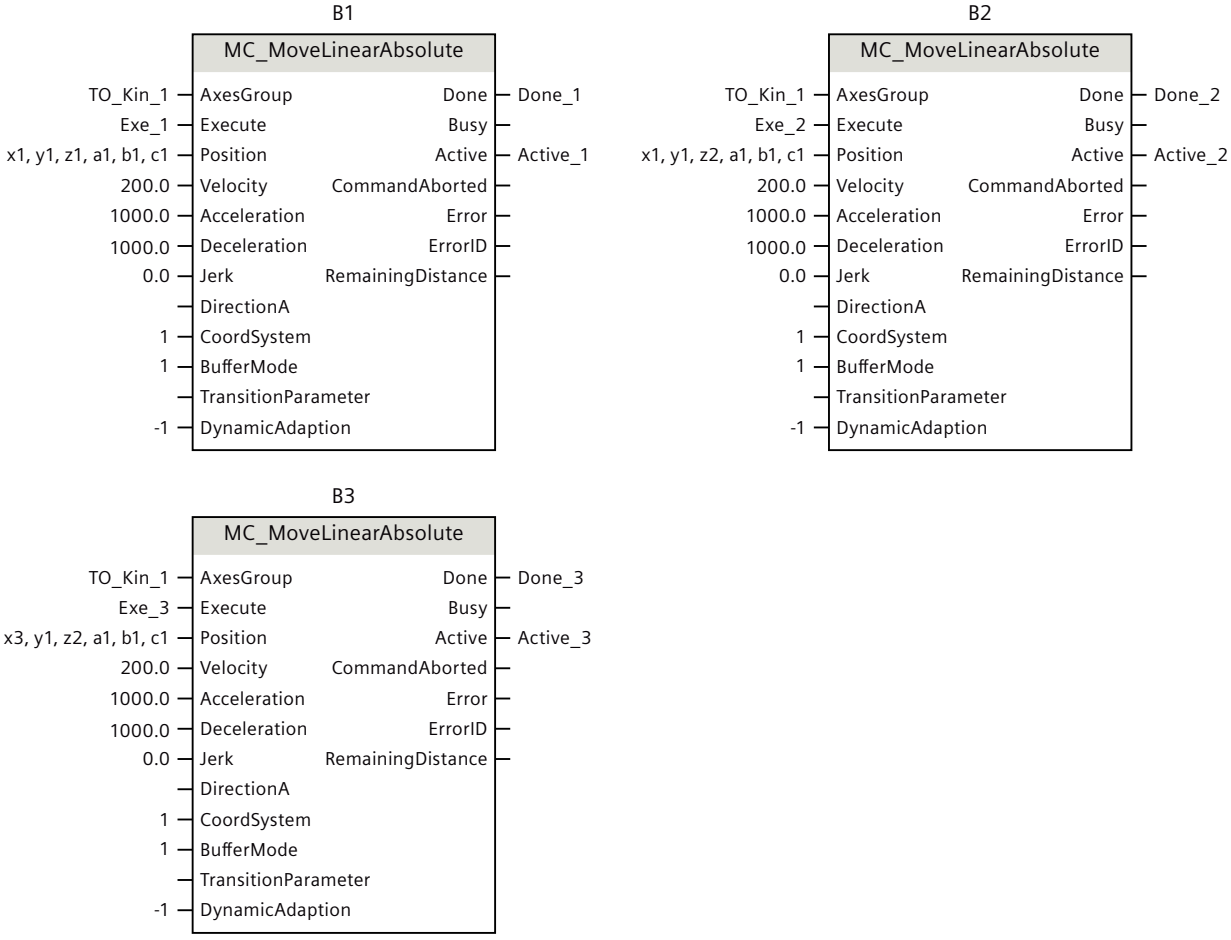

The motions are not blended. A path velocity of 200 mm/s is specified on all 3 jobs.

The 3 motion jobs are processed together in the job sequence.

The dynamic limits of the kinematics axes A1, A2 and A3 are parameterized as follows:

- <A1...A3>.DynamicLimits.Velocity := 100.0
- <A1...A3>.DynamicsLimits.MaxVelocity := 100.0
- <A1...A3>.DynamicLimits.MaxAcceleration := 2000.0
- <A1...A3>.DynamicLimits.MaxDeceleration := 2000.0

The dynamic limits of the "TO_Kin_1" kinematics are parameterized as follows:

- <TO_Kin_1>.DynamicLimits.Path.Velocity := 100.0
- <TO_Kin_1>.DynamicLimits.Path.Acceleration := 1000.0
- <TO_Kin_1>.DynamicLimits.Path.Deceleration := 1000.0

Conveyor tracking with dynamic adaptation without segmentation of the path

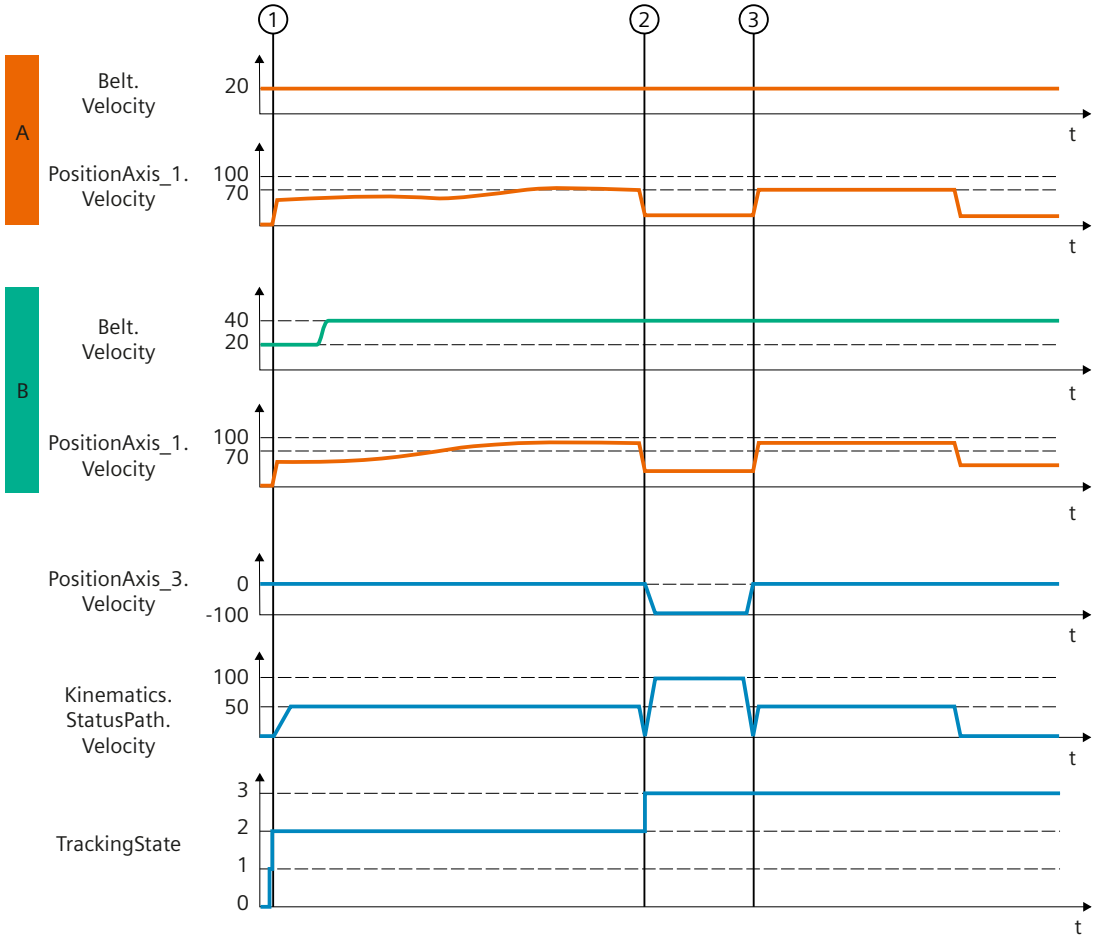

A Scenario A

1. Due to the activated dynamic adaptation, the velocity limit of 100 mm/s and the dynamic reserve of 30 % are effective. The axis velocity of the A1 axis is limited to a maximum of 70 mm/s. The axis velocity is made up of the path velocity and the conveyor velocity (20 mm/s). Thus, the resulting path velocity of the motion job during motion preparation is 50 mm/s.
2. After the kinematics have been synchronized, the kinematics move downward at 100 mm/s in z direction. During motion preparation, the velocity is limited to 100 mm/s. The dynamic reserve is not effective because the kinematics motion is not executed in the x direction of the tracked OCS.
3. As the motion takes place while motion is coupled in the OCS, the path velocity within the tracked OCS is limited to 50 mm/s. The resulting axis velocity is 70 mm/s, as the conveyor velocity of 20 mm/s is superimposed on the path velocity. The dynamic reserve of 30 mm/s to the dynamic limit of 100 mm/s is therefore available.

B Scenario B

① The conveyor velocity increases to 40 mm/s during synchronization. The axis velocity of axis A1 during synchronization is thus higher, but remains within the dynamic limits.

② After the kinematics have been synchronized, the kinematics move downward at 100 mm/s in z direction. During motion preparation, the velocity is limited to 100 mm/s. The dynamic reserve is not effective because the kinematics motion is not executed in the x direction of the tracked OCS.

③ As in scenario A, a resulting axis velocity of 70 mm/s was calculated in the motion preparation. As the conveyor velocity increases by 20 mm/s after motion preparation, the axis velocity of axis A1 increases to approx. 90 mm/s.

Conveyor tracking without dynamic adaptation

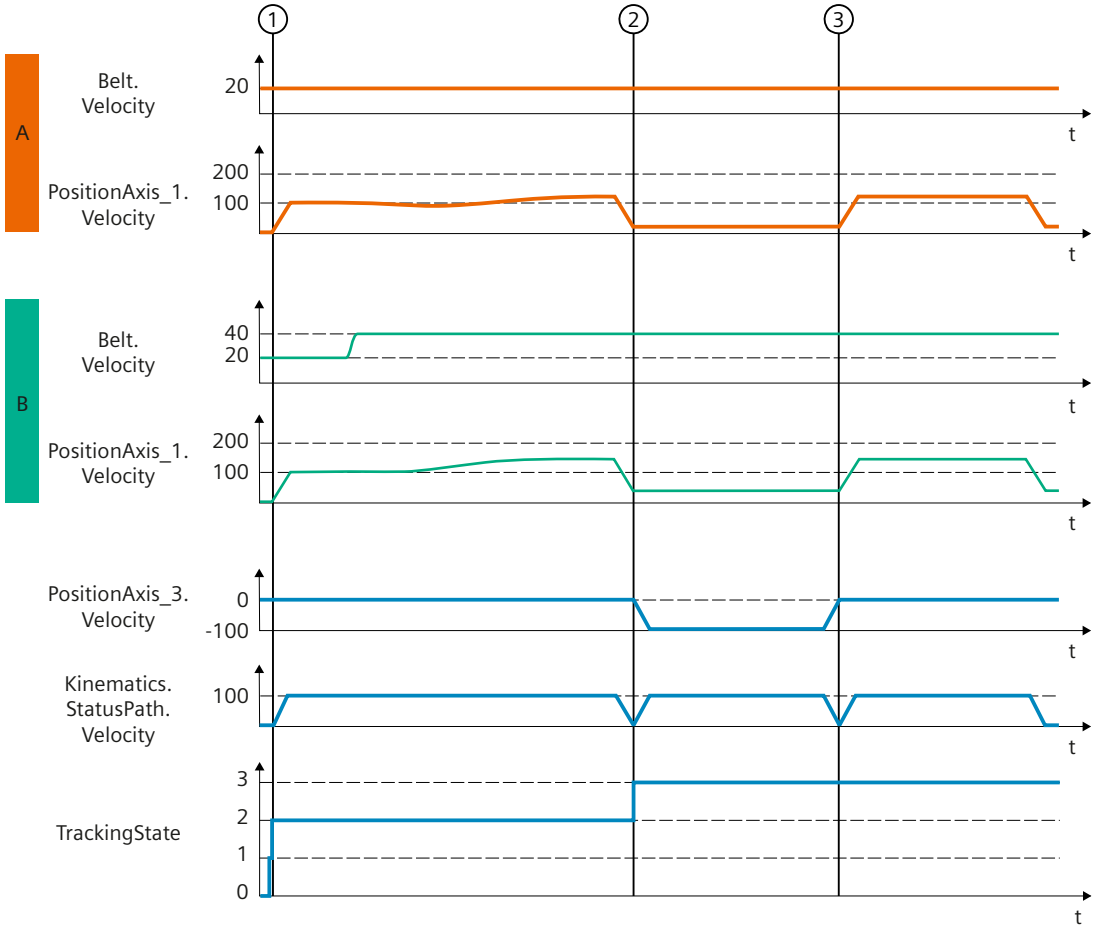

A **Scenario A**

① The dynamic adaptation is not used and the axis velocity of axis A1 is not reduced to the velocity limit of 100 mm/s during synchronization.

② After the kinematics have been synchronized, the kinematics move downward at 100 mm/s in z direction. During motion preparation, the axis velocity is limited to 100 mm/s. As the kinematics motion only runs in the z direction of the tracked OCS, the kinematics travels with a path velocity of 100 mm/s within the tracked OCS.

③ Without dynamic adaptation, the axis velocity is not limited within the tracked OCS.

B Scenario B

① The conveyor velocity increases to 40 mm/s after motion preparation. The axis velocity exceeds the dynamic limits even more in this scenario when synchronizing.

② After the kinematics have been synchronized, the kinematics move downward at 100 mm/s in z direction. During motion preparation, the axis velocity is limited to 100 mm/s. As the kinematics motion only runs in the z direction of the tracked OCS, the kinematics travels with a path velocity of 100 mm/s within the tracked OCS.

③ The axis velocity exceeds the velocity limit higher than in scenario A, because the conveyor velocity has increased after motion preparation.

8.9.6 Stopping behavior with "MC_GroupStop" and "MC_GroupInterrupt"

"TrackingState" = "2" and "4"

An "MC_GroupStop" or "MC_GroupInterrupt" instruction completes the tracking of the OCS with "TrackingState" = "2" and "4". Alarm 811 is triggered and all kinematics motions are stopped.

"TrackingState" = "3"

The path motion within the coupled OCS is stopped with an "MC_GroupInterrupt" job or "MC_GroupStop" job. The status of the conveyor tracking "<TO>.StatusConveyor[1..3].TrackingState" = "3" is retained. The kinematics continues to follow the OCS.

An "MC_GroupContinue" job can be used to continue a motion that was interrupted with an "MC_GroupInterrupt" job.

The job sequence is emptied after an executed "MC_GroupStop" job. A new path motion is restarted with a new job in the tracked OCS.

To end all kinematics motions, follow these steps:

1. To stop the path motion within the tracked OCS, transmit an "MC_GroupStop" job.
2. If required, move the kinematics upward, e.g. with an "MC_MoveLinearRelative" job within the tracked OCS, to prevent mechanical collisions.
   If possible, you can alternatively stop the conveyor with a "MC_Halt" job.
3. To stop moving the TCP on the conveyor belt, move the kinematics, e.g. with an "MC_MoveLinearAbsolute" job to a position in WCS or in non-tracked OCS, e.g. to a waiting position.

8.9.7 Blending behavior

During conveyor tracking, blending between the following motions is possible:

"Tracking-State"	Description
1 → 2	In a motion job for moving into the first position in the tracked OCS
3 → 3	In a motion job for moving into the first position in the tracked OCS
4 → 0	From a motion job that desynchronizes the TCP from the tracked OCS, in the following motion job (see section "Motion between two tracked OCS")
As of technology version V8.0 in addition	
2 → 3	From a motion job that synchronizes the TCP with the tracked OCS to the subsequent motion job in the tracked OCS
3 → 4	In a motion job that desynchronizes the TCP from the tracked OCS

See also

Motion between two tracked OCS (Page 298)

8.10 Set kinematics to simulation mode

When disabling the kinematics axes or in case of single-axis motions, a kinematics motion is canceled, and the job sequence is cleared. By setting the kinematics to simulation mode, you will keep the motion processing at the kinematics technology object active. The jobs in the job sequence are retained.

With the "MC_KinematicsMotionSimulation" (Page 433) Motion Control instruction, you start or end the simulation mode for a kinematics technology object. In simulation mode, the setpoints of the kinematics are still being calculated. Setpoint changes through motion jobs at the kinematics technology object are no longer taken into consideration at the kinematics axes and are no longer being forwarded to the drives.

8.10.1 Starting simulation mode

With the "MC_KinematicsMotionSimulation (Page 433)" Motion Control instruction with "Execute" = TRUE and "Mode" = 1, you start simulation mode for a kinematics technology object. When the simulation is started, the position setpoints of the kinematics axes are kept constant. The velocity setpoint and the setpoint acceleration of the kinematics axes are immediately set to zero.

NOTE

Setpoint jump

When you activate the simulation during a kinematics motion, the kinematics axes will decelerate immediately with a jump of the velocity setpoint.

To stop the kinematics axes in a controlled manner, interrupt the kinematics motion with a "MC_GroupInterrupt" job before you activate the simulation. Once you have ended the simulation, you can continue the kinematics motion with a "MC_GroupContinue" job.

While the kinematics technology object is in simulation, you can move, disable and enable the kinematics axes again using single-axis jobs, without the motion processing being

canceled at the kinematics technology object. The same is true for technology alarms pending at the kinematics axes during the kinematics simulation.

Interrupting a kinematics motion and locking kinematics axes

1. Interrupt the kinematics motion with a "MC_GroupInterrupt" job.

   The kinematics axes are stopped.
2. Set the kinematics to simulation with a "MC_KinematicsMotionSimulation" job with "Execute" = TRUE and "Mode" = 1.
3. If necessary, move the individual kinematics axes using single-axis jobs.
4. Disable the individual kinematics axes with a "MC_Power" job.

   The jobs in the job sequence are retained.

8.10.2 Ending simulation mode

With the "MC_KinematicsMotionSimulation (Page 433)" Motion Control instruction with "Execute" = TRUE and "Mode" = 0, you end simulation mode for a kinematics technology object.

When simulation is exited with the "MC_KinematicsMotionSimulation" Motion Control instruction, the kinematics motion is continued. The setpoints take effect directly on the kinematics axes.

Releasing kinematics axes and resuming kinematics motion

1. Enable the individual kinematics axes again with a "MC_Power" job.
2. Move the individual kinematics axes using single-axis jobs to positions "<TO>.AxesData.A[1..6].Position". These position values match the position values after stopping the kinematics motion. With a modulo axis, additionally ensure that the axis is in the same modulo cycle as at the start time of the simulation.
3. Exit the kinematics simulation with a "MC_KinematicsMotionSimulation" job with "Execute" = TRUE and "Mode" = 0.
4. Continue the kinematics motion with a "MC_GroupContinue" job.

8.10.3 Tags: Kinematics to simulation

The following tags of the technology object are relevant for simulation:

Status indicators		
Tag	**Description**	
<TO>.StatusWord.X19 (InSimulation)	Kinematics simulation	
	FALSE	Not simulated
	TRUE	Simulated

Status indicators	
Tag	**Description**
<TO>.AxesData.A[1..6].Position	Position setpoints of the kinematics motion for the kinematics axes 1 to 6
<TO>.AxesData.A[1..6].Velocity	Velocity setpoints of the kinematics motion for the kinematics axes 1 to 6
<TO>.AxesData.A[1..6].Acceleration	Acceleration setpoints of the kinematics motion for the kinematics axes 1 to 6

8.11 Setting a tool to active

If you use kinematics with multiple tools, you can set the tool that is configured and mounted on the real kinematics to active in the following way:

- You select the active tool in the kinematics control panel during commissioning (Page 322).
- With the "MC_SetTool" Motion Control instruction, you set a tool to active in the user program.

Tool 1 is active by default.

NOTE

Zone monitoring

Before changing the tool, make sure that the dimensioning of the activated tool zone (Page 212) is suitable for the new tool and the tool is enveloped by the zone.

Otherwise, create a suitable zone for the tool and activate it. In addition, deactivate the tool zone of the unused tool.

Setting a tool to active with a Motion Control instruction

Specify the tool number in the "ToolNumber" parameter in an "MC_SetTool" Motion Control instruction.

The "<TO>.StatusTool.ActiveTool" tag of the technology object data block contains the tool number of the currently active tool.

See also

Define tool frames (Page 206)

3D visualization

9

The 3D visualization supports you visually in the configuration, commissioning and diagnostics of the kinematics technology object with the following components:

- 3D display (Page 310)
- Diagnostics window (Page 339)
- Toolbar (Page 311)
- Directional pad (Page 314)
- Kinematics control panel (Page 317)

Online view

In the online view, the kinematics, zones and coordinate systems are updated based on the online values. The refresh rate depends on multiple factors, for example, on the performance of the programming device and the CPU, the communication times, etc. The 3D visualization, therefore, does not show the behavior of the real machine. Note the behavior of the real machine when using calibration, diagnostics and the kinematics trace.

9.1 Structure of the 3D visualization

The 3D visualization has a function-oriented structure. Different functions are available in the 3D visualization depending on the configuration window.

The following table gives you an overview of the configuration windows with a 3D visualization and the available functions:

Configuration window	Structure				
	3D display	Toolbar	Visualization of the positions	Directional pad	Kinematics control panel with "Control panel status" diagnostics window.
Zones configuration window	✓	✓	–	–	–
Diagnostics	✓	✓	✓	–	–
Kinematics trace	✓	✓	✓	–	–
Calibration	✓	✓	✓	✓	✓
Commissioning	✓	✓	✓	✓	✓

3D display

The following values and information are visualized in the 3D display:

Configuration window	Graphically displayed values and information
Zones	• Zones • Position KCS in WCS
Diagnostics	• Kinematics and tool center point (TCP) • Zones
Kinematics trace	• Kinematics and tool center point (TCP) • Traces – Tool center point (TCP) – Kinematics – OCS frames
Calibration	• Kinematics and tool center point (TCP) • Zones – Calibrated workspace zones – Configured kinematics zones • Calibrated object coordinate systems • Values for the calibration – Configured points and angles – Guide lines – Offset of the OCS from the origin – Current position of the TCP – Graphically highlighted active calibration point
Commissioning	• Kinematics and tool center point (TCP) • Zones

NOTE

You set the dimensions for the representation of the kinematics in the 3D display under "Technology object > Configuration > Geometry".

9.2 Working with the 3D display

A description is provided below of how to adapt the view of the coordinate system with mapped kinematics in the 3D view using the toolbar or the mouse.

Customizing the appearance of the 3D display

You can adapt the display in the 3D view as follows:

1. To hide or show the coordinate system in the display, click the # symbol in the toolbar.
2. To adjust the brightness of the 3D display, select a preset brightness level via the 100 selection box.

   Alternatively, change the brightness using the (darker) button or the (brighter) button.

Customizing the display of the kinematics and the coordinate system

1. In the WCS selection box, select a coordinate system that is displayed in the 3D display.

   In addition, the selected coordinate system is displayed in the "Positions" window. If you select the kinematics coordinate system (KCS), the WCS is displayed in the "Positions" window.

   See also Monitoring and comparing position values (Page 315).

   You can select the FCS or TCS in the configuration of the kinematics zones.

2. To change the display of the kinematics, click the button. If you click on the arrow, the other display options of the kinematics are shown and you can directly select the desired display:

Button	Description
	Shows the kinematics.
	Shows a simplified view of the kinematics.
	Hides the view of the kinematics.

3. To change the tool, select an already configured tool in the Tool 1 selection box.

   This selection box is available in the configuration of the kinematics zones and in the calibration.

4. To display the TCS, click the button. With more clicks on the button, or if you click the arrow, the following buttons are displayed and you can display or hide the TCS or the TCP:

Button	Description
	Shows the TCS
	Shows the TCP
	Hides the TCS selected via the button or the TCP selected via the button.

   During calibration, the TCS is already shown in the online view and you can change the display using the button.

5. To switch the focus of the view to the TCS or TCP, click the button.

   During the path motion of the kinematics, the focus is always on the TCS or the TCP. In standstill, the view can be moved or rotated using the mouse.

Change screen section

1. To switch the view between 2D or 3D display, use the following buttons:
   – To use the 2D display, click the button.
   – To use the 3D display, click the button.
2. To change the plane view of the selected coordinate system, use the following buttons:

Button/mouse	Description
	Show xz plane
	Show the xz plane rotated around the z axis
	Show yz plane
	Show the yz plane rotated around the z axis
	Show xy plane
	Show the xy plane rotated around the x axis

3. To rotate the view as desired, hold down the left mouse button and move the mouse in the desired direction.
4. To center the view and display the entire kinematics, click the icon in the toolbar.
5. Use the mouse wheel to zoom in and out of the display of the kinematics continuously.
6. To move the kinematics in the view, hold down the right mouse button and move the mouse in the desired direction.

9.3 Operating the zone display

You show or hide all active and inactive zones with the button.

In addition, with the active icon , you can show and hide all active and inactive workspace zones individually with the icon in the following areas:

- Diagnostics > "Status zones" window
- Calibration > Object coordinate systems / Workspace zones > "Zone display" window

Zone display in calibration

When you click on the icon, values of the workspace zones and the kinematics zones at the current point in time are read back from the CPU. When you click the icon in the "Number" column, 2 additional rows are displayed. The additional rows contain the following values:

- Start values of the CPU
- Start values in project

  You can edit these values. If you want to apply the change, load the changes from the project into the device.

If you have performed an offline recalibration of a workspace zone calibrated online, both zones are displayed in the graphic view. Load the changes from the project to the device. The display is updated and the result of the last calibration is displayed.

9.4 Operating the directional pad

The directional pad offers the following functions:

- In offline mode: Move the tool center point (TCP) in the 3D view
- In online mode: Specify target position in "Jog to target position" mode in the WCS or OCS

Moving the tool center point (TCP)

During calibration, you can move the tool center point (TCP) in the 3D view in offline mode using the directional pad.

NOTE

Singularity

When you move the kinematics into a singularity (Page 183), a message is output in the graphic display and you can no longer move the kinematics using the directional pad. To be able to move the kinematics once again, click on "Reset kinematics" in the message.

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1. To move the TCP to a position, click on the positive or negative x, y or z direction on the directional pad.

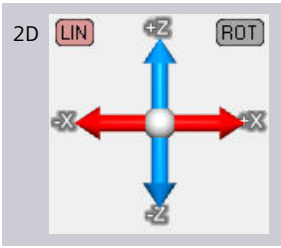

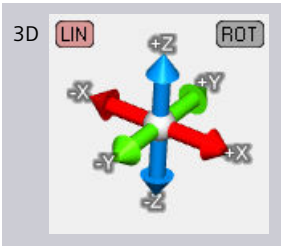

In the 3D view, you can see the motion of the kinematics model and the TCP.

The coordinates of the TCP are displayed in the Positions window.

2. To change the orientation of the TCP, click "ROT" or the intersection of the axes.

Instead of the directional pad, arrows for the orientation motion are displayed.

3. Click the arrow to rotate in a positive or negative direction.

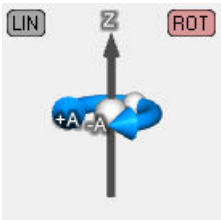

The Cartesian coordinates and the Cartesian orientations in space are displayed in the "Positions" window.

If you have shown a kinematics zone, you will see the rotation of the kinematics zone in the 3D view.

4. To move the TCP again, click "LIN".

   The directional pad is displayed.

Specify target position

In online mode, you can use the directional pad to specify the target position in the WCS or OCS in "Jog to target position" mode. This function is available during commissioning and calibration.

The target position in the selected coordinate system is applied and you can jog the kinematics to the target position with the kinematics control panel.

The operation of the kinematics control panel in "Jog to target position" mode is described in the section "Jogging the kinematics (Page 333)".

9.5 Monitoring and comparing position values

You monitor and compare position information with the following 3D visualization functions:

- "Positions" diagnostics window
- Position values in the graphically displayed trace

Operating the "Positions" diagnostics window

The "Positions" window provides the following functions:

- Monitor position values, e.g. during diagnostics
- Check approached points of the kinematics during calibration with the current position
- Compare position values in two different coordinate systems, e.g. during calibration

The values in the "Positions" window are displayed as follows:

- During commissioning, in the diagnostics and in the kinematics trace, the positions are displayed in online mode.
- The positions in offline and online mode are displayed in the calibration.

Selecting a reference coordinate system for recording in the kinematics trace

The selection of the coordinate systems in the toolbar and in the "Positions" window depends on the signals you have activated under "Technology object > Kinematics trace > Configuration > Traces". The following table shows the available coordinate systems depending on the active signals:

Active signals	Coordinate system 1	Coordinate system 2
TCP and kinematics	World coordinate system (WCS), kinematics coordinate system (KCS)	Machine coordinate system (MCS), WCS, JCS
TCP	WCS, KCS,	WCS

Active signals	Coordinate system 1	Coordinate system 2
TCP, OCS1	WCS, KCS, OCS1	WCS
TCP, OCS1, OCS2	WCS, KCS, OCS1, OCS2	WCS
TCP, OCS1, OCS2, OCS3	WCS, KCS, OCS1, OCS2, OCS3	WCS

If you activate another signal or the "Monitoring on/off" function, the available coordinate systems are updated.

Comparing position values

1. Select a coordinate system in the toolbar. The selected coordinate system is displayed in the left field of the "Positions" window.

   When you select the kinematics coordinate system (KCS) in the toolbar, the WCS is displayed in the "Positions" window.
2. Select another coordinate system in the "Positions" window in the right drop-down list.
3. The actual position of the active tool in the selected reference coordinate system is displayed.

The meaning of the position information is described in the table in the section "Positions (Page 345)".

Position values in the graphic display

If you position the mouse cursor on one of the traces in the 3D visualization in the kinematics trace, the position values are displayed directly on the trace.

The following values are displayed:

- Measuring point number
- Coordinates x, y, z and A, B, C

The values displayed show the position and rotation in the set coordinate system.

Commissioning 10

You can find the kinematics control panel under "Technology object > Commissioning". The kinematics control panel enables you to assume master control for a kinematics technology object and control the motions of the kinematics, the individual axes or the individual joints. You can therefore move the kinematics without affecting the user program.

You can find the dynamics settings (Page 331) for commissioning in the Inspector window under "Properties".

3D visualization (Page 310) provides visual support for commissioning the kinematics technology object. The status LEDs in the "Control panel status (Page 317)" diagnostics window show you whether all kinematics axes are switched on and homed and whether errors are pending at the kinematics or the kinematics axes. You can also show additional diagnostics windows (Page 339) via the toolbar.

You can also find the kinematics control panel in the project tree under "Technology object > Calibrate (Page 355)". In calibration, you move the real kinematics online via the kinematics control panel in the "Jog" or "Jog to target position" operating modes.

10.1 Control panel status

You use the "Control panel status" diagnostics window in "Technology object > Commissioning" in the TIA Portal to monitor the status and error messages of the kinematics and the kinematics axes during commissioning.

The diagnostics function is available in online operation. The "Control panel status" diagnostics window is shown in the graphical display during commissioning. You can show the diagnostics window via the symbol of the toolbar and move the window to a desired position within the graphic display.

Kinematics status

The following table shows the possible statuses of the kinematics:

Status	Description
Valid	The transformation values are valid. (<TO>.StatusKinematics.Valid)
Error	An error occurred at the technology object. Error messages are displayed in the Inspector window under "Diagnostics > Alarm display".

Axis status

The following table shows the possible states of the kinematics axes:

Status	Description
Enabled	The technology object has been enabled. The axis can be moved with motion jobs.
Error	An error occurred at the technology object. Error messages are displayed in the Inspector window under "Diagnostics > Alarm display".
Homed	The technology object is homed.

10.2 Taking over master control and enabling kinematics

WARNING

Unexpected axis motions

During operation with the kinematics control panel, the kinematics can execute unexpected motions (for example, due to incorrect configuration of the drive or technology object). In addition, when a leading axis is moved with the kinematics control panel, any synchronized following axis is also moved.

Therefore, take the following protective measures before operation with the kinematics control panel:

- Ensure that the EMERGENCY OFF switch is within the reach of the operator.
- Enable the hardware limit switches.
- Enable the software limit switches.
- Use blocked zones to prevent mechanical collisions.
- Ensure that following error monitoring is enabled.
- Make sure that no following axis is coupled to the axis to be moved.
- Make sure that the dynamic settings in the kinematics control panel do not violate the dynamic limits of the kinematics axes or process.
- Ensure that the kinematics control panel is configured correctly.

WARNING

Overrun of the dynamics through singularities

Overruns of the dynamics in the vicinity of singularities can result in the following damages:

- Machine damage through overload of the mechanical components
- Personal injury caused by products or machine parts coming loose

To prevent dynamic overruns in the vicinity of singularities, take the following measures:

- Move the kinematics in the MCS or the JCS.
- In the WCS or OCS, avoid the "Jog" mode. The dynamic adaptation in "Jog" mode in the WCS or OCS is not active in the kinematics control panel. The dynamic limits of the kinematics axes are not taken into account during a kinematics motion with the kinematics control panel.
- Up to technology version V5: In the WCS or OCS, avoid using the "Jog to target position" mode. The dynamic adaptation in "Jog to target position" mode in the WCS or OCS is not active in the kinematics control panel. The dynamic limits of the kinematics axes are not taken into account during a kinematics motion with the kinematics control panel.
- As of technology version V6: Move the kinematics to the "Jog to target position" mode in the WCS or OCS using the kinematics control panel. "Dynamic adaptation without segmentation of the path" is permanently active in the "Jog to target position" mode, and the dynamic limits of the kinematics axes are taken into account.

WARNING

Moving leading axes with active synchronous operation

Any synchronized following axis is moved as well when a leading axis is moved with the kinematics control panel.

Requirements

- The kinematics and the kinematics axes are locked in the user program.
- No axis control panel or drive control panel is active for any kinematics axis.
- The kinematics technology object is configured.
- The travel directions of the kinematics axes match the joint travel directions of the kinematics used.

  Use the axis control panel to check whether the travel directions of the kinematics axes match the joint travel directions of the kinematics used. The joint travel direction can be found in the Manufacturer descriptions. Invert the drive and encoder directions in the kinematics axis if the directions are inverse.
- The joint travel directions of the kinematics used correspond to the travel directions defined by Siemens from the kinematics type.

  Check whether the joint travel directions of the kinematics used match the travel directions defined by Siemens from the Kinematics type (Page 58). If the directions are inverse, then invert the joint direction at the associated joint in the Kinematics technology object.

- The kinematics axes are homed.

  The joint zero position corresponds to the position 0.0 of the kinematics axis. For mechanical axis couplings, first home the coupling axes.
- Possible joint offsets are defined.

  Check whether the joint zero position of the kinematics deviates from the joint zero position of the kinematics type defined by Siemens. In this case, you must define a joint offset. If the offset cannot be determined from data sheets, then you can determine it practically. To do this, jog the joint in the zero position defined by Siemens and then accept the position of the joint as offset.
- All kinematics axes are ready to start.
- The CPU must be in the RUN mode.
- No alarm is active on the kinematics technology object.

Procedure

1. Click the "Activate" button.
2. Read the warning.
3. Set the sign-of-life monitoring time to a value between 1000 and 60 000 ms.

Setting the sign-of-life monitoring time

The kinematics control panel requires a direct connection from its TIA Portal to the controller, which is monitored cyclically. If there is no sign-of-life from the PG/PC within the monitoring time, master control is handed over for safety reasons.

Monitoring time	Effect
Too low	Master control is often handed over because the monitoring time is exceeded. The kinematics stops with maximum deceleration because the communication time between TIA Portal and CPU is longer than the configured monitoring time.
Appropriate	The monitoring time is not exceeded. The kinematics is stopped in time if the online connection is lost or the sign-of-life monitoring is exceeded. Recommendation: 1000 ms to 2000 ms
Too high	The kinematics continues to move with the last setpoints of the kinematics control panel, although the connection between the TIA Portal and the CPU has been interrupted or the communication time between the TIA Portal and the CPU is too long. The kinematics is not stopped on time because the monitoring time is still running.

Result

- An online connection to the CPU is established and the kinematics control panel takes master control of the technology object.
- The kinematics can now only be moved with this kinematics control panel. The user program has no influence on the functions of the technology object. Motion Control jobs from the user program to the technology object are rejected with error ("ErrorID" = 16#8012: Kinematics control panel enabled).
- Access to the kinematics and the kinematics axes is blocked by another instance of the TIA Portal.

Enabling the kinematics

1. Click the "Enable" button to enable interconnected axes of the selected kinematics technology object.
   Result: The kinematics or the kinematics axes can now be moved or actively homed with the kinematics control panel.
2. Use the status LEDs in the "Control panel status" diagnostics window to check whether all kinematics axes are switched on and homed and whether errors are pending. Use the alarm display (Inspector window > "Diagnostics > Alarm display") in the TIA Portal to display pending causes of the error.

Behavior during operation of the kinematics control panel

In the following situation, the kinematics control panel retains master control and the kinematics remain in motion:

- The kinematics control panel is embedded in the TIA Portal, and you switch to another window, for example, to the kinematics trace. Use the "Split editor area" option to use the kinematics control panel and the kinematics trace at the same time.

In the following situation, the kinematics control panel retains master control but stops the kinematics with maximum deceleration and revokes the enabling of the technology objects:

- The kinematics control panel is detached in the TIA Portal, and you switch to another window within the TIA Portal, for example, to the kinematics trace.
- You switch to a window outside the TIA Portal.

In the following situations, the kinematics is stopped or the axes are stopped with maximum deceleration and the kinematics control panel returns the master control to the user program:

- The communication time between TIA Portal and CPU is longer than the configured monitoring time. In the banner above the toolbar, the message is displayed that the master control has been handed over because the monitoring time has been exceeded. Adapt the time for the sign-of-life monitoring in the warning.
- The online connection to the CPU is impaired by a communication load that is too high. The following message is entered in the alarm display log: "Commissioning error. Sign-of-life failure between controller and TIA Portal". Adapt the time for the sign-of-life monitoring in the warning.
- A dialog (e.g. "Save as") or another window within the TIA Portal covers the kinematics control panel.

10.3 Selecting an active tool

If you use kinematics with multiple tools, you can select the different tools in the kinematics control panel. This allows you to define the position of the TCP in the flange coordinate system (FCS) in relation to this tool. In the real kinematics, the tool is not changed by the changed selection.

Requirement

Kinematics is enabled in the kinematics control panel.

Procedure

1. In the "Active tool" drop-down list, select the tool that is mounted on the real kinematics.
2. If you want to use zone monitoring (Page 208), activate the tool zone associated with the active tool. If necessary, deactivate the tool zone that is not required (e.g. after a tool change). See section "Activating zone monitoring" (Page 219).

NOTE

Before you return master control to the user program, the tool that the user program expects must be installed and set. The active tool is not set automatically to the active tool at the time of takeover of master control.

In the user program, you can change the tool with the "MC_SetTool" Motion Control instruction after handing over master control.

10.4 Operator controls for jogging and homing

You can use the slider to execute the following functions of the kinematics control panel:

- Jog axes, joints, or the kinematics Cartesian in a direction or to the set target position. (Page 333)
- Start active homing of a kinematics axis (Page 330)

Different sliders and buttons are displayed in the "Control" area in the kinematics control panel depending on the selected coordinate system, the kinematics type and the operating mode.

NOTICE
Deviating jog velocity due to velocity override with technology versions <V10.0 If the velocity override is changed by the user program while the kinematics control panel is active, undesired deviations in the jog velocity can occur. With active master control, both settings on velocity override take effect in jog mode of the kinematics. The value set under "Adapt" with the "Velocity" slider as well as the value configured in the "<TO>.Override.Velocity" tag have a multiplicative effect on the final velocity in jog mode. For example, the following settings result in a final velocity of 25 mm/s: • Jog velocity = 100 mm/s • "<TO>.Override.Velocity" is set cyclically to 50% in OB1. • The "Velocity" slider is set to 50%. The resulting final velocity is calculated as follows: 100 mm/s × 0.5 × 0.5 = 25 mm/s. To avoid undesired deviations in the resulting final velocity, make sure that both parameters are set correctly and the velocity override with active master control is not changed by the user program. With a query of the kinematics control panel status (<TO>.StatusWord.X4 (ControlPanelActive)) when the "<TO>.Override.Velocity" tag is written, you can prevent writing of the tag with an active kinematics control panel.

Jogging and homing velocity

The preset jogging and homing velocity is calculated as follows:

Jogging/homing velocity = configured velocity * slider position * "Velocity" factor under "Adjust"

The following shows the operation of the slider using kinematics axis A1. Operation is identical for jogging of joints and the kinematics in the Cartesian space.

Jogging with the keyboard

WARNING

Using keyboard control

When keyboard control is activated, keyboard entries cause immediate kinematics motions.

Deactivate the keyboard control immediately after the last operation to avoid unintended kinematic motions.

You can operate the slider for jogging the axes, joints or kinematics with the mouse or with the keyboard.

You use keys of the number pad for keyboard control.

Follow these steps to control the slider with the keyboard:

1. Activate keyboard control with the "Activate" button.

   The buttons that can be controlled via the keyboard show the respective key for the controller.
2. To choose an axis or joint with the numbers 1 to 6, enable the number pad on your keyboard using the Num-Lock key.
3. To use the number pad for the cursor control, disable the number pad on your keyboard using the Num-Lock key.
4. You can now control the slider using the four direction keys, the two scroll keys and the "Home" and "End" keys of the number pad.
5. To end keyboard control, click "Deactivate".

NOTE

Ending keyboard control with other operator actions

Other operator actions, e.g. clicking with the mouse in the "Control" area, deactivate keyboard control.

Selecting the axes for jogging/jogging to target position in the MCS

To jog the axes in the MCS, first select the respective axis.

For example, the selection of interconnected axes with the Cartesian portal 3D with orientation kinematics type looks like this:

① All interconnected kinematics axes

② Selected axis

When keyboard control is enabled, the number keys are shown with which you can select the axes.

Selecting the joints for jogging/jogging to target position in the JCS

To jog the joints in the MCS, first select the respective joint.

① All joints of the kinematics type

② Selected joint

When keyboard control is enabled, the number keys are shown with which you can select the joints.

Jogging/jogging to target position in the MCS/JCS

Jogging

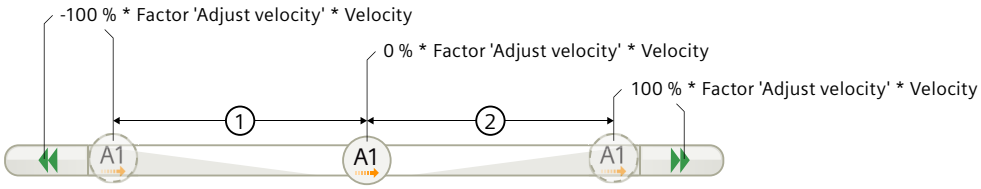

① Jog backward

② Jog forward

Select one of the following operating options to jog an axis/joint:

- Slider

  ①: Click the slider and drag the slider to the left.

  ②: Click the slider and drag the slider to the right.

  The further you drag the slider away from the central position, the faster the axis/joint moves in the respective direction.

- Button

  ①: To jog backward at the maximum preset jogging velocity, click the ◀◀ symbol.

  ②: To jog forward at the maximum preset jogging velocity, click the ▶▶ symbol.

- Keyboard control

  ①: When keyboard control is enabled, you jog backward with the direction keys ←.

  ②: When keyboard control is enabled, you jog forward with the direction key →.

  As soon as you press the number key, the axis/joint moves backward/forward at the maximum preset velocity.

Jogging to target position

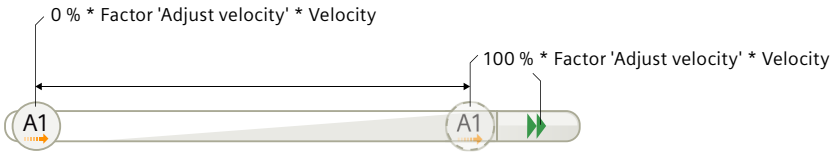

Select one of the following operating options to jog an axis/joint to target position:

- Slider

  Click the slider and drag the slider to the right. The further you move the slider to the right, the faster the axis/joint moves at the maximum preset velocity.

- Button

  To jog to the target position at the maximum preset jog velocity, click the icon ▶▶.

- Keyboard control

  When keyboard control is enabled, you jog with the direction key → to the target position. As soon as you press the number key, the axis/joint moves to the target position at the maximum preset velocity.

Stop jogging

If you release the pressed mouse button/key when jogging using the slider/keyboard control, the slider automatically jumps to zero and the axis/joint is stopped with the specified deceleration.

Jogging in the WCS/OCS

To jog the kinematics in the WCS/OCS, you can choose between the following modes for kinematics types with orientation:

- Cartesian

  In "Cartesian" mode, you jog the kinematics in the x, y and z direction.

- Orientation

  In "Orientation" mode, you can rotate the TCS and move the TCP.

You activate the respective mode using the button of the same name.

You can only jog kinematics types without orientation in Cartesian mode.

Jogging in "Cartesian" mode

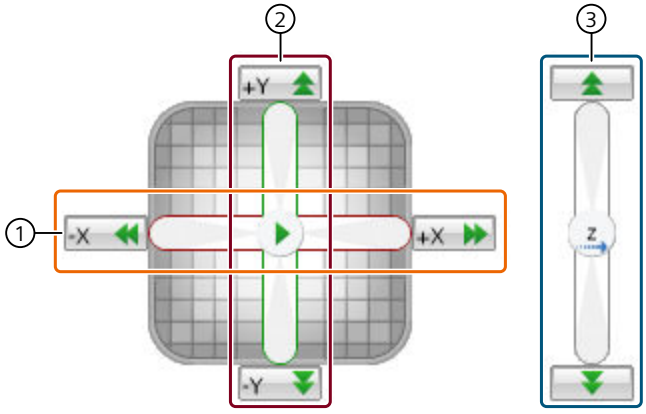

① Jogging kinematics in positive/negative x direction
② Jogging kinematics in positive/negative y direction
③ Jogging kinematics in positive/negative z direction

Select one of the following operating options to jog the kinematics:

- Slider

  Click the slider and drag the slider to the left/right/up/down. The further you drag the slider away from the central position, the faster the kinematics moves in the respective direction.

- Button

  To jog at the maximum preset jogging velocity, click the respective icon / / / .

- Keyboard control

  When keyboard control is enabled, you jog with the four direction keys and the two scroll keys. As soon as you press one of the keys, the kinematics travels with the maximum preset velocity.

Jogging 2D and 3D kinematics types with orientation in "Orientation" mode

To change the position of the TCS, rotate the TCS around the z axis or move the TCP along the z axis.

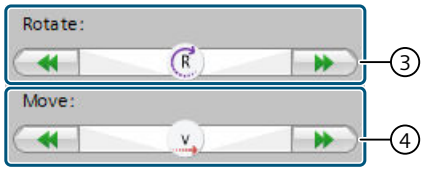

① Rotate TCS around the z axis

② Move TCP along the z axis

To rotate the TCS around the z axis, select one of the following operating options for the slider ①:

- Slider

  Click the slider and drag the slider to the left or right. The further you drag the slider away from the central position, the faster the TCS is rotated.

- Button

  To jog at the maximum preset velocity, click the icon / .

- Keyboard control
  - To rotate in the negative direction, tap the "Up" scroll key.
  - To rotate in the positive direction, tap the "Down" scroll key.

  As soon as you press one of the keys, the kinematics travels with the maximum preset velocity.

Use one of the following operating options to move the TCP along the z axis:

- Slider

  Click the slider and drag the slider to the left or right. The further you drag the slider away from the central position, the faster the TCP is moved.

- Button

  To jog in the negative direction at the maximum preset velocity, click the icon ◀◀ / ▶▶.

- Keyboard control

  – To jog in the negative direction, tap the "End" scroll key.

  – To jog in the positive direction, tap the "Home" scroll key.

  As soon as you press one of the keys, the kinematics travels with the maximum preset velocity.

Jog kinematic types with more than four interpolating kinematics axes in "Orientation" mode

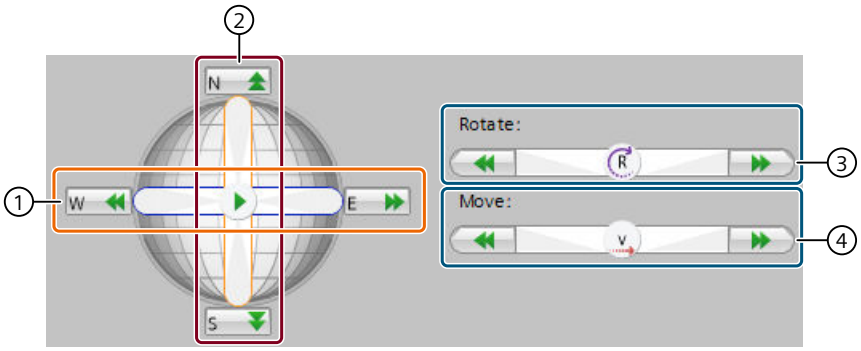

① Turn TCS in the west/east direction

② Turn TCS in the north/south direction

③ Rotate TCS around the x axis (only for kinematics types "6-axis articulated arm with central wrist" and "6-axis articulated arm with offset wrist")

④ Move TCP along the x axis

In the graphical display, a sphere is represented on which you can jog the orientation in four directions. The center of the sphere is the TCP. The x axis of the TCS is shown extended and intersects the surface of the sphere. With the sliders in the controller, you move this intersection point along the sphere surface in the four directions. You thus change the orientation of the TCS. The position of the TCP remains the same.

To change the orientation of the TCS, use one of the following operating options of the sliders ① and ②:

- Slider

  Click the slider and drag the slider to the left/right/up/down. The further you drag the slider away from the central position, the faster the TCS is rotated.

- Button

  To jog at the maximum preset jogging velocity, click the respective icon ◀◀ / ▶▶ / ▲ / ▼.

- Keyboard control

  When keyboard control is enabled, you jog with the four direction keys. As soon as you press one of the keys, the kinematics travels with the maximum preset velocity.

With the "6-axis articulated arm with central wrist" and "6-axis articulated arm with offset wrist" kinematics type, you can rotate the TCS around the x axis with the slider ③.

To rotate the TCS around the x axis, select one of the following operating options for the slider:

- Slider

  Click the slider and drag the slider to the left or right. The further you drag the slider away from the central position, the faster the TCS is rotated.

- Button

  To jog at the maximum preset velocity, click the icon ◀◀ / ▶▶.

- Keyboard control
  - To rotate in the negative direction, tap the ↑ scroll key.
  - To rotate in the positive direction, tap the ↓ scroll key.

  As soon as you press one of the keys, the kinematics travels with the maximum preset velocity.

You move the TCP along the x axis using the slider ④.

Use one of the following operating options to move the TCP along the x axis:

- Slider

  Click the slider and drag the slider to the left or right. The further you drag the slider away from the central position, the faster the TCP is moved.

- Button

  To jog in the negative direction at the maximum preset velocity, click the icon ◀◀ / ▶▶.

- Keyboard control
  - To jog in the negative direction, tap the "End" key.
  - To jog in the positive direction, tap the "Home" key.

  As soon as you press one of the keys, the kinematics travels with the maximum preset velocity.

Stop jogging

Release the pressed mouse button. The slider automatically jumps to zero and the axis/joint/kinematics is stopped with the specified deceleration.

Set home position

To set the reference position for a kinematics axis, click the "Set" button.

Active homing

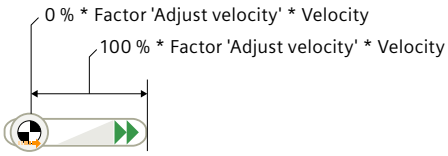

Click the slider and drag the slider to the right. Homing is executed at the maximum preset velocity. The homing stops automatically with the set dynamics.

To home at the maximum preset velocity, click the ▶▶ symbol.

See also

Specifying dynamics in the kinematics control panel (Page 331)

10.5 Setting the home position of a kinematics axis

This function corresponds to direct homing (absolute) or setting the actual position or "Mode" = 0 at the "MC_Home" Motion Control instruction. The current position of the technology object is set to the value of parameter "Position".

Requirements

Kinematics is enabled in the kinematics control panel.

Procedure

1. In the drop-down list, select "Single axes: Set home position".
2. Enter the home position of the respective kinematics axis in the text box.
3. Click the "Set" button of the axis with the actual position you want to set.

   Result: The specified actual position is set. The kinematics axis is homed.
4. In the "Status and errors bits" diagnostics window, check whether the axis was homed.

10.6 Active homing of the kinematics axis

This function corresponds to active homing with "Mode" = 3. The positioning axis/synchronous axis technology object performs a homing movement according to the configuration of the active homing.

⚠ WARNING
Avoiding collisions Make sure that no unwanted positions are approached and that no collisions occur during the automatic homing movement.

Requirements

- Kinematics is enabled in the kinematics control panel.
- The kinematics are in a position from which the homing movement of the kinematics axes is possible.

Procedure

1. In the drop-down list, select "Single axes: Homing".
2. Enter the home position of the respective kinematics axis in the text box.
3. To start active homing, click the slider and drag the slider to the right.
4. To cancel homing, release the pressed mouse button.
   Result: The axis executes the homing movement configured under "Active homing". The other kinematics axes are not moved. The entered position of the kinematics control panel is used as home position.

NOTE

Up to technology version V7: Absolute encoder calibration is not possible in the kinematics control panel. The technology object is not homed when this mode is used with an absolute encoder.

As technology version V7: Absolute encoder adjustment can be performed in the kinematics control panel.

10.7 Specifying dynamics in the kinematics control panel

In the "Jog" and "Jog to target position" modes, you can specify the dynamics for the next step of the commissioning. The dynamics settings can be found in the Inspector window under "Properties".

Default setting of dynamic values

The default settings of the dynamic values are as follows when the kinematics control panel is called:

Dynamic value	Default value MCS/JCS coordinate systems	Default value WCS/OCS coordinate system
Acceleration	10% of the maximum acceleration of the kinematics axis	10% of the maximum acceleration of the kinematics motion
Deceleration	100% of the maximum deceleration of the kinematics axis	100% of the maximum deceleration of the kinematics motion
Jerk	100% of the maximum jerk of the kinematics axis	100% of the maximum jerk of the kinematics motion

Specifying dynamic values

In the WCS or OCS, these values apply to the motion in x, y and z direction and for the orientation.

To change these defaults temporarily, select the "User-defined dynamics" check box and enter the dynamic values.

If you have changed the values in the configuration of the technology object during operation with the kinematics control panel, these changes have no effect on the operation of the kinematics control panel. Changed values in the configuration only take effect after they have been loaded into the CPU and the control panel has been reopened.

Resetting dynamic values to default values

As soon as the check box "User-defined dynamics" is cleared or the commissioning is completed, the original default values are valid again. The specified dynamics values are replaced by the predefined default values in the following cases. If necessary, transfer the values to your configuration.

Transferring dynamic values from the kinematics control panel to the technology object

If you want to retain your specified dynamic values as default values or as dynamic limits after jogging in the WCS or OCS, transfer the dynamic values of the kinematics control panel to the configuration of the technology objects.

1. Make a note of the dynamic values of the kinematics control panel.
2. Click the "Deactivate" button.
3. Apply the noted dynamics values as the default setting of the dynamics or dynamics limit in the "Dynamics" configuration window of the kinematics.
4. Load the changed configuration into the CPU.

   The changed parameters are now effective in the user program.

Adjusting the velocity

To adjust the velocity for traversing with the kinematics control panel, define a velocity override under "Adjust".

Under "Adjust", you correct the configured velocity using a percentage.

Example:

- Configured velocity in the kinematics control panel: 100 mm/s
- Adjust velocity: 50%
- Resulting velocity specification: 50 mm/s

You can set a value with the slider or enter a value between 1% and 200% directly in the text box below. With the two buttons to the left and right of the slider, you can increase or decrease the velocity in 10% increments.

The velocity override set in the kinematics control panel is not adopted in the configuration of the kinematics technology object ("<TO>.Override.Velocity" tag). When you close the kinematics control panel, the changed values under "Adjust" are reset.

NOTICE

Deviating jog velocity due to velocity override with technology versions <V10.0

If the velocity override is changed by the user program while the kinematics control panel is active, undesired deviations in the jog velocity can occur.

With active master control, both settings on velocity override take effect in jog mode of the kinematics. The value set under "Adapt" with the "Velocity" slider as well as the value configured in the "<TO>.Override.Velocity" tag have a multiplicative effect on the final velocity in jog mode.

For example, the following settings result in a final velocity of 25 mm/s:

- Jog velocity = 100 mm/s
- "<TO>.Override.Velocity" is set cyclically to 50% in OB1.
- The "Velocity" slider is set to 50%.

The resulting final velocity is calculated as follows: 100 mm/s × 0.5 × 0.5 = 25 mm/s.

To avoid undesired deviations in the resulting final velocity, make sure that both parameters are set correctly and the velocity override (<TO>.Override.Velocity) with active master control is not changed by the user program. With a query of the kinematics control panel status (<TO>.StatusWord.X4 (ControlPanelActive)) when the "<TO>.Override.Velocity" tag is written, you can prevent writing of the tag with an active kinematics control panel.

NOTE

Adapting the velocity as a percentage in the "Individual axis: Homing" mode

For kinematics as of technology version V8.0, you can adapt the velocity as a percentage in the kinematics control panel, also in "Individual axis: Homing" mode.

For kinematics up to technology version V7.0, the "Adjust" area is in the "Single axis: Homing" mode.

10.8 Jogging the kinematics

In "Jog" mode, the following values are preset with 10% of the default value:

- Velocity of kinematics axes
- Velocity of the joints or joint angle
- Velocity in x, y and z direction
- Velocity for the orientations A, B and C

You can define the velocity override under "Adjust" (Page 331).

Requirement

Kinematics is enabled in the kinematics control panel.

10.8.1 Jogging the kinematics axes in the MCS

In the MCS, you can jog each kinematics axis individually forwards, backwards or to a predefined target position or target angle. With mechanical couplings of the axes, select the "JCS" coordinate system to jog the joints of the kinematics (Page 335).

WARNING

Limits of the joint traversing range are not taken into consideration in the MCS in the technology version < V9.0

When you move the kinematics axes in the kinematics control panel in the MCS, the limits that have been set for the joint traversing ranges (Page 56) are not taken into account for the joints.

In the case of kinematics without mechanically coupled axes, you can limit the joint position to the operating range by using software limit switches. The software limit switches have to be correctly set and existing offsets or the inverted traversing direction of the joints must be taken into consideration.

In the case of kinematics with mechanically coupled axes, you cannot completely limit the joint position to the operating range using the software limit switches. Therefore, you must yourself take into consideration the configured limits for the joint traversing ranges. Make sure that no unwanted positions are approached and that no collisions occur.

Procedure for jogging forwards or backwards

1. Select the "Jog" operating mode in the drop-down list.
2. Select the "MCS" coordinate system in the drop-down list.
3. Select the axis that you want to move using the button "A1 ... A6".
4. Enter the velocity for the axis.
5. Move the axis by dragging the slider forward or backward.
6. To stop the axis, release the pressed mouse button. The slider automatically jumps to the center position and the axis is stopped with the specified dynamics.

Procedure for jogging to a target position

1. Select the "Jog to target position" operating mode in the drop-down list.
2. Select the "MCS" coordinate system in the drop-down list.
3. Select the axis that you want to move using the button "A1 ... A6".
4. Enter the target position for the kinematics axis.
5. Enter the velocity for the axis.
6. To specify the velocity, drag the slider to the right. The further you drag the slider to the right, the higher the velocity of the axis movement.
7. To stop the axis before the target position is reached, release the pressed mouse button. The slider automatically jumps to zero to the left and the axis stops with the set dynamics.
8. The axis stops automatically with the specified dynamics when the target position has been approached.

10.8.2 Jogging joints in the JCS

In the JCS, you can jog each kinematics joint individually forwards, backwards or to a set target position. In contrast to jogging in the MCS where only the axis coordinates are taken into account, the mechanical axis coupling is taken into account when jogging in the JCS.

For kinematics types with up to 4 interpolating axes, the jogging of the joints in the JCS corresponds to the jogging of the axes in the MCS.

NOTE

Jogging joints in the JCS

For coupled axes with coupling factor ≠ 1, the jogging of joints in the JCS can result in an unwanted position change of the coupled axes.

Jog forward or backward

To move a joint forward or backward in jog mode, proceed as follows:

1. In the "Operating mode" drop-down list, select the "Jog" entry.
2. In the "Coordinate system" drop-down list, select the "JCS" entry.
3. Select the joint that you want to move using the button "J1 ... J6".
4. Enter the velocity for the joint.
5. To move a joint in the positive direction, drag the slider to the right.

   The joint moves in the positive direction as long as you keep the slider pressed and to the right of the zero position.
6. To move a joint in the negative direction, drag the slider to the left.

   The joint moves in the negative direction as long as you keep the slider pressed and hold it to the left of the zero position.
7. To stop the joint moving, release the pressed mouse button.

   The slider automatically jumps to the center position and the joint is stopped with the specified dynamics.

Jogging to a target position

To move a joint to a target position in jog mode, proceed as follows:

1. In the "Operating mode" drop-down list, select the "Jog to target position" entry.
2. In the "Coordinate system" drop-down list, select the "JCS" entry.
3. Select the joint that you want to move using the button "J1 ... J6".
4. Enter the velocity for the joint.
5. Enter the target position for the joint.
6. To move the joint to the target position, move the slider to the right. The further you move the slider to the right, the higher the velocity of the joint movement.

   The kinematics stops as soon as you release the pressed mouse button or the target position is reached.

10.8.3 Cartesian kinematics jogging in WCS/OCS

In WCS or OCS, you can move each kinematic in jog mode in x, y and z direction or rotate the tool center point around the x, y and z-axis (rotation A, B, C).

When jogging to a target position, you move the kinematics to the position specified under "Target position" with a linear motion. The direction of movement of the Cartesian orientation is not limited to the positive direction here. For kinematics with up to 4 interpolating axes, the A4 kinematics axis is moved using the "Shortest path" mode.

WARNING

Overrun of the dynamics through singular positions

Overruns of the dynamics in the vicinity of singular positions can result in the following damage:

- Machine damage through overload of the mechanical components
- Personal injury caused by products or machine parts coming loose

To prevent dynamic overruns in the vicinity of singular positions, take the following measures:

- Move the kinematics in the MCS or the JCS.
- In the WCS or OCS, avoid the "Jog" mode. The dynamic adaptation in "Jog" mode in the WCS or OCS is not active in the kinematics control panel. The dynamic limits of the kinematics axes are not taken into account during a kinematics motion with the kinematics control panel.
- Up to technology version V5: In the WCS or OCS, avoid using the "Jog to target position" mode. The dynamic adaptation in "Jog to target position" mode in the WCS or OCS is not active in the kinematics control panel. The dynamic limits of the kinematics axes are not taken into account during a kinematics motion with the kinematics control panel.
- As of technology version V6: Move the kinematics to the "Jog to target position" mode in the WCS or OCS using the kinematics control panel. "Dynamic adaptation without segmentation of the path" is permanently active in the "Jog to target position" mode, and the dynamic limits of the kinematics axes are taken into account.

Jog

To jog the kinematics in the WCS/OCS, you can choose between the following modes for kinematics types with orientation:

- Cartesian

  In "Cartesian" mode, you jog the kinematics in the x, y and z direction.
- Orientation

  In "Orientation" mode, you can rotate the TCS and move the TCP.

You activate the respective mode using the button of the same name.

You can only jog kinematics types without orientation in Cartesian mode.

To move the kinematics axes in jog mode, follow these steps:

1. In the "Operating mode" drop-down list, select the "Jog" entry.
2. In the "Coordinate system" drop-down list, select the "WCS" or "OCS" entry.
3. Choose whether you want to jog the kinematics in "Cartesian" or "Orientation" mode.

Jogging kinematics in "Cartesian" mode

1. Enter the velocity for the x, y and z directions.
2. To move a kinematics axis in the positive or negative direction, click the slider and drag the slider in the respective direction.

   The kinematics moves in the respective direction as long as you keep the slider pressed and not in the zero position. As soon as you release the pressed mouse button, the slider automatically jumps to zero and the kinematics is stopped with the specified dynamics. Depending on the kinematics type, several axes can be moved.

Jogging 2D and 3D kinematics types with orientation in "Orientation" mode

1. Enter the velocity for the rotation of the TCS and the offset of the TCP.
2. To rotate the TCS around the z axis, click the "R" slider and drag the slider to the left or right. The further you drag the slider away from the central position, the faster the TCS is rotated.

   As soon as you press one of the keys, the kinematics travels with the maximum preset velocity.
3. To move the TCP along the z axis of the TCS, click the "v" slider and drag the slider to the left or right. The further you drag the slider away from the central position, the faster the TCP is moved.

Jogging 3D kinematics types with 2 orientations, "6-axis articulated arm with central wrist" and "6-axis articulated arm with offset wrist" in "Orientation" mode

1. Enter the velocity for the orientation, the rotation of the TCS and the offset of the TCP.
2. To change the orientation of the TCS, click the slider and drag the slider to the left/right/up/down. The further you drag the slider away from the central position, the faster the TCS is rotated.
3. To rotate the TCS around the x axis for the "6-axis articulated arm with central wrist" and "6-axis articulated arm with offset wrist" kinematics type, click the "R" slider and drag the slider to the left or right. The further you drag the slider away from the central position, the faster the TCS is rotated.

   As soon as you press one of the keys, the kinematics travels with the maximum preset velocity.
4. To move the TCP along the x axis of the TCS, click the "v" slider and drag the slider to the left or right. The further you drag the slider away from the central position, the faster the TCP is moved.

Jogging to a Cartesian target position

To move the kinematics to a target position in jog mode, proceed as follows:

1. In the "Operating mode" drop-down list, select the "Jog to target position" entry.
2. In the "Coordinate system" drop-down list, select the "WCS" or "OCS" entry.

   The target position is shown in the 3D display.
3. Enter the velocity for the path and the orientation motion.
4. Enter the Cartesian target position (Page 226) in the selected coordinate system.

   With a 3D kinematics with 2 orientations, you can select the value 0° or -180° for the rotation C.

   Alternatively, you can specify the target position with the directional pad (Page 314).
5. To move the kinematics to the target position, click the "Start" slider, hold down the mouse button and move the slider to the right.

   The kinematics moves to the specified target position. Movements of the kinematics axis are possible in both the positive and the negative direction. For kinematics with up to 4 interpolating axes, the A4 kinematics axis is moved using the "Shortest path" mode.

   The kinematics stops as soon as you release the pressed mouse button or the target position is reached.

10.9 Disabling kinematics and handing over master control

Procedure

To return the master control to the user program, perform the following steps:

1. Jog the kinematics to a basic position from which the kinematics can be moved with the user program.
2. Set the currently mounted tool in the kinematics control panel and activate the tool zone associated with the active tool. If necessary, deactivate the tool zone that is no longer required (e.g. after a tool change).
3. Click the "Disable" button.

   The kinematics axes are disabled.
4. Click "Deactivate".

   The master control is returned from the kinematics control panel to the user program.

Result

You can move the kinematics via an automatic program or an HMI.

Diagnostics 11

The description of Motion Control diagnostics is limited to the diagnostics view of the technology objects in TIA Portal, the technology alarms and the error IDs on Motion Control instructions.

"Debug" program mode is available for testing the execution of your Interpreter program.

The following descriptions can be found in the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation:

- Diagnostics concept
- Technology alarms
- Error IDs in Motion Control instructions

A comprehensive description of the system diagnostics of the S7-1500 CPU can be found in the "Diagnostics" function manual (https://support.industry.siemens.com/cs/ww/en/view/59192926).

11.1 Kinematics technology object

11.1.1 Structure of the diagnostics

The diagnostics of the kinematics in "Technology object > Diagnostics" is divided into the following areas:

- Graphic display
- Diagnostics window

Diagnostics window

The following diagnostics windows are available in the graphic display:

- Status and error bits (Page 340)
- Zones status (Page 342)
- Motion and Tools (Page 343)
- Positions (Page 345)

With the following buttons, you can show or hide the associated diagnostics windows:

Button	Function
	Status and error bits
	Zones status
	Motion and tools
	Positions

You can also move the diagnostics window to a desired position within the graphic display.

11.1.2 Status and error bits

With the diagnostics window "Status and error bits" in "Technology object > Diagnostics" you monitor the status and error messages of the technology object in the TIA Portal. The diagnostics function is available in online operation.

The diagnostics window "Status and error bits" is shown in the graphic display of the diagnostics. You can show the diagnostics window via the symbol of the toolbar and move the window to a desired position within the graphic display.

The meaning of the status and error messages is described in the following tables. The associated technology object tag is given in parentheses.

"Kinematics status"

The following table shows the possible statuses of the kinematics:

Status	Description
Error	An error occurred at the technology object. Detailed information about the error is available in the "Error" area and in the "<TO>.ErrorDetail.Number" and "<TO>.ErrorDetail.Reaction" tags of the technology object. (<TO>.StatusWord.X1 (Error))
Restart active	The technology object is being reinitialized. (<TO>.StatusWord.X2 (RestartActive))
Kinematics control panel active	The kinematics control panel is activated. The kinematics control panel has master control over the technology object. The kinematics cannot be controlled from the user program. (<TO>.StatusWord.X4 (ControlPanelActive))
Restart required	Data relevant for the restart has been changed. The changes are applied only after a restart of the technology object. (<TO>.StatusWord.X3 (OnlineStartValuesChanged))
Valid	The transformation values are valid. (<TO>.StatusKinematics.Valid)
Simulation active	The kinematics technology object is in simulation. (<TO>.StatusWord.X19 (InSimulation))
JCS enabled	The kinematics technology object uses the JCS. (<TO>.StatusWord.X21 (EnabledJCS))

"Error"

The following table shows the possible errors:

Error	Description
System	A system-internal error has occurred. (<TO>.ErrorWord.X0 (SystemFault))
Configuration	A configuration error has occurred. One or more configuration parameters are inconsistent or invalid. The technology object was incorrectly configured, or editable configuration data was incorrectly modified during runtime of the user program. (<TO>.ErrorWord.X1 (ConfigFault))

Error	Description
Transformation	A transformation error has occurred. (<TO>.ErrorWord.X4 (TransformationFault))
User program	An error has occurred in the user program at a Motion Control instruction or its use (e.g. by the kinematics control panel). (<TO>.ErrorWord.X2 (UserFault))
Job rejected	A job cannot be executed. A Motion Control instruction cannot be executed because necessary requirements have not been met (e.g. technology object not homed). (<TO>.ErrorWord.X3 (CommandNotAccepted))
Dynamic limitation	The dynamic values are limited to the dynamic limits. (<TO>.ErrorWord.X6 (DynamicError))

"Warnings"

The following table shows the possible warnings:

Warning	Description
Configuration	One or more configuration parameters are temporarily adjusted internally. (<TO>.WarningWord.X1 (ConfigWarning))
Job rejected	A job cannot be executed. A Motion Control instruction cannot be executed because the necessary conditions have not been met. (<TO>.WarningWord.X3 (CommandNotAccepted))
Dynamic limitation	The dynamic values are limited to the dynamic limits. (<TO>.WarningWord.X6 (DynamicWarning))

"Motion status"

The following table shows the possible statuses of the kinematics motion:

Status	Description
Done (no job running)	There is no active motion job at the technology object. (<TO>.StatusWord.X6 (Done))
Linear motion active	There is a linear motion job active at the technology object. (<TO>.StatusWord.X8 (LinearCommand))
Circular motion active	There is a circular motion job active at the technology object. (<TO>.StatusWord.X9 (CircularCommand))
sPTP motion active	There is a synchronous "point-to-point" motion job active at the technology object. (<TO>.StatusWord.X11 (DirectCommand))
Constant velocity	The kinematics is moved with constant velocity or is stationary. (<TO>.StatusWord.X12 (ConstantVelocity))
Accelerating	The kinematics is being accelerated. (<TO>.StatusWord.X13 (Accelerating))

Status	Description
Decelerating	The kinematics is being decelerated. (<TO>.StatusWord.X14 (Decelerating))
Motion interrupted	The active kinematics motion is interrupted by an "MC_GroupInterrupt" job. (<TO>.StatusWord.X17 (Interrupted))
Orientation movement active	There is an orientation motion active at the technology object. (<TO>.StatusWord.X15 (OrientationMotion))

See also

"StatusWord" tag (kinematics) (Page 501)
"ErrorWord" tag (kinematics) (Page 502)
"WarningWord" tag (kinematics) (Page 504)

11.1.3 Zones status

Using the diagnostics windows "Status Zones" in "Technology object > Diagnostics", you monitor the status of the workspace zones and the kinematics zones of the technology object in the TIA portal. The diagnostics function is available in online operation.

The diagnostics window "Zones Status" is displayed in the graphic display of the diagnostics. You can show the diagnostics window via the symbol of the toolbar and move the window to a desired position within the graphic display.

"Zones status"

The "Workspace zones" and "Kinematics zones" tables show the status of the individual zones. The following symbols are displayed for this purpose:

Symbol	Description
	The zone is not defined.
	The zone is inactive.
	The zone is active.
	The zone was violated.

You can use the toolbar icon in the graphic display of the diagnostics to show and hide all zones. In addition, when the icon is active, you can display and hide the zones using the symbol .

See also

Structure of the diagnostics (Page 339)

11.1.4 Motion and tools

You monitor the path motions and the tools of the technology object in the TIA Portal using the diagnostics window "Motion and Tools" in "Technology object > Diagnostics". The diagnostics function is available in online operation.

The diagnostics window "Motion and Tools" is shown in the graphic display of the diagnostics. You can show the diagnostics window via the symbol of the toolbar and move the window to a desired position within the graphic display.

"Motion and Tools"

The following table describes the meaning of the parameters of the motion and tools:

Status	Description
Path dynamics values	
Limit path dynamics to axis dynamics	Dynamic adaptation (<TO>.StatusPath.DynamicAdaption)
Velocity	Current path velocity (setpoint reference) (<TO>.StatusPath.Velocity)
Acceleration	Current path acceleration (setpoint reference) (<TO>.StatusPath.Acceleration)
Orientation velocity	Resulting orientation velocity (<TO>.StatusPath.OrientationVelocity)
Override	Percentage correction of the velocity specification The setpoint velocity set in Motion Control instructions or from the kinematics control panel is superimposed with an override signal and corrected as a percentage. The following values are permitted as velocity correction: • Path motion: from 0.0% to 200.0% • sPTP motion: from 0.0% to 100.0% (<TO>.Override.Velocity)
Job sequence	
Existing jobs	Current number of jobs for the kinematics technology object in the job sequence. (<TO>.StatusMotionQueue.NumberOfCommands)
Prepared jobs	Number of prepared jobs for the kinematics technology object in the job sequence. (<TO>.StatusMotionQueue.NumberOfPreparedCommands)
Prepared jobs (distance)	
Total path length	Total path length of linear and circular path motions (<TO>.StatusPath.TotalPathLength) Sum of: • Distance of all completed motion jobs • Distance travelled of the active motion job • Remaining distance of the motion job • Calculated distance of all jobs in the job sequence
Accumulated path length	Accumulated path length of linear and circular path motions (<TO>.StatusPath.AccumulatedPathLength) Sum of: • Distance of all completed motion jobs • Distance travelled of the active motion job
Active tool	

Status	Description
Active tool	Currently selected tool (<TO>.StatusTool.ActiveTool)
Tool center point in the FCS	
x position	x coordinate of the current tool frame in the flange coordinate system (FCS) (<TO>.StatusTool.Frame[1..3].x)
y position	y coordinate of the current tool frame in the FCS (<TO>.StatusTool.Frame[1..3].y)
z position	z coordinate of the current tool frame in the FCS (<TO>.StatusTool.Frame[1..3].z)
Rotation A	A-coordinate of the current tool frame in the FCS (<TO>.StatusTool.Frame[1..3].a)
Rotation B	B-coordinate of the current tool frame in the FCS (<TO>.StatusTool.Frame[1..3].b)
Rotation C	C-coordinate of the current tool frame in the FCS (<TO>.StatusTool.Frame[1..3].c)
Joints	
J1 ... J6 velocity setpoint	Current velocity setpoint of the respective joint J1 to J6 (<TO>.JointData.J[1..6].Velocity)
J1 ... J6 acceleration setpoint	Current acceleration setpoint of joint J1 to J6 (<TO>.JointData.J[1..6].Acceleration)
Conveyor tracking	
OCS1 ... 3	Active coupled OCS 1, 2 or 3
Coupled technology object	Technology object for active conveyor tracking Leading-value-capable technology objects are: • Positioning axis • Synchronous axis • External encoder • Leading axis proxy (<TO>.StatusConveyor[1..3].ConveyorBelt)
Conveyor position	Conveyor position of the technology object (<TO>.StatusConveyor[1..3].BeltPosition)
Position of the OCS in x direction	Position of the OCS in x direction on the conveyor (<TO>.StatusConveyor[1..3].ObjectPosition)
Conveyor tracking status	Conveyor tracking status (<TO>.StatusConveyor[1..3].TrackingState)
	OCS not assigned: The OCS is not assigned to a leading-value-capable technology object. (<TO>.StatusConveyor[1..3].TrackingState = 0)
	OCS assigned: The Motion Control instruction "MC_TrackConveyorBelt" is finished and the OCS is assigned to a leading-value-capable technology object. The first path motion job in the tracked OCS can be sent. (<TO>.StatusConveyor[1..3].TrackingState = 1)

Status			Description	
		Conveyor tracking status	TCP synchronizes to OCS	The OCS is assigned to a leading-value-capable technology object. The first path motion job in the tracked OCS is active. (<TO>.StatusConveyor[1..3].TrackingState = 2)
			TCP follows OCS	The OSC is assigned to a leading-value-capable technology object. The position of the OCS is reached. The kinematics is moved with the position of the OCS. (<TO>.StatusConveyor[1..3].TrackingState = 3)
			TCP desynchronizes from OCS	The motion of the kinematics in the tracked OCS is ended by a motion job in the WCS or a non-tracked OCS. When the motion job is completed, the "TrackingState" changes to 0 and the OCS is not tracked with the product position anymore. (<TO>.StatusConveyor[1..3].TrackingState = 4)

See also

Structure of the diagnostics (Page 339)

11.1.5 Positions

You monitor the position values of the technology object in the TIA Portal using the diagnostics window "Positions" in "Technology object > Diagnostics". The diagnostics function is available in online operation.

The diagnostics window "Positions" is shown in the graphical display of the diagnostics. You can show the diagnostics window via the symbol of the toolbar and move the window to a desired position within the graphic display.

The available functions are described in the section "Monitoring and comparing position values (Page 315)".

"Positions"

The following table describes the meaning of the position information:

Status		Description
Coordinate system 1		Reference coordinate system • In "Diagnostics", in "Calibration" and in "Kinematics trace", this field shows the coordinate system that you have selected in the toolbar. • In "Commissioning", this field shows the coordinate system that you have selected in the kinematics control panel. • When you select the kinematics coordinate system (KCS) in the toolbar, the WCS is displayed in the "Positions" window in "Diagnostics" and in "Kinematics trace".
	x position	x coordinate of the active tool in the set coordinate system (<TO>.Tcp.x; <TO>.TcpInOcs[1..3].x.Position)
	y position	y coordinate of the active tool in the set coordinate system (<TO>.Tcp.y; <TO>.TcpInOcs[1..3].y.Position)
	z position	z coordinate of the active tool in the set coordinate system (<TO>.Tcp.z; <TO>.TcpInOcs[1..3].z.Position)

Status	Description
Rotation A	A coordinate of the active tool in the set coordinate system (<TO>.Tcp.a; <TO>.TcpInOcs[1..3].a.Position)
Rotation B	B coordinate of the active tool in the set coordinate system (<TO>.Tcp.b; <TO>.TcpInOcs[1..3].b.Position)
Rotation C	C coordinate of the active tool in the set coordinate system (<TO>.Tcp.c; <TO>.TcpInOcs[1..3].c.Position)
Coordinate system 2	Reference coordinate system In the drop-down list, you can select an additional coordinate system in order to display the actual position of the active tool in this coordinate system.
WCS, OCS1, OCS2, OCS3	
x position	x coordinate of the active tool in the set coordinate system (<TO>.Tcp.x; <TO>.TcpInOcs[1..3].x.Position)
y position	y coordinate of the active tool in the set coordinate system (<TO>.Tcp.y; <TO>.TcpInOcs[1..3].y.Position)
z position	z coordinate of the active tool in the set coordinate system (<TO>.Tcp.z; <TO>.TcpInOcs[1..3].z.Position)
Rotation A	A coordinate of the active tool in the set coordinate system (<TO>.Tcp.a; <TO>.TcpInOcs[1..3].a.Position)
Rotation B	B coordinate of the active tool in the set coordinate system (<TO>.Tcp.b; <TO>.TcpInOcs[1..3].b.Position)
Rotation C	C coordinate of the active tool in the set coordinate system (<TO>.Tcp.c; <TO>.TcpInOcs[1..3].c.Position)
MCS	
A[1..6]	Current position setpoint of axis A[1..6] (<TO>.Position)
JCS	
J[1..6]	Current position setpoint of joint JJ[1..6] (<TO>.JointData.J[1..6].Position)

See also

Structure of the diagnostics (Page 339)

Kinematics trace 12

The kinematics trace offers the following functions:

- 3D visualization of the current motion of the tool center point (TCP) and the object coordinate systems (OCS)
- Recording, playing and saving kinematic motions
- Exporting and importing the recordings

You can find the kinematics trace of the kinematics technology object in the project tree under "Technology object > Kinematics trace".

12.1 Defining parameter values for recording

You specify the parameter values for the recording under "Technology object > Kinematics trace > Configuration"

Setting the sampling

Configure the duration of a recording as follows:

1. In the "Time of recording" drop-down list, select the desired recording time between the following OBs:
   - MC_Servo
   - MC_Interpolator
2. In the "Record all" drop-down list, select the desired value for the recording interval:
   - Specification in cycles
   - Specification in seconds
3. The calculated value of the maximum recording duration is displayed in the "Max. recording duration" field.

   If you change the recording interval in the field "Record all", the maximum recording time changes.
4. To set the recording duration to the maximum possible, select the "Use maximum recording duration" check box.
5. In the "Recording duration (a)" drop-down list, select the desired type of recording duration display for the recording:
   - In seconds
   - Number of samples

Setting triggers

Configure the start of a recording as follows:

1. In the "Trigger mode" drop-down list, select the desired trigger mode for your recording:
   - Record now
     The recording starts immediately after the configuration is loaded.
   - Trigger on tag
     The system waits for a trigger event that triggers the recording.
2. In the "Trigger tag" field, select a tag of the data type "BOOL".
3. In the "Event" drop-down list, select the desired event to be used as trigger event:
   - Positive edge
   - Falling edge
4. In the "Pretrigger (b)" drop-down list, select a suitable pretrigger for your recording:
   - In seconds
   - Number of samples

   The "pretrigger" is used to record measuring points in advance of the start of the trigger event. As soon as the trigger event occurs, the recording is displayed in the graphic view.

Selecting the traces to be recorded

Select the traces for the recording as follows.

1. Select whether the setpoint positions of the kinematics axes should be recorded with the coordinates of the tool center point (TCP). You have the following options:
   - Tool center point (TCP) and kinematics

     If you activate this option, the coordinates of the TCP and the set positions of the kinematics axis are recorded. The motions of the TCP and the motions of the kinematic axes are displayed when a recording is played.
   - Tool center point (TCP)

     If you activate this option, only the coordinates of the TCP will be recorded. The motions of the TCP are displayed when a recording is played, the motions of the kinematic axes are not displayed.
2. Select the object coordinate systems (OCS) to be recorded.
   - OCS 1 frame
   - OCS 2 frame
   - OCS 3 frame

Maximum number of signals per kinematics trace

You can record a maximum of 64 signals in a kinematics trace. The following table shows how many signals are required for the traces.

Kinematics type	Trace	Required signals
2D	Tool center point (TCP) and kinematics	4
	Tool center point (TCP)	2
	per OCS	3
2D with orientation	Tool center point (TCP) and kinematics	6
	Tool center point (TCP)	3
	per OCS	2
3D	Tool center point (TCP) and kinematics	6
	Tool center point (TCP)	3
	per OCS	6
3D with orientation	Tool center point (TCP) and kinematics	8
	Tool center point (TCP)	4
	per OCS	4
3D with 2 orientations A, B	Tool center point (TCP) and kinematics	10
	Tool center point (TCP)	5
	per OCS	4
3D with 3 orientations	Tool center point (TCP) and kinematics	12
	Tool center point (TCP)	6
	per OCS	6
6-axis articulated arm with central wrist, 6-axis articulated arm with offset wrist	Tool center point (TCP) and kinematics	12
	Tool center point (TCP)	6
	per OCS	6

The more traces you record, the lower the maximum recording duration and the number of samples per trace.

12.2 List of recordings

The list of recordings is displayed below the graphic display as tabular editor. The list contains the following recordings:

- The current recording
- All saved recordings for the selected technology object

The recordings are displayed line by line.

Functions

The following functions are available in the list of recordings:

- Saving and deleting recordings (Page 352)
- Showing traces of a recording

  You can also show all traces of a recording by expanding the line of a recording.
- Showing and hiding traces in the graphic display

  The button for showing and hiding a trace has the following functions depending on the status:

Button	Status and function
	The recording or the trace is hidden. Shows the hidden recording or trace.
	The traces of the recording are partially shown and hidden.
	The recording or the trace is shown. Hides the recording or trace

12.3 Recording and playing kinematics motions

For the recording, use the values set under "Technology object > Kinematics trace > Configuration".

Switch to live display

You can show the current motion or position of the kinematics with the icon in online mode. The button for the live display is active when a saved recording is selected or while a recording is played. In offline mode and when no recording is available, the live display button is inactive.

Requirement

- The kinematics trace was configured under "Technology object > Kinematics trace > Configuration".

Record kinematics motion

To record a kinematics motion, proceed as follows:

1. Click the icon in the toolbar to establish an online connection to the device.

   The kinematics trace establishes an online connection to the device. If the online and offline trace configurations differ, the trace configuration is loaded into the device.
2. To start a recording, click on the symbol in the toolbar.

   If you start a recording directly without previously establishing the online connection (step 1), an online connection is established automatically.
3. Move the kinematics.
4. To end the recording, click on the symbol on the toolbar.

   The current recording and the configuration are kept until the "kinematics trace" has been closed. When you start a new recording, the current recording is overwritten.

Play kinematics motion

To play a kinematics motion, proceed as follows:

1. If the live display is activated, switch off the live display by clicking the symbol .
2. In the list of recordings, select the recording you want to play.
3. To show the trace in the graphic display, click on the symbol in the line of the selected recording.

   The complete trace of the selected recording is displayed graphically in the display.
4. To play the recording, click on the symbol at the bottom of the graphic display.

   The recording that is selected as a line in the list is played.
5. To adjust the playback speed, change the position of the speed slider in the toolbar for playing a recording.

   .
6. Use the following buttons to control the playback of a recording:

Button	Function
	Jumps back to the start of the selected recording.
	Jumps back step-by-step in the selected recording.
	Jumps forward step-by-step in the selected recording.
	Jumps to the end of the selected recording.

7. To pause a recording, click on the symbol in the toolbar for playing a recording.
8. To stop a recording, click on the symbol in the toolbar for playing a recording.

Show TCP orientation

Use the button to show or hide the TCP orientation as a trace in the kinematics trace.

Displaying and comparing position values

In the kinematics trace, you can monitor position values of the technology object or compare the position values in two different reference coordinate systems with the "Positions" window.

In addition, you can view position values directly on the trace.

The available functions are described in the section "Monitoring and comparing position values (Page 315)".

12.4 Saving and deleting recordings

Saving a recording

You can save a current recording. A saved recording contains the following data:

- Kinematics type
- Coordinates of:
  - Kinematics
  - Tool center point (TCP)
  - Object coordinate systems (OCS)
- Valid online geometry at the time of the recording

To adjust and save a recording, proceed as follows:

1. In the "Current recording" area, enter the name of the recording in the "Name" column.
2. In the "Color" column, select the desired colors for the traces.
3. If necessary, enter comments in the "Comment" column.
4. To save the current recording, click on the symbol in the "Current recording" area.

   The recording is inserted in the "Saved recordings" area in the tabular editor.

NOTE

Up to 20 recordings which can be saved

The tabular editor can save a maximum of 20 recordings.

To save additional recordings, delete the recording you no longer need.

Deleting saved recordings

To delete a recording, follow these steps:

1. To delete a recording, click on the symbol ✕ in the corresponding line in the "Saved recordings" area.

   The record is deleted.

NOTE

Traces cannot be deleted individually

You cannot delete traces individually. When you delete a recording, all included traces are deleted.

12.5 Importing and exporting recordings

You have the option to export a recording as measurement, as *.ltr or *.csv file. The exported file contains the TCP position values, the OCS position values and the configuration of the kinematics technology object. Optionally, the following values can be exported:

- Up to technology version V6.0: Axis position values
- As of technology version V7.0: Joint position values

You can re-import an exported *.ltr file into the kinematics trace. The recordings saved under measurements cannot be imported into the kinematics trace again.

Export record as file

To export a record, proceed as follows:

1. From the list of recordings, select the record to be exported.
2. Click on the symbol in the toolbar.

   The "Export recording" dialog opens.
3. Select "*.csv" or "*.ltr" as file format.
4. Select the storage location.
5. Click "Save".

   The file is exported and saved.

Import recording as file

To import a recording, proceed as follows:

1. Click on the symbol in the toolbar.

   The "Import recording" dialog opens.
2. In the corresponding folder, select the file of the "*.ltr" file format to be imported.
3. Click the "Open" button.

   The file is imported. The recording is displayed in the tabular editor under saved recordings.

Save recording as measurement

With the trace you have extended evaluation options to analyze kinematics motion in detail.

To save the recording as a measurement, proceed as follows:

1. Select the current recording or a saved recording.
2. Click on the symbol in the toolbar.

   The recording is saved under "Traces > Measurements".
3. Open the recording stored under "Traces > Measurements" in the trace.

   The recorded parameters are displayed in the trace.

Calibration 13

During calibration, you move a kinematics to relevant points and use the position values to determine the exact position of an object coordinate system (OCS) in the world coordinate system (WCS), to check a predefined OCS in the WCS or to define a workspace zone.

Open calibration under "Technology object > Calibration".

Alternatively, you can open the calibration to the following type:

- To calibrate an object coordinate system, select an object coordinate system in the selection box under "Technology object > Configuration > Extended parameters > Object coordinate systems" and click the symbol.
- To calibrate a workspace zone, go to "Technology object > Configuration > Extended parameters > Zones > Workspace zones" and click the symbol in the line for the respective workspace zone.

Requirement

The kinematics technology object is correctly configured and connected.

Structure

Calibration is divided into two views:

- Object coordinate systems
- Workspace zones

Each view is divided into the following areas:

- Configuration section (Page 355)
- 3D visualization (Page 355) and control pad (Page 314)
- Kinematics control panel (Page 317)

13.1 Using 3D display for the calibration

The 3D display provides you with visual support during calibration. The following values are displayed graphically depending on the configured calibration method:

- Configured points and angles
- Guide lines
- Offset of the OCS from the origin
- Current position of the TCP
- Graphically highlighted active calibration point
- Active and inactive workspace zones

In addition, you can also use the following functions of the 3D visualization for the calibration:

- Operating the zone display (Page 313)
- Selecting values for the calibration (Page 311)
- Monitoring and comparing position values (Page 315)

In the configuration area, select a calibration method and set all the required parameters for the calibration.

The configuration area is structured differently for the calibration of object coordinate systems, the calibration of workspace zones and depending on the selected calibration method.

- Configuring calibration of an object coordinate system (Page 359)
- Configuring calibration of a workspace zone (Page 378)

13.2 Moving the kinematics for calibration

For the calibration, you can move the kinematics as follows:

- **Offline, move the tool center point in the 3D view using the control pad**

  See also section "Operating the directional pad (Page 314)".

- **Moving real kinematics online**

  You move the real kinematics online via the control panel in the "Jog" or "Jog to target position" mode. In the 3D view, you can see the motion of the kinematics model.

  To specify the target position in the "Jog to target position" mode, you can determine the coordinates with the control pad or enter them directly on the control panel.

  The functionality of the kinematics control panel is described in section "Commissioning (Page 317)".

13.3 Display progress and status

The progress and notes on the input of the values are displayed in the configuration area of the calibration method.

The entered values of the calibration are checked for the "Three-point" and "Two-point" methods. The distances between the points in the OCS are compared with the distances between the points in the WCS. Comparison of the points is not required with the "One-point" method.

If the entries are still incomplete, the status indicator is displayed in red. Depending on your inputs, the status indicator shows the following:

- In the case of the "Three-point" (Page 361) calibration method
  - Angle of triangles in the WCS and the OCS, less than 20°
  - Deviation of the points in WCS and OCS to each other greater than 5%
- In the case of the "Two-point" (Page 360) calibration method
  - Deviation of the points in WCS and OCS to each other greater than 5%

Each correctly set point is shown in green in the progress display.

If your entries are complete and correct, the status indicator "Finished" appears green. You can accept the values in the configuration.

13.4 Setting points

To set points, use the following input options:

- Enter the position manually
- Apply TCP position
- Couple coordinates to TCP position

Each of the values displayed in the fields is a position value in the following coordinate system:

- Calibrate object coordinate system: WCS or selected object coordinate system (marking in adjustment range of the individual points)
- Calibrate workspace zone: Coordinate system of the workspace zone (selection in the zone properties)

Enter the position manually

1. Enter the position of the workspace zone in the x, y and z directions in the respective field.

Apply TCP position

To adopt the current position value of the TCP, proceed as follows:

1. Move the kinematics to a position.

   You can monitor the current position values in the "Positions" window.

2. To adopt the current position value of the TCP, click the symbol.
   - To apply all coordinates of a position, click the uppermost and higher-level symbol in the area for a point.
   - To apply the coordinates individually or an angle of a position, click the symbol next to the field for the coordinates or the angle.

   The position value of the TCP is displayed in the selected fields. An angle for a rotation defined by the position value is displayed in the graphical view.

Couple coordinates to TCP position

1. To link the coordinates to the TCP, click the symbol.
   - To couple all coordinates of a position, click the uppermost and higher-level symbol in the area for a point.
   - To couple a single coordinate or angle, click the symbol next to the respective field for the coordinate or angle.

   The symbol changes to and the position value is coupled to the TCP. The corresponding fields of the coordinates are inactive.

2. Move the kinematics to a position.

   In the corresponding fields of the coupled coordinates, the current value of the TCP is displayed while moving the kinematics. An angle for a rotation defined by the position value is displayed in the graphical view.

3. To decouple the coordinates from the TCP, click the symbol .
   - To decouple all coordinates of a position, click the uppermost and higher-level symbol in the area for a point.
   - To uncouple a single coordinate or angle, click the symbol next to the respective field for the coordinate or angle.

   The corresponding fields of the coordinates can be edited again.

4. To adopt the current position value or the angle of the TCP, click the symbol.

   The position value of the TCP is displayed in the selected fields. An applied angle is shown in the graphic view .

See also

Apply or reset values (Page 359)

13.5 Apply or reset values

Apply values

If you have entered new values for the calibration and the "status indicator" is green, you can click on the button "Apply values". The values from the calibration are applied to the configuration. If you calibrate an already defined zone and adopt the calibrated values, the previously defined values are overwritten.

The "Apply values" button becomes inactive as soon as the values from the calibration have been successfully applied in the configuration.

Reset values

With the "Reset values" button, you reset the entered values of the calibration.

13.6 Calibrate object coordinate systems

13.6.1 Configuring calibration of an object coordinate system

Requirement

The kinematics technology object is correctly configured and connected.

Selecting the object coordinate system

1. Select an OCS from the drop-down list.

Selecting the calibration method

Select a calibration method In the drop-down list.

Depending on the type of kinematics, you can use the calibration methods as follows:

Kinematics type	Definition OCS / Checking the OCS position	Calibration methods
2D	Move OCS	Two-point (Page 360)
	Move OCS and rotate around the y axis	Move and rotate around y (Page 361)
2D with orientation	Move OCS	One-point (Page 361)
3D, 3D with 3 orienta-	Move OCS	Three-point (Page 361)

Kinematics type	Definition OCS / Checking the OCS position	Calibration methods
tions, 6-axis articulated arm with central wrist and 6-axis articulated arm with offset wrist	Move OCS and rotate around an axis	• Three-point (Page 361) • Move and rotate (Page 361)
	Move OCS and rotate around two axes	• Three-point (Page 361) • Plane (Page 361)
3D with orientation and 3D with 2 orientations A, B	Move OCS	Two-point (Page 360)
	Move OCS and rotate around the z axis	Move and rotate around z (Page 363)

13.6.2 Move OCS with the "Two-point" calibration method

To move the origin of the object coordinate system (OCS) and define the location of the OCS, use the "Two-point" calibration method.

"Two-point" calibration method

Using this method, you can move the OCS origin or check the position of an already defined OCS in the WCS.

The calibration method assumes that the defined points for the tool center point (TCP) of the kinematics can be reached.

With this method, you calibrate the OCS based on 2 points. You define the OCS origin using the first item in the menu "1. Set point 1" .

You define the second point in the "2. Set point 2" menu as follows:

- With 2D kinematics: Define a point on the xz plane
- With 3D kinematics with orientation or with 2 orientations: Define a point on the xy plane. The z coordinate is automatically applied from the first point and cannot be changed for the second point.

The points entered in the WCS and in the OCS each form a route. The method compares the length and location of the two distances in the WCS and the OCS. If the deviation between the two distances is greater than 5%, this is shown in red in the status display. If the entries are incomplete, this is also shown in red in the status display.

To compare the actual position of an OCS in the WCS with your configured OCS frames, move the kinematics to the corresponding points.

13.6.3 Move OCS and rotate around the y axis

To move the origin of the object coordinate system (OCS) and define the position of the OCS, use the "Move and rotate around y" calibration method.

"Move and rotate around y" calibration method

With this method, you can move the OCS origin to a point and rotate the OCS with an angle of rotation around the y axis.

In the menu "1. Move origin of OCS", you define the new position of the OCS origin.

In the second step, you define the rotation of the OCS in the menu "2. Rotate OCS around one coordinate axis". First select the x axis or z axis from the "Rotate around" drop-down list. This determines which axis should be rotated around the y axis. Then move the kinematics to a point through which the selected coordinate axis should run after rotation. In the "Angle" field, you accept the value of the TCP and thus define the angle of rotation for the selected coordinate axis and the OCS.

13.6.4 Move OCS with the "One-point" calibration method

To move the origin of the object coordinate system (OCS) and define the position of the OCS, use the "One-point" calibration method.

"One-point" calibration method

Using this method, you can move the OCS origin or check the position of an already defined OCS in the WCS.

The calibration method assumes that the defined points for the tool center point (TCP) of the kinematics can be reached.

With this method, you calibrate the OCS based on one point. In the menu "1. Set point 1" you define the x and z coordinates of the point in the WCS. Then enter the corresponding coordinates in the OCS.

The method checks whether all coordinates for the point have been entered. If the entries are still incomplete, the status indicator is displayed in red.

To compare the actual position of an OCS in the WCS with your configured OCS frames, move the kinematics to the corresponding point.

13.6.5 Move OCS and rotate around one axis or two axes

Use one of the following calibration methods to move the origin of the object coordinate system (OCS) and define the position of the OCS:

- Move and rotate
- Three-point
- Plane

With the "Move and rotate" calibration method, you can rotate the OCS around 1 axis. If you want to rotate the OCS around a second axis, use the "Three-point" or "Plane" calibration method.

"Three-point" calibration method

With this method, you can:

- Move the OCS origin and rotate the OCS around 2 axes
- Check the position of an already defined OCS in the WCS

The calibration method assumes that the defined points for the tool center point (TCP) of the kinematics can be reached.

With this method, you calibrate the OCS based on 3 points. You define the coordinates of the points in the WCS. Then enter the corresponding coordinates in the OCS.

The points entered in the WCS and the OCS each form a triangle. The method compares the angles and side lengths of the two triangles.

The status of the check gives you feedback on the accuracy of your information. Depending on your inputs, the status indicator shows the following:

- Angle of triangles in the WCS and the OCS, less than 20°
- Deviation of the points in WCS and OCS to each other greater than 5%
- Conformity error of the side lengths of the triangle greater than 5%

If the entries are incomplete, this is also shown in red in the status display.

If the two triangles are within the tolerances, the position of the OCS is defined via the 3 points.

To compare the actual position of an OCS in the WCS with your configured OCS frames, move the kinematics to the corresponding points.

"Move and rotate" calibration method

With this method, you can move the OCS origin to a point and rotate the OCS with an angle of rotation around one of the three coordinate axes.

In the menu "1. Move origin of OCS", you define the new position of the OCS origin.

In the second step, you define the rotation of the OCS in the menu "2. Rotate OCS around one coordinate axis". First, select a coordinate axis (x, y or zaxis) in the drop-down list "Rotate around" around which the OCS is to be rotated. Then select a coordinate axis in the "Axis to rotate" drop-down list that is to be rotated around the previously selected coordinate axis. To conclude, move the kinematics to a point through which the coordinate axis selected in the second step should pass after the rotation. In the "Angle" field, you accept the value of the TCP and thus define the angle of rotation for the selected coordinate axis and the OCS.

"Plane" calibration method

With this method, you can move the OCS origin to a point and rotate the OCS with 2 angles of rotation around 2 coordinate axes.

In the menu "1. Move origin of OCS", you define the new position of the OCS origin.

In the second step, you define the first rotation of the OCS in the menu "2. Rotate coordinate axis to TCP". In the "Axis" drop-down list, first select the coordinate axis (x, y or z-axis) to be rotated to the TCP. Then move the kinematics to a point through which the selected

coordinate axis should run after rotation. Adopt the value of the TCP to define the angle of rotation for the selected coordinate axis and the OCS.

In the last step, you define the second rotation of the OCS in the menu "Span plane over two coordinate axes". First select a plane from the "Plane" drop-down list, which is spanned between the previously rotated and a second coordinate axis. Then move the kinematics to a point through which the spanned plane should run. Adopt the value of the TCP to define the angle of rotation for the selected coordinate axes and the OCS.

13.6.6 Move OCS and rotate around the z axis

To move the origin of the object coordinate system (OCS) and define the position of the OCS, use the "Move and rotate around z" calibration method.

"Move and rotate around z" calibration method

With this method, you can move the OCS origin to a point and rotate the OCS with an angle of rotation around the z axis.

In the menu "1. Move origin of OCS", you define the new position of the OCS origin.

In the second step, you define the rotation of the OCS in the menu "2. Rotate OCS around one coordinate axis". First select the x or y axis in the "Rotate around" drop-down list. This determines which axis should be rotated around the z axis. Then move the kinematics to a point through which the selected coordinate axis should run after rotation. In the "Angle" field, you accept the value of the TCP and thus define the angle of rotation for the selected coordinate axis and the OCS.

13.6.7 Examples

13.6.7.1 Introduction

The following examples show you how to calibrate an object coordinate system using the different calibration methods.

The example looks at the following application. A kinematics stacks products on pallets. The products have 4 different shapes, for which the pallet is repositioned in each case depending on the surrounding area. The position of the pallet is described by the OCS 1 frame. Based on a few details relating to position, the calibration determines the position of the OCS 1 frame after a change of position.

To illustrate all calibration methods, the following examples are carried out with the different types of Cartesian Portal kinematics.

Kinematics	New position of the pallet	Calibration method used	Example
Cartesian portal 2D	Position 1	Two-point	Move OCS 1 (Page 368)
Cartesian portal 2D with orientation		One-point	
Cartesian portal 2D	Position 2	Move and rotate around y	Move OCS 1 and rotate around the y axis (Page 370)
Cartesian portal 3D		Move and rotate	

Kinematics	New position of the pallet	Calibration method used	Example
Cartesian portal 3D	Position 3	Move and rotate	Move OCS 1 and rotate around z axis (Page 372)
Cartesian portal 3D with orientation		Move and rotate around z	
Cartesian portal 3D	Position 4	• Three-point • Plane	Move OCS 1 and rotate it around the z axis and y axis (Page 374)

Pallet

The pallet has the following dimensions:

- Width: 800.0 mm
- Height: 144.0 mm
- Depth: 1200.0 mm

The origin of the pallet is the same for all four positions and has the following position in the WCS:

	Position in the WCS (mm)	
	2D	3D
x	600.0	600.0
y	0.0	600.0
z	0.0	0.0

The pallet is rotated differently in each position. The following angles are used for the new positioning:

- **Position 1**

  2D kinematics

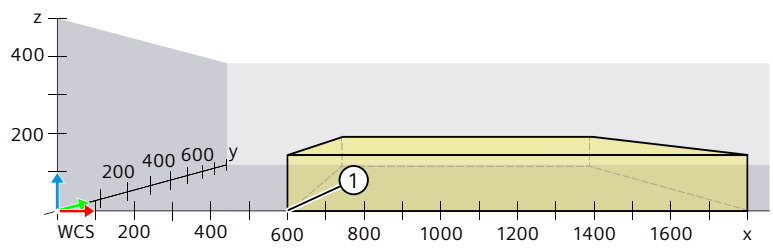

① Origin of the pallet

3D kinematics

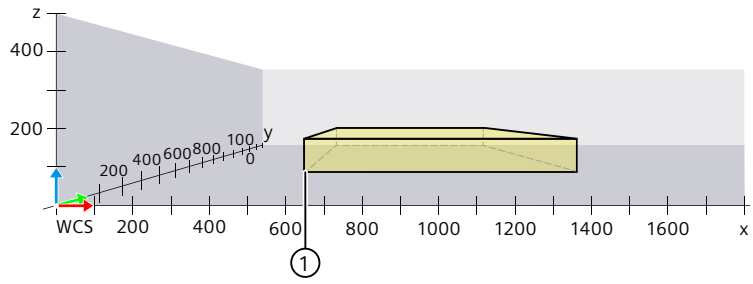

① Origin of the pallet

- **Position 2**

  2D kinematics

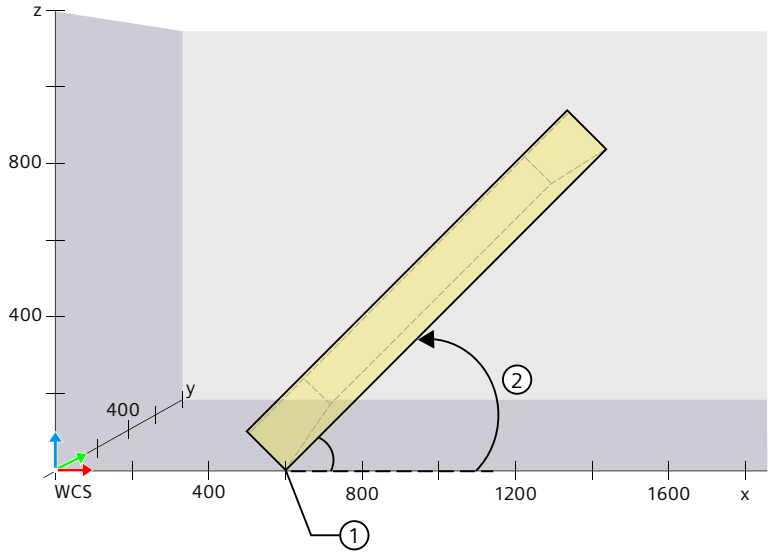

① Origin of the pallet

② Rotation with angle B

3D kinematics

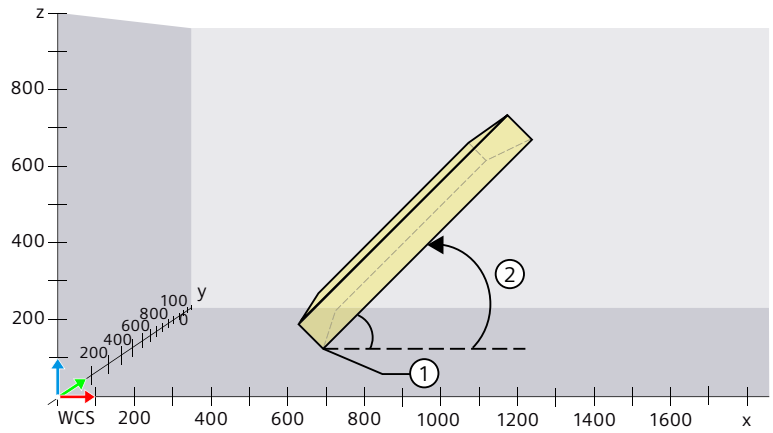

① Origin of the pallet

② Rotation with angle B

- **Position 3**

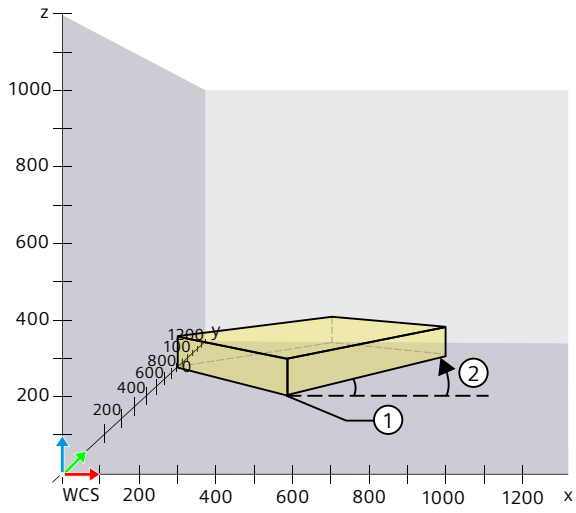

① Origin of the pallet

② Rotation with angle A

- **Position 4**

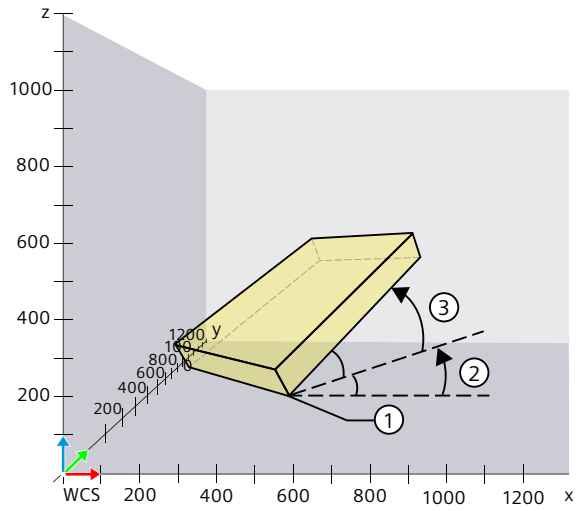

① Origin of the pallet
② First rotation with angle A
③ Second rotation with angle B

Position	Angle		
	A	B	C
1	0°	0°	0°
2	0°	-45°	0°
3	45°	0°	0°
4	45°	30°	0°

Kinematics

Execute the examples for each of the kinematics types mentioned in the overview and enter the following values for the geometry:

Parameters	2D kinematics / 2D kinematics with orientation	3D kinematics / 3D kinematics with orientation
Length L1	500.0 mm	
Length L2	500.0 mm	
Length L3	-	500.0 mm
Flange length FL	100.0 mm	
x minimum	-500.0 mm	
x maximum	2500.0 mm	
y minimum	-	0.0 mm

Parameters	2D kinematics / 2D kinematics with orientation	3D kinematics / 3D kinematics with orientation
y maximum	-	2000.0 mm
z minimum	0.0 mm	
z maximum	1000.0 mm	

If you want to use a different kinematics, consider the position and dimensions of the pallet when defining the geometric parameters of the kinematics. Make sure that all points are accessible for the kinematics.

13.6.7.2 Move OCS 1

Introduction

The pallet was moved in the direction of the x axis in the WCS. Two corner points at the pallet edge are used to determine the new position of the OCS 1 frame.

The position of the first pallet corner defines the origin of the OCS 1. Using the position of the second pallet corner, an additional point for the OCS 1 in the WCS can be determined using the "Two-point" calibration method.

The following methods are used for calibration:

- 2D kinematics: "Two-point" calibration method
- 2D kinematics with orientation: "One-point" calibration method

Coordinates of the points used in the example

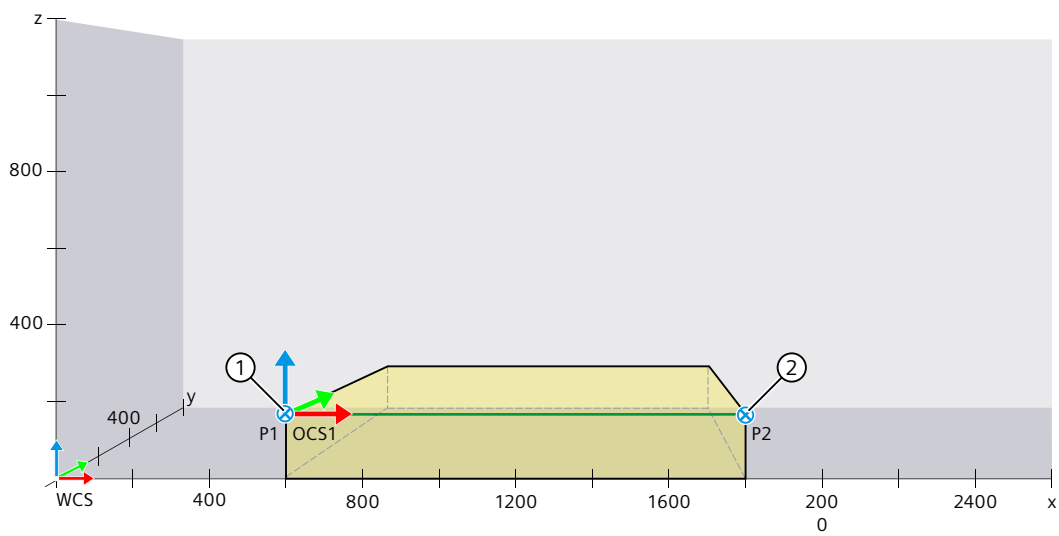

		Position in the WCS (mm)		Position in the OCS (mm)	
		x	z	x	z
1	Point P1 on pallet corner	600.0	144.0	0.0	0.0
2	Point P2 on pallet corner	1800.0	144.0	1200.0	0.0

2D kinematics: "Two-point" calibration method

Two corner points at the pallet edge are used to determine the new position of the OCS 1 frame.

The position of the first pallet corner defines the origin of the OCS 1. The position of the second pallet corner can be used to determine the position in the WCS for another point.

1. Select the object coordinate system "OCS 1".
2. Select the "Two-point" calibration method in the drop-down list.

Define the origin for the OCS 1 as follows:

1. Move the kinematics to the point P1 ① on the pallet.
2. Accept the position coordinates of the TCP in WCS by clicking on the symbol next to the field "Position in WCS".
3. Enter the values for the position in OCS for the point P1 ①.

   You have defined the origin of OCS 1.

Define the point P2 ② as follows:

1. Move the kinematics to the point P2 ② on the pallet.
2. Define the coordinates for point P2 ② in the WCS by adopting the current position values of the TCP. Click the symbol next to the "Position in WCS" field.
3. For the point P2 ②, enter the values for the position in the OCS.

The position of the OCS is thus unambiguously determined and the "Apply values" button is active.

1. Accept the values from the calibration into the configuration.

2D kinematics with orientation: "One-point" calibration method

A corner point of the pallet is used to determine the new position of the OCS 1 frame.

The position of the pallet corner defines the origin of the OCS 1.

1. Select the object coordinate system "OCS 1".
2. Select the "One-point" calibration method in the drop-down list.

Define the origin for the OCS 1 as follows:

1. Move the kinematics to the point P1 ① on the pallet.
2. Accept the position coordinates of the TCP in WCS by clicking on the symbol next to the field "Position in WCS".
3. Enter the values for the position in OCS for the point P1 ①.

   You have defined the origin of OCS 1.

The position of the OCS is thus unambiguously determined and the "Apply values" button is active.

1. Accept the values from the calibration into the configuration.

13.6.7.3 Move OCS 1 and rotate around the y axis

Introduction

The pallet has been tilted. Two points at the pallet edge are used to determine the new position of the OCS 1 frame.

The position of the pallet corner defines the origin of the OCS 1. The angle of rotation for the OCS 1 is determined via a point on the pallet edge.

The following methods are used for calibration:

- 3D kinematics: "Move and rotate" calibration method
- 2D kinematics: "Move and rotate around y" calibration method

Coordinates of the points used in the example

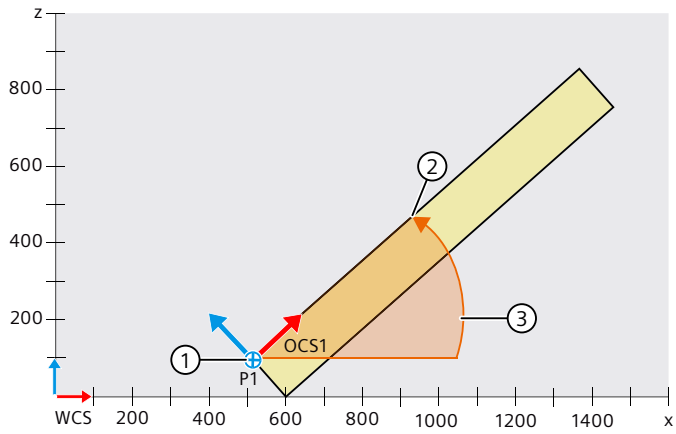

① Point P1 pallet corner

② Point at pallet edge
The rotated x axis now runs through this point

③ Angle of rotation OCS 1

		Position in the WCS (mm)				
		3D kinematics			2D kinematics	
		x	y	z	x	z
①	Point pallet corner	498.5	600.0	102.0	498.5	102.0
②	Point at pallet edge	900.0	600.0	504.0	900.0	504.0

3D kinematics: "Move and rotate" calibration method

1. Select the object coordinate system "OCS 1".
2. Select the "Move and rotate" calibration method in the drop-down list.

Define the origin for the OCS 1 as follows:

1. Move the kinematics to the point P1 ① on the pallet.
2. Accept the position coordinates of the TCP in WCS by clicking the button next to the field "Position in WCS".

   You have defined the origin of the OCS 1 with point P1 ①.

Define the angle of rotation ③ for the OCS 1 as follows:

1. Select the y axis as the coordinate axis around which the OCS 1 is rotated.
2. Select the x axis as the coordinate axis that is rotated around the y axis to the TCP or point ②.
3. Move the kinematics to the point ② at the pallet edge.
4. Rotate OCS 1 by clicking on the symbol next to the field for the angle.

   The set angle of rotation ③ is shown in the field and in the graphic display . The rotated x axis now runs through the point ②.

The position of the OCS 1 is thus unambiguously determined and the "Apply values" button is active.

1. Accept the values from the calibration into the configuration.

2D kinematics: "Move and rotate around y" calibration method

1. Select the object coordinate system "OCS 1".
2. Select the "Move and rotate around y" calibration method in the drop-down list.

Define the origin for the OCS 1 as follows:

1. Move the kinematics to the point P1 ① on the pallet.
2. Accept the position coordinates of the TCP in WCS by clicking on the symbol next to the field "Position in WCS".

   You have defined the origin of the OCS 1 with point P1 ①.

Define the angle of rotation ③ for the OCS 1 as follows:

1. Select the rotation of the x axis around the y axis.

   In this way, you specify that the x axis is rotated around the y axis to the TCP or point ②.
2. Move the kinematics to the point ② at the pallet edge.
3. Rotate OCS 1 by clicking on the symbol next to the field for the angle.

   The set angle of rotation ③ is shown in the field and in the graphic display . The rotated x axis now runs through the point ②.

The position of the OCS 1 is thus unambiguously determined and the "Apply values" button is active.

1. Accept the values from the calibration into the configuration.

13.6.7.4 Move OCS 1 and rotate around z axis

Introduction

The pallet was rotated horizontally. Two points at the pallet edge are used to determine the new position of the OCS 1 frame.

The position of the pallet corner defines the origin of the OCS 1. The angle of rotation for the OCS 1 is determined via a point on the pallet edge.

The following methods are used for calibration:

- 3D kinematics: "Move and rotate" calibration method
- 3D kinematics with orientation: "Move and rotate around z" calibration method

Coordinates of the points used in the example

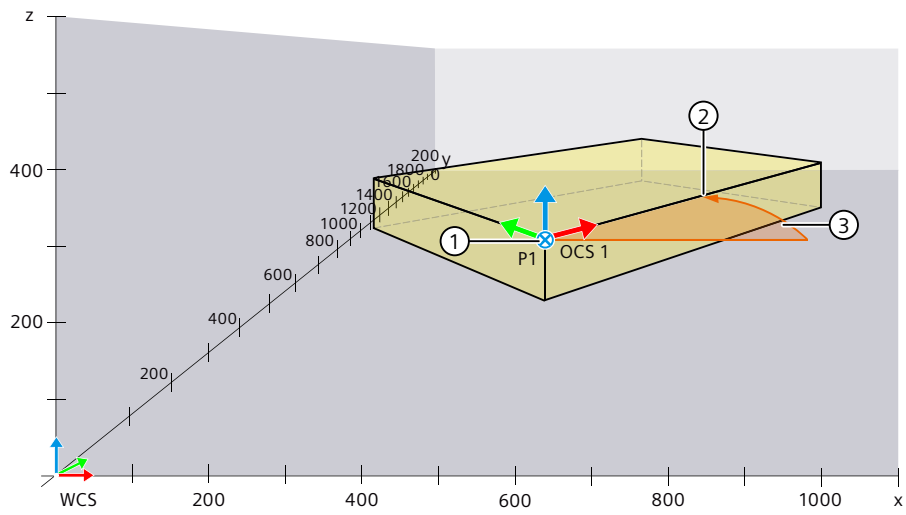

① Point P1 on pallet corner

② Point at pallet edge
The rotated x axis now runs through this point

③ Angle of rotation OCS 1

		Position in the WCS (mm)		
		x	y	z
①	Point P1 on pallet corner	600.0	600.0	144.0
②	Point at pallet edge	1000.0	1000.0	144.0

3D kinematics: "Move and rotate" calibration method

1. Select the object coordinate system "OCS 1".
2. Select the "Move and rotate" calibration method in the drop-down list.

Define the origin for the OCS 1 as follows:

1. Move the kinematics to the point P1 ① on the pallet.
2. Accept the position coordinates of the TCP in WCS by clicking on the symbol ←1 next to the field "Position in WCS".

   You have defined the origin of the OCS 1 with point P1.

Define the angle of rotation ③ for the OCS 1 as follows:

1. Select the z axis as the coordinate axis around which the OCS 1 is rotated.
2. Select the x axis as the coordinate axis that is rotated around the z axis to the TCP or point ②.
3. Move the kinematics to the point ② at the pallet edge.
4. Rotate OCS 1 by clicking on the symbol ←1 next to the field for the angle.

   The set angle of rotation ③ is shown in the field and in the graphic display . The rotated x axis now runs through the point ②.

The position of the OCS 1 is thus unambiguously determined and the "Apply values" button is active.

1. Accept the values from the calibration into the configuration.

3D kinematics with orientation: "Move and rotate around z" calibration method

1. Select the object coordinate system "OCS 1".
2. Select the "Move and rotate around z" calibration method in the drop-down list.

Define the origin for the OCS 1 as follows:

1. Move the kinematics to the point P1 ① on the pallet.
2. Accept the position coordinates of the TCP in WCS by clicking on the symbol ←1 next to the field "Position in WCS".

   You have defined the origin of the OCS 1 with point P1 ①.

Define the angle of rotation ③ for the OCS 1 as follows:

1. Select the rotation of the x axis around the z axis.

   In this way, you specify that the x axis is rotated around the z axis to the TCP or point ②.
2. Move the kinematics to the point ② at the pallet edge.
3. Rotate OCS 1 by clicking on the symbol ←1 next to the field for the angle.

   The set angle of rotation ③ is shown in the field and in the graphic display . The rotated x axis now runs through the point ②.

The position of the OCS 1 is thus unambiguously determined and the "Apply values" button is active.

1. Accept the values from the calibration into the configuration.

13.6.7.5 Move OCS 1 and rotate it around the z axis and y axis

Introduction

The pallet was tilted and also rotated horizontally.

3D kinematics: "Plane" calibration method

Three points on the pallet surface are used to determine the new position of the OCS 1 frame.

The origin of the OCS 1 is determined via the position of a pallet corner. The positions of the other two points are used to determine the angles of rotation for the OCS 1.

The "Plane" calibration method is used for calibration with 3D kinematics.

Coordinates of the points used in the example

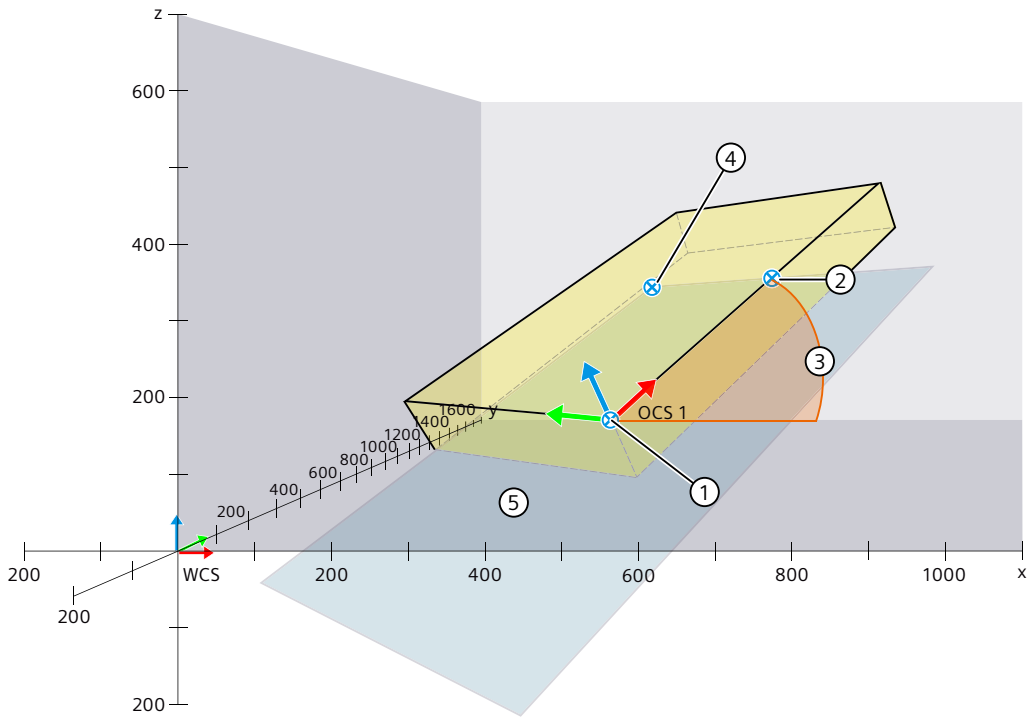

① Point pallet corner as origin of the OCS 1

② Point at pallet edge
The set point through which the rotated x axis passes defines the angle of rotation for the x axis.

③ Angle of rotation for the x axis

④ Point on pallet surface
The set point, together with the first two points, defines the selected xy plane.

⑤ xy plane which passes through the three set points

		Position in the WCS (mm)		
		x	y	z
①	Point pallet corner	549.1	549.1	124.7
②	Point pallet edge	916.5	916.5	424.7
④	Point pallet surface	633.7	1199.3	424.7

1. Select the object coordinate system "OCS 1".
2. Select the "Plane" calibration method in the drop-down list.

Define the origin for the OCS 1 as follows:

1. Move the kinematics to point P1 on the pallet.
2. Accept the position coordinates of the TCP in WCS by clicking on the symbol ↵1 next to the field "Position in WCS".

   You have defined the origin for OCS 1.

Define the angle of rotation for the OCS 1 as follows:

1. Select the x axis as the coordinate axis to be rotated to the TCP or point ②.
2. Move the kinematics to the point ② at the pallet edge.
3. Rotate OCS 1 by clicking on the symbol next to the field for the coordinate axis.
   The set angles of rotation are shown in the graphic display.
4. Select the xy plane to be spanned between the three set points.
5. Move the kinematics to the point ④ on the pallet surface.
6. To align the OCS 1, click the symbol next to the field for the plane.
   The spanned plane is shown in the graphic display.

The position of the OCS 1 is thus unambiguously determined and the "Apply values" button is active.

1. Accept the values from the calibration into the configuration.

3D kinematics: "Three-point" calibration method

Three corner points of the pallet are used to determine the new position of the OCS 1 frame.

The positions of the corner points in OCS 1 can be derived from the dimensions of the pallet. The position of the corner points in the WCS is determined using the "three-point" method.

The origin of the OCS 1 is determined via the position of a pallet corner. The positions of the other two corner points are used to determine the angles of rotation for OCS 1.

Coordinates of the points used in the example

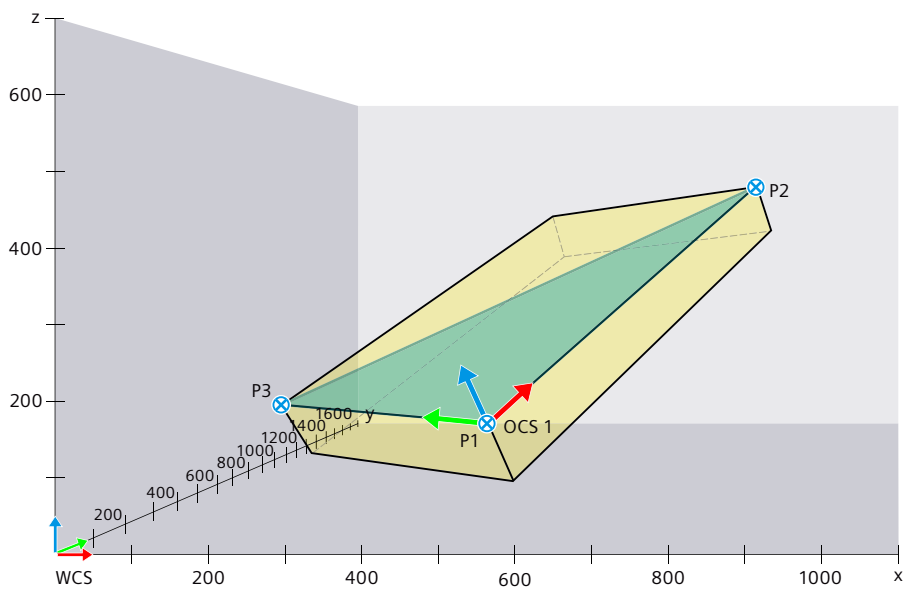

	Position in the WCS (mm)			Position in the OCS (mm)		
	x	y	z	x	y	z
Point P1 pallet corner	549.1	549.1	124.7	0.0	0.0	0.0
Point P2 pallet corner	1283.9	1283.9	724.7	1200.0	0.0	0.0
Point P3 pallet corner	-16.6	1114.8	124.7	0.0	800.0	0.0

1. Select the object coordinate system "OCS 1".
2. Select the "Plane" calibration method in the drop-down list.

Define the origin for the OCS 1 as follows:

1. Move the kinematics to the pallet corner (point P1).
2. Accept the position coordinates of the TCP in WCS by clicking on the symbol next to the field "Position in WCS".
3. For the point P1, enter the values for the position in OCS 1.

   You have defined the origin of OCS 1.

Define the angle of rotation for the OCS 1 as follows:

1. Move the kinematics to the second pallet corner (point P2).
2. Define the coordinates for point P2 in the WCS by adopting the current position values of TCP. Click the symbol next to the "Position in WCS" box.
3. For the point P2, enter the values for the position in the OCS.
4. Move the kinematics to point P3 on the pallet.
5. Define the coordinates for point P3 in the WCS by adopting the current position values of the TCP. Click the symbol next to the "Position in WCS" box.
6. For the point P3, enter the values for the position in the OCS.

The position of the OCS is thus unambiguously determined and the "Apply values" button is active.

1. Accept the values from the calibration into the configuration.

13.7 Calibrate workspace zones

13.7.1 Configuring calibration of a workspace zone

Requirement

The kinematics technology object is correctly configured and connected.

Configuring zone properties

1. In the "Workspace zone" drop-down list, select the zone you want to calibrate.

   If you have opened the calibration for a zone via the symbol in the configuration window "Configuration > Extended parameters > Zones", the corresponding zone is already preselected. If you open the calibration via the project tree, workspace zone 1 is preselected.
2. In the "Status" drop-down list, select the activation status "Active" or "Inactive".

   If you select status "Not defined", all other settings in the configuration mask for the calibration are deactivated.
3. In the "Zone type" drop-down list, select the Blocked zone or Signal zone work zone type.
4. In the "Geometry" drop-down list, select the shape Cuboid, Cylinder or Sphere.
5. In the "Coordinate system" drop-down list, select the "WCS" or an "OCS".

You can find more information on the zone parameters in the section "Defining zones (Page 211)".

Selecting the suitable calibration method

The selectable calibration methods are dependent on the selected geometry of the zone. The calibration methods "circular plane" and "radius" are not suitable for calibrating zones containing obstacles as the zones are traversed during calibration. As a result, these two calibration methods for calibrating blocked and signal zones which usually contain obstacles are not suitable.

The following table shows an overview of the calibration methods that are suitable for the selected type of zone:

Selected zone type	Suitable calibration methods		
	Cuboid	Cylinder	Sphere
Work zone	Corner points (Page 379)	Circular plane (Page 381)	Radius (Page 383)
Signal zones		Surface line (Page 380)	Diameter (Page 382)
Blocked zones			

The individual points are fixed for each calibration method. However, you can calibrate the individual points in any order.

13.7.2 Calibrate cuboid zone with corner points

You calibrate a cuboid workspace zone using the "Corner points" calibration method.

Definition

With this calibration method, the cuboid zone is defined by the position values of three or four corner points.

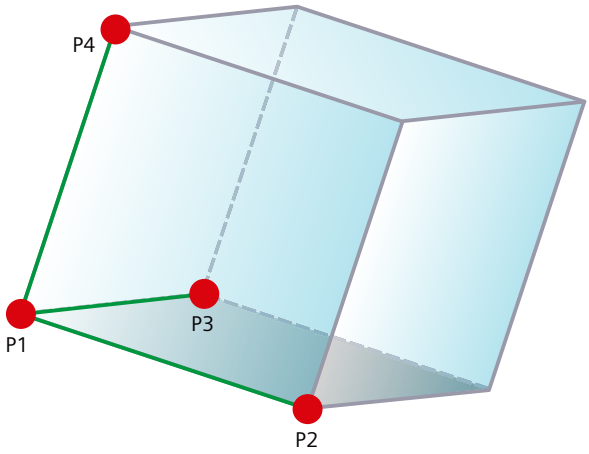

A cuboid workspace zone for 2D kinematics is defined by three points.

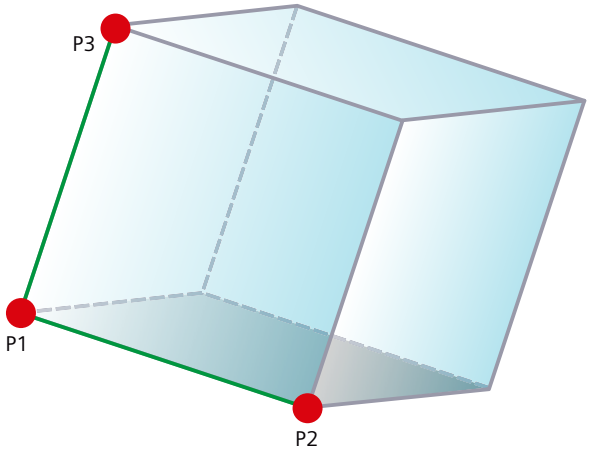

Requirements

- The kinematics technology object is correctly configured and connected.
- You have selected a cuboid workspace zone for the calibration.

Procedure

1. Enter the origin of the cuboid as point P1.
2. Starting from the origin, use the other points to determine the edge lengths in x, y and z direction.

13.7.3 Calibrate cylindrical zone with surface line

A cylindrical signal or blocked zone is calibrated using the "Surface line" calibration method.

Definition

With this calibration method, the cylindrical zone is defined by the points of the surface line and the diameter.

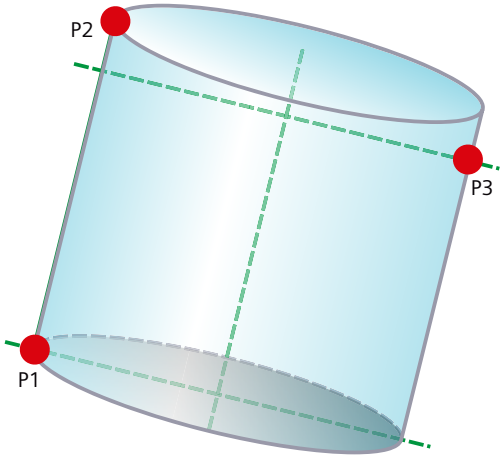

Requirements

- The kinematics technology object is correctly configured and connected.
- You have selected a cylindrical signal or blocked zone for the calibration.

Procedure

1. Set the point P1 as the start of the surface line.
2. Set point P2 as the end of the surface line.

   With the points P1 and P2 you have defined the surface line of the cylinder. The surface line defines the height and orientation of the cylinder.
3. To define the diameter of the cylinder, set point P3 diametrically to the surface line P1 ↔ P2.

   The surface opposite the P1 ↔ P2 surface line runs through the point P3. As the height of the cylinder is defined by surface line P1 ↔ P2, you can also set point P3 outside the cylinder height.

13.7.4 Calibrate cylindrical zone with circular plane

You calibrate a cylindrical workspace zone using the "Circular plane" calibration method.

Definition

With this calibration method, the cylindrical zone is defined by the points of the circular plane and the height.

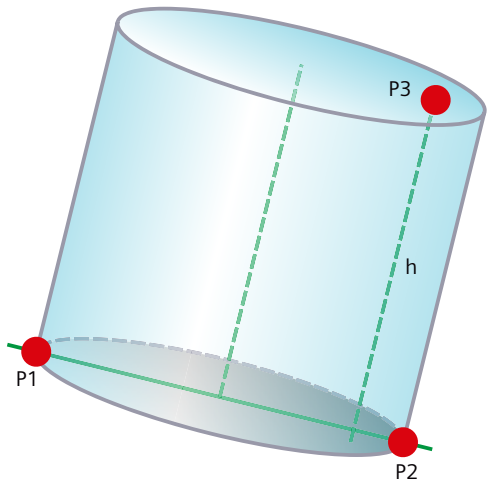

Requirements

- The kinematics technology object is correctly configured and connected.
- You have selected a cylindrical work zone for the calibration.

Procedure

1. Set the point P1 on the circumference of the cylinder.
2. Set point P2 diametrically to point P1 and on the circumference of the cylinder.

   With points P1 and P2, you have defined the diameter and orientation of the cylinder.
3. To define the height of the cylinder, set point P3 at distance h from the circular plane.

   Since point P3 only determines the height of the cylinder, you can also set point P3 outside the previously set cylinder width.

13.7.5 Calibrate spherical zone with diameter

You calibrate a spherical signal or blocked zone using the "Diameter" calibration method.

Definition

With this calibration method, the spherical zone is defined by two points for the diameter.

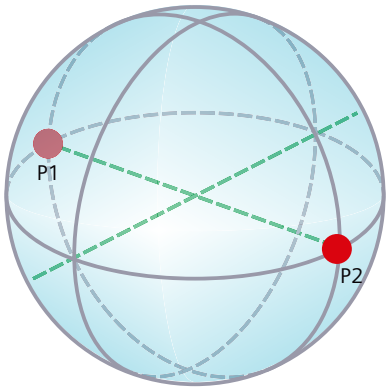

Requirements

- The kinematics technology object is correctly configured and connected.
- You have selected a spherical signal or blocked zone for the calibration.

Procedure

1. Enter the first point on the surface of the sphere as point P1.
2. To form the diameter, enter the point P2 on the surface of the sphere and diametrical to the point P1.

13.7.6 Calibrate spherical zone with radius

You calibrate a spherical workspace zone using the "Radius" calibration method.

Definition

With this calibration method, the spherical zone is defined by two points for the radius.

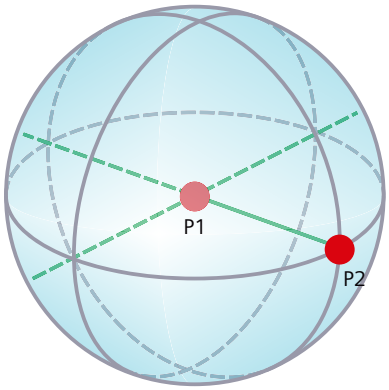

Requirements

- The kinematics technology object is correctly configured and connected.
- You have selected a spherical work zone for the calibration.

Procedure

1. Enter the origin of the sphere as point P1.
2. To determine the radius, set the second point P2 on the surface.

Instructions 14

14.1 Kinematics motions

14.1.1 MC_GroupInterrupt V10

14.1.1.1 MC_GroupInterrupt: Interrupt motion execution V10

Description

With the Motion Control instruction "MC_GroupInterrupt", you interrupt the execution of the motion on a kinematics technology object.

The Motion Control instruction offers you the following:

- Interrupting motion control at the kinematics technology object (Page 234)

Applies to

- Kinematics

Requirement

- The technology object has been configured correctly.
- The interconnected axes are enabled.

Override response

The override response for "MC_GroupInterrupt" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_GroupInterrupt":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge

Parameter	Declaration	Data type	Default value	Description	
Mode	INPUT	DINT	0	Mode for dynamic behavior (Page 234)	
				0	Stop with the dynamics of the motion job to be interrupted When dynamic adaptation is activated, the dynamics of the motion can also be reduced so that the dynamic limits of the axes are not exceeded.
				1	Stop with maximum dynamics of kinematics motion When dynamic adaptation is activated, the dynamics of the motion can also be reduced so that the dynamic limits of the axes are not exceeded.
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Active	OUTPUT	BOOL	FALSE	TRUE	The setpoints are calculated.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

14.1.2 MC_GroupContinue V10

14.1.2.1 MC_GroupContinue: Continue motion execution V10

Description

With the Motion Control instruction "MC_GroupContinue", you continue a kinematics motion that was previously interrupted with a "MC_GroupInterrupt" job.

The Motion Control instruction offers you the following:

- Resuming interrupted motion control at the kinematics technology object (Page 234)

Applies to

- Kinematics

Requirement

- The technology object has been configured correctly.
- The interconnected axes are enabled.

Override response

- An "MC_GroupContinue" job is not aborted by any other Motion Control job.
- A new "MC_GroupContinue" job aborts a current "MC_GroupInterrupt" job.
- The override response for "MC_GroupContinue" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_GroupContinue":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

14.1.2.2 MC_GroupContinue: Function chart V10

Function chart: Continue motion execution

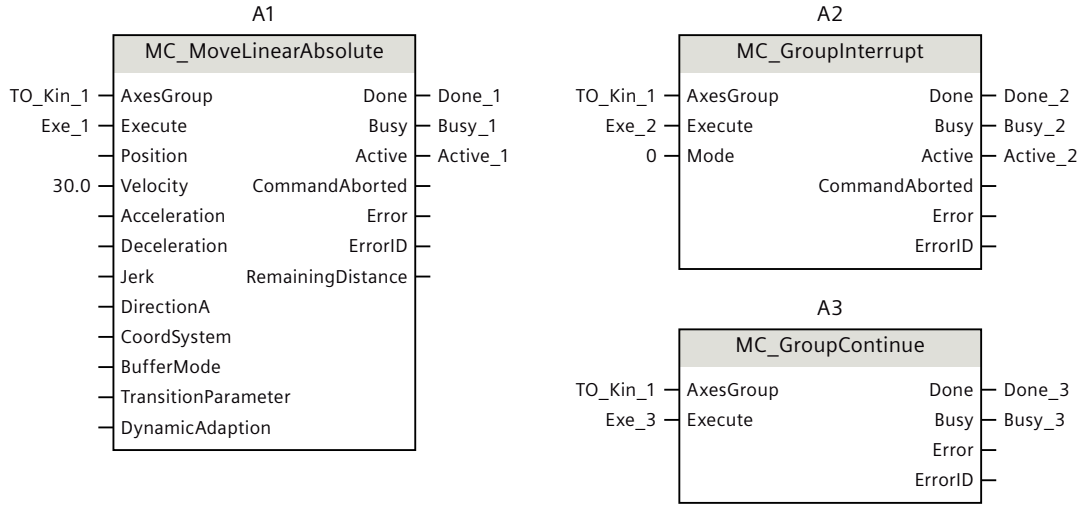

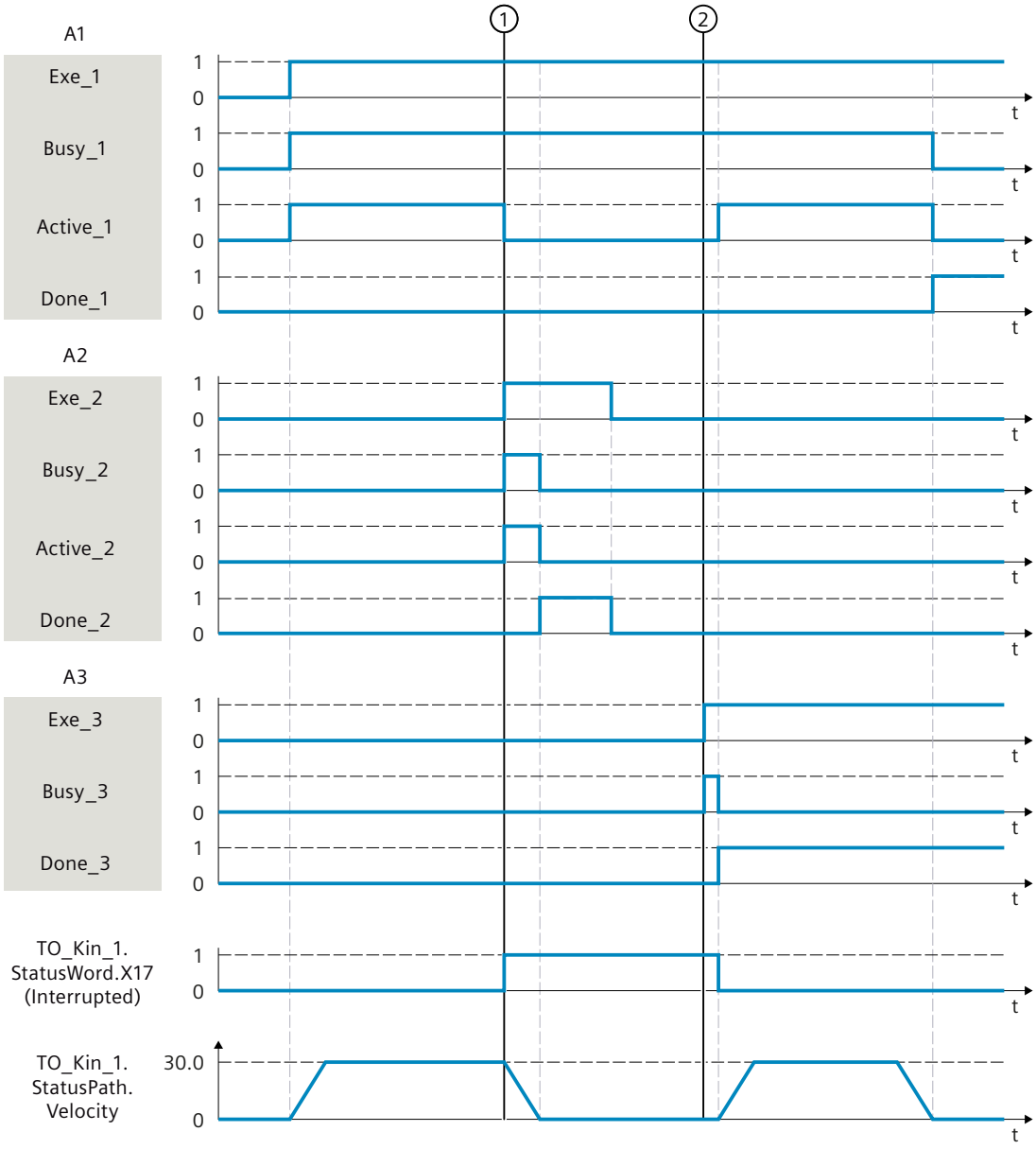

The kinematics is moved with an "MC_MoveLinearAbsolute" job (A1).

At time ①, the "MC_MoveLinearAbsolute" job is interrupted by an "MC_GroupInterrupt" job (A2). The kinematics is in "Interrupted" state. With "Mode" = 0 the motion is stopped with the dynamics of the "MC_MoveLinearAbsolute" job. The completion of the "MC_GroupInterrupt" job is reported via "Done_2".

At time ②, the "MC_MoveLinearAbsolute" job is continued by an "MC_GroupContinue" job (A3).

14.1.3 MC_GroupStop V10

14.1.3.1 MC_GroupStop: Stop motion V10

Description

With the Motion Control instruction "MC_GroupStop", you stop and abort an active motion on the kinematics technology object.

The Motion Control instruction offers you the following:

- Stopping active motion at the kinematics technology object (Page 234)

Applies to

- Kinematics

Requirement

- The technology object has been configured correctly.
- The interconnected axes are enabled.

Override response

The override response for "MC_GroupStop" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_GroupStop":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Mode	INPUT	DINT	0	Mode for dynamic behavior (Page 234)	
				0	Stop with the dynamics of the motion job to be interrupted When dynamic adaptation is activated, the dynamics of the motion can also be reduced so that the dynamic limits of the axes are not exceeded.

Parameter	Declaration	Data type	Default value	Description	
Mode	INPUT	DINT	0	1	Stop with maximum dynamics of kinematics motion When dynamic adaptation is activated, the dynamics of the motion can also be reduced so that the dynamic limits of the axes are not exceeded.
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Active	OUTPUT	BOOL	FALSE	TRUE	The setpoints are calculated.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

14.1.3.2 MC_GroupStop: Function chart V10

Function chart: Stop motion

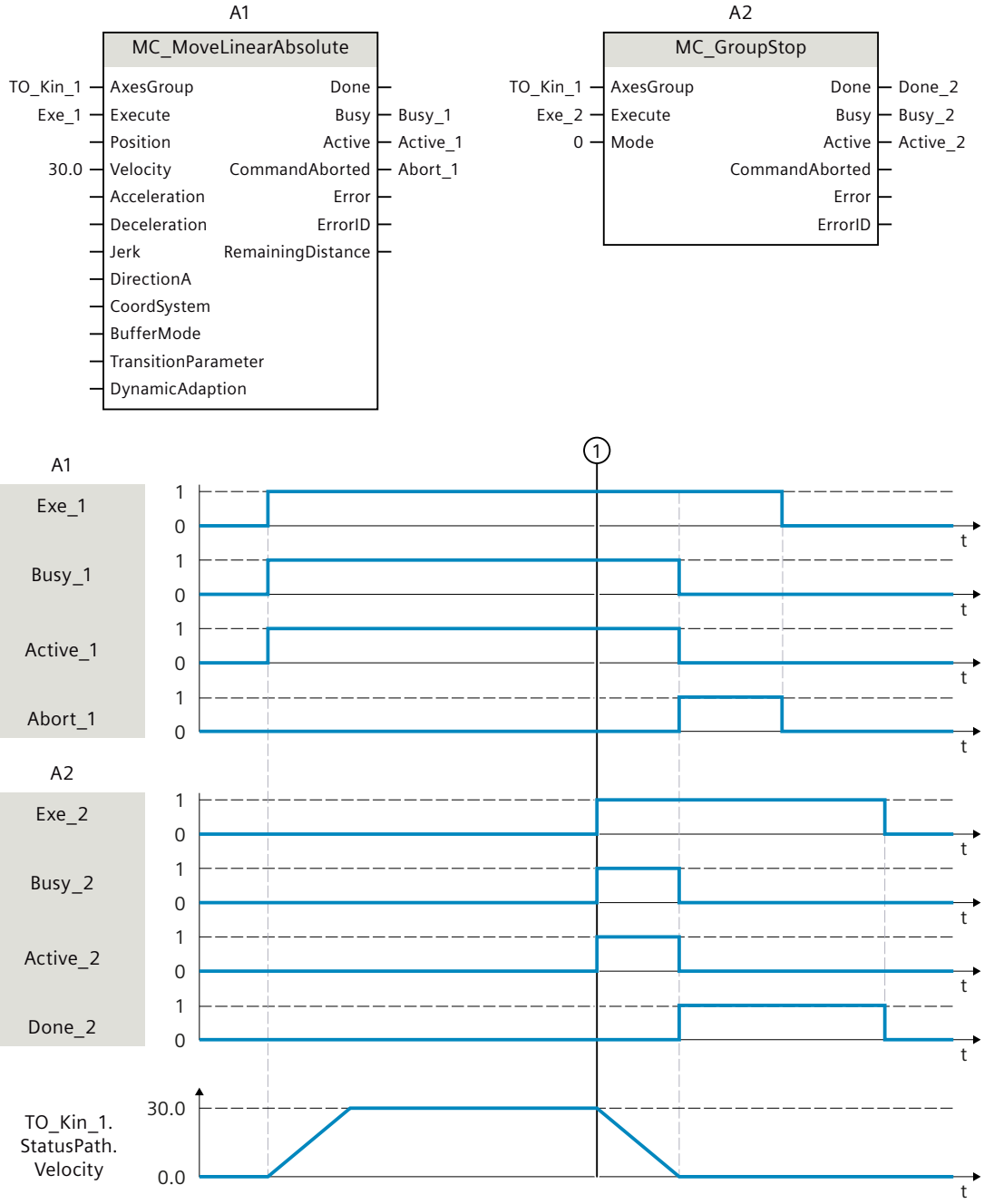

The kinematics is moved with an "MC_MoveLinearAbsolute" job (A1).

At time ①, the "MC_MoveLinearAbsolute" job is aborted by an "MC_GroupStop" job (A2). The job abort is signaled via "Abort_1". With "Mode" = 0 the motion is stopped with the dynamics of the "MC_MoveLinearAbsolute" job. The completion of the "MC_GroupStop" job is reported via "Done_2".

14.1.4 MC_MoveLinearAbsolute V10

14.1.4.1 MC_MoveLinearAbsolute: Position kinematics with linear path motion V10

Description

With the Motion Control instruction "MC_MoveLinearAbsolute", you move a kinematics with a linear motion (Page 258) to an absolute position. Cartesian orientation is also used absolute.

The Motion Control instruction offers you the following:

- Define absolute target position (Page 258)
- Define dynamics (Page 259)
- Define motion transition (Page 261)
- Start job (Page 263)
- Show motion status and remaining distance (Page 230)

Applies to

- Kinematics

Requirements

- The technology object has been configured correctly.
- The interconnected axes are enabled.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.

Override response

With the "TransitionParameter[1]" parameter, you determine the distance from the target point of the previous motion job at which the new motion job is superimposed.

The override response for "MC_MoveLinearAbsolute" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MoveLinearAbsolute":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Position	INPUT	ARRAY [1..6] OF LREAL	-	Absolute target coordinates in the specified reference coordinate system (Page 258)	
Position[1]	INPUT	LREAL	0.0	x coordinate	
Position[2]	INPUT	LREAL	0.0	y coordinate	
Position[3]	INPUT	LREAL	0.0	z coordinate	
Position[4]	INPUT	LREAL	0.0	A coordinate	
Position[5]	INPUT	LREAL	0.0	B coordinate[1)]	
Position[6]	INPUT	LREAL	0.0	C coordinate[1)]	
Velocity	INPUT	LREAL	-1.0	Velocity (Page 259)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The value configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Velocity)
Acceleration	INPUT	LREAL	-1.0	Acceleration (Page 259)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The value configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration (Page 259)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The value configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk (Page 259)	
				> 0.0	The specified value is used.
				= 0.0	No jerk limitation

1) Only relevant with more than 4 interpolating kinematics axes.

Parameter	Declaration	Data type	Default value	Description	
Jerk	INPUT	LREAL	-1.0	< 0.0	The value configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Jerk)
DirectionA	INPUT	DINT	3	Direction of movement of the Cartesian orientation A (Page 258)	
				1	Positive direction
				2	Negative direction
				3	Shortest distance
				With more than 4 interpolating kinematics axes: Not relevant	
CoordSystem	INPUT	DINT	0	Reference coordinate system (Page 258)	
				0	World coordinate system (WCS)
				1	Object coordinate system 1 (OCS1)
				2	Object coordinate system 2 (OCS2)
				3	Object coordinate system 3 (OCS3)
BufferMode	INPUT	DINT	1	Motion transition (Page 261)	
				1	Append motion
				2	Smooth with the lower velocity
				5	Smooth with the higher velocity
TransitionParameter	INPUT	ARRAY [1..5] OF LREAL		Transition parameter	
TransitionParameter[1]	INPUT	LREAL	-1.0	Rounding clearance (Page 261)	
				≥ 0.0	The specified value is used.
				< 0.0	The maximum possible rounding clearance is used.
TransitionParameter[2..5]	INPUT	LREAL	-	Reserved	
DynamicAdaption	INPUT	DINT	-1	Dynamic adaptation (Page 259)	
				< 0	The configured setting in "Technology object > Configuration > Extended parameters > Dynamic" is used. (<TO>.DynamicDefaults.DynamicAdaption)
				0	Without dynamic adaptation
				1	Dynamic adaptation with segmentation of the path
				2	Dynamic adaptation without segmentation of the path
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Active	OUTPUT	BOOL	FALSE	TRUE	The setpoints are calculated.

1) Only relevant with more than 4 interpolating kinematics axes.

Parameter	Declaration	Data type	Default value	Description	
Active	OUTPUT	BOOL	FALSE	FALSE	When "Busy" = TRUE: Job is waiting. (Typical: A preceding job is still active.)
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
RemainingDistance	OUTPUT	LREAL	-1.0	Remaining distance of the current job (Page 230)	

1) Only relevant with more than 4 interpolating kinematics axes.

14.1.4.2 MC_MoveLinearAbsolute: Function chart V10

Function chart: Position kinematics with linear path motion

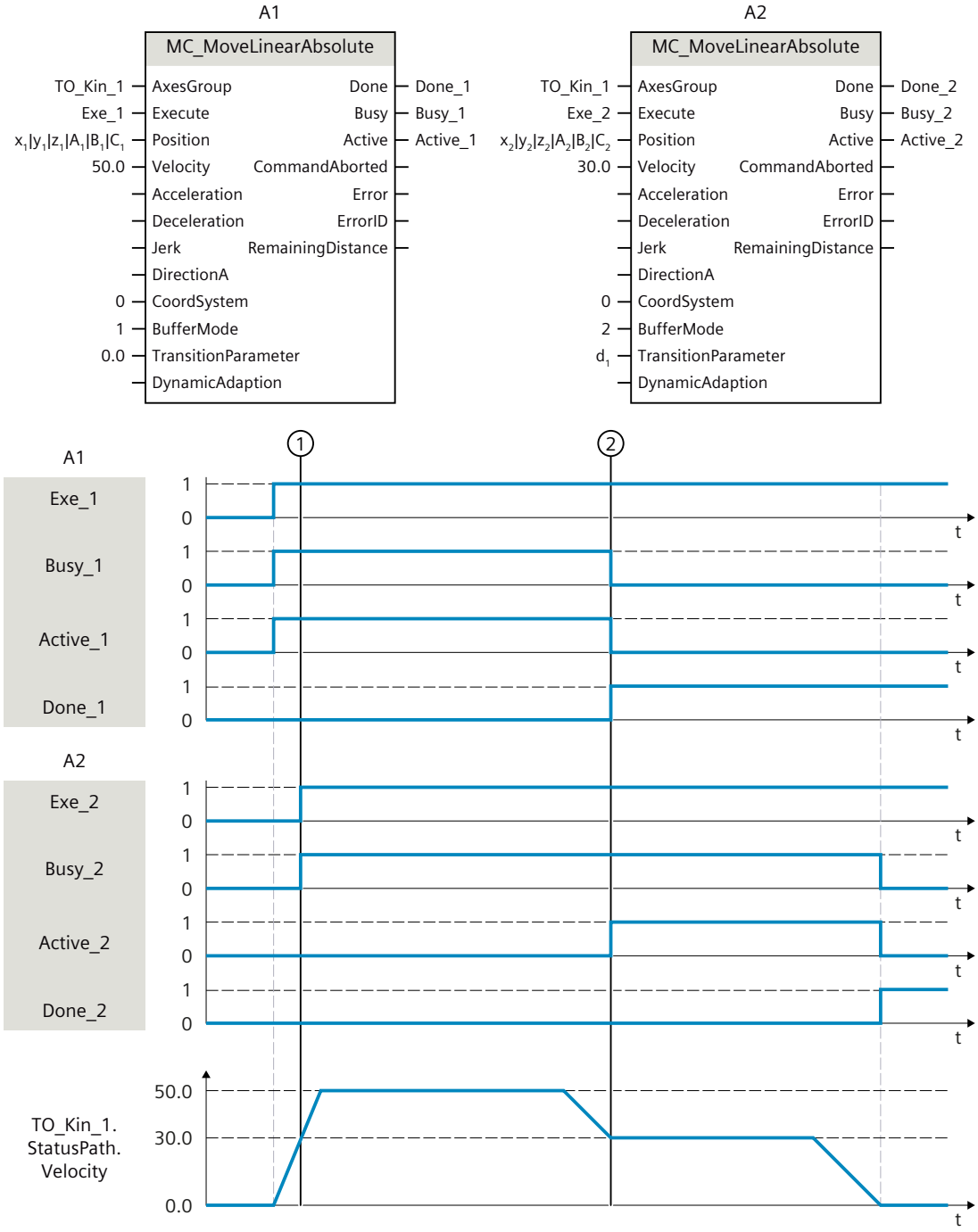

The kinematics is moved with an "MC_MoveLinearAbsolute" job (A1).

At time ① an additional "MC_MoveLinearAbsolute" job (A2) is initiated. As the "MC_MoveLinearAbsolute" jobs have no override effect on one another, the job A2 is arranged in the job sequence.

At the point in time ②, completion of the A1 job is signaled via "Done_1" and the job A2 is started. As "BufferMode" = 2 is set for job A2, the motion transition is blended with the lower velocity of the two jobs. As soon as the target position is reached, the completion of the A2 job is signaled via "Done_2".

14.1.5 MC_MoveLinearRelative V10

14.1.5.1 MC_MoveLinearRelative: Relative positioning of kinematics with linear path motion V10

Description

With the Motion Control instruction "MC_MoveLinearRelative", you move a kinematics with a linear motion (Page 258) relative to the position which was present at the start of the job processing. Cartesian orientation is also used relative.

The Motion Control instruction offers you the following:

- Define relative target position (Page 258)
- Define dynamics (Page 259)
- Define motion transition (Page 261)
- Start job (Page 263)
- Show motion status and remaining distance (Page 230)

Applies to

- Kinematics

Requirements

- The technology object has been configured correctly.
- The interconnected axes are enabled.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.

Override response

With the "TransitionParameter[1]" parameter, you determine the distance from the target point of the previous motion job at which the new motion job is superimposed.

The override response for "MC_MoveLinearRelative" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MoveLinearRelative":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Distance	INPUT	ARRAY [1..6] OF LREAL	-	Relative target coordinates in the specified reference coordinate system (Page 258)	
Distance[1]	INPUT	LREAL	0.0	x coordinate	
Distance[2]	INPUT	LREAL	0.0	y coordinate	
Distance[3]	INPUT	LREAL	0.0	z coordinate	
Distance[4]	INPUT	LREAL	0.0	A coordinate	
Distance[5]	INPUT	LREAL	0.0	B coordinate[1)]	
Distance[6]	INPUT	LREAL	0.0	C coordinate[1)]	
Velocity	INPUT	LREAL	-1.0	Velocity (Page 259)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The value configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Velocity)
Acceleration	INPUT	LREAL	-1.0	Acceleration (Page 259)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The value configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration (Page 259)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The value configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk (Page 259)	
				> 0.0	The specified value is used.
				= 0.0	No jerk limitation

1) Only relevant with more than 4 interpolating kinematics axes.

Parameter	Declaration	Data type	Default value	Description	
Jerk	INPUT	LREAL	-1.0	< 0.0	The value configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Jerk)
CoordSystem	INPUT	DINT	0	Reference coordinate system (Page 258)	
				0	World coordinate system (WCS)
				1	Object coordinate system 1 (OCS1)
				2	Object coordinate system 2 (OCS2)
				3	Object coordinate system 3 (OCS3)
BufferMode	INPUT	DINT	1	Motion transition (Page 261)	
				1	Append motion
				2	Smooth with the lower velocity
				5	Smooth with the higher velocity
TransitionParameter	INPUT	ARRAY [1..5] OF LREAL	-	Transition parameter	
TransitionParameter[1]	INPUT	LREAL	-1.0	Rounding clearance (Page 261)	
				≥ 0.0	The specified value is used.
				< 0.0	The maximum possible rounding clearance is used.
TransitionParameter[2..-5]	INPUT	LREAL	-	Reserved	
DynamicAdaption	INPUT	DINT	-1	Dynamic adaptation (Page 259)	
				< 0	The configured setting in "Technology object > Configuration > Extended parameters > Dynamic" is used. (<TO>.DynamicDefaults.DynamicAdaption)
				0	Without dynamic adaptation
				1	Dynamic adaptation with segmentation of the path
				2	Dynamic adaptation without segmentation of the path
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Active	OUTPUT	BOOL	FALSE	TRUE	The setpoints are calculated.
				FALSE	When "Busy" = TRUE: Job is waiting. (Typical: A preceding job is still active.)
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.

1) Only relevant with more than 4 interpolating kinematics axes.

Parameter	Declaration	Data type	Default value	Description	
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
RemainingDistance	OUTPUT	LREAL	-1.0	Remaining distance of the current job (Page 230)	

1) Only relevant with more than 4 interpolating kinematics axes.

14.1.5.2 MC_MoveLinearRelative: Function chart V10

Function chart: Relative positioning of kinematics with linear path motion

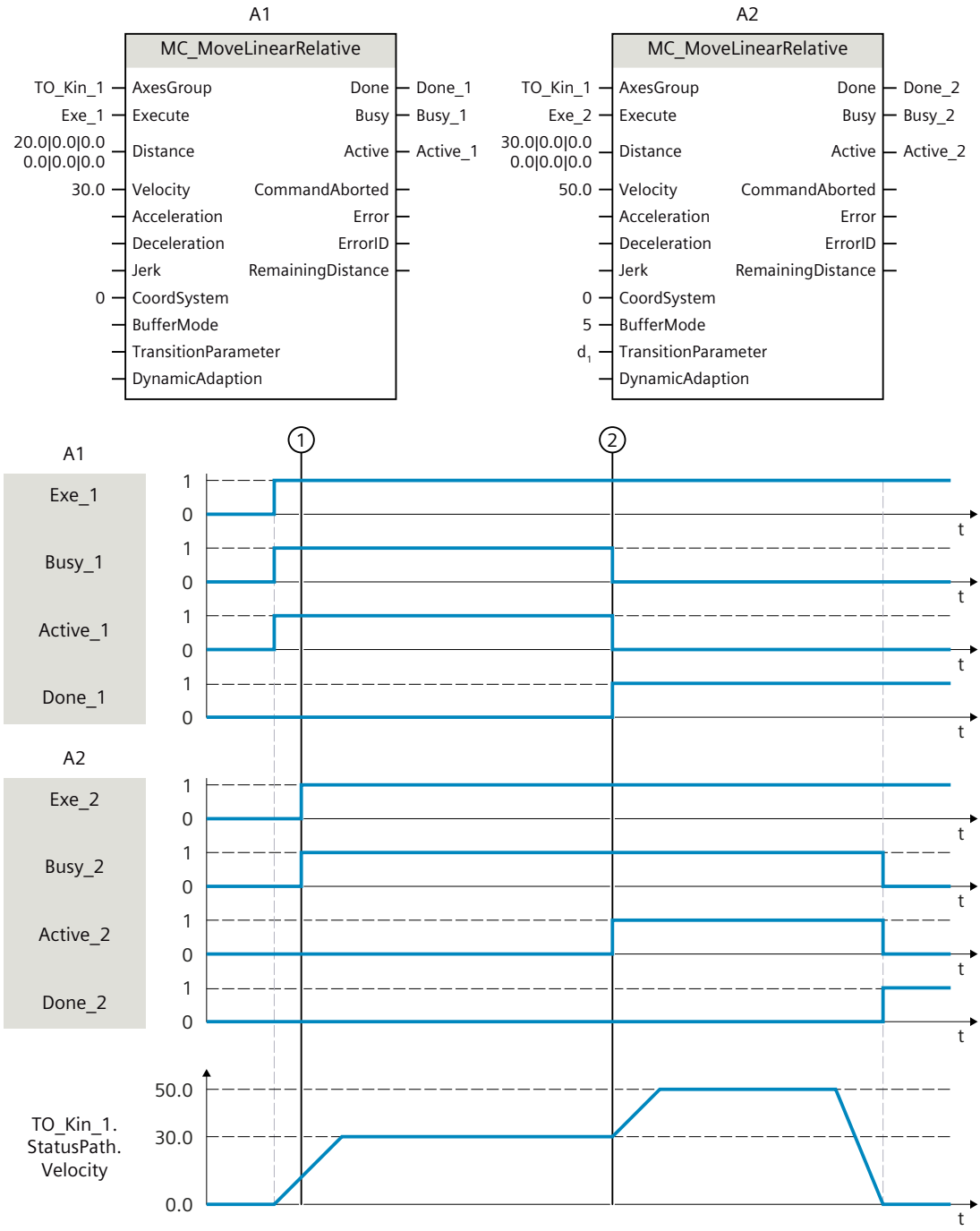

The kinematics is moved with an "MC_MoveLinearRelative" job (A1).

At time ① an additional "MC_MoveLinearRelative" job (A2) is initiated. As the "MC_MoveLinearRelative" jobs have no override effect on one another, the job A2 is arranged in the job sequence.

At the point in time ②, completion of the A1 job is signaled via "Done_1" and the job A2 is started. As "BufferMode" = 5 is set for job A2, the motion transition is blended with the higher velocity of the two jobs. As soon as the target position is reached, the completion of the A2 job is signaled via "Done_2".

14.1.6 MC_MoveCircularAbsolute V10

14.1.6.1 MC_MoveCircularAbsolute: Position kinematics with circular path motion V10

Description

With the Motion Control instruction "MC_MoveCircularAbsolute", you move a kinematics with a circular motion (Page 265) to an absolute position. Cartesian orientation is also used absolute.

The Motion Control instruction offers you the following:

- Define circular path:
  - Define circular path via intermediate point and target position (Page 265)
  - Define circular path via center point and angle (Page 267)
  - Define circular path via radius and target position (Page 269)
- Define dynamics (Page 272)
- Define motion transition (Page 273)
- Start job (Page 276)
- Show motion status and remaining distance (Page 230)

Applies to

- Kinematics

Requirements

- The technology object has been configured correctly.
- The interconnected axes are enabled.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.

Override response

With the "TransitionParameter[1]" parameter, you determine the distance from the target point of the previous motion job at which the new motion job is superimposed.

The override response for "MC_MoveCircularAbsolute" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MoveCircularAbsolute":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
CircMode	INPUT	DINT	0	Definition of circular path	
				0	Define circular path via intermediate point and target position (Page 265)
				1	Define circular path via center point and angle (Page 267)
				2	Define circular path via radius and target position (Page 269)
AuxPoint	INPUT	ARRAY [1..3] OF LREAL	-	When "CircMode" = 0: Intermediate point on the circular path (Page 265)	
				When "CircMode" = 1: Center point of the circular path (Page 267)	
				When "CircMode" = 2: Not relevant	
AuxPoint[1]	INPUT	LREAL	0.0	x coordinate	
AuxPoint[2]	INPUT	LREAL	0.0	y coordinate	
AuxPoint[3]	INPUT	LREAL	0.0	z coordinate	
EndPoint	INPUT	ARRAY [1..6] OF LREAL	-	Target position in the specified reference coordinate system	
				When "CircMode" = 1: "EndPoint[1..3]" not relevant	
EndPoint[1]	INPUT	LREAL	0.0	x coordinate	
EndPoint[2]	INPUT	LREAL	0.0	y coordinate	
EndPoint[3]	INPUT	LREAL	0.0	z coordinate	
EndPoint[4]	INPUT	LREAL	0.0	A coordinate	
EndPoint[5]	INPUT	LREAL	0.0	B coordinate[1)]	
EndPoint[6]	INPUT	LREAL	0.0	C coordinate[1)]	
PathChoice	INPUT	DINT	0	When "CircMode" = 1: Orientation of the circular path (Page 267)	
				0	Positive direction of rotation
				1	Negative direction of rotation
				When "CircMode" = 2: Orientation of the circular path (Page 269)	
				0	Shorter positive circle segment
				1	Shorter negative circle segment
				2	Longer positive circle segment

1) Only relevant with more than 4 interpolating kinematics axes.

Parameter	Declaration	Data type	Default value	Description	
PathChoice	INPUT	DINT	0	3	Longer negative circle segment
				When "CircMode" = 0: Not relevant	
CirclePlane	INPUT	DINT	0	When "CircMode" = 1 and 2: Main plane of the circular path	
				0	xz plane
				1	yz plane
				2	xy plane
				When "CircMode" = 0: Not relevant	
Radius	INPUT	LREAL	0.0	When "CircMode" = 2: Radius of the circular movement (Page 269)	
				When "CircMode" = 0 and 1: Not relevant	
Arc	INPUT	LREAL	0.0	When "CircMode" = 1: Angle of the circular movement (Page 267) The absolute value of the specified value is used.	
				When "CircMode" = 0 and 2: Not relevant	
Velocity	INPUT	LREAL	-1.0	Velocity (Page 272)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The value configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Velocity)
Acceleration	INPUT	LREAL	-1.0	Acceleration (Page 272)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The value configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Acceleration)
Deceleration	INPUT	LREAL	-1.0	Deceleration (Page 272)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted

1) Only relevant with more than 4 interpolating kinematics axes.

Parameter	Declaration	Data type	Default value	Description	
Deceleration	INPUT	LREAL	-1.0	< 0.0	The value configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk (Page 272)	
				> 0.0	The specified value is used.
				= 0.0	No jerk limitation
				< 0.0	The value configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Jerk)
DirectionA	INPUT	DINT	3	Direction of movement of the Cartesian orientation A	
				1	Positive direction
				2	Negative direction
				3	Shortest distance
				With more than 4 interpolating kinematics axes: Not relevant	
CoordSystem	INPUT	DINT	0	Reference coordinate system	
				0	World coordinate system (WCS)
				1	Object coordinate system 1 (OCS1)
				2	Object coordinate system 2 (OCS2)
				3	Object coordinate system 3 (OCS3)
BufferMode	INPUT	DINT	1	Motion transition (Page 273)	
				1	Append motion
				2	Smooth with the lower velocity
				5	Smooth with the higher velocity
TransitionParameter	INPUT	ARRAY [1..5] OF LREAL		Transition parameter	
TransitionParameter[1]	INPUT	LREAL	-1.0	Rounding clearance (Page 273)	
				≥ 0.0	The specified value is used.
				< 0.0	The maximum possible rounding clearance is used.
TransitionParameter[2..5]	INPUT	LREAL	-	Reserved	
DynamicAdaption	INPUT	DINT	-1	Dynamic adaptation (Page 272)	
				< 0	The configured setting in "Technology object > Configuration > Extended parameters > Dynamic" is used. (<TO>.DynamicDefaults.DynamicAdaption)

1) Only relevant with more than 4 interpolating kinematics axes.

Parameter	Declaration	Data type	Default value	Description	
DynamicAdaption	INPUT	DINT	-1	0	Without dynamic adaptation
				1	Dynamic adaptation with segmentation of the path
				2	Dynamic adaptation without segmentation of the path
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Active	OUTPUT	BOOL	FALSE	TRUE	The setpoints are calculated.
				FALSE	When "Busy" = TRUE: Job is waiting. (Typical: A preceding job is still active.)
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
RemainingDistance	OUTPUT	LREAL	-1.0	Remaining distance of the current job (Page 230)	

1) Only relevant with more than 4 interpolating kinematics axes.

14.1.6.2 MC_MoveCircularAbsolute: Function chart V10

Function chart: Position kinematics with circular path motion

In the function chart, sections A1 and A2 of the following kinematics motion are viewed:

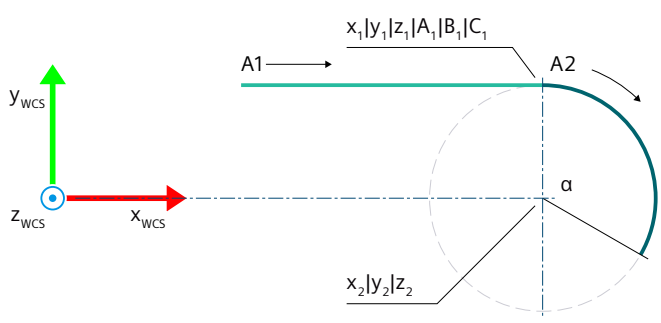

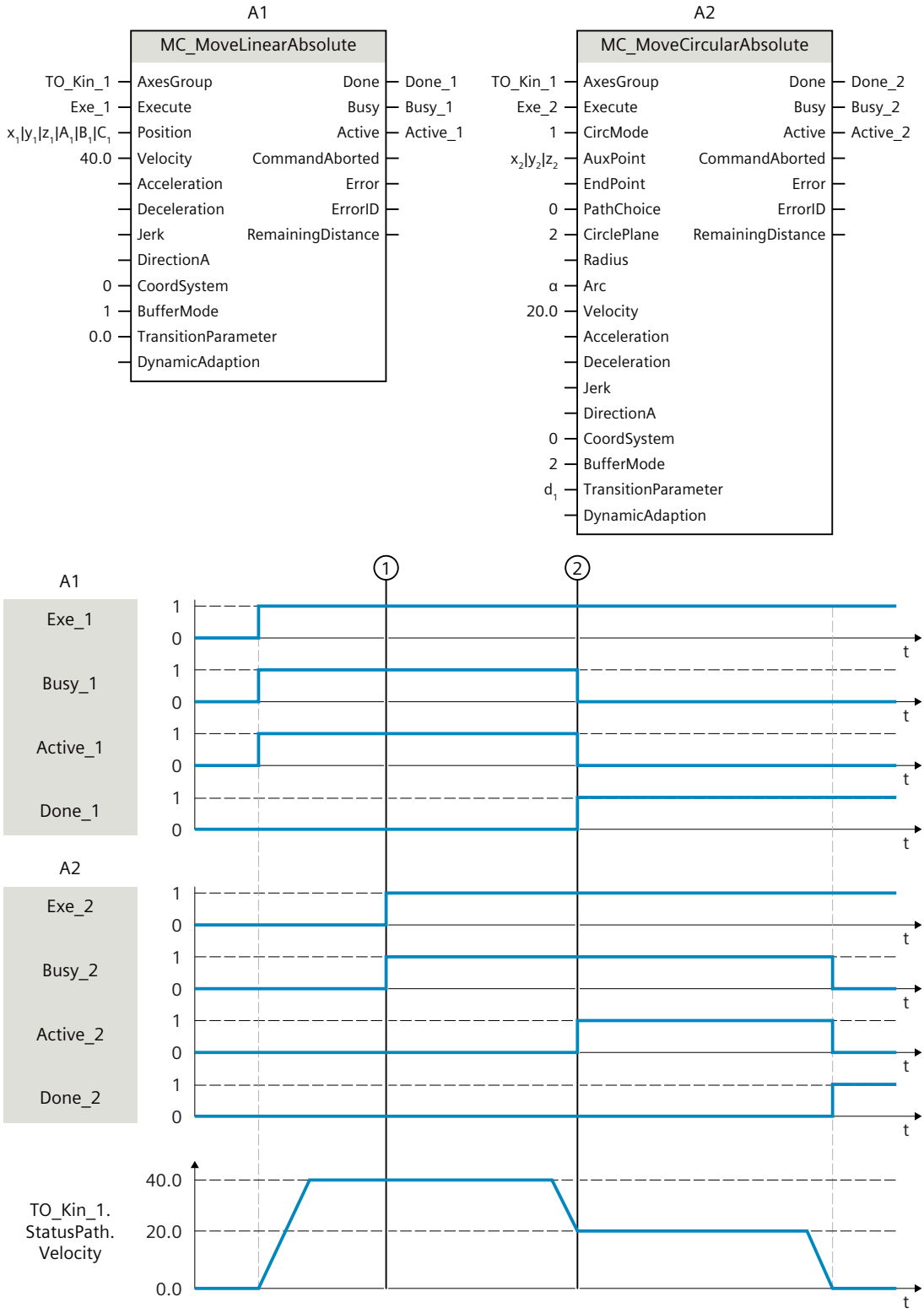

The kinematics is moved with an "MC_MoveLinearAbsolute" job (A1).

At time ① an "MC_MoveCircularAbsolute" job (A2) is initiated. As the "MC_MoveCircularAbsolute" job has no overdrive effect, the job A2 is arranged in the job sequence.

At the point in time ②, completion of the A1 job is signaled via "Done_1" and the job A2 is started. As "BufferMode" = 2 is set for job A2, the motion transition is smoothed with the lower velocity of both jobs and the rounding clearance d_1. The circular motion is determined with "CircMode" = 1 via the center of the circle ($x_2|y_2|z_2$) and the angle α. As soon as the target position is reached, the completion of the A2 job is signaled via "Done_2".

14.1.7 MC_MoveCircularRelative V10

14.1.7.1 MC_MoveCircularRelative: Relative positioning of kinematics with circular path motion V10

Description

With the Motion Control instruction "MC_MoveCircularRelative", you move a kinematics with a circular motion (Page 265) to a relative position. Cartesian orientation is also used relative.

The Motion Control instruction offers you the following:

- Define circular path:
  - Define circular path via intermediate point and target position (Page 265)
  - Define circular path via center point and angle (Page 267)
  - Define circular path via radius and target position (Page 269)
- Define dynamic response (Page 272)
- Define motion transition (Page 273)
- Start job (Page 276)
- Show motion status and remaining distance (Page 230)

Applies to

- Kinematics

Requirements

- The technology object has been configured correctly.
- The interconnected axes are enabled.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.

Override response

With the "TransitionParameter[1]" parameter, you determine the distance from the target point of the previous motion job at which the new motion job is superimposed.

The override response for "MC_MoveCircularRelative" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MoveCircularRelative":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
CircMode	INPUT	DINT	0	Definition of circular path	
				0	Define circular path via intermediate point and target position (Page 265)
				1	Define circular path via center point and angle (Page 267)
				2	Define circular path via radius and target position (Page 269)
AuxPoint	INPUT	ARRAY [1..3] OF LREAL	-	When "CircMode" = 0: Intermediate point on the circular path relative to the start position (Page 265)	
				When "CircMode" = 1: Center point of the circular path relative to the start position (Page 267)	
				When "CircMode" = 2: Not relevant	
AuxPoint[1]	INPUT	LREAL	0.0	x coordinate	
AuxPoint[2]	INPUT	LREAL	0.0	y coordinate	
AuxPoint[3]	INPUT	LREAL	0.0	z coordinate	
EndPoint	INPUT	ARRAY [1..6] OF LREAL	-	Target position relative to the start position in the specified reference coordinate system	
				When "CircMode" = 1: "EndPoint[1..3]" not relevant	
EndPoint[1]	INPUT	LREAL	0.0	x coordinate	
EndPoint[2]	INPUT	LREAL	0.0	y coordinate	
EndPoint[3]	INPUT	LREAL	0.0	z coordinate	
EndPoint[4]	INPUT	LREAL	0.0	A coordinate	
EndPoint[5]	INPUT	LREAL	0.0	B coordinates[1)]	
EndPoint[6]	INPUT	LREAL	0.0	C coordinates[1)]	
PathChoice	INPUT	DINT	0	When "CircMode" = 1: Orientation of the circular path (Page 267)	

1) Only relevant with more than 4 interpolating kinematics axes.

Parameter	Declaration	Data type	Default value	Description	
PathChoice	INPUT	DINT	0	0	Positive direction of rotation
				1	Negative direction of rotation
				When "CircMode" = 2: Orientation of the circular path (Page 269)	
				0	Shorter positive circular path
				1	Shorter negative circular path
				2	Longer positive circular path
				3	Longer negative circular path
				When "CircMode" = 0: Not relevant	
CirclePlane	INPUT	DINT	0	When "CircMode" = 1 and 2: Main plane of the circular path	
				0	xz plane
				1	yz plane
				2	xy plane
				When "CircMode" = 0: Not relevant	
Radius	INPUT	LREAL	0.0	When "CircMode" = 2: Radius of the circular movement (Page 269)	
				When "CircMode" = 0 and 1: Not relevant	
Arc	INPUT	LREAL	0.0	When "CircMode" = 1: Angle of the circular movement (Page 267) The absolute value of the specified value is used.	
				When "CircMode" = 0 and 2: Not relevant	
Velocity	INPUT	LREAL	-1.0	Velocity (Page 272)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Velocity)
Acceleration	INPUT	LREAL	-1.0	Acceleration (Page 272)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Acceleration)

1) Only relevant with more than 4 interpolating kinematics axes.

Parameter	Declaration	Data type	Default value	Description	
Deceleration	INPUT	LREAL	-1.0	Deceleration (Page 272)	
				> 0.0	The specified value is used.
				= 0.0	Not permitted
				< 0.0	The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Deceleration)
Jerk	INPUT	LREAL	-1.0	Jerk (Page 272)	
				> 0.0	The specified value is used.
				= 0.0	No jerk limitation
				< 0.0	The velocity configured in "Technology object > Configuration > Extended parameters > Dynamic default values" is used. (<TO>.DynamicDefaults.Path.Jerk)
CoordSystem	INPUT	DINT	0	Reference coordinate system	
				0	World coordinate system (WCS)
				1	Object coordinate system 1 (OCS1)
				2	Object coordinate system 2 (OCS2)
				3	Object coordinate system 3 (OCS3)
BufferMode	INPUT	DINT	1	Motion transition (Page 273)	
				1	Append motion
				2	Smooth with the lower velocity
				5	Smooth with the higher velocity
TransitionParameter	INPUT	ARRAY [1..5] OF LREAL		Transition parameter	
TransitionParameter[1]	INPUT	LREAL	-1.0	Rounding clearance (Page 273)	
				≥ 0.0	The specified value is used.
				< 0.0	The maximum possible rounding clearance is used.
TransitionParameter[2..5]	INPUT	LREAL	-	Reserved	
DynamicAdaption	INPUT	DINT	-1	Dynamic adaptation (Page 272)	
				< 0	The configured setting in "Technology object > Configuration > Extended parameters > Dynamic" is used. (<TO>.DynamicDefaults.DynamicAdaption)
				0	Without dynamic adaptation
				1	Dynamic adaptation with segmentation of the path

1) Only relevant with more than 4 interpolating kinematics axes.

Parameter	Declaration	Data type	Default value	Description	
DynamicAdaption	INPUT	DINT	-1	2	Dynamic adaptation without segmentation of the path
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Active	OUTPUT	BOOL	FALSE	TRUE	The setpoints are calculated.
				FALSE	When "Busy" = TRUE: Job is waiting. (Typical: A preceding job is still active.)
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
RemainingDistance	OUTPUT	LREAL	-1.0	Remaining distance of the current job (Page 230)	

1) Only relevant with more than 4 interpolating kinematics axes.

14.1.7.2 MC_MoveCircularRelative: Function chart V10

Function chart: Relative positioning of kinematics with circular path motion

In the function chart, sections A1 and A2 of the following kinematics motion are viewed:

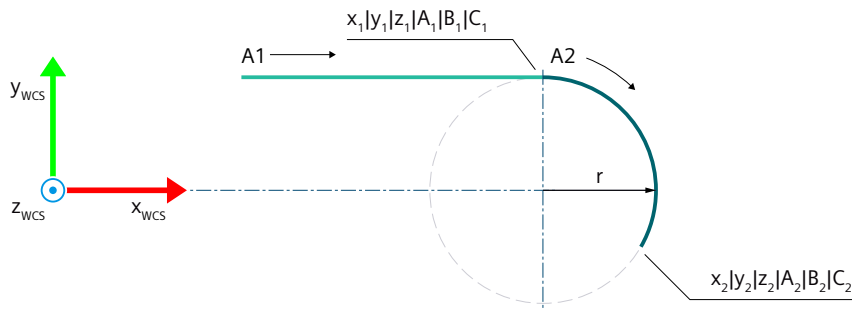

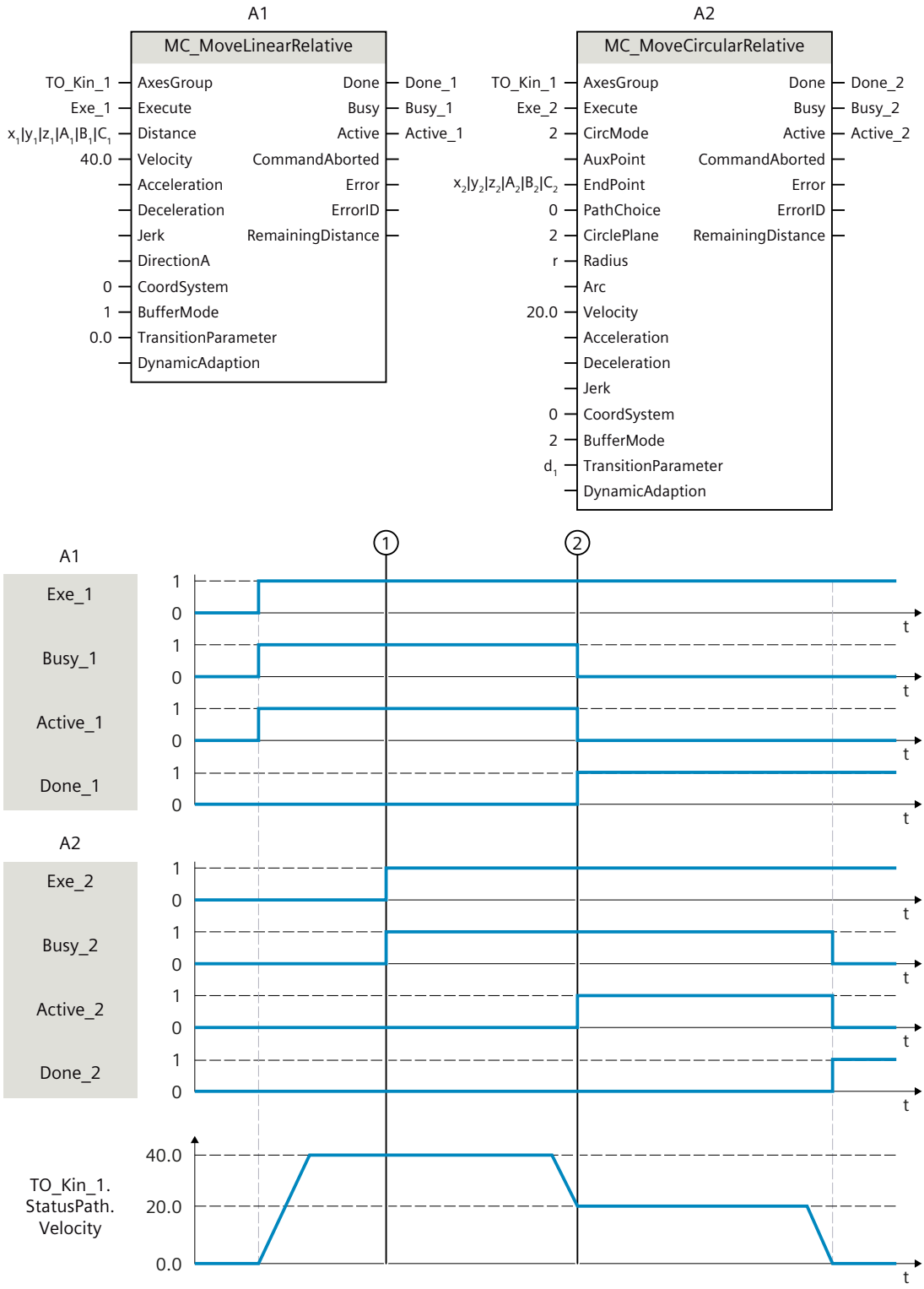

The kinematics is moved with an "MC_MoveLinearRelative" job (A1).

At time ① an "MC_MoveCircularRelative" job (A2) is initiated. As the "MC_MoveCircularRelative" job has no overdrive effect, the job A2 is arranged in the job sequence.

At the point in time ②, completion of the A1 job is signaled via "Done_1" and the job A2 is started. As "BufferMode" = 2 is set for job A2, the motion transition is smoothed with the lower velocity of both jobs and the rounding clearance d_1. The circular motion is determined with "CircMode" = 2 via the radius r and the end point (x_2|y_2|z_2). As soon as the target position is reached, the completion of the A2 job is signaled via "Done_2".

14.1.8 MC_MoveDirectAbsolute V10

14.1.8.1 MC_MoveDirectAbsolute: Absolute movement of kinematics with synchronous "point-to-point" motion V10

Description

With the Motion Control instruction "MC_MoveDirectAbsolute", you can move the kinematics with a synchronous "point-to-point" motion (sPTP motion) (Page 278) to absolute positions. All kinematics axes are moved at the same time. The axes start the movement at the same time and reach the target position at the same time.

The movement path of the tool center point (TCP) results from the dynamic values of the axes. The kinematics axis with the longest travel time determines the travel time of the sPTP motion and therefore the travel time of all other kinematics axes. The position of the TCP results from the positions of the kinematics axes.

The Motion Control instruction offers you the following:

- Define target position:
  - Define absolute axis target positions (Page 279)
  - Define absolute joint target positions (Page 280)
  - Defining absolute Cartesian target coordinates (Page 281)
- Define dynamic factors (Page 283)
- Define motion transition (Page 284)
- Start job and show execution progress (Page 286)

Applies to

- Kinematics

Requirements

- The technology object has been configured correctly.
- The interconnected axes are enabled.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.

Override response

With the "TransitionParameter[1]" parameter, you determine the distance from the target point of the previous motion job at which the new motion job is superimposed.

The override response for "MC_MoveDirectAbsolute" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MoveDirectAbsolute":

Parameter	Declaration	Data type	Default value	Description
AxesGroup	INPUT	TO_Kinematics	-	Technology object
Execute	INPUT	BOOL	FALSE	TRUE: Start job with a positive edge
Position	INPUT	ARRAY [1..6] OF LREAL	-	When "CoordSystem" = 100: Absolute axis positions (Page 279)
				When "CoordSystem" = 101[1) 2)]: Absolute joint positions (Page 280)
				When "CoordSystem" = 0, 1, 2 or 3 and "PositionMode" = 1: Absolute Cartesian target coordinates in the specified reference coordinate system (Page 281)
				When "CoordSystem" = 0, 1, 2 or 3 and "PositionMode" = 2: Absolute Cartesian position and relative Cartesian orientation (Page 281)
Position[1]	INPUT	LREAL	0.0	When "CoordSystem" = 100: Position of axis A1
				When "CoordSystem" = 101[1) 2)]: Position of joint J1
				When "CoordSystem" = 0, 1, 2 or 3 and "PositionMode" = 1 or 2: x coordinate
Position[2]	INPUT	LREAL	0.0	When "CoordSystem" = 100: Position of axis A2
				When "CoordSystem" = 101[1) 2)]: Position of joint J2
				When "CoordSystem" = 0, 1, 2 or 3 and "PositionMode" = 1 or 2: y coordinate
Position[3]	INPUT	LREAL	0.0	When "CoordSystem" = 100: Position of axis A3
				When "CoordSystem" = 101[1) 2)]: Position of joint J3

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint target position in the JCS corresponds to the axis target position in the MCS.

Parameter	Declaration	Data type	Default value	Description
Position[3]	INPUT	LREAL	0.0	When "CoordSystem" = 0, 1, 2 or 3 and "PositionMode" = 1 or 2: z coordinate
Position[4]	INPUT	LREAL	0.0	When "CoordSystem" = 100: Position of axis A4
				When "CoordSystem" = 101[1) 2)]: Position of joint J4
				When "CoordSystem" = 0, 1, 2 or 3 and "PositionMode" = 1 or 2: A coordinate
Position[5]	INPUT	LREAL	0.0	When "CoordSystem" = 100[1)]: Position of axis A5
				When "CoordSystem" = 101[1)]: Position of joint J5
				When "CoordSystem" = 0, 1, 2 or 3[1)]: B coordinate
				With up to 4 interpolating kinematics axes: Not relevant
Position[6]	INPUT	LREAL	0.0	When "CoordSystem" = 100[1)]: Position of axis A6
				When "CoordSystem" = 101[1)]: Position of joint J6
				When "CoordSystem" = 0, 1, 2 or 3[1)]: C coordinate
				With up to 4 interpolating kinematics axes: Not relevant
VelocityFactor	INPUT	LREAL	-1.0	Factor for the velocity (Page 283) of axis motions in relation to the respective maximum velocity of the axes (<TO>.DynamicLimits.MaxVelocity) Permitted range of values: Factor < 0.0 and 0.01 ≤ Factor ≤ 1.0
				< 0.0 — The velocity factor configured under "Technology object > Configuration > Extended parameters > Dynamics > Settings for sPTP motion" is used. (<TO>.DynamicDefaults.MoveDirect.VelocityFactor)
				≥ 0.01 — The specified factor is used.
				1.0 — The maximum velocity of the axes is used.
AccelerationFactor	INPUT	LREAL	-1.0	Factor for the acceleration (Page 283) of axis motions in relation to the respective maximum acceleration of the axis (<TO>.DynamicLimits.MaxAcceleration) Permitted range of values: Factor ≤ 1.0

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint target position in the JCS corresponds to the axis target position in the MCS.

Parameter	Declaration	Data type	Default value	Description	
AccelerationFactor	INPUT	LREAL	-1.0	< 0.0	The acceleration factor configured under "Technology object > Configuration > Extended parameters > Dynamics > Settings for sPTP motion" is used. (<TO>.DynamicDefaults.MoveDirect.AccelerationFactor)
				0.0	Not permitted
				> 0.0	The specified factor is used.
				1.0	The maximum acceleration of the axes is used.
DecelerationFactor	INPUT	LREAL	-1.0	Factor for the deceleration (Page 283) of axis motions in relation to the respective maximum deceleration of the axis (<TO>.DynamicLimits.MaxDeceleration) Permitted range of values: Factor ≤ 1.0	
				< 0.0	The deceleration factor configured under "Technology object > Configuration > Extended parameters > Dynamics > Settings for sPTP motion" is used. (<TO>.DynamicDefaults.MoveDirect.DecelerationFactor)
				0.0	Not permitted
				> 0.0	The specified factor is used.
				1.0	The maximum deceleration of the axes is used.
JerkFactor	INPUT	LREAL	-1.0	Factor for the jerk (Page 283) of axis motions in relation to the respective maximum jerk of the axis (<TO>.DynamicLimits.MaxJerk) Permitted range of values: Factor < 0.0 and 0.1 < Factor ≤ 0.9	
				< 0.0	The jerk factor configured under "Technology object > Configuration > Extended parameters > Dynamics > Settings for sPTP motion" is used. (<TO>.DynamicDefaults.MoveDirect.JerkFactor)
				0.0	No jerk limitation
				≥ 0.1	The specified factor is used.
LinkConstellation	INPUT	DWORD	16#FFFF FFFF	When "CoordSystem" = 0, 1, 2 or 3: Target joint position space (Page 281) The joint position space is specified depending on the respective kinematics type (Page 58).	
				#FFFF FFFF	Keep current joint position space

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint target position in the JCS corresponds to the axis target position in the MCS.

Parameter	Declaration	Data type	Default value	Description	
LinkConstellation	INPUT	DWORD	16#FFFF FFFF	When "CoordSystem" = 100 or 101: Not relevant	
CoordSystem	INPUT	DINT	0	Reference coordinate system	
				0	World coordinate system (WCS)
				1	Object coordinate system 1 (OCS1)
				2	Object coordinate system 2 (OCS2)
				3	Object coordinate system 3 (OCS3)
				100	Machine coordinate system (MCS)
				101	Joint coordinate system (JCS)[1) 2)]
BufferMode	INPUT	DINT	1	Motion transition (Page 284)	
				1	Append motion
				2	Smooth with the lower velocity
				5	Smooth with the higher velocity
TransitionParameter	INPUT	ARRAY [1..5] OF LREAL	-	Transition parameter	
TransitionParameter[1]	INPUT	LREAL	-1.0	Rounding clearance (Page 284)	
				≥ 0.0	The specified value is used.
				< 0.0	The maximum possible rounding clearance is used.
TransitionParameter[2..5]	INPUT	LREAL	-	Reserved	
PositionMode	INPUT	DINT	1	When "CoordSystem" = 0, 1, 2 or 3, kinematics types with orientation A and enabled Modulo functionality: Use of the "Position" parameter (Page 281)	
				1	Absolute Cartesian position and absolute Cartesian orientation A
				2	Absolute Cartesian position and relative Cartesian orientation A
				With more than 4 interpolating kinematics axes: Not relevant	
DirectionA	INPUT	DINT	3	When "CoordSystem" = 0, 1, 2 or 3, "PositionMode" = 1, kinematics types with orientation A and enabled Modulo functionality: Direction of movement of the Cartesian orientation A (Page 281)	
				1	Positive direction
				2	Negative direction
				3	Shortest distance
				With more than 4 interpolating kinematics axes: Not relevant	

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint target position in the JCS corresponds to the axis target position in the MCS.

Parameter	Declaration	Data type	Default value	Description	
TurnJoint	INPUT	ARRAY [1..6] OF DINT	-	With up to 4 interpolating kinematics axes: Not relevant	
				When "CoordSystem" = 0, 1, 2 or 3[1]: Target joint position range of the joint J[1..6] (Page 281)	
TurnJoint[1..6]	INPUT	DINT	0	m (m < 0)	-180° + m · 360° ≤ Position < 180° + m · 360°
				-2	-900 ≤ position < -540
				-1	-540 ≤ position < -180
				0	Shortest distance
				1	-180 ≤ position < 180
				2	180 ≤ position < 540
				3	540 ≤ position < 900
				n (n > 0)	-180° + (n - 1) · 360° ≤ Position < 180° + (n - 1) · 360°
ExecutionTimeStatus	OUTPUT	LREAL	0.0	Display of execution progress (Page 286) Value range: 0.0 ... 1.0 The job is completed with "ExecutionTimeStatus" = 1.0.	
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Active	OUTPUT	BOOL	FALSE	TRUE	The setpoints are calculated.
				FALSE	When "Busy" = TRUE: Job is waiting. (Typical: A preceding job is still active.)
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint target position in the JCS corresponds to the axis target position in the MCS.

14.1.8.2 MC_MoveDirectAbsolute: Function chart V10

Function chart: Absolute movement of kinematics with synchronous "point-to-point" motion

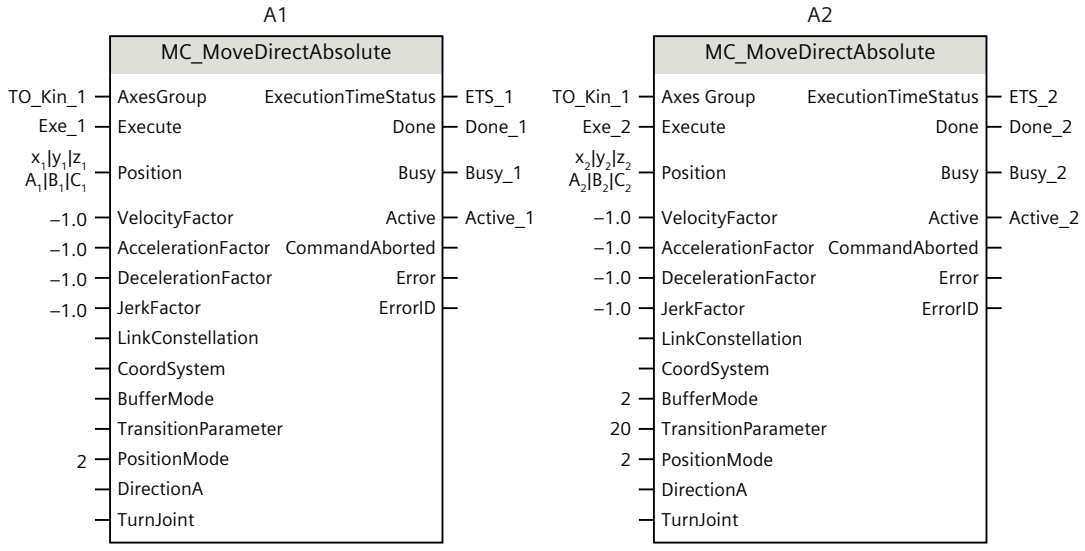

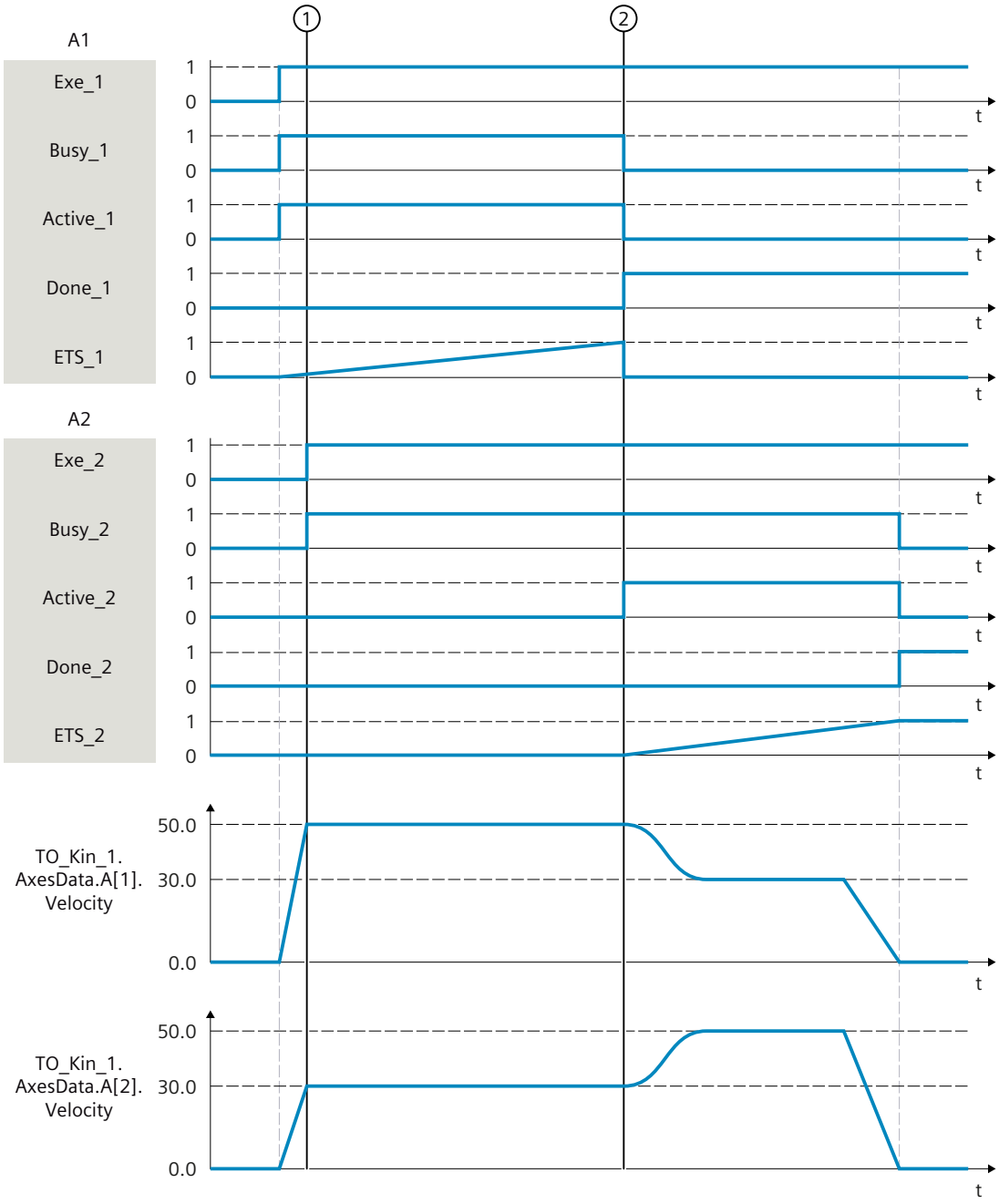

The kinematics is moved with an "MC_MoveDirectAbsolute" job (A1).

At time ①, an additional "MC_MoveDirectAbsolute" job (A2) is initiated. As the "MC_MoveDirectAbsolute" jobs have no override effect on one another, the job A2 is arranged in the job sequence.

At time ②, completion of the job A1 is signaled via "Done_1" and the job A2 is started. As "BufferMode" = 2 is set for job A2, the motion transition is blended with the lower velocity of the two jobs. As soon as the target position is reached, the completion of the A2 job is signaled via "Done_2".

14.1.9 MC_MoveDirectRelative V10

14.1.9.1 MC_MoveDirectRelative: Relative movement of kinematics with synchronous "point-to-point" motion V10

Description

With the Motion Control instruction "MC_MoveDirectRelative", you can move the kinematics with a synchronous "point-to-point" motion (sPTP motion) (Page 278) to relative positions. All kinematics axes are moved at the same time. The axes start the movement at the same time and reach the target position at the same time.

The movement path of the tool center point (TCP) results from the dynamic values of the axes. The kinematics axis with the longest travel time determines the travel time of the sPTP motion and therefore the travel time of all other kinematics axes. The position of the TCP results from the positions of the kinematics axes.

The Motion Control instruction offers you the following:

- Define target position:
  - Define relative axis target positions (Page 279)
  - Define relative joint target positions (Page 280)
  - Define relative Cartesian target coordinates (Page 281)
- Define dynamic factors (Page 283)
- Define motion transition (Page 284)
- Start job and show execution progress (Page 286)

Applies to

- Kinematics

Requirements

- The technology object has been configured correctly.
- The interconnected axes are enabled.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.

Override response

With the "TransitionParameter[1]" parameter, you determine the distance from the target point of the previous motion job at which the new motion job is superimposed.

The override response for "MC_MoveDirectRelative" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_MoveDirectRelative":

Parameter	Declaration	Data type	Default value	Description
AxesGroup	INPUT	TO_Kinematics	-	Technology object
Execute	INPUT	BOOL	FALSE	TRUE: Start job with a positive edge
Distance	INPUT	ARRAY [1..6] OF LREAL	-	When "CoordSystem" = 100: Relative axis positions (Page 279)
				When "CoordSystem" = 101[1) 2)]: Relative joint positions (Page 280)
				When "CoordSystem" = 0, 1, 2 or 3: Relative target coordinates in the specified reference coordinate system (Page 281)
Distance[1]	INPUT	LREAL	0.0	When "CoordSystem" = 100: Relative position of the axis A1
				When "CoordSystem" = 101[1) 2)]: Relative position of joint J1
				When "CoordSystem" = 0, 1, 2 or 3: x coordinate
Distance[2]	INPUT	LREAL	0.0	When "CoordSystem" = 100: Relative position of the axis A2
				When "CoordSystem" = 101[1) 2)]: Relative position of joint J2
				When "CoordSystem" = 0, 1, 2 or 3: y coordinate
Distance[3]	INPUT	LREAL	0.0	When "CoordSystem" = 100: Relative position of the axis A3
				When "CoordSystem" = 101[1) 2)]: Relative position of joint J3
				When "CoordSystem" = 0, 1, 2 or 3: z coordinate
Distance[4]	INPUT	LREAL	0.0	When "CoordSystem" = 100: Relative position of the axis A4
				When "CoordSystem" = 101[1) 2)]: Relative position of joint J4
				When "CoordSystem" = 0, 1, 2 or 3: A coordinate
Distance[5]	INPUT	LREAL	0.0	When "CoordSystem" = 100[1)]: Relative position of axis A5
				When "CoordSystem" = 101[1)]: Relative position of joint J5
				When "CoordSystem" = 0, 1, 2 or 3[1)]: B coordinate

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint target position in the JCS corresponds to the axis target position in the MCS.

Parameter	Declaration	Data type	Default value	Description
Distance[5]	INPUT	LREAL	0.0	With up to 4 interpolating kinematics axes: Not relevant
Distance[6]	INPUT	LREAL	0.0	When "CoordSystem" = 100[1]: Relative position of axis A6
				When "CoordSystem" = 101[1]: Relative position of joint J6
				When "CoordSystem" = 0, 1, 2 or 3[1]: C coordinate
				With up to 4 interpolating kinematics axes: Not relevant
VelocityFactor	INPUT	LREAL	-1.0	Factor for the velocity (Page 283) of axis motions in relation to the respective maximum velocity of the axes (<TO>.DynamicLimits.MaxVelocity) Permitted range of values: Factor < 0.0 and 0.01 ≤ Factor ≤ 1.0
				< 0.0: The velocity factor configured under "Technology object > Configuration > Extended parameters > Dynamics > Settings for sPTP motion" is used. (<TO>.DynamicDefaults.MoveDirect.VelocityFactor)
				≥ 0.01: The specified factor is used.
				1.0: The maximum velocity of the axes is used.
AccelerationFactor	INPUT	LREAL	-1.0	Factor for the acceleration (Page 283) of axis motions in relation to the respective maximum acceleration of the axis (<TO>.DynamicLimits.MaxAcceleration) Permitted range of values: Factor ≤ 1.0
				< 0.0: The acceleration factor configured under "Technology object > Configuration > Extended parameters > Dynamics > Settings for sPTP motion" is used. (<TO>.DynamicDefaults.MoveDirect.AccelerationFactor)
				0.0: Not permitted
				> 0.0: The specified factor is used.
				1.0: The maximum acceleration of the axes is used.
DecelerationFactor	INPUT	LREAL	-1.0	Factor for the deceleration (Page 283) of axis motions in relation to the respective maximum deceleration of the axis (<TO>.DynamicLimits.MaxDeceleration) Permitted range of values: Factor ≤ 1.0

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint target position in the JCS corresponds to the axis target position in the MCS.

Parameter	Declaration	Data type	Default value	Description	
DecelerationFactor	INPUT	LREAL	-1.0	< 0.0	The deceleration factor configured under "Technology object > Configuration > Extended parameters > Dynamics > Settings for sPTP motion" is used. (<TO>.DynamicDefaults.MoveDirect.DecelerationFactor)
				0.0	Not permitted
				> 0.0	The specified factor is used.
				1.0	The maximum deceleration of the axes is used.
JerkFactor	INPUT	LREAL	-1.0	Factor for the jerk (Page 283) of axis motions in relation to the respective maximum jerk of the axis (<TO>.DynamicLimits.MaxJerk) Permitted range of values: Factor < 0.0 and 0.1 < Factor ≤ 0.9	
				< 0.0	The jerk factor configured under "Technology object > Configuration > Extended parameters > Dynamics > Settings for sPTP motion" is used. (<TO>.DynamicDefaults.MoveDirect.JerkFactor)
				0.0	No jerk limitation
				≥ 0.1	The specified factor is used.
LinkConstellation	INPUT	DWORD	16#FFFF FFFF	When "CoordSystem" = 0, 1, 2 or 3: Target joint position space (Page 281) The joint position space is specified depending on the respective kinematics type (Page 58).	
				#FFFF FFFF	Keep current joint position space
				When "CoordSystem" = 100 or 101: Not relevant	
CoordSystem	INPUT	DINT	0	Reference coordinate system	
				0	World coordinate system (WCS)
				1	Object coordinate system 1 (OCS1)
				2	Object coordinate system 2 (OCS2)
				3	Object coordinate system 3 (OCS3)
				100	Machine coordinate system (MCS)
				101	Joint coordinate system (JCS)[1) 2)]
BufferMode	INPUT	DINT	1	Motion transition (Page 284)	
				1	Append motion
				2	Smooth with the lower velocity

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint target position in the JCS corresponds to the axis target position in the MCS.

Parameter	Declaration	Data type	Default value	Description	
BufferMode	INPUT	DINT	1	5	Smooth with the higher velocity
TransitionParameter	INPUT	ARRAY [1..5] OF LREAL	-	Transition parameter	
TransitionParameter[1]	INPUT	LREAL	-1.0	Rounding clearance (Page 284)	
				≥ 0.0	The specified value is used.
				< 0.0	The maximum possible rounding clearance is used.
TransitionParameter[2..5]	INPUT	LREAL	-	Reserved	
TurnJoint	INPUT	ARRAY [1..6] OF DINT	-	With up to 4 interpolating kinematics axes: Not relevant	
				When "CoordSystem" = 0, 1, 2 or 3[1]: Target joint position range of the joint J[1..6] (Page 281)	
TurnJoint[1..6]	INPUT	DINT	0	m (m < 0)	-180° + m · 360° ≤ Position < 180° + m · 360°
				-2	-900 ≤ position < -540
				-1	-540 ≤ position < -180
				0	Shortest distance
				1	-180 ≤ position < 180
				2	180 ≤ position < 540
				3	540 ≤ position < 900
				n (n > 0)	-180° + (n - 1) · 360° ≤ Position < 180° + (n - 1) · 360°
ExecutionTimeStatus	OUTPUT	LREAL	0.0	Display of execution progress (Page 286) Value range: 0.0 ... 1.0 The job is completed with "ExecutionTimeStatus" = 1.0.	
				0.0	The job has not yet been executed.
				> 0.0	The job is being executed.
				1.0	The job was executed.
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Active	OUTPUT	BOOL	FALSE	TRUE	The setpoints are calculated.
				FALSE	When "Busy" = TRUE: Job is waiting. (Typical: A preceding job is still active.)

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint target position in the JCS corresponds to the axis target position in the MCS.

Parameter	Declaration	Data type	Default value	Description	
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint target position in the JCS corresponds to the axis target position in the MCS.

14.1.9.2 MC_MoveDirectRelative: Function chart V10

Function chart: Relative movement of kinematics with synchronous "point-to-point" motion

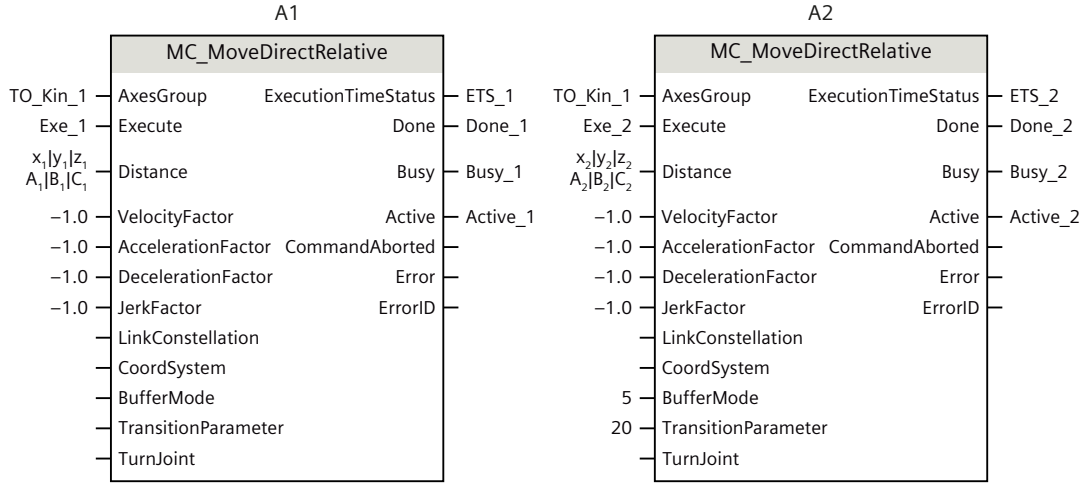

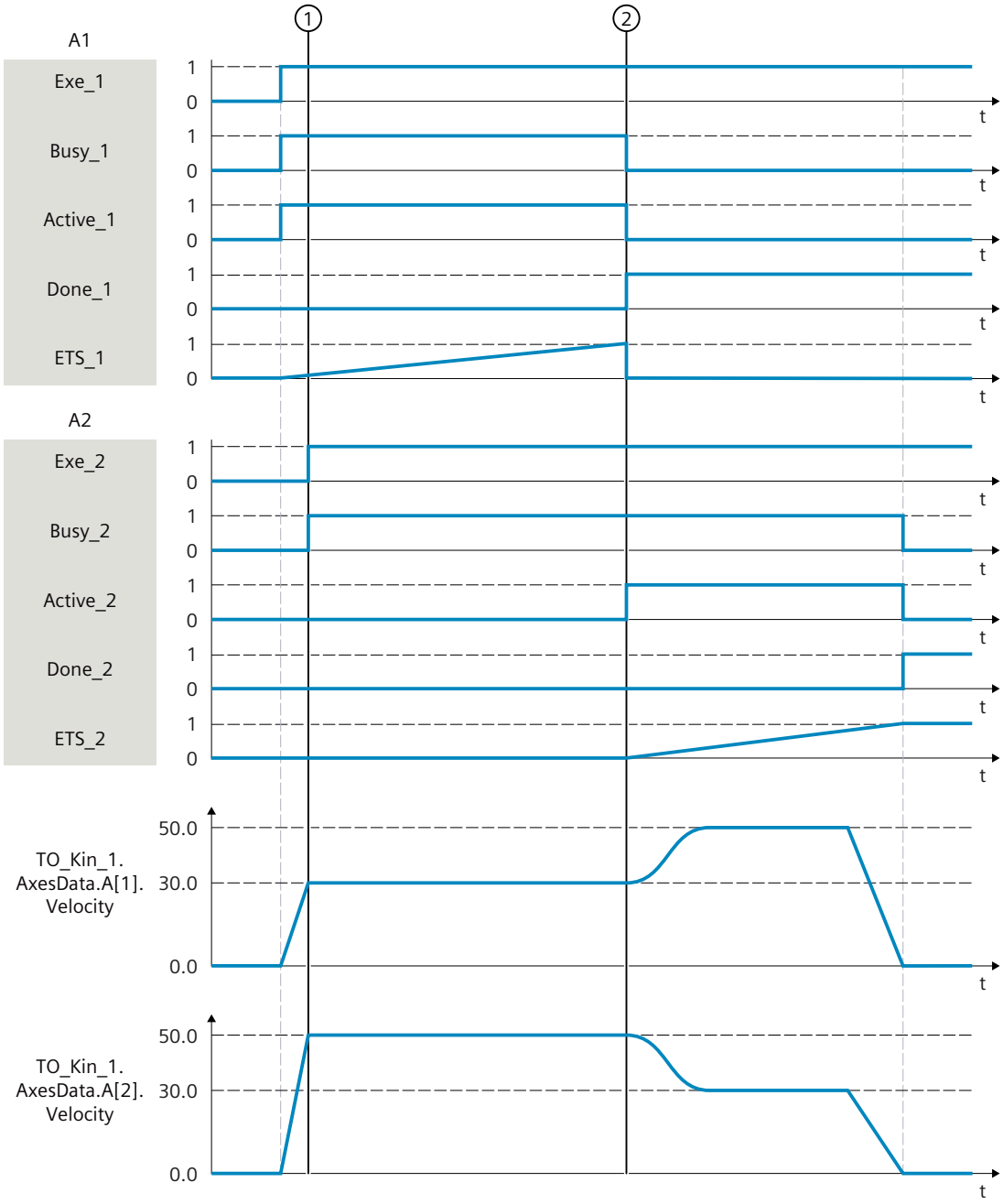

The kinematics is moved with an "MC_MoveDirectRelative" job (A1).

At time ①, an additional "MC_MoveDirectRelative" job (A2) is initiated. As the "MC_MoveDirectRelative" jobs have no override effect on one another, the job A2 is arranged in the job sequence.

At time ②, completion of the job A1 is signaled via "Done_1" and the job A2 is started. As "BufferMode" = 5 is set for job A2, the motion transition is blended with the higher velocity of the two jobs. As soon as the target position is reached, the completion of the A2 job is signaled via "Done_2".

14.1.10 MC_TrackConveyorBelt V10

14.1.10.1 MC_TrackConveyorBelt: Start conveyor tracking V10

Description

With the "MC_TrackConveyorBelt" Motion Control instruction, an OCS is assigned to a leading value-capable technology object which represents the conveyor belt.

The Motion Control instruction offers you the following:

- Assigning tracked OCS and defining reference position (Page 290)

Applies to

- Kinematics

Requirement

- The technology objects have been configured correctly.
- You have selected a kinematics type that can execute path motion jobs.
- There is no active single axis job (e.g. "MC_MoveVelocity") on the interconnected axes.

Override response

- A "MC_SetOcsFrame" job cancels the tracking of the OCS with a leading value-capable technology object.
- A technology alarm on the kinematics, with the alarm response of terminating the motion, cancels the tracking of the OCS on the conveyor.
- The override response for "MC_TrackConveyorBelt" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_TrackConveyorBelt":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Kinematics technology object	
ConveyorBelt	INPUT	TO_PositioningAxis TO_SynchronousAxis TO_ExternalEncoder TO_LeadingAxisProxy	-	Leading value-capable technology object to which the OCS is coupled. Leading-value-capable technology objects are: • Positioning axis • Synchronous axis • External encoder • Leading axis proxy	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
ConveyorBeltOrigin	INPUT	TO_Struct_Kinematics_Frame	-	Frame for the OCS reference position on the conveyor	
InitialObjectPosition	INPUT	TO_Struct_Kinematics_Frame	0.0	"InitialObjectPosition.x" contains the differential value on the belt position to determine the tracked position of the OCS in relation to the OCS reference position Permitted values: • "InitialObjectPosition.x" <=> 0.0 • "InitialObjectPosition.y" = 0.0 • "InitialObjectPosition.z" = 0.0 • "InitialObjectPosition.a" = 0.0 • "InitialObjectPosition.b" = 0.0 • "InitialObjectPosition.c" = 0.0	
CoordSystem	INPUT	DINT	1	Number of the tracked OCS	
				1	OCS1
				2	OCS2
				3	OCS3
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

14.1.10.2 MC_TrackConveyorBelt: Function chart V10

Function chart: Start conveyor tracking

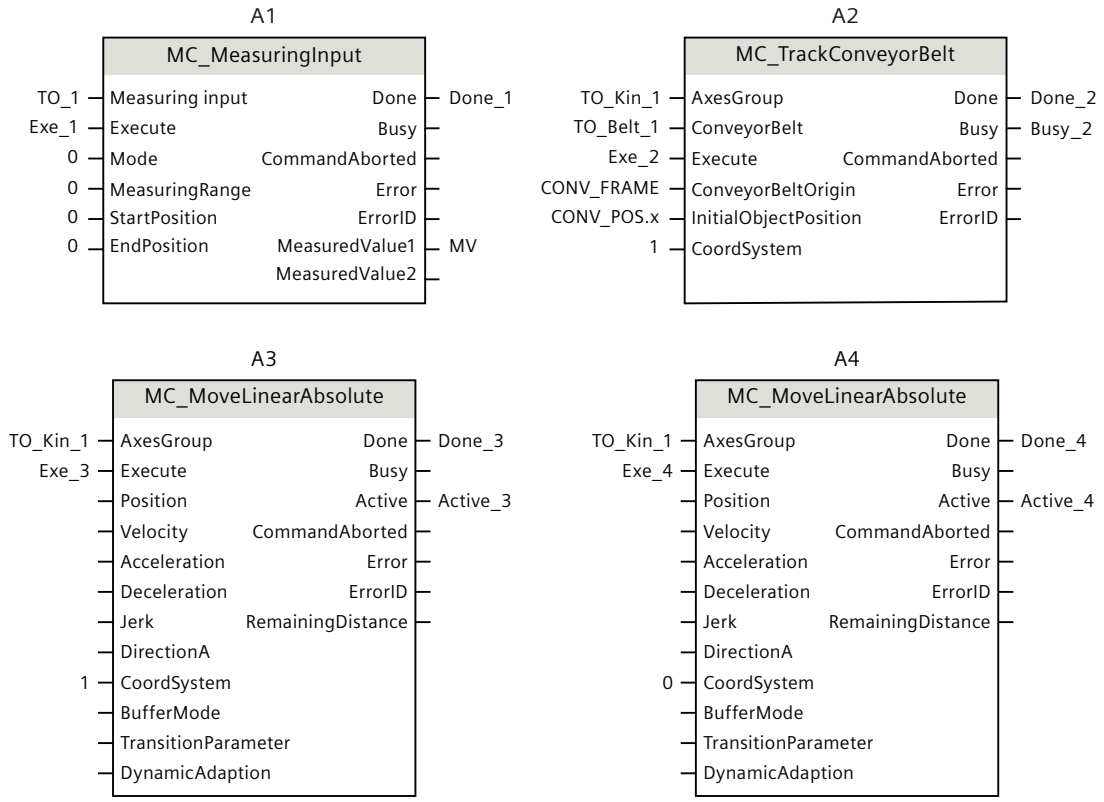

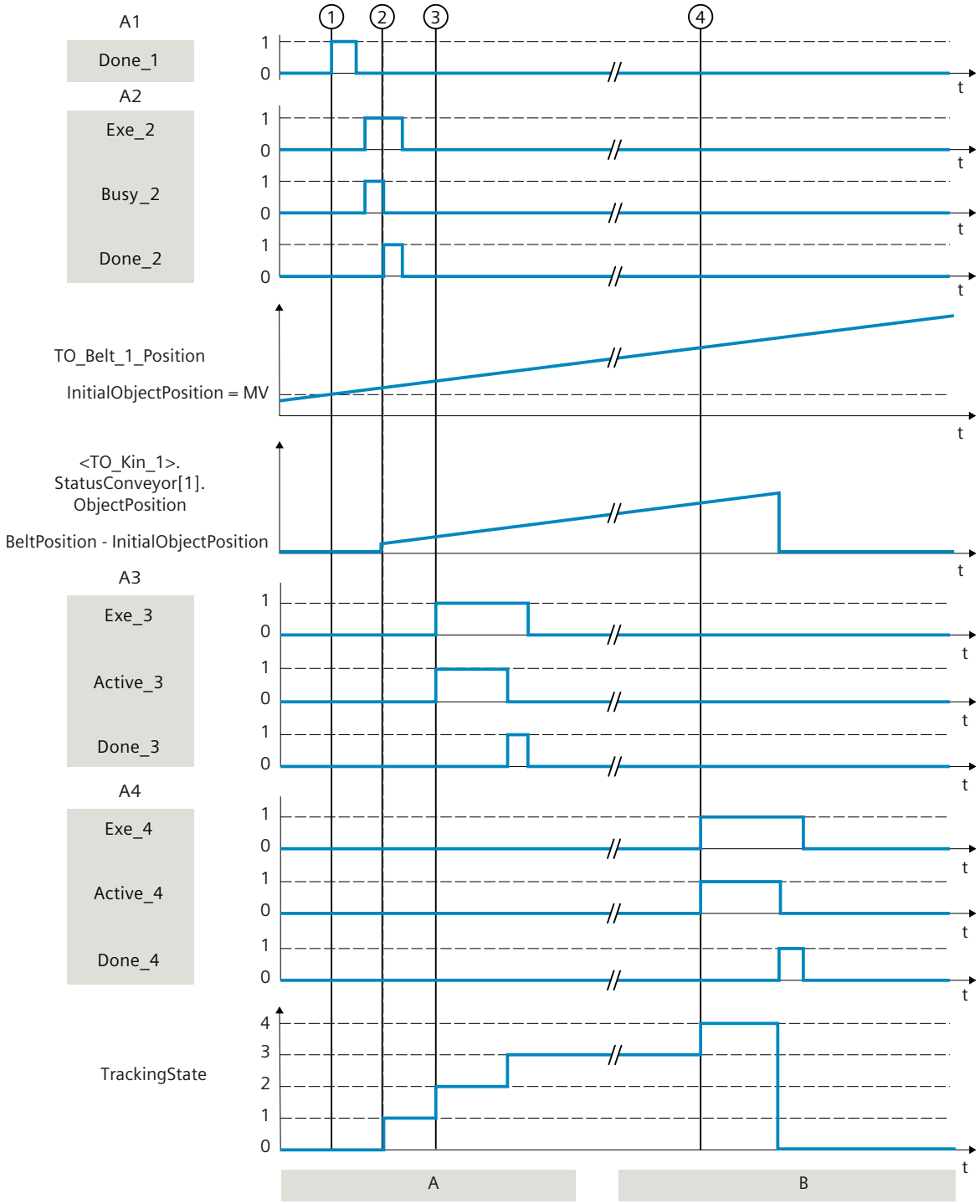

Section A

The position of an object at time ① is recorded via a "MC_MeasuringInput" job (A1). The recorded position "MV" is reported via "Done_1" and written into the variable "CONV_POS.x".

With a "MC_TrackConveyorBelt" job (A2), an OCS is assigned at the time ② via the parameter "ConveyorBelt" to a leading-value capable technology object, which represents the conveyor belt. The OCS is assigned to a known conveyor position to this purpose. The OCS is assigned with the OCS frame and the object position to an object on the conveyor.

The "ObjectPosition" is calculated from the conveyor position minus the "InitialObjectPosition". In the present case the "InitialObjectPosition" is the position of the conveyor ("MV") at the time ①.

The status of conveyor tracking ("TrackingState") changes from 0 to 1.

Via a "MC_MoveLinearAbsolute" job at the time ③ the kinematics is moved to the position specified in the OCS. When the kinematics moves to the object position, the status of conveyor tracking changes from 1 to 2. When the kinematics follows the object position, the status of conveyor tracking changes from 2 to 3.

Section B

To complete the process of the kinematics with the tracked OCS, a "MC_MoveLinearAbsolute" job is started in the WCS at the time ④. When the kinematics moves to the position in WCS, the status of conveyor tracking changes from 3 to 4.

The completed conveyor tracking is reported via "Done_4" and the "TrackingState" changes to 0. The OCS is not tracked with the conveyor position anymore.

14.1.11 MC_KinematicsMotionSimulation V10

14.1.11.1 MC_KinematicsMotionSimulation: Start/end simulation of kinematics V10

Description

With the "MC_KinematicsMotionSimulation" Motion Control instruction, you start or end the simulation mode (Page 307) for a kinematics technology object.

The Motion Control instruction offers you the following:

- Interrupting a kinematics motion and locking kinematics axes (Page 307)
- Releasing kinematics axes and resuming kinematics motion (Page 308)

Applies to

- Kinematics

Requirements

- The technology object has been configured correctly.
- The interconnected axes are enabled.
- When switching on and off, a single-axis job (e.g. "MC_MoveAbsolute") is not active on any of the interconnected axes.
- To exit the simulation with "Execute" = TRUE and "Mode" = 0, the kinematics axes must be at position "<TO>.AxesData.A[1..6].Position". A modulo axis must also be in the same modulo cycle as at the start time of the simulation.

Override response

An "MC_KinematicsMotionSimulation" job is not aborted by any other Motion Control job. You can add more motion jobs to the job sequence or cancel the kinematics motion with an "MC_GroupStop" job without exiting the simulation. The simulation remains active even when the kinematics axes is disabled with "MC_Power.Enable" = FALSE or "MC_Stop".

When a single-axis job is active on a kinematics axis when you exit the simulation, execution of the "MC_KinematicsMotionSimulation" job is rejected with an error.

A restart of the kinematics technology object or one of the kinematics axes terminates the kinematics motion and the simulation.

A new "MC_KinematicsMotionSimulation" job does not abort any other Motion Control jobs.

A new "MC_KinematicsMotionSimulation" job is aborted without errors in the following cases and has no effect:

- The kinematics are not in simulation mode when the job is started with "Execute" = TRUE and "Mode" = 0 .
- The kinematics are already in simulation mode when the job is started with "Execute" = TRUE and "Mode" = 1 .

Parameter

The following table shows the parameters of the Motion Control instruction "MC_KinematicsMotionSimulation":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Kinematics technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Mode	INPUT	DINT	FALSE	0	Exit simulation mode of the kinematics
				1	Set kinematics to simulation mode or leave in simulation
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	0	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

14.2 Zones

14.2.1 MC_DefineWorkspaceZone V10

14.2.1.1 MC_DefineWorkspaceZone: Define workspace zone V10

Description

With the Motion Control instruction "MC_DefineWorkspaceZone", you define a workspace zone in relation to the world coordinates system or an object coordinates system. The zones (<TO>.WorkspaceZone[1..10]) defined under "Technology object > Configuration > Extended parameters > Zones" are not hereby changed are available again after a restart of the technology object. The "<TO>.StatusWorkspaceZone" tag of the technology object data block contains the currently effective workspace zones.

The "MC_DefineWorkspaceZone" job interjects itself in the job sequence on the Kinematics technology object and therefore effective for the following motion jobs.

The Motion Control instruction offers you the following:

- Defining workspace zones (Page 211)

Applies to

- Kinematics

Requirement

- The technology object has been configured correctly.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.

Override response

- The override response for "MC_DefineWorkspaceZone" jobs is described in section "Override response V10: Kinematics motion commands".

Parameter

The following table shows the parameters of the Motion Control instruction "MC_DefineWorkspaceZone":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	The job is accepted in the job sequence.

Parameter	Declaration	Data type	Default value	Description	
ZoneType	INPUT	DINT	0	Zone type (Page 214)	
				0	Blocked zone
				1	Work zone
				2	Signal zone
ZoneNumber	INPUT	DINT	1	Zone number (Page 214)	
				1 to 10	Zone 1 ... 10
ReferenceSystem	INPUT	DINT	0	Reference coordinate system (Page 215)	
				0	World coordinate system (WCS)
				1	Object coordinate system 1 (OCS1)
				2	Object coordinate system 2 (OCS2)
				3	Object coordinate system 3 (OCS3)
Frame	INPUT	TO_Struct_Kinematics_-Frame	-	Offset of the zone zero point in relation to the reference system (Page 219)	
GeometryType	INPUT	DINT	0	Zone geometry type (Page 216)	
				0	Cuboid
				1	Sphere
				2	Cylinder
GeometryParameter	INPUT	ARRAY [1..3] OF LREAL	-	Geometric parameters (Page 216)	
GeometryParameter[1]	INPUT	LREAL	0.0	Length x	
				When "GeometryType" = 1 or 2: Radius	
GeometryParameter[2]	INPUT	LREAL	0.0	Length y	
				When "GeometryType" = 2: Height	
GeometryParameter[3]	INPUT	LREAL	0.0	Length z	
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

14.2.2 MC_DefineKinematicsZone V10

14.2.2.1 MC_DefineKinematicsZone: Define kinematics zone V10

Description

With the Motion Control instruction "MC_DefineKinematicsZone", you define a kinematics zone in relation to the tool and flange coordinate system. The zones (<TO>.KinematicsZone[2..10]) defined under "Technology object > Configuration > Extended parameters > Zones" are not hereby changed are available again after a restart of the technology object. The "<TO>.StatusKinematicsZone" tag of the technology object data block contains the currently effective kinematics zones.

The "MC_DefineKinematicsZone" job is added to the queue of the job sequence and is therefore effective for subsequent motion jobs.

The Motion Control instruction offers you the following:

- Defining kinematics zones (Page 212)

Applies to

- Kinematics

Requirement

- The technology object has been configured correctly.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.

Override response

- The override response for "MC_DefineKinematicsZone" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_DefineKinematicsZone":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	The job is accepted in the job sequence.
ZoneNumber	INPUT	DINT	2	Zone number (Page 214)	
				2 ... 10	Zone 2 ... 10

Parameter	Declaration	Data type	Default value	Description	
ReferenceSystem	INPUT	DINT	0	Reference coordinate system (Page 215)	
				0	Flange coordinate system (FCS)
				1	Tool coordinate system (TCS)
Frame	INPUT	TO_Struct_Kinematics_-Frame	-	Offset of the zone zero point in relation to the reference system (Page 219)	
GeometryType	INPUT	DINT	0	Zone geometry type (Page 216)	
				0	Cuboid
				1	Sphere
				2	Cylinder
GeometryParameter	INPUT	ARRAY [1..3] OF LREAL	-	Geometric parameters (Page 216)	
GeometryParameter[1]	INPUT	LREAL	0.0	Length x	
				When "GeometryType" = 1 or 2: Radius	
GeometryParameter[2]	INPUT	LREAL	0.0	Length y	
				When "GeometryType" = 2: Height	
GeometryParameter[3]	INPUT	LREAL	0.0	Length z	
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

14.2.3 MC_SetWorkspaceZoneActive V10

14.2.3.1 MC_SetWorkspaceZoneActive: Activate workspace zone V10

Description

You use the "MC_SetWorkspaceZoneActive" Motion Control instruction to set a defined workspace zone to active

The Motion Control instruction offers you the following:

- Activating zone monitoring (Page 219)

The "MC_SetWorkspaceZoneActive" job is added to the queue of the job sequence and is therefore effective for subsequent motion jobs. When an "MC_SetWorkspaceZoneActive" job becomes part of the job sequence, the zone specified at the "ZoneNumber" parameter must already be defined. Otherwise, the job is rejected with "ErrorID" = 16#80C7. You can ensure this as follows:

- Do not submit the "MC_SetWorkspaceZoneActive" job until the "MC_DefineWorkspaceZone" job is completed ("Done" = TRUE).
- Check whether the tag "StatusWorkspaceZone[1..10].Valid" = TRUE before you submit the "MC_SetWorkspaceZoneActive" job.

Applies to

- Kinematics

Requirement

- The technology object has been configured correctly.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.
- The zone to be activated is defined.

Override response

- The override response for "MC_SetWorkspaceZoneActive" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_SetWorkspaceZoneActive":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
ZoneNumber	INPUT	DINT	1	Zone number	
				1 to 10	Zone 1 ... 10
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.

Parameter	Declaration	Data type	Default value	Description	
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

See also

MC_DefineWorkspaceZone: Define workspace zone V10 (Page 435)
MC_SetWorkspaceZoneInactive: Deactivate workspace zone V10 (Page 440)

14.2.4 MC_SetWorkspaceZoneInactive V10

14.2.4.1 MC_SetWorkspaceZoneInactive: Deactivate workspace zone V10

Description

You use the "MC_SetWorkspaceZoneInactive" Motion Control instruction to set one or more active workspace zones to inactive.

The Motion Control instruction offers you the following:

- Deactivating zone monitoring (Page 220)

The "MC_SetWorkspaceZoneInactive" job is added to the queue of the job sequence and is therefore effective for subsequent motion jobs.

Applies to

- Kinematics

Requirement

- The technology object has been configured correctly.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.
- The zone to be deactivated is defined.

Override response

- The override response for "MC_SetWorkspaceZoneInactive" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_SetWorkspaceZoneInactive":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
ZoneNumber	INPUT	DINT	1	Zone number	
				1 to 10	Zone 1 ... 10
Mode	INPUT	DINT	0	Set zones of a zone type to inactive	
				0	Set a specific zone to inactive
				1	Set all workspace zones to inactive
				2	Set all blocked zones to inactive
				3	Set all signal zones to inactive
				4	Set workspace to inactive.
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

See also

MC_DefineWorkspaceZone: Define workspace zone V10 (Page 435)

MC_SetWorkspaceZoneActive: Activate workspace zone V10 (Page 438)

14.2.5 MC_SetKinematicsZoneActive V10

14.2.5.1 MC_SetKinematicsZoneActive: Activate kinematics zone V10

Description

You use the "MC_SetKinematicsZoneActive" Motion Control instruction to set a defined kinematics zone to active.

The Motion Control instruction offers you the following:

- Activating zone monitoring (Page 219)

The "MC_SetKinematicsZoneActive" job is added to the queue of the job sequence and is therefore effective for subsequent motion jobs. When an "MC_SetKinematicsZoneActive" job becomes part of the job sequence, the zone specified at the "ZoneNumber" parameter must already be defined. Otherwise, the job is rejected with "ErrorID" = 16#80C7. You can ensure this as follows:

- Do not submit the "MC_SetKinematicsZoneActive" job until the "MC_DefineKinematicsZone" job is completed ("Done" = TRUE).
- Check whether the tag "StatusKinematicsZone[2..10].Valid" = TRUE before you submit the "MC_SetWorkspaceZoneActive" job.

Applies to

- Kinematics

Requirement

- The technology object has been configured correctly.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.
- The kinematics zone to be activated is defined.

Override response

- The override response for "MC_SetKinematicsZoneActive" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_SetKinematicsZoneActive":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
ZoneNumber	INPUT	DINT	2	Zone number	
				2 ... 10	Zone 2 ... 10
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

See also

MC_DefineKinematicsZone: Define kinematics zone V10 (Page 437)

MC_SetKinematicsZoneInactive: Deactivate kinematics zone V10 (Page 443)

14.2.6 MC_SetKinematicsZoneInactive V10

14.2.6.1 MC_SetKinematicsZoneInactive: Deactivate kinematics zone V10

Description

You use the "MC_SetKinematicsZoneInactive" Motion Control instruction to set one or more active kinematics zones to inactive.

The Motion Control instruction offers you the following:

- Deactivating zone monitoring (Page 220)

The "MC_SetKinematicsZoneInactive" job is added to the queue of the job sequence and is therefore effective for subsequent motion jobs.

Applies to

- Kinematics

Requirement

- The technology object has been configured correctly.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.
- The kinematics zone to be deactivated is defined.

Override response

- The override response for "MC_SetKinematicsZoneInactive" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_SetKinematicsZoneInactive":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
ZoneNumber	INPUT	DINT	2	Zone number	
				2 ... 10	Zone 2 ... 10
Mode	INPUT	DINT	0	Set zones to inactive	
				0	Set a specific zone to inactive
				1	Set all zones to inactive
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

See also

MC_DefineKinematicsZone: Define kinematics zone V10 (Page 437)
MC_SetKinematicsZoneActive: Activate kinematics zone V10 (Page 442)

14.3 Tools

14.3.1 MC_DefineTool V10

14.3.1.1 MC_DefineTool: Redefine tool V10

Description

You redefine the tool frame for Tool 1 with the "MC_DefineTool" Motion Control instruction. The configured start values are not overwritten. Tool 1 is active by default.

The "MC_DefineTool" job is not added to the queue of the job sequence of the kinematics technology object and therefore takes effect immediately.

The Motion Control instruction offers you the following:

- Defining a tool frame for Tool 1 (Page 206)

Applies to

- Kinematics

Requirement

- The technology object has been configured correctly.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.
- The kinematics is at a standstill.
- The kinematics is not in "Interrupted" state.
- No kinematics motion is active.

Override response

- An "MC_DefineTool" job cannot be aborted by any other Motion Control job.
- A new "MC_DefineTool" job does not abort any active Motion Control job.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_DefineTool":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
Frame	INPUT	TO_Struct_Kinematics_KinematicsFrame	-	Coordinates in relation to the FCS (Page 206)	
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

14.3.2 MC_SetTool V10

14.3.2.1 MC_SetTool: Change active tool V10

Description

With the "MC_SetTool" Motion Control instruction, you activate a tool.

The Motion Control instruction offers you the following:

- Setting a tool to active (Page 309)

Applies to

- Kinematics

Requirements

- The technology object has been configured correctly.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.
- The kinematics is at a standstill.
- The kinematics is not in "Interrupted" state.
- No kinematics motion is active.

Override response

- An "MC_SetTool" job cannot be aborted by any other Motion Control job.
- A new "MC_SetTool" job does not abort any active Motion Control job.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_SetTool":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	Start job with a positive edge
ToolNumber	INPUT	DINT	1	Number of the tool to be activated (Page 309)	
				1 to 3	Tool 1 to 3
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

14.4 Coordinate systems

14.4.1 MC_SetOcsFrame V10

14.4.1.1 MC_SetOcsFrame: Redefine object coordinate systems V10

Description

With the "MC_SetOcsFrame" Motion Control instruction, you define the position of an object coordinate system (OCS) in relation to the world coordinate system (WCS). The initial values stored in the technology object data block are not overwritten in the process.

The "MC_SetOcsFrame" job is added to the queue of the job sequence and is therefore effective only for subsequent motion jobs.

The Motion Control instruction offers you the following:

- Defining an OCS frame (Page 204)

Applies to

- Kinematics

Requirement

- The technology object has been configured correctly.
- A single axis job (e.g. "MC_MoveVelocity") is not active on any of the interconnected axes.

Override response

The override response for "MC_SetOcsFrame" jobs is described in section "Override response V10: Kinematics motion commands".

Parameters

The following table shows the parameters of the Motion Control instruction "MC_SetOcsFrame":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Execute	INPUT	BOOL	FALSE	TRUE	The job is accepted in the job sequence.
Frame	INPUT	TO_Struct_Kinematics_Frame	-	Coordinates in relation to the WCS (Page 204)	
OcsNumber	INPUT	DINT	1	Object coordinate system (Page 204)	

Parameter	Declaration	Data type	Default value	Description	
OcsNumber	INPUT	DINT	1	1 to 3	OCS1 to OCS3
Done	OUTPUT	BOOL	FALSE	TRUE	Job is completed. The new values are active for the display and the motion.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
CommandAborted	OUTPUT	BOOL	FALSE	TRUE	The job was aborted by another job during execution.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	

14.4.2 MC_KinematicsTransformation V10

14.4.2.1 MC_KinematicsTransformation: Convert axis coordinates to Cartesian coordinates V10

Description

With the Motion Control instruction "MC_KinematicsTransformation", you convert the setpoints of positions, velocity and acceleration of the kinematics axes or joints to Cartesian coordinates, velocity and acceleration of the tool center point (TCP). The active tool is hereby taken into consideration.

With the instruction, you can determine the Cartesian position, orientation, velocity and acceleration of the axis values or joints.

The instruction is for information purposes only - the kinematics is not moved.

Use the Motion Control instruction "MC_KinematicsTransformation" in the following organization blocks, depending on the kinematics type and the transformation of the values:

Transformation of values	Predefined kinematics	User-defined kinematics
Synchronous to the MC_Servo or MC_Interpolator cycle	MC_PreServo MC_PostServo MC_PreInterpolator	MC_PreInterpolator **Note** The call in MC_PreServo and MC_PostServo triggers technology alarm 803.
In the Main cycle	Main	Main

Applies to

- Kinematics

Requirements

- The technology object has been configured correctly.

Override response

- An "MC_KinematicsTransformation" job cannot be aborted by any other Motion Control job.
- A new "MC_KinematicsTransformation" job does not abort any active Motion Control jobs.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_KinematicsTransformation":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Enable	INPUT	BOOL	FALSE	TRUE	The calculation is carried out in the cycle of the calling organization block.
AxesPosition	INPUT	ARRAY[1..6] OF LREAL	-	When "AxesCoordSystem" = 100: Positions of the kinematics axes	
				When "AxesCoordSystem" = 101[1]: Positions of the joints	
AxesPosition[1..6]	INPUT	LREAL	0.0	When "AxesCoordSystem" = 100: Position of the axis A[1..6]	
				When "AxesCoordSystem" = 101[1]: Position of the joint J[1..6]	
AxesVelocity	INPUT	ARRAY[1..6] OF LREAL	-	When "AxesCoordSystem" = 100: Velocity of kinematics axes	
				When "AxesCoordSystem" = 101[1]: Velocity of the joints	
AxesVelocity[1..6]	INPUT	LREAL	0.0	When "AxesCoordSystem" = 100: Velocity of axis A[1..6]	
				When "AxesCoordSystem" = 101[1]: Velocity of the joint J[1..6]	
AxesAcceleration	INPUT	ARRAY[1..6] OF LREAL	-	When "AxesCoordSystem" = 100: Acceleration of the kinematics axes	
				When "AxesCoordSystem" = 101[1]: Acceleration of the joints	
AxesAcceleration[1..6]	INPUT	LREAL	0.0	When "AxesCoordSystem" = 100: Acceleration of the axis A[1..6]	
				When "AxesCoordSystem" = 101[1]: Acceleration of the joint J[1..6]	

[1] Only relevant with more than 4 interpolating kinematics axes.

[2] With up to 4 interpolating kinematics axes, the joint position in the JCS corresponds to the axis position in the MCS.

Parameter	Declaration	Data type	Default value	Description	
CoordSystem	INPUT	DINT	0	Reference coordinate system of the output parameters	
				0	World coordinate system (WCS)
				1	Object coordinate system 1 (OCS1)
				2	Object coordinate system 2 (OCS2)
				3	Object coordinate system 3 (OCS3)
AxesCoordSystem	INPUT	DINT	100	Reference coordinate system of the input parameters	
				100	Machine coordinate system (MCS)
				101	Joint coordinate system (JCS)[1) 2)]
Valid	OUTPUT	BOOL	FALSE	TRUE	The output parameters are valid.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
Position	OUTPUT	ARRAY[1..6] OF LREAL	-	Cartesian position of the TCP in the reference coordinate system	
Position[1]	OUTPUT	LREAL	0.0	x coordinate	
Position[2]	OUTPUT	LREAL	0.0	y-coordinate	
Position[3]	OUTPUT	LREAL	0.0	z coordinate	
Position[4]	OUTPUT	LREAL	0.0	A coordinate	
Position[5]	OUTPUT	LREAL	0.0	B coordinate[1)]	
Position[6]	OUTPUT	LREAL	0.0	C coordinate[1)]	
Velocity	OUTPUT	ARRAY[1..6] OF LREAL	-	Cartesian velocity of the TCP	
Velocity[1]	OUTPUT	LREAL	0.0	Velocity in x direction	
Velocity[2]	OUTPUT	LREAL	0.0	Velocity in y direction	
Velocity[3]	OUTPUT	LREAL	0.0	Velocity in z direction	
Velocity[4]	OUTPUT	LREAL	0.0	Velocity of rotation A	
Velocity[5]	OUTPUT	LREAL	0.0	Velocity of rotation B[1)]	
Velocity[6]	OUTPUT	LREAL	0.0	Velocity of rotation C[1)]	
Acceleration	OUTPUT	ARRAY[1..6] OF LREAL	-	Cartesian acceleration of the TCP	
Acceleration[1]	OUTPUT	LREAL	0.0	Acceleration in x direction	
Acceleration[2]	OUTPUT	LREAL	0.0	Acceleration in y direction	
Acceleration[3]	OUTPUT	LREAL	0.0	Acceleration in z direction	

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint position in the JCS corresponds to the axis position in the MCS.

Parameter	Declaration	Data type	Default value	Description
Acceleration[4]	OUTPUT	LREAL	0.0	Acceleration of rotation A
Acceleration[5]	OUTPUT	LREAL	0.0	Acceleration of rotation B[1)]
Acceleration[6]	OUTPUT	LREAL	0.0	Acceleration of rotation C[1)]
LinkConstellation	OUTPUT	DINT	0	Joint position information The joint position space is specified depending on the respective kinematics type (Page 58). The parameter is to be interpreted bit by bit.

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint position in the JCS corresponds to the axis position in the MCS.

14.4.3 MC_InverseKinematicsTransformation V10

14.4.3.1 MC_InverseKinematicsTransformation: Convert Cartesian coordinates to axis coordinates V10

Description

With the Motion Control instruction "MC_InverseKinematicsTransformation", you convert Cartesian coordinates, velocity and acceleration of the tool center point (TCP) to the setpoints of positions, velocity and acceleration of the kinematics axes or joints. The active tool is hereby taken into consideration.

You can use the instruction to test, for example, whether specific Cartesian positions can be reached with the kinematics or whether software limit switches of the axes or joint traversing ranges are violated with kinematics movements.

The instruction is for information purposes only - the kinematics is not moved.

Use the Motion Control instruction "MC_InverseKinematicsTransformation" in the following organization blocks, depending on the kinematics type and the transformation of the values:

Transformation of values	Predefined kinematics	User-defined kinematics
Synchronous to the MC_Servo or MC_Interpolator cycle	MC_PreServo MC_PostServo MC_PreInterpolator	MC_PreInterpolator **Note** The call in MC_PreServo and MC_PostServo triggers technology alarm 803.
In the Main cycle	Main	Main

Applies to

- Kinematics

Requirements

- The technology object has been configured correctly.

Override response

- An "MC_InverseKinematicsTransformation" job cannot be aborted by any other Motion Control job.
- A new "MC_InverseKinematicsTransformation" job does not abort any active Motion Control jobs.

Parameters

The following table shows the parameters of the Motion Control instruction "MC_InverseKinematicsTransformation":

Parameter	Declaration	Data type	Default value	Description	
AxesGroup	INPUT	TO_Kinematics	-	Technology object	
Enable	INPUT	BOOL	FALSE	TRUE	The calculation is carried out in the cycle of the calling organization block.
Position	INPUT	ARRAY[1..6] OF LREAL	-	Cartesian position of the TCP in the reference coordinate system	
Position[1]	INPUT	LREAL	0.0	x coordinate	
Position[2]	INPUT	LREAL	0.0	y coordinate	
Position[3]	INPUT	LREAL	0.0	z coordinate	
Position[4]	INPUT	LREAL	0.0	A-coordinate	
Position[5]	INPUT	LREAL	0.0	B coordinate[1)]	
Position[6]	INPUT	LREAL	0.0	C coordinate[1)]	
Velocity	INPUT	ARRAY[1..6] OF LREAL	-	Cartesian velocity of the TCP	
Velocity[1]	INPUT	LREAL	0.0	Velocity in x direction	
Velocity[2]	INPUT	LREAL	0.0	Velocity in y direction	
Velocity[3]	INPUT	LREAL	0.0	Velocity in z direction	
Velocity[4]	INPUT	LREAL	0.0	Velocity of rotation A	
Velocity[5]	INPUT	LREAL	0.0	Velocity of rotation B[1)]	
Velocity[6]	INPUT	LREAL	0.0	Velocity of rotation C[1)]	
Acceleration	INPUT	ARRAY[1..6] OF LREAL	-	Cartesian acceleration of the TCP	
Acceleration[1]	INPUT	LREAL	0.0	Acceleration in x direction	
Acceleration[2]	INPUT	LREAL	0.0	Acceleration in y direction	
Acceleration[3]	INPUT	LREAL	0.0	Acceleration in z direction	
Acceleration[4]	INPUT	LREAL	0.0	Acceleration of rotation A	

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint position in the JCS corresponds to the axis position in the MCS.

Parameter	Declaration	Data type	Default value	Description	
Acceleration[5]	INPUT	LREAL	0.0	Acceleration of rotation B[1]	
Acceleration[6]	INPUT	LREAL	0.0	Acceleration of rotation C[1]	
CoordSystem	INPUT	DINT	0	Reference coordinate system of the input parameters	
				0	World coordinate system (WCS)
				1	Object coordinate system 1 (OCS1)
				2	Object coordinate system 2 (OCS2)
				3	Object coordinate system 3 (OCS3)
LinkConstellation	INPUT	DINT	0	Joint position information The joint position space is specified depending on the respective kinematics type (Page 58). The parameter is to be interpreted bit by bit.	
AxesCoordSystem	INPUT	DINT	100	Reference coordinate system of the output parameters	
				100	Machine coordinate system (MCS)
				101	Joint coordinate system (JCS)[1] [2]
TurnJoint	INPUT	ARRAY [1..6] OF DINT	-	Target joint position range of the joint J[1..6][1]	
TurnJoint[1..6]	INPUT	DINT	0	m (m < 0)	-180° + m · 360° ≤ Position < 180° + m · 360°
				-2	-900 ≤ position < -540
				-1	-540 ≤ position < -180
				0	Basic joint position area: -180 ≤ position < 180
				1	-180 ≤ position < 180
				2	180 ≤ position < 540
				3	540 ≤ position < 900
				n (n > 0)	-180° + (n - 1) · 360° ≤ Position < 180° + (n - 1) · 360°
Valid	OUTPUT	BOOL	FALSE	TRUE	The output parameters are valid.
Busy	OUTPUT	BOOL	FALSE	TRUE	The job is being processed.
Error	OUTPUT	BOOL	FALSE	TRUE	An error occurred while processing the job. The job is rejected. The cause of the error can be found in the "ErrorID" parameter.
ErrorID	OUTPUT	WORD	16#0000	Error ID for parameter "ErrorID" You can find more detailed information in the "Error IDs" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.	
AxesPosition	OUTPUT	ARRAY[1..6] OF LREAL	-	When "AxesCoordSystem" = 100: Positions of the kinematics axes	

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint position in the JCS corresponds to the axis position in the MCS.

Parameter	Declaration	Data type	Default value	Description
AxesPosition	OUTPUT	ARRAY[1..6] OF LREAL	-	When "AxesCoordSystem" = 101[1]: Positions of the joints
AxesPosition[1..6]	OUTPUT	LREAL	0.0	When "AxesCoordSystem" = 100: Position of the axis A[1..6]
				When "AxesCoordSystem" = 101[1]: Position of the joint J[1..6]
AxesVelocity	OUTPUT	ARRAY[1..6] OF LREAL	-	When "AxesCoordSystem" = 100: Velocity of kinematics axes
				When "AxesCoordSystem" = 101[1]: Velocity of the joints
AxesVelocity[1..6]	OUTPUT	LREAL	0.0	When "AxesCoordSystem" = 100: Velocity of axis A[1..6]
				When "AxesCoordSystem" = 101[1]: Velocity of the joint J[1..6]
AxesAcceleration	OUTPUT	ARRAY[1..6] OF LREAL	-	When "AxesCoordSystem" = 100: Acceleration of the kinematics axes
				When "AxesCoordSystem" = 101[1]: Acceleration of the joints
AxesAcceleration[1..6]	OUTPUT	LREAL	0.0	When "AxesCoordSystem" = 100: Acceleration of the axis A[1..6]
				When "AxesCoordSystem" = 101[1]: Acceleration of the joint J[1..6]

1) Only relevant with more than 4 interpolating kinematics axes.

2) With up to 4 interpolating kinematics axes, the joint position in the JCS corresponds to the axis position in the MCS.

14.5 Override response of Motion Control jobs V10

14.5.1 Override response V10: Homing and motion jobs

The following table shows how a new Motion Control job affects active homing and motion jobs:

⇒ **Active job** ⇓ **New job**	**MC_Home "Mode" = 2-, 8, 10**	**MC_Home "Mode" = 3, 5**	**MC_Halt "Mode" = 1 MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 0, 1 active MC_Move-Velocity MC_MoveJog**	**MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 1 waiting**	**MC_Halt "Mode" = 0**	**MC_Stop**	**MC_Move-Super-imposed MC_Motion-InSuper-imposed MC_Motion-InSuper-imposed-Axes MC_Halt-Super-imposed**	**MC_Motion-InVelocity MC_Motion-InPosition**
MC_Home[1)] "Mode" = 3, 5	A	A	A	A	A	N	A	A
MC_Home "Mode" = 9	A	-	-	-	-	N	-	-
MC_Halt "Mode" = 1	-	A	A	A	-	N	-	A
MC_Halt "Mode" = 0 **MC_MoveAbsolute/ MC_MoveRelative/ MC_PositionProfile** "BufferMode" = 0 Active **MC_MoveVelocity MC_MoveJog**	-	A	A	A	A	N	A	A

A The running job is aborted with "CommandAborted" = TRUE.

B An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) The status "Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE corresponds to a waiting synchronous operation.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) The status "Busy" = TRUE, "StartSyncOut" = FALSE corresponds to a pending desynchronization job.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) An "MC_CamIn" job with "SyncProfileReference" = 5 does not abort an "MC_[...]Superimposed" job. Running job continues to be executed.

⇒ Active job ⇓ New job	MC_Home "Mode" = 2-, 8, 10	MC_Home "Mode" = 3, 5	MC_Halt "Mode" = 1 MC_MoveAbsolute/ MC_MoveRelative/ MC_PositionProfile "BufferMode" = 0, 1 active MC_MoveVelocity MC_MoveJog	MC_MoveAbsolute/ MC_MoveRelative/ MC_PositionProfile "BufferMode" = 1 waiting	MC_Halt "Mode" = 0	MC_Stop	MC_MoveSuperimposed MC_MotionInSuperimposed MC_MotionInSuperimposedAxes MC_HaltSuperimposed	MC_MotionInVelocity MC_MotionInPosition
MC_MotionInVelocity MC_MotionInPosition								
MC_MoveAbsolute/ MC_MoveRelative/ MC_PositionProfile "BufferMode" = 1 active, waiting	N	N	-/N	N	N	N	-	N
MC_MoveSuperimposed MC_MotionInSuperimposed MC_MotionInSuperimposedAxes MC_HaltSuperImposed	-	-	-	-	-	N	A	-
MC_Stop	A	A	A	A	A	B	A	A
MC_GearIn MC_GearInVelocity	-	A	A	A	A	N	A	A
MC_GearInPos MC_CamIn waiting[2]	-	-	-	A	-	N	-	-
MC_GearInPos MC_CamIn active[3]	-	A	A	A	A	N	A[6]	A

A The running job is aborted with "CommandAborted" = TRUE.

B An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) The status "Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE corresponds to a waiting synchronous operation.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) The status "Busy" = TRUE, "StartSyncOut" = FALSE corresponds to a pending desynchronization job.

⇒ Active job ⇓ New job	MC_Home "Mode" = 2-, 8, 10	MC_Home "Mode" = 3, 5	MC_Halt "Mode" = 1 MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 0, 1 active MC_Move-Velocity MC_MoveJog	MC_Move-Absolute/ MC_Move-Relative/ MC_Position-Profile "Buffer-Mode" = 1 waiting	MC_Halt "Mode" = 0	MC_Stop	MC_Move-Super-imposed MC_Motion-InSuper-imposed MC_Motion-InSuper-imposed-Axes MC_Halt-Super-imposed	MC_Motion-InVelocity MC_Motion-InPosition
MC_Leading-ValueAdditive	-	-	-	-	-	-	-	-
MC_GearOut MC_CamOut waiting[4)]	N	N	N	N	N	N	-	N
MC_GearOut MC_CamOut active[5)]	N	N	N	N	N	N	A	N

A The running job is aborted with "CommandAborted" = TRUE.

B An "MC_Stop" job is aborted by another "MC_Stop" job with a stop response that is the same or higher.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) The status "Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE corresponds to a waiting synchronous operation.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) The status "Busy" = TRUE, "StartSyncOut" = FALSE corresponds to a pending desynchronization job.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) An "MC_CamIn" job with "SyncProfileReference" = 5 does not abort an "MC_[...]Superimposed" job. Running job continues to be executed.

NOTE

Override response with active fixed stop

With an active force and torque limiting with "MC_TorqueLimiting", running jobs are aborted if the drive is held at the fixed stop with "InClamping" = TRUE.

14.5.2 Override response V10: Synchronous operation jobs

The following table shows how a new Motion Control job affects the motion of the axis on active synchronous operation jobs:

⇒ Active job ⇓ New job	MC_GearIn	MC_GearInVelocity	MC_GearInPos MC_CamIn waiting[2]	MC_GearInPos MC_CamIn active[3]	MC_PhasingAbsolute MC_PhasingRelative	MC_OffsetAbsolute MC_OffsetRelative	MC_LeadingValueAdditive	MC_GearOut MC_CamOut waiting[4]	MC_GearOut MC_CamOut active[5]
MC_Home[1] "Mode" = 3, 5	A	A	-	N	-	-	-	-	A
MC_Halt "Mode" = 0, 1 **MC_MoveAbsolute/ MC_MoveRelative** "BufferMode" = 0 Active **MC_PositionProfile** "BufferMode" = 0 Active **MC_MoveVelocity** **MC_MoveJog**	A	A	-	A	A	A	-	A	A

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) A waiting synchronous operation job ("Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) A pending desynchronization job ("Busy" = TRUE, "StartSyncOut" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) When the following axis is in position-controlled mode, execution of the running job is continued. When the following axis is not in position-controlled mode, the new job is rejected.

7) An "MC_GearOut" job only terminates an "MC_Gear[...]" job. Correspondingly, an "MC_CamOut" job only cancels a "MC_Cam[...]" job.

8) A job with "SyncProfileReference" = 5 aborts a pending synchronous operation. Canceling a pending synchronous operation has no influence on an active synchronous operation.

⇒ Active job ⇓ New job	MC_GearIn	MC_GearInVelocity	MC_GearInPos MC_CamIn waiting[2]	MC_GearInPos MC_CamIn active[3]	MC_PhasingAbsolute MC_PhasingRelative	MC_OffsetAbsolute MC_OffsetRelative	MC_LeadingValueAdditive	MC_GearOut MC_CamOut waiting[4]	MC_GearOut MC_CamOut active[5]
MC_MoveAbsolute/-MC_MoveRelative "BufferMode" = 1 active, waiting **MC_PositionProfile** "BufferMode" = 1 active, waiting	N	N	-	N	N	N	-	N	N
MC_MotionInVelocity **MC_MotionInPosition**	A	A	-	A	A	A	-	A	A
MC_MoveSuperimposed **MC_MotionInSuperimposed** **MC_MotionInSuperimposedAxes** **MC_HaltSuperImposed**	-	-/N[6]	-	-	-	-	-	-	-
MC_Stop	A	A	A	A	A	A	-	A	A

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) A waiting synchronous operation job ("Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) A pending desynchronization job ("Busy" = TRUE, "StartSyncOut" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) When the following axis is in position-controlled mode, execution of the running job is continued. When the following axis is not in position-controlled mode, the new job is rejected.

7) An "MC_GearOut" job only terminates an "MC_Gear[...]" job. Correspondingly, an "MC_CamOut" job only cancels a "MC_Cam[...]" job.

8) A job with "SyncProfileReference" = 5 aborts a pending synchronous operation. Canceling a pending synchronous operation has no influence on an active synchronous operation.

⇒ Active job ⇓ New job	MC_GearIn	MC_GearInVelocity	MC_GearInPos MC_CamIn waiting[2]	MC_GearInPos MC_CamIn active[3]	MC_PhasingAbsolute MC_PhasingRelative	MC_OffsetAbsolute MC_OffsetRelative	MC_LeadingValueAdditive	MC_GearOut MC_CamOut waiting[4]	MC_GearOut MC_CamOut active[5]
MC_GearIn MC_GearInVelocity	A	A	A	A	A	A	-	A	A
MC_GearInPos MC_CamIn waiting[2]	-	-	A	-	-	-	-	A	-
MC_GearInPos MC_CamIn active[3]	A	A[6]	A	A	A	A	-	A	A
MC_PhasingAbsolute MC_PhasingRelative	-	N	-	-	A	N	-	-	N
MC_OffsetAbsolute MC_OffsetRelative	-	N	-	-	N	A	-	-	N
MC_LeadingValueAdditive	-	-	-	-	-	-	A	-	-
MC_GearOut MC_CamOut waiting[4]	-	N	A[7] [8]	-	-	-	-	A[7]	N
MC_GearOut MC_CamOut active[5]	A[7]	N	A[7] [8]	A[7]	A	A	-	A[7]	N

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) In the case of a virtual or simulated axis, the running job is not aborted.

2) A waiting synchronous operation job ("Busy" = TRUE, "StartSync" = FALSE, "InSync" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

3) The status "Busy" = TRUE, "StartSync" or "InSync" = TRUE corresponds to an active synchronous operation.

4) A pending desynchronization job ("Busy" = TRUE, "StartSyncOut" = FALSE) does not abort any active jobs. Abort with an "MC_Power" job is possible.

5) The status "Busy" = TRUE, "StartSyncOut" = TRUE corresponds to an active desynchronization job.

6) When the following axis is in position-controlled mode, execution of the running job is continued. When the following axis is not in position-controlled mode, the new job is rejected.

7) An "MC_GearOut" job only terminates an "MC_Gear[...]" job. Correspondingly, an "MC_CamOut" job only cancels a "MC_Cam[...]" job.

8) A job with "SyncProfileReference" = 5 aborts a pending synchronous operation. Canceling a pending synchronous operation has no influence on an active synchronous operation.

NOTE
Override response with active fixed stop
With an active force and torque limiting with "MC_TorqueLimiting", running jobs are aborted if the drive is held at the fixed stop with "InClamping" = TRUE.

14.5.3 Override response V10: Measuring input jobs

The following table shows which new Motion Control jobs will override active measuring input jobs:

⇒ **Active job** ⇓ **New job**	**MC_MeasuringInput**	**MC_MeasuringInputCyclic**
MC_Home "Mode" = 2, 3, 5, 8, 9, 10	B	B
MC_Home "Mode" = 0, 1, 6, 7, 11, 12	-	-
MC_MeasuringInput **MC_MeasuringInputCyclic** **MC_AbortMeasuringInput**	A	A

A The running job is aborted with "CommandAborted" = TRUE.

B The running job is aborted with "ErrorID" = 16#80A3.

- No effect. Running job continues to be executed.

14.5.4 Override response V10: Kinematics motion commands

Single axis jobs are not overridden by kinematics jobs.

The following table shows how a new Motion Control job affects active kinematics motion jobs:

⇒ **Active job** ⇓ **New job**	**MC_MoveLinearAbsolute** **MC_MoveLinearRelative** **MC_MoveCircularAbsolute** **MC_MoveCircularRelative** **MC_MoveDirectAbsolute** **MC_MoveDirectRelative** **MC_TrackConveyorBelt** **MC_DefineWorkspaceZone** **MC_DefineKinematicsZone** **MC_SetWorkspaceZoneActive** **MC_SetWorkspaceZoneInactive** **MC_SetKinematicsZoneActive** **MC_SetKinematicsZoneInactive** **MC_SetOcsFrame**	**MC_GroupInterrupt**	**MC_GroupStop**
MC_Home **MC_MoveSuperimposed** **MC_GearOut** **MC_CamOut**	N	N	N
MC_Halt **MC_MoveAbsolute/** **MC_MoveRelative/** **MC_PositionProfile** "BufferMode" = 0 Active **MC_MoveVelocity** **MC_MoveJog** **MC_Stop** **MC_GearIn** **MC_GearInPos** **MC_GearInVelocity** **MC_CamIn** **MC_MotionInVelocity** **MC_MotionInPosition**	A	A	A
MC_GroupStop	A	A	N
MC_GroupInterrupt **MC_GroupContinue**	B	A	N
MC_MoveLinearAbsolute **MC_MoveLinearRelative** **MC_MoveCircularAbsolute** **MC_MoveCircularRelative** **MC_MoveDirectAbsolute** **MC_MoveDirectRelative** **MC_TrackConveyorBelt**	-	-	N

⇒ Active job ⇓ New job	MC_MoveLinearAbsolute MC_MoveLinearRelative MC_MoveCircularAbsolute MC_MoveCircularRelative MC_MoveDirectAbsolute MC_MoveDirectRelative MC_TrackConveyorBelt MC_DefineWorkspaceZone MC_DefineKinematicsZone MC_SetWorkspaceZoneActive MC_SetWorkspaceZoneInactive MC_SetKinematicsZoneActive MC_SetKinematicsZoneInactive MC_SetOcsFrame	MC_GroupInterrupt	MC_GroupStop
MC_DefineWorkspaceZone MC_DefineKinematicsZone MC_SetWorkspaceZoneActive MC_SetWorkspaceZoneInactive MC_SetKinematicsZoneActive MC_SetKinematicsZoneInactive			
MC_SetOcsFrame	C, -	-	N

A The running job is aborted with "CommandAborted" = TRUE.

B Running job is interrupted or resumed.

C Synchronization of the OCS with the conveyor belt is aborted with "MC_SetOcsFrame" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed. A new kinematics job is added to the job sequence.

14.5.5 Override response V10: Interpreter jobs

The following table shows how a new Motion Control job affects running Interpreter jobs:

⇒ Active job ⇓ New job	MC_LoadProgram	MC_RunProgram	MC_StopProgram
MC_LoadProgram	N	N	N
MC_RunProgram	-[1]	N	N
MC_StopProgram	A	A	A[2]
MC_Reset	-/N[3]	-/N[3]	-/N[3]

A The running job is aborted with "CommandAborted" = TRUE.

N Not permitted. Running job continues to be executed. The new job is rejected.

- No effect. Running job continues to be executed.

1) The new job is also executed.

2) A new "MC_StopProgram" job with "Mode" = 0 cancels a running "MC_StopProgram" job with "Mode" = 1 or 2. A new "MC_StopProgram" job with "Mode" = 1 aborts a current "MC_StopProgram" job with "Mode" = 2.

3) An "MC_Reset" job with "Restart" = TRUE is rejected. Running job continues to be executed.

Override response for technology objects controlled by the Interpreter

The following table shows how a new Motion Control job acts in relation to a technology object controlled by the Interpreter during the execution of an Interpreter program ("<TO>.StatusInterpreterMotion.StatusWord.X0" = TRUE (ControlledByInterpreter)):

⇓ New job	The new job will be executed.	The new job aborts the execution of the Interpreter program.
MC_Power disable/enable with technology object	✓	✓
MC_Reset with "Restart" = TRUE	✓	✓
MC_Reset with "Restart" = FALSE	✓	-
MC_Home **MC_Halt** **MC_Stop**	✓	✓
MC_MoveAbsolute **MC_MoveRelative** **MC_MoveVelocity** **MC_MoveJog**	✓	✓
MC_SetAxisSTW **MC_WriteParameter**	✓	-
MC_MoveSuperimposed **MC_MotionInSuperimposed** **MC_MotionInSuperimposedAxes** **MC_HaltSuperimposed**	-	-
MC_MotionInVelocity **MC_MotionInPosition**	✓	✓
MC_GearIn **MC_GearInPos** **MC_GearInVelocity** **MC_GearOut** **MC_CamIn** **MC_CamOut**	✓	✓[1)]
MC_PhasingRelative **MC_PhasingAbsolute**	-	-
MC_LeadingValueAdditive	✓	-
MC_OffsetRelative **MC_OffsetAbsolute**	-	-
MC_TorqueAdditive **MC_TorqueRange**	✓	-
MC_TorqueLimiting	✓	-/✓[2)]
MC_SynchronizedMotionSimulation	✓	-

1) When the synchronization/desynchronization starts, the execution of the Interpreter program is cancelled.

2) If a technology alarm is issued due to a fixed stop, the execution of the Interpreter program is cancelled.

⇓ New job	The new job will be executed.	The new job aborts the execution of the Interpreter program.
MC_MoveLinearAbsolute **MC_MoveLinearRelative** **MC_MoveCircularAbsolute** **MC_MoveCircularRelative** **MC_MoveDirectAbsolute** **MC_MoveDirectRelative**	-	-
MC_GroupInterrupt **MC_GroupContinue**	-	-
MC_GroupStop	✓	✓
MC_KinematicsMotionSimulation	✓	-
MC_TrackConveyorBelt	-	-
MC_DefineTool **MC_SetTool** **MC_SetOcsFrame**	-	-
MC_KinematicsTransformation **MC_InverseKinematicsTransformation**	✓	-
MC_DefineWorkspaceZone **MC_SetWorkspaceZoneActive** **MC_SetWorkspaceZoneInactive** **MC_DefineKinematicsZone** **MC_SetKinematicsZoneActive** **MC_SetKinematicsZoneInactive**	-	-

1) When the synchronization/desynchronization starts, the execution of the Interpreter program is cancelled.

2) If a technology alarm is issued due to a fixed stop, the execution of the Interpreter program is cancelled.

NOTE

MC_Power

Note that a "MC_Power" request with "Enable" = FALSE always locks the specified technology object, even if the technology object was enabled via an Interpreter program with "powerOn()".

Mixed operation of MC_Power (SCL) and powerOn() (MCL) is not permitted.

NOTE

MC_Stop

Note that when starting a motion controlled by the Interpreter no "MC_Stop" job may be active, otherwise the motion job will be aborted.

NOTE

MC_GroupStop

Note that when starting a kinematics motion controlled by the Interpreter, no "MC_GroupStop" job may be active, otherwise the motion job will be aborted.

A "MC_GroupStop" job only affects active kinematics motions or if the kinematics technology object is controlled by the Interpreter ("<TO>.StatusInterpreterMotion.StatusWord.X0" = TRUE (ControlledByInterpreter)).

See also

Override response V10: Homing and motion jobs (Page %getreference)
Override response V10: Synchronous operation jobs (Page %getreference)
Override response V10: Kinematics motion commands (Page %getreference)

Tags of the technology object data blocks 15

15.1 Legend

Tag	Name of the tag	
Data type	Data type of the tag	
Values	Value range of the tag - minimum value to maximum value (L - linear specification R - rotary specification) If no specific value is shown, the value range limits of the relevant data type apply or the information under "Description".	
W	Effectiveness of changes in the technology data block	
	DIR	Direct: Values are changed via direct assignment and take effect at the start of the next MC_Servo.
	CAL	At call of Motion Control instruction: Values are changed directly and take effect at the start of the next MC_Servo after the call of the corresponding Motion Control instruction in the user program.
	RES	Restart: Changes to the start value in the load memory are made using the extended instruction "WRIT_DBL" (write to DB in load memory). Changes will not take effect until after restart of the technology object.
	RON	Read only: The tag cannot and must not be changed during runtime of the user program.
Description	Description of the tag	

Access to the tags is with "<TO>.<tag name>". The placeholder <TO> represents the name of the technology object.

15.2 Tags of the kinematics technology object

15.2.1 "Tcp" tag (kinematics)

The tag structure "<TO>.Tcp.<Tag name>" contains the position of the tool center point (TCP), the TCP frame in the World Coordinate System (WCS).

Tags

Legend

Tag		Data type	Values	W	Description
Tcp.		TO_Struct_Kinematics_StatusKinematicsFrameTcp			
	x	LREAL	-1.0E12 ... 1.0E12	RON	x coordinate
	y	LREAL	-1.0E12 ... 1.0E12	RON	y coordinate
	z	LREAL	-1.0E12 ... 1.0E12	RON	z coordinate
	a	LREAL	-180.0 to 179.999	RON	A coordinate
	b	LREAL	-90.0 to 90.0	RON	B coordinate
	c	LREAL	-180.0 to 179.999	RON	C coordinate

See also

Tags: Coordinate systems and frames (Page 208)

15.2.2 "Kinematics" tag (kinematics)

The tag structure "<TO>.Kinematics.<Tag name>" contains the defined kinematics type.

Tags

Legend

Tag		Data type	Values	W	Description	
Kinematics.		TO_Struct_Kinematics_Kinematics				
	TypeOfKinematics	DINT	1 to 36	RON	Kinematics type The configuration is performed using the function view.	
					1	Cartesian portal 2D
					2	Cartesian portal 2D with orientation
					3	Cartesian portal 3D
					4	Cartesian portal 3D with orientation
					5	Roller picker 2D
					6	Roller picker 2D with orientation

Tag	Data type	Values	W	Description	
TypeOfKinematics	DINT	1 to 36	RON	7	Roller picker 3D (vertical)
				8	Roller picker 3D with orientation (vertical)
				9	Roller picker 3D with orientation (horizontal)
				10	SCARA 3D with orientation
				11	Articulated arm 2D
				12	Articulated arm 2D with orientation
				13	Articulated arm 3D
				14	Articulated arm 3D with orientation
				15	Delta picker 2D
				16	Delta picker 2D with orientation
				17	Delta picker 3D
				18	Delta picker 3D with orientation
				19	Reserved
				20	SCARA 2D with orientation
				21	Cylindrical robot 3D
				22	Cylindrical robot 3D with orientation
				23	Tripod 3D
				24	Tripod 3D with orientation
				25	6-axis articulated arm with central wrist
				26	Cartesian portal 3D with 2 orientations A, B
				27	Delta picker 3D with 2 orientations A, B
				28	6-axis articulated arm with offset wrist
				29 ... 30	Reserved
				31	User-defined 2D
				32	User-defined 2D with orientation A
				33	User-defined 3D
				34	User-defined 3D with orientation A
				36	User-defined 3D with 3 orientations
Parameter[1..32]	ARRAY [1..32] OF LREAL	-1.0E12 ... 1.0E12	RES	Kinematics-specific parameters	

See also

Tags: Cartesian portal (Page 71)
Tags: Delta picker (Page 158)
Tags: Roller picker (Page 86)
Tags: Articulated arm (Page 139)
Tags: Cylindrical robot (Page 167)
Tags: Tripod (Page 175)
Tags: SCARA (Page 95)

Tags: User-defined kinematics systems (Page 176)

15.2.3 "KcsFrame" tag (kinematics)

The tag structure "<TO>.KcsFrame.<Tag name>" contains the frame of the Kinematic Coordinate System (KCS) in the World Coordinate System (WCS).

Tags

Legend

Tag	Data type	Value range	W	Description
KcsFrame.	TO_Struct_Kinematics_Frame			
x	LREAL	-1.0E12 ... 1.0E12	RES	x coordinate
y	LREAL	-1.0E12 ... 1.0E12	RES	y coordinate
z	LREAL	-1.0E12 ... 1.0E12	RES	z coordinate
a	LREAL		RES	A coordinate
		0.0		With kinematics type: • "2D" • "2D with orientation"
		-180.0 to 179.9-99		With kinematics type: • "3D" • "3D with orientation" • "3D with 2 orientations" • "3D with 3 orientations" • "with central wrist" • "with offset wrist"
b	LREAL		RES	B coordinates
		0.0		With kinematics type: • "2D with orientation" • "3D with orientation" • "3D with 2 orientations"
		-90.0 to 90.0		With kinematics type: • "3D" • "with central wrist" • "with offset wrist"
		-180.0 to 179.9-99		With kinematics type: • "2D"
c	LREAL		RES	C coordinates
		0.0		With kinematics type: • "2D" • "2D with orientation" • "3D with orientation" • "3D with 2 orientations"

Tag	Data type	Value range	W	Description
c	LREAL	-180.0 to 179.9-99	RES	With kinematics type: • "3D" • "3D with 3 orientations" • "with central wrist" • "with offset wrist"

See also

Tags: Coordinate systems and frames (Page 208)

15.2.4 "OcsFrame[1..3]" tag (kinematics)

The tag structure "<TO>.OcsFrame[1..3].<Tag name>" contains the frames of the Object Coordinate Systems 1 to 3 (OCS) in the World Coordinate System (WCS).

Tags

Legend

Tag	Data type	Value range	W	Description
OcsFrame[1..3].	ARRAY [1..3] OF TO_Struct_Kinematics_Frame			
x	LREAL	-1.0E12 ... 1.0E12	RES	x coordinate
y	LREAL	-1.0E12 ... 1.0E12	RES	y coordinate
z	LREAL	-1.0E12 ... 1.0E12	RES	z coordinate
a	LREAL		RES	A-coordinate
		0.0		With kinematics type: • "2D" • "2D with orientation"
		-180.0 to 179.9-99		With kinematics type: • "3D" • "3D with orientation" • "3D with 2 orientations" • "3D with 3 orientations" • "with central wrist" • "with offset wrist"
b	LREAL		RES	B coordinates
		0.0		With kinematics type: • "2D with orientation" • "3D with orientation" • "3D with 2 orientations"
		-90.0 to 90.0		With kinematics type: • "3D" • "with central wrist" • "with offset wrist"

Tag	Data type	Value range	W	Description
b	LREAL	-180.0 to 179.9-99	RES	With kinematics type "2D"
c	LREAL		RES	C coordinates
		0.0		With kinematics type: • "2D" • "2D with orientation" • "3D with orientation" • "3D with 2 orientations"
		-180.0 to 179.9-99		With kinematics type: • "3D" • "3D with 3 orientations" • "with central wrist" • "with offset wrist"

See also

Tags: Coordinate systems and frames (Page 208)

15.2.5 "Tool[1..3]" tag (kinematics)

The tag structure "<TO>.Tool[1..3].<Tag name>" contains the tool frame in the Flange Coordinate System (FCS).

Tags

Legend

Tag	Data type	Value range	W	Description
Tool[1..3].	ARRAY [1..3] OF TO_Struct_Kinematics_Tool			
Frame.	TO_Struct_Kinematics_KinematicsFrame			
x	LREAL	-1.0E12 ... 1.0E12	RES	x coordinate in the FCS
y	LREAL	-1.0E12 ... 1.0E12	RES	y coordinate in the FCS
z	LREAL	-1.0E12 ... 1.0E12	RES	z coordinate in the FCS
a	LREAL		RES	A coordinate
		0.0		With kinematics type: • "2D" • "3D" • "3D with 2 orientations A, B"
		-180.0 to 179.9-99		With kinematics type: • "2D with orientation" • "3D with orientation" • "3D with 3 orientations" • "with central wrist" • "with offset wrist"

Tag	Data type	Value range	W	Description
b	LREAL		RES	B coordinates
		0.0		With kinematics type: • "2D" • "2D with orientation" • "3D" • "3D with orientation"
		-180.0 to 179.9-99		With kinematics type: • "3D with 2 orientations A, B"
		-90.0 to 90.0		With kinematics type: • "3D with 3 orientations" • "with central wrist" • "with offset wrist"
c	LREAL		RES	C coordinates
		0.0		With kinematics type: • "2D" • "2D with orientation" • "3D" • "3D with orientation" • "3D with 2 orientations A, B"
		-180.0 to 179.9-99		With kinematics type: • "3D with 3 orientations" • "with central wrist" • "with offset wrist"

See also

Tags: Coordinate systems and frames (Page 208)

15.2.6 "DynamicDefaults" tag (kinematics)

The tag structure "<TO>.DynamicDefaults.<Tag name>" contains the configuration of the dynamic presets. These settings will be used when you specify a dynamic value less than 0.0 for a Motion Control instruction. Changes to the default dynamics will be applied at the next positive edge at the "Execute" parameter of a Motion Control instruction.

Tags

Legend

Tag	Data type	Values	W	Description
DynamicDefaults.	TO_Struct_Kinematics_DynamicDe-faults			
Path.	TO_Struct_Kinematics_Dynamics			
Velocity	LREAL	0.0 to 1.0E12	DIR	Default setting of the velocity of the path
Acceleration	LREAL	0.0 to 1.0E12	DIR	Default setting of the acceleration of the path
Deceleration	LREAL	0.0 to 1.0E12	DIR	Default setting of the deceleration of the path
Jerk	LREAL	0.0 to 1.0E12	DIR	Default setting of the jerk of the path

Tag	Data type	Values	W	Description
Orientation.	TO_Struct_Kinematics_Orientation-Dynamics			
Velocity	LREAL	0.0 to 1.0E12	DIR	Default setting of the velocity of the Cartesian orientation
Acceleration	LREAL	0.0 to 1.0E12	DIR	Default setting of the acceleration of the Cartesian orientation
Deceleration	LREAL	0.0 to 1.0E12	DIR	Default setting of the deceleration of the Cartesian orientation
Jerk	LREAL	0.0 to 1.0E12	DIR	Default setting of the jerk of the Cartesian orientation
DynamicAdaption	DINT	0 to 2	CAL	Default setting of the dynamic adaptation
				0 No dynamic adaptation
				1 Dynamic adaptation with segmentation of the path
				2 Dynamic adaptation without segmentation of the path
MoveDirect	TO_Struct_Kinematics_MoveDirect-Dynamics			
VelocityFactor	LREAL	0.0 to 1.0E12	CAL	Factor for the velocity of the axis motions in relation to the respective maximum velocity of the axes with sPTP motion.
AccelerationFactor	LREAL	0.0 to 1.0E12	CAL	Factor for the acceleration of the axis motions in relation to the respective maximum acceleration of the axes with sPTP motion.
DecelerationFactor	LREAL	0.0 to 1.0E12	CAL	Factor for the deceleration of the axis motions in relation to the respective maximum deceleration of the axes with sPTP motion.
JerkFactor	LREAL	0.0 to 1.0E12	CAL	Factor for the jerk of the axis motions in relation to the respective maximum jerk of the axes with sPTP motion.

See also

Tags: Kinematics motions (Page 235)

15.2.7 "DynamicLimits" tag (kinematics)

The tag structure "<TO>.DynamicLimits.<Tag name>" contains the configuration of the dynamic limits. During Motion Control, no dynamic values greater than the dynamic limits are permitted. If you specify greater values in a Motion Control instruction, then motion is performed using the dynamic limits, and a warning is indicated (alarm 501 to 503 - Dynamic values are limited).

Tags

Legend

Tag	Data type	Values	W	Description
DynamicLimits.	TO_Struct_Kinematics_DynamicLimits			
Path.	TO_Struct_Kinematics_Dynamics			

Tag	Data type	Values	W	Description
Velocity	LREAL	0.0 to 1.0E12	DIR	Dynamic limitation for the maximum velocity of the path
Acceleration	LREAL	0.0 to 1.0E12	DIR	Dynamic limitation for the maximum acceleration of the path
Deceleration	LREAL	0.0 to 1.0E12	DIR	Dynamic limitation for the maximum deceleration of the path
Jerk	LREAL	0.0 to 1.0E12	DIR	Dynamic limitation for the maximum jerk of the path
Orientation.	TO_Struct_Kinematics_Orientation-Dynamics			
Velocity	LREAL	0.0 to 1.0E12	DIR	Dynamic limitation for the maximum velocity of the Cartesian orientation
Acceleration	LREAL	0.0 to 1.0E12	DIR	Dynamic limitation for the maximum acceleration of the Cartesian orientation
Deceleration	LREAL	0.0 to 1.0E12	DIR	Dynamic limitation for the maximum deceleration of the Cartesian orientation
Jerk	LREAL	0.0 to 1.0E12	DIR	Dynamic limitation for the maximum jerk of the Cartesian orientation

See also

Tags: Kinematics motions (Page 235)

15.2.8 "Joint" tag (kinematics)

The tag structure "<TO>.Joint.<Tag name>" contains the configuration of the joints for kinematics types with more than four interpolating kinematics axes.

Tags

Legend

Tag	Data type	Value range	W	Description	
Joint.	TO_Struct_Kinematics_Joint				
J[1..6].	ARRAY [1..6] OF TO_Struct_Kinematics_JointParamet-ers				
InverseDirection	BOOL	-	RES	FALSE	Direction of movement of the joint corresponds to the defined direction of movement of the kin-ematics type (Page 58)
				TRUE	Direction of movement of the joint is inverse to the defined direction of movement of the kin-ematics type (Page 58)

1) If position values with higher resolution are used

Tag	Data type	Value range	W	Description
Offset	LREAL	-1.0E12 ... 1.0E12	RES	Difference between the defined zero position of the joint of the kinematics type (Page 58) and the mechanical zero position of the joint at the kinematics used
LowerLimit	LREAL	-5.0E11 ... 5.0E11, -5.0E8 ... 5.0E8 [1]	RES	Lower limit of the joint traversing range
UpperLimit	LREAL	-5.0E11 ... 5.0E11, -5.0E8 ... 5.0E8 [1]	RES	Upper limit of the joint traversing range

[1] If position values with higher resolution are used

15.2.9 "AxisCoupling" tag (kinematics)

The tag structure "<TO>.AxisCoupling.<Tag name>" contains the configuration of the mechanical axis coupling for kinematics types with more than four interpolating kinematics axes.

Tags

Legend

Tag	Data type	Value range	W	Description	
AxisCoupling.	TO_Struct_Kinematics_AxisCoupling				
N[1..5].	ARRAY [1..5] OF TO_Struct_Kinematics_AxisCoupling-Parameters				
Enable	BOOL	-	RES	FALSE	Mechanical axis coupling is disabled
				TRUE	Mechanical axis coupling is enabled
CausingAxis	DINT	1 to 6	RES	Mechanically coupled axis that is moved	
AffectedAxis	DINT	1 to 6	RES	Mechanically coupled axis that is also moved	
Factor	LREAL	-1.0E12 ... 1.0E12	RES	Coupling factor	

15.2.10 "MotionQueue" tag (kinematics)

The tag structure "<TO>.MotionQueue.<Tag name>" contains the configuration of parameters of the job sequence.

Tags

Legend

Tag	Data type	Values	W	Description
MotionQueue.	TO_Struct_Kinematics_MotionQueue			
MaxNumberOfCommands	DINT	1 to 10	RON	Maximum number of commands in job sequence The configuration takes place in "Technology object > Configuration > Extended parameters > Job sequence".

See also

Tags: Kinematics motions (Page 235)

15.2.11 "Transition" tag (kinematics)

The tag structure "<TO>.Transition.<tag name>" contains the configuration of motion jobs.

Tags

Legend

Tag	Data type	Values	W	Description	
Transition.	TO_Struct_Kinematics_Transition				
FactorBlendingLength	LREAL	0 to 100.0	DIR	Factor of the maximum rounding distance in percent [%] The configuration takes place in "Technology object > Configuration > Extended parameters > Job sequence". Change the factor in the user program before sending the motion jobs to the job sequence so that the change is effective.	
				= 0.0	No blending possible
				= 50.0	Default This configuration ensures compatibility with projects that are compatible with Motion Control versions < V6.0.
				= 100.0	Blending possible with complete segment length or motion length

15.2.12 "Override" tag (kinematics)

The tag structure "<TO>.Override.<Tag name>" contains the configuration of override parameters.

Tags

Legend

Tag		Data type	Values	W	Description
Override.		TO_Struct_Kinematics_Override			
	Velocity	LREAL	0.0 to 200.0	DIR	Velocity override The following values are permitted as velocity correction: • Path motion: from 0.0% to 200.0% • sPTP motion: from 0.0% to 100.0%

See also

Tags: Kinematics motions (Page 235)

15.2.13 "Conveyor" variable (kinematics)

The tag structure "<TO>.Conveyor.<tag name>" contains the configuration of the Dynamic reserve (Page 299) for the conveyor tracking.

Tags

Legend

Tag		Data type	Value range	W	Description	
Conveyor.		TO_Struct_Kinematics_Conveyor				
	DynamicReserve[1..3]	ARRAY [1..3] OF LREAL	0.0 ... 50.0	RES	Dynamic reserve for dynamics changes during conveyor tracking for object coordinate systems 1 to 3. Value in percent [%].	
					30%	Default setting (default)

15.2.14 "WorkspaceZone[1..10]" tag (kinematics)

The tag structure "<TO>.WorkspaceZone[1..10].<Tag name>" contains the parameter for the workspace zones.

Tags

Legend

Tag		Data type	Values	W	Description	
WorkspaceZone[1..10].		ARRAY [1..10] OF TO_Struct_Kinematics_Work-SpaceZone				
	Active	BOOL	-	RES	FALSE	Workspace zone deactivated

Tag	Data type	Values	W	Description	
Active	BOOL	-	RES	TRUE	Workspace zone activated
Valid	BOOL	-	RES	FALSE	Zone is not defined
				TRUE	Zone is defined
Type	DINT	0 to 2	RES	Type of the workspace zone	
				0	Blocked zone
				1	Work zone
				2	Signal zone
ReferenceSystem	DINT	0 ... 3	RES	Reference coordinate system for the workspace zone	
				0	WCS
				1	OCS1
				2	OCS2
				3	OCS3
Frame.	TO_Struct_Kinematics_Frame				
x	LREAL	-1.0E12 to 1.0E-12	RES	x coordinate	
y	LREAL	-1.0E12 to 1.0E-12	RES	y coordinate	
z	LREAL	-1.0E12 to 1.0E-12	RES	z coordinate	
a	LREAL	-180.0 to 179.9-99	RES	A coordinate	
b	LREAL	-90.0 to 90.0	RES	B coordinate	
c	LREAL	-180.0 to 179.9-99	RES	C coordinate	
Geometry.	TO_Struct_Kinematics_ZoneGeo-metry				
Type	DINT	0 to 2	RES	Zone geometry	
				0	Cuboid
				1	Sphere
				2	Cylinder
Parameter[1..3]	ARRAY [1..3] OF LREAL	0.0 to 1.0E12	RES	1	Length x (cuboid) or radius (sphere, cylinder)
				2	Length y (cuboid) or height (cylinder)
				3	Length z (cuboid)

See also

Tags: Zone monitoring (Page 223)

15.2.15 "KinematicsZone[2..10]" tag (kinematics)

The tag structure "<TO>.KinematicsZone[2..10].<Tag name>" contains the parameters for kinematic zones.

Tags

Legend

Tag	Data type	Values	W	Description	
KinematicsZone[2..10].	ARRAY [2..10] OF TO_Struct_Kinematics_Kinematic-sZone				
Active	BOOL	-	RES	FALSE	Kinematics zone deactivated
				TRUE	Kinematics zone activated
Valid	BOOL	-	RES	FALSE	Zone is not defined
				TRUE	Zone is defined
ReferenceSystem	DINT	0 to 1	RES	Reference coordinate system for the kinematics zone	
				0	FCS
				1	TCS
Frame.	TO_Struct_Kinematics_Frame				
x	LREAL	-1.0E12 to 1.0E-12	RES	x coordinate	
y	LREAL	-1.0E12 to 1.0E-12	RES	y coordinate	
z	LREAL	-1.0E12 to 1.0E-12	RES	z coordinate	
a	LREAL	-180.0 to 179.9-99	RES	A coordinate	
b	LREAL	-90.0 to 90.0	RES	B coordinate	
c	LREAL	-180.0 to 179.9-99	RES	C coordinate	
Geometry.	TO_Struct_Kinematics_ZoneGeo-metry				
Type	DINT	0 to 2	RES	Zone geometry	
				0	Cuboid
				1	Sphere
				2	Cylinder
Parameter[1..3]	ARRAY [1..3] OF LREAL	0.0 to 1.0E12	RES	1	Length x (cuboid) or radius (sphere, cylinder)
				2	Length y (cuboid) or height (cylinder)
				3	Length z (cuboid)

See also

Tags: Zone monitoring (Page 223)

15.2.16 "StatusPath" tag (kinematics)

The tag structure "<TO>.StatusPath.<Tag name>" contains the parameters of the current kinematics movement. With a synchronous "point-to-point" motion (sPTP motion) the parameters "<TO>.StatusPath.Velocity" and "<TO>.StatusPath.Acceleration" = 0.0.

Tags

Legend

Tag	Data type	Values	W	Description	
StatusPath.	TO_Struct_Kinematics_StatusPath				
CoordSystem	DINT	0 ... 100	RON	Coordinate system of the active motion job	
				0	World coordinate system
				1, 2, 3	Object coordinate system 1, 2, 3
				100	Machine coordinate system
				101	Joint coordinate system[1)]
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Current path velocity (setpoint reference)	
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Current path acceleration (setpoint reference)	
OrientationVelocity	LREAL	0 ... 1.0E12	RON	Resulting orientation velocity	
DynamicAdaption	DINT	0 ... 2	RON	Dynamic adaptation	
				0	No dynamic adaptation
				1	Dynamic adaptation with segmentation of the path
				2	Dynamic adaptation without segmentation of the path
TotalPathLength	LREAL	0 ... 1.0E12	RON	Total path length of linear and circular path motions Sum of: • Distance of all completed motion jobs • Distance travelled of the active motion job • Remaining distance of the motion job • Calculated distance of all jobs in the job sequence	
AccumulatedPathLength	LREAL	0 ... 1.0E12	RON	Accumulated path length of linear and circular path motions Sum of: • Distance of all completed motion jobs • Distance travelled of the active motion job	
DynamicLimit	DWORD	-	RON	Dynamic limits affecting the running motion job	

1) Only relevant with more than 4 kinematics axes.

2) Not relevant with sPTP motion

3) Not relevant with orientation motion

Tag	Data type	Values	W	Description	
Bit 0	BOOL	-	RON	"LIMIT_ORIENTATION" Dynamic limits of the orientation motion [2]	
				TRUE	The dynamic response of the current motion is limited by the dynamic limits of the orientation motion.
				FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the orientation motion.
Bit 1	BOOL	-	RON	"LIMIT_PATH" Dynamic limits of the kinematics motion [2]	
				TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics motion.
				FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics motion.
Bit 16	BOOL	-	RON	"LIMIT_AXIS_A1" Dynamic limits of the kinematics axis A1 [3]	
				TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics axis A1.
				FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics axis A1.
					Dynamic adaptation is not activated. [2]
Bit 17	BOOL	-	RON	"LIMIT_AXIS_A2" Dynamic limits of the kinematics axis A2 [3]	
				TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics axis A2.
				FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics axis A2.
					Dynamic adaptation is not activated. [2]
Bit 18	BOOL	-	RON	"LIMIT_AXIS_A3" Dynamic limits of the kinematics axis A3 [3]	
				TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics axis A3.
				FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics axis A3.
					Dynamic adaptation is not activated. [2]

[1] Only relevant with more than 4 kinematics axes.

[2] Not relevant with sPTP motion

[3] Not relevant with orientation motion

Tag		Data type	Values	W	Description	
	Bit 19	BOOL	-	RON	"LIMIT_AXIS_A4" Dynamic limits of the kinematics axis A4 [3]	
					TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics axis A4.
					FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics axis A4.
						Dynamic adaptation is not activated. [2]
	Bit 20	BOOL	-	RON	"LIMIT_AXIS_A5" Dynamic limits of the kinematics axis A5 [3]	
					TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics axis A5.
					FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics axis A5.
						Dynamic adaptation is not activated. [2]
	Bit 21	BOOL	-	RON	"LIMIT_AXIS_A6" Dynamic limits of the kinematics axis A6 [3]	
					TRUE	The dynamic response of the current motion is limited by the dynamic limits of the kinematics axis A6.
					FALSE	The dynamic response of the current motion is not limited by the dynamic limits of the kinematics axis A6.
						Dynamic adaptation is not activated. [2]

[1] Only relevant with more than 4 kinematics axes.

[2] Not relevant with sPTP motion

[3] Not relevant with orientation motion

See also

Tags: Kinematics motions (Page 235)

15.2.17 "TcpInWcs" tag (kinematics)

The tag structure "<TO>.TcpInWcs.<Tag name>" contains the parameters for the tool center point (TCP) in the World Coordinate System (WCS).

Tags

Legend

Tag	Data type	Values	W	Description
TcpInWcs.	TO_Struct_Kinematics_StatusKinematicsFrameWithDynamics			
x.	TO_Struct_Kinematics_StatusMotionVector			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of path coordinate x
Position	LREAL	-1.0E12 ... 1.0E12	RON	Position of path coordinate x
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of path coordinate x
y.	TO_Struct_Kinematics_StatusMotionVector			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of path coordinate y
Position	LREAL	-1.0E12 ... 1.0E12	RON	Position of path coordinate y
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of path coordinate y
z.	TO_Struct_Kinematics_StatusMotionVector			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of path coordinate z
Position	LREAL	-1.0E12 ... 1.0E12	RON	Position of path coordinate z
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of path coordinate z
a.	TO_Struct_Kinematics_StatusMotionVector			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of rotation A
Position	LREAL	-1.0E12 ... 1.0E12	RON	Position of rotation A
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of rotation A
b.	TO_Struct_Kinematics_StatusMotionVector			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of rotation B

Tag	Data type	Values	W	Description
Position	LREAL	-1.0E12 ... 1.0E12	RON	Position of rotation B
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of the rotation B
c.	TO_Struct_Kinematics_StatusMotionVector			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of rotation C
Position	LREAL	-1.0E12 ... 1.0E12	RON	Position of rotation C
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity the rotation C

See also

Tags: Coordinate systems and frames (Page 208)

15.2.18 "TcpInOcs[1..3]" tag (kinematics)

The tag structure "<TO>.TcpInOcs[1..3].<Tag name>" contains the parameters for the tool center point (TCP) in the Object Coordinate Systems 1 to 3 (OCS).

Tags

Legend

Tag	Data type	Values	W	Description
TcpInOcs[1..3].	ARRAY [1..3] OF TO_Struct_Kinematics_StatusKinematicsFrameWithDynamicsOcs			
x.	TO_Struct_Kinematics_StatusMotionVectorOcs			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of the x coordinate of the tool center point in the object coordinate system 1 to 3
Position	LREAL	-1.0E12 ... 1.0E12	RON	x coordinate of the tool center point in the object coordinate system 1 to 3
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of the x coordinate of the tool center point in the object coordinate system 1 to 3
y.	TO_Struct_Kinematics_StatusMotionVectorOcs			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of the y coordinate of the tool center point in the object coordinate system 1 to 3
Position	LREAL	-1.0E12 ... 1.0E12	RON	y coordinate of the tool center point in the object coordinate system 1 to 3
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of the y coordinate of the tool center point in the object coordinate system 1 to 3
z.	TO_Struct_Kinematics_StatusMotionVectorOcs			

Tag			Data type	Values	W	Description
		Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of the z coordinate of the tool center point in the object coordinate system 1 to 3
		Position	LREAL	-1.0E12 ... 1.0E12	RON	z coordinate of the tool center point in the object coordinate system 1 to 3
		Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of the z coordinate of the tool center point in the object coordinate system 1 to 3
	a.		TO_Struct_Kinematics_StatusMotionVectorOcs			
		Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of the A coordinate of the tool center point in the object coordinate system 1 to 3
		Position	LREAL	-1.0E12 ... 1.0E12	RON	A coordinate of the tool center point in the object coordinate system 1 to 3
		Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of the A coordinate of the tool center point in the object coordinate system 1 to 3
	b.		TO_Struct_Kinematics_StatusMotionVectorOcs			
		Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of the B coordinate of the tool center point in the object coordinate system 1 to 3
		Position	LREAL	-1.0E12 ... 1.0E12	RON	B coordinate of the tool center point in the object coordinate system 1 to 3
		Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of the B coordinate of the tool center point in the object coordinate system 1 to 3
	c.		TO_Struct_Kinematics_StatusMotionVectorOcs			
		Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of the C coordinate of the tool center point in the object coordinate system 1 to 3
		Position	LREAL	-1.0E12 ... 1.0E12	RON	C coordinate of the tool center point in the object coordinate system 1 to 3
		Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity the C coordinate of the tool center point in the object coordinate system 1 to 3

See also

Tags: Coordinate systems and frames (Page 208)

15.2.19 "StatusOcsFrame[1..3]" tag (kinematics)

The tag structure "<TO>.StatusOcsFrame[1..3].<Tag name>" contains the frames of the Object Coordinate Systems 1 to 3 (OCS) in the World Coordinate System (WCS).

Tags

Legend

Tag	Data type	Value range	W	Description
StatusOcsFrame[1..3].	ARRAY [1..3] OF TO_Struct_Kinematics_StatusFrame			
x	LREAL	-1.0E12 ... 1.0E12	RON	x coordinate in the WCS
y	LREAL	-1.0E12 ... 1.0E12	RON	y coordinate in the WCS
z	LREAL	-1.0E12 ... 1.0E12	RON	z coordinate in the WCS
a	LREAL		RON	A coordinate in the WCS
		0.0		With kinematics type: • "2D" • "2D with orientation"
		-180.0 to 179.9-99		With kinematics type: • "3D" • "3D with orientation" • "3D with 2 orientations" • "3D with 3 orientations" • "with central wrist" • "with offset wrist"
b	LREAL		RON	B coordinate in the WCS
		0.0		With kinematics type: • "2D with orientation" • "3D with orientation" • "3D with 2 orientations"
		-90.0 to 90.0		With kinematics type: • "3D" • "with central wrist" • "with offset wrist"
		-180.0 to 179.9-99		With kinematics type "2D"
c	LREAL		RON	C coordinate in the WCS
		0.0		With kinematics type: • "2D" • "2D with orientation" • "3D with orientation" • "3D with 2 orientations"

Tag	Data type	Value range	W	Description
c	LREAL	-180.0 to 179.9-99	RON	With kinematics type: • "3D" • "3D with 3 orientations" • "with central wrist" • "with offset wrist"

See also

Tags: Coordinate systems and frames (Page 208)

15.2.20 "StatusKinematics" tag (kinematics)

The tag structure "<TO>.StatusKinematics.<Tag name>" contains the status of the kinematics.

Tags

Legend

Tag	Data type	Values	W	Description	
StatusKinematics.	TO_Struct_Kinematics_StatusKinematics				
Type5D6D	BOOL	-	RON	FALSE	The kinematics type can be operated without "S7-1500T Motion Control KinPlus".
				TRUE	The kinematics type can only be operated with "S7-1500T Motion Control KinPlus".
Valid	BOOL	-	RON	Validity of the transformation values	
				FALSE	Invalid
				TRUE	Valid
LinkConstellation	DWORD	0 ... n	RON	Joint position space	
Bit 0	-	-	-	Angle α1 of axis A1 in the front/rear area (standard area/overhead area)	
				0	The zero point of the FCS is located in the front area (standard area) of the joint position lines for the axis A1. $\alpha 1 = \arctan(y_{FCS}/x_{FCS})$
					With 6-axis articulated arm with central wrist and 6-axis articulated arm with offset wrist (KinPlus): The wrist point is located in the front area (standard area) of the joint position lines for joint J1.
				1	The zero point of the FCS is located in the rear area (overhead area) of the joint position lines for the axis A1. $\alpha 1 = -\arctan(y_{FCS}/x_{FCS})$
					With 6-axis articulated arm with central wrist and 6-axis articulated arm with offset wrist (KinPlus): The wrist point is located in the rear area (overhead area) of the joint position lines for joint J1.

Tag		Data type	Values	W	Description	
	Bit 1	-	-	-	Angle α2 of axis A2 positive/negative taking into consideration the mechanical axis coupling	
					0	α2 positive
					1	α2 negative
	Bit 2	-	-	-	Angle α3 of axis A3 positive/negative taking into consideration the mechanical axis coupling	
					0	α3 positive
						With 6-axis articulated arm with central wrist and 6-axis articulated arm with offset wrist (KinPlus): The wrist point is located on, in the standard area above or in the overhead area below the joint position lines for joint J3.
					1	α3 negative
						With 6-axis articulated arm with central wrist and 6-axis articulated arm with offset wrist (KinPlus): The wrist point is located in the standard area below or in the overhead above the joint position lines for joint J3.
	Bit 3	-	-	-	Angle α4 of axis A4 positive/negative taking into consideration the mechanical axis coupling	
					0	α4 positive
					1	α4 negative
	Bit 4	-	-	-	Geometric joint position joint J5 (KinPlus)	
					0	α5 positive
					1	α5 negative or α5 = 0°
	Bit 5	-	-	-	Geometric joint position joint J6 (KinPlus)	
					0	α6 positive
					1	α6 negative
	Bit 6 ... 31	-	-	-	Not relevant	

See also

Tags: Kinematics transformation (Page 201)

15.2.21 "AxesData" tag (kinematics)

The tag structure "<TO>.AxesData.<Tag name>" contains the setpoints of the kinematics motion for the kinematics axes.

Tags

Legend

Tag	Data type	Values	W	Description
AxesData.	TO_Struct_Kinematics_AxesData			
A[1..6].	ARRAY [1..6] OF TO_Struct_Kinematics_AxisMotion-Vector			Setpoints of the kinematics motion for the kinematics axes A1 to A6
Position	LREAL	-1.0E12 ... 1.0E12	RON	Current position setpoint
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Current velocity setpoint
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Current acceleration setpoint

15.2.22 "JointData" tag (kinematics)

The tag structure "<TO>.JointData.<Tag name>" contains the setpoints of the kinematics motion for the joints.

Tags

Legend

Tag	Data type	Values	W	Description
JointData.	TO_Struct_Kinematics_StatusJoint-Data			
J[1..6].	ARRAY [1..6] OF TO_Struct_Kinematics_StatusJoint-MotionVector			Setpoints of the kinematics motion for the joints J1 to J6
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Current acceleration setpoint
Position	LREAL	-1.0E12 ... 1.0E12	RON	Current position setpoint
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Current velocity setpoint

15.2.23 "FlangeInKcs" tag (kinematics)

The tag structure "<TO>.FlangeInKcs.<Tag name>" contains the parameters for the Flange Coordinate System (FCS) in the Kinematics Coordinate System (KCS).

Tags

Legend

Tag	Data type	Values	W	Description
FlangeInKcs.	TO_Struct_Kinematics_Status-FlangeInKcs			
x.	TO_Struct_Kinematics_StatusMotionVectorKcs			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of the x coordinate of the flange coordinate system (FCS) in the kinematics coordinate system (KCS)
Position	LREAL	-1.0E12 ... 1.0E12	RON	x coordinate of the flange coordinate system in the kinematics coordinate system
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of the x coordinate of the flange coordinate system in the kinematics coordinate system
y.	TO_Struct_Kinematics_StatusMotionVectorKcs			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of the y coordinate of the flange coordinate system in the kinematics coordinate system
Position	LREAL	-1.0E12 ... 1.0E12	RON	y coordinate of the flange coordinate system in the kinematics coordinate system
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of the y coordinate of the flange coordinate system in the kinematics coordinate system
z.	TO_Struct_Kinematics_StatusMotionVectorKcs			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of the z coordinate of the flange coordinate system in the kinematics coordinate system
Position	LREAL	-1.0E12 ... 1.0E12	RON	z coordinate of the flange coordinate system in the kinematics coordinate system
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of the z coordinate of the flange coordinate system in the kinematics coordinate system
a.	TO_Struct_Kinematics_StatusMotionVectorKcs			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of the rotation A of the flange coordinate system in the kinematics coordinate system
Position	LREAL	-1.0E12 ... 1.0E12	RON	Position of the rotation A of the flange coordinate system in the kinematics coordinate system
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of the rotation A of the flange coordinate system in the kinematics coordinate system
b.	TO_Struct_Kinematics_StatusMotionVectorKcs			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of the rotation B of the flange coordinate system in the kinematics coordinate system.

Tag	Data type	Values	W	Description
Position	LREAL	-1.0E12 ... 1.0E12	RON	Position of rotation B of the flange coordinate system in the kinematics coordinate system.
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of the rotation B of the flange coordinate system in the kinematics coordinate system.
c.	TO_Struct_Kinematics_StatusMotionVectorKcs			
Acceleration	LREAL	-1.0E12 ... 1.0E12	RON	Acceleration of the rotation C of the flange coordinate system in the kinematics coordinate system.
Position	LREAL	-1.0E12 ... 1.0E12	RON	Position of the rotation C of the flange coordinate system in the kinematics coordinate system.
Velocity	LREAL	-1.0E12 ... 1.0E12	RON	Velocity of the rotation C of the flange coordinate system in the kinematics coordinate system.

See also

Tags: Coordinate systems and frames (Page 208)

15.2.24 "StatusTool" tag (kinematics)

The tag structure "<TO>.StatusTool.<Tag name>" contains the parameters for the tools.

Tags

Legend

Tag	Data type	Values	W	Description
StatusTool.	TO_Struct_Kinematics_StatusTool			
ActiveTool	DINT	1 to 3	RON	Currently effective tool
Frame[1..3].	ARRAY [1..3] OF TO_Struct_Kinematics_StatusKinematicsFrame			Current coordinates of tools 1 to 3
x	LREAL	-1.0E12 ... 1.0E12	RON	x coordinate
y	LREAL	-1.0E12 ... 1.0E12	RON	y coordinate
z	LREAL	-1.0E12 ... 1.0E12	RON	z coordinate
a	LREAL	-1.0E12 ... 1.0E12	RON	A coordinate
b	LREAL	-1.0E12 ... 1.0E12	RON	B coordinate
c	LREAL	-1.0E12 ... 1.0E12	RON	C coordinate

See also

Tags: Coordinate systems and frames (Page 208)

15.2.25 "StatusConveyor[1..3]" tag (kinematics)

The tag structure "<TO>.StatusConveyor[1..3].<Tag name>" contains the conveyor tracking status.

Tags

Legend

Tag	Data type	Values	W	Description
StatusConveyor[1..3].	ARRAY [1..3] OF TO_Struct_Kinematics_StatusConveyor			
ConveyorBelt	DB_ANY	-	RON	Active leading-value-capable technology object to which the object coordinate system (OCS) is coupled: Leading-value-capable technology objects are: • Positioning axis • Synchronous axis • External encoder • Leading axis proxy
BeltPosition	LREAL	-	RON	Position of the leading-value-capable technology object.
ObjectPosition	TO_Struct_Kinematics_Status_Frame	-	RON	Object position Relative offset of the OCS in x direction to the reference position "ConveyorBeltOrigin" "ObjectPosition.x" = "BeltPosition" - "InitialObjectPosition.x"
x	LREAL	-1.0E12 ... 1.0E12	RON	x coordinate
y	LREAL	-1.0E12 ... 1.0E12	RON	y coordinate
z	LREAL	-1.0E12 ... 1.0E12	RON	z coordinate
a	LREAL	-180.0 to 179.999	RON	A coordinate
b	LREAL	-180.0 to 179.999	RON	B coordinate
c	LREAL	-180.0 to 179.999	RON	C coordinate
TrackingState	DINT	0 to 4	RON	Conveyor tracking status
				0 — OCS not assigned The OCS is not assigned to a leading-value-capable technology object.
				1 — OCS assigned The Motion Control instruction "MC_TrackConveyorBelt" is finished and the OCS is assigned to a leading-value-capable technology object. The first path motion job in the tracked OCS can be sent.

Tag	Data type	Values	W	Description	
TrackingState	DINT	0 to 4	RON	2	TCP synchronizes to OCS The OCS is assigned to a leading-value-capable technology object. The first path motion job in the tracked OCS is active.
				3	TCP follows OCS The OCS is assigned to a leading-value-capable technology object. The first path motion job in the tracked OCS is completed. The kinematics has reached the position programmed in the path motion job. The kinematics follows the motion of the OCS.
				4	TCP desynchronizes from OCS The motion of the kinematics in the tracked OCS is ended by a motion job in the WCS or a non-tracked OCS. When the motion job is completed, the "TrackingState" changes to 0 and the OCS is not tracked with the object position anymore.

15.2.26 "StatusWorkspaceZone[1..10]" tag (kinematics)

The tag structure "<TO>.StatusWorkspaceZone[1..10].<Tag name>" contains the status of the workspace zones.

Tags

Legend

Tag	Data type	Values	W	Description	
StatusWorkspaceZone[1..10].	ARRAY [1..10] OF TO_Struct_Kinematics_StatusWorkSpaceZone				
Active	BOOL	-	RON	FALSE	Workspace zone deactivated
				TRUE	Workspace zone activated
Valid	BOOL	-	RON	FALSE	Zone is not defined
				TRUE	Zone is defined
Type	DINT	0 ... 2	RON	Type of the workspace zone	
				0	Blocked zone
				1	Work zone
				2	Signal zone
ReferenceSystem	DINT	0 ... 3	RON	Reference coordinate system for the workspace zone	
				0	WCS
				1	OCS1
				2	OCS2
				3	OCS3
Frame.	TO_Struct_Kinematics_StatusFrame				

Tag	Data type	Values	W	Description	
x	LREAL	-1.0E12 ... 1.0E12	RON	x coordinate	
y	LREAL	-1.0E12 ... 1.0E12	RON	y coordinate	
z	LREAL	-1.0E12 ... 1.0E12	RON	z coordinate	
a	LREAL	-180.0 to 179.9-99	RON	A coordinate	
b	LREAL	-90.0 to 90.0	RON	B coordinate	
c	LREAL	-180.0 to 179.9-99	RON	C coordinate	
Geometry.	TO_Struct_Kinematics_StatusZoneG-eometry				
Type	DINT	0 ... 2	RON	Zone geometry	
				0	Cuboid
				1	Sphere
				2	Cylinder
Parameter[1..3]	ARRAY [1..3] OF LREAL	0.0 to 1.0E12	RON	1	Length x (cuboid) or radius (sphere, cylinder)
				2	Length y (cuboid) or height (cylinder)
				3	Length z (cuboid)

See also

Tags: Zone monitoring (Page 223)

15.2.27 "StatusKinematicsZone[2..10]" tag (kinematics)

The tag structure "<TO>.StatusKinematicsZone[2..10].<Tag name>" contains the status of the kinematics zones.

Tags

Legend

Tag	Data type	Values	W	Description	
StatusKinematicsZone[2..1-0].	ARRAY [2..10] OF TO_Struct_Kinematics_StatusKinem-aticsZone				
Active	BOOL	-	RON	FALSE	Kinematics zone deactivated
				TRUE	Kinematics zone activated
Valid	BOOL	-	RON	FALSE	Zone is not present
				TRUE	Zone is present
ReferenceSystem	DINT	0 to 1	RON	Reference coordinate system for the kinematics zone	
				0	FCS

Tag	Data type	Values	W	Description	
ReferenceSystem	DINT	0 to 1	RON	1	TCS
Frame.	TO_Struct_Kinematics_StatusFrame				
x	LREAL	-1.0E12 ... 1.0E12	RON	x coordinate	
y	LREAL	-1.0E12 ... 1.0E12	RON	y coordinate	
z	LREAL	-1.0E12 ... 1.0E12	RON	z coordinate	
a	LREAL	-180.0 to 179.9-99	RON	A coordinate	
b	LREAL	-90.0 to 90.0	RON	B coordinate	
c	LREAL	-180.0 to 179.9-99	RON	C coordinate	
Geometry.	TO_Struct_Kinematics_StatusZoneG-eometry				
Type	DINT	0 to 2	RON	Zone geometry	
				0	Cuboid
				1	Sphere
				2	Cylinder
Parameter[1..3]	ARRAY [1..3] OF LREAL	0.0 to 1.0E12	RON	1	Length x (cuboid) or radius (sphere, cylinder)
				2	Length y (cuboid) or height (cylinder)
				3	Length z (cuboid)

See also

Tags: Zone monitoring (Page 223)

15.2.28 "StatusZoneMonitoring" tag (kinematics)

The tag structure "<TO>.StatusZoneMonitoring.<Tag name>" contains the status of the violated zones.

Tags

Legend

Tag	Data type	Values	W	Description
StatusZoneMonitoring.	TO_Struct_Kinematics_StatusZone-Monitoring			
WorkingZones	DWORD	-	RON	Display of violated work zones Bit numbers 0 to 9 correspond to the configured zone numbers.

Tag	Data type	Values	W	Description
BlockedZones	DWORD	-	RON	Display of violated blocked zones Bit numbers 0 to 9 correspond to the configured zone numbers.
SignalizingZones	DWORD	-	RON	Display of approached signal zones Bit numbers 0 to 9 correspond to the configured zone numbers.
KinematicsZones	DWORD	-	RON	Display of kinematics zones that violate workspace zones Bit number 0 indicates the monitoring status of the tool center point (TCP). Bit numbers 1 to 9 correspond to the configured zone numbers.

See also

Tags: Zone monitoring (Page 223)

15.2.29 "StatusMotionQueue" tag (kinematics)

The tag structure "<TO>.StatusMotionQueue.<Tag name>" contains the status of the job sequence.

Tags

Legend

Tag	Data type	Values	W	Description
StatusMotionQueue.	TO_Struct_Kinematics_StatusMotionQueue			
NumberOfCommands	DINT	-	RON	Number of queued jobs in the job sequence
NumberOfPreparedCommands	DINT	-	RON	Number of prepared commands in the job sequence

See also

Tags: Kinematics motions (Page 235)

15.2.30 "KinematicsAxis" tag (kinematics)

The tag structure "<TO>.KinematicsAxis.<Tag name>" contains the defined kinematics axes.

Tags

Legend

Tag	Data type	Values	W	Description
KinematicsAxis.	TO_Struct_Kinematics_KinematicsAxis			
A1	DB_ANY	-	RON	Technology object data block of the kinematics axis A1
A2	DB_ANY	-	RON	Technology object data block of the kinematics axis A2
A3	DB_ANY	-	RON	Technology object data block of the kinematics axis A3

Tag	Data type	Values	W	Description
A4	DB_ANY	-	RON	Technology object data block of the kinematics axis A4
A5	DB_ANY	-	RON	Technology object data block of the kinematics axis A5
A6	DB_ANY	-	RON	Technology object data block of the kinematics axis A6

15.2.31 "Units" tag (kinematics)

The tag structure "<TO>.Units.<Tag name>" contains the configured technological units of measure.

Tags

Legend

Tag	Data type	Values	W	Description	
Units.	TO_Struct_Kinematics_Units				
LengthUnit	UDINT	-	RON	Unit of measure for the position	
				1010	m
				1013	mm
				1536	mm[1)]
				1011	km
				1014	µm
				1015	nm
				1019	in
				1018	ft
				1021	mi
LengthVelocityUnit	UDINT	-	RON	Unit of measure for the velocity	
				1062	mm/s
				1538	mm/s[1)]
				1061	m/s
				1524	mm/min
				1525	m/min
				1526	mm/h
				1063	m/h
				1527	km/min
				1064	km/h
				1066	in/s
				1069	in/min
				1067	ft/s
				1070	ft/min
				1075	mi/h

1) Position values with higher resolution or six decimal places

Tag	Data type	Values	W	Description	
AngleUnit	UDINT	-	RON	Unit of measure for the position of the rotary axes	
				1004	rad
				1005	°
				1537	°[1)]
AngleVelocityUnit	UDINT	-	RON	Unit of measure for the velocity of the rotary axes	
				1521	°/s
				1522	°/min
				1539	°/s[1)]
				1086	rad/s
				1523	rad/min

1) Position values with higher resolution or six decimal places

See also

Units of measure (Page 47)

15.2.32 "StatusInterpreterMotion" tag (kinematics)

The tag structure "<TO>.StatusInterpreterMotion.<tag name>" contains status information on motion jobs controlled by a technology object Interpreter.

Tags

Legend

Tag	Data type	Values	W	Description
StatusInterpreterMotion.	TO_Struct_Kinematics_StatusInterpreterMotion			
StatusWord.	DWORD	-	RON	Status information
Bit 0	-	-	-	"ControlledByInterpreter" An MCL job is processed or active or the bit is set via the MCL instruction "setControlledByInterpreter()".
Bit 1	-	-	-	"MotionByInterpreter" An MCL motion job is in effect.
Bit 2 ... Bit 31	-	-	-	Reserved

15.2.33 "StatusWord" tag (kinematics)

The "<TO>.StatusWord" tag contains the status information of the technology object.

Information on the evaluation of the individual bits (e.g. bit 2 "RestartActive") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag		Data type	Values	W	Description
StatusWord		DWORD	-	RON	Status information of the technology object
	Bit 0	-	-	-	Reserved
	Bit 1	-	-	-	"Error" An error is present.
	Bit 2	-	-	-	"RestartActive" A restart is active. The technology object is being reinitialized.
	Bit 3	-	-	-	"OnlineStartValuesChanged" The restart tags have been changed. For the changes to be applied, the technology object must be reinitialized.
	Bit 4	-	-	-	"ControlPanelActive" The kinematics control panel is activated.
	Bit 5	-	-	-	Reserved
	Bit 6	-	-	-	"Done" No motion job is in progress and the kinematics control panel is deactivated.
	Bit 7	-	-	-	Reserved
	Bit 8	-	-	-	"LinearCommand" A linear motion is active.
	Bit 9	-	-	-	"CircularCommand" A circular motion is active.
	Bit 10	-	-	-	Reserved
	Bit 11	-	-	-	"DirectCommand" A synchronous point-to-point motion is active.
	Bit 12	-	-	-	"ConstantVelocity" The velocity setpoint is reached. The path motion of the kinematics is moving at this constant velocity or is at a standstill.
	Bit 13	-	-	-	"Accelerating" An acceleration operation of a path motion is active.
	Bit 14	-	-	-	"Decelerating" A deceleration operation of a path motion is active.
	Bit 15	-	-	-	"OrientationMotion" An orientation motion is active.
	Bit 16	-	-	-	"Stopping" An "MC_GroupStop" job is running. The motion of the kinematics technology object is aborted

Tag	Data type	Values	W	Description
Bit 17	-	-	-	"Interrupted" The motion of the kinematics technology object is interrupted with an "MC_GroupInterrupt" job. The motion can be continued with a "MC_GroupContinue" job.
Bit 18	-	-	-	"Blending" A blending segment is active.
Bit 19	-	-	-	"InSimulation" The technology object is in simulation.
Bit 20	-	-	-	Reserved
Bit 21	-	-	-	"EnabledJCS" The kinematics technology object uses the JCS.
Bit 22	-	-	-	Reserved
Bit 23	-	-	-	Reserved
Bit 24	-	-	-	"StandardOrientationMode5D" A linear or circular motion of a 3D kinematics with 2 orientations is active.
Bit 25	-	-	-	"StandardOrientationMode6D" A linear or circular motion of a 3D kinematics with 3 orientations is active.
Bit 26 ... Bit 31	-	-	-	Reserved

15.2.34 "ErrorWord" tag (kinematics)

The "<TO>.ErrorWord" tag indicates technology object errors (technology alarms).

Information on the evaluation of the individual bits (e.g. bit 3 "CommandNotAccepted") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control Overview" documentation.

Tags

Legend

Tag	Data type	Values	W	Description
ErrorWord	DWORD	-	RON	
Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.
Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters are inconsistent or invalid.
Bit 2	-	-	-	"UserFault" Error in the user program at a Motion Control instruction or its use (e.g. by the kinematics control panel).
Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.

Tag		Data type	Values	W	Description
	Bit 4	-	-	-	"TransformationFault" Error in the kinematics transformation
	Bit 5	-	-	-	Reserved
	Bit 6	-	-	-	"DynamicError" Specified dynamic values are limited to permissible values.
	Bit 7	-	-	-	"ConveyorFault" Error in the conveyor tracking
	Bit 8	-	-	-	"JointLimit" Joint traversing range limit approached or overtraveled.
	Bit 9 ... Bit 31	-	-	-	Reserved

15.2.35 "ErrorDetail" tag (kinematics)

The tag structure "<TO>.ErrorDetail.<Tag name>" contains the alarm number and the effective local alarm response for the technology alarm that is currently pending on the technology object.

You can find a list of the technology alarms and alarm responses in the "Overview of the technology alarms" section of the "S7-1500/S7-1500T Motion Control alarms and error IDs" documentation.

Tags

Legend

Tag		Data type	Values	W	Description	
ErrorDetail.		TO_Struct_Kinematics_ErrorDetail				
	Number	UDINT	-	RON	Alarm number	
	Reaction	DINT	0, 11, 12	RON	Effective alarm response	
					0	No reaction (warnings only)
					11	Stop without leaving the path
					12	Stop with maximum dynamic values of the axes

15.2.36 "WarningWord" tag (kinematics)

The "<TO>.WarningWord" tag indicates pending warnings at the technology object.

Information on the evaluation of the individual bits (e.g. bit 2 "UserFault") can be found in the "Evaluating StatusWord, ErrorWord and WarningWord" section of the "S7-1500/S7-1500T Motion Control overview" documentation.

Tags

Legend

Tag		Data type	Values	W	Description
WarningWord		DWORD	-	RON	
	Bit 0	-	-	-	"SystemFault" A system-internal error has occurred.
	Bit 1	-	-	-	"ConfigFault" Configuration error One or more configuration parameters will be adjusted internally.
	Bit 2	-	-	-	"UserFault" Error in user program at a Motion Control instruction or its use
	Bit 3	-	-	-	"CommandNotAccepted" Job cannot be executed A Motion Control instruction cannot be executed because the necessary conditions have not been met.
	Bit 4	-	-	-	Reserved
	Bit 5	-	-	-	Reserved
	Bit 6	-	-	-	"DynamicWarning" Specified dynamic values are limited to permissible values.
	Bit 7 ... Bit 31	-	-	-	Reserved

15.2.37 "ControlPanel" tag (kinematics)

The tag structure "<TO>.ControlPanel.<tag name>" contains no relevant data for you. This tag structure is internally used.

15.2.38 "InternalToTrace" tag (kinematics)

The tag structure "<TO>.InternalToTrace.<tag name>" contains no relevant data for you. This tag structure is internally used.

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SIMATIC

S7-1500
S7-1500/S7-1500T Motion Control alarms and error detection V10.0 as of STEP 7 V21

Diagnostics Manual

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S7-1500/S7-1500T Motion Control

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Introduction 1

Purpose of the documentation

This documentation provides important information that you need to configure and commission the integrated Motion Control functionality of the S7-1500 Automation systems.

Required basic knowledge

In order to understand this documentation, the following knowledge is required:

- General knowledge in the field of automation
- General knowledge in the field of drive engineering and motion control

Validity of the documentation

This documentation is valid for the S7-1500 product range.

Conventions

- The path specifications in the project tree assume that the "Technology objects" folder is open in the subtree of the CPU. The "Technology object" placeholder represents the name of the technology object.

  Example: "Technology object > Configuration > Basic parameters".
- The <TO> placeholder represents the name set in tags for the respective technology object.

  Example: <TO>.Actor.Type
- This documentation contains pictures of the devices described. The pictures may differ in minor details from the devices supplied.

You should also observe the notes that are marked as follows:

NOTE

A note contains important information about the product described in the documentation, about the handling of the product, and about sections in this documentation demanding your particular attention.

Industry Mall

The Industry Mall is the catalog and ordering system of Siemens Aktiengesellschaft for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com).

1.1 S7-1500 Motion Control Documentation Guide

Product information

Please also note the supplementary information on the Motion Control documentation:

- Product information on the S7-1500/1500T Motion Control documentation
  https://support.industry.siemens.com/cs/ww/en/view/109794046
  (https://support.industry.siemens.com/cs/ww/en/view/109794046)

Documentation

The documentation of the Motion Control functions is divided into the following documents:

- S7-1500/S7-1500T Motion Control Overview
  https://support.industry.siemens.com/cs/en/view/109990070
  (https://support.industry.siemens.com/cs/ww/en/view/109990070)

  This document describes the innovations in the technology versions, how to upgrade the technology version, functions that are used for all technology objects, and the operational sequence of Motion Control applications.
- S7-1500/S7-1500T Motion Control alarms and error IDs
  https://support.industry.siemens.com/cs/ww/en/view/109990076
  (https://support.industry.siemens.com/cs/ww/en/view/109990076)

  This document describes the technology alarms of the technology objects and the error identifications of the Motion Control instructions.
- S7-1500/S7-1500T Axis functions
  https://support.industry.siemens.com/cs/en/view/109990072
  (https://support.industry.siemens.com/cs/ww/en/view/109990072)

  This document describes the drive and encoder connection and functions for single-axis movements.
- S7-1500/S7-1500T Synchronous operation functions
  https://support.industry.siemens.com/cs/ww/en/view/109990074
  (https://support.industry.siemens.com/cs/ww/en/view/109990074)

  This document describes gearing, velocity synchronous operation and camming as well as cross-PLC synchronous operation.

- S7-1500/S7-1500T Measuring input and output cam functions
  https://support.industry.siemens.com/cs/ww/en/view/109990075
  (https://support.industry.siemens.com/cs/ww/en/view/109990075)
  This document describes the detection of the actual position via a measuring input and the output of switching signals via output cam or cam track.
- S7-1500T kinematics functions
  https://support.industry.siemens.com/cs/ww/en/view/109990073
  (https://support.industry.siemens.com/cs/ww/en/view/109990073)
  This document describes the control of kinematics with up to 6 interpolating axes.
- S7-1500T Interpreter functions
  https://support.industry.siemens.com/cs/ww/en/view/109990077
  (https://support.industry.siemens.com/cs/ww/en/view/109990077)
  This documentation describes the control of technology objects via an Interpreter program.

See also

Topic page "SIMATIC Technology - Motion Control: Overview and Important Links"
https://support.industry.siemens.com/cs/ww/en/view/109751049
(https://support.industry.siemens.com/cs/ww/en/view/109751049)

1.2 Function Manuals documentation guide

1.2.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.2.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information
- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.2.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 General safety instructions

The safety instructions can be found in section "Safety instructions" in the System Manual "SIMATIC S7-1500, ET 200MP Automation System" (https://support.industry.siemens.com/cs/ww/en/view/59191792) document.

Cybersecurity-relevant information can be found in the Industrial Cybersecurity section.

2.2 Warnings in this document

You can find explanations of the warnings used in this document in the "Legal information" section.

Industrial cybersecurity 3

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

3.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Diagnostics concept

4

The diagnostics concept encompasses alarms and associated messages, as well as error messages in the Motion Control instructions. The TIA Portal also supports you with consistency checks during configuration of the technology objects, and during the creation of your user program.

All alarms in runtime (from the CPU, technology, hardware etc.) are displayed in the Inspector window of the TIA Portal. Diagnostic information that relates to technology objects (technology alarms, status information) are additionally displayed in the Diagnostics window of the respective technology object.

During motion control, if an error occurs at a technology object (e.g. approaching a hardware limit switch), then a technology alarm (Page 18) is triggered, and a corresponding message is displayed in the TIA Portal as well as on HMI devices.

In your user program, technology alarms are generally signaled via error bits in the technology data block. The number of the technology alarm with the highest priority is also displayed. In order to simplify error evaluation, the "Error" and "ErrorID" parameters of the Motion Control instructions also indicate that a technology alarm is pending.

Program errors (Page 89) can occur during parameter assignment or during the processing sequence of the Motion Control instructions (e.g. invalid parameter specification when calling the instruction, initiation of a job without enable via "MC_Power"). With active jobs, errors in Motion Control instructions are indicated by the "Error" and "ErrorID" parameters.

Technology alarms

5

If an error occurs at a technology object (e.g. approaching a hardware limit switch), a technology alarm is triggered and indicated. The impact of a technology alarm on the technology object is specified by the alarm response.

Alarm classes

Technology alarms are divided into three classes:

- **Acknowledgeable warning**

  The processing of Motion Control job is continued. The current motion of the axis can be influenced, e.g. by limiting the current dynamic values to the configured limit values.

- **Alarm requiring acknowledgment**

  Motion jobs are aborted in accordance with the alarm response. You must acknowledge the alarms in order to continue execution of new jobs after eliminating the cause of the error.

- **Fatal error**

  Motion jobs are aborted in accordance with the alarm response.

  To be able to use the technology object again after eliminating the cause of the error, you must restart the technology object.

Display of technology alarms

A technology alarm is displayed in the following locations:

- **TIA Portal**
  - **"Technology object > Diagnostics > Status and error bits"**

    Display of pending technology alarms for each technology object
  - **"Technology object > Commissioning > Axis control panel"**

    Display of the last pending technology alarm for each technology object
  - **"Inspector window > Diagnostics > Message display"**

    Select the "Receive messages" check box under "Online & Diagnostics > Online Access" in order to display technology alarms via the message display.

    With an online connection to the CPU, the pending technology alarms for all technology objects are displayed. Additionally, the archive view is available to you.

    The message display can also be activated and displayed on a connected HMI.
  - **"CPU > Online & diagnostics"**

    Display of the technology alarms that have been entered in the diagnostic buffer

- **User program**
  - **Tags "<TO>.ErrorDetail.Number" and "<TO>.ErrorDetail.Reaction"**

    Indication of the number and the reaction of the technology alarm with the highest priority
  - **Tag "<TO>.StatusWord"**

    A pending technology alarm is indicated with bit 1 ("Error").
  - **Tag "<TO>.ErrorWord"**

    The "<TO>.ErrorWord" tag shows the error groups in which there is at least one technology alarm for the technology object. The tag takes into consideration the alarms requiring acknowledgment and serious errors alarm classes.
  - **Tag "<TO>.WarningWord"**

    The "<TO>.WarningWord" tag shows the error groups in which there is at least one technology alarm for the technology object. The tag takes technology alarms of the acknowledgeable warnings alarm class into consideration.
  - **Parameter "Error" and "ErrorID"**

    In a Motion Control instruction, the parameters "Error" = TRUE and "ErrorID" = 16#8001 indicate that a technology alarm is pending.
- **Display of the CPU**

  In order to show technology alarms on the CPU display, make the following setting when loading to the CPU:
  In the "Load preview" dialog, select the action "Consistent download" for the "Text libraries" entry.
- **Web server**
  - **"Motion Control diagnostics > Diagnostics"**

    Display of pending technology alarms for each technology object
  - **"Motion Control diagnostics > Service overview"**

    Status display of technology objects

Alarm response

A technology-alarm always leads to an alarm response, which describes the effect on the technology object. The alarm response is specified by the system.

The following table shows possible alarm response:

Alarm response	Validity		Description
	TO[1]	Kin[2]	
No reaction (warnings only) <TO>.ErrorDetail.Reaction = 0	✓	✓	The processing of Motion Control job is continued. The current motion of the axis can be influenced, e.g. by limiting the current dynamic values to the configured limit values.
Stop with current dynamic values <TO>.ErrorDetail.Reaction = 1	✓	-	Active motion commands are aborted. The axis is braked with the dynamic values that present in the Motion Control instruction and brought to a standstill.
Stop with maximum dynamic values <TO>.ErrorDetail.Reaction = 2	✓	-	Active motion commands are aborted. The axis is braked with the dynamic values configured under "Technology object > Extended parameters > Dynamic limits", and brought to a standstill. The configured maximum jerk is hereby taken into account.
Stop with emergency stop ramp <TO>.ErrorDetail.Reaction = 3	✓	-	Active motion commands are aborted. The axis is braked with the emergency stop deceleration configured under "Technology object > Extended parameters > Emergency stop ramp", without any jerk limit, and brought to a standstill.
Remove enable <TO>.ErrorDetail.Reaction = 4	✓	-	Active motion commands are aborted. The setpoint zero is output and the enable is removed. The axis is braked to a standstill according to the configuration in the drive.
Track setpoints <TO>.ErrorDetail.Reaction = 5	✓	-	Active motion commands are aborted. The setpoint zero is output. The actual values supplied by the drive are automatically tracked as setpoints.
Terminate processing of the technology object: • Output cam <TO>.ErrorDetail.Reaction = 6 • Cam track <TO>.ErrorDetail.Reaction = 7 • Measuring input <TO>.ErrorDetail.Reaction = 8 • Cam <TO>.ErrorDetail.Reaction = 9 • External encoder <TO>.ErrorDetail.Reaction = 10 • Leading axis proxy <TO>.ErrorDetail.Reaction = 13	✓	-	Processing of the technology object is terminated. All running Motion Control jobs are aborted.
Stop without leaving the path <TO>.ErrorDetail.Reaction = 11	-	✓	The kinematics are decelerated and brought to a standstill. The current path is not exited when the kinematics is stopped. Linear and circular motion jobs are braked without jerk limit.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

Alarm response	Validity		Description
	TO[1]	Kin[2]	
Stop with maximum dynamic values of the axes <TO>.ErrorDetail.Reaction = 12	-	✓	Active and queued motion jobs are canceled. The axes are decelerated with the maximum dynamic values configured under "Technology object > Configuration > Extended parameters > Limits > Dynamic limits", and brought to a standstill. The configured maximum jerk is hereby taken into account.
Stop Interpreter program with diagnostics option <TO>.ErrorDetail.Reaction = 14	✓	-	Execution of the Interpreter program is stopped. One diagnostic option is to read out the last values, for example.
Stop and recompile Interpreter program <TO>.ErrorDetail.Reaction = 15	✓	-	Execution of the Interpreter program is stopped. The Interpreter program is prepared for another execution. The preparation of the Interpreter program starts. All parameters are reinitialized. The Interpreter program can be executed again.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

Acknowledging technology alarms

You can acknowledge technology alarms as follows:

- **TIA Portal**
  - **"Technology object > Commissioning > Axis control panel"**

    Click "Confirm" to acknowledge all alarms and warnings pending for the selected technology object.
  - **"Inspector window > Diagnostics > Message display"**

    You can acknowledge the alarms and warnings for all technology objects either individually, or all at once.
- **HMI**

  At an HMI with enabled message display, you can acknowledge the alarms and warnings for all technology objects either individually, or all at once.
- **User program**

  Acknowledge pending technology alarms for a technology object with the Motion Control instruction "MC_Reset".
- **CPU display**

  Acknowledge pending technology alarms via the display of the CPU.
- **Web server**

  Acknowledge pending technology alarms under "Alarms".

5.1 Overview of the technology alarms

The following table shows an overview of the technology alarms and the corresponding alarm responses. When a technology alarm occurs, evaluate the entire indicated alarm text, in order to find the precise cause.

Legend

Table column	Description
No.	Number of the technology alarm (corresponds to "<TO>.ErrorDetail.Number")
Validity	Validity of the descriptions for the technology objects
TO	Applies to all technology objects with the exception of the kinematics technology object.
Kin	Applies only to the kinematics technology object.
Reaction	Effective alarm response (corresponds to "<TO>.ErrorDetail.Reaction")
F	Error bit Bit that is set in "<TO>.ErrorWord" when the technology alarm occurs A description of the bits can be found in the tags of the corresponding technology object.
W	Warning bit Bit that is set in "<TO>.WarningWord" when the technology alarm occurs A description of the bits can be found in the tags of the corresponding technology object.
R	Restart To acknowledge the technology alarm, the technology object must be reinitialized (Restart).
D	Diagnostic buffer The alarm is entered in the diagnostic buffer.
Alarm text	Displayed alarm text

List of the technology alarms

No.	Validity		Reaction	F	W	R	D	Alarm text
	TO	Kin						
101	✓	-	Remove enable	X1	-	✓	✓	Configuration error.
	-	✓	Stop with maximum dynamic values of the axes					
	✓	-	Interpreter technology object: Stop Interpreter program with diagnostics option	X1	-	-[1]	✓	
102	✓	-	Remove enable	X15	-	✓	✓	Error in drive configuration adaptation.
103	✓	-	Remove enable	X15	-	✓	✓	Encoder configuration adaptation error.
104	✓	-	Stop with maximum dynamic values	X1	-	-	-	SW limit switch specification error.
105	✓	-	Remove enable	X1	-	✓	✓	Drive configuration error.

1) To acknowledge the technology alarm, the Interpreter technology object must be enabled.

2) To acknowledge the technology alarm, the execution of the Interpreter program must be restarted.

No.	Validity		Reaction	F	W	R	D	Alarm text
	TO	Kin						
106	✓	-	Remove enable	X1	-	-	✓	Drive connection configuration error.
107	✓	-	Remove enable	X1	-	✓	✓	Encoder configuration error.
108	✓	-	Remove enable	X1	-	-	✓	Encoder connection configuration error.
109	✓	-	Remove enable	X1	-	✓	-	Configuration error.
110	✓	-	No reaction	-	X1	-	-	Configuration is adjusted internally.
111	✓	-	No reaction	-	X15	-	✓	TO and drive configuration inconsistent.
112	✓	-	No reaction	-	X15	-	✓	TO and encoder configuration inconsistent.
113	✓	-	Remove enable	X2	-	✓	-	Isochronous mode not possible.
114	✓	-	Remove enable	X1	-	✓	✓	Cross-PLC synchronous operation configuration error.
201	✓	-	Remove enable	X0	-	✓	✓	Internal error.
	-	✓	Stop with maximum dynamic values of the axes					
	✓	-	Interpreter technology object: Stop Interpreter program with diagnostics option	X0	-	-[2]	✓	
202	✓	-	No reaction	X0	-	✓	-	Internal configuration error.
	-	✓	Stop with maximum dynamic values of the axes					
	✓	-	Interpreter technology object: Stop Interpreter program with diagnostics option	X0	-	-[2]	-	
203	✓	-	Remove enable	X0	-	✓	-	Internal error.
	-	✓	Stop with maximum dynamic values of the axes					
204	✓	-	Remove enable	X0	-	-	✓	Commissioning error.
	-	✓	Stop with maximum dynamic values of the axes					
	✓	-	Interpreter technology object: No reaction	X0	-	-[2]	✓	
301	✓	-	Stop with maximum dynamic values	X16	-	-	-	Superimposing axis not assigned or defective.
304	✓	-	Stop with emergency stop ramp	X2	-	-	-	Velocity limit is zero.
	-	✓	Stop with maximum dynamic values of the axes					
305	✓	-	Stop with emergency stop ramp	X2	-	-	-	• Limit value of the acceleration is zero. • Limit value of the deceleration is zero.
	-	✓	Stop with maximum dynamic values of the axes					

[1] To acknowledge the technology alarm, the Interpreter technology object must be enabled.

[2] To acknowledge the technology alarm, the execution of the Interpreter program must be restarted.

No.	Validity		Reaction	F	W	R	D	Alarm text
	TO	Kin						
306	✓	-	Stop with emergency stop ramp	X2	-	-	-	Jerk limit is zero.
	-	✓	Stop with maximum dynamic values of the axes					
307	✓	-	Stop with maximum dynamic values	X2	-	-	✓	• Negative numerical value range of the position reached. • Positive numerical value range of the position reached.
308	✓	-	Remove enable	X2	-	-	✓	• Negative numerical value range of the position exceeded. • Positive numerical value range of the position exceeded.
321	✓	-	Stop with emergency stop ramp	X3	-	-	-	Axis is not homed.
322	✓	-	No reaction	-	X3	-	-	Restart not executed.
	✓	-	Interpreter technology object: No reaction	X0	X3	-[2]	-	
323	✓	-	Remove enable	X3	-	-	-	Homing could not be performed.
341	✓	-	Stop with maximum dynamic values	X10	-	-	-	Homing data faulty.
342	✓	-	Stop with emergency stop ramp	X10	-	-	-	Reference output cam/encoder zero mark not found.
343	✓	-	Remove enable	X1	-	-	-	Homing function not supported by device.
401	✓	-	Remove enable	X13	-	-	✓	Error accessing logical address.
411	✓	-	Remove enable	X5	-	-	✓	Encoder at the logical address disrupted.
412	✓	-	Remove enable	X5	-	-	-	Permitted actual value range exceeded.
421	✓	-	Remove enable	X4	-	-	✓	Drive disrupted at the logical address.
431	✓	-	Remove enable	X7	-	-	✓	Communication to the device under logical address is disturbed.
501	✓	✓	No reaction	-	X6	-	-	Programmed velocity is limited.
502	✓	✓	No reaction	-	X6	-	-	• Programmed acceleration is being limited. • Programmed deceleration is being limited.
503	✓	✓	No reaction	-	X6	-	-	Programmed jerk is limited.
504	✓	-	No reaction	-	X6	-	-	Speed setpoint monitoring active.
511	✓	-	No reaction	-	X6	-	-	Dynamic limit is violated by the kinematics motion.
521	✓	-	Remove enable	X11	-	-	-	Following error.
522	✓	-	No reaction	-	X11	-	-	Warning following error tolerance.

1) To acknowledge the technology alarm, the Interpreter technology object must be enabled.

2) To acknowledge the technology alarm, the execution of the Interpreter program must be restarted.

No.	Validity		Reaction	F	W	R	D	Alarm text
	TO	Kin						
531	✓	-	Remove enable	X9	-	-	-	• Positive HW limit switch approached. • Negative HW limit switch approached. • Invalid retraction direction, HW limit switch active.
						✓	-	• HW limit switch polarity reversed, retraction not possible. • Both HW limit switches active, retraction not possible. • Encoder error with triggered HW limit switch, no retraction possible.
533	✓	-	The alarm response depends on the configured response and the type of axis motion. • Stop with maximum dynamic values When "<TO>.PositionLimits_SW.LimitReachedBehavior" = 0 and an interconnected axis. – Axis motion as following axis in synchronous operation – Kinematics axis in kinematics motion • Stop with current dynamic values When "<TO>.PositionLimits_SW.LimitReachedBehavior" = 1 and interconnected axis	X8	-	-	-	• Negative SW limit switch is approached. • Positive SW limit switch is approached.
534	✓	-	You can configure the alarm response. • Remove enable Setting: "<TO>.PositionLimits_SW.LimitReachedBehavior" = 0 • Stop with emergency stop ramp Setting: "<TO>.PositionLimits_SW.LimitReachedBehavior" = 1	X8	-	-	-	• Negative SW limit switch was overtraveled. • Positive SW limit switch was overtraveled.
541	✓	-	Remove enable	X12	-	-	-	Positioning monitoring error.
542	✓	-	Remove enable	X2	-	-	-	Clamping monitoring error: Axis leaving clamping tolerance window.
550	✓	-	Track setpoints	X13	-	-	✓	Drive-autonomous motion is being executed.
551	✓	-	No reaction	-	X6	-	-	Maximum velocity cannot be reached with drive/axis parameters.

1) To acknowledge the technology alarm, the Interpreter technology object must be enabled.

2) To acknowledge the technology alarm, the execution of the Interpreter program must be restarted.

No.	Validity		Reaction	F	W	R	D	Alarm text
	TO	Kin						
552	✓	-	Remove enable	X15	-	-	-	Encoder adaptation error during ramp-up.
561	-	✓	No reaction	-	X6	-	-	Programmed velocity of the orientation motion is limited.
562	-	✓	No reaction	-	X6	-	-	• Programmed acceleration of the orientation motion is limited. • Programmed deceleration of the orientation motion is limited.
563	-	✓	No reaction	-	X6	-	-	Programmed jerk of the orientation motion is limited.
601	✓	-	Stop with maximum dynamic values	X14	-	-	-	Leading axis is not assigned or defective.
603	✓	-	Remove enable	X14	-	-	-	Leading axis is not in position-controlled mode.
608	✓	-	Stop with maximum dynamic values	X14	-	-	-	Error during synchronization/desynchronization.
612	✓	-	Remove enable	X2	-	-	-	Specified cam has not been interpolated.
700	✓	-	Remove enable	X2	-	-	-	Error when calculating the switching position.
701	✓	-	Remove enable	X13	-	-	-	I/O output error.
702	✓	-	Remove enable	X2	-	-	-	Position value invalid.
703	✓	-	Remove enable	X2	-	-	-	Cam track data faulty.
704	✓	-	Remove enable	X2	-	-	-	Output cam data faulty.
750	✓	-	Remove enable	X2	-	-	-	Measuring job not possible during homing of assigned axis.
752	✓	-	No reaction	X2	-	-	-	Validity range of measuring job not recognized.
753	✓	-	Remove enable	X2	-	-	-	Only one measuring input can access an encoder at a time.
754	✓	-	Remove enable	X2	-	-	-	Measuring input configuration in external device is not correct.
755	✓	-	Remove enable	X13	-	-	-	Measuring job not possible.
758	✓	-	No reaction	X2	-	-	-	A measuring edge was not evaluated.
801	-	✓	Stop with maximum dynamic values of the axes	X2	-	-	-	Kinematics axis not ready.
802	-	✓	Stop with maximum dynamic values of the axes	X3	-	-	-	Cannot calculate the geometry element.
803	-	✓	Stop with maximum dynamic values of the axes	X4	-	-	-	Error in the calculation of the transformation.
804	-	✓	Stop with maximum dynamic values of the axes	X2	-	-	-	Kinematics motion cannot be stopped at the end.
805	-	✓	Stop with maximum dynamic values of the axes	X2	-	-	-	Limitation of path dynamics by axis dynamics incorrect.

1) To acknowledge the technology alarm, the Interpreter technology object must be enabled.

2) To acknowledge the technology alarm, the execution of the Interpreter program must be restarted.

No.	Validity		Reaction	F	W	R	D	Alarm text
	TO	Kin						
806	-	✓	Stop without leaving the path	X2	-	-	-	Zone violation of work or blocked zones.
807	-	✓	No reaction	-	X2	-	-	Zone violation of signal zones.
808	-	✓	Stop with maximum dynamic values of the axes	X2	-	-	-	Ambiguity due to multiple active work zones.
809	-	✓	Stop with maximum dynamic values of the axes	X2	-	-	-	Path dynamic limit through dynamic response of the orientation motion faulty.
810	-	✓	Stop with maximum dynamic values of the axes	X7	-	-	-	Conveyor belt not assigned or faulty (OCS <number>).
811	-	✓	Stop with maximum dynamic values of the axes	X7	-	-	-	Error when approaching the TCP to an object coordinate system (OCS <number>).
812	-	✓	Stop with maximum dynamic values of the axes	X4	-	-	-	Error in the treatment of singularities. • The kinematics has reached the singularity. • Too many singularities occur in the path command.
820	-	✓	Stop with maximum dynamic values of the axes	X8	-	-	-	• Upper limit of joint traversing range joint <No.> overtraveled. • Lower limit of joint traversing range joint <No.> overtraveled.
900	✓	-	Set leading value invalid	X2	-	-	✓	Leading values invalid.
901	✓	-	Set leading value invalid	X2	-	-	✓	Data transmission error.
902	✓	-	No reaction	-	X2	-	-	Leading value accuracy limited.
903	✓	-	Set leading value invalid	X2	-	✓	✓	Modulo settings of the leading axis changed in cyclic mode.
1001	✓	-	Stop and recompile Interpreter program	X4	-	-	✓	Configuration error Interpreter or max. Interpreter program configuration limits reached.
1002	✓	-	Stop Interpreter program with diagnostics option	X5	-	-	✓	Configuration error Interpreter or max. Interpreter mapping configuration limits reached.
1003	✓	-	Stop and recompile Interpreter program	X4	-	-	✓	Syntax error in Interpreter program.
1004	✓	-	Stop Interpreter program with diagnostics option	X5	-	-	✓	Syntax error in Interpreter mapping.
1005	✓	-	Stop and recompile Interpreter program	X4	-	-	✓	Semantics error in Interpreter program.
1006	✓	-	Stop and recompile Interpreter program	X5	-	-	✓	Semantics error in Interpreter mapping.
1007	✓	-	Stop and recompile Interpreter program	X4	-	-	✓	Parameter error in MCL instruction.
1008	✓	-	Stop and recompile Interpreter program	X4	-	-	✓	Processing error in MCL instruction.
1009	✓	-	Stop and recompile Interpreter program	X4	-	-	✓	Processing error in synchronous action.

1) To acknowledge the technology alarm, the Interpreter technology object must be enabled.

2) To acknowledge the technology alarm, the execution of the Interpreter program must be restarted.

No.	Validity		Reaction	F	W	R	D	Alarm text
	TO	Kin						
1010	✓	-	Stop and recompile Interpreter program	X4	-	-	-	Processing error during synchronous start.
1011	✓	-	Stop Interpreter program with diagnostics option	X5	-	-	✓	Error when mapping technology objects.
1012	✓	-	No reaction	-	X4	-	-	Critical programming.

1) To acknowledge the technology alarm, the Interpreter technology object must be enabled.

2) To acknowledge the technology alarm, the execution of the Interpreter program must be restarted.

5.2 Technology alarms 101 - 114

5.2.1 Technology alarm 101

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Alarm response interpreter: Stop Interpreter program with diagnostics option

Restart: Required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Configuration error.	✓	✓	
Value in <tag> not allowed.	✓	✓	Adjust the specified value.
Value in Kinematics.TypeOfKinematics not permissible.			• Select a valid kinematics type. • If you are using a kinematics type with more than 4 interpolating axes, ensure that the "S7-1500T Motion Control KinPlus" Motion Control package is supported by the CPU and is loaded into the CPU and activated.
Faulty load gear factors.	✓	-	Adjust the load gear factors in the "<TO>.LoadGear.Numerator" and/or "<TO>.LoadGear.Denominator" parameters.
At least one encoder required. Sensor[].existent	✓	-	Configure at least one encoder.
Sensor[1] must be configured for DSC.	✓	-	Configure Sensor[1].
Values in Sensor[1..4].Parameter.FineResolutionXist1 and p979 are not equal.	✓	-	Set the identical fine resolution on the technology as on the drive.
Encoder position cannot be displayed due to the encoder configuration/mechanics.	✓	-	Check the configuration of the encoder and mechanics.
Linear encoder in not permitted on rotary drive system (Sensor.System).	✓	-	
Backlash compensation not permitted with encoder on load side.	✓	-	

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Controller parameter incorrect.	✓	-	Adjust the value of the "<TO>.PositionController.Kv" parameter.
PROFIBUS parameter assignment inconsistent. Sum of Ti and To greater than send clock.	✓	-	Adjust the send clock in the hardware configuration.
Drive or drive telegram type or encoder not suitable for DSC.	✓	-	Check whether the drive can be operated with DSC and adjust the drive telegram if required.
Technology data block is only possible with digital drive coupling.	✓	-	Check the drive coupling.
The VREF of the analog output or the bit drivers are assigned multiple times.	✓	-	Make sure that different addresses are assigned for all technology objects in the project.
TimeOut parameter outside of limits.	✓	-	Set the monitoring time of the axis control panel to a valid value.
Telegram in Actor.Interface.AddressIn and AddressOut not equal.	✓	-	Set the identical drive telegram type for sending and receiving direction.
Illegal combination for homing data with incremental encoder. encoder.	✓	-	Check the active and passive homing settings.
Telegram in Sensor[1..4].Interface.AddressIn and AddressOut not equal.	✓	-	Set the identical encoder telegram type for sending and receiving direction.
Kinematics axis A<No.> not connected	-	✓	Interconnect the axis.
Delta picker 2D: No formation of a closed parallel structure.	-	✓	Adjust the geometry data of the mechanics.
Delta picker 3D: No formation of a closed parallel structure.	-	✓	
Delta picker 3D: Angular offset does not permit a third arm.	-	✓	
Invalid arm distances.	-	✓	
Tripod: Angular offset does not permit a third arm.	-	✓	
Multiple versions of the same kinematics axis specified as AxisCoupling.N[].CausingAxis.	-	✓	Adjust the configuration for the mechanical axis coupling.
Kinematics axes coupled in a circle under AxisCoupling.N[].	-	✓	
6-axis articulated arm with angled hand: Configuration does not lead to the formation of an angled hand.	-	✓	Adjust the configuration of the lengths L7 and L8. Both lengths, L7 and L8, must not be equal to "0.0" for the kinematics type "6-axis articulated arm with angled hand".

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.2.2 Technology alarm 102

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Drive configuration adaptation error.	✓	-	
Drive is not assigned to a SINAMICS device.	✓	-	The drive adaptation is only available for SINAMICS drives.
Parameter does not exist, value unreadable or invalid.	✓	-	Check whether your device supports acyclic data communication according to PROFIdrive.
Maximum speed.	✓	-	
Maximum torque (p1520).	✓	-	
Maximum torque (p1521)	✓	-	
Fine resolution torque.	✓	-	
Rated speed.	✓	-	
Rated torque.	✓	-	
Motor type.	✓	-	
Unspecified.	✓	-	
Adaptation canceled due to insufficient resources.	✓	-	
Drive is not interconnected directly to I/O area.	✓	-	In the configuration of the axis, the logical addresses were placed, for example, in a data block. The adaptation is only possible when the encoder has been directly interconnected to an I/O area.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.2.3 Technology alarm 103

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Encoder configuration adaptation error.	✓	-	
Encoder is not assigned to a SINAMICS device.	✓	-	The encoder adaptation is only available for SINAMICS devices and external Siemens encoders.
Parameter does not exist, value unreadable or invalid.	✓	-	Check whether your device supports acyclic data communication according to PROFIdrive.
Encoder system	✓	-	

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Encoder resolution	✓	-	Check whether your device supports acyclic data communication according to PROFIdrive.
Encoder fine resolution Gx_XIST1	✓	-	
Encoder fine resolution Gx_XIST2	✓	-	
Encoder revolutions	✓	-	
Unspecified	✓	-	
Adaptation canceled due to insufficient resources.	✓	-	
Encoder is not interconnected directly to I/O area.	✓	-	In the configuration of the axis, the logical addresses were placed, for example, in a data block. The adaptation is only possible when the encoder has been directly interconnected to an I/O area.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.2.4 Technology alarm 104

Alarm response TO[1]: Stop with maximum dynamic values

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
SW limit switch specification error.	✓	-	
Neg. SW limit switch greater than pos. SW limit switch.	✓	-	Change the position of the software limit switches.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.2.5 Technology alarm 105

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Drive configuration error.	✓	-	
HW Configuration.	✓	-	• Connect a suitable device.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
The TO needs a smaller servo cycle clock.	✓	-	• Check the device (I/Os). • Check the topology of the project. • Compare the device configuration and the configuration of the technology object. • Open a Support request. The following data is required for the error analysis: – The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) – The diagnostic buffer of the CPU as text file (Online & diagnostics > Diagnostics > Diagnostics buffer) – The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) – The project in the state that led to this alarm – The password for the project – Steps for reproduction
Error in internal communication.	✓	-	• Check the project for consistency and reload the project into the controller. • Open a Support request. The following data is required for the error analysis: – The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) – The diagnostic buffer of the CPU as text file (Online & diagnostics > Diagnostics > Diagnostics buffer) – The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) – The project in the state that led to this alarm – The password for the project – Steps for reproduction
Address for drive data does not exist in project.	✓	-	Check the project for consistency and reload the project into the controller.
Error during the parameter assignment of the frame for the torque data.	✓	-	Check the interconnection of the SIEMENS additional telegram 750 (torque data).
Address overlap during drive interconnection.	✓	-	Make sure that different addresses are assigned for all technology objects in the project.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.2.6 Technology alarm 106

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Drive connection configuration error.	✓	-	
System has no communication with drive.	✓	-	Internal system error. • Check the project for consistency and reload the project into the controller. • Open a Support request. The following data is required for the error analysis: – The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) – The diagnostic buffer of the CPU as text file (Online & diagnostics > Diagnostics > Diagnostics buffer) – The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) – The project in the state that led to this alarm – The password for the project – Steps for reproduction
Drive not initialized during ramp-up.	✓	-	• Ensure that the communication between the controller and drive is established. To do this, evaluate the "<TO>.StatusDrive.CommunicationOK" parameter before enabling the axis. • To enable a technology object, the drive initialization must be complete. Trigger the job again later.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.2.7 Technology alarm 107

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Encoder configuration error.	✓	-	
HW Configuration.	✓	-	• Connect a suitable device.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
The TO needs a smaller servo cycle clock.	✓	-	• Check the device (I/Os). • Check the topology of the project. • Compare the device configuration and the configuration of the technology object. • Open a Support request. The following data is required for the error analysis: – The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) – The diagnostic buffer of the CPU as text file (Online & diagnostics > Diagnostics > Diagnostics buffer) – The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) – The project in the state that led to this alarm – The password for the project – Steps for reproduction
Error in internal communication.	✓	-	• Check the project for consistency and reload the project into the controller. • Open a Support request. The following data is required for the error analysis: – The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) – The diagnostic buffer of the CPU as text file (Online & diagnostics > Diagnostics > Diagnostics buffer) – The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) – The project in the state that led to this alarm – The password for the project – Steps for reproduction
Address overlap during encoder interconnection.	✓	-	Make sure that different addresses are assigned for all technology objects in the project.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.2.8 Technology alarm 108

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Encoder connection configuration error.	✓	-	
System without communication to encoder.	✓	-	Internal system error. • Check the project for consistency and reload the project into the controller. • Open a Support request. The following data is required for the error analysis: – The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) – The diagnostic buffer of the CPU as text file (Online & diagnostics > Diagnostics > Diagnostics buffer) – The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) – The project in the state that led to this alarm – The password for the project – Steps for reproduction
Encoder not initialized during ramp-up.	✓	-	• Ensure that the communication between the controller and encoder is established. To do this, evaluate the "<TO>.StatusSensor[1..4].CommunicationOK" parameter before enabling the axis and also check if the status of the encoder actual value is "<TO>.StatusSensor[1..4].State" = VALID (2). • To enable a technology object, the encoder initialization must be complete. Trigger the job again later.
Encoder data address missing in project.	✓	-	Check the project for consistency and reload the project into the controller.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.2.9 Technology alarm 109

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Configuration error.	✓	-	
Neg. HW limit switch.	✓	-	• Connect a suitable device. • Check the device (I/Os). • Check the topology of the project. • Compare the device configuration and the configuration of the technology object. • Open a Support request. The following data is required for the error analysis: – The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) – The diagnostic buffer of the CPU as text file (Online & diagnostics > Diagnostics > Diagnostics buffer) – The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) – The project in the state that led to this alarm – The password for the project – Steps for reproduction
Pos. HW limit switch.	✓	-	
Reference output cam "Active homing".	✓	-	
Reference output cam "Passive homing".	✓	-	
Enable bit for the analog drive interface.	✓	-	
DriveReady bit of the analog drive interface.	✓	-	
Input for measuring input faulty.	✓	-	
Output cam output faulty.	✓	-	
Data exchange with the drive.	✓	-	• Check whether telegram 750 has been created. • Check the configuration of the logical address.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.2.10 Technology alarm 110

Alarm response TO[1]: No reaction

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Configuration is adjusted internally.	✓	-	
Actor.DriveParameter.MaxSpeed is limited.	✓	-	• Correct the reference speed in the drive and in the technology object "<TO>.Actor.DriveParameter.ReferenceSpeed". The reference speed (parameter p2000) must be at least half the maximum speed (parameter p1082) "<TO>.Actor.DriveParameter.ReferenceSpeed" ≥ 0.5 "<TO>.Actor.DriveParameter.MaxSpeed". • During the automatic transfer of the drive parameters to the technology object during runtime (online), slight accuracy deviations may occur from the reference speed and maximum speed configured in the drive. • With analog drive connection, correct the reference value in the drive and in the configuration of the technology object to "<TO>.Actor.MaxSpeed" / 1.17.
PositioningMonitoring.ToleranceTime is limited.	✓	-	Change the configuration data.
DynamicDefaults.EmergencyDeceleration is limited.	✓	-	
DriveParameter.ReferenceTorque too low.	✓	-	
Sensor[].Backlash.Size is limited.	✓	-	
Sensor[].Backlash.Velocity is limited.	✓	-	

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.2.11 Technology alarm 111

Alarm response TO[1]: No reaction

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
TO and drive configuration inconsistent.	✓	-	
Different telegram.	✓	-	Match the telegram configuration for the technology object with the telegram configuration in the drive (p922 in the drive).

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Incompatible torque resolution.	✓	-	Adjust the high torque resolution for the drive.
Application cycle of the drive and servo cycle are different.	✓	-	Adjust the application cycle of the drive in the device configuration for the PROFIBUS drive.
Application cycle of the drive and processing cycle of the TO are different.	✓	-	
Linear motor configured.	✓	-	Set round-frame motor (P300) in the drive.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.2.12 Technology alarm 112

Alarm response TO[1]: No reaction

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
TO and encoder configuration inconsistent.	✓	-	
Different telegram type.	✓	-	Match the telegram configuration for the technology object with the telegram configuration in the encoder.
Encoder is not an absolute encoder.	✓	-	Configure the encoder for the technology object as absolute encoder.
Application cycle of the encoder and servo cycle are different.	✓	-	Adjust the application cycle of the encoder in the device configuration for the PROFIBUS encoder.
Application cycle of the encoder and processing cycle of the TO are different.	✓	-	
Encoder is not an incremental encoder.	✓	-	Configure the encoder for the technology object as an incremental encoder.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.2.13 Technology alarm 113

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Isochronous mode not possible.	✓	-	• The configured output for the technology object output cam or cam track or input for the technology object measuring input cannot be used in isochronous mode. Configure the I/O in the device configuration as isochronous I/O. • The maximum permissible application cycle T_{Servo} has been exceeded. When using SINAMICS sensors, the maximum application cycle may be up to 8 ms. • Make sure that the organization block MC_Servo is called synchronously with the bus system. • The digital IO module for the output cam, cam track or measuring input technology object is configured at a different PROFINET interface of the PLC than the associated axis drive. In the HW configuration, set the send clocks of both PROFINET interfaces to the same send clock and synchronize the interfaces: – In the Inspector window, navigate to "Advanced options > Real time settings > IO communication". – In the drop-down menu "Synchronization of the send clock", select the entry "Based on the send clock of the PROFINET interface". Result: The PROFINET interface couples or synchronizes with the send clock of the other PROFINET interface.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.2.14 Technology alarm 114

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Cross-PLC synchronous operation configuration error.	✓	-	
Configuration error.	✓	-	Check the configuration of the interconnected leading and following axes. Make sure that all relevant tags are correctly configured for cross-PLC synchronous operation.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.3 Technology alarms 201 - 204

5.3.1 Technology alarm 201

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Alarm response interpreter: Stop Interpreter program with diagnostics option

Restart: Required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Internal error.	✓	✓	Open a Support request. The following data is required for the error analysis: • The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) • The diagnostic buffer of the CPU as text file (Online & diagnostics > Diagnostics > Diagnostics buffer) • The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) • The project in the state that led to this alarm • The password for the project • Steps for reproduction

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.3.2 Technology alarm 202

Alarm response TO[1]: No reaction

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Alarm response interpreter: Stop Interpreter program with diagnostics option

Restart: Required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Internal configuration error.	✓	✓	Open a Support request. The following data is required for the error analysis: • The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) • The diagnostic buffer of the CPU as text file (Online & diagnostics > Diagnostics > Diagnostics buffer) • The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) • The project in the state that led to this alarm • The password for the project • Steps for reproduction

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.3.3 Technology alarm 203

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Internal error.	✓	✓	Open a Support request. The following data is required for the error analysis: • The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) • The diagnostic buffer of the CPU as text file (Online & diagnostics > Diagnostics > Diagnostics buffer) • The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) • The project in the state that led to this alarm • The password for the project • Steps for reproduction

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.3.4 Technology alarm 204

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Alarm response interpreter: No reaction

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Commissioning error.	✓	✓	
Connection to the TIA Portal interrupted or master control axis control panel lost.	✓	✓	Check the connection properties. Retrieve the master control in the axis control panel.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.4 Technology alarms 301 - 343

5.4.1 Technology alarm 301

Alarm response TO[1]: Stop with maximum dynamic values

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Superimposing axis not assigned or defective.	✓	-	Configure the possible superimposing axes at the superimposed axis "Axis" under "Configuration > Extended parameters > Superimposing axes".

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.4.2 Technology alarm 304

Alarm response TO[1]: Stop with emergency stop ramp

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Velocity limit is zero.	✓	-	Enter a non-zero value for the maximum velocity (<TO>.DynamicLimits.MaxVelocity) in the dynamic limits.
	-	✓	Enter a non-zero value for the velocity (<TO>.DynamicLimits.Path.Velocity) in the dynamic limits.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.4.3 Technology alarm 305

Alarm response TO[1]: Stop with emergency stop ramp

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Acceleration/deceleration limit is zero.	✓	✓	
Acceleration	✓	-	Enter a non-zero value for the maximum acceleration (DynamicLimits.MaxAcceleration) in the dynamic limits.
	-	✓	Enter a value for the acceleration (DynamicLimits.Path.Acceleration) that does not equal zero in the dynamic limits.
Deceleration	✓	-	Enter a non-zero value for the maximum deceleration (DynamicLimits.MaxDeceleration) in the dynamic limits.
	-	✓	Enter a value for the deceleration (DynamicLimits.Path.Deceleration) that does not equal zero in the dynamic limits.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.4.4 Technology alarm 306

Alarm response TO[1]: Stop with emergency stop ramp

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Jerk limit is zero.	✓	-	Enter a non-zero value for the maximum jerk (DynamicLimits.MaxJerk) in the dynamic limits.
	-	✓	Enter a value for the JERK (DynamicLimits.Path.Jerk) that does not equal zero in the dynamic limits.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.4.5 Technology alarm 307

Alarm response TO[1]: Stop with maximum dynamic values

Alarm response Kin[2]: -

Restart: Not required

Alarm text		Validity		Remedy
		TO[1]	Kin[2]	
Negative/positive numerical value range of the position reached.		✓	-	
	Negative	✓	-	Enable the "Modulo" setting for the technology object.
	Positive	✓	-	

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.4.6 Technology alarm 308

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text		Validity		Remedy
		TO[1]	Kin[2]	
Negative/positive numerical value range of the position exceeded.		✓	-	
	Negative	✓	-	Enable the "Modulo" setting for the technology object.
	Positive	✓	-	

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.4.7 Technology alarm 321

Alarm response TO[1]: Stop with emergency stop ramp

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Axis is not homed.	✓	-	To perform an absolute positioning motion, you must home the technology object.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.4.8 Technology alarm 322

Alarm response TO[1]: No reaction

Alarm response Kin[2]: -

Alarm response interpreter: No reaction

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Restart not executed.	✓	-	
TO is not ready for restart.	✓	-	Download the project again.
Condition for TO restart not satisfied.	✓	-	Disable the technology object.
			Cam technology object: Make sure that the cam is not in use.
			Interpreter technology object Ensure that the Interpreter technology object is not in operation. Stop the execution of the Interpreter program.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.4.9 Technology alarm 323

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Homing could not be performed.	✓	-	• Enable the "Modulo" setting for the technology object. • Adjust the position value for homing. • The following applies to modulo axes: The position setpoint after resolving the modulo (number of modulo overflows + position within the modulo cycle) must be within the valid value range: – 9.0E9 if "Use position values with higher resolution" is activated – 9.0E12 if "Use position values with higher resolution" is deactivated

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.4.10 Technology alarm 341

Alarm response TO[1]: Stop with maximum dynamic values

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Homing data faulty.	✓	-	
Approach velocity is zero.	✓	-	Check the configuration for homing (Homing.ApproachVelocity).
Homing velocity is zero.	✓	-	Check the configuration for homing (Homing.ReferencingVelocity).

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.4.11 Technology alarm 342

Alarm response TO[1]: Stop with emergency stop ramp

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Reference cam/encoder zero mark not found.	✓	-	The reference cam configured for homing was not found in the traversing range of the axis.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.4.12 Technology alarm 343

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Homing function not supported by device.	✓	-	Configure a reference switch input for the pulse generator output used in the properties of the C-CPU. ("Pulse generators (PTO/PWM) > PTO[n]/PWN[n] > Hardware inputs/outputs") When homing across a zero mark, the CPU transfers the reference switch input as zero mark.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.5 Technology alarms 401 - 431

5.5.1 Technology alarm 401

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Error accessing logical address.	✓	-	
Address is invalid.	✓	-	• Connect a suitable device. • Check the device (I/Os). • Check the topology of the project. • Compare the device configuration and the configuration of the technology object. • Configure the valid hardware limit switch. • Open a Support request. The following data is required for the error analysis: – The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) – The diagnostic buffer of the CPU as text file (Online & diagnostics > Diagnostics > Diagnostics buffer) – The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) – The project in the state that led to this alarm – The password for the project – Steps for reproduction
Input address is invalid.	✓	-	
Output address is invalid.	✓	-	
Error during parameter assignment of the address area.	✓	-	Make sure that different addresses are assigned for all technology objects in the project.
Address overlap during drive interconnection.	✓	-	
Address overlap during encoder interconnection.	✓	-	

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.5.2 Technology alarm 411

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Encoder at the logical address disrupted.	✓	-	
Alarm message from encoder.	✓	-	Check the function, connections and I/Os of the encoder.
HW error encoder.	✓	-	
Encoder dirty.	✓	-	
Read error encoder absolute value.	✓	-	Compare the encoder type in the drive or encoder parameter P979 with the configuration data of the technology object.
Zero mark monitoring encoder.	✓	-	Encoder signals error in zero mark monitoring (fault code 0x0002 in Gx_XIST2, see PROFIdrive profile).
Encoder in Parking state.	✓	-	• Search for the cause of the error in the connected drive or encoder. • Check whether the alarm was possibly triggered by a commissioning action involving the drive or encoder.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.5.3 Technology alarm 412

Alarm response TO[1)]: Remove enable

Alarm response Kin[2)]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Permitted actual value range exceeded.	✓	-	
Positive.	✓	-	• Home the axis/encoder in a valid actual value range. • When using an absolute encoder, check the transfer of the incremental actual value "Gx_XIST1" in PROFIdrive Telegram. If the incremental actual value is transmitted at less than 32 bit, configure the evaluation of "Gx_XIST1" in "<TO>.Sensor[1..4].Parameter.BehaviorGx_XIST1" to the value "0" in the data block of the technology object. For more detailed information on the evaluation of the incremental actual value "Gx_XIST1", refer to the section "Drive and encoder connection" in the "S7-1500/S7-1500T Axis functions" documentation.
Negative.	✓	-	
Modulo length.	✓	-	Note the maximum permissible velocity for modulo axes: • The modulo axis is not configured as a possible leading value for a synchronous axis technology object: The maximum permissible velocity is limited to the Modulo length/cycle time of MC_Servo. • The modulo axis is configured as a possible leading value for a synchronous axis technology object: The maximum permissible velocity is limited to half the Modulo length/cycle time of MC_Servo. Reduce the cycle time of MC_Servo. Configure the maximum velocity "<TO>.DynamicLimits.MaxVelocity" to the maximum permissible velocity of the modulo axis. This limits the velocity of the axis to the maximum permissible velocity. The axis remains enabled. Increase the modulo length or disable the "Modulo" setting if that is possible for your application. **Notice** You must adapt the user program after changing the modulo configuration. Modify the following points in the user program: • Calculation of the target positions and the motion direction for positioning instructions • Parameter assignment of synchronous operation instructions and cams • Display of positions in the HMI and other user interfaces Additional modifications may be necessary depending on your application.

[1] Applies to all technology objects with the exception of the Kinematics technology object.

[2] Applies to the Kinematics technology object only.

5.5.4 Technology alarm 421

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Drive disrupted at the logical address.	✓	-	
Alarm message from drive.	✓	-	• Check the function and the connections of the drive. • Enable the safety function in the drive. You can find more detailed information in the section "Safety functions in the drive" of the "S7-1500/S7-1500T Axis functions" documentation. • In the case of analog connected axes, check if the "<TO>.StatusDrive.InOperation" tag = TRUE. • Wait to enable the drive until the axis has reached a standstill (<TO>.StatusWord.X7 (Standstill)). You can configure the standstill detection in the configuration of the axis technology object under "Extended parameters > Position monitoring > Standstill signal".
No drive control requested.	✓	-	
Drive has shut down.	✓	-	
Drive enable not possible.	✓	-	
Error controlling the PROFIdrive State Machine.	✓	-	Wait until the axis has reached a standstill (<TO>.StatusWord.X7 (Standstill)). You can configure the standstill detection in the configuration of the axis technology object under "Extended parameters > Position monitoring > Standstill signal". Disable the technology object. Acknowledge the alarm. Enable the technology object again.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.5.5 Technology alarm 431

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Communication to the device under logical address is disturbed.	✓	-	
Drive failed.	✓	-	Check the function, connections and I/Os of the drive.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Signs of life of drive faulty.	✓	-	• Check the function, connections and I/Os of the drive. • Compare the cycle times in the device configuration (PROFINET sync master, PROFINET sync device or PROFIBUS DP master system, PROFIBUS device) and in the MC_Servo. The cycle of the master application and the application cycle of the MC_Servo must be parameterized with the same cycle time. (An incorrect parameter assignment is indicated with 0x0080.) • If you call the application cycle of the MC_Servo reduced to the send clock of a PROFINET IO system and the technology alarm 431 (Signs of life of drive faulty) is repeatedly shown, increase the update time of the send clock.
Encoder failed.	✓	-	Check the function, connections and I/Os of the encoder.
Signs of life of encoder faulty.	✓	-	• Check the function, connections and I/Os of the encoder. • Compare the cycle times in the device configuration (PROFINET sync master, PROFINET sync device or PROFIBUS DP master system, PROFIBUS device) and in the MC_Servo. The cycle of the master application and the application cycle of the MC_Servo must be parameterized with the same cycle time.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6 Technology alarms 501 - 563

5.6.1 Technology alarm 501

Alarm response TO[1]: No reaction

Alarm response Kin[2]: No reaction

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Programmed velocity is limited.	✓	✓	• Check the value for the velocity at the instruction or for the time-based position profile. • Check the configuration of the dynamic limits. • Check the value of the "<TO>.DynamicLimits.Velocity" tag.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Programmed velocity is limited.	✓	-	Observe the maximum permissible velocity for modulo axes: • The modulo axis is not configured as a possible leading value for a synchronous axis technology object: The maximum permissible velocity is limited to the modulo length/cycle time of MC_Servo. • The modulo axis is configured as a possible leading value for a synchronous axis technology object: The maximum permissible velocity is limited to half the modulo length/cycle time of MC_Servo. Reduce the cycle time of MC_Servo. Set the maximum velocity "<TO>.DynamicLimits.MaxVelocity" to the maximum permissible velocity of the modulo axis. This limits the velocity of the axis to the maximum permissible velocity. The axis remains enabled. Increase the modulo length or disable the "Modulo" setting if that is possible for your application. **Notice** You must adapt the user program after changing the modulo configuration. Modify the following points in the user program: • Calculation of the target positions and the direction of movement for positioning instructions • Parameter assignment of synchronous operation instructions and cams • Display of positions in the HMI and other user interfaces Additional modifications may be necessary depending on your application.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.6.2 Technology alarm 502

Alarm response TO[1]: No reaction

Alarm response Kin[2]: No reaction

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Programmed acceleration/deceleration is being limited.	✓	✓	
Acceleration	✓	✓	• Check the value for the acceleration at the instruction or for the time-based position profile. • Check the configuration of the dynamic limits.
Deceleration	✓	✓	• Check the value for the delay at the instruction or for the time-based position profile. • Check the configuration of the dynamic limits.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.6.3 Technology alarm 503

Alarm response TO[1]: No reaction

Alarm response Kin[2]: No reaction

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Programmed jerk is limited.	✓	✓	• Check the value for the jerk at the instruction or for the time-based position profile. • Check the configuration of the dynamic limits.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.6.4 Technology alarm 504

Alarm response TO[1]: No reaction

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Speed setpoint monitoring active.	✓	-	• Check the mechanical configuration. • Check the encoder connection. • Check the configuration of the speed setpoint interface. • Check the configuration of the control loop. • Check the value for the maximum velocity (<TO>.DynamicLimits.MaxVelocity). • When using an absolute encoder, check the transfer of the incremental actual value "Gx_XIST1" in PROFIdrive Telegram. If the incremental actual value is transmitted at less than 32 bit, configure the evaluation of "Gx_XIST1" in "<TO>.Sensor[1..4].Parameter.BehaviorGx_XIST1" to the value "0" in the data block of the technology object. For more detailed information on the evaluation of the incremental actual value "Gx_XIST1", refer to the section "Drive and encoder connection" of the "S7-1500/S7-1500T" documentation.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6.5 Technology alarm 511

Alarm response TO[1]: No reaction

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Dynamic limit is violated by kinematics motion.	✓	-	
Velocity.	✓	-	Reduce the velocity of the kinematics motion.
Acceleration.	✓	-	Reduce the acceleration of the kinematics motion.
Deceleration.	✓	-	Reduce the deceleration of the kinematics motion.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6.6 Technology alarm 521

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Following error.	✓	-	• Check the configuration of the control loop. • Check the direction signal of the encoder. • Check the configuration of the following error monitoring. • When using an absolute encoder, check the transfer of the incremental actual value "Gx_XIST1" in PROFIdrive Telegram. If the incremental actual value is transmitted at less than 32 bit, configure the evaluation of "Gx_XIST1" in "<TO>.Sensor[1..4].Parameter.BehaviorGx_XIST1" to the value 0 in the data block of the technology object. For more detailed information on the evaluation of the incremental actual value "Gx_XIST1", refer to the section "Drive and encoder connection" in the "S7-1500/S7-1500T Axis functions" documentation.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6.7 Technology alarm 522

Alarm response TO[1]: No reaction

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Warning following error tolerance.	✓	-	• Check the configuration of the control loop. • Check the direction signal of the encoder. • Check the configuration of the following error monitoring.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6.8 Technology alarm 531

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Positive HW limit switch approached.	✓	-	Acknowledge the alarm. After the acknowledgment, motions in the negative direction are allowed.
Negative HW limit switch approached.	✓	-	Acknowledge the alarm. After the acknowledgment, motions in the positive direction are allowed.
Invalid retraction direction, HW limit switch active.	✓	-	The programmed direction of movement is disabled due to the active HW limit switch. Retract the axis in the opposite direction.

Restart: Required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Encoder error with triggered HW limit switch, no retraction possible.	✓	-	Correct the fault in the encoder. Acknowledge the alarm by switching the controller off and on or by restarting the technology object.

Restart: See Remedy

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
HW limit switch polarity reversed, retraction not possible.	✓	-	• Check the mechanical configuration of the HW limit switch. • Check the limit switches. • Make sure that only one of the two tags is "TRUE": – <TO>.StatusWord.X17 (HWLimitMinActive) – <TO>.StatusWord.X18 (HWLimitMaxActive) • To enable retraction, you can temporarily disable the HW limit switches. Technology version ≥ V7.0: Only required for traversable HW limit switches: Acknowledge the alarm by switching the controller off and on or by restarting the technology object. Technology version < V7.0: Acknowledge the alarm by switching the controller off and on or by restarting the technology object.
Both HW limit switches active, retraction not possible.	✓	-	

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6.9 Technology alarm 533

Alarm response TO[1]: The alarm response depends on the configured response and the type of axis motion.

- Stop with maximum dynamic values

  When "<TO>.PositionLimits_SW.LimitReachedBehavior" = 0 and an interconnected axis.

  – Axis motion as following axis in synchronous operation

  – Kinematics axis in kinematics motion

- Stop with current dynamic values

  When "<TO>.PositionLimits_SW.LimitReachedBehavior" = 1 and interconnected axis

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Software limit switch is approached.	✓	-	
Negative	✓	-	With the current dynamic values, the axis will approach the negative software limit switch. For positioning axes, check the position setpoint. For following axes, check whether the current dynamics violates the configured dynamic limits. Move the axis in positive direction away from the negative software limit switch.
Positive	✓	-	With the current dynamic values, the axis will approach the positive software limit switch. For positioning axes, check the position setpoint. For following axes, check whether the current dynamics violates the configured dynamic limits. Move the axis in negative direction away from the positive software limit switch

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6.10 Technology alarm 534

Alarm response TO[1]: You can configure the alarm response.

- Remove enable

  Setting: "<TO>.PositionLimits_SW.LimitExceededBehavior" = 0

- Stop with emergency stop ramp

  Setting: "<TO>.PositionLimits_SW.LimitExceededBehavior" = 1

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
SW limit switch was overtraveled.	✓	-	
Negative	✓	-	The software limit switch was overtraveled. Acknowledge the alarm. After the acknowledgment, motions in the positive direction are allowed.
Positive	✓	-	The software limit switch was overtraveled. Acknowledge the alarm. After the acknowledgment, motions in the negative direction are allowed.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6.11 Technology alarm 541

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Position monitoring error.	✓	-	
Target range not reached.	✓	-	The target range was not reached within the tolerance time. • Check the configuration of the position monitoring. • Check the configuration of the control loop.
Exit target range again.	✓	-	The target range was exited within the minimum dwell time. • Check the configuration of the position monitoring. • Check the configuration of the control loop.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6.12 Technology alarm 542

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Clamping monitoring error: Axis leaving clamping tolerance window.	✓	-	The axis has executed a motion greater than the permissible tolerance at the fixed stop. Check whether the fixed stop has broken away.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6.13 Technology alarm 550

Alarm response TO[1]: Track setpoints

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Drive-autonomous motion is being executed.	✓	-	• The drive is performing a motion that was not specified by the technology object. • Check if a safety function is active in the drive. You can find more detailed information in the section "Safety functions in the drive" of the "S7-1500/S7-1500T Axis functions" documentation.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6.14 Technology alarm 551

Alarm response TO[1]: No reaction

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Maximum velocity cannot be reached with drive/axis parameters.	✓	-	The configured maximum velocity cannot be reached with the configured mechanics of the axis. Check the configuration of the mechanics and the set reference speed. Check the adapted reference speed "<TO>.Actor.DriveParameter.ReferenceSpeed" during automatic transfer of the drive parameters during runtime (online). During the automatic transfer of the drive parameters in runtime (online), slight accuracy deviations may occur from the reference speed configured in the drive.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6.15 Technology alarm 552

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Encoder adaptation error during ramp-up.	✓	-	
Encoder is not assigned to a SINAMICS device.	✓	-	• The operationally active encoder could not be adapted. Other encoders that can be used are configured. Use the encoder switch. • The encoder set as the operationally active encoder could not be adapted. • Specify a different sensor for the initialization of the technology object.
Encoder system.	✓	-	
Encoder resolution.	✓	-	
Encoder fine resolution.	✓	-	
Encoder revolutions.	✓	-	
Unspecified.	✓	-	
Reference value NACT.	✓	-	
Parameter does not exist, value unreadable or invalid.	✓	-	Check whether your device supports acyclic data communication according to PROFIdrive.
Encoder system.	✓	-	
Encoder resolution.	✓	-	
Encoder fine resolution.	✓	-	
Encoder revolutions.	✓	-	

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Unspecified.	✓	-	Check whether your device supports acyclic data communication according to PROFIdrive.
Reference value NACT.	✓	-	
Adaptation canceled due to insufficient resources.	✓	-	
Encoder system.	✓	-	
Encoder resolution.	✓	-	
Encoder fine resolution.	✓	-	
Encoder revolutions.	✓	-	
Unspecified.	✓	-	
Reference value NACT.	✓	-	
Encoder is not interconnected directly to I/O area.	✓	-	During the configuration of the axis, the logical addresses were set to a data block or bit memory address area, for example. The adaptation is only possible when the encoder has been directly interconnected to an I/O area.
Encoder system.	✓	-	
Encoder resolution.	✓	-	
Encoder fine resolution.	✓	-	
Encoder revolutions.	✓	-	
Unspecified.	✓	-	
Reference value NACT.	✓	-	

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.6.16 Technology alarm 561

Alarm response TO[1]: -

Alarm response Kin[2]: No reaction

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Programmed velocity of the orientation motion is limited.	-	✓	Check the configuration of the velocity of the orientation motion.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6.17 Technology alarm 562

Alarm response TO[1]: -

Alarm response Kin[2]: No reaction

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Programmed acceleration/deceleration of the orientation motion is limited.	-	✓	
Acceleration	-	✓	Check the configuration of the acceleration of the orientation motion.
Deceleration	-	✓	Check the configuration of the deceleration of the orientation motion.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.6.18 Technology alarm 563

Alarm response TO[1]: -

Alarm response Kin[2]: No reaction

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Programmed jerk of the orientation motion is limited.	-	✓	Check the configuration of the jerk of the orientation motion.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.7 Technology alarms 601 - 612

5.7.1 Technology alarm 601

Alarm response TO[1]: Stop with maximum dynamic values

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Leading axis is not assigned or defective.	✓	-	Configure the possible leading value axes for the following axis under "Configuration > Leading value interconnections". For cross-PLC synchronous operation, make sure that the option "Synchronous to the bus" is selected for the MC_Servo OBs of all connected CPUs under "Properties > General > Cycle time".

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.7.2 Technology alarm 603

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Leading axis is not in position-controlled mode.	✓	-	During synchronization/desynchronization, the leading axis must be operated in position-controlled mode.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.7.3 Technology alarm 608

Alarm response TO[1]: Stop with maximum dynamic values

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Error during synchronization/desynchronization.	✓	-	• Prevent a reverse leading value motion during the synchronization/desynchronization. If necessary, increase the reverse tolerance of the leading value. • If necessary, use a higher hysteresis value (<TO>.Extrapolation.Hysteresis.Value) for actual value coupling. You can find more information at Siemens Industry Online Support in the FAQ entry 109798578 (https://support.industry.siemens.com/cs/ww/en/view/109798578). • Check the direction specification for the synchronization or desynchronization at the instruction.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.7.4 Technology alarm 612

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Specified cam has not been interpolated.	✓	-	Interpolate the cam used for camming.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.8 Technology alarms 700 - 758

5.8.1 Technology alarm 700

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Error when calculating the switching position.	✓	-	
Cam position: OnPosition	✓	-	The position for the "OnPosition" parameter could not be calculated. Invalid positions (e.g. "OnPosition" > "OffPosition") were calculated due to lead times. The output cam cannot be switched due to the axis dynamics and compensation times.
Cam position: OffPosition	✓	-	The position for the "OffPosition" parameter could not be calculated. Invalid positions (e.g. "OffPosition" > "OnPosition") were calculated due to lead times. The output cam cannot be switched due to the axis dynamics and compensation times.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.8.2 Technology alarm 701

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
I/O output error.	✓	-	The digital output for the output cam or cam track technology object cannot be addressed. Download the device configuration again.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.8.3 Technology alarm 702

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Position value invalid.	✓	-	• A restart of the technology object is performed. Wait until the technology object restart is complete. • The encoder values are invalid due to an encoder error. Check the encoder and adjust the configuration if necessary.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.8.4 Technology alarm 703

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Output cam data faulty.	✓	-	
Output cam: Output cam number	✓	-	Check the configuration of the relevant output cam in the cam track and adjust the values if necessary. Examples of a correct configuration: • "<TO>.Parameter.Cam[1..32].OnPosition" < "<TO>.Parameter.Cam[1..32].OffPosition" • "<TO>.Parameter.Cam[1..32].Duration" > "<TO>.Parameter.OffCompensation" - "<TO>.Parameter.OnCompensation"

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.8.5 Technology alarm 704

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Output cam data faulty.	✓	-	Check the configuration of the output cam and adjust the values if necessary. Examples of a correct configuration: • "MC_OutputCam.OnPosition" < "MC_OutputCam.OffPosition" • "MC_OutputCam.Duration" > "<TO>.Parameter.OffCompensation" - "<TO>.Parameter.OnCompensation"

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.8.6 Technology alarm 750

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Measuring job not possible during homing of assigned axis.	✓	-	Do not use a measuring job and a homing job simultaneously. Wait until homing of the axis is complete.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.8.7 Technology alarm 752

Alarm response TO[1]: No reaction

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Validity range of measuring job not recognized.	✓	-	The pre-defined measuring range was not recognized. Adjust the measuring range.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.8.8 Technology alarm 753

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Only one measuring input can access an encoder at a time.	✓	-	Use only one measuring job for an encoder.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.8.9 Technology alarm 754

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Measuring input configuration in external device is not correct.	✓	-	Check the configuration of the measuring inputs on the external device.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.8.10 Technology alarm 755

Alarm response TO[1]: Remove enable

Alarm response Kin[2]: -

Restart: Not required

Alarm text		Validity		Remedy
		TO[1]	Kin[2]	
Measuring job not possible.		✓	-	
	Device has reported an error.	✓	-	The measurement was aborted with error. Check the measuring input functionality in the utilized device.
	Cyclic measuring with telegram 39x is not possible.[3]	✓	-	• Use a job to start a one-time measurement. • Cyclic measuring is only possible when measuring using TM Timer DIDQ. Change the configuration of the measuring input type to "TM Timer DIDQ".

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

3) Relevant for technology version ≤ V7.0

5.8.11 Technology alarm 758

Alarm response TO[1]: No reaction

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
A measuring edge was not evaluated.	✓	-	An edge was already detected at the input of the measuring input even though the module was not yet ready. The measured value is provided at the next edge.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.9 Technology alarms 801 - 820

5.9.1 Technology alarm 801

Alarm response TO[1]: -

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Kinematics axis <no.> not ready.	-	✓	
Axis not released.	-	✓	Enable the technology object.
Axis job programmed.	-	✓	To be able to transmit another kinematics job, set the specified axis to a standstill.
Axis alarm.	-	✓	Check and acknowledge the technology alarms of the specified kinematics axis.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.9.2 Technology alarm 802

Alarm response TO[1]: -

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Cannot calculate the geometry element.	-	✓	
Radius less than half the path distance.	-	✓	Adjust the radius.
Starting, intermediate, or end point identical	-	✓	Specify different values for starting point, intermediate point and end point.
Intermediate point cannot be accessed.	-	✓	Adjust the intermediate point.
Starting and end points identical.	-	✓	Define different start and end points.
Unable to execute dynamic adaptation.	-	✓	Switch off the dynamic adaptation.
Movement is outside the transformation area.	-	✓	Define the motions within the transformation area
Transformation only works with sPTP motions.	-	✓	Use one job for an absolute or relative sPTP motion.
Not possible to approach tracked OCS.	-	✓	• Use an absolute linear or circular motion. • For an absolute circular motion, define the circular path via intermediate point and target position. • Switch off the dynamic adaptation. • Use a route > 0 for the linear or circular motion. An orientation motion without kinematics motion is not possible.
Kinematics motion in the coupled OCS cannot be terminated by job configuration.	-	✓	
Change of the coordinate system is not possible with coupled OCS.	-	✓	It is not possible to directly change from one coupled OCS into another coupled OCS with a motion command. First transmit an instruction in the WCS or a non-tracked OCS to complete the process of the kinematics with the tracked OCS.
sPTP motion not possible with coupled OCS.	-	✓	An sPTP motion cannot be used in a moved OCS. To move the kinematics in a coupled OCS, use one of the following motions: • Absolute or relative linear motion • Absolute or relative circular motion
Active coordinate system cannot be changed with coupled OCS.	-	✓	The following instructions can only be performed in the status "TrackingState" = 0 or 1: • Redefine tool • Change active tool • Start conveyor tracking The following instruction can only be performed in the status "TrackingState" = 0: • Redefine object coordinate systems First transmit an instruction in the WCS or a non-tracked OCS to complete the process of the kinematics with the tracked OCS.
Dynamic values of the user transformation not correctly specified.	-	✓	Check the calculation of the velocities and accelerations in the user transformation in the MC_Transformation.

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
The target joint position is outside the valid joint travel range.	-	✓	Check the set limits of the joint travel range. Specify a valid target joint position.
Override motion could not be calculated.	-	✓	Change the blending radius or the programmed target point of the overriding motion.
The programmed motion job exceeds the max. permissible traversing duration.	-	✓	Reduce the traversing distance or increase the dynamic response.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.9.3 Technology alarm 803

Alarm response TO[1]: -

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Error in the calculation of the transformation.	-	✓	
Error during transformation of the axis coordinates into Cartesian coordinates.	-	✓	• Correct your specified motion with regard to the joint positioning space and the transformation areas: • Position the kinematics axes with single-axis motions in a permitted transformation area. • For user transformation: Check the calculation in the MC_Transformation.
Error during transformation of the Cartesian coordinates into axis coordinates.	-	✓	
Additional info:	-	✓	
With predefined kinematics systems:			
0 Cartesian position cannot be reached			
1 Singularity			
With user-defined kinematics systems: "FunctionResult" of MC_Transformation			

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.9.4 Technology alarm 804

Alarm response TO[1]: -

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Kinematics motion cannot be stopped at end.	-	✓	Ensure that the path is sufficiently long.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.9.5 Technology alarm 805

Alarm response TO[1]: -

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Limitation of path dynamics by axis dynamics incorrect.	-	✓	
Path velocity is limited to zero.	-	✓	Configure a higher "Maximum velocity" on the kinematics axes.
Acceleration/deceleration is limited to zero.	-	✓	Configure a larger "Maximum acceleration" or "Maximum deceleration" on the kinematics axes.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.9.6 Technology alarm 806

Alarm response TO[1]: -

Alarm response Kin[2]: Stop without leaving the path

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Zone violation of work or blocked zones.	-	✓	Move the kinematics into the work zone or out of the blocked zone.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.9.7 Technology alarm 807

Alarm response TO[1]: -

Alarm response Kin[2]: No reaction

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Zone violation of signal zones.	-	✓	-

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.9.8 Technology alarm 808

Alarm response TO[1]: -

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Ambiguity due to multiple active work zones.	-	✓	
<Number of current active work zones>	-	✓	Activate only one work zone.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.9.9 Technology alarm 809

Alarm response TO[1]: -

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Path dynamic limit through dynamic of the orientation motion faulty.	-	✓	
Velocity is limited to zero.	-	✓	Configure a higher maximum velocity for the axes involved in the orientation motion.
Acceleration/deceleration is limited to zero.	-	✓	Configure a higher maximum acceleration or deceleration for the axes involved in the orientation motion.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.9.10 Technology alarm 810

Alarm response TO[1]: -

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Conveyor belt not assigned or faulty (OCS <number>).	-	✓	• Check the parameter inputs for initiating conveyor tracking. • Check the configuration of the leading-value-capable technology object which represents the conveyor belt.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.9.11 Technology alarm 811

Alarm response TO[1]: -

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Error when approaching the TCP to an object coordinate system (OCS <number>).	-	✓	• You have used an impermissible motion job for approaching the TCP on the object coordinate system. Use an absolute linear or circular motion. • The kinematics motion was stopped or interrupted, and the tracking of the OCS in the state "TrackingState" = "2" and "4" was terminated.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.9.12 Technology alarm 812

Alarm response TO[1]: -

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Error in the treatment of singularities.	-	✓	
The kinematics has reached the singularity.	-	✓	Correct the given path motion with respect to the singularities.
Too many singularities occur in the path command.	-	✓	

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.9.13 Technology alarm 820

Alarm response TO[1]: -

Alarm response Kin[2]: Stop with maximum dynamic values of the axes

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Upper limit of joint traversing range joint <No.> overtraveled.	-	✓	Move the joint back into the joint traversing range via a single-axis job.
Lower limit of joint traversing range joint <No.> overtraveled.	-	✓	

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.10 Technology alarms 900 - 903

5.10.1 Technology alarm 900

Alarm response TO[1]: Set leading value invalid

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Leading values invalid.	✓	-	Set a higher tolerance time (<TO>.Parameter.ToleranceTimeExternalLeading-ValueInvalid). Check the connection of the interconnected components. Make sure that there is no communication interference. Make sure that the CPUs involved are in RUN operating state.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.10.2 Technology alarm 901

Alarm response TO[1]: Set leading value invalid

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Data transmission error.	✓	-	
Reason: Invalid version	✓	-	Check the communication.
Reason: Invalid modulo start value	✓	-	
Reason: Invalid modulo length	✓	-	
Reason: Sign-of-life error	✓	-	
Reason: Invalid position	✓	-	Check the leading value of the leading axis on the other CPU.
Reason: Invalid velocity	✓	-	
Reason: Invalid acceleration	✓	-	

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.10.3 Technology alarm 902

Alarm response TO[1]: No reaction

Alarm response Kin[2]: -

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Leading value accuracy limited.	✓	-	Decrease the configured delay time.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

5.10.4 Technology alarm 903

Alarm response TO[1]: Set leading value invalid

Alarm response Kin[2]: -

Restart: Required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Modulo settings of the leading axis changed in cyclic operation.	✓	-	The changed modulo settings of the leading axis are only adopted by the leading axis proxy after a restart and a change in the operating state of the CPU. Acknowledge the alarm by switching the controller off and on and perform a restart of the technology object.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.11 Technology alarms 1001 - 1012

5.11.1 Technology alarm 1001

Alarm response TO[1]: -

Alarm response Kin[2]: -

Alarm response interpreter: Stop and recompile Interpreter program

Restart: Not required

Alarm text		Validity		Remedy
		TO[1]	Kin[2]	
Max. Interpreter program configuration limits reached.		✓	-	
	General error	✓	-	Check whether the Interpreter program adheres to the configuration limits.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Max. number of global Interpreter variables reached	✓	-	Reduce the number of global interpreter variables.
Max. number of local variables and parameters in function reached	✓	-	Reduce the number of local tags and parameters in the function.
Max. number of synchronous actions reached	✓	-	Reduce the number of synchronized actions.
Max. number of symbols reached, e.g. operators, identifiers, literals, data types, etc.	✓	-	Reduce the number of symbols, e.g. operators, identifiers, literals, data types etc.
Max. number of mapped technology objects reached	✓	-	Reduce the number of mapped technology objects.
Max. number of mapped PLC tags reached	✓	-	Reduce the number of mapped technology PLC tags.
Max. character length of identifier reached	✓	-	Reduce the character length of the identifier.
Max. number of functions reached	✓	-	Reduce the number of functions.
Max. calls of the stack depth of functions reached	✓	-	Reduce the function calls.
Max. nesting depth of control instructions reached	✓	-	Reduce the nesting depth of control instructions.
Max. number of user-defined data types reached	✓	-	Reduce the number of user-defined data types.
Max. nesting depth of user-defined data types reached	✓	-	Reduce the nesting depth of the user-defined data types.
Max. number of jump labels reached	✓	-	Reduce the number of jump labels.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

More information

You can find more information on the configuration limits of the Interpreter program in the documentation "S7-1500T Interpreter functions", section "Configuration limits".

5.11.2 Technology alarm 1002

Alarm response TO[1]: -

Alarm response Kin[2]: -

Alarm response interpreter: Stop Interpreter program with diagnostics option

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Max. Interpreter mapping configuration limits reached.	✓	-	
General error	✓	-	Check whether the Interpreter mapping adheres to the configuration limits.
Max. number of global Interpreter variables reached	✓	-	Reduce the number of global interpreter variables.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Max. number of local variables and parameters in function reached	✓	-	Reduce the number of local tags and parameters in the function.
Max. number of synchronous actions reached	✓	-	Reduce the number of synchronized actions.
Max. number of symbols reached, e.g. operators, identifiers, literals, data types, etc.	✓	-	Reduce the number of symbols, e.g. operators, identifiers, literals, data types etc.
Max. number of mapped technology objects reached	✓	-	Reduce the number of mapped technology objects.
Max. number of mapped PLC tags reached	✓	-	Reduce the number of mapped technology PLC tags.
Max. character length of identifier reached	✓	-	Reduce the character length of the identifier.
Max. number of functions reached	✓	-	Reduce the number of functions.
Max. calls of the stack depth of functions reached	✓	-	Reduce the function calls.
Max. nesting depth of control instructions reached	✓	-	Reduce the nesting depth of control instructions.
Max. number of user-defined data types reached	✓	-	Reduce the number of user-defined data types.
Max. nesting depth of user-defined data types reached	✓	-	Reduce the nesting depth of the user-defined data types.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

More information

You can find more information on the configuration limits of the Interpreter mapping in the documentation "S7-1500T Interpreter functions", section "Configuration limits".

5.11.3 Technology alarm 1003

Alarm response TO[1]: -

Alarm response Kin[2]: -

Alarm response interpreter: Stop and recompile Interpreter program

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Syntax error in Interpreter program.	✓	-	
General syntax error	✓	-	Correct the expression.
Invalid expression	✓	-	Use a different expression.
Declaration invalid	✓	-	Move the declaration to the declaration area.
Invalid characters	✓	-	Correct the characters.
Invalid value	✓	-	Correct the value.
Object invalid or typo	✓	-	Use a different object or correct the typos.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Characters in string invalid	✓	-	Use only valid characters.
Keyword or identifier reserved	✓	-	Use a different identifier.
Identifier already declared in the current context	✓	-	Use a different identifier.
Keywords of the control structure incorrect	✓	-	Correct the keywords.
PROGRAM not declared, entry point for Interpreter missing	✓	-	Complete the "PROGRAM" structure.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.11.4 Technology alarm 1004

Alarm response TO[1]: -

Alarm response Kin[2]: -

Alarm response interpreter: Stop Interpreter program with diagnostics option

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Syntax error in Interpreter mapping.	✓	-	
General syntax error	✓	-	Correct the expression.
Invalid expression	✓	-	Use a different expression.
Declaration invalid	✓	-	Move the declaration to the declaration area.
Invalid characters	✓	-	Correct the characters.
Invalid value	✓	-	Correct the value.
Object invalid or typo	✓	-	Use a different object or correct the typos.
Characters in string invalid	✓	-	Use only valid characters.
Keyword or identifier reserved	✓	-	Use a different identifier.
Identifier already declared in the current context	✓	-	Use a different identifier.
PROGRAM not declared, entry point for Interpreter missing	✓	-	Complete the "PROGRAM" structure.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.11.5 Technology alarm 1005

Alarm response TO[1]: -

Alarm response Kin[2]: -

Alarm response interpreter: Stop and recompile Interpreter program

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Semantics error in Interpreter program.	✓	-	
Variable access failed	✓	-	Check the access rights of the tag.
Index limit exceeded	✓	-	Check the array size.

Step size of the FOR loop is zero	✓	-	The step size of a FOR loop must be not equal to zero. Correct or supplement the step size of the FOR loop.
			`FOR i := <Start value> TO <Target value> BY <Step size> DO`
			`...`
			`END_FOR;`

Return value missing	✓	-	Add a return value.
Data type conflict	✓	-	Use a tag with the suitable data type.
Implicit conversion not possible	✓	-	Check the data types used.
Invalid expression	✓	-	Use a valid expression.
Reference invalid	✓	-	Use a valid reference.
Declaration not found	✓	-	Complete the declaration.
Multiple declaration	✓	-	Declare an object only once. Delete all additional declarations of the object.
Assignment not possible	✓	-	• Check the access rights of the tag. Use a writable tag. • Check the data types.
Invalid result (NaN)	✓	-	Correct the calculation or correct the data type of the return value.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.11.6 Technology alarm 1006

Alarm response TO[1]: -

Alarm response Kin[2]: -

Alarm response interpreter: Stop and recompile Interpreter program

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Semantics error in Interpreter mapping.	✓	-	
Variable access failed	✓	-	Check the access rights of the tag.
Index limit exceeded	✓	-	Check the array size.

Step size of the FOR loop is zero	✓	-	The step size of a FOR loop must be not equal to zero. Correct or supplement the step size of the FOR loop.
			`FOR i := <Start value> TO <Target value> BY <Step size> DO`
			`...`
			`END_FOR;`

Return value missing	✓	-	Add a return value.
Data type conflict	✓	-	Use a tag with the suitable data type.
Implicit conversion not possible	✓	-	Check the data types used.
Invalid expression	✓	-	Use a valid expression.
Reference invalid	✓	-	Use a valid reference.
Declaration not found	✓	-	Complete the declaration.
Multiple declaration	✓	-	Declare an object only once. Delete all additional declarations of the object.
Assignment not possible	✓	-	• Check the access rights of the tag. Use a writable tag. • Check the data types.
Invalid result (NaN)	✓	-	Correct the calculation or correct the data type of the return value.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.11.7 Technology alarm 1007

Alarm response TO[1]: -

Alarm response Kin[2]: -

Alarm response interpreter: Stop and recompile Interpreter program

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Parameter error in MCL instruction.	✓	-	
Parameter value invalid	✓	-	Correct the parameter value.
Parameter unknown	✓	-	Correct the parameter specification.
Parameter missing	✓	-	Complete the obligatory parameters.
Multiple parameter	✓	-	Delete redundantly specified parameters.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.11.8 Technology alarm 1008

Alarm response TO[1]: -

Alarm response Kin[2]: -

Alarm response interpreter: Stop and recompile Interpreter program

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Processing error in MCL instruction.	✓	-	
Access to connected or mapped object not possible	✓	-	Check the links and mappings
No kinematics connected	✓	-	Connect a kinematics technology object.
Error reaction of a technology object controlled by the Interpreter	✓	-	Check and acknowledge the technology alarms of the technology object controlled by the Interpreter
Kinematics job cannot be run, job active at least one axis	✓	-	Terminate the active jobs of the kinematics axes.
Job cannot be executed, axis or kinematics control panel active	✓	-	Relinquish master control of the active axis or kinematics control panel.
Other job active at an axis controlled by the Interpreter	✓	-	Terminate the active jobs of the axis.
setControlledByInterpreter() cannot be executed, job is running in the technology object	✓	-	Terminate the active job at the technology object.
Technology error	✓	-	Check the error ID named in this alarm.
Execution not possible, missing enable(s)	✓	-	Enable the technology object controlled by the interpreter using the Motion Control instruction "MC_Power" or the MCL instruction "powerOn()".

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.11.9 Technology alarm 1009

Alarm response TO[1]: -

Alarm response Kin[2]: -

Alarm response interpreter: Stop and recompile Interpreter program

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Processing error in synchronous action.	✓	-	
General error	✓	-	Open a Support request. The following data is required for the error analysis: • The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) • The diagnostic buffer of the CPU as text file (Online & diagnostics > Diagnostics > Diagnostics buffer) • The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) • The project in the state that led to this alarm • The password for the project • Steps for reproduction
Invalid expression	✓	-	Use only valid expressions.
Programming cannot be realized	✓	-	Correct the programming of the synchronized action.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.11.10 Technology alarm 1010

Alarm response TO[1]: -

Alarm response Kin[2]: -

Alarm response interpreter: Stop and recompile Interpreter program

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Processing error during synchronous start.	✓	-	
Programming invalid	✓	-	Correct the programming of the synchronized action.
Invalid expression	✓	-	Correct the expression.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

	Alarm text	Validity		Remedy
		TO[1]	Kin[2]	
	Complete preparation not possible	✓	-	All MCL instructions of the synchronous action between SYNC and END_SYNC must be completely prepared. • Check the MCL instructions of the synchronous action. MCL instructions that interrupt the preparation are not permitted, e.g. "preHalt()". • Check the number of MCL instructions of the synchronous action and reduce this if necessary. • Check the maximum number of jobs to be prepared in the Interpreter job sequence and increase this if necessary (<TO_Interpreter>.Parameter.MaxNumberOfCommands).
	Mutual dependency of instructions/instruction sequence	✓	-	The MCL instructions of the synchronous action are contradictory. Contradictory MCL instructions cannot be applied to the same technology object simultaneously. Check whether the same technology object is accessed simultaneously with the synchronous action.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.11.11 Technology alarm 1011

Alarm response TO[1]: -

Alarm response Kin[2]: -

Alarm response interpreter: Stop Interpreter program with diagnostics option

Restart: Not required

	Alarm text	Validity		Remedy
		TO[1]	Kin[2]	
	Error when mapping technology objects.	✓	-	
	General error	✓	-	Open a Support request. The following data is required for the error analysis: • The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) • The diagnostic buffer of the CPU as text file (Online & diagnostics > Diagnostics > Diagnostics buffer) • The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) • The project in the state that led to this alarm • The password for the project • Steps for reproduction

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Type of the mapped technology object is not supported	✓	-	Correct the mapping.
Mapped technology object cannot be found	✓	-	Check the mapped technology object.
Technology object to be mapped already connected	✓	-	Check the mapping.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

5.11.12 Technology alarm 1012

Alarm response TO[1]: -

Alarm response Kin[2]: -

Alarm response interpreter: No reaction

Restart: Not required

Alarm text	Validity		Remedy
	TO[1]	Kin[2]	
Critical programming.	✓	-	
System function overridden by a function with the same identifier	✓	-	Correct the programming of the function.
Job is ignored due to a "MC_Power" job in the user program	✓	-	To enable or disable a technology object to be controlled by the Interpreter, use the MCL instructions "powerOn()" and "powerOff()" or the Motion Control instruction "MC_Power".

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

Error IDs in Motion Control instructions 6

Errors in Motion Control instructions are indicated by the "Error" and "ErrorID" output parameters.

Under the following conditions, "Error" = TRUE and "ErrorID" = 16#8xxx are indicated for the Motion Control instruction:

- Illegal status of the technology object, which prevents the execution of the job.
- Invalid parameter assignment of the Motion Control instruction, which prevents the execution of the job.
- As a result of the alarm response for a technology object error.

Error display

If there is a Motion Control instruction error, the "Error" parameter shows the value "TRUE". The cause of the error is given in the "ErrorID" parameter.

Jobs to the technology object are rejected when "Error" = TRUE. Running jobs are not influenced by rejected jobs.

If "Error" = TRUE and "ErrorID" = 16#8001 is indicated during job execution, a technology alarm has occurred. In this case, evaluate the indication of the technology alarm.

If "Error" = TRUE is displayed during execution of a "MC_MoveJog" job, the axis is braked and brought to a standstill. In this case, the deceleration configured for the "MC_MoveJog" instruction takes effect.

Acknowledge error

Acknowledging errors in Motion Control instructions is not required.

Restart a job after resolving the error.

6.1 Error IDs 16#0000 - 16#800F

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#0000	✓	✓	No error	-
16#8001	✓	✓	A technology alarm (error at the technology object) has occurred during processing of the Motion Control job.	In the technology object data block, an error message is displayed at the "ErrorDetail.Number" tag. You can find a list of the technology alarms and alarm responses in the section "Overview of the technology alarms (Page 22)".

[1] Applies to all technology objects with the exception of the Kinematics technology object.

[2] Applies to the Kinematics technology object only.

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8002	✓	-	Invalid specification of the technology object	• Check the specification of the technology object at the parameter "Axis", "Master", "Slave", "OutputCam", "CamTrack", "MeasuringInput", "Cam" or "Interpreter". • With "MC_MeasuringInputCyclic": Specify a valid measuring input type for parameter "MeasuringInputType".
	-	✓		Check the specification of the technology object for the "Axis" or "AxesGroup" parameter. You can use a kinematics technology object only for the "AxesGroup" parameter.
16#8003	✓	✓	Invalid velocity specification	Specify a permissible value for the velocity for parameter "Velocity".
	-	✓	Invalid velocity factor	Specify a permissible value for the velocity factor for the "VelocityFactor" parameter.
16#8004	✓	✓	Invalid acceleration specification	Specify a permissible value for the acceleration for the "Acceleration" parameter.
	-	✓	Invalid acceleration factor	Specify a permissible value for the acceleration factor for the "AccelerationFactor" parameter.
16#8005	✓	✓	Invalid deceleration specification	Specify a permissible value for the deceleration for the "Deceleration" parameter.
	-	✓	Invalid deceleration factor	Specify a permissible value for the deceleration factor for the "DecelerationFactor" parameter.
16#8006	✓	✓	Invalid jerk specification	Specify a permissible value for the jerk for parameter "Jerk".
	-	✓	Invalid jerk factor	Specify a permissible value for the jerk factor for the "JerkFactor" parameter.
16#8007	✓	-	Invalid entry Both the "JogForward" and "JogBackward" parameters are set to TRUE at the same time. The axis is braked at the last valid deceleration.	Reset both the "JogForward" parameter and the "JogBackward" parameter.
	✓	-	Invalid direction specification	Specify a permissible value for the direction at the parameter "Direction" or "SyncDirection".
	-	✓		Specify a permissible value for the motion direction for the "DirectionA" parameter.
16#8008	✓	-	Invalid distance specification	Set a permissible distance value for the "Distance" parameter.
	-	✓	Invalid specification of the relative target coordinate	Specify permissible values for the relative target coordinate for the "Distance" parameter.
16#8009	✓	-	Invalid position specification	Set a permissible position value for the "Position" parameter.
	-	✓	Invalid specification of the absolute target coordinate	Specify a permissible value for the absolute target coordinate in the "Position" parameter.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#800A	✓	-	Invalid operating mode	Specify a permissible operating mode for parameter "Mode".
	✓	✓	Invalid mode specification	Specify a permissible value for the mode for the "Mode" parameter.
16#800B	✓	-	Invalid stop mode specifications	Specify a permissible value for the stop mode at the "StopMode" parameter.
16#800C	✓	-	Only one instance of the instruction per technology object is allowed.	• The instruction is called at multiple points in the user program with identical value for parameter "Axis", "Master", "Slave" or "Cam". Ensure that only one instruction with the value for parameter "Axis", "Master", "Slave" or "Cam" is called. • The error message can occur through the DB editor functions "Load snapshot as actual values" or "Load start values as actual values". Correct the error of the affected data block technology object by switching the CPU to STOP, recompiling the affected data block, and loading it into the device.
16#800D	✓	✓	The job is not permitted in the current state. Technology objects are initialized.	When the operating state changes from STOP to RUN, the technology objects are initialized one after the other (STARTUP operating state). Depending on the number of technology objects used, this may take several application cycles. Wait until the initialization of the technology objects is complete. Alternatively, extend the application cycle.
	✓	-	The job is not permitted in the current state. "Restart" is executed.	While a "Restart" is being performed, the technology object cannot perform any jobs. Active jobs on the technology objects an output cam, cam track, measuring input or cam were canceled. Wait until the "Restart" of the technology object is complete.
	-	✓		While a restart is being performed, the technology object cannot perform any jobs. Active jobs were canceled. Restarting the kinematics technology object can take up to one second. Wait until the technology object restart is complete.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#800E	✓	-	If the technology object is enabled, a "Restart" is not possible.	Before a "Restart", deactivate the technology object with "MC_Power.Enable" = FALSE.
			Interpreter technology object: "Restart" of the technology object not possible. Other Motion Control job active. The debug program mode performs a Motion Control job.	Wait until the active job is complete. Restart the job.
16#800F	✓	✓	The job cannot be executed because the technology object is locked.	• Enable the technology object with "MC_Power.Enable" = TRUE. Restart the job. • A "MC_Stop" job is active with "Execute" = TRUE. Reset the job with the parameter "Execute" = FALSE.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

6.2 Error IDs 16#8010 - 16#801F

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8010	✓	-	Invalid homing mode for incremental encoder	Absolute encoder adjustment is not possible with an incremental encoder ("Mode" = 6, 7). Technology version ≥ V7.0: Start a homing process for an incremental encoder using parameter "Mode" = 0, 1, 2, 3, 5, 8, 10, 11, 12, 13. Technology version < V7.0: Start a homing process for an incremental encoder using parameter "Mode" = 0, 1, 2, 3, 5, 8, 10, 11, 12.
16#8011	✓	-	Invalid homing mode for absolute encoder	Technology version ≥ V7.0: Start a homing process for an absolute encoder using parameter "Mode" = 0, 1, 2, 3, 5, 6, 7, 8, 10, 11, 12. Technology version < V7.0: Start a homing process for an absolute encoder using parameter "Mode" = 0, 1, 6, 7, 11, 12.
16#8012	✓	-	The job cannot be executed because the axis control panel is active.	Give back master control to your user program. Restart the job.
	✓	-	Interpreter technology object: The job cannot be executed because the "Debug" program mode is active.	End the debug program mode. Restart the job.
	-	✓	The job cannot be executed because the kinematics control panel is active.	Give back master control to your user program. Restart the job.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

3) Applies if the "Use position values with higher resolution" check box is selected in the configuration of the technology object.

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8013	✓	-	The online connection between the CPU and the TIA Portal is down.	Check the online connection to the CPU.
16#8014	✓	✓	No internal job memory available.	The maximum possible number of motion control job has been reached. Reduce the number of jobs to be executed (parameter "Execute" = FALSE).
16#8015	✓	✓	Error acknowledgment with "MC_Reset" is not possible. Error in the configuration of the technology object.	Check the configuration of the technology object.
16#8016	✓	-	The actual values are not valid.	To execute an "MC_Home" or positioning job, the actual values must be valid. Check the status of the actual values. The "<TO>.StatusSensor[1..4].State" tag of the technology object must show the value 2 (valid).
16#8017	✓	-	Illegal value for gear ratio numerator	Specify a permissible value for the gear ratio numerator for parameter "RatioNumerator". Permitted integer values: -2147483648 to 2147483647 (value 0 not permitted)
16#8018	✓	-	Illegal value for gear ratio denominator	Specify a permissible value for the gear ratio denominator for parameter "RatioDenominator". Permitted integer values: 1 to 2147483647
16#8019	✓	-	Job cannot be executed. The specified following axis is the original leading value for the synchronous operation chain.	Recursive interconnections are not possible. A leading axis cannot be interconnected as a following axis to its own leading value. Specify a permissible following axis for parameter "Slave".
16#801A	✓	-	Impermissibly low value for velocity, acceleration, deceleration or jerk	With the "Velocity", "Acceleration", "Deceleration" or "Jerk" parameter, enter a larger value for velocity, acceleration, deceleration or jerk.
16#801F	✓	-	Job cannot be executed. The specified superimposed axis is the original superimposing axis for the superimposed motion chain.	Recursive interconnections are not possible. A superimposing axis cannot be interconnected as the superimposed axis to its own superimposing value. Specify a permissible superimposed axis at the "Axis" parameter.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

3) Applies if the "Use position values with higher resolution" check box is selected in the configuration of the technology object.

6.3 Error IDs 16#8020 - 16#802F

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8021	✓	-	Illegal value for shift of the leading value range	Specify a permissible value for the shift of the leading value range for parameter "MasterOffset".
16#8022	✓	-	Illegal value for shift of the following value range	Specify a permissible value for the shift of the leading value range for parameter "SlaveOffset".
16#8023	✓	-	Illegal value for scaling of the leading value range	Specify a permissible value for the scaling of the leading value range for parameter "MasterScaling".
16#8024	✓	-	Illegal value for scaling of the following value range	Specify a permissible value for the scaling of the following value range for parameter "SlaveScaling".
16#8026	✓	-	Illegal value for leading value distance	Specify a permissible value for the leading value distance at parameter "MasterStartDistance" or "MasterStopDistance".
16#8027	✓	-	Illegal value for use of cam	Specify a permissible value for cyclic/acyclic use of the cam for parameter "ApplicationMode".
			Invalid value for read mode	Specify a permissible value for the read mode at the "ApplicationMode" parameter.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

6.4 Error IDs 16#8030 - 16#803F

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8034	✓	-	Illegal value for synchronous position of the leading axis	Specify a permissible value for the synchronous position of the leading axis for parameter "MasterSyncPosition".
16#8035	✓	-	Illegal value for synchronous position of the following axis	Specify a permissible value for the synchronous position of the following axis for parameter "SlaveSyncPosition".
16#8036	✓	-	Invalid value for type of synchronization/desynchronization	Specify a permissible value for the type of synchronization/desynchronization for the "SyncProfileReference" parameter.
16#8037	✓	-	Invalid value for stop position of the following axis	Specify a permissible value for the stop position of the following axis for the "SlavePosition" parameter.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

6.5 Error IDs 16#8040 - 16#804F

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8040	✓	-	Illegal value for start position of output cam	Specify a permissible value for the start position of the output cam for parameter "OnPosition".
16#8041	✓	-	Illegal value for end position of distance output cam	Specify a permissible value for the end position of the distance output cam for parameter "OffPosition".
16#8042	✓	-	Illegal value for switch-on duration of time-based output cam	Specify a permissible value for the switch-on duration of the time-based output cam for parameter "Duration".
16#8043	✓	-	Illegal value for force/torque limiting	Specify a value within the permissible range at the "Limit" parameter. Permitted integer values: -2147483648 to 2147483648
16#8044	✓	-	The axis is not configured for torque reduction.	Select drive telegram 102, 103, 105 or 106
16#8045	✓	-	The job cannot be executed because a job for traveling to fixed stop is active.	Switchover to non-position-controlled mode is not possible during active travel to fixed stop.
16#8046	✓	-	The "MC_TorqueLimiting" job cannot be deactivated in the "InClamping" state.	Retract the axis and deactivate "MC_TorqueLimiting".
16#8047	✓	-	The motion results in a fixed stop.	Only motions away from the fixed stop are permitted.
16#8048	✓	-	The job cannot be executed because a "MC_Stop" job is active.	A "MC_Stop" job is active with "Execute" = TRUE. Reset the job with the parameter "Execute" = FALSE.
16#804A	✓	-	Illegal value for additive torque setpoint	Specify a permissible value for the additive torque setpoint at the "Value" parameter.
16#804B	✓	-	Illegal value for torque high limit	Specify a permissible value for the high limit of the torque at the "UpperLimit" parameter.
16#804C	✓	-	Illegal value for torque low limit	Specify a permissible value for the low limit of the torque at the "LowerLimit" parameter.
16#804D	✓	-	The value of the high limit of the torque is less than or equal to the value of the low limit of the torque.	Adapt the values of the "UpperLimit" and "LowerLimit" parameters so that the high limit of the torque is greater than the value of the low limit of the torque.
16#804E	✓	-	The job cannot be executed because a "MC_TorqueLimiting" job is active.	Exit the setting of the high and low torque limits. Restart the "MC_TorqueLimiting" job.
			The job cannot be executed because a "MC_TorqueRange" job is active.	Stop the force/torque limit or fixed stop detection. Restart the "MC_TorqueRange" job.
16#804F	✓	-	The axis is not configured for additional torque values.	Use supplemental telegram 750.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

6.6 Error IDs 16#8050 - 16#805F

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8050	✓	-	Illegal encoder number	Technology version < V7.0: MC_SetSensor: At the "Sensor" parameter, enter a permissible number for the encoder. Technology version ≥ V7.0: MC_SetSensor: At the "Sensor" parameter, enter a permissible number (1, 2, 3, 4) for the encoder. MC_Home: At the "Sensor" parameter, enter a permissible number (0, 1, 2, 3, 4) used for an encoder.
16#8051	✓	-	Illegal number of the reference encoder	Specify a permissible number of the reference encoder for parameter "MC_SetSensor.ReferenceSensor". If you call the instruction "MC_SetSensor" with parameter "Mode" = 0, enter a different number for the parameter "ReferenceSensor" than for the parameter "Sensor".
16#8055	✓	-	Bit masking not permitted at "MC_SetAxisSTW"	Non-controllable bits are selected in the "STW1 BitMask" and "STW2 BitMask" bit masks. Only control permissible bits.
16#805A	✓	-	Illegal value of the parameter to be changed	At parameter "ParameterNumber", enter a permissible value for the index of the parameter to be changed.
16#805B	✓	-	Error in the configuration of the hardware limit switch.	Specify a valid tag at the input of the positive/negative HW limit switch.
16#805C	✓	-	Illegal data type of the value to be written.	Specify a valid data type at the parameter "Value".
16#805D	✓	-	• Direct PROFIdrive data connection from axis or external encoder. • Axis is in simulation. • Axis is configured as virtual axis.	Configure the T_i, T_o, T_{DC} communication times only if the PROFIdrive data connection via data block is configured.
16#805E	✓	-	Invalid value for the tag "Actor.RemoveEnableReaction"	Specify a permissible value for the stop mode at the "Remove enable" alarm response.
16#805F	✓	-	Invalid state of the PROFIdrive state machine	Call the "MC_WriteParameter" Motion Control instruction with the parameter in the Profidrive state S1 or S4.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

6.7 Error IDs 16#8060 - 16#806F

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8062	✓	-	Invalid approach value	Specify a permissible approach value for the searched for leading value for parameter "ApproachLeadingValue".
16#8063	✓	-	A valid mapping to the definition range (leading values) does not exist for the specified following value.	• Specify a permissible following value for parameter "FollowingValue". • Ensure that the cam is interpolated ("MC_InterpolateCam.Done" = TRUE, "<TO>.StatusWord.X5 (Interpolated)" = TRUE).
16#8064	✓	-	A valid mapping to the range of the function (following values) does not exist for the specified leading value.	• Specify a permissible leading value for parameter "LeadingValue". • Ensure that the cam is interpolated ("MC_InterpolateCam.Done" = TRUE, "<TO>.StatusWord.X5 (Interpolated)" = TRUE).
16#8065	✓	-	Invalid approach direction	Specify a permissible value for the approach direction for the searched for leading value for the "ApproachDirection" parameter.
16#8066	✓	-	The end of the cam has been reached in the specified approach direction. No suitable leading value could be found.	• Specify the opposite approach direction at the "ApproachDirection" parameter. • Specify a different approach value for the searched for leading value for parameter "ApproachLeadingValue". • Specify a permissible following value for parameter "FollowingValue".

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

6.8 Error IDs 16#8070 - 16#807F

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8070	✓	-	Illegal value for leading value shift	Specify a permissible value for the leading value shift for parameter "PhaseShift".
16#8071	✓	-	The job cannot be executed because the axis is not in position-controlled mode.	Activate position-controlled mode.
16#8074	✓	-	The job cannot be executed because a "MC_Home" job is active.	During active or passive homing, an encoder switchover is rejected. Wait until the "MC_Home" job is complete. Restart the job.
16#8075	✓	-	The job cannot be executed because no synchronization operation is active on the axis.	Switch on the synchronous operation function. Restart the job.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8076	✓	-	The job cannot be executed because synchronization is being simulated at the specified axis.	End the simulation of the synchronous operation. Restart the job.
16#8077	✓	-	The job cannot be executed because no "MC_GearInPos" or "MC_GearIn" job is waiting or active.	Switch on the synchronous operation function. Restart the job. To desynchronize a camming, use the Motion Control instruction "MC_CamOut".
16#8078	✓	-	The job cannot be executed because no "MC_CamIn" job is waiting or active.	Switch on the camming function. Restart the job. To desynchronize gearing, use the Motion Control instruction "MC_GearOut".
16#8079	✓	-	The job cannot be executed because a velocity gearing with "MC_GearInVelocity" is active.	A job to offset the leading or following value is only applicable during an active gearing or camming.
				Following axis is in non-position-controlled operation. Stop velocity gearing and restart "MC_GearInPos" job or "MC_CamIn" job.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

6.9 Error IDs 16#8080 - 16#808F

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8080	✓	-	Invalid value for the following value offset	Specify a permissible value for the following value offset for the "Offset" parameter.
16#8081	✓	-	Invalid value for leading value distance	Specify a permissible value for the following value offset for the "OffsetDistance" parameter.
16#8082	✓	-	Invalid value for leading value distance	Specify a permissible value for the leading value offset for parameter "PhasingDistance".
16#8083	✓	-	Invalid value for the type of traversing of the leading/following value offset or for the traversing motion of the time-based position profile	MC_PhasingAbsolute/Relative, MC_OffsetAbsolute/Relative: Specify a permissible value for the leading value/following value offset shift for parameter "ProfileReference". MC_PositionProfile: Specify a permissible value for the traversing motion of the time-based position profile for the "ProfileReference" parameter.
16#8084	✓	-	Invalid value for start position	Specify a permissible value for the leading value/following value offset shift for parameter "StartPosition".
16#808A	✓	-	The job for the leading value offset cannot be executed because a following value offset is active on the axis.	Exit the active following value offset via "MC_OffsetAbsolute" or "MC_OffsetRelative". Restart the job.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#808A	✓	-	The job for the following value offset cannot be executed because a leading value offset is active on the axis.	Exit the active leading value offset via "MC_PhasingAbsolute" or "MC_PhasingRelative". Restart the job.
16#808B	✓	-	The job cannot be executed because no camming is active on the axis.	A "MC_CamIn" job with "SyncProfileReference" = 5 can only be used if the camming is already active.
16#808C	✓	-	Reversing the leading value is not permitted during an active leading value offset or following value offset.	Start the job again after reversing the leading value.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

6.10 Error IDs 16#80A0 - 16#80AF

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#80A1	✓	-	The order cannot be executed because a synchronous operation job is active.	A "MC_Home" job on a following axis is not executed when a "MC_CamIn" or "MC_GearInPos" job is active. Exit the synchronous operation job. Restart the job.
16#80A2	✓	-	• For one-time measuring with measuring range, the measuring range was run without a measuring edge being detected. • The measuring range is invalid with the configured modulo axis settings.	Check and adjust the measuring input and adjust the measuring range positions, if necessary.
16#80A3	✓	-	The measuring input job via PROFIdrive telegram could not be started because a homing job is active.	Simultaneous execution of a homing job and a measuring input job via PROFIdrive telegram is not possible. Wait until the homing job has ended. Restart the measuring job via PROFIdrive telegram.
16#80A5	✓	-	Illegal value for start position of measuring range	Specify a permissible value for the start position of the measuring range for parameter "MC_MeasuringInput.StartPosition" or "MC_MeasuringInputCyclic.StartPosition".
16#80A6	✓	-	Illegal value for end position of measuring range	Specify a permissible value for the end position of the measuring range for parameter "MC_MeasuringInput.EndPosition" or "MC_MeasuringInputCyclic.EndPosition".
16#80A7	✓	-	A measurement is performed when measuring with the measuring range, but the calculated position is outside the specified measuring range. The measured value is discarded.	Check and adjust the measuring input and adjust the measuring range positions, if necessary.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#80A8	✓	-	The job cannot be executed because camming is active on the axis.	An "MC_PhasingRelative" or "MC_PhasingAbsolute" job with "ProfileReference" = 0 can only be used on an active gearing with "MC_GearIn" or "MC_GearInPos" in the "synchronous" status ("MC_GearIn.InGear" = TRUE or "MC_GearInPos.InSync" = TRUE).
16#80A9	✓	-	The job cannot be executed because no synchronous gearing or camming is active on the axis.	A job for leading/following value offset is only applicable to up an active gearing or camming in "synchronous" status ("MC_GearIn.InGear" = TRUE, "MC_GearInPos.InSync" = TRUE or "MC_CamIn.InSync" = TRUE).
16#80AA	✓	-	The cam contains no points or segments and cannot be interpolated.	Fill the cam with points/segments. Restart the job.
16#80AB	✓	-	The cam is currently being used and cannot be interpolated.	End the current use of the cam. Restart the job.
16#80AC	✓	-	The cam contains incorrect points or segments and cannot be interpolated. (for example, the cam contains only one point.)	Fill the cam with permissible points/segments. Restart the job.
16#80AD	✓	-	The specified synchronous position or the specified start time is outside the definition range of the cam.	MC_CamIn: When "SyncProfileReference" = 0, 1, 2, 3, 5, 6: Specify a permissible synchronous position for parameter "MasterSyncPosition". Restart the job. When "SyncProfileReference" = 4: With the "MasterOffset" parameter, you offset the leading values of the cam or move the leading axis into the definition range of the cam. Restart the job. MC_PositionProfile: Specify a permissible value for the start time of the time-based position profile at the "StartTime" parameter. Restart the job.
16#80AE	✓	-	The job cannot be executed because a kinematic motion is active.	End the current kinematic motion. Restart the job.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

6.11 Error IDs 16#80B0 - 16#80BF

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#80B1	-	✓	Illegal specification of the coordinate system	Specify a permissible value for the coordinate system for the "CoordSystem" parameter.
16#80B2	✓	✓	Illegal specification of the motion transition	Specify a permissible value for the motion transition for the "BufferMode" parameter.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#80B3	-	✓	Illegal specification of the rounding clearance	Specify a permissible value for the rounding clearance for the "TransitionParameter" parameter.
16#80B4	-	✓	Illegal specification for the joint position range	Specify a permissible value for the joint target position range at the "TurnJoint" parameter.
16#80B5	-	✓	Illegal specification of the dynamic adaptation	Specify a permissible value for the dynamic adaptation for the "DynamicAdaption" parameter.
16#80B6	-	✓	Illegal specification for the definition of the circular path	Specify a permissible value for the definition of the circular path for the "CircMode" parameter.
16#80B7	-	✓	Illegal specification for the circular path auxiliary point	Specify a permissible value for the circular path auxiliary point for the "AuxPoint" parameter.
16#80B8	-	✓	Illegal specification of the target position	Specify a permissible value for the target position for the "EndPoint" parameter.
16#80B9	-	✓	Illegal specification of the orientation of the circular path	Specify a permissible value for the orientation of the circular path for the "PathChoice" parameter.
16#80BA	-	✓	Illegal specification for the main plane of the circular path	Specify a permissible value for the main plane of the circular path for the "CirclePlane" parameter.
16#80BB	-	✓	Illegal radius specification	Specify a permissible value for the radius of the circular path for the "Radius" parameter.
16#80BC	-	✓	Illegal angle specification	Specify a permissible value for the angle of the circular path for the "Arc" parameter.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

6.12 Error IDs 16#80C0 - 16#80CF

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#80C1	-	✓	Illegal specification of the zone type	Specify a permissible value for the zone type for the "ZoneType" parameter.
16#80C2	-	✓	Illegal specification of the zone position	Specify a permissible value for the zone number for the "ZoneNumber" parameter.
16#80C3	-	✓	Illegal specification of the reference system	Specify a permissible value for the reference system for the "ReferenceSystem" parameter.
16#80C4	-	✓	Illegal coordinate specification	Specify permissible values for the coordinates for the "Frame" parameter.
16#80C5	-	✓	Illegal specification of the zone geometry	Specify a permissible value for the zone geometry for the "GeometryType" parameter.
16#80C6	-	✓	Illegal specification of the geometric parameters	Specify permissible values for the geometric parameters for the "GeometryParameter" parameter.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#80C7	-	✓	The zone is not defined.	Define a workspace zone using the "MC_DefineWorkspaceZone" job or a kinematics zone using the "MC_DefineKinematicsZone" job.
16#80C8	-	✓	A tool cannot be redefined during a motion.	Exit the active motion. Restart the "MC_DefineTool" job.
	-	✓	An active tool cannot be changed during a motion.	Exit the active motion. Restart the "MC_SetTool" job.
16#80CA	-	✓	Illegal specification of the tool number	Specify a permissible value for the tool number for the "ToolNumber" parameter.
16#80CB	-	✓	Illegal specification of the object coordinate system	Specify a permissible value for the object coordinate system for the "OcsNumber" parameter.
16#80CC	-	✓	The job cannot be executed because a single-axis motion is active at a kinematics axis or a kinematics axis is controlled by an Interpreter.	Exit the current single-axis motion or the running Interpreter program. Restart the job.
16#80CD	-	✓	The job cannot be executed because a "MC_GroupStop" job is active.	Set the "MC_GroupStop.Execute" parameter to "FALSE". Restart the job.
16#80CE	✓	✓	The job sequence is used to capacity.	The maximum possible Motion Control jobs have been transmitted.
	✓	-		Interpreter technology object: The job sequence contains the maximum number of possible MLC jobs.
16#80CF	-	✓	The kinematics motion cannot be executed.	Configure the kinematics motion within the working range of the kinematics axes.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

6.13 Error IDs 16#80D0 - 16#80DF

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#80D1	-	✓	Invalid value for the use of the parameter "Position"	At the "PositionMode"parameter, specify a valid value for the use of the "Position" parameter.
16#80D2	-	✓	Illegal value for the target arm positioning space	Enter a permissible value for the target arm positioning space in the "LinkConstellation" parameter.
16#80D3	-	✓	Illegal value for the positions of the kinematics axes	Enter a permissible value for the positions of the kinematics axes at the parameter "AxesPosition".
16#80D4	-	✓	Illegal value for the velocity of the kinematics axes	Specify a permissible value for the velocity of the kinematics axes for the "AxesVelocity" parameter.
16#80D5	-	✓	Illegal value for the acceleration of the kinematics axes	Specify a permissible value for the acceleration of the kinematics axes for the "AxesAcceleration" parameter.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#80D6	-	✓	An error occurred during the transformation.	Specify permissible values for the transformation.
16#80D7	-	✓	The job on the kinematics transformation cannot be executed.	A "MC_KinematicsTransformation" or "MC_InverseKinematicsTransformation" instruction cannot perform a calculation, when the kinematics moves a tracked OCS or the moving of a tracked OCS is completed. Wait until the current job for the conveyor tracking has been completed and restart the job for the kinematics transformation.
16#80D8	-	✓	Invalid value for the reference coordinate system	Specify a permissible value for the reference coordinate system for the "AxesCoordSystem" parameter.
16#80DA	-	✓	Invalid value parameter "InitialObjectPosition"	Enter permissible values for the frame at the parameter "InitialObjectPosition".
16#80DB	-	✓	Simulation mode of kinematics cannot be ended	Ensure that when you end the simulation, the setpoints of the axis positions on the kinematics technology object match the setpoints of the axis positions on the assigned axes. If you use a modulo axis, make sure that the axis is in the same modulo cycle as at the start time of the simulation.
16#80DC	-	✓	The job cannot be executed, because only one job of this type can be active at the technology object.	Wait until the active job is finished or finish the active job. Restart the job.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

6.14 Error IDs 16#80E0 - 16#80EF

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#80E0	-	✓	The kinematics motion cannot be executed.	Configure the kinematics motion within the workspace zone of the kinematics.
16#80E1	✓	-	Invalid value for the index of the starting point in the cam	At the "StartPointCam" parameter, specify a valid value for the index of the starting point in the cam.
16#80E2	✓	-	Invalid value for the index of the starting segment in the cam	At the "StartSegmentCam" parameter, specify a valid value for the index of the starting segment in the cam.
16#80E3	✓	-	Invalid value for the index of the starting point in the "ArrayOfPoints".	At the "StartPointArray" parameter, specify a valid value for the index of the starting point in the "ArrayOfPoints".
16#80E4	✓	-	Invalid value for the index of the starting segment in the "ArrayOfSegments".	At the "StartSegmentArray" parameter, specify a valid value for the index of the starting segment in the "ArrayOfSegments".

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#80E5	✓	-	Invalid value for the number of points to be copied	At the "NumberOfPoints" parameter, specify a valid value for the number of points to be copied.
16#80E6	✓	-	Invalid value for the number of segments to be copied	At the "NumberOfSegments"parameter, specify a valid value for the number of segments to be copied.
16#80E7	✓	-	The job cannot be executed because a copy operation is active.	Wait until the active copy operation is completed via "MC_CopyCamData". Restart the job.
16#80E8	✓	-	The job cannot be executed because the cam is being interpolated.	Wait until the interpolation of the cam is completed via "MC_InterpolateCam". Restart the job.
16#80E9	✓	-	Invalid array of points to be copied	At the "ArrayOfPoints" parameter, specify an array of the data type "ARRAY[*] OF TO_Cam_Struct_PointData". Do not use a variable declared as temporary. Ensure that the "Optimized block access" option is selected under "General > Attributes" in the properties of the data block that contains the array.
16#80EA	✓	-	Invalid array of segments to be copied	At the "ArrayOfSegments" parameter, specify an array of the data type "ARRAY[*] OF TO_Cam_Struct_SegmentData". Do not use a variable declared as temporary. Ensure that the "Optimized block access" option is selected under "General > Attributes" in the properties of the data block that contains the array.
16#80EB	✓	-	SIMATIC Memory Card has insufficient storage space for the backup file.	Ensure there is sufficient storage space available on the SIMATIC Memory Card used.
16#80EC	✓	-	An error occurred when writing the backup file.	-
16#80ED	✓	-	More than two instances of the "MC_SaveAbsoluteEncoderData" instruction are used in the user program.	Use a maximum of two instances of the "MC_SaveAbsoluteEncoderData" instruction in your user program.
16#80EE	✓	-	Job cannot be executed.	Wait until the current "MC_SaveAbsoluteEncoderData" job has finished with "Done" = TRUE and restart the job.
16#80EF	✓	-	The SIMATIC Memory Card is write-protected.	Deactivate the write protection on your SIMATIC Memory Card.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

6.15 Error IDs 16#80F0 - 16#80FE

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#80F0	✓	-	The name of the Interpreter program technology object has been incorrectly defined or contains invalid characters	Specify a valid name for the Interpreter program technology object at the "Program" parameter.
16#80F1	✓	-	Source of the Interpreter program contains Illegal characters or does not exist	At the "ProgramSource" parameter, specify a valid source for the Interpreter program.
16#80F2	✓	-	The name of the Interpreter mapping technology object has been incorrectly defined or contains invalid characters	Specify a valid name for the Interpreter Mapping technology object at the parameter "Mapping".
16#80F3	✓	-	Source of the Interpreter mapping contains Illegal characters or does not exist	At the "MappingSource" parameter, specify a valid source for the Interpreter Mapping technology object defined at the "Mapping" parameter.
16#80F4	✓	-	User program cannot be opened/does not exist	Check whether the specified Interpreter program exists.
16#80F5	✓	-	Mapping cannot be opened/does not exist	Check whether the specified Interpreter mapping exists.
16#80F6	✓	-	User programs cannot be read during loading	Check whether the specified Interpreter program exists.
16#80F7	✓	-	Mapping cannot be read during loading	Check whether the specified Interpreter mapping exists.
16#80F8	✓	-	Maximum program memory reached.	Check whether the Interpreter program adheres to the configuration limits. You can find more information on the configuration limits of the Interpreter program in the documentation "S7-1500T Interpreter functions", section "Configuration limits".
16#80F9	✓	-	Error during discharge of the Interpreter program.	Check whether the Interpreter program is still active. Stop the Interpreter program or wait until the Interpreter program has finished. Restart the job.
16#80FA	✓	-	The job cannot be executed because a "MC_StopProgram" job is active.	Reset the "Execute" parameter of the "MC_StopProgram" job to "FALSE". Restart the job.
16#80FB	✓	-	The job cannot be executed because a Motion Control job is active or the execution of the Interpreter program is interrupted on the Interpreter technology object (<TO>.StatusWord.X8 (Interrupted) = TRUE)	• An "MC_LoadProgram" job is not executed while a Motion Control job is active at the Interpreter technology object. • An "MC_RunProgram" job is not executed as long as another "MC_RunProgram" job is active at the Interpreter technology object or program execution is interrupted. End the active Motion Control jobs on the Interpreter technology object. Restart the job. Resume program execution.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#80FC	✓	-	The job cannot be executed because the Interpreter program is not loaded in the Interpreter technology object or is being loaded.	An "MC_RunProgram" job is not executed as long as an Interpreter program has not been loaded into the Interpreter technology object or is in the process of being loaded. Load the Interpreter program to the Interpreter technology object or wait until the loading is completed. Restart the job.
16#80FD	✓	-	The job cannot be executed because the loaded Interpreter program was stopped.	Correct the error that is preventing preparation of the Interpreter program. Restart the job.
16#80FE	✓	-	The job is not executed as a further job with the same or higher-priority dynamic mode is active at the Interpreter technology object.	An "MC_StopProgram" job is not executed while a further "MC_StopProgram" job with the same or higher-priority dynamic mode is active at the Interpreter technology object. Wait until the current "MC_StopProgram" job has ended. Restart the job.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

6.16 Error IDs 16#8110 - 16#8121

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8110	✓	✓	Value for override is impermissible	Specify a permissible value for the override in the axis or kinematics control panel.
16#8111	✓	✓	Commissioning mode is impermissible	Correct the settings in the axis or kinematics control panel.
16#8120	✓	-	The active Motion Control job on the axis is not a positioning job or not a positioning job with time-based position profile.	Terminate the active Motion Control job on the axis. Restart the positioning job or the positioning job with time-based position profile with "BufferMode"= 1. **Or**: To abort the active Motion Control job on the axis, start the positioning job or the positioning job with the time-based position profile with "BufferMode" = 0.
16#8121	✓	-	Value for the start time of the time-based position profile is impermissible	Specify a permissible value for the start time of the time-based position profile at the "StartTime" parameter.

1) Applies to all technology objects with the exception of the kinematics technology object.

2) Applies to the kinematics technology object only.

6.17 Error detection 16#8130 - 16#813F

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8130	✓	-	Value for number of scaling range not permitted	Enter a permissible number for the scaling range in "RangeNumber" parameter.
16#8131	✓	-	Value for start point not permitted	Enter a permissible start point at "RangeStartPoint" parameter.
16#8132	✓	-	Value for end point not permitted	Enter a permissible end point for the "RangeEndPoint" parameter.
16#8133	✓	-	Combination of values for start point and end point not permitted	Enter the "RangeStartPoint" and "RangeEndPoint" parameters to specify a permissible combination of start point and end point. Start point ≤ End point
16#8134	✓	-	Value for scaling factor not permitted	Enter a permissible scaling factor at the "RangeScaling" parameter.
16#8135	✓	-	The job cannot be executed because the cam is not interpolated.	Interpolate the cam with a "MC_InterpolateCam" job. Restart the job.
16#8136	✓	-	The job cannot be executed because the calculation of a range scaling is active.	Wait until the active "MC_SetCamRangeScaling" job is completed. Restart the job.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

6.18 Error IDs 16#8200 - 16#82FF

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8200	✓	-	Job cannot be executed. Master control over the axis control panel/kinematics control panel is active on a technology object connected with the Interpreter.	Hand over master control in the axis control panel to the user program.
	-	✓		Hand over master control in the kinematics control panel to the user program.

1) Applies to all technology objects with the exception of the Kinematics technology object.

2) Applies to the Kinematics technology object only.

6.19 Error IDs 16#8FF0 - 16#8FFF

ErrorID	Validity		Description	Remedy
	TO[1]	Kin[2]		
16#8FFF	✓	✓	Unspecified error	Open a Support request. The following data is required for the error analysis: • The service data of the CPU directly after the occurrence of the error (Online & diagnostics > Functions > Save service data) • The diagnostic buffer of the CPU as a text file (Online & diagnostics > Diagnostics > Diagnostics buffer) • The software installed on the PG as an export file (Help > Service & Support in TIA Portal > Support request) • The project in the state that led to this alarm • The password for the project • The steps for reproduction

[1] Applies to all technology objects with the exception of the kinematics technology object.

[2] Applies to the kinematics technology object only.

See also

Link to contact information for Industry Automation and Drive Technologies (https://www.siemens.com/automation/partner)

SIEMENS

SIMATIC

S7-1500, ET 200MP, ET 200SP, ET 200AL, ET 200eco PN, ET 200pro Counting, measurement and position detection

Function Manual

Function Manuals Documentation Guide 1

Industrial Cybersecurity 2

The basics of counting, measurement and position detection 3

Using the High_Speed_Counter technology object 4

Using the SSI_Absolute_Encoder technology object 5

Using the module 6

12/2025

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Preface

Purpose of the documentation

This documentation supports you in configuring and programming modules for counting and measuring tasks of the S7-1500, ET 200MP and ET 200SP, as well as in position feedback and position detection.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Knowledge about the use of Windows-based computers
- Proficiency with STEP 7

Scope of the documentation

This documentation applies to the use of the following modules:

- S7-1500 modules
  - TM Count 2x24V (as of firmware version V2.0)
  - TM PosInput 2 (as of firmware version V2.0)
  - TM Timer DIDQ 16x24V
  - TM Timer DIDQ 24x24V
  - CPU 1511C-1 PN
  - CPU 1512C-1 PN
  - DI 32x24VDC HF (as of firmware version V2.2.1)
  - DI 16x24VDC HF (as of firmware version V2.2.0)
  - DI 16xNAMUR HF
  - DI 16x24VDC HS
- SIMATIC Drive Controller
  - CPU 1504D TF
  - CPU 1507D TF

- ET 200SP modules
  - TM Count 1x24V (as of firmware version V2.0)
  - TM PosInput 1 (as of firmware version V2.0)
  - TM Timer DIDQ 10x24V
  - DI 8x24VDC HS
- ET 200AL modules
  - DIQ 16x24VDC/0.5A 8xM12
- ET 200eco PN M12-L modules
  - TM PosInput 2
- ET 200pro modules
  - EM 2 SSI
  - EM 2 Count 24V

TM Count, TM PosInput and compact CPU are suitable for complex counting and measuring tasks and for position detection. TM Timer DIDQ and digital modules are suitable for simple counting tasks. SIMATIC Drive Controller is suitable for measuring the number of edge and cycle durations.

Conventions

Observe notes marked as follows:

NOTE

The notes contain important information on the product described in the documentation, on the handling of the product or on part of the documentation to which particular attention should be paid.

Recycling and disposal

For environmentally sustainable recycling and disposal of your old equipment, contact a certified electronic waste disposal service and dispose of the equipment according to the applicable regulations in your country.

Additional support

The range of technical documentation for the individual SIMATIC products and automation systems is available on the Internet (http://www.siemens.com/simatic-tech-doku-portal).

SiePortal

You can find current information on the following topics quickly and easily here:

- **Catalog and Order System**

  Ordering system for automation and drive solutions based on Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.

- **mySiePortal**

  Your personal working area in SiePortal for notifications, support requests and configurable documents.

This information is provided by SiePortal on the Internet (https://sieportal.siemens.com).

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Function Manuals Documentation Guide 1

1.1 Function Manuals Documentation Guide

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
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Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.3 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

See also

PRONETA Professional (https://support.industry.siemens.com/cs/ww/en/view/109781283)

Industrial Cybersecurity 2

2.1 Security information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens products and solutions form one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on industrial cybersecurity measures, please visit (http://www.siemens.com/cybersecurity-industry).

Siemens products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed here (https://www.siemens.com/cert).

The basics of counting, measurement and position detection

3

3.1 Overview of modules and properties

Modules for the S7-1500 and ET 200MP systems

The table below summarizes the performance features of the modules for counting, measuring and position input for the S7-1500 and ET 200MP systems.

Property	S7-1500 / ET 200MP			
	Technology module			Digital input module
	TM Count 2x24V	TM PosInput 2	TM Timer DIDQ 16x24V TM Timer DIDQ 24x24V	DI 32x24VDC HF DI 16x24VDC HF
Number of counters	2	2	4[1]	2
Use of counters can be activated/deactivated	—	—	X	X
Maximum signal frequency	200 kHz	1 MHz	50 kHz	3 kHz
Maximum count frequency for incremental encoders with quadruple evaluation (Page 74)	800 kHz	4 MHz	200 kHz	—
Maximum counting range	32 bits (Page 29)	32 bits (Page 29)	32 bits (Page 78)	32 bits (Page 83)
Maximum position value range (Page 31)	—	32 bits	—	—
24 V incremental encoder connection	X (Page 70)	—	X (Page 80)	—
24 V pulse encoder connection	X (Page 70)	—	X (Page 80)	X (Page 90)
RS422 or TTL incremental and pulse encoder (Page 72) connection	—	X	—	—
SSI absolute encoder (Page 73) connection	—	X	—	—
Operation with High_Speed_Counter technology object	X	X	—	—
Operation with SSI_Absolute_Encoder technology object	X	X	—	—

[1] The number of available counters is dependent on the channel configuration. In order to use four counters, you must choose the use of eight inputs in the channel configuration. If you choose the use of three inputs, you can use one counter. Other channel configurations do not allow any counter use.

Property	S7-1500 / ET 200MP			
	Technology module			Digital input module
	TM Count 2x24V	TM PosInput 2	TM Timer DIDQ 16x24V TM Timer DIDQ 24x24V	DI 32x24VDC HF DI 16x24VDC HF
Position detection for Motion Control (Page 69)	X	X	—	—
Fast Mode	X	X	—	—
5 V encoder supply	—	X	—	—
24 V encoder supply	X	X	X	—
Number of additional digital inputs per counter	3	2	0	0
Number of physical digital outputs per counter	2	2	0	0
Number of logical digital outputs per counter	2	2	0	1
Software gate	X (Page 35)	X (Page 35)	—	X (Page 85)
Hardware gate	X (Page 35)	X (Page 35)	—	—
Capture function (Latch) (Page 37)	X	X	—	—
Synchronization (Page 41)	X	X	—	—
Comparison functions	X (Page 48)	X (Page 48)	—	X (Page 87)
Hysteresis (Page 65)	X	X	—	—
Frequency, velocity and period duration measurement (Page 59)	X	X	—	—
Isochronous mode support	X (Page 76)	X (Page 76)	X (Page 81)	X (Page 90)
Support of diagnostic interrupts for sensor signals	X (Page 69)	X (Page 69)	—	—
Hardware interrupt support	X (Page 69)	X (Page 69)	—	X (Page 89)
Configurable filter for count signals and digital inputs	X	X	—	X

[1] The number of available counters is dependent on the channel configuration. In order to use four counters, you must choose the use of eight inputs in the channel configuration. If you choose the use of three inputs, you can use one counter. Other channel configurations do not allow any counter use.

Property	S7-1500 / ET 200MP		S7-1500	Drive Controller
	Digital input module		Compact CPU	SIMATIC Drive Controller
	DI 16x24VDC HS	DI 16xNAMUR HF	CPU 1511C-1 PN CPU 1512C-1 PN	CPU 1504D TF CPU 1507D TF
Number of counters	4	4	6	8
Use of counters can be activated/deactivated	X	X	X	X
Maximum signal frequency	20 kHz	20 kHz	100 kHz	32 kHz
Maximum count frequency for incremental encoders with quadruple evaluation (Page 74)	—	—	400 kHz	—
Maximum counting range	32 bits (Page 83)	32 bits (Page 83)	32 bits (Page 29)	Event counter: 16 bits Period duration measurement: 32 bits
24 V incremental encoder connection	—	—	X (Page 70)	—
24 V pulse encoder connection	X (Page 90)	X	X (Page 70)	X (Page 92)
Operation with High_Speed_Counter technology object	—	—	X	—
Operation with SSI_Absolute_Encoder technology object	—	—	X	—
Position detection for Motion Control (Page 69)	—	—	X	—
Fast Mode	—	—	X	—
24 V encoder supply	X	—	X	Via 24 V supply
NAMUR encoder supply	—	X	—	—
Number of additional digital inputs per counter	2	2	2	0
Number of physical digital outputs per counter	0	0	1	0
Number of logical digital outputs per counter	1	1	2	0
Software gate	X	X	X (Page 35)	—
Hardware gate	X (Page 86)	X (Page 86)	X (Page 35)	—
Capture function (Latch) (Page 37)	—	—	X	—
Synchronization (Page 41)	—	—	X	—
Comparison functions	X (Page 87)	X (Page 87)	X (Page 48)	—
Hysteresis (Page 65)	—	—	X	—
Frequency measurement	—	—	X	—

Property	S7-1500 / ET 200MP		S7-1500	Drive Controller
	Digital input module		Compact CPU	SIMATIC Drive Controller
	DI 16x24VDC HS	DI 16xNAMUR HF	CPU 1511C-1 PN CPU 1512C-1 PN	CPU 1504D TF CPU 1507D TF
Period duration measurement	—	—	X	X
Velocity measurement	—	—	X	—
Isochronous mode support	X (Page 90)	X (Page 90)	—	X
Support of diagnostic interrupts for sensor signals	—	—	X (Page 69)	—
Hardware interrupt support	X (Page 89)	X (Page 89)	X (Page 69)	—
Configurable filter for digital inputs	X	X	X	X

Modules for the ET 200SP system

The following table provides an overview of the performance features of the modules for counting, measuring and position input for the ET 200SP system.

Property	ET 200SP			
	Technology module			Digital input module
	TM Count 1x24V	TM PosInput 1	TM Timer DIDQ 10x24V	DI 8x24VDC HS
Number of counters	1	1	3[1]	4
Use of counters can be activated/deactivated	—	—	X	X
Maximum signal frequency	200 kHz	1 MHz	50 kHz	10 kHz
Maximum count frequency for incremental encoders with quadruple evaluation (Page 74)	800 kHz	4 MHz	200 kHz	—
Maximum counting range	32 bits (Page 29)	32 bits (Page 29)	32 bits (Page 78)	32 bits (Page 83)
Maximum position value range (Page 31)	—	32 bits	—	—
24 V incremental encoder connection	X (Page 70)	—	X (Page 80)	—
24 V pulse encoder connection	X (Page 70)	—	X (Page 80)	X (Page 90)
RS422 or TTL incremental and pulse encoder (Page 72) connection	—	X	—	—
SSI absolute encoder (Page 73) connection	—	X	—	—
Operation with High_Speed_Counter technology object	X	X	—	—

[1] One counter for incremental encoder (A, B phase-shifted) and two counters for pulse encoder

Property	ET 200SP			
	Technology module			Digital input module
	TM Count 1x24V	TM PosInput 1	TM Timer DIDQ 10x24V	DI 8x24VDC HS
Operation with SSI_Absolute_Encoder technology object	X	X	—	—
Position detection for Motion Control (Page 69)	X	X	—	—
Fast Mode	X	X	—	—
24 V encoder supply	X	X	X	X
Number of additional digital inputs per counter	3	2	0	1
Number of physical digital outputs per counter	2	2	0	0
Number of logical digital outputs per counter	2	2	0	1
Software gate	X (Page 35)	X (Page 35)	—	X (Page 85)
Hardware gate	X (Page 35)	X (Page 35)	—	X (Page 85)
Capture function (Latch) (Page 37)	X	X	—	—
Synchronization (Page 41)	X	X	—	—
Comparison functions	X (Page 48)	X (Page 48)	—	X (Page 87)
Hysteresis (Page 65)	X	X	—	—
Frequency, velocity and period duration measurement (Page 59)	X	X	—	—
Isochronous mode support	X (Page 76)	X (Page 76)	X (Page 81)	X (Page 90)
Support of diagnostic interrupts for sensor signals	X (Page 69)	X (Page 69)	—	—
Hardware interrupt support	X (Page 69)	X (Page 69)	—	—
Configurable filter for count signals and digital inputs	X	X	—	X

[1] One counter for incremental encoder (A, B phase-shifted) and two counters for pulse encoder

Modules for the ET 200AL system

The following table provides an overview of the performance features of the modules for counting, measuring and position input for the ET 200AL system.

Property	ET 200AL
	Digital input/digital output module
	DIQ 16x24VDC/0.5A 8xM12
Number of counters	4
Use of counters can be activated/deactivated	X
Maximum signal frequency	2 kHz
Maximum counting range	32 bits
24 V incremental encoder connection	—
24 V pulse encoder connection	X
Operation with High_Speed_Counter technology object	—
Operation with SSI_Absolute_Encoder technology object	—
Position detection for Motion Control	—
Fast Mode	—
24 V encoder supply	X
Number of additional digital inputs per counter	2
Number of physical digital outputs per counter	1
Number of logical digital outputs per counter	1
Software gate	X
Hardware gate	X
Capture function (Latch)	—
Synchronization	—
Comparison functions	X
Frequency, velocity and period duration measurement	—
Isochronous mode support	—
Support of diagnostic interrupts for sensor signals	X
Hardware interrupt support	X
Configurable filter digital inputs	X

Modules for the ET 200eco PN M12-L system

The following table provides an overview of the performance features of the modules for counting, measuring and position detection for the ET 200eco PN M12-L system.

Property	ET 200eco PN M12-L
	Technology module
	TM PosInput 2
Number of counters	2
Use of counters can be activated/deactivated	—
Maximum signal frequency	200 kHz[1] or 1 MHz[2]
Maximum count frequency for incremental encoders with quadruple evaluation (Page 74)	800 kHz[1] or 4 MHz[2]
Maximum counting range	32 bits (Page 29)
Maximum position value range (Page 31)	32 bits
24 V incremental encoder connection	X (Page 70)
24 V pulse encoder connection	X (Page 70)
RS422 incremental and pulse encoder (Page 72) connection	X
SSI absolute encoder (Page 73) connection	X
Operation with High_Speed_Counter technology object	X
Operation with SSI_Absolute_Encoder technology object	X
Position detection for Motion Control (Page 69)	X
Fast Mode	—
5 V encoder supply	—
24 V encoder supply	X
Number of additional digital inputs per counter	2
Number of physical digital outputs per counter	2
Number of logical digital outputs per counter	2
Software gate	X (Page 35)
Hardware gate	X (Page 35)
Capture function (Latch) (Page 37)	X
Synchronization (Page 41)	X
Comparison functions	X (Page 48)
Hysteresis (Page 65)	X
Frequency, velocity and period duration measurement (Page 59)	X
Isochronous mode support	X (Page 76)

1 Value with 24 V incremental and pulse encoders

2 Value with RS422 incremental and pulse encoders

Property	ET 200eco PN M12-L
	Technology module
	TM PosInput 2
Support of diagnostic interrupts for sensor signals	X (Page 69)
Hardware interrupt support	—
Configurable filter for count signals and digital inputs	X

1 Value with 24 V incremental and pulse encoders

2 Value with RS422 incremental and pulse encoders

Modules for the ET 200pro system

The following table provides an overview of the performance features of the modules for counting, measuring and position input for the ET 200pro system.

Property	ET 200pro	
	Electronic module	
	EM 2 SSI	EM 2 Count 24V
Maximum position value range (Page 31)	25 bits	25 Bits
24 V incremental encoder connection	—	X (Page 70)
24 V pulse encoder connection	—	X (Page 70)
RS422 or TTL incremental and pulse encoder (Page 72) connection	—	—
SSI absolute encoder (Page 73) connection	X	—
Operation with High_Speed_Counter technology object	—	—
Operation with SSI_Absolute_Encoder technology object	—	—
Position detection for Motion Control	—	—
Fast Mode	X (Page 211)	X (Page 201)
24 V encoder supply	X	X
Isochronous mode support	—	—
Support of diagnostic interrupts for sensor signals	X (Page 69)	X (Page 69)
Hardware interrupt support	—	—

3.2 Basics of counting, measuring and position input (TM Count, TM PosInput, Compact CPU)

3.2.1 Convention

Technology module: We use the term "technology module" in this documentation both for the technology modules TM Count and TM PosInput and the technology component of the compact CPUs.

3.2.2 Overview of applications

Introduction

The technology module is configured and assigned parameters using the configuration software.

The operation and control of the technology module functions is effected either via the technology object or through the application program via the control and feedback interface.

System environment for TM Count and TM PosInput

The technology modules can be used in the following system environments:

Application scenarios	Components required	Configuration software	In the user program
Central operation with an S7-1500 CPU or 151xSP CPU	• S7-1500 automation system or ET 200SP CPU • Technology module	STEP 7 (TIA Portal): Operation with "Counting and measuring" technology object • Device configuration with hardware configuration (Page 160) • Parameter setting with High_Speed_Counter or SSI_Absolute_Encoder technology object	For incremental / pulse encoders: High_Speed_Counter instruction for the technology object For SSI absolute encoder: SSI_Absolute_Encoder instruction for the technology object
		STEP 7 (TIA Portal): Position input for "Motion Control" technology object • Device configuration with hardware configuration (Page 160) • Parameter setting with axis and measuring input technology object (Page 167)	Instructions for "Motion Control" technology object
		STEP 7 (TIA Portal): Manual operation (without technology object) • Device configuration and parameter setting (Page 160) with hardware configuration	Direct access to control and feedback interface of the technology module in the I/O data

Application scenarios	Components required	Configuration software	In the user program
Distributed operation with an S7-1500 CPU	• S7-1500 automation system • ET 200 distributed I/O system • Technology module or • S7-1500 automation system • Technology module of the ET 200eco PN M12-L distributed I/O system	STEP 7 (TIA Portal): Operation with "Counting and measuring" technology object • Device configuration with hardware configuration (Page 160) • Parameter setting with High_Speed_Counter or SSI_Absolute_Encoder technology object	For incremental / pulse encoders: High_Speed_Counter instruction for the technology object For SSI absolute encoder: SSI_Absolute_Encoder instruction for the technology object
		STEP 7 (TIA Portal): Position input for "Motion Control" technology object • Device configuration with hardware configuration (Page 160) • Parameter setting with axis and measuring input technology object (Page 167)	Instructions for "Motion Control" technology object
		STEP 7 (TIA Portal): Manual operation (without technology object) • Device configuration and parameter setting (Page 160) with hardware configuration	Direct access to control and feedback interface (Page 217) of the technology module in the I/O data
Distributed operation with an S7-1200 CPU	• S7-1200 automation system • ET 200 distributed I/O system • Technology module or • S7-1200 automation system • Technology module of the ET 200eco PN M12-L distributed I/O system	STEP 7 (TIA Portal): Device configuration and parameter setting (Page 160) with hardware configuration	Direct access to control and feedback interface (Page 217) of the technology module in the I/O data
Distributed operation with an S7-300/400 CPU	• S7-300/400 automation system • ET 200 distributed I/O system • Technology module or • S7-300/400 automation system • Technology module of the ET 200eco PN M12-L distributed I/O system	STEP 7 (TIA Portal): Device configuration and parameter setting (Page 160) with hardware configuration STEP 7: Device configuration and parameter settings with HSP or GSD file	Direct access to control and feedback interface (Page 217) of the technology module in the I/O data

Application scenarios	Components required	Configuration software	In the user program
Distributed operation in a third-party system	• Third-party automation system • ET 200 distributed I/O system • Technology module or • Third-party automation system • Technology module of the ET 200eco PN M12-L distributed I/O system	Third-party configuration software: Device configuration and parameter settings with GSD file	Direct access to control and feedback interface (Page 217) of the technology module in the I/O data

System environment for a Compact CPU

The Compact CPUs can be used in the following system environments:

Application scenarios	Components required	Configuration software	In the user program
Central operation with a S7-1500 Compact CPU	• S7-1500 automation system • Compact CPU	STEP 7 (TIA Portal): Operation with "Counting and measuring" technology object • Device configuration with hardware configuration (Page 160) • Parameter setting with High_Speed_Counter technology object	High_Speed_Counter instruction for the technology object
		STEP 7 (TIA Portal): Position input for "Motion Control" technology object • Device configuration with hardware configuration (Page 160) • Parameter setting with axis and measuring input technology object (Page 167)	Instructions for "Motion Control" technology object
		STEP 7 (TIA Portal): Manual operation (without technology object) • Device configuration and parameter setting (Page 160) with hardware configuration	Direct access to control and feedback interface of the technology module in the I/O data

Parameter assignment options of the technology module

In an S7-1500 system, you have two options for parameter assignment and control of technology module functions:

- Configuration using the technology object and control using the associated instruction
  Access to the control and feedback interface of the technology module takes place through the technology object.
- Parameter setting via hardware configuration
  The control and feedback interface of the technology module is accessed using direct access to the I/O data.

Configuration via technology object

For central and distributed use, we recommend the convenient, graphics-assisted configuration using a technology object. A detailed description of this configuration can be found in section High_Speed_Counter technology object or SSI_Absolute_Encodertechnology object.

You specify the "Operation with technology object "Counting and measuring"" in the device configuration of the technology module: see section Operating mode (Page 166).

You can assign the technology module and counting channel in the basic parameters of the technology object: see section Basic parameters (Page 98).

Parameter setting via hardware configuration

You specify the "Manual operation (without technology object)" or "Fast Mode" in the device configuration of the technology module: see section Operating mode (Page 166).

Additional support for parameter setting via hardware configuration is available in the context-sensitive help for the parameters in STEP 7 (TIA Portal). A description of the control and feedback interface is available in the following sections:

- Assignment of the control interface (Page 218)
- Assignment of the feedback interface (Page 220)

System environment for electronic module

The electronic modules and the associated connection modules can be used in the following system environments:

Possible applications	Components required	Configuration software	In the user program
Central operation or distributed operation with a CPU S7-1500	• S7-1500 automation system • ET 200pro distributed I/O system • Electronic module with associated connection module	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to the feedback interface in the I/O data
Central operation with an ET 200pro CPU	• S7-1500 automation system • ET 200pro distributed I/O system • Electronic module with associated connection module	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	
Distributed operation in a third-party system	• Third-party automation system • ET 200pro distributed I/O system • Electronic module with associated connection module	Third-party configuration software: Device configuration and parameter setting with GSD file	

3.2.3 Recording of count signals

3.2.3.1 Counting with incremental or pulse encoder

Counting refers to the recording and adding up of events. The counters of the technology modules capture and evaluate pulse and incremental signals. The count direction can be specified using encoder or pulse signals or through the user program.

You can control counting processes using the digital inputs of the technology module. You can switch the digital outputs exactly at defined counter values, regardless of the user program.

You can configure the response of the counters using the functionalities described below.

Counter limits

The counter limits define the counter value range used. The counter limits are configurable and can be modified during runtime using the user program.

The highest counter limit that can be set is 2147483647 (2^{31}–1). The lowest counter limit that can be set is –2147483648 (–2^{31}).

You can configure the response of the counter at the counter limits:

- Continue or stop counting upon violation of a counter limit (automatic gate stop)
- Set counter value to start value or to opposite counter limit upon violation of a counter limit

Start value

You can configure a start value within the counter limits. The start value can be modified during runtime by the user program.

The technology module can, as configured, set the current counter value to the start value upon synchronization, upon Capture function activation, upon violation of a counter limit or when the gate is opened.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are captured.

The hardware gate is controlled externally via a digital input of the technology module. The software gate is controlled via the user program. The hardware gate can be enabled through parameter assignment. The software gate (bit in the control interface of the cyclic I/O data) cannot be disabled.

Capture (Latch)

You can configure an external reference signal edge that triggers the saving of the current counter value or position value as a Capture value. The following external signals can trigger the Capture function:

- Rising or falling edge of a digital input
- Both edges of a digital input
- Rising edge of the N signal at the encoder input

When using a digital input, you can specify whether counting is to continue from the current counter value or from the start value after the Capture function. When using the rising edge of the N signal at the encoder input, counting is to continue from the current counter value after the Capture function. The use of a digital input and the use of the N signal are not mutually exclusive for the Capture function.

The parameter "Frequency of the Capture function" determines if the function is executed for each configured edge or only once after each enable.

Measuring input

If you use the position input for Motion Control (Page 69), you can use the "Measuring input" technology object to execute a measuring input function with a hardware digital input.

Synchronization

You can configure an external reference signal edge to load the counter with the specified start value. The following external signals can load the counter with the start value:

- Rising or falling edge of a digital input
- Rising edge of signal N at the encoder input
- Rising edge of signal N at the encoder input depending on the level of the assigned digital input

The parameter "Frequency of synchronization" determines whether the function is executed for each configured edge or only once after each enable.

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output is prevented from switching again. An encoder can come to a standstill at a specific position, and slight movements may make the counter value fluctuate around this position. If a comparison value or a counting limit lies within this fluctuation range, the corresponding digital output will be switched on and off with corresponding frequency if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

3.2.3.2 Position input with SSI absolute encoder

Description

You can use the TM PosInput technology modules with an SSI absolute encoder for position detection. The technology module reads the position value via a synchronous serial interface from the SSI absolute encoder and makes it available to the controller.

You can switch the digital outputs of the technology module exactly at defined position values, regardless of the user program. Position input with an SSI absolute encoder does not involve gate control. Due to system constraints, synchronization is not possible with an SSI absolute encoder.

Gray- and dual-code

Gray-code and dual-code SSI absolute encoders are supported.

Capture (Latch)

You can configure one or both edges of a digital input that triggers a saving of the current position value as Capture value.

The parameter "Frequency of the Capture function" determines if the function is executed for each configured edge or only once after each enable.

Measuring input

If you use the position input for Motion Control (Page 69), you can use the "Measuring input" technology object to execute a measuring input function with a hardware digital input.

Hysteresis

You can specify hysteresis for the comparison values, within which a digital output is prevented from switching again. An encoder can come to a standstill at a specific position, and slight movements may make the position value fluctuate around this position. If a comparison value or a limit lies within this fluctuation range, the corresponding digital output is switched on and off with corresponding frequency if hysteresis is not used. The hysteresis prevents these unwanted switching operations.

Range for position value

You can specify a frame length of 10 bits to 40 bits for the SSI absolute encoder. The configurable bit numbers of the LSB and the MSB of the position value in the frame define the value range. The technology module can read a position value with a maximum length of 32 bits and communicate it to the controller.

If you use an encoder with a position value length of up to 31 bits, the position value is handled unsigned as a positive value and can assume values between 0 and $2^{(MSB-LSB+1)}$-1. If you use an encoder with a position value length of 32 bits, the MSB of the position value corresponds to the sign and the position value can assume values between –2147483648 and 2147483647. If you use a 32 bit position value for the comparison function, the position value is interpreted as DINT.

Complete SSI frame

Instead of having a measured variable returned, you can choose to have the least significant 32 bits of the current unprocessed SSI frame returned. This provides you with encoder-specific additional bits, such as error bits, in addition to the position value. If the SSI frame is shorter than 32 bits, the complete SSI frame is returned right-aligned and the top unused bits are returned with "0" in the feedback interface.

3.2.4 Behavior at the counting limits

Violation of a counting limit

The high counting limit is violated when the current counter value is equal to the high counting limit and another upward count pulse is received. The counter low limit is violated when the current counter value is equal to the counter low limit and another downward count pulse is received.

The appropriate status bit is set in the feedback interface in the event of limit violation:

Counting limit violated	Status bit
High counting limit	EVENT_OFLW is set
Low counting limit	EVENT_UFLW is set

You can reset the status bits with RES_EVENT .

You can configure whether or not and from which counter value counting is to continue following counting limit violation.

NOTE

The high counting limit and the start value define the value range of the counter:

Value range of the counter = (high limit – start value) + 1

Examples

The figure below shows an example for terminating the counting process (automatic gate stop) after an overflow and setting the counter to the start value:

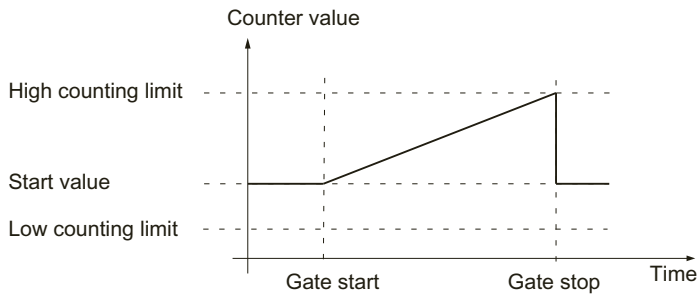

The figure below shows an example for continuing the counting process after an overflow and setting the counter to the start value:

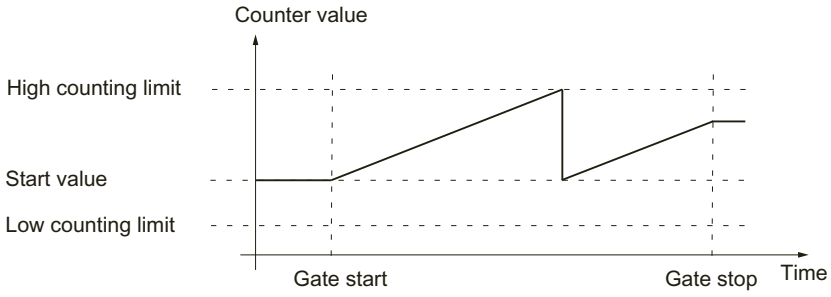

The figure below shows an example for terminating counting after an overflow and setting the counter to the opposite counting limit:

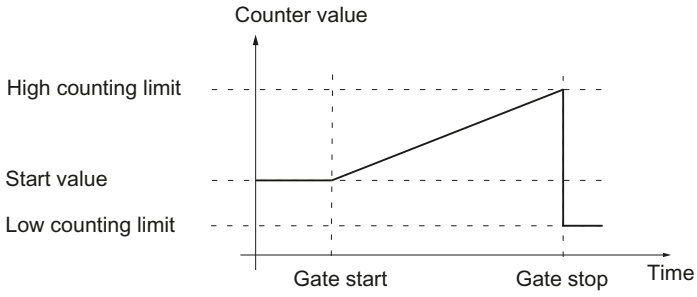

The figure below shows an example for continuing the counting process after an overflow and setting the counter to the opposite counting limit:

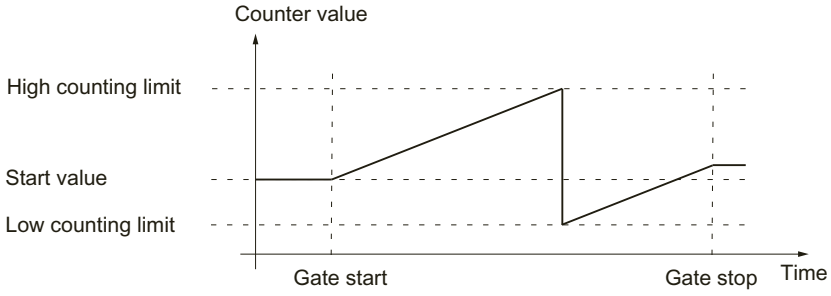

3.2.5 Gate control with incremental or pulse encoder

Many applications require counting processes to be started or stopped in accordance with other events. In such cases, counting is started and stopped using the gate function.

The technology modules have two gates for each channel. These define the resulting internal gate:

- Software gate
- Hardware gate

3.2.5.1 Software gate

The software gate of the channel is opened and closed with the control bit (Page 218) SW_GATE. The status of the software gate is indicated by the feedback bit (Page 220) STS_SW_GATE .

3.2.5.2 Hardware gate

The hardware gate is optional. You open and close the hardware gate by means of signals at the configured digital inputs of the channel.

NOTE

The configured input filters delay the control signal of the digital input.

The status of a DIm digital input is indicated by the respective feedback bit (Page 220) STS_DIm .

Level-triggered opening and closing of the hardware gate with a digital input

The figure below shows an example of level-triggered opening and closing with a digital input. The digital input is configured to be active with high level:

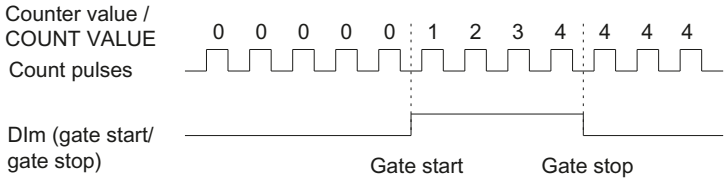

As long as the digital input is active, the hardware gate is open and the count pulses are counted. The hardware gate is closed when the digital input becomes inactive. The counter value stays constant and ignores any further count pulses.

Edge-triggered opening and closing of the hardware gate with two digital inputs

The figure below shows an example of opening and closing with two digital inputs. The two digital inputs are configured so that the rising edge is evaluated:

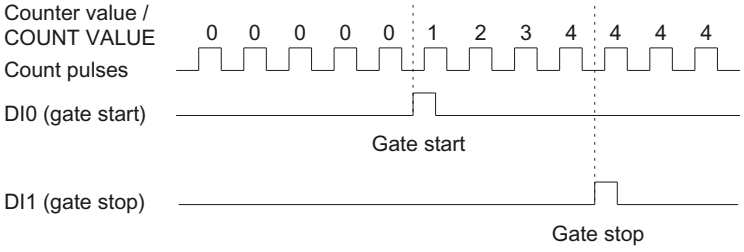

The hardware gate is opened with the configured edge at the digital input that is configured for opening. The hardware gate is closed with the configured edge at the digital input that is configured for closing.

3.2.5.3 Internal gate

Internal gate

The internal gate is open if the software gate is open and the hardware gate is open or has not been configured. The status of the internal gate is indicated by the feedback bit (Page 220) STS_GATE.

If the internal gate is open, counting is started. If the internal gate is closed, all other count pulses are ignored and counting is stopped.

If you want to control a counting process with the hardware gate only, the software gate must be open. If you do not configure a hardware gate, the hardware gate is considered to be always open. In this case, you open and close the internal gate with the software gate only.

Hardware gate	Software gate	Internal gate
Open/not configured	open	open
Open/not configured	closed	closed
closed	open	closed
closed	closed	closed

When you configure the counter behavior, you can specify whether the counting process is to start from the start value or from the current counter value when the internal gate is opened.

The internal gate can also be automatically closed upon violation of a counting limit. The software or hardware gate must then be closed and reopened to continue counting.

3.2.5.4 Counter behavior at gate start

You have the following configuration options for counter behavior upon gate start:

- Setting counter to start value
- Continuing with the current counter value

Setting counter to start value

Counter behavior is as follows for this configuration:

Each counting process starts with the start value when the internal gate is opened.

The figure below shows an example for continuing the counting process after counter is set to the start value:

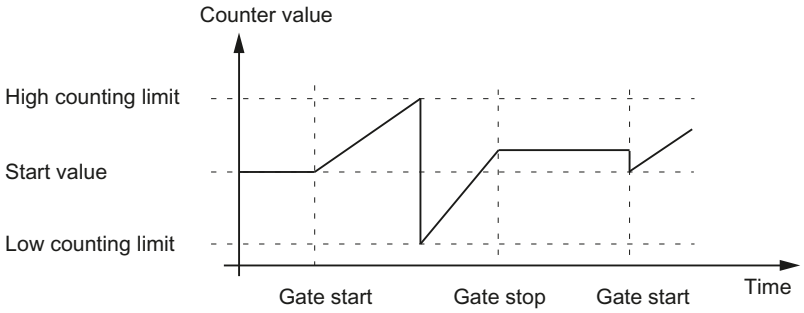

Continuing with the current counter value

Counter behavior is as follows for this configuration:

Each counting process starts from the current counter value after the internal gate is reopened.

The figure below shows an example for continuing the counting process with the current counter value:

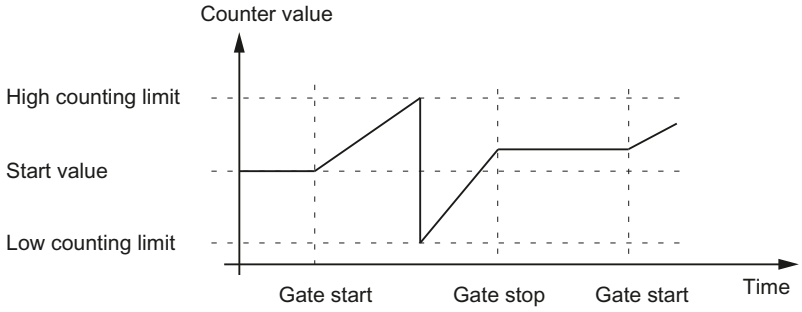

3.2.6 Capture (Latch)

3.2.6.1 Capture with incremental or pulse encoder

Description

The "Capture" function is used to save the current counter value with an external reference signal. You can configure the Capture function for the following reference signals:

- Rising or falling edge at a digital input
- Rising and falling edge at a digital input
- Rising edge of signal N at the encoder input

Function principle

The Capture value is always the exact counter value at the time of the respective edge (delayed by the configured input filter time). The Capture function is effective regardless of the status of the internal gate. The unchanged counter value is saved when the gate is closed.

The figure below shows an example of the Capture function with the following configuration:

- Start value = 0
- Capture event upon rising edge at configured digital input
- Set counter to start value at gate start
- Continue counting after Capture event

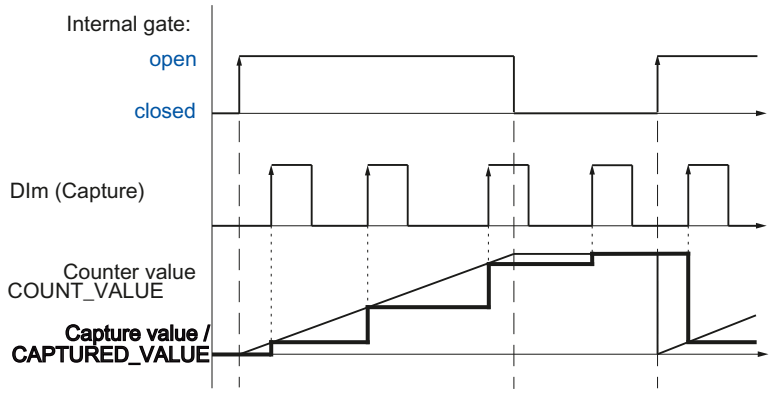

The figure below shows another example of the Capture function with the following configuration:

- Start value = 0
- Capture event upon rising edge at configured digital input
- Set counter to start value at gate start
- Reset counter value to start value after Capture event and continue counting.

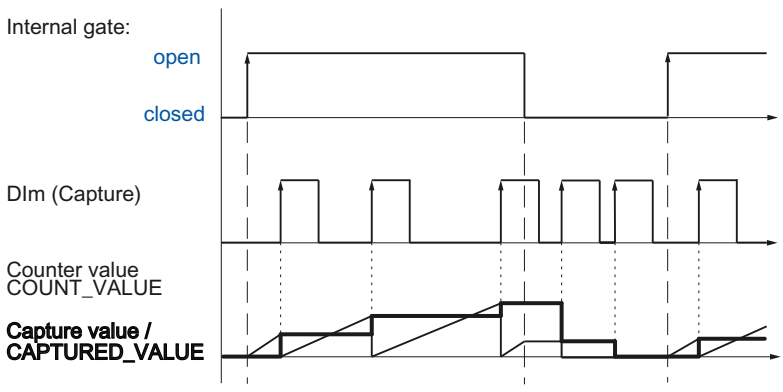

The control bit (Page 218) EN_CAPTURE is used to enable the Capture function. The feedback bit (Page 220) EVENT_CAP indicates that a counter value has been saved as a Capture in the feedback interface. If you reset EN_CAPTURE, EVENT_CAP is also reset. The status of a digital input is indicated by the respective feedback bit (Page 220) STS_DIm .

The figure below shows an example of the EN_CAPTURE and EVENT_CAP bits with use of the one-time Capture function by the rising edge at a digital input:

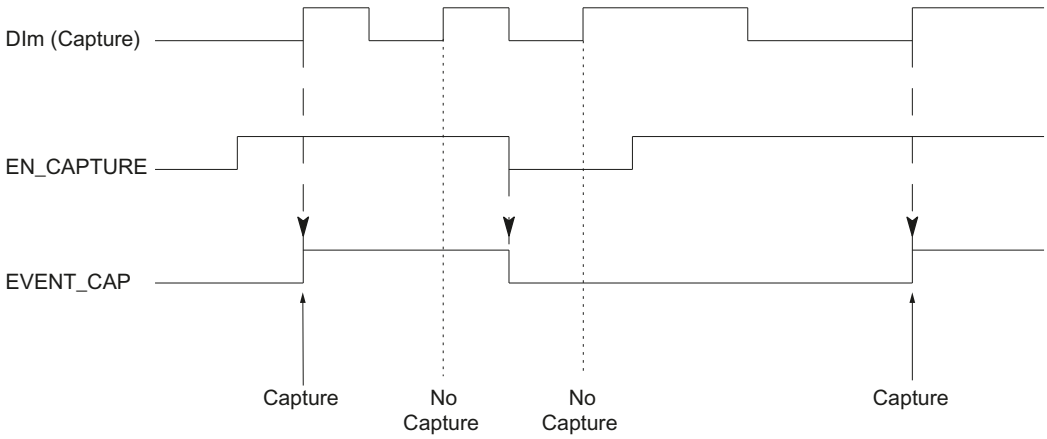

The figure below shows an example of the EN_CAPTURE and EVENT_CAP bits with use of the periodic Capture function by the rising edge at a digital input:

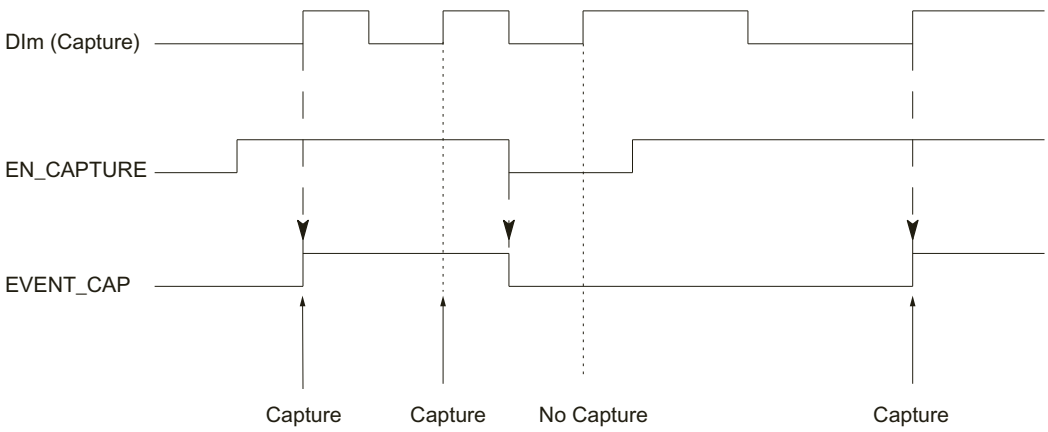

NOTE

The configured input filters delay the control signal of the corresponding digital input.

The Capture function has no effect on the feedback bit STS_CNT and the LEDs UP and DN.

Hardware interrupt

You can configure a hardware interrupt for the Capture function, if the module supports hardware interrupts. If the hardware interrupts are triggered more quickly by the system than they can be acknowledged, hardware interrupts are lost and the "Hardware interrupt" diagnostic interrupt is signaled.

3.2.6.2 Capture with SSI absolute encoder

Description

The "Capture" function is used to save the current position value using an external reference signal. You can configure the Capture function for the following reference signals:

- Rising **or** falling edge at a digital input
- Rising **and** falling edge at a digital input

Function principle

At the time of each edge, the position value of the last valid SSI frame is stored in the Capture value.

The figure below shows an example of the Capture event by a rising edge at the configured digital input:

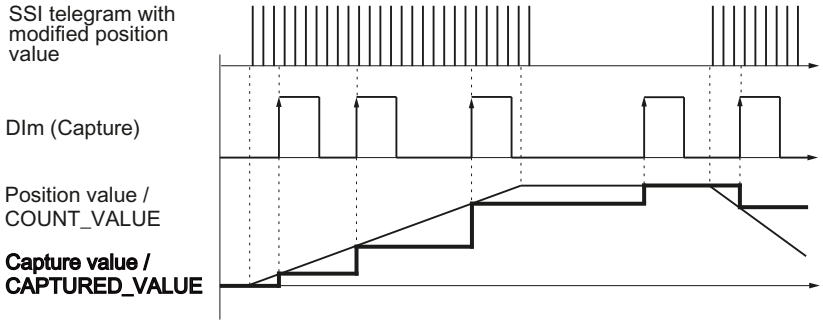

The control bit (Page 218) EN_CAPTURE is used to enable the Capture function. The feedback bit (Page 220) EVENT_CAP indicates that a position value has been saved as Capture value in the feedback interface. If you reset EN_CAPTURE, EVENT_CAP is also reset. The status of a digital input is indicated by the respective feedback bit (Page 220) STS_DIm .

The figure below shows an example of the EN_CAPTURE and EVENT_CAP bits with use of the one-time Capture function by the rising edge at a digital input:

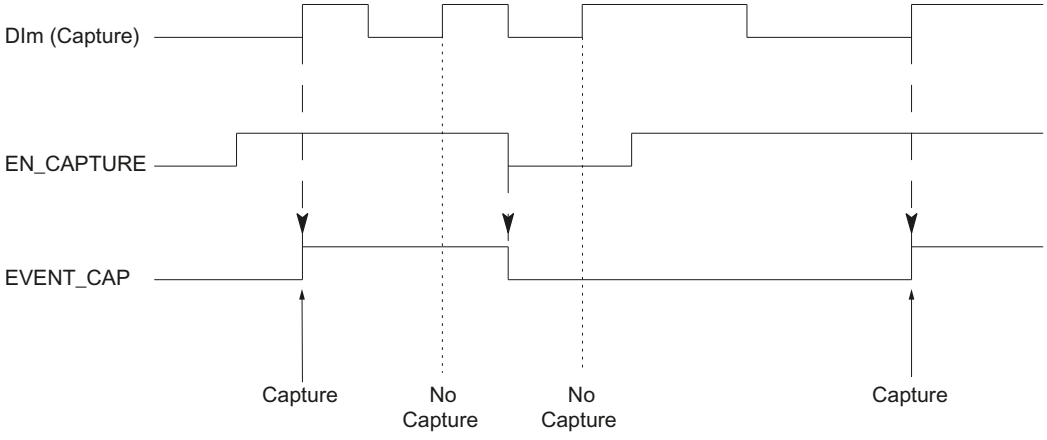

The figure below shows an example of the EN_CAPTURE and EVENT_CAP bits with use of the periodic Capture function by the rising edge at a digital input:

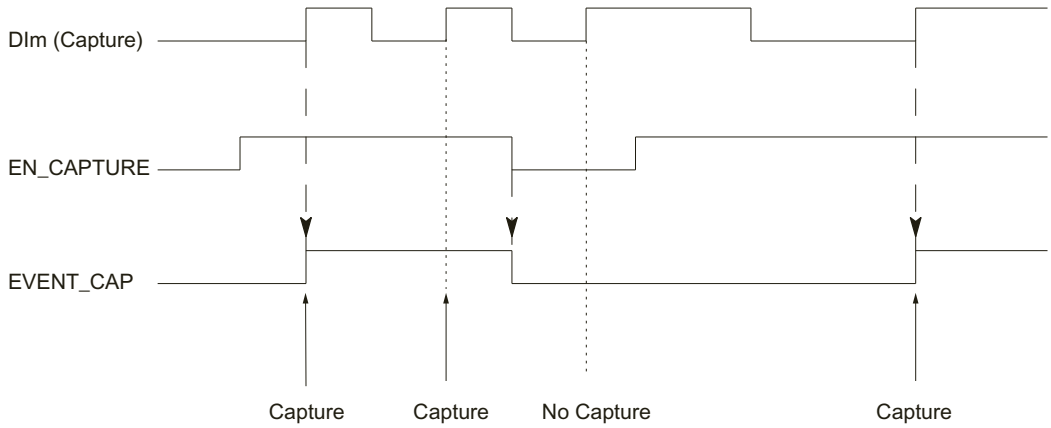

NOTE

The configured input filters delay the control signal of the corresponding digital input.

Hardware interrupt

You can configure a hardware interrupt for the Capture function, if the module supports hardware interrupts. If the hardware interrupts are triggered more quickly by the system than they can be acknowledged, hardware interrupts are lost and the "Hardware interrupt" diagnostic interrupt is signaled.

3.2.7 Synchronization

Description

You use the "Synchronization" function to set the counter to the pre-defined start value with an external reference signal. You can configure synchronization for the following reference signals:

- Rising or falling edges at a digital input
- Rising edge of signal N at the encoder input
- Rising edge of signal N at the encoder input defined by the level of a digital input

Function principle

Synchronization always takes place exactly at the time of the reference signal. Synchronization is effective regardless of the status of the internal gate.

You use the control bit (Page 218) EN_SYNC_UP to enable synchronization for counting in an up direction. Use the control bit (Page 218) EN_SYNC_DN to enable synchronization for

counting down. The feedback bit (Page 220) EVENT_SYNC indicates that synchronization has been performed. Resetting EN_SYNC_UP or EN_SYNC_DN also resets EVENT_SYNC.

NOTE

The configured input filters delay the control signal of the corresponding digital input.

Synchronization has no effect on the feedback bit (Page 220) STS_CNT.

Single synchronization

The figure below shows an example of the EN_SYNC_UP, EN_SYNC_DN and EVENT_SYNC bits with single synchronization by an edge at a digital input for count pulses in an up direction:

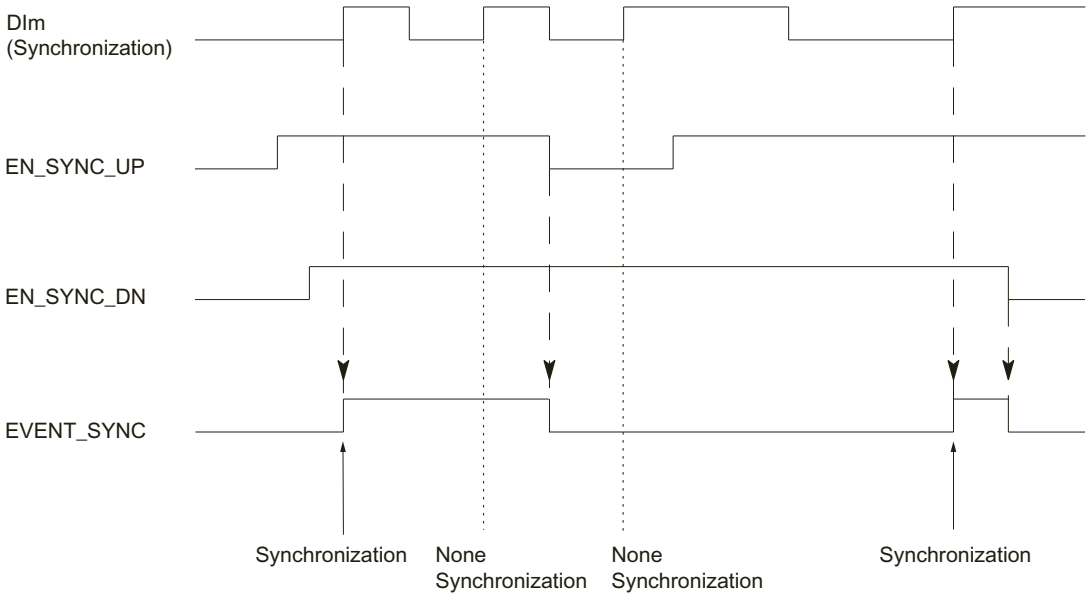

After synchronization is enabled for counting in an up direction, the counter is synchronized at the first rising edge at the configured digital input. The counter can only be synchronized again once the control bit (Page 218) EN_SYNC_UP has been reset and set again.

Periodic synchronization

The figure below shows an example of the EN_SYNC_UP, EN_SYNC_DN and EVENT_SYNC bits with periodic synchronization by an edge at a digital input for count pulses in an up direction:

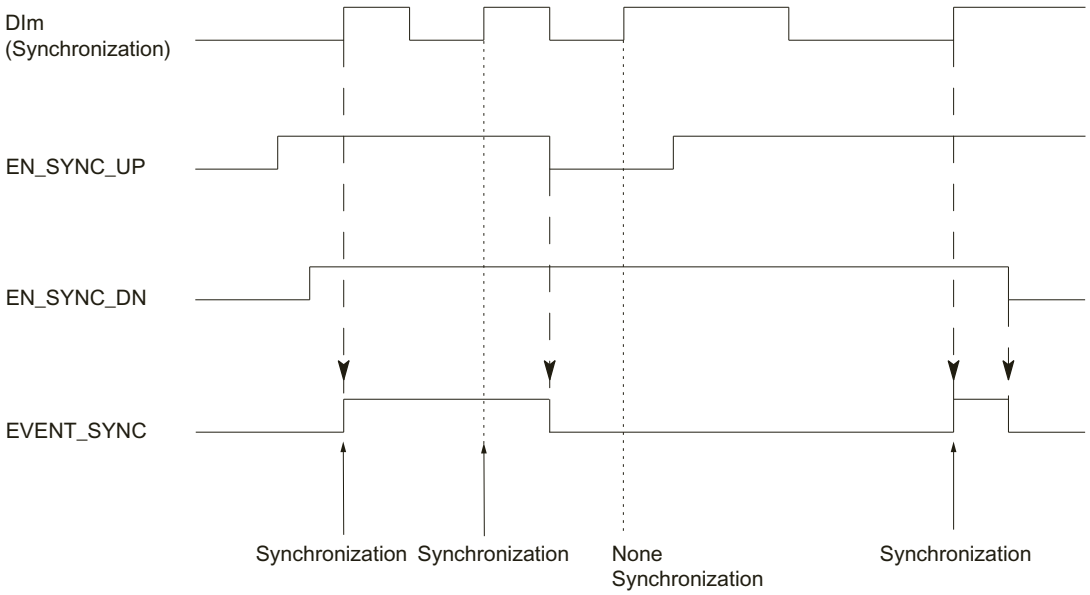

As long as synchronization for counting in an up direction is enabled, the counter is synchronized at each rising edge at the configured digital input.

Hardware interrupt

You can configure a hardware interrupt for the synchronization, if the module supports hardware interrupts. If the hardware interrupts are triggered more quickly by the system than they can be acknowledged, hardware interrupts are lost and the "Hardware interrupt" diagnostic interrupt is signaled.

3.2.7.1 Synchronization by digital input

You can trigger synchronization by edges at a digital input.

Single synchronization

The figure below shows an example for single synchronization by an edge at a digital input:

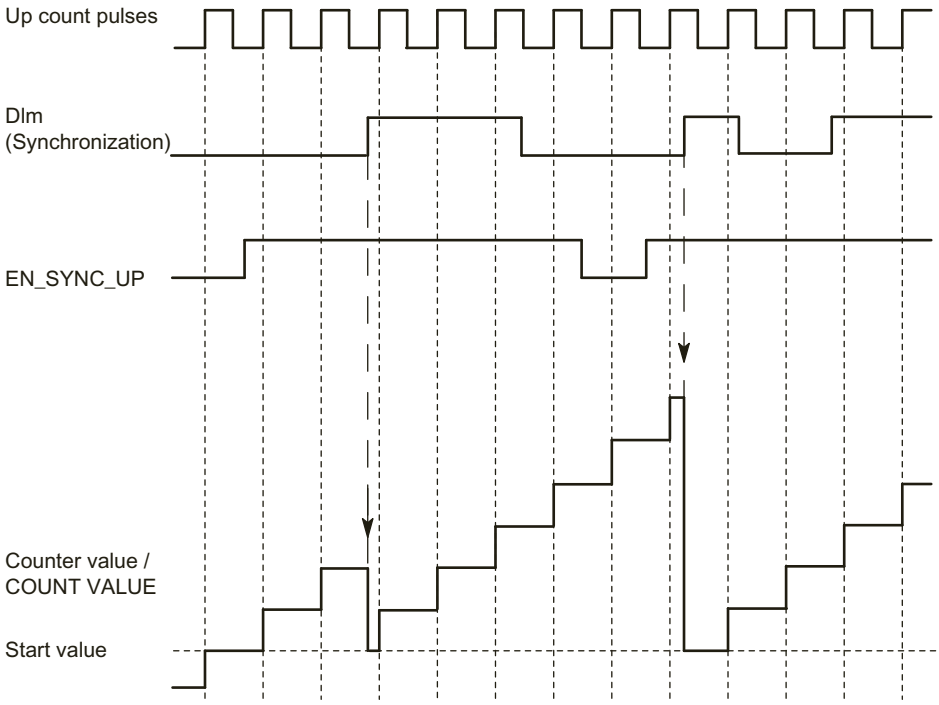

After synchronization is enabled for counting in an upwards direction, the counter is synchronized at the first rising edge at the configured digital input. Until the control bit (Page 218) EN_SYNC_UP has been reset and set again, any additional rising edge at the digital output is ignored. The counter can then be synchronized again.

Periodic synchronization

The figure below shows an example for periodic synchronization by an edge at a digital input:

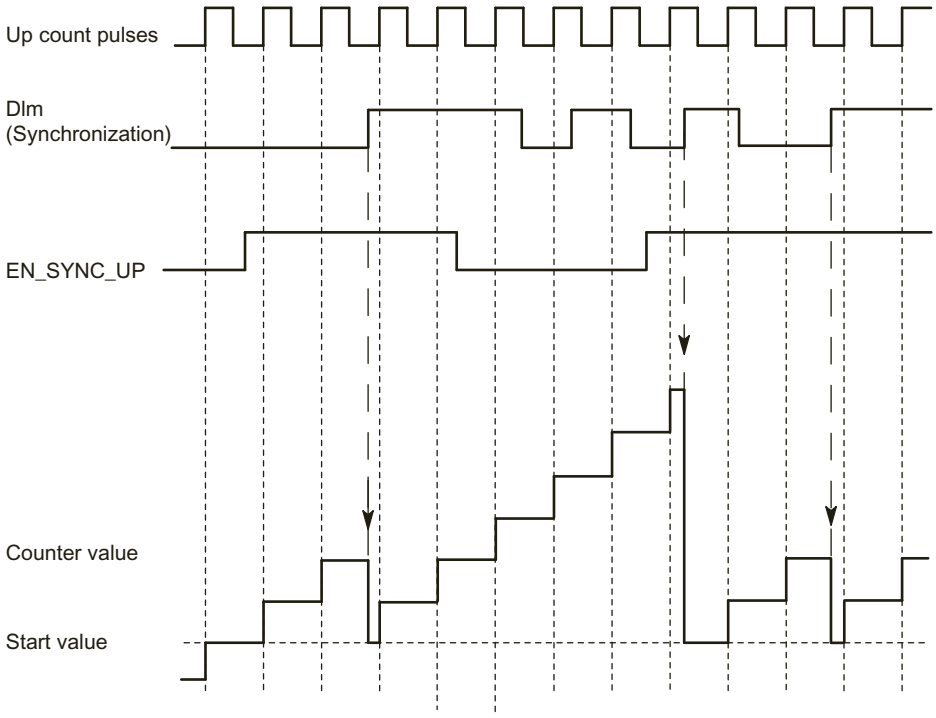

As long as synchronization for counting in an upwards direction is enabled, the counter is synchronized at each rising edge at the configured digital input.

3.2.7.2 Synchronization at signal N

You can trigger synchronization at signal N at the encoder input either directly or depending on the status of a digital input.

Single synchronization

The figure below shows an example of single synchronization at signal N (not dependent on a digital input):

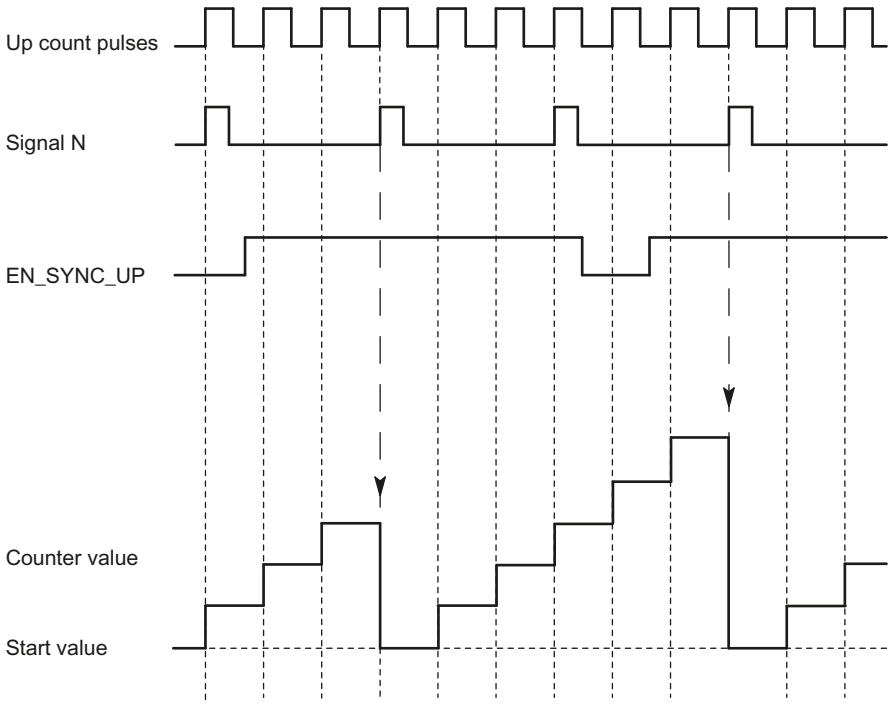

After synchronization is enabled for counting in an upwards direction, the counter is synchronized at the first signal N. After resetting and setting the control bit (Page 218) EN_SYNC_UP once again, the counter can be synchronized again.

Periodic synchronization

The figure below shows an example for periodic synchronization at signal N:

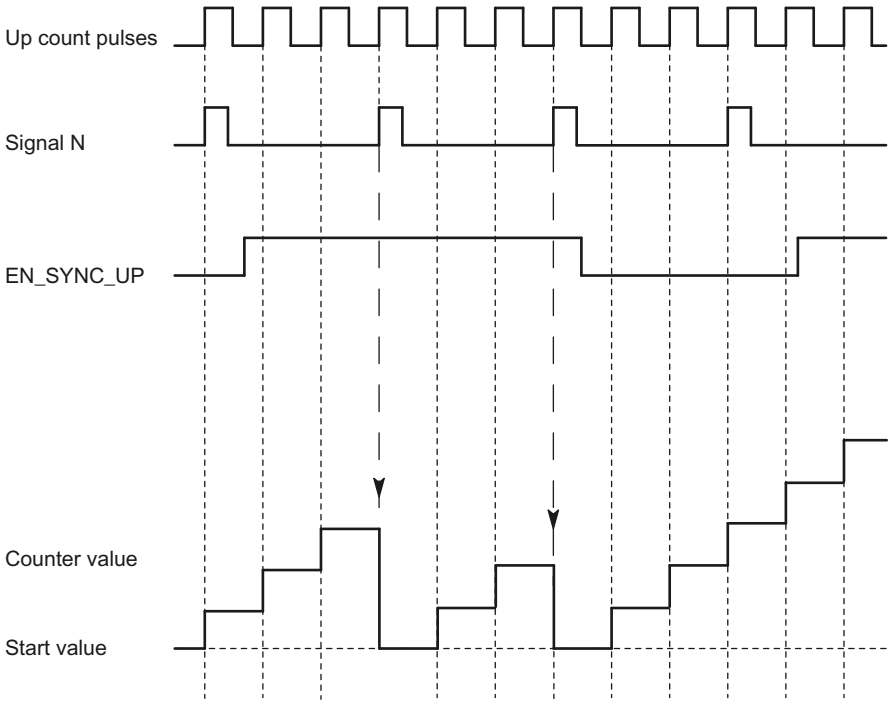

As long as synchronization for counting in an upwards direction is enabled, the counter is synchronized at each signal N.

Enable by a digital input

The figure below shows an example for periodic synchronization at signal N depending on the status of a digital input:

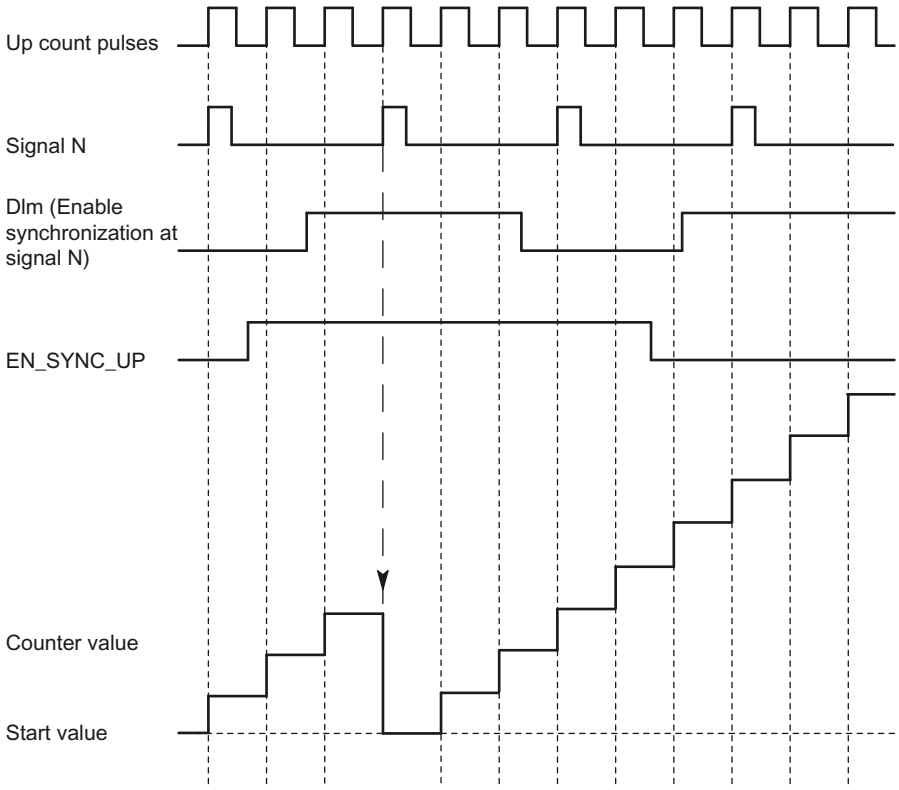

As long as synchronization for counting up is enabled and the corresponding digital input is active, the counter is synchronized at each signal N. If one of the conditions is not met, the counter is not synchronized at the signal N.

3.2.8 Comparison values

3.2.8.1 Comparison values and outputs

Description

You can specify two comparison values to control both digital outputs of the channel independently of the user program:

- Comparison value 0 for digital output DQ0
- Comparison value 1 for digital output DQ1

Depending on the operating mode and the encoder used, define two position, counter or measured values as comparison value. The comparison values are configurable and can be modified during runtime using the user program.

NOTE

DQ0 of a counter of a Compact CPU

With a Compact CPU, the respective digital output DQ0 is available via the feedback interface, but not as a physical output.

Switching digital outputs from the user program

The control bits (Page 218) TM_CTRL_DQ0 and TM_CTRL_DQ1 are used to control use of the digital outputs.

If TM_CTRL_DQm is set to 0, you can control the relevant digital output from the user program with the control bit SET_DQm regardless of the configured technological function. If TM_CTRL_DQm is set to 1, the technological function of the controller of the respective digital output is enabled.

The status of a digital output is indicated by the respective STS_DQm feedback bit.

3.2.8.2 Switching at comparison values with counter value as reference

The comparison values are compared with the current counter value. If the counter value meets the assigned comparison condition and the technological function of the associated digital output is enabled, the digital output is set. If you assign "Between comparison value 0 and 1" for digital output DQ1, both comparison values affect DQ1.

You can make switching for a digital output dependent on one of the following comparison events:

Setting between comparison value and high counting limit

The digital output is set to 1 if:

Comparison value <= counter value <= high counting limit

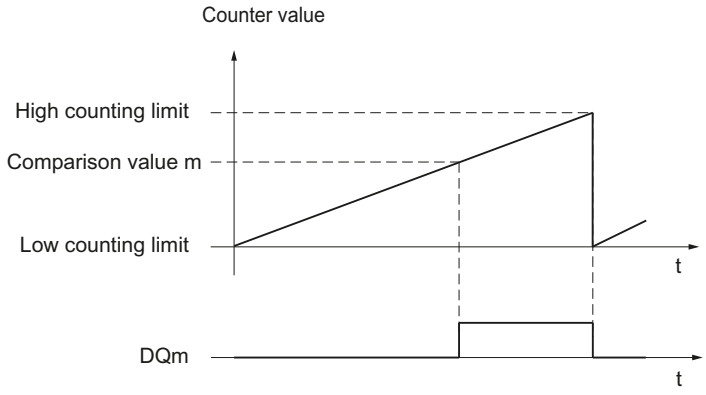

The comparison event is independent of the count direction.

Setting between comparison value and low limit

The digital output is set to 1 if:

Low counting limit <= counter value <= comparison value

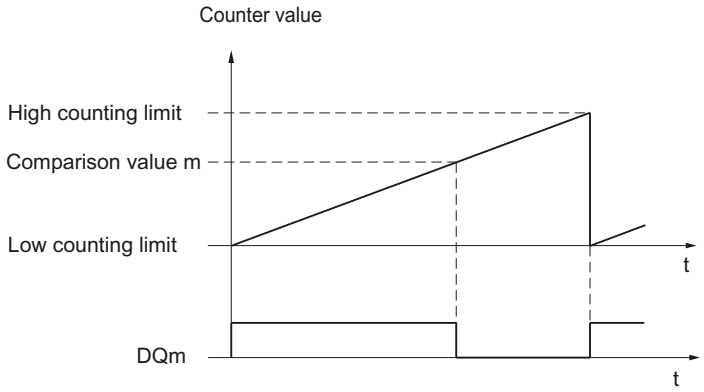

The comparison event is independent of the count direction.

Setting between comparison value 0 and comparison value 1

The comparison event can be configured for the digital output DQ1 if "Use by user program" has been configured for the digital output DQ0. Comparison value 1 must be greater than Comparison value 0.

DQ1 is set to 1 if:

Comparison value 0 <= counter value <= comparison value 1

The figure below shows an example of the comparison event when counting in an upwards direction:

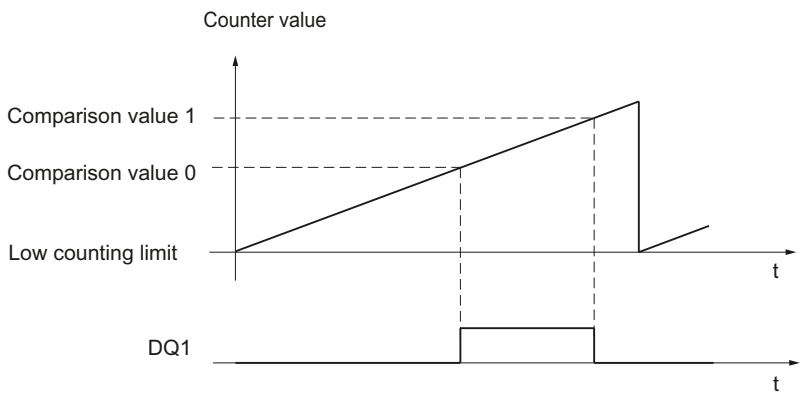

Setting at comparison value for one pulse duration

The respective digital output is set to 1 for a specified period of time when the following conditions are fulfilled:

- Counter value = comparison value
- Current count direction = configured count direction for the comparison event

The figure below shows an example of the comparison event when counting in an upwards direction:

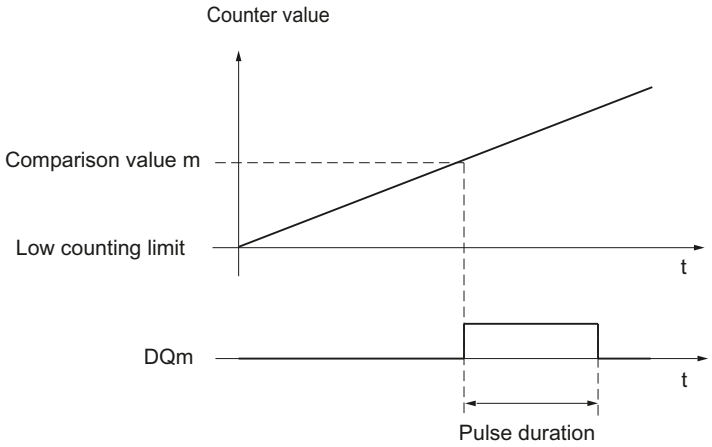

The figure below shows an example of the comparison event when counting in a downward direction:

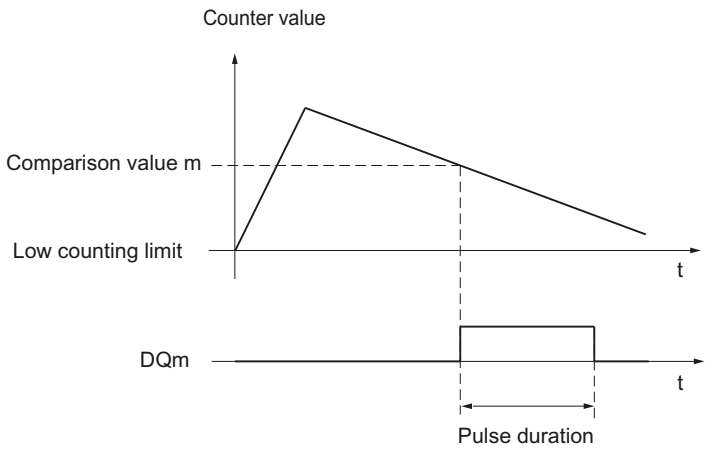

To repeat the comparison event, the counter value must change and then correspond to the respective comparison value again.

If the pulse duration has been defined as "0" and the counter value is equal to the comparison value, the digital output is set to 1 until the next count pulse:

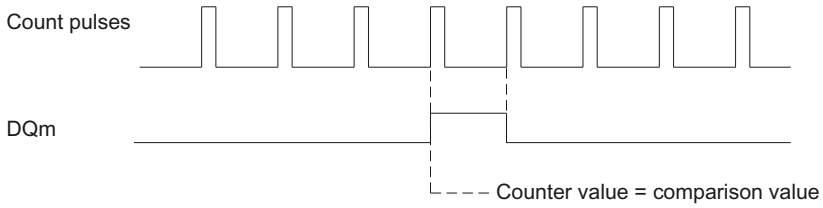

NOTE

This comparison event switches the relevant digital output if a count pulse reaches the comparison value. The digital output does not switch when the counter value is set, by synchronization for example.

Setting by the user program up to comparison value

You can set the respective digital output to 1 (edge) by setting the control bit (Page 218) SET_DQm. The respective digital output is set to 0 by any of the following events:

- Match of the counter value and the comparison value in the configured direction of the comparison event
- Reset of the corresponding SET_DQm control bit.

The figure below shows an example of the comparison event when counting in an upwards direction:

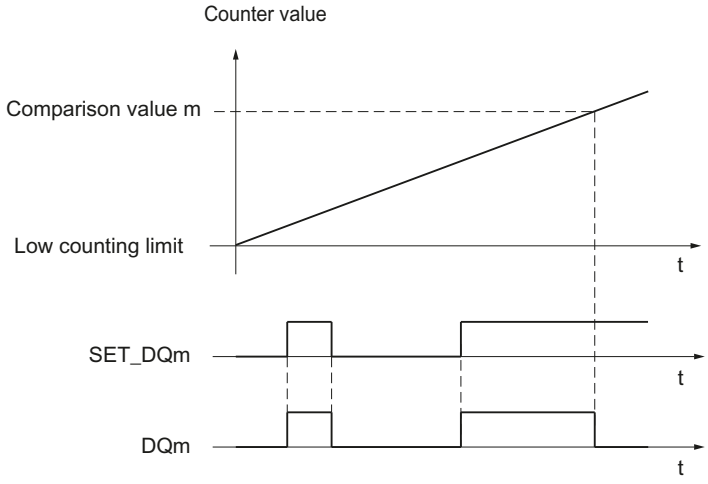

You can disable the digital output before the counter value reaches the comparison value by setting the control bit SET_DQm to 0.

NOTE

If the comparison value is reached in the configured count direction, the feedback bit EVENT_CMPm is set independently of the state of the control bit SET_DQm.

The comparison event switches a digital output when a count pulse reaches the respective comparison value. The digital output does not switch when the counter value is set, by synchronization for example.

3.2.8.3 Switching at comparison values with position value (SSI absolute value) as reference

The comparison values are compared with the current position value. If the position value meets the assigned comparison condition and the technological function of the associated digital output is enabled, the digital output is set. If you assign "Between comparison value 0 and 1" for digital output DQ1, both comparison values affect DQ1.

If you use a 32 bit position value for the comparison function, the position value is interpreted as DINT.

You can make switching for a digital output dependent on one of the following comparison events:

Setting between comparison value and high limit

The high limit corresponds to the maximum position value.

The digital output is set to 1 if:

Comparison value <= position value <= maximum position value

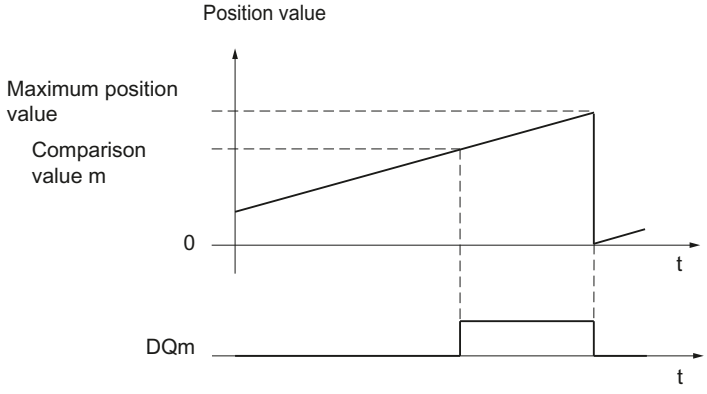

The comparison event is independent of the direction of the position value change. The maximum position value depends on the resolution of the SSI absolute encoder.

Setting between comparison value and low limit

The low limit corresponds to the position value "0".

The digital output is set to 1 if:

0 <= position value <= comparison value

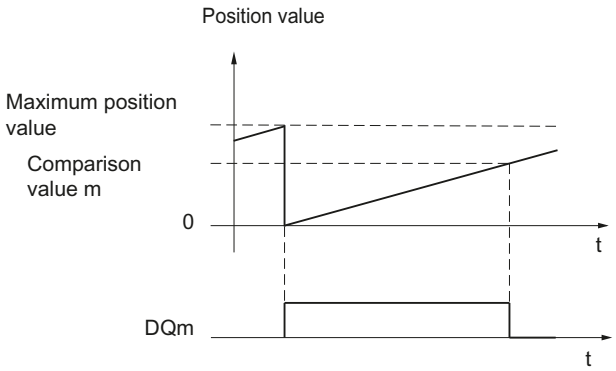

The comparison event is independent of the direction of the position value change.

Setting between comparison value 0 and comparison value 1

The comparison event can be configured for the digital output DQ1 if "Use by user program" has been configured for the digital output DQ0. Comparison value 1 must be greater than Comparison value 0.

DQ1 is set to 1 if:

Comparison value 0 <= position value <= comparison value 1

The figure below shows an example of the comparison event when counting up:

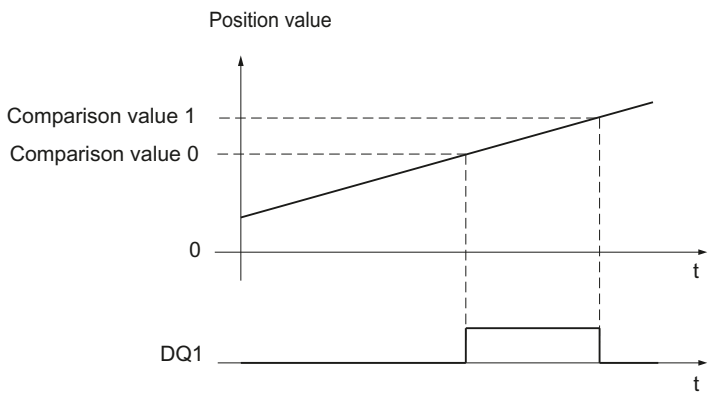

Setting at comparison value for one pulse duration

The respective digital output is set to 1 for a specified period of time when the following conditions are fulfilled:

- Matching of the position value and comparison value or crossing of the comparison value
- Current direction of the position value change = assigned direction for the comparison event

The figure below shows an example of the comparison event when counting up:

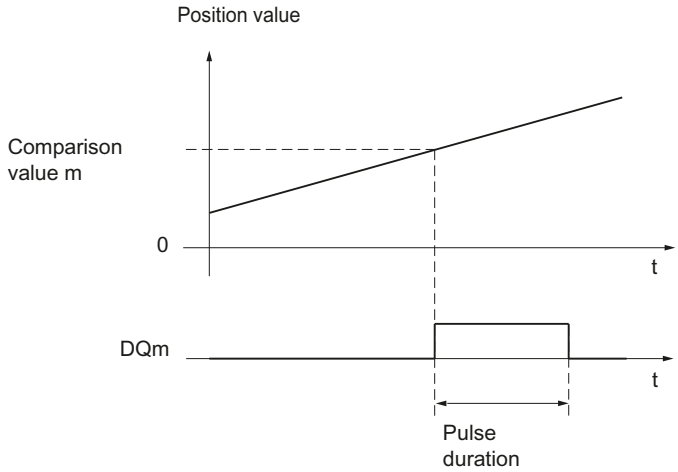

The figure below shows an example of the comparison event when counting down:

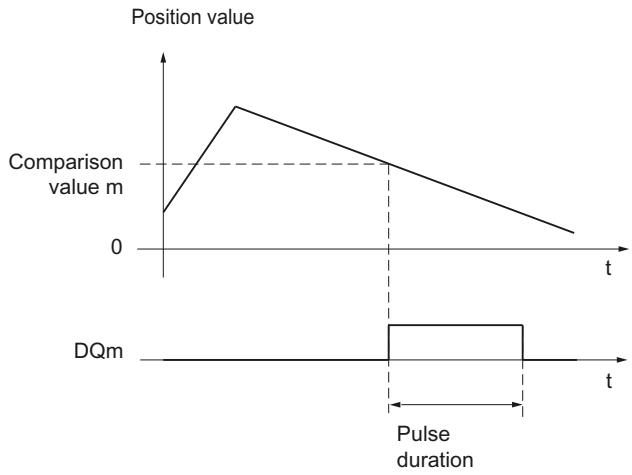

To repeat the comparison event, the position value must change and then correspond to or cross the respective comparison value again.

Setting by the user program up to comparison value

You can set each digital output to 1 (edge) by setting the control bit (Page 218) SET_DQm. The respective digital output is set to 0 by any of the following events:

- Matching of the position value and the comparison value or crossing of the comparison value in the configured direction of the comparison event
- Resetting of the SET_DQm control bit.

The figure below shows an example of the comparison event when counting up:

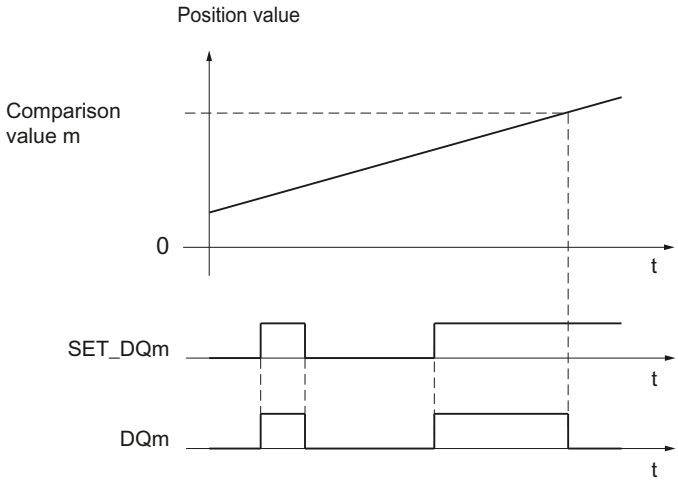

You can disable the digital output before the position value corresponds to or exceeds the comparison value by setting the control bit SET_DQm to 0.

NOTE

If the comparison value is reached or exceeded in the assigned direction, feedback bit EVENT_CMPm is set independently of the status of control bit SET_DQm.

3.2.8.4 Switching at comparison values with measured value as reference

The comparison values are compared with the current measured value. If the measured value meets the configured comparison condition and the technological function of the corresponding digital output is enabled, the digital output is set. If you configure "Between comparison value 0 and 1" or "Not between comparison value 0 and 1" for digital output DQ1, both comparison values affect DQ1.

You can make switching for a digital output dependent on one of the following comparison events:

Setting above the comparison value

The digital output is set to 1 if:

Measured value >= comparison value

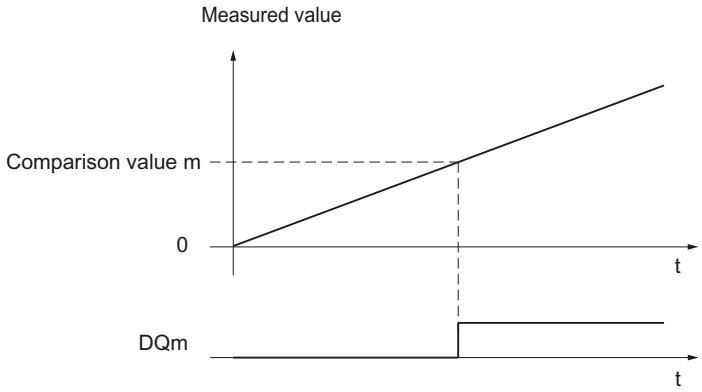

Setting below the comparison value

The digital output is set to 1 if:

Measured value <= comparison value

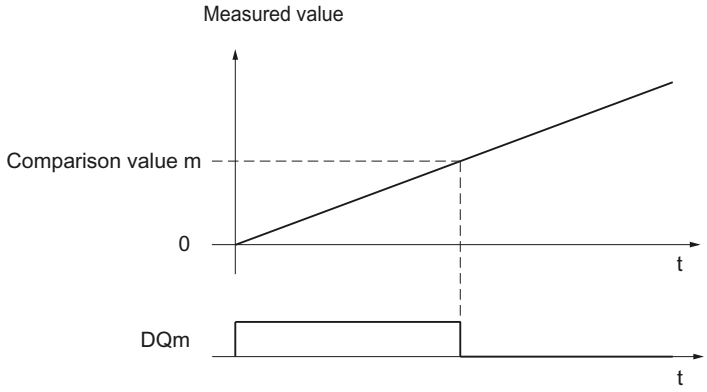

Setting between comparison value 0 and comparison value 1

The comparison event can be configured for the digital output DQ1 if "Use by user program" has been configured for the digital output DQ0. Comparison value 1 must be greater than Comparison value 0.

DQ1 is set to 1 if:

Comparison value 0 <= measured value <= comparison value 1

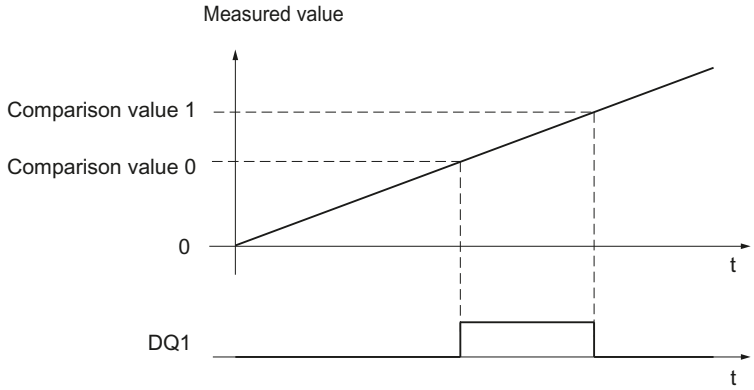

Not setting between comparison value 0 and comparison value 1

The comparison event can be configured for the digital output DQ1 if "Use by user program" has been configured for the digital output DQ0. Comparison value 1 must be greater than Comparison value 0.

DQ1 is set to 1 if:

Comparison value 1 <= measured value <= comparison value 0

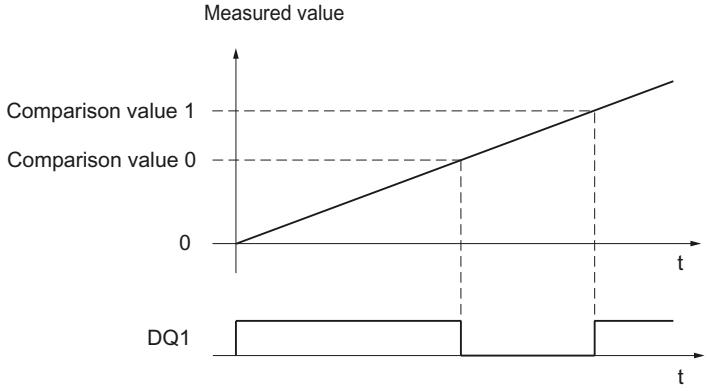

3.2.9 Measured value determination

3.2.9.1 Overview of measuring functions

The following highly accurate measuring functions are available (accuracy up to 100 ppm):

Measurement type (Page 59)	Description
Frequency measurement	The mean frequency is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and returned in Hertz as floating point number.
Period measurement	The mean period duration is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and returned in seconds as floating point number.
Velocity measurement	The mean velocity is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and other parameters, and returned in the configured unit of measurement.

Measured values and counter values are available concurrently in the feedback interface.

Update time

You can configure the interval at which the technology module updates the measured values cyclically as the update time. Setting longer update time intervals allows uneven measured variables to be smoothed and increases measuring accuracy.

Gate control for incremental and pulse encoders

Opening and closing the internal gate defines the period of time during which the count pulses are captured. The update time is asynchronous to the opening of the gate, which means that the update time is not started when the gate is opened. After the internal gate is closed, the last measured value captured is still returned.

3.2.9.2 Measured value determination with incremental or pulse encoder

Measuring range (TM Count and TM PosInput)

The measuring functions have the following measuring limits:

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0.04 Hz	800 kHz* / 4 MHz**
Period measurement	1.25 µs* / 0.25 µs**	25 s
Velocity measurement	Depending on the configured number of "increments per unit" and the "time base for velocity measurement"	

* Applies to 24 V incremental encoders and "quadruple" signal evaluation.

** Applies to RS422 incremental encoders and "quadruple" signal evaluation.

All measured values are returned as signed values. The sign indicates whether the counter value increased or decreased during the relevant time period.

Measuring range (Compact CPU)

The measuring functions have the following measuring range limits:

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0.04 Hz	400 kHz*
Period measurement	2.5 µs*	25 s
Velocity measurement	Depends on the configured number of "Increments per unit" and the "Time base for velocity measurement"	

* Applies to 24 V incremental encoders and "quadruple“ signal evaluation.

All measured values are returned as signed values. The sign indicates whether the counter value increased or decreased during the relevant time period.

Measuring principle

The technology module assigns a time value to each count pulse. The measuring interval is defined as the time between each last count pulse before and during the previous update time. The measuring interval and the number of pulses in the measuring interval are evaluated to calculate measured variables.

If there is no count pulse within an update time, the measuring interval is dynamically adjusted. In this case, a pulse is assumed at the end of the update time and the measuring interval is calculated as the time between that point and the last pulse which occurred. The number of pulses is then 1.

The feedback bit STS_M_INTERVAL indicates whether a count pulse occurred in the previous measuring interval. This allows for a differentiation between an assumed and an actual count pulse.

The following figures show the principle of measurement and the dynamic adjustment of the measuring interval:

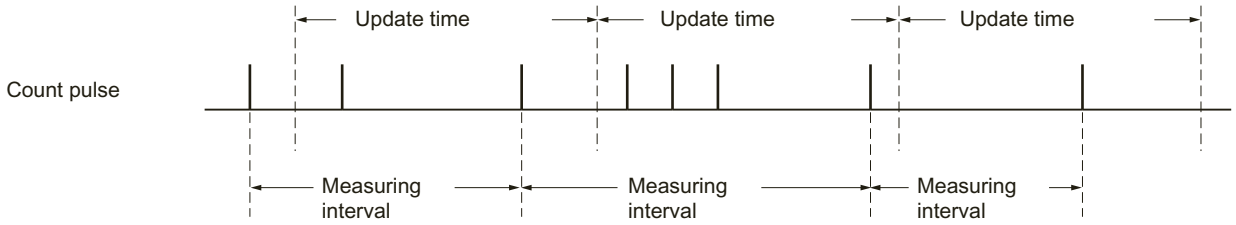

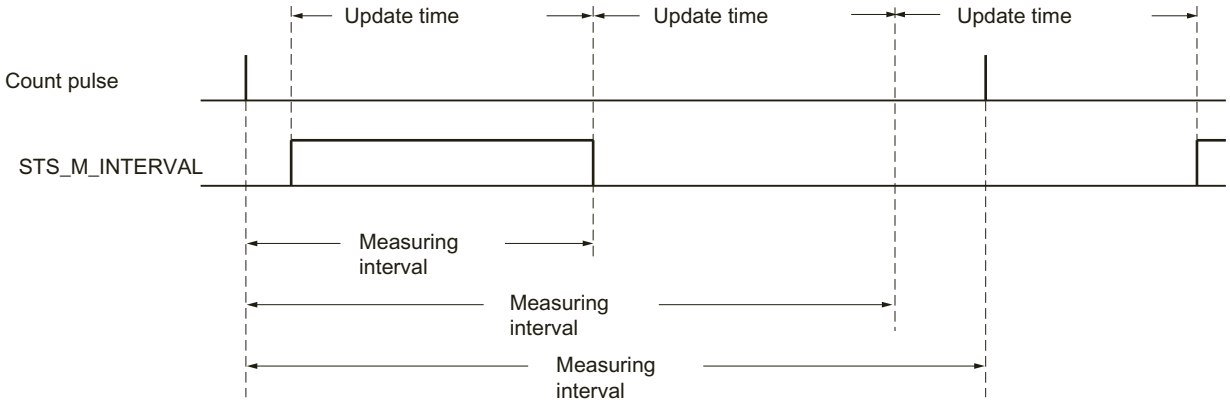

Frequency measurement

A value "0" is returned until the first measured value is available.

The measurement process begins with the first pulse detected once the internal gate has been opened. The first measured value can be calculated after the second pulse at the earliest.

The measured value is updated in the feedback interface (Page 220) upon completion of each update time. If the internal gate is closed, measuring stops and the measured value is no longer updated.

The figures below shows an example of frequency measurement with an update time of 1 s:

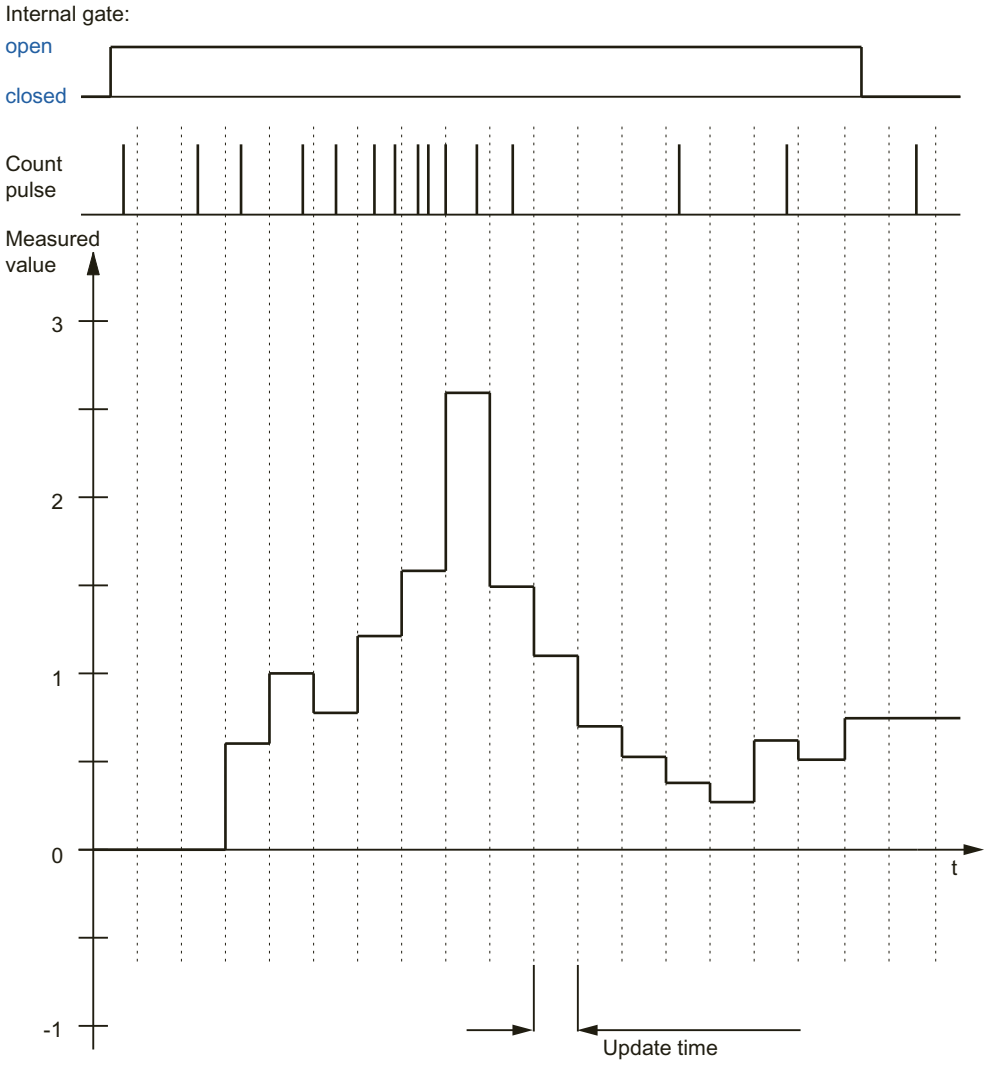

Period measurement

The reciprocal of the frequency is output as the measured value for period measurement.

A value "25 s" is returned until the first measured value is available.

Velocity measurement

The normalized frequency is output as the measured value in velocity measurement. You can configure the scaling using the time basis and the number of increments that your encoder delivers per unit.

Example:

Your encoder delivers 4000 increments per meter. The velocity is to be measured in meters per minute.

In this case, you need to configure 4000 Increments per unit and a time basis of one minute.

3.2.9.3 Measured value determination with SSI absolute encoder

Measuring range SSI absolute encoder

The measuring functions have the following measuring limits:

Measurement type	Low measuring range limit	High measuring range limit
Frequency measurement	0,04 Hz	4 MHz
Period measurement	0,25 µs	25 s
Velocity measurement	Depending on the configured number of "increments per unit" and the "time base for velocity measurement"	

All measured values are returned as signed values. The sign indicates whether the position value increased or decreased during the relevant time period.

Measuring principle

The technology module assigns a time value to each SSI frame. The measuring interval is defined as the time between the last SSI frame with a change of position value before and during the previous update time. The measuring interval and the total change in position value in the measuring interval are evaluated to calculate a measured variable. The total change in position value in a measuring interval corresponds to the number of encoder increments in the same measuring interval.

If there is no change in position value within an update time, the measuring interval is dynamically adjusted. In this case, a change in position value is assumed at the end of the update time and the measuring interval is calculated as the time between that point and the last SSI frame with a change in position value. The change in position value is then 1.

The feedback bit STS_M_INTERVAL indicates whether a change in position value occurred in the previous measuring interval. This allows for a differentiation between an assumed and an actual change in position value. If the technology module cannot calculate measured values because the measuring range limit has been violated, the feedback bit STS_M_INTERVAL is not set.

Frequency measurement

The value "0.0" is reported in the time up to the first available measured value.

The measuring process begins with the first detected change in position value. The first measured value can be calculated after the second detected change in position value at the earliest.

The measured value is updated in the feedback interface (Page 220) upon completion of each update time.

The figures below shows an example of frequency measurement with an update time of 1 s:

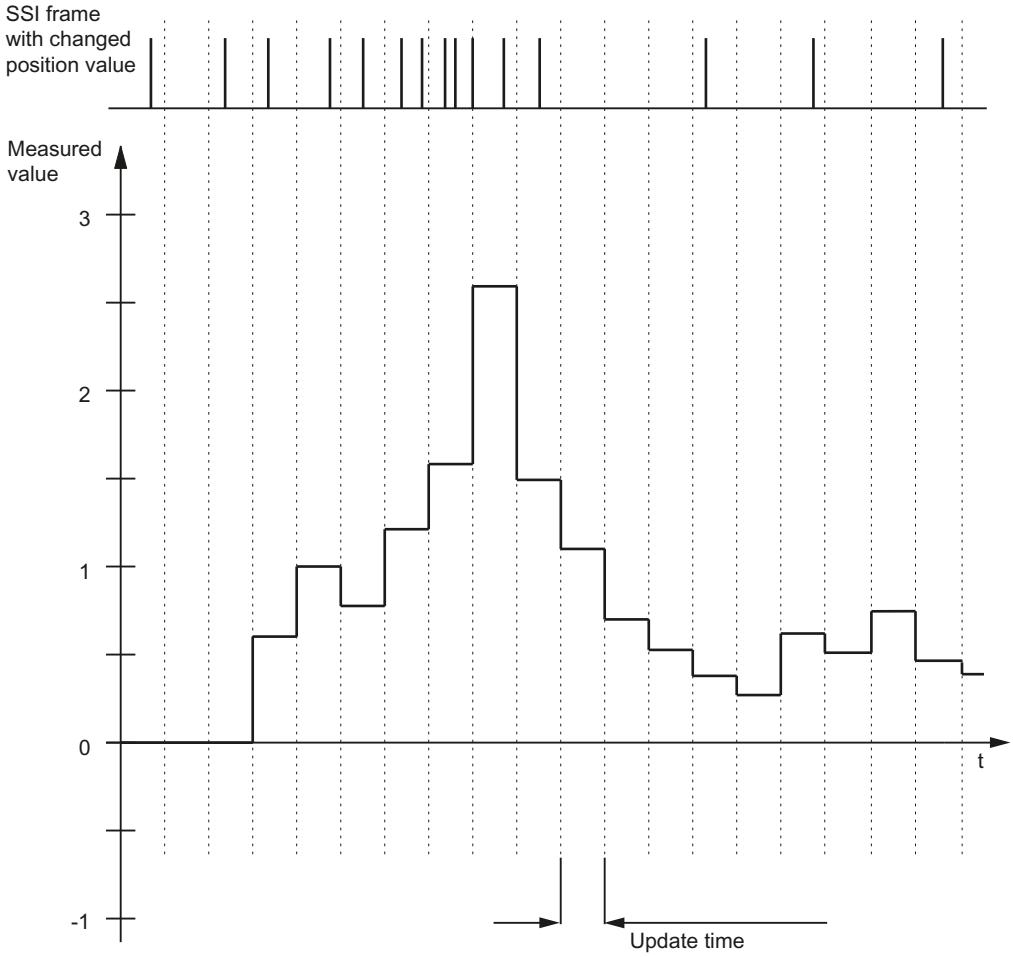

Period measurement

The reciprocal of the frequency is output as the measured value for period measurement.

A value "25 s" is returned until the first measured value is available.

Velocity measurement

The normalized frequency is output as the measured value in velocity measurement. You can configure the scaling using the time basis and the number of increments that your encoder delivers per unit.

Example:

Your SSI absolute encoder operates with a resolution of 12 bits per revolution and performs 4096 increments per revolution. The velocity should be measured in revolutions per minute.

In this case, you need to configure 4096 Increments per unit and a time basis of one minute.

NOTE

Excessive encoder speed can provide wrong direction of rotation.

If an SSI absolute encoder rotates so quickly that more than half of the value range is covered within one module cycle[1], the velocity and direction of rotation can not be determined correctly anymore. This can result in an incorrect function at:

- DQ functions
- Feedback bits EVENT_OFLW, EVENT_UFLW, EVENT_ZERO, EVENT_CMP0, EVENT_CMP1 and STS_DIR

[1] Non isochronous mode: 500 µs; isochronous mode: PROFINET cycle time

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NOTE

If you are using an SSI absolute encoder whose value range does not correspond to the power of 2, the calculated speed measured value may be incorrect at the moment of the overflow.

3.2.10 Hysteresis

3.2.10.1 Hysteresis with incremental or pulse encoder

Description

Hysteresis allows you to specify a range around the comparison values within which the digital outputs are not to be switched again until the counter value has gone outside this range.

Slight movements by the encoder can result in the counter value fluctuating around a certain value. If a comparison value or a counting limit lies within this fluctuation range, the corresponding digital output is switched on and off with corresponding frequency if hysteresis is not used. Hysteresis prevents this unwanted switching, and configured hardware interrupts when a comparison event occurs.

The hysteresis becomes active when the respective comparison value is reached by a count pulse. If the counter value is set to the start value during an active hysteresis, the hysteresis becomes inactive.

Regardless of the hysteresis value, the hysteresis range ends at the low/high counting limits.

Function principle

The figure below shows an example for the hysteresis with the following configuration:

- Setting of a digital output between comparison value and high counting limit
- Comparison value = 5
- Hysteresis = 0 or 2 (gray background)

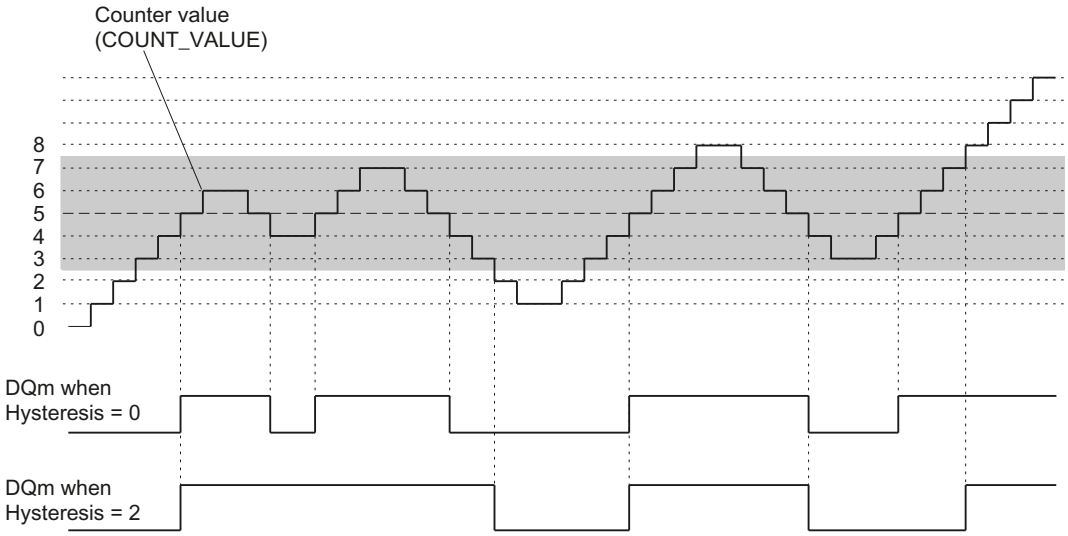

Hysteresis is enabled when the counter value 5 is reached. When the hysteresis is active, the comparison result remains unchanged. Hysteresis is disabled when the counter value 2 or 8 is reached.

The figure below shows an example for the hysteresis with the following configuration:

- Setting at comparison value for one pulse duration
- Comparison value = 5
- Comparison in both count directions
- Hysteresis = 0 or 2 (gray background)

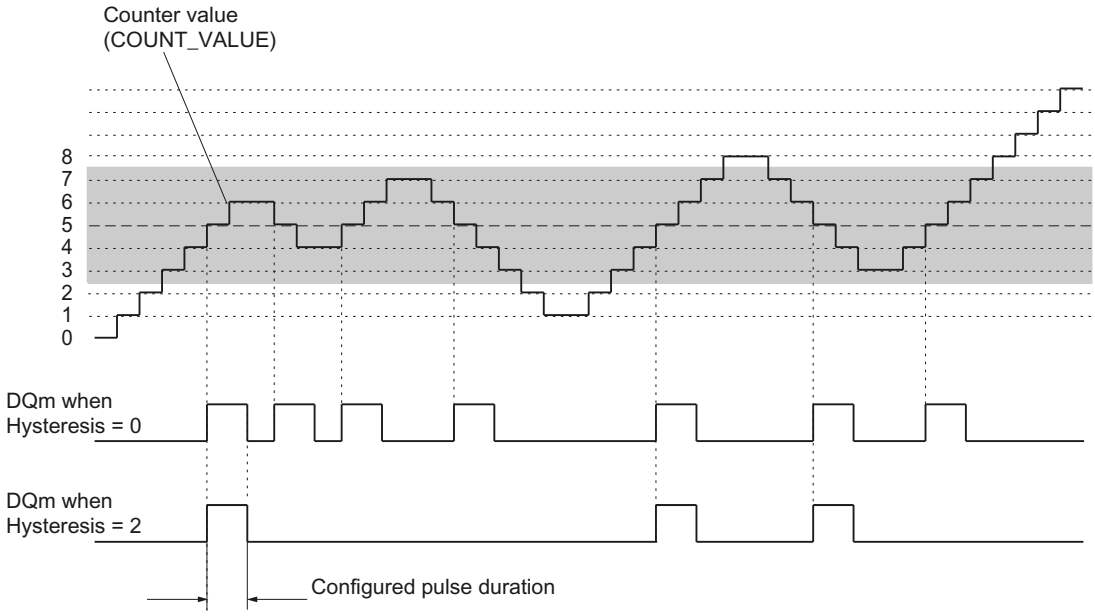

3.2.10.2 Hysteresis with SSI absolute encoder

Description

Hysteresis allows you to specify a range around the comparison values within which the digital outputs are not to be switched again until the position value has gone outside this range.

Slight movements by the encoder can result in the position value fluctuating around a certain value. If a comparison value, the minimum or maximum position value, lies within the fluctuation range, the associated digital output is switched on and off if a hysteresis is not used. Hysteresis prevents this unwanted switching, and configured hardware interrupts when a compare event occurs.

Regardless of the hysteresis value, the hysteresis range ends at the respective minimum or maximum position value.

Function principle

The figure below shows an example for the hysteresis with the following parameter assignment:

- Setting of a digital output between comparison value and high limit
- Comparison value = 10
- Hysteresis = 0 or 2 (gray background)

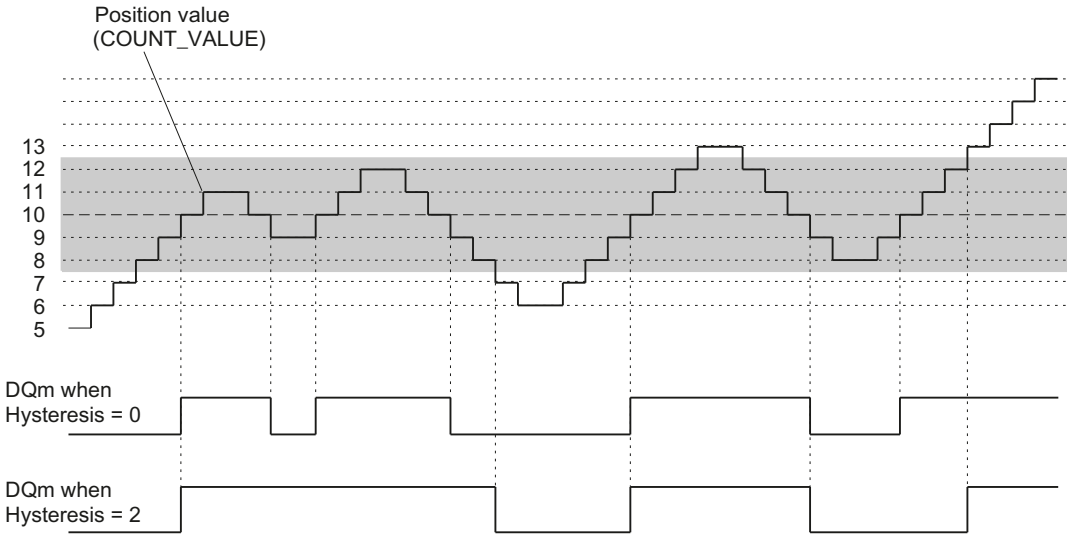

Hysteresis is enabled when the position value 10 is reached. When the hysteresis is active, the comparison result remains unchanged. Hysteresis is disabled when the position values 7 or 13 are reached.

The figure below shows an example for the hysteresis with the following parameter assignment:

- Setting at comparison value for one pulse duration
- Comparison value = 10
- Comparison in both directions of position value changes
- Hysteresis = 0 or 2 (gray background)

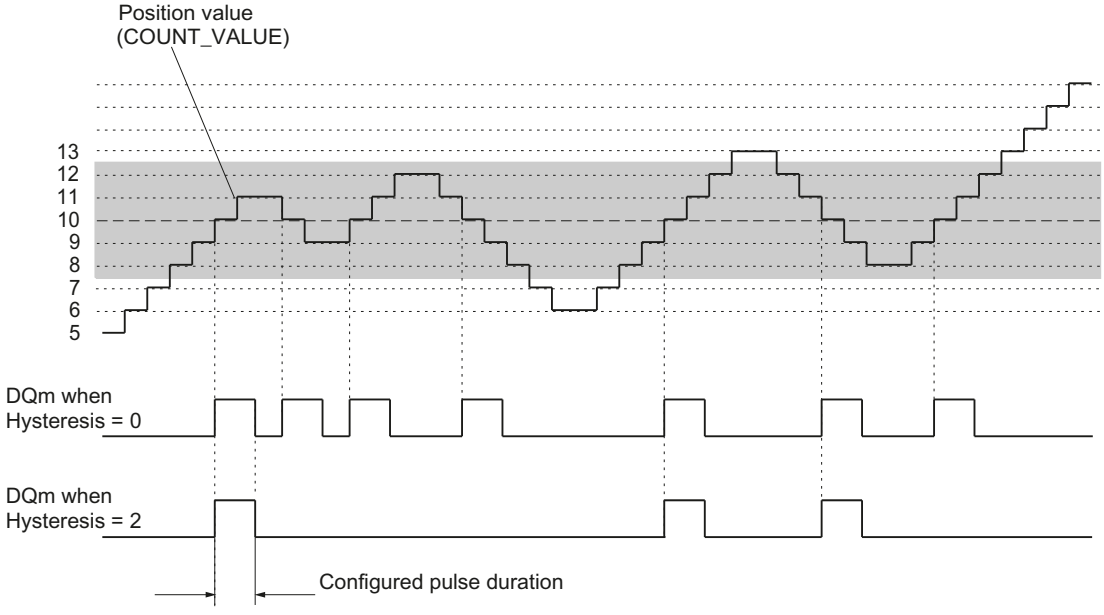

3.2.11 Interrupts

Hardware interrupt

If the technology module supports hardware interrupts, it can trigger a hardware interrupt in the CPU, for example, if a compare event occurs, in the event of overflow or underflow, in the event of a zero crossing of the counter and/or of a change of count direction (direction reversal). You can specify which events are to trigger a hardware interrupt during operation.

Diagnostic interrupt

The module can trigger diagnostic interrupts in the event of errors. You enable the diagnostic interrupts for certain errors in the device configuration. Refer to the device manual for the module to learn about the events that can trigger a diagnostic interrupt during operation.

3.2.12 Position detection for Motion Control

Description

You can use the technology module for example with an incremental encoder for the following axis technology objects of S7-1500 Motion Control for position detection :

- TO_PositioningAxis
- TO_SynchronousAxis
- TO_ExternalEncoder

When using an incremental or pulse encoder, the position detection is based on the counting function of the technology module. With an SSI absolute encoder, the absolute value is read in via a synchronous, serial interface and prepared according to the parameter assignment and made available for S7-1500 Motion Control.

The range of functions of the technology module has the following limitations in this case:

- Counter behavior not configurable
- No functions for digital inputs available apart from measuring input function
- No comparison functions for digital outputs available
- No hardware interrupts available

In the device configuration of the technology module in STEP 7 (TIA Portal), select the "Position input for technology object "Motion Control"" operating mode and use the corresponding technology object in the program. This reduces the configuration options to the parameters that are essential. For TM Count or TM PosInput, the mode automatically applies to all channels of the technology module. For a Compact CPU, the mode automatically applies to the respective channel.

In this operating mode you can use the (TO_MeasuringInput) measuring input technology object to execute a measuring input function with a hardware digital input. To do this select the measuring input type "Measuring via PROFIdrive telegram" in the measuring input technology object and the value "1" as the number of the measuring input.

You can find information about further configuring in the help for the axis technology objects and the measuring input technology object of S7-1500 Motion Control.

3.2.13 Encoder signals

3.2.13.1 24 V or TTL count signals

Count signals of 24 V or TTL incremental encoders

The 24 V incremental encoder returns the 24 V signals A, B, and N to the technology module. The A and B signals are phase-shifted by 90°. You can also connect incremental encoders without an N signal.

A 24 V incremental encoder uses the A and B signals for counting. If configured accordingly, the N signal is used for setting the counter to the start value or for saving the current counter value to the Capture value.

The figure below shows an example of the time profile of the signals of an 24 V incremental encoder:

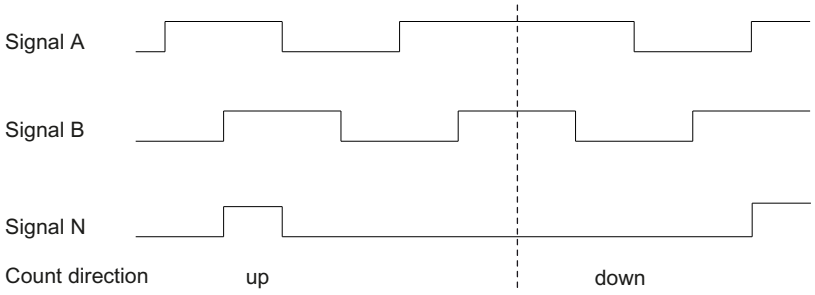

The technology module detects the count direction by evaluating the sequence of edges of the A and B signals. You can specify an inversion of the count direction.

Count signals of 24 V or TTL pulse encoders without/with direction signal

The encoder, for example an initiator (BERO) or a light barrier, returns only a count signal that is connected to terminal A of the counter.

In addition, you can connect a signal for direction detection to terminal B of the counter. In case of a high level the direction signal is counted backwards. If your encoder does not return a corresponding signal, you can specify the count direction with the user program using the control interface.

The figure below shows an example of the time profile of the signals of a 24 V pulse encoder with direction signal and the resulting count pulses:

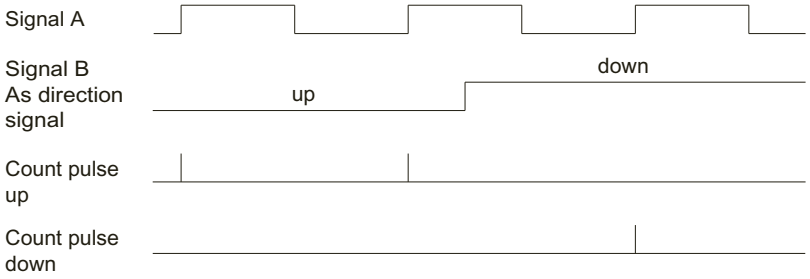

Count signals of 24 V or TTL pulse encoders with Up/Down count signal

The Up count signal is connected to terminal A. The Down count signal is connected to terminal B.

The figure below shows an example of the time profile of the signals of a pulse encoder with Up/Down count signal and the resulting count pulses:

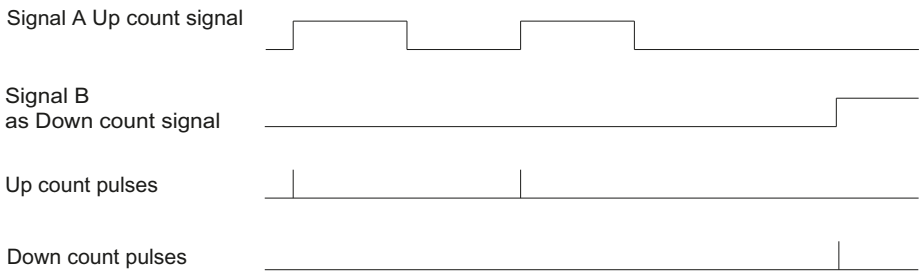

Sourcing output/sinking output for 24 V count signals (TM Count and ET 200eco PN M12-L TM PosInput 2)

You can connect the following encoders/sensors to the counter inputs:

- Sourcing output:
  The A, B, and N inputs are wired to 24VDC .
- Sinking output:
  The A, B, and N inputs are wired to ground M .
- Push-pull (sourcing and sinking output):
  The A, B, and N inputs are wired alternately to 24VDC and ground M .

Sourcing output for 24 V counter signals (Compact CPU)

You can connect the sourcing output and push-pull encoders or sensors to the counter inputs.

Monitoring of the encoder signals (TM Count and TM PosInput)

The signals of push-pull 24 V encoders are monitored for wire breaks by the technology module. TTL signals are monitored by the technology module for faulty supply voltages.

If you enable the diagnostic interrupt in the device configuration, the technology module triggers a diagnostic interrupt in the event of encoder signal errors.

3.2.13.2 RS422 count signals

RS422 incremental encoder count signals

The RS422 incremental encoder sends the following differential signals to the technology module:

- +A and -A
- +B and -B
- +N and -N

The signal information for RS422 signals is encoded in the differential voltage between A and -A, B and -B, and +N and -N. The A and B signals are phase-shifted by 90°. You can also connect incremental encoders without an N signal.

RS422 incremental encoders use the A and B signals for counting. If configured accordingly, the N signal is used for setting the counter to the start value or for saving the current counter value as the Capture value.

The figure below shows an example of the time profile of the signals of an RS422 incremental encoder:

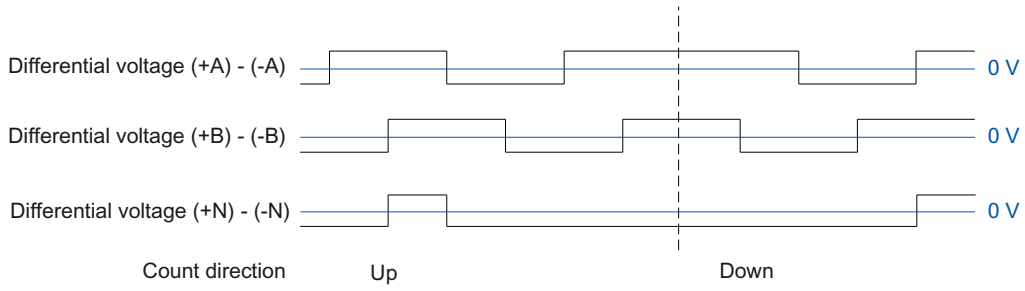

The technology module detects the count direction by evaluating the sequence of edges of the A and B signals. You can specify an inversion of the count direction.

Count signals of RS422 pulse encoders without/with direction signal

The encoder, for example a light barrier, only returns a count signal that is connected to terminal A.

You can also connect a signal for direction detection to terminal B. In case of a high level the direction signal is counted backwards. If your encoder does not return a corresponding signal, you can specify the count direction with the user program using the control interface.

The figure below shows an example of the time profile of the signals of a RS422 pulse encoder with direction signal and the resulting count pulses:

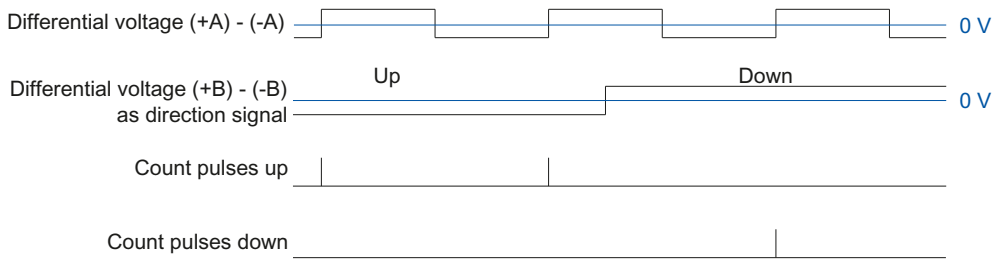

Count signals of RS422 pulse encoders with Up/Down count signal

The Up count signal is connected to the A terminals. The Down count signal is connected to the B terminals.

The figure below shows an example of the time profile of the signals of an RS422 pulse encoder with Up/Down count signal and the resulting count pulses:

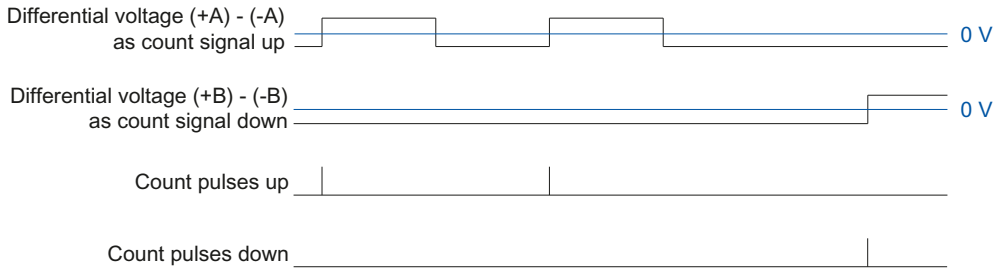

Monitoring of encoder signals

RS422 signals are monitored by the technology module for wire breaks, short-circuits, and incorrect supply voltage.

If you enable the diagnostic interrupt in the device configuration, the technology module triggers a diagnostic interrupt in the event of encoder signal errors.

3.2.13.3 SSI signals

Signals from SSI absolute encoders

The SSI absolute encoder and the module communicate by means of the SSI data signals +D and -D and the SSI clock signals +C and -C. SSI uses the RS422 signal standard. The signal information is coded in the respective differential voltage between +C and -C as well as +D and -D.

Monitoring of the encoder signals and the SSI frames

The signals of an SSI absolute encoder are monitored for wire breaks, short-circuits and incorrect supply voltage. The module also monitors the SSI frames for errors.

If you enable the diagnostic interrupts in the device configuration, the module triggers a diagnostic interrupt in the event of encoder signal or SSI frame errors.

3.2.14 Signal evaluation of incremental signals

3.2.14.1 Overview

The technology module counter counts the edges of encoder signals A and B. For incremental encoders with phase-shifted signals A and B, you can select either single or multiple evaluation to improve the resolution.

You can configure the following signal evaluations:

- Single evaluation (Page 74)
- Double evaluation (Page 75)
- Quadruple evaluation (Page 75)

NOTE

The phase offset between the edges of signals A and B is evaluated. If no phase shift is identifiable, an encoder error (invalid transition of A/B signals) is reported via the ENC_ERROR feedback bit.

3.2.14.2 Single evaluation

Single evaluation evaluates the rising and falling edge at signal A when signal B has a low level.

Count pulses in an upwards direction are generated with a rising edge at signal A during a low level at signal B. Count pulses in a downwards direction are generated with a falling edge at signal A during a low level of signal B.

The following figure shows an example for single evaluation of 24 V and TTL count signals:

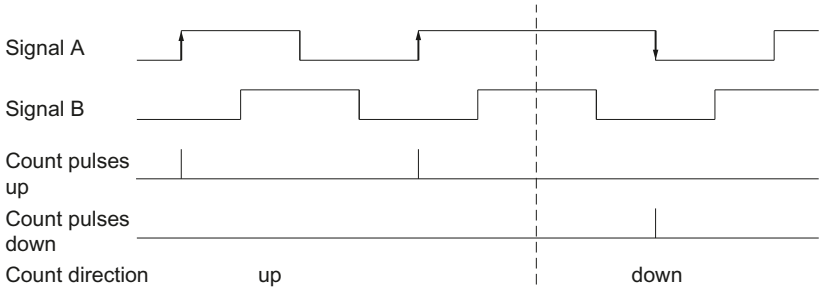

The following figure shows an example for single evaluation of RS422 count signals:

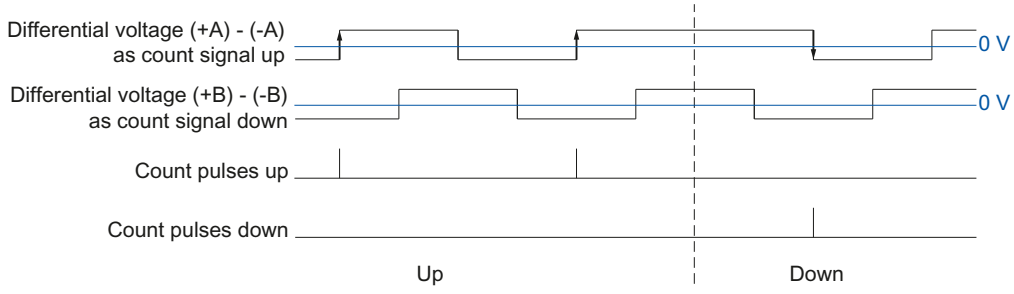

3.2.14.3 Double evaluation

With double evaluation, the rising and falling edges of signal A are evaluated.

The edge direction of signal A and the level at signal B determines whether count pulses are generated in an upward or downward direction.

The following figure shows an example for double evaluation of 24 V and TTL count signals:

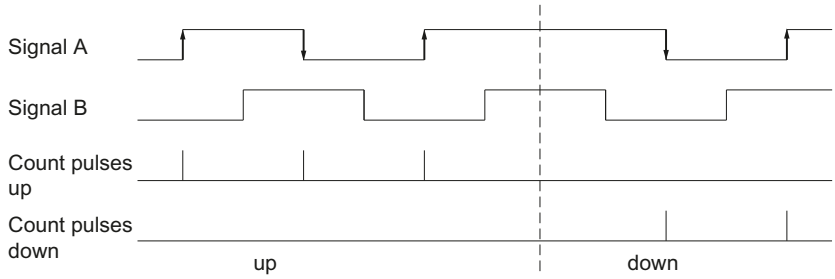

The following figure shows an example for double evaluation of RS422 count signals:

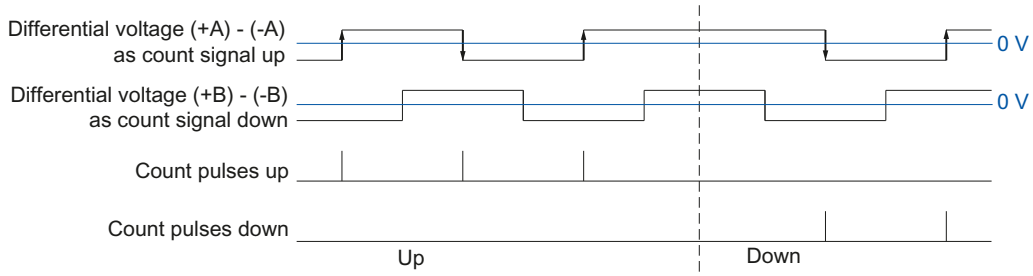

3.2.14.4 Quadruple evaluation

With quadruple evaluation, the rising and falling edges of signals A and B are evaluated.

The edge direction of one signal and the level of the other signal determines whether count pulses are generated in an upward or downward direction.

The figure below shows an example for quadruple evaluation of 24 V and TTL count signals:

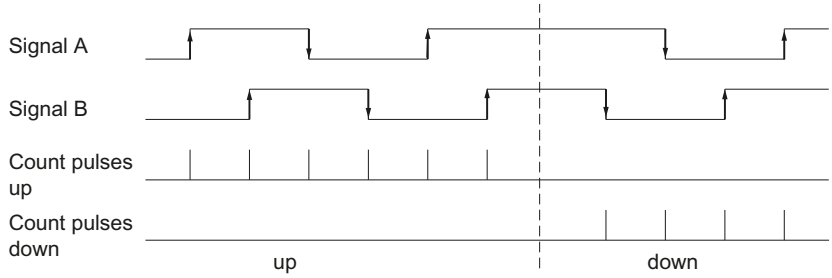

The figure below shows an example for quadruple evaluation of RS422 count signals:

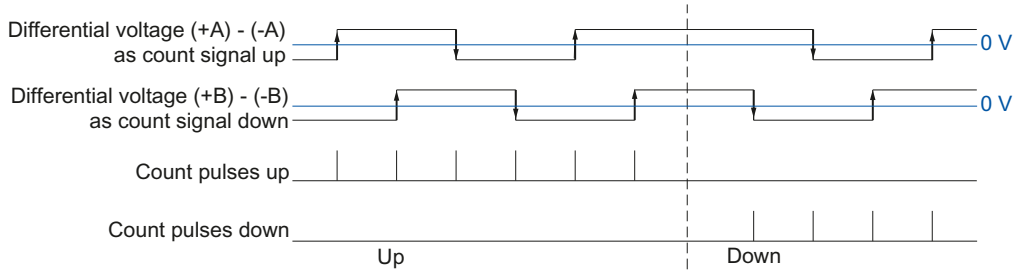

3.2.15 Clock synchronization (TM Count and TM PosInput)

The technology module supports the system function "Isochronous mode". This system function enables position, count and measured values to be recorded in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input and output data and the processing in the module are synchronized with each other. The output signals switch immediately if the relevant comparison condition is met. A change in the state of a digital input immediately affects the planned reaction of the technology module and changes the status bit of the digital input in the feedback interface.

In the case of operation with a "Counting and measurement" technology object use an OB of the type "Synchronous Cycle" (for example OB61). In the assigned OB the instruction High_Speed_Counter or SSI_Absolute_Encoder is called.

For position detection of a "Motion Control" technology object use the OB of the type "MC-Servo". When using the technology objects cam and cam track, isochronous mode is required. When using the measuring input technology object in connection with the hardware digital input DI1, no isochronous mode is required.

In case of manual operation use an OB of the "Synchronous Cycle" type (for example OB61). In the assigned OB the input and output data is processed.

Data processing

The data that was transmitted to the technology module in the current bus cycle via the control interface takes effect when it is processed in the internal technology module cycle. At the moment when the input data (T_i) are read, the position and counter value and, if appropriate, the measured value as well as status bits are detected and made available in the feedback interface for retrieval in the current bus cycle.

The update time for the measured value is synchronized in a suitable relationship to the system cycle and, if required, adapted in length. If you configure "0", the measured value is updated once per system cycle.

Isochronous mode parameter

In isochronous mode, the following parameters can have an effect on the isochronous parameters of the Sync domain.

- Filter frequency
- Frame length[1]
- Transmission rate[1]
- Monoflop time[1]
- Parity[1]

[1] Only when using an SSI absolute encoder

Because the isochronous parameters are not checked in RUN, overflows can occur when you change one or more of the named parameters in RUN: You prevent overflows by already selecting the option with the greatest time demand during the offline parameter assignment.

Additional information

For a detailed description of the isochronous mode refer to:

- The isochronous mode function manual available as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401).
- The PROFINET with STEP 7 function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

3.3 Basics of counting (TM Timer DIDQ)

3.3.1 Overview of applications

Introduction

You configure the TM Timer DIDQ and assign its parameters with the configuration software.

The module's functions are controlled and monitored via the user program with the control and feedback interface.

System environment

The respective module can be used in the following system environments with its counter functions:

Applications	Components required	Configuration software	In the user program
Central operation with an S7-1500 CPU or 151xSP CPU	• S7-1500 automation system or ET 200SP CPU • TM Timer DIDQ	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to feedback interface of the technology module in the I/O data
Distributed operation with a S7-1500 CPU	• S7-1500 Automation System • ET 200 Distributed I/O System • TM Timer DIDQ		
Distributed operation with a S7-300/400 CPU	• S7-300/400 automation system • ET 200 distributed I/O system • TM Timer DIDQ	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration STEP 7: Device configuration and parameter setting with hardware configuration (only ET 200SP)	

NOTE

A description of the control and feedback interface is available in the device manual for the TM Timer DIDQ.

3.3.2 Counting with incremental encoder

You can use a few channels of a TM Timer DIDQ for simple counting tasks with an incremental encoder. Counting refers to the recording and adding up of events. The channels configured as counters each acquire the two incremental signals and evaluate these accordingly.

Count direction

The technology module can count up and down with an incremental encoder. You can invert the counting direction to adapt it to the process.

Counting limits

The counting limits define the counter value range used.

The minimum counter value is -2147483648 (-2^{31}). The maximum counter value is 2147483647 ($2^{31}-1$). The respective counter counts continuously. At an overflow, the counter jumps to the other counting limit in each case and continues counting.

The counter value cannot be influenced by the user program.

Parameter assignment

For use of a counter for an incremental encoder, two digital inputs each of a channel group are combined. For this purpose, you choose the configuration "Incremental encoder (A, B phase-shifted)" in the channel parameters for the respective group.

NOTE

Counters of the TM Timer DIDQ 16x24V / TM Timer DIDQ 24x24V

The number of available counters of the TM Timer DIDQ 16x24V and the TM Timer DIDQ 24x24V depends on the channel configuration. In order to use 4 counters, you must choose the use of 8 inputs in the channel configuration. If you choose the use of 3 inputs, you can use 1 counter. Other channel configurations do not allow any counter use.

Counter value feedback

The current counter value is indicated in the feedback interface in the TEC_IN value (DIm). DIm corresponds to the first of the two grouped digital inputs in each case. For the second digital input, "0" is returned in the value TEC_IN (DIm+1).

3.3.3 Counting with pulse encoder

You can use a few channels of a TM Timer DIDQ for simple counting tasks with a pulse encoder. Counting refers to the recording and adding up of events. The channels configured as counters each acquire one pulse signal and evaluate this accordingly.

Count direction

The technology module can count up and down with a pulse encoder.

Counting limits

The counting limits define the counter value range used.

The minimum counter value is -2147483648 (-2^{31}). The maximum counter value is 2147483647 ($2^{31}-1$). The respective counter counts continuously. At an overflow, the counter jumps to the other counting limit in each case and continues counting.

The counter value cannot be influenced by the user program.

Parameter assignment

For use of a counter for a pulse encoder, you choose the configuration "Use inputs individually" or "Use input/output individually" in the channel parameters for the respective group. You can configure the first digital input of a group as a counter.

NOTE

Counters of the TM Timer DIDQ 16x24V

The number of available counters of the TM Timer DIDQ 16x24V is dependent on the channel configuration. In order to use 4 counters, you must choose the use of 8 inputs in the channel configuration. If you choose the use of 3 inputs, you can use 1 counter. Other channel configurations do not allow any counter use.

Counter value feedback

The current counter value is indicated in the feedback interface in the TEC_IN value (DIm). DIm corresponds to the respective digital input.

3.3.4 24 V count signals

Count signals of 24 V incremental encoders

The 24 V incremental encoder returns the 24 V signals A and B to the technology module. The A and B signals are phase-shifted by 90°.

The figure below shows an example of the time profile of the signals of an 24 V incremental encoder:

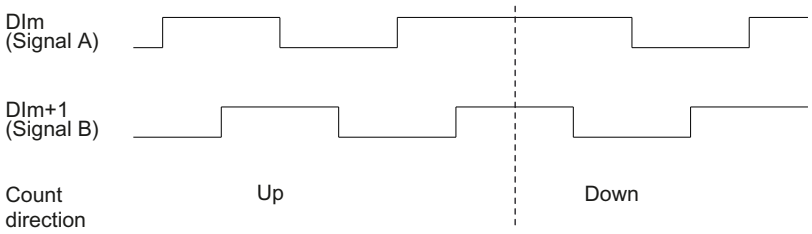

The technology module detects the count direction by evaluating the sequence of edges of the A and B signals. You can specify an inversion of the count direction.

Signal evaluation

The two phase-shifted signals of an incremental encoder are evaluated four times. With quadruple evaluation, the positive and negative edges of signal A and signal B are evaluated.

Whether count pulses are generated in an upward or downward direction depends on the edge direction of the one signal and the level of the other signal in the meantime.

The figure below shows an example of the quadruple evaluation of 24 V count signals:

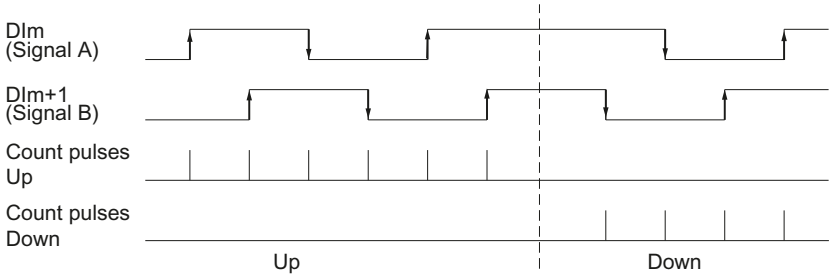

Count signals of 24 V pulse encoders

An encoder, for example, a proximity switch (BERO) or a light barrier, returns only one count signal that is connected to the digital input of a counter.

You can count the positive or the negative edges of the signal.

3.3.5 Isochronous mode

The TM Timer DIDQ supports the system function "Isochronous mode". This system function enables counter values to be acquired in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input and output data and the processing in the module are synchronized with each other.

Data processing

The data that was transmitted to the module in the current bus cycle via the control interface takes effect when it is processed in the module's internal cycle. The counter value and status bits are detected at time T_i and made available in the feedback interface for retrieval in the current bus cycle.

Additional information

You will find detailed description of the isochronous mode:

- In the Isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401) .
- In the PROFINET with STEP 7 function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

3.4 Basics of counting (digital modules)

3.4.1 Overview of applications

Introduction

You configure the digital module and assign its parameters using the configuration software.

The module's functions are controlled and monitored via the user program with the control and feedback interface.

System environment

The respective module can be used in the following system environments:

Applications	Components required	Configuration software	In the user program
Central operation with a S7-1500 CPU or ET 200SP CPU	• S7-1500 automation system or ET 200SP CPU • Digital module	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration	Direct access to the control and feedback interface of the digital module in the I/O data
Distributed operation with a S7-1500 CPU	• S7-1500 Automation System • ET 200 Distributed I/O System • Digital module		
Distributed operation with a S7-300/400 CPU	• S7-300/400 automation system • ET 200 distributed I/O system • Digital module	STEP 7 (TIA Portal): Device configuration and parameter setting with hardware configuration STEP 7: Device configuration and parameter setting with hardware configuration (ET 200SP) or GSD file (ET 200MP)	
Distributed operation in a third-party system	• Third-party automation system • ET 200 distributed I/O system • Digital module	Third-party configuration software: Device configuration and parameter settings with GSD file	

NOTE

A description of the control and feedback interface is available in the device manual for the digital module.

3.4.2 Counting with pulse encoders

Counting refers to the detection and summation of events. The modules' counters record and evaluate pulse signals. The counting direction can be specified using encoder or pulse signals or through the configuration.

You can use feedback bits to switch the digital outputs of digital output modules at defined counter values.

You can configure the characteristics of the counters using the functionalities described below.

Counter limits

The counter limits define the counter value range used. The counter limits are configurable and can be modified during runtime using the user program. See the module's device manual for the maximum and minimum configurable counter limits.

You can configure whether the counting processes are terminated or continue when a counter limit is violated (automatic gate stop).

Start value

You can configure a start value within the counter limits. The start value can be modified during runtime with the user program.

Gate control

Opening and closing the hardware gate and software gate defines the period of time during which the counting signals are recordd.

The hardware gate is controlled externally via a digital input of the digital module. The hardware gate can be enabled through parameter assignment. The software gate is controlled via the user program. A description of the control and feedback interface is available in the device manual for the digital module.

3.4.3 Behavior at the counting limits

Violation of a counting limit

The high counting limit is violated when the current counter value is equal to the high counting limit and another upward count pulse is received. The counter low limit is violated when the current counter value is equal to the counter low limit and another downward count pulse is received.

For digital modules of ET 200SP and ET 200AL, the corresponding event bit is set in the feedback interface when the limit is exceeded. You can reset an event bit with the respective control bit:

Counting limit violated	Event bit	Reset bit
High counting limit	EVENT_OFLW	RES_EVENT_OFLW
Low counting limit	EVENT_UFLW	RES_EVENT_UFLW

NOTE

A description of the control and feedback interface is available in the device manual for the digital module.

You can configure whether or not you want to continue counting to another counter limit after a counting limit violation.

NOTE

The high counting limit and the start value define the value range of the counter:

Value range of the counter = (high limit – start value) + 1

Examples

The figure below shows an example for terminating counting after overflow and setting the counter to the opposite counting limit:

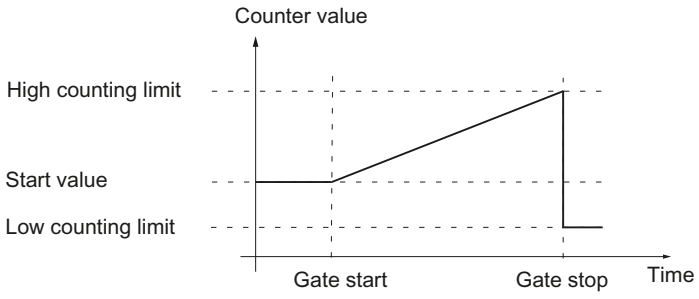

The figure below shows an example for continuing the counting process after an overflow and setting the counter to the opposite counting limit:

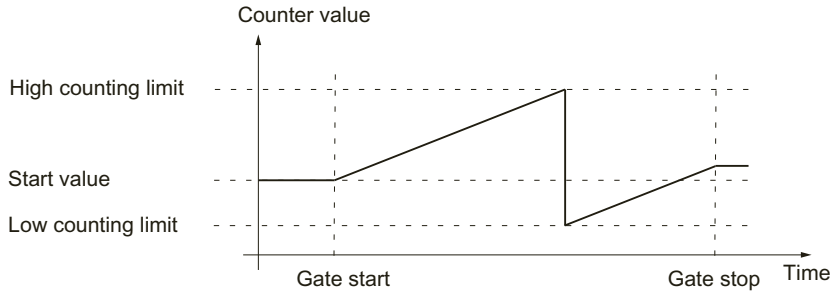

3.4.4 Gate control

Many applications require counting processes to be started or stopped in accordance with other events. In such cases, counting is started and stopped using the gate function.

The digital modules have two gates for each counting channel. These define the resulting internal gate:

- Software gate
- Hardware gate

NOTE

The hardware gate is not available for all digital modules.

3.4.4.1 Software gate

The software gate of the channel is opened and closed with the SW_GATEcontrol bit.

NOTE

A description of the control and feedback interface is available in the device manual for the digital module.

3.4.4.2 Hardware gate

The hardware gate is optional. You open and close the hardware gate using signals at the corresponding digital input.

NOTE

A configurable input delay delays the control signal of the digital input.

The status of a DIm digital input is indicated by the respective STS_DIm feedback bit. A description of the control and feedback interface is available in the device manual for the digital module.

Opening and closing the hardware gate

The figure below shows an example of opening and closing with a digital input:

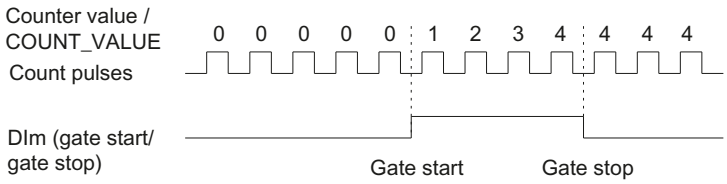

As long as the digital input is set, the hardware gate is open and the count pulses are counted. The hardware gate is closed when the digital input is reset. The counter value stays constant and ignores any further count pulses.

3.4.4.3 Internal gate

Internal gate

The internal gate is open if the software gate is open and the hardware gate is open or has not been configured. The status of the internal gate is indicated by the STS_GATE feedback bit. A description of the control and feedback interface is available in the device manual for the digital module.

If the internal gate is open, counting is started. If the internal gate is closed, all other count pulses are ignored and counting is stopped.

If you want to control a counting process with the hardware gate only, the software gate must be open. If you do not configure a hardware gate, the hardware gate is considered to be always open. In this case, you open and close the internal gate with the software gate only.

Hardware gate	Software gate	Internal gate
Open/not configured	open	open
Open/not configured	closed	closed
closed	open	closed
closed	closed	closed

The internal gate can also be automatically closed upon violation of a counting limit. The software or hardware gate must then be closed and reopened to continue counting.

3.4.4.4 Counting once with hardware gate

One-time counting with hardware gate

The following section describes the one-time counting with hardware gate (HW_Gate).

The counting process stops when the high counting limit is violated. The count value jumps to the lower count limit (= 0).

When counting with hardware gate, the software gate (SW_Gate) and the hardware gate must be set (AND operation). When counting once, the software gate must be set and is controlled with the hardware gate, i.e. when the limit is reached, the counter stops and only when the hardware gate is reset and set again does the counter restart.

If the "SW_Gate" control bit or the hardware gate is reset before the high counting limit is reached, the counter stops.

The following picture shows an example of the principle for counting with hardware gate.

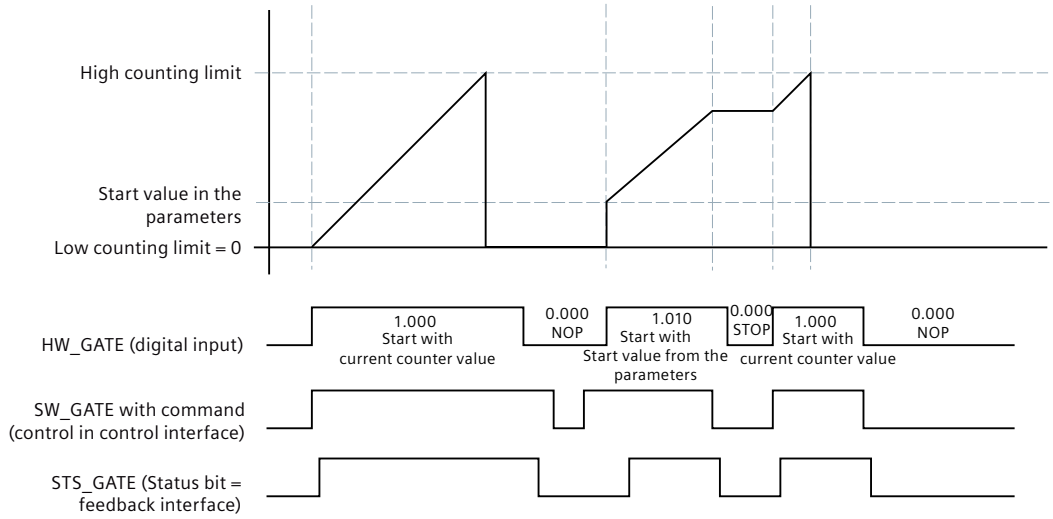

Figure 3-875 Principle: Counting with hardware gate

3.4.5 Comparison values

Depending on the module, you can define up to two comparison values that control a feedback bit for the channel, independent of the user program.

When there are two comparison values, comparison value 1 must be greater than comparison value 0. The comparison values are configurable and can be modified during runtime using the user program.

The comparison values are compared with the current counter value. If the counter value meets the configured comparison condition, the respective STS_DQ feedback bit is set.

You can use the respective feedback bit in order to switch a digital output module's digital output. You can make setting the respective STS_DQ feedback bit dependent on one of the following comparison events. See the device manual for the digital module to find out which comparison events can be configured.

Setting between comparison value and high counter limit

The respective STS_DQ feedback bit is set to 1 when:

Comparison value <= counter value <= high counter limit

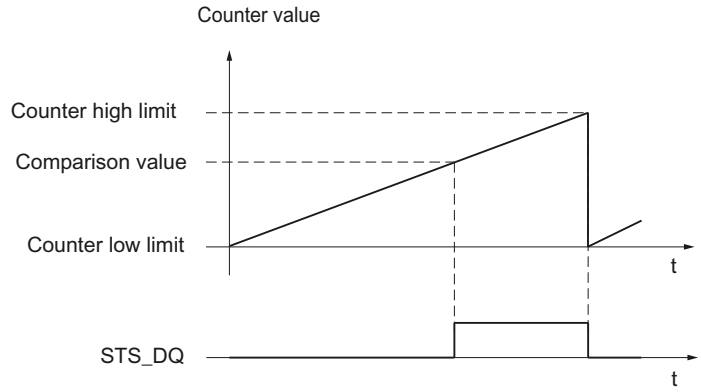

Setting between comparison value and low counter limit

The respective STS_DQ feedback bit is set to 1 when:

Low counter limit <= counter value <= comparison value

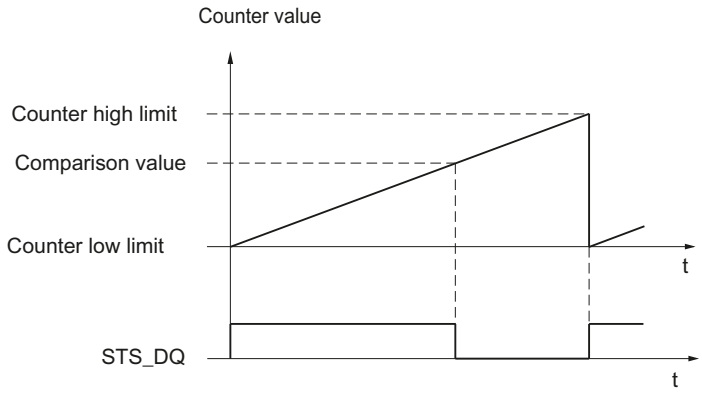

Setting between comparison value 0 and comparison value 1

The respective STS_DQ feedback bit is set to 1 when:

Comparison value 0 <= counter value <= comparison value 1

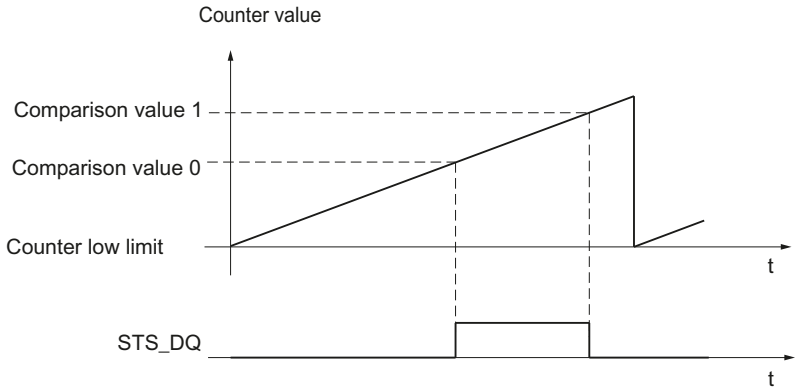

Not setting between comparison value 0 and comparison value 1

The respective STS_DQ feedback bit is set to 1 when:

Comparison value 0 <= counter value <= comparison value 1

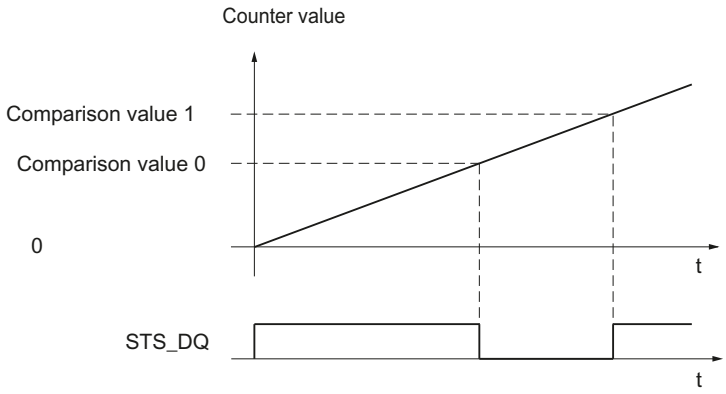

3.4.6 Interrupts

Hardware interrupt

The modules can trigger a hardware interrupt in the CPU for certain events during operation. Process interrupts are enabled via the parameter assignment. Refer to the device manual for the module for information about the events that can trigger a hardware interrupt during operation.

NOTE

Hardware interrupts for counting are not available at all the modules.

3.4.7 24 V count signals

24 V pulse encoder count signals

An encoder, for example an initiator (BERO) or a light barrier, returns a count signal that is connected to the terminal of a counter. For some modules you change the count direction via the parameter assignment of the DI function.

The figure below shows an example of the time profile of the signals of a 24 V pulse encoder with direction signal and the resulting count pulses:

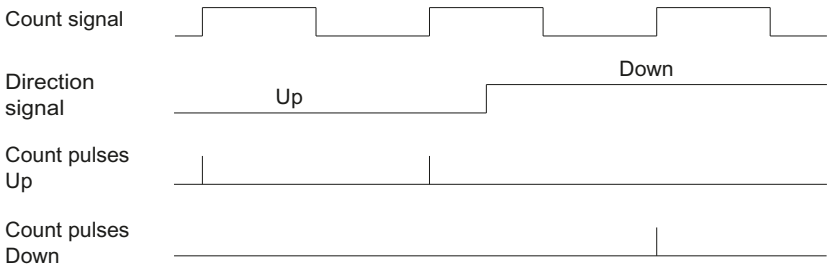

NOTE

A signal for direction detection is not connectable for all digital modules.

3.4.8 Isochronous mode

The digital module supports the system function "Isochronous mode". This system function enables counter values to be acquired in a defined system cycle.

In isochronous mode, the cycle of the user program, the transmission of the input and output data and the processing in the module are synchronized with each other.

Data processing

The data that was transmitted to the module in the current bus cycle via the control interface takes effect when it is processed in the module's internal cycle. The counter value and status bits are detected at time T_i and made available in the feedback interface for retrieval in the current bus cycle.

Additional information

You will find detailed description of the isochronous mode:

- In the Isochronous mode function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109755401) .
- In the PROFINET with STEP 7 function manual as a download from the Internet (https://support.industry.siemens.com/cs/ww/en/view/49948856).

3.4.9 Counting once with direction setting via digital input

Counting once with direction setting via digital input

The following section describes the direction setting via a digital input.

The "Digital input" count direction is set via the parameters. This means that the count direction is specified via the "Partner digital input".

Count direction:

- "0" up
- "1" down

The start command determines the behavior when starting the counter:

- The counting process starts with the current count value.
- The counting process starts with the start value that was specified via parameter/command interface.

The following figure shows an example of the principle for counting with direction setting via a digital input.

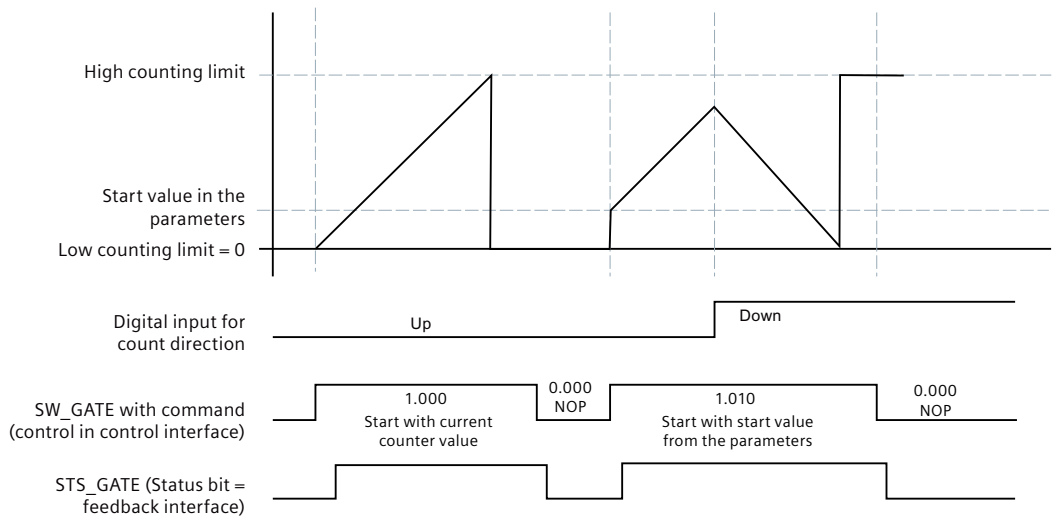

Figure 3-876 Principle: Counting with direction specification

3.5 Basics of counting (SIMATIC Drive Controller)

3.5.1 Overview of applications

Introduction

You configure the X142 technology I/Os of the SIMATIC Drive Controller and assign its parameters with the STEP 7 configuration software. The event counter and the period duration measurement are evaluated via the feedback interface of the X142 technology I/Os in the IO data.

NOTE

A description of the control and feedback interface is available in the SIMATIC Drive Controller system manual (https://support.industry.siemens.com/cs/ww/en/view/109766665).

System environment

The SIMATIC Drive Controllers can be used in the following system environment:

Application scenarios	Components required	Configuration software	In the user program
Drive-based automation solution with SIMATIC Drive Controller	• SIMATIC Drive Controller[1] • SINAMICS S120 drive components (power units, ...)	STEP 7[1] and SINAMICS S120 Startdrive (TIA Portal): Device configuration and parameter setting (Page 232)	Direct access to control and feedback interface of the X142 technology I/Os

[1] Required for X142 technology I/Os

3.5.2 Event counter

You can use up to 8 channels of the X142 technology I/Os for counting tasks.

With the event counter (16-bit value), you measure the number of positive edges per application cycle via the feedback interface.

The event counter is a circumferential counter.

- An overflow of the event counter is not displayed.
- The exact value must be calculated from the difference.

Count direction

Counting always takes place in the forward direction.

3.5.3 Period duration measurement

You can use up to 8 channels of the X142 technology I/Os for period duration measurement.

With period duration measurement (32-bit value), you measure the number of increments of 41.67 ns between the last two incoming positive edges in the application cycle via the feedback interface.

Period duration = 41.67 ns x number of increments

3.5.4 Isochronous mode

The event/period duration measurement requires isochronous operation.

You can find more information in the SIMATIC Drive Controller system manual (https://support.industry.siemens.com/cs/ww/en/view/109766665).

Using the High_Speed_Counter technology object 4

4.1 Convention

Technology module: We use the term "technology module" in this documentation both for the technology modules TM Count and TM PosInput and the technology component of the compact CPUs.

4.2 High_Speed_Counter technology object

STEP 7 (TIA Portal) supports you in the configuration, commissioning and diagnostics of counting and measuring functions for the following technology modules with the "Technology objects" function:

- You configure the High_Speed_Counter technology object in STEP 7 (TIA Portal) with the settings for the counting and measuring functions.
- The corresponding High_Speed_Counter instruction is programmed in the user program. This instruction supplies the control and feedback interface of the technology module.

The High_Speed_Counter technology object corresponds to the instance DB of the High_Speed_Counter instruction. The configuration of the counting and measuring functions is saved in the technology object. The technology object is located in the folder "PLC > Technology objects".

The High_Speed_Counter technology object can be used equally for technology modules of the S7-1500, ET 200SP and ET 200eco PN M12-L systems.

Operating mode

In order to assign the technology module parameters using the technology object, you specify the operating mode (Page 166) "Operating with "Counting and measurement" technology object" in the hardware configuration of the technology module. This selection is already preset.

4.3 Overview of the configuration steps

Introduction

The overview below shows the basic procedure for configuring the counting and measuring functions of the technology module with the High_Speed_Counter technology object.

Requirement (TM Count and TM PosInput)

Before you can use the High_Speed_Counter technology object, a project with an S7-1500 CPU or an ET 200SP CPU must be created in STEP 7 (TIA Portal) .

Requirement (Compact CPU)

Before you can use the High_Speed_Counter technology object, a project with a Compact CPU S7-1500 must be created in STEP 7 (TIA Portal).

Procedure

Proceed in the recommended sequence outlined below:

Step	Description
1	Configure a technology module (Page 160)
2	Add technology object (Page 95)
3	Configure a technology object according to your application (Page 97)
4	Call instruction in the user program (Page 118)
5	Load to CPU
6	Commissioning the technology object (Page 129)
7	Diagnostics of the technology object (Page 130)

4.4 Add technology object

Adding a technology object in the project navigation

When a technology object is added, an instance DB is created for the instruction of this technology object. The configuration of the technology object is stored in this instance DB.

Requirement (TM Count and TM PosInput)

A project with a CPU S7-1500 has been created.

Requirement (Compact CPU)

A project with a Compact CPU S7-1500 has been created.

Procedure

To add a technology object, proceed as follows:

1. Open the CPU folder in the project tree.
2. Open the "Technology objects" folder.
3. Double-click on "Add new object".
   The "Add new object" dialog opens.
4. Select the technology "Counting, measurement, cams".
5. Select the "High_Speed_Counter" object.
6. Enter an individual name for the technology object in the "Name" text box.
7. Click "Additional information" if you want to add your own information to the technology object.
8. Confirm with "OK".

Result

The new technology object has now been created and stored in the project tree in the "Technology objects" folder.

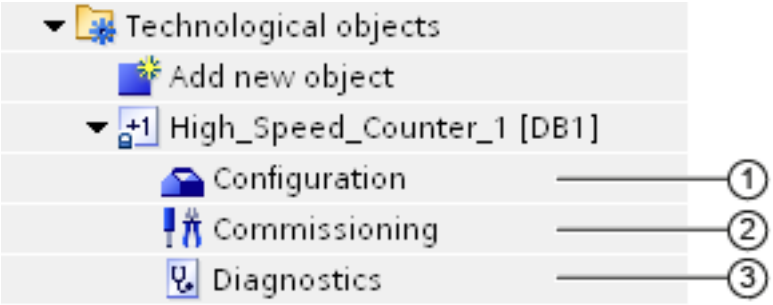

	Object	Description
1	Configuration (Page 97)	In the configuration dialog: • Assignment of technology module and channel • Technology object parameter settings for counting and measurement functions When you change the configuration of the technology object, you must download the technology object **and** the hardware configuration to the CPU.
2	Commissioning (Page 129)	Commissioning and function test of the technology object: Simulating parameters of the High_Speed_Counter instruction and monitoring the effects
3	Diagnostics (Page 130)	Monitoring the counting and measuring functions

4.5 Configuring the High_Speed_Counter

4.5.1 Working with the configuration dialog

You configure the properties of the technology object in the configuration window. Proceed as follows to open the configuration window of the technology object:

1. Open the "Technology objects" folder in the project tree.
2. Open the technology object in the project tree.
3. Double-click on the "Configuration" object.

The configuration is divided into the following categories:

- **Basic parameters**

  The basic parameters include the selection of the technology module and the number of the counting channel for which the technology object is configured.

- **Extended parameters**

  The extended parameters include the parameters for adapting the counting and measuring functions and for setting the characteristics of the digital inputs and digital outputs.

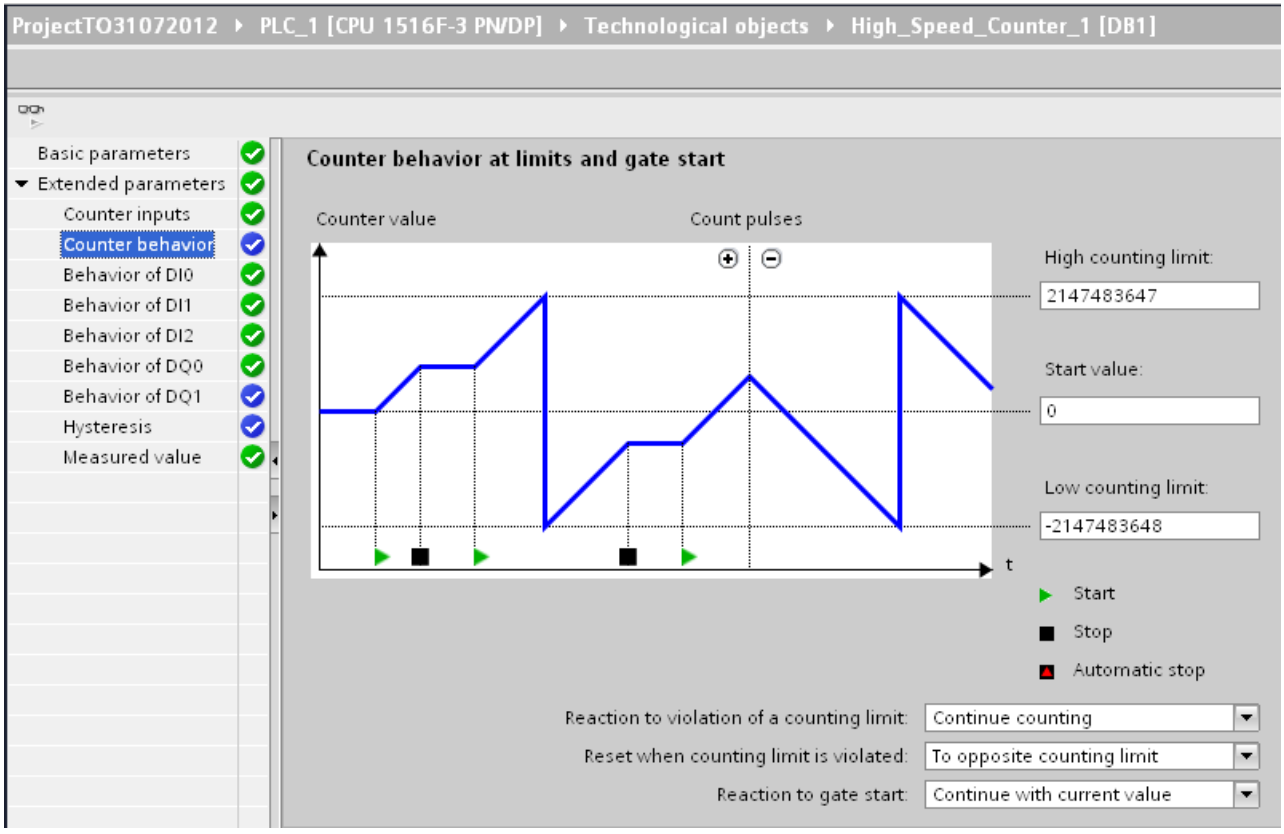

Configuration window icons

Icons in the area navigation of the configuration show additional details about the status of the configuration:

	The configuration contains default values and is complete. The configuration contains only default values. With these default values, you can use the technology object without additional changes.
	The configuration contains values set by the user or automatically adapted values and is complete All text boxes of the configuration contain valid values and at least one default value was changed.
	The configuration is incomplete or incorrect At least one text box or drop-down list contains an invalid value. The corresponding field or the drop-down list is displayed on a red background. Click the roll-out error message to indicate the cause of error.

4.5.2 Basic parameters

You can establish the connection between the High_Speed_Counter technology object and the technology module under "Basic parameters".

Module (TM Count and TM PosInput)

You select the technology module in a subsequent dialog box. All technology modules (central or distributed) that are configured for use with a "Counting and measurement" technology object under the S7-1500 CPU or ET 200SP CPU are available for selection.

After selecting the technology module, you can open the device configuration associated with the technology module by clicking the"Device configuration" button.

The technology module parameter settings required for the use of the technology object are made in the "Extended parameters" of the technology object.

Module (Compact CPU)

You can select a high-speed counter for the Compact CPU in a subsequent dialog. You can choose any of the high-speed counters which are enabled and configured for use with a technology object from "Counting and measuring".

After selecting the high-speed counter, you can open the device configuration associated with the Compact CPU by clicking the"Device configuration" button.

The parameter settings of the high-speed counter required for the use of the technology object are made in the "Extended parameters" of the technology object.

Channel

For a technology module with several counting channels, you can also select the number of the counting channel for which the High_Speed_Counter technology object is to be valid.

NOTE

A channel can be assigned to only *one* technology object. A channel that is already assigned to a technology object can no longer be selected.

Synchronization of the parameter values

If, after assignment of the channel to the technology object, there is an inconsistency between the parameter values in the property dialog of the module and in the technology object, a button with a corresponding inquiry appears. When you click the button, the parameter values in the property dialog are overwritten by the parameter values in the property dialog within STEP 7 (TIA Portal). The current parameter values of the technology object are displayed in the property dialog (read-only).

NOTE

If you change parameter values of the technology object, the corresponding parameter values are also overwritten without prompt in the properties dialog of the hardware configuration. As after every change in hardware configuration, the next time the project is loaded in the CPU, a prompt appears asking whether the CPU should go to STOP mode.

4.5.3 Counter inputs (High_Speed_Counter)

Signal type

You can choose from the following signal types (Page 70):

Symbol	Signal type	Meaning	Additional option-specific parameters
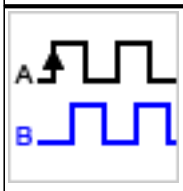	Incremental encoder (A, B phase-shifted)	An incremental encoder with phase-shifted A and B signals is connected.	• Signal evaluation • Invert direction • Filter frequency • Sensor type or Interface standard
	Incremental encoder (A, B, N)	An incremental encoder with phase-shifted signals A and B and a zero signal N is connected.	• Signal evaluation • Invert direction • Filter frequency • Sensor type or Interface standard • Reaction to signal N • Frequency of synchronization • Frequency of the Capture function
	Pulse (A) and direction (B)	A pulse encoder (signal A) with direction signal (signal B) is connected.	• Filter frequency • Sensor type or Interface standard
	Pulse (A)	A pulse encoder (signal A) without direction signal is connected. You can specify the counting direction by means of the control interface (Page 218).	• Filter frequency • Sensor type or Interface standard
	Count up (A), count down (B)	Signals for counting up (signal A) and down (signal B) are connected.	• Filter frequency • Sensor type or Interface standard

Invert direction

You can invert the counting direction to adapt it to the process.

The inverting of the direction can be configured and active for the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Signal evaluation

By configuring signal evaluation (Page 74), you can specify which edges of the signals are counted.

You can select from the following options:

Symbol	Signal evaluation	Meaning
	Single (Page 74) (default)	The edges of signal A are evaluated during a low level of signal B.
	Double (Page 75)	Each edge of signal A is evaluated.
	Quadruple (Page 75)	Each edge of signals A and B is evaluated.

The parameter can be assigned with the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Filter frequency

By configuring the filter frequency, you suppress interferences at the counter inputs A, B and N.

The selected filter frequency is based on a pulse/break ratio of between around 40:60 and around 60:40. This results in a specific minimum pulse/break time. Signal changes with a duration shorter than the minimum pulse/break time are suppressed.

You can select from the following filter frequencies:

Filter frequency	Minimum pulse/break time
100 Hz	4.0 ms
200 Hz	2.0 ms
500 Hz	800 µs
1 kHz	400 µs
2 kHz	200 µs
5 kHz	80 µs
10 kHz	40 µs
20 kHz	20 µs
50 kHz	8.0 µs
100 kHz (default for Compact CPU)	4.0 µs
200 kHz[2] (default for TM Count and ET 200eco PN TM PosInput 2)	2.0 µs
500 kHz[1]	0.8 µs
1 MHz[1] (default for TM PosInput)	0.4 µs

[1] Only available with TM PosInput

2 Not available with Compact CPU

Sensor type (TM Count)

By configuring the sensor type, you specify how the counter inputs are switched for the TM Count.

You can select from the following options:

Sensor type	Meaning
Sourcing output (default)	The encoder/sensor switches the inputs A, B and N to 24VDC.
Sinking output	The encoder/sensor switches the inputs A, B and N to M.
Push-pull (sinking and sourcing output)	The encoder/sensor alternately switches the inputs A, B and N to M and 24VDC.

"Push-pull" is usually selected when incremental encoders are used. If using 2-wire sensors, such as light barriers or proximity switches, you need to select the corresponding wiring "Sourcing output" or "Sinking output".

The data sheet of the encoder includes information on whether your incremental encoder is a push-pull encoder.

NOTE

If you use a push-pull encoder and the sensor type "Push-pull (sinking and sourcing output)" is configured, you can monitor the encoder signals for wire break.

Sensor type (Compact CPU)

The "Sourcing output" sensor type is set for the Compact CPU and cannot be changed. The encoder or sensor switches the inputs A, B and N to 24V DC.

You can operate both sourcing output encoders and push-pull encoders on the Compact CPU. You can find additional information on the sensor type in the data sheet for the encoder.

Sensor type (ET 200eco PN TM PosInput 2)

By configuring the sensor type, you specify how the counter inputs are switched for the ET 200eco PN TM PosInput 2.

You can select from the following options:

Sensor type	Meaning
Sourcing output (default)	The encoder or sensor switches the inputs A, B and N to 1U $_{Sx}$.
Sinking output	The encoder or sensor switches the inputs A, B and N to 1M.
Push-pull (sinking and sourcing output)	The encoder or sensor switches the inputs A, B and N alternately to 1M and 1U_{Sx}.

"Push-pull" is usually selected when incremental encoders are used. If using 2-wire sensors, such as light barriers or proximity switches, you need to select the corresponding wiring "Sourcing output" or "Sinking output".

The data sheet of the encoder includes information on whether your incremental encoder is a push-pull encoder.

This parameter can only be configured if you have selected "24 V, asymmetrical" as the interface standard.

NOTE

If you use a push-pull encoder and the sensor type "Push-pull (sinking and sourcing output)" is configured, you can monitor the encoder signals for wire break.

Interface standard (TM PosInput)

You use this parameter to specify whether the encoder outputs symmetric (RS422) or asymmetric (TTL) signals for the TM PosInput.

You can select from the following options:

Interface standard	Meaning
RS422, symmetrical (default)	The encoder outputs symmetric signals according to the RS422 standard (Page 72).
TTL (5 V), asymmetrical	The encoder outputs asymmetric 5 V signals according to the TTL standard (Page 70).

NOTE

The RS422 standard provides greater interference immunity than the TTL standard. If your incremental or pulse encoder supports the RS422 standard **and** the TTL standard, we recommend using the RS422 standard.

Interface standard (ET 200eco PN M12-L TM PosInput 2)

You use this parameter to specify whether the encoder outputs symmetrical (RS422) or asymmetrical (24 V) signals for the ET 200eco PN M12-L TM PosInput 2.

You can select from the following options:

Interface standard	Meaning
RS422, symmetrical (default)	The encoder outputs symmetric signals according to the RS422 standard (Page 72).
24 V, asymmetrical	The encoder outputs asymmetric 24 V signals according to the TTL standard (Page 70).

Reaction to signal N

You use this parameter to specify which reaction is triggered to signal N.

You can select from the following options:

Option	Meaning
No reaction to signal N (default)	The counter is not affected by signal N.
Synchronization at signal N (Page 46)	The counter is set to the start value at signal N. If you select the function "Enable synchronization at signal N" for a digital input, the synchronization depends on the level at the digital input.
Capture at signal N (Page 37)	The counter value is stored in the Capture value at signal N. The use of a digital input and the use of the N signal are not mutually exclusive for the Capture function. The technology object displays the Capture value at the output parameter CapturedValue.

NOTE

You can only select the reaction to signal N if you have selected the "Incremental encoder (A, B, N)" signal type.

NOTE

If "Synchronization at signal N" is selected, you can select the function "Enable synchronization at signal N" for a digital input (Page 107).

NOTE

For High_Speed_Counter as of V3.0, the following applies:

You can choose "Capture at signal N" only in operating mode "Use count value as reference":

Frequency of synchronization

This parameter is used to define the frequency of the following events:

- Synchronization at signal N
- Synchronization as a function of a digital input

You can select from the following options:

Option	Meaning
Once (default)	The counter is only set at the first signal N or the first configured edge of the digital input.
Periodic	The counter is set at each signal N or each configured edge of the digital input.

Frequency of the Capture function

This parameter is used to define the frequency of Capture events for the following functions:

- Capture at Signal N
- Capture as function of a digital input

You can select from the following options:

Option	Meaning
Once	The first configured edge at the respective digital input or first rising edge of the N signal saves the current counter value as a Capture value.
Periodic (default)	Each configured edge at the respective digital input or each rising edge of the N signal saves the current counter value as a Capture value.

NOTE

This parameter is available for High_Speed_Counter as of V3.2.

4.5.4 Counter behavior

4.5.4.1 Counting limits and start value

High counting limit

You limit the counting range by setting the high counting limit. You can enter a value up to 2147483647 (2^{31}-1). You must enter a value that lies above the low counting limit.

The default setting is "2147483647".

Low counting limit

You limit the counting range by setting the low counting limit. You can enter a value up to -2147483648 (-2^{31}). You must enter a value below the high counting limit.

The default setting is "-2147483648".

Start value

By configuring the start value, you specify the value at which counting is to start and where it is to continue in the case of defined events. You must enter a value between the counting limits or equal to the counting limits.

The default setting is "0".

Additional information

For more information, see Behavior at the counting limits (Page 33) and Counter behavior at gate start (Page 36).

4.5.4.2 Counter behavior at limits and gate start

Reaction to violation of a counting limit

You can configure the following characteristics for violation of a counting limit (Page 33):

Reaction	Meaning
Stop counting	If a counting limit is violated, counting is stopped and the internal gate is closed. To restart counting, you must also close and reopen the software/hardware gate.
Continue counting (default)	Counting continues either with the start value or at the opposite counting limit, depending on the additional parameter assignment.

Reset when counting limit is violated

You can reset the counter to the following values when a counting limit is violated:

Reset the value	Meaning
To start value	The counter value is set to the start value.
To opposite counting limit (default)	The counter value is set to the opposite counting limit.

Reaction to gate start

You can set the following Reaction to gate start (Page 36):

Reaction	Meaning
Set to start value	When the gate is opened, the counter value is set to the start value.
Continue with current value (default)	When the gate is opened, counting is continued with the last counter value.

4.5.5 Behavior of a DI (High_Speed_Counter)

Setting function of the DI

By configuring a digital input, you specify which functions the digital input triggers at switching.

You can select from the following options:

Function of a digital input	Meaning	Additional option-specific parameters
Gate start/stop (level-triggered)	The level at the respective digital input opens and closes the hardware gate (Page 35).	• Input delay • Select level
Gate start (edge-triggered)	The configured edge at the respective digital input opens the hardware gate (Page 35).	• Input delay • Edge selection
Gate stop (edge-triggered)	The configured edge at the respective digital input closes the hardware gate (Page 35).	• Input delay • Edge selection
Synchronization (Page 41)	The configured edge at the respective digital input sets the counter to the start value. The technology object indicates whether a synchronization has occurred at the output parameter SyncStatus.	• Input delay • Edge selection • Frequency of synchronization
Enable synchronization at signal N	The active level at the respective digital input enables synchronization of the counter at signal N (Page 46).	• Input delay • Select level
Capture	The configured edge at the respective digital input saves the current counter value (Page 37) as a Capture value. The use of a digital input and the use of the N signal are not mutually exclusive for the Capture function. The technology object displays the Capture value at the output parameter CapturedValue.	• Input delay • Edge selection • Frequency of the Capture function • Behavior of counter value after Capture
Digital input without function	No technological function is assigned to the respective digital input. You can read the signal state of the digital input via the respective static variable of the technology object (number of digital inputs depends on the module): • UserStatusFlags.StatusDI0 • UserStatusFlags.StatusDI1 • UserStatusFlags.StatusDI2	• Input delay

NOTE

With the exception of "Digital input without function", each function can only be used once for each counter, and if used for one digital input is not available to the others.

NOTE

For High_Speed_Counter as of V3.0, the following applies:

You can choose the "Capture" function only in operating mode "Use count value as reference".

Input delay (TM Count and TM PosInput)

You use this parameter to suppress signal interference at the digital inputs. Changes to the signal are only detected if they remain stable for longer than the configured input delay time.

You can select from the following input delays:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

NOTE

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

NOTE

You configure the input delay under "Behavior of DI0" for all digital inputs together. The input delay is also displayed under "Behavior of DI1" and for TM Count also under "Behavior of DI2".

Input delay (Compact CPU)

You use this parameter to suppress interference at the digital inputs of the DIn signals. Changes to the signal are only detected if they remain stable for longer than the configured input delay time.

You can configure the input delay for a digital input of a Compact CPU in the Inspector window of the device configuration under "Properties > DI 16/DQ 16 > Inputs > Channel n".

You can select from the following input delays:

- None
- 0.05 ms
- 0.1 ms
- 0.4 ms
- 1.6 ms
- 3.2 ms (default)
- 12.8 ms
- 20 ms

NOTE

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

Select level

You use this parameter to specify the level at which the digital input is active.

You can select from the following options:

Level	Meaning
Active with high level (default)	The respective digital input is active when it is set.
Active with low level	The respective digital input is active when it is not set.

The parameter can be set for the following functions of a digital input:

- Gate start/stop (level-triggered)
- Enable synchronization at signal N

Edge selection

You can use this parameter to specify the edge of the digital input at which the configured function is triggered.

The following options may be available depending on the function selected:

- At rising edge (default)
- At falling edge
- At rising and falling edge

The parameter can be set for the following functions of a digital input:

- Gate start (edge-triggered)
- Gate stop (edge-triggered)
- Synchronization
- Capture

NOTE

"At rising and falling edge" can only be configured for the "Capture" function.

Frequency of synchronization

This parameter is used to define the frequency of the following events:

- Synchronization at signal N
- Synchronization as a function of a digital input

You can select from the following options:

Option	Meaning
Once (default)	The counter is only set at the first signal N or the first configured edge of the digital input.
Periodic	The counter is set at each signal N or each configured edge of the digital input.

Frequency of the Capture function

This parameter is used to define the frequency of Capture events for the following functions:

- Capture at Signal N
- Capture as function of a digital input

You can select from the following options:

Option	Meaning
Once	The first configured edge at the respective digital input or first rising edge of the N signal saves the current counter value as a Capture value.
Periodic (default)	Each configured edge at the respective digital input or each rising edge of the N signal saves the current counter value as a Capture value.

NOTE

This parameter is available for High_Speed_Counter as of V3.2.

Behavior of counter value after Capture

You can configure the following characteristics for the counter after a capture event (Page 37):

Reaction	Meaning
Continue counting (default)	After saving the current counter value as Capture value, counting is continued unchanged.
Set to start value and continue counting	After saving the current counter value as Capture value, counting is continued with the start value.

4.5.6 Behavior of a DQ (High_Speed_Counter)

Operating mode (High_Speed_Counter V3.0 or higher)

The operating mode determines which value comparison functions work.

Operating mode	Meaning
Use count value as reference (default)	The comparison functions and hardware interrupts for compare events work with the counter value. This functionality corresponds to the functionality of the High_Speed_Counter in versions before V3.0.
Use measured value as reference	The comparison functions and hardware interrupts for compare events work with the measured value.

NOTE

You configure the operating mode under "Behavior of DQ0" for both digital outputs together. The operating mode is also displayed under "Behavior of DQ1".

Set output

With the parameter assignment of a digital output, you specify the condition upon which the digital output switches.

You can select from the following options:

Function of a digital output (Page 49) in operating mode "Use count value as reference"	Meaning	Additional option-specific parameters
Between comparison value and high limit (default)	The respective digital output is active if: Comparison value <= counter value <= high counting limit	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value and low limit	The respective digital output is active if: Low counting limit <= counter value <= comparison value	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= counter value <= comparison value 1	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)

Function of a digital output (Page 49) in operating mode "Use count value as reference"	Meaning	Additional option-specific parameters
At comparison value for a pulse duration	The respective digital output is active once for the configured time and count direction when the counter value reaches the comparison value.	• Comparison value 0 • Comparison value 1 • Count direction • Pulse duration • Hysteresis (in increments)
After set command from CPU until comparison value	When a set command is sent from the CPU, the respective digital output is active until the counter value is equal to the comparison value.	• Comparison value 0 • Comparison value 1 • Count direction • Hysteresis (in increments)
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 48).	—

NOTE

DQ0 of a counter of a Compact CPU

With a Compact CPU, the respective digital output DQ0 is available via the feedback interface, but not as a physical output.

NOTE

You can only select the "Between comparison value 0 and 1" function for digital output DQ1 and only if you have selected the "Use by user program" function for digital output DQ0.

NOTE

The "At comparison value for a pulse duration" and "After set command from CPU until comparison value" functions only switch the digital output in question if a count pulse reaches the comparison value. When the counter value is set, e.g. by synchronization, the digital output does not switch.

Function of a digital output (Page 56) in operating mode "Use measured value as reference"	Meaning	Additional option-specific parameters
Measured value >= comparison value (default)	The respective digital output is active if the measured value is greater than or equal to the comparison value.	• Comparison value 0 • Comparison value 1
Measured value <= comparison value	The respective digital output is active if the measured value is less than or equal to the comparison value.	• Comparison value 0 • Comparison value 1

Function of a digital output (Page 56) in operating mode "Use measured value as reference"	Meaning	Additional option-specific parameters
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= measured value <= comparison value 1	• Comparison value 0 • Comparison value 1
Not between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 1 <= measured value <= comparison value 0	• Comparison value 0 • Comparison value 1
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 48).	—

NOTE

You can select the "Between comparison value 0 and 1" and "Not between comparison value 0 and 1" functions only for digital output DQ1 and only if you have selected the "Use by user program" function for digital output DQ0.

Comparison value 0(TM Count and TM PosInput)

Operating mode "Use count value as reference"

With the parameter assignment of the comparison value (Page 49), you specify the counter value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter an integer (DINT) that is greater than or equal to the low counting limit. If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "0".

Operating mode "Use measured value as reference"

With the parameter assignment of the comparison value (Page 56), you specify the measured value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter a floating point number (REAL). If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The minimum value is -7.922816×10^{28}. The default setting is "0.0". The unit of the comparison value depends on the measured variable.

Comparison value 0(Compact CPU)

Operating mode "Use count value as reference"

With the parameter assignment of the Comparison value (Page 49), you specify the counter value at which the STS_DQ0 bit is set in the feedback interface of the selected comparison event. The digital output DQ0 is not available as a physical output in a Compact CPU.

You must enter an integer (DINT) that is greater than or equal to the low counting limit. If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "0".

Operating mode "Use measured value as reference"

With the parameter assignment of the Comparison value (Page 56), you specify the measured value at which the STS_DQ0 bit is set in the feedback interface of the selected comparison event. The digital output DQ0 is not available as a physical output in a Compact CPU.

You must enter a floating point number (REAL). If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The minimum value is -7.922816 x 10^{28}. The default setting is "0.0". The unit of the comparison value depends on the measured variable.

Comparison value 1

Operating mode "Use count value as reference"

With the parameter assignment of the comparison value (Page 49), you specify the counter value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter an integer (DINT) that is smaller than or equal to the high counting limit. If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "10".

Operating mode "Use measured value as reference"

With the parameter assignment of the comparison value (Page 56), you specify the measured value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter a floating point number (REAL). If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The maximum value is 7.922816 x 10^{28}. The default setting is "10.0". The unit of the comparison value depends on the measured variable.

Count direction

You use this parameter to specify the count direction for which the selected function is valid.

You can select from the following options:

Count direction	Meaning
In both directions (default)	The comparison and switching of the respective digital output take place regardless of the count direction.
Up	The comparison and switching of the respective digital output only takes place when the counter counts up.
Down	The comparison and switching of the respective digital output only takes place when the counter counts down.

The parameter can be configured for the following functions:

- At comparison value for a pulse duration
- After set command from CPU until comparison value

Pulse duration

By configuring the pulse duration for the function "At comparison value for a pulse duration", you specify the number of milliseconds for which the respective digital output is active.

If you enter "0" and the counter value corresponds to the comparison value, the digital output remains active until the next count pulse.

You can enter a value between 0.0 and 6553.5.

The default setting is "500.0", which is equivalent to a pulse duration of 0.5 s.

Hysteresis (in increments)

By configuring the hysteresis (Page 65), you can define a range around the comparison values. For the functions "Between comparison value and upper counter limit" and "Between comparison value and lower counter limit" the hysteresis also applies at the counter limits. Within the hysteresis range, the digital outputs cannot switch again until the counter value is outside the range.

Choose a small enough hysteresis. When the hysteresis range, starting from the configured comparison value, spans the entire counter value range, proper functioning of the comparison values cannot be guaranteed.

If a comparison value lies so close to the counter limit that the hysteresis range would extend beyond this counter limit, the hysteresis range ends at it.

If you enter "0", the hysteresis is turned off. You can enter a value between 0and 255. The default setting is "0".

NOTE

The following applies for High_Speed_Counter as of V3.0:

You configure the hysteresis under "Behavior of DQ0" for both digital outputs together. The hysteresis is also displayed under "Behavior of DQ1".

The hysteresis is only available in operating mode "Use count value as reference".

4.5.7 Specify measured value (High_Speed_Counter)

Measured variable

This parameter is used to specify the measured variable (Page 59) to be provided by the technology module. The technology object displays the measured value at the output parameter MeasuredValue.

You can select from the following options:

Measured variable	Meaning	Additional option-specific parameters
Frequency (default)	The measured variable shows the number of increments per second. The value is a floating point number (REAL). The unit is Hz. The technology object displays the measured value at the output parameter MeasuredValue.	• Update time

Measured variable	Meaning	Additional option-specific parameters
Period	The measured variable is the average period between two increments. The value is an integer (DINT). The unit is s. The technology object displays the measured value at the output parameter MeasuredValue.	• Update time
Velocity	The measured variable is a velocity. Examples of a velocity measurement can be found in the explanation of the "Increments per unit" parameter. The technology object displays the measured value at the output parameter MeasuredValue.	• Update time • Time base for velocity measurement • Increments per unit

Update time

By configuring the update time (Page 59) in milliseconds, you can specify the time interval between two measured value updates.

The update time and the signal type effect the accuracy of the measurement. In the case of update times of at least 100 ms, the effect of the signal type is negligible.

In the case of update times of less than 100 ms, you achieve maximum measurement accuracy using the following signal types:

- Incremental encoder (A, B phase-shifted) with Signal evaluation "Single"
- Incremental encoder (A, B, N) with Signal evaluation "Single"
- Pulse (A) and direction (B)
- Pulse (A)

In the case of other signal types, measurement accuracy depends on the encoder and cable used.

If you enter "0", the measured value is updated once per module-internal cycle. Up to three decimal places can be entered. A value from 0.0 to 25000.0 is permissible. The default setting is "10.0".

Time base for velocity measurement

This parameter defines the time base on which the velocity is to be returned.

You can select from the following options:

- 1 ms
- 10 ms
- 100 ms
- 1 s
- 60 s

The default setting is "60 s".

Increments per unit

You can use this parameter to define the number of count pulses per relevant unit that the incremental or absolute encoder supplies for the velocity measurement.

The number of count pulses depends on the configured signal evaluation. You can enter a value between 1 and 65535.

Example 1:

You encoder delivers 4000 count pulses for travel over one meter. The velocity is to be measured in meters per second. "Double" is configured as signal evaluation.

In this case, you need to assign the following parameters:

- Increments per unit: 8000
- Time base for velocity measurement: 1 s

Example 2:

Your encoder delivers 4096 count pulses per revolution. The velocity is to be measured in revolutions per minute. "Single" is configured as the signal evaluation.

In this case, you need to assign the following parameters:

- Increments per unit: 4096
- Time base for velocity measurement: 60 s

4.6 Programming the High_Speed_Counter

4.6.1 High_Speed_Counter instruction

High_Speed_Counter

The High_Speed_Counter instruction is part of the High_Speed_Counter technology object. It supplies the control and feedback interface of the technology module.

The High_Speed_Counter instruction thereby forms the software interface between the user program and the technology module. It must be called cyclically from the user program in order to synchronize the input and output data.

The High_Speed_Counter instruction can be used equally for the technology modules of the S7-1500, ET 200SP and ET 200eco PN M12-L systems. The modules can be used centrally and decentrally. The instruction applies in each case to the channel of the technology module that was assigned to the associated technology object.

Additional information

Description High_Speed_Counter (Page 119)
High_Speed_Counter input parameters (Page 123)
High_Speed_Counter output parameters (Page 124)
Error codes of parameter ErrorID (Page 127)
High_Speed_Counter static variables (Page 125)

4.6.2 Call instruction in the user program

The High_Speed_Counter instruction can be called once for each counter in the cycle or, alternatively, in a time-controlled program. The call is not permitted in an event-controlled interrupt program.

Procedure

Proceed as follows to call the instruction in the user program:

1. Open the CPU folder in the project tree.
2. Open the "Program blocks" folder.
3. Double-click the OB for cyclic program execution.
   The block is opened in the work area.
4. In the "Instructions" window, open the "Technology" group and the "Counting, measurement, cams" folder.
   The folder contains the instruction.
5. Select the instruction and drag it to your OB.
   The "Call options" dialog opens.
6. Select a technology object from the "Name" list or enter the name for a new technology object.
7. Confirm with "OK".

Result

If the technology object does not exist yet, it is added. The instruction is added in the OB. The technology object is assigned to this call of the instruction.

NOTE

If you click one of the buttons "Configuration", "Commissioning" or "Diagnostics" in the user interface of the instruction, the respective editor opens.

4.6.3 Description High_Speed_Counter

Description

The High_Speed_Counter instruction is used to control the technology module counting and measuring functions via the user program.

Call

The instruction High_Speed_Counter must be called once per counter, either cyclically or in a time-controlled program. The call is not permitted in an event-controlled interrupt program.

Operating principle

Counter value: The counter value is available at the output parameter CountValue. The counter value is updated at every call of the High_Speed_Counter instruction.

Measured value: The technology module updates the measured value asynchronously to the instruction call based on the configured update time. The measured value last determined by the technology module is updated at the output parameter MeasuredValue each time the instruction is called.

The measured value and the counter value are available in parallel in the feedback interface.

Capture: The output parameter CaptureStatus = TRUE indicates a valid Capture value at the output parameter CapturedValue.

- A Capture value is captured under the following conditions:
  - A digital input has the parameter assignment "Capture"
  - CaptureEnable = TRUE
  - Edge at digital input with the Capture function
- The output parameter CaptureStatus is reset by a negative edge at the input parameter CaptureEnable.

Synchronization: The output parameter SyncStatus = TRUE indicates that a synchronization has occurred.

- The counter value is synchronized under the following conditions:
  - A digital input has the parameter assignment "Synchronization" **or** the incremental encoder has the parameter assignment "Synchronization at signal N"
  - SyncEnable = TRUE
  - The static tag SyncUpDirection (or SyncDownDirection) = TRUE
  - Edge at the digital input with the synchronization function **or** positive edge of the signal N at the encoder input
- The output parameter SyncStatus is reset by a negative edge at
  - the input parameter SyncEnable or
  - the static tag SyncDownDirection or
  - the static tag SyncUpDirection

Parameter changes via the user program

Proceed as follows to modify parameters using the user program:

1. Check based on the respective Set tag to determine whether the technology object is ready for the parameter change (Set tag = FALSE) or whether a change job is still running (Set tag = TRUE).
   The following Set tags in UserCmdFlags are available for this in the static tags of the technology object instance DB:
   - SetReferenceValue0
   - SetReferenceValue1
   - SetUpperLimit
   - SetLowerLimit
   - SetCountValue
   - SetStartValue
   - SetNewDirection
2. If the technology object is ready for the parameter change, modify the relevant static tag. The following static tags of the technology object instance DB are available for this:
   - NewReferenceValue0 / NewReferenceValue0_M (for SetReferenceValue0)
   - NewReferenceValue1 / NewReferenceValue1_M (for SetReferenceValue1)
   - NewUpperLimit
   - NewLowerLimit
   - NewCountValue
   - NewStartValue
   - NewDirection
3. Set the relevant Set tag for execution of the change command.
4. Use the output parameter Error to check whether an error has occurred.
   If no errors have occurred and the Set tag has been automatically reset by the technology object, the parameter change was successful.

NOTE

Changed counting limit

If the new high counting limit is less than the current counter value, the counter value is set to the low counting limit or the start value according on the parameter assignment. If the new low counting limit is greater than the current counter value, the counter value is set to the high counting limit or the start value according to the parameter assignment.

Operating mode (High_Speed_Counter V3.0 or higher)

Configure the operating mode in the technology object under "Behavior of DQ0".

The operating mode is indicated by the output parameter CompareMeasuredValue:

State	Description
FALSE	Operating mode "Use count value as reference" The comparison functions work with the counter value. The following static variables are specifically used in this operating mode: • NewReferenceValue0 • NewReferenceValue1 • CurReferenceValue0 • CurReferenceValue1 The four specific static variables of operating mode "Use measured value as reference" are ignored.
TRUE	Operating mode "Use measured value as reference": The comparison functions work with the measured value. The following static variables are specifically used in this operating mode: • NewReferenceValue0_M • NewReferenceValue1_M • CurReferenceValue0_M • CurReferenceValue1_M The four specific static variables of operating mode "Use count value as reference" are ignored.

Acknowledgment of events

You acknowledge signaled events using the positive edge of the input parameter EventAck . EventAck must stay set until the technology object has reset the status bits of the following events of the count channel:

- CompResult0
- CompResult1
- ZeroStatus
- PosOverflow
- NegOverflow

Status of the digital inputs (TM Count and TM PosInput)

You can obtain the status of the digital inputs with the static tags StatusDI0, StatusDI1 or StatusDI2.

Status of the digital inputs (Compact CPU)

You can obtain the status of the digital inputs with the static tags StatusDI0 and StatusDI1. When a digital input of the Compact CPU is not used for a counter, you can use it via the user program.

Use of digital outputs by the user program (TM Count and TM PosInput)

You can set the digital outputs with the High_Speed_Counter instruction,

- If the "Use by user program" setting is configured for "Set output".
- If the "After set command from CPU until comparison value" setting is configured for "Set output".
- if you set the corresponding static tag ManualCtrlDQm (temporary overwrite).

The static tags SetDQ0 and SetDQ1 only have an effect in these cases. In the first and third case, DQm follows the value of SetDQm. In the second case, DQm is set with a positive edge of SetDQm. DQm is reset when the counter value corresponds to the comparison value or at a negative edge of SetDQm.

Use digital outputs by user program (Compact CPU)

You can set the DQ1 digital output with the High_Speed_Counter instruction.

- If the "Use by user program" setting is configured for "Set output".
- If the "After set command from CPU until comparison value" setting is configured for "Set output".
- if you set the corresponding static tag ManualCtrlDQ1 (temporary overwrite).

The static tag SetDQ1 only has an effect in these cases. In the first and third case, DQ1 follows the value of SetDQ1. In the second case, DQ1 is set and reset with a positive edge of SetDQ1 when the counter value corresponds to the comparison value or at a negative edge of SetDQ1.

NOTE

Before you can set a physical digital output of the Compact CPU with the High_Speed_Counter instruction, you have to assign the DQ1 signal to the desired digital output.

You can set the DQ0 signal using the High_Speed_Counter instruction with the static tag StatusDQ0.

- If the "Use by user program" setting is configured for "Set output".
- If the "After set command from CPU until comparison value" setting is configured for "Set output".
- If you set the static tag ManualCtrlDQ0 (temporary overwrite).

The static tag SetDQ0 only has an effect in these cases. In the first and third case, DQ0 follows the value of SetDQ0. In the second case, StatusDQ0 is set and reset with an edge (positive or negative) by SetDQ0 and is reset when the counter value corresponds to the comparison value.

NOTE

The digital output DQ0 is not available as a physical output.

Reaction to error

If an error has occurred during the call of the instruction or in the technology module, the output parameter Error is set. More detailed error information can be read at the output parameter ErrorID.

Eliminate the cause of the error and acknowledge the error message by setting the input parameter ErrorAck. When no more errors are pending, the technology object resets the output parameter Error . No new error is signaled until you acknowledge the previous error.

Changing the count direction

The count direction can only be changed by the user program if "Pulse (A)" is configured as the signal type. In all other cases, the count direction is determined by the input signals of the technology module. The count direction is controlled by the static tag NewDirection:

- +1: Upward count direction
- -1: Downward count direction

To execute the change command, you need to set the static tag SetNewDirection = TRUE.

4.6.4 High_Speed_Counter input parameters

Parameter	Declaration	Data type	Default	Description
SwGate	INPUT	BOOL	FALSE	Control software gate: • Positive edge: Software gate opens • Negative edge: Software gate closes Together with the hardware gate, the SwGate enables the internal gate.
CaptureEnable	INPUT	BOOL	FALSE	Enable Capture function After the enable, a Capture event occurs at the next configured edge at the relevant digital input. A negative edge at CaptureEnable resets the output parameter CaptureStatus. A negative edge at CaptureEnable resets the enable even if no Capture event has occurred. Irrespective of CaptureEnable the last value is retained at the output parameter CapturedValue until the next Capture event.
SyncEnable	INPUT	BOOL	FALSE	Enable synchronization The direction enabled for synchronization is indicated in the static tags SyncUpDirection and SyncDownDirection. A negative edge at SyncEnable resets the output parameter SyncStatus .
ErrorAck	INPUT	BOOL	FALSE	High_Speed_Counter up to V3.0: A positive edge acknowledges the status reported. High_Speed_Counter as of V3.1: A high level acknowledges the error status reported.
EventAck	INPUT	BOOL	FALSE	A positive edge resets the following output parameters: • CompResult0 • CompResult1 • ZeroStatus • PosOverflow • NegOverflow

Parameter	Declaration	Data type	Default	Description
SetCountValue	INOUT	BOOL	FALSE	A positive edge starts the transfer of the new counter value in the static tag NewCountValue to the technology module. The counter value takes effect immediately after the transfer.

4.6.5 High_Speed_Counter output parameters

Parameter	Declaration	Data type	Default	Description
StatusHW	OUTPUT	BOOL	FALSE	Status bit technology module: The module is configured and ready for operation. The module data is valid.
StatusGate	OUTPUT	BOOL	FALSE	Status bit: Internal gate is released if parameter is set
StatusUp	OUTPUT	BOOL	FALSE	Status bit: The last count pulse incremented the counter and took place no more than 0.5 s ago
StatusDown	OUTPUT	BOOL	FALSE	Status bit: The last count pulse decremented the counter and took place no more than 0.5 s ago
CompResult0	OUTPUT	BOOL	FALSE	Status bit: Compare event for DQ0 occurred (status change) based on the selected comparison condition. If the counter value is set to the start value in operating mode "Use count value as reference", CompResult0 is not set. The positive edge of the input parameter EventAck is used to reset CompResult0 .
CompResult1	OUTPUT	BOOL	FALSE	Status bit: Compare event for DQ1 occurred (status change) based on the selected comparison condition. If the counter value is set to the start value in operating mode "Use count value as reference", CompResult1 is not set. The positive edge of the input parameter EventAck is used to reset CompResult1 .
SyncStatus	OUTPUT	BOOL	FALSE	Status bit: Synchronization event occurred If the input parameter SyncEnable is set, the configured edge sets the status bit SyncStatus at the respective digital input . SyncStatus is reset by a negative edge at • SyncEnable (input parameter) or • SyncUpDirection (static tag) or • SyncDownDirection (static tag)
CaptureStatus	OUTPUT	BOOL	FALSE	Status bit: Capture event occurred, the output parameter CapturedValue has a valid Capture value If the input parameter CaptureEnable is set, the configured edge sets the status bit CaptureStatus. at the respective digital input. You reset CaptureStatus using the negative edge of the input parameter CaptureEnable .
ZeroStatus	OUTPUT	BOOL	FALSE	Status bit: CountValue has reached the value "0" irrespective of the count direction You reset ZeroStatus using the positive edge of the input parameter EventAck.
PosOverflow	OUTPUT	BOOL	FALSE	Status bit: CountValue has violated high counting limit in the positive direction You reset PosOverflow using the positive edge of the input parameter EventAck.

[1] Available for High_Speed_Counter version V3.0 or higher

Parameter	Declaration	Data type	Default	Description
NegOverflow	OUTPUT	BOOL	FALSE	Status bit: CountValue has violated low counting limit in the negative direction You reset NegOverflow using the positive edge of the input parameter EventAck.
Error	OUTPUT	BOOL	FALSE	An error has occurred. Refer to the output parameter ErrorID for the cause of the error.
ErrorID	OUTPUT	WORD	0	The ErrorID (Page 127) parameter displays the number of the error message. ErrorID = 0000_H: There is no error.
CountValue	OUTPUT	DINT	0	Current counter value
CapturedValue	OUTPUT	DINT	0	The last acquired Capture value The value is retained until the next Capture event, irrespective of the input parameter CaptureEnable. If a new Capture event has occurred, CaptureStatus is set and is reset by you using the negative edge of the input parameter CaptureEnable .
MeasuredValue	OUTPUT	REAL	0.0	Current measured value for frequency, period duration or velocity (depending on configuration)
CompareMeasuredValue[1]	OUTPUT	BOOL	FALSE	Status bit: FALSE: Operating mode "Use count value as reference"; comparison functions work with counter value TRUE: Operating mode "Use measured value as reference"; comparison functions work with measured value

[1] Available for High_Speed_Counter version V3.0 or higher

4.6.6 High_Speed_Counter static variables

Tag	Data type	Default	Access	Description
NewCountValue	DINT	L#0	Write	New counter value
NewReferenceValue0	DINT	L#0	Write	New comparison value 0 in the operating mode "Use count value as reference"
NewReferenceValue1	DINT	L#10	Write	New comparison value 1 in the operating mode "Use count value as reference"
NewReferenceValue0_M[1]	REAL	L#0.0	Write	New comparison value 0 in operating mode "Use measured value as reference"
NewReferenceValue1_M[1]	REAL	L#10.0	Write	New comparison value 1 in operating mode "Use measured value as reference"
NewUpperLimit	DINT	L#2147483647	Write	New high counting limit
NewLowerLimit	DINT	L#-2147483648	Write	New low counting limit
NewStartValue	DINT	L#0	Write	New start value
NewDirection	INT	0	Write	New count direction: +1: Upward count direction -1: Downward count direction

[1] Available for High_Speed_Counter version V3.0 or higher

[2] Available for High_Speed_Counter version V5.0 or higher

Tag		Data type	Default	Access	Description
CurReferenceValue0		DINT	L#0	Read	Current comparison value 0 in operating mode "Use count value as reference"
CurReferenceValue1		DINT	L#10	Read	Current comparison value 1 in operating mode "Use count value as reference"
CurReferenceValue0_M[1]		REAL	L#0.0	Read	Current comparison value 0 in operating mode "Use measured value as reference"
CurReferenceValue1_M[1]		REAL	L#10.0	Read	Current comparison value 1 in operating mode "Use measured value as reference"
CurUpperLimit		DINT	L#2147483647	Read	Current high counting limit
CurLowerLimit		DINT	L#-2147483648	Read	Current low counting limit
CurStartValue		DINT	L#0	Read	Current start value
AdditionalErrorID		DWORD	W#16#0000	Read	Error information of an internal instruction, e.g. RDREC
OutputByteOffset[2]		DINT	L#0	Read	For internal use
InputByteOffset[2]		DINT	L#0	Read	For internal use
Initialized[2]		BOOL	FALSE	Write	Instruction is initialized and ready for operation. Resetting to FALSE leads to the re-initialization of the technology object.
UserCmdFlags		STRUCT	-		
	SetNewDirection	BOOL	FALSE	Write	Set new count direction
	SetUpperLimit	BOOL	FALSE	Write	Set high counting limit
	SetLowerLimit	BOOL	FALSE	Write	Set low counting limit
	SetReferenceValue0	BOOL	FALSE	Write	Set comparison value 0
	SetReferenceValue1	BOOL	FALSE	Write	Set comparison value 1
	SetStartValue	BOOL	FALSE	Write	Set start value
	SyncDownDirection	BOOL	TRUE	Write	Enable synchronization in downward count direction
	SyncUpDirection	BOOL	TRUE	Write	Enable synchronization in upward count direction
	SetDQ0	BOOL	FALSE	Write	Set digital output DQ0
	SetDQ1	BOOL	FALSE	Write	Set digital output DQ1
	ManualCtrlDQ0	BOOL	FALSE	Write	Enable setting of digital output DQ0: TRUE: • SetDQ0 sets DQ0 • Control bit TM_CTRL_DQ0 = FALSE FALSE: • Setting not enabled • Control bit TM_CTRL_DQ0 = TRUE

1 Available for High_Speed_Counter version V3.0 or higher

2 Available for High_Speed_Counter version V5.0 or higher

Tag		Data type	Default	Access	Description
	ManualCtrlDQ1	BOOL	FALSE	Write	Enable setting of digital output DQ1: TRUE: • SetDQ1 sets DQ1 • Control bit TM_CTRL_DQ1 = FALSE FALSE: • Setting not enabled • Control bit TM_CTRL_DQ1 = TRUE
UserStatusFlags		STRUCT	-		
	StatusDI0	BOOL	FALSE	Read	Current status of digital input DI0
	StatusDI1	BOOL	FALSE	Read	Current status of digital input DI1
	StatusDI2	BOOL	FALSE	Read	Current status of digital input DI2
	StatusDQ0	BOOL	FALSE	Read	Current status of digital output DQ0
	StatusDQ1	BOOL	FALSE	Read	Current status of digital output DQ1

[1] Available for High_Speed_Counter version V3.0 or higher

[2] Available for High_Speed_Counter version V5.0 or higher

4.6.7 Error codes of parameter ErrorID

Error code (W#16#...)	Description
0000	No error
Error messages from technology module	
80A1	POWER_ERROR from feedback interface: Incorrect supply voltage L+
80A2	ENC_ERROR from feedback interface: Incorrect encoder signal
80A3	LD_ERROR from feedback interface: Error when loading via control interface
Error messages of the instruction High_Speed_Counter	
80B1	Invalid count direction
80B4	For operating mode "Use count value as reference", the following applies: New low counting limit does not meet the following conditions: • Low counting limit < high counting limit • Low counting limit <= comparison value/start value For operating mode "Use measured value as reference", the following applies: New low counting limit does not meet the following conditions: • Low counting limit < high counting limit • Low counting limit <= start value

Error code (W#16#...)	Description
80B5	For operating mode "Use count value as reference", the following applies: New high counting limit does not meet the following conditions: • Low counting limit < high counting limit • High counting limit >= comparison value/start value For operating mode "Use measured value as reference", the following applies: New high counting limit does not meet the following conditions: • Low counting limit < high counting limit • High counting limit >= start value
80B6	New start value does not meet the following condition: • Low counting limit <= start value <= high counting limit
80B7	New counter value does not meet the following condition: • Low counting limit <= counter value <= high counting limit
80B8	For operating mode "Use count value as reference", the following applies: New comparison value 0 does not meet the following conditions: • Low counting limit <= comparison value 0 <= high counting limit • Comparison value 0 < comparison value 1 For operating mode "Use measured value as reference", the following applies: New comparison value 0 does not meet the following conditions: • Comparison value 0 < comparison value 1
80B9	For operating mode "Use count value as reference", the following applies: New comparison value 1 does not meet the following conditions: • Low counting limit <= comparison value 1 <= high counting limit • Comparison value 0 < comparison value 1 For operating mode "Use measured value as reference", the following applies: New comparison value 1 does not meet the following conditions: • Comparison value 0 < comparison value 1
80C0	Instruction High_Speed_Counter was called multiple times with the same instance (DB)
80C1	Communication with technology module failed (read data records): Error information of internal instruction RDREC saved in static tag AdditionalErrorID
80C2	Communication with technology module failed (write data records): Error information of internal instruction WRREC saved in static tag AdditionalErrorID
80C3	Access to input data (feedback interface) failed: Error information of internal instruction GETIO_PART saved in static tag AdditionalErrorID
80C4	Access to output data (control interface) failed: Error information of internal instruction SETIO_PART saved in static tag AdditionalErrorID
80C5	Reading of the current start information of the OB failed: Error information of internal instruction RD_SINFO saved in static tag AdditionalErrorID
80C6	Failed to get I/O addresses of the technology module: Error information of internal instruction RD_ADDR saved in static tag AdditionalErrorID
80C7	Module not inserted or No supply voltage L+ or Process image partition (PIP) is not updated / not available
80C8	Specified module is not permitted in the static tag Configuration.HWID

4.7 Commissioning the High_Speed_Counter

4.7.1 Commissioning the technology object

A graphic display of the block in the commissioning editor helps you with commissioning and the function test for the technology object. You can change specific parameters of the High_Speed_Counter instruction in CPU/IM online mode and monitor their effects.

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.
- The corresponding High_Speed_Counter instruction is called cyclically from the user program.
- The parameters of the technology object are not overwritten by the user program.

Procedure

To open the commissioning editor of a technology object and to simulate a parameter value change, follow these steps:

1. Open the "Technology objects" folder in the project tree.
2. Open the High_Speed_Counter technology object in the project tree.
3. Double-click on the "Commissioning" object.
   The functions for commissioning the High_Speed_Counter technology object are displayed.
4. In the commissioning dialog, click on the "Monitor all" button.
   The parameters (online values) of the High_Speed_Counter technology object are loaded and displayed.
5. If the parameter you want to change has a text box, enter the new value there.
6. Select the check box of the parameter.
   The new parameter value becomes effective and the effects of the change are simulated.

Online mode

In online mode, you can modify the following parameters to test the technology object function:

- New counter value (NewCountValue)
- New high counting limit (NewUpperLimit)
- New low counting limit (NewLowerLimit)
- New comparison value 0 (NewReferenceValue0 or NewReferenceValue0_M)
- New comparison value 1 (NewReferenceValue1 or NewReferenceValue1_M)
- New start value (NewStartValue)

- Start and stop counter (SwGate)
- Enable Capture (CaptureEnable)
- Enable synchronization (SyncEnable)
- Acknowledgment of signaled error states (ErrorAck)
- Resetting the status flag (EventAck)

4.8 High_Speed_Counter diagnostics

4.8.1 Monitoring counter values, measured values, DIs and DQs

You use the diagnostic functions to monitor the counting and measuring functions.

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.

Procedure

To open the display editor for the diagnostic functions, follow these steps:

1. Open the "Technology objects" folder in the project tree.
2. Open the High_Speed_Counter technology object in the project tree.
3. Double-click on the "Diagnostics" object.
4. Click the "Monitor all" button.

Display

The following values are read by the technology object from the feedback interface and displayed:

- Event display/diagnostics information
- Signal states of the digital inputs and digital outputs
- Counter value
- Capture value
- Measured value

Additional information on status displays is available in the context-sensitive help for each event in STEP 7 (TIA Portal). When the CPU is in STOP, the status display is not updated.

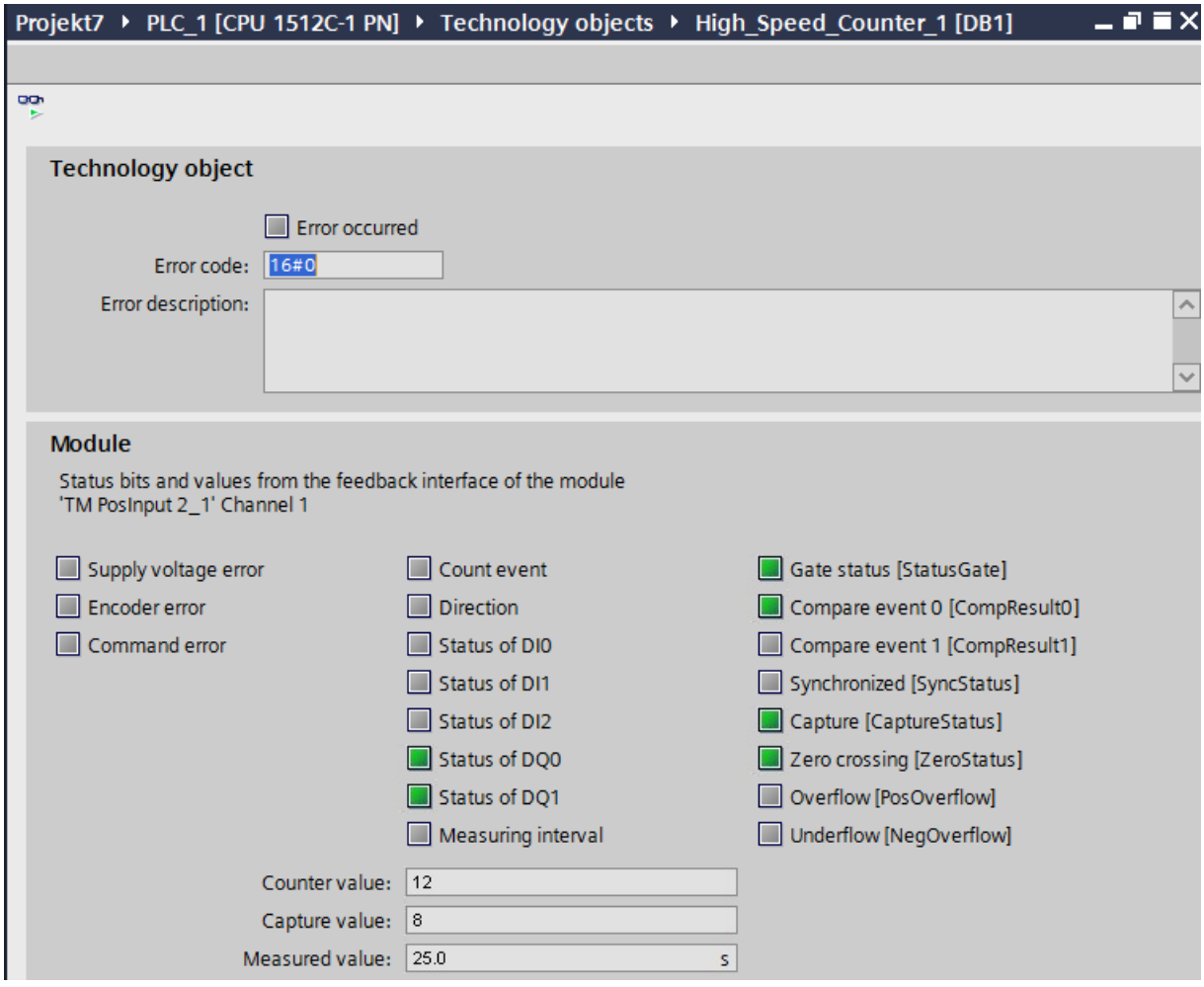

Using the SSI_Absolute_Encoder technology object 5

5.1 Technology object SSI_Absolute_Encoder

STEP 7 (TIA Portal) supports you in the configuration, commissioning and diagnostics of counting and measuring functions for the TM PosInput technology module with the "Technology objects" function in combination with the SSI absolute encoders:

- In STEP 7 (TIA Portal) you configure the SSI_Absolute_Encoder technology object by entering the encoder parameters.
- The corresponding SSI_Absolute_Encoder instruction is programmed in the user program. This instruction supplies the control and feedback interface of the technology module.

The SSI_Absolute_Encoder technology object corresponds to the instance DB of the SSI_Absolute_Encoder instruction. The configuration of the position input and measuring functions is saved in the technology object. The technology object is located in the folder "PLC > Technology objects".

The SSI_Absolute_Encoder technology object can be used equally for the TM PosInput of the S7-1500, ET 200SP and ET 200eco PN M12-L systems.

Operating mode

In order to assign the technology module parameters using a TM PosInput, you specify the operating mode (Page 166) "Operation with technology objects for "counting and measurement"" in the hardware configuration of the TM PosInput. This selection is already preset.

5.2 Overview of the configuration steps

Introduction

The overview below shows the basic procedure for configuring the position input and measuring functions of the technology module with the SSI_Absolute_Encoder technology object.

Requirement

Before you can use the technology object, a project with an S7-1500 CPU or an ET 200SP CPU must be created in STEP 7 (TIA Portal).

Procedure

Proceed in the recommended sequence outlined below:

Step	Description
1	Configure a technology module (Page 160)
2	Add technology object (Page 133)
3	Configure a technology object according to your application (Page 134)
4	Call instruction in the user program (Page 150)
5	Load to CPU
6	Commissioning the technology object (Page 157)
7	Diagnostics of the technology object (Page 158)

5.3 Add technology object

Adding a technology object in the project navigation

When a technology object is added, an instance DB is created for the instruction of this technology object. The configuration of the technology object is stored in this instance DB.

Requirement

A project with a CPU S7-1500 has been created.

Procedure

To add a technology object, proceed as follows:

1. Open the CPU folder in the project tree.
2. Open the "Technology objects" folder.
3. Double-click on "Add new object".
   The "Add new object" dialog opens.
4. Select the technology "Counting, measurement, cams".
5. Select the "SSI_Absolute_Encoder" object.
6. Enter an individual name for the technology object in the "Name" text box.
7. Click "Additional information" if you want to add your own information to the technology object.
8. Confirm with "OK".

Result

The new technology object has now been created and stored in the project tree in the "Technology objects" folder.

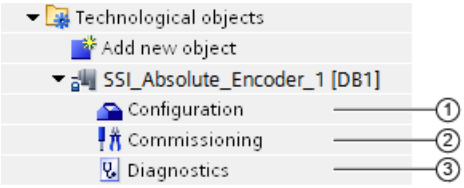

	Object	Description
1	Configuration (Page 134)	In the configuration dialog: • Assignment of technology module and channel • Technology object parameter settings for position input and measurement functions When you change the configuration of the technology object, you must download the technology object **and** the hardware configuration to the CPU.
2	Commissioning (Page 157)	Commissioning and function test of the technology object: Simulating parameters of the SSI_Absolute_Encoder instruction and monitoring the effects
3	Diagnostics (Page 158)	Monitoring of the position input and measurement functions

5.4 Configuring SSI_Absolute_Encoder

5.4.1 Working with the configuration dialog

You configure the properties of the technology object in the configuration window. Proceed as follows to open the configuration window of the technology object:

1. Open the "Technology objects" folder in the project tree.
2. Open the technology object in the project tree.
3. Double-click on the "Configuration" object.

The configuration is divided into the following categories:

- **Basic parameters**

  The basic parameters include the selection of the technology module and the number of the channel for which the technology object is configured.

- **Extended parameters**

  The extended parameters include the parameters for adapting the position input and measuring functions and for setting the characteristics of the digital inputs and digital outputs.

Configuration window icons

Icons in the area navigation of the configuration show additional details about the status of the configuration:

	The configuration contains default values and is complete. The configuration contains only default values. With these default values, you can use the technology object without additional changes.
	The configuration contains values set by the user or automatically adapted values and is complete All text boxes of the configuration contain valid values and at least one default value was changed.
	The configuration is incomplete or incorrect At least one text box or drop-down list contains an invalid value. The corresponding field or the drop-down list is displayed on a red background. Click the roll-out error message to indicate the cause of error.

5.4.2 Basic parameters

Under "Basic parameters", you can establish the connection between the technology object and the TM PosInput technology module.

Module

You select the technology module in a subsequent dialog box. All TM PosInput technology modules (central or distributed) that are configured for use with a "Counting and measurement" technology object under the S7-1500 CPU or ET 200SP CPU are available for selection.

After selecting the technology module, you can open the device configuration associated with the technology module by clicking the"Device configuration" button.

The technology module parameter settings required for the use of the technology object are made in the "Extended parameters" of the technology object.

Channel

For a technology module with several channels, you select the number of the channel for which the technology object is valid.

NOTE

A channel can be assigned to only *one* technology object. A channel that is already assigned to a technology object can no longer be selected.

Synchronization of the parameter values

If, after assignment of the channel to the technology object, there is an inconsistency between the parameter values in the property dialog of the TM PosInput module and in the technology object, a button with a corresponding inquiry appears. When you click the button, the parameter values in the property dialog of the assigned module are overwritten by the parameter values of the technology object within STEP 7 (TIA Portal). The current parameter

values of the technology object are displayed in the property dialog of the module (read-only).

NOTE

If you change parameter values of the technology object, the corresponding parameter values are also overwritten without prompt in the properties dialog of the hardware configuration. As after every change in hardware configuration, the next time the project is loaded in the CPU, a prompt appears asking whether the CPU should go to STOP mode.

5.4.3 SSI absolute encoder

Frame length

With the parameter assignment of the frame length, you specify the number of bits of an SSI frame of the SSI absolute encoder (Page 31) used. You can find the frame length of your SSI absolute encoder in the data sheet of the encoder. Special bits are also included in the frame length. A parity bit does not count in the frame length.

A frame length of between 10 bits and 40 bits is permitted. The default setting is "13 Bit".

You can find two examples of the SSI frame format at Examples of the frame format (Page 147).

Code type

You use the parameter assignment of the code type to specify whether the encoder supplies Dual code or Gray code.

You can select from the following options:

Code type	Meaning
Gray (default)	The gray-coded position value returned by the SSI absolute encoder is converted to dual code.
Dual	The value returned by the SSI absolute encoder is not converted.

Transmission rate

With the parameter assignment of the transmission rate, you specify the data transmission rate between the technology module and the SSI absolute encoder.

You can select from the following options:

- 125 kHz (preset)
- 250 kHz
- 500 kHz
- 1 MHz
- 1.5 MHz
- 2 MHz

The maximum transmission rate depends on the cable length and the technical specifications of the SSI absolute encoder. For additional information, refer to the product manual of the TM PosInput and the encoder description.

Monoflop time

With the parameter assignment of the monoflop time, you specify the idle time between two SSI frames.

The configured monoflop time must be at least equal to the monoflop time of the SSI absolute encoder used. You can find this value in the technical specifications of the SSI absolute encoder.

You can select from the following options:

- Automatically (default)
- 16 µs
- 32 µs
- 48 µs
- 64 µs

NOTE

If you select the "Automatic" option, the monoflop time automatically adapts to the encoder used.

In isochronous mode, the "Automatic" option corresponds to a monoflop time of 64 µs. If the monoflop time of the employed SSI absolute value encoder is less than 64 µs, you can select the value of the encoder to achieve faster isochronous times.

Parity

With the parameter assignment of the parity, you specify whether the SSI absolute encoder transfers a parity bit.

If, for example, a 25-bit encoder with parity is assigned, the technology module reads 26 bits. A parity error is indicated by the technology object at the ErrorID output parameter with the value 80A2.

Bit number LSB of the position value

This parameter is used to specify the bit number of the LSB (least significant bit) of the position value in the frame of the SSI absolute encoder. In this way you limit the range in the frame that supplies the position value.

The value must be less than the bit number of the MSB of the position value. The difference between the bit numbers of the MSB and the LSB of the position value must be less than 32.

The default setting is "0".

NOTE

If you have selected the Code type "Gray", only the range from the LSB to the MSB of the position value is converted to binary code.

Bit number MSB of the position value

This parameter is used to specify the bit number of the MSB (most significant bit) of the position value in the frame of the SSI absolute encoder. In this way you limit the range in the frame that supplies the position value.

The value must be less than the frame length and higher than the bit number of the LSB of the position value. The difference between the bit numbers of the MSB and the LSB of the position value must be less than 32.

The default setting is "12".

NOTE

If you have selected the Code type "Gray", only the range from the LSB to the MSB of the position value is converted to binary code.

Invert direction

You can use this parameter to invert the values supplied by the SSIabsolute encoder. This allows you to adapt the detected direction of the encoder to the motor's direction of rotation.

NOTE

This parameter acts only on the range from the LSB to the MSB of the position value in the frame.

SSI frame

You can also set the following parameters in the graphic with drag-and-drop:

- Frame length
- Bit number LSB of the position value
- Bit number MSB of the position value

Complete SSI frame

If "Complete SSI frame" has been selected as the measured variable, the module returns the least significant 32 bits of the unprocessed current SSI frame as the measured value. The graphic shows the corresponding meaning of a supplied bit. The following abbreviations are used:

V	Value: Position value as gray or dual code
S	Special: Special bit
P	Parity: Parity bit When you have configured a parity bit, the module returns the least significant 31 bits of the SSI frame *and* the parity bit.

5.4.4 Behavior of a DI (SSI_Absolute_Encoder)

Setting function of the DI

By configuring a digital input, you specify which functions the digital input triggers at switching.

You can select from the following options:

Function of a digital input	Meaning	Additional option-specific parameters
Capture (Page 40)	The configured edge at the respective digital input saves the current position value as a Capture value. The technology object displays the Capture value at the output parameter CapturedValue. The function can only be used for one of the two digital inputs.	• Input delay • Edge selection • Frequency of the Capture function
Digital input without function	No technological function is assigned to the respective digital input. You can read the signal state of the digital input via the respective static variable of the technology object: • UserStatusFlags.StatusDI0 • UserStatusFlags.StatusDI1	• Input delay

NOTE

You can choose the "Capture" function only in operating mode "Use position value (SSI absolute value) as reference".

Input delay

By configuring the input delay, you suppress interferences at the digital inputs. Signals with a pulse duration below the configured input delay are suppressed.

You can select from the following input delays:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

NOTE

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

NOTE

You configure the input delay under "Behavior of DI0" for all digital inputs together. The input delay is also displayed under "Behavior of DI1".

Edge selection

You can use this parameter to specify the edge of the digital input at which the configured function is triggered for the "Capture" function.

You can select from the following options:

- At rising edge (default)
- At falling edge
- At rising and falling edge

Frequency of the Capture function

This parameter is used to define the frequency of Capture events (Page 40):

You can select from the following options:

Option	Meaning
Once	The first configured edge at the respective digital input saves the current counter value as Capture value.
Periodic (default)	Each configured edge at the respective digital input saves the current counter value as a Capture value.

NOTE

This parameter is available for SSI_Absolute_Encoder as of V3.0.

5.4.5 Behavior of a DQ (SSI_Absolute_Encoder)

Operating mode

With the operating mode, you specify the reference value with which the comparison functions work.

Operating mode	Meaning
Use position value (SSI absolute value) as reference (default)	The comparison functions and hardware interrupts for compare events work with the position value.
Use measured value as reference	The comparison functions and hardware interrupts for compare events work with the measured value.

NOTE

You configure the operating mode under "Behavior of DQ0" for both digital outputs together. The operating mode is also displayed under "Behavior of DQ1".

Set output

With the parameter assignment of a digital output, you specify the condition upon which the digital output switches.

You can select from the following options depending on the operating mode:

Function of a digital output (Page 53) **in operating mode "Use position value (SSI absolute value) as reference"**	**Meaning**	**Additional option-specific parameters**
Between comparison value and high limit (default)	The respective digital output is active if: Comparison value <= position value <= maximum position value	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value and low limit	The respective digital output is active if: Minimum position value <= Position value <= Comparison value	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= position value <= comparison value 1	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
At comparison value for a pulse duration	The respective digital output is active once for the assigned time and direction of the position value change when the position value is equal to the comparison value or has fallen below or exceeded it.	• Comparison value 0 • Comparison value 1 • Count direction • Pulse duration • Hysteresis (in increments)
After set command from CPU until comparison value	When a set command is sent from the CPU, the respective digital output is active for the assigned direction of the position value change until the position value is equal to the comparison value or has fallen below or exceeded it.	• Comparison value 0 • Comparison value 1 • Count direction • Hysteresis (in increments)
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 48).	—

NOTE

You can only select the "Between comparison value 0 and 1" function for digital output DQ1 and only if you have selected the "Use by user program" function for digital output DQ0.

Function of a digital output (Page 56) **in operating mode "Use measured value as reference"**	**Meaning**	**Additional option-specific parameters**
Measured value >= comparison value (default)	The respective digital output is active if the measured value is greater than or equal to the comparison value.	• Comparison value 0 • Comparison value 1
Measured value <= comparison value	The respective digital output is active if the measured value is less than or equal to the comparison value.	• Comparison value 0 • Comparison value 1

Function of a digital output (Page 56) in operating mode "Use measured value as reference"	Meaning	Additional option-specific parameters
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= measured value <= comparison value 1	• Comparison value 0 • Comparison value 1
Not between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 1 <= measured value <= comparison value 0	• Comparison value 0 • Comparison value 1
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 48).	—

NOTE

You can select the "Between comparison value 0 and 1" and "Not between comparison value 0 and 1" functions only for digital output DQ1 and only if you have selected the "Use by user program" function for digital output DQ0.

Comparison value 0

Operating mode "Use position value (SSI absolute value) as reference"

With the parameter assignment of the comparison value (Page 53), you specify the position value at which the digital output DQ0 switches as a result of the selected comparison event.

If you use an SSI absolute encoder with a position value length of up to 31 bits, you must enter a positive integer (DINT) with a value between 0 and $2^{(MSB-LSB+1)}$-1. If you use an SSI absolute encoder with a position value length of 32 bits, you must enter a signed integer (DINT) with a value between –2147483648 and 2147483647.

If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "0".

Operating mode "Use measured value as reference"

With the parameter assignment of the comparison value (Page 56), you specify the measured value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter a floating point number (REAL). If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The minimum value is -7.922816 x 10^{28}. The default setting is "0.0". The unit of the comparison value depends on the measured variable.

Comparison value 1

Operating mode "Use position value (SSI absolute value) as reference"

With the parameter assignment of the comparison value (Page 53), you specify the position value at which the digital output DQ1 switches as a result of the selected comparison event.

If you use an SSI absolute encoder with a position value length of up to 31 bits, you must enter a positive integer (DINT) with a value between 0 and $2^{(MSB-LSB+1)}$-1. If you use an SSI

absolute encoder with a position value length of 32 bits, you must enter a signed integer (DINT) with a value between –2147483648 and 2147483647.

If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "10".

Operating mode "Use measured value as reference"

With the parameter assignment of the comparison value (Page 56), you specify the measured value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter a floating point number (REAL). If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The maximum value is 7.922816×10^{28}. The default setting is "10.0". The unit of the comparison value depends on the measured variable.

Count direction

You use this parameter to specify the direction of position value change for which the selected function is valid.

You can select from the following options:

Direction of position value change	Meaning
In both directions (default)	The comparison and switching of the respective digital output is carried out regardless of whether the position value increases of decreases.
Up	The comparison and switching of the respective digital output only takes place when the position value increases.
Down	The comparison and switching of the respective digital output only takes place when the position value decreases.

The parameter can be configured for the following functions:

- At comparison value for a pulse duration
- After set command from CPU until comparison value

Pulse duration

By configuring the pulse duration for the function "At comparison value for a pulse duration", you specify the number of milliseconds for which the respective digital output is active.

A value from 0.1 to 6553.5 ms is permissible.

The default setting is "500.0", which is equivalent to a pulse duration of 0.5 s.

Hysteresis (in increments)

By configuring the hysteresis (Page 67), you can define a range around the comparison values. For the functions "Between comparison value and upper counter limit" and "Between comparison value and lower counter limit" the hysteresis also applies at the counter limits. Within the hysteresis range, the digital outputs cannot switch again until the position value has left this range once.

Choose a small enough hysteresis. When the hysteresis range, starting from the configured comparison value, spans the entire position value range, proper functioning of the comparison values cannot be guaranteed.

If a comparison value lies so close to the counter limit that the hysteresis range would extend beyond this counter limit, the hysteresis range ends there.

If you enter "0", the hysteresis is turned off. You can enter a value between 0and 255. The default setting is "0".

NOTE

You configure the hysteresis under "Behavior of DQ0" for both digital outputs together. The hysteresis is also displayed under "Behavior of DQ1".

NOTE

The hysteresis is only available in operating mode "Use position value (SSI absolute value) as reference".

5.4.6 Specify measured value (SSI_Absolute_Encoder)

Measured variable

With this parameter you specify whether the technology module is to provide a certain measured variable (Page 63) or the complete SSI frame.

You can select from the following options:

Option	Meaning	Additional option-specific parameters
Frequency (default)	The measured variable shows the number of increments per second, where each increment corresponds to one position value change. The value is a floating point number (REAL). The unit is Hz. The technology object displays the measured value at the output parameter MeasuredValue.	• Update time
Period	The measured variable is the average period between two increments of the position value. The value is an integer (DINT). The unit is s. The technology object displays the measured value at the output parameter MeasuredValue.	• Update time

Option	Meaning	Additional option-specific parameters
Velocity	The measured variable is a velocity. Examples of a velocity measurement can be found in the explanation of the "Increments per unit" parameter. The technology object displays the measured value at the output parameter MeasuredValue.	• Update time • Time base for velocity measurement • Increments per unit
Complete SSI frame	Instead of a measured variable, the first 32 bits of the SSI frame are returned (bit 0 to bit 31). In so doing, special bits that do not belong to the position information are also supplied. A configured inversion of the direction is ignored. The technology object displays the value at the output parameter CompleteSSIFrame. You can find examples under Examples of the frame format (Page 147). This option is only available in operating mode "Use position value (SSI absolute value) as reference".	—

NOTE

If the increment per revolution is required for calculation of the measured values, it is automatically calculated from the parameterized telegram length as the power of 2, e.g. 8192 increments per revolution with a telegram length of 13 bit. If you are using an SSI absolute encoder whose increment per revolution does not correspond to the power of 2, the calculated measured value may be incorrect for a short time.

Update time

By configuring the update time (Page 63) in milliseconds, you can specify the time interval between two measured value updates. Unsteady measured variables can be smoothed through longer update times

If you enter "0", the measured value is updated once per module-internal cycle. Up to three decimal places can be entered. A value from 0.0 to 25000.0 is permissible. The default setting is "10.0".

Time base for velocity measurement

This parameter defines the time base on which the velocity is to be returned.

You can select from the following options:

- 1 ms
- 10 ms
- 100 ms
- 1 s
- 60 s

The default setting is "60 s".

Increments per unit

With this parameter you define the number of increments per relevant unit that the SSI absolute encoder supplies for the velocity measurement.

You can enter a value between 1 and 65535.

Example 1:

Your absolute encoder operates with a resolution of 12 bits per revolution and performs 4096 increments per revolution. The velocity should be measured in revolutions per minute.

In this case, you need to assign the following parameters:

- Increments per unit: 4096
- Time base for velocity measurement: 60 s

Example 2:

You encoder delivers 10000 increments for travel over one meter. The velocity is to be measured in meters per second.

In this case, you need to assign the following parameters:

- Increments per unit: 10000
- Time base for velocity measurement: 1 s

5.4.7 Examples of the frame format

Example 1

In this example the SSI absolute encoder has the following specification:

- The encoder has a resolution of 13 bits per revolution and a value range of 12 bits of revolutions. The SSI frame has a length of 25 bits.
- The MSB of the position value is bit 24.
- The LSB of the position value is bit 0.
- The position value is Gray coded.
- A parity bit is not available.

The frame has the following format:

Cycle:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Bit:	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG
	MSB																								LSB

Position value

MG Multiturn bit as Gray code

SG Singleturn bit as Gray code

Complete SSI frame

If you configure "Complete SSI frame", the technology module returns the unprocessed SSI frame in the return interface right-justified:

Cycle:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Bit:	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	0	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG

MG Multiturn bit as Gray code

SG Singleturn bit as Gray code

Position value feedback value

The position value supplied in Gray code is converted into binary code by the technology module and returned right-justified in the feedback interface:

Cycle:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Bit:	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	0	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD

MD Multiturn bit as binary code

SD Singleturn bit as binary code

Example 2

In this example the SSI absolute encoder has the following specification:

- The encoder has a resolution of 17 bits per revolution and a value range of 11 bits of revolutions. The SSI frame has a length of 34 bits.
- The MSB of the position value is bit 33.
- The LSB of the position value is bit 6.
- The position value is Gray coded.
- The SSI frame has six special bits.
- A parity bit is available. A parity bit does not count in the frame length.

The frame has the following format:

Clock:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
Bit:	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	*	3	2	1	0
	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	S1	S2	P	S3	S4	S5	S6
	MSB																											LSB							

Position value

MG Multiturn bit as Gray code

SG Singleturn bit as Gray code

Sn Special bit n

P Parity bit

Complete SSI frame

If you configure "Complete SSI frame", the technology module returns the least significant 32 bits of the SSI frame as an unprocessed bit string. The technology module returns the bit following the LSB as parity bit. In this example, the technology module therefore returns only the least significant 31 bits of the SSI frame. With the complete SSI frame, you can evaluate the additional special bits in your application.

The returned bit string is structured as follows:

Clock:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Bit:	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	MG	MG	MG	MG	MG	MG	MG	MG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	P	S1	S2	S3	S4	S5	S6

MG Multiturn bit as Gray code

SG Singleturn bit as Gray code

Sn Special bit n

P Parity bit

Position value

The position value supplied in Gray code is converted into binary code by the technology module and returned right-justified in the feedback interface: The special bits are ignored in this case. The parity bit is evaluated but is not returned with the position value:

Cycle:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Bit:	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	0	0	0	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	MD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD	SD

MD Multiturn bit as binary code

SD Singleturn bit as binary code

5.5 Programming the SSI_Absolute_Encoder

5.5.1 Instruction SSI_Absolute_Encoder

SSI_Absolute_Encoder

The SSI_Absolute_Encoder instruction is part of the SSI_Absolute_Encoder technology object. It supplies the control and feedback interface of the TM PosInput technology module.

The SSI_Absolute_Encoder instruction thereby forms the software interface between the user program and the technology module. It must be called cyclically from the user program in order to synchronize the input and output data.

The SSI_Absolute_Encoder instruction can be used equally for the TM PosInput of the S7-1500, ET 200SP and ET 200eco PN M12-L systems. The TM PosInput modules can be used centrally and decentrally. The instruction applies in each case to the channel of the technology module that was assigned to the associated technology object.

Additional information

Description SSI_Absolute_Encoder (Page 151)
Input parameter SSI_Absolute_Encoder (Page 153)
Output parameter SSI_Absolute_Encoder (Page 154)
Error codes of parameter ErrorID (Page 156)
Static tags SSI_Absolute_Encoder (Page 155)

5.5.2 Call instruction in the user program

The SSI_Absolute_Encoder instruction can be called once per channel, either cyclically or in a time-controlled program. The call is not permitted in an event-controlled interrupt program.

Procedure

Proceed as follows to call the instruction in the user program:

1. Open the CPU folder in the project tree.
2. Open the "Program blocks" folder.
3. Double-click the OB for cyclic program execution.
   The block is opened in the work area.
4. In the "Instructions" window, open the "Technology" group and the "Counting, measurement, cams" folder.
   The folder contains the instruction.
5. Select the instruction and drag it to your OB.
   The "Call options" dialog opens.
6. Select a technology object from the "Name" list or enter the name for a new technology object.
7. Confirm with "OK".

Result

If the technology object does not exist yet, it is added. The instruction is added in the OB. The technology object is assigned to this call of the instruction.

NOTE

If you click one of the buttons "Configuration", "Commissioning" or "Diagnostics" in the user interface of the instruction, the respective editor opens.

5.5.3 Description SSI_Absolute_Encoder

Description

The SSI_Absolute_Encoder instruction is used to control the position input and measuring functions of the technology module TM PosInput via the user program.

Call

The instruction must be called once per channel, either cyclically or in a time-controlled program. The call is not permitted in an event-controlled interrupt program.

Operating principle

Position value: The position value is available at the output parameter PositionValue. The position value is updated every time the instruction is called.

Measured value: The technology module updates the measured value asynchronously to the instruction call based on the configured update time. The measured value last determined by the technology module is updated at the output parameter MeasuredValue each time the instruction is called.

Measured value and position value are available in parallel as output parameters.

Instead of a measured value, the complete SSI frame can be returned at the output parameter CompleteSSIFrame. Either MeasuredValue or CompleteSSIFrame is valid, depending on the parameter assignment.

Capture: The output parameter CaptureStatus = TRUE indicates a valid Capture value at the output parameter CapturedValue.

- A Capture value is captured under the following conditions:
  - A digital input has the parameter assignment "Capture"
  - CaptureEnable = TRUE
  - Edge at digital input with the Capture function
- The output parameter CaptureStatus is reset by a negative edge at the input parameter CaptureEnable.

Parameter changes via the user program

Proceed as follows to modify parameters using the user program:

1. Check the relevant Set tag to establish whether the technology object is ready for the parameter change (Set tag = FALSE) or whether a change job is still running (Set tag = TRUE).
   The following Set tags in UserCmdFlags are available for this in the static tags of the technology object instance DB:
   - SetReferenceValue0
   - SetReferenceValue1

2. If the technology object is ready for the parameter change, modify the relevant static tag. The following static tags of the technology object instance DB are available for this:
   – NewReferenceValue0 / NewReferenceValue0_M (for SetReferenceValue0)
   – NewReferenceValue1 / NewReferenceValue1_M (for SetReferenceValue1)
3. Set the relevant Set tag for execution of the change job.
4. Use the output parameter Error to check whether an error has occurred.
   If no errors have occurred and the Set tag has been automatically reset by the technology object, the parameter change was successful.

Operating mode

Configure the operating mode in the technology object under "Behavior of DQ0".

The operating mode is indicated by the output parameters CompareMeasuredValue:

State	Description
FALSE	Operating mode "Use position value (SSI absolute value) as reference": The comparison functions work with the position value. The following static variables are specifically used in this operating mode: • NewReferenceValue0 • NewReferenceValue1 • CurReferenceValue0 • CurReferenceValue1 The four specific static variables of operating mode "Use measured value as reference" are ignored.
TRUE	Operating mode "Use measured value as reference": The comparison functions work with the measured value. The following static variables are specifically used in this operating mode: • NewReferenceValue0_M • NewReferenceValue1_M • CurReferenceValue0_M • CurReferenceValue1_M The four specific static tags of operating mode "Use position value (SSI absolute value) as reference" are ignored.

Acknowledgment of events

You acknowledge signaled events using the positive edge of the input parameter EventAck . EventAck must stay set until the technology object has reset the status bits of the following events of the count channel:

- CompResult0
- CompResult1
- ZeroStatus
- PosOverflow
- NegOverflow

Status of the digital inputs

You obtain the status of the digital inputs via the static tags StatusDI0 and StatusDI1.

Using digital outputs with user program

In the following cases you can set the digital outputs via the instruction:

Case	Description
The setting "Use by user program" is configured for "Set output".	The respective digital output DQM follows the value of SetDQm.
The setting "After set command from CPU until comp. value" is configured for "Set output".	The respective digital output DQm is set with a negative edge of SetDQm. DQm is reset when the position value corresponds to the comparison value or at a negative edge of SetDQm.
Set the respective static variable ManualCtrlDQm (temporary overwrite).	The respective digital output DQM follows the value of SetDQm.

Reaction to error

If an error has occurred during the call of the instruction or in the technology module, the output parameter Error is set. More detailed error information can be read at the output parameter ErrorID (Page 156).

Eliminate the cause of the error and acknowledge the error message by setting the input parameter ErrorAck. When no more errors are pending, the technology object resets the output parameter Error . No new error is signaled until you acknowledge the previous error.

5.5.4 Input parameter SSI_Absolute_Encoder

Parameter	Declaration	Data type	Default	Description
CaptureEnable	INPUT	BOOL	FALSE	Enable Capture function After the enable, a Capture event occurs at the next configured edge at the relevant digital input. A negative edge at CaptureEnable resets the output parameter CaptureStatus. A negative edge at CaptureEnable resets the enable even if no Capture event has occurred. Irrespective of CaptureEnable the last value is retained at the output parameter CapturedValue until the next Capture event.
ErrorAck	INPUT	BOOL	FALSE	SSI_Absolute_Encoder V1.0: A positive edge acknowledges the error status reported. SSI_Absolute_Encoder as of V2.0: A high level acknowledges the error status reported.
EventAck	INPUT	BOOL	FALSE	A positive edge resets the following output parameters: • CompResult0 • CompResult1 • ZeroStatus • PosOverflow • NegOverflow

5.5.5 Output parameter SSI_Absolute_Encoder

Parameter	Declaration	Data type	Default	Description
StatusHW	OUTPUT	BOOL	FALSE	Status bit technology module: The module is configured and ready for operation. The module data is valid.
StatusUp	OUTPUT	BOOL	FALSE	Status bit: Last position value has changed in the positive direction and took place no more than 0.5 s ago.
StatusDown	OUTPUT	BOOL	FALSE	Status bit: Last position value has changed in the negative direction and took place no more than 0.5 s ago.
CompResult0	OUTPUT	BOOL	FALSE	Status bit: Comparison event for DQ0 (change of state) occurs as a result of the selected comparison condition. The positive edge of the input parameter EventAck is used to reset CompResult0 .
CompResult1	OUTPUT	BOOL	FALSE	Status bit: Comparison event for DQ1 (change of state) occurs as a result of the selected comparison condition. The positive edge of the input parameter EventAck is used to reset CompResult1 .
CaptureStatus	OUTPUT	BOOL	FALSE	Status bit: Capture event occurred, the output parameter CapturedValue has a valid Capture value If the input parameter CaptureEnable is set, the configured edge sets the status bit CaptureStatus. at the respective digital input. You reset CaptureStatus using the negative edge of the input parameter CaptureEnable .
CapturedValue	OUTPUT	DINT	0	The last acquired Capture value The value is retained until the next Capture event, irrespective of the input parameter CaptureEnable. If a new Capture event has occurred, CaptureStatus is set and is reset by you using the negative edge of the input parameter CaptureEnable .
ZeroStatus	OUTPUT	BOOL	FALSE	Status bit: PositionValue has reached or exceeded the value "0" irrespective of the count direction. You reset ZeroStatus using the positive edge of the input parameter EventAck.
PosOverflow	OUTPUT	BOOL	FALSE	Status bit: PositionValue has exceeded the high limit of the position value range of the encoder in the positive direction. You reset PosOverflow using the positive edge of the input parameter EventAck.
NegOverflow	OUTPUT	BOOL	FALSE	Status bit: PositionValue has exceeded the low limit of the position value range of the encoder in the negative direction. You reset NegOverflow using the positive edge of the input parameter EventAck.
Error	OUTPUT	BOOL	FALSE	An error has occurred. Refer to the output parameter ErrorID for the cause of the error.
ErrorID	OUTPUT	WORD	0	The ErrorID (Page 156) parameter displays the number of the error message. ErrorID = 0000_H: There is no error.
PositionValue	OUTPUT	DINT	0	Current position value

Parameter	Declaration	Data type	Default	Description
MeasuredValue	OUTPUT	REAL	0.0	Current measured value for frequency, period duration or velocity (depending on configuration) Either MeasuredValue or CompleteSSIFrame is valid, depending on the parameter assignment in the technology object under "Measured value".
CompleteSSIFr-ame	OUTPUT	DWORD	0	Last received complete SSI frame (least significant 32 bits) Either MeasuredValue or CompleteSSIFrame is valid, depending on the parameter assignment in the technology object under "Measured value".
CompareMeas-uredValue	OUTPUT	BOOL	FALSE	Status bit: FALSE: Operating mode "Use position value (SSI absolute value) as reference"; position value is used as reference TRUE: Operating mode "Use measured value as reference"; meas-ured value is used as reference

5.5.6 Static tags SSI_Absolute_Encoder

Tag		Data type	Default	Access	Description
NewReferenceValue0		DINT	L#0	Write	New comparison value 0 in operating mode "Use position value (SSI absolute value) as reference"
NewReferenceValue1		DINT	L#10	Write	New comparison value 1 in operating mode "Use position value (SSI absolute value) as reference"
NewReferenceValue0_M		REAL	L#0.0	Write	New comparison value 0 in operating mode "Use measured value as reference"
NewReferenceValue1_M		REAL	L#10.0	Write	New comparison value 1 in operating mode "Use measured value as reference"
CurReferenceValue0		DINT	L#0	Read	Current comparison value 0 in operating mode "Use position value (SSI absolute value) as reference"
CurReferenceValue1		DINT	L#10	Read	Current comparison value 1 in operating mode "Use position value (SSI absolute value) as reference"
CurReferenceValue0_M		REAL	L#0.0	Read	Current comparison value 0 in operating mode "Use measured value as reference"
CurReferenceValue1_M		REAL	L#10.0	Read	Current comparison value 1 in operating mode "Use measured value as reference"
AdditionalErrorID		DWORD	W#16#0000	Read	Error information of an internal instruction, e.g.,RDREC
UserCmdFlags		STRUCT	-		
	SetReferenceValue0	BOOL	FALSE	Write	Set comparison value 0
	SetReferenceValue1	BOOL	FALSE	Write	Set comparison value 1
	SetDQ0	BOOL	FALSE	Write	Set digital output DQ0
	SetDQ1	BOOL	FALSE	Write	Set digital output DQ1

[1] The instruction sets the TM_CTRL_DQm bit to FALSE. in the control interface of the module. The static tag SetDQm acts on the control bit SET_DQm.

Tag		Data type	Default	Access	Description
	ManualCtrlDQ0	BOOL	FALSE	Write	Enable setting of digital output DQ0. TRUE: SetDQ0 sets DQ0[1] FALSE: Setting not enabled
	ManualCtrlDQ1	BOOL	FALSE	Write	Enable setting of digital output DQ1: TRUE: SetDQ1 sets DQ1[1] FALSE: Setting not enabled
UserStatusFlags		STRUCT	-		
	StatusDI0	BOOL	FALSE	Read	Current status of digital input DI0
	StatusDI1	BOOL	FALSE	Read	Current status of digital input DI1
	StatusDQ0	BOOL	FALSE	Read	Current status of digital output DQ0
	StatusDQ1	BOOL	FALSE	Read	Current status of digital output DQ1

[1] The instruction sets the TM_CTRL_DQm bit to FALSE. in the control interface of the module. The static tag SetDQm acts on the control bit SET_DQm.

5.5.7 Error codes of parameter ErrorID

Error code (W#16#...)	Description
0000	No error
Error messages from technology module	
80A1	POWER_ERROR from feedback interface: Incorrect supply voltage L+
80A2	ENC_ERROR from feedback interface: Incorrect encoder signal
80A3	LD_ERROR from feedback interface: Error when loading via control interface
Error messages of the instruction SSI_Absolute_Encoder	
80B8	New comparison value 0 does not meet the following conditions: • Low counting limit <= comparison value 0 <= high counting limit • Comparison value 0 < comparison value 1
80B9	New comparison value 1 does not meet the following conditions: • Low counting limit <= comparison value 1 <= high counting limit • Comparison value 0 < comparison value 1
80C0	Instruction was called multiple times with the same instance (DB)
80C1	Communication with technology module failed (read data records): Error information of internal instruction RDREC saved in static tag AdditionalErrorID
80C2	Communication with technology module failed (write data records): Error information of internal instruction WRREC saved in static tag AdditionalErrorID
80C5	Reading of the current start information of the OB failed: Error information of internal instruction RD_SINFO saved in static tag AdditionalErrorID
80C6	Failed to get I/O addresses of the technology module: Error information of internal instruction RD_ADDR saved in static tag AdditionalErrorID
80C7	Module not inserted or No supply voltage L+ or Process image partition (PIP) is not updated / not available
80C8	Specified module is not permitted in the static tag Configuration.HWID

5.6 Commissioning SSI_Absolute_Encoder

5.6.1 Commissioning the technology object

A graphic display of the block in the commissioning editor helps you with commissioning and the function test for the technology object. You can change specific parameters of the SSI_Absolute_Encoder instruction in CPU/IM online mode and monitor their effects.

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.
- The corresponding SSI_Absolute_Encoder instruction is called cyclically from the user program.
- The parameters of the technology object are not overwritten by the user program.

Procedure

To open the commissioning editor of a technology object and to simulate a parameter value change, follow these steps:

1. Open the "Technology objects" folder in the project tree.
2. Open the SSI_Absolute_Encoder technology object in the project tree.
3. Double-click on the "Commissioning" object.
   The functions for commissioning the SSI_Absolute_Encoder technology object are displayed.
4. In the commissioning dialog, click on the "Monitor all" button.
   The parameters (online values) of the SSI_Absolute_Encoder technology object are loaded and displayed.
5. If the parameter you want to change has a text box, enter the new value there.
6. Select the check box of the parameter.
   The new parameter value becomes effective and the effects of the change are simulated.

Online mode

In online mode, you can modify the following parameters to test the technology object function:

- New comparison value 0 (NewReferenceValue0 or NewReferenceValue0_M)
- New comparison value 1 (NewReferenceValue1 or NewReferenceValue1_M)
- Enable Capture (CaptureEnable)
- Acknowledgment of signaled error states (ErrorAck)
- Resetting the status flag (EventAck)

5.7 SSI_Absolute_Encoder diagnostics

5.7.1 Monitoring counter values, measured values, DIs and DQs

The diagnostic functions are used to monitor the position input and measuring functions.

Requirements

- There is an online connection between STEP 7 (TIA Portal) and the CPU.
- The CPU is in RUN.

Procedure

To open the display editor for the diagnostic functions, follow these steps:

1. Open the "Technology objects" folder in the project tree.
2. Open the SSI_Absolute_Encoder technology object in the project tree.
3. Double-click on the "Diagnostics" object.
4. Click the "Monitor all" button.

Display

The following values are read by the technology object from the feedback interface and displayed:

- Event display/diagnostics information
- Signal states of the digital inputs and digital outputs
- Position value
- Capture value
- Measured value

Additional information on status displays is available in the context-sensitive help for each event in STEP 7 (TIA Portal). When the CPU is in STOP, the status display is not updated.

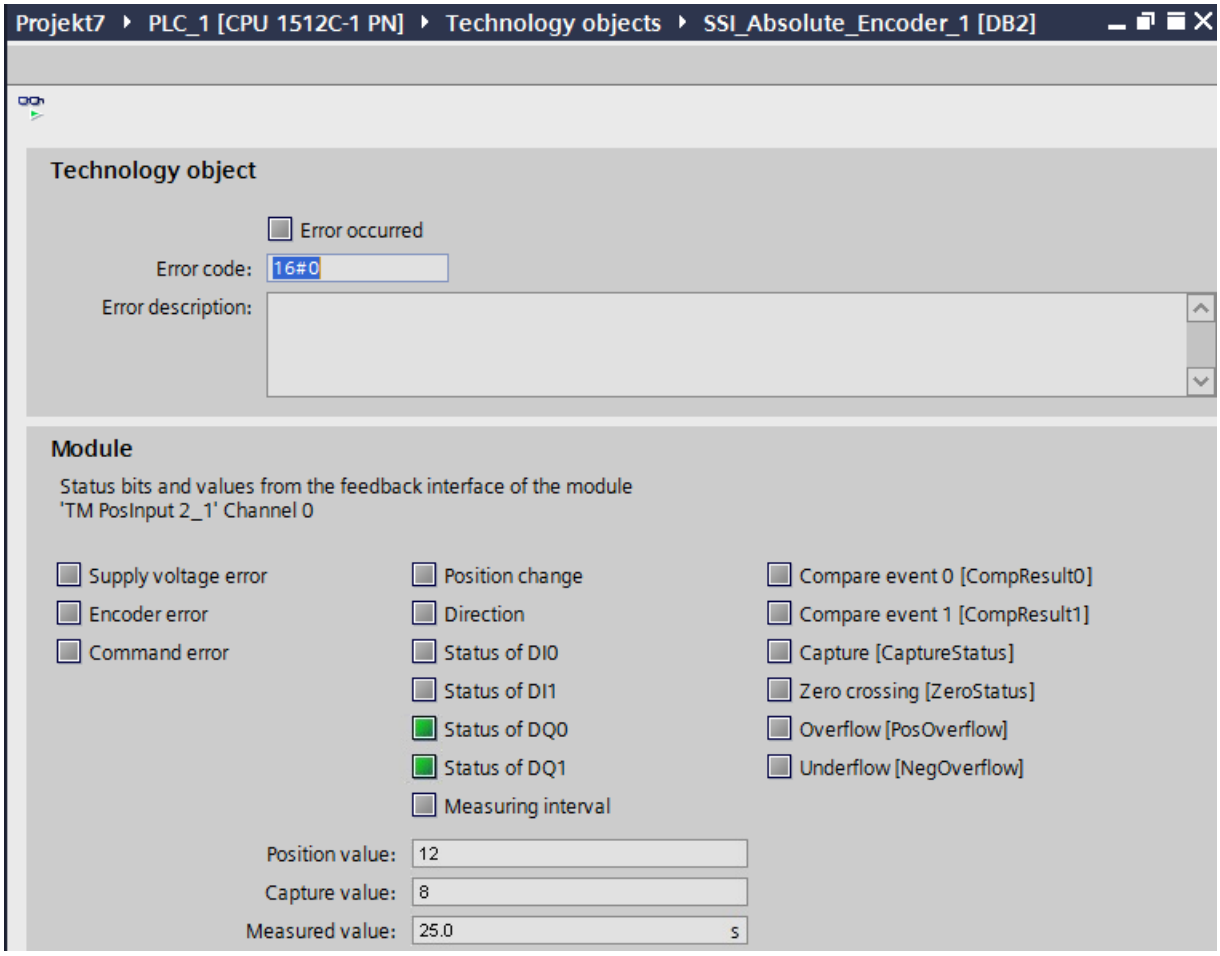

Using the module

6

6.1 Using the technology module

6.1.1 Convention

Technology module: We use the term "technology module" in this documentation both for the technology modules TM Count and TM PosInput and the technology component of the compact CPUs.

6.1.2 Configuring a module

6.1.2.1 Adding a technology module for hardware configuration (TM Count and TM PosInput)

Requirement

- The project has been created.
- The CPU S7-1500 has been created.
- At decentralized operation a distributed I/O ET 200 is created.

Procedure

To add a technology module to the hardware configuration, proceed as follows:

1. Open the device configuration of the CPU or IM.
2. Select a module rack.
3. Select the technology module from the module catalog:
   "Technology module > Counting or Position input > Technology module > Article number"
4. Drag the technology module to the required slot in the module rack.

6.1.2.2 Adding a technology module to hardware configuration (Compact CPU)

Requirement

The project has been created.

Procedure

To add a Compact CPU to the project tree, follow these steps:

1. Double-click "Add new device".
   The "Add new object" dialog opens.
2. Select Controller".
3. Select the Compact CPU:
   "SIMATIC S7-1500 > CPU > Compact CPU > Article number"
4. Confirm with "OK".

Result

The new Compact CPU is displayed with the following objects in the project tree. Double-click to open the required editor.

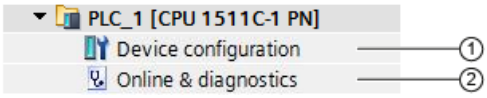

	Object	Description
1	Device configuration (Page 163)	In the Inspector window (per channel): • Activation of the counter (Page 174) • Assign signals to inputs and outputs (Page 174) • Setting the reaction to CPU STOP (Page 164) • Enable diagnostic interrupts (Page 165) • Setting the operating mode (Page 166) • Enable hardware interrupts (Page 171) • Setting the module addresses
2	Online & Diagnostics (Page 216)	• Hardware diagnostics • Obtain information about the Compact CPU • Run firmware update

6.1.2.3 Adding a technology module to the hardware configuration (ET 200eco PN TM PosInput 2)

Requirement

- The project has been created.
- The CPU S7-1500 has been created.

Procedure

To add a technology module to the hardware configuration, proceed as follows:

1. Open the device configuration of the CPU.
2. Select the network view.
3. Select the technology module from the hardware catalog:
   "Distributed I/O systems > ET 200eco PN > Interface modules > Technology modules > Position detection > Module > Article number"
4. Drag-and-drop the technology module to the required location in the network view.

6.1.2.4 Open hardware configuration

Procedure

1. Open the device configuration of the CPU or IM.
2. Select the device view.
3. Click on the module.

6.1.2.5 Parameter assignment options

Counting, measuring and position input with SSI absolute encoder

For the counting and measuring function as well as the position input with an SSI absolute encoder, you have the following alternatives for parameter assignment and control of the technology module:

- Configuration of a technology object and control using the related instruction:

  When using an incremental or pulse encoder, we recommend the simple configuration with graphic support using thee High_Speed_Counter technology object. A detailed description of this configuration can be found in section Technology Object High_Speed_Counter.

  When using an SSI absolute value encoder, we recommend the simple configuration with graphic support using the SSI_Absolute_Encoder technology object. A detailed description of this configuration can be found in section Technology Object High_Speed_Counter.

  For configuration of a technology object, select the operating mode (Page 166) "Operating with "Counting and measurement" technology object".

- Parameter setting via hardware configuration and control via the control and feedback interface of the technology module:

  Select the operating mode (Page 166) "Manual operation (without technology object)" for this.

  A description of the control and feedback interface for TM Count and TM PosInput is available in the following sections:

  Assignment of the control interface (Page 218)

  Assignment of the feedback interface (Page 220)

- Parameter settings via GSD file and control via the control and feedback interface of the technology module.

  A description of the control and feedback interface for TM Count and TM PosInput is available in the following sections:

  Assignment of the control interface (Page 218)

  Assignment of the feedback interface (Page 220)

Position input for Motion Control

Alternatively, you have the option of using the technology module for position input for Motion Control.

Select the operating mode (Page 166) "Position input for "Motion Control" technology object" and assign the parameters of the encoder using the module parameters (Page 167) in the device configuration of the technology module. You perform the rest of the configuration of this application using an axis technology object of S7-1500 Motion Control .

6.1.2.6 Basic parameters

Activate channel (ET 200eco PN TM PosInput 2)

Channel 0/Channel 1

With this parameter, you specify whether the respective channel is used:

Option	Meaning
Deactivated	The channel is not used. The channel cannot trigger any alarms. No addresses are allocated for the channel.
Enabled (default)	The channel is used. Addresses for the control and feedback interface of the channel are allocated.

NOTE

You must use at least one channel.

Reaction to CPU STOP

Reaction to CPU STOP

You set the response of the technology module for each channel to CPU STOP in the basic parameters of the device configuration.

Option	Meaning
Continue operation	The technology module remains fully functional. Incoming count pulses are processed or the actual position is read. The digital outputs continue to switch according to the parameter assignment.
Output substitute value	The technology module outputs the configured substitute values at the digital outputs until the next CPU STOP-RUN transition. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.
Keep last value	The technology module outputs the values at the digital outputs that were valid when the transition to STOP took place until the next CPU STOP-RUN transition. If a digital output with the function "In case of comparison value for a pulse duration" is set at CPU stop, the digital output is reset after expiry of pulse duration. The technology module is returned to its startup state after a STOP-RUN transition: The counter value is set to the Start value (with incremental encoders or pulse encoders) and the digital outputs switch according to the parameter assignment.

Substitute value for DQ0 (TM Count und TM PosInput)

This parameter lets you specify which value the technology module is to output to the digital output DQ0 in the event of a CPU STOP under "Output substitute value".

NOTE

In operating mode "Operating with "Counting and measurement" technology object", you assign this parameter using the technology object.

Substitute value for DQ0 (Compact CPU)

You can use this parameter to specify the value to be output for a STOP of the Compact CPU in the feedback interface for DQ0 in the context of the "Substitute value for DQ0" behavior.

NOTE

In operating mode "Operating with "Counting and measurement" technology object", you assign this parameter using the technology object.

Substitute value for DQ1

This parameter lets you specify which value the technology module is to output to the digital output DQ1 in the event of a CPU STOP under "Output substitute value".

NOTE

In operating mode "Operating with "Counting and measurement" technology object", you assign this parameter using the technology object.

Diagnostic interrupts (TM Count, TM PosInput, EM)

The module can trigger additional diagnostic interrupts when you enable the diagnostic interrupts in the basic parameters. These diagnostic interrupts are processed in an interrupt OB.

Detailed information on the error event is available in the error organization block with the instruction "RALRM" (read alarm supplementary information) and in the Diagnostics function manual (https://support.industry.siemens.com/cs/ww/en/view/59192926), section "System diagnostics by means of the user program".

Enable diagnostic interrupt on wire break

You use this parameter to specify whether a diagnostic interrupt is to be triggered in the event of wire breaks of the utilized signals for the following encoders:

- Push-pull 24 V encoder (Page 70)
- RS422 encoder (Page 72) (additionally monitored for short-circuits and incorrect supply voltage)
- SSI absolute encoder (Page 73) (additionally monitored for short-circuits and incorrect supply voltage)

NOTE

If you use an encoder with a different sensor type or interface standard, wire break cannot be detected.

Enable additional diagnostic interrupts

You use this parameter to specify whether diagnostic interrupts are to be triggered for additional errors.

See the device manual for the module to find out which errors during operation can trigger a diagnostic interrupt.

Diagnostics interrupts (Compact CPU)

Enable diagnostic interrupts

A Compact CPU can trigger diagnostic interrupts for certain faults if you have enabled diagnostic interrupts. These diagnostic interrupts are processed in an interrupt OB.

You use this parameter to determine if the Compact CPU should trigger diagnostic interrupts when a given error occurs.

See the device manual for the Compact CPU to find out which errors can trigger a diagnostic interrupt during operation. The diagnostic interrupts are not enabled in the default setting.

Operating mode

Selection of the operating mode for the channel

This setting defines how the channel counting and measuring functions are to be configured and controlled.

Operating mode	Description
Operating with "Counting and measurement" technology object	A technology object is used for the parameter assignment of the channel. The related instruction for the technology object in the user program provides the access to the control and feedback interfaces of the technology module. You specify the assignment between the technology module/channel and technology object in the basic parameters of the technology object.
Position input for "Motion Control" technology object	The technology module is used for position input for a higher-level Motion Control controller. This operating mode affects all channels of the technology module for TM Count and TM PosInput. Setting the operating mode only affects the given channel of the Compact CPU. Parameter assignment is implemented via the Device configuration of the technology module. Parameter assignment of the encoder signals is implemented by means of the Module parameters (Page 167).
Manual operation (without technology object)	Parameter assignment of the channel is effected via the hardware configuration of the technology module: • Manual operation (incremental or pulse encoder) (Page 175) • Manual operation (SSI absolute encoder) (Page 191) You have direct access to the control and feedback interface of the channel through the user program.
Fast Mode	The technology module is used for very fast acquisition of the counter value or position value. No control interface is available. The parameter setting (hardware configuration) of the module is used for the parameter assignment of the channel. You have direct access to the feedback interface of the channel through the user program.

NOTE

GSD file

When using a GSD file you determine the operating mode via the selection of the module name in the hardware catalog. You can select manual operation or Fast Mode in the process.

Selection of the operating type for the channel

You use this parameter in "Manual operation" to specify the main task for which the channel of the technology module is used. This defines the setting options under "Parameters" (hardware configuration).

Operating mode	Description
Counting (Page 29) / Position input (Page 31)	The main function of the channel is counting or position input. The comparison functions and hardware interrupts work with the counter value or position value. The measured values are available concurrently.
Measuring (Page 59)	The main function of the channel is counting. The comparison functions (Page 56) and hardware interrupts for compare events work with the measured value. The counter value is available concurrently.

NOTE

GSD file

When using a GSD file, you determine the operating mode via the selection of the module name in the hardware catalog.

Module parameters (position input for Motion Control)

In operating mode "Position input for technology object "Motion Control"", the parameters for the encoder signals of the channel are assigned under "Module parameters". The parameters depend on the encoder used.

NOTE

You cannot use this operating mode with a GSD file.

Module parameters for incremental encoders and pulse encoders

If you use an incremental or pulse encoder, you need to configure the following parameters for the encoder signals of the channel.

- Signal type
- Invert direction
- Signal evaluation
- Filter frequency
- Sensor type (for TM Count)
- Interface standard (for TM PosInput)
- Signal selection for reference mark 0
- Measuring input
- Encoder type
- Increments per revolution
- Steps per revolution
- Reference speed
- Distance between increments

- Fine-resolution increment distance
- Reference velocity

You can find a description of the first six parameters in section Counter inputs (Page 175).

Module parameters for SSI absolute encoders

If you use an TM PosInput with an SSI absolute encoder, you need to configure the following parameters for the encoder signals of the channel.

- Signal type
- Invert direction
- Frame length
- Code type
- Transmission rate
- Monoflop time
- Parity
- Bit number LSB of the position value
- Bit number MSB of the position value
- Measuring input
- Encoder type
- Steps per revolution
- Number of revolutions
- Reference speed
- Distance between increments
- Reference velocity

You can find additional information on the first new parameters in section Counter inputs (Page 191).

Signal selection for reference mark 0 (TM Count and TM PosInput)

You can use this parameter to specify the external reference signal upon which a new reference mark is saved for the encoder position.

You can select from the following options:

Option	Meaning
DI0	The current counter value is saved as the new encoder position reference mark upon a positive edge at digital input DI0.
Signal N of incremental encoder (default)	The current counter value is saved as the new encoder position reference mark upon a positive edge of the signal N of incremental encoder.

Signal selection for reference mark 0 (Compact CPU)

You can use this parameter to specify the external reference signal upon which a new reference mark is saved for the encoder position.

You can select from the following options:

Option	Meaning
None	No external reference signal is used.
DI0	The current counter value is saved as the new encoder position reference mark upon a positive edge at digital input DI0.
Signal N of incremental encoder (default[1])	The current counter value is saved as the new encoder position reference mark upon a positive edge of the signal N of incremental encoder.

1 Exceptions: "DI0" is the default for HSC 3 and HSC 6 on the 1511C as well as on the 1512C in compatibility mode

Measuring input (TM Count and TM PosInput)

The parameter specifies that the hardware digital input DI1 serves as a measuring input. For rising, falling or both edges of the DI1, the current counter value or position value is saved as the current encoder position. The value of the parameter cannot be changed.

Measuring input (compact CPU)

This parameter is used to define the hardware input which is used as the external measuring input for saving the encoder position.

You can select from the following options:

Option	Meaning
None (default)	No external measuring input is used.
DI1	The hardware digital input DI1 serves as the measuring input. For rising, falling or both edges of the DI1, the current counter value is saved as current encoder position.

Increments per revolution

With this parameter you specify the line count of the incremental and pulse encoder. The line count can be found in the data sheet for the encoder.

Steps per revolution (incremental and pulse encoder)

The parameter specifies the number of count pulses per encode rotation.

The number of count pulses depends on the increment per rotation and the parameterized signal evaluation.

Example:

Your incremental or pulse encoder delivers 2048 increments per revolution. Depending on the signal evaluation the following value is displayed:

Signal evaluation	Steps per revolution
Single	2048
Double	4096
Quadruple	8192

Steps per revolution (SSI absolute encoder)

With this parameter you define the number of increments the SSI absolute encoder supplies per revolution.

Number of revolutions

The parameter specifies how many rotations the value range of the SSI absolute encoder encompasses.

The value is calculated from the parameterized values for the bit numbers LSB and MSB of the position value as well as the steps per revolution.

Reference speed

The encoder transmits the process value of the speed as a percentage of the reference speed. This parameter defines the speed in rpm which is to be correspond to the value 100 % . The reference speed must be identical to the setting in the controller.

You can enter a value between 6.00 and 210000.00. The default setting is "3000.00 rpm".

Encoder type

You can use this parameter to specify whether the encoder records linear or rotatory movements. The encoder type must be identical to the setting in the controller.

The default setting is "Rotary".

Distance between increments

You can use this parameter to specify the distance between two increments of the encoder in nm.

The value must be identical to the setting in the controller.

Fine-resolution increment distance

The parameter specifies the distance between two count pulses in nm.

The value depends on the distance between two increments and the configured signal evaluation.

Example:

Your incremental or pulse encoder has an incremental distance of 16000 nm. Depending on the signal evaluation the following value is displayed:

Signal evaluation	Fine-resolution increment distance
Single	16000.00 nm
Double	8000.00 nm
Quadruple	4000.00 nm

Reference velocity

The encoder transmits the process value of the velocity as a percentage of the reference velocity. This parameter defines the velocity in m/min which corresponds to a value of 100%.

You can enter a value between 0.60 and 600.00. The default setting is "16.00 m/min".

Further configuring

You can perform the further configuration by using an axis or measuring input technology object of S7-1500 Motion Control . See the S7-1500 Motion Control (https://support.industry.siemens.com/cs/ww/en/view/59381279) and S7-1500T Motion Control (https://support.industry.siemens.com/cs/ww/en/view/109481326) function manuals for further details on configuring and commissioning position input and the measuring input technology object.

See also

Position detection for Motion Control (Page 69)

Hardware interrupts

You can set for each channel the events which are to trigger a hardware interrupt during operation when assigning the basic parameters of the technology module.

In an S7-1500 system, you enter a matching event name for each enabled hardware interrupt and assign a corresponding hardware interrupt OB to each hardware interrupt. If a hardware interrupt is triggered, the corresponding OB is started to evaluate the hardware interrupt data.

NOTE

In the following cases you can only release only *one* hardware interrupt per module.

- Distributed operation with an S7-300/400 CPU
- Use of a GSD file

You cannot release a hardware interrupt in the following cases:

- Distributed operation with ET 200eco PN M12-L

A hardware interrupt is triggered if the condition for changing the respective status bit or event bit in the feedback interface is fulfilled.

Lost hardware interrupt

If the hardware interrupts are triggered more quickly by the system than they can be acknowledged, hardware interrupts are lost and the "Hardware interrupt" diagnostic interrupt is signaled.

Hardware interrupts that can be activated

Hardware interrupt	Available in counting mode using		Available in measuring mode using		Available in operating mode Position input for "Motion Control" technology object	Description	Event Type number
	Incremental or pulse encoder	SSI absolute encoder	Incremental or pulse encoder	SSI absolute encoder			
New Capture value available	Yes	Yes	No	No	No	Hardware interrupt when current counter value or position value is saved as Capture value	1000_B
Synchronization of the counter by an external signal	Yes	No	Yes	No	No	Hardware interrupt upon synchronization of the counter by signal N or DI edge	1001_B
Gate start	Yes	No	Yes	No	No	Hardware interrupt when internal gate opens	0001_B
Gate stop	Yes	No	Yes	No	No	Hardware interrupt when internal gate closes	0010_B
Overflow (high counting limit violated)	Based on counter value	No	Based on counter value	No	No	Hardware interrupt when counter value exceeds high counting limit	0011_B
Underflow (low counting limit violated)	Based on counter value	No	Based on counter value	No	No	Hardware interrupt when counter value falls below low counting limit	0100_B
Change of direction[1]	Based on counter value	Based on position value	Based on counter value	Based on position value	No	Hardware interrupt when counter value or position value changes direction	1010_B
Zero crossing	Based on counter value	Based on position value	Based on counter value	Based on position value	No	Hardware interrupt with zero crossing of counter value or position value	0111_B
Comparison event for DQ0 occurred	Based on counter value	Based on position value	Based on measured value	Based on measured value	No	Hardware interrupt when a comparison event for DQ0 occurs as a result of the selected comparison condition. No hardware interrupt when the change of the counter value for an incremental or pulse encoder was not caused by a count pulse	0101_B

[1] The STS_DIR feedback bit has a default of "0". A hardware interrupt is not triggered when the first change to the counter value or position value immediately after the technology module is switched on is in the down direction.

Hardware interrupt	Available in counting mode using		Available in measuring mode using		Available in operating mode Position input for "Motion Control" technology object	Description	Event Type number
	Incremental or pulse encoder	SSI absolute encoder	Incremental or pulse encoder	SSI absolute encoder			
Comparison event for DQ1 occurred	Based on counter value	Based on position value	Based on measured value	Based on measured value	No	Hardware interrupt when a comparison event for DQ1 occurs as a result of the selected comparison condition. No hardware interrupt when the change of the counter value for an incremental or pulse encoder was not caused by a count pulse	0110_B

[1] The STS_DIR feedback bit has a default of "0". A hardware interrupt is not triggered when the first change to the counter value or position value immediately after the technology module is switched on is in the down direction.

Default setting

No hardware interrupts are enabled in the default setting.

6.1.2.7 Additional parameters for Compact CPU

Introduction

When using a Compact CPU, the following parameters are additionally available for the signals of the high-speed counter.

Compatibility 1511C (high-speed counters of Compact CPU 1512C-1 PN)

Front connector assignment same as CPU 1511C

You can use this parameter to specify if the pin assignment for the front connector of the CPU 1511C-1 PN is to be used for the high-speed counter of the CPU 1512C-1 PN:

Option	Meaning
Disabled (default)	CPU 1512C-1 PN uses the pin assignment of the onboard front connector. 1512C-1 PN supports the use of the connections of both front connectors of the digital onboard I/Os for the high-speed counter. The assignment of hardware inputs and outputs for the HSC channels is described in the CPU 1512C-1 PN manual.
Enabled	CPU 1512C-1 PN uses the pin assignment of the front connector of the CPU 1511C-1 PN. 1511C-1 PN supports the use of the connections of the first front connector of the digital onboard I/Os for the high-speed counter. The assignment of hardware inputs and outputs for the HSC channels is described in the CPU 1511C-1 PN manual.

General

Activate this high-speed counter

You can use this parameter to specify whether the respective high speed counter is to be used:

Option	Meaning
Disabled (default)	The high-speed counter is not used. The counter uses no connections of the onboard front connector and can not trigger interrupts. Writing to its control interface is ignored and its feedback interface returns zero values.
Enabled	The high-speed counter is used. The assignment of HSC addresses to the connections of the onboard front connector is described in the device manual of the Compact CPU.

Hardware inputs/outputs

Clock generator input (A) / Pulse input (A) / Clock generator forward (A)

This parameter specifies which input is used for the encoder signal A for the respective counter. The value cannot be changed.

Clock generator input (B) / Pulse input (B) / Clock generator forward (B)

If you use an encoder with multiple signals for the respective counter, this parameter specifies which input is used for the encoder signal B. The value cannot be changed.

Reset input (N)

If you use an incremental encoder for the respective counter, this parameter specifies which input is used for the reset input (encoder signal N). The value cannot be changed.

HSC DI0 / HSC DI1

This parameter determines which digital input of the Compact CPU is to be used as the DIm of the counter.

NOTE

You can configure the input delay for a digital input in the Inspector window of the device configuration under "Properties > DI 16/DQ 16 > Inputs > Channel n".

HSC DQ0

You can read the status of the DQ0 via the feedback interface. You cannot assign DQ0 to a physical digital output of the Compact CPU.

HSC DQ1

This parameter determines which digital output of the Compact CPU is to be used as DQ1. You can select an output with an output delay of 5 µs or 500 µs.

You can find an overview of the output delay for all digital outputs in the device manual of the Compact CPU.

6.1.2.8 Manual operation (incremental or pulse encoder)

Counter inputs

Signal type

You can choose from the following signal types (Page 70):

Signal type	Meaning	Additional option-specific parameters
Incremental encoder (A, B phase-shifted)	An incremental encoder with phase-shifted A and B signals is connected.	• Invert direction • Signal evaluation • Filter frequency • Sensor type or Interface standard
Incremental encoder (A, B, N)	An incremental encoder with phase-shifted signals A and B and a zero signal N is connected.	• Invert direction • Signal evaluation • Filter frequency • Sensor type or Interface standard • Reaction to signal N • Frequency of synchronization • Frequency of the Capture function
Pulse (A) and direction (B)	A pulse encoder (signal A) with direction signal (signal B) is connected.	• Filter frequency • Sensor type or Interface standard
Pulse (A)	A pulse encoder (signal A) without direction signal is connected. You can specify the counting direction by means of the control interface (Page 218).	• Filter frequency • Sensor type or Interface standard
Count up (A), count down (B)	Signals for counting up (signal A) and down (signal B) are connected.	• Filter frequency • Sensor type or Interface standard

Invert direction

You can invert the counting direction to adapt it to the process.

The inverting of the direction can be configured and active for the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Signal evaluation

By configuring signal evaluation (Page 74), you can specify which edges of the signals are counted.

You can select from the following options:

Signal evaluation	Meaning
Single (default)	The edges of signal A are evaluated during a low level of signal B.
Double	Each edge of signal A is evaluated.
Quadruple	Each edge of signals A and B is evaluated.

The parameter can be assigned with the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Filter frequency

By configuring the filter frequency, you suppress interferences at the counter inputs A, B and N.

The selected filter frequency is based on a pulse/break ratio of between around 40:60 and around 60:40. This results in a specific minimum pulse/break time. Signal changes with a duration shorter than the minimum pulse/break time are suppressed.

You can select from the following filter frequencies:

Filter frequency	Minimum pulse/break time
100 Hz	4.0 ms
200 Hz	2.0 ms
500 Hz	800 µs
1 kHz	400 µs
2 kHz	200 µs
5 kHz	80 µs
10 kHz	40 µs
20 kHz	20 µs
50 kHz	8.0 µs
100 kHz (default for Compact CPU)	4.0 µs
200 kHz[2] (default for TM Count and ET 200eco PN TM PosInput 2)	2.0 µs
500 kHz[1]	0.8 µs
1 MHz[1] (default for TM PosInput)	0.4 µs

1 Only available with TM PosInput

2 Not available with Compact CPU

Sensor type (TM Count)

By configuring the sensor type, you specify how the counter inputs are switched for the TM Count.

You can select from the following options:

Sensor type	Meaning
Sourcing output (default)	The encoder/sensor switches the inputs A, B and N to 24VDC.
Sinking output	The encoder/sensor switches the inputs A, B and N to M.
Push-pull (sinking and sourcing output)	The encoder/sensor alternately switches the inputs A, B and N to M and 24VDC.

"Push-pull" is usually selected when incremental encoders are used. If using 2-wire sensors, such as light barriers or proximity switches, you need to select the corresponding wiring "Sourcing output" or "Sinking output".

The data sheet of the encoder includes information on whether your incremental encoder is a push-pull encoder.

NOTE

If you use a push-pull encoder and the sensor type "Push-pull (sinking and sourcing output)" is configured, you can monitor the encoder signals for wire break.

Sensor type (Compact CPU)

The "Sourcing output" sensor type is set for the Compact CPU and cannot be changed. The encoder or sensor switches the inputs A, B and N to 24V DC.

You can operate both sourcing output encoders and push-pull encoders on the Compact CPU. You can find additional information on the sensor type in the data sheet for the encoder.

Sensor type (ET 200eco PN TM PosInput 2)

By configuring the sensor type, you specify how the counter inputs are switched for the ET 200eco PN TM PosInput 2.

You can select from the following options:

Sensor type	Meaning
Sourcing output (default)	The encoder or sensor switches the inputs A, B and N to $1U_{Sx}$.
Sinking output	The encoder or sensor switches the inputs A, B and N to 1M.
Push-pull (sinking and sourcing output)	The encoder or sensor switches the inputs A, B and N alternately to 1M and $1U_{Sx}$.

"Push-pull" is usually selected when incremental encoders are used. If using 2-wire sensors, such as light barriers or proximity switches, you need to select the corresponding wiring "Sourcing output" or "Sinking output".

The data sheet of the encoder includes information on whether your incremental encoder is a push-pull encoder.

This parameter can only be configured if you have selected "24 V, asymmetrical" as the interface standard.

NOTE

If you use a push-pull encoder and the sensor type "Push-pull (sinking and sourcing output)" is configured, you can monitor the encoder signals for wire break.

Interface standard (TM PosInput)

You use this parameter to specify whether the encoder outputs symmetric (RS422) or asymmetric (TTL) signals for the TM PosInput.

You can select from the following options:

Interface standard	Meaning
RS422, symmetrical (default)	The encoder outputs symmetric signals according to the RS422 standard (Page 72).
TTL (5 V), asymmetrical	The encoder outputs asymmetric 5 V signals according to the TTL standard (Page 70).

NOTE

The RS422 standard provides greater interference immunity than the TTL standard. Therefore, if your incremental or pulse encoder supports the RS422 **and** the TTL standard, it is recommended to use the RS422 signal standard.

Interface standard (ET 200eco PN M12-L TM PosInput 2)

You use this parameter to specify whether the encoder outputs symmetrical (RS422) or asymmetrical (24 V) signals for the ET 200eco PN M12-L TM PosInput 2. You can select from the following options:

Interface standard	Meaning
RS422, symmetrical (default)	The encoder outputs symmetric signals according to the RS422 standard (Page 72).
24 V, asymmetrical	The encoder outputs asymmetric 24 V signals according to the TTL standard (Page 70).

Reaction to signal N

You use this parameter to specify which reaction is triggered to signal N.

You can select from the following options:

Option	Meaning
No reaction to signal N (default)	The counter is not affected by signal N.
Synchronization at signal N (Page 46)	The counter is set to the start value at signal N. If you select the function "Enable synchronization at signal N" for a digital input, the synchronization depends on the level at the digital input.
Capture at signal N (Page 37)	The counter value is stored in the Capture value at signal N. The use of a digital input and the use of the N signal are not mutually exclusive for the Capture function. The technology object displays the Capture value at the output parameter CapturedValue.

NOTE

You can only select the reaction to signal N if you have selected the "Incremental encoder (A, B, N)" signal type.

NOTE

If "Synchronization at signal N" is selected, you can select the function "Enable synchronization at signal N" for a digital input (Page 181).

NOTE

For High_Speed_Counter as of V3.0, the following applies:

You can choose "Capture at signal N" only in operating mode "Use count value as reference":

Frequency of synchronization

This parameter is used to define the frequency of the following events:

- Synchronization at signal N
- Synchronization as a function of a digital input

You can select from the following options:

Option	Meaning
Once (default)	The counter is only set at the first signal N or the first configured edge of the digital input.
Periodic	The counter is set at each signal N or each configured edge of the digital input.

Frequency of the Capture function

This parameter is used to define the frequency of Capture events for the following functions:

- Capture at Signal N
- Capture as function of a digital input

You can select from the following options:

Option	Meaning
Once	The first configured edge at the respective digital input or first rising edge of the N signal saves the current counter value as a Capture value.
Periodic (default)	Each configured edge at the respective digital input or each rising edge of the N signal saves the current counter value as a Capture value.

Counting limits and start value

High counting limit

You limit the counting range by setting the high counting limit. You can enter a value up to 2147483647 (2^{31}-1). You must enter a value that lies above the low counting limit.

The default setting is "2147483647".

Low counting limit

You limit the counting range by setting the low counting limit. You can enter a value up to -2147483648 (-2^{31}). You must enter a value below the high counting limit.

The default setting is "-2147483648".

Start value

By configuring the start value, you specify the value at which counting is to start and where it is to continue in the case of defined events. You must enter a value between the counting limits or equal to the counting limits.

The default setting is "0".

Additional information

For more information, see Behavior at the counting limits (Page 33) and Counter behavior at gate start (Page 36).

Counter behavior at limits and gate start

Reaction to violation of a counting limit

You can configure the following characteristics for violation of a counting limit (Page 33):

Reaction	Meaning
Stop counting	If a counting limit is violated, counting is stopped and the internal gate is closed. To restart counting, you must also close and reopen the software/hardware gate.
Continue counting (default)	Counting continues either with the start value or at the opposite counting limit, depending on the additional parameter assignment.

Reset when counting limit is violated

You can reset the counter to the following values when a counting limit is violated:

Reset the value	Meaning
To start value	The counter value is set to the start value.
To opposite counting limit (default)	The counter value is set to the opposite counting limit.

Reaction to gate start

You can set the following Reaction to gate start (Page 36):

Reaction	Meaning
Set to start value	When the gate is opened, the counter value is set to the start value.
Continue with current value (default)	When the gate is opened, counting is continued with the last counter value.

Behavior of a DI

Set function of DI

By configuring a digital input, you specify which functions the digital input triggers at switching.

You can select from the following options:

Function of a digital input	Meaning	Additional option-specific parameters
Gate start/stop (level-triggered)	The level at the respective digital input opens and closes the hardware gate (Page 35).	• Input delay • Select level
Gate start (edge-triggered)	The configured edge at the respective digital input opens the hardware gate (Page 35).	• Input delay • Edge selection
Gate stop (edge-triggered)	The configured edge at the respective digital input closes the hardware gate (Page 35).	• Input delay • Edge selection

Function of a digital input	Meaning	Additional option-specific parameters
Synchronization (Page 41)	The configured edge at the respective digital input sets the counter to the start value. The EVENT_SYNC feedback bit indicates whether a synchronization has occurred.	• Input delay • Edge selection • Frequency of synchronization
Enable synchronization at signal N	The active level at the respective digital input enables synchronization of the counter at signal N (Page 46).	• Input delay • Select level
Capture	The configured edge at the respective digital input saves the current counter value (Page 37) as a Capture value. The use of a digital input and the use of the N signal are not mutually exclusive for the Capture function. The CAPTURED_VALUE value in the feedback interface indicates the Capture value.	• Input delay • Edge selection • Frequency of the Capture function • Behavior of counter value after Capture
Digital input without function	No technological function is assigned to the respective digital input. You can read the signal state of the digital input via the respective feedback bit (number of digital inputs depends on the module): • STS_DI0 • STS_DI1 • STS_DI2	• Input delay

NOTE

With the exception of "Digital input without function", each function can only be used once for each counter, and if used for one digital input is not available to the others.

Input delay (TM Count and TM PosInput)

You use this parameter to suppress signal interference at the digital inputs. Changes to the signal are only detected if they remain stable for longer than the configured input delay time.

You can select from the following input delays:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

NOTE

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

NOTE

You configure the input delay under "Behavior of DI0" for all digital inputs together. The input delay is also displayed under "Behavior of DI1" and for TM Count also under "Behavior of DI2".

Input delay (Compact CPU)

You use this parameter to suppress interference at the digital inputs of the DIn signals. Changes to the signal are only detected if they remain stable for longer than the configured input delay time.

You can configure the input delay for a digital input of a Compact CPU in the Inspector window of the device configuration under "Properties > DI 16/DQ 16 > Inputs > Channel n".

You can select from the following input delays:

- None
- 0.05 ms
- 0.1 ms
- 0.4 ms
- 1.6 ms
- 3.2 ms (default)
- 12.8 ms
- 20 ms

NOTE

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

Select level

You use this parameter to specify the level at which the digital input is active.

You can select from the following options:

Level	Meaning
Active with high level (default)	The respective digital input is active when it is set.
Active with low level	The respective digital input is active when it is not set.

The parameter can be set for the following functions of a digital input:

- Gate start/stop (level-triggered)
- Enable synchronization at signal N

Edge selection

You can use this parameter to specify the edge of the digital input at which the configured function is triggered.

The following options may be available depending on the function selected:

- At rising edge (default)
- At falling edge
- At rising and falling edge

The parameter can be set for the following functions of a digital input:

- Gate start (edge-triggered)
- Gate stop (edge-triggered)
- Synchronization
- Capture

NOTE

"At rising and falling edge" can only be configured for the "Capture" function.

Frequency of synchronization

This parameter is used to define the frequency of the following events:

- Synchronization at signal N
- Synchronization as a function of a digital input

You can select from the following options:

Option	Meaning
Once (default)	The counter is only set at the first signal N or the first configured edge of the digital input.
Periodic	The counter is set at each signal N or each configured edge of the digital input.

Frequency of the Capture function

This parameter is used to define the frequency of Capture events for the following functions:

- Capture at Signal N
- Capture as function of a digital input

You can select from the following options:

Option	Meaning
Once	The first configured edge at the respective digital input or first rising edge of the N signal saves the current counter value as a Capture value.
Periodic (default)	Each configured edge at the respective digital input or each rising edge of the N signal saves the current counter value as a Capture value.

Behavior of counter value after Capture

You can configure the following characteristics for the counter after a capture event (Page 37):

Reaction	Meaning
Continue counting (default)	After saving the current counter value as Capture value, counting is continued unchanged.
Set to start value and continue counting	After saving the current counter value as Capture value, counting is continued with the start value.

Behavior of a DQ

Set output

With the parameter assignment of a digital output, you specify the condition upon which the digital output switches.

You can select from the following options:

Function of a digital output (Page 49) **in the operating mode "Counting"**	**Meaning**	**Additional option-specific parameters**
Between comparison value and high limit (default)	The respective digital output is active if: Comparison value <= counter value <= high counting limit	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value and low limit	The respective digital output is active if: Low counting limit <= counter value <= comparison value	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= counter value <= comparison value 1	• Comparison value 0 • Comparison value 1 • Count direction • Hysteresis (in increments)
At comparison value for a pulse duration	The respective digital output is active once for the configured time and count direction when the counter value reaches the comparison value.	• Comparison value 0 • Comparison value 1 • Count direction • Pulse duration • Hysteresis (in increments)
After set command from CPU until comparison value	When a set command is sent from the CPU, the respective digital output is active until the counter value is equal to the comparison value.	• Comparison value 0 • Comparison value 1 • Count direction • Hysteresis (in increments)
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 48).	—

NOTE

DQ0 of a counter of a Compact CPU

With a Compact CPU, the respective digital output DQ0 is available via the feedback interface, but not as a physical output.

NOTE

You can only select the "Between comparison value 0 and 1" function for digital output DQ1 and only if you have selected the "Use by user program" function for digital output DQ0.

NOTE

The "At comparison value for a pulse duration" and "After set command from CPU until comparison value" functions only switch the digital output in question if a count pulse reaches the comparison value. When the counter value is set, e.g. by synchronization, the digital output does not switch.

Function of a digital output (Page 56) **in the operating mode "Measuring"**	**Meaning**	**Additional option-specific parameters**
Measured value >= comparison value (default)	The respective digital output is active if the measured value is greater than or equal to the comparison value.	• Comparison value 0 • Comparison value 1
Measured value <= comparison value	The respective digital output is active if the measured value is less than or equal to the comparison value.	• Comparison value 0 • Comparison value 1
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= measured value <= comparison value 1	• Comparison value 0 • Comparison value 1
Not between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 1 <= measured value <= comparison value 0	• Comparison value 0 • Comparison value 1
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 48).	—

NOTE

You can select the "Between comparison value 0 and 1" and "Not between comparison value 0 and 1" functions only for digital output DQ1 and only if you have selected the "Use by user program" function for digital output DQ0.

Comparison value 0 (TM Count and TM PosInput)

Operating mode "Counting":

With the parameter assignment of the comparison value (Page 49), you specify the counter value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter an integer (DINT) that is greater than or equal to the low counting limit. If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "0".

Operating mode "Measurement":

With the parameter assignment of the comparison value (Page 56), you specify the measured value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter a floating point number (REAL). If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The minimum value is -7.922816×10^{28}. The default setting is "0.0". The unit of the comparison value depends on the measured variable.

Comparison value 0 (compact CPU)

Operating mode "Counting":

With the parameter assignment of the Comparison value (Page 49), you specify the counter value at which the STS_DQ0 bit is set in the feedback interface of the selected comparison event. The digital output DQ0 is not available as a physical output in a Compact CPU.

You must enter an integer (DINT) that is greater than or equal to the low counting limit. If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "0".

Operating mode "Measurement":

With the parameter assignment of the Comparison value (Page 56), you specify the measured value at which the STS_DQ0 bit is set in the feedback interface of the selected comparison event. The digital output DQ0 is not available as a physical output in a Compact CPU.

You must enter a floating point number (REAL). If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The minimum value is -7.922816×10^{28}. The default setting is "0.0". The unit of the comparison value depends on the measured variable.

Comparison value 1

Operating mode "Counting":

With the parameter assignment of the comparison value (Page 49), you specify the counter value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter an integer (DINT) that is less than or equal to the high counting limit. If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "10".

Operating mode "Measurement":

With the parameter assignment of the comparison value (Page 56), you specify the measured value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter a floating point number (REAL). If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The maximum value is 7.922816×10^{28}. The default setting is "10.0". The unit of the comparison value depends on the measured variable.

Count direction

You use this parameter to specify the count direction for which the selected function is valid.

You can select from the following options:

Count direction	Meaning
In both directions (default)	The comparison and switching of the respective digital output take place regardless of the count direction.
Up	The comparison and switching of the respective digital output only takes place when the counter counts up.
Down	The comparison and switching of the respective digital output only takes place when the counter counts down.

The parameter can be configured for the following functions:

- Between Comparison value 0 and 1 (Operating mode "Counting")
- At comparison value for a pulse duration
- After set command from CPU until comparison value

Pulse duration

By configuring the pulse duration for the function "At comparison value for a pulse duration", you specify the number of milliseconds for which the respective digital output is active.

If you enter "0" and the counter value corresponds to the comparison value, the digital output remains active until the next count pulse.

A value from 0.0 to 6553.5 ms is permissible.

The default setting is "500.0", which is equivalent to a pulse duration of 0.5 s.

Hysteresis (in increments)

By configuring the hysteresis (Page 65), you can define a range around the comparison values. For the functions "Between comparison value and high limit" and "Between comparison value and low limit", the hysteresis also applies at the counter limits. Within the hysteresis range, the digital outputs cannot switch again until the counter value is outside the range.

Choose a small enough hysteresis. When the hysteresis range, starting from the configured comparison value, spans the entire counting range, proper functioning of the comparison values cannot be guaranteed.

Regardless of the hysteresis value, the hysteresis range ends at the low or high counting limit.

If you enter "0", the hysteresis is turned off. You can enter a value between 0 and 255. The default setting is "0".

NOTE

The hysteresis is only available in operating mode "Counting".

Specifying the measured value

Measured variable

This parameter is used to specify the measured variable (Page 59) to be provided by the technology module. The MEASURED_VALUE value in the feedback interface indicates the measured value.

You can select from the following options:

Measured variable	Meaning	Additional option-specific parameters
Frequency (default)	The measured variable shows the number of increments per second. The value is a floating point number (REAL). The unit is Hz.	• Update time
Period	The measured variable is the average period between two increments. The value is an integer (DINT). The unit is s.	• Update time
Velocity	The measured variable is a velocity. Examples of a velocity measurement can be found in the explanation of the "Increments per unit" parameter.	• Update time • Time base for velocity measurement • Increments per unit

Update time

By configuring the update time (Page 59) in milliseconds, you can specify the time interval between two measured value updates.

The update time and the signal type (Page 175) effect the accuracy of the measurement. In the case of update times of at least 100 ms, the effect of the signal type is negligible.

In the case of update times of less than 100 ms, you achieve maximum measurement accuracy using the following signal types:

- Incremental encoder (A, B phase-shifted) with Signal evaluation "Single"
- Incremental encoder (A, B, N) with Signal evaluation "Single"
- Pulse (A) and direction (B)
- Pulse (A)

In the case of other signal types, measurement accuracy depends on the encoder and cable used.

If you enter "0", the measured value is updated once per module-internal cycle. Up to three decimal places can be entered. A value from 0.0 to 25000.0 is permissible. The default setting is "10.0".

Time base for velocity measurement

This parameter defines the time base on which the velocity is to be returned.

You can select from the following options:

- 1 ms
- 10 ms
- 100 ms
- 1 s
- 60 s

The default setting is "60 s".

Increments per unit

You can use this parameter to define the number of count pulses per relevant unit that the incremental or absolute encoder supplies for the velocity measurement.

The number of count pulses depends on the configured signal evaluation. You can enter a value between 1 and 65535.

Example 1:

You encoder delivers 4000 count pulses for travel over one meter. The velocity is to be measured in meters per second. "Double" is configured as signal evaluation.

In this case, you need to assign the following parameters:

- Increments per unit: 8000
- Time base for velocity measurement: 1 s

Example 2:

Your encoder delivers 4096 count pulses per revolution. The velocity is to be measured in revolutions per minute. "Single" is configured as the signal evaluation.

In this case, you need to assign the following parameters:

- Increments per unit: 4096
- Time base for velocity measurement: 60 s

6.1.2.9 Manual operation (SSI absolute encoder)

Counter inputs

Signal type

If an SSI absolute encoder with the data signal (Signal ID) and cycle signal (Signal C) is connected, select the signal type (Page 73) "Absolute encoder (SSI)".

Invert direction

You can use this parameter to invert the values supplied by the SSI absolute encoder. This allows you to adapt the detected direction of the encoder to the motor's direction of rotation.

NOTE

This parameter acts only on the range from the LSB to the MSB of the position value in the frame.

Frame length

With the parameter assignment of the frame length, you specify the number of bits of an SSI frame of the SSI absolute encoder (Page 31) used. You can find the frame length of your SSI absolute encoder in the data sheet of the encoder. Special bits are also included in the frame length. A parity bit does not count in the frame length.

A frame length of between 10 bits and 40 bits is permitted. The default setting is "13 Bit".

You can find two examples of the SSI frame format at Examples of the frame format (Page 147).

Code type

You use the parameter assignment of the code type to specify whether the encoder supplies Dual code or Gray code.

You can select from the following options:

Code type	Meaning
Gray (default)	The gray-coded position value returned by the SSI absolute encoder is converted to dual code.
Dual	The value returned by the SSI absolute encoder is not converted.

Transmission rate

With the parameter assignment of the transmission rate, you specify the data transmission rate between the technology module and the SSI absolute encoder.

You can select from the following options:

- 125 kHz (preset)
- 250 kHz
- 500 kHz
- 1 MHz
- 1.5 MHz
- 2 MHz

The maximum transmission rate depends on the cable length and the technical specifications of the SSI absolute encoder. For additional information, refer to the product manual of the TM PosInput and the encoder description.

Monoflop time

With the parameter assignment of the monoflop time, you specify the idle time between two SSI frames.

The configured monoflop time must be at least equal to the monoflop time of the SSI absolute encoder used. You can find this value in the technical specifications of the SSI absolute encoder.

You can select from the following options:

- Automatically (default)
- 16 µs
- 32 µs
- 48 µs
- 64 µs

NOTE

If you select the "Automatic" option, the monoflop time automatically adapts to the encoder used.

In isochronous mode, the "Automatic" option corresponds to a monoflop time of 64 µs. If the monoflop time of the employed SSI absolute value encoder is less than 64 µs, you can select the value of the encoder to achieve faster isochronous times.

Parity

With the parameter assignment of the parity, you specify whether the SSI absolute encoder transfers a parity bit.

If, for example, a 25-bit encoder with parity is assigned, the technology module reads 26 bits. A parity error is reported in the feedback interface by means of the ENC_ERROR bit.

Bit number LSB of the position value

This parameter is used to specify the bit number of the LSB (least significant bit) of the position value in the frame of the SSI absolute encoder. In this way you limit the range in the frame that supplies the position value.

The value must be less than the bit number of the MSB of the position value. The difference between the bit numbers of the MSB and the LSB of the position value must be less than 32.

The default setting is "0".

NOTE

If you have selected the Code type "Gray", only the range from the LSB to the MSB of the position value is converted to binary code.

Bit number MSB of the position value

This parameter is used to specify the bit number of the MSB (most significant bit) of the position value in the frame of the SSI absolute encoder. In this way you limit the range in the frame that supplies the position value.

The value must be less than the frame length and higher than the bit number of the LSB of the position value. The difference between the bit numbers of the MSB and the LSB of the position value must be less than 32.

The default setting is "12".

NOTE

If you have selected the Code type "Gray", only the range from the LSB to the MSB of the position value is converted to binary code.

Behavior of a DI

Setting function of the DI

By configuring a digital input, you specify which functions the digital input triggers at switching.

You can select from the following options:

Function of a digital input	Meaning	Additional option-specific parameters
Capture (Page 40)	The configured edge at the respective digital input saves the current position value as a Capture value. The CAPTURED_VALUE feedback bit indicates the capture value. The function can only be used for one of the two digital inputs.	• Input delay • Edge selection • Frequency of the Capture function
Digital input without function	No technological function is assigned to the respective digital input. You can read the signal state of the digital input via the respective feedback bit: • STS_DI0 • STS_DI1	• Input delay

NOTE

You can choose the "Capture" function only in operating mode "Use position value (SSI absolute value) as reference".

Input delay

By configuring the input delay, you suppress interferences at the digital inputs. Signals with a pulse duration below the configured input delay are suppressed.

You can select from the following input delays:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

NOTE

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

NOTE

You configure the input delay under "Behavior of DI0" for all digital inputs together. The input delay is also displayed under "Behavior of DI1".

Edge selection

You can use this parameter to specify the edge of the digital input at which the configured function is triggered for the "Capture" function.

You can select from the following options:

- At rising edge (default)
- At falling edge
- At rising and falling edge

Frequency of the Capture function

This parameter is used to define the frequency of Capture events (Page 40):

You can select from the following options:

Option	Meaning
Once	The first configured edge at the respective digital input saves the current counter value as Capture value.
Periodic (default)	Each configured edge at the respective digital input saves the current counter value as a Capture value.

Behavior of a DQ

Set output

With the parameter assignment of a digital output, you specify the condition upon which the digital output switches.

You can select from the following options depending on the operating mode:

Function of a digital output (Page 53) **in the operating mode "Position input"**	**Meaning**	**Additional option-specific parameters**
Between comparison value and high limit (default)	The respective digital output is active if: Comparison value <= position value <= maximum position value	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value and low limit	The respective digital output is active if: Minimum position value <= Position value <= Comparison value	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= position value <= comparison value 1	• Comparison value 0 • Comparison value 1 • Count direction • Hysteresis (in increments)
At comparison value for a pulse duration	The respective digital output is active once for the assigned time and direction of the position value change when the position value is equal to the comparison value or has fallen below or exceeded it.	• Comparison value 0 • Comparison value 1 • Count direction • Pulse duration • Hysteresis (in increments)
After set command from CPU until comparison value	When a set command is sent from the CPU, the respective digital output is active for the assigned direction of the position value change until the position value is equal to the comparison value or has fallen below or exceeded it.	• Comparison value 0 • Comparison value 1 • Count direction • Hysteresis (in increments)
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 48).	—

NOTE

You can only select the "Between comparison value 0 and 1" function for digital output DQ1 and only if you have selected the "Use by user program" function for digital output DQ0.

Function of a digital output (Page 56) **in the operating mode "Measuring"**	**Meaning**	**Additional option-specific parameters**
Measured value >= comparison value (default)	The respective digital output is active if the measured value is greater than or equal to the comparison value.	• Comparison value 0 • Comparison value 1
Measured value <= comparison value	The respective digital output is active if the measured value is less than or equal to the comparison value.	• Comparison value 0 • Comparison value 1

Function of a digital output (Page 56) in the operating mode "Measuring"	Meaning	Additional option-specific parameters
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= measured value <= comparison value 1	• Comparison value 0 • Comparison value 1
Not between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 1 <= measured value <= comparison value 0	• Comparison value 0 • Comparison value 1
Use by user program	The respective digital output can be switched by the CPU via the control interface (Page 48).	—

NOTE

You can select the "Between comparison value 0 and 1" and "Not between comparison value 0 and 1" functions only for digital output DQ1 and only if you have selected the "Use by user program" function for digital output DQ0.

Comparison value 0

Operating mode "Position input":

With the parameter assignment of the comparison value (Page 53), you specify the position value at which the digital output DQ0 switches as a result of the selected comparison event.

If you use an SSI absolute encoder with a position value length of up to 31 bits, you must enter a positive integer (DINT) with a value between 0 and $2^{(MSB-LSB+1)}$-1. If you use an SSI absolute encoder with a position value length of 32 bits, you must enter a signed integer (DINT) with a value between -2147483648 and 2147483647.

If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "0".

Operating mode "Measurement":

With the parameter assignment of the comparison value (Page 56), you specify the measured value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter a floating point number (REAL). If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The minimum value is -7.922816 x 10^{28}. The default setting is "0.0". The unit of the comparison value depends on the measured variable.

Comparison value 1

Operating mode "Position input"

With the parameter assignment of the comparison value (Page 53), you specify the position value at which the digital output DQ1 switches as a result of the selected comparison event.

If you use an SSI absolute encoder with a position value length of up to 31 bits, you must enter a positive integer (DINT) with a value between 0 and $2^{(MSB-LSB+1)}$-1. If you use an SSI absolute encoder with a position value length of 32 bits, you must enter a signed integer (DINT) with a value between -2147483648 and 2147483647.

If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "10".

Operating mode "Measurement"

With the parameter assignment of the comparison value (Page 56), you specify the measured value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter a floating point number (REAL). If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The maximum value is 7.922816 x 10^{28}. The default setting is "10.0". The unit of the comparison value depends on the measured variable.

Count direction

You use this parameter to specify the direction of position value change for which the selected function is valid.

You can select from the following options:

Direction of position value change	Meaning
In both directions (default)	The comparison and switching of the respective digital output is carried out regardless of whether the position value increases of decreases.
Up	The comparison and switching of the respective digital output only takes place when the position value increases.
Down	The comparison and switching of the respective digital output only takes place when the position value decreases.

The parameter can be configured for the following functions:

- Between comparison value 0 and 1 (operating mode "Position input")
- At comparison value for a pulse duration
- After set command from CPU until comparison value

Pulse duration

By configuring the pulse duration for the function "At comparison value for a pulse duration", you specify the number of milliseconds for which the respective digital output is active.

A value from 0.1 to 6553.5 ms is permissible.

The default setting is "500.0", which is equivalent to a pulse duration of 0.5 s.

Hysteresis (in increments)

By configuring the hysteresis (Page 67), you can define a range around the comparison values. For the functions "Between comparison value and high limit" and "Between comparison value and low limit", the hysteresis also applies at the counter limits. Within the hysteresis range, the digital outputs cannot switch again until the position value has left this range once.

Choose a small enough hysteresis. When the hysteresis range, starting from the configured comparison value, spans the entire position value range, proper functioning of the comparison values cannot be guaranteed.

Regardless of the hysteresis value, the hysteresis range ends at the low or high counting limit.

If you enter "0", the hysteresis is turned off. You can enter a value between 0 and 255. The default setting is "0".

NOTE

The hysteresis is only available in "Position input" operating mode.

Specifying the measured value

Measured variable

With this parameter you specify whether the technology module is to provide a certain measured variable (Page 59) or the complete SSI frame.

You can select from the following options:

Option	Meaning	Additional option-specific parameters
Frequency (default)	The measured variable shows the number of increments per second, where each increment corresponds to one position value change. The value is a floating point number (REAL). The unit is Hz. The MEASURED_VALUE value in the feedback interface indicates the measured value.	• Update time
Period	The measured variable is the average period between two increments of the position value. The value is an integer (DINT). The unit is s. The MEASURED_VALUE value in the feedback interface indicates the measured value.	• Update time
Velocity	The measured variable is a velocity. Examples of a velocity measurement can be found in the explanation of the "Increments per unit" parameter. The MEASURED_VALUE value in the feedback interface indicates the measured value.	• Update time • Time base for velocity measurement • Increments per unit
Complete SSI frame	Instead of a measured variable, the first 32 bits of the SSI frame are returned (bit 0 to bit 31). In so doing, special bits that do not belong to the position information are also supplied. A configured inversion of the direction is ignored. The MEASURED_VALUE value in the feedback interface indicates the 32 bits. You can find examples under Examples of the frame format (Page 147). This option is only available in operating mode "Use position value (SSI absolute value) as reference".	—

NOTE

If the increment per revolution is required for calculation of the measured values, it is automatically calculated from the parameterized telegram length as the power of 2, e.g. 8192 increments per revolution with a telegram length of 13 bit. If you are using an SSI absolute encoder whose increment per revolution does not correspond to the power of 2, the calculated measured value may be incorrect for a short time.

Update time

By configuring the update time (Page 59) in milliseconds, you can specify the time interval between two measured value updates. Unsteady measured variables can be smoothed through longer update times

If you enter "0", the measured value is updated once per module-internal cycle. Up to three decimal places can be entered. A value from 0.0 to 25000.0 is permissible. The default setting is "10.0".

Time base for velocity measurement

This parameter defines the time base on which the velocity is to be returned.

You can select from the following options:

- 1 ms
- 10 ms
- 100 ms
- 1 s
- 60 s

The default setting is "60 s".

Increments per unit

With this parameter you define the number of increments per relevant unit that the SSI absolute encoder supplies for the velocity measurement.

You can enter a value between 1 and 65535.

Example 1:

Your absolute encoder operates with a resolution of 12 bits per revolution and performs 4096 increments per revolution. The velocity should be measured in revolutions per minute.

In this case, you need to assign the following parameters:

- Increments per unit: 4096
- Time base for velocity measurement: 60 s

Example 2:

You encoder delivers 10000 increments for travel over one meter. The velocity is to be measured in meters per second.

In this case, you need to assign the following parameters:

- Increments per unit: 10000
- Time base for velocity measurement: 1 s

6.1.2.10 Fast Mode (incremental or pulse encoder)

Counter inputs

Signal type

You can choose from the following signal types (Page 70):

Signal type	Meaning	Additional option-specific parameters
Incremental encoder (A, B phase-shifted)	An incremental encoder with phase-shifted A and B signals is connected.	• Invert direction • Signal evaluation • Filter frequency • Sensor type or Interface standard
Incremental encoder (A, B, N)	An incremental encoder with phase-shifted signals A and B and a zero signal N is connected.	• Invert direction • Signal evaluation • Filter frequency • Sensor type or Interface standard • Reaction to signal N • Frequency of synchronization • Count direction for synchronization
Pulse (A) and direction (B)	A pulse encoder (signal A) with direction signal (signal B) is connected.	• Filter frequency • Sensor type or Interface standard
Pulse (A)	A pulse encoder (signal A) without direction signal is connected.	• Filter frequency • Sensor type or Interface standard
Count up (A), count down (B)	Signals for counting up (signal A) and down (signal B) are connected.	• Filter frequency • Sensor type or Interface standard

Invert direction

You can invert the count direction to adapt it to the process.

The inverting of the direction is configurable and active for the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Signal evaluation

By configuring signal evaluation (Page 74), you can specify which edges of the signals are counted.

You can select from the following options:

Signal evaluation	Meaning
Single (default)	The edges of signal A are evaluated during a low level of signal B.
Double	Each edge of signal A is evaluated.
Quadruple	Each edge of signals A and B is evaluated.

The parameter can be assigned with the following signal types:

- Incremental encoder (A, B phase-shifted)
- Incremental encoder (A, B, N)

Filter frequency

By configuring the filter frequency, you suppress interferences at the counter inputs A, B and N.

The selected filter frequency is based on a pulse/break ratio of between around 40:60 and around 60:40. This results in a specific minimum pulse/break time. Signal changes with a duration shorter than the minimum pulse/break time are suppressed.

You can select from the following filter frequencies:

Filter frequency	Minimum pulse/break time
100 Hz	4.0 ms
200 Hz	2.0 ms
500 Hz	800 µs
1 kHz	400 µs
2 kHz	200 µs
5 kHz	80 µs
10 kHz	40 µs
20 kHz	20 µs
50 kHz	8.0 µs
100 kHz	4.0 µs
200 kHz (default for TM Count, EM Count)	2.0 µs
500 kHz*	0.8 µs
1 MHz* (default for TM PosInput)	0.4 µs

* Only available with TM PosInput

Sensor type

By configuring the sensor type, you specify how the counter inputs are switched.

You can select from the following options:

Sensor type	Meaning
Sourcing output (default)	The encoder/sensor switches the inputs A, B and N to 24VDC.
Sinking output	The encoder/sensor switches the inputs A, B and N to M.
Push-pull (sinking and sourcing output)	The encoder/sensor alternately switches the inputs A, B and N to M and 24VDC.

"Push-pull" is usually selected when incremental encoders are used. If using 2-wire sensors, such as light barriers or proximity switches, you need to select the corresponding wiring "Sourcing output" or "Sinking output".

The data sheet of the encoder includes information on whether your incremental encoder is a push-pull encoder.

NOTE

If you use a push-pull encoder and the sensor type "Push-pull (sinking and sourcing output)" is configured, you can monitor the encoder signals for wire break.

Interface standard (TM PosInput)

You use this parameter to specify whether the encoder outputs symmetric (RS422) or asymmetric (TTL) signals for the TM PosInput.

You can select from the following options:

Interface standard	Meaning
RS422, symmetrical (default)	The encoder outputs symmetric signals according to the RS422 standard (Page 72).
TTL (5 V), asymmetrical	The encoder outputs asymmetric 5 V signals according to the TTL standard (Page 70).

NOTE

The RS422 standard provides greater interference immunity than the TTL standard. Therefore, if your incremental or pulse encoder supports the RS422 **and** the TTL standard, it is recommended to use the RS422 signal standard.

Reaction to signal N

You use this parameter to specify which reaction is triggered to signal N.

You can select from the following options:

Option	Meaning
No reaction to signal N (default)	The counter is not affected by signal N.
Synchronization at signal N (Page 46)	The counter is set to the start value at signal N. If you select the function "Enable synchronization at signal N" for a digital input, the synchronization depends on the level at the digital input.

NOTE

You can only select the reaction to signal N if you have selected the "Incremental encoder (A, B, N)" signal type.

NOTE

If "Synchronization at signal N" is selected, you can select the function "Enable synchronization at signal N" for a digital input (Page 206).

Frequency of synchronization

This parameter is used to define the frequency of the following events:

- Synchronization at signal N
- Synchronization as a function of a digital input

You can select from the following options:

Option	Meaning
Once (default)	The counter is only set at the first signal N or the first configured edge of the digital input.
Periodic	The counter is set at each signal N or each configured edge of the digital input.

Count direction for synchronization

You use this parameter to define the count direction for which the following functions are enabled:

- Synchronization at signal N
- Synchronization as a function of a digital input

You can select from the following options:

Option	Meaning
Up (default)	The synchronization only takes place when the counter counts up.
Down	The synchronization only takes place when the counter counts down.
In both directions	The synchronization takes place regardless of the count direction.

Counting limits and start value

High counting limit

You limit the counting range by setting the high counting limit. You can enter a value up to 33554431 (2^{25}-1). You must enter a value that lies above the low counting limit.

The default setting is "33554431".

Low counting limit

You limit the counting range by setting the low counting limit. You can enter a value starting with 0. You must enter a value below the high counting limit.

The default setting is "0".

Start value

By configuring the start value, you specify the value at which counting is to start and where it is to continue in the case of defined events. You must enter a value between the counting limits or equal to the counting limits.

The default setting is "0".

More information

For more information, see Behavior at the counting limits (Page 33) and Counter behavior at gate start (Page 36).

Counter behavior at limits and gate start

Reaction to violation of a counting limit

You can configure the following Reaction to violation of a counting limit (Page 33):

Reaction	Meaning
Stop counting	If a counting limit is violated, counting is stopped and the internal gate is closed. To restart counting, you must also close and reopen the software/hardware gate.
Continue counting (default)	Counting continues either with the start value or at the opposite counting limit, depending on the additional parameter assignment.

Reset when counting limit is violated

You can reset the counter to the following values when a counting limit is violated:

Reset the value	Meaning
To start value	The counter value is set to the start value.
To opposite counting limit (default)	The counter value is set to the opposite counting limit.

Reaction to gate start

You can set the following Reaction to gate start (Page 36):

Reaction	Meaning
Set to start value	When the gate is opened, the counter value is set to the start value.
Continue with current value (default)	When the gate is opened, counting is continued with the last counter value.

NOTE

The parameter is only active if you have configured a hardware gate.

Behavior of a DI

Set function of DI

By configuring a digital input, you specify which functions the digital input triggers at switching.

You can select from the following options:

Function of a digital input	Meaning	Additional option-specific parameters
Gate start/stop (level-triggered)	The level at the respective digital input opens and closes the hardware gate (Page 35).	• Input delay • Select level
Gate start (edge-triggered)	The configured edge at the respective digital input opens the hardware gate (Page 35).	• Input delay • Edge selection
Gate stop (edge-triggered)	The configured edge at the respective digital input closes the hardware gate (Page 35).	• Input delay • Edge selection
Synchronization (Page 41)	The configured edge at the respective digital input sets the counter to the start value.	• Input delay • Edge selection • Frequency of synchronization • Count direction for synchronization
Enable synchronization at signal N	The active level at the respective digital input enables synchronization of the counter at signal N (Page 46).	• Input delay • Select level
Digital input without function	No technological function is assigned to the respective digital input. You can read the signal state of the digital input via the respective feedback bit (number of digital inputs depends on the module): • STS_DI0 • STS_DI1 • STS_DI2	• Input delay

NOTE

With the exception of "Digital input without function", each function can only be used once for each counter, and if used for one digital input is not available to the others.

Input delay

You use this parameter to suppress signal interference at the digital inputs. Changes to the signal are only detected if they remain stable for longer than the configured input delay time.

You can select from the following input delays:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

NOTE

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

NOTE

You configure the input delay under "Behavior of DI0" for all digital inputs together. The input delay is also displayed under "Behavior of DI1" and for TM Count also under "Behavior of DI2".

Select level

You use this parameter to specify the level at which the digital input is active.

You can select from the following options:

Level	Meaning
Active with high level (default)	The respective digital input is active when it is set.
Active with low level	The respective digital input is active when it is not set.

The parameter can be set for the following functions of a digital input:

- Gate start/stop (level-triggered)
- Enable synchronization at signal N

Edge selection

You can use this parameter to specify the edge of the digital input at which the configured function is triggered.

The following options may be available depending on the function selected:

- At rising edge (default)
- At falling edge

The parameter can be set for the following functions of a digital input:

- Gate start (edge-triggered)
- Gate stop (edge-triggered)
- Synchronization

Frequency of synchronization

This parameter is used to define the frequency of the following events:

- Synchronization at signal N
- Synchronization as a function of a digital input

You can select from the following options:

Option	Meaning
Once (default)	The counter is only set at the first signal N or the first configured edge of the digital input.
Periodic	The counter is set at each signal N or each configured edge of the digital input.

Count direction for synchronization

You use this parameter to define the count direction for which the following functions are enabled:

- Synchronization at signal N
- Synchronization as a function of a digital input

You can select from the following options:

Option	Meaning
Up (default)	The synchronization only takes place when the counter counts up.
Down	The synchronization only takes place when the counter counts down.
In both directions	The synchronization takes place regardless of the count direction.

Behavior of a DQ

Set output

With the parameter assignment of a digital output, you specify the condition upon which the digital output switches.

You can select from the following options:

Function of a digital output (Page 49)	**Meaning**	**Additional option-specific parameters**
Between comparison value and high limit (default)	The respective digital output is active if: Comparison value <= counter value <= high counting limit	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value and low limit	The respective digital output is active if: Low counting limit <= counter value <= comparison value	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= counter value <= comparison value 1	• Comparison value 0 • Comparison value 1 • Count direction • Hysteresis (in increments)
At comparison value for a pulse duration	The respective digital output is active once for the configured time and count direction when the counter value reaches the comparison value.	• Comparison value 0 • Comparison value 1 • Count direction • Pulse duration • Hysteresis (in increments)
Digital output without function	The respective digital output is set to 0 regardless of the reaction to CPU STOP.	—

NOTE

You can only set the "Between comparison value 0 and 1" function for digital output DQ1 and only if you have selected the function "Digital output without function" for digital output DQ0.

Comparison value 0

With the parameter assignment of the comparison value (Page 49), you specify the counter value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter an integer (DINT) with a value between 0 and 33554431. If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "0".

Comparison value 1

With the parameter assignment of the comparison value (Page 49), you specify the counter value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter an integer (DINT) with a value between 0 and 33554431. If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "10".

Count direction

You use this parameter to specify the count direction for which the selected function is valid.

You can select from the following options:

Count direction	Meaning
In both directions (default)	The comparison and switching of the respective digital output take place regardless of the count direction.
Up	The comparison and switching of the respective digital output only takes place when the counter counts up.
Down	The comparison and switching of the respective digital output only takes place when the counter counts down.

The parameter can be configured for the following functions:

- Between comparison value 0 and 1
- At comparison value for a pulse duration

Pulse duration

By configuring the pulse duration for the function "At comparison value for a pulse duration", you specify the number of milliseconds for which the respective digital output is active.

A value from 0.0 to 6553.5 ms is permissible.

The default setting is "500.0", which is equivalent to a pulse duration of 0.5 s.

Hysteresis (in increments)

By configuring the hysteresis (Page 65), you can define a range around the comparison values. For the functions "Between comparison value and high limit" and "Between comparison value and low limit", the hysteresis also applies at the counter limits. Within the hysteresis range, the digital outputs cannot switch again until the counter value is outside the range.

Choose a small enough hysteresis. When the hysteresis range, starting from the configured comparison value, spans the entire counting range, proper functioning of the comparison values cannot be guaranteed.

Regardless of the hysteresis value, the hysteresis range ends at the low or high counting limit.

If you enter "0", the hysteresis is turned off. You can enter a value between 0 and 255. The default setting is "0".

6.1.2.11 Fast Mode (SSI absolute encoder)

Counter inputs

Signal type

If an SSI absolute encoder with the data signal (Signal ID) and cycle signal (Signal C) is connected, select the signal type (Page 31) "Absolute encoder (SSI)".

Invert direction

You can use this parameter to invert the values supplied by the SSI absolute encoder. This allows you to adapt the detected direction of the encoder to the motor's direction of rotation.

NOTE

This parameter acts only on the range from the LSB to the MSB of the position value in the frame.

Frame length

With the parameter assignment of the frame length, you specify the number of bits of an SSI frame of the SSI absolute encoder (Page 73) used. You can find the frame length of your SSI absolute encoder in the data sheet of the encoder. Special bits are also included in the frame length. A parity bit does not count in the frame length.

A frame length of between 10 bits and 40 bits is permitted. The default setting is "13 Bit".

You can find two examples of the SSI frame format at Examples of the frame format (Page 147).

Code type

You use the parameter assignment of the code type to specify whether the encoder supplies Dual code or Gray code.

You can select from the following options:

Code type	Meaning
Gray (default)	The gray-coded position value returned by the SSI absolute encoder is converted to dual code.
Dual	The value returned by the SSI absolute encoder is not converted.

Transmission rate

With the parameter assignment of the transmission rate, you specify the data transmission rate between the technology module and the SSI absolute encoder.

You can select from the following options:

- 125 kHz (preset)
- 250 kHz
- 500 kHz
- 1 MHz
- 1.5 MHz
- 2 MHz

The maximum transmission rate depends on the cable length and the technical specifications of the SSI absolute encoder. For additional information, refer to the product manual of the TM PosInput and the encoder description.

Monoflop time

With the parameter assignment of the monoflop time, you specify the idle time between two SSI frames.

The configured monoflop time must be at least equal to the monoflop time of the SSI absolute encoder used. You can find this value in the technical specifications of the SSI absolute encoder.

You can select from the following options:

- Automatically (default)
- 16 µs
- 32 µs
- 48 µs
- 64 µs

NOTE

If you select the "Automatic" option, the monoflop time automatically adapts to the encoder used.

In isochronous mode, the "Automatic" option corresponds to a monoflop time of 64 µs. If the monoflop time of the employed SSI absolute value encoder is less than 64 µs, you can select the value of the encoder to achieve faster isochronous times.

Parity

With the parameter assignment of the parity, you specify whether the SSI absolute encoder transfers a parity bit.

If, for example, a 25-bit encoder with parity is assigned, the technology module reads 26 bits. A parity error is reported in the feedback interface by means of the ENC_ERROR bit.

Bit number LSB of the position value

This parameter is used to specify the bit number of the LSB (least significant bit) of the position value in the frame of the SSI absolute encoder. In this way you limit the range in the frame that supplies the position value.

The value must be less than the bit number of the MSB of the position value. The difference between the bit numbers of the MSB and the LSB of the position value must be less than 32.

The default setting is "0".

NOTE

If you have selected the Code type "Gray", only the range from the LSB to the MSB of the position value is converted to binary code.

Bit number MSB of the position value

This parameter is used to specify the bit number of the MSB (most significant bit) of the position value in the frame of the SSI absolute encoder. In this way you limit the range in the frame that supplies the position value.

The value must be less than the frame length and higher than the bit number of the LSB of the position value. The difference between the bit numbers of the MSB and the LSB of the position value must be less than 32.

The default setting is "12".

NOTE

If you have selected the Code type "Gray", only the range from the LSB to the MSB of the position value is converted to binary code.

Behavior of a DI

Set function of DI

By configuring a digital input, you specify which functions the digital input triggers at switching.

You can select from the following options:

Function of a digital input	Meaning	Additional option-specific parameters
Digital input without function	No technological function is assigned to the respective digital input. You can read the signal state of the digital input via the respective feedback bit: • STS_DI0 • STS_DI1	• Input delay

Input delay

By configuring the input delay, you suppress interferences at the digital inputs. Signals with a pulse duration below the configured input delay are suppressed.

You can select from the following input delays:

- None
- 0.05 ms
- 0.1 ms (default)
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms
- 12.8 ms
- 20 ms

NOTE

If you select the "None" or "0.05 ms" option, you have to use shielded cables for connection of the digital inputs.

NOTE

You configure the input delay under "Behavior of DI0" for all digital inputs together. The input delay is also displayed under "Behavior of DI1".

Behavior of a DQ

Set output

With the parameter assignment of a digital output, you specify the condition upon which the digital output switches.

You can select from the following options depending on the operating mode:

Function of a digital output (Page 53)	**Meaning**	**Additional option-specific parameters**
Between comparison value and high limit (default)	The respective digital output is active if: Comparison value <= position value <= maximum position value	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value and low limit	The respective digital output is active if: Minimum position value <= Position value <= Comparison value	• Comparison value 0 • Comparison value 1 • Hysteresis (in increments)
Between comparison value 0 and 1	The digital output DQ1 is active if: Comparison value 0 <= position value <= comparison value 1	• Comparison value 0 • Comparison value 1 • Count direction • Hysteresis (in increments)
At comparison value for a pulse duration	The respective digital output is active once for the assigned time and direction of the position value change when the position value is equal to the comparison value or has fallen below or exceeded it.	• Comparison value 0 • Comparison value 1 • Count direction • Pulse duration • Hysteresis (in increments)

Function of a digital output (Page 53)	Meaning	Additional option-specific parameters
Digital output without function	The respective digital output is set to 0 regardless of the reaction to CPU STOP.	—

NOTE

You can only select the "Between comparison value 0 and 1" function for digital output DQ1 and only if you have selected the "Use by user program" function for digital output DQ0.

Comparison value 0

With the parameter assignment of the comparison value (Page 53), you specify the position value at which the digital output DQ0 switches as a result of the selected comparison event.

You must enter an integer (DINT) that is greater than or equal to the low counting limit. If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "0".

If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "0".

Comparison value 1

With the parameter assignment of the comparison value (Page 53), you specify the position value at which the digital output DQ1 switches as a result of the selected comparison event.

You must enter an integer (DINT) that is less than or equal to the high counting limit. If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "10".

If you use the DQ function "Between comparison value 0 and 1", the comparison value 0 has to be smaller than comparison value 1. The default setting is "10".

Count direction

You use this parameter to specify the direction of position value change for which the selected function is valid.

You can select from the following options:

Direction of position value change	Meaning
In both directions (default)	The comparison and switching of the respective digital output is carried out regardless of whether the position value increases of decreases.
Up	The comparison and switching of the respective digital output only takes place when the position value increases.
Down	The comparison and switching of the respective digital output only takes place when the position value decreases.

The parameter can be configured for the following functions:

- Between comparison value 0 and 1
- At comparison value for a pulse duration

Pulse duration

By configuring the pulse duration for the function "At comparison value for a pulse duration", you specify the number of milliseconds for which the respective digital output is active.

A value from 0.1 to 6553.5 ms is permissible.

The default setting is "500.0", which is equivalent to a pulse duration of 0.5 s.

Hysteresis (in increments)

By configuring the hysteresis (Page 67), you can define a range around the comparison values. For the functions "Between comparison value and high limit" and "Between comparison value and low limit", the hysteresis also applies at the counter limits. Within the hysteresis range, the digital outputs cannot switch again until the position value has left this range once.

Choose a small enough hysteresis. When the hysteresis range, starting from the configured comparison value, spans the entire position value range, proper functioning of the comparison values cannot be guaranteed.

Regardless of the hysteresis value, the hysteresis range ends at the low or high counting limit.

If you enter "0", the hysteresis is turned off. You can enter a value between 0 and 255. The default setting is "0".

6.1.3 Online & diagnostics module

6.1.3.1 Displaying and evaluating diagnostics

The online and diagnostics view enables hardware diagnostics. You can also

- Obtain information on the technology module (e.g., Firmware version and serial number)
- Execute a firmware update if required

Procedure (TM Count and TM PosInput)

To open the display editor for the diagnostic functions, follow these steps:

1. Open the device configuration of the CPU or IM.
2. Select the device view.
3. Right-click the module and select "Online & Diagnostics".

1. Select the required display in the diagnostics navigation.

Procedure (ET 200eco PN TM PosInput 2)

To open the display editor for the diagnostic functions, follow these steps:

1. Open the device configuration of the CPU.
2. Select the network view.
3. Right-click the module and select "Online & Diagnostics".
1. Select the required display in the diagnostics navigation.

Procedure (Compact CPU)

To open the display editor for the diagnostic functions, follow these steps:

1. Open the Compact CPU folder in the project tree.
2. Double-click on the "Online & diagnostics" object.
3. Select the required display in the diagnostics navigation.

Additional information

Additional information on the diagnostic alarms and possible remedies can be found in the technology module device manual.

NOTE

Position input for Motion Control

In operating mode "Position input for "Motion Control" technology object", channel diagnostics is not available for the technology module.

6.1.4 Control and feedback interface (TM Count, TM PosInput)

Information on using the control and feedback interface can be found under Overview of application options (Page 24).

NOTE

The following description does not apply for the operating modes "Fast Mode" and "Position input for technology object "Motion Control"". You can find a description of the feedback interface in the respective device manual for those technology modules that support the "Fast Mode" operating mode.

6.1.4.1 Assignment of the control interface

The user program uses the control interface to influence the behavior of the technology module.

Control interface per channel

The following table shows control interface assignment:

Byte offset to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 ... 3	12 ... 15	SLOT_0: DINT or REAL: Load value (significance of the value is specified in LD_SLOT_0) Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
4 ... 7	16 ... 19	SLOT_1: DINT or REAL: Load value (significance of the value is specified in LD_SLOT_1) Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$							
8	20	LD_SLOT_1				LD_SLOT_0			
9	21	EN_ CAPTURE	EN_ SYNC_DN	EN_ SYNC_UP	SET_DQ1	SET_DQ0	TM_ CTRL_DQ1	TM_ CTRL_DQ0	SW_GATE
10	22	SET_DIR	Reserved					RES_ EVENT	RES_ ERROR
11	23	Reserved							

Notes

Control bit/value	Notes
SLOT_m	You specify the load value with this value. You specify the meaning of the value in LD_SLOT_m. If you want to load a comparison value in the "Measuring" operating mode, specify the load value as floating-point number (REAL). In all other cases, you specify the load value as an integer (DINT). Value range: –2147483648 to 2147483647_D or 80000000 to $7FFFFFFF_H$
LD_SLOT_m	With this load request you specify the meaning of the value in SLOT_m: • 0000 means: No action, idle • 0001 means: Load count value (with incremental or pulse encoder) • 0010 not permitted • 0011 means: Load start value (with incremental or pulse encoder) • 0100 means: Load Comparison value 0 • 0101 means: Load comparison value 1 • 0110 means: Load low counting limit (with incremental or pulse encoder) • 0111 means: Load high counting limit (with incremental or pulse encoder) • 1000 to 1111 not permitted The technology module executes the respective action as soon as LD_SLOT_m changes. If values are loaded simultaneously via LD_SLOT_0 and LD_SLOT_1, the first value is applied internally from SLOT_0 and then the value from SLOT_1 is applied. This might lead to unexpected intermediate states.

Control bit/value	Notes
	A change of the COUNT_VALUE value via LD_SLOT_m has no influence on the MEASURED_VALUE value.
EN_CAPTURE	Use this bit to enable the Capture function. Resetting this bit resets a set EVENT_CAP in the feedback interface.
EN_SYNC_DN	Use this bit to enable the synchronization of the counter when counting down with an incremental encoder or pulse encoder. Resetting this bit resets a set EVENT_SYNC in the feedback interface.
EN_SYNC_UP	Use this bit to enable the synchronization of the counter when counting up with an incremental encoder or pulse encoder. Resetting this bit resets a set EVENT_SYNC in the feedback interface.
SET_DQ0	Use this bit to set digital output DQ0 when TM_CTRL_DQ0 is set to 0. In the case of the function "After set command from CPU until comparison value", SET_DQ0 is effective regardless of TM_CTRL_DQ0 as long as the counter value is not equal to the comparison value.
SET_DQ1	Use this bit to set digital output DQ1 when TM_CTRL_DQ1 is set to 0. In the case of the function "After set command from CPU until comparison value", SET_DQ1 is effective regardless of TM_CTRL_DQ1 as long as the counter value is not equal to the comparison value.
TM_CTRL_DQ0	Use this bit to enable the technological function of digital output DQ0. • 0 means: SET_DQ0 defines the state of DQ0 • 1 means: assigned function defines the state of DQ0
TM_CTRL_DQ1	Use this bit to enable the technological function of digital output DQ1. • 0 means: SET_DQ1 defines the state of DQ1 • 1 means: assigned function defines the state of DQ1
SW_GATE	Use this bit to open and close the software gate when using an incremental encoder or pulse encoder. Together, the software gate and the hardware gate form the internal gate. The technology module only counts when the internal gate is open. • 0 means: Software gate closed • 1 means: Software gate open The control of the hardware gate takes place externally via the digital inputs of the technology module. The hardware gate can be activated through parameter assignment. The software gate cannot be deactivated.
SET_DIR	Use this bit to specify the counting direction for signal type "Pulse (A)". • 0 means: Up • 1 means: Down
RES_EVENT	Use this bit to trigger the reset of the saved events in the EVENT_ZERO, EVENT_OFLW, EVENT_UFLW, EVENT_CMP0, EVENT_CMP1 feedback bits.
RES_ERROR	Use this bit to trigger the reset of the saved error states LD_ERROR and ENC_ERROR .
Reserved	Reserved bits must be set to 0.

6.1.4.2 Assignment of the feedback interface

The user program receives current values and status information from the technology module via the feedback interface.

Feedback interface per channel

The following table shows the assignment of the feedback interface:

Byte offset to start address Channel 0/1 ↓ ↓		Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0 ... 3	16 ... 19	COUNT_VALUE: DINT: Current counter value or position value							
4 ... 7	20 ... 23	CAPTURED_VALUE: DINT: The last acquired Capture value							
8 ... 11	24 ... 27	MEASURED_VALUE: REAL: Current measured value or DWORD: Full SSI frame							
12	28	Reserved					LD_ERROR	ENC_ ERROR	POWER_ ERROR
13	29	Reserved		STS_SW_ GATE	STS_ READY	LD_STS_ SLOT_1	LD_STS_ SLOT_0	RES_EVENT_- ACK	Reserved
14	30	STS_DI2[1]	STS_DI1	STS_DI0	STS_DQ1	STS_DQ0	STS_GATE	STS_CNT	STS_DIR
15	31	STS_M_ INTERVAL	EVENT_ CAP	EVENT_ SYNC	EVENT_ CMP1	EVENT_ CMP0	EVENT_ OFLW	EVENT_ UFLW	EVENT_ ZERO

[1] For TM PosInput applies: Reserved

NOTE
Validity of the data
The data of the feedback interface is valid when STS_READY is set to 1. STS_READY is set to 0 while the module starts up.

NOTE
Validity of the position value
The position value of an SSI absolute encoder is valid if STS_READY is set to 1 and ENC_ERROR is set to 0. STS_READY is set to 0 while the module starts up.

Notes

Feedback bit/value	Notes
COUNT_VALUE	This DINT value shows the current counter value or position value. If you use an SSI absolute encoder with a position value length of up to 31 bits, the position value is treated unsigned as a positive value and can assume values between 0 and $2^{(MSB-LSB+1)}$-1. If you use an SSI absolute encoder with a position value length of 32 bits, the MSB of the position value corresponds to the sign and the position value can assume values between -2147483648 and 2147483647. If you use a 32 bit position value for the comparison function, the position value is interpreted as DINT. A change of the COUNT_VALUE value via LD_SLOT_m has no influence on the MEASURED_VALUE value.
CAPTURED_VALUE	This DINT value indicates the last detected Capture value. The following external signals can trigger the Capture function: • Rising or falling edge of a digital input • Both edges of a digital input The parameter "Frequency of the Capture function" determines if the function is executed for each configured edge or only once after each enable.
MEASURED_ VALUE	This value shows the current measurement value with the REAL data type or the complete SSI frame with the DWORD data type: • Frequency: The mean frequency is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and returned in Hertz as floating point number. • Period duration: The mean period duration is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and returned in seconds as floating point number. • Velocity: The mean velocity is calculated at set measuring intervals on the basis of the time profile of the count pulses or position value changes and other parameters, and returned in the configured unit of measurement. • Complete SSI frame: Instead of a measured variable, the least significant 32 bits of the unprocessed current SSI frame are returned. This provides you with encoder-specific additional bits, such as error bits, in addition to the position value. If the SSI frame is shorter than 32 bits, the complete SSI frame is returned right-aligned and the top unused bits are returned with "0" in the feedback interface. The measured values are returned as signed values. The sign indicates whether the counter value or position value increased or decreased during the relevant time period. The update time is asynchronous to the opening of the internal gate, which means that the update time is not started when the gate is opened. After the internal gate is closed, the last measured value captured is still returned.
LD_ERROR	This bit indicates that an error occurred (latching) during loading via the control interface. The loaded values were not applied. When using an incremental or pulse encoder, one of the following conditions is not fulfilled: • Low counting limit <= counter value <= high counting limit • Low counting limit <= start value <= high counting limit • Low counting limit <= comparison value 0/1 <= high counting limit When using an SSI absolute encoder, one of the following conditions is not fulfilled: • 0 <= position value <= maximum position value • 0 <= comparison value 0/1 <= maximum position value The bit is reset once you have acknowledged the error with RES_ERROR .

Feedback bit/value	Notes
ENC_ERROR	This bit indicates that one of the following errors has occurred at the encoder signals (retentive) for the respective technology module: TM Count: • Wire break of digital input A, B, or N (with push-pull encoder) • Invalid transition of A/B signals (with incremental encoder) TM PosInput: • Invalid transition of A/B signals (with incremental encoder) • RS422/TTL error • SSI encoder error or SSI frame error (with SSI absolute encoder) If you have enabled the diagnostic interrupts, the respective diagnostic interrupt is triggered in the event of encoder signal errors. For information on the meaning of the diagnostic interrupts, refer to the manual for the respective technology module. The bit is reset once you have acknowledged the error with RES_ERROR .
POWER_ERROR	For an S7-1500 technology module, this bit indicates that the supply voltage L+ is not available or too low or that the front plug is not plugged in. For an ET 200SP technology module, this bit indicates that the supply voltage L+ is too low. If you have enabled the diagnostic interrupts, the respective diagnostic interrupt is triggered in the event of errors in the supply voltage. For details on the diagnostic interrupts and the corrective measures they require, refer to the device manual for the respective technology module. If the supply voltage L+ is available at a sufficient level once again, POWER_ERROR is automatically set to 0.
STS_SW_GATE	This bit indicates the status of the software gate. 0 means: Gate closed 1 means: Gate open
STS_READY	This bit indicates that the technology module supplies valid user data. The technology module has been started up and configured.
LD_STS_SLOT_0	This bit indicates by a status change (toggling) that the load request for Slot 0 (LD_SLOT_0) has been detected and executed.
LD_STS_SLOT_1	This bit indicates by a status change (toggling) that the load request for Slot 1 (LD_SLOT_1) has been detected and executed.
RES_EVENT_ACK	This bit indicates that the reset of event bit EVENT_SYNC, EVENT_CMP0, EVENT_CMP1, EVENT_OFLW, EVENT_UFLW, EVENT_ZERO is active.
STS_DI0	This bit indicates the status of digital input DI0.
STS_DI1	This bit indicates the status of digital input DI1.
STS_DI2	This bit indicates the status of digital input DI2 of the TM Count .
STS_DQ0	This bit indicates the status of digital output DQ0.
STS_DQ1	This bit indicates the status of digital output DQ1.
STS_GATE	This bit indicates the status of the internal gate when using an incremental or pulse encoder. 0 means: Gate closed 1 means: Gate open Information for TM PosInput: In order for the counting logic including the gate control to function correctly, the startup of the technology module must complete correctly at least once with a connected incremental or pulse encoder (STS_READY at 1). If a connected encoder is not ready yet during startup, the function of the STS_GATE feedback bit is delayed until the encoder for the technology module is available. If the technology module starts up without a connected encoder, the startup does not complete correctly and STS_READY as well as STS_GATE remain at 0. As soon as an encoder is then connected, the startup completes and the STS_GATE functions correctly. An encoder error after a completed startup has no influence on STS_GATE.

Feedback bit/value	Notes
STS_CNT	This bit indicates that at least one count pulse or a position value change has been detected in the last approx. 0.5 s.
STS_DIR	This bit indicates the counting direction of the last count pulse or the direction of the last position value change. 0 means: Down 1 means: Up
STS_M_INTERVAL	This bit indicates that at least one count pulse or a position value change was detected in the previous measurement interval.
EVENT_CAP	This bit indicates that a Capture event has occurred and a counter value has been saved in CAPTURED_VALUE . You reset the state by resetting EN_CAPTURE .
EVENT_SYNC	This bit indicates the saved state that the counter was loaded with the start value by an external reference signal (synchronization) when using an incremental or pulse encoder. You reset the state by resetting EN_SYNC_UP or EN_SYNC_DN .
EVENT_CMP0	This bit indicates the saved state that a comparison event (state change) has occurred for the digital output DQ0 based on the selected comparison condition. You reset the state by acknowledgment with RES_EVENT. If the counter value is set to the start value in counting operating mode, EVENT_CMP0 is not set.
EVENT_CMP1	This bit indicates the saved state that a comparison event (state change) has occurred for the digital output DQ1 based on the selected comparison condition. You reset the state by acknowledgment with RES_EVENT. If the counter value is set to the start value in counting operating mode, EVENT_CMP1 is not set.
EVENT_OFLW	This bit indicates the saved state that there was a counter value overflow. You reset the state by acknowledgment with RES_EVENT.
EVENT_UFLW	This bit indicates the saved state, that there was a counter value underflow. You reset the state by acknowledgment with RES_EVENT.
EVENT_ZERO	This bit indicates the saved state that the counter value or position value experienced a zero crossing. You reset the state by acknowledgment with RES_EVENT.
Reserved	Reserved bits are set to 0.

Complete acknowledgment principle

Saving bits are acknowledged according to the complete acknowledgment principle.

The figure below shows an example of the sequence of the complete acknowledgment principle in the event of an overflow:

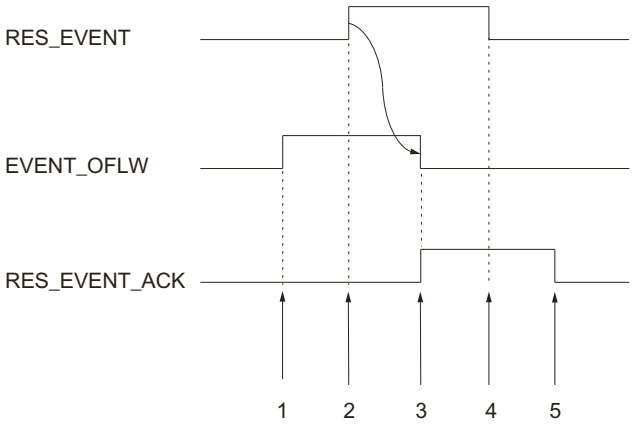

① The EVENT_OFLW feedback bit is set as a saving event upon overflow.

② You set the RES_EVENT control bit to trigger EVENT_OFLW reset.

③ The RES_EVENT_ACK feedback bit is set when reset of EVENT_OFLW is detected.

④ You then rest the control bit RES_EVENT .

⑤ The RES_EVENT_ACK feedback bit is reset.

Applying values via load prompt

The figure below shows an example of the procedure of application of values with the load prompt and on error detection:

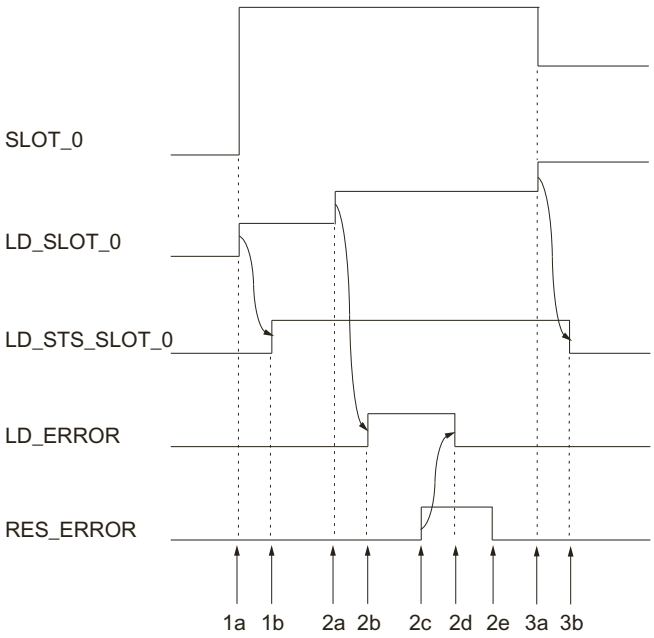

1a You write the valid value 1 (load count value) to LD_SLOT_0 and the desired load value to SLOT_0.

1b The LD_STS_SLOT_0 feedback bit is toggled because the LD_SLOT_0 load request was recognized by the module and implemented.

2a You write the invalid value 2 to LD_SLOT_0.

2b The LD_ERROR feedback bit is set because the value in LD_STS_SLOT_0 is invalid. The value in SLOT_0 is not applied.

2c You set the RES_ERROR control bit in order to acknowledge the error.

2d The LD_ERROR feedback bit is reset.

2e You reset the RES_ERROR control bit.

3a You write the valid value 3 (load start value) to LD_SLOT_0 and the desired load value to SLOT_0.

3b The LD_STS_SLOT_0 feedback bit is toggled because the LD_SLOT_0 load request was recognized by the module and implemented.

6.2 Using the digital module

6.2.1 Configuring and assigning parameters to the module

6.2.1.1 Adding a module to the hardware configuration

Requirements

- The project has been created.
- The CPU S7-1500 has been created.
- At decentralized operation an ET 200 distributed I/O system is created.

Procedure

1. Open the device configuration of the CPU or IM.
2. Select a module rack.
3. Select the digital input module from the module catalog:
   "DI > Digital input module > Article number" or
   "DIQ > Digital input module /Digital output module > Article number"
4. Drag the module to the required slot in the module rack.

6.2.1.2 Open hardware configuration

Procedure

1. Open the device configuration of the CPU or IM.
2. Select the device view.
3. Click on the module.

6.2.1.3 Counting operating mode

In counting operating mode or in the counter configuration you can set the following parameters for each channel.

NOTE

Some of the parameters and options are not available for all digital modules. See the module's device manual for the associated parameters and options.

Channel enabled

You use this parameter to specify whether the respective channel is enabled or disabled.

Each channel is enabled by default.

Input delay

By configuring the input delay, you suppress signal errors at the digital inputs. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

Isochronous configuration is only possible if there is an input delay of 0.05 ms configured for at least one channel. In isochronous mode, the feedback interface is updated at the time T_i (time for reading the input data).

You can select from the following options:

- 0.05 ms
- 0.1 ms
- 0.4 ms
- 0.8 ms
- 1.6 ms
- 3.2 ms (default)
- 12.8 ms
- 20 ms

NOTE

If you select the "0.05 ms" option for the input delay, you have to use shielded cables for connection of the digital inputs.

Reaction to violation of a counting limit

The following behavior can be configured for Violation of the counter high limit in the upward direction or the counter low limit in the downward direction (Page 84):

Reaction	Meaning
Stop counting (default at ET200SP and ET200AL)	After a counting limit is violated, the internal gate is closed (automatic gate stop). As a result, the counting process is stopped and the module ignores any further counting signals. The counter value is set to the opposite counting limit. To restart counting, you must close and reopen the software/hardware gate.
Continue counting (default at S7-1500)	After a counting limit is violated, the counter value is set to the opposite counting limit and counting continues.

Edge selection

This parameter is used to specify which edge the respective counter counts:

Edge selection	Meaning
At rising edge (default)	The respective counter counts all rising edges at the digital input.
At falling edge	The respective counter counts all falling edges at the digital input.
At rising and falling edge	The respective counter counts all edges at the digital input.

Count direction

Use this parameter to specify the counting direction of the respective counter.

You can select from the following options:

- Up
- Down

Set output

Use this parameter to specify the Function (Page 87) that controls the STS_DQ feedback bit. You can use the STS_DQ reset bit in order to control a digital output module's digital output.

You can select from the following options:

Option	Meaning
Off (DQ = 0)	Regardless of the counter value, STS_DQ is permanently not set.
Off (DQ = 1)	Regardless of the counter value, STS_DQ is permanently set.
Between comparison value 0 and 1	STS_DQ is set if the counter value between comparison values 0 and 1.
Not between comparison value 0 and 1	STS_DQ is set if the counter value is outside the range between comparison values 0 and 1.
Between comparison value and counter high limit	STS_DQ is set if the counter value is between the comparison value and the counter high limit.
Between comparison value and counter low limit	STS_DQ is set if the counter value is between the comparison value and the counter low limit.

Setting function of the DI

Use this parameter to specify which function the respective digital input DI_{n+4} triggers.

You can select from the following options:

Option	Meaning
Digital input without function	No function is assigned to the respective digital input DI_{n+4}. The signal status of DI_{n+4} can be read by the CPU using the feedback interface.
Gate start/stop	Setting the respective digital input DI_{n+4} opens the hardware gate (Page 85) for DI_n. Resetting the respective digital input DI_{n+4} closes the hardware gate for DI_n.
Count direction	The respective DI_{n+4} digital input determines the counting direction at DI_n, in order to adjust it to the process. If DI_{n+4} is not set, DI_n counts up. If DI_{n+4} is set, DI_n counts down.

NOTE

If "Count direction" is selected and the counting direction in the process changes, the counting edge is automatically adjusted (opposite edges).

High counting limit

You limit the counting range by setting the counter high limit. The maximum value for the counter high limit depends on the module:

High counting limit	DI 8x24VDC HS, DIQ 16x24VDC/0.5A 8xM12	DI 32x24VDC HF, DI 16x24VDC HF, DI 16xNAMUR HF, DI 16x24VDC HS
Maximalwert	2147483647 (2^{31}–1)	4294967295 (2^{32}–1)
Voreinstellung	2147483647	4294967295

You must enter a value that lies above the counter low limit.

Counter low limit

You limit the counting range by setting the counter low limit. The minimum value for the counter low limit depends on the module:

Counter low limit	DI 8x24VDC HS, DIQ 16x24VDC/0.5A 8xM12	DI 32x24VDC HF, DI 16x24VDC HF, DI 16xNAMUR HF, DI 16x24VDC HS
Minimum value	–2147483648 (-2^{31})	0 (not configurable)
Default	0	0

You must enter a value below the counter high limit.

Start value

By configuring the start value, you specify the value at which counting is to start. You must enter a value between the counting limits or equal to the counting limits.

The default setting is "0".

Comparison value

By configuring a comparison value (Page 87), you specify the counter value that controls the STS_DQ reset bit based on the comparison function that was selected under "Set output".

You have to enter a value that is greater than or equal to the low counting limit as well as smaller than or equal to the high counting limit.

The default setting depends on the module:

Comparison value	DI 8x24VDC HS, DIQ 16x24VDC/0.5A 8xM12	DI 32x24VDC HF, DI 16x24VDC HF, DI 16xNAMUR HF, DI 16x24VDC HS
Default	10	1

Comparison value 0

By configuring a comparison value (Page 87), you specify the counter value that controls the STS_DQ reset bit based on the comparison function that was selected under "Set output".

You must enter a value which is greater than or equal to the counter low limit and less than comparison value 1.

The default setting is "0".

Comparison value 1

By configuring the second comparison value (Page 87), you specify the additional counter value that controls the STS_DQ reset bit based on the comparison function that was selected under "Set output".

You must enter a value which is greater than comparison value 0 and less than or equal to the counter high limit.

The default setting is "10".

Hardware gate

Use this parameter to specify the one-time counting process.

With the hardware gate, as with the software gate, you can start and stop the counting process with an external signal. If you use the hardware gate, the software gate must be enabled ("1").

Counting is stopped when the upper counting limit is violated. The count value jumps to the lower count limit (= 0).

Hardware interrupt: Comparison event for DQ occurred

With this parameter, you specify for S7-1500 and ET200AL whether a process alarm is given off when a comparison event occurs based on the comparison function that was selected under "Set output".

The hardware interrupt is not enabled in the default setting.

6.2.2 Online & diagnostics module

6.2.2.1 Displaying and evaluating diagnostics

The online and diagnostics view enables hardware diagnostics. You can also

- Obtain information on the module (e.g., Firmware version and serial number)
- Execute a firmware update if required

Procedure

To open the display editor for the diagnostic functions, follow these steps:

1. Open the device configuration of the CPU or IM.
2. Select the device view.
3. Right-click on the module and select "Online & Diagnostics".
4. Select the required display in the diagnostics navigation.

Additional information

Additional information on the diagnostic alarms and possible remedies can be found in the module's device manual.

6.3 Using SIMATIC Drive Controller

6.3.1 Configuration and parameter assignment of SIMATIC Drive Controller

6.3.1.1 Adding the SIMATIC Drive Controller to the hardware configuration

Requirements

The project has been created.

Procedure

1. Double-click "Add new device".
   The "Add new object" dialog opens.
2. Select "Controller".
3. Select the SIMATIC Drive Controller:
   "SIMATIC Drive Controller > CPU variant > Article number"
4. With the "Open device view" check box, you define whether the hardware configuration view should be opened after creation of a new device is completed. Leave the check box selected if you want to configure the CPU next.
5. Confirm with "OK".

6.3.1.2 Open hardware configuration

Procedure

1. Select the device configuration item below the CPU in the project tree.
   The device view opens.
2. Click on the interface DI/DQ 8x24VDC [X142] in the device view.
   You can adapt the configurable properties in the Inspector window under Properties. Under Channel parameters, you will find an overview of all channels and their selected settings. To assign parameters to the desired channels, click on the arrow symbol after the channel number in the overview. Alternatively, you can also select the channel directly in the navigation.
3. Select the "Event/period duration measurement" operating mode for the desired channel.

6.3.1.3 Event/period duration measurement operating mode

In Event/period duration measurement operating mode (Page 92), you can count positive edges and determine the period duration between two positive edges.

You can set the following parameters in event/period duration measurement operating mode:

Invert

You can invert the 24 V signal in order to adapt the signal to your process.

The signal is not inverted in the default setting.

Input delay

By configuring the input delay, you suppress signal errors at the digital inputs. Changes to the signal are only detected if they are constantly pending longer than the set input delay time.

To be able to record the very briefly pending signals at high counting frequencies, you need to set an input delay of 1 µs.

You can select from the following options:

- 125 µs (default)
- 1 µs

Isochronous mode

The event/period duration measurement requires isochronous operation.

You can find more information in the SIMATIC Drive Controller system manual (https://support.industry.siemens.com/cs/ww/en/view/109766665).

6.3.2 Online & diagnostics module

6.3.2.1 Displaying and evaluating diagnostics

The online and diagnostics view enables hardware diagnostics. You can also

- Obtain information on the CPU or SINAMICS Integrated (e.g. Firmware version and serial number)
- Execute a firmware update if required

Procedure

To open the display editor for the diagnostic functions of the CPU, follow these steps:

1. Open the CPU folder in the project tree.
2. Double-click on the "Online & diagnostics" object.
3. Select the required display in the diagnostics navigation.

Additional information

You can find more information in the SIMATIC Drive Controller system manual (https://support.industry.siemens.com/cs/ww/en/view/109766665).

SIEMENS

SIMATIC

Industrial Software SIMATIC Safety - Configuring and Programming

Programming and Operating Manual

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Industrial Software
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Important notes

Purpose of this documentation

The information in this documentation enables you to configure (Page 34) and program (Page 113) SIMATIC Safety fail-safe systems. In addition, you will obtain information on acceptance (Page 427) of a SIMATIC Safety F-system.

NOTE

The Programming and Operating Manual "SIMATIC Safety - Configuring and Programming" in its latest version (possibly including product information for the manual) is the relevant source of all information on functional safety regarding configuring and programming. This also applies in the event of discrepancies between this manual and other documentation on functional safety regarding configuring and programming of SIMATIC Safety.

You must heed all warnings in the Programming and Operating Manual "SIMATIC Safety - Configuring and Programming".

Basic knowledge requirements

General basic knowledge of automation engineering is needed to understand this documentation. Basic knowledge of the following is also necessary:

- Fail-safe automation systems
- Automation systems
  - S7-300
  - S7-400
  - S7-1200
  - S7-1500
  - S7-1500H
  - S7-1500 Virtual Controller
  - S7-1500 Software Controller
  - SIMATIC Drive Controller
- Distributed I/O systems on
  - PROFIBUS DP
  - PROFINET IO

- Totally Integrated Automation Portal, including:
  - Hardware configuration with the *hardware and network editor*
  - Programming in the LAD and FBD programming languages using the *program editor*.
  - Communication between CPUs
  - OPC UA for communication between CPUs with OPC UA Safety

Scope of this documentation

This documentation is valid for *STEP 7 Safety Advanced V21*.

STEP 7 Safety Advanced V21 is used for configuring and programming the SIMATIC Safety fail-safe system.

In this context, integration of the F-I/O listed below in SIMATIC Safety is also addressed:

- S7-1500/ET 200MP fail-safe modules
- ET 200SP fail-safe modules
- ET 200SP HA fail-safe modules
- ET 200S fail-safe modules
- ET 200eco fail-safe I/O modules
- ET 200eco PN fail-safe I/O modules
- ET 200AL fail-safe I/O modules
- ET 200pro fail-safe modules
- ET 200iSP fail-safe modules
- S7-300 fail-safe signal modules
- S7-1200 fail-safe modules
- Fail-safe GSD based DP slaves
- Fail-safe GSD based I/O devices

Approvals

The SIMATIC Safety F-system is certified for use in safety mode up to:

- Safety Integrity Level SIL3 in accordance with IEC 61508:2010
- Performance Level (PL) e and category 4 in accordance with ISO 13849-1:2015 or EN ISO 13849-1:2015

Incorporation in the information landscape

Depending on your application, you will need the following supplementary documentation when working with *STEP 7 Safety*.

This documentation includes references to the supplementary documentation where appropriate.

Documentation	Brief description of relevant content
For the SIMATIC Safety F-system	Depending on which F-CPU you are using, you will need the following documentation: • For the F-CPUs S7-1200/1500, a Product Information (https://support.industry.siemens.com/cs/ww/en/view/109478599) describes all deviations from the respective standard CPUs. • Each F-CPU S7-300/400 that can be used has its own product information. The product information describes the deviations from the respective standard CPUs. • The Device manuals (https://support.industry.siemens.com/cs/ww/en/ps/13717/man) describe the S7-1500 CPUs. • The "S7-300, CPU 31xC and CPU 31x: Installation" (https://support.industry.siemens.com/cs/ww/en/view/13008499) operating instructions describe the installation and wiring of S7-300 systems. • The "CPU 31xC and CPU 31x, Technical Data" (https://support.industry.siemens.com/cs/ww/en/view/12996906) device manual describes the CPUs 315-2 DP and PN/DP, the CPU 317-2 DP and PN/DP, and the CPU 319-3 PN/DP. • The "S7-400 Automation System, Installation (https://support.industry.siemens.com/cs/ww/en/view/1117849) installation manual describes the installation and wiring of S7-400 systems. • The "S7-400 Automation System, CPU Data" (https://support.industry.siemens.com/cs/ww/en/view/109818285) reference manual describes the CPUs 414-3 PN/DP, the CPU 416-2, and the CPU 416-3 PN/DP. • The "ET 200S Interface Module IM 151-7 CPU" (https://support.industry.siemens.com/cs/ww/en/view/12714722) manual describes the IM 151-7 CPU. • The "ET 200S, Interface Module IM 151-8 PN/DP CPU" (https://support.industry.siemens.com/cs/ww/en/view/47409312) manual describes the IM 151-8 PN/DP CPU. • The "ET 200S, Interface Module IM 154-8 CPU" (https://support.industry.siemens.com/cs/ww/en/view/44251850) manual describes the IM 154-8 CPU. • The "SIMATIC S7-1500 Software Controller CPU 1505SP (F), CPU 1507S (F) and CPU 1508S (F) SIMATIC Industrial OS Version (https://support.industry.siemens.com/cs/ww/en/view/109808199)" manual describes the SIMATIC S7-1500 Software Controllers CPU 1505SP (F), CPU 1507S (F) and CPU 1508S (F). • The function manuals (https://sieportal.siemens.com/su/blSqW) describe the S7-1500 Virtual Controller.
"S7-1200 Functional Safety manual (https://support.industry.siemens.com/cs/ww/en/view/104547552)" system manual	Describes the F-CPUs S7-1200 and the fail-safe modules S7-1200 (including installation, wiring, and technical specifications)

Documentation	Brief description of relevant content
"S7-1500/ET 200MP system manual (https://support.industry.siemens.com/cs/ww/en/view/59191792)" system manual and the product manuals (https://support.industry.siemens.com/cs/ww/en/ps/29727/man) for the corresponding S7-1500/ET 200MP fail-safe modules	Describes the hardware of the S7-1500 systems and the S7-1500/ET 200MP fail-safe modules (including installation, wiring, and technical specifications)
System manual "Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833)"	Describes the hardware of S7-1500R/H systems (including design, wiring and technical specifications)
"SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766665)" system manual and "SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/109766666)" equipment manual	Describes the hardware of the SIMATIC Drive Controller (including design, wiring and technical specifications)
"SIMATIC S7-1500 S7-PLCSIM Advanced (https://support.industry.siemens.com/cs/ww/en/view/109955578)" function manual	Describes the operation of S7-PLCSIM Advanced
"ET 200SP distributed I/O system (https://support.industry.siemens.com/cs/ww/en/view/58649293)" system manual and the product manuals (https://support.industry.siemens.com/cs/ww/en/ps/14059/man) for the corresponding ET 200SP fail-safe modules	Describes the hardware of the ET 200SP fail-safe modules (including installation, wiring, and technical specifications)
System manual "Distributed I/O System ET 200SP HA (https://support.industry.siemens.com/cs/ww/en/view/109817158)" and the equipment manuals (https://support.industry.siemens.com/cs/ww/en/ps/28940/man) for the respective ET 200SP HA fail-safe modules	Describes the hardware of the ET 200SP HA fail-safe modules (including setup, wiring and technical specifications).
"ET 200eco Distributed I/O Station Fail-safe I/O Block (https://support.industry.siemens.com/cs/ww/en/view19033850)" manual	Describes the hardware of the ET 200eco fail-safe I/O module (including installation, wiring, and technical specifications)
Manual "ET 200eco PN F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A PM, 3xM12 (https://support.industry.siemens.com/cs/ww/en/view/109765611)"	Describes the hardware of the ET 200eco PN fail-safe I/O module (including installation, wiring, and technical specifications)

Documentation	Brief description of relevant content
System manual "ET 200AL system manual (https://support.industry.siemens.com/cs/ww/en/view/89254965)" and equipment manual "Digital I/O Module F-DI 4+F-DQ 2x24VDC/2A, 4xM12" (https://support.industry.siemens.com/cs/ww/en/view/109798489)	Describes the hardware of the ET 200AL fail-safe I/O module (including installation, wiring, and technical specifications)
"Distributed I/O System ET 200S, Fail-Safe Modules (https://support.industry.siemens.com/cs/ww/en/view/27235629)" operating instructions	Describes the hardware of the ET 200S fail-safe modules (including installation, wiring, and technical specifications)
"S7-300 Automation System, ET 200M Distributed I/O System, Fail-safe Signal Modules (https://support.industry.siemens.com/cs/ww/en/view/19026151)" manual	Describes the hardware of the S7-300 fail-safe signal modules (including installation, wiring, and technical specifications)
"Distributed I/O system ET 200pro, fail-safe I/O modules (https://support.industry.siemens.com/cs/ww/en/view22098524)" operating instructions	Describes the hardware of the ET 200pro fail-safe modules (including installation, wiring, and technical specifications)
"ET 200iSP distributed I/O device - Fail-safe modules (https://support.industry.siemens.com/cs/ww/en/view/47357221)" operating instructions	Describes the hardware of the ET 200iSP fail-safe modules (including installation, wiring, and technical specifications)
"Communication (https://support.industry.siemens.com/cs/ww/en/view/59192925)" Function Manual	Contains the description of communication with OPC UA
Help on *STEP 7*	• Describes the operation of the standard tools in *STEP 7* • Contains information regarding configuration and parameter assignment of hardware • Contains a description of the programming languages FBD and LAD • Contains the description of communication with OPC UA

Fail-safe modules Manual Collection

The Manual Collection contains all the documentation for the SIMATIC fail-safe modules collected into one file.

You can find the Manual Collection on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109806400).

Guide

This documentation describes how to work with *STEP 7 Safety*. It includes instructions and reference sections (description of the instructions for the Safety program).

The following topics are addressed:

- Configuration of SIMATIC Safety
- Access protection for SIMATIC Safety
- Programming of the Safety program (safety-related user program)
- Safety-related communication
- Instructions for the Safety program
- Support for the system acceptance
- Operation and maintenance of SIMATIC Safety
- Monitoring and response times

Conventions

The following conventions apply:

- In this documentation, the terms "safety engineering" and "fail-safe engineering" are used synonymously. The same applies to the terms "fail-safe" and "F-".
- "F-systems" include redundant S7-1500HF systems. Special features and restrictions of H systems are described in the system manual "Redundant S7-1500R/H system (https://support.industry.siemens.com/cs/ww/en/view/109754833)" and also apply to the redundant S7-1500HF systems.
- *"STEP 7 Safety V21"* stands for *"STEP 7 Safety Advanced V21"*.
- "(S7-300)" indicates that the section **only** applies to S7-300 F-CPUs. S7-300 F-CPUs also includes the F-CPUs ET 200S and ET 200pro (IM F-CPUs).
- "(S7-400)" indicates that the section **only** applies to S7-400 F-CPUs.
- "(S7-1200 G1)" indicates that the section **only** applies to S7-1200 F-CPUs with article number 6ES721x-1xF**40**....
- "(S7-1200 G2)" indicates that the section **only** applies to S7-1200 F-CPUs with article number 6ES721x-1xF**50**....
- "(S7-1200)" indicates that the section **only** applies to S7-1200 G1 F-CPUs and S7-1200 G2 F-CPUs.
- "(S7-1500)" indicates that the section **only** applies to S7-1500 F-CPUs. S7-1500 F-CPUs also include S7-1500 HF-CPUs, ET 200SP F-CPUs, the CPU 151xpro F-2 PN, the S7-1500 F Software Controller, the SIMATIC Drive Controller and the S7-1500 F Virtual Controller. In the case of exceptions, these are indicated.

The scopes can be combined.

The term **Safety program** refers to the fail-safe portion of the user program and is used instead of "fail-safe user program", "F-program", etc. For purposes of contrast, the non-safety-related part of the user program is referred to as the "standard user program".

The **hardware configuration** includes the configuration of standard CPUs and standard I/Os as well as the configuration of F-CPUs and F-I/Os.

The **safety-related hardware configuration** includes the safety-related parameters of the F-CPUs and F-I/Os.

The **safety-related project data** includes the safety-related hardware configuration as well as the Safety program.

NOTE

Each warning is marked with a unique number at the end of the text. This enables you to easily reference other documents, for example, to obtain an overview of the safety requirements for the system.

Additional support

If you have further questions about the use of products presented in this manual, contact your local Siemens representative.

You can find information on whom to contact on the Web (https://www.automation.siemens.com/aspa_app).

A guide to the technical documentation for the various SIMATIC products and systems is available on the Web (http://www.siemens.com/simatic-tech-doku-portal).

You can find the online catalog and online ordering system on the Web (www.siemens.com/industrymall).

Training center

We offer courses to help you get started with the S7 automation system. To do this, contact your regional training center or the central training center in Nuremberg, Germany.

More information can be found on the Internet (http://www.sitrain.com).

Technical Support

To contact Technical Support for all Industry Automation products, use the Support Request Web form (http://www.siemens.com/automation/support-request).

More information can be found about our Technical Support on the Web (http://www.siemens.com/automation/service).

Important note for maintaining the operational safety of your system

NOTE

The operators of systems with safety-related characteristics must adhere to operational safety requirements. The supplier is also obliged to comply with special product monitoring measures. Siemens informs system operators in the form of personal notifications about product developments and properties which could be or become important issues in terms of operational safety.

You should subscribe to the corresponding notifications in order to obtain the latest information and to allow you to make any necessary modifications to your system.

Log in to the Industry Online Support. Follow the links below and click on "Email on update" on the right-hand side in each case:

- SIMATIC S7-300/S7-300F (https://support.industry.siemens.com/cs/products?pnid=13751&lc=en-WW)
- SIMATIC S7-400/S7-400H/S7-400F/FH (https://support.industry.siemens.com/cs/products?pnid=13828&lc=en-WW)
- SIMATIC S7-1500/SIMATIC S7-1500F/SIMATIC S7-1500HF (https://support.industry.siemens.com/cs/products?pnid=13716&lc=en-WW)
- SIMATIC S7-1200/SIMATIC S7-1200F (https://support.industry.siemens.com/cs/products?pnid=13683&lc=en-WW)
- Software Controller (https://support.industry.siemens.com/cs/products?pnid=13911&lc=en-WW)
- Distributed I/O (https://support.industry.siemens.com/cs/products?pnid=14029&lc=en-WW)
- STEP 7 (TIA Portal) (https://support.industry.siemens.com/cs/products?pnid=24471&lc=en-WW)
- Virtual Controller (https://support.industry.siemens.com/cs/ww/en/ps/29702)

Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

SiePortal

You can find current information on the following topics quickly and easily here:

- **Catalog and ordering system**

  Ordering system for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

- **Product support**

  All the information and extensive know-how on your product, technical specifications, FAQs, certificates, downloads, and manuals.

- **Application examples**

  Tools and examples to solve your automation tasks – as well as function blocks, performance information and videos.

- **Services**

  Information about Industry Services, Field Services, Technical Support, spare parts and training offers.

- **Forums**

  For answers and solutions concerning automation technology.

- **mySiePortal**

  Your personal work area in the SiePortal for notifications, support requests, and configurable documents.

This information is provided by SiePortal on the Internet (https://sieportal.siemens.com/).

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Product Overview 1

1.1 Overview

SIMATIC Safety fail-safe system

The SIMATIC Safety fail-safe system is available to implement safety concepts in the area of machine and personnel protection (for example, for emergency STOP devices for machining and processing equipment) and in the process industry (for example, for implementation of protection functions for safety devices of instrumentation and controls and of burners).

⚠ WARNING

The SIMATIC Safety F-system is used to control processes that reach their safe state immediately through shutdown. This also applies in particular to redundant S7-1500HF systems.

SIMATIC Safety may only be used for controlling processes in which a shutdown does not pose a danger to humans or the environment.

When realizing safety applications including the creation of the safety-related project data you have to take into consideration the standards, directives and guidelines relevant for your application. In particular include standards in which the software creation process is described (for example IEC 61508-3 or ISO 13849-1). *(S062)*

Achievable safety requirements

SIMATIC Safety F-systems can satisfy the following safety requirements:

- Safety Integrity Level SIL3 in accordance with IEC 61508:2010
- Performance Level (PL) e and category 4 in accordance with ISO 13849-1:2015 or EN ISO 13849-1:2015

Functional safety in SIMATIC Safety

Functional safety is implemented primarily in the software. The SIMATIC Safety F-System brings the plant into a safe state in the event of a hazardous event and maintains this state. Safety mechanisms are contained mainly in the following components:

- In the safety-related user program (safety program) in the F-CPU
- In the fail-safe inputs and outputs (F-I/O)

The F-I/O ensure the safe processing of field information (sensors: e.g. emergency STOP pushbutton, light barriers; actuators, e.g. for motor control). They have all of the required hardware and software components for safe processing, in accordance with the required

Safety Integrity Level. The user only has to program the user safety function. Functional safety for the process can be provided by a user safety function or a fault reaction function. The F-system cyclically checks the integrity of the safety program and the safety-related data. This check is generally always performed when safety-related data leaves an F-runtime group via safety-related communication or F-I/O access. If this check detects a fault, the F-system executes the fault reaction function, which switches off the associated outputs and, if necessary, sets the F-CPU to STOP.

NOTE

If the F-CPU switches to STOP mode due to a fault reaction function, with a redundant S7-1500HF system, it leads to the STOP of the primary CPU **and** the backup CPU.

Example of user safety function and fault reaction function

In the event of overpressure, the F-system will open a valve (user safety function). In the event of a hazardous fault in the F-CPU, all outputs are deactivated (fault reaction function), whereby the valve is opened, and the other actuators also attain a safe state. For a non-faulty F-system, only the valve would be opened.

1.2 Hardware and Software Components

Hardware and software components of SIMATIC Safety

The following schematic diagram provides an overview of the hardware and software components required to configure and operate a SIMATIC Safety F-system.

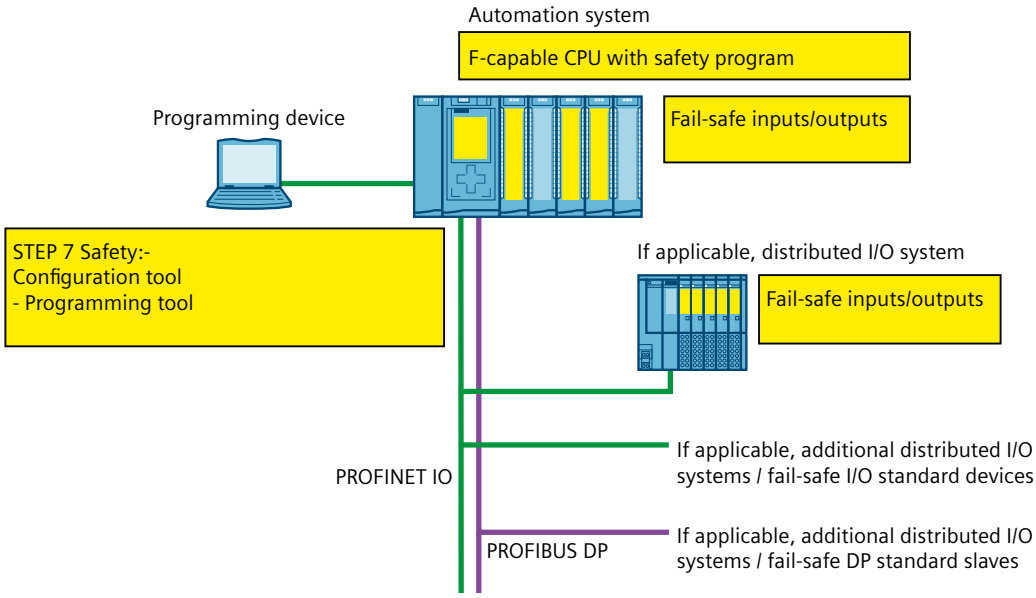

Hardware components for PROFIBUS DP

You can use the following fail-safe components in SIMATIC Safety F-systems on PROFIBUS DP:

- F-CPUs with DP interface, such as CPU 1516F-3 PN/DP
- SIMATIC Drive Controller, for example, CPU 1504D TF
- Fail-safe inputs and outputs (F-I/O), such as:
  - S7-300 fail-safe signal modules in ET 200M
  - S7-1500/ET 200MP fail-safe modules
  - ET 200SP fail-safe modules
  - ET 200S fail-safe modules
  - ET 200pro fail-safe modules
  - ET 200iSP fail-safe modules
  - Fail-safe I/O modules ET 200eco (S7-300, S7-400)
  - Fail-safe GSD based DP slaves (light array, laser scanner, etc.)

You have the option to expand the configuration with standard I/O.

The following CPs/CMs can be used in a SIMATIC Safety F-system on PROFIBUS DP for connection to distributed F-I/O:

- CP 443-5 Extended
- CM 1243-5
- CM 1542-5
- CP 1542-5
- SP CM DP

Hardware components for PROFINET IO

You can use the following fail-safe components in SIMATIC Safety F-systems on PROFINET IO:

- F-CPUs with PN interface, e.g. CPU 1214FC DC/DC/DC
- SIMATIC Drive Controller, for example, CPU 1504D TF
- Fail-safe inputs and outputs (F-I/O), such as:
  - S7-300 fail-safe signal modules in ET 200M
  - S7-1500/ET 200MP fail-safe modules
  - ET 200SP fail-safe modules
  - ET 200SP HA fail-safe modules
  - ET 200S fail-safe modules
  - ET 200pro fail-safe modules
  - ET 200eco PN fail-safe I/O modules
  - ET 200AL fail-safe I/O modules
  - Fail-safe GSD based I/O devices (light array, laser scanner, etc.)

You have the option to expand the configuration with standard I/O.

The following CPs/CMs can be used in a SIMATIC Safety F-system on PROFINET IO for connection to distributed F-I/O:

- CP 443-1
- CP 443-1 Advanced-IT
- CM 1542-1

Hardware components for central configuration

You can use the following fail-safe components in SIMATIC Safety F-systems centrally on an F-CPU (not HF-CPU):

- S7-300/ET 200M fail-safe signal modules
- S7-1200 fail-safe modules
- S7-1500/ET 200MP fail-safe modules
- ET 200SP fail-safe modules
- ET 200S fail-safe modules
- ET 200pro fail-safe modules (can also be used with CPU 1516proF-2)

You have the option to expand the configuration with standard I/O.

STEP 7 Safety

This documentation describes *STEP 7 Safety Advanced V21*. *STEP 7 Safety* is the configuration and programming software for the SIMATIC Safety F-system. With *STEP 7 Safety*, you receive the following:

- The support for configuring the F-I/O in the *hardware and network editor* of TIA Portal
- The support for creating the Safety program using LAD and FBD and integrating error detection functions into the Safety program
- Instructions for programming your Safety program in LAD and FBD, which you are familiar with from the standard user programs
- Instructions for programming your Safety program in LAD and FBD with special safety functions

Moreover, *STEP 7 Safety* offers functions for comparing Safety programs and for assisting you with the system acceptance.

⚠ WARNING

The configuration of F-CPUs and F-I/Os as well as the programming of F-blocks must be carried out in TIA Portal as described in this documentation. To ensure safe operation with the SIMATIC Safety system, you must comply with the requirements of the relevant standards, such as IEC 61508. The section System acceptance (Page 427) describes procedures and tools of STEP 7 Safety to meet these requirements. *(S056)*

Optional packages

In addition to *STEP 7 Safety*, you can use option packages with F-I/O and F-CPUs and use instructions for programming your Safety program with special safety functions within the SIMATIC Safety F-system, for example SINUMERIK.

The installation, parameter assignment and programming as well as what is important to note during system acceptance, is described in the documentation for the specific optional packages.

Also read the notes in "Configurations supported by the SIMATIC Safety F-system (Page 63)".

TIA Portal Cloud Connector

WARNING

Use of the TIA Portal Cloud Connector is only intended for engineering work with TIA Portal. This means online access in productive operation (e.g. SCADA) is not permitted. This is particularly true for Safety programs. *(S068)*

Openness

Openness (https://support.industry.siemens.com/cs/ww/en/view/109826886) as part of *STEP 7 Safety* is supported with the functions listed below. The use of Openness in productive operation is not permitted.

As part of *STEP 7 Safety* the following is supported:

- Inserting / removing F-CPUs and F-I/Os
- Copying / deleting F-CPUs and F-I/Os from templates
- Compiling hardware
- Compiling software (incl. Safety program)
- Handling access protection for the safety-related project data (for TIA projects not protected by project protection)
- Reading/configuring F-parameters of the F-CPU (for S7-1500 F-CPUs)
- Reading/configuring F-parameters of F-I/Os
- Reading/configuring i-parameters of F-I/Os (for ET 200SP, ET 200AL, ET 200MP, ET 200eco PN, ET 200pro)
- Downloading safety-related project data to a SIMATIC Memory Card or storing it in a file folder
- Reading, declaring or deleting fail-safe tags in the PLC tag table
- Updating projects to the latest type versions of F-blocks
- Consistent station upload
- Export and import of F-blocks and F-compliant PLC data types (UDT)
- Comparison of hardware and software

- Version control interface (VCI) support
- Reading out PLC online fingerprint for the Safety program
- Storing safety-related project data as a PC System Configuration file
- Reading out the F-signatures and block signatures
- Adding and removing OPC UA Safety configurations (SafetyProvider/SafetyConsumer)

The following are not supported.

- Downloading to device

WARNING

When using Openness or other tools for operating the TIA Portal in combination with safety-related project data, integrity of the data must be ensured (for example, as part of the save or transfer functions of "Source Code Management" applications). If there is a connection of external tools, the requirements for offline support tools according to IEC 61508-3 must be observed. A violation of the integrity of the safety-related project data either offline or online cannot be detected by *STEP 7 Safety*. A final verification of the correctness of the safety-related project data has to be carried out as described in the section System acceptance (Page 427). *(S070)*

Openness programs can also be integrated into TIA Portal as an add-in. It is also possible to include so-called workflow add-ins, which are automatically called before a Safety program is compiled. See "Extending workflows" in the standard help.
If you have integrated such a workflow add-in, this is output in the safety summary.

Openness service

The Openness interface has been expanded to include the following services:

- `GlobalSettings` (see name area **Siemens.Engineering.Safety**), which provides the following actions:
  - `SafetyModificationsPossible(bool safetyModificationsPossible)`
  - `UsernameForFChangeHistory(string userName)`
  - `bool SafetyModificationsPossible()`
  - `string UsernameForFChangeHistory()`
- `SafetyBaseIdProvider` with the following action in the name area **Siemens.Engineering.Safety**:
  - `void GenerateBaseId()`

  `SafetySignatureProvider` which provides the following actions and properties:
  - `SafetySignatureComposition Signatures`
  - `UInt64 SafetySignature.Value`
  - `SafetySignatureType SafetySignature.Type`

- `SafetyAdministration` with the following actions and properties in the name area **Siemens.Engineering.Safety:**
  - `bool IsSafetyOfflineProgramPasswordSet`
  - `void SetSafetyOfflineProgramPassword(SecureString newPassword)`
  - `void RevokeSafetyOfflineProgramPassword(SecureString currentPassword)`
  - `bool IsLoggedOnToSafetyOfflineProgram`
  - `void LoginToSafetyOfflineProgram(SecureString currentPassword)`
  - `void LogoffFromSafetyOfflineProgram()`
- `Safety Administration`, which can be accessed from the `PLc-DeviceItem`.

  The `SafetyAdministration` service offers the following properties in the **Siemens.Engineering.Safety** namespace. These three properties include additional properties that are listed in the description.
  - `RuntimegroupComposition RuntimeGroups { get; }`
  - `SafetySettings Settings { get; }`
  - `SafetySignatureProvider ProgramSignatures { get; }`
- `SafetyPrintout` with the following action in the name area **Siemens.Engineering.Safety**:
  - `bool Print(SafetyPrintoutFilePrinter filePrinter, FileInfo fullOutputPath, string documentLayout, SafetyPrintoutOption documentationOption);`

More information can be found in the System Manual "SIMATIC TIA Portal Openness: Automating creation of projects (https://support.industry.siemens.com/cs/ww/en/view/109826886)" in the section "F-specific openness".

Virtual environments

WARNING

Use of virtual environments in the engineering system

Note that a hypervisor or a client software of a hypervisor is not permitted to perform any function that reproduces recorded message frame sequences with correct time response in a network with real F-CPUs and F-I/Os.

Make sure that this condition is met, for example, when using the following functions:

- Reset of captured statuses (snapshots) of the virtual machines (VMs)
- Suspending and resuming the VMs
- Replay of recorded sequences in the VMs
- Moving VMs between hosts in productive operation (e.g. Fault Tolerance (FT))
- Digital twins of VMs in the virtual environment

If in doubt, disable these functions in the settings (Hypervisor administration console). *(S067)*

Operating system installations with S7-150xS(P) F

⚠ WARNING

When using a PC with multiple Windows or Linux operating system installations (e.g. via boot manager), only one S7-150xS(P) F may be installed on this PC. *(S095)*

Safety program

You can create a Safety program using the *program editor*. You can program fail-safe FBs and FCs in the FBD or LAD programming languages using the instructions from *STEP 7 Safety* and create fail-safe DBs.

Safety checks are automatically performed and additional fail-safe blocks for error detection and fault reaction are inserted when the Safety program is compiled. This ensures that failures and errors are detected and appropriate reactions are triggered to maintain the F-system in the safe state or bring it to a safe state.

In addition to the Safety program, a standard user program can be run on the F-CPU. A standard program can coexist with a Safety program in an F-CPU because unintentional influencing of the safety-related data of the Safety program is uncovered by the standard user program.

Data can be exchanged between the safety program and the standard user program in the F-CPU by means of bit memory or data of a standard DB or by accessing the process image input and output.

Note possible restrictions/particularities when using Software Units or a Safety Unit (Page 118).

See also

Data Transfer from the Safety Program to the Standard User Program (Page 204)

1.3 Installing/uninstalling the STEP 7 Safety Advanced V21 license

After installation of the *STEP 7 Safety Advanced V21* license, the range of functions of *STEP 7 Safety Advanced V21* is available to you. This license is not required for S7-1200 F-CPUs.

Software requirements for *STEP 7 Safety Advanced V21*

At a minimum, the following software package must be installed on the programming device or PC:

- *SIMATIC STEP 7 Professional V21*

Installing the *STEP 7 Safety Advanced V21* license

1. Start the *Automation License Manager* on the programming device/PC on which the *"SIMATIC STEP 7 Professional V21"* software package is installed.
2. Install the *STEP 7 Safety Advanced V21* license as described in the *Automation License Manager help*.

Uninstalling the *STEP 7 Safety Advanced V21* license

To uninstall the *STEP 7 Safety Advanced V21* license, proceed as described in the *Automation License Manager help*.

1.4 Migrating projects from S7 Distributed Safety V5.4 SP5 to STEP 7 Safety Advanced

Migration of *S7 Distributed Safety* projects to *STEP 7 Safety Advanced* is no longer supported as of *STEP 7 Safety V21*. Migration is still possible with earlier versions of the *TIA Portal*. The project can then be upgraded from an earlier version to the current version in the usual way.

1.5 Migrating PLC programs to a n F-CPU S7-1500

To migrate an F-CPU S7-300/400 onto an F-CPU S7-1500, proceed as with the migration of a standard CPU S7-300/400 onto a CPU S7-1500.

Points to note after migration:

- Non-automatable actions
  - Creating an F-runtime group and assigning it to the main safety block.
  - The hardware configuration including the I/O of the initial F-CPU is not automatically transferred to an S7-1500 F-CPU. Implement the hardware configuration of the new CPU manually after migration.

    Please also read the sections
    "Specify F-destination address for F-I/O of PROFIsafe address type 1" and "Specify F-destination address for F-I/O of PROFIsafe address type 2" in chapter "Configuring an F-CPU (Page 40)". Otherwise, this can lead to a reassignment of the F-destination addresses in the configuration.
  - When using F-I/O with PROFIsafe Protocol Version = Expanded Protocol (XP) (for example S7-1500/ET 200MP F-modules), keep in mind that you need one byte more in the address area of S7-1200/1500 F-CPUs than in S7-300/400 F-CPUs.
  - Replacement of the OV instruction by the connection of the ENO output for mathematical functions (Page 567).
  - Replacement of the RD_FDB instruction by the instructions RD_ARRAY_I (Page 584) and RD_ARRAY_DI (Page 587).
  - Replacement of the F-runtime group communication through Communication via Flexible F-Link (Page 149).

- Instructions not supported:
  - MUTING
  - TWO_HAND
  - WR_FDB
  - OPN
  - SENDS7
  - RCVS7
- Data types not supported
  - DWORD
- Changes to safety program programming
  - F_GLOBDB.VKE0/1 replaced by FALSE/TRUE (Page 121).
  - Readable values from the F_GLOBDB replaced by the F-runtime group information DB. Additional information is available under F-shared DB (S7-300, S7-400) (Page 157) and F-runtime group information DB (S7-1200, S7-1500) (Page 158).
  - Replacement of the QBAD_I_xx or QBAD_O_xx tag by the value status. Additional information is available under Value status (S7-1200, S7-1500) (Page 163) and F-I/O DB (Page 168).
- New naming convention when naming the F-I/O DBs
- Modified behavior of QBAD and PASS_OUT (Page 174) tags for F-I/O with "RIOforFA safety" profile.

Compile the safety program and eliminate any compilation errors displayed.

NOTE

A new acceptance must be carried out following F-CPU migration.

See also

Programming (Page 113)

1.6 Upgrading projects to the latest version of STEP 7 Safety

Re-create the safety summary after an upgrade to a newer version of *STEP 7 Safety*. The versions listed in the new safety summary of *STEP 7 Safety* will then match the new version of *STEP 7 Safety*.

1.6.1 Upgrading projects from STEP 7 Safety as of V14 SP1 to the latest version

If you want to continue working with a project from *STEP 7 Safety* as of *V14 SP1*, you must upgrade the project to the latest version of *STEP 7 Safety*.

NOTE

The project must be consistent before upgrading.

Perform the upgrade following the usual procedure for *STEP 7*. After upgrading to the latest version, you must compile your safety program and download it in STOP.

If you want to compile a migrated safety program with STEP 7 Safety for the first time, we recommend that you first update to the latest available version of the instruction. You will then avoid number conflicts.

If you have upgraded a project <= V17 to the latest version and compiled it, the Collective F-signature remains the same, but the version comparison between the online and offline programs shows a change. The differences shown are due to the improved calculation of the signatures as of V18. Because the Collective F-Signature has remained the same, re-acceptance is not necessary. We recommend creating a new safety summary so that the new signatures are documented.

Keep in mind that existing change histories are not upgraded. All previous entries are deleted after the upgrade. If required, print out the change log before you upgrade.

If you have created your project with *STEP 7 Safety V18* and have stored the Safety program in a Safety unit in this project, you must upgrade the project and then re-create the safety summary, which replaces the Safety summary created with *STEP 7 Safety V18*. This is required for the SENDDP and RCVDP instructions in the "System library elements used in Safety program" section to be displayed correctly.

1.7 First steps

Getting Started in SIMATIC Safety

Three Getting Started documents are available to help you begin using SIMATIC Safety.

The Getting Started documentation is an instruction manual that provides a step-by-step description of how to create a project with SIMATIC Safety. It gives you the opportunity to quickly become familiar with the scope of features of SIMATIC Safety.

Contents

The Getting Started documentation describes the creation of a single, continuous project that is extended with each section. Based on the configuration, you program a fail-safe shutdown, make changes to the programming, and accept the system.

In addition to the step-by-step instructions, the Getting Started documentation also gives you background information for every new topic, which explains the functions used in more detail and how they interrelate.

Target audience

The Getting Started documentation is intended for beginners but is also suitable for users who are switching from *S7 Distributed Safety*.

Download

Three Getting Started documents are available as PDF files for free download in the Industry Online Support:

- STEP 7 Safety Advanced V11 with S7-300/400 F-CPUs (https://support.industry.siemens.com/cs/ww/en/view/49972838)
- STEP 7 Safety Basic V13 SP1 with S7-1200 F-CPUs (https://support.industry.siemens.com/cs/ww/en/view/104547552) (part of the manual "S7-1200 Functional Safety manual")
- STEP 7 Safety Advanced V13 with S7-1500 F-CPUs (https://support.industry.siemens.com/cs/ww/en/view/101177693)

Configuring 2

2.1 Overview of Configuration

Introduction

You basically configure a SIMATIC Safety F-system in the same way as a standard S7-300, S7-400, S7-1200, S7-1500 or ET 200MP, ET 200SP, ET 200SP HA, ET 200AL, ET 200S, ET 200iSP, ET 200eco, ET 200eco PN or ET 200pro automation system in *STEP 7*.

This section presents only the essential differences compared to standard configuration you encounter when configuring a SIMATIC Safety F-system.

This documentation distinguishes between three groups of F-I/O:

F-I/Os of PROFIsafe address type 1

F-I/Os which ensure the uniqueness of the PROFIsafe address solely with the F-destination address, for example, ET 200S F-modules. The PROFIsafe address is usually assigned by DIP switches.

F-I/Os of PROFIsafe address type 2

F-I/O for which the uniqueness of the PROFIsafe address can be ensured through the combination of F-source address and F-destination address, for example, S7-1500/ET 200MP F-modules. You normally assign the PROFIsafe address with *STEP 7 Safety*.

F-I/O of PROFIsafe address type 3

F-I/O for which the uniqueness of the PROFIsafe address can be ensured through an F-BaseID in addition to the combination of F-source address and F-destination address, for example, certain S7-1500/ET 200SP F-modules. The F-BaseID saves you the work of ensuring the uniqueness of the PROFIsafe address network-wide/worldwide yourself (for more information, see "PROFIsafe addresses for F-I/O of PROFIsafe address type 3 (Page 69)"). You normally assign the PROFIsafe address (including the F-BaseID) with *STEP 7 Safety*.

NOTE

The terminology "PROFIsafe address type 3" used in this documentation is equivalent to the designation "PROFIsafe address type 2 with BaseID". This applies in TIA Portal as well as to F-I/Os.

Which F-components can you configure with *STEP 7 Basic/STEP 7 Professional* and *STEP 7 Safety Advanced*?

The table below shows you which F-CPUs you can configure with *STEP 7 Safety Advanced*:

F-CPUs	*STEP 7 Safety Advanced*
S7-300	x
S7-400	x
S7-1200	x *
S7-1500(H)	x
SIMATIC Drive Controller	x
S7-1500 F Software Controller	x
S7-1500 F Virtual Controller	x

* You can configure S7-1200 F-CPUs without a license for *STEP 7 Safety*.

The table below shows you which F-I/Os you can configure with *STEP 7 Safety Advanced* as well as which PROFIsafe address type they support:

F-I/O	*STEP 7 Safety Advanced*	PROFIsafe address type
S7-300 F-SMs	x**	1
ET 200S F-modules	x	1
ET 200pro F-modules	x	1
ET 200iSP F-modules	x	1
ET 200eco DP F-I/O modules	With S7-300/400 F-CPUs (only PROFIsafe V1 mode)	1
ET 200eco PN F-I/O modules	x	2
S7-1200 F-modules (centrally on S7-1200 F-CPUs)	x***	2
ET 200SP F-modules	x	2 or 3
ET 200SP HA F-modules	x	2
S7-1500/ET 200MP F-modules	x	2
ET 200AL F-modules	x	2
fail-safe GSD based DP slaves	x	*
fail-safe GSD based I/O devices	x	*

* Consult the respective documentation to determine the PROFIsafe address type of a GSD based DP slave/GSD based I/O device. If in doubt, assume that the PROFIsafe address is type 1.

*** F-SMs that only support PROFIsafe V1 mode can only be used on F-CPUs S7-300/400.

*** You can configure S7-1200 F-modules without a license for *STEP 7 Safety*.

Special F-parameters

For the F-functionality there are special F-parameters that you can review and set in the "Properties" of the fail-safe components (F-CPU and F-I/O). F-parameters are marked in yellow.

F-parameters are explained in "Configuring an F-CPU (Page 40)" and "Configuring F-I/O (Page 52)".

Changing safety-related parameters

NOTE

If you change a safety-related parameter (marked in yellow) for an F-I/O or an F-CPU, you must then compile and download the modified hardware configuration and the Compiling the safety program (Page 361) (context menu "Compile > Hardware and software (only changes)"). This also applies to changes to F-I/O that are not used in the safety program. F-I/O in standard operation is not affected by this.

Compiling the hardware configuration

You must compile the hardware configuration of the SIMATIC Safety F-system (context menu "Compile > Hardware configuration"). A configured F-CPU with enabled F-capability is the only prerequisite for programming the safety program.

NOTE

Inconsistencies are possible when configuring the hardware and can also be saved. A full consistency check of the hardware configuration and possible connection data is performed only during compilation. Therefore, perform "Edit > Compile" regularly.

Example: Configured F-system in *STEP 7 Professional*

The following figure presents a configured F-system. You choose the fail-safe components in the "Hardware catalog" task card as you would do with standard components and place them in the work area of the network or device view. F-components are shown in yellow.

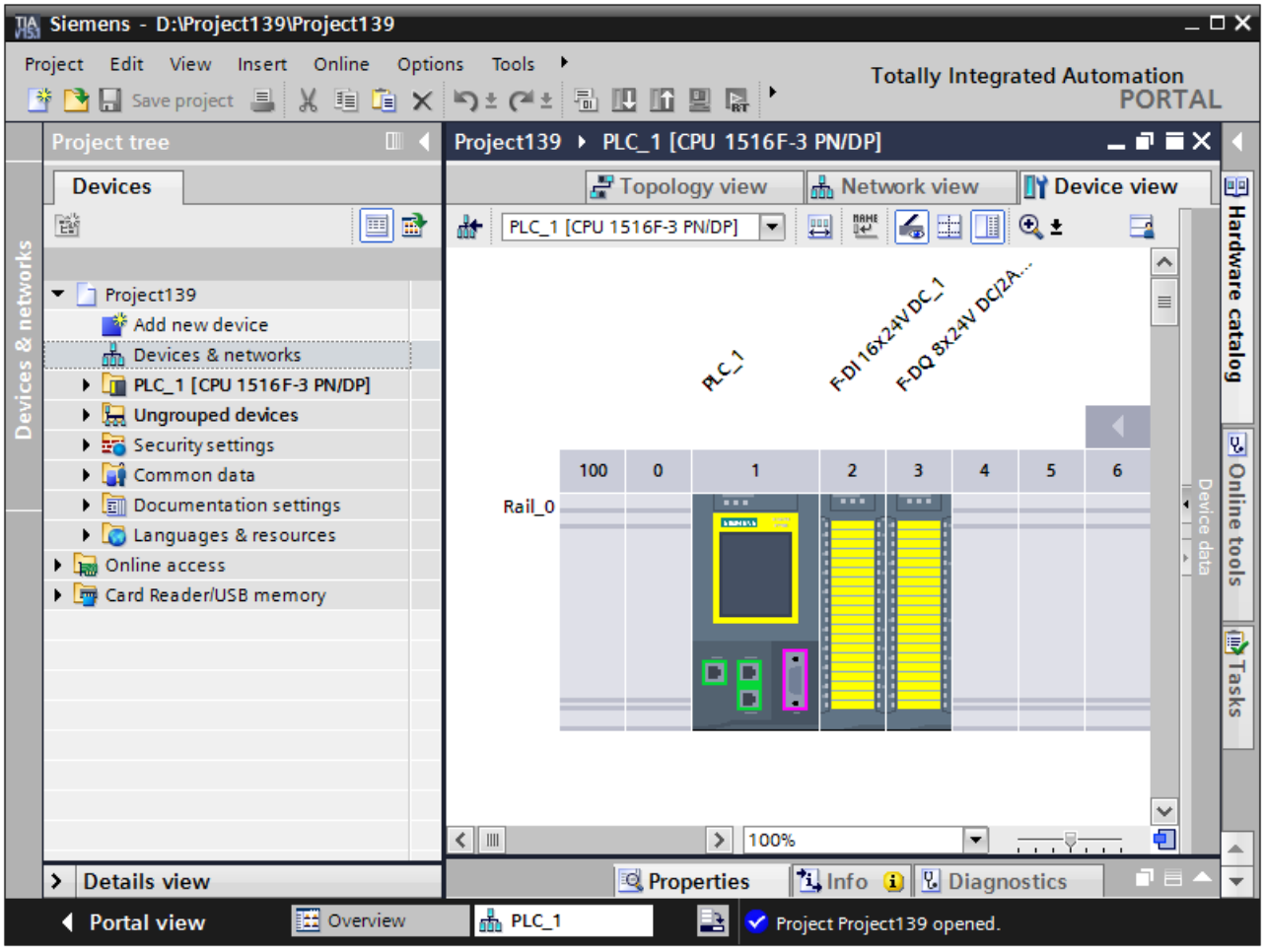

More information

For detailed information on F-I/O, refer to the *manuals for the relevant F-I/O*.

Which safety-related communication options can you configure?

You need to use the *hardware and network editor* to configure the following safety-related communication options (see Communication via SENDDP/RCVDP or SENDS7/RCVS7(S7-300, S7-400) instructions: (Page 208) or Communication via SENDDP/RCVDP instructions (S7-1200, S7-1500): (Page 257)):

- Communication with OPC UA Safety (Page 297)
- Communication with Flexible F-Link (Page 355)

- Safety-related master-master communication
- Safety-related master-master communication for *S7 Distributed Safety*
- Safety-related master-I-slave communication
- Safety-related I-slave-I-slave communication
- Safety-related I-slave-slave communication
- Safety-related IO controller-IO controller communication
- Safety-related IO controller-IO controller communication for *S7 Distributed Safety*
- Safety-related IO controller-I-device communication
- Safety-related IO controller-I-slave communication
- Safety-related communication via S7 connections
- Safety-related communication via S7 connections for *S7 Distributed Safety* or *S7 F Systems*

2.2 Peculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices

Requirement

In order to use fail-safe GSD based DP slaves for SIMATIC Safety, these GSD based slaves must be operated on PROFIBUS DP and support the PROFIsafe bus profile. When used in an S7-1200/1500 F-CPU, they must support the PROFIsafe bus profile in V2 mode.

Fail-safe GSD based DP slaves used in hybrid configurations on PROFIBUS DP and PROFINET IO downstream from a IE/PB link must support the PROFIsafe bus profile in V2 mode.

In order to use fail-safe GSD based I/O devices for SIMATIC Safety, the GSD based devices must be operated on PROFINET IO and support the PROFIsafe bus profile in V2 mode.

Configuration with GSD files

As is the case in a standard system, the basis for configuring fail-safe GSD based DP slaves/IO devices is the device specification in the GSD file (device master file).

A GSD file contains all of the properties of a GSD based DP slave or GSD based I/O device. For fail-safe GSD based DP slaves/GSD based I/O devices, certain parts are protected by a CRC.

The GSD files are supplied by the device manufacturers.

Protection of the data structure of the device in GSD files

The only GSD files supported are those that satisfy the requirements for protection defined as of *PROFIsafe Specification* V2.0 using a CRC stored in this file ("setpoint" for F_IO_StructureDescCRC).

The data structure described in the GSD file is checked when the F-I/O is added to the hardware configuration and when the hardware configuration is compiled. When an error is detected, you should clarify whether the GSD file provided by the device manufacturer contains the setpoint for F_IO_StructureDescCRC.

Assignment and setting of the PROFIsafe address

WARNING

Check the documentation for your fail-safe GSD based DP slaves / fail-safe GSD based I/O devices to find out the valid PROFIsafe address type. If you do not find the necessary information, assume PROFIsafe address type 1. For configuring, proceed as described under PROFIsafe addresses for F-I/O of PROFIsafe address type 1 (Page 66), PROFIsafe addresses for F-I/O of PROFIsafe address type 2 (Page 67) or PROFIsafe addresses for F-I/O of PROFIsafe address type 3 (Page 69).

Set the F-source address for fail-safe GSD based DP slaves / fail-safe GSD based I/O devices according to the manufacturer's specifications. If the F-source address needs to correspond to the "Central F-source address" parameter of the F-CPU (PROFIsafe address type 2), you will find the latter in the "Properties" tab of the F-CPU. In this case, check the safety summary to verify that the value for the "Central F-source address" parameter corresponds to the value of the F-source address of the fail-safe GSD based DP slave/fail-safe GSD based I/O device. *(S053)*

Configuration procedure with GSD files

You import the GSD files to your project (see *Help on STEP 7 "GSD files"*).

1. Select the fail-safe GSD based DP slave / GSD based I/O device in the "Hardware catalog" task card and connect it to the relevant subnet in the network view.
2. Select the fail-safe GSD based DP slave/GSD based I/O device and insert the necessary F-modules, if this does not occur automatically.
3. Select the relevant F-module and open the "Properties" tab in the inspector window.

For fail-safe GSD based DP slaves/GSD based I/O devices (contrary to other F-I/O), the "Manual assignment of F-monitoring time" parameter is enabled. The result is that the value specified in the GSD file for the F-monitoring time is used as default value when the slaves/devices are plugged. You can change both values (time and type of assignment) later manually.

F-parameter "F_CRC_Seed" and "F_Passivation" for fail-safe GSD based I/O devices

The F-parameters "F_CRC_Seed" and "F_Passivation" influence the behavior of a fail-safe GSD based I/O device. The combination of the F-parameters cannot be set but is specified by selecting a corresponding F-module. Up to three F-module variants can be used, depending on the S7-300/400 or S7-1200/1500 F-CPU used.

F-module variant	F_CRC_Seed	F_Passivation	Behavior of the fail-safe GSD based I/O device	Can be used with F-CPU
1	Parameter does not exist	Parameter does not exist	The GSD based I/O device works with the Basic Protocol (BP) from PROFIsafe. The "RIOforFA-Safety" profile is not supported.	S7-300/400/1200/1-500*
2	CRC-Seed24/32	Device/module	The GSD based I/O device works with the Expanded Protocol (XP) from PROFIsafe. The "RIOforFA-Safety" profile is not supported.	S7-1200/1500
3	CRC-Seed24/32	Channel	The GSD based I/O device works with the Expanded Protocol (XP) from PROFIsafe. The "RIOforFA-Safety" profile is supported.	S7-1200/1500

* Only use the F-module variant 1 with S7-1200/1500 F-CPUs if neither F-module variant 2 nor 3 exists.

More information

You can find the description of the parameters in the Help on fail-safe GSD based DP slaves and GSD based I/O devices.

2.3 Configuring an F-CPU

Introduction

You configure the F-CPU basically in the same way as a standard automation system.

F-CPUs are always configurable in *STEP 7*, regardless of whether or not the *STEP 7 Safety* license is installed.

If you want to use the F-I/O in safety mode or in safety-related communication, the F-capability of the F-CPU must be enabled.

F-capability is activated by default when *STEP 7 Safety* license is installed.

Enabling F-capability

If you want to enable the F-capability, proceed as follows:

1. Select the F-CPU in the device or network view, and select the "Properties" tab in the Inspector window.
2. Select "Fail-safe" in the area navigation.
3. Enable the F-capability with the "Enable F-activation" button.

Disabling F-capability

If you want to disable the F-capability for an F-CPU because you intend to use the F-CPU as a standard CPU, note the following:

- You need F-access permission for the safety program, if assigned.
- The Safety Administration Editor (Page 80) is deleted from the project tree.
- The F-OBs are deleted. (S7-1200, S7-1500)
- All F-blocks are deleted.
- From now on you cannot use F-I/O in safety mode with this F-CPU.

If you want to disable the F-capability, proceed as follows:

1. Select the F-CPU in the device or network view, and select the "Properties" tab in the Inspector window.
2. Select "Fail-safe" in the area navigation.
3. Disable the F-capability with the "Disable F-activation" button.
4. Confirm the "Disable F-activation" dialog with "Yes".

Although you can enable the F-capability of the F-CPU without F-access permission, this permission is required to disable it.
If you do not have F-access permission and have enabled the F-capability accidentally, you can only disable it using "Undo".

Configuring the F-parameters of the F-CPU

In the "Properties" tab of the F-CPU, you can change or apply the default settings for the following parameters:

- F-destination address range
  - Low limit for F-destination addresses for F-I/Os of PROFIsafe address type 1
  - High limit for F-destination addresses for F-I/Os of PROFIsafe address type 1
- The F-source address for F-I/Os of PROFIsafe address types 2 and 3.
- The F-BaseID for F-I/O of PROFIsafe address type 3 at the F-CPU
  - Enable manual assignment and set F-BaseID
  - Button for automatic generation according to PROFIsafe specification
  - Activate delayed transfer (internal value 0x7C6)
- Default F-monitoring time for central or distributed F-I/O at the F-CPU

  (For HF-CPUs, only the default F-monitoring time for distributed F-I/O.)

NOTE

A change of the F-monitoring time for central or distributed F-I/O at the F-CPU results in modifications to the safety program when it is recompiled. A new acceptance may therefore be required.

Specify F-destination address for F-I/O of PROFIsafe address type 1

With the parameters "Low limit for F-destination addresses" and "High limit for F-destination addresses" you specify a range for this F-CPU in which the F-destination address of newly inserted F-I/Os of PROFIsafe address type 1 (Page 66) is assigned automatically. The F-destination address of an F-I/O is automatically moved to the destination address range of an F-CPU as soon as it is newly assigned to it.

The F-destination address is assigned in ascending order starting at the "Low limit for F-destination addresses". When no free F-destination address is available in the F-destination address range, the next available free F-destination address outside the F-destination address range is assigned and a warning is output during compilation.

The maximum possible F-destination address for ET 200S, ET 200eco, ET 200pro, ET 200iSP F-modules and S7-300 F-SMs is 1022.

The F-destination addresses for F-I/O of PROFIsafe address type 1 must be unique network-wide and CPU-wide.

By selecting different F-destination address ranges for different F-CPUs, you can define different ranges for the automatic assignment of the F-destination address. This is useful when you are operating multiple F-CPUs in one network. Subsequent manual address changes are possible. (see also Recommendation for PROFIsafe address assignment (Page 62))

Example:

You have configured the F-destination address range as follows:

- Low limit for F-destination addresses = 100
- High limit for F-destination addresses = 199

When inserting the first F-I/O of PROFIsafe address type 1, the F-destination address 100 is assigned. When inserting an additional F-I/O of PROFIsafe address type 1, the F-destination address 101 is assigned.

NOTE

The parameters "Low limit for F-destination addresses" and "High limit for F-destination addresses" have no effect on the following F-I/Os:

- SM 326; DI 8 x NAMUR (as of article number 6ES7326-1RF00-0AB0)
- SM 326; DO 10 x DC 24V/2A (article number 6ES7326-2BF01-0AB0)
- SM 336; AI 6 x 13 bit (article number 6ES7336-1HE00-0AB0)

Specifying the F-destination address range for F-I/O of PROFIsafe address types 2 and 3

The F-destination address of F-I/O of PROFIsafe address type 2 (Page 67) and F-I/O of PROFIsafe address type 3 (Page 69) is assigned automatically for each F-CPU in descending order starting from 65534. The low limit is the value configured with the parameter "High limit for F-destination addresses" (for F-I/O of PROFIsafe address type 1) + 1.
If the value configured with the parameter "High limit for F-destination addresses" is reached, a warning is output during compilation. (See also Recommendation for PROFIsafe address assignment (Page 62))

Specifying F-source address for F-I/O of PROFIsafe address types 2 and 3

You specify the F-source address for F-I/O of PROFIsafe address type 2 (Page 67) and for F-I/O of PROFIsafe address type 3 (Page 69) assigned to this F-CPU with the parameter "Central F-source address". The F-source address must be unique network-wide for F-I/O of PROFIsafe address type 2. The F-source address or F-BaseID must be unique network-wide for F-I/O of PROFIsafe address type 3 (see also Recommendation for PROFIsafe address assignment (Page 62))

NOTE

A change to the "Central F-source address" parameter has the consequence that the safety program is different after recompilation. A new acceptance may therefore be required because the F-source addresses of all F-I/Os of address types 2 and 3 are changed centrally as a result.

Specifying F-BaseID for F-I/O of PROFIsafe address type 3

You specify the F-BaseID for the F-CPU and for F-I/O of PROFIsafe address type 3 (Page 69) assigned to this F-CPU with the parameter "F-BaseID". This is a uniformly distributed 64-bit random number that is generated by an algorithm in accordance with the PROFIsafe specification.
A manual assignment of values generated otherwise in accordance with the PROFIsafe specification is possible provided that the requirement for uniqueness is complied with:

WARNING

Only use generation tools with which you can track adherence to the PROFIsafe generation rules, e.g. based on the documentation. The TIA Portal tools comply with these rules. *(S116)*

WARNING

The F-BaseID may only be assigned manually in exceptional cases, when you are sure that the PROFIsafe addresses of the F-I/Os of the F-CPU are unique (worldwide). F-I/Os with the same F-BaseID must differ in the combination of F-source and F-destination address. We explicitly advise against manual assignment and recommend generation with the tools offered in the TIA Portal.

With the manual assignment of value "0" as F-BaseID, you lose the advantages of PROFIsafe address type 3 and must adhere to the specifications for PROFIsafe address type 2 (see warning S052). *(S115)*

To enable assignment of the F-BaseID during startup of the F-CPU, "Delayed transfer" can be activated (see also Assignment of the F-BaseID during runtime (delayed transfer) (S7-1200 G2, S7-1500) (Page 658)).

NOTE

A change to the "F-BaseID " parameter has the consequence that the hardware configuration must be compiled and downloaded again because the F-BaseID values of all F-I/Os of address type 3 are changed centrally as a result. If you change the F-BaseID from "Delayed transfer" to another setting, you must also compile and download the safety program again.

Normally, a new acceptance of the safety-related project data (Page 448) is not required after a change of the F-BaseID because this does not change the behavior of the safety program and/or the F-I/Os. For this reason, it is also not included in the Collective F-Signature. However, an acceptance of the overall function on the destination hardware may still be necessary.

"Default F-monitoring time" parameter

Configure the "Default F-monitoring time" for monitoring the communication between the F-CPU and F-I/O.

You can adjust the F-monitoring time via the following parameters:

- "Default F-monitoring time for central F-I/O"
- "Default F-monitoring time for F-I/O of this interface"

The **default F-monitoring time for the central F-I/O** acts on the F-I/O that is arranged centrally, i.e. near the F-CPU. You set this parameter in the properties of the F-CPU (select F-CPU, then select "Properties > Fail-safe > F-parameters").

The **default F-monitoring time for the F-I/O of this interface** acts on the F-I/O that is assigned to this interface of the F-CPU (PROFIBUS or PROFINET). You change this parameter in the properties of the relevant interface (selection of the interface in the "Device view" tab, then "F-parameters").

The various settings available allow you to flexibly adapt the F-monitoring time to the conditions of your F-system, for example to take account of different bus cycles.

You can also change the F-monitoring time individually for each F-I/O in the F-I/O properties (see Configuring F-I/O (Page 52) or Peculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices (Page 38)).

NOTE

A change of the F-monitoring time for central or distributed F-I/O at the F-CPU results in modifications to the safety program when it is recompiled. A new acceptance may therefore be required.

NOTE

The default value for the "Default F-monitoring time for the F-I/O" for an HF-system is 2300 ms and is designed for an MRP ring. For line topology, you can set the "Default F-monitoring time for the F-I/O" smaller by a factor of approx. 2. You can determine the exact value as described in section "Monitoring and response times (Page 643)". You can set this value in the properties of the F-CPU (selection of the F-CPU, then "Properties > Fail-safe > F-parameters > PROFINET interface [X1]").

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

You can find more information in Monitoring and response times (Page 643).

Automatic generation of the safety program

The safety program of an F-CPU consists of one or two F-runtime groups that contain the F-blocks (see also Defining F-Runtime Groups (Page 136)). When the F-CPU (with activated F-capability) is inserted into the work area of the device view or network view, a safety program with an F-runtime group is generated automatically.

You can define in *STEP 7 Safety* that no F-runtime group is generated while inserting the F-CPU (with activated F-capability).

Proceed as follows:

1. Select the "Options > Settings" menu command.
2. Select the "STEP 7 Safety" area.
3. If it is not already disabled, disable automatic generation of an F-runtime group by deselecting the "Generate default fail-safe program" option.

This change has no influence on any existing safety programs; it only defines whether an F-runtime group is automatically generated for each one of the subsequently inserted F-CPUs.

Configuring the protection level of the F-CPU

WARNING

(S7-300, S7-400) In productive operation, it must be prevented that changes to the standard user program are unintentionally made in the safety program as well. For this purpose, you must configure the protection level "Write protection for fail-safe blocks" and configure a password for the F-CPU.

With the "Write protection" or "Write/read protection" protection level, the password would apply to the standard and the safety program. *(S001)*

WARNING

(S7-1200, S7-1500) In productive operation, the safety-related project data must be protected against unintentional changes.

If you use user management, the Runtime rights "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" and the engineering right "Manage users and roles" may only be granted to authorized users. You must also limit the assignment of user rights to trained personnel. Before the transition into productive operation, you must remove the "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" rights from the "Anonymous" user.

If you are not using user management or the "Access control via access levels" parameter is activated, then configure at least the "Full access (no protection)" protection level and assign a password under "Full access incl. fail-safe (no protection)". This protection level allows full access only to the standard user program and not the safety program.

If you select a higher protection level, for example to protect the standard user program, you must assign an additional password for "Full access (no protection)".

Assign different passwords for the individual access levels. *(S041)*

You configure the protection level following the same procedure as for standard CPUs.

For information on the password for the F-CPU, refer to Access protection (Page 100). Pay special attention to the warnings in Access protection for the F-CPU (Page 104).

2.3.1 Special features of the S7-1500 F Virtual Controller

When you configure an S7-1500 F Virtual Controller, you must provide an additional timer for forming the safe time within the S7-1500 F Virtual Controller. This timer must always involve a network card or a selected Ethernet interface of the Edge device.

In this context, observe the following warning:

WARNING

You must configure an Ethernet interface or network adapter for your S7-1500 F Virtual Controller or central Virtual Timeservice in the Edge Resource Manager of the respective Edge Device.

You need to add the respective network card via the installation interface in the configuration menu of the Industrial Edge applications S7-1500VF or the virtual time service.

- Ensure, for example using data sheets or manufacturer confirmation, that the network card you selected is a separate, non-integrated IEEE1588-capable network card within your device or an externally plugged IEEE1588-capable network card.
- Ensure that the network card has a built-in quartz for the functionality according to IEEE 1588, e.g. through data sheets or manufacturer confirmation.

You must not use network cards or Ethernet interfaces configured for the safe time of an S7-1500 F Virtual Controller for time synchronization via PTP. Neither read nor write access is permitted to the physical hardware clock (PHC) of the network card.

You must differentiate between two types of operation in the Edge environment of an S7-1500 F Virtual Controller.

- You can operate the S7-1500 F Virtual Controller on an IED. In this case, you must always configure the network card or Ethernet interface directly for the S7-1500 F Virtual Controller.
- In the second case, you can operate the S7-1500 F Virtual Controller on an IEVD within a host. Depending on the application, you can directly assign a network card or Ethernet interface to the S7-1500 F Virtual Controller in an IEVD, as in the IED case.

  If you operate multiple S7-1500 F Virtual Controllers, you can use the Virtual Timeservice offered as an Industrial Edge application. The Virtual Timeservice distributes the safe time centrally for all S7-1500 F Virtual Controllers within your host. For this, you must configure the network card or Ethernet interface for the Virtual Timeservice and set up a suitable network for distributing the time stamp. An S7-1500 F Virtual Controller supports up to two Virtual Timeservices in a network. You must label the network for the Virtual Timeservice for each S7-1500 F Virtual Controller as "virtual-timeservice".

  If you operate the S7-1500 F Virtual Controller on a virtual Edge device within a host, you must provide the network cards or Ethernet interfaces for forming the safe time of an S7-1500 F Virtual Controller in the hypervisor of your host directly, exclusively and not virtualized via PCI passthrough for the respective Virtual Timeservice application or your S7-1500 F Virtual Controller application.

Check that the network card driver for the hardware time stamping function based on PTP is compatible with the version of your hypervisor and the kernel version of your IE(V)D.

Note that a reconfiguration of the settings of an IE(V)D with an S7-1500 F Virtual Controller during operation can result in STOP. *(S101)*

2.3.1.1 Operating the S7-1500 F Virtual Controller without central Virtual Timeservice

Installing the S7-1500 F Virtual Controller application

If you have not set up a central Virtual Timeservice and you want to configure a shared IEEE1588-capable interface (according to warning S101) for PROFINET communication and provision of the 2nd time base for the S7-1500 F Virtual Controller, add the network card or Ethernet interface to the "allow list" of the network cards.

NOTE

In the Installation menu, if you click "Back" and deselect the configuration with the plus sign, the previously configured networkcard_allowlist is installed/updated nonetheless. If you wish to correct your configuration, close the window by clicking the "X" and start the installation/update again.

Proceed as follows:

1. Select the "CPU 1517VF" app in the "Edge Management" under "Catalog".
2. Click "Install".
3. Add an IEEE1588-capable network card to the "vplc_x1" interface from the Resource Manager in accordance with warning S101. The "Application Manager" must be installed for this purpose.
   - To do this, check the box next to "networkcard_allowlist" and click on the plus sign in the "Allowed Devices" list.
   - Fill in "Vendor ID" and "Device ID" and, if desired, "Comment".

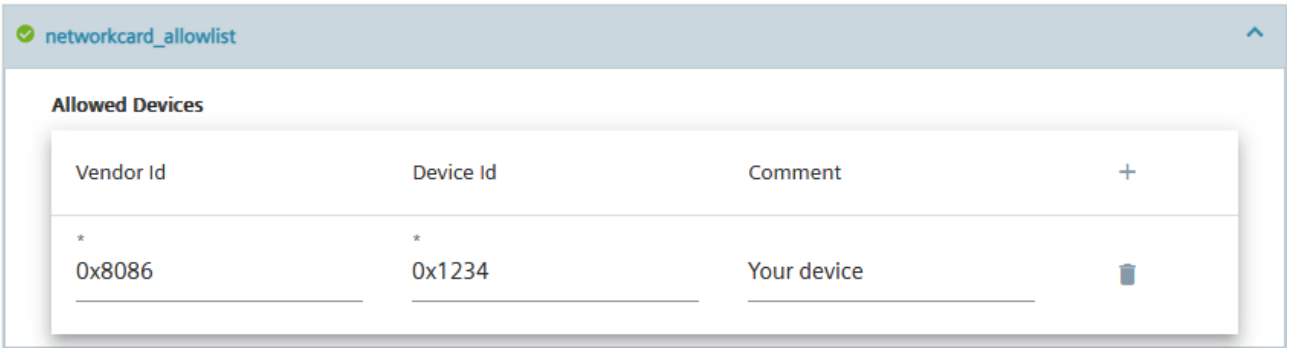

4. Click "Next".
5. Select the Edge device on which you want to install the app.
6. Click "Install Now".

Please note: The allow list can also be replaced later by updating the app.

If you are using the new UX of Edge via "new experience", follow these steps:

1. In "Edge Management", under Devices, select the Edge device on which you wish to install the "CPU 1517VF" app.
2. Click "Install application".
3. By means of the checkbox, select the "CPU 1517VF" app, whereupon the configuration menu for the app appears on the right.

4. Add an IEEE1588-capable network card to the "vplc_x1" interface from the Resource Manager in accordance with S101.
   - Open the "networkcard_allowlist" tab and click the plus sign in the "Allowed Devices" list.
   - Fill in "Vendor ID" and "Device ID" and, if desired, "Comment".
   - To install the configuration, put a check mark in the checkbox at the top right of the field so that the field becomes green.
5. Click "Install(1)".

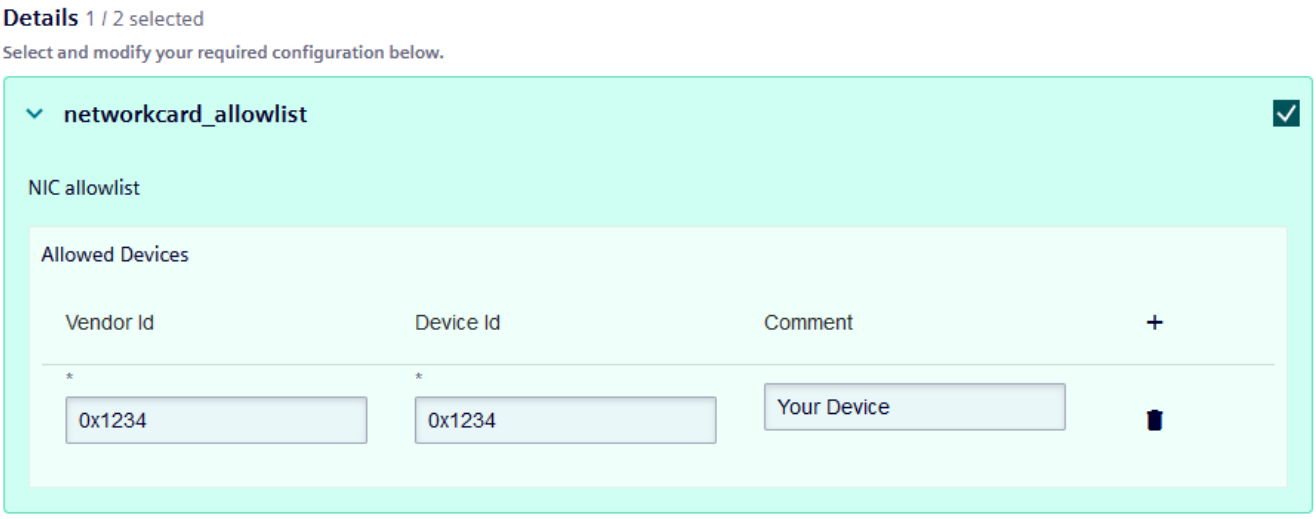

Updating the S7-1500 F Virtual Controller application or replacing the allow list by updating the configuration

If you want to update the S7-1500 F Virtual Controller app without a set-up central Virtual Timeservice and **not** replace the allow list in the process, follow these steps:

1. Select the new version of the "CPU1517VF" app under "Catalog" in "Edge Management".
2. Click "Update". (For all Edge devices on which no version of the "CPU1517VF" app is installed, "Install" is displayed)
3. Use "Next" to jump to the "Configuration" menu. The green check mark next to "networkcard_allowlist" must be cleared.

If you want to update the S7-1500 F Virtual Controller app or update the configuration and replace the allow list in the process, follow these steps:

1. In "My Installed Apps", click on the respective app and select "Update Configuration" in the menu.

   For an update of the app, select the new version of the "CPU1517VF" app under "Catalog" in "Edge Management".
2. Click "Update".
3. Click on the plus sign.
4. Fill in "Vendor ID" and "Device ID" and, if desired, "Comment".

5. Set the green check mark to the left of "networkcard-allowlist".
6. Click "Next".
7. Select "Update Now".

Note that when the configuration is updated, the allow list is only replaced after a STOP/START of the "CPU1517VF" app and not after a STOP/RUN of the S7-1500VF Virtual Controller.

If you are using the new UX of Edge via "new experience", follow these steps for an "Update Configuration":

1. Select the Edge device with your app in "Edge Management", under Devices.
2. Right-click on the three dots and select "Update Configuration".
3. Thereafter, follow the same procedure as for installing an app.
4. Click "Update(1)".

If you are using the new UX of Edge via "new experience", follow these steps for an "Update":

1. Select the Edge device with your app in "Edge Management", under Devices.
2. If there is an update available, you will see the "Update" button. Click "Update".
3. Thereafter, follow the same procedure as for installing an app.
4. Click "Update(1)".

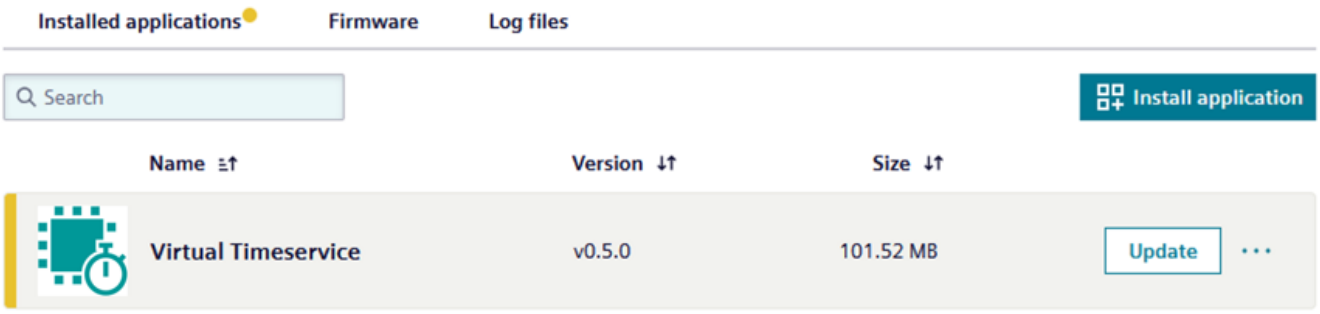

NOTE

When you perform an Update Configuration, you need to stop and then restart the app for the configuration change to take effect.

2.3.1.2 Operating the S7-1500 F Virtual Controller with central Virtual Timeservice

Installation and setup of the Industrial Edge Virtual Timeservice application for forming a second time base for the S7-1500 F Virtual Controller

If you want to set up the Virtual Timeservice centrally for multiple S7-1500 F Virtual Controllers on a host with multiple S7-1500 F Virtual Controllers, observe the following:

- Install the Virtual Timeservice on a separate virtual Edge Device. You must not operate a Virtual Timeservice and an S7-1500 F Virtual Controller on the same virtual Edge Device.
- Connect all participating virtual Edge devices with an S7-1500 F Virtual Controller to the virtual Edge Device on which the central Virtual Timeservice has been installed and set up via a dedicated real-time capable network.
- This network should be used exclusively by the Virtual Timeservice for distributing the second time base.
- You can set up up to two central Virtual Timeservices for a dedicated network. To increase the availability of the system, you should set up two Virtual Timeservices.
- You must configure a separate IEEE1588-capable Ethernet interface or network card for each virtual time service in accordance with warning S101.
- Active PTP synchronization between the Virtual Timeservice and the S7-1500VF using, for example, boundary clock switches in the network can result in a connection abort and, thus, a STOP of the S7-1500VF. The active Virtual Timeservice ID indicated in the S7-1500VF can be changed by an active PTP-synchronizing component and consequently differ from the original Virtual Timeservice ID.

More information on setting up the Virtual Timeservice is provided in the "Virtual Timeservice App" Operating Manual.

Configuring a second network interface for the S7-1500 F Virtual Controller with a central Virtual Timeservice

For the S7-1500 F Virtual Controller to use the Virtual Timeservice as 2nd time base, follow these steps to configure network resources for the IEVD with the S7-1500 F Virtual Controller.

1. Open the "Settings" menu item in the IEVD web interface.
2. Go to the "Ressource Manager" tab.
3. To add a network, click on the plus sign to the right of "Isolatable Networks" under "Configuration".

   The new input fields appear at the end of the page (you may have to scroll down).
4. Under "Name", enter the name of the corresponding network interface.

   In "Annotations", right-click on the plus sign again to be able to assign a label for the interface.
5. For the S7-1500 F Virtual Controller with a Virtual Timeservice, create an additional entry for the provision of the 2nd time base next to the interface with label "vplc_x1".

   Assign the "virtual-timeservice" label to the interface to the real-time-capable network via which the time stamp is distributed and received by the S7-1500 F Virtual Controller
6. Click on "Submit" at the bottom to accept the entries.

Installing the S7-1500 F Virtual Controller application with central Virtual Timeservice

If you have set up a central Virtual Timeservice, install the app as described in the "Virtual Timeservice App" Operating Manual. Do not specify any additional network card under "Configurations" in the installation menu.

2.4 Configuring F-I/O

Introduction

You configure the S7-1500/ET 200MP, ET 200SP, ET 200SP HA, ET 200AL, ET 200S, ET 200eco (S7-300, S7-400), ET 200eco PN, ET 200pro, ET 200iSP F-modules, the S7-300 F-SMs and the S7-1200 F-modules as usual in *STEP 7*.

After you have inserted the F-I/O in the work area of the *device or network view*, you access the configuration dialogs by selecting the relevant F-I/O and the "Properties" tab.

NOTE

Changes to the parameter assignment result in modifications to the safety program when it is recompiled. A new acceptance may therefore be required.

The ET 200SP F-modules can be used in distributed system with:

- IM 155-6 PN ST as of firmware V1.1
- IM 155-6 PN HF
- IM 155-6 PN/2 HF as of firmware V4.2
- IM 155-6 PN/3 HF as of firmware V4.2
- IM 155-6 MF HF
- IM 155-6 PN HS
- IM 155-6 DP HF
- IM 155-6 PN R1

  You can find information on whether operation with R1 is supported for an ET 200SP F-module on the Internet. (https://support.industry.siemens.com/cs/ww/en/view/73021864)

The distributed use of S7-1500/ET 200MP F-modules is possible with:

- IM 155-5 PN BA as of firmware V4.3
- IM 155-5 PN ST as of firmware V3.0
- IM 155-5 PN HF as of firmware V2.0
- IM 155-5 DP ST as of firmware V3.0

The central use of S7-1500/ET 200MP F-modules is possible with S7-1500 F-CPUs as of firmware V1.7, distributed use as of firmware V1.5.

(S7-1200 G1) We recommend you limit the total number of F-I/Os used centrally or distributed in an S7-1200 G1 F-CPU to 12. Depending on the volume of project data, the maximum number of F-I/Os can be smaller.

WARNING

When you make changes in which the assignment of input/output addresses and wiring can change, then you must perform a wiring test (Page 409).

Examples for such changes are:

- Adding F-I/O
- Changing the start address of F-I/O
- Changing the slot position of F-I/O
- Changing
  - the rack
  - the slave/device address
  - the PROFIBUS DP/PROFINET IO subnet
  - the IP address
  - the device name

(S071)

Channel-granular passivation after channel faults

You can configure how the F-I/O will respond to channel faults, such as a short-circuit, overload, discrepancy error, or wire break, provided the F-I/O supports this parameter (e.g. for ET 200S or ET 200pro F-modules). You configure this response in the properties for the relevant F-I/O ("Behavior after channel fault" parameter). This parameter is used to specify whether the entire F-I/O or just the faulty channel(s) are passivated in the event of channel faults.

NOTE

(S7-300, S7-400) Note that channel-granular passivation increases the runtime of the F-runtime group(s) compared to passivation of the entire F-I/O (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).

"Channel failure acknowledge" parameter (S7-1200, S7-1500)

In the case of F-I/Os that support the "Channel failure acknowledge" channel parameter (for example S7-1500/ET 200MP F-modules, S7-1200 F-modules or ET 200AL F-modules), this function replaces the ACK_NEC tag of the F-I/O DB.

If an F-I/O fault is detected by the F-I/O, passivation of all channels of the relevant F-I/O occurs. If channel faults are detected, the relevant channels are passivated if "Passivate channel" is configured. If "Passivate the entire module" is configured, all channels of the relevant F-I/O are passivated. Once the F-I/O fault or channel fault has been eliminated,

reintegration of the relevant F-I/O/the relevant channel occurs in line with the "Channel failure acknowledge" parameter.

- Automatically
- Manually

The parameter "Channel failure acknowledge" can be set individually for each channel with channel-granular passivation if "Adjustable" has been parameterized at the "Reintegration after channel fault" parameter.

WARNING

The parameter assignment "Channel failure acknowledge = Automatic" is only allowed if automatic reintegration is permitted for the relevant process from a safety standpoint.*(S045)*

NOTE

The default assignment for the "Channel failure acknowledge" parameter when the F-module is created is "Manually".

Organization block/Process image (S7-1200, S7-1500)

If you use F-I/O in standard mode, you can select the organization block/process image as you do for standard I/O.

If you use F-I/O in safety mode, no selection is possible. The process image is always updated automatically at the beginning or end of the F-runtime group (see section Program structure of the safety program (S7-1200, S7-1500) (Page 116)).

Contrary to F-I/O operated in non-isochronous mode, you need to selected a process image partition, such as PIP 1 for F-I/O that is operated in isochronous mode (see "Configuring isochronous mode (S7-1200 G2, S7-1500) (Page 61)").

Changing the name and number of the F-I/O DB

For more information, refer to the section "Fail-safe I/O data block (Page 168)".

Customizing the F-monitoring time for F-I/O

You can customize the F-monitoring time in the properties of the F-I/O under "F-parameters". This may be necessary to prevent a timeout being triggered when no error occurs and the F-I/O requires a longer F-monitoring time or assignment with a default F-monitoring time is not possible. For this purpose, activate the corresponding check box and assign an F-monitoring time.

NOTE

A change of the F-monitoring time for central or distributed F-I/O at the F-CPU results in modifications to the safety program when it is recompiled. A new acceptance may therefore be required.

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

You can find more information in Monitoring and response times (Page 643).

Group diagnostics for fail-safe S7-300 signal modules

By disabling a channel of the fail-safe signal module in the module properties, you also disable the group diagnostics for this channel.

Exception for S7-300/400 F-CPUs:

For the following S7-300 fail-safe signal modules, the monitoring of channel-specific diagnostic messages (for example, wire break, short-circuit) from the F-SM to the F-CPU is enabled and disabled with the "Group diagnostics" parameter.

- SM 326; DI 8 x NAMUR (as of article number 6ES7326-1RF00-0AB0)
- SM 326; DO 10 x DC 24V/2A (article number 6ES7326-2BF01-0AB0)
- SM 336; AI 6 x 13Bit (article number 6ES7336-1HE00-0AB0)

You should disable group diagnostics for **unused** input or output channels.

WARNING

(S7-300, S7-400) For the following S7-300 fail-safe signal modules (F-SMs) with activated safety mode, "Group diagnostics" must be enabled on all used channels:

- SM 326; DI 8 x NAMUR (article numbers 6ES7326-1RF00-0AB0 and 6ES7326-1RF01-0AB0)
- SM 326; DO 10 x DC 24V/2A (article number 6ES7326-2BF01-0AB0)
- SM 336; AI 6 x 13 Bit (article number 6ES7336-1HE00-0AB0)

(S003)

Diagnostic interrupts can be enabled optionally.

More information

For detailed description of the **parameters**, refer to the help on the properties of the respective F-I/O and in the respective *manual for the F-I/O*.

2.5 Configuration control (option handling) for F-I/Os

For configuration control (option handling) with F-I/Os proceed as with the standard I/O devices. Detailed information can be obtained by searching for "Configuration control (option handling)" in the help of *STEP 7*.

The following section describes what you have to observe additionally for F-I/Os.

Requirements

- The requirements that are specified under "Configuration control (option handling)" in the help of *STEP 7* are fulfilled.
- The requirements that are specified under "Configuration control (option handling)" in the help of *STEP 7* are fulfilled. Handle the F-I/O as standard I/O.
- V2.1 or higher is set as the safety system version.
- The F-I/Os for which you use the configuration control (option handling) are located
  - Distributed at an F-CPU S7-300/400/1200/1500
  - Centrally at an F-CPU S7-1500

  The PROFIsafe address of the F-I/Os are set or assigned.

NOTE

Only if the maximum configuration actually exists is assigning the PROFIsafe addresses (Page 72) possible.

Procedure

(S7-1200, S7-1500) Disable the F-I/Os not existing in the respective variant (option) by setting the DISABLE (Page 173) variable in the associated F-I/O DB (Page 168) to "1". This prevents the flashing of the error LED of the F-CPU and diagnostic entries of the safety program that reference these F-I/Os. With the DISABLED (Page 174) variable of the associated F-IO data block, you can evaluate whether an F-module is deactivated.

(S7-300, S7-400) To prevent the flashing of the error LEDs of the F-CPUs you do not have to observe anything further. You cannot suppress diagnostics entries.

WARNING

If configuration control is used, your actual configuration deviates from the configured maximum configuration. You identify F-I/Os that do not exist in the current option (station option) via control record as "not available".

If an F-I/O marked as "not available" is possibly nevertheless in the real system, it has to be ensured that substitute values (0) are provided for these F-I/Os in the safety program or output at the outputs. This is achieved by setting the DISABLE tag (S7-1200, S7-1500) or respectively PASS_ON tag (S7-300, S7-400) in the associated F-I/O DB to "1". *(S077)*

2.5.1 Example

Introduction

The following example shows how you to

- Select/detect a station option
- Deactivate F-I/Os that are not present in a station option (S7-1200, S7-1500)
- Provide your safety program for various station options

Safe selection/detection of the station option

You carry out a safe selection/detection of a station option with inputs of an F-I/O wired fixed to M/L+.

For example, you can select up to 4 station options with 2 inputs of an F-I/O.

Option	OptionSelection_Bit_0	OptionSelection_Bit_1
Q	0	0
B	0	1
C	1	0
D	1	1

Note when detecting the station option that substitute values (0) are used for the inputs of the F-I/O in certain situations, e.g. during startup of the F-system or when F-I/O channel errors occur.

In these situations, the present station option cannot be detected. You should therefore also evaluate the value status of inputs and only apply the station option one-time after startup of the F-system.

For one-time recognition of the station option, define a static local datum, for example, OptionSelectionRuns with default value "TRUE".

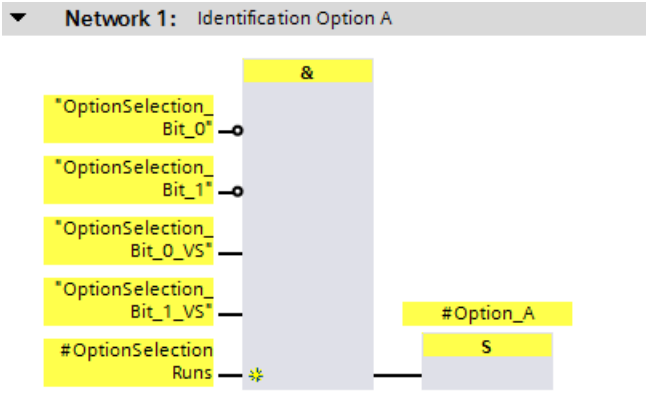

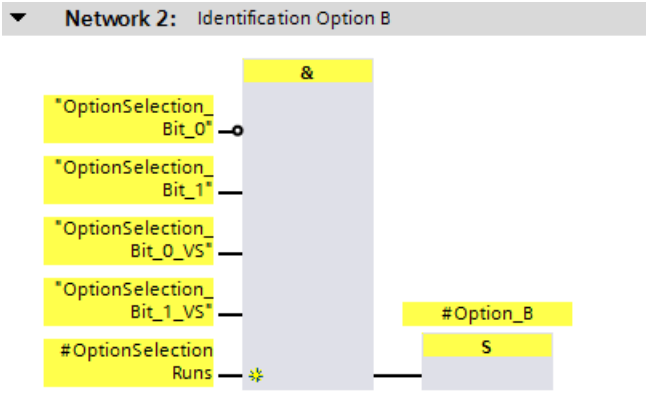

Correspondingly for options C and D.

As soon as a station option is detected, reset the static local datum for one-time detection of the station option:

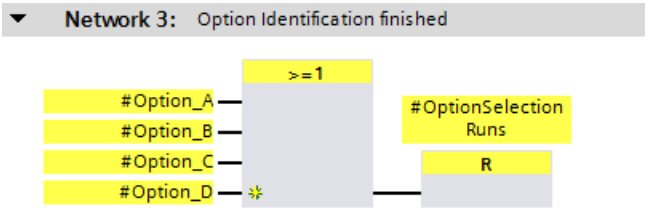

NOTE

When you make the selection/detection of a station option only in the standard user program, only the "Station option" is available to you as a standard datum that is not secured.

Make sure that no dangerous states arise from this.

Read the section "Data exchange between standard user program and safety program (Page 204)".

Disabling F-I/Os that are not present in a station option

If one or more F-I/Os are not present in a station option, you can prevent the blinking of the error LED of the F-CPU by disabling these F-I/Os.

In addition, diagnostic messages of the safety program that refer to these F-I/Os are suppressed.

NOTE

As long as the detection of the station option (during startup of the F-system) is not yet complete (OptionSelectionRuns = TRUE), you should disable all "optional" F-I/O devices.

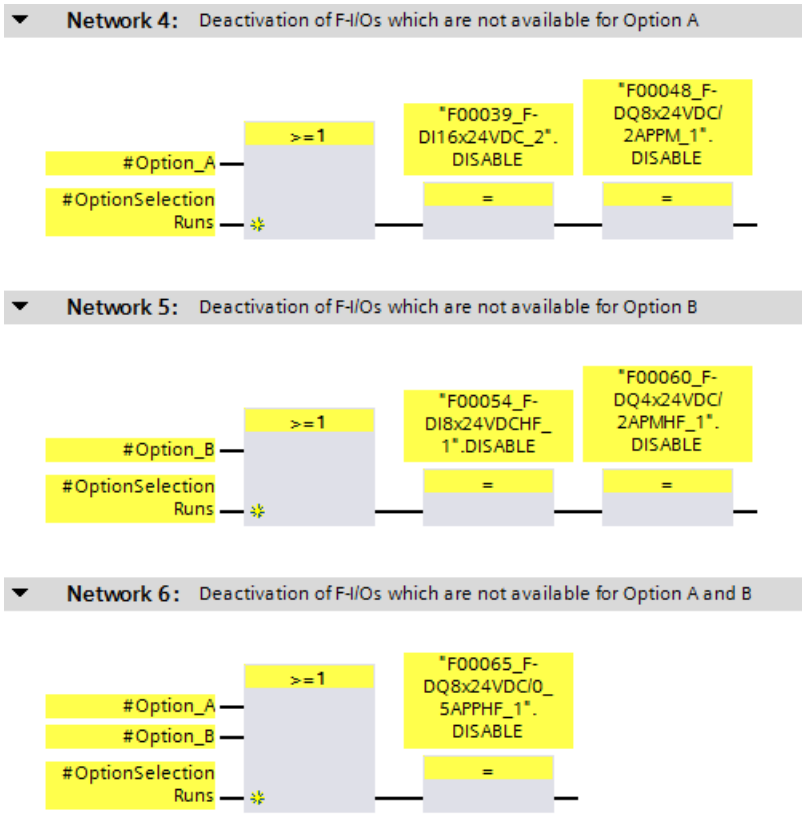

Providing the safety program for various station options

In the following example, the EMERGENCY STOP signals of different plant units or machines are combined into a collective EMERGENCY STOP signal.

Machines I and III and the corresponding F-I/O with the EMERGENCY STOP signal for machines I and III are not present with station option A.

Machine II and the corresponding F-I/O with the EMERGENCY STOP signal for machine II is not present with station option B.

The substitute values (0) are therefore used in the safety program for the EMERGENCY STOP signals from the respective unavailable machines.

In order to prevent the collective EMERGENCY STOP from being triggered because machines / EMERGENCY STOP signals are not present with certain station options, you can suppress the

evaluation of the EMERGENCY STOP signal for unavailable machines by taking into account the present station option.

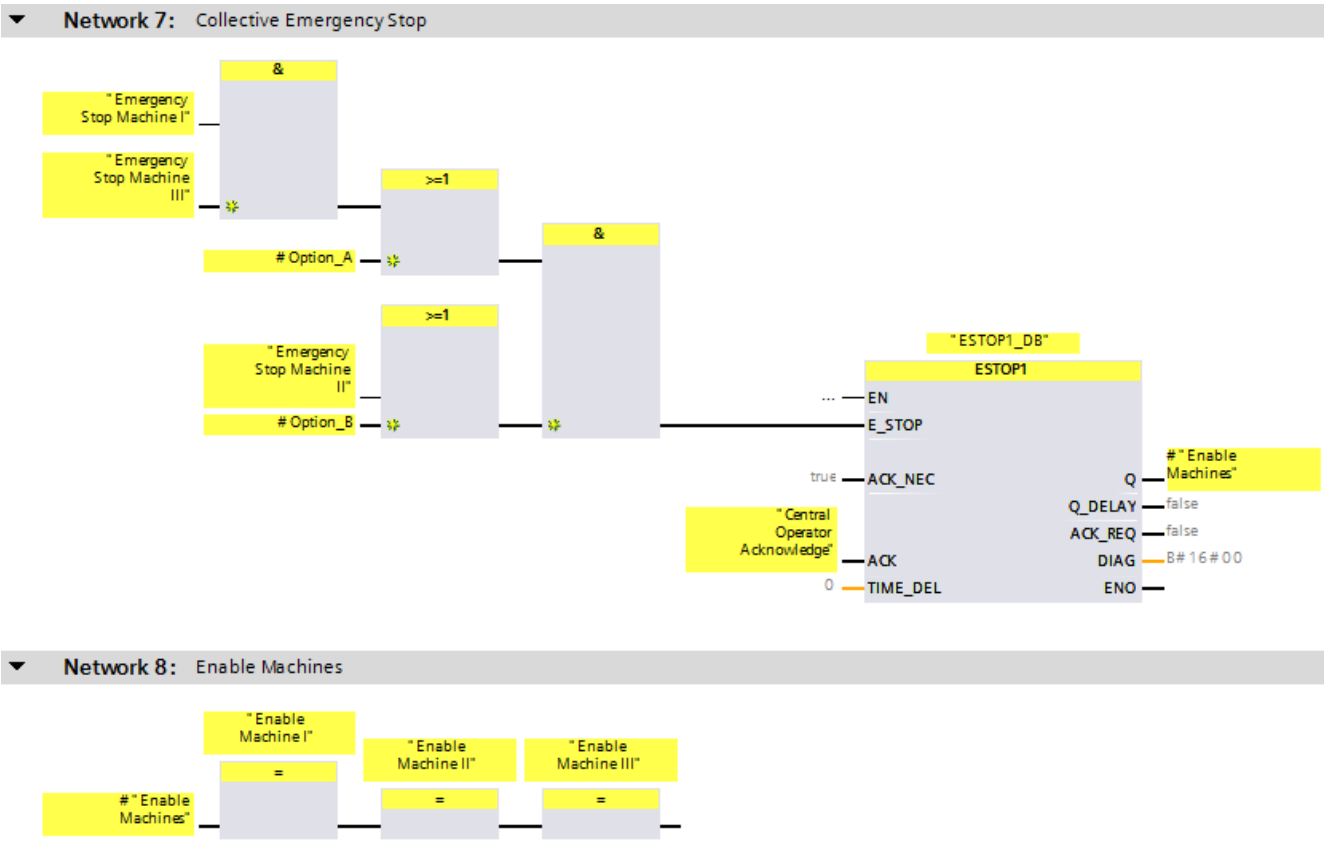

2.6 Configuring shared device

To configure shared devices follow the procedure as in the standard. The configuration is described in the *STEP 7* help under "Configuring shared devices" and in the function manual "PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/49948856)" in the chapter "Shared Device".

F-destination addresses

Please also read the chapter "Recommendation for PROFIsafe address assignment (Page 62)" for assigning the F-destination address.

See also

Assigning PROFIsafe address to an F-module in a shared device in multiple projects (Page 77)

Assigning PROFIsafe address to an F-module in a shared device in a common project (Page 78)

2.7 Configuring isochronous mode (S7-1200 G2, S7-1500)

To configure isochronous mode for F-I/Os that support this mode, e.g. "Profisafe Telgr 902" submodule of the SINAMICS S120 CU310-2 PN V5.1 drive, proceed as in the standard. The configuration is described in the *STEP 7* help under "Configuring isochronous mode".

Note the following:

- Contrary to F-I/O operated in non-isochronous mode, you need to selected a process image partition, such as PIP 1 for F-I/O that is operated in isochronous mode.
  This process image partition must contain only F-I/O operated in isochronous mode and no standard I/O.
- The assigned isochronous mode interrupt OB must first be generated as F-OB by specifying a F-runtime group (see Procedure for defining an F-runtime group (S7-1200, S7-1500) (Page 141)). It is not possible to add an F-OB with event class "Synchronous Cycle" directly during the configuration of the isochronous mode.

Requirement

F-CPUs that support IRT.

Connection of F-I/O operated in isochronous mode to the isochronous mode interrupt OB

You access F-I/O operated in isochronous mode in the same way as you do standard I/O operated in isochronous mode, via the select process image partition.

Contrary to standard I/O that is operated in isochronous mode, the process image partition is updated by the F-system at the beginning or end of the F-OB (see Program structure of the safety program (S7-1200, S7-1500) (Page 116)).

No calling of the instructions SYNC_PI and SYNC_PO is required in the F-OB.

NOTE

With isochronously operated F-I/O, it is not ensured (fail-safe) that all input data of the F-I/Os assigned to the process image partition are consistently available at the beginning of the main safety block or all output data is transferred consistently to the F-I/Os, in other words, logically and temporally together. The consistency is only ensured within an F-I/O.

The consistency of all isochronous F-I/Os of the process image partition usually depends on the number of isochronous F-I/Os and the scope of the safety program in the isochronous mode interrupt OB.

If corresponding consistency requirements exist, you need to check the consistency of the input and output data yourself, e.g. by also transferring and evaluating time stamps in the input and output data of the isochronously operated F-I/O.

2.8 Recommendation for PROFIsafe address assignment

Before inserting the F-I/O, specify an address range for each F-CPU for the F-destination addresses of the F-I/O of PROFIsafe address type 1 (Page 66) that does not overlap with the address range of any other F-CPU network-wide or CPU-wide (system-wide). You define the range with the parameters "Low limit for F-destination addresses" and "High limit for F-destination addresses" (see also section Configuring an F-CPU (Page 40)).

In a redundant S7-1500HF system, consider both F-CPUs of the redundant S7-1500HF system as one F-CPU with regard to the PROFIsafe addresses. The "Low/high limit for F-destination addresses" or the "Central F-source address" and, if present, the F-BaseID is therefore set identically by the system for both F-CPUs.

The F-destination addresses of F-I/O of PROFIsafe address type 2 (Page 67) must not overlap with any address range of the F-I/O of PROFIsafe address type 1. The ranges of the F-destination addresses of the F-I/O of PROFIsafe address type 2 may overlap if the F-source addresses are different. This is the case for supported configurations (Page 63) if the "Central F-source address" parameter has been set differently for each F-CPU.

If the F-BaseID was generated individually for each F-CPU by the TIA Portal for an F-I/O of PROFIsafe address type 3, its F-source addresses and/or F-destination addresses can overlap with those of the F-I/Os of F-address type 1 or 2 of any other F-CPUs as needed.

Assign relatively low F-destination addresses for F-I/O of PROFIsafe address type 1 and relatively high F-destination addresses for F-I/O of PROFIsafe address type 2 and 3.

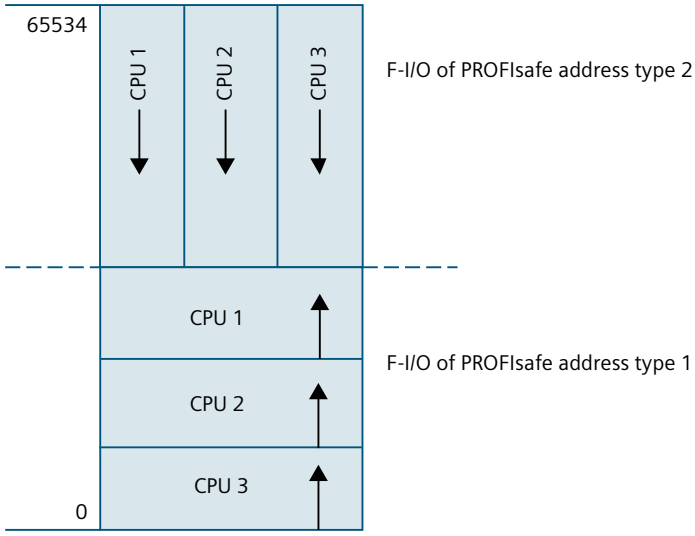

Figure 3-877 Address assignment for F-I/O of PROFIsafe address types 1 and 2

The safety summary (Page 429) lists the following information for each F-CPU:

- "Central F-source address" parameter (F-source address for F-I/O of PROFIsafe address type 2 and 3)
- Actually used range of the F-destination addresses of the assigned F-I/O of PROFIsafe address type 1
- Actually used range of the F-destination addresses of the assigned F-I/O of PROFIsafe address type 2
- Actually used range of the F-destination addresses of the assigned F-I/O of PROFIsafe address type 3

Any F-I/O configured using I-slave-slave communication is taken into account in the safety summary as part of the F-destination address range of the I-slave.

Any F-I/O configured in a shared device is indicated in the safety summary as part of the F-destination address range of the F-CPU to which this F-I/O is assigned.

2.9 Configurations supported by the SIMATIC Safety F-system

Supported configurations

F-I/Os (see Overview of Configuration (Page 34)) are supported in the following configurations:

Central configuration (also I-slave):

- The F-I/O is in the same rack as the associated F-CPU.
- The F-I/O is located in a subrack of the rack of the associated F-CPU.

Distributed configuration (at integrated DP-/PN interface of the CPU or at CP/CM):

- PROFIBUS DP (also after IE/PB link)
  - The F-I/O is located on a DP Slave.
  - The F-I/O is located on a DP Slave and is addressed via I-slave-slave communication. The assigned DP master (of the assigned IO controller of the IE/PB link) can be a standard CPU or an F-CPU.
- PROFINET IO
  - The F-I/O is located on an IO Device.
  - The F-I/O is located in a shared I-device.
  - The F-I/O is located in a shared device.

For a redundant S7-1500HF system the only supported configuration is:

Distributed configuration (at integrated PN interface of the HF-CPU)

- PROFIBUS DP after IE/PB link
  - The F-I/O is located on a DP slave
- PROFINET IO
  - The F-I/O is located in an IO device that is assigned to the IO systems of both F-CPUs.

    More information on IO devices for R1, S1 and S2 redundancy is available in the PROFINET Function Manual (https://support.industry.siemens.com/cs/ww/en/view/49948856) in section "PROFINET with the redundant S7-1500R/H system".

For F-I/O not listed in "Overview of Configuration (Page 34)", check the relevant documentation to see whether it is supported by the SIMATIC Safety F-system. If in doubt, treat these F-I/Os as part of a configuration that is not supported.

Checks performed by the SIMATIC Safety F-system

For supported configuration, the F-system checks:

- Whether the PROFIsafe operating mode parameter (F_Par_Version) is set to V2 mode in the PROFINET IO environment**.
- Whether the F-destination addresses have been assigned uniquely CPU-wide.
  You yourself must ensure the network-wide uniqueness of the PROFIsafe address when using F-modules with F-PROFIsafe address type 1 and/or PROFIsafe address type 2 (see also "Recommendation for PROFIsafe address assignment (Page 62)")
- Whether the F-source address for F-I/O of PROFIsafe address types 2 and 3 corresponds to the "Central F-source address" parameter of the F-CPU.
- Whether the F-BaseID for F-I/O of PROFIsafe address type 3 corresponds to the "F-BaseID" parameter of the F-CPU.

NOTE

For more information on the assignment of PROFIsafe addresses that are unique for the CPU and across the network, see this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).

Not supported configurations

For configurations that are not supported, the TIA Portal cannot automatically check the parameter assignment of the F-I/Os. In addition, it is not assured that these have been captured in the safety summary. You must therefore observe the following warning:

WARNING

If you create a configuration that is not one of the supported configurations, you must observe the following in addition to the warnings S051, S052, S053 and S115:

- Make sure that the F-I/O of this configuration appears in the safety summary and that an F-I/O DB has been created for it. Otherwise, you cannot use the F-I/O in this configuration. (Contact Customer Support.)
- For F-I/O in the PROFINET IO environment[1], you must check the safety summary for correctness of the PROFIsafe operating mode parameter (F_Par_Version). V2 mode must be set in the PROFINET IO environment. F-I/O that support only V1 mode must not be used in the PROFINET IO environment.
- Based on the safety summary, you must check whether the components of the PROFIsafe address centrally assigned for the F-CPU were transferred correctly into the respective F-I/Os:
  - PROFIsafe address type 3: F-BaseID from the "F-BaseID" parameter of the F-CPU.
  - PROFIsafe address type 2 and 3: F-source addresses from the "Central F-source address" parameter of the F-CPU.
- You must ensure the CPU-wide[2,3] and/or network-wide[4] unique assignment of the F-destination address for F-I/Os:
  - For F-I/O of PROFIsafe address type 1 or 2 (if you cannot set the F-source address to match the "Central F-source address" parameter of the F-CPU), you must ensure the network-wide[4] uniqueness of the PROFIsafe address through the unique assignment of the F-destination address alone.
  - In an unsupported configuration, you must check the uniqueness of the F-destination address individually for each F-I/O using the safety summary, regardless of the PROFIsafe address type.

    PROFIsafe address type 1: Network-wide[4] and CPU-wide[2,3]

    PROFIsafe address type 2 and 3: Only CPU-wide[2,3].

(S050)

1) The F-I/O is located in the "PROFINET IO environment" if at least part of safety-related communication with the F-CPU takes place via PROFINET IO. If the F-I/O is connected via I-slave-slave communication, also keep in mind the communication line to the DP master/IO controller.

2) "CPU-wide" means all F-I/Os assigned to an F-CPU: Central F-I/O of this F-CPU, F-I/O for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

3) In a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be considered as one F-CPU with regard to the PROFIsafe addresses. The "Central F-source address" and, if present, the F-BaseID are therefore set identically for both F-CPUs by the system.

4) A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

2.10 PROFIsafe addresses for F-I/O of PROFIsafe address type 1

F-destination address

The uniqueness of the PROFIsafe address is ensured solely with the F-destination address. The F-source address is not displayed and has no effect on whether or not the PROFIsafe address is unique.

Therefore, the F-destination address must be unique network-wide and CPU-wide (see the following rules for address assignment).

To prevent incorrect parameter assignment, an F-destination address which is unique CPU-wide is automatically assigned during placement of the F-I/O in the work area of the device or network view as long as you only configure supported configurations (Page 63).

To ensure a network-wide unique F-destination address assignment when multiple DP master systems and PROFINET IO systems are operated on one network, you must set the "Low limit for F-destination addresses" and "High limit for F-destination addresses" in the properties of the F-CPU in SIMATIC Safety F-systems appropriately, before placing the F-I/O (see section "Recommendations for address assignment") so that the F-destination address ranges do not overlap.

When you change the F-destination address of an F-I/O, the CPU-wide uniqueness of the F-destination address is checked automatically for supported configurations. You yourself must ensure the network-wide uniqueness of the F-destination address.

For ET 200S, ET 200eco (PROFIBUS), ET 200pro, ET 200iSP F-modules and S7-300 F-SMs: You must set the F-destination address at the F-I/O with the DIP switch before you install the F-I/O. You can assign up to 1022 different F-destination addresses.

NOTE

(S7-300, S7-400) For the following fail-safe S7-300 signal modules, the F-destination address is the start address of the F-SM divided by 8:

- SM 326; DI 8 x NAMUR (as of article number 6ES7326-1RF00-0AB0)
- SM 326; DO 10 x DC 24V/2A (article number 6ES7326-2BF01-0AB0)
- SM 336; AI 6 x 13 Bit (article number 6ES7336-1HE00-0AB0)

You can show the columns "F-source address" and "F-destination address" in the device view of the device overview. The addresses displayed in these columns are for information purposes only. You must check the F-destination addresses in the safety summary during system acceptance.

Rules for address assignment

WARNING

F-I/Os of PROFIsafe address type 1 are uniquely addressed by their F-destination address (e.g. with the switch setting on the address switch).

The F-destination address (and therefore also the switch position on the address switch) of the F-I/O of PROFIsafe address type 1 must be unique network-wide* and CPU-wide**/*** (system-wide) **for the entire** F-I/O. For this, the F-I/O of PROFIsafe address type 2 and PROFIsafe address type 3 when F-BaseID is inactive (value = 0) must also be taken into account. *(S051)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** "CPU-wide" means all F-I/O assigned to an F-CPU: Central F-I/O of this F-CPU, F-I/O for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

*** In a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be considered as one F-CPU with regard to the PROFIsafe addresses. The "Central F-source address" and, if present, the F-BaseID are therefore set identically for both F-CPUs by the system.

Also note Recommendation for PROFIsafe address assignment (Page 62).

NOTE

For more information on the assignment of PROFIsafe addresses that are unique for the CPU and across the network, see this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).

See also

Completeness of the safety summary (Page 429)

2.11 PROFIsafe addresses for F-I/O of PROFIsafe address type 2

F-source address and F-destination address

The uniqueness of the PROFIsafe address is ensured by the combination of F-source address and F-destination address.

The PROFIsafe address must be unique network-wide and CPU-wide. This is the case if the following two conditions are met:

- The F-source address ("Central F-source address" parameter) of the F-CPU is unique network-wide. Keep this in mind for changes.
- The F-destination address of the F-module is unique CPU-wide.

You define the F-source address using the "Central F-source address" parameter in the F-CPU. Provided you only configure supported configurations (Page 63), this parameter is automatically applied as the F-source address and a CPU-wide unique F-destination address is assigned (usually in descending order starting with 65534).

For supported configurations, if you change the F-destination address, then the CPU-wide uniqueness of the F-destination address is checked automatically.

You must assign the F-source address and F-destination address to the F-I/O before you commission the F-I/O. You can find more information in Assigning a PROFIsafe address of the F-I/Os with SIMATIC Safety (Page 72).

You can show the columns "F-source address" and "F-destination address" in the device view of the device overview. The addresses displayed in these columns are for information purposes only. You must check the F-source and F-destination addresses in the safety summary during system acceptance.

Rules for address assignment

WARNING

F-I/O of PROFIsafe address type 2 is uniquely addressed using a combination of F-source address ("Central F-source address" parameter of the assigned F-CPU) and F-destination address.

The combination of F-source address and F-destination address for each F-I/O of PROFIsafe address type 2 must be unique network-wide* and CPU-wide**/*** (system-wide). In addition, the F-destination address must not be occupied by F-I/O of PROFIsafe address type 1.

If you use a supported configuration (Page 63), you only have to ensure that the "Central F-source address" parameter of all F-CPUs is unique network-wide*. *(S052)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** "CPU-wide" means all F-I/O assigned to an F-CPU: Central F-I/O of this F-CPU, F-I/O for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

*** In a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be considered as one F-CPU with regard to the PROFIsafe addresses. The "Central F-source address" and, if present, the F-BaseID are therefore set identically for both F-CPUs by the system.

Also note Recommendation for PROFIsafe address assignment (Page 62).

NOTE

For more information on the assignment of PROFIsafe addresses that are unique for the CPU and across the network, see this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).

See also

Completeness of the safety summary (Page 429)

2.12 PROFIsafe addresses for F-I/O of PROFIsafe address type 3

Introduction

As well as the F-source address and F-destination address, F-I/Os of the PROFIsafe address type 3 have an additional address named the F-BaseID.

NOTE

The terminology "PROFIsafe address type 3" used in this documentation is equivalent to the designation "PROFIsafe address type 2 with BaseID". This applies in TIA Portal as well as to F-I/Os.

This F-BaseID is a 64-bit number, which is valid centrally for all F-I/Os of PROFIsafe address type 3 of an F-CPU and must be randomly generated and evenly distributed by a generator. The TIA Portal has these generators so that you can easily generate an F-BaseID.

The advantage of the F-BaseID is that, for F-I/Os with PROFIsafe address type 3, you do not need to worry about uniqueness within the network and CPU. Network boundaries are irrelevant, so you do not need network isolators (e.g. SCALANCE SC622-2C) in systems in which only F-I/Os with F-address type 3 are used. Due to its 64-bit size and its generation as an evenly distributed random number, the F-BaseID is sufficiently likely to be unique worldwide.

You no longer need to manage or coordinate the PROFIsafe addresses of your plant for F-I/Os with PROFIsafe address type 3 to guarantee that they are unique network-wide. The TIA Portal ensures that the F-destination addresses are unique CPU-wide (for supported configurations (Page 63)). Therefore, you only need to generate a new F-BaseID.

Delayed transfer

Another advantage of the F-BaseID is the "delayed transfer" property. With this, you can have the F-BaseID generated in the user program on an F-CPU on the first startup. In this way, you can create series machine programs that you distribute to multiple F-CPUs by simply copying SD cards. *STEP 7 Safety* offers specific instructions, which are described in the appendix "Assignment of the F-BaseID during runtime (delayed transfer) (S7-1200 G2, S7-1500) (Page 658)", to generate the F-BaseID in the user program.

Requirements for using the F-BaseID

The F-BaseID is supported for S7-1200 G2 F-CPUs and S7-1500 F-CPUs as of firmware V4.1 or F-Software Controllers as of V40.1. Safety system version V2.8 or higher must also be set in the *Safety Administration Editor*.

To find out which F-modules support the F-BaseID, refer to the respective equipment manual.

Generation of the F-BaseID

To have an F-BaseID generated, press the "Generate F-BaseID" button in the "F-BaseID for PROFIsafe address type 3" section in the "Fail-safe" area of the properties of an F-CPU.

WARNING

The F-BaseID may only be assigned manually in exceptional cases, when you are sure that the PROFIsafe addresses of the F-I/Os of the F-CPU are unique (worldwide). F-I/Os with the same F-BaseID must differ in the combination of F-source and F-destination address. We explicitly advise against manual assignment and recommend generation with the tools offered in the TIA Portal.

With the manual assignment of value "0" as F-BaseID, you lose the advantages of PROFIsafe address type 3 and must adhere to the specifications for PROFIsafe address type 2 (see warning S052). *(S115)*

You can also generate the F-BaseID using tools outside of the TIA Portal and then assign it manually. However, observe the following warning in this case:

WARNING

Only use generation tools with which you can track adherence to the PROFIsafe generation rules, e.g. based on the documentation. The TIA Portal tools comply with these rules. *(S116)*

If you select the "Activate delayed transfer of F-BaseID" option, a specific value (0x7C6) is set for the F-BaseID which informs the F-CPU and all F-I/Os (of PROFIsafe address type 3) assigned to it that the F-BaseID will be determined and possibly re-generated on startup of the F-CPU. It is not possible to operate the F-I/Os with this F-BaseID (0x7C6). You can find more information on this in the appendix "Assignment of the F-BaseID during runtime (delayed transfer) (S7-1200 G2, S7-1500) (Page 658)".

Rules for address assignment

In a homogeneous network in which all F-I/O have PROFIsafe address type 3 and a generated F-BaseID, the following conditions must be met:

- The F-destination address of the F-module is unique CPU-wide.
- The F-BaseID has been generated individually for the F-CPU according to the requirements of the PROFIsafe specification.

The F-destination address is automatically assigned uniquely CPU-wide for supported configurations by the TIA Portal (normally in descending order from 65534) and there is an

automatic check that the F-destination address is unique CPU-wide in the event of changes. If you have the F-BaseID generated in the TIA Portal, the requirements of the PROFIsafe specification are adhered to.

WARNING

If you are uncertain whether the F-BaseID is unique, generate a new F-BaseID. *(S117)*

Note that F-I/Os of PROFIsafe address type 3 with inactive F-BaseID (value = 0) should be viewed the same as F-I/Os of PROFIsafe address type 2.

In a heterogeneous network with F-I/O of PROFIsafe address types 2 and 3, the F-source address ("Central F-source address" parameter) of the F-CPUs ensures that the PROFIsafe addresses are unique network-wide. Therefore, for the F-I/Os of PROFIsafe address type 3, you can use the F-BaseID with the value "0", but you must consider the network boundaries and the conditions for the F-destination address (see warning S052) for PROFIsafe address type 2. To be future-proof, generate an F-BaseID for the F-I/Os of PROFIsafe address type 3.

We recommend that you generate the F-BaseID directly before downloading the fail-safe project data to a productive system for the first time. In general, you are prompted at this time for the serial number of the productive F-CPU, and the PROFIsafe addresses of the F-I/Os of PROFIsafe address type 2 and 3 are not yet assigned. If you assign them after downloading, the newly generated F-BaseID is automatically also assigned.

Even with a generated F-BaseID, uniqueness is not automatically guaranteed. For example, when copying a TIA project or an SD card with loaded fail-safe project data, the F-BaseIDs contained therein are also copied. It is your responsibility to generate new F-BaseIDs in each copy after the copying in order to restore their uniqueness.

WARNING

For copy operations that also copy the value of the F-BaseID, e.g. copying the project or copying the SD card, we strongly recommend generating a new F-BaseID. Otherwise, you must ensure the uniqueness of the PROFIsafe addresses for F-I/Os in another way. *(S114)*

Projects in which you have activated the delayed transfer for the F-BaseID are an exception. In these projects, a valid F-BaseID is generated using the instructions made available by the TIA Portal on the first startup of the F-CPU. You can copy the SD card as much as you like before this first startup. Copying the TIA Portal project data is also possible later. Therefore, the delayed transfer is especially suitable for creating series machines.

2.13 Setting the F-destination address for F-I/O with DIP switches

Information on how to set the F-destination address for F-I/O with DIP switches is available in the documentation of the respective F-I/O.

2.14 Assigning a PROFIsafe address of the F-I/Os with SIMATIC Safety

Introduction

You assign the PROFIsafe address of PROFIsafe address type 2 (Page 67) or PROFIsafe address type 3 (Page 69), consisting of F-source address and F-destination address and, optionally for PROFIsafe address type 3, the F-BaseID for the following F-I/Os directly from *STEP 7 Safety*:

- ET 200SP fail-safe modules
- ET 200SP HA fail-safe modules
- S7-1500/ET 200MP fail-safe modules
- ET 200AL fail-safe I/O modules
- ET 200eco PN fail-safe I/O modules

Refer to the equipment manual of the respective F-I/O for the exact PROFIsafe address type.

The PROFIsafe addresses for S7-1200 F-modules are automatically assigned during download of the hardware configuration.

None of these F-I/O modules have a DIP switch for setting the unique F-destination address for each module.

A new assignment is required for the F-modules mentioned above in the following situations:

- Later placement of a fail-safe module during initial commissioning (not for ET 200eco PN)
- Intentional modification of the F-destination address
- Modification of the "Central F-source address" parameter for the associated F-CPU (changes the F-source address).
- Modification of the "F-BaseID" parameter of the associated F-CPU
- Replacement of the electronic coding element
- Commissioning of a mass-produced machine

In the following cases, a reassignment is not required for fail-safe ET 200SP modules, fail-safe ET 200SP HA modules and fail-safe S7-1500/ET 200MP modules:

- POWER OFF/POWER ON
- Replacement of an F-module (repair) without PG/PC
- Replacement of the BaseUnit (transfer of electronic coding element with assigned F-source address and F-destination address and, if present, F-BaseID to the new BaseUnit)
- Replacement of a BaseUnit without electronic coding element
- Changes in the design in case a new BaseUnit is inserted in front of a fail-safe module
- Repair/replacement of the interface module

Reassignment is not required for fail-safe ET 200eco PN and ET 200AL I/O modules in the following cases:

- POWER OFF/POWER ON
- Replacement of the compact device (transfer of electronic coding element with assigned F-source address and F-destination address and, if present, F-BaseID to the new compact device)

Basic procedure

NOTE

Assigning the PROFIsafe address for S7-1200 fail-safe modules

The procedure described below for identifying and assigning the PROFIsafe addresses is not required for S7-1200 fail-safe modules.

Note that an S7-1200 must not include an additional unconfigured F-module.

1. Set the F-destination address (Page 67) and F-source address (Page 67) and, optionally for F-I/Os of PROFIsafe address type 3, the F-BaseID (Page 69) in the hardware configuration in *STEP 7 Safety*.
2. Identify the F-modules ET 200SP, ET 200SP HA, S7-1500/ET 200MP, F-I/O modules ET 200AL or F-I/O modules ET 200eco PN to which you want to assign the PROFIsafe address.
3. Assign the PROFIsafe address to the F-I/Os.

Assigning the PROFIsafe address for F-I/Os via a redundant S7-1500HF system

In the "Assign PROFIsafe address" dialog under "Select PLC of HF-System", select the HF-CPU of the redundant S7-1500HF system via which you want to assign the PROFIsafe address.

The following table uses the system status to show you via which HF-CPU of the redundant S7-1500HF system you can assign the PROFIsafe address.

System status/F-CPU role	Primary	Backup
RUN-Redundant	x	x
RUN-Solo	x	-
STOP	x	-

x: Assignment possible, -: Assignment not possible

NOTE

Use of R1 devices

Assigning the PROFIsafe address for F-I/Os in an R1 device is only possible via the left interface module of the R1 device. Therefore, the left interface module is always displayed in the "Assign PROFIsafe address" dialog. The left interface module must be supplied with voltage for the assignment of the PROFIsafe address.

If the two HF-CPUs of the redundant S7-1500HF system are located in two separate subnets, the PG and the HF-CPU via which the assignment of the PROFIsafe address is to be performed must be located in the same subnet.

2.14.1 Identifying F-modules

Requirement

The following requirements must be met:

- The F-CPU and fail-safe modules are configured.
- When using an ET 200SP Open Controller, the hardware configuration of the ET 200SP Open Controller **and** of the fail-safe Software Controller must be downloaded.
- The F-CPU and fail-safe modules can be reached online.

WARNING

Make sure that the latest hardware configuration has been downloaded to the F-CPU before identification. By clicking the "Identification" button and then clicking on "Assign PROFIsafe address", you confirm the correctness of the PROFIsafe addresses for the F-I/Os.

Therefore, proceed carefully when confirming the F-I/Os by LED flashing or the serial number of the F-CPU with central F-I/Os or the serial number of the interface module with F-I/Os.

To do this, you must read and write down the serial number directly at the F-CPU* or the interface module**. Reading out the serial number via the online and diagnostics view of the TIA Portal is not permitted.

With F-I/O of PROFIsafe address type 3, you need to confirm the assignment by flashing or serial number even if you have only changed the F-BaseID.

A special rule applies for F-I/Os of the ET 200AL distributed I/O system. For these F-I/Os, only identification by LED flashing is permissible and only exactly one F-I/Os at a time may be selected for assignment of the PROFIsafe address.

* When an ET 200SP Open Controller is used, you must read and write down the serial number from the display of the S7-1500 Fail-safe Software Controller in menu "Overview > CPU".

** When an R1 device is used, you must read and write down the serial number of the left interface module. *(S046)*

Procedure

Proceed as follows to identify the F-modules:

1. Establish an online connection to the F-CPU to which the F-modules are assigned.
2. In the network view, select
   - the F-CPU with F-modules,
   - the interface module with F-modules,

   to which you want to assign PROFIsafe addresses.

   Alternatively, you can select only a single F-module.

3. Select "Assign PROFIsafe address" from the shortcut menu.

NOTE

If you integrate a fail-safe ET 200AL module into a configuration of the ET 200SP distributed I/O system (mixed configuration ET 200AL/ET 200SP with ET connection), you must open the dialog "Assign PROFIsafe address" in the device view of the ET 200SP separately for each fail-safe ET 200AL module.

4. Under "Assign PROFIsafe address by", select the method to be used for identifying the F-modules.
   - "Identification by LED flashing"

     This is the default setting. The DIAG and STATUS LEDs of the F-modules to be identified flash upon identification.
   - "Identification by serial number"

     If you cannot see the fail-safe modules directly, you can identify the fail-safe modules by the noted serial number of the F-CPU or interface module.

     NOTE

     The displayed serial number may be amended with a year number compared to the serial number printed on the F-CPU or the interface module. The serial numbers are nevertheless identical.

5. With identification in the "Assign" column, select all F-modules to which you want to assign the PROFIsafe address.

   If you select the F-CPU or the interface module in the "Assign" column, all F-modules of the station are selected.

NOTE

For F-I/Os of PROFIsafe address type 3 for which the F-BaseID is set to "Delayed transfer", there can be no identification or assignment (see section PROFIsafe addresses for F-I/O of PROFIsafe address type 3 (Page 69)). For identification and assignment of the F-source address and F-destination address only, the value "0" must be configured and downloaded for the F-Base ID of these F-I/Os.

6. Click the "Identification" button. Check whether the DIAG and STATUS LEDs for the F-modules whose PROFIsafe address you want to assign are flashing green. If you identify using the serial number, compare the displayed serial number to the noted serial number of the F-CPU with central fail-safe modules or the interface module with fail-safe modules.

   Observe the following behavior for certain F-modules and configuration variants:
   - If you have configured more F-modules than actually exist, a dialog is displayed. In this dialog, enter the number of F-modules actually existing and confirm the dialog.
   - If you have configured fewer F-modules than are actually available, an online-offline difference is shown and the assignment of the PROFIsafe address is not possible.

2.14.2 Assign PROFIsafe address

Requirement

The F-modules have been successfully identified.

Procedure

To assign a PROFIsafe address, proceed as follows:

1. In the "Confirm" column, select all the F-modules to which you want to assign the PROFIsafe address.
2. Use the "Assign PROFIsafe address" button to assign the PROFIsafe address to the fail-safe modules. You may have to enter the password of the F-CPU or need the user right "Full access including fail-safe".

   To assign the PROFIsafe address, you must confirm the "Confirm PROFIsafe address assignment" dialog within 60 seconds.

2.14.3 Assigning PROFIsafe address to an F-module in a shared device in multiple projects

Introduction

The assignment of the PROFIsafe address for a F-module in a shared device in different projects can only take place after the selection of the IO Controller (F-CPU) to which the F-module is assigned

Therefore, only the F-modules that are assigned to an IO controller (F-CPU) of this project can be selected for assigning the PROFIsafe address in the "Assign PROFIsafe address" dialog.

Requirement

The following requirements must be met:

- All requirements from the sections "Identifying F-modules (Page 75)" and "Assign PROFIsafe address (Page 77)".
- The hardware configuration of all IO controllers (F-CPUs) to which an F-module from the shared device has been assigned is loaded.
- All IO controllers (F-CPUs) to which an F-module from the shared device has been assigned and the shared device must be located in the same subnet.

Procedure

To identify the F-modules and assign the PROFIsafe address, proceed as described in sections "Identifying F-modules (Page 75)" and "Assign PROFIsafe address (Page 77)".

If the F-modules in a shared device are assigned to several IO controllers (F-CPUs) in different projects, make the assignment from the different projects one after the other.

See also

Configuring shared device (Page 60)

2.14.4 Assigning PROFIsafe address to an F-module in a shared device in a common project

Introduction

The assignment of the PROFIsafe address for a F-module in a shared device in a common project can only take place after the selection of the IO Controller (F-CPU) to which the F-module is assigned.
Therefore, only the F-modules that are assigned to the selected IO controller (F-CPU) can be selected for assigning the PROFIsafe address in the "Assign PROFIsafe address" dialog.

Requirement

The following requirements must be met:

- All requirements from the sections "Identifying F-modules (Page 75)" and "Assign PROFIsafe address (Page 77)".
- The hardware configuration of all IO controllers (F-CPUs) to which an F-module from the shared device has been assigned is loaded.
- All IO controllers (F-CPUs) to which an F-module from the shared device has been assigned and the shared device must be located in the same subnet.

Procedure

To identify the F-modules and assign the PROFIsafe address, proceed as described in sections "Identifying F-modules (Page 75)" and "Assign PROFIsafe address (Page 77)".

If the F-modules in a shared device in a common project are assigned to several IO controllers (F-CPUs), select an IO controller in the "Assign PROFIsafe address" dialog and first carry out the assignment for the F-modules that are assigned to the selected IO controller. Subsequently you select further IO controllers and proceed accordingly.

See also

Configuring shared device (Page 60)

2.14.5 Changing the PROFIsafe address

Changing the PROFIsafe address

NOTE

Keep in mind that after changing the PROFIsafe address of an F-I/O you must also carry out an acceptance (Page 432) including a check of your change (Page 448) in the safety summary (Page 400).

1. Change the PROFIsafe address (F-destination address, F-source address and, if present, F-BaseID) in the hardware configuration.
2. Compile the hardware configuration.
3. Download the hardware configuration to the F-CPU.
4. Select "Assign PROFIsafe address" from the shortcut menu.
5. Proceed as described under Identifying F-modules (Page 75) and Assign PROFIsafe address (Page 77).

Safety Administration Editor

3

Overview

The *Safety Administration Editor* supports you as follows:

- Displaying of status of safety mode
- Disabling safety mode
- (S7-1200, S7-1500) Displaying and changing the Fast Commissioning Status
- Displaying of status of the safety program
- Displaying of Collective F-Signature
- (S7-1200, S7-1500) Show Collective F-SW-Signature
- (S7-1200, S7-1500) Show Collective F-HW-Signature
- (S7-1200, S7-1500) F-communication address signature
- (S7-1200 G2 as of firmware V4.1, S7-1500 as of firmware V4.1, S7-1500 F Software Controller as of V40.1) Display F-BaseID
- (S7-1200, S7-1500) Specify/change serial number for F-CPU identification
- Creating a safety summary
- Creating and organizing of F-runtime groups
- Displaying information on the F-blocks
- Displaying information about F-compliant PLC data types (UDT)
- Specifying/changing access protection
- (S7-1200 G1, S7-1500) Information for users with F-Admin permission
- Set/modify settings for the safety program, e.g. Enable F-change history
- (S7-1200, S7-1500) Create/display/delete F-communications via Flexible F-Link

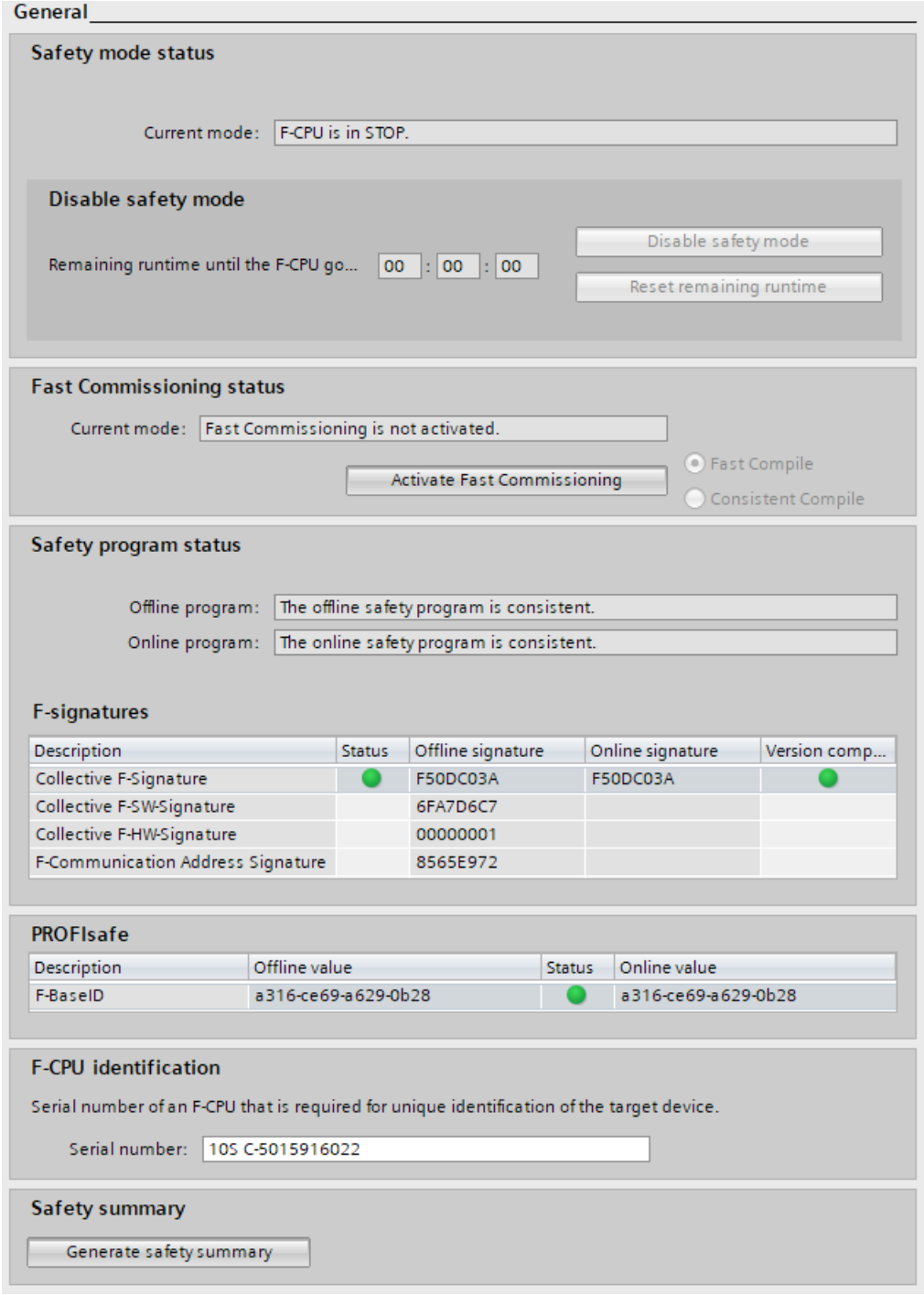
General
Safety mode status
Current mode:
F-CPU is in STOP.
Disable safety mode
Remaining runtime until the F-CPU go...
00
00
00
Disable safety mode
Reset remaining runtime
Fast Commissioning status
Current mode:
Fast Commissioning is not activated.
Activate Fast Commissioning
Fast Compile
Consistent Compile
Safety program status
Offline program:
The offline safety program is consistent.
Online program:
The online safety program is consistent.
F-signatures
Description
Status
Offline signature
Online signature
Version comp...
Collective F-Signature
F50DC03A
F50DC03A
Collective F-SW-Signature
6FA7D6C7
Collective F-HW-Signature
00000001
F-Communication Address Signature
8565E972
PROFIsafe
Description
Offline value
Status
Online value
F-BaseID
a316-ce69-a629-0b28
a316-ce69-a629-0b28
F-CPU identification
Serial number of an F-CPU that is required for unique identification of the target device.
Serial number:
10S C-5015916022
Safety summary
Generate safety summary

The *Safety Administration Editor* is divided into the following areas:

- General

  Under "General" the following is displayed:

  – Safety mode status
  – Fast Commissioning Status
  – Safety program status
  – F-signatures
  – PROFIsafe
  – F-CPU identification
  – Safety summary

  More information on the "General" area can be obtained in ""General" area of the Safety Administration Editor (Page 84)".

- F-runtime group

  You define the blocks and properties of an F-runtime under "F-runtime group".

  You can find information on F-runtime groups at ""F-runtime group" area (Page 87)".

- F-blocks

  Under "F-blocks", you can find information on the F-blocks used in your safety program and their properties . More information on the "F-blocks" area can be obtained in ""F-blocks" area of the Safety Administration Editor (Page 89)".

- F-compliant PLC data types

  Under "F-compliant PLC data types", you obtain information on the created F-compliant PLC data types (UDT). There you also obtain information whether or not an F-compliant PLC data type (UDT) is used in the safety program. More information on "F-compliant PLC data types" can be found in ""F-compliant PLC data types" area of the Safety Administration Editor (S7-1200, S7-1500) (Page 90)".

- Access protection

  Under "Access protection", you can set up, change, or revoke the password for the safety program. Alternatively, you can set up access protection for safety-related project data via project protection. Access protection is mandatory for productive operation. More information on access protection can be found in "CPU-wide access protection for the safety-related project data (Page 102)".

- Web server F-Admins

  Under "Web server F-admins", you obtain information on users with the F-Admin attribute for the Web server of the F-CPU. More information on the "Web server F-Admins" area can be obtained in ""Web server F-admins" area of the Safety Administration Editor (S7-1200 G1, S7-1500) (Page 91)".

- Settings

  Under "Settings", you set the parameters for the safety program. Information on the settings for your safety program can be found in ""Settings" area of the Safety Administration Editor (Page 92)".

- Flexible F-Link

  In the "Flexible F-Link" area, you will find information about the configured F-communications via Flexible F-Link in tabular form and create F-communications. You can obtain information at ""Flexible F-Link" area of the Safety Administration Editor (S7-1200, S7-1500) (Page 98)".

See also

Program structure of the safety program (S7-1200, S7-1500) (Page 116)
Program structure of the safety program (S7-300, S7-400) (Page 113)
Defining F-Runtime Groups (Page 136)

3.1 Opening the Safety Administration Editor

Requirement

The *Safety Administration Editor* is visible as an element in the project tree, if you have configured a CPU as an F-CPU in the project, which means the "F-capability activated" option must be selected (in the properties of the F-CPU).

Procedure

To open the *Safety Administration Editor*, follow these steps:

1. Open the folder for your F-CPU in the project tree.
2. Double-click on "Safety administration" or right-click and select the corresponding shortcut menu for the *Safety Administration Editor*.

Result

The *Safety Administration Editor* for your F-CPU opens in the work area.

3.2 "General" area of the Safety Administration Editor

"Safety mode status"

The "Safety mode status" shows the current status of safety mode. The prerequisite is an existing online connection to the selected F-CPU.

The following statuses are possible:

- "Safety mode is activated"
- "The safety mode is not activated"
- "F-CPU is in STOP"
- "No active F-CPU available"
- "F-runtime group was not called"
- "The safety program is not called"
- "(No online connection)"

"Disable safety mode"

For existing online connection and active safety mode operation, you have the option of using the "Disable safety mode" button to disable safety mode for the selected F-CPU. Safety mode can be deactivated only for the entire safety program and not for individual F-runtime groups.

As of Safety system version V2.4, disabled Safety mode for S7-1200/1500 F-CPUs is time-limited.

To use Fast Commissioning mode, make sure that the option "Safety mode can be disabled" is selected in the "Settings" area (Page 92).

For more information, refer to the section "Disabling safety mode (Page 405)".

"Fast Commissioning Status"

To use the Fast Commissioning mode, make sure that the option "Safety mode can be disabled" is selected in the "Settings" area (Page 92) and that the safety program was compiled consistently. The Fast Commissioning mode can be executed with "Fast Compile" (default setting) or with "Consistent Compile". For more information, refer to the section "Safety program in RUN mode (S7-1200, S7-1500) (Page 419)".

"Safety program status"

"Safety program status" displays the current status of your online and offline program.

The following statuses are possible:

- Consistent

  With information if no password has been assigned. This information does not apply when project protection is used.
- Inconsistent
- Modified
- Fast Commissioning mode is active

  If Fast Commissioning mode was activated with "Fast Compile" and a change was made in the program.
- (No online connection)

  If no connection to the online program could be established.

"F-signatures"

When no online connection exists

Under "F-signatures" multiple signatures are displayed. Each signature is formed from different parts of the fail-safe project data.

- Collective F-Signature: This signature changes with each change of the fail-safe project data. It can contain the signatures described below.
- Collective F-SW-Signature (S7-1200, S7-1500): This signature changes with each change of the safety program.
- Collective F-HW-Signature (S7-1200, S7-1500): This signature changes with each change of the fail-safe HW configuration.
- F-Communication address signature (S7-1200, S7-1500): This signature changes with each change of the name or the F-communication UUID of communication connections with Flexible F-Link.

Note that the F-BaseID does not enter into the Collective F-HW-Signature or the Collective F-Signature.

The time of the last compilation process is displayed for the Collective F-Signature in the "Time stamp" column.

When an online connection exists

For an existing online connection, the following is displayed under the "Program signature":

- The status of safety program

Status	Meaning
●	The online and offline Collective F-Signatures match.
!	The online and offline Collective F-Signatures *do not* match.
—	The safety program status could not be determined.

- The online and offline Collective F-Signatures
- When the Collective F-Signatures match: Information on whether the F-block versions are consistent online and offline.

Status	Version comparison	Statement
!	Not relevant	The online and offline Collective F-Signatures *do not* match.
●	!	The online and offline Collective F-Signatures match, but the online versions of F-blocks differ from the offline versions.
●	●	The online and offline Collective F-Signatures match, identical versions of F-blocks are being used online and offline.
Not relevant	—	The safety system versions could not be determined.

You can find more information on the consistency of the online safety program at under Identity of online and offline program (Page 444).

"PROFIsafe" (S7-1200 G2, S7-1500)

When no online connection exists

The F-BaseID is displayed under "PROFIsafe". It applies to all F-I/Os of PROFIsafe address type 3 (Page 34) assigned to the F-CPU. The F-BaseID allows a clear differentiation to be made between F-I/Os of PROFIsafe address type 3 having the same F-source address and F-destination address.

More information on the F-BaseID can be found in section "Configuring an F-CPU (Page 40)".

For S7-1200/1500 F-CPUs that do not support the F-BaseID, this area is grayed out.

When an online connection exists

When an online connection exists, the following is also displayed under "PROFIsafe":

Table 3-1102 Status of the F-BaseID

Status	Meaning
●	The online and offline F-BaseIDs match.
!	The online and offline F-BaseIDs do *not* match.
●	The F-BaseID could not be determined online or is not supported.

The online-offline comparison of the F-BaseID does not enter into the status of the "General" area.

"F-CPU identification" (S7-1200, S7-1500)

The serial number of the F-CPU to which the safety program is to be downloaded is entered under "F-CPU identification". This serial number is used to ensure connection to the correct F-CPU in the network. If the serial number is not entered at the time of download to the F-CPU, you must confirm it in the "Load preview" dialog to be able to continue the download. The confirmed serial number is then automatically entered in this field.

"Safety summary"

Under "Safety summary", you have the option to create the safety summary (Page 400) for the F-CPU.

See also

Program identification (Page 396)

3.3 "F-runtime group" area of the Safety Administration Editor

3.3.1 "F-runtime group" area

A safety program consists of one or two F-runtime groups.

General information on F-runtime groups can be found in "Program structure of the safety program (S7-300, S7-400) (Page 113)" and "Program structure of the safety program (S7-1200, S7-1500) (Page 116)".

You can find information on creating F-runtime groups at Defining F-Runtime Groups (Page 136)

(S7-1200, S7-1500) "Creating a global F-I/O status block"

You can create a standard block (FB) with the name "RTGx_GLOB_FIO_STATUS", which evaluates whether substitute values are output instead of process values for at least one F-I/O or at least one channel of an F-I/O of an F-runtime group x. The result of the evaluation is available at the "QSTATUS" output.

The following are not included:

- F-I/O that you disabled with the DISABLE tag in the F-I/O DB.
- Channel error of channels that you disabled when configuring an F-I/O.

The "RIOforFA_VALUE_STATUS" output is set to "1" if no substitute value is output for **any** F-I/O **with "RIOforFA-Safety"** profile of the F-runtime group x.

To generate this standard FB, you use the "Create global F-I/O status block" button. You can only create the standard FB when your safety program has been compiled. You can call the standard FB anywhere in your standard user program.

NOTE

When adding or deleting an F-I/O, you have to generate "RTGx_GLOB_FIO_STATUS" again.

See also

Process Data or Fail-Safe Values (Page 166)

3.3.2 Pre-/postprocessing (S7-1200, S7-1500)

With pre-processing and post-processing you have the option of calling standard blocks (FCs) directly before or after an F-runtime group, for example for data transfer with fail-safe communication via Flexible F-Link (Page 355) or OPC UA Safety (Page 297). The calls are made in the same F-OB or synchronized with the F-runtime group.

Requirement

- Only standard-FCs usable.
- Only temporary local data and constants are permitted in the block interface of a standard-FC.

Procedure

1. Create the standard-FCs for the pre-processing and the post-processing.
2. Assign the standard-FCs in the Safety Administration Editor under "Pre-/post-processing of the F-runtime group".

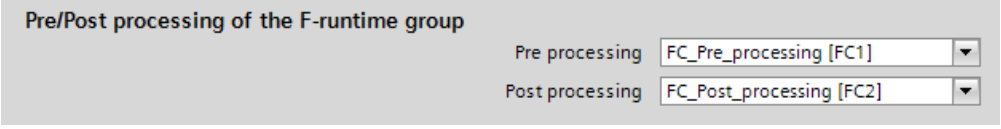

NOTE

When you delete an assigned FC or overwrite it by copying, its selection as a pre-processing / post-processing block is automatically reset.

Effect on the safety program

- The runtime of the F-runtime group is extended by the runtime of the standard FCs for pre-/post-processing (influence on TRTG_CURR and TRTG_LONG in the F-runtime group information DB).
- Because the pre-processing / post-processing does not change the functionality of the safety program, the collective F-signature remains unchanged after compilation.

Load behavior

The calls of the selected standard FCs are placed during compiling or after the call of the main safety block in the F-OB.
This means that the STOP operating state is required during a subsequent download.

Changes in the contents at the selected standard FCs can take place in RUN.

Exceptions are changes of the block name and block numbers which also include the compilation of the safety program.

When a pre-processing/post-processing block is uploaded individually by the F-CPU, it does not automatically connect to the F-runtime group in the *Safety Administration Editor*.

If consistent loading of the F-CPU into the PG/PC is performed instead, the settings for pre-processing and post-processing are updated according to the online CPU.

3.4 "F-blocks" area of the Safety Administration Editor

Overview

The "F-Blocks" area helps you in the following tasks:

- Displaying the F-blocks used in your safety programs.
- Displaying the F-blocks used in the F-runtime groups.
- Displaying additional information about the F-blocks.

The F-blocks are hierarchically displayed as in the "Program blocks" folder.

A description of the F-blocks is available in "Creating F-blocks (Page 153)".

Displayed information

The following information is displayed in offline mode:

- Have displayed F-blocks been compiled and used?
- Function of F-blocks in safety program
- Block signature
- Group signature
- Change time stamp of the F-blocks

The following information is displayed in online mode:

- Status (whether block has the same time stamp online and offline)
- Function of F-block in the safety program
- Block signature offline
- Group signature offline
- Block signature online
- Group signature online

NOTE

During the offline-online comparison, the comparison statuses may occasionally differ between the *comparison editor* and status display in the *Safety Administration Editor*. The decisive status is the result of the comparison in the *comparison editor*, since this is the only comparison that takes into account the contents of the F-blocks.

NOTE

Group signatures are formed from the signatures of the F-blocks contained in the group and in subgroups. Only F-blocks that are used in the safety program are taken into account. Only the group signatures up to the 6th hierarchy level are displayed.

Filter function

Using the filter function, you can select whether you want to view all F-blocks of a certain F-runtime group or the entire safety program.

- Select "All F-blocks " from the drop-down list to view all F-blocks.
- Select an F-runtime group from the drop-down list to see all F-blocks of this F-runtime group.

3.5 "F-compliant PLC data types" area of the Safety Administration Editor (S7-1200, S7-1500)

Overview

Under "F-compliant PLC Data Types" you obtain information on the F-compliant PLC data types (UDT) you have defined.

You can delete F-compliant PLC data types (UDT) from the shortcut menu.

More information on the F-compliant PLC data types (UDT) can be found in "F-compliant PLC data types (UDT) (S7-1200, S7-1500) (Page 128)".

Displayed information

The following information is displayed for F-compliant PLC data types (UDT) in offline mode:

- Is the F-compliant PLC data type used in the Safety program?
- Time stamp of the last change.

The following information is displayed for F-compliant PLC data types (UDT) in online mode:

- Status (whether the F-compliant PLC data types (UDT) have the same time stamp online and offline)

The F-compliant PLC data types (UDT) are displayed hierarchically as in the folder "PLC Data Types".

Double-click the F-compliant PLC data type (UDT) to open it for editing.

More information can be found on the symbols in the "Status" column at "Comparing Safety Programs (Page 398)".

NOTE

During offline-online comparison, the comparison statuses between the *comparison editor* and status display in the *Safety Administration Editor* can be different under certain circumstances. The comparison result in the *comparison editor* is decisive, since this is the only comparison that takes into account the contents of the F-compliant PLC data types (UDT).

3.6 "Web server F-admins" area of the Safety Administration Editor (S7-1200 G1, S7-1500)

The "Web server F-Admins" area is displayed for S7-1500 F-CPUs only for firmware < V3.1 and for S7-1200 G1 F-CPUs only for firmware <V4.7.

You need "F-admin" rights in order to restore a backup (Page 386) via the Web server or Web API interface of your F-CPU. You assign the "F-admin" right in the hardware configuration of the F-CPU under the user management of the Web server.

In this section, you obtain information on which users have the "F-admin" right online or offline for F-CPUs that support this right. You can see from this whether a change to the "F-admin" right is active on the F-CPU. In order to make a change to the "F-admin" right effective, you have to load the configuration to the F-CPU.

If you are using user management, this area is omitted.

See also

Completeness and correctness of the hardware configuration (Page 432)

3.7 "Settings" area of the Safety Administration Editor

"Number ranges of the generated F-system blocks"

The number ranges assigned here are used by the F-System for new, automatically generated F-blocks.

At this point, you can select whether the number ranges are managed by the F-system or if a fixed range specified by you is used.

- "F-system managed"

  The number ranges are managed automatically by the F-system, depending on the F-CPU used. The F-system selects an available number range. The start and end ranges of the number ranges are displayed.

- "Fixed range"

  You can select the start and end ranges of the number ranges from the available range. The available range depends on the F-CPU used.

  An invalid number range selection is indicated by an error message.

  The only check performed during configuration is whether the configured low limit is less than or equal to the high limit and within the available range of the F-CPU. The check as to whether the configured range is sufficiently large is first made during compiling. You need to ensure a sufficiently large range. Where the available range is insufficient, a compiling error occurs. Not all blocks are generated and the safety program is not executable.

Changes will become valid only during the next compilation. The automatically created F-blocks may be moved into the new area during compilation. The F-I/O DBs are an exception. They always retain their original number that you may change in the properties of the F-I/O.

"Safety system version"

This parameter is used to specify the safety system version (including version of the F-system blocks and automatically generated F-blocks, see Overview of Programming (Page 113)).

A number of versions are available:

Version	S7-300/4-00	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.6	—	x	—	x	These versions have identical functions. Depending on the set version, the result may be different runtimes of the F-runtime group(s) (see Excel file for response time calculation on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
2.0	x	x[1]	—	x[2]	

1 Supported as of firmware V4.2

2 Supported as of firmware V2.0

3 Fast Commissioning mode with "Fast Compile" is supported as of firmware V4.5.

4 Fast Commissioning mode with "Consistent Compile" is supported as of firmware V3.0. With the S7-1500 F-Software Controller, it is available only for approved IPCs as of firmware V30.0.

5 The F-BaseID is supported for S7-1200 G2 and S7-1500 as of firmware V4.1 or F-Software Controller as of V40.1.

6 If the F-OB of the associated F-runtime group has the event class "Cyclic interrupt".

Version	S7-300/4-00	S7-1200 G1	S7-1200 G2	S7-1500	Function
2.1	—	x[1]	—	x[2]	Additionally supports the variables "DISABLE" and "DISABLED" in the F-I/O DB
2.2	—	x[1]	—	x[2]	Supports the safety-related CPU-CPU communication and F-runtime group communication with Flexible F-Link.
2.3	—	x[1]	—	x[2]	This version has identical functions to version 2.2.
2.4	—	x[1, 3]	—	x[2]	Additionally supports: • F-CPUs • Fast Commissioning mode with "Fast Compile" • Runtime for the deactivated safety mode
2.5	—	x	—	x[4]	Additionally supports: • Fast Commissioning mode with "Consistent Compile" (S7-1500) • F-I/Os with more than 13 bytes net data (e.g. F-AI 8xI 0(4)..20mA)
2.6	—	x	—	x	The functions of this version are identical to those of version 2.5.
2.7	—	x	x	x	Additionally supports: • S7-1500 F Virtual Controller • OPC UA Safety
2.8	—	x	x[5]	x[5]	Additionally supports: • F-BaseID[5] • Improved response time of F-I/O for inputs[6]

1 Supported as of firmware V4.2

2 Supported as of firmware V2.0

3 Fast Commissioning mode with "Fast Compile" is supported as of firmware V4.5.

4 Fast Commissioning mode with "Consistent Compile" is supported as of firmware V3.0. With the S7-1500 F-Software Controller, it is available only for approved IPCs as of firmware V30.0.

5 The F-BaseID is supported for S7-1200 G2 and S7-1500 as of firmware V4.1 or F-Software Controller as of V40.1.

6 If the F-OB of the associated F-runtime group has the event class "Cyclic interrupt".

Usually, you do not need to make any settings for this parameters.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

"Local data used in safety program" (S7-300, S7-400)

You use this parameter to specify the amount of temporary local data (in bytes) that is available for the call hierarchy below the main safety block.

The setting applies to each F-runtime group of a safety program. More information on F-runtime groups can be found in "Program structure of the safety program (S7-1200, S7-1500) (Page 116)" and "Program structure of the safety program (S7-300, S7-400) (Page 113)".

The **minimum possible amount** is determined by the local data requirement of the F-blocks generated automatically when the safety program is compiled.

For this reason, you must provide at least 440 bytes. However, the local data requirement for the automatically added F-blocks may be higher depending on the local data requirement of the F-blocks you created with FBD or LAD.

Therefore, provide as much local data as possible. If there is not enough local data available for the automatically added F-blocks (440 bytes or more), the safety program will be compiled nevertheless.

Data in automatically added F-DBs are then used instead of local data. However, this increases the runtime of the F-runtime group(s). You will receive a notice when the automatically added F-blocks require more local data than configured.

WARNING

The calculated maximum runtime of the F-runtime group using the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) is no longer correct in this case because the calculation assumes sufficient availability of F-local data.

In this case, use the value you configured for the maximum cycle time of the F-runtime group (F-monitoring time) as the maximum runtime of the F-runtime group when calculating the maximum response times in the event of an error and for any runtimes of the standard system using the above-mentioned Excel file. *(S004)*

The maximum possible amount depends on:

- Local data requirement of the main safety block and the higher-level standard user program. For this reason, you should call the main safety blocks directly in OBs (cyclic interrupt OBs, whenever possible), and additional local data should not be declared in these cyclic interrupt OBs.
- Maximum volume of local data of the utilized F-CPU (see Technical Specifications in the product information for the utilized F-CPU). For S7-400 F-CPUs, you can configure the local data for each priority class. Therefore, assign the largest possible local data volume for the priority classes in which the safety program (the main safety blocks) is called (e.g., OB 35).

Maximum possible amount of local data as a function of local data requirement of main safety block and higher-level standard user program (S7-300, S7-400):

Case 1: Main safety block called directly from OBs

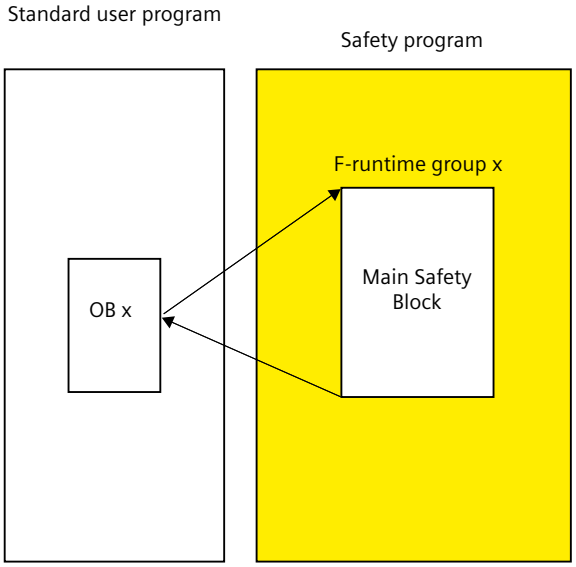

Set the "Local data used in safety program" parameter to the maximum amount of local data of the utilized F-CPU minus the local data requirement of the main safety block (if the main safety block has 2 F-runtime groups, use the largest local data requirement) and minus the local data requirement of the calling OBx (if there are 2 F-runtime groups, use the OB with the largest local data requirement).

Note: If you have not declared any temporary local data in the main safety blocks and calling OBx, the local data requirement of the main safety blocks is 6 bytes and the local data requirement of the calling OBx is 26 bytes. You can derive the local data requirement of the main safety blocks and calling OBx from the program structure.

Select the utilized F-CPU in the project tree and then "Tools > Call structure". The table gives the local data requirement in the path or for the individual blocks (see also the help on *STEP 7*).

Case 2: Main safety block not called directly from OBs

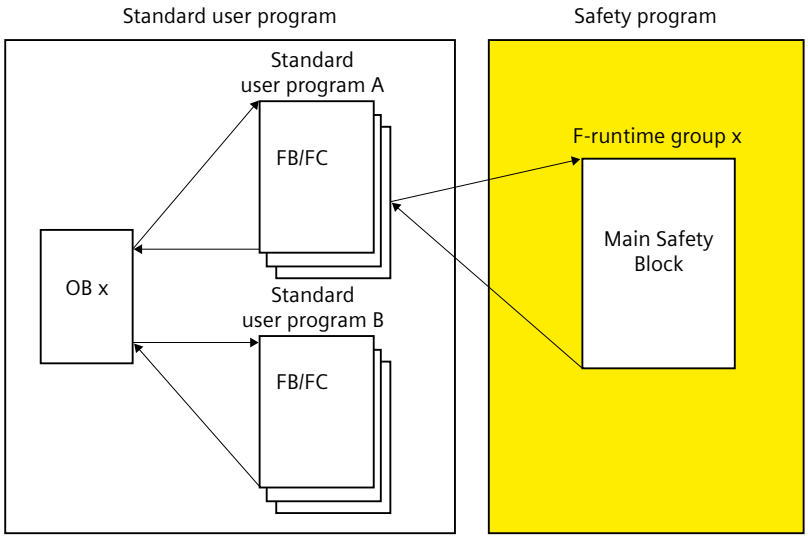

Set the "Local data settings" parameter to the value calculated for Case 1, minus the local data requirement of standard user program A (if standard user program A has 2 F-runtime groups, use the largest local data requirement).

Note: You can derive the local data requirement of the standard user program A from the program structure.

Select the utilized F-CPU in the project tree and then "Tools > Call structure". The table gives the local data requirement in the path or for the individual blocks (see also the help on *STEP 7*).

"Advanced settings"

"Safety mode can be disabled"

With this option you can prevent the safety mode for a safety program from being disabled.

Under "Runtime for the deactivated safety mode", you set the time after which the F-CPU goes to STOP after safety mode is deactivated.

When you change the setting for this option, you need to recompile the safety program and download it to the F-CPU for the change to become effective. This changes the Collective F-Signature and the Collective F-SW-Signatures of your safety program.

To exclude an unintentional disabling of the safety mode, make sure that the option is disabled in productive operation.

"Enable F-change history"

Enable the logging of changes to the safety program by using the "Enable F-change history" option. For more information, refer to the section "F-change history (Page 425)".

"Enable consistent upload from the F-CPU" (S7-1500)

This option allows you to load the loaded project data (including safety-related project data) consistently from the F-CPU to the PG/PC.

The option can only be activated if the F-CPU and the firmware of the F-CPU supports the loading of the project data (including safety-related project data).

F-CPUs S7-1500 as of firmware V2.1 are supported. S7-1500 F Software Controllers are not supported.

At every change to this option you have to load the project data to the F-CPU.

Note that the activation of this option extends the loading of the safety-related project data into the F-CPU.

"Activate variable F-communication- IDs" (S7-1200, S7-1500)

If you activate this option, you can supply the DP_DP_ID input of the SENDDP or RCVDP instructions with the variable values from a global F-DB.

WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide**** at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.

You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure a unique F-communication ID during startup of the safety program, because it is only specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

**** With a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be regarded as one single F-CPU with regard to the DP_DP_ID.

"System-generated objects" (S7-1200, S7-1500)

"Creates F-I/O DBs without prefix"

When you select this option, the names of the F-I/O DBs (Page 168) are created without prefix.

"Clean up"

The "Clean up" button is provided for service and support purposes and cleans up the result of the fail-safe compilation.

3.8 "Flexible F-Link" area of the Safety Administration Editor (S7-1200, S7-1500)

In the "Flexible F-Link" area, you create new F-communications, obtain information on existing F-communications and delete F-communications.

Requirement

- S7-1500 F-CPUs as of firmware V2.0
- S7-1200 G1 F-CPUs as of firmware V4.2
- S7-1200 G2 F-CPUs as of firmware V1.0
- Safety system version as of V2.2

Information on created F-communications

In the "Flexible F-Link" area, you receive information on configured F-communications in tabular form:

- CPU-wide unique name of F-communication
- F-compliant PLC data type (UDT) for send/receive data
- Direction of F-communication: Transmitting/receiving
- F-monitoring time of F-communication
- F-Communication UUID
- Tag for send data
- Tag for receive data

Creating F-communication

1. In an empty row of the table click "<Add new>"
2. Assign a name to the communication connection.
3. Select an F-compliant PLC data type (UUID) for the communication connection.

   If you have not yet created an F-compliant PLC data type (UDT) for the communication connection or wish to create a new one, create a new F-compliant PLC data type (UDT) (Page 128) with any structure. Note that the size can be up to 1500 bytes.
4. Select the direction of the communication connection ("Send" or "Receive").
5. Select the F-monitoring time of the communication connection (Page 644).

The UUID of the F-communication is displayed via Flexible F-Link in the "F communication UUID" column. The F-communication UUID ensures sufficient uniqueness of the safety-related communication ID even across network limits.

The "Tag for send data" column shows you the newly created tag for send data of the F-communication DB (Page 358).

The "Tag for receive data" column shows you the newly created tag for receive data of the F-communication DB (Page 358).

You can find the newly created F-communication DB for this F-communication under "Program blocks\System blocks\STEP 7 Safety\F-communication DBs".

Deleting F-communication

1. Select the entire row and confirm "Delete" in the shortcut menu. You can also delete multiple F-communications at the same time.

Copying F-communication

1. Select the entire row and confirm "Copy" in the shortcut menu. You can also copy multiple F-communications at the same time.
2. With the "Paste" menu command, you can paste the copied F-communications into the table as often as needed. The UUID for the respective F-communication is retained during copying. If necessary, re-generate the UUID.

Generating a new F-communication-UUID

1. Select the entire row and confirm "Generate UUID" in the shortcut menu. You can also generate multiple UUIDs at the same time.

See also

Flexible F-Link (Page 355)

F-runtime group communication (S7-1200, S7-1500) (Page 149)

Access protection

4

Access protection is necessary for productive operation

Access protection to the SIMATIC Safety F-system is mandatory for productive operation.

⚠ WARNING

Access to the SIMATIC Safety F-system without access protection is intended for test purposes, commissioning, etc., when the system is not in productive operation. Without access protection, you need to ensure the safety of the plant through other organizational measures.

Before you transition into productive operation, you must have set up and activated access protection. *(S005)*

NOTE

We recommend making the settings for access protection in the "PLC security settings" dialog when creating the project.

4.1 Overview of access protection

Introduction

You can control access to the SIMATIC Safety F-system with the access protection for the safety-related project data and the access protection for the F-CPU.

Access protection for the safety-related project data

Access protection for the safety-related project data (Page 101) is available in two forms:

- Assignment of a password for the safety-related project data (F-CPU-granular), assigned in the *Safety Administration Editor*
- Setup of project protection for all safety-related project data in the TIA project

Access protection for the F-CPU

The access protection (Page 104) is set at the F-CPU level. To do this, you assign a password for the F-CPU in the F-CPU configuration or assign F rights as part of user management, if supported by the respective F-CPU (only 1200/1500 F-CPUs as of certain firmware versions (Page 108)). For S7-300/400 F-CPUs, the password is also used to identify the F-CPU and must therefore be unique network-wide. For S7-1200/1500 F-CPUs, the password no longer needs to be unique because the serial number is used for identification.

4.2 Access protection for the safety-related project data

The access protection for the safety-related project data is in effect for all operations in which the safety-related project data can be inconsistent offline, for example:

- When changing the Safety program
- When changing and deleting F-runtime groups
- When changing safety-related parameters of F-I/O

NOTE

Note that, for usability reasons, the F-BaseID falls under the offline access protection for the safety-related project data, but it is not covered by the online access protection of the F-CPU for safety-related project data. Here, the F-BaseID is treated like a standard parameter.

There is an exception for switching between an F-BaseID with the value "Delayed transfer" and an F-BaseID with a specific value (either 0 or an active F-BaseID).

- When compiling

NOTE

Note that the access protection for the safety-related project data is only effective if you are making the changes in the TIA Portal. Although the TIA Portal detects changes to the project data made directly in the related files in the file system, these changes cannot be prevented or undone.

Safety program recompilation is required after changes to standard DBs to which the safety program has read or write access.

4.2.1 CPU-wide access protection for the safety-related project data

Requirement

The project does not use user management to protect the project data

Setting up CPU-wide access protection for safety-related project data

To set up CPU-wide access protection for safety-related project data, assign a password for the safety program. Proceed as follows:

1. Open the folder for your F-CPU in the project tree.
2. Select "Safety Administration" and select "Go to access protection" in the shortcut menu.

   Alternatively, double-click on "Safety Administration". The *Safety Administration Editor* of the F-CPU will open. Select "Access protection" in the navigation area.
3. Under "Offline safety program protection", click "Setup" and enter the password (max. 30 characters) for the safety program in the following dialog in the "New password" and "Confirm password" fields.
4. Confirm the assigned password with "OK".

You have set up CPU-wide access protection for safety-related project data and have gained access permission for the safety-related project data.

NOTE

Use different passwords for the F-CPU and the safety program to optimize access protection.

Changing the password for safety-related project data

You can change the password for the safety-related project data as long as you have the necessary access permissions. It also takes place in the "Access protection" area (via "Change" button) and is carried out as usual under Windows through entry of the old and double entry of the new password.

Deleting CPU-wide access protection for safety-related project data

To delete CPU-wide access protection for safety-related project data, delete the password for the safety program. Proceed as follows:

1. Open the folder for your F-CPU in the project tree.
2. Select "Safety Administration" and select "Go to access protection" in the shortcut menu.

   Alternatively, double-click on "Safety Administration". The *Safety Administration Editor* of the F-CPU will open. Select "Access protection" in the navigation area.
3. Click the "Change" button.
4. Under "Old password", enter the password for the safety program.
5. Click "Revoke" and then on "OK".

Gaining access permission through login to the safety program

Log in to the safety program as follows:

1. Open the folder for your F-CPU in the project tree.
2. Select "Safety Administration" and select "Go to access protection" in the shortcut menu.

   Alternatively, double-click on "Safety Administration". The *Safety Administration Editor* of the F-CPU will open. Select "Access protection" in the navigation area.
3. Enter the password for the safety program in the "Password" input field.
4. Select the "Login" button.

Validity of access permission for safety-related project data

If access permission for safety-related project data was obtained by entering the password, this remains until the project is closed. When the TIA Portal is closed, any project that is still open is automatically closed and any access permission granted is canceled.

Cancelling access permission through logoff

The access permission for safety-related project data can be cancelled as follows:

- By clicking the "Log off" button in the "Access protection" area in the "*Safety Administration Editor*".
- In the shortcut menu for the *Safety Administration Editor* (access by right-clicking).
- By using the lock symbol in the line of the *Safety Administration Editor*.

The user will then be prompted to enter the password for the safety program again the next time an action requiring a password is performed.

Displaying the availability of access authorization

The status of the access authorization is displayed in the project tree as follows:

- The access authorization is available when the lock symbol in the line of the *Safety Administration Editor* is shown unlocked.
- The access permission is not available, if the lock symbol shows a closed lock.
- If no lock symbol is shown, no password was assigned.

4.2.2 Project-wide access protection for the safety-related project data

As an alternative to CPU-wide access protection for the safety-related project data with a password in the *Safety Administration Editor*, you can use the project protection for the TIA project.

To do this, assign the "Edit safety-related project data" function right to users who are allowed to edit safety-related project data. To do this, proceed as usual for function rights. You can find more information in the help for *STEP 7* under "Managing users and roles".

NOTE

When project-wide project access protection is activated, any existing passwords for safety-related project data for all F-CPUs of the project are deleted.

Users who need the "Edit safety-related project data" function right may require additional function rights, for example:

- "Modify PLC program" to change the safety program
- "Downloading to PLC" to load the safety-related project data into the F-CPU
- "Modify hardware configuration" to make changes to the safety-related hardware configuration

4.3 Access protection for the F-CPU

The access protection for the F-CPU is effective for all operations in which the safety-related project data can be changed online, for example:

- When downloading the safety program to the F-CPU
- When downloading the hardware configuration to the F-CPU, also when changes are made to F-I/O not used in the Safety program

  NOTE

  Note that, for usability reasons, the F-BaseID falls under the access protection for the safety-related project data, but it is not covered by the access protection of the F-CPU for safety-related project data. Here, the F-BaseID is treated like a standard parameter.

  There is an exception for switching between an F-BaseID with the value "Delayed transfer" and an F-BaseID with a specific value (either 0 or an active F-BaseID).

- (S7-1200, S7-1500) When downloading a hardware configuration to the F-CPU containing safety-related changes
- When assigning the PROFIsafe address
- When loading or deleting F-blocks used in the safety program

- When disabling safety mode or when resetting the remaining runtime (the password must always be entered, even if access permission for the F-CPU is still valid.)
- When restoring a backup of the F-CPU

  Exception with S7-1200/1500 F-CPUs: If neither the Safety program nor the password for the F-CPU or users with the rights "Change F-System parameters (F-Admin)" or "Full access including fail-safe" are changed as a result, the access protection for the F-CPU is not queried.

4.3.1 Access protection through the use of protection levels

This section describes the access protection for F-CPUs through the use of protection levels.

You can use access levels for the following F-CPUs:

- S7-300/400
- S7-1200 G1 up to firmware 4.6 (as of firmware V4.7 only if the option "Use access control via access levels" is activated)
- S7-1200 G2 if the parameter "Use access control via access levels" is selected.
- S7-1500 up to firmware V3.0 (as of firmware V3.1 only if the parameter "Use access control via access levels" is activated)
- S7-1500 F Software Controller up to firmware V3x.0 (as of firmware V3x.1 only if the parameter "Use access control via access levels" is activated)

Setting up access protection for the F-CPU

To set up access protection for the F-CPU, assign a password in the F-CPU configuration. Proceed as described in the *STEP 7* help under "Configuring access levels".

Clicking on the link "Go to the "Protection" area of the F-CPU" in the "Access protection" area of the *Safety Administration Editor* takes you directly to the password for the F-CPU.

WARNING

(S7-300, S7-400) In productive operation, it must be prevented that changes to the standard user program are unintentionally made in the Safety program as well. For this purpose, you must configure the protection level "Write protection for fail-safe blocks" and configure a password for the F-CPU.

With the "Write protection" or "Write/read protection" protection level, the password would apply to the standard and the Safety program. *(S001)*

WARNING

(S7-1200, S7-1500) In productive operation, the safety-related project data must be protected against unintentional changes.

If you use user management, the Runtime rights "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" and the engineering right "Manage users and roles" may only be granted to authorized users. You must also limit the assignment of user rights to trained personnel. Before the transition into productive operation, you must remove the "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" rights from the "Anonymous" user.

If you are not using user management or the "Access control via access levels" parameter is activated, then configure at least the "Full access (no protection)" protection level and assign a password under "Full access incl. fail-safe (no protection)". This protection level allows full access only to the standard user program and not the Safety program.

If you select a higher protection level, for example to protect the standard user program, you must assign an additional password for "Full access (no protection)".

Assign different passwords for the individual access levels. *(S041)*

You enable access protection by downloading (Page 362) the hardware configuration to the F-CPU.

WARNING

(S7-300, S7-400) If **several F-CPUs** can be reached via a network (such as Industrial Ethernet) by **the same programming device or PC**, you must take the following additional measures to ensure that the safety-related project data is downloaded to the correct F-CPU:

Use passwords specific to each F-CPU, such as a uniform password for the F-CPUs with attached Ethernet address for each.

Note the following:

- A point-to-point connection must be used to activate the access protection of an F-CPU when the hardware configuration is loaded for the first time (similar to assigning an MPI address to an F-CPU for the first time).
- Before downloading the safety-related project data to an F-CPU, existing access permission for any other F-CPU must first be cancelled.
- The last download of the safety-related project data prior to switching to productive operation must be made with enabled access protection. *(S021)*

WARNING

When using tools for the automation or operation (of TIA Portal or web server) with which the access protection for the F-CPU can be removed, the safety-related project data may not be protected against unintentional changes anymore. When using corresponding tools, the requirements regarding access protection of the F-CPU must still be met. *(S078)*

Changing the password for the F-CPU

For the new password to become valid after a change to an access level password for the F-CPU, you must download the changed configuration into the F-CPU. If necessary, you must enter the "old" password for the F-CPU for this load operation. The F-CPU must be in STOP mode.

Deleting access protection for the F-CPU

To delete configured access protection for the F-CPU, change the access level and delete the passwords for the F-CPU that are no longer required. To do this, proceed as in the standard.

Obtaining access permission for the F-CPU

You obtain access permission for the F-CPU by entering the password for the F-CPU, according to the configured protection level, prior to performing an action requiring a password.

Validity of access permission for the F-CPU

Access permission for the F-CPU remains valid until the TIA Portal is closed or access permission is revoked.

Canceling access permission for the F-CPU

You cancel the access permission with the menu command "Online > Delete access rights" auf.

⚠ WARNING

The safety-related project data must be protected against unintentional changes.

For this you must cancel the access permission and the online connection for the F-CPU whenever you leave the PG/PC.

Alternatively, you can also take other organizational measures. *(S006)*

4.3.2 Access protection through user management

This section describes the access protection for F-CPUs through the use of user management and the runtime right for the F-CPU.

You can use local user management for the following F-CPUs if the "Use access control via access levels" parameter is not activated:

- S7-1200 G1 as of firmware V4.7
- S7-1200 G2 as of firmware V1.0
- S7-1500 as of firmware V3.1
- S7-1500 F Software Controller as of firmware V3x.1

You can use central user management for the following F-CPUs:

- S7-1200 G2 as of firmware V4.1
- S7-1500 as of firmware V4.0
- S7-1500 F Software Controller as of firmware V4x.0

Setting up access protection for the F-CPU

To set up access protection for the F-CPU, use the user management with the function right for the F-CPU. Proceed as described in the *STEP 7* help under "Local user management" or "Central user management" and "Settings for users and roles".

If the "Use access control via access levels" option is selected in addition to "Enable access control", you must assign at least a password for "Full access including fail-safe" for the F-CPU in the F-CPU configuration. Proceed as described in the *STEP 7* help under "Configuring access levels".

You can go directly to the settings for access protection of the F-CPU if you click the link "Go to the "Protection" area of the F-CPU" in the "Access protection" area in the *Safety Administration Editor*.

WARNING

(S7-1200, S7-1500) In productive operation, the safety-related project data must be protected against unintentional changes.

If you use user management, the Runtime rights "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" and the engineering right "Manage users and roles" may only be granted to authorized users. You must also limit the assignment of user rights to trained personnel. Before the transition into productive operation, you must remove the "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" rights from the "Anonymous" user.

If you are not using user management or the "Access control via access levels" parameter is activated, then configure at least the "Full access (no protection)" protection level and assign a password under "Full access incl. fail-safe (no protection)". This protection level allows full access only to the standard user program and not the safety program.

If you select a higher protection level, for example to protect the standard user program, you must assign an additional password for "Full access (no protection)".

Assign different passwords for the individual access levels. *(S041)*

You enable access protection by downloading (Page 362) the hardware configuration to the F-CPU.

WARNING

When using tools for the automation or operation (of TIA Portal or web server) with which the access protection for the F-CPU can be removed, the safety-related project data may not be protected against unintentional changes anymore. When using corresponding tools, the requirements regarding access protection of the F-CPU must still be met. *(S078)*

Changing access protection for the F-CPU

For the changed users or the changed password to take effect after a change to the users with F-right or a password change for the F-CPU, you must download the changed configuration to the F-CPU and select the "Download all user management data (reset to project settings)" option in the "Load preview" dialog when downloading. For this download, you must legitimate yourself as a user with F-right or enter the existing password for the F-CPU, if necessary. For changes in the "Access protection via protection levels" area, the F-CPU must be in STOP.

Changes that you make as part of the central user management on the associated UMC server of the F-CPU (e.g. a new user password) take effect immediately without a download.

Deleting access protection for the F-CPU

To delete the access protection for the F-CPU, grant the user Anonymous the F-right ("Full access including fail-safe").

Obtaining access permission for the F-CPU

You obtain access permission for the F-CPU by legitimating yourself as a user with F-right or when "Use access control via access levels" mode is enabled by entering the password for the F-CPU prior to performing an action requiring a password.

Validity of access permission for the F-CPU

Access permission for the F-CPU remains valid until the TIA Portal is closed, access permission is revoked or the maximum legitimation time is exceeded. A maximum legitimation time of up to 600 minutes can be set for each user.

Canceling access permission for the F-CPU

You revoke the access permission with the menu command "Online > Delete access rights".

WARNING

The safety-related project data must be protected against unintentional changes.

For this you must cancel the access permission and the online connection for the F-CPU whenever you leave the PG/PC.

Alternatively, you can also take other organizational measures. *(S006)*

4.4 Access protection through organizational measures

To prevent a safety program from being swapped without authorization by exchanging removable media (e.g. flash card, SIMATIC Micro Memory Card or hard disk with S7-1500 F Software Controller), you must observe the following warning:

WARNING

You must limit access to the F-CPU through organizational measures to persons who are authorized to plug in removable devices. *(S079)*

To prevent unintentional access to an S7-1500 F Virtual Controller and the virtual time service, you need to observe the following warning:

WARNING

You must take organizational measures to limit access to an IE(V)D with an S7-1500 F Virtual Controller or a virtual time service to persons who are authorized and appropriately trained to commission and operate an IE(V)D.

The following change must not be made by a system administrator under any circumstances, either at the level of a host hypervisor, in Industrial Edge Management or within the IE(V)D operating system:

- Change of data storage of the portion of the Linux file system of the IE(V)D managed by Docker.

If you operate the S7-1500 F Virtual Controller, note the following:

- You may not use images to duplicate the S7-1500 F Virtual Controller because the uniqueness of the S7-1500 F Virtual Controller when loading cannot be guaranteed based on the unique serial number.
- When creating images (e.g. snapshots) of virtual machines or Edge Devices with an S7-1500 F Virtual Controller, you must label them clearly. When importing an image, use program identification to ensure that the correct Safety program is executed.
- If you use automated mechanisms for mirroring images of virtual machines (e.g. cyclical mechanisms provided by the hypervisor for data backup), you need to perform the following steps each time you import new safety-related project data. This ensures that the correct Safety program is executed when the mirrored images of your virtual machines are started:
  1. Load the safety-related project data into the active target CPU
  2. Ensure that hypervisor mechanisms are used to delete all virtual machine images of the active target CPU.
  3. Make a program identification in the active target CPU.
- If you use a mechanism to provide distributed shared data storage (e.g. vSAN) without multiple protection of the data (FTT Failures To Tolerate = 0) in the virtualized environment, you have to ensure for each change of the configuration of this data storage to other retentive memory areas that the previously used memory area does not contain any safety-related project data by deleting this. If you use multiple protection of the data (FTT > 0) in this distributed data storage, you have to perform program identification before each restart of the active target CPU.

(S100)

To ensure that an S7-1500 F Software Controller is not uninstalled or installed unintentionally, you must observe the following warning:

WARNING

You must limit access to an S7-1500 F Software Controller by organizational measures to persons who are authorized to uninstall and install or repair an S7-1500 F Software Controller (e.g. via the Windows administrator privileges (ADMIN)). *(S075)*

With an S7-1500 F-Software Controller with a PC station version up to incl. V2.1, the function "Delete Configuration" on the PC Station Panel is only offered when no access protection (no protection) is set up on the F-CPU.

With a PC station as of V2.2, it is checked whether the current Windows user is a member of the "Failsafe Operators" Windows user group. When the logged-on Windows user is a member of the group, he/she can execute the "Delete Configuration" function even when the F-password is set. If the logged-on Windows user is not a member of the group, the PC station behaves as up to V2.1.

We therefore recommend that you do not set up F-access protection until after commissioning.

To prevent unintentional restoration of the safety-related project data, formatting of the F-CPU and deletion of program folders via the display of an S7-1500 F-CPU, you must observe the following warning:

WARNING

The password for the display of the F-CPU may only be disclosed to persons who are authorized to restore safety-related project data, to format the F-CPU and to delete program folders. If a password is not set up for the display, you must protect the display through organizational measures against unauthorized operation. *(S063)*

To prevent unintentional restoration of the safety-related project data of the safety program with the web server in an S7-1200/1500 F-CPU, you must observe the following warning:

WARNING

The "Change parameter of the F-System (F-Admin)" authorization for the web server (including web server API) without password protection (user "Everybody", or user "Anonymous" when using the user management) is intended only for testing, commissioning, etc. This means only when the system is not in productive operation. In this case, you must ensure the safety of the system through other organizational measures.

Before the transition to productive operation, you must remove the rights "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" from the "Everybody" or "Anonymous" user.

The password of the web server user with "Change parameter of the F-System (F-Admin)" right may only be disclosed to authorized persons. After downloading the hardware configuration, check whether only permitted users of the web server have the "Change parameter of the F-System (F-Admin)" right on the F-CPU. To do so, use the online mode of the *Safety Administration Editor* for an F-CPU without user management or the "Security settings\Users and roles" tab for an F-CPU with user management.

Saving the login file and the password of the web server in the browser is only permitted when usage by unauthorized persons is prevented through other organizational measures.

If you use the ticket mechanism, handling of the tickets must be just as restrictive as handling of the user password of the web server with the "Change parameter of the F-System (F-Admin)" right. *(S064)*

Programming 5

5.1 Overview of Programming

Introduction

A safety program consists of F-blocks that you create using the FBD or LAD programming language and F-blocks that are automatically added. Fault detection measures and fault reaction measures are automatically added to the safety program you create, and additional safety-related tests are performed. Moreover, you have the option to incorporate special ready-made safety functions in the form of instructions into your safety program.

An overview of the following is given below:

- The structure of the safety program
- The fail-safe blocks
- Differences in the programming of the safety program with FBD/LAD compared to programming of standard user programs

5.1.1 Program structure of the safety program (S7-300, S7-400)

Representation of program structure

For structuring purposes, a safety program consists of one or two F-runtime groups.

Each F-runtime group contains:

- F-blocks that you create using FBD or LAD or that are inserted from the project library or global libraries
- F-blocks that are added automatically (F-system blocks, automatically generated F-blocks, and F-I/O DBs)

Below is a schematic diagram of a safety program or an F-runtime group for an S7-300/400 F-CPU.

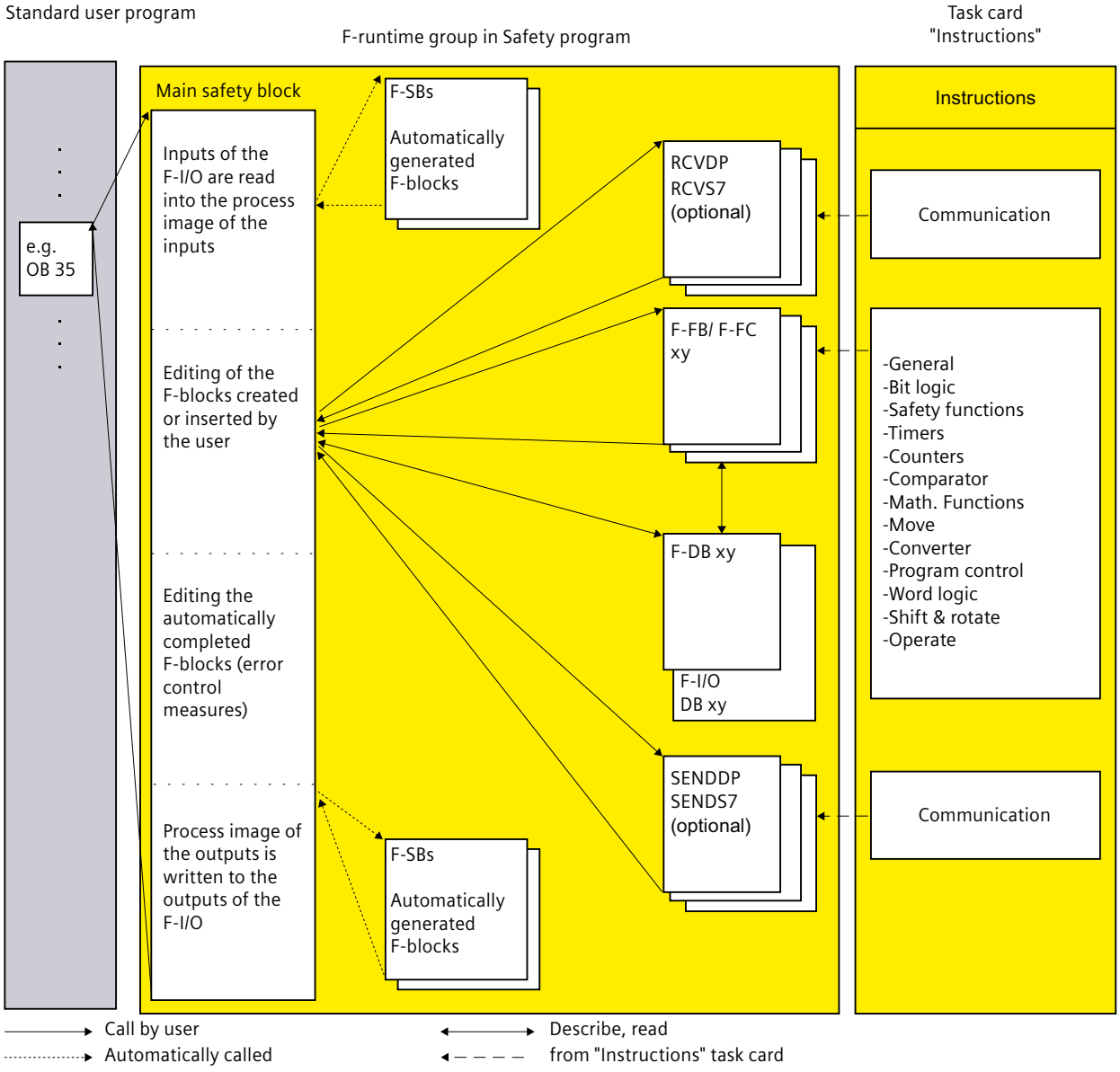

Main safety block

The main safety block is the first F-block of the safety program that you program yourself. During compiling, it is supplemented by additional invisible calls of F-system blocks.

You must assign the main safety block to an F-runtime group (Page 136).

The main safety block in an S7-300/400 F-CPU is called from any block in the standard user program. We recommend a call from an OB 3x.

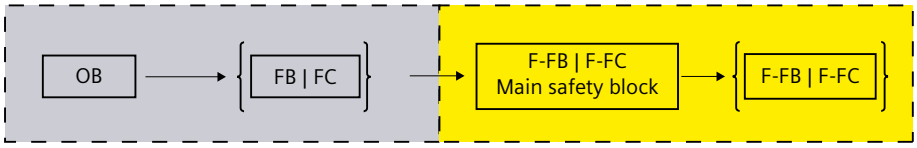

F-runtime groups

To improve handling, a safety program consists of one or two "F-runtime groups". An F-runtime group is a logical construct of several related F-blocks that is formed internally by the F-system.

An F-runtime group consists of the following:

- A main safety block (an F-FB/F-FC that you assign to the calling OB (FB/FC) as needed)
- Any additional F-FBs/F-FCs that you call from the main safety block
- One or more F-DBs, as needed
- F-I/O DBs
- F-blocks from the project library or global libraries
- F-system blocks F-SBs
- Automatically generated F-blocks

Structuring the safety program in two F-runtime groups

You can divide your safety program into two F-runtime groups. By having parts of the safety program (one F-runtime group) run in a faster priority class, you achieve faster safety circuits with shorter response times.

You can only transfer data between the F-runtime groups using F-runtime group communication (Page 146).

5.1.2 Program structure of the safety program (S7-1200, S7-1500)

Representation of program structure

For structuring purposes, a safety program consists of one or two F-runtime groups.

Each F-runtime group contains:

- F-blocks that you create using FBD or LAD or that are inserted from the project library or global libraries
- F-blocks that are added automatically (F-system blocks F-SBs, automatically generated F-blocks, F-runtime DB, and F-I/O DBs)

Below is a schematic diagram of a safety program or an F-runtime group for an S7-1200/1500 F-CPU.

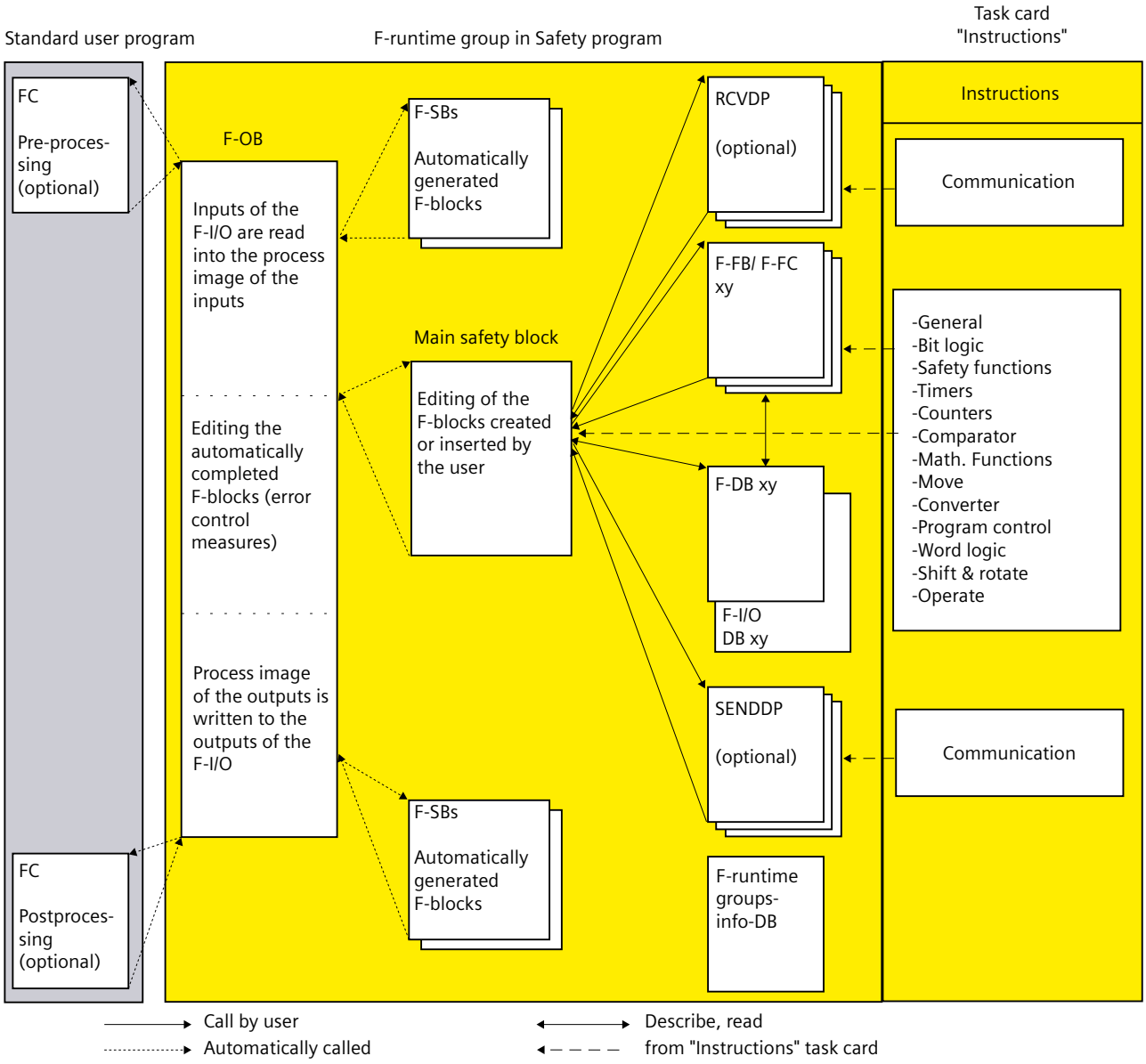

Main safety block

The main safety block is the first F-block of the safety program that you program yourself.

You must assign the main safety block to an F-runtime group (Page 136).

The main safety block in an S7-1200/1500 F-CPU is called by the F-OB assigned to the F-runtime group.

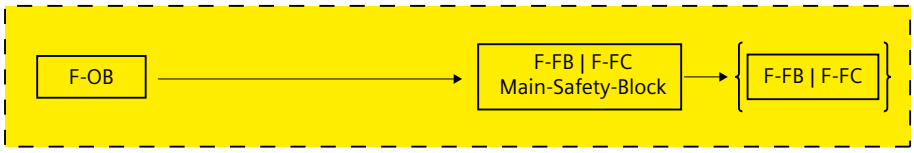

F-runtime groups

To improve handling, a safety program consists of one or two "F-runtime groups". An F-runtime group is a logical construct of several related F-blocks that is formed internally by the F-system.

An F-runtime group consists of the following:

- An F-OB which calls the main safety block
- A main safety block (an F-FB/F-FC that you assign to the F-OB)
- Any additional F-FBs or F-FCs that you call from the main safety block
- One or more F-DBs, as needed
- F-I/O DBs
- F-runtime group information DB
- F-blocks from the project library or global libraries
- F-system blocks F-SBs
- Automatically generated F-blocks
- A preprocessing and/or postprocessing block, as needed (see Pre-/postprocessing (S7-1200, S7-1500) (Page 88))

Pre-/postprocessing of an F-runtime group

You have the option of calling blocks of the standard user program (FCs) directly before or after an F-runtime group, for example, for data transfer during fail-safe communication via Flexible F-Link. (see Pre-/postprocessing (S7-1200, S7-1500) (Page 88))

Structuring the safety program in two F-runtime groups

You can divide your safety program into two F-runtime groups. By having parts of the safety program (one F-runtime group) run in a faster priority class, you achieve faster safety circuits with shorter response times.

You can only transfer data between the F-runtime groups using F-runtime group communication (Page 149).

See also

F-runtime group information DB (S7-1200, S7-1500) (Page 158)

5.1.3 Safety program in Software Unit (Safety Unit) (S7-1500)

Introduction

You can use Safety Units if you want to use the advantages of the Software Units for the safety program as well, e.g. independent compiling and loading.
The blocks of the safety program are then located exclusively in the Safety Unit and can no longer be created in the "Program blocks" folder directly below the F-CPU.
You must make the decision for the Safety Unit before creating the F-CPU. After creating the F-CPU, the decision for this F-CPU can no longer be changed.

Requirement

- F-CPU S7-1500 as of FW V2.6
- The check box "Manages safety program in 'Safety Units' environment" is selected under "Options/Settings/STEP 7 Safety".
- The F-CPU is newly created.

Safety program in the Safety Unit

After a new F-CPU has been created, the safety program is located in the Safety Unit.

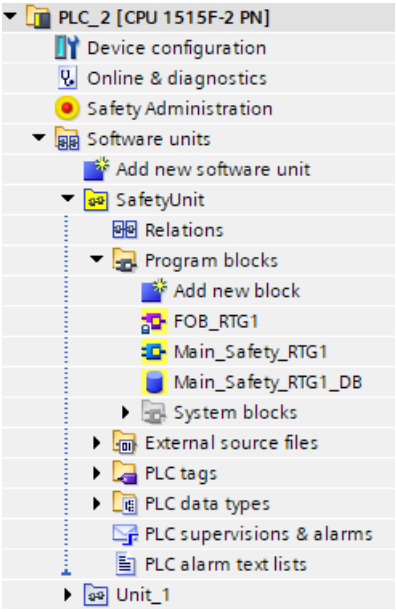

Store the transfer DBs for the data transfer from/to the standard user program (Page 204) in the Safety unit.

Information on Software Units is available in the help for *STEP 7* under "Using Software Units".

Particularities

- You cannot store the Safety Unit in a library.
- System blocks in the Safety Unit cannot be published.

5.1.4 Fail-Safe Blocks

F-blocks of an F-runtime group

The following table shows the F-blocks that you use in an F-runtime group:

F-block	Function	S7-300/400 F-CPUs	S7-1200/1-500 F-CPUs
Main safety block	The first step in programming of the Safety program is the main safety block. The main safety block in S7-300/400 F-CPUs is an F-FC or F-FB (with instance DB), which is called by a standard block (recommendation: OB 35) from the standard user program. The main safety block in S7-1200/1500 F-CPUs is an F-FC or F-FB (with instance DB), which is called by the F-OB.	X	X
F-FB/F-FC	Both in the main safety block as well as additional F-FBs and F-FCs, you can perform the following: • Program the Safety program with the instructions available for F-blocks • Call other created F-FBs/F-FCs for structuring the Safety program • Insert F-blocks from the project library or global libraries	X	X
F-DB	Optional fail-safe data blocks that can be read- and write-accessed within the entire Safety program.	X	X
F-I/O DB	An F-I/O DB is automatically generated for each F-I/O when it is configured. You access the tags of the F-I/O DB in connection with F-I/O access.	X	X
F-shared DB	The F-shared DB is a fail-safe data block that contains all of the shared data of the Safety program and additional information needed by the F-system.	X	—
F-runtime group information DB	An F-runtime group information DB is created when you create an F-runtime group. The F-runtime group information DB provides information on the F-runtime group and on the Safety program as a whole.	—	X
DB for F-runtime group communication	Created for safety-related communication between F-runtime groups in the *Safety Administration Editor*. With this, you can read fail-safe tags that were made available in an F-DB from an F-runtime group in a different F-runtime group.	X	—

F-block	Function	S7-300/400 F-CPUs	S7-1200/1-500 F-CPUs
F_SystemInfo_DB	More information (e.g. signatures) on the Safety program can be found in the F_SystemInfo_DB. You cannot access this information in the Safety program.	—	X
F-communication DB	For each communication connection with Flexible F-Link, an F-communication DB is generated automatically when the communication connection is created. You access the tags of the F-communication DB in connection with Flexible F-Link communication connections.	—	X
F-OPC UA Consumer DB	For communication connections via OPC UA Safety, an F-OPC UA Consumer DB is automatically generated for each SafetyConsumer when the OPC UA SafetyProvider information model is imported. You access the variables of the F-OPC UA Consumer DB in connection with OPC UA Safety communication connections.	—	X

NOTE

You are not permitted to insert F-system blocks from the "System blocks" folder in a main safety block/F-FB/F-FC.

Instructions for the Safety program

In the "Instructions" task card, you can find instructions for the F-CPU used and which you can to use program the Safety program.

You can find instructions that you know from the standard user program, such as bit logic operations, mathematical functions, functions for program control, and word logic operations.

Moreover, there are instructions with safety functions, e.g., for two-hand monitoring, discrepancy analysis, muting, emergency STOP/emergency OFF, safety door monitoring, feedback monitoring and instructions for safety-related communication between F-CPUs.

More information

For a detailed description of the instructions for the Safety program, refer to Overview of instructions (Page 464).

Using instruction versions

As with the instructions for the standard user program, there may also be different versions of the instructions for the Safety program.

More information on instruction versions can be found in the help on STEP 7 in "Basics for instruction versions".

More information on the differences of the individual versions of the instructions for the Safety program can be found in the relevant chapter of the instructions.

NOTE

Note the following:

- If you change the version of an instruction used in the Safety program in the task card "Instructions" to a version which does not have identical functions, the functioning of your Safety program may change after recompiling the Safety program. In addition to the signature of the F-block that uses the instruction, the Collective F-Signature and the Collective F-SW-Signature of your Safety program also change. You may have to perform an acceptance test (Page 448).
- (S7-300, S7-400) If you use a know-how protected F-block in your Safety program which uses an instruction which is not the same version as that set in the task card "Instructions", when the program is compiled without entering the password for the know-how protected F-block, it is adjusted to the version set in the task card "Instructions". If the instruction versions do not have identical functions, the functioning of the know-how protected F-block may change and always its signature.

5.1.5 Restrictions in the programming languages FBD/LAD

LAD and FBD programming languages

The user program in the F-CPU typically consists of a standard user program and a safety program.

The standard user program is created using standard programming languages such as SCL, STL, LAD, or FBD.

For the safety program, LAD or FBD may be used with certain restrictions in the instructions and the applicable data types and operand areas. Also note the restrictions for the individual instructions.

Supported instructions

The instructions available depend on the F-CPU used. You can find the supported instructions in the description of the instructions (starting from STEP 7 Safety V21 instructions (Page 464)).

NOTE

Enable input EN cannot be connected.

(S7 -300, S7-400) Output ENO cannot be connected.

(S7-1200, S7-1500) Output ENO can only be connected with the following instructions:

- ADD: Add (Page 567)
- SUB: Subtract (Page 570)
- MUL: Multiply (Page 573)
- DIV: Divide (Page 576)
- NEG: Create twos complement (Page 579)
- ABS: Form absolute value (Page 582)
- CONVERT: Convert value (Page 593)

Supported data types and parameter types

Only the following data types are supported:

- BOOL
- INT
- WORD
- DINT
- DWORD (S7-300, S7-400)
- TIME
- ARRAY, ARRAY[*] when using the instructions RD_ARRAY_I: Read value from INT F-array (STEP 7 Safety V21) (S7-1200 G2, S7-1500) (Page 584) and RD_ARRAY_DI: Read value from DINT F-array (STEP 7 Safety V21) (S7-1200 G2, S7-1500) (Page 587).

  Restrictions:

  – ARRAY only in F-DBs
  – ARRAY limits: 0 up to max. 10000
  – ARRAY[*] only as InOut parameter (InOut) in F-FCs and F-FBs
  – Only ARRAY of INT or ARRAY of DINT permissible
- F-compliant PLC data type (UDT) (S7-1200, S7-1500) (Page 128)
- Named value data types (S7-1500) (Page 134)

NOTE

If the result of an instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostic buffer of the F-CPU.
You must therefore ensure that the permitted range for the data type is observed when creating the program, select a matching data type or use the ENO output for S7-1200/1500 F-CPUs or the OV instruction (Page 624) for S7-300/400 F-CPUs.

Note the description of the individual instructions.

Non-permitted data and parameter types

The following types are **not** permitted:

- All types not listed in the section "Supported data types and parameters types" (e.g. BYTE, REAL)
- Compound data types (e.g. STRING, ARRAY (S7-300, S7-400, S7-1200 G1), STRUCT, PLC data type (UDT) (S7-300, S7-400), Named value data types (S7-300, S7-400, S7-1200))
- Parameter types (e.g. BLOCK_FB, BLOCK_DB, ANY)

Supported operand areas

The system memory of an F-CPU is divided into the same operand areas as the system memory of a standard CPU. You can access the operand areas listed in the table below from within the safety program.

Table 3-1103 Supported operand areas

Operand area	Description
Process image of the inputs	
• Of F-I/O	Only read-only access to input channels of F-I/O is possible. Transfer to InOut parameters of an F-FB or F-FC is therefore not valid either. The process image of the inputs of F-I/O is updated prior to the start of the main safety block.
• Of standard I/O	Input channels of standard I/O can only be accessed read-only. Transfer to InOut parameters of an F-FB or F-FC is therefore not valid either. In addition, a process-specific validity check is required. See the *STEP 7 help* for the update times of the process image of the inputs of standard I/O.
Process image of the outputs	
• Of F-I/O	Only write-only access to output channels of F-I/O is possible. Transfer to InOut parameters of an F-FB or F-FC is therefore not valid either. In the safety program, the values for the outputs of the F-I/O are calculated and stored in the process image of the outputs. The process image of the outputs for F-I/O is updated after the end of the main safety block.
• Of standard I/O	Output channels of standard I/O are write-only channels. Transfer to InOut parameters of an F-FB or F-FC is therefore not valid either. In the safety program, the values for the outputs of the standard I/O are also calculated and stored in the process image of the outputs, if needed. See the *STEP 7 help* for the update times of the process image of the outputs of standard I/O.
Bit memory	This area is used for data exchange with the standard user program. In addition, read access requires a process-specific validity check. A particular element of the bit memory can be either read- or write-accessed in the safety program. Transfer to InOut parameters of an F-FB or F-FC is therefore not valid either. Note that it is only permitted to use bit memory for connecting the standard user program and the safety program; it must not be used as a buffer for F-data.
Data blocks	
• F-DB	Data blocks store information for the program. They can either be defined as global data blocks such that all F-FBs, F-FCs, or main safety blocks can access them or assigned to a particular F-FB or main safety block (instance DB). A tag of a shared DB can only be accessed from one F-runtime group, and an instance DB only from the F-runtime group in which the corresponding F-FB/instruction is called.

Operand area	Description
• DB	This area is used for data exchange with the standard user program. In addition, read access requires a process-specific validity check. For a tag of a DB, either read access or write access is possible in the safety program. Transfer to InOut parameters of an F-FB or F-FC is therefore not valid either. Note that the tags of a DB can only be used for transferring data between the standard user program and the safety program; DBs must not be used as a buffer for F-data.
Temporary local data	This memory area holds the temporary tags of a block (or F-block) while the (F-) block is being executed. The local data stack also provides memory for transferring block parameters and for saving intermediate results.

Data type conversion

As with the standard user program, there are two possibilities for data type conversion in the safety program:

- Implicit conversion

  The implicit conversion is executed as in the standard user program with the following restrictions: The bit length of the source data type has to match the bit length of the destination data type.

- Explicit conversion

  You use an explicit conversion instruction (Page 593) before the actual instruction is executed.

Slice access

Slice access is not possible in the safety program.

Non-permitted operand areas

Access via units other than those listed in the table above is **not** permitted. The same applies to access to operand areas not listed, in particular:

- Data blocks that were automatically added

  Exception: Certain tags in the F-I/O DB (Page 168) and in the F-shared DB (S7-300, S7-400) (Page 157) or F-runtime group information DB (S7-1200, S7-1500) (Page 158)

- I/O area: Inputs
- I/O area: Outputs

Boolean constants "0" or "FALSE" and "1" or "TRUE" (S7-300, S7-400)

The Boolean constants "0" or "FALSE" and "1" or "TRUE" are available for S7-300/400 F-CPUs as "Tags" "RLO0" and "RLO1" in the F-shared DB. You access them through a fully qualified DB access ("F_GLOBDB".RLO0 or "F_GLOBDB".RLO1).

Boolean constants "0" or "FALSE" and "1" or "TRUE" (S7-1200, S7-1500)

The Boolean constants "0" or "FALSE" and "1" or "TRUE" are available for S7-1200/1500 F-CPUs to assign parameters during block calls. You can enter this directly in FBD or LAD at the respective block inputs.

Example FBD:

Example LAD:

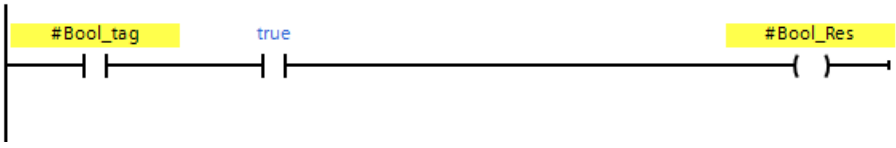

As an alternative, as before you have the option to also set "1" or "TRUE" in a tag using the "Assignment (Page 476)" instruction.

To do so, do not interconnect the box input of the "Assignment" instruction in FBD. In LAD, you interconnect the input directly with the supply rail.

You obtain a tag with "0" or "FALSE" by subsequent inversion with the instruction "Invert RLO (Page 473)".

Example FBD:

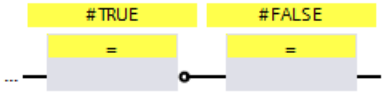

Example LAD:

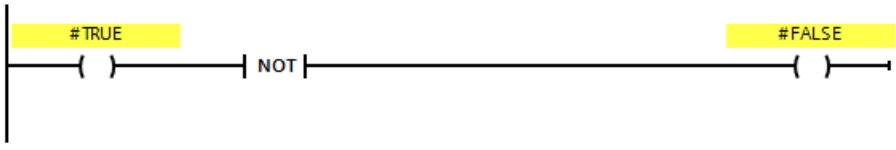

Operand area of temporary local data: Particularities

NOTE

Note when using the operand area of temporary local data that the first access of a local data element in a main safety block/F-FB/F-FC must always be a write access. This initializes the local data element.

Make sure that a temporary local data element is initialized prior to the first JMP, JMPN, or RET instruction.

The "local data bit" should be initialized with the Assign ("=") (FBD) or ("--( )") (LAD) instruction. Assign the local data bit a signal state of "0" or "1" as a Boolean constant.

Local data bits cannot be initialized with the Flip Flop (SR, RS), Set Output (S) or Reset Output (R) instructions.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

"Fully qualified DB access"

Access to tags of a data block in an F-FB/F-FC is "fully qualified DB access". This also applies to initial access to tags of a data block after a jump label.

For S7-300/400 F-CPUs, only initial access needs to be "fully qualified DB access". Alternatively, you can use the instruction "OPN".

Example of "fully qualified DB access":

Assign a name for the F-DB, e.g. "F_Data_1". Use the names assigned in the declaration of the F-DB instead of the absolute addresses.

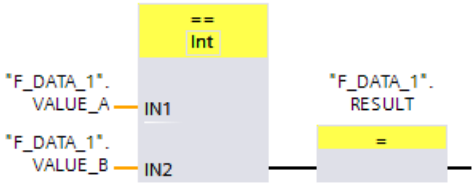

Figure 3-878 Example with fully-qualified access

Example of "non-fully qualified DB access" (S7-300, S7-400):

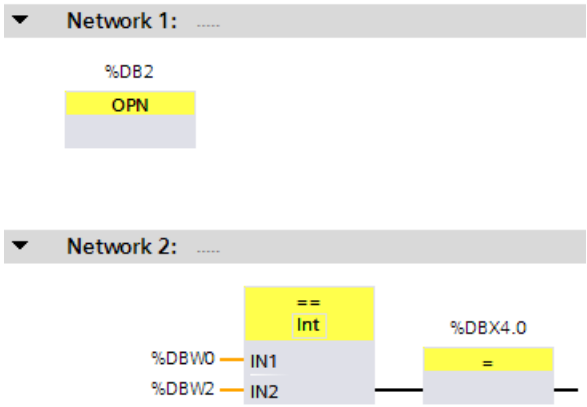

Figure 3-879 Example without fully-qualified access

Access to instance DBs

You can also access instance DBs of F-FBs with fully qualified access, e.g., for transfer of block parameters. It is not possible to access static local data in single/multi-instances of other F-FBs.

(S7-300, S7-400) Note that accessing instance DBs of F-FBs that are not called in the safety program can cause the F-CPU to go to STOP mode.

Note the following warning for S7-1200/1500 F-CPUs:

WARNING

When you program global access to instance DBs of F-FBs, you must ensure that the associated F-FB is called in the safety program. *(S096)*

5.1.6 F-compliant PLC data types (UDT) (S7-1200, S7-1500)

Introduction

You declare and use F-compliant PLC data types (UDT) as you would standard PLC data types (UDT). You can use F-compliant PLC data types (UDT) in the safety program as well as in the standard user program.

Differences to standard PLC data types (UDT) are described in this chapter.

Information on the use and declaration of standard PLC data types (UDT) is available in the *STEP 7 help* under "Declaring PLC data types".

Declaring F-compliant PLC data types (UDT)

You declare F-compliant PLC data types (UDT) as you would PLC data types (UDT).

In F-compliant PLC data types (UDT), you can use all data types (Page 121) that you can also use in safety programs. Exception: ARRAY.

Proceed as follows for declaration:

1. Click on "Add new PLC data type" in the "PLC Data Types" folder in the project tree.
2. To create an F-compliant PLC data type (UDT), enable the option "Create F-compliant PLC data type" in the "Add new PLC data type" dialog.
3. Proceed as described in the *STEP 7 help* under "Programming structure of PLC data types".

You specify default values for F-compliant PLC data types (UDT) during the declaration.

Using F-compliant PLC data types (UDT)

You use F-compliant PLC data types as you would standard PLC data types (UDT).

Nesting depth for F-compliant PLC data types

For F-compliant PLC data types, the maximum nesting depth is limited compared to the standard PLC data types (maximum nesting depth = 8). There is a dependency on the call sequence of the block in which a tag of the nested F-compliant PLC data type is declared. Each call level of F-FCs or multi-instance F-FBs reduces the maximum nesting depth of the F-compliant PLC data type used. For multi-instance F-FBs, the caller counts as an additional level.

When a tag of a nested F-compliant PLC data type is declared in a global F-DB, its maximum nesting depth is 7.

Example 1

The main safety block (level 1) calls an F-FB as multi-instance (level 2) which, in turn, calls an F-FC (level 3) in which a tag of the type of a nested F-compliant PLC data type is declared. This means a maximum nesting depth of 5 is available for the fail-safe compliant PLC data type used by the tag.

Example 2

The main safety block calls an F-FB as a single instance (level 1) which, in turn, calls an F-FC (level 2) in which a tag of the type of a nested F-compliant PLC data type is declared. This means a maximum nesting depth of 6 is available for the fail-safe compliant PLC data type used by the tag.

Changes to F-compliant PLC data types (UDT)

You need the password for the safety program to change F-compliant PLC data types (UDT). Regardless if you are using the F-compliant PLC data type (UDT) in an F-block, in a standard block or not at all.

See also

"F-compliant PLC data types" area of the Safety Administration Editor (S7-1200, S7-1500) (Page 90)

5.1.6.1 Grouping PLC tags for inputs and outputs of F-I/O in structures (S7-1200, S7-1500)

You group PLC tags for inputs and outputs of F-I/O in structures (structured PLC tag) as you would for inputs and outputs of standard I/O.

Use F-compliant PLC data types (UDT).

Rules

When creating structured PLC tags for inputs and outputs of F-I/O, you must also observe the following rules in addition to the rules in the standard:

- You must not group inputs/outputs of standard I/O and F-I/O at the same time in a structured PLC tag.
- You may only group inputs/outputs of actually existing channels (channel value and value status) in a structured PLC tag.

  See also Addressing F-I/O (Page 161)
- You may only group inputs/outputs of channels (channel value and value status) that are enabled in the hardware configuration in a structured PLC tag.

  See also Addressing F-I/O (Page 161)
- You may only group inputs of channels (channel value and value status) that provide the result of the "1oo2 sensor evaluation" with set "1oo2 sensor evaluation".

  See also Addressing F-I/O (Page 161)
- You should combine all inputs and outputs of an F-I/O in a structured PLC tag. When divided into several structured PLC tags, these can only begin with multiples of 16 bits. This also applies to nested F-compliant PLC data types (UDT). See rules in the standard.

  The F-CPU can go to STOP mode if this is disregarded. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.
- A structured PLC tag that groups outputs of an F-I/O must not overlap with other PLC tags.

  The F-CPU can go to STOP mode if this is disregarded. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.
- In a structured PLC tag for inputs and outputs of F-I/O, the data types WORD, DWORD and TIME are not permitted in the associated PLC data type (UDT).

NOTE

To observe these rules, you must declare the F-compliant PLC data type that is used for the structured PLC tag accordingly.

You can find the addresses allocated to a structured PLC tag in the "IO tags" tab of an F-I/O configuration.

5.1.6.2 Example of structured PLC tags for inputs and outputs of F-I/O (S7-1200, S7-1500)

Introduction

This example uses the F-module 4 F-DI/3 F-DO DC24V/2A with 1oo2 evaluation to demonstrate how you use structured PLC tags for access to F-I/O.

Channel structure of the 4 F-DI/3 F-DO DC24V/2A F-module

The table below sets out the channel structure and address assignment of the F-module 4 F-DI/3 F-DO DC24V/2A with 1oo2 evaluation. You may only access existing and enabled channels (addresses I15.0 to I15.3 and I16.0 to I16.3). These channels provide the result of 1oo2 evaluation generated internally in the F-module.

Table 3-1104 Channel structure and addresses of the channel values of inputs with 1oo2 evaluation

Channel	Address
DI channel 0 channel value	I15.0
DI channel 1 channel value	I15.1
DI channel 2 channel value	I15.2
DI channel 3 channel value	I15.3
—	I15.4
—	I15.5
—	I15.6
—	I15.7

Table 3-1105 Channel structure and addresses of the value status of the inputs with 1oo2 evaluation

Channel	Address
DI channel 0 value status	I16.0
DI channel 1 value status	I16.1
DI channel 2 value status	I16.2
DI channel 3 value status	I16.3
—	I16.4
—	I16.5
—	I16.6
—	I16.7

Table 3-1106 Channel structure and addresses of the value status of outputs

Channel	Address
DO channel 0 value status	I17.0
DO channel 1 value status	I17.1
DO channel 2 value status	I17.2
DO channel 3 value status	I17.3

Table 3-1107 Channel structure and addresses of the channel values of outputs

Channel	Address
DO channel 0 channel value	Q15.0
DO channel 1 channel value	Q15.1
DO channel 2 channel value	Q15.2
DO channel 3 channel value	Q15.3

Creating F-compliant PLC data types (UDT)

Create two F-compliant PLC data types (UDT), for example, for access to all channels.

The figure below shows an F-compliant PLC data type (UDT) for access to the channel values and value status of the inputs with 1oo2 evaluation:

4 F-DI/3 F-DO DC24V/2A_DI

		Name	Data type	Comment
1		CH_DI_0	Bool	Channel 0 (DI)
2		CH_DI_1	Bool	Channel 1 (DI)
3		CH_DI_2	Bool	Channel 2 (DI)
4		CH_DI_3	Bool	Channel 3 (DI)

The figure below shows the F-compliant PLC data type (UDT) for access to the channel values and value status of the outputs:

4 F-DI/3 F-DO DC24V/2A_DO

		Name	Data type	Comment
1		CH_DO_0	Bool	Channel 0 (DO)
2		CH_DO_1	Bool	Channel 1 (DO)
3		CH_DO_2	Bool	Channel 2 (DO)

Using F-compliant PLC data types (UDT)

As demonstrated in the figure below, you can use the two F-compliant PLC data types (UDT) that you have created in an F-FC (e.g. "Motor"):

Motor

	Name	Data type	Comment
1	Input		
2	Motor SS DI	"4 F-DI/3 F-DO DC24V/2A_DI"	Motor interface channel values DI
3	CH_DI_0	Bool	Kanal 0 (DI)
4	CH_DI_1	Bool	Kanal 1 (DI)
5	CH_DI_2	Bool	Kanal 2 (DI)
6	CH_DI_3	Bool	Kanal 3 (DI)
7	Motor SS DI VS	"4 F-DI/3 F-DO DC24V/2A_DI"	Motor interface value status DI
8	CH_DI_0	Bool	Kanal 0 (DI)
9	CH_DI_1	Bool	Kanal 1 (DI)
10	CH_DI_2	Bool	Kanal 2 (DI)
11	CH_DI_3	Bool	Kanal 3 (DI)
12	Motor SS DO VS	"4 F-DI/3 F-DO DC24V/2A_DO"	Motor interface value status DI
13	CH_DO_0	Bool	Kanal 0 (DO)
14	CH_DO_1	Bool	Kanal 1 (DO)
15	CH_DO_2	Bool	Kanal 2 (DO)
16	Output		
17	Motor SS DO	"4 F-DI/3 F-DO DC24V/2A_DO"	Motor interface channel values DO
18	CH_DO_0	Bool	Kanal 0 (DO)
19	CH_DO_1	Bool	Kanal 1 (DO)
20	CH_DO_2	Bool	Kanal 2 (DO)

Creating structured PLC tag for the F-module 4 F-DI/3 F-DO DC24V/2A

Create structured PLC tags for the F-module 4 F-DI/3 F-DO DC24V/2A:

Tag table_1

	Name	Data type	Address	Comment
1	TagDI_4 F-DI/3 F-DO	"4 F-DI/3 F-DO DC24V/2A_DI"	%I15.0	Motor 1 DI
2	TagDI_VS_4 F-DI/3 F-DO	"4 F-DI/3 F-DO DC24V/2A_DI"	%I16.0	Motor 1 DI VS
3	TagDO_VS_4 F-DI/3 F-DO	"4 F-DI/3 F-DO DC24V/2A_DO"	%I17.0	Motor 1 DO VS
4	TagDO_4 F-DI/3 F-DO	"4 F-DI/3 F-DO DC24V/2A_DO"	%Q15.0	Motor 1 DO

Accessing the F-FC

Transfer the structured PLC tags you have created when you call the F-FC (e.g. "Motor"):

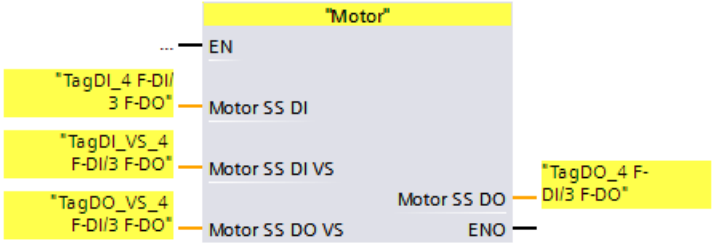

See also

Addressing F-I/O (Page 161)
Value status (S7-1200, S7-1500) (Page 163)

5.1.7 Named value data types (S7-1500)

You use named value data types as in the standard.

For named value data types in a safety program, you can only use the data types supported by the safety program (Page 121) (except TIME) as base data types.

NOTE

If you change Named value data types, this also changes the collective F signature.

You can find more information on named value data types in the *STEP 7 online help* under "Named value data types" and "Declaring named value data types".

5.1.8 Editing PLC tags with external editors

To edit PLC tags with external editors follow the procedure as in the standard. Additional information can be found in the *STEP 7* help in "Editing PLC tags with external editors".

Note the following:

NOTE

After importing a tag table which contains tags used in the safety program, the collective F-signature of the safety program is reset.

To form the collective F-signature again you have to recompile the project data. For this, with access protection set up for the safety program, you need a valid access authorization for the safety program.

If you would like to edit PLC tags with external editors, we therefore recommend that you store PLC tags to be used in the safety program in a separate tag table.

5.1.9 Using Multiuser engineering

If you want to use Multiuser engineering, proceed as described in the *STEP 7* help under "Using Multiuser engineering".

5.1.10 Deleting the safety program

Deleting individual F-blocks

To delete an F-block, follow the same procedure as in *STEP 7*.

Deleting an F-runtime group

See Deleting an F-runtime group (Page 152)

(S7-300, S7-400) Remove all calls that you have used to call the safety program (Main_Safety).

Deleting the entire safety program for S7-300/400 F-CPUs *with* inserted memory card (SIMATIC Micro Memory Card or flash card)

To delete an entire safety program, proceed as follows:

1. Delete all F-blocks (shown with yellow symbol) in the project tree.
2. Remove all calls that you have used to call the safety program (Main_Safety).
3. Select the F-CPU in the *hardware and network editor* and clear the "F-capability activated" option in the properties of the F-CPU.
4. Compile the project data of the F-CPU

   The offline project no longer contains a safety program.
5. To delete a safety program on the Memory Card (SIMATIC Micro Memory Card or Flash Card), insert the Memory Card (SIMATIC Micro Memory Card or Flash Card) in the programming device or PC or in a SIMATIC USB prommer.
6. Select the menu command "Project > Card Reader/USB memory > Show Card Reader/USB memory" in the menu bar.
7. Open the "SIMATIC Card Reader" folder and delete the Memory Card.
8. Insert the Memory Card into the F-CPU.
9. Perform a memory reset of the F-CPU (flashing of the STOP LED requests a memory reset).

You can then download the offline standard user program to the F-CPU.

Deleting the entire safety program for S7-400 F-CPUs *without* inserted flash card

To delete an entire safety program, proceed as follows:

1. Delete all F-blocks (shown with yellow symbol) in the project tree.
2. Remove all calls that you have used to call the safety program (Main_Safety).
3. Select the F-CPU in the *hardware and network editor* and clear the "F-capability activated" option in the properties of the F-CPU.
4. Compile the project data of the F-CPU

   The offline project no longer contains a safety program.
5. Perform a memory reset on the F-CPU (in the "Online tools" task card of the F-CPU).

You can then download the offline standard user program to the F-CPU.

Delete the entire safety program for SIMATIC S7-1200/1500 F-CPUs

To delete an entire safety program, proceed as follows:

1. Delete all F-blocks (shown with yellow symbol) in the project tree.
2. Select the F-CPU in the *hardware and network editor* and clear the "F-capability activated" option in the properties of the F-CPU.
3. Compile the project data of the F-CPU

   The offline project no longer contains a safety program.

You can then download the offline standard user program to the F-CPU.

5.2 Defining F-Runtime Groups

5.2.1 Rules for F-Runtime Groups of the Safety Program

Rules

Note the following:

- The channels (channel values and value status) of an F-I/O can only be accessed from a single F-runtime group.
- Tags of the F-I/O DB of an F-I/O can only be accessed from one F-runtime group and only from that F-runtime group from which the channels or value status of this F-I/O are also accessed (if access is made).
- F-FBs can be used in more than one F-runtime group but they must be called with different instance DBs.
- Instance DBs of F-FB can only be accessed from the F-runtime group in which the associated F-FB is called.
- A tag of a global F-DB (except the F-global DB) can only be accessed from one F-runtime group (however, a global F-DB can be used in more than one F-runtime group).

- (S7-300, S7-400) A DB for F-runtime group communication can be read and write accessed by the F-runtime group to which it was assigned as "DB for runtime group communication", but only read-accessed by the "receiver" F-runtime group.
- (S7-300, S7-400) An F-communication DB can only be accessed from one F-runtime group.
- (S7-1200, S7-1500) You must not call the main safety block yourself. It is automatically called by the assigned F-OB.

NOTE

F-OBs are protected by F-system know-how. The OB start information of F-OBs therefore cannot be evaluated.

- (S7-1200, S7-1500). The F-OB should be created with the highest priority of all OBs.

NOTE

The cycle time/runtime of an F-OB can be prolonged by, among other things, communication load, the processing of higher-priority interrupts, as well as by test and commissioning functions. In a redundant S7-1500HF system, it is also dependent on the current system state.

- (S7-300, S7-400) The main safety block may only be called once from a standard block. Multiple calls can cause the F-CPU to go to STOP mode.
- (S7-300, S7-400) For optimal use of temporary local data, you must call the F-runtime group (the main safety block) directly in an OB (cyclic interrupt OB, if possible); you should not declare any additional temporary local data in this cyclic interrupt OB.
- (S7-300, S7-400) Within a cyclic interrupt OB, the F-runtime group should be executed **before** the standard user program; i.e. it should be called at the very beginning of the OB, so that the F-runtime group is always called at fixed time intervals, regardless of how long it takes to process the standard user program.

  For this reason, the cyclic interrupt OB should also not be interrupted by higher priority interrupts.
- The process image of the inputs and outputs of standard I/O, bit memory, and tags of DBs in the standard user program may be accessed either as read-only or read/write from more than one F-runtime group. (see also Data exchange between standard user program and safety program (Page 204))
- F-FCs can generally be called in more than one F-runtime group.

NOTE

You can improve performance by writing sections of the program that are not required for the safety function in the standard user program.

When determining which elements to include in the standard user program and which to include in the Safety program, you should keep in mind that the standard user program can be modified and downloaded to the F-CPU more easily. In general, changes in the standard user program do not require an acceptance.

5.2.2 Procedure for defining an F-runtime group (S7-300, S7-400)

Requirements

- You have inserted an S7-300/400 F-CPU in your project.
- In the "Properties" tab of the F-CPU, the "F-capability activated" check box is selected (default setting).

F-runtime group created by default

STEP 7 Safety inserts F-blocks for an F-runtime group in the project tree by default after an F-CPU has been added. When you open the "Program blocks" folder, you see the (F-)blocks of the F-runtime group (CYC_INT5 [OB 35], Main_Safety [FB 1], and Main_Safety_DB [DB1]) in the project tree.

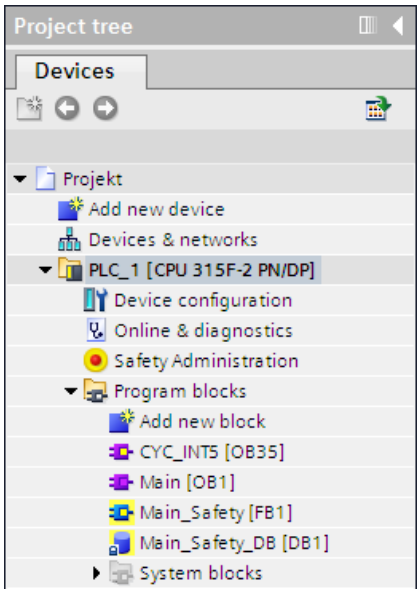

The following section describes how you modify the settings / parameters of the F-runtime group created by default or add and additional F-runtime group.

Procedure for defining an F-runtime group

Proceed as follows to define an F-runtime group:

1. Open the *Safety Administration Editor* by double-clicking in the project tree.
2. Select "F-runtime group" in the area navigation.

   Result: The work area for defining an F-runtime group with the (default) settings for F-runtime group 1 opens.

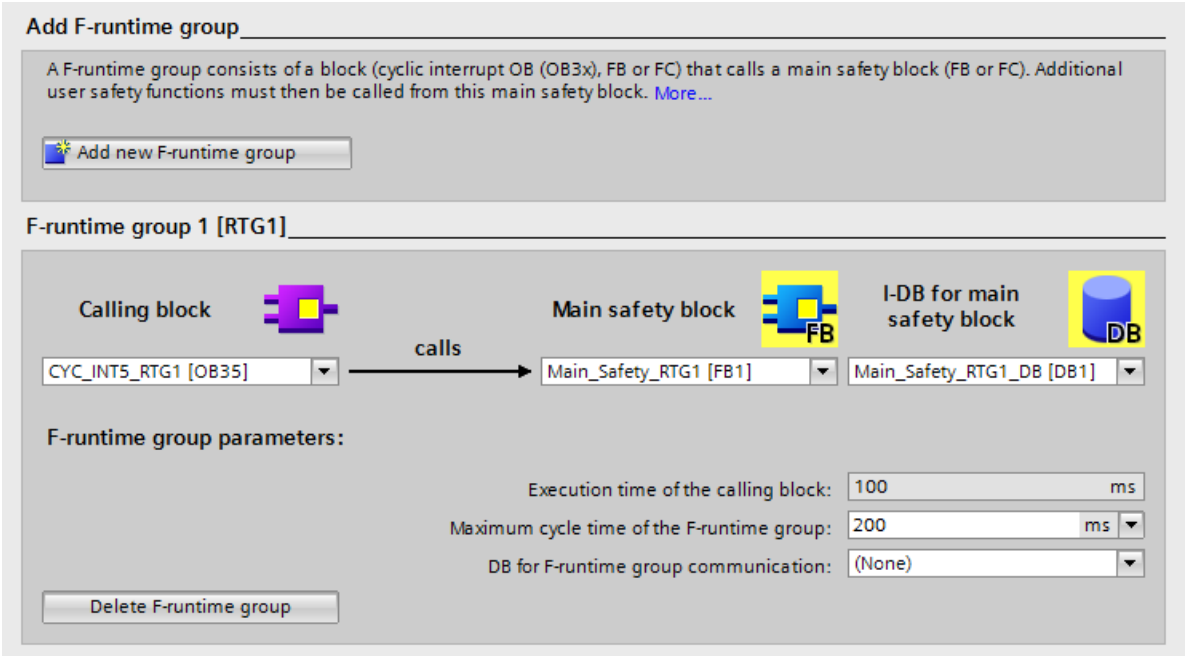

3. Specify the block in which the main safety block is to be called.

   Cyclic interrupt OB 35 is suggested here by default. The advantage of cyclic interrupt OBs is that they interrupt the cyclic program processing in OB 1 of the standard user program at fixed intervals. This means that the safety program is called and run at fixed time intervals in a cyclic interrupt OB.

   In this input field, you can select only those blocks that were created in the LAD, FBD, or STL programming language. If you select a block here, the call is inserted automatically into the selected block and, if necessary, removed from a previously selected block.

   If you want to call the main safety block in a block that was created in another programming language, you must program this call itself. The input field is then not editable (grayed out), and you can change the call only in the calling block and not the *Safety Administration Editor*.

4. Assign the desired main safety block to the F-runtime group. If the main safety block is an FB, you must also assign an instance DB.

   Main_Safety [FB1] and Main_Safety_DB [DB1] are suggested by default.

5. The F-CPU monitors the F-cycle time of the F-runtime group. For "Maximum cycle time of F-runtime group", enter the maximum permitted time between two calls of the F-runtime group.

WARNING

The call interval of the F-runtime group is monitored for a maximum value. This means that monitoring is performed to determine whether the call is executed often enough, but not whether it is executed too often or, for example, isochronously. Fail-safe timers must therefore be implemented using the TP, TON, or TOF instructions (Page 545) from the "Instructions" task card and not using counters (OB calls). *(S007)*

WARNING

The response time of your safety function depends, among other things, on the cycle time of the F-OB, the runtime of the F-runtime group and, when distributed F-I/O is used, the parameter assignment of PROFINET/PROFIBUS.

Therefore, the configuration/parameter assignment of the standard system influences the response time of your safety function.

Examples:

- Increasing the priority of a standard OB compared to an F-OB can extend the cycle time of the F-OB or the runtime of the F-runtime group due to the higher-priority processing of the standard OB. Note that during the creation of technology objects, OBs with very high priority may be created automatically.
- The change of the send clock cycle of PROFINET changes the cycle time of an F-OB with event class "Synchronous cycle".

Note that the configuration / parameter assignment of the standard system is not subject to access protection for the safety-related project data and does not lead to a modification of the Collective F-Signature.

If you do not take organizational measures to prevent changes in the configuration / parameter assignment of the standard system with influence on the response time, you must always use the monitoring times for the calculation of the maximum response time of a safety function (see Configuring monitoring times (Page 644)).

The monitoring times are protected against change with the access protection of the safety-related project data and are captured by the Collective F-Signature as well as the Collective F-SW-Signature.

When calculating with the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) you need to consider the value that is specified for "Any standard system runtimes" as value for the maximum response time. *(S085)*

6. If one F-runtime group is to provide tags for evaluation to another F-runtime group of the safety program, assign a DB for F-runtime group communication. Select an F-DB for "DB for F-runtime group communication". (See also F-runtime group communication (S7-300, S7-400) (Page 146))
7. If you want to create a **second F-runtime group**, click the "Add new F-runtime group" button.

8. Assign an F-FB or F-FC as the main safety block to a calling block. This F-FB or F-FC is automatically generated in the project tree, if not already present.
9. If the main safety block is an F-FB, assign an instance DB to the main safety block. The instance DB is generated automatically in the project tree.
10. Follow steps 3 to 5 above to complete generation of the second F-runtime group.

5.2.3 Procedure for defining an F-runtime group (S7-1200, S7-1500)

Requirements

- You have inserted an S7-1200/1500 F-CPU in your project.
- In the "Properties" tab of the F-CPU, the "F-capability activated" check box is selected (default setting).

F-runtime group created by default

STEP 7 Safety inserts F-blocks for an F-runtime group in the project tree by default after an F-CPU has been added. When you open the "Program blocks", you see the (F-)blocks of the F-runtime group (FOB_RTG1 [OB123], Main_Safety_RTG1 [FB1] and Main_Safety_RTG1_DB [DB1]) in the project tree.

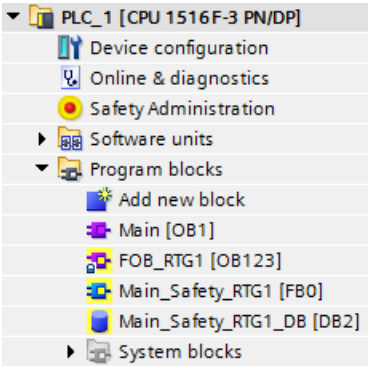

The following section describes how you modify the settings / parameters of the F-runtime group created by default or add and additional F-runtime group.

Procedure for defining an F-runtime group

Proceed as follows to define an F-runtime group:

1. Open the *Safety Administration Editor* by double-clicking in the project tree.
2. Select "F-runtime group" in the area navigation.

   Result: The work area for defining an F-runtime group with the (default) settings for F-runtime group 1 opens.

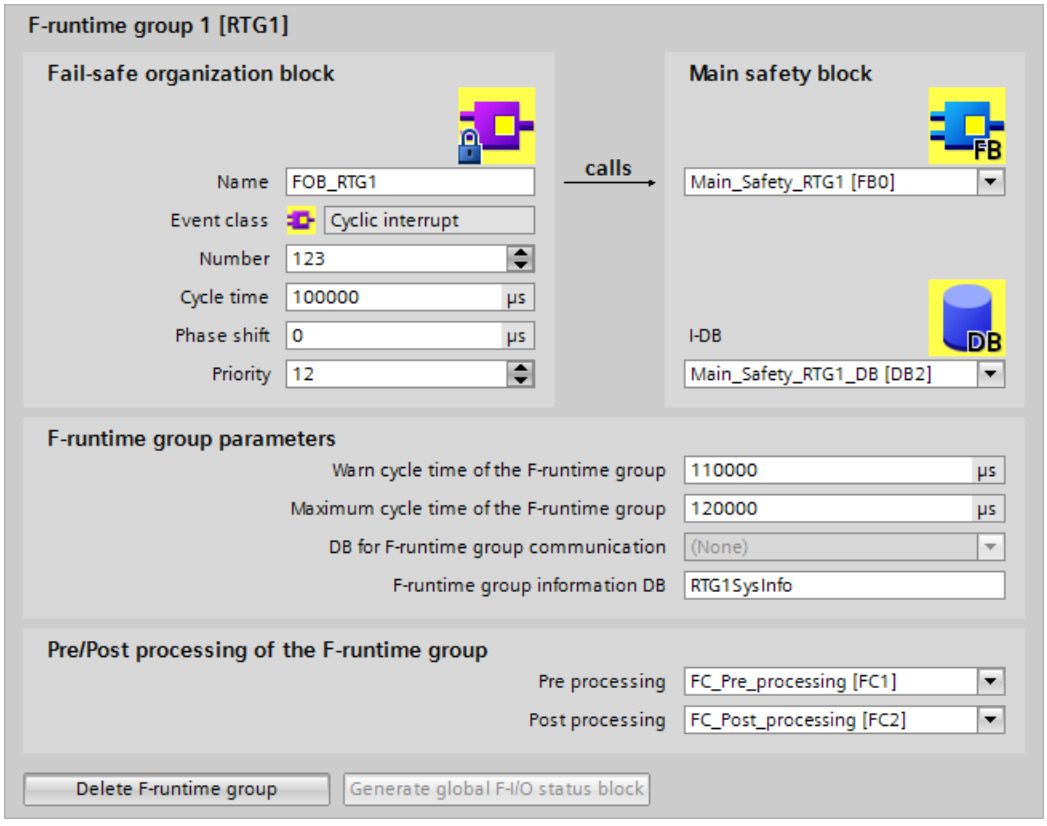

3. Assign a name for the F-OB under "F-OB".

4. Specify the event class of the F-OB when you create a new F-runtime group.

   For an F-OB you can select between the event classes "Program cycle", "Cyclic interrupt" or "Synchronous cycle".

   In the case of the F-runtime group created by default, the F-OB has the event class "Cyclic interrupt". To change the event class of the F-OB of an already created F-runtime group, you need to delete and F-runtime group and create a new one.

   NOTE

   We recommend creating the F-OB with the event class "Cyclic interrupt". The safety program will then be called and executed at fixed time intervals.

   F-OBs with the event class "Synchronous cycle" are only recommended in conjunction with F-IOs that support isochronous mode, for example submodule "Profisafe Telgr 902" of drive SINAMICS S120 CU310-2 PN V5.1.

   F-OBs with the event class "Program cycle" are not recommended, as these have the lowest priority "1" (see below).

   NOTE

   Note the maximum permissible number of OBs (incl. F-OBs) with event class "Synchronous cycle" (see technical specifications in the product manuals of the S7-1500 CPUs).

5. If required, you can manually change the number of the F-OB proposed by the system. To do so, note the number ranges valid for the relevant event class.
6. Assign cycle time, phase shift and priority parameters for F-OBs with event class "Cyclic interrupt".

   Assign the priority parameter for F-OBs with event class "Synchronous cycle".

   – Select a cycle time which is less than the "Maximum cycle time of the F-runtime group" and less than the "Cycle time warning limit of F-runtime group".
   – Select a phase shift which is less than the cycle time.
   – If possible, select a priority that is higher than the priority of all other OBs.

   NOTE

   Through a high priority of the F-OB you ensure that the run time of the safety program and the reaction time of your safety functions (Page 644) are influenced as little as possibly by the standard user program.

   NOTE

   For F-OBs with event class "Synchronous cycle" you need to also assign parameters for application cycle (ms) and possibly delay time (ms) after defining the F-runtime group and the connection of the isochronous F-I/O to the isochronous mode interrupt OB. You can find these parameters in the "Properties" dialog box of the isochronous mode interrupt OB in the "Isochronous mode" group. Proceed as described in the STEP 7 help under "Configuring isochronous mode interrupt OBs".

7. Assign the calling main safety block to the F-OB. If the main safety block is an FB, you must also assign an instance DB.

   Main_Safety_RTG1 [FB1] and Main_Safety_RTG1_DB [DB1] are suggested by default.

8. The F-CPU monitors the F-cycle time of the F-runtime group. Two parameters are available:

   – If the "Warn cycle time of the F-runtime group" is exceeded, a maintenance demanded is written to the diagnostics buffer of the F-CPU and the MAINT LED of the F-CPU is activated. This parameter can, for example, be used to determine whether the cycle time exceeds a required value without the F-CPU switching to STOP mode.

     NOTE

     The maintenance demanded is marked as an outgoing event by a STOP/RUN transition of the F-CPU. In an HF-system you must set both HF-CPUs or the redundant S7-1500HF system to STOP before you restart the HF-CPUs.

     As an alternative, you can mark the maintenance demanded as outgoing with the standard instruction "ACK_FCT_WARN". To do so, call the instruction "ACK_FCT_WARN" with a rising edge at the input parameter "ACK_WARN" in your standard user program.

     A renewed violation of the warning limit is not signaled until after a STOP/RUN transition of the F-CPU.

   – If the "Maximum cycle time of F-runtime group" is exceeded, the F-CPU will go to STOP. For "Maximum cycle time of F-runtime group", select the maximum time that can elapse between two calls of this F-runtime group (max. 20000000 µs).

     ⚠ WARNING

     The call interval of the F-runtime group is monitored for a maximum value. This means that monitoring is performed to determine whether the call is executed often enough, but not whether it is executed too often or, for example, isochronously. Fail-safe timers must therefore be implemented using the TP, TON, or TOF instructions (Page 545) from the "Instructions" task card and not using counters (OB calls). *(S007)*

WARNING

The response time of your safety function depends, among other things, on the cycle time of the F-OB, the runtime of the F-runtime group and, when distributed F-I/O is used, the parameter assignment of PROFINET/PROFIBUS.

Therefore, the configuration/parameter assignment of the standard system influences the response time of your safety function.

Examples:

- Increasing the priority of a standard OB compared to an F-OB can extend the cycle time of the F-OB or the runtime of the F-runtime group due to the higher-priority processing of the standard OB. Note that during the creation of technology objects, OBs with very high priority may be created automatically.
- The change of the send clock cycle of PROFINET changes the cycle time of an F-OB with event class "Synchronous cycle".

Note that the configuration / parameter assignment of the standard system is not subject to access protection for the safety-related project data and does not lead to a modification of the Collective F-Signature.

If you do not take organizational measures to prevent changes in the configuration / parameter assignment of the standard system with influence on the response time, you must always use the monitoring times for the calculation of the maximum response time of a safety function (see Configuring monitoring times (Page 644)).

The monitoring times are protected against change with the access protection of the safety-related project data and are captured by the Collective F-Signature as well as the Collective F-SW-Signature.

When calculating with the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) you need to consider the value that is specified for "Any standard system runtimes" as value for the maximum response time. *(S085)*

The "Cycle time warning limit of F-runtime group" must be configured as less than or equal to the "Maximum cycle time of F-runtime group".

9. If necessary, you can change the name suggested by the system for the F-runtime group information DB (Page 158) under "F-runtime group information DB".
10. If required, you can select blocks of the standard program (FCs) with regard to preprocessing or postprocessing of an F-runtime group (see Pre-/postprocessing (S7-1200, S7-1500) (Page 88))
11. If you want to create a **second F-runtime group**, click the "Add new F-runtime group" button. Follow steps 3 to 10 above.

5.2.4 F-runtime group communication (S7-300, S7-400)

Safety-related communication between F-runtime groups

Safety-related communication can take place between the two F-runtime groups of a safety program. This means fail-safe tags can be provided by one F-runtime group in an F-DB and read in another F-runtime group.

NOTE

A DB for F-runtime group communication can be read and write accessed by the F-runtime group to which it was assigned as "DB for runtime group communication", while it can only be read-accessed by the "receiver" F-runtime group.

Tip: You can improve performance by structuring your safety program in such a way that as few tags as possible are exchanged between the F-runtime groups.

Procedure for defining a DB for F-runtime group communication

You define the DB for F-runtime group communication in the work area "F-runtime groups". Proceed as follows:

1. Click "F-runtime groups" in "*Safety Administration Editor*".
2. Select an existing F-DB in the "DB for F-runtime group communication" field or assign a new one.
3. Assign a name to the F-DB.

Up-to-dateness of tags read from another F-runtime group

NOTE

Tags read are up-to-date as at the time of the last completed processing cycle of the F-runtime group providing the tags prior to start-up of the F-runtime group reading the tags.

If the tags supplied undergo multiple changes during runtime of the F-runtime group supplying the tags, the F-runtime group reading the tags only receives the last change (see figure below).

Assignment of fail-safe values

After F-system start-up, fail-safe values are supplied to the F-runtime group which has read access to tags in the DB for F-runtime group communication of another F-runtime group (for example, F-runtime group 2). These are the values you specified as initial values in the DB for F-runtime group communication of F-runtime group 1.

F-runtime group 2 reads the fail-safe values the first time it is called. The second time the F-runtime group 2 is called, it reads the latest tags if F-runtime group 1 has been processed completely between the two calls of F-runtime group 2. If F-runtime group 1 has not been processed completely, F-runtime group 2 continues to read the fail-safe values until F-runtime group 1 is completely processed.

The behavior is illustrated in the two figures below.

Reading tags from F-runtime group 1, which has a longer OB cycle and lower priority than F-runtime group 2

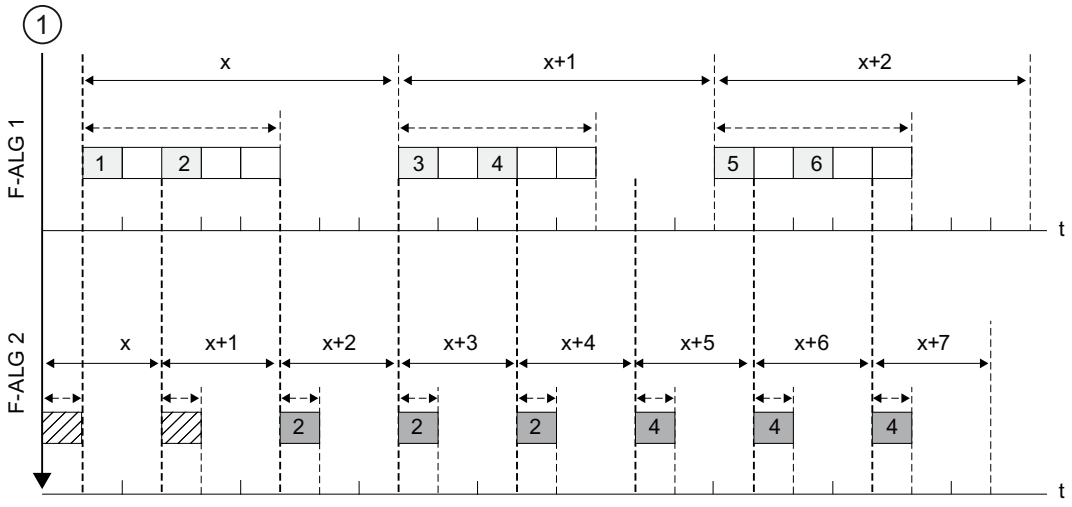

①	Startup of F-system
←——→	Cycle time of the (F-)OB in which the F-runtime group is called.
←- - -→	Runtime of the F-runtime group
1	... Tag of F-runtime group 1, written to DB for F-runtime group communication of F-runtime group 1
2	...Tag of F-runtime group 2, read in DB for F-runtime group communication of F-runtime group 1
▨	Initial value in the DB for F-runtime group communication

Reading tags from F-runtime group 1, which has a shorter OB cycle and higher priority than F-runtime group 2

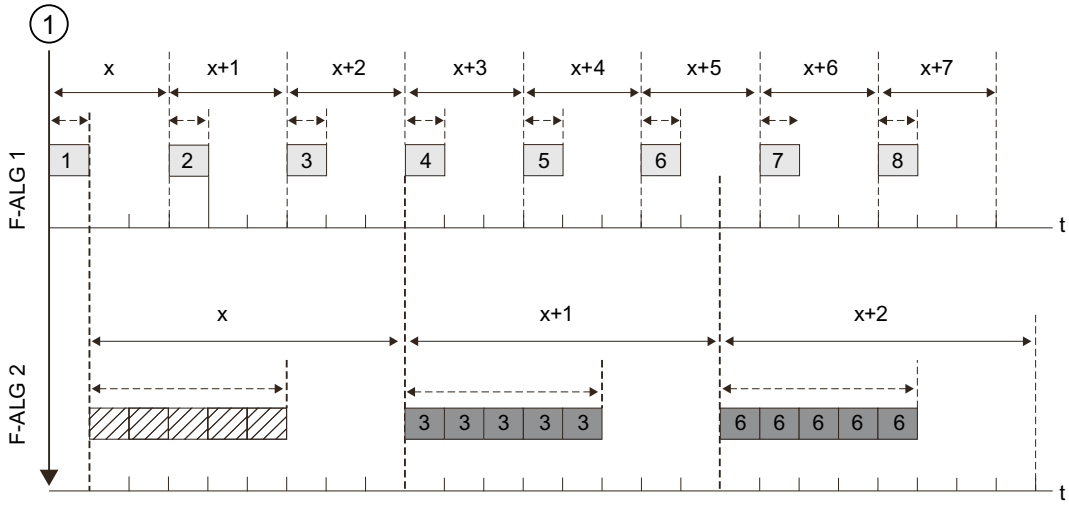

①	Startup of F-system
←→	Cycle time of the (F-)OB in which the F-runtime group is called.
←- - -→	Runtime of the F-runtime group
1	... Tag of F-runtime group 1, written to DB for F-runtime group communication of F-runtime group 1
2	... Tag of F-runtime group 2, read in DB for F-runtime group communication of F-runtime group 1
▨	Initial value in the DB for F-runtime group communication

F-runtime group supplying tags is not processed

NOTE

If the F-runtime group whose DB for F-runtime group communication is to supply the tags is not processed (the main safety block of the F-runtime group is not called), the F-CPU goes to STOP mode. One of the following diagnostics events is then entered in the diagnostics buffer of the F-CPU:

- Error in safety program: cycle time exceeded
- Number of the relevant main safety block (of F-runtime group that is not processed)
- Current cycle time in ms: "0"

5.2.5 F-runtime group communication (S7-1200, S7-1500)

Introduction

With the help of Flexible F-Link you realize a F-runtime group communication.

With Flexible F-Link, a coded F-array is made available for the send data of the F-runtime group. The coded F-array is transferred to the other F-runtime group with standard instructions such as UNMOVE_BLK.

Requirement

- S7-1500 F-CPUs as of firmware V2.0
- S7-1200 G1 F-CPUs as of firmware V4.2
- S7-1200 G2 F-CPUs as of firmware V1.0
- Safety system version as of V2.2

F-runtime group communication

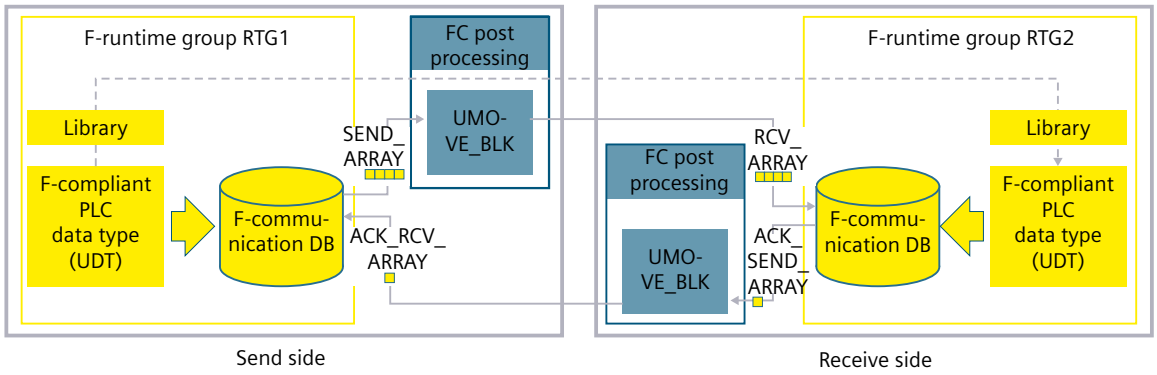

If you want to send a data fail-safe from one F-runtime group to another F-runtime group, follow these steps:

1. Create a non-nested F-compliant PLC data type (UDT) for the F-runtime group communication. The size can be up to 1500 bytes, including a maximum of 800 elements of data type BOOL.
2. Create two safety-related communications for F-runtime group communication in the Safety Administration Editor in the "Flexible F-Link" area. One safety-related communication each for the send and receive sides.

3. Configure the same F-monitoring time and F-communication UUID for each F-runtime group communication relationship.

   Information on calculating the F-monitoring times can be found in Monitoring and response times (Page 643).

   For example:

Flexible F-Link settings

	Name	PLC Data Type	Direction	F-monitoring time: (ms)	F-communication UUID
1	Send	Data	Send	500	5d61f443-ede6-4e4e-9db6-e79af634f9ad
2	Receive	Data	Receive	500	5d61f443-ede6-4e4e-9db6-e79af634f9ad

4. On the send side (e.g. RTG1) supply the data of the F-communication DB (Page 358) for the send direction with the data to be sent.

   For example:

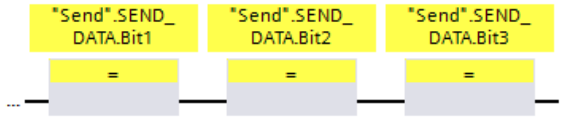

5. On the receive side (e.g. RTG2), read the received data from the F-communication DB (Page 358) for the receive direction.

   For example:

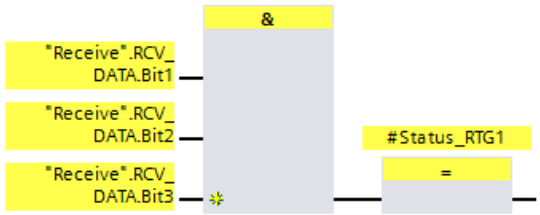

6. Call the instruction "UMOVE_BLK" in the F-runtime group for the send data (e.g. RTG1) in the FC for post processing (Page 88).

7. Interconnect the "UMOVE_BLK" instruction for the data to be sent as follows:

   "Send" is the F-communication DB (Page 358) of the F-runtime group that sends the data.

   "Receive" is the F-communication DB (Page 358) of the F-runtime group that receives the data.

8. Call the instruction "UMOVE_BLK" in the F-runtime group for acknowledgment (e.g. RTG2) in the FC for post processing (Page 98).

9. Interconnect the "UMOVE_BLK" instruction for the acknowledgment connection as follows:

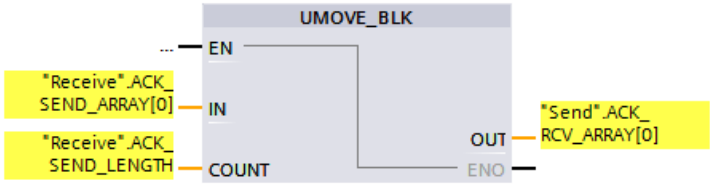

"Receive" is the F-communication DB (Page 358) of the F-runtime group that sends the acknowledgment telegram.

"Send" is the F-communication DB (Page 358) of the F-runtime group that receives the acknowledgment telegram.

10. Compile the user program.

11. Download the user program to the F-CPU.

WARNING

For each communication connection via Flexible F-Link, you must check that the offsets of the elements of the F-compliant PLC data type (UDT) used for the communication connection match on the transmit and receive sides when you accept the safety program.

You can find the offsets in the respective safety summary. To do this identify the communication connection by means of the UUID. *(S088)*

WARNING

When a new Flexible F-Link communication is created in the Safety Administration Editor, a unique F-communication UUID for the communication is provided by the system. When communication is copied in the Safety Administration Editor within the parameterization table or copied to another F-CPU, the F-communication UUIDs are not regenerated and therefore not unique anymore. If the copy is used to configure a new communication relationship, you yourself must ensure the uniqueness. To do this, select the relevant UUIDs and generate them again via the "Generate UUID" context menu. You must ensure the uniqueness in the safety summary during acceptance, at the latest. *(S087)*

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Up-to-dateness of tags read from another F-runtime group

The same statements as those in the section "F-runtime group communication (S7-300, S7-400) (Page 146)" apply (except for the storage locations written or read or initial values).

5.2.6 Deleting an F-runtime group

Deleting an F-runtime group

To delete an F-runtime group, proceed as follows:

1. In the area navigation of the *Safety Administration Editor*, click on the F-runtime group to be deleted.
2. Select the "Delete F-runtime group" button in the work area.
3. Confirm the dialog with "Yes".
4. Perform a Compilation of the safety program (Page 361) (menu command "Edit > Compile") for your changes to take effect.

The assignment of the F-blocks to an F-runtime group (to the calling block of the main safety block) is deleted. However, the F-blocks continue to exist.

5.2.7 Changing the F-runtime group (S7-300, S7-400)

Changing an F-runtime group

You can make the following changes for each F-runtime group in your safety program in the corresponding "F-runtime group" work area:

- Specify another block as the calling block of the main safety block.
- Specify another F-FB or F-FC as main safety block.
- Enter a different or new I-DB for the main safety block.
- Change the value for the maximum cycle time of the F-runtime group
- Specify another DB as a data block for F-runtime group communication.

5.2.8 Changing the F-runtime group (S7-1200, S7-1500)

Changing an F-runtime group

You can make the following changes for each F-runtime group in your safety program in the corresponding "F-runtime group" work area:

- Change the name, number, cycle time, phase shift and priority of the F-OB.
- Specify another F-FB or F-FC as main safety block.
- Enter a different or new I-DB for the main safety block.
- Change the value for the maximum cycle time and the cycle time warning limit of the F-runtime group.

- Assign another name for the F-runtime group information DB.
- Specify an FC for the preprocessing and postprocessing.

5.3 Creating F-blocks

5.3.1 Creating F-blocks

Introduction

In order to create F-FBs, F-FCs, and F-DBs for the safety program, you should follow the same basic procedure as in the standard. In the following, only the deviations from the procedure for standard blocks are presented.

Creating F-FBs, F-FCs, and F-DBs

You create F-blocks in the same way as for standard blocks. Proceed as follows:

1. In the project tree of the F-CPU or the Safety Unit, double-click on "Add new block" under "Program blocks".
2. In the dialog that appears, specify the type, name, and language and select the "Create F-block" check box. (If you do not select the check box, a standard block is created.)
3. After the dialog is confirmed, the F-block is opened in the *Program editor*.

Note the following

Note the following important instructions:

NOTE

- You may not declare block parameters in the block interface of the main safety block because they cannot be supplied.
- (S7-1200, S7-1500) You can edit start values in instance DBs.
- The function "Apply actual values" is not supported.
- You may not access static local data in single instances or multi-instances of other F-FBs.
- You must always initialize outputs of F-FCs.

  The F-CPU can go to STOP mode if the information above is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.
- (S7-300, S7-400) If you wish to assign an address from the data area (data block) to a formal parameter of an F-FC as an actual parameter, you have to use fully qualified DB access.
- Its inputs may only be accessed by a block in reading mode and its outputs only in writing mode.

  Use an in/out if you wish to have both read and write access.
- For greater clarity, assign meaningful names to the F-blocks you have created.

Copying/pasting F-blocks

You can copy F-FBs, F-FCs, and F-DBs in exactly the same was as blocks of the standard user program.

Exceptions:

- (S7-1200, S7-1500) You may not copy an F-OB.
- You cannot copy blocks from the folder "Program blocks > System blocks".
- (S7-1500) F-blocks cannot be copied from the Safety Unit to a standard unit or between the Safety Unit and the "Program blocks" folder of the F-CPU.

See also

Changing the F-runtime group (S7-1200, S7-1500) (Page 152)

5.3.2 Know-how protection

For know-how protection of F-blocks, proceed as described in the *STEP 7* help under "Protecting blocks".

Requirements

Note the following with regard to know-how protection of F-blocks for S7-1200/1500 F-CPUs:

- An F-block to which you wish to assign know-how protection must be called in the Safety program.
- Before you can set up the know-how protection for an F-block, the Safety program must be consistent. For this purpose, compile (Page 361) the Safety program.

NOTE

No source code is output in the safety summary for know-how-protected F-blocks. Therefore, create the safety summary (for example, for carrying out a code review or for F-block acceptance) before you set up the know-how protection.

NOTE

If you want to edit the program code and/or the block interface of a know-how protected F-block, we recommend that you do not open the F-block by entering a password, but rather remove the know-how protection completely and set it up again after compiling.

NOTE

(S7-1200, S7-1500) When a know-how protected F-block or F-blocks called by it are renamed, the signature of the know-how protected F-block is not changed until the password is entered when opening or removing the know-how protection.

NOTE

When know-how protected F-blocks are used, warnings and error messages whose cause can lie in the know-how protected F-blocks can be displayed during compilation of the Safety program. The warnings and error messages contain corresponding information. Example: In a know-how protected F-block, you perform read access to a tag of the standard user program to which write access is taking place in a different (know-how protected) F-block.

For S7-1200/1500 F-CPUs, you can obtain additional information in the section "Know-how protected F-blocks in the Safety program" of the safety summary.

See also

Reuse of F-blocks (Page 156)

5.3.3 Reuse of F-blocks

Introduction

You can reuse F-blocks that you have already tested and, if applicable, approved, in other Safety programs – without having to test and approve them again.

You can protect the content of the F-block by setting up the know-how protection. You may only set this protection after acceptance of the F-block to ensure that the safety summary contains this F-block in its entirety.

Like standard blocks, you can store F-blocks as master copies or types in global libraries or in the project library.

More information can be found in the *STEP 7 help* under "Using libraries".

Creating safety summary for the F-block to be reused

Create a safety summary with the following information for F-blocks that you want to reuse.

S7-300/400 F-CPUs

- Signature and initial value signature of the know-how protected F-block
- Versions of all the used versioned LAD/FBD instructions
- Signatures and initial value signatures of all called F-FBs and F-FCs
- Signatures of all F-DBs accessed by the fail-safe block to be reused.

S7-1200/1500 F-CPUs

- Signature of the know-how protected F-block
- Safety system version when setting up the know-how protection
- Versions of all the used versioned LAD/FBD instructions
- Signatures of all called F-FBs and F-FCs
- Signatures of all F-DBs accessed by the fail-safe block to be reused.

The safety summary should also contain a description of the functionality of the F-block, in particular if it is know-how protected.

The required information is obtained by creating the safety summary of the Safety program in which you originally created, tested and approved the F-block to be reused.

This safety summary can also serve directly as the safety summary for the F-block to be reused.

Checks when using the F-block to be reused

When reusing the F-block, ensure the following:

- The signature and initial value signature (S7-300, S7-400) of the F-block are unchanged.
- (SIMATIC S7-1200, S7-1500) The documented safety system version is set.
- The documented (or functionally identical) versions of the versioned LAD/FBD instructions are set. You can find information about the instruction versions in the description of the instructions.
- (S7-1200, S7-1500) The called and accessed F-blocks with the documented signatures are used.
- (S7-300, S7-400) The called F-blocks with the documented signatures and initial value signatures are used.

If the version conflicts cannot be eliminated due to other dependencies, contact the author of the know-how protected block in order to obtain a compatible approved version.

See also

Compliance of the know-how protected F-blocks used in the Safety program with their safety summary. (Page 431)

5.4 Information interface to the safety program

5.4.1 F-shared DB (S7-300, S7-400)

Function

The F-shared DB is a fail-safe data block that contains all of the shared data of the safety program and additional information needed by the F-system. The F-shared DB is automatically inserted when the hardware configuration is compiled.

Using its name F_GLOBDB, you can evaluate certain data elements of the safety program in the standard user program.

Reading an F-shared DB in the standard user program

You can read out the following information in the F-shared DB in the standard user program or on an operator control and monitoring system:

- Operating mode: safety mode or disabled safety mode ("MODE" tag)
- Error information "Error occurred when executing safety program" ("ERROR" tag)
- Collective F-Signature ("F_PROG_SIG" tag)
- Compilation date of the safety program ("F_PROG_DAT" tag, DATE_AND_TIME data type)

You use fully qualified access to access these tags (e.g. ""F_GLOBDB".MODE").

5.4.2 F-runtime group information DB (S7-1200, S7-1500)

Introduction

The F-runtime group information DB provides key information on the corresponding F-runtime group and on the safety program as a whole.

The F-runtime group information DB is generated automatically when an F-runtime group is created. A symbol, for example, "RTG1SysInfo", is assigned for the F-runtime group information DB. You can change the name in the *Safety Administration Editor*.

You must not access the information in the "F_SYSINFO" parameter from the safety program.

Information in the F-runtime group information DB

The F-runtime group information DB provides the following information:

Name		Data type	For processing in the safety program	For processing in the standard user program	Description
MODE		BOOL	x	x	1 = Disabled safety mode
MODE_REMAINING_TIME		TIME	x	x	Remaining runtime in deactivated safety mode until the F-CPU switches to STOP [1]
MODE_VPLC_TIME_SER-VICE		BOOL	—	x	1 = Redundant operation of the Virtual Time Service application [2]
F_SYSINFO					
	MODE	BOOL	—	x	1 = Disabled safety mode
	TCYC_CURR	DINT	—	x	Current cycle time of the F-runtime group, in ms
	TCYC_LONG	DINT	—	x	Longest cycle time of the F-runtime group, in ms
	TRTG_CURR	DINT	—	x	Current runtime of the F-runtime group, in ms
	TRTG_LONG	DINT	—	x	Longest runtime of the F-runtime group, in ms
	T1RTG_CURR	DINT	—	x	Not supported by *STEP 7 Safety V21*.
	T1RTG_LONG	DINT	—	x	Not supported by *STEP 7 Safety V21*.
	F_PROG_SIG	DWORD	—	x	Collective F-Signature of the safety pro-gram
	F_PROG_DAT	DTL	—	x	Compilation date of the safety program
	F_RTG_SIG	DWORD	—	x	F-runtime groups signature
	F_RTG_DAT	DTL	—	x	Compilation date of the F-runtime group
	VERS_S7SAF	DWORD	—	x	Version identifier for *STEP 7 Safety*

1 When the F-CPU switches to STOP after the runtime for the deactivated safety mode has expired, the remaining time still present in the last cycle is displayed.

2 Only relevant for S7-1500 F Virtual Controller.

You access the content of the F-runtime group information DB with fully qualified addressing. Either collectively with the F_SYSINFO PLC data type (UDT), for example,

"RTG1SysInfo.F_SYSINFO", provided by the F-system or individual information, for example, "RTG1SysInfo.F_SYSINFO.MODE".

See also

Program identification (Page 396)

5.5 Programming startup protection

Introduction

⚠ WARNING

Unintentional restart

In contrast to the standard user program, when the safety program starts up, all tags of the F-DBs are generally initialized with their start values. This means that saved error information is lost. The F-system performs automatic reintegration of the F-I/O.

If an unintentional startup of your process is not allowed, you must program restart/startup protection in the safety program. For this, the output of process values must be blocked until user acknowledgment takes place (see "Implementation of user acknowledgment (Page 196)"). This user acknowledgment must not take place until safe output of process values is possible.

You must expect an unintentional restart in the following cases:

- After a STOP generated by PG/PC operation, mode switch, communication function or "STP" instruction
- After an operating error
- After a STOP caused by a fault reaction function
- The following applies to the S7-1500 F Virtual Controller:
  After a STOP or a restart of the S7-1500 F Virtual Controller via Industrial Edge Management.

(S008)

Example of restart/startup prevention

In order to implement a restart/startup prevention, it must be possible to detect a startup. To detect a startup, you declare a tag of data type BOOL with initial value "TRUE" in an F-DB.

Block the output of process data when this tag has the value "1," for example, by passivating F-I/O using the PASS_ON tag in the F-I/O DB.

If the output of the process values is safely possible and errors have been corrected, reset this tag by a user acknowledgment.

See also

Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller (Page 196)

Implementing user acknowledgment in the safety program of the F-CPU of a I-slave or I-device (Page 201)

F-I/O DB (Page 168)

F-I/O access

6

The following sections contain a general description of F-I/O access.

The following sections are only valid to a limited extent for technology modules (e.g. F-TM Count 1x1Vpp sin/cos HF). You can find more detailed information in the respective equipment manuals.

For F-I/O with integrated safety functions (such as ET 200ecoPN M12-L F), outputs can be written from both the safety program of the F-CPU and from the integrated safety functions. You can find information on which values ultimately take effect here in the respective manuals.

6.1 Addressing F-I/O

Overview

Below you will find a description of how to address the F-I/O in the safety program and which rules must be observed in the process.

Addressing via the process image

As with standard I/O, you access F-I/O (e.g., S7-1500/ET 200MP fail-safe modules) via the **process image** (PII and PIQ).

Direct reading (with I/O identification ":P") of inputs or writing of outputs is not possible in the safety program.

Updating the process image

The process image of the inputs of F-I/O is updated at the start of the F-runtime group. The process image of the outputs of F-I/O is updated at the end of the F-runtime group (see Program structure of the safety program (S7-300, S7-400) (Page 113) or Program structure of the safety program (S7-1200, S7-1500) (Page 116)). For more information on updating the process image, refer to the note in Data Transfer from the Safety Program to the Standard User Program (Page 204).

The communication required between the F-CPU (process image) and the F-I/O to update the process image uses a special safety protocol in accordance with PROFIsafe.

Rules

- You may only address a channel (channel value and value status) of an F-I/O in **one** F-runtime group. The first programmed addressing defines the assignment for the F-runtime group.
- You may only address a channel (channel value and value status) of an F-I/O with a unit that matches the data type of the channel.
  Example: To access input channels of data type BOOL, you must use the "input (bit)" (I x.y) unit. Access to the 16 consecutive input channels of the data type BOOL via the unit "input word" (IW x) is not possible.
- Analog channels always need to be entered in the tag table with data type INT or DINT. The data types WORD, DWORD and TIME are not permissible.
- Address only inputs and outputs that reference an actually existing channel (channel value and value status) (e.g. for an F-DO 10xDC24V with start address 10 only the outputs Q10.0 to Q11.1 for the channel values and the inputs I10.0 to I11.1 for the value status). Keep in mind that due to the special safety protocol, the F-I/O occupies a larger area of the process image than is required for the existing and enabled channels on the F-I/O (channel values and value status). To find the area of the process image where the channels (channel values and value status) are stored (channel structure), refer to the relevant manuals for the F-I/O.
- Channels can be disabled for certain F-I/O (such as ET 200SP fail-safe modules or S7-1500/ET 200MP fail-safe modules). Address only channels (channel value and value status) that are enabled in the hardware configuration. When you address channels that are disabled in the hardware configuration, a warning may be output when compiling the safety program.
- For certain F-I/O (such as ET 200SP fail-safe modules or S7-1500/ET 200MP fail-safe modules), a "1oo2 (2v2) sensor evaluation" can be specified. Two channels are grouped into one channel pair in this case, and the result of the "1oo2 sensor evaluation" is usually provided under the address of the channel with the lower channel number (see relevant manuals of the F-I/O). Address only this channel (channel value and value status) of the channel pair. When you address a different channel, a warning may be output when compiling the safety program.

⚠ WARNING

If you use an additional component between the F-CPU (S7-300, S7-400) and the F-I/O that copies the safety message frame in accordance with PROFIsafe between the F-CPU (S7-300, S7-400) and F-I/O per user program, you must test all safety functions affected by the copy function whenever you change the user-programmed copy function. *(S049)*

See also

Safety-related I-slave-slave communication - F-I/O access via process image (Page 195)
Value status (S7-1200, S7-1500) (Page 163)

6.2 Value status (S7-1200, S7-1500)

Properties

The value status is additional binary information for the channel value of an F-I/O. The value status is entered in the process image input (PII).

The value status is supported by fail-safe modules S7-1500/ET 200MP, ET 200SP, ET 200SP HA, ET 200AL, ET 200eco PN, ET 200S, ET 200iSP, ET 200pro, S7-1200 or F-SMs S7-300, fail-safe GSD based IO devices as well as fail-safe GSD based DP slaves that support the "RIOforFA-Safety" profile. Information about the value status can be found in the documentation of the respective F-I/O.

We recommend you amend the name of the channel value with "_VS" for the value status, for example, "TagIn_1_VS".

The value status provides information on the validity of the corresponding channel value:

- 1: A valid process value is output for the channel.
- 0: A fail-safe value is output for the channel.

The channel value and value status of an F-I/O can only be accessed from the same F-runtime group.

Location of value status bits in the PII for F-I/O with digital inputs

The value status bits come straight after the channel values in the PII.

Table 3-1108 Example: Address assignment in PII for F-I/O with 16 digital input channels

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	DI_7	DI_6	DI_5	DI_4	DI_3	DI_2	DI_1	DI_0
x + 1	DI_{15}	DI_{14}	DI_{13}	DI_{12}	DI_{11}	DI_{10}	DI_9	DI_8
x + 2	Value status DI_7	Value status DI_6	Value status DI_5	Value status DI_4	Value status DI_3	Value status DI_2	Value status DI_1	Value status DI_0
x + 3	Value status DI_{15}	Value status DI_{14}	Value status DI_{13}	Value status DI_{12}	Value status DI_{11}	Value status DI_{10}	Value status DI_9	Value status DI_8

x = Module start address

The location of the channel values in the PII can be found in the device manual for the F-I/O.

Location of value status bits in the PII for F-I/O with digital outputs

The value status bits in the PII are mapped with the same structure as the channel values in the PIQ.

Table 3-1109 Example: Address assignment in PIQ for F-I/O with 4 digital output channels

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	DQ_3	DQ_2	DQ_1	DQ_0

x = Module start address

Table 3-1110 Example: Address assignment in PII for F-I/O with 4 digital output channels

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	Value status DQ_3	Value status DQ_2	Value status DQ_1	Value status DQ_0

x = Module start address

The location of the channel values in the PIQ can be found in the device manual for the F-I/O.

Location of value status bits in the PII for F-I/O with digital outputs and digital inputs

The value status bits come directly after the channel values in the PII in the following order:

- Value status bits for the digital inputs
- Value status bits for the digital outputs

Table 3-1111 Example: Address assignment in PIQ for F-I/O with 2 digital input channels and 1 digital output channel

Byte in the F-CPU	Assigned bit in the F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	—	—	—	DQ_0

x = Module start address

Table 3-1112 Example: Address assignment in PII for F-I/O with 2 digital input channels and 1 digital output channel

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	—	—	—	—	DI_1	DI_0
x + 1	—	—	—	—	—	—	Value status DI_1	Value status DI_0
x + 2	—	—	—	—	—	—	—	Value status DQ_0

x = Module start address

The location of the channel values in the PII and PIQ can be found in the device manual for the F-I/O.

Location of value status bits in the PII for F-I/O with analog inputs

The value status bits come straight after the channel values in the PII.

Table 3-1113 Example: Address assignment in PII for F-I/O with 6 analog input channels (data type INT)

Byte in the F-CPU	Assigned bytes/bits in the F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	Channel value AI_0							
...	...							
x + 10	Channel value AI_5							
x + 12	—	—	Value status AI_5	Value status AI_4	Value status AI_3	Value status AI_2	Value status AI_1	Value status AI_0

x = Module start address

The location of the channel values in the PII can be found in the device manual for the F-I/O.

Location of value status bits in the PII for F-I/O with analog outputs

The value status bits are mapped in the PII.

Table 3-1114 Example: Address assignment in PIQ for F-I/O with 6 analog output channels (data type INT)

Byte in the F-CPU	Assigned bytes in the F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	Channel value AO_0							
...	...							
x + 10	Channel value AO_5							

x = Module start address

Table 3-1115 Example: Address assignment in PII for F-I/O with 6 analog output channels (data type INT)

Byte in the F-CPU	Assigned bits in F-CPU per F-I/O:							
	7	6	5	4	3	2	1	0
x + 0	—	—	Value status AO_5	Value status AO_4	Value status AO_3	Value status AO_2	Value status AO_1	Value status AO_0

x = Module start address

The location of the channel values in the PIQ can be found in the device manual for the F-I/O.

6.3 Process Data or Fail-Safe Values

When are fail-safe values used?

The safety function requires that fail-safe values (0) be used instead of process data for passivation of the entire F-I/O or individual channels of an F-I/O in the following cases. This applies both to digital channels (data type BOOL) as well as for analog channels (data type INT or DINT):

- When the F-system starts up
- When errors occur during safety-related communication (communication errors) between the F-CPU and F-I/O using the safety protocol in accordance with PROFIsafe
- When F-I/O faults and channel faults occur (such as wire break, short circuit, and discrepancy errors)
- As long as you enable passivation of the F-I/O with PASS_ON = 1 in the F-I/O DB (see below)
- As long as you disable the F-I/O with DISABLE = 1 in the F-I/O DB (see below)

Fail-safe value output for F-I/O/channels of an F-I/O

When **passivation** occurs for an **F-I/O with inputs**, the F-system provides the safety program with fail-safe values (0) in the PII instead of the process data pending at the fail-safe inputs of the F-I/O.

The overflow or underflow of a channel of the **SM 336; AI 6 x 13Bit** or **SM 336; F-AI 6 x 0/4 ... 20 mA HART** is recognized by the F-system as an F-I/O/channel fault. The fail-safe value 0 is provided in place of $7FFF_H$ (for overflow) or 8000_H (for underflow) in the PII for the safety program.

If you want to process fail-safe values other than "0" in the safety program for an F-I/O with inputs **for analog channels of data type INT or DINT**, you can assign individual fail-safe values for QBAD = 1 and value status = 0 or QBAD_I_xx/QBAD_O_xx = 1 (instructions JMP/JMPN, LABEL and MOVE). For details about the characteristics go to QBAD/PASS_OUT/DISABLED/QBAD_I_xx/QBAD_O_xx and value status (Page 174).

WARNING

For an F-I/O with digital input channels (data type BOOL), the value provided in the PII must always be processed in the safety program, regardless of the value status or QBAD/QBAD_I_xx. *(S009)*

When **passivation** occurs in an **F-I/O with outputs**, the F-system outputs fail-safe values (0) at the fail-safe outputs instead of the output values provided by the safety program in the PIQ.

<table>
<tr><th>State of associated PAA/PIQ by ...</th><th>F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPUs</th><th>F-I/O without "RIOforFA-Safety" profile with S7-1200/1500 F-CPUs</th><th>F-I/O with S7-300/400 F-CPUs</th></tr>
<tr><td>Startup of F-system[1]</td><td colspan="3" rowspan="2">The F-system overwrites the PII/PIQ with fail-safe values (0).</td></tr>
<tr><td>Communication errors</td></tr>
<tr><td>F-I/O faults</td><td rowspan="3">The F-system overwrites the PII with fail-safe values (0). In the PII the values formed in the safety program are retained.</td><td colspan="2" rowspan="2">The F-system overwrites the PII/PIQ with fail-safe values (0).</td></tr>
<tr><td>Channel faults in configuration of passivation for complete F-I/O</td></tr>
<tr><td>Channel faults during configuration of channel-granular passivation</td><td colspan="2">For the affected channels: The F-system overwrites the PII/PIQ with fail-safe values (0).</td></tr>
<tr><td>As long as passivation of the F-I/O is activated in the F-I/O DB with PASS_ON = 1</td><td colspan="3">The F-system overwrites the PII/PIQ with fail-safe values (0).</td></tr>
<tr><td>As long as the F-I/O is deactivated in the F-I/O DB with DISABLE = 1</td><td colspan="2">The F-system overwrites the PII/PIQ with fail-safe values (0).</td><td>-</td></tr>
</table>

[1] During the delayed transfer of the F-Base ID, the F-system remains in startup.

Reintegration of F-I/O/channels of an F-I/O

The switchover from fail-safe values (0) to process data (**reintegration of an F-I/O**) takes place **automatically** or following **user acknowledgment** in the F-I/O DB. The reintegration method depends on the following:

- The reason for passivation of the F-I/O or channels of the F-I/O
- At F-I/Os without the "Channel failure acknowledge" channel parameter on the value of the ACK_NEC variable of the associated F-IO data blocks (Page 168).
- At F-I/Os with the "Channel failure acknowledge" channel parameter (for example F-modules S7-1500 / ET 200 MP / F-modules SIMATIC S7-1200) on the value of the channel parameter.

For fail-safe GSD based DP slaves / GSD based I/O devices with "RIOforFA-Safety" profile, consult the respective documentation.

NOTE

Note that for channel faults in the F-I/O, channel-granular passivation takes place if configured accordingly in the *hardware and network editor*. For the concerned channels, fail-safe values (0) are output.

Reintegration after channel faults reintegrates all channels whose faults were eliminated; faulty channels remain passivated.

See also

Configuring F-I/O (Page 52)

6.4 F-I/O DB

Introduction

An F-I/O DB is automatically generated for each F-I/O (in safety mode) when the F-I/O is configured in the *hardware and network editor*. The F-I/O DB contains tags that you can evaluate or can/must write to in the safety program. It is not permitted to change the initial values of the tags directly in the F-I/O DB. When an F-I/O is deleted, the associated F-I/O DB is also deleted.

Access to an F-I/O DB

You access tags of the F-I/O DB for the following reasons:

- For reintegration of F-I/O after communication errors, F-I/O faults, or channel faults
- If you want to passivate the F-I/O depending on particular states of your safety program (for example, group passivation)
- If you want to deactivate the F-I/O (for example, configuration control)
- For changing parameters for fail-safe GSD based DP slaves/GSD based I/O devices
- If you want to evaluate whether fail-safe values or process data are output

6.4.1 Name and number of the F-I/O DB

The name of the F-I/O DB is formed by:

- the fixed prefix "F"
- the start address of the F-I/O, and the names entered in the properties of the F-I/O in the *hardware and network editor* or in the device view (max. the first 24 characters)

Example: F00004_F-DI24xDC24V_1

The number is assigned within the number range defined in the "Settings" area (Page 92) of the *Safety Administration Editor*.

Option "Creates F-I/O DBs without prefix" (S7-1200, S7-1500)

When you select the option "Creates F-I/O DBs without prefix" in the "Settings" (Page 92) area in the *Safety Administration Editor*, the name is formed only from:

- the name entered in the properties of the F-I/O in the *hardware and network editor* or in the device view (max. 117 characters)

Example: F-DI24xDC24V_1

Changing the name and number of the F-I/O DB

You change the name by changing the name entered in the properties of the F-I/O in the *hardware and network editor* or in the device view.

You change the number in the "Properties"/"F-parameters" tab of the associated F-I/O.

6.4.2 Tags of the F-I/O DB

The following table presents the variables of an F-I/O DB:

	Tag	Data type	Description	Initial value
Tags that you can or must write	PASS_ON	BOOL	1=enable passivation	0
	ACK_NEC	BOOL	1=acknowledgment for reintegration required in the event of F-I/O or channel faults	1
	ACK_REI	BOOL	1=acknowledgment for reintegration	0
	IPAR_EN	BOOL	Tag for parameter reassignment of fail-safe GSD based DP slaves/GSD based I/O devices or, in the case of SM 336; F-AI 6 x 0/4 ... 20 mA HART, for enabling HART communication	0
	DISABLE[1]	BOOL	1=Deactivate F-I/O	0
Tags that you can evaluate	PASS_OUT	BOOL	Passivation output	1
	QBAD	BOOL	1=Fail-safe values are output	1
	ACK_REQ	BOOL	1=Acknowledgment request for reintegration	0
	IPAR_OK	BOOL	Tag for parameter reassignment of fail-safe GSD based DP slaves/GSD based I/O devices or, in the case of SM 336; F-AI 6 x 0/4 ... 20 mA HART, for enabling HART communication	0
	DIAG	BYTE	Non-fail-safe service information	0
	DISABLED[1]	BOOL	1=F-I/O is deactivated	0
	QBAD_I_xx	BOOL	1=Fail-safe values are output to input channel xx (S7-300, S7-400)	1
	QBAD_O_xx	BOOL	1=Fail-safe values are output to output channel xx (S7-300, S7-400)	1
	BASEID_ACTIVE[2]	LWORD	Active F-BaseID Non-fail-safe information	0

1 As of Safety system version V2.1 for S7-1200/1500

2 As of Safety system version V2.8 for S7-1200 G2/1500

Differences in evaluation in S7-1200/1500 F-CPUs and S7-300/400

The following table describes the differences in the evaluation of tags of the F-I/O DB and the value status depending on the F-I/O and F-CPU used.

Tag in the F-I/O DB or value status	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O with S7-300/400 F-CPU
ACK_NEC	—[2]	x	x
QBAD[3]	x	x	x
PASS_OUT[3]	x	x	x
QBAD_I_xx[1]	—	—	x
QBAD_O_xx[1]	—	—	x
Wertstatus[1]	x	x	—

1 QBAD_I_xx and QBAD_O_xx display the validity of the channel value channel-granular and thus correspond to the inverted value status with S7-1200/1500. Value status or QBAD_I_xx and QBAD_O_xx are not available with fail-safe DP GSD based slaves or fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

2 In the case of F-I/Os that support the "Channel failure acknowledge" channel parameter (for example S7-1500/ET 200MP F-modules or S7-1200 F-modules), this replaces the ACK_NEC variable of the F-IO data block.

3 For details about the characteristics, see "QBAD/PASS_OUT/DISABLED/QBAD_I_xx/QBAD_O_xx and value status"

6.4.2.1 PASS_ON

The PASS_ON tag allows you to enable passivation of an F-I/O, for example, depending on particular states in your safety program.

Using the PASS_ON tag in the F-I/O DB, you can passivate F-I/O; channel-granular passivation is not possible.

As long as PASS_ON = 1, **passivation** of the associated F-I/O occurs.

6.4.2.2 ACK_NEC

If an F-I/O fault is detected by the F-I/O, **passivation** of the relevant F-I/O occurs. If channel faults are detected and channel granular passivation is configured, the relevant channels are passivated. If passivation of the entire F-I/O is configured, all channels of the relevant F-I/O are passivated. Once the F-I/O fault or channel fault has been eliminated, **reintegration** of the relevant F-I/O occurs, depending on ACK_NEC:

- With ACK_NEC = 0, you can assign an **automatic reintegration**.
- With ACK_NEC = 1, you can assign a **reintegration** by **user acknowledgment**.

WARNING

The parameter assignment of the ACK_NEC tag of the F-I/O DB with the value "0" is only allowed if automatic reintegration is permitted for the relevant process from a safety standpoint. *(S010)*

NOTE

The initial value for ACK_NEC is 1 after creation of the F-I/O DB. If you do not require automatic reintegration, you do not have to write ACK_NEC.

See also

After F-I/O or channel faults (Page 183)

6.4.2.3 ACK_REI

When the F-system detects a communication error or an F-I/O fault for an F-I/O, the relevant F-I/O is passivated. If channel faults are detected and channel granular passivation is configured, the relevant channels are passivated. If passivation of the entire F-I/O is configured, all channels of the relevant F-I/O are passivated. **Reintegration** of the F-I/O/channels of the F-I/O after the fault has been eliminated requires a **user acknowledgment** with a positive edge at variable ACK_REI of the F-I/O DB:

- After every communication error
- After F-I/O or channel faults only with parameter assignment "Channel failure acknowledgement = manual" or ACK_NEC = 1

Reintegration after channel faults reintegrates all channels whose faults were eliminated.

Acknowledgment is not possible until tag ACK_REQ = 1.

In your safety program, you must provide a user acknowledgment by means of the ACK_REI tag for each F-I/O.

WARNING

A user acknowledgment (Page 196) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted. *(S011)*

NOTE

Alternatively, you can use the "ACK_GL" instruction to carry out reintegration of the F-I/O following communication errors or F-I/O/channel faults (ACK_GL: Global acknowledgment of all F-I/O in an F-runtime group (STEP 7 Safety V21) (Page 543)).

6.4.2.4 IPAR_EN

The IPAR_EN tag corresponds to the iPar_EN_C tag in the PROFIsafe bus profile as of PROFIsafe Specification V1.20 and higher.

Fail-safe GSD based DP slaves/GSD based I/O devices

To find out when this tag must be set or reset when parameters of fail-safe GSD based DP slaves/GSD based I/O devices are reassigned, consult the PROFIsafe Specification V1.20 or higher or the documentation for the fail-safe GSD based DP slave/GSD based I/O device.

Note that IPAR_EN = 1 does not trigger passivation of the relevant F-I/O.

If passivation is to occur when IPAR_EN = 1, you must also set tag PASS_ON = 1.

HART communication with SM 336; F-AI 6 x 0/4 ... 20 mA HART

If you set the IPAR_EN tag to "1" while parameter "HART_Tor" = "switchable" is assigned, the HART communication for the SM 336; F-AI 6 x 0/4 ... 20 mA HART is enabled. Setting this tag to "0" disables the HART communication. The F-SM acknowledges the enabled or disabled HART communication with tag IPAR_OK = 1 or 0.

Enable HART communication only when your system is in a status, in which any reassignment of parameters for an associated HART device can be done without any risk.

If you want to evaluate the "HART communication enabled" status in your safety program, e.g., for the purpose of programming interlocks, you must build up the information as shown in the following example. This is necessary to ensure that the information is properly available even if communication errors occur while the HART communication is enabled with IPAR_EN = 1. Only change the status of the IPAR_EN tag during this evaluation if there is no passivation due to a communication error or F-I/O or channel fault.

Example of enabling HART communication

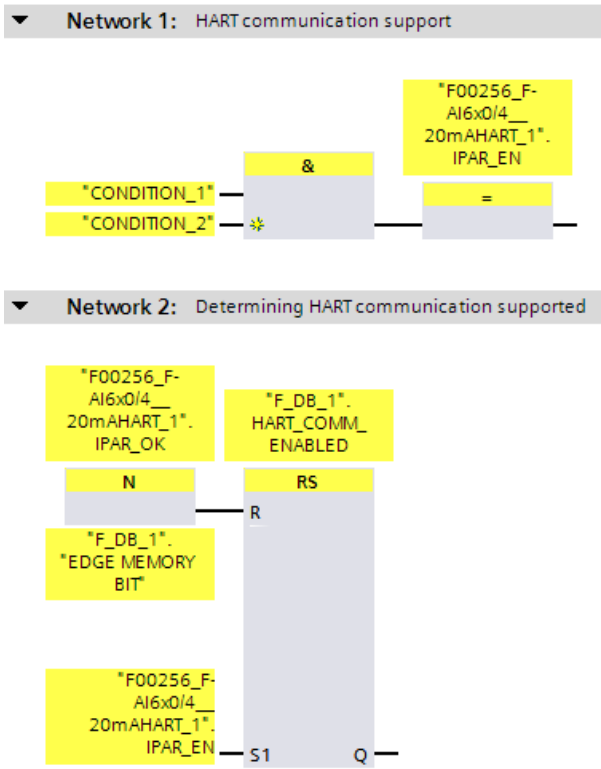

Additional information on HART communication with SM 336; F-AI 6 x 0/4 ... 20 mA HART can be found in the Automation System S7-300, ET 200M Distributed I/O System manual, Fail-Safe Signal Modules (https://support.industry.siemens.com/cs/ww/en/view/19026151) manual and in the help on the F-module.

6.4.2.5 DISABLE

The DISABLE variable allows you to deactivate an F-I/O.

As long as DISABLE = 1, the associated F-I/Os are **passivated**.

Diagnostics entries of the safety program may no longer be entered in the diagnostics buffer of the F-CPU for this F-I/O (for example, due to communication error).

Existing diagnostics entries are marked as outgoing.

6.4.2.6 QBAD/PASS_OUT/DISABLED/QBAD_I_xx/QBAD_O_xx and value status

The following table set outs differences in the reaction of the channel values and QBAD, PASS_OUT, DISABLED, QBAD_I_xx/QBAD_O_xx variables and of the value status depending on the F-I/O and F-CPU used.

<table>
<tr><th>Fail-safe value output after...</th><th>F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU</th><th>F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPUs</th><th>F-I/O with S7-300/400 F-CPU</th></tr>
<tr><td>Startup of F-system[2]</td><td colspan="2" rowspan="4">QBAD and PASS_OUT = 1
DISABLED unchanged
For all channels:
Channel value = fail-safe value (0)
Value status = 0[1]</td><td rowspan="4">QBAD and PASS_OUT = 1
For all channels:
Channel value = fail-safe value (0)
QBAD_I_xx and QBAD_O_xx = 1[1]</td></tr>
<tr><td>Communication errors</td></tr>
<tr><td>F-I/O faults</td></tr>
<tr><td>Channel faults
in configuration of passivation for complete F-I/O</td></tr>
<tr><td>Channel faults during configuration of channel-granular passivation</td><td>QBAD, PASS_OUT and DISABLED unchanged
For the affected channels:
Channel value = fail-safe value (0)
Value status = 0</td><td>QBAD and PASS_OUT = 1
DISABLED unchanged
For the affected channels:
Channel value = fail-safe value (0)
Value status = 0[1]</td><td>QBAD and PASS_OUT = 1
For the affected channels:
Channel value = fail-safe value (0)
QBAD_I_xx and QBAD_O_xx = 1[1]</td></tr>
<tr><td>As long as passivation of the F-I/O is activated in the F-I/O DB with PASS_ON = 1</td><td colspan="2">QBAD = 1, PASS_OUT and DISABLED unchanged
For all channels:
Channel value = fail-safe value (0)
Value status = 0[1]</td><td>QBAD = 1,
PASS_OUT unchanged
For all channels:
Channel value = fail-safe value (0)
QBAD_I_xx and QBAD_O_xx = 1[1]</td></tr>
<tr><td>As long as the F-I/O is deactivated in the F-I/O DB with DISABLE = 1</td><td colspan="2">QBAD, PASS_OUT and DISABLED = 1
For all channels:
Channel value = fail-safe value (0)
Value status = 0[1]</td><td>-</td></tr>
</table>

1 Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile

2 During delayed transfer of the F-Base ID, the F-system remains in startup.

6.4.2.7 ACK_REQ

When the F-system detects a communication error or an F-I/O fault or channel fault for an F-I/O, the relevant F-I/O or individual channels of the F-I/O are passivated. ACK_REQ = 1 signals that **user acknowledgment** is required for reintegration of the relevant F-I/O or channels of the F-I/O.

The F-system sets ACK_REQ = 1 as soon as the fault has been eliminated and user acknowledgment is possible. For channel-granular passivation, the F-system sets ACK_REQ = 1 as soon as the channel fault is corrected. User acknowledgment is possible for this fault. Once acknowledgment has occurred, the F-system resets ACK_REQ to 0.

NOTE

For F-I/O with outputs, acknowledgment after F-I/O or channel faults may only be possible some minutes after the fault has been eliminated, until the necessary test signal is applied (see *F-I/O manuals*).

6.4.2.8 IPAR_OK

The IPAR_OK tag corresponds to the iPar_OK_S tag in the PROFIsafe bus profile, PROFIsafe Specification V1.20 and higher.

Fail-safe GSD based DP slaves/GSD based I/O devices

To find out how to evaluate this tag when parameters of fail-safe GSD based DP slaves or GSD based I/O devices are reassigned, consult the PROFIsafe Specification V1.20 or higher or the documentation for the fail-safe GSD based DP slave/GSD based I/O device.

For HART communication with SM 336; F-AI 6 x 0/4 ... 20 mA HART see Chapter IPAR_EN (Page 172).

6.4.2.9 DIAG

The DIAG tag provides non-fail-safe information (1 byte) about errors or faults that have occurred for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits are saved until you perform an acknowledgment with the ACK_REI tag or until automatic reintegration takes place.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Timeout detected by F-I/O	The PROFIBUS/PROFINET connection between F-CPU and F-I/O is faulty. The value of the F-monitoring time for the F-I/O is set too low. The F-I/O are receiving invalid parameter assignment data or	• Check the PROFIBUS/PROFINET connection and ensure that there are no external sources of interference. • Check the parameter assignment of the F-I/O. If necessary, set a higher value for the monitoring time. Recompile the hardware configuration, and download it to the F-CPU. Recompile the safety program. • Check the diagnostics buffer of the F-I/O. • Turn the power of the F-I/O off and back on.
		Internal F-I/O fault or	Replace F-I/O
		Internal F-CPU fault	Replace F-CPU
Bit 1	F-I/O fault or channel fault detected by F-I/O[1]	See *F-I/O manuals*	See *F-I/O manuals*
Bit 2	CRC error or sequence number error detected by F-I/O	See description for bit 0	See description for bit 0
Bit 3	Reserved	—	—
Bit 4	Timeout detected by F-system	See description for bit 0	See description for bit 0
Bit 5	Sequence number error detected by F-system[2]	See description for bit 0	See description for bit 0
Bit 6	CRC-error detected by F-system	See description for bit 0	See description for bit 0
Bit 7	Addressing error[3]	—	Contact Service & Support

1 Not for F-I/O that support the "RIOforFA-Safety" profile.

2 For S7-300/400 F-CPUs only

3 For S7-1200/1500 F-CPUs only

6.4.2.10 BASEID_ACTIVE

The BASEID_ACTIVE tag contains the active F-BaseID as non-fail-safe information. The tag is available as of Safety System Version V2.8 and is only relevant if both the F-CPU and the F-I/O support PROFIsafe address type 3.

6.4.3 Accessing tags of the F-I/O DB

Rule for accessing tags of the F-I/O DB

Tags of the F-I/O DB of an F-I/O can only be accessed from the F-runtime group from which the channels of this F-I/O are accessed (if access is made).

"Fully qualified DB access"

You can access the tags of the F-I/O DB via a "fully qualified DB access" (that is, by specifying the name of the F-I/O DB and by specifying the name of the tag).

Example of evaluating the QBAD tag

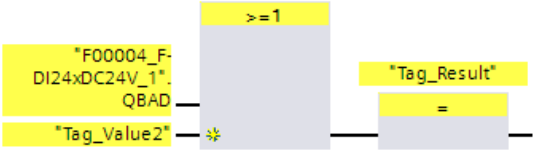

See also

F-I/O DB (Page 168)

6.5 Passivation and reintegration of F-I/O

Overview

In the following you can find information on passivation and reintegration of F-I/O.

Signal sequence charts

The signal sequences presented below represent typical signal sequences for the indicated behavior.

Actual signal sequences and, in particular, the relative position of the status change of individual signals can deviate from the given signal sequences within the scope of known "fuzzy" cyclic program execution factors, depending on the following:

- The F-I/O used
- The F-CPU used
- The cycle time of the (F-)OB in which the associated F-runtime group is called
- The target rotation time of the PROFIBUS DP or the update time of the PROFINET IO

NOTE

The signal sequences shown refer to the status of signals in the user's safety program.

6.5.1 After startup of F-system

Behavior after a startup

Fail-safe value output after startup of the F-system	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPU	Every F-I/O with S7-300/400 F-CPU
Passivation of the entire F-I/O occurs during startup.	QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*

* Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

Reintegration of F-I/O

Reintegration of the F-I/O, i.e. the provision of process values in the PII or the output of process values provided in the PIQ at the fail-safe outputs, takes place **automatically**, regardless of the setting at the ACK_NEC tag or the configuration "Channel failure acknowledge", no sooner than the second cycle of the F-runtime group after F-system startup.

You can find more information on pending F-communication, F-I/O or channel errors during startup of the F-system in the sections After communication errors (Page 181) and After F-I/O or channel faults (Page 183).

For fail-safe GSD based DP slaves/GSD based I/O devices with "RIOforFA-Safety" profile, consult the respective documentation for the fail-safe GSD based DP slave/GSD based I/O device.

Depending on the F-I/O you are using and the cycle time of the F-runtime group and PROFIBUS DP/PROFINET IO, several cycles of the F-runtime group can elapse before reintegration occurs.

If communication between the F-CPU and F-I/O takes longer to establish than the F-monitoring time set in the properties for the F-I/O, automatic reintegration does not take place.

Signal sequence for passivation and reintegration of F-I/O after F-system startup

Example for an F-I/O with inputs:

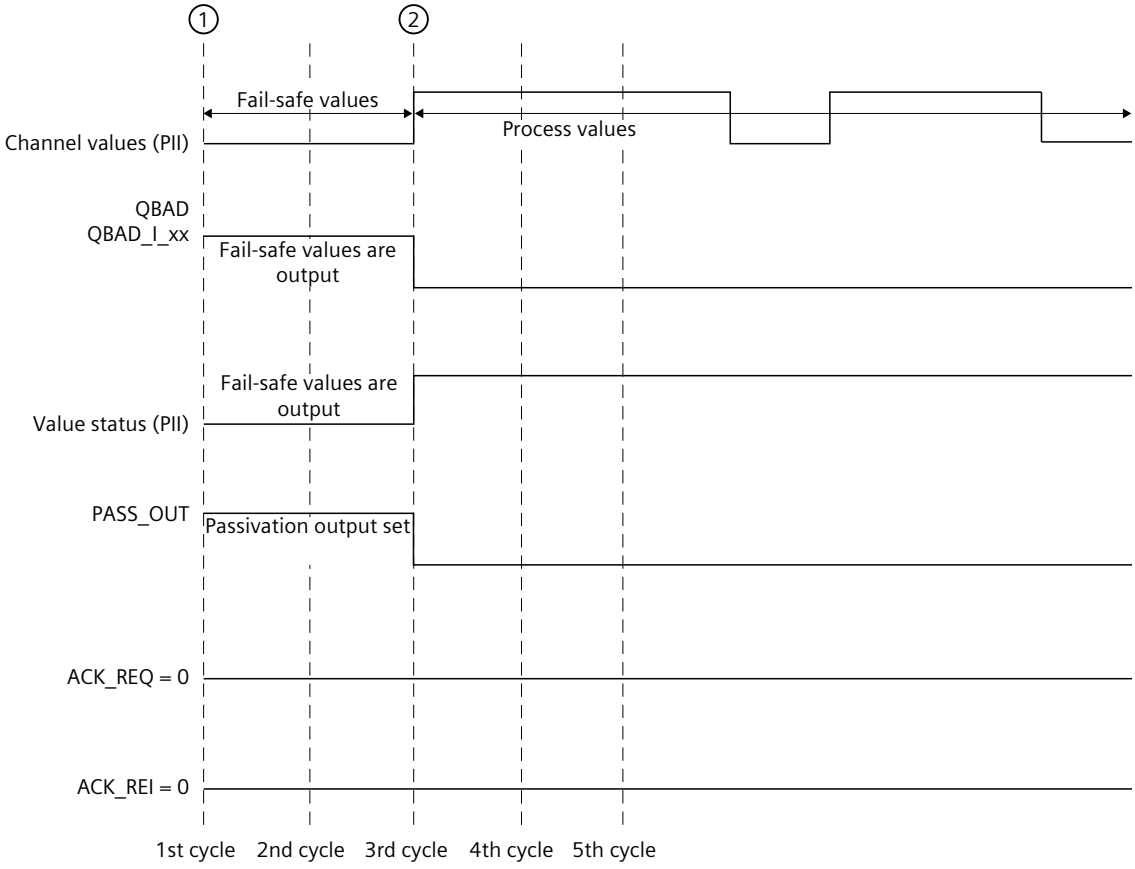

① Startup of F-system/passivation

② Automatic reintegration (e.g. third cycle)

WARNING

Unintentional restart

In contrast to the standard user program, when the safety program starts up, all tags of the F-DBs are generally initialized with their start values. This means that saved error information is lost. The F-system performs automatic reintegration of the F-I/O.

If an unintentional startup of your process is not allowed, you must program restart/startup protection in the safety program. For this, the output of process values must be blocked until user acknowledgment takes place (see "Implementation of user acknowledgment (Page 196)"). This user acknowledgment must not take place until safe output of process values is possible (see "Programming startup protection (Page 159)").

You must expect an unintentional restart in the following cases:

- After a STOP generated by PG/PC operation, mode switch, communication function or "STP" instruction
- After an operating error
- After a STOP caused by a fault reaction function
- The following applies to the S7-1500 F Virtual Controller:

  After a STOP or a restart of the S7-1500 F Virtual Controller via Industrial Edge Management.

(S008)

6.5.2 After communication errors

Behavior after communication errors

Fail-safe value output after communication errors	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPU	Every F-I/O with S7-300/400 F-CPU
If a communication error between the F-CPU and the F-I/O is detected, all channels of the entire F-I/O are passivated.	QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*

* Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

Reintegration of F-I/O

Reintegration of the relevant F-I/O, that is, provision of process values in the PII or output of process data provided in the PIQ at the fail-safe outputs, takes place only when the following occurs:

- All communication errors have been eliminated and the F-system has set tag ACK_REQ = 1
- A **user acknowledgment** with a positive edge has occurred:
  - At the ACK_REI tag of the F-I/O DB (Page 171) or
  - At the ACK_REI_GLOB input of the "ACK_GL" instruction (ACK_GL: Global acknowledgment of all F-I/O in an F-runtime group (STEP 7 Safety V21) (Page 543))

Signal sequence for passivation and reintegration of F-I/O after communication errors

Example for an F-I/O with inputs:

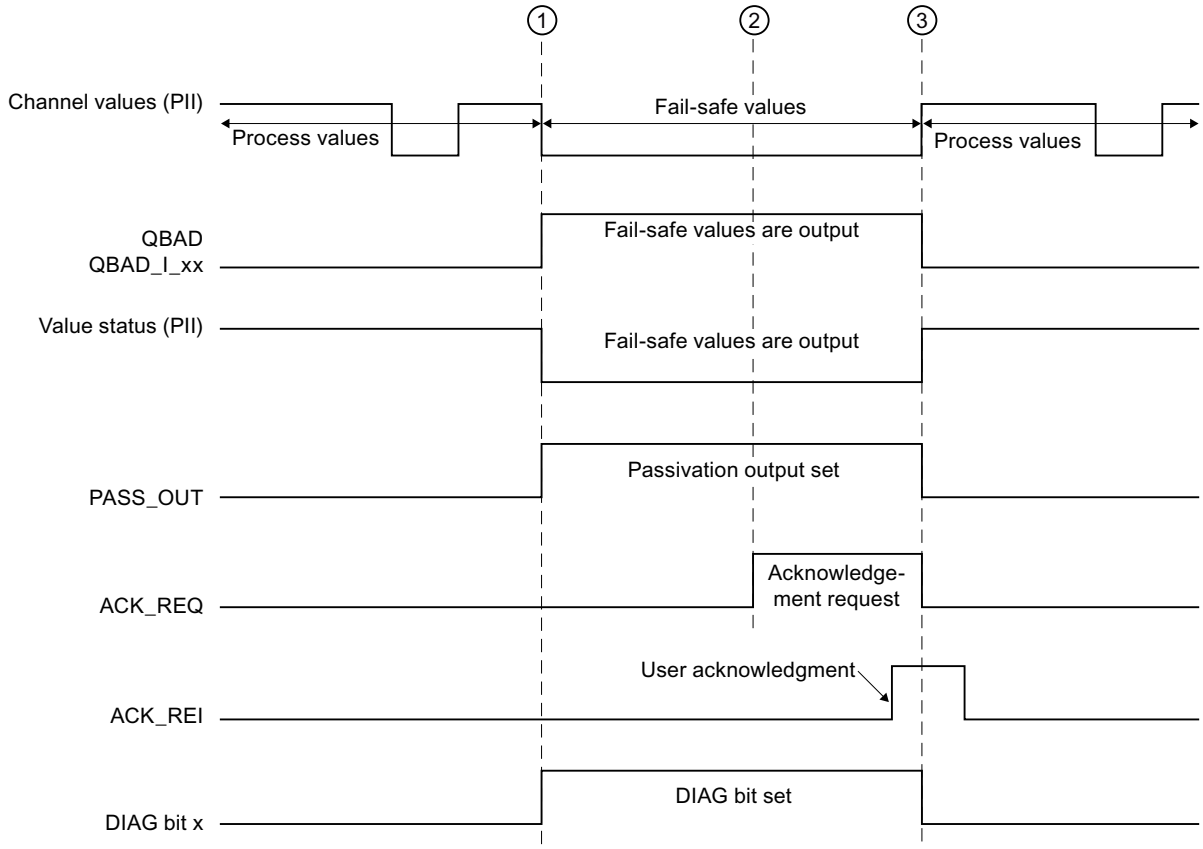

① Communication error/passivation
② All communication errors have been eliminated
③ Reintegration

See also

Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller (Page 196)

Implementing user acknowledgment in the safety program of the F-CPU of a I-slave or I-device (Page 201)

6.5.3 After F-I/O or channel faults

Behavior after F-I/O faults

Fail-safe value output after F-I/O faults	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPU	Every F-I/O with S7-300/400 F-CPU
If an F-I/O fault is detected by the F-system, passivation of all channels of the entire F-I/O occurs.	QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*

* Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

Behavior after channel fault

Fail-safe value output after channel faults	F-I/O with "RIOforFA-Safety" profile with S7-1200/1500 F-CPU	F-I/O without profile "RIOforFA-Safety" with S7-1200/1500 F-CPU	Every F-I/O with S7-300/400 F-CPU
When passivation for **complete** F-I/O is configured: If a channel fault is detected by the F-system, passivation of all channels of the entire F-I/O occurs.	QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) Value status = 0*		QBAD and PASS_OUT = 1 For **all** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*
With configuration of **channel-granular** passivation: If a channel fault is detected by the F-system, passivation of all the affected channels of the entire F-I/O occurs.	QBAD and PASS_OUT **unchanged** For the **affected** channels: Channel value = fail-safe value (0) Value status = 0	QBAD and PASS_OUT = 1 For the **affected** channels: Channel value = fail-safe value (0) Value status = 0*	QBAD and PASS_OUT = 1 For the **affected** channels: Channel value = fail-safe value (0) QBAD_I_xx and QBAD_O_xx = 1*

* Value status or QBAD_I_xx and QBAD_O_xx are not available for fail-safe GSD based DP slaves and fail-safe GSD based I/O devices without the "RIOforFA-Safety" profile.

Reintegration of F-I/O

Reintegration of the relevant F-I/O or the relevant channels of the F-I/O, that is, provision of process data in the PII or output of process data provided in the PIQ at the failsafe outputs, takes place only when the following occurs:

- All F-I/O or channel faults have been eliminated.

If you have configured channel-granular passivation for the F-I/O, the relevant channels are reintegrated once the fault is corrected; any faulty channels remain passivated.

Reintegration is performed depending on your setting for the ACK_NEC tag or the "Channel failure acknowledge" parameter (configuration of the S7-1500/ET 200MP F-module and S7-1200 F-module)

- With ACK_NEC = 0 or the configuration "Channel failure acknowledge = automatic", **automatic reintegration** is performed as soon as the F-system detects that the fault has been corrected. For F-I/O with inputs, reintegration takes place right away. For F-I/O with outputs or F-I/O with inputs and outputs, depending on the F-I/O you are using, reintegration can take several minutes, first after the necessary test signals have been applied, which are used by the F-I/O to determine that the fault has been eliminated.
- With ACK_NEC = 1 or the configuration "Channel failure acknowledge = manual", reintegration is performed only as a result of user acknowledgment with a positive edge at the ACK_REI tag of the F-I/O DB or at the ACK_REI_GLOB input of the "ACK_GL" instruction. Acknowledgment can be made as soon as the F-system detects that the fault has been eliminated and tag ACK_REQ = 1 has been set.

  For fail-safe GSD based I/O devices with "RIOforFA-Safety" profile, consult the respective documentation for the fail-safe GSD based I/O device .

⚠ WARNING

Following a supply voltage failure of the F-I/O lasting less than the F-monitoring time assigned for the F-I/O, automatic reintegration can occur regardless of the setting for the ACK_NEC tag or the "Channel failure acknowledge" configuration.

If automatic reintegration is not permitted for the relevant process in this case, you must program startup protection by evaluating tags QBAD or QBAD_I_xx and QBAD_O_xx or value status or PASS_OUT.

In the event of a supply voltage failure of the F-I/O lasting longer than the specified F-monitoring time for the F-I/O, the F-system detects a communication error. *(S012)*

Signal sequence for passivation and reintegration of F-I/O after F-I/O faults or channel faults when ACK_NEC = 0 or configuration "Channel failure acknowledge = automatic" (for passivation of entire F-I/O after channel faults)

Example for an F-I/O with inputs:

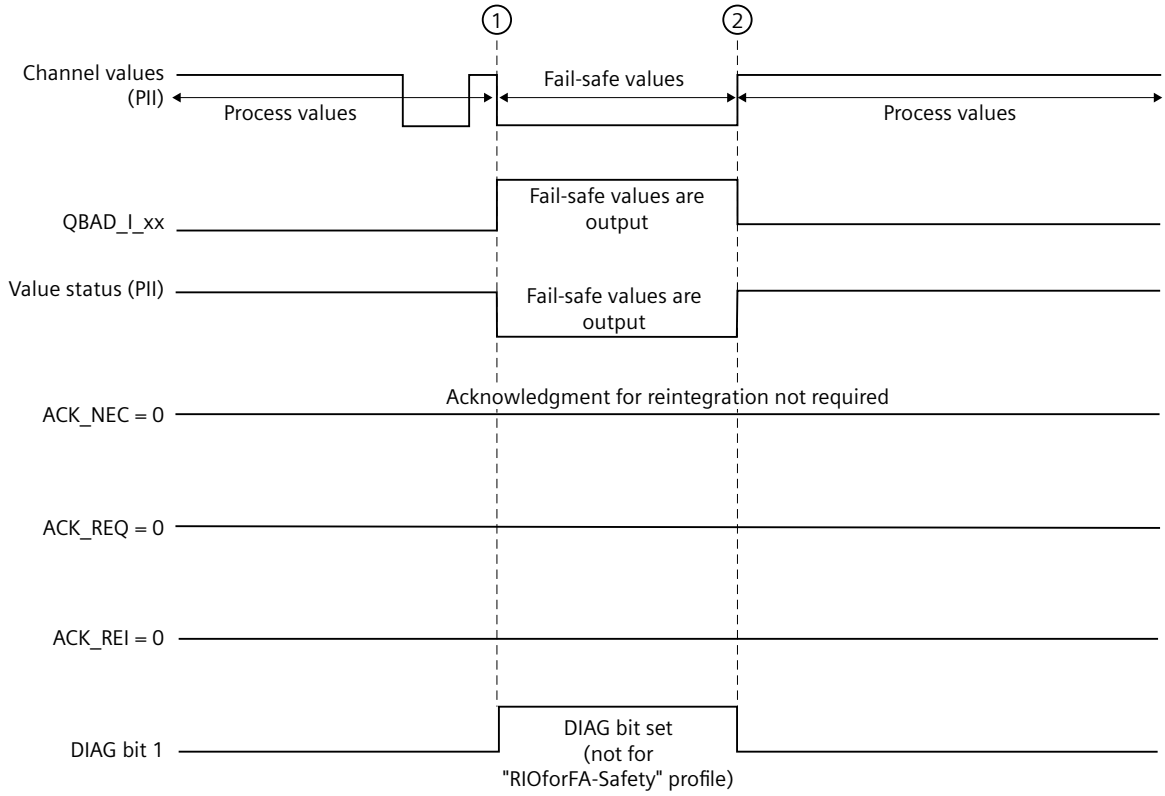

① F-I/O or channel faults
Passivation

② F-I/O or channel faults corrected
Automatic reintegration

Signal sequence for passivation and reintegration of F-I/O after F-I/O faults or channel faults when ACK_NEC = 1 or configuration "Channel failure acknowledge = manual" (for passivation of entire F-I/O after channel faults)

For the signal sequence for passivation and reintegration of F-I/O after F-I/O or channel faults when ACK_NEC = 1 or configuration "Channel failure acknowledge = manual" (initial value), see After communication errors (Page 181).

Signal sequence for passivation and reintegration of F-I/O after channel faults when ACK_NEC = 1 or configuration "Channel failure acknowledge = manual" (for channel-granular passivation)

Example for an F-I/O with inputs:

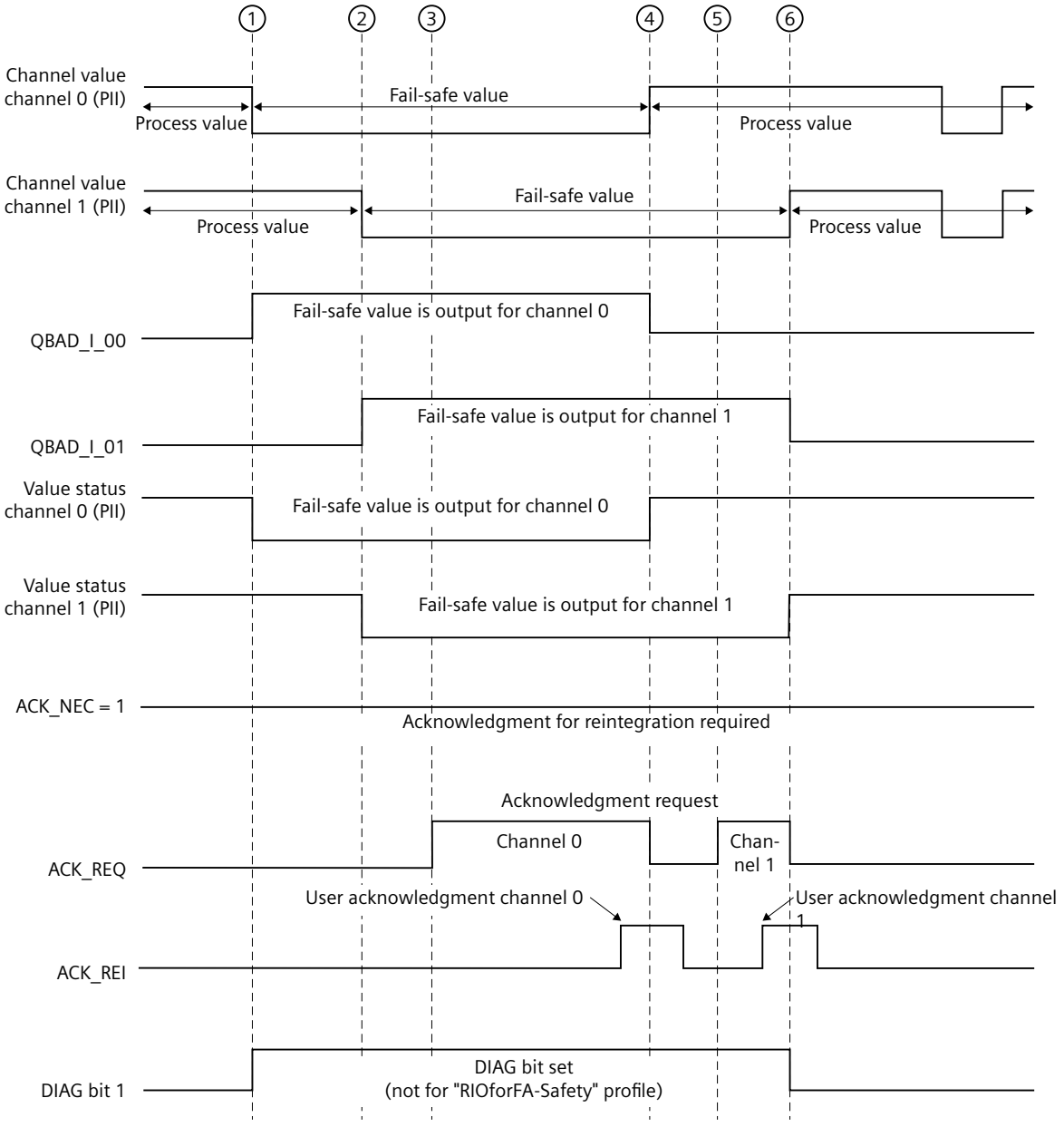

① Channel fault for channel 0/passivation of channel 0
② Channel fault for channel 1/passivation of channel 1
③ Channel fault eliminated for channel 0
④ Reintegration of channel 0
⑤ Channel fault eliminated for channel 1
⑥ Reintegration of channel 1

6.5.4 Group passivation

Programming a group passivation

If you want to enable passivation of additional F-I/O when an F-I/O or a channel of an F-I/O is passivated by the F-system, you can use the PASS_OUT/PASS_ON tags to perform **group passivation** of the associated F-I/O.

Group passivation by means of PASS_OUT/PASS_ON can, for example, be used to force simultaneous reintegration of all F-I/O after startup of the F-system.

For group passivation, you must OR all PASS_OUT tags of the F-I/O in the group and assign the result to all PASS_ON tags of the F-I/O in the group.

During use of fail-safe values (0) due to group passivation by means of PASS_ON = 1, the QBAD tag of the F-I/O of this group = 1.

NOTE

Note the different behavior of PASS_OUT for F-I/O with/without "RIOforFA-Safety" profile (see table in section QBAD/PASS_OUT/DISABLED/QBAD_I_xx/QBAD_O_xx and value status (Page 174)).

Example of group passivation

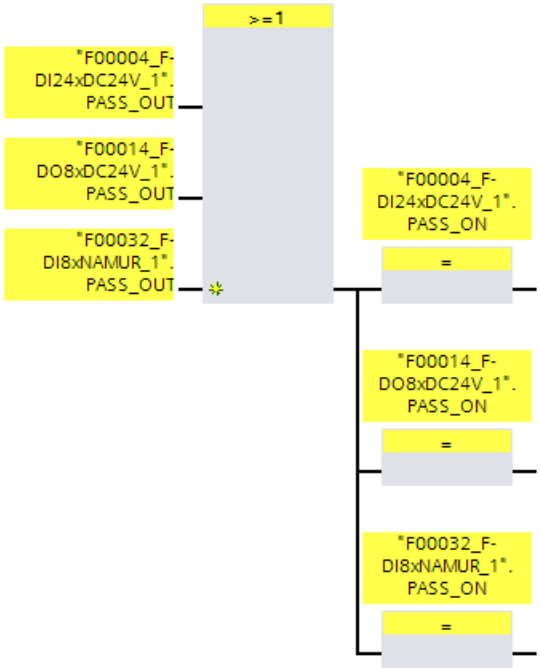

Reintegration of F-I/O

Reintegration of F-I/O passivated by group passivation occurs **automatically**, if a reintegration (**automatic** or **through user acknowledgment**) occurs for the F-I/O that triggered the group passivation (PASS_OUT = 0).

Signal sequence for group passivation following communication error

Example for two F-I/O with inputs:

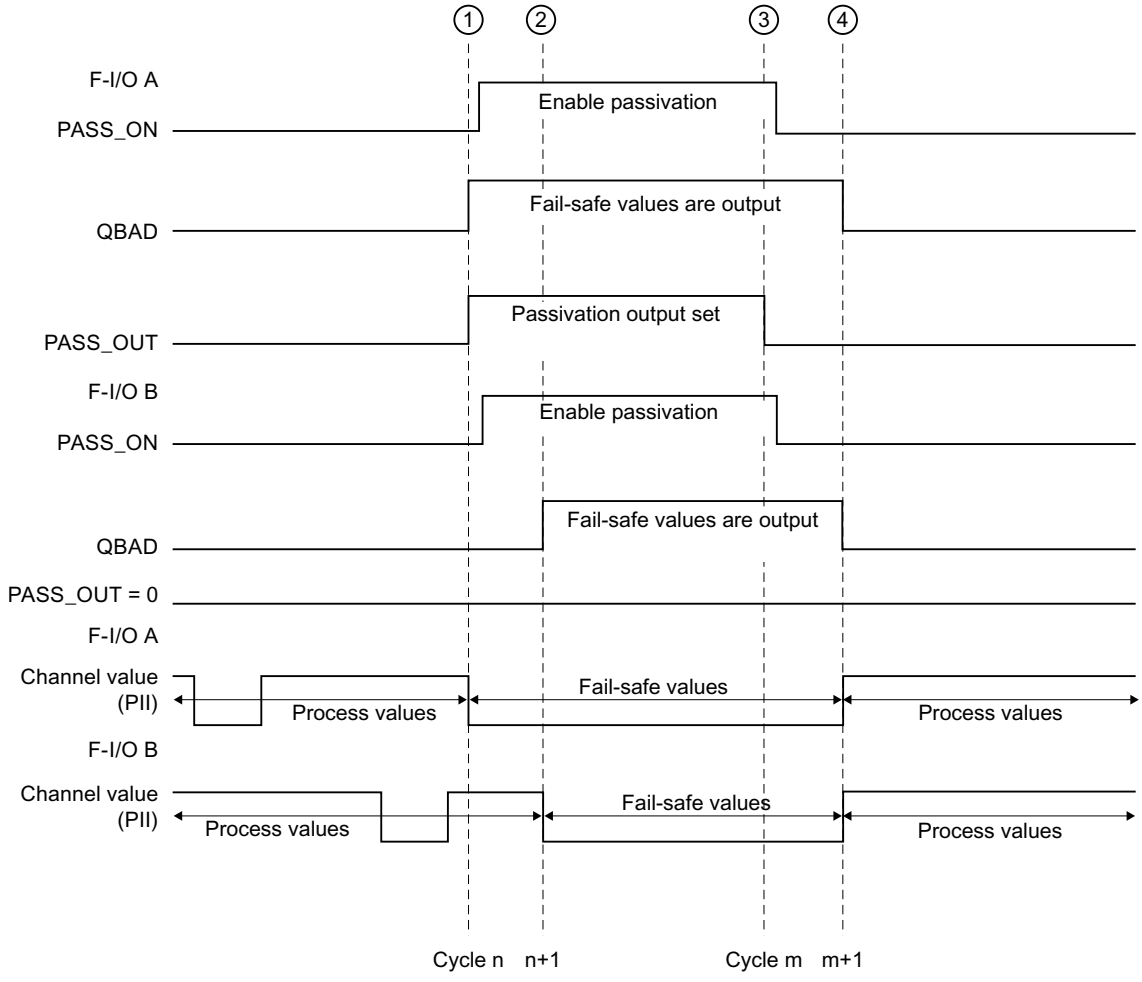

① Communication error in F-I/O A
Passivation of F-I/O A

② Passivation of F-I/O B

③ Communication error in F-I/O A corrected and acknowledged

④ Reintegration F-I/O A and B

6.6 F-I/O access via I-slave-slave communication (S7-300, S7-400)

6.6.1 Overview

Principle of F-I/O access via I-slave-slave communication

The following figure shows the principle of F-I/O access via I-slave-slave communication.

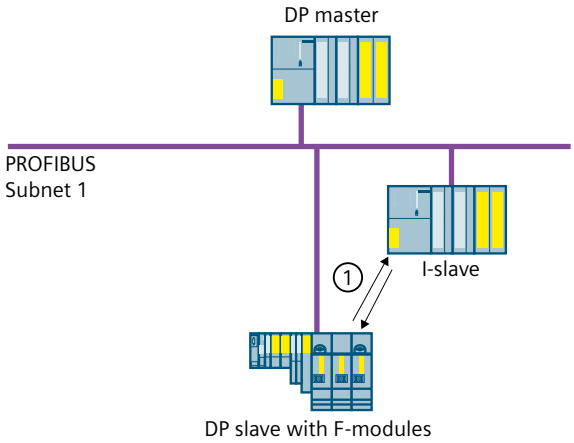

① F-I/O access via I-slave-slave communication

F-I/O access via I-slave-slave communication

F-I/O access via I-slave-slave communication is possible with F-I/O in a DP slave that supports safety-related I-slave-slave communication, for example with all ET 200SP F-modules with IM 155-6 DP HF, firmware > V3.1, with all ET 200S F-modules with IM 151-1 HF, with all fail-safe S7-300 signal modules with IM 153-2, as of article number 6ES7153-2BA01-0XB0, firmware > V4.0.0.

Safety-related communication between the safety program of the F-CPU of an I-slave and F-I/O of a DP slave takes place using direct data exchange, as in the standard program. The process image is used to access the channels of the F-I/O in the safety program of the F-CPU of the I-slave.

6.6.2 Configuring Safety-Related I-Slave-Slave Communication

Introduction

Safety-related communication between the safety program of the F-CPU of an I-slave and F-I/O in a DP slave takes place using direct data exchange (**F**-DX-Mod), same as in standard programs.

You do not need any additional hardware for I-slave-slave communication.

I-slave-slave communication is also possible:

- when the assigned DP master is a standard CPU, if the standard CPU supports direct data exchange
- when instead of a DP master, an IO controller is networked with the I-slaves via an IE/PB link

An F-I/O DB is automatically generated for each F-I/O when it is configured in the *hardware and network editor*; this is required for the F-I/O access via safety-related I-slave-slave communication. The F-I/O DB is initially created in the safety program of the DP master, provided it is an F-CPU with F-activation. Only with the setup of the F-DX-Mod connection is the F-I/O DB created in the safety program of the I-slave and deleted in the safety program of the DP master.

The process image input is used to access the channels of the F-I/O in the safety program of the F-CPU of the I-slave (see description in Safety-related I-slave-slave communication - F-I/O access via process image (Page 195)).

Restrictions

NOTE

Safety-related I-slave-slave communication with F-I/O is possible in a DP slave that supports safety-related I-slave-slave communication, for example with all ET 200SP F-modules with IM 155-6 DP HF, firmware > V3.1, with all ET 200S F-modules with IM 151-1 HF, with all fail-safe S7-300 signal modules with IM 153-2, as of article number 6ES7153-2BA01-0XB0, firmware > V4.0.0.

NOTE

With safety-related I-slave-slave communication, make sure that the CPU of the DP master is powered up before the F-CPU of the I-slave.

Otherwise, depending on the F-monitoring time specified for the F-I/O, the F-system can detect an error in safety-related communication (communication error) between the F-CPU and the F-I/O assigned to the I-slave. This means that the F-I/O are not reintegrated automatically after F-system startup. They are instead only reintegrated after a user acknowledgment with a positive edge in the ACK_REI tag of the F-I/O DB (see also After communication errors (Page 181) and After startup of F-system (Page 178)).

Configuring transfer areas

For every safety-related communication connection between an I-slave and slave, you must configure transfer areas in the *hardware and network editor*.

The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-DX-Mod_PLC_2-PLC_1_1" for the first F-DX-Mod connection between F-CPU 1 and F-CPU 2.

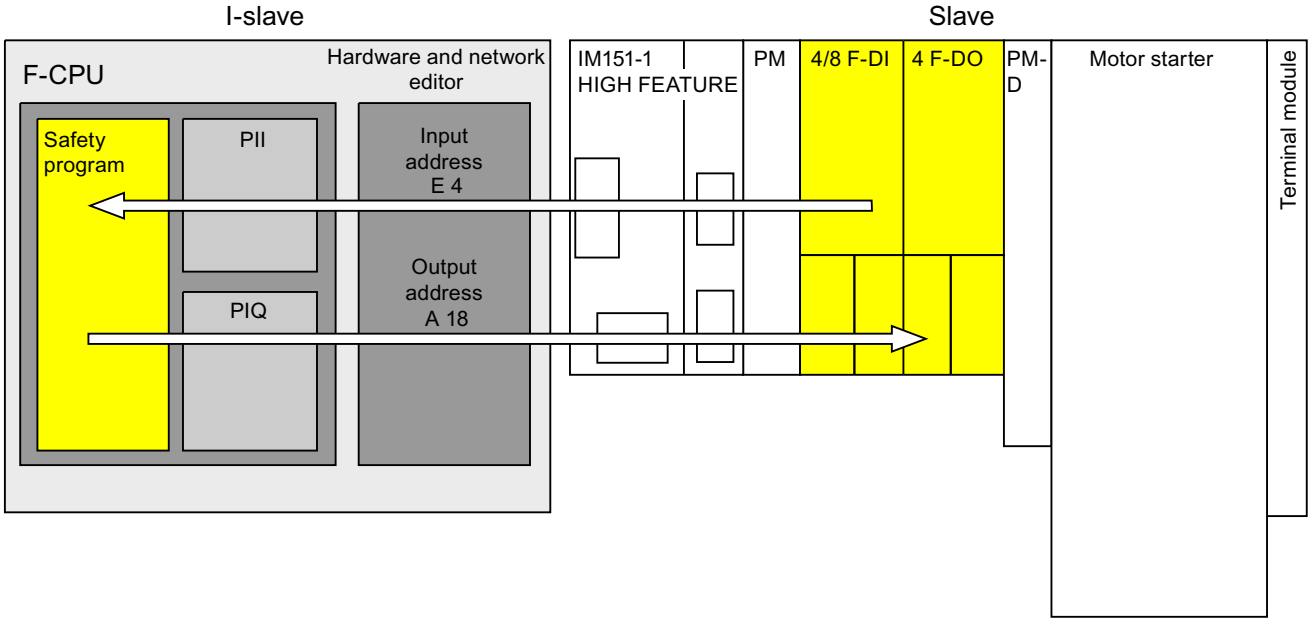

Configuration procedure using the example of an ET 200S with F-modules in the slave

The procedure for configuring safety-related I-slave-slave communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Insert a suitable DP slave, e.g. IM 151-1 HF, article no. 6ES7151-1BA0... from the "Hardware catalog" task card into the network view of the *hardware and network editor*.
3. Insert a power module, a 4/8 F-DI module and a 4 F-DQ module in the device view of the ET 200S.
4. Activate "DP slave" mode (I-slave) for F-CPU 2 in the properties of its DP interface and assign this to F-CPU 1.
5. Assign the DP interface of the IM 151-1 HF to the DP master (F-CPU 1).
6. Select the DP interface of F-CPU 2 (I-slave) in the network view.
7. Select the "I/O communication" tab.

8. Use a drag-and-drop operation in the network view to move the ET 200S to the "Partner 2" column in the "I/O-communication" tab.

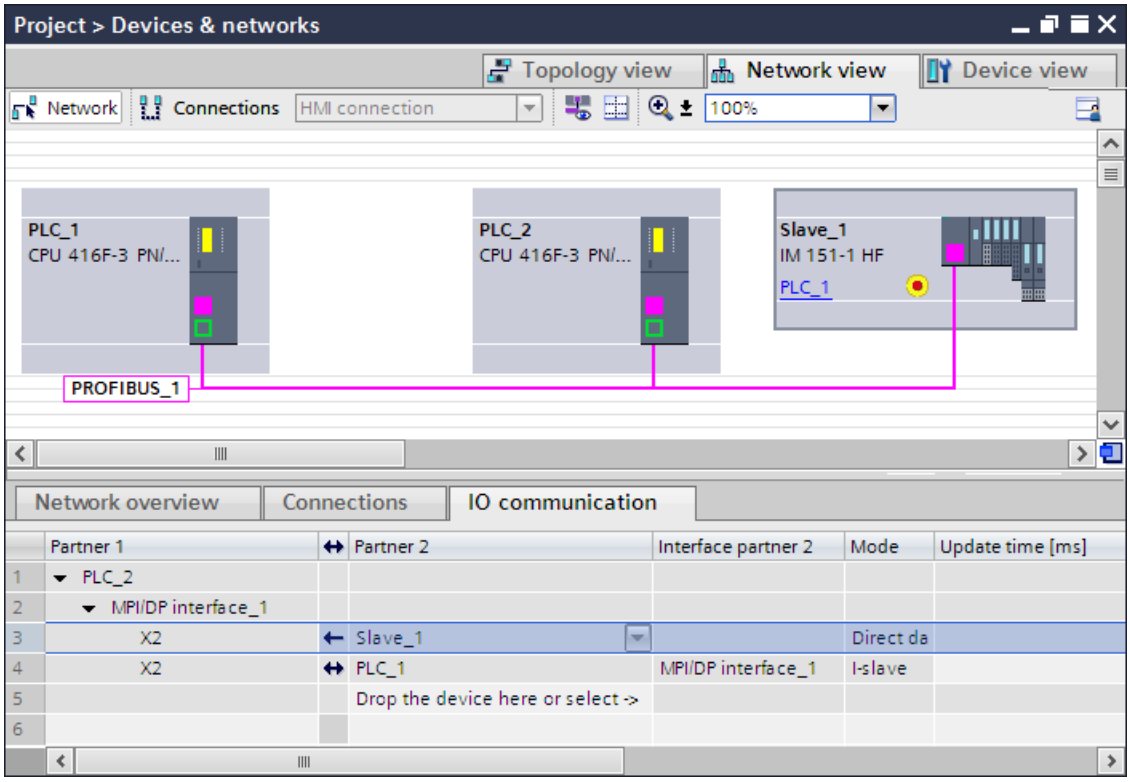

9. Click in the newly created line (←).
10. In "Transfer areas", create an F-DX-Mod connection (type "F-DX-Mod"). The F-DX-Mod connection is marked in yellow in the table. The addresses for the "partner module" 4/8 F-DI in the I-Slave (PLC_2) are displayed. You can change the addresses directly in the table, if required.

    This completes the configuration for the 4/8 F-DI module.
11. In "Transfer areas", create another F-DX-Mod connection.

12. Change the partner module to the 4 F-DO module, either directly in the "Transfer areas" table or in the details of transfer area 2, if the 4 F-DO module was not already selected.

    This completes the configuration for the 4 F-DO module.

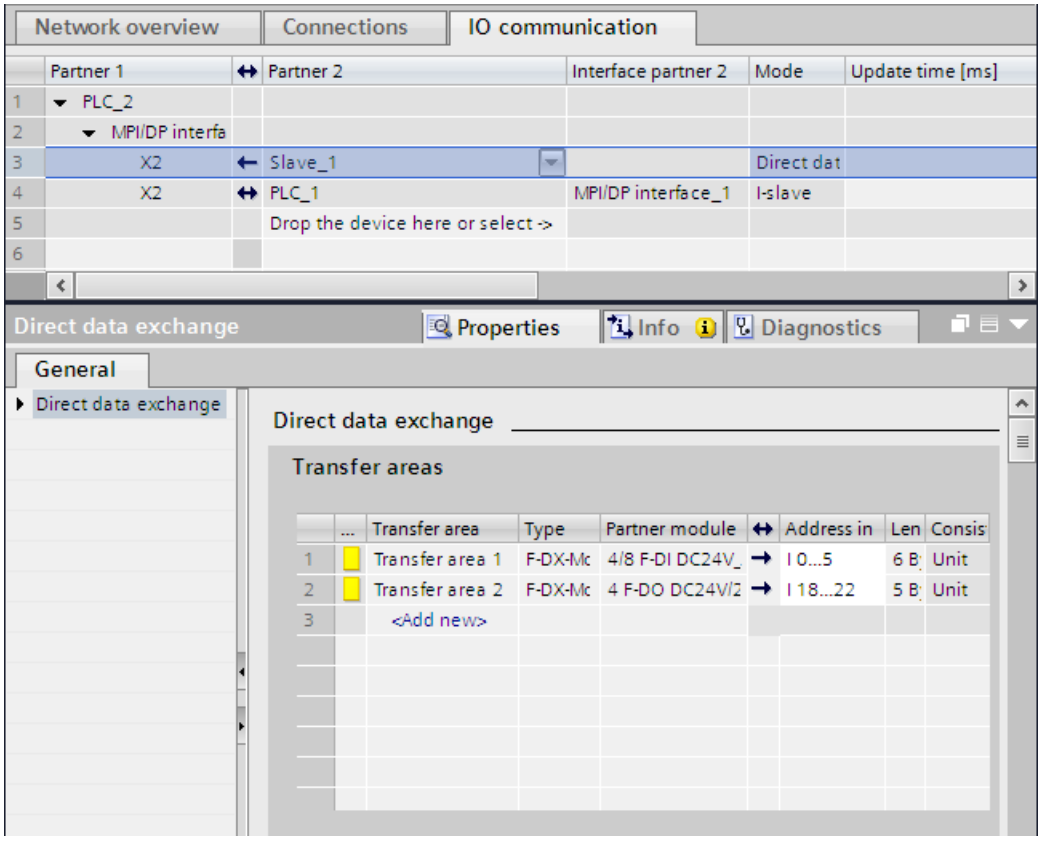

In the "I-slave communication table" of the I-slave, a transfer area (type F-MS) for the master CPU is automatically created for each F-DX-Mod connection:

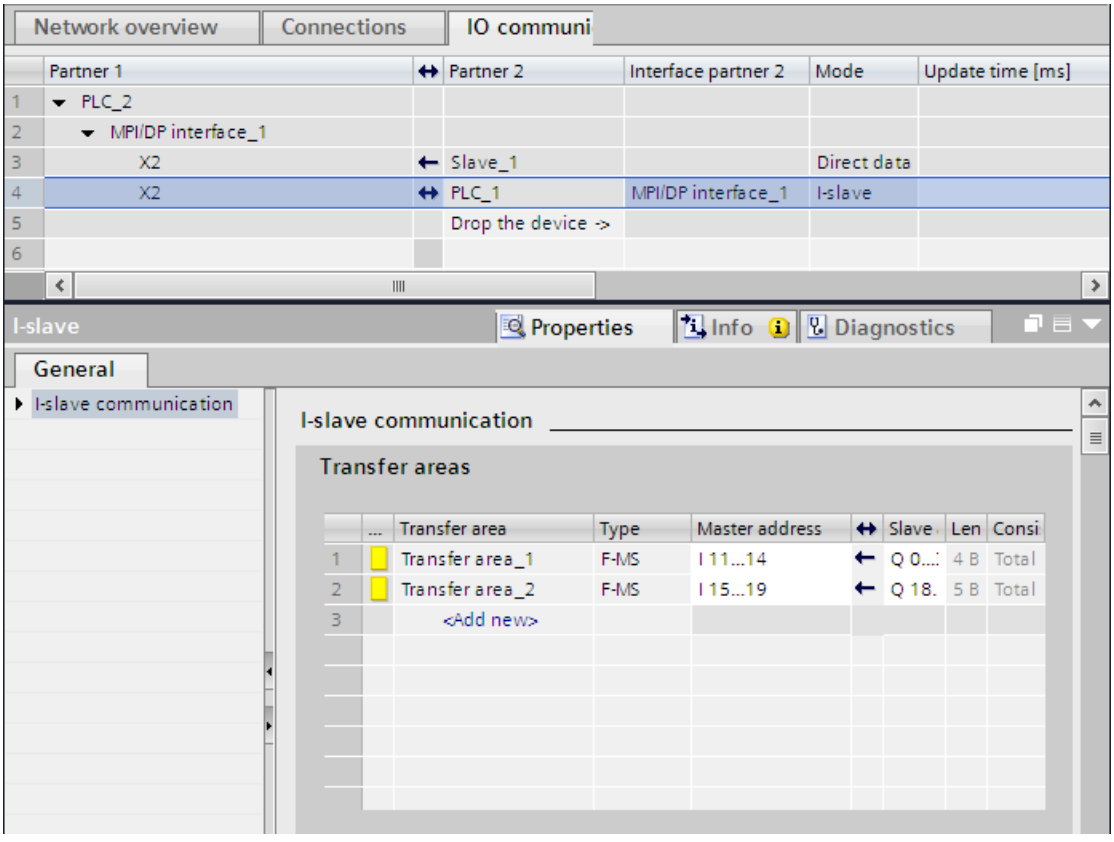

Change in configuration of I-slave-slave communication

WARNING

If you have added or deleted I-slave-slave communication for an F-I/O, you must compile and download the hardware configuration of the DP master as well as the hardware configuration of the I-slave.

The Collective F-Signature in the F-CPU of the I-slave and the Collective F-Signature in the F-CPU of the DP master (if a safety program exists there, too) are set to "0". You must then recompile the safety program(s). *(S019)*

6.6.3 Safety-related I-slave-slave communication - F-I/O access via process image

For F-I/O access via I-slave-slave communication, you use the process image (PII or PIQ) to access the F-I/O in the Safety program of the F-CPU of the I-slave. This is the same as F-I/O access to F-I/O that are directly assigned to an I-slave or DP master. In the I-slave you access the F-I/O with the addresses that were assigned for the F-DX-Mod connection in "Transfer areas" ("Direct data exchange" table).

In this case, ignore the displayed operand area. Access F-I/O with inputs using the PII and F-I/O with outputs using PIQ.

Information on I/O access can be found in F-I/O access (Page 161).

6.6.4 Limits for data transfer of safety-related I-slave-I-slave communication

Limits for data transfer

Note the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-slave and a DP master.

An example of the amount of output data and input data that are assigned for safety-related communication is shown in the table below for an ET 200S 4/8 F-DI and an ET 200S 4 F-DO:

Safety-related communication	Communication connection	Assigned input and output data*	
		Between I-slave and DP master	
		Output Data in the I-slave	Input data in the I-slave
I-slave-slave	I-slave-slave communication with 4/8 F-DI	4 bytes	6 bytes
	I-slave-slave communication with 4 F-DO	5 bytes	5 bytes

* Example for 4/8 F-DI and 4 F-DO of ET 200S

Consider all additional configured safety-related and standard communication connections (F-MS, F-DX, F-DX-Mod., MS and DX connections) for the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-slave and a DP master. If the maximum limit of 244 bytes of input data or 244 bytes of output data is exceeded, you will receive a corresponding error message.

Implementation of user acknowledgment 7

7.1 Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller

Options for user acknowledgment

Depending on the result of the risk analysis, you have the following options for implementing a user acknowledgment:

- With an acknowledgment key that you connect to an F-I/O with inputs.
- With an operator control and monitoring system.
- With an acknowledgment key that you connect to a standard I/O with inputs.
- By other mechanisms for reading in the user acknowledgment.

User acknowledgment by means of acknowledgment key

NOTE

When you implement user acknowledgment by means of acknowledgment key, and a communication error, an F-I/O fault, or a channel fault occurs in the F-I/O to which the acknowledgment key is connected, then it will not be possible to acknowledge the reintegration of this F-I/O.

This "blocking" can only be removed by a STOP-to-RUN transition of the F-CPU. In a redundant S7-1500HF system, you must set both HF CPUs or the redundant S7-1500HF system to STOP before you restart the HF CPUs.

Consequently, it is recommended that you also provide for an acknowledgment by means of an operator control and monitoring system, in order to acknowledge reintegration of an F-I/O to which an acknowledgment key is connected.

A user acknowledgment may be issued using an acknowledgment key connected to a standard I/O with inputs or other mechanisms for reading the user acknowledgment if the risk analysis allows this.

User acknowledgment by means of an operator control and monitoring system

For implementation of a user acknowledgment by means of an operator control and monitoring system, the ACK_OP: Fail-safe acknowledgment (STEP 7 Safety V21) (Page 619) instruction is required.

Procedure for programming user acknowledgment by means of an operator control and monitoring system (S7-300, S7-400)

1. Select the "ACK_OP" instruction in the "Instructions" task card and place it in your safety program. The acknowledgment signal for evaluating user acknowledgments is provided at output OUT of ACK_OP.
2. On your operator control and monitoring system, set up a field for manual entry of an "acknowledgment value" of "6" (1st step in acknowledgment) and an "acknowledgment value" of "9" (2nd step in acknowledgment).

   or

   Assign function key 1 to transfer an "acknowledgment value" of "6" (1st step in acknowledgment) once, and function key 2 to transfer an "acknowledgment value" of "9" (2nd step in acknowledgment) once. You must assign the InOut IN (in the data area of the ACK_OP instruction) to the field or the function keys.
3. Optional: In your operator control and monitoring system, evaluate output Q in the instance DB of ACK_OP to show the time frame within which the 2nd step in acknowledgment must occur or to indicate that the 1st step in acknowledgment has already occurred.

If you want to perform a user acknowledgment exclusively from a programming device or PC using the watch table (monitor/modify tag) without having to disable safety mode, then you must transfer an operand (memory word or DBW of a DB of the standard user program) at InOut IN when calling ACK_OP. You can then transfer "acknowledgment values" "6" and "9" on the programming device or PC by modifying the memory word or DBW of a DB once. The memory word or DBW of a DB must not be written by the program.

NOTE

If you connect the InOut IN to a memory word or DBW of a DB, you must use a separate memory word or DBW of a DB of the standard user program for each instance of the ACK_OP instruction at the InOut IN.

⚠ WARNING

The two acknowledgment steps must **not** be triggered by one single operation, for example, by programming them including the time conditions and using one function key to trigger them.

The two separate acknowledgment steps also prevent erroneous triggering of an acknowledgment, for example, by your non-fail-safe operator control and monitoring system. *(S013)*

WARNING

If you have operator control and monitoring systems and F-CPUs that are interconnected and use the ACK_OP instruction for fail-safe acknowledgment, you need to ensure that the intended F-CPU will be addressed **before** you perform the two acknowledgment steps.

- Store a network-wide* unique name for the F-CPU in a DB of your standard user program in each F-CPU.
- In your operator control and monitoring system, set up a text box from which you can read out the F-CPU name from the DB online before executing the two acknowledgment steps.
- Optional:

  In your operator control and monitoring system, set up a text box to permanently store the F-CPU name. Then, you can determine whether the intended F-CPU is being addressed by simply comparing the F-CPU name read out online with the permanently stored name. *(S014)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet.

NOTE

The configuration of your operator control and monitoring system does not have any effect on the Collective F-Signature.

Procedure for programming user acknowledgment by means of an operator control and monitoring system (S7-1200, S7-1500)

1. Select the "ACK_OP" instruction in the "Instructions" task card and place it in your safety program. The acknowledgment signal for evaluating user acknowledgments is provided at output OUT of ACK_OP.
2. Assign the ACK_ID input an identifier between 9 and 30000 for the acknowledgment.
3. Assign the InOut IN a memory word or DBW of a DB of the standard user program.

   NOTE

   You must supply the InOut IN with a separate memory word or DBW of a DB of the standard user program for each instance of the ACK_OP instruction.

4. On your operator control and monitoring system, set up a field for manual entry of an "acknowledgment value" of "6" (1st step in acknowledgment) and the "Identifier" configured at the ACK_ID input (2nd step in acknowledgment).

   or

   Allocate a function key 1 for a one-time transfer of the "acknowledgment value" of "6" (1st step in acknowledgment) and a function key 2 for a one-time transfer of the "Identifier" set at the ACK_ID input (2nd step in acknowledgment).
   You must assign the memory word or the DBW of the DB of the standard user program assigned to the InOut IN to the field or the function keys.

5. Optional: In your operator control and monitoring system, evaluate output Q in the instance DB of ACK_OP to show the time frame within which the 2nd step in acknowledgment must occur or to indicate that the 1st step in acknowledgment has already occurred.

WARNING

The two acknowledgment steps must not be triggered by one single operation, for example, by programming them including the time conditions and using one function key to trigger them.

The two separate acknowledgment steps also prevent erroneous triggering of an acknowledgment, for example, by your non-fail-safe operator control and monitoring system. *(S013)*

WARNING

If you have operator control and monitoring systems and F-CPUs that are interconnected and use the ACK_OP instruction for fail-safe acknowledgment, you need to ensure that the intended F-CPU will be addressed **before** you perform the two acknowledgment steps.

Alternative 1:

- The value for each identifier of the acknowledgment (ACK_ID input; data type: INT) can be freely selected in the range from 9 to 30000, but must be unique network-wide* for all instances of the ACK_OP instruction.
  You must supply the ACK_ID input with constant values when calling the instruction. Direct read or write access to the ACK_ID tag in the associated instance DB is not permitted!

Alternative 2:

- Store a network-wide* unique name for the F-CPU in a DB of your standard user program in each F-CPU.
- In your operator control and monitoring system, set up a text box from which you can read out the F-CPU name from the DB online before executing the two acknowledgment steps.
- Optional:
  In your operator control and monitoring system, set up a text box to permanently store the F-CPU name. Then, you can determine whether the intended F-CPU is being addressed by simply comparing the F-CPU name read out online with the permanently stored designation. *(S047)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet.

NOTE

The supply of the IN iInOut of the ACK_OP instruction as well as the configuration of your operator control and monitoring system do not have any effect on the Collective F-Signature, the Collective F-SW-Signature or the signature of the block that calls the ACK_OP instruction.

Changes to the supply of the IN InOut or to the configuration of your operator control and monitoring system therefore do not result in a changed Collective F-Signature/Collective F-SW-Signature/signature of the calling block.

Example of procedure for programming a user acknowledgment for reintegrating an F-I/O

1. Optional: set the ACK_NEC tag in the respective F-I/O DB (Page 171) to "0" if automatic reintegration (without user acknowledgment) is to take place after an F-I/O fault or a channel fault.

   WARNING

   The parameter assignment of the ACK_NEC tag of the F-I/O DB with the value "0" is only allowed if automatic reintegration is permitted for the relevant process from a safety standpoint. *(S010)*

2. Optional: Evaluate the QBAD or QBAD_I_xx/QBAD_O_xx (S7-300, S7-400) tags or value status (S7-1200, S7-1500) or DIAG in the respective F-I/O DB to trigger an indicator light in the event of an error, and/or generate error messages on the operator control and monitoring system in your standard user program by evaluating the above tags or the value status. These messages can be evaluated before performing the acknowledgment operation. Alternatively, you can evaluate the diagnostic buffer of the F-CPU.
3. Optional: Evaluate the ACK_REQ tag in the respective F-I/O DB, for example, in the standard user program or on the operator control and monitoring system, to query or to indicate whether user acknowledgment is required.
4. Assign the input of the acknowledgment key or the OUT output of the ACK_OP instruction to the ACK_REI tag in the respective F-I/O DB or the ACK_REI_GLOB input of the ACK_GL instruction (see above).

7.2 Implementing user acknowledgment in the safety program of the F-CPU of a I-slave or I-device

Options for user acknowledgment

You can implement a user acknowledgment by means of:

1. An HMI system that you can use to access the F-CPU of the I-slave/I-Device
2. An acknowledgment key that you connect to an F-I/O with inputs that is assigned to the F-CPU of the I-slave/I-Device
3. An acknowledgment key that you connect to an F-I/O with inputs that is assigned to the F-CPU of the DP master/IO controller

These three options are illustrated in the figure below.

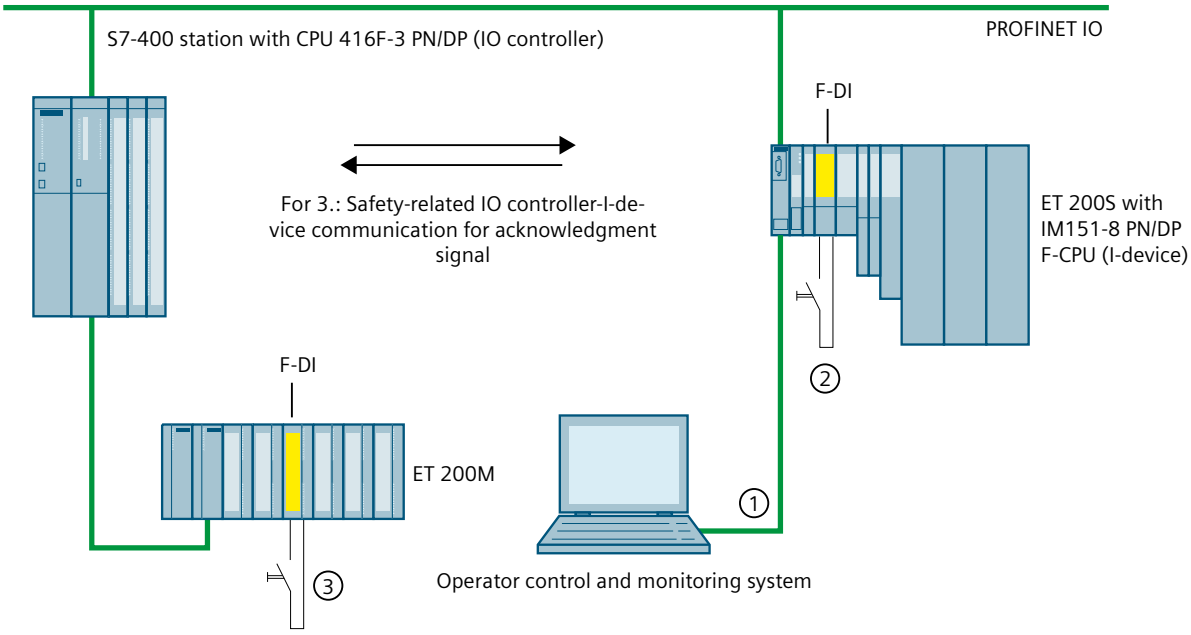

1. User acknowledgment by means of an HMI system with which you can access the F-CPU of the I-slave/I-device

The ACK_OP: Fail-safe acknowledgment (STEP 7 Safety V21) (Page 619) instruction is required to implement user acknowledgment with an HMI system that you can use to access the F-CPU of the I-slave/I-device.

Programming procedure

Follow the procedure described in "Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller (Page 196)" under "Programming procedure ...".

From your HMI system, you can then directly access the instance DB of ACK_OP in the I-slave/I-Device.

2. User acknowledgment by means of an acknowledgment key at an F-I/O with inputs that are assigned to the F-CPU of the I-slave/I-device

NOTE

In the event of a communication error, F-I/O fault, or channel fault in the F-I/O to which the acknowledgment key is connected, an acknowledgment for reintegration of this F-I/O is no longer possible.

This "blocking" can only be removed by a STOP-to-RUN transition of the F-CPU of the I-slave/I-Device.

Consequently, it is recommended that you also provide for an acknowledgment by means of an HMI system that you can use to access the F-CPU of the I-slave/I-device, in order to acknowledge reintegration of an F-I/O to which an acknowledgment key is connected (see 1).

3. User acknowledgment by means of an acknowledgment key at an F-I/O with inputs that are assigned to the F-CPU of the DP master/IO controller

If you want to use the acknowledgment key that is assigned to the F-CPU at the DP master/IO controller to perform user acknowledgment in the safety program of the F-CPU of an I-slave/I-device as well, you must transmit the acknowledgment signal from the safety program in the F-CPU of the DP master/IO controller to the safety program in the F-CPU of the I-slave/I-device using safety-related master-I-slave/IO controller-I-device communication.

Programming procedure

1. Place the SENDDP (Page 627) instruction in the safety program in the F-CPU of the DP master/IO controller.
2. Place the RCVDP (Page 627) instruction in the safety program in the F-CPU of the I-slave/I-Device.
3. Supply an input SD_BO_xx of SENDDP with the input of the acknowledgment key.
4. The acknowledgment signal for evaluating user acknowledgments is now available at the corresponding RD_BO_xx output of RCVDP.

   The acknowledgment signal can now be read in the program sections in which further processing is to take place with fully qualified access directly in the associated instance DB (for example, "RCVDP_DB".RD_BO_02).

5. Supply the corresponding input SUBBO_xx of RCVDP with FALSE (fail-safe value 0) to ensure that user acknowledgment is not accidentally triggered before communication is established for the first time after startup of the sending and receiving F-systems, or in the event of a safety-related communication error.

NOTE

If a communication error, an F-I/O error, or a channel fault occurs at the F-I/O to which the acknowledgment key is connected, then an acknowledgment for reintegration of this F-I/O will no longer be possible.

This "blocking" can only be removed by a STOP-to-RUN transition of the F-CPU of the DP master/IO controller.

Consequently, it is recommended that you also provide for an acknowledgment by means of an HMI system that you can use to access the F-CPU of the DP master/IO controller, in order to acknowledge reintegration of the F-I/O to which an acknowledgment key is connected.

If a safety-related master-I-slave/IO controller-I-Device communication error occurs, the acknowledgment signal cannot be transmitted, and an acknowledgment for reintegration of safety-related communication is no longer possible.

This "blocking" can only be removed by a STOP-to-RUN transition of the F-CPU of the I-slave/I-Device.

Consequently, it is recommended that you also provide for an acknowledgment by means of an HMI system that you can use to access the F-CPU of the I-slave/I-Device, in order to acknowledge reintegration of the safety-related communication for transmission of the acknowledgment signal (see 1).

Data exchange between standard user program and safety program

8

You have the option of transferring data between the safety program and the standard user program. Tags can be transferred using DBs, F-DBs and bit memory:

	From the standard user program		From the safety program	
	Read access	**Write access**	**Read access**	**Write access**
Tag from DB	Permitted	Permitted	A tag from the DB can be read-accessed *or* write-accessed	
Tag from F-DB	Permitted	**Not permitted**	Permitted	Permitted
Bit memory	Permitted	Permitted	Bit memory can be read-accessed *or* write-accessed	

You can also access the process image of the standard I/O and F-I/O:

		From the standard user program		From the safety program	
		Read access	**Write access**	**Read access**	**Write access**
Process image of standard I/O	PII	Permitted	Permitted	Permitted	**Not permitted**
	PIQ	Permitted	Permitted	**Not permitted**	Permitted
Process image of F-I/O	PII	Permitted	**Not permitted**	Permitted	**Not permitted**
	PIQ	Permitted	**Not permitted**	**Not permitted**	Permitted

Note possible restrictions/particularities when using Software Units or a Safety Unit (Page 118).

Decoupling of the safety program from the standard user program

For data exchange between standard user program and safety program, we recommend that you define special data blocks (transfer data blocks) in which the data to be exchanged is stored. This action allows you to decouple the blocks of the standard user program and the safety program. The changes in the standard user program do not affect the safety program (and vice versa) provided these data blocks are not modified.

8.1 Data Transfer from the Safety Program to the Standard User Program

Reading data of the safety program in the standard user program

The standard user program can read all data of the safety program, for example using symbolic (fully qualified) accesses to the following:

- The instance DBs of the F-FBs ("Name of instance DB".Signal_x)
- F-DBs (for example "Name of F_DB".Signal_1)

- The process image input and output of F-I/O (for example "Emergency_Stop_Button_1" (I 5.0))

NOTE

For S7-300/400 F-CPUs

The process image input of F-I/O is updated not only at the start of the F-runtime group, but also by the standard operating system.

To find the standard operating system update times, refer to the *Help on STEP 7* under "Process image input and output". For F-CPUs that support process image partitions, also bear in mind the update times when process image partitions are used. For this reason, when the process image input of F-I/O is accessed in the standard user program, it is possible to obtain different values than in the safety program. The differing values can occur due to:

– Different update times
– Use of fail-safe values in the safety program

To obtain the same values in the standard user program as in the safety program, you must not access the process image input in the standard program until after execution of an F-runtime group. In this case, you can also evaluate the QBAD or QBAD_I_xx tag in the associated F-I/O DB in the standard user program, in order to find out whether the process image input is receiving fail-safe values (0) or process data. When using process image partitions, also make sure that the process image is not updated by the standard operating system or by the UPDAT_PI instruction between execution of an F-runtime group and evaluation of the process image input in the standard user program.

NOTE

For S7-1200/1500 F-CPUs

The process image input of F-I/O is updated prior to processing the main safety block.

During the data transfer from the safety program to the standard user program, the integrity of the safety program and the safety-related data is not checked (see also section "Product Overview (Page 22)").

Writing data from the safety program to the standard user program

You can also write safety program data directly in the safety program to the standard user program (see also the table of supported operand areas in: Restrictions in the programming languages FBD/LAD (Page 121)).

This is also true for non-fail-safe service information (e.g. outputs DIAG of the fail-safe instructions).

Note the table in section "Data exchange between standard user program and safety program (Page 204)".

When writing to a tag of the ARRAY data type, the index can either be a constant or a tag.

8.2 Data Transfer from Standard User Program to Safety Program

As a basic principle, only fail-safe data or fail-safe signals from F-I/O and other safety programs (in other F-CPUs) can be processed in the safety program, as standard tags are unsafe.

If you have to process tags from the standard user program in the safety program, however, you can evaluate either bit memory, tags from a standard DB, or the process image input (PII) of standard I/O in the safety program (see table of supported operand areas in: Restrictions in the programming languages FBD/LAD (Page 121)).

Note the table in section "Data exchange between standard user program and safety program (Page 204)".

When reading a tag of the ARRAY data type, the index must be a constant. Tags are not permitted as index.

Note that structural changes to standard data blocks which are used in the safety program lead to inconsistencies of the safety program and can therefore only be executed if access permission for the safety-related project data is available. In this case the Collective F-Signature is the same as the original again after compilation. To prevent this effect, use "transfer data blocks" between the standard user program and the safety program.

WARNING

Because the values in these tags are not generated safely, you must program additional process-specific plausibility checks in the safety program to ensure that no dangerous states can arise. If bit memory, a tag of a standard DB, or an input of standard I/O is used in both F-runtime groups, you must perform the plausibility check separately in each F-runtime group. *(S015)*

To facilitate checks, all PLC tags from the standard user program that are evaluated in the safety program are printed out when creating the safety summary. (Page 400)

PLC tags from the standard user program that are evaluated in know-how-protected F-blocks are not included in the safety summary. The plausibility check must already be implemented by the creator of the know-how protected F-blocks.

Examples: Programming plausibility checks

- Use Comparison (Page 559) instructions to check whether tags from the standard user program exceed or fall below permitted high and low limits. You can then influence your safety function with the result of the comparison.
- Use the ---(S)---: Set output (STEP 7 Safety V21) (Page 478), ---(R)---: Reset output (STEP 7 Safety V21) (Page 476) or SR: Set/reset flip-flop (STEP 7 Safety V21) (Page 479) instructions, for example, with tags from the standard user program to allow a motor to be switched off, but not switched on.
- For switch-on sequences, use the AND logic operation instruction, for example, to logically combine tags from the standard user program with switch-on conditions that you derive from fail-safe tags.

If you want to process tags from the standard user program in the safety program, bear in mind that there is not a sufficiently simple method of checking plausibility for all tags.

Reading tags from the standard user program that can change during the runtime of an F-runtime group

If you want to read tags from the standard user program (bit memory, tags of a standard DB, or PII of standard I/O) in the safety program, and these tags can be changed - either by the standard user program or an operator control and monitoring system - during runtime of the F-runtime group in which they are read (for example because your standard user program is being processed by a higher-priority cyclic interrupt), you must use bit memory or tags of a standard DB for this purpose. We recommend using standard FCs for preprocessing (Page 88) for S7-1200/1500 F-CPUs.

(S7-300, S7-400) You must write the bit memory or tags of a standard DB with the tags from the standard user program immediately before calling the F-runtime group.

You are then permitted to access only this bit memory or these tags of a standard DB in the safety program.

Also note that **clock memory** that you defined when configuring your F-CPU in the "Properties" tab can change during runtime of the F-runtime group, since clock memory runs asynchronously to the F-CPU cycle.

NOTE

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Safety-related communication 9

9.1 Communication via SENDDP/RCVDP or SENDS7/RCVS7(S7-300, S7-400) instructions:

9.1.1 Overview

Introduction

This section gives an overview of the options for safety-related communication options using the SENDDP/RCVDP or SENDS7/RCVS7 instructions in SIMATIC Safety F-systems.

Options for safety-related CPU-CPU communication

Safety-related CPU-CPU communication	On subnet	Additional hardware required	Required instructions
IO controller-IO controller communication	PROFINET IO	PN/PN coupler	SENDDP/RCVDP
Master-master communication	PROFIBUS DP	DP/DP coupler	SENDDP/RCVDP
IO controller-I-device communication	PROFINET IO	—	SENDDP/RCVDP
Master-I-slave communication	PROFIBUS DP	—	SENDDP/RCVDP
I-slave-I-slave communication	PROFIBUS DP	—	SENDDP/RCVDP
IO controller-I-slave communication	PROFINET IO and PROFIBUS DP	IE/PB link	SENDDP/RCVDP
Safety-related communication via S7 connections	Industrial Ethernet	—	SENDS7/RCVS7
IO controller-IO controller communication for S7 Distributed Safety	PROFINET IO	PN/PN coupler	SENDDP/RCVDP
Master-master communication for S7 Distributed Safety	PROFIBUS DP	DP/DP coupler	SENDDP/RCVDP
Safety-related communication to S7 Distributed Safety or S7 F Systems via S7 connections	Industrial Ethernet	—	SENDS7/RCVS7

Overview of safety-related communication via PROFIBUS DP

The figure below presents an overview of the three options for safety-related communication via PROFIBUS DP in SIMATIC Safety F-systems with S7-300/400 F-CPUs.

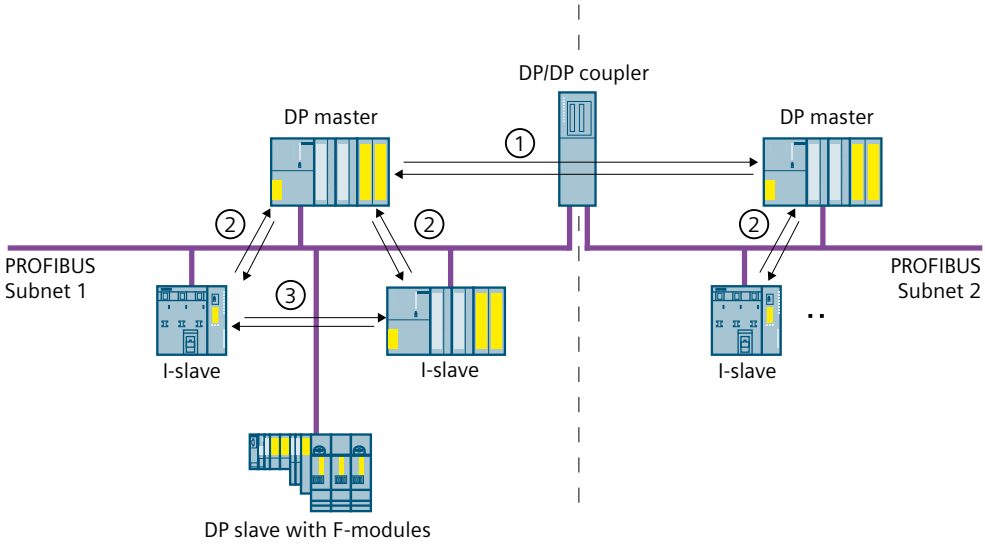

① Safety-related master-master communication

② Safety-related master-I-slave communication

③ Safety-related I-slave-I-slave communication

Overview of safety-related communication via PROFINET IO

The figure below presents an overview of the four options for safety-related communication via PROFINET IO in SIMATIC Safety F-systems with S7-300/400 F-CPUs. If an IE/PB-link is used, safety-related communication is possible between assigned I-slaves.

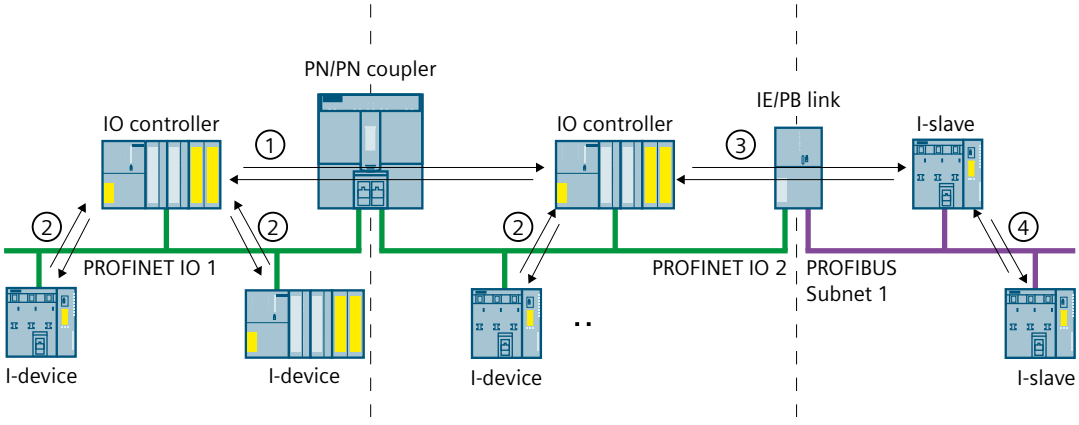

① Safety-related IO controller-IO controller communication

② Safety-related IO controller-I-device communication

③ Safety-related IO controller-I-slave communication

④ Safety-related I-slave-I-slave communication integrating an IO controller

Safety-related CPU-CPU communication via PROFIBUS DP or PROFINET IO

In safety-related CPU-CPU communication, a fixed amount of fail-safe data of the data type INT or BOOL is transmitted fail-safe between the safety programs in F-CPUs of DP masters/I-slaves or IO controllers/I-devices.

The data are transferred using the SENDDP instruction for sending and the RCVDP instruction for receiving. The data are stored in configured transfer areas of the devices. Each transfer area consists of one input and one output address area.

Safety-related I-slave-slave communication via PROFIBUS DP

Safety-related I-slave-slave communication with F-I/O is possible in a DP slave that supports safety-related I-slave-slave communication, for example with all ET 200SP F-modules with IM 155-6 DP HF, firmware > V3.1, with all ET 200S F-modules with IM 151-1 HF, with all fail-safe S7-300 signal modules with IM 153-2, as of article number 6ES7153-2BA01-0XB0, firmware > V4.0.0.

Safety-related communication between the safety program of the F-CPU of an I-slave and F-I/O of a DP slave takes place using direct data exchange, as in the standard program. The process image is used to access the channels of the F-I/O in the safety program of the F-CPU of the I-slave.

Safety-related CPU-CPU communication via Industrial Ethernet

Safety-related CPU-CPU communication via Industrial Ethernet is possible using S7 connections, both from and to the following:

- S7-300 F-CPUs via the integrated PROFINET interface
- S7-400 F-CPUs via the integrated PROFINET interface or a CP 443-1 or CP 443-1 Advanced-IT

In safety-related communication via S7 connections, a specified amount of fail-safe data of data type BOOL, INT, WORD, DINT, DWORD, or TIME is transferred fail-safe between the safety programs of the F-CPUs linked by the S7 connection.

The data transfer makes use of the SENDS7 instruction for sending and the RCVS7 instruction for receiving. Data are exchanged using one F-DB ("F-communication DB") each at the sender and receiver ends.

Safety-related CPU-CPU communication with *S7 Distributed Safety* or *S7 F-systems*

Safety-related communication is possible from F-CPUs in *SIMATIC Safety* to F-CPUs in *S7 Distributed Safety* or *S7 F-systems*.

9.1.2 Safety-related IO controller-IO controller communication

9.1.2.1 Configure safety-related IO controller-IO controller communication

Introduction

Safety-related communication between safety programs of the F-CPUs of IO controllers takes place over a PN/PN coupler that you set up between the F-CPUs.

For 416F-2 DP CPUs without an integrated PROFINET interface, use a CP 443-1 or CP 443-1 Advanced-IT.

NOTE

Deactivate the "Data validity display DIA" parameter in the properties for the PN/PN coupler in the *hardware and network editor*. This is the default setting. Otherwise, safety-related IO controller-IO controller communication is not possible.

Configuring transfer areas

You must configure one transfer area for output data and one transfer area for input data in the *hardware and network editor* for each safety-related communication connection between two F-CPUs in the PN/PN coupler. The figure below shows how both of the F-CPUs are able to send **and** receive data (bidirectional communication). One transfer area for output data and one transfer area for input data must be configured in the PN/PN coupler for each of the two communication connections.

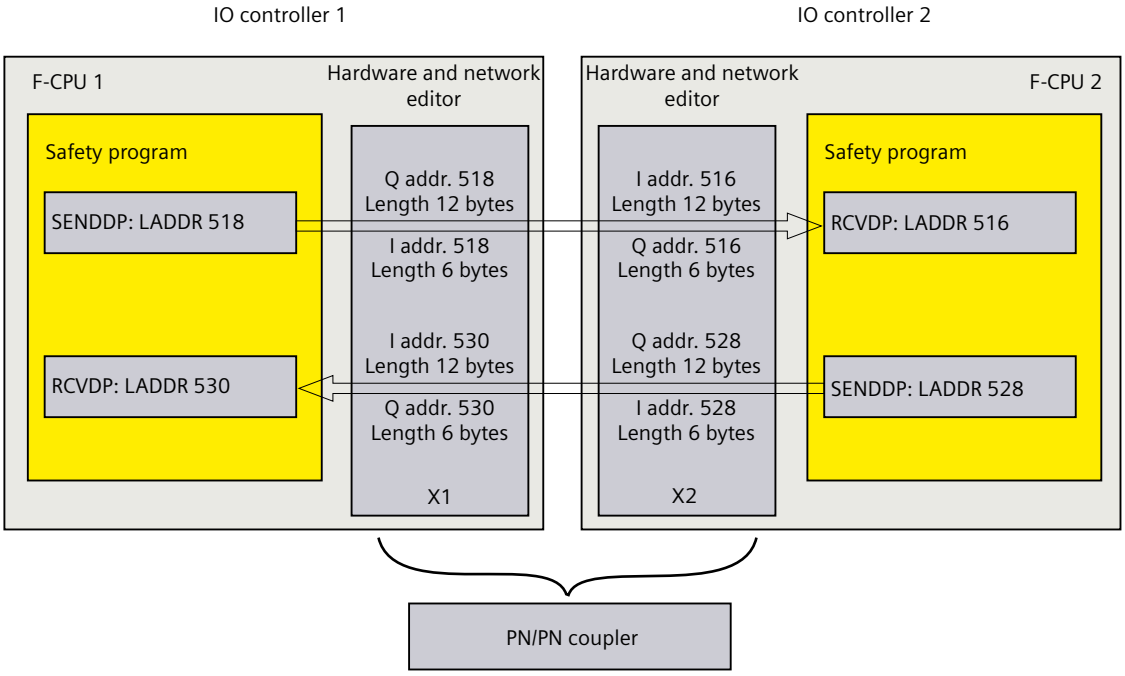

Rules for defining transfer areas

The transfer area for output data and the transfer area for input data for the **data to be sent** must begin with the same start address. A total of 12 bytes (consistent) is required for the transfer area for output data; 6 bytes (consistent) are required for the transfer area for input data.

The transfer area for input data and the transfer area for output data for the **data to be received** must begin with the same start address. A total of 12 bytes (consistent) is required for the transfer area for input data; 6 bytes (consistent) are required for the transfer area for output data.

Procedure for configuration

The procedure for configuring safety-related IO controller-IO controller communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Switch to the network view of the *hardware and network editor*.
3. Select a PN/PN Coupler X1 and a PN/PN Coupler X2 from "Other field devices\PROFINET IO\Gateway\Siemens AG\PN/PN Coupler" in the "Hardware catalog" task card and insert them into the network view of the hardware and network editor.
4. Connect the PN interface of the F-CPU 1 with the PN interface of the PN/PN Coupler X1 and the PN interface of the F-CPU 2 with the PN interface of PN/PN Coupler X2.

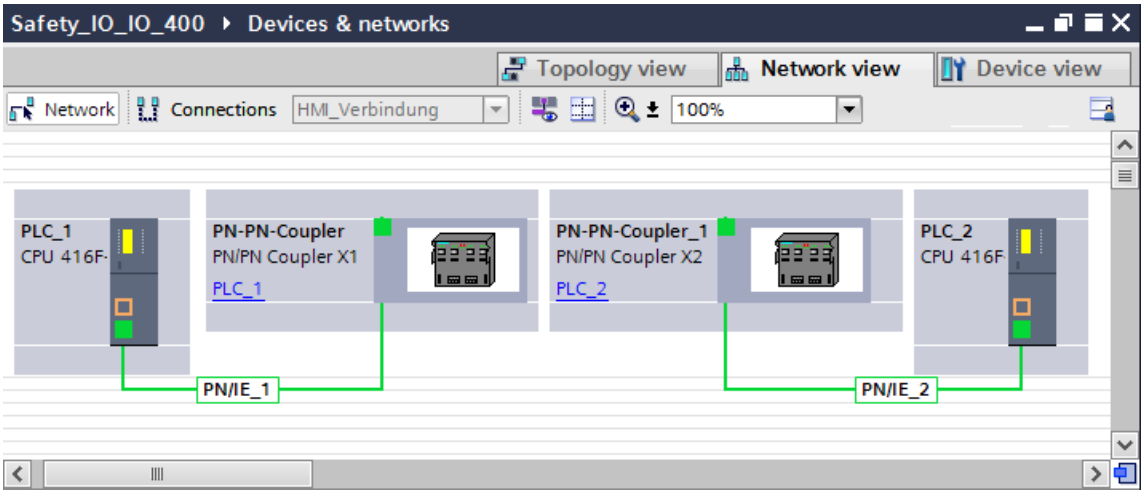

5. Switch to the device view of PN/PN Coupler X1 for bidirectional communication connections i.e. where each F-CPU is both to send and to receive data. Select the following modules from "IN/OUT" in the "Hardware catalog" task card (with filter activated), and insert them in the "Device overview" tab:
   - One "IN/OUT 6 bytes / 12 bytes" module and
   - One "IN/OUT 12 bytes / 6 bytes" module

6. In the properties of the modules, assign the addresses outside the process image as follows:

   For the "IN/OUT 6 bytes / 12 bytes" module for sending data for example:

   – Input addresses: Start address 518
   – Output addresses: Start address 518

   For the "IN/OUT 12 bytes / 6 bytes" module for receiving data for example:

   – Input addresses: Start address 530
   – Output addresses: Start address 530

NOTE

Make sure that you assign identical start addresses for the address areas of the output and input data.

Tip: Make a note of the start addresses of the transfer areas. You need these to program the SENDDP and RCVDP blocks (LADDR input).

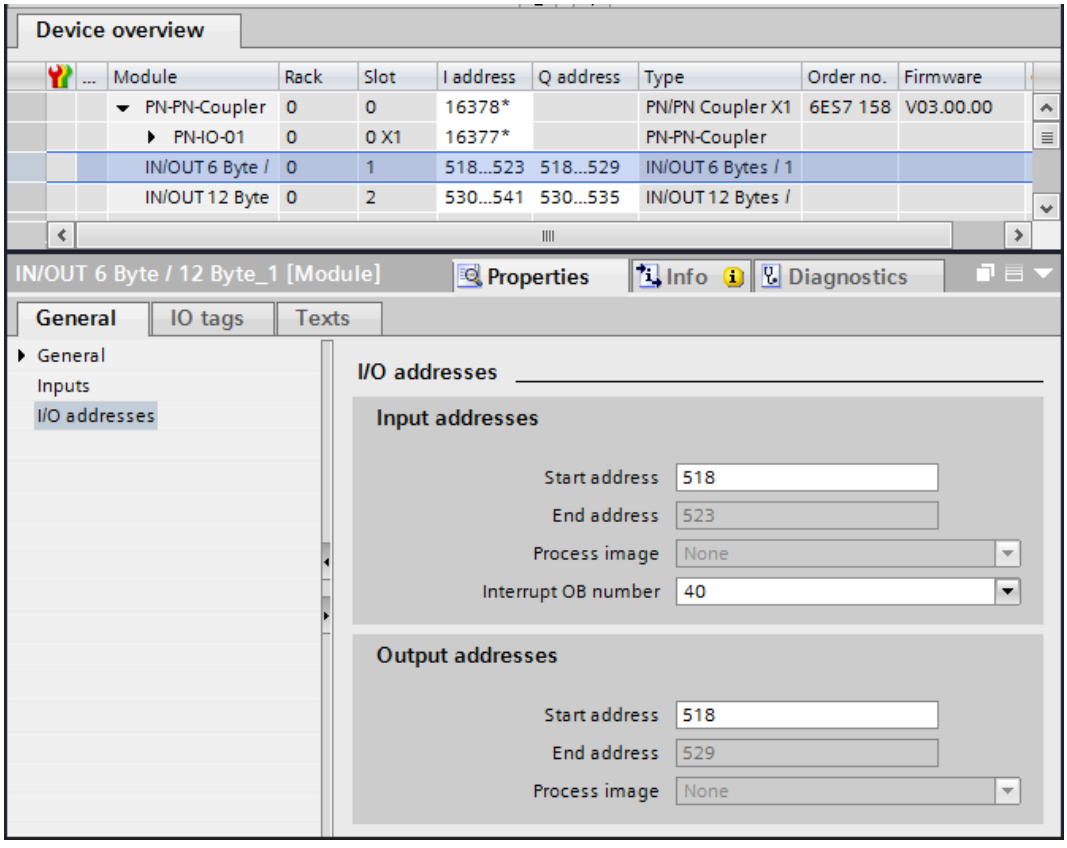

7. Select the following modules from "IN/OUT" in the device view of PN/PN coupler X2 and insert them in the "Device overview" tab:

   – One "IN/OUT 12 bytes / 6 bytes" module and
   – One "IN/OUT 6 bytes / 12 bytes" module

8. In the properties of the modules, assign the addresses outside the process image as follows:

   For the "IN/OUT 12 bytes / 6 bytes" module for receiving data for example:

   – Input addresses: Start address 516
   – Output addresses: Start address 516

   For the "IN/OUT 6 bytes / 12 bytes" module for sending data for example:

   – Input addresses: Start address 528
   – Output addresses: Start address 528

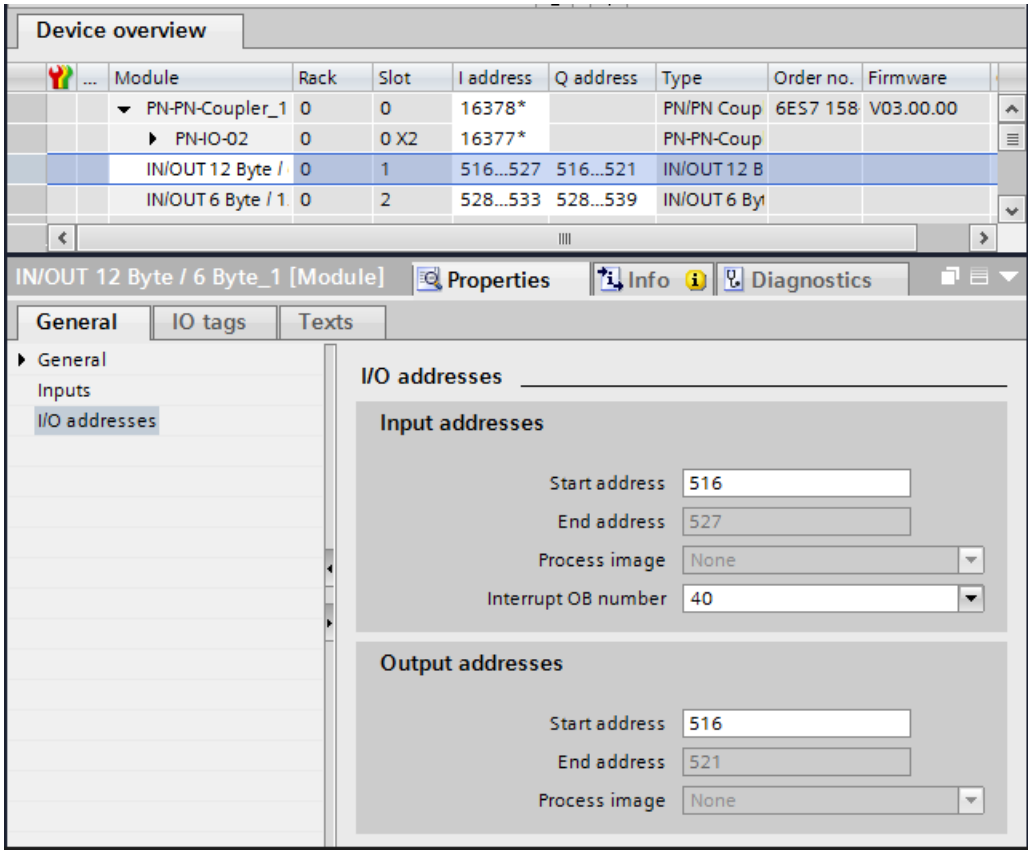

9.1.2.2 Program safety-related IO controller-IO controller communication

Communication via SENDDP and RCVDP instructions

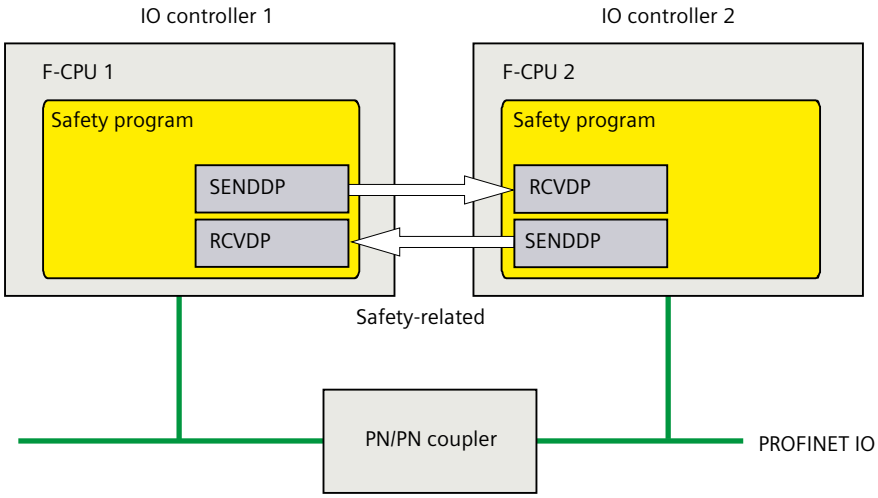

Safety-related communication between the F-CPUs of the IO controllers uses the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type INT or BOOL.

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 627).

Requirement for programming

The transfer areas for input and output data for the PN/PN coupler must be configured.

Programming procedure

You program safety-related IO controller-IO controller communication as follows:

1. In the safety program from which data is to be sent, call the SENDDP instruction (Page 627) for sending at the end of the main safety block.
2. In the safety program in which data is to be received, call the RCVDP instruction (Page 627) for receiving at the start of the main safety block.
3. Assign the start addresses of the output and input data transfer areas of the PN/PN coupler configured in the *hardware and network editor* to the respective LADDR inputs.

   You must carry out this assignment for every communication connection for each of the F-CPUs involved.

4. Assign the value for the respective F-communication ID to the DP_DP_ID inputs. This establishes the communication relationship between the SENDDP instruction in one F-CPU and the RCVDP instruction in the other F-CPU: The associated instructions receive the same value for DP_DP_ID.

   The figure below contains an example of how to specify the F-communication IDs at the inputs of the SENDDP and RCVDP instructions for 5 safety-related IO controller-IO controller communication relationships.

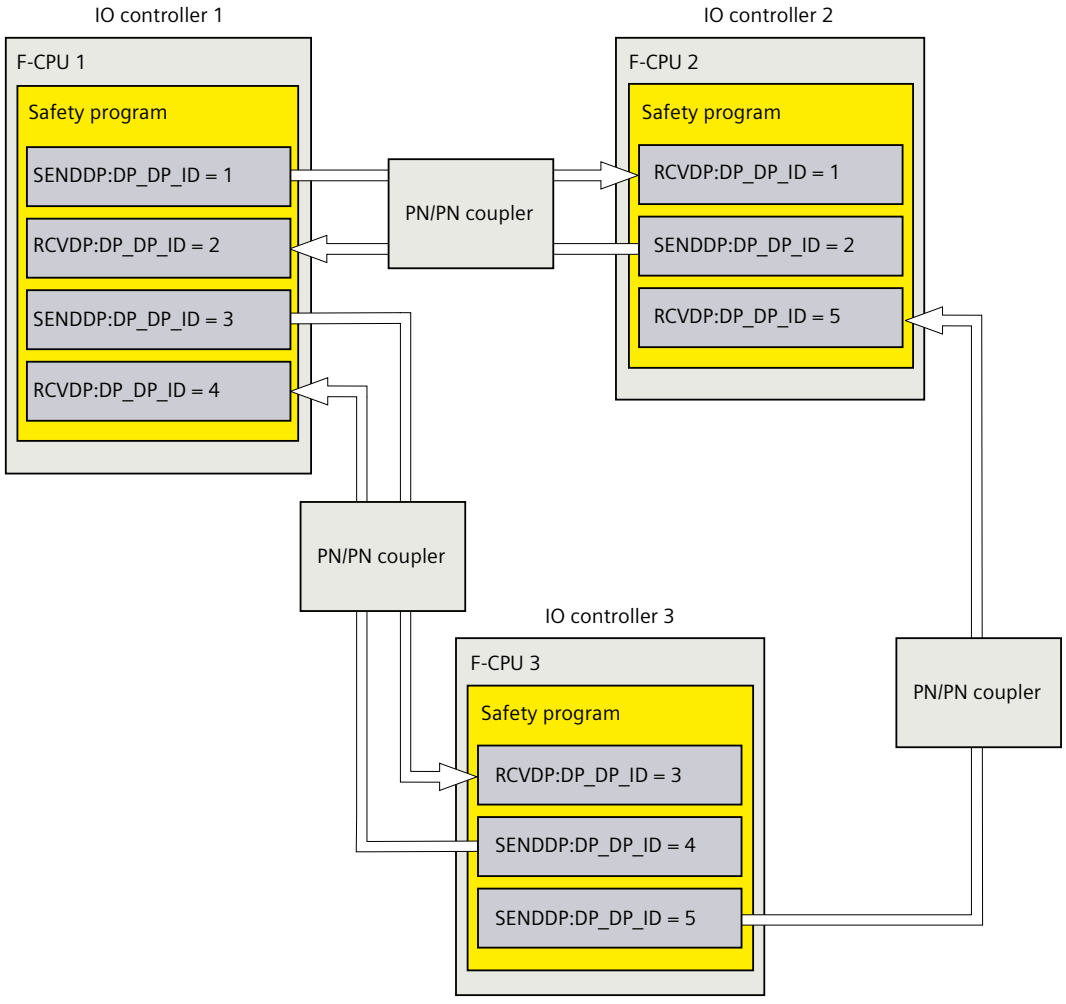

WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected; however, it must be unique network-wide* and CPU-wide at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.

You must supply constant values to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

5. Supply the SD_BO_xx and SD_I_xx inputs of SENDDP with the send signals. To cut down on intermediate signals when transferring block parameters, you can write the value directly to the instance DB of SENDDP using fully qualified access (for example, "Name SENDDP_1".SD_BO_02) before calling SENDDP.
6. Supply the RD_BO_xx and RD_I_xx outputs of RCVDP with the signals that you want to process further in other program sections or use fully qualified access to read the received signals directly in the associated instance DB in the program sections to be processed further (e.g., "Name RCVDP_1".RD_BO_02).
7. Supply the SUBBO_xx and SUBI_xx inputs of RCVDP with the fail-safe values that are to be output by RCVDP in place of the process data until communication is established for the first time after startup of the sending and receiving F-systems or in the event of an error in safety-related communication.
   - Specification of constant fail-safe values:

     For data of data type INT, you can enter constant fail-safe values directly as constants in the SUBI_xx input (initial value = "0"). If you want to specify a constant fail-safe value "TRUE" for data of the data type BOOL, provide the tag "F_GOBDB".VKE1 for the SUBBO_xx input (initial value = "FALSE").
   - Specification of variable substitute values:

     If you want to specify variable substitute values, define a tag that you calculate through your safety program in an F-DB and specify this tag (fully qualified) in the SUBI_xx or SUBBO_xx input.

     WARNING

     Note: The program logic for calculating variable substitute values can only be inserted after the RCVDP calls, because there must be no program logic before the RCVDP calls. This is why the initial values of the substitute values are active in all RCVDP instructions in the first cycle after a startup of the F-system. You must therefore assign appropriate initial values for these tags. *(S017)*

8. Configure the TIMEOUT inputs of the RCVDP and SENDDP instructions with the required monitoring time.

   WARNING

   It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

   Information on calculating the monitoring times can be found in Monitoring and response times (Page 643).

9. Optional: Evaluate the ACK_REQ output of the RCVDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether user acknowledgment is required.
10. Supply the ACK_REI input of the RCVDP instruction with the acknowledgment signal for reintegration.
11. Optional: Evaluate the SUBS_ON output of the RCVDP or SENDDP instruction in order to query whether the RCVDP instruction is outputting the fail-safe values assigned in the SUBBO_xx and SUBI_xx inputs.
12. Optional: Evaluate the ERROR output of the RCVDP or SENDDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether a communication error has occurred.
13. Optional: Evaluate the SENDMODE output of the RCVDP instruction in order to query whether the F-CPU with the associated SENDDP instruction is in disabled safety mode (Page 405).

9.1.2.3 Safety-related IO controller-IO controller communication - Limits for data transfer

NOTE

If the data quantities to be transmitted exceed the capacity of the SENDDP / RCVDP correlated instructions, a second (or third) SENDDP / RCVDP call can be used. This requires configuration of an additional communication connection via the PN/PN coupler. Whether or not this is possible with one single PN/PN coupler depends on the capacity restrictions of the PN/PN coupler.

9.1.3 Safety-related master-master communication

9.1.3.1 Configure safety-related master-master communication

Introduction

Safety-related communication between safety programs of the F-CPUs of DP masters takes place via a DP/DP coupler.

NOTE

Switch the data validity indicator "DIA" on the DIP switch of the DP/DP coupler to "OFF". Otherwise, safety-related CPU-CPU communication is not possible.

Configuring transfer areas

You must configure one transfer area for output data and one transfer area for input data in the *hardware and network editor* for each safety-related communication connection between two F-CPUs in the DP/DP coupler. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication). One transfer area for output data and one transfer area for input data must be configured in the DP/DP coupler for each of the two communication connections.

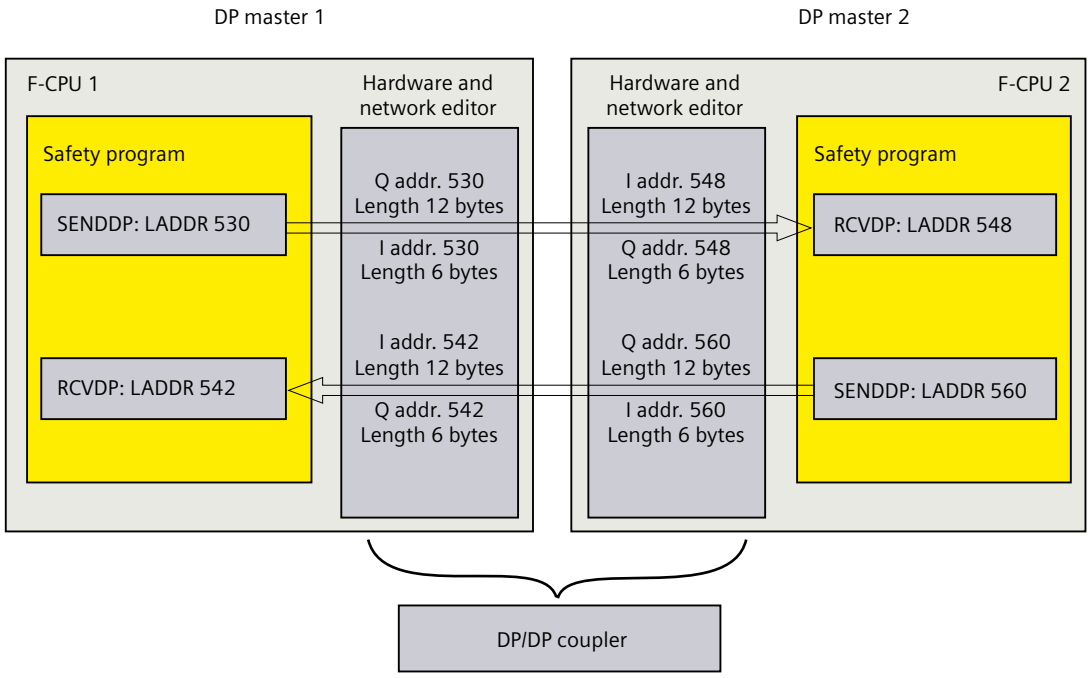

Rules for defining transfer areas

The transfer area for input data and the transfer area for output data for the **data to be sent** must begin with the same start address. A total of 6 bytes (consistent) is required for the transfer area for input data; 12 bytes (consistent) are required for the transfer area for output data.

The transfer area for input data and the transfer area for output data for the **data to be received** must begin with the same start address. A total of 12 bytes (consistent) is required for the transfer area for input data; 6 bytes (consistent) are required for the transfer area for output data.

Procedure for configuration

The procedure for configuring safety-related master-master communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Switch to the network view of the *hardware and network editor*.

3. Select a DP/DP coupler from "Other field devices\PROFIBUS DP\Gateways\Siemens AG\DP/DP Coupler" in the "Hardware catalog" task card and insert it into the network view of the hardware and network editor.
4. Insert a second DP/DP coupler.
5. Connect a DP interface of F-CPU 1 to the DP interface of a DP/DP coupler and a DP interface of F-CPU 2 to the DP interface of the other DP/DP coupler.

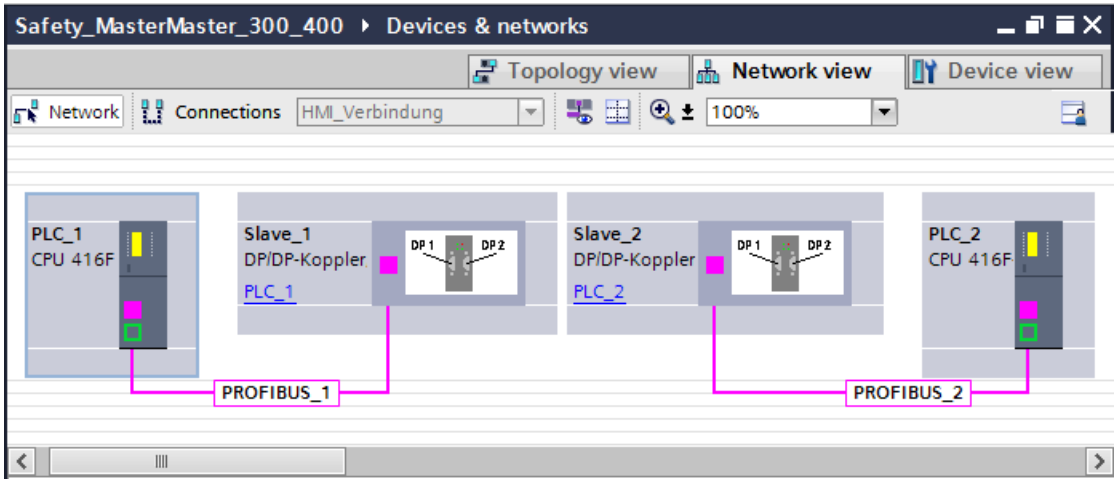

6. A free PROFIBUS address is assigned automatically in the properties of the DP/DP-coupler in the device view. You must set this address on the DP/DP coupler of PLC 1, either by using the DIP switch on the device or in the configuration of the DP/DP coupler (see DP/DP Coupler (https://support.industry.siemens.com/cs/ww/en/view/1179382) manual).
7. Switch to the device view of the DP/DP coupler for PLC1 for bidirectional communication connections i.e. where each F-CPU is both to send and to receive data. Select the following modules from the "Hardware catalog" task card (with filter activated), and insert them in the "Device overview" tab:
   - One "6 bytes I/12 bytes Q consistent" module, and
   - One "12 bytes I/6 bytes Q consistent" module
8. In the properties of the modules, assign the addresses outside the process image as follows:

   For "6 bytes I/12 bytes Q consistent" module for sending data for example:
   - Input addresses: Start address 530
   - Output addresses: Start address 530

For "12 bytes I/6 bytes Q consistent" module for receiving data for example:

– Input addresses: Start address 542
– Output addresses: Start address 542

NOTE

Make sure that you assign identical start addresses for the address areas of the output and input data.

Tip: Make a note of the start addresses of the transfer areas. You need these to program the SENDDP and RCVDP blocks (LADDR input).

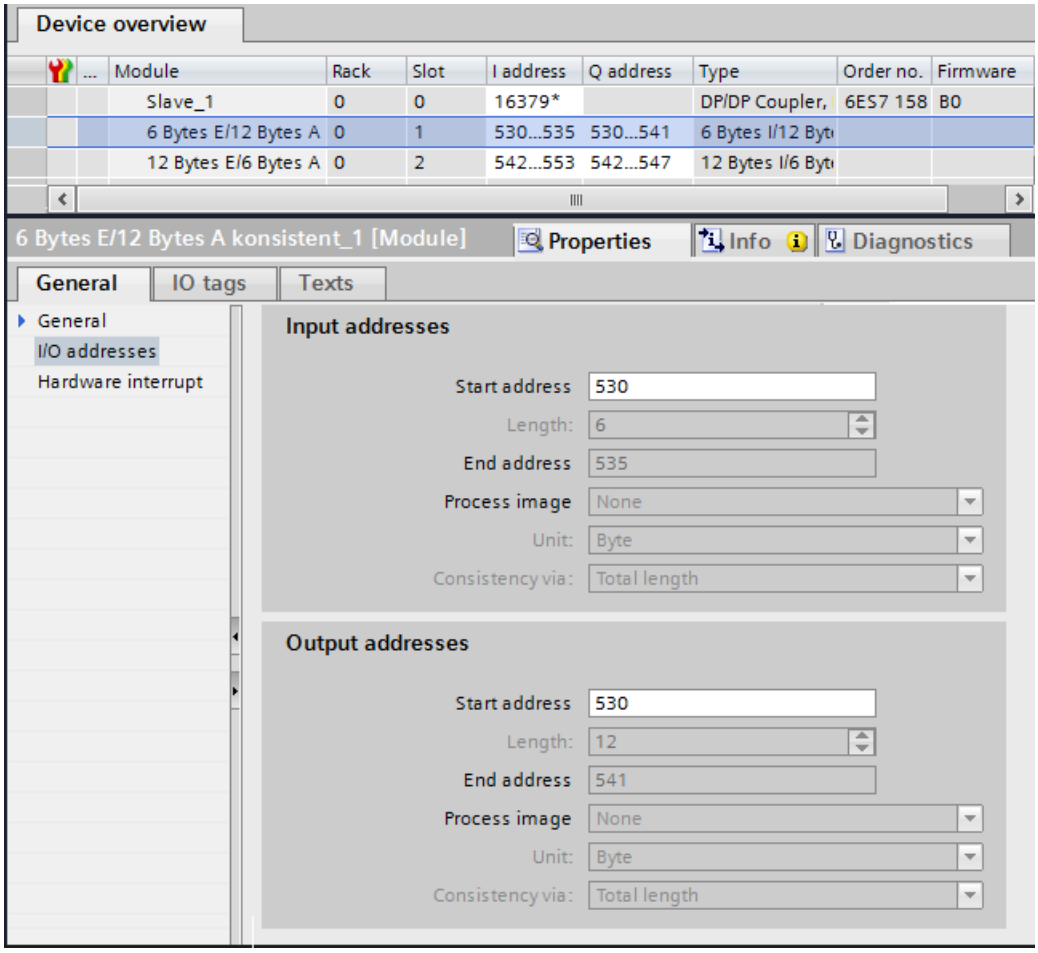

9. Select the following modules from the "Hardware catalog" task card (with filter activated) in the device view of DP/DP coupler PLC2, and insert them in the "Device overview" tab:
   – One "12 bytes I/6 bytes Q consistent" module, and
   – One "6 bytes I/12 bytes Q consistent" module

10. In the properties of the modules, assign the addresses outside the process image as follows:

    For "12 bytes I/6 bytes Q consistent" module for receiving data for example:

    – Input addresses: Start address 548
    – Output addresses: Start address 548

    For "6 bytes I/12 bytes Q consistent" module for sending data for example:

    – Input addresses: Start address 560
    – Output addresses: Start address 560

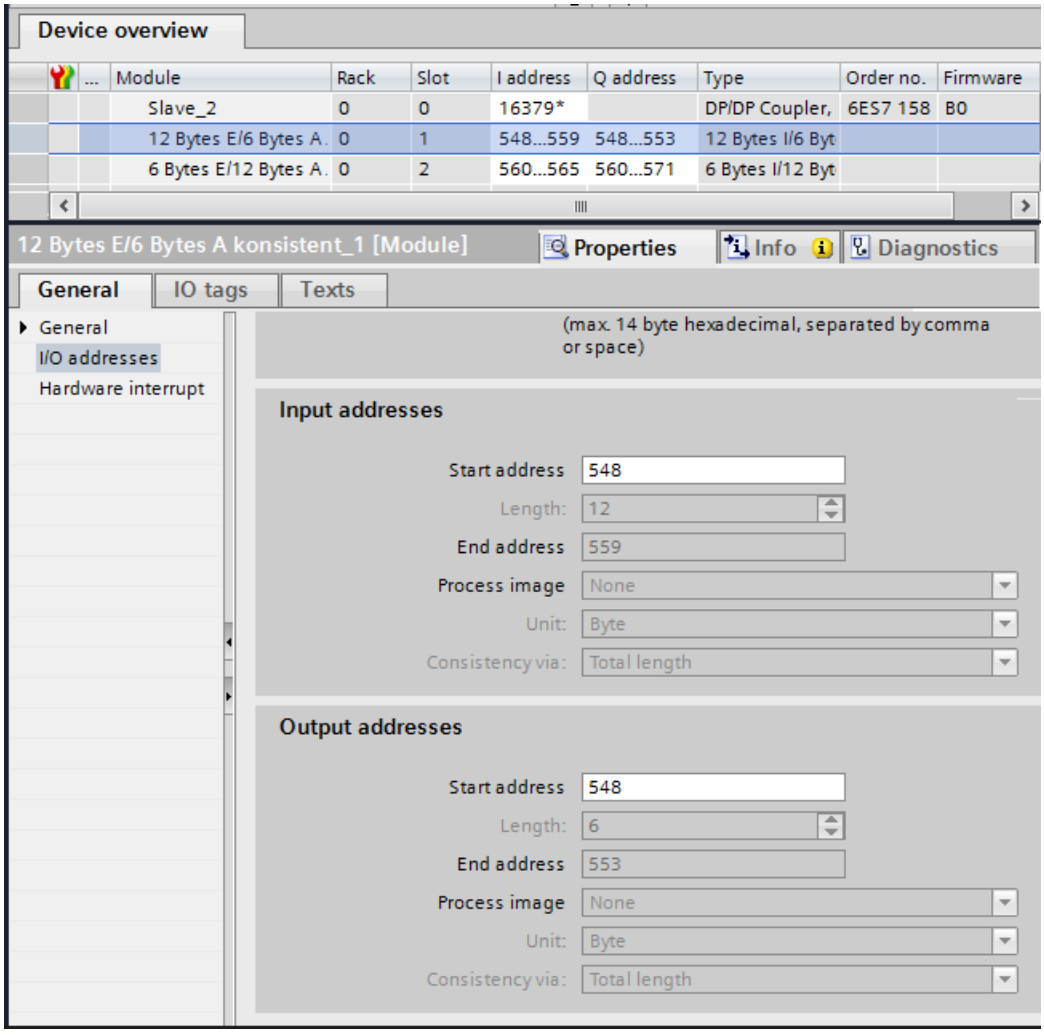

9.1.3.2 Program safety-related master-master communication

Communication via SENDDP and RCVDP instructions

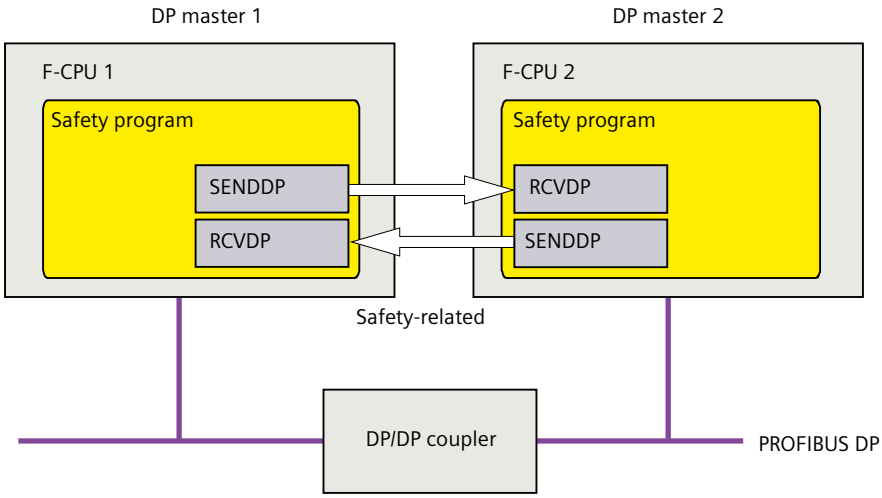

Safety-related communication between the F-CPUs of the DP master uses the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type INT or BOOL.

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 627).

Requirement for programming

The transfer areas for input and output data for the DP/DP coupler must be configured.

Programming procedure

You program safety-related master-master communication as follows:

1. In the safety program from which data is to be sent, call the SENDDP instruction (Page 627) for sending at the end of the main safety block.
2. In the safety program in which data is to be received, call the RCVDP instruction (Page 627) for receiving at the start of the main safety block.
3. Assign the start addresses of the transfer areas for output and input data of the DP/DP coupler configured in the *hardware and network editor* to the respective LADDR inputs.

   You must carry out this assignment for every communication connection for each of the F-CPUs involved.

4. Assign the value for the respective F-communication ID to the DP_DP_ID inputs. This establishes the communication relationship between the SENDDP instruction in one F-CPU and the RCVDP instruction in the other F-CPU: The associated instructions receive the same value for DP_DP_ID.

   The figure below contains an example of how to specify the F-communication IDs at the inputs of the SENDDP and RCVDP instructions for 5 safety-related master-master communications relationships.

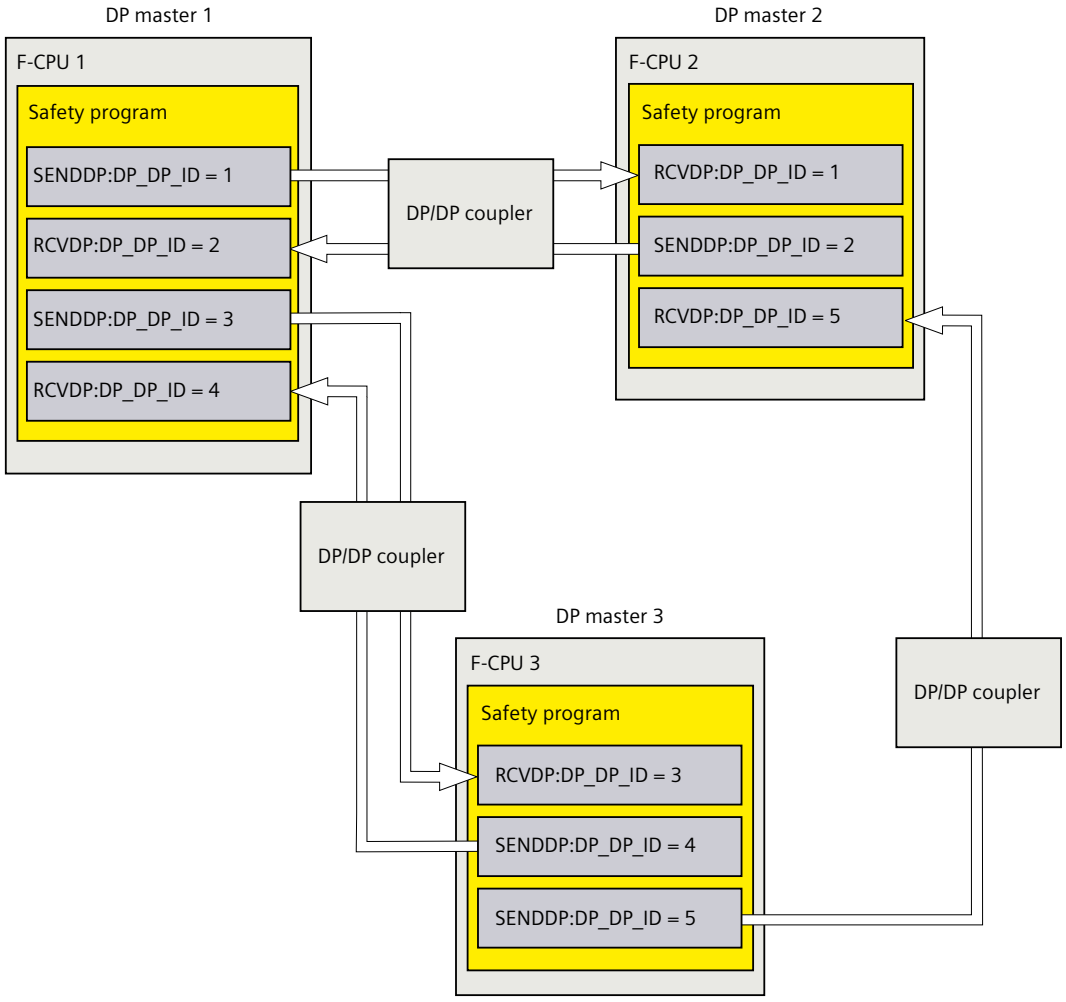

WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected; however, it must be unique network-wide* and CPU-wide at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.

You must supply constant values to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

5. Supply the SD_BO_xx and SD_I_xx inputs of SENDDP with the send signals. To cut down on intermediate signals when transferring block parameters, you can write the value directly to the instance DB of SENDDP using fully qualified access (for example, "Name SENDDP_1".SD_BO_02) before calling SENDDP.
6. Supply the RD_BO_xx and RD_I_xx outputs of RCVDP with the signals that you want to process further in other program sections or use fully qualified access to read the received signals directly in the associated instance DB in the program sections to be processed further (e.g. "Name RCVDP_1".RD_BO_02).
7. Supply the SUBBO_xx and SUBI_xx inputs of RCVDP with the fail-safe values that are to be output by RCVDP in place of the process data until communication is established for the first time after startup of the sending and receiving F-systems or in the event of an error in safety-related communication.
   - Specification of constant fail-safe values:

     For data of data type INT, you can enter constant fail-safe values directly as constants in the SUBI_xx input (initial value = "0"). If you want to specify a constant fail-safe value for data of the data type BOOL, provide the tag "F_GLOBDB".VKE1 for the SUBBO_xx input (initial value = "FALSE").
   - Specification of variable substitute values:

     If you want to specify variable substitute values, define a tag that you calculate through your safety program in an F-DB and specify this tag (fully qualified) in the SUBI_xx or SUBBO_xx input.

     WARNING

     Note: The program logic for calculating variable substitute values can only be inserted after the RCVDP calls, because there must be no program logic before the RCVDP calls. This is why the initial values of the substitute values are active in all RCVDP instructions in the first cycle after a startup of the F-system. You must therefore assign appropriate initial values for these tags. *(S017)*

8. Configure the TIMEOUT inputs of the RCVDP and SENDDP instructions with the required monitoring time.

   WARNING

   It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

   Information on calculating the monitoring times can be found in Monitoring and response times (Page 643).

9. Optional: Evaluate the ACK_REQ output of the RCVDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether user acknowledgment is required.
10. Supply the ACK_REI input of the RCVDP instruction with the acknowledgment signal for reintegration.
11. Optional: Evaluate the SUBS_ON output of the RCVDP or SENDDP instruction in order to query whether the RCVDP instruction is outputting the fail-safe values assigned in the SUBBO_xx and SUBI_xx inputs.
12. Optional: Evaluate the ERROR output of the RCVDP or SENDDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether a communication error has occurred.
13. Optional: Evaluate the SENDMODE output of the RCVDP instruction in order to query whether the F-CPU with the associated SENDDP instruction is in disabled safety mode (Page 405).

9.1.3.3 Safety-related master-master communication:Limits for data transfer

NOTE

If the data quantities to be transmitted exceed the capacity of the SENDDP / RCVDP correlated instructions, a second (or third) SENDDP / RCVDP call can be used. This requires configuration of an additional connection via the DP/DP coupler. Whether or not this is possible with one single DP/DP coupler depends on the capacity restrictions of the DP/DP coupler.

9.1.4 Safety-related IO controller-I-device communication

9.1.4.1 Configuring safety-related communication between IO controller and I-device

Introduction

Safety-related communication between the safety program of the F-CPU of an IO controller and the safety program(s) of the F-CPU(s) of one or more I-devices takes place via IO controller-I-device transfer areas (**F**-CD) in PROFINET IO, as in standard systems.

You do not need any additional hardware for IO controller-I-device communication.

The F-CPU to be used as an I-device must support the "IO-device" operating mode.

Configuring transfer areas

For every safety-related communication connection between two F-CPUs, you must configure transfer areas in the *hardware and network editor*. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).

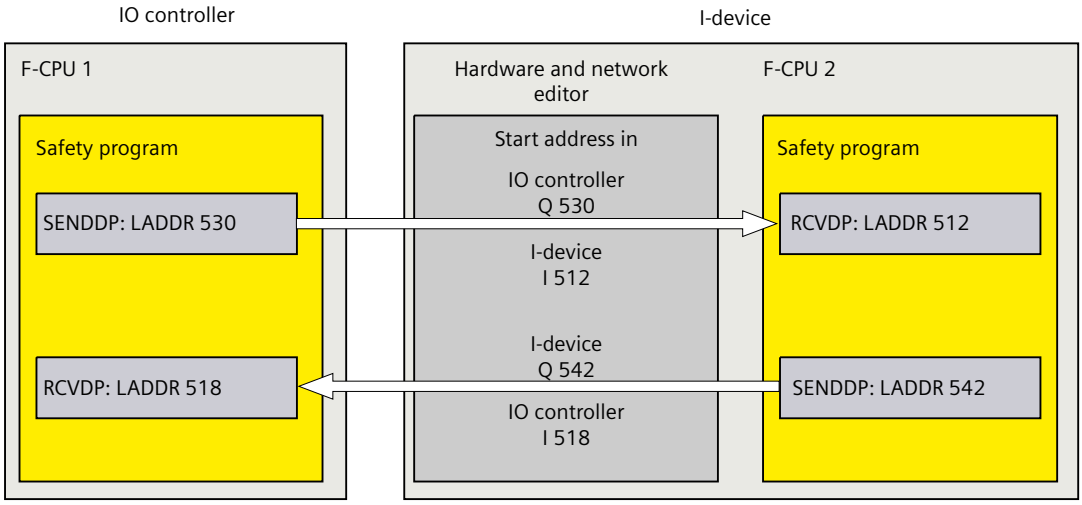

The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-CD_PLC_2 PLC_1_1" for the first F-CD connection between IO controller F-CPU 1 and I-device F-CPU 2.

You assign the start addresses of the transfer areas to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

The procedure for configuring safety-related IO controller-I-device communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Enable the "IO Device" mode for F-CPU 2 in the properties of its PN interface and assign this PN interface to a PN interface of F-CPU 1.
3. Select the PROFINET interface of F-CPU 2. Under "Transfer areas", you create an F-CD connection (type "F-CD") for sending to the IO controller (←). The F-CD connection is shown in yellow in the table and the address areas in the I-device and IO controller assigned outside of the process image are displayed.

   In addition, an acknowledgment connection is created automatically for each F-CD connection. (see "Transfer area details").
4. Create an additional F-CD connection for receiving from the IO controller.

5. In the transfer area you just created, click the arrow in order to change the transfer direction to receiving from IO controller (→).

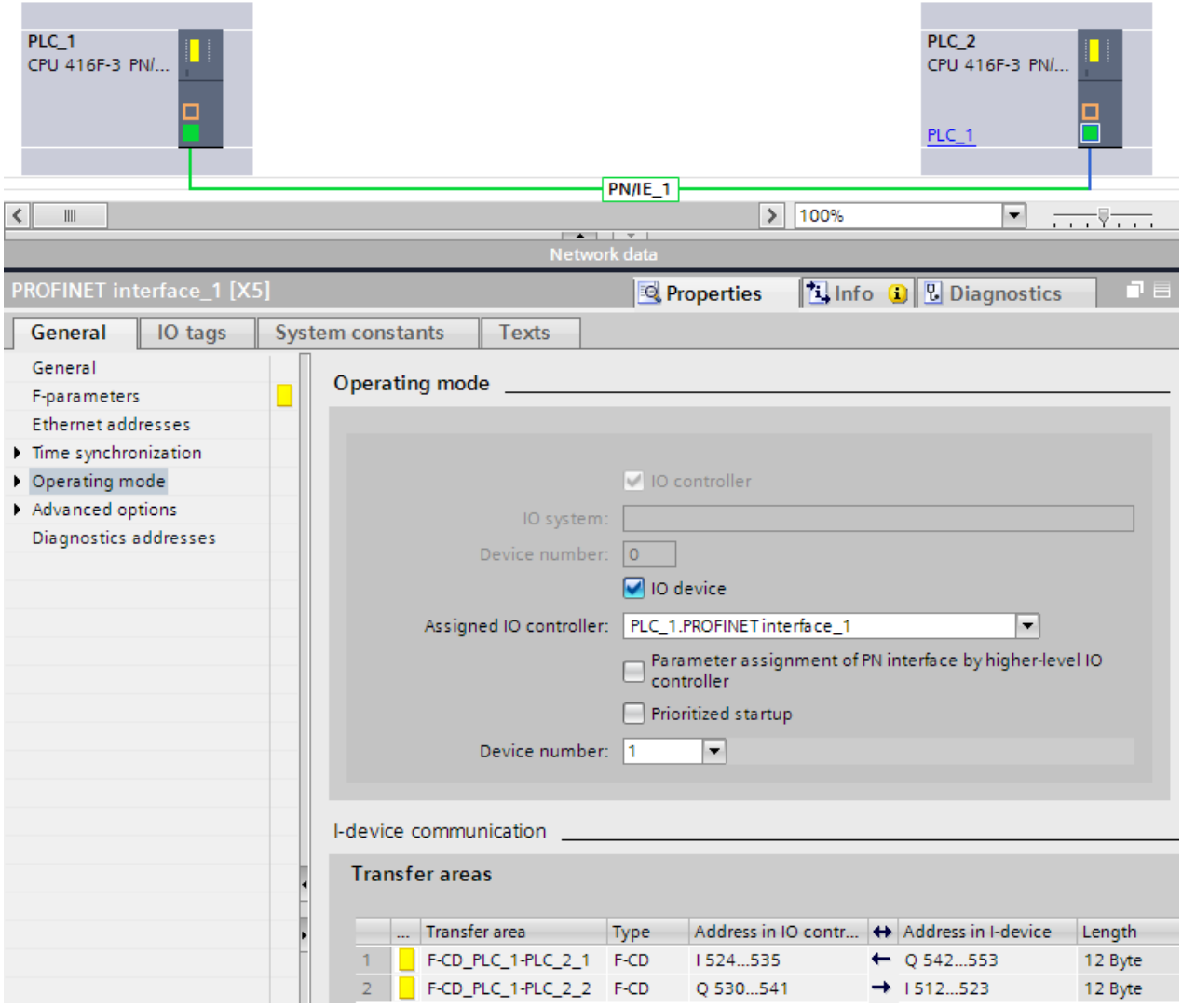

9.1.4.2 Programming safety-related IO controller I-device communication

Communication via SENDDP and RCVDP instructions

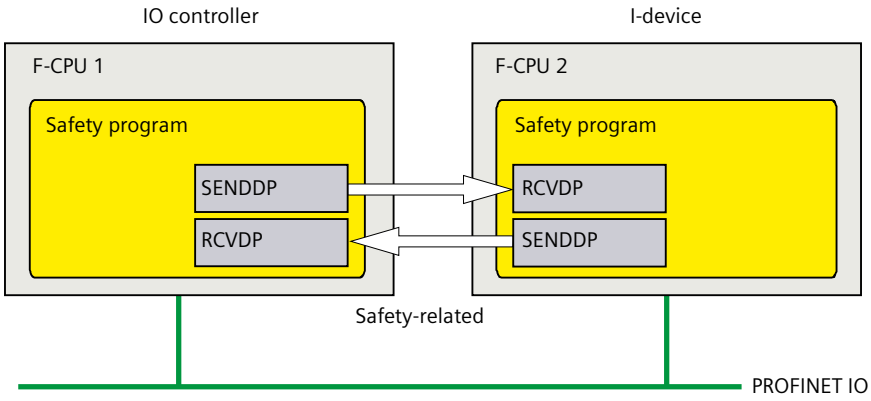

Safety-related communication between the F-CPUs of the IO controller and an I-device makes use of the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type INT or BOOL.

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 627).

Requirement for programming

The transfer areas must be configured.

Programming procedure

The procedure for programming safety-related IO controller-I-device communication is the same as that for programming safety-related IO controller-IO controller communication (see Program safety-related IO controller-IO controller communication (Page 215)).

The assignment of the start addresses of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table.

Instruction	Start address LADDR	
	From row	From column
SENDDP in the IO controller	→	Address in the IO controller
RCVDP in the IO controller	←	Address in the IO controller
SENDDP in the I-device	←	Address in the IO device
RCVDP in the I-device	→	Address in the IO device

The figure below contains an example of how to specify the F-communication IDs for the inputs of the SENDDP and RCVDP instructions for 4 safety-related IO controller-I-device communication relationships.

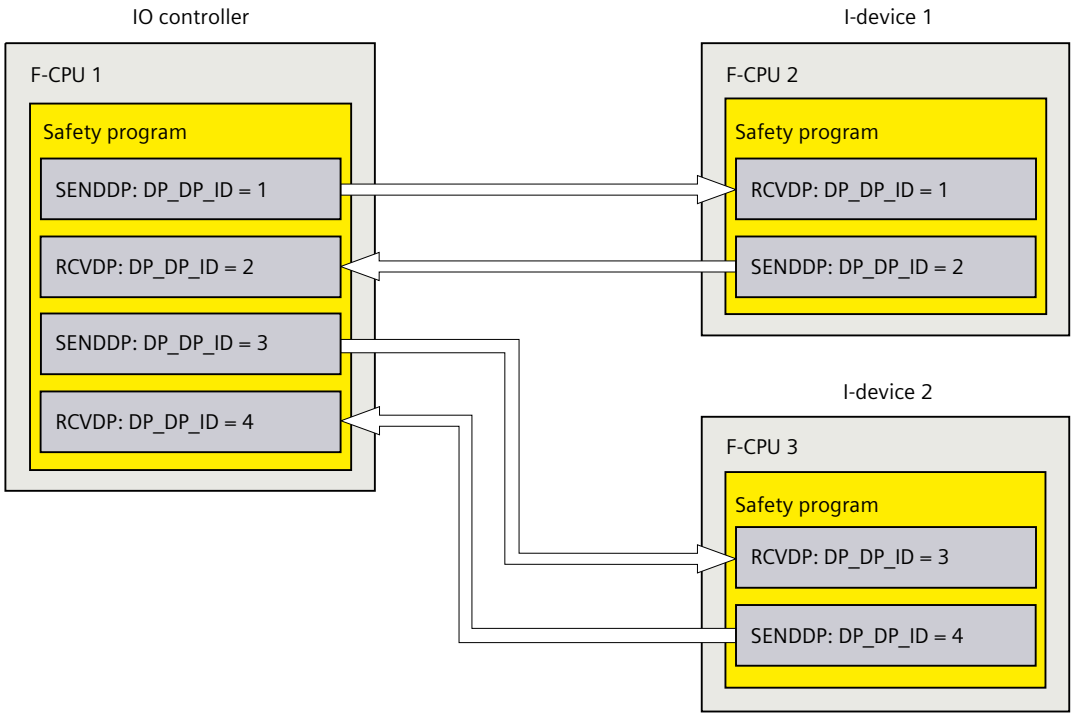

WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected; however, it must be unique network-wide* and CPU-wide at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.

You must supply constant values to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time.*(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 643).

9.1.4.3 Safety-related IO-Controller-IO-Device communication - Limits for data transfer

Limits for data transfer

If the amount of data to be transferred is greater than the capacity of related SENDDP/RCVDP instructions, you can use additional SENDDP/RCVDP instructions. Configure additional transfer areas for this purpose. Remember the maximum limit of 1440 bytes of input data or 1440 bytes of output data for transfer between an I-device and a IO controller.

The following table shows the amount of output and input data assigned in safety-related communication connections:

Safety-related communication	Communication connection	Assigned input and output data			
		In the IO controller		In the I-device	
		Output data	Input data	Output data	Input data
IO controller-I-Device	**Sending:** I-Device 1 to IO controller	6 bytes	12 bytes	12 bytes	6 bytes
	Receiving: I-Device 1 from IO controller	12 bytes	6 bytes	6 bytes	12 bytes

Consider all additional configured safety-related and standard communication connections (transfer areas of type F-CD and CD) for the maximum limit of 1440 bytes of input data or 1440 bytes of output data for transfer between an I-device and an IO controller. In addition, data are assigned for internal purposes such that the maximum limit may be reached sooner.

When the limit is exceeded, a corresponding error message is displayed.

9.1.5 Safety-related master-I-slave communication

9.1.5.1 Configuring safety-related master-I-slave communication

Introduction

Safety-related communication between the safety program of the F-CPU of a DP master and the safety program(s) of the F-CPU(s) of one or more I-slaves takes place via master-I-slave transfer areas (**F-**MS), as in standard systems.

You do not need a DP/DP coupler for master-I-slave communication.

Configuring transfer areas

For every safety-related communication connection between two F-CPUs, you must configure transfer areas in the *hardware and network editor*. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).

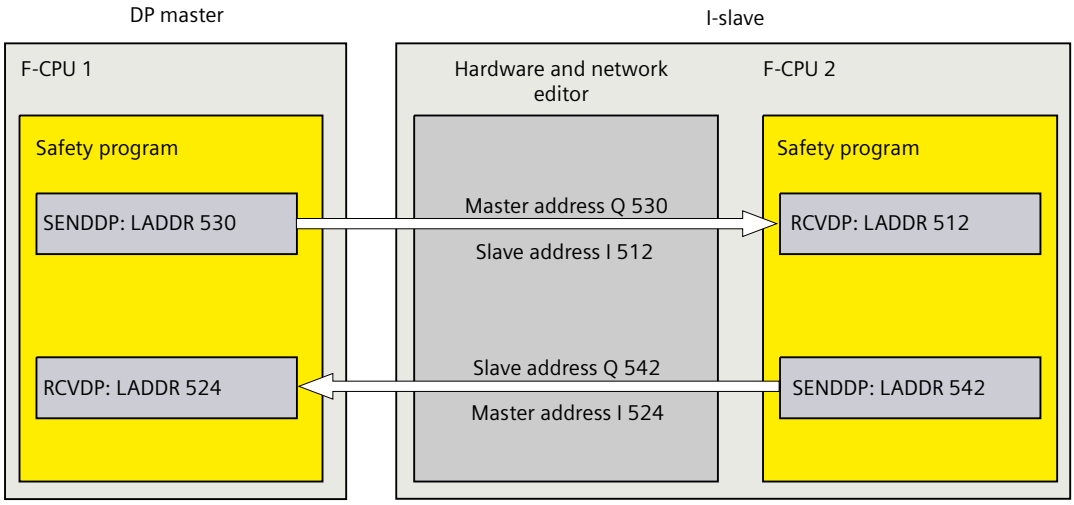

The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-MS_PLC_2-PLC_1_1" for the first F-MS connection between DP master F-CPU 1 and I-slave F-CPU 2.

You assign the start addresses of the transfer areas to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

The procedure for configuring safety-related master-I-slave communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Activate the "DP slave" mode (I-slave) for F-CPU 2 in the properties of its DP interface and assign this DP interface to a DP interface of F-CPU 1.
3. Select the PROFIBUS interface of F-CPU 2. Under "Transfer areas", you create an F-MS connection (type "F-MS") for sending to the DP master (←). The F-MS connection is shown in yellow in the table and the transfer areas in the I-slave and DP master assigned outside of the process image are displayed.

   In addition, an acknowledgment connection is created automatically for each F-MS connection. (see "Transfer area details").
4. Create an additional F-MS connection for receiving from the DP master.

5. In the transfer area you just created, click the arrow in order to change the transfer direction to receiving from DP master (→).

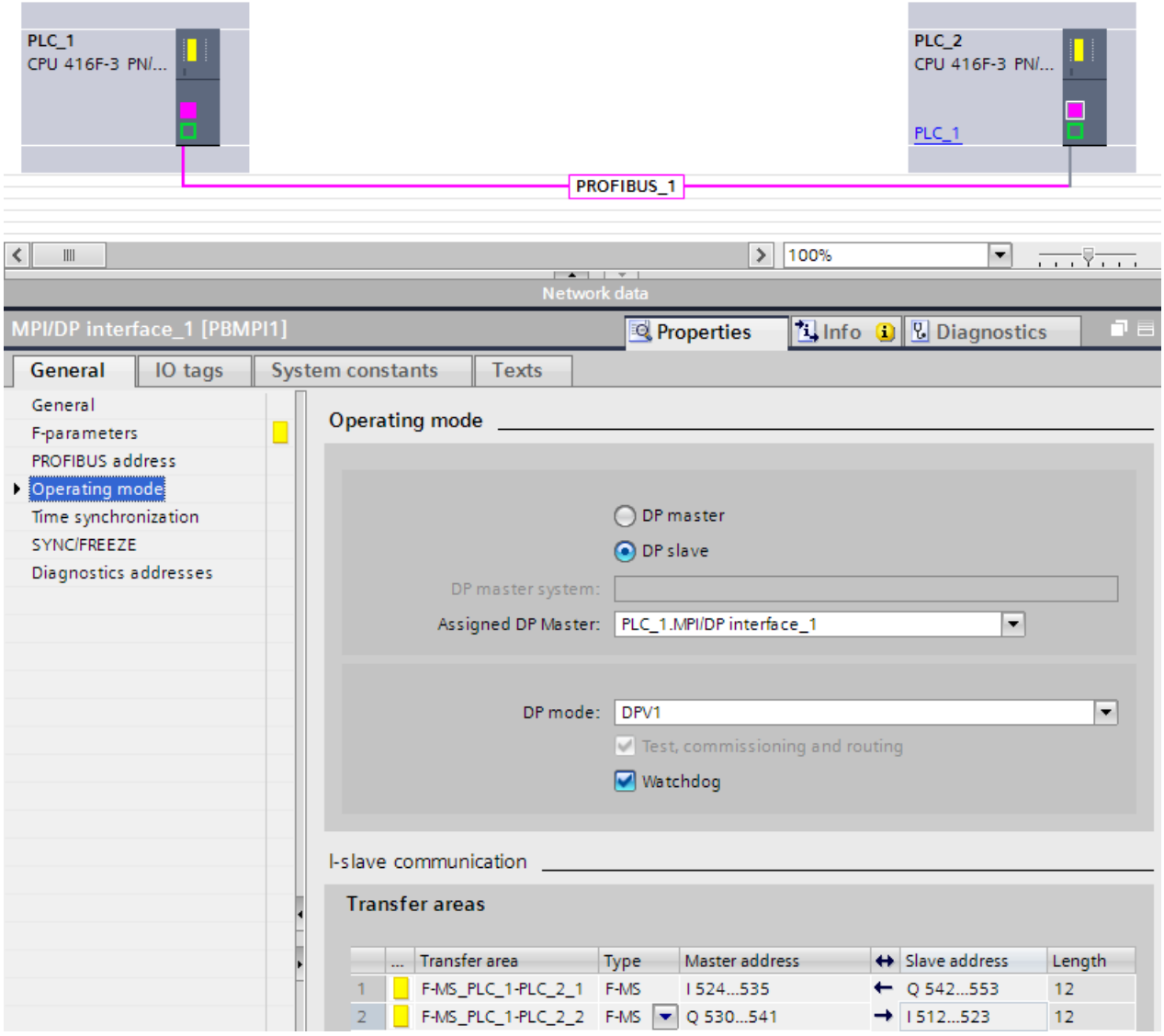

9.1.5.2 Program the safety-related master-I-slave or I-slave-I-slave communication

Communication via SENDDP and RCVDP instructions

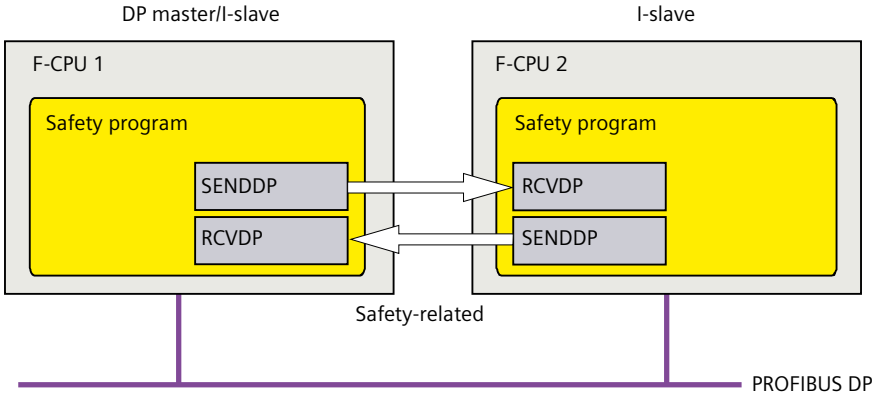

Safety-related communication between the F-CPUs of the DP master and an I-slave or between the F-CPUs of multiple I-slaves makes use of the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type INT or BOOL.

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 627).

Requirement for configuration

The transfer areas must be configured.

Programming procedure

The procedure for programming safety-related master-I-slave communication or I-slave-I-slave communication is the same as that for programming safety-related master-master communication (see Program safety-related master-master communication (Page 223)).

The assignment of the start addresses of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table.

Instruction	Start address LADDR	
	From row	From column
SENDDP in the DP master	→	Master address
RCVDP in the DP master	←	Master address
SENDDP in the I-slave	←	Slave address
RCVDP in the I-slave	→	Slave address

The figure below contains an example of how to specify the F-communication IDs at the inputs of SENDDP and RCVDP instructions for four safety-related master-I-slave and two I-slave-I-slave communications relationships.

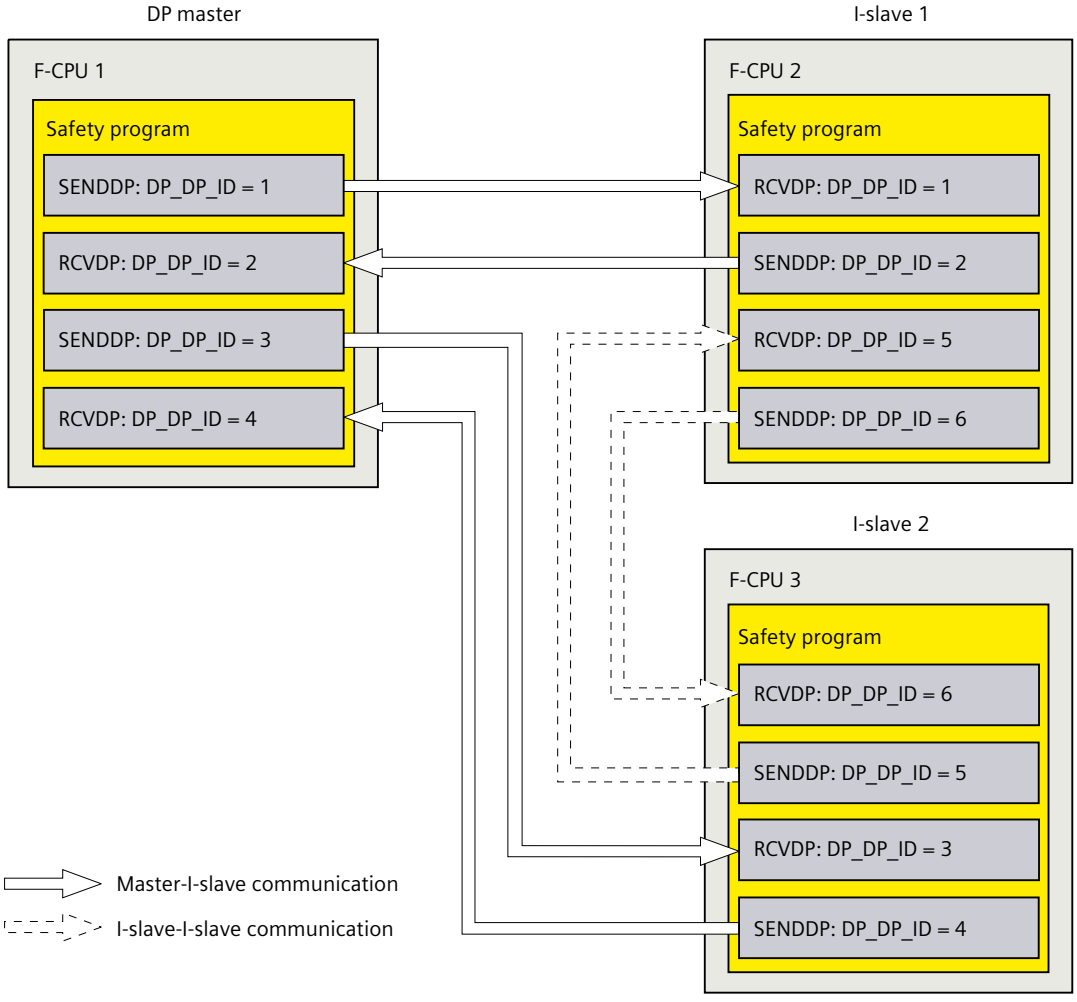

WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected; however, it must be unique network-wide* and CPU-wide at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.

You must supply constant values to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 643).

9.1.5.3 Limits for data transfer of safety-related master-I-slave or I-slave-I-slave communication

Limits for data transfer

If the amount of data to be transferred is greater than the capacity of related SENDDP/RCVDP instructions, you can use additional SENDDP/RCVDP instructions. Configure additional transfer areas for this purpose. Note the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-slave and a DP master.

The following table shows the amount of output and input data assigned in safety-related communication connections:

Safety-related communication	Communication connection	Assigned input and output data					
		DP master		I-slave 1		I-slave 2	
		Output data	Input data	Output data	Input data	Output data	Input data
Master-I-slave	**Sending:** I-slave 1 to DP master	6 bytes	12 bytes	12 bytes	6 bytes	—	—
	Receiving: I-slave 1 from DP master	12 bytes	6 bytes	6 bytes	12 bytes	—	—
I-slave-I-slave	**Sending:** I-slave 1 to I-slave 2	—	18 bytes	12 bytes	6 bytes	6 bytes	12 bytes
	Receiving: I-slave 1 from I-slave 2	—	18 bytes	6 bytes	12 bytes	12 bytes	6 bytes

Consider all additional configured safety-related and standard communication connections (transfer areas of type F-MS-, F-DX-, F-DX-Mod., MS-, DX- and DX-Mod) for the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-device and a DP master F-MS, F-DX, F-DX-Mod., MS, DX). If the maximum limit of 244 bytes of input data or 244 bytes of output data is exceeded, you will receive a corresponding error message.

9.1.6 Safety-related I-slave-I-slave communication

9.1.6.1 Configure safety-related I-slave-I-slave communication

Introduction

Safety-related communication between the safety program of the F-CPUs of I-slaves takes place using direct data exchange (**F**-DX) – same as in standard programs.

You do not need any additional hardware for I-slave-I-slave communication.

I-slave-I-slave communication is also possible:

- If the assigned DP master is a standard CPU that supports direct data exchange
- when instead of a DP master, an IO controller is networked with the I-slaves via an IE/PB link

Configuring transfer areas

For every safety-related communication connection between two I-slaves, you must configure transfer areas in the *hardware and network editor*. In the figure below, both of the I-slaves are to be able to send and receive data (bidirectional communication).

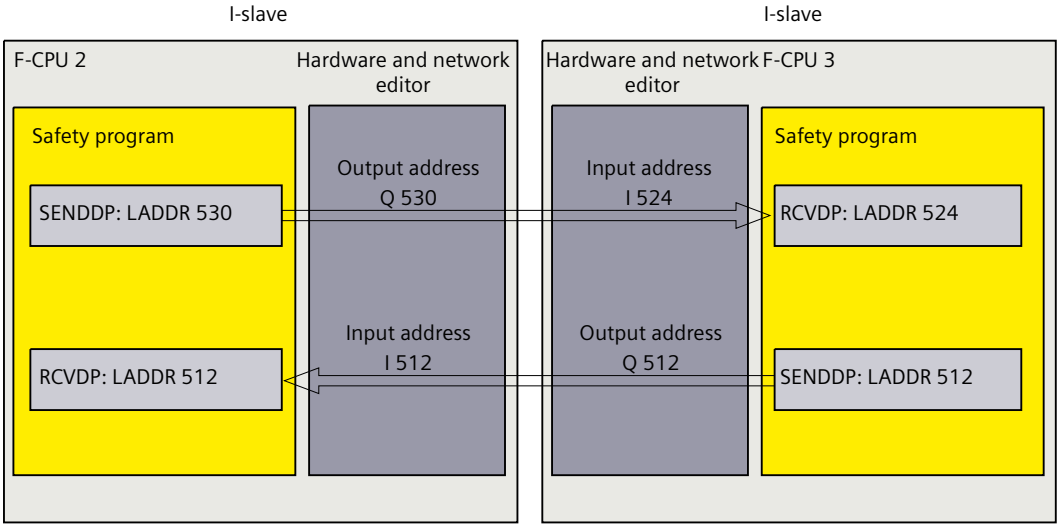

The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-DX_PLC_2-PLC_1_1" for the first F-DX connection between F-CPU 1 and F-CPU 2.

You assign the start addresses of the transfer areas to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

The procedure for configuring safety-related I-slave-I-slave communication is identical to that in the standard system. Proceed as follows:

1. Insert three F-CPUS from the "Hardware catalog" task card in the project.
2. Activate "DP slaves" mode (I-slave) for F-CPU 2 and F-CPU 3 in the properties of their DP interfaces and assign these DP interfaces to a DP interface of F-CPU 1.
3. Select the DP interface of F-CPU 3 in the network view.
4. Select the "I/O communication" tab.
5. Use a drag-and-drop operation in the network view to move F-CPU 2 to the "Partner 2" column on the "I/O-communication" tab.

   This creates a line with "Direct data exchange" mode for sending to the I-slave (F-CPU 2) (→).

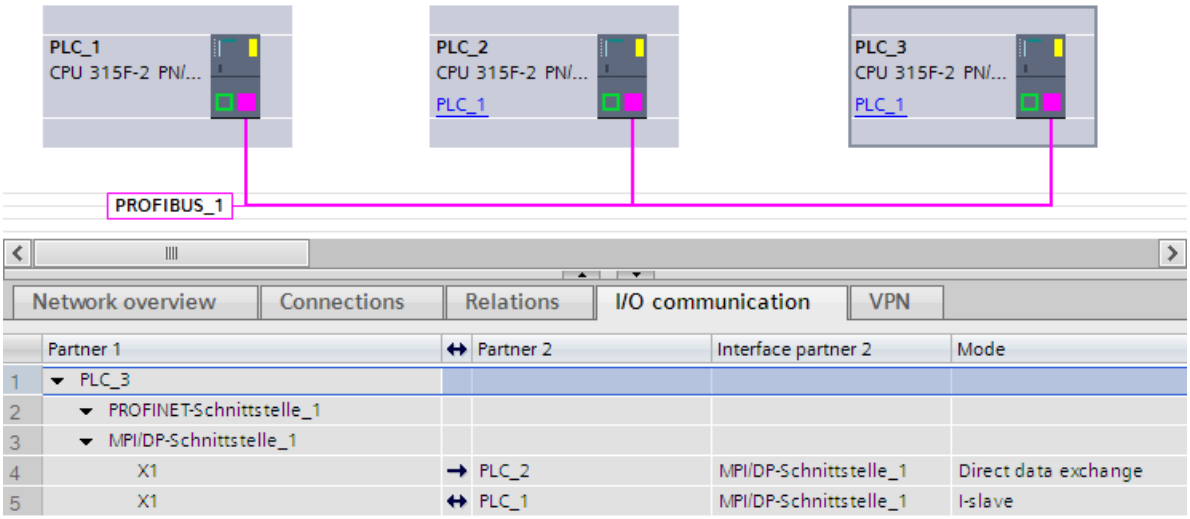

6. Click in the newly created line (→).
7. In "Transfer areas" ("Direct data exchange" table), create an F-DX connection (type "F-DX") for sending to the I-slave (F-CPU 2) (→). The F-DX connection is shown in yellow in the table and the transfer areas in the I-slaves assigned outside of the process image (PLC_2 and PLC_3) are displayed.

   In addition, a line with "Direct data exchange" mode for receiving from the I-slave (F-CPU 2) (←) is created automatically in the "I/O communication" tab, and an acknowledgment connection (→, transfer area x_Ack) is created automatically in the associated "Direct data exchange" table.

   One transfer area (type F-MS) for the master CPU is created in the "I-slave communication table" of each I-slave.

This completes the configuration for sending to F-CPU 2.

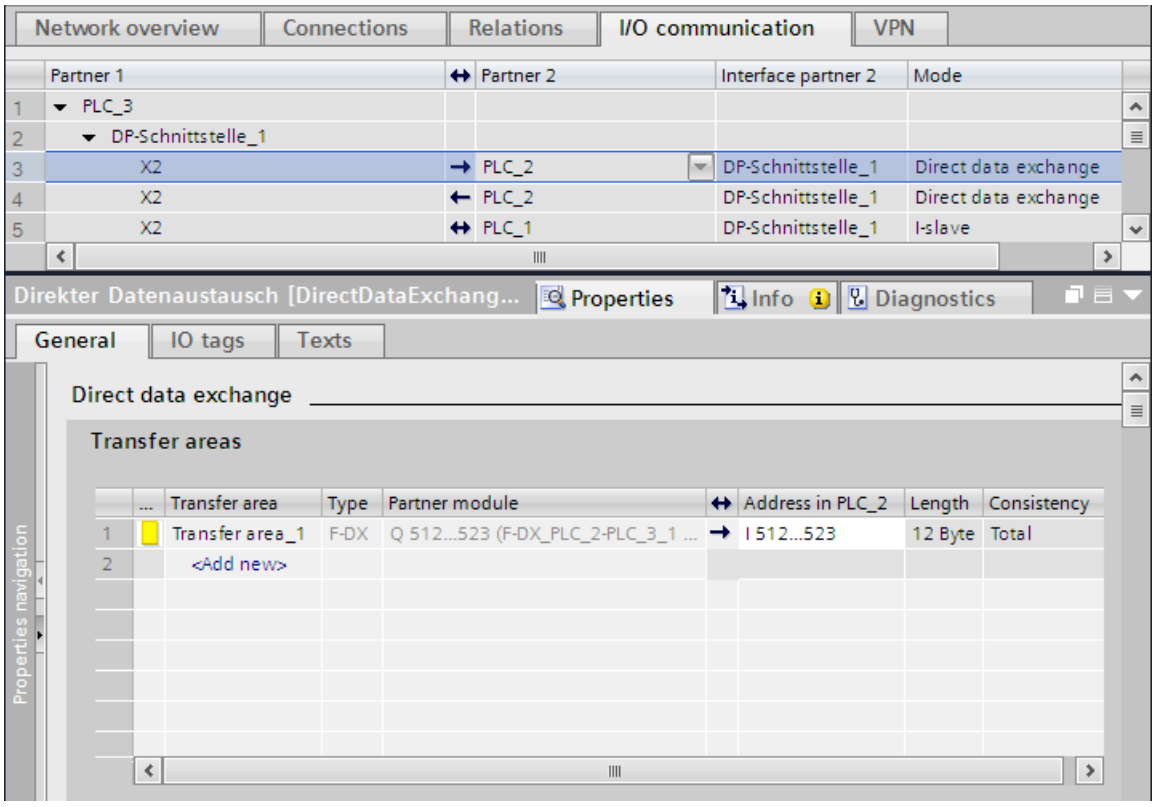

8. In the "I/O communication" tab, select the automatically created line with "Direct data exchange" mode for receiving from the I-slave (F-CPU 2) (←).
9. In "Transfer areas" ("Direct data exchange" table), create another F-DX connection for receiving from the I-slave (F-CPU 3).

   In this case, as well, an acknowledgment connection (→, transfer area x_Ack) is created automatically in the "Direct data exchange table" and two transfer areas (type F-MS) for the master CPU are created in the "I-slave communication" table of both I-slaves.

This completes the configuration for receiving from F-CPU 2.

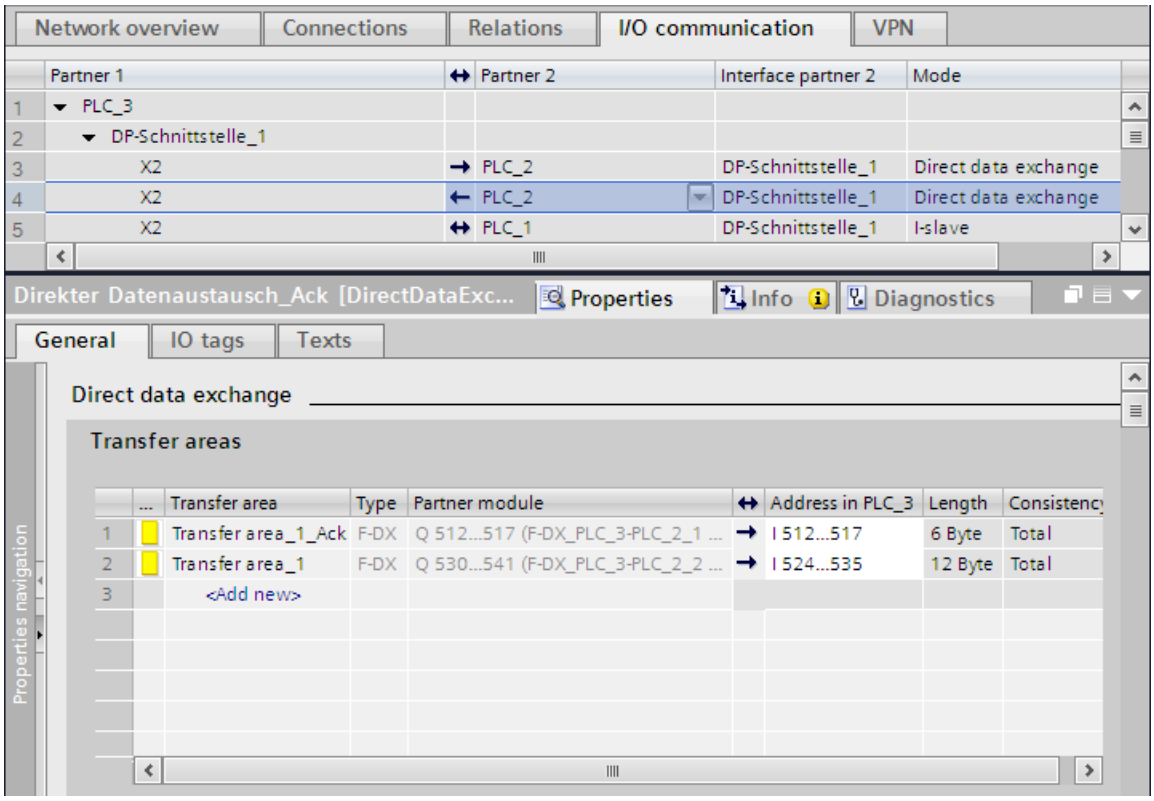

Changing disabled local address areas of the transfer areas

To change the disabled local address area of the "Transfer area x", you must change the start address of the address area of the corresponding acknowledgment connection "Transfer area x_Ack".

1. In "I/O communication", select the line with the arrow pointing in the same direction as the arrow of "Transfer area x" in the "Direct data exchange" table.
2. Then select the line with "Transfer area x_Ack" in the "Direct data exchange" table.
3. Change the start address of the address range there.

9.1.6.2 Programming safety-related I-slave-I-slave communication

Reference

The description of the programming of safety-related I-slave-I-slave communication can be found in Program the safety-related master-I-slave or I-slave-I-slave communication (Page 235).

The assignment of the start addresses of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table.

Instruction	Start address LADDR	
	From row	From column
SENDDP in the 1st I-slave	→	Address in the <1st I-slave> (in example column "Address in PLC_2")
RCVDP in the 1st I-slave	←	Address in the <1st I-slave> (in example column "Address in PLC_2")
SENDDP in the 2nd I-slave	←	Address in the <2nd I-slave> (in example column "Address in PLC_3")
RCVDP in the 2nd I-slave	→	Address in the <2nd I-slave> (in example column "Address in PLC_3")

9.1.6.3 Limits for data transfer of safety-related I-slave-I-slave communication

Limits for data transfer

The description of the limits for the data transfer of safety-related I-slave-I-slave communication can be found in Limits for data transfer of safety-related master-I-slave or I-slave-I-slave communication (Page 238).

9.1.7 Safety-related IO controller-I-slave communication

Introduction

Safety-related communication between the safety program of the F-CPU of an IO controller and the safety program(s) of the F-CPU(s) of one or more I-slaves takes place via master-I-slave transfer areas (**F-**MS), as in standard systems.

IE/PB link

For the safety-related IO-controller-I-slave communication, the IE/PB link is mandatory. Each of the two F-CPUs is linked to the IE/PB link by means of its PROFIBUS DP or PROFINET-interface.

NOTE

If you are using an IE/PB link, you must take this into account when configuring the F-specific monitoring times and when calculating the maximum response time of your F-system (see also Monitoring and response times (Page 643)).

Note that the Excel file for calculating response times (https://support.industry.siemens.com/cs/ww/en/view/109783831) for S7-300/400 F-CPUs does not support all conceivable configurations.

Reference

The information on safety-related master-I-slave communication in Safety-related master-I-slave communication (Page 232) also applies.

9.1.8 Safety-related communication via S7 connections

9.1.8.1 Configuring safety-related communication via S7 connections

Introduction

Safety-related communication between the safety programs of F-CPUs via S7 connections takes place by means of established S7 connections that you create in the network view of the *hardware and network editor* - same as in standard programs.

Restrictions

NOTE

In SIMATIC Safety, S7 connections are generally permitted only via Industrial Ethernet.

Safety-related communication via S7 connections is possible from and to the following CPUs:

- S7-300 F-CPUs via the integrated PROFINET interface
- S7-400 F-CPUs via the integrated PROFINET interface or a CP 443-1 or CP 443-1 Advanced-IT

Creating S7 connections

For each connection between two F-CPUs, you must create an S7 connection in the network view of the *hardware and network editor*.

For every end-point of a connection, a local and a partner ID is automatically assigned from the perspective of the end-point (the F-CPU). If necessary, you can change both IDs in the "Connections" tab. You assign the local ID to the "ID" input of the SENDS7 and RCVS7 instructions in the safety programs.

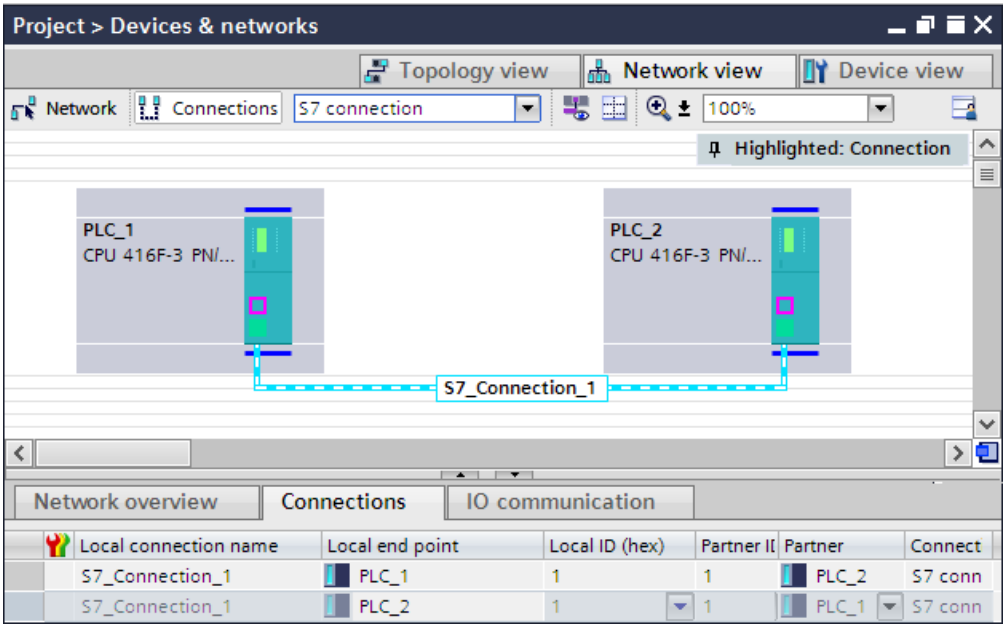

Procedure for configuring S7 connections

You configure the S7 connections for safety-related CPU-to-CPU communication in the same way as in *STEP 7 Professional* (see *Help on STEP 7 Professional* "S7 connections").

9.1.8.2 Programming safety-related communication via S7 connections

Communication via the SENDS7 and RCVS7 instructions

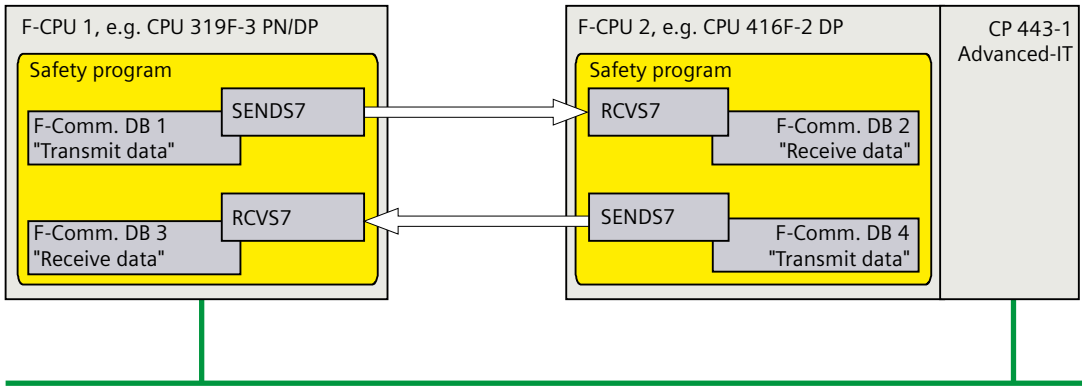

You use the **SENDS7 and RCVS7** instructions for fail-safe sending and receiving of data via S7 connections.

These instructions can be used to transmit a specified amount of fail-safe data of data types BOOL, INT, WORD, DINT, DWORD, and TIME in a fail-safe manner. The fail-safe data is stored in F-DBs (F-Communication DBs), which you create for each communication connection on the send and receive side.

You can find these instructions in the "Instructions" task card under "Communication". The RCVS7 instruction **must** be called at the start of the main safety block. The SENDS7 instruction **must** be called at the end of the main safety block.

Note that the send signals are sent only after calling the SENDS7 instruction at the end of the relevant F-runtime group execution.

A detailed description of the SENDS7 and RCVS7 instructions is found in SENDS7 and RCVS7: Communication via S7 connections (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 636).

Requirement for programming

The S7 connections between the relevant F-CPUs must be configured in the network view in the "Connections" tab of the *hardware and network editor*.

Creating and Editing an F-Communication DB

F-communication DBs are F-DBs that you create and edit in the same way as other F-DBs in the project tree. You can assign the F-communication DB numbers in the SENDS7 and RCVS7 instructions.

NOTE

The length and structure of the F-communication DB on the receiver side must match the length and structure of the associated F-communication DB on the sender side.

If the F-communication DBs do not match, the F-CPU can go to STOP mode. A diagnostics event is entered in the diagnostics buffer of the F-CPU.

For this reason, we recommend that you use the following procedure:

1. Create an F-communication DB in the project tree in or below the "Program blocks" folder of the F-CPU at the sender end.
2. Specify the appropriate structure of the F-communication DB, taking into account the data to be transferred.
3. Copy this F-communication DB to the project tree in or below the "Program blocks" folder of the F-CPU at the receiver end, and change the name, if necessary.

Other requirements for F-communication DBs

F-communication DBs must also conform to the following properties:

- They are not permitted to be instance DBs.
- Their length is not permitted to exceed 100 bytes.
- In F-communication DBs, only the following data types may be declared: BOOL, INT, WORD, DINT, DWORD, and TIME.
- The data types must be arranged block-wise and in the following order: BOOL, data types with bit length of 16 bits (INT, WORD), and data types with bit length of 32 bits (DINT, DWORD, and TIME). Within the data blocks with lengths of 16 bits and 32 bits, the data types can be arranged in any order.
- No more than 128 data elements of data type BOOL are permitted to be declared.
- The amount of data of data type BOOL must always be an integer multiple of 16 (word limit). Reserve data must be added, if necessary.

If these criteria are not fulfilled, *STEP 7 Safety Advanced* outputs an error message during compilation.

Assignment of fail-safe values

Fail-safe values are made available at the receiver end:

- While the connection between the communication partners is being established the first time after startup of the F-systems
- Whenever a communication error occurs

The values you specified as initial values in the F-communication DB at the receiver end are made available as initial values.

Programming procedure

You program safety-related communication via S7 connections as follows:

1. Supply the tags in the F-communication DB at the sender end with send signals using fully qualified access (e.g., "Name of F-communication DB".tag name).
2. Read the tags in the F-communication DB at the receiver end (receive signals) that you want to process further in other sections of the program using fully qualified access (e.g., "Name of F-communication DB".tag name).
3. In the safety program from which data is to be sent, call the SENDS7 instruction for sending at the end of the main safety block.
4. In the safety program in which data is to be received, call the instruction RCVS7 for receiving at the start of the main safety block.
5. Assign F-communication DB numbers to the SEND_DB input of SENDS7 and the RCV_DB input of RCVS7.
6. Assign the local ID of the S7 connection (data type: WORD) from the perspective of the F-CPU that was configured in the "Connections" tab of the network view to the ID input of SENDS7.
7. Assign the local ID of the S7 connection (data type: WORD) that was configured in the "Connections" tab of the network view to the ID input of RCVS7.

8. Assign an odd number (data type: DWORD) to the R_ID inputs of SENDS7 and RCVS7. This serves to specify that a SENDS7 instruction belongs to an RCVS7 instruction. The associated instructions receive the same value for R_ID.

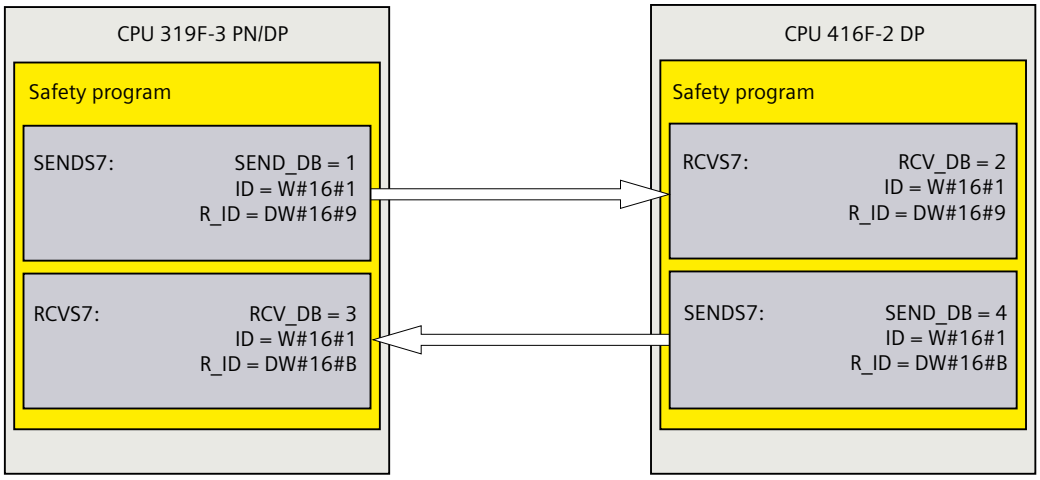

WARNING

The value of the respective F-communication ID (input R_ID; data type: DWORD) can be freely selected; however, it must be odd and unique for all safety-related communication connections network-wide* and CPU-wide. The value R_ID + 1 is internally assigned and must not be used.

You must supply inputs ID and R_ID with constant values when calling the instruction. Direct read or write access to ID and R_ID in the associated instance DB is not permitted in the safety program. *(S020)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

9. Assign the TIMEOUT inputs of the SENDS7 and RCVS7 instructions with the required monitoring time.

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 643).

10. To reduce the bus load, you can temporarily shut down communication between the F-CPUs at input EN_SEND of the SENDS7 instruction. To do so, supply input EN_SEND (initial value = "TRUE") with 0. In this case, send data is no longer sent to the F-communication DB of the associated RCVS7 instruction and the receiver RCVS7 provides fail-safe values for this period (initial values in its F-communication DB). If communication was already established between the partners, a communication error is detected.
11. Optional: Evaluate the ACK_REQ output of RCVS7, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether user acknowledgment is required.
12. Supply the ACK_REI input of RCVS7 with the signal for the acknowledgment for reintegration.
13. Optional: evaluate the SUBS_ON output of RCVS7 or SENDS7 in order to query whether the RCVS7 instruction is outputting the fail-safe values you specified as initial values in the F-communication DB.
14. Optional: Evaluate the ERROR output of RCVS7 or SENDS7, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether a communication error has occurred.
15. Optional: evaluate the SENDMODE output of RCVS7 in order to query whether the F-CPU with the associated SENDS7 instruction is in disabled safety mode (Page 405).

Particularities for migrated projects

If you have migrated a project from *S7 Distributed Safety V5.4 SP5* to *STEP 7 Safety Advanced* in which safety-related communication via S7 connections is programmed, you must note the following:

- Do not delete migrated instance DBs for the SENDS7 and RCVS7 instructions in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks".

Otherwise, communication errors may occur in the relevant communication connections.

A migrated instance DB for the SENDS7 and RCVS7 instructions has been deleted if, after compiling the safety program, the "User-defined ID" in the newly generated instance DB is not identical to "FRCVS7CL" or "FSNDS7CL".

You can find the "User-defined ID" of a block in its properties in the "Information" area.

9.1.8.3 Safety-related communication via S7 connections - Limits of data transfer

NOTE

If the amount of data to be transmitted exceeds the permitted length for the F-communication DB (100 bytes), you can create a further F-communication DB that you transfer to additional SENDS7/RCVS7 instructions with a modified R_ID.

Note that USEND and URCV instructions are called internally at each SENDS7 or RCVS7 call and use connection resources in the F-CPU. This affects the maximum number of communication connections available (*see manuals for F-CPUs*).

More information can be found on the data transfer limits for S7 connections of individual F-CPUs is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/38549114).

9.1.9 Safety-related communication with other S7 F-systems

9.1.9.1 Introduction

Safety-related communication from F-CPUs in SIMATIC Safety to F-CPUs in S7 Distributed Safety F-systems is possible via a PN/PN coupler or DP/DP coupler that you use between the two F-CPUs as IO controller-IO controller communication, master-master communication or communication via established S7 connections.

Safety-related communication from F-CPUs in SIMATIC Safety to F-CPUs in S7 F/FH Systems F-systems is possible via established S7 connections.

9.1.9.2 Communication with S7 Distributed Safety via PN/PN coupler (IO controller-IO controller communication)

Communication functions between SENDDP/RCVDP instructions at the *STEP 7 Safety Advanced* end and F-application blocks F_SENDDP/F_RCVDP at the *S7 Distributed Safety* end:

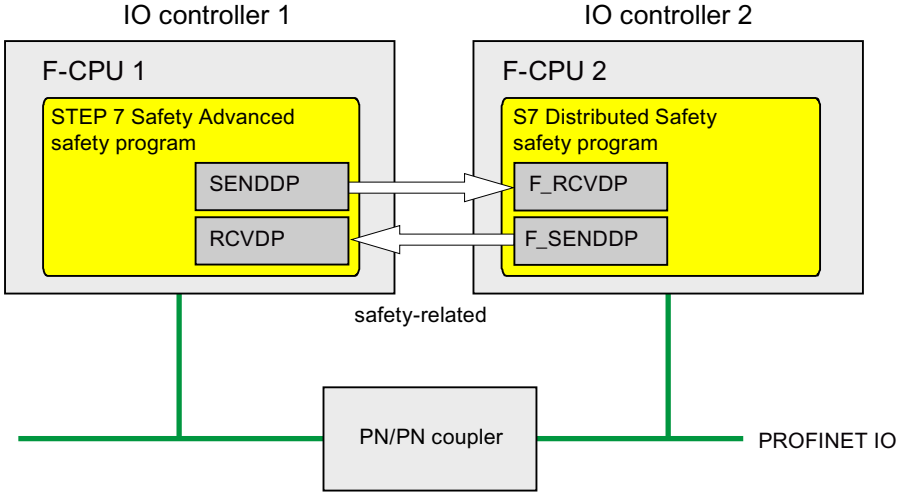

Procedure at the *S7 Distributed Safety* end

At the *S7 Distributed Safety* end, proceed as described in "Safety-related IO controller-IO controller communication" in the S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875) manual.

Procedure at the *STEP 7 Safety Advanced* end

At the *STEP 7 Safety Advanced* end, proceed as described in Safety-related IO controller-IO controller communication (Page 211).

9.1.9.3 Communication with S7 Distributed Safety via DP/DP coupler (master-master communication)

Communication functions between SENDDP/RCVDP instructions at the *STEP 7 Safety Advanced* end and F-application blocks F_SENDDP/F_RCVDP at the *S7 Distributed Safety* end:

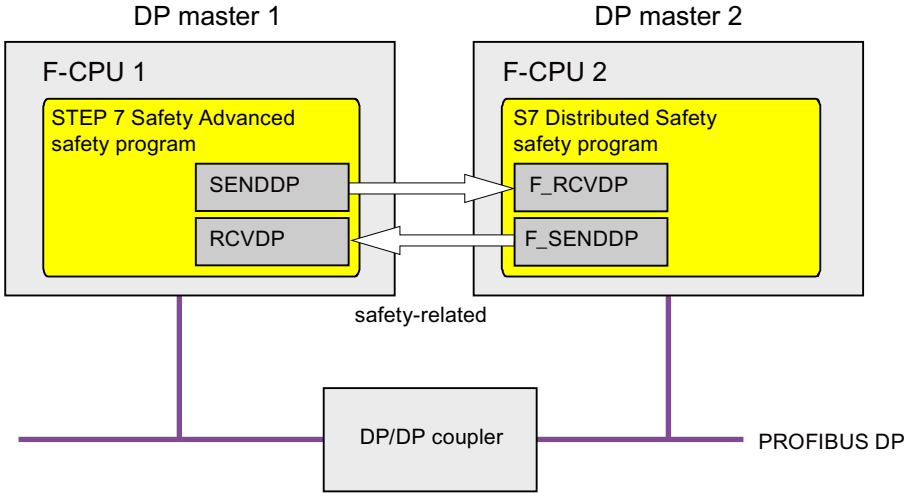

Procedure at the *S7 Distributed Safety* end

At the *S7 Distributed Safety* end, proceed as described in "Safety-related master-master communication" in the S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875) manual.

Procedure at the *STEP 7 Safety Advanced* end

At the *STEP 7 Safety Advanced* end, proceed as described in Safety-related master-master communication (Page 218).

9.1.9.4 Communication with S7 Distributed Safety via S7 connections

Communication functions between SENDS7/RCVS7 instructions at the *STEP 7 Safety Advanced* end and F_SENDS7/F_RCVS7 F-application blocks at the *S7 Distributed Safety* end:

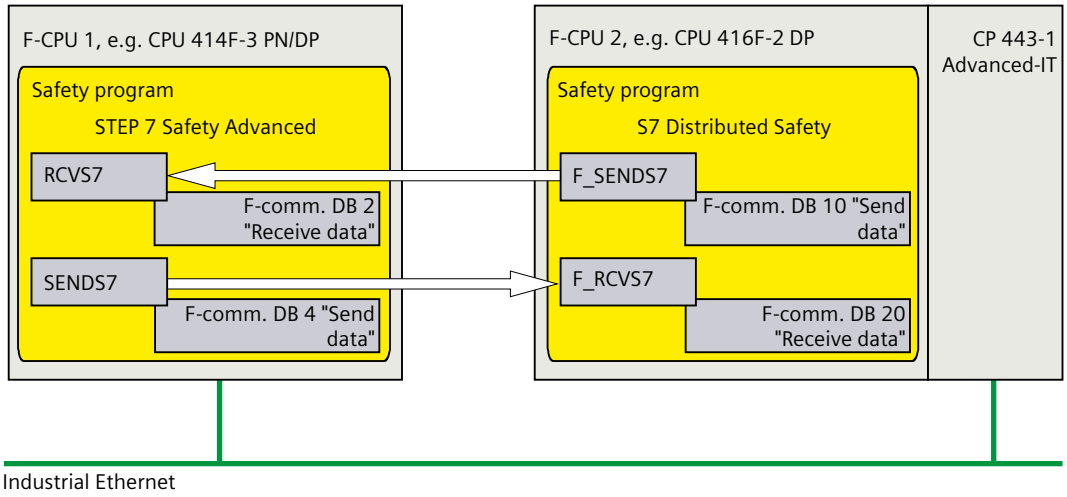

Procedure at the *S7 Distributed Safety* end

At the *S7 Distributed Safety* end, proceed as described in section "Safety-related communication via S7 communications" in the S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875) manual.

Because safety-related communication via S7 connections is not possible with unspecified partners in S7 Distributed Safety, you must first create a "virtual" SIMATIC station in *S7 Distributed Safety* in which you configure an F-CPU as a proxy for the F-CPU in *STEP 7 Safety Advanced* with its IP address.

You then insert an S7 connection to this F-CPU in the connection table. Both the local connection and partner connection resources (hex) are thereby fixed. You must then set these in the associated, unspecified S7 connection that you created in *STEP 7 Professional*.

In addition, for all communication connections to this F-CPU, you must transfer the F-communication ID that you assigned in the R_ID input of the associated calls of the F_SENDS7 and F_RCVS7 F-application blocks additionally to the CRC_IMP tag in the instance DB of F_SENDS7 and F_RCVS7, respectively, in the standard user program immediately before calling the F-CALL.

Program example:

Network 1: Communication to STEP 7 Safety Advanced: R_ID -> CRC_IMP

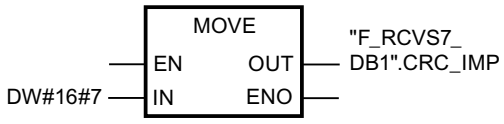

Network 2: Communication to STEP 7 Safety Advanced: R_ID -> CRC_IMP

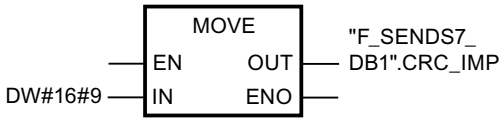

Procedure at the *STEP 7 Safety Advanced* end

At the *STEP 7 Safety Advanced* end, proceed as described in Safety-related communication via S7 connections (Page 244).

For the F-CPU in *S7 Distributed Safety*, you must create and specify an unspecified S7 connection. You can find information on this in the *STEP 7* help, under "Creating an unspecified connection" or "Specifying and unspecified connection".

For these you must set the local and partner connection resources (hex) that are fixed as a result of the associated S7 connection that you have created in *S7 Distributed Safety*.

If the local connection resource (hex) is already occupied by an existing connection, you must change the connection resource (hex) for it.

If the instance DBs of the SENDS7 and RCVS7, instructions that you want to use for communication with *S7 Distributed Safety* were migrated from *S7 Distributed Safety*, you must delete them in the project tree in the "STEP 7 Safety" folder, under "Program blocks > System blocks" (contrary to the information in Programming safety-related communication via S7 connections (Page 246), section "Particularities for migrated projects").

9.1.9.5 Communication with S7 F/FH Systems via S7 connections

Communication functions between SENDS7/RCVS7 instructions at the *STEP 7 Safety Advanced* end and F_SDS_BO/F_RDS_BO F-blocks at the *S7 F Systems* end.

A maximum of 32 data elements of data type BOOL can be exchanged.

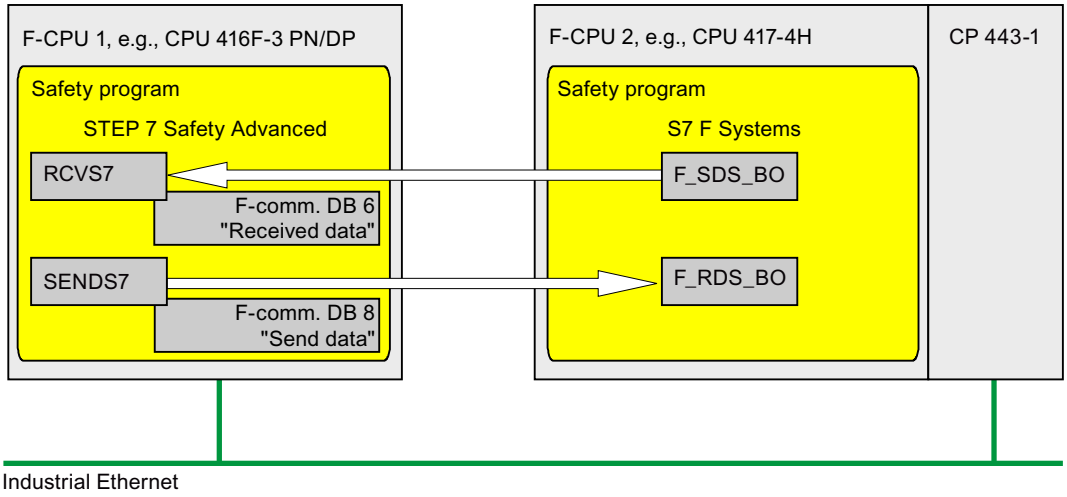

Procedure at the *S7 F Systems* end

At the *S7 F systems* end, proceed as described in section "Safety-related communication between F-CPUs" in the S7 F/FH Systems - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/109802562) manual.

Because safety-related communication via S7 connections is not possible with unspecified partners in *S7 F/FH Systems*, you must first create a "virtual" SIMATIC station in *S7 F/FH Systems* in which you configure an F-CPU as a proxy for the F-CPU in *STEP 7 Safety Advanced* with its IP address.

You then insert an S7 connection to this F-CPU in the connection table. Both the local connection and partner connection resources (hex) are thereby fixed. You must then set these in the associated, unspecified S7 connection that you created in *STEP 7 Safety Advanced*.

In addition, you must insert a function in your S7 program (in the area reserved in CFC for other applications), in which, for all communication connections for this F-CPU, you transfer the F-communication ID that you assigned in the R_ID input of the associated calls of the F_SDS_BO and F_RDS_BO F-blocks additionally to the CRC_IMP tag in the instance DB of the F_SDS_BO and F_RDS_BO, respectively. You obtain the number of the instance DB from the object properties of the block in CFC. Assign descriptive names for these instance DBs. If you perform a compress operation in CFC, you must check whether the numbers of these instance DBs have changed.

Program example:

Network 1: Communication to STEP 7 Safety Advanced: R_ID -> CRC_IMP

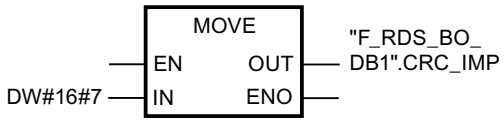

Network 2: Communication to STEP 7 Safety Advanced: R_ID -> CRC_IMP

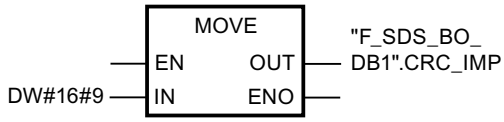

You must then import the function in CFC as block type and insert your standard user program in a chart. In the run sequence, make sure that the associated standard runtime group is processed before the F-runtime group.

Procedure at the *STEP 7 Safety Advanced* end

At the *STEP 7 Safety Advanced* end, proceed as described in "Safety-related communication via S7 connections" (Page 244).

Particularity: In *STEP 7 Safety Advanced*, you must create the F-communication DB with exactly 32 data elements of data type BOOL.

For the F-CPU in *S7 F/FH Systems*, you must create and specify an unspecified S7 connection. You can find information on this in the *STEP 7* help, under "Creating an unspecified connection" or "Specifying an unspecified connection".

For these you must set the local and partner connection resources (hex) that are fixed as a result of the associated S7 connection that you have created in *S7 F Systems*.

If the local connection resource (hex) is already occupied by an existing connection, you must change the connection resource (hex) for it.

9.2 Communication via SENDDP/RCVDP instructions (S7-1200, S7-1500):

9.2.1 Overview

Introduction

This section gives an overview of the options for safety-related communication using the SENDDP/RCVDP instructions in SIMATIC Safety F-systems.

Options for safety-related CPU-CPU communication

Safety-related CPU-CPU communication	On subnet	Additional hardware required	Required instructions
IO controller-IO controller communication	PROFINET IO	PN/PN coupler	SENDDP/RCVDP
Master-master communication	PROFIBUS DP	DP/DP coupler	SENDDP/RCVDP
IO controller-I-device communication	PROFINET IO	—	SENDDP/RCVDP
Master-I-slave communication	PROFIBUS DP	—	SENDDP/RCVDP
IO controller-I-slave communication	PROFINET IO and PROFIBUS DP	IE/PB link	SENDDP/RCVDP
IO controller-IO controller communication for *S7 Distributed Safety*	PROFINET IO	PN/PN coupler	SENDDP/RCVDP
Master-master communication for *S7 Distributed Safety*	PROFIBUS DP	DP/DP coupler	SENDDP/RCVDP

NOTE

The options for safety-related communication depend on the F-CPUs used.

NOTE

Safety-related communication with S7-1200 G1 F-CPUs is only permitted as of firmware V4.1.2.

Overview of safety-related communication via PROFIBUS DP

The figure below provides an overview of the options for safety-related communication via PROFIBUS DP in SIMATIC Safety F-systems with S7-1200/1500 F-CPUs.

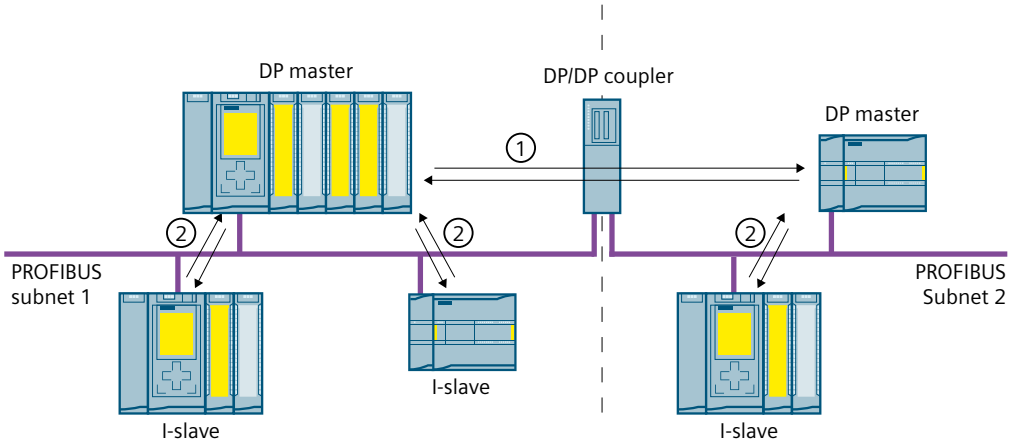

① Safety-related master-master communication

② Safety-related master-I-slave communication

Overview of safety-related communication via PROFINET IO

The figure below provides an overview of the options for safety-related communication via PROFINET IO in SIMATIC Safety F-systems with S7-1200/1500 F-CPUs.

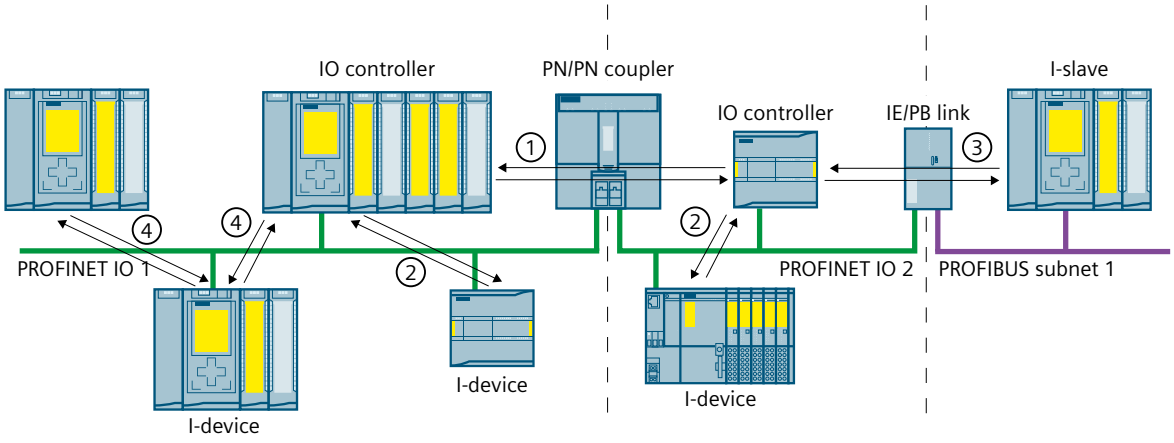

① Safety-related IO controller-IO controller communication

② Safety-related IO controller-I-device communication

③ Safety-related IO controller-I-slave communication

④ Safety-related IO controller-I-device communication (shared I-device)

Safety-related CPU-CPU communication via PROFIBUS DP or PROFINET IO

In safety-related CPU-CPU communication, a fixed amount of data of the data type BOOL or INT (DINT as alternative) is transmitted fail-safe between the safety programs in F-CPUs of DP masters/I-slaves or IO controllers/I-devices.

The data are transferred using the SENDDP instruction for sending and the RCVDP instruction for receiving. The data are stored in configured transfer areas of the devices. The hardware identifier (HW identifier) defines the transfer areas configured.

Safety-related CPU-CPU communication for *S7 Distributed Safety*

Safety-related communication is possible from F-CPUs in *SIMATIC Safety* to F-CPUs in *S7 Distributed Safety*.

9.2.2 Safety-related IO controller-IO controller communication

9.2.2.1 Configure safety-related IO controller-IO controller communication

Introduction

Safety-related communication between safety programs of the F-CPUs of IO controllers takes place over a PN/PN coupler that you set up between the F-CPUs.

NOTE

Deactivate the "Data validity display DIA" parameter in the properties for the PN/PN coupler in the *hardware and network editor*. This is the default setting. Otherwise, safety-related IO controller-IO controller communication is not possible.

Configuring transfer areas

You must configure one transfer area for output data and one transfer area for input data in the *hardware and network editor* for each safety-related communication connection between two F-CPUs in the PN/PN coupler. The figure below shows how both of the F-CPUs are able to send **and** receive data (bidirectional communication).

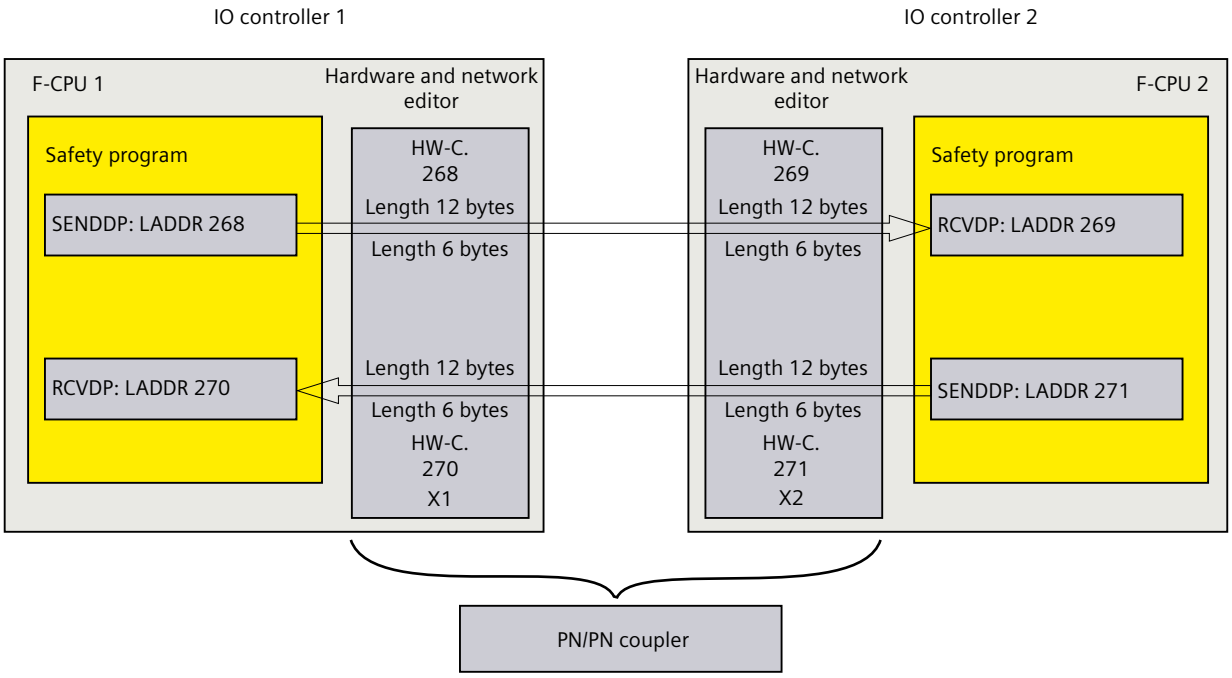

Rules for defining transfer areas

Data to be sent:

A total of 12 bytes (consistent) is required for the transfer area for output data; 6 bytes (consistent) are required for the transfer area for input data.

Data to be received:

A total of 12 bytes (consistent) is required for the transfer area for input data; 6 bytes (consistent) are required for the transfer area for output data.

NOTE

PN/PN Coupler article number 6ES7158-3AD10-0XA0

When configuring the transfer areas for the output and input data, proceed as described in the "SIMATIC bus links PN/PN coupler (https://support.industry.siemens.com/cs/ww/en/view/44319532)" manual, section "Configuring the PN/PN Coupler with STEP 7 TIA Portal".

Procedure for configuration

The procedure for configuring safety-related IO controller-IO controller communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Switch to the network view of the *hardware and network editor*.
3. Select a PN/PN Coupler X1 and a PN/PN Coupler X2 from "Other field devices\PROFINET IO\Gateway\Siemens AG\PN/PN Coupler" in the "Hardware catalog" task card and insert them into the network view of the hardware and network editor.
4. Connect the PN interface of the F-CPU 1 with the PN interface of the PN/PN Coupler X1 and the PN interface of the F-CPU 2 with the PN interface of PN/PN Coupler X2.

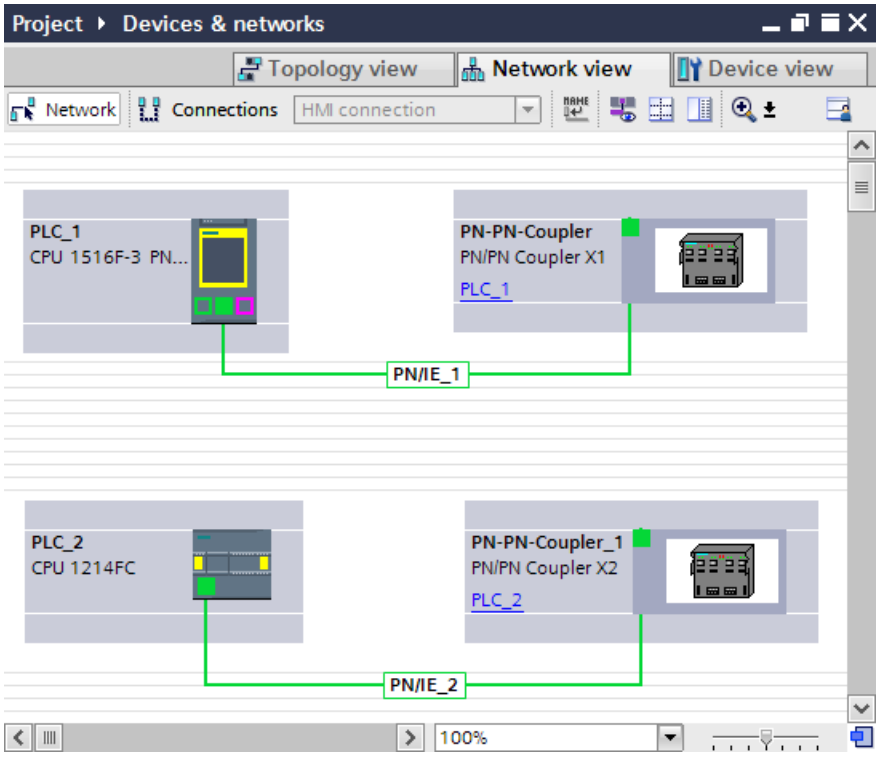

5. Switch to the device view of PN/PN Coupler X1 for bidirectional communication connections i.e. where each F-CPU is both to send and to receive data. Select the following modules from "IN/OUT" in the "Hardware catalog" task card (with filter activated), and insert them in the "Device overview" tab:
   - One "IN/OUT 6 bytes / 12 bytes" module and
   - One "IN/OUT 12 bytes / 6 bytes" module

NOTE

The transfer areas are assigned on the basis of the hardware identifier which is automatically assigned to the modules and devices. You need the HW identifier to program the SENDDP and RCVDP blocks (LADDR input). A system constant is created in the corresponding F-CPU for each hardware identifier of the transfer area. You can assign these system constants symbolically to the SENDDP and RCVDP blocks.

Device overview

Module	...	Rack	Slot	I address	Q address	Type	Article n...	Firmware
PN-PN-Coupler		0	0	8186*		PN/PN Coupler X1	6ES7 158...	V03.00.00
PN-IO-01		0	0 X1	8185*		PN-PN-Coupler		
IN/OUT 6 Byte / 12 Byte_1		0	1	0...5	0...11	IN/OUT 6 Bytes ...		
IN/OUT 12 Byte / 6 Byte_1		0	2	6...17	12...17	IN/OUT 12 Byte...		

6. Select the following modules from "IN/OUT" in the device view of PN/PN coupler X2 and insert them in the "Device overview" tab:
   - One "IN/OUT 12 bytes / 6 bytes" module and
   - One "IN/OUT 6 bytes / 12 bytes" module

Device overview

Module	...	Rack	Slot	I address	Q address	Type	Article n...	Firmware
PN-PN-Coupler_1		0	0	8186*		PN/PN Coupler X2	6ES7 158...	V03.00.00
PN-IO-02		0	0 X2	8185*		PN-PN-Coupler		
IN/OUT 12 Byte / 6 Byte_1		0	1	0...11	0...5	IN/OUT 12 Byte...		
IN/OUT 6 Byte / 12 Byte_1		0	2	12...17	6...17	IN/OUT 6 Bytes ...		

9.2.2.2 Program safety-related IO controller-IO controller communication

Communication via SENDDP and RCVDP instructions

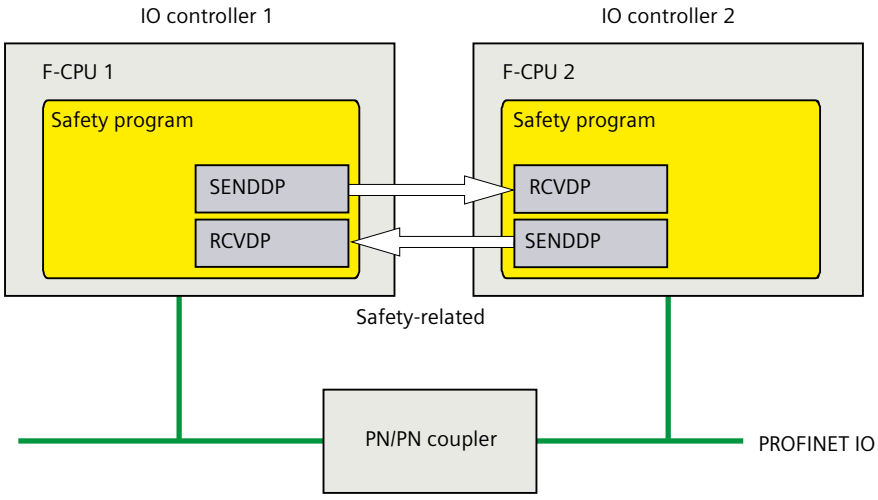

Safety-related communication between the F-CPUs of the IO controllers uses the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type BOOL or INT (DINT as alternative).

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

You can also call the RCVDP and SENDDP instructions in separate F-FBs/F-FCs which you have to call up at the beginning or end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 627).

Requirement for programming

The transfer areas for input and output data for the PN/PN coupler must be configured.

Programming procedure

You program safety-related IO controller-IO controller communication as follows:

1. In the safety program from which data is to be sent, call the SENDDP instruction (Page 627) for sending at the end of the main safety block.
2. In the safety program in which data is to be received, call the RCVDP instruction (Page 627) for receiving at the start of the main safety block.

3. Assign the HW identifiers (system constants in the default tag table) of the transfer areas for output and input data of the PN/PN coupler that are configured in the hardware and network editor to the respective LADDR inputs.

   You must carry out this assignment for every communication connection for each of the F-CPUs involved.

4. Assign the value for the respective F-communication ID to the DP_DP_ID inputs. This establishes the communication relationship between the SENDDP instruction in one F-CPU and the RCVDP instruction in the other F-CPU: The associated instructions receive the same value for DP_DP_ID.

   The figure below contains an example of how to specify the F-communication IDs at the inputs of the SENDDP and RCVDP instructions for 5 safety-related IO controller-IO controller communication relationships.

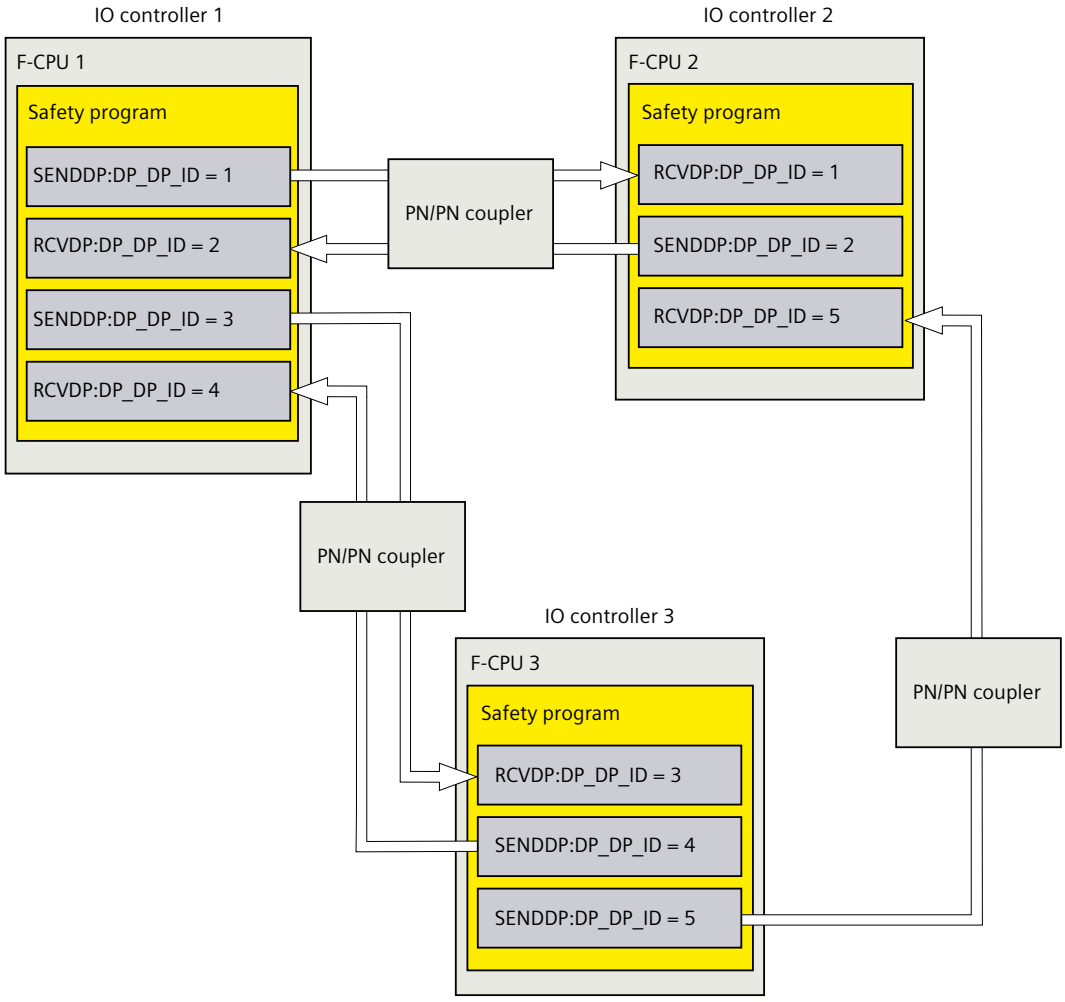

WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide**** at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.

You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure a unique F-communication ID during startup of the safety program, because it is only specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

**** With a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be regarded as one single F-CPU with regard to the DP_DP_ID.

5. Supply the SD_BO_xx and SD_I_xx inputs (SD_DI_00 as alternative) of SENDDP with the send signals. To cut down on intermediate signals when transferring block parameters, you can write the value directly to the instance DB of SENDDP using fully qualified access (for example, "Name SENDDP_1".SD_BO_02) before calling SENDDP.
6. Supply the RD_BO_xx and RD_I_xx outputs (RD_DI_00 as alternative) of RCVDP with the signals that you want to process further in other program sections or use fully qualified access to read the received signals directly in the associated instance DB in the program sections to be processed further (e.g., "Name RCVDP_1".RD_BO_02).
7. If you want to send the data at the SD_DI_00 input instead of the data at the SD_I_00 and SD_I_01 inputs, supply the DINTMODE input (initial value = "FALSE") of SENDDP with TRUE.

8. Supply the SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs of RCVDP with the fail-safe values that are to be output by RCVDP in place of the process data until communication is established for the first time after startup of the sending and receiving F-systems or in the event of an error in safety-related communication.
   - Specification of constant fail-safe values:

     For data of data type INT/DINT, you can enter constant fail-safe values directly as constants in the SUBI_xx or alternatively SUBDI_00 input (initial value = "0"). If you want to specify a constant fail-safe value "TRUE" for data of the data type BOOL, set TRUE for the SUBBO_xx input (initial value = "FALSE").
   - Specification of variable substitute values:

     If you want to specify variable substitute values, define a tag that you calculate through your safety program in an F-DB and specify this tag (fully qualified) in the SUBBO_xx or SUBI_xx or alternatively SUBDI_00 input.

     WARNING

     Note: The program logic for calculating variable substitute values can only be inserted after the RCVDP calls, because there must be no program logic before the RCVDP calls. This is why the initial values of the substitute values are active in all RCVDP instructions in the first cycle after a startup of the F-system. You must therefore assign appropriate initial values for these tags. *(S017)*

9. Configure the TIMEOUT inputs of the RCVDP and SENDDP instructions with the required monitoring time.

   WARNING

   It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

   Information on calculating the monitoring times can be found in Monitoring and response times (Page 643).
10. Optional: Evaluate the ACK_REQ output of the RCVDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether user acknowledgment is required.
11. Supply the ACK_REI input of the RCVDP instruction with the acknowledgment signal for reintegration.
12. Optional: Evaluate the SUBS_ON output of the RCVDP or SENDDP instruction in order to query whether the RCVDP instruction is outputting the fail-safe values assigned in the SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs.

13. Optional: Evaluate the ERROR output of the RCVDP or SENDDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether a communication error has occurred.
14. Optional: Evaluate the SENDMODE output of the RCVDP instruction in order to query whether the F-CPU with the associated SENDDP instruction is in disabled safety mode (Page 405).

9.2.2.3 Safety-related IO controller-IO controller communication - Limits for data transfer

NOTE

If the data quantities to be transmitted exceed the capacity of the SENDDP / RCVDP correlated instructions, a second (or third) SENDDP / RCVDP call can be used. This requires configuration of an additional communication connection via the PN/PN coupler. Whether or not this is possible with one single PN/PN coupler depends on the capacity restrictions of the PN/PN coupler.

9.2.3 Safety-related master-master communication

9.2.3.1 Configure safety-related master-master communication

Introduction

Safety-related communication between safety programs of the F-CPUs of DP masters takes place via a DP/DP coupler.

NOTE

Switch the data validity indicator "DIA" on the DIP switch of the DP/DP coupler to "OFF". Otherwise, safety-related CPU-CPU communication is not possible.

Configuring transfer areas

You must configure one transfer area for output data and one transfer area for input data in the *hardware and network editor* for each safety-related communication connection between two F-CPUs in the DP/DP coupler. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).

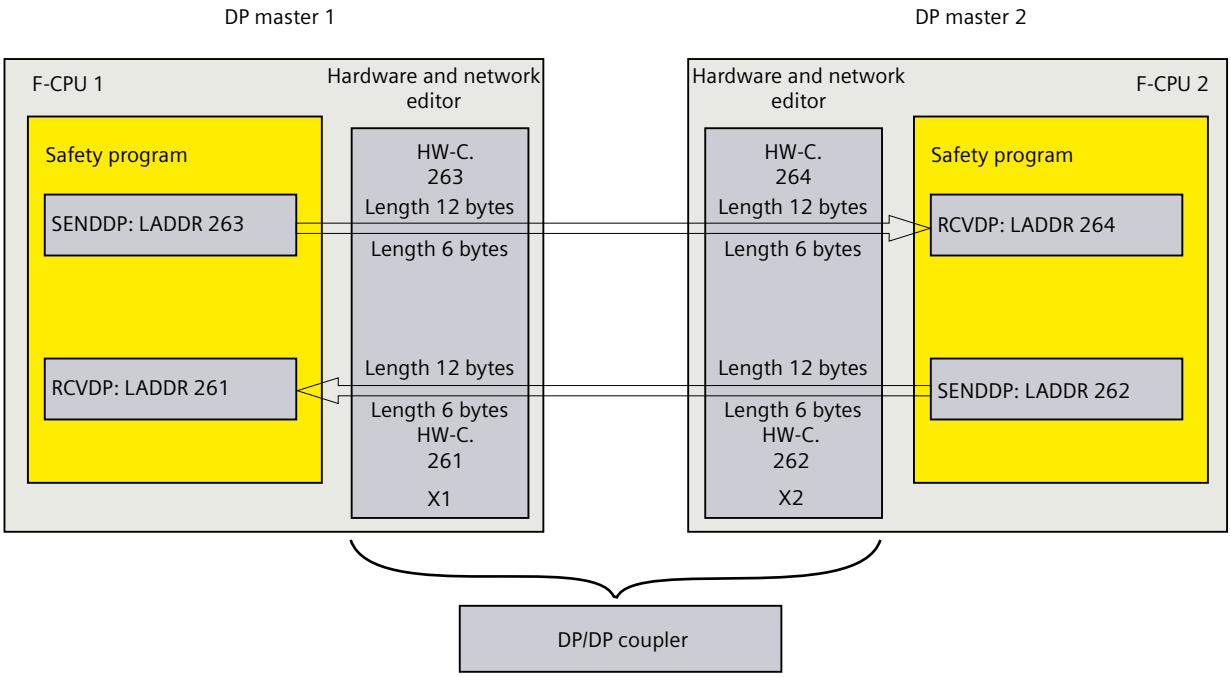

Rules for defining transfer areas

Data to be sent:

A total of 12 bytes (consistent) is required for the transfer area for output data; 6 bytes (consistent) are required for the transfer area for input data.

Data to be received:

A total of 12 bytes (consistent) is required for the transfer area for input data; 6 bytes (consistent) are required for the transfer area for output data.

Procedure for configuration

The procedure for configuring safety-related master-master communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Switch to the network view of the *hardware and network editor*.
3. Select a DP/DP coupler from "Other field devices\PROFIBUS DP\Gateways\Siemens AG\DP/DP Coupler" in the "Hardware catalog" task card and insert it into the network view of the hardware and network editor.

4. Insert a second DP/DP coupler.
5. Connect a DP interface of F-CPU 1 to the DP interface of a DP/DP coupler and a DP interface of F-CPU 2 to the DP interface of the other DP/DP coupler.

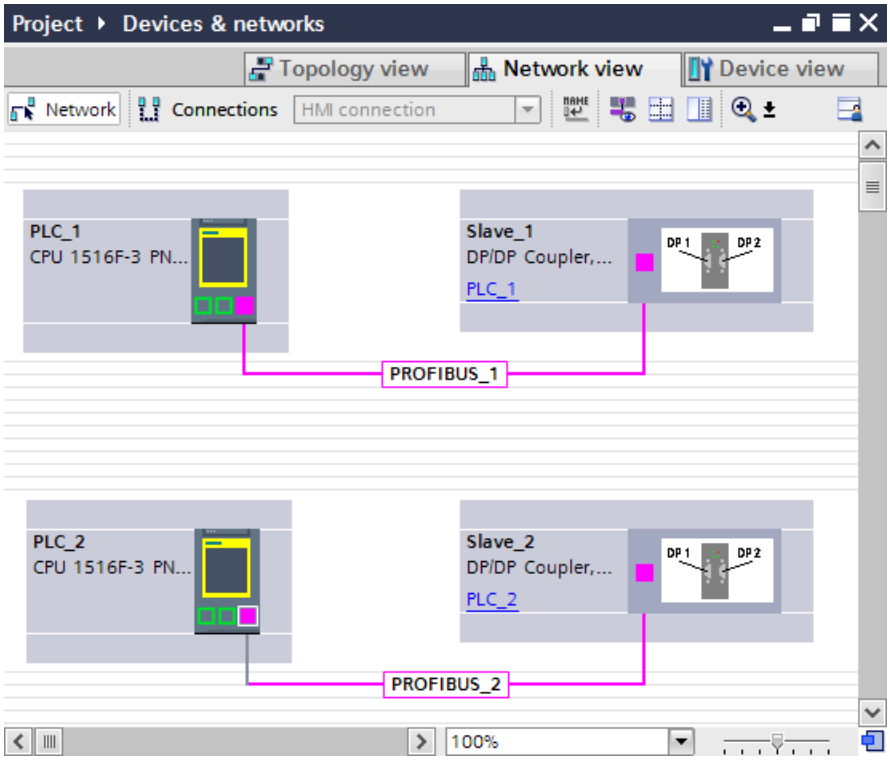

6. A free PROFIBUS address is assigned automatically in the properties of the DP/DP-coupler in the device view. You must set this address on the DP/DP coupler, either via the DIP switch on the device or in the configuration of the DP/DP coupler (see DP/DP Coupler (https://support.industry.siemens.com/cs/ww/en/view/1179382) manual).
7. Switch to the device view of the DP/DP coupler PLC1 for bidirectional communication connections i.e. where each F-CPU should both send and receive data. Select the following modules from the "Hardware catalog" task card (with filter activated), and insert them in the "Device overview" tab of the DP/DP coupler:
   - One "6 bytes I/12 bytes Q consistent" module, and
   - One "12 bytes I/6 bytes Q consistent" module

NOTE

The transfer areas are assigned on the basis of the hardware identifier which is automatically assigned to the modules and devices. You need the HW identifier to program the SENDDP and RCVDP blocks (LADDR input). A system constant is created in the corresponding F-CPU for each hardware identifier of the transfer area. You can assign these system constants symbolically to the SENDDP and RCVDP blocks.

Device overview

...	Module	Rack	Slot	I address	Q address	Type	Article no.	Firmw...
	Slave_1	0	0 0	8186*		DP/DP Co...	6ES7 158-0AD01...	B0
	6 Bytes E/12 Bytes A konsist...	0	0 1	256...261	256...267	6 Bytes I/...		
	12 Bytes E/6 Bytes A konsist...	0	0 2	262...273	268...273	12 Bytes ...		
		0	3					

8. Select the following modules from the "Hardware catalog" task card (with filter activated) in the device view of DP/DP coupler PLC2, and insert them in the "Device overview" tab:
   - One "12 bytes I/6 bytes Q consistent" module, and
   - One "6 bytes I/12 bytes Q consistent" module

Device overview

...	Module	Rack	Slot	I address	Q address	Type	Article no.	Firmw...
	Slave_2	0	0 0	8186*		DP/DP Co...	6ES7 158-0AD01...	B0
	12 Bytes E/6 Bytes A konsist...	0	0 1	256...267	256...261	12 Bytes ...		
	6 Bytes E/12 Bytes A konsist...	0	0 2	268...273	262...273	6 Bytes I/...		
		0	3					

9.2.3.2 Program safety-related master-master communication

Communication via SENDDP and RCVDP instructions

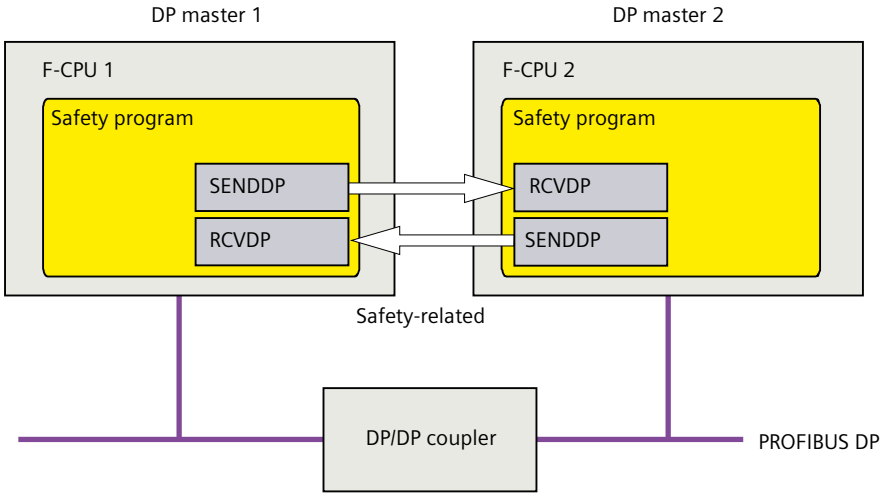

Safety-related communication between the F-CPUs of the DP master uses the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type BOOL or INT (DINT as alternative).

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

You can also call the RCVDP and SENDDP instructions in separate F-FBs/F-FCs which you have to call up at the beginning or end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 627).

Requirement for programming

The address areas for input and output data for the DP/DP coupler must be configured.

Programming procedure

You program safety-related master-master communication as follows:

1. In the safety program from which data is to be sent, call the SENDDP instruction (Page 627) for sending at the end of the main safety block or a separate F-FC/F-FB.
2. In the safety program in which data is to be received, call the RCVDP instruction (Page 627) for receiving at the start of the main safety block or a separate F-FC/F-FB.
3. Assign the HW identifiers for the output and input data of the DP/DP coupler configured in the *hardware and network editor* (constant in the tag table) to the respective LADDR inputs.

   You must carry out this assignment for every communication connection for each of the F-CPUs involved.

4. Assign the value for the respective F-communication ID to the DP_DP_ID inputs. This establishes the communication relationship between the SENDDP instruction in one F-CPU and the RCVDP instruction in the other F-CPU: The associated instructions receive the same value for DP_DP_ID.

   The figure below contains an example of how to specify the F-communication IDs at the inputs of the SENDDP and RCVDP instructions for 5 safety-related master-master communications relationships.

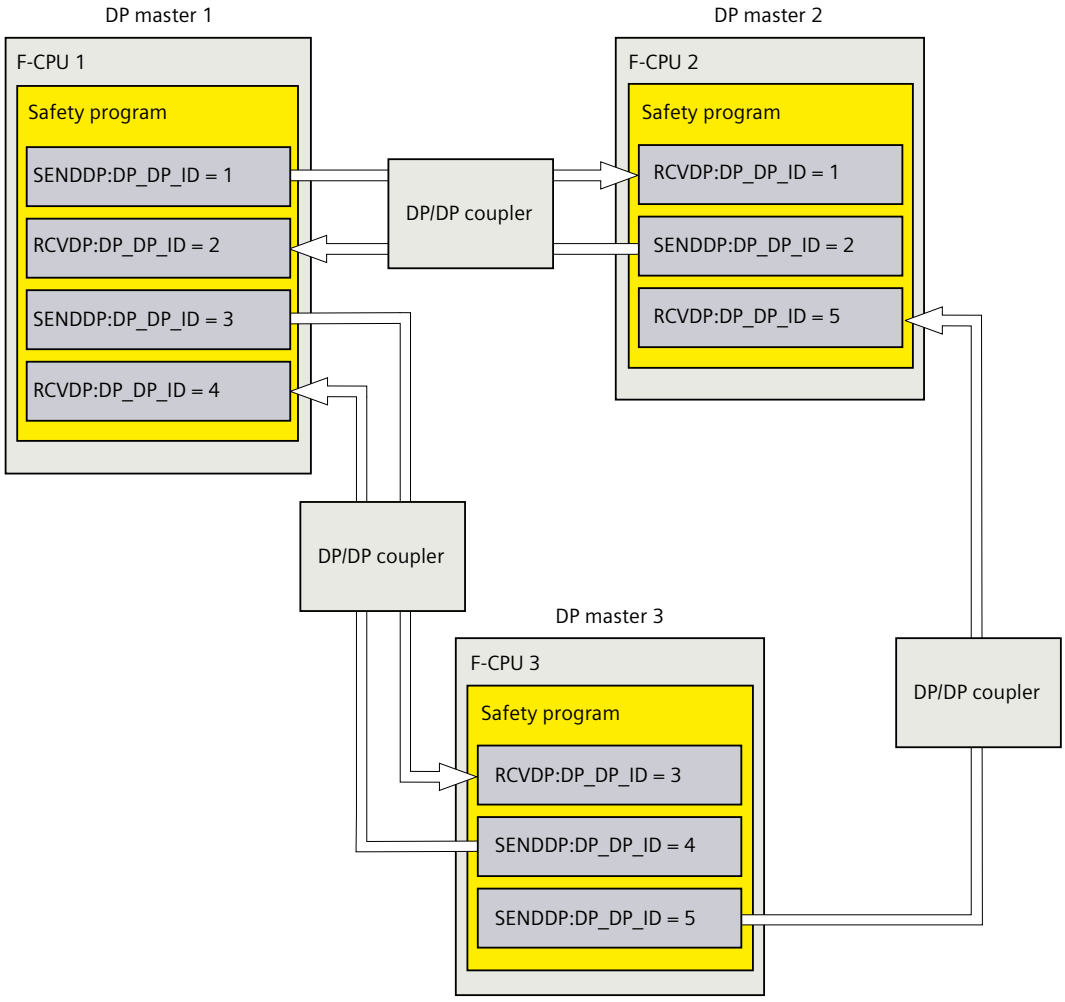

WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.

You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure a unique F-communication ID during startup of the safety program, because it is only specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

5. Supply the SD_BO_xx and SD_I_xx inputs (SD_DI_00 as alternative) of SENDDP with the send signals. To cut down on intermediate signals when transferring block parameters, you can write the value directly to the instance DB of SENDDP using fully qualified access (for example, "Name SENDDP_1".SD_BO_02) before calling SENDDP.
6. Supply the RD_BO_xx and RD_I_xx outputs (RD_DI_00 as alternative) of RCVDP with the signals that you want to process further in other program sections or use fully qualified access to read the received signals directly in the associated instance DB in the program sections to be processed further (e.g., "Name RCVDP_1".RD_BO_02).
7. If you want to send the data at the SD_DI_00 input instead of the data at the SD_I_00 and SD_I_01 inputs, supply the DINTMODE input (initial value = "FALSE") of SENDDP with TRUE.
8. Supply the SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs of RCVDP with the fail-safe values that are to be output by RCVDP in place of the process data until communication is established for the first time after startup of the sending and receiving F-systems or in the event of an error in safety-related communication.
   - Specification of constant fail-safe values:

     For data of data type INT/DINT, you can enter constant fail-safe values directly as constants in the SUBI_xx or alternatively SUBDI_00 input (initial value = "0"). If you want to specify a constant fail-safe value "TRUE" for data of the data type BOOL, set TRUE for the SUBBO_xx input (initial value = "FALSE").
   - Specification of variable substitute values:

     If you want to specify variable substitute values, define a tag that you calculate through your safety program in an F-DB and specify this tag (fully qualified) in the SUBBO_xx or SUBI_xx or alternatively SUBDI_00 input.

WARNING

Note: The program logic for calculating variable substitute values can only be inserted after the RCVDP calls, because there must be no program logic before the RCVDP calls. This is why the initial values of the substitute values are active in all RCVDP instructions in the first cycle after a startup of the F-system. You must therefore assign appropriate initial values for these tags. *(S017)*

9. Configure the TIMEOUT inputs of the RCVDP and SENDDP instructions with the required monitoring time.

   WARNING

   It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

   Information on calculating the monitoring times can be found in Monitoring and response times (Page 643).

10. Optional: Evaluate the ACK_REQ output of the RCVDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether user acknowledgment is required.
11. Supply the ACK_REI input of the RCVDP instruction with the acknowledgment signal for reintegration.
12. Optional: Evaluate the SUBS_ON output of the RCVDP or SENDDP instruction in order to query whether the RCVDP instruction is outputting the fail-safe values assigned in the SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs.
13. Optional: Evaluate the ERROR output of the RCVDP or SENDDP instruction, for example, in the standard user program or on the operator control and monitoring system in order to query or to indicate whether a communication error has occurred.
14. Optional: Evaluate the SENDMODE output of the RCVDP instruction in order to query whether the F-CPU with the associated SENDDP instruction is in disabled safety mode (Page 405).

9.2.3.3 Safety-related master-master communication:Limits for data transfer

NOTE

If the data quantities to be transmitted exceed the capacity of the SENDDP / RCVDP correlated instructions, a second (or third) SENDDP / RCVDP call can be used. This requires configuration of an additional connection via the DP/DP coupler. Whether or not this is possible with one single DP/DP coupler depends on the capacity restrictions of the DP/DP coupler.

9.2.4 Safety-related IO controller-I-device communication

9.2.4.1 Configuring safety-related communication between IO controller and I-device

Introduction

Safety-related communication between the safety program of the F-CPU of an IO controller and the safety program(s) of the F-CPU(s) of one or more I-devices takes place via IO controller-I-device transfer areas (F-CD) in PROFINET IO, as in standard systems.

You do not need any additional hardware for IO controller-I-device communication.

Configuring transfer areas

For every safety-related communication connection between two F-CPUs, you must configure transfer areas in the *hardware and network editor*. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).

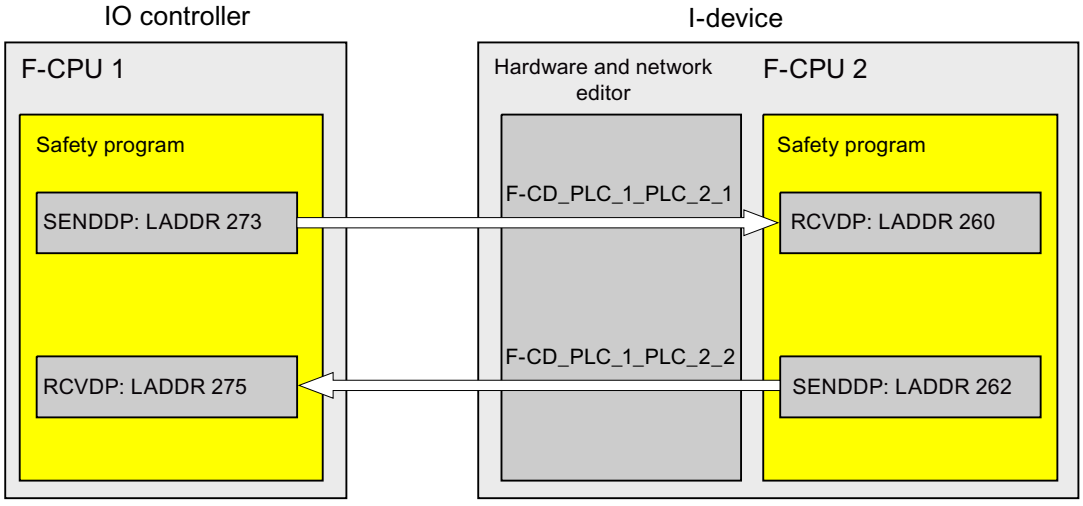

The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-CD_PLC_2 PLC_1_1" for the first F-CD connection between IO controller F-CPU 1 and I-device F-CPU 2.

When you create a transfer area, a system constant with the name of the transfer area is created in the F-CPU of the IO controller and in the F-CPU of the I-device. The system constant contains the hardware identifier of the transfer area for the corresponding F-CPU.

You assign the hardware identifier (system constant from the default tag table) of the transfer areas symbolically to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

The procedure for configuring safety-related IO controller-I-device communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. Enable the "IO Device" mode for F-CPU 2 in the properties of its PN interface and assign this PN interface to a PN interface of F-CPU 1.
3. Select the PROFINET interface of F-CPU 2. Under "Transfer areas", you create an F-CD connection (type "F-CD") for receiving from the IO controller (←). The F-CD connection is shown in yellow in the table and the address areas in the I-device and IO controller assigned are displayed.

   In addition, an acknowledgment connection is created automatically for each F-CD connection. (see "Transfer area details").
4. Create an additional F-CD connection for sending to the IO controller.

5. In the transfer area you just created, click on the arrow to change the transfer direction to sending to the IO controller (←).

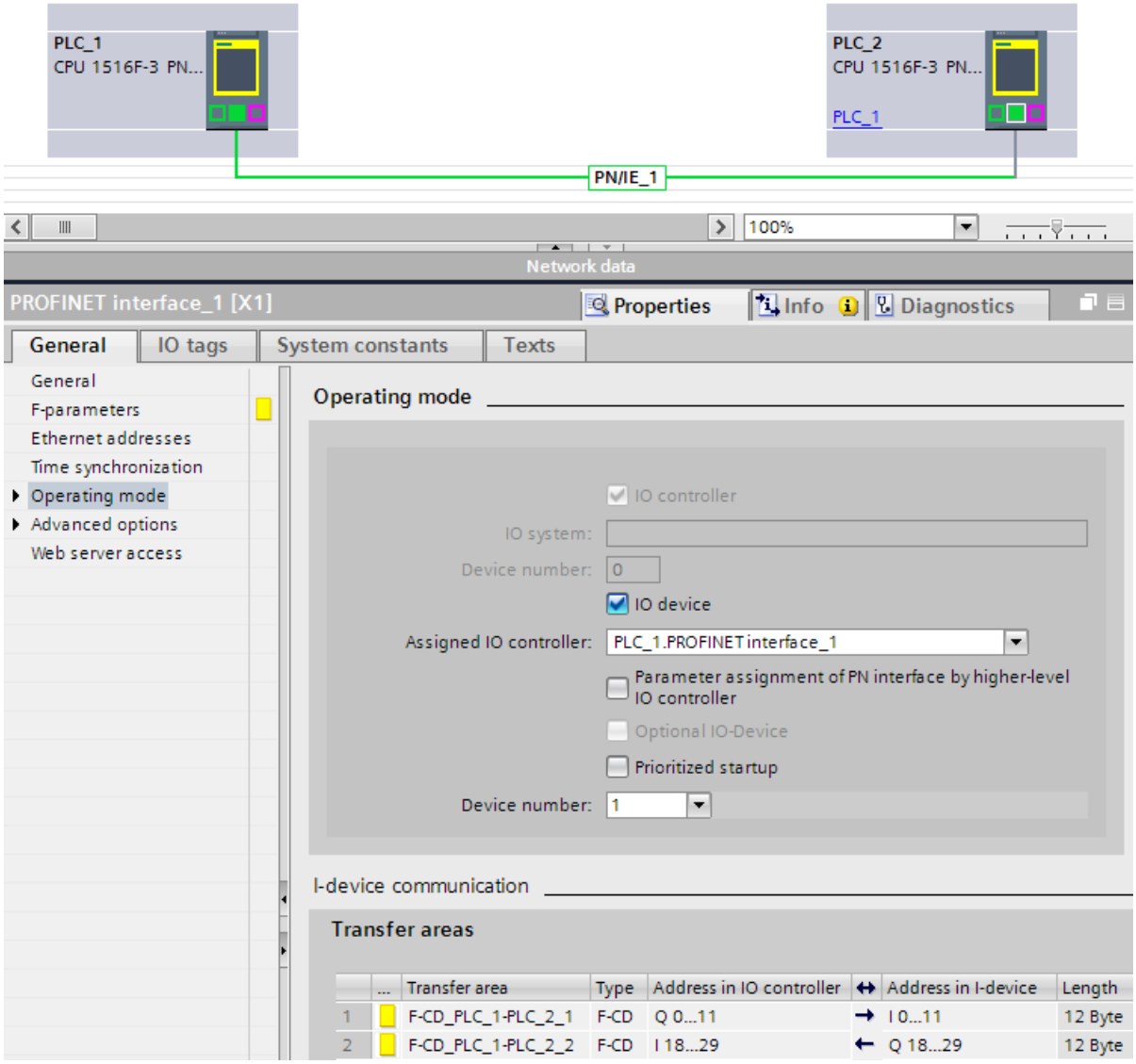

NOTE

You can assign up to four IO controllers in separate projects to the shared I-device, as in standard systems. To do this, export the I-device as a GSD file and import the GSD file into the projects of the IO controllers. Proceed as described in the *STEP 7 help* under "Configuring an I-device as a shared device".

Configuration procedure for an S7-1500 F-CPU as of firmware V3.1 or S7-1200 G2 F-CPU as I-device

The procedure for configuring safety-related IO controller-I-device communication is identical to that in the standard system.

Proceed as follows:

1. From the "Hardware catalog" task card, insert any S7-1200/1500 F-CPU into the project as F-CPU 1.
2. From the "Hardware catalog" task card, insert an S7-1200 G2/S7-1500 F-CPU as of firmware V3.1 into the project as F-CPU 2 (I-device).
3. Enable the "IO Device" mode for F-CPU 2 in the properties of its PN interface and assign this PN interface to a PN interface of F-CPU 1.
4. Assign F-CPU 1 as an IO controller under "Assigned IO controllers".
5. Under "Transfer areas", you create an F-CD connection (type "F-CD") for receiving from the IO controller (←). The F-CD connection is shown in yellow in the table and the address areas in the I-device and IO controller assigned are displayed.

   In addition, an acknowledgment connection is created automatically for each F-CD connection. (see "Transfer area details").
6. Create an additional F-CD connection for sending to the IO controller.

7. In the transfer area you just created, click on the arrow to change the transfer direction to sending to the IO controller (←).

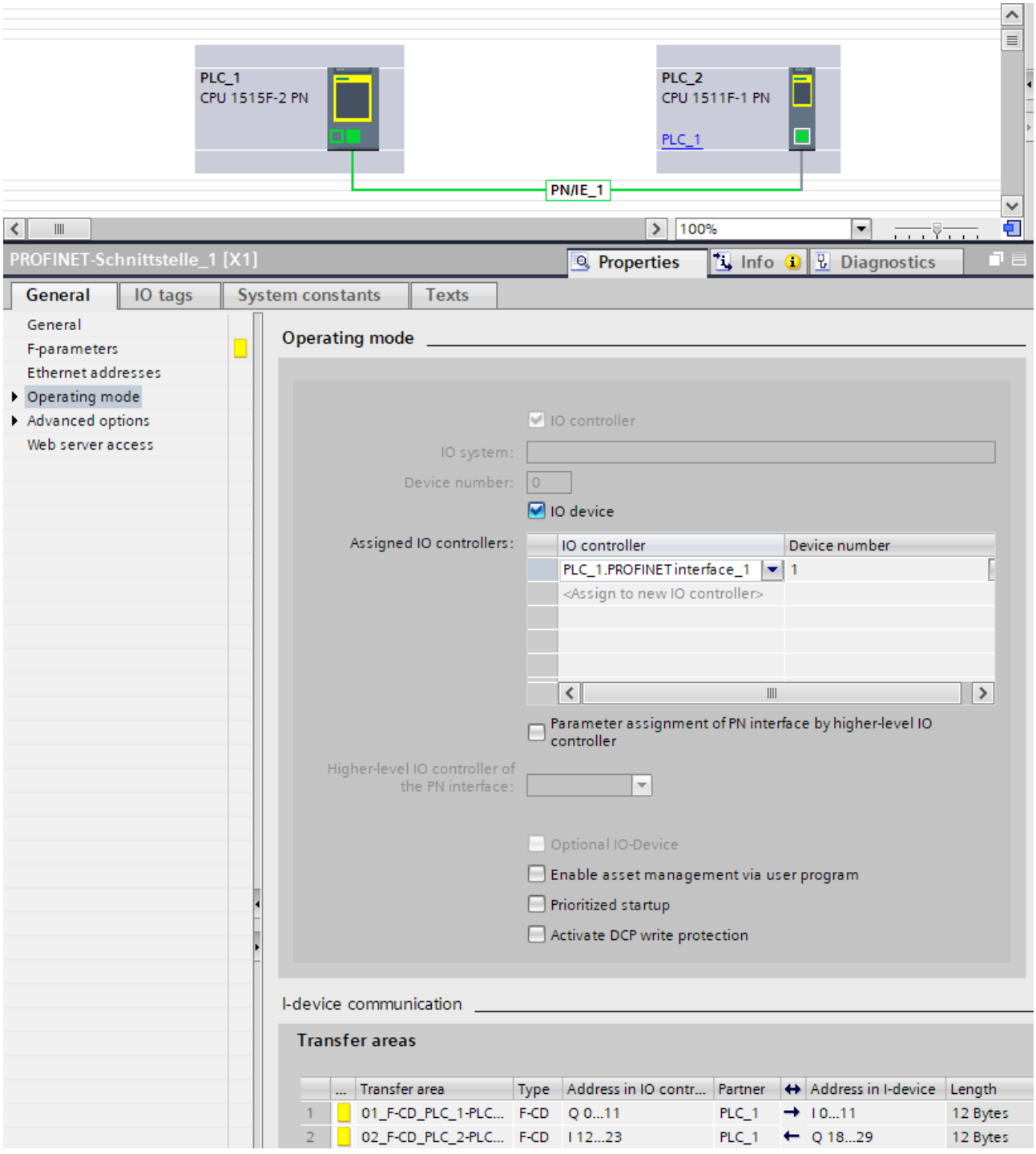

NOTE

Shared I-device

If you use S7-1500 F-CPUs as of firmware V3.1 or S7-1200 G2 F-CPUs as IO controller, you can divide different transfer areas of an I-device (S7-1500 F-CPU as of firmware V3.1 or S7-1200 G2 F-CPU) between two IO controllers within the project. As of *STEP 7 Safety V20*, you can divide between four IO controllers within the project, if the I-device is an S7-1500 F-CPU with firmware V3.1 or higher.

To do this, assign the I-device to a second IO controller under "Assigned IO controllers". Select the desired IO controller (partner) for each transfer area.

More information can be found in the *STEP 7 help*.

NOTE

You have the option to assign up to four additional IO controllers to the shared I-device, like in the standard. To do this, export the I-device as a GSD file and import the GSD file into the projects of the IO controllers. Proceed as described in the *STEP 7 help* under "Configuring an I-device as a shared device".

9.2.4.2 Programming safety-related IO controller I-device communication

Communication via SENDDP and RCVDP instructions

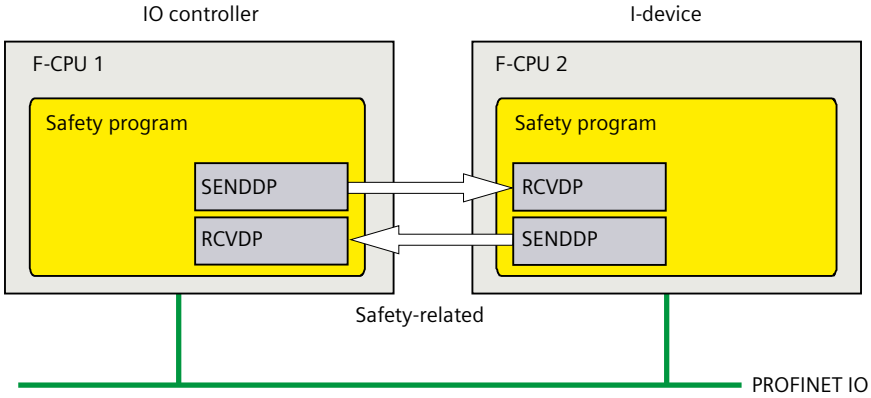

Safety-related communication between the F-CPUs of the IO controller and an I-device makes use of the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of data of the data type BOOL or INT (DINT as alternative).

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

You can also call the RCVDP and SENDDP instructions in separate F-FBs/F-FCs which you have to call up at the beginning or end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 627).

Requirement for programming

The transfer areas must be configured.

Programming procedure

The procedure for programming safety-related IO controller-I-device communication is the same as that for programming safety-related IO controller-IO controller communication (see Program safety-related IO controller-IO controller communication (Page 263)).

The assignment of the HW identifiers (system constants in the standard tag table) of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table:

Instruction	HW identifier
SENDDP in the IO controller	Hardware identifier of the transfer area in the IO controller
RCVDP in the IO controller	Hardware identifier of the transfer area in the IO controller
SENDDP in the I-device	Hardware identifier of the transfer area in the I-device
RCVDP in the I-device	Hardware identifier of the transfer area in the I-device

The figure below contains an example of how to specify the F-communication IDs for the inputs of the SENDDP and RCVDP instructions for 4 safety-related IO controller-I-device communication relationships.

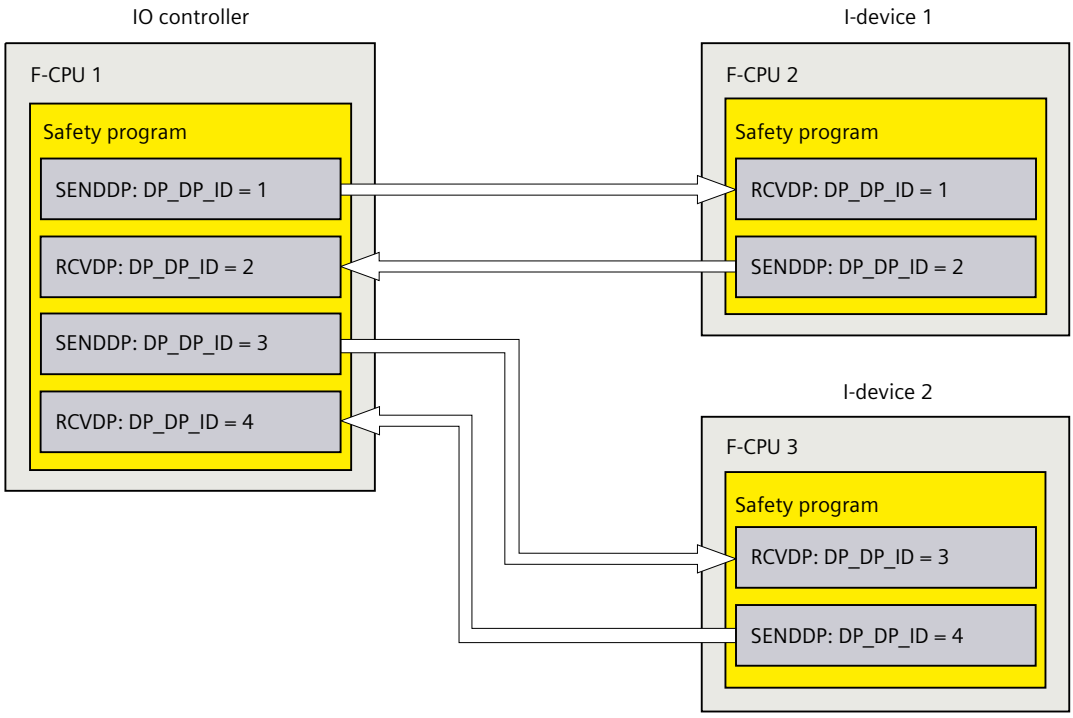

WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide**** at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.

You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure a unique F-communication ID during startup of the safety program, because it is only specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

**** With a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be regarded as one single F-CPU with regard to the DP_DP_ID.

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time.*(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 643).

9.2.4.3 Safety-related IO-Controller-IO-Device communication - Limits for data transfer

Limits for data transfer

If the amount of data to be transferred is greater than the capacity of related SENDDP/RCVDP instructions, you can use additional SENDDP/RCVDP instructions. Configure additional transfer areas for this purpose. Remember the maximum limit of 1440 bytes of input data or 1440 bytes of output data for transfer between an I-device and a IO controller.

The following table shows the amount of output and input data assigned in safety-related communication connections:

Safety-related communication	Communication connection	Assigned input and output data			
		In the IO controller		In the I-device	
		Output data	Input data	Output data	Input data
IO controller-I-Device	**Sending:** I-Device 1 to IO controller	6 bytes	12 bytes	12 bytes	6 bytes
	Receiving: I-Device 1 from IO controller	12 bytes	6 bytes	6 bytes	12 bytes

Consider all additional configured safety-related and standard communication connections (transfer areas of type F-CD and CD) for the maximum limit of 1440 bytes of input data or 1440 bytes of output data for transfer between an I-device and an IO controller. In addition, data are assigned for internal purposes such that the maximum limit may be reached sooner.

When the limit is exceeded, a corresponding error message is displayed.

You can find more information on the transfer areas in the *STEP 7 help* under "Rules for creating transfer areas".

9.2.5 Safety-related master-I-slave communication

9.2.5.1 Configuring safety-related master-I-slave communication

Introduction

Safety-related communication between the safety program of the F-CPU of a DP master and the safety program(s) of the F-CPU(s) of one or more I-slaves takes place via master-I-slave transfer areas (**F-**MS), as in standard systems.

You do not need a DP/DP coupler for master-I-slave communication.

Configuring transfer areas

For every safety-related communication connection between two F-CPUs, you must configure transfer areas in the *hardware and network editor*. The figure below shows how both of the F-CPUs are able to send and receive data (bidirectional communication).

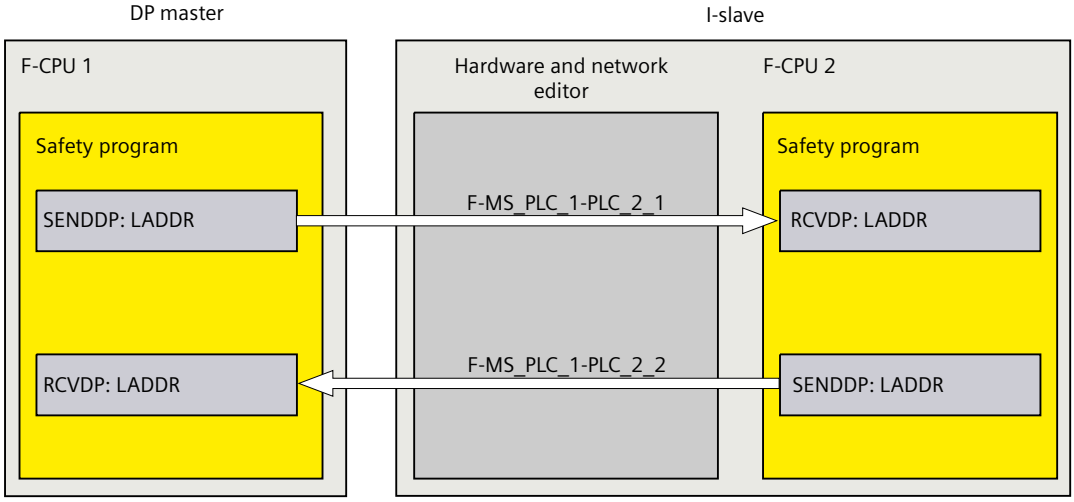

The transfer area is assigned a label when it is created to identify it as the communication relationship. For example, "F-MS_PLC_2-PLC_1_1" for the first F-MS connection between DP master F-CPU 1 and I-slave F-CPU 2.

When you create a transfer area, a system constant with the name of the transfer area is created in the F-CPU of the DP master and in the F-CPU of the I-slave. The system constant contains the hardware identifier of the transfer area for the corresponding F-CPU.

You assign the hardware identifier (system constant from the default tag table) of the transfer areas symbolically to the LADDR input of the SENDDP and RCVDP instructions in the safety programs.

Procedure for configuration

The procedure for configuring safety-related master-I-slave communication is identical to that in the standard system.

Proceed as follows:

1. Insert two F-CPUS from the "Hardware catalog" task card into the project.
2. If the F-CPU which is to be operated as DP master (F-CPU 1) does not have an integrated PROFIBUS DP interface, insert an PROFIBUS-CM, for example.
3. From the device view of the F-CPUs which are to be operated as I-slaves (F-CPU 2), insert a suitable CM DP module or CP DP module.
4. If necessary, enable "DP-slave" (I-slave) mode in the properties for the CM/CP DP module.
5. Assign the DP interface of the CM/CP to a DP interface of F-CPU 1.
6. Select the PROFIBUS interface of F-CPU 2 or of the CM. Under "Transfer areas", you create an F-MS connection (type "F-MS") for sending to the DP master (←). The F-MS connection is shown in yellow in the table and the assigned transfer areas in the I-slave and DP master are displayed.

   In addition, an acknowledgment connection is created automatically for each F-MS connection. (see "Transfer area details").
7. Create an additional F-MS connection for receiving from the DP master.

8. In the transfer area you just created, click the arrow in order to change the transfer direction to receiving from DP master (→).

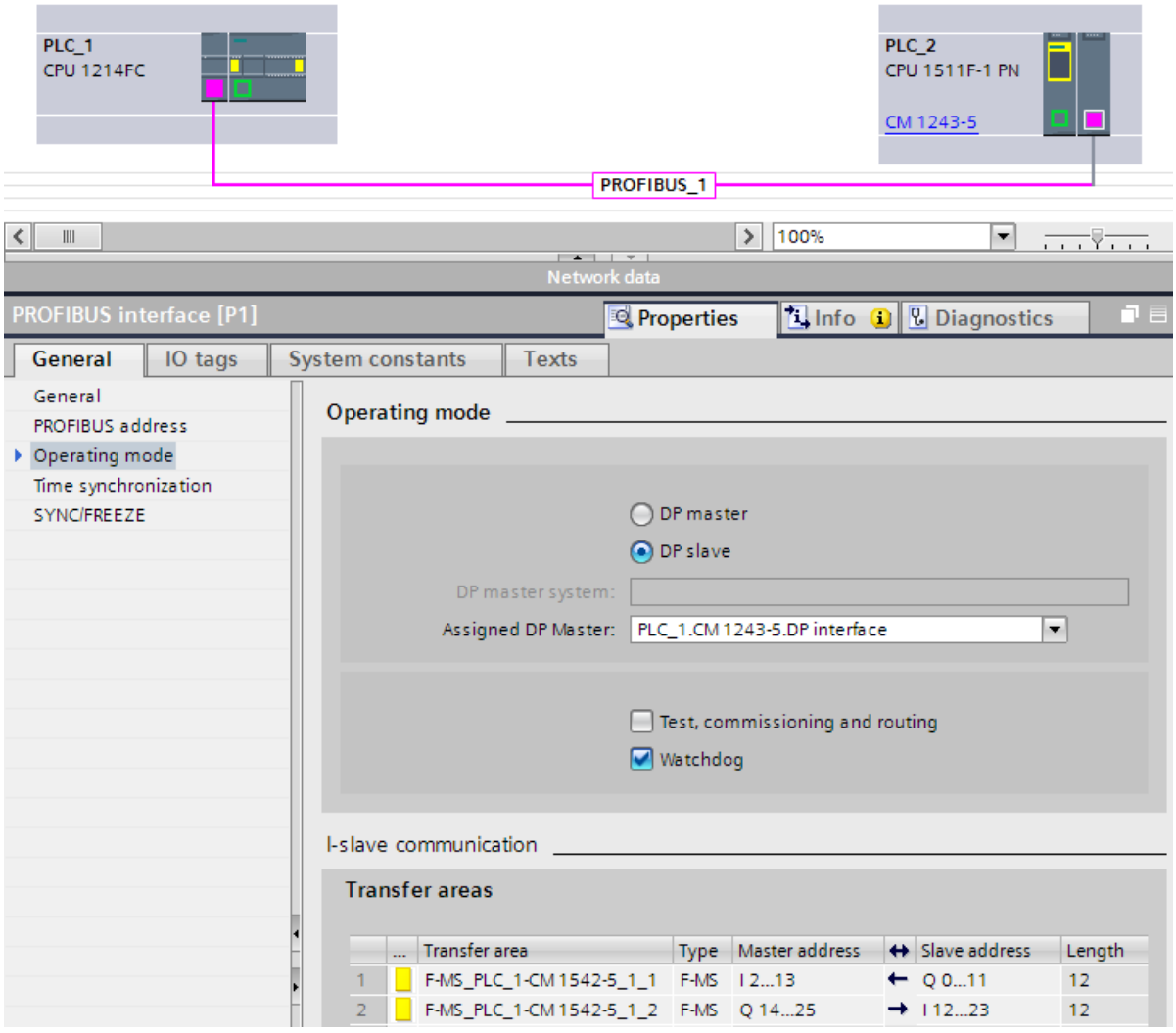

9.2.5.2 Programming safety-related master-I-slave communication

Communication via SENDDP and RCVDP instructions

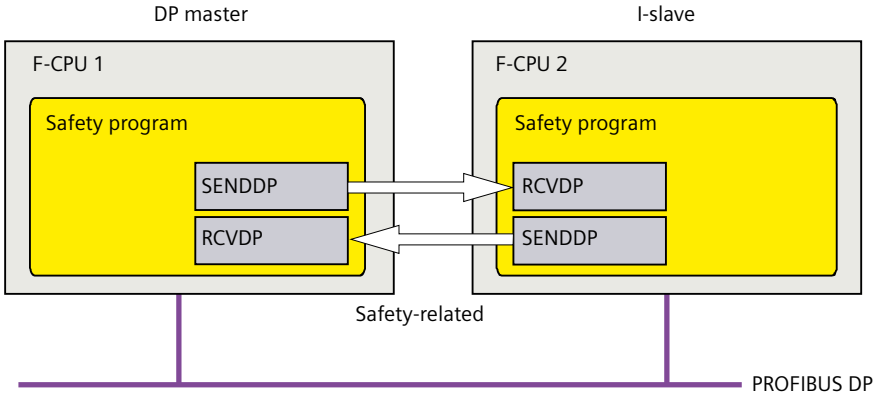

Safety-related communication between the F-CPUs of the DP master and an I-slave makes use of the SENDDP and RCVDP instructions for sending and receiving, respectively. These can be used to perform a fail-safe transfer of a *fixed* amount of fail-safe data of the data type BOOL or INT (DINT as alternative).

You can find these instructions in the "Instructions" task card under "Communication". The RCVDP instruction **must** be called at the start of the main safety block. The SENDDP instruction **must** be called at the end of the main safety block.

You can also call the RCVDP and SENDDP instructions in separate F-FBs/F-FCs which you have to call up at the beginning or end of the main safety block.

Note that the send signals are not sent until after the SENDDP instruction call at the end of execution of the relevant F-runtime group.

You can find a detailed description of the SENDDP and RCVDP instructions in SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21) (Page 627).

Requirements

The transfer areas must be configured.

Programming procedure

The procedure for programming safety-related master-I-slave communication is the same as that for programming safety-related master-master communication (see Safety-related master-master communication (Page 268)).

The assignment of the HW identifiers of the transfer areas to the LADDR input of the SENDDP/RCVDP instructions can be obtained from the following table.

Instruction	HW identifier
SENDDP in the DP master	Hardware identifier of the respective transfer area in the DP master
RCVDP in the DP master	Hardware identifier of the respective transfer area in the DP master
SENDDP in the I-slave	Hardware identifier of the transfer area in the I-slave
RCVDP in the I-slave	Hardware identifier of the transfer area in the I-slave

The figure below contains an example of how to specify the F-communication IDs at the inputs of the SENDDP and RCVDP instructions for four safety-related master-I-slave communication relationships.

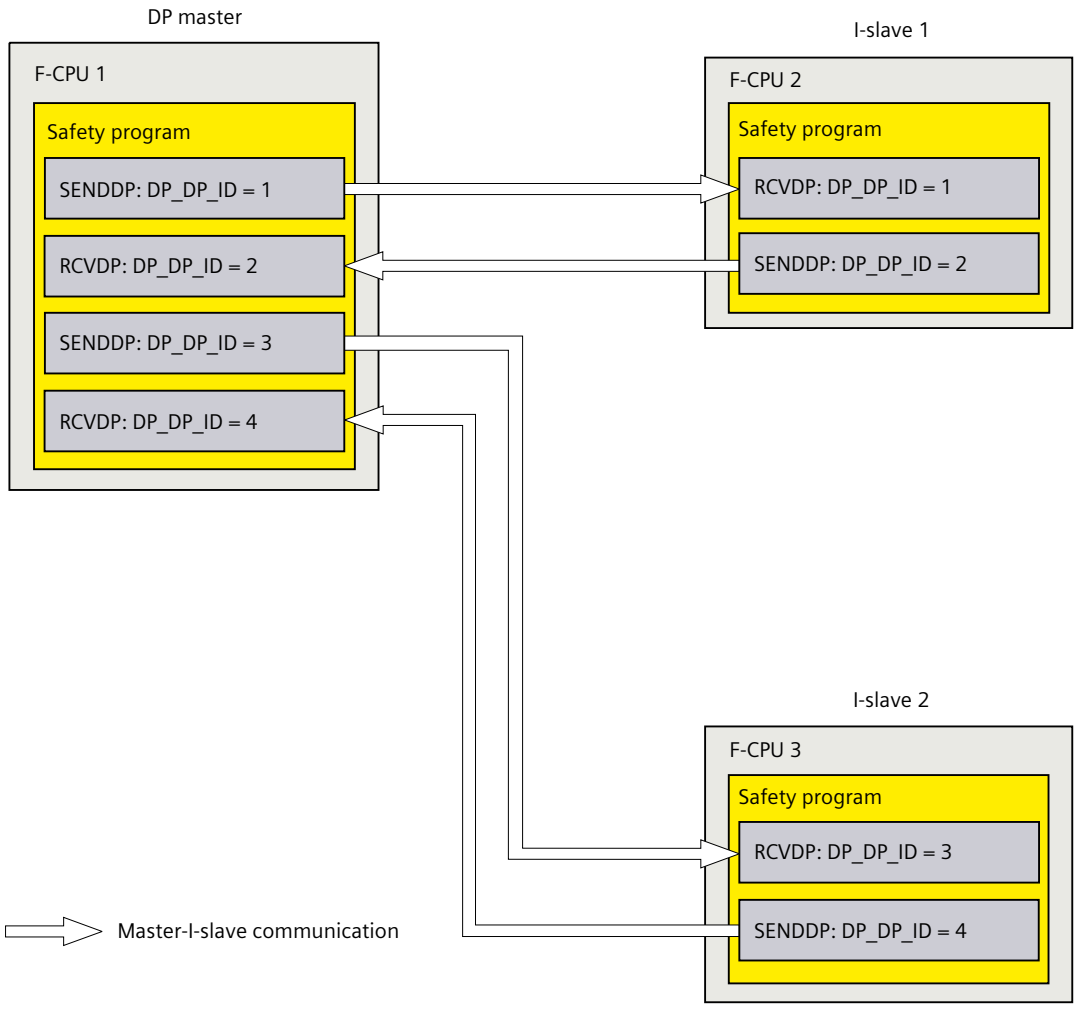

WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.

You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure a unique F-communication ID during startup of the safety program, because it is only specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

Information on calculating the monitoring times can be found in Monitoring and response times (Page 643).

9.2.5.3 Limits for data transfer of safety-related master-I-slave communication

Limits for data transfer

If the amount of data to be transferred is greater than the capacity of related SENDDP/RCVDP instructions, you can use additional SENDDP/RCVDP instructions. Configure additional transfer areas for this purpose. Note the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-slave and a DP master.

The following table shows the amount of output and input data assigned in safety-related communication connections:

Safety-related communication	Communication connection	Assigned input and output data			
		DP master		I-slave	
		Output data	Input data	Output data	Input data
Master-I-slave	**Sending:** I-slave 1 to DP master	6 bytes	12 bytes	12 bytes	6 bytes
	Receiving: I-slave 1 from DP master	12 bytes	6 bytes	6 bytes	12 bytes

Consider all additional configured safety-related and standard communication connections (transfer areas of type F-MS-, F-DX-, F-DX-Mod., MS-, DX- and DX-Mod) for the maximum limit of 244 bytes of input data or 244 bytes of output data for transfer between an I-device and a DP master F-MS and MS). If the maximum limit of 244 bytes of input data or 244 bytes of output data is exceeded, you will receive a corresponding error message.

9.2.6 Safety-related IO controller-I-slave communication

Introduction

Safety-related communication between the safety program of the F-CPU of an IO controller and the safety program(s) of the F-CPU(s) of one or more I-slaves takes place via master-I-slave transfer areas (**F-**MS), as in standard systems.

IE/PB link

For the safety-related IO-controller-I-slave communication, the IE/PB link is mandatory. Each of the two F-CPUs is linked to the IE/PB link by means of its PROFIBUS DP or PROFINET-interface.

NOTE

If you are using an IE/PB link, you must take this into account when configuring the F-specific monitoring times and when calculating the maximum response time of your F-system (see also Monitoring and response times (Page 643)).

Note that the Excel file for calculating response times (https://support.industry.siemens.com/cs/ww/en/view/109783831) for S7-300/400 F-CPUs does not support all conceivable configurations.

Reference

The information on safety-related master-I-slave communication in Safety-related master-I-slave communication (Page 285) also applies.

9.2.7 Safety-related communication to S7 F-System S7 Distributed Safety

Introduction

Safety-related communication from F-CPUs in SIMATIC Safety to F-CPUs in S7 Distributed Safety F-systems is possible, via a PN/PN coupler or DP/DP coupler that you use between the two F-CPUs, as IO controller-IO controller communication or master-master communication.

9.2.7.1 Communication with S7 Distributed Safety via PN/PN coupler (IO controller-IO controller communication)

Communication functions between SENDDP/RCVDP instructions at the *STEP 7 Safety* end and F-application blocks F_SENDDP/F_RCVDP at the *S7 Distributed Safety* end:

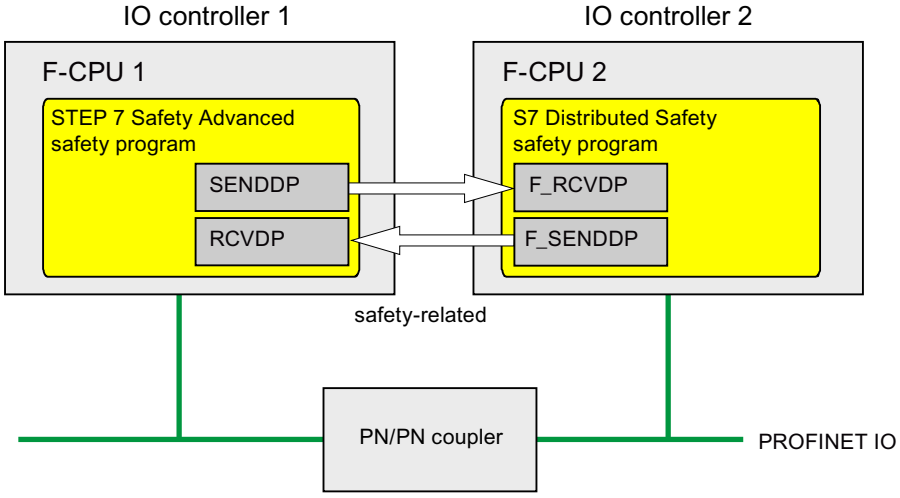

Procedure at the *S7 Distributed Safety* end

At the *S7 Distributed Safety* end, proceed as described in "Safety-related IO controller-IO controller communication" in the S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875) manual.

Procedure at the *STEP 7 Safety* end

At the *STEP 7 Safety* end, proceed as described in Safety-related IO controller-IO controller communication (Page 259).

9.2.7.2 Communication with S7 Distributed Safety via DP/DP coupler (master-master communication)

Communication functions between SENDDP/RCVDP instructions at the *STEP 7 Safety* end and F-application blocks F_SENDDP/F_RCVDP at the *S7 Distributed Safety* end:

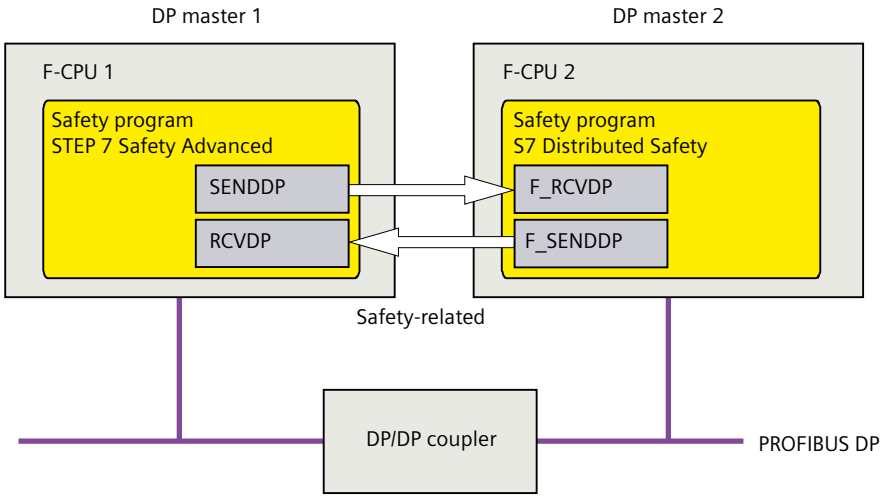

Procedure at the *S7 Distributed Safety* end

At the *S7 Distributed Safety* end, proceed as described in the section "Safety-related master-master communication" of the "S7 Distributed Safety - Configuring and Programming (https://support.industry.siemens.com/cs/ww/en/view/22099875)" manual.

Procedure at the *STEP 7 Safety* end

At the *STEP 7 Safety* end, proceed as described in Safety-related master-master communication (Page 268).

9.3 Communication via SENDDP/RCVDP instructions between S7-300/400 and S7-1200/1500 F-CPUs

Introduction

This section provides an overview of the options for safety-related communication using SENDDP/RCVDP instructions between S7-300/400 F-CPUs and S7-1200/1500 F-CPUs in SIMATIC Safety F-systems.

Options for safety-related CPU-CPU communication

Safety-related communication	On subnet	Additional hardware required	Required instructions
Master-master communication	PROFIBUS DP	DP/DP coupler	SENDDP/RCVDP
Master-I-slave communication	PROFIBUS DP	—	SENDDP/RCVDP
IO controller-IO controller communication	PROFINET IO	PN/PN coupler	SENDDP/RCVDP
IO controller-I-device communication	PROFINET IO	—	SENDDP/RCVDP
IO controller-I-slave communication	PROFINET IO and PROFIBUS DP	IE/PB link	SENDDP/RCVDP

Basic procedure for configuring and programming

Configure and program safety-related communication between S7-300/400 F-CPUs and S7-1200/1500 F-CPUs as described in Communication via SENDDP/RCVDP or SENDS7/RCVS7(S7-300, S7-400) instructions: (Page 208) and Communication via SENDDP/RCVDP instructions (S7-1200, S7-1500): (Page 257) for your application.

To program an S7-300/400 F-CPU, use the start addresses of the transfer areas. To program an S7-1200/1500 F-CPU, use the HW identifiers of the transfer areas.

9.4 Communication via SENDDP/RCVDP instructions: IO controller and I-device in different projects

9.4.1 Configuring safety-related communication between IO controller and I-device

Introduction

Safety-related communication between the safety program of the F-CPU of an IO controller and the safety program(s) of the F-CPU(s) of one or more I-devices takes place via IO controller-I-device transfer areas (F-CD) in PROFINET IO, as in standard systems.

The following section describes particular aspects when the IO Controller and the I-device are located in different projects.

Requirement

- The IO Controller is an S7-1200/1500 F-CPU that supports the IO Controller functionality.
- The I-device is an S7-300/400/1200/1500 F-CPU that supports the I-device functionality.
- The project in which the I-device is located, must have been created with *S7 Distributed Safety V5.4*, *STEP 7 Safety V13* or later.

Configuring

1. Configure the safety-related communication in the project with the I-device as described under "Configuring safety-related communication between IO controller and I-device (Page 226)" (S7-300, S7-400) or "Configuring safety-related communication between IO controller and I-device (Page 276)" (S7-1200, S7-1500) respectively. In this case the F-CPU 1 (IO Controller) is only a placeholder for the F-CPU in the project of the IO Controller.

   NOTE

   When creating with *STEP 7 Safety* < V14 SP1 avoid a subsequent change from the transfer areas from CD to F-CD.

   When creating with *S7 Distributed Safety V5.4* create the application transfer areas of the address type "Output" and "Input" directly after each other.

2. Export the I-device as a GSD file. Proceed as described in the *STEP 7* help under "Configuring an I-device".
3. Import the GSD file in the project with the IO Controller. Proceed as described in the *STEP 7* help under "Installing a GSD file".
4. Insert the I-device from the "Hardware catalog" task card into the project with the IO Controller.
5. Assign the F-CPU of the IO Controller to the I-device.

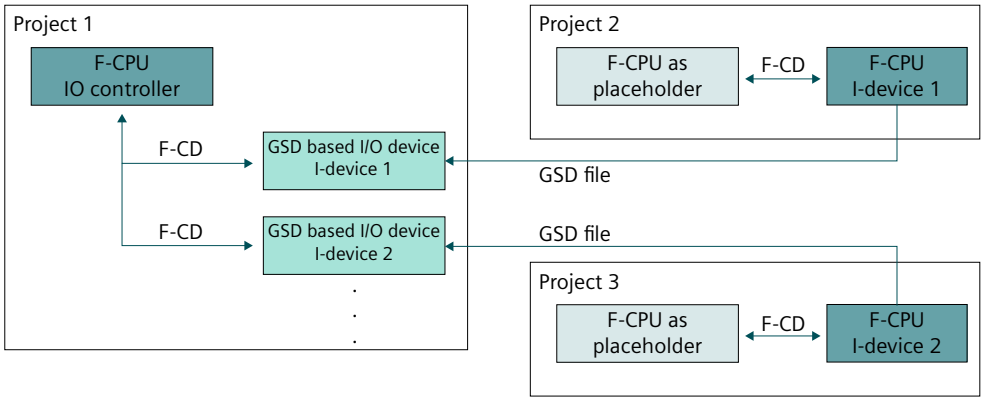

9.4.2 Programming safety-related IO Controller I-device communication

Programming procedure

To program the safety-related communication between the IO controller and I-device for an F-CPU S7-300/400, analogously follow the procedure described under "Programming safety-related IO controller I-device communication (Page 229)". To program an S7-300/400 F-CPU, use the start addresses of the transfer areas.

To program the safety-related communication between the IO controller and I-device for an F-CPU S7-1200/1500, analogously follow the procedure described under "Programming safety-related IO controller I-device communication (Page 281)". To program an S7-1200/1500 F-CPU, use the HW identifiers of the transfer areas.

9.5 Communication with OPC UA Safety (S7-1500)

With OPC UA Safety, you can exchange a defined data structure between an F-CPU S7-1500 and another F-CPU S7-1500 F-CPU or a device of a third-party manufacturer in a safety-related manner that supports OPC UA Safety. Optionally, you can also transfer non-safety-related data.

OPC UA Safety enables the configuration of static and dynamic connections. In the case of static connections, the communication relationship is already specified in the TIA Portal. In the case of dynamic connections, the communication relationship is only specified during runtime.

OPC UA Safety is specified by the OPC Foundation in OPC UA Specification OPC 10000-15 and is based on the mechanisms of OPC UA. SIMATIC Safety supports OPC UA client/server communication. More information can be found in the *STEP 7* help under "OPC UA communication".

For OPC UA Safety, the OPC Foundation provides a basic information model with the data types and methods needed for OPC UA Safety via a nodeset.

Based on this nodeset, you create the information model for your individual data structure as a nodeset as well.

OPC UA Safety designates a server interface that makes the safety-related data available as a SafetyProvider, and a corresponding client interface that reads the safety-oriented data from a SafetyProvider as a SafetyConsumer.

For a bidirectional communication connection, each communication partner must implement a SafetyProvider and a SafetyConsumer.

OPC UA Safety communication requires special parameter assignments, which you make using the Safety Parameter Interface (SPI). For communication with your Safety program or standard user program, the Safety Application Program Interface (SAPI) is available.

The following sections describe the Safety Parameter Interface (SPI) and the Safety Application Program Interface (SAPI) and the configuration and programming actions needed for an S7-1500 F-CPU for OPC UA Safety communication. All descriptions as well as the implementation of OPC UA Safety in the SIMATIC Safety F-system are based on the Version 1.05.04 of the OPC UA specification OPC 10000-15. For information on the procedure for devices of a third-party manufacturer, refer to the documentation of the device manufacturer.

NOTE

During simulation with *S7-PLCSIM*, the time monitoring that generates an error message after expiration when communication with real communication partners is interrupted (e.g. by setting a CPU to STOP) is not activated. This is why no error message is displayed in this case.

NOTE

The OPC UA Specification OPC 10000-15 specifies for the transfer of values of the BOOL data type that these be transferred in Byte format.

- "TRUE" is transferred as "0x01"
- "FALSE" is transferred as "0x00"

Since OPC UA Safety does not provide qualifier bits, they must be modeled, transferred and evaluated as part of the safety-related user data if necessary. The OPC UA Specification OPC 10000-15 prescribes the following semantics:

- "TRUE" or "0x01" corresponds to the "valid value" state
- "FALSE" or "0x00" corresponds to the "invalid value" state

Restrictions

The following *STEP 7 Safety* functions cannot be used together with OPC UA Safety:

- Safety program in RUN mode (S7-1200, S7-1500) (Page 419) (Fast Commissioning)
- Safety program in Software Unit (Safety Unit) (S7-1500) (Page 118)
- Consistent upload from the F-CPU (Page 92)

9.5.1 Configuration and programming interfaces

Introduction

A Safety Parameter Interface (SPI) and Safety Application Program Interface (SAPI) is available for each SafetyConsumer or SafetyProvider.

You must make special parameter assignments, which are required for the safety-related data transfer, in the SPI for each OPC UA Safety communication. To facilitate this, values are automatically assigned to the parameters whenever possible.

The SAPI forms the interface to your Safety program (or standard user program).

9.5.1.1 Safety Parameter Interface (SPI) of the SafetyProvider

The SPI of a SafetyProvider is shown in the properties of the SafetyProvider in the editor for server interfaces either during the creation of the information model with the special OPC UA modeling tool SiOME (Page 320) or later after import of the information model into TIA Portal (Page 325).

The following table shows the parameters of the SPI of a SafetyProvider.

Parameter	Data type	Changeable in TIA Portal	Description
SafetyProviderIDConfigured	UDINT	x	ID for authentication of a SafetyProvider
SafetyBaseIDConfigured	GUID	x	ID for authentication of a SafetyProvider
SafetyProviderLevel	BYTE	-	Safety Integrity Level (SIL) that can be achieved with the specific implementation of the SafetyProvider

Parameter	Data type	Changeable in TIA Portal	Description
SafetyStructureSignature	UDINT	-	Signature via the data structure of the OPC UA data type of the fail-safe data to be transferred
SafetyStructureSignatureVer-sion	UINT	-	Version of the algorithm for forming the SafetyStructureSignature
SafetyStructureIdentifier	STRING	-	Identifier of the OPC UA data types of the fail-safe data to be trans-ferred (max. length 128 characters)
SafetyProviderDelay	UDINT	-	Maximum time in µs between the request of a SafetyConsumer and the response of a Safety-Provider
SafetyServerImplemented	BOOL	-	1=SafetyProvider supports OPC UA Client/Server communication
SafetyPubSubImplemented	BOOL	-	1=SafetyProvider supports OPC UA PubSub communication

The values of the SPI parameters of a SafetyProvider are always assigned automatically during import of the information model (Page 320) if a value has not yet been entered for a parameter in the information model. Previously entered values are applied if permissible. If there are impermissible values, an error message is output.

SafetyProviderIDConfigured/SafetyBaseIDConfigured

The SafetyProviderIDConfigured and SafetyBaseIDConfigured SPI parameters are used to uniquely and safely authenticate a SafetyProvider. For applications with changing communication partners (Page 344) or series machines (Page 343), you can overwrite the values of these SPI parameters using the SAPI parameters SafetyProviderID and SafetyBaseID (Page 302). The value that is actually in effect during runtime of the Safety program is referred to in this document as the "active SafetyBaseID" or "active SafetyProviderID".
Different combinations are conceivable with regard to the unique authentication:

- The active SafetyBaseID is identical for all SafetyProviders within a certain area of the system. The unique authentication within this plant area must take place through different active SafetyProviderIDs.
- The active SafetyProviderID is identical for all SafetyProviders. The unique authentication must then take place solely through different active SafetyBaseIDs.
- Neither the active SafetyProviderIDs nor the active SafetyBase IDs of all SafetyProviders within a specific area are identical. The unique authentication only takes place through different combinations of active SafetyProviderIDs and active SafetyBaseIDs.

In the case of automatic assignment, the following values are entered. The uniqueness is achieved solely using the SafetyBaseIDConfigured:

- **SafetyProviderIDConfigured:** If no local data mapping is available for the SAPI parameter SafetyProviderID, the value "1" is assigned. Otherwise, the value "0" is assigned.
- **SafetyBaseIDConfigured:** If no local data mapping is available for the SAPI parameter SafetyBaseID, a randomly generated value is assigned that fulfills the safety requirements of OPC UA Specification OPC 10000-15. Otherwise, the value "0" is assigned.

WARNING

For the unique and secure authentication of a SafetyProvider, the combination of active SafetyProviderID and active SafetyBaseID at any point in time must be unique for all OPC UA Safety communication connections network-wide. **

If your network is not safely separated from the outside world through physical separation, the active SafetyBaseID at any point in time must be a value that was generated randomly in accordance with the OPC UA Specification OPC 10000-15. ***

You must ensure the uniqueness in the safety summary during acceptance of the safety program. If the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S102)*

* If you cannot ensure a unique combination during startup of the Safety program because the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID is "0" during this phase.

** SafetyProviders to which the same local data element of your safety program is mapped (Safety Multicast (Page 342)) at the SafetyData SAPI parameter are permitted to use the same combination.

*** If you have entered a value for the SPI parameter SafetyBaseIDConfigured of a SafetyProvider (either in the NodeSet or in the properties of a SafetyProvider), you yourself must ensure that the value meets the safety requirements of the OPC UA Specification OPC 10000-15. Alternatively, generate the value of SafetyBaseIDConfigured again by opening the properties tab of the affected SafetyProvider and clicking on the "Generate" button.

WARNING

If you have not defined any value for the SPI parameter of a SafetyProvider in the NodeSet for the SPI parameter, a sufficiently clear UUIDV4 is made available from the system as a value for the parameter of the respective SafetyProvider when importing the NodeSet into the TIA Portal.

Through subsequent copying of a SafetyProvider (e.g. copying the NodeSet to another F-CPU, copying the F-CPU or copying the project), values provided by the system are not generated again and are therefore not unique anymore.

If such a copy is used to configure a new communication relationship, you yourself need to ensure the uniqueness. To do this, open the properties tab of all affected SafetyProvider and generate the value of SafetyBaseIDConfigured again by clicking on the "Generate" button. The uniqueness must be checked in the safety summary during acceptance. *(S110)*

SafetyProviderLevel

The SafetyProviderLevel SPI parameter is used to publicize the Safety Integrity Level (SIL) that can be achieved by a specific SafetyProvider implementation.

With automatic assignment, the value "3" is entered. This corresponds to the maximum SIL achievable with SIMATIC Safety and is the only permissible value.

SafetyStructureSignature

The SafetyStructureSignature SPI parameter is used to protect and identify the data structure at the SafetyData of the OPC UA data type of the SAPI parameters via a signature.

With automatic assignment, the value is calculated according to the algorithm prescribed in OPC UA Specification OPC 10000-15.

SafetyStructureSignatureVersion

The SafetyStructureSignatureVersion SPI parameter is used to specify the version of the algorithm used to calculate the SafetyStructureSignature.

With automatic assignment, the value "1" is entered. This corresponds to the only permissible value at the present time.

SafetyStructureIdentifier

With the SPI parameter SafetyStructureIdentifier the identifier of the OPC UA data types of the SAPI parameter SafetyData is publicized. The SafetyStructureIdentifier is included in the calculation of the SafetyStructureSignature.

With automatic assignment, the name of the OPC UA data type that describes the data structure at the SafetyData SAPI parameter is entered.

SafetyProviderDelay

The SafetyProviderDelay SPI parameter is used to publicize the maximum time (in µs) that can elapse between the reception of the request of a SafetyConsumer and the sending of the response of a SafetyProvider under worst-case conditions. For more details, refer to OPC UA Specification OPC 10000-15.

In the case of automatic assignment, the value "0" is entered at the present time.

SafetyServerImplemented

The SafetyServerImplemented SPI parameter is used to publicize whether the SafetyProvider supports OPC UA Client/Server communication mechanisms.

In the case of automatic assignment, the value "TRUE" is entered. This corresponds to the only permissible value since SIMATIC Safety supports only OPC UA client/server communication.

SafetyPubSubImplemented

The SafetyPubSubImplemented SPI parameter is used to publicize whether the SafetyProvider supports OPC UA PubSub communication mechanisms.

With automatic assignment, the value "FALSE" is entered. This corresponds to the only permissible value since SIMATIC Safety does not support OPC UA PubSub communication.

9.5.1.2 Safety Application Program Interface (SAPI) of the SafetyProvider

The SAPI of a SafetyProvider is shown in the properties of the SafetyProvider in the editor for server interfaces either when the information model is created in SiOME (Page 320) or after the information model is imported into TIA Portal (Page 325). These properties are stored in the internal F-OPC-UA-Provider-DB. The name is shown in the SAPI interface and listed in the safety summary.

The following table shows the parameters of the SAPI of a SafetyProvider.

SAPI parameters		Data type of the mapped local data element	Mapping to a local data element of the Safety program	Mapping to a local data element of the standard user program	Description
SafetyData		UDT	x	-	Data that is made available to a SafetyConsumer in a safety-related manner
NonSafetyData		UDT	-	x	Data that is made available to a SafetyConsumer in a non-safety-related manner
InputSignals		UDT			Summary of the following SAPI parameters
	OperatorAck-Provider	BOOL	x	-	1=User acknowledgment at SafetyProvider end
	ActivateFSV	BOOL	x	-	1=SafetyConsumer to output substitute values
	EnableTest-Mode	BOOL	x	-	1=Current values at the SafetyData SAPI parameter are test data
OutputSignals		UDT			Summary of the following SAPI parameters
	OperatorAck-Requested	BOOL	-	x	1=Acknowledgment request at the SafetyConsumer side is pending
	Monitoring-Number	UDINT	-	x	Current MonitoringNumber
	SafetyCon-sumerID	UDINT	-	x	ID for authentication of the connected SafetyConsumer
SafetyProviderID		UDINT	x	-	ID for authentication of a SafetyProvider
SafetyBaseID		GUID	-	x	ID for authentication of a SafetyProvider

To establish a connection of your Safety program (or standard user program) to a SafetyProvider, you must map all required SAPI parameters to a local data element of your Safety program (or standard user program) in SiOME (Page 320) ("Local data mapping").

SafetyData

The SAPI parameter SafetyData is used to transfer the data of your Safety program that you want to make available to a connected SafetyConsumer in a safety-related manner. The data structure of this data must be described in an F-compliant PLC data type (UDT) which agrees with the data structure of the OPC UA data type of SafetyData. This F-compliant PLC data type (UDT) may only contain the BOOL, INT and DINT data types.

WARNING

During communication with OPC UA Safety, it is only ensured that a signal state to be transferred is acquired and transferred to the receiver if it is pending for at least twice as long as the assigned monitoring time (SafetyConsumerTimeout). *(S109)*

WARNING

For each communication connection with OPC UA Safety, you must ensure when accepting the Safety program that the data structure of the OPC UA data types used by SafetyData matches on the SafetyProvider and SafetyConsumer side. In particular, the correct order of elements of the same data type is relevant. You can find the structures of the OPC UA data types used in the respective safety summary.

To identify the communication connection, note the following points:

- For static connections:

  To do this identify the communication connection by means of the combination of SafetyProviderIDConfigured and SafeBaseIDConfigured.
- For dynamic connections:

  To do this, identify the communication connection by means of the algorithm for the allocation of the values for SafetyProviderID and SafetyConsumerID.

(S111)

NonSafetyData

The SAPI parameter NonSafetyData is used to transfer the data of your standard user program that you want to make available to a connected SafetyConsumer in a non-safety-related manner synchronously with the SafetyData. The data structure of this data must be written in a PLC data type (UDT) which agrees with the data structure of the OPC UA data type of NonSafetyData.

This PLC data type (UDT) can only contain the data types BOOL, SINT, INT, UINT, DINT, UDINT, LINT, ULINT, REAL, LREAL, WSTING, LDT and nested PLC data types (UDTs).

InputSignals

The SAPI parameter InputSignals is used to summarize the SAPI parameters OperatorAckProvider, ActivateFSV and EnableTestMode. These SAPI parameters enable you to trigger certain actions on the connected SafetyConsumer or communicate certain status information about the SafetyData to the SafetyConsumer.

An F-compliant PLC data type (UDT) that contains all the InputSignals listed in the above table is needed to use these SAPI parameters:

- **OperatorAckProvider**

  With the OperatorAckProvider SAPI parameter, you also have the option of performing user acknowledgment on the SafetyProvider side and informing the Safety program on the SafetyConsumer side (see also SAPI parameters OperatorAckConsumer and OperatorAckProvider (Page 311) of the SafetyConsumer).

  WARNING

  A user acknowledgment (Page 196) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted. *(S011)*

- **ActivateFSV**

  With the ActivateFSV SAPI parameter, you can instruct a connected SafetyConsumer to output the designated substitute values from the F-OPC-UA-Consumer-DB (Page 316) instead of the current values at the SafetyData SAPI parameter. In order for the current values to be output at the SAPI parameter SafetyData again after ActivateFSV is reset, a user acknowledgment may be required.

- **EnableTestMode**

  With the SAPI parameter EnableTestMode, you can inform a connected SafetyConsumer that the current values at the SAPI parameter SafetyData are test data and, thus, were not formed in a safety-related manner.

OutputSignals

The SAPI parameter OutputSignals is used to summarize the SAPI parameters OperatorAckRequested, MonitoringNumber and SafetyConsumerID. These SAPI parameters allow you to evaluate certain information of the connected SafetyConsumer.

A PLC data type (UDT) that contains all the OutputSignals listed in the above table is needed to use these SAPI parameters:

- **OperatorAckRequested**

  You can use the OperatorAckRequested SAPI parameter to evaluate whether there is an acknowledgment request on the SafetyConsumer.

- **MonitoringNumber**

  With the SAPI parameter MonitoringNumber, you can evaluate the current MonitoringNumber for diagnostic purposes. More information can be found in the OPC UA Specification OPC 10000-15.

- **SafetyConsumerID**

  With the SAPI parameter SafetyConsumerID, you can evaluate the SafetyConsumerID of the SafetyConsumer for diagnostic purposes. More information can be found in the OPC UA Specification OPC 10000-15.

SafetyProviderID/SafetyBaseID

With the SAPI parameters SafetyProviderID and SafetyBaseID, you can uniquely and reliably authenticate a SafetyProvider at dynamic connections. For more information, refer to the sections "Series machines (Page 343)" and "Changing communication partners (Page 344)".

SafetyProviderID and/or SafetyBaseID are initialized with values matched to the specific situation in the system during runtime of the Safety program (or standard user program). As long as the relevant value <> 0, the value assigned to the SPI parameters SafetyProviderIDConfigured and SafetyBaseIDConfigured is overwritten.

If the active SafetyProviderID or SafetyBaseID is "0", no communication with a SafetyConsumer can take place.

NOTE

The instructions "Random", "Get_IM_Data", "RD_SYS_T" and "SHA2" are available for generating a SafetyBaseID. These instructions enable the safety requirements of OPC UA Specification OPC 10000-15 regarding randomly generated values to be fulfilled.

You can find application examples for concrete implementation on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109977450).

WARNING

For the unique and secure authentication of a SafetyProvider, the combination of active SafetyProviderID and active SafetyBaseID at any point in time must be unique for all OPC UA Safety communication connections network-wide. **

If your network is not safely separated from the outside world through physical separation, the active SafetyBaseID at any point in time must be a value that was generated randomly in accordance with the OPC UA Specification OPC 10000-15. ***

You must ensure the uniqueness in the safety summary during acceptance of the safety program. If the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S102)*

* If you cannot ensure a unique combination during startup of the Safety program because the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID is "0" during this phase.

** SafetyProviders to which the same local data element of your safety program is mapped (Safety Multicast (Page 342)) at the SafetyData SAPI parameter are permitted to use the same combination.

*** If you have entered a value for the SPI parameter SafetyBaseIDConfigured of a SafetyProvider (either in the NodeSet or in the properties of a SafetyProvider), you yourself must ensure that the value meets the safety requirements of the OPC UA Specification OPC 10000-15. Alternatively, generate the value of SafetyBaseIDConfigured again by opening the properties tab of the affected SafetyProvider and clicking on the "Generate" button.

WARNING

Due to system constraints, formation of a SafetyBaseID at runtime of your Safety program is only possible in your standard user program.

Note that these program sections are therefore not captured by the Collective F-Signature and are not protected by "Access protection for safety-related project data (Page 101)" or "F-CPU access protection (Page 104)".

For this reason, you must take organizational measures to ensure that only authorized persons can change these program sections.

Print the relevant program sections and supplement your safety summary with this printout. *(S103)*

9.5.1.3 Safety Parameter Interface (SPI) of the SafetyConsumer

The SPI of a SafetyConsumer is displayed to you after adding a SafetyProvider in the SafetyProvider list of the client interface (Page 332) in the properties of the SafetyConsumer in the editor for client interfaces (Page 336).

The following table shows the parameters of the SPI of a SafetyConsumer.

Parameter	Data type	Changeable in TIA Portal	Description
SafetyProviderIDConfigured	UDINT	x	ID for authentication of the intended SafetyProvider
SafetyBaseIDConfigured	GUID	x	ID for authentication of the intended SafetyProvider
SafetyConsumerIDConfigured	UDINT	x	ID for authentication of a SafetyConsumer
SafetyProviderLevel	BYTE	x	Safety Integrity Level (SIL) expected from the specific implementation of the connected SafetyProvider
SafetyStructureSignature	UDINT	-	Signature via the data structure of the OPC UA data type of the fail-safe data to be transferred
SafetyStructureSignatureVersion	UINT	-	Version of the algorithm for forming the SafetyStructureSignature
SafetyStructureIdentifier	STRING	-	Identifier of the OPC UA data types of the fail-safe data to be transferred (max. length 128 characters)
SafetyConsumerTimeout	UDINT	x	Monitoring time in µs: Maximum permissible time between the request from a SafetyConsumer and the receipt of the response from a SafetyProvider in the SafetyConsumer
SafetyOperatorAckNecessary	BOOL	x	1=Acknowledgment required
SafetyErrorIntervalLimit	INT	x	Minimum time in min. between two communication errors
SafetyClientImplemented	BOOL	-	1=SafetyConsumer supports OPC UA client/server communication mechanism
SafetyPubSubImplemented	BOOL	-	1=SafetyConsumer supports OPC UA PubSub communication mechanism

The values of individual SPI parameters of a SafetyConsumer are automatically assigned when the intended SafetyProvider is added to the SafetyProvider list of the client interface (Page 332) if no value has yet been entered for these parameters in the OPC UA SafetyProvider information model or if the parameters do not exist at the SafetyProvider. Previously entered values are applied if permissible. If necessary, you have to adjust the values in the properties of the SafetyConsumer in the editor for client interfaces (Page 332). An error message is displayed for invalid values.

SafetyProviderIDConfigured/SafetyBaseIDConfigured

The SafetyProviderIDConfigured and SafetyBaseIDConfigured SPI parameters are used to uniquely and safely authenticate a SafetyProvider. For applications with changing communication partners (Page 344) or series machines (Page 343), you can overwrite the values of these SPI parameters in the F-OPC-UA-Consumer-DB (Page 316) using the SAPI parameters SafetyProviderID and SafetyBaseID. The value that is actually in effect during runtime of the Safety program is referred to hereinafter as the "active SafetyBaseID" or "active SafetyProviderID".

If the active SafetyProviderID or SafetyBaseID is "0", the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 316) to the Safety program instead of the current values at the SafetyData SAPI parameter.

If the correct values are not yet present in the SafetyProvider list of the client interface (Page 332) when adding the intended SafetyProvider, you must enter these in the properties of the SafetyConsumer in the editor for client interfaces (Page 332).

WARNING

For secure authentication of the SafetyProvider whose SafetyData is to be evaluated, the values of the active SafetyProviderID and active SafetyBaseID of the SafetyConsumer must correspond to the values of the active SafetyProviderID and active SafetyBaseID of this SafetyProvider at all times*.

When accepting the Safety programs, you must ensure compliance in the relevant safety summary. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S104)*

* If you cannot yet provide the values when starting the Safety program because they are only created during the runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID or the Enable "0" SAPI parameter in this phase.

SafetyConsumerIDConfigured

The SafetyConsumerIDConfigured SPI parameter can be used to uniquely authenticate a SafetyConsumer, particularly for diagnostic purposes in applications with Safety Multicast (Page 342). For more details, refer to OPC UA Specification OPC 10000-15.

For applications with changing communication partners (Page 344) or series machines (Page 343), you can overwrite the value of this SPI parameter via the SafetyConsumerID (Page 311) SAPI parameter. The value that is actually in effect at runtime of the Safety program is referred to below as the "active SafetyConsumerID".

If the active SafetyConsumerID is "0", the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 316) to the Safety program instead of the current values at the SafetyData SAPI parameter.

When the foreseen SafetyProvider is added to the SafetyProvider list of the client interface (Page 332), a randomly generated value is assigned.

SafetyProviderLevel

The SafetyProviderLevel SPI parameter sets an expected value of the safety integrity level (SIL) achievable from the specific implementation of the connected SafetyProvider.

With automatic assignment, the value "3" is entered. This corresponds to the maximum SIL achievable with SIMATIC Safety. You may need to adapt this value to your individual application.

If the value does not match the value of the connected SafetyProvider, a communication error is detected (error code "0x14", see DIAG variable in the F-OPC-UA-Consumer-DB (Page 316)).

SafetyStructureSignature

The SafetyStructureSignature SPI parameter is used to protect the data structure of the OPC UA data type at the SafetyData SAPI parameter via a signature.

With automatic assignment, the value is calculated according to the algorithm prescribed in OPC UA Specification OPC 10000-15.

SafetyStructureSignatureVersion

The SafetyStructureSignatureVersion SPI parameter is used to specify the version of the algorithm used to calculate the SafetyStructureSignature.

With automatic assignment, the value "1" is entered. This corresponds to the only permissible value at the present time.

SafetyStructureIdentifier

With the SPI parameter SafetyStructureIdentifier the identifier of the OPC UA data types of the SAPI parameter SafetyData is publicized. The SafetyStructureIdentifier is included in the calculation of the SafetyStructureSignature.

With automatic assignment, the name of the OPC UA data type that describes the data structure at the SafetyData SAPI parameter is entered.

SafetyConsumerTimeout

The SafetyConsumerTimeout SPI parameter specifies the maximum time (in µs) that may elapse between the request from a SafetyConsumer and the response from the connected SafetyProvider.

If this monitoring time expires before a response from the connected SafetyProvider arrives, a communication error is detected (see DIAG variable in the F-OPC-UA-Consumer-DB (Page 316)) and the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 316) at the SafetyData SAPI parameter instead of the current values.

With automatic assignment, the value "2500000" (2.5 s) is currently entered as the default value. You must adapt this value to your individual application. More information can be found in the section "Response Times of Safety Functions (Page 649)".

WARNING

During communication with OPC UA Safety, it is only ensured that a signal state to be transferred is acquired and transferred to the receiver if it is pending for at least twice as long as the assigned monitoring time (SafetyConsumerTimeout). *(S109)*

SafetyOperatorAckNecessary

The SafetyOperatorAckNecessary SPI parameter is used to specify whether a manual user acknowledgment is required before the current values are output again at the SafetyData SAPI parameter instead of the substitute values from the F-OPC-UA-Consumer-DB (Page 316) after the following states have passed:

- Communication error "Timeout" (error code "0x08", see DIAG variable in the F-OPC-UA-Consumer-DB (Page 316)).
- ActivateFSV SPI parameter of the connected SafetyProvider is "1" (error code "0x20", see DIAG variable in the F-OPC-UA-Consumer-DB (Page 316)).

In the case of automatic assignment, the value "TRUE" is entered. You can adapt this value to your individual application if necessary.

SafetyErrorIntervalLimit

The SafetyErrorIntervalLimit SPI parameter specifies the minimum time (in minutes) that must elapse between two consecutive communication errors.

If this time is not reached, the SafetyConsumer outputs the substitute values from the F-OPC-UA-Consumer-DB (Page 316) at the SafetyData SAPI parameter instead of the current values. If this time is maintained, the SafetyConsumer tolerates a communication error by discarding the bad response from the SafetyProvider and waiting for the next error-free response. However, this can lead to a "Timeout" communication error if the monitoring time on the SafetyConsumerTimeout SPI parameter does not allow any reserves for repeats.

The value influences the probability of failure values (Page 461) (PFD_{avg-} and PFH values) that you must take into account for communication with OPC UA Safety.

With automatic assignment, the value "600" is entered. This value achieves the lowest possible probability of failure values.

SafetyClientImplemented

The SafetyClientImplemented SPI parameter is used to indicate whether the SafetyConsumer supports OPC UA client/server communication mechanisms.

In the case of automatic assignment, the value "TRUE" is entered. This corresponds to the only permissible value since SIMATIC Safety supports only OPC UA client/server communication.

SafetyPubSubImplemented

The SafetyPubSubImplemented SPI parameter is used to indicate whether the SafetyConsumer supports OPC UA PubSub communication mechanisms.

With automatic assignment, the value "FALSE" is entered. This corresponds to the only permissible value since SIMATIC Safety does not support OPC UA PubSub communication.

9.5.1.4 Safety Application Program Interface (SAPI) of the SafetyConsumer in the F-OPC UA Consumer DB

The SAPI of a SafetyConsumer is available in the F-OPC-UA-Consumer-DB. The F-OPC-UA-Consumer-DB is automatically generated when the intended SafetyProvider is added to the SafetyProvider list of the client interface (Page 332). You can read or write directly to the corresponding variables in the F-OPC-UA-Consumer-DB.

You can find the name automatically assigned to the F-OPC-UA-Consumer-DB in the properties of the SafetyConsumer in the editor for client interfaces. If necessary, you can also adapt the name there. You can find the F-OPC-UA-Consumer-DB in the folder "Program blocks/System blocks/STEP 7 Safety/OPC UA Safety" folder in the project tree.

The following table shows the parameters of the SAPI of a SafetyConsumer.

SAPI parameter	Tag in the F-OPC-UA-Consumer-DB	Data type	Access to in the Safety program	Access in the standard user program	Description
Tags that you can or must write					
Enable	ENABLE	BOOL	x	-	1=Activation of communication to the connected SafetyProvider
OperatorAckConsumer	OPERATOR_ACK_CONSUMER	BOOL	x	-	1=User acknowledgment at SafetyConsumer end
SafetyProviderID	SAFETY_PROVIDER_ID	DINT	x	-	ID for authentication of the intended SafetyProvider
SafetyBaseID	SAFETY_BASE_ID	GUID	-	x	ID for authentication of the intended SafetyProvider
SafetyConsumerID	SAFETY_CONSUMER_ID	DINT	x	-	ID for authentication of a SafetyConsumer
Tags that you can/must evaluate					
SafetyData	SAFETY_DATA	UDT	x	(x)	Data provided by the connected SafetyProvider in a safety-related manner
NonSafetyData	NON_SAFETY_DATA	UDT	-	x	Data that is not made available by the connected SafetyProvider in a safety-related manner
FSV_Activated	FSV_ACTIVATED	BOOL	x	(x)	1=SafetyConsumer outputs substitute values
OperatorAckRequested	OPERATOR_ACK_REQUESTED	BOOL	x	(x)	1=Acknowledgment request is pending
OperatorAckProvider	OPERATOR_ACK_PROVIDER	BOOL	x	(x)	1=User acknowledgment at SafetyProvider end
TestModeActivated	TEST_MODE_ACTIVATED	BOOL	x	(x)	1=Current values at the SafetyData SAPI parameter are test data

(x) can also be evaluated non-safety-related in the standard user program if required

Enable

The Enable SAPI parameter is used to activate communication with OPC UA Safety to the connected SafetyProvider. If Enable = 0, no SafetyData/NonSafetyData is requested from the connected SafetyProvider. Instead of the current values, the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 316) at the SafetyData SAPI parameter.

With Enable = 0, for example, you can delay the start of communication with OPC UA Safety until the underlying OPC UA communication is ready (e.g. after switching the power supply on). This allows you to avoid communication errors such as "timeout" in this phase (see SafetyConsumerTimeout (Page 307) SPI parameter).

NOTE

When changing from Enable = 1 to Enable = 0, the output of substitute values at the SafetyData SAPI parameter only take effect after the next data package has been received or after the monitoring time parameterized via SafetyConsumerTimeout.

OperatorAckConsumer

The OperatorAckConsumer SAPI parameter is used to perform user acknowledgment. This requires a positive edge after an acknowledgment request has been made at the OperatorAckRequested SAPI parameter.

Once the user acknowledgment has been carried out, the SafetyConsumer outputs the current values at the SafetyData SAPI parameter again instead of the substitute values from the F-OPC-UA-Consumer-DB (Page 316).

WARNING

A user acknowledgment (Page 196) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted. *(S011)*

SafetyProviderID/SafetyBaseID

With the SafetyProviderID and SafetyBaseID SAPI parameters, you can uniquely and reliably authenticate the foreseen SafetyProvider for dynamic connections. For more information, refer to the sections "Series machines (Page 343)" and "Changing communication partners (Page 344)".

SafetyProviderID and/or SafetyBaseID are initialized with values matched to the specific situation in the system during runtime of the Safety program (or standard user program). As long as both values <> 0, the values assigned to the SafetyProviderIDConfigured and SafetyBaseIDConfigured SPI parameters are overwritten.

If the active SafetyProviderID or SafetyBaseID is "0", the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 316) to the Safety program instead of the current values at the SafetyData SAPI parameter.

NOTE

A changed value at the SAPI parameters SafetyProviderID and SafetyBaseID only becomes effective after a positive edge at the Enable SAPI parameter.

WARNING

Due to system constraints, formation of a SafetyBaseID at runtime of your Safety program is only possible in your standard user program.

Note that these program sections are therefore not captured by the collective F-signature and are not protected by "Access protection for safety-related project data (Page 101)" or "F-CPU access protection (Page 104)".

For this reason, you must take organizational measures to ensure that only authorized persons can change these program sections.

Print the relevant program sections and supplement your safety summary with this printout. *(S103)*

WARNING

For secure authentication of the SafetyProvider whose SafetyData is to be evaluated, the values of the active SafetyProviderID and active SafetyBaseID of the SafetyConsumer must correspond to the values of the active SafetyProviderID and active SafetyBaseID of this SafetyProvider at all times*.

When accepting the Safety programs, you must ensure compliance in the relevant safety summary. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S104)*

* If you cannot yet provide the values when starting the Safety program because they are only created during the runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID or the Enable "0" SAPI parameter in this phase.

SafetyConsumerID

You can also use the SafetyConsumerID SAPI parameter to uniquely authenticate a SafetyConsumer in use cases with changing communication partners (Page 344) or series machines (Page 343).

The SafetyConsumerID is then only supplied with a value adapted to the specific system situation during the runtime of the Safety program. As long as the relevant value <> 0, the value assigned to the SafetyProviderIDConfigured PI parameter is overwritten.

If the active SafetyConsumerID is "0", the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 316) to the Safety program instead of the current values at the SafetyData SAPI parameter.

NOTE

A changed value at the SAPI parameter SafetyConsumerID only becomes effective after a positive edge at the Enable SAPI parameter.

SafetyData

The SafetyData SAPI parameter provides the data that is made available by the connected SafetyProvider in a safety-related manner for evaluation in your Safety program.

WARNING

For each communication connection with OPC UA Safety, you must ensure when accepting the Safety program that the data structure of the OPC UA data types used by SafetyData matches on the SafetyProvider and SafetyConsumer side. In particular, the correct order of elements of the same data type is relevant. You can find the structures of the OPC UA data types used in the respective safety summary.

To identify the communication connection, note the following points:

- For static connections:

  To do this identify the communication connection by means of the combination of SafetyProviderIDConfigured and SafeBaseIDConfigured.
- For dynamic connections:

  To do this, identify the communication connection by means of the algorithm for the allocation of the values for SafetyProviderID and SafetyConsumerID.

(S111)

NonSafetyData

The NonSafetyData SAPI parameter provides the data that is not made available by the connected SafetyProvider in a safety-related manner for evaluation in your standard user program.

FSV_Activated

You can use the FSV_Activated SAPI parameter to evaluate whether the SafetyConsumer outputs the designated substitute values from the F-OPC-UA-Consumer-DB (Page 316) at the SafetyData SAPI parameter instead of the current values.

OperatorAckRequested

You can use the OperatorAckRequested SAPI parameter to evaluate whether there is an acknowledgment request on the SafetyConsumer.

OperatorAckProvider

You can use the OperatorAckProvider SAPI parameter to evaluate whether there is a user acknowledgment on the side of the connected SafetyProvider.

To use this as an alternative (or in addition) to your acknowledgment signal on the SafetyConsumer side, you must link the OperatorAckProvider SAPI parameter with the OperatorAckConsumer SAPI parameter (possibly OR-linked with the acknowledgment signal on the SafetyConsumer side).

TestModeActivated

You can use the TestModeActivated SAPI parameter to evaluate whether the connected SafetyProvider "only" provides test data, i.e. non-safety-related data, at its SafetyData SAPI parameter.

This is the case if the EnableTestMode SAPI parameter has been set to "1" on the connected SafetyProvider.

If the connected SafetyProvider is located on an F-CPU S7-1500, TestModeActivated is also set to "1" if the Safety program belonging to the connected SafetyProvider is running in disabled safety mode or on an *S7-PLCSIM*. For information on the behavior of devices of a third-party manufacturer, refer to the documentation of the device manufacturer.

WARNING

If the TEST_MODE_ACTIVATED variable in the F-OPC-UA-Consumer-DB is set to "1" during communication with OPC UA Safety, you can no longer assume that the data at the SAFETY_DATA variable is formed in a safety-related manner. This is the case when the connected SafetyProvider is in deactivated safety mode on a PLCSIM instance or the EnableTestMode SAPI parameter of the connected SafetyProvider has been set in the associated user program. During this time, you must take organizational measures to ensure the safety of the system components that are affected by this data. Alternatively, you can also use safe substitute values in your Safety program with TEST_MODE_ACTIVATED = 1 instead of the data in the SAFETY_DATA tag. *(S108)*

9.5.1.5 Other variables in the F-OPC UA Consumer DB

In addition to the SAPI of a SafetyConsumer, the F-OPC-UA-Consumer-DB also provides you with other variables that you need for communication with OPC UA Safety in the *SIMATIC Safety* F-system and the underlying OPC UA communication ("client instructions"):

Tag in the F-OPC-UA-Consumer-DB	Data type	Access in the Safety program:	Access in the standard user program	Description
Tags that you can or must write				
RESPONSE_SPDU	STRUCT	-	x	Tag for the in-out parameter (InOut) OutputArguments of the client instruction OPC_UA_MethodCall
METHOD_CALL_DONE	BOOL	-	x	Variable for the Done output of the client instruction OPC_UA_MethodCall
METHOD_CALL_BUSY	BOOL	-	x	Variable for the Busy output of the client instruction OPC_UA_MethodCall
METHOD_CALL_ERROR	BOOL	-	x	Variable for the Error output of the client instruction OPC_UA_MethodCall
METHOD_RESULT	DWORD	-	x	Tag for the in-out parameter (InOut) MethodResult of the client instruction OPC_UA_MethodCall
Tags that you can/must evaluate				
REQUEST_SPDU	STRUCT	-	x	Tag for the in-out parameter (InOut) InputArguments of the client instruction OPC_UA_MethodCall
METHOD_CALL_REQUEST	BOOL	-	x	Tag for the REQ input of the client instruction OPC_UA_MethodCall
DIAG	BYTE	-	x	Non-fail safe service information
SAFETY_PROVIDER_ID_ACTIVE	UDINT	-	x	Active SafetyProviderID
SAFETY_BASE_ID_ACTIVE	GUID	-	x	Active SafetyBaseID
SAFETY_CONSUMER_ID_ACTIVE	UDINT	-	x	Active SafetyConsumerID
Variables for which you can/must assign start values				
PASS_VALUES	UDT (analog SafetyData)	-	-	Substitute values for SafetyData

RESPONSE_SPDU

You need this variable to call up the client instruction OPC_UA_MethodCall, which is part of the underlying OPC UA communication.

When using the F-OPC-UA-Consumer-Com-FB (Page 340), this variable is automatically interconnected with the OPC_UA_MethodCall instruction.

METHOD_CALL_DONE, METHOD_CALL_BUSY, METHOD_CALL_ERROR, METHOD_RESULT

You need these variables to call up the client instruction OPC_UA_MethodCall, which is part of the underlying OPC UA communication.

When using the F-OPC-UA-Consumer-Com-FB (Page 340), these variables are automatically interconnected with the OPC_UA_MethodCall instruction.

REQUEST_SPDU

You need this variable to call up the client instruction OPC_UA_MethodCall, which is part of the underlying OPC UA communication.

When using the F-OPC-UA-Consumer-Com-FB (Page 340), this variable is automatically interconnected with the OPC_UA_MethodCall instruction.

METHOD_CALL_REQUEST

You need this variable to call up the client instruction OPC_UA_MethodCall, which is part of the underlying OPC UA communication.

When using the F-OPC-UA-Consumer-Com-FB (Page 340), this variable is automatically interconnected with the OPC_UA_MethodCall instruction.

DIAG

The DIAG variable is used to provide a non-fail-safe code for communication errors/states that have occurred for service purposes up to the user acknowledgement. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program.

Error code	Cause	Bad response from the SafetyProvider discarded *	Output of substitute values FSV_Activated = 1	User acknowledgment required
0x01	Discrepancy detected with active SafetyProviderID or SafetyBaseID	x	-	-
0x11	Discrepancy with active SafetyBaseID detected	-	x	x
0x12	Discrepancy with active SafetyProviderID detected	-	x	x

(-): A user acknowledgment is required for the SafetyOperatorAckNecessary SPI parameter of the SafetyConsumer = 1.

0x13	Discrepancy with SafetyStructureSignature or SafetyStructureSignatureVersion or SafetyStructureIdentifier detected	-	x	x
0x14	Discrepancy detected with SafetyProviderLevel	-	x	x
0x05	CRC error detected	x	-	-
0x15	CRC error detected	-	x	x
0x06	Discrepancy with active SafetyConsumerID detected	x	-	-
0x16	Discrepancy with active SafetyConsumerID detected	-	x	x
0x07	MonitoringNumber error detected	x	-	-
0x17	MonitoringNumber error detected	-	x	x
0x08	Timeout error detected	-	x	(-)
0x09	Enable SAPI parameter of the SafetyConsumer = 0	-	x	-
0x0A	SafetyConsumer SPI parameters are invalid.	-	x	-
0x20	SAPI parameter ActivateFSV of the SafetyProvider = 1	-	x	(-)

(-): A user acknowledgment is required for the SafetyOperatorAckNecessary SPI parameter of the SafetyConsumer = 1.

* More information can be found in the section "Safety Parameter Interface (SPI) of the SafetyConsumer (Page 307)" under "SafetyErrorIntervalLimit".

SAFETY_PROVIDER_ID_ACTIVE/SAFETY_BASE_ID_ACTIVE/SAFETY_CONSUMER_ID_ACTIVE

You can use these variables to evaluate the active SafetyProviderID, SafetyBaseID or SafetyConsumerID for diagnostic purposes.

These variables are also required for the correct display of all data of the SafetyConsumerTypes (Page 348).

PASS_VALUES

You use this variable to define the substitute values as start values in the F-OPC-UA-Consumer-DB, which the SafetyConsumer outputs instead of the current values at the SafetyData SAPI parameter in the following cases (for details see DIAG variable):

- Communication error detected.
- Enable SAPI parameter of the SafetyConsumer is "0"
- ActivateFSV SAPI parameter of the connected SafetyProvider is "1"

NOTE

If you do not explicitly define any start values in the PASS_VALUES variable in the F-OPC-UA-Consumer-DB, the default values of the PLC data type (UDT) automatically created by *STEP 7 Safety* for this data structure are used as start values. If necessary, you can adapt these default values. For further details see "Configuring properties of a SafetyConsumer (Page 336)".

9.5.2 Configuring and programming a SafetyProvider

Requirements

- An F-CPU S7-1500 as of FW 4.0 (except HF-CPUs) or an S7-1500 F Software Controller as of firmware V40.0.
- The following function right is available for the "SafetyAdmin" role: OPC UA server access. More information can be found in the help for *STEP 7* under "Users and roles with OPC UA function rights (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-as-an-opc-ua-server-s7-1500-s7-1500t/configuring-the-opc-ua-server-s7-1500-s7-1500t/users-and-roles-with-opc-ua-function-rights-s7-1500-s7-1500t)".
- The required Runtime license for OPC UA is available and is configured in *STEP 7*.
- The OPC UA server is activated.

Configuring and programming a SafetyProvider

Proceed as follows to configure and program a SafetyProvider. Repeat the following steps for each data structure that you want to make available to a SafetyConsumer.

9.5.2.1 Preparing the Safety program (or standard user program) for creation of an OPC UA SafetyProvider information model

You must make the following preparations in your Safety program (or standard user program) before creating an OPC UA SafetyProvider information model.

1. Create an F-compliant PLC data type (UDT) that describes the data structure of your safety message frame that you want to make available to a SafetyConsumer in a safety-related manner.
2. Create a tag with the previously created F-compliant PLC data type (UDT) in an F-shared DB.
3. Optional:

   Create a PLC data type (UDT) that describes the data structure of the data of your standard user program that you want to make available to a SafetyConsumer in a non-safety-related manner "synchronously" with the data of your Safety program.

   Create a tag with the previously created PLC data type (UDT) in a shared DB.
4. Optional:

   If you want to trigger certain actions on a SafetyConsumer or communicate certain status information to the SafetyConsumer, create an F-compliant PLC data type (UDT) that describes the data structure of the SAPI parameter InputSignals.

   Order, names and data types are specified as follows:

   – OperatorAckProvider: BOOL
   – ActivateFSV: BOOL
   – EnableTestMode: BOOL

   Create a tag with the previously created F-compliant PLC data type (UDT) in an F-shared DB.

5. Optional:

   If you want to evaluate certain information of a SafetyConsumer, create a PLC data type (UDT) that describes the data structure of the SAPI parameter OutputSignals.

   Order, names and data types are specified as follows:

   – OperatorAckRequested: BOOL
   – MonitoringNumber: UDINT
   – SafetyConsumerID: UDINT

   Create a tag with the previously created PLC data type (UDT) in a shared DB.

6. Optional:

   If you want to change the value of the active SafetyProviderID of a SafetyProvider at runtime, create a tag with the data type DINT in an F-shared DB.

7. Optional:

   If you want to change the value of the active SafetyBaseID of a SafetyProvider at runtime, create a tag with the GUID data type in a shared DB.

8. Compile the Safety program and, if applicable, the standard user program.

9.5.2.2 Creating an OPC UA SafetyProvider information model for an individual data structure

You create an OPC UA SafetyProvider information model for your individual data structure based on a nodeset file provided by the OPC Foundation for OPC UA Safety and using SiOME. For this purpose, you must map all the SAPI parameters you require in your Safety program (or standard user program) to the designated local data (local data mapping).

You then export the OPC UA SafetyProvider information model created in this way to an XML file (nodeset file).

Requirements

The individual data structures have been created as (F-compliant) PLC data types (UDTs).

The local data needed for the local data mapping of the SAPI parameters is available and compiled in your Safety program (or standard user program).

In order to connect SiOME (https://support.industry.siemens.com/cs/ww/en/view/109755133) to the TIA project, Openness must be installed and set up.

Creating an OPC UA SafetyProvider information model

Proceed as follows to create an OPC UA SafetyProvider XML file (nodeset file).

1. First, download the nodeset file "Opc.Ua.Safety.NodeSet2.xml" of the OPC UA Safety Specification V1.05.04 from the GitHub website of the OPC Foundation. You can find the download link here (https://github.com/OPCFoundation/UA-Nodeset/tree/Safety-1.05.04-2025-02-05/Safety).

   The "Opc.Ua.Safety.NodeSet2.xml" file serves as the basis for your individual nodeset file. It contains the type and method definitions you need to create an OPC UA SafetyProvider XML file.

2. Start SiOME.
3. First, import the namespace "http://opcfoundation.org/UA/Safety".

   To do so, click the "Import XML" button in the SiOME menu.

   SiOME displays the dialog for opening files.
4. Select the "Opc.Ua.Safety.NodeSet2.xml" file and click the "Open" button to import it.

   Result: SiOME imports the XML file and shows the namespace "http://opcfoundation.org/UA/Safety" in the "Namespaces" area.
5. Create your own namespace for your project.

   To do so, click "Add New Namespace" in the "Namespaces: Editing (current)" area in the SiOME menu.

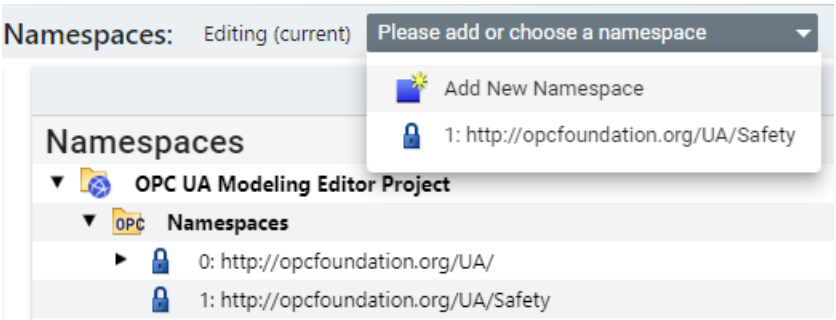

   SiOME opens the "Add Namespace" dialog.
6. Enter the name of the new namespace.

   The namespace "UserNamespace.com" is used in the example.

   SiOME additionally shows the new namespace:

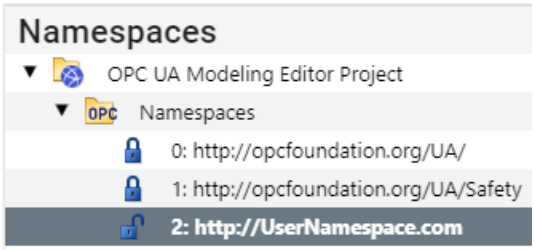

7. Create an instance from the object type "SafetyProviderType" of the OPC UA Safety Specification.

   To do so, right-click the folder "Root/Objects/SafetyACSet" in the "Information model" area and select "Add Instance".

   NOTE

   Instances of the "SafetyProviderType" object type must always be located in the folder "SafetyACSet".

   SiOME displays the dialog "Add Instance".

8. Enter a descriptive name for the new instance for "Name".

   The name "SafetyProvider_1" is used in the example.

   For "TypeDefinition", select "SafetyProviderType". You can find the type under "BaseObjectTypes/SafetyObjectsType".

9. Click "OK".

   SiOME shows the new instance "SafetyProvider_1" under "SafetyACSet" in the "Information model" area. This instance already contains the SPI parameters required for communication with OPC UA Safety:

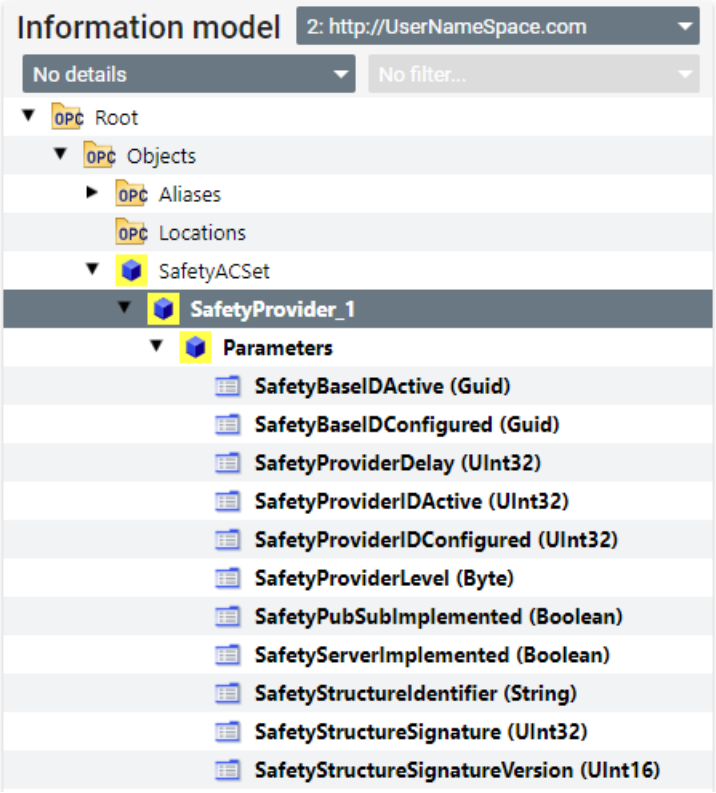

10. Select the Safety layout.
    To do so, select the "Safety" layout under "SIEMENS products functions" in the "Layout" area of the SiOME menu.

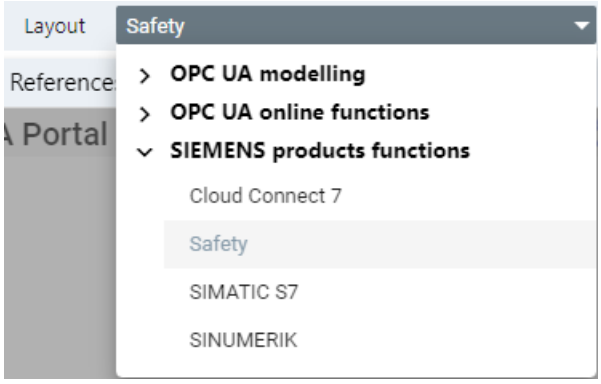

SiOME now shows the "Safety Configuration" area.

11. Add the "ReadSafetyData" and "ReadSafetyDataDiagnostics" methods. These methods are required for client access of the communication with OPC UA Safety.

    Select the corresponding check boxes for this in the "Attributes/References" area.

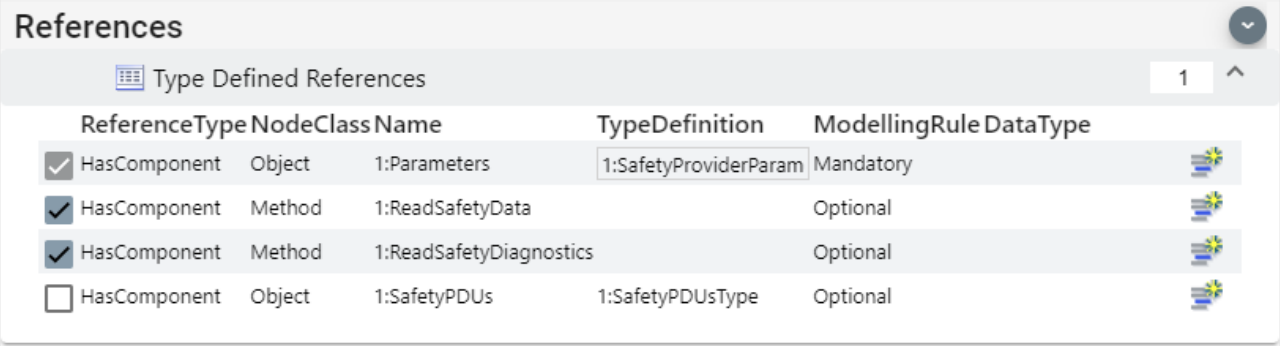

12. In SiOME, connect to the TIA project in which you created the data structures and local data.

    To do so, click the "Open TIA Portal project" button in the "Safety Configuration" area.

    – If a project is already opened in TIA Portal, SiOME shows the dialog "Attach to already opened TIA Portal project".
    – If no project is opened in TIA Portal, the dialog for opening of TIA Portal projects is displayed.

13. Select the project and click "Attach to selected project" or "Open". If required, enable the access in parallel in TIA Portal.

    SiOME displays the project tree of the project.

    Note: If the project contains more than one (F-)CPU, SiOME first displays the dialog "Select PLC". In this case, select the desired F-CPU.

14. Perform the mapping for SafetyData in the Safety Application Program Interface (SAPI).

    To do so, use drag-and-drop to move the variable with the data structure of the data to be sent from the F-DB to the SafetyData parameter in the SAPI. Answer "Yes" to the displayed question "Do you want to generate the OPC UA DataTyp.".

    SiOME generates the associated OPC UA data type.

15. Optional:

    Perform the mapping for NonSafetyData, InputSignals, OutputSignals, SafetyProviderID and/or SafetyBaseID accordingly. The maximum length for strings is 128 characters.

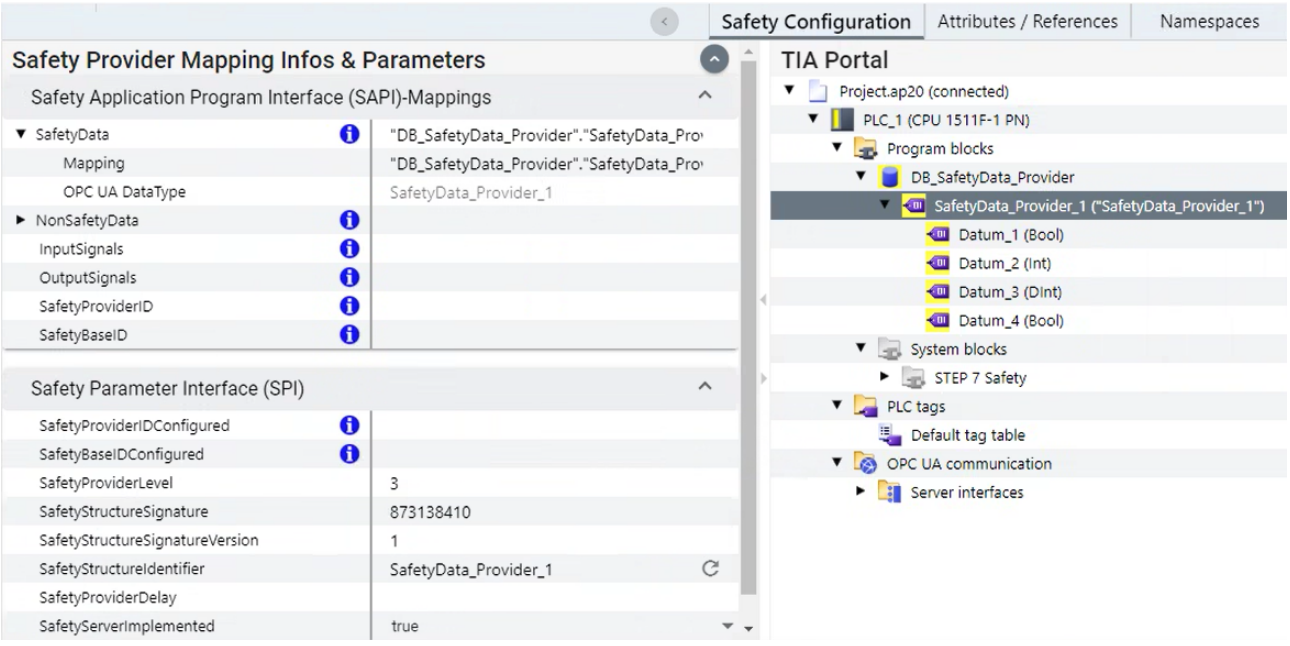

16. Optional:

    Validate the now available nodeset.
    To do so, click the "Validate information model" button in the SiOME menu.

    SiOME displays the dialog "Choose the validation settings".

17. Select the desired settings and click "Validate".

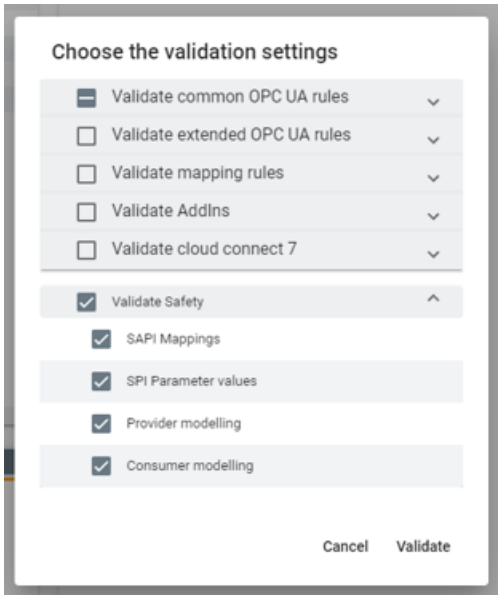

SiOME displays the result of the validation in the "Validation" area.

18. Export the XML file.

    To do so, click the "Export XML" button in the SiOME menu.

SiOME displays the dialog "Export XML".

Select the path for the export and a descriptive name for the file. The name "SafetyProvider_1" is used in the example.

Have all namespaces activated and click "OK".

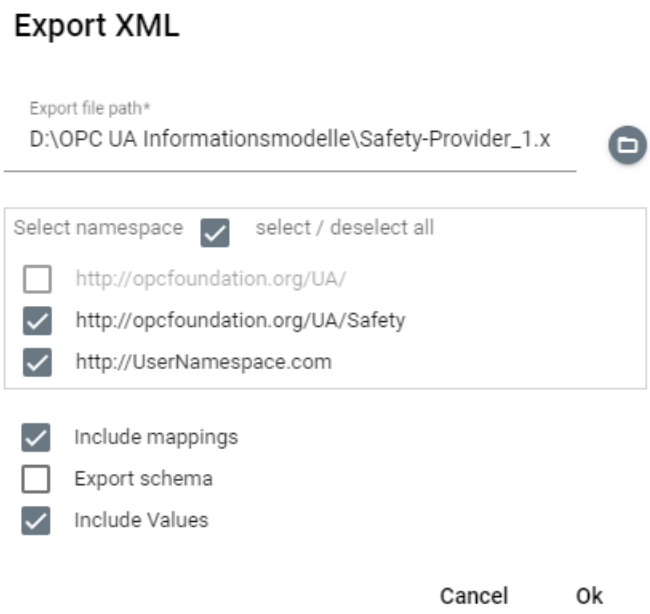

9.5.2.3 Creating a server interface for an OPC UA SafetyProvider information model

You create a server interface for an OPC UA SafetyProvider information model in a similar way as a server interface for a companion specification. More information can be found in the *STEP 7* help under "Creating a server interface for a companion specification (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-as-an-opc-ua-server-s7-1500-s7-1500t/opc-ua-server-interface-configuration-s7-1500-s7-1500t/creating-a-server-interface-for-companion-specification-s7-1500-s7-1500t)".

WARNING

Note that the data of a SafetyProvider can only be received safety-oriented if it is provided by a SafetyConsumer in the associated F-OPC UA Consumer DB. All other options for communication via OPC UA with a SafetyProvider or SafetyConsumer (OPC UA Read/Write access, OPC UA method calls) do not take place safety-oriented. *(S113)*

NOTICE

When making various changes in your user program, note that the OPC UA server of the F-CPU may need to be restarted. This can lead to an interruption of the safety-related communication with OPC UA Safety, which means that all connected SafetyConsumer output substitute values. In this case, the received process values are only output again after a user acknowledgement.

More information can be found in the *STEP 7* help under "Behavior of the OPC UA server during operation (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-as-an-opc-ua-server-s7-1500-s7-1500t/interesting-information-about-the-opc-ua-server-of-the-s7-1500-cpus-s7-1500-s7-1500t/runtime-behavior-of-the-opc-ua-server-s7-1500-s7-1500t)".

Creating a server interface for an OPC UA SafetyProvider information model

Proceed as follows to create a server interface for a companion specification with *STEP 7 (TIA Portal)*:

1. Select the F-CPU you are using as the OPC UA server.
2. In the project tree, click "OPC UA communication > Server interfaces".
3. Double-click "Add new server interface".
4. To select the type of this server interface, click the "Companion specification" button.

   A general name for the new interface, e.g. "Server_Interface_1", is entered in the dialog.

5. Change the name of the new server interface to a descriptive name in your project.

   The name "SafetyProvider_1_Instance_1" is used in the example.

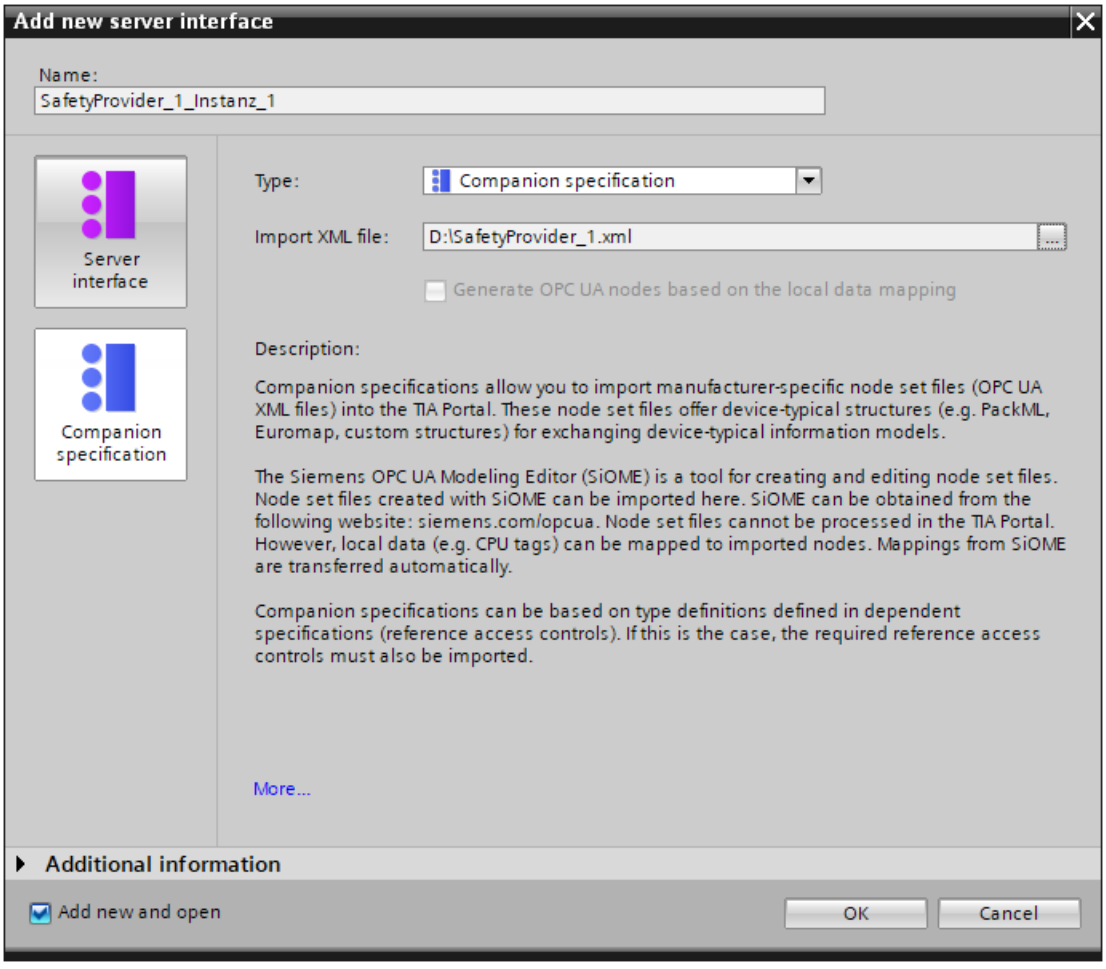

6. In the "Import XML file" field, select the OPC UA SafetyProvider XML file that was created and exported in SiOME (Page 320) and contains the description of the information model for your individual data structure.
7. Click the "OK" button.

   STEP 7 (TIA Portal) imports the information model described in the selected XML file.
8. Select your SafetyProvider instance in the OPC UA server interface.

   Under "OPC UA Safety Provider" on the "Properties" tab, you see the local data of your Safety program (or standard user program) that was mapped to the SAPI parameters and the values of the SPI parameters that you assigned or that were assigned automatically during import.

NOTE

You performed the mapping of your local data previously when creating your OPC UA Safety XML file in SiOME. It is not necessary to create and map further local data with the "Generate local data" button.

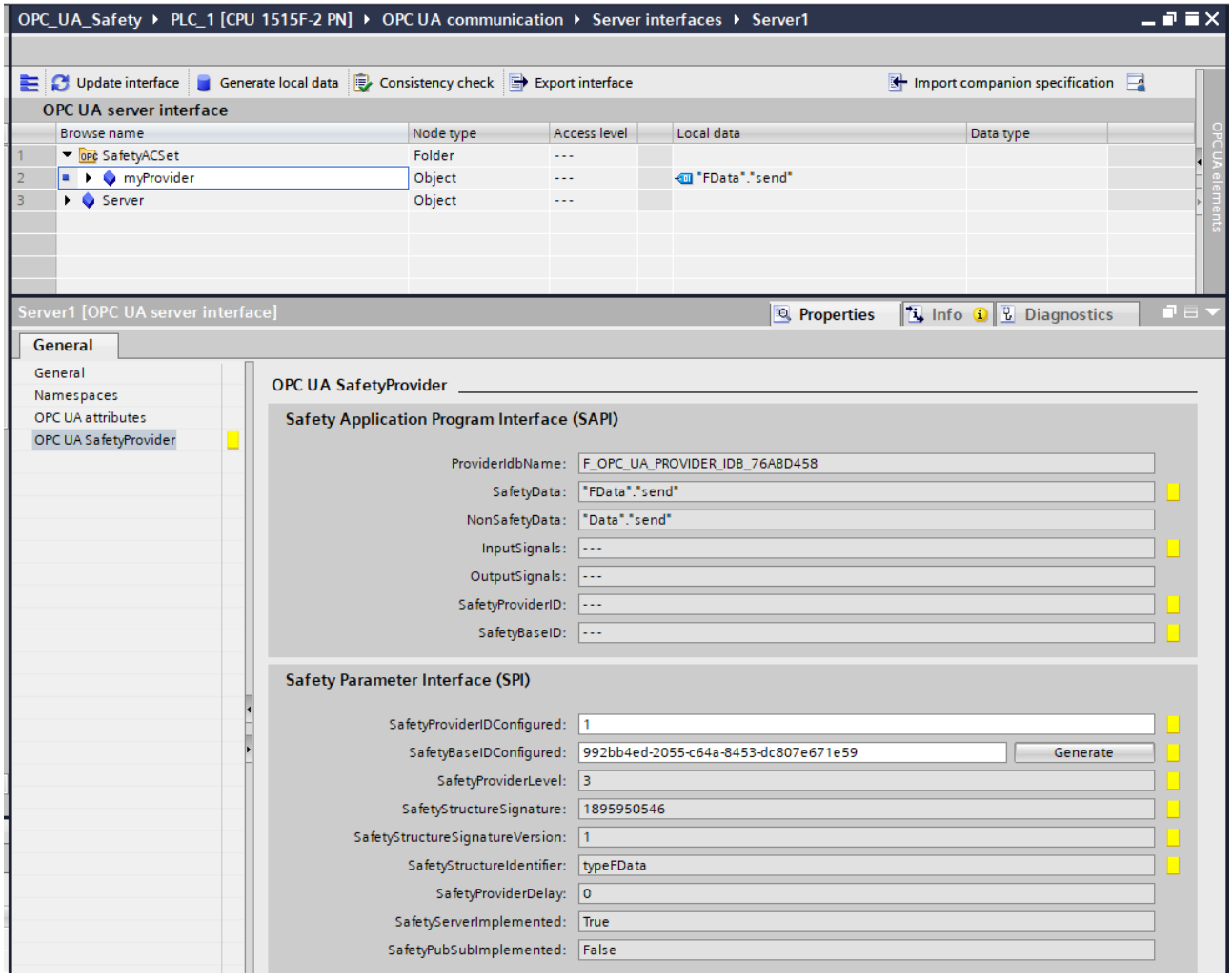

9. Optional:

   Check the imported server interface for consistency.

   To do so, select your SafetyProvider instance in the OPC UA server interface and click the "Consistency check" button.

   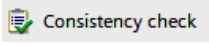

   STEP 7 displays the result of the consistency check on the "Info > General" tab.

10. Optional:

    Change the values of the SPI parameter SafetyProviderIDConfigured and/or SafetyBaseIDConfigured according to the requirements of your specific application.

    To do this, open the editor for the server interface and select "OPC UA Safety Provider" select the "Properties" tab.

    – SafetyProviderIDConfigured: Overwrite a previously entered value.
    – SafetyBaseIDConfigured: Click the "Generate" button.
      STEP 7 Safety generates a random value that fulfills the safety requirements of OPC UA Specification OPC 10000-15.

WARNING

For the unique and secure authentication of a SafetyProvider, the combination of active SafetyProviderID and active SafetyBaseID at any point in time must be unique for all OPC UA Safety communication connections network-wide. **

If your network is not safely separated from the outside world through physical separation, the active SafetyBaseID at any point in time must be a value that was generated randomly in accordance with the OPC UA Specification OPC 10000-15. ***

You must ensure the uniqueness in the safety summary during acceptance of the safety program. If the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S102)*

* If you cannot ensure a unique combination during startup of the Safety program because the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID is "0" during this phase.

** SafetyProviders to which the same local data element of your safety program is mapped (Safety Multicast (Page 342)) at the SafetyData SAPI parameter are permitted to use the same combination.

*** If you have entered a value for the SPI parameter SafetyBaseIDConfigured of a SafetyProvider (either in the NodeSet or in the properties of a SafetyProvider), you yourself must ensure that the value meets the safety requirements of the OPC UA Specification OPC 10000-15. Alternatively, generate the value of SafetyBaseIDConfigured again by opening the properties tab of the affected SafetyProvider and clicking on the "Generate" button.

9.5.2.4 Programming the initialization or evaluation of SAPI parameters in your safety program (or standard user program)

Programming procedure

You program the initialization or evaluation of SAPI parameters as follows:

1. Initialize the local data in your Safety program that you have mapped to the SafetyData SAPI parameter with the current values that you want to make available to a connected SafetyConsumer in a safety-related manner.
2. Optional:

   Initialize the local data in your standard user program that you have mapped to the NonSafetyData SAPI parameter with the current values that you want to make available to a connected SafetyConsumer in a non-safety-related manner.
3. Optional:

   If you want to perform user acknowledgment required on the connected SafetyConsumer on the SafetyProvider side:

   Initialize the local data element in your Safety program that you have mapped to the InputSignals.OperatorAckProvider SAPI parameter with your acknowledgment signal. For this purpose, you can also evaluate the local data element that you have mapped to the InputSignals.OperatorAckProvider SAPI parameter in your standard user program. You

can then, for example, have an operator control and monitoring system display that there is an acknowledgment on the connected SafetyConsumer.

WARNING

A user acknowledgment (Page 196) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted. *(S011)*

4. Optional:

   If a connected SafetyConsumer should use the designated substitute values from the F-OPC-UA-Consumer-DB instead of the current values at the SafetyData SAPI parameter:

   Initialize the local data element in your Safety program that you have mapped to the InputSignals.ActivateFSV SAPI parameter with "TRUE".

   NOTE

   Always set the date to "TRUE" if you cannot provide any safety-related values for the SafetyData SAPI parameter, while, for example, the F-CPU with the associated SafetyConsumer is already integrated in a productive operation.

   Non-safety-related values are present, for example, if your Safety program with the SafetyProvider is in disabled Safety mode during a test phase, is running on an *S7-PLCSIM* or is still incomplete.

5. Optional:

   If you want to inform a connected SafetyConsumer that the current values at the SAPI parameter SafetyData are test data and, thus, were not formed in a safety-related manner:

   Initialize the local data element in your safety program that you have mapped to the InputSignals.EnableTestMode SAPI parameter with "TRUE".

   NOTE

   The EnableTestMode SAPI parameter is also set internally to "TRUE" by the Safety program if it is in disabled Safety mode or is running on an *S7-PLCSIM*.

6. Optional:

   Applications with changing communication partners (Page 344) or series machines (Page 343):

   Initialize the local data element in your Safety program that you have mapped to the SafetyProviderID SAPI parameter with a SafetyProviderID matched to the specific situation in the system.

7. Optional:

   Applications with changing communication partners (Page 344) or series machines (Page 343):

   Initialize the local data element in your standard user program that you have mapped to the SafetyBaseID SAPI parameter with a SafetyBaseID matched to the specific situation in the system.

WARNING

For the unique and secure authentication of a SafetyProvider, the combination of active SafetyProviderID and active SafetyBaseID at any point in time must be unique for all OPC UA Safety communication connections network-wide. **

If your network is not safely separated from the outside world through physical separation, the active SafetyBaseID at any point in time must be a value that was generated randomly in accordance with the OPC UA Specification OPC 10000-15. ***

You must ensure the uniqueness in the safety summary during acceptance of the safety program. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S102)*

* If you cannot ensure a unique combination during startup of the Safety program because the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID is "0" during this phase.

** SafetyProviders to which the same local data element of your safety program is mapped (Safety Multicast (Page 342)) at the SafetyData SAPI parameter are permitted to use the same combination.

*** If you have entered a value for the SPI parameter SafetyBaseIDConfigured of a SafetyProvider (either in the NodeSet or in the properties of a SafetyProvider), you yourself must ensure that the value meets the safety requirements of the OPC UA Specification OPC 10000-15. Alternatively, generate the value of SafetyBaseIDConfigured again by opening the properties tab of the affected SafetyProvider and clicking on the "Generate" button.

WARNING

Due to system constraints, formation of a SafetyBaseID at runtime of your Safety program is only possible in your standard user program.

Note that these program sections are therefore not captured by the collective F-signature and are not protected by "Access protection for safety-related project data (Page 101)" or "F-CPU access protection (Page 104)".

For this reason, you must take organizational measures to ensure that only authorized persons can change these program sections.

Print the relevant program sections and supplement your safety summary with this printout. *(S103)*

9.5.3 Configuring and programming a SafetyConsumer

Requirements

- An F-CPU S7-1500 as of FW 4.0 (except HF-CPUs) or an S7-1500 F Software Controller as of firmware V40.0.
- The required Runtime license for OPC UA is available and is configured in *STEP 7*.
- The OPC UA client is activated.
- An OPC UA SafetyProvider information model for your individual data structure has been created or supplied for the device from a third-party manufacturer.

Configuring and programming a SafetyConsumer

Proceed as follows to configure and program a SafetyConsumer. Repeat the following steps for each SafetyProvider from which you want to evaluate data.

9.5.3.1 Creating a client interface for an OPC UA SafetyProvider information model

You create a client interface for an OPC UA SafetyProvider information model using the editor for client interfaces as in the standard. More information can be found in the *STEP 7* help under "Creating client interfaces (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-cpu-as-an-opc-ua-client-s7-1500-s7-1500t/creating-client-interfaces-s7-1500-s7-1500t)".

Only the special features of OPC UA Safety are described below.

WARNING

Note that the data of a SafetyProvider can only be received safety-oriented if it is provided by a SafetyConsumer in the associated F-OPC UA Consumer DB. All other options for communication via OPC UA with a SafetyProvider or SafetyConsumer (OPC UA Read/Write access, OPC UA method calls) do not take place safety-oriented. *(S113)*

Creating a client interface for an OPC UA SafetyProvider information model

To create a client interface for an OPC UA SafetyProvider information model with *STEP 7 (TIA Portal)*, proceed as follows:

1. Select the F-CPU you are using as the OPC UA client.
2. In the project tree, click "OPC UA communication > Client interfaces".

3. Double-click on "Add new client interface".

   STEP 7 creates a new client interface and displays it in the editor:

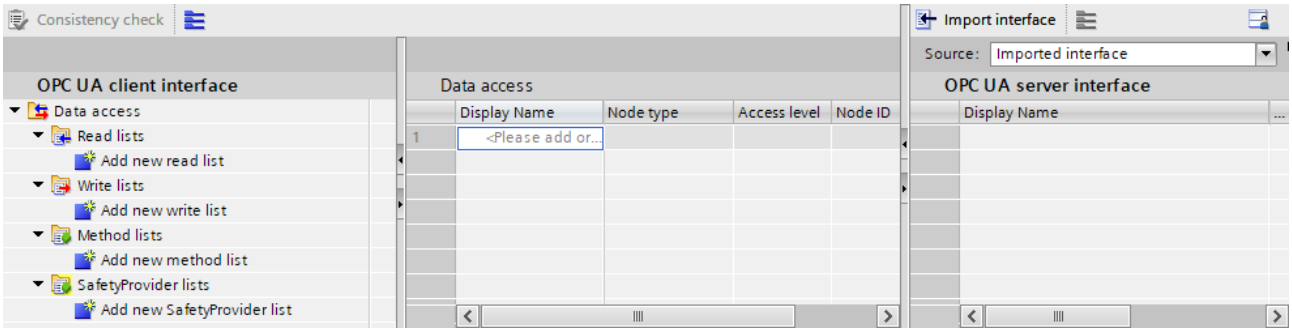

   STEP 7 calls the new interface "Client interface_1".

   STEP 7 also generates the following data blocks:

   – **Client interface_1_Configuration**

     The data block contains variables that require to call the client instructions for the underlying OPC UA communication.

     When using the F-OPC-UA-Consumer-Com-FB (Page 340), these variables are automatically interconnected with the OPC_UA_MethodCall instruction.

   – **Client interface_1_Data**

     This data block is not required for OPC UA Safety.

4. Change the name of the new client interface to a descriptive name in your project.

   The name "Failsafe_Device" is used in the example.

   This also changes the names of the associated data blocks to:

   – Failsafe_Device_Data
   – Failsafe_Device_Configuration

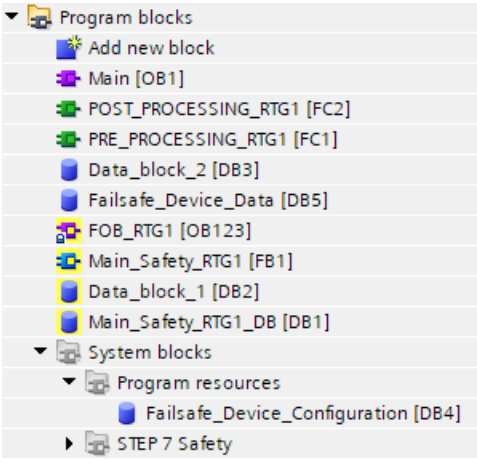

5. In the dialog that appears, specify the IP address of the desired OPC UA server in the Properties/Configuration tab under Connection parameters.

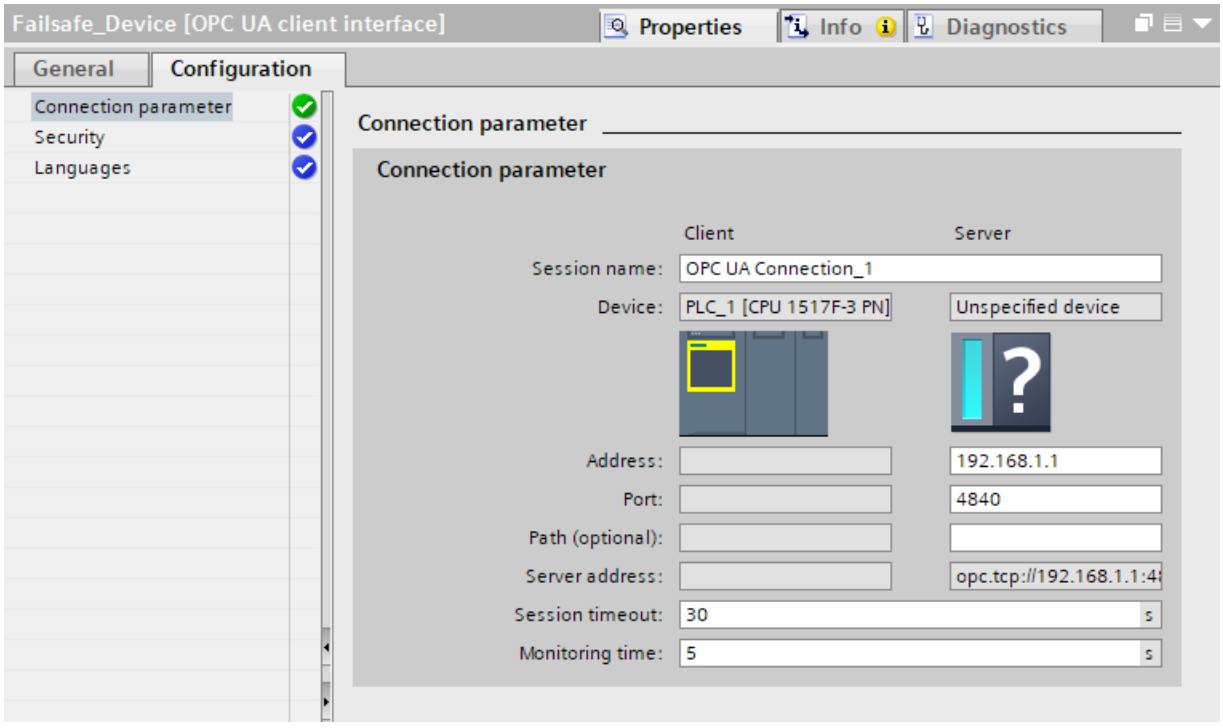

6. To import an OPC UA server interface, click the "Import interface" button at the top right of the editor when it is selected.

   Alternatively: You determine the server interface of a connected OPC UA server online. More information can be found in the STEP 7 online help under "Determining the server interface online (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-cpu-as-an-opc-ua-client-s7-1500-s7-1500t/determine-server-interface-online-s7-1500-s7-1500t)".

7. In the "Import XML file" field of the dialog that appears, select the exported OPC UA SafetyProvider XML file (Page 320) created and exported in SiOME or the OPC UA SafetyProvider XML file supplied for a device by a third-party manufacturer, in which the information model of the intended SafetyProvider is described.

8. Generate a SafetyProvider list in this client interface.

   To do this, click on "Add new SafetyProvider list" in the left section of the editor.

   STEP 7 adds a new list with the name "SafetyProvider list_1".

9. Add the intended SafetyProvider to the new SafetyProvider list.

   To do this, drag-and-drop the SafetyProvider from the OPC UA server interface to the "SafetyProvider list_1" SafetyProvider list in the middle field of the editor.

   In the example, the SafetyProvider has the name "SafetyProvider_Instance".

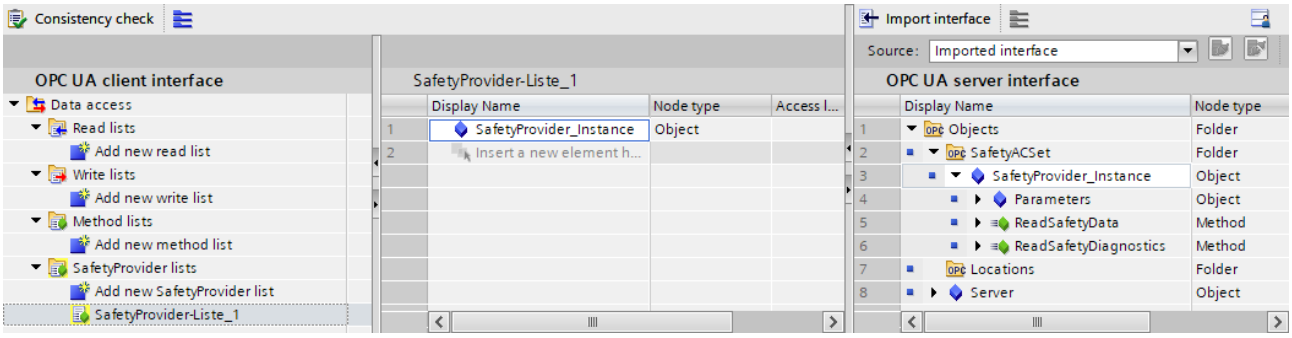

STEP 7 Safety generates the following program blocks and PLC data types:

– F-OPC-UA-Consumer-DB (Page 316)

  (for example F_OPC_UA_CONSUMER)

– F-OPC-UA-Consumer-Com-FB (Page 340)

  (for example F_OPC_UA_CONSUMER_COM)

– UDT for the SafetyData SAPI parameter (Page 311) and the PASS_VALUES in the F-OPC-UA-Consumer-DB (Page 316)

  (for example Failsafe_Device.SafetyData_Type)

– UDT for the NonSafetyData SAPI parameter (Page 311)

  (for example Failsafe_Device_NonSafetyDataPlaceholderDataType)

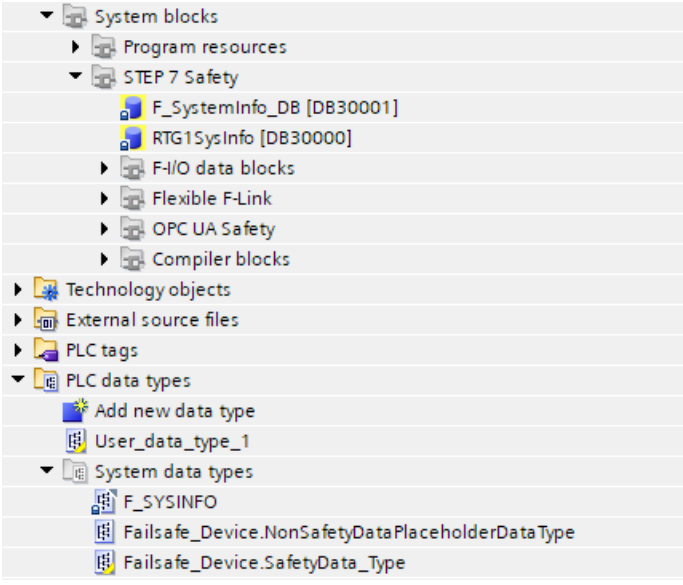

10. Optional:

    Check the imported client interface for consistency.

    To do this, select your SafetyProvider list in the OPC UA client interface and click the "Consistency check" button.

    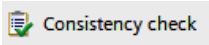

    STEP 7 displays the result of the consistency check on the "Info > General" tab.

9.5.3.2 Configuring properties of a SafetyConsumer

You configure the properties of a SafetyConsumer in the "Properties" tab in the editor for client interfaces or in the F-OPC UA Consumer DB. Note the requirements of your specific application.

Configuring properties of a SafetyConsumer

To configure the properties of a SafetyConsumer, proceed as follows:

1. Select the intended SafetyProvider in the SafetyProvider list.

   In the "Properties/General" tab, the F-OPC UA Consumer DB is displayed under "OPC UA Safety Consumer" as a substitute for the SAPI parameters and the SPI parameters.

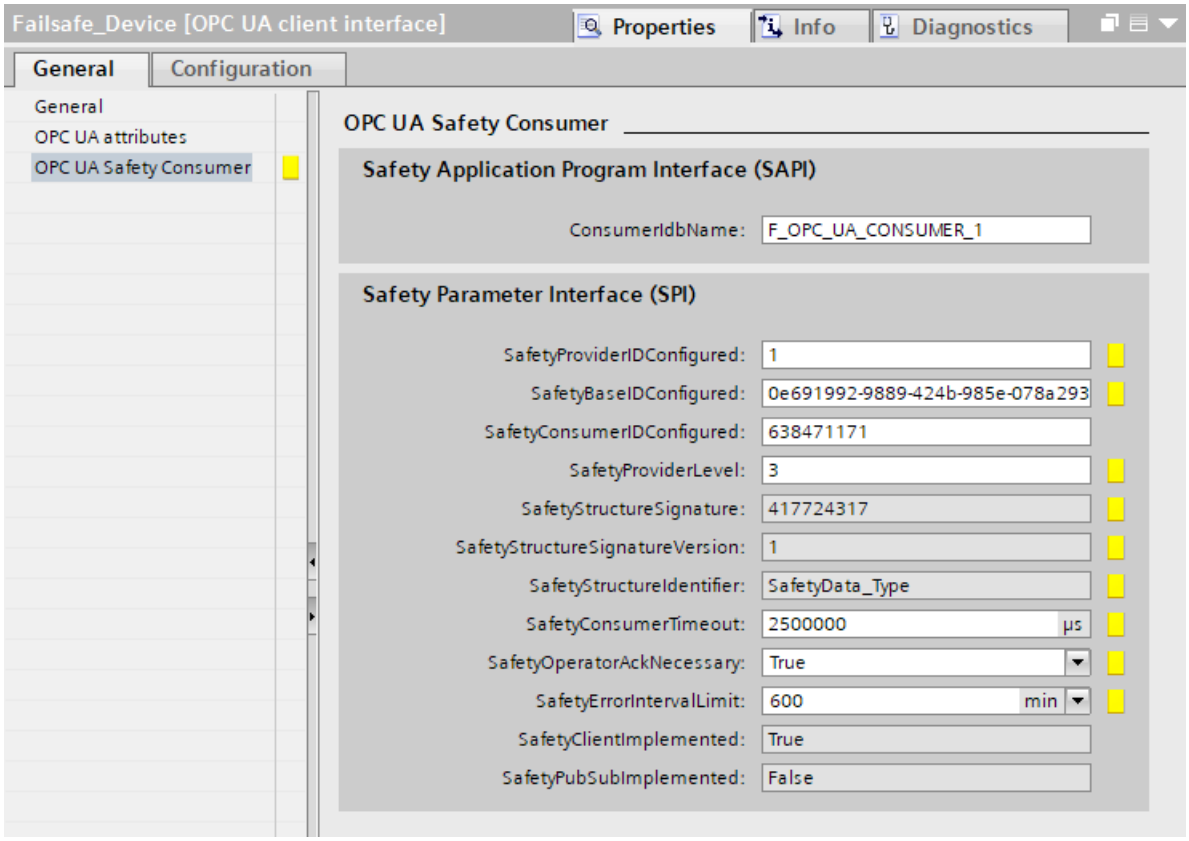

2. Optional:

   Change the name of the F-OPC UA Consumer DB.

3. Specify the values of the SPI parameters SafetyProviderIDConfigured (Page 307) and SafetyBaseIDConfigured (Page 307). The values must match the corresponding values of the intended SafetyProvider.

   WARNING

   For secure authentication of the SafetyProvider whose SafetyData is to be evaluated, the values of the active SafetyProviderID and active SafetyBaseID of the SafetyConsumer must correspond to the values of the active SafetyProviderID and active SafetyBaseID of this SafetyProvider at all times*.

   When accepting the Safety programs, you must ensure compliance in the relevant safety summary. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S104)*

   * If you cannot yet provide the values when starting the Safety program because they are only created during the runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID or the Enable "0" SAPI parameter in this phase.

4. Optional:

   Change the value of the SPI parameter SafetyConsumerIDConfigured (Page 307).

5. Specify the value of the SafetyProviderLevel (Page 307) SPI parameter. The value must match the value on the connected SafetyProvider.

6. Change the value of the SPI parameter SafetyConsumerTimeout (Page 307).

   More information can be found in the section "Response Times of Safety Functions (Page 649)".

7. Optional:

   Change the value of the SafetyOperatorAckNecessary (Page 307) SPI parameter to "FALSE" if your specific system situation allows the values on the SafetyData SAPI parameter to be switched from substitute values to current values without manual user acknowledgment.

8. Optional:

   Change the value of the SafetyErrorIntervalLimit (Page 307) SPI parameter if your specific system situation requires this **as an exception**.

   Note the effects on the probability of failure values (PFDavg and PFH values) (Page 461).

9. Define the substitute values that are to be output instead of the current values at the SafetyData SAPI parameter in certain communication states.

   To do this, open the F-OPC UA Consumer DB belonging to your SafetyConsumer. You can find this in the project tree in the folder "Program blocks/System blocks/STEP 7 Safety/OPC UA Safety".

   Define the substitute values as start values in the PASS_VALUES (Page 316) variable. The data structure of the PASS_VALUES variable corresponds exactly to the data structure of your SafetyData and is specified by an automatically created PLC data type (UDT).

   Alternatively:

   If you use multiple SafetyConsumers with identical data structure (combination of SafetyData and NonSafetyData) and want to define identical substitute values for all locations of use, you can alternatively proceed as follows:

Open the automatically created PLC data type (UDT). You can find this in the project tree in the folder "PLC data types/system data types".

Define the substitute values as default values in this PLC data type (UDT).

9.5.3.3 Programming the initialization or evaluation of SAPI parameters in your Safety program (or standard user program)

Programming procedure

You program the initialization or evaluation of SAPI parameters as follows:

1. In your Safety program, set the ENABLE variable in the F-OPC-UA-Consumer-DB to "1" if you want to activate communication with OPC UA Safety to the connected SafetyProvider.

   Set the ENABLE variable to "0" if you want to deactivate an active communication to the connected SafetyProvider.

   NOTE

   When changing from Enable = 1 to Enable = 0, the output of substitute values at the SafetyData SAPI parameter only take effect after the next data package has been received or after the monitoring time parameterized via SafetyConsumerTimeout.

2. Optional:
   If you want to perform user acknowledgment on the SafetyConsumer side: In your Safety program, supply the OPERATOR_ACK_CONSUMER variable in the F-OPC-UA-Consumer-DB with your acknowledgment signal.
   You can evaluate the OPERATOR_ACK_REQUESTED variable for this. This allows you, for example, to display whether an acknowledgment request has been received on an operator control and monitoring system.

   ⚠ WARNING

   A user acknowledgment (Page 196) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted. *(S011)*

3. Applications with changing communication partners (Page 344) or series machines (Page 343):

   In your Safety program, supply the SAFETY_PROVIDER_ID variable in the F-OPC-UA-Consumer-DB with the corresponding value of the currently intended SafetyProvider.

4. Applications with changing communication partners (Page 344) or series machines (Page 343):

   In your standard user program, supply the SAFETY_BASE_ID variable in the F-OPC-UA-Consumer-DB with the corresponding value of the currently intended SafetyProvider.

   WARNING

   For secure authentication of the SafetyProvider whose SafetyData is to be evaluated, the values of the active SafetyProviderID and active SafetyBaseID of the SafetyConsumer must correspond to the values of the active SafetyProviderID and active SafetyBaseID of this SafetyProvider at all times*.

   When accepting the Safety programs, you must ensure compliance in the relevant safety summary. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S104)*

   * If you cannot yet provide the values when starting the Safety program because they are only created during the runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID or the Enable "0" SAPI parameter in this phase.

   WARNING

   Due to system constraints, formation of a SafetyBaseID at runtime of your Safety program is only possible in your standard user program.

   Note that these program sections are therefore not captured by the collective F-signature and are not protected by "Access protection for safety-related project data (Page 101)" or "F-CPU access protection (Page 104)".

   For this reason, you must take organizational measures to ensure that only authorized persons can change these program sections.

   Print the relevant program sections and supplement your safety summary with this printout. *(S103)*

5. Applications with changing communication partners (Page 344) or series machines (Page 343):

   In your Safety program, supply the SAFETY_CONSUMER_ID variable in the F-OPC-UA-Consumer-DB with a SafetyConsumerID that is adapted to the specific system situation.

6. In your Safety program, evaluate the SAFETY DATA variable in the F-OPC-UA-Consumer-DB. This supplies the SafetyData currently provided by the SafetyProvider in a safety-related manner or, in an error case, the intended substitute values from the PASS VALUES variable.

7. Optional:

   In your standard user program, evaluate the NON_SAFETY_DATA variable in the F-OPC-UA-Consumer-DB with the NonSafetyData currently not provided by the SafetyProvider in a safety-related manner.

8. Optional:

   Use the FSV_ACTIVATED variable in the F-OPC-UA-Consumer-DB to evaluate whether current values or substitute values are output at the SAFETY_DATA variable.

9. Optional:

   Use the TEST_MODE_ACTIVATED variable in the F-OPC UA consumer DB to evaluate whether "only" test data, i.e. data not created for safety-related purposes, is available at the SAFETY_DATA variable.

WARNING

If the TEST_MODE_ACTIVATED variable in the F-OPC-UA-Consumer-DB is set to "1" during communication with OPC UA Safety, you can no longer assume that the data at the SAFETY_DATA variable is formed in a safety-related manner. This is the case when the connected SafetyProvider is in deactivated safety mode on a PLCSIM instance or the EnableTestMode SAPI parameter of the connected SafetyProvider has been set in the associated user program. During this time, you must take organizational measures to ensure the safety of the system components that are affected by this data. Alternatively, you can also use safe substitute values in your Safety program with TEST_MODE_ACTIVATED = 1 instead of the data in the SAFETY_DATA tag. *(S108)*

9.5.3.4 Programming underlying OPC UA communication ("client instructions") using the F-OPC UA Consumer Com FB

OPC UA Safety is based on the mechanisms of OPC UA. SIMATIC Safety supports OPC UA client/server communication. To use OPC UA Safety communication, you first need to call the required client instructions in the standard user program for each SafetyConsumer (see *STEP 7* help "Useful information about the client instructions (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-cpu-as-an-opc-ua-client-s7-1500-s7-1500t/useful-information-about-the-client-instructions-s7-1500-s7-1500t)" and "Client instructions (https://docs.tia.siemens.cloud/r/en-us/v20/communication-s7-1200-s7-1500/opc-ua-s7-1200-s7-1500/client-instructions-s7-1500)).

To make handling in the context of OPC UA Safety easier for you, *STEP 7 Safety* has already automatically generated an F-OPC UA Consumer-Com FB when adding the foreseen SafetyProvider in the SafetyProvider list of the client interface (Page 332). This already contains the call of the
client instruction OPC_UA_MethodCall required for a specific SafetyConsumer and can be used by you.

In the project tree, you will find the F-OPC-UA-Consumer-Com-FB in the "Program blocks/System blocks/STEP 7 Safety/OPC UA Safety" folder.

You can find application examples for concrete implementation on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109977450).

Programming calls of the F-OPC-UA-Consumer-Com-FB

1. If no pre-processing or post-processing module (Page 88) exists in your F-runtime group, first create the corresponding standard FCs and select them in the *Safety Administration Editor* for your F-runtime group.
   The FCs PRE_PROCESSING_RTG1 or POST_PROCESSING_RTG1 are used in the example.

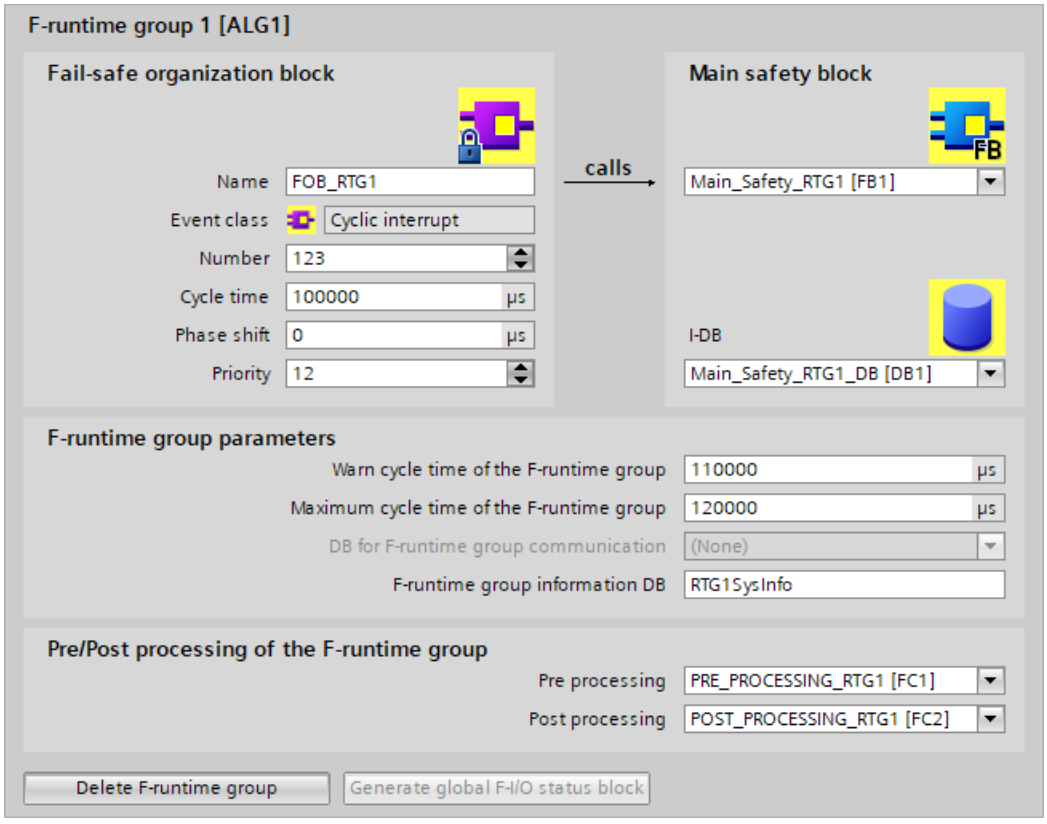

2. Call the F-OPC-UA-Consumer-Com-FB in the pre-processing module. To do this, set the IsPre input to "TRUE".
3. Call the F-OPC-UA-Consumer-Com-FB in the post-processing module. To do this, set the IsPre input to "FALSE".

NOTE

If you also use OPC UA "Standard" communication, you may want to organize the call of the client statements differently. You can find examples on this in the application examples on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109977450).

WARNING

You may only use the Excel file for response time calculation or for timeout calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) when using OPC UA Safety communication, if you have observed the following rules with regard to the standard instruction OPC_UA_MethodCall:

You must call up the standard instruction OPC_UA_METHODCALL to receive the data in the pre-processing of the F-runtime group (Page 88) and to send the request in the post-processing of the F-runtime group (Page 88). The REQ input of the instruction must be supplied with a positive signal edge during preprocessing. You can use the F-OPC-UA-Consumer-Com-FB provided by the system. *(S112)*

9.5.4 Special use cases for communication with OPC UA Safety

9.5.4.1 Introduction

This section describes some special use cases in the context of communication with OPC UA Safety. However, the details of implementation depend on your specific application. The following descriptions are therefore to be understood as suggestions and do not claim to be exhaustive. When implementing your specific application, you must observe the corresponding warnings in this manual.

9.5.4.2 Safety Multicast

In a multicast, a communication partner provides data of several communication partners on different devices at the same time.

If you want to provide data on a F-CPU via Safety Multicast, you have to set up an individual SafetyProvider for each receiver (SafetyConsumer).

If all SafetyConsumers communicate with a shared SafetyProvider, timeout errors might occur because of competing SafetyConsumer requests.

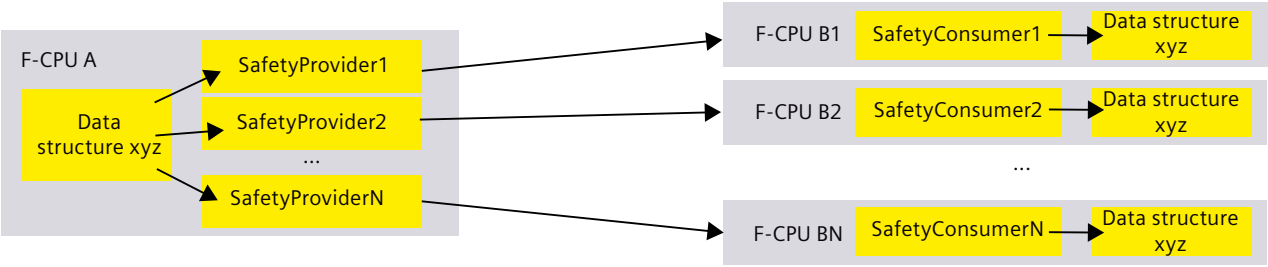

Procedure

Proceed as follows:

1. Create a SafetyProvider by copying the underlying SafetyProviderType correspondingly often for each SafetyConsumer that evaluates it from the same associated OPC UA Safety information model on the F-CPU that provides the multicast data.

   NOTE

   As the underlying SafetyProvider already contains the mapping for SafetyData in the Safety Application Program Interface (SAPI), these SafetyProviders automatically use the same data from their Safety program.

2. Create a server interface (Page 325) on the basis of this OPC UA Safety information model.

   NOTE

   All SafetyProviders belonging to a multicast may use the same combination of active SafetyProviderID and active SafetyBaseID.

3. Create a client interface (Page 332) on each F-CPU that evaluates the multicast data and add the SafetyProvider from one of the created server interfaces (Page 325) ("SafetyConsumer_x") to a SafetyProvider list.

   NOTE

   Use a different one of the created SafetyProviders for each SafetyConsumer.

9.5.4.3 Series machines

In the context of series machines, there is usually a series machine project with a configured maximum configuration, from which different variants for a series machine can then be loaded. When a real machine is commissioned, the corresponding variant is then activated.

If the series machine project includes a Safety program, there is usually a requirement that the collective F-signature from the series machine project remains unchanged after the commissioning of a real machine.

In the context of communication with OPC UA Safety, however, it is necessary for each OPC UA Safety communication connection to have a unique combination of active SafetyProviderID and active SafetyBaseID. This means that the series machine project cannot yet contain the final values for a real machine, e.g. by defining them via the SPI parameters SafetyProviderIDConfigured and/or SafetyBaseIDConfigured.

Possible solutions:

1. Use the value "1" for the SafetyProviderIDConfigured SPI parameter in the series machine project for all OPC UA Safety communication connections.

   Note: The value is usually assigned automatically by *STEP 7 Safety*.

2. Use the value "0" for the SafetyBaseIDConfigured SPI parameter in the series machine project for all OPC UA Safety communication connections.

3. In the standard user program in the series machine project, program a block that generates a randomly generated value once for each OPC UA Safety communication connection during commissioning of a real machine and assigns it to the associated SAPI parameter SafetyBaseID.

   For this purpose, use the "Random", "Get_IM_Data", "RD_SYS_T" and "SHA2" instructions to ensure that the safety requirements of the OPC UA Specification OPC 10000-15 regarding randomly generated values are fulfilled.

You can find application examples for concrete implementation on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109977450).

9.5.4.4 Changing communication partners

There are changing communication partners when, during the runtime of a Safety program,

- a SafetyProvider is to communicate with changing SafetyConsumers
- a SafetyConsumer with changing SafetyProviders

with identical data structures of the parameters SafetyData and, if applicable, NonSafetyData.

In these situations, you must pay particular attention to the correct handling of the active SafetyProviderID, SafetyBaseID, SafetyConsumerID and the Enable SAPI parameter of the SafetyConsumer.

SafetyProvider with changing SafetyConsumers

SafetyProvider:

- Specify the SafetyProviderID and SafetyBaseID consistently via the SPI parameters SafetyProviderIDConfigured and SafetyBaseIDConfigured.

  Note: The values are usually assigned automatically by *STEP 7 Safety*.

SafetyConsumer:

- Specify the SafetyProviderID and SafetyBaseID consistently via the SPI parameters SafetyProviderIDConfigured and SafetyBaseIDConfigured. The values must match the corresponding values of the intended SafetyProvider.
- Specify the SafetyConsumerID consistently via the SafetyConsumerIDConfigured SPI parameter. Use different values for each SafetyConsumer.

  Note: *STEP 7 Safety* automatically assigns a randomly generated value.
- In your safety program, only set the ENABLE variable in the F-OPC-UA-Consumer-DB to "1" once the underlying OPC UA communication to the SafetyProvider has been established.
- In your safety program, set the ENABLE variable in the F-OPC-UA-Consumer-DB to "0" before terminating the underlying OPC UA communication to the SafetyProvider.

SafetyConsumer with changing SafetyProviders for a known number of SafetyProviders.

The SafetyConsumer knows all possible SafetyProviders and their SafetyProviderIDConfigured and SafetyBaseIDConfigured and can determine the system state of the foreseen SafetyProvider.

SafetyProvider:

- For each SafetyProvider, specify the SafetyProviderID and SafetyBaseID consistently via the SPI parameters SafetyProviderIDConfigured and SafetyBaseIDConfigured.

  Note: The values are usually assigned automatically by *STEP 7 Safety*.

SafetyConsumer:

- Specify the value "0" for the SPI parameters SafetyProviderIDConfigured and SafetyBaseIDConfigured.
- Specify the SafetyConsumerID consistently via the SafetyConsumerIDConfigured SPI parameter.

  Note: *STEP 7 Safety* automatically assigns a randomly generated value.
- Save the SafetyProviderIDConfigured and SafetyBaseIDConfigured of all possible SafetyProviders in an F-DB or Standard DB.
- On the basis of the current system state, select the value of the SafetyProviderIDConfigured of the foreseen SafetyProvider in your safety program and copy this into the variable SAFETY_PROVIDER_ID of the F-OPC-UA-Consumer-DB. Use the value 0 as long as no connection is to exist to a SafetyProvider.
- On the basis of the current system state, select the value of the SafetyBaseIDConfigured of the foreseen SafetyProvider in your safety program and copy this into the variable SAFETY_BASE_ID of the F-OPC-UA-Consumer-DB. Use the value 0 as long as no connection is to exist to a SafetyProvider.
- In your safety program, only set the ENABLE variable in the F-OPC-UA-Consumer-DB to "1" if the values of the foreseen SafetyProvider are pending and the underlying OPC UA communication to the SafetyProvider has been established at the variables SAFETY_PROVIDER_ID and SAFETY_BASE_ID of the F-OPC-UA-Consumer-DB.
- In your safety program, set the ENABLE variable in the F-OPC-UA-Consumer-DB to "0" before terminating the underlying OPC UA communication to the SafetyProvider.

SafetyConsumer with changing SafetyProvider for unknown number of SafetyProviders

Not all possible SafetyProviders and their active SafetyBase ID are known to the SafetyConsumer, since, for example, additional SafetyProviders are added during running system operation.

In this case, you must use a different method (e.g. via an RFID system) to make the active SafetyBaseID of the foreseen SafetyProvider, depending on the system status, known to the SafetyConsumer.

SafetyProvider:

- Constantly and identically specify the SafetyProviderID for each SafetyProvider via the SPI parameter SafetyProviderIDConfigured.

  Note: The value is usually assigned automatically by *STEP 7 Safety*.
- For each SafetyProvider specify the SafetyBaseID analogously to the use case for series machines (Page 343). Specify the value "0" at the SPI parameter SafetyBaseIDConfigured.

SafetyConsumer:

- Constantly specify SafetyProviderIDConfigured for the SafetyProviderID via the SPI parameters. The value must match the corresponding value of the SafetyProvider setting.
- Specify the value "0" for the SPI parameter SafetyBaseIDConfigured.
- Specify the SafetyConsumerID consistently via the SafetyConsumerIDConfigured SPI parameter.

  Note: *STEP 7 Safety* automatically assigns a randomly generated value.
- In your safety program, copy the value of the active SafetyBaseID of the intended SafetyProvider determined via the diversity path into the SAFETY_BASE_ID variable of the F-OPC-UA-Consumer-DB. Use the value 0 as long as no connection is to exist to a SafetyProvider.
- In your safety program, only set the ENABLE variable in the F-OPC-UA-Consumer-DB to "1" if the value of the foreseen SafetyProvider is pending and the underlying OPC UA communication to the SafetyProvider has been established at the variable SAFETY_BASE_ID of the F-OPC-UA-Consumer-DB.
- Set the ENABLE variable in the F-OPC-UA-Consumer-DB to "0" before closing the underlying OPC UA communication to the SafetyProvider.

You can find application examples for concrete implementation on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109977450).

9.5.5 Avoiding connection resource bottlenecks

Note that influences on the lower-level OPC UA communication may cause extended response times. As a result, "Timeout" communication errors can occur.

In particular, use of encrypted communication can lead to significantly extended response times on low and medium performance class F-CPUs.

The following factors can also affect the response times:

- Utilization of the F-CPU
- Number of OPC UA and OPC UA Safety connections
- Number of implemented server methods
- Open user communication
- Web server
- S7 connections

Take this into account when configuring the OPC UA Safety connection.

Also refer to the *STEP 7* help under "Details on OPC UA client/server connections (https://docs.tia.siemens.cloud/r/en-us/v20/editing-devices-and-networks/configure-networks/communication-via-connections/working-with-connections/connection-

resources/connection-resources-s7-1500-s7-1500/details-about-opc-ua-client/server-connections-s7-1500)".

9.5.6 Using diagnostic options when communicating with OPC UA Safety

Introduction

You have all diagnostic options of OPC UA at your disposal. For example, you can diagnose the OPC UA server of the F-CPU online with common OPC UA clients, such as UaExpert. In addition, you can access nodes in the OPC UA address space and thus on SafetyProvider or SafetyConsumer in your standard user program in order to evaluate the content for diagnostic purposes.

WARNING

Note that the data of a SafetyProvider can only be received safety-oriented if it is provided by a SafetyConsumer in the associated F-OPC UA Consumer DB. All other options for communication via OPC UA with a SafetyProvider or SafetyConsumer (OPC UA Read/Write access, OPC UA method calls) do not take place safety-oriented. *(S113)*

NOTICE

Writing online access to nodes in the OPC UA address space, which have a connection to variables of your Safety program, are not permitted and can lead to a STOP of the F-CPU or to communication errors.

9.5.6.1 ReadSafetyDiagnostics

For diagnostic purposes, one OPC UA server method ReadSafetyDiagnostics is available for each SafetyProvider.

You can call the method via the OPC UA server interface. It transfers the input and output data of the last processing of the associated SafetyProvider.

More information can be found in the OPC UA Safety Specification OPC 10000-15.

9.5.6.2 SafetyConsumerType

Configuring and programming a SafetyConsumerType

In accordance with the OPC UA Safety specification OPC 10000-15 a SafetyConsumerType should be provided for each SafetyConsumer in an OPC UA information model. The SafetyConsumerType is not necessary for a functioning client-server-communication. More information can be found in the OPC UA Safety Specification OPC 10000-15.

Requirements

- An F-CPU S7-1500 as of FW 4.0 (except HF-CPUs) or an S7-1500 F Software Controller as of firmware V40.0.
- The following function right is available for the "SafetyAdmin" role: OPC UA server access. More information can be found in the help for *STEP 7* under "Users and roles with OPC UA function rights (https://docs.tia.siemens.cloud/r/en-us/v20/configuring-automation-systems/using-opc-ua-communication-s7-1200-s7-1500-s7-1500t/using-the-s7-1500-as-an-opc-ua-server-s7-1500-s7-1500t/configuring-the-opc-ua-server-s7-1500-s7-1500t/users-and-roles-with-opc-ua-function-rights-s7-1500-s7-1500t)".
- The required Runtime license for OPC UA is available and is configured in *STEP 7*.
- The OPC UA server is activated.

Configuring and programming a SafetyConsumerType

Proceed as follows to configure and program a SafetyConsumerType. Repeat the following steps for each SafetyConsumer that you want to make available to a SafetyConsumerType.

Creating an OPC UA SafetyConsumerType information model

You create an OPC UA SafetyConsumer information model for a SafetyConsumer on the basis of a nodeset file provided by the OPC Foundation for OPC UA Safety using SiOME. To do this you have to create the parameters SafetyBaseIDActive, SafetyConsumerIDActive and SafetyProviderIDActive of the SafetyConsumerType local data mappings on the SafetyConsumer previously created in TIA Portal and transfer the SPI parameters of each SafetyConsumer manually into the information model.

You then export the OPC UA SafetyConsumerType information model created in this way to an XML file (nodeset file).

Requirements

You require the name of the F-OPC-UA-Consumer-DB (Page 336) for the local data mapping of the parameters SafetyBaseIDActive, SafetyConsumerIDActive and SafetyProviderIDActive. It is assigned automatically during the creation of a SafetyConsumer and can be modified subsequently.

Creating an OPC UA SafetyConsumerType information model

Proceed as follows to create an OPC UA SafetyConsumerType XML file (nodeset file).

1. First, download the nodeset file "Opc.Ua.Safety.NodeSet2.xml" of the OPC UA Safety Specification V1.05.04 from the GitHub website of the OPC Foundation. You can find the download link here (https://github.com/OPCFoundation/UA-Nodeset/tree/Safety-1.05.04-2025-02-05/Safety).

   The "Opc.Ua.Safety.NodeSet2.xml" file serves as the basis for your individual nodeset file. It contains the type and method definitions you need to create an OPC UA SafetyConsumerType XML file.

2. Start SiOME.

3. First, import the namespace "http://opcfoundation.org/UA/Safety".

   To do so, click the "Import XML" button in the SiOME menu.

   SiOME displays the dialog for opening files.

4. Select the "Opc.Ua.Safety.NodeSet2.xml" file and click the "Open" button to import it.

   Result: SiOME imports the XML file and shows the namespace "http://opcfoundation.org/UA/Safety" in the "Namespaces" area.

5. Create your own namespace for your project.

   To do so, click "Add New Namespace" in the "Namespaces: Editing (current)" area in the SiOME menu.

   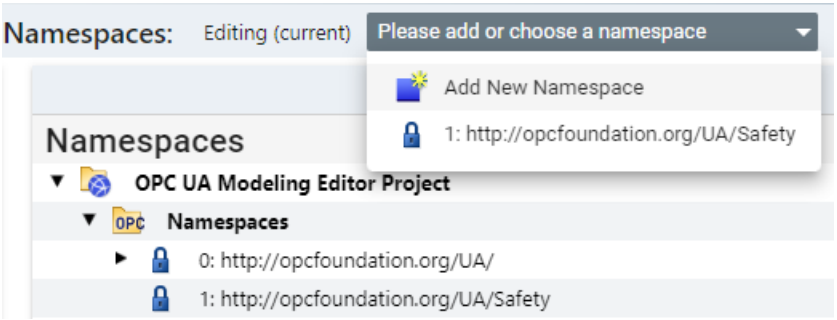

   SiOME opens the "Add Namespace" dialog.

6. Enter the name of the new namespace.

   The namespace "UserNamespace.com" is used in the example.

   SiOME additionally shows the new namespace:

   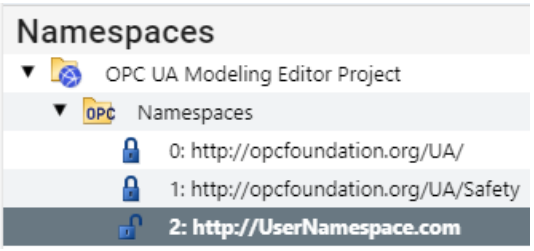

7. Create an instance from the object type "SafetyConsumerType" of the OPC UA Safety Specification.

   To do so, right-click the folder "Root/Objects/SafetyACSet" in the "Information model" area and select "Add Instance".

   NOTE

   Instances of the "SafetyConsumerType" object type must always be located in the folder "SafetyACSet".

   SiOME displays the dialog "Add Instance".

8. Enter a descriptive name for the new instance for "Name".

   The name "SafetyConsumer_1" is used in the example.

   For "TypeDefinition", select "SafetyConsumerType". You can find the type under "BaseObjectTypes/SafetyObjectsType".

9. Click "OK".

   SiOME shows the new instance "SafetyConsumer_1" under "SafetyACSet" in the "Information model" area. This instance already contains the required parameters:

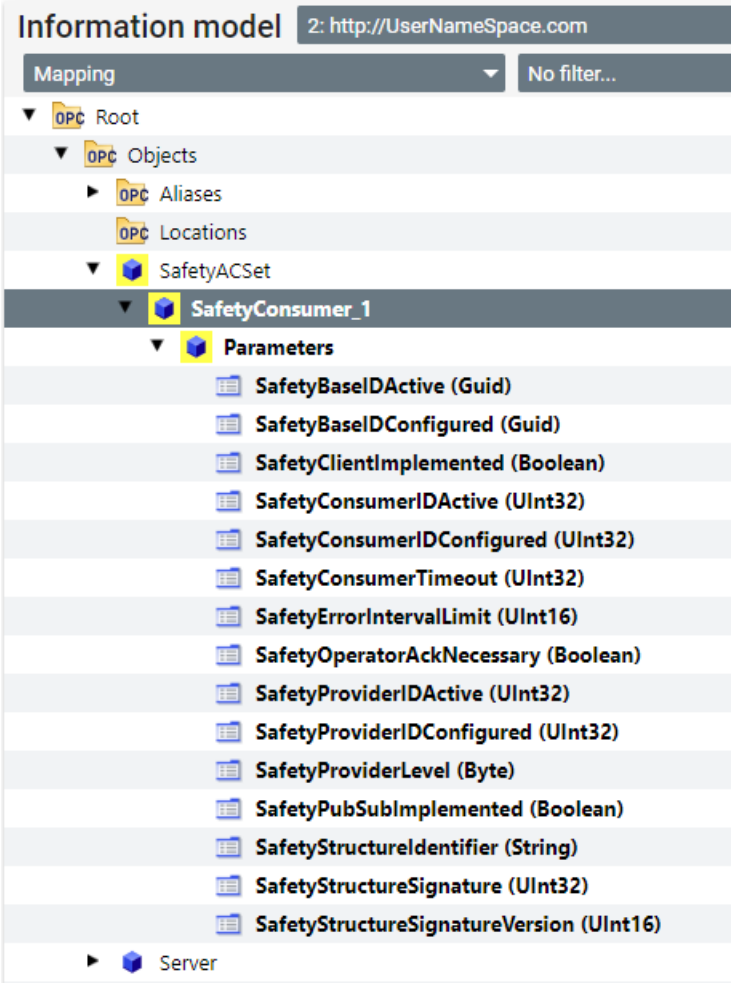

10. Select the safety layout.

    To do so, select the "Safety" layout in the SiOME menu in the "Layout" area under "SIEMENS products functions".

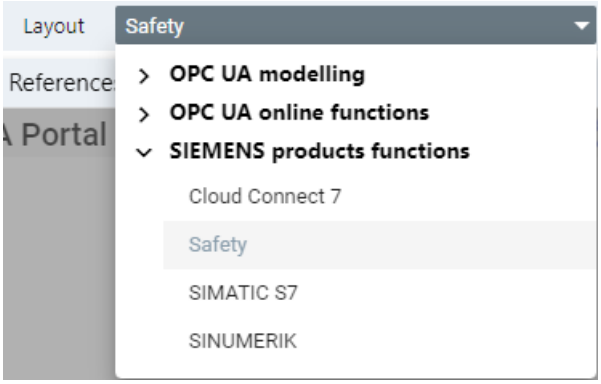

    SiOME now shows the "Safety Configuration" area.

11. Create the local data mapping for the ActiveIDs by entering the name of the F-OPC-UA-Consumer-DB in the designated field in the "ActiveIDs-Mappings" section.

    SiOME automatically generates the associated mappings for the parameters SafetyBaseIDActive, SafetyConsumerIDActive and SafeyProviderIDActive.

12. Optional:

    Transfer the values of the Safety Parameter Interface (SPI) from the SafetyConsumer from TIA Portal (Page 336) manually to the Safety Parameter Interface (SPI) of SiOME, so that this data can be queried via the OPC UA information model after completion of the configuration.

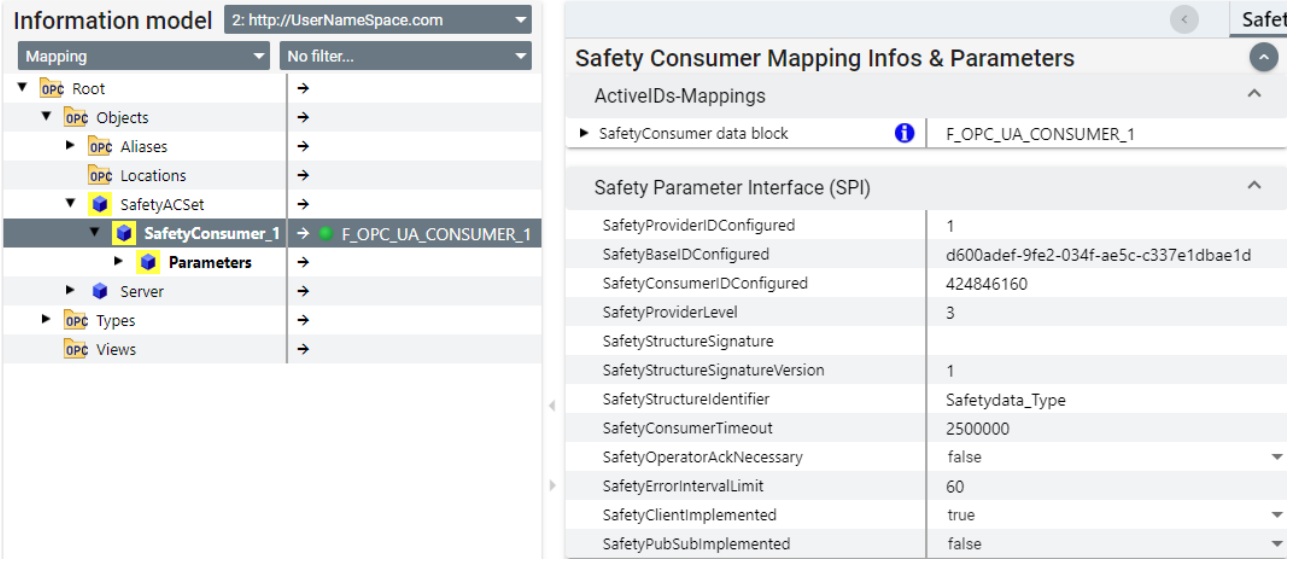

13. Export the XML file.

    To do so, click the "Export XML" button in the SiOME menu.

    SiOME displays the dialog "Export XML".

Select the path for the export and a descriptive name for the file. The name "SafetyConsumer_1" is used in the example.

Have all namespaces activated and click "OK".

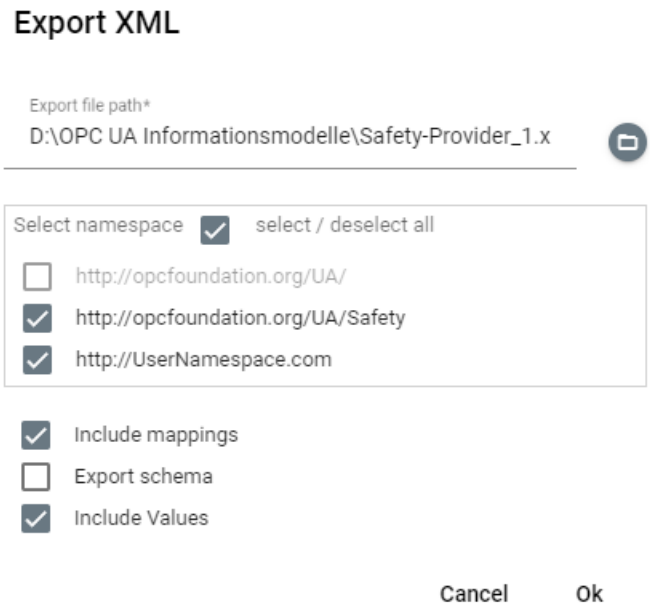

Creating a server interface for an OPC UA SafetyConsumerType information model

You create a server interface for an OPC UA SafetyConsumerType information model in a similar way as a server interface for a companion specification. More information can be found in the *STEP 7* help under "Creating a server interface for a companion specification".

Creating a server interface for an OPC UA SafetyConsumerType information model

Proceed as follows to create a server interface for a companion specification with *STEP 7 (TIA Portal)*:

1. Select the F-CPU you are using as the OPC UA server.
2. In the project tree, click "OPC UA communication > Server interfaces".
3. Double-click "Add new server interface".
4. To select the type of this server interface, click the "Companion specification" button.

   A general name for the new interface, e.g. "Server_Interface_1", is entered in the dialog.

5. Change the name of the new server interface to a descriptive name in your project.
   In the example the name "SafetyConsumerType" is used.

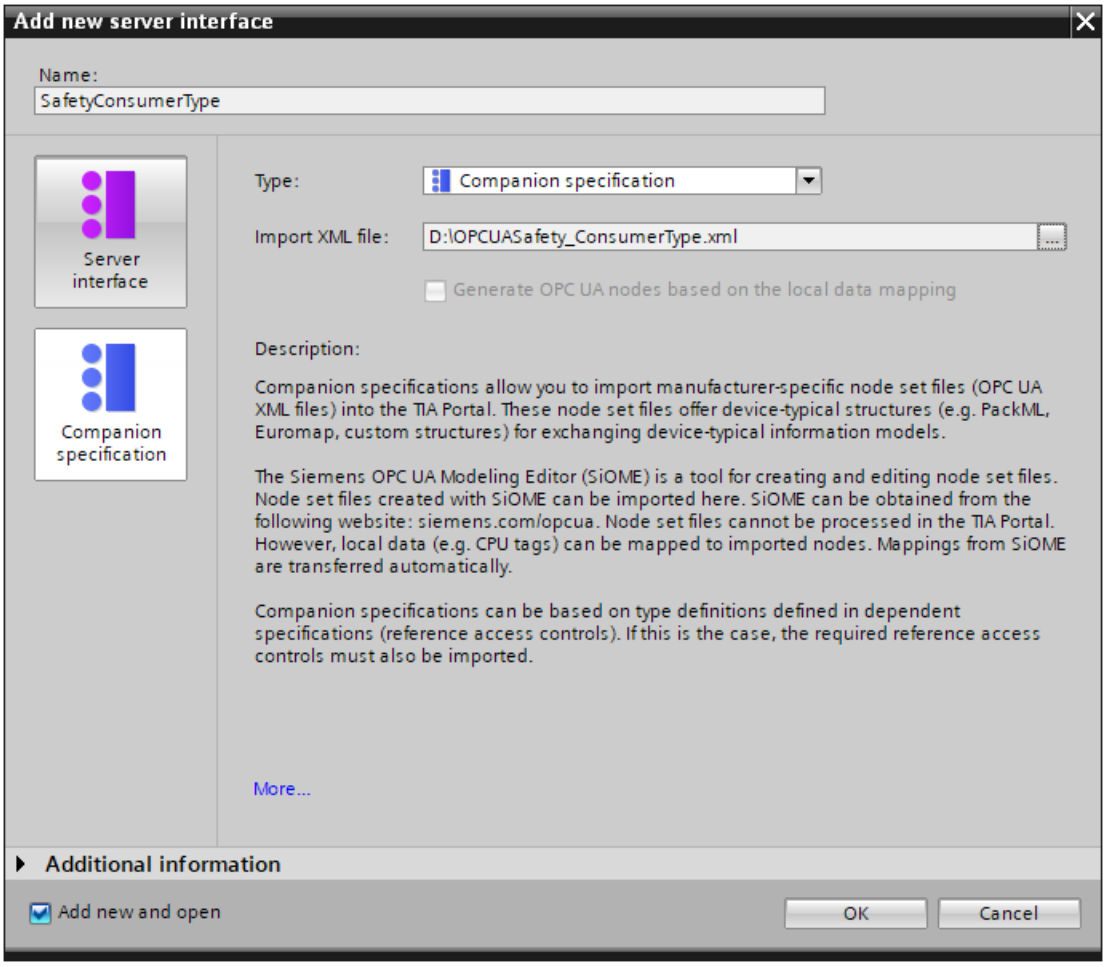

6. In the "Import XML file" field, select the OPC UA SafetyConsumerType XML file that was created and exported in SiOME (Page 348) and contains the description of the information model for your individual data structure.

7. Click the "OK" button.

   STEP 7 (TIA Portal) imports the information model described in the selected XML file.

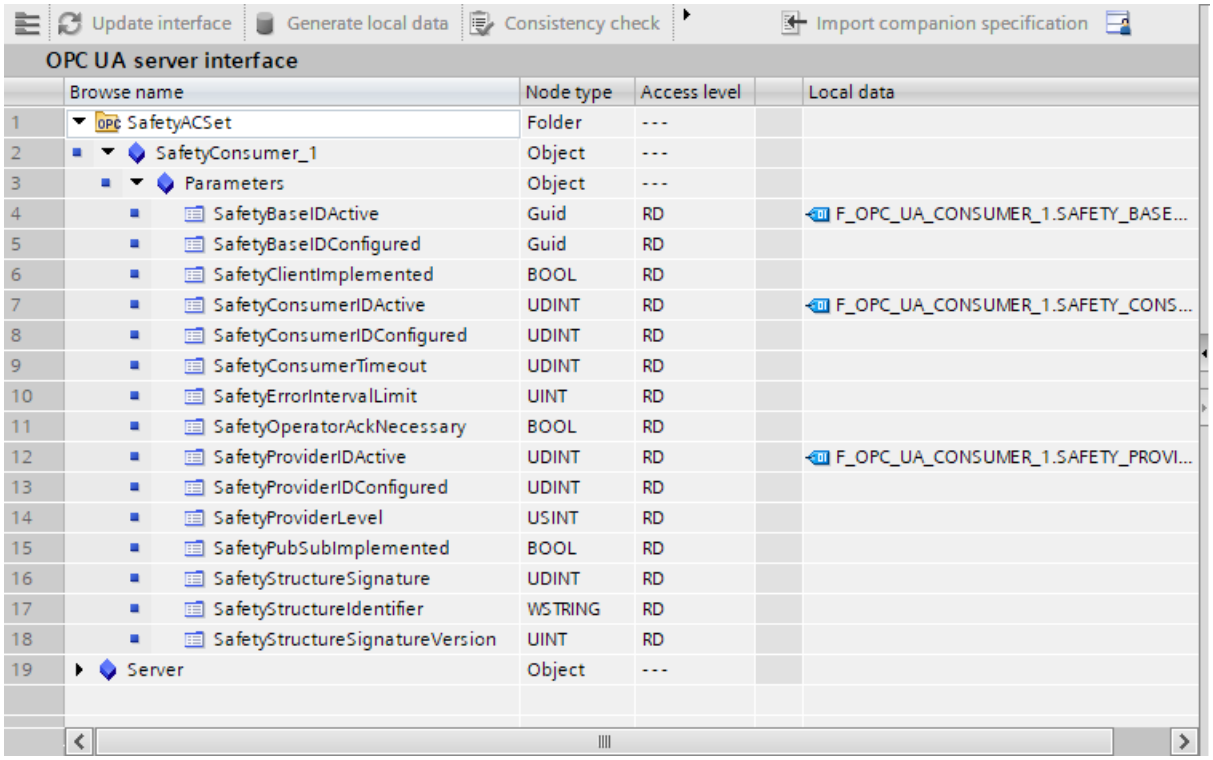

	Browse name	Node type	Access level	Local data
1	SafetyACSet	Folder	---	
2	SafetyConsumer_1	Object	---	
3	Parameters	Object	---	
4	SafetyBaseIDActive	Guid	RD	F_OPC_UA_CONSUMER_1.SAFETY_BASE...
5	SafetyBaseIDConfigured	Guid	RD	
6	SafetyClientImplemented	BOOL	RD	
7	SafetyConsumerIDActive	UDINT	RD	F_OPC_UA_CONSUMER_1.SAFETY_CONS...
8	SafetyConsumerIDConfigured	UDINT	RD	
9	SafetyConsumerTimeout	UDINT	RD	
10	SafetyErrorIntervalLimit	UINT	RD	
11	SafetyOperatorAckNecessary	BOOL	RD	
12	SafetyProviderIDActive	UDINT	RD	F_OPC_UA_CONSUMER_1.SAFETY_PROVI...
13	SafetyProviderIDConfigured	UDINT	RD	
14	SafetyProviderLevel	USINT	RD	
15	SafetyPubSubImplemented	BOOL	RD	
16	SafetyStructureSignature	UDINT	RD	
17	SafetyStructureIdentifier	WSTRING	RD	
18	SafetyStructureSignatureVersion	UINT	RD	
19	Server	Object	---	

NOTE

You performed the mapping of your local data previously when creating your OPC UA Safety XML file in SiOME. It is not necessary to create and map further local data with the "Generate local data" button.

With this OPC UA server interface, you can request information on the associated SafetyConsumer with any OPC UA clients (e.g. UaExpert).

9.6 Communication with Flexible F-Link (S7-1200, S7-1500)

9.6.1 Flexible F-Link

Introduction

The fail-safe CPU-CPU communication "Flexible F-Link" is available for S7-1200 and S7-1500 F-CPUs. This means fail-safe data can be easily exchanged as fail-safe arrays with standard communication mechanisms between F-CPUs.

Flexible F-Link offers a series of advantages for exchanging fail-safe data:

- Collection of fail-safe data to be transmitted in F-compliant PLC data types (UDTs)

  (Nested F-compliant PLC data types (UDT) are not supported.)
- Up to 1500 bytes of fail-safe data per UDT, including a maximum of 800 elements of data type BOOL.
- Easy parameter assignment and automatic generation of fail-safe communication DBs
- Transmission of fail-safe data with standard communication blocks also across network limits
- F-runtime group communication (Page 98) for F-CPUs 1200/1500
- System-integrated and globally sufficiently unique F-communication UUID
- Separate F-communication address signature for easy detection of changes to the F-communication UUID

Requirement

- S7-1500 F-CPUs as of firmware V2.0
- S7-1200 G1 F-CPUs as of firmware V4.2
- S7-1200 G2 F-CPUs as of firmware V1.0
- As of safety system version V2.2

Principles of communication via Flexible F-Link

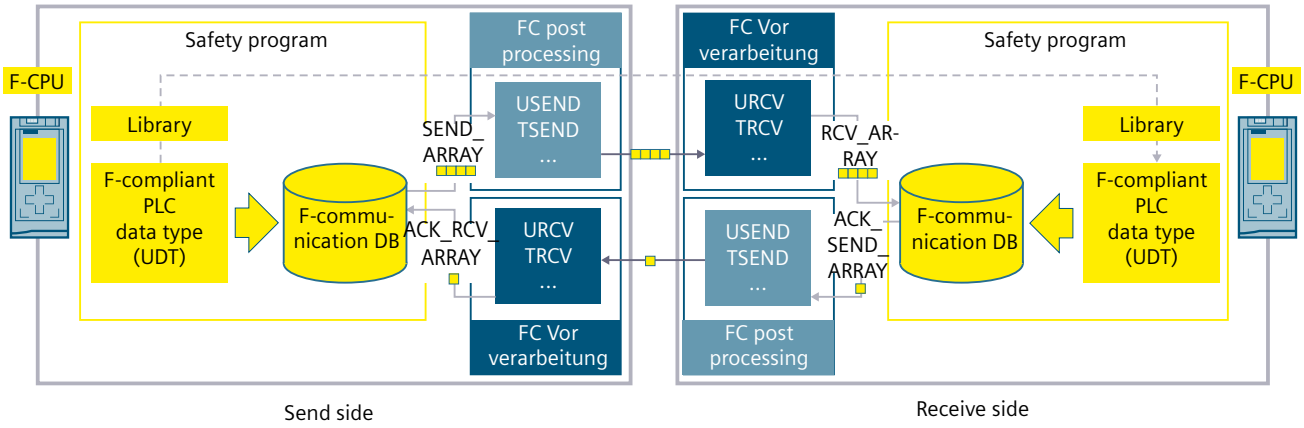

Proceed as follows on the **send side**:

1. Create an F-compliant PLC data type (UDT) for the data to be sent. The size is up to 1500 bytes, including a maximum of 800 elements of data type BOOL.
2. Create safety-related communication with the "Send" direction in the *Safety Administration Editor* (Page 98).

   A new F-communication DB (Page 358) is created for the safety-related communication under "Program blocks\System blocks\STEP 7 Safety\F-communication DBs".
3. Set the F-monitoring time (Page 649) for the safety-related communication.
4. In the Safety program, supply the tags for the send data (SEND_DATA) in the F-communication DB (Page 358) of the safety-related communication.
5. Create standard blocks in which the fail-safe arrays created automatically in the F-communication DB are sent with the send data and received with the acknowledgment data. For processing the process values in the correct chronological order, you can make use of the F-OB Pre-/post-processing (Page 88). When using the communication instructions, ensure that the fail-safe arrays are available consistently at the time of evaluation and that the F-monitoring time (Page 649) is observed. Observe the note below.

Proceed as follows on the **receive side**:

1. Create an F-compliant PLC data type (UDT) with the same structure as on the send side.

   To do so, copy the F-compliant PLC data type (UDT) from the send side or use the project library or global library.
2. Create safety-related communication with the "Receive" direction in the *Safety Administration Editor* (Page 98).

   A new F-communication DB is created for the safety-related communication under "Program blocks\System blocks\STEP 7 Safety\F-communication DBs".
3. Copy the F-communication UUID of the safety-related communication from the send side.
4. Set the same F-monitoring time as for the send side.
5. In the Safety program, evaluate the tags for the receive data (RCV_DATA) at the F-communication DB (Page 358).

6. Create standard blocks in which the fail-safe arrays automatically created in the F-communication DB are received with the receive data and sent with the acknowledgment data. For processing the process values in the correct chronological order, you can make use of the F-OB Pre-/post-processing (Page 98). When using the communication instructions, ensure that the fail-safe arrays are available consistently at the time of evaluation and that the F-monitoring time (Page 649) is observed. Observe the note below.

NOTE

When using non-deterministic communication protocols (e.g. TCP/IP), you must take into account the following:

- Increased communication load can fundamentally impair the availability of your application (runtime of the F-monitoring time of the F-communication connection). This holds true especially when OPC UA and Secure Open User Communication (OUC) are used in parallel.
- Communication buffer overflows can adversely affect the availability of your application and should be avoided.

  Refer to the following application example for more helpful information: "Configuring Flexible F-Link Communication (https://support.industry.siemens.com/cs/ww/en/view/109768964)".

NOTE

The compilation time increases with increasing data frame size. The compilation times can rise significantly when the maximum frame length of 1500 bytes is fully used.

NOTE

During simulation with *S7-PLCSIM*, the time monitoring that generates an error message after expiration when communication with real communication partners is interrupted (e.g. by setting a CPU to STOP) is not activated. This is why no error message is displayed in this case.

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

WARNING

If the SENDMODE tag in the F-communication DB (Page 358) is set to "1" for receiving during communication with Flexible F-Link, you can no longer assume that the data at the RCV_DATA tag is formed in a safety-related manner.

During this time, you must take organizational measures to ensure the safety of the system components that are affected by this data. Alternatively, you can also use safe substitute values in your Safety program with SENDMODE = 1 instead of the data in the RCV_DATA tag. *(S086)*

WARNING

When a new Flexible F-Link communication is created in the Safety Administration Editor, a unique F-communication UUID for the communication is provided by the system. When communication is copied in the Safety Administration Editor within the parameterization table or copied to another F-CPU, the F-communication UUIDs are not regenerated and therefore not unique anymore. If the copy is used to configure a new communication relationship, you yourself must ensure the uniqueness. To do this, select the relevant UUIDs and generate them again via the "Generate UUID" context menu. You must ensure the uniqueness in the safety summary during acceptance, at the latest. *(S087)*

WARNING

For each communication connection via Flexible F-Link, you must check that the offsets of the elements of the F-compliant PLC data type (UDT) used for the communication connection match on the transmit and receive sides when you accept the Safety program.

You can find the offsets in the respective safety summary. To do this identify the communication connection by means of the UUID. *(S088)*

See also

F-runtime group communication (S7-1200, S7-1500) (Page 149)

9.6.2 F-communication DB (S7-1200, S7-1500)

F-communication DB for sending

The following table shows you the interface of the F-communication DB for the communication connection with the direction "Send":

Section	Name	Data type	Initial value	Description
Input	SEND_DATA	F-compliant PLC data type (UDT)	As in the F-compliant PLC data type (UDT).	User data to be sent.
	ACK_RCV_ARRAY	Array[0..n] of Byte	Each element with 16#0	Array with the received raw data.

Section	Name	Data type	Initial value	Description
Output	ERROR	BOOL	False	Signals currently pending communication errors or communication errors not acknowledged yet at the receiver (not in the initial start). 1=Communication error
	ACTIVATE_FV	BOOL	True	Communication passivated, in the initial start (for example receiver not started), or HOST sends ACTIVATE_FV. DEVICE sends status bit: FV_ACTVATED, but no 0-values. 1=The communication uses fail-safe values
	DIAG	Byte	16#0	Error bits (Timeout or CRC error currently still pending, or communication after error not depassivated yet) Bit 3: Acknowledgement request active at the receiver Bit 4: Timeout detected Bit 6: CRC error detected
	SEND_ARRAY	Array[0..n] of Byte	Each element with 16#0	Array with the raw data to be sent.
	ACK_RCV_LENGTH	UInt	0	Length information to ACK_RCV_ARRAY in bytes
	SEND_LENGTH	UInt	0	Length information to SEND_ARRAY in bytes
InOut	—	—	—	—
Static	—	—	—	—

F-communication DB for receiving

The following table shows you the interface of the F-communication DB for the communication connection with the direction "Receive":

Section	Name	Data type	Initial value	Description
Input	PASS_ON	BOOL	False	This way you can passivate the output data (output of the passivation values) 1=Enable passivation
	ACK_REI	BOOL	False	Reintegration (in case of reintegration request) by means of positive edge 1=Acknowledgment for reintegration
	RCV_ARRAY	Array[0..n] of Byte	Each element with 16#0	Array with the received raw data
Output	RCV_DATA	F-compliant PLC data type (UDT)	As in the F-compliant PLC data type (UDT).	Output data (PASS_VALUES or data received).

Section	Name	Data type	Initial value	Description
Output	ERROR	BOOL	False	Signals currently pending communication errors or communication errors not acknowledged yet (not in the initial start). 1=Communication error
	PASS_OUT	BOOL	True	At PASS_OUT=1 the PASS_VALUES are output Could be: ERROR, PASS_ON, in the initial start (e.g. sender not started), or ACK_REQ is pending (error not acknowledged)
	ACK_REQ	BOOL	False	Reintegration requirement (communication stable again after error, substitute values are still output) 1=Acknowledgment request for reintegration
	SENDMODE	BOOL	False	1=The Safety program on the sender side is in disabled Safety mode or is running on an S7-PLCSIM.
	DIAG	Byte	16#0	Error bits (Timeout or CRC error) Bit 0: Timeout detected by the sender Bit 1: Communication error currently pending in the sender Bit 2: CRC error detected by the sender Bit 4: Timeout detected by the receiver Bit 6: CRC error detected by the receiver
	ACK_SEND_ARRAY	Array[0..n] of Byte	Each element with 16#0	Array with the raw data to be sent.
	RCV_LENGTH	UInt	0	Length information of RCV_ARRAY in bytes
	ACK_SEND_LENGTH	UInt	0	Length information of ACK_SEND_ARRAY in bytes
InOut	—	—	—	—
Static	PASS_VALUES	F-compliant PLC data type (UDT)	Same as the F-compliant PLC data type (UDT) or in the I/O DB	Passivation or substitute values

Compiling and commissioning a safety program 10

10.1 Compiling the safety program

To get a consistent Safety program, follow these steps:

1. Select the "Program blocks" folder or the Safety Unit folder or a higher level.
2. Start the compile.

   To do this, proceed essentially in the same way as when compiling a standard user program. You can start at various points to accomplish this in *STEP 7*. The basics for compiling user programs can be found in the *Help on STEP 7*.

NOTE

Please note that following a safety-related change to the hardware configuration that not only this, but also the Safety program has to be recompiled and downloaded. This also applies for changes to the F-I/O which are not used in the Safety program.

NOTE

The following applies for S7-300/400 F-CPUs:

If you want to compile a know-how-protected F-block after a change, you must remove the know-how protection for this F-block before compiling.

Reporting compiling errors

You can recognize whether or not the compilation was successful based on the message in the inspector window under "Info > Compile", error messages and warnings are output.

For information on the procedure you must follow to eliminate compiling errors, see "Eliminating compiling errors" in the *Help on STEP 7*.

10.2 Safety program work memory requirements (S7-300, S7-400)

Estimation

You can estimate the work memory requirement for the safety program as follows:

Work memory required for the safety program

32 KB for F-system blocks

+ 4.4 KB for safety-related communication between F-runtime groups
+ 4.5 x work memory requirement for all F-FB/F-FCs/main safety blocks

+ 4.5 x work memory requirement of all utilized instructions, which are shown in the "Instructions" task card with the block icon.
(except SENDDP, RCVDP, SENDS7, and RCVS7)
+ Work memory requirement of the utilized SENDDP and RCVDP instructions (4.3 KB each)
+ Work memory requirement of the utilized SENDS7 and RCVS7 instructions (8.5 KB each)

Work memory required for data

5 x work memory requirement for all F-DBs (including F-communication DB, but excluding DB for F-runtime group communication) and I-DBs for main safety block/F-FB

+ 24 x work memory requirement for all DBs for F-runtime group communication
+ 2.3 x work memory requirement for all I-DBs of instructions (except SENDDP, RCVDP, SENDS7 and RCVS7)
+ Work memory requirement of all I-DBs of instructions SENDDP (0.2 KB), RCVDP(0.3 KB), SENDS7 (0.6 KB), and RCVS7 (1.0 KB)
+ 0.7 KB per F-FC
+ 0.7 KB per F-I/O (for F-I/O DBs, etc.)
+ 4.5 KB

Block size of automatically generated F-blocks

Do not utilize the entire maximum size of an F-block, because the automatically generated F-blocks are larger and as a result, the maximum possible size may be exceeded in the F-CPU. If the block size is exceeded, this triggers a corresponding error message with information on which F-blocks are too large. These must be divided up, if necessary.

10.3 Downloading project data

Introduction

Once you have successfully compiled your safety program, you can download it together with the standard application program to the F-CPU.

(S7-1500) If the safety program is in a Safety Unit, you can load the Safety Unit independently into the F-CPU.

To download a safety program, you follow essentially the same approach as for downloading a standard user program, via different starting points in *STEP 7*.

- In the "Load preview" dialog, enter data (e.g. password for the F-CPU) and set the requirements for downloading (e.g. that the F-CPU is switched to STOP mode before downloading).
- The "Load results" dialog shows the results after loading.

We will show you the options for downloading the safety program later. For basic information on downloading, refer to the *Help on STEP 7*.

Rules for downloading the project data into an F-CPU

WARNING

(S7-300, S7-400) If **several F-CPUs** can be reached via a network (such as Industrial Ethernet) by **the same programming device or PC**, you must take the following additional measures to ensure that the safety-related project data is downloaded to the correct F-CPU:

Use passwords specific to each F-CPU, such as a uniform password for the F-CPUs with attached Ethernet address for each.

Note the following:

- A point-to-point connection must be used to activate the access protection of an F-CPU when the hardware configuration is loaded for the first time (similar to assigning an MPI address to an F-CPU for the first time).
- Before downloading the safety-related project data to an F-CPU, existing access permission for any other F-CPU must first be cancelled.
- The last download of the safety-related project data prior to switching to productive operation must be made with enabled access protection. *(S021)*

WARNING

(S7-1200, S7-1500) If **several F-CPUs** can be reached via a network (such as Industrial Ethernet) by the **same PG/PC**, you must take the following additional measures to ensure that the safety-related project data is downloaded to the correct F-CPU or that safety mode is deactivated in the correct F-CPU:

- Enter the serial number of the specific F-CPU in the *Safety Administration Editor*.

Depending on the respective CPU type (see documentation of the CPU), you have several possibilities for determining the serial number of an F-CPU:

- Print of the serial number on the housing of the F-CPU.
- Scanning of the ID link on the F-CPU.
- Display of the F-CPU
- Web server*
- Industrial Edge application user interface under /SIMATIC_MC/system/serialno* and via the UI or API of the Industrial Edge application
- TIA Portal (I&M data)*

Note the following when downloading:

- If the "Load preview" window does not contain a warning, the connection to the correct F-CPU has been established. You can confirm the download of the safety-related project data without an additional check.
- If a serial number has not yet been entered in the *Safety Administration Editor* or if the connected F-CPU has a different serial number, check the proposed serial number of the F-CPU in the "Load preview" window or "Disable safety mode" window. If you determine an error, cancel the download or the disabling of safety mode. Otherwise, you can confirm the procedure.
- When the serial number is confirmed (online), it is always applied in the *Safety Administration Editor* and any existing entry is overwritten.

  (S099)

* To make use of these possibilities, you must ensure a connection to the expected F-CPU. You achieve this through:

- A point-to-point connection to the respective F-CPU
- Verification of the flashing of the F-CPU after selecting the "Flash LED" check box in the online and diagnostics view of the F-CPU.
- Unplugging the network cable to the respective F-CPU
- For an S7-1500 F Virtual Controller, a unique connection can be achieved by a targeted switch to STOP of the Industrial Edge application.

NOTE

You can perform the downloading of a consistent safety program only in STOP mode.

NOTE

If *STEP 7 Safety* detects an inconsistent safety program during startup of the F-CPU, the F-CPU startup is prevented, provided the F-CPU supports this detection. (see product information for the respective S7-300/400 F-CPU. This is always supported with S7-1200/1500 F-CPUs.) A corresponding diagnostics event is entered in the diagnostics buffer of the F-CPU.

If the F-CPU does not support this detection function, the F-CPU can go to STOP mode if an inconsistent safety program is executed in activated safety mode.

The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

When downloading the safety program, ensure that the "Consistent download" action is set for the "Safety program" selection in the "Load preview" dialog.

Inconsistent downloading is only possible in disabled safety mode.

Password prompt before downloading to an F-CPU

Before the download or, at the latest, during the download (in the "Load preview" dialog), you must gain access permission (Page 104) through legitimation with a user with F-right.

Check of serial number before the download to an S7-1200/1500 F-CPU

Before loading, the serial number of the F-CPU to be loaded is compared with the serial number entered in the *Safety Administration Editor*. If the serial numbers match, you can continue loading. If the serial numbers do not match or no serial number was entered in the *Safety Administration Editor*, you must check whether the serial number of the expected F-CPU is shown. If this is the case, confirm this with a check box in the "Load preview" dialog. The serial number is entered in the *Safety Administration Editor* for subsequent load processes.

"Load preview" dialog

For an F-CPU, the "Load preview" dialog also contains the section "Safety program".

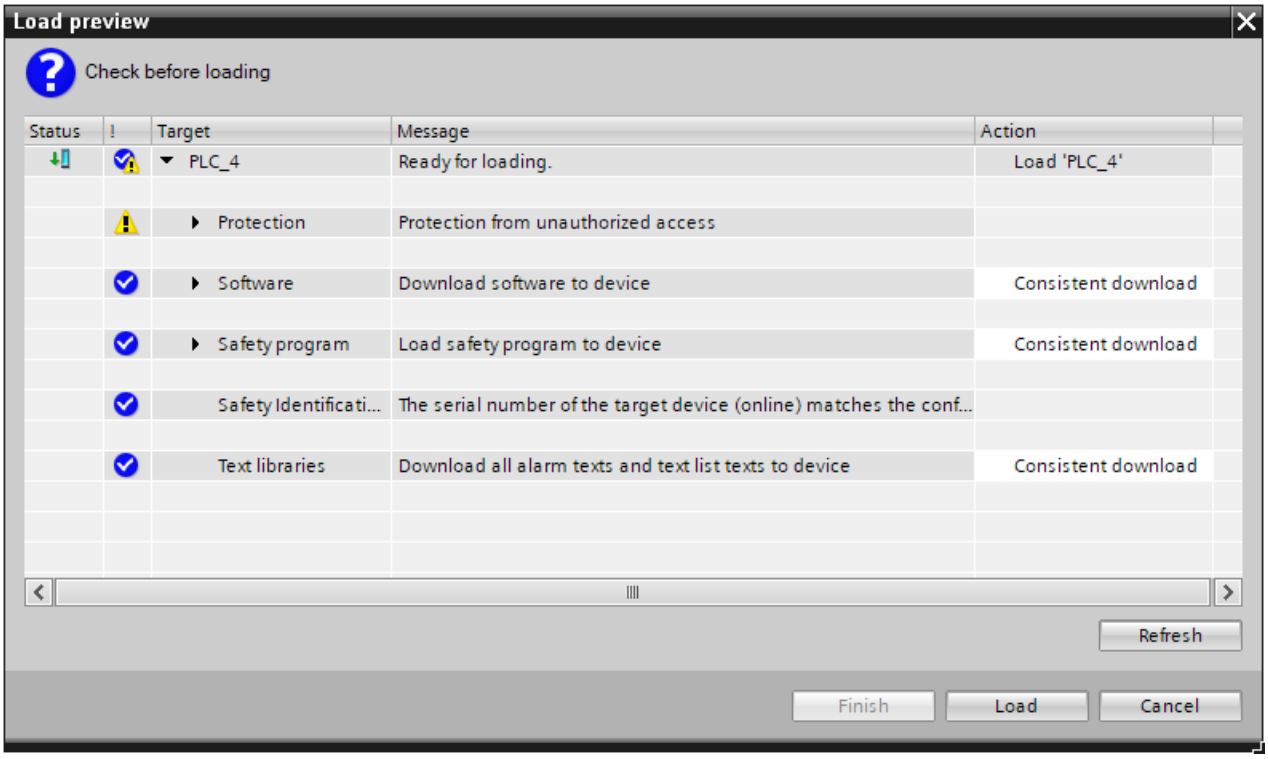

Make the following selection:

- In order to download a consistent safety program, select the "Consistent download" action under target "Safety program".
- (S7-300, S7-400) To download individual F-blocks selectively (Page 369), select the "Download selection" action under the target "Safety program", and then select the required F-blocks. If necessary, you will be prompted to disable safety mode under "Disable safety mode". This setting is only suitable for the online test of individual F-blocks.
- (S7-300, S7-400) In order to download the safety program only, select the "Consistent download" action under target "Safety program" and the "Download selection" action under target" Standard software", and then select only the standard blocks that call the main safety block.
- (S7-300, S7-400) To download no safety program, for example, because you do not know the password of the F-CPU, select the "No action" action under target "Safety program".

For S7-1200/1500 F-CPUs, only the "Consistent download" value is possible as an action in the "Load preview" dialog. You cannot change the selection of program parts to be loaded in this dialog. The selection is made automatically based on the selection in the project tree when starting the loading process.

NOTE

If the function "Security Logging" is activated, the event "Download fail-safe program to a CPU" is entered as a log entry during the download.

For more information on the "Security Logging" function and its activation, refer to the help on STEP 7 under "Using Security Logging".

Dialog "Load results"

After downloading into the F-CPU, the dialog "Load results" is opened. This dialog shows you the status and the necessary actions after downloading.

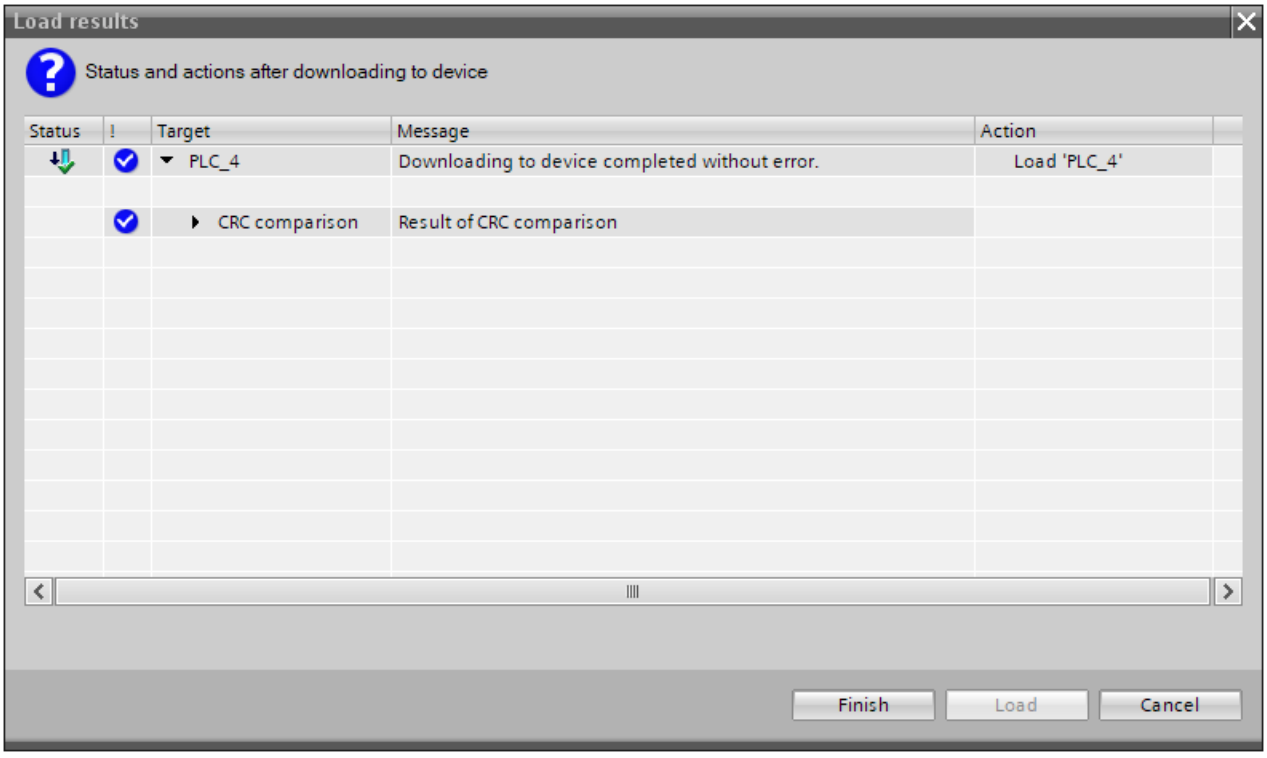

Verify that the "Downloading to device completed without error" message appears in the "Load results" dialog. If not, repeat the download operation.

10.3.1 Downloading project data to an S7-300/400 F-CPU

10.3.1.1 Downloading project data to an S7-300/400 F-CPU with memory card inserted (SIMATIC Micro memory card or flash card)

When you download project data to an S7-300/400 F-CPU with memory card inserted (SIMATIC Micro Memory Card for S7-300 or flash card for S7-400), you must observe the following warning:

WARNING

If the function test of the safety program is not performed in the destination F-CPU, you must adhere to the following procedure when downloading the safety-related project data to the F-CPU with a **PG/PC** to ensure that no "old" safety-related project data is stored in the F-CPUs:

- Download the safety-related project data to the F-CPU.
- Perform a program identification (i.e. check whether the collective F-signatures match online and offline).
- Perform a memory reset of the F-CPU using the mode switch or via the PG/PC. During the reset, after the work memory has been deleted, the project data is again transferred from the load memory (memory card, SIMATIC Micro Memory Card for S7-300 F-CPUs, flash card for S7-400 F-CPUs) to the work memory. *(S022)*

10.3.1.2 Downloading project data to an S7-400 F-CPU without flash card inserted

When you download project data to an S7-400 F-CPU without flash card inserted, you must observe the following warning:

WARNING

If the function test of the safety program is not performed in the destination F-CPU, you must adhere to the following procedure when downloading the safety-related project data to the F-CPU with a **PG/PC** to ensure that the F-CPU does not contain any "old" safety-related project data:

- Perform a memory reset of the F-CPU using the **mode switch** or via the **PG/PC**.
- Download the safety-related project data to the F-CPU.
- Perform a program identification (i.e. check whether the collective F-signatures match online and offline). *(S023)*

10.3.1.3 Downloading individual F-blocks to an S7-300/400 F-CPU

Download F-blocks in disabled safety mode.

You can download F-blocks and standard blocks simultaneously to the F-CPU via the project tree. However, as soon as F-blocks are to be downloaded, a check is carried out to determine whether or not the F-CPU is in STOP mode or disabled safety mode. If not, you have the option of switching to disabled safety mode or placing the F-CPU in STOP mode.

If you want to load individual F-blocks into the F-CPU, e.g. to test changes, make sure that you have not selected the "Program blocks" folder or the F-CPU in the project navigation, but only the blocks to be loaded.

Only then will you be prompted in the "Load preview" dialog to disable Safety mode once you have changed the option from "Consistent download" to "Download selection" and have changed the option "Stop modules" to "No action".

If you fail to observe this prompt, the blocks will be downloaded without disabling safety mode, which can lead to STOP of the F-CPU.

You can also deactivate the safety mode explicitly in the *Safety Administration Editor* before you start the download.

Be aware that the consistency of the safety program in the F-CPU cannot be guaranteed when individual F-blocks are downloaded. For a consistent safety program, always download the entire safety program to the F-CPU.

Rules for downloading individual F-blocks

The following rules apply to downloading of individual F-blocks:

- Downloading is only possible in disabled safety mode or when the F-CPU is in STOP mode.
- F-blocks can only be downloaded to an F-CPU to which a safety program has already been downloaded.

Consequently, you have to download the entire safety program when initially downloading the safety program and after changing the password for the safety program.

NOTE

If you are downloading F-blocks only, the blocks in which the main safety blocks are called (e.g., cyclic interrupt OB 35) are not downloaded. To do so, select the "Selection" option under "Standard software" in the preview dialog, and select the necessary blocks.

NOTE

Downloading of individual F-blocks is only suitable for testing F-blocks. Prior to the transition to productive mode, you must download the safety program consistently to the F-CPU.

10.3.1.4 Downloading project data to a memory card and inserting at an F-CPU S7-300/400

Follow the same procedure as for a standard CPU to load project data of an F-CPU to a memory card (flash card for S7-400, SIMATIC Micro Memory Card for S7-300) or save it to a file folder. You must also observe the following warning:

WARNING

If the function test of the safety program is not performed in the destination CPU, you must ensure that the correct safety-related project data is on the memory card or in the file folder after loading or saving.

Follow these steps:

1. Always load or save the project data to an empty memory card or file folder. Existing project data must not be overwritten.
2. Label the memory card or file folder uniquely (e.g. with the Collective F-Signature).

You must limit access to the loaded or saved safety-related project data to authorized persons through organizational measures. *(S043)*

When inserting a memory card (flash card for S7-400 or SIMATIC Micro Memory Card for S7-300) with project data of an F-CPU, you must observe the following warning:

WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must ensure through program identification (Page 396) or other suitable measures (for example, by checking the label of the memory card or removable data storage medium) that the inserted memory card or removable data storage medium contains the correct safety-related project data. *(S025)*

When you insert a memory card (flash card for S7-400 or SIMATIC Micro Memory Card for S7-300) into S7-300/400 F-CPUs, you must observe the following warning:

WARNING

If the function test of the safety program is not performed in the destination F-CPU, you must adhere to the following procedure when inserting the memory card to ensure that no "old" safety-related project data is stored in the F-CPUs:

- Switch off the power to the F-CPU. For F-CPUs with battery backup (e.g. CPU 416F-2), remove any battery. (To ensure that the F-CPU is de-energized, wait for the buffer time of the power supply you are using or, if this is not known, remove the F-CPU.)
- Remove the memory card with the old safety-related project data from the F-CPU.
- Insert the memory card with the new safety-related project data into the F-CPU.
- Switch on the F-CPU again and reinsert the battery, if it was removed.

(S026)

10.3.2 Downloading project data into an F-CPU S7-1200

10.3.2.1 Downloading project data to an S7-1200 F-CPU without program card inserted

When you download project data to an S7-1200 F-CPU without program card inserted, you must observe the following warning:

WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety-related project data to the F-CPU with a **PG/PC** to ensure that the F-CPU does not contain any "old" safety-related project data:

- Download the safety-related project data to the F-CPU.
- Perform a program identification (Page 396). *(S042)*

10.3.2.2 Downloading project data to an S7-1200 F-CPU with program card inserted

When you download project data to an S7-1200 F-CPU G2 with program card inserted, you must observe the following warning:

WARNING

You must observe the following procedure to ensure that there is no "old" safety-related project data in the internal load memory of the F-CPU when you insert a program card into an S7-1200 F-CPU G2:

1. Check whether the STOP/RUN LED (yellow) and the maintenance LED flash for 3 seconds during startup **when the card slot is empty.** If this is the case, the internal load memory of the F-CPU has already been deleted (for example, when the F-CPU has already been operated with a program card as external load memory), step 3 is skipped and you can skip step 5.
2. Insert the program card into the F-CPU.

   The F-CPU then performs an automatic restart, regardless of whether it is in RUN or STOP.
3. If the internal load memory contains project data, **the STOP/RUN LED (yellow) and the maintenance LED must flash after the restart**. In this case, the internal load memory of the F-CPU is deleted (therefore no longer contains any "old" safety-related project data) and step 5 can be skipped.

   Use one of the following variants to evaluate the program card:
   - Turn the F-CPU off and back on.
   - Remove and insert the program card.
   - Execute the "Memory reset" (MRES) function.

   The F-CPU then performs a restart.
4. After the restart, the program card is evaluated. The F-CPU then enters the startup mode (RUN or STOP) that was set up for the F-CPU (variant 1 of step 3) or remains in STOP (variant 2 or 3 of step 3 or if step 3 is skipped because the internal load memory was empty).
5. Perform a program identification. *(S106)*

When you download project data to an S7-1200 F-CPU G1 with program card inserted, you must observe the following warning:

WARNING

You must observe the following procedure to ensure that there is no "old" safety-related project data in the internal load memory of the F-CPU when you insert a program card into an S7-1200 G1 F-CPU:

1. Check to see whether **the STOP/RUN LED (yellow) and the maintenance LED flash during startup for 3 seconds on an F-CPU without memory card**.
   If this is the case, the internal load memory of the F-CPU has already been deleted (for example, when the F-CPU has already been operated with a program card as external load memory) and you can skip steps 3 and 5.
2. Insert the program card into the F-CPU.
   If the F-CPU is in RUN, it will change to STOP. The maintenance LED on the F-CPU is flashing to indicate that the program card has to be evaluated or that the internal load memory has to be deleted.
3. Use one of the following methods to delete the internal load memory:
   – Turn the F-CPU off and back on.
   – Switch the F-CPU from STOP to RUN.
   – Execute the "Memory reset" (MRES) function.

   After restart of the F-CPU and deletion of the internal load memory, **the STOP/RUN LED (yellow) and the maintenance LED must be flashing**. In this case, the internal load memory of the F-CPU is deleted (no longer contains any "old" safety-related project data) and step 5 can be skipped.
4. Use one of the following methods to trigger evaluation of the program card on the F-CPU:
   – Turn the F-CPU off and back on.
   – Switch the F-CPU from STOP to RUN.
   – Execute the "Memory reset" (MRES) function.

   The F-CPU restarts and evaluates the program card.

   The F-CPU then enters the startup mode (RUN or STOP) that has been set up for the F-CPU. *(S061)*
5. Perform a program identification.

For an S7-1200 F-CPU without inserted SIMATIC Memory Card and deleted internal load memory, the status LEDs have the status described in the table below.

Description	STOP/RUN Yellow/Green	ERROR Red	MAINT Yellow
Internal load memory deleted and SIMATIC Memory Card **not** inserted.	Flashing (yellow) (for 3 seconds during startup)	Off	Flashing (for 3 seconds during startup)

When you download project data to an S7-1200 F-CPU with program card inserted, you must observe the following warning:

WARNING

If you use a programming device/PC to download F-blocks to an S7-1200 F-CPU with inserted program card (external load memory), you must ensure that the transfer takes place to the external load memory. This can be accomplished by the following measure:

- Insert a program card whose memory size is different from the size of the internal load memory. Check in the project tree under "Online & Diagnostics > Diagnostics > Memory" if the memory size displayed for the load memory matches the memory size of the program card. *(S058)*

WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety-related project data to the F-CPU with a **PG/PC** to ensure that the F-CPU does not contain any "old" safety-related project data:

- Download the safety-related project data to the F-CPU.
- Perform a program identification (Page 396). *(S042)*

10.3.2.3 Loading project data of an F-CPU S7-1200 with a transfer card into the internal load memory

When you insert a transfer card into an S7-1200 F-CPU G2, you must observe the following warning:

WARNING

You must observe the following procedure to ensure that there is no "old" safety-related project data in the internal load memory when you copy the safety-related project data to an S7-1200 F-CPU G2 using a transfer card:

1. Check whether the STOP/RUN LED (yellow) and the maintenance LED flash for 3 seconds during startup **when the card slot is empty.** If this is the case, the internal load memory of the F-CPU has already been deleted, step 3 is skipped and you can skip step 7.
2. Insert the transfer card into the F-CPU.

   The F-CPU then performs an automatic restart, regardless of whether it is in RUN or STOP.
3. If the internal load memory contains project data, **the STOP/RUN LED (yellow) and the maintenance LED must flash after the restart**. In this case, the internal load memory of the F-CPU is deleted (therefore no longer contains any "old" safety-related project data) and step 7 can be skipped.

   Use one of the following variants to evaluate the transfer card (transfer from the transfer card to the internal load memory):
   - Turn the F-CPU off and back on.
   - Remove and insert the transfer card.
   - Execute the "Memory reset" (MRES) function.

   The F-CPU then performs a restart.
4. After restart of the F-CPU and evaluation of the SIMATIC Memory Card, the F-CPU copies the project data to the internal load memory of the F-CPU. Once the copy process is complete, the maintenance LED on the F-CPU is flashing to indicate that you can remove the transfer card.
5. Remove the transfer card from the F-CPU. The F-CPU then performs an automatic restart.
6. The F-CPU remains in STOP after the restart.
7. Perform a program identification. *(S105)*

When you insert a transfer card into an S7-1200 F-CPU G1, you must observe the following warning:

WARNING

You must observe the following procedure to ensure that there is no "old" safety-related project data in the internal load memory when you copy the safety-related project data to an S7-1200 F-CPU G1 using a transfer card:

1. Check whether **the STOP/RUN LED (yellow) and the maintenance LED flash during startup for 3 seconds on an F-CPU without memory card**.
   If this is the case, the internal load memory of the F-CPU has already been deleted and you can skip steps 3 and 6.
2. Insert the transfer card into the F-CPU.
   If the F-CPU is in RUN, it will change to STOP. The maintenance LED on the F-CPU is flashing to indicate that the transfer card has to be evaluated or that the internal load memory has to be deleted.
3. Use one of the following methods to delete the internal load memory:
   - Turn the F-CPU off and back on.
   - Switch the F-CPU from STOP to RUN.
   - Execute the "Memory reset" (MRES) function.

   After restart of the F-CPU and deletion of the internal load memory, **the STOP/RUN LED (yellow) and the maintenance LED must be flashing**. In this case, the internal load memory of the F-CPU is deleted (no longer contains any "old" safety-related project data) and step 6 can be skipped.
4. Use one of the following methods to evaluate the transfer card (transfer from the transfer card to the internal load memory):
   - Turn the F-CPU off and back on.
   - Switch the F-CPU from STOP to RUN.
   - Execute the "Memory reset" (MRES) function.

   After restart of the F-CPU and evaluation of the SIMATIC Memory Card, the F-CPU copies the project data to the internal load memory of the F-CPU. Once the copy process is complete, the maintenance LED on the F-CPU is flashing to indicate that you can remove the transfer card.
5. Remove the transfer card from the F-CPU.
6. Perform a program identification.
7. Use one of the following methods to initiate evaluation of the internal load memory:
   - Turn the F-CPU off and back on.
   - Switch the F-CPU from STOP to RUN.
   - Execute the "Memory reset" (MRES) function.

   The F-CPU then enters the startup mode (RUN or STOP) that has been set up for the F-CPU. *(S059)*

For an S7-1200 F-CPU without inserted SIMATIC Memory Card and deleted internal load memory, the status LEDs have the status described in the table below.

Description	STOP/RUN Yellow/Green	ERROR Red	MAINT Yellow
Internal load memory deleted and SIMATIC Memory Card **not** inserted.	Flashing (yellow) (for 3 seconds during startup)	Off	Flashing (for 3 seconds during startup)

When you want to update the project data on an S7-1200 F-CPU using a transfer card, you must observe the following warning:

WARNING

If you run an update of the safety-related project data on an S7-1200 F-CPU using a transfer card, you must ensure that the transfer to the internal load memory took place correctly by means of a subsequent program identification (Page 396). *(S060)*

10.3.2.4 Downloading project data of an S7-1200 F-CPU from the internal load memory to an empty SIMATIC Memory Card

When you download project data from the internal load memory of an S7-1200 F-CPU G2 to an empty SIMATIC Memory Card, you must observe the following warning:

WARNING

To ensure that the safety program is downloaded from the internal load memory of the F-CPU to the SIMATIC Memory Card when plugging an empty SIMATIC Memory Card into an S7-1200 F-CPU G2 and that the internal load memory of the F-CPU is deleted afterward, you must observe the following procedure:

1. Make sure that you are using an empty SIMATIC Memory Card, for example, by checking in the Windows Explorer that the "SIMATIC.S7S" folder and the "S7_JOB.S7S" file are deleted.
2. Insert the empty SIMATIC Memory Card into the F-CPU.

   The F-CPU then performs an automatic restart, regardless of whether it is in RUN or STOP.
3. If copying the project data from the internal to the external load memory is permitted, this will be performed automatically after the restart. The internal load memory is then deleted (therefore no longer contains any "old" safety-related project data) and **the STOP/RUN LED (yellow) and the maintenance LED must flash**. The SIMATIC Memory Card is now a program card. If copying the project data is not permitted, the error LED flashes and the project data remains in the internal load memory.
4. Use one of the following variants to evaluate the program card:
   - Turn the F-CPU off and back on.
   - Remove and insert the program card.
   - Execute the "Memory reset" (MRES) function.

   The F-CPU restarts and evaluates the program card.

   The F-CPU then enters the startup mode (RUN or STOP) that has been set up for the F-CPU (variant 1) or remains in STOP (variant 2 or 3). *(S107)*

When you download project data from the internal load memory of an S7-1200 F-CPU G1 to an empty SIMATIC Memory Card, you must observe the following warning:

WARNING

To ensure that the safety-related project data is transferred from the internal load memory of the F-CPU to the SIMATIC Memory Card when plugging an empty SIMATIC Memory Card into an S7-1200 F-CPU G1 and that the internal load memory of the F-CPU is deleted afterward, you must observe the following procedure:

1. Make sure that you are using an empty SIMATIC Memory Card, for example, by checking in the Windows Explorer that the "SIMATIC.S7S" folder and the "S7_JOB.S7S" file are deleted.
2. Insert the empty SIMATIC Memory Card into the F-CPU.

   If the F-CPU is in RUN, it will change to STOP. The maintenance LED on the F-CPU is flashing to indicate that the program can be copied from the internal load memory to the SIMATIC Memory Card and that the internal load memory is deleted afterward.
3. Use one of these methods to trigger copying from the internal load memory to the SIMATIC Memory Card and subsequent deletion of the internal load memory:
   - Turn the F-CPU off and back on.
   - Switch the F-CPU from STOP to RUN.
   - Execute the "Memory reset" (MRES) function.

   After restart of the F-CPU and copying of the project data from the internal load memory to the SIMATIC Memory Card and subsequent deletion of the internal load memory, **the STOP/RUN LED (yellow) and the maintenance LED must flash**. In this case, the internal load memory of the F-CPU is deleted and no longer contains any safety-related project data. The SIMATIC Memory Card is now a program card.
4. Use one of the following methods to trigger evaluation of the program card on the F-CPU:
   - Turn the F-CPU off and back on.
   - Switch the F-CPU from STOP to RUN.
   - Execute the "Memory reset" (MRES) function.

   The F-CPU restarts and evaluates the program card.

   The F-CPU then enters the startup mode (RUN or STOP) that has been set up for the F-CPU. *(S057)*

NOTE

Also observe the setting "Disable copying from internal load memory to external load memory" in the hardware configuration of your F-CPU.

10.3.2.5 Downloading project data to a SIMATIC Memory Card and inserting it at an F-CPU S7-1200

When loading project data of an F-CPU to a SIMATIC Memory Card or saving it to a file folder, follow the same procedure as for a standard CPU. You must also observe the following warning:

WARNING

If the function test of the safety program is not performed in the destination CPU, you must ensure that the correct safety-related project data is on the memory card or in the file folder after loading or saving.

Follow these steps:

1. Always load or save the project data to an empty memory card or file folder. Existing project data must not be overwritten.
2. Label the memory card or file folder uniquely (e.g. with the Collective F-Signature).

You must limit access to the loaded or saved safety-related project data to authorized persons through organizational measures. *(S043)*

When inserting a SIMATIC Memory Card with project data from an F-CPU, you must observe the following warning:

WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must ensure through program identification (Page 396) or other suitable measures (for example, by checking the label of the memory card or removable data storage medium) that the inserted memory card or removable data storage medium contains the correct safety-related project data. *(S025)*

10.3.3 Downloading project data to an S7-1500 F-CPU

10.3.3.1 Downloading project data to an S7-1500 F-CPU

When you download project data to an S7-1500 F-CPU, you must observe the following warning:

WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety-related project data to the F-CPU with a **PG/PC** to ensure that the F-CPU does not contain any "old" safety-related project data:

- Download the safety-related project data to the F-CPU.
- Perform a program identification (Page 396). *(S042)*

10.3.3.2 Downloading project data into a redundant S7-1500HF system

With a redundant S7-1500HF system, a consistent safety program can only be downloaded in STOP mode of the redundant S7-1500HF system.

To do this, you must heed one of the following warnings:

- Loading the redundant S7-1500HF system in STOP.

WARNING

If the function test of the safety program is not performed in the redundant destination system S7-1500HF, you must adhere to the following procedure when downloading the safety-related project data to the HF-CPUs with a PG/PC. This way you ensure that no "old" safety-related project data is stored in the HF-CPUs:

1. Switch the two HF-CPUs to STOP.
2. If you did not program restart/startup protection in your previous safety program (Programming startup protection (Page 159)), you must format the SIMATIC Memory Card or delete the program, for example, via the display for both HF-CPUs.
3. Download the safety-related project data to one of the two HF-CPUs.
4. Switch the HF-CPU, to which you have downloaded the new safety-related project data, to RUN mode.
5. Switch the second HF-CPU to RUN mode.
6. As soon as the RUN-Redundant mode is reached, perform a program identification on one of the two HF-CPUs (i.e. check whether the Collective F-Signatures match online and offline).

   If you have programmed restart/startup protection in your new safety program, you may only acknowledge this after successful program identification.*(S090)*

- Loading the redundant S7-1500HF system with reduced STOP time.

WARNING

If the function test of the safety program is not performed in the redundant destination system S7-1500HF, you must adhere to the following procedure when downloading the safety-related project data to the HF-CPUs with a PG/PC. This way you ensure that no "old" safety-related project data is stored in the HF-CPUs:

1. Switch one of the two HF-CPUs to STOP.
2. If you did not program restart/startup protection in your previous safety program (Programming startup protection (Page 159)), you must format the SIMATIC Memory Card or delete the program, for example, via the display for the HF-CPU in STOP mode.
3. Download the safety-related project data to the HF-CPU, which is in STOP mode (to the backup CPU with the context menu command "Load into backup CPU").
4. Switch the HF-CPU that is still in RUN mode to STOP mode.
5. If you did not program restart/startup protection in your previous safety program, you must format the SIMATIC Memory Card or delete the program, for example, via the display for the HF-CPU recently switched in STOP mode.
6. Switch the HF-CPU with the newly downloaded safety-related project data to RUN mode.
7. Switch the second HF-CPU to RUN mode.
8. As soon as the RUN-Redundant mode is reached, perform a program identification on one of the two HF-CPUs (i.e. check whether the Collective F-Signatures match online and offline).

   If you have programmed restart/startup protection in your new safety program, you may only acknowledge this after successful program identification. *(S091)*

10.3.3.3 Downloading project data to an S7-1500 F Software Controller

When you download project data to an S7-1500 F Software Controller, you must observe the following warnings:

WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must adhere to the following procedure when downloading the safety-related project data to the F-CPU with a **PG/PC** to ensure that the F-CPU does not contain any "old" safety-related project data:

- Download the safety-related project data to the F-CPU.
- Perform a program identification (Page 396). *(S042)*

The following warning applies to an S7-1500 F Software Controller with firmware ≤ V21.9.x on an IPC 627E, IPC 647E, IPC 677E, or IPC 847E:

WARNING

When you download the safety program, you must perform a POWER OFF/POWER ON afterwards before you run a program identification for acceptance. *(S097)*

The following warning applies to an S7-1500 F Software Controller with firmware < V30.1

WARNING

For safety reasons, the password of an S7-1500 F Software Controller is stored in a separate memory in addition to the load memory.

Unlike the load memory, this separate memory is not deleted. This means the previous passwords are once again active after deleting the S7-1500 F Software Controller followed by a start-up.

For this reason, note the following:

- The S7-1500 F Software Controller is deleted in case of the following download scenarios of the PC station:
  - Downloading a PC station with revised interface assignment.
  - Downloading a PC station with revised storage location for retentive data.
- We recommend that you do not set up F-access protection until after commissioning. If you still have to change the interface assignment of the PC station or the storage location for retentive data, you do not have to enter the F-password during the subsequent mandatory download of the S7-1500 F Software Controller.
- We recommend that you remove the F-access protection from an S7-1500 F Software Controller that is no longer in use. If you use the S7-1500 F Software Controller later and don't remember the password, the F-password can only be removed by performing an uninstall/install/repair, installing an image file or importing a configuration file. *(S076)*

See also

Downloading project data (Page 362)
Software Controller (https://support.industry.siemens.com/cs/ww/en/view/109249299)

10.3.3.4 Downloading project data to a SIMATIC Memory Card or removable storage device and inserting it into an F-CPU S7-1500

When loading project data of an (H)F-CPU to a SIMATIC Memory Card or saving it to a file folder, follow the same procedure as for a standard CPU. You must also observe the following warning:

WARNING

If the function test of the safety program is not performed in the destination CPU, you must ensure that the correct safety-related project data is on the memory card or in the file folder after loading or saving.

Follow these steps:

1. Always load or save the project data to an empty memory card or file folder. Existing project data must not be overwritten.
2. Label the memory card or file folder uniquely (e.g. with the Collective F-Signature).

You must limit access to the loaded or saved safety-related project data to authorized persons through organizational measures. *(S043)*

When inserting a SIMATIC Memory Card or an S7-1500 F Software Controller removable disk with project data of an (H)F-CPU, you must observe the following warning:

WARNING

If the function test of the safety program is not carried out in the destination F-CPU, you must ensure through program identification (Page 396) or other suitable measures (for example, by checking the label of the memory card or removable data storage medium) that the inserted memory card or removable data storage medium contains the correct safety-related project data. *(S025)*

Inserting SIMATIC Memory Cards in a redundant S7-1500HF system

WARNING

When inserting **two** new SIMATIC Memory Cards with new safety-related project data for a redundant S7-1500HF system, proceed as follows:

1. Switch the two HF-CPUs to STOP.
2. Replace the SIMATIC Memory Cards of both HF-CPUs with
   - Two SIMATIC Memory Cards, each with the new safety-related project data, or
   - One SIMATIC Memory Card with the new safety-related project data and one empty SIMATIC Memory Card

Procedure for ensuring correct safety-related project data through program identification:

1. Check on both HF CPUs in STOP mode, e.g. via the display, whether the correct safety-related project data is located on the SIMATIC Memory Card and that the second SIMATIC Memory Card is empty.
2. After a successful check, switch the HF-CPUs to RUN mode. If the new safety-related project data is only available on one SIMATIC Memory Card, you must first switch the HF-CPU with the new safety-related project data to RUN mode and then the HF-CPU with the empty SIMATIC Memory Card.

Procedure when it is ensured with clear identifiers that the correct safety-related project data is stored on the SIMATIC Memory Cards:

1. Switch the F-CPUs to RUN mode. If the new safety-related project data is only available on one SIMATIC Memory Card, you must first switch the HF-CPU with the new safety-related project data to RUN mode and then the HF-CPU with the empty SIMATIC Memory Card. *(S092)*

WARNING

When inserting **one** new SIMATIC Memory Card with new safety-related project data for a redundant S7-1500HF system, proceed as follows:

1. Switch the two HF-CPUs to STOP.
2. Remove the SIMATIC Memory Card on one of the two HF-CPUs.
3. Format the SIMATIC Memory Card or delete the program, for example via the display, for the HF-CPU that you did not remove.
4. Insert the SIMATIC memory card with the new safety-related project data into the HF-CPU without SIMATIC Memory Card.
5. If you cannot ensure by other suitable measures (e.g. by clear labeling of the SIMATIC Memory Card) that the correct safety-related project data is located on the SIMATIC Memory Card, you have to carry out a program identification on the HF-CPU with the new safety-related project data.
6. Switch the HF-CPU with the new safety-related project data to RUN mode.
7. Switch the second HF-CPU to RUN mode. *(S093)*

10.3.4 Restoring a backup of the safety program to an F-CPU

You have the option of backing up an F-CPU in the same way as a standard CPU and then restoring it. You can find information on backing up a CPU in the *help on STEP 7* under "Creating a backup of an S7-CPU". Saving an F-CPU S7-400 is only possible with an inserted flash card.

Note the following warnings when restoring the software and hardware configuration of an F-CPU:

WARNING

Once you have restored a backup of an F-CPU, you must perform a program identification (Page 396).

In a redundant S7-1500HF system, you must perform the program identification (Page 396) in RUN-Redundant mode. *(S055)*

NOTE

We recommend that you use the Collective F-Signature that is included in the name of the backup file for program identification. You must not change the Collective F-Signature in the name in this case.

WARNING

(S7-1200 G1, S7-1200 G2 as of FW 4.1, S7-1500) If several F-CPUs with activated web server can be accessed from a PG/PC, you must ensure through additional measures that the safety program is restored in the correct F-CPU when safety-relevant project data is restored via the web server. Use unique identifiers for this, such as the Collective F-Signature, serial number, station name or plant designation. *(S065)*

NOTE

When restoring, you must enter the previous password for the F-CPU.

10.3.5 Specifics on creating and installing an image file of an S7-1500 F Software Controller

Creating an image file

WARNING

When creating image files (for example, of an image) with safety-related project data, you must comply with the following points:

- You must take organizational measures to limit access to an S7-1500 F Software Controller to persons who are authorized to create image files.
- Before creating an image file, you must ensure through program identification (Page 396) that the correct safety-related project data is located in the S7-1500 F Software Controller.
- Image files with safety-related project data must be created on an empty data storage medium (deleted or formatted). Existing image files on a data storage medium or in a file system must be explicitly deleted; you are not permitted to overwrite an existing image file.
- After creating the image file, remove the data storage medium containing the image file or remove the image file from the file system.
- Clearly label the data storage medium or image file (e.g. with the Collective F-Signature). *(S073)*

Installing an image file

WARNING

When installing an image file (for example, of an image) with safety-related project data, you must comply with the following points:

- You must take organizational measures to limit access to an S7-1500 F Software Controller to persons who are authorized to install image files.
- When installing an image file via LAN, remote access or comparable access, you must ensure access protection (for example, using Windows administrator rights (ADMIN) or the Linux root user). Note, however, that only authorized persons are set up as users.
- To ensure that the image file is written to the correct S7-1500 F Software Controller, you must make sure when installing that the safety-related project data is installed in the correct device (for example, by comparing the serial number or the hardware identification of the device determined by the operating system).
- You must ensure that the image file contains the correct safety-related project data, for example, by checking the labeling of the data storage medium or image file.
- Remove the image file once you have installed it in the S7-1500 F Software Controller. Also remove any copies.

The following applies to firmware version as of V40.0 of the S7-1500 F Software Controller:

- After installing the image file, you must ensure through program identification (Page 396) that the correct safety-related project data is in the S7-1500 F Software Controller, for example with the display or with the command line command "GetCollectiveFSignature".

The following applies to firmware versions V30.0 and higher and < V40.0 of the S7-1500 F Software Controller:

- After installing the image file, you must ensure that the correct safety-related project data is in the S7-1500 F Software Controller through a program identification, for example, by reading out the Collective F-Signature with the command line command "GetCollectiveFSignature" or the display.
- Then you must enter and confirm the expected Collective F-Signature with the command line command "ConfirmCollectiveFSignature".

The following applies to firmware versions < V30.0 of the S7-1500 F Software Controller:

If the safety-related project data in the image file and the safety-related project data on the S7-1500 F Software Controller is different, the installed Safety program would not start up. In this case, you must download the project data to the F-CPU once again. For example, with TIA Portal. Therefore, you should always keep up-to-date backups of the image file.

In the same way that you can start up a Safety program from another CFast card, you can also install and run the image file created by another device or data storage medium.

(S074)

10.3.6 Loading project data (including safety-related project data) from an F-CPU into a PG/PC (S7-1500/S7-1200 G2 V4.1)

The "Upload from device (software)" or "Upload device as new station (hardware and software)" function is only possible for S7-1500/S7-1200 G2 V4.1 F-CPUs if the "Enable consistent upload from the F-CPU" option is activated for the F-CPU in the *Safety Administration Editor* and the project data is loaded to the F-CPU afterwards.

To load the project data (including safety-related project data) to a programming device or PC, proceed as in the standard scenario.

If "Delayed transfer" (internal value 0x7C6) was set for the F-BaseID in the original hardware configuration in the F-CPU, the actually assigned value is read when loading from the F-CPU and the option "Delayed transfer" is activated at the same time in the hardware configuration of the F-CPU. For connected F-I/Os of PROFIsafe address type 3, the setting "Delayed transfer" (internal value 0x7C6) remains in the hardware configuration.

When the data is downloaded to the F-CPU again, the actually assigned value for F-BaseID is thus retained and is transferred again to the F-I/O of PROFIsafe address type 3. If this behavior is not desired, you must deactivate the "Delayed transfer" option and generate the F-BaseID again, if necessary. The value for F-BaseID set in the hardware configuration then takes effect directly in the F-CPU and F-I/O of PROFIsafe address type 3 after a new compile and download of hardware and software.

If multiple F-CPUs can be reached over a network (e.g. Industrial Ethernet) by the programming device / PC, you have to ensure that the project data is uploaded from the correct F-CPU. For example, with "Online & diagnostics" > "Online access " > "Flash LED".

After successful loading from the device you can continue working as with a project that was created offline.

WARNING

If you want to carry out an acceptance with the project data loaded to the programming device / PC or want to carry out changes to the safety-related project data, you must ensure that the safety program is executable before loading.

This is fulfilled when loading from an F-CPU if the F-CPU is in RUN mode and in activated safety mode or can be set to RUN before loading. If the F-CPU remains in STOP, you are not allowed to perform acceptance or changes with the safety-related project data.

When loading from a memory card, it must have been in a suitable S7-1500/S7-1200 G2 V4.1 CPU beforehand. The same conditions apply as for loading from an F-CPU. *(S080)*

You can upload individual F-blocks into a PG/PC irrespective of the "Enable consistent upload from the F-CPU" option.

You cannot upload individual know-how protected F-blocks to a programming device / PC.

As of STEP 7 Safety V18, loading the project data from a memory card is possible as a new station (hardware and software) and device (software).

See also

"Settings" area of the Safety Administration Editor (Page 92)

10.3.7 Loading project data (including safety-related project data) from a memory card into a PG/PC (S7-1500/S7-1200 G2 V4.1)

The "Upload from device (software)" or "Upload device as new station (hardware and software)" function is only possible for S7-1500/S7-1200 G2 V4.1 F-CPUs if the "Enable consistent upload from the F-CPU" option is activated for the F-CPU in the *Safety Administration Editor* and the project data is loaded to the memory card afterwards.

To load the project data (including safety-related project data) to a programming device or PC, proceed as in the standard scenario.

If "Delayed transfer" (internal value 0x7C6) was set for the F-BaseID in the original hardware configuration in the F-CPU, the actually assigned value is read when loading from the F-CPU and the option "Delayed transfer" is activated at the same time in the hardware configuration of the F-CPU. For connected F-I/Os of PROFIsafe address type 3, the setting "Delayed transfer" (internal value 0x7C6) remains in the hardware configuration.

When the data is downloaded to the F-CPU again, the actually assigned value for F-BaseID is thus retained and is transferred again to the F-I/O of PROFIsafe address type 3. If this behavior is not desired, you must deactivate the "Delayed transfer" option and generate the F-BaseID again, if necessary. The value for F-BaseID set in the hardware configuration then takes effect directly in the F-CPU and F-I/O of PROFIsafe address type 3 after a new compile and download of hardware and software.

After successful loading from the memory card, you can continue working as with a project that was created offline.

WARNING

If you want to carry out an acceptance with the project data loaded to the programming device / PC or want to carry out changes to the safety-related project data, you must ensure that the safety program is executable before loading.

This is fulfilled when loading from an F-CPU if the F-CPU is in RUN mode and in activated safety mode or can be set to RUN before loading. If the F-CPU remains in STOP, you are not allowed to perform acceptance or changes with the safety-related project data.

When loading from a memory card, it must have been in a suitable S7-1500/S7-1200 G2 V4.1 CPU beforehand. The same conditions apply as for loading from an F-CPU. *(S080)*

See also

"Settings" area of the Safety Administration Editor (Page 92)

10.3.8 Loading a PC system configuration file for S7-1500 F software controllers

You can save the entire configuration of your S7-1500 F Software Controller in a configuration file, transport it and load it to a target system. The entire configuration of your S7-1500 F Software Controller is saved from the TIA Portal in a configuration file with the extension *.psc.

Saving and loading of the configuration file is supported as of:

- *STEP 7 Safety V15*
- S7-1500 F Software Controller V2.5

Example

You can find a detailed example on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109759142).

Identification parameters

The identification parameters include:

- File name
- Information in the project and the station that was stored from the TIA Portal in the PSC file in the metadata.

  For example:

  – Project version
  – Plant designation
  – Station comment

Save the identification parameters in a file, if necessary, that you store on the target system.

For evaluating and testing these identification parameters via script, you must store this information directly in the script or save the identification parameters in a separate file, if necessary, that you store on the target system.

10.3.8.1 Creating a configuration file

1. In TIA Portal create a new configuration file with "Project > Memory Card file > New > PC system configuration file (.psc)".

   The configuration file is created in the project tree under "Card Reader/USB memory".
2. Use the Collective F-Signature and, if necessary, the F-BaseID to check in the *Safety Administration Editor* that you have selected the correct project/station.
3. Use your mouse to drag the selected PC station to the configuration file.

   This loads the PC station to the configuration file.

⚠ WARNING

Instead of program identification, you can use a unique name for the PC system configuration file *.psc (**P**C **S**ystem **C**onfiguration) to ensure that the correct safety-related project data is located in the configuration file.

In addition, you have to observe the following when creating a configuration file:

When creating a configuration file with the safety-related project data, an existing file must not be used. You have to create a new file.

You should also delete configuration files with incorrect safety-related project data from the data storage.

You must limit access to the configuration file (*.psc) through organizational measures to persons who are authorized to import and modify the configuration file. *(S081)*

10.3.8.2 Importing the configuration file

You have the following options for importing the configuration file:

- Via the PC Station Panel menu (Import configuration file) **(only FW < V30.0)**
- By means of a script

Import via the PC Station Panel menu (only possible with firmware < V30.0)

Requirement

If you want to start the import of the configuration file via the menu in the PC Station Panel of an S7-150xS(P) F, the executing user must be in the Windows user group "Failsafe Operators".

Procedure

WARNING

If the import operation was successful, you will receive a positive feedback. If you do not receive a positive message, you must assume that the import operation was not successful and that the old safety-related project data is still present.

When a configuration file with safety-related project data is imported, you must adhere to the following points:

- Use the unique name of the configuration file to check that you have selected the required configuration file.
- To ensure that a configuration file imported via LAN is imported to the correct S7-1500 F Software Controller, use the following measures:
  - Remove the physical connections and possible routings to other S7-1500 F Software Controllers.
  - Use unique computer names and unique user logins or use other identification options. *(S084)*

Import by means of a script

WARNING

You must check in the script based on the specified identification parameters whether the import of the configuration file is permitted for the respective target system (e.g. by evaluating the F-CPU name, project name or using the plant designation).

In addition, it may be necessary or useful to check the respective instance of the target system. This means a diversity check of your addressing and/or checking the version of the configuration file, for example, only higher versions or the exclusion of specific versions (block list).

Example of checking the respective version for validity:

- The script evaluates the information about the version and only allows configuration files of a higher version, for example.

As a machine manufacturer, you must ensure that the script is protected against manipulation (unauthorized change of content or name).

If, as a machine manufacturer, you only make available the configuration files, you have to ensure that no incorrect configuration file is imported during import. You achieve this through technical measures (extended checks in the script) and training of the machine operators. *(S082)*

The script checks for:

- Matching machine ID
- Version ID greater than current one. If so, the new version is written to the txt file.
- Instance number

The figure below contains a systematic overview of checking the configuration file in the script with the help of an identification parameter stored in a separate file (shown in violet in the figure below):

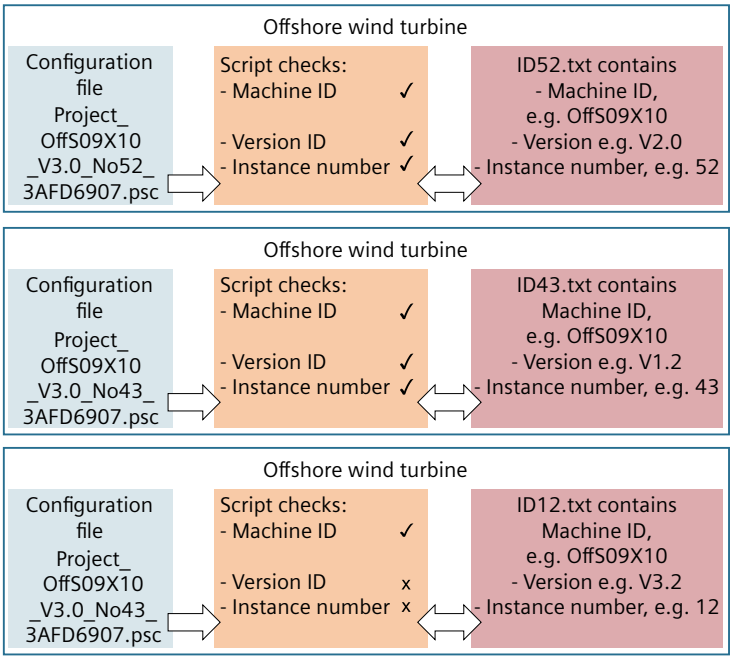

WARNING

You must determine whether the safety-related project data was successfully imported via the script by evaluating the corresponding return value (0x51A3 or 20899). If the corresponding return value is not returned, the import has failed and the old safety-related project data may still be present.

If the import operation is triggered by a server, feedback about the positive return value must also be given.

For traceability we recommend that you document the import operation in a log file.

The following applies to firmware versions V40.0 and higher of the S7-1500 F Software Controller:

To have the return value 0x51A3 displayed after the import, you must call the import command with extension "/v" for verbose.

After a successful import, you must perform a program identification (for example, manually or via a script).

The following applies to firmware versions V30.0 and higher and < V40.0 of the S7-1500 F Software Controller:

To have the return value 0x51A3 displayed after the import, you must call the import command with extension "/v" for verbose.

After successful import, you must read out the Collective F-signature from the meta file (PSC file) and enter and confirm it with the command line command "ConfirmCollectiveFSignature". This confirmation is required to restart the safety program.

The following applies to firmware versions < V30.0 of the S7-1500 F Software Controller:

To ensure that the return value is not from the previous import, you must reset the return value to 0x3FF ("PCSystem_Control /ImportConfig" without entering a file name) before the import. Then check whether the return value was reset to 0x3FF (enter "PCSystem_Control/GetStatus /ImportConfig" and then enter "echo %errorlevel%". This instruction must deliver the return value 0x3FF).

If the configuration file is imported manually via the Windows command line (via script command), you need to do one of the following:

- Reset the return value to 0x3FF and check it before the import (see above).
  - Carry out the import.
  - Evaluate return value (enter "PCSystem_Control /GetStatus /ImportConfig" and then enter "echo %errorlevel%". This instruction must return the return value 0x51A3 or 20899).
- Carry out the import.
  - Perform a manual program identification, for example, using the display of the F-CPU.

(S083)

NOTE

The positive return value when importing a configuration file via script is "0x51A3" for an S7-1500 F Software Controller, in contrast to the S7-1500 Software Controller, in which case it is "0x0000".

When the file is imported via script, the authorization should be moved to the script. This means that the executing user does not need a higher authorization level, since the script that was made available to the user by the machine manufacturer contains the necessary authorizations (user group "Failsafe Operators").

The rights are assigned via script by assignment of the Windows service to the corresponding user group. This initial installation must be performed beforehand by the Windows administrator on every computer with S7-150xS(P) F. The Windows service can be called by the executing user and the Windows service executes the script.

10.4 Program identification

You use the program identification to determine that the correct safety-related project data has been downloaded to the F-CPU To do so, you compare the Collective F-Signature with an expected value. The expected value can be, for example, the offline Collective F-Signature from the *Safety Administration Editor* or from the safety summary.

For S7-1500 F-CPUs with firmware < V3.1 and S7-1200 G1 F-CPUs with firmware < V4.7, you also compare the "F-admin" right online and offline in the *Safety Administration Editor*.

F-I/Os of PROFIsafe address type 3 (with active F-BaseID or the value "Delayed transfer") can be used for S7-1500 and S7-1200 G2 F-CPUs with firmware V4.1 or higher, or S7-1500 F-Software Controllers with firmware V40.1 or higher, as well as Safety System Version V2.8. The F-BaseID is not part of the Collective F-Signature and may need to be checked separately. In general, this is not necessary because the F-I/Os passivate if inconsistencies occur. Checking the F-BaseID could be useful if, for example, you want to check which value is active online.

For information on the F-BaseID, see also sections "Configuring an F-CPU (Page 40)" and "PROFIsafe addresses for F-I/O of PROFIsafe address type 3 (Page 69)". To check the F-BaseID using the *Safety Administration Editor*, see the section "General" area of the *Safety Administration Editor* (Page 84).

Use organizational measures to ensure that the safety-related project data is not downloaded by any other TIA Portal (on a separate programming device or PC) during the program identification.

With the *Safety Administration Editor*

For a program identification using the *Safety Administration Editor* (Page 80), follow these steps:

1. Open the *Safety Administration Editor* of the F-CPU you want to check.
2. Connect online with the F-CPU you want to check.
3. Compare the Collective F-Signature displayed online with the expected value in the "General" section.
4. Check whether the offline and online program are consistent (Page 444).

5. Check whether the green symbol is displayed in the column "status" and "Version comparison".

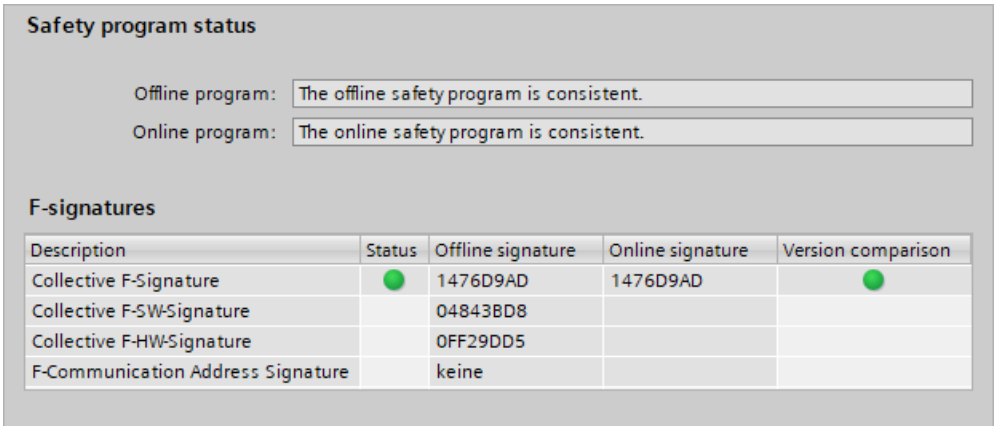

6. For S7-1500 F-CPUs with firmware < V3.1 and S7-1200 G1 F-CPUs with firmware < V4.7: Check in the "Web server F-admins" section whether only authorized users have the "F-admin" right offline and online.
7. If the check of the F-BaseID is required:

   Check in the "General" area of the *Safety Administration Editor* under "PROFIsafe" to see if the F-BaseID is the same offline and online. If it is the same, this is indicated by the green icon. (For information on checking the F-BaseID using the *Safety Administration Editor*, see also section "General" area of the Safety Administration Editor (Page 84).)

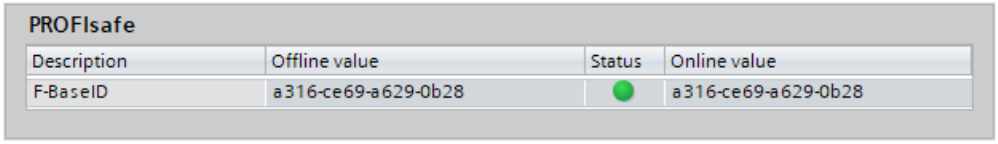

With HMI

For a program identification using the HMI, follow these steps:

1. Read the Collective F-Signature of the safety program from the F_PROG_SIG tag of the F-global DB (Page 157) (S7-300, S7-400) or the F_SYSINFO.F_PROG_SIG tag of the F-runtime group information DB (Page 158) (S7-1200, S7-1500).
2. Compare the value of the F_PROG_SIG tag with the expected value.
3. If the check of the F-BaseID is required:

   Compare the value of parameter BASEID_ACTIVE at the F-I/O DB of any F-I/O of PROFIsafe address type 3 of the relevant F-CPU with the expected value of the F-BaseID (e.g. from the safety summary). For information regarding BASEID_ACTIVE, see also section BASEID_ACTIVE (Page 177).

With the display of an S7-1500 F-CPU

For a program identification using the display of an F-CPU, follow these steps:

1. In the display menu, go to "Overview > Fail-safe".
2. Compare the displayed Collective F-Signature with the expected value.
3. If the check of the F-BaseID is required:
   Compare the displayed F-BaseID with the expected value (e.g. from the safety summary).

With the web server of an S7-1200 G1/S7-1200 G2 F-CPU as of V4.1/S7-1500

For a program identification with the web server of an S7-1200 G1/S7-1200 G2 F-CPU as of V4.1/S7-1500, follow these steps:

1. Read the Collective F-Signature on the homepage of the Web server.
2. Compare the displayed Collective F-Signature with the expected value.
3. If the check of the F-BaseID is required:
   Compare the displayed F-BaseID with the expected value (e.g. from the safety summary).

With the application UI of the S7-1500VF

For program identification using the UI of the S7-1500VF application, follow these steps:

1. Open the UI of the S7-1500VF by clicking on the app icon.
2. Compare the displayed Collective F-Signature with the expected value.

10.5 Comparing Safety Programs

Compare safety programs as in standard

You can use the *comparison editor* in *STEP 7* for offline-online or offline-offline comparison of safety programs. The procedure is the same as for standard user programs. The contents of F-blocks are also compared for the comparison of safety programs. As a result, an offline-offline comparison can also be used for an acceptance of changes (Page 448). You enable this comparison by selecting the "Safety" comparison criterion and disabling all other comparison criteria.

NOTE

You must not use the *Comparison editor* to detect changes offline-online in the safety program/configuration of the F-IOs when accepting changes. Only the offline-offline comparison is suitable for this purpose. To accept changes, proceed as described under Acceptance of Changes (Page 448).

Comparison result for safety programs

The representation of the comparison result corresponds to the representation of *STEP 7*.

Please note:
The status symbol of the "Program blocks" folder merely summarizes the comparison result of all lower-level program blocks, without taking into account the comparison values of program consistency and the collective F-signature.
To establish whether the two Safety programs are the same, you need to click the "Program blocks" folder on the left of the comparison editor. Then the collective F-signatures of both Safety programs are shown under "Comparison result". You also receive information about whether the safety program is consistent.

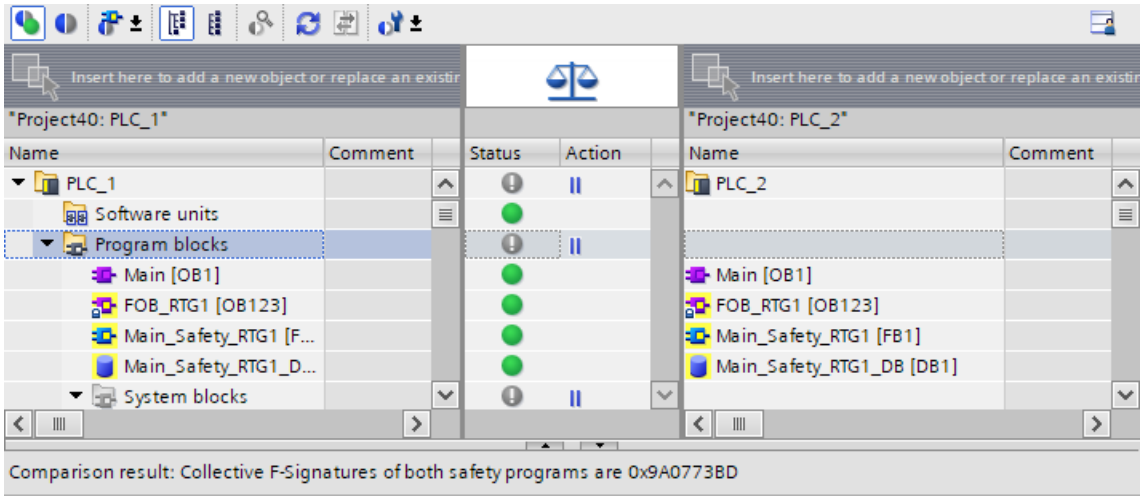

If you click on an F-block, you can see the respective signatures and interface signatures in addition to the standard information.

NOTE

If you interrupt the connection to the F-CPU during the online/offline comparison, the comparison result will be incorrect.

Comparison filter options

You can use filters in the *comparison editor* to limit the comparison result to the following block groups:

- Compare only F-blocks
- Compare only F-blocks relevant for certification
- Compare only standard blocks

You also have the *STEP 7* filter options "Show only objects with differences" and "Show identical and different objects".

For comparison of safety programs, F-blocks in the "System blocks" folder are also relevant.

Comparison criteria

Make sure that under only the comparison criterion "Safety" is enabled.

Classification of displayed changes

Regardless of whether you carried out an offline/online or offline/offline-comparison, the following changes could account for the indicated changes to the automatically generated F-blocks:

- Changing in the maximum cycle time of the F-runtime group and warning limit F-cycle time of the
  F-runtime group
- Change in F-parameters of the F-CPU
- (S7-1200/1500) Modified Safety system version
- (S7-300, S7-400) Change in the F-runtime group communication, for example, change in the number of a DB for F-runtime group communication
- Change in main safety block, F-FB, F-FC, F-DB
- Change of the hardware configuration for the F-I/O addressed in the safety program
- (S7-1200, S7-1500) Change in the communication with Flexible F-Link
- (S7-1500) Change in the communication with OPC UA Safety

It is possible that a block is displayed as changed, but no changes are displayed in the detailed comparison of the block content. This is not a display problem but means that changes of addresses in the tag table, for example, have an effect on this block. Test this block in case of doubt.

Document the result of the comparison

The comparison result can be printed via "Project > Print" in the menu bar or the "Print" icon in the toolbar or create a PDF file. Select "Print objects/area" "All" and "Properties" "All".

10.6 Creating a safety summary

The documentation of the safety-related project data (safety summary) serves, in addition to other system documentation, as the basis for checking the correctness of the individual components of the system. Correctness is a prerequisite for system acceptance.

The Collective F-Signature in the footer on the pages of the safety summary guarantees unambiguous assignment of the safety summary to a Safety program.

Bear in mind, however, that the F-BaseID does not enter into the Collective F-Signature. If this parameter is relevant to your archiving, you must separately check that the right F-BaseID was printed.

The safety summary can be created in printed or electronic form, for example, as a PDF file.

Procedure for creating the safety summary

To create the safety summary, follow these steps:

1. Open the *Safety Administration Editor* (Page 83) of the F-CPU whose safety summary you want to create.
2. Under "Safety summary" in the "General" section, press the "Create safety summary" button.

   In the displayed dialog, you can make layout settings for the printout and specify the scope of the printout (all/subset), among other things.

   Alternatively, you can select an F-CPU in the project tree and open the dialog using "Print" in the shortcut menu, "Project > Print" in the menu bar or the print button in the toolbar.
3. If you want to print the safety summary on paper, we recommend one of the ISO formats, e.g. "DocuInfo_Simple_A4_Portrait_Small_Footer" or "DocuInfo_ISO_A4_Portrait".

   In these formats, the summary contains page numbers with which you can verify the completeness of the summary.
4. Select the "All" option, if the F-blocks and F-compliant PLC data types (UDT) are to be shown in the printout. This is necessary, for example, to document the program code for the acceptance (see Acceptance of system (Page 427)). Select the "Compact" option to exclude the source code from the printout.
5. Click the "Print" button.

As a result, you receive the safety summary for the F-CPU.

After printing, make sure that all pages were printed. Incomplete printouts (e.g. lines cut off, insufficient toner when printing to paper) must not be used for an acceptance.

Overview of the contents of the safety summary

The information included in the safety summary is summarized below:

- General information on program identification, signatures, software versions, access protection, settings of the Safety program (from the "Settings" work area of the *Safety Administration Editor*), for example safety system version.
- System library elements used in Safety program (from the "Instructions" task card) along with their versions
- Information about the F-runtime groups (e.g. cycle time warning limit of the F-runtime group, maximum cycle time of the F-runtime group)
- List of F-blocks within the "Program blocks" folder (e.g. name, function, associated F-runtime group, signature)
- (S7-1200, S7-1500) List of the know-how protected F-blocks used in the Safety program (e.g., name, signature, used safety system version, used versioned instructions, named value types (NVT) or called F-blocks).
- (S7-1200, S7-1500) List of F-compliant PLC data types (UDT) used in the Safety program, if these exist in the Safety program.
- (S7-1200, S7-1500) List of the definitions of all named-value types (NVT) used in the safety program and all named-value types (NVT) that can be used in the safety program via a relation to another software unit.

- (S7-1200, S7-1500) List of all named-value types (NVT) used in the Safety program.
- (S7-1200, S7-1500) List of all system NVTs used in the safety program.
- List of all global constants used in the Safety program.
- Data from the standard user program that are evaluated in the Safety program
- Block parameters of the safety-related CPU-CPU communication by means of the instructions SENDDP/RCVDP or SENDS7/RCVS7
- (S7-300, S7-400) Absolute addresses and names of the F-shared DB tags that can be accessed from the standard user program.
- Information on the F-CPU used (e.g. firmware version, central F-source address, F-BaseID) Information on the F-I/O used (e.g. firmware version, general and specific parameters)
- Information on the printout (print date, number of pages)
- Parameters of the safety-oriented communication with OPC UA Safety
- Parameters of the safety-oriented communication with Flexible F-Link

Content of the footer of the safety summary

Based on the footer of the safety summary, you can see whether the printed safety-related project data is consistent and whether all pages of the safety summary belong to the same Safety program and the same version (the same Collective F-Signature in the footer of every page means that the safety summary belongs to the Safety program with this Collective F-Signature).

The footer is only added to the source code of the F-blocks if the "All" option was selected when creating the Safety program. If F-blocks are printed by other means, the footer is omitted, and you can no longer easily identify whether the block printout belongs to the current Safety program version.

Safety summary for a migrated project

You can only create the safety summary for a project migrated from *S7 Distributed Safety V5.4 SP5* if the project was compiled with *STEP 7 Safety Advanced* and the new program structure for safety programs (main safety block) was thereby applied. Otherwise, the safety documentation cannot be created and you will receive a corresponding error message.

We recommend that you create a safety summary for your project in *S7 Distributed Safety V5.4 SP5* before the migration.

10.7 Testing the safety program

10.7.1 Overview of Testing the Safety Program

Complete function test or test of changes

After creating a safety program, you must carry out a complete function test in accordance with your automation task.

For changes made to a safety program that has already undergone a complete function test, only the changes and that there is no effect on the parts of the safety program that were not changed need be tested.

Monitoring

Read-only test functions (such as monitoring tags of the safety program) are available for safety programs as in the standard.

Modifying

Read and write test functions (such as controlling tags of the safety program) are only available to a limited extent for safety programs and only in disabled safety mode.

Simulation via *S7-PLCSIM*

You can test the safety program using *S7-PLCSIM*. You use *S7-PLCSIM* in the same way as for standard user programs.

You start the simulation with *S7-PLCSIM* using menu item "Online > Simulation > Start"

Rules for testing

- Forcing of F-I/O inputs and F-I/O outputs is not possible.
- Controlling F-I/O outputs in connection with the function "Enabling F-I/O outputs" is not possible.
- Setting breakpoints in the standard user program will cause errors in the safety program (see also Testing the safety program (Page 409)).
- Changes in the configuration of F-I/O or safety-related CPU-CPU communication can only be tested after the hardware configuration has been saved and downloaded, and after the safety program has been compiled and downloaded to the F-CPU.

See also

Disabling safety mode (Page 405)

10.7.2 Disabled safety mode

The safety program generally runs in the F-CPU in safety mode after a STOP/RUN transition. This means that all fault control measures are activated. The safety program cannot be modified during operation (in RUN mode) in safety mode. You must disable safety mode of the safety program to, for example, modify tags in the safety program in RUN mode. Safety mode remains disabled until the F-CPU is next switched from STOP to RUN mode.

As of Safety system version V2.4, disabled safety mode for S7-1200/1500 CPUs is time-limited.

After the time limit has expired, the F-CPU or the redundant S7-1500HF system automatically goes to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You can avoid an unplanned STOP of the F-CPU after the time limit has expired as follows:

- Ending the disabled safety mode through a targeted STOP/RUN transition.
- Resetting the remaining runtime. Resetting can be used as often as needed.

10.7.2.1 Configuring the time limit for disabled safety mode (S7-1200, S7-1500)

Introduction

You can configure the duration of the time limit.

Requirements

- In the *Safety Administration Editor*, the "Safety mode can be disabled" option is activated.
- The minimum Safety system version is set to V2.4.

Procedure for configuring the runtime

To configure the time limit, follow these steps:

1. Open the *Safety Administration Editor* of the F-CPU.
2. Open the "Settings (Page 92)" area in the area navigation.
3. Under "Runtime for the deactivated safety mode", configure the time limit for the safety mode. The default time is 4 hours. You have the option to configure the time limit to a maximum of 8 hours and a minimum of 1 minute.

NOTE

The value of the configured time is not included in the Collective F-Signature.

10.7.2.2 Disabling safety mode

Requirements

- In the *Safety Administration Editor*, the "Safety mode can be disabled" option is activated.
- (S7-1200, S7-1500) The serial number of the F-CPU (Page 84) has been entered in the *Safety Administration Editor*.
- The project is loaded to the F-CPU.
- The F-CPU is in RUN.
- The Safety program runs in safety mode.

Rules for disabling safety mode

WARNING

When safety mode is disabled, you must take the following into consideration:

- Disabling of safety mode is intended for test purposes, commissioning, etc. While safety mode is disabled, plant security must be ensured by organizational measures.

  After the test or commissioning, safety mode must be enabled again. To do this, execute a STOP/RUN transition of the F-CPU.

  In a redundant S7-1500HF system you have to set both HF-CPUs or the redundant system S7-1500HF to STOP before you restart the HF-CPUs.
- A disabling of the safety mode must be displayed.

  Use the MODE tag in the F-shared DB ("F_GLOBDB".MODE) for S7-300/400 F-CPUs or in the F-runtime group information DB (e.g. RTG1SysInfo.F_SYSINFO.MODE) for S7-1200/1500 F-CPUs, which you can evaluate to read the operating mode (1 = Disabled safety mode).
- It must be possible to verify that safety mode has been disabled. A log is required, if possible by recording and, if applicable, archiving alarms to the operator control and monitoring system or, if need be, through organizational measures. In addition, it is recommended that a disabling of the safety mode be indicated on the operator control and monitoring system.
- With safety-related communication, you must also take into account a possible deactivation of Safety mode on the communication partner's side*. You can then no longer assume that the data provided by the communication partner is formed in a safety-related manner.
  During this time, you must take organizational measures to ensure the safety of the system components that are affected by this data. Alternatively, you can also use safe substitute values in your Safety program instead of the received data.

(S027)

*You can determine whether Safety mode has been deactivated on the communication partner's side as follows:

- Communication via SENDDP/RCVDP instructions: SENDMODE output at RCVDP (Page 627)
- Communication via SENDS//RCVS7 instructions: SENDMODE output at RCVS7 (Page 636)
- Communication with OPC UA Safety: TEST_MODE_ACTIVATED variable in the F-OPC UA Consumer DB
- Communication with Flexible F-Link: SENDMODE tag in the F-Communication DB (Page 358) for receiving

WARNING

(S7-1200, S7-1500) If **several F-CPUs** can be reached via a network (such as Industrial Ethernet) by the **same PG/PC**, you must take the following additional measures to ensure that the safety-related project data is downloaded to the correct F-CPU or that safety mode is deactivated in the correct F-CPU:

- Enter the serial number of the specific F-CPU in the *Safety Administration Editor*.

Depending on the respective CPU type (see documentation of the CPU), you have several possibilities for determining the serial number of an F-CPU:

- Print of the serial number on the housing of the F-CPU.
- Scanning of the ID link on the F-CPU.
- Display of the F-CPU
- Web server*
- Industrial Edge application user interface under /SIMATIC_MC/system/serialno*
- TIA Portal (I&M data)*

Note the following when downloading:

- If the "Load preview" window does not contain a warning, the connection to the correct F-CPU has been established. You can confirm the download of the safety-related project data without an additional check.
- If a serial number has not yet been entered in the *Safety Administration Editor* or if the connected F-CPU has a different serial number, check the proposed serial number of the F-CPU in the "Load preview" window or "Disable safety mode" window. If you determine an error, cancel the download or the disabling of safety mode. Otherwise, you can confirm the procedure.
- When the serial number is confirmed (online), it is always applied in the *Safety Administration Editor* and any existing entry is overwritten.

  (S099)

* To make use of these possibilities, you must ensure a connection to the expected F-CPU. You achieve this through:

- A point-to-point connection to the respective F-CPU
- Verification of the flashing of the F-CPU after selecting the "Flash LED" check box in the online and diagnostics view of the F-CPU.
- Unplugging the network cable to the respective F-CPU
- For an S7-1500 F Virtual Controller, a unique connection can be achieved by a targeted switch to STOP of the Industrial Edge application.

Procedure for disabling safety mode

To disable safety mode, follow these steps:

1. Open the *Safety Administration Editor* of the corresponding F-CPU.
2. Open the "General (Page 84)" area in the area navigation.
3. Click the "Disable safety mode" button.
4. If access protection is set up for the F-CPU, enter the password for the F-CPU or legitimate yourself again as a user with F-right.
5. Only for S7-300/400 F-CPUs for which access protection is **not** set up:
   Make sure that you disable safety mode of the desired F-CPU by checking the Collective F-Signature in the dialog that is displayed next.
6. Confirm the deactivation.

Safety mode is then disabled.

The remaining runtime until an S7-1200/1500 F-CPU goes into STOP starts immediately after the safety mode is disabled. The remaining runtime is displayed in the *Safety Administration Editor* in the "General (Page 84)" area in online mode. In addition, the remaining runtime is displayed in the web server of an S7-1500 F-CPU as of firmware V2.9.

Reset remaining runtime until the F-CPU goes to STOP

To avoid the expiration of the remaining runtime and the associated STOP of the F-CPU, you can reset the remaining runtime in the *Safety Administration Editor*. This resets the remaining runtime to the configured value and starts it running again immediately after that.

Proceed as follows:

1. Open the *Safety Administration Editor* of the corresponding F-CPU.
2. Open the "General (Page 84)" area in the area navigation.
3. Click the "Reset remaining runtime" button.
4. If access protection is set up for the F-CPU, enter the password for the F-CPU or legitimate yourself again as a user with F-right.
5. Only for S7-300/400 F-CPUs for which access protection is **not** set up:
   Make sure that you disable the remaining runtime of the correct F-CPU by checking the Collective F-Signature in the dialog that is displayed next.
6. Confirm the reset of the remaining runtime.

NOTE

The remaining runtime is also displayed in the F-runtime group information DB (Page 158) of the respective F-runtime group in the MODE_REMAINING_TIME tag.

In case of two F-runtime groups, different values may be displayed caused by different update times.

The value "0" is not displayed after expiration of the remaining runtime, but the remaining runtime existing in the last cycle.

Enabling safety mode

To enable safety mode, the F-CPU must be switched from STOP to RUN mode.

In a redundant S7-1500HF system you have to set both HF-CPUs or the redundant system S7-1500HF to STOP before you restart the HF-CPUs.

Switching the F-CPU from STOP to RUN mode always enables safety mode, even if the Safety program has been modified or is not consistent.

If you have changed your Safety program, but have not recompiled and downloaded it, the F-CPU can revert to STOP mode.

Evaluating safety mode/disabled safety mode

If you wish to evaluate safety mode/disabled safety mode in the Safety program, you can evaluate the "MODE" tag in the F-shared DB (Page 157) for S7-300/400 F-CPUs or F-runtime group information DB for S7-1200/1500 F-CPUs (1 = Disabled safety mode). You use fully qualified access to access this tag (e.g. "F_GLOBDB".MODE or RTG1SysInfo.MODE).

You can use this evaluation, for example, to passivate F-I/O when the Safety program is in disabled safety mode. To do so, assign the "MODE" tag in the F-shared DB or F-runtime group information DB to all "PASS_ON" tags in the F-I/O DBs of the F-I/O that you wish to passivate.

WARNING

When the Safety program is in disabled safety mode, the "MODE" tag in the F-shared DB or F-runtime group information DB is also evaluated in disabled safety mode.

Even if the F-I/O is passivated in disabled safety mode by evaluating the "MODE" tag, the safety of the plant must be ensured during disabled safety mode by organizational measures. *(S028)*

See also

Configuring the time limit for disabled safety mode (S7-1200, S7-1500) (Page 404)

10.7.3 Testing the safety program

Introduction

Tags of the safety program can be monitored at any time.

Controlling tags of the safety program is only possible in deactivated safety mode as some fault control measures of the safety program have to be disabled for this.

You can control the following tags of the safety program:

- Inputs and outputs of the F-I/O (channel values and value status (S7-1200, S7-1500))
- Tags in F-global DB (except DB for F-runtime group communication)
- Tags in instance DBs of F-FBs
- Tags in F-I/O DBs (for permitted tags see F-I/O DB (Page 168))

Procedure for monitoring tags of the safety program

Monitor the required tags of the safety program from an open watch table or from the *program editor* (program status).

1. Proceed as in the standard. More information can be found in the *STEP 7 help* in "Testing user programs".

Procedure for controlling tags of the safety program

Control the required tags of the safety program from an open watch table:

1. For modifying, deactivate the safety mode (Page 405) in the automatically shown dialog.
2. Terminate existing modify requests after testing is complete before activating safety mode.

Values in F-DBs can only be modified online in the F-CPU. If the value is also to be changed offline, you must do this by editing the start value offline and compiling the safety program.

Proceed as follows to control tags of F-I/O:

1. Create a separate row for each channel value and value status (S7-1200, S7-1500) to be modified. The control value must correspond to the channel value or value status.
2. Set "start of scan cycle" or "end of scan cycle" and "permanent" or "once".

   Regardless of the trigger point setting, requests to modify inputs (PII) of F-I/O always become effective before the main safety block is executed and requests to modify outputs (PIQ) always become effective after execution of the main safety block.
3. (S7-300, S7-400) Create an additional watch table if you want to control more than 5 inputs/outputs.

NOTE

F-I/O can only be modified in RUN mode of the F-CPU.

You cannot modify a configured F-I/O from which neither a channel value or a value status (S7-1200, S7-1500), nor any tag from the associated F-I/O DB has been used in the safety program. In your safety program, you should therefore always use at least one tag from the associated F-I/O DB or at least one channel value or value status (S7-1200, S7-1500) of the F-I/O to be modified.

For inputs (PII), modify requests take priority over fail-safe value output, while for outputs (PIQ), fail-safe value output takes priority over modify requests. For outputs (channels) that are not activated in the properties for the F-I/O, modify requests affect the PIQ only, and not the F-I/O.

NOTE

The following applies for S7-1200/1500 F-CPUs:

To avoid invalid combinations of channel value and status value:

- The value status is set by the F-system automatically to 1 when setting a channel value to a value <> fail-safe value 0
- The fail-safe value 0 is automatically output when setting the value status to 0 for the associated channel value

---

WARNING

You need to specifically reset constant modify requests in the watch table in disabled safety mode.

Note that constant modify requests that are not correctly reset can remain active in the background even after a STOP/RUN transition of the F-CPU.

Because the F-CPU is in safety mode again after a STOP/RUN transition, the constant modify requests are no longer effective and are not shown in the watch table.

The requests become active again as soon as you disable safety mode again.

With a memory reset of the F-CPU, you can make sure that no constant modify requests are active in the background on the F-CPU. *(S029)*

Wiring test using watch table

You can carry out a wiring test for an input by changing an input signal and verifying whether or not the new value arrives in the PII.

You can carry out a wiring test for an output by changing the output with the Modify function and verifying whether the required actuator responds.

For the wiring test, note that a safety program must be running on the F-CPU, in which at least one channel value or value status (S7-1200, S7-1500) of the F-I/O to be monitored or modified or one tag from the associated F-I/O DB has been used.

For F-I/O that can also be operated as standard I/O (e.g., S7-300 fail-safe signal modules), you can also carry out the wiring test for outputs using the Modify function in STOP mode by operating the F-I/O as standard I/O rather than in safety mode.

Additional rules for testing (S7-300, S7-400, S7-1500)

Setting breakpoints in the standard user program will cause the following errors in the safety program:

- F-cycle time monitoring has expired
- Error during communication with the F-I/O

  (S7-1500) Fail-safe modules switch to safe mode after the configured F-monitoring time has expired.
- Error during safety-related CPU-CPU communication
- Internal CPU faults

If you nevertheless want to use breakpoints for testing, you must first disable safety mode. This will result in the following errors:

- Error during communication with the F-I/O
- Error during safety-related CPU-CPU communication

Difference between S7-1500 F-CPUs and S7-300/400 F-CPUs:

- If a breakpoint is activated and reached, the F-CPU goes directly to STOP after HOLD.
- If you want to switch to RUN again after HOLD to test your standard user program further, you can simulate this with S7-PLCSIM.

No access protection is initially necessary for test purposes, commissioning, etc. This means you can execute all offline and online actions without access protection, that is, without password prompt.

See also

Changing the safety program in RUN mode (S7-300, S7-400) (Page 417)

Downloading project data (Page 362)

10.7.4 Testing the Safety program with S7-PLCSIM/S7-PLCSIM Advanced

You can test your Safety program together with your standard program on a simulated CPU with *S7-PLCSIM* and without the need for hardware. Also observe warning S030 in the section "Notes on Safety Mode of the Safety Program (Page 456)".

You use *S7-PLCSIM* for SIMATIC Safety F-systems as you would for S7 standard systems. Note the following special features:

Safety mode/disabled safety mode

We recommend that you test your Safety program in safety mode to detect whether the F-CPU goes into STOP as early as in the test phase of your Safety program in *S7-PLCSIM* as a result of, for example, that the results of instructions were outside the permitted range for the data type.

The following simulations can be run in *S7-PLCSIM*, just as on an actual F-CPU, in disabled safety mode only.

- Modifying tags in F-DBs and F-I/O DBs.

(S7-1200, S7-1500) To prevent unintentional modification of tags in F-DBs and F-I/O DBs in Safety mode, we recommend that you do not select the "Enable/disable modification of non-inputs" button in *S7-PLCSIM*

During the simulation with *S7-PLCSIM* , monitoring of the maximum cycle time of the F-runtime group and the cycle time warning limit of the F-runtime group (S7-1200, S7-1500) are disabled.

Differences between a simulated F-CPU and real F-CPU

Note that *S7-PLCSIM* does not fully behave like a real F-CPU down to the individual details. In particular, the startup behavior of an F-I/O cannot be simulated exactly.

Input simulation of F-I/O

Simulation of inputs (channel values) in *S7-PLCSIM:*

You simulate inputs (channel values) of F-I/O in *S7-PLCSIM* as you would inputs (channel values) of standard I/O. Keep in mind the following notes/restrictions:

During the transition of the F-CPU from "STOP" to "RUN" mode in *S7-PLCSIM*, all inputs (channel values) of F-I/O are initialized with 0 in the process image input (PII).

The inputs (channel values) can be simulated starting from the 2nd cycle and are then available in the PII.

Simulation of inputs (value status) in *S7-PLCSIM:*

(S7-1200 G1, S7-1500) By simulating inputs (value status) of F-I/O, you can simulate incoming and outgoing F-I/O / channel faults. Keep in mind the following notes/restrictions:

- To realistically simulate the behavior of the F-I/O, you must note the connection between channel value and value status on the real F-I/O. The combination value status = 0 and channel value <> fail-safe value (0) is invalid and can result in the simulation deviating from the behavior of the real F-CPU.
- During the transition of the F-CPU from "STOP" to "RUN" in *S7-PLCSIM*, all inputs (value status) of F-I/O are initialized with 1 in the process image input (PII). This means you can start with the simulation of inputs (channel values) immediately without simulation of the inputs (value status). For more information, refer to the sections "Addressing F-I/O (Page 161)" and "Value status (S7-1200, S7-1500) (Page 163)".
- The simulation of inputs (value status) in *S7-PLCSIM* does not have an effect on the QBAD and PASS_OUT tags in the F-I/O DB. Note that with real F-I/O, QBAD and PASS_OUT can be 1 as soon as the value status is 0 for at least one channel of the F-I/O (see tags of the F-I/O DB: PASS_OUT/QBAD/QBAD_I_xx/QBAD_O_xx and value status (Page 174)).
- For F-I/O configured with "Behavior after channel fault" = "Passivation of the complete F-I/O", use the tag PASS_ON in the F-I/O DB for simulation of the passivation of the complete F-I/O for F-I/O / channel faults. If you limit the simulation to passivation of individual inputs (channel value including value status), the behavior of the simulation will deviate from that of the real F-CPU.
- You can also use the PASS_ON tag in the F-I/O DB for F-I/O without value status to simulate the passivation of the entire F-I/O in case of F-I/O or channel faults.
- To simulate an F-I/O / channel fault of the SM 336; AI 6 x 13Bit or SM 336; F-AI 6 x 0/4...20 mA HART with configuration "Behavior after channel fault" = "Passivate channel", you must simulate the inputs (channel values) with $7FFF_H$ (for overflow) or 8000_H (for underflow).
- For F-I/O which does not support the "RIOforFA-Safety" profile, you must run a user acknowledgment with a positive edge at the ACK_REI tag of the F-I/O DB as with a real F-I/O for reintegration after the value status has changed from 0 to 1 or when the channel value has changed from $7FFF_H$/8000_H to unequal $7FFF_H$/8000_H (see above) when ACK_NEC = 1 of the F-I/O DB. Reintegration takes place automatically in all other cases possibly deviating from the real F-I/O.

Update times

Keep in mind that the status of the inputs (channel values or value status (S7-1200 G1, S7-1500)) that you are monitoring in the SIM table in *S7-PLCSIM* is only identical to the status being processed in the Safety program if there is no passivation of the associated F-I/O.

When the F-I/O is passivated, the Safety program operates with substitute values (channel value and value status (S7-1200 G1, S7-1500) =0).

Communication via SENDDP/RCVDP instructions

The following applies for SENDDP/RCVDP (S7-300, S7-400) instructions and SENDDP/RCVDP instructions with Version < 3.0 (S7-1200, S7-1500):

You cannot simulate communication between F-CPUs with the SENDDP and RCVDP instructions in *S7-PLCSIM*. You can, however, use the SENDDP and RCVDP instructions together with *S7-PLCSIM*. During simulation in *S7-PLCSIM*, the RCVDP instruction outputs the substitute values pending at its inputs SUBBO_xx and SUBI_xx ((S7-1200, S7-1500) or alternatively SUBDI_00). The SENDDP and RCVDP instructions signal this with 1 at output SUBS_ON.

For SENDDP/RCVDP instructions with Version >= 3.0 (S7-1200, S7-1500) the following applies:

During the simulation with *S7-PLCSIM* it is possible to simulate the received data and the information "Deactivated Safety Mode" (RCVDP) or respectively the information "Substitute value output" (SENDDP) in the corresponding transfer area for inputs. Note the following notes:

- The simulated values do not become active until you set the SIMULATION bit for the first time in the respective simulation control word (see the following table) after the F-system has started up. Before setting the SIMULATION bit, the RCVDP instruction outputs the fail-safe values that are pending at its inputs SUBBO_xx and SUBI_yy (or alternatively SUBDI_00).
- The setting of the SEND_MODE bit in the simulation control word causes a setting of the SENDMORE output for the RCVDP instruction.
- The setting of the STATUS_SUBS bit in the simulation control word causes a setting of the SUBS_ON output for the SENDDP instruction.
- Reserved bits in the simulation control word always have to be 0.
- During a STOP/RUN transition from *S7-PLCSIM* the most recently simulated values in the transfer area for inputs are kept.

The start address(es) of the configured transfer area for the input and output data can be found in the respective configuration (see also "Communication via SENDDP/RCVDP instructions (S7-1200, S7-1500): (Page 257)").

Table 3-1116 Structure of the relevant transfer area for inputs of the simulation control word (instruction RCVDP)

Byte	Meaning	Comment
0	RD_BO_15 ... RD_BO_08	
1	RD_BO_07 ... RD_BO_00	
	DINTMODE=0:	

1) MSB: most significant bit

2	RD_I_00	Word RD_I_00, MSB[1)] first
3		
4	RD_I_01	Word RD_I_01, MSB[1)] first
5		
	Alternative DINTMODE=1:	
2	RD_DI_00	High Word from RD_DI_00, MSB[1)] first
3		
4		Low Word from RD_DI_00 **XOR 0x8000**, MSB[1)] first
5		
6	Simulation control word (High Byte)	Bit 0...6: Reserved Bit 7: SIMULATION: Activating RCVDP simulation
7	Simulation control word (Low Byte)	Bit 0: SEND_MODE: Set output SENDMODE Bit 1...7: Reserved
8 ... 11	Reserved	

1) MSB: most significant bit

Table 3-1117 Structure of the relevant transfer area for inputs of the simulation control word (instruction SENDDP)

Byte	Meaning	Comment
0	Simulation control word (High Byte)	Bit 0: STATUS_SUBS: Set output SUBS_ON Bit 1...6: Reserved Bit 7: SIMULATION: Activating SENDDP simulation
1	Simulation control word (Low Byte)	Bit 0...7: Reserved
2 ... 5	Reserved	

(S7-300, S7-400) Communication via the SENDS7/RCVS7 instructions

You cannot simulate communication between F-CPUs with the SENDS7 and RCVS7 instructions in *S7-PLCSIM*. You can, however, use the SENDS7 and RCVS7 instructions together with *S7-PLCSIM*.

During simulation in *S7-PLCSIM*, the RCVS7 instruction outputs the initial values specified in the communication DB as fail-safe values. The SENDS7 and RCVS7 instructions signal this with 1 at output SUBS_ON.

Communication with OPC UA Safety

You can simulate CPU-CPU communication with OPC UA Safety with S7-PLCSIM Advanced as of V7.0. Use the "TCP/IP Single Adapter" option under "Online Access" for this. Note the following warning if the Safety program associated with the connected SafetyProvider is running on an S7-PLCSIM:

WARNING

If the TEST_MODE_ACTIVATED variable in the F-OPC-UA-Consumer-DB is set to "1" during communication with OPC UA Safety, you can no longer assume that the data at the SAFETY_DATA variable is formed in a safety-related manner. This is the case when the connected SafetyProvider is in deactivated safety mode on a PLCSIM instance or the EnableTestMode SAPI parameter of the connected SafetyProvider has been set in the associated user program. During this time, you must take organizational measures to ensure the safety of the system components that are affected by this data. Alternatively, you can also use safe substitute values in your Safety program with TEST_MODE_ACTIVATED = 1 instead of the data in the SAFETY_DATA tag. *(S108)*

Communication with Flexible F-Link

Note the following warning if the Safety program on the sender side is running on an S7-PLCSIM:

WARNING

If the SENDMODE tag in the F-communication DB (Page 311) is set to "1" for receiving during communication with Flexible F-Link, you can no longer assume that the data at the RCV_DATA tag is formed in a safety-related manner.

During this time, you must take organizational measures to ensure the safety of the system components that are affected by this data. Alternatively, you can also use safe substitute values in your Safety program with SENDMODE = 1 instead of the data in the RCV_DATA tag. *(S086)*

Inconsistent Safety program (S7-1200, S7-1500)

If the CPU goes into STOP in *S7-PLCSIM* with the diagnostic entry "Safety program: inconsistent", the F-CPU is not initialized correctly in *S7-PLCSIM* yet. Perform a memory reset of the F-CPU in *S7-PLCSIM* and download the project data once again to the CPU in *S7-PLCSIM*.

See also

F-communication DB (S7-1200, S7-1500) (Page 358)

10.7.5 Changing the safety program in RUN mode (S7-300, S7-400)

Introduction

You make changes to F-blocks offline in the *program editor* in the same way as for a standard program. You download the changed F-blocks in RUN to the F-CPU in the "disabled safety mode (Page 405)".

NOTE

If you do **not** want to make changes to the safety program during operation, see Creating F-blocks in FBD/LAD (Page 153).

Procedure for changing the safety program in RUN mode

To change the safety program, follow these steps:

1. Change the main safety block or F-FB and its associated instance DB, F-FC, or F-DB in the *Program editor*.
2. Download the changed F-block(s) to the F-CPU (for procedure, see Downloading project data (Page 362)). The entire program is then automatically compiled.
3. If safety mode is active, the "Load preview" dialog will prompt you to deactivate it and to enter the password for the safety program.

   NOTE

   When downloading in disabled safety mode, you can only download the fail-safe blocks created by you (main safety blocks, F-FB, F-FC, or F-DB), F-application blocks, or standard blocks and their associated instance DBs. If you download automatically added F-blocks (F-SBs or automatically generated F-blocks and associated instance DBs, F-shared DB), the F-CPU can go to STOP mode or safety mode can be activated.

   Therefore, always select individual blocks only when downloading in disabled safety mode.

Sequence for downloading changes

Changes in the safety program in RUN mode when safety mode is disabled can, for example, cause the status of an actuator to change as a result of program changes.

After changes, start by downloading the safety program and then the function of the standard user program monitored by the safety program.

Restrictions on safety-related CPU-CPU communication

During operation (in RUN mode), you cannot establish new safety-related CPU-CPU communication by means of new SENDDP/RCVDP or SENDS7/RCVS7 instructions.

To establish new safety-related CPU-CPU communication you must always download the relevant safety program consistently to the F-CPU while in STOP mode after inserting a new SENDDP, SENDS7, RCVDP, or RCVS7 instruction.

Restrictions on F-runtime group communication

You cannot make any changes to the safety-related communication between F-runtime groups in RUN mode. This means that you cannot assign, delete, or change any DBs for F-runtime group communication of an F-runtime group.

Following changes in the F-runtime group communication, you must always download the safety program consistently to the F-CPU while in STOP mode.

Restrictions on F-I/O access

If during operation (in RUN mode), you insert an F-I/O access to an F-I/O of which no single channel value or tag from the associated F-I/O DB has yet been used in the safety program, the F-I/O access only becomes effective when the safety program is downloaded consistently to the F-CPU.

Changing the standard user program

You can download changes in the standard user program when the F-CPU is in RUN mode, regardless of whether safety mode is enabled or disabled.

WARNING

(S7-300, S7-400) In productive operation, it must be prevented that changes to the standard user program are unintentionally made in the safety program as well. For this purpose, you must configure the protection level "Write protection for fail-safe blocks" and configure a password for the F-CPU.

With the "Write protection" or "Write/read protection" protection level, the password would apply to the standard and the safety program. *(S001)*

Procedure for applying changes to the safety program

If you download individual F-blocks to the F-CPU during operation (in RUN mode), the F-system blocks (F-SBs) and the automatically generated F-blocks are neither updated nor downloaded, resulting in an inconsistent safety program in the F-CPU. Use the following procedure to apply changes to the safety program:

1. Download the safety program consistently to the F-CPU, and activate safety mode by switching the F-CPU from STOP to RUN mode (for procedure, see Downloading project data (Page 362)).
2. Follow the steps described in Acceptance of Changes (Page 448).

10.7.6 Safety program in RUN mode (S7-1200, S7-1500)

Introduction

You make changes to F-blocks offline in the *program editor* in the same way as for a standard program. Loading the changed F-blocks in RUN to the F-CPU is done with the Fast Commissioning mode in deactivated safety mode (Page 405).

The Fast Commissioning mode distinguishes between "Fast Compile" (default setting) and "Consistent Compile".

Fast Commissioning mode with "Fast Compile"can be used for minor software changes to the Safety program, e.g. for testing and commissioning. It enables a fast compile, as only the F-blocks created by the user are compiled here.

In contrast, the Fast Commissioning mode with "Consistent Compile" can be used, for example, at the end of commissioning to compile the safety program consistently and then download it consistently to the F-CPU. In this case, you forego the advantage of the fast compiling, but after downloading the safety program to the F-CPU, you can enable safety mode again immediately with a short STOP-RUN transition of the F-CPU.

NOTE

Do not switch the F-CPU to STOP in Fast Commissioning mode with "Fast Compile". Otherwise, the F-CPU does not restart afterwards because the F-CPU contains an inconsistent safety program.

Solution:

- Download a consistent safety program to the F-CPU and then carry out a STOP-RUN transition. The deactivated safety mode is hereby terminated.
- If your F-CPU supports "Consistent Compile", select "Consistent Compile" and download the safety program consistently to your F-CPU. After that, a STOP-RUN transition is possible.

NOTE

Fast Commissioning mode with "Fast Compile" behaves differently with *S7-PLCSIM* than with a real F-CPU.

An *S7-PLCSIM* restarts after a STOP.

Requirements

To activate and use Fast Commissioning mode, the following requirements must be met:

- You can use Fast Commissioning mode with "Fast Compile" as of Safety System version V2.4. It is available for S7-1200 G2 F-CPUs as of firmware V1.0, S7-1200 G1 F-CPUs as of firmware V4.5 and S7-1500 F-CPUs as of firmware V2.0.
- You can use the Fast Commissioning mode with "Consistent Compile" from Safety System version V2.5. It is available for S7-1200 G2 F-CPUs as of firmware V1.0 and for S7-1500 F-CPUs as of firmware V3.0. With S7-1500 F-Software Controller, it is available as of Safety System version V2.5 only for approved IPCs as of firmware V30.0.

  NOTE

  S7-1500 F Software Controller

  The approved IPCs can be found in the table in the Product information for the F-CPUs (https://support.industry.siemens.com/cs/ww/en/view/109478599).

  If IPCs that have not been approved are used, an error or restart of the F Software Controller occurs. The download must then be repeated in STOP.

- The "Safety mode can be disabled" option must be selected in the "Settings" area of the *Safety Administration Editor*.
- The offline Safety program must be consistent and identical to the online Safety program.
- The F-CPU is in RUN.

Enabling Fast Commissioning mode

You enable Fast Commissioning mode by clicking the "Enable Fast Commissioning" button in the "General" area of the Safety Administration Editor.

Here, "Fast Compile" is selected as the default setting.

Once Fast Commissioning mode with "Fast Compile" is active, the behavior when compiling changes (shortcut menu "Compile > Software (only changes)" and "Compile > Hardware and software (only changes)") switches to the behavior when compiling changes in Fast Commissioning mode with "Fast Compile".

As soon as you change to the "Consistent Compile" setting, you can also compile the safety program consistently and download it to the F-CPU in RUN.

NOTE

After enabling Fast Commissioning mode, all other areas in the *Safety Administration Editor* are grayed out except the "General" area. Write access in the *Safety Administration Editor* is not permitted, also not via Openness. Read access is still possible.

While Fast Commissioning mode with "Fast Compile" is activated, the *Safety Administration Editor* displays the information "Fast Commissioning is activated" as the status of the safety program.

No signatures are calculated in Fast Commissioning mode with "Fast Compile". Therefore, no statement can be made in this mode about the status of the safety program and the F-blocks with regard to the offline-online comparison. The status of the signature comparisons is displayed with the icon in this case.

Downloading changes in Fast Commissioning mode

To download changes to the Safety program to the F-CPU in RUN in Fast Commissioning mode, the following 3 conditions must be met:

- The F-CPU is in RUN.
- Safety mode is deactivated.
- Fast Commissioning is enabled.

If at least one of these 3 conditions is not met, the "Download" dialog displays a note that download in RUN mode is not possible.

NOTE

In case of a connection abort between the PG/PC and the F-CPU during loading in RUN mode, loading to the F-CPU can **not** be completed properly. Even the indicators of the safety program on the display and in the web server of the F-CPU are no longer current.

A subsequent loading in RUN is no longer possible in this case, even though all requirements for Fast Commissioning mode are being met.

Solution: Switch the F-CPU to STOP mode and download a consistent safety program to the F-CPU.

NOTE

If the work memory utilization of the F-CPU is > 80%, a download in RUN mode with "Consistent Compile" may be aborted and the download to the F-CPU may not be properly completed. Even the indicators regarding the safety program on the display and in the web server of the F-CPU are no longer current.

A subsequent download in RUN is no longer possible, even though all requirements for Fast Commissioning mode are met.

Solution: Switch the F-CPU to STOP mode and download a consistent safety program to the F-CPU.

Supported changes in Fast Commissioning mode

While Fast Commissioning mode is enabled, you cannot arbitrarily change your Safety program. The following is an overview of the supported changes.

- Changes to F-FBs/F-FCs/F-DBs. See "Changes not supported" for exceptions.
- Changes to fail-safe-compliant PLC data types. See "Changes not supported" for exceptions.
- Changes to the standard user program that influence the safety program, for example, DBs used in both the standard user program and the safety program.
- Creating and using F-blocks. See "Changes not supported" for exceptions.

Unsupported changes in Fast Commissioning mode with "Fast Compile"

While Fast Commissioning mode with "Fast Compile" is activated, you cannot make changes to your safety program at will. The following is an overview of the changes **not** supported .

Type of change	System response
All changes to the hardware configuration.	A STOP is required for the download to the F-CPU.
Change in an F-FB/F-FC:	
• Insertion of a new call of a time-processing instruction (for example, TON, TOF, TP, MUT_P...) or an ACK_OP/ACK_GL instruction. (Time value parameters can be reassigned in existing calls).	Compiling errors
• Insertion of a new call of a SENDDP/RCVDP instruction.	
• Insertion of a new access to an F-I/O (access to a tag of the F-I/O DB or to the process image) that has not yet been used in the F-runtime group.	
• Insertion of a new access to a communication with Flexible F-Link (access to a tag of the F-communication DB) which has not yet been used in the F-runtime group.	
Deleting in an F-FB/F-FC:	
• Deletion of a call of a time-processing instruction (for example, TON, TOF, TP, MUT_P...) or an ACK_OP/ACK_GL instruction.	Compiling errors when the instances are also deleted
• Delete a call to a SENDDP/RCVDP instruction.	Compiling errors
• Deletion of the last access to an F-IO (access to a tag of the F-I/O DB or to the process image) so that it is no longer used in the F-runtime group.	
• Deletion of the last access to a communication with Flexible F-Link (access to a tag of the F-communication DB) so that it is no longer used in the F-runtime group.	
Deleting an F-FB or F-FC when it was called before Fast Commissioning mode was activated. However, a call can be deleted.	Compiling errors
Deleting an F-DB when tags of this F-DB were already being used before Fast Commissioning mode was activated.	Compiling errors
Deleting a standard DB when tags of this DB were already being used for reading before Fast Commissioning mode was activated.	Compiling errors
Deleting a tag from the standard user program when it was already being used for reading before Fast Commissioning mode was activated.	Compiling errors
Structural changes of fail-safe-compliant PLC data types that are referenced in a Flexible F-Link communication.	Compiling errors
Creating library types of blocks	Compiling errors
Adding/deleting of:	
• F-OBs	Compiling errors
• Flexible F-Link communications	Blocking in the Safety Administration

Type of change	System response
• F-runtime groups (including changes)	Editor
• F-CD/F-MS connections (including changes)	
Inserting an F-FB/F-FC (e.g. from a library or a different F-CPU) with global access to an F-DB.	Compiling errors
Changing the instruction version in the "Instructions" task card.	Compiling errors
Creating and changing instruction profiles	
Downloading a Safety program compiled in Fast Commissioning mode from the F-CPU to the PG/PC.	Interlocking by loading the station from the device
Changes in the "Settings" area of the *Safety Administration Editor*.	Blocking in the *Safety Administration Editor*
Changes to the password for the safety program.	
Renaming of the F-OB	Errors during download
All changes with Openness. (Name area *SafetyAdministration*)	Are rejected with an exception.

NOTE

For the changes marked with "Compiling errors", the compiling of the safety program is aborted in Fast Commissioning mode. An additional note is displayed in the inspector window under "Info > Compile" indicating the F-block containing the unsupported change.

NOTE

The table "Unsupported changes in Fast Commissioning mode with Fast Compile" serves as an aid. When you see errors during compiling that refer to blocks that you have not programmed yourself, an unsupported change was most likely made. In this case, undo the previous changes or exit Fast Commissioning mode and compile the entire safety program.

NOTE

Logging in the F-change history is incomplete when Fast Commissioning mode with "Fast Compile" is activated, the following entries are not recorded:

- Collective F-Signature
- Compiling time stamp
- Compiled F-blocks with signature and time stamp

Unsupported changes in Fast Commissioning mode with "Consistent Compile"

In Fast Commissioning mode with "Consistent Compile", you also cannot change your safety program at will. Compared to "Fast Compile", however, many more changes to the safety program are possible. The following is an overview of the changes **not** supported .

NOTE

Note that the changes mentioned here must not be present when enabling Fast Commissioning mode with "Consistent Compile". Therefore, make sure that the offline safety program is consistent and identical to the online safety program. If you do not observe this, the F-CPU may STOP.

Type of change	System response
All changes to the hardware configuration.	A STOP is required for the download to the F-CPU.
Adding/deleting of:	
• Flexible F-Link communications	Blocking in the *Safety Administration Editor*
• F-runtime groups (including changes)	
Changes in the "Settings" area of the *Safety Administration Editor*.	
Changes to the password for the safety program.	
Renaming of the F-OB	CPU goes to STOP
All changes with Openness. (Name area *SafetyAdministration*)	Are rejected with an exception.
Insertion of a new call of an ACK_GL instruction.	Possible, but results in passivation of all F-I/Os. Reintegration is only possible with a STOP-RUN transition.
Insertion of a new access to an F-I/O (access to a tag of the F-I/O DB or to the process image) that has not yet been used in the F-runtime group.	Possible, but results in passivation of the affected F-I/O. Reintegration is only possible with a STOP-RUN transition.
Deletion of a call to an ACK_GL instruction.	Possible, but results in passivation of all F-I/Os. Reintegration is only possible with a STOP-RUN transition.
Deletion of the last access to an F-IO (access to a tag of the F-I/O DB or to the process image) so that it is no longer used in the F-runtime group.	Possible, but results in a diagnostic buffer entry via a "Profisafe communication error".

Exiting Fast Commissioning mode

To exit Fast Commissioning mode with "Fast Compile" and return to Safety mode, proceed as follows:

1. Click on the "Deactivate Fast Commissioning" button.
2. Compile the Safety program with Software (rebuild all).
3. Download the safety program to the F-CPU. The F-CPU is set to STOP mode by this.

   In a redundant S7-1500HF system, you have to select "Stop R/H system" in the "Load preview" dialog.

After that, the online Safety program is consistent again and the F-CPU can be switched to RUN with Safety mode enabled.

To exit Fast Commissioning mode with "Consistent Compile" and return to Safety mode, proceed as follows:

1. Click on the "Deactivate Fast Commissioning" button.
2. Perform a STOP-RUN transition to enable safety mode again.

10.8 F-change history

Enable the logging of changes of the safety-related project data by using the option "Enable F-change history" in the *Safety Administration Editor*.

An F-change history is created for each F-CPU in the project navigation under "Common data/logs".

The following is logged in the F-change history:

- Collective F-Signature
- User name
- Compile time stamp
- Download of the safety-related project data with time stamp
- Compiled F-blocks with signature and time stamp

The F-change history can contain a maximum of 5000 entries per F-CPU. When the 5000 entries are exceeded, a new F-change history is created using the naming scheme "F-change history <CPU name> YYYY-MM-DD hh:mm:ss".

After a project upgrade, the "Go to" function is not supported anymore for the F-change history of the project for the entries which were created before *STEP 7 Safety* V15.1.

NOTICE
The connection between the F-CPU and the associated F-change history is made through the name of the F-change history. Therefore, do not rename the F-CPU and the F-change history. If you rename the F-CPU or the F-change history, a new F-change history with the current name of the F-CPU is started.

NOTE

You are not permitted to use the F-change history to identify changes of the safety-related project data for acceptance of changes.

To accept changes, proceed as described under Acceptance of Changes (Page 448).

NOTE

We recommend activating the F-change history before changing over to productive operation.

System acceptance 11

11.1 Overview of System Acceptance

Introduction

When performing a system acceptance test, all the standards and guidelines (for example PROFINET Installation Guidelines) relevant to the specific application must be complied with. This also applies to systems that are not "subject to acceptance". For the acceptance, you must consider the requirements in the Certification Report (https://support.industry.siemens.com/cs/ww/en/view/109825198).

As a general rule, the acceptance of an F-System is performed by an independent expert. The independence required of the expert must be defined in the safety plan and depends on the required PL/SIL.

Observe all warnings in this manual.

WARNING

The configuration of F-CPUs and F-I/Os as well as the programming of F-blocks must be carried out in TIA Portal as described in this documentation. To ensure safe operation with the SIMATIC Safety system, you must comply with the requirements of the relevant standards, such as IEC 61508. The section System acceptance (Page 427) describes procedures and tools of STEP 7 Safety to meet these requirements. *(S056)*

Proof of the correct implementation of the safety-related project data

In order for a system acceptance to be granted, you must assess and document the correctness of the individual components. For documentation of the component characteristics, you must create the safety summary.

The following characteristics must be covered:

- Correctness of the safety program including hardware configuration (including testing) (Page 428)
- Completeness of the safety summary (Page 429)
- Compliance of the system library elements used in the safety program with Annex 1 of the Report for the TÜV certificate (Page 430)
- Compliance of the know-how protected F-blocks used in the Safety program with their safety summary. (Page 431)
- Completeness and correctness of the hardware configuration (Page 432)
- Completeness and correctness of safety-related communication (Page 438)

- Identity of online and offline program (Page 444)
- Other characteristics (Page 445) such as software version, use of data from the standard user program

After the acceptance, you should archive all relevant documents and also the project data so as to make the accepted project available as a reference for a subsequent acceptance.

Safety summary

The safety summary (Page 400) is the documentation of the project that is required for system acceptance

11.2 Correctness of the safety program including hardware configuration (including testing)

The correctness of software cannot only be ensure through tests and verifications during commissioning, but rather already requires the observance of a wide variety of measures during creation. Also see warning S062 on this in chapter "Overview (Page 22)".

Verification/function test

Already during the creation, you will test (Page 403) your safety program and the associated hardware configuration. You must carry out these tests with regard to the specification of your safety functions and document them before you perform the system acceptance.

In order to perform a code review of your safety program and/or document the accepted program code, you can include the source code of all F-blocks in the safety summary (Page 400). To do this, select the "All" option when printing.

If you want to carry out a function test after loading, you have to carry out program identification. More information is available in "Downloading project data (Page 362)".

The correct function of the safety program must be guaranteed by complying with all steps from the "Overview of System Acceptance (Page 427)" chapter before it can be used productively. When using configuration control (option handling), you must ensure correct operation of the safety program for all possible station options by performing appropriate functional tests. You should archive the test reports along with the safety summary and the acceptance documents.

Times, for example monitoring times (Page 643) and delay times, can only be verified to a limited extent with functional tests (Page 362). For this reason, you should check these times selectively to determine whether they are dimensioned correctly, for example, using the safety summary.

Some of these times are itemized specifically in the safety summary, for example, the F-monitoring time (for communication between F-CPU and F-I/O) and the monitoring time of the safety-related CPU-CPU communication (TIMEOUT). To determine the monitoring times derived under normative conditions, the Excel file for response time calculation is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109783831). These have to be considered together with the practically determined conditions of the application. Note that these monitoring times have an impact on the response times of your safety functions.

Consistency of the safety program

Check in the "General information" section of the safety summary to determine whether the safety program was recognized as "consistent".

This is the case for S7-300/400 F-CPUs only if the following signatures are also identical:

- Collective F-Signature ("General information" section, "Collective F-Signature")
- "Signature of F-blocks with F-attribute" ("General information" section, "Current compilation")

Consistency of the safety program is required for the acceptance. If the signatures are not identical, you have the possibility to establish consistency by recompiling the safety program and re-creating the safety summary.

11.3 Completeness of the safety summary

Introduction

When you have an acceptance-ready version of your safety-related project data, you must perform and document additional checks of the safety summary to prove that the safety summary is complete and belongs to the safety program to be accepted.

Creating a safety summary

Follow the procedures described in Creating a safety summary (Page 400) to create the safety summary. In so doing, select "All" under Properties in the "Print" dialog to include the source code of your F-blocks and their utilized named value data types and PLC data types in the documentation.

Completeness of the safety summary

The safety summary of *STEP 7 Safety* is always created in its entirety. When performing subsequent processing steps (for example, creating copies, inserting (electronic) signatures, comments, etc.), the completeness must continue to be maintained.

If you created the safety summary with the "All" option, the source code of all F-blocks will also be printed. The printout of this source code also includes the footer, which contains the collective F-signature of the associated safety program.

The information "Number of pages in the safety summary" does not include the pages on which the source code of the F-blocks is output.

Association with the safety program

In the "General information" section of the safety summary, check whether the Collective F-Signature corresponds online and offline to the Collective F-Signature of the safety program to be accepted in the work area of the *Safety Administration Editor* under "General". If they are not the same, then the summary and safety program do not match. Bear in mind that the F-BaseID is not included in the Collective F-Signature and, if relevant, must be checked separately.

11.4 Compliance of the system library elements used in the safety program with Annex 1 of the Report for the TÜV certificate

Introduction

STEP 7 Safety contains LAD/FBD instructions for programming of your safety program as well as F-system blocks for creating an executable safety program that have been created and tested by SIEMENS and certified by TÜV. The F-system blocks used are automatically inserted by the F-system based on the set safety system version (see section "Settings" area of the Safety Administration Editor (Page 92)).

To allow you to check whether the used versioned LAD/FBD instructions and F-system blocks correspond to Annex 1 of the Report for the TÜV certificate and to the versions you intend to use, these are listed in the safety summary.

Procedure

To check, download the current Annex 1 of the report for the TÜV certificate "SIMATIC Safety" from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109825198).

Proceed as follows for the check:

WARNING

- (S7-1200, S7-1500) The versions of the versioned LAD/FBD instructions listed in the safety summary in the section "System library elements used in safety program" must correspond to the versions in Annex 1 of the Report for the TÜV certificate.
- (S7-300, S7-400) The versions, signatures and initial value signatures of the versioned LAD/FBD instructions and F-system blocks listed in the safety summary in the section "System library elements used in safety program" must correspond to the versions, signatures and initial value signatures in Annex 1 of the Report for the TÜV certificate.
- The versions of the versioned LAD/FBD instructions listed in the safety summary must meet the safety requirements of your application.

  Keep in mind possible differences in functionality of different versions specified in the section for the respective instruction.
- The safety system version listed in the safety summary under "Safety program settings" must match the versions in Annex 1 of the Report for the TÜV certificate. *(S054)*

In case of discrepancies, recheck whether you have the correct versions.

(S7-300, S7-400) Differences can also arise when there are F-blocks / instructions in your safety program that are not used.

11.5 Compliance of the know-how protected F-blocks used in the Safety program with their safety summary.

If you use know-how protected F-blocks (for example, from libraries) to program your Safety program, the source code for these is not output in the safety summary.

Therefore, the author of the know-how protected F-block must already carry out acceptance of the F-block and provide the following information:

S7-300/400 F-CPUs

- Signature and initial value signature of the know-how protected F-block
- Versions of all the used versioned LAD/FBD instructions
- Signatures and initial value signatures of all called F-blocks
- Signatures of all F-DBs accessed by the fail-safe block to be reused.

For system acceptance, you must perform the following checks using the safety summary:

- The signature and initial value signature of each know-how protected F-block listed in the safety summary in the section "F-blocks in Safety program" must correspond to the signature and initial value signature documented by the author.
- The versions of the versioned LAD/FBD instructions listed in the safety summary in the section "System library elements used in Safety program" must correspond to the versions of each know-how protected F-block documented by the author or must be functionally identical with them.
- The signatures and initial value signatures of the F-blocks called in each know-how protected F-block listed in the safety summary in the section "F-blocks in Safety program" must correspond to the signatures and initial value signatures (of the called F-blocks) documented by the author.

In case of differences, set the documented (or functionally identical) versions and use the F-blocks with the documented signatures and initial value signatures. If the version conflicts cannot be eliminated due to other dependencies, contact the author of the know-how protected block in order to obtain a compatible approved version.

S7-1200/1500 F-CPUs

- Signature of the know-how protected F-block
- Safety system version that was set while setting up the know-how protection
- Versions of all the used versioned LAD/FBD instructions
- Signatures of all called F-FBs/F-FCs in the know-how protected F-block.
- Signatures of all F-DBs accessed by the know-how protected F-block.

For system acceptance, you must perform the following checks using the safety summary:

- The signature of each know-how protected F-block listed in the safety summary in the section "Know-how protected F-blocks in the Safety program" must correspond to the signature documented by the author.
- The safety system version of each know-how protected F-block listed in the safety summary under "Know-how protected F-blocks in the Safety program" must correspond to one of the versions listed in Annex 1 of the Report for the TÜV certificate.
- The versions of the versioned LAD/FBD instructions of each know-how protected F-block listed in the safety summary in the section "Know-how protected F-blocks in the Safety program" must correspond to the versions documented by the author or must be functionally identical with them.
- The signatures of the F-blocks called in each know-how protected F-block listed in the safety summary in the section "Know-how protected F-blocks in the Safety program" must correspond to the signatures (of the called F-blocks) documented by the author.

In case of differences, set the documented (or functionally identical) versions and use the F-blocks with the documented signatures. If the version conflicts cannot be eliminated due to other dependencies, contact the author of the know-how protected block in order to obtain a compatible approved version.

11.6 Completeness and correctness of the hardware configuration

Introduction

The hardware configuration is an essential component of the project to be accepted. With the configuration of the hardware, you have set properties that can influence the safety of signals. You must document these settings with the safety summary to prove that you fulfill the safety requirements of your application.

The section "Hardware configuration of F-I/O" is available in the safety summary for this. This section consists of several tables:

- A table with information about the F-CPU and about the ranges of F-destination addresses used, the "Central F-source address" and the F-BaseID of the F-CPU.
- Overview tables with the F-I/O used.
- A table for each F-I/O with information on the F-I/O and all parameters of the F-I/O with the configured values.

NOTE

Note that you will find F-I/O that you address via safety-related I-slave-slave communication in the safety summary of the F-CPU of the I-slave and not in the safety summary of the F-CPU of the assigned DP master.

The safety summary of the F-CPU of the DP master contains a note in the overview table for this F-I/O indicating that it is not assigned to this F-CPU.

NOTE

When using shared devices:

Note that F-I/O that you address in a shared device can be found in the safety summary of the F-CPU of the IO controller to which it is assigned.

The safety summary of the other F-CPUs (IO controllers) that share the cross-project shared device contains a note in the overview table for this F-I/O indicating that it is not assigned to this F-CPU.

Procedure for checking that the hardware configuration is complete

Check whether the safety summary contains all the configured F-I/O. Also make sure that there is no F-I/O that you have not configured as belonging to this F-CPU.

NOTE

If configuration control (option handling) is used, the safety summary must contain all the F-I/Os of the maximum configuration. The following checks are to be carried out for al the F-I/Os of the maximum configuration.

Procedure for checking the correctness of the hardware configuration using the safety summary

To check the hardware configuration for correctness, proceed as follows:

1. Check in the "Hardware configuration of F-IO" section to verify the uniqueness of the PROFIsafe addresses.

   Observe the information in sections

   PROFIsafe addresses for F-I/O of PROFIsafe address type 1 (Page 66)

   PROFIsafe addresses for F-I/O of PROFIsafe address type 2 (Page 67)

   PROFIsafe addresses for F-I/O of PROFIsafe address type 3 (Page 69)

   Peculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices (Page 38)

   Recommendation for PROFIsafe address assignment (Page 62)

   – For F-CPUs to which F-I/Os of PROFIsafe address type 2 are assigned:

     Check if the "Central F-source address" parameter of the individual F-CPUs differs network-wide.

     (This also applies to F CPUs that have F-I/O of PROFIsafe address type 3 assigned to them, unless an individual active F-BaseID is generated for each F-CPU.)

   – Check that the setting of the F-BaseID parameter is as expected, i.e. inactive (value 0), "Delayed transfer" (value 0x7C6) or an individually generated value for the F-CPU. Observe also warnings S115 and S116.

– For F-I/Os of PROFIsafe address type 1 check whether the F-destination addresses comply with the following warning:

WARNING

F-I/Os of PROFIsafe address type 1 are uniquely addressed by their F-destination address (e.g. with the switch setting on the address switch).

The F-destination address (and therefore also the switch position on the address switch) of the F-I/O of PROFIsafe address type 1 must be unique network-wide* and CPU-wide**/*** (system-wide) **for the entire** F-I/O. For this, the F-I/O of PROFIsafe address type 2 and PROFIsafe address type 3 when F-BaseID is inactive (value = 0) must also be taken into account. *(S051)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** "CPU-wide" means all F-I/O assigned to an F-CPU: Central F-I/O of this F-CPU, F-I/O for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

*** In a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be considered as one F-CPU with regard to the PROFIsafe addresses. The "Central F-source address" and, if present, the F-BaseID are therefore set identically for both F-CPUs by the system.

NOTE

For more information on the assignment of PROFIsafe addresses that are unique for the CPU and across the network, see this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).

– For F-I/Os of PROFIsafe address type 2 check whether the F-destination addresses comply with the following warning:

WARNING

F-I/O of PROFIsafe address type 2 is uniquely addressed using a combination of F-source address ("Central F-source address" parameter of the assigned F-CPU) and F-destination address.

The combination of F-source address and F-destination address for each F-I/O of PROFIsafe address type 2 must be unique network-wide* and CPU-wide**/*** (system-wide). In addition, the F-destination address must not be occupied by F-I/O of PROFIsafe address type 1.

If you use a supported configuration (Page 63), you only have to ensure that the "Central F-source address" parameter of all F-CPUs is unique network-wide*. *(S052)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** "CPU-wide" means all F-I/O assigned to an F-CPU: Central F-I/O of this F-CPU, F-I/O for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

*** In a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be considered as one F-CPU with regard to the PROFIsafe addresses. The "Central F-source address" and, if present, the F-BaseID are therefore set identically for both F-CPUs by the system.

NOTE

For more information on the assignment of PROFIsafe addresses that are unique for the CPU and across the network, see this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).

– For F-I/O of PROFIsafe address type 3, check whether the F-destination addresses comply with the following warning:

WARNING

The F-BaseID may only be assigned manually in exceptional cases, when you are sure that the PROFIsafe addresses of the F-I/Os of the F-CPU are unique (worldwide). F-I/Os with the same F-BaseID must differ in the combination of F-source and F-destination address. We explicitly advise against manual assignment and recommend generation with the tools offered in the TIA Portal.

With the manual assignment of value "0" as F-BaseID, you lose the advantages of PROFIsafe address type 3 and must adhere to the specifications for PROFIsafe address type 2 (see warning S052). *(S115)*

– Check whether the PROFIsafe addresses of fail-safe GSD based DP slaves / GSD based I/O devices comply with the following warning:

WARNING

Check the documentation for your fail-safe GSD based DP slaves / fail-safe GSD based I/O devices to find out the valid PROFIsafe address type. If you do not find the necessary information, assume PROFIsafe address type 1. For configuring, proceed as described under PROFIsafe addresses for F-I/O of PROFIsafe address type 1 (Page 66), PROFIsafe addresses for F-I/O of PROFIsafe address type 2 (Page 67) or PROFIsafe addresses for F-I/O of PROFIsafe address type 3 (Page 69).

Set the F-source address for fail-safe GSD based DP slaves / fail-safe GSD based I/O devices according to the manufacturer's specifications. If the F-source address needs to correspond to the "Central F-source address" parameter of the F-CPU (PROFIsafe address type 2), you will find the latter in the "Properties" tab of the F-CPU. In this case, check the safety summary to verify that the value for the "Central F-source address" parameter corresponds to the value of the F-source address of the fail-safe GSD based DP slave/fail-safe GSD based I/O device. *(S053)*

2. Check the safety-related parameters (including F-monitoring time or F_WD_Time) of all configured F-I/O.

   You can find these parameters in the "Hardware configuration of F-I/O" section in the detailed tables for the F-I/O.

   The table consists of two parts:

   – The left part contains the parameters which refer to the F-I/O itself ("Module data").
   – The right part contains the parameters of the individual channels ("Channel parameters")

   These parameters must be set as prescribed by the safety requirements of your application.

   When using fail-safe GSD based DP slaves/GSD based I/O devices, note the relevant documents for the possible additional safety-related (technological) parameters.

NOTE

F-I/O that are to be assigned the same safety-related parameters (except for PROFIsafe addresses) can be copied during configuration. Except for the PROFIsafe addresses, you no longer have to check the safety-related parameters individually. It is sufficient to compare the "F-parameter signature (without addresses)" in the "Hardware configuration of the F-I/O" section in the overview table. This also applies to fail-safe GSD based DP slaves/GSD based I/O devices without i-parameters. For GSD based DP slaves/GSD based I/O devices with i-parameters, it might be that the "F-parameter signature (without addresses)" does not match, even though all safety-related parameters, except for the PROFIsafe addresses, do match. In this case, you need to compare all safety-related parameters.

Exception:

For F-I/Os that do not support the "RIOforFA-Safety" profile, you need to compare the "Behavior after channel fault" parameter, if any, in addition to the "F-parameter signature (without addresses)".

3. Check whether the article numbers of the F-I/O in the safety summary correspond to the article numbers of the F-I/O actually present in the system. If the article numbers are different, the F-I/O present must be compatible as a replacement part for the F-I/O listed in the safety summary.
4. For non-supported configuration, see Configurations supported by the SIMATIC Safety F-system (Page 63).

WARNING

If you create a configuration that is not one of the supported configurations, you must observe the following in addition to the warnings S051, S052, S053 and S115:

- Make sure that the F-I/O of this configuration appears in the safety summary and that an F-I/O DB has been created for it. Otherwise, you cannot use the F-I/O in this configuration. (Contact Customer Support.)
- For F-I/O in the PROFINET IO environment[1], you must check the safety summary for correctness of the PROFIsafe operating mode parameter (F_Par_Version). V2 mode must be set in the PROFINET IO environment. F-I/O that support only V1 mode must not be used in the PROFINET IO environment.
- Based on the safety summary, you must check whether the components of the PROFIsafe address centrally assigned for the F-CPU were transferred correctly into the respective F-I/Os:
  - PROFIsafe address type 3: F-BaseID from the "F-BaseID" parameter of the F-CPU.
  - PROFIsafe address type 2 and 3: F-source addresses from the "Central F-source address" parameter of the F-CPU.
- You must ensure the CPU-wide[2,3] and/or network-wide[4] unique assignment of the F-destination address for F-I/Os:
  - For F-I/O of PROFIsafe address type 1 or 2 (if you cannot set the F-source address to match the "Central F-source address" parameter of the F-CPU), you must ensure the network-wide[4] uniqueness of the PROFIsafe address through the unique assignment of the F-destination address alone.
  - In an unsupported configuration, you must check the uniqueness of the F-destination address individually for each F-I/O using the safety summary, regardless of the PROFIsafe address type.

    PROFIsafe address type 1: Network-wide[4] and CPU-wide[2,3]

    PROFIsafe address type 2 and 3: Only CPU-wide[2,3].

(S050)

1) The F-I/O is located in the "PROFINET IO environment" if at least part of safety-related communication with the F-CPU takes place via PROFINET IO. If the F-I/O is connected via I-slave-slave communication, also keep in mind the communication line to the DP master/IO controller.

2) "CPU-wide" means all F-I/Os assigned to an F-CPU: Central F-I/O of this F-CPU, F-I/O for which the F-CPU is DP master/IO controller and assigned F-I/O in a shared device. An F-I/O that is addressed using I-slave-slave communication is assigned to the F-CPU of the I-slave and not to the F-CPU of the DP master / IO controller.

3) In a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be considered as one F-CPU with regard to the PROFIsafe addresses. The "Central F-source address" and, if present, the F-BaseID are therefore set identically for both F-CPUs by the system.

4) A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

NOTE

For more information on the assignment of PROFIsafe addresses that are unique for the CPU and across the network, see this FAQ (https://support.industry.siemens.com/cs/ww/en/view/109740240).

11.7 Completeness and correctness of safety-related communication

Introduction

Safety-related communication is based on the mechanisms of the standard communication of *STEP 7*.

Safety-related communication must also detect and uncover communication errors, which remain undetected in the lower-level standard communication. Further parameters are required for this, which you have to document and check on acceptance.

For this purpose, the "Block parameters for safety-related CPU-CPU communication", "Communications via Flexible F-Link Overview" and "Communications via OPC UA Safety Overview" sections are available in the safety summary.

The section "Block parameters for safety-related CPU-CPU-communication" contains up to two tables (for communication via PROFIBUS DP or PROFINET IO and for communication via S7 connections).

The section "Communications via Flexible F-Link Overview" contains a table with an overview of the connection configurations and a "Communications via Flexible F-Link for UDT" table for each used F-compliant PLC data type (UDT).

The section "Communications via OPC UA Safety Overview" contains multiple tables with an overview of all OPC UA data types used by SafetyProviders or SafetyConsumers, as well as a detailed view of all communication parameters for every SafetyProvider and every SafetyConsumer.

Not all safety-related communication is available for all F-CPUs. More information can be found in the section "Safety-related communication (Page 208)".

NOTE

The statements made regarding communication via Flexible F-Link in this section also apply when this communication is used between F-runtime groups.

11.7.1 Completeness and correctness of safety-related communication

(S7-300, S7-400) Observe the following warning for safety-related communication with the SENDS7/RCVS7 instructions:

WARNING

The value of the respective F-communication ID (input R_ID; data type: DWORD) can be freely selected; however, it must be odd and unique for all safety-related communication connections network-wide* and CPU-wide. The value R_ID + 1 is internally assigned and must not be used.

You must supply inputs ID and R_ID with constant values when calling the instruction. Direct read or write access to ID and R_ID in the associated instance DB is not permitted in the Safety program. *(S020)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

Observe the following warning for safety-related communication with the SENDDP/RCVDP instructions:

WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide**** at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.

You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure a unique F-communication ID during startup of the safety program, because it is only specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

**** With a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be regarded as one single F-CPU with regard to the DP_DP_ID.

Observe the following warnings for communication via Flexible F-Link:

WARNING

When a new Flexible F-Link communication is created in the Safety Administration Editor, a unique F-communication UUID for the communication is provided by the system. When communication is copied in the Safety Administration Editor within the parameterization table or copied to another F-CPU, the F-communication UUIDs are not regenerated and therefore not unique anymore. If the copy is used to configure a new communication relationship, you yourself must ensure the uniqueness. To do this, select the relevant UUIDs and generate them again via the "Generate UUID" context menu. You must ensure the uniqueness in the safety summary during acceptance, at the latest. *(S087)*

WARNING

For each communication connection via Flexible F-Link, you must ensure that the offsets of the elements of the F-compliant PLC data type (UDT) used for the communication connection match on the transmit and receive sides during acceptance of the safety program.

You can find the offsets in the respective safety summary. To do this identify the communication connection by means of the UUID. *(S088)*

11.7.2 Procedure to check the correctness of the configuration of communication with OPC UA Safety

Procedure to check the correctness of the project planning for every SafetyProvider

You must carry out the following verifications for each SafetyProvider in the respective SafetyProvider detail view of your safety summary.

- Check the correctness of the values of the SPI parameters.
- Check the correctness of the assignments of the local data on the SAPI parameters.
- Check whether the necessary uniqueness of the combination of active SafetyProviderID and active SafetyBaseID of all SafetyProviders is available at all times.
  - For static connections:

    The set values can be found in the respective SafetyProvider detail view.

    If the value for SafetyBaseIDConfigured has been generated by the system, you do not have to undergo the SafetyBaseID, since the sufficient uniqueness is ensured by the STEP 7 Safety Engineering. If you have entered the value yourself, you must verify

sufficient uniqueness. You will be shown whether this is necessary in the respective SafetyProvider detail view.

– For dynamic connections:

  Ensure correct implementation of the algorithm for generating the values of the local data that is mapped to the SafetyProviderID and SafetyBaseID SAPI parameters.

Note the following warnings:

WARNING

For the unique and secure authentication of a SafetyProvider, the combination of active SafetyProviderID and active SafetyBaseID at any point in time must be unique for all OPC UA Safety communication connections network-wide. **

If your network is not safely separated from the outside world through physical separation, the active SafetyBaseID at any point in time must be a value that was generated randomly in accordance with the OPC UA Specification OPC 10000-15. ***

You must ensure the uniqueness in the safety summary during acceptance of the safety program. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S102)*

* If you cannot ensure a unique combination during startup of the Safety program because the active SafetyProviderID or active SafetyBaseID is not formed until runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID is "0" during this phase.

** SafetyProviders to which the same local data element of your safety program is mapped (Safety Multicast (Page 342)) at the SafetyData SAPI parameter are permitted to use the same combination.

*** If you have entered a value for the SPI parameter SafetyBaseIDConfigured of a SafetyProvider (either in the NodeSet or in the properties of a SafetyProvider), you yourself must ensure that the value meets the safety requirements of the OPC UA Specification OPC 10000-15. Alternatively, generate the value of SafetyBaseIDConfigured again by opening the properties tab of the affected SafetyProvider and clicking on the "Generate" button.

WARNING

Due to system constraints, formation of a SafetyBaseID at runtime of your Safety program is only possible in your standard user program.

Note that these program sections are therefore not captured by the collective F-signature and are not protected by "Access protection for safety-related project data (Page 101)" or "F-CPU access protection (Page 104)".

For this reason, you must take organizational measures to ensure that only authorized persons can change these program sections.

Print the relevant program sections and supplement your safety summary with this printout. *(S103)*

WARNING

If you have not defined any value for the SPI parameter of a SafetyProvider in the NodeSet for the SPI parameter, a sufficiently clear UUIDV4 is made available from the system as a value for the parameter of the respective SafetyProvider when importing the NodeSet into the TIA Portal.

Through subsequent copying of a SafetyProvider (e.g. copying the NodeSet to another F-CPU, copying the F-CPU or copying the project), values provided by the system are not generated again and are therefore not unique anymore.

If such a copy is used to configure a new communication relationship, you yourself need to ensure the uniqueness. To do this, open the properties tab of all affected SafetyProvider and generate the value of SafetyBaseIDConfigured again by clicking on the "Generate" button. The uniqueness must be checked in the safety summary during acceptance. *(S110)*

Procedure to check the correctness of the configuration for every SafetyConsumer

You must carry out the following verifications for each SafetyConsumer in the respective SafetyConsumer detail view of your safety summary.

- Check the correctness of the values of the SPI parameters.
- Check for compliance of the active SafetyProviderID and active SafetyBaseID with the SafetyProvider intended for communication.
  - For static connections:

    The set values can be found in the respective SafetyConsumer detail view.
  - For dynamic connections:

    Ensure correct implementation of the algorithm for generating the values of the local data that is assigned to the SAFETY_PROVIDER_ID and SAFETY_BASE_ID variables of the associated F-OPC-UA-Consumer-DB.
- Check the correctness of the substitute value.
- Check that the data structure of SafetyData of the SafetyConsumer matches the data structure of SafetyData of the intended SafetyProvider. This means that at each position of the data structure, the data type must match the data type on the corresponding position on the side of the SafetyProvider on the side of the SafetyConsumer. Different names may be permitted if it is ensured that there are no confusion of the meanings of the individual elements of the data structure. In particular, the correct order of elements of the same data type is relevant.

Note the following warnings:

WARNING

Due to system constraints, formation of a SafetyBaseID at runtime of your Safety program is only possible in your standard user program.

Note that these program sections are therefore not captured by the collective F-signature and are not protected by "Access protection for safety-related project data (Page 101)" or "F-CPU access protection (Page 104)".

For this reason, you must take organizational measures to ensure that only authorized persons can change these program sections.

Print the relevant program sections and supplement your safety summary with this printout. *(S103)*

WARNING

For secure authentication of the SafetyProvider whose SafetyData is to be evaluated, the values of the active SafetyProviderID and active SafetyBaseID of the SafetyConsumer must correspond to the values of the active SafetyProviderID and active SafetyBaseID of this SafetyProvider at all times*.

When accepting the Safety programs, you must ensure compliance in the relevant safety summary. If the active SafetyProviderID or active SafetyBaseID is not generated until runtime of your Safety program, you must ensure the correct implementation of the algorithm for the generation of the values. *(S104)*

* If you cannot yet provide the values when starting the Safety program because they are only created during the runtime of your Safety program, you must ensure that the active SafetyProviderID or active SafetyBaseID or the Enable "0" SAPI parameter in this phase.

WARNING

For each communication connection with OPC UA Safety, you must ensure when accepting the Safety program that the data structure of the OPC UA data types used by SafetyData matches on the SafetyProvider and SafetyConsumer side. In particular, the correct order of elements of the same data type is relevant. You can find the structures of the OPC UA data types used in the respective safety summary.

To identify the communication connection, note the following points:

- For static connections:

  To do this identify the communication connection by means of the combination of SafetyProviderIDConfigured and SafeBaseIDConfigured.
- For dynamic connections:

  To do this, identify the communication connection by means of the algorithm for the allocation of the values for SafetyProviderID and SafetyConsumerID.

(S111)

11.8 Identity of online and offline program

Once you have checked all properties of the offline safety program you must ensure that the safety program is identical on the F-CPU on which it is supposed to be run.

WARNING

In a redundant S7-1500HF system, you must perform the verification of identity of the online and offline program in RUN-Redundant mode. In so doing, it is sufficient to perform the verification only for one S7-1500 HF-CPU. *(S098)*

1. Connect online with the F-CPU. If multiple F-CPUs can be reached over a network (e.g. Industrial Ethernet) by the programming device / PC, you have to ensure that you are connected with the correct F-CPU. For example with "Online & diagnostics" > "Online accesses " > "Flash LED".
2. Open the *Safety Administration Editor*.
3. Check whether the online and offline Collective F-Signatures correspond to the Collective F-Signature from the safety summary.
4. Now check in the "General" area under "Safety program status" whether the safety programs are identical online and offline.

   Use the "Status" and "Version comparison" display to check which situation you are dealing with and, if necessary, execute the recommended measure:

Status	Version comparison	Statement	Measure
!	Not relevant	The safety programs are different.	– Ensure that you are connected to the desired F-CPU. – Download the safety program to the F-CPU.
●	!	The safety programs are identical but different versions of F-blocks are used.	The safety program must be downloaded to the F-CPU for the latest versions to become effective.
●	●	The safety programs are identical.	None

5. If relevant:
   Check in the "General" area under "PROFIsafe" to see if the values for the F-BaseID match offline and online. See also warning S116.

Status	Meaning
●	The online and offline F-BaseIDs match.
!	The online and offline F-BaseIDs do *not* match.
○	The F-BaseID could not be determined online or is not supported.

11.9 Other characteristics

Introduction

In addition, you must check a few more characteristics that are also relevant for the acceptance of the project.

Plausibility check for data transfer from the standard program to the safety program

Check to determine whether a plausibility check was programmed for all data transferred from the standard user program to the safety program. For this purpose, the "Data from the standard user program" section lists all tags of the standard user program that you are reading in the safety program. Tags of the standard user program that you are writing in the safety program are not listed here because a plausibility check is not required for them. For more information, refer to the S015 warning in section "Data Transfer from Standard User Program to Safety Program (Page 206)".

Multiple call of an F-FB or an instruction with the same instance (single instance or multi-instance)

Check whether you used a separate instance for each call of an F-FB or an instruction.

Multiple calls with the same instance are usually not worthwhile and require special care:

For example, if you explicitly transfer an operand (for example, as a constant) in the 1st call to the instance, and there is no explicit transfer in the 2nd call (so that the start value is valid), you must verify which value in the 2nd call is valid for this operand. Also consider startup processes in this regard; higher priority OBs or similar in which the 1st call may be present.

Checking the program version

Check whether the version of *STEP 7 Safety* used to create the summary (in the footer of the printout) is as least as high as the version used to compile the safety program. You can find the latter version in the section "General information" of the safety summary under "Used versions". Both versions must be listed in Annex 1 of the Report for the TÜV certificate.

Ability to disable safety mode

Make sure that safety mode cannot be disabled. For information about this, refer to section "General information" under "Safety program settings". This setting ensures that the safety mode of the safety program cannot be disabled inadvertently. For more information, refer to the S027 warning in section "Disabling safety mode (Page 405)".

Safety system version with an S7-1500 HF-CPU

Check whether the safety system version is V2.4 or higher when using an S7-1500 HF-CPU.

For information about this, refer to section "General information" under "Safety program settings".

Access protection

Check in the "General information" section under "Access protection" to determine whether the setting for access protection is permitted. Note the following warnings.

Otherwise, the project must not be accepted, because the safety program in the F-CPU is not protected against unauthorized accesses.

WARNING

(S7-300, S7-400) In productive operation, it must be prevented that changes to the standard user program are unintentionally made in the safety program as well. For this purpose, you must configure the protection level "Write protection for fail-safe blocks" and configure a password for the F-CPU.

With the "Write protection" or "Write/read protection" protection level, the password would apply to the standard and the safety program. *(S001)*

WARNING

(S7-1200, S7-1500) In productive operation, the safety-related project data must be protected against unintentional changes.

If you use user management, the Runtime rights "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" and the engineering right "Manage users and roles" may only be granted to authorized users. You must also limit the assignment of user rights to trained personnel. Before the transition into productive operation, you must remove the "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" rights from the "Anonymous" user.

If you are not using user management or the "Access control via access levels" parameter is activated, then configure at least the "Full access (no protection)" protection level and assign a password under "Full access incl. fail-safe (no protection)". This protection level allows full access only to the standard user program and not the safety program.

If you select a higher protection level, for example to protect the standard user program, you must assign an additional password for "Full access (no protection)".

Assign different passwords for the individual access levels. *(S041)*

F-Admin right of the web server

For S7-1200 G1 F-CPUs with firmware < V4.7 and S7-1500 F-CPUs with firmware < V3.1, the user management of the web server is part of the hardware configuration.

For S7-1500 F-CPUs as of firmware V3.1 and S7-1200 G1 as of firmware V4.7 or S7-1200 G2 as of firmware V1.0, this right is set in the Runtime rights of the respective F-CPU in the "Users and roles" area.

When downloading for the last time before the transition to productive operation, ensure that only authorized persons have the "F-admin" right for the web server.

After the download, the "F-Admin" right setting can only be checked online in the TIA Portal in the *Safety Administration Editor* (S7-1200 G1 F-CPUs with firmware < V4.7 and S7-1500 F-CPUs with firmware < V3.1) or in the "Security settings\Users and roles" tab (F-CPUs S7-1500 as of firmware V3.1 and S7-1200 G1 as of firmware V4.7 or S71200 G2 as of firmware V1.0).

WARNING

The "Change parameter of the F-System (F-Admin)" authorization for the web server (including web server API) without password protection (user "Everybody", or user "Anonymous" when using the user management) is intended only for testing, commissioning, etc. This means only when the system is not in productive operation. In this case, you must ensure the safety of the system through other organizational measures.

Before the transition to productive operation, you must remove the rights "Change parameter of the F-System (F-Admin)" and "Full access including fail-safe" from the "Everybody" or "Anonymous" user.

The password of the web server user with "Change parameter of the F-System (F-Admin)" right may only be disclosed to authorized persons. After downloading the hardware configuration, check whether only permitted users of the web server have the "Change parameter of the F-System (F-Admin)" right on the F-CPU. To do so, use the online mode of the *Safety Administration Editor* for an F-CPU without user management or the "Security settings\Users and roles" tab for an F-CPU with user management.

Saving the login file and the password of the web server in the browser is only permitted when usage by unauthorized persons is prevented through other organizational measures.

If you use the ticket mechanism, handling of the tickets must be just as restrictive as handling of the user password of the web server with the "Change parameter of the F-System (F-Admin)" right. *(S064)*

11.10 Acceptance of Changes

Introduction

In general, you can adopt the same approach for the acceptance of changes as the initial system acceptance (see Overview of System Acceptance (Page 427)).

You have to check the entire safety-related project data (Safety program and safety-related hardware configuration) for changes and determine the safety-related project data to be validated and approved as part of an impact analysis.

WARNING

In the case of acceptance of changes, you must check whether the intended changes were made correctly and completely.

You must also check whether unintentional changes may have been made at another location (for example, F-I/O or instructions that were added). *(S072)*

To avoid the acceptance of the entire system in case of negligible changes, *STEP 7 Safety* helps you to identify those parts of your Safety program that have changed.

To accept changes, proceed as follows:

1. Localize the changes in the safety-related project data:
   - changed or newly added F-blocks
   - changed or newly added instructions and F-system blocks
   - safety-related parameters of the changed or newly added F-I/O
   - structure of the safety-related hardware configuration (e.g. slot positions or start addresses of the F-I/Os)
   - changed safety-related communication via Flexible F-Link
   - changed safety-related communication via OPC UA Safety
2. From these changes, determine the safety-related project data affected by them (impact analysis). This can also be safety-related project data that has not been changed.
3. Then you carry out a validation and acceptance of the safety-related project data affected by the changes.

NOTE

Acceptance of changes is not possible after CPU migration.

WARNING

When you make changes in which the assignment of input/output addresses and wiring can change, then you must perform a wiring test (Page 409).

Examples for such changes are:

- Adding F-I/Os
- Changing the start address of F-I/Os
- Changing the slot position of F-I/Os
- Changing
  - the rack
  - the slave/device address
  - the PROFIBUS DP/PROFINET IO subnet
  - the IP address
  - the device name

(S071)

Localization of changes in the safety-related project data

To be able to localize relevant changes, you need two TIA projects:

- Reference project: Contains the initially accepted project data. They are the starting point for the upcoming comparison.
- Project to be accepted: Contains the current safety-related project data. It is the result of the reference project and the changes made in it.

To localize changes you have to compare the safety-related project data from the reference project with the safety-related data of the project to be accepted (see Comparing Safety Programs (Page 398)). Use filter setting "Compare only F-blocks relevant for certification". This limits the output of the comparison to the relevant F-blocks.

We recommend adding the summary (possibly as PDF) of the compare result to the acceptance documents.

The Collective F-Signature is a quick first step to determine whether relevant changes have been made. If the signature has changed, relevant changes are present in the safety-related project data.

(S7-1200, S7-1500) You can now use the Collective F-SW-Signature, the Collective F-HW-Signature and the F-Communication Address Signature to narrow down whether these changes are contained in the Safety program (Collective F-HW-Signature changed) and/or in the safety-related hardware configuration (Collective F-HW-Signature) and/or in the communication data (with Flexible F-Link, F-Communication Address Signature).

Bear in mind that the F-BaseID does not enter into any of the specified signatures and, if relevant, must be checked separately (see "Completeness and correctness of the hardware configuration (Page 432)").

Localization of changes in the Safety program

(S7-1200, S7-1500) A quick possibility to detect changes in the Safety program is the comparison of the Collective F-SW-Signature of the safety-related project data in the reference project with the Collective F-SW-Signature in the safety-related project data in the project to be accepted. If they differ from each other, this means that there are changes in the Safety program which need to be validated and, if necessary, accepted.

To localize changes in the Safety program, perform an offline-offline comparison between the Safety program to be accepted of the project to be accepted and the Safety program of the reference project (see Comparing Safety Programs (Page 398)).

WARNING

Make sure that the comparison criterion "Safety" is enabled and all other comparison criteria are disabled so that the criteria relevant for acceptance of changes are taken into consideration in the comparison. *(S069)*

If additional comparison criteria are enabled, you will see additional changes not relevant for the acceptance of changes (e.g. time stamp).

The status of the comparison helps you to identify which F-blocks were changed.

(S7-1200, S7-1500) As an alternative to the offline-offline comparison, you can localize the changes in the Safety program by comparing the group signatures. Use the safety summary of the reference project and of the project to be accepted for this purpose. Groups with an unchanged signature indicate that no F-blocks in them or lower-level groups have been changed. In groups with a changed group signature, you can localize the changed F-blocks using their changed block signature. Note that the assignment of F-blocks to groups is not recorded by the Collective F-Signature.

Changes to the maximum cycle time of an F-runtime group and F-cycle time warning limit of an F-runtime group are visible during comparison output through changes to the system block F-runtime group info DB.

The following changes do not influence the behavior of the Safety program directly and neither lead to a change of the Collective F-Signature nor are they shown during an offline-offline comparison. In the event of a change acceptance test, you should be able to identify these specifically using the safety summaries:

- Changes to the runtime for the deactivated safety mode
- Changes of the Safety System version
- Changes in the group structuring of the program blocks

Localization of changes in the safety-related hardware configuration

(S7-1200, S7-1500) A quick possibility to detect changes in the safety-related hardware configuration is the comparison of the Collective F-HW-Signature of the safety-related project data in the reference project with the Collective F-HW-Signature of the safety-related project data in the project to be accepted. If they differ from each other, this means that there are changes in the safety-related hardware configuration which need to be validated and, if necessary, accepted.

(S7-1200, S7-1500) If the Collective F-HW-Signature has changed and all F-IOs are unchanged, this indicates that safety-related parameters of the F-CPU have changed, or that the structure of the safety-related hardware configuration has changed, for example, slot positions.

Bear in mind that the F-BaseID does not enter into the Collective F-HW-Signature.

There are two possible ways for localizing safety-related changes in the safety-related hardware configuration:

- Localization by offline-offline comparison
- Localization by comparison of two safety summaries

The procedure is described below.

Localization by offline-offline comparison

The reference project and the project to be accepted must be consistent and compiled for a comparison. To perform the comparison, see Comparing Safety Programs (Page 398).

1. Navigate in the comparison result to the "System blocks > STEP 7 Safety > F-I/O DBs" folder. All data blocks listed in this folder are F-I/O-DBs and are each assigned to an F-I/O.
   - If the F-I/O-DBs in the comparison result are identical, this means that the safety-related configuration of the assigned F-I/O was also not changed. Standard-parameters might have changed.
   - If the F-I/O-DBs in the comparison result are not identical, this means that the safety-related configuration of the assigned F-I/O was also changed.
   - If F-IO DBs in the comparison result are marked as "not existing", associated F-IOs might have been deleted or added or the name or start addresses of the F-IOs have been changed. In this case, you can find the assignment of an F-I/O DB to a specific F-I/O in the safety summary under "Hardware configuration of F-I/O".
2. If you have found changed F-I/O, you can check the changed parameters in the safety summary as described below.

Note that this method is not suitable for identifying differences for the following parameters: HW ID, slot address, F-BaseID.

Localization by comparison of two safety summaries

Carry out a comparison based on two safety summaries as follows:

1. In the section "Hardware configuration of the F-I/Os" compare the start addresses (I/O addresses), the parameter "Behavior after channel fault" and the slot of the F-I/Os.
2. In the "Hardware configuration of F-I/O" section in the overview table of the F-I/O used, compare the parameter CRCs of the F-I/O with those in the safety summary of the corresponding F-CPU from the reference project.
   - If the "Parameter signature (without addresses)" is different for an F-I/O, this indicates the existence of a change in the safety-related parameters of the F-I/O.

     In this case, check the corresponding detail table of the safety-related parameters of the F-I/O and verify the uniqueness of the PROFIsafe addresses.
   - If the "Parameter signature (w/o addresses)" is identical, only the PROFIsafe addresses have been changed.

     In this case it is sufficient to verify the uniqueness of the PROFIsafe addresses.

Check as described in section "Completeness and correctness of the hardware configuration (Page 432)".

(S7-1200, S7-1500) Detecting changes in the communication with Flexible F-Link

A quick possibility to detect changes in the configuration of the communication with Flexible F-Link is the comparison of the F-communication address signature of the safety-related project data in the reference project with the F-communication address signature of the safety-related project data in the project to be accepted. If they differ from each other, this means that there are changes in the configuration of the communication (UUID only) with Flexible F-Link that must be validated and, if necessary, accepted. Other communication parameters such as timeout or transmission direction are covered by the Collective F-SW-Signature (see "Localization of changes in the Safety program" above).

There are two ways to localize safety-related changes in the communication with Flexible F-Link:

- Localization by offline-offline comparison
- Localization by comparison of two safety summaries

The procedure is described below.

Localization by offline-offline comparison

The reference project and the project to be accepted must be consistent and compiled for a comparison. For information on performing the comparison, see Comparing Safety Programs (Page 398).

1. Navigate in the comparison result to the "System blocks > STEP 7 Safety > Flexible F-Link" folder. All data blocks listed in this folder are F-communication DBs, and they are each assigned to a Flexible F-Link communication.
   - If F-communication DBs in the comparison result are identical, this means that the safety-related configuration of the assigned Flexible F-Link communication was not changed.
   - If F-communication DBs in the comparison result are different, this means that the safety-related configuration of the assigned Flexible F-Link communication was changed.
   - If F-communication DBs in the comparison result are marked as "not available", associated Flexible F-Link communications might have been deleted or added. In this case, you can find the assignment of an F-communication DB to a specific Flexible F-Link communication in the safety summary in the "Overview of communication via Flexible F-Link" table.
2. If you have identified a changed Flexible F-Link communication, you can check the changed parameters in the safety summary as described below.

Localization by comparison of two safety summaries

To localize changes in the configuration of the communication with Flexible F-Link, compare the section "Communications via Flexible F-Link Overview" of the reference project with that of the project to be accepted in the respective safety summary.

(S7-1500) Detecting changes in the communication with OPC UA Safety

There are two ways to localize safety-related changes in communication with OPC UA Safety:

- Localization by offline-offline comparison
- Localization by comparison of two safety summaries

The procedure is described below.

Localization by offline-offline comparison

The reference project and the project to be accepted must be consistent and compiled for a comparison. For information on performing the comparison, see Comparing Safety Programs (Page 398).

- For a comparison of SafetyConsumers, follow these steps:

  Navigate in the comparison result to the "System blocks > STEP 7 Safety > OPC UA Safety" folder. All data blocks listed in this folder are F-OPC-UA-Consumer-DBs, and they are each assigned to a SafetyConsumer. You can determine the specific SafetyConsumer based on the safety summary under "OPC UA Safety communication".

  – If F-OPC-UA-Consumer-DBs in the comparison result are identical, this means that the safety-related configuration of the associated SafetyConsumer was not changed.
  – If F-OPC-UA-Consumer-DBs in the comparison result are different, this means that the safety-related configuration of the associated SafetyConsumer was changed.
  – If F-OPC-UA-Consumer-DBs in the comparison result are marked as "not available", associated SafetyConsumers might have been deleted or added.

- You can perform the comparison of SafetyProviders using the F-OPC-UA-Provider-DBs. Follow these steps:

  Navigate in the comparison result to the "System blocks > STEP 7 Safety > Compiler blocks" folder. You can recognize the F-OPC-UA-Provider-DBs from the prefix "F_OPC_UA_PROVIDER_IDB_". Each F-OPC-UA-Provider-DB has been assigned to a SafetyProvider. You can determine the specific SafetyProvider based on the safety summary under "OPC UA Safety communication".

  – If F-OPC-UA-Provider-DBs in the comparison result are identical, this means that the safety-related configuration of the associated SafetyProvider was not changed.
  – If F-OPC-UA-Provider-DBs in the comparison result are different, this means that the safety-related configuration of the associated SafetyProvider was changed.
  – If F-OPC-UA-Provider-DBs in the comparison result are marked as "not available", associated SafetyProviders might have been deleted or added.

If you have identified a changed OPC UA Safety communication, you can check the changed parameters in the safety summary as described below.

Localization by comparison of two safety summaries

To localize changes in the configuration of the communication with OPC UA Safety, compare the detailed views of all SafetyProviders and all SafetyConsumers in the "Communications with OPC UA Safety Overview" area of the reference project with that of the project to be accepted in the respective safety summary.

See also

Accessing tags of the F-I/O DB (Page 177)

Operation and maintenance 12

12.1 Notes on startup of the F-system

In "STARTUP" mode of an F-CPU, the startup of the standard user program occurs as usual.

In the safety program, all DB contents of the F-DBs are generally reset to their start values from the load memory.

An automatic reintegration of the F-I/O (Page 178) takes place starting from the 2nd cycle of the F-runtime group.

NOTE

Resetting the F-DBs to start values from the load memory also triggers the following:

- Any stored error information is reset.
- Edge memory bits in instructions or F-FBs with edge evaluations (e.g. TON instruction) are reset, so that for a signal that already has the "TRUE" state in the 1st cycle of an F-runtime group, a positive signal edge is detected immediately at a query for positive signal edge.

12.2 Notes on Safety Mode of the Safety Program

Introduction

Pay attention to the following important notes on safety mode of the Safety program.

Use of simulation devices/simulation programs

WARNING

Use of simulation devices/simulation programs in plants

If you operate simulation devices or simulation programs that generate safety message frames, for example, based on PROFIsafe, and make them available to the SIMATIC Safety F-system via the bus system (such as PROFIBUS DP or PROFINET IO), you must ensure the safety of the plant through organizational measures.

Note, for example, that a protocol analyzer is not permitted to perform any function that reproduces recorded message frame sequences with correct time behavior.

- **S7-PLCSIM version < 15.1 or S7-PLCSIM Advanced version < 2.0 SP1 and Safety System version < V2.2**

  If you use *S7-PLCSIM* (Page 403) to simulate Safety programs, the measures mentioned above are not necessary because S7-PLCSIM cannot establish an online connection to a real component.

- **S7-PLCSIM version ≥ 15.1 or S7-PLCSIM Advanced version ≥ 2.0 SP1 or Safety System version ≥ V2.2**

  You must ensure the safety of the plant through organizational measures.

  In addition, the loading of the safety-related project data with Safety System version V2.2 and higher onto an *S7-PLCSIM* is only permissible as of *S7-PLCSIM* V15.1 or *S7-PLCSIM Advanced* V2.0 SP1 and higher.

(S030)

NOTE

For an *S7-PLCSIM* before V15.1 or *S7-PLCSIM Advanced* before V2.0 SP1 and a Safety system version V2.2 and higher, the Safety program changes to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

Switching F-CPU to STOP mode

WARNING

Unintentional restart

In contrast to the standard user program, when the Safety program starts up, all tags of the F-DBs are generally initialized with their start values. This means that saved error information is lost. The F-system performs automatic reintegration of the F-I/O.

If an unintentional startup of your process is not allowed, you must program restart/startup protection in the Safety program. For this, the output of process values must be blocked until user acknowledgment takes place (see "Implementation of user acknowledgment (Page 196)"). This user acknowledgment must not take place until safe output of process values is possible (see "Programming startup protection (Page 159)").

You must expect an unintentional restart in the following cases:

- After a STOP generated by PG/PC operation, mode switch, communication function or "STP" instruction
- After an operating error
- After a STOP caused by a fault reaction function
- The following applies to the S7-1500 F Virtual Controller:

  After a STOP or a restart of the S7-1500 F Virtual Controller via Industrial Edge Management.

(S008)

CRC error in F-I/O or safety-related communication

If you observe that a manual acknowledgment is requested more than once every 100 hours due to a CRC error and this occurs repeatedly, this indicates that the underlying communication infrastructure (cabling, wireless connections, network components, etc.) does not have the required reliability.

CRC errors are present:

- For F-I/O access, the ACK_REQ tag of the F-I/O DB is set and the DIAG tag of the F-I/O DB indicates CRC errors with bit 2 or bit 6.
- For communication with the SENDDP/RCVDP instructions, the ACK_REQ output of the RCVDP instruction is set and the DIAG output of the SENDDP/RCVDP instruction indicates CRC errors with bit 6.
- For communication with the SENDS7/RCVS7 instructions, the ACK_REQ output of the RCVS7 instruction is set and the DIAG output of the SENDS7/RCVS7 instruction indicates CRC errors with bit 6.
- For communication with Flexible F-Link, the ACK_REQ tag of the F-communication DB is set for receiving and the DIAG tag of the F-communication DB for sending/receiving indicates CRC errors with bit 6.

  or

- A CRC error is entered in the diagnostic buffer of the F-CPU.

In this case, the failure probability values (Page 461) (PFD_{avg}/PFH) for safety-related communication no longer apply.

Errors in safety-related communication with OPC UA Safety

The OPC UA Safety communication protocol contains a mechanism that tolerates a communication error within a configurable period of time (see description SafetyErrorIntervalLimit (Page 307) in the SPI of the SafetyConsumer).

If you observe that, despite this mechanism, a manual acknowledgment is requested more than once within 24 hours due to a communication error, this indicates that the underlying communication infrastructure (cabling, wireless connections, network components, etc.) does not have the required reliability.

You can recognize communication errors by the fact that the FSV_ACTIVATED output of an F-OPC UA Consumer DB is set and the DIAG output is set according to the type of error.

In this case, the failure probability values (Page 461) (PFDavg/PFH) for safety-related communication no longer apply.

12.3 Replacing Software and Hardware Components

Introduction

Proceed as in the standard. Also note the following sections.

Replacement of software components

When replacing software components on your programming device or PC, e.g. with a new version of *STEP 7*, you must adhere to the information regarding upward and downward compatibility in the documentation and readme files for these products (e.g. *STEP 7 Safety*).

When replacing *STEP 7 Safety*, check whether the version of *STEP 7 Safety* is listed in Annex 1 of the Report for the TÜV certificate.

Replacement of hardware components

Hardware components for SIMATIC Safety (F-CPU, F-I/O, batteries, etc.) are replaced in the same way as in Standard automation systems.

If you replace an F-I/O in the TIA Portal with an F-I/O with a newer article number that occupies more I/O addresses, the now larger I/O address range may already be occupied by another F-I/O.

For example, if you replace an F module F-DI 8x24VDC HF with part number 6ES7136-6BA00-0CA0 by an F module with 6ES7136-6BA01-0CA0. The end address of the input and output addresses is increased by 1 byte each by the exchange. In this case, *STEP 7* assigns a new free I/O address range to the F module. The corresponding tag in the tag table must then be manually adapted to the new I/O addresses.

Replacement of an HF-CPU in the redundant S7-1500 HF system

Note the following warning when replacing an HF-CPU of a redundant S7-1500HF system:

WARNING

If you replace an F-CPU of a redundant S7-1500HF system (e.g. due to CPU failure, defect, etc.), you must put into operation the replacement F-CPU with the SIMATIC Memory Card of the previous F-CPU or with an empty SIMATIC Memory Card. This ensures that after successful SYNCUP of the replacement F-CPU, only the previous safety program is executed. *(S094)*

Replacement of S7-1500 F Software Controllers

WARNING

The following applies to firmware versions V30.0 and higher and < V40.0 of the S7-1500 F Software Controller:

After a CPU module replacement (for example, new PC with data storage medium from old PC), a data storage medium replacement (for example, data storage medium with safety-related project data 1 is replaced by data storage medium with safety-related project data 2) or a UEFI update (if no NVRAM is present), you must ensure that the correct safety program is located in the S7-1500 F Software Controller by reading out the Collective F-signature with the command line command "GetCollectiveFSignature" or the display.

Then you must enter and confirm the expected Collective F-signature with the command line command "ConfirmCollectiveFSignature". This confirmation is required to restart the safety program.

For both command line commands, you must be a member of the "Software Controller Operators" (Windows) or "software_controller_operators" (Linux) user group and the "Failsafe Operators" (Windows) or "failsafe_operators" (Linux) user group.

The following applies to firmware versions < V30.0 of the S7-1500 F Software Controller:

After a CPU module replacement (e.g. new PC with data storage medium from old PC), a data storage medium replacement (e.g. data storage medium containing safety program 1 is replaced with data storage medium containing safety program 2) or a UEFI update, you must check via the display whether the correct collective F-signature is displayed or perform a program identification. *(S066)*

Removing and inserting F-I/O during operation

If removing and inserting is possible for standard I/O during operation, it is also possible for the respective F-I/O. However, be aware that replacing an F-I/O module during operation can cause a communication error in the F-CPU.

You must acknowledge the communication error in your safety program in the ACK_REI tag of the F-I/O DB (Page 168) or, alternatively, by using the "ACK_GL (Page 543)" instruction. Without an acknowledgment, the F-I/O will remain passivated.

CPU firmware update

Check of the CPU operating system for F-approval: When using a new CPU operating system (firmware update), you must check to see if the CPU operating system you are using is approved for use in an F-system.

The minimum CPU operating system versions with guaranteed F-capability are specified in the appendix of the Certificate. This information and any notes on the new CPU operating system must be taken into account.

Firmware update for interface module

When using a new operating system for an interface module, such as IM 151-1 HIGH FEATURE for ET 200S (firmware update), you must observe the following:

If you have selected the "Activate firmware after update" option for the firmware update (see *Help on STEP 7*, "Online & Diagnostics"), the interface module is automatically reset following a successful download operation and then runs on the new operating system. Note that the firmware update for interface modules during operation causes a communication error in the F-CPU.

You must acknowledge the communication error in your safety program in the ACK_REI tag of the F-I/O DB (Page 168) or, alternatively, by using the "ACK_GL (Page 543)" instruction. Without an acknowledgment, the F-I/O will remain passivated.

Preventive maintenance (proof test)

Proof test for complex electronic components generally means replacement with new, unused components.

12.4 PFDavg and PFH values

PFD_{avg} and PFH values for S7-300/400 F-CPUs and F-I/O

You will find a list of the failure probability values (PFD_{avg}, PFH values) for components that can be used in SIMATIC Safety on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109481784).

PFD_{avg} and PFH values for S7-1200/1500 F-CPUs

Below are the probability of failure values (PFD_{avg}, PFH values) for S7-1200/1500 F-CPUs with a service life of 20 years and a mission time of 100 hours:

Operation in low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	**Operation in high demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure [h^{-1}]**
< 2E-05	< 1E-09 up to an operating altitude of 3 000 m or < 2E-09 at an operating altitude above 3 000 m and up to 5 000 m

More information can be found on the operating conditions of the F-CPUs in the PI F-CPUs (https://support.industry.siemens.com/cs/ww/en/view/109478599) and in the PI of the PFD_{avg}, PFH values (https://support.industry.siemens.com/cs/ww/en/view/109481784).

PFD_{avg} and PFH values for safety-related communication without OPC UA Safety

Below you will find the failure probability values (PFD_{avg}, PFH values) for safety-related communication:

Operation in low demand mode low demand mode According to IEC 61508:2010: PFD_{avg} = Average probability of dangerous failure on demand	**Operation in high demand or continuous mode high demand/continuous mode According to IEC 61508:2010: PFH = Average frequency of a dangerous failure [h^{-1}]**
< 1E-05*	< 1E-09*

*** Note on S7-300/400 F-CPUs:**
The PFH value is valid under the assumption that a maximum of 100 F-I/Os are involved in a safety function. If you use more than 100 F-I/Os, you have to also add 4E-12 per F-I/O for the safety function.
The PFD_{avg} value is valid for a mission time of 20 years and under the assumption that a maximum of 25 F-I/Os are involved in a safety function. If more than 25 F-I/Os are used, you need to add 3.5E-7 per F-I/O for this safety function.

More information can be found on the operating conditions of the F-CPUs in the PI of the PFD_{avg} and PFH values (https://support.industry.siemens.com/cs/ww/en/view/109478599).

PFD_{avg} and PFH values for safety-related communication with OPC UA Safety (S7-1500)

Below you will find the probability of failure values (PFD_{avg} and PFH values) for safety-related communication via OPC UA Safety:

Operation in low demand mode **low demand mode** **According to IEC 61508:2010:** **PFD_{avg} = Average probability of dangerous failure on demand**	**Operation in high demand or continuous mode** **high demand/continuous mode** **According to IEC 61508:2010:** **PFH = Average frequency of a dangerous failure [h^{-1}]**
< 8E-08*	< 4E-11*

* **Note**:
The values listed in the table above apply when configuring the SafetyErrorIntervalLimit (Page 307) SPI parameter of a SafetyConsumer with the value 600.
In exceptional cases, you can consider a lower setting (60 or 6). A lower setting may reduce the risk of false tripping. A lower setting is appropriate if the unnecessary triggering of the safety function or the output of fail-safe substitute values would have particularly serious consequences. However, this also worsens the PFD_{avg}/PFH values as follows:

SafetyErrorIntervalLimit	PFD_{avg} value	PFH value
60	< 2.5E-07	< 4E-10
6 (not permitted for SIL3)	< 1E-06	< 4E-09

12.5 Guide to Diagnostics

Introduction

Here you find a compilation of diagnostic capabilities that can be evaluated for your system when an error occurs. Most of the diagnostic capabilities are the same as those in standard automation systems. The sequence of steps represents a recommendation.

Steps for evaluating diagnostic capabilities

The following table shows the steps you take to evaluate diagnostic capabilities.

Step	Procedure	Reference
1	**Evaluate LEDs on the hardware (F-CPU, F-I/O):** • BUSF LED on the F-CPU: Flashes when a communication error occurs on PROFIBUS DP/PROFINET IO; On if a programming error occurs when OB 85 and OB 121 are programmed (e.g. instance DB is not loaded) • STOP LED on the F-CPU: illuminates when the F-CPU is in STOP mode • Fault LEDs on the F-I/O: e.g. SF-LED (group error LED) on if any fault occurs in the individual F-I/O	*Manuals for F-CPU and F-I/O*
2	**Evaluate diagnostic buffer of the modules:** You read the diagnostic buffer of a module (F-CPU, F-I/O, CP) in its online and diagnostic view in the "Diagnostic buffer" group under the "Online & Diagnostics" folder.	*Help on STEP 7 and manuals for the F-CPU and F-I/O*

Step	Procedure	Reference
3	**Evaluate stacks of the F-CPU:** when the F-CPU is in STOP mode, read the following successively: • Block stack: Check whether STOP mode of the F-CPU was triggered by an F-block of the Safety program • Interruption stack • Local data stack	*STEP 7 help, Diagnostics Function Manual, system manuals*
4	**Evaluate diagnostic tag of the F-I/O DB using testing and commissioning functions, by means of an operator control and monitoring system, or in the standard user program:** Evaluate the DIAG tag in the F-I/O DB	DIAG (Page 176)
5	**Evaluate diagnostic tag of the F-OPC UA Consumer DB using testing and commissioning functions, by means of an operator control and monitoring system, or in the standard user program:** in the F-OPC UA Consumer DB of the variable DIAG	Other variables in the F-OPC UA Consumer DB (Page 316) OPC UA access to SafetyProvider and SafetyConsumer information models (Page 347)
6	**Evaluate diagnostic tag of the F-communication DB using testing and commissioning functions, by means of an operator control and monitoring system, or in the standard user program:** Evaluate the DIAG tag in the F-communication DB	F-communication DB (S7-1200, S7-1500) (Page 358)
7	**Evaluate diagnostic outputs of the instance DBs of instructions using testing and commissioning functions, using an operator control and monitoring system, or in the standard user program:** • Evaluate the following for MUTING, EV1oo2DI, TWO_H_EN, MUT_P, ESTOP1, FDBACK, SFDOOR in the assigned instance DB: – Output DIAG • Evaluate the following for SENDDP or RCVDP in the assigned instance DB: – Output RET_DPRD/RET_DPWR – Output DIAG • Evaluate the following for SENDS7 or RCVS7 in the assigned instance DB: – Output STAT_RCV – Output STAT_SND – Output DIAG	Instructions

Tip on RET_DPRD/RET_DPWR

The diagnostic information of the RET_DPRD/RET_DPWR outputs of the SENDDP or RCVDP instructions corresponds to the diagnostic information of the RETVAL return value of the "DPRD_DAT" and "DPWR_DAT" instructions. You can find the description in the help on *STEP 7* for the "DPRD_DAT" and "DPWR_DAT" instructions.

Tip: STAT_RCV and STAT_SND

The diagnostic information of the STAT_RCV output of the SENDS7 or RCVS7 instructions corresponds to the diagnostic information of the STATUS output of the "URCV" instruction. The diagnostic information of the STAT_SND output of the SENDS7 or RCVS7 instructions corresponds to the diagnostic information of the STATUS output of the "USEND" instruction. You can find the description in the help on *STEP 7* for the instruction "UCRV" or "USEND" .

STEP 7 Safety V21 instructions 13

Overview of instructions for the safety program

When programming an F-block, you can find all instructions available for programming an F-block in LAD or FBD with the configured F-CPU in the "Instructions" task card.

In addition to the instructions that are familiar to you from programming a standard block, there are also special safety functions, e.g., for two-hand monitoring, discrepancy analysis, muting, emergency STOP/emergency OFF, safety door monitoring, and feedback monitoring and instructions for safety-related CPU-CPU communication.

13.1 Connection of the Enable input EN and Enable output ENO

The enable input EN cannot be connected.

(S7 -300, S7-400) It is not possible to connect the ENO output.

(S7-1200, S7-1500) The ENO output can only be wired with the following instructions:

- ADD: Add (Page 567)
- SUB: Subtract (Page 570)
- MUL: Multiply (Page 573)
- DIV: Divide (Page 576)
- NEG: Create two's complement (Page 579)
- ABS: Form absolute value (Page 582)
- CONVERT: Convert value (Page 593)

13.2 Temporal blurring for instructions with time processing

Observe the following warning for the following instructions with time processing:

- ESTOP1: Emergency STOP/emergency OFF up to stop category 1 (STEP 7 Safety V21) (Page 500)
- TWO_HAND: Two-hand monitoring (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 504)
- TWO_H_EN: Two-hand monitoring with enable (STEP 7 Safety V21) (Page 505)
- MUTING: Muting (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 509)
- MUT_P: Parallel muting (STEP 7 Safety V21) (Page 517)
- EV1oo2DI: 1oo2 evaluation with discrepancy analysis (STEP 7 Safety V21) (Page 528)
- FDBACK: Feedback monitoring (STEP 7 Safety V21) (Page 533)
- TP: Generate pulse (STEP 7 Safety V21) (Page 545)
- TON: Generate on-delay (STEP 7 Safety V21) (Page 548)

- TOF: Generate off-delay (STEP 7 Safety V21) (Page 550)
- ACK_OP: Fail-safe acknowledgment (STEP 7 Safety V21) (Page 619)

WARNING

When using an instruction with time processing, take the following timing imprecision sources into account when determining your response times:

- The temporal blurring known from the standard user program, which is caused by the cyclic processing
- Timing imprecision resulting from the update time of the time base used in the instruction (see figure in section "Timing imprecision resulting from the update time of the time base used in the instruction")
- Tolerance of internal time monitoring in the F-CPU
  - For time values up to 200 ms, a maximum of 4 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value
- Tolerance of internal time monitoring in the S7-1500 HF-CPU
  - For time values up to 500 ms, a maximum of 10 ms
  - For time values greater than or equal to 500 ms, a maximum of 2% of the (assigned) time value
- Tolerance of internal time monitoring in the S7-1500 F Virtual Controller

  Without setup of Virtual Time Service:
  - For time values up to 200 ms, a maximum of 5 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value plus 1 ms

  With setup of Virtual Time Service:
  - For time values up to 200 ms, a maximum of 10 ms
  - For time values greater than or equal to 200 ms, a maximum of 2% of the (assigned) time value plus 6 ms

You must choose the interval between two calls of an instruction with time processing in such a way that the required response times are achieved, taking into account the possible timing imprecision. *(S034)*

Timing imprecision resulting from the update time of the time base used in the instruction:

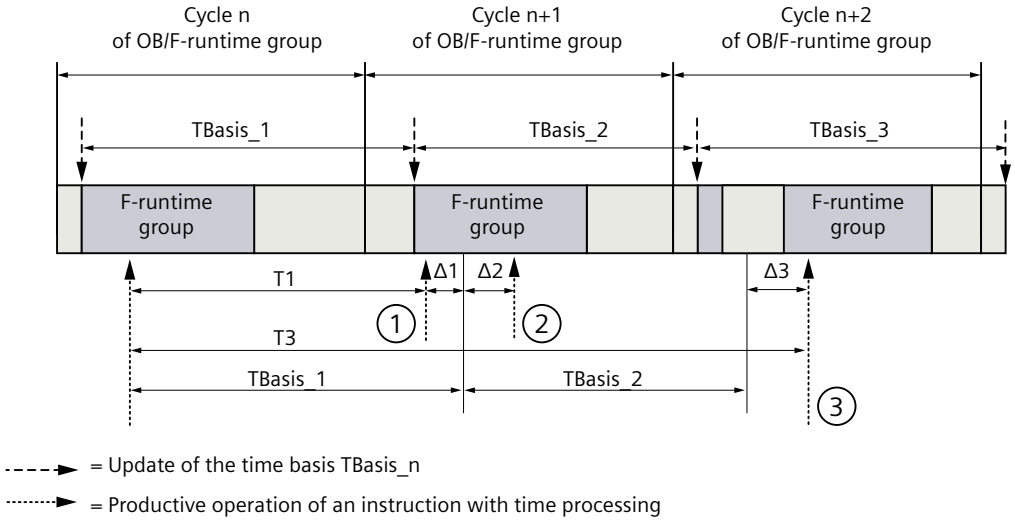

① For the first call in cycle n+1, the call time of the instruction relative to the start of the F-runtime group is earlier than that in cycle n by the amount of Δ_1, e.g. because parts of the Safety program of the F-runtime group before the call time of the instruction in cycle n+1 are skipped. For the time update, the instruction takes account of time T_{Base_1} instead of the time T_1 that has actually elapsed in cycle n since the call.

② The instruction is called a second time in cycle n+1. This does not involve another time update (by Δ_2).

③ For the call in cycle n+2, the call time of the instruction relative to the start of the F-runtime group is later than that in cycle n by the amount of Δ_3, e.g. because the F-runtime group was interrupted by a higher priority interrupt before the call time of the instruction in cycle n+2. The instruction took into account time $T_{Base_1} + T_{Base_2}$ instead of the time T_3 that has actually elapsed in cycle n since the call. This would also be the case if no call occurred in cycle n+1.

13.3 General

13.3.1 LAD

13.3.1.1 New network (STEP 7 Safety V21)

Requirement

An F-block is open.

Procedure

To insert a new network, follow these steps:

1. Select the network after which you want to insert a new network.
2. Select the "Insert network" command in the shortcut menu.

NOTE

If you insert an element into the last empty network of the F-block in an LAD program, a new empty network is automatically inserted below it.

Result

A new empty network is inserted into the F-block.

13.3.1.2 Empty box (STEP 7 Safety V21)

Requirement

A network is available.

Procedure

To insert an LAD instruction into a network using an empty box, follow these steps:

1. Open the "Instructions" task card.
2. Navigate to "Basic instructions > General > Empty box".
3. Use a drag-and-drop operation to move the "Empty box" element to the desired place in the network.
4. Hover the cursor over the yellow triangle in the top right corner of the empty box.

   A drop-down list is displayed.
5. Select the required instruction from the drop-down list.

If the instruction acts as a function block (FB) within the system, the "Call options" dialog opens. In this dialog, you can create an instance data block for the function block, either as a single instance or, if necessary, multi-instance, in which data of the inserted instruction are stored. Once it is created, the new instance data block can be found in the "Program resources" folder in the project tree under "Program blocks > System blocks". If you have selected "multi-instance", you can find it in the block interface in the "Static" section.

Result

The empty box is changed to the appropriate instruction. Placeholders are inserted for the parameters.

13.3.1.3 Open branch (STEP 7 Safety V21)

Description

Use branches to program parallel connections with the Ladder Logic (LAD) programming language. Branches are inserted into the main current path. You can insert several contacts into the branch, thereby creating a parallel connection from series connections. You can program complex ladder diagrams in this way.

Requirement

- A network is available.
- The network contains elements.

Procedure

To insert a new branch in a network, follow these steps:

1. Open the "Instructions" task card.
2. Navigate to "Basic instructions > General > Open branch".
3. Use a drag-and-drop operation to move the element to the desired place in the network.
4. If you want to connect the new branch directly to the power rail, drag the element to the power rail.

Example

The following figure provides an example of how to use branches:

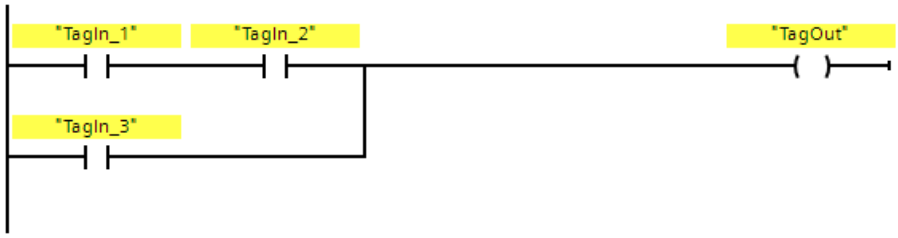

13.3.1.4 Close branch (STEP 7 Safety V21)

Description

Branches must be closed again at suitable places. If necessary, branches will be arranged so that they do not cross each other.

Requirement

A branch is available.

Procedure

To close an open branch, follow these steps:

1. Select the open branch.
2. Press and hold down the left mouse button.

   A dashed line will appear as soon as the cursor is moved.
3. Drag the dashed line to a suitable place on the network. Permissible connections are indicated by green lines.
4. Release the left mouse button.

Example

The figure below provides an example of how to use branches:

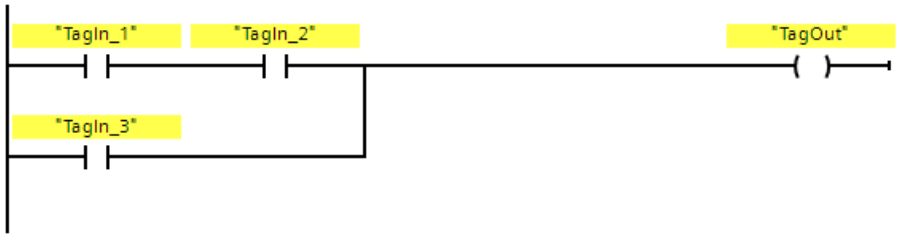

13.3.2 FBD

13.3.2.1 New network (STEP 7 Safety V21)

Requirement

An F-block is open.

Procedure

To insert a new network, follow these steps:

1. Select the network after which you want to insert a new network.
2. Select the "Insert network" command in the shortcut menu.

NOTE

If you insert an element into the last empty network of the F-block in an FBD program, a new empty network is automatically inserted below it.

Result

A new empty network is inserted into the F-block.

13.3.2.2 Empty box (STEP 7 Safety V21)

Requirement

A network is available.

Procedure

To insert FBD elements into a network using an empty box, follow these steps:

1. Open the "Instructions" task card.
2. Navigate to "Basic instructions > General > Empty box".
3. Use a drag-and-drop operation to move the "Empty box" element to the desired place in the network.
4. Hover the cursor over the yellow triangle in the top right corner of the empty box.

   A drop-down list is displayed.
5. Select the desired FBD element from the drop-down list.

If the instruction acts as a function block (FB) within the system, the "Call options" dialog opens. In this dialog, you can create an instance data block for the function block, either as a single instance or, if necessary, multi-instance, in which data of the inserted instruction are

stored. Once it is created, the new instance data block can be found in the "Program resources" folder in the project tree under "Program blocks > System blocks". If you have selected "multi-instance", you can find it in the block interface in the "Static" section.

Result

The empty box is changed to the appropriate instruction. Placeholders are inserted for the parameters.

13.3.2.3 Open branch (STEP 7 Safety V21)

Description

You use branches, which you insert between the boxes, to program parallel connections with the Function Block Diagram (FBD) programming language You can insert additional boxes in the branch, thereby programming complex function block diagrams.

Requirement

A network is available.

Procedure

To insert a new branch in a network, follow these steps:

1. Open the "Instructions" task card.
2. Navigate in the pane to "Basic instructions > General > Branch".
3. Use a drag-and-drop operation to move the element to the desired place to a connecting line between two boxes.

Example

The following figure provides an example of how to use branches:

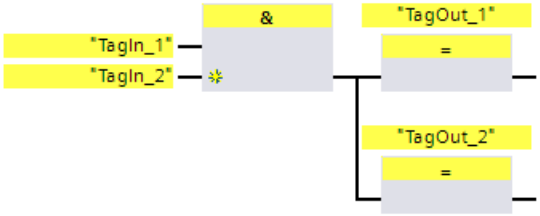

13.3.2.4 Insert binary input (STEP 7 Safety V21)

Description

Use the "Insert binary input" instruction to expand the box of one of the following instructions by a binary input:

- "AND logic operation"
- "OR logic operation"
- "EXCLUSIVE OR logic operation"

You can query the signal state of several operands by expanding the instruction box.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	The operand indicates the bit whose signal state will be queried.

Example

The following example shows how the instruction works:

The box of instruction "AND logic operation" has been expanded by an additional binary input at which the signal state of operand "TagIn_3" is queried. Output "TagOut" is set when the signal state of operands "TagIn_1", "TagIn_2", and "TagIn_3" is "1".

See also

AND logic operation (STEP 7 Safety V21) (Page 487)
OR logic operation (STEP 7 Safety V21) (Page 488)
X: EXCLUSIVE OR logic operation (STEP 7 Safety V21) (Page 489)

13.3.2.5 Invert RLO (STEP 7 Safety V21)

Description

You can use the "Invert RLO" instruction to invert the result of logic operation (RLO).

Example

The following example shows how the instruction works:

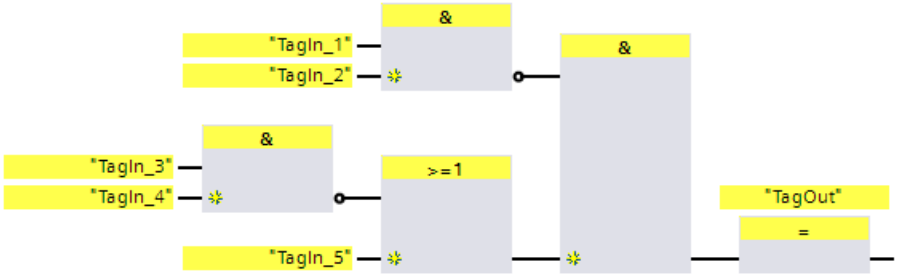

Output "TagOut" is set when the following conditions are fulfilled:

- The "TagIn_1" and/or "TagIn_2" input has the signal state "0".
- The "TagIn_3" or "TagIn_4" input has the signal state "0" or the "TagIn_5" input has the signal state "1".

13.4 Bit logic operations

13.4.1 LAD

13.4.1.1 ---| |---: Normally open contact (STEP 7 Safety V21)

Description

The activation of the normally open contact depends on the signal state of the associated operand. If the operand has signal state "1," the normally open contact is closed. Power flows from the left power rail through the normally open contact into the right power rail and the signal state at the output of the instruction is set to "1".

If the operand has signal state "0," the normally open contact is not activated. The power flow to the right power rail is interrupted and the signal state at the output of the instruction is reset to "0".

Two or more normally open contacts are linked bit-by-bit by AND when connected in series. With a series connection, power flows when all contacts are closed.

The normally open contacts are linked by OR when connected in parallel. With a parallel connection, power flows when one of the contacts is closed.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	Operand whose signal state is queried.

Example

The following example shows how the instruction works:

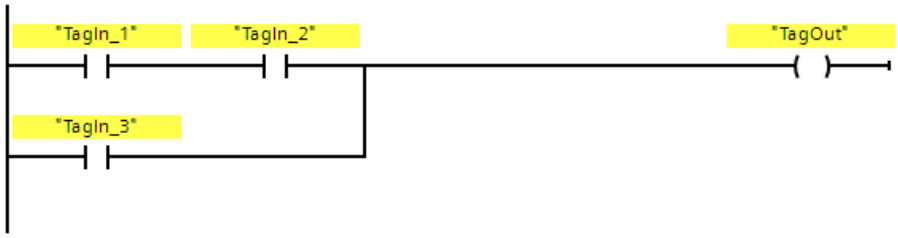

Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state at operand "TagIn_3" is "1".

13.4.1.2 ---| / |---: Normally closed contact (STEP 7 Safety V21)

Description

The activation of the normally closed contact depends on the signal state of the associated operand. If the operand has signal state "1", the normally closed contact is opened and the signal state at the output of the instruction is reset to "0".

If the operand has signal state "0", the normally closed contact is not activated and the signal state at the output of the instruction is set to "1".

Two or more normally closed contacts are linked bit-by-bit by AND when connected in series. With a series connection, power flows when all contacts are closed.

The normally closed contacts are linked by OR when connected in parallel. With a parallel connection, power flows when one of the contacts is closed.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	Operand whose signal state is queried.

Example

The following example shows how the instruction works:

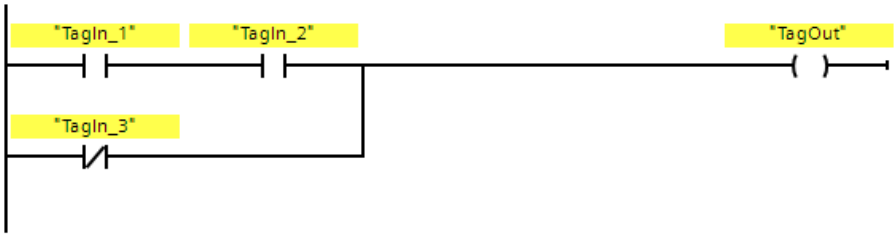

Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state at operand "TagIn_3" is "0".

13.4.1.3 --|NOT|--: Invert RLO (STEP 7 Safety V21)

Description

You can use the "Invert RLO" instruction to invert the signal state of the result of logic operation (RLO). When the signal state is "1" at the input of the instruction, the output of the instruction has the signal state "0". When the signal state is "0" at the input of the instruction, the output has the signal state "1".

Example

The following example shows how the instruction works:

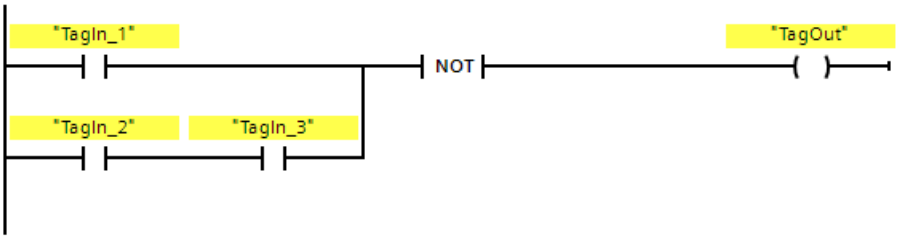

Operand "TagOut" is reset when one of the following conditions is fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operands "TagIn_2" and "TagIn_3" have signal state "1".

13.4.1.4 ---( )---: Assignment (STEP 7 Safety V21)

Description

You can use the "Assignment" instruction to set the bit of a specified operand. When the result of logic operation (RLO) at the input of the coil is "1," the specified operand is set to signal state "1". When the signal state is "0" at the input of the coil, the bit of the specified operand is reset to "0".

The instruction does not influence the RLO. The RLO at the input of the coil is sent immediately to the output.

The "Assignment" instruction can be placed at any position in the network.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand to which the RLO is assigned.

Example

The following example shows how the instruction works:

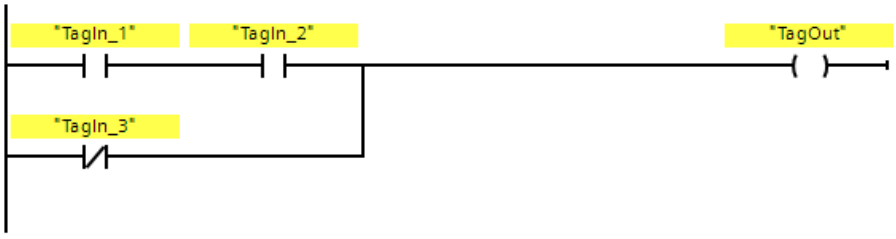

Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state at operand "TagIn_3" is "0".

13.4.1.5 ---(R)---: Reset output (STEP 7 Safety V21)

Description

You can use the "Reset output" instruction to reset the signal state of a specified operand to "0".

If power flows to the coil (RLO is "1"), the specified operand is set to "0". If the result of logic operation at the input of the coil is "0" (no signal flow to the coil), the signal state of the specified operand remains unchanged.

The instruction does not influence the RLO. The RLO at the input of the coil is sent directly to the output of the coil.

NOTE

If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

NOTE

You cannot use the "process image of the inputs", "process image of the outputs" from standard I/O and "standard DB" and "bit memory" operand areas for the operands of the instruction.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand that is reset when RLO = "1".

Example

The following example shows how the instruction works:

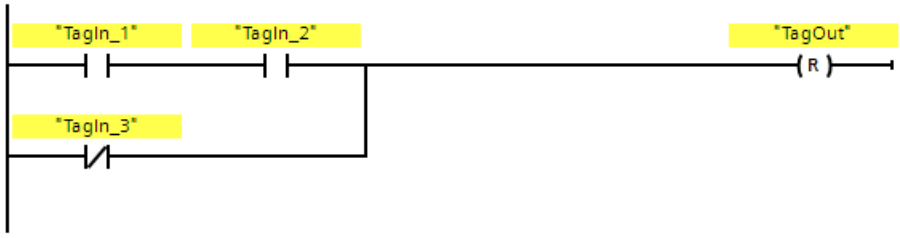

Operand "TagOut" is reset when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state of operand "TagIn_3" is "0".

13.4.1.6 ---(S)---: Set output (STEP 7 Safety V21)

Description

You can use the "Set output" instruction to set the signal state of a specified operand to "1".

If power flows to the coil (RLO is "1"), the specified operand is set to "1". If the result of logic operation at the input of the coil is "0" (no signal flow to the coil), the signal state of the specified operand remains unchanged.

The instruction does not influence the RLO. The RLO at the input of the coil is sent directly to the output of the coil.

NOTE

The instruction is not executed if it is applied to an output of an F-I/O that is passivated (e.g., during startup of the F-system). Therefore, it is preferable to access outputs of the F-I/O using only the "Assignment" instruction.

An F-I/O output is passivated if QBAD or QBAD_O_xx = 1 or value status = 0 is set in the corresponding F-I/O DB.

NOTE

If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

NOTE

You cannot use the "process image of the inputs", "process image of the outputs" from standard I/O and "standard DB" and "bit memory" operand areas for the operands of the instruction.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand that is set when RLO = "1".

Example

The following example shows how the instruction works:

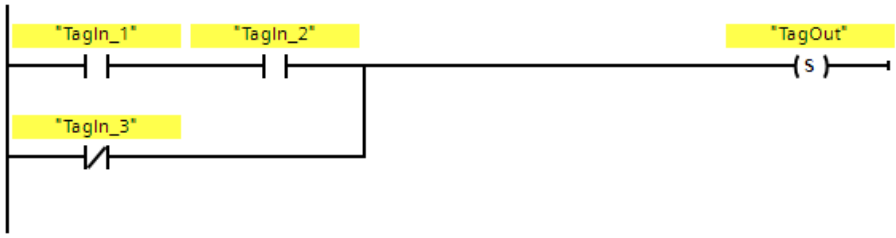

Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state of operand "TagIn_3" is "0".

13.4.1.7 SR: Set/reset flip-flop (STEP 7 Safety V21)

Description

You can use the "Set/reset flip-flop" instruction to set or reset the bit of the specified operand based on the signal state of inputs S and R1. If the signal state at input S is "1" and the signal state at input R1 is "0", the specified operand is set to "1". If the signal state at input S is "0" and the signal state at input R1 is "1", the specified operand is reset to "0".

Input R1 takes priority over input S. If the signal state is "1" at the two inputs S and R1, the signal state of the specified operand is reset to "0".

The instruction is not executed if the signal state at the two inputs S and R1 is "0". The signal state of the operand then remains unchanged.

The current signal state of the operand is transferred to output Q and can be queried there.

NOTE

If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the operands of the instruction.

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
S	Input	BOOL	Enable set
R1	Input	BOOL	Enable reset
<Operand>	Output	BOOL	Operand that is set or reset.
Q	Output	BOOL	Signal state of the operand

Example

The following example shows how the instruction works:

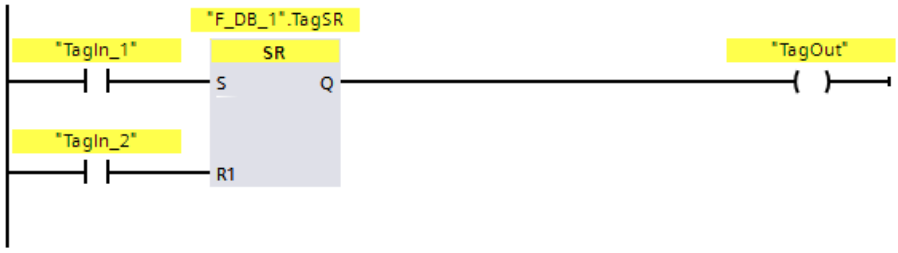

Operands ""F_DB_1".TagSR" and "TagOut" are set when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operand "TagIn_2" has signal state "0".

Operands ""F_DB_1".TagSR" and "TagOut" are reset when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "0" and operand "TagIn_2" has signal state "1".
- Both operands "TagIn_1" and "TagIn_2" have signal state "1".

13.4.1.8 RS: Reset/set flip-flop (STEP 7 Safety V21)

Description

You can use the "Reset/set flip-flop" instruction to reset or set the bit of the specified operand based on the signal state of inputs R and S1. When the signal state is "1" at input R and "0" at input S1, the specified operand is reset to "0". When the signal state is "0" at input R and "1" at input S1, the specified operand is set to "1".

Input S1 takes priority over input R. If the signal state is "1" at the two inputs R and S1, the signal state of the specified operand is set to "1".

The instruction is not executed if the signal state at the two inputs R and S1 is "0". The signal state of the operand then remains unchanged.

The current signal state of the operand is transferred to output Q and can be queried there.

NOTE

If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the operands of the instruction.

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
R	Input	BOOL	Enable reset
S1	Input	BOOL	Enable set
<Operand>	Output	BOOL	Operand that is reset or set.
Q	Output	BOOL	Signal state of the operand

Example

The following example shows how the instruction works:

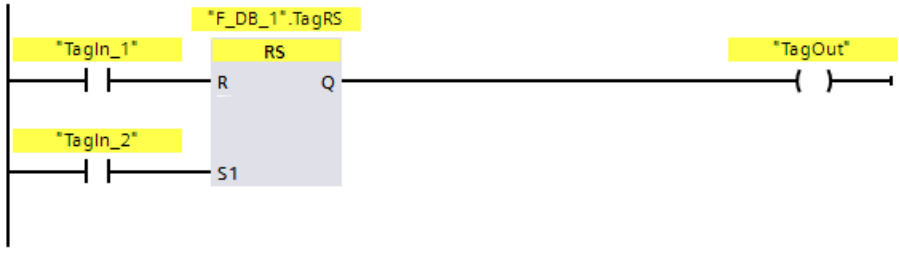

Operands ""F_DB_1".TagRS" and "TagOut" are reset when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operand "TagIn_2" has signal state "0".

Operands ""F_DB_1".TagRS" and "TagOut" are set when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "0" and operand "TagIn_2" has signal state "1".
- Operands "TagIn_1" and "TagIn_2" have signal state "1".

13.4.1.9 --|P|--: Scan operand for positive signal edge (STEP 7 Safety V21)

Description

You can use the "Scan operand for positive signal edge" instruction to determine if there is a change from "0" to "1" in the signal state of a specified operand (<Operand1>). The instruction compares the current signal state of <Operand1> with the signal state of the previous query saved in <Operand2>. If the instruction detects a change in the result of logic operation from "0" to "1", there is a positive, rising edge.

If a rising edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Enter the operand to be queried (<Operand1>) in the operand placeholder above the instruction. Enter the edge memory bit (<Operand2>) in the operand placeholder below the instruction.

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand2> of the instruction, it must be declared as an InOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand2> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand2> of the instruction, the local data bit used must be initialized beforehand.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand1>	Input	BOOL	Signal to be queried
<Operand2>	InOut	BOOL	Edge memory bit in which the signal state of the previous query is saved.

Example

The following example shows how the instruction works:

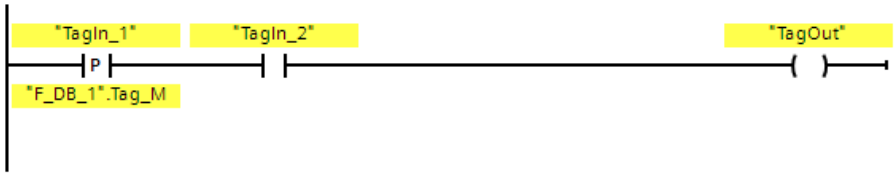

Operand "TagOut" is set when the following conditions are fulfilled:

- There is a rising edge at input "TagIn_1". The signal state of the previous query is saved at edge memory bit ""F_DB_1".Tag_M".
- The signal state of operand "TagIn_2" is "1".

13.4.1.10 --|N|--: Scan operand for negative signal edge (STEP 7 Safety V21)

Description

You can use the "Scan operand for negative signal edge" instruction to determine if there is a change form "1" to "0" in the signal state of a specified operand. The instruction compares the current signal state of <Operand1> with the signal state of the previous query saved in <Operand2>. If the instruction detects a change in the result of logic operation from "1" to "0", there is a negative, falling edge.

If a falling edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Enter the operand to be queried (<Operand1>) in the operand placeholder above the instruction. Enter the edge memory bit (<Operand2>) in the operand placeholder below the instruction.

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand2> of the instruction, it must be declared as an InOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand2> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand2> of the instruction, the local data bit used must be initialized beforehand.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand1>	Input	BOOL	Signal to be queried
<Operand2>	InOut	BOOL	Edge memory bit in which the signal state of the previous query is saved.

Example

The following example shows how the instruction works:

Operand "TagOut" is set when the following conditions are fulfilled:

- There is a falling edge at operand "TagIn_1". The signal state of the previous query is saved at edge memory bit ""F_DB_1".Tag_M".
- The signal state of operand "TagIn_2" is "1".

13.4.1.11 P_TRIG: Scan RLO for positive signal edge (STEP 7 Safety V21)

Description

You can use the "Scan RLO for positive signal edge" instruction to query a change in the signal state of the result of logic operation from "0" to "1". The instruction compares the current signal state of the result of logic operation (RLO) with the signal state of the previous query, which is saved in the edge bit memory (<Operand>). If the instruction detects a change in the RLO from "0" to "1", there is a positive, rising edge.

If a rising edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand> of the instruction, it must be declared as an iInOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand> of the instruction, the local data bit used must be initialized beforehand.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CLK	Input	BOOL	Current RLO
<Operand>	InOut	BOOL	Edge memory bit in which the RLO of the previous query is saved.
Q	Output	BOOL	Result of edge evaluation

Example

The following example shows how the instruction works:

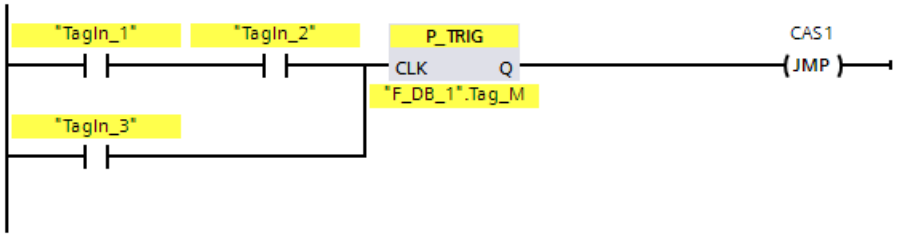

The RLO from the previous bit logic operation is saved in edge memory bit ""F_DB_1".Tag_M". If a change in the RLO signal state from "0" to "1" is detected, the program jumps to jump label CAS1.

13.4.1.12 N_TRIG: Scan RLO for negative signal edge (STEP 7 Safety V21)

Description

You can use the "Scan RLO for negative signal edge" instruction to query a change in the signal state of the result of logic operation from "1" to "0". The instruction compares the current signal state of the result of logic operation with the signal state from the previous query, which is saved in the edge memory bit (<Operand>). If the instruction detects a change in the RLO from "1" to "0", there is a negative, falling edge.

If a falling edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand> of the instruction, it must be declared as an iInOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand> of the instruction, the local data bit used must be initialized beforehand.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CLK	Input	BOOL	Current RLO
<Operand>	InOut	BOOL	Edge memory bit in which the RLO of the previous query is saved.
Q	Output	BOOL	Result of edge evaluation

Example

The following example shows how the instruction works:

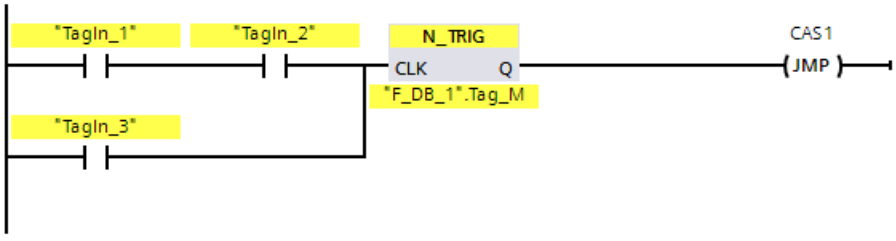

The RLO of the previous bit logic operation is saved in edge bit memory ""F_DB_1".Tag_M". If a change in the RLO signal state from "1" to "0" is detected, the program jumps to jump label CAS1.

13.4.2 FBD

13.4.2.1 AND logic operation (STEP 7 Safety V21)

Description

You can use the "AND logic operation" instruction to query the signal states of two or more specified operands and evaluate them according to the AND truth table.

If the signal state of all the operands is "1", then the conditions are fulfilled and the instruction returns the result "1". If the signal state of one of the operands is "0", then the conditions are not fulfilled and the instruction generates the result "0".

If the "AND logic operation" instruction is the first instruction in a logic string, it saves the result of its signal state query in the RLO bit.

Each "AND logic operation" instruction that is not the first instruction in the logic string logically combines the result of its signal state query with the value saved in the RLO bit. This logical combination is performed according to the AND truth table.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	The operand indicates the bit whose signal state will be queried.

Example

The following example shows how the instruction works:

Output "TagOut" is set when the signal state of operands "TagIn_1" and "TagIn_2" is "1".

AND truth table

The following table shows the results when linking two operands by an AND logic operation:

Signal state of the first operand	Signal state of the second operand	Result of logic operation
1	1	1
0	1	0
1	0	0
0	0	0

See also

Insert binary input (STEP 7 Safety V21) (Page 472)

13.4.2.2 OR logic operation (STEP 7 Safety V21)

Description

You can use the "OR logic operation" instruction to get the signal states of two or more specified operands and evaluate them according to the OR truth table.

If the signal state of at least one of the operands is "1", then the conditions are fulfilled and the instruction returns the result "1". If the signal state of all of the operands is "0", then the conditions are not fulfilled and the instruction generates the result "0".

If the "OR logic operation" instruction is the first instruction in a logic string, it saves the result of its signal state query in the RLO bit.

Each "OR logic operation" instruction that is not the first instruction in the logic string, logically combines the result of its signal state query with the value saved in the RLO bit. This logical combination is performed according to the OR truth table.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	The operand indicates the bit whose signal state will be queried.

Example

The following example shows how the instruction works:

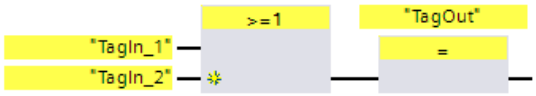

Output "TagOut" is set when the signal state of operand "TagIn_1" or "TagIn_2" is "1".

OR truth table

The following table shows the results when linking two operands by an OR logic operation:

Signal state of the first operand	Signal state of the second operand	Result of logic operation
1	0	1
0	1	1
1	1	1
0	0	0

See also

Insert binary input (STEP 7 Safety V21) (Page 472)

13.4.2.3 X: EXCLUSIVE OR logic operation (STEP 7 Safety V21)

Description

You can use the "EXCLUSIVE OR logic operation" instruction to get the result of a signal state query according to the the EXCLUSIVE OR truth table.

With an "EXCLUSIVE OR logic operation" instruction, the signal state is "1" when the signal state of one of the two specified operands is "1". When more than two operands are queried, the overall result of logic operation is "1" if an odd-numbered quantity of queried operands returns the result "1".

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Input	BOOL	The operand indicates the bit whose signal state will be queried.

Example

The following example shows how the instruction works:

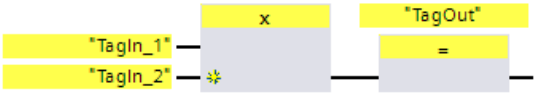

Output "TagOut" is set when the signal state of one of the two operands "TagIn_1" and "TagIn_2" is "1". When both operands have signal state "1" or "0" then output "TagOut" is reset.

EXCLUSIVE OR truth table

The following table shows the results when two operands are linked by an EXCLUSIVE OR:

Signal state of the first operand	Signal state of the second operand	Result of logic operation
1	0	1
0	1	1
1	1	0
0	0	0

The following table shows the results when three operands are linked by an EXCLUSIVE OR:

Signal state of the first operand	Signal state of the second operand	Signal state of the third operand	Result of logic operation
1	0	0	1
0	1	1	0
0	1	0	1
1	0	1	0
0	0	1	1
1	1	0	0
1	1	1	1
0	0	0	0

See also

Insert binary input (STEP 7 Safety V21) (Page 472)

13.4.2.4 =: Assignment (STEP 7 Safety V21)

Description

You can use the "Assignment" instruction to set the bit of a specified operand. If the result of logic operation (RLO) at the box input has signal state "1" or the box input for S7-1200/1500 F-CPUs is not connected, the specified operand is set to signal state "1". If the signal state at the box input is "0", the bit of the specified operand is reset to "0".

The instruction does not influence the RLO. The RLO at the box input is assigned directly to the operand located above the Assign box.

The "Assignment" instruction can be placed at any position in the logic operation sequence.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand to which the RLO is assigned.

Example

The following example shows how the instruction works:

Operand "TagOut" at the output of the "Assignment" instruction is set when one of the following conditions is fulfilled:

- Inputs "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state at input "TagIn_3" is "0".

13.4.2.5 R: Reset output (STEP 7 Safety V21)

Description

You can use the "Reset output" instruction to reset the signal state of a specified operand to "0".

If the box input has signal state "1" or the box input for S7-1200/1500 F-CPUs is not connected, the specified operand is reset to "0". If there is a result of logic operation of "0" at the box input, the signal state of the specified operand remains unchanged.

The instruction does not influence the RLO. The RLO at the box input is transferred directly to the box output.

NOTE

If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

NOTE

You cannot use the "process image of the inputs", "process image of the outputs" from standard I/O and "standard DB" and "bit memory" operand areas for the operands of the instruction.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand that is reset with RLO = "1".

Example

The following example shows how the instruction works:

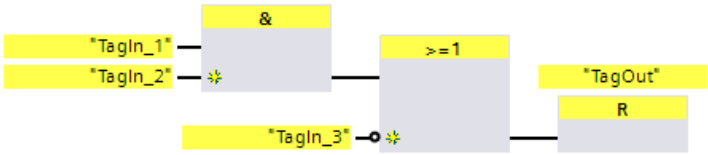

Operand "TagOut" is reset when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state of operand "TagIn_3" is "0".

13.4.2.6 S: Set output (STEP 7 Safety V21)

Description

You can use the "Set output" instruction to set the signal state of a specified operand to "1".

If the box input has signal state "1" or the box input for S7-1200/1500 F-CPUs is not connected, the specified operand is set to "1". If there is a result of logic operation of "0" at the box input, the signal state of the specified operand remains unchanged.

The instruction does not influence the RLO. The RLO at the box input is transferred directly to the box output.

NOTE

The instruction is not executed if it is applied to an output of an F-I/O that is passivated (e.g., during startup of the F-system). Therefore, it is preferable to access outputs of the F-I/O using only the "Assignment" instruction.

An F-I/O output is passivated if QBAD or QBAD_O_xx = 1 or value status = 0 is set in the corresponding F-I/O DB.

NOTE

If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE

If the operand area "local data (temp)" is used for the operands of the instruction, the local data bit used must be initialized beforehand.

NOTE

You cannot use the "process image of the inputs", "process image of the outputs" from standard I/O and "standard DB" and "bit memory" operand areas for the operands of the instruction.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand>	Output	BOOL	Operand that is set when RLO = "1".

Example

The following example shows how the instruction works:

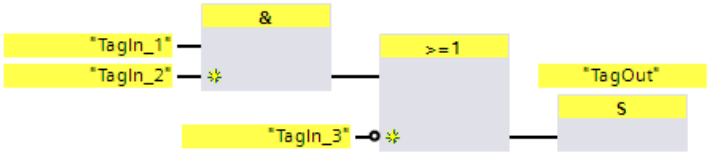

Operand "TagOut" is set when one of the following conditions is fulfilled:

- Operands "TagIn_1" and "TagIn_2" have signal state "1".
- The signal state of operand "TagIn_3" is "0".

13.4.2.7 SR: Set/reset flip-flop (STEP 7 Safety V21)

Description

You can use the "Set/reset flip-flop" instruction to set or reset the bit of the specified operand based on the signal state of inputs S and R1. If the signal state at input S is "1" and the signal state at input R1 is "0", the specified operand is set to "1". If the signal state at input S is "0" and the signal state at input R1 is "1", the specified operand is reset to "0".

Input R1 takes priority over input S. If the signal state is "1" at the two inputs S and R1, the signal state of the specified operand is reset to "0".

The instruction is not executed if the signal state at the two inputs S and R1 is "0". The signal state of the operand then remains unchanged.

The current signal state of the operand is transferred to output Q and can be queried there.

NOTE

If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the operands of the instruction.

If the operand area "local data (temp)" is used for the edge bit memory of the instruction, the local data bit used must be initialized beforehand.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
S	Input	BOOL	Enable set
R1	Input	BOOL	Enable reset
<Operand>	Output	BOOL	Operand that is set or reset.
Q	Output	BOOL	Signal state of the operand

Example

The following example shows how the instruction works:

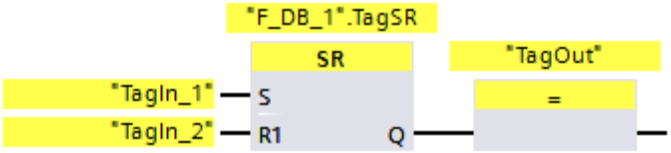

Operands ""F_DB_1".TagSR" and "TagOut" are set when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operand "TagIn_2" has signal state "0".

Operands ""F_DB_1".TagSR" and "TagOut" are reset when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "0" and operand "TagIn_2" has signal state "1".
- Both operands "TagIn_1" and "TagIn_2" have signal state "1".

13.4.2.8 RS: Reset/set flip-flop (STEP 7 Safety V21)

Description

You can use the "Reset/set flip-flop" instruction to reset or set the bit of the specified operand based on the signal state of inputs R and S1. When the signal state is "1" at input R and "0" at input S1, the specified operand is reset to "0". When the signal state is "0" at input R and "1" at input S1, the specified operand is set to "1".

Input S1 takes priority over input R. If the signal state is "1" at the two inputs R and S1, the signal state of the specified operand is set to "1".

The instruction is not executed if the signal state at the two inputs R and S1 is "0". The signal state of the operand then remains unchanged.

The current signal state of the operand is transferred to output Q and can be queried there.

NOTE

If you want to use a formal parameter of an F-FC for the operand of the instruction, it must be declared as an InOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the operands of the instruction.

If the operand area "local data (temp)" is used for the edge bit memory of the instruction, the local data bit used must be initialized beforehand.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
R	Input	BOOL	Enable reset
S1	Input	BOOL	Enable set
<Operand>	Output	BOOL	Operand that is reset or set.
Q	Output	BOOL	Signal state of the operand

Example

The following example shows how the instruction works:

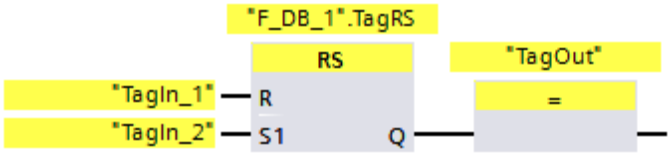

Operands ""F_DB_1".TagRS" and "TagOut" are reset when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "1".
- Operand "TagIn_2" has signal state "0".

Operands ""F_DB_1".TagRS" and "TagOut" are set when the following conditions are fulfilled:

- Operand "TagIn_1" has signal state "0" and operand "TagIn_2" has signal state "1".
- Operands "TagIn_1" and "TagIn_2" have signal state "1".

13.4.2.9 P: Scan operand for positive signal edge (STEP 7 Safety V21)

Description

You can use the "Scan operand for positive signal edge" instruction to determine if there is a change from "0" to "1" in the signal state of a specified operand (<Operand1>). The instruction compares the current signal state of <Operand1> with the signal state of the previous query saved in <Operand2>. If the instruction detects a change in the result of logic operation from "0" to "1", there is a positive, rising edge.

If a rising edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Enter the operand to be queried (<Operand1>) in the operand placeholder above the instruction. Enter the edge memory bit (<Operand2>) in the operand placeholder below the instruction.

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand2> of the instruction, it must be declared as an InOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand2> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand2> of the instruction, the local data bit used must be initialized beforehand.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand1>	Input	BOOL	Signal to be queried
<Operand2>	InOut	BOOL	Edge memory bit in which the signal state of the previous query is saved.

Example

The following example shows how the instruction works:

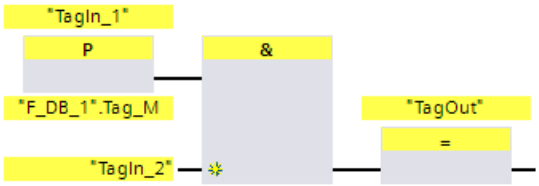

"TagOut" is set when the following conditions are fulfilled:

- There is a rising edge at input "TagIn_1".
- The signal state of operand "TagIn_2" is "1".

13.4.2.10 N: Scan operand for negative signal edge (STEP 7 Safety V21)

Description

You can use the "Scan operand for negative signal edge" instruction to determine if there is a change form "1" to "0" in the signal state of a specified operand. The instruction compares the current signal state of <Operand1> with the signal state of the previous query saved in <Operand2>. If the instruction detects a change in the result of logic operation from "1" to "0", there is a negative, falling edge.

If a falling edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

Enter the operand to be queried (<Operand1>) in the operand placeholder above the instruction. Enter the edge memory bit (<Operand2>) in the operand placeholder below the instruction.

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand2> of the instruction, it must be declared as an InOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand2> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand2> of the instruction, the local data bit used must be initialized beforehand.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Operand1>	Input	BOOL	Signal to be queried
<Operand2>	InOut	BOOL	Edge memory bit in which the signal state of the previous query is saved.

Example

The following example shows how the instruction works:

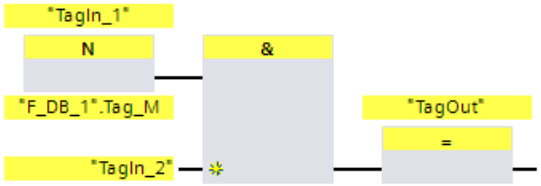

Output "TagOut" is set when the following conditions are fulfilled:

- There is a falling edge at input "TagIn_1".
- The signal state of operand "TagIn_2" is "1".

13.4.2.11 P_TRIG: Scan RLO for positive signal edge (STEP 7 Safety V21)

Description

You can use the "Scan RLO for positive signal edge" instruction to query a change in the signal state of the result of logic operation from "0" to "1". The instruction compares the current signal state of the result of logic operation with the signal state from the previous query, which is saved in the edge memory bit (<Operand>). If the instruction detects a change in the RLO from "0" to "1", there is a positive, rising edge.

If a rising edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand> of the instruction, it must be declared as an iInOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand> of the instruction, the local data bit used must be initialized beforehand.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CLK	Input	BOOL	Current RLO
<Operand>	InOut	BOOL	Edge memory bit in which the RLO of the previous query is saved.
Q	Output	BOOL	Result of edge evaluation

Example

The following example shows how the instruction works:

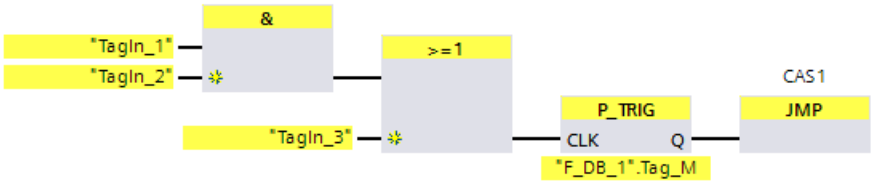

The RLO from the previous bit logic operation is saved in edge memory bit ""F_DB_1".Tag_M". If a change in the RLO signal state from "0" to "1" is detected, the program jumps to jump label CAS1.

13.4.2.12 N_TRIG: Scan RLO for negative signal edge (STEP 7 Safety V21)

Description

You can use the "Scan RLO for negative signal edge" instruction to query a change in the signal state of the result of logic operation from "1" to "0". The instruction compares the current signal state of the result of logic operation with the signal state from the previous query, which is saved in the edge memory bit (<Operand>). If the instruction detects a change in the RLO from "1" to "0", there is a negative, falling edge.

If a falling edge is detected, the output of the instruction has signal state "1". In all other cases, the signal state at the output of the instruction is "0".

NOTE

The address of the edge memory bit must not be used more than once in the program, otherwise the edge memory bit would be overwritten. This would influence edge evaluation and the result would no longer be unequivocal.

NOTE

If you want to use a formal parameter of an F-FC for the edge memory bit <Operand> of the instruction, it must be declared as an iInOut parameter.

NOTE

You cannot use the "process image", "standard DB" and "bit memory" operand areas for the edge memory bit <Operand> of the instruction.

If operand area "local data (temp)" is used for the edge memory bit <Operand> of the instruction, the local data bit used must be initialized beforehand.

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CLK	Input	BOOL	Current RLO
<Operand>	InOut	BOOL	Edge memory bit in which the RLO of the previous query is saved.
Q	Output	BOOL	Result of edge evaluation

Example

The following example shows how the instruction works:

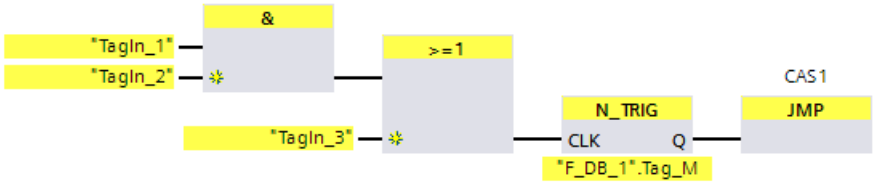

The RLO of the previous bit logic operation is saved in edge bit memory ""F_DB_1".Tag_M". If a change in the RLO signal state from "1" to "0" is detected, the program jumps to jump label CAS1.

13.5 Safety functions

13.5.1 ESTOP1: Emergency STOP/emergency OFF up to stop category 1 (STEP 7 Safety V21)

Description

This instruction supports the implementation of an EMERGENCY STOP/EMERGENCY OFF shutdown with acknowledgment for STOP categories 0 and 1 for the purpose of complying with requirements of IEC 60204 or IEC 61800-5-2. However, additional measures described in the respective standard may have to be taken in order to fully comply with the requirements of the respective standard.

Enable signal Q is reset to 0, as soon as input E_STOP takes a signal state of 0 (Stop category 0). Enable signal Q_DELAY is reset to 0 after the time delay set at input TIME_DEL (Stop Category 1).

Enable signal Q is reset to 1 not before input E_STOP takes a signal state of 1 and an acknowledgment occurs. The acknowledgment for the enable takes place according to the parameter assignment at input ACK_NEC:

- If ACK_NEC = 0, the acknowledgment is automatic.
- If ACK_NEC = 1, you must use a rising edge at input ACK for acknowledging the enable.

Output ACK_REQ is used to signal that a user acknowledgment is required at input ACK for the acknowledgment. The instruction sets output ACK_REQ to 1, as soon as input E_STOP = 1.

Following an acknowledgment, the instruction resets ACK_REQ to 0.

Every call of the "Emergency STOP/Emergency OFF up to Stop Category 1" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., ESTOP1_DB_1) or a multi-instance (e.g., ESTOP1_Instance_1) for the "Emergency STOP/Emergency OFF up to Stop Category 1" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

WARNING

The ACK_NEC tag must not be assigned a value of "0" unless an automatic restart of the affected process is otherwise excluded. *(S033)*

Note: In case of two channels according to category 3.4 of ISO 13849-1:2015 or EN ISO 13849-1:2015, the discrepancy monitoring of the two NC contacts of the EMERGENCY STOP/EMERGENCY OFF must already take place in the F-I/O. The F-I/O has to be configured accordingly (sensor evaluation: two-channel, equivalent), and the result of the evaluation interconnected with the E_STOP input. In order to keep the discrepancy time from influencing the response time, you must assign "Supply value 0" for the behavior of discrepancy during configuration.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
E_STOP	Input	BOOL	EMERGENCY STOP/EMERGENCY OFF
ACK_NEC	Input	BOOL	1=Acknowledgment necessary
ACK	Input	BOOL	1=Acknowledgment
TIME_DEL	Input	TIME	Time delay
Q	Output	BOOL	1=Enable
Q_DELAY	Output	BOOL	Enable is OFF delayed
ACK_REQ	Output	BOOL	1=Acknowledgment necessary
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	Version 1.0 requires that the F_TOF block with the number FB 186 is available in the project tree in the "Program blocks/System blocks/STEP 7 Safety" folder.
1.1	x	—	—	—	These versions have identical functions to version 1.0, but do not require the F_TOF block to have a particular number.
1.2	x	—	—	o	
1.3	x	o	—	o	
1.4	x	o	—	o	
1.5	x	x	—	x	
1.6	x	x	x	x	The reaction of the delay time TIME_DEL for F-CPUs S7-1200/1500 was adapted to the reaction of F-CPUs S7-300/400: If the input ESTOP (0 -> 1 (including acknowledgment) -> 0) is changed while the delay time is running, the delay time is restarted.

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Startup behavior

After an F-system startup, when ACK_NEC = 1, you must acknowledge the instruction using a rising edge at input ACK.

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 4 and 5 are saved until you acknowledge at the ACK input.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Incorrect TIM_DEL setting	Time delay setting < 0	Set time delay > 0
Bit 1	Reserved	—	—
Bit 2	Reserved	—	—
Bit 3	Reserved	—	—

Bit no.	Assignment	Possible error causes	Remedies
Bit 4	Acknowledgment not possible because emergency STOP/emergency OFF is still active	Emergency STOP/Emergency OFF pushbutton is locked	Release Emergency STOP/Emergency OFF pushbutton
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of emergency STOP/emergency OFF pushbutton	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 176)
		Emergency STOP/Emergency OFF pushbutton is defective	Check emergency STOP/emergency OFF pushbutton
		Wiring fault	Check wiring of the emergency STOP/emergency OFF pushbutton
Bit 5	If enable is missing: input ACK has a permanent signal state of 1	Acknowledgment button defective	Check acknowledgment button
		Wiring fault	Check wiring of acknowledgment button
Bit 6	Acknowledgment required (= state of ACK_REQ)	—	—
Bit 7	State of output Q	—	—

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 464)" for more on this.

Example

The following example shows how the instruction works:

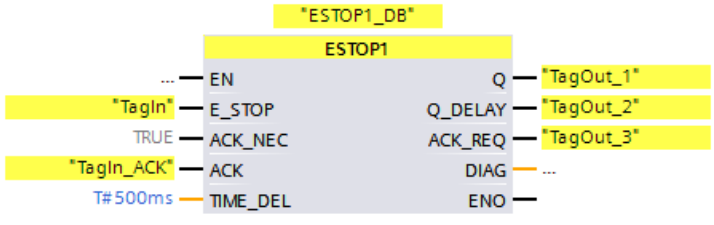

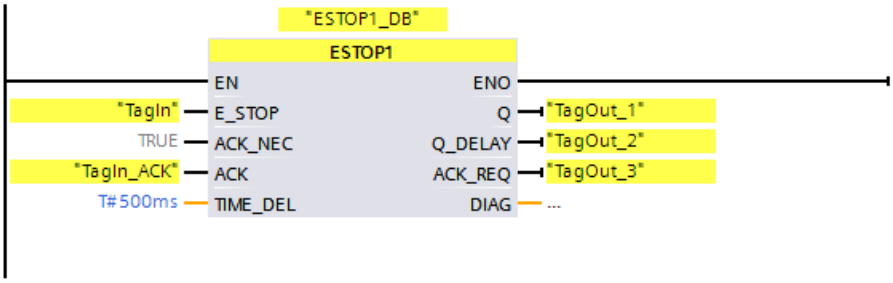

13.5.2 TWO_HAND: Two-hand monitoring (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

This instruction supports the implementation of two-hand monitoring for the purpose of complying with requirements of ISO 13851. However, additional measures described in the standard may have to be taken in order to fully comply with the requirements of the standard.

NOTE

This instruction is only available for S7-300 and S7-400 F-CPUs. For S7-1200/1500 F-CPUs, you use the instruction "Two-hand monitoring with enable". The application "Two-hand monitoring with enable" replaces the instruction "Two-hand monitoring" with compatible functions.

If pushbuttons IN1 and IN2 are activated within the permitted discrepancy time DISCTIME ≤ 500 ms (IN1/IN2 = 1) (synchronous activation), output signal Q is set to 1. If the time difference between activation of pushbutton IN1 and pushbutton IN2 is greater than DISCTIME, then the pushbuttons must be released and reactivated.

Q is reset to 0 as soon as one of the pushbuttons is released (IN1/IN2 = 0). Enable signal Q can be reset to 1 only if the other pushbutton has been released, and if both pushbuttons are then reactivated within the discrepancy time. Enable signal Q can never be set to 1 if the discrepancy time is set to values less than 0 or greater than 500 ms.

Every call of the "Two-hand monitoring" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., TWO_HAND_DB_1) or a multi-instance (e.g., TWO_HAND_Instance_1) for the "Two-hand monitoring" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Note: Only one signal per pushbutton can be evaluated in the instruction. Discrepancy monitoring of the NC and NO contacts of pushbuttons IN1 and IN2 is performed directly during suitable configuration (sensor evaluation: 1oo2 evaluation, non-equivalent) directly through the F-I/O with inputs. The normally open contact must be wired in such a way that it supplies the useful signal (see manual for the F-I/O you are using). In order to keep the discrepancy time from influencing the response time, you must assign "Supply value 0" for the behavior of discrepancy during configuration. If a discrepancy is detected, a fail-safe value of 0 is entered in the process image of the inputs (PII) for the pushbutton and QBAD or QBAD_I_xx = 1 is set in the relevant F-I/O DB. (See also F-I/O access (Page 161))

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	BOOL	Pushbutton 1
IN2	Input	BOOL	Pushbutton 2
DISCTIME	Input	TIME	Discrepancy time (0 to 500 ms)
Q	Output	BOOL	1=Enable

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction:

Refer to section "Temporal blurring for instructions with time processing (Page 464)" for more on this.

Example

The following example shows how the instruction works:

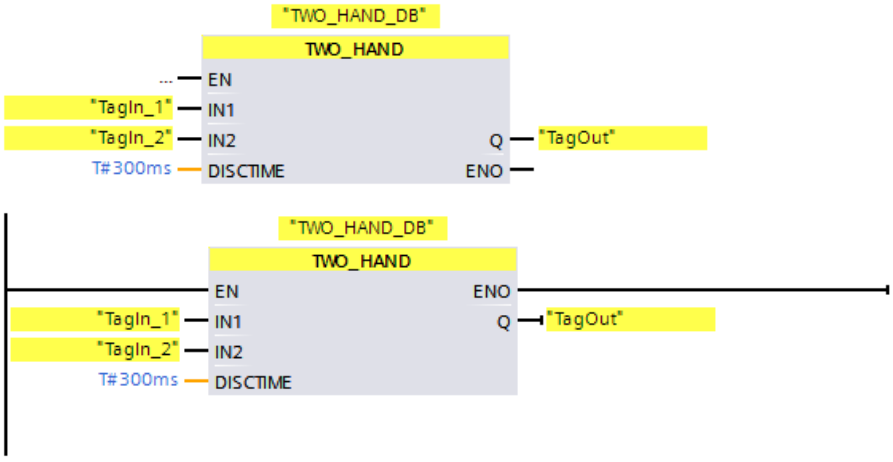

13.5.3 TWO_H_EN: Two-hand monitoring with enable (STEP 7 Safety V21)

Description

This instruction supports the implementation of two-hand monitoring with enable for the purpose of complying with requirements of ISO 13851. However, additional measures described in the standard may have to be taken in order to fully comply with the requirements of the standard.

If pushbuttons IN1 and IN2 are activated within the permitted discrepancy time DISCTIME ≤ 500 ms (IN1/IN2 = 1) (synchronous activation), output signal Q is set to 1 when existing ENABLE = 1. If the time difference between activation of pushbutton IN1 and pushbutton IN2 is greater than DISCTIME, then the pushbuttons must be released and reactivated.

Q is reset to 0 as soon as one of the pushbuttons is released (IN1/IN 2 = 0) or ENABLE = 0. Enable signal Q can be reset to 1 only if the other pushbutton has been released, and if both pushbuttons are then reactivated within the discrepancy time when existing ENABLE = 1.

Every call of the "Two-hand monitoring with enable" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., TWO_H_EN_DB_1) or a multi-instance (e.g., TWO_H_EN_Instance_1) for the "Two-hand monitoring with enable" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Note: Only one signal per pushbutton can be evaluated in the instruction. Discrepancy monitoring of the NC and NO contacts of pushbuttons IN1 and IN2 is performed directly during corresponding configuration (sensor evaluation: 1oo2 evaluation, non-equivalent) directly through the F-I/O with inputs. The normally open contact must be wired in such a way that it supplies the useful signal (see manual for the F-I/O you are using). In order to keep the discrepancy time from influencing the response time, during the configuration of discrepancy behavior, you must configure "Supply value 0".

If a discrepancy is detected, a fail-safe value of 0 is entered in the process image of the inputs (PII) for the pushbutton and QBAD or QBAD_I_xx = 1 or respectively value status = 0 is set in the relevant F-I/O DB.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	BOOL	Pushbutton 1
IN2	Input	BOOL	Pushbutton 2
ENABLE	Input	BOOL	Enable input
DISCTIME	Input	TIME	Discrepancy time (0 to 500 ms) For productive use, select a discrepancy time > 0 ms.
Q	Output	BOOL	1=Enable
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 0 to 5 are saved until the cause of the error has been eliminated.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Incorrect discrepancy time DISCTIME setting	Discrepancy time setting is <0 or > 500 ms	Set discrepancy time in range of 0 to 500 ms
Bit 1	Discrepancy time elapsed	Discrepancy time setting is too low	If necessary, set a higher discrepancy time
		Pushbuttons were not activated within the discrepancy time	Release pushbuttons and activate them within the discrepancy time
		Wiring fault	Check wiring of pushbuttons
		Pushbuttons defective	Check pushbuttons
		Pushbuttons are wired to different F-I/O, and F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON on an F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 176)
Bit 2	Reserved	—	—
Bit 3	Reserved	—	—
Bit 4	Incorrect activation sequence	One pushbutton was not released	Release pushbuttons and activate them within the discrepancy time
		Pushbuttons defective	Check pushbuttons

Bit no.	Assignment	Possible error causes	Remedies
Bit 5	ENABLE does not exist	ENABLE = 0	Set ENABLE = 1, release pushbutton and activate it within the discrepancy time
Bit 6	Reserved	—	—
Bit 7	State of output Q	—	—

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 464)" for more on this.

Example

The following example shows how the instruction works:

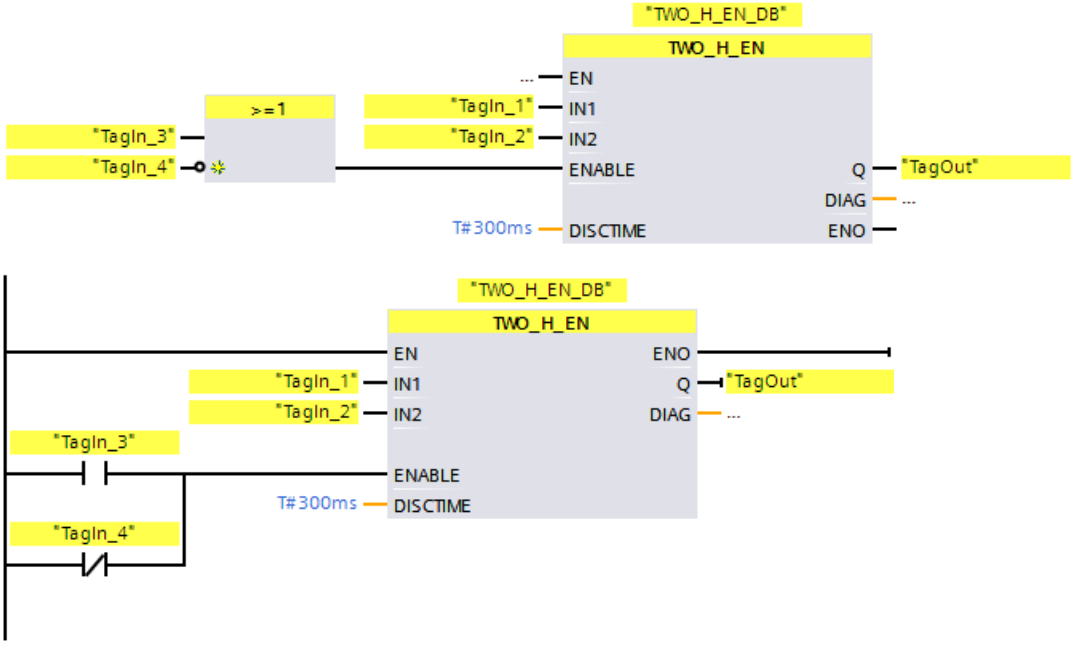

13.5.4 MUTING: Muting (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

This instruction performs parallel muting with two or four muting sensors.

NOTE

This instruction is only available for S7-300 and S7-400 F-CPUs. For S7-1200/1500 F-CPUs, you use the instruction "Parallel muting (Page 517)". The instruction "Parallel muting" replaces the instruction "Muting" with compatible functions.

Muting is a defined suppression of the protective function of light curtains. Light curtain muting can be used to introduce goods or objects into the danger area monitored by the light curtain without causing the machine to stop.

To utilize the muting function, at least two independently wired muting sensors must be present. The use of two or four muting sensors and correct integration into the production sequence must ensure that no persons enter the danger area while the light curtain is muted.

Every call of the "Muting" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., MUTING_DB_1) or a multi-instance (e.g., MUTING_Instance_1) for the "Muting" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
MS_11	Input	BOOL	Muting sensor 1 of sensor pair 1
MS_12	Input	BOOL	Muting sensor 2 of sensor pair 1
MS_21	Input	BOOL	Muting sensor 1 of sensor pair 2
MS_22	Input	BOOL	Muting sensor 2 of sensor pair 2
STOP	Input	BOOL	1=Conveyor system stopped
FREE	Input	BOOL	1=Light curtain uninterrupted
QBAD_MUT	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal of the muting lamp channel
DISCTIM1	Input	TIME	Discrepancy time of sensor pair 1 (0 to 3 s)
DISCTIM2	Input	TIME	Discrepancy time of sensor pair 2 (0 to 3 s)
TIME_MAX	Input	TIME	Maximum muting time (0 to 10 min)
ACK	Input	BOOL	Acknowledgment of restart inhibit
Q	Output	BOOL	1= Enable, not off

Parameter	Declaration	Data type	Description
MUTING	Output	BOOL	Display of muting is active
ACK_REQ	Output	BOOL	Acknowledgment necessary
FAULT	Output	BOOL	Group error
DIAG	Output	BYTE	Non-fail safe service information

Schematic sequence of error-free muting procedure with 4 muting sensors (MS_11, MS_12, MS_21, MS_22)

1

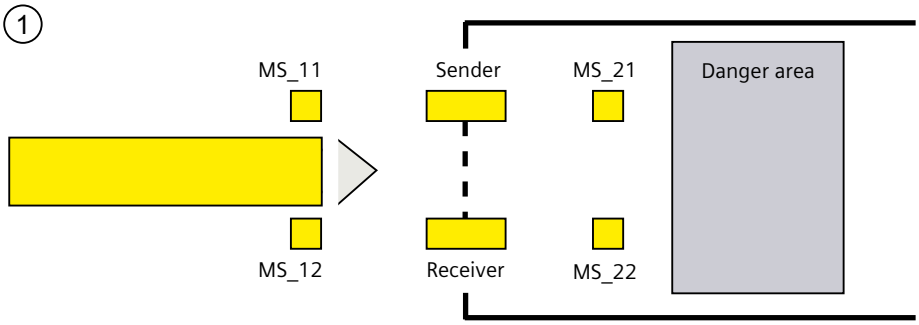

- If both muting sensors MS_11 and MS_12 are activated by the product within DISCTIM1 (apply signal state = 1), the instruction starts the MUTING function. Enable signal Q remains 1, even when input FREE = 0 (light curtain interrupted by product). The MUTING output for setting the muting lamp switches to 1.

NOTE

The muting lamp can be monitored using the QBAD_MUT input. To do this, you must wire the muting lamp to an output with wire break monitoring of an F-I/O and supply the QBAD_MUT input with the QBAD signal of the associated F-I/O or the QBAD_O_xx signal of the associated channel. If QBAD_MUT = 1, muting is terminated by the instruction. If monitoring of the muting lamp is not necessary, you do not have to supply input QBAD_MUT.

F-I/O that can promptly detect a wire break after activation of the muting operation must be used (*see manual for specific F-I/O*).

2

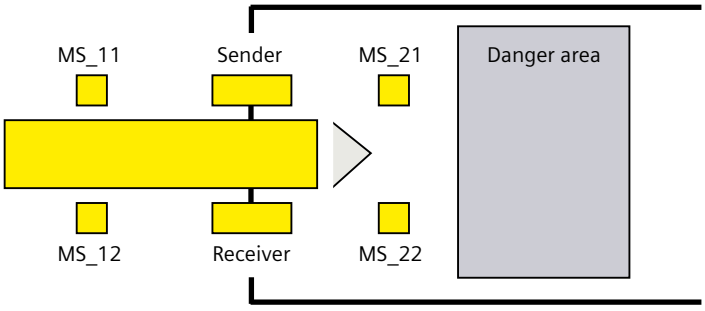

- As long as both muting sensors MS_11 and MS_12 continue to be activated, the MUTING function of the instruction causes Q to remain 1 and MUTING to remain 1 (so that the product can pass through the light curtain without causing the machine to stop).

③

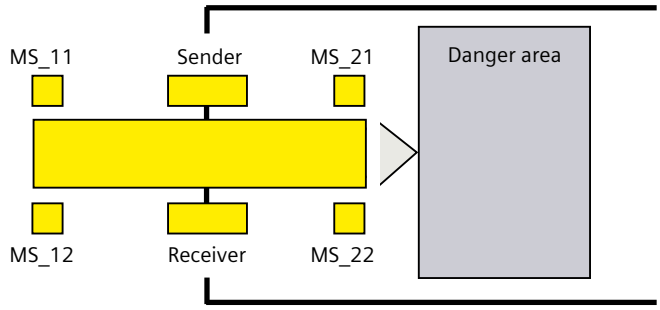

- The two muting sensors MS_21 and MS_22 must be activated (within DISCTIM2) before muting sensors MS_11 and MS_12 are switched to inactive (apply signal state 0). In this way, the instruction retains the MUTING function. (Q = 1, MUTING = 1).

④

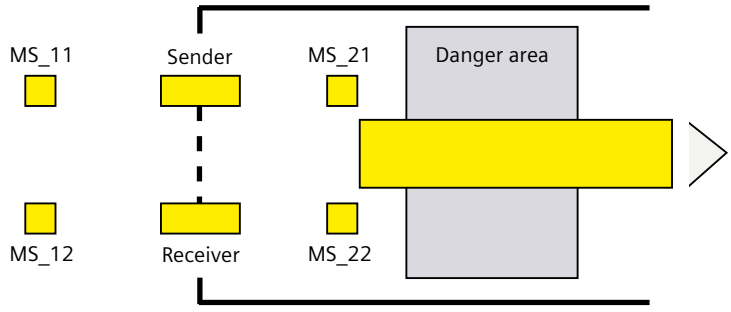

- Only if one of the two muting sensors MS_21 and MS_22 is switched to inactive (product enables sensors) is the MUTING function terminated (Q = 1, MUTING = 0). The maximum activation time for the MUTING function is the time set at input TIME_MAX.

NOTE

The MUTING function is also started if the product passes the light curtain in the reverse direction and the muting sensors are thus activated by the product in reverse order.

Timing diagrams for error-free muting procedure with 4 muting sensors

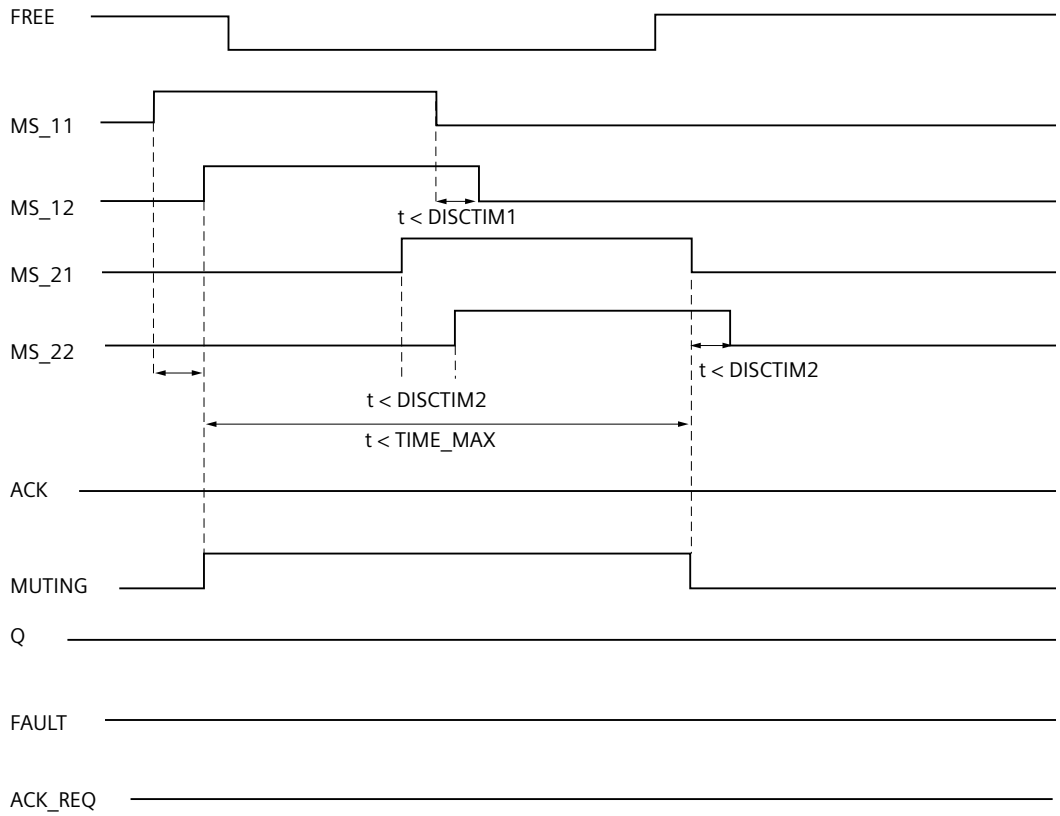

Schematic sequence of muting procedure with reflection light barriers

If reflection light barriers are used as muting sensors, they are generally arranged diagonally.

In general, this arrangement of reflection light barriers as muting sensors requires only two light barriers, and only MS_11 and MS_12 are interconnected.

The sequence is similar to that of the muting procedure with 4 muting sensors. Step 3 is omitted. In step 4, replace MS_21 and MS_22 with MS_11 and MS_12, respectively.

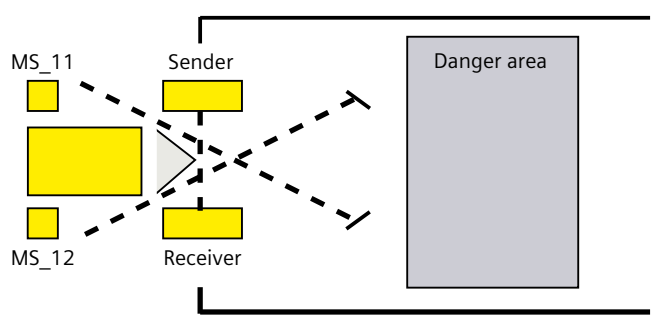

Restart inhibit upon interruption of light curtain (if MUTING is not active), when errors occur, and during F-system startup

Enable signal Q cannot be set to 1 or becomes 0, if:

- Light curtain is interrupted (e.g., by a person or material transport) while the MUTING function is not active
- The muting lamp monitoring function responds at input QBAD_MUT
- Sensor pair 1 (MS_11 and MS_12) or sensor pair 2 (MS_21 and MS_22) is not activated or deactivated during discrepancy time DISCTIM1 or DISCTIM2, respectively
- The MUTING function is active longer than the maximum muting time TIME_MAX
- Discrepancy times DISCTIM1 and DISCTIM2 have been set to values < 0 or > 3 s
- Maximum muting time TIME_MAX has been set to a value< 0 or > 10 min

In the identified cases, output FAULT (group error) is set to 1 (restart inhibit). If the MUTING function is started, it will be terminated and the Muting output becomes 0.

⚠ WARNING

When a valid combination of signal states of muting sensors is immediately detected at startup of the F-system (for example, because the muting sensors are interconnected to inputs of a standard I/O that immediately provide process values during the F-system startup), the MUTING function is immediately started and the MUTING output and enable signal Q are set to 1. The FAULT output (group error) is not set to 1 (no restart inhibit!). *(S035)*

Acknowledgment of restart inhibit

Enable signal Q becomes 1 again, when:

- The light curtain is no longer interrupted
- If present, errors are eliminated (see output DIAG)

  and
- A user acknowledgment with positive edge occurs at input ACK (see also Implementation of user acknowledgment (Page 196)).

The FAULT output is set to 0. Output ACK_REQ = 1 signals that user acknowledgment at input ACK is required to eliminate the restart inhibit. The instruction sets ACK_REQ = 1 as soon as the light curtain is no longer interrupted or the errors have been eliminated. Once acknowledgment has occurred, the instruction resets ACK_REQ to 0.

NOTE

Following discrepancy errors and once the maximum muting time has been exceeded, ACK_REQ is immediately set to 1. As soon as a user acknowledgment has taken place at input ACK, discrepancy times DISCTIM1 and DISCTIM2 and maximum muting time TIME_MAX are reset.

Timing diagrams for discrepancy errors at sensor pair 1 or interruption of the light curtain (if MUTING is not active)

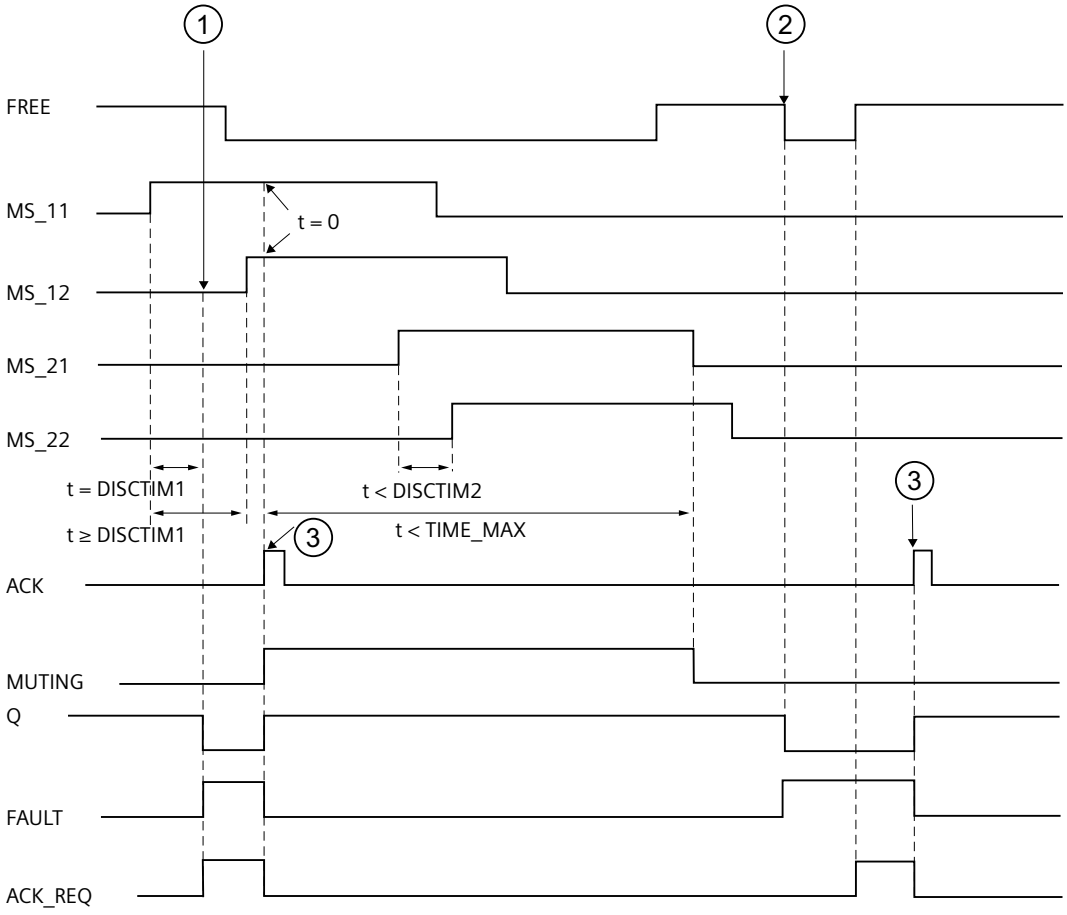

① Sensor pair 1 (MS_11 and MS_12) is not activated within discrepancy time DISCTIM1.

② The light curtain is interrupted even though the MUTING function is not active.

③ Acknowledgment

Behavior with stopped conveyor equipment

If, while the conveyor equipment has stopped, the monitoring for one of the following reasons is to be deactivated:

- To comply with discrepancy time DISCTIM1 or DISCTIM2
- To comply with maximum muting time TIME_MAX

You must supply input STOP with a "1" signal for as long as the conveyor equipment is stopped. As soon as the conveyor equipment is running again (STOP = 0), discrepancy times DISCTIM1 and DISCTIM2 and maximum muting time TIME_MAX are reset.

WARNING

When STOP = 1, the discrepancy monitoring is shut down. During this time, if inputs MSx1/MSx2 of a sensor pair both take a signal state of 1 due to an undetected error, for example, because both muting sensors have adopted signal state 1 in the event of an error, the fault is not detected and the MUTING function can be started unintentionally. *(S036)*

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits are saved until acknowledgment at input ACK.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Discrepancy error or incorrect discrepancy time DISCTIM 1 setting for sensor pair 1	Malfunction in production sequence	Malfunction in production sequence eliminated
		Sensor defective	Check sensors
		Wiring fault	Check wiring of sensors
		Sensors are wired to different F-I/O, and F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON on an F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 176)
		Discrepancy time setting is too low	If necessary, set a higher discrepancy time
		Discrepancy time setting is < 0 s or > 3 s	Set discrepancy time in range between 0 s and 3 s
Bit 1	Discrepancy error or incorrect discrepancy time DISCTIM 2 setting for sensor pair 2	Same as Bit 0	Same as Bit 0
Bit 2	Maximum muting time exceeded or incorrect muting time TIME_MAX setting	Malfunction in production sequence	Malfunction in production sequence eliminated
		Maximum muting time setting is too low	If necessary, set a higher maximum muting time
		Muting time setting is < 0 s or > 10 min	Set muting time in range from 0 s to 10 min
Bit 3	Light curtain interrupted and muting not active	Light curtain is defective	Check light curtain
		Wiring fault	Check wiring of light curtain (FREE input)

Bit no.	Assignment	Possible error causes	Remedies
Bit 3	Light curtain interrupted and muting not active	F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of light curtain (FREE input)	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 176)
		See other DIAG bits	
Bit 4	Muting lamp is defective or cannot be set	Muting lamp is defective	Replace muting lamp
		Wiring fault	Check wiring of muting lamp
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of muting lamp	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 176)
Bit 5	Reserved	—	—
Bit 6	Reserved	—	—
Bit 7	Reserved	—	—

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction:

Refer to section "Temporal blurring for instructions with time processing (Page 464)" for more on this.

Example

The following example shows how the instruction works:

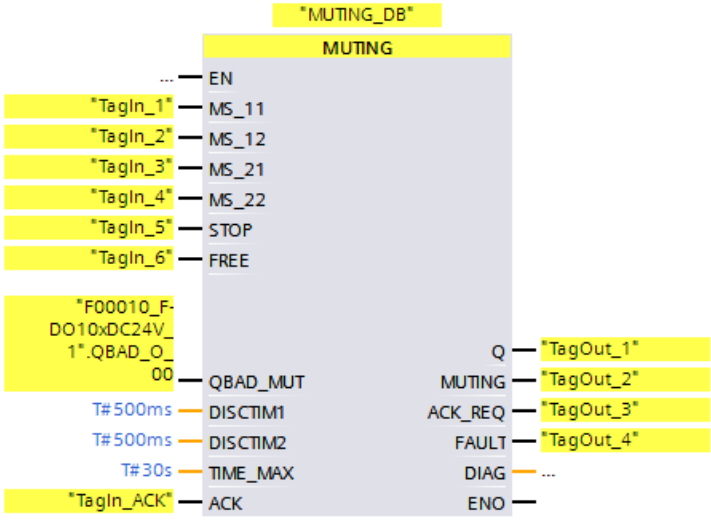

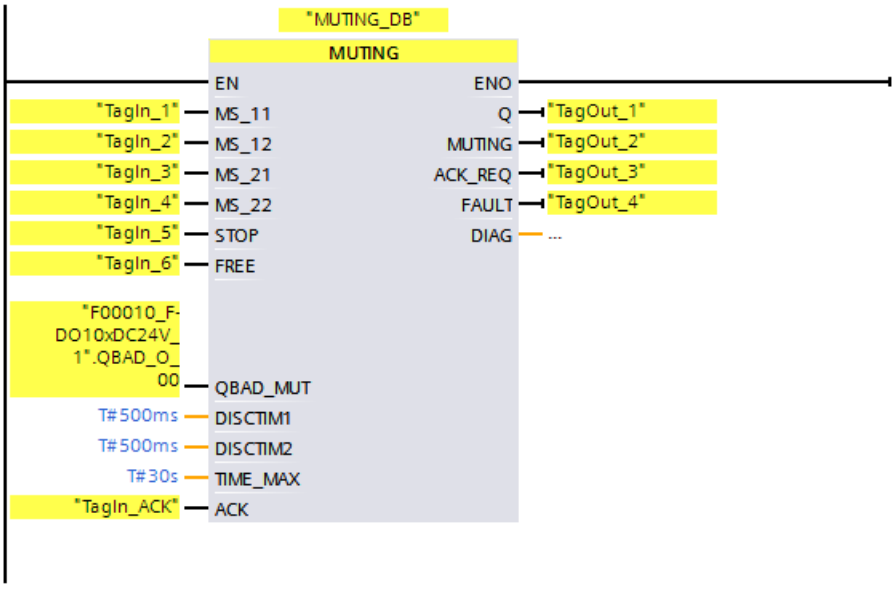

13.5.5 MUT_P: Parallel muting (STEP 7 Safety V21)

Description

This instruction performs parallel muting with two or four muting sensors.

Muting is a defined suppression of the protective function of light curtains. Light curtain muting can be used to introduce goods or objects into the danger area monitored by the light curtain without causing the machine to stop.

To utilize the muting function, at least two independently wired muting sensors must be present. The use of two or four muting sensors and correct integration into the production sequence must ensure that no persons enter the danger area while the light curtain is muted.

Every call of the "Parallel muting" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., MUT_P_DB_1) or a multi-instance (e.g., MUT_P_Instance_1) for the "Parallel muting" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
MS_11	Input	BOOL	Muting sensor 11
MS_12	Input	BOOL	Muting sensor 12

Parameter	Declaration	Data type	Description
MS_21	Input	BOOL	Muting sensor 21
MS_22	Input	BOOL	Muting sensor 22
STOP	Input	BOOL	1=Conveyor system stopped
FREE	Input	BOOL	1=Light curtain uninterrupted
ENABLE	Input	BOOL	1=Enable MUTING
QBAD_MUT	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal / inverted value status of the muting lamp channel
ACK	Input	BOOL	Acknowledgment of restart inhibit
DISCTIM1	Input	TIME	Discrepancy time of sensor pair 1 (0 to 3 s)
DISCTIM2	Input	TIME	Discrepancy time of sensor pair 2 (0 to 3 s)
TIME_MAX	Input	TIME	Maximum muting time (0 to 10 min)
Q	Output	BOOL	1= Enable, not off
MUTING	Output	BOOL	Display of muting is active
ACK_REQ	Output	BOOL	Acknowledgment necessary
FAULT	Output	BOOL	Group error
DIAG	Output	WORD	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x*	—	—	—	
1.1	x*	—	—	—	These versions have identical functions to version 1.0. The output DIAG can now be correctly interconnected with the operand of data type WORD.
1.2	x*	—	—	o	
1.3	x*	o	—	o	
1.4	x	x	x	x	

o This version is no longer supported.

* S7-300/400: When a restart inhibit (output FAULT = 1) and ENABLE = 1 is present, output ACK_REQ is set to 1 even if not at least one muting sensor is activated. Use the DIAG bits 5 and 6 for more information.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Schematic sequence of error-free muting procedure with 4 muting sensors (MS_11, MS_12, MS_21, MS_22)

1

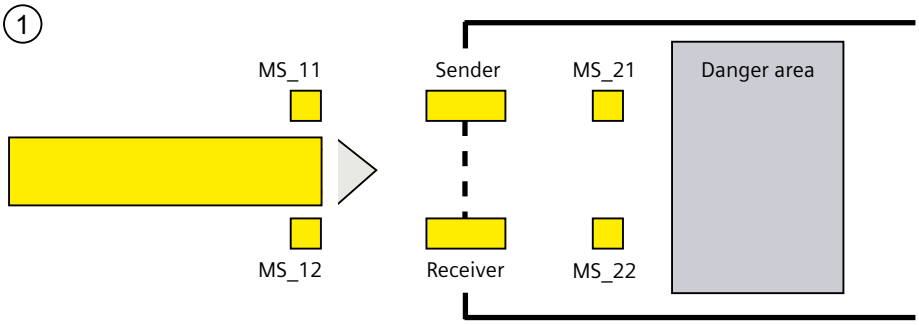

- If muting sensors MS_11 and MS_12 are both activated by the product within DISCTIM1 (apply signal state = 1) and MUTING is enabled by setting the ENABLE input to 1, the instruction starts the MUTING function. Enable signal Q remains 1, even when input FREE = 0 (light curtain interrupted by product). The MUTING output for setting the muting lamp switches to 1.

NOTE

The muting lamp can be monitored using the QBAD_MUT input. To do this, you must wire the muting lamp to an output with wire break monitoring of an F-I/O and supply the QBAD_MUT input with the QBAD signal of the associated F-I/O or the QBAD_O_xx signal / with inverted value statues of the associated channel. If QBAD_MUT = 1, muting is terminated by the instruction. If monitoring of the muting lamp is not necessary, you do not have to supply input QBAD_MUT.

F-I/O that can promptly detect a wire break after activation of the muting operation must be used (*see manual for specific F-I/O*).

2

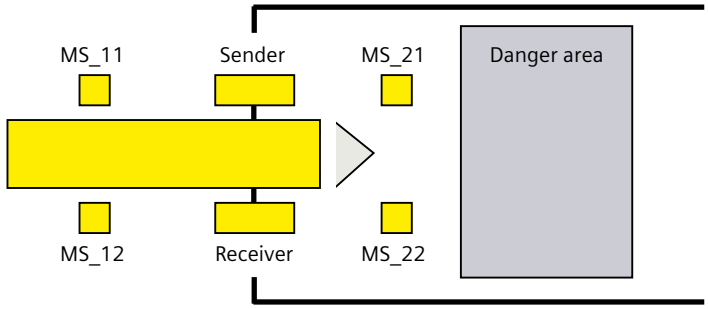

- As long as both muting sensors MS_11 and MS_12 continue to be activated, the MUTING function of the instruction causes Q to remain 1 and MUTING to remain 1 (so that the product can pass through the light curtain without causing the machine to stop). Each of the two muting sensors MS_11 and MS_12 may be switched to inactive (t < DISCTIM1) for a short time (apply signal state 0).

③

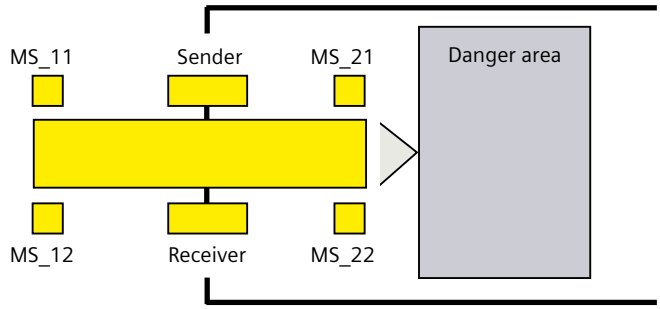

- Muting sensors MS_21 and MS_22 must both be activated (within DISCTIM2) before muting sensors MS_11 and MS_12 are switched to inactive (apply signal state 0). In this way, the instruction retains the MUTING function. (Q = 1, MUTING = 1).

④

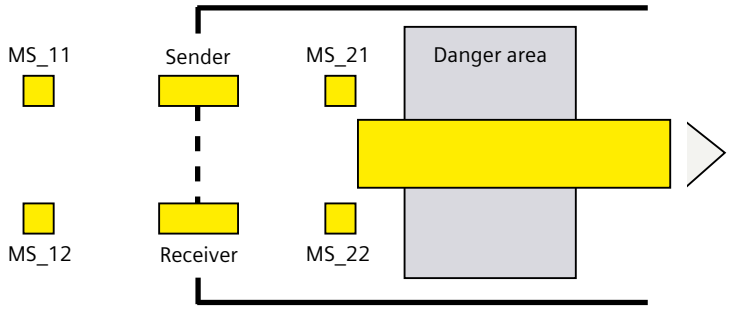

Only if muting sensors MS_21 and MS_22 are both switched to inactive (product enables sensors) is the MUTING function terminated (Q = 1, MUTING = 0). The maximum activation time for the MUTING function is the time set at input TIME_MAX.

NOTE

The MUTING function is also started if the product passes the light curtain in the reverse direction and the muting sensors are thus activated by the product in reverse order.

Timing diagrams for error-free muting procedure with 4 muting sensors

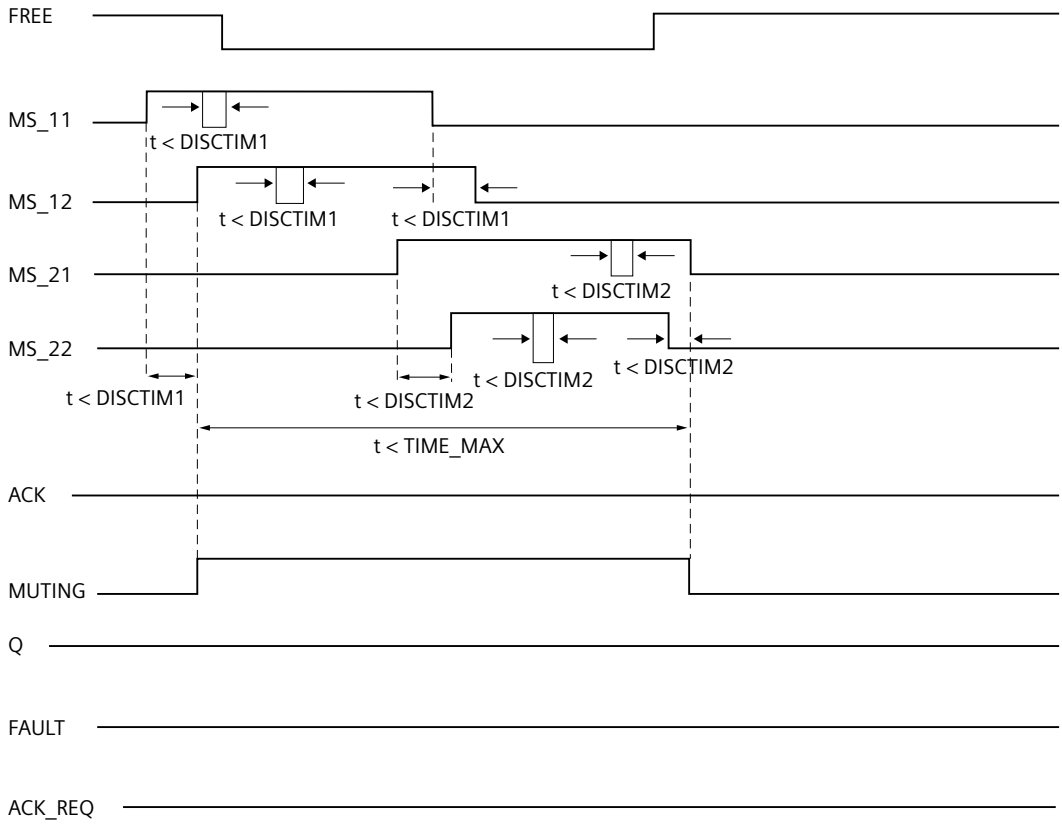

Schematic sequence of muting procedure with reflection light barriers

If reflection light barriers are used as muting sensors, they are generally arranged diagonally.

In general, this arrangement of reflection light barriers as muting sensors requires only two light barriers, and only MS_11 and MS_12 are interconnected.

The sequence is similar to that of the muting procedure with 4 muting sensors. Step 3 is omitted. In step 4, replace MS_21 and MS_22 with MS_11 and MS_12, respectively.

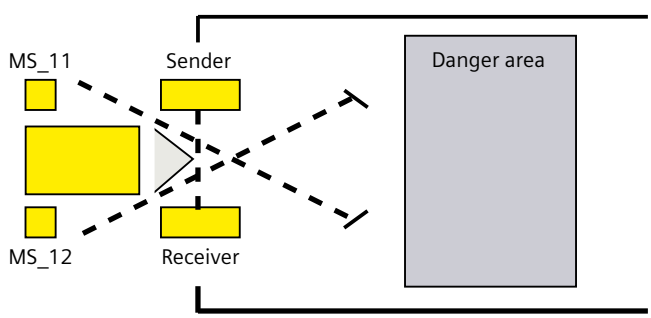

Restart inhibit upon interruption of light curtain (MUTING is not active), as well as when errors occur and during F-system startup

Enable signal Q cannot be set to 1 or becomes 0, if:

- Light curtain is interrupted (e.g., by a person or material transport) while the MUTING function is not active
- Light curtain is (being) interrupted and the muting lamp monitoring at input QBAD_MUT is set to 1
- Light curtain is (being) interrupted and the MUTING function is not enabled by setting input ENABLE to 1
- Sensor pair 1 (MS_11 and MS_12) or sensor pair 2 (MS_21 and MS_22) is not activated or deactivated during discrepancy time DISCTIM1 or DISCTIM2, respectively
- The MUTING function is active longer than the maximum muting time TIME_MAX
- Discrepancy times DISCTIM1 and DISCTIM2 have been set to values < 0 or > 3 s
- Maximum muting time TIME_MAX has been set to a value< 0 or > 10 min
- The F-system starts up (regardless of whether or not the light curtain is interrupted, because the F-I/O is passivated after F-system startup and, thus, the FREE input is initially supplied with 0)

In the identified cases, output FAULT (group error) is set to 1 (restart inhibit). If the MUTING function is started, it will be terminated and the Muting output becomes 0.

User acknowledgment of restart inhibit (no muting sensor is activated or ENABLE = 0)

Enable signal Q becomes 1 again, when:

- The light curtain is no longer interrupted
- If present, errors are eliminated (see output DIAG)

  and
- A user acknowledgment with positive edge occurs at input ACK (see also Implementation of user acknowledgment (Page 196)).

The FAULT output is set to 0. Output ACK_REQ = 1 (and DIAG bit 6) signals that user acknowledgment at input ACK is required to eliminate the restart inhibit. The instruction sets ACK_REQ = 1 as soon as the light curtain is no longer interrupted or the errors have been eliminated. Once acknowledgment has occurred, the instruction resets ACK_REQ to 0.

User Acknowledgment of restart inhibit (at least one muting sensor is activated and ENABLE = 1)

Enable signal Q becomes 1 again, when:

- If present, errors are eliminated (see output DIAG)
- FREE function occurs until a valid combination of muting sensors is detected

The FAULT output is set to 0. The MUTING function is restarted, if necessary, and the MUTING output becomes 1 if a valid combination of muting sensors is detected. When ENABLE = 1, output ACK_REQ = 1 (and DIAG-Bit 5) signals that FREE function is necessary for error

elimination and for removal of the restart inhibit. Once FREE function has occurred successfully, the instruction resets ACK_REQ to 0.

NOTE

Once the maximum muting time is exceeded, TIME_MAX is reset as soon as the MUTING function is restarted.

FREE function

If an error cannot be corrected immediately, the FREE function can be used to free the muting range. Enable signal Q and output MUTING =1 temporarily. The FREE function can be used if:

- ENABLE = 1
- At least one muting sensor is activated
- A user acknowledgment with rising edge at input ACK occurs twice within 4 s, and the second user acknowledgment at input ACK remains at a signal state of 1 (acknowledgment button remains activated)

WARNING

When using the FREE function, the action must be observed. A dangerous situation must be able to be interrupted at any time by releasing the acknowledgment button. The acknowledgment button must be mounted in such a way that the entire danger area can be observed by the operator. *(S037)*

Timing diagrams for discrepancy errors at sensor pair 1 or interruption of the light curtain (MUTING is not active)

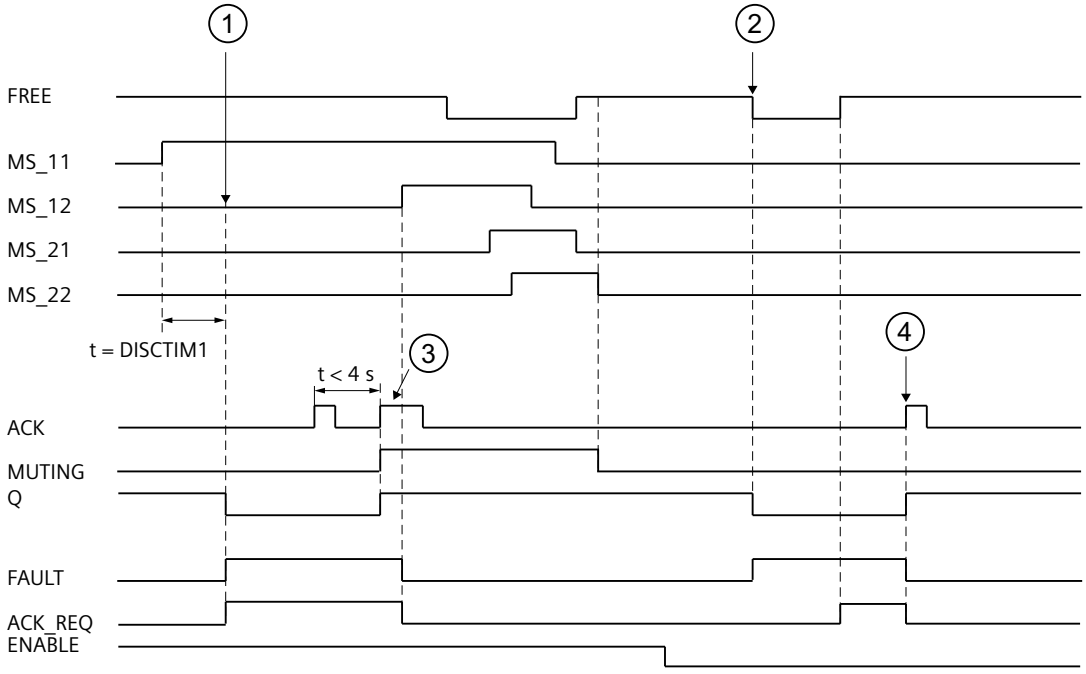

1	Sensor pair 1 (MS_11 and MS_22) is not activated within discrepancy time DISCTIM1.
2	The light curtain is interrupted even though there is no enable (ENABLE=0)
3	FREE function
4	Acknowledgment

Behavior with stopped conveyor equipment

If, while the conveyor equipment has stopped, the monitoring for one of the following reasons is to be deactivated:

- To comply with discrepancy time DISCTIM1 or DISCTIM2
- To comply with maximum muting time TIME_MAX

You must supply input STOP with a "1" signal for as long as the conveyor equipment is stopped. As soon as the conveyor equipment is running again (STOP = 0), discrepancy times DISCTIM1 and DISCTIM2 and maximum muting time TIME_MAX are reset.

WARNING

When STOP = 1 or ENABLE = 0, discrepancy monitoring is shut down. During this time, if inputs MSx1/MSx2 of a sensor pair both take a signal state of 1 due to an undetected error, for example, because both muting sensors have adopted signal state 1 in the event of an error, the fault is not detected and the MUTING function can be started unintentionally (when ENABLE =1). *(S038)*

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 0 to 6 are saved until acknowledgment at input ACK.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Discrepancy error or incorrect discrepancy time DISCTIM 1 setting for sensor pair 1	Malfunction in production sequence	Malfunction in production sequence eliminated
		Sensor defective	Check sensors
		Wiring fault	Check wiring of sensors
		Sensors are wired to different F-I/O, and F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON on an F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 176)
		Discrepancy time setting is too low	If necessary, set a higher discrepancy time
		Discrepancy time setting is < 0 s or > 3 s	Set discrepancy time in range between 0 s and 3 s
Bit 1	Discrepancy error or incorrect discrepancy time DISCTIM 2 setting for sensor pair 2	Same as Bit 0	Same as Bit 0
Bit 2	Maximum muting time exceeded or incorrect muting time TIME_MAX setting	Malfunction in production sequence	Malfunction in production sequence eliminated
		Maximum muting time setting is too low	If necessary, set a higher maximum muting time
		Muting time setting is < 0 s or > 10 min	Set muting time in range from 0 s to 10 min
Bit 3	Light curtain interrupted and muting not active	ENABLE = 0	Set ENABLE = 1
		Light curtain is defective	Check light curtain

Bit no.	Assignment	Possible error causes	Remedies
Bit 3	Light curtain interrupted and muting not active	Wiring fault	Check wiring of light curtain (FREE input)
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of light curtain (FREE input)	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 176)
		Startup of F-system	For FREE function, see DIAG Bit 5
		See other DIAG bits	
Bit 4	Muting lamp is defective or cannot be set	Muting lamp is defective	Replace muting lamp
		Wiring fault	Check wiring of muting lamp
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of muting lamp	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 176)
Bit 5	FREE function is necessary	See other DIAG bits	Two rising edges at ACK within 4 s, and activate acknowledgment button until ACK_REQ = 0
Bit 6	Acknowledgment necessary	—	—
Bit 7	State of output Q	—	—
Bit 8	State of output MUTING	—	—
Bit 9	FREE function active	—	—
Bit 10	Reserved	—	—
...			
Bit 15	Reserved	—	—

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 464)" for more on this.

Example

The following example shows how the instruction works:

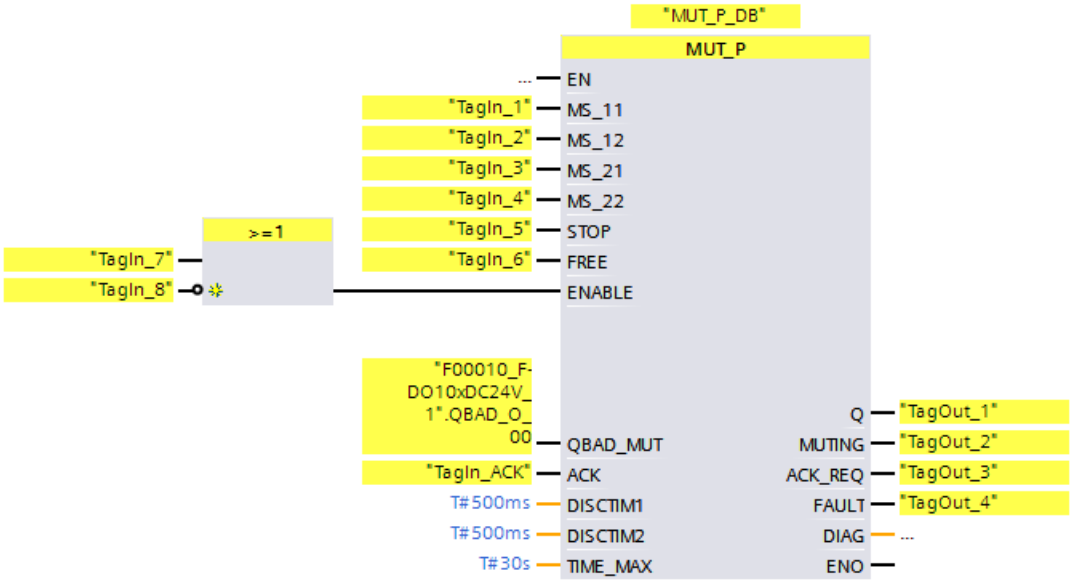

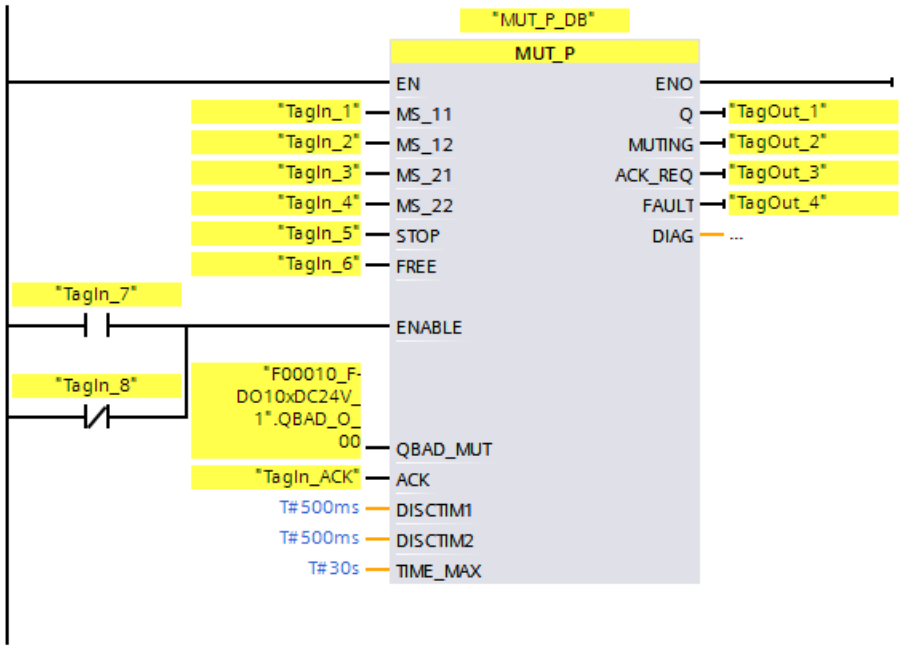

13.5.6 EV1oo2DI: 1oo2 evaluation with discrepancy analysis (STEP 7 Safety V21)

Description

This instruction implements a 1oo2 evaluation of two single-channel sensors combined with a discrepancy analysis.

Output Q is set to 1, if the signal states of inputs IN1 and IN2 both equal 1 and no discrepancy error DISC_FLT is stored. if the signal state of one or both inputs is 0, output Q is set to 0.

As soon as the signal states of inputs IN1 and IN2 are different, the discrepancy time DISCTIME is started. If the signal states of the two inputs are still different once the discrepancy time expires, a discrepancy error is detected and DISC_FLT is set to 1 (restart inhibit).

If the discrepancy between inputs IN1 and IN2 is no longer detected, the discrepancy error is acknowledged according to the parameter assignment of ACK_NEC:

- If ACK_NEC = 0, the acknowledgment is automatic.
- If ACK_NEC = 1, you must use a rising edge at input ACK to acknowledge the discrepancy error.

The output ACK_REQ = 1 signals that a user acknowledgment at input ACK is necessary to acknowledge the discrepancy error (cancel the restart inhibit). The instruction sets ACK_REQ = 1 as soon as discrepancy is no longer detected. After acknowledgment or if, prior to acknowledgment, there is once again a discrepancy between inputs IN1 and IN2, the instruction resets ACK_REQ to 0.

Output Q can never be set to 1 if the discrepancy time setting is < 0 or > 60 s. In this case, output DISC_FLT is also set to 1 (restart inhibit). The call interval of the safety program (e.g., OB 35) must be less than the discrepancy time setting.

Every call of the "1oo2 evaluation with discrepancy analysis" instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., EV1oo2DI_DB_1) or a multi-instance (e.g., EV1oo2DI_Instance_1) for the "1oo2 evaluation with discrepancy analysis" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

The ACK_NEC tag must not be assigned a value of "0" unless an automatic restart of the affected process is otherwise excluded. *(S033)*

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	BOOL	Sensor 1
IN2	Input	BOOL	Sensor 2
DISCTIME	Input	TIME	Discrepancy time (0 to 60 s)
ACK_NEC	Input	BOOL	1 = acknowledgment necessary for discrepancy error
ACK	Input	BOOL	Acknowledgment of discrepancy error
Q	Output	BOOL	Output
ACK_REQ	Output	BOOL	1 = acknowledgment required
DISC_FLT	Output	BOOL	1 = discrepancy error
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Ver-sion	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Activating inputs IN1 and IN2

Inputs IN1 and IN2 must both be activated in such a way that their safe state is 0.

Example with QBAD or QBAD_I_xx signal

For non-equivalent signals you need to OR the input (IN1 and IN2) with which you assign the encoder signal to the safe state 1, with the QBAD signal of the associated F-I/O or the QBAD_I_xx signal of the associated channel (with S7-300/400 F-CPUs) and negate the result. Signal state 0 is then at input IN1 or IN2 when fail-safe values are output.

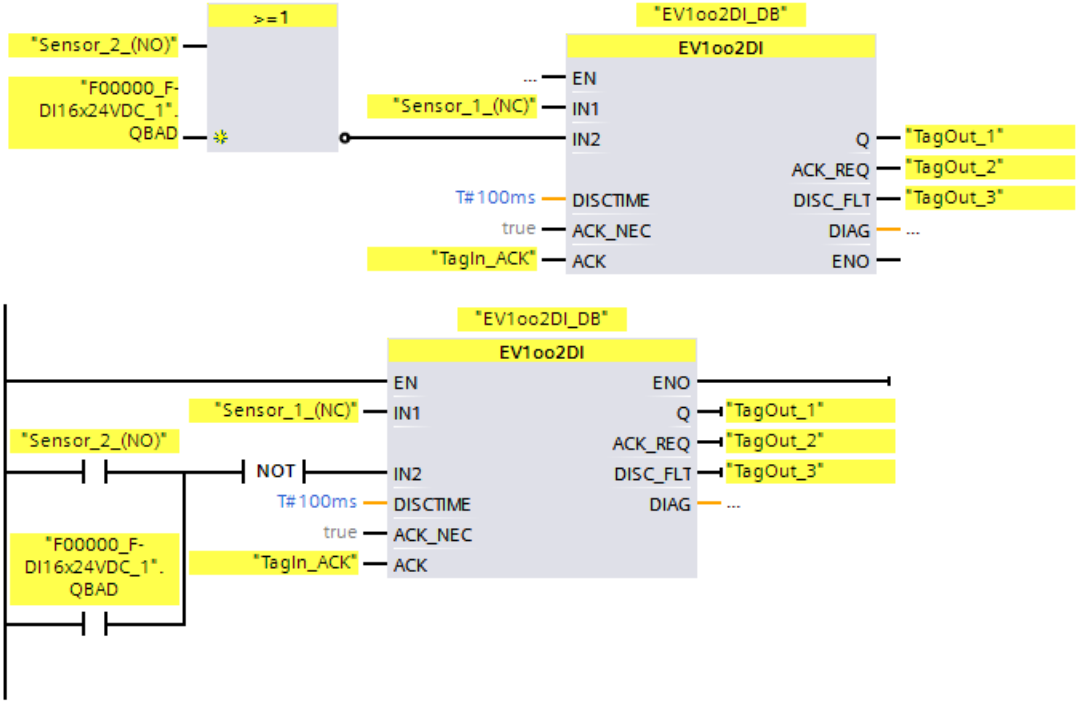

Example with value status

For non-equivalent signals, you have to negate the input (IN1 or IN2) with which you have assigned the encoder signal to a safe state of 1 and AND it with the value status of the associated channel. Signal state 0 is then at input IN1 or IN2 when fail-safe values are output.

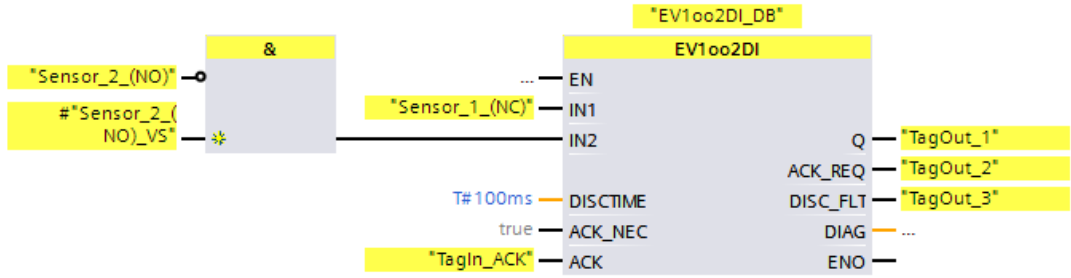

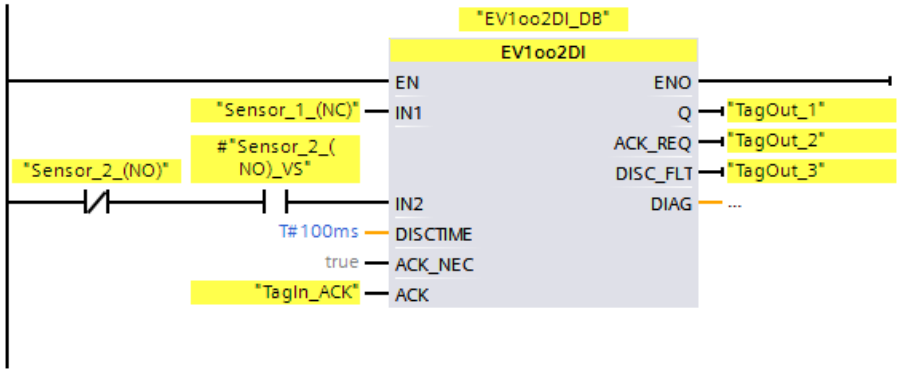

Timing diagrams EV1oo2DI

If ACK_NEC = 1:

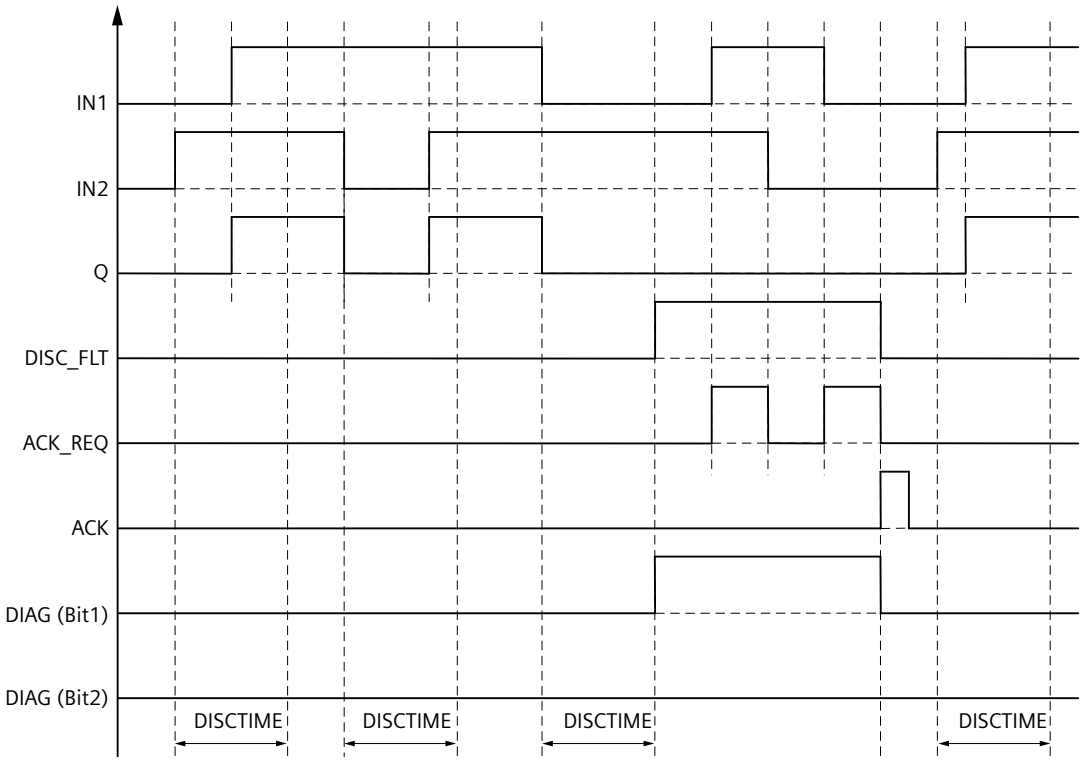

Startup behavior

NOTE

If the sensors at inputs IN1 and IN2 are assigned to different F-I/O, it is possible that the fail-safe values are output for different lengths of time following startup of the F-system due to different startup behavior of the F-I/O. If the signal states of inputs IN1 and IN2 remain different after the discrepancy time DISCTIME has expired, a discrepancy error is detected after the F-system starts up.

If ACK_NEC = 1 you must acknowledge the discrepancy error with a rising edge at input ACK.

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits are saved until acknowledgment at input ACK.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Discrepancy error or incorrect discrepancy time setting (= status of DISC_FLT)	Sensor defective	Check sensors
		Wiring fault	Check wiring of sensors
		Sensors are wired to different F-I/O, and F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON on an F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 176)
		Discrepancy time setting is too low	If necessary, set a higher discrepancy time
		Discrepancy time setting is < 0 s or > 60 s	Set discrepancy time in range between 0 s and 60 s
Bit 1	For discrepancy errors: last signal state change was at input IN1	—	—
Bit 2	For discrepancy errors: last signal state change was at input IN2	—	—
Bit 3	Reserved	—	—
Bit 4	Reserved	—	—
Bit 5	For discrepancy errors: input ACK has a permanent signal state of 1	Acknowledgment button defective	Replace acknowledgment button
		Wiring fault	Check wiring of acknowledgment button
Bit 6	Acknowledgment necessary	—	—
Bit 7	State of output Q	—	—

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 464)" for more on this.

Example

The following example shows how the instruction works:

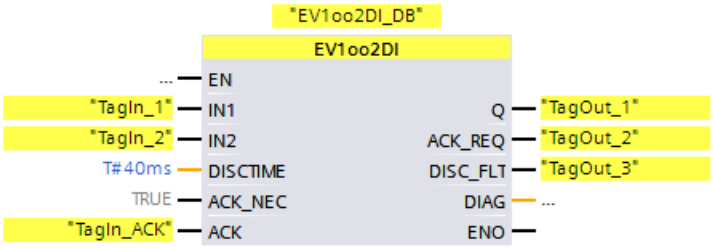

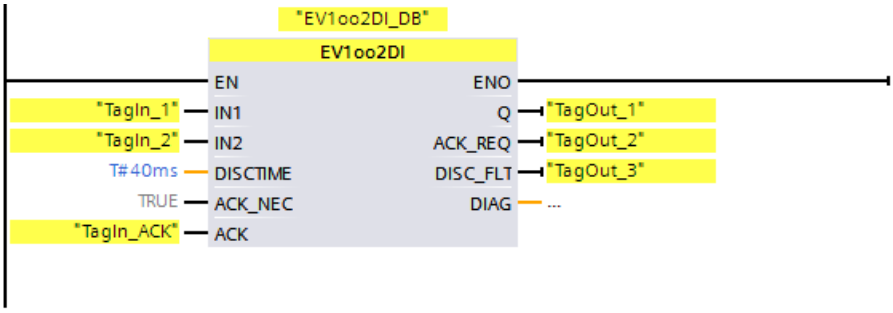

13.5.7 FDBACK: Feedback monitoring (STEP 7 Safety V21)

Description

This instruction implements feedback monitoring.

The signal state of output Q is checked to see whether it corresponds to the inverse signal state of the feedback input FEEDBACK.

Output Q is set to 1 as soon as input ON = 1. Requirement for this is that the feedback input FEEDBACK = 1 and no feedback error is saved.

Output Q is reset to 0, as soon as input ON = 0 or if a feedback error is detected.

A feedback error ERROR = 1 is detected if the inverse signal state of the feedback input FEEDBACK (to input Q) does not follow the signal state of output Q within the maximum tolerable feedback time. The feedback error is saved.

If a discrepancy is detected between the feedback input FEEDBACK and the output Q after a feedback error, the feedback error is acknowledged in accordance with the parameter assignment of ACK_NEC:

- If ACK_NEC = 0, the acknowledgment is automatic.
- If ACK_NEC = 1, you must acknowledge the feedback error with a rising edge at input ACK.

The ACK_REQ = 1 output then signals that a user acknowledgment is necessary at input ACK to acknowledge the feedback error. Following an acknowledgment, the instruction resets ACK_REQ to 0.

To avoid a feedback errors from being detected and acknowledgment from being required when the F-I/O controlled by the Q output are passivated, you need to supply input QBAD_FIO with the QBAD signal of the associated F-I/O or the QBAD_O_xx signal / inverted value status of the associated channel.

Every call of the "Feedback monitoring" instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., FDBACK_DB_1) or a multi-instance (e.g., FDBACK_Instance_1) for the "Feedback monitoring" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

WARNING

The ACK_NEC tag must not be assigned a value of "0" unless an automatic restart of the affected process is otherwise excluded. *(S033)*

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ON	Input	BOOL	1= Enable output
FEEDBACK	Input	BOOL	Feedback input
QBAD_FIO	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal / inverted value status of the Q output
ACK_NEC	Input	BOOL	1=Acknowledgment necessary
ACK	Input	BOOL	Acknowledgment
FDB_TIME	Input	TIME	Feedback time
Q	Output	BOOL	Output
ERROR	Output	BOOL	Feedback error
ACK_REQ	Output	BOOL	Acknowledgment request
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	Version 1.0 requires that the F_TOF block with the number FB 186 is available in the project tree in the "Program blocks/System blocks/STEP 7 Safety" folder.
1.1	x	—	—	—	These versions have identical functions to version 1.0, but do not require the F_TOF block to have a particular number.
1.2	x	—	—	o	
1.3	x	o	—	o	
1.4	x	o	—	o	
1.5	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Interconnection example

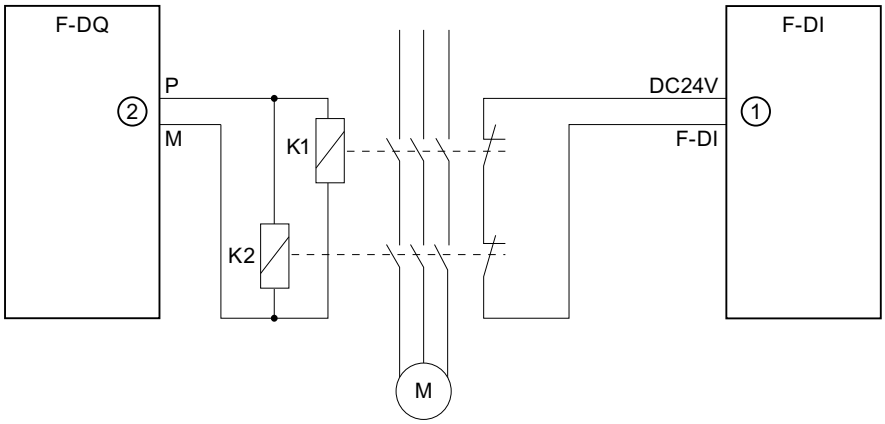

① Sent to the FEEDBACK input of the instruction

② from output Q of the instruction

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 0, 2, and 5 are saved until acknowledgment at input ACK.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Feedback error or incorrect feedback time setting (= state of ERROR)	Feedback time setting < 0	Set feedback time > 0
		Feedback time setting is too low	If necessary, set a higher feedback time
		Wiring fault	Check wiring of actuator and feedback contact
		Actuator or feedback contact is defective	Check actuator and feedback contact
		I/O fault or channel fault of feedback input	Check I/O
Bit 1	Passivation of F-I/O/channel controlled by output Q (= state of QBAD_FIO)	F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 176)
Bit 2	After feedback error: feedback input has permanent signal state of 0	F-I/O fault or channel fault of feedback input	Check I/O
		Feedback contact is defective	Check feedback contact
		F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O of feedback input	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 176)
Bit 3	Reserved	—	—
Bit 4	Reserved	—	—
Bit 5	For feedback error: input ACK has a permanent signal state of 1	Acknowledgment button defective	Check acknowledgment button
		Wiring fault	Check wiring of acknowledgment button
Bit 6	Acknowledgment required (= state of ACK_REQ)	—	—
Bit 7	State of output Q	—	—

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 464)" for more on this.

Example

The following example shows how the instruction for S7-300/400 F-CPUs works:

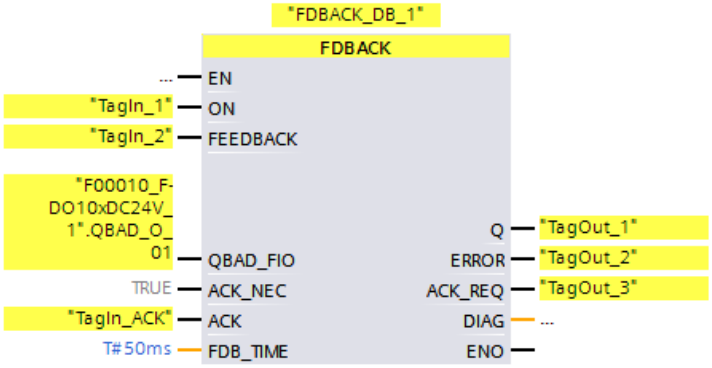

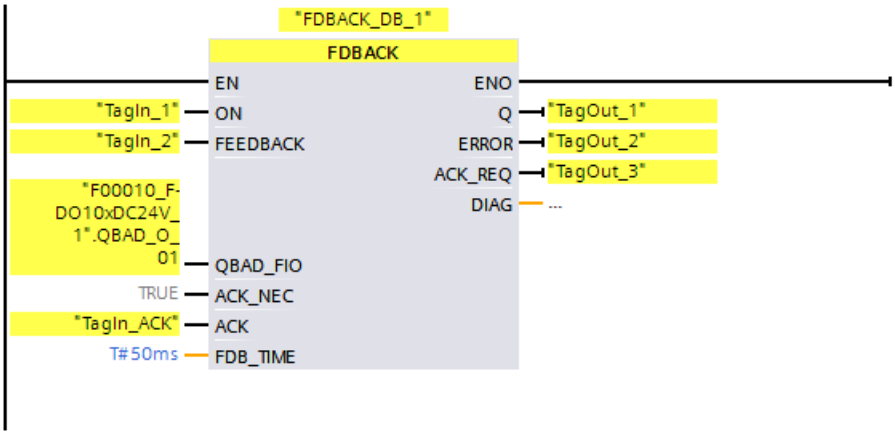

The following example shows how the instruction for S7-1200/1500 F-CPUs works:

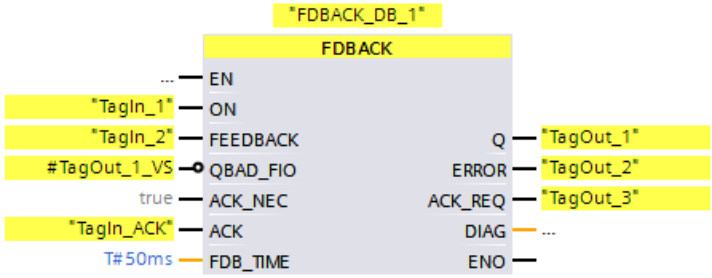

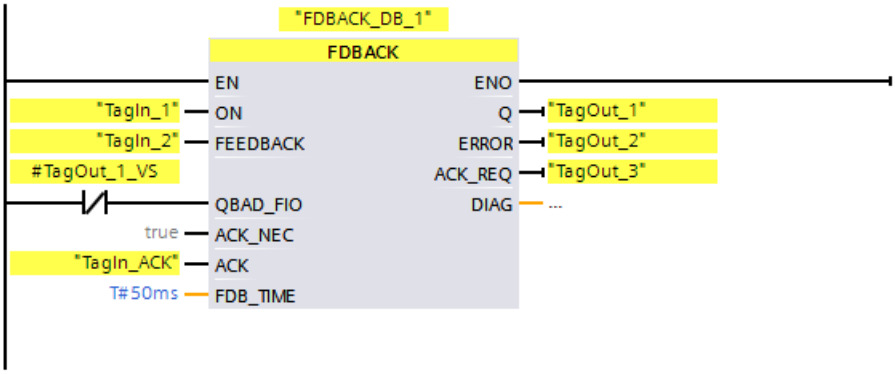

13.5.8 SFDOOR: Safety door monitoring (STEP 7 Safety V21)

Description

This instruction implements safety door monitoring.

Enable signal Q is reset to 0 as soon as one of the inputs IN1 or IN2 take a signal state of 0 (safety door is opened). The enable signal can be reset to 1, only if:

- Inputs IN1 and IN2 both take a signal state of 0 prior to opening the door (safety door has been completely opened)
- Inputs IN1 and IN2 then both take a signal state of 1 (safety door is closed)
- An acknowledgment occurs

The acknowledgment for the enable takes place according to the parameter assignment at input ACK_NEC:

- If ACK_NEC = 0, the acknowledgment is automatic.
- If ACK_NEC = 1, you must use a rising edge at input ACK for acknowledging the enable.

Output ACK_REQ = 1 is used to signal that a user acknowledgment is required at input ACK for the acknowledgment. The instruction sets ACK_REQ = 1 as soon as the door is closed. Following an acknowledgment, the instruction resets ACK_REQ to 0.

In order for the instruction to recognize whether inputs IN1 and IN2 are 0 merely due to passivation of the associated F-I/O, you need to supply inputs QBAD_IN1 or QBAD_IN2 with the QBAD signal of the associated F-I/O or QBAD_I_xx signal / inverted value status of the associated channel. Among other things, this will prevent you from having to open the safety door completely prior to an acknowledgment in the event the F-I/O are passivated.

Every call of the "Safety door monitoring" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., SFDOOR_DB_1) or a multi-instance (e.g., SFDOOR_Instance_1) for the "Safety door monitoring" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

The ACK_NEC tag must not be assigned a value of "0" unless an automatic restart of the affected process is otherwise excluded. *(S033)*

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	BOOL	Input 1
IN2	Input	BOOL	Input 2
QBAD_IN1	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal / inverted value status of the channel of input IN1
QBAD_IN2	Input	BOOL	QBAD signal of the F-I/O or QBAD_O_xx signal / inverted value status of the channel of input IN2
OPEN_NEC	Input	BOOL	1= Open necessary at startup
ACK_NEC	Input	BOOL	1=Acknowledgment necessary
ACK	Input	BOOL	Acknowledgment
Q	Output	BOOL	1= Enable, safety door closed
ACK_REQ	Output	BOOL	Acknowledgment request
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Interconnection example

You must interconnect the NC contact of position switch 1 of the safety door at input IN1 and the NO contact of position switch 2 at input IN2. Position switch 1 must be mounted in such a way that it is positively operated when the safety door is open. Position switch 2 must be mounted in such a way that it is operated when the safety door is closed.

Safety door open:

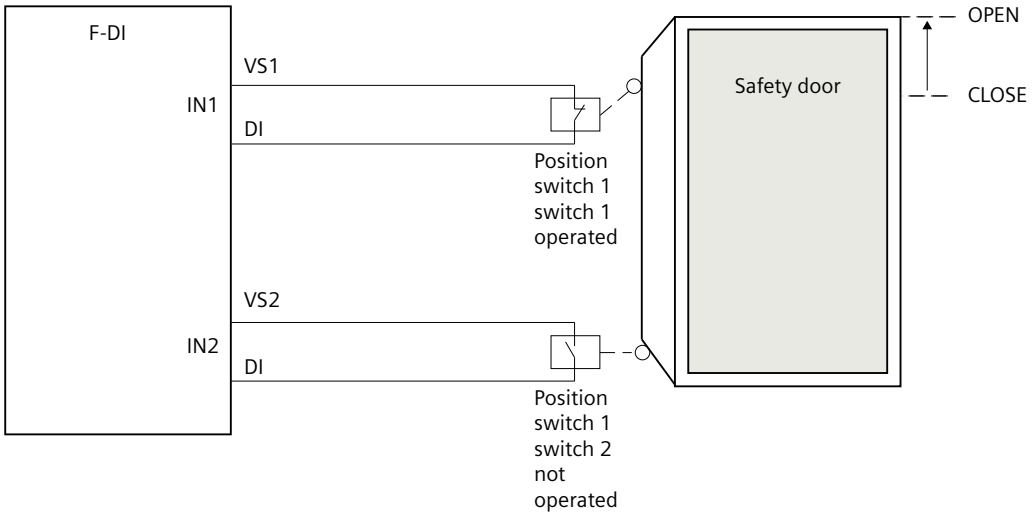

Safety door closed:

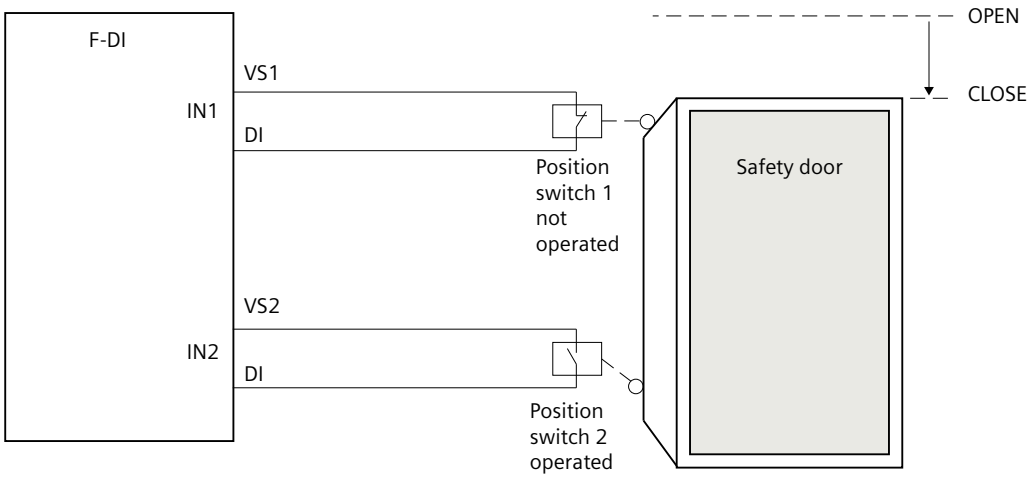

Startup behavior

After an F-system startup, enable signal Q is reset to 0. The acknowledgment for the enable takes place according to the parameter assignment at inputs OPEN_NEC and ACK_NEC:

- When OPEN_NEC = 0, an automatic acknowledgment occurs **independently** of ACK_NEC, as soon as the two inputs IN1 and IN2 take signal state 1 for the first time following reintegration of the associated F-I/O (safety door is closed).
- When OPEN_NEC = 1 **or** if at least one of the IN1 and IN2 inputs still has a signal state of 0 after reintegration of the associated F-I/O, an automatic acknowledgment occurs **according** to ACK_NEC or you have to use a rising edge at input ACK for the enable. Prior to acknowledgment, inputs IN1 and IN2 both have to take a signal state of 0 (safety door has been completely opened) followed by a signal state of 1 (safety door is closed).

WARNING

The OPEN_NEC tag must not be assigned a value of "0" unless an automatic restart of the affected process is otherwise excluded. *(S039)*

Output DIAG

The DIAG output provides non-fail-safe information on errors for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program.

Structure of DIAG

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Reserved	—	—
Bit 1	Signal state 0 is missing at both IN1 and IN2 inputs	Safety door was not completely opened when OPEN_NEC = 1 after F-system startup	Open safety door completely
		Open safety door was not completely opened	Open safety door completely
		Wiring fault	Check wiring of position switch
		Position switch is defective	Check position switch
		Position switch is incorrectly adjusted	Adjust position switch properly
Bit 2	Signal state 1 is missing at both IN1 and IN2 inputs	Safety door was not closed	Close safety door
		Wiring fault	Check wiring of position switch
		Position switch is defective	Check position switch
		Position switch is incorrectly adjusted	Adjust position switch properly

Bit no.	Assignment	Possible error causes	Remedies
Bit 3	QBAD_IN1 and/or QBAD_IN2 = 1	F-I/O fault, channel fault, or communication error, or passivation by means of PASS_ON of F-I/O or channel of IN1 and/or IN2	For a solution, see the section "Structure of DIAG", bits 0 to 6 in DIAG (Page 176)
Bit 4	Reserved	—	—
Bit 5	If enable is missing: input ACK has a permanent signal state of 1	Acknowledgment button defective	Check acknowledgment button
		Wiring fault	Check wiring of acknowledgment button
Bit 6	Acknowledgment required (= state of ACK_REQ)	—	—
Bit 7	State of output Q	—	—

Example

The following example shows how the instruction for S7-300/400 F-CPUs works:

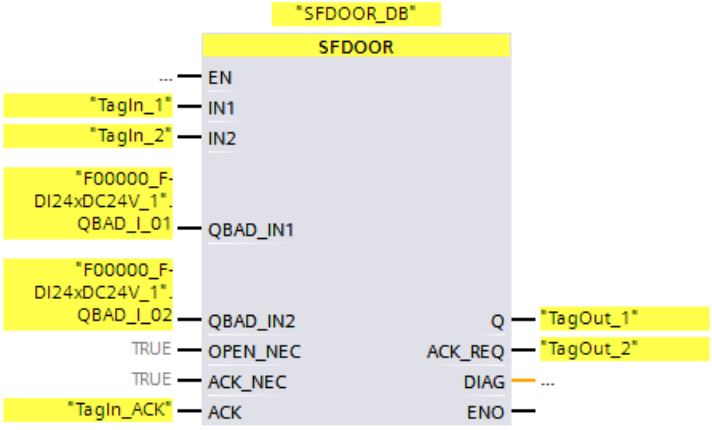

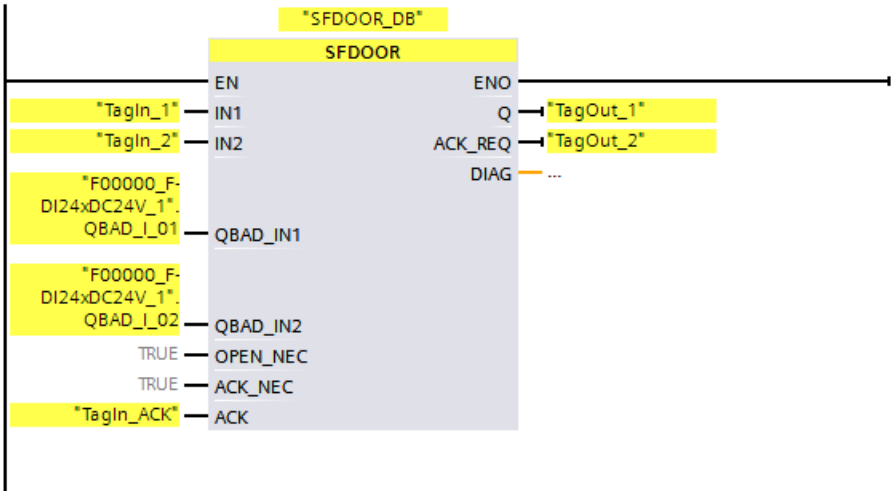

The following example shows how the instruction for S7-1200/1500 F-CPUs works:

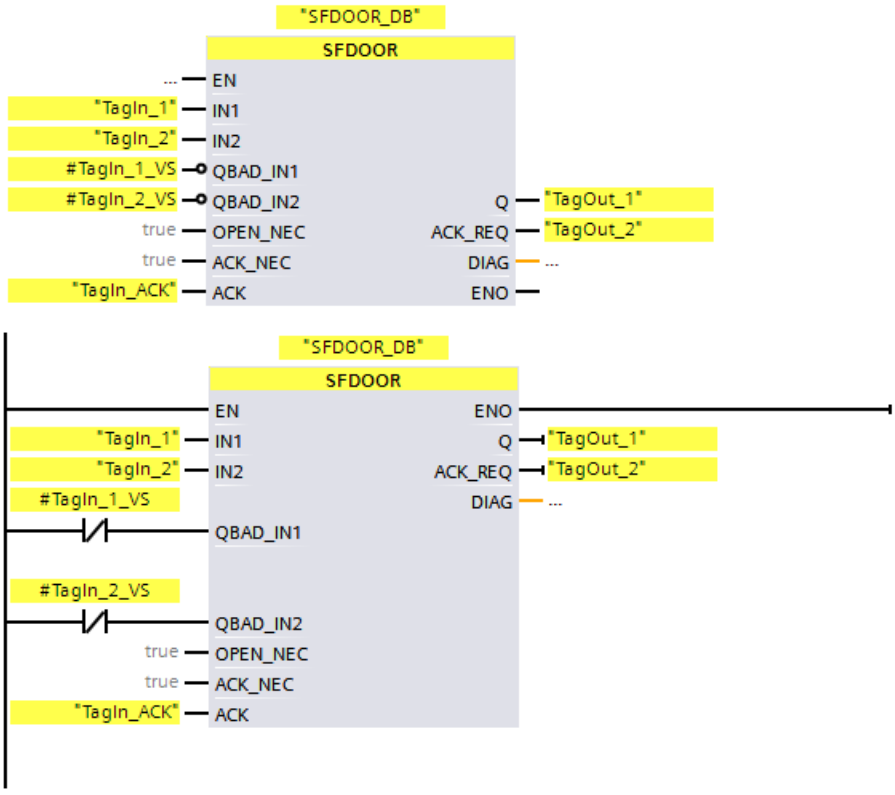

13.5.9 ACK_GL: Global acknowledgment of all F-I/O in an F-runtime group (STEP 7 Safety V21)

Description

This instruction creates an acknowledgment for the simultaneous reintegration of all F-I/O or channels of the F-I/O of an F-runtime group after communication errors, F-I/O errors, or channel faults.

A user acknowledgment (Page 196) with a positive edge at input ACK_GLOB is required for reintegration. The acknowledgment occurs analogously to the user acknowledgment via the ACK_REI tag of the F-I/O DB (Page 171), but it acts simultaneously on all F-I/O of the F-runtime group in which the instruction is called.

If you use the instruction ACK_GL, you do not have to provide a user acknowledgment for each F-I/O of the F-runtime group via the ACK_REI tag of the F-I/O DB.

Every call of the "Global acknowledgment of all F-I/O of a runtime group" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., ACK_GL_DB_1) or a multi-instance (e.g., ACK_GL_Instance_1) for the "Global acknowledgment of all F-I/O of a runtime group" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

NOTE

An acknowledgment via the ACK_GL instruction is only possible if the tag ACK_REI of the F-I/O DB = 0. Accordingly, an acknowledgment via the tag ACK_REI of the F-I/O DB is only possible if the input ACK_GLOB of the instruction = 0.

The instruction is only allowed to be called once per F-runtime group.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ACK_GLOB	Input	BOOL	1=acknowledgment for reintegration

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:

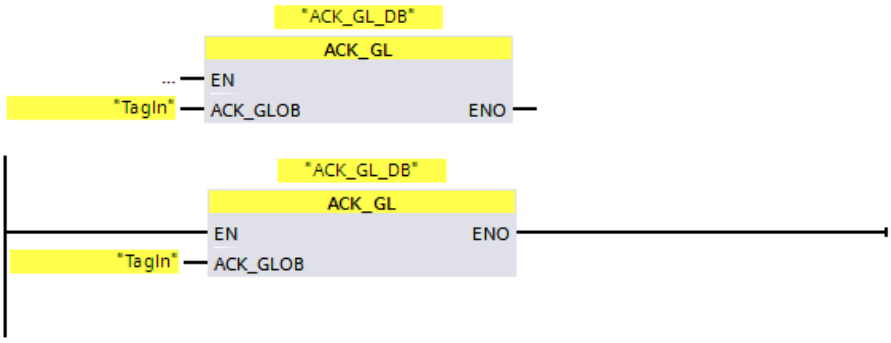

13.6 Timer operations

13.6.1 TP: Generate pulse (STEP 7 Safety V21)

Description

You can use the "Generate pulse" instruction to set output Q for a programmed period. The instruction is started if the result of logic operation (RLO) changes from "0" to "1" (positive edge) at input IN. The programmed period PT starts running when the instruction starts. Output Q is set for period PT, regardless of the subsequent sequence of the input signal. Also the detection of a new positive signal edge does not influence the signal state at output Q as long as period PT runs.

You can query the current time value at the output ET. The time value begins at T#0s and ends when the value of period PT is reached. If period PT is reached and the signal state at input IN is "0", output ET is reset.

Every call of the "Generate pulse" instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Timer_DB_1) or a multi-instance (e.g., F_IEC_Timer_Instance_1) for the "Generate pulse" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Generate pulse" instruction on a startup of the F-system.

NOTE

The functionality of this instruction differs from the corresponding standard TP instruction in the following points:

- If the instruction is called while the time is running with PT = 0 ms, the outputs Q and ET are reset.
- If the instruction is called with PT < 0 ms, the outputs Q and ET are reset.

To restart the pulse, a new rising signal edge at input IN is required once PT is greater than 0 again.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	BOOL	Start input
PT	Input	TIME	Duration of pulse; must be positive.
Q	Output	BOOL	Pulse output
ET	Output	TIME	Current time value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	o	—	o	
1.4	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Pulse diagram

The following figure shows the pulse diagram of the instruction "Generate pulse":

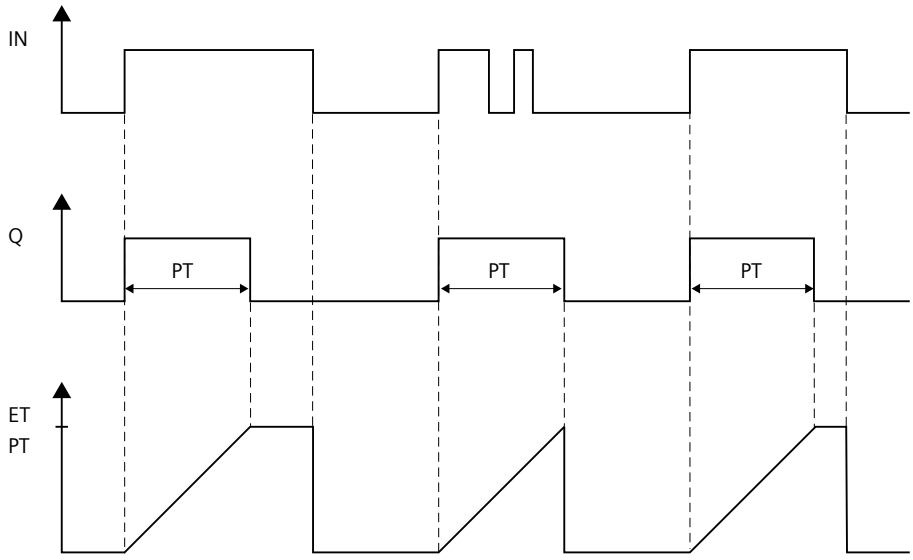

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 464)" for more on this.

Example

The following example shows how the instruction works:

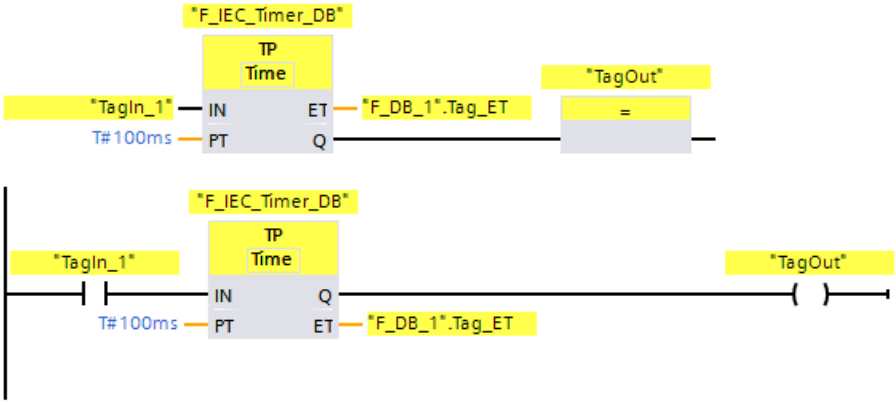

If the signal state of operand "TagIn_1" changes from "0" to "1", the "Generate pulse" instruction is started and the period assigned at input PT (100 ms) runs, regardless of the further course of operand "TagIn_1".

Operand "TagOut" at output Q has signal state "1" as long as the period is running. Operand ""F_DB_1".Tag_ET" contains the current time value.

13.6.2 TON: Generate on-delay (STEP 7 Safety V21)

Description

You use the "Generate on-delay" instruction to delay the setting of output Q by the assigned period PT. The instruction is started if the result of logic operation (RLO) changes from "0" to "1" (positive edge) at input IN. The programmed period PT starts running when the instruction starts. When period PT has expired, output Q is set to signal state "1". Output Q remains set as long as the start input is set to "1". When the signal state at the start input changes from "1" to "0", output Q is reset. The time function is restarted when a new positive signal edge is detected at the start input.

You can query the current time value at the output ET. The time value begins at T#0s and ends when the value of period PT is reached. Output ET is reset, as soon as the signal state at input IN changes to "0".

Every call of the "Generate on-delay" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Timer_DB_1) or a multi-instance (e.g., F_IEC_Timer_Instance_1) for the "Generate on-delay" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Generate on-delay" instruction on a startup of the F-system.

NOTE

The functionality of this instruction differs from the corresponding standard TON instruction in the following points:

- If the instruction is called while the time is running with PT = 0 ms, the output ET is reset.
- If the instruction is called with PT < 0 ms, the outputs Q and ET are reset.

To restart the on-delay, a new rising signal edge at input IN is required once PT is greater than 0 again.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	BOOL	Start input
PT	Input	TIME	Duration of on-delay; must be positive.
Q	Output	BOOL	Output that is set after expiration of time PT.
ET	Output	TIME	Current time value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	o	—	o	
1.4	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Pulse diagram

The following figure shows the pulse diagram of the instruction "Generate on-delay":

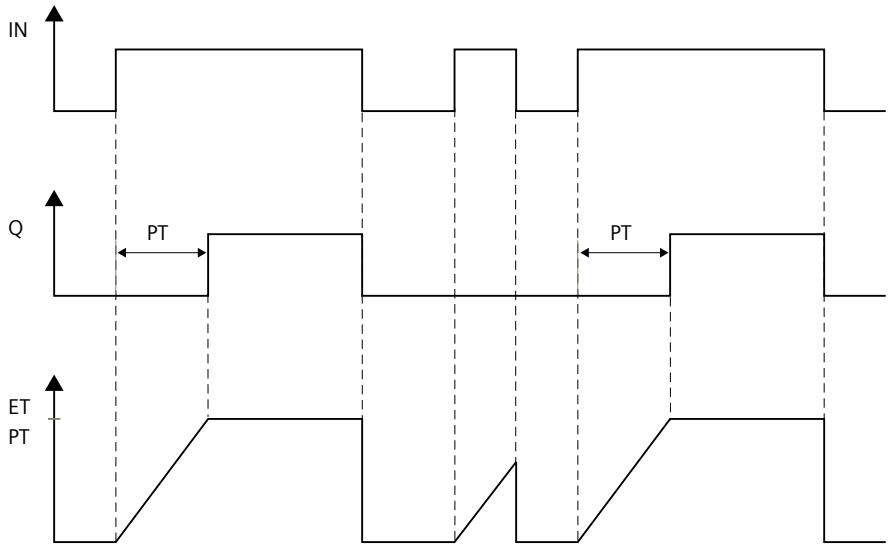

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 464)" for more on this.

Example

The following example shows how the instruction works:

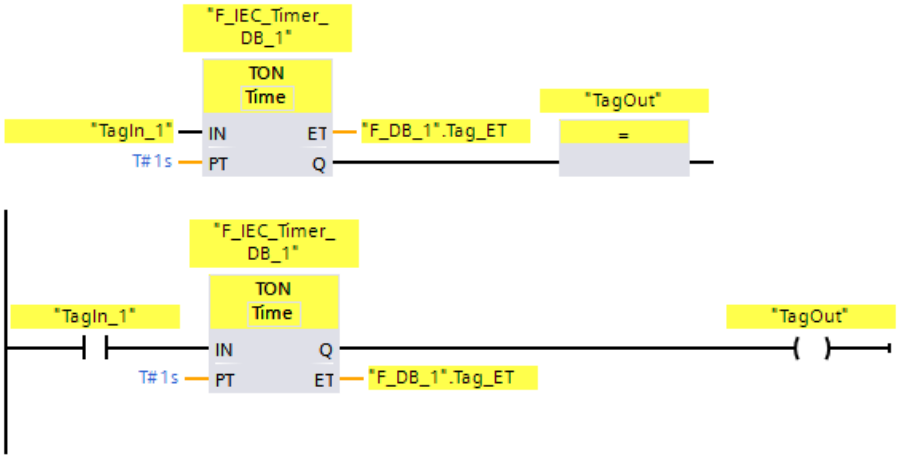

When the signal state of operand "TagIn_1" changes from "0" to "1", the "Generate on-delay" instruction is started and the period assigned at input PT (1 s) runs.

Operand "TagOut" at output Q feeds signal state "1" when the period has elapsed and remains set as long as operand "TagIn_1" still feeds signal state "1". Operand ""F_DB_1".Tag_ET" contains the current time value.

13.6.3 TOF: Generate off-delay (STEP 7 Safety V21)

Description

You use the "Generate off-delay" instruction to delay the resetting of output Q by the assigned period PT. Output Q is set if the result of logic operation (RLO) changes from "0" to "1" (positive edge) at input IN. When the signal state at input IN changes back to "0", the programmed period PT starts. Output Q remains set as long as period PT runs. After period PT expires, output Q is reset. If the signal state at input IN changes to "1" before period PT has expired, then the time is reset. The signal state at output Q remains at "1".

You can query the current time value at the output ET. The time value begins at T#0s and ends when the value of period PT is reached. After time PT has elapsed, output ET remains at its current value until input IN changes back to "1". If input IN changes to "1" before time PT has expired, the output ET is reset to value T#0.

Every call of the "Generate off-delay" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is in inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Timer_DB_1) or a multi-instance (e.g., F_IEC_Timer_Instance_1) for the "Generate off-delay" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Generate off-delay" instruction on a startup of the F-system.

NOTE

The functionality of this instruction differs from the corresponding standard TOF instruction in the following points:

- If the instruction is called while the time is running with PT = 0 ms, the outputs Q and ET are reset.
- If the instruction is called with PT < 0 ms, the outputs Q and ET are reset.

To restart the off-delay, another falling signal edge at input IN is required once PT is greater than 0 again.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	BOOL	Start input
PT	Input	TIME	Duration of off delay; must be positive.
Q	Output	BOOL	Output that is reset after expiration of time PT.
ET	Output	TIME	Current time value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	o	—	o	
1.4	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Pulse diagram

The following figure shows the pulse diagram of the instruction "Generate off-delay":

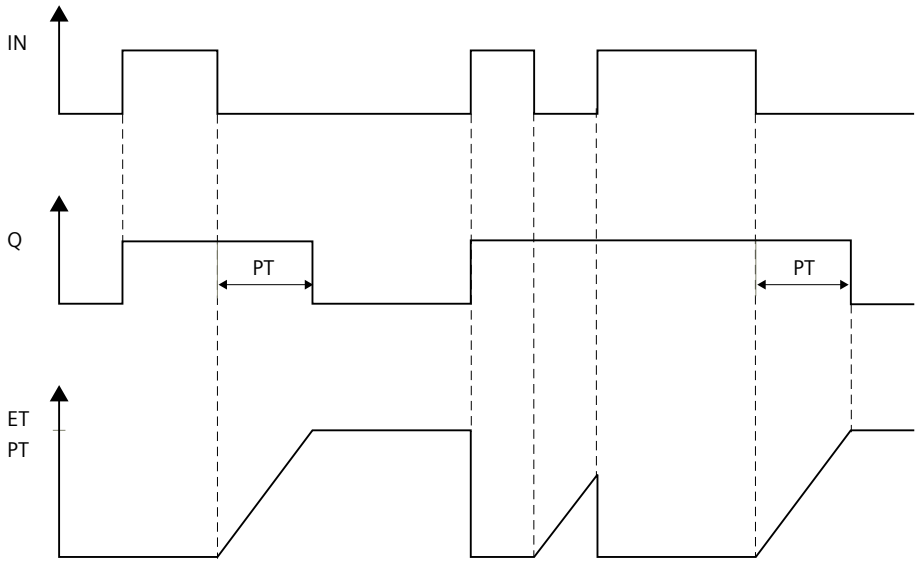

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 464)" for more on this.

Example

The following example shows how the instruction works:

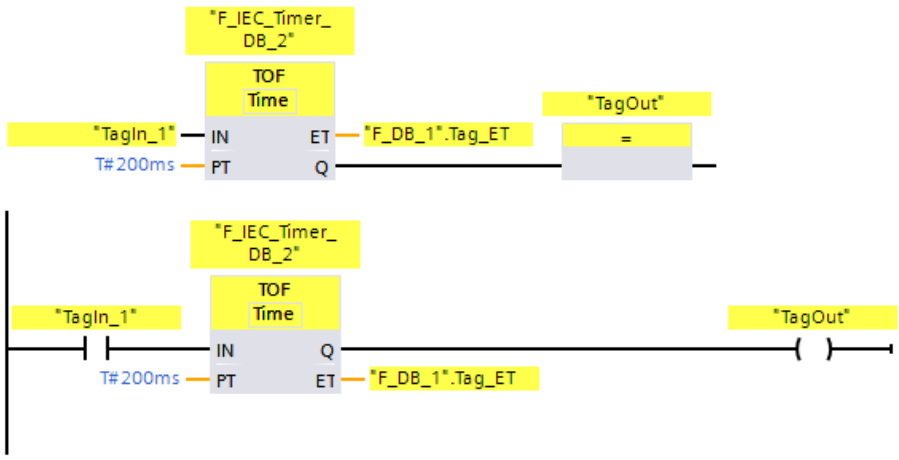

If the signal state of operand "TagIn_1" changes from "0" to "1", the signal state of operand"TagOut" at output Q is set to "1".

If the signal state of operand "TagIn_1" changes back to "0", the period assigned at input PT (200 ms) runs.

The "TagOut" operand at output Q is set back to "0" when the period expires. Operand ""F_DB_1".Tag_ET" contains the current time value.

13.7 Counter operations

13.7.1 CTU: Count up (STEP 7 Safety V21)

Description

You can use the "Count up" instruction to increment the value at output CV. When the signal state at the CU input changes from "0" to "1" (positive signal edge), the instruction is executed and the current count at the CV output increases by one. The count value is increased on each detection of a positive signal edge until it reaches the high limit of the data type specified at the CV output. When the high limit is reached, the signal state at the CU input no longer affects the instruction.

The counter status can be queried at output Q. The signal state at output Q is determined by parameter PV. When the current count value is greater than or equal to the value of parameter PV, output Q is set to signal state "1". In all other cases, the signal state at output Q is "0".

The value at output CV is reset to zero when the signal state at input R changes to "1". As long as signal state "1" exists at input R, the signal state at input CU has no effect on the instruction.

Every call of the "Count up" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Counter_DB_1) or a multi-instance (e.g., F_IEC_Counter_Instance_1) for the "Count up" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Count up" instruction on a startup of the F-system.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CU	Input	BOOL	Counter input
R	Input	BOOL	Reset input
PV	Input	INT	Value for which output Q is set
Q	Output	BOOL	Counter status
CV	Output	INT	Current count value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:

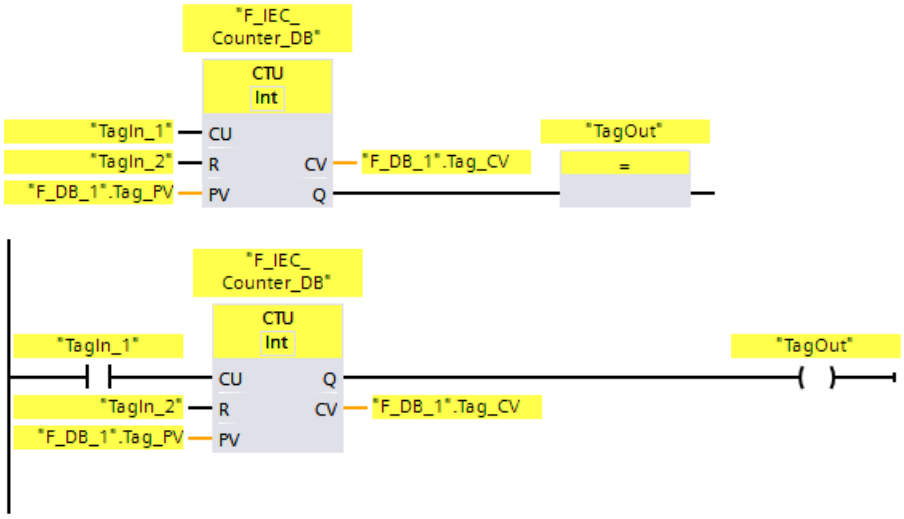

When the signal state of the "CU" input changes from "0" to "1", the "Count up" instruction is executed and the current count of the "CV" output increases by one. The count value is increased on every additional positive signal edge until the high limit of the specified data type (32767) is reached.

The value at the PV parameter is applied as the limit for determining the "TagOut" operands at the Q output. Output "Q" returns the signal state "1" as long as the current count is greater than or equal to the value of operand "PV". In all other cases, the "Q" output has the signal state "0".

13.7.2 CTD: Count down (STEP 7 Safety V21)

Description

You can use the "Count down" instruction to decrement the value at output CV. When the signal state at input CD changes from "0" to "1" (positive signal edge), the instruction is executed and the current count value at output CV is decreased by one. The count value is decreased on each detection of a positive signal edge until it reaches the low limit of the specified data type. When the low limit is reached, the signal state at input CD no longer affects the instruction.

The counter status can be queried at output Q. When the current count value is less than or equal to zero, output Q is set to signal state "1". In all other cases, the signal state at output Q is "0".

The value at output CV is set to the value of parameter "PV" when the signal state at input LD changes to "1". As long as signal state "1" exists at input LD, the signal state at input CD has no effect on the instruction.

Every call of the "Count down" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Counter_DB_1) or a multi-instance (e.g., F_IEC_Counter_Instance_1) for the "Count down" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Count down" instruction on a startup of the F-system.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CD	Input	BOOL	Counter input
LD	Input	BOOL	Load input
PV	Input	INT	Value at the output CV when LD = 1 is set
Q	Output	BOOL	Counter status
CV	Output	INT	Current count value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:

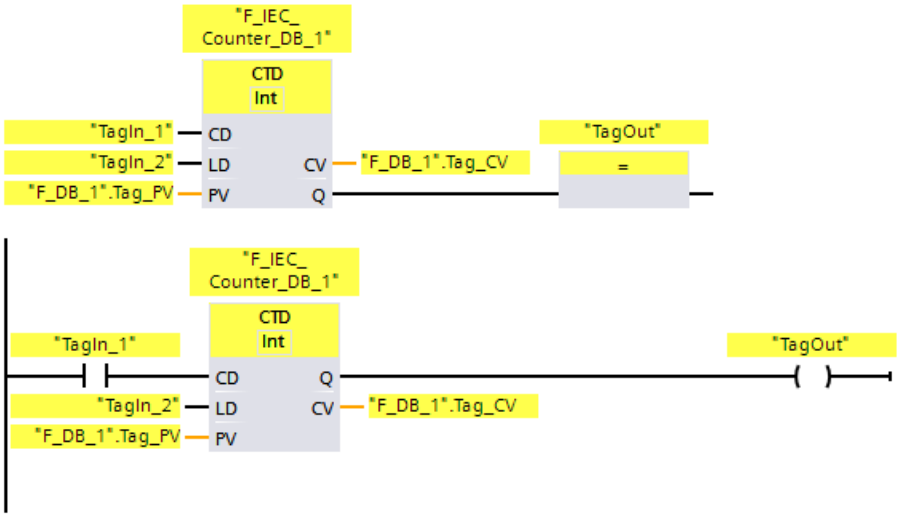

When the signal state of the "CD" input changes from "0" to "1", the "Count down" instruction is executed and the current count at "CV" output decreases by one. The count value is decreased on each additional positive signal edge until the low limit of the specified data type (-32768) is reached.

Output "Q" returns the signal state "1" as long as the current count is less than or equal to zero. In all other cases, output "Q" has signal state "0".

13.7.3 CTUD: Count up and down (STEP 7 Safety V21)

Description

You can use the "Count up and down" instruction to increment and decrement the count value at output CV. If the signal state at the CU input changes from "0" to "1" (positive signal edge), the current count at the CV output increases by one. If the signal state at input CD changes from "0" to "1" (positive signal edge), the count value at output CV is decreased by one. If a positive signal edge is present at inputs CU and CD in one program cycle, the current count value at output CV remains unchanged.

The count value can be increased until it reaches the high limit of the data type specified at output CV. When the high limit is reached, the count value is no longer incremented on a positive signal edge. When the low limit of the specified data type is reached, the count value is no longer decreased.

When the signal state at input LD changes to "1", the count value at output CV is set to the value of parameter PV. As long as signal state "1" exists at input LD, the signal state at inputs CU and CD has no effect on the instruction.

The count value is set to zero, when the signal state at input R changes to "1". As long as signal state "1" exists at input R, the signal state at inputs CU, CD, and LD has no effect on the "Count up and down" instruction.

The status of the up counter can be queried at output QU. When the current count value is greater than or equal to the value of parameter PV, output QU delivers signal state "1". In all other cases, the signal state at output QU is "0".

The status of the down counter can be queried at output QD. When the current count value is lesser than or equal to zero, output QD delivers signal state "1". In all other cases, the signal state at output QD is "0".

Every call of the "Count up and down" instruction must be assigned a data area in which the instruction data are stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., F_IEC_Counter_DB_1) or a multi-instance (e.g., F_IEC_Counter_Instance_1) for the "Count up and down" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the *help on STEP 7*.

The operating system resets the instances of the "Count up and down" instruction when the F-system is started up.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
CU	Input	BOOL	Count up input
CD	Input	BOOL	Count down input
R	Input	BOOL	Reset input
LD	Input	BOOL	Load input

Parameter	Declaration	Data type	Description
PV	Input	INT	Value at which the output QU is set / to which the output CV is set when LD = 1
QU	Output	BOOL	Status of up counter
QD	Output	BOOL	Status of down counter
CV	Output	INT	Current count value

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	o	—	o	
1.3	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:

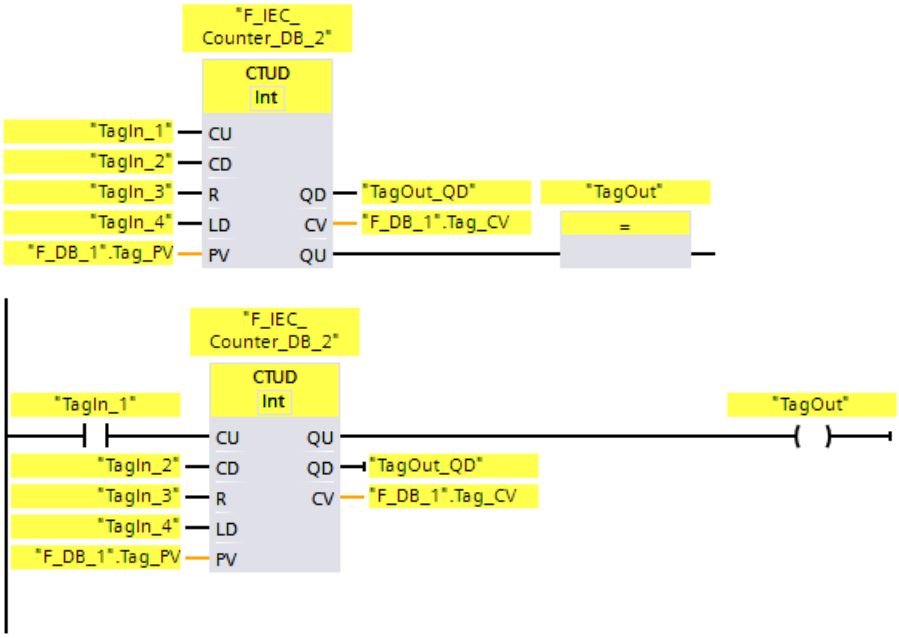

When the signal state at the "CU" input or at the "CD" input changes from "0" to "1" (positive signal edge), the "Count up and down" instruction is executed. When a positive signal edge is present at the "CU" input, the current count of the "CV" output increases by one. When a positive signal edge is present at the "CD" input, the current count at the "CV" output decreases by one. The count value is increased on each positive signal edge at the CU input until it reaches the high limit of 32767. The count value is decreased on each positive signal edge at the CD input until it reaches the low limit of -32768.

Output "QU" returns the signal state "1" as long as the current count is greater than or equal to the value at the "PV" input. In all other cases, output "QU" has signal state "0".

Output "QD" returns the signal state "1" as long as the current count is less than or equal to zero. In all other cases, output "QD" has signal state "0".

13.8 Comparator operations

13.8.1 CMP ==: Equal (STEP 7 Safety V21)

Description

You can use the "Equal" instruction to determine if the first comparison value (IN1 or <Operand1>) is equal to the second comparison value (IN2 or <Operand2>).

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME, WORD, (S7-300, S7-400) DWORD	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME, WORD, (S7-300, S7-400) DWORD	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:

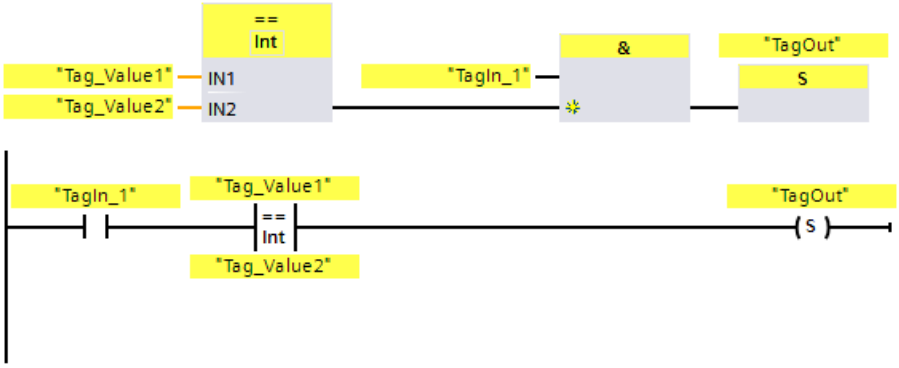

Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" = "Tag_Value2").

13.8.2 CMP <>: Not equal (STEP 7 Safety V21)

Description

You can use the "Not equal" instruction to determine if the first comparison value (IN1 or <Operand1>) is not equal to the second comparison value (IN2 or <Operand2>).

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME, WORD, (S7-300, S7-400) DWORD	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME, WORD, (S7-300, S7-400) DWORD	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:

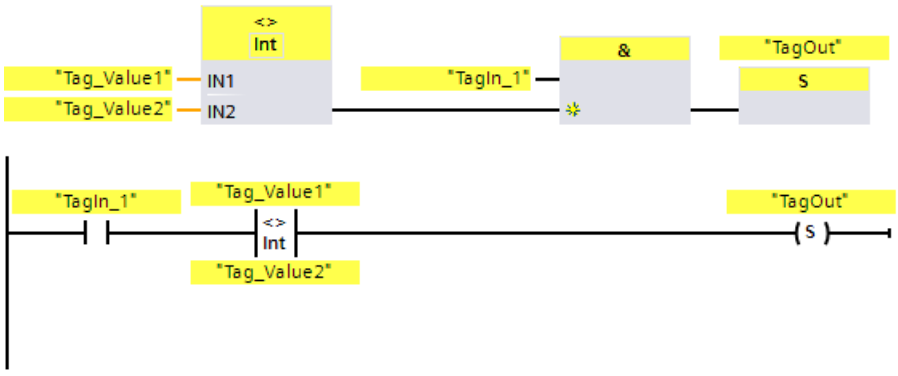

Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" <> "Tag_Value2").

13.8.3 CMP >=: Greater or equal (STEP 7 Safety V21)

Description

You can use the "Greater or equal" instruction to determine if the first comparison value (IN1 or <Operand1>) is greater than or equal to the second comparison value (IN2 or <Operand2>). Both comparison values must be of the same data type.

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:

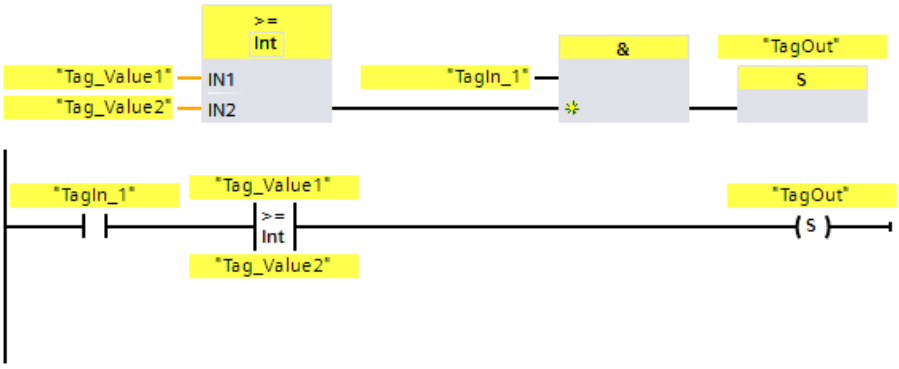

Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" >= "Tag_Value2").

13.8.4 CMP <=: Less or equal (STEP 7 Safety V21)

Description

You can use the "Less or equal" instruction to determine if the first comparison value (IN1 or <Operand1>) is less than or equal to the second comparison value (IN2 or <Operand2>). Both comparison values must be of the same data type.

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:

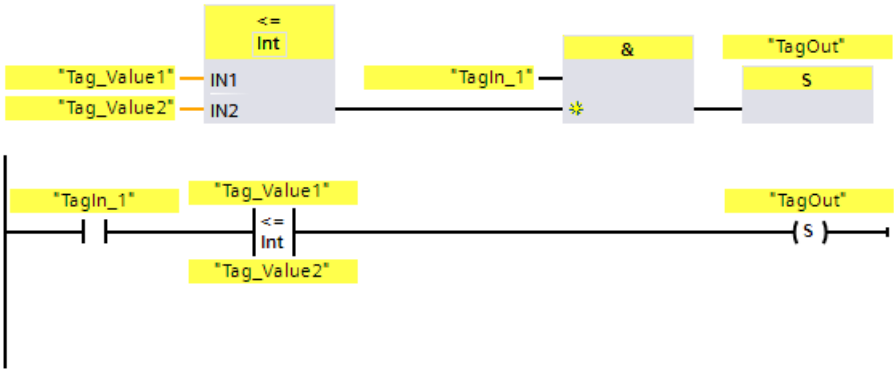

Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" <= "Tag_Value2").

13.8.5 CMP >: Greater than (STEP 7 Safety V21)

Description

You can use the "Greater than" instruction to determine if the first comparison value (IN1 or <Operand1>) is greater than the second comparison value (IN2 or <Operand2>). Both comparison values must be of the same data type.

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:

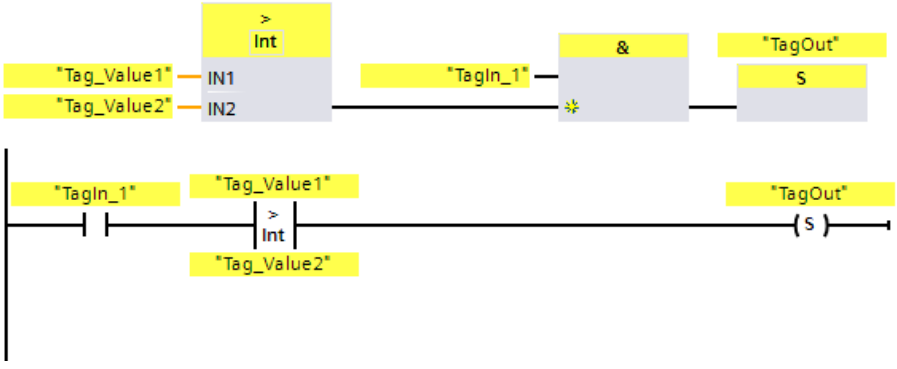

Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" > "Tag_Value2").

13.8.6 CMP <: Less than (STEP 7 Safety V21)

Description

You can use the "Less than" instruction to determine if the first comparison value (IN1 or <Operand1>) is less than the second comparison value (IN2 or <Operand2>). Both comparison values must be of the same data type.

If the condition of the comparison is satisfied, the instruction returns result of logic operation (RLO) "1". If the condition of the comparison is not satisfied, the instruction returns RLO "0".

For LAD:

The RLO of the instruction is linked to the RLO of the entire current path as follows:

- By AND, when the comparison instruction is connected in series.
- By OR, when the comparison instruction is connected in parallel.

Enter the first comparison value (<Operand1>) in the operand placeholder above the instruction. Enter the second comparison value (<Operand2>) in the operand placeholder below the instruction.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
FBD: IN1 LAD: <Operand1>	Input	INT, DINT, TIME	First value to compare
FBD: IN2 LAD: <Operand2>	Input	INT, DINT, TIME	Second value to compare

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:

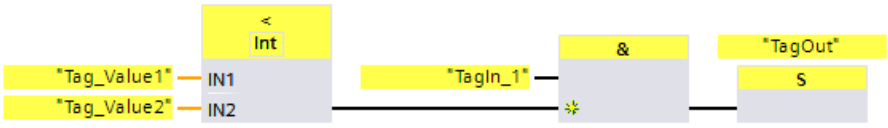

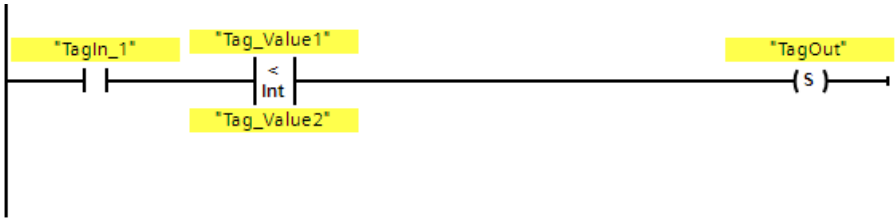

Output "TagOut" is set when the following conditions are fulfilled:

- "Tag_In1" has signal state "1".
- The condition of the comparison instruction is fulfilled ("Tag_Value1" < "Tag_Value2").

13.9 Math functions

13.9.1 ADD: Add (STEP 7 Safety V21)

Description

You can use the "Add" instruction to add the value at input IN1 and the value at input IN2 and query the sum at the OUT output (OUT = IN1 + IN2).

Enable input "EN" or (S7-300, S7-400) enable output "ENO" cannot be connected. The instruction is therefore always executed regardless of the signal state at enable input "EN".

NOTE

When the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-1200, S7-1500) You can avoid a STOP of the F-CPU by connecting the ENO enable output, thereby programming overflow detection.

Note the following:

- If the result of the instruction is located outside the permitted range for this data type, the enable output ENO returns the signal state "0".
- The result of the instruction reacts like the analogous instruction in a standard block.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- Work memory requirement of safety program is increased.

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.
- Work memory requirement of safety program is increased.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	(S7-1200, S7-1500) Enable output
IN1	Input	INT, DINT	First addend
IN2	Input	INT, DINT	Second addend
OUT	Output	INT, DINT	Total

You select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example for S7-300/400 F-CPUs

The following example shows how the instruction works:

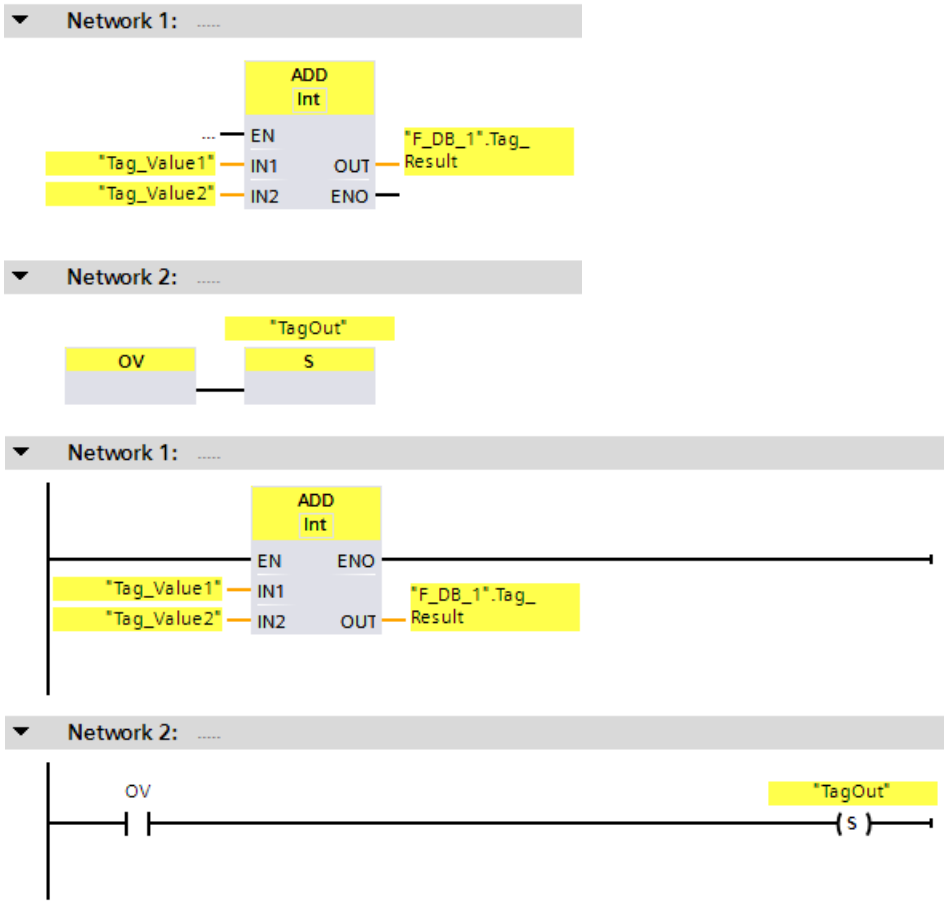

The "Add" instruction is always executed regardless of the signal state at enable input EN.

The value of the "Tag_Value1" operand is added to value of the "Tag_Value2" operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

If needed, you can also store the signal status of the ENO enable output in an (F-)DB, and centrally evaluate whether overflows have occurred for all or one group of instructions with overflow detection.

When an overflow occurs during execution of the "Add" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

Example for S7-1200/1500 F-CPUs

The following example shows how the instruction works:

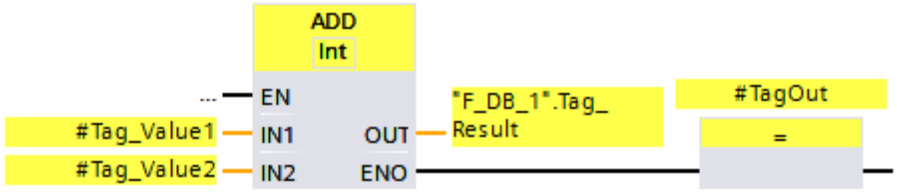

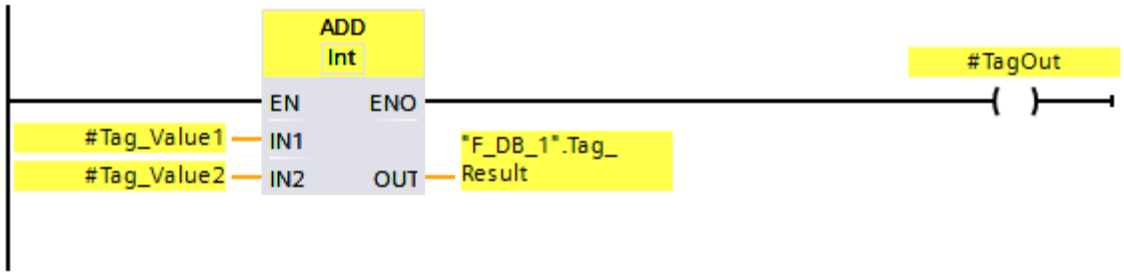

The "Add" instruction is always executed regardless of the signal state at enable input EN.

The value of the "#Tag_Value1" operand is added to value of the "#Tag_Value2" operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

When no overflow occurs during execution of the "Add" instruction, the ENO enable output has the signal state "1" and the "#TagOut" operand is set.

If needed, you can also store the signal status of the ENO enable output in an (F-)DB, and centrally evaluate whether overflows have occurred for all or one group of instructions with overflow detection.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 624)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 625)

13.9.2 SUB: Subtract (STEP 7 Safety V21)

Description

You can use the "Subtract" instruction to subtract the value at input IN2 from the value at input IN1 and query the difference at the OUT output (OUT = IN1 – IN2).

Enable input "EN" or (S7-300, S7-400) enable output "ENO" cannot be connected. The instruction is therefore always executed regardless of the signal state at enable input "EN".

NOTE

When the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-1200, S7-1500) You can avoid a STOP of the F-CPU by connecting the ENO enable output, thereby programming overflow detection.

Note the following:

- If the result of the instruction is located outside the permitted range for this data type, the enable output ENO returns the signal state "0".
- The result of the instruction reacts like the analogous instruction in a standard block.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- Work memory requirement of safety program is increased.

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.
- Work memory requirement of safety program is increased.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	(S7-1200, S7-1500) Enable output
IN1	Input	INT, DINT	Minuend
IN2	Input	INT, DINT	Subtrahend
OUT	Output	INT, DINT	Difference

You select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example for S7-300/400 F-CPUs

The following example shows how the instruction works:

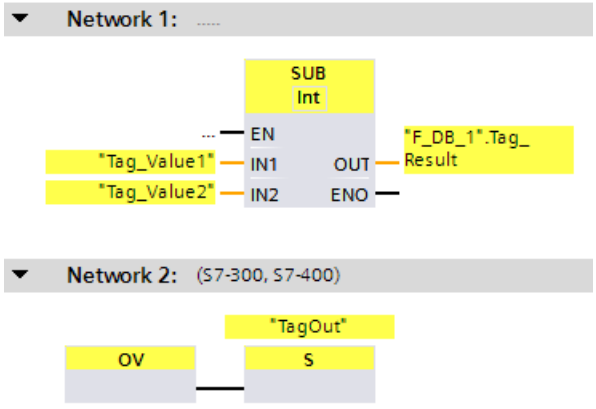

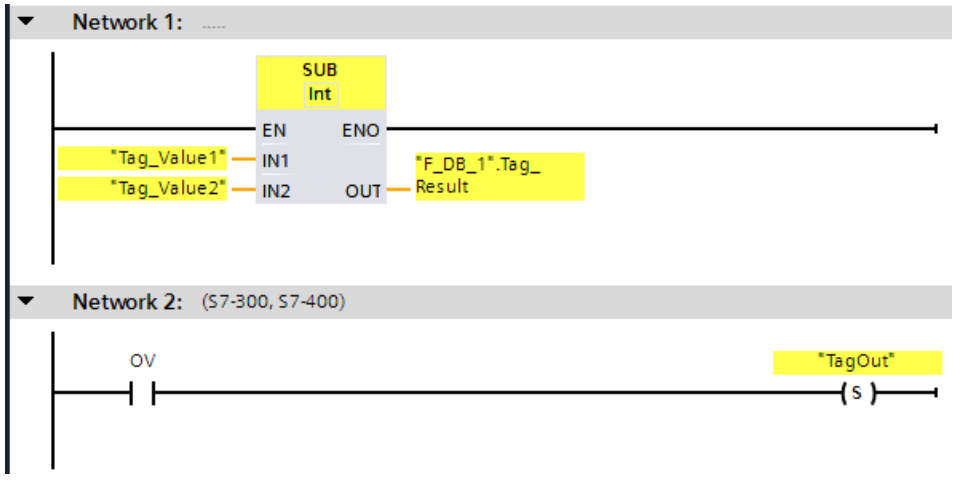

The "Subtract" instruction is always executed regardless of the signal state at enable input EN.

The value of the "Tag_Value2" operand is subtracted from the value of the "Tag_Value1" operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

When an overflow occurs during execution of the "Subtract" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

Example for S7-1200/1500 F-CPUs

The following example shows how the instruction works:

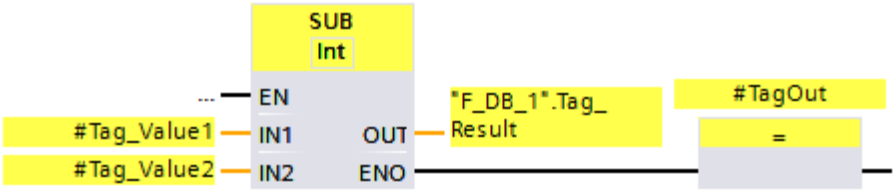

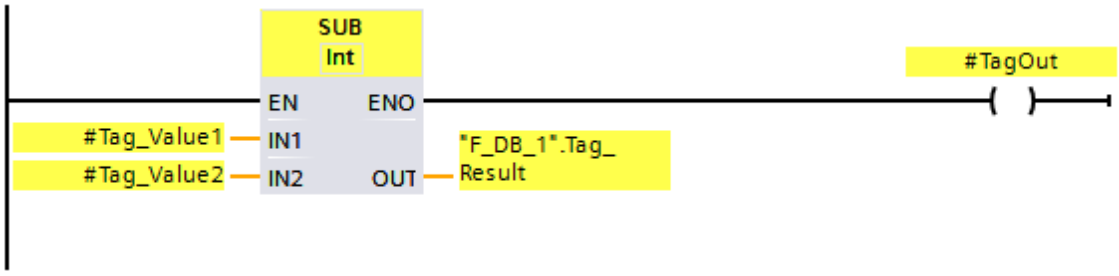

The "Subtract" instruction is always executed regardless of the signal state at enable input EN.

The value of the "#Tag_Value2" operand is subtracted from the value of the "#Tag_Value1" operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

When no overflow occurs during execution of the "Subtract" instruction, the ENO enable output has the signal state "1" and the "#TagOut" operand is set.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 624)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 625)

13.9.3 MUL: Multiply (STEP 7 Safety V21)

Description

You can use the "Multiply" instruction to multiply the value at input IN1 by the value at input IN2 and query the product at output OUT (OUT = IN1 × IN2).

Enable input "EN" or (S7-300, S7-400) enable output "ENO" cannot be connected. The instruction is therefore always executed regardless of the signal state at enable input "EN".

NOTE

When the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-1200, S7-1500) You can avoid a STOP of the F-CPU by connecting the ENO enable output, thereby programming overflow detection.

Note the following:

- If the result of the instruction is located outside the permitted range for this data type, the enable output ENO returns the signal state "0".
- The result of the instruction reacts like the analogous instruction in a standard block.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- Work memory requirement of safety program is increased.

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.
- Work memory requirement of safety program is increased.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	(S7-1200, S7-1500) Enable output
IN1	Input	INT, DINT	Multiplier
IN2	Input	INT, DINT	Multiplicand
OUT	Output	INT, DINT	Product

You select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example for S7-300/400 F-CPUs

The following example shows how the instruction works:

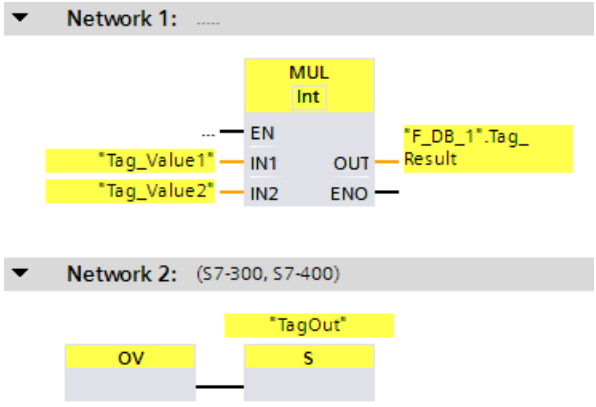

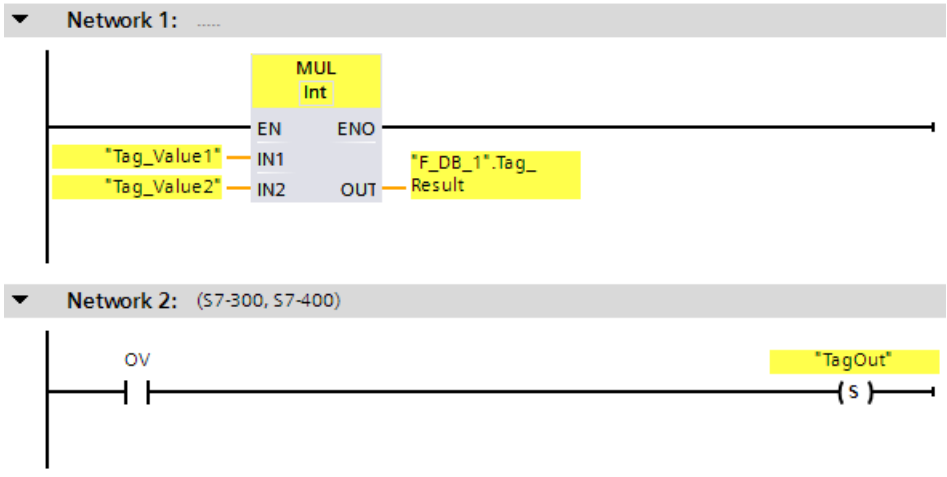

The "Multiply" instruction is always executed regardless of the signal state at enable input EN.

The value of the "Tag_Value1" operand is multiplied by the value of the "Tag_Value2" operand. The result of the multiplication is stored in the ""F_DB_1".Tag_Result" operand.

When an overflow occurs during execution of the "Multiply" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

Example for S7-1200/1500 F-CPUs

The following example shows how the instruction works:

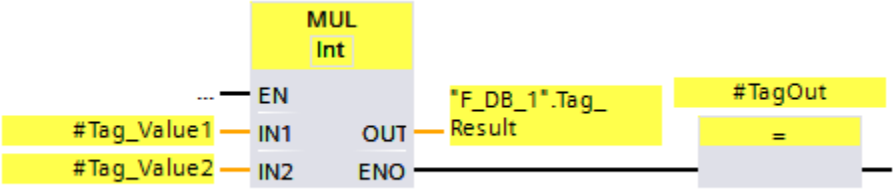

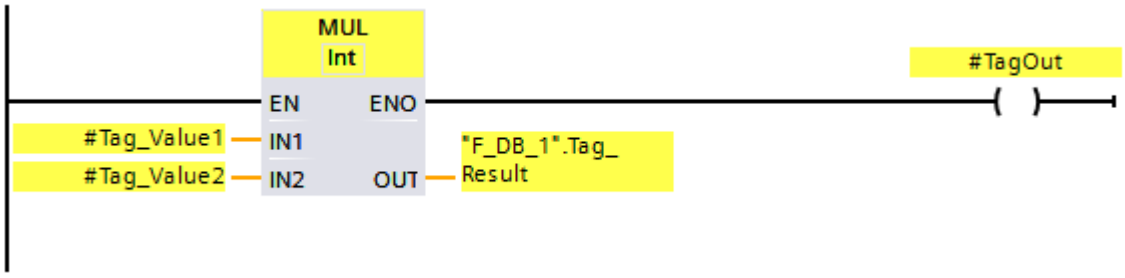

The "Multiply" instruction is always executed regardless of the signal state at enable input EN.

The value of the "#Tag_Value1" operand is multiplied by the value of the "#Tag_Value2" operand. The result of the multiplication is stored in the ""F_DB_1".Tag_Result" operand.

When no overflow occurs during execution of the "Multiply" instruction, the ENO enable output has the signal state "1" and the "#TagOut" operand is set.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 624)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 625)

13.9.4 DIV: Divide (STEP 7 Safety V21)

Description

You can use the "Divide" instruction to divide the value at input IN1 by the value at input IN2 and query the quotient at the OUT output (OUT = IN1 / IN2).

Enable input "EN" or (S7-300, S7-400) enable output "ENO" cannot be connected. The instruction is therefore always executed regardless of the signal state at enable input "EN".

NOTE

When the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-1200, S7-1500) You can avoid a STOP of the F-CPU by connecting the ENO enable output, thereby programming overflow detection.

Note the following:

- If the result of the instruction is located outside the permitted range for this data type, the enable output ENO returns the signal state "0".
- The result of the instruction reacts like the analogous instruction in a standard block.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- Work memory requirement of safety program is increased.

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.
- Work memory requirement of safety program is increased.

NOTE

S7-300/400, S7-1200/1500 (enable output ENO connected):

If the divisor (input IN2) of a DIV instruction = 0, the quotient of the division (result of division at output OUT) = 0. The result reacts like the corresponding instruction in a standard block. The F-CPU does *not* go to STOP mode.

S7-1200/1500 (enable output ENO not connected):

If the divisor (input IN2) of a DIV instruction = 0, the F-CPU goes to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU. We recommend that you rule out a divisor (input IN2) = 0 when creating the program.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	(S7-1200, S7-1500) Enable output
IN1	Input	INT, DINT	Dividend
IN2	Input	INT, DINT	Divisor
OUT	Output	INT, DINT	Quotient

You select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example for S7-300/400 F-CPUs

The following example shows how the instruction works:

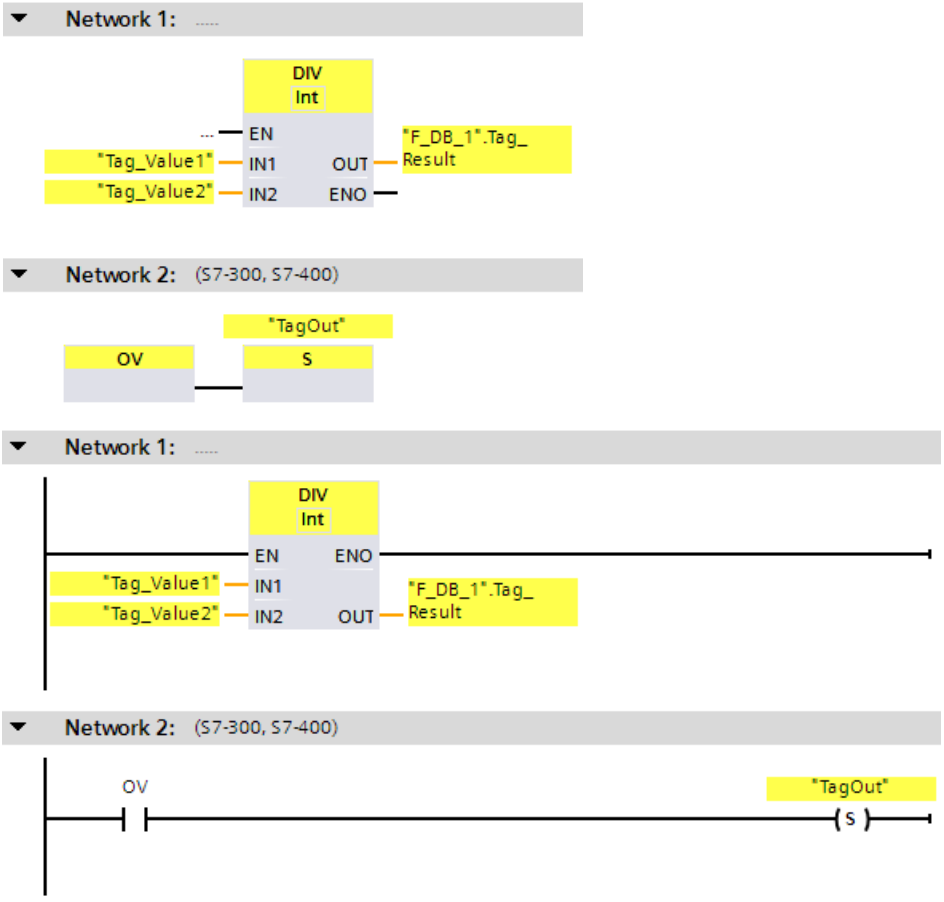

The "Divide" instruction is always execute regardless of the signal state at enable input EN.

The value of the "Tag_Value1" operand is divided by the value of the "Tag_Value2" operand. The result of the division is stored in the ""F_DB_1".Tag_Result" operand.

When an overflow occurs during execution of the "Divide" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

Example for S7-1200/1500 F-CPUs

The following example shows how the instruction works:

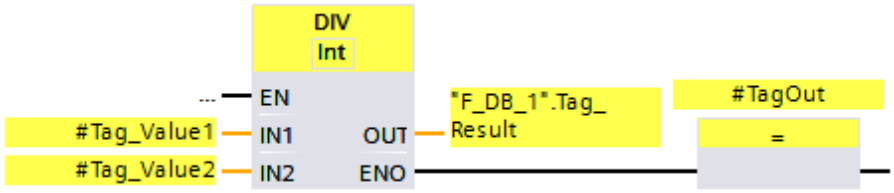

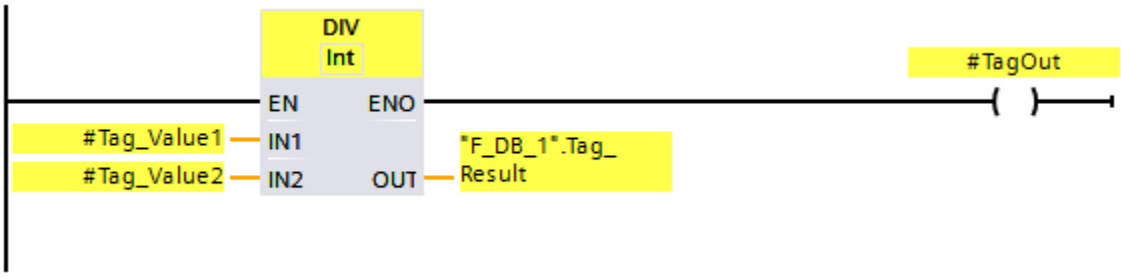

The "Divide" instruction is always execute regardless of the signal state at enable input EN.

The value of the "#Tag_Value1" operand is divided by the value of the "#Tag_Value2" operand. The result of the division is stored in the ""F_DB_1".Tag_Result" operand.

When no overflow occurs during execution of the "Divide" instruction, the ENO enable output has the signal state "1" and the "#TagOut" operand is set.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 624)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 625)

13.9.5 NEG: Create twos complement (STEP 7 Safety V21)

Description

You can use the "Create twos complement" instruction to change the sign of the value at input IN input and query the result at output OUT. If there is a positive value at input IN, for example, the negative equivalent of this value is sent to output OUT.

Enable input "EN" or (S7-300, S7-400) enable output "ENO" cannot be connected. The instruction is therefore always executed regardless of the signal state at enable input "EN".

NOTE

When the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

(S7-1200, S7-1500) You can avoid a STOP of the F-CPU by connecting the ENO enable output, thereby programming overflow detection.

Note the following:

- If the result of the instruction is located outside the permitted range for this data type, the enable output ENO returns the signal state "0".
- The result of the instruction reacts like the analogous instruction in a standard block.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- Work memory requirement of safety program is increased.

(S7-300, S7-400) You can avoid a STOP of the F-CPU by inserting a "Get status bit OV" instruction in the next network, thereby programming overflow detection.

Note the following:

- The result of the instruction reacts like the analogous instruction in a standard block.
- The network with the "Get status bit OV" instruction must not contain any jump labels.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- A warning is issued if you do not insert a "Get status bit OV" instruction.
- Work memory requirement of safety program is increased.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	(S7-1200, S7-1500) Enable output
IN	Input	INT, DINT	Input value
OUT	Output	INT, DINT	Twos complement of the input value

You select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example for S7-300/400 F-CPUs

The following example shows how the instruction works:

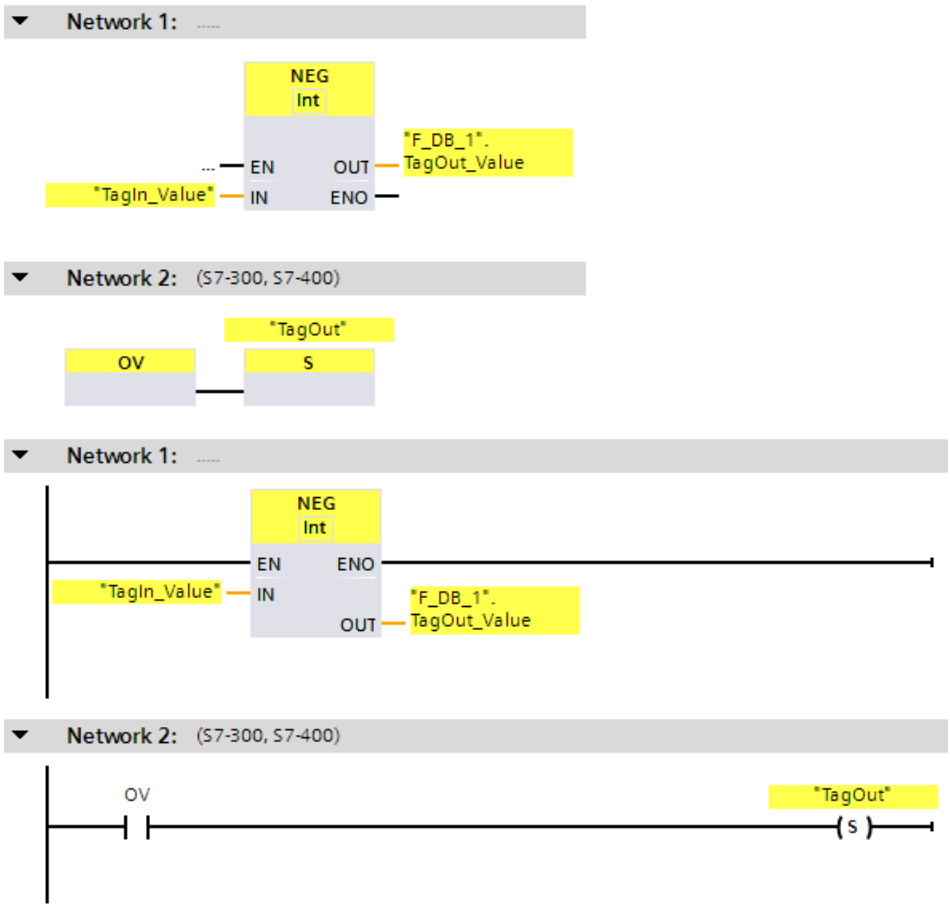

The "Create two's complement" instruction is always executed regardless of the signal state at enable input EN.

The sign of the "TagIn_Value" operand is changed and the result is stored in the ""F_DB_1".TagOut_Value" operand.

When an overflow occurs during execution of the "Create two's complement" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

Example for S7-1200/1500 F-CPUs

The following example shows how the instruction works:

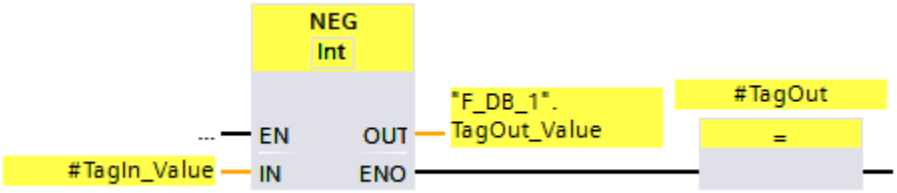

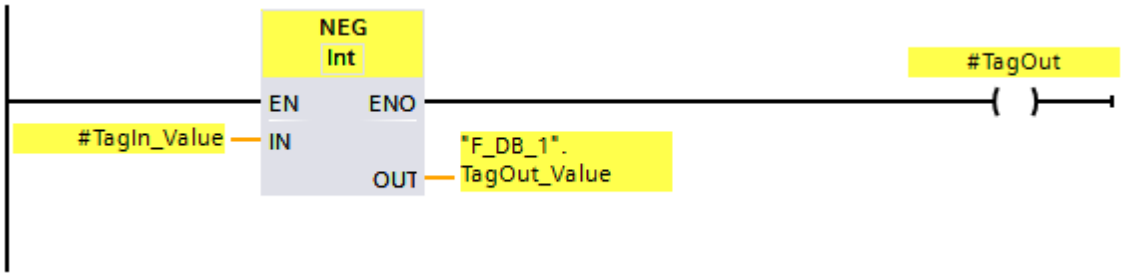

The "Create two's complement" instruction is always executed regardless of the signal state at enable input EN.

The sign of the "#TagIn_Value" operand is changed and the result is stored in the ""F_DB_1".TagOut_Value" operand.

When no overflow occurs during execution of the "Create two's complement" instruction, the ENO enable output has the signal state "1" and the "TagOut" operand is set.

See also

---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 624)

---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 625)

13.9.6 ABS: Form absolute value (STEP 7 Safety V21) (S7-1200, S7-1500)

Description

You use the "Form absolute value" instruction to calculate the absolute amount of the value which is specified at the input "IN". The result of the instruction is output at the OUT output and can be queried there.

Enable input "EN" or (S7-300, S7-400) enable output "ENO" cannot be connected. The instruction is therefore always executed regardless of the signal state at enable input "EN".

NOTE

When the result of the instruction is located outside the permitted range for this data type, the F-CPU may switch to STOP. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

You must therefore ensure that the permitted range for the data type is observed when creating the program!

You can avoid a STOP of the F-CPU by connecting the ENO enable output, thereby programming overflow detection.

Note the following:

- If the result of the instruction is located outside the permitted range for this data type, the enable output ENO returns the signal state "0".
- The result of the instruction reacts like the analogous instruction in a standard block.
- The execution time of the instruction is extended (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).
- Work memory requirement of safety program is increased.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	(S7-1200, S7-1500) Enable output
IN	Input	INT, DINT	Input value
OUT	Output	INT, DINT	Absolute value of the input value

You select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:

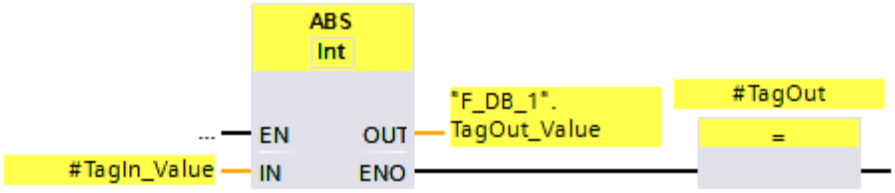

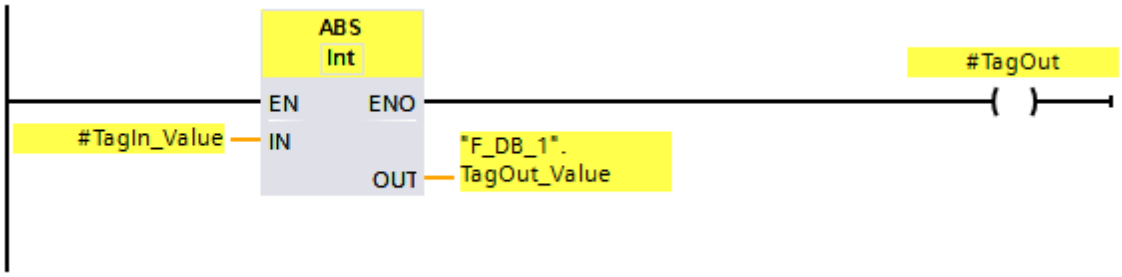

The instruction "Form absolute value"is always executed regardless of the signal state at enable input "EN".

The absolute amount of the value at the "TagIn_Value" operand is calculated and the result is stored in the ""F_DB_1".TagOut_Value" operand.

When no overflow occurs during execution of the "Form absolute value" instruction, the enable output ENO has the signal state "1" and the "#TagOut" operand is set.

13.10 Move operations

13.10.1 MOVE: Move value (STEP 7 Safety V21)

Description

You can use the "Move value" instruction to transfer the content of the operand at input IN to the operand at output OUT1.

Only operands with identical operand width and identical data structure can be specified for input IN and output OUT1.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

(S7-1200, S7-1500) In the basic state, the instruction box contains an output (OUT1). The number of outputs can be expanded. The inserted outputs are numbered in ascending order on the box. During execution, the content of the operand at the IN input is transferred to all available outputs. The instruction box cannot be expanded if operands with F-compliant PLC data types (UDT) are transferred.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	INT, DINT, WORD, (S7-300, S7-400) DWORD, TIME, F-compliant PLC data type (UDT)	Source value
OUT1	Output	INT, DINT, WORD, (S7-300, S7-400) DWORD, TIME, F-compliant PLC data type (UDT)	Destination address

Example

The following example shows how the instruction works:

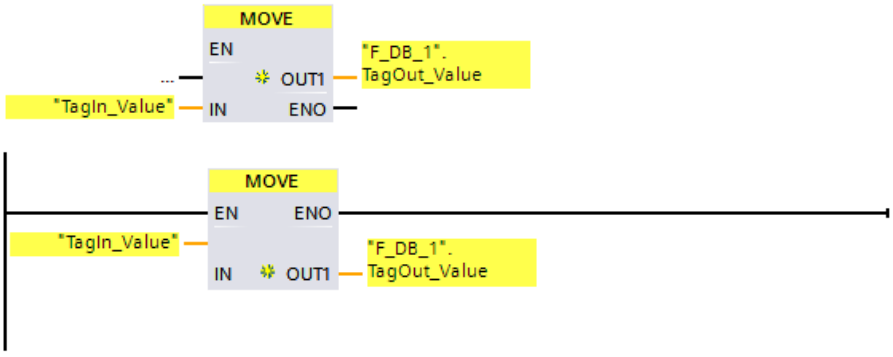

The instruction is always executed regardless of the signal state at enable input "EN". The instruction copies the content of operand "TagIn_Value" to operand ""F_DB_1".TagOut_Value".

13.10.2 RD_ARRAY_I: Read value from INT F-array (STEP 7 Safety V21) (S7-1200 G2, S7-1500)

Description

You use the "Read value from INT F-array" instruction to read an element from the array at the ARRAY input, which refers to the index at the INDEX input, and write its value at the OUT output. If an error occurs while accessing the array during runtime, this is displayed at the output ERROR.

The array must be created in an F-DB and can contain only one dimension. The elements of the ARRAY must be data type INT. The following applies for the array limits in contrast:

- The low limit must be 0.
- The high limit can be 10000 maximum.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ARRAY	Input	VARIANT	Array from which is read
INDEX	Input	DINT	Element in the array which is read. The specification may be a constant or a tag.
OUT	Output	INT	Value which is read and output.
ERROR	Output	BOOL	Error information The parameter ERROR is set if an error occurs during the processing of the instruction.

ARRAY parameter

In addition to the direct connection with an array within a fail-safe global DB, this input can also be interconnected with an INOUT of data type ARRAY[*] of INT. This enables the decoupling of data and program logic in order, for example, to create a library function without any connection existing to a dedicated data block.

ERROR parameter

The table below shows the meaning of the value of the ERROR parameter:

Value	Description
FALSE	No error
TRUE	Value at the INDEX parameter is outside the limit value of the ARRAY.

Instruction versions

One version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	—	—	x	x[1]	

[1] supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Reaction to errors

If the value at the INDEX input is outside the array limits, the output ERROR = 1 is set, and the array value of the element with index = 0 is output at OUT output, regardless of the value passed at the INDEX input.

Therefore, set the value of the element with index = 0 as a fail-safe substitute value.

Example

The following example shows how the instruction works:

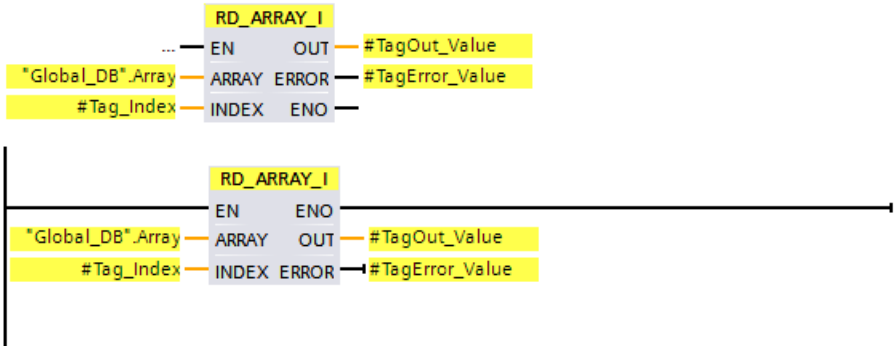

The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
ARRAY	"Global_DB".Array	The "Global_DB".Array operand is an ARRAY of data type Array[0..10] of INT
INDEX	#Tag_Index	2
OUT	#TagOut_Value	Value of the element at the location array[2]
ERROR	#TagError_Value	False

The instruction "Read value from INT F-array" is always executed regardless of the signal state at enable input "EN".

The content of the 2nd element of the operand "Global_DB.Array" is output at the "#TagOut_Value" output.

13.10.3 RD_ARRAY_DI: Read value from DINT F-array (STEP 7 Safety V21) (S7-1200 G2, S7-1500)

Description

You use the "Read value from DINT F-array" instruction to read an element from the array at the ARRAY input, which refers to the index at the INDEX input, and write its value at the OUT output. If an error occurs while accessing the array during runtime, this is displayed at the output ERROR.

The array must be created in an F-DB and can contain only one dimension. The elements of the array must be of the DINT data type. The following applies for the array limits in contrast:

- The low limit must be 0.
- The high limit can be 10000 maximum.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ARRAY	Input	VARIANT	Array from which is read
INDEX	Input	DINT	Element in the array which is read. The specification may be a constant or a tag.
OUT	Output	DINT	Value which is read and output.
ERROR	Output	BOOL	Error information The parameter ERROR is set if an error occurs during the processing of the instruction.

ARRAY parameter

In addition to the direct connection with an array within a fail-safe global DB, this input can also be interconnected with an INOUT of data type ARRAY[*] of DINT. This enables the decoupling of data and program logic in order, for example, to create a library function without any connection existing to a dedicated data block.

ERROR parameter

The table below shows the meaning of the value of the ERROR parameter:

Value	Description
FALSE	No error
TRUE	Value at the INDEX parameter is outside the limit value of the ARRAY.

Instruction versions

One version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	—	—	x	x[1]	

[1] supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Reaction to errors

If the value at the INDEX input is outside the array limits, the output ERROR = 1 is set, and the array value of the element with index = 0 is output at OUT output, regardless of the value passed at the INDEX input.

Therefore, set the value of the element with index = 0 as a fail-safe substitute value.

Example

The following example shows how the instruction works:

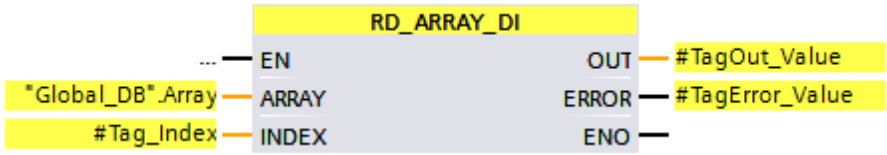

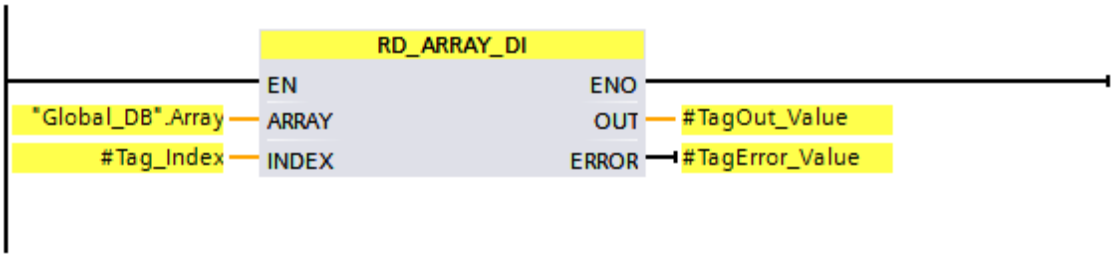

The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
ARRAY	"Global_DB".Array	The operand "Global_DB".Array is an ARRAY of data type Array[0..10] of DINT
INDEX	#Tag_Index	2
OUT	#TagOut_Value	Value of the element at the location array[2]
ERROR	#TagError_Value	False

The instruction "Read value from DINT F-array" is always executed regardless of the signal state at enable input "EN".

The content of the 2nd element of the operand "Global_DB.Array" is output at the "#TagOut_Value" output.

13.10.4 WR_FDB: Write value indirectly to an F-DB (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

This instruction writes the value specified in input IN to the tag addressed by INI_ADDR and OFFSET in an F-DB.

The address of the tags addressed using INI_ADDR and OFFSET must be within the address range defined by addresses INI_ADDR and END_ADDR.

If the F-CPU has gone to STOP mode with diagnostics event ID 75E2, check to determine if this condition is satisfied.

The start address of the area in an F-DB to which the value at input IN is to be written is transferred using input INI_ADDR. The associated offset in this area is transferred using input OFFSET.

The addresses transferred in input INI_ADDR or END_ADDR must point to a tag of the selected data type in an F-DB. Only tags of the selected data type are permitted between the INI_ADDR and END_ADDR addresses. The INI_ADDR address must be smaller than the END_ADDR address.

As shown in the following example, the INI_ADDR and END_ADDR addresses must be transferred fully-qualified as "DBx".DBWy or in the corresponding symbolic representation. Transfers in other forms are not permitted.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	INT, DINT	Value to be written to the F-DB
INI_ADDR	Input	POINTER	Start address of the area in an F-DB
END_ADDR	Input	POINTER	End address of the area in an F-DB
OFFSET	Input	INT	Offset

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Examples of parameter assignment of INI_ADDR, END_ADDR, and OFFS

Name	Data type	Initial value	Comment
Static			
VAR_BOOL10	BOOL	false	
VAR_BOOL11	BOOL	false	
VAR_BOOL12	BOOL	false	
VAR_BOOL13	BOOL	false	
VAR_TIME10	TIME	T#0MS	
VAR_TIME11	TIME	T#0MS	
VAR_INT10	INT	0	<- INI_ADDR = "F-DB_1".VAR_INT10 Example 1
VAR_INT11	INT	0	
VAR_INT12	INT	0	
VAR_INT13	INT	0	<- OFFSET = 3
VAR_INT14	INT	0	
VAR_INT15	INT	0	<- END_ADDR = "F-DB_1".VAR_INT15
VAR_BOOL20	BOOL	false	
VAR_BOOL21	BOOL	false	
VAR_BOOL22	BOOL	false	
VAR_BOOL23	BOOL	false	
VAR_INT20	INT	0	<- INI_ADDR = "F-DB_1".VAR_INT20 Example 2
VAR_INT21	INT	0	
VAR_INT22	INT	0	
VAR_INT23	INT	0	<- END_ADDR = "F-DB_1".VAR_INT23
VAR_INT30	INT	0	<- INI_ADDR = "F-DB_1".VAR_INT30 Example 3
VAR_INT31	INT	0	<- OFFSET = 1
VAR_INT32	INT	0	
VAR_INT33	INT	0	
VAR_INT34	INT	0	<- END_ADDR = "F-DB".VAR_INT34
VAR_TIME20	TIME	T#0MS	
VAR_DINT10	DINT	0	<- INI_ADDR = "F-DB_1".VAR_DINT10 Example 4
VAR_DINT11	DINT	0	
VAR_DINT12	DINT	0	<- OFFSET = 2
VAR_DINT13	DINT	0	<- END_ADDR = "F-DB_1".VAR_DINT13

Example

The following example shows how the instruction works:

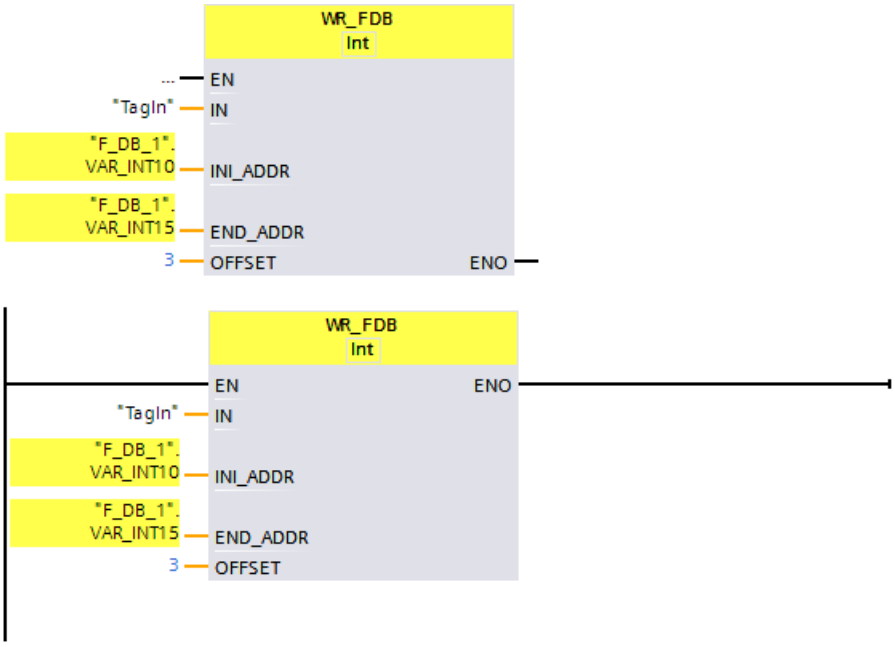

13.10.5 RD_FDB: Read value indirectly from an F-DB (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

This instruction reads the tag addressed via INI_ADDR and OFFSET in an F-DB and provides it at output OUT.

The address of the tags addressed using INI_ADDR and OFFSET must be within the address range defined by addresses INI_ADDR and END_ADDR.

If the F-CPU has gone to STOP mode with diagnostics event ID 75E2, check to determine if this condition is satisfied.

The start address of the area in an F-DB from which the tag is to be read is transferred using input INI_ADDR. The associated offset in this area is transferred using input OFFSET.

The addresses transferred in input INI_ADDR or END_ADDR must point to a tag of the selected data type in an F-DB. Only tags of the selected data type are permitted between the INI_ADDR and END_ADDR addresses. The INI_ADDR address must be smaller than the END_ADDR address.

The INI_ADDR and END_ADDR addresses must be transferred fully-qualified as "DBx".DBWy or in the corresponding symbolic representation. Transfers in other forms are not permitted. Examples of parameter assignment of INI_ADDR, END_ADDR, and OFFSET are contained in WR_FDB: Write value indirectly to an F-DB (STEP 7 Safety Advanced V21) (S7-300, S7-400) (Page 589).

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
INI_ADDR	Input	POINTER	Start address of the area in an F-DB
END_ADDR	Input	POINTER	End address of the area in an F-DB
OFFSET	Input	INT	Offset
OUT	Output	INT, DINT	Value to be read from the F-DB

You can select the data type of the instruction in the "<???>" drop-down list in the instruction box.

Example

The following example shows how the instruction works:

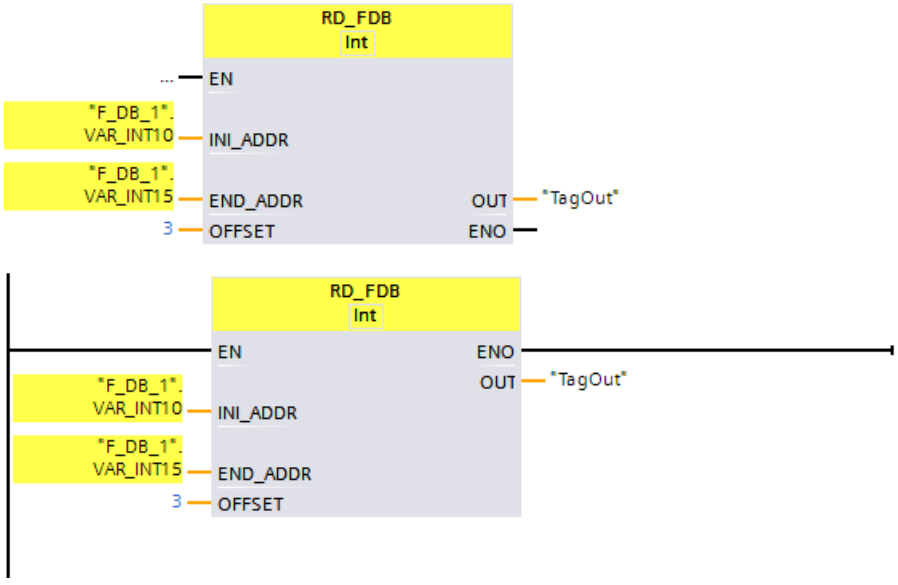

13.11 Conversion operations

13.11.1 CONVERT: Convert value (STEP 7 Safety V21)

Description

The "Convert value" instruction reads the content of parameter IN and converts it according to the data types selected in the instruction box. The converted value is output at the OUT output .

Enable input "EN" cannot be connected. The instruction is therefore always executed (regardless of the signal state at the "EN" enable input). The connection of the "ENO" enable output is only possible and required when converting from the "DINT" to the "INT" data type.

NOTE

When converting from "DINT" to the "INT" data type, you need to connect the ENO enable output and thereby programming overflow detection.

Note the following:

- If the value at the input is outside the INT range, ENO returns 0.
- The result of the instruction reacts like the analogous instruction in a standard block.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ENO	Output	BOOL	Enable output
IN	Input	INT, DINT	Value to be converted.
OUT	Output	INT, DINT	Result of the conversion

You can select the data types of the instruction in the "<???>" drop-down lists of the instruction box. The supported conversions are from "INT to DINT" and "DINT to INT".

Example

The following example shows how the "Convert value "DINT to INT"" instruction for S7-1200/1500 F-CPUs works:

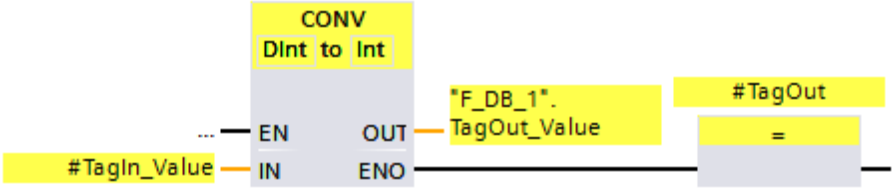

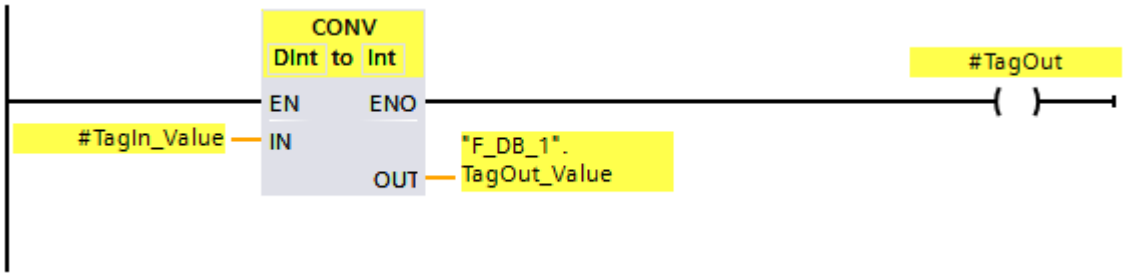

The instruction is always executed regardless of the signal state at enable input EN.

The value of the "TagIn_Value" operand is converted to an integer (16-bit) and the result is stored in the ""F_DB_1".TagOut_Value" operand.

When no overflow occurs during execution of the "Convert value "DINT to INT"" instruction, the ENO enable output has the signal state "1" and the "TagOut" operand is set.

You can also store the signal status of the ENO enable output in an (F-)DB, and centrally evaluate whether overflows have occurred for all or one group of instructions with overflow detection.

13.11.2 BO_W: Convert 16 data elements of data type BOOL to a data element of data type WORD (STEP 7 Safety V21)

Description

This instruction converts the 16 values of data type BOOL at inputs IN0 to IN15 to a value of data type WORD, which is made available at output OUT. The conversion takes place as follows: The i-th bit of the WORD value is set to 0 (or 1), if the value at input INi = 0 (or 1).

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN0	Input	BOOL	Bit 0 of WORD value
IN1	Input	BOOL	Bit 1 of WORD value
...			...
IN15	Input	BOOL	Bit 15 of WORD value
OUT	Output	WORD	WORD value consisting of IN0 to IN15

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	o	—	—	o	These versions have identical functions to version 1.0.
1.2	x	—	—	o	
1.3	x	o	—	o	
1.4	x	x	—	x	
2.0	x	x[1]	x	x[2]	

o This version is no longer supported.

[1] supported as of firmware V4.2

[2] supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:

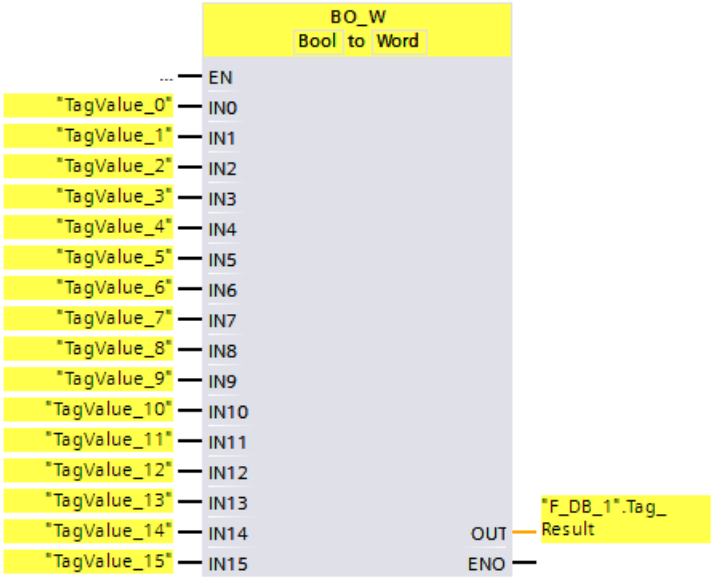

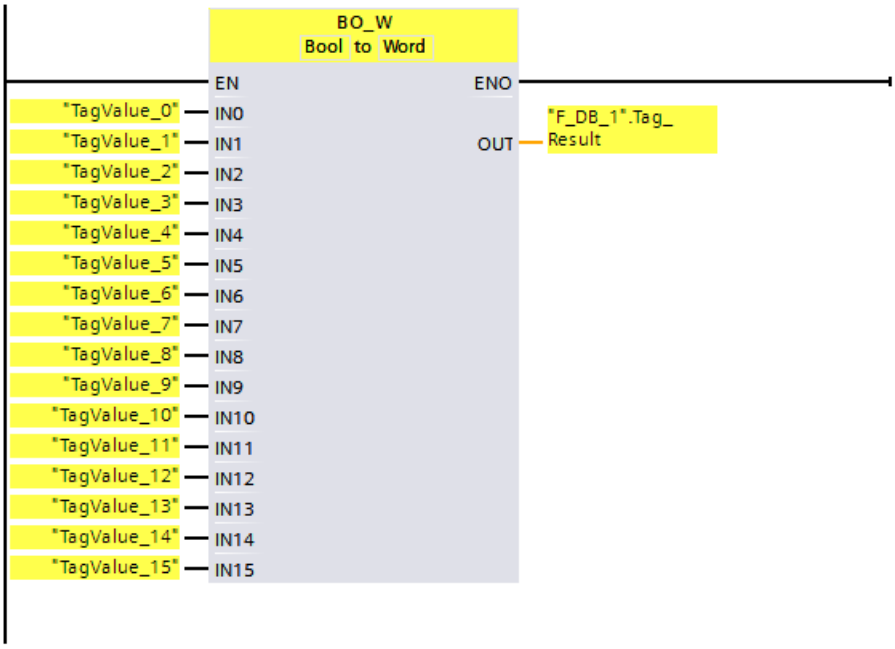

The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
IN0	TagValue_0	FALSE
IN1	TagValue_1	FALSE
...		...
IN13	TagValue_13	FALSE
IN14	TagValue_14	TRUE
IN15	TagValue_15	TRUE
OUT	"F_DB_1".Result	W#16#C000

The values of operands "TagValue_0" to "TagValue_15" are combined into a value of the data type WORD and assigned to operand ""F_DB_1".TagResult".

13.11.3 W_BO: Convert a data element of data type WORD to 16 data elements of data type BOOL (STEP 7 Safety V21)

Description

This instruction converts the value of data type WORD at input IN to 16 values of data type BOOL, which are provided at outputs OUT0 to OUT15. The conversion takes place as follows: Output OUTi is set to 0 (or 1), if the i-th bit of the WORD value is 0 (or 1).

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	WORD	WORD value
OUT0	Output	BOOL	Bit 0 of WORD value
OUT1	Output	BOOL	Bit 1 of WORD value
...			...
OUT15	Output	BOOL	Bit 15 of WORD value

Instruction versions

A number of versions are available for this instruction:

Ver-sion	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	o	—	—	o	These versions have identical functions to version 1.0.
1.2	x	—	—	o	
1.3	x	o	—	o	
1.4	x	x	—	x	
2.0	x	x[1]	x	x[2]	

o This version is no longer supported.

[1] supported as of firmware V4.2

[2] supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:

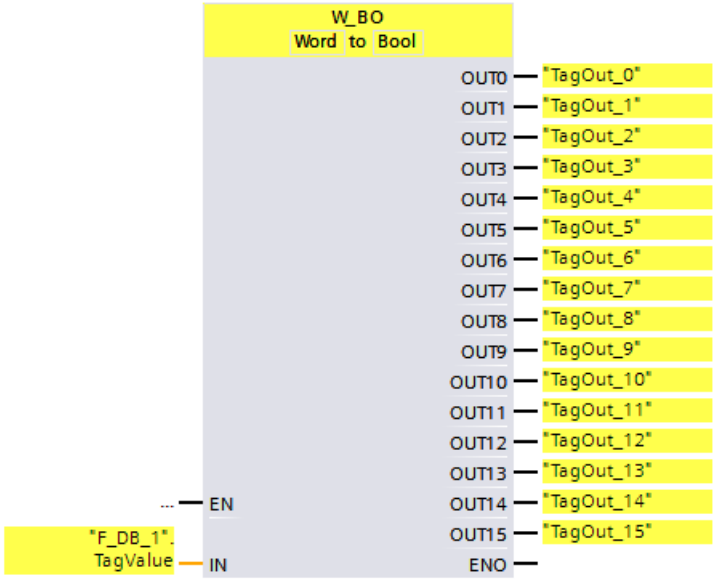

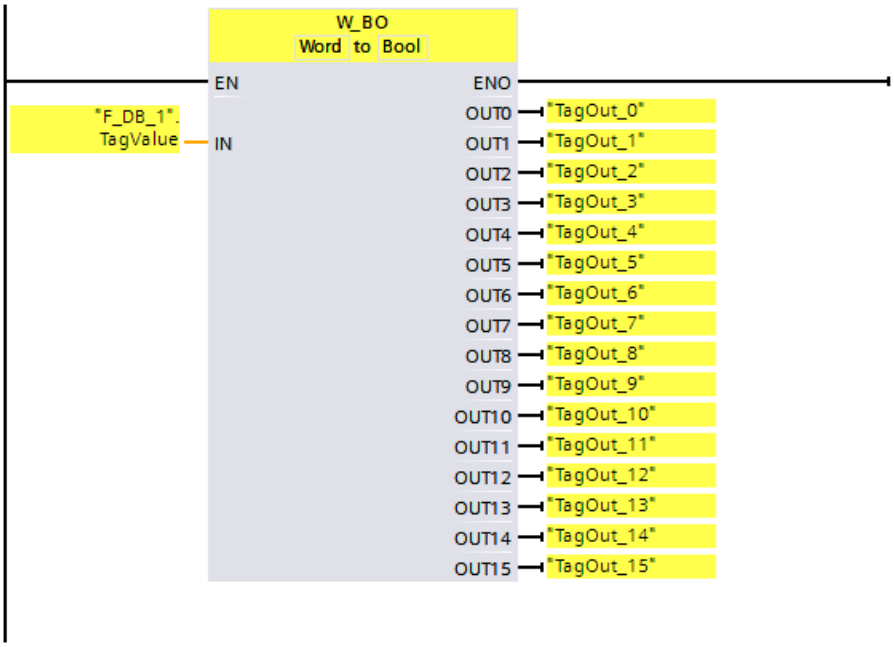

The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
IN	"F_DB_1".TagValue	W#16#C000
OUT0	TagOUT_0	FALSE
OUT1	TagOUT_1	FALSE
...		...

Parameter	Operand	Value
OUT13	TagOUT_13	FALSE
OUT14	TagOUT_14	TRUE
OUT15	TagOUT_15	TRUE

The value of operand ""F_DB_1".TagValue" of data type WORD is converted to the 16 values "TagOUT_0" to "TagOUT_15" of data type BOOL.

13.11.4 SCALE: Scale (STEP 7 Safety V21)

Description

This instruction scales the value at input IN in physical units between the low limit value at input LO_LIM and the high limit value at input HI_LIM. It is assumed that the value at input IN is between 0 and 27648. The scaling result is provided at output OUT.

The instruction uses the following equation:

OUT = [IN × (HI_LIM – LO_LIM)] / 27648 + LO_LIM

As long as the value at input IN is greater than 27648, output OUT is linked to HI_LIM and OUT_HI is set to 1.

As long as the value at input IN is less than 0, output OUT is linked to LO_LIM and OUT_LO is set to 1.

For inverse scaling, you must assign LO_LIM > HI_LIM. With inverse scaling, the output value at output OUT decreases while the input value at input IN increases.

Every call of the "Scale value" instruction must be assigned a data area in which the instruction data is stored. In addition, when the instruction is inserted in the program, the "Call options" dialog is automatically opened, where you can create a data block (single instance) (e.g., SCALE_DB_1) or a multi-instance (e.g., SCALE_Instance_1) for the "Scale value" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	INT	Input value to be scaled in physical units
HI_LIM	Input	INT	High limit value of value range of OUT
LO_LIM	Input	INT	Low limit value of value range of OUT
OUT	Output	INT	Result of scaling
OUT_HI	Output	BOOL	1 = Input value > 27648: OUT = HI_LIM
OUT_LO	Output	BOOL	1 = Input value < 0: OUT = LO_LIM

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0.
1.2	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Behavior in the event of overflow or underflow of analog values and fail-safe value output

NOTE

If inputs from the PII of an SM 336; AI 6 x 13Bit or SM 336; F-AI 6 x 0/4 ... 20 mA HART are used as input values, note that the F-system detects an overflow or underflow of a channel of this F-SM as an F-I/O fault or channel fault. The fail-safe value 0 is provided in place of $7FFF_H$ (for overflow) or 8000_H (for underflow) in the PII for the safety program.

If other fail-safe values should be output in this case, you need to evaluate the QBAD signal of the associated F-I/O or QBAD_I_xx signal / value status of the corresponding channel.

If the value in the PII of the F-SM is within the overrange or underrange, but is > 27648 or < 0, you can likewise branch to the output of an individual fail-safe value by evaluating outputs OUT_HI and OUT_LO, respectively.

Example

The following example shows how the instruction works:

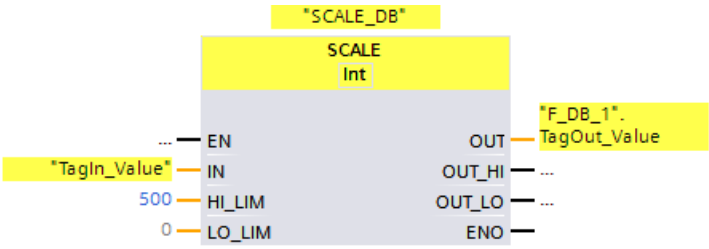

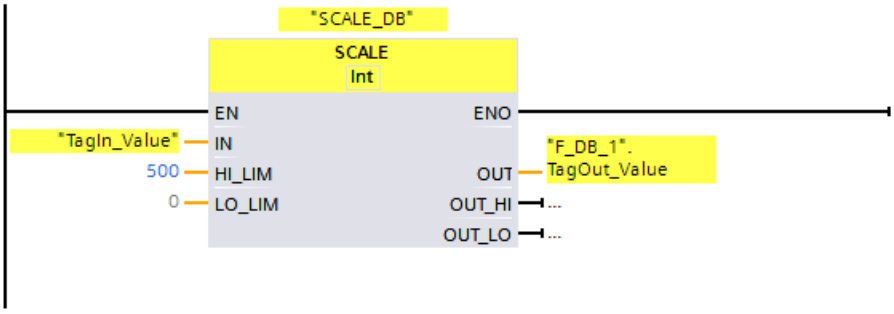

When operand "TagIn_Value" = 20000, the result for ""F_DB_1".TagOut_Value" is 361.

13.11.5 SCALE_D: Scale to data type DINT (STEP 7 Safety V21) (S7-1200, S7-1500)

Description

This instruction scales the value at input IN in physical units between the low limit value at input LO_LIM and the high limit value at input HI_LIM. It is assumed that the value at input IN is between 0 and 27648. The scaling result is provided at output OUT.

The instruction uses the following equation:

OUT = [IN × (HI_LIM – LO_LIM)] / 27648 + LO_LIM

As long as the value at input IN is greater than 27648, output OUT is linked to HI_LIM and OUT_HI is set to 1.

As long as the value at input IN is less than 0, output OUT is linked to LO_LIM and OUT_LO is set to 1.

For inverse scaling, you must assign LO_LIM > HI_LIM. With inverse scaling, the output value at output OUT decreases while the input value at input IN increases.

Every call of the "Scale value to data type DINT" instruction must be assigned a data area in which the instruction data is stored. In addition, when the instruction is inserted in the program, the "Call options" dialog is automatically opened, where you can create a data block (single instance) (e.g., SCALE_D_DB_1) or a multi-instance (e.g., SCALE_D_Instance_1) for the "Scale value to data type DINT" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameter

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	INT	Input value to be scaled in physical units
HI_LIM	Input	DINT	High limit value of value range of OUT
LO_LIM	Input	DINT	Low limit value of value range of OUT
OUT	Output	DINT	Result of scaling
OUT_HI	Output	BOOL	1 = Input value > 27648: OUT = HI_LIM
OUT_LO	Output	BOOL	1 = Input value < 0: OUT = LO_LIM

Instruction versions

One version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
2.0	—	x[1]	x	x[2]	

[1] supported as of firmware V4.2

[2] supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Behavior in the event of overflow or underflow of analog values and fail-safe value output

NOTE

If inputs from the PII of an SM 336; AI 6 x 13Bit or SM 336; F-AI 6 x 0/4 ... 20 mA HART are used as input values, note that the F-system detects an overflow or underflow of a channel of this F-SM as an F-I/O fault or channel fault. The fail-safe value 0 is provided in place of $7FFF_H$ (for overflow) or 8000_H (for underflow) in the PII for the safety program.

If other fail-safe values should be output in this case, you need to evaluate the QBAD signal of the associated F-I/O or QBAD_I_xx signal / value status of the corresponding channel.

If the value in the PII of the F-SM is within the overrange or underrange, but is > 27648 or < 0, you can likewise branch to the output of an individual fail-safe value by evaluating outputs OUT_HI and OUT_LO, respectively.

Example

The following example shows how the instruction works:

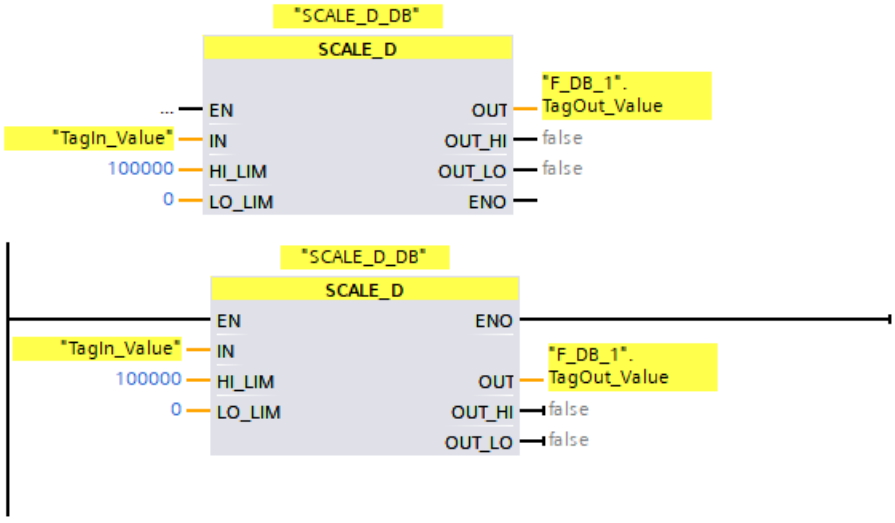

When the operand "TagIn_Value" = 20000, the result for ""F_DB_1".TagOut_Value" is 72337.

13.12 Program control operations

13.12.1 JMP: Jump if RLO = 1 (STEP 7 Safety V21)

Description

You can use the "Jump if RLO = 1" instruction to interrupt the linear execution of the program and resume it in another network. The destination network must be identified by a jump label (Page 607) (LABEL). The description of the jump label is specified in the placeholder above the instruction.

The specified jump label must be in the same block in which the instruction is executed. The name you specify can only occur once in the block.

If the result of logic operation (RLO) at the input of the instruction is "1" or the input is not connected, the jump to the network identified by the jump label is executed. The jump direction can be towards higher or lower network numbers.

If the result of logic operation (RLO) at the input of the instruction is "0", the program continues executing in the next network.

NOTE

(S7-1200, S7-1500)
If the jump destination (jump label) for an instruction "JMP" or "JMPN" is above the associated instruction "JMP" or "JMPN" (backwards jump), you cannot insert any other instructions for program control (JMP, JMPN, RET, jump label) between them.
Exception: You can insert an instruction "JMP" or "JMPN" between them if you also insert the associated jump destination in between as well as below the associated instruction "JMP" or "JMPN" (forward jump).
Non-compliance can lead to compilation errors or to the F-CPU going to STOP.

NOTE

You are not permitted to insert any SENDDP or SENDS7 instructions between an instruction JMP or JMPN and the associated jump destination (jump label).

Example

The following example shows how the instruction works:

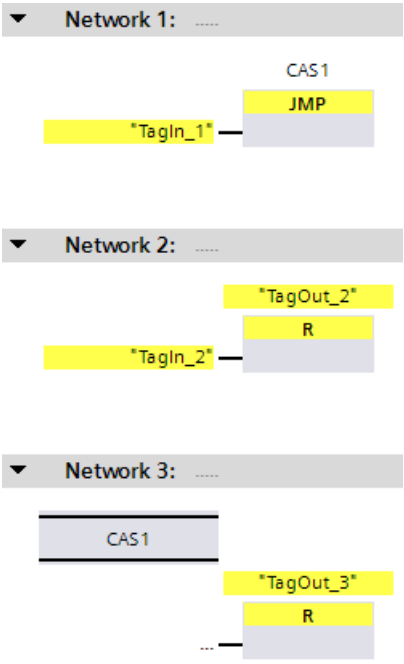

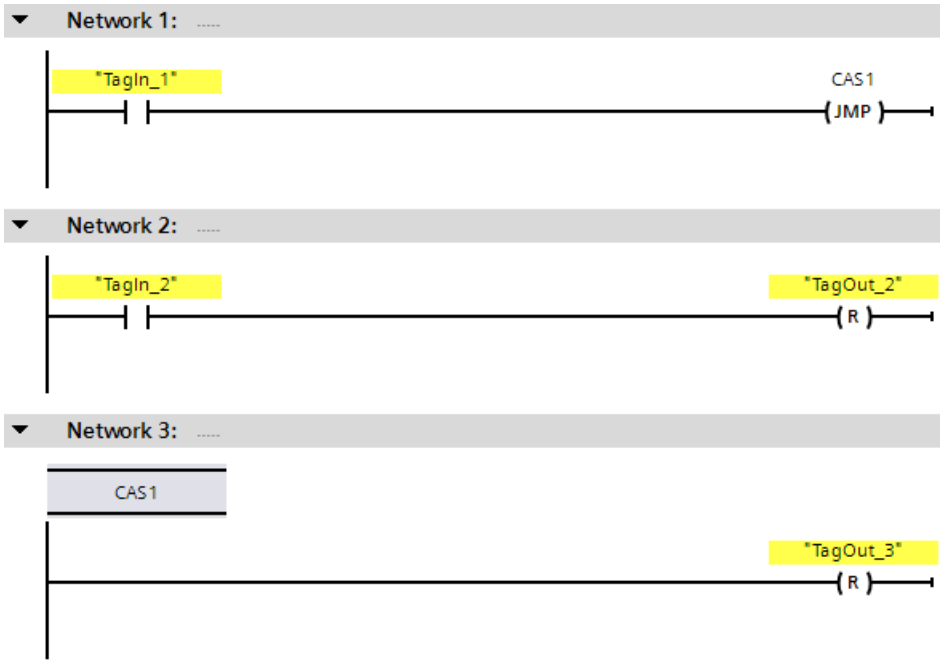

When operand "TagIn_1" has signal state "1", the "Jump if RLO = 1" instruction is executed. The linear execution of the program is interrupted and continues in Network 3, which is identified by the jump label CAS1. When input "TagIn_3" has signal state "1", output "TagOut_3" is reset.

13.12.2 JMPN: Jump if RLO = 0 (STEP 7 Safety V21)

Description

You can use the "Jump if RLO = 0" instruction to interrupt the linear execution of the program and resume it in another network, when the result of logic operation at the input of the instruction is "0". The destination network must be identified by a jump label (Page 607) (LABEL). The description of the jump label is specified in the placeholder above the instruction.

The specified jump label must be in the same block in which the instruction is executed. The name you specify can only occur once in the block.

If the result of logic operation (RLO) at the input of the instruction is "0", the jump to the network identified by the jump label is executed. The jump direction can be towards higher or lower network numbers.

If the result of logic operation (RLO) at the input of the instruction is "1", the program continues executing in the next network.

NOTE

(S7-1200, S7-1500)
If the jump destination (jump label) for an instruction "JMP" or "JMPN" is above the associated instruction "JMP" or "JMPN" (backwards jump), you cannot insert any other instructions for program control (JMP, JMPN, RET, jump label) between them.
Exception: You can insert an instruction "JMP" or "JMPN" between them if you also insert the associated jump destination in between as well as below the associated instruction "JMP" or "JMPN" (forward jump).
Non-compliance can lead to compilation errors or to the F-CPU going to STOP.

NOTE

You are not permitted to insert any SENDDP or SENDS7 instructions between an instruction JMP or JMPN and the associated jump destination (jump label).

Example

The following example shows how the instruction works:

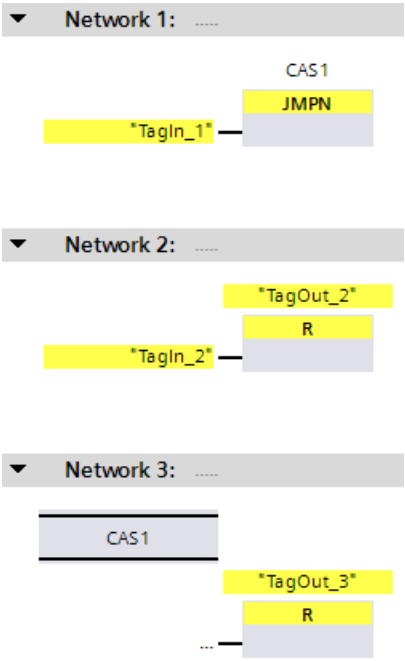

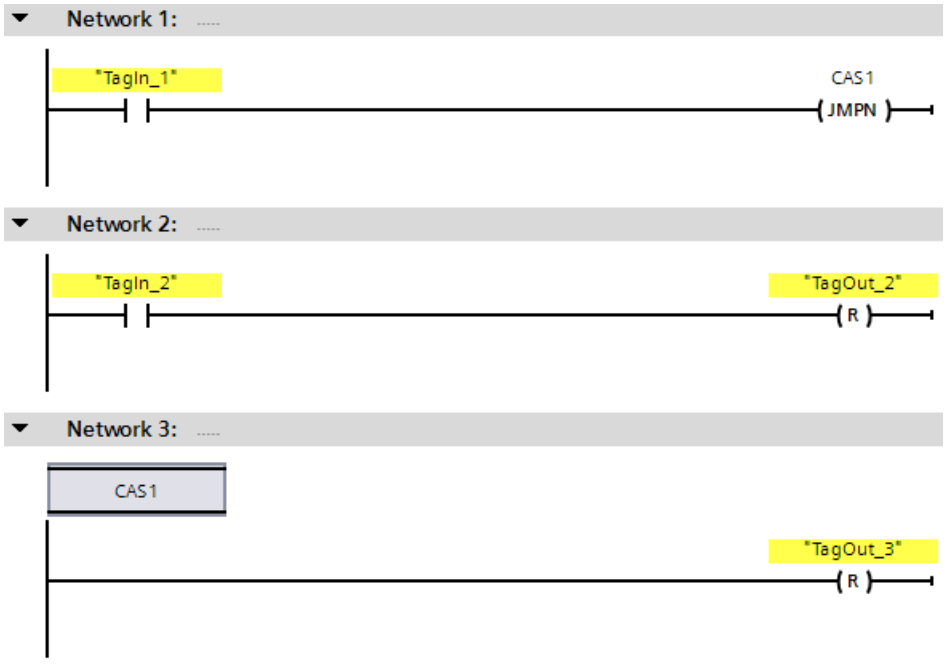

When operand "TagIn_1" has signal state "0", the "Jump if RLO = 0" instruction is executed. The linear execution of the program is interrupted and continues in Network 3, which is identified by the jump label CAS1. When input "TagIn_3" has signal state "1", output "TagOut_3" is reset.

13.12.3 LABEL: Jump label (STEP 7 Safety V21)

Description

You can use a jump label to specify a destination network, in which the program execution should resume after a jump.

The jump label and the instruction in which the jump label is specified must be located in the same block. The name of a jump label can only be assigned once in a block.

Only one jump label can be placed in a network. To each jump label can be jumped from several locations.

Example

The following example shows how the instruction works:

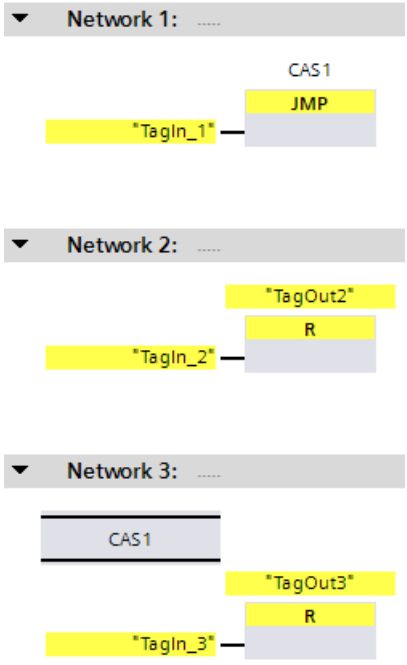

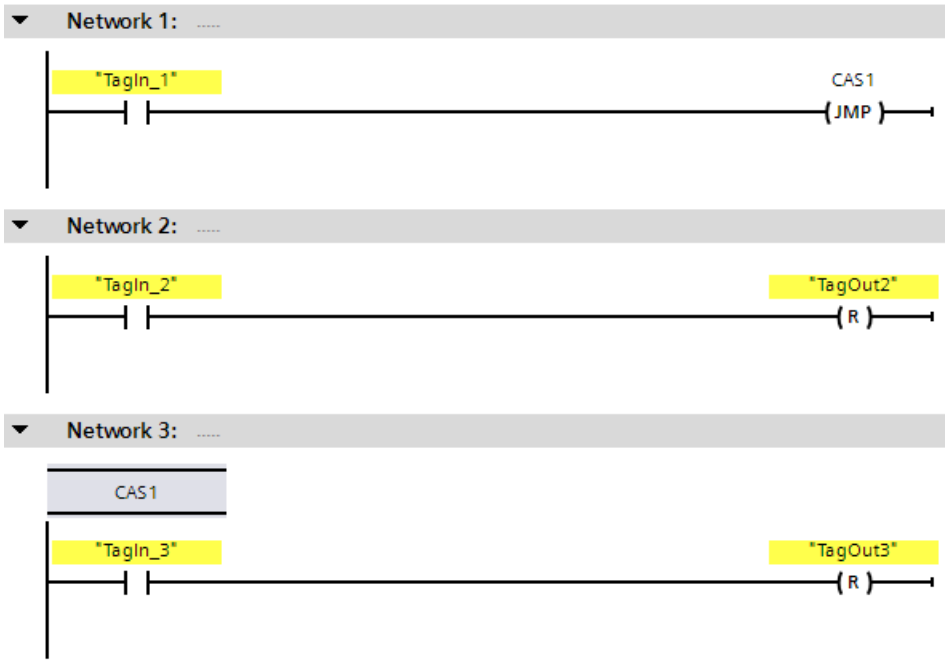

When operand "TagIn_1" has signal state "1", the "Jump if RLO = 1" instruction is executed. The linear execution of the program is interrupted and continues in Network 3, which is identified by the jump label CAS1. When input "TagIn_3" has signal state "1", output "TagOut_3" is reset.

See also

JMP: Jump if RLO = 1 (STEP 7 Safety V21) (Page 603)
JMPN: Jump if RLO = 0 (STEP 7 Safety V21) (Page 605)
RET: Return (STEP 7 Safety V21) (Page 609)

13.12.4 RET: Return (STEP 7 Safety V21)

Description

You can use the "Return" instruction to stop the processing of a block.

If the result of logic operation (RLO) at the input of the "Return" instruction is "1" or the box input of the S7-1200/1500 F-CPUs is not connected in FBD, program execution is terminated in the currently called block and continued in the calling block (for example, in the main safety block) after the call function. If the RLO at the input of the "Return" instruction is "0", the instruction is not executed. Program execution continues in the next network of the called block.

Influencing the status of the call function (ENO) is irrelevant, because the enable output "ENO" cannot be connected.

NOTE

(S7-300, S7-400) You may not program a RET instruction in the main safety block.

Example

The following example shows how the instruction works:

When the "TagIn" operand delivers signal state "1", the "Return" instruction is executed. Program execution is terminated in the called block and continues in the calling block.

See also

JMP: Jump if RLO = 1 (STEP 7 Safety V21) (Page 603)
JMPN: Jump if RLO = 0 (STEP 7 Safety V21) (Page 605)
LABEL: Jump label (STEP 7 Safety V21) (Page 607)

13.12.5 OPN: Open global data block (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

You can use the "Open global data block" instruction to open a data block. The number of the data block is transferred to the DB register. Subsequent DB commands access the relevant blocks depending on the register contents.

NOTE

Note when using the "Open global data block" instruction that the content of the DB register can be changed after calls of F-FB/F-FC and "fully qualified DB accesses", such that there is no guarantee that the last data block you opened with "Open global data block" is still open.

You should therefore use the following method for addressing data to avoid errors when accessing data of the DB register:

- Use symbolic addressing.
- Use only fully qualified DB accesses.

If you still want to use the "Open global data block" operation, you must ensure that the DB register is restored by repeating the "Open global data block" instruction following calls of F-FB/F-FC and "fully qualified DB accesses." Otherwise, a malfunction could result.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
<Data block>	Input	BLOCK_DB	Data block that is opened

"Fully qualified DB access"

The initial access to data of a data block in an F-FB/F-FC must always be a "fully qualified DB access," or it must be preceded by the "Open global data block" instruction. This also applies to the initial access to data of a data block after a jump label.

An example of "fully qualified DB access" and "non-fully qualified DB access" is provided in Restrictions in the programming languages FBD/LAD (Page 121).

Access to instance DBs

You can also access instance DBs of F-FBs with fully qualified access, e.g., for transfer of block parameters. It is not possible to access static local data in single/multi-instances of other F-FBs.

Note that accessing instance DBs of F-FBs that are not called in the safety program can cause the F-CPU to go to STOP mode.

Example

The following example shows how the instruction works:

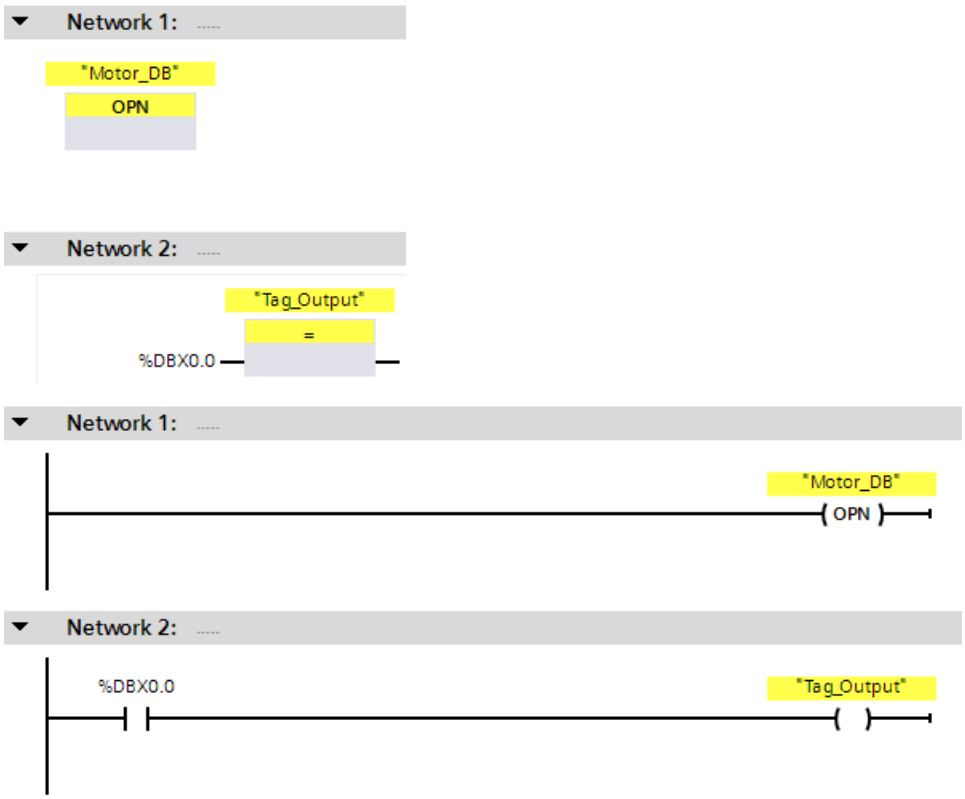

The "Motor_DB" data block is called in network 1. The number of the data block is transferred to the DB register. The "DBX0.0" operand is queried in network 2. The signal state of the "DBX0.0" operand is assigned to the "Tag_Output" operand.

13.13 Word logic operations

13.13.1 AND: AND logic operation (STEP 7 Safety V21)

Description

You can use the "AND logic operation" instruction to combine the value at input IN1 to the value at input IN2 bit-by-bit by AND logic and query the result at output OUT.

When the instruction is executed, bit 0 of the value at input IN1 and bit 0 of the value at input IN2 are ANDed. The result is stored in bit 0 of output OUT. The same logic operation is executed for all other bits of the specified values.

The result bit has signal state "1" only when both of the bits in the logic operation also have signal state "1". If one of the two bits of the logic operation has signal state "0", the corresponding result bit is reset.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	WORD	First value of logic operation
IN2	Input	WORD	Second value of logic operation
OUT	Output	WORD	Result of the instruction

Example

The following example shows how the instruction works:

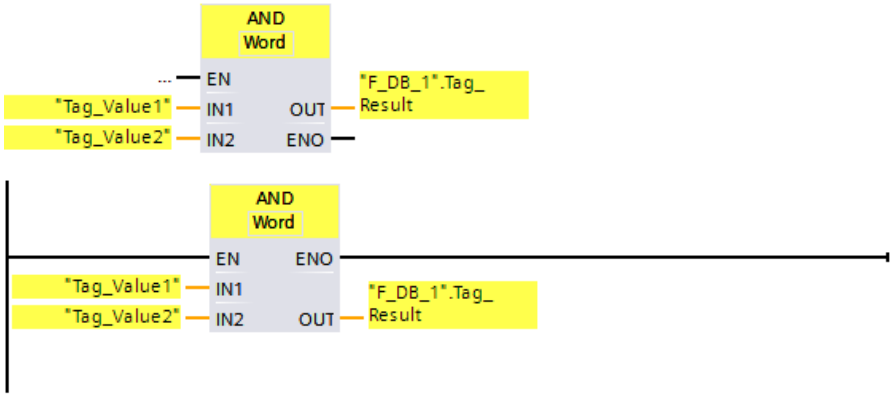

IN1	`"Tag_Value1" = 01010101 01010101`
IN2	`"Tag_Value2" = 00000000 00001111`
OUT	`"F_DB_1"."Tag_Result" = 00000000 00000101`

The instruction is always executed regardless of the signal state at enable input "EN". The value of the "Tag_Value1" operand and the value of the "Tag_Value2" operand are ANDed. The result is mapped bit-by-bit and output in the ""F_DB_1".Tag_Result" operand.

13.13.2 OR: OR logic operation (STEP 7 Safety V21)

Description

You can use the "OR logic operation" instruction to connect the value at input IN1 input to the value at input IN2 bit-by-bit by OR logic and query the result at output OR.

When the instruction is executed, bit 0 of the value at input IN1 and bit 0 of the value at input IN2 are ORed. The result is stored in bit 0 of output OUT. The same logic operation is executed for all bits of the specified tags.

The result bit has signal state "1" when at least one of the two bits in the logic operation has signal state "1". If both of the bits of the logic operation have signal state "0", the corresponding result bit is reset.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	WORD	First value of logic operation
IN2	Input	WORD	Second value of logic operation
OUT	Output	WORD	Result of the instruction

Example

The following example shows how the instruction works:

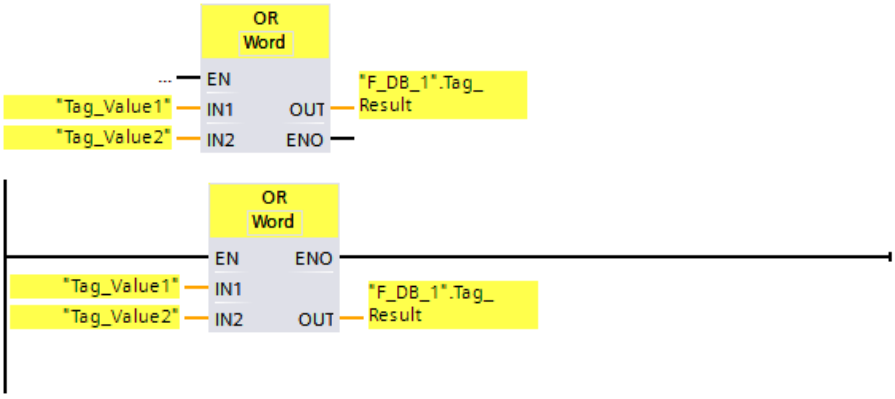

IN1	`"Tag_Value1" = 01010101 01010101`
IN2	`"Tag_Value2" = 00000000 00001111`
OUT	`"F_DB_1"."Tag_Result" = 01010101 01011111`

The instruction is always executed regardless of the signal state at enable input "EN". The value of the "Tag_Value1" operand and the value of the "Tag_Value2" operand are ORed. The result is mapped bit-by-bit and output in the ""F_DB_1".Tag_Result" operand.

13.13.3 XOR: EXCLUSIVE OR logic operation (STEP 7 Safety V21)

Description

You can use the "EXCLUSIVE OR logic operation" instruction to combine the value at input IN1 and the value at input IN2 bit-by-bit by EXCLUSIVE OR logic and query the result at output OUT.

When the instruction is executed, bit 0 of the value at input IN1 input and bit 0 of the value at input IN2 are logically combined by EXCLUSIVE OR. The result is stored in bit 0 of output OUT. The same logic operation is executed for all other bits of the specified value.

The result bit has signal state "1" when one of the two bits in the logic operation has signal state "1". If both of the bits of the logic operation have signal state "1" or "0", the corresponding result bit is reset.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN1	Input	WORD	First value of logic operation
IN2	Input	WORD	Second value of logic operation
OUT	Output	WORD	Result of the instruction

Example

The following example shows how the instruction works:

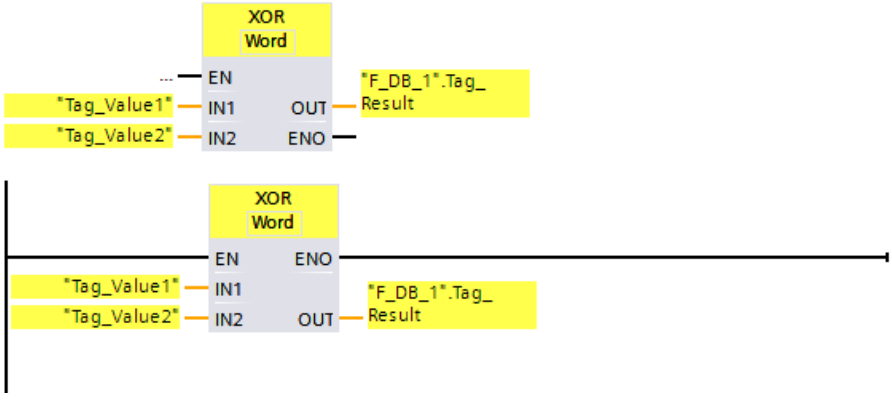

IN1	`"Tag_Value1" = 01010101 01010101`
IN2	`"Tag_Value2" = 00000000 00001111`
OUT	`"F_DB_1"."Tag_Result" = 01010101 01011010`

The instruction is always executed regardless of the signal state at enable input "EN". The value of the "Tag_Value1" operand and the value of the "Tag_Value2" operand are logically combined by EXCLUSIVE OR. The result is mapped bit-by-bit and output in the ""F_DB_1".Tag_Result" operand.

13.14 Shift and rotate

13.14.1 SHR: Shift right (STEP 7 Safety V21)

Description

Use the "Shift right" instruction to shift the content of the operand at input IN bit-by-bit to the right and query the result at output OUT. Use input N to specify the number of bit positions by which the specified value is to be moved.

If the value at input N is "0", the value at input IN is copied to the operand at output OUT.

If the value at input N is greater than the number of available bit positions, the operand value at input IN is shifted to the right by the available number of bit positions.

The bit locations that are freed up in the left area of the operand during the shift operation are filled with zeros.

The following figure shows how the content of an operand of data type WORD is moved by 6 bit positions to the right:

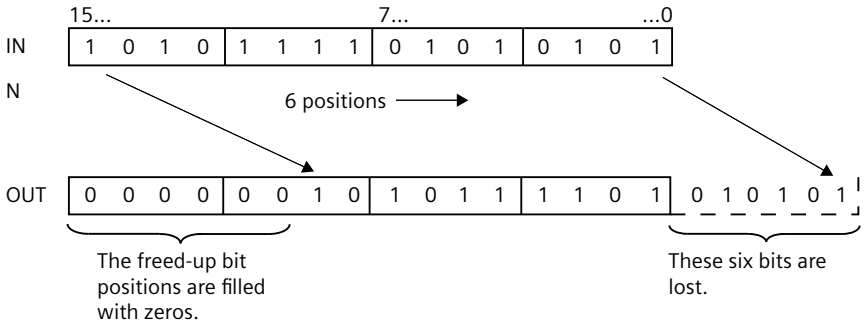

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

NOTE

S7-300/400:

Only the low-byte is evaluated from input N.

S7-1200/1500:

If the value at input N < 0, the output OUT is set to 0.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	WORD	Value that is shifted
N	Input	INT	Number of bit positions by which the value is shifted
OUT	Output	WORD	Result of the instruction

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	o	—	—	o	These versions have identical functions to version 1.0.
1.2	x	—	—	o	
1.3	x	o	—	o	
1.4	x	x	—	x	
2.0	x	x[1]	x	x[2]	

o This version is no longer supported.

[1] supported as of firmware V4.2

[2] supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:

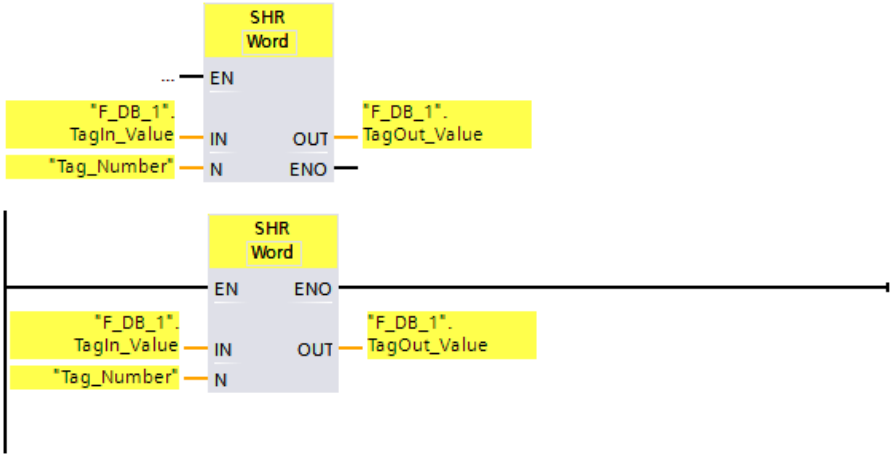

The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
IN	"F_DB_1".TagIn_Value	`0011 1111 1010 1111`
N	Tag_Number	3
OUT	"F_DB_1".TagOut_Value	`0000 0111 1111 0101`

The instruction is always executed regardless of the signal state at enable input "EN". The content of the operand ""F_DB_1".TagIn_Value" is moved three bit positions to the right. The result is output at output ""F_DB_1".TagOut_Value".

13.14.2 SHL: Shift left (STEP 7 Safety V21)

Description

Use the "Shift left" instruction to shift the content of the operand at input IN bit-by-bit to the left and query the result at output OUT. Use input N to specify the number of bit positions by which the specified value is to be moved.

If the value at input N is "0", the value at input IN is copied to the operand at output OUT.

If the value at input N is greater than the number of available bit positions, the operand value at input IN is shifted to the left by the available number of bit positions.

The bit positions that are freed up in the right area of the operand during the shift operation are filled with zeros.

The following figure shows how the content of an operand of data type WORD is moved by 6 bit positions to the left:

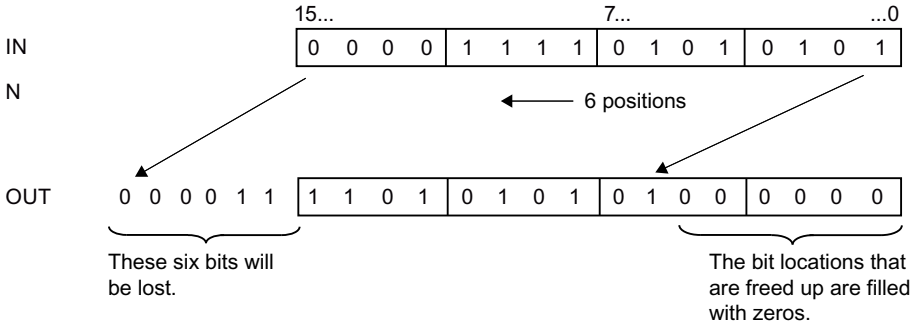

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

NOTE

S7-300/400:

Only the low-byte is evaluated from input N.

S7-1200/1500:

If the value at input N < 0, the output OUT is set to 0.

Parameters

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	Input	WORD	Value that is shifted
N	Input	INT	Number of bit positions by which the value is shifted
OUT	Output	WORD	Result of the instruction

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	o	—	—	o	These versions have identical functions to version 1.0.
1.2	x	—	—	o	
1.3	x	o	—	o	
1.4	x	x	—	x	
2.0	x	x[1]	x	x[2]	

o This version is no longer supported.

[1] supported as of firmware V4.2

[2] supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Example

The following example shows how the instruction works:

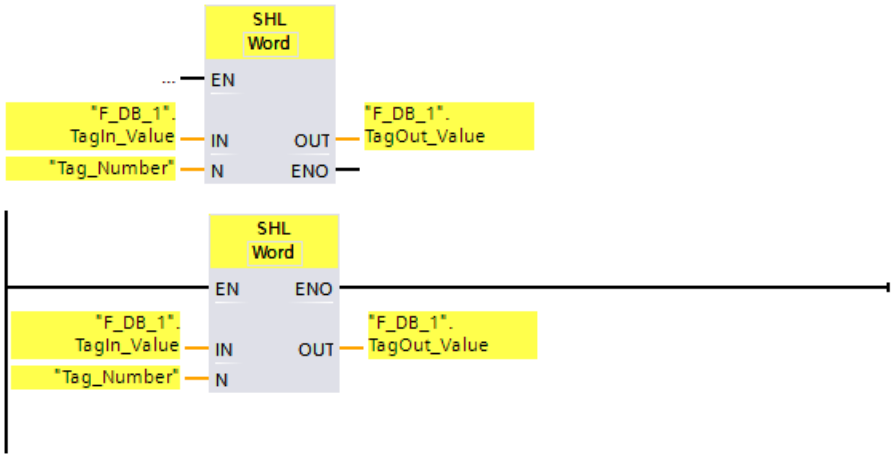

The following table shows how the instruction works using specific operand values:

Parameter	Operand	Value
IN	"F_DB_1".TagIn_Value	`0011 1111 1010 1111`
N	Tag_Number	4
OUT	"F_DB_1".TagOut_Value	`1111 1010 1111 0000`

The instruction is always executed regardless of the signal state at enable input "EN". The content of the operand ""F_DB_1".TagIn_Value" is moved four bit positions to the left. The result is output at output ""F_DB_1".TagOut_Value".

13.15 Operating

13.15.1 ACK_OP: Fail-safe acknowledgment (STEP 7 Safety V21)

Description (S7-300, S7-400)

This instruction enables fail-safe acknowledgment from an operator control and monitoring system. It allows, for example, reintegration of F-I/O to be controlled from the operator control and monitoring system. Acknowledgment takes place in two steps:

- InOut IN changes to a value of 6 for exactly one cycle
- InOut IN changes to a value of 9 within a minute for exactly one cycle

Once InOut IN has changed to a value of 6, the instruction evaluates whether this parameter has changed to a value of 9 after 1 second, at the earliest, or one minute, at the latest. Output OUT (output for acknowledgment) is then set to 1 for one cycle.

If an invalid value is input or if InOut IN has not changed to the value 9 within one minute or the change occurred before one second has elapsed, then InOut IN is reset to 0, and both steps listed above must be repeated.

During the time in which InOut IN must change from 6 to the value 9, output Q is set to 1. Otherwise, Q has a value of 0.

Every call of the "Fail-safe acknowledgment" instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., ACK_OP_DB_1) or a multi-instance (e.g., ACK_OP_Instance_1) for the "Fail-safe acknowledgment" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

NOTE

A separate data area must be used for each call of ACK_OP. Each call can be processed only once in an F-runtime group cycle.

If this is not observed, the behavior described under "Description" is no longer ensured.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

⚠ WARNING

The two acknowledgment steps must **not** be triggered by one single operation, for example, by programming them including the time conditions and using one function key to trigger them.

The two separate acknowledgment steps also prevent erroneous triggering of an acknowledgment, for example, by your non-fail-safe operator control and monitoring system. *(S013)*

WARNING

If you have operator control and monitoring systems and F-CPUs that are interconnected and use the ACK_OP instruction for fail-safe acknowledgment, you need to ensure that the intended F-CPU will be addressed **before** you perform the two acknowledgment steps.

- Store a network-wide* unique name for the F-CPU in a DB of your standard user program in each F-CPU.
- In your operator control and monitoring system, set up a text box from which you can read out the F-CPU name from the DB online before executing the two acknowledgment steps.
- Optional:

  In your operator control and monitoring system, set up a text box to permanently store the F-CPU name. Then, you can determine whether the intended F-CPU is being addressed by simply comparing the F-CPU name read out online with the permanently stored designation. *(S014)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet.

NOTE

You can read out output Q by means of operator control and monitoring systems or, if applicable, evaluate it in your standard user program.

You can supply InOut IN with a separate memory word or DBW of a DB of the standard user program supply for each call of the ACK_OP instruction.

NOTE

The configuration of your operator control and monitoring system does not have any effect on the Collective F-Signature.

Description (S7-1200, S7-1500)

This instruction enables fail-safe acknowledgment from an operator control and monitoring system. It allows, for example, reintegration of F-I/O to be controlled from the operator control and monitoring system. Acknowledgment takes place in two steps:

- InOut IN changes to a value of 6 for exactly one cycle
- InOut IN changes to the value at the ACK_ID input within a minute for exactly one cycle

Once InOut IN has changed to a value of 6, the instruction evaluates whether this parameter has changed to a value at the ACK_ID input after 1 second, at the earliest, or one minute, at the latest. Output OUT (output for acknowledgment) is then set to 1 for one cycle.

If an invalid value is input or if InOut IN has not changed to the value at the ACK_ID input within one minute or the change occurred before one second has elapsed, then iInOut IN is reset to 0, and both steps listed above must be repeated.

During the time in which InOut IN must change from 6 to the value at the ACK_ID input, output Q is set to 1. Otherwise, Q has a value of 0.

Every call of the "Fail-safe acknowledgment" instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., ACK_OP_DB_1) or a multi-instance (e.g., ACK_OP_Instance_1) for the "Fail-safe acknowledgment" instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

NOTE

A separate data area must be used for each call of ACK_OP. Each call can be processed only once in an F-runtime group cycle.

If this is not observed, the behavior described under "Description" is no longer ensured.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

WARNING

The two acknowledgment steps must **not** be triggered by one single operation, for example, by programming them including the time conditions and using one function key to trigger them.

The two separate acknowledgment steps also prevent erroneous triggering of an acknowledgment, for example, by your non-fail-safe operator control and monitoring system. *(S013)*

WARNING

If you have operator control and monitoring systems and F-CPUs that are interconnected and use the ACK_OP instruction for fail-safe acknowledgment, you need to ensure that the intended F-CPU will be addressed **before** you perform the two acknowledgment steps.

Alternative 1:

- The value for each identifier of the acknowledgment (ACK_ID input; data type: INT) can be freely selected in the range from 9 to 30000, but must be unique network-wide* for all instances of the ACK_OP instruction.
  You must supply the ACK_ID input with constant values when calling the instruction. Direct read or write access to the ACK_ID tag in the associated instance DB is not permitted!

Alternative 2:

- Store a network-wide* unique name for the F-CPU in a DB of your standard user program in each F-CPU.
- In your operator control and monitoring system, set up a text box from which you can read out the F-CPU name from the DB online before executing the two acknowledgment steps.
- Optional:
  In your operator control and monitoring system, set up a text box to permanently store the F-CPU name. Then, you can determine whether the intended F-CPU is being addressed by simply comparing the F-CPU name read out online with the permanently stored designation. *(S047)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet.

NOTE

You can read out output Q by means of operator control and monitoring systems or, if applicable, evaluate it in your standard user program.

You must supply InOut IN with a separate memory word or DBW of a DB of the standard user program for each call of the ACK_OP instruction.

NOTE

The supply of the IN iInOut of the ACK_OP instruction as well as the configuration of your operator control and monitoring system do not have any effect on the Collective F-Signature, the Collective F-SW-Signature or the signature of the block that calls the ACK_OP instruction.

Changes to the supply of the IN InOut or to the configuration of your operator control and monitoring system therefore do not result in a changed Collective F-Signature/Collective F-SW-Signature/signature of the calling block.

Parameters (S7-300, S7-400)

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
IN	InOut	INT	Input variable from operator control and monitoring system
OUT	Output	BOOL	Output for acknowledgment
Q	Output	BOOL	Time status

Parameters (S7-1200, S7-1500)

The following table shows the parameters of the instruction:

Parameter	Declaration	Data type	Description
ACK_ID	Input	INT	Identifier of the acknowledgment (9 to 30000)
IN	InOut	INT	Input variable from operator control and monitoring system
OUT	Output	BOOL	Output for acknowledgment
Q	Output	BOOL	Time status

Instruction versions

A number of versions are available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	x	—	—	o	These versions have identical functions to version 1.0 for S7-300/400 F-CPUs. The input ACK_ID must also be taken into consideration for S7-1200/1500 F-CPUs.
1.2	x	o	—	o	
1.3	x	x	x	x	

o This version is no longer supported.

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Timing imprecision resulting from the update time and the tolerance of the time base used in the instruction

Refer to section "Temporal blurring for instructions with time processing (Page 464)" for more on this.

Example

An example how the instruction is used is available under Implementing User Acknowledgment in the Safety Program of the F-CPU of a DP Master or IO controller (Page 196).

See also

Implementing user acknowledgment in the safety program of the F-CPU of a I-slave or I-device (Page 201)

13.16 Additional instructions

13.16.1 LAD

13.16.1.1 ---| |--- OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

You can use the "Get status bit OV" instruction to detect whether a number range overflow occurred in the last arithmetic instruction processed.

The "Get status bit OV" instruction functions like a normally open contact. If the query is fulfilled, the instruction has signal state "1". If the query is not fulfilled, the instruction has signal state "0".

The "Get status bit OV" evaluation must be inserted in the network that follows the instruction that influences the OV. This network must not contain any jump labels.

NOTE

The execution time of the OV-affecting instruction is extended when the "Get status bit OV " instruction is used (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).

Example

The following example shows how the instruction works:

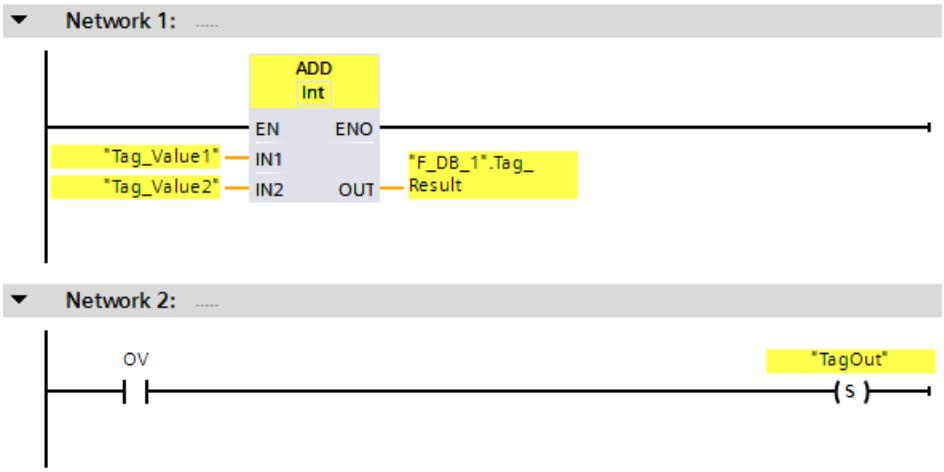

The "Add" instruction is always executed (regardless of the signal state at enable input EN).

The value of the "Tag_Value1" operand is added to value of the Tag_Value2 operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

If an overflow occurs during execution of the "Add" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

13.16.1.2 ---| / |--- OV: Get negated status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

You can use the "Get negated status bit OV" instruction to detect whether a number range overflow occurred in the last arithmetic instruction processed. This instruction is only available in LAD.

The "Get negated status bit OV" instruction functions like a normally closed contact. If the query is satisfied, the instruction has signal state "0". If the query is not satisfied, the instruction has signal state "1".

The "Get negated status bit OV" evaluation must be inserted in the network following the instruction that influences the OV. This network must not contain any jump labels.

NOTE

The execution time of the OV-affecting instruction is extended when the "Get negated status bit OV " instruction is used (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).

Example

The following example shows how the instruction works:

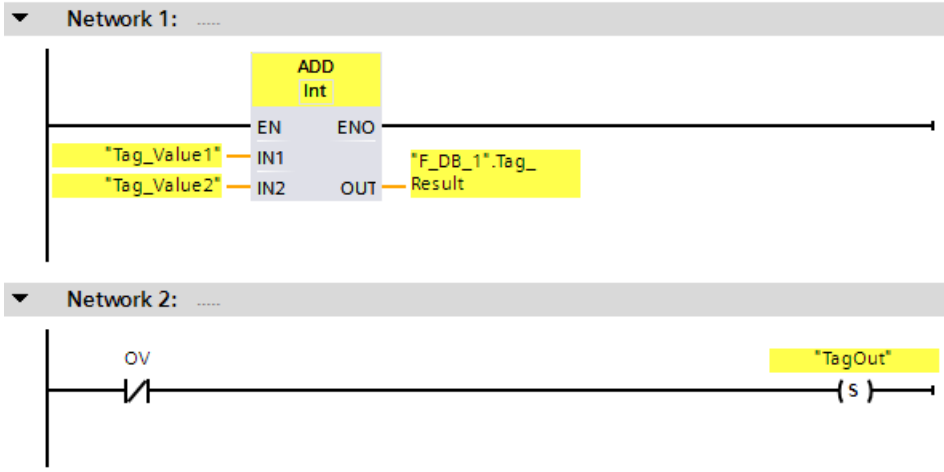

The "Add" instruction is always executed (regardless of the signal state at enable input EN).

The value of the "Tag_Value1" operand is added to value of the Tag_Value2 operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

If an overflow does *not* occur during execution of the "Add" instruction, the status bit OV is reset to "0". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

13.16.2 FBD

13.16.2.1 OV: Get status bit OV (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Description

You can use the "Get status bit OV" instruction to detect whether a number range overflow occurred in the last arithmetic instruction processed.

The "Get status bit OV" evaluation must be inserted in the network that follows the instruction that influences the OV. This network must not contain any jump labels.

If the query is fulfilled, the instruction has signal state "1". If the query is not fulfilled, the instruction has signal state "0".

You can program a query of status bit OV for "0" with the "Invert RLO" instruction.

NOTE

The execution time of the OV-affecting instruction is extended when the "Get status bit OV " instruction is used (see also Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831)).

Example

The following example shows how the instruction works:

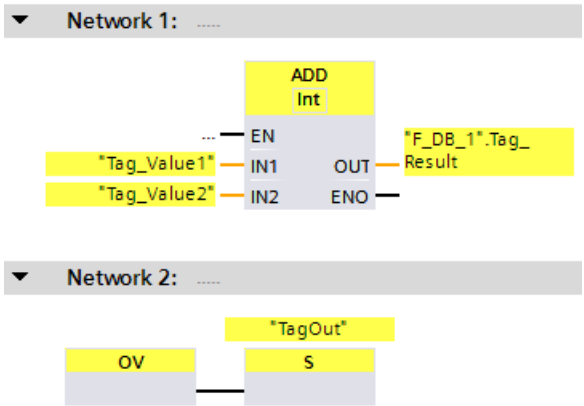

The value of the "Tag_Value1" operand is added to value of the Tag_Value2 operand. The result of the addition is stored in the ""F_DB_1".Tag_Result" operand.

If an overflow occurs during execution of the "Add" instruction, the status bit OV is set to "1". In network 2, following the query of the status bit OV, the "Set output" (S) instruction is executed and the "TagOut" operand is set.

13.17 Communication

13.17.1 PROFIBUS/PROFINET

13.17.1.1 SENDDP and RCVDP: Send and receive data via PROFIBUS DP/PROFINET IO (STEP 7 Safety V21)

Introduction

You use the SENDDP and RCVDP instructions for fail-safe sending and receiving of data using:

- Safety-related master-master communication
- Safety-related master-master communication for S7 Distributed Safety
- Safety-related master-I-slave communication
- Safety-related I-slave-I-slave communication
- Safety-related IO controller-IO controller communication
- Safety-related IO controller-IO controller communication for S7 Distributed Safety
- Safety-related IO controller-I-device communication
- Safety-related IO controller-I-slave communication

Description

The SENDDP instruction sends 16 data elements of data type BOOL and 2 data elements of data type INT or one data element of the data type DINT (S7-1200, S7-1500) in a fail-safe manner to another F-CPU via PROFIBUS DP/PROFINET IO. The data can be received there by the related RCVDP instruction.

Every call of this instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g. RCVDP_DB_1) for these instructions. Once it is created, the new data block can be found in the "STEP 7 Safety" folder in the project tree under "Program blocks > System blocks". For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

With the SENDDP instruction, the data to be sent (for example, outputs of other F-blocks/instructions) are available at input SD_BO_xx or SD_I_xx or SD_DI_00 as alternative.

With the RCVDP instruction, the data received are available at outputs RD_BO_xx and RD_I_xx or RD_DI_00 as alternative for additional processing by other F-blocks/instructions.

(S7-1200, S7-1500) At the DINTMODE input of the SENDDP instruction you specify if the data at the inputs SD_I_00 and SD_I_01 or the data at the input SD_DI_00 is sent.

The operating mode of the F-CPU with the SENDDP instruction is provided at output SENDMODE. If the F-CPU with the SENDDP instruction is in disabled safety mode, output SENDMODE = 1.

Communication between F-CPUs takes place in the background by means of a special safety protocol. You must define the communication relationship between a SENDDP instruction in one F-CPU and a RCVDP instruction in the other F-CPU by specifying an F-communication ID at the DP_DP_ID inputs of the SENDDP and RCVDP instructions. Associated SENDDP and RCVDP instructions are assigned the same value for DP_DP_ID.

WARNING

The value for the respective F-communication ID (input DP_DP_ID; data type: INT) can be freely selected**; however, it must be unique network-wide* and CPU-wide**** at all times for all safety-related communication connections. You must check the uniqueness in the safety summary during acceptance of the safety program.

You must supply constant values*** to the DP_DP_ID and LADDR inputs when calling the instruction. Direct write access to DP_DP_ID and LADDR in the associated instance DB is not permitted in the safety program! *(S016)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, no connection is established at the DP_DP_ID input for a F-communication ID "0".

*** S7-1200/1500: As of version V3.0 of the SENDDP and RCVDP instructions, the DP_DP_ID input can also be supplied with variable values from a global F-DB. In this case also, you have to check during acceptance of the safety program that uniqueness is ensured at all times. You need to check the algorithm for forming the variable value accordingly. If you cannot ensure

a unique F-communication ID during startup of the safety program, because it is only specified after startup of the safety program, you must make sure that the value at the DP_DP_ID input is "0" during this phase.

**** With a redundant S7-1500HF system, both F-CPUs of the redundant S7-1500HF system are to be regarded as one single F-CPU with regard to the DP_DP_ID.

NOTE

Within a safety program, you must assign a different start address (S7-300, S7-400) or HW identifier (S7-1200, S7-1500) for every call of the SENDDP and RCVDP instructions at input LADDR.

A separate instance DB must be used for each call of the SENDDP and RCVDP instructions. You must not declare and call these instructions as multi-instances.

(S7-300, S7-400) The inputs of the RCVDP and RCVS7 instructions may not have preceding logic operations (for example "AND logic operation").

The inputs of the RCVDP instruction cannot be initialized using fully qualified DB accesses with outputs of a RCVDP or RCVS7 instruction called in an upstream network.

(S7-1200, S7-1500) The RD_D_00 output must not be evaluated for DINTMODE = 0; the RD_I_xx outputs of the RCVDP instruction must not be evaluated for DINTMODE = 1.

(S7-1200, S7-1500) The outputs of the SENDDP and RCVDP instructions must not be supplied with tags from the standard user program. Exception: RET_DPRD, RET_DPWR and DIAG outputs.

Fully qualified access to DP_DP_ID and LADDR is not possible in the safety program.

You cannot use an actual parameter for an output of an RCVDP instruction, if it is already being used for an input of the same or another RCVDP or RCVS7 instruction.

The F-CPU can go to STOP if this is not observed. The cause of the diagnostics event is entered in the diagnostics buffer of the F-CPU.

NOTE

You are not permitted to insert any SENDDP/RCVDP instructions between a JMP or JMPN instruction and the associated jump destination (jump label).

You cannot insert a RET instruction prior to a SENDDP instruction.

SENDDP parameter

The following table shows the parameters of the SENDDP instruction:

Parameter	Declaration	Data type	Description
SD_BO_00	Input	BOOL	Send data BOOL 00
...			...
SD_BO_15	Input	BOOL	Send data BOOL 15
SD_I_00	Input	INT	Send data INT 00
SD_I_01	Input	INT	Send data INT 01

Parameter	Declaration	Data type	Description
SD_DI_00	Input	DINT	(S7-1200, S7-1500) (hidden) Send data DINT 00
DINTMODE	Input	DINT	(S7-1200, S7-1500) (hidden) 0=SD_I_00 u. SD_I_01 are sent 1=SD_DI_00 is sent
DP_DP_ID	Input	INT	F-communication ID between SENDDP and RCVDP
TIMEOUT	Input	TIME	Monitoring time in ms for safety-related communication (see also Monitoring and response times (Page 643))
LADDR	Input	INT (S7-300, S7-400) HW_SUBMODULE (S7-1200, S7-1500)	The start address (S7-300, S7-400) or HW identifier (S7-1200, S7-1500) of the address area/transfer area: • Of DP/DP coupler for safety-related master-master communication • For safety-related master-I-slave communication • For safety-related I-slave-I-slave communication • Of PN/PN coupler for safety-related IO controller-IO controller communication • For safety-related IO controller-I-device communication • For safety-related IO controller-I-slave communication
ERROR	Output	BOOL	1=Communication error
SUBS_ON	Output	BOOL	1=RCVDP outputs fail-safe values
RET_DPRD	Output	WORD	Non-fail-safe error code RET_VAL of the DPRD_DAT instruction (for a description of error codes, refer to the help for the DPRD_DAT instruction ("Extended instructions > Distributed I/O > Other")).
RET_DPWR	Output	WORD	Non-fail-safe error code RET_VAL of the DPWR_DAT instruction (for a description of error codes, refer to the help for the DPWR_DAT instruction ("Extended instructions > Distributed I/O > Other")).
DIAG	Output	BYTE	Non-fail safe service information

RCVDP parameter:

The following table shows the parameters of the RCVDP instruction:

Parameter	Declaration	Data type	Description
ACK_REI	Input	BOOL	1=Acknowledgment for reintegration of send data following communication error
SUBBO_00	Input	BOOL	Fail-safe value for receive data BOOL 00
...			...
SUBBO_15	Input	BOOL	Fail-safe value for receive data BOOL 15
SUBI_00	Input	INT	Fail-safe value for receive data INT 00
SUBI_01	Input	INT	Fail-safe value for receive data INT 01
SUBDI_00	Input	DINT	(S7-1200, S7-1500) (hidden) Fail-safe value for receive data DINT 00
DP_DP_ID	Input	INT	F-communication ID between SENDDP and RCVDP

Parameter	Declaration	Data type	Description
TIMEOUT	Input	TIME	Monitoring time in ms for safety-related communication (see also Monitoring and response times (Page 643))
LADDR	Input	INT (S7-300, S7-400) HW_SUBMODULE (S7-1200, S7-1500)	The start address (S7-300, S7-400) or HW identifier (S7-1200, S7-1500) of the address area/transfer area: • Of DP/DP coupler for safety-related master-master communication • For safety-related master-I-slave communication • For safety-related I-slave-I-slave communication • Of PN/PN coupler for safety-related IO controller-IO controller communication • For safety-related IO controller-I-device communication • For safety-related IO controller-I-slave communication
ERROR	Output	BOOL	1=Communication error
SUBS_ON	Output	BOOL	1=Fail-safe values are output
ACK_REQ	Output	BOOL	1=Acknowledgment for reintegration of send data required
SENDMODE	Output	BOOL	1=F-CPU with SENDDP instruction in disabled safety mode
RD_BO_00	Output	BOOL	Receive data BOOL 00
...			...
RD_BO_15	Output	BOOL	Receive data BOOL 15
RD_I_00	Output	INT	Receive data INT 00
RD_I_01	Output	INT	Receive data INT 01
RD_DI_00	Output	DINT	(S7-1200, S7-1500) (hidden) Receive data DINT 00
RET_DPRD	Output	WORD	Non-fail-safe error code RET_VAL of the DPRD_DAT instruction (for a description of error codes, refer to the help for the DPRD_DAT instruction ("Extended instructions > Distributed I/O > Other")).
RET_DPWR	Output	WORD	Non-fail-safe error code RET_VAL of the DPWR_DAT instruction (for a description of error codes, refer to the help for the DPWR_DAT instruction ("Extended instructions > Distributed I/O > Other")).
DIAG	Output	BYTE	Non-fail safe service information

Instruction versions

A number of versions are available for these instructions:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	x	—	—	—	
1.1	o	—	—	o	These versions have identical functions to version 1.0.
1.2	x	—	—	o	
1.4	x	—	—	x	

o This version is no longer supported.

[1] supported as of firmware V4.2

[2] supported as of firmware V2.0

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.3	x	—	—	o	S7-300/400: These versions have identical functions to version 1.0. S7-1200/1500: Instead of 2 data of data type INT, one data of data type DINT can be sent/received as alternative. Otherwise functionally identical to version 1.0.
1.5	x	x	—	x	
2.0	x	x[1]	—	x[2]	
3.0	x	x[1]	—	x[2]	S7-300/400: This version has identical functions to version 2.0. S7-1200/1500: • The DP_DP_ID input can also be supplied with tags of a global F-DB. In case of DP_DP_ID = 0 no connection is established. • Supports the data status byte of the PN/PN coupler as of firmware V4.0 • Supports the simulation of the communication in S7-PLCISM operation • Use for communication with S7-1200/1500 CPUs is not recommended Otherwise functionally identical to version 2.0
3.1	x	x[1]	x	x[2]	S7-300/400: This version has identical functions to version 3.0. S7-1200/1500: • This version has identical functions to version 3.0. If the communication partner also uses a version > V3.0, a communication protocol with improved safety features becomes active. Upgrading to version V3.1 is recommended before new acceptance of an existing system. • Incompatible with S7-300/400 F-CPUs.

o This version is no longer supported.

1 supported as of firmware V4.2

2 supported as of firmware V2.0

When a new F-CPU is created with *STEP 7 Safety*, the latest available version for the F-CPU created is automatically preset.

Check if all communication partners of this F-CPU with SENDDP/RCVDP are S7-1200/1500 F-CPUs. In this case, use version 3.1. Otherwise, only version 3.0 or lower is possible.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Placement

You must insert the RCVDP instruction *either* at the start of the main safety block *or* (for S7-1200/1500 F-CPUs) in an F-FB/F-FC called directly at the start of the main safety block. No other instructions can be located before in the main safety block and no other instructions can be located before or afterwards in the F-FB/F-FC.

You need to insert the SENDDP instruction *either* at the end of the main safety block *or* (with S7-1200/1500 F-CPUs) in an F-FB/F-FC called directly at the end of the main safety block. No other instructions can be located afterwards in the main safety block and no other instructions can be located before or afterwards in the F-FB/F-FC.

Startup behavior

After the sending and receiving F-systems are started up, communication must be established between the connection partners for the fist time (SENDDP and RCVDP instructions). During this time, the receiver (RCVDP instruction) outputs the fail-safe values present at its inputs SUBBO_xx and SUBI_xx or alternatively SUBDI_00.

The SENDDP and RCVDP instructions signal this with 1 at output SUBS_ON. The SENDMODE output has default setting "0" and is not updated as long as output SUBS_ON = 1.

As of version V3.0 of the SENDDP and RCVDP instructions, communication is only established when DP_DP_ID <> 0.

Behavior in the event of communication errors

If a communication error occurs, for example, due to a signature error (CRC) or when monitoring time TIMEOUT expires or for S7-1200/1500 F-CPUs as of V3.0 due to a change of DP_DP_ID to 0 after establishment of communication, the outputs ERROR and SUBS_ON = 1 are set. The receiver (RCVDP instruction) then outputs the fail-safe values assigned at its inputs SUBBO_xx and SUBI_xx or alternatively SUBDI_00 inputs. Output SENDMODE is not updated while output SUBS_ON = 1.

The send data of the SENDDP instruction present at inputs SD_BO_xx and SD_I_xx, SD_DI_00 as alternative, are only output again when communication errors are no longer detected (ACK_REQ = 1) and you acknowledge (Page 196) the RCVDP instruction with a positive edge at input ACK_REI.

Communication errors also occur if the values of the DP_DP_IDs between associated SENDDP and RCVDP are temporarily different on a change of the values of variable DP_DP_IDs after communication establishment.

⚠ WARNING

A user acknowledgment (Page 196) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted.* *(S011)*

* If variable F-communication IDs are used, the communication partner of the SENDDP or RCVDP instructions can be changed during running operation. The resultant communication errors may only be acknowledged with an automatically generated signal at the ACK_REI input under the following conditions:

- The safety program reliably forms a signal "Communication partner change is in progress" with the RCVDP instruction on the basis of the process state.
- The signal "Communication partner change is in progress" is only formed if there is no communication error.
- While the signal "Communication partner change is in progress" is active, no evaluation of the received process values is carried out at the RCVDP instruction.
- Automatic acknowledgment takes place only if the "Communication partner change is in progress" signal is present.
- From a safety standpoint automatic reintegration is permitted for the relevant process.

Note that output ERROR (1=communication error) for a communication error will not be set unless communication between the connection partners (SENDDP and RCVDP instructions) has been previously established. If communication cannot be established after startup of the sending and receiving F-Systems, check the configuration of the safety-related CPU-CPU communication, the parameter assignment of the SENDDP and the RCVDP instructions, and the bus connection. You also obtain information on possible error causes by evaluating outputs DIAG, RET_DPRD and RETDP_WR.

In general, always evaluate RET_DPRD and RETDP_WR, since it is possible that only one of the two outputs will contain error information.

Timing diagrams SENDDP/RCVDP

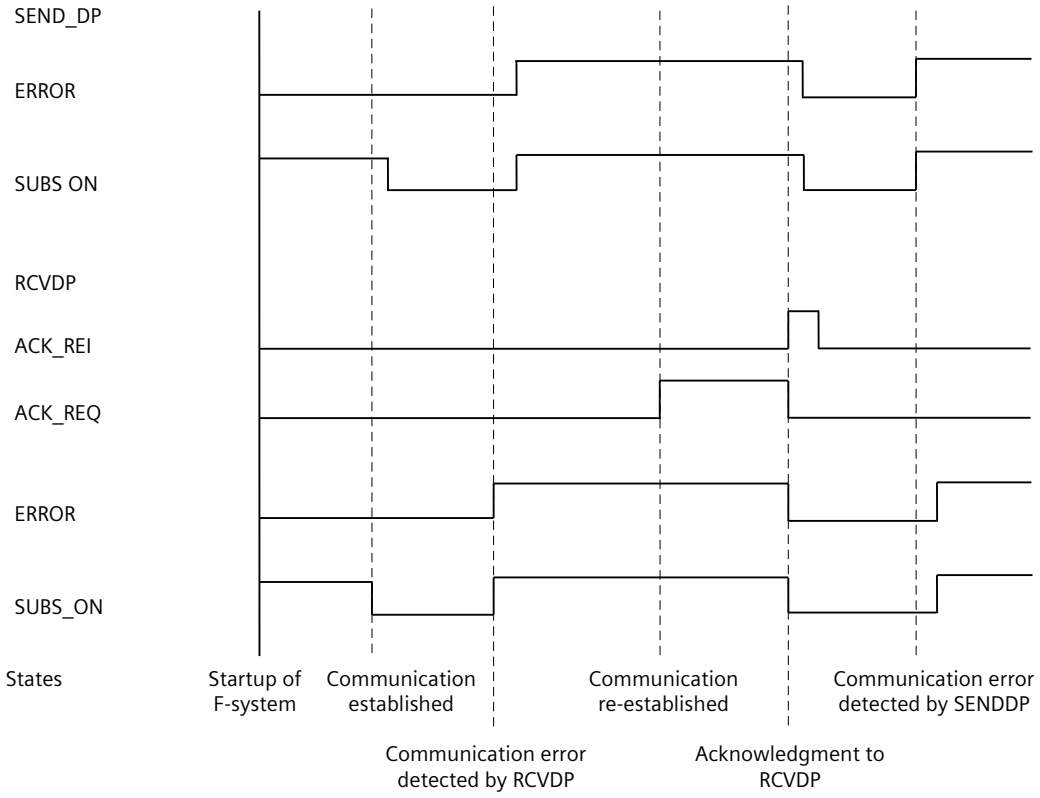

Output DIAG

In addition, non-fail-safe information about the communication states that occurred is provided at output DIAG of the SENDDP and RCVDP instructions for service purposes.

You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits 0-6 remain saved until you acknowledge the RCVDP instruction at the ACK_REI input.

Structure of DIAG of the SENDDP/RCVDP instruction

Bit no.	Assignment	Possible error causes	Remedies
Bit 0	Reserved	—	—
Bit 1	Reserved	—	—
Bit 2	Reserved	—	—
Bit 3	Invalid DP_DP_ID	The DP_DP_ID is 0.	Check the DP_DP_ID of SENDDP or RCVDP.
Bit 4	Timeout of SENDDP/RCVDP detected	The standard user program overwrites transfer areas of SENDDP and RCVDP.	Check the standard user program for write access to the transfer areas of SENDDP and RCVDP. Also take indirect accesses into account.
		DP_DP_ID of SENDDP and RCVDP different.	Check the DP_DP_ID of SENDDP and RCVDP.
		For variable F-communication IDs the values are changed at the DP_DP_ID input.	When the DP_DP_ID of SENDDP and RCVD is consistent again, perform an acknowledgment at the ACK_REI input.
		Interference in bus connection to partner F-CPU.	Check the bus connection and ensure that there are no external sources of interference.
		The values at the TIMEOUT input are different for SENDDP and RCVDP.	Configure identical values at the TIMEOUT input of SENDDP and RCVDP.
		Monitoring time setting for F-CPU and partner F-CPU is too low.	Check the parameterized monitoring time TIMEOUT at SENDDP and RCVDP of both CPUs. Set a higher value if necessary. Recompile the safety program.
		Configuration of the DP/DP coupler or PN/PN coupler is invalid.	Check the configuration of the DP/DP coupler or of the PN/PN coupler.
		Data validity indicator "DIA" of the DP/DP coupler is "ON".	Set the data validity indicator "DIA" at the DIL switch of the DP/DP coupler to "OFF".
		Parameter "Data validity indicator DIA" of the PN/PN coupler is activated.	Deactivate the "Data validity display DIA" parameter in the properties for the PN/PN coupler.
		Parameter "Activate data status" of the PN/PN coupler (as of V4.0) is activated.	Deactivate the "Activate data status" parameter in the properties for the PN/PN coupler (as of V4.0) or S7-1200/1500: Use Version V3.0 of the SENDDP and RCVDP instructions.
		Internal fault of DP/DP coupler or PN/PN coupler	Replace the DP/DP coupler or PN/PN coupler
		CP in STOP mode, or internal fault in CP	Switch the CP to RUN. Check the diagnostics buffer of the CP. If necessary, replace the CP.
		F-CPU/partner F-CPU in STOP mode, or internal fault in F-CPU/partner F-CPU	Switch the F-CPUs to RUN. Check the diagnostics buffer of the F-CPUs. If necessary, replace the F-CPUs.

Bit no.	Assignment	Possible error causes	Remedies
Bit 5	Sequence number error of SENDDP/RCVDP detected	See description for bit 4	See description for bit 4
Bit 6	CRC-error of SENDDP/RCVDP detected	See description for bit 4	See description for bit 4
Bit 7	Communication protocol with improved safety features is not active.	Communication partner uses an instruction version < V3.1	Upgrade the communication partner to an instruction version > V3.0 at the next opportunity.

See also

Communication with S7 Distributed Safety via PN/PN coupler (IO controller-IO controller communication) (Page 251)

Communication with S7 Distributed Safety via DP/DP coupler (master-master communication) (Page 252)

Communication via SENDDP/RCVDP or SENDS7/RCVS7(S7-300, S7-400) instructions: (Page 208)

Safety-related IO controller-IO controller communication (Page 211)

Safety-related master-master communication (Page 218)

Safety-related IO controller-I-device communication (Page 226)

Safety-related master-I-slave communication (Page 232)

Safety-related IO controller-I-slave communication (Page 244)

13.17.2 S7 communication

13.17.2.1 SENDS7 and RCVS7: Communication via S7 connections (STEP 7 Safety Advanced V21) (S7-300, S7-400)

Introduction

You use the SENDS7 and RCVS7 instructions for fail-safe sending and receiving of data using S7 connections.

NOTE

In *STEP 7 Safety Advanced*, S7 connections are generally permitted over Industrial Ethernet only.

Safety-related communication via S7 connections is possible from and to F-CPUs with PROFINET interface or S7-400 F-CPUs with PROFINET-capable CPs. See also Safety-related communication via S7 connections (Page 244).

Description

The SENDS7 instruction sends the send data contained in an F-communication DB to the F-communication DB of the associated RCVS7 instruction of another F-CPU in a fail-safe manner using an S7 connection.

Every call of this instruction must be assigned a data area in which the instruction data is stored. The "Call options" dialog is automatically opened when the instruction is inserted in the program for this reason. There you can create a data block (single instance) (e.g., SENDS7_DB_1) or a multi-instance (e.g., SENDS7_Instance_1) for this instruction. Once it is created, you can find the new data block in the project tree in the "STEP 7 Safety" folder under "Program blocks > System blocks" or the multi-instance as a local tag in the "Static" section of the block interface. For more information, refer to the help on *STEP 7*.

Enable input "EN" and enable output "ENO" cannot be connected. The instruction is therefore always executed (regardless of the signal state at enable input "EN").

Information on the F-communication DB is contained in "Programming safety-related communication via S7 connections (Page 246)".

An F-communication DB is an F-DB for safety-related CPU-CPU communication with special properties. You must specify the numbers of the F-communication DBs at inputs SEND_DB and RCV_DB of instructions SENDS7 and RCVS7.

The operating mode of the F-CPU with the SENDS7 instruction is provided at output SENDMODE of the RCVS7 instruction. If the F-CPU with the SENDS7 instruction is in disabled safety mode, then output SENDMODE = 1.

To reduce the bus load, you can temporarily shut down communication between the F-CPUs at input EN_SEND of the SENDS7 instruction. To do so, supply input EN_SEND with "0" (default = "1"). In this case, send data is no longer sent to the F-communication DB of the associated RCVS7 instruction, and the receiver provides fail-safe values for this period of time (initial values in its F-communication DB). If communication was already established between the partners, a communication error is detected.

You must specify the local ID - from the perspective of the F-CPU - of the S7 connection (from the connection table in the network view) at input ID of the SENDS7 instruction (see also Configuring (Page 34)).

Communication between F-CPUs takes place in the background by means of a special safety protocol. You must define a communication relationship between an SENDS7 instruction in one F-CPU and a communication relationship between an RCVS7 instruction and the other F-CPU by assigning an odd number at input R_ID (of the SENDS7 and RCVS7 instructions). Associated SENDS7 and RCVS7 instructions receive the same value for R_ID.

⚠ WARNING

The value of the respective F-communication ID (input R_ID; data type: DWORD) can be freely selected; however, it must be odd and unique for all safety-related communication connections network-wide* and CPU-wide. The value R_ID + 1 is internally assigned and must not be used.

You must supply inputs ID and R_ID with constant values when calling the instruction. Direct read or write access to ID and R_ID in the associated instance DB is not permitted in the safety program. *(S020)*

* A network consists of one or more subnets. "Network-wide" means beyond the boundaries of the subnet. In PROFIBUS, a network includes all the nodes accessible via PROFIBUS DP. In

PROFINET IO, a network includes all the nodes accessible via RT_Class_1/2/3 (Ethernet/WLAN/Bluetooth, Layer 2) and, if applicable, RT_Class_UDP (IP, Layer 3).

NOTE

A separate instance DB must be used for each call of the SENDS7 and RCVS7 instructions within a safety program. You must not declare and call these instructions as multi-instances.

The inputs of the RCVS7 instruction cannot be initialized with outputs (using fully qualified DB accesses) of a RCVS7 or RCVDP instruction called in an upstream network.

You cannot use an actual parameter for an output of an RCVS7 instruction, if it is already being used for an input of the same or another RCVS7 or RCVDP instruction.

The F-CPU can go to STOP if this is not observed. A diagnostics event is entered in the diagnostics buffer of the F-CPU.

NOTE

You must not program any SENDS7/RCVS7 instruction between a JMP or JMPN instruction and the associated destination network of the JMP or JMPN instruction.

You cannot program a RET instruction prior to a SENDS7 instruction.

SENDS7 parameter

The following table shows the parameters of the SENDS7 instruction:

Parameter	Declaration	Data type	Description
SEND_DB	Input	BLOCK_DB	Number of F-communication DB
TIMEOUT	Input	TIME	Monitoring time in ms for safety-related communication (see also Monitoring and response times (Page 643))
EN_SEND	Input	BOOL	1= Send enable
ID	Input	WORD	Local ID of the S7 connection
R_ID	Input	DWORD	Network-wide unique value for a F-communication ID between a SENDS7 instruction and a RCVS7 instruction
ERROR	Output	BOOL	1=Communication error
SUBS_ON	Output	BOOL	1=Receiving block outputs fail-safe values
STAT_RCV	Output	WORD	Non-fail-safe status parameter STATUS of the URCV instruction (You can find a description of error codes in the help for the URCV instruction ("Communication > S7 Communication"))
STAT_SND	Output	WORD	Non-fail-safe status parameter STATUS of the USEND instruction (You can find a description of error codes in the help for the USEND instruction ("Communication > S7 Communication"))
DIAG	Output	BYTE	Non-fail-safe service information

RCVS7 parameter

The following table shows the parameters of the RCVS7 instruction.

Parameter	Declaration	Data type	Description
ACK_REI	Input	BOOL	Acknowledgment for reintegration of send data after communication error
RCV_DB	Input	BLOCK_DB	Number of F-communication DB
TIMEOUT	Input	TIME	Monitoring time in ms for safety-related communication (see also Monitoring and response times (Page 643))
ID	Input	WORD	Local ID of the S7 connection
R_ID	Input	DWORD	Network-wide unique value for a F-communication ID between a SENDS7 instruction and a RCVS7 instruction
ERROR	Output	BOOL	1=Communication error
SUBS_ON	Output	BOOL	1=Fail-safe values are output
ACK_REQ	Output	BOOL	1=Acknowledgment for reintegration of send data required
SENDMODE	Output	BOOL	1=F-CPU with the SENDS7 instruction in disabled safety mode
STAT_RCV	Output	WORD	Non-fail-safe status parameter STATUS of the URCV instruction (You can find a description of error codes in the help for the URCV instruction ("Communication > S7 Communication"))
STAT_SND	Output	WORD	Non-fail-safe status parameter STATUS of the USEND instruction (You can find a description of error codes in the help for the USEND instruction ("Communication > S7 Communication"))
DIAG	Output	BYTE	Non-fail-safe service information

Instruction versions

A number of versions are available for these instructions:

Version	S7-300/400	S7-1500	Function
1.0	x	—	
1.1	x	—	This version has identical functions to version 1.0. It also supports later versions of internally called instructions.
1.2	x	—	This version has identical functions to version 1.0/1.1. It also supports later versions of internally called instructions.

When a new F-CPU is created with *STEP 7 Safety Advanced*, the latest available version for the F-CPU created is automatically preset.

For more information on the use of instruction versions, refer to the help on *STEP 7* under "Using instruction versions".

Placement

You must insert the RCVS7 instruction at the start of the main safety block. No other instructions may be located before it in the main safety block.

You must insert the SENDS7 instruction at the end of the main safety block. No other instructions may be located after it in the main safety block.

Startup behavior

After the sending and receiving F-systems are started up, communication must be established between the connection partners for the fist time (SENDS7 and RCVS7 instructions). The receiver (RCVS7 instruction) provides fail-safe values for this time period (initial values in its F-communication DB).

The SENDS7 and RCVS7 instructions signal this with 1 at output SUBS_ON. The SENDMODE output (RCVS7 instruction) has default setting "0" and is not updated as long as output SUBS_ON = 1.

Behavior in the event of communication errors

If a communication error occurs, for example, due to a signature error (CRC) or when monitoring time TIMEOUT expires, outputs ERROR and SUBS_ON = 1 are set. The receiver (RCVS7 instruction) then provides fail-safe values (initial values in its F-communication DB). Output SENDMODE is not updated while output SUBS_ON = 1.

The send data present in the F-communication DB (SENDS7 instruction) are not output before the communication error is no longer detected (ACK_REQ = 1) and you acknowledge (Page 196) with a positive edge at input ACK_REI of the RCVS7 instruction.

WARNING

A user acknowledgment (Page 196) must always take place with a signal that was generated by manual operation. Implementation with an automatically generated signal is not permitted. *(S011)*

Note that output ERROR (1=communication error) will be set for the first time on a communication error if communication has already been established between the connection partners (SENDS7 and RCVS7 instructions). If communication cannot be established after startup of the sending and receiving F-Systems, check the configuration of the safety-related CPU-CPU communication, the parameter assignment of the SENDS7 and the RCVS7 instructions, and the bus connection. You can also receive information on possible error causes by evaluating the STAT_RCV and STAT_SND outputs.

In general, always evaluate STAT_RCV and STAT_SND, since it is possible that only one of the two outputs will contain error information.

If one of the DIAG bits is set at output DIAG, also check whether the length and structure of the associated F-communication DB on both the sending and receiving ends match.

Timing diagrams SENDS7 and RCVS7

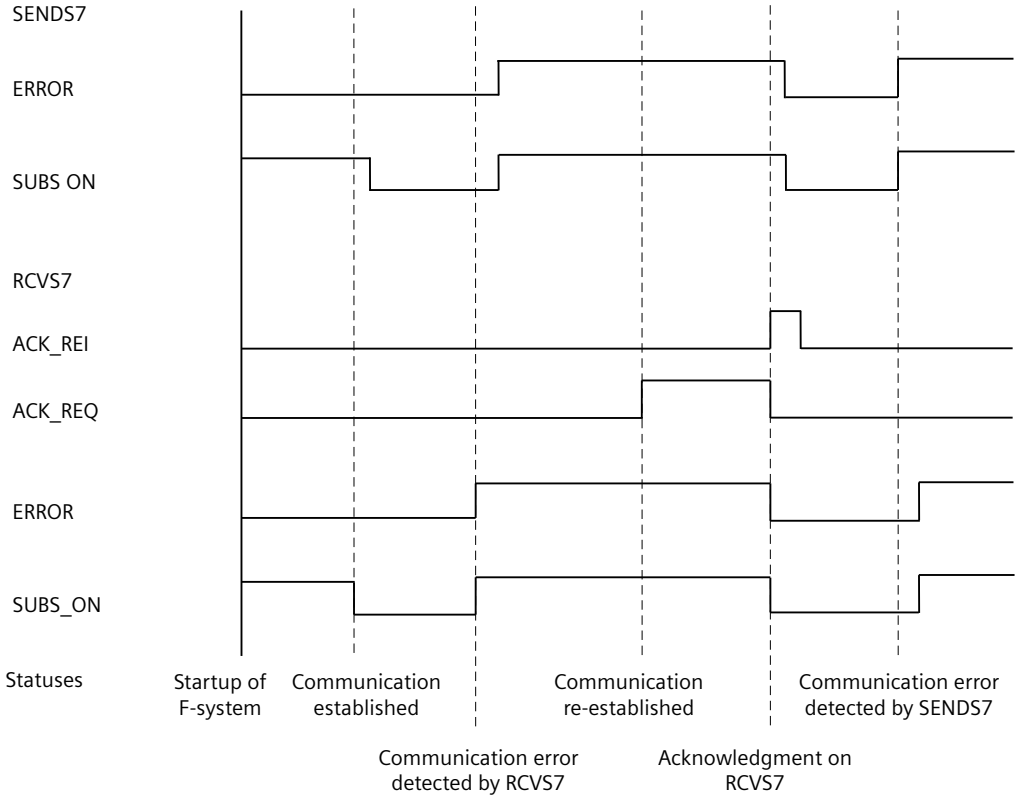

Output DIAG

Non-fail-safe information on the type of communication errors that have occurred is made available at output DIAG for service purposes. You can read out this information by means of operator control and monitoring systems or, if applicable, you can evaluate it in your standard user program. DIAG bits are saved until you acknowledge them at input ACK_REI of the associated RCVS7 instruction.

Structure of DIAG

Bit no.	Assignment of SENDS7 and RCVS7	Possible error causes	Remedies
Bit 0	Reserved	—	—
Bit 1	Reserved	—	—
Bit 2	Reserved	—	—
Bit 3	Reserved	—	—
Bit 4	Timeout detected by SENDS7 and RCVS7	Fault in bus connection to partner F-CPU	Check bus connection and ensure that no external fault sources are present.

Bit no.	Assignment of SENDS7 and RCVS7	Possible error causes	Remedies
Bit 4	Timeout detected by SENDS7 and RCVS7	Monitoring time setting for F-CPU and partner F-CPU is too low	Check assigned monitoring time TIMEOUT for SENDS7 and RCVS7 of both F-CPUs. If possible, set a higher value. Recompile safety program
		CPs in STOP mode, or internal fault in CPs	• Switch CPs to RUN mode • Check diagnostic buffer of CPs • Replace CPs, if necessary
		F-CPU/partner F-CPU in STOP mode, or internal fault in F-CPU/partner F-CPU	• Switch F-CPUs to RUN mode • Check diagnostic buffer of F-CPUs • Replace F-CPUs, if necessary
		Communication was shut down with EN_SEND = 0.	Enable communication again at the associated SENDS7 with EN_SEND = 1
		S7 connection has changed, the IP address of the CP has changed, for example	Recompile the safety programs and download them to the F-CPUs
Bit 5	Sequence number error detected by SENDS7 and RCVS7	See description for bit 4	See description for bit 4
Bit 6	CRC-error detected by SENDS7 and RCVS7	See description for bit 4	See description for bit 4
Bit 7	RCVS7: Communication cannot be established	Configuration of the safety-related CPU-CPU communication is incorrect, parameter assignment of the SENDS7 and RCVS7 instructions is incorrect See also description for Bit 4	Check configuration of the safety-related CPU-CPU communication, the parameter assignment of the SENDS7 and the RCVS7 instructions is incorrect See also description for Bit 4
	SENDS7: Reserved	—	—

Monitoring and response times

A

Introduction

In the following, you will learn:

- Which F-specific monitoring times you must configure
- Which rules must be followed when specifying monitoring times
- Where you enter the F-specific monitoring times
- Which rules must be followed with regard to the maximum response time of a safety function

Support for calculations

An Excel file is available on the Internet (https://support.industry.siemens.com/cs/ww/en/view/109783831) to support you in the approximative calculation of the runtimes of the F-runtime groups, the F-specific minimum monitoring times and the maximum response times for your F-system.

Additional information

The monitoring and response times for the standard part are calculated in SIMATIC Safety in exactly the same way as for standard S7-300, S7-400, S7-1200 and S7-1500 automation systems and are not addressed here. For a description of this calculation, refer to the *hardware manuals for the CPUs*. For redundant S7-1500HF systems, also observe the system manual "Redundant System S7-1500R/H (https://support.industry.siemens.com/cs/ww/en/view/109754833)".

A.1 Configuring monitoring times

Monitoring times to be configured

You must configure the following monitoring times:

Monitoring...	Setting...	Parameter	See
F-cycle time or cycle time warning limit of the F-runtime groups that contain the Safety program	in *Safety Administration Editor*: • Dialog for definition of an F-runtime group	Maximum cycle time of the F-runtime group	• Procedure for defining an F-runtime group (S7-300, S7-400) (Page 138) • Procedure for defining an F-runtime group (S7-1200, S7-1500) (Page 141)
of the safety-related communication between F-CPU and F-I/O via PROFIsafe (PROFIsafe monitoring time)	In the *hardware and network editor*: • Centrally when configuring the F-CPU; properties of the F-CPU; or • when configuring the F-I/O; properties of the F-I/O	F-monitoring time F_WD_TIME	• Configuring an F-CPU (Page 40) • Configuring F-I/O (Page 52) • Peculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices (Page 38)
Communication via SENDDP/RCVDP or SENDS7/RCVS7 instructions:	At the TIMEOUT input of the instructions: • SENDDP; RCVDP; SENDS7; RCVS7	TIMEOUT	• Communication (Page 627)
(S7-1500) Communication via OPC UA Safety	After adding a SafetyProvider to a SafetyProvider list of a client interface (Page 332) in the properties of the SafetyConsumer in the editor for client interfaces (Page 336)	SafetyConsumer-Timeout	• Safety Parameter Interface (SPI) of the SafetyConsumer (Page 307)
(S7-1200, S7-1500) Communication with Flexible F-Link	in Safety Administration Editor: • "Flexible F-Link" area	F-monitoring time of F-communication	• "Flexible F-Link" area of the Safety Administration Editor (S7-1200, S7-1500) (Page 98) • F-runtime group communication (S7-1200, S7-1500) (Page 149) • Communication with Flexible F-Link (S7-1200, S7-1500) (Page 355)

(S7-300, S7-400) You do not have to configure the monitoring time for safety-related communication between F-runtime groups.

Rules for configuring monitoring times

When configuring monitoring times, you must take into account the availability as well as the safety of the F-system as follows:

- Availability: Sufficiently large monitoring times must be selected so that time monitoring is not exceeded in an error-free scenario.
- Safety: Sufficiently small monitoring times must be selected so that the process safety time of the process is not exceeded.

WARNING

It can only be ensured (from a fail-safe standpoint) that a signal state to be transferred will be acquired and transferred to the receiver if the signal level is pending for at least as long as the assigned monitoring time. *(S018)*

General procedure for configuring monitoring times

Use the following procedure for configuring monitoring times:

1. Configure the standard system.

   Refer to the applicable *hardware manuals* and *Help on STEP 7* for the necessary information.

2. Configure the specific monitoring times of the F-System with respect to availability. You use the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) to calculate the approximate minimum monitoring time.

   NOTE

   To avoid a triggering of the time monitoring in the special operating and system states of the redundant S7-1500HF system in case of error-free operation, higher minimum monitoring times are required for a redundant S7-1500HF system with regard to availability. This is taken into account accordingly in the Excel file for the response time calculation.

3. Use the Excel file for response time calculation to calculate the maximum response time and then verify that the process safety time of the process is not exceeded. If necessary, you must reduce the specific monitoring times of the F-System.

See also

Redundant System S7-1500R/H
(https://support.industry.siemens.com/cs/ww/en/view/109754833)

A.1.1 Minimum monitoring time for the F-runtime group cycle time

Parameter "Maximum cycle time of the F-runtime group"

You configure the monitoring time for the F-runtime group cycle time in the *Safety Administration Editor* in the work area for definition of the F-runtime group (Page 136).

To prevent F-runtime group cycle time monitoring from being triggered when there are no pending faults and causing the F-CPU to go to STOP, you must set the maximum cycle time of the F-runtime group high enough.

Use the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) to determine the minimum monitoring time for the F-runtime group cycle time. Note also the comments in the Excel file.

For S7-1200/1500 F-CPUs, you can also use the tags TCYC_CURR (Page 158) and TCYC_LONG (Page 158) to determine the current and longest cycle time of the F-runtime group that occurred since the last STOP-RUN transition for dimensioning.

A.1.2 Minimum monitoring time of the F-I/O access

Parameter "F-monitoring time"

You have two options for configuring the monitoring time of safety-related communication between the F-CPU and F-I/O:

- Centrally in the *hardware and network editor* during parameter assignment of the F-CPU (Page 40); in the properties of the F-CPU, or
- During parameter assignment of the F-I/O (Page 52) in the *hardware and network editor*; in the properties of the F-I/O

NOTE

Note that in a redundant S7-1500HF system and use of an IO device that does not support system redundancy S2, there is an interruption of PROFINET communication with this device when the primary CPU fails and thus a communication error in the F-I/Os of this IO device, which requires reintegration of the F-I/Os (see section "After communication errors (Page 181)").

For IO devices with system redundancy S2, the redundant S7-1500HF system switches to the backup CPU without interruption if the primary CPU fails. During the primary backup switchover, the fail-safe outputs remain active.

"F-monitoring time" = PROFIsafe monitoring time T_{PSTO}

The specified PROFIsafe monitoring time T_{PSTO} must be high enough to prevent tripping the F-cycle time monitoring when no faults are present.

Use the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) available for SIMATIC Safety to calculate the minimum monitoring time for safety-related communication between the F-CPU and F-I/O.

Note also the comments in the Excel file.

Check to determine whether configured PROFIsafe monitoring time is too short

NOTE

During commissioning of the F-system, you can perform a check while safety mode is active to determine whether the configured PROFIsafe monitoring time is too short.

This check of the PROFIsafe monitoring time is useful if you want to ensure that the configured monitoring time exceeds the minimum monitoring time by a sufficient amount. In this way, you can avoid the possible occurrence of sporadic monitoring time errors.

Procedure:

1. Insert an F-I/O (one that will not be needed later for system operation).
2. Assign a shorter monitoring time for this F-I/O than for the F-I/O of the system.
3. If the additional F-I/O fails and the "Monitoring time for safety message frame exceeded" diagnostic is signaled, you have fallen below the minimum possible PROFIsafe monitoring time.
4. Increase the monitoring time for the added F-I/O just to the point where it no longer fails. This monitoring time corresponds approximately to the minimum possible monitoring time.

Conditions:

The F-I/O to be inserted additionally and the F-I/O whose PROFIsafe monitoring time is to be checked must have the following properties in common:

- They must be inserted in the same rack
- They must be nodes in the same subnet

Tip:

It may be useful to leave the additional F-I/O in place for systems that will be modified or expanded during operation after commissioning. This F-I/O will then provide an early warning in the event of changes in the time behavior, enabling you to avoid a process shutdown triggered by the F-I/O in the process.

In a redundant S7-1500HF system, the check as to whether the configured PROFIsafe monitoring time is too short should be carried out in all operating and system states, because the response times there also depend on the respective operating and system state.

A.1.3 Minimum monitoring time for communication via the SENDDP/RCVDP or SENDS7/RCVS7 instructions

TIMEOUT Input at SENDDP and RCVDP or SENDS7 and RCVS7

The time monitoring is performed in the SENDDP and RCVDP (Page 627) or SENDS7 and RCVS7 (Page 636) instructions of the communication partners. You must assign the time monitoring with identical monitoring time for both instructions at the TIMEOUT input.

You must specify a monitoring time TIMEOUT that is large enough so that monitoring is not initiated when no faults are present.

Use the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) that is available for SIMATIC Safety to determine the minimum value for TIMEOUT.

Note also the comments in the Excel file.

A.1.4 Minimum monitoring time of communication with OPC UA Safety

"SafetyConsumerTimeout" SAPI parameter

For communication with OPC UA Safety, specify the F-monitoring time for this safety-related communication after adding a SafetyProvider to a SafetyProvider list of a client interface (Page 338) in the properties of the SafetyConsumer in the editor for client interfaces (Page 332).

You must specify a monitoring time that is high enough so that SafetyConsumerTimeout is not triggered when no error has occurred.

Use the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) that is available for SIMATIC Safety to determine the minimum value for SafetyConsumerTimeout.

Note also the comments in the Excel file.

A.1.5 Minimum monitoring time for communication with Flexible F-Link

"F-monitoring time" parameter in the settings for Flexible F-Link

For communication with Flexible F-Link, you specify the F-monitoring time for the safety-related communication when establishing safety-related communication (Page 98).

You must specify a monitoring time that is large enough so that F-monitoring is not initiated when no faults are present.

Use the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) that is available for SIMATIC Safety to determine the minimum value for the F-monitoring time.

Note also the comments in the Excel file.

A.1.6 Monitoring Time for Safety-Related Communication between F-Runtime Groups

Monitoring time for safety-related communication between F-runtime groups (S7-300, S7-400)

The monitoring time for safety-related communication between F-runtime groups with Flexible F-Link is determined automatically from the values of the "Maximum cycle time of F-runtime group" (work area for Definition of the F-runtime group (Page 136) in the *Safety Administration Editor*).

Monitoring time = (maximum cycle time of the 1st F-runtime group) + (maximum cycle time of the 2nd F-runtime group)

Monitoring time for safety-related communication between F-runtime groups (S7-1200, S7-1500)

You can calculate the monitoring time for safety-related communication between F-runtime groups from the values for the "Maximum cycle time of the F-runtime group" (area for Definition of the F-runtime group (Page 136) in the *Safety Administration Editor*), if you place the default user program for the F-runtime group communication into pre-/postprocessing (Page 88).

Monitoring time = (Maximum cycle time of the 1st F-runtime group) + (Maximum cycle time of the 2nd F-runtime group).

A.2 Response Times of Safety Functions

Definition of response time

The response time is the time from detection of an input signal until the linked output signal changes.

Fluctuation range

The actual response time lies between a minimum response time and maximum response time. You must always take the maximum response time into account in your system configuration.

Also note the comments in the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831).

NOTE

In a redundant S7-1500HF system, the current operating and system state influences the actual response time.

Rules for maximum response time of a safety function

The maximum response time of a safety function must be shorter than the process safety time of the process.

Definition for process safety time of a process

The process safety time of a process is the time interval between the occurrence of an error, within which the process can be left on its own without causing injury to operating personnel or damage to the environment, and the point in time the response is completed.

The controlling F-system can perform any control during the process safety time, this includes incorrectly or not at all. The process safety time of a process depends on the process type and must be determined on a case-by-case basis.

Procedure for response time calculation

The Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) is available for calculating the maximum response time of a safety function.

Use the Excel file to calculate the approximate maximum response time of the safety function and then check that the process safety time of the process is not exceeded.

If necessary, you must reduce the specific monitoring times of the F-system (see Minimum monitoring time of the F-I/O access (Page 646)).

WARNING

The response time of your safety function depends, among other things, on the cycle time of the F-OB, the runtime of the F-runtime group and, when distributed F-I/O is used, the parameter assignment of PROFINET/PROFIBUS.

Therefore, the configuration/parameter assignment of the standard system influences the response time of your safety function.

Examples:

- Increasing the priority of a standard OB compared to an F-OB can extend the cycle time of the F-OB or the runtime of the F-runtime group due to the higher-priority processing of the standard OB. Note that during the creation of technology objects, OBs with very high priority may be created automatically.
- The change of the send clock cycle of PROFINET changes the cycle time of an F-OB with event class "Synchronous cycle".

Note that the configuration / parameter assignment of the standard system is not subject to access protection for the safety-related project data and does not lead to a modification of the collective F-signature.

If you do not take organizational measures to prevent changes in the configuration / parameter assignment of the standard system with influence on the response time, you must always use the monitoring times for the calculation of the maximum response time of a safety function (see Configuring monitoring times (Page 644)).

The monitoring times are protected against change with the access protection of the safety-related project data and are captured by the Collective F-Signature as well as the collective F-SW-signature.

When calculating with the Excel file for response time calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) you need to consider the value that is specified for "Any standard system runtimes" as value for the maximum response time. *(S085)*

WARNING

You may only use the Excel file for response time calculation or for timeout calculation when using Flexible F-Link communication, if you have observed the following rules with regard to the standard instructions for consistent transfer of data:

CPU-CPU communication (Page 355)

You must call the standard instruction for consistent sending of data and acknowledgment in the post-processing of the F-runtime group (Page 88). With the standard instructions for receiving data and acknowledgments consistently, you must differentiate whether or not the standard communication connection is deterministic. For deterministic connections (such as DPRD_DAT / DPWR_DAT), you need to call the standard instruction in the pre-processing of the F-runtime group (Page 88). If the connection is non-deterministic (e.g. S7 connection, TCP connections), you must call the standard instruction in a cyclic interrupt OB. This cyclic interrupt OB must be called at shorter intervals than the F-runtime group. A ratio of 1:5 is recommended for this.

F-runtime group communication (Page 149)

You have to call up the standard instruction UMOVE_BLK for transferring the data to be sent in the postprocessing of the sending F-runtime group. You have to call the standard instruction UMOVE_BLK for transferring the acknowledgment to be sent in the postprocessing of the receiving F-runtime group. *(S089)*

WARNING

You may only use the Excel file for response time calculation or for timeout calculation (https://support.industry.siemens.com/cs/ww/en/view/109783831) when using OPC UA Safety communication, if you have observed the following rules with regard to the standard instruction OPC_UA_MethodCall:

You must call up the standard instruction OPC_UA_METHODCALL to receive the data in the pre-processing of the F-runtime group (Page 88) and to send the request in the post-processing of the F-runtime group (Page 88). The REQ input of the instruction must be supplied with a positive signal edge during preprocessing. You can use the F-OPC-UA-Consumer-Com-FB provided by the system for this. *(S112)*

Checklist

B

Life cycle of fail-safe automation systems

The following table contains a checklist summarizing all activities in the life cycle of a fail-safe SIMATIC Safety system, including requirements and rules that must be observed for each activity.

Checklist

Legend:

- Stand-alone section references refer to this documentation.
- *"F-SMs manual"* refers to the Automation System S7-300, ET 200M Distributed I/O System, Fail-Safe Signal Modules manual (https://support.industry.siemens.com/cs/ww/en/view/19026151)
- *"F-Modules manual"* refers to the ET 200S Distributed I/O System, Fail-Safe Modules manual (https://support.industry.siemens.com/cs/ww/en/view/27235629)
- *"ET 200eco manual"* refers to the ET 200eco Distributed I/O Station, Fail-Safe I/O Module manual (https://support.industry.siemens.com/cs/ww/en/view19033850)
- *"ET 200eco PN manual"* refers to the ET 200eco PN F-DI 8 x 24 VDC, 4xM12 / F-DQ 3 x 24 VDC/2.0A PM, 3xM12 equipment manual (https://support.industry.siemens.com/cs/ww/en/view/109765611)
- *"ET 200pro manual"* refers to the ET 200pro Distributed I/O System, Fail-Safe I/O Module manual (https://support.industry.siemens.com/cs/ww/en/view22098524)
- *"ET 200iSP manual"* refers to the ET 200iSP Distributed I/O Device, Fail-Safe Modules manual (https://support.industry.siemens.com/cs/ww/en/view/47357221)
- *"ET 200SP manual"* refers to the ET 200SP system manual (https://support.industry.siemens.com/cs/ww/en/view/58649293)
- *"ET 200SP HA manual"* refers to the ET 200SP HA system manual (https://support.industry.siemens.com/cs/ww/en/view/109817158)
- *"ET 200AL manual"* refers to the ET 200AL system manual (https://support.industry.siemens.com/cs/ww/en/view/89254965)
- *"ET 200MP manual"* refers to the S7-1500/ET 200MP Distributed I/O system manual (https://support.industry.siemens.com/cs/ww/en/view/59191792)
- *"S7-1500R/H manual"* refers to the S7-1500R/H system manual (https://support.industry.siemens.com/cs/ww/en/view/109754833)
- *"SIMATIC Drive Controller manual"* refers to the SIMATIC Drive Controller system manual (https://support.industry.siemens.com/cs/ww/en/view/109766665)
- *"ET 200SP Modules manual"* refers to the equipment manuals for F-Modules of the ET 200SP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/ps/14059/man)
- *"ET 200SP HA Modules manual"* refers to the equipment manuals for F-Modules of the ET 200SP HA Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/ps/28940/man)

- *"ET 200MP Modules manual"* refers to the equipment manuals for F-Modules of the ET 200MP Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/ps/29727/man)
- *"ET 200AL Module manual"* refers to the equipment manual for the F-Module of the ET 200AL Distributed I/O System (https://support.industry.siemens.com/cs/ww/en/view/109798489)

Phase	Note the following	Reference	Check
Planning			
Requirement: "Safety requirements specification" available for the intended application	Process-dependent	—	
Specification of system architecture	Process-dependent	—	
Assignment of functions and subfunctions to system components	Process-dependent	under Product Overview (Page 22)	
Selection of sensors and actuators	Requirements for actuators	*F-SMs Manual*, section 6.5; *F-Modules Manual*, section 4.5; *ET 200eco Manual*, section 5.5 *ET 200eco PN Manual*, section 5.2; *ET 200pro Manual*, section 4.4 *ET 200iSP Manual*, section 4.5 *ET 200SP Manual*, section 6.2.2 *ET 200SP HA Manual*, sec. 9 *ET 200MP Manual*, section 6.2.2	
Specification of required safety properties for individual components	IEC 61508:2010	—	
Configuration			
Installing license	Requirement for installation	under Installing/uninstalling the STEP 7 Safety Advanced V21 license (Page 29)	
Selection of S7 components	Descriptions of configuration	under Product Overview (Page 22); *F-SMs Manual*, section 3; *F-Modules Manual*, section 3; *ET 200eco Manual*, section 3 *ET 200eco PN Manual*, section 4; *ET 200pro Manual*, section 2 *ET 200iSP Manual*, section 3 *ET 200SP Manual*, section 4 *ET 200SP HA Manual*, sec. 4 *ET 200AL Manual*, section 3 *ET 200MP Manual*, section 4 *S7-1500R/H Manual*, section 4 *HB SIMATIC Drive Controller*, section 4	
Configuration of hardware	• Description of F-systems • Verification of utilized hardware components based on Annex 1 of Report in the Certificate	under Configuring (Page 34); Annex 1 of Report on the Certificate	

Phase	Note the following	Reference	Check
Configuration of F-CPU	• Protection level, "Write protection for F-blocks" (S7-300, S7-400) • Protection level, at least "Full access" (S7-1200, S7-1500) • Password • F-capability enabled • Definition/setting of F-specific parameters • Cycle time for the F-runtime group in which the safety program is to be executed, defined in accordance with the requirements and safety regulations - same as with standard system	under Configuring an F-CPU (Page 40); *Standard-S7-300 Manual;* *Standard-S7-400 Manual;* *Standard-S7-1200 Manual;* *Standard-S7-1500 Manual;* under Monitoring and response times (Page 643)	
Configuration of F-I/O	• Settings for safety mode • Setting of passivation type • Configuring monitoring times • Defining sensor evaluation • Defining diagnostic behavior • Special F-parameters • Assigning names • Unique PROFIsafe address	under Configuring F-I/O (Page 52) orPeculiarities when configuring fail-safe GSD based DP slaves and fail-safe GSD based I/O devices (Page 38) under Monitoring and response times (Page 643); *F-SMs Manual*, sections 3, 9, 10; *F-Modules Manual*, sections 2.4, 7; *ET 200eco Manual*, sections 3, 8; *ET 200eco PN Manual*, section 6; *ET 200pro Manual,* Sections 2.4, 8; *ET 200iSP Manual,* Sections 2.4, 7, 8 *ET 200SP Modules Manual*, section 4 *ET 200SP HA Modules manual,* sec. 9 *ET 200MP Modules Manual*, section 4 *ET 200AL Module Manual*, section 4	
Programming			
Defining program design and structure	• Follow warnings and notes on programming	under Overview of Programming (Page 113), Program structure of the safety program (S7-300, S7-400) (Page 113), Program structure of the safety program (S7-1200, S7-1500) (Page 116); Programming startup protection (Page 159);	
Creating the F-runtime groups	• Assignment of F-FB or F-FC as main safety block to the calling block (S7-300, S7-400) or F-OB (S7-1200, S7-1500) • Setting maximum cycle time for the F-runtime group in accordance with requirements (dependent on process and safety regulations) • Creating DB for F-runtime group communication • (S7-300, S7-400) Call of main safety blocks directly in OBs (e.g. OB 35), FBs, or FCs • (S7-1200, S7-1500) Call of the main safety block from the F-OB	under Defining F-Runtime Groups (Page 136) under Monitoring and response times (Page 643)	

Phase	Note the following	Reference	Check
Creating/inserting the F-blocks	• Generating, editing, and saving F-FBs, F-FCs, and F-DBs in accordance with the requirements of the program structure • Description: – F-I/O access – Passivation and reintegration of F-I/O – Inserting F-blocks from global libraries – Safety-related CPU-CPU communication – Communication with the standard user program	under Creating F-blocks (Page 153) under Addressing F-I/O (Page 161) under Implementation of user acknowledgment (Page 196) under Reuse of F-blocks (Page 156) under Communication via SENDDP/RCVDP or SENDS7/RCVS7(S7-300, S7-400) instructions: (Page 208) and Communication via SENDDP/RCVDP instructions (S7-1200, S7-1500): (Page 257) under Data exchange between standard user program and safety program (Page 204)	
Compiling the safety program	—	under Compiling the safety program (Page 361)	
Implementing safety program call (S7-300, S7-400)	Check whether the main safety block is called directly in OBs (e.g., OB 35), FBs, or FCs.	under Defining F-Runtime Groups (Page 136)	
Installation			
Hardware configuration	Description of • Installation • Wiring	under Overview of Configuration (Page 34); AUTOHOTSPOT; *F-SMs Manual*, sections 5, 6; *F-Modules Manual*, sections 3, 4; *ET 200eco Manual*, sections 3, 4; *ET 200eco PN Manual*, sections 4, 5; *ET 200pro Manual*, Sections 2, 3; *ET 200iSP Manual*, sections 3 and 4; *ET 200SP Manual*, sections 5 and 6 *ET 200SP HA Manual*, sec. 5, 6 *ET 200AL Manual*, sections 4, 5 *ET 200MP Manual*, sections 5 and 6 *S7-1500R/H Manual*, sections 5, 6 *HB SIMATIC Drive Controller*, section 5, 6	
Commissioning, Testing			
Switching on	Description of commissioning – same as in standard	*Standard-S7-300 Manual;* *Standard-S7-400 Manual;* *Standard-S7-1200 Manual;* *Standard-S7-1500 Manual;* *Standard-S7-1500 Software Controller Manual;* *S7-1500R/H Module Manual* *HB SIMATIC Drive Controller Manual*	
Downloading safety program and standard user program	Description • Downloading • Program identification • Comparing safety programs	under Downloading project data (Page 362) under Comparing Safety Programs (Page 398)	
Testing the safety program	• Description of disabling of safety mode • Procedures for changing safety program data	under Downloading project data (Page 362); Testing the safety program (Page 409); Disabling safety mode (Page 405)	

Phase	Note the following	Reference	Check
Changing the safety program	Description • Disabling safety mode • Changing the safety program	under Changing the safety program in RUN mode (S7-300, S7-400) (Page 417), Safety program in RUN mode (S7-1200, S7-1500) (Page 419), Disabling safety mode (Page 405), Deleting the safety program (Page 135)	
Testing the safety-related parameters	Description of configuration	under Creating a safety summary (Page 400); *F-SMs Manual*, sections 4, 9, 10; *F-Modules Manual*, sections 2.4, 7; *ET 200eco Manual*, sections 3, 8; *ET 200eco Manual*, section 6; *ET 200pro Manual,* Sections 2.4, 8; *ET 200iSP Manual,* Sections 2.4, 7, 8 *ET 200SP Modules Manual*, section 4 *ET 200SP HA Modules manual*, sec. 5 *ET 200MP Modules Manual*, section 4 *ET 200AL Module Manual*, section 4	
System acceptance			
Acceptance	• Description and notes on acceptance • Printouts	under System acceptance (Page 427)	
Operation, maintenance			
General operation	Notes on operation	under Notes on Safety Mode of the Safety Program (Page 456)	
Access protection	—	under Access protection (Page 100)	
Diagnostics	Responses to faults and events	under Guide to Diagnostics (Page 462)	
Replacement of software and hardware components	Description • Module replacement • Update of operating systems of F-CPU – same as in standard • Update of SW components Notes • Operating system update of IMs	under Replacing Software and Hardware Components (Page 458); Addressing F-I/O (Page 161); Help on *STEP 7*	
Uninstalling the license, Disassembly	• Notes for uninstalling the license • Notes for disassembling modules	under Installing/uninstalling the STEP 7 Safety Advanced V21 license (Page 29), Replacing Software and Hardware Components (Page 458)	

Assignment of the F-BaseID during runtime (delayed transfer) (S7-1200 G2, S7-1500)

C

If the F-BaseID with the value "Delayed transfer" (0x7C6) has been configured, you must generate an active F-BaseID in runtime and assign it to the F-CPU and the F-I/O. The following instructions are available to you for this purpose.

- BASEID_GEN
- BASEID_DATA
- BASEID_CODING
- BASEID_HOST

The instructions are made available in the "Extended instructions" area under "Safety-Extensions".

These instructions are not fail-safe instructions and can only be placed in a standard block. They may only be used in the case "Delayed transfer of the F-BaseID".

In the case "Delayed transfer of the F-BaseID", the F-BaseID is generated once by these instructions on the first startup of the F-CPU, saved in the F-CPU and assigned to the F-I/Os. After the F-CPU starts up again, the F-BaseID previously saved in the F-CPU is applied again and forwarded to the F-I/O.

NOTE

The F-I/Os of PROFIsafe address type 3 remain passivated until the logic for assignment of the F-BaseID is complete.

NOTE

You can find the BaseIDAssign application example on the Internet. It presents a possible interconnection of the above-named instructions for the delayed transfer of the F-BaseID.

NOTE

The BASEID_GEN instruction is only supported for S7-1500 HF-CPUs as of firmware V4.2.

Configuring delayed transfer of the F-BaseID

For delayed transfer of the F-BaseID, configure the F-CPUs and the F-I/Os with the "Activate delayed transfer of F-BaseID" option enabled in accordance with the PROFIsafe specification.

Proceed as follows:

1. For the F-I/Os of PROFIsafe address type 3, configure (Page 69) the F-BaseID with the value 0 and with the intended F-source and F-destination addresses.
2. Download (Page 362) the project data to the F-CPU.
3. Assign (Page 72) the PROFIsafe addresses with SIMATIC Safety.
4. Create the user program.

5. In the F-CPU parameters (Page 40), enable the "Activate delayed transfer of the F-BaseID" option. The F-BaseID changes to 0x7C6.

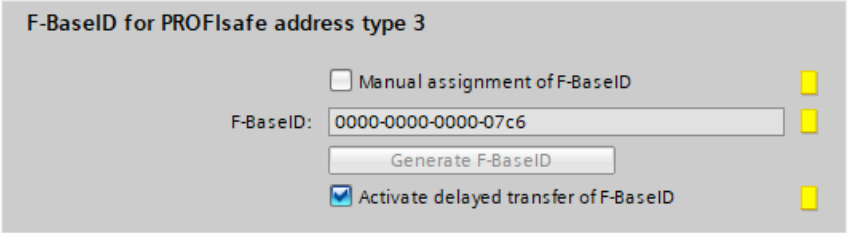

6. In the standard program, program the logic for assigning the F-BaseID with BASEID_GEN, BASEID_DATA, BASEID_CODING and BASEID_HOST.
7. Download (Page 362) the project data to the F-CPU.
8. Switch the F-CPU to RUN. The F-BaseID is assigned.

WARNING

During assignment of the F-BaseID by means of the BASEID_CODING instruction, only the F-modules to which the F-BaseID is to be assigned should be accessible. Therefore, temporarily isolate the network in which the F-CPU and the assigned F-modules are located. *(S119)*

As an alternative to the BASEID_CODING instruction, you can use the instruction PROFIsafeAddrAssign (https://support.industry.siemens.com/cs/ww/en/view/109748466) (as of Version 3.0). With this instruction, you can additionally assign the F-destination and F-source addresses. Steps 1 to 3 are omitted in this case.

WARNING

Note that when the PROFIsafeAddrAssign instruction with F-I/Os of PROFIsafe address type 3 is being used, you must always confirm the correctness of the assignment using suitable measures. This applies even if you only changed the F-BaseID, because all parts of the PROFIsafe address are assigned at the same time in this case. In addition, you must prevent an unintended execution of the PROFIsafeAddrAssign instruction. You can find details on this in the named application example. *(S118)*

Order when programming the instructions for F-BaseID

In order to set the F-BaseID at runtime, you must interconnect the following instructions from the standard library under "Safety Extensions" in a cyclic standard user program:

- BASEID_GEN
- BASEID_DATA
- BASEID_CODING
- BASEID_HOST

NOTE

The instructions BASEID_GEN, BASEID_DATA, BASEID_CODING and BASEID_HOST are processed asynchronously. You must interconnect these instructions in such a way that they are processed sequentially in the above-named order.

C.1 Safety Extensions

C.1.1 BASEID_GEN

Description

At a positive edge at input REQ, the BASEID_GEN instruction generates the F-BaseID once and provides it at output BASEID.

If the F-CPU already has a set F-BaseID, this F-BaseID is provided at output BASEID.

Parameters

The following table shows the parameters of the BASEID_GEN instruction:

Parameter	Declaration	Data type	Description
REQ	Input	BOOL	REQ = 1: Runs BASEID_GEN.
HW_IDENTIFIER_IM	Input	HW_IO	The HW identifier of the executing F-CPU.
BASEID	Output	LINT	The read or generated F-BaseID.
CALCULATED	Output	BOOL	CALCULATED = 1: The output F-BaseID was generated.
DONE	Output	BOOL	DONE = 1: Processing of the instruction is complete.
BUSY	Output	BOOL	BUSY = 1: Generation of the F-BaseID is active.
ERROR	Output	BOOL	ERROR = 1: An error has occurred.
STATUS	Output	DWORD	Error information

NOTE

If you want to regenerate the F-BaseID but the parameter of the F-CPU no longer has the value 0x7C6, you must first reset this to 0x7C6 using the BASEID_Host instruction.

Instruction versions

The following version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	—	—	x[1]	x[1]	BASEID_GEN reads the F-BaseID from the parameters of the F-CPU or, if F-BaseID = 0x7C6 was read, generates a new F-BaseID.

[1] Supported as of firmware V4.1 (for S7-1500 HF-CPUs only as of V4.2) or as of V40.1 for S7-1500 F Software Controllers

STATUS output

The table below shows the meaning of the values for the STATUS parameter:

Error code	Explanation
0x0000	No error
0x8001	Error in the generation of the F-BaseID

C.1.2 BASEID_DATA

Description

The instruction BASEID_DATA calculates the F-BaseID CRC according to the PROFIsafe specification and writes the F-BaseID with the calculated F-BaseID CRC to the data record of the F-module specified at input HW_WRITE_RECORD_NR. To calculate the F-BaseID CRC, the F_Par_CRC is read from the data record of the F-module specified at the HW_READ_RECORD_NR input.

Parameters

The following table shows the parameters of the BASEID_DATA instruction:

Parameter	Declaration	Data type	Description
REQ	Input	BOOL	REQ = 1: Runs BASEID_DATA.
BASEID	Input	LINT	The F-BaseID to be written.
HW_IDENTIFIER_MODULE	Input	HW_IO	The HW identifier of the F-module.
HW_READ_RECORD_NR	Input	DINT	Data record number of the F-module for reading the F_Par_CRC (needed to calculate the F-BaseID CRC).
HW_WRITE_RECORD_NR	Input	DINT	Data record number of the F-module for writing the F-BaseID.
DONE	Output	BOOL	DONE = 1: Processing of the instruction is complete.
BUSY	Output	BOOL	BUSY = 1: The instruction is running.
ERROR	Output	BOOL	ERROR = 1: An error has occurred.
STATUS	Output	DWORD	Error information

NOTE

The inputs HW_READ_RECORD_NR (128) and HW_WRITE_RECORD_NR (130) are preassigned with the usual data record numbers for F-modules by SIEMENS.

Instruction versions

The following version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	—	—	x[1]	x[1]	BASEID_DATA writes the F-BaseID to the data record of an F-module

[1] Supported as of firmware V4.1 or as of V40.1 for S7-1500 F Software Controllers

STATUS output

The table below shows the meaning of the values for the STATUS parameter:

Error code	Explanation
0x0000	No error
0x8001	Error during generation of the F-BaseID CRC
0x0050	The F-BaseID is in the reserved range.

C.1.3 BASEID_CODING

Description

The instruction BASEID_CODING writes the F-BaseID to the electronic coding element of the F-module specified at input HW_IDENTIFIER_MODULE. If the values in the data record and the electronic coding element do not match, an inconsistency occurs and the F-module is passivated until the values match.

NOTE

Using the BASEID_CODING instruction, the F-BaseID in the electronic coding element can only be overwritten if it still has the value 0.

Otherwise, the firmware prevents the writing of the new F-BaseID and the existing value in the electronic coding element is retained. To be able to change an F-BaseID, a project with F-BaseID with value 0 must therefore first be loaded and an assignment made via TIA Portal.

"Delayed transfer" must then be parameterized again in the project and this project must be loaded. Now the F-BaseID can be set at the electronic coding element again with the BASEID_CODING instruction.

NOTE

As an alternative to using the BASEID_CODING instruction, the F-BaseID can also be assigned together with the PROFIsafe addresses. For this you can use the instruction PROFIsafeAddrAssign (https://support.industry.siemens.com/cs/ww/en/view/109748466) (as of Version 3.0) available on the Internet.

WARNING

Note that when the PROFIsafeAddrAssign instruction with F-I/Os of PROFIsafe address type 3 is being used, you must always confirm the correctness of the assignment using suitable measures. This applies even if you only changed the F-BaseID, because all parts of the PROFIsafe address are assigned at the same time in this case. In addition, you must prevent an unintended execution of the PROFIsafeAddrAssign instruction. You can find details on this in the named application example. *(S118)*

WARNING

During assignment of the F-BaseID by means of the BASEID_CODING instruction, only the F-modules to which the F-BaseID is to be assigned should be accessible. Therefore, temporarily isolate the network in which the F-CPU and the assigned F-modules are located. *(S119)*

Parameters

The following table shows the parameters of the BASEID_CODING instruction:

Parameter	Declaration	Data type	Description
REQ	Input	BOOL	REQ = 1: Runs BASEID_CODING.
BASEID	Input	LINT	The F-BaseID to be written.
HW_IDENTIFIER_MODULE	Input	HW_IO	The HW identifier of the F-module.
DONE	Output	BOOL	DONE = 1: Processing of the instruction is complete.
BUSY	Output	BOOL	BUSY = 1: The instruction is running.
ERROR	Output	BOOL	ERROR = 1: An error has occurred.
STATUS	Output	DWORD	Error information

Instruction versions

The following version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	—	—	x[1]	x[1]	BASEID_CODING writes the F-BaseID to the electronic coding element of an F-module.

[1] Supported as of firmware V4.1 or as of V40.1 for S7-1500 F Software Controllers

STATUS output

The table below shows the meaning of the values for the STATUS parameter:

Error code	Explanation
0x0000	No error
0x0050	The F-BaseID is in the reserved range.

C.1.4 BASEID_HOST

Description

The instruction BASEID_HOST writes the specified F-BaseID to the parameters of the executing F-CPU.

Parameters

The following table shows the parameters of the BASEID_HOST instruction:

Parameter	Declaration	Data type	Description
REQ	Input	BOOL	REQ = 1: Runs BASEID_HOST.
BASEID	Input	LINT	The F-BaseID to be written.
DONE	Output	BOOL	DONE = 1: Processing of the instruction is complete.
BUSY	Output	BOOL	BUSY = 1: The instruction is running.
ERROR	Output	BOOL	ERROR = 1: An error has occurred.
STATUS	Output	DWORD	Error information

Instruction versions

The following version is available for this instruction:

Version	S7-300/400	S7-1200 G1	S7-1200 G2	S7-1500	Function
1.0	—	—	x[1]	x[1]	BASEID_HOST writes the F-BaseID to the parameters of the F-CPU.

[1] Supported as of firmware V4.1 or as of V40.1 for S7-1500 F Software Controllers

STATUS output

The table below shows the meaning of the values for the STATUS parameter:

Error code	Explanation
0x0000	No error
0x0050	The F-BaseID is in the reserved range.

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S7-1200, S7-1500 PID control

Function Manual

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Introduction 1

1.1 Purpose, conventions and supplementary information

Purpose of the documentation

This documentation will support you in configuring and programming control tasks with the S7-1200 and S7-1500 automation systems.

Basic knowledge required

The following knowledge is required in order to understand the documentation:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Experience of working with STEP 7 (TIA Portal)

Scope of the documentation

This documentation applies to the use of SW controllers on the CPUs of automation systems S7-1200, S7-1200G2 and S7-1500 together with STEP 7 (TIA Portal). Additional SW controllers that are not covered in this documentation are available for the use of S7-300 and S7-400 with STEP 7 (TIA Portal). Section Overview of software controller (Page 41) gives a complete overview of all SW controllers in STEP 7 (TIA Portal) and their possible applications.

Conventions

Observe notes marked as follows:

NOTE

The notes contain important information on the product described in the documentation, on the handling of the product or on part of the documentation to which particular attention should be paid.

Industry Mall

The Industry Mall is the Siemens AG catalog and ordering system for automation and drive solutions based on Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

Catalogs for all automation and drive technology products can be found on the Internet (https://mall.industry.siemens.com).

See also

Topic page "SIMATIC Technology - PID Control: Overview and important links"
https://support.industry.siemens.com/cs/ww/en/view/109751051
(https://support.industry.siemens.com/cs/ww/en/view/109751051)

1.2 Guide to the Function Manuals documentation

1.2.1 Information classes Function Manuals

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.2.2 Basic tools

Tools

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SIMATIC Automation Tool

You can use the SIMATIC Automation Tool to perform commissioning and maintenance activities on various SIMATIC S7 stations as bulk operations independent of TIA Portal.

The SIMATIC Automation Tool offers a wide range of functions:

- Scanning of a PROFINET/Ethernet system network and identification of all connected CPUs
- Assignment of addresses (IP, subnet, Gateway) and device name (PROFINET device) to a CPU
- Transfer of the date and the programming device/PC time converted to UTC time to the module
- Program download to CPU
- RUN/STOP mode switchover
- CPU localization through LED flashing
- Reading out of CPU error information

- Reading the CPU diagnostic buffer
- Reset to factory settings
- Firmware update of the CPU and connected modules

You can find the SIMATIC Automation Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/98161300)

PRONETA

SIEMENS PRONETA (PROFINET network analysis) is a commissioning and diagnostic tool for PROFINET networks. PRONETA Basic has two core functions:

- In the network analysis, you get an overview of the PROFINET topology. Compare a real configuration with a reference installation or make simple parameter changes, e.g. to the names and IP addresses of the devices.
- The "IO test" is a simple and rapid test of the wiring and the module configuration of a plant, including documentation of the test results.

You can find SIEMENS PRONETA Basic on the Internet:
(https://support.industry.siemens.com/cs/ww/en/view/67460624)

SIEMENS PRONETA Professional is a licensed product that offers you additional functions. It offers you simple asset management in PROFINET networks and supports operators of automation systems in automatic data collection/acquisition of the components used through various functions:

- The user interface (API) offers an access point to the automation cell to automate the scan functions using MQTT or a command line.
- With PROFIenergy diagnostics, you can quickly detect the current pause mode or the readiness for operation of devices that support PROFIenergy and change these as needed.
- The data record wizard supports PROFINET developers in reading and writing acyclic PROFINET data records quickly and easily without PLC and engineering.

You can find SIEMENS PRONETA Professional on the Internet.
(https://www.siemens.com/proneta-professional)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet (https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

1.2.3 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International (https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

Safety instructions 2

2.1 General safety instructions

The safety instructions can be found in section "Safety instructions" in the System Manual "SIMATIC S7-1500, ET 200MP Automation System" (https://support.industry.siemens.com/cs/ww/en/view/59191792) document.

Cybersecurity-relevant information can be found in the Industrial Cybersecurity section.

2.2 Warnings in this document

You can find explanations of the warnings used in this document in the "Legal information" section.

Industrial cybersecurity 3

Due to the digitalization and increasing networking of machines and industrial plants, the risk of cyber attacks is also growing. Appropriate protective measures are therefore mandatory, particularly in the case of critical infrastructure facilities.

3.1 Cybersecurity information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines and networks.

In order to protect plants, systems, machines and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens' products and solutions constitute one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For additional information on industrial cybersecurity measures that may be implemented, please visit
https://www.siemens.com/cybersecurity-industry.

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply the latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed under
https://new.siemens.com/cert.

Principles for control

4

4.1 Controlled system and actuators

Controlled system

Room temperature control by means of a heating system is a simple example of a controlled system. A sensor measures the room temperature and transfers the value to a controller. The controller compares the current room temperature with a setpoint and calculates an output value (manipulated variable) for heating control.

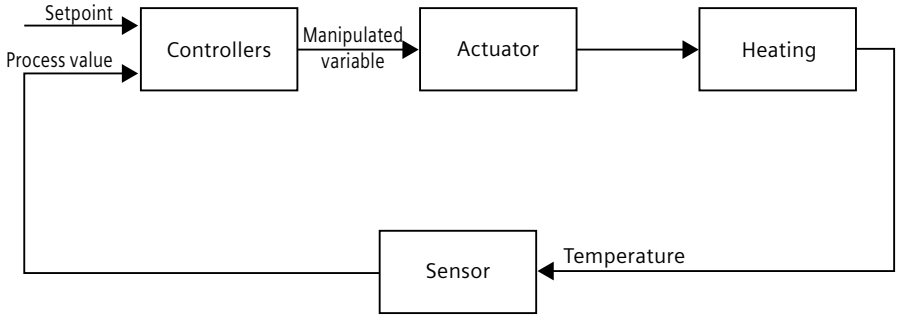

A properly set PID controller reaches this setpoint as quickly as possible and then holds it a constant value. After a change in the output value, the process value often changes only with a time delay. The controller has to compensate for this response.

Actuators

The actuator is an element of the controlled system and is influenced by the controller. Its function modifies mass and energy flows.

The table below provides an overview of actuator applications.

Application	Actuator
Liquid and gaseous mass flow	Valve, shutter, gate valve
Solid mass flow, e.g., bulk material	Articulated baffle, conveyor, vibrator channel
Flow of electrical power	Switching contact, contactor, relay, thyristor
	Variable resistor, variable transformer, transistor

Actuators are distinguished as follows:

- Proportional actuators with constant actuating signal

  These elements set degrees of opening, angular positions or positions in proportion to the output value. The output value has an analog effect on the process within the control range.

  Actuators in this group include spring-loaded pneumatic drives, as well as motorized drives with position feedback for which a position control system is formed.

An continuous controller, such as PID_Compact, generates the output value.

- Proportional actuators with pulse-width modulated signal

  These actuators are used to generate the output of pulses with a length proportional to the output value within the sampling time intervals. The actuator - e.g. a heating resistor or cooling apparatus - is switched on in isochronous mode for durations that differ depending on the output value.

  The actuating signal can assume unipolar "On" or "Off" states, or represent bipolar states such as "open/close", "forward/backward", "accelerate/brake".

  The output value is generated by a two-step controller such as PID_Compact with pulse-width modulation.

- Actuators with integral action and three-step actuating signal

  Actuators are frequently operated by motors with an on period that is proportional to the actuator travel of the choke element. This includes elements such as valves, shutters, and gate valves. In spite of their different design, all of these actuators follow the effect of an integral action at the input of the controlled system.

  A step controller, such as PID_3Step. generates the output value.

4.2 Controlled systems

The properties of a controlled system can hardly be influenced as these are determined by the technical requirements of the process and machinery. Acceptable control results can only be achieved by selecting a suitable controller type for the specific controlled system and adapting the controller to the time response of the controlled system. Therefore, it is indispensable for the configuration of the proportional, integral and derivative actions of the controller to have precise knowledge of the type and parameters of the controlled system.

Controlled system types

Controlled systems are classified based on their time response to step changes of the output value.

We distinguish between the following controlled systems:

- Self-regulating controlled systems
  - Proportional-action controlled systems
  - PT1 controlled systems
  - PT2 controlled systems
- Non-self-regulating controlled systems
- Controlled systems with and without dead time

Self-regulating controlled systems

Proportional-action controlled systems

In proportional-action controlled systems, the process value follows the output value almost immediately. The ratio between the process value and output value is defined by the proportional Gain of the controlled system.

Examples:

- Gate valve in a piping system
- Voltage dividers
- Step-down function in hydraulic systems

PT1 controlled systems

In a PT1 controlled system, the process value initially changes in proportion to the change of the output value. The rate of change of the process value is reduced as a function of the time until the end value is reached, i.e., it is delayed.

Examples:

- Spring damping system
- Charge of RC elements
- Water container that is heated with steam.

The time constants are often identical for heating and cooling processes, or for charging and discharge characteristics. With different time constants, controlling is clearly more complex.

PT2 controlled systems

In a PT2 controlled system, the process value does not immediately follow a step change of the output value, i.e., it increases in proportion to the positive rate of rise and then approaches the setpoint at a decreasing rate of rise. The controlled system shows a proportional response characteristic with second order delay element.

Examples:

- Pressure control
- Flow rate control
- Temperature control

Non-self-regulating controlled systems

Non-self-regulating controlled systems have an integral response. The process value approaches an infinite maximum value.

Example:

- Liquid flow into a container

Controlled systems with dead time

A dead time always represents the runtime or transport time that has to expire before a change to the system input can be measured at the system output.

In controlled systems with dead time, the process value change is delayed by the amount of the dead time.

Example:

- Conveyor

4.3 Characteristic values of the control section

Determining the time response from the step response

Time response of the controlled system can be determined based on the time characteristic of process value x following a step change of output value y. Most controlled systems are self-regulating controlled systems.

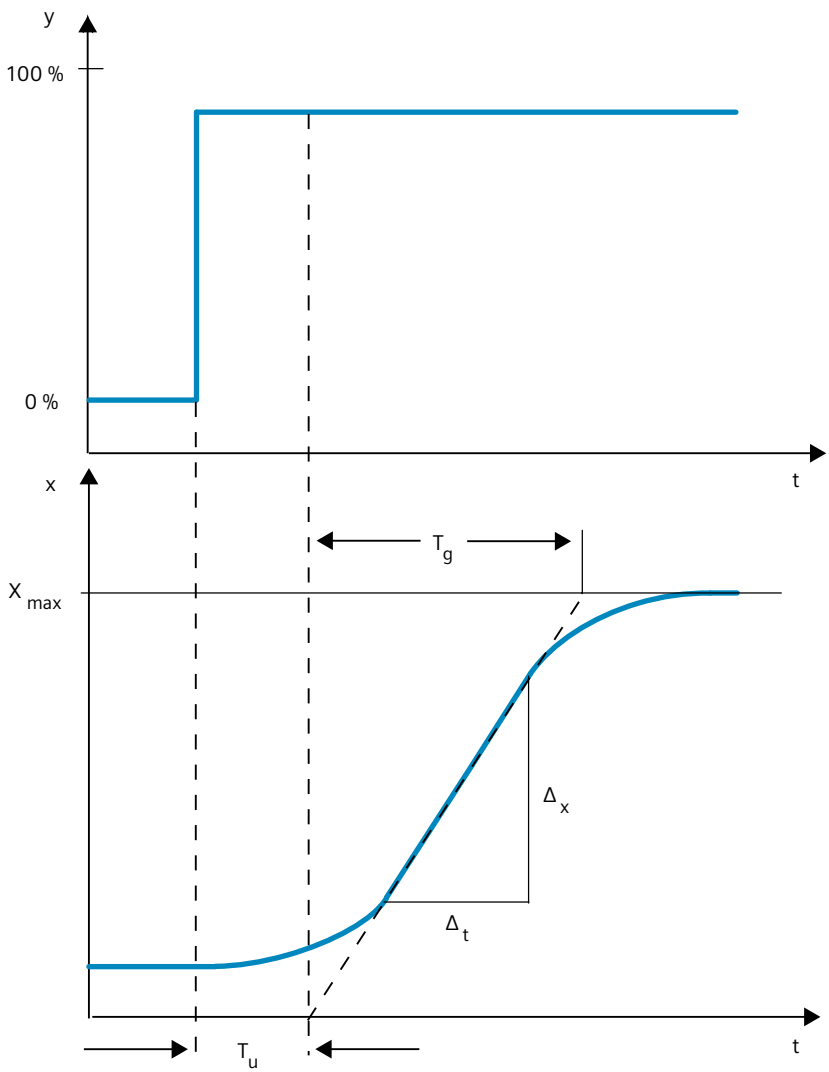

The time response can be determined by approximation using the variables Delay time T_u, Recovery time T_g and Maximum value X_{max}. The variables are determined by applying tangents to the maximum value and the inflection point of the step response. In many situations, it is not possible to record the response characteristic up to the maximum value because the process value cannot exceed specific values. In this case, the rate of rise v_{max} is used to identify the controlled system ($v_{max} = \Delta_x/\Delta_t$).

The controllability of the controlled system can be estimated based on the ratio T_u/T_g, or $T_u \times v_{max}/X_{max}$. Rule:

Process type	T_u / T_g	Suitability of the controlled system for controlling
I	< 0.1	can be controlled well
II	0.1 to 0.3	can still be controlled
III	> 0.3	difficult to control

Influence of the dead time on the controllability of a controlled system

A controlled system with dead time and recovery reacts as follows to a jump of the output value.

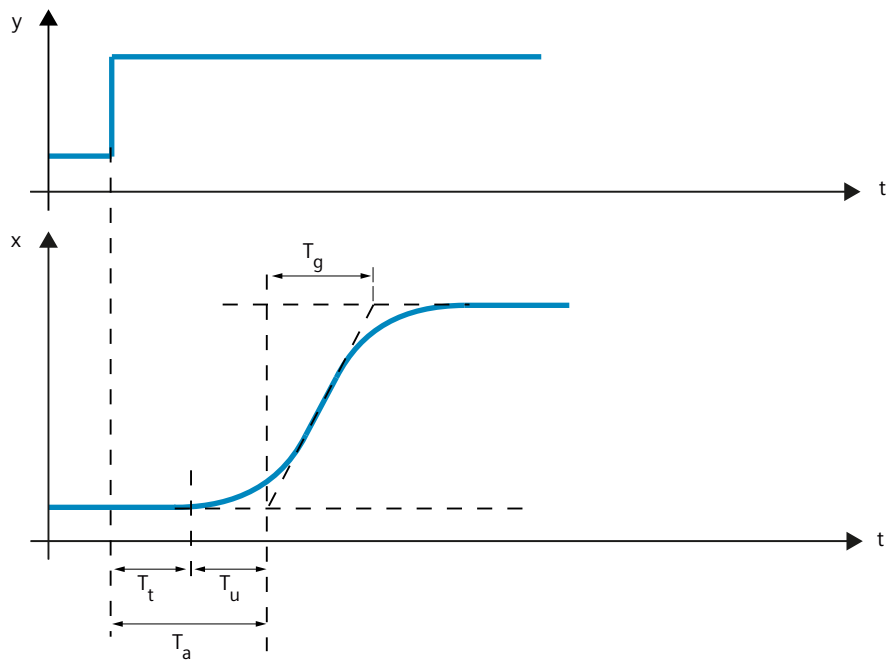

T_t	Dead time
T_u	Delay time
T_g	Recovery time
y	Output value
x	Process value

The controllability of a self-regulating controlled system with dead time is determined by the ratio of T_t to T_g. T_t must be small compared to T_g. Rule:

$T_t/T_g \leq 1$

Response rate of controlled systems

Controlled systems can be judged on the basis of the following values:

$T_u < 0.5$ min, $T_g < 5$ min = fast controlled system

$T_u > 0.5$ min, $T_g > 5$ min = slow controlled system

Parameters of certain controlled systems

Physical quantity	Controlled system	Delay time T_u	Recovery time T_g	Rate of rise v_{max}
Temperature	Small electrically heated furnace	0.5 to 1 min	5 to 15 min	Up to 60 K/min.
	Large electrically heated annealing furnace	1 to 5 min	10 to 20 min	Up to 20 K/min.
	Large gas-heated annealing furnace	0.2 to 5 min	3 to 60 min	1 to 30 K/min
	Distillation tower	1 to 7 min	40 to 60 min	0.1 to 0.5° C/s
	Autoclaves (2.5 m^3)	0.5 to 0.7 min	10 to 20 min	Not specified
	High-pressure autoclaves	12 to 15 min	200 to 300 min	Not specified
	Steam superheater	30 s to 2.5 min	1 to 4 min	2°C/s
	Injection molding machines	0.5 to 3 min	3 to 30 min	5 to 20 K/min
	Extruders	1 to 6 min	5 to 60 min	
	Packaging machines	0.5 to 4 min	3 to 40 min	2 to 35 K/min
	Room heating	1 to 5 min	10 to 60 min	1° C/min
Flow rate	Pipeline with gas	0 to 5 s	0.2 to 10 s	Not relevant
	Pipeline with liquid	None	None	
Pressure	Gas pipeline	None	0.1 s	Not relevant
	Drum boiler with gas or oil firing	None	150 s	Not relevant
	Drum boiler with impact grinding mills	1 to 2 min	2 to 5 min	Not relevant
Vessel level	Drum boiler	0.6 to 1 min	Not specified	0.1 to 0.3 cm/s
Speed	Small electric drive	None	0.2 to 10 s	Not relevant
	Large electric drive	None	5 to 40 s	Not relevant
	Steam turbine	None	Not specified	50 min^{-1}
Voltage	Small generators	None	1 to 5 s	Not relevant
	Large generators	None	5 to 10 s	Not relevant

4.4 Pulse controller

Two-step controllers without feedback

Two-step controllers have the state "ON" and "OFF" as the switching function. This corresponds to 100% or 0% output. This behavior generates a sustained oscillation of process value x around setpoint w.

The amplitude and duration of the oscillation increase in proportion to the ratio between the delay time T_u and recovery time T_g of the controlled system. These controllers are used mainly

for simple temperature control systems (such as electrically directly heated furnaces) or as limit-value signaling units.

The following diagram shows the characteristic of a two-step controller

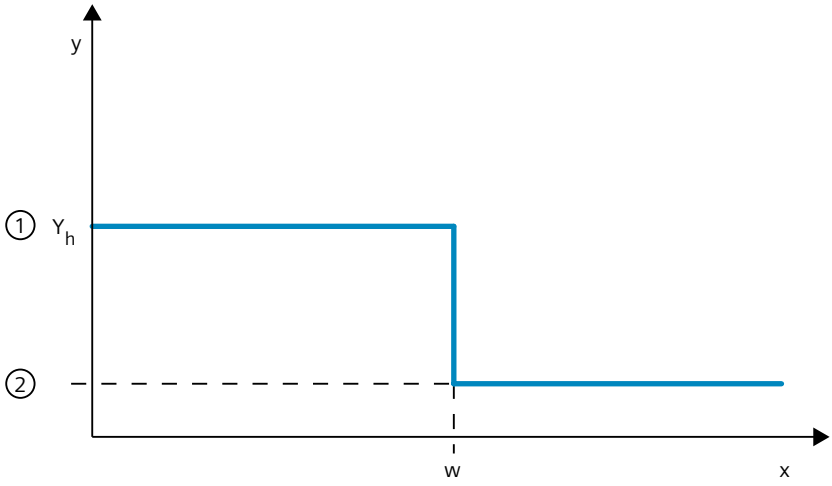

①	ON
②	OFF
Y_h	Control range
w	Setpoint

The following diagram shows the control function of a two-step controller

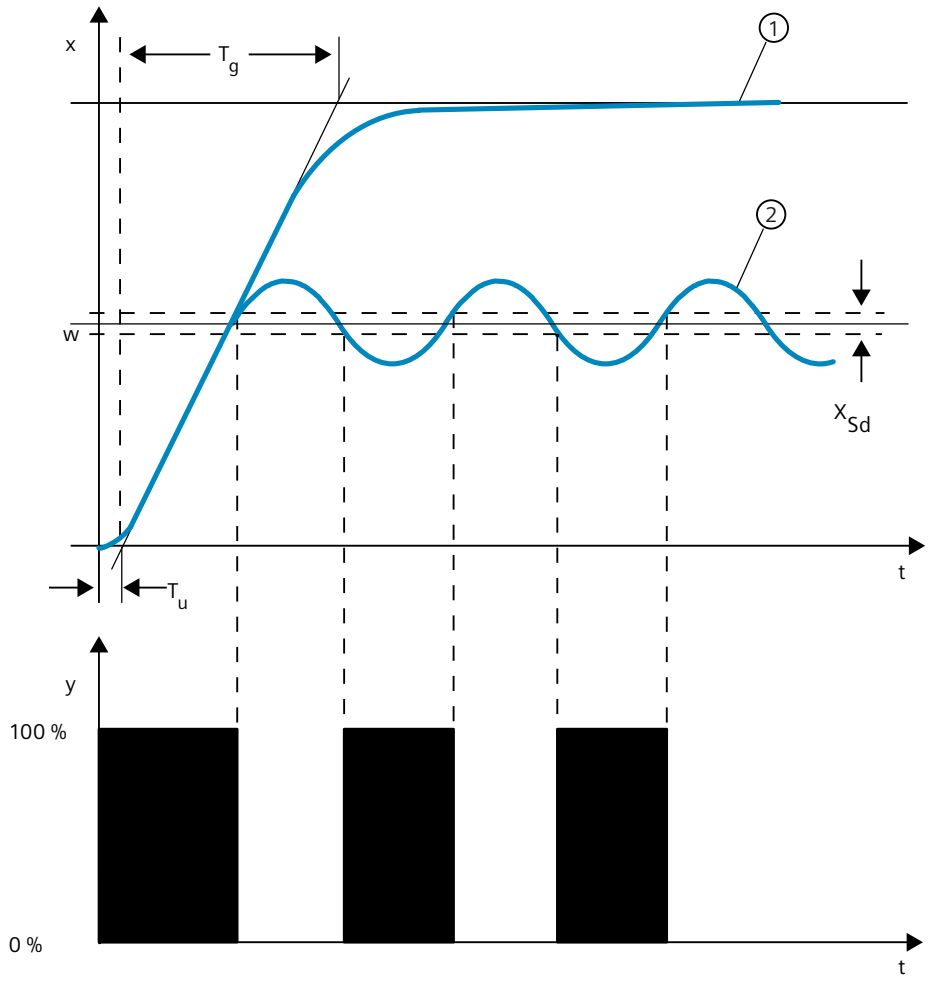

①	Response characteristic without controller
②	Response characteristic with two-step controller
T_u	Delay time
T_g	Recovery time
X_{Sd}	Switching difference

Two-step controllers with feedback

The behavior of two-step controllers in the case of controlled systems with larger delay times, such as furnaces where the functional space is separated from the heating, can be improved by the use of electronic feedback.

The feedback is used to increase the switching frequency of the controller, which reduces the amplitude of the process value. In addition, the control-action results can be improved substantially in dynamic operation. The limit for the switching frequency is set by the output level. It should not exceed 1 to 5 switches per minute at mechanical actuators, such as relays and contactors. In the case of binary voltage and current outputs with downstream thyristor

or Triac controllers high switching frequencies can be selected that exceed the limit frequency of the controlled system by far.

Since the switching pulses can no longer be determined at the output of the controlled system, results comparable with those of continuous controllers are obtained.

The output value is generated by pulse-width modulation of the output value of a continuous controller.

Two-step controllers with feedback are used for temperature control in furnaces, at processing machines in the plastics, textile, paper, rubber and foodstuff industries as well as for heating and cooling devices.

Three-step controllers

Three-step controllers are used for heating / cooling. These controllers have two switching points as their output. The control-action results are optimized through electronic feedback structures. Fields of applications for such controllers are heating, low-temperature, climatic chambers and tool heating units for plastic-processing machines.

The following diagram shows the characteristic of a three-step controller

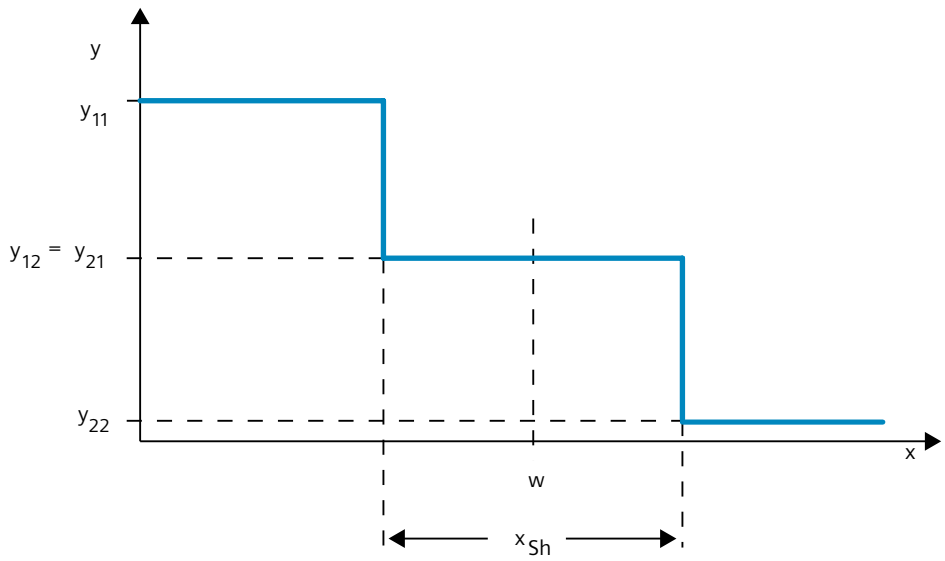

y	Output value, e.g. y11 = 100% heating y12 = 0% heating y21 = 0% cooling y22 = 100% cooling
x	Physical quantity of the process value, e.g., temperature in° C
w	Setpoint
x_{Sh}	Distance between Switching Point 1 and Switching Point 2

4.5 Response to setpoint changes and disturbances

Response to setpoint changes

The process value should follow a setpoint change as quickly as possible. The response to setpoint changes is improved by minimizing fluctuation of the process value and the time required to reach the new setpoint.

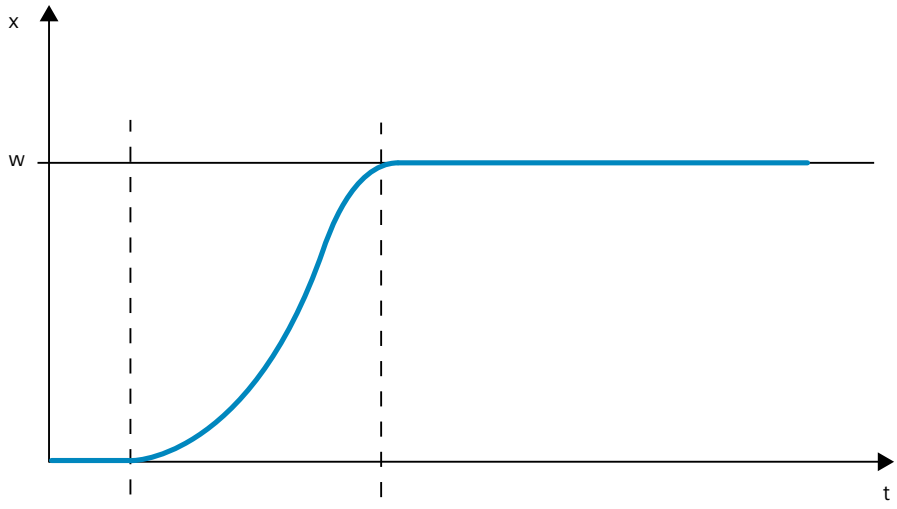

x Process value

w Setpoint

Response to disturbances

The setpoint is influenced by disturbance variables. The controller has to eliminate the resulting control deviations in the shortest time possible. The response to disturbances is improved by minimizing fluctuation of the process value and the time required to reach the new setpoint.

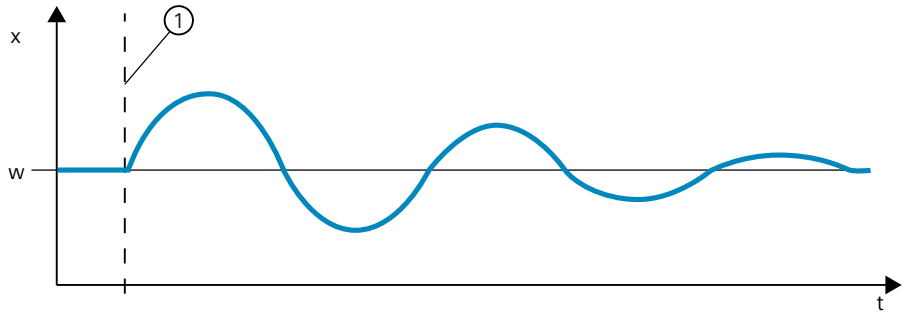

x Process value

w Setpoint

① Influencing a disturbance variable

Disturbance variables are corrected by a controller with integral action. A persistent disturbance variable does not reduce control quality because the control deviation is relatively constant. Dynamic disturbance variables have a more significant impact on control

quality because of control deviation fluctuation. The control deviation is eliminated again only by means of the slow acting integral action.

A measurable disturbance variable can be included in the controlled system. This inclusion would significantly accelerated the response of the controller.

4.6 Control Response at Different Feedback Structures

Control behavior of controllers

A precise adaptation of the controller to the time response of the controlled system is decisive for the controller's precise settling to the setpoint and optimum response to disturbance variables.

The feedback circuit can have a proportional action (P), proportional-derivative action (PD), proportional-integral action (PI), or proportional-integral-derivative action (PID).

If step functions are to be triggered by control deviations, the step responses of the controllers differ depending on their type.

Step response of a proportional action controller

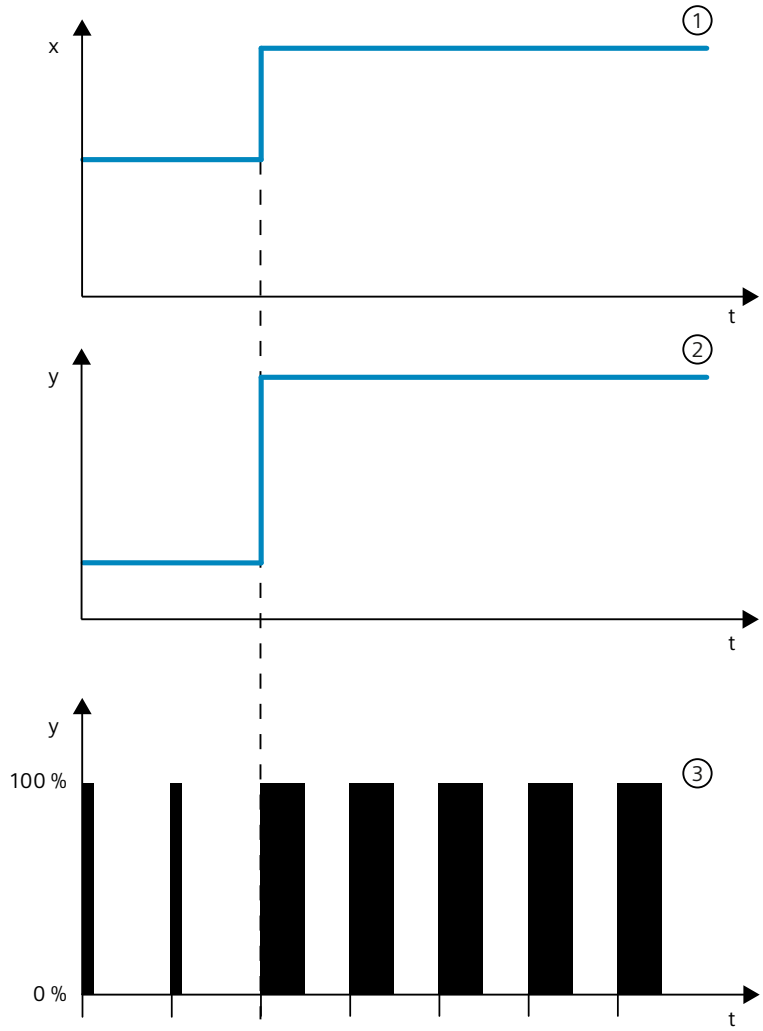

① Control deviation
② Output value of a continuous controller
③ Output value of a pulse controller

Equation for proportional action controller

Output value and control deviation are directly proportional, meaning:

Output value = proportional gain × control deviation

y = GAIN × x

Step response of a PD-action controller

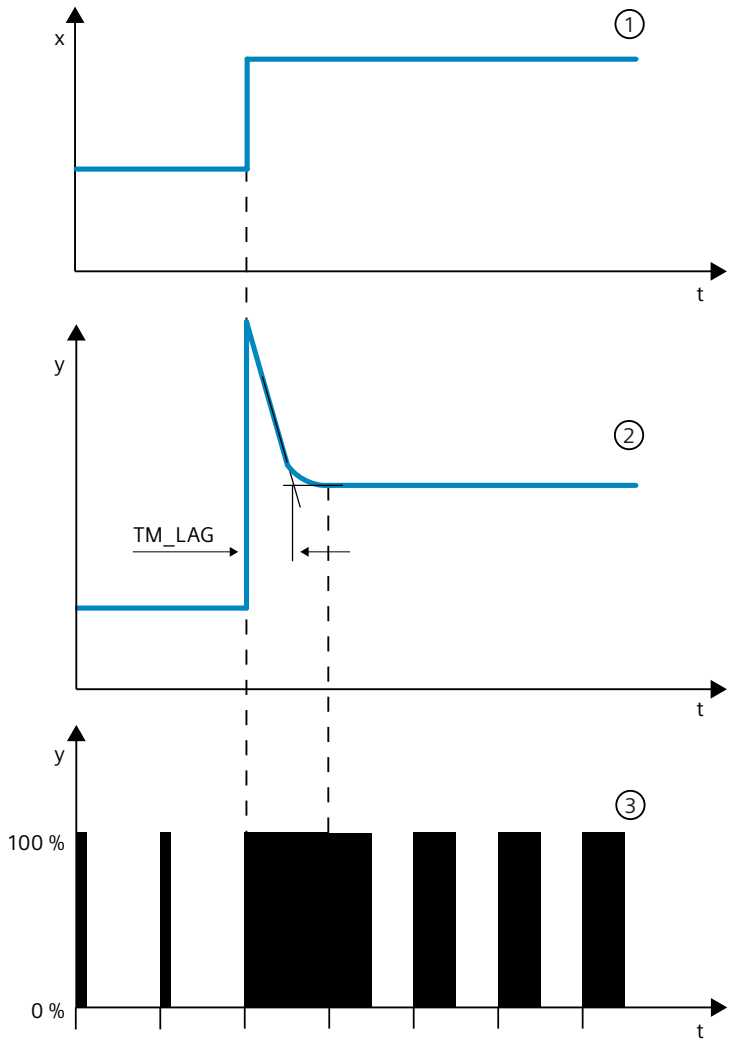

①	Control deviation
②	Output value of a continuous controller
③	Output value of a pulse controller
TM_LAG	Delay of the Derivative action

Equation for PD-action controller

The following applies for the step response of the PD-action controller in the time range:

$$y = GAIN \cdot X_W \cdot \left(1 + \frac{TD}{TM_LAG} \cdot e^{\frac{-t}{TM_LAG}} \right)$$

t = time interval since the step of the control deviation

The derivative action generates a output value as a function of the rate of change of the process value. A derivative action by itself is not suitable for controlling because the output value only follows a step of the process value. As long as the process value remains constant, the output value will no longer change.

The response to disturbances of the derivative action is improved in combination with a proportional action. Disturbances are not corrected completely. The good dynamic response is advantageous. A well attenuated, non-oscillating response is achieved during approach and setpoint change.

A controller with derivative action is not appropriate if a controlled system has pulsing measured quantities, for example, in the case of pressure or flow control systems.

Step response of a PI-action controller

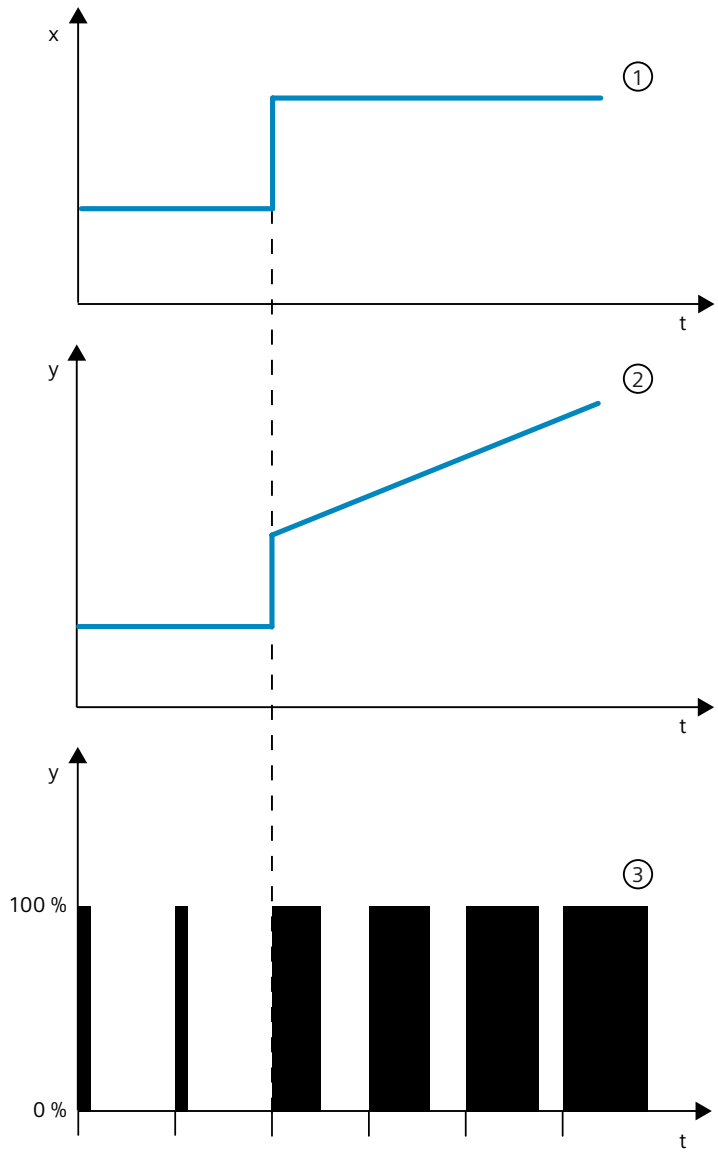

① Control deviation
② Output value of a continuous controller
③ Output value of a pulse controller

An integral action in the controller adds the control deviation as a function of the time. This means that the controller corrects the system until the control deviation is eliminated. A sustained control deviation is generated at controllers with proportional action only. This effect can be eliminated by means of an integral action in the controller.

In practical experience, a combination of the proportional, integral and derivative actions is ideal, depending on the requirements placed on the control response. The time response of the individual components can be described by the controller parameters proportional gain GAIN, integration time TI (integral action), and derivative action time TD (derivative action).

Equation for PI-action controller

The following applies for the step response of the PI-action controller in the time range:

$$y = GAIN \cdot X_W \cdot \left(1 + \frac{1}{TI \cdot t}\right)$$

t = time interval since the step of the control deviation

Step response of a PID controller

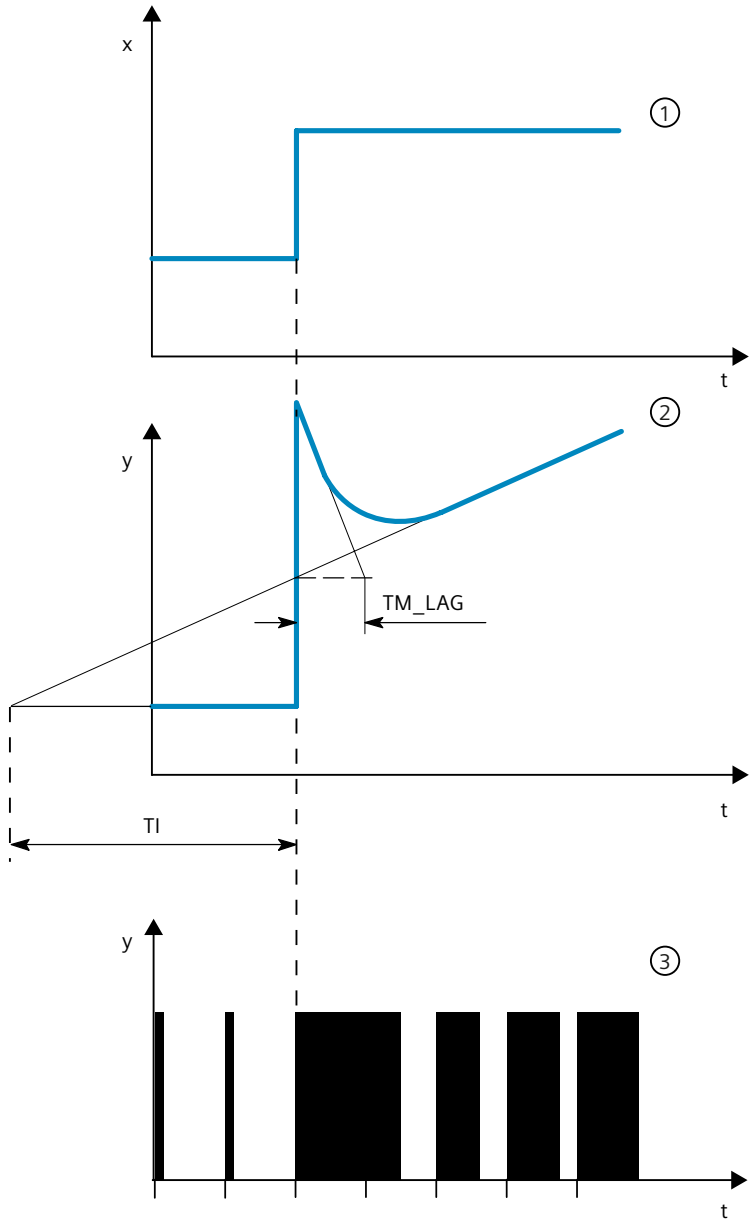

①	Control deviation
②	Output value of a continuous controller
③	Output value of a pulse controller
TM_LAG	Delay of the Derivative action
T_i	Integration time

Equation for PID controller

The following applies for the step response of the PID controller in the time range:

$$y = GAIN \cdot X_w \cdot \left(1 + \frac{1}{TI \cdot t} + \frac{TD}{TM_LAG} \cdot e^{\frac{-t}{TM_LAG}} \right)$$

t = time interval since the step of the control deviation

Response of a controlled system with different controller structures

Most of the controller systems occurring in process engineering can be controlled by means of a controller with PI-action response. In the case of slow controlled system with a large dead time, for example temperature control systems, the control result can be improved by means of a controller with PID action.

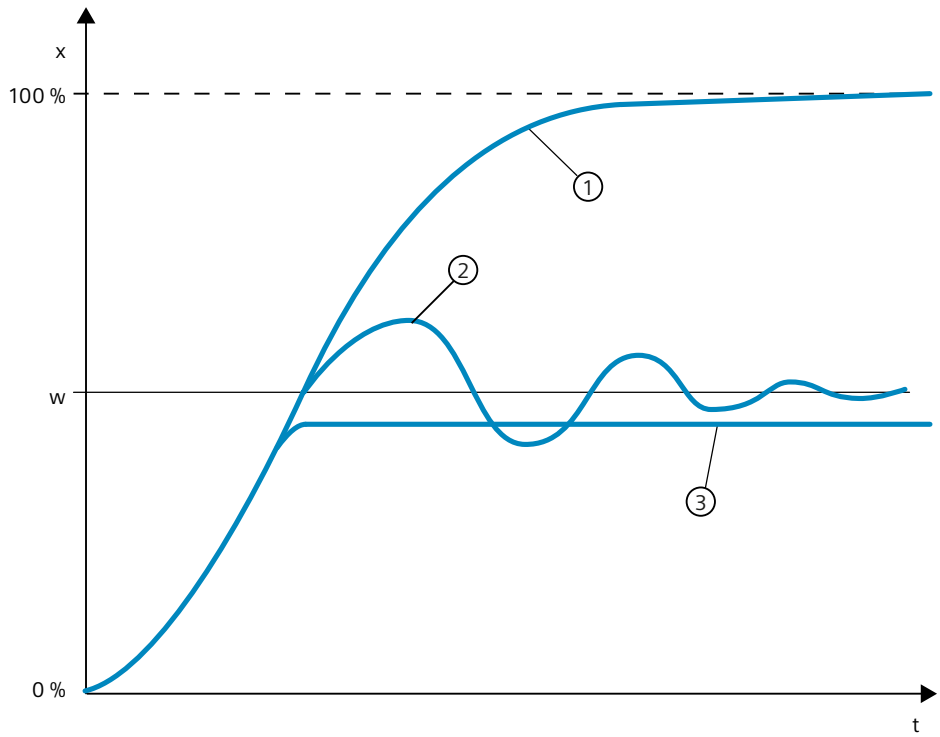

①	No controller
②	PID controller
③	PD-action controller
w	Setpoint
x	Process value

Controllers with PI and PID action have the advantage that the process value does not have any deviation from the setpoint value after settling. The process value oscillates over the setpoint during approach.

4.7 Selection of the controller structure for specified controlled systems

Selection of the Suitable Controller Structures

To achieve optimum control results, select a controller structure that is suitable for the controlled system and that you can adapt to the controlled system within specific limits.

The table below provides an overview of suitable combinations of a controller structure and controlled system.

Controlled system		Controller structure			
		P	**PD**	**PI**	**PID**
	With dead time only	Unsuitable	Unsuitable	Suitable	Unsuitable
	PT1 with dead time	Unsuitable	Unsuitable	Well suited	Well suited
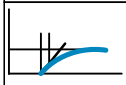	PT2 with dead time	Unsuitable	Suited conditionally	Well suited	Well suited
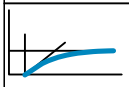	Higher order	Unsuitable	Unsuitable	Suited conditionally	Well suited
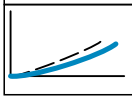	Not self-regulating	Well suited	Well suited	Well suited	Well suited

The table below provides an overview of suitable combinations of a controller structure and physical quantity.

Physical quantity	Controller structure			
	P	**PD**	**PI**	**PID**
	Sustained control deviation		**No sustained control deviation**	
Temperature	For low performance requirements and proportional action controlled systems with T_u/Tg < 0,1	Well suited	The most suitable controller structures for high performance requirements (except for specially adapted special controllers)	
Pressure	Suitable, if the delay time is inconsiderable	Unsuitable	The most suitable controller structures for high performance requirements (except for specially adapted special controllers)	
Flow rate	Unsuitable, because required GAIN range is usually too large	Unsuitable	Suitable, but integral action controller alone often better	Hardly required

4.8 PID parameter settings

Rule of Thumb for the Parameter Setting

Controller structure	Setting
P	GAIN ≈ $v_{max} \times T_u$ [° C]
PI	GAIN ≈ 1.2 × $v_{max} \times T_u$ [° C] TI ≈ 4 × T_u [min]
PD	GAIN ≈ 0.83 × $v_{max} \times T_u$ [° C] TD ≈ 0.25 × $v_{max} \times T_u$ [min] TM_LAG ≈ 0.5 × TD[min]
PID	GAIN ≈ 0.83 × $v_{max} \times T_u$ [° C] TI ≈ 2 × T_u [min] TD ≈ 0.4 × T_u [min] TM_LAG ≈ 0.5 × TD[min]
PD/PID	GAIN ≈ 0.4 × $v_{max} \times T_u$ [° C] TI ≈ 2 × T_u [min] TD ≈ 0.4 × T_u [min] TM_LAG ≈ 0.5 × TD[min]

Instead of $v_{max} = \Delta_x / \Delta_t$, you can use X_{max} / T_g.

In the case of controllers with PID structure the setting of the integral action time and differential-action time is usually coupled with each other.

The ratio TI / TD lies between 4 and 5 and is optimal for most controlled systems.

Non-observance of the differential-action time TD is uncritical at PD controllers.

In the case of PI and PID controllers, control oscillations occur if the integral action time TI has been select by more than half too small.

An integral action time that is too large slows down the settling times of disturbances. One cannot expect that the control loops operate "optimally" after the first parameter settings. Experience shows that adjusting is always necessary, when a system exists that is "difficult to control" with $T_u / T_g > 0.3$.

Configuring a software controller 5

5.1 Overview of software controller

For the configuration of a software controller, you need an instruction with the control algorithm and a technology object. The technology object for a software controller corresponds with the instance DB of the instruction. The configuration of the controller is saved in the technology object. In contrast to the instance DBs of other instructions, technology objects are not stored for the program resources, but rather under CPU > Technology objects.

Technology objects and instructions

CPU	Library	Instruction	Technology object	Description
S7-1200	Compact PID	PID_Compact V1.x	PID_Compact V1.x	Universal PID controller with integrated tuning
S7-1200		PID_3Step V1.x	PID_3Step V1.x	PID controller with integrated tuning for valves
S7-1500 S7-1200 V4.x		PID_Compact V2.x	PID_Compact V2.x	Universal PID controller with integrated tuning
S7-1500 S7-1200 V4.x S7-1200 G2		PID_3Step V2.x	PID_3Step V2.x	PID controller with integrated tuning for valves
S7-1500 ≥ V1.7 S7-1200 ≥ V4.1 S7-1200 G2		PID_Temp V1.x	PID_Temp V1.x	Universal PID temperature controller with integrated tuning
S7-1500 ≥ V3.1 S7-1200 G2		PID_Compact V3.x	PID_Compact V3.x	Universal PID controller with integrated tuning
S7-1500 ≥ V4.1 S7-1200 G2 ≥ V4.1		PID_Temp V2.0	PID_Temp V2.0	Universal PID temperature controller with integrated tuning
S7-1500/300/40-0	PID basic functions	CONT_C	CONT_C	Continuous controller
S7-1500/300/40-0		CONT_S	CONT_S	Step controller for actuators with integrating behavior
S7-1500/300/40-0		PULSEGEN	-	Pulse generator for actuators with proportional behavior
S7-1500/300/40-0		TCONT_CP	TCONT_CP	Continuous temperature controller with pulse generator
S7-1500/300/40-0		TCONT_S	TCONT_S	Temperature controller for actuators with integrating behavior
S7-300/400	PID Self Tuner	TUN_EC	TUN_EC	Optimization of a continuous controller
S7-300/400		TUN_ES	TUN_ES	Optimization of a step controller
S7-300/400	Standard PID Con-	PID_CP	PID_CP	Continuous controller with pulse generator

CPU	Library	Instruction	Technology object	Description
S7-300/400	trol (PID Professional optional package)	PID_ES	PID_ES	Step controller for actuators with integrating behavior
S7-300/400		LP_SCHED	-	Distribute controller calls
S7-300/400	Modular PID Control (PID Professional optional package)	A_DEAD_B	-	Filter interfering signal from control deviation
S7-300/400		CRP_IN	-	Scale analog input signal
S7-300/400		CRP_OUT	-	Scale analog output signal
S7-300/400		DEAD_T	-	Delay output of input signal
S7-300/400		DEADBAND	-	Suppress small fluctuations to the process value
S7-300/400		DIF	-	Differentiate input signals over time
S7-300/400		ERR_MON		Monitor control deviation
S7-300/400		INTEG	-	Integrate input signals over time
S7-300/400		LAG1ST	-	First-order delay element
S7-300/400		LAG2ND	-	Second-order delay element
S7-300/400		LIMALARM	-	Report limit values
S7-300/400		LIMITER	-	Limiting the manipulated variable
S7-300/400		LMNGEN_C	-	Determine manipulated variable for continuous controller
S7-300/400		LMNGEN_S	-	Determine manipulated variable for step controller
S7-300/400		NONLIN	-	Linearize encoder signal
S7-300/400		NORM	-	Scale process value physically
S7-300/400		OVERRIDE	-	Switch manipulated variable from 2 PID controllers to 1 actuator
S7-300/400		PARA_CTL	-	Switch parameter sets
S7-300/400		PID	-	PID algorithm
S7-300/400		PUSLEGEN_M	-	Generate pulse for proportional actuators
S7-300/400		RMP_SOAK	-	Specify setpoint according to ramp / soak
S7-300/400		ROC_LIM	-	Limit rate of change
S7-300/400		SCALE_M	-	Scale process value
S7-300/400		SP_GEN	-	Specify setpoint manually
S7-300/400		SPLT_RAN	-	Split manipulated variable range
S7-300/400		SWITCH	-	Switch analog values
S7-300/400		LP_SCHED_M	-	Distribute controller calls

5.2 Steps for the configuration of a software controller

All SW-controllers are configured according to the same scheme:

Step	Description
1	Add technology object (Page 43)
2	Configure technology object (Page 44)
3	Call instruction in the user program (Page 45)
4	Download technology object to device (Page 46)
5	Commission software controller (Page 47)
6	Save optimized PID parameters in the project (Page 47)
7	Comparing values (Page 51)
8	Display instances of a technology object (Page 73)

5.3 Add technology objects

Add technology object in the project navigator

When a technology object is added, an instance DB is created for the instruction of this technology object. The configuration of the technology object is stored in this instance DB.

Requirement

A project with a CPU has been created.

Procedure

To add a technology object, proceed as follows:

1. Open the CPU folder in the project tree.
2. Open the "Technology objects" folder.
3. Double-click "Add new object".
   The "Add new object" dialog box opens.
4. Click on the "PID" button.
   All available PID controllers for this CPU are displayed.
5. Select the instruction for the technology object, for example, PID_Compact.
6. Enter an individual name for the technology object in the "Name" input field.
7. Select the "Manual" option if you want to change the suggested data block number of the instance DB.
8. Click "Further information" if you want to add own information to the technology object.
9. Confirm with "OK".

Result

The new technology object has been created and stored in the project tree in the "Technology objects" folder. The technology object is used if the instruction for this technology object is called in a cyclic interrupt OB.

NOTE

You can select the "Add new and open" check box at the bottom of the dialog box. This opens the configuration of the technology object after adding has been completed.

5.4 Configure technology objects

The properties of technology objects PID_Compact, PID_3Step and PID_Temp can be configured in two ways.

- In the Inspector window of the programming editor
- In the configuration editor

The properties of other technology objects for PID control can only be configured in the Configuration Editor.

Inspector window of the programming editor

In the Inspector window of the programming editor you can only configure the parameters required for operation.

The offline values of the parameters are also shown in online mode. You can only change the online values in the commissioning window.

To open the Inspector window of the technology object, follow these steps:

1. Open the "Program blocks" folder in the project tree.
2. Double-click the block (cyclic interrupt OB) in which you open the instruction of the SW controller.
   The block is opened in the work area.
3. Click on the instruction of the SW controller.
4. In the Inspector window, select the "Properties" and "Configuration" tabs consecutively.

Configuration window

For each technology object, there is a specific configuration window in which you can configure all properties.

To open the configuration window of the technology object, follow these steps:

1. Open the "Technology objects" folder in the project tree.
2. Open the technology object in the project tree.
3. Double-click the "Configuration" object.

Symbols

Icons in the area navigation of the configuration and in the Inspector window show additional details about the completeness of the configuration:

	The configuration contains default values and is complete. The configuration exclusively contains default values. With these default values the use of the technology object is possible without further changes.
	The configuration contains user-defined or automatically adjusted values and is complete. All input fields of the configuration contain valid values and at least one default setting was changed.
	The configuration is incomplete or faulty. At least one input field or a collapsible list contains no value or an invalid value. The corresponding field or the drop-down list box has a red background. When clicked, the roll-out error message indicates the cause of the error.

The properties of a technology object are described in detail in the section for the technology object.

5.5 Call instruction in the user program

The instruction of the software controller must be called in a cyclic interrupt OB. The sampling time of the software controller is determined by the interval between the calls in the cyclic interrupt OB.

Requirement

The cyclic interrupt OB is created and the cycle time of the cyclic interrupt OB is correctly configured.

Procedure

Proceed as follows to call the instruction in the user program:

1. Open the CPU folder in the project tree.
2. Open the "Program blocks" folder.
3. Double-click the cyclic interrupt OB.
   The block is opened in the work area.
4. Open the "Technology" group in the "Instructions" window and the "PID Control" folder.
   The folder contains all instructions for software controllers that can be configured on the CPU.
5. Select the instruction and drag it to your cyclic interrupt OB.
   The "Call options" dialog box opens.
6. Select a technology object or type the name for a new technology object from the "Name" list.

Result

If the technology object does not exist yet, it is added. The instruction is added in the cyclic interrupt OB. The technology object is assigned to this call of the instruction.

5.6 Downloading technology objects to device

A new or modified configuration of the technology object must be downloaded to the CPU for the online mode. The following characteristics apply when downloading retentive data:

- **Software (changes only)**
  - S7-1200, S7-1200 G2, S7-1500:
    Retentive data is retained.
  - S7-300/400:
    Retentive data is updated immediately. CPU does not change to STOP.
- **Download PLC program to device and reset**
  - S7-1200, S7-1200 G2, S7-1500:
    Retentive data is updated at the next change from STOP to RUN. The PLC program can only be downloaded completely.
  - S7-300/400:
    Retentive data is updated at the next change from STOP to RUN.

Downloading retentive data to an CPU S7-1200, S7-1200 G2 or S7-1500

NOTE

The download and reset of the PLC program during ongoing system operation can result in serious damages or injuries in the case of malfunctions or program errors.

Make sure that dangerous states cannot occur before you download and reset the PLC program.

Proceed as follows to download the retentive data:

1. Select the entry of the CPU in the project tree.
2. Select the command "Download and reset PLC program" from the "Online" menu.
   - If you have not established an online connection yet, the "Extended download" dialog opens. In this case, set all required parameters for the connection and click "Download".
   - If the online connection has been defined, the project data is compiled, if necessary, and the dialog "Load preview" opens. This dialog displays messages and recommends actions necessary for download.
3. Check the messages.

   As soon as download is possible, the "Download" button becomes active.
4. Click on "Download".

   The complete PLC program is downloaded and the "Load results" dialog opens. This dialog displays the status and the actions after the download.

5. If the modules are to restart immediately after the download, select the check box "Start all".
6. Close the dialog "Download results" with "Finish".

Result

The complete PLC program is downloaded to the device. Blocks that only exist online in the device are deleted. By downloading all affected blocks and by deleting any blocks in the device that are not required, you avoid inconsistencies between the blocks in the user program.

The messages under "Info > General" in the Inspector window indicate whether the download was successful.

5.7 Commissioning software controller

Procedure

To open the "Commissioning" work area of the technology object, follow these steps:

1. Open the "Technology objects" folder in the project tree.
2. Open the technology object in the project tree.
3. Double-click the "Commissioning" object.

The commissioning functions are specific for each controller and are described there.

5.8 Save optimized PID parameter in the project

The software controller is optimized in the CPU. Through this, the values in the instance-DB on the CPU no longer agree with those in the project.

To update the PID parameter in the project with the optimized PID parameters, proceed as follows:

Requirement

- An online connection to the CPU is established and the CPU is in "RUN" mode.
- The functions of the commissioning window have been enabled by means of the "Start" button.

Procedure

1. Open the CPU folder in the project tree.
2. Open the "Technology objects" folder.
3. Open a technology object.
4. Double click on "Commissioning".
5. Click on the icon "Upload PID parameters".
6. Save the project.

Result

The currently active PID parameters are stored in the project data. When reloading the project data in the CPU, the optimized parameters are used.

5.9 Working with multi-instance objects

If a function block (FB) calls another FB, its instance data can also be saved in the instance DB of the calling FB. This type of block call is referred to as a multi-instance. The PID software controllers support this type of call and can be used as multi-instance.

Advantages

The use of multi-instances offers the following advantages:

- Good structuring possibility
- Lower number of instance DBs
- Individually configured FBs as template for a software controller than you can instantiate as often as you wish

Restrictions

When using multi-instances for PID software controllers, the following restrictions are in place compared to using a single instance:

- No support of Openness for PID multi-instance objects
- No comparison of PID multi-instance objects in a comparison editor. Comparison is only possible via the block containing the multi-instance objects.
- No technology object-specific Inspector window of the programming editor for calling the PID_Compact, PID_3Step and PID_Temp instructions

Configuration of multi-instance objects

The configuration and commissioning of PID multi-instance objects is not opened via the "Technology objects" folder in the project tree, as is the case with single-instance objects. For multi-instance objects, you can find configuration and commissioning in the "Technology objects" tab of the detail view.

To open the configuration of multi-instance objects, follow these steps:

1. Select the FB or instance DB with the multi-instance object in the project tree.
2. Click on the "Technology objects" tab in the detail view.
3. Navigate to the desired multi-instance object.
4. Open the configuration of the multi-instance object.

NOTE

The configuration editor does not offer online functionality for multi-instance objects in an FB. Instance DBs do not have this restriction.

Commissioning of multi-instance objects

To open the commissioning of multi-instance objects, follow these steps:

1. Select the instance DB with the multi-instance object in the project tree.
2. Click on the "Technology objects" tab in the detail view.
3. Navigate to the desired multi-instance object.
4. Open the commissioning of the multi-instance object.

This functionality is not available for PID multi-instance objects in FBs.

NOTE

If PID multi-instance objects are in an array, you can only navigate to these multi-instance objects in the detail view if the number of array elements does not exceed 100. For arrays with more than 100 elements, the individual PID multi-instance objects are not displayed and the editors for configuration and commissioning are not available.

Example for the use of PID multi-instance objects

To use PID multi-instance objects for your application, you can do the following:

1. Add a function block to your program.
2. Call one or multiple suitable PID controllers with the "Multi-instance" call option in this FB.
3. Add your own application-dependent functionality in the same FB, for example, pre-processing of the setpoint.
4. Select the FB in the project tree and then open the configuration editors of the PID multi-instance objects via the "Technology objects" tab of the detail view.

5. Perform the configuration, which should be identical for all instances of the FB, in the configuration editors.
6. Close the configuration editors.
7. Instantiate the FB as required in the user program so that instance DBs are created.
8. Select one of these instance DBs in the project tree and then open the configuration editors of the PID multi-instance objects via the "Technology objects" tab of the detail view.
9. Perform the configuration, which is individual for this instance DB, in the configuration editors.
10. Close the configuration editors.
11. Repeat steps 8 to 10 for the other instance DBs with PID multi-instance objects.
12. Compile the program, load it into the device and set up an online connection.
13. Select an instance DB that contains PID multi-instance objects in the project tree and then open the commissioning editors of the PID multi-instance objects via the "Technology objects" tab of the detail view.
14. Commission the PID multi-instance objects.
15. Close the commissioning editors.
16. Repeat steps 13 to 15 for the other instance DBs with PID multi-instance objects.

5.10 Comparing values

5.10.1 Comparison display and boundary conditions

The "Compare values" function provides the following options:

- Comparison of configured start values of the project with the start values in the CPU and the actual values
- Direct editing of actual values and the start values of the project
- Immediate detection and display of input errors with suggested corrections
- Backup of actual values in the project
- Transfer of start values of the project to the CPU as actual values

Icons and operator controls

The following icons and operator controls are available:

Icon	Function
	Start value in CPU is equal to the configured Start value in project
	Start value in CPU is not equal to the configured Start value in project
	The comparison of the Start value in CPU with the configured Start value in project cannot be performed
	At least one of the two comparison values has a process-related or syntax error.
	Create snapshot of monitor values and accept setpoints of this snapshot as start values
	Load start values of setpoints as actual values (initialize setpoints)
	Opens the "Compare values" dialog

Boundary conditions

The "Compare values" function is available for S7-1200, S7-1200 G2 and S7-1500 without limitations.

The following limitation applies to S7-300 and S7-400:

In monitoring mode, an S7-300/S7-400 cannot transfer the start values to the CPU. These values cannot be displayed online with "Compare values".

The actual values of the technology object are displayed and can be changed directly.

5.10.2 Comparing values

The procedure is shown in the following using "PID Parameters" as an example.

Requirements

- A project with a software controller is configured.
- The project is downloaded to the CPU.
- The configuration dialog is open in the project navigator.

Procedure

1. Open a software controller in the project navigation.
2. Double-click the "Configuration" object.
3. Navigate within the configuration window to the "PID Parameters" dialog.
4. Click the icon to activate monitoring mode.

   The icons and operator controls (Page 50) of the "Compare values" function are shown behind the parameters.

5. To change values in the "PID parameters" dialog, select the "Enable manual input" check box.
6. Click in the input field of a parameter and enter the new parameter value.

   If the background of the input field is gray, you can only read the values, not change them.
7. Click the icon to open the dialog for the start values.

   This dialog indicates two values of the parameter:
   – Start value in CPU: The start value in the CPU is shown in the top part.
   – Start value in the project: The configured start value in the project is shown in the bottom part.
8. Enter the desired value in the input box for the project.

Error detection

The input of incorrect values is detected. Corrections are suggested in this case.

If you enter a value with incorrect syntax, a rollout containing the corresponding error message opens below the parameter. The incorrect value is not applied.

If you enter a value that is incorrect for the process, a dialog opens containing the error message and a suggested correction:

- Click "No" to accept this suggested correction and correct your input.
- Click "OK" to apply the incorrect value.

NOTICE
Malfunction of the controller Values incorrect for the process can result in controller malfunctions.

Backing up actual values

Click the icon to transfer the actual controller values to the start values of your configured project.

Transferring project values to the CPU

Click the icon to transfer the configured values of your project to the CPU.

> **CAUTION**
>
> **Prevent personal injury and property damage!**
>
> Downloading and resetting of the user program while the plant is operating may result in significant property damage and severe personal injuries in the event of malfunctions or program errors.
>
> Make sure that dangerous states cannot occur before you download and reset the user program.

5.11 Parameter view

5.11.1 Introduction to the parameter view

The Parameter view provides you with a general overview of all relevant parameters of a technology object. You obtain an overview of the parameter settings and can easily change them in offline and online mode.

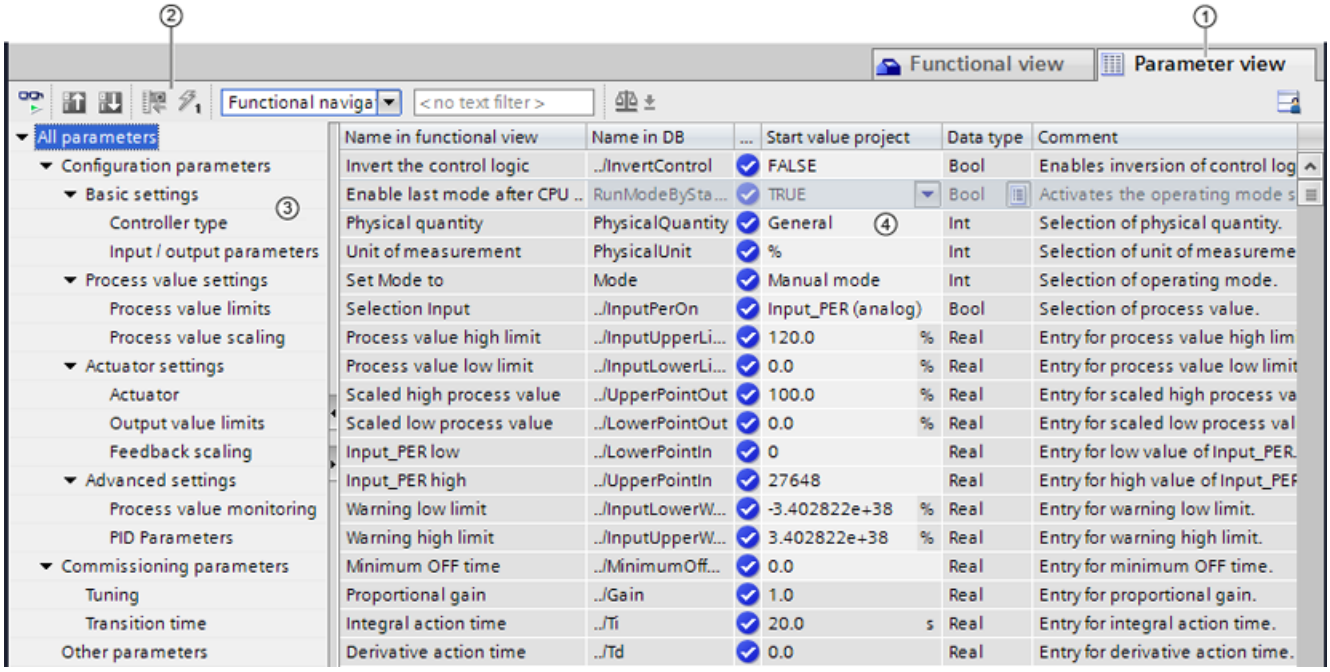

① "Parameter view" tab

② Toolbar (Page 55)

③ Navigation (Page 56)

④ Parameter table (Page 56)

Function scope

The following functions are available for analyzing the parameters of the technology objects and for enabling targeted monitoring and modification.

Display functions**:**

- Display of parameter values in offline and online mode
- Display of status information of the parameters
- Display of value deviations and option for direct correction
- Display of configuration errors
- Display of value changes as a result of parameter dependencies
- Display of all memory values of a parameter: Start value PLC, Start value project, Monitor value
- Display of the parameter comparison of the memory values of a parameter

Operator control functions:

- Navigation for quickly changing between the parameters and parameter structures.
- Text filter for faster searches for particular parameters.
- Sorting function for customizing the order of parameters and parameter groups to requirements.
- Memory function for backing up structural settings of the Parameter view.
- Monitoring and modifying of parameter values online.
- Change display format of value.
- Function for saving a snapshot of parameter values of the CPU in order to capture momentary situations and to respond to them.
- Function for applying a snapshot of parameter values as start values.
- Download of modified start values to the CPU.
- Comparison functions for comparing parameter values with one another.

Validity

The Parameter view described here is available for the following technology objects:

- Motion Control
  - TO_Positioning_Axis_PTO (S7-1200 G2 Motion Control)
  - TO_CommandTable_PTO (S7-1200 G2 Motion Control)
  - TO_Positioning_Axis (S7-1200 Motion Control)
  - TO_CommandTable (S7-1200 Motion Control)
  - TO_Axis_PTO (S7-1200 Motion Control)
  - TO_CommandTable_PTO (S7-1200 Motion Control)

- PID
  - PID_Compact
  - PID_3Step
  - PID_Temp
  - CONT_C (S7-1500 only)
  - CONT_S (S7-1500 only)
  - TCONT_CP (S7-1500 only)
  - TCONT_S (S7-1500 only)

5.11.2 Structure of the parameter view

5.11.2.1 Toolbar

The following functions can be selected in the toolbar of the parameter view.

Icon	Function	Explanation
	Monitor all	Starts the monitoring of visible parameters in the active Parameter view (online mode).
	Create snapshot of monitor values and accept setpoints of this snapshot as start values	Applies the current monitor values to the “Snapshot” column and updates the start values in the project. Only in online mode for PID_Compact, PID_3Step and PID_Temp.
	Load start values of setpoints as actual values (initialize setpoints)	Transfers the start values updated in the project to the CPU. Only in online mode for PID_Compact, PID_3Step and PID_Temp.
	Create snapshot of monitor values	Applies the current monitor values to the “Snapshot” column. Only in online mode.
	Modify all selected parameters immediately and once	This command is executed once and as quickly as possible without reference to any particular point in the user program. Only in online mode.
Functional naviga	Select navigation structure	Toggles between functional navigation and data navigation.
< no text filter >	Text filter...	After entry of a character string: Display of all parameters containing the specified string in one of the currently visible columns.
	Selection of compare values	Selection of parameter values that are to be compared with one another in online mode (Start value in project, Start value in PLC, Snapshot) Only in online mode.
	Save window settings	Saves your display settings for the Parameter view (e.g., selected navigation structure, activated table columns, etc.)

5.11.2.2 Navigation

Within the "Parameter view" tab, the following alternative navigation structures can be selected.

Navigation		Explanation
Functional navigation	All parameters Configuration parameters Commissioning parameters Other parameters	In the functional navigation, the structure of the parameters is based on the structure in the configuration dialog ("Functional view" tab), commissioning dialog, and diagnostics dialog. The last group "Other parameters" contains all other parameters of the technology object.
Data navigation	All parameters Input Output InOut Static Other parameters	In the data navigation, the structure of the parameters is based on the structure in the instance DB / technology DB. The last group "Other parameters" contains the parameters that are not contained in the instance DB / technology DB.

You can use the "Select navigation structure" drop-down list to toggle the navigation structure.

5.11.2.3 Parameter table

The table below shows the meaning of the individual columns of the parameter table. You can show or hide the columns as required.

- Column "Offline" = X: Column is visible in offline mode.
- Column "Online" = X: Column is visible in online mode (online connection to the CPU).

Column	Explanation	Offline	Online
Name in functional view	Name of the parameter in the functional view. The display field is empty for parameters that are not configured via the technology object.	X	X
Full name in DB	Complete path of the parameter in the instance DB / technology DB. The display field is empty for parameters that are not contained in the instance DB / technology DB.	X	X
Name in DB	Name of the parameter in the instance DB / technology DB. If the parameter is part of a structure or UDT, the prefix ". ./" is added. The display field is empty for parameters that are not contained in the instance DB / technology DB.	X	X
Status of configuration	Display of the completeness of the configuration using status symbols. see Status of configuration (offline) (Page 65)	X	
Compare result	Result of the "Compare values" function. This column is shown if there is an online connection and the "Monitor all" button is selected.		X
Start value project	Configured start value in the project. Error indication if entered values have a syntax or process-related error.	X	X
Default value	Value that is pre-assigned to the parameter. The display field is empty for parameters that are not contained in the instance DB / technology DB.	X	X

Column	Explanation	Offline	Online
Snapshot	Snapshot of the current values in the CPU (monitor values). Error indication if values have a process-related error.	X	X
Start value PLC	Start value in the CPU. This column is shown if there is an online connection and the "Monitor all" button is selected. Error indication if values have a process-related error.		X
Monitor value	Current value in the CPU. This column is shown if there is an online connection and the "Monitor all" button is selected. Error indication if values have a process-related error.		X
Modify value	Value that is to be used to change the monitor valuet. This column is shown if there is an online connection and the "Monitor all" button is selected. Error indication if entered values have a syntax or process-related error.		X
Selection for transmission	Selection of the Modify values that are to be transmitted using the "Modify all selected parameters immediately and once" button. This column is displayed together with the "Modify value" column.		X
Minimum value	Minimum process-related value of the parameter. If the minimum value is dependent on other parameters, it is defined: • Offline: By the Start value project. • Online: By the Monitor values.	X	X
Maximum value	Maximum process-related value of the parameter. If the maximum value is dependent on other parameters, it is defined: • Offline: By the Start value project. • Online: By the Monitor values.	X	X
Setpoint	Designates the parameter as a setpoint. These parameters can be initialized online.	X	X
Data type	Data type of the parameter. The display field is empty for parameters that are not contained in the instance DB / technology DB.	X	X
Retain	Designates the value as a retentive value. The values of retentive parameters are retained even after the voltage supply is switched off.	X	X
Accessible from HMI	Indicates whether the HMI can access this parameter during runtime.	X	X
Visible in HMI	Indicates whether the parameter is visible in the selection list of the HMI by default.	X	X
Comment	Brief description of the parameter.	X	X

See also

Comparing values (Page 50)

5.11.3 Opening the parameter view

Requirement

The technology object has been added in the project tree, i.e., the associated instance DB / technology DB of the instruction has been created.

Procedure

1. Open the "Technology objects" folder in the project tree.
2. Open the technology object in the project tree.
3. Double-click the "Configuration" object.
4. Select the "Parameter view" tab in the top right corner.

Result

The Parameter view opens. Each displayed parameter is represented by one row in the parameter table.

The displayable parameter properties (table columns) vary depending on whether you are working with the Parameter view in offline or online mode.

In addition, you can selectively display and hide individual table columns.

See also

Default setting of the parameter view (Page 58)

5.11.4 Default setting of the parameter view

Default settings

To enable you to work efficiently with the Parameter view, you can customize the parameter display and save your settings.

The following customizations are possible and can be saved:

- Show and hide columns
- Change column width
- Change order of the columns
- Toggle navigation
- Select parameter group in the navigation
- Selection of compare values

Show and hide columns

To show or hide columns in the parameter table, follow these steps:

1. Position the cursor in the header of the parameter table.
2. Select the "Show/Hide" command in the shortcut menu.
   The selection of available columns is displayed.
3. To show a column, select the check box for the column.
4. To hide a column, clear the check box for the column.

or

1. Position the cursor in the header of the parameter table.
2. Select the "Show all columns" command in the shortcut menu if all columns of the offline or online mode are to be displayed.

Some columns can only be displayed in online mode: see Parameter table (Page 56).

Change column width

To customize the width of a column so that all texts in the rows can be read, follow these steps:

1. Position the cursor in the header of the parameter table to the right of the column to be customized until the shape of the cursor changes to a cross.
2. Then double-click this location.

or

1. Open the shortcut menu on the header of the parameter table.
2. Click
   - "Optimize column width" or
   - "Optimize width of all columns".

If the column width setting is too narrow, the complete content of individual fields are shown if you hover the cursor briefly over the relevant field.

Change order of the columns

The columns of the parameter table can be arranged in any way.

To change the order of the columns, follow these steps:

1. Click on the column header and use a drag-and-drop operation to move it to the desired location.

   When you release the mouse button, the column is anchored to the new position.

Toggle navigation

To toggle the display form of the parameters, follow these steps:

1. Select the desired navigation in the “Select navigation structure” drop-down list.
   - Data navigation
   - Functional navigation

See also Navigation (Page 56).

Select parameter group in the navigation

Within the selected navigation, you choose between the “All parameters” display or the display of a subordinate parameter group of your choice.

1. Click the desired parameter group in the navigation.

   The parameter table only displays the parameters of the parameter group.

Selection of compare values (online)

To set the compare values for the “Compare values” function, follow these steps:

1. Select the desired compare values in the “Selection of compare values” drop-down list.
   - Start value project / Start value PLC
   - Start value project / Snapshot
   - Start value PLC / Snapshot

The “Start value project / Start value PLC” option is set by default.

Saving the default setting of the Parameter view

To save the above customizations of the Parameter view, follow these steps:

1. Customize the Parameter view according to your requirements.
2. Click the “Save window settings” button at the top right of the Parameter view.

5.11.5 Working with the parameter view

5.11.5.1 Overview

The following table provides an overview of the functions of the Parameter view in online and offline mode described in the following.

- Column "Offline" = X: This function is possible in offline mode.
- Column "Online" = X: This function is possible in online mode.

Function/action	Offline	Online
Filtering the parameter table (Page 61)	X	X
Sorting the parameter table (Page 62)	X	X
Transferring parameter data to other editors (Page 62)	X	X
Indicating errors (Page 63)	X	X
Editing start values in the project (Page 63)	X	X
Status of configuration (offline) (Page 65)	X	
Monitoring values online in the parameter view (Page 65)		X
Create snapshot of monitor values (Page 67)		X
Modifying values (Page 68)		X
Comparing values (Page 70)		X
Applying values from the online program as start values (Page 71)		X
Initializing setpoints in the online program (Page 72)		X

5.11.5.2 Filtering the parameter table

You can filter the parameters in the parameter table in the following ways:

- With the text filter
- With the subgroups of the navigation

Both filter methods can be used simultaneously.

With the text filter

Texts that are visible in the parameter table can be filtered. This means only texts in displayed parameter rows and columns can be filtered.

1. Enter the desired character string for filtering in the “Text filter...” input box.

   The parameter table displays only the parameters containing the character string.

The text filtering is reset.

- When another parameter group is selected in the navigation.
- When navigation is changed from data navigation to functional navigation, or vice versa.

With the subgroups of the navigation

1. Click the desired parameter group in the navigation, e.g., "Static".

   The parameter table only shows the static parameters. You can select further subgroups for some groups of the navigation.
2. Click “All parameters” in the navigation if all parameters are to be shown again.

5.11.5.3 Sorting the parameter table

The values of the parameters are arranged in rows. The parameter table can be sorted by any displayed column.

- In columns containing numerical values, sorting is based on the magnitude of the numerical value.
- In text columns, sorting is alphabetical.

Sorting by column

1. Position the cursor in the header cell of the desired column.

   The background of this cell turns blue.
2. Click the column header.

Result

The entire parameter table is sorted by the selected column. A triangle with tip facing up appears in the column header.

Clicking the column header again changes the sorting as follows:

- Symbol “▲”: Parameter table is sorted in ascending order.
- Symbol “▼”: Parameter table is sorted in descending order.
- No symbol: The sorting is removed again. The parameter table assumes the default display.

The “../” prefix in the “Name in DB” column is ignored when sorting.

5.11.5.4 Transferring parameter data to other editors

After selecting an entire parameter row of the parameter table, you can use the following:

- Drag-and-drop
- <Ctrl+C>/<Ctrl+V>
- Copy/Paste via shortcut menu

Transfer parameters to the following editors of the TIA Portal:

- Program editor
- Watch table
- Signal table for trace function

The parameter is inserted with its full name: See information in “Full name in DB” column.

5.11.5.5 Indicating errors

Error indication

Parameter assignment errors that result in compilation errors (e.g. limit violation) are indicated in the Parameter view.

Every time a value is input in the Parameter view, a check is made for process-related and syntax errors and the result is indicated.

Bad values are indicated by:

- Red error symbol in the "Status of configuration" (offline mode) or "Compare result" (online mode, depending on the selected comparison type) columns

and/or

- Table field with red background

  If you click the bad field, a roll-out error message appears with information of the permissible value range or the required syntax (format)

Compilation error

From the error message of the compiler, you can directly open the Parameter view (functional navigation) containing the parameter causing the error in situations where the parameter is not displayed in the configuration dialog.

5.11.5.6 Editing start values in the project

With the Parameter view, you can edit the start values in the project in offline mode and online mode.

- You make value changes in the “Start value project” column of the parameter table.
- In the “Status of configuration” column of the parameter table, the progress of the configuration is indicated by the familiar status symbols from the configuration dialog of the technology object.

Boundary conditions

- If other parameters depend on the parameter whose start value was changed, the start value of the dependent parameters are also adapted.
- If a parameter of a technology object is not editable, it is also not editable in the parameter view. The ability to edit a parameter can also depend on the values of other parameters.

Defining new start values

To define start values for parameters in the Parameter view, follow these steps:

1. Open the Parameter view of the technology object.
2. Enter the desired start values in the "Start value project" column. The value must match the data type of the parameter and must not exceed the value range of the parameter. The limits of the value range can be seen in the “Maximum value” and “Minimum value” columns.

The "Status of configuration" column indicates the progress of the configuration with colored symbols.

See also Status of configuration (offline) (Page 65)

Following adaptation of the start values and downloading of the technology object to the CPU, the parameters take the defined value at startup if they are not declared as retentive (“Retain” column).

Error indication

When a start value is input, a check is made for process-related and syntax errors and the result is indicated.

Bad start values are indicated by:

- Red error symbol in the "Status of configuration" (offline mode) or "Compare result" (online mode, depending on the selected comparison type) columns

and/or

- Red background in the “Start value project” field
  If you click on the bad field, a roll-out error message appears with information of the permissible value range or the necessary syntax (format)

Correcting bad start values

1. Correct bad start values using information from the roll-out error message.

   Red error symbol, red field background, and roll-out error message are no longer displayed.

The project cannot be successfully compiled unless the start values are error-free.

5.11.5.7 Status of configuration (offline)

The status of the configuration is indicated by icons:

- In the “Status of configuration” column in the parameter table
- In the navigation structure of the functional navigation and data navigation

Symbol in “Status of configuration” column

Symbol	Meaning
	The start value of the parameter corresponds to the default value and is valid. A start value has not yet been defined by the user.
	The start value of the parameter contains a value defined by the user or an automatically adjusted value. The start value is different than the default value. The start value is error-free and valid.
	The start value of the parameter is invalid (syntax or process-related error). The input box has a red background. When clicked, the roll-out error message indicates the cause of the error.
	Only for S7-1200 Motion Control: The start value of the parameter is valid but contains warnings. The input box has a yellow background.
	The parameter is not relevant in the current configuration.

Symbol in the navigation

The symbols in the navigation indicate the progress of the configuration in the same way as in the configuration dialog of the technology object.

See also

Configure technology objects (Page 44)

5.11.5.8 Monitoring values online in the parameter view

You can monitor the values currently taken by the parameters of the technology object in the CPU (monitor values) directly in the Parameter view.

Requirements

- There is an online connection.
- The technology object is downloaded to the CPU.
- The program execution is active (CPU in "RUN").
- The Parameter view of the technology object is open.

Procedure

1. Start the monitoring by clicking .

   As soon as the Parameter view is online, the following columns are additionally displayed:

   – Compare result
   – Start value PLC
   – Monitor value
   – Modify value
   – Selection for transmission

   The "Monitor value" column shows the current parameter values on the CPU.

   Meaning of the additional columns: see Parameter table (Page 56)

2. Stop the monitoring by clicking again.

Display

All columns that are only available online have an orange background:

- Values in light-orange cells can be changed.
- Values in cells with a dark orange background cannot be changed.

5.11.5.9 Change display format of value

The display format of the value can be selected via the shortcut menu of a table row in the Parameter view of the technology object.

The display format of the following values can be changed both in online mode and in offline mode:

- Start value project
- Start value PLC
- Maximum value
- Minimum value
- Snapshot
- Monitor value
- Default value
- Modify value

The set display format applies to all values of the table row.

The following display formats of the value can be changed:

- Default
- Hex
- Octal
- Bin
- Dec (+/-)
- DEC

Depending on the parameter selected in the parameter view, only the supported display formats can be selected.

Requirements

- The Parameter view of the technology object is open.

Procedure

To change the display format of the value, proceed as follows:

1. Select one or more table rows in which you want to change the display format.
2. Select the "Display format" command in the shortcut menu.
3. Select the desired display format.

NOTE

To change the display format of a certain data type in multiple table rows, sort the Parameter view by this data type. Then select the first and last table row with this data type while keeping the <Shift> key pressed and change the display format for the selected table rows.

5.11.5.10 Create snapshot of monitor values

You can back up the current values of the technology object on the CPU (monitor values) and display them in the Parameter view.

Requirements

- There is an online connection.
- The technology object is downloaded to the CPU.
- The program execution is active (CPU in "RUN").
- The Parameter view of the technology object is open.
- The “Monitor all” button is selected.

Procedure

To show the current parameter values, follow these steps:

1. In the Parameter view, click the “Create snapshot of monitor values" icon .

Result

The current monitor values are transferred once to the "Snapshot" column of the parameter table.

You can analyze the values "frozen" in this way while the monitor values continue to be updated in the "Monitor values" column.

5.11.5.11 Modifying values

With the Parameter view, you can modify values of the technology object in the CPU.

You can assign values to the parameter once (Modify value) and modify them immediately. The modify request is executed as quickly as possible without reference to any particular point in the user program.

DANGER

Danger when modifying:

Changing the parameter values while the plant is operating may result in severe damage to property and personal injury in the event of malfunctions or program errors.

Make sure that dangerous states cannot occur before you use the "Modify" function.

Requirements

- There is an online connection.
- The technology object is downloaded to the CPU.
- The program execution is active (CPU in "RUN").
- The Parameter view of the technology object is open.
- The “Monitor all” button is selected.
- The parameter can be modified (associated field in the "Modify value" column has a light-orange background).

Procedure

To modify parameters immediately, follow these steps:

1. Enter the desired modify values in the “Modify values” column of the parameter table.
2. Check whether the check box for modifying is selected in the "Select for transmission" column.

   The modify values and associated check boxes of dependent parameters are automatically adapted at the same time.
3. Click the “Modify all selected parameters immediately and once” icon .

The selected parameters are modified once and immediately with the specified values and can be monitored in the "Monitor values" column. The check boxes for modifying in the "Selection for transmission" column are automatically cleared after the modify request is complete.

Error indication

When a start value is input, a check is made immediately for process-related and syntax errors and the result is indicated.

Bad start values are indicated by:

- Red background in the “Modify value” field

and

- If you click the bad field, a roll-out error message appears with information of the permissible value range or the necessary syntax (format)

Bad modify values

- Modify values with process-related errors can be transmitted.
- Modify values with syntax errors **cannot** be transmitted.

5.11.5.12 Comparing values

You can use comparison functions to compare the following memory values of a parameter:

- Start value project
- Start value PLC
- Snapshot

Requirements

- There is an online connection.
- The technology object is downloaded to the CPU.
- The program execution is active (CPU in "RUN").
- The Parameter view of the technology object is open.
- The “Monitor all” button is selected.

Procedure

To compare the start values on the various target systems, follow these steps:

1. Click the "Selection of comparison values" icon .

   A selection list containing the comparison options opens:

   – Start value project - Start value PLC (default setting)
   – Start value project - Snapshot
   – Start value PLC - Snapshot

2. Select the desired comparison option.

   The selected comparison option is executed as follows:

   – A scales symbol appears in the header cells of the two columns selected for comparison.
   – Symbols are used in the "Compare result" column to indicate the result of the comparison of the selected columns.

Symbol in "Compare result" column

Symbol	Meaning
	The compare values are equal and error-free.
	The compare values are not equal and error-free.

Symbol	Meaning
	At least one of the two compare values has a process-related or syntax error.
	The comparison cannot be performed. At least one of the two comparison values is not available (e.g. snapshot).
	Comparison of the value is inappropriate since it is not relevant in one of the configurations.

Symbol in the navigation

The symbols are shown in the same way in the navigation if the comparison result applies to at least one of the parameters below the displayed navigation structure.

5.11.5.13 Applying values from the online program as start values

In order to apply optimized values from the CPU to the project as start values, you create a snapshot of the monitor values. Values of the snapshot marked as a "Setpoint" are then applied to the project as start values.

Requirements

- The technology object is of the type "PID_Compact", "PID_3Step" or "PID_Temp".
- There is an online connection.
- The technology object is downloaded to the CPU.
- The program execution is active (CPU in "RUN").
- The Parameter view of the technology object is open.
- The “Monitor all” button is selected.

Procedure

To apply optimized values from the CPU, follow these steps:

1. Click the "Create snapshot of monitor values and accept setpoints of this snapshot as start values" icon .

Result

The current monitor values are applied to the "Snapshot" column and their setpoints are copied to the "Start value in project" column as new start values.

NOTE

Applying values of individual parameters

You can also apply the values of individual parameters that are not marked as a setpoint from the "Snapshot" column to the "Start values project" column. To do so, copy the values and insert them into the "Start value in project" column using the "Copy" and "Paste" commands in the shortcut menu.

5.11.5.14 Initializing setpoints in the online program

You can initialize all parameters that are marked as a "Setpoint" in the Parameter view with new values in the CPU in one step. In so doing, the start values are downloaded from the project to the CPU. The CPU remains in "RUN" mode.

To avoid data loss on the CPU during a cold restart or warm restart, you must also download the technology object to the CPU.

⚠ DANGER

Danger when changing parameter values

Changing the parameter values while the plant is operating may result in severe damage to property and personal injury in the event of malfunctions or program errors.

Make sure that dangerous states cannot occur before you reinitialize the setpoints.

Requirements

- The technology object is of the type "PID_Compact", "PID_3Step" or "PID_Temp".
- There is an online connection.
- The technology object is downloaded to the CPU.
- The program execution is active (CPU in "RUN").
- The Parameter view of the technology object is open.
- The “Monitor all” button is selected.
- The parameters marked as " have a "Start value in project" that is free of process-related and syntax errors.

Procedure

To initialize all setpoints, follow these steps:

1. Enter the desired values in the "Start value in project" column.
   Ensure that the start values are free of process-related and syntax errors.
2. Click the icon "Load start values of setpoints as actual values".

Result

The setpoints in the CPU are initialized with the start values from the project.

5.12 Display instance DB of a technology object.

An instance DB, in which the parameter and static variables are saved, is created for each technology object.

Procedure

To display the instance DB of a technology object, proceed as follows:

1. Open the CPU folder in the project tree.
2. Open the "Technology objects" folder.
3. Highlight a technology object.
4. Select the command "Open DB editor" in the shortcut menu.

Using PID_Compact

6

6.1 Technology object PID_Compact

The technology object PID_Compact provides a continuous PID controller with integrated optimization. You can alternatively configure a pulse controller. Both manual and automatic mode are possible.

PID-Compact continuously acquires the measured process value within a control loop and compares it with the required setpoint. From the resulting control deviation, the instruction PID_Compact calculates an output value by which the process value is adapted as quickly and stable as possible to the setpoint. The output value for the PID controller consists of three actions:

- **Proportional** action

  The proportional action of the output value increases in proportion to the control deviation.

- **I** action

  The integral action of the output value increases until the control deviation has been balanced.

- **D** action

  The derivative action increases with the rate of change of control deviation. The process value is corrected to the setpoint as quickly as possible. The derivative action will be reduced again if the rate of change of control deviation drops.

The instruction PID_Compact calculates the proportional, integral and derivative parameters for your controlled system during pretuning. Fine tuning can be used to tune the parameters further. You do not need to manually determine the parameters.

Additional information

- Overview of software controller (Page 41)
- Add technology objects (Page 43)
- Configure technology objects (Page 44)
- Configuring PID_Compact as of V2 (Page 75)
- Configuring PID_Compact V1 (Page 98)

FAQ

For more information, see the following FAQs in the Siemens Industry Online Support:

- Entry ID 79047707 (https://support.industry.siemens.com/cs/ww/en/view/79047707)

6.2 PID_Compact as of V2

6.2.1 Configuring PID_Compact as of V2

6.2.1.1 Basic settings as of V2

Introduction as of V2

Configure the following properties of the "PID_Compact" technology object under "Basic settings" in the Inspector window or in the configuration window:

- Physical quantity
- Control logic
- Start-up behavior after reset
- Setpoint (only in the Inspector window)
- Process value (only in the Inspector window)
- Output value (only in the Inspector window)

Setpoint, process value and output value

You can only configure the setpoint, process value and output value in the Inspector window of the programming editor. Select the source for each value:

- Instance DB

  The value saved in the instance DB is used.

  Value must be updated in the instance DB by the user program.

  There should be no value at the instruction.

  Can be changed using HMI.
- Instruction

  The value connected to the instruction is used.
  The value is written to the instance DB each time the instruction is called.

  Cannot be changed using HMI.

Control mode as of V2

Physical quantity

Select the unit of measurement and physical quantity for the setpoint and the process value in the "Controller type" group. The setpoint and the process value are displayed in this unit.

Control logic

An increase of the output value is generally intended to cause an increase in the process value. This is referred to as a normal control logic.

PID_Compact does not work with negative proportional gain. Select the check box "Invert control logic" to reduce the process value with a higher output value.

Examples

- Opening the drain valve will reduce the level of a container's contents.
- Increasing cooling will reduce the temperature.

Startup characteristics

1. To switch to "Inactive" mode after CPU restart, clear the "Activate Mode after CPU restart" check box.

   To switch to the operating mode saved in the Mode parameter after CPU restart, select the "Activate Mode after CPU restart" check box.

2. In the "Set Mode to" drop-down list, select the mode that is to be enabled after a complete download to the device.

   After a complete download to the device, PID_Compact starts in the selected operating mode. With each additional restart, PID_Compact starts in the mode that was last saved in Mode.

Example

You have selected the "Activate Mode after CPU restart" check box and the entry "Pretuning" in the "Set Mode to" list. After a complete download to the device, PID_Compact starts in the "Pretuning" mode. If pretuning is still active, PID_Compact starts in "Pretuning" mode again after restart of the CPU. If pretuning was successfully completed and automatic mode is active, PID_Compact starts in "Automatic mode" after restart of the CPU.

Setpoint as of V2

Procedure

Proceed as follows to define a fixed setpoint:

1. Select "Instance DB".
2. Enter a setpoint, e.g. 80° C.
3. Delete any entry in the instruction.

Proceed as follows to define a variable setpoint:

1. Select "Instruction".
2. Enter the name of the REAL variable in which the setpoint is saved.

   Program-controlled assignment of various values to the REAL variable is possible, for example for the time controlled change of the setpoint.

Process value as of V2

PID_Compact will scale the value of the analog input to the physical quantity if you use the analog input value directly.

You will need to write a program for processing if you wish first to process the analog input value. The process value is, for example, not directly proportional to the value at the analog input. The processed process value must be in floating point format.

Procedure

Proceed as follows to use the analog input value without processing:

1. Select the entry "Input_PER" in the drop-down list "Input".
2. Select "Instruction" as source.
3. Enter the address of the analog input.

Proceed as follows to use the processed process value in floating point format:

1. Select the entry "Input" in the drop-down list "Input".
2. Select "Instruction" as source.
3. Enter the name of the variable in which the processed process value is saved.

Output value as of V2

PID_Compact offers three output values. Your actuator will determine which output value you use.

- Output_PER

  The actuator is triggered via an analog output and controlled with a continuous signal, e.g. 0...10V, 4...20mA.
- Output

  The output value needs to be processed by the user program, for example because of non-linear actuator response.
- Output_PWM

  The actuator is controlled via a digital output. Pulse width modulation creates minimum ON and minimum OFF times.

Procedure

Proceed as follows to use the analog output value:

1. Select the entry "Output_PER (analog)" in the drop-down list "Output".
2. Select "Instruction".
3. Enter the address of the analog output.

Proceed as follows to process the output value using the user program:

1. Select the entry "Output" in the drop-down list "Output".
2. Select "Instance DB".
   The calculated output value is saved in the instance data block.
3. For the preparation of the output value, use the output parameter Output.
4. Transfer the processed output value to the actuator via a digital or analog CPU output.

Proceed as follows to use the digital output value:

1. Select the entry "Output_PWM" in the drop-down list "Output".
2. Select "Instruction".
3. Enter the address of the digital output.

6.2.1.2 Process value settings as of V2

Scaling process value as of V2

If you have configured the use of Input_PER in the basic setting, you must convert the value of the analog input to the physical quantity of the process value. The current configuration is displayed in the Input_PER display.

Input_PER will be scaled using a low and high value pair if the process value is directly proportional to the value of the analog input.

Procedure

To scale the process value, follow these steps:

1. Enter the low pair of values in the "Scaled low process value" and "Low" input fields.
2. Enter the high pair of values in the "Scaled high process value" and "High" input boxes.

Default settings for the value pairs are stored in the hardware configuration. To use the value pairs from the hardware configuration, follow these steps:

1. Select the PID_Compact instruction in the programming editor.
2. Interconnect Input_PER with an analog input in the basic settings.
3. Click the "Automatic setting" button in the process value settings.

The existing values will be overwritten with the values from the hardware configuration.

Process value limits as of V2

You must specify an appropriate absolute high limit and low limit for the process value as limit values for your controlled system. As soon as the process value violates these limits, an error occurs (ErrorBits = 0001h). Tuning is canceled when the process value limits are violated. You can configure how PID_Compact reacts to an error in automatic mode in the output value settings.

6.2.1.3 Advanced settings as of V2

Process value monitoring as of V2

Configure a warning high and low limit for the process value in the "Process value monitoring" configuration window. If one of the warning limits is exceeded or undershot during operation, a warning will be displayed at the PID_Compact instruction:

- At the InputWarning_H output parameter if the warning high limit has been exceeded
- At the InputWarning_L output parameter if the warning low limit has been undershot

The warning limits must be within the process value high and low limits.

The process value high and low limits will be used if you do not enter values.

Example

Process value high limit = 98 °C; warning high limit = 90 °C

Warning low limit = 10 °C; process value low limit = 0 °C

PID_Compact will respond as follows:

Process value	InputWarning_H	InputWarning_L	ErrorBits	Operating mode
> 98 °C	TRUE	FALSE	0001h	Inactive or Substitute output value with error monitoring
≤ 98 °C and > 90 °C	TRUE	FALSE	0000h	Automatic mode
≤ 90 °C and ≥ 10 °C	FALSE	FALSE	0000h	Automatic mode
< 10 °C and ≥ 0 °C	FALSE	TRUE	0000h	Automatic mode
< 0 °C	FALSE	TRUE	0001h	Inactive or Substitute output value with error monitoring

In the output value settings, you can specify the reaction of PID_Compact when the process value high limit or low limit is violated.

See also

State and Mode as of V2 parameters (Page 267)

PWM limits as of V2

Via pulse width modulation, the value at the output parameter Output is transformed into a pulse sequence that is output at output parameter Output_PWM.

Output is calculated in the PID algorithm sampling time. The sampling time is used as time period of the pulse width modulation.

The PID algorithm sampling time is determined during pretuning or fine tuning. If manually setting the PID parameters, you will also need to configure the PID algorithm sampling time.

Output_PWM is output in the PID_Compact sampling time. The PID_Compact sampling time is equivalent to the cycle time of the calling OB.

The pulse duration is proportional to the value at Output and is always an integer multiple of the PID_Compact sampling time.

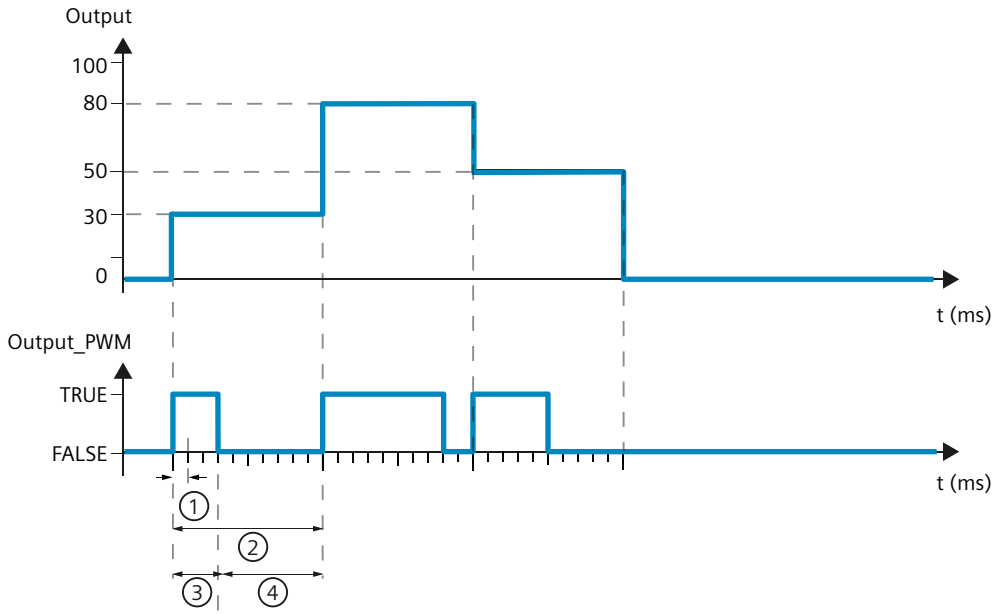

① PID_Compact sampling time

② PID algorithm sampling time

③ Pulse duration

④ Break time

The "Minimum ON time" and the "Minimum OFF time" are rounded to an integer multiple of the PID_Compact sampling time.

A pulse or a break is never shorter than the minimum ON or OFF time. The inaccuracies this causes are added up and compensated in the next cycle.

Example

PID_Compact sampling time (equivalent to the cycle time of the calling OB) = 100 ms

PID algorithm sampling time (equivalent to the time period)= 1000 ms

Minimum ON time = 200 ms

Output is a constant 15%. The smallest pulse that PID_Compact can output is 20%. In the first cycle, no pulse is output. In the second cycle, the pulse not output in the first cycle is added to the pulse of the second cycle.

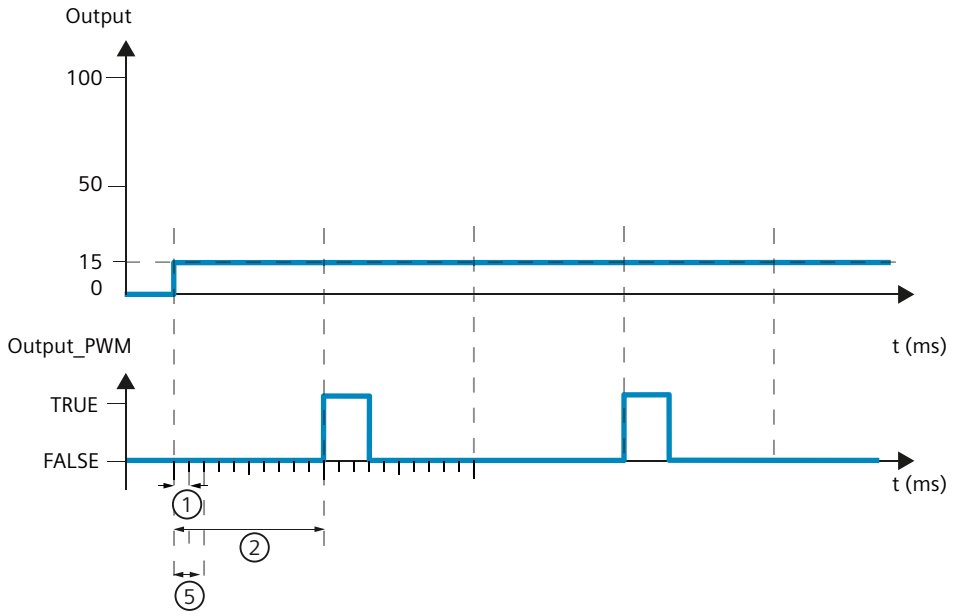

① PID_Compact sampling time

② PID algorithm sampling time

⑤ Minimum ON time

In order to minimize operation frequency and conserve the actuator, extend the minimum ON and OFF times.

If you are using "Output" or "Output_PER", you must configure the value 0.0 for the minimum ON and OFF times.

NOTE

The minimum ON and OFF times only affect the output parameter Output_PWM and are not used for any pulse generators integrated in the CPU.

Output value as of V2

Output value limits

In the "Output value limits" configuration window, configure the absolute limits of your output value in percent. Absolute output value limits are not violated in neither manual mode nor automatic mode. If an output value outside the limits is specified in manual mode, the effective value is limited in the CPU to the configured limits.

The output value limits must match the control logic.

The valid output value limit values depend on the Output used.

Output	-100.0 to 100.0%
Output_PER	-100.0 to 100.0%
Output_PWM	0.0 to 100.0%

Reaction to error

NOTICE
Your system may be damaged. If you output "Current value while error pending " or "Substitute output value while error pending" in the event of an error, PID_Compact remains in automatic mode. This may cause a violation of the process value limits and damage your system. It is essential to configure how your controlled system reacts in the event of an error to protect your system from damage.

PID_Compact is preset so that the controller stays active in most cases in the event of an error. If errors occur frequently in controller mode, this default reaction has a negative effect on the control response. In this case, check the Errorbits parameter and eliminate the cause of the error.

PID_Compact generates a programmable output value in response to an error:

- Zero (inactive)

  PID_Compact outputs 0.0 as output value for all errors and switches to "Inactive" mode. The controller is only reactivated by a falling edge at Reset or a rising edge at ModeActivate.

- Current value while error is pending

  If the following errors occur in **automatic mode**, PID_Compact returns to automatic mode as soon as the errors are no longer pending.

  If one or more of the following errors occur, PID_Compact stays in automatic mode:

  – 0001h: The "Input" parameter is outside the process value limits.

  – 0800h: Sampling time error

  – 40000h: Invalid value at Disturbance parameter.

  If one or more of the following errors occur in **automatic mode**, PID_Compact switches to "Substitute output value with error monitoring" mode and outputs the last valid output value:

  – 0002h: Invalid value at Input_PER parameter.

  – 0200h: Invalid value at Input parameter.

  – 0400h: Calculation of output value failed.

  – 1000h: Invalid value at Setpoint parameter.

  If an error occurs in **manual mode**, PID_Compact continues using the manual value as the output value. If the manual value is invalid, the substitute output value is used. If the manual value and substitute output value are invalid, the output value low limit is used.

If the following error occurs during a **pretuning or fine tuning**, PID_Compact remains in active mode:

– 0020h: Pretuning is not permitted during fine tuning.

When any other error occurs, PID_Compact cancels the tuning and switches to the mode from which tuning was started.

As soon as no errors are pending, PID_Compact returns to automatic mode.

- Substitute output value while error is pending

  PID_Compact outputs the substitute output value.

  If the following error occurs, PID_Compact stays in "Substitute output value with error monitoring" mode and outputs the output value low limit:

  – 20000h: Invalid value at SubstituteOutput tag.

  For all other errors, PID_Compact reacts as described for "Current value while error is pending".

See also

State and Mode as of V2 parameters (Page 267)

PID parameters V2

The PID parameters are displayed in the "PID Parameters" configuration window. The PID parameters will be adapted to your controlled system during controller tuning. You do not need to enter the PID parameters manually.

NOTE

The currently active PID parameters are located for PID_Compact V1 in the sRet structure and as of PID_Compact V2 in the Retain.CtrlParams structure.

Change the currently active PID parameters only in "Inactive" mode online to prevent malfunction of the PID controller.

If you want to change the PID parameters in "Automatic mode" or "Manual mode" online, change the PID parameters as follows:

- PID_Compact V1: Change the PID parameters in the sBackUp structure and apply these changes with sPid_Cmpt.b_LoadBackUp = TRUE to the sRet structure.
- PID_Compact as of V2: Change the PID parameters in the CtrlParamsBackUp structure and apply these changes with LoadBackUp = TRUE to the Retain.CtrlParams structure.

Online changes to the PID parameters in "Automatic mode" can result in jumps at the output value.

The PID algorithm operates according to the following transfer function:

$$y = K_p \left[(b \cdot w - x) + \frac{1}{T_I \cdot s}(w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1}(c \cdot w - x) \right]$$

The table below shows the meaning of the icons used in the transfer function and in the subsequent figures:

Icon	Description
y	Output value of the PID algorithm
K_p	Proportional gain
s	Laplace operator
b	Proportional action weighting
w	Setpoint
x	Process value
T_I	Integration time
T_D	Derivative action time
a	Derivative delay coefficient (derivative delay T1 = a × T_D)
c	Derivative action weighting

The diagram below illustrates the integration of the parameters into the PID algorithm:

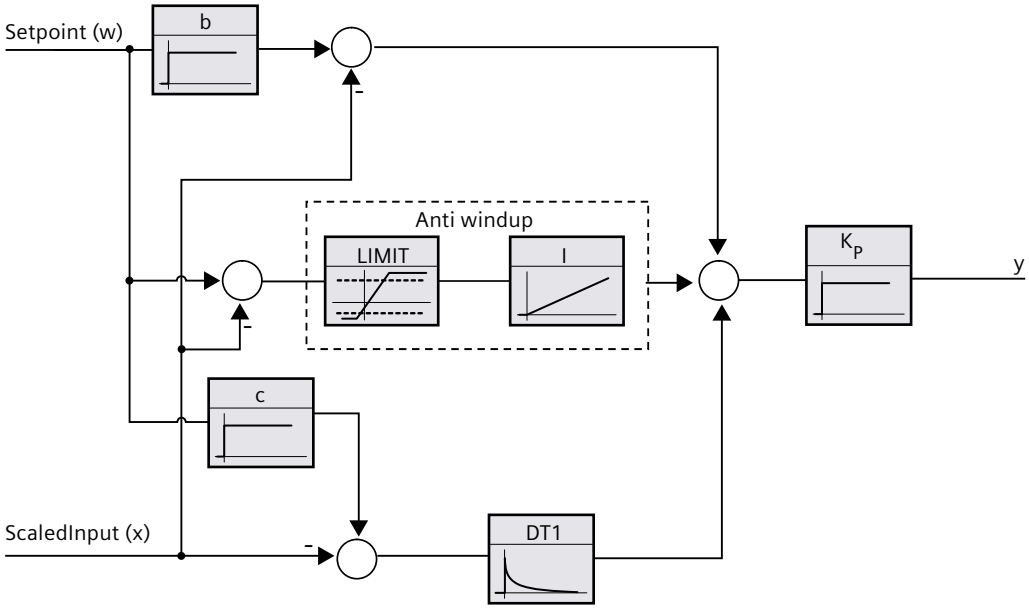

All PID parameters are retentive. If you enter the PID parameters manually, you must completely download PID_Compact.

Downloading technology objects to device (Page 46)

Proportional gain

The value specifies the proportional gain of the controller. PID_Compact does not work with a negative proportional gain. Control logic is inverted under Basic settings > Controller type.

Integration time

The integration time determines the time response of the integral action. The integral action is deactivated with integration time = 0.0. When the integration time is changed from a different value to 0.0 online in "Automatic mode", the previous integral action is deleted and the output value jumps.

Derivative action time

The derivative action time determines the time response of the derivative action. Derivative action is deactivated with derivative action time = 0.0.

Derivative delay coefficient

The derivative delay coefficient delays the effect of the derivative action.

Derivative delay = derivative action time × derivative delay coefficient

- 0.0: Derivative action is effective for one cycle only and therefore almost not effective.
- 0.5: This value has proved useful in practice for controlled systems with **one** dominant time constant.
- > 1.0: The greater the coefficient, the longer the effect of the derivative action is delayed.

Proportional action weighting

The proportional action may weaken with changes to the setpoint.

Values from 0.0 to 1.0 are applicable.

- 1.0: Proportional action for setpoint change is fully effective
- 0.0: Proportional action for setpoint change is not effective

The proportional action is always fully effective when the process value is changed.

Derivative action weighting

The derivative action may weaken with changes to the setpoint.

Values from 0.0 to 1.0 are applicable.

- 1.0: Derivative action is fully effective upon setpoint change
- 0.0: Derivative action is not effective upon setpoint change

The derivative action is always fully effective when the process value is changed.

PID algorithm sampling time

The controlled system needs a certain amount of time to respond to changes in the output value. It is therefore not advisable to calculate the output value in every cycle. The sampling time of the PID algorithm represents the time between two calculations of the output value. It is calculated during tuning and rounded to a multiple of the cycle time. All other functions of PID_Compact are executed at every call.

If you use Output_PWM, the sampling time of the PID algorithm is used as the period duration of the pulse width modulation. The accuracy of the output signal is determined by the ratio of the PID algorithm sampling time to the cycle time of the OB. It is therefore recommended that the cycle time is a maximum of one tenth of the PID algorithm sampling time.

Rule for tuning

Select whether PI or PID parameters are to be calculated in the "Controller structure" drop-down list.

- **PID**

  Calculates PID parameters during pretuning and fine tuning.
- **PI**

  Calculates PI parameters during pretuning and fine tuning.
- **User-defined**

  The drop-down list displays "User-defined" if you have configured different controller structures for pretuning and fine tuning via a user program.

PID parameters V3

The PID parameters are displayed in the "PID Parameters" configuration window. During tuning, the PID parameters are adapted to the controlled system with the exception of the dead zone width that has to be configured manually.

NOTE

The currently active PID parameters are located in the Retain.CtrlParams structure.

Change the currently active PID parameters only in "Inactive" mode online to prevent malfunction of the PID controller.

If you want to change the PID parameters in "Automatic mode" or "Manual mode" online, change the PID parameters in the CtrlParamsBackUp structure and apply these changes with LoadBackUp = TRUE to the Retain.CtrlParams structure.

Online changes to the PID parameters in "Automatic mode" can result in jumps at the output value.

PID_Compact is a PIDT1 controller with Anti-Windup and weighting of the proportional and derivative actions.

The PID algorithm operates according to the following equation (dead zone deactivated):

$$y = K_p \left[(b \cdot w - x) + \frac{1}{T_I \cdot s} (w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1} (c \cdot w - x) \right]$$

The table below shows the meaning of the icons used in the transfer function and in the subsequent figures:

Icon	Description	Associated parameters of the PID_Compact instruction
y	Output value of the PID algorithm	-
K_p	Proportional gain	Retain.CtrlParams.Gain
s	Laplace operator	-
b	Proportional action weighting	Retain.CtrlParams.PWeighting
w	Setpoint	CurrentSetpoint
x	Process value	ScaledInput
T_I	Integration time	Retain.CtrlParams.Ti
T_D	Derivative action time	Retain.CtrlParams.Td
a	Derivative delay coefficient (derivative delay T1 = a × T_D)	Retain.CtrlParams.TdFiltRatio
c	Derivative action weighting	Retain.CtrlParams.DWeighting
DeadZone	Dead zone width	Retain.CtrlParams.DeadZone

The diagram below illustrates the integration of the parameters into the PID algorithm:

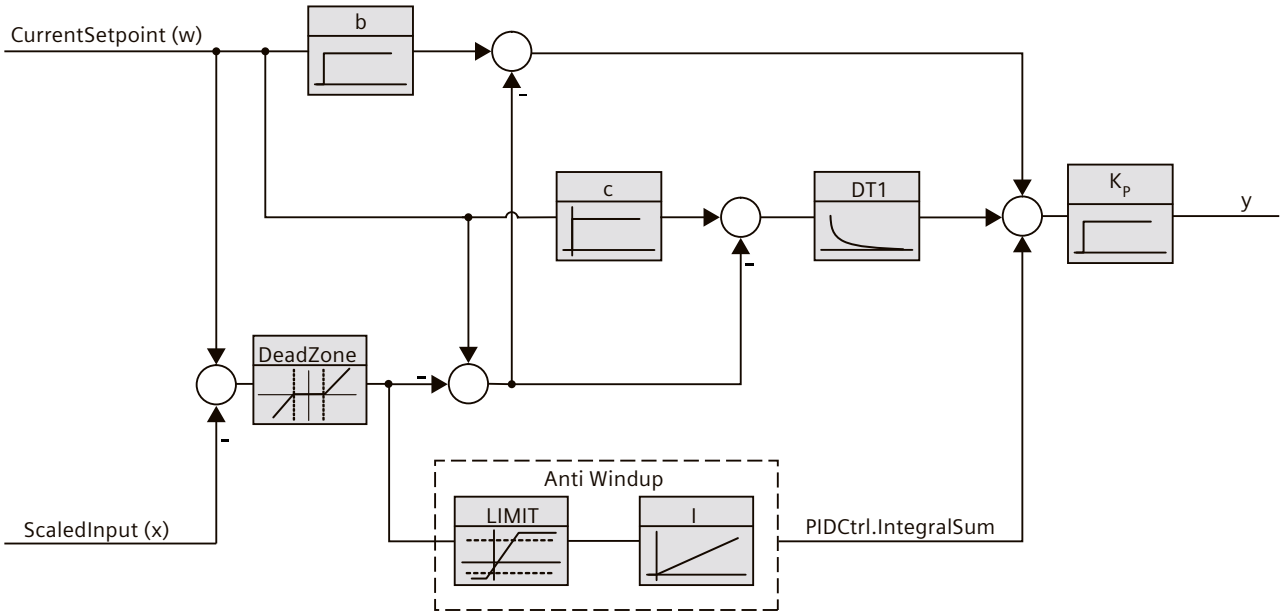

All PID parameters are retentive. If you enter the PID parameters manually, you must completely download PID_Compact.

Download technology objects to device

Proportional gain

The value specifies the proportional gain of the controller. PID_Compact does not work with a negative proportional gain. Control logic is inverted under Basic settings > Controller type.

Integration time

The integration time determines the time response of the integral action. The integral action is deactivated with integration time = 0.0. When the integration time is changed from a different value to 0.0 online in "Automatic mode", the previous integral action is deleted and the output value jumps.

If the output value reaches an output value limit in automatic mode, the integral action is stopped depending on the direction (Anti-Windup). As of PID_Compact Version 3.0, the integral component is also actively limited in order to prevent delayed control behavior, e.g. when the output value limits change. Changes to the following tags can lead to an adjustment of the integral component in automatic mode:

- Output value limits (Config.OutputLowerLimit and Config.OutputUpperLimit tags)
- Setpoint (Setpoint tag)
- Proportional gain (Retain.CtrlParams.Gain tag)
- Proportional action weighting (Retain.CtrlParams.PWeighting tag)
- Disturbance variable (Disturbance variable)

Derivative action time

The derivative action time determines the time response of the derivative action. Derivative action is deactivated with derivative action time = 0.0.

Derivative delay coefficient

The derivative delay coefficient delays the effect of the derivative action.

Derivative delay = derivative action time × derivative delay coefficient

- 0.0: Derivative action is effective for one cycle only and therefore almost not effective.
- 0.5: This value has proved useful in practice for controlled systems with **one** dominant time constant.
- > 1.0: The greater the coefficient, the longer the effect of the derivative action is delayed.

Proportional action weighting

The proportional action may weaken with changes to the setpoint.

Values from 0.0 to 1.0 are applicable.

- 1.0: Proportional action for setpoint change is fully effective
- 0.0: Proportional action for setpoint change is not effective

The proportional action is always fully effective when the process value is changed.

Derivative action weighting

The derivative action may weaken with changes to the setpoint.

Values from 0.0 to 1.0 are applicable.

- 1.0: Derivative action is fully effective upon setpoint change
- 0.0: Derivative action is not effective upon setpoint change

The derivative action is always fully effective when the process value is changed.

PID algorithm sampling time

The controlled system needs a certain amount of time to respond to changes in the output value. It is therefore not advisable to calculate the output value in every cycle. The sampling time of the PID algorithm represents the time between two calculations of the output value. It is calculated during tuning and rounded to a multiple of the cycle time. All other functions of PID_Compact are executed at every call.

If you use Output_PWM, the sampling time of the PID algorithm is used as the period duration of the pulse width modulation. The accuracy of the output signal is determined by the ratio of the PID algorithm sampling time to the cycle time of the OB. It is therefore recommended that the cycle time is a maximum of one tenth of the PID algorithm sampling time.

Dead zone width

If the process value is affected by noise, the noise can also have an effect on the output value. The output value may fluctuate considerably when the controller gain is high and the derivative action is activated. If the process value lies within the dead zone around the setpoint, the control deviation is suppressed so that the PID algorithm does not react and unnecessary fluctuations of the output value are reduced.

The dead zone width is not set automatically during tuning. You must correctly configure the dead zone width manually. The dead zone is deactivated by setting the dead zone width = 0.0.

When the dead zone is switched on, the result can be a permanent control deviation (deviation between setpoint and process value). This can have a negative effect on fine tuning.

If values other than 1.0 are configured for the proportional action weighting or the derivative action weighting, setpoint changes even within the dead zone affect the output value.

Process value changes within the dead zone do not affect the output value, regardless of the weighting.

The diagram below illustrates the effect of the dead zone: The X / horizontal axis shows the control deviation = Setpoint - Process value. The Y / vertical axis shows the output signal of the dead zone that is passed to the PID algorithm.

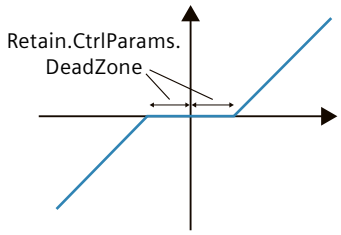

Rule for tuning

Select whether PI or PID parameters are to be calculated in the "Controller structure" drop-down list.

- **PID**

  Calculates PID parameters during pretuning and fine tuning.
- **PI**

  Calculates PI parameters during pretuning and fine tuning.
- **User-defined**

  The drop-down list displays "User-defined" if you have configured different controller structures for pretuning and fine tuning via a user program.

See also

Selection of the controller structure for specified controlled systems (Page 39)

6.2.2 Commissioning PID_Compact as of V2

6.2.2.1 Pretuning as of V2

The pretuning determines the process response to a jump change of the output value and searches for the point of inflection. The PID parameters are calculated from the maximum rate of rise and dead time of the controlled system. You obtain the best PID parameters when you perform pretuning and fine tuning.

The more stable the process value is, the easier it is to calculate the PID parameters and the more precise the result will be. Noise on the process value can be tolerated as long as the rate of rise of the process value is significantly higher compared to the noise. This is most likely the case in operating modes "Inactive" and "manual mode". The PID parameters are backed up before being recalculated.

Requirement

- The "PID_Compact" instruction is called in a cyclic interrupt OB.
- ManualEnable = FALSE
- Reset = FALSE
- PID_Compact is in one of the following modes: "Inactive", "Manual mode", or "Automatic mode".
- The setpoint and the process value lie within the configured limits (see "Process value monitoring" configuration).
- The difference between setpoint and process value is greater than 30% of the difference between process value high limit and process value low limit.
- The distance between the setpoint and the process value is > 50% of the setpoint.

Procedure

To perform pretuning, follow these steps:

1. Double-click the "PID_Compact > Commissioning" entry in the project tree.
2. Select the entry "Pretuning" in the "Tuning mode" drop-down list.
3. Click the "Start" icon.
   - An online connection will be established.
   - Value recording is started.
   - Pretuning is started.
   - The "Status" field displays the current steps and any errors that may have occurred. The progress bar indicates the progress of the current step.

   NOTE

   Click the "Stop" icon when the progress bar has reached 100% and it can be assumed the controller tuning function is blocked. Check the configuration of the technology object and, if necessary, restart controller tuning.

Result

If pretuning was performed without an error message, the PID parameters have been tuned. PID_Compact switches to automatic mode and uses the tuned parameters. The tuned PID parameters will be retained during power OFF and a restart of the CPU.

If pretuning is not possible, PID_Compact responds with the configured reaction to errors.

See also

State and Mode as of V2 parameters (Page 267)

6.2.2.2 Fine tuning as of V2

Fine tuning generates a constant, limited oscillation of the process value. The PID parameters are tuned for the operating point from the amplitude and frequency of this oscillation. All PID parameters are recalculated from the results. PID parameters from fine tuning usually have better master control and disturbance characteristics than PID parameters from pretuning. You obtain the best PID parameters when you perform pretuning and fine tuning.

PID_Compact automatically attempts to generate an oscillation greater than the noise of the process value. Fine tuning is only minimally influenced by the stability of the process value. The PID parameters are backed up before being recalculated.

Requirement

- The PID_Compact instruction is called in a cyclic interrupt OB.
- ManualEnable = FALSE
- Reset = FALSE
- The setpoint and the process value lie within the configured limits.
- The control loop has stabilized at the operating point. The operating point is reached when the process value corresponds to the setpoint.
- No disturbances are expected.
- PID_Compact is in inactive mode, automatic mode or manual mode.

Process depends on initial situation

Fine tuning can be started from the following operating modes: "Inactive", "automatic mode", or "manual mode". Fine tuning proceeds as follows when started from:

- Automatic mode

  Start fine tuning from automatic mode if you wish to improve the existing PID parameters through tuning.

  PID_Compact controls the system using the existing PID parameters until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start.

- Inactive or manual mode

  If the requirements for pretuning are met, pretuning is started. The determined PID parameters will be used for control until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start. If pretuning is not possible, PID_Compact responds with the configured responses in the event of an error.

  An attempt is made to reach the setpoint with the minimum or maximum output value if the process value for pretuning is already too near the setpoint. This can produce increased overshoot.

Procedure

To perform fine tuning, follow these steps:

1. Select the entry "Fine tuning" in the "Tuning mode" drop-down list.
2. Click the "Start" icon.
   - An online connection will be established.
   - Value recording is started.
   - The process of fine tuning is started.
   - The "Status" field displays the current steps and any errors that may have occurred. The progress bar indicates the progress of the current step.

NOTE

Click the "Stop" icon in the "Tuning mode" group when the progress bar has reached 100% and it is to be assumed that tuning is blocked. Check the configuration of the technology object and, if necessary, restart controller tuning.

Result

If fine tuning was performed without errors, the PID parameters have been tuned. PID_Compact switches to automatic mode and uses the tuned parameters. The tuned PID parameters will be retained during power OFF and a restart of the CPU.

If errors occurred during "fine tuning", PID_Compact responds with the configured response to errors.

See also

State and Mode as of V2 parameters (Page 267)

6.2.2.3 "Manual" mode as of V2

The following section describes how you can use the "manual mode" operating mode in the commissioning window of the "PID_Compact" technology object. Manual mode is also possible when an error is pending.

Requirement

- The "PID_Compact" instruction is called in a cyclic interrupt OB.
- An online connection to the CPU has been established and the CPU is in "RUN" mode.

Procedure

Use "Manual mode" in the commissioning window if you want to test the controlled system by specifying a manual value. To define a manual value, proceed as follows:

1. Click the "Start" icon.
2. Select the "Manual mode" check box in the "Online status of controller" area.

   PID_Compact operates in manual mode. The most recent current output value remains in effect.
3. Enter the manual value in the "Output" field as a % value.
4. Click the icon.

Result

The manual value is written to the CPU and immediately goes into effect.

Clear the "Manual mode" check box if the output value is to be specified again by the PID controller. The switchover to automatic mode is bumpless.

See also

State and Mode as of V2 parameters (Page 267)

6.2.3 Override control with PID_Compact as of V2

Override control

In case of override control, two or more controllers share one actuator. Only one controller has access to the actuator at any time and influences the process.

A logic operation decides which controller has access to the actuator. This decision is often made based on a comparison of the output values of all controllers, for example, in case of a maximum selection, the controller with the largest output value gets access to the actuator.

The selection based on the output value requires that all controllers operate in automatic mode. The controllers that do not have an effect on the actuator are updated. This is necessary to prevent windup effects and their negative impacts on the control response and the switchover between the controllers.

PID_Compact supports override controls as of version 2.3 by offering a simple process for updating the controllers that are not active:

- By using the OverwriteInitialOutputValue and PIDCtrl.PIDInit tags, you can preassign the integral action of the controller in automatic mode as though the PID algorithm had calculated Output = OverwriteInititalOutputValue for the output value in the last cycle.
- To do this, OverwriteInitialOutputValue is interconnected with the output value of the controller that currently has access to the actuator.
- By setting the bit PIDCtrl.PIDInit, you trigger the preassignment of the integral action as well as the restart of the controller cycle and the PWM period.

- The subsequent calculation of the output value in the current cycle takes place based on the preassigned (and synchronized for all controllers) integral action as well as the proportional action and integral action from the current control deviation.
- The derivative action is not active during the call with PIDCtrl.PIDInit = TRUE and therefore does not contribute to the output value.

This procedure ensures that the calculation of the current output value and thus the decision on which controller is to have access to the actuator is only based on the current process state and the PI parameters. Windup effects for controllers that are not active and thus incorrect decisions of the switchover logic are prevented.

Requirements

- PIDCtrl.PIDInit only takes effect if the integral action is activated (Retain.CtrlParams.Ti tag > 0.0).
- You must assign PIDCtrl.PIDInit and OverwriteInitialOutputValue in your user program yourself (see example below). PID_Compact does not automatically change these tags.
- PIDCtrl.PIDInit only takes effect when PID_Compact is in automatic mode (parameter State = 3)
- If possible, select the sampling time of the PID algorithm (Retain.CtrlParams.Cycle tag) in such a way that it is identical for all controllers, and call all controllers in the same cyclic interrupt OB. In this way, you ensure that the switchover does not take place within a controller cycle or a PWM period.

NOTE

Constant adaptation of the output value limits

Instead of the active updating of the controllers without access to the actuator described here, this is implemented alternatively by constant adaptation of the output value limits in other controller systems.

This is not possible with PID_Compact, because a change of the output value limits is not supported in automatic mode.

Example: Control of a gas pipeline

PID_Compact is used for control of a gas pipeline.

The main goal is to control the flow rate Input1. The controller PID_Compact_1 is used for this purpose. In addition, the pressure Input2 (measured in flow direction in front of the valve) is to be kept below the high limit with the limiting controller PID_Compact_2.

Flow rate and pressure are controlled by a single solenoid valve. The output value of the controller corresponds to the valve opening: The valve is opened when the output value increases. This means the flow rate increases (normal control logic) while the pressure drops (inverted control logic).

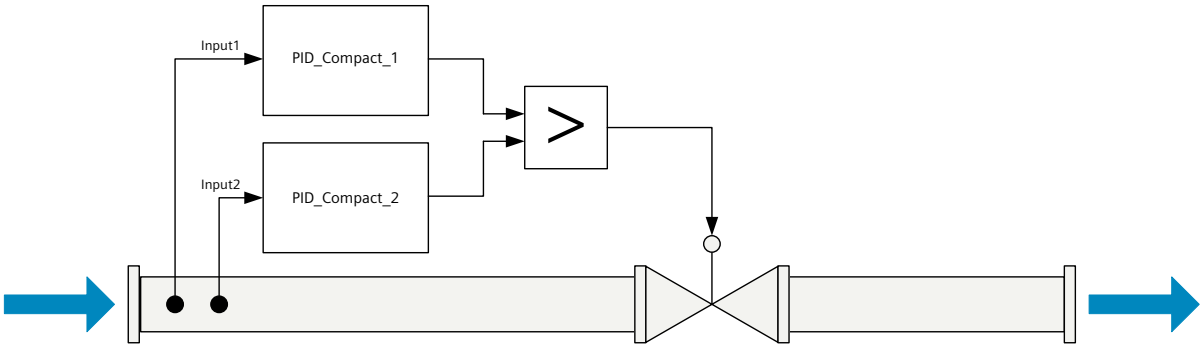
Input1
PID_Compact_1
Input2
PID_Compact_2
>
>
>

In normal operation of the plant, the process value of the flow rate corresponds to the setpoint. The flow controller PID_Compact_1 has settled on a stationary output value PID_Compact_1.Output. The process value of the pressure in normal operation is significantly below the high limit that is specified as setpoint for PID_Compact_2. The pressure regulator therefore wants to close the valve even further to increase the pressure, which means it will calculate an output value PID_Compact_2.Output that is less than the output value of the flow controller PID_Compact_1.Output. The maximum selection of the switchover logic therefore gives the flow controller PID_Compact_1 continued access to the actuator. In addition, it is ensured that PID_Compact_2 is updated by means of the assignments PID_Compact_2.OverwriteInitialOutputValue = PID_Compact_1.Output and PID_Compact_2.PIDCtrl.PIDInit = TRUE.

If the pressure now approaches the high limit or exceeds it, for example due to a fault, the pressure regulator PID_Compact_2 calculates a higher output value to open the valve even further and thus reduce the pressure. If PID_Compact_2.Output is greater than PID_Compact_1.Output, the pressure regulator PID_Compact_2 receives access to the actuator through the maximum selection and opens it. It is ensured that PID_Compact_1 is updated by means of the assignments PID_Compact_1.OverwriteInitialOutputValue = PID_Compact_2.Output and PID_Compact_1.PIDCtrl.PIDInit = TRUE.

The pressure is reduced while the flow rate increases and can no longer be kept at the setpoint.

Once the fault has been remedied, the pressure will continue to drop and the opening of the valve is reduced by the pressure regulator. If the flow controller calculates a larger opening as output value, the plant returns to normal operation so that the flow controller PID_Compact_1 once again has access to the actuator.

This example can be implemented with the following SCL program code:

```
"PID_Compact_1"(Input := "Input1");
"PID_Compact_2"(Input := "Input2");
IF "PID_Compact_1".Output >= "PID_Compact_2".Output THEN
  "ActuatorInput" := "PID_Compact_1".Output_PER;
  "PID_Compact_1".PIDCtrl.PIDInit := FALSE;
  "PID_Compact_2".PIDCtrl.PIDInit := TRUE;
  "PID_Compact_2".OverwriteInitialOutputValue :=
  "PID_Compact_1".Output;
ELSE
  "ActuatorInput" := "PID_Compact_2".Output_PER;
  "PID_Compact_1".PIDCtrl.PIDInit := TRUE;
  "PID_Compact_2".PIDCtrl.PIDInit := FALSE;
  "PID_Compact_1".OverwriteInitialOutputValue :=
  "PID_Compact_2".Output;
END_IF;
```

6.2.4 Simulating PID_Compact as of V2 with PLCSIM

NOTE

Simulation with PLCSIM

The simulation of PID_Compact V2.x with PLCSIM for CPU S7-1200 is not supported.

PID_Compact as of V2 can be simulated only for CPU S7-1500 and CPU S7-1200 G2 with PLCSIM.

For the simulation with PLCSIM, the time behavior of the simulated PLC is not exactly identical to that of a "real" PLC. The actual cycle clock of a cyclic interrupt OB can have larger fluctuations with a simulated PLC than with "real" PLCs.

In the standard configuration, PID_Compact determines the time between calls automatically and monitors them for fluctuations.

For the simulation of PID_Compact with PLCSIM, for example, a sampling time error (ErrorBits = DW#16#00000800) can therefore be detected.

This results in ongoing tuning being aborted.

The response in automatic mode depends on the value of the ActivateRecoverMode tag.

To prevent this from happening, you should configure PID_Compact for simulation with PLCSIM as follows:

- CycleTime.EnEstimation = FALSE
- CycleTime.EnMonitoring = FALSE
- CycleTime.Value: Assign the cycle clock of the calling cyclic interrupt OB in seconds to this tag.

6.3 PID_Compact V1

6.3.1 Configuring PID_Compact V1

6.3.1.1 Basic settings V1

Introduction V1

Configure the following properties of the "PID_Compact" technology object under "Basic settings" in the Inspector window or in the configuration window:

- Physical quantity
- Control logic
- Start-up behavior after reset
- Setpoint (only in the Inspector window)
- Process value (only in the Inspector window)
- Output value (only in the Inspector window)

Setpoint, process value and output value

You can only configure the setpoint, process value and output value in the Inspector window of the programming editor. Select the source for each value:

- Instance DB

  The value saved in the instance DB is used.

  Value must be updated in the instance DB by the user program.

  There should be no value at the instruction.

  Change via HMI possible.

- Instruction

  The value connected to the instruction is used.
  The value is written to the instance DB each time the instruction is called.

  No change via HMI possible.

Control mode V1

Physical quantity

Select the unit of measurement and physical quantity for the setpoint and process value in the "Controller type" group. The setpoint and process value will be displayed in this unit.

Control logic

An increase of the output value is generally intended to cause an increase in the process value. This is referred to as a normal control logic.

PID_Compact does not work with negative proportional gain. Select the check box "Invert control logic" to reduce the process value with a higher output value.

Examples

- Opening the drain valve will reduce the level of a container's contents.
- Increasing cooling will reduce the temperature.

Start-up behavior after reset

To change straight to the last active operating mode after restarting the CPU, select the "Enable last mode after CPU restart" check box.

PID_Compact will remain in "Inactive" mode if the check box is cleared.

Setpoint V1

Procedure

Proceed as follows to define a fixed setpoint:

1. Select "Instance DB".
2. Enter a setpoint, e.g. 80° C.
3. Delete any entry in the instruction.

Proceed as follows to define a variable setpoint:

1. Select "Instruction".
2. Enter the name of the REAL variable in which the setpoint is saved.

   Program-controlled assignment of various values to the REAL variable is possible, for example for the time controlled change of the setpoint.

Process value V1

PID_Compact will scale the value of the analog input to the physical quantity if you use the analog input value directly.

You will need to write a program for processing if you wish first to process the analog input value. The process value is, for example, not directly proportional to the value at the analog input. The processed process value must be in floating point format.

Procedure

Proceed as follows to use the analog input value without processing:

1. Select the entry "Input_PER" in the drop-down list "Input".
2. Select "Instruction" as source.
3. Enter the address of the analog input.

Proceed as follows to use the processed process value in floating point format:

1. Select the entry "Input" in the drop-down list "Input".
2. Select "Instruction" as source.
3. Enter the name of the variable in which the processed process value is saved.

Output value V1

PID_Compact offers three output values. Your actuator will determine which output value you use.

- Output_PER

  The actuator is triggered via an analog output and controlled with a continuous signal, e.g. 0...10V, 4...20mA.

- Output

  The output value needs to be processed by the user program, for example because of non-linear actuator response.

- Output_PWM

  The actuator is controlled via a digital output. Pulse width modulation creates minimum ON and minimum OFF times.

Procedure

Proceed as follows to use the analog output value:

1. Select the entry "Output_PER (analog)" in the drop-down list "Output".
2. Select "Instruction".
3. Enter the address of the analog output.

Proceed as follows to process the output value using the user program:

1. Select the entry "Output" in the drop-down list "Output".
2. Select "Instance DB".

   The calculated output value is saved in the instance data block.
3. For the preparation of the output value, use the output parameter Output.
4. Transfer the processed output value to the actuator via a digital or analog CPU output.

Proceed as follows to use the digital output value:

1. Select the entry "Output_PWM" in the drop-down list "Output".
2. Select "Instruction".
3. Enter the address of the digital output.

6.3.1.2 Process value settings V1

Configure the scaling of your process value and specify the process value absolute limits In the "Process value settings" configuration window.

Scaling the process value

If you have configured the use of Input_PER in the basic settings, you will need to convert the value of the analog input into the physical quantity of the process value. The current configuration will be displayed in the Input_PER display.

Input_PER will be scaled using a low and high value pair if the process value is directly proportional to the value of the analog input.

1. Enter the low pair of values in the "Scaled low process value" and "Low" input fields.
2. Enter the high pair of values in the "Scaled high process value" and "High" input boxes.

Default settings for the value pairs are saved in the hardware configuration. Proceed as follows to use the value pairs from the hardware configuration:

1. Select the instruction PID_Compact in the programming editor.
2. Connect Input_PER with an analog input in the basic settings.
3. Click on the "Automatic setting" button in the process value settings.

The existing values will be overwritten with the values from the hardware configuration.

Monitoring process value

Specify the absolute high and low limit of the process value. As soon as these limits are violated during operation, the controller switches off and the output value is set to 0%. You must enter reasonable limits for your controlled system. Reasonable limits are important during optimization to obtain optimal PID parameters.

The default for the "High limit process value" is 120 %. At the I/O input, the process value can be a maximum of 18% higher than the standard range (overrange). An error is no longer reported for a violation of the "High limit process value". Only a wire-break and a short-circuit are recognized and the PID_Compact switches to "Inactive" mode.

WARNING

If you set very high process value limits (for example $-3.4*10^{38}$...$+3.4*10^{38}$), process value monitoring will be disabled. Your system may then be damaged if an error occurs.

See also

Process value monitoring V1 (Page 103)
PWM limits V1 (Page 104)
Output value limits V1 (Page 106)
PID parameters V1 (Page 106)

6.3.1.3 Advanced settings V1

Process value monitoring V1

Configure a warning high and low limit for the process value in the "Process value monitoring" configuration window. If one of the warning limits is exceeded or undershot during operation, a warning will be displayed at the PID_Compact instruction:

- At the InputWarning_H output parameter if the warning high limit has been exceeded
- At the InputWarning_L output parameter if the warning low limit has been undershot

The warning limits must be within the process value high and low limits.

The process value high and low limits will be used if you do not enter values.

Example

Process value high limit = 98° C; warning high limit = 90° C

Warning low limit = 10° C; process value low limit = 0° C

PID_Compact will respond as follows:

Process value	InputWarning_H	InputWarning_L	Operating mode
> 98° C	TRUE	FALSE	Inactive
≤ 98° C and > 90° C	TRUE	FALSE	Automatic mode
≤ 90° C and ≥ 10° C	FALSE	FALSE	Automatic mode
< 10° C and ≥ 0° C	FALSE	TRUE	Automatic mode
< 0° C	FALSE	TRUE	Inactive

See also

Process value settings V1 (Page 102)
PWM limits V1 (Page 104)
Output value limits V1 (Page 106)
PID parameters V1 (Page 106)

PWM limits V1

Via pulse width modulation, the value at the output parameter Output is transformed into a pulse sequence that is output at output parameter Output_PWM.

Output is calculated in the PID algorithm sampling time. The sampling time is used as time period of the pulse width modulation.

The PID algorithm sampling time is determined during pretuning or fine tuning. If manually setting the PID parameters, you will also need to configure the PID algorithm sampling time.

Output_PWM is output in the PID_Compact sampling time. The PID_Compact sampling time is equivalent to the cycle time of the calling OB.

The pulse duration is proportional to the value at Output and is always an integer multiple of the PID_Compact sampling time.

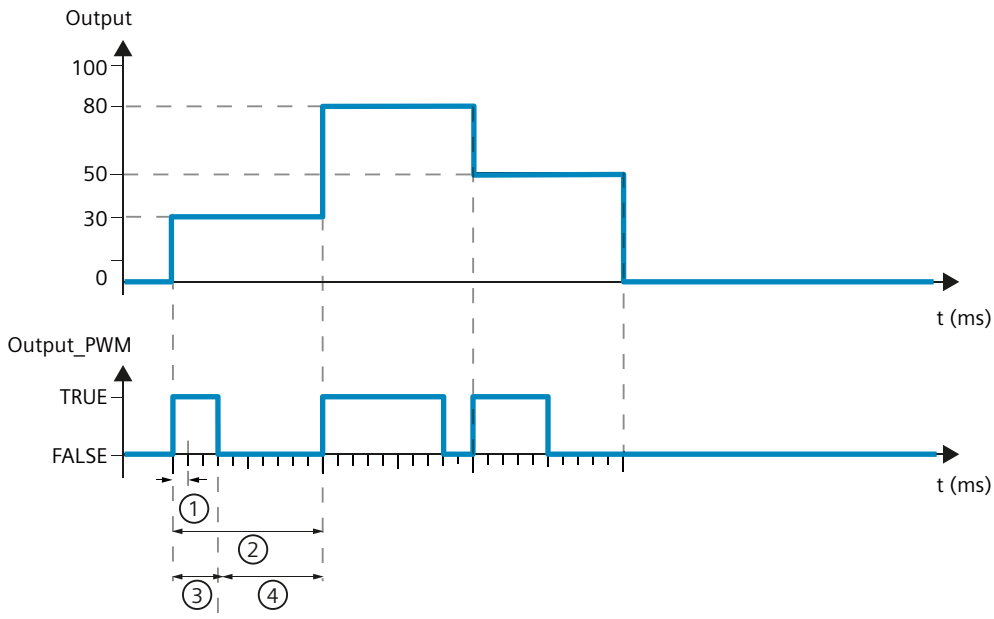

① PID_Compact sampling time

② PID algorithm sampling time

③ Pulse duration

④ Break time

The "Minimum ON time" and the "Minimum OFF time" are rounded to an integer multiple of the PID_Compact sampling time.

A pulse or a break is never shorter than the minimum ON or OFF time. The inaccuracies this causes are added up and compensated in the next cycle.

Example

PID_Compact sampling time (equivalent to the cycle time of the calling OB) = 100 ms

PID algorithm sampling time (equivalent to the time period)= 1000 ms

Minimum ON time = 200 ms

Output is a constant 15%. The smallest pulse that PID_Compact can output is 20%. In the first cycle, no pulse is output. In the second cycle, the pulse not output in the first cycle is added to the pulse of the second cycle.

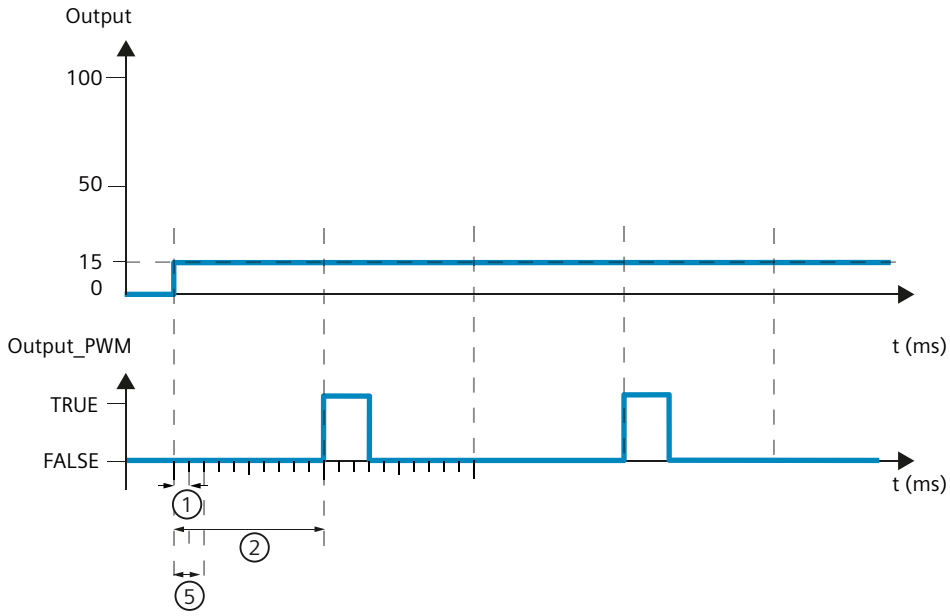

① PID_Compact sampling time

② PID algorithm sampling time

⑤ Minimum ON time

In order to minimize operation frequency and conserve the actuator, extend the minimum ON and OFF times.

If you are using "Output" or "Output_PER", you must configure the value 0.0 for the minimum ON and OFF times.

NOTE

The minimum ON and OFF times only affect the output parameter Output_PWM and are not used for any pulse generators integrated in the CPU.

See also

Process value settings V1 (Page 102)

Process value monitoring V1 (Page 103)

Output value limits V1 (Page 106)

PID parameters V1 (Page 106)

Output value limits V1

In the "Output value limits" configuration window, configure the absolute limits of your output value in percent. Absolute output value limits are not violated in neither manual mode nor in automatic mode. If a output value outside the limits is specified in manual mode, the effective value is limited in the CPU to the configured limits.

The valid output value limit values depend on the Output used.

Output	-100.0 to 100.0
Output_PER	-100.0 to 100.0
Output_PWM	0.0 to 100.0

PID_Compact sets the output value to 0.0 if an error occurs. 0.0 must therefore always be within the output value limits. You will need to add an offset to Output and Output_PER in the user program if you want an output value low limit of greater than 0.0.

See also

Process value settings V1 (Page 102)

Process value monitoring V1 (Page 103)

PWM limits V1 (Page 104)

PID parameters V1 (Page 106)

PID parameters V1

The PID parameters are displayed in the "PID Parameters" configuration window. The PID parameters will be adapted to your controlled system during controller tuning. You do not need to enter the PID parameters manually.

NOTE

The currently active PID parameters are located for PID_Compact V1 in the sRet structure and as of PID_Compact V2 in the Retain.CtrlParams structure.

Change the currently active PID parameters only in "Inactive" mode online to prevent malfunction of the PID controller.

If you want to change the PID parameters in "Automatic mode" or "Manual mode" online, change the PID parameters as follows:

- PID_Compact V1: Change the PID parameters in the sBackUp structure and apply these changes with sPid_Cmpt.b_LoadBackUp = TRUE to the sRet structure.
- PID_Compact as of V2: Change the PID parameters in the CtrlParamsBackUp structure and apply these changes with LoadBackUp = TRUE to the Retain.CtrlParams structure.

Online changes to the PID parameters in "Automatic mode" can result in jumps at the output value.

The PID algorithm operates according to the following transfer function:

$$y = K_p \left[(b \cdot w - x) + \frac{1}{T_I \cdot s}(w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1}(c \cdot w - x) \right]$$

The table below shows the meaning of the icons used in the transfer function and in the subsequent figures:

Icon	Description
y	Output value of the PID algorithm
K_p	Proportional gain
s	Laplace operator
b	Proportional action weighting
w	Setpoint
x	Process value
T_I	Integration time
T_D	Derivative action time
a	Derivative delay coefficient (derivative delay T1 = a × T_D)
c	Derivative action weighting

The diagram below illustrates the integration of the parameters into the PID algorithm:

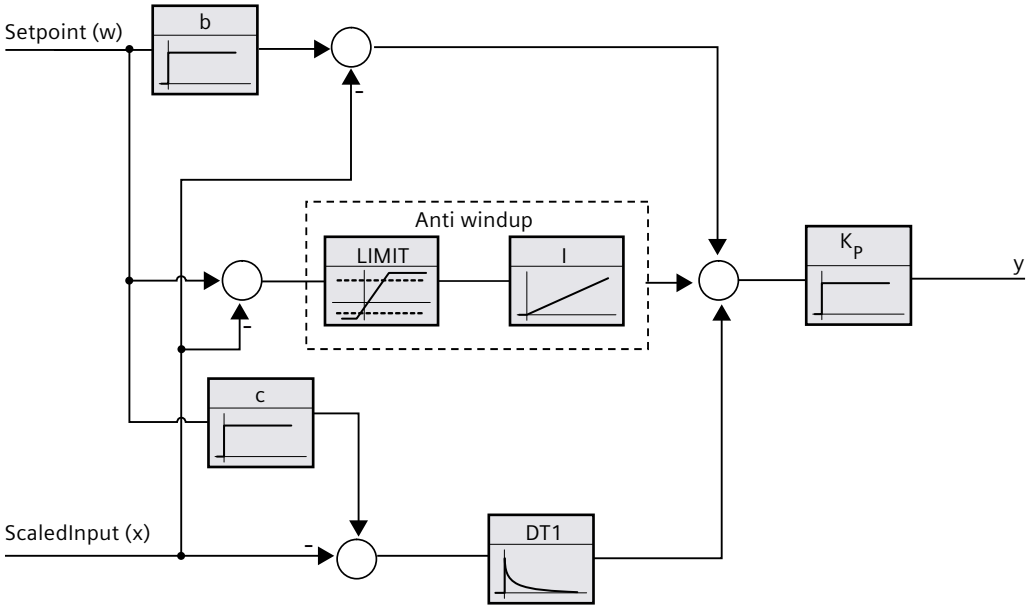

All PID parameters are retentive. If you enter the PID parameters manually, you must completely download PID_Compact.

Downloading technology objects to device (Page 46)

Proportional gain

The value specifies the proportional gain of the controller. PID_Compact does not work with a negative proportional gain. Control logic is inverted under Basic settings > Controller type.

Integration time

The integration time determines the time response of the integral action. The integral action is deactivated with integration time = 0.0. When the integration time is changed from a different value to 0.0 online in "Automatic mode", the previous integral action is deleted and the output value jumps.

Derivative action time

The derivative action time determines the time response of the derivative action. Derivative action is deactivated with derivative action time = 0.0.

Derivative delay coefficient

The derivative delay coefficient delays the effect of the derivative action.

Derivative delay = derivative action time × derivative delay coefficient

- 0.0: Derivative action is effective for one cycle only and therefore almost not effective.
- 0.5: This value has proved useful in practice for controlled systems with **one** dominant time constant.
- > 1.0: The greater the coefficient, the longer the effect of the derivative action is delayed.

Proportional action weighting

The proportional action may weaken with changes to the setpoint.

Values from 0.0 to 1.0 are applicable.

- 1.0: Proportional action for setpoint change is fully effective
- 0.0: Proportional action for setpoint change is not effective

The proportional action is always fully effective when the process value is changed.

Derivative action weighting

The derivative action may weaken with changes to the setpoint.

Values from 0.0 to 1.0 are applicable.

- 1.0: Derivative action is fully effective upon setpoint change
- 0.0: Derivative action is not effective upon setpoint change

The derivative action is always fully effective when the process value is changed.

PID algorithm sampling time

The controlled system needs a certain amount of time to respond to changes in the output value. It is therefore not advisable to calculate the output value in every cycle. The sampling time of the PID algorithm represents the time between two calculations of the output value. It is calculated during tuning and rounded to a multiple of the cycle time. All other functions of PID_Compact are executed at every call.

If you use Output_PWM, the sampling time of the PID algorithm is used as the period duration of the pulse width modulation. The accuracy of the output signal is determined by the ratio of the PID algorithm sampling time to the cycle time of the OB. It is therefore recommended that the cycle time is a maximum of one tenth of the PID algorithm sampling time.

Rule for tuning

Select whether PI or PID parameters are to be calculated in the "Controller structure" drop-down list.

- **PID**

  Calculates PID parameters during pretuning and fine tuning.
- **PI**

  Calculates PI parameters during pretuning and fine tuning.
- **User-defined**

  The drop-down list displays "User-defined" if you have configured different controller structures for pretuning and fine tuning via a user program.

6.3.2 Commissioning PID_Compact V1

6.3.2.1 Commissioning V1

The commissioning window helps you commission the PID controller. You can monitor the values for the setpoint, process value and output value along the time axis in the trend view. The following functions are supported in the commissioning window:

- Controller pretuning
- Controller fine tuning

  Use fine tuning for fine adjustments to the PID parameters.
- Monitoring the current closed-loop control in the trend view
- Testing the controlled system by specifying a manual output value

All functions require an online connection to the CPU to have been established.

Basic handling

- Select the desired sampling time in the "Sampling time" drop-down list.

  All values in the commissioning window are updated in the selected update time.
- Click the "Start" icon in the measuring group if you want to use the commissioning functions.

  Value recording is started. The current values for the setpoint, process value and output value are entered in the trend view. Operation of the commissioning window is enabled.
- Click the "Stop" icon if you want to end the commissioning functions.

  The values recorded in the trend view can continue to be analyzed.

Closing the commissioning window will terminate recording in the trend view and delete the recorded values.

See also

Pretuning V1 (Page 110)
Fine tuning V1 (Page 111)
"Manual" mode V1 (Page 113)

6.3.2.2 Pretuning V1

The pretuning determines the process response to a jump change of the output value and searches for the point of inflection. The tuned PID parameters are calculated as a function of the maximum slope and dead time of the controlled system.

The more stable the process value is, the easier it is to calculate the PID parameters and the more precise the result will be. Noise on the process value can be tolerated as long as the rate of rise of the process value is significantly higher compared to the noise. The PID parameters are backed up before being recalculated.

Requirement

- The "PID_Compact" instruction is called in a cyclic interrupt OB.
- ManualEnable = FALSE
- PID_Compact is in "inactive" or "manual" mode.
- The setpoint may not be changed during controller tuning. PID_Compact will otherwise be deactivated.
- The setpoint and the process value lie within the configured limits (see "Process value monitoring" configuration).
- The difference between setpoint and process value is greater than 30% of the difference between process value high limit and process value low limit.
- The distance between the setpoint and the process value is > 50% of the setpoint.

Procedure

To perform pretuning, follow these steps:

1. Double-click the "PID_Compact > Commissioning" entry in the project tree.
2. Select the entry "Pretuning" in the "Tuning mode" drop-down list.
3. Click the "Start" icon.
   - An online connection will be established.
   - Value recording is started.
   - Pretuning is started.
   - The "Status" field displays the current steps and any errors that may have occurred. The progress bar indicates the progress of the current step.

NOTE

Click the "Stop" icon when the progress bar has reached 100% and it is to be assumed the controller tuning function is blocked. Check the configuration of the technology object and, if necessary, restart controller tuning.

Result

If pretuning was performed without an error message, the PID parameters have been tuned. PID_Compact switches to automatic mode and uses the tuned parameters. The tuned PID parameters will be retained during power OFF and a restart of the CPU.

If pretuning is not possible, PID_Compact will change to "Inactive" mode.

See also

Parameters State and sRet.i_Mode V1 (Page 292)
Commissioning V1 (Page 109)
Fine tuning V1 (Page 111)
"Manual" mode V1 (Page 113)

6.3.2.3 Fine tuning V1

Fine tuning generates a constant, limited oscillation of the process value. The PID parameters are optimized for the operating point from the amplitude and frequency of this oscillation. All PID parameters are recalculated on the basis of the findings. PID parameters from fine tuning usually have better master control and disturbance behavior than PID parameters from pretuning.

PID_Compact automatically attempts to generate an oscillation greater than the noise of the process value. Fine tuning is only minimally influenced by the stability of the process value. The PID parameters are backed up before being recalculated.

Requirement

- The PID_Compact instruction is called in a cyclic interrupt OB.
- ManualEnable = FALSE
- The setpoint and the process value lie within the configured limits (see "Process value monitoring" configuration).
- The control loop has stabilized at the operating point. The operating point is reached when the process value corresponds to the setpoint.
- No disturbances are expected.
- The setpoint may not be changed during controller tuning.
- PID_Compact is in inactive mode, automatic mode or manual mode.

Process depends on initial situation

Fine tuning can be started in "inactive", "automatic" or "manual" mode. Fine tuning proceeds as follows when started in:

- Automatic mode

  Start fine tuning in automatic mode if you wish to improve the existing PID parameters using controller tuning.

  PID_Comact will regulate using the existing PID parameters until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start.

- Inactive or manual mode

  If the requirements for pretuning are met, pretuning is started. The PID parameters established will be used for adjustment until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start. If pretuning is not possible, PID_Compact will change to "Inactive" mode.

  An attempt is made to reach the setpoint with a minimum or maximum output value if the process value for pretuning is already too near the setpoint. This can produce increased overshoot.

Procedure

Proceed as follows to carry out "fine tuning":

1. Select the entry "Fine tuning" in the "Tuning mode" drop-down list.
2. Click the "Start" icon.
   - An online connection will be established.
   - Value recording is started.
   - The process of fine tuning is started.
   - The "Status" field displays the current steps and any errors that may have occurred. The progress bar indicates the progress of the current step.

NOTE

Click the "Stop" icon in the "Tuning mode" group when the progress bar has reached 100% and it is to be assumed the controller tuning function is blocked. Check the configuration of the technology object and, if necessary, restart controller tuning.

Result

The PID parameters will have been optimized if fine tuning has been executed without errors. PID_Compact changes to automatic mode and uses the optimized parameters. The optimized PID parameters will be retained during power OFF and a restart of the CPU.

If errors occurred during "fine tuning", PID_Compact will change to "inactive" mode.

See also

Parameters State and sRet.i_Mode V1 (Page 292)

Commissioning V1 (Page 109)

Pretuning V1 (Page 110)

"Manual" mode V1 (Page 113)

6.3.2.4 "Manual" mode V1

The following section describes how you can use the "Manual" operating mode in the commissioning window of the "PID Compact" technology object.

Requirement

- The "PID_Compact" instruction is called in a cyclic interrupt OB.
- An online connection to the CPU has been established and the CPU is in the "RUN" mode.
- The functions of the commissioning window have been enabled via the "Start" icon.

Procedure

Use "Manual mode" in the commissioning window if you want to test the controlled system by specifying a manual value. To define a manual value, proceed as follows:

1. Select the "Manual mode" check box in the "Online status of controller" area.

   PID_Compact operates in manual mode. The most recent current output value remains in effect.
2. Enter the manual value in the "Output" field as a % value.
3. Click the control icon .

Result

The manual value is written to the CPU and immediately goes into effect.

NOTE

PID_Compact continues to monitor the process value. If the process value limits are exceeded, PID_Compact is deactivated.

Clear the "Manual mode" check box if the output value is to be specified again by the PID controller. The switchover to automatic mode is bumpless.

See also

Parameters State and sRet.i_Mode V1 (Page 292)

Commissioning V1 (Page 109)

Pretuning V1 (Page 110)

Fine tuning V1 (Page 111)

6.3.3 Simulating PID_Compact V1 with PLCSIM

NOTE

Simulation with PLCSIM

For the simulation with PLCSIM, the time behavior of the simulated PLC is not exactly identical to that of a "real" PLC. The actual cycle clock of a cyclic interrupt OB can have larger fluctuations with a simulated PLC than with "real" PLCs.

In the standard configuration, PID_Compact determines the time between calls automatically and monitors them for fluctuations.

For a simulation of PID_Compact with PLCSIM, for example, a sampling time error (ErrorBits = DW#16#00000800) can therefore be detected.

PID_Compact switches to "Inactive" mode (State = 0) in this case.

To prevent this from happening, you should configure PID_Compact for simulation with PLCSIM as follows:

- sb_EnCyclEstimation = FALSE
- sb_EnCyclMonitoring = FALSE
- sPid_Calc.r_Cycle: Assign the cycle clock of the calling cyclic interrupt OB in seconds to this tag.

Using PID_3Step

7

7.1 Technology object PID_3Step

The technology object PID_3Step provides a PID controller with tuning for valves or actuators with integral response.

You can configure the following controllers:

- Three-point step controller with position feedback
- Three-point step controller without position feedback
- Valve controller with analog output value

PID_3Step continuously acquires the measured process value within a control loop and compares it with the setpoint. From the resulting control deviation, PID_3Step calculates an output value through which the process value reaches the setpoint as quickly and steadily as possible. The output value for the PID controller consists of three actions:

- **Proportional** action

  The proportional action of the output value increases in proportion to the control deviation.

- **I** action

  The integral action of the output value increases until the control deviation has been balanced.

- **D** action

  The derivative action increases with the rate of change of control deviation. The process value is corrected to the setpoint as quickly as possible. The derivative action will be reduced again if the rate of change of control deviation drops.

The instruction PID_3Step calculates the proportional, integral and derivative parameters for your controlled system during pretuning. Fine tuning can be used to tune the parameters further. You do not need to manually determine the parameters.

Additional information

- Overview of software controller (Page 41)
- Add technology objects (Page 43)
- Configure technology objects (Page 44)
- Configuring PID_3Step V2 (Page 117)
- Configuring PID_3Step V1 (Page 135)

Principle

For more information, see the following FAQs in the Siemens Industry Online Support:

- Entry ID 68011827 (https://support.industry.siemens.com/cs/ww/en/view/68011827)

7.2 PID_3Step V2

7.2.1 Configuring PID_3Step V2

7.2.1.1 Basic settings V2

Introduction V2

Configure the following properties of the "PID_3Step" technology object under "Basic settings" in the Inspector window or in the configuration window:

- Physical quantity
- Control logic
- Start-up behavior after reset
- Setpoint (only in the Inspector window)
- Process value (only in the Inspector window)
- Output value (only in the Inspector window)
- Position feedback (only in the Inspector window)

Setpoint, process value, output value and position feedback

You can only configure the setpoint, process value, output value and position feedback in the Inspector window of the programming editor. Select the source for each value:

- Instance DB

  The value saved in the instance DB is used.

  Value must be updated in the instance DB by the user program.

  There should be no value at the instruction.

  Change via HMI possible.
- Instruction

  The value connected to the instruction is used.
  The value is written to the instance DB each time the instruction is called.

  No change via HMI possible.

Control mode V2

Physical quantity

Select the unit of measurement and physical quantity for the setpoint and the process value in the "Controller type" group. The setpoint and the process value are displayed in this unit.

Control logic

An increase of the output value is generally intended to cause an increase in the process value. This is referred to as a normal control logic.

PID_3Step does not work with negative proportional gain. Select the check box "Invert control logic" to reduce the process value with a higher output value.

Examples

- Opening the drain valve will reduce the level of a container's contents.
- Increasing cooling will reduce the temperature.

Startup characteristics

1. To switch to "Inactive" mode after CPU restart, clear the "Activate Mode after CPU restart" check box.

   To switch to the operating mode saved in the Mode parameter after CPU restart, select the "Activate Mode after CPU restart" check box.

2. In the "Set Mode to" drop-down list, select the mode that is to be enabled after a complete download to the device.

   After a complete download to the device, PID_3Step starts in the selected operating mode. With each additional restart, PID_3Step starts in the mode that was last saved in Mode.

Example

You have selected the "Activate Mode after CPU restart" check box and the entry "Pretuning" in the "Set Mode to" list. After a complete download to the device, PID_3Step starts in the "Pretuning" mode. If pretuning is still active, PID_3Step starts in "Pretuning" mode again after restart of the CPU. If pretuning was successfully completed and automatic mode is active, PID_3Step starts in "Automatic mode" after restart of the CPU.

Setpoint V2

Procedure

Proceed as follows to define a fixed setpoint:

1. Select "Instance DB".
2. Enter a setpoint, e.g. 80° C.
3. Delete any entry in the instruction.

Proceed as follows to define a variable setpoint:

1. Select "Instruction".
2. Enter the name of the REAL variable in which the setpoint is saved.

   Program-controlled assignment of various values to the REAL variable is possible, for example for the time controlled change of the setpoint.

Process value V2

PID_3Step will scale the value of the analog input to the physical quantity if you use the analog input value directly.

You will need to write a program for processing if you wish first to process the analog input value. The process value is, for example, not directly proportional to the value at the analog input. The processed process value must be in floating point format.

Procedure

Proceed as follows to use the analog input value without processing:

1. Select the entry "Input_PER" in the drop-down list "Input".
2. Select "Instruction" as source.
3. Enter the address of the analog input.

Proceed as follows to use the processed process value in floating point format:

1. Select the entry "Input" in the drop-down list "Input".
2. Select "Instruction" as source.
3. Enter the name of the variable in which the processed process value is saved.

Position feedback V2

Position feedback configuration depends upon the actuator used.

- Actuator without position feedback
- Actuator with digital endstop signals
- Actuator with analog position feedback
- Actuator with analog position feedback and endstop signals

Actuator without position feedback

Proceed as follows to configure PID_3Step for an actuator without position feedback:

1. Select the entry "No Feedback" in the drop-down list "Feedback".

Actuator with digital endstop signals

Proceed as follows to configure PID_3Step for an actuator with endstop signals:

1. Select the entry "No Feedback" in the drop-down list "Feedback".
2. Activate the "Actuator endstop signals" check box.
3. Select "Instruction" as source for Actuator_H and Actuator_L.
4. Enter the addresses of the digital inputs for Actuator_H and Actuator_L.

Actuator with analog position feedback

Proceed as follows to configure PID_3Step for an actuator with analog position feedback:

1. Select the entry "Feedback" or "Feedback_PER" in the drop-down list "Feedback".
   - Use the analog input value for Feedback_PER. Configure Feedback_PER scaling in the actuator settings.
   - Process the analog input value for Feedback using your user program.
2. Select "Instruction" as source.
3. Enter the address of the analog input or the variable of your user program.

Actuator with analog position feedback and endstop signals

Proceed as follows to configure PID_3Step for an actuator with analog position feedback and endstop signals:

1. Select the entry "Feedback" or "Feedback_PER" in the drop-down list "Feedback".
2. Select "Instruction" as source.
3. Enter the address of the analog input or the variable of your user program.
4. Activate the "Actuator endstop signals" check box.
5. Select "Instruction" as source for Actuator_H and Actuator_L.
6. Enter the addresses of the digital inputs for Actuator_H and Actuator_L.

Output value V2

PID_3Step offers an analog output value (Output_PER) and digital output values (Output_UP, Output_DN). Your actuator will determine which output value you use.

- Output_PER

  The actuator has a relevant motor transition time and is triggered via an analog output and controlled with a continuous signal, e.g. 0...10 V or 4...20 mA. The value at Output_PER corresponds to the target position of the valve, e.g. Output_PER = 13824, when the valve is to be opened by 50%.

  For auto-tuning and anti windup behavior, for example, PID_3Step takes into consideration that the analog output value has a delayed effect on the process due to the motor transition time. If no relevant motor transition time is in effect in your process (e.g. with solenoid valves), so that the output value has a direct and full effect on the process, use PID_Compact instead.

- Output_UP, Output_DN

  The actuator has a relevant motor transition time and is controlled by two digital outputs.
  Output_UP moves the valve in the open state direction.
  Output_DN moves the valve in the closed state direction.

The motor transition time is taken into consideration in the calculation of the analog output value as well as in the calculation of the digital output values. It is mainly required for correct operation during auto-tuning and the anti-windup behavior. You should therefore configure the motor transition time under "Actuator settings" with the value that the motor requires to move the actuator from the closed to the opened state.

Procedure

Proceed as follows to use the analog output value:

1. Select the entry "Output (analog)" in the drop-down list "Output".
2. Select "Instruction".
3. Enter the address of the analog output.

Proceed as follows to use the digital output value:

1. Select the entry "Output (digital)" in the drop-down list "Output".
2. Select "Instruction" for Output_UP and Output_DN.
3. Enter the addresses of the digital outputs.

Proceed as follows to process the output value using the user program:

1. Select the entry corresponding to the actuator in the drop-down list "Output".
2. Select "Instruction".
3. Enter the name of the tag you are using to process the output value.
4. Transfer the processed output value to the actuator by means of an analog or digital CPU output.

7.2.1.2 Process value settings V2

Process value scaling V2

If you have configured the use of Input_PER in the basic setting, you must convert the value of the analog input to the physical quantity of the process value. The current configuration is displayed in the Input_PER display.

Input_PER will be scaled using a low and high value pair if the process value is directly proportional to the value of the analog input.

Procedure

To scale the process value, follow these steps:

1. Enter the low pair of values in the "Scaled low process value" and "Low" text boxs.
2. Enter the high pair of values in the "Scaled high process value" and "High" input boxes.

Default settings for the value pairs are stored in the hardware configuration. To use the value pairs from the hardware configuration, follow these steps:

1. Select the PID_3Step instruction in the programming editor.
2. Interconnect Input_PER with an analog input in the basic settings.
3. Click the "Automatic setting" button in the process value settings.

The existing values will be overwritten with the values from the hardware configuration.

Process value limits V2

You must specify an appropriate absolute high limit and low limit for the process value as limit values for your controlled system. As soon as the process value violates these limits, an error occurs (ErrorBits = 0001h). Tuning is canceled when the process value limits are violated. You can specify how PID_3Step responds to errors in automatic mode in the actuator settings.

7.2.1.3 Actuator settings V2

Actuator V2

Actuator-specific times

Configure the motor transition time and the minimum ON and OFF times to prevent damage to the actuator. You can find the specifications in the actuator data sheet.

The motor transition time is the time in seconds the motor requires to move the actuator from the closed to the opened state. You can measure the motor transition time during commissioning.

The motor transition time is taken into consideration in the calculation of the analog output value as well as in the calculation of the digital output values. It is mainly required for correct operation during auto-tuning and the anti-windup behavior.

If no relevant motor transition time is in effect in your process (e.g. with solenoid valves), so that the output value has a direct and full effect on the process, use PID_Compact instead.

The motor transition time is retentive. If you enter the motor transition time manually, you must completely download PID_3Step.

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If you are using "Output_UP" or "Output_DN", you can reduce the switching frequency with the minimum on and minimum OFF time.

The on or off times calculated are totaled in automatic mode and only take effect when the sum is greater than or equal to the minimum on or OFF time.

Manual_UP = TRUE or Manual_DN = TRUE in manual mode operates the actuator for at least the minimum ON or OFF time.

If you have selected the analog output value Output_PER in the basic settings, the minimum ON time and the minimum OFF time are not evaluated and cannot be changed.

Response to errors

PID_3Step is preset so that the controller stays active in most cases in the event of an error. If errors occur frequently in controller mode, this default reaction has a negative effect on the control response. In this case, check the Errorbits parameter and eliminate the cause of the error.

NOTICE
Your system may be damaged. If you output "Current value while error pending" or "Substitute output value while error pending" in the event of an error, PID_3Step remains in automatic mode even if the process value limits are violated. This may damage your system. It is essential to configure how your controlled system reacts in the event of an error to protect your system from damage.

PID_3Step generates a programmable output value in response to an error:

- Current value

  PID_3Step is switched off and no longer modifies the actuator position.

- Current value while error is pending

  The controller functions of PID_3Step are switched off and the position of the actuator is no longer changed.

  If the following errors occur in automatic mode, PID_3Step returns to automatic mode as soon as the errors are no longer pending.

  – 0002h: Invalid value at Input_PER parameter.
  – 0200h: Invalid value at Input parameter.
  – 0400h: Calculation of output value failed.
  – 1000h: Invalid value at Setpoint parameter.
  – 2000h: Invalid value at Feedback_PER parameter.
  – 4000h: Invalid value at Feedback parameter.
  – 8000h: Error during digital position feedback.
  – 20000h: Invalid value at SavePosition tag.

If one or more of the following errors occur, PID_3Step stays in automatic mode:

– 0001h: The Input parameter is outside the process value limits.

– 0800h: Sampling time error

– 40000h: Invalid value at Disturbance parameter.

PID_3Step remains in manual mode if an error occurs in manual mode.

If an error occurs during tuning or transition time measurement, PID_3Step switches to the mode in which tuning or transition time measurement was started. Only in the event of the following error is tuning not aborted:

– 0020h: Pretuning is not permitted during fine tuning.

- Substitute output value

  PID_3Step moves the actuator to the substitute output value and then switches off.

- Substitute output value while error is pending

  PID_3Step moves the actuator to the substitute output value. When the substitute output value is reached, PID_3Step reacts as it does with "Current value for while error is pending".

Enter the substitute output value in "%".

Only substitute output values 0% and 100% can be configured when using Output_UP and Output_DN without analog position feedback (Config.OutputPerOn = FALSE and Config.FeedbackOn = FALSE). To reach the high or low endstop, the actuator is moved in the corresponding direction. If endstops are available (Config.ActuatorEndStopOn = TRUE), Output_UP and Output_DN are reset with Actuator_H = TRUE or Actuator_L = TRUE. If no endstop signals are available (Config.ActuatorEndStopOn = FALSE), Output_UP and Output_DN are reset after a travel time of Config.VirtualActuatorLimit * Retain.TransitTime/100.

Any substitute output values within the output value limits can be configured when using Output_PER or analog position feedback (Config.OutputPerOn = TRUE or Config.FeedbackOn = TRUE).

Feedback scaling V2

Scaling position feedback

If you have configured the use of Feedback_PER in the basic settings, you will need to convert the value of the analog input into %. The current configuration will be displayed in the "Feedback" display.

Feedback_PER is scaled using a low and high value pair.

1. Enter the low pair of values in the "Low endstop" and "Low" input boxes.
2. Enter the high pair of values in the "High endstop" and "High" input boxes.

"Low endstop" must be less than "High endstop"; "Low" must be less than "High".

The valid values for "High endstop" and "Low endstop" depend upon:

- No Feedback, Feedback, Feedback_PER
- Output (analog), Output (digital)

Output	Feedback	Low endstop	High endstop
Output (digital)	No Feedback	Cannot be set (0.0%)	Cannot be set (100.0%)
Output (digital)	Feedback	-100.0% or 0.0%	0.0% or +100.0%
Output (digital)	Feedback_PER	-100.0% or 0.0%	0.0% or +100.0%
Output (analog)	No Feedback	Cannot be set (0.0%)	Cannot be set (100.0%)
Output (analog)	Feedback	-100.0% or 0.0%	0.0% or +100.0%
Output (analog)	Feedback_PER	-100.0% or 0.0%	0.0% or +100.0%

Output value limits V2

Limiting the output value

You can exceed or undershoot the output value limits during the transition time measurement and with mode = 10. The output value is limited to these values in all other modes.

Enter the absolute output value limits in the "Output value high limit" and "Output value low limit" input boxes. The output value limits must be within "Low endstop" and "High endstop".

If no Feedback is available and Output (digital) is set, you cannot limit the output value. Output_UP and Output_DN are then reset upon Actuator_H = TRUE or Actuator_L = TRUE. If no endstop signals are available, Output_UP and Output_DN are reset after a travel time of 150% of the motor actuating time.

The default value of 150% can be adjusted using the tagConfig.VirtualActuatorLimit. As of PID_3Step Version 2.3 the monitoring and limiting of the travel time can be deactivated with Config.VirtualActuatorLimit = 0.0.

7.2.1.4 Advanced settings V2

Process value monitoring V2

Configure a warning high and low limit for the process value in the "Process value monitoring" configuration window. If one of the warning limits is exceeded or undershot during operation, a warning will be displayed at the PID_3Step instruction:

- At the InputWarning_H output parameter if the warning high limit has been exceeded
- At the InputWarning_L output parameter if the warning low limit has been undershot

The warning limits must be within the process value high and low limits.

The process value high and low limits will be used if you do not enter values.

Example

Process value high limit = 98° C; warning high limit = 90° C

Warning low limit = 10° C; process value low limit = 0° C

PID_3Step will respond as follows:

Process value	InputWarning_H	InputWarning_L	ErrorBits	Operating mode
> 98° C	TRUE	FALSE	0001h	As configured
≤ 98° C and > 90° C	TRUE	FALSE	0000h	Automatic mode

Process value	InputWarning_H	InputWarning_L	ErrorBits	Operating mode
≤ 90° C and ≥ 10° C	FALSE	FALSE	0000h	Automatic mode
< 10° C and ≥ 0° C	FALSE	TRUE	0000h	Automatic mode
< 0° C	FALSE	TRUE	0001h	As configured

In the actuator settings, you can configure the response of PID_3Step when the process value high limit or low limit is violated.

PID parameters V2

The PID parameters are displayed in the "PID Parameters" configuration window. The PID parameters will be adapted to your controlled system during controller tuning. You do not need to enter the PID parameters manually.

NOTE

The currently active PID parameters are located in the Retain.CtrlParams structure.

Change the currently active PID parameters only in "Inactive" mode online to prevent malfunction of the PID controller.

If you want to change the PID parameters in "Automatic mode" or "Manual mode" online, change the PID parameters in the CtrlParamsBackUp structure and apply these changes to the Retain.CtrlParams structure as follows:

- PID_3Step V1: Apply the changes with Config.LoadBackUp = TRUE
- PID_3Step V2: Apply the changes with LoadBackUp = TRUE

Online changes to the PID parameters in "Automatic mode" can result in jumps at the output value.

The PID algorithm operates according to the following transfer function:

$$\Delta y = K_p \cdot s \cdot \left[(b \cdot w - x) + \frac{1}{T_I \cdot s}(w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1}(c \cdot w - x)\right]$$

The table below shows the meaning of the icons used in the transfer function and in the subsequent figures:

Icon	Description
Δy	Output value of the PID algorithm
K_p	Proportional gain
s	Laplace operator
b	Proportional action weighting
w	Setpoint
x	Process value
T_I	Integration time
T_D	Derivative action time
a	Derivative delay coefficient (derivative delay T1 = a × T_D)
c	Derivative action weighting

The diagram below illustrates the integration of the parameters into the PID algorithm:

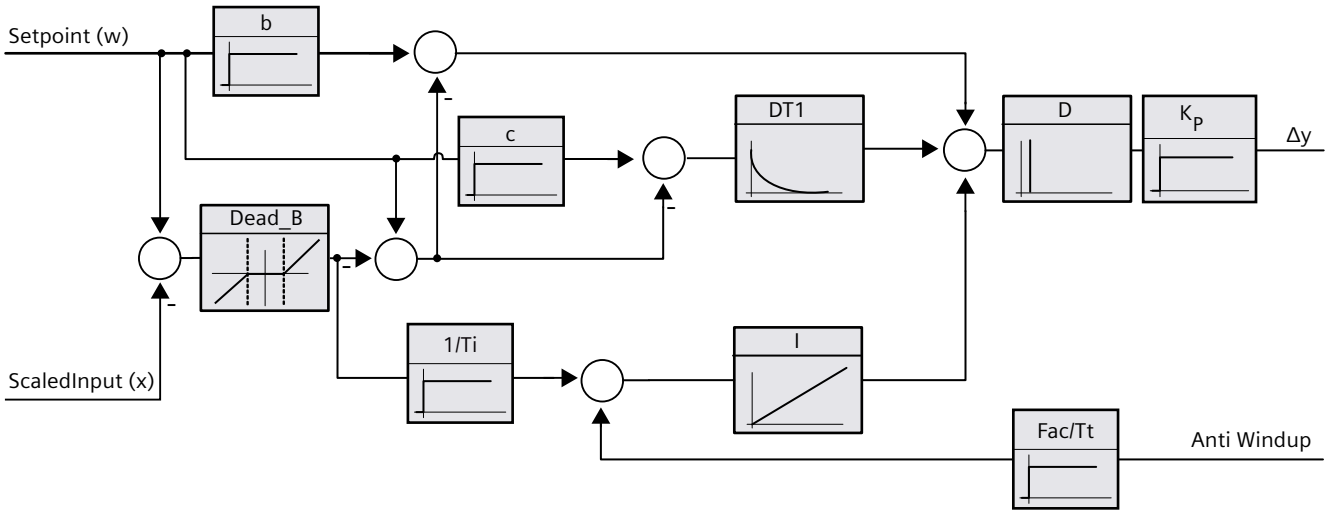

All PID parameters are retentive. If you enter the PID parameters manually, you must completely download PID_3Step.

Downloading technology objects to device (Page 46)

Proportional gain

The value specifies the proportional gain of the controller. PID_3Step does not work with a negative proportional gain. Control logic is inverted under Basic settings > Controller type.

Integration time

The integration time determines the time response of the integral action. The integral action is deactivated with integration time = 0.0. When the integration time is changed from a different value to 0.0 online in "Automatic mode", the previous integral action is deleted and the output value jumps.

Derivative action time

The derivative action time determines the time response of the derivative action. Derivative action is deactivated with derivative action time = 0.0.

Derivative delay coefficient

The derivative delay coefficient delays the effect of the derivative action.

Derivative delay = derivative action time × derivative delay coefficient

- 0.0: Derivative action is effective for one cycle only and therefore almost not effective.
- 0.5: This value has proved useful in practice for controlled systems with **one** dominant time constant.
- > 1.0: The greater the coefficient, the longer the effect of the derivative action is delayed.

Proportional action weighting

The proportional action may weaken with changes to the setpoint.

Values from 0.0 to 1.0 are applicable.

- 1.0: Proportional action for setpoint change is fully effective
- 0.0: Proportional action for setpoint change is not effective

The proportional action is always fully effective when the process value is changed.

Derivative action weighting

The derivative action may weaken with changes to the setpoint.

Values from 0.0 to 1.0 are applicable.

- 1.0: Derivative action is fully effective upon setpoint change
- 0.0: Derivative action is not effective upon setpoint change

The derivative action is always fully effective when the process value is changed.

PID algorithm sampling time

The controlled system needs a certain amount of time to respond to changes in the output value. It is therefore not advisable to calculate the output value in every cycle. The sampling time of the PID algorithm represents the time between two calculations of the output value. It is calculated during tuning and rounded to a multiple of the PID_3Step sampling time. All other functions of PID_3Step are executed at every call.

Dead zone width

The dead zone suppresses the noise component in the steady controller state. The dead zone width specifies the size of the dead zone. The dead zone is off if the dead zone width is 0.0.

If values not equal to 1.0 are configured for the proportional action weighting or the derivative action weighting, setpoint changes even within the dead zone affect the output value.
Process value changes within the dead zone do not affect the output value, regardless of the weighting.

7.2.2 Commissioning PID_3Step V2

7.2.2.1 Pretuning V2

The pretuning determines the process response to a pulse of the output value and searches for the point of inflection. The tuned PID parameters are calculated as a function of the maximum slope and dead time of the controlled system. You obtain the best PID parameters when you perform pretuning and fine tuning.

The more stable the process value is, the easier it is to calculate the PID parameters and the more precise the result will be. Noise on the process value can be tolerated as long as the rate of rise of the process value is significantly higher compared to the noise. This is most likely the case in operating modes "Inactive" and "manual mode". The PID parameters are backed up before being recalculated.

The setpoint is frozen during pretuning.

Requirement

- The PID_3Step instruction is called in a cyclic interrupt OB.
- ManualEnable = FALSE
- Reset = FALSE
- The motor transition time has been configured or measured.
- PID_3Step is in one of the following modes: "Inactive", "Manual mode", or "Automatic mode".
- The setpoint and the process value lie within the configured limits (see "Process value settings" configuration).

Procedure

To perform pretuning, follow these steps:

1. Double-click the "PID_3Step > Commissioning" entry in the project tree.
2. Select the entry "Pretuning" in the "Tuning mode" drop-down list in the working area "Tuning".
3. Click the "Start" icon.
   - An online connection will be established.
   - Value recording is started.
   - Pretuning is started.
   - The "Status" field displays the current steps and any errors that may have occurred. The progress bar indicates the progress of the current step.

NOTE

Click the "Stop" icon when the progress bar has reached 100% and it is to be assumed the controller tuning function is blocked. Check the configuration of the technology object and, if necessary, restart controller tuning.

Result

If pretuning was performed without an error message, the PID parameters have been tuned. PID_3Step switches to automatic mode and uses the tuned parameters. The tuned PID parameters will be retained during power OFF and a restart of the CPU.

If pretuning is not possible, PID_3Step responds with the configured reaction to errors.

7.2.2.2 Fine tuning V2

Fine tuning generates a constant, limited oscillation of the process value. The PID parameters are tuned for the operating point from the amplitude and frequency of this oscillation. All PID parameters are recalculated from the results. PID parameters from fine tuning usually have better master control and disturbance characteristics than PID parameters from pretuning. You obtain the best PID parameters when you perform pretuning and fine tuning.

PID_3Step automatically attempts to generate an oscillation greater than the noise of the process value. Fine tuning is only minimally influenced by the stability of the process value. The PID parameters are backed up before being recalculated.

The setpoint is frozen during fine tuning.

Requirement

- The PID_3Step instruction is called in a cyclic interrupt OB.
- ManualEnable = FALSE
- Reset = FALSE
- The motor transition time has been configured or measured.
- The setpoint and the process value lie within the configured limits (see "Process value settings" configuration).
- The control loop has stabilized at the operating point. The operating point is reached when the process value corresponds to the setpoint.
- No disturbances are expected.
- PID_3Step is in inactive mode, automatic mode or manual mode.

Process depends on initial situation

Fine tuning proceeds as follows when started from:

- Automatic mode

  Start fine tuning from automatic mode if you wish to improve the existing PID parameters through tuning.

  PID_3Step controls the system using the existing PID parameters until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start.

- Inactive or manual mode

  Pretuning is always started first. The determined PID parameters will be used for control until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start.

Procedure

To perform fine tuning, follow these steps:

1. Select the entry "Fine tuning" in the "Tuning mode" drop-down list.
2. Click the "Start" icon.
   - An online connection will be established.
   - Value recording is started.
   - The process of fine tuning is started.
   - The "Status" field displays the current steps and any errors that may have occurred. The progress bar indicates the progress of the current step.

NOTE

Click the "Stop" icon in the "Tuning mode" group when the progress bar has reached 100% and it is to be assumed the controller tuning function is blocked. Check the configuration of the technology object and, if necessary, restart controller tuning.

Result

If no errors occurred during fine tuning, the PID parameters have been tuned. PID_3Step switches to automatic mode and uses the tuned parameters. The tuned PID parameters will be retained during power OFF and a restart of the CPU.

If errors occurred during fine tuning, PID_3Step responds with the configured response to errors.

7.2.2.3 Commissioning with manual PID parameters V2

Requirement

- The PID_3Step instruction is called in a cyclic interrupt OB.
- ManualEnable = FALSE
- Reset = FALSE
- The motor transition time has been configured or measured.
- PID_3Step is in "inactive" mode.
- The setpoint and the process value lie within the configured limits (see "Process value settings" configuration).

Procedure

Proceed as follows to commission PID_3Step with manual PID parameters:

1. Double-click on "PID_3Step > Configuration" in the project tree.
2. Click on "Advanced settings > PID Parameters" in the configuration window.
3. Select the check box "Enable direct input".
4. Enter the PID parameters.
5. Double-click the "PID_3Step > Commissioning" entry in the project tree.
6. Establish an online connection to the CPU.
7. Load the PID parameters to the CPU.
8. Click the "Start PID_3Step" icon.

Result

PID_3Step changes to automatic mode and controls using the current PID parameters.

See also

PID parameters V2 (Page 126)

7.2.2.4 Measuring the motor transition time V2

Introduction

PID_3Step requires the motor transition time to be as accurate as possible for good controller results. The data in the actuator documentation contains average values for this type of actuator. The value for the specific actuator used may differ.

You can measure the motor transition time during commissioning if you are using actuators with position feedback or endstop signals. The output value limits are not taken into

consideration during the motor transition time measurement. The actuator can travel to the high or the low endstop.

The motor transition time cannot be measured if neither position feedback nor endstop signals are available.

Actuators with analog position feedback

Proceed as follows to measure motor transition time with position feedback:

Requirement

- Feedback or Feedback_PER has been selected in the basic settings and the signal has been connected.
- An online connection to the CPU has been established.

1. Select the "Use position feedback" check box.
2. Enter the position to which the actuator is to be moved in the "Target position" input field.

   The current position feedback (starting position) will be displayed. The difference between "Target position" and "Position feedback" must be at least 50% of the valid output value range.
3. Click the "Start" icon.

Result

The actuator is moved from the starting position to the target position. Time measurement starts immediately and ends when the actuator reaches the target position. The motor transition time is calculated according to the following equation:

Motor transition time = (output value high limit – output value low limit) × Measuring time / AMOUNT (target position – starting position).

The progress and status of transition time measurement are displayed. The transition time measured is saved in the instance data block on the CPU and displayed in the "Measured transition time" field. When the transition time measurement is ended and ActivateRecoverMode = TRUE, PID_3Step switches to the operating mode from which the transition time measurement was started. If the transition time measurement is ended and ActivateRecoverMode = FALSE, PID_3Step changes to "Inactive" mode.

NOTE

Click on the icon "Upload measured transition time" to load the motor transition time measured to the project.

Actuators with endstop signals

Proceed as follows to measure the transition time of actuators with endstop signals:

Requirement

- The "Endstop signals" check box in the basic settings has been selected and Actuator_H and Actuator_L are connected.
- An online connection to the CPU has been established.

Proceed as follows to measure motor transition time with endstop signals:

1. Select the "Use actuator endstop signals" check box.
2. Select the direction in which the actuator is to be moved.
   - Open - Close - Open

     The actuator is moved first to the high endstop, then to the low endstop and then back to the high endstop.
   - Close - Open - Close

     The actuator is moved first to the low endstop, then to the high endstop and then back to the low endstop.
3. Click the "Start" icon.

Result

The actuator is moved in the selected direction. Time measurement will start once the actuator has reached the first endstop and will end when the actuator reaches this endstop for the second time. The motor transition time is equal to the time measured divided by two.

The progress and status of transition time measurement are displayed. The transition time measured is saved in the instance data block on the CPU and displayed in the "Measured transition time" field. When the transition time measurement is ended and ActivateRecoverMode = TRUE, PID_3Step switches to the operating mode from which the transition time measurement was started. If the transition time measurement is ended and ActivateRecoverMode = FALSE, PID_3Step changes to "Inactive" mode.

Cancelling transition time measurement

PID_3Step switches to "Inactive" mode if you cancel transition time measurement by pressing the Stop button.

7.2.3 Simulating PID_3Step V2 with PLCSIM

NOTE

Simulation with PLCSIM

The simulation of PID_3Step V2.x with PLCSIM for CPU S7-1200 is not supported.

PID_3Step V2.x can only be simulated for CPU S7-1500 and CPU S7-1200 G2 with PLCSIM.

For the simulation with PLCSIM, the time behavior of the simulated PLC is not exactly identical to that of a "real" PLC. The actual cycle clock of a cyclic interrupt OB can have larger fluctuations with a simulated PLC than with "real" PLCs.

In the standard configuration, PID_3Step determines the time between calls automatically and monitors them for fluctuations.

For a simulation of PID_3Step with PLCSIM, for example, a sampling time error ((ErrorBits = DW#16#00000800) can therefore be detected.

This results in ongoing tuning being aborted.

The response in automatic mode depends on the value of the ActivateRecoverMode tag.

To prevent this from happening, you should configure PID_3Step for simulation with PLCSIM as follows:

- CycleTime.EnEstimation = FALSE
- CycleTime.EnMonitoring = FALSE
- CycleTime.Value: Assign the cycle clock of the calling cyclic interrupt OB in seconds to this tag.

7.3 PID_3Step V1

7.3.1 Configuring PID_3Step V1

7.3.1.1 Basic settings V1

Introduction V1

Configure the following properties of the "PID_3Step" technology object under "Basic settings" in the Inspector window or in the configuration window:

- Physical quantity
- Control logic
- Start-up behavior after reset
- Setpoint (only in the Inspector window)
- Process value (only in the Inspector window)
- Output value (only in the Inspector window)
- Position feedback (only in the Inspector window)

Setpoint, process value, output value and position feedback

You can only configure the setpoint, process value, output value and position feedback in the Inspector window of the programming editor. Select the source for each value:

- Instance DB

  The value saved in the instance DB is used.

  Value must be updated in the instance DB by the user program.

  There should be no value at the instruction.

  Change via HMI possible.

- Instruction

  The value connected to the instruction is used.
  The value is written to the instance DB each time the instruction is called.

  No change via HMI possible.

Control mode V1

Physical quantity

Select the unit of measurement and physical quantity for the setpoint and process value in the "Controller type" group. The setpoint and process value will be displayed in this unit.

Control logic

An increase of the output value is generally intended to cause an increase in the process value. This is referred to as a normal control logic.

PID_3Step does not work with negative proportional gain. Select the check box "Invert control logic" to reduce the process value with a higher output value.

Examples

- Opening the drain valve will reduce the level of a container's contents.
- Increasing cooling will reduce the temperature.

Start-up behavior after reset

To change straight to the last active mode after restarting the CPU, select the "Enable last mode after CPU restart" check box.

PID_3Step will remain in "Inactive" mode if the check box is cleared.

Setpoint V1

Procedure

Proceed as follows to define a fixed setpoint:

1. Select "Instance DB".
2. Enter a setpoint, e.g. 80° C.
3. Delete any entry in the instruction.

Proceed as follows to define a variable setpoint:

1. Select "Instruction".
2. Enter the name of the REAL variable in which the setpoint is saved.

   Program-controlled assignment of various values to the REAL variable is possible, for example for the time controlled change of the setpoint.

Process value V1

PID_3Step will scale the value of the analog input to the physical quantity if you use the analog input value directly.

You will need to write a program for processing if you wish first to process the analog input value. The process value is, for example, not directly proportional to the value at the analog input. The processed process value must be in floating point format.

Procedure

Proceed as follows to use the analog input value without processing:

1. Select the entry "Input_PER" in the drop-down list "Input".
2. Select "Instruction" as source.
3. Enter the address of the analog input.

Proceed as follows to use the processed process value in floating point format:

1. Select the entry "Input" in the drop-down list "Input".
2. Select "Instruction" as source.
3. Enter the name of the variable in which the processed process value is saved.

Position feedback V1

Position feedback configuration depends upon the actuator used.

- Actuator without position feedback
- Actuator with digital endstop signals
- Actuator with analog position feedback
- Actuator with analog position feedback and endstop signals

Actuator without position feedback

Proceed as follows to configure PID_3Step for an actuator without position feedback:

1. Select the entry "No Feedback" in the drop-down list "Feedback".

Actuator with digital endstop signals

Proceed as follows to configure PID_3Step for an actuator with endstop signals:

1. Select the entry "No Feedback" in the drop-down list "Feedback".
2. Activate the "Actuator endstop signals" check box.
3. Select "Instruction" as source for Actuator_H and Actuator_L.
4. Enter the addresses of the digital inputs for Actuator_H and Actuator_L.

Actuator with analog position feedback

Proceed as follows to configure PID_3Step for an actuator with analog position feedback:

1. Select the entry "Feedback" or "Feedback_PER" in the drop-down list "Feedback".
   - Use the analog input value for Feedback_PER. Configure Feedback_PER scaling in the actuator settings.
   - Process the analog input value for Feedback using your user program.
2. Select "Instruction" as source.
3. Enter the address of the analog input or the variable of your user program.

Actuator with analog position feedback and endstop signals

Proceed as follows to configure PID_3Step for an actuator with analog position feedback and endstop signals:

1. Select the entry "Feedback" or "Feedback_PER" in the drop-down list "Feedback".
2. Select "Instruction" as source.
3. Enter the address of the analog input or the variable of your user program.
4. Activate the "Actuator endstop signals" check box.
5. Select "Instruction" as source for Actuator_H and Actuator_L.
6. Enter the addresses of the digital inputs for Actuator_H and Actuator_L.

Output value V1

PID_3Step offers an analog output value (Output_PER) and digital output values (Output_UP, Output_DN). Your actuator will determine which output value you use.

- Output_PER

  The actuator has a relevant motor transition time and is triggered via an analog output and controlled with a continuous signal, e.g. 0...10 V or 4...20 mA. The value at Output_PER corresponds to the target position of the valve, e.g. Output_PER = 13824, when the valve is to be opened by 50%.

  For auto-tuning and anti windup behavior, for example, PID_3Step takes into consideration that the analog output value has a delayed effect on the process due to the motor transition time. If no relevant motor transition time is in effect in your process (e.g. with solenoid valves), so that the output value has a direct and full effect on the process, use PID_Compact instead.

- Output_UP, Output_DN

  The actuator has a relevant motor transition time and is controlled by two digital outputs.
  Output_UP moves the valve in the open state direction.
  Output_DN moves the valve in the closed state direction.

The motor transition time is taken into consideration in the calculation of the analog output value as well as in the calculation of the digital output values. It is mainly required for correct operation during auto-tuning and the anti-windup behavior. You should therefore configure the motor transition time under "Actuator settings" with the value that the motor requires to move the actuator from the closed to the opened state.

Procedure

Proceed as follows to use the analog output value:

1. Select the entry "Output (analog)" in the drop-down list "Output".
2. Select "Instruction".
3. Enter the address of the analog output.

Proceed as follows to use the digital output value:

1. Select the entry "Output (digital)" in the drop-down list "Output".
2. Select "Instruction" for Output_UP and Output_DN.
3. Enter the addresses of the digital outputs.

Proceed as follows to process the output value using the user program:

1. Select the entry corresponding to the actuator in the drop-down list "Output".
2. Select "Instruction".
3. Enter the name of the tag you are using to process the output value.
4. Transfer the processed output value to the actuator by means of an analog or digital CPU output.

7.3.1.2 Process value settings V1

Configure the scaling of your process value and specify the process value absolute limits In the "Process value settings" configuration window.

Scaling the process value

If you have configured the use of Input_PER in the basic settings, you will need to convert the value of the analog input into the physical quantity of the process value. The current configuration will be displayed in the Input_PER display.

Input_PER will be scaled using a low and high value pair if the process value is directly proportional to the value of the analog input.

1. Enter the low pair of values in the "Scaled low process value" and "Low" input fields.
2. Enter the high pair of values in the "Scaled high process value" and "High" input boxes.

Default settings for the value pairs are saved in the hardware configuration. Proceed as follows to use the value pairs from the hardware configuration:

1. Select the instruction PID_3Step in the programming editor.
2. Connect Input_PER to an analog input in the basic settings.
3. Click on the "Automatic setting" button in the process value settings.

   The existing values will be overwritten with the values from the hardware configuration.

Monitoring process value

Specify the absolute high and low limit of the process value. You must enter reasonable limits for your controlled system. Reasonable limits are important during optimization to obtain optimal PID parameters. The default for the "High limit process value" is 120 %. At the I/O input, the process value can be a maximum of 18% higher than the standard range (overrange). This setting ensures that an error is no longer signaled due to a violation of the "Process value high limit". Only a wire-break and a short-circuit are recognized and PID_3Step reacts according to the configured reaction to error.

NOTICE
Your system may be damaged. If you set very high process value limits (for example $-3.4*10^{38}$...$+3.4*10^{38}$), process value monitoring will be disabled. Your system may then be damaged if an error occurs. You need to configure useful process value limits for your controlled system.

7.3.1.3 Actuator settings V1

Actuator-specific times

Configure the motor transition time and the minimum ON and OFF times to prevent damage to the actuator. You can find the specifications in the actuator data sheet.

The motor transition time is the time in seconds the motor requires to move the actuator from the closed to the opened state. The maximum time that the actuator is moved in one direction is 110% of the motor transition time. You can measure the motor transition time during commissioning.

The motor transition time is taken into consideration in the calculation of the analog output value as well as in the calculation of the digital output values. It is mainly required for correct operation during auto-tuning and the anti-windup behavior.

If no relevant motor transition time is in effect in your process (e.g. with solenoid valves), so that the output value has a direct and full effect on the process, use PID_Compact instead.

If you are using "Output_UP" or "Output_DN", you can reduce the switching frequency with the minimum on and minimum OFF time.

The on or off times calculated are totaled in automatic mode and only take effect when the sum is greater than or equal to the minimum on or OFF time.

A rising edge at Manual_UP or Manual_DN in manual mode will operate the actuator for at least the minimum on or OFF time.

If you have selected the analog output value Output_PER in the basic settings, the minimum ON time and the minimum OFF time are not evaluated and cannot be changed.

Response to errors

PID_3Step is preset so that the controller stays active in most cases in the event of an error. If errors occur frequently in controller mode, this default reaction has a negative effect on the control response. In this case, check the Errorbits parameter and eliminate the cause of the error.

PID_3Step outputs a programmable output value in response to an error:

- Current value

  PID_3Step is switched off and no longer modifies the actuator position.

- Current value while error is pending

  The controller functions of PID_3Step are switched off and the position of the actuator is no longer changed.

  If the following errors occur in automatic mode, PID_3Step returns to automatic mode as soon as the errors are no longer pending.

  – 0002h: Invalid value at Input_PER parameter.
  – 0200h: Invalid value at Input parameter.
  – 0800h: Sampling time error
  – 1000h: Invalid value at Setpoint parameter.
  – 2000h: Invalid value at Feedback_PER parameter.
  – 4000h: Invalid value at Feedback parameter.
  – 8000h: Error during digital position feedback.

  If one of these error occurs in manual mode, PID_3Step remains in manual mode.

  If an error occurs during the tuning or transition time measurement, PID_3Step is switched off.

- Substitute output value

  PID_3Step moves the actuator to the substitute output value and then switches off.

- Substitute output value while error is pending

  PID_3Step moves the actuator to the substitute output value. When the substitute output value is reached, PID_3Step reacts as it does with "Current value for while error is pending".

Enter the substitute output value in "%".

Only substitute output values 0% and 100% can be configured when using Output_UP and Output_DN without analog position feedback (Config.OutputPerOn = FALSE and Config.FeedbackOn = FALSE). The actuator is moved in one direction at 110% of the motor transition time to ensure the high or low endstop is reached. There endstop signals take priority.

Any substitute output values within the output value limits can be configured when using Output_PER or analog position feedback (Config.OutputPerOn = TRUE or Config.FeedbackOn = TRUE).

Feedback scaling

If you have configured the use of Feedback_PER in the basic settings, you will need to convert the value of the analog input into %. The current configuration will be displayed in the "Feedback" display.

Feedback_PER is scaled using a low and high value pair.

1. Enter the low pair of values in the "Low endstop" and "Low" input boxes.
2. Enter the high pair of values in the "High endstop" and "High" input boxes.

"Low endstop" must be less than "High endstop"; "Low" must be less than "High".

The valid values for "High endstop" and "Low endstop" depend upon:

- No Feedback, Feedback, Feedback_PER
- Output (analog), Output (digital)

Output	Feedback	Low endstop	High endstop
Output (digital)	No Feedback	Cannot be set (0.0%)	Cannot be set (100.0%)
Output (digital)	Feedback	-100.0% or 0.0%	0.0% or +100.0%
Output (digital)	Feedback_PER	-100.0% or 0.0%	0.0% or +100.0%
Output (analog)	No Feedback	Cannot be set (0.0%)	Cannot be set (100.0%)
Output (analog)	Feedback	-100.0% or 0.0%	0.0% or +100.0%
Output (analog)	Feedback_PER	-100.0% or 0.0%	0.0% or +100.0%

Limiting the output value

You can only exceed or undershoot the output value limits during the transition time measurement. The output value is limited to these values in all other modes.

Enter the absolute output value limits in the "Output value high limit" and "Output value low limit" input boxes. The output value limits must be within "Low endstop" and "High endstop".

If no Feedback is available and Output (digital) is set, you cannot limit the output value. The digital outputs are reset with Actuator_H = TRUE or Actuator_L = TRUE, or after a travel time amounting to 110% of the motor transition time.

7.3.1.4 Advanced settings V1

Process value monitoring V1

Configure a warning high and low limit for the process value in the "Process value monitoring" configuration window. If one of the warning limits is exceeded or undershot during operation, a warning will be displayed at the PID_3Step instruction:

- At the InputWarning_H output parameter if the warning high limit has been exceeded
- At the InputWarning_L output parameter if the warning low limit has been undershot

The warning limits must be within the process value high and low limits.

The process value high and low limits will be used if you do not enter values.

Example

Process value high limit = 98° C; warning high limit = 90° C

Warning low limit = 10° C; process value low limit = 0° C

PID_3Step will respond as follows:

Process value	InputWarning_H	InputWarning_L	Operating mode
> 98° C	TRUE	FALSE	Inactive
≤ 98° C and > 90° C	TRUE	FALSE	Automatic mode
≤ 90° C and ≥ 10° C	FALSE	FALSE	Automatic mode
< 10° C and ≥ 0° C	FALSE	TRUE	Automatic mode
< 0° C	FALSE	TRUE	Inactive

PID parameters V1

The PID parameters are displayed in the "PID Parameters" configuration window. The PID parameters will be adapted to your controlled system during controller tuning. You do not need to enter the PID parameters manually.

NOTE

The currently active PID parameters are located in the Retain.CtrlParams structure.

Change the currently active PID parameters only in "Inactive" mode online to prevent malfunction of the PID controller.

If you want to change the PID parameters in "Automatic mode" or "Manual mode" online, change the PID parameters in the CtrlParamsBackUp structure and apply these changes to the Retain.CtrlParams structure as follows:

- PID_3Step V1: Apply the changes with Config.LoadBackUp = TRUE
- PID_3Step V2: Apply the changes with LoadBackUp = TRUE

Online changes to the PID parameters in "Automatic mode" can result in jumps at the output value.

The PID algorithm operates according to the following transfer function:

$$\Delta y = K_p \cdot s \cdot \left[(b \cdot w - x) + \frac{1}{T_I \cdot s}(w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1}(c \cdot w - x)\right]$$

The table below shows the meaning of the icons used in the transfer function and in the subsequent figures:

Icon	Description
Δy	Output value of the PID algorithm
K_p	Proportional gain
s	Laplace operator
b	Proportional action weighting
w	Setpoint
x	Process value

Icon	Description
T_I	Integration time
T_D	Derivative action time
a	Derivative delay coefficient (derivative delay T1 = a × T_D)
c	Derivative action weighting

The diagram below illustrates the integration of the parameters into the PID algorithm:

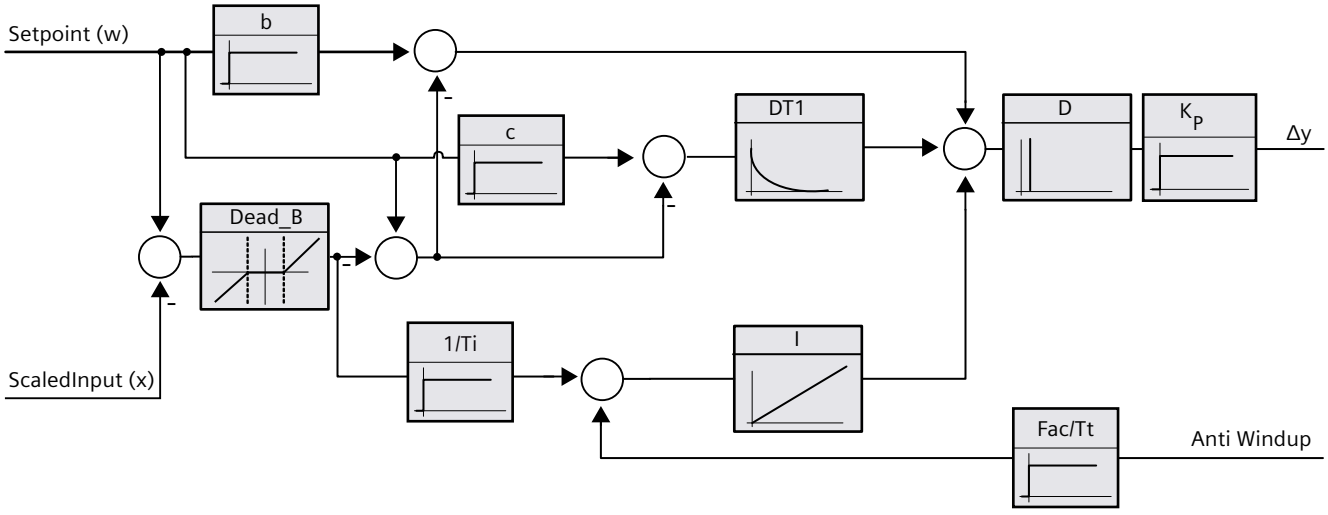

All PID parameters are retentive. If you enter the PID parameters manually, you must completely download PID_3Step.

Downloading technology objects to device (Page 46)

Proportional gain

The value specifies the proportional gain of the controller. PID_3Step does not work with a negative proportional gain. Control logic is inverted under Basic settings > Controller type.

Integration time

The integration time determines the time response of the integral action. The integral action is deactivated with integration time = 0.0. When the integration time is changed from a different value to 0.0 online in "Automatic mode", the previous integral action is deleted and the output value jumps.

Derivative action time

The derivative action time determines the time response of the derivative action. Derivative action is deactivated with derivative action time = 0.0.

Derivative delay coefficient

The derivative delay coefficient delays the effect of the derivative action.

Derivative delay = derivative action time × derivative delay coefficient

- 0.0: Derivative action is effective for one cycle only and therefore almost not effective.
- 0.5: This value has proved useful in practice for controlled systems with **one** dominant time constant.
- > 1.0: The greater the coefficient, the longer the effect of the derivative action is delayed.

Proportional action weighting

The proportional action may weaken with changes to the setpoint.

Values from 0.0 to 1.0 are applicable.

- 1.0: Proportional action for setpoint change is fully effective
- 0.0: Proportional action for setpoint change is not effective

The proportional action is always fully effective when the process value is changed.

Derivative action weighting

The derivative action may weaken with changes to the setpoint.

Values from 0.0 to 1.0 are applicable.

- 1.0: Derivative action is fully effective upon setpoint change
- 0.0: Derivative action is not effective upon setpoint change

The derivative action is always fully effective when the process value is changed.

PID algorithm sampling time

The controlled system needs a certain amount of time to respond to changes in the output value. It is therefore not advisable to calculate the output value in every cycle. The sampling time of the PID algorithm represents the time between two calculations of the output value. It is calculated during tuning and rounded to a multiple of the PID_3Step sampling time. All other functions of PID_3Step are executed at every call.

Dead zone width

The dead zone suppresses the noise component in the steady controller state. The dead zone width specifies the size of the dead zone. The dead zone is off if the dead zone width is 0.0.

If values not equal to 1.0 are configured for the proportional action weighting or the derivative action weighting, setpoint changes even within the dead zone affect the output value.
Process value changes within the dead zone do not affect the output value, regardless of the weighting.

7.3.2 Commissioning PID_3Step V1

7.3.2.1 Commissioning V1

You can monitor the setpoint, process value and output value over time in the "Tuning" working area. The following commissioning functions are supported in the curve plotter:

- Controller pretuning
- Controller fine tuning
- Monitoring the current closed-loop control in the trend view

All functions require an online connection to the CPU to have been established.

Basic handling

- Select the desired sampling time in the "Sampling time" drop-down list.

  All values in the tuning working area are updated in the selected update time.
- Click the "Start" icon in the measuring group if you want to use the commissioning functions.

  Value recording is started. The current values for the setpoint, process value and output value are entered in the trend view. Operation of the commissioning window is enabled.
- Click the "Stop" icon if you want to end the commissioning functions.

  The values recorded in the trend view can continue to be analyzed.
- Closing the commissioning window will terminate recording in the trend view and delete the recorded values.

7.3.2.2 Pretuning V1

The pretuning determines the process response to a pulse of the output value and searches for the point of inflection. The tuned PID parameters are calculated as a function of the maximum slope and dead time of the controlled system.

The more stable the process value is, the easier it is to calculate the PID parameters and the more precise the result will be. Noise on the process value can be tolerated as long as the rate of rise of the process value is significantly higher compared to the noise. The PID parameters are backed up before being recalculated.

The setpoint is frozen during pretuning.

Requirement

- The PID_3Step instruction is called in a cyclic interrupt OB.
- ManualEnable = FALSE
- PID_3Step is in "inactive" or "manual" mode.
- The setpoint and the process value lie within the configured limits (see "Process value settings" configuration).

Procedure

To perform pretuning, follow these steps:

1. Double-click the "PID_3Step > Commissioning" entry in the project tree.
2. Select the entry "Pretuning" in the "Tuning mode" drop-down list in the working area "Tuning".
3. Click the "Start" icon.
   - An online connection will be established.
   - Value recording is started.
   - Pretuning is started.
   - The "Status" field displays the current steps and any errors that may have occurred. The progress bar indicates the progress of the current step.

NOTE

Click the "Stop" icon when the progress bar has reached 100% and it is to be assumed the controller tuning function is blocked. Check the configuration of the technology object and, if necessary, restart controller tuning.

Result

If pretuning was performed without an error message, the PID parameters have been tuned. PID_3Step switches to automatic mode and uses the tuned parameters. The tuned PID parameters will be retained during power OFF and a restart of the CPU.

If pretuning is not possible, PID_3Step changes to "Inactive" mode.

7.3.2.3 Fine tuning V1

Fine tuning generates a constant, limited oscillation of the process value. The PID parameters are optimized for the operating point from the amplitude and frequency of this oscillation. All PID parameters are recalculated on the basis of the findings. PID parameters from fine tuning usually have better master control and disturbance behavior than PID parameters from pretuning.

PID_3Step automatically attempts to generate an oscillation greater than the noise of the process value. Fine tuning is only minimally influenced by the stability of the process value. The PID parameters are backed up before being recalculated.

The setpoint is frozen during fine tuning.

Requirement

- The PID_3Step instruction is called in a cyclic interrupt OB.
- ManualEnable = FALSE
- The motor transition time has been configured or measured.
- The setpoint and the process value lie within the configured limits (see "Process value settings" configuration).
- The control loop has stabilized at the operating point. The operating point is reached when the process value corresponds to the setpoint.
- No disturbances are expected.
- PID_3Step is in inactive mode, automatic mode or manual mode.

Process depends on initial situation

Fine tuning proceeds as follows when started in:

- Automatic mode

  Start fine tuning in automatic mode if you wish to improve the existing PID parameters using controller tuning.

  PID_3Step will regulate using the existing PID parameters until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start.
- Inactive or manual mode

  Pretuning is always started first. The PID parameters established will be used for adjustment until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start.

Procedure

Proceed as follows to carry out "fine tuning":

1. Select the entry "Fine tuning" in the "Tuning mode" drop-down list.
2. Click the "Start" icon.
   - An online connection will be established.
   - Value recording is started.
   - The process of fine tuning is started.
   - The "Status" field displays the current steps and any errors that may have occurred. The progress bar indicates the progress of the current step.

   NOTE

   Click the "Stop" icon in the "Tuning mode" group when the progress bar has reached 100% and it is to be assumed the controller tuning function is blocked. Check the configuration of the technology object and, if necessary, restart controller tuning.

Result

The PID parameters will have been optimized if fine tuning has been executed without errors. PID_3Step changes to automatic mode and uses the optimized parameters. The optimized PID parameters will be retained during power OFF and a restart of the CPU.

If errors occurred during fine tuning, PID_3Step will change to "inactive" mode.

7.3.2.4 Commissioning with manual PID parameters V1

Procedure

Proceed as follows to commission PID_3Step with manual PID parameters:

1. Double-click on "PID_3Step > Configuration" in the project tree.
2. Click on "Advanced settings > PID Parameters" in the configuration window.
3. Select the check box "Enable direct input".
4. Enter the PID parameters.
5. Double-click on "PID_3Step > Commissioning" in the project tree.
6. Establish an online connection to the CPU.
7. Load the PID parameters to the CPU.
8. Click on the "Activate controller" icon.

Result

PID_3Step changes to automatic mode and controls using the current PID parameters.

7.3.2.5 Measuring the motor transition time V1

Introduction

PID_3Step requires the motor transition time to be as accurate as possible for good controller results. The data in the actuator documentation contains average values for this type of actuator. The value for the specific actuator used may differ.

You can measure the motor transition time during commissioning if you are using actuators with position feedback or endstop signals. The output value limits are not taken into consideration during the motor transition time measurement. The actuator can travel to the high or the low endstop.

The motor transition time cannot be measured if neither position feedback nor endstop signals are available.

Actuators with analog position feedback

Proceed as follows to measure motor transition time with position feedback:

Requirement

- Feedback or Feedback_PER has been selected in the basic settings and the signal has been connected.
- An online connection to the CPU has been established.

1. Select the "Use position feedback" check box.
2. Enter the position to which the actuator is to be moved in the "Target position" input field.

   The current position feedback (starting position) will be displayed. The difference between "Target position" and "Position feedback" must be at least 50% of the valid output value range.
3. Click the "Start transition time measurement" icon.

Result

The actuator is moved from the starting position to the target position. Time measurement starts immediately and ends when the actuator reaches the target position. The motor transition time is calculated according to the following equation:

Motor transition time = (output value high limit – output value low limit) × Measuring time / AMOUNT (target position – starting position).

The progress and status of transition time measurement are displayed. The transition time measured is saved in the instance data block on the CPU and displayed in the "Measured transition time" field. PID_3Step will change to "Inactive" mode once transition time measurement is complete.

NOTE

Click on the icon "Upload measured transition time" to load the motor transition time measured to the project.

Actuators with endstop signals

Proceed as follows to measure the transition time of actuators with endstop signals:

Requirement

- The "Endstop signals" check box in the basic settings has been selected and Actuator_H and Actuator_L are connected.
- An online connection to the CPU has been established.

Proceed as follows to measure motor transition time with endstop signals:

1. Select the "Use actuator endstop signals" check box.
2. Select the direction in which the actuator is to be moved.
   - Open - Close - Open

     The actuator is moved first to the high endstop, then to the low endstop and then back to the high endstop.
   - Close - Open - Close

     The actuator is moved first to the low endstop, then to the high endstop and then back to the low endstop.
3. Click the "Start transition time measurement" icon.

Result

The actuator is moved in the selected direction. Time measurement will start once the actuator has reached the first endstop and will end when the actuator reaches this endstop for the second time. The motor transition time is equal to the time measured divided by two.

The progress and status of transition time measurement are displayed. The transition time measured is saved in the instance data block on the CPU and displayed in the "Measured transition time" field. PID_3Step will change to "Inactive" mode once transition time measurement is complete.

Cancelling transition time measurement

PID_3Step will change to "Inactive" mode immediately if you cancel transition time measurement. The actuator will stop being moved. You can reactive PID-3Step in the curve plotter.

7.3.3 Simulating PID_3Step V1 with PLCSIM

NOTE

Simulation with PLCSIM

For the simulation with PLCSIM, the time behavior of the simulated PLC is not exactly identical to that of a "real" PLC. The actual cycle clock of a cyclic interrupt OB can have larger fluctuations with a simulated PLC than with "real" PLCs.

In the standard configuration, PID_3Step determines the time between calls automatically and monitors them for fluctuations.

For a simulation of PID_3Step with PLCSIM, for example, a sampling time error (ErrorBits = DW#16#00000800) can therefore be detected.

This results in ongoing tuning being aborted.

The response in automatic mode depends on the value of the ActivateRecoverMode tag.

To prevent this from happening, you should configure PID_3Step for simulation with PLCSIM as follows:

- CycleTime.EnEstimation = FALSE
- CycleTime.EnMonitoring = FALSE
- CycleTime.Value: Assign the cycle clock of the calling cyclic interrupt OB in seconds to this tag.

Using PID_Temp

8

8.1 Technology object PID_Temp

The technology object PID_Temp provides a continuous PID controller with integrated tuning. PID_Temp is specially designed for temperature control and is suitable for heating or heating/cooling applications. As of PID_Temp V2, the instruction can also be used for exclusive cooling applications. Two outputs are available for this purpose, one each for heating and cooling. In addition to temperature control, PID_Temp can also be used for other control tasks. PID_Temp can be cascaded and used in manual or automatic mode.

PID_Temp continuously acquires the measured process value within a control loop and compares it with the set setpoint. From the resulting control deviations, the PID_Temp instruction calculates the output values which are used to adjust the process value to the setpoint. The output values for the PID controller consist of three actions:

- Proportional action

  The proportional action of the output value increases in proportion to the control deviation.

- Integral action

  The integral action of the output value increases until the control deviation has been balanced.

- Derivative action

  The derivative action increases with the rate of change of control deviation. The process value is corrected to the setpoint as quickly as possible. The derivative action will be reduced again if the rate of change of control deviation drops.

The instruction PID_Temp calculates the proportional, integral and derivative parameters for your controlled system during "pretuning". "Fine tuning" can be used to tune the parameters further. You do not need to manually determine the parameters.

Either a fixed cooling factor or two PID parameter sets can be used for heating-and-cooling applications.

Additional information

- Overview of software controller (Page 41)
- Add technology objects (Page 43)
- Configure technology objects (Page 44)
- Configuring PID_Temp (Page 155)

8.2 Configuring PID_Temp

8.2.1 Basic settings

8.2.1.1 Introduction

Configure the following properties of the "PID_Temp" technology object under "Basic settings" in the Inspector window or in the configuration window:

- Physical quantity
- Start-up behavior after reset
- Source and input of the setpoint (only in the Inspector window)
- Selection of the process value
- Source and input of the process value (only in the Inspector window)
- Activation (from PID_Temp V2) and selection of the heating output value
- Source and input of the heating output value (only in the Inspector window)
- Activation and selection of the cooling output value
- Source and input of the cooling output value (only in the Inspector window)
- Activation of PID_Temp as master or slave of a cascade
- Number of slaves
- Selection of masters (only in the Inspector window)

Setpoint, process value, heating output value and cooling output value

You can select the source and enter values or tags for the setpoint, process value, heating output value and cooling output value in the Inspector window of the programming editor.

Select the source for each value:

- Instance DB:

  The value saved in the instance DB is used. The value must be updated by the user program in the instance DB. There should be no value at the instruction. Can be changed using HMI.

- Instruction:

  The value connected to the instruction is used. The value is written to the instance DB each time the instruction is called. Cannot be changed using HMI.

8.2.1.2 Controller type

Physical quantity

Select the unit of measurement and physical quantity for the setpoint and the process value in the "Controller type" group. The setpoint and the process value are displayed in this unit.

Startup characteristics

1. To switch to "Inactive"mode after CPU restart, clear the "Activate Mode after CPU restart"check box.

   To switch to the operating mode saved in the Mode parameter after CPU restart, select the "Activate Mode after CPU restart" check box.

2. In the "Set Mode to" drop-down list, select the mode that is to be enabled after a complete download to the device.

   After a complete "Download to device", PID_Temp starts in the selected operating mode. With each additional restart, PID_Temp starts in the mode that was last saved in Mode.

   When selecting pretuning or fine tuning, you also have to set or reset the Heat.EnableTuning and Cool.EnableTuning tags in order to choose between tuning for heating and tuning for cooling.

Example:

You have selected the "Activate Mode after CPU restart" check box and the "Pretuning" entry in the "Set Mode to" list. After a complete "Download to device", PID_Temp starts in the "Pretuning" mode. If pretuning is still active, PID_Temp starts in "Pretuning" mode again after restart of the CPU (heating/cooling depends on the tags Heat.EnableTuning and Cool.EnableCooling). If pretuning was successfully completed and automatic mode is active, PID_Temp starts in "Automatic mode" after restart of the CPU.

8.2.1.3 Setpoint

Procedure

Proceed as follows to define a fixed setpoint:

1. Select "Instance DB".
2. Enter a setpoint, e.g. 80° C.
3. Delete any entry in the instruction.

Proceed as follows to define a variable setpoint:

1. Select "Instruction".
2. Enter the name of the REAL tag in which the setpoint is saved.

   Program-controlled assignment of various values to the REAL tag is possible, for example for the time-controlled change of the setpoint.

8.2.1.4 Process value

PID_Temp will scale the value of the analog input to the physical quantity if you use the analog input value directly.

You will need to write a program for processing if you wish first to process the analog input value. The process value is, for example, not directly proportional to the value at the analog input. The processed process value must be in floating point format.

Procedure

Proceed as follows to use the analog input value without processing:

1. Select the entry "Input_PER" in the drop-down list "Input".
2. Select "Instruction" as source.
3. Enter the address of the analog input.

Proceed as follows to use the processed process value in floating point format:

1. Select the entry "Input" in the drop-down list "Input".
2. Select "Instruction" as source.
3. Enter the name of the variable in which the processed process value is saved.

8.2.1.5 Heating and cooling output value

The PID_Temp instruction provides a PID controller with integrated tuning for temperature processes. PID_Temp is suitable for heating or heating-and-cooling applications. As of PID_Temp V2, the instruction can also be used for exclusive cooling applications.

The activation of heating and cooling determines which outputs can be used, which PID parameter set is used and which tuning is available. With PID_Temp V1.x, the heating is always activated.

- If heating is activated and cooling is deactivated, the output value of the PID algorithm (PidOutputSum) is scaled and output at the outputs for heating. The output value is calculated using the PID parameters for heating. Only the tuning for heating is available.
- If the heating and cooling are activated, positive output values of the PID algorithm (PidOutputSum) are scaled and output at the outputs for heating. Negative output values of the PID algorithm are scaled and output at the outputs for cooling. You can choose between two methods for output value calculation at the output settings (Page 161). The selected method determines which PID parameters are used and which tuning is available.
- If heating is deactivated and cooling is activated, the output value of the PID algorithm (PidOutputSum) is scaled and output at the outputs for cooling. The output value is calculated using the PID parameters for cooling. Only the tuning for cooling is available.

  PID_Temp continues to work with normal control logic: If the setpoint value is below the process value, this results in a negative output value of the PID algorithm (PidOutputSum). This is scaled and output as a positive value at the outputs for cooling. A lower start value of the PID algorithm (PidOutputSum) or a lower manual value (ManualValue) leads to a higher value at the outputs for cooling due to the scaling.

  Example with default setting:

  ManualValue = -50.0 -> OutputCool = 50.0, ManualValue = -100.0 -> OutputCool = 100.0

PID_Temp provides the following output values. Your actuator will determine which output value you use.

- OutputHeat

  Heating output value (floating-point format): The output value for heating needs to be processed by the user program, for example, because of non-linear actuator response.

- OutputHeat_PER

  Analog heating output value: The actuator for heating is triggered via an analog output and controlled with a continuous signal, e.g. 0...10 V, 4...20 mA.

- OutputHeat_PWM

  Pulse-width modulated heating output value: The actuator for heating is controlled via a digital output. Pulse width modulation creates variable ON and OFF times.

- OutputCool

  Cooling output value (floating-point format): The output value for cooling needs to be processed by the user program, for example because of non-linear actuator response.

- OutputCool_PER

  Analog cooling output value: The actuator for cooling is triggered via an analog output and controlled with a continuous signal, e.g. 0...10 V, 4...20 mA.

- OutputCool_PWM

  Pulse-width modulated cooling output value: The actuator for cooling is controlled via a digital output. Pulse width modulation creates variable ON and OFF times.

NOTE

- The OutputHeat_PWM, OutputHeat_PER, OutputCool_PWM, OutputCool_PER outputs are only calculated if you select these correspondingly from the drop-down list.
- The output OutputHeat for PID_Temp as of V2 is calculated if the check box for heating is selected. For PID_Temp V1.x, the OutputHeat output is always calculated.
- The OutputCool output is calculated if the check box for cooling is selected.
- The "Activate heating" check box is only available if the controller is not configured as a master in a cascade or if the check box for cooling is deactivated for the master controller.
- The "Activate cooling" check box is only available if the controller is not configured as a master in a cascade or if the check box for heating is deactivated for the master controller.

Procedure

Proceed as follows to use the analog output value:

1. Select the entry "OutputHeat_PER" or "OutputCool_PER" in the drop-down list "OutputHeat" or "OutputCool".
2. Select "Instruction".
3. Enter the address of the analog output.

Proceed as follows to use the pulse-width modulated output value:

1. Select the entry "OutputHeat_PWM" or "OutputCool_PWM" in the drop-down list "OutputHeat" or "OutputCool".
2. Select "Instruction".
3. Enter the address of the digital output.

Proceed as follows to process the output value using the user program:

1. Select the entry "OutputHeat" or "OutputCool" in the drop-down list "OutputHeat" or "OutputCool".
2. Select "Instruction".
3. Enter the name of the variable you are using to process the output value.
4. Transfer the processed output value to the actuator by means of an analog or digital CPU output.

8.2.1.6 Cascade

If a PID_Temp instance receives its setpoint from a higher-level master controller and outputs its output value in turn to a subordinate slave controller, this PID_Temp instance is both a master controller and a slave controller simultaneously. Both configurations listed below then have to be carried out for such a PID_Temp instance. This is the case, for example, for the middle PID_Temp instance in a cascade control system with three concatenated measured variables and three PID_Temp instances.

Configuring a controller as master in a cascade

A master controller defines the setpoint of a slave controller with its output.

In order to use PID_Temp as master in a cascade, you have to deactivate either the heating or cooling in the basic settings. In order to configure this PID_Temp instance as a master controller in a cascade, activate the "Controller is master" check box. The selection of the output value for heating is set automatically to OutputHeat or OutputCool.

OutputHeat_PWM, OutputCool_PWM, OutputHeat_PER and OutputCool_PER cannot be used at a master in a cascade.

Subsequently specify the number of directly subordinate slave controllers that receive their setpoint from this master controller.

If no own scaling function is used when assigning the OutputHeat or OutputCool parameter of the master to the Setpoint parameter of the slave, it may be necessary to adapt the output value limits and the output scaling of the master to the setpoint / process value range of the slave. This can be done in the output settings of the master in the "OutputHeat / OutputCool" section.

Configuring a controller as a slave in a cascade

A slave controller receives its setpoint (Setpoint parameter) from the output of its master controller (OutputHeat or OutputCool parameter).

In order to configure this PID_Temp instance as a slave controller in a cascade, activate the "Controller is slave" check box in the basic settings.

Subsequently select the PID_Temp instance that is to be used as the master controller for this slave controller in the Inspector window of the programming editor. The Master and Setpoint parameters of the slave controller are interconnected with the selected master controller through this selection (the existing interconnections at these parameters are overwritten). This interconnection allows the exchange of information and the setpoint specification between master and slave. If required, the interconnection can be changed subsequently at the Setpoint parameter of the slave controller in order, for example, to insert an additional filter. The interconnection at the parameter Master may not be changed subsequently.

The "Controller is master" check box must be selected at the selected master controller, and the number of slaves must be configured correctly. The master controller must be called before the slave controller in the same cyclic interrupt OB.

Additional information

Additional information about program creation, configuration and commissioning when PID_Temp is used in cascade control systems is available under Cascade control with PID_Temp (Page 188).

8.2.2 Process value settings

8.2.2.1 Process value limits

You must specify an appropriate absolute high limit and low limit for the process value as limit values for your controlled system. As soon as the process value violates these limits, an error occurs (ErrorBits = 16#0000_0001). Tuning is canceled when the process value limits are violated. You can specify how PID_Temp responds to errors in automatic mode in the output settings.

8.2.2.2 Process value scaling

If you have configured the use of Input_PER in the basic settings, you will need to convert the value of the analog input into the physical quantity of the process value. The current configuration will be displayed in the Input_PER display.

Input_PER is scaled using a low and high value pair if the process value is directly proportional to the value of the analog input.

Procedure

To scale the process value, follow these steps:

1. Enter the low pair of values in the "Scaled low process value" and "Low" input fields.
2. Enter the high pair of values in the "Scaled high process value" and "High" input fields.

Default settings for the value pairs are stored in the HW configuration of CPU S7-1500 and CPU S7-1200 (not S7-1200 G2). Proceed as follows to use the value pairs from the hardware configuration:

1. Select the instruction PID_Temp in the programming editor.
2. Connect Input_PER to an analog input in the basic settings.
3. Click on the "Automatic setting" button in the process value settings.

The existing values are overwritten with the values from the hardware configuration.

8.2.3 Output settings

8.2.3.1 Basic settings of output

Method for heating and cooling

If heating and cooling are activated in the basic settings, the following methods are available for calculating the PID output value:

- PID parameter switching (Config.AdvancedCooling = TRUE):

  The output value calculation for cooling takes place by means of a separate PID parameter set. The PID algorithm decides on the basis of the calculated output value and the control deviation whether the PID parameters for heating or cooling are used. This method is suitable if the heating and cooling actuator have different time responses and different gains.

  Tuning for heating and cooling is available if this method is selected.

- Cooling factor (Config.AdvancedCooling = FALSE):

  Output value calculation for cooling is effected with the PID parameters for heating under consideration of the configurable cooling factor Config.CoolFactor. This method is suitable if the heating and cooling actuators have a similar time response but different gains. If this method is selected, pretuning and fine tuning for cooling as well as the PID parameter set for cooling are not available. You can only execute the tuning for heating.

Cooling factor

If the cooling factor is selected as the method for heating/cooling, this factor is used in the calculation of the output value for cooling. This allows different gains of heating and cooling actuators to be taken into account.

The cooling factor is not set automatically or adjusted during tuning. You must correctly configure the cooling factor manually with the ratio "heating actuator gain / cooling actuator gain".

Example: Cooling factor = 2.0 means that the heating actuator gain is twice as high as the cooling actuator gain.

The cooling factor only takes effect and can only be changed if "Cooling factor" is selected as the method for heating / cooling.

Response to errors

NOTICE
Your system may be damaged. If you output "Current value while error pending" or "Substitute output value while error pending" in the event of an error, PID_Temp remains in automatic or manual mode. This may cause a violation of the process value limits and damage your system. It is essential to configure how your controlled system reacts in the event of an error to protect your system from damage.

PID_Temp is preset so that the controller stays active in most cases in the event of an error.

If errors occur frequently in controller mode, this default reaction has a negative effect on the control response. In this case, check the ErrorBits parameter and eliminate the cause of the error.

PID_Temp generates a programmable output value in response to an error:

- Zero (inactive)

  With all errors PID_Temp, switches to the "Inactive" mode and outputs the following:

  – 0.0 as PID output value (PidOutputSum)
  – 0.0 as output value for heating (OutputHeat) and output value for cooling (OutputCool)
  – 0 as analog output value for heating (OutputHeat_PER) and analog output value for cooling (OutputCool_PER)
  – FALSE as PWM output value for heating (OutputHeat_PWM) and PWM output value for cooling (OutputCool_PWM)

  This is independent of the configured output value limits and the scaling. The controller is only reactivated by a falling edge at Reset or a rising edge at ModeActivate.

- Current value while error is pending

  The error response depends on the error occurring and the operating mode.

  If one or more of the following errors occur in automatic mode, PID_Temp stays in automatic mode:

  – 16#0000_0001: The Input parameter is outside the process value limits.
  – 16#0000_0800: Sampling time error
  – 16#0004_0000: Invalid value at Disturbance parameter.
  – 16#0800_0000: Error during the calculation of the PID parameters.

  If one or more of the following errors occur in automatic mode, PID_Temp switches to "Substitute output value with error monitoring" mode and outputs the last valid PID output value (PidOutputSum):

  – 16#0000_0002: Invalid value at Input_PER parameter.
  – 16#0000_0200: Invalid value at Input parameter.
  – 16#0000_0400: Calculation of output value failed.
  – 16#0000_1000: Invalid value at Setpoint or SubstituteSetpoint parameter.

  The values at the outputs for heating and cooling resulting from the PID output value are the result of the configured output scaling.

  As soon as the errors are no longer pending, PID_Temp switches back to automatic mode.

  If an error occurs in manual mode, PID_Temp continues using the manual value as the PID output value.

  If the manual value is invalid, the configured substitute output value is used.

  If the manual value and substitute output value are invalid, the PID output value low limit for heating (Config.Output.Heat.PidLowerLimit) is used.

  If the following error occurs during pretuning or fine tuning, PID_Temp remains in active mode:

  – 16#0000_0020: Pretuning is not permitted during fine tuning.

  When any other error occurs, PID_Temp cancels the tuning and switches to the mode from which tuning was started.

- Substitute output value while error is pending

  PID_Temp behaves as described at "Current value while error is pending", but outputs the configured substitute output value (SubstituteOutput) as a PID output value (PidOutputSum) in "Substitute output value with error monitoring" operating mode.

  The values at the outputs for heating and cooling resulting from the PID output value are the result of the configured output scaling.

  In the case of controllers with activated heating output and cooling output (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE), enter:

  – A positive substitute output value to output the value at the outputs for heating.
  – A negative substitute output value to output the value at the outputs for cooling.

If the following error occurs, PID_Temp stays in "Substitute output value with error monitoring" mode and outputs the PID output value low limit for heating (Config.Output.Heat.PidLowerLimit) or the PID output value high limit for cooling (Config.Output.Cool.PidUpperLimit):

– 16#0002_0000: Invalid value at SubstituteOutput tag.

8.2.3.2 Output value limits and scaling

Depending on the operating mode, the PID output value (PidOutputSum) is calculated automatically by the PID algorithm or by the manual value (ManualValue) or the configured substitute output value (SubstituteOutput).

The PID output value is limited as defined in the configuration.

- If the heating is deactivated in the basic settings and the cooling deactivated (Config.ActivateHeating = TRUE, Config.ActivateCooling = FALSE), the value is limited to the PID output value high limit (heating) and the PID output value low limit (heating).
- If the heating and cooling are activated in the basic settings (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE), the value is limited to the PID output value high limit (heating) and the PID output value low limit (cooling).

  The PID output value low limit (heating) and the PID output value high limit (cooling) cannot be changed and have to be assigned the value 0.0.
- As of PID_Temp V2:

  If heating is deactivated in the basic settings and cooling is activated (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE), the value is limited to the PID output value high limit (cooling) and the PID output value low limit (cooling).

You can configure both limits at the horizontal axis of the scaling characteristic line in the "OutputHeat / OutputCool" section. These are displayed in the "OutputHeat_PWM / OutputCool_PWM" and "OutputHeat_PER / OutputCool_PER" sections, but cannot be changed.

The PID output value is scaled and output at the outputs for heating and cooling. Scaling can be specified separately for each output and is specified across 2 value pairs each, consisting of a limit value of the PID output value and a scaling value:

Output	Value pair	Parameter
OutputHeat	Value pair 1	PID output value high limit (heating) Config.Output.Heat.PidUpperLimit, Scaled high output value (heating) Config.Output.Heat.UpperScaling
	Value pair 2	PID output value low limit (heating) Config.Output.Heat.PidLowerLimit, Scaled low output value (heating) Config.Output.Heat.LowerScaling

The PID output value low limit (heating) and the PID output value high limit (cooling) must have the value 0.0 if heating and cooling are activated
(Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE).

Output	Value pair	Parameter
OutputHeat_PWM	Value pair 1	PID output value high limit (heating) Config.Output.Heat.PidUpperLimit, Scaled high PWM output value (heating) Config.Output.Heat.PwmUpperScaling
	Value pair 2	PID output value low limit (heating) Config.Output.Heat.PidLowerLimit, Scaled low PWM output value (heating) Config.Output.Heat.PwmLowerScaling
OutputHeat_PER	Value pair 1	PID output value high limit (heating) Config.Output.Heat.PidUpperLimit, Scaled high analog output value (heating) Config.Output.Heat.PerUpperScaling
	Value pair 2	PID output value low limit (heating) Config.Output.Heat.PidLowerLimit, Scaled low analog output value (heating) Config.Output.Heat.PerLowerScaling
OutputCool	Value pair 1	PID output value low limit (cooling) Config.Output.Cool.PidLowerLimit, Scaled high output value (cooling) Config.Output.Cool.UpperScaling
	Value pair 2	PID output value high limit (cooling) Config.Output.Cool.PidUpperLimit, Scaled low output value (cooling) Config.Output.Cool.LowerScaling
OutputCool_PWM	Value pair 1	PID output value low limit (cooling) Config.Output.Cool.PidLowerLimit, Scaled high PWM output value (cooling) Config.Output.Cool.PwmUpperScaling
	Value pair 2	PID output value high limit (cooling) Config.Output.Cool.PidUpperLimit, Scaled low PWM output value (cooling) Config.Output.Cool.PwmLowerScaling
OutputCool_PER	Value pair 1	PID output value low limit (cooling) Config.Output.Cool.PidLowerLimit, Scaled high analog output value (cooling) Config.Output.Cool.PerUpperScaling
	Value pair 2	PID output value high limit (cooling) Config.Output.Cool.PidUpperLimit, Scaled low analog output value (cooling) Config.Output.Cool.PerLowerScaling

The PID output value low limit (heating) and the PID output value high limit (cooling) must have the value 0.0 if heating and cooling are activated
(Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE).

Example:

Output scaling when the OutputHeat output is used (cooling deactivated; the low limit of PID output value (heating) may be unequal to 0.0):

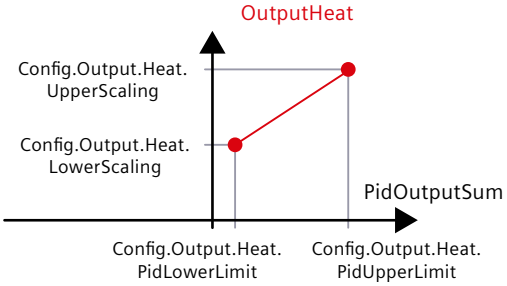

Example:

Output scaling when using output OutputHeat_PWM and OutputCool_PER (heating and cooling activated; the PID output value low limit (heating) and the PID output value high limit (cooling) must have the value 0.0):

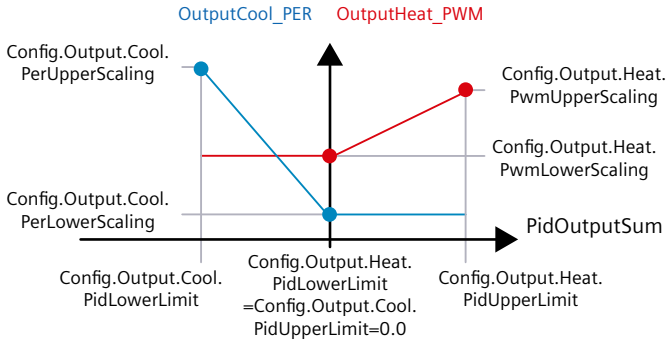

With the exception of the "Inactive" operating mode, the value at an output always lies between its scaled high output value and the scaled low output value, for example for OutputHeat always between the scaled high output value (heating) and the scaled low output value (heating).

If you want to limit the value at the associated output, you therefore have to adapt these scaling values as well.

You can configure the scaling values of an output at the vertical axes of the scaling characteristic line. Each output has two separate scaling values. These can only be changed for OutputHeat_PWM, OutputCool_PWM, OutputHeat_PER and OutputCool_PER if the corresponding output is selected in the basic settings. The cooling has to be activated additionally in the basic settings at all the outputs for cooling. Heating must also be activated in the basic settings for all heating outputs.

The trend view in the commissioning dialog box only records the values of OutputHeat and OutputCool, irrespective of the selected output in the basic settings. Therefore, if necessary, adapt the scaling values for OutputHeat or OutputCool if you use OutputHeat_PWM, or OutputHeat_PER or OutputCool_PWM or OutputCool_PER and want to use the trend display in the commissioning dialog.

8.2.4 Advanced settings

8.2.4.1 Process value monitoring

Configure a warning high and low limit for the process value in the "Process value monitoring" configuration window. If one of the warning limits is exceeded or undershot during operation, a warning is displayed at the PID_Temp instruction:

- At the InputWarning_H output parameter if the warning high limit has been exceeded
- At the InputWarning_L output parameter if the warning low limit has been undershot

The warning limits must be within the process value high and low limits.

The process value high and low limits are used if you do not enter values.

Example

Process value high limit = 98° C; warning high limit = 90° C

Warning low limit = 10° C; process value low limit = 0° C

PID_Temp will respond as follows:

Process value	InputWarning_H	InputWarning_L	ErrorBits
> 98 °C	TRUE	FALSE	0001h
≤ 98° C and > 90° C	TRUE	FALSE	0000h
≤ 90° C and ≥ 10° C	FALSE	FALSE	0000h
< 10° C and ≥ 0° C	FALSE	TRUE	0000h
< 0° C	FALSE	TRUE	0001h

You can configure the response of PID_Temp when the process value high limit or low limit is violated in the output settings.

8.2.4.2 PWM limits

The PID output value PidOutputSum is scaled and transformed via a pulse width modulation into a pulse train that is output at the output parameter OutputHeat_PWM or OutputCool_PWM.

The "Sampling time of PID algorithm" represents the time between two calculations of the PID output value. The sampling time is used as time period of the pulse width modulation.

During heating, the PID output value is always calculated in the "Sampling time of PID algorithm for heating".

If heating is deactivated and cooling is activated, the PID output value is always calculated in the "Sampling time PID algorithm for cooling".

If heating and cooling are activated, the calculation of the PID output value during cooling depends on the type of cooling selected in "Basic settings of output":

- If the cooling factor is used, the "Sampling time of PID algorithm for heating" applies.
- If the PID parameter switching is used, the "Sampling time of PID algorithm for cooling" applies.

The PID algorithm sampling time for heating or cooling is determined during pretuning or fine tuning. If you set the PID parameters manually, you will also need to configure the PID algorithm sampling time for heating or cooling.

OutputHeat_PWM and OutputCool_PWM are output in the PID_Temp sampling time. The PID_Temp sampling time is equivalent to the cycle time of the calling OB.

The pulse duration is proportional to the PID output value and is always an integer multiple of the PID_Temp sampling time.

Example for OutputHeat_PWM

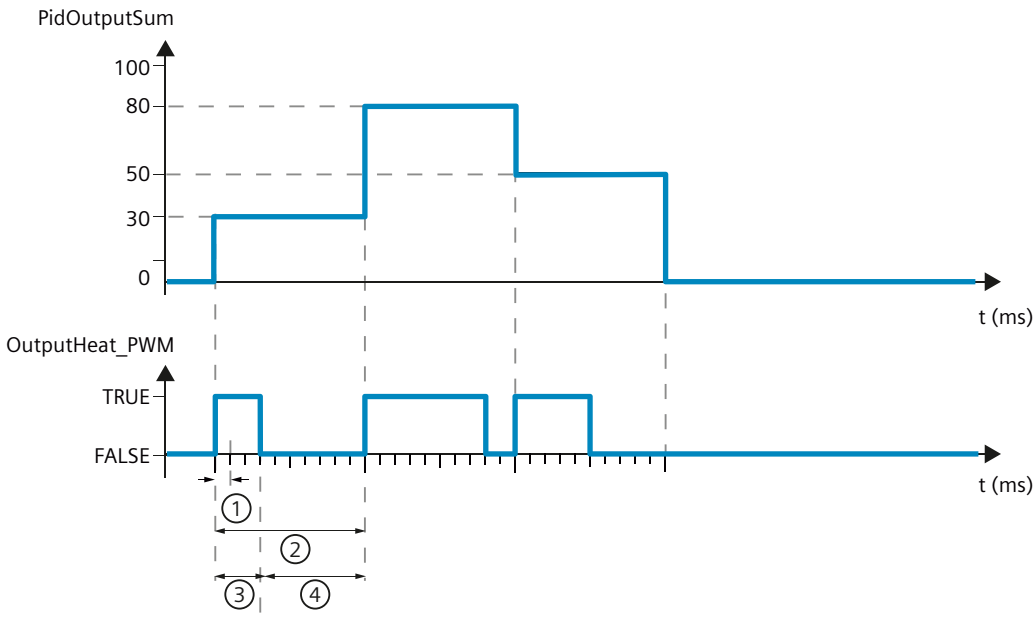

① PID_Temp sampling time

② PID algorithm sampling time for heating

③ Pulse duration

④ Break time

The "Minimum ON time" and the "Minimum OFF time" can be set separately for heating and cooling, rounded to an integer multiple of the PID_Temp sampling time.

A pulse or a break is never shorter than the minimum ON or OFF time. The inaccuracies this causes are added up and compensated in the next cycle.

Example for OutputHeat_PWM

PID_Temp sampling time (equivalent to the cycle time of the calling OB) = 100 ms

PID algorithm sampling time (equivalent to the time period) = 1000 ms

Minimum ON time = 200 ms

The PID output value PidOutputSum amounts to a constant 15%. The smallest pulse that PID_Temp can output corresponds to 20%. In the first cycle, no pulse is output. In the second cycle, the pulse not output in the first cycle is added to the pulse of the second cycle.

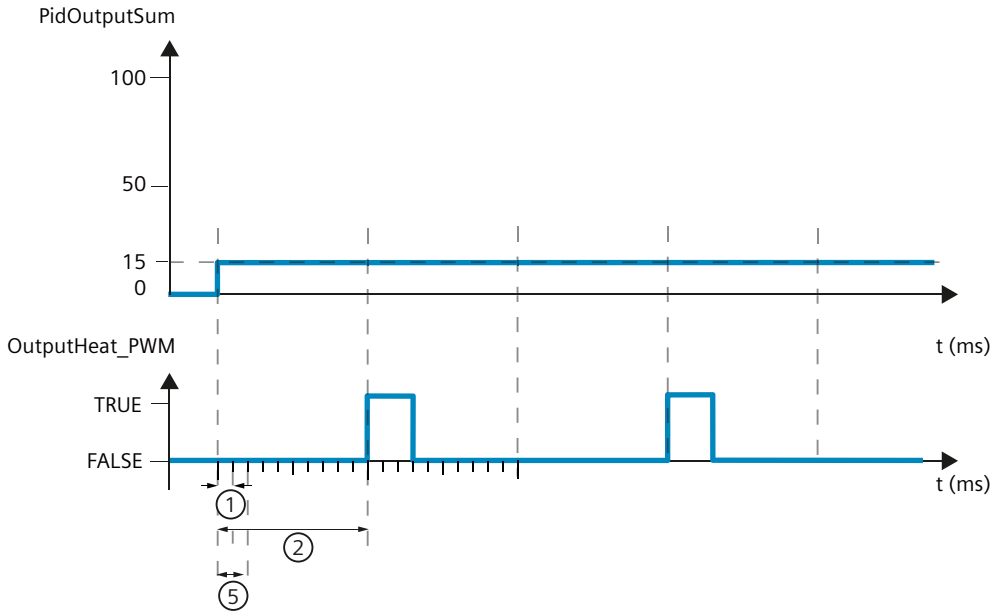

① PID_Temp sampling time

② PID algorithm sampling time for heating

⑤ Minimum ON time

In order to minimize operation frequency and conserve the actuator, extend the minimum ON and OFF times.

If you have selected OutputHeat or OutputCool or OutputHeat_PER or OutputCool_PER as the output in the basic settings, the minimum ON time and the minimum OFF time are not evaluated and cannot be changed.

If the "sampling time of the PID algorithm" (Retain.CtrlParams.Heat.Cycle bzw. Retain.CtrlParams.Cool.Cycle) and thus the period duration of the pulse width modulation is very high when OutputHeat_PWM or OutputCool_PWM is used, you can specify a deviating shorter period duration with the Config.Output.Heat.PwmPeriode or Config.Output.Cool.PwmPeriode (Page 422) parameters in order to improve smoothing of the process value.

NOTE

The minimum ON and OFF times only affect the output parameters OutputHeat_PWM or OutputCool_PWM and are not used for any pulse generators integrated in the CPU.

8.2.4.3 PID parameters

The PID parameters are displayed in the "PID Parameters" configuration window.

If heating and cooling are activated in the basic settings and PID parameter switching is selected as the method for heating/cooling in the output settings, two parameter sets are available: One for heating and one for cooling. In this case, the PID algorithm decides on the basis of the calculated output value and the control deviation whether the PID parameters for heating or cooling are used.

If heating is activated and the cooling deactivated or the cooling factor is selected as the method for heating/cooling, the parameter set for heating is always used.

If heating is deactivated and cooling is activated, the parameter set for cooling is always used.

During tuning, the PID parameters are adapted to the controlled system with the exception of the dead zone width that has to be configured manually.

NOTE

The currently active PID parameters are located in the Retain.CtrlParams structure.

Change the currently active PID parameters only in "Inactive" mode online to prevent malfunction of the PID controller.

If you want to change the PID parameters in "Automatic mode" or "Manual mode" online, change the PID parameters in the CtrlParamsBackUp structure and apply these changes with LoadBackUp = TRUE to the Retain.CtrlParams structure.

Online changes to the PID parameters in "Automatic mode" can result in jumps at the output value.

PID_Temp is a PIDT1 controller with anti-windup and weighting of the proportional and derivative actions.

The PID algorithm operates according to the following transfer function (control zone and dead zone deactivated):

$$y = K_p \left[(b \cdot w - x) + \frac{1}{T_I \cdot s} (w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1} (c \cdot w - x) \right]$$

The table below shows the meaning of the icons used in the transfer function and in the subsequent figures:

Symbol	Description	Associated parameters of the PID_Temp instruction
y	Output value of the PID algorithm	-
K_p	Proportional gain	Retain.CtrlParams.Heat.Gain Retain.CtrlParams.Cool.Gain CoolFactor
s	Laplace operator	-
b	Proportional action weighting	Retain.CtrlParams.Heat.PWeighting Retain.CtrlParams.Cool.PWeighting
w	Setpoint	CurrentSetpoint
x	Process value	ScaledInput

Symbol	Description	Associated parameters of the PID_Temp instruction
T_I	Integration time	Retain.CtrlParams.Heat.Ti Retain.CtrlParams.Cool.Ti
T_D	Derivative action time	Retain.CtrlParams.Heat.Td Retain.CtrlParams.Cool.Td
a	Coefficient for derivative-action delay (Derivative delay T1 = a × T_D)	Retain.CtrlParams.Heat.TdFiltRatio Retain.CtrlParams.Cool.TdFiltRatio
c	Derivative action weighting	Retain.CtrlParams.Heat.DWeighting Retain.CtrlParams.Cool.DWeighting
DeadZone	Dead zone width	Retain.CtrlParams.Heat.DeadZone Retain.CtrlParams.Cool.DeadZone
ControlZone	Control zone width	Retain.CtrlParams.Heat.ControlZone Retain.CtrlParams.Cool.ControlZone

The diagram below illustrates the integration of the parameters into the PID algorithm:

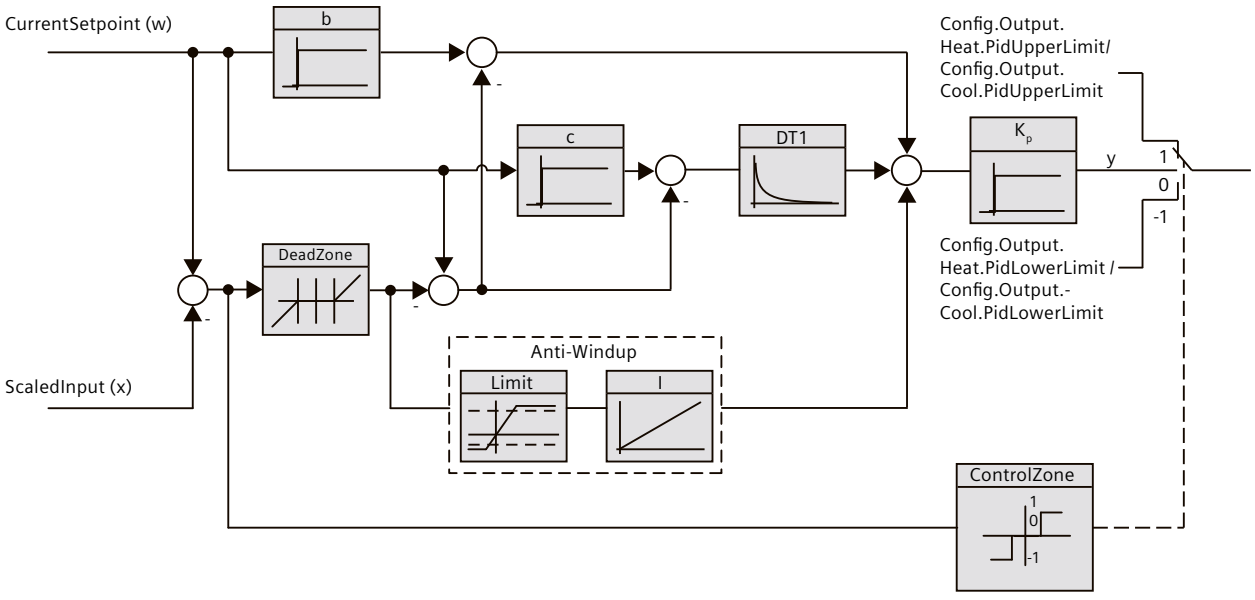

All PID parameters are retentive. If you enter the PID parameters manually, you must completely download PID_Temp (Downloading technology objects to device (Page 46)).

PID_Temp block diagram

The following block diagram shows how the PID algorithm is integrated in the PID_Temp.

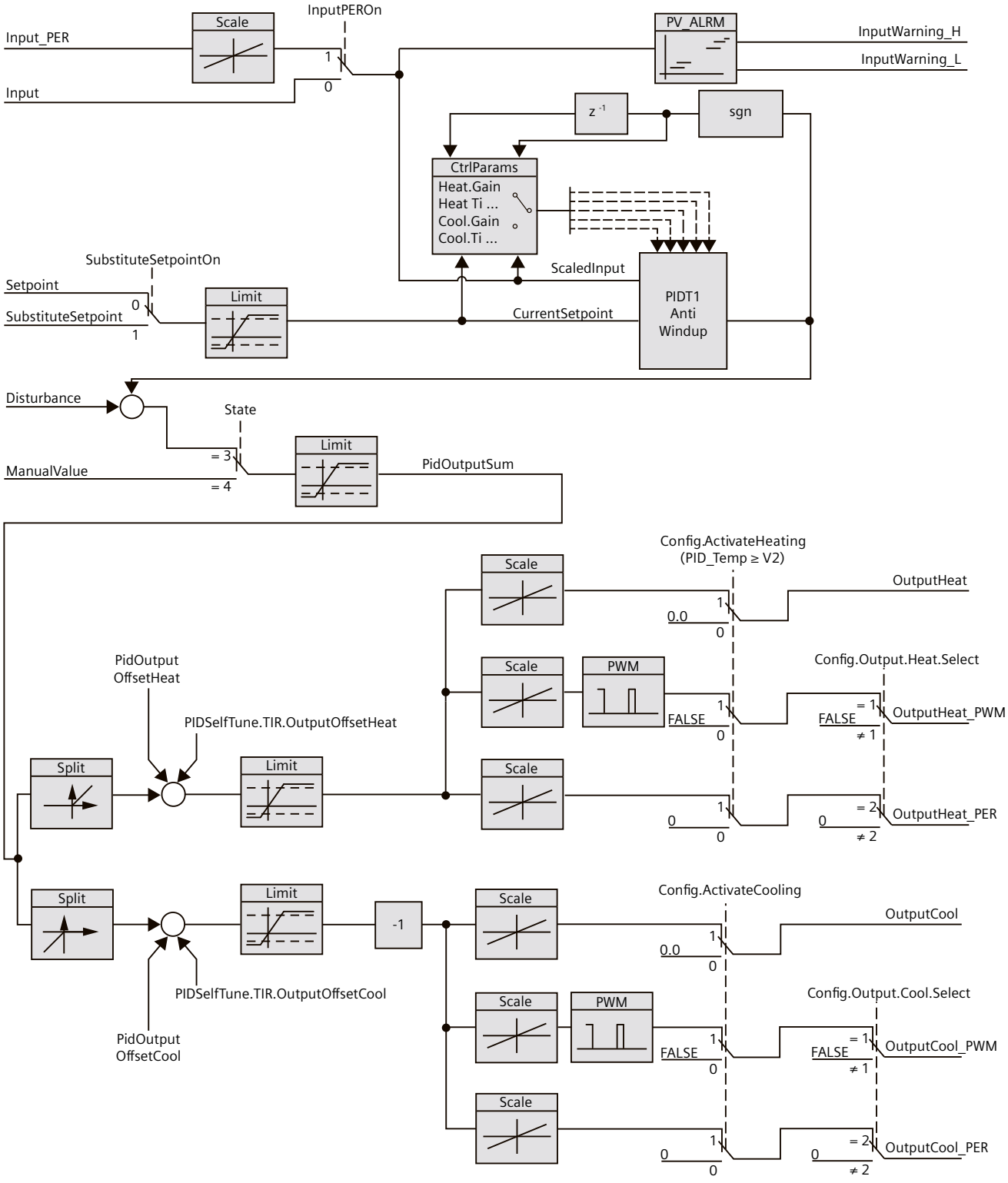

Proportional gain

The value specifies the proportional gain of the controller. PID_Temp does not operate with a negative proportional gain and only supports the normal control logic, meaning that an increase in the process value is achieved by an increase in the PID output value (PidOutputSum).

When cooling is activated, negative PID output values are output as positive values at the outputs for cooling due to the output scaling.

Integration time

The integration time determines the time response of the integral action. The integral action is deactivated with integration time = 0.0. When the integration time is changed from a different value to 0.0 online in "Automatic mode", the previous integral action is deleted and the output value jumps.

If the PID output value (PidOutputSum) reaches an output value limit in automatic mode, the integral action is stopped depending on the direction (anti-windup). As of PID_Temp Version 2.0, the integral component is also actively limited in order to prevent delayed control behavior, e.g. when the output value limits change. Changes to the following tags can lead to an adjustment of the integral component in automatic mode:

- Output value limits (Config.Output.Heat.PidUpperLimit, Config.Output.Heat.PidLowerLimit, Config.Output.Cool.PidUpperLimit and Config.Output.Cool.PidLowerLimit tags)
- Setpoint (Setpoint and SubstituteSetpoint tag)
- Proportional gain (Retain.CtrlParams.Heat.Gain or Retain.CtrlParams.Cool.Gain tag)
- Proportional action weighting (Retain.CtrlParams.Heat.PWeighting or Retain.CtrlParams.Cool.PWeighting tag)
- Disturbance variable (Disturbance variable)

As of PID_Temp V2, it is possible to use the static tags PIDCtrl.IntegralHoldPositive and PIDCtrl.IntegralHoldNegative to manually stop the integral action in the positive or negative direction.

Derivative action time

The derivative action time determines the time response of the derivative action. Derivative action is deactivated with derivative action time = 0.0.

Derivative delay coefficient

The derivative delay coefficient delays the effect of the derivative action.

Derivative delay = derivative action time × derivative delay coefficient

- 0.0: Derivative action is effective for one cycle only and therefore almost not effective.
- 0.5: This value has proved useful in practice for controlled systems with one dominant time constant.
- > 1.0: The greater the coefficient, the longer the effect of the derivative action is delayed.

Proportional action weighting

The proportional action may weaken with changes to the setpoint.

Values from 0.0 to 1.0 are applicable.

- 1.0: Proportional action for setpoint change is fully effective
- 0.0: Proportional action for setpoint change is not effective

The proportional action is always fully effective when the process value is changed.

Derivative action weighting

The derivative action may weaken with changes to the setpoint.

Values from 0.0 to 1.0 are applicable.

- 1.0: Derivative action is fully effective upon setpoint change
- 0.0: Derivative action is not effective upon setpoint change

The derivative action is always fully effective when the process value is changed.

PID algorithm sampling time

The controlled system needs a certain amount of time to respond to changes in the output value. It is therefore not advisable to calculate the output value in every cycle. The "Sampling time of PID algorithm" represents the time between two calculations of the PID output value. It is calculated during tuning and rounded to a multiple of the PID_Temp sampling time (cycle time of the cyclic interrupt OB). All other functions of PID_Temp are executed at every call.

If you use OutputHeat_PWM or OutputCool_PWM, the sampling time of the PID algorithm is additionally used as the period duration of the pulse width modulation. The accuracy of the output signal is determined by the ratio of the PID algorithm sampling time to the cycle time of the OB. The cycle time should be no more than a tenth of the PID algorithm sampling time.

The sampling time of the PID algorithm that is used as the period duration of the pulse width modulation for OutputCool_PWM depends on the method selected for heating/cooling in "Basic settings of output" when heating and cooling are activated:

- If the cooling factor is used, the "sampling time of the PID algorithm for heating" also applies to OutputCool_PWM.
- If PID parameter switching is used, the "sampling time PID algorithm for cooling" applies as the period duration for OutputCool_PWM.

If the sampling time of the PID algorithm and thus the period duration of the pulse width modulation is very high when OutputHeat_PWM or OutputCool_PWM is used, you can specify a deviating shorter period duration with the Config.Output.Heat.PwmPeriode or Config.Output.Cool.PwmPeriode (Page 422) parameters in order to improve smoothing of the process value.

Dead zone width

If the process value is affected by noise, the noise can also have an effect on the output value. The output value may fluctuate considerably when the controller gain is high and the derivative action is activated. If the process value lies within the dead zone around the setpoint, the control deviation is suppressed so that the PID algorithm does not react and unnecessary fluctuations of the output value are reduced.

The dead zone width for heating or cooling is not set automatically during tuning. You must correctly configure the dead zone width manually. The dead zone is deactivated by setting the dead zone width = 0.0.

When the dead zone is switched on, the result can be a permanent control deviation (deviation between setpoint and process value). This can have a negative effect on fine tuning.

For controllers with activated heating output and deactivated cooling output, or controllers with activated heating output and cooling output with cooling factor, the dead zone is located symmetrically between "Setpoint - Dead zone width (heating)" and "Setpoint + Dead zone width (heating)".

For controllers with activated heating output and cooling output with PID parameter switching, the dead zone is between "Setpoint - Dead zone width (heating)" and "Setpoint + Dead zone width (cooling)".

For controllers with deactivated heating output and activated cooling output, the dead zone is symmetrical between "Setpoint - Dead zone width (cooling)" and "Setpoint + Dead zone width (cooling)".

If values other than 1.0 are configured for the proportional action weighting or the derivative action weighting, setpoint changes even within the dead zone affect the output value.

Process value changes within the dead zone do not affect the output value, regardless of the weighting.

Dead zone depending on the configuration:

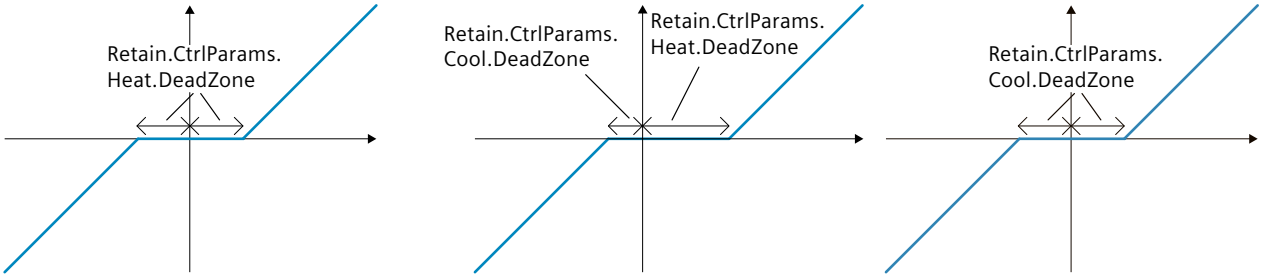

- Activated heating and deactivated cooling or activated heating and cooling with cooling factor (left)
- Activated heating and cooling with PID parameter switching (center)
- Deactivated heating and activated cooling (right)

The x / horizontal axis displays the Control deviation = Setpoint - Process value. The Y / vertical axis shows the output signal of the dead zone that is passed to the PID algorithm.

Control zone width

If the process value exits the control zone around the setpoint, the minimum or maximum output value is output. This means that the process value reaches the setpoint faster.

If the process value lies within the control zone around the setpoint, the output value is calculated by the PID algorithm.

The control zone width for heating or cooling is only set automatically during the pretuning, if "PID (temperature)" is selected as the controller structure for cooling or heating (PIDSelfTune.SUT.TuneRuleHeat = 2 or PIDSelfTune.SUT.TuneRuleCool = 2).

The control zone is deactivated by setting the control zone width = 3.402822e+38.

For controllers with activated heating output and deactivated cooling output or controllers with activated heating output and cooling output with cooling factor, the control zone is symmetrical between "Setpoint - Control zone width (heating)" and "Setpoint + Control zone width (heating)".

For controllers with activated heating output and cooling output with PID parameter switching, the control zone is between "Setpoint - Control zone width (heating)" and "Setpoint + Control zone width (cooling)".

For controllers with deactivated heating output and activated cooling output, the control zone is symmetrical between "Setpoint - Control zone width (cooling)" and "Setpoint + Control zone width (cooling)".

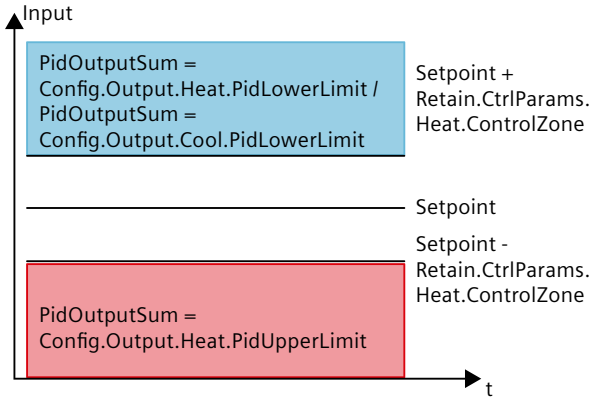

Control zone with activated heating and deactivated cooling or activated heating and cooling with cooling factor.

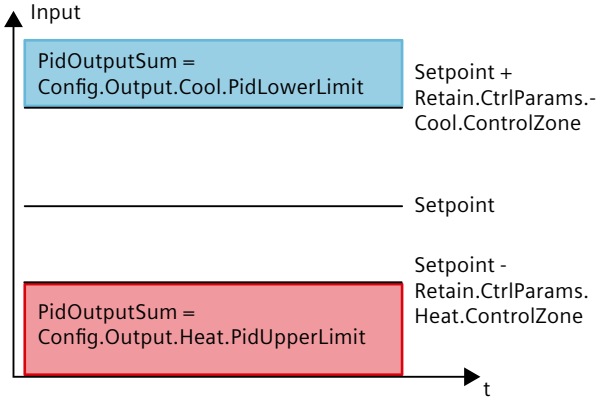

Control zone with activated heating and cooling and PID parameter switching.

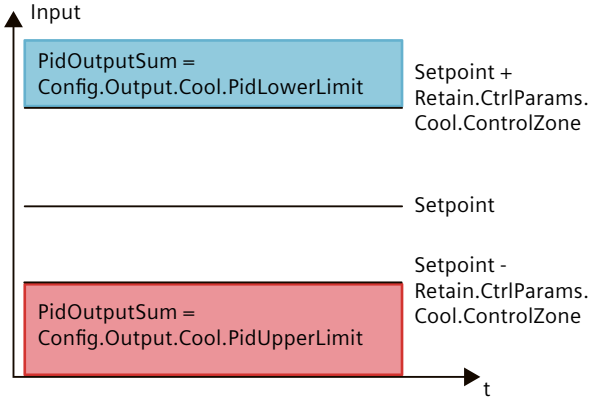

Control zone with deactivated heating and activated cooling.

Rule for tuning

Select whether PI or PID parameters are to be calculated in the "Controller structure" drop-down list. You can specify the rules for tuning for heating and for tuning for cooling separately.

- PID (temperature)

  Calculates PID parameters during pretuning and fine tuning.

  Pretuning is designed for temperature processes and results in a slower and rather asymptotic control response with lower overshoot than with the "PID" option. Fine tuning is identical to the "PID" option.

  The control zone width is determined automatically during pretuning only if this option is selected.
- PID

  Calculates PID parameters during pretuning and fine tuning.
- PI

  Calculates PI parameters during pretuning and fine tuning.
- User-defined

  The drop-down list displays "User-defined" if you have configured different controller structures for pretuning and fine tuning via a user program or the parameter view.

8.3 Commissioning PID_Temp

8.3.1 Commissioning

The commissioning window helps you commission the PID controller. You can monitor the values for the setpoint, process value and the output values for heating and cooling along the time axis in the trend view. The following functions are supported in the commissioning window:

- Controller pretuning
- Controller fine tuning

  Use fine tuning for fine adjustments to the PID parameters.
- Observation of the current control in the trend display
- Testing the controlled system by specifying a manual PID output value and a substitute setpoint
- Saving the actual values of the PID parameters to an offline project.

All functions require an online connection to the CPU.

The online connection to the CPU is established, if it does not exist already, and operation of the commissioning window is enabled by means of the "Monitor all" or "Start" buttons of the trend view.

Operation of the trend view

- Select the desired sampling time in the "Sampling time" drop-down list.

  All the values of the trend view are updated in the selected sampling time.
- Click the "Start" icon in the Measurement group if you want to use the trend display.

  Value recording is started. The current values for the setpoint, process value and output values for heating and cooling are entered in the trend view.
- Click the "Stop" icon if you want to close the trend display.

  The values recorded in the trend view can continue to be analyzed.

Closing the commissioning window will terminate recording in the trend view and delete the recorded values.

8.3.2 Pretuning

The pretuning determines the process response to a jump change of the output value and searches for the point of inflection. The optimized PID parameters are calculated as a function of the maximum rate of rise and dead time of the controlled system. You obtain the best PID parameters when you perform pretuning and fine tuning.

The more stable the process value is, the easier it is to calculate the PID parameters and the more precise the result will be. Noise on the process value can be tolerated as long as the rate of rise of the process value is significantly higher compared to the noise. This is most likely the case in operating modes "Inactive" or "Manual mode". The PID parameters are backed up before being recalculated.

PID_Temp offers different pretuning types depending on the configuration:

- Pretuning heating

  A jump is output at the output value heating, the PID parameters for heating are calculated and control to the setpoint then takes place in automatic mode.
- Pretuning heating and cooling

  A jump is output at the output value heating.

  As soon as the process value is close to the setpoint, a jump change is output at the output value cooling.

  The PID parameters for heating (Retain.CtrlParams.Heat structure) and cooling (Retain.CtrlParams.Cool structure) are calculated and then the setpoint is used as the control variable in automatic mode.
- Pretuning cooling

  A jump is output at the output value cooling.

  The PID parameters for cooling are calculated and then the setpoint is used as the control variable in automatic mode.

Depending on the configuration, the pretuning cooling can be started from two different operating states:

– After pretuning for heating and with process value close to the setpoint:

  This option is available for all versions of PID_Temp for controllers with activated heating output and cooling output with PID parameter switching.

– With distance between process value and setpoint:

  This option is also available for PID_Temp as of V2.0 for controllers with activated cooling output regardless of the activation of the heating output.

If you want to tune the PID parameters for heating and cooling, you can expect improved control response by carrying out "Pretuning heating" and subsequently "Pretuning cooling" than by carrying out "Pretuning heating and cooling". However, carrying out pretuning in two steps takes more time.

General requirements

- The PID_Temp instruction is called in a cyclic interrupt OB.
- ManualEnable = FALSE
- Reset = FALSE
- PID_Temp is in one of the following modes: "Inactive", "Manual mode", or "Automatic mode".
- The setpoint and the process value lie within the configured limits (see Process value monitoring (Page 167) configuration).
- The variables Heat.EnableTuning and Cool.EnableTuning are set automatically when the commissioning editor is used. If you are not using the commissioning editor, you must enter the appropriate values for both tags yourself.

Requirements for pretuning heating

- The heating output in the "Basic settings" is activated (Config.ActivateHeating = TRUE).
- The difference between setpoint and process value is greater than 30% of the difference between process value high limit and process value low limit.
- The distance between the setpoint and the process value is greater than 50% of the setpoint.
- The setpoint is greater than the process value.

Requirements for pretuning heating and cooling

- The heating and cooling output in the "Basic settings" are activated (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE).
- The PID parameter switching in the "Basic settings of output" is activated (Config.AdvancedCooling = TRUE).

- The difference between setpoint and process value is greater than 30% of the difference between process value high limit and process value low limit.
- The distance between the setpoint and the process value is greater than 50% of the setpoint.
- The setpoint is greater than the process value.

Requirements for pretuning cooling with process value close to the setpoint

- The heating and cooling output in the "Basic settings" are activated (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE).
- The PID parameter switching in the "Basic settings of output" is activated (Config.AdvancedCooling = TRUE).
- "Pretuning heating" or "Pretuning heating and cooling" has been carried out successfully if possible at the same setpoint. Successful execution is indicated by PIDSelfTune.SUT.ProcParHeatOk = TRUE .
- The difference between setpoint and process value is less than 5% of the difference between process value high limit and process value low limit.

Requirements for pretuning cooling with distance between process value and setpoint

- PID_Temp as of V2.0
- The cooling output in the "Basic settings" is activated (Config.ActivateCooling = TRUE).
- If the heating output is activated (Config.ActivateHeating = TRUE), PID parameter switching must also be activated (Config.AdvancedCooling = TRUE).
- The difference between setpoint and process value is greater than 30% of the difference between process value high limit and process value low limit.
- The distance between the setpoint and the process value is greater than 50% of the setpoint.
- The setpoint is less than the process value.

Procedure

To perform pretuning, follow these steps:

1. Double-click the "PID_Temp > Commissioning" entry in the project tree.
2. Activate the "Monitor all" button or start the trend view.

   An online connection will be established.
3. Select the desired pretuning entry from the "Tuning mode" drop-down list.

4. Click the "Start" icon.
   - Pretuning is started.
   - The "Status" field displays the current steps and any errors that may have occurred. The progress bar indicates the progress of the current step.

NOTE

Click the "Stop" icon when the progress bar ("Progress" tag) has not changed for a long period and it is to be assumed that the tuning function is blocked. Check the configuration of the technology object and, if necessary, restart controller tuning.

Result

If pretuning was performed without an error message, the PID parameters have been tuned. PID_Temp switches to automatic mode and uses the tuned parameters. The tuned PID parameters will be retained during power OFF and a restart of the CPU.

If pretuning is not possible, PID_Temp responds with the configured reaction to errors.

8.3.3 Fine tuning

Fine tuning generates a constant, limited oscillation of the process value. The PID parameters are tuned for the operating point from the amplitude and frequency of this oscillation. The PID parameters are recalculated from the results. PID parameters from fine tuning usually have better master control and disturbance characteristics than PID parameters from pretuning. You obtain the best PID parameters when you perform pretuning and fine tuning.

PID_Temp automatically attempts to generate an oscillation greater than the noise of the process value. Fine tuning is only minimally influenced by the stability of the process value. The PID parameters are backed up before being recalculated.

PID_Temp offers different fine tuning types depending on the configuration:

- Fine tuning heating:

  PID_Temp generates an oscillation of the process value with periodic changes at the output value heating and calculates the PID parameters for heating.
- Fine tuning cooling:

  PID_Temp generates an oscillation of the process value with periodic changes at the output value cooling and calculates the PID parameters for cooling.

Temporary tuning offset for heating/cooling controllers

If PID_Temp is used as a heating/cooling controller (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE), the PID output value (PidOutputSum) at the setpoint has to fulfill the following requirements so that process value oscillation can be generated and fine tuning can be carried out successfully:

- Positive PID output value for fine tuning heating
- Negative PID output value for fine tuning cooling

If this condition is not fulfilled, you can specify a temporary offset for fine tuning that is output at the opposing output.

- Offset for cooling output (PIDSelfTune.TIR.OutputOffsetCool) at fine tuning heating.

  Before starting tuning, enter a negative tuning offset cooling that is lower than the PID output value (PidOutputSum) at the setpoint in the stationary state.

- Offset for heating output (PIDSelfTune.TIR.OutputOffsetHeat) at fine tuning cooling

  Before starting tuning, enter a positive tuning offset heating that is higher than the PID output value (PidOutputSum) at the setpoint in the stationary state.

The defined offset is balanced by the PID algorithm so that the process value remains at the setpoint. The height of the offset allows the PID output value to be adapted correspondingly so that it fulfills the requirement mentioned above.

To avoid larger overshoots of the process value when defining the offset, it can also be increased in several steps.

If PID_Temp exits the fine tuning mode, the tuning offset is reset.

Example: Specification of an offset for fine tuning cooling

- Without offset
  - Setpoint = Process value (ScaledInput) = 80 °C
  - PID output value (PidOutputSum) = 30.0
  - Output value heating (OutputHeat) = 30.0
  - Output value cooling (OutputCool) = 0.0

    Oscillation of the process value around the setpoint cannot be generated with the cooling output alone. Fine tuning would fail here.
- With offset for heating output (PIDSelfTune.TIR.OutputOffsetHeat) = 80.0
  - Setpoint = Process value (ScaledInput) = 80 °C
  - PID output value (PidOutputSum) = -50.0
  - Output value heating (OutputHeat) = 80.0
  - Output value cooling (OutputCool) = -50.0

    Thanks to the specification of an offset for the heating output, the cooling output can now generate oscillation of the process value around the setpoint. Fine tuning can now be carried out successfully.

General requirements

- The PID_Temp instruction is called in a cyclic interrupt OB.
- ManualEnable = FALSE
- Reset = FALSE
- The setpoint and the process value lie within the configured limits (see "Process value settings" configuration).

- The control loop has stabilized at the operating point. The operating point is reached when the process value corresponds to the setpoint.

  When the dead zone is switched on, the result can be a permanent control deviation (deviation between setpoint and process value). This can have a negative effect on fine tuning.
- No disturbances are expected.
- PID_Temp is in inactive mode, automatic mode or manual mode.
- The Heat.EnableTuning and Cool.EnableTuning tags are set automatically when the commissioning editor is used. If you are not using the commissioning editor, you must enter the appropriate values for both tags yourself.

Requirements for fine tuning heating

- The heating output is activated (Config.ActivateHeating = TRUE).
- If PID_Temp is configured as a heating/cooling controller (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE), the heating output has to be active at the operating point at which tuning is to be performed.

  PidOutputSum > 0.0 (see tuning offset)

Requirements for fine tuning cooling

- The cooling output is activated (Config.ActivateCooling = TRUE).
- If the heating output is activated (Config.ActivateHeating = TRUE), PID parameter switching must also be activated (Config.AdvancedCooling = TRUE).
- If PID_Temp is configured as a heating/cooling controller (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE), the heating output has to be active at the operating point at which tuning is to be performed.

  PidOutputSum < 0.0 (see tuning offset)

Process depends on initial situation

Fine tuning can be started from the following operating modes: "Inactive", "automatic mode", or "manual mode".

Fine tuning proceeds as follows when started from:

- Automatic mode with PIDSelfTune.TIR.RunIn = FALSE (default)

  Start fine tuning from automatic mode if you wish to improve the existing PID parameters through tuning.

  PID_Temp controls the system using the existing PID parameters until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start.

- Inactive, manual mode or automatic mode with PIDSelfTune.TIR.RunIn = TRUE

  An attempt is made to reach the setpoint with the minimum or maximum output value (two-point control):

  – With minimum or maximum output value heating at fine tuning heating.
  – With minimum or maximum output value cooling for fine tuning cooling.

  This can produce increased overshoot. When the setpoint is reached, fine tuning is started.

  If the setpoint cannot be reached, PID_Temp does not abort tuning automatically.

Procedure

To perform fine tuning, follow these steps:

1. Double-click the "PID_Temp > Commissioning" entry in the project tree.
2. Activate the "Monitor all" button or start the trend view.

   An online connection will be established.
3. Select the desired fine tuning entry from the "Tuning mode" drop-down list.
4. If required (see tuning offset), specify a tuning offset and wait until the stationary state is reached again.

5. Click the "Start" icon.
   - The process of fine tuning is started.
   - The "Status" field displays the current steps and any errors that may have occurred.

     The progress bar indicates the progress of the current step.

NOTE

Click the "Stop" icon in the "Tuning mode" group if the progress bar ("Progress" tag) has not changed for a long period and it is to be assumed that the tuning function is blocked. Check the configuration of the technology object and, if necessary, restart controller tuning.

In the following phases in particular, tuning is not aborted automatically if the setpoint cannot be reached.

- "Attempting to reach setpoint for heating with two-point control."
- "Attempting to reach setpoint with two-step control cooling."

Result

If fine tuning was performed without errors, the PID parameters have been tuned. PID_Temp switches to automatic mode and uses the tuned parameters. The tuned PID parameters will be retained during power OFF and a restart of the CPU.

If errors occurred during fine tuning, PID_Temp responds with the configured response to errors.

8.3.4 "Manual" mode

In manual mode, a manual PID output value is specified via the ManualValue parameter. The resulting output values for heating and cooling are determined by the configured output scaling. With the preset output scaling, specify a negative manual value to obtain a positive value at the outputs for cooling.

The following section describes how you can use the "manual mode" operating mode in the commissioning window of the "PID_Temp" technology object.

Manual mode is also possible when an error is pending.

Requirement

- The "PID_Temp" instruction is called in a cyclic interrupt OB.
- An online connection to the CPU has been established.
- The CPU is in "RUN" mode.

Procedure

Use "Manual mode" in the commissioning window if you want to test the controlled system by specifying a manual value.

To define a manual value, follow these steps:

1. Double-click the "PID_Temp > Commissioning" entry in the project tree.
2. Activate the "Monitor all" button or start the trend view.

   An online connection will be established.
3. Select the "Manual mode" check box in the "Online status of controller" area.

   PID_Temp operates in manual mode. The most recent current output value remains in effect.
4. Enter the manual value in the editable field as a % value.

   If heating and cooling are activated in the basic settings, enter the manual value as follows:

   – Enter a positive manual value to output the value at the outputs for heating.
   – Enter a negative manual value to output the value at the outputs for cooling.
5. Click the icon.

Result

The manual value is written to the CPU and immediately goes into effect.

Clear the "Manual mode" check box if the output value is to be specified again by the PID controller.

The switchover to automatic mode is bumpless.

8.3.5 Substitute setpoint

The following section describes how you can use the substitute setpoint in the commissioning window of the "PID_Temp" technology object.

Requirement

- The "PID_Temp" instruction is called in a cyclic interrupt OB.
- An online connection to the CPU has been established.
- The CPU is in "RUN" mode.

Procedure

If you want to use a different value as the setpoint than that specified at the "Setpoint" parameter (for example to tune a slave in a cascade), use the substitute setpoint in the commissioning window.

Proceed as follows to specify a substitute setpoint:

1. Double-click the "PID_Temp > Commissioning" entry in the project tree.
2. Activate the "Monitor all" button or start the trend view.

   An online connection will be established.
3. Select the "Subst.Setpoint" check box in the "Online status of controller" section.

   The substitute setpoint (SubstituteSetpoint tag) is initialized with the most recently updated setpoint and now used.
4. Enter the substitute setpoint in the editable field.
5. Click the icon.

Result

The substitute setpoint is written to the CPU and immediately goes into effect.

Clear the "Subst.Setpoint" check box if the value at the "Setpoint" parameter is to be used again as setpoint.

The switchover is not bumpless.

8.3.6 Cascade commissioning

Information about cascade commissioning with PID_Temp is available under Commissioning (Page 193).

8.4 Cascade control with PID_Temp

8.4.1 Introduction

In cascade control, several control loops are nested within each other. In the process, slaves receive their setpoint (Setpoint) from the output value (OutputHeat or OutputCool) of the respective higher-level master.

A prerequisite for establishing a cascade control system is that the controlled system can be divided into subsystems, each with its own measured variable.

Setpoint specification for the controlled variable is carried out at the outmost master.

The output value of the innermost slave is applied to the actuator and thus acts on the controlled system.

The following major advantages result from the use of a cascade control system in comparison with a single-loop control system:

- Thanks to the additional subordinate control loops, disturbances which occur there are corrected quickly. Their influence on the controlled variable is reduced considerably. The disturbance behavior is thus improved.
- The subordinate control loops act in linearizing form. The negative effects of such non-linearities on the controlled variable are thus moderated.

PID_Temp offers the following functionality especially for use in cascade control systems:

- Specification of a substitute setpoint
- Exchange of status information between master and slave (for example, current operating mode)
- Different Anti-Windup modes (response of the master to limitation of its slave)

Example

The following block diagram shows a cascade control system with PID_Temp using the simplified example of a chocolate melting unit:

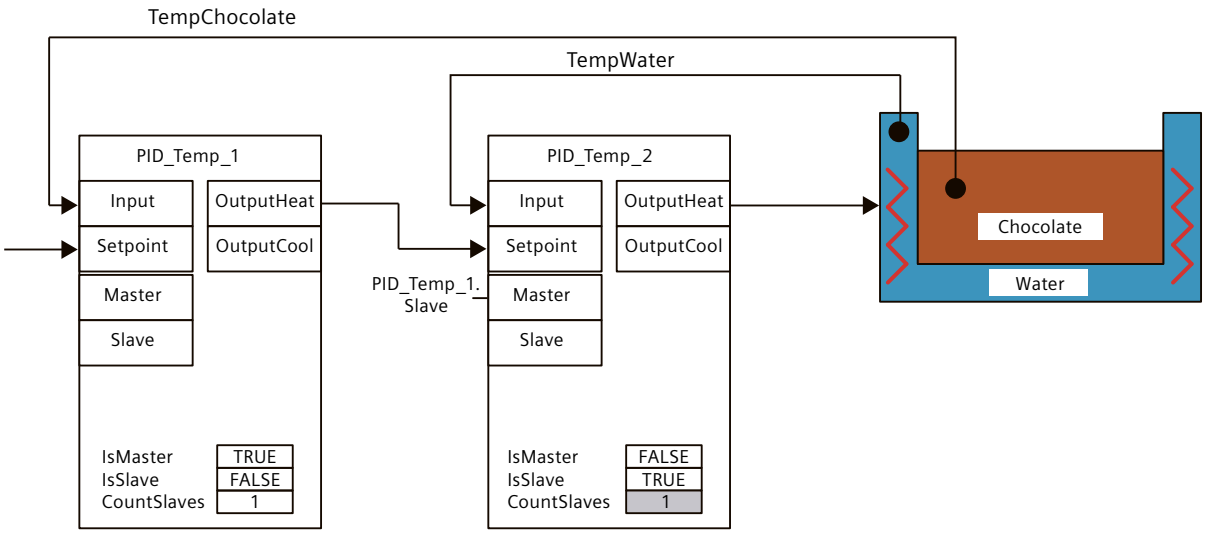

The PID_Temp_1 master compares the process value of the chocolate temperature (TempChocolate) with the setpoint specification by the user at the Setpoint parameter. Its output value OutputHeat forms the setpoint of the slave PID_Temp_2.

PID_Temp_2 attempts to regulate the process value of the water-bath temperature (TempWater) to this setpoint. The output value of PID_Temp_2 acts directly on the actuator of the controlled system (heating of the water bath) and thus influences the water-bath temperature. The water-bath temperature in turn has an effect on the chocolate temperature.

As an increasing water bath temperature causes an increasing chocolate temperature, only the heating is activated on the PID_Temp_1 master (Config.ActivateHeating = TRUE, Config.ActivateCooling = FALSE) and the output value OutputHeat is used as the setpoint for the slave.

FAQ

For more information, see the following FAQs in the Siemens Industry Online Support:

- Entry ID 103526819 (https://support.industry.siemens.com/cs/ww/en/view/103526819)

See also

Program creation (Page 190)

8.4.2 Program creation

Note the following points during program creation:

- Number of PID_Temp instances

  The number of different PID_Temp instances called up in a cyclic interrupt OB has to agree with the number of concatenated measured variables in the process.

  There are two concatenated measured variables in the example: TempChocolate and TempWater. Therefore two PID_Temp instances are required.

- Call sequence

  A master has to be called before its slaves in the same cyclic interrupt OB.

  The outermost master at which the user setpoint is specified is called first.

  The slave whose setpoint is specified by the outermost master is called next, etc.

  The innermost slave that acts on the actuator of the process with its output value is called last.

  In the example, PID_Temp_1 is called before PID_Temp_2.

- Interconnection of the measured variables

  The outermost master is interconnected with the outermost measured variable that is to be regulated to the user setpoint.

  The innermost slave is interconnected with the innermost measured variable that is influenced directly by the actuator.

  Interconnection of the measured variables with PID_Temp is carried out with the parameters Input or Input_PER.

  In the example, the outermost measured variable TempChocolate is interconnected with PID_Temp_1 and the innermost measured variable TempWater with PID_Temp_2.

- Interconnection of the output value of the master to the setpoint of the slave

  The output value (OutputHeat or OutputCool) of a master has to be assigned to the setpoint (Setpoint) of its slave. The output value that is used depends on the configuration (Page 191).

  This interconnection can be carried out in the programming editor or automatically in the Inspector window of the slave in the basic settings via the selection of the master.

  If required, you can insert your own filter or scaling functions, for example in order to adapt the output value range of the master to the setpoint / process value range of the slave.

  In the example, OutputHeat of PID_Temp_1 is assigned to Setpoint of PID_Temp_2.

- Interconnection of the interface for information exchange between master and slave

  The "Slave" parameter of a master has to be assigned to the "Master" parameter of all its directly subordinate slaves (which receive their setpoint from this master). The assignment should be carried out via the interface of the slave in order to allow the interconnection of a master with multiple slaves and the display of the interconnection in the Inspector window of the slave in the basic settings.

  This interconnection can be carried out in the programming editor or automatically in the Inspector window of the slave in the basic settings via the selection of the master.

  The Anti-Windup function and the evaluation of the slave operating modes at the master can only function correctly if this interconnection is carried out.

  In the example, the "Slave" parameter of PID_Temp_1 is assigned to the "Master" parameter of PID_Temp_2.

Program code of the example using SCL (without assignment of the output value of the slave to the actuator):

```
"PID_Temp_1"(Input:="TempChocolate");
"PID_Temp_2"(Input:="TempWater", Master := "PID_Temp_1".Slave,
Setpoint := "PID_Temp_1".OutputHeat);
```

See also

PID_Temp ActivateRecoverMode tag (Page 419)

8.4.3 Configuration

You can carry out the configuration via your user program, the configuration editor or the Inspector window of the PID_Temp call.

When using PID_Temp in a cascade control system, ensure the correct configuration of the settings specified below.

If a PID_Temp instance receives its setpoint from a superior master controller and outputs its output value in turn to a subordinate slave controller, this PID_Temp instance is both a master controller and a slave controller simultaneously. Both configurations listed below have to be carried out for such a PID_Temp instance. This is the case, for example, for the middle PID_Temp instance in a cascade control system with three concatenated measured variables and three PID_Temp instances.

Configuration of a master

Setting in the configuration editor or Inspector window	DB parameter	Explanation
Basic settings → Cascade: Activate "Controller is master" check box	Config.Cascade.IsMaster = TRUE	Activates this controller as master in a cascade.
Basic settings → Cascade: Number of slaves	Config.Cascade.CountSlaves	Number of directly subordinate slaves that receive their setpoint directly from this master
Basic settings → Input/output parameters: Clear the "Activate heating" or "Activate cooling" check box	PID_Temp V1.x: Config.ActivateCooling = FALSE PID_Temp as of V2.0 Config.ActivateHeating = TRUE, Config.ActivateCooling = FALSE or: Config.ActivateHeating = FALSE,	PID_Temp V1.x: The cooling has to be deactivated at a master. This allows cascade control to be realized, in which an increasing measured variable of the slave causes an increasing measured variable of the master.

Setting in the configuration editor or Inspector window	DB parameter	Explanation
	Config.ActivateCooling = TRUE	The output value OutputHeat is used as the setpoint for the slave. PID_Temp as of V2.0 With a master, either the cooling or the heating must be deactivated. If a rising measured variable of the slave causes a rising measured variable of the master (see example (Page 188)), activate the heating and deactivate the cooling. The output value OutputHeat is used as the setpoint for the slave. If a rising measured variable of the slave causes a falling measured variable of the master (e.g. rising coolant flow leads to falling temperature), deactivate the heating and activate the cooling. The output value OutputCool is used as the setpoint for the slave.
Basic settings → Input/output parameters: Selection of the output value (heating) = OutputHeat or selection of the output value (cooling) = OutputCool	Config.Output.Heat.Select = 0 or Config.Output.Cool.Select = 0	The master only uses the output parameter OutputHeat or OutputCool. OutputHeat_PWM, OutputCool_PWM, OutputHeat_PER and OutputCool_PER are deactivated.
Output settings → Output limits and scaling → OutputHeat / OutputCool: PID output value low limit (heating), PID output value high limit (heating), Scaled low output value (heating) Scaled high output value (heating) or: PID output value low limit (cooling), PID output value high limit (cooling), Scaled low output value (cooling) Scaled output high value (cooling)	Config.Output.Heat.PidLowerLimit, Config.Output.Heat.PidUpperLimit, Config.Output.Heat.LowerScaling, Config.Output.Heat.UpperScaling or: Config.Output.Cool.PidLowerLimit, Config.Output.Cool.PidUpperLimit, Config.Output.Cool.LowerScaling, Config.Output.Cool.UpperScaling	If no own scaling function is used when assigning OutputHeat or OutputCool of the master to Setpoint of the slave, it may be necessary to adapt the output value limits and the output scaling of the master to the setpoint / process value range of the slave.

Setting in the configuration editor or Inspector window	DB parameter	Explanation
This tag is not available in the Inspector window or in the functional view of the configuration editor. You can change it via the parameter view of the configuration editor.	Config.Cascade.AntiWindUp-Mode	The Anti-Windup mode determines how the integral action of this master is treated if directly subordinate slaves reach their output value limits. Options are: • AntiWindUpMode = 0: The Anti-Windup function is deactivated. The master does not react to the limitation of its slaves. • AntiWindUpMode = 1 (default): The integral action of the master is reduced in the ratio "Slaves in limitation/Number of slaves". This reduces the effects of the limitation on the control behavior. • AntiWindUpMode = 2: The integral action of the master is held as soon as a slave is in limitation.

Configuration of a slave

Setting in the configuration editor or Inspector window	DB parameter	Explanation
Basic settings → Cascade: Select the "Controller is slave" check box	Config.Cascade.IsSlave = TRUE	Activates this controller as slave in a cascade.

8.4.4 Commissioning

After compiling and loading of the program, you can start commissioning of the cascade control system.

Begin with the innermost slave at commissioning (implementation of tuning or change to automatic mode with existing PID parameters) and continue outwards until the outermost master has been reached.

In the example above, commissioning starts with PID_Temp_2 and is then continued with PID_Temp_1.

Tuning the slave

Tuning of PID_Temp requires a constant setpoint. Therefore, activate the substitute setpoint of a slave (SubstituteSetpoint and SubstituteSetpointOn tags) to tune the slave or set the associated master to manual mode with a corresponding manual value. This ensures that the setpoint of the slave remains constant during tuning.

Tuning the master

In order for a master to influence the process or to carry out tuning, all the downstream slaves have to be in automatic mode and their substitute setpoint has to be deactivated. A master evaluates these conditions through the interface for information exchange between master and slave (Master parameter and Slave parameter) and displays the current state at the AllSlaveAutomaticState and NoSlaveSubstituteSetpoint tags. Corresponding status messages are output in the commissioning editor.

Status message in the commissioning editor of the master	DB parameter of the master	Correction
One or more slaves are not in automatic mode.	AllSlaveAutomaticState = FALSE, NoSlaveSubstituteSetpoint = TRUE	First, carry out commissioning of all downstream slaves. Ensure that the following conditions are fulfilled before carrying out tuning or activating manual mode or automatic mode of the master: • All downstream slaves are in automatic mode (state = 3). • All downstream slaves have deactivated the substitute setpoint (SubstituteSetpointOn = FALSE).
One or more slaves have activated the substitute setpoint.	AllSlaveAutomaticState = TRUE, NoSlaveSubstituteSetpoint = FALSE	
One or more slaves are not in automatic mode and have activated the substitute setpoint.	AllSlaveAutomaticState = FALSE, NoSlaveSubstituteSetpoint = FALSE	

If pretuning or fine tuning is started for a master, PID_Temp aborts tuning in the following cases and displays an error with ErrorBits = 16#0020_0000:

- One or more slaves are not in automatic mode (AllSlaveAutomaticState = FALSE)
- One or more slaves have activated the substitute setpoint (NoSlaveSubstituteSetpoint = FALSE).

The subsequent operating mode changeover depends on ActivateRecoverMode.

8.4.5 Substitute setpoint

In order to specify a setpoint, PID_Temp offers a substitute setpoint at the SubstituteSetpoint tag in addition to the Setpoint parameter. This can be activated by setting SubstituteSetpointOn = TRUE or by selecting the corresponding check box in the commissioning editor.

The substitute setpoint allows you to specify the setpoint temporarily directly at the slave, for example during commissioning or tuning.

In this case, the interconnection of the output value of the master with the setpoint of the slave that is required for normal operation of the cascade control system does not have to be changed in the program

In order for a master to influence the process or to carry out tuning, the substitute setpoint has to be deactivated at all downstream slaves.

You can monitor the currently effective setpoint as it is used by the PID algorithm for calculation at the CurrentSetpoint tag.

8.4.6 Operating modes and fault response

The master or slave of a PID_Temp instance does not change the operating mode of this PID_Temp instance.

If a fault occurs at one of its slaves, the master remains in its current operating mode.

If a fault occurs at its master, the slave remains in its current operating mode. However, further operation of the slave then depends on the fault and the configured fault response of the master since the output value of the master is used as the setpoint of the slave:

- If ActivateRecoverMode = TRUE is configured at the master and the fault does not prevent the calculation of OutputHeat or OutputCool, the fault does not have any effect on the slave.
- If ActivateRecoverMode = TRUE is configured at the master and the fault prevents the calculation of OutputHeat or OutputCool, the master outputs the last valid output value or the configured substitute output value SubstituteOutput depending on SetSubstituteOutput. This is then used by the slave as the setpoint.

  PID_Temp is preconfigured so that the substitute output value 0.0 is output in this case (ActivateRecoverMode = TRUE, SetSubstituteOutput = TRUE, SubstituteOutput = 0.0). Configure a suitable substitute output value for your application or activate the use of the last valid PID output value (SetSubstituteOutput = FALSE).
- If ActivateRecoverMode = FALSE is configured at the master, the master changes to the "Inactive" mode when an error occurs and outputs OutputHeat = 0.0 and OutputCool = 0.0. The slave then uses 0.0 as the setpoint.

The fault response is located in the output settings in the configuration editor.

8.5 Multi-zone controlling with PID_Temp

Introduction

In a multi-zone control system, several sections, so-called zones, of a plant are controlled simultaneously to different temperatures. A multi-zone control system is characterized by the mutual influence of the temperature zones through thermal coupling, i.e. the process value of one zone can influence the process value of a different zone through thermal coupling. The strength that this influence has depends on the structure of the plant and the selected operating points of the zones.

Example: Extrusion plant as it is used, for example, in plastics processing.

The substance mixture that passes through the extruder has to be controlled to different temperatures for optimal processing. For example, different temperatures can be required at the filling point of the extruder than at the outlet nozzle. The individual temperature zones mutually influence each other through thermal coupling.

When PID_Temp is used in multi-zone control systems, each temperature zone is controlled by a separate PID_Temp instance.

Observe the following explanations if you want to use the PID_Temp in a multi-zone control system.

Separate pretuning for heating and cooling

Initial commissioning of a plant as a rule begins with the carrying out of pretuning in order to carry out initial setting of the PID parameters and control to the operating point. The pretuning for multi-zone control systems is often carried out simultaneously for all zones.

PID_Temp offers for controllers with activated heating and cooling and PID parameter switching as a method for heating/cooling (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) the possibility to perform the pretuning for heating and cooling in one step (Mode = 1, Heat.EnableTuning = TRUE, Cool.EnableTuning = TRUE).

However, it is advisable not to use this tuning for simultaneous pretuning of several PID_Temp instances in a multi-zone control system. Instead, first carry out the pretuning for heating (Mode = 1, Heat.EnableTuning = TRUE, Cool.EnableTuning = FALSE) and the pretuning for cooling (Mode = 1, Heat.EnableTuning = FALSE, Cool.EnableTuning = TRUE) separately.

Pretuning for cooling should not be started until all zones have completed pretuning for heating and have reached their operating points.

This reduces mutual influencing through thermal coupling between the zones during tuning.

Adapting the delay time

If PID_Temp is used in a multi-zone control system with strong thermal couplings between the zones, you should ensure that the adaption of the delay time is deactivated for pretuning with PIDSelfTune.SUT.AdaptDelayTime = 0. Otherwise, the determination of the delay time can be incorrect if the cooling of a zone is prevented by the thermal influence of other zones during the adapting of the delay time (heating is deactivated in this phase).

Temporary deactivation of cooling

PID_Temp offers the possibility of deactivating cooling temporarily in automatic mode for controllers with activated heating and cooling (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE) by setting DisableCooling = TRUE.

This ensures that this controller does not cool in automatic mode during commissioning while the controllers of other zones have not yet completed tuning of heating. The tuning could otherwise be influenced negatively by the thermal coupling between the zones.

Procedure

You can proceed as follows during the commissioning of multi-zone control systems with relevant thermal couplings:

1. Set DisableCooling = TRUE for all controllers with activated heating and cooling.
2. Set PIDSelfTune.SUT.AdaptDelayTime = 0 for all controllers.
3. Specify the desired setpoints (Setpoint parameter) and start pretuning for heating (Mode = 1, Heat.EnableTuning = TRUE, Cool.EnableTuning = FALSE) simultaneously for all controllers.
4. Wait until all the controllers have completed pretuning for heating.

5. Set DisableCooling = FALSE for all controllers with activated heating and cooling.
6. Wait until the process values of all the zones are steady and close to the respective setpoint.

   If the setpoint cannot be reached permanently for a zone, the heating or cooling actuator is too weak.
7. Start pretuning for heating and cooling (Mode = 1, Heat.EnableTuning = FALSE, Cool.EnableTuning = TRUE) for all controllers with activated cooling.

NOTE

Limit violation of the process value

If the cooling is deactivated in automatic mode with DisableCooling = TRUE, this can cause the process value to exceed the setpoint and the process value limits while DisableCooling = TRUE. Observe the process values and intervene, if needed, if you use DisableCooling.

NOTE

Multi-zone control systems

For multi-zone control systems, the thermal couplings between the zones can result in increased overshoots, permanent or temporary violation of limits and permanent or temporary control deviations during commissioning or operation. Observe the process values and be ready to intervene. Depending on the system, it can be necessary to deviate from the procedure described above.

Synchronization of several fine tuning processes

If fine tuning is started from automatic mode with PIDSelfTune.TIR.RunIn = FALSE, PID_Temp tries to reach the setpoint with PID controlling and the current PID parameters. The actual tuning does not start until the setpoint is reached. The time required to reach the setpoint can be different for the individual zones of a multi-zone control system.

If you want to carry out fine tuning for several zones simultaneously, PID_Temp offers the possibility to synchronize these by waiting with the further tuning steps after the setpoint has been reached.

Procedure

This ensures that all the controllers have reached their setpoint when the actual tuning steps start. This reduces mutual influencing through thermal coupling between the zones during tuning.

Proceed as follows for controllers for whose zones you want to carry out fine tuning simultaneously:

1. Set PIDSelfTune.TIR.WaitForControlIn = TRUE for all controllers.

   These controllers have to be in automatic mode with PIDSelfTune.TIR.RunIn = FALSE.
2. Specify the desired setpoints (Setpoint parameters) and start fine tuning for all controllers.
3. Wait until PIDSelfTune.TIR.ControlInReady = TRUE at all controllers.
4. Set PIDSelfTune.TIR.FinishControlIn = TRUE for all controllers.

All controllers then start the actual tuning simultaneously.

8.6 Override control with PID_Temp

Override control

In case of override control, two or more controllers share one actuator. Only one controller has access to the actuator at any time and influences the process.

A logic operation decides which controller has access to the actuator. This decision is often made based on a comparison of the output values of all controllers, for example, in case of a maximum selection, the controller with the largest output value gets access to the actuator.

The selection based on the output value requires that all controllers operate in automatic mode. The controllers that do not have an effect on the actuator are updated. This is necessary to prevent windup effects and their negative impacts on the control response and the switchover between the controllers.

PID_Temp supports override controls as of version 1.1 by offering a simple process for updating the controllers that are not active: By using the OverwriteInitialOutputValue and PIDCtrl.PIDInit tags, you can preassign the integral action of the controller in automatic mode as though the PID algorithm had calculated PidOutputSum = OverwriteInititalOutputValue for the PID output value in the last cycle. To do this, OverwriteInitialOutputValue is interconnected with the PID output value of the controller that currently has access to the actuator. By setting the bit PIDCtrl.PIDInit, you trigger the preassignment of the integral action as well as the restart of the controller cycle and the PWM period. The subsequent calculation of the PID output value in the current cycle takes place based on the preassigned (and synchronized for all controllers) integral action as well as the proportional action and integral action from the current control deviation. The derivative action is not active during the call with PIDCtrl.PIDInit = TRUE and therefore does not contribute to the output value.

This procedure ensures that the calculation of the current PID output value and thus the decision on which controller is to have access to the actuator is only based on the current process state and the PI parameters. Windup effects for controllers that are not active and thus incorrect decisions of the switchover logic are prevented.

Requirement

- PIDCtrl.PIDInit only takes effect if the integral action is activated (tags Retain.CtrlParams.Heat.Ti and Retain.CtrlParams.Cool.Ti > 0.0).
- You must assign PIDCtrl.PIDInit and OverwriteInitialOutputValue in your user program yourself (see example below). PID_Temp does not automatically change these tags.
- PIDCtrl.PIDInit only takes effect when PID_Temp is in automatic mode (parameter State = 3)
- If possible, select the sampling time of the PID algorithm (Retain.CtrlParams.Heat.Cycle and Retain.CtrlParams.Cool.Cycle tags) so that it is identical for all controllers, and call all controllers in the same cyclic interrupt OB. In this way, you ensure that the switchover does not take place within a controller cycle or a PWM period.

NOTE

Constant adaptation of the output value limits

Instead of the active updating of the controllers without access to the actuator described here, this is implemented alternatively by constant adaptation of the output value limits in other controller systems.

This is not possible with PID_Temp, because a change of the output value limits is not supported in automatic mode.

Example: Control of a large boiler

PID_Temp is used for control of a large boiler.

The main goal is to control the temperature Input1. The controller PID_Temp_1 is used for this purpose. In addition, the temperature Input2 is to be kept below a high limit at an additional measuring point with the limiting controller PID_Temp_2.

Both temperatures are influenced by only one heater. The output value of the controller corresponds to the heating power.

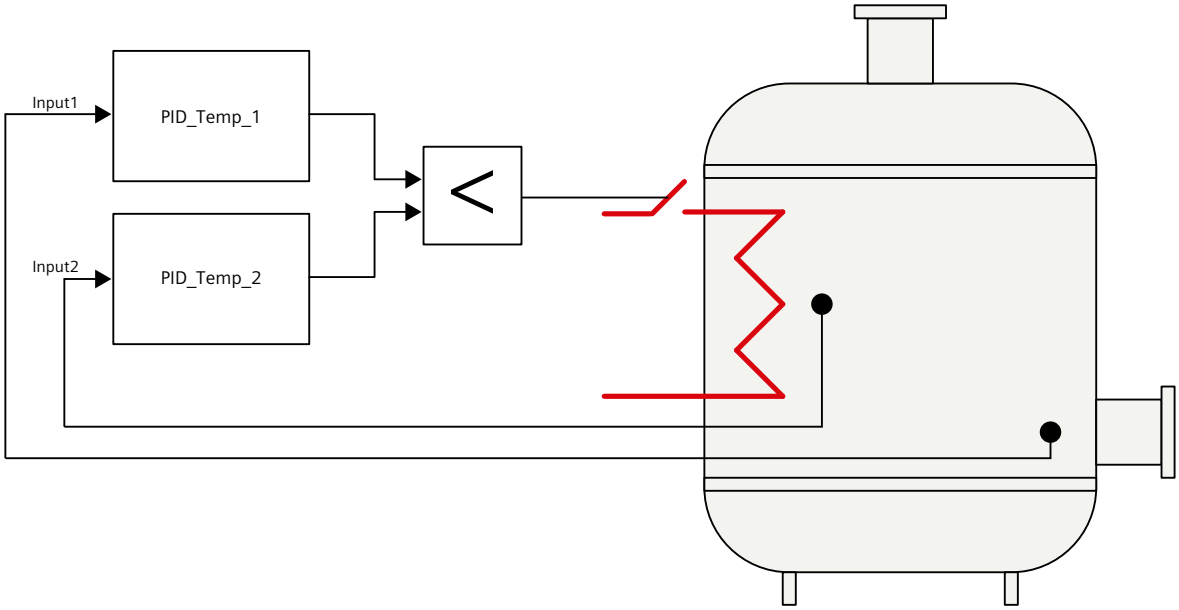

The heater is controlled with the pulse-width modulated output value of PID_Temp (parameter OutputHeat_PWM) by writing the program tag ActuatorInput. The setpoint for the temperature Input1 is specified at the parameter PID_Temp_1.Setpoint. The temperature high limit for the additional measuring point is specified as setpoint at the parameter PID_Temp_2.Setpoint.

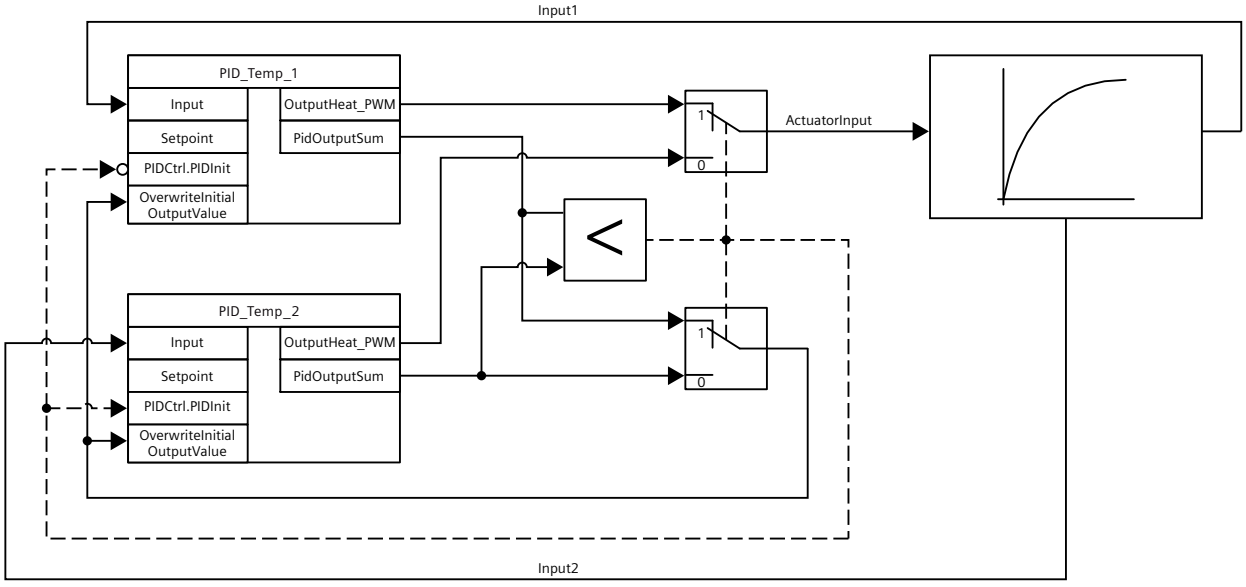

Both controllers must share one heater as shared actuator. The logic that decides which controller gets access to the actuator is implemented by a minimum selection of the PID output value (in Real format, PidOutputSum parameter) in this case. Because the PID output value corresponds to the heating power, the controller that requires lower heating power gets the control.

In normal operation of the plant, the process value of the main controlled variable corresponds to the setpoint. The main controller PID_Temp_1 has settled on a stationary PID output value PID_Temp_1.PidOutputSum. The process value of the limiting controller Input2 in normal operation is significantly below the high limit that is specified as setpoint for PID_Temp_2. The limiting controller therefore wants to increase the heating power to increase its process value, which means it will calculate a PID output value PID_Temp_2.PidOutputSum that is greater than the output value of the main controller PID_Temp_1.PidOutputSum. The minimum selection of the switchover logic therefore gives the main controller PID_Temp_1 continued access to the actuator. In addition, it is ensured that PID_Temp_2 is updated by means of the assignments PID_Temp_2.OverwriteInitialOutputValue = PID_Temp_1.PidOutputSum and PID_Temp_2.PIDCtrl.PIDInit = TRUE.

If Input2 now approaches the high limit or exceeds it, for example due to a fault, the limiting controller PID_Temp_2 calculates a smaller PID output value to restrict the heating power and thus reduce Input2. If PID_Temp_2.PidOutputSum is less than PID_Temp_1.PidOutputSum, the limiting controller PID_Temp_2 receives access to the actuator through the minimum selection and reduces the heating power. It is ensured that PID_Temp_1 is updated by means of the assignments PID_Temp_1.OverwriteInitialOutputValue = PID_Temp_2.PidOutputSum and PID_Temp_1.PIDCtrl.PIDInit = TRUE.

The temperature at the additional measuring point Input2 drops. The temperature of the main controlled variable Input1 drops as well and cannot be held at the setpoint any longer.

Once the fault has been remedied, the Input2 will continue to drop and the heating power is further increased by the limiting controller. As soon as the main controller has calculated a lower heating power as output value, the plant returns to normal operation so that the main controller PID_Temp_1 once again has access to the actuator. This example can be implemented with the following SCL program code:

```
"PID_Temp_1"(Input := "Input1");
"PID_Temp_2"(Input := "Input2");
IF "PID_Temp_1".PidOutputSum <= "PID_Temp_2".PidOutputSum THEN
  "ActuatorInput" := "PID_Temp_1".OutputHeat_PWM;
  "PID_Temp_1".PIDCtrl.PIDInit := FALSE;
  "PID_Temp_2".PIDCtrl.PIDInit := TRUE;
  "PID_Temp_2".OverwriteInitialOutputValue := "PID_Temp_1".PidOutputSum;
ELSE
  "ActuatorInput" := "PID_Temp_2".OutputHeat_PWM;
  "PID_Temp_1".PIDCtrl.PIDInit := TRUE;
  "PID_Temp_2".PIDCtrl.PIDInit := FALSE;
  "PID_Temp_1".OverwriteInitialOutputValue := "PID_Temp_2".PidOutputSum;
END_IF;
```

8.7 Simulating PID_Temp with PLCSIM

NOTE

Simulation with PLCSIM

The simulation of PID_Temp with PLCSIM for CPU S7-1200 is not supported.

PID_Temp can only be simulated for CPU S7-1500 and CPU S7-1200 G2 with PLCSIM.

For the simulation with PLCSIM, the time behavior of the simulated PLC is not exactly identical to that of a "real" PLC. The actual cycle clock of a cyclic interrupt OB can have larger fluctuations with a simulated PLC than with "real" PLCs.

In the standard configuration, PID_Temp determines the time between calls automatically and monitors them for fluctuations.

For the simulation of PID_Temp with PLCSIM, for example, a sampling time error (ErrorBits = DW#16#00000800) can therefore be detected.

This results in ongoing tuning being aborted.

The response in automatic mode depends on the value of the ActivateRecoverMode tag.

To prevent this from happening, you should configure PID_Temp for simulation with PLCSIM as follows:

- CycleTime.EnEstimation = FALSE
- CycleTime.EnMonitoring = FALSE
- CycleTime.Value: Assign the cycle clock of the calling cyclic interrupt OB in seconds to this tag.

Using PID basic functions 9

9.1 CONT_C

9.1.1 Technology object CONT_C

The technology object CONT_C provides a continual PID-controller for automatic and manual mode. It corresponds to the instance data block of the instruction CONT_C. You can configure a pulse controller using the PULSEGEN instruction.

The proportional, integral (INT) and differential components (DIF) are switched parallel to each other and can be turned on and off individually. With this, P-, I, PI-, PD- and PID-controller can be set.

S7-1500
All parameters and tags of the technology object are retentive and can only be changed during download to the device if you completely download CONT_C.

See also

Overview of software controller (Page 41)

Add technology objects (Page 43)

Configure technology objects (Page 44)

Downloading technology objects to device (Page 46)

CONT_C (Page 425)

9.1.2 Configure controller difference CONT_C

Use process value periphery

To use the process value in the periphery format at the PV_PER input parameter, follow these steps:

1. Select the "Enable I/O" check box.
2. If the process value is available as a physical size, enter the factor and offset for the scaling in percent.
   The process value is then determined according to the following formula:
   PV = PV_PER × PV_FAC + PV_OFF

Use internal process values

To use the process value in the floating-point format at the PV_IN input parameter, follow these steps:

1. Clear the "Enable I/O" check box.

Control deviation

Set a dead zone range under the following requirement:

- The process value signal is noisy.
- The controller gain is high.
- The derivative action is activated.

The noise component of the process value causes strong deviations of the output value in this case. The dead zone suppresses the noise component in the steady controller state. The dead zone range specifies the size of the dead zone. With a dead zone range of 0.0, the dead zone is turned off.

See also

How CONT_C works (Page 426)

9.1.3 Configure the controller algorithm CONT_C

General

To determine which components of the control algorithm are activated, proceed as follows:

1. Select an entry from the "Controller structure" list.
   You can only specify required parameters for the selected controller structure.

Proportional action

1. If the controller structure contains a proportional action, enter the "proportional gain".

Integral action

1. If the controller structure contains an integral action, enter the integral action time.
2. To give the integral action an initialization value, select the check box "Initialize integral action" and enter the initialization value.
3. In order to permanently set the integral action to this initialization value, select the "Integral action hold" check box.

Derivative action

1. If the controller structure contains a derivative action, enter the derivative action time, the derivative action weighting and the delay time.

See also

How CONT_C works (Page 426)

9.1.4 Configure the output value CONT_C

General

You can set CONT_C in the manual or automatic mode.

1. To set a manual manipulated value, activate the option "Activate manual mode" option check box.
   You can specify a manual manipulated value on the input parameter MAN.

Manipulated value limits

The manipulated value is limited at the top and bottom so that it can only accept valid values. You cannot turn off the limitation. Exceeding the limits is displayed through the output parameters QLMN_HLM and QLMN_LLM.

1. Enter a value for the high and low manipulated value limits.
   If the manipulated value is a physical size, the units for the high and low manipulated value limits must match.

Scaling

The manipulated value can be scaled for output as a floating point and periphery value through a factor and an offset according to the following formula.

Scaled manipulated value = manipulated value x factor + offset

Default is a factor of 1.0 and an offset of 0.0.

1. Enter a value for the factor and offset.

See also

How CONT_C works (Page 426)

9.1.5 Programming a pulse controller

With the continuous controller CONT_C and the pulse shaper PULSEGEN, you can implement a fixed setpoint controller with a switching output for proportional actuators. The following figure shows the signal flow of the control loop.

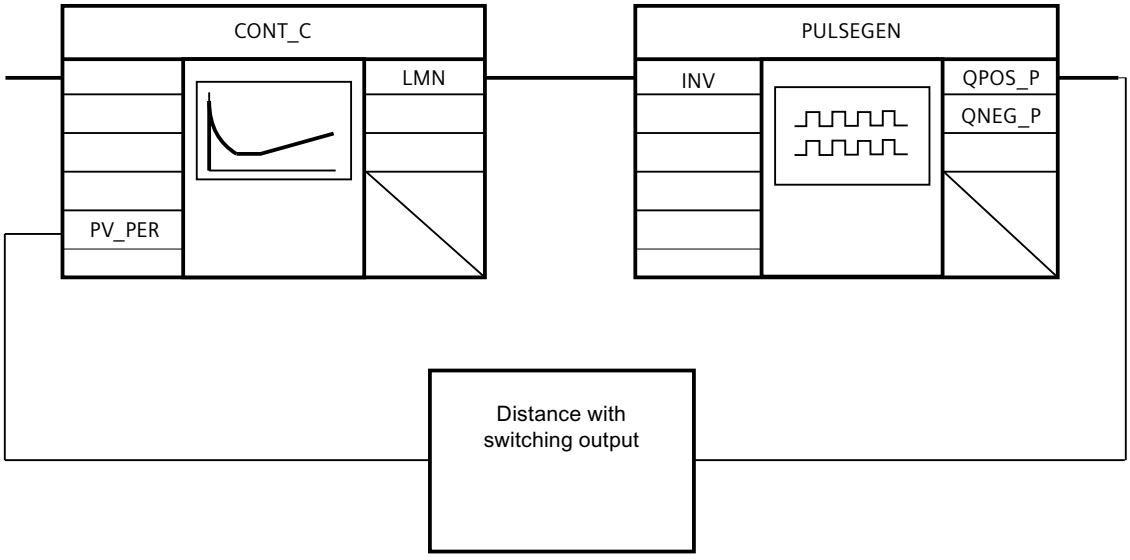

The continuous controller CONT_C forms the output value LMN that is converted by the pulse shaper PULSEGEN into pulse/break signals QPOS_P or QNEG_P.

See also

PULSEGEN (Page 435)

9.1.6 Commissioning CONT_C

Requirements

- The instruction and the technology object have been loaded to the CPU.

Procedure

To manually determine the optimal PID parameters, proceed as follows:

1. Click the "Start" icon.

   If there is no online connection, this will be established. The current values for the setpoint, process value and output value are recorded.
2. Enter new PID parameters in the "P", "I", "D" and "Delay time" fields.
3. Click on the icon "Send parameter to CPU" in the "Tuning" group.
4. Select the "Change setpoint" check box in the "Current values" group.
5. Enter a new setpoint and click the icon in the "Current values" group.

6. Clear the "Manual mode" check box.
   The controller works with the new PID parameters and controls the new setpoint.
7. Check the quality of the PID parameter to check the curve points.
8. Repeat steps 2 to 6 until you are satisfied with the controller results.

9.2 CONT_S

9.2.1 Technology object CONT_S

The technology object CONT_S provides a step controller for actuators with integrating behavior and is used to control technical temperature processes with binary output value output signals. The technology object corresponds to the instance data block of the CONT_S instruction. The operating principle is based on the PI control algorithm of the sampling controller. The step controller operates without a position feedback signal. Both manual and automatic mode are possible.

S7-1500
All parameters and tags of the technology object are retentive and can only be changed during download to the device if you completely download CONT_S.

See also

Overview of software controller (Page 41)
Add technology objects (Page 43)
Configure technology objects (Page 44)
Downloading technology objects to device (Page 46)
CONT_S (Page 430)

9.2.2 Configure controller difference CONT_S

Use process value periphery

To use the process value in the periphery format at the PV_PER input parameter, follow these steps:

1. Select the "Enable I/O" check box.
2. If the process value is available as a physical quantity, enter the factor and offset for the scaling in percent.
   The process value is then determined according to the following formula:
   PV = PV_PER × PV_FAC + PV_OFF

Use internal process values

To use the process value in the floating-point format at the PV_IN input parameter, follow these steps:

1. Clear the "Enable I/O" check box.

Control deviation

Set a deadband range under the following requirement:

- The process value signal is noisy.
- The controller gain is high.
- The derivative action is activated.

The noise component of the process value causes strong deviations of the manipulated variable in this case. The deadband suppresses the noise component in the steady controller state. The deadband range specifies the size of the deadband. With a deadband range of 0.0, the deadband is turned off.

See also

Mode of operation CONT_S (Page 431)

9.2.3 Configuring control algorithm CONT_S

PID algorithm

1. Enter the "proportional amplification" for the P-component.
2. Enter the integration time for the time behavior of the I-component.
   With an integration time of 0.0, the I-component is switched off.

See also

Mode of operation CONT_S (Page 431)

9.2.4 Configure manipulated value CONT_S

General

You can set CONT_S in the manual or automatic mode.

1. To set a manual manipulated value, activate the "Activate manual mode" option check box.
   Enter a manual manipulated value for the input parameters LMNUP and LMNDN.

Pulse generator

1. Enter the minimum impulse duration and minimum pause duration.
   The values must be greater than or equal to the cycle time for the input parameter CYCLE.
   The frequency of operation is reduced through this.
2. Enter the motor setting time.
   The value must be greater than or equal to the cycle time of the input parameter CYCLE.

See also

Mode of operation CONT_S (Page 431)

9.2.5 Commissioning CONT_S

Requirements

- The instruction and the technology object have been loaded to the CPU.

Procedure

To manually determine the optimal PID parameters, proceed as follows:

1. Click the "Start" icon.

   If there is no online connection, this will be established. The current values for the setpoint, process value and output value are recorded.
2. In the fields "P" and "I", enter a new proportional value and a new integration time.
3. Click on the icon "Send parameter to CPU" in the "Tuning" group.
4. Select the "Change setpoint" check box in the "Current values" group.
5. Enter a new setpoint and click the icon in the "Current values" group.
6. Clear the "Manual mode" check box.

   The controller works with the new parameters and controls the new setpoint.
7. Check the quality of the PID parameter to check the curve points.
8. Repeat steps 2 to 6 until you are satisfied with the controller results.

9.3 TCONT_CP

9.3.1 Technology object TCONT_CP

The technology object TCONT_CP provides a continual temperature controller with pulse generator. It corresponds to the instance data block of the instruction TCONT_CP. The operation is based on the PID control algorithm of the sampling controller. Both manual and automatic mode are possible.

The instruction TCONT_CP calculates the proportional, integral and derivative parameters for your controlled system during pretuning. "Fine tuning" can be used to tune the parameters further. You can also enter the PID parameters manually.

S7-1500
All parameters and tags of the technology object are retentive and can only be changed during download to the device if you completely download TCONT_CP.

See also

Overview of software controller (Page 41)
Add technology objects (Page 43)
Configure technology objects (Page 44)
Downloading technology objects to device (Page 46)
TCONT_CP (Page 443)

9.3.2 Configure TCONT_CP

9.3.2.1 Controller difference

Use process value periphery

To use the input parameter PV_PER, proceed as follows:

1. Select the entry "Periphery" from the "Source" list.
2. Select the "sensor type".
   Depending on the sensor type, the process value is scaled according to different formulas.
   - Standard
     Thermoelements; PT100/NI100

     PV = 0.1 × PV_PER × PV_FAC + PV_OFFS
   - Cooling;
     PT100/NI100

     PV = 0.01 × PV_PER × PV_FAC + PV_OFFS
   - Current/voltage

     PV = 100/27648 × PV_PER × PV_FAC + PV_OFFS
3. Enter the factor and offset for the scaling of the process value periphery.

Use internal process values

To use the input parameter PV_IN, proceed as follows:

1. Select the entry "Internal" from the "Source" list.

Control deviation

Set a deadband range under the following requirement:

- The process value signal is noisy.
- The controller gain is high.
- The derivative action is activated.

The noise component of the process value causes strong deviations of the manipulated variable in this case. The deadband suppresses the noise component in the steady controller state. The deadband range specifies the size of the deadband. With a deadband range of 0.0, the deadband is turned off.

See also

Mode of operation TCONT_CP (Page 444)

9.3.2.2 Controlling algorithm

General

1. Enter the "Sampling time PID algorithm".
   A controller sampling time should not exceed 10 % of the determined integratl action time of the controller (TI).
2. If the controller structure contains a proportional action, enter the "proportional gain".
   A negative proportional gain inverts the rule meaning.

Proportional action

For changes of the setpoint, it may lead to overshooting of the proportional action. Through the weighting of the proportional action, you can select how strongly the proportional action should react when setpoint changes are made. The weakening of the proportional action is reached through a compensation of the integral action.

1. To weaken the proportional action for setpoint changes, enter a "Proportional action weighting".
   - 1.0: Proportional action for setpoint change is fully effective
   - 0.0: Proportional action for setpoint change is not effective

Integral action

With a limitation of the manipulated value, the integral action is stopped. With a control deviation that moves the integral action in the direction of an internal setting range, the integral action is released again.

1. If the controller structure contains an integral action, enter the "integral action time". With an integral action time of 0.0, the integral action is switched off.
2. To give the integral action an initialization value, select the "Initialize integral action" check box and enter the "Initialization value".
   Upon restart or COM_RST = TRUE, the integral action is set to this value.

Derivative action

1. If the controller structure contains a derivative action, enter the derivative action time (TD) and the coefficients DT1 (D_F).
   With switched derivative action, the following equation should be maintained:
   TD = 0.5 × CYCLE× D_F.
   The delay time is calculated from this according to the formula:
   delay time = TD/D_F

Set PD-controller with operating point

1. Enter the integral action time 0.0.
2. Activate the "Initialize integral action" check box.
3. Enter the operating point as the initialization value.

Set P-controller with operating point

1. Set a PD-controller with an operating point.
2. Enter the derivative action time 0.0.
   The derivative action is disabled.

Control zone

The control zone limits the value range of the control deviation. If the control deviation is outside of this value range, the manipulated value limits are used.

With an occurrence in the control zone, the derivative action leads to a very quick reduction of the manipulated variable. Thus, the control zone only makes sense for switched on derivative actions. Without control zone, only the reducing proportional action would reduce the manipulated value. The control zone leads to a quick oscillation without over/under shooting if the emitted minimum or maximum manipulated values are removed from the manipulated value required for the new operating point.

1. Activate the "Activate" check box in the "control zone" group.
2. Enter a setpoint value in the "Width" input field from which the process value may deviate above or below.

See also

Mode of operation TCONT_CP (Page 444)

9.3.2.3 Manipulated value continual controller

Manipulated value limits

The manipulated value is limited at the top and bottom so that it can only accept valid values. You cannot turn off the limitation. Exceeding the limits is displayed through the output parameters QLMN_HLM and QLMN_LLM.

1. Enter a value for the high and low manipulated value limits.

Scaling

The manipulated value can be scaled for output as a floating point and periphery value through a factor and an offset according to the following formula.

Scaled manipulated value = manipulated value x factor + offset

Default is a factor of 1.0 and an offset of 0.0.

1. Enter a value for the factor and offset.

Pulse generator

The pulse generator must be turned on for a continual controller.

1. Disable the "Activate" option check box in the "Pulse generator" group.

See also

Mode of operation TCONT_CP (Page 444)

9.3.2.4 Manipulated value pulse controller

Pulse generator

The analog manipulated value (LmnN) can be emitted through pulse-duration modulation on the output parameter QPULSE as an impulse sequence.

To use the pulse generator, proceed as follows:

1. Activate the "Activate" option check box in the "pulse generator" group.
2. Enter the "sampling time pulse generator", the "minimum impulse/break duration" and the "period duration".

The following graphics clarify the connection between the "sampling pulse generator" (CYCLE_P), the "minimum impulse/break duration" (P_B_TM) and the "period duration" (PER_TM):

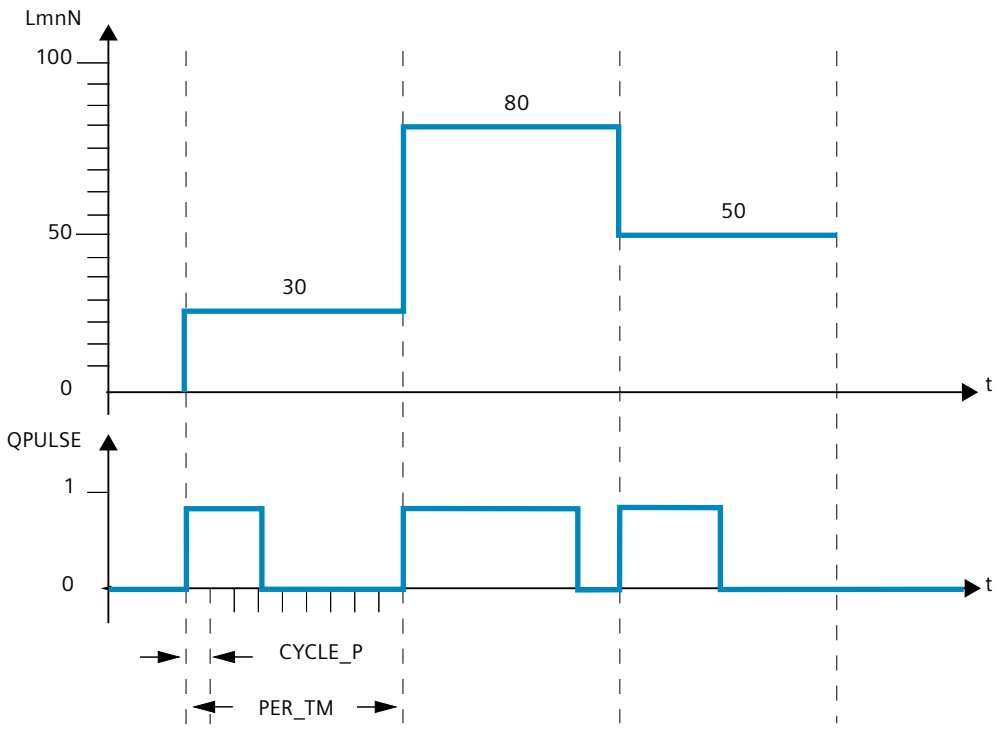

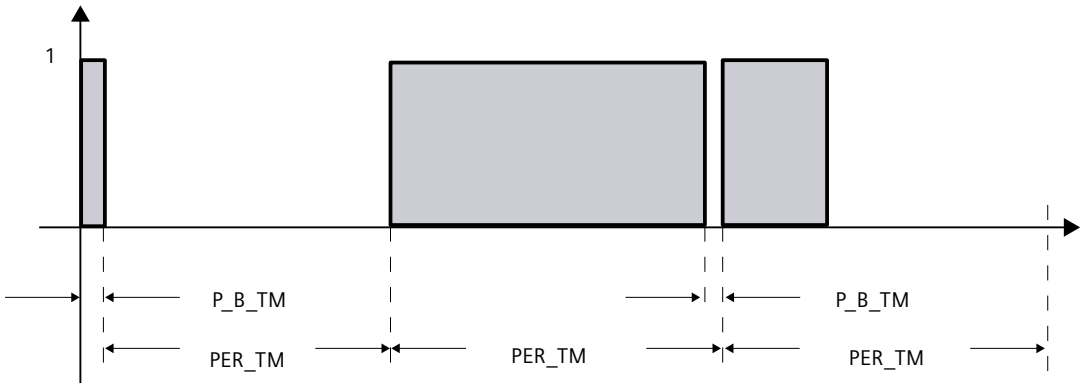

Sampling time pulse generator

The sampling time pulse generator must agree with the time tact of the cyclic interrupt OB being called. The duration of the created impulse is always a whole number factor of this value. For an adequately precise manipulated value resolution, the following relationship should apply:
CYCLE_P ≤ PER_TM/50

Minimum impulse/break duration

Through the minimum impulse/break duration, short on or off times on the actuator are avoided. An impulse smaller than P_B_TM is suppressed.

Recommended are values P_B_TM ≤ 0.1 × PER_TM.

Period duration

The period duration should not exceed 20% of the determined integration time of the controller (TI):
PER_TM ≤ TI/5

Example for the effect of the parameter CYCLE_P, CYCLE and PER_TM:

Period duration PER_TM = 10 s

Sampling time PID-algorithm CYCLE = 1 s

Sampling time pulse generator CYCLE_P = 100 ms.

Every second, a new manipulated value, every 100 ms the comparison of the manipulated value occurs with the previously emitted impulse length and break length.

- If an impulse is emitted, there are 2 possibilities:
  - The calculated manipulated value is larger than the previous impulse length/PER_TM. Then the impulse is extended.
  - The calculated manipulated value is less than or equal to the previous impulse length/PER_TM. Then no impulse signal will be emitted.
- If no impulse is emitted, there are also 2 possibilities:
  - The value (100 % - calculated manipulated value) is greater than the previous break length / PER_TM. Then the break is extended.
  - The value (100 % - calculated manipulated value) is less than or equal to the previous break length / PER_TM. Then an impulse signal will be emitted.

See also

Mode of operation TCONT_CP (Page 444)

Operating principle of the pulse generator (Page 453)

9.3.3 Commissioning TCONT_CP

9.3.3.1 Optimization of TCONT_CP

Application possibilities

The controller optimization for heating or cooling processes from process type I is applicable. But you can use the block for processes with higher levels like process type II or III.

The PI/PID parameters are automatically determined and set. The controller draft is designed for an optimal disruption behavior The "precise" parameters resulting from this lead to overshooting of 10% to 40% of the jump height for setpoint jump heights.

Phases of controller optimization

For the controller optimization, individual phases are run through, which you can read on the parameter PHASE .

PHASE = 0

No tuning is running. TCONT_CP works in automatic or manual mode.

During PHASE = 0, you can make sure that the controlled system fulfills the requirements for an optimization.

At the end of the optimization, TCONT_CP changes back into PHASE = 0.

PHASE = 1

TCONT_CP is prepared for optimization. PHASE = 1 may only be started if the requirements for an optimization are fulfilled.

During PHASE = 1, the following values are determined:

- Process value noise NOISE_PV
- Initial slope PVDT0
- Average of the manipulated variable
- Sampling time PID algorithm CYCLE
- Sampling time pulse generator CYCLE_P

PHASE = 2

In phase 2, the process value attempts to detect the point of inflection with a constant manipulated variable. This method prevents the point of inflection from being found too early as a result of process variable noise.

With the pulse controller, the process variable is averaged over N pulse cycles and then made available to the controller stage. There is a further averaging of the process variable in the controller stage: Initially, this averaging is inactive; in other words, averaging always takes place over 1 cycle. As long as the noise exceeds a certain level, the number of cycles is doubled.

The period and amplitude of the noise are calculated. The search for the point of inflection is canceled and phase 2 is exited only when the gradient is always smaller than the maximum rise during the estimated period. TU and T_P_INF are, however, calculated at the actual point of inflection.

Tuning, however, is only ended when the following two conditions are met:

1. The process value is more than 2*NOISE_PV away from the point of inflection.
2. The process value has exceeded the point of inflection by 20%.

NOTE

When exciting the process using a setpoint step change, tuning is ended at the latest when the process value exceeds 75% of the setpoint step change (SP_INT-PV0) (see below).

PHASE = 3, 4, 5

The phases 3, 4 and 5 last 1 cycle each.

In Phase 3, the valid PI/PID parameters are saved before the optimization and the process parameter is calculated.

In Phase 4, the new PI/PID parameters are calculated.

In Phase 5, the new manipulated variable is calculated and the controlled system is given.

PHASE = 7

The process type is inspected in Phase 7, because TCONT_CP always changes to automatic mode after optimization. The automatic mode starts with LMN = LMN0 + 0.75*TUN_DLMN as a manipulated variable. The testing of the process type occurs **in the automatic mode** with the recently recalculated controller parameters and ends at the latest 0.35*TA (equilibrium time) after the point of inflection. If the process order deviates strongly from the estimated value, the controller parameters are newly calculated and STATUS_D is counted up by 1, otherwise, the controller parameters remain unchanged.

Then the optimization mode is complete and TCONT_CP is back in PHASE = 0. At the STATUS_H parameter, you can identify whether the tuning was successfully completed.

Premature cancellation of the optimization

In Phase 1, 2 or 3, you can cancel the optimization by resetting TUN_ON = FALSE without calculating new parameters. The controller starts in the automatic mode with LMN = LMN0 + TUN_DLMN. If the controller was in manual mode before the tuning, the old manual manipulated variable is output.

If the tuning is canceled in Phase 4, 5 or 7 with TUN_ON = FALSE, the determined controlled parameters are contained until then.

9.3.3.2 Requirements for an optimization

Transient response

The process must have a stable, asymptotic transient response with time lag.

The process value must settle to steady state after a step change of the manipulated variable. This therefore excludes processes that already show an oscillating response without control, as well as processes with no recovery (integrator in the control system).

⚠ WARNING

This may result in death, severe injury or considerable property damage.

During an tuning, the parameter MAN_ON is ineffective. Through this, the output value or process value may take on undesired - even extreme - values.

The output value is defined through the tuning. To cancel the tuning, you first have to set TUN_ON = FALSE. This makes MAN_ON effective again.

Guaranteeing a stationary initial state (phase 0)

With lower-frequency oscillations of the process value, for example, due to incorrect controller parameters, the controller must be put in manual mode before the tuning is started and wait for the oscillation to stop. Alternatively, you could switch to a "soft" set PI controller (small loop gain large integration time).

Now you have to wait until the stationary state is reached, this means, until the process value and output value have a steady state. It is also permissible to have an asymptotic transient oscillation or slow drifting of the process value (stationary state, see the following image). The output value must be constant or fluctuate by a constant average.

NOTE

Avoid changing the manipulated variable shortly before starting the tuning. A change of the manipulated variable can occur in an unintended manner through the establishment of the test conditions (for example, closing an oven door)! If this does happen, you have to at least wait until the process value has an asymptotic transient oscillation in a stationary state again. Better controller parameters can be reached if you wait until the transient effect has completely subsided.

In the following image, the transient oscillation is illustrated in the stationary state:

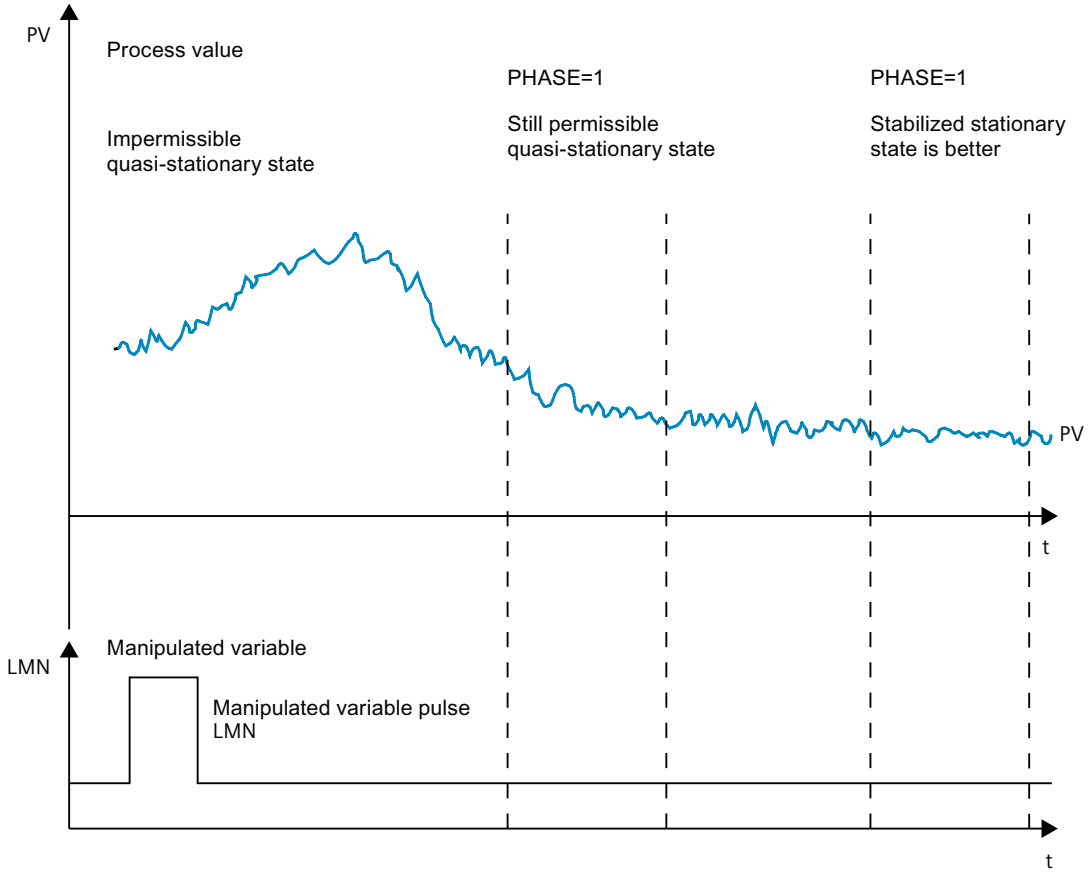

Linearity and operating range

The process response must be linear across the operating range. Non-linear response occurs, for example, when an aggregation state changes. Tuning must take place in a linear part of the operating range.

This means, during tuning and normal control operation non-linear effects within the operating range must be insignificant. It is, however possible to retune the process when the operating point changes, providing tuning is repeated in the close vicinity of the new operating point and non-linearity does not occur during tuning.

If a specific static non-linearity (e.g., valve characteristics) is known, it is always advisable to compensate this with a polyline to linearize the process response.

Disturbance in temperature processes

Disturbances such as thermal transfer to neighboring zones must not influence the overall temperature process to any great extent. For example, when zones of an extruder are tuned, all zones must be heated up simultaneously.

9.3.3.3 Possibilities for optimization

The following possibilities for tuning exist:

- Pretuning
- Fine tuning
- Manual fine-tuning in control mode

Pretuning

During this tuning, the working point is approached from the cold state through a setpoint jump.

With TUN_ON = TRUE, you can establish the tuning readiness. The controller switches from PHASE = 0 to PHASE = 1.

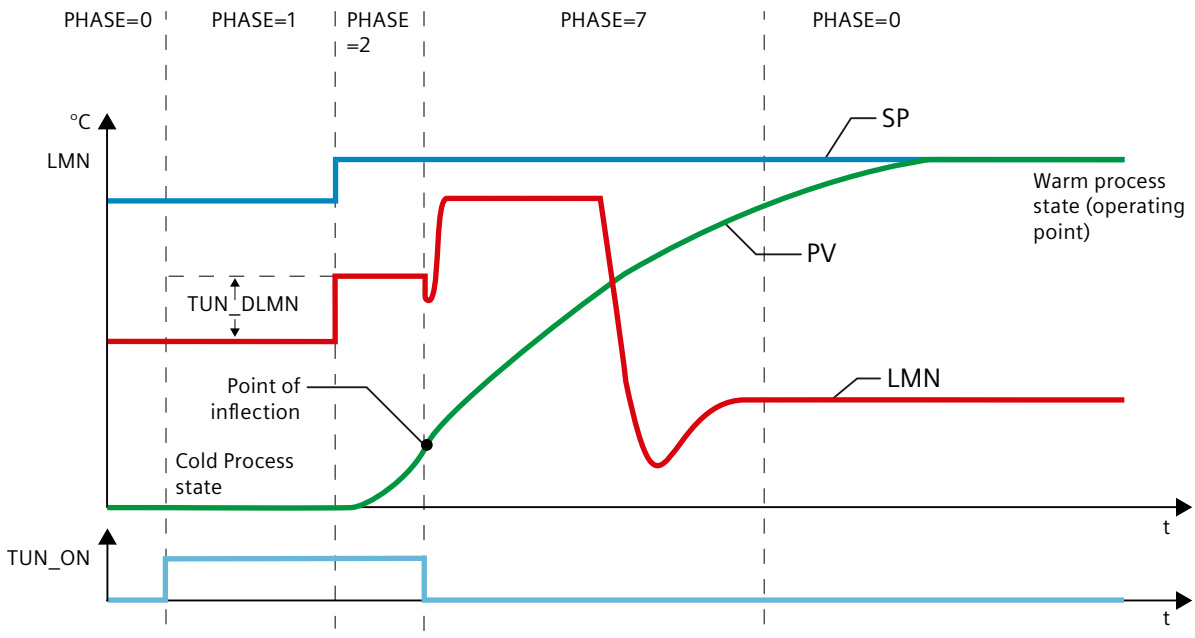

The tuning manipulated variable (LMN0 + TUN_DLMN) is activated by a setpoint change (transition phase 1 -> 2). The setpoint is not effective until the inflection point has been reached (automatic mode is not enabled until this point is reached).

The user is responsible for defining the output excitation delta (TUN_DLMN) according to the permitted process value change. The sign of TUN_DLMN must be set depending on the intended process value change (take into account the direction in which the control is operating).

The setpoint step change and TUN_DLMN must be suitably matched. If the value of TUN_DLMN is too high, there is a risk that the point of inflection will not be found before 75% of the setpoint step change is reached.

TUN_DLMN must nonetheless be high enough to ensure that the process value reaches at least 22 % of the setpoint step change. Otherwise, the process will remain in tuning mode (phase 2).

Remedy: Reduce the setpoint value during the inflection point search.

NOTE

If processes are extremely sluggish, it is advisable during tuning to specify a target setpoint that is somewhat lower than the desired operating point and to monitor the status bits and PV closely (risk of overshooting).

Tuning only in the linear range:

The signals of certain processes (e.g., zinc or magnesium smelters) will pass a non-linear area at the approach of the operating range (change in the state of aggregation).

By selecting a suitable setpoint step change, tuning can be limited to the linear range. When the process value has passed 75% of the setpoint step change (SP_INT-PV0), tuning is ended.

At the same time, TUN_DLMN should be reduced to the extent that the point of inflection is guaranteed to be found before 75% of the setpoint step change is reached.

Fine tuning

During this tuning, the process with a constant setpoint is activated through a output value jump.

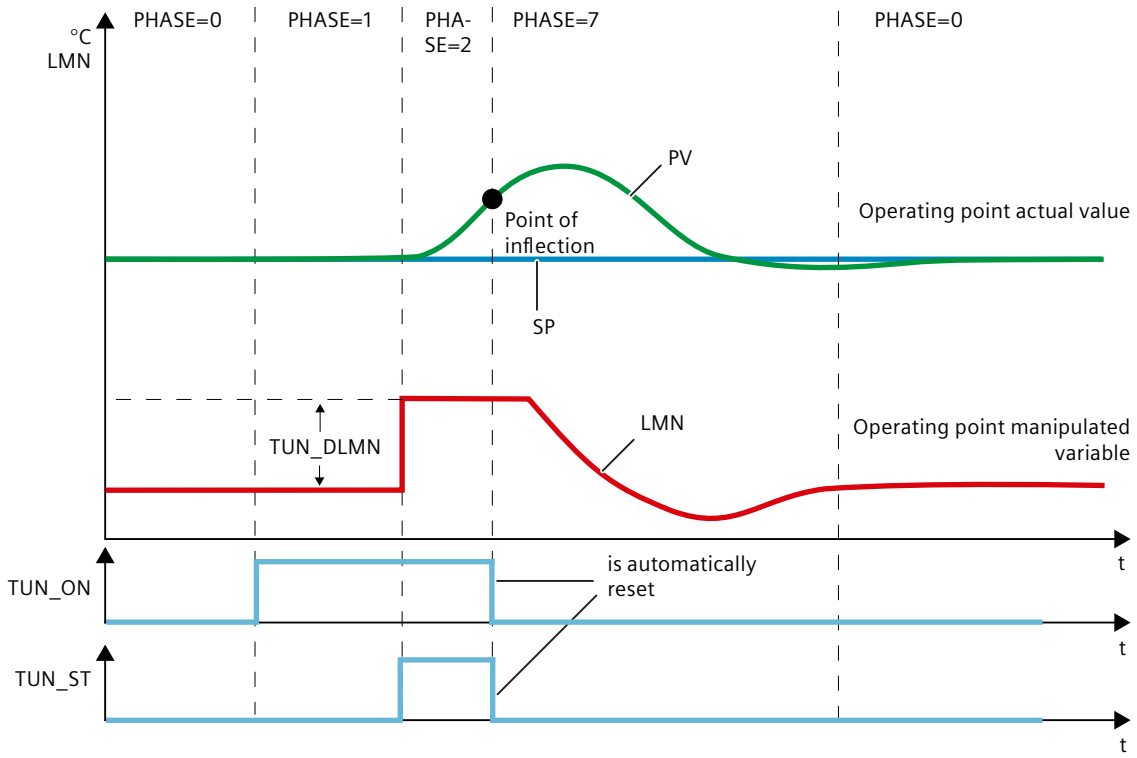

The tuning manipulated variable (LMN0 + TUN_DLMN) is activated by setting the start bit TUN_ST (transition from phase 1 -> 2). When you modify the setpoint value, the new value will not take effect until the point of inflection has been reached (automatic mode will not be enabled until this point has been reached).

The user is responsible for defining the output excitation delta (TUN_DLMN) according to the permitted process value change. The sign of TUN_DLMN must be set depending on the intended process value change (take into account the direction in which the control is operating).

NOTICE
Safety off at 75% is not available when you excite the process via TUN_ST. Tuning is ended when the point of inflection is reached. However, in noisy processes the point of inflection may be significantly exceeded.

Manual fine-tuning in control mode

The following measures can be employed to achieve an overshoot-free setpoint response:

- Adapting the control zone
- Optimize command action
- Attenuation of control parameters
- Modifying control parameters

9.3.3.4 Tuning result

The left digit of STATUS_H displays the tuning status

STATUS_H	Result
0	Default or new controller parameters have not yet been found.
10000	Suitable control parameters found.
2xxxx	Control parameters have been found via estimated values; check the control response or check the STATUS_H diagnostic message and repeat controller tuning.
3xxxx	An operator error has occurred; check the STATUS_H diagnostic message and repeat controller tuning.

The CYCLE and CYCLE_P sampling times were already checked in phase 1.

The following controller parameters are updated on TCONT_CP:

- P (proportional GAIN)
- I (integration time TI)
- D (derivative time TD)
- Weighting of the proportional action PFAC_SP
- Coefficient DT1 (D_F)
- Control zone on/off CONZ_ON
- Control zone width CON_ZONE

The control zone is only activated if the process type is suitable (process type I and II) and a PID controller is used (CONZ_ON = TRUE).

Depending on PID_ON, control is implemented either with a PI or a PID controller. The old controller parameters are saved and can be retrieved with UNDO_PAR. A PI parameter record and a PID parameter record are saved additionally in the PI_CON and PID_CON structures. Using LOAD_PID and making a suitable setting for PID_ON, it is also possible to switch later between the tuned PI or PID parameters.

9.3.3.5 Parallel tuning of controller channels

Adjacent zones (strong heat coupling)

If two or more controllers are controlling the temperature, on a plate, for example (in other words, there are two heaters and two measured process values with strong heat coupling), proceed as follows:

1. OR the two outputs QTUN_RUN.
2. Interconnect each TUN_KEEP input with the output of the OR element.
3. Start both controllers by specifying a setpoint step change at the same time or by setting TUN_ST at the same time.

The following schematic illustrates the parallel tuning of controller channels.

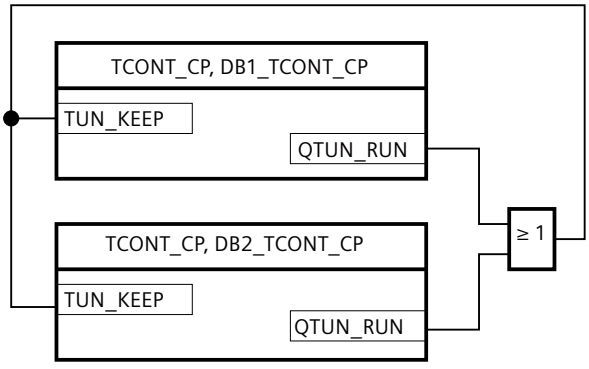

Advantage:

Both controllers output LMN0 + TUN_DLMN until both controllers have left phase 2. This prevents the controller that completes tuning first from falsifying the tuning result of the other controller due to the change in its manipulated variable.

NOTICE
Reaching 75% of the setpoint step change causes an exiting of phase 2 and resetting of output QTUN_RUN. However, automatic mode does not start until TUN_KEEP is also 0.

Adjacent zones (weak heat coupling)

In general terms, tuning should be carried out to reflect the way in which the controller will operate subsequently. If zones are operated together during production such that the temperature differences between the zones remain the same, the temperature of the adjacent zones ought to be increased accordingly during tuning.

Differences in temperature at the beginning of the tuning are irrelevant since they will be compensated by the initial heating (-> initial rise = 0).

9.3.3.6 Fault descriptions and corrective measures

Compensating operator errors

Operator error	STATUS and action	Comment
TUN_ON and setpoint step change or TUN_ST are set simultaneously	Transition to phase 1; however, tuning is not started. • SP_INT = SP_{old} or • TUN_ST = FALSE	The setpoint change is canceled. This prevents the controller from settling to the new setpoint value and from leaving the stationary operating point unnecessarily.
Effective TUN_DLMN < 5% (end of phase 1)	STATUS_H = 30002 • Transition to phase 0 • TUN_ON = FALSE • SP = SP_{old}	Tuning is canceled. The setpoint change is canceled. This prevents the controller from settling to the new setpoint value and from leaving the stationary operating point unnecessarily.

Point of inflection not reached (only if excited by setpoint step change)

At the latest, tuning is ended when the process value has passed 75% of the setpoint step change (SP_INT-PV0). This is signaled by "inflection point not reached" in STATUS_H (2xx2x).

The currently valid setpoint always applies. By reducing the setpoint, it is possible to achieve an earlier end of the tuning function.

In typical temperature processes, cancelation of tuning at 75% of the setpoint step change is normally adequate to prevent overshoot. However, **caution** is advised, particularly in processes with a greater delay (TU/TA > 0.1, process type III). If manipulated variable excitation is too strong compared to the setpoint step change, the process value can overshoot heavily (up to a factor of 3).

In higher-order processes, if the point of inflection is still a long way off after reaching 75% of the setpoint step change, there will be significant overshoot. In addition, the controller parameters are too stringent. In this case, you should reduce the controller parameters or repeat the attempt.

The following schematic illustrates the overshoot of the process variable when the excitation is too strong (process type III):

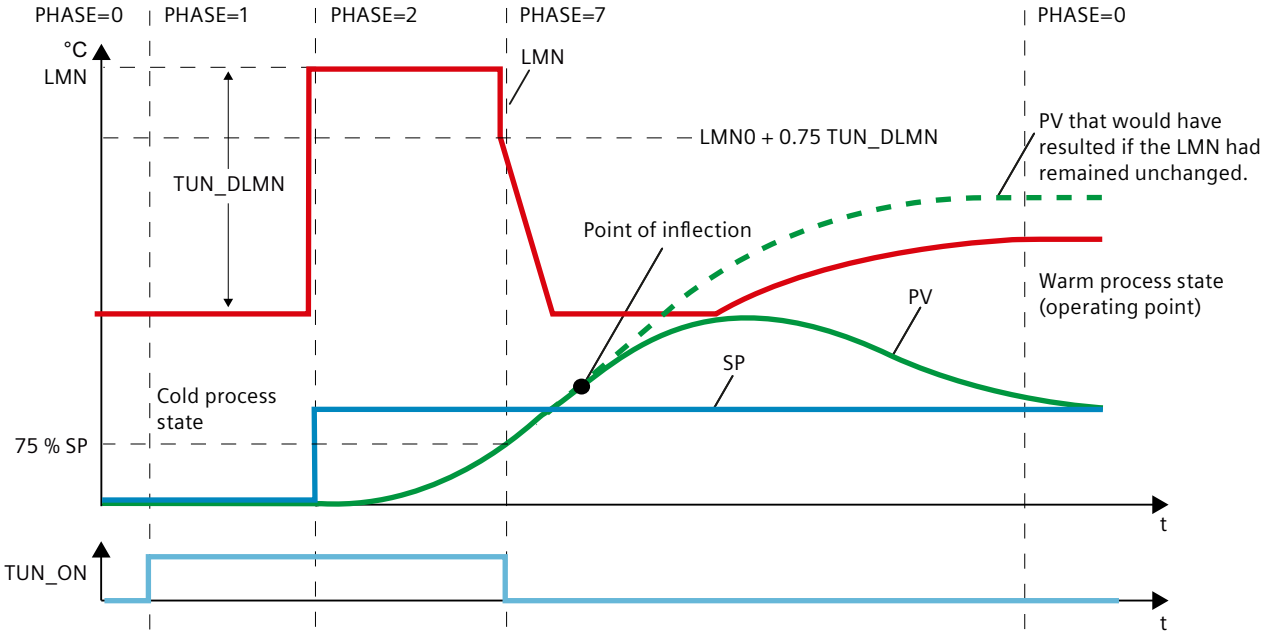

In typical temperature processes, cancelation shortly before reaching the point of inflection is not critical in terms of the controller parameters.

If you repeat the attempt, reduce TUN_DLMN or increase the setpoint step change.

Principle: The value of the manipulated variable used for tuning must be suitable for the setpoint step change.

Error estimating the delay time or order

The delay time (STATUS_H = 2x1xx or 2x3xx) or order (STATUS_H = 21xxx or 22xxx) were not acquired correctly. Operation continues with an estimate that can lead to non-optimum controller parameters.

Repeat the tuning procedure and ensure that disturbances do not occur at the process value.

NOTE

The special case of a PT1-only process is also indicated by STATUS_H = 2x1xx (TU <= 3*CYCLE). In this case, it is not necessary to repeat the attempt. Reduce the controller parameters if the control oscillates.

Quality of measuring signals (measurement noise, low-frequency interference)

The results of tuning can be distorted by measurement noise or by low-frequency interference. Note the following:

- If you encounter measurement noise, set the sampling frequency higher rather than lower. During one noise period, the process value should be sampled at least twice. In pulse mode, integrated mean value filtering can be helpful. This assumes, however, that the process variable PV is transferred to the instruction in the fast pulse cycle. The degree of noise should not exceed 5% of the useful signal change.
- High-frequency interference cannot be filtered out by TCONT_CP. This should be filtered earlier in the measuring sensor to prevent the aliasing effect.

  The following schematic illustrates the aliasing effect when the sampling time is too long:

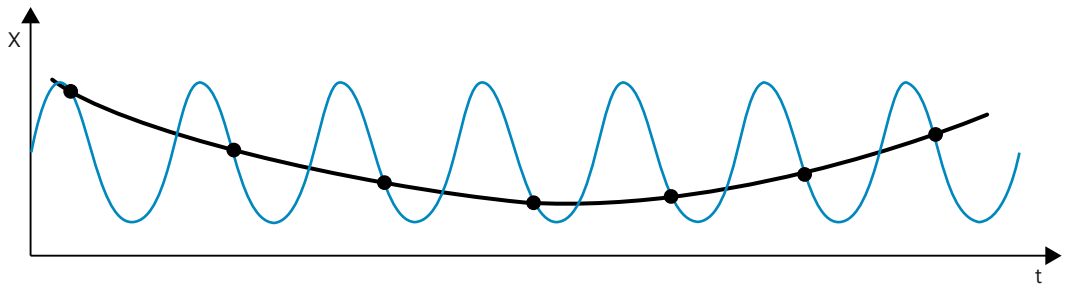

- With low-frequency interference, it is relatively easy to ensure an adequately high sampling rate. However, the TCONT_CP must then generate a uniform measuring signal by having a large interval in the mean value filtering. Mean value filtering must extend over at least two noise periods. Internally in the block, this soon results in higher sampling times such that the accuracy of the tuning is adversely affected. Adequate accuracy is guaranteed with at least 40 noise periods up to the point of inflection.

  Possible remedy when repeating the attempt:

  Increase TUN_DLMN.

Overshoot

Overshoot can occur in the following situations:

Situation	Cause	Remedy
End of tuning	• Excitation by a too high manipulated value change compared with the set-point step change (see above). • PI controller activated by PID_ON = FALSE.	• Increase the setpoint step change or reduce the manipulated value step change. • If the process permits a PID controller, start tuning with PID_ON = TRUE.
Tuning in phase 7	Initially, less aggressive controller parameters were determined (process type III); these can lead to an overshoot in phase 7.	-
Control mode	PI controller with PFAC_SP = 1.0 for process type I.	If the process permits a PID controller, start tuning with PID_ON = TRUE.

9.3.3.7 Performing pretuning

Requirements

- The instruction and the technology object have been loaded to the CPU.

Procedure

To manually determine the optimum PID parameters for initial commissioning, follow these steps:

1. Click the "Start" icon.

   If there is no online connection, this will be established. The current values for the setpoint, process value and output value are recorded.
2. Select "Pretuning" from the "Mode" drop-down list.

   TCONT_CP is ready for tuning.
3. In the "Output value jump" field, specify how much the output value should be increased.
4. Enter a setpoint in the "Setpoint" field. The output value jump only takes effect when another setpoint is entered.
5. Click the "Start tuning" icon.

   The pretuning starts. The status of the tuning is displayed.

9.3.3.8 Performing fine tuning

Requirements

- The instruction and the technology object have been loaded to the CPU.

Procedure

To determine the optimal PID parameters at the operating point, follow these steps:

1. Click the "Start" icon.

   If there is no online connection, this will be established. The current values for the setpoint, process value and output value are recorded.
2. Select "Fine tuning" from the "Mode" drop-down list.

   TCONT_CP is ready for tuning.
3. In the "Output value jump" field, specify how much the output value should be increased.
4. Click the "Start tuning" icon.

   Fine tuning starts. The status of the tuning is displayed.

9.3.3.9 Cancelling pretuning or fine tuning

To cancel pretuning or fine tuning, click on the ■ icon, "Stop tuning".

If the PID parameters have not yet been calculated and stored, TCONT_CP starts in automatic mode LMN = LMN0 + TUN_DLMN. If the controller was in manual mode before the tuning, the old manual manipulated variable is output.

If the calculated PID parameters have already been saved, TCONT_CP starts in automatic mode and works with the previously determined PID parameters.

9.3.3.10 Manual fine-tuning in control mode

The following measures can be employed to achieve an overshoot-free setpoint response:

Adapting the control zone

During tuning, "TCONT_CP" determines a control zone CON_ZONE and activated if the process type is suitable (process type I and II) and a PID controller is used (CONZ_ON = TRUE). In control mode, you can modify the control zone or switch it off completely (with CONZ_ON = FALSE).

NOTE

Activating the control zone with higher-order processes (process type III) does not normally provide any benefit since the control zone is then larger than the control range that can be achieved with a 100% manipulated variable. There is also no advantage in activating the control zone for PI controllers.

Before you switch on the control zone manually, make sure that the control zone is not too narrow. If the control zone is set too narrow, oscillations occur in the manipulated variable and the process value.

Continuous attenuation of the control response with PFAC_SP

The control response can be attenuated with the PFAC_SP parameter. This parameter specifies the percentage of proportional component that is effective for setpoint step changes.

Regardless of the process type, PFAC_SP is set to a default value of 0.8 by the tuning function; you can later modify this value if required. To limit overshoot during setpoint step changes (with otherwise correct controller parameters) to approximately 2%, the following values are adequate for PFAC_SP:

	Process type I	**Process type II**	**Process type III**
	Typical temperature process	Intermediate range	Higher-order temperature process
PI	0.8	0.82	0.8
PID	0.6	0.75	0.96

Adjust the default factor (0.8) in the following situations, in particular:

- Process type I with PID (0.8 →0.6): Setpoint step changes within the control zone still lead to approximately 18% overshoot with PFAC_SP = 0.8.
- Process type III with PID (0.8 →0.96): Setpoint step changes with PFAC_SP = 0.8 are attenuated too strongly. This leads to a significantly slower response time.

Attenuation of control parameters

When a closed-loop control circuit oscillates or if overshoot occurs after setpoint step changes, you can reduce the controller GAIN (e.g., to 80% of the original value) and increase integral time TI (e.g., to 150% of the original value). If the analog output value of the continuous controller is converted to binary actuating signals by a pulse shaper, quantization noise may cause minor permanent oscillation. You can eliminate this by increasing the controller deadband DEADB_W.

Modifying control parameters

Proceed as follows to modify control parameters:

1. Save the current parameters with SAVE_PAR.
2. Modify the parameters.
3. Test the control response.

If the new parameter settings are worse than the old ones, retrieve the old parameters with UNDO_PAR.

9.3.3.11 Performing fine tuning manually

Requirements

- The instruction and the technology object have been loaded to the CPU.

Procedure

To manually determine the optimal PID parameters, proceed as follows:

1. Click the "Start" icon.

   If there is no online connection, this will be established. The current values for the setpoint, process value and output value are recorded.
2. Select "Manual" from the "Mode" drop-down list.
3. Enter the new PID parameters.
4. Click on the icon "Send parameter to CPU" in the "Tuning" group.
5. Select the "Change setpoint" check box in the "Current values" group.
6. Enter a new setpoint and click the icon in the "Current values" group.

7. Clear the "Manual mode" check box.
   The controller works with the new PID parameters and controls the new setpoint.
8. Check the quality of the PID parameter to check the curve points.
9. Repeat steps 3 to 8 until you are satisfied with the controller results.

9.4 TCONT_S

9.4.1 Technology object TCONT_S

The technology object TCONT_S provides a step controller for actuators with integrating behavior and is used to control technical temperature processes with binary output value output signals. The technology object corresponds to the instance data block of the TCONT_S instruction. The operating principle is based on the PI control algorithm of the sampling controller. The step controller operates without a position feedback signal. Both manual and automatic mode are possible.

S7-1500
All parameters and tags of the technology object are retentive and can only be changed during download to the device if you completely download TCONT_S.

See also

Overview of software controller (Page 41)
Add technology objects (Page 43)
Configure technology objects (Page 44)
Downloading technology objects to device (Page 46)
TCONT_S (Page 465)

9.4.2 Configure controller difference TCONT_S

Use process value periphery

To use the input parameter PV_PER, proceed as follows:

1. Select the entry "Periphery" from the "Source" list.
2. Select the "sensor type".
   Depending on the sensor type, the process value is scaled according to different formulas.
   - Standard
     Thermoelements; PT100/NI100

     PV = 0.1 × PV_PER × PV_FAC + PV_OFFS
   - Cooling;
     PT100/NI100

     PV = 0.01 × PV_PER × PV_FAC + PV_OFFS
   - Current/voltage

     PV = 100/27648 × PV_PER × PV_FAC + PV_OFFS
3. Enter the factor and offset for the scaling of the process value periphery.

Use internal process values

To use the input parameter PV_IN, proceed as follows:

1. Select the entry "Internal" from the "Source" list.

Control deviation

Set a dead zone range under the following requirement:

- The process value signal is noisy.
- The controller gain is high.
- The derivative action is activated.

The noise component of the process value causes strong deviations of the output value in this case. The dead zone suppresses the noise component in the steady controller state. The dead zone range specifies the size of the dead zone. With a dead zone range of 0.0, the dead zone is turned off.

See also

Mode of operation TCONT_S (Page 466)

9.4.3 Configure controller algorithm TCONT_S

General

1. Enter the "Sampling time PID algorithm".
   A controller sampling time should not exceed 10 % of the determined integral action time of the controller (TI).
2. If the controller structure contains a proportional action, enter the "proportional gain".
   A negative proportional gain inverts the rule meaning.

Proportional action

For changes of the setpoint, it may lead to overshooting of the proportional action. Through the weighting of the proportional action, you can select how strongly the proportional action should react when setpoint changes are made. The weakening of the proportional action is reached through a compensation of the integral action.

1. To weaken the proportional action for setpoint changes, enter a "Proportional action weighting".
   - 1.0: Proportional action for setpoint change is fully effective
   - 0.0: Proportional action for setpoint change is not effective

Integral action

1. If the controller structure contains an integral action, enter the "integral action time". With an integral action time of 0.0, the integral action is switched off.

See also

Mode of operation TCONT_S (Page 466)

9.4.4 Configure manipulated value TCONT_S

Pulse generator

1. Enter the minimum impulse duration and minimum pause duration.
   The values must be greater than or equal to the cycle time for the input parameter CYCLE. The frequency of operation is reduced through this.
2. Enter the motor setting time.
   The value must be greater than or equal to the cycle time of the input parameter CYCLE.

See also

Mode of operation TCONT_S (Page 466)

9.4.5 Commissioning TCONT_S

Requirements

- The instruction and the technology object have been loaded to the CPU.

Procedure

To manually determine the optimal PID parameters, proceed as follows:

1. Click the "Start" icon.

   If there is no online connection, this will be established. The current values for the setpoint, process value and output value are recorded.
2. Enter new PID parameters in the "P", "I" and weighting proportional action fields.
3. Click on the icon "Send parameter to CPU" in the "Tuning" group.
4. Select the "Change setpoint" check box in the "Current values" group.
5. Enter a new setpoint and click the icon in the "Current values" group.
6. Clear the "Manual mode" check box.

   The controller works with the new parameters and controls the new setpoint.
7. Check the quality of the PID parameter to check the curve points.
8. Repeat steps 2 to 6 until you are satisfied with the controller results.

Auxiliary functions 10

10.1 Polyline

Polyline

The Polyline instruction provides a function with the characteristic curve of the polyline whose points can be used, for example, to linearize the behavior of non-linear sensors.

More information

Compatibility with CPU and FW (Page 475)
Description Polyline (Page 475)
Operating principle Polyline (Page 478)
Input parameters of Polyline (Page 481)
Output parameters of Polyline (Page 482)
Static tags of Polyline (Page 482)
ErrorBits parameter (Page 483)

10.2 SplitRange

SplitRange

The SplitRange instruction splits the output value range of the PID controller into multiple subranges. These subranges enable control of a process that is influenced by multiple actuators.

More information

Compatibility with CPU and FW (Page 486)
SplitRange description (Page 487)
SplitRange input parameters (Page 489)
SplitRange static tags (Page 490)
SplitRange output parameters (Page 490)
ErrorBits parameter (Page 490)

10.3 RampFunction

RampFunction

The RampFunction instruction limits the slew rate of a signal. A signal jump at the input is output as ramp function of the output value, to achieve a smoother response, for example, without influencing the disturbance reaction.

More information

Compatibility with CPU and FW (Page 492)
RampFunction description (Page 492)
RampFunction mode of operation (Page 496)
RampFunction input parameters (Page 500)
RampFunction output parameters (Page 500)
RampFunction static tags (Page 501)
ErrorBits parameter (Page 502)

10.4 RampSoak

RampSoak

You can use this instruction to generate an output value that follows a configurable profile on a time-dependent basis. Every point of this profile has a target value and a time value. When the profile is executed, the target value of the current point is reached within the time value. The instruction can be used, for example, to provide a setpoint value profile for regulating a temperature process.

More information

Compatibility with CPU and FW (Page 505)
Description of RampSoak (Page 506)
Operating principle RampSoak (Page 508)
Input parameter RampSoak (Page 521)
Output parameter RampSoak (Page 522)
In-out parameter RampSoak (Page 522)
Static tags RampSoak (Page 522)
ErrorBits parameter (Page 524)

10.5 Filter_PT1

Filter_PT1

The instruction Filter_PT1 is a proportional transfer element with a first-order lag. You can use Filter_PT1 as a low-pass filter, delay element or process simulation block.

More information

Compatibility with CPU and FW (Page 528)
Description of Filter_PT1 (Page 528)
Operating principle Filter_PT1 (Page 535)
Input parameter Filter_PT1 (Page 536)
Output parameter Filter_PT1 (Page 537)
Static tags Filter_PT1 (Page 537)
ErrorBits parameter (Page 537)

10.6 Filter_PT2

Filter_PT2

The instruction Filter_PT2 is a proportional transfer element with a second-order lag. You can use Filter_PT2 as a low-pass filter, delay element or process simulation block.

More information

Compatibility with CPU and FW (Page 541)
Description of Filter_PT2 (Page 541)
Operating principle Filter_PT2 (Page 548)
Input parameter Filter_PT2 (Page 549)
Output parameter Filter_PT2 (Page 550)
Static tags Filter_PT2 (Page 550)
Description of Filter_PT2 (Page 541)

See also

ErrorBits parameter (Page 550)

10.7 Filter_DT1

Filter_DT1

The instruction Filter_DT1 is a differentiator with a first-order lag. You can use Filter_DT1 as a high-pass filter, differentiator, or feed-forward control.

More information

Compatibility with CPU and FW (Page 554)
Description of Filter_DT1 (Page 554)
Operating principle Filter_DT1 (Page 561)
Input parameter Filter_DT1 (Page 562)
Output parameter Filter_DT1 (Page 563)
Static tags Filter_DT1 (Page 563)
ErrorBits parameter (Page 563)

10.8 Filter_Universal

Filter_Universal

The Filter_Universal instruction is a configurable digital filter of the order 1 to 10. You can use Filter_Universal as a high-pass, low-pass, band-pass or band-stop filter.

More information

Compatibility with CPU and FW (Page 566)
Description Filter_Universal (Page 567)
Operating principle Filter_Universal (Page 569)
Input parameter Filter_Universal (Page 579)
Output parameter Filter_Universal (Page 579)
Static tags Filter_Universal (Page 580)
ErrorBits parameter (Page 581)

Instructions 11

11.1 PID_Compact

11.1.1 New features of PID_Compact

PID_Compact V3.0

- **Use with S7-1200 G2**

  As of PID_Compact V3.0, the instruction can also be used on an S7-1200 G2.

  Older versions of the instruction are not supported on S7-1200 G2.

  If you transfer programs from S7-1200 to S7-1200 G2, the version of PID_Compact will be changed to V3.0 at the next compile.
  Note the behavior changes described below that were introduced between your previous version of PID_Compact on CPU 1200 and PID_Compact V3.0.

- **Dead zone**

  If the process value is noisy, unnecessary fluctuations in the output value can be reduced by manually setting a dead zone width.

- **Active limitation of the integral action and change of the output value limits in automatic mode**

  In addition to the direction-dependent stopping of the integral component, this is now actively limited.

  This allows the change of the output value limits in automatic mode.

- **New tags Config.OutputSelect and Retain.CtrlParams.SetByUser**

  The tags Config.OutputSelect and Retain.CtrlParams.SetByUser replace the previous tags _Config.OutputSelect and _Retain.CtrlParams.SetByUser, which are only available via the Openness API.

  The tags Config.OutputSelect and Retain.CtrlParams.SetByUser are available both in the instance data block and via the Openness API.

  The existing values for the new tags Config.OutputSelect and Retain.CtrlParams.SetByUser are transferred to individual instances after switching to V3. For multi-instances, the new tags will have the default value after switching to V3. You restore the associated settings manually.

  If you have been using _Config.OutputSelect or _Retain.CtrlParams.SetByUser in your Openness application so far, replace them with the tags Config.OutputSelect and Retain.CtrlParams.SetByUser when you switch to PID_Compact V3.

PID_Compact V2.4

- **Initialization of the integral action**

  PID_Compact now initializes the integral action if you use OverwriteInitialOutputValue together with inverted control logic.

  If you have been using OverwriteInitialOutputValue together with inverted control logic up to now, please note that the sign of the output value changes with PID_Compact V2.4.

PID_Compact V2.3

- **Response of the output value when switching from "Inactive" operating mode to "Automatic mode"**

  The new option IntegralResetMode = 4 was added and defined as default. With IntegralResetMode = 4, the integral action is automatically preassigned when switching from "Inactive" operating mode to "Automatic mode" so that a control deviation results in a jump of the output value with identical sign.

- **Initialization of the integral action in automatic mode**

  The integral action can be initialized in automatic mode with the OverwriteInitialOutputValue and PIDCtrl.PIDInit tags. This simplifies the use of PID_Compact for override controls.

PID_Compact V2.2

- **Use with S7-1200**

  As of PID_Compact V2.2, the instruction with V2 functionality can also be used on S7-1200 as of firmware version 4.0.

PID_Compact V2.0

- **Response to errors**

  The response in the event of an error has been completely overhauled. PID_Compact now responds in a more fault-tolerant manner in the default setting. This reaction is set when copying PID_Compact V1.X from an S7-1200 CPU to an S7-1500 CPU.

NOTICE
Your system may be damaged. If you use the default setting, PID_Compact remains in automatic mode when the process value limits are exceeded. This may damage your system. It is essential to configure how your controlled system reacts in the event of an error to protect your system from damage.

The Error parameter indicates if an error is pending. When the error is no longer pending, Error = FALSE. The ErrorBits parameter shows which errors have occurred. Use ErrorAck to acknowledge the errors and warnings without restarting the controller or clearing the integral action. Switching operating modes no longer clears errors that are no longer pending.

You can configure the responses in the event of an error with SetSubstituteOutput and ActivateRecoverMode.

- **Substitute output value**

  You can configure a substitute output value that is to be output if an error occurs.

- **Switching the operating mode**

  You specify the operating mode at the Mode in/out parameter and use a positive edge at ModeActivate to start the operating mode. The sRet.i_Mode tag has been omitted.

- **Multi-instance capability**

  You can call up PID_Compact as multi-instance DB.

- **Startup characteristics**

  The operating mode specified at the Mode parameter is also started on a falling edge at Reset and during a CPU cold restart, if RunModeByStartup = TRUE.

- **ENO characteristics**

  ENO is set depending on the operating mode.

  If State = 0, then ENO = FALSE.

  If State ≠ 0, then ENO = TRUE.

- **Setpoint value specification during tuning**

  You configure the permitted fluctuation of the setpoint during tuning at the CancelTuningLevel tag.

- **Value range for output value limits**

  The value 0.0 no longer has to fall within the output value limits.

- **Preassigning the integral action**

  Using the tags IntegralResetMode and OverwriteInitialOutputValue, you can determine the preassignment of the integral action when switching from "Inactive" operating mode to "Automatic mode".

- **Switching a disturbance variable on**

  You can switch a disturbance variable on at the Disturbance parameter.

- **Default value of PID parameters**

  The following default settings have been changed:

  – Proportional action weighting (PWeighting) from 0.0 to 1.0
  – Derivative action weighting (DWeighting) from 0.0 to 1.0
  – Coefficient for derivative delay (TdFiltRatio) from 0.0 to 0.2

- **Renaming tags**

  The static tags have been given new names that are compatible with PID_3Step.

PID_Compact V1.2

- **Manual mode on CPU startup**

  If ManualEnable = TRUE when the CPU starts, PID_Compact starts in manual mode. A rising edge at ManualEnable is not necessary.

- **Pretuning**

  If the CPU is switched off during pretuning, pretuning starts again when the CPU is switched back on.

PID_Compact V1.1

- **Manual mode on CPU startup**

  When the CPU starts up, PID_Compact only switches to manual mode with a rising edge at ManualEnable. Without rising edge, PID_Compact starts in the last operating mode in which ManualEnable was FALSE.

- **Reaction to reset**

  A rising edge at Reset resets the errors and warnings and clears the integral action. A falling edge at Reset triggers a switchover to the most recently active operating mode.

- **Default of process value high limit**

  The default value of r_Pv_Hlm has been changed to 120.0.

- **Monitoring the sampling time**

  – An error is no longer output when the current sampling time is ≥ 1.5 x current mean value or when the current sampling time is ≤ 0.5 x current mean value. The sampling time may deviate much more in automatic mode.

  – PID_Compact is compatible with FW as of V2.0.

- **Access to tags**

  The following tags can now be used in the user program.

  – i_Event_SUT

  – i_Event_TIR

  – r_Ctrl_Ioutv

- **Troubleshooting**

  PID_Compact now outputs the correct pulses when the shortest ON time is not equal to the shortest OFF time.

11.1.2 Compatibility with CPU and FW

The following table shows which version of PID_Compact can be used on which CPU.

CPU	FW	PID_Compact
S7-1200	as of V4.2	V2.3 V2.2 V1.2
	V4.0 to V4.1	V2.2 V1.2
	V3.x	V1.2 V1.1
	V2.x	V1.2 V1.1
S7-1200 G2	V1.0 or higher	V3.0
S7-1500	as of V3.1	V3.0 V2.4
	V3.0	V2.4
	V2.5 to V2.9	V2.4 V2.3 V2.2 V2.1 V2.0
	V2.0 and V2.1	V2.3 V2.2 V2.1 V2.0
	V1.5 to V1.8	V2.2 V2.1 V2.0
	V1.1	V2.1 V2.0
	V1.0	V2.0

11.1.3 CPU processing time and memory requirement PID_Compact as of V2

CPU processing time

Typical CPU processing times of the PID_Compact technology object as of Version V2.0, depending on CPU type and operating mode for standard, F, T and TF CPUs.

CPU	FW	Typ. CPU processing time Automatic mode	Typ. CPU processing time pre-tuning and fine tuning
CPU 1211	≥ V4.0	190 µs	270 µs
CPU 1212			
CPU 1214			
CPU 1215			

CPU 1217	≥ V4.0	190 µs	270 µs
CPU 1212 G2	≥ V1.0	100 µs	130 µs
CPU 1214 G2			
CPU 1216 G2	≥ V4.0	20 µs	30 µs
CPU 1217 G2			
CPU 1510SP	≤ V2.9	65 µs	80 µs
CPU 1511			
CPU 1511C			
CPU 1512C			
CPU 1512SP			
CPU 1513			
CPU 1515		50 µs	65 µs
CPU 1516			
CPU 1517	≤ V3.1	8 µs	12 µs
CPU 1518		4 µs	6 µs
CPU 1510SP	V3.0, V3.1	55 µs	70 µs
CPU 1511			
CPU 1511C			
CPU 1512C			
CPU 1512SP			
CPU 1513			
CPU 1514SP			
CPU 1515		40 µs	55 µs
CPU 1516			
CPU 1510SP	≥ V4.0	40 µs	55 µs
CPU 1511			
CPU 1511C			
CPU 1512C			
CPU 1512SP			
CPU 1513			
CPU 1514SP			
CPU 1515			
CPU 1516			
CPU 1516T		3 µs	4 µs
CPU 1517		2 µs	3 µs
CPU 1518		1 µs	2 µs

Typical CPU processing times of the PID_Compact technology object as of Version V2.0, depending on the CPU type and operating mode for R/H-CPUs in the RUN-Redundant system state.

CPU	FW	Typ. CPU processing time Automatic mode	Typ. CPU processing time pretuning and fine tuning
CPU 1513R	V3.0, V3.1	90 µs	140 µs
CPU 1515R		85 µs	100 µs
CPU 1513R	≥ V4.0	85 µs	100 µs
CPU 1515R			
CPU 1517H		4 µs	6 µs
CPU 1518HF			

Memory requirement

Memory requirement of an instance DB of the PID_Compact technology object as of Version V2.0.

Memory requirement	Memory requirement of the instance DB of PID_Compact V2.x	Memory requirement of the instance DB of PID_Compact V3.x
Load memory requirement	Approx. 3700 bytes	Approx. 3750 bytes
Total work memory requirement	788 bytes	802 bytes
Retentive work memory requirement	44 bytes	52 bytes

11.1.4 PID_Compact as of V2

11.1.4.1 Description of PID_Compact V3

Description

The PID_Compact instruction provides a PID controller with integrated tuning for actuators with proportional action.

The following operating modes are possible:

- Inactive
- Pretuning
- Fine tuning
- Automatic mode
- Manual mode
- Substitute output value with error monitoring

For a more detailed description of the operating modes, see the State parameter.

PID algorithm

PID_Compact is a PIDT1 controller with anti-windup and weighting of the proportional and derivative actions. The PID algorithm operates according to the following equation (dead zone deactivated):

$$y = K_p \left[(b \cdot w - x) + \frac{1}{T_I \cdot s} (w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1} (c \cdot w - x) \right]$$

The table below shows the meaning of the icons used in the transfer function and in the subsequent figures:

Icon	Description	Associated parameters of the PID_Compact instruction
y	Output value of the PID algorithm	-
K_p	Proportional gain	Retain.CtrlParams.Gain
s	Laplace operator	-
b	Proportional action weighting	Retain.CtrlParams.PWeighting
w	Setpoint	CurrentSetpoint
x	Process value	ScaledInput
T_I	Integration time	Retain.CtrlParams.Ti
T_D	Derivative action time	Retain.CtrlParams.Td
a	Derivative delay coefficient (derivative delay T1 = a × T_D)	Retain.CtrlParams.TdFiltRatio
c	Derivative action weighting	Retain.CtrlParams.DWeighting
DeadZone	Dead zone width	Retain.CtrlParams.DeadZone

Block diagram of PID_Compact

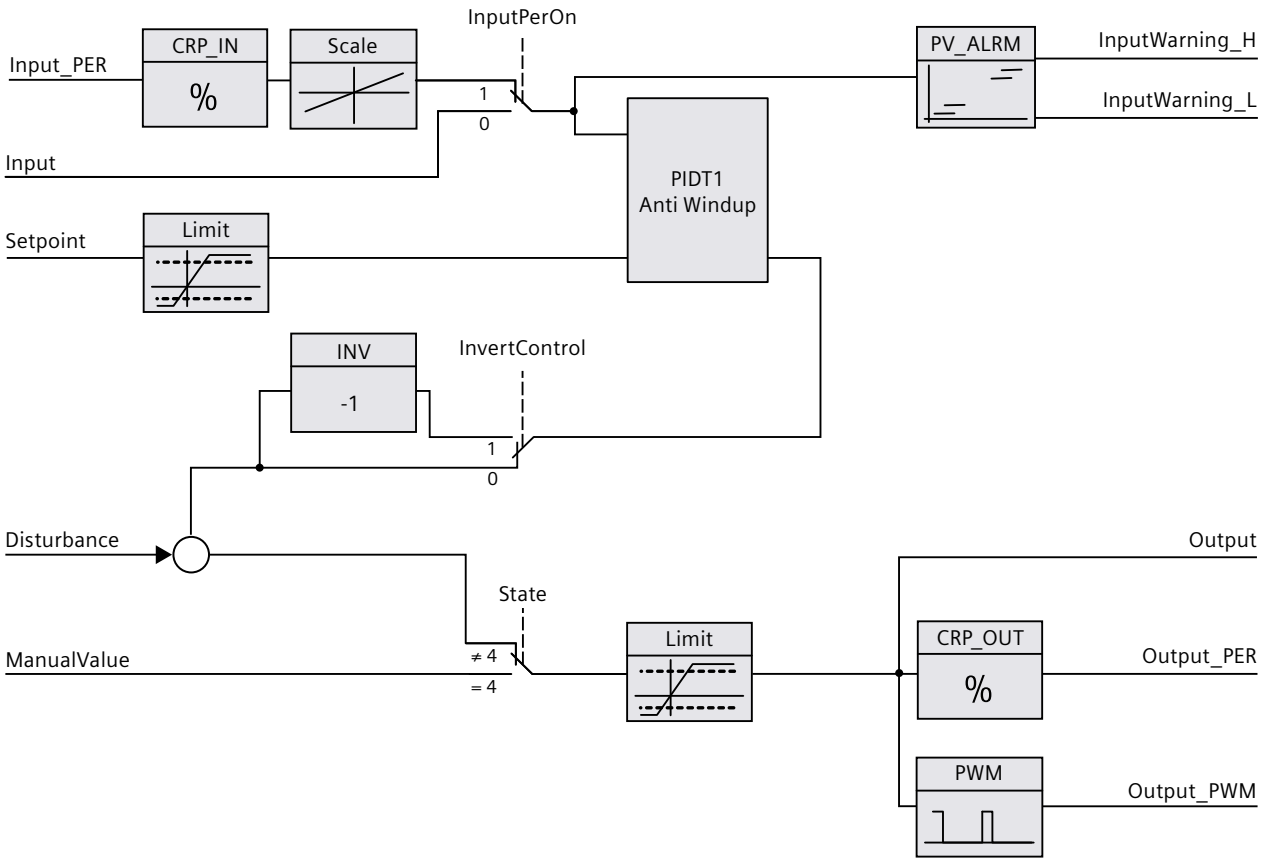

Block diagram of PIDT1 with anti-windup

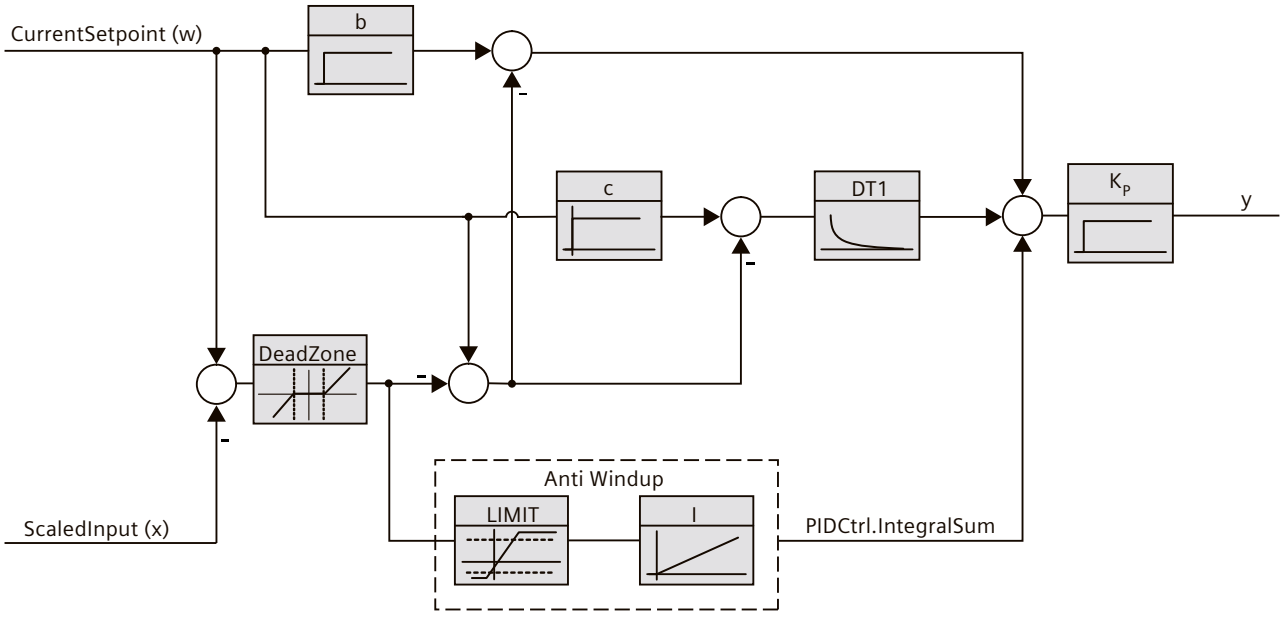

Call

PID_Compact is called in the constant time scale of a cyclic interrupt OB.

Download to device

The actual values of retentive tags are only updated when you download PID_Compact completely.

Download technology object to device

Startup

When the CPU starts up, PID_Compact starts in the operating mode saved in the Mode in/out parameter. To switch to "Inactive" operating mode during startup, set RunModeByStartup = FALSE.

Response to errors

The response in the event of an error is determined by the tags SetSubstituteOutput and ActivateRecoverMode. If ActivateRecoverMode = TRUE, the reaction additionally depends on the error that occurred.

SetSubstitu-teOutput	**ActivateR-ecoverMode**	**Configuration editor > output value > Set Output to**	**Reaction**
Not relevant	FALSE	Zero (inactive)	Switch to "Inactive" mode (State = 0) The value 0.0 is transferred to the actuator.
FALSE	TRUE	Current output value while error is pending	Switch to "Substitute output value with error monitoring" mode (State = 5) The current output value is transferred to the actu-ator while the error is pending.
TRUE	TRUE	Substitute output value while error is pending	Switch to "Substitute output value with error monitoring" mode (State = 5) The value at SubstituteOutput is transferred to the actuator while the error is pending.

In manual mode, PID_Compact uses ManualValue as output value, unless ManualValue is invalid. If ManualValue is invalid, SubstituteOutput is used. If ManualValue and SubstituteOutput are invalid, Config.OutputLowerLimit is used.

The Error parameter indicates if an error is pending. When the error is no longer pending, Error = FALSE. The ErrorBits parameter shows which errors have occurred. ErrorBits is reset by a rising edge at Reset or ErrorAck.

11.1.4.2 Description of PID_Compact V2

Description

The PID_Compact instruction provides a PID controller with integrated tuning for actuators with proportional action.

The following operating modes are possible:

- Inactive
- Pretuning
- Fine tuning
- Automatic mode
- Manual mode
- Substitute output value with error monitoring

For a more detailed description of the operating modes, see the State parameter.

PID algorithm

PID_Compact is a PIDT1 controller with anti-windup and weighting of the proportional and derivative actions. The PID algorithm operates according to the following transfer function:

$$y = K_p \left[(b \cdot w - x) + \frac{1}{T_I \cdot s} (w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1} (c \cdot w - x) \right]$$

The table below shows the meaning of the icons used in the transfer function and in the subsequent figures:

Icon	Description	Associated parameters of the PID_Compact instruction
y	Output value of the PID algorithm	-
K_p	Proportional gain	Retain.CtrlParams.Gain
s	Laplace operator	-
b	Proportional action weighting	Retain.CtrlParams.PWeighting
w	Setpoint	CurrentSetpoint
x	Process value	ScaledInput
T_I	Integration time	Retain.CtrlParams.Ti
T_D	Derivative action time	Retain.CtrlParams.Td
a	Derivative delay coefficient (derivative delay T1 = a × T_D)	Retain.CtrlParams.TdFiltRatio
c	Derivative action weighting	Retain.CtrlParams.DWeighting

$$y = K_p \left[(b \cdot w - x) + \frac{1}{T_I \cdot s} (w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1} (c \cdot w - x) \right]$$

Symbol	Description	Associated parameters of the **PID_Compact** instruction
y	Output value of the PID algorithm	-
K_p	Proportional gain	Retain.CtrlParams.Gain
s	Laplace operator	-
b	Proportional action weighting	Retain.CtrlParams.PWeighting
w	Setpoint	CurrentSetpoint
x	Process value	ScaledInput
T_I	Integration time	Retain.CtrlParams.Ti
T_D	Derivative action time	Retain.CtrlParams.Td
a	Derivative delay coefficient (derivative delay T1 = a × T_D)	Retain.CtrlParams.TdFiltRatio
c	Derivative action weighting	Retain.CtrlParams.DWeighting

Block diagram of PID_Compact

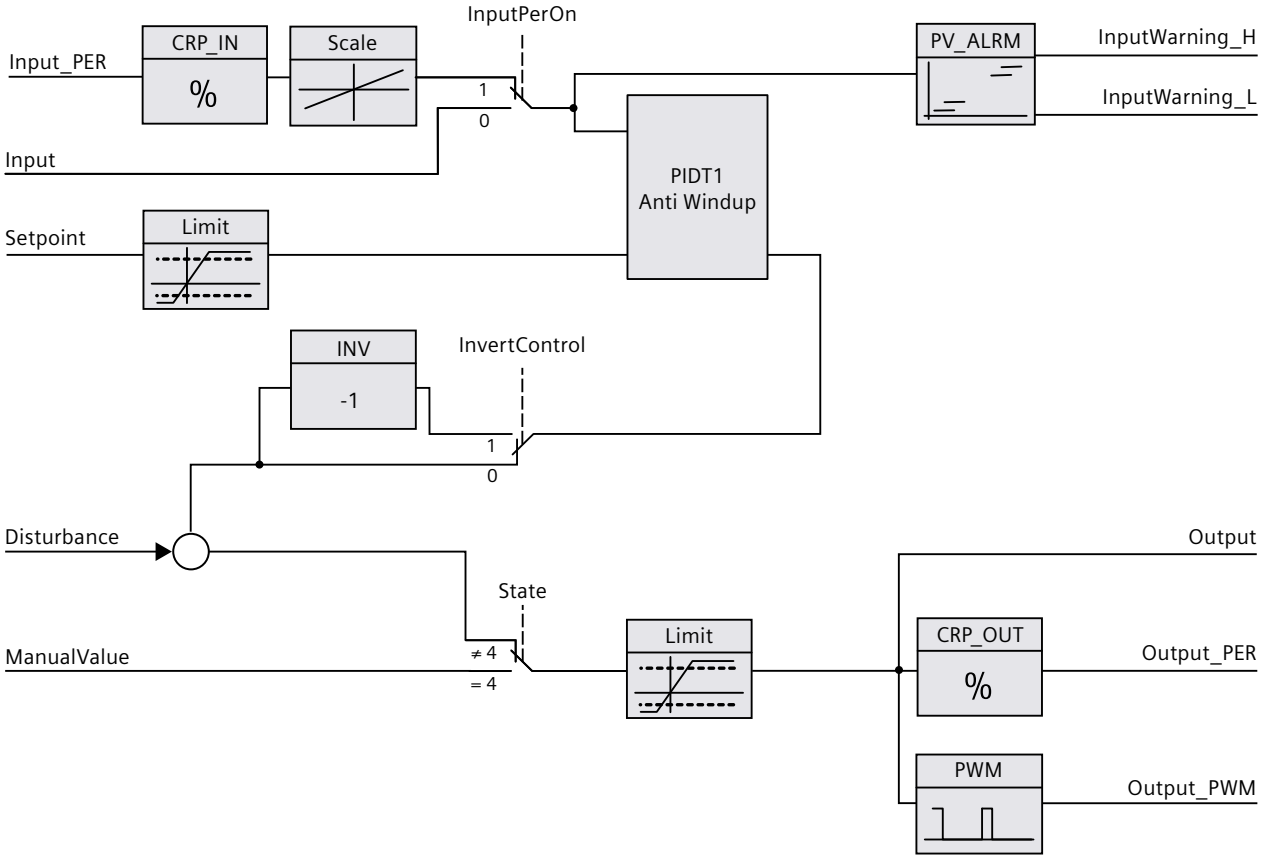

Block diagram of PIDT1 with anti-windup

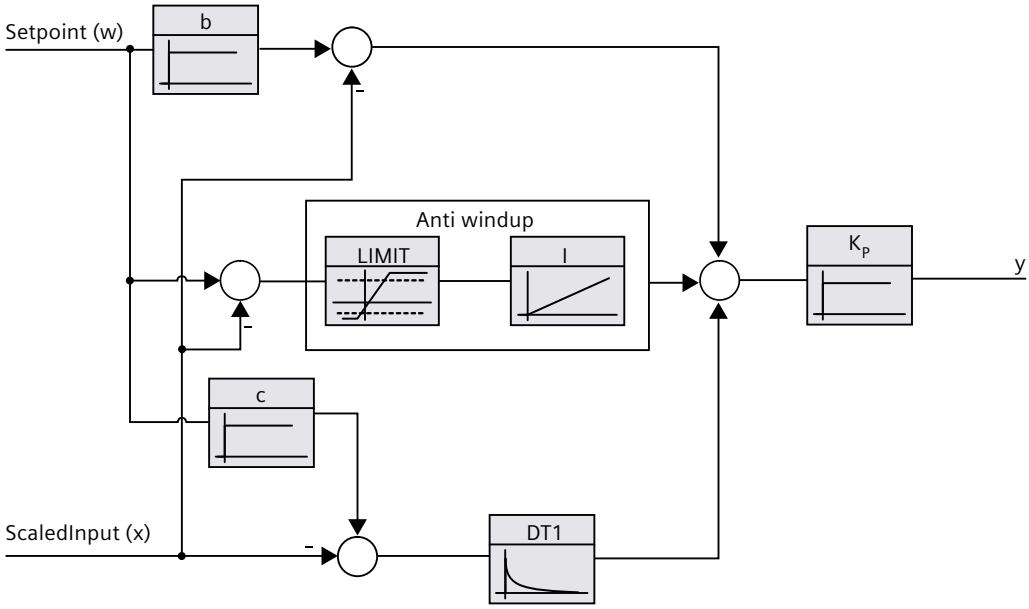

Call

PID_Compact is called in the constant time scale of a cyclic interrupt OB.

Download to device

The actual values of retentive tags are only updated when you download PID_Compact completely.

Downloading technology objects to device (Page 46)

Startup

When the CPU starts up, PID_Compact starts in the operating mode saved in the Mode in/out parameter. To switch to "Inactive" operating mode during startup, set RunModeByStartup = FALSE.

Response to errors

The response in the event of an error is determined by the tags SetSubstituteOutput and ActivateRecoverMode. If ActivateRecoverMode = TRUE, the reaction additionally depends on the error that occurred.

SetSubstitu-teOutput	ActivateR-ecoverMode	Configuration editor > output value > Set Output to	Reaction
Not relevant	FALSE	Zero (inactive)	Switch to "Inactive" mode (State = 0) The value 0.0 is transferred to the actuator.
FALSE	TRUE	Current output value while error is pending	Switch to "Substitute output value with error monitoring" mode (State = 5) The current output value is transferred to the actu-ator while the error is pending.
TRUE	TRUE	Substitute output value while error is pending	Switch to "Substitute output value with error monitoring" mode (State = 5) The value at SubstituteOutput is transferred to the actuator while the error is pending.

In manual mode, PID_Compact uses ManualValue as output value, unless ManualValue is invalid. If ManualValue is invalid, SubstituteOutput is used. If ManualValue and SubstituteOutput are invalid, Config.OutputLowerLimit is used.

The Error parameter indicates if an error is pending. When the error is no longer pending, Error = FALSE. The ErrorBits parameter shows which errors have occurred. ErrorBits is reset by a rising edge at Reset or ErrorAck.

11.1.4.3 PID_Compact as of V2 operating principle

Monitoring process value limits

You specify the high limit and low limit of the process value in the Config.InputUpperLimit and Config.InputLowerLimit tags. If the process value is outside these limits, an error occurs (ErrorBits = 0001h).

You specify a high and low warning limit of the process value in the Config.InputUpperWarning and Config.InputLowerWarning tags. If the process value is outside these warning limits, a warning occurs (Warning = 0040h), and the InputWarning_H or InputWarning_L output parameter changes to TRUE.

Limiting the setpoint

You specify a high limit and low limit of the setpoint in the Config.SetpointUpperLimit and Config.SetpointLowerLimit tags. PID_Compact automatically limits the setpoint to the process value limits. You can limit the setpoint to a smaller range. PID_Compact checks whether this range falls within the process value limits. If the setpoint is outside these limits, the high or low limit is used as the setpoint, and output parameter SetpointLimit_H or SetpointLimit_L is set to TRUE.

The setpoint is limited in all operating modes.

Limiting the output value

You specify a high limit and low limit of the output value in the Config.OutputUpperLimit and Config.OutputLowerLimit tags. Output, ManualValue and SubstituteOutput are limited to these values. The output value limits must match the control logic.

The valid output value limit values depend on the Output used.

Output	-100.0 to 100.0%
Output_PER	-100.0 to 100.0%
Output_PWM	0.0 to 100.0%

Rule:

OutputUpperLimit > OutputLowerLimit

NOTE

Use with two or more actuators

PID_Compact is not suitable for use with two or more actuators (for example, in heating/cooling applications), because different actuators need different PID parameters to achieve a good control response. Use PID_Temp for applications with two actuators acting in opposite directions.

Substitute output value

In the event of an error, PID_Compact can output a substitute output value that you define at the SubstituteOutput tag. The substitute output value must be within the output value limits.

Monitoring signal validity

The values of the following parameters are monitored for validity when used:

- Setpoint
- Input
- Input_PER
- Disturbance
- ManualValue
- SubstituteOutput
- Output
- Output_PER
- Output_PWM

Monitoring of the sampling time PID_Compact

Ideally, the sampling time is equivalent to the cycle time of the calling OB. The PID_Compact instruction measures the time interval between two calls. This is the current sampling time. On every switchover of operating mode and during the initial startup, the mean value is formed from the first 10 sampling times. Too great a difference between the current sampling time and this mean value triggers an error (Error = 0800h).

The error occurs during tuning if:

- New mean value >= 1.1 x old mean value
- New mean value <= 0.9 x old mean value

The error occurs in automatic mode if:

- New mean value >= 1.5 x old mean value
- New mean value <= 0.5 x old mean value

If you deactivate the sampling time monitoring (CycleTime.EnMonitoring = FALSE), you can also call PID_Compact in OB1. You must then accept a lower control quality due to the deviating sampling time.

Sampling time of the PID algorithm

The controlled system needs a certain amount of time to respond to changes in the output value. It is therefore not advisable to calculate the output value in every cycle. The sampling time of the PID algorithm represents the time between two calculations of the output value. It is calculated during tuning and rounded to a multiple of the cycle time. All other functions of PID_Compact are executed at every call.

If you use Output_PWM, the sampling time of the PID algorithm is used as the period duration of the pulse width modulation. The accuracy of the output signal is determined by the ratio of the PID algorithm sampling time to the cycle time of the OB. It is therefore recommended that the cycle time is a maximum of one tenth of the PID algorithm sampling time.

Control logic

An increase of the output value is generally intended to cause an increase in the process value. This is referred to as a normal control logic. For cooling and discharge control systems, it may be necessary to invert the control logic. PID_Compact does not work with negative proportional gain. If InvertControl = TRUE, an increasing control deviation causes a reduction in the output value. The control logic is also taken into account during pretuning and fine tuning.

11.1.4.4 Input parameters of PID_Compact as of V2

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1118

Parameter	Data type	Default	Description
Setpoint	REAL	0.0	Setpoint of the PID controller in automatic mode
Input	REAL	0.0	A tag of the user program is used as source for the process value. If you are using Input parameter, then Config.InputPerOn = FALSE must be set.
Input_PER	INT	0	An analog input is used as the source of the process value. If you are using Input_PER parameter, then Config.InputPerOn = TRUE must be set.
Disturbance	REAL	0.0	Disturbance variable or precontrol value
ManualEnable	BOOL	FALSE	• A FALSE -> TRUE edge activates "Manual mode", State = 4, Mode remains unchanged. As long as ManualEnable = TRUE, you cannot change the operating mode via a rising edge at ModeActivate or use the commissioning dialog. • A TRUE -> FALSE edge activates the operating mode that is specified by Mode. We recommend that you change the operating mode using ModeActivate only.
ManualValue	REAL	0.0	Manual value This value is used as the output value in manual mode. Values from Config.OutputLowerLimit to Config.OutputUpperLimit are permitted.
ErrorAck	BOOL	FALSE	• FALSE -> TRUE edge ErrorBits and Warning are reset.
Reset	BOOL	FALSE	Restarts the controller. • FALSE -> TRUE edge – Switch to "Inactive" mode – ErrorBits and Warnings are reset. • As long as Reset = TRUE, – PID_Compact remains in "Inactive" mode (State = 0). – You cannot change the operating mode with Mode and ModeActivate or ManualEnable. – You cannot use the commissioning dialog. • TRUE -> FALSE edge – If ManualEnable = FALSE, PID_Compact switches to the operating mode that is stored in the Mode parameter. – If Mode = 3, the integral action is treated as configured with the IntegralResetMode tag.
ModeActivate	BOOL	FALSE	• FALSE -> TRUE edge PID_Compact switches to the operating mode saved in the Mode parameter.

11.1.4.5 Output parameters of PID_Compact as of V2

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1119

Parameter	Data type	Default	Description
ScaledInput	REAL	0.0	Scaled process value
The "Output", "Output_PER", and "Output_PWM" outputs can be used concurrently.			
Output	REAL	0.0	Output value in REAL format
Output_PER	INT	0	Analog output value
Output_PWM	BOOL	FALSE	Pulse-width-modulated output value The output value is formed by variable On and Off times.
SetpointLimit_H	BOOL	FALSE	If SetpointLimit_H = TRUE, the absolute setpoint high limit is reached (Setpoint ≥ Config.SetpointUpperLimit). The setpoint is limited to Config.SetpointUpperLimit .
SetpointLimit_L	BOOL	FALSE	If SetpointLimit_L = TRUE, the absolute setpoint low limit has been reached (Setpoint ≤ Config.SetpointLowerLimit). The setpoint is limited to Config.SetpointLowerLimit .
InputWarning_H	BOOL	FALSE	If InputWarning_H = TRUE, the process value has reached or exceeded the warning high limit.
InputWarning_L	BOOL	FALSE	If InputWarning_L = TRUE, the process value has reached or fallen below the warning low limit.
State	INT	0	The State parameter (Page 267) shows the current operating mode of the PID controller. You can change the operating mode using the input parameter Mode and a rising edge at ModeActivate. • State = 0: Inactive • State = 1: Pre-tuning • State = 2: Fine tuning • State = 3: Automatic mode • State = 4: Manual mode • State = 5: Substitute output value with error monitoring
Error	BOOL	FALSE	If Error = TRUE, at least one error message is pending in this cycle.
ErrorBits	DWORD	DW#16#0	The ErrorBits parameter (Page 271) shows which error messages are pending. ErrorBits is retentive and is reset upon a rising edge at Reset or ErrorAck.

11.1.4.6 In/out parameter of PID_Compact as of V2

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1120

Parameter	Data type	Default	Description
Mode	INT	4	At Mode, specify the operating mode to which PID_Compact is to switch. Options are: • Mode = 0: Inactive • Mode = 1: Pretuning • Mode = 2: Fine tuning • Mode = 3: Automatic mode • Mode = 4: Manual mode The operating mode is activated by: • Rising edge at ModeActivate • Falling edge at Reset • Falling edge at ManualEnable • Cold restart of CPU if RunModeByStartup = TRUE Mode is retentive. A detailed description of the operating modes can be found in State and Mode as of V2 parameters (Page 267).

See also

State and Mode as of V2 parameters (Page 267)

11.1.4.7 Static tags of PID_Compact as of V2

NOTE

Change the tags identified with (1) only in "Inactive" mode to prevent malfunction of the PID controller.

Unless otherwise specified, the names of the following variables apply both to the data block and to access via the Openness API.

Tag	Data type	Default	Description
IntegralResetMode	INT	Up to V2.2: 1, as of V2.3: 4	The Tag IntegralResetMode as of V2 (Page 275) determines how the integral action PIDCtrl.IntegralSum is preassigned when switching from "Inactive" operating mode to "Automatic mode". This setting only works for one cycle. Options are: • IntegralResetMode = 0: Smooth • IntegralResetMode = 1: Delete • IntegralResetMode = 2: Hold • IntegralResetMode = 3: Preassign • IntegralResetMode = 4: Like setpoint change (only for PID_Compact with version ≥ 2.3)

Tag	Data type	Default	Description
OverwriteInitialOutputValue	REAL	0.0	If one of the following conditions is met, the integral action PIDCtrl.IntegralSum is preassigned automatically as if Output = OverwriteInitialOutputValue in the previous cycle: • IntegralResetMode = 3 when switching from "Inactive" operating mode to "Automatic mode" • IntegralResetMode = 3, TRUE -> FALSE edge at parameter Reset and parameter Mode = 3 • PIDCtrl.PIDInit = TRUE in "Automatic mode" (available as of PID_Compact version 2.3)
RunModeByStartup	BOOL	TRUE	Activate operating mode at Mode parameter after CPU restart If RunModeByStartup = TRUE, PID_Compact starts in the operating mode saved in the Mode parameter after CPU startup. If RunModeByStartup = FALSE, PID_Compact remains in "Inactive" mode after CPU startup.
LoadBackUp	BOOL	FALSE	If LoadBackUp = TRUE, the last set of PID parameters is reloaded from the CtrlParamsBackUp structure. The set was saved prior to the last tuning. LoadBackUp is automatically set back to FALSE.
PhysicalUnit	INT	0	Unit of measurement of the process value and setpoint, e.g., °C, or °F. PhysicalUnit serves the display in the editors and has no influence on the behavior of the control algorithm in the CPU. When importing PID_Compact up to Version 2.4 via the Openness API, PhysicalUnit is reset to the default value. As of Version 3.0, the value of PhysicalUnit is retained when importing.
PhysicalQuantity	INT	0	Physical quantity of the process value and setpoint, e.g., temperature. PhysicalQuantity serves the display in the editors and has no influence on the behavior of the control algorithm in the CPU. When importing PID_Compact up to Version 2.4 via the Openness API, PhysicalQuantity is reset to the default value. As of Version 3.0, the value of PhysicalQuantity is retained when importing.
ActivateRecoverMode	BOOL	TRUE	The ActivateRecoverMode tag as of V2 (Page 273) determines the response in the event of an error.
Warning	DWORD	0	Warning tag as of V2 (Page 274) shows the warnings since Reset = TRUE or ErrorAck =TRUE. Warning is retentive.
Progress	REAL	0.0	Progress of current tuning phase as a percentage (0.0 - 100.0)
CurrentSetpoint	REAL	0.0	CurrentSetpoint always displays the currently effective setpoint. This value is frozen during tuning.

Tag	Data type	Default	Description
CancelTuningLevel	REAL	10.0	Permissible fluctuation of setpoint during tuning. Tuning is not canceled until: • Setpoint > CurrentSetpoint + CancelTuningLevel or • Setpoint < CurrentSetpoint - CancelTuningLevel
SubstituteOutput	REAL	0.0	Substitute output value When the following conditions are met, the substitute output value is used as the output value: • One or more errors are pending in automatic mode for which ActivateRecoverMode is in effect. • SetSubstituteOutput = TRUE • ActivateRecoverMode = TRUE Config.OutputUpperLimit ≥ SubstituteOutput ≥ Config.OutputLowerLimit
SetSubstituteOutput	BOOL	TRUE	Selection of the output value while an error is pending (State = 5) • If SetSubstituteOutput = TRUE and ActivateRecoverMode = TRUE, the SubstituteOutput substitute output value configured is output as long as an error is pending. • If SetSubstituteOutput = FALSE and ActivateRecoverMode = TRUE, the actuator remains at the current output value as long as an error is pending. • If ActivateRecoverMode = FALSE, SetSubstituteOutput is not effective. • If SubstituteOutput is invalid (ErrorBits = 16#0002_0000), the substitute output value cannot be output. In this case, the low limit of the output value (Config.OutputLowerLimit) is used as output value.
Config.InputPerOn(1)	BOOL	TRUE	If InputPerOn = TRUE, the Input_PER parameter is used for detecting the process value. If InputPerOn = FALSE, the Input parameter is used.
Config.InvertControl(1)	BOOL	FALSE	Invert control logic If InvertControl = TRUE, an increasing control deviation causes a reduction in the output value.
Config.OutputSelect	INT	0	Selection of the output value (as of Version 3.0): • OutputSelect = 0: Output_PER (analog) • OutputSelect = 1: Output • OutputSelect = 2: Output_PWM Config.OutputSelect is used for configuring the controller in the TIA Portal and has no influence on the calculation of the output values in the CPU.

Tag	Data type	Default	Description
_Config.OutputSelect	INT	0	Selection of the output value (up to Version 2.4): • OutputSelect = 0: Output_PER (analog) • OutputSelect = 1: Output • OutputSelect = 2: Output_PWM _Config.OutputSelect is used for configuring the controller in the TIA Portal and has no influence on the calculation of the output values in the CPU. _Config.OutputSelect is not available in the data block and can only be configured in the configuration editor or via the Openness API. When importing PID_Compact via the Openness API, _Config.OutputSelect is reset to the default value.
Config.InputUpperLimit(1)	REAL	120.0	High limit of the process value Input and Input_PER are monitored to ensure adherence to this limit. If the limit is exceeded, an error is output and the reaction is determined by ActivateRecoverMode. At the I/O input, the process value can be a maximum of 18% higher than the standard range (overrange). This means the limit cannot be exceeded when you use an I/O input with the pre-setting for high limit and process value scaling. When pretuning is started, the difference between high and low limit of the process value is checked to determine whether the distance between setpoint and process value meets the necessary requirements. InputUpperLimit > InputLowerLimit
Config.InputLowerLimit(1)	REAL	0.0	Low limit of the process value Input and Input_PER are monitored to ensure adherence to this limit. If the limit is undershot, an error is output and the reaction is determined by ActivateRecoverMode. InputLowerLimit < InputUpperLimit
Config.InputUpperWarning(1)	REAL	3.402822e+38	Warning high limit of the process value Input and Input_PER are monitored to ensure adherence to this limit. If the limit is exceeded, a warning is output at the parameter. If you set InputUpperWarning outside the process value limits, the configured absolute process value high limit is used as the warning high limit. If you configure InputUpperWarning within the process value limits, this value is used as the warning high limit. InputUpperWarning > InputLowerWarning
Config.InputLowerWarning(1)	REAL	-3.402822e+38	Warning low limit of the process value Input and Input_PER are monitored to ensure adherence to this limit. If the limit is undershot, a warning is output at the Warning parameter. If you set InputLowerWarning outside the process value limits, the configured absolute process value low limit is used as the warning low limit. If you configure InputLowerWarning within the process value limits, this value is used as the warning low limit. InputLowerWarning < InputUpperWarning
Config.OutputUpperLimit	REAL	100.0	High limit of output value For details, see OutputLowerLimit 100.0 ≥ OutputUpperLimit > OutputLowerLimit

Tag	Data type	Default	Description
Config.OutputLowerLimit	REAL	0.0	Low limit of the output value For Output and Output_PER, the range of values from -100.0 to +100.0, including zero, is valid. At -100.0, Output_PER = -27648; at +100.0, Output_PER = 27648. For Output_PWM, the value range 0.0 to +100.0 applies. The output value limits must match the control logic. As of Version 3.0, PID_Compact supports the change of the output value limits in automatic mode. Up to version 2.4, these may only be changed in the inactive or manual modes. OutputLowerLimit < OutputUpperLimit
Config.SetpointUpperLimit(1)	REAL	3.402822e+38	High limit of setpoint Setpoint is monitored to ensure adherence to this limit. If the limit is exceeded, a warning is output at the Warning parameter. If you configure SetpointUpperLimit outside the process value limits, the configured process value absolute high limit is used as the setpoint high limit. If you configure SetpointUpperLimit within the process value limits, this value is used as the setpoint high limit. SetpointUpperLimit > SetpointLowerLimit
Config.SetpointLowerLimit(1)	REAL	-3.402822e+38	Low limit of the setpoint Setpoint is monitored to ensure adherence to this limit. If the limit is undershot, a warning is output at the Warning parameter. If you set SetpointLowerLimit outside the process value limits, the configured process value absolute low limit is used as the setpoint low limit. If you set SetpointLowerLimit within the process value limits, this value is used as the setpoint low limit. SetpointLowerLimit < SetpointUpperLimit
Config.MinimumOnTime(1)	REAL	0.0	The minimum ON time of the pulse width modulation in seconds is rounded to MinimumOnTime = n×CycleTime.Value 100000.0 ≥ MinimumOnTime ≥ 0.0
Config.MinimumOffTime(1)	REAL	0.0	The minimum OFF time of the pulse width modulation in seconds is rounded to MinimumOffTime = n×CycleTime.Value 100000.0 ≥ MinimumOffTime ≥ 0.0
Config.InputScaling.UpperPointIn(1)	REAL	27648.0	Scaling Input_PER high Input_PER is scaled based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn. Only takes effect if Input_PER is used for process value acquisition (Config.InputPerOn = TRUE). UpperPointIn > LowerPointIn
Config.InputScaling.LowerPointIn(1)	REAL	0.0	Scaling Input_PER low Input_PER is scaled based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn. Only takes effect if Input_PER is used for process value acquisition (Config.InputPerOn = TRUE). LowerPointIn < UpperPointIn

Tag	Data type	Default	Description
Config.InputScaling.UpperPointOut(1)	REAL	100.0	Scaled high process value Input_PER is scaled based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn. Only takes effect if Input_PER is used for process value acquisition (Config.InputPerOn = TRUE). UpperPointOut > LowerPointOut
Config.InputScaling.LowerPointOut(1)	REAL	0.0	Scaled low process value Input_PER is scaled based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn. Only takes effect if Input_PER is used for process value acquisition (Config.InputPerOn = TRUE). LowerPointOut < UpperPointOut
CycleTime.StartEstimation	BOOL	TRUE	If CycleTime.EnEstimation = TRUE, CycleTime.StartEstimation = TRUE starts the automatic determination of the PID_Compact sampling time (cycle time of the calling OB). Once measurement is complete, CycleTime.StartEstimation = FALSE is set.
CycleTime.EnEstimation	BOOL	TRUE	If CycleTime.EnEstimation = TRUE, the PID_Compact sampling time is determined automatically. If CycleTime.EnEstimation = FALSE, the PID_Compact sampling time is not determined automatically and must be configured correctly manually with CycleTime.Value.
CycleTime.EnMonitoring	BOOL	TRUE	If CycleTime.EnMonitoring = FALSE, the PID_Compact sampling time is not monitored. If PID_Compact cannot be executed within the sampling time, no error (ErrorBits=16#0000_0800) is output and PID_Compact does not respond as configured with ActivateRecoverMode.
CycleTime.Value(1)	REAL	0.1	PID_Compact sampling time (cycle time of the calling OB) in seconds CycleTime.Value is determined automatically and is usually equivalent to the cycle time of the calling OB.
You can load values from the CtrlParamsBackUp structure with LoadBackUp = TRUE.			
CtrlParamsBackUp.SetByUser	BOOL	FALSE	Saved value of Retain.CtrlParams.SetByUser (as of Version 3.0)
CtrlParamsBackUp.Gain	REAL	1.0	Saved proportional gain
CtrlParamsBackUp.Ti	REAL	20.0	Saved integration time in seconds
CtrlParamsBackUp.Td	REAL	0.0	Saved derivative action time in seconds
CtrlParamsBackUp.TdFiltRatio	REAL	0.2	Saved derivative delay coefficient
CtrlParamsBackUp.PWeighting	REAL	1.0	Saved proportional action weighting factor
CtrlParamsBackUp.DWeighting	REAL	1.0	Saved derivative action weighting factor
CtrlParamsBackUp.Cycle	REAL	1.0	Saved sampling time of PID algorithm in seconds
CtrlParamsBackUp.DeadZone	REAL	0.0	Saved dead zone width (as of Version 3.0)

Tag	Data type	Default	Description
PIDSelfTune.SUT.CalculateParams	BOOL	FALSE	The properties of the controlled system are saved during tuning. If SUT.CalculateParams = TRUE, the parameters for pretuning are recalculated according to these properties. This enables you to change the parameter calculation method without having to repeat controller tuning. SUT.CalculateParams is set to FALSE after the calculation.
PIDSelfTune.SUT.TuneRule	INT	0	Methods used to calculate parameters during pretuning: • SUT.TuneRule = 0: PID according to Chien, Hrones and Reswick • SUT.TuneRule = 1: PI according to Chien, Hrones and Reswick
PIDSelfTune.SUT.State	INT	0	The SUT.State tag indicates the current phase of pretuning: • State = 0: Initialize pretuning • State = 100: Calculate the standard deviation • State = 200: Find the point of inflection • State = 9900: Pretuning successful • State = 1: Pretuning not successful
PIDSelfTune.TIR.RunIn	BOOL	FALSE	With the RunIn tag, you can specify that fine tuning can also be performed without pretuning. • RunIn = FALSE Pretuning is started when fine tuning is started from inactive or manual mode. If the requirements for pretuning are not met, PID_Compact reacts as if RunIn = TRUE. If fine tuning is started from automatic mode, the system uses the existing PID parameters to control to the setpoint. Only then will fine tuning start. If pretuning is not possible, PID_Compact switches to the mode from which tuning was started. • RunIn = TRUE The pretuning is skipped. PID_Compact attempts to reach the setpoint with the minimum or maximum output value. This can produce increased overshoot. Fine tuning then starts automatically. RunIn is set to FALSE after fine tuning.
PIDSelfTune.TIR.CalculateParams	BOOL	FALSE	The properties of the controlled system are saved during tuning. If TIR.CalculateParams = TRUE, the parameters for fine tuning are recalculated according to these properties. This enables you to change the parameter calculation method without having to repeat controller tuning. TIR.CalculateParams is set to FALSE after the calculation.

Tag	Data type	Default	Description
PIDSelfTune.TIR.TuneRule	INT	0	Methods used to calculate parameters during fine tuning: • TIR.TuneRule = 0: PID automatic • TIR.TuneRule = 1: PID fast (faster control response with higher amplitudes of the output value than with TIR.TuneRule = 2) • TIR.TuneRule = 2: PID slow (slower control response with lower amplitudes of the output value than with TIR.TuneRule = 1) • TIR.TuneRule = 3: Ziegler-Nichols PID • TIR.TuneRule = 4: Ziegler-Nichols PI • TIR.TuneRule = 5: Ziegler-Nichols P To be able to repeat the calculation of the PID parameters with TIR.CalculateParams and TIR.TuneRule = 0, 1 or 2, the previous fine tuning also has to have been executed with TIR.TuneRule = 0, 1 or 2. If this is not the case, TIR.TuneRule = 3 is used. The recalculation of the PID parameters with TIR.CalculateParams and TIR.TuneRule = 3, 4 or 5 is always possible.
PIDSelfTune.TIR.State	INT	0	The TIR.State tag indicates the current phase of fine tuning: • State = -100 Fine tuning is not possible. Pretuning will be performed first. • State = 0: Initialize fine tuning • State = 200: Calculate the standard deviation • State = 300: Attempt to reach setpoint • State = 400: Attempt to reach setpoint with existing PID parameters (if pretuning was successful) • State = 500: Determine oscillation and calculate parameters • State = 9900: Fine tuning successful • State = 1: Fine tuning not successful
PIDCtrl.IntegralSum(1)	REAL	0.0	Current integral action
PIDCtrl.PIDInit	BOOL	FALSE	PIDCtrl.PIDInit is available as of PID_Compact version 2.3. If PIDCtrl.PIDInit = TRUE in "Automatic mode", the integral action PIDCtrl.IntegralSum is preassigned automatically as if Output = OverwriteInitialOutputValue in the previous cycle. This can be used for a Override control with PID_Compact as of V2 (Page 94).
Retain.CtrlParams.SetByUser(1)	BOOL	FALSE	Enable manual input of PID parameters (as of Version 3.0) If Retain.CtrlParams.SetByUser = TRUE, the PID parameters are editable. Retain.CtrlParams.SetByUser is used for configuring the controller in the TIA Portal and has no influence on the behavior of the control algorithm in the CPU. SetByUser is retentive.
_Retain.CtrlParams.SetByUser(1)	BOOL	FALSE	Enable manual input of PID parameters (up to Version 2.4) If _Retain.CtrlParams.SetByUser = TRUE, the PID parameters are editable.

Tag	Data type	Default	Description
			_Retain.CtrlParams.SetByUser is used for configuring the controller in the TIA Portal and has no influence on the behavior of the control algorithm in the CPU. _Retain.CtrlParams.SetByUser is not available in the data block and can only be configured in the configuration editor or via the Openness API. When importing PID_Compact via the Openness API, _Retain.CtrlParams.SetByUser is reset to the default value.
Retain.CtrlParams.Gain(1)	REAL	1.0	Active proportional gain PID_Compact does not work with a negative proportional gain. To invert the control logic, use the Config.InvertControl tag. Gain is retentive. Gain ≥ 0.0
Retain.CtrlParams.Ti(1)	REAL	20.0	• CtrlParams.Ti > 0.0: Active integration time in seconds • CtrlParams.Ti = 0.0: Integral action is deactivated Ti is retentive. 100000.0 ≥ Ti ≥ 0.0
Retain.CtrlParams.Td(1)	REAL	0.0	• CtrlParams.Td > 0.0: Active derivative action time in seconds • CtrlParams.Td = 0.0: Derivative action is deactivated Td is retentive. 100000.0 ≥ Td ≥ 0.0
Retain.CtrlParams.TdFiltRatio(1)	REAL	0.2	Active derivative delay coefficient The derivative delay coefficient delays the effect of the derivative action. Derivative delay = derivative action time × derivative delay coefficient • 0.0: Derivative action is effective for one cycle only and therefore almost not effective. • 0.5: This value has proved useful in practice for controlled systems with **one** dominant time constant. • > 1.0: The greater the coefficient, the longer the effect of the derivative action is delayed. TdFiltRatio is retentive. TdFiltRatio ≥ 0.0
Retain.CtrlParams.PWeighting(1)	REAL	1.0	Active proportional action weighting The proportional action may weaken with changes to the setpoint. Values from 0.0 to 1.0 are applicable. • 1.0: Proportional action for setpoint change is fully effective • 0.0: Proportional action for setpoint change is not effective The proportional action is always fully effective when the process value is changed. PWeighting is retentive. 1.0 ≥ PWeighting ≥ 0.0

Tag	Data type	Default	Description
Retain.CtrlParams.DWeighting(1)	REAL	1.0	Active derivative action weighting The derivative action may weaken with changes to the setpoint. Values from 0.0 to 1.0 are applicable. • 1.0: Derivative action is fully effective upon setpoint change • 0.0: Derivative action is not effective upon setpoint change The derivative action is always fully effective when the process value is changed. DWeighting is retentive. 1.0 ≥ DWeighting ≥ 0.0
Retain.CtrlParams.Cycle(1)	REAL	1.0	Active sampling time of the PID algorithm in seconds CtrlParams.Cycle is calculated during tuning and rounded to an integer multiple of CycleTime.Value. CtrlParams.Cycle is used as time period of the pulse width modulation. Cycle is retentive. 100000.0 ≥ Cycle > 0.0
Retain.CtrlParams.DeadZone(1)	REAL	0.0	Active dead zone width CtrlParams.DeadZone is available as of PID_Compact Version 3.0. With CtrlParams.DeadZone = 0.0, the dead zone is switched off. CtrlParams.DeadZone is not set automatically or adjusted during tuning. You must correctly configure CtrlParams.DeadZone manually. When the dead zone is switched on, the result can be a permanent control deviation (deviation between setpoint and process value). This can have a negative effect on fine tuning. DeadZone is retentive. DeadZone ≥ 0.0

See also

ActivateRecoverMode tag as of V2 (Page 273)
Warning tag as of V2 (Page 274)
Downloading technology objects to device (Page 46)

11.1.4.8 Changing the interface of PID_Compact as of V2

The following table shows what has changed in the PID_Compact instruction interface.

PID_Compact V1	PID_Compact as of V2	Change
Input_PER	Input_PER	Data type from Word to Int
	Disturbance	New
	ErrorAck	New
	ModeActivate	New
Output_PER	Output_PER	Data type from Word to Int

PID_Compact V1	PID_Compact as of V2	Change
Error	ErrorBits	Renamed
	Error	New
	Mode	New
sb_RunModeByStartup	RunModeByStartup	Function
	IntegralResetMode	
	OverwriteInitialOutputValue	New
	SetSubstituteOutput	New
	CancelTuningLevel	New
	SubstituteOutput	New

The following table shows which variables have been renamed.

PID_Compact V1.x	PID_Compact as of V2
sb_GetCycleTime	CycleTime.StartEstimation
sb_EnCyclEstimation	CycleTime.EnEstimation
sb_EnCyclMonitoring	CycleTime.EnMonitoring
sb_RunModeByStartup	RunModeByStartup
si_Unit	PhysicalUnit
si_Type	PhysicalQuantity
sd_Warning	Warning
sBackUp.r_Gain	CtrlParamsBackUp.Gain
sBackUp.r_Ti	CtrlParamsBackUp.Ti
sBackUp.r_Td	CtrlParamsBackUp.Td
sBackUp.r_A	CtrlParamsBackUp.TdFiltRatio
sBackUp.r_B	CtrlParamsBackUp.PWeighting
sBackUp.r_C	CtrlParamsBackUp.DWeighting
sBackUp.r_Cycle	CtrlParamsBackUp.Cycle
sPid_Calc.r_Cycle	CycleTime.Value
sPid_Calc.b_RunIn	PIDSelfTune.TIR.RunIn
sPid_Calc.b_CalcParamSUT	PIDSelfTune.SUT.CalculateParams
sPid_Calc.b_CalcParamTIR	PIDSelfTune.TIR.CalculateParams
sPid_Calc.i_CtrlTypeSUT	PIDSelfTune.SUT.TuneRule
sPid_Calc.i_CtrlTypeTIR	PIDSelfTune.TIR.TuneRule
sPid_Calc.r_Progress	Progress
sPid_Cmpt.r_Sp_Hlm	Config.SetpointUpperLimit
sPid_Cmpt.r_Sp_Llm	Config.SetpointLowerLimit
sPid_Cmpt.r_Pv_Norm_IN_1	Config.InputScaling.LowerPointIn
sPid_Cmpt.r_Pv_Norm_IN_2	Config.InputScaling.UpperPointIn
sPid_Cmpt.r_Pv_Norm_OUT_1	Config.InputScaling.LowerPointOut
sPid_Cmpt.r_Pv_Norm_OUT_2	Config.InputScaling.UpperPointOut

PID_Compact V1.x	PID_Compact as of V2
sPid_Cmpt.r_Lmn_Hlm	Config.OutputUpperLimit
sPid_Cmpt.r_Lmn_Llm	Config.OutputLowerLimit
sPid_Cmpt.b_Input_PER_On	Config.InputPerOn
sPid_Cmpt.b_LoadBackUp	LoadBackUp
sPid_Cmpt.b_InvCtrl	Config.InvertControl
sPid_Cmpt.r_Lmn_Pwm_PPTm	Config.MinimumOnTime
sPid_Cmpt.r_Lmn_Pwm_PBTm	Config.MinimumOffTime
sPid_Cmpt.r_Pv_Hlm	Config.InputUpperLimit
sPid_Cmpt.r_Pv_Llm	Config.InputLowerLimit
sPid_Cmpt.r_Pv_HWrn	Config.InputUpperWarning
sPid_Cmpt.r_Pv_LWrn	Config.InputLowerWarning
sParamCalc.i_Event_SUT	PIDSelfTune.SUT.State
sParamCalc.i_Event_TIR	PIDSelfTune.TIR.State
sRet.i_Mode	sRet.i_Mode has been omitted. The operating mode is changed using Mode and ModeActivate.
sRet.r_Ctrl_Gain	Retain.CtrlParams.Gain
sRet.r_Ctrl_Ti	Retain.CtrlParams.Ti
sRet.r_Ctrl_Td	Retain.CtrlParams.Td
sRet.r_Ctrl_A	Retain.CtrlParams.TdFiltRatio
sRet.r_Ctrl_B	Retain.CtrlParams.PWeighting
sRet.r_Ctrl_C	Retain.CtrlParams.DWeighting
sRet.r_Ctrl_Cycle	Retain.CtrlParams.Cycle

11.1.4.9 State and Mode as of V2 parameters

Correlation of the parameters

The State parameter shows the current operating mode of the PID controller. You cannot change the State parameter.

With a rising edge at ModeActivate, PID_Compact switches to the operating mode saved in the Mode in-out parameter.

When the CPU is switched on or switches from Stop to RUN mode, PID_Compact starts in the operating mode that is saved in the Mode parameter. To retain PID_Compact in "Inactive" mode, set RunModeByStartup = FALSE.

Meaning of values

State / Mode	Description of operating mode
0	Inactive In "Inactive" operating mode, the output value 0.0 is always output, regardless of Config.OutputUpperLimit and Config.OutputLowerLimit. Pulse width modulation is off.
1	Pretuning The pretuning determines the process response to a jump change of the output value and searches for the point of inflection. The PID parameters are calculated from the maximum rate of rise and dead time of the controlled system. You obtain the best PID parameters when you perform pretuning and fine tuning. Pretuning requirements: • Inactive (State = 0), manual mode (State = 4), or automatic mode (State = 3) • ManualEnable = FALSE • Reset = FALSE • The process value must not be too close to the setpoint. |Setpoint - Input| > 0.3 * | Config.InputUpperLimit - Config.InputLowerLimit| and |Setpoint - Input| > 0.5 * |Setpoint| • The setpoint and the process value lie within the configured limits. The more stable the process value is, the easier it is to calculate the PID parameters and the more precise the result will be. Noise on the process value can be tolerated as long as the rate of rise of the process value is significantly higher compared to the noise. The setpoint is frozen in the CurrentSetpoint tag. Tuning is canceled when: • Setpoint > CurrentSetpoint + CancelTuningLevel or • Setpoint < CurrentSetpoint - CancelTuningLevel Before the PID parameters are recalculated, they are backed up and can be reactivated with LoadBackUp. The controller switches to automatic mode following successful pretuning. If pretuning is unsuccessful, the switchover of the operating mode is dependent on ActivateRecoverMode. The phase of pretuning is indicated with PIDSelfTune.SUT.State. For starting pretuning in Automatic mode, it is recommended to perform the required setpoint change simultaneously with the rising edge at ModeActivate. If the setpoint is changed first and the pretuning is started later, the output value in automatic mode is adjusted accordingly and causes a change to the process value. This can have a negative effect on the subsequent pretuning or prevent it from starting.
2	Fine tuning Fine tuning generates a constant, limited oscillation of the process value. The PID parameters are recalculated based on the amplitude and frequency of this oscillation. PID parameters from fine tuning usually have better master control and disturbance characteristics than PID parameters from pretuning. You obtain the best PID parameters when you perform pretuning and fine tuning. PID_Compact automatically attempts to generate an oscillation greater than the noise of the process value. Fine tuning is only minimally influenced by the stability of the process value. The setpoint is frozen in the CurrentSetpoint tag. Tuning is canceled when: • Setpoint > CurrentSetpoint + CancelTuningLevel or • Setpoint < CurrentSetpoint - CancelTuningLevel Before the PID parameters are recalculated, they are backed up and can be reactivated with LoadBackUp. Requirements for fine tuning: • No disturbances are expected. • The setpoint and the process value lie within the configured limits. • ManualEnable = FALSE • Reset = FALSE • Automatic (State = 3), inactive (State = 0) or manual (State = 4) mode

State / Mode	Description of operating mode
	Fine tuning proceeds as follows when started from: • Automatic mode (State = 3) Start fine tuning from automatic mode if you wish to improve the existing PID parameters through tuning. PID_Compact controls the system using the existing PID parameters until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start. • Inactive (State = 0) or manual mode (State = 4) If the requirements for pretuning are met, pretuning is started. The determined PID parameters will be used for control until the control loop has stabilized and the requirements for fine tuning have been met. If the process value for pretuning is already too near the setpoint or PIDSelfTune.TIR.RunIn = TRUE, an attempt is made to reach the setpoint with the minimum or maximum output value. This can produce increased overshoot. Only then will fine tuning start. The controller switches to automatic mode following successful fine tuning. If fine tuning is unsuccessful, the switchover of the operating mode is dependent on ActivateRecoverMode. The "Fine tuning" phase is indicated with PIDSelfTune.TIR.State.
3	Automatic mode In automatic mode, PID_Compact corrects the controlled system in accordance with the parameters specified. The controller switches to automatic mode if one the following requirements is fulfilled: • Pretuning successfully completed • Fine tuning successfully completed • Changing of the Mode in-out parameter to the value 3 and a rising edge at ModeActivate. The switchover from automatic mode to manual mode is only bumpless if carried out in the commissioning editor. The ActivateRecoverMode tag is taken into consideration in automatic mode.
4	Manual mode In manual mode, you specify a manual output value in the ManualValue parameter. You can also activate this operating mode using ManualEnable = TRUE. We recommend that you change the operating mode using Mode and ModeActivate only. The switchover from manual mode to automatic mode is bumpless. Manual mode is also possible when an error is pending.
5	Substitute output value with error monitoring The control algorithm is deactivated. The SetSubstituteOutput tag determines which output value is output in this operating mode. • SetSubstituteOutput = FALSE: Last valid output value • SetSubstituteOutput = TRUE: Substitute output value You cannot activate this operating mode using Mode = 5. In the event of an error, it is activated instead of "Inactive" operating mode if all the following conditions are met: • Automatic mode (Mode = 3) • ActivateRecoverMode = TRUE • One or more errors have occurred in which ActivateRecoverMode is effective. As soon as the errors are no longer pending, PID_Compact switches back to automatic mode.

ENO characteristics

If State = 0, then ENO = FALSE.

If State ≠ 0, then ENO = TRUE.

Automatic switchover of operating mode during commissioning

Automatic mode is activated following successful pretuning or fine tuning. The following table shows how Mode and State change during successful pretuning.

Cycle no.	Mode	State	Action
0	4	4	Set Mode = 1
1	1	4	Set ModeActivate = TRUE
1	4	1	Value of State is saved in Mode parameter Pretuning is started
n	4	1	Pretuning successfully completed
n	3	3	Automatic mode is started

PID_Compact automatically switches the operating mode in the event of an error. The following table shows how Mode and State change during pretuning with errors.

Cycle no.	Mode	State	Action
0	4	4	Set Mode = 1
1	1	4	Set ModeActivate = TRUE
1	4	1	Value of State is saved in Mode parameter Pretuning is started
n	4	1	Pretuning canceled
n	4	4	Manual mode is started

If ActivateRecoverMode = TRUE, the operating mode that is saved in the Mode parameter is activated. At the start of pretuning or fine tuning, PID_Compact has saved the value of State in the Mode in/out parameter. PID_Compact therefore switches to the operating mode from which tuning was started.

If ActivateRecoverMode = FALSE, the system switches to "Inactive" operating mode.

See also

Output parameters of PID_Compact as of V2 (Page 255)

11.1.4.10 ErrorBits as of V2 parameter

If several errors are pending simultaneously, the values of the ErrorBits are displayed with binary addition. The display of ErrorBits = 16#0000_0003, for example, indicates that the errors 16#0000_0001 and 16#0000_0002 are pending simultaneously.

In manual mode, PID_Compact uses ManualValue as output value. The exception is Errorbits = 16#0001_0000.

ErrorBits (DW#16#...)	Description
0000_0000	There is no error.
0000_0001	The "Input" parameter is outside the process value limits. • Input > Config.InputUpperLimit or • Input < Config.InputLowerLimit If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Compact remains in automatic mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Compact switches to the operating mode saved in the Mode parameter.
0000_0002	Invalid value at "Input_PER" parameter. Check whether an error is pending at the analog input. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Compact outputs the configured substitute output value. As soon as the error is no longer pending, PID_Compact switches back to automatic mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Compact switches to the operating mode saved in the Mode parameter.
0000_0004	Error during fine tuning. The oscillation of the process value could not be maintained. If ActivateRecoverMode = TRUE before the error occurred, PID_Compact cancels the tuning and switches to the operating mode saved in the Mode parameter.
0000_0008	Error at start of pretuning. The process value is too close to the setpoint. Start fine tuning. If ActivateRecoverMode = TRUE before the error occurred, PID_Compact cancels the tuning and switches to the operating mode saved in the Mode parameter.
0000_0010	The setpoint was changed during tuning. You can set the permitted fluctuation of the setpoint at the CancelTuningLevel tag. If ActivateRecoverMode = TRUE before the error occurred, PID_Compact cancels the tuning and switches to the operating mode saved in the Mode parameter.
0000_0020	Pretuning is not permitted during fine tuning. If ActivateRecoverMode = TRUE before the error occurred, PID_Compact remains in fine tuning mode.
0000_0080	Error during pretuning. The output value limits are not configured correctly or the process value does not react as expected. Make sure that: • The limits of the output value are configured correctly and match the control logic. • It is possible to change the output value so that the process value approaches the setpoint. The output value is not already limited by the corresponding output value limit before the pretuning. Example: With normal control logic and a process value that is below the setpoint, the output value must not have reached the high limit before the start of the pretuning. • The process value does not show a strong oscillation before the start of the pretuning. For starting a pretuning in automatic mode, it is recommended to perform the required setpoint change simultaneously with the rising edge at ModeActivate. This prevents the output value from running into the limitation between the setpoint change and the start of the pretuning. Alternatively, this can also be achieved by starting from manual mode or "Inactive" mode. If ActivateRecoverMode = TRUE before the error occurred, PID_Compact cancels the tuning and switches to the operating mode saved in the Mode parameter.

ErrorBits (DW#16#...)	Description
0000_0100	Error during fine tuning resulted in invalid parameters. If ActivateRecoverMode = TRUE before the error occurred, PID_Compact cancels the tuning and switches to the operating mode saved in the Mode parameter.
0000_0200	Invalid value at "Input" parameter: Value has an invalid number format. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Compact outputs the configured substitute output value. As soon as the error is no longer pending, PID_Compact switches back to automatic mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Compact switches to the operating mode saved in the Mode parameter.
0000_0400	Calculation of output value failed. Check the PID parameters. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Compact outputs the configured substitute output value. As soon as the error is no longer pending, PID_Compact switches back to automatic mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Compact switches to the operating mode saved in the Mode parameter.
0000_0800	Sampling time error: PID_Compact is not called within the sampling time of the cyclic interrupt OB. It is recommended to call PID_Compact in a cyclic interrupt OB without conditions and to activate or deactivate it via the operating mode at the Mode parameter. Conditional calls or the call in OB1 can have a negative effect on the control quality. Monitoring of the sampling time can be disabled with CycleTime.EnMonitoring = FALSE. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Compact remains in automatic mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Compact switches to the operating mode saved in the Mode parameter. If this error occurred during simulation with PLCSIM, see the notes under Simulating PID_Compact as of V2 with PLCSIM (Page 98).
0000_1000	Invalid value at "Setpoint" parameter: Value has an invalid number format. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Compact outputs the configured substitute output value. As soon as the error is no longer pending, PID_Compact switches back to automatic mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Compact switches to the operating mode saved in the Mode parameter.
0001_0000	Invalid value at ManualValue parameter. Value has an invalid number format. If ActivateRecoverMode = TRUE before an error occurred, PID_Compact uses SubstituteOutput as the output value. As soon as you specify a valid value in ManualValue, PID_Compact uses it as the output value.
0002_0000	Invalid value at SubstituteOutput tag. Value has an invalid number format. PID_Compact uses the output value low limit as the output value. If automatic mode was active before the error occurred, ActivateRecoverMode = TRUE, and the error is no longer pending, PID_Compact switches back to automatic mode.
0004_0000	Invalid value at Disturbance parameter. Value has an invalid number format. If automatic mode was active and ActivateRecoverMode = TRUE before the error occurred, Disturbance is set to zero. PID_Compact remains in automatic mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Compact switches to the operating mode saved in the Mode parameter. If Disturbance in the current phase has no effect on the output value, tuning is not be canceled.

11.1.4.11 ActivateRecoverMode tag as of V2

The ActivateRecoverMode tag determines the response in the event of an error. The Error parameter indicates if an error is pending. When the error is no longer pending, Error = FALSE. The ErrorBits parameter shows which errors have occurred.

Automatic mode

NOTICE
Your system may be damaged. If ActivateRecoverMode = TRUE, PID_Compact remains in automatic mode even if there is an error and the process limit values are exceeded. This may damage your system. It is essential to configure how your controlled system responds in the event of an error to protect your system from damage.

ActivateRecover-Mode	Description
FALSE	PID_Compact automatically switches to "Inactive" mode in the event of an error. The controller is only activated by a falling edge at Reset or a rising edge at ModeActivate.
TRUE	If errors occur frequently in automatic mode, this setting has a negative effect on the control response, because PID_Compact switches between the calculated output value and the substitute output value at each error. In this case, check the ErrorBits parameter and eliminate the cause of the error. If one or more of the following errors occur, PID_Compact stays in automatic mode: • 0001h: The "Input" parameter is outside the process value limits. • 0800h: Sampling time error • 40000h: Invalid value at Disturbance parameter. If one or more of the following errors occur, PID_Compact switches to "Substitute output value with error monitoring" mode: • 0002h: Invalid value at Input_PER parameter. • 0200h: Invalid value at Input parameter. • 0400h: Calculation of output value failed. • 1000h: Invalid value at Setpoint parameter. If the following error occurs, PID_Compact switches to "Substitute output value with error monitoring" mode and moves the actuator to Config.OutputLowerLimit: • 20000h: Invalid value at SubstituteOutput tag. Value has an invalid number format. This characteristics are independent of SetSubstituteOutput. As soon as the errors are no longer pending, PID_Compact switches back to automatic mode.

Pretuning and fine tuning

ActivateRecover-Mode	Description
FALSE	PID_Compact automatically switches to "Inactive" mode in the event of an error. The controller is only activated by a falling edge at Reset or a rising edge at ModeActivate.
TRUE	If the following error occurs, PID_Compact remains in the active mode: • 0020h: Pretuning is not permitted during fine tuning. The following errors are ignored: • 10000h: Invalid value at ManualValue parameter. • 20000h: Invalid value at SubstituteOutput tag. When any other error occurs, PID_Compact cancels the tuning and switches to the mode from which tuning was started.

Manual mode

ActivateRecoverMode is not effective in manual mode.

11.1.4.12 Warning tag as of V2

If several warnings are pending simultaneously, the values of the Warning tag are displayed with binary addition. The display of the warning 16#0000_0003, for example, indicates that the warnings 0000_0001 and 0000_0002 are pending simultaneously.

Warning (DW#16#....)	Description
0000_0000	No warning pending.
0000_0001	The point of inflection was not found during pretuning.
0000_0004	The setpoint was limited to the configured limits.
0000_0008	Not all the necessary controlled system properties were defined for the selected method of calculation. Instead, the PID parameters were calculated using the TIR.TuneRule = 3 method.
0000_0010	The operating mode could not be changed because Reset = TRUE or ManualEnable = TRUE.
0000_0020	The cycle time of the calling OB limits the sampling time of the PID algorithm. Improve results by using shorter OB cycle times.
0000_0040	The process value exceeded one of its warning limits.
0000_0080	Invalid value at Mode. The operating mode is not switched.
0000_0100	The manual value was limited to the limits of the controller output.
0000_0200	The specified rule for tuning is not supported. No PID parameters are calculated.
0000_1000	The substitute output value cannot be reached because it is outside the output value limits.

The following warnings are deleted as soon as the cause is eliminated:

- 16#0000_0001
- 16#0000_0004
- 16#0000_0008
- 16#0000_0040
- 16#0000_0100

All other warnings are cleared with a rising edge at Reset or ErrorAck.

11.1.4.13 Tag IntegralResetMode as of V2

The IntegralResetMode tag determines how the integral action PIDCtrl.IntegralSum is preassigned:

- When switching from "Inactive" operating mode to "Automatic mode"
- With edge TRUE -> FALSE at parameter Reset and parameter Mode = 3

This setting only works for one cycle and only takes effect if the integral action is activated (Retain.CtrlParams.Ti > 0.0 tags).

IntegralReset-Mode	Description
0	Smooth The value of PIDCtrl.IntegralSum is preassigned so that the switchover is bumpless, which means "Automatic mode" starts with the output value = 0.0 (Output parameter) and there is no jump of the output value regardless of the control deviation (setpoint – process value).
1	Delete We recommend setting the weighting of the proportional action (Retain.CtrlParams.PWeighting) to 1.0 when this option is used. The value of PIDCtrl.IntegralSum is deleted. Any control deviation will cause a jump change of the output value. The direction of the output value jump depends on the configured weighting of the proportional action (Retain.CtrlParams.PWeighting tag) and the control deviation: • Proportional action weighting = 1.0: Output value jump and control deviation have identical signs. Example: If the process value is less than the setpoint (positive control deviation), the output value jumps to a positive value. • Proportional action weighting < 1.0: For large control deviations, the output value jump and control deviation have identical signs. Example: If the process value is much less than the setpoint (positive control deviation), the output value jumps to a positive value. For small control deviations, the output value jump and control deviation have different signs. Example: If the process value is just below the setpoint (positive control deviation), the output value jumps to a negative value. This is usually not desirable, because it results in a temporary increase in the control deviation. The smaller the configured weighting of the proportional action, the greater the control deviation must be to receive an output value jump with identical sign. We recommend setting the weighting of the proportional action (Retain.CtrlParams.PWeighting) to 1.0 when this option is used. Otherwise, you may experience the undesirable behavior described for small control deviations. Alternatively, you can also use IntegralResetMode = 4. This option guarantees identical signs of the output value jump and control deviation independent of the configured weighting of the proportional action and the control deviation.
2	Hold The value of PIDCtrl.IntegralSum is not changed. You can define a new value using the user program.
3	Preassign The value of PIDCtrl.IntegralSum is automatically preassigned as if Output = OverwriteInitialOutputValue in the last cycle.
4	Like setpoint change (only for PID_Compact with version ≥ 2.3) The value of PIDCtrl.IntegralSum is automatically preassigned so that a similar output value jump results as for a PI controller in automatic mode in case of a setpoint change from the current process value to the current setpoint. Any control deviation will cause a jump change of the output value. Output value jump and control deviation have identical signs.

IntegralReset-Mode	Description
	Example: If the process value is less than the setpoint (positive control deviation), the output value jumps to a positive value. This is independent of the configured weighting of the proportional action and the control deviation.

If IntegralResetMode is assigned a value outside the valid value range, PID_Compact behaves as with the preassignment of IntegralResetMode:

- PID_Compact up to V2.2: IntegralResetMode = 1
- PID_Compact as of V2.3: IntegralResetMode = 4

All statements made above regarding the sign of the output value jump are based on a normal control logic (Config.InvertControl = FALSE tag). With an inverted control logic (Config.InvertControl = TRUE), the output value jump will have a reverse sign.

11.1.4.14 Example program for PID_Compact V2

In the following example, you are controlling temperature values with the technology object of the instruction "PID_Compact". The temperature values are simulated based on a block which simulates a delay element of the third order (PT3 element). The PID parameters of the technology object can be set automatically via the pretuning.

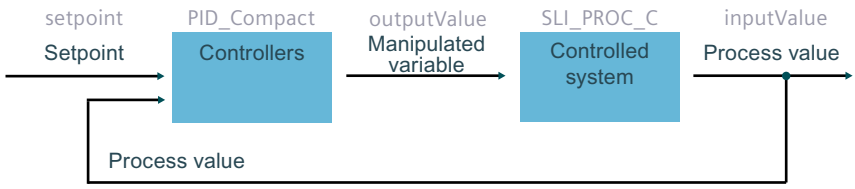

Data storage

Create seven tags in a global data block for storage of the interconnection data.

SLI_gDB_PID_Compact

		Name	Data type	Start value
1		Static		
2		setpoint	Real	75.0
3		inputValue	Real	0.0
4		outputValue	Real	0.0
5		state	Int	0
6		error	Bool	false
7		errorBits	DWord	16#0
8		resetAll	Bool	false

Interconnection of the parameters

You call the following interconnections in a cyclic interrupt OB.

Network 1: You interconnect the parameters of the instruction "PID_Compact" as follows.

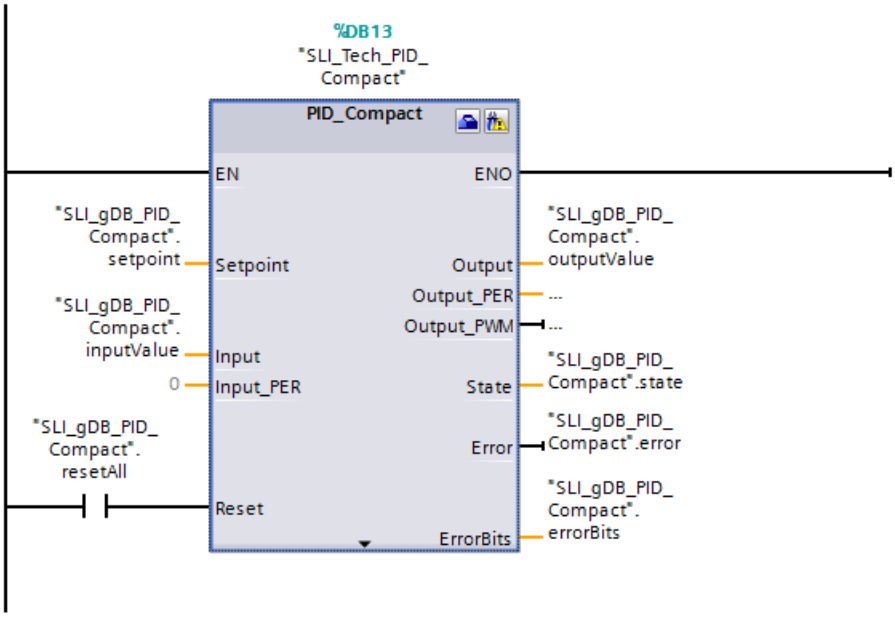

Network 2: You interconnect the parameters of the block simulating the temperature values "SLI_PROC_C" as follows.

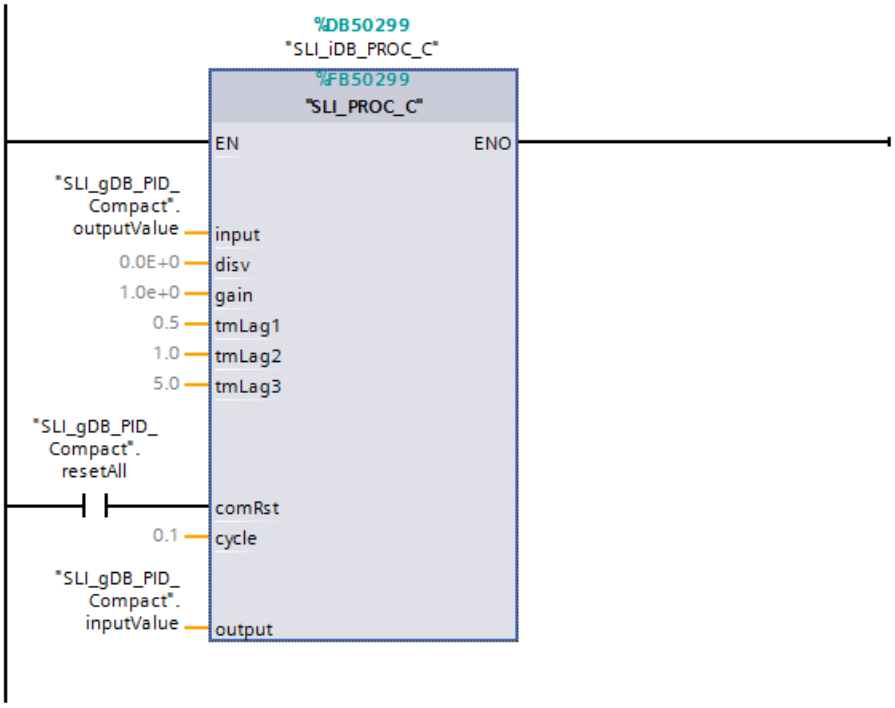

Technology object

You configure the technology object with the properties of the instruction "PID_Compact" or by using the path Technology object > Configuration. The controller type and the input/output parameters are important for the example. With the controller type, you make a preselection for the unit of the value to the controlled. In this example, "Temperature" with the unit "°C" is used as controller type. The parameters of the "PID_Compact" are already interconnected with global tags. Therefore, the information on use of the parameters Input and Output is sufficient.

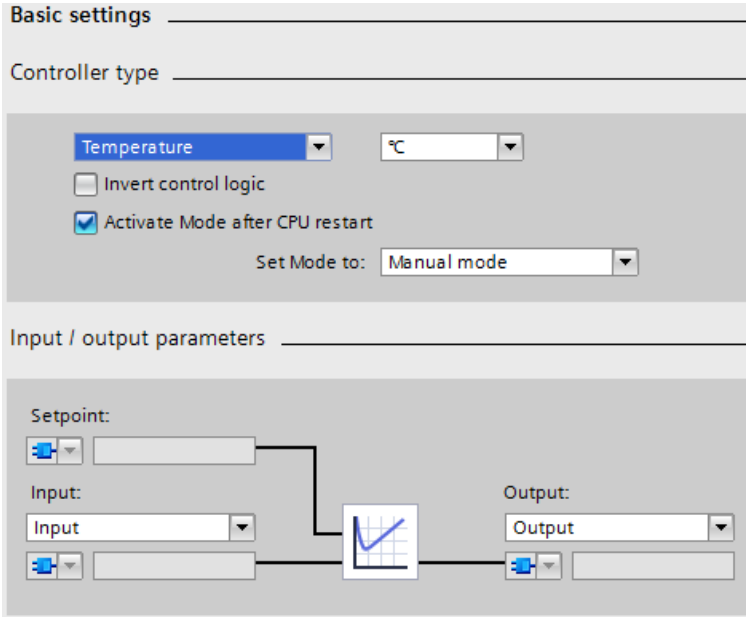

Procedure for starting the control

After the download to the CPU the PID_Compact is in manual mode with manual value 0.0. To start the control, follow these steps:

1. Open the Commissioning of the technology object "SLI_Tech_PID_Compact".
2. Click the "Start" button in the "Measurement" area.

Measurement starts and PID_Compact can be activated.

3. Pretuning is selected.

   Click the "Start" button in the "Tuning mode" area.

   A pretuning is performed. The PID parameters are automatically adjusted to the process. After the completion of the pretuning PID_Compact switches to automatic mode.

NOTE

Alternative to start PID_Compact

Alternatively, you can switch PID_Compact to automatic mode in the "Online status of controller" area with the "Stop PID_Compact" / "Start PID_Compact" without pretuning. In this case the controller uses default values for the PID parameters and shows a worse controller behavior for the application case.

Procedure for stopping control

To stop and exit PID_Compact and the program, follow these steps:

1. Click the "Stop PID_Compact" button in the technology object "SLI_Tech_PID_Compact" in the "Online status of controller" area.

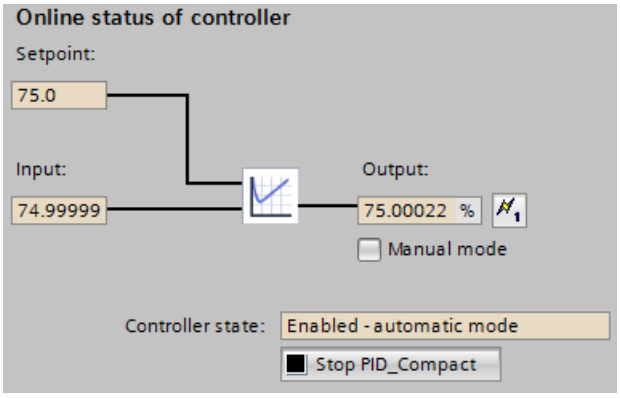

   The instruction "PID_Compact" exits the control and outputs the value "0.0" as manipulated variable.

2. Click the "Stop" button in the "Measurement" area.
3. To set the process value immediately to the value "0.0", follow these steps:

   In the block "SLI_OB_PID_Compact", set the "resetAll" tag to the value "TRUE", and then to the value "FALSE".

"PID_Compact" instruction

The setpoint for the temperature that is to be controlled is specified at the parameter Setpoint ("setpoint"). The control is started when the instruction "PID_Compact" was started with the technology object. The instruction "PID_Compact" outputs a manipulated variable at the output parameter Output ("outputValue"). The process value of the temperature is transferred to the instruction "PID_Compact" with the input parameter Input ("inputValue").

The instruction "PID_Compact" adjusts the manipulated variable ("outputValue") depending on the history of the difference between setpoint ("setpoint") and process value ("inputValue") . The process is repeated so that the process value ("inputValue") approaches the setpoint ("setpoint") through the manipulated variable ("outputValue").

The current operating mode of the instruction "PID_Compact" is displayed at the output parameter State ("state"). After pretuning (the value of "state" is "1"), the PID_Compact switches to automatic mode (the value is "3").

The output parameter Error ("error") currently shows that no error is pending. The output parameter ErrorBits ("errorBits") provides information on the error type in case of error. If an error occurs, this can be acknowledged in the technology object, in the optimization status area with the "ErrorAck" button.

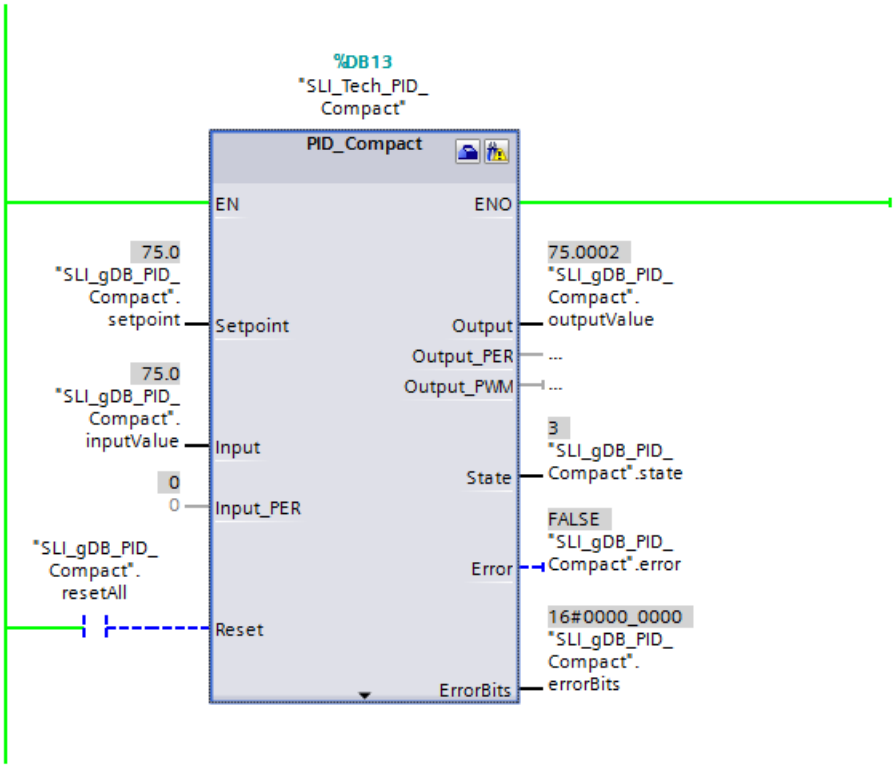

"SLI_PROC_C" block

The "SLI_PROC_C" block simulates the process value ("inputValue") of the rising temperature of a plant. The block "SLI_PROC_C" contains the manipulated variable of the controller ("outputValue) and simulates the temperature behavior of the process. This temperature is fed as process value ("inputValue") into the controller.

A change in the values of the "resetAll" tag (of the comRst parameter) has the following effects:

Parameter comRst ("resetAll")	The instruction "PID_Compact" is running	The instruction "PID_Compact" was stopped
comRst ("resetAll") remains set to the value "FALSE"	The "SLI_PROC_C" block outputs a new process value ("inputValue") based on a manipulated variable ("outputValue").	The "SLI_PROC_C" block does not receive a manipulated variable > "0.0", but it still outputs a new process value > "0.0".
comRst ("resetAll"): Change from "FALSE" to the value "TRUE"	Both manipulated variable ("outputValue") and output process value ("inputValue") are reset to "0.0".	The output process value ("inputValue") / the temperature of the "SLI_PROC_C" block is reset to "0.0".
comRst ("resetAll"): Change from "TRUE" to the value "FALSE"	Temperature control starts again.	The output process value / the temperature ("inputValue") remains "0.0".

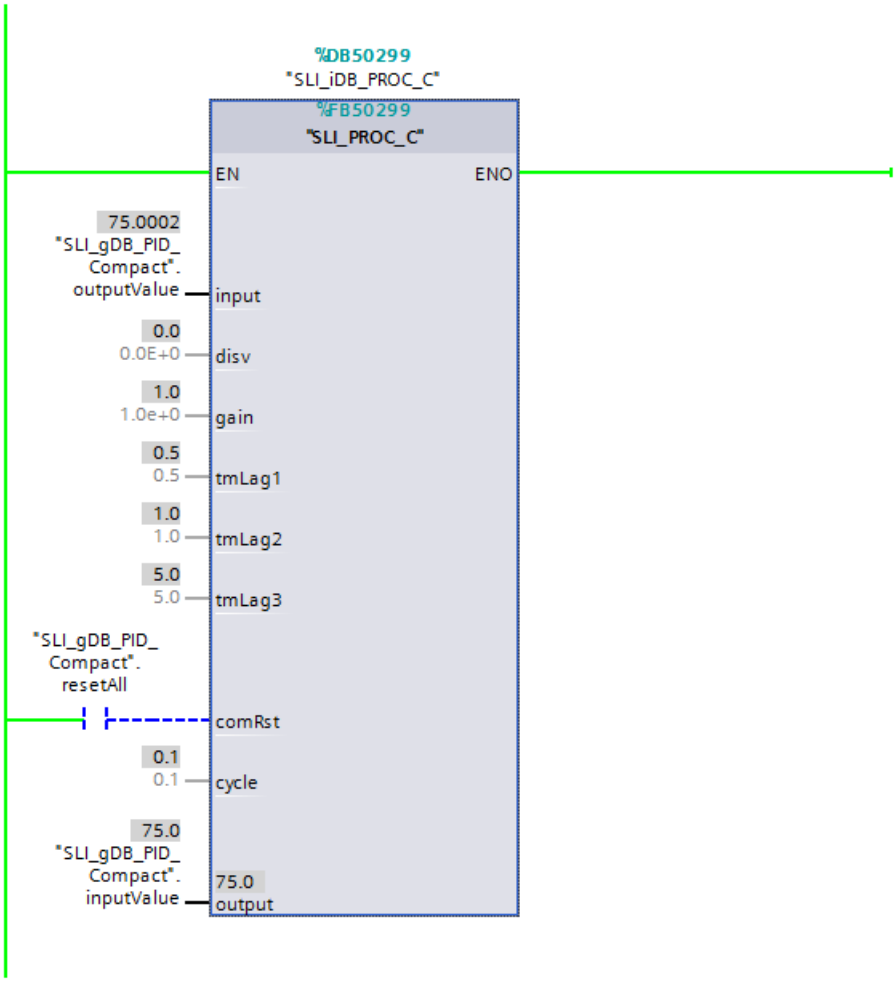

Program code

You can find additional information about the program code for the above-named example under the keyword "Sample Library for Instructions".

11.1.5 PID_Compact V1

11.1.5.1 Description of PID_Compact V1

Description

The PID_Compact instruction provides a PID controller with integrated tuning for automatic and manual mode.

Call

PID_Compact is called in the constant interval of the cycle time of the calling OB (preferably in a cyclic interrupt OB).

Download to device

The actual values of retentive tags are only updated when you download PID_Compact completely.

Downloading technology objects to device (Page 46)

Startup

At the startup of the CPU, PID_Compact starts in the operating mode that was last active. To retain PID_ Compact in "Inactive" mode, set sb_RunModeByStartup = FALSE.

Monitoring of the sampling time PID_Compact

Ideally, the sampling time is equivalent to the cycle time of the calling OB. The PID_Compact instruction measures the time interval between two calls. This is the current sampling time. On every switchover of operating mode and during the initial startup, the mean value is formed from the first 10 sampling times. Too great a difference between the current sampling time and this mean value triggers an error (Error = 0800 hex) and PID_Compact switches to "Inactive" mode.

PID_Compact as of Version 1.1 is set to "Inactive" mode during controller tuning under the following conditions:

- New mean value >= 1.1 x old mean value
- New mean value <= 0.9 x old mean value

In automatic mode, PID_Compact, as of Version 1.1, is set to "Inactive" mode under the following conditions:

- New mean value >= 1.5 x old mean value
- New mean value <= 0.5 x old mean value

During controller tuning and in automatic mode, PID_Compact 1.0 is set to "Inactive" operating mode under the following conditions:

- New mean value >= 1.1 x old mean value
- New mean value <= 0.9 x old mean value
- Current sampling time >= 1.5 x current mean value
- Current sampling time <= 0.5 x current mean value

Sampling time of the PID algorithm

The controlled system needs a certain amount of time to respond to changes in the output value. It is therefore not advisable to calculate the output value in every cycle. The sampling time of the PID algorithm represents the time between two calculations of the output value. It is calculated during tuning and rounded to a multiple of the cycle time. All other functions of PID_Compact are executed at every call.

PID algorithm

PID_Compact is a PIDT1 controller with anti-windup and weighting of the proportional and derivative actions. The following equation is used to calculate the transfer function:

$$y = K_p \left[(b \cdot w - x) + \frac{1}{T_I \cdot s}(w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1}(c \cdot w - x) \right]$$

The table below shows the meaning of the icons used in the transfer function and in the subsequent figures:

Icon	Description
y	Output value of the PID algorithm
K_p	Proportional gain
s	Laplace operator
b	Proportional action weighting
w	Setpoint
x	Process value
T_I	Integration time
T_D	Derivative action time
a	Derivative delay coefficient (derivative delay T1 = a × T_D)
c	Derivative action weighting

Block diagram of PID_Compact

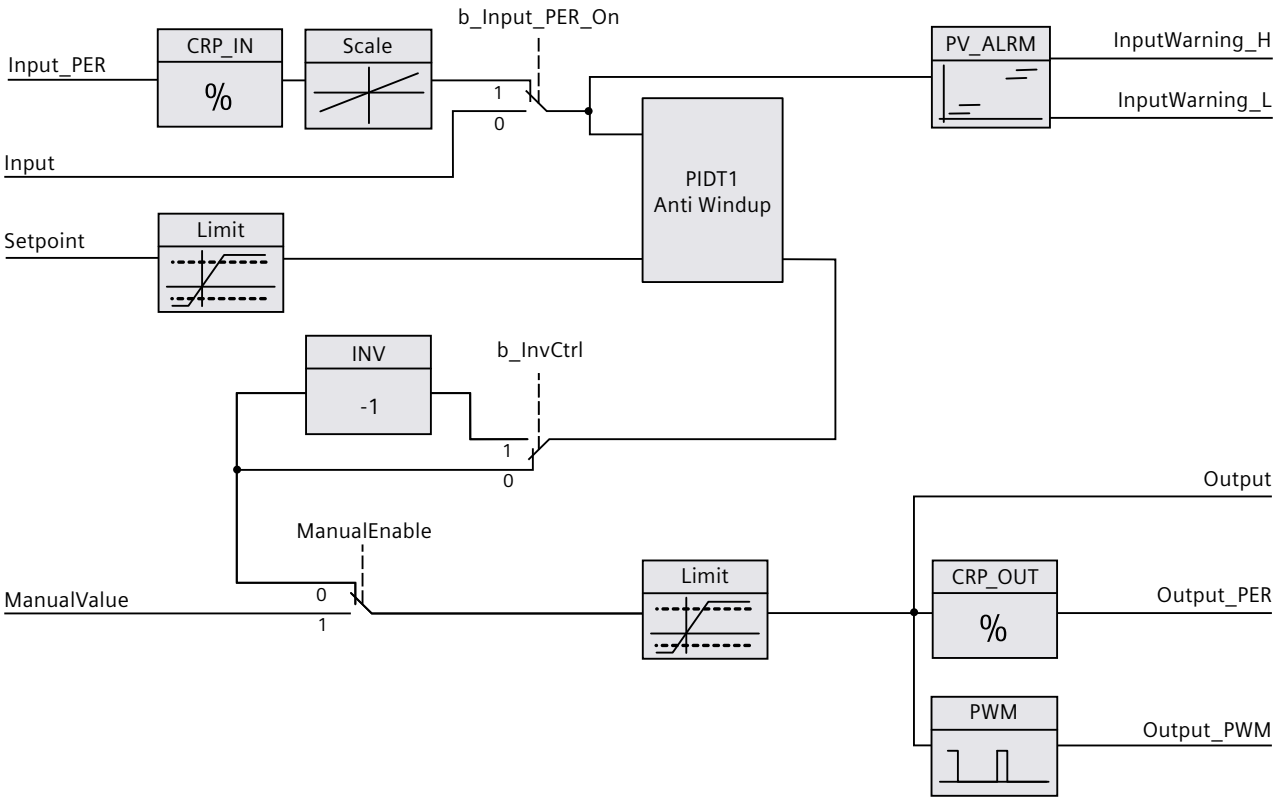

Block diagram of PIDT1 with anti-windup

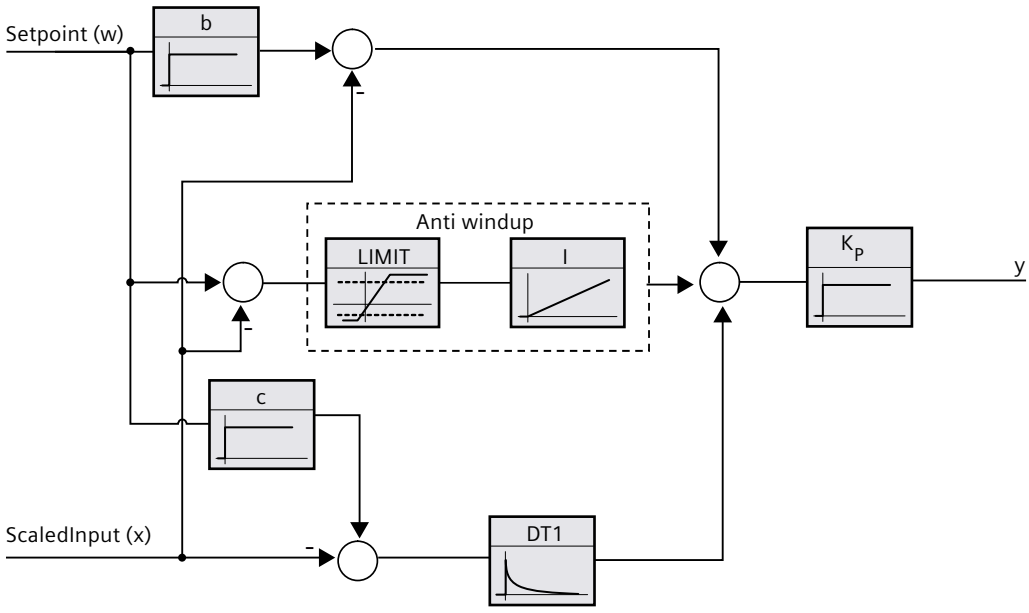

Response to errors

If errors occur, they are output in parameter Error, and PID_Compact changes to "Inactive" mode. Reset the errors using the Reset parameter.

Control logic

An increase of the output value is generally intended to cause an increase in the process value. This is referred to as a normal control logic. For cooling and discharge control systems, it may be necessary to invert the control logic. PID_Compact does not work with negative proportional gain. If InvertControl = TRUE, an increasing control deviation causes a reduction in the output value. The control logic is also taken into account during pretuning and fine tuning.

See also

Control mode V1 (Page 99)

11.1.5.2 Input parameters of PID_Compact V1

Table 3-1121

Parameter	Data type	Default	Description
Setpoint	REAL	0.0	Setpoint of the PID controller in automatic mode
Input	REAL	0.0	A variable of the user program is used as source for the process value. If you are using parameter Input, then sPid_Cmpt.b_Input_PER_On = FALSE must be set.
Input_PER	WORD	W#16#0	Analog input as the source of the process value If you are using parameter Input_PER, then sPid_Cmpt.b_Input_PER_On = TRUE must be set.
ManualEnable	BOOL	FALSE	• A FALSE -> TRUE edge selects "Manual mode", while State = 4, sRet.i_Mode remains unchanged. • A TRUE -> FALSE edge selects the most recently active operating mode, State =sRet.i_Mode. A change of sRet.i_Mode will not take effect during ManualEnable = TRUE. The change of sRet.i_Mode will only be considered upon a TRUE -> FALSE edge at ManualEnable . **PID_Compact V1.2 and PID_Compact V1.0** If at start of the CPU ManualEnable = TRUE, PID_Compact starts in manual mode. A rising edge (FALSE > TRUE) at ManualEnable is not necessary. **PID_Compact V1.1** At the start of the CPU, PID_Compact only switches to manual mode with a rising edge (FALSE->TRUE) at ManualEnable . Without rising edge, PID_Compact starts in the last operating mode in which ManualEnable was FALSE.
ManualValue	REAL	0.0	Manual value This value is used as the output value in manual mode.
Reset	BOOL	FALSE	The Reset parameter (Page 296) restarts the controller.

11.1.5.3 Output parameters of PID_Compact V1

Table 3-1122

Parameter	Data type	Default	Description
ScaledInput	REAL	0.0	Output of the scaled process value
Outputs "Output", "Output_PER", and "Output_PWM" can be used concurrently.			
Output	REAL	0.0	Output value in REAL format
Output_PER	WORD	W#16#0	Analog output value
Output_PWM	BOOL	FALSE	Pulse-width-modulated output value The output value is formed by minimum On and Off times.
SetpointLimit_H	BOOL	FALSE	If SetpointLimit_H = TRUE, the setpoint absolute high limit is reached. The setpoint in the CPU is limited to the configured setpoint absolute high limit. The configured process value absolute high limit is the default for the setpoint high limit. If you set sPid_Cmpt.r_Sp_Hlm to a value within the process value limits, this value is used as the setpoint high limit.
SetpointLimit_L	BOOL	FALSE	If SetpointLimit_L = TRUE, the setpoint absolute low limit has been reached. In the CPU, the setpoint is limited to the configured setpoint absolute low limit. The configured process value absolute low limit is the default setting for the setpoint low limit. If you set sPid_Cmpt.r_Sp_Llm to a value within the process value limits, this value is used as the setpoint low limit.
InputWarning_H	BOOL	FALSE	If InputWarning_H = TRUE, the process value has reached or exceeded the warning high limit.
InputWarning_L	BOOL	FALSE	If InputWarning_L = TRUE, the process value has reached or fallen below the warning low limit.
State	INT	0	The State parameter (Page 292) shows the current operating mode of the PID controller. To change the operating mode, use variable sRet.i_Mode. • State = 0: Inactive • State = 1: pretuning • State = 2: fine tuning • State = 3: Automatic mode • State = 4: Manual mode
Error	DWORD	W#16#0	The Error parameter (Page 294) indicates the error messages. Error = 0000: No error pending.

11.1.5.4 Static tags of PID_Compact V1

NOTE

You must not change tags that are not listed. These are used for internal purposes only.

Change the tags identified with (1) only in "Inactive" mode to prevent malfunction of the PID controller. "Inactive" mode is forced by setting the "sRet.i_Mode" tag to "0".

Table 3-1123

Tag	Data type	Default	Description
sb_GetCycleTime	BOOL	TRUE	If sb_GetCycleTime = TRUE, the automatic determination of the cycle time is started. CycleTime.StartEstimation = FALSE once measurement is complete.
sb_EnCyclEstimation	BOOL	TRUE	If sb_EnCyclEstimation = TRUE, the PID_Compact sampling time is calculated.
sb_EnCyclMonitoring	BOOL	TRUE	If sb_EnCyclMonitoring = FALSE, the PID_Compact sampling time is not monitored. If it is not possible to execute PID_Compact within the sampling time, an 0800 error is not output and PID_Compact does not change to "Inactive" mode.
sb_RunModeByStartup	BOOL	TRUE	Activate Mode after CPU restart If sb_RunModeByStartup = FALSE, the controller remains inactive after a CPU startup. If sb_RunModeByStartup = TRUE, the controller returns to the last active operating mode after a CPU restart.
si_Unit	INT	0	Unit of measurement of the process value and setpoint, e.g., °C, or °F.
si_Type	INT	0	Physical quantity of the process value and setpoint, e.g., temperature.
sd_Warning	DWORD	DW#16#0	Variable sd_warning (Page 297) displays the warnings generated since the reset, or since the last change of the operating mode.
sBackUp.r_Gain	REAL	1.0	Saved proportional gain You can reload values from the sBackUp structure with sPid_Cmpt.b_LoadBackUp = TRUE.
sBackUp.r_Ti	REAL	20.0	Saved integral action time [s]
sBackUp.r_Td	REAL	0.0	Saved derivative action time [s]
sBackUp.r_A	REAL	0.0	Saved derivative delay coefficient
sBackUp.r_B	REAL	0.0	Saved proportional action weighting factor
sBackUp.r_C	REAL	0.0	Saved derivative action weighting factor
sBackUp.r_Cycle	REAL	1.0	Saved sampling time of PID algorithm
sPid_Calc.r_Cycle(1)	REAL	0.1	Sampling time of the PID_Compact instruction r_Cycle is determined automatically and is usually equivalent to the cycle time of the calling OB.
sPid_Calc.b_RunIn	BOOL	FALSE	• b_RunIn = FALSE Pretuning is started when fine tuning is started from inactive or manual mode. If the requirements for pretuning are not met, PID_Compact reacts as if b_RunIn = TRUE. If fine tuning is started from automatic mode, the system uses the existing PID parameters to control to the setpoint. Only then will fine tuning start. If pretuning is not possible, PID_Compact switches to "Inactive" mode.

Tag	Data type	Default	Description
			• b_RunIn = TRUE The pretuning is skipped. PID_3Compact tries to reach the setpoint with minimum or maximum output value. This can produce increased overshoot. Fine tuning then starts automatically. b_RunIn is set to FALSE after fine tuning.
sPid_Calc.b_CalcParamSUT	BOOL	FALSE	The parameters for pretuning will be recalculated if b_CalcParamSUT = TRUE. This enables you to change the parameter calculation method without having to repeat controller tuning. b_CalcParamSUT is set to FALSE after the calculation.
sPid_Calc.b_CalcParamTIR	BOOL	FALSE	The parameters for fine tuning will be recalculated if b_CalcParamTIR = TRUE. This enables you to change the parameter calculation method without having to repeat controller tuning. b_CalcParamTIR will be set to FALSE after calculation.
sPid_Calc.i_CtrlTypeSUT	INT	0	Methods used to calculate parameters during pretuning: • i_CtrlTypeSUT = 0: PID according to Chien, Hrones and Reswick • i_CtrlTypeSUT = 1: PI according to Chien, Hrones and Reswick
sPid_Calc.i_CtrlTypeTIR	INT	0	Methods used to calculate parameters during fine tuning: • i_CtrlTypeTIR = 0: PID automatic • i_CtrlTypeTIR = 1: PID fast (faster control response with higher amplitudes of the output value than with i_CtrlTypeTIR = 2) • i_CtrlTypeTIR = 2: PID slow (slower control response with lower amplitudes of the output value than with i_CtrlTypiTIR = 1) • i_CtrlTypeTIR = 3: Ziegler-Nichols PID • i_CtrlTypeTIR = 4: Ziegler-Nichols PI • i_CtrlTypeTIR = 5: Ziegler-Nichols P To be able to repeat the calculation of the PID parameters with b_CalcParamTIR and i_CtrlTypeTIR = 0, 1 or 2, the previous fine tuning also has to have been executed with i_CtrlTypeTIR = 0, 1 or 2. If this is not the case, i_CtrlTypeTIR = 3 is used. The recalculation of the PID parameters with b_CalcParamTIR and i_CtrlTypeTIR = 3, 4 or 5 is always possible.
sPid_Calc.r_Progress	REAL	0.0	Progress of tuning as a percentage (0.0 - 100.0)
sPid_Cmpt.r_Sp_Hlm(1)	REAL	+3.402822e+-38	High limit of setpoint If you configure sPid_Cmpt.r_Sp_Hlm outside the process value limits, the configured process value absolute high limit is used as the setpoint high limit. If you configure sPid_Cmpt.r_Sp_Hlm within the process value limits, this value is used as the setpoint high limit.

Tag	Data type	Default	Description
sPid_Cmpt.r_Sp_Llm(1)	REAL	-3.402822e+3-8	Low limit of the setpoint If you set sPid_Cmpt.r_Sp_Llm outside the process value limits, the configured process value absolute low limit is used as the setpoint low limit. If you set sPid_Cmpt.r_Sp_Llm within the process value limits, this value is used as the setpoint low limit.
sPid_Cmpt.r_Pv_Norm_IN_1(1)	REAL	0.0	Scaling Input_PER low Input_PER is converted to a percentage based on the two value pairs r_Pv_Norm_OUT_1, r_Pv_Norm_IN_1 and r_Pv_Norm_OUT_2, r_Pv_Norm_IN_2 of the sPid_Cmpt structure.
sPid_Cmpt.r_Pv_Norm_IN_2(1)	REAL	27648.0	Scaling Input_PER high Input_PER is converted to a percentage based on the two value pairs r_Pv_Norm_OUT_1, r_Pv_Norm_IN_1 and r_Pv_Norm_OUT_2, r_Pv_Norm_IN_2 of the sPid_Cmpt structure.
sPid_Cmpt.r_Pv_Norm_OUT_1(1)	REAL	0.0	Scaled low process value Input_PER is converted to a percentage based on the two value pairs r_Pv_Norm_OUT_1, r_Pv_Norm_IN_1 and r_Pv_Norm_OUT_2, r_Pv_Norm_IN_2 of the sPid_Cmpt structure.
sPid_Cmpt.r_Pv_Norm_OUT_2(1)	REAL	100.0	Scaled high process value Input_PER is converted to a percentage based on the two value pairs r_Pv_Norm_OUT_1, r_Pv_Norm_IN_1 and r_Pv_Norm_OUT_2, r_Pv_Norm_IN_2 of the sPid_Cmpt structure.
sPid_Cmpt.r_Lmn_Hlm(1)	REAL	100.0	Output value high limit for output parameter "Output"
sPid_Cmpt.r_Lmn_Llm(1)	REAL	0.0	Low output value limit for output parameter "Output"
sPid_Cmpt.b_Input_PER_On(1)	BOOL	TRUE	If b_Input_PER_On = TRUE, the Input_PER parameter is used. If b_Input_PER_On = FALSE, the Input parameter is used.
sPid_Cmpt.b_LoadBackUp	BOOL	FALSE	Activate the back-up parameter set. If an optimization has failed, you can reactivate the previous PID parameters by setting this bit.
sPid_Cmpt.b_InvCtrl(1)	BOOL	FALSE	Invert control logic If b_InvCtrl = TRUE, an increasing control deviation causes a reduction in the output value.
sPid_Cmpt.r_Lmn_Pwm_PPTm(1)	REAL	0.0	The minimum ON time of the pulse width modulation in seconds is rounded to r_Lmn_Pwm_PPTm = r_Cycle or r_Lmn_Pwm_PPTm = n*r_Cycle
sPid_Cmpt.r_Lmn_Pwm_PBTm(1)	REAL	0.0	The minimum OFF time of the pulse width modulation in seconds is rounded to r_Lmn_Pwm_PBTm = r_Cycle or r_Lmn_Pwm_PBTm = n*r_Cycle

Tag	Data type	Default	Description
sPid_Cmpt.r_Pv_Hlm(1)	REAL	120.0	High limit of the process value At the I/O input, the process value can be a maximum of 18% higher than the standard range (overrange). An error is no longer reported for a violation of the "Process value high limit". Only a wire-break and a short-circuit are recognized and the PID_Compact switches to "Inactive" mode. r_Pv_Hlm > r_Pv_Llm
sPid_Cmpt.r_Pv_Llm(1)	REAL	0.0	Low limit of the process value r_Pv_Llm < r_Pv_Hlm
sPid_Cmpt.r_Pv_HWrn(1)	REAL	+3.402822e+-38	Warning high limit of the process value If you set r_Pv_HWrn outside the process value limits, the configured process value absolute high limit is used as the warning high limit. If you configure r_Pv_HWrn within the process value limits, this value is used as the warning high limit. r_Pv_HWrn > r_Pv_LWrn r_Pv_HWrn ≤ r_Pv_Hlm
sPid_Cmpt.r_Pv_LWrn(1)	REAL	-3.402822e+3-8	Warning low limit of the process value If you set r_Pv_LWrn outside the process value limits, the configured process value absolute low limit is used as the warning low limit. If you configure r_Pv_LWrn within the process value limits, this value is used as the warning low limit. r_Pv_LWrn < r_Pv_HWrn r_Pv_LWrn ≥ r_Pv_LWrn
sPidCalc.i_Ctrl_IOutv(1)	REAL	0.0	Current integral action
sParamCalc.i_Event_SUT	INT	0	Variable i_Event_SUT (Page 298) indicates the current phase of "pretuning":
sParamCalc.i_Event_TIR	INT	0	Variable i_Event_TIR (Page 298) indicates the current phase of "fine tuning":
sRet.i_Mode	INT	0	The operating mode is changed edge-triggered. The following operating mode is enabled on a change to • i_Mode = 0: "Inactive" mode (controller stop) • i_Mode = 1: "Pretuning" mode • i_Mode = 2: "Fine tuning" mode • i_Mode = 3: "Automatic" mode • i_Mode = 4: "Manual" mode i_Mode is retentive.
sRet.r_Ctrl_Gain(1)	REAL	1.0	Active proportional gain Gain is retentive.
sRet.r_Ctrl_Ti(1)	REAL	20.0	• r_Ctrl_Ti > 0.0: Active integral action time • r_Ctrl_Ti = 0.0: Integral action is deactivated r_Ctrl_Ti is retentive.
sRet.r_Ctrl_Td(1)	REAL	0.0	• r_Ctrl_Td > 0.0: Active derivative action time • r_Ctrl_Td = 0.0: Derivative action is deactivated r_Ctrl_Td is retentive.
sRet.r_Ctrl_A(1)	REAL	0.0	Active derivative delay coefficient r_Ctrl_A is retentive.

Tag	Data type	Default	Description
sRet.r_Ctrl_B(1)	REAL	0.0	Active proportional action weighting r_Ctrl_B is retentive.
sRet.r_Ctrl_C(1)	REAL	0.0	Active derivative action weighting r_Ctrl_C is retentive.
sRet.r_Ctrl_Cycle(1)	REAL	1.0	Active sampling time of the PID algorithm r_Ctrl_Cycle is calculated during tuning and rounded to an integer multiple of r_Cycle. r_Ctrl_Cycle is used as time period of the pulse width modulation. r_Ctrl_Cycle is retentive.

See also

Downloading technology objects to device (Page 46)

11.1.5.5 Parameters State and sRet.i_Mode V1

Correlation of the parameters

The State parameter indicates the current operating mode of the PID controller. You cannot modify the State parameter.

You need to modify the sRet.i_Mode tag to change the operating mode. This also applies when the value for the new operating mode is already in sRet.i_Mode. First set sRet.i_Mode = 0 and then sRet.i_Mode = 3. Provided the current operating mode of the controller supports this change, State is set to the value of sRet.i_Mode.

When PID_Compact automatically switches the operating mode, the following applies: State != sRet.i_Mode.

Examples:

- Successful pretuning
  State = 3 and sRet.i_Mode = 1
- Error
  State = 0 and sRet.i_Mode remains at the same value, e.g sRet.i_Mode = 3
- ManualEnalbe = TRUE
  State = 4 and sRet.i_Mode remain at the previous value, for example, sRet.i_Mode = 3

NOTE

You wish to repeat successful fine tuning without exiting automatic mode with i_Mode = 0.

Setting sRet.i_Mode to an invalid value such as 9999 for one cycle has no effect on State. Set Mode = 2 in the next cycle. You can generate a change to sRet.i_Mode without first switching to "inactive" mode.

Meaning of values

State / sRet.i_Mode	Description of the operating mode
0	Inactive The controller is switched off. The controller was in "inactive" mode before pretuning was performed. The PID controller will change to "inactive" mode when running if an error occurs or if the "Deactivate controller" icon is clicked in the commissioning window.
1	Pretuning The pretuning determines the process response to a jump of the output value and searches for the point of inflection. The optimized PID parameters are calculated as a function of the maximum rate of rise and dead time of the controlled system. Pretuning requirements: • The controller is in inactive mode or manual mode • ManualEnable = FALSE • The process value must not be too close to the setpoint. |Setpoint - Input| > 0.3 * |sPid_Cmpt.r_Pv_Hlm - sPid_Cmpt.r_Pv_Llm| and |Setpoint - Input| > 0.5 * |Setpoint| • The setpoint may not be changed during pretuning. The higher the stability of the process value, the easier it is to calculate the PID parameters and increase precision of the result. Noise on the process value can be tolerated as long as the rate of rise of the process value is significantly higher compared to the noise. PID parameters are backed up before they are recalculated and can be reactivated with sPid_Cmpt.b_LoadBackUp. There is a change to automatic mode following successful pretuning and to "inactive" mode following unsuccessful pretuning. The phase of pretuning is indicated with Tag i_Event_SUT V1 (Page 298).
2	Fine tuning Fine tuning generates a constant, limited oscillation of the process value. The PID parameters are optimized based on the amplitude and frequency of this oscillation. The differences between the process response during pretuning and fine tuning are analyzed. All PID parameters are recalculated on the basis of the findings. PID parameters from fine tuning usually have better master control and disturbance behavior than PID parameters from pretuning. PID_Compact automatically attempts to generate an oscillation greater than the noise of the process value. Fine tuning is only minimally influenced by the stability of the process value. PID parameters are backed up before they are recalculated and can be reactivated with sPid_Cmpt.b_LoadBackUp. Requirements for fine tuning: • No disturbances are expected. • The setpoint and the process value lie within the configured limits. • The setpoint may not be changed during fine tuning. • ManualEnable = FALSE • Automatic (State = 3), inactive (State = 0) or manual (State = 4) mode Fine tuning proceeds as follows when started in: • Automatic mode (State = 3) Start fine tuning in automatic mode if you wish to improve the existing PID parameters using controller tuning. PID_Comact will regulate using the existing PID parameters until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start.

State / sRet.i_Mode	Description of the operating mode
	• Inactive (State = 0) or manual (State = 4) mode If the requirements for pretuning are met, pretuning is started. The PID parameters established will be used for adjustment until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start. If pretuning is not possible, PID_Compact will change to "Inactive" mode. An attempt is made to reach the setpoint with a minimum or maximum output value if the process value for pretuning is already too near the setpoint or sPid_Calc.b_RunIn = TRUE. This can produce increased overshoot. The controller will change to "automatic mode" after successfully completed "fine tuning" and to "inactive" mode if "fine tuning" has not been successfully completed. The "Fine tuning" phase is indicated with Tag i_Event_TIR V1 (Page 298).
3	Automatic mode In automatic mode, PID_Compact corrects the controlled system in accordance with the parameters specified. The controller changes to automatic mode if one the following conditions is fulfilled: • Pretuning successfully completed • Fine tuning successfully completed • Change of variable sRet.i_Mode to the value 3. After CPU startup or change from Stop to RUN mode, PID_Compact will start in the most recently active operating mode. To retain PID_Compact in "Inactive" mode, set sb_RunModeByStartup = FALSE.
4	Manual mode In manual mode, you specify a manual output value in the ManualValue parameter. This operating mode is enabled if sRet.i_Mode = 4, or at the rising edge on ManualEnable. If ManualEnable changes to TRUE, only State will change. sRet.i_Mode will retain its current value. PID_Compact will return to the previous operating mode upon a falling edge at ManualEnable. The change to automatic mode is bumpless.

See also

Output parameters of PID_Compact V1 (Page 287)
Pretuning V1 (Page 110)
Fine tuning V1 (Page 111)
"Manual" mode V1 (Page 113)
Tag i_Event_SUT V1 (Page 298)
Tag i_Event_TIR V1 (Page 298)

11.1.5.6 Error V1 parameter

If several errors are pending simultaneously, the values of the error codes are displayed with binary addition. The display of error code 0003, for example, indicates that the errors 0001 and 0002 are pending simultaneously.

Error (DW#16#...)	Description
0000	There is no error.
0001	The "Input" parameter is outside the process value limits. • Input > sPid_Cmpt.r_Pv_Hlm or • Input < sPid_Cmpt.r_Pv_Llm You cannot move the actuator again until you eliminate the error.
0002	Invalid value at "Input_PER" parameter. Check whether an error is pending at the analog input.

Error (DW#16#...)	Description
0004	Error during fine tuning. Oscillation of the process value could not be maintained.
0008	Error at start of pretuning. The process value is too close to the setpoint. Start fine tuning.
0010	The setpoint was changed during tuning.
0020	Pretuning is not permitted in automatic mode or during fine tuning.
0080	Error during pretuning. The output value limits are not configured correctly or the process value does not react as expected. Check whether the limits of the output value are configured correctly and match the control logic. Also make sure that the process value does not oscillate strongly before starting pretuning.
0100	Error during tuning resulted in invalid parameters.
0200	Invalid value at "Input" parameter: Value has an invalid number format.
0400	Calculation of output value failed. Check the PID parameters.
0800	Sampling time error: PID_Compact is not called within the sampling time of the cyclic interrupt OB. If this error occurred during simulation with PLCSIM, see the notes under Simulating PID_Compact V1 with PLCSIM (Page 115).
1000	Invalid value at "Setpoint" parameter: Value has an invalid number format.

See also

Output parameters of PID_Compact V1 (Page 287)

11.1.5.7 Reset V1 parameter

The response to Reset = TRUE depends on the version of the PID_Compact instruction.

Reset response PID_Compact as of Version 1.1

A rising edge at Reset triggers a change to "Inactive" mode; errors and warnings are reset and the integral action is deleted. A falling edge at Reset triggers a change to the most recently active operating mode. If automatic mode was active before, the integral action is preassigned in such a way that the switchover is bumpless.

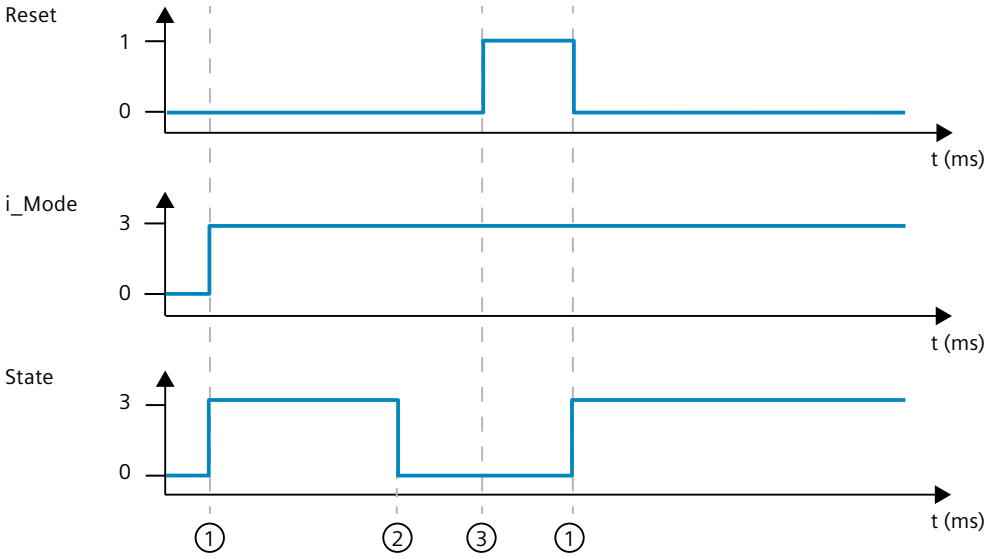

① Activation
② Error
③ Reset

Reset response PID_Compact V.1.0

A rising edge at Reset triggers a change to "Inactive" mode; errors and warnings are reset and the integral action is deleted. The controller is not reactivated until the next edge at i_Mode.

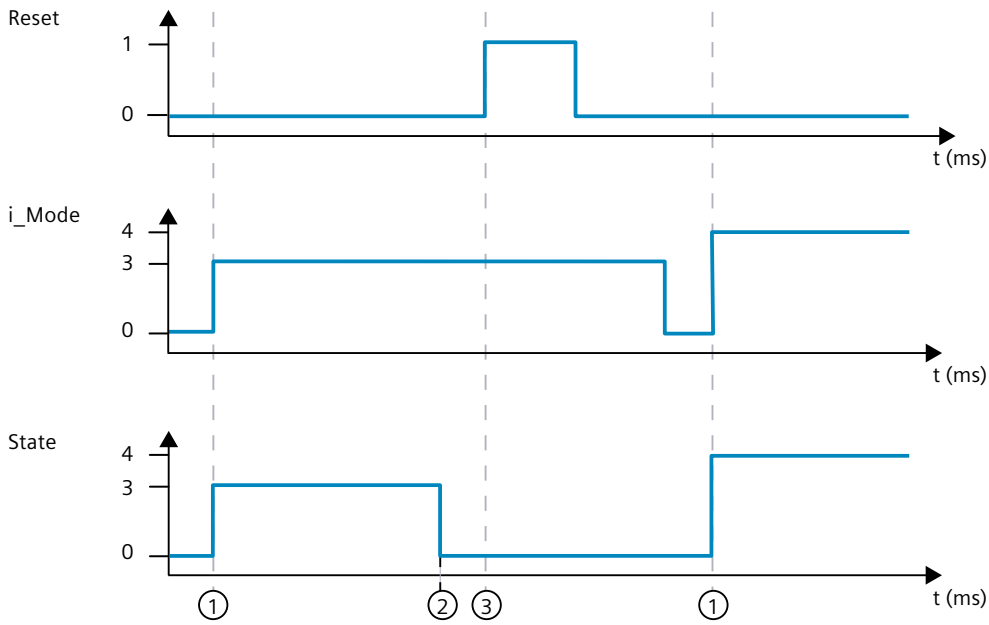

① Activation
② Error
③ Reset

11.1.5.8 Tag sd_warning V1

If several warnings are pending, the values of variable sd_warning are displayed by means of binary addition. The display of warning 0003, for example, indicates that the warnings 0001 and 0002 are also pending.

sd_warning (DW#16#....)	Description
0000	No warning pending.
0001	The point of inflection was not found during pretuning.
0002	Oscillation increased during fine tuning.
0004	The setpoint was outside the set limits.
0008	Not all the necessary controlled system properties were defined for the selected method of calculation. The PID parameters were instead calculated using the "i_CtrlTypeTIR = 3" method.
0010	The operating mode could not be changed because ManualEnable = TRUE.
0020	The cycle time of the calling OB limits the sampling time of the PID algorithm. Improve results by using shorter OB cycle times.
0040	The process value exceeded one of its warning limits.

The following warnings are deleted as soon as the cause is dealt with:

- 0004
- 0020
- 0040

All other warnings are cleared with a rising edge at Reset.

11.1.5.9 Tag i_Event_SUT V1

i_Event_SUT	Name	Description
0	SUT_INIT	Initialize pretuning
100	SUT_STDABW	Calculate the standard deviation
200	SUT_GET_POI	Find the point of inflection
9900	SUT_IO	Pretuning successful
1	SUT_NIO	Pretuning not successful

See also

Static tags of PID_Compact V1 (Page 287)
Parameters State and sRet.i_Mode V1 (Page 292)

11.1.5.10 Tag i_Event_TIR V1

i_Event_TIR	Name	Description
-100	TIR_FIRST_SUT	Fine tuning is not possible. Pretuning will be executed first.
0	TIR_INIT	Initialize fine tuning
200	TIR_STDABW	Calculate the standard deviation
300	TIR_RUN_IN	Attempt to reach the setpoint
400	TIR_CTRLN	Attempt to reach the setpoint with the existing PID parameters (if pretuning has been successful)
500	TIR_OSZIL	Determine oscillation and calculate parameters
9900	TIR_IO	Fine tuning successful
1	TIR_NIO	Fine tuning not successful

See also

Static tags of PID_Compact V1 (Page 287)
Parameters State and sRet.i_Mode V1 (Page 292)

11.2 PID_3Step

11.2.1 New features of PID_3Step

PID_3Step V2.3

- **Use with S7-1200 G2**

  As of PID_3Step V2.3, the instruction can also be used on an S7-1200 G2.

  Older versions of the instruction are not supported on S7-1200 G2.

- **Monitoring the travel time**

  As of PID_3Step Version 2.3 the monitoring and limiting of the travel time can be deactivated with Config.VirtualActuatorLimit = 0.0.

PID_3Step V2.2

- **Use with S7-1200**

  As of PID_3Step V2.2, the instruction with V2 functionality can also be used on S7-1200 as of firmware version 4.0.

PID_3Step V2.0

- **Reaction to error**

  The reaction to ActivateRecoverMode = TRUE has been completely overhauled. PID_3Step reacts in a more fault tolerant manner in the default setting.

NOTICE
Your system may be damaged. If you use the default setting, PID_3Step remains in automatic mode even if the process value limits are exceeded. This may damage your system. It is essential to configure how your controlled system reacts in the event of an error to protect your system from damage.

  You use the ErrorAck input parameter to acknowledge the errors and warnings without restarting the controller or clearing the integral action.

  Switching operating modes does not acknowledge errors that are no longer pending.

- **Switching the operating mode**

  You specify the operating mode at the Mode in/out parameter and use a positive edge at ModeActivate to start the operating mode. The Retain.Mode tag has been omitted.

  The transition time measurement can no longer be started with GetTransitTime.Start, but only with Mode = 6 and a positive edge at ModeActivate.

- **Multi-instance capability**

  You can call up PID_3Step as multi-instance DB.

- **Startup characteristics**

  The operating mode specified at the Mode parameter is also started on a falling edge at Reset and during a CPU cold restart, if RunModeByStartup = TRUE.

- **ENO characteristics**

  ENO is set depending on the operating mode.

  If State = 0, then ENO = FALSE.

  If State ≠ 0, then ENO = TRUE.

- **Manual mode**

  The Manual_UP and Manual_DN input parameters no longer function as edge-triggered parameters. Edge-triggered manual mode continues to be possible using the ManualUpInternal and ManualDnInternal tags.

  In "Manual mode without endstop signals" (Mode = 10), the endstop signals Actuator_H and Actuator_L are ignored even though they are activated.

- **Default value of PID parameters**

  The following default settings have been changed:

  – Proportional action weighting (PWeighting) from 0.0 to 1.0
  – Derivative action weighting (DWeighting) from 0.0 to 1.0
  – Coefficient for derivative delay (TdFiltRatio) from 0.0 to 0.2

- **Limiting of motor transition time**

  You configure the maximum percentage of the motor transition time that the actuator will travel in one direction in the Config.VirtualActuatorLimit tag.

- **Setpoint value specification during tuning**

  You configure the permitted fluctuation of the setpoint during tuning at the CancelTuningLevel tag.

- **Switching a disturbance variable on**

  You can switch a disturbance variable on at the Disturbance parameter.

- **Troubleshooting**

  If the endstop signals are not activated (ActuatorEndStopOn = FALSE), ScaledFeedback is determined without Actuator_H or Actuator_L.

PID_3Step V1.1

- **Manual mode on CPU startup**

  If ManualEnable = TRUE when the CPU starts, PID_3Step starts in manual mode. A rising edge at ManualEnable is not necessary.

- **Reaction to error**

  The ActivateRecoverMode tag is no longer effective in manual mode.

- **Troubleshooting**

  The Progress tag is reset following successful tuning or transition time measurement.

11.2.2 Compatibility with CPU and FW

The following table shows which version of PID_3Step can be used on which CPU.

CPU	FW	PID_3Step
S7-1200	as of V4.2	V2.3 V2.2 V1.1
	V4.0 to V4.1	V2.2 V1.1
	V3.x	V1.1 V1.0
	V2.x	V1.1 V1.0
S7-1200 G2	V1.0 or higher	V2.3
S7-1500	as of V3.0	V2.3
	V2.0 to V2.9	V2.3 V2.2 V2.1 V2.0
	V1.5 to V1.8	V2.2 V2.1 V2.0
	V1.1	V2.1 V2.0
	V1.0	V2.0

11.2.3 CPU processing time and memory requirement PID_3Step V2.x

CPU processing time

Typical CPU processing times of the PID_3Step technology object as of Version V2.0, depending on CPU type and operating mode for standard, F, T and TF CPUs.

CPU	FW	Typ. CPU processing time Automatic mode	Typ. CPU processing time pre-tuning and fine tuning
CPU 1211	≥ V4.0	260 µs	310 µs
CPU 1212			
CPU 1214			
CPU 1215			
CPU 1217			
CPU 1212 G2	≥ V1.0	120 µs	140 µs
CPU 1214 G2			
CPU 1216 G2	≥ V4.0	25 µs	35 µs
CPU 1217 G2			
CPU 1510SP	≤ V2.9	80 µs	95 µs

CPU 1511	≤ V2.9	80 µs	95 µs
CPU 1511C			
CPU 1512C			
CPU 1512SP			
CPU 1513			
CPU 1515		70 µs	80 µs
CPU 1516			
CPU 1517	≤ V3.1	11 µs	15 µs
CPU 1518		5 µs	7 µs
CPU 1510SP	V3.0, V3.1	65 µs	85 µs
CPU 1511			
CPU 1511C			
CPU 1512C			
CPU 1512SP			
CPU 1513			
CPU 1514SP			
CPU 1515		55 µs	70 µs
CPU 1516			
CPU 1510SP	≥ V4.0	55 µs	65 µs
CPU 1511			
CPU 1511C			
CPU 1512C			
CPU 1512SP			
CPU 1513			
CPU 1514SP			
CPU 1515			
CPU 1516			
CPU 1516T		3 µs	5 µs
CPU 1517		2 µs	3 µs
CPU 1518		1 µs	2 µs

Typical CPU processing times of the PID_3Step technology object as of Version V2.0, depending on the CPU type and operating mode for R/H-CPUs in the RUN-Redundant system state.

CPU	**FW**	**Typ. CPU processing time Automatic mode**	**Typ. CPU processing time pre-tuning and fine tuning**
CPU 1513R	V3.0, V3.1	110 µs	150 µs
CPU 1515R		100 µs	120 µs
CPU 1513R	≥ V4.0	100 µs	120 µs

CPU 1515R	≥ V4.0	100 µs	120 µs
CPU 1517H		4 µs	6 µs
CPU 1518HF			

Memory requirement

Memory requirement of an instance DB of the PID_3Step technology object as of Version V2.0.

Memory requirement	Memory requirement of the instance DB of PID_3Step V2.x
Load memory requirement	Approx. 4400 bytes
Total work memory requirement	1040 bytes
Retentive work memory requirement	60 bytes

11.2.4 PID_3Step V2

11.2.4.1 Description of PID_3Step V2

Description

You use the PID_3Step instruction to configure a PID controller with self tuning for valves or actuators with integrating behavior.

The following operating modes are possible:

- Inactive
- Pretuning
- Fine tuning
- Automatic mode
- Manual mode
- Approach substitute output value
- Transition time measurement
- Error monitoring
- Approach substitute output value with error monitoring
- Manual mode without endstop signals

For a more detailed description of the operating modes, see the State parameter.

PID algorithm

PID_3Step is a PIDT1 controller with anti-windup and weighting of the proportional and derivative actions. The PID algorithm operates according to the following transfer function:

$$\Delta y = K_p \cdot s \cdot \left[(b \cdot w - x) + \frac{1}{T_I \cdot s}(w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1}(c \cdot w - x)\right]$$

The table below shows the meaning of the icons used in the transfer function and in the subsequent figures:

Icon	Description
Δy	Output value of the PID algorithm
K_p	Proportional gain
s	Laplace operator
b	Proportional action weighting
w	Setpoint
x	Process value
T_I	Integration time
T_D	Derivative action time
a	Derivative delay coefficient (derivative delay T1 = a × T_D)
c	Derivative action weighting

Block diagram without position feedback

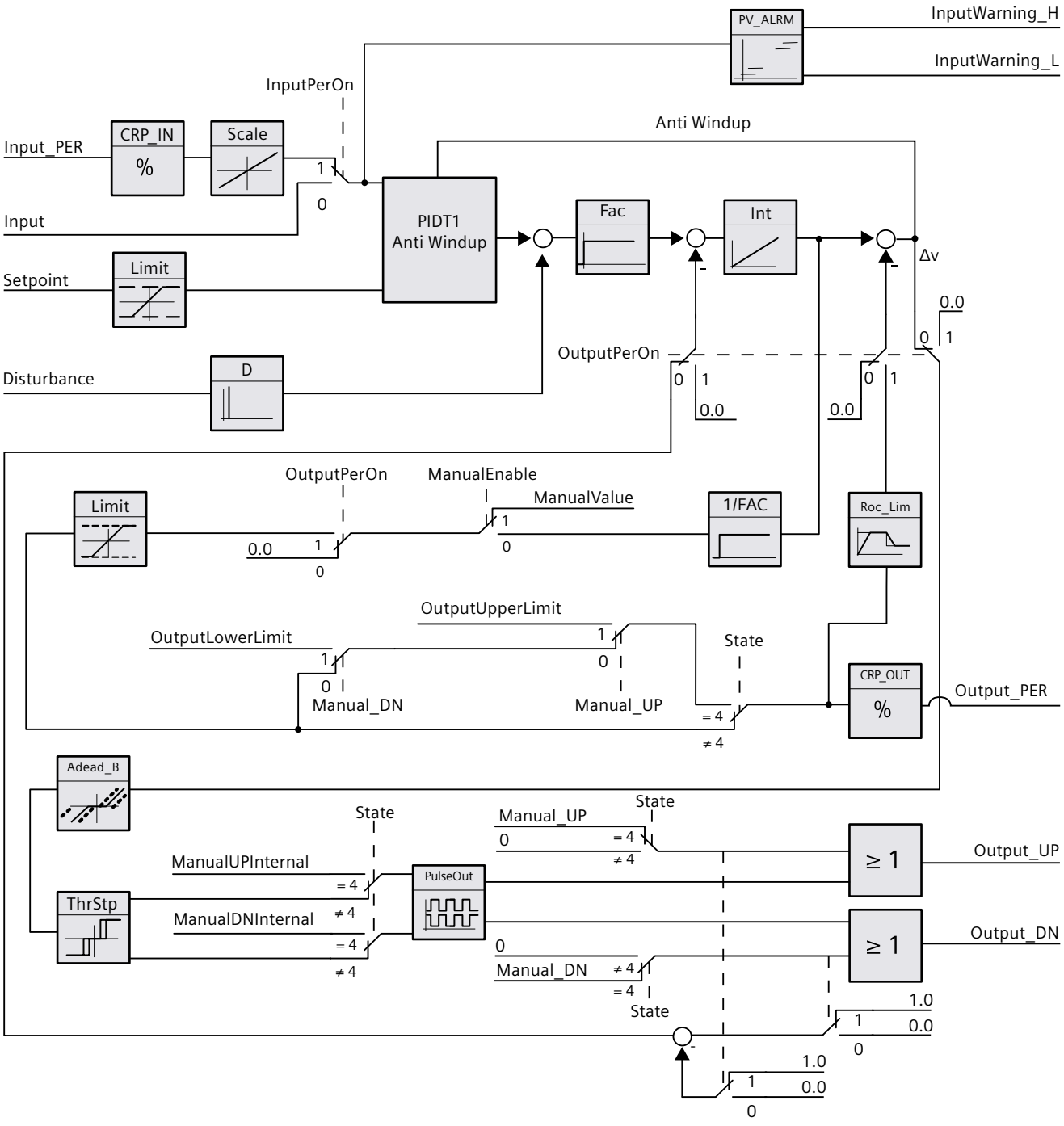

Block diagram with position feedback

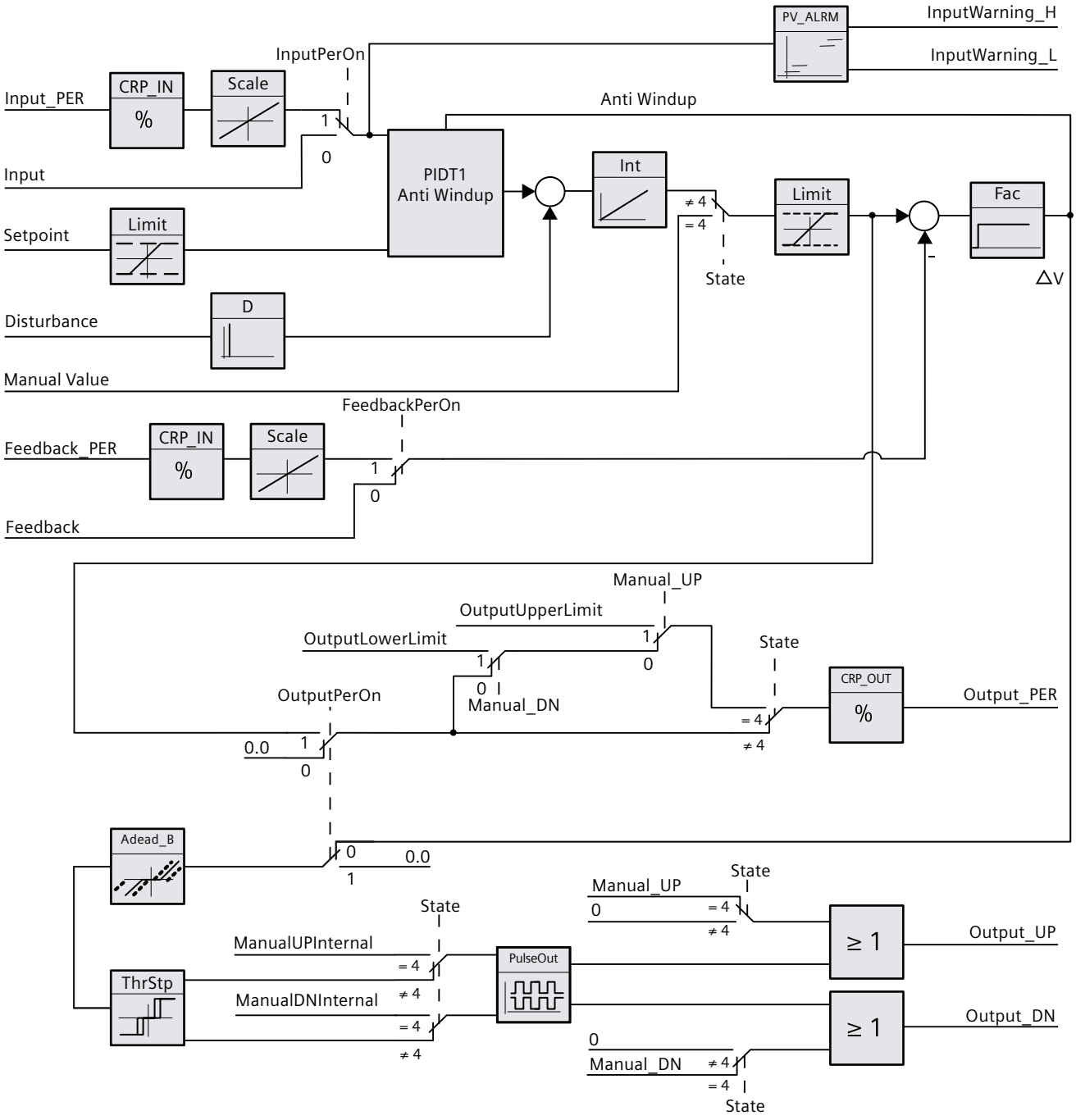

Block diagram of PIDT1 with anti-windup

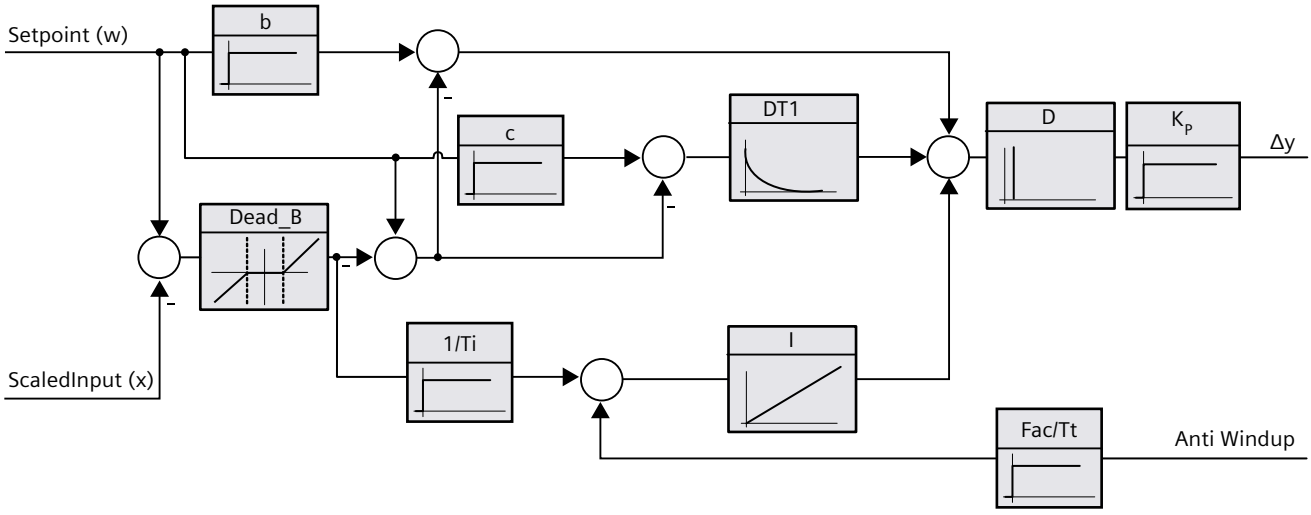

Call

PID_3Step is called in the constant time scale of a cyclic interrupt OB.

Download to device

The actual values of retentive tags are only updated when you download PID_3Step completely.

Downloading technology objects to device (Page 46)

Startup

When the CPU starts up, PID_3Step starts in the operating mode saved in the Mode in/out parameter. To retain PID_3Step in "Inactive" mode, set RunModeByStartup = FALSE.

Response to errors

In automatic mode and during commissioning, the response in the event of an error depends on the ErrorBehaviour and ActivateRecoverMode tags. In manual mode, the reaction is independent of ErrorBehaviour and ActivateRecoverMode. If ActivateRecoverMode = TRUE, the reaction additionally depends on the error that occurred.

ErrorBehaviour	ActivateRecoverMode	Configuration editor > actuator setting > Set Output to	Reaction
FALSE	FALSE	Current output value	Switch to "Inactive" mode (State = 0) The actuator remains in the current position.
FALSE	TRUE	Current output value while error is pending	Switch to "Error monitoring" mode (State = 7) The actuator remains in the current position while the error is pending.
TRUE	FALSE	Substitute output value	Switch to "Approach substitute output value" mode (State = 5) The actuator moves to the configured substitute output value. Switch to "Inactive" mode (State = 0) The actuator remains in the current position.
TRUE	TRUE	Substitute output value while error is pending	Switch to "Approach substitute output value with error monitoring" mode (State = 8) The actuator moves to the configured substitute output value. Switch to "Error monitoring" mode (State = 7)

In manual mode, PID_3Step uses ManualValue as output value, unless the following errors occur:

- 2000h: Invalid value at Feedback_PER parameter.
- 4000h: Invalid value at Feedback parameter.
- 8000h: Error during digital position feedback.

You can only change the position of the actuator with Manual_UP and Manual_DN, not with ManualValue.

The Error parameter indicates whether an error has occurred in this cycle. The ErrorBits parameter shows which errors have occurred. ErrorBits is reset by a rising edge at Reset or ErrorAck.

See also

State and Mode V2 parameters (Page 325)
ErrorBits V2 parameter (Page 330)
Configuring PID_3Step V2 (Page 117)

11.2.4.2 Mode of operation of PID_3Step V2

Monitoring process value limits

You specify the high limit and low limit of the process value in the Config.InputUpperLimit and Config.InputLowerLimit tags. If the process value is outside these limits, an error occurs (ErrorBits = 0001h).

You specify a high and low warning limit of the process value in the Config.InputUpperWarning and Config.InputLowerWarning tags. If the process value is outside these warning limits, a warning occurs (Warning = 0040h), and the InputWarning_H or InputWarning_L output parameter changes to TRUE.

Limiting the setpoint

You specify a high limit and low limit of the setpoint in the Config.SetpointUpperLimit and Config.SetpointLowerLimit tags. PID_3Step automatically limits the setpoint to the process value limits. You can limit the setpoint to a smaller range. PID_3Step checks whether this range falls within the process value limits. If the setpoint is outside these limits, the high or low limit is used as the setpoint, and output parameter SetpointLimit_H or SetpointLimit_L is set to TRUE.

The setpoint is limited in all operating modes.

Limiting the output value

You specify a high limit and low limit of the output value in the Config.OutputUpperLimit and Config.OutputLowerLimit tags. The output value limits must be within "Low endstop" and "High endstop".

- High endstop: Config.FeedbackScaling.UpperPointOut
- Low endstop: Config.FeedbackScaling.LowerPointOut

Rule:

UpperPointOut ≥ OutputUpperLimit > OutputLowerLimit ≥ LowerPointOut

The valid values for "High endstop" and "Low endstop" depend upon:

- FeedbackOn
- FeedbackPerOn
- OutputPerOn

OutputPerOn	FeedbackOn	FeedbackPerOn	LowerPointOut	UpperPointOut
FALSE	FALSE	FALSE	Cannot be set (0.0%)	Cannot be set (100.0%)
FALSE	TRUE	FALSE	-100.0% or 0.0%	0.0% or +100.0%
FALSE	TRUE	TRUE	-100.0% or 0.0%	0.0% or +100.0%
TRUE	FALSE	FALSE	Cannot be set (0.0%)	Cannot be set (100.0%)
TRUE	TRUE	FALSE	-100.0% or 0.0%	0.0% or +100.0%
TRUE	TRUE	TRUE	-100.0% or 0.0%	0.0% or +100.0%

If OutputPerOn = FALSE and FeedbackOn = FALSE, you cannot limit the output value. Output_UP and Output_DN are then reset upon Actuator_H = TRUE or Actuator_L = TRUE. If endstop signals are also not present, Output_UP and Output_DN are reset after a travel time of Config.VirtualActuatorLimit × Retain.TransitTime/100. As of PID_3Step Version 2.3 the monitoring and limiting of the travel time can be deactivated with Config.VirtualActuatorLimit = 0.0.

The output value is 27648 at 100% and -27648 at -100%. PID_3Step must be able to completely close the valve.

NOTE

Use with two or more actuators

PID_3 Step is not suitable for use with two or more actuators (for example, in heating/cooling applications), because different actuators need different PID parameters to achieve a good control response.

Substitute output value

If an error has occurred, PID_3Step can output a substitute output value and move the actuator to a safe position that is specified in the SavePosition tag. The substitute output value must be within the output value limits.

Monitoring signal validity

The values of the following parameters are monitored for validity when used:

- Setpoint
- Input
- Input_PER
- Input_PER
- Feedback
- Feedback_PER
- Disturbance
- ManualValue
- SavePosition
- Output_PER

Monitoring the PID_3Step sampling time

Ideally, the sampling time is equivalent to the cycle time of the calling OB. The PID_3Step instruction measures the time interval between two calls. This is the current sampling time. On every switchover of operating mode and during the initial startup, the mean value is formed from the first 10 sampling times. Too great a difference between the current sampling time and this mean value triggers an error (ErrorBits = 0800h).

The error occurs during tuning if:

- New mean value >= 1.1 x old mean value
- New mean value <= 0.9 x old mean value

The error occurs in automatic mode if:

- New mean value >= 1.5 x old mean value
- New mean value <= 0.5 x old mean value

If you deactivate the sampling time monitoring (CycleTime.EnMonitoring = FALSE), you can also call PID_3Step in OB1. You must then accept a lower control quality due to the deviating sampling time.

Sampling time of the PID algorithm

The controlled system needs a certain amount of time to respond to changes in the output value. It is therefore not advisable to calculate the output value in every cycle. The sampling time of the PID algorithm represents the time between two calculations of the output value. It is calculated during tuning and rounded to a multiple of the cycle time. All other functions of PID_3Step are executed at every call.

Measuring the motor transition time

The motor transition time is the time in seconds the motor requires to move the actuator from the closed to the opened state. The actuator is moved in one direction for a maximum time of Config.VirtualActuatorLimit × Retain.TransitTime/100. PID_3Step requires the motor transition time to be as accurate as possible for good controller results. The data in the actuator documentation contains average values for this type of actuator. The value for the specific actuator used may differ. You can measure the motor transition time during commissioning. The output value limits are not taken into consideration during the motor transition time measurement. The actuator can travel to the high or the low endstop.

The motor transition time is taken into consideration in the calculation of the analog output value as well as in the calculation of the digital output values. It is mainly required for correct operation during auto-tuning and the anti-windup behavior. You should therefore configure the motor transition time with the value that the motor requires to move the actuator from the closed to the opened state.

If no relevant motor transition time is in effect in your process (e.g. with solenoid valves), so that the output value has a direct and full effect on the process, use PID_Compact instead.

Control logic

An increase of the output value is generally intended to cause an increase in the process value. This is referred to as a normal control logic. For cooling and discharge control systems, it may be necessary to invert the control logic. PID_3Step does not work with negative proportional gain. If InvertControl = TRUE, an increasing control deviation causes a reduction in the output value. The control logic is also taken into account during pretuning and fine tuning.

See also

Configuring PID_3Step V1 (Page 135)

11.2.4.3 Changing the PID_3Step V2 interface

The following table shows what has changed in the PID_3Step instruction interface.

PID_3Step V1	PID_3Step V2	Change
Input_PER	Input_PER	Data type from Word to Int
Feedback_PER	Feedback_PER	Data type from Word to Int
	Disturbance	New
Manual_UP	Manual_UP	Function
Manual_DN	Manual_DN	Function
	ErrorAck	New
	ModeActivate	New
Output_PER	Output_PER	Data type from Word to Int
	ManualUPInternal	New
	ManualDNInternal	New
	CancelTuningLevel	New
	VirtualActuatorLImit	New
Config.Loadbackup	Loadbackup	Renamed
Config.TransitTime	Retain.TransitTime	Renamed and retentivity added
GetTransitTime.Start		Replaced by Mode and ModeActivate
SUT.CalculateSUTParams	SUT.CalculateParams	Renamed
SUT.TuneRuleSUT	SUT.TuneRule	Renamed
TIR.CalculateTIRParams	TIR.CalculateParams	Renamed
TIR.TuneRuleTIR	TIR.TuneRule	Renamed
Retain.Mode	Mode	Function Declaration of static for in-out parameters

11.2.4.4 Input parameters of PID_3Step V2

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1124

Parameter	Data type	Default	Description
Setpoint	REAL	0.0	Setpoint of the PID controller in automatic mode
Input	REAL	0.0	A tag of the user program is used as source for the process value. If you are using Input parameter, then Config.InputPerOn = FALSE must be set.

Parameter	Data type	Default	Description
Input_PER	INT	0	An analog input is used as the source of the process value. If you are using Input_PER parameter, then Config.InputPerOn = TRUE must be set.
Actuator_H	BOOL	FALSE	Digital position feedback of the valve for the high endstop If Actuator_H = TRUE, the valve is at the high endstop and is no longer moved towards this direction.
Actuator_L	BOOL	FALSE	Digital position feedback of the valve for the low endstop If Actuator_L = TRUE, the valve is at the low endstop and is no longer moved towards this direction.
Feedback	REAL	0.0	Position feedback of the valve If you are using Feedback parameter, then Config.FeedbackPerOn = FALSE must be set.
Feedback_PER	INT	0	Analog position feedback of a valve If you are using Feedback_PER parameter, then Config.FeedbackPerOn = TRUE must be set. Feedback_PER is scaled based on the tags: • Config.FeedbackScaling.LowerPointIn • Config.FeedbackScaling.UpperPointIn • Config.FeedbackScaling.LowerPointOut • Config.FeedbackScaling.UpperPointOut
Disturbance	REAL	0.0	Disturbance variable or precontrol value
ManualEnable	BOOL	FALSE	• A FALSE -> TRUE edge activates "Manual mode", while State = 4, Mode remains unchanged. As long as ManualEnable = TRUE, you cannot change the operating mode via a rising edge at ModeActivate or use the commissioning dialog. • A TRUE -> FALSE edge activates the operating mode that is specified by Mode. We recommend that you change the operating mode using ModeActivate only.
ManualValue	REAL	0.0	In manual mode, you specify the absolute position of the valve. ManualValue will only be evaluated if you are using Output_PER, **or** if position feedback is available.
Manual_UP	BOOL	FALSE	• Manual_UP = TRUE The valve is opened even if you are using Output_PER or a position feedback. The valve is no longer moved if the high endstop has been reached. See also Config.VirtualActuatorLimit • Manual_UP = FALSE If you are using Output_PER or a position feedback, the valve is moved to ManualValue. Otherwise, the valve is no longer moved. If Manual_UP and Manual_DN are set to TRUE simultaneously, the valve is not moved.

Parameter	Data type	Default	Description
Manual_DN	BOOL	FALSE	• Manual_DN = TRUE The valve is closed even if you are using Output_PER or a position feedback. The valve is no longer moved if the low endstop has been reached. See also Config.VirtualActuatorLimit • Manual_DN = FALSE If you are using Output_PER or a position feedback, the valve is moved to ManualValue. Otherwise, the valve is no longer moved.
ErrorAck	BOOL	FALSE	• FALSE -> TRUE edge ErrorBits and Warning are reset.
Reset	BOOL	FALSE	Restarts the controller. • FALSE -> TRUE edge – Switch to "Inactive" mode – ErrorBits and Warnings are reset. • As long as Reset = TRUE, – PID_3Step remains in "Inactive" mode (State = 0). – You cannot change the operating mode with Mode and ModeActivate or ManualEnable. – You cannot use the commissioning dialog. • TRUE -> FALSE edge – If ManualEnable = FALSE, PID_3Step switches to the operating mode that is stored in the Mode parameter. – If Mode = 3, the switchover to automatic mode is bump-less.
ModeActivate	BOOL	FALSE	• FALSE -> TRUE edge PID_3Step switches to the operating mode saved in the Mode parameter.

11.2.4.5 Output parameters of PID_3Step V2

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1125

Parameter	Data type	Default	Description
ScaledInput	REAL	0.0	Scaled process value
ScaledFeedback	REAL	0.0	Scaled position feedback For an actuator without position feedback, the position of the actuator indicated by ScaledFeedback is very imprecise. ScaledFeedback may only be used for rough estimation of the current position in this case.
Output_UP	BOOL	FALSE	Digital output value for opening the valve If Config.OutputPerOn = FALSE, the Output_UP parameter is used.
Output_DN	BOOL	FALSE	Digital output value for closing the valve If Config.OutputPerOn = FALSE, the Output_DN parameter is used.
Output_PER	INT	0	Analog output value If Config.OutputPerOn = TRUE, Output_PER is used.

Parameter	Data type	Default	Description
			Use Output_PER if you are using a valve as actuator which is triggered via an analog output and controlled with a continuous signal, e.g. 0...10V or 4...20mA. The value at Output_PER corresponds to the target position of the valve, e.g. Output_PER = 13824, when the valve is to be opened by 50%.
SetpointLimit_H	BOOL	FALSE	If SetpointLimit_H = TRUE, the absolute high limit of setpoint is reached (Setpoint ≥ Config.SetpointUpperLimit). The setpoint is limited to Config.SetpointUpperLimit .
SetpointLimit_L	BOOL	FALSE	If SetpointLimit_L = TRUE, the absolute low limit of the setpoint has been reached (Setpoint ≤ Config.SetpointLowerLimit). The setpoint is limited to Config.SetpointLowerLimit .
InputWarning_H	BOOL	FALSE	If InputWarning_H = TRUE, the process value has reached or exceeded the warning high limit.
InputWarning_L	BOOL	FALSE	If InputWarning_L = TRUE, the process value has reached or fallen below the warning low limit.
State	INT	0	The State parameter (Page 325) shows the current operating mode of the PID controller. You can change the operating mode using the input parameter Mode and a rising edge at ModeActivate. • State = 0: Inactive • State = 1: Pretuning • State = 2: Fine tuning • State = 3: Automatic mode • State = 4: Manual mode • State = 5: Approach substitute output value • State = 6: Transition time measurement • State = 7: Error monitoring • State = 8: Approach substitute output value with error monitoring • State = 10: Manual mode without endstop signals
Error	BOOL	FALSE	If Error = TRUE, at least one error message is pending in this cycle.
ErrorBits	DWORD	DW#16#0	The ErrorBits parameter (Page 330) shows which error messages are pending. ErrorBits is retentive and is reset upon a rising edge at Reset or ErrorAck.

See also

State and Mode V2 parameters (Page 325)
ErrorBits V2 parameter (Page 330)

11.2.4.6 In/out parameters of PID-3Step V2

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1126

Parameter	Data type	Default	Description
Mode	INT	4	At the Mode parameter, you specify the operating mode to which PID_3Step is to switch. Options are: • Mode = 0: Inactive • Mode = 1: Pretuning • Mode = 2: Fine tuning • Mode = 3: Automatic mode • Mode = 4: Manual mode • Mode = 6: Transition time measurement • Mode = 10: Manual mode without endstop signals The operating mode is activated by: • Rising edge at ModeActivate • Falling edge at Reset • Falling edge at ManualEnable • Cold restart of CPU if RunModeByStartup = TRUE Mode is retentive. A detailed description of the operating modes can be found in State and Mode V2 parameters (Page 325).

11.2.4.7 Static tags of PID_3Step V2

NOTE

Change the tags identified with (1) only in "Inactive" mode to prevent malfunction of the PID controller.

The names of the following variables apply both to the data block and to access via the Openness API.

Tag	Data type	Default	Description
ManualUpInternal	BOOL	FALSE	In manual mode, each rising edge opens the valve by 5% of the total control range or for the duration of the minimum motor transition time. ManualUpInternal is only evaluated if you are not using Output_PER or a position feedback. This tag is used in the commissioning dialog.
ManualDnInternal	BOOL	FALSE	In manual mode, every rising edge closes the valve by 5% of the total control range or for the duration of the minimum motor transition time. ManualDnInternal is only evaluated if you are not using Output_PER or position feedback. This tag is used in the commissioning dialog.
ActivateRecoverMode	BOOL	TRUE	The ActivateRecoverMode V2 (Page 332) tag determines the response in the event of an error.

Tag	Data type	Default	Description
RunModeByStartup	BOOL	TRUE	Activate operating mode at Mode parameter after CPU restart If RunModeByStartup = TRUE, PID_3Step starts in the operating mode saved in the Mode parameter after CPU startup. If RunModeByStartup = FALSE, PID_3Step remains in "Inactive" mode after CPU startup.
LoadBackUp	BOOL	FALSE	If LoadBackUp = TRUE, the last set of PID parameters is reloaded. The set was saved prior to the last tuning. LoadBackUp is automatically set back to FALSE.
PhysicalUnit	INT	0	Unit of measurement of the process value and setpoint, e.g., °C, or °F. PhysicalUnit serves the display in the editors and has no influence on the behavior of the control algorithm in the CPU. When importing PID_3Step via the Openness API, PhysicalUnit is reset to the default value.
PhysicalQuantity	INT	0	Physical quantity of the process value and setpoint, e.g., temperature PhysicalQuantity serves the display in the editors and has no influence on the behavior of the control algorithm in the CPU. When importing PID_3Step via the Openness API, PhysicalQuantity is reset to the default value.
ErrorBehaviour	BOOL	FALSE	If ErrorBehaviour = FALSE and an error has occurred, the valve stays at its current position and the controller switches directly to "Inactive" or "Error monitoring" mode. If ErrorBehaviour = TRUE and an error occurs, the actuator moves to the substitute output value and only then switches to "Inactive" or "Error monitoring" mode. If the following errors occur, you can no longer move the valve to a configured substitute output value. • 2000h: Invalid value at Feedback_PER parameter. • 4000h: Invalid value at Feedback parameter. • 8000h: Error during digital position feedback. • 20000h: Invalid value at SavePosition tag.
Warning	DWORD	DW#16#0	The Warning tag (Page 325) shows the warnings since Reset = TRUE or ErrorAck =TRUE. Warning is retentive. Cyclic warnings (for example, process value warning) are shown until the cause of the warning is removed. They are automatically deleted once their cause has gone. Non-cyclic warnings (for example, point of inflection not found) remain and are deleted like errors.
SavePosition	REAL	0.0	Substitute output value If ErrorBehaviour = TRUE, the actuator is moved to a position that is safe for the plant when an error occurs. As soon as the substitute output value has been reached, PID_3Step switches the operating mode according to ActivateRecoverMode. The permitted value range is determined by the configuration. • Config.FeedbackOn = FALSE and Config.OutputPerOn = FALSE: SavePosition = 0.0 or 100.0 • Config.FeedbackOn = TRUE or Config.OutputPerOn = TRUE: Config.OutputUpperLimit ≥ SavePosition ≥ Config.OutputLowerLimit
CurrentSetpoint	REAL	0.0	Currently active setpoint. This value is frozen at the start of tuning.

Tag	Data type	Default	Description
CancelTuningLevel	REAL	10.0	Permissible fluctuation of setpoint during tuning. Tuning is not canceled until: • Setpoint > CurrentSetpoint + CancelTuningLevel or • Setpoint < CurrentSetpoint - CancelTuningLevel
Progress	REAL	0.0	Progress of tuning as a percentage (0.0 - 100.0)
Config.InputPerOn(1)	BOOL	TRUE	If InputPerOn = TRUE, the Input_PER parameter is used. If InputPerOn = FALSE, the Input parameter is used.
Config.OutputPerOn(1)	BOOL	FALSE	If OutputPerOn = TRUE, the Output_PER parameter is used. If OutputPerOn = FALSE, the Ouput_UP and Output_DN parameters are used.
Config.InvertControl(1)	BOOL	FALSE	Invert control logic If InvertControl = TRUE, an increasing control deviation causes a reduction in the output value.
Config.FeedbackOn(1)	BOOL	FALSE	If FeedbackOn = FALSE, a position feedback is simulated. Position feedback is generally activated when FeedbackOn = TRUE.
Config.FeedbackPerOn(1)	BOOL	FALSE	FeedbackPerOn only takes effect when FeedbackOn = TRUE. If FeedbackPerOn = TRUE, the analog input is used for the position feedback (Feedback_PER parameter). If FeedbackPerOn = FALSE, the Feedback parameter is used for the position feedback.
Config.ActuatorEndStopOn(1)	BOOL	FALSE	If ActuatorEndStopOn = TRUE, the digital position feedback Actuator_L and Actuator_H are taken into consideration.
Config.InputUpperLimit(1)	REAL	120.0	High limit of the process value Input and Input_PER are monitored to ensure adherence to this limit. At the I/O input, the process value can be a maximum of 18% higher than the standard range (overrange). An error is no longer signaled due to a violation of the "Process value high limit". Only a wire-break and a short-circuit are recognized and PID_3Step reacts according to the configured reaction to error. InputUpperLimit > InputLowerLimit
Config.InputLowerLimit(1)	REAL	0.0	Low limit of the process value InputLowerLimit < InputUpperLimit
Config.InputUpperWarning(1)	REAL	+3.40282-2e+38	Warning high limit of the process value If you set InputUpperWarning outside the process value limits, the configured absolute process value high limit is used as the warning high limit. If you configure InputUpperWarning within the process value limits, this value is used as the warning high limit. InputUpperWarning > InputLowerWarning InputUpperWarning ≤ InputUpperLimit
Config.InputLowerWarning(1)	REAL	-3.402822 e+38	Warning low limit of the process value If you set InputLowerWarning outside the process value limits, the configured absolute process value low limit is used as the warning low limit. If you configure InputLowerWarning within the process value limits, this value is used as the warning low limit. InputLowerWarning < InputUpperWarning InputLowerWarning ≥ InputLowerLimit

Tag	Data type	Default	Description
Config.OutputUpperLimit(1)	REAL	100.0	High limit of output value The following value range is permitted: UpperPointOut ≥ OutputUpperLimit > OutputLowerLimit For more details, see OutputLowerLimit.
Config.OutputLowerLimit(1)	REAL	0.0	Low limit of the output value The following value range is permitted: OutputUpperLimit > OutputLowerLimit ≥ LowerPointOut When using Output_PER, an output value limit of -100% corresponds to the value Output_PER = -27648; 100% correspond to the value Output_PER = 27648. If OutputPerOn = FALSE and FeedbackOn = FALSE, OutputLowerLimit and OutputUpperLimit are not evaluated. Output_UP and Output_DN are then reset at Actuator_H = TRUE or Actuator_L = TRUE (if ActuatorEndStopOn = TRUE) or after a travel time of Config.VirtualActuatorLimit * Retain.TransitTime/100 (if ActuatorEndStopOn = FALSE).
Config.SetpointUpperLimit(1)	REAL	+3.40282-2e+38	High limit of setpoint If you set SetpointUpperLimit outside the process value limits, the configured absolute process value high limit is preassigned as the setpoint high limit. If you configure SetpointUpperLimit within the process value limits, this value is used as the setpoint high limit.
Config.SetpointLowerLimit(1)	REAL	-3.402822e+38	Low limit of the setpoint If you set SetpointLowerLimit outside the process value limits, the configured absolute process value low limit is preassigned as the setpoint low limit. If you set SetpointLowerLimit within the process value limits, this value is used as the setpoint low limit.
Config.MinimumOnTime(1)	REAL	0.0	Minimum ON time Minimum time in seconds for which the servo drive must be switched on. Config.MinimumOnTime only takes effect when Output_UP and Output_DN are used (Config.OutputPerOn = FALSE).
Config.MinimumOffTime(1)	REAL	0.0	Minimum OFF time Minimum time in seconds for which the servo drive must be switched off. Config.MinimumOffTime only takes effect when Output_UP and Output_DN are used (Config.OutputPerOn = FALSE).
Config.VirtualActuatorLimit(1)	REAL	150.0	If all the following conditions have been satisfied, the actuator is moved in one direction for the maximum period of VirtualActuatorLimit × Retain.TransitTime/100 and the warning 2000h is output: • Config.OutputPerOn = FALSE • Config.ActuatorEndStopOn = FALSE • Config.FeedbackOn = FALSE If Config.OutputPerOn = FALSE and Config.ActuatorEndStopOn = TRUE or Config.FeedbackOn = TRUE, only the warning 2000h is output. If Config.OutputPerOn = TRUE, VirtualActuatorLimit is not taken into consideration. As of PID_3Step Version 2.3 the monitoring and limiting of the travel time can be deactivated with Config.VirtualActuatorLimit = 0.0.

Tag	Data type	Default	Description
Config.InputScaling.UpperPointIn(1)	REAL	27648.0	Scaling Input_PER high Input_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the InputScaling structure.
Config.InputScaling.LowerPointIn(1)	REAL	0.0	Scaling Input_PER low Input_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the InputScaling structure.
Config.InputScaling.UpperPointOut(1)	REAL	100.0	Scaled high process value Input_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the InputScaling structure.
Config.InputScaling.LowerPointOut(1)	REAL	0.0	Scaled low process value Input_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the InputScaling structure.
Config.FeedbackScaling.UpperPointIn(1)	REAL	27648.0	Scaling Feedback_PER high Feedback_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the FeedbackScaling structure.
Config.FeedbackScaling.LowerPointIn(1)	REAL	0.0	Scaling Feedback_PER low Feedback_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the FeedbackScaling structure.
Config.FeedbackScaling.UpperPointOut(1)	REAL	100.0	High endstop Feedback_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the FeedbackScaling structure. The permitted value range is determined by the configuration. • FeedbackOn = FALSE: UpperPointOut = 100.0 • FeedbackOn = TRUE: UpperPointOut = 100.0 or 0.0 UpperPointOut ≠ LowerPointOut
Config.FeedbackScaling.LowerPointOut(1)	REAL	0.0	Low endstop Feedback_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the FeedbackScaling structure. The permitted value range is determined by the configuration. • FeedbackOn = FALSE: LowerPointOut = 0.0 • FeedbackOn = TRUE: LowerPointOut = 0.0 or -100.0 LowerPointOut ≠ UpperPointOut
GetTransitTime.InvertDirection	BOOL	FALSE	If InvertDirection = FALSE, the valve is fully opened, closed, and then reopened in order to determine the valve transition time. If InvertDirection = TRUE, the valve is fully closed, opened, and then closed again.
GetTransitTime.SelectFeedback	BOOL	FALSE	If SelectFeedback = TRUE, then Feedback_PER, or Feedback is taken into consideration in the transition time measurement. If SelectFeedback = FALSE, then Actuator_H and Actuator_L are taken into consideration in the transition time measurement.

Tag	Data type	Default	Description
GetTransitTime.State	INT	0	Current phase of the transition time measurement • State = 0: Inactive • State = 1: Open valve completely • State = 2: Close valve completely • State = 3: Move valve to target position (NewOutput) • State = 4: Transition time measurement successfully completed • State = 5: Transition time measurement canceled
GetTransitTime.NewOutput	REAL	0.0	Target position for transition time measurement with position feedback The target position must be between "High endstop" and "Low endstop". The difference between NewOutput and ScaledFeedback must be at least 50% of the permissible control range.
CycleTime.StartEstimation	BOOL	TRUE	If StartEstimation = TRUE, the measurement of the PID_3Step sampling time is started. CycleTime.StartEstimation = FALSE once measurement is complete.
CycleTime.EnEstimation	BOOL	TRUE	If EnEstimation = TRUE, the PID_3Step sampling time is calculated. If CycleTime.EnEstimation = FALSE, the PID_3Step sampling time is not calculated and you need to correct the configuration of CycleTime.Value manually.
CycleTime.EnMonitoring	BOOL	TRUE	If EnMonitoring = TRUE, the PID_3Step sampling time is monitored. If it is not possible to execute PID_3Step within the sampling time, the error 0800h is output and the operating mode is switched. ActivateRecoverMode and ErrorBehaviour determine which operating mode is switched to. If EnMonitoring = FALSE, the PID_3Step sampling time is not monitored, the error 0800h is not output, and the operating mode is not switched.
CycleTime.Value(1)	REAL	0.1	PID_3Step sampling time in seconds CycleTime.Value is determined automatically and is usually equivalent to the cycle time of the calling OB.
CtrlParamsBackUp.SetByUser	BOOL	FALSE	Saved value of Retain.CtrlParams.SetByUser You can reload values from the CtrlParamsBackUp structure with LoadBackUp = TRUE.
CtrlParamsBackUp.Gain	REAL	1.0	Saved proportional gain
CtrlParamsBackUp.Ti	REAL	20.0	Saved integration time in seconds
CtrlParamsBackUp.Td	REAL	0.0	Saved derivative action time in seconds
CtrlParamsBackUp.TdFiltRatio	REAL	0.2	Saved derivative delay coefficient
CtrlParamsBackUp.PWeighting	REAL	1.0	Saved proportional action weighting
CtrlParamsBackUp.DWeighting	REAL	1.0	Saved derivative action weighting
CtrlParamsBackUp.Cycle	REAL	1.0	Saved sampling time of PID algorithm in seconds
CtrlParamsBackUp.InputDeadBand	REAL	0.0	Saved deadzone width of the control deviation
PIDSelfTune.SUT.CalculateParams	BOOL	FALSE	The properties of the controlled system are saved during tuning. If CalculateParams = TRUE, the PID parameters are recalculated on the basis of these properties. The PID parameters are calculated using the method set in TuneRule. CalculateParams is set to FALSE following calculation.

Tag	Data type	Default	Description
PIDSelfTune.SUT.TuneRule	INT	1	Methods used to calculate parameters during pretuning: • SUT.TuneRule = 0: PID fast I (faster control response with higher amplitudes of the output value than with SUT.TuneRule =1) • SUT.TuneRule = 1: PID slow I (slower control response with lower amplitudes of the output value than with SUT.TuneRule = 0) • SUT.TuneRule = 2: Chien, Hrones and Reswick PID • SUT.TuneRule = 3: Chien, Hrones, Reswick PI • SUT.TuneRule = 4: PID fast II (faster control response with higher amplitudes of the output value than with SUT.TuneRule = 5) • SUT.TuneRule = 5: PID slow II (slower control response with lower amplitudes of the output value than with SUT.TuneRule = 4) The methods SUT.TuneRule = 0 and 1 differ from the methods SUT.TuneRule = 4 and 5 only in the calculation of the proportional gain: When SUT.TuneRule = 0 and 1, the proportional gain is calculated based on the compensation time of the process. When SUT.TuneRule = 4 and 5, this happens based on the delay time of the process. SUT.TuneRule = 4 and 5 returns a higher value for the proportional gain and thus a faster control response with higher amplitudes of the output value than with SUT.TuneRule = 0 and 1.
PIDSelfTune.SUT.State	INT	0	The SUT.State tag indicates the current phase of pretuning: • State = 0: Initialize pretuning • State = 50: Determine start position without position feedback • State = 100: Calculate the standard deviation • State = 200: Find the point of inflection • State = 300: Determine the rise time • State = 9900: Pretuning successful • State = 1: Pretuning not successful
PIDSelfTune.TIR.RunIn	BOOL	FALSE	With the RunIn tag, you can specify that fine tuning can also be performed without pretuning. • RunIn = FALSE Pretuning is started when fine tuning is started from inactive or manual mode. If fine tuning is started from automatic mode, the system uses the existing PID parameters to control to the setpoint. Only then will fine tuning start. If pretuning is not possible, PID_3Step switches to the mode from which tuning was started. • RunIn = TRUE The pretuning is skipped. PID_3Step attempts to reach the setpoint with the minimum or maximum output value. This can produce increased overshoot. Only then will fine tuning start. RunIn is set to FALSE after fine tuning.
PIDSelfTune.TIR.Calculate-Params	BOOL	FALSE	The properties of the controlled system are saved during tuning. If CalculateParams = TRUE, the PID parameters are recalculated on the basis of these properties. The PID parameters are calculated using the method set in TuneRule. CalculateParams is set to FALSE following calculation.

Tag	Data type	Default	Description
PIDSelfTune.TIR.TuneRule	INT	0	Methods used to calculate parameters during fine tuning: • TIR.TuneRule = 0: PID automatic • TIR.TuneRule = 1: PID fast (faster control response with higher amplitudes of the output value than with TIR.TuneRule = 2) • TIR.TuneRule = 2: PID slow (slower control response with lower amplitudes of the output value than with TIR.TuneRule = 1) • TIR.TuneRule = 3: Ziegler-Nichols PID • TIR.TuneRule = 4: Ziegler-Nichols PI • TIR.TuneRule = 5: Ziegler-Nichols P To be able to repeat the calculation of the PID parameters with TIR.CalculateParams and TIR.TuneRule = 0, 1 or 2, the previous fine tuning also has to have been executed with TIR.TuneRule = 0, 1 or 2. If this is not the case, TIR.TuneRule = 3 is used. The recalculation of the PID parameters with TIR.CalculateParams and TIR.TuneRule = 3, 4 or 5 is always possible.
PIDSelfTune.TIR.State	INT	0	The TIR.State tag indicates the current phase of fine tuning: • State = -100 Fine tuning is not possible. Pretuning will be performed first. • State = 0: Initialize fine tuning • State = 200: Calculate the standard deviation • State = 300: Attempt to reach the setpoint with the maximum or minimum output value • State = 400: Attempt to reach the setpoint with existing PID parameters (if pretuning was successful) • State = 500: Determine oscillation and calculate parameters • State = 9900: Fine tuning successful • State = 1: Fine tuning not successful
Retain.TransitTime(1)	REAL	30.0	Motor transition time in seconds Time in seconds the actuating drive requires to move the valve from the closed to the opened state. TransitTime is retentive.
Retain.CtrlParams.SetByUser(1)	BOOL	FALSE	If SetByUser = FALSE, the PID parameters are determined automatically and PID_3Step operates with a dead zone at the output value. The deadzone width is calculated during tuning on the basis of the standard deviation of the output value and saved in Retain.CtrlParams.OutputDeadBand. If SetByUser = TRUE, the PID parameters are entered manually and PID_3 Step operates without a dead zone at the output value. Retain.CtrlParams.OutputDeadBand = 0.0 SetByUser is retentive.
Retain.CtrlParams.Gain(1)	REAL	1.0	Active proportional gain To invert the control logic, use the Config.InvertControl tag. Negative values at Gain also invert the control logic. We recommend you use only InvertControl to set the control logic. The control logic is also inverted if InvertControl = TRUE and Gain < 0.0. Gain is retentive.
Retain.CtrlParams.Ti(1)	REAL	20.0	• Ti > 0.0: Active integration time in seconds • Ti = 0.0: Integral action is deactivated Ti is retentive.
Retain.CtrlParams.Td(1)	REAL	0.0	• Td > 0.0: Active derivative action time in seconds • Td = 0.0: Derivative action is deactivated Td is retentive.

Tag	Data type	Default	Description
Retain.CtrlParams.TdFiltRatio(1)	REAL	0.2	Active derivative delay coefficient The derivative delay coefficient delays the effect of the derivative action. Derivative delay = derivative action time × derivative delay coefficient • 0.0: Derivative action is effective for one cycle only and therefore almost not effective. • 0.5: This value has proved useful in practice for controlled systems with **one** dominant time constant. • > 1.0: The greater the coefficient, the longer the effect of the derivative action is delayed. TdFiltRatio is retentive.
Retain.CtrlParams.PWeighting(1)	REAL	1.0	Active proportional action weighting The proportional action may weaken with changes to the setpoint. Values from 0.0 to 1.0 are applicable. • 1.0: Proportional action for setpoint change is fully effective • 0.0: Proportional action for setpoint change is not effective The proportional action is always fully effective when the process value is changed. PWeighting is retentive.
Retain.CtrlParams.DWeighting(1)	REAL	1.0	Active derivative action weighting The derivative action may weaken with changes to the setpoint. Values from 0.0 to 1.0 are applicable. • 1.0: Derivative action is fully effective upon setpoint change • 0.0: Derivative action is not effective upon setpoint change The derivative action is always fully effective when the process value is changed. DWeighting is retentive.
Retain.CtrlParams.Cycle(1)	REAL	1.0	Active sampling time of PID algorithm in seconds, rounded to an integer multiple of the cycle time of the calling OB. Cycle is retentive.
Retain.CtrlParams.InputDeadBand(1)	REAL	0.0	Deadzone width of the control deviation InputDeadBand is retentive.

See also

State and Mode V2 parameters (Page 325)
Tag ActivateRecoverMode V2 (Page 332)
Downloading technology objects to device (Page 46)

11.2.4.8 State and Mode V2 parameters

Correlation of the parameters

The State parameter shows the current operating mode of the PID controller. You cannot change the State parameter.

With a rising edge at ModeActivate, PID_3Step switches to the operating mode saved in the Mode in-out parameter.

When the CPU is switched on or switches from Stop to RUN mode, PID_3Step starts in the operating mode that is saved in the Mode parameter. To retain PID_3Step in "Inactive" mode, set RunModeByStartup = FALSE.

Meaning of values

State	Description of operating mode
0	Inactive The controller is switched off and no longer changes the valve position. The change from Inactive mode to Automatic mode is bumpless.
1	Pretuning The pretuning determines the process response to a pulse of the output value and searches for the point of inflection. The PID parameters are calculated from the maximum rate of rise and dead time of the controlled system. You obtain the best PID parameters when you perform pretuning and fine tuning. Pretuning requirements: • The motor transition time has been configured or measured. • Inactive (State = 0), manual mode (State = 4), or automatic mode (State = 3) • ManualEnable = FALSE • Reset = FALSE • The setpoint and the process value lie within the configured limits. The more stable the process value is, the easier it is to calculate the PID parameters and the more precise the result will be. Noise on the process value can be tolerated as long as the rate of rise of the process value is significantly higher as compared to the noise. This is most likely the case in operating modes "Inactive" and "manual mode". The setpoint is frozen in the CurrentSetpoint tag. Tuning is canceled when: • Setpoint > CurrentSetpoint + CancelTuningLevel or • Setpoint < CurrentSetpoint - CancelTuningLevel Before the PID parameters are recalculated, they are backed up and can be reactivated with LoadBackUp. The controller switches to automatic mode following successful pretuning. If pretuning is unsuccessful, the switchover of operating mode is dependent on ActivateRecoverMode and ErrorBehaviour. The phase of pretuning is indicated with PIDSelfTune.SUT.State.
2	Fine tuning Fine tuning generates a constant, limited oscillation of the process value. The PID parameters are recalculated based on the amplitude and frequency of this oscillation. PID parameters from fine tuning usually have better master control and disturbance characteristics than PID parameters from pretuning. You obtain the best PID parameters when you perform pretuning and fine tuning. PID_3Step automatically attempts to generate an oscillation greater than the noise of the process value. Fine tuning is only minimally influenced by the stability of the process value. The setpoint is frozen in the CurrentSetpoint tag. Tuning is canceled when: • Setpoint > CurrentSetpoint + CancelTuningLevel or • Setpoint < CurrentSetpoint - CancelTuningLevel The PID parameters are backed up before fine tuning. They can be reactivated with LoadBackUp.

State	Description of operating mode
	Requirements for fine tuning: • The motor transition time has been configured or measured. • The setpoint and the process value lie within the configured limits. • ManualEnable = FALSE • Reset = FALSE • Automatic (State = 3), inactive (State = 0) or manual (State = 4) mode Fine tuning proceeds as follows when started from: • Automatic mode (State = 3) Start fine tuning from automatic mode if you wish to improve the existing PID parameters through tuning. PID_3Step controls the system using the existing PID parameters until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start. • Inactive (State = 0) or manual mode (State = 4) If the requirements for pretuning are met, pretuning is started. The determined PID parameters will be used for control until the control loop has stabilized and the requirements for fine tuning have been met. If PIDSelfTune.TIR.RunIn = TRUE, pretuning is skipped and an attempt is made to reach the setpoint with the minimum or maximum output value. This can produce increased overshoot. Fine tuning then starts automatically. The controller switches to automatic mode following successful fine tuning. If fine tuning is unsuccessful, the switchover of operating mode is dependent on ActivateRecoverMode and ErrorBehaviour. The phase of fine tuning is indicated with PIDSelfTune.TIR.State.
3	Automatic mode In automatic mode, PID_3Step controls the controlled system in accordance with the parameters specified. The controller switches to automatic mode if one the following requirements is fulfilled: • Pretuning successfully completed • Fine tuning successfully completed • Changing of the Mode in-out parameter to the value 3 and a rising edge at ModeActivate. The switchover from automatic mode to manual mode is only bumpless if carried out in the commissioning editor. The ActivateRecoverMode tag is taken into consideration in automatic mode.
4	Manual mode In manual mode, you specify manual output values in the Manual_UP and Manual_DN parameters or ManualValue parameter. Whether or not the actuator can be moved to the output value in the event of an error is described in the ErrorBits parameter. You can also activate this operating mode using ManualEnable = TRUE. We recommend that you change the operating mode using Mode and ModeActivate only. The switchover from manual mode to automatic mode is bumpless. Manual mode is also possible when an error is pending.
5	Approach substitute output value This operating mode is activated in the event of an error, if Errorbehaviour = TRUE and ActivateRecoverMode = FALSE.. PID_3Step moves the actuator to the substitute output value and then switches to "Inactive" mode.
6	Transition time measurement The time that the motor needs to completely open the valve from the closed condition is determined. This operating mode is activated when Mode = 6 and ModeActivate = TRUE is set. If endstop signals are used to measure the transition time, the valve will be opened completely from its current position, closed completely, and opened completely again. If GetTransitTime.InvertDirection = TRUE, this behavior is inverted. If position feedback is used to measure the transition time, the actuator will be moved from its current position to a target position. The output value limits are not taken into consideration during the transition time measurement. The actuator can travel to the high or the low endstop.

State	Description of operating mode
7	Error monitoring The control algorithm is switched off and no longer changes the valve position. This operating mode is activated instead of "Inactive" mode in the event of an error. All the following conditions must be met: • Automatic mode (Mode = 3) • Errorbehaviour = FALSE • ActivateRecoverMode = TRUE • One or more errors have occurred in which ActivateRecoverMode (Page 332) is effective. As soon as the errors are no longer pending, PID_3Step switches back to automatic mode.
8	Approach substitute output value with error monitoring This operating mode is activated instead of "approach substitute output value" mode when an error occurs. PID_3Step moves the actuator to the substitute output value and then switches to "error monitoring" mode. All the following conditions must be met: • Automatic mode (Mode = 3) • Errorbehaviour = TRUE • ActivateRecoverMode = TRUE • One or more errors have occurred in which ActivateRecoverMode (Page 332) is effective. As soon as the errors are no longer pending, PID_3Step switches back to automatic mode.
10	Manual mode without endstop signals The endstop signals are **not** taken into consideration, even though Config.ActuatorEndStopOn = TRUE. The output value limits are not taken into consideration. Otherwise, PID_3Step behaves the same as in manual mode.

ENO characteristics

If State = 0, then ENO = FALSE.

If State ≠ 0, then ENO = TRUE.

Automatic switchover of operating mode during commissioning

Automatic mode is activated following successful pretuning or fine tuning. The following table shows how Mode and State change during successful pretuning.

Cycle no.	Mode	State	Action
0	4	4	Set Mode = 1
1	1	4	Set ModeActivate = TRUE
1	4	1	Value of State is saved in Mode parameter Pretuning is started
n	4	1	Pretuning successfully completed
n	3	3	Automatic mode is started

PID_3Step automatically switches the operating mode in the event of an error. The following table shows how Mode and State change during pretuning with errors.

Cycle no.	Mode	State	Action
0	4	4	Set Mode = 1
1	1	4	Set ModeActivate = TRUE
1	4	1	Value of State is saved in Mode parameter Pretuning is started
n	4	1	Pretuning canceled
n	4	4	Manual mode is started

If ActivateRecoverMode = TRUE, the operating mode that is saved in the Mode parameter is activated. At the start of transition time measurement, pretuning, or fine tuning, PID_3Step saved the value of State in the Mode in/out parameter. PID_3Step therefore switches to the operating mode from which transition time measurement or tuning was started.

If ActivateRecoverMode = FALSE, "Inactive" or "Approach substitute output value" mode is activated.

Automatic switchover of operating mode after transition time measurement

If ActivateRecoverMode = TRUE, the operating mode that is saved in the Mode parameter is activated after successful transition time measurement.

If ActivateRecoverMode = FALSE, the system switches to "Inactive" operating mode after successful transition time measurement.

Automatic switchover of operating mode in automatic mode

PID_3Step automatically switches the operating mode in the event of an error. The following diagram illustrates the influence of ErrorBehaviour and ActivateRecoverMode on this switchover of operating mode.

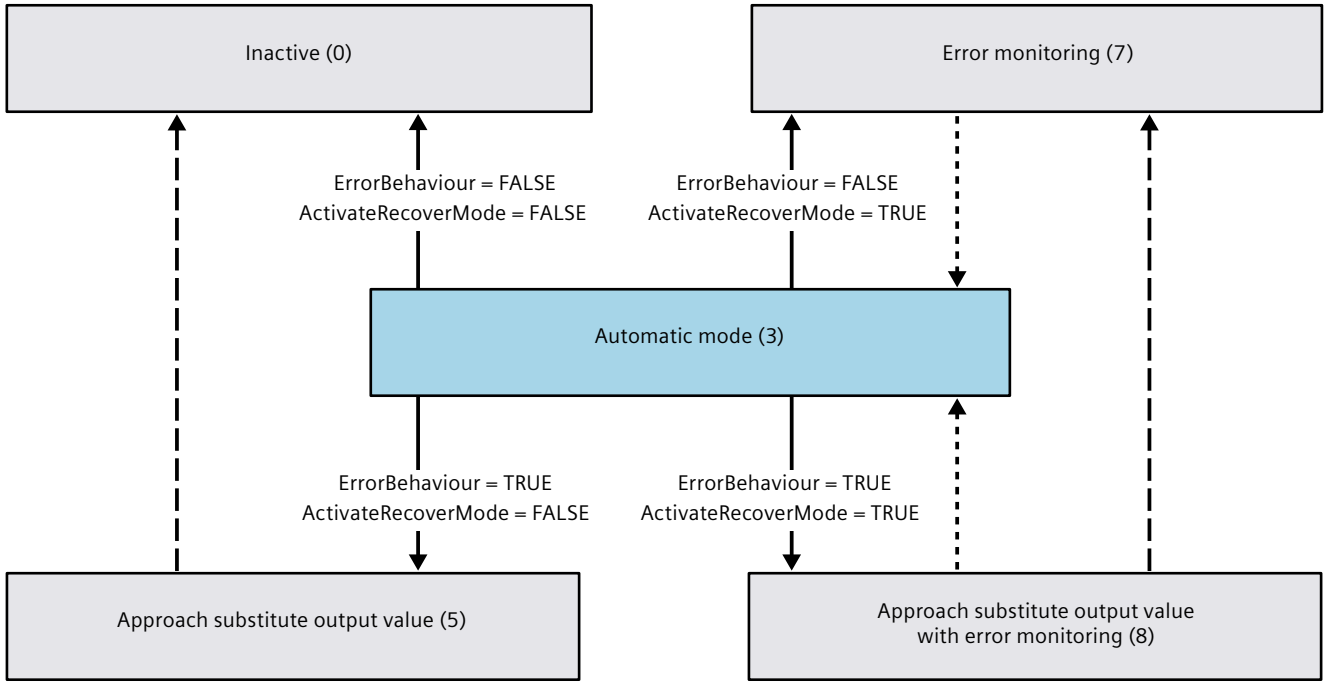

Automatic switchover of operating mode in the event of an error

Automatic switchover of operating mode once the current operation has been completed.

Automatic switchover of operating mode when error is no longer pending.

See also

Tag ActivateRecoverMode V2 (Page 332)
ErrorBits V2 parameter (Page 330)

11.2.4.9 ErrorBits V2 parameter

If several errors are pending simultaneously, the values of the ErrorBits are displayed with binary addition. The display of ErrorBits = 16#0000_0003, for example, indicates that the errors 16#0000_0001 and 16#0000_0002 are pending simultaneously.

If there is a position feedback, PID_3Step uses ManualValue as output value in manual mode. The exception is Errorbits = 16#0001_0000.

ErrorBits (DW#16#...)	Description
0000_0000	There is no error.
0000_0001	The "Input" parameter is outside the process value limits. • Input > Config.InputUpperLimit or • Input < Config.InputLowerLimit If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_3Step remains in automatic mode. If pretuning, fine tuning, or transition time measurement mode and ActivateRecoverMode = TRUE were active before the error occurred, PID_3Step switches to the operating mode saved in the Mode parameter.
0000_0002	Invalid value at "Input_PER" parameter. Check whether an error is pending at the analog input. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_3Step switches to "Approach substitute output value with error monitoring" or "Error monitoring" mode. As soon as the error is no longer pending, PID_3Step switches back to automatic mode. If pretuning, fine tuning, or transition time measurement mode and ActivateRecoverMode = TRUE were active before the error occurred, PID_3Step switches to the operating mode saved in the Mode parameter.
0000_0004	Error during fine tuning. The oscillation of the process value could not be maintained. If ActivateRecoverMode = TRUE before the error occurred, PID_3Step cancels the tuning and switches to the operating mode saved in the Mode parameter.
0000_0010	The setpoint was changed during tuning. You can set the permitted fluctuation of the setpoint at the CancelTuningLevel tag. If ActivateRecoverMode = TRUE before the error occurred, PID_3Step cancels the tuning and switches to the operating mode saved in the Mode parameter.
0000_0020	Pretuning is not permitted during fine tuning. If ActivateRecoverMode = TRUE before the error occurred, PID_3Step remains in fine tuning mode.
0000_0080	Error during pretuning. The output value limits are not configured correctly or the process value does not react as expected. Make sure that: • The limits of the output value are configured correctly and match the control logic. • It is possible to change the output value so that the process value approaches the setpoint. The output value is not already limited by the corresponding output value limit before the start of pretuning and the actuator has not yet reached the corresponding endstop. Example: With normal control logic and a process value that is below the setpoint, the output value must not have reached the high limit and the actuator must not have reached the high endstop before the start of the pretuning. • The process value does not show a strong oscillation before the start of the pretuning. If ActivateRecoverMode = TRUE before the error occurred, PID_3Step cancels the tuning and switches to the operating mode saved in the Mode parameter.
0000_0100	Error during fine tuning resulted in invalid parameters. If ActivateRecoverMode = TRUE before the error occurred, PID_3Step cancels the tuning and switches to the operating mode saved in the Mode parameter.
0000_0200	Invalid value at "Input" parameter: Value has an invalid number format. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_3Step switches to "Approach substitute output value with error monitoring" or "Error monitoring" mode. As soon as the error is no longer pending, PID_3Step switches back to automatic mode.

ErrorBits (DW#16#...)	Description
	If pretuning, fine tuning, or transition time measurement mode and ActivateRecoverMode = TRUE were active before the error occurred, PID_3Step switches to the operating mode saved in the Mode parameter.
0000_0400	Calculation of output value failed. Check the PID parameters. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_3Step switches to "Approach substitute output value with error monitoring" or "Error monitoring" mode. As soon as the error is no longer pending, PID_3Step switches back to automatic mode. If pretuning, fine tuning, or transition time measurement mode and ActivateRecoverMode = TRUE were active before the error occurred, PID_3Step switches to the operating mode saved in the Mode parameter.
0000_0800	Sampling time error: PID_3Step is not called within the sampling time of the cyclic interrupt OB. It is recommended to call PID_3Step in a cyclic interrupt OB without conditions and to activate or deactivate it via the operating mode at the Mode parameter. Conditional calls or the call in OB1 can have a negative effect on the control quality. Monitoring of the sampling time can be disabled with CycleTime.EnMonitoring = FALSE. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_3Step remains in automatic mode. If pretuning, fine tuning, or transition time measurement mode and ActivateRecoverMode = TRUE were active before the error occurred, PID_3Step switches to the operating mode saved in the Mode parameter. If this error occurred during simulation with PLCSIM, see the notes under Simulating PID_3Step V2 with PLCSIM (Page 135).
0000_1000	Invalid value at "Setpoint" parameter: Value has an invalid number format. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_3Step switches to "Approach substitute output value with error monitoring" or "Error monitoring" mode. As soon as the error is no longer pending, PID_3Step switches back to automatic mode. If pretuning, fine tuning, or transition time measurement mode and ActivateRecoverMode = TRUE were active before the error occurred, PID_3Step switches to the operating mode saved in the Mode parameter.
0000_2000	Invalid value at Feedback_PER parameter. Check whether an error is pending at the analog input. The actuator cannot be moved to the substitute output value and remains in its current position. In manual mode, you can change the position of the actuator only with Manual_UP and Manual_DN, and not with ManualValue. If automatic mode was active before the error occurred, ActivateRecoverMode = TRUE, and the error is no longer pending, PID_3Step switches back to automatic mode. If pretuning, fine tuning, or transition time measurement mode and ActivateRecoverMode = TRUE were active before the error occurred, PID_3Step switches to the operating mode saved in the Mode parameter.
0000_4000	Invalid value at Feedback parameter. Value has an invalid number format. The actuator cannot be moved to the substitute output value and remains in its current position. In manual mode, you can change the position of the actuator only with Manual_UP and Manual_DN, and not with ManualValue. If automatic mode was active before the error occurred, ActivateRecoverMode = TRUE, and the error is no longer pending, PID_3Step switches back to automatic mode. If pretuning, fine tuning, or transition time measurement mode and ActivateRecoverMode = TRUE were active before the error occurred, PID_3Step switches to the operating mode saved in the Mode parameter.
0000_8000	Error during digital position feedback. Actuator_H = TRUE and Actuator_L = TRUE. The actuator cannot be moved to the substitute output value and remains in its current position. Manual mode is not possible in this state. In order to move the actuator from this state, you must deactivate the "Actuator endstop" (Config.ActuatorEndStopOn = FALSE) or switch to manual mode without endstop signals (Mode = 10). If automatic mode was active before the error occurred, ActivateRecoverMode = TRUE, and the error is no longer pending, PID_3Step switches back to automatic mode. If pretuning, fine tuning, or transition time measurement mode and ActivateRecoverMode = TRUE were active before the error occurred, PID_3Step switches to the operating mode saved in the Mode parameter.

ErrorBits (DW#16#...)	Description
0001_0000	Invalid value at ManualValue parameter. Value has an invalid number format. The actuator cannot be moved to the manual value and remains in its current position. Specify a valid value in ManualValue or move the actuator in manual mode with Manual_UP and Manual_DN.
0002_0000	Invalid value at SavePosition tag. Value has an invalid number format. The actuator cannot be moved to the substitute output value and remains in its current position.
0004_0000	Invalid value at Disturbance parameter. Value has an invalid number format. If automatic mode was active and ActivateRecoverMode = TRUE before the error occurred, Disturbance is set to zero. PID_3Step remains in automatic mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_3Step switches to the operating mode saved in the Mode parameter. If Disturbance in the current phase has no effect on the output value, tuning is not be canceled. The error has no effect during transition time measurement.

11.2.4.10 Tag ActivateRecoverMode V2

The ActivateRecoverMode tag determines the reaction to error. The Error parameter indicates if an error is pending. When the error is no longer pending, Error = FALSE. The ErrorBits parameter shows which errors have occurred.

NOTICE
Your system may be damaged. If ActivateRecoverMode = TRUE, PID_3Step remains in automatic mode even if the process limit values are exceeded. This may damage your system. It is essential to configure how your controlled system reacts in the event of an error to protect your system from damage.

Automatic mode

ActivateRecover-Mode	Description
FALSE	In the event of an error, PID_3Step switches to "Inactive" or "Approach substitute output value" mode. The controller is only activated by a falling edge at Reset or a rising edge at ModeActivate.
TRUE	If errors occur frequently in automatic mode, this setting has a negative effect on the control response, because PID_3Step switches between the calculated output value and the substitute output value at each error. In this case, check the ErrorBits parameter and eliminate the cause of the error. If one or more of the following errors occur, PID_3Step stays in automatic mode: • 0001h: The "Input" parameter is outside the process value limits. • 0800h: Sampling time error • 40000h: Invalid value at Disturbance parameter. If one or more of the following errors occur, PID_3Step switches to "Approach substitute output value with error monitoring" or "Error monitoring" mode: • 0002h: Invalid value at Input_PER parameter. • 0200h: Invalid value at Input parameter. • 0400h: Calculation of output value failed. • 1000h: Invalid value at Setpoint parameter.

ActivateRecover-Mode	Description
	If one or more of the following errors occur, PID_3Step can no longer move the actuator: • 2000h: Invalid value at Feedback_PER parameter. • 4000h: Invalid value at Feedback parameter. • 8000h: Error during digital position feedback. • 20000h: Invalid value at SavePosition tag. Value has an invalid number format. The characteristics are independent of ErrorBehaviour. As soon as the errors are no longer pending, PID_3Step switches back to automatic mode.

Pretuning, fine tuning, and transition time measurement

ActivateRecover-Mode	Description
FALSE	In the event of an error, PID_3Step switches to "Inactive" or "Approach substitute output value" mode. The controller is only activated by a falling edge at Reset or a rising edge at ModeActivate. The controller changes to "Inactive" mode after successful transition time measurement.
TRUE	If the following error occurs, PID_3Step remains in the active mode: • 0020h: Pretuning is not permitted during fine tuning. The following errors are ignored: • 10000h: Invalid value at ManualValue parameter. • 20000h: Invalid value at SavePosition tag. When any other error occurs, PID_3Step cancels the tuning and switches to the mode from which tuning was started.

Manual mode

ActivateRecoverMode is not effective in manual mode.

See also

Static tags of PID_3Step V2 (Page 316)
State and Mode V2 parameters (Page 325)

11.2.4.11 Tag Warning V2

If several warnings are pending simultaneously, their values are displayed with binary addition. The display of warning 16#0000_0005, for example, indicates that the warnings 16#0000_0001 and 16#0000_0004 are pending simultaneously.

Warning (DW#16#...)	Description
0000_0000	No warning pending.
0000_0001	The point of inflection was not found during pretuning.
0000_0004	The setpoint was limited to the configured limits.
0000_0008	Not all the necessary controlled system properties were defined for the selected method of calculation. Instead, the PID parameters were calculated using the TIR.TuneRule = 3 method.
0000_0010	The operating mode could not be changed because Reset = TRUE or ManualEnable = TRUE.

Warning (DW#16#...)	Description
0000_0020	The cycle time of the calling OB limits the sampling time of the PID algorithm. Improve results by using shorter OB cycle times.
0000_0040	The process value exceeded one of its warning limits.
0000_0080	Invalid value at Mode. The operating mode is not switched.
0000_0100	The manual value was limited to the limits of the controller output.
0000_0200	The specified rule for tuning is not supported. No PID parameters are calculated.
0000_0400	The transition time cannot be measured because the actuator settings do not match the selected measuring method.
0000_0800	The difference between the current position and the new output value is too small for transition time measurement. This can produce incorrect results. The difference between the current output value and new output value must be at least 50% of the entire control range.
0000_1000	The substitute output value cannot be reached because it is outside the output value limits.
0000_2000	The actuator was moved in one direction for longer than Config.VirtualActuatorLimit × Retain.TransitTime. Check whether the actuator has reached an endstop signal.

The following warnings are deleted as soon as the cause is eliminated:

- 16#0000_0001
- 16#0000_0004
- 16#0000_0008
- 16#0000_0040
- 16#0000_0100
- 16#0000_2000

All other warnings are cleared with a rising edge at Reset or ErrorAck.

11.2.5 PID_3Step V1

11.2.5.1 Description PID_3Step V1

Description

You use the PID_3Step instruction to configure a PID controller with self tuning for valves or actuators with integrating behavior.

The following operating modes are possible:

- Inactive
- Pretuning
- Fine tuning
- Automatic mode
- Manual mode
- Approach substitute output value
- Transition time measurement
- Approach substitute output value with error monitoring
- Error monitoring

For a more detailed description of the operating modes, see the State parameter.

PID algorithm

PID_3Step is a PIDT1 controller with anti-windup and weighting of the proportional and derivative actions. The following equation is used to calculate the transfer function.

$$\Delta y = K_p \cdot s \cdot \left[(b \cdot w - x) + \frac{1}{T_I \cdot s}(w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1}(c \cdot w - x)\right]$$

The table below shows the meaning of the icons used in the transfer function and in the subsequent figures:

Icon	Description
Δy	Output value of the PID algorithm
K_p	Proportional gain
s	Laplace operator
b	Proportional action weighting
w	Setpoint
x	Process value
T_I	Integration time
T_D	Derivative action time
a	Derivative delay coefficient (T1 = a × TD)
c	Derivative action weighting

Block diagram without position feedback

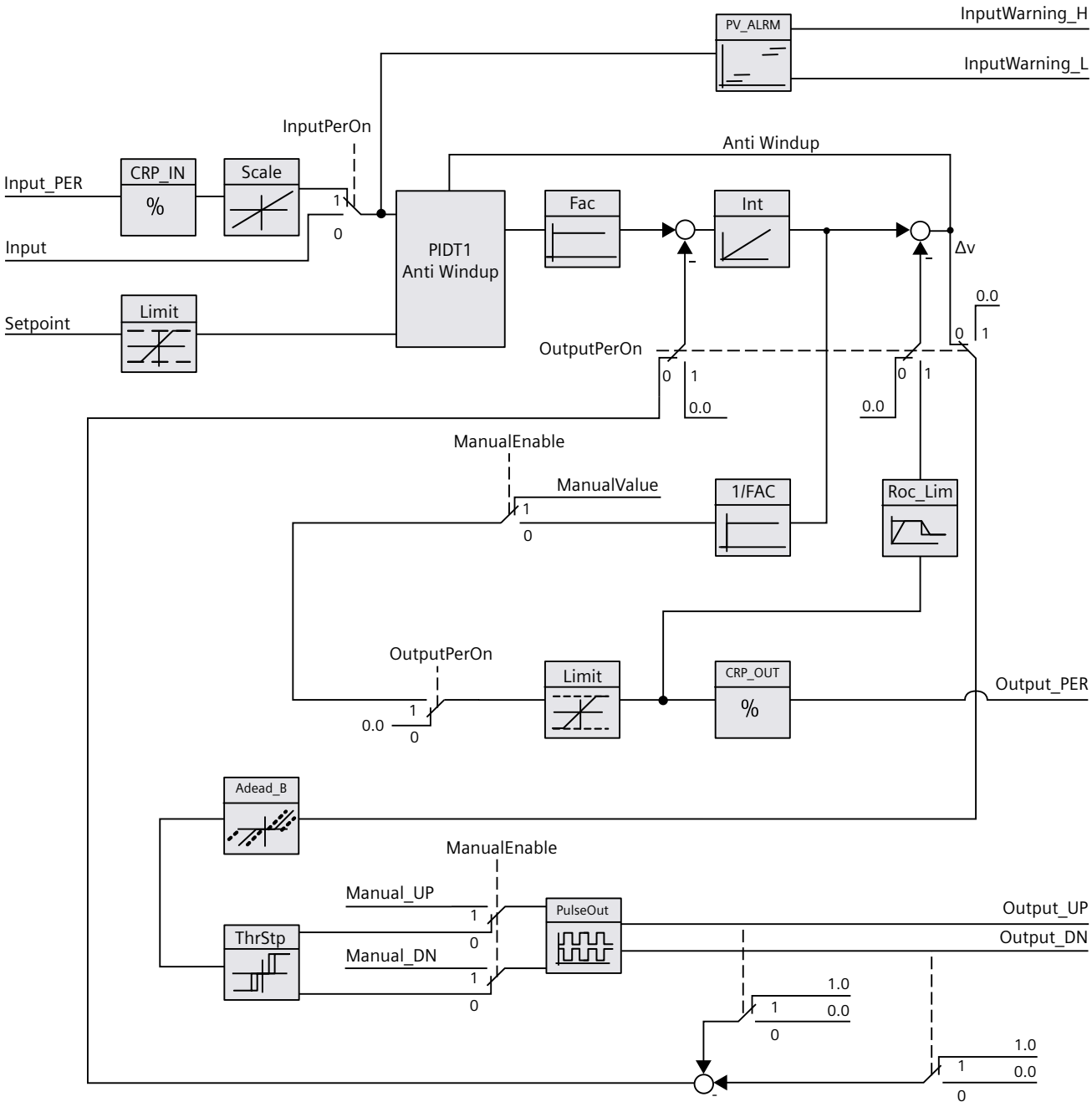

Block diagram with position feedback

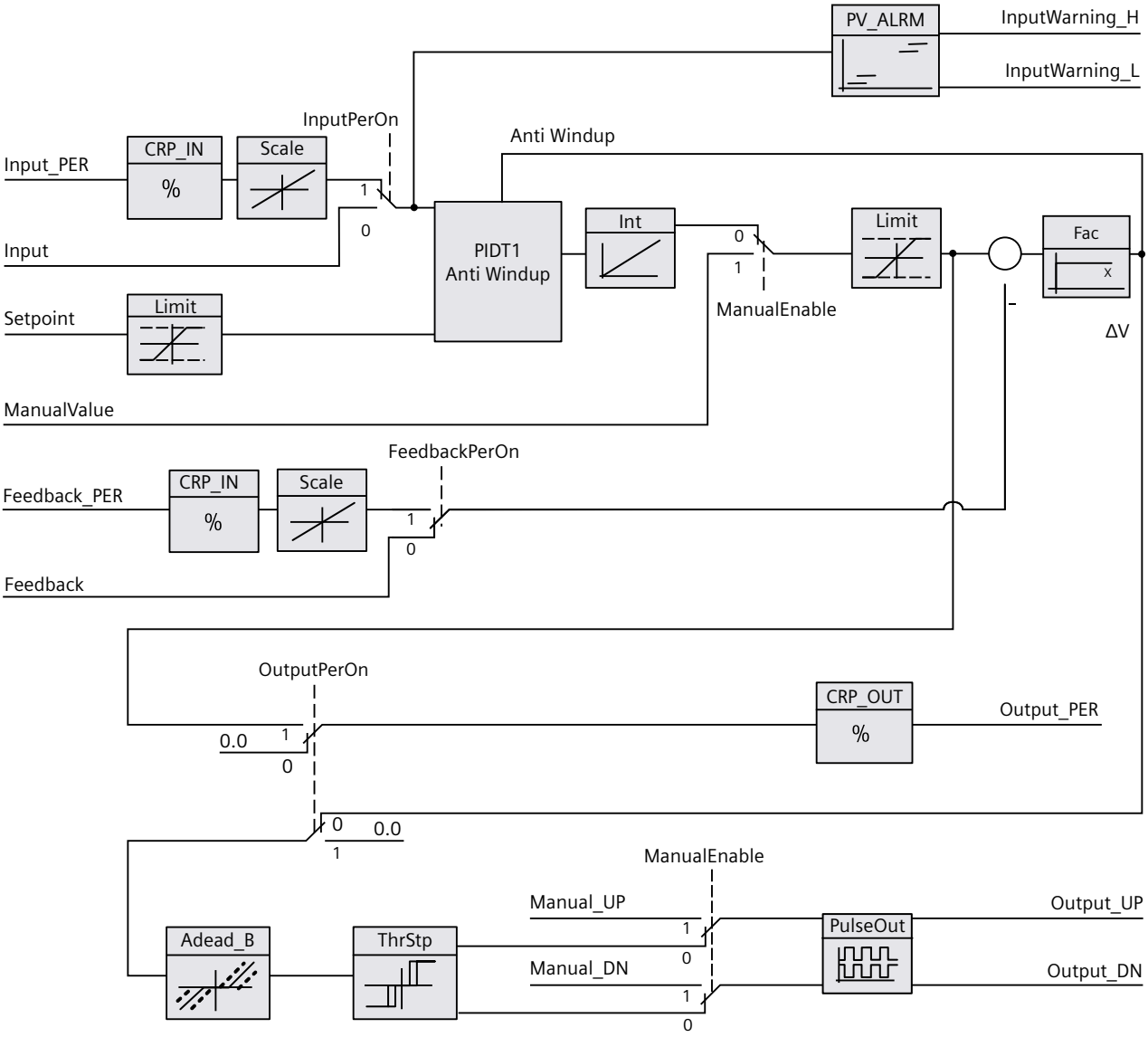

Block diagram of PIDT1 with anti-windup

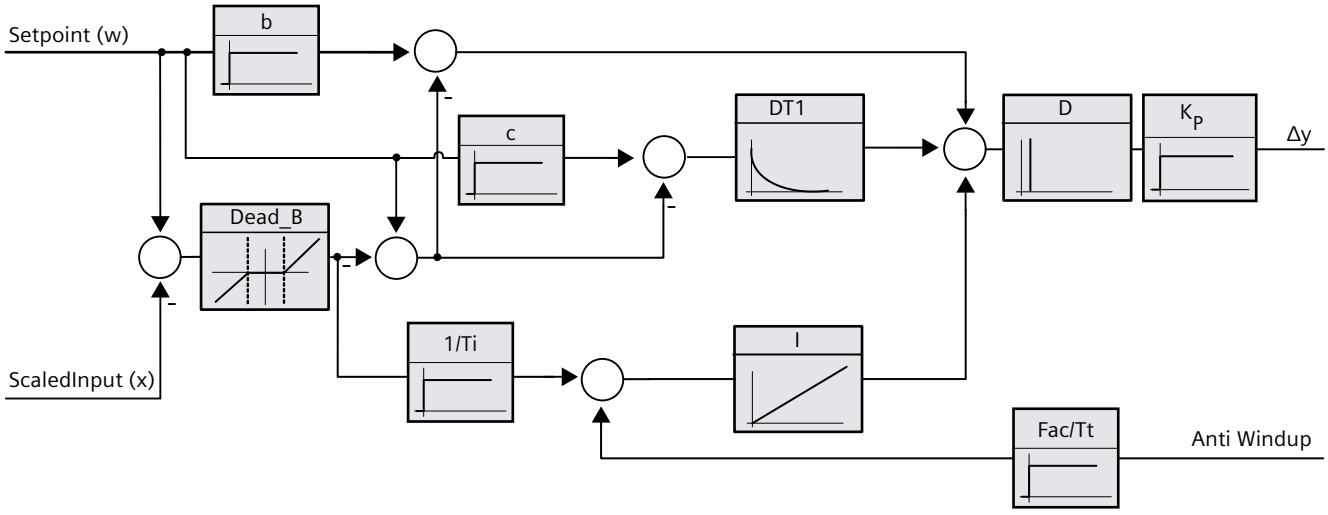

Call

PID_3Step is called in the constant interval of the cycle time of the calling OB (preferably in a cyclic interrupt OB).

Download to device

The actual values of retentive tags are only updated when you download PID_3Step completely.

Downloading technology objects to device (Page 46)

Startup

At the startup of the CPU, PID_3Step starts in the operating mode that was last active. To retain PID_3Step in "Inactive" mode, set RunModeByStartup = FALSE.

Response to errors

If errors occur, these are output in the Error parameter. You configure the reaction of PID_3Step using the ErrorBehaviour and ActivateRecoverMode tags.

ErrorBehaviour	ActivateRecoverMode	Actuator setting configuration Set Output to	Reaction
0	FALSE	Current output value	Switch to "Inactive" mode (Mode = 0)
0	TRUE	Current output value while error is pending	Switch to "Error monitoring" mode (Mode = 7)
1	FALSE	Substitute output value	Switch to "Approach substitute output value" mode (Mode = 5) Switch to "Inactive" mode (Mode = 0)
1	TRUE	Substitute output value while error is pending	Switch to "Approach substitute output value with error monitoring" mode (Mode = 8) Switch to "Error monitoring" mode (Mode = 7)

The ErrorBits parameter shows which errors have occurred.

See also

State and Retain.Mode V1 parameters (Page 352)
ErrorBits V1 parameter (Page 358)
Configuring PID_3Step V1 (Page 135)

11.2.5.2 Operating principle PID_3Step V1

Monitoring process value limits

You specify the high limit and low limit of the process value in the Config.InputUpperLimit and Config.InputLowerLimit tags. If the process value is outside these limits, an error occurs (ErrorBits = 0001hex).

You specify a high and low warning limit of the process value in the Config.InputUpperWarning and Config.InputLowerWarning tags. If the process value is outside these warning limits, a warning occurs (Warnings = 0040hex), and the InputWarning_H or InputWarning_L output parameter changes to TRUE.

Limiting the setpoint

You specify a high limit and low limit of the setpoint in the Config.SetpointUpperLimit and Config.SetpointLowerLimit tags. PID_3Step automatically limits the setpoint to the process value limits. You can limit the setpoint to a smaller range. PID_3Step checks whether this range falls within the process value limits. If the setpoint is outside these limits, the high or low limit is used as the setpoint, and output parameter SetpointLimit_H or SetpointLimit_L is set to TRUE.

The setpoint is limited in all operating modes.

Limiting the output value

You specify a high limit and low limit of the output value in the Config.OutputUpperLimit and Config.OutputLowerLimit tags. The output value limits must be within "Low endstop" and "High endstop".

- High endstop: Config.FeedbackScaling.UpperPointOut
- Low endstop: Config.FeedbackScaling.LowerPointOut

Rule:

UpperPointOut ≥ OutputUpperLimit > OutputLowerLimit ≥ LowerPointOut

The valid values for "High endstop" and "Low endstop" depend upon:

- FeedbackOn
- FeedbackPerOn
- OutputPerOn

OutputPerOn	FeedbackOn	FeedbackPerOn	LowerPointOut	UpperPointOut
FALSE	FALSE	FALSE	Cannot be set (0.0%)	Cannot be set (100.0%)
FALSE	TRUE	FALSE	-100.0% or 0.0%	0.0% or +100.0%
FALSE	TRUE	TRUE	-100.0% or 0.0%	0.0% or +100.0%
TRUE	FALSE	FALSE	Cannot be set (100.0%)	Cannot be set (100.0%)
TRUE	TRUE	FALSE	-100.0% or 0.0%	0.0% or +100.0%
TRUE	TRUE	TRUE	-100.0% or 0.0%	0.0% or +100.0%

If OutputPerOn = FALSE and FeedbackOn = FALSE, you cannot limit the output value. The digital outputs are reset with Actuator_H = TRUE or Actuator_L = TRUE, or after a travel time amounting to 110% of the motor transition time.

The output value is 27648 at 100% and -27648 at -100%. PID_3Step must be able to completely close the valve. Therefore, zero must be included in the output value limits.

NOTE

Use with two or more actuators

PID_3 Step is not suitable for use with two or more actuators (for example, in heating/cooling applications), because different actuators need different PID parameters to achieve a good control response.

Substitute output value

If an error has occurred, PID_3Step can output a substitute output value and move the actuator to a safe position that is specified in the SavePosition tag. The substitute output value must be within the output value limits.

Monitoring signal validity

The values of the following parameters are monitored for validity:

- Setpoint
- Input
- Input_PER
- Feedback
- Feedback_PER
- Output

Monitoring the PID_3Step sampling time

Ideally, the sampling time is equivalent to the cycle time of the calling OB. The PID_3Step instruction measures the time interval between two calls. This is the current sampling time. On every switchover of operating mode and during the initial startup, the mean value is formed from the first 10 sampling times. Too great a difference between the current sampling time and this mean value triggers an error (ErrorBits = 0800 hex).

PID_3Step is set to "Inactive" mode during tuning under the following conditions:

- New mean value >= 1.1 x old mean value
- New mean value <= 0.9 x old mean value

In automatic mode, PID_3Step is set to "Inactive" mode under the following conditions:

- New mean value >= 1.5 x old mean value
- New mean value <= 0.5 x old mean value

Sampling time of the PID algorithm

The controlled system needs a certain amount of time to respond to changes in the output value. It is therefore not advisable to calculate the output value in every cycle. The sampling time of the PID algorithm represents the time between two calculations of the output value. It is calculated during tuning and rounded to a multiple of the cycle time. All other functions of PID_3Step are executed at every call.

Measuring the motor transition time

The motor transition time is the time in seconds the motor requires to move the actuator from the closed to the opened state. The maximum time that the actuator is moved in one direction is 110% of the motor transition time. PID_3Step requires the motor transition time to be as accurate as possible for good controller results. The data in the actuator documentation contains average values for this type of actuator. The value for the specific actuator used may differ. You can measure the motor transition time during commissioning. The output value limits are not taken into consideration during the motor transition time measurement. The actuator can travel to the high or the low endstop.

The motor transition time is taken into consideration in the calculation of the analog output value as well as in the calculation of the digital output values. It is mainly required for correct

operation during auto-tuning and the anti-windup behavior. You should therefore configure the motor transition time with the value that the motor requires to move the actuator from the closed to the opened state.

If no relevant motor transition time is in effect in your process (e.g. with solenoid valves), so that the output value has a direct and full effect on the process, use PID_Compact instead.

Control logic

An increase of the output value is generally intended to cause an increase in the process value. This is referred to as a normal control logic. For cooling and discharge control systems, it may be necessary to invert the control logic. PID_3Step does not work with negative proportional gain. If InvertControl = TRUE, an increasing control deviation causes a reduction in the output value. The control logic is also taken into account during pretuning and fine tuning.

See also

Configuring PID_3Step V1 (Page 135)

11.2.5.3 PID_3Step V1 input parameters

Table 3-1127

Parameters	Data type	Default	Description
Setpoint	REAL	0.0	Setpoint of the PID controller in automatic mode
Input	REAL	0.0	A tag of the user program is used as source for the process value. If you are using Input parameter, then Config.InputPerOn = FALSE must be set.
Input_PER	WORD	W#16#0	An analog input is used as the source of the process value. If you are using Input_PER parameter, then Config.InputPerOn = TRUE must be set.
Actuator_H	BOOL	FALSE	Digital position feedback of the valve for the high endstop If Actuator_H = TRUE, the valve is at the high endstop and is no longer moved towards this direction.
Actuator_L	BOOL	FALSE	Digital position feedback of the valve for the low endstop If Actuator_L = TRUE, the valve is at the low endstop and is no longer moved towards this direction.
Feedback	REAL	0.0	Position feedback of the valve If you are using Feedback parameter, then Config.FeedbackPerOn = FALSE must be set.
Feedback_PER	WORD	W#16#0	Analog position feedback of a valve If you are using Feedback_PER parameter, then Config.FeedbackPerOn = TRUE must be set. Feedback_PER is scaled based on the tags: • Config.FeedbackScaling.LowerPointIn • Config.FeedbackScaling.UpperPointIn • Config.FeedbackScaling.LowerPointOut • Config.FeedbackScaling.UpperPointOut

Parameters	Data type	Default	Description
ManualEnable	BOOL	FALSE	• A FALSE -> TRUE edge selects "Manual mode", while State = 4, Retain.Mode remains unchanged. • A TRUE -> FALSE edge selects the most recently active operating mode A change of Retain.Mode will not take effect during ManualEnable = TRUE. The change of Retain.Mode will only be considered upon a TRUE -> FALSE edge at ManualEnable . **PID_3Step V1.1**If ManualEnable = TRUE when the CPU starts, PID_3Step starts in manual mode. A rising edge (FALSE > TRUE) at ManualEnable is not necessary. **PID_3Step V1.0** At the start of the CPU, PID_3Step only switches to manual mode with a rising edge (FALSE->TRUE) at ManualEnable . Without rising edge, PID_3Step starts in the last operating mode in which ManualEnable was FALSE.
ManualValue	REAL	0.0	In manual mode, you specify the absolute position of the valve. ManualValue will only be evaluated if you are using OutputPer, **or** if position feedback is available.
Manual_UP	BOOL	FALSE	In manual mode, every rising edge opens the valve by 5% of the total control range, or for the duration of the minimum motor transition time. Manual_UP is evaluated only if you are not using Output_PER and there is no position feedback available.
Manual_DN	BOOL	FALSE	In manual mode, every rising edge closes the valve by 5% of the total control range, or for the duration of the minimum motor transition time. Manual_DN is evaluated only if you are not using Output_PER and there is no position feedback available.
Reset	BOOL	FALSE	Restarts the controller. • FALSE -> TRUE edge – Switch to "Inactive" mode – ErrorBits and Warning are reset – Intermediate controller values are reset (PID parameters are retained) • TRUE -> FALSE edge – Change in most recent active mode – If automatic mode was active before, switchover to automatic mode is bumpless.

11.2.5.4 PID_3Step V1 output parameters

Table 3-1128

Parameter	Data type	Default	Description
ScaledInput	REAL	0.0	Scaled process value
ScaledFeedback	REAL	0.0	Scaled position feedback For an actuator without position feedback, the position of the actuator indicated by ScaledFeedback is very imprecise. ScaledFeedback may only be used for rough estimation of the current position in this case.
Output_UP	BOOL	FALSE	Digital output value for opening the valve If Config.OutputPerOn = FALSE, the Output_UP parameter is used.

Parameter	Data type	Default	Description
Output_DN	BOOL	FALSE	Digital output value for closing the valve If Config.OutputPerOn = FALSE, the Output_DN parameter is used.
Output_PER	WORD	W#16#0	Analog output value If Config.OutputPerOn = TRUE, Output_PER is used. Use Output_PER if you are using a valve as actuator which is triggered via an analog output and controlled with a continuous signal, e.g. 0...10V or 4...20mA. The value at Output_PER corresponds to the target position of the valve, e.g. Output_PER = 13824, when the valve is to be opened by 50%.
SetpointLimit_H	BOOL	FALSE	If SetpointLimit_H = TRUE, the absolute high limit of setpoint is reached. In the CPU, the setpoint is limited to the configured absolute setpoint high limit. The configured absolute process value high limit is the default for the setpoint high limit. If you configure Config.SetpointUpperLimit to a value within the process value limits, this value is used as the setpoint high limit.
SetpointLimit_L	BOOL	FALSE	If SetpointLimit_L = TRUE, the absolute low limit of the setpoint has been reached. In the CPU, the setpoint is limited to the configured absolute setpoint low limit. The configured absolute process value low limit is the default setting for the setpoint low limit. If you configure Config.SetpointLowerLimit to a value within the process value limits, this value is used as the setpoint low limit.
InputWarning_H	BOOL	FALSE	If InputWarning_H = TRUE, the process value has reached or exceeded the warning high limit.
InputWarning_L	BOOL	FALSE	If InputWarning_L = TRUE, the process value has reached or fallen below the warning low limit.
State	INT	0	The State parameter (Page 352) shows the current operating mode of the PID controller. You change the operating mode with the Retain.Mode tag. • State = 0: Inactive • State = 1: Pretuning • State = 2: Fine tuning • State = 3: Automatic mode • State = 4: Manual mode • State = 5: Approach substitute output value • State = 6: Transition time measurement • State = 7: Error monitoring • State = 8: Approach substitute output value with error monitoring
Error	BOOL	FALSE	If Error = TRUE, at least one error message is pending.
ErrorBits	DWORD	DW#16#0	The ErrorBits parameter (Page 358) indicates the error messages.

See also

State and Retain.Mode V1 parameters (Page 352)
ErrorBits V1 parameter (Page 358)

11.2.5.5 PID_3Step V1 static tags

NOTE

You must not change tags that are not listed. These are used for internal purposes only.

Change the tags identified with (1) only in "Inactive" mode to prevent malfunction of the PID controller. "Inactive" mode is forced by setting the "Retain.Mode" tag to "0".

Table 3-1129

Tag	Data type	Default	Description
ActivateRecoverMode	BOOL	TRUE	The ActivateRecoverMode tag (Page 360) determines the response in the event of an error.
RunModeByStartup	BOOL	TRUE	Activate Mode after CPU restart If RunModeByStartup = TRUE, the controller returns to the last active operating mode after a CPU restart. If RunModeByStartup = FALSE, the controller remains inactive after a CPU startup.
PhysicalUnit	INT	0	Unit of measurement of the process value and setpoint, e.g., °C, or °F.
PhysicalQuantity	INT	0	Physical quantity of the process value and setpoint, e.g., temperature
ErrorBehaviour	INT	0	If ErrorBehaviour = 0 and an error has occurred, the valve stays at its current position and the controller switches directly to "Inactive" or "Error monitoring" mode. If ErrorBehaviour = 1 and an error occurs, the actuator moves to the substitute output value and only then switches to "Inactive" or "Error monitoring" mode. If the following errors occur, you can no longer move the valve to a configured substitute output value. • 2000h: Invalid value at Feedback_PER parameter. • 4000h: Invalid value at Feedback parameter. • 8000h: Error during digital position feedback.
Warning	DWORD	DW#16#0	The Warning tag (Page 352) displays the warnings generated since a Reset or since the last operating mode switchover. Cyclic warnings (for example, process value warning) are shown until the cause of the warning is removed. They are automatically deleted once their cause has gone. Non-cyclic warnings (for example, point of inflection not found) remain and are deleted like errors.

Tag	Data type	Default	Description
SavePosition	REAL	0.0	Substitute output value If ErrorBehaviour = 1 and an error occurs, the actuator moves to a safe position for the plant and only then switches to "Inactive" mode. The permitted value range is determined by the configuration. • Config.FeedbackOn = FALSE and Config.OutputPerOn = FALSE: SavePosition = 0.0 or 100.0 • Config.FeedbackOn = TRUE or Config.OutputPerOn = TRUE: Config.OutputUpperLimit ≥ SavePosition ≥ Config.OutputLowerLimit
CurrentSetpoint	REAL	0.0	Currently active setpoint. This value is frozen at the start of tuning.
Progress	REAL	0.0	Progress of tuning as a percentage (0.0 - 100.0)
Config.InputPerOn(1)	BOOL	TRUE	If InputPerOn = TRUE, the Input_PER parameter is used. If InputPerOn = FALSE, the Input parameter is used.
Config.OutputPerOn(1)	BOOL	FALSE	If OutputPerOn = TRUE, the Output_PER parameter is used. If OutputPerOn = FALSE, the Ouput_UP and Output_DN parameters are used.
Config.LoadBackUp	BOOL	FALSE	If LoadBackUp = TRUE, the last set of PID parameters is reloaded. The set was saved prior to the last tuning. LoadBackUp is automatically set back to FALSE.
Config.InvertControl(1)	BOOL	FALSE	Invert control logic If InvertControl = TRUE, an increasing control deviation causes a reduction in the output value.
Config.FeedbackOn(1)	BOOL	FALSE	If FeedbackOn = FALSE, a position feedback is simulated. Position feedback is generally activated when FeedbackOn = TRUE.
Config.FeedbackPerOn(1)	BOOL	FALSE	FeedbackPerOn only takes effect when FeedbackOn = TRUE. If FeedbackPerOn = TRUE, the analog input is used for the position feedback (Feedback_PER parameter). If FeedbackPerOn = FALSE, the Feedback parameter is used for the position feedback.
Config.ActuatorEndStopOn(1)	BOOL	FALSE	If ActuatorEndStopOn = TRUE, the digital position feedback Actuator_L and Actuator_H are taken into consideration.
Config.InputUpperLimit(1)	REAL	120.0	High limit of the process value At the I/O input, the process value can be a maximum of 18% higher than the standard range (overrange). An error is no longer signaled due to a violation of the "Process value high limit". Only a wire-break and a short-circuit are recognized and PID_3Step reacts according to the configured reaction to error. InputUpperLimit > InputLowerLimit
Config.InputLowerLimit(1)	REAL	0.0	Low limit of the process value InputLowerLimit < InputUpperLimit
Config.InputUpperWarning(1)	REAL	+3.40282-2e+38	Warning high limit of the process value If you set InputUpperWarning outside the process value limits, the configured absolute process value high limit is used as the warning high limit. If you configure InputUpperWarning within the process value limits, this value is used as the warning high limit. InputUpperWarning > InputLowerWarning InputUpperWarning ≤ InputUpperLimit

Tag	Data type	Default	Description
Config.InputLowerWarning(1)	REAL	-3.402822 e+38	Warning low limit of the process value If you set InputLowerWarning outside the process value limits, the configured absolute process value low limit is used as the warning low limit. If you configure InputLowerWarning within the process value limits, this value is used as the warning low limit. InputLowerWarning < InputUpperWarning InputLowerWarning ≥ InputLowerLimit
Config.OutputUpperLimit(1)	REAL	100.0	High limit of output value The following value range is permitted: UpperPointOut ≥ OutputUpperLimit > OutputLowerLimit For more details, see OutputLowerLimit.
Config.OutputLowerLimit(1)	REAL	0.0	Low limit of the output value The following value range is permitted: OutputUpperLimit > OutputLowerLimit ≥ LowerPointOut When using Output_PER, an output value limit of -100% corresponds to the value Output_PER = -27648; 100% correspond to the value Output_PER = 27648. If OutputPerOn = FALSE and FeedbackOn = FALSE, OutputLowerLimit and OutputUpperLimit are not evaluated. Output_UP and Output_DN are then reset at Actuator_H = TRUE or Actuator_L = TRUE (if ActuatorEndStopOn = TRUE) or after a travel time of 110% * Config.TransitTime (if ActuatorEndStopOn = FALSE).
Config.SetpointUpperLimit(1)	REAL	+3.40282-2e+38	High limit of setpoint If you set SetpointUpperLimit outside the process value limits, the configured absolute process value high limit is preassigned as the setpoint high limit. If you configure SetpointUpperLimit within the process value limits, this value is used as the setpoint high limit.
Config.SetpointLowerLimit(1)	REAL	-3.402822e+38	Low limit of the setpoint If you set SetpointLowerLimit outside the process value limits, the configured absolute process value low limit is preassigned as the set-point low limit. If you set SetpointLowerLimit within the process value limits, this value is used as the setpoint low limit.
Config.MinimumOnTime(1)	REAL	0.0	Minimum ON time Minimum time in seconds for which the servo drive must be switched on. Config.MinimumOnTime only takes effect when Output_UP and Output_DN are used (Config.OutputPerOn = FALSE).
Config.MinimumOffTime(1)	REAL	0.0	Minimum OFF time Minimum time in seconds for which the servo drive must be switched off. Config.MinimumOffTime only takes effect when Output_UP and Output_DN are used (Config.OutputPerOn = FALSE).
Config.TransitTime(1)	REAL	30.0	Motor transition time Time in seconds the actuating drive requires to move the valve from the closed to the opened state.
Config.InputScaling.Upper-PointIn(1)	REAL	27648.0	Scaling Input_PER high Input_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the InputScaling structure.

Tag	Data type	Default	Description
Config.InputScaling.LowerPointIn(1)	REAL	0.0	Scaling Input_PER low Input_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the InputScaling structure.
Config.InputScaling.UpperPointOut(1)	REAL	100.0	Scaled high process value Input_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the InputScaling structure.
Config.InputScaling.LowerPointOut(1)	REAL	0.0	Scaled low process value Input_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the InputScaling structure.
Config.FeedbackScaling.UpperPointIn(1)	REAL	27648.0	Scaling Feedback_PER high Feedback_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the FeedbackScaling structure.
Config.FeedbackScaling.LowerPointIn(1)	REAL	0.0	Scaling Feedback_PER low Feedback_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the FeedbackScaling structure.
Config.FeedbackScaling.UpperPointOut(1)	REAL	100.0	High endstop Feedback_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the FeedbackScaling structure. The permitted value range is determined by the configuration. • FeedbackOn = FALSE: UpperPointOut = 100.0 • FeedbackOn = TRUE: UpperPointOut = 100.0 or 0.0 UpperPointOut ≠ LowerPointOut
Config.FeedbackScaling.LowerPointOut(1)	REAL	0.0	Low endstop Feedback_PER is converted to a percentage based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn of the FeedbackScaling structure. The permitted value range is determined by the configuration. • FeedbackOn = FALSE: LowerPointOut = 0.0 • FeedbackOn = TRUE: LowerPointOut = 0.0 or -100.0 LowerPointOut ≠ UpperPointOut
GetTransitTime.InvertDirection	BOOL	FALSE	If InvertDirection = FALSE, the valve is fully opened, closed, and then reopened in order to determine the valve transition time. If InvertDirection = TRUE, the valve is fully closed, opened, and then closed again.
GetTransitTime.SelectFeedback	BOOL	FALSE	If SelectFeedback = TRUE, then Feedback_PER, or Feedback is taken into consideration in the transition time measurement. If SelectFeedback = FALSE, then Actuator_H and Actuator_L are taken into consideration in the transition time measurement.
GetTransitTime.Start	BOOL	FALSE	If Start = TRUE, the transition time measurement is started.

Tag	Data type	Default	Description
GetTransitTime.State	INT	0	Current phase of the transition time measurement • State = 0: Inactive • State = 1: Open valve completely • State = 2: Close valve completely • State = 3: Move valve to target position (NewOutput) • State = 4: Transition time measurement successfully completed • State = 5: Transition time measurement canceled
GetTransitTime.NewOutput	REAL	0.0	Target position for transition time measurement with position feedback The target position must be between "High endstop" and "Low endstop". The difference between NewOutput and ScaledFeedback must be at least 50% of the permissible control range.
CycleTime.StartEstimation	BOOL	TRUE	If StartEstimation = TRUE, the measurement of the PID_3Step sampling time is started. CycleTime.StartEstimation = FALSE once measurement is complete.
CycleTime.EnEstimation	BOOL	TRUE	If EnEstimation = TRUE, the PID_3Step sampling time is calculated.
CycleTime.EnMonitoring	BOOL	TRUE	If EnMonitoring = TRUE, the PID_3Step sampling time is monitored. If it is not possible to execute PID_3Step within the sampling time, the error 0800h is output and the operating mode is switched. ActivateRecoverMode and ErrorBehaviour determine which operating mode is switched to. If EnMonitoring = FALSE, the PID_3Step sampling time is not monitored, the error 0800h is not output, and the operating mode is not switched.
CycleTime.Value(1)	REAL	0.1	PID_3Step sampling time in seconds CycleTime.Value is determined automatically and is usually equivalent to the cycle time of the calling OB.
CtrlParamsBackUp.SetByUser	BOOL	FALSE	Saved value of Retain.CtrlParams.SetByUser You can reload values from the CtrlParamsBackUp structure with Config.LoadBackUp = TRUE.
CtrlParamsBackUp.Gain	REAL	1.0	Saved proportional gain
CtrlParamsBackUp.Ti	REAL	20.0	Saved integral action time
CtrlParamsBackUp.Td	REAL	0.0	Saved derivative action time
CtrlParamsBackUp.TdFiltRatio	REAL	0.0	Saved derivative delay coefficient
CtrlParamsBackUp.PWeighting	REAL	0.0	Saved proportional action weighting
CtrlParamsBackUp.DWeighting	REAL	0.0	Saved derivative action weighting
CtrlParamsBackUp.Cycle	REAL	1.0	Saved sampling time of PID algorithm
CtrlParamsBackUp.InputDeadBand	REAL	0.0	Saved deadzone width of the control deviation
PIDSelfTune.SUT.CalculateSUTParams	BOOL	FALSE	The properties of the controlled system are saved during tuning. If CalculateSUTParams = TRUE, the PID parameters are recalculated on the basis of these properties. The PID parameters are calculated using the method set in TuneRuleSUT. CalculateSUTParams is set to FALSE following calculation.
PIDSelfTune.SUT.TuneRuleSUT	INT	1	Methods used to calculate parameters during pretuning: • TuneRuleSUT = 0: PID fast I (faster control response with higher amplitudes of the output value than with TuneRuleSUT = 1) • TuneRuleSUT = 1: PID slow I (slower control response with lower amplitudes of the output value than with TuneRuleSUT = 0)

Tag	Data type	Default	Description
			• TuneRuleSUT = 2: Chien, Hrones and Reswick PID • TuneRuleSUT = 3: Chien, Hrones, Reswick PI • TuneRuleSUT = 4: PID fast II (faster control response with higher amplitudes of the output value than with TuneRuleSUT = 5) • TuneRuleSUT = 5: PID slow II (slower control response with lower amplitudes of the output value than with TuneRuleSUT = 4) The methods TuneRuleSUT = 0 and 1 differ from the methods TuneRuleSUT = 4 and 5 only in the calculation of the proportional gain: When TuneRuleSUT = 0 and 1, the proportional gain is calculated based on the compensation time of the process. When TuneRuleSUT = 4 and 5, this happens based on the delay time of the process. TuneRuleSUT = 4 and 5 returns a higher value for the proportional gain and thus a faster control response with higher amplitudes of the output value than with TuneRuleSUT = 0 and 1.
PIDSelfTune.SUT.State	INT	0	The SUT.State tag indicates the current phase of pretuning:
PIDSelfTune.TIR.RunIn	BOOL	FALSE	• RunIn = FALSE Pretuning is started when fine tuning is started from inactive or manual mode. If fine tuning is started from automatic mode, the system uses the existing PID parameters to control to the setpoint. Only then will fine tuning start. If pretuning is not possible, PID_3Step switches to "Inactive" mode. • RunIn = TRUE The pretuning is skipped. PID_3Step attempts to reach the setpoint with the minimum or maximum output value. This can produce increased overshoot. Only then will fine tuning start. RunIn is set to FALSE after fine tuning.
PIDSelfTune.TIR.CalculateTIRParams	BOOL	FALSE	The properties of the controlled system are saved during tuning. If CalculateTIRParams = TRUE, the PID parameters are recalculated on the basis of these properties. The PID parameters are calculated using the method set in TuneRuleTIR. CalculateTIRParams is set to FALSE following calculation.
PIDSelfTune.TIR.TuneRuleTIR	INT	0	Methods used to calculate parameters during fine tuning: • TuneRuleTIR = 0: PID automatic • TuneRuleTIR = 1: PID fast (faster control response with higher amplitudes of the output value than with TuneRuleTIR = 2) • TuneRuleTIR = 2: PID slow (slower control response with lower amplitudes of the output value than with TuneRuleTIR = 1) • TuneRuleTIR = 3: Ziegler-Nichols PID • TuneRuleTIR = 4: Ziegler-Nichols PI • TuneRuleTIR = 5: Ziegler-Nichols P To be able to repeat the calculation of the PID parameters with CalculateTIRParams and TuneRuleTIR = 0, 1 or 2, the previous fine tuning also has to have been executed with TuneRuleTIR = 0, 1 or 2. If this is not the case, TuneRuleTIR = 3 is used. The recalculation of the PID parameters with CalculateTIRParams and TuneRuleTIR = 3, 4 or 5 is always possible.
PIDSelfTune.TIR.State	INT	0	The TIR.State tag indicates the current phase of "fine tuning":
Retain.Mode	INT	0	A change to the value of Retain.Mode initiates a switch to another operating mode.

Tag	Data type	Default	Description
			The following operating mode is enabled upon a change of Mode to: • Mode = 0: Inactive • Mode = 1: Pretuning • Mode = 2: Fine tuning • Mode = 3: Automatic mode • Mode = 4: Manual mode • Mode = 5: Approach substitute output value • Mode = 6: Transition time measurement • Mode = 7: Error monitoring • Mode = 8: Approach substitute output value with error monitoring Mode is retentive.
Retain.CtrlParams.SetByUser(1)	BOOL	FALSE	If SetByUser = FALSE, the PID parameters are determined automatically and PID_3Step operates with a dead zone at the output value. The deadzone width is calculated during tuning on the basis of the standard deviation of the output value and saved in Retain.CtrlParams.OutputDeadBand. If SetByUser = TRUE, the PID parameters are entered manually and PID_3 Step operates without a dead zone at the output value. Retain.CtrlParams.OutputDeadBand = 0.0 SetByUser is retentive.
Retain.CtrlParams.Gain(1)	REAL	1.0	Active proportional gain Gain is retentive.
Retain.CtrlParams.Ti(1)	REAL	20.0	• Ti > 0.0: Active integral action time • Ti = 0.0: Integral action is deactivated Ti is retentive.
Retain.CtrlParams.Td(1)	REAL	0.0	• Td > 0.0: Active derivative action time • Td = 0.0: Derivative action is deactivated Td is retentive.
Retain.CtrlParams.TdFiltRatio(1)	REAL	0.0	Active derivative delay coefficient TdFiltRatio is retentive.
Retain.CtrlParams.PWeighting(1)	REAL	0.0	Active proportional action weighting PWeighting is retentive.
Retain.CtrlParams.DWeighting(1)	REAL	0.0	Active derivative action weighting DWeighting is retentive.
Retain.CtrlParams.Cycle(1)	REAL	1.0	Active sampling time of PID algorithm in seconds, rounded to an integer multiple of the cycle time of the calling OB. Cycle is retentive.
Retain.CtrlParams.InputDeadBand(1)	REAL	0.0	Deadzone width of the control deviation InputDeadBand is retentive.

See also

State and Retain.Mode V1 parameters (Page 352)
Tag ActivateRecoverMode V1 (Page 360)
Downloading technology objects to device (Page 46)

11.2.5.6 State and Retain.Mode V1 parameters

Correlation of the parameters

The State parameter shows the current operating mode of the PID controller. You cannot change the State parameter.

To switch from one operating mode to another, you must change the Retain.Mode tag. This also applies when the value for the new operating mode is already in Retain.Mode. For example, set Retain.Mode = 0 first and then Retain.Mode = 3. Provided the current operating mode of the controller permits this switchover, State will be set to the value of Retain.Mode.

When PID_3Step automatically switches from one operating mode to another, the following applies: State != Retain.Mode.

Examples:

- After successful pretuning
  State = 3 and Retain.Mode = 1
- In the event of an error
  State = 0 and Retain.Mode remain at the previous value, for example, Retain.Mode = 3
- ManualEnalbe = TRUE
  State = 4 and Retain.Mode remain at the previous value, e.g., Retain.Mode = 3

NOTE

You want, for example, to repeat successful fine tuning without exiting automatic mode with Mode = 0.

Setting Retain.Mode to an invalid value such as 9999 for one cycle has no effect on State. Set Mode = 2 in the next cycle. In this way, you can generate a change to Retain.Mode without first switching to "Inactive" mode.

Meaning of values

State / Retain.Mode	Description
0	Inactive The controller is switched off and no longer changes the valve position.
1	Pretuning The pretuning determines the process response to a pulse of the output value and searches for the point of inflection. The optimized PID parameters are calculated as a function of the maximum rate of rise and dead time of the controlled system. Pretuning requirements: • State = 0 or State = 4 • ManualEnable = FALSE • The motor transition time has been configured or measured. • The setpoint and the process value lie within the configured limits. The more stable the process value is, the easier it is to calculate the PID parameters and the more precise the result will be. Noise on the process value can be tolerated as long as the rate of rise of the process value is significantly higher as compared to the noise. Before the PID parameters are recalculated, they are backed up and can be reactivated with Config.LoadBackUp. The setpoint is frozen in the CurrentSetpoint tag.

State / Retain.Mode	Description
	The controller switches to automatic mode following successful pretuning and to "Inactive" mode following unsuccessful pretuning. The pretuning phase is indicated with the SUT.State tag.
2	Fine tuning Fine tuning generates a constant, limited oscillation of the process value. The PID parameters are tuned based on the amplitude and frequency of this oscillation. The differences between the process response during pre-tuning and fine tuning are analyzed. All PID parameters are recalculated from the results. PID parameters from fine tuning usually have better master control and disturbance characteristics than PID parameters from pre-tuning. PID_3Step automatically attempts to generate an oscillation greater than the noise of the process value. Fine tuning is only minimally influenced by the stability of the process value. The PID parameters are backed up before fine tuning. They can be reactivated with Config.LoadBackUp. The setpoint is frozen in the CurrentSetpoint tag. Requirements for fine tuning: • The motor transition time has been configured or measured. • The setpoint and the process value lie within the configured limits. • ManualEnable = FALSE • Automatic (State = 3), inactive (State = 0) or manual (State = 4) mode Fine tuning proceeds as follows when started from: • Automatic mode (State = 3) Start fine tuning from automatic mode if you wish to improve the existing PID parameters through tuning. PID_3Step controls the system using the existing PID parameters until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start. • Inactive (State = 0) or manual mode (State = 4) Pretuning is always started first. The determined PID parameters will be used for control until the control loop has stabilized and the requirements for fine tuning have been met. If PIDSelfTune.TIR.RunIn = TRUE, pretuning is skipped and an attempt is made to reach the setpoint with the minimum or maximum output value. This can produce increased overshoot. Fine tuning then starts automatically. The controller switches to automatic mode following successful fine tuning. If fine tuning was not successful, the controller switches to "Inactive" mode. The fine tuning phase is indicated with the TIR.State tag.
3	Automatic mode In automatic mode, PID_3Step controls the controlled system in accordance with the parameters specified. The controller switches to automatic mode if one the following requirements is fulfilled: • Pretuning successfully completed • Fine tuning successfully completed • Changing the Retain.Mode tag to the value 3. When the CPU is switched on or switches from Stop to RUN mode, PID_3Step starts in the most recently active operating mode. To retain PID_3Step in "Inactive" mode, set RunModeByStartup = FALSE. The ActivateRecoverMode tag is taken into consideration in automatic mode.
4	Manual mode In manual mode, you specify manual output values in the Manual_UP and Manual_DN parameters or ManualValue parameter. Whether or not the actuator can be moved to the output value in the event of an error is described in the ErrorBits parameter. This operating mode is enabled if Retain.Mode = 4, or on a rising edge at ManualEnable. If ManualEnable changes to TRUE, only State changes. Retain.Mode retains its current value. On a falling edge at ManualEnable, PID_3Step returns to the previous operating mode. The switchover to automatic mode is bumpless. **PID_3Step V1.1** Manual mode is always possible in the event of an error. **PID_3Step V1.0** Manual mode is dependent on the ActivateRecoverMode tag in the event of an error.

State / Retain.Mode	Description
5	Approach substitute output value This operating mode is activated in the event of an error or when Reset = TRUE if Errorbehaviour = 1 and ActivateRecoverMode = FALSE.. PID_3Step moves the actuator to the substitute output value and then switches to "Inactive" mode.
6	Transition time measurement The time that the motor needs to completely open the valve from the closed condition is determined. This operating mode is activated when GetTransitTime.Start = TRUE is set. If endstop signals are used to measure the transition time, the valve will be opened completely from its current position, closed completely, and opened completely again. If GetTransitTime.InvertDirection = TRUE, this behavior is inverted. If position feedback is used to measure the transition time, the actuator will be moved from its current position to a target position. The output value limits are not taken into consideration during the transition time measurement. The actuator can travel to the high or the low endstop.
7	Error monitoring The control algorithm is switched off and no longer changes the valve position. This operating mode is activated instead of "Inactive" mode in the event of an error. All the following conditions must be met: • Mode = 3 (automatic mode) • Errorbehaviour = 0 • ActivateRecoverMode = TRUE • One or more errors have occurred in which ActivateRecoverMode (Page 360) is effective. As soon as the errors are no longer pending, PID_3Step switches back to automatic mode.
8	Approach substitute output value with error monitoring This operating mode is activated instead of "Approach substitute output value" mode in the event of an error. PID_3Step moves the actuator to the substitute output value and then switches to "Error monitoring" mode. All the following conditions must be met: • Mode = 3 (automatic mode) • Errorbehaviour = 1 • ActivateRecoverMode = TRUE • One or more errors have occurred in which ActivateRecoverMode (Page 360) is effective. As soon as the errors are no longer pending, PID_3Step switches back to automatic mode.

Automatic switchover of operating mode during commissioning

PID_3Step automatically switches the operating mode in the event of an error. The following diagram illustrates the influence of ErrorBehaviour on the switchover of operating mode from transition time measurement, pretuning, and fine tuning modes.

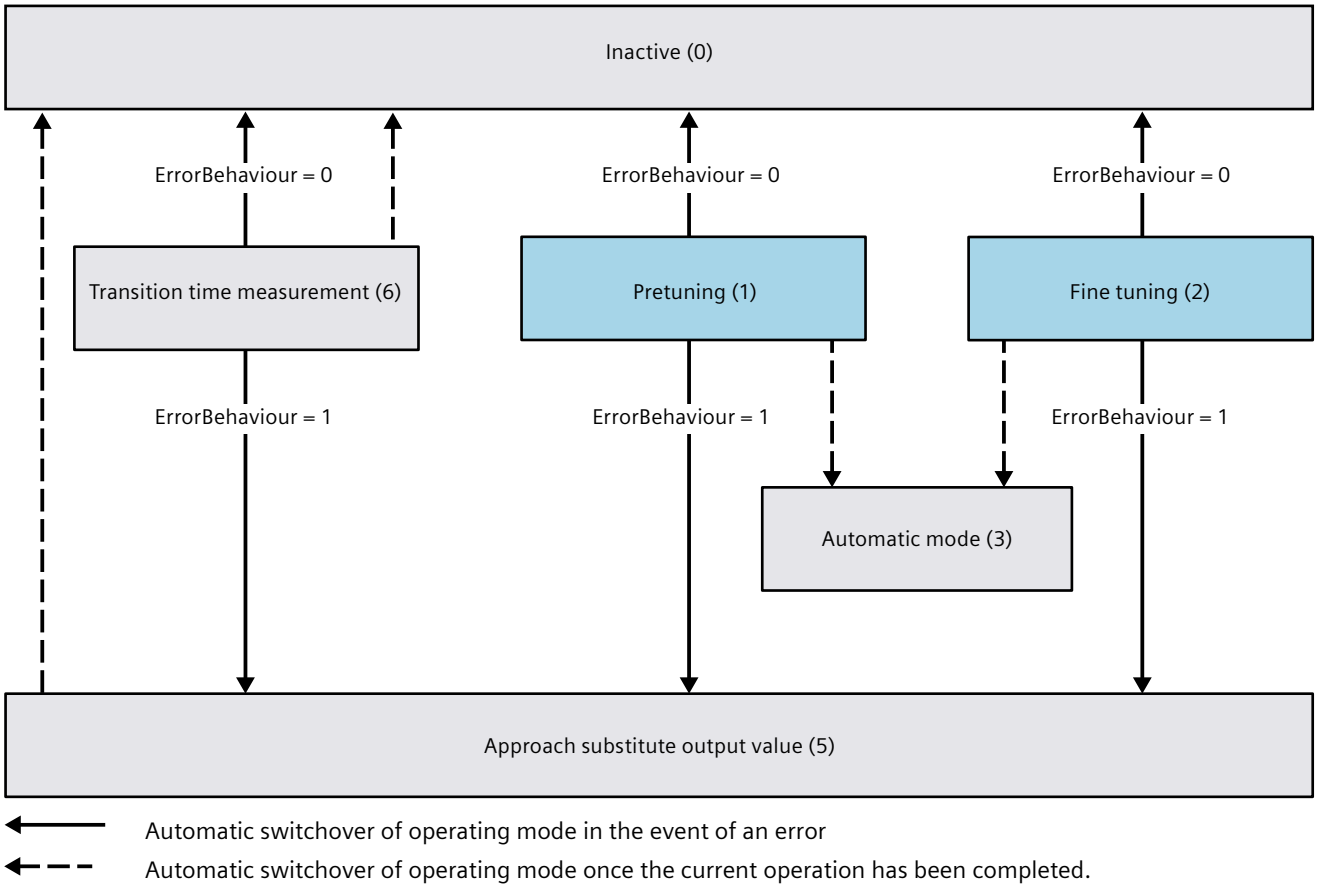

Automatic switchover of operating mode in automatic mode (PID_3Step V1.1)

PID_3Step automatically switches the operating mode in the event of an error. The following diagram illustrates the influence of ErrorBehaviour and ActivateRecoverMode on this switchover of operating mode.

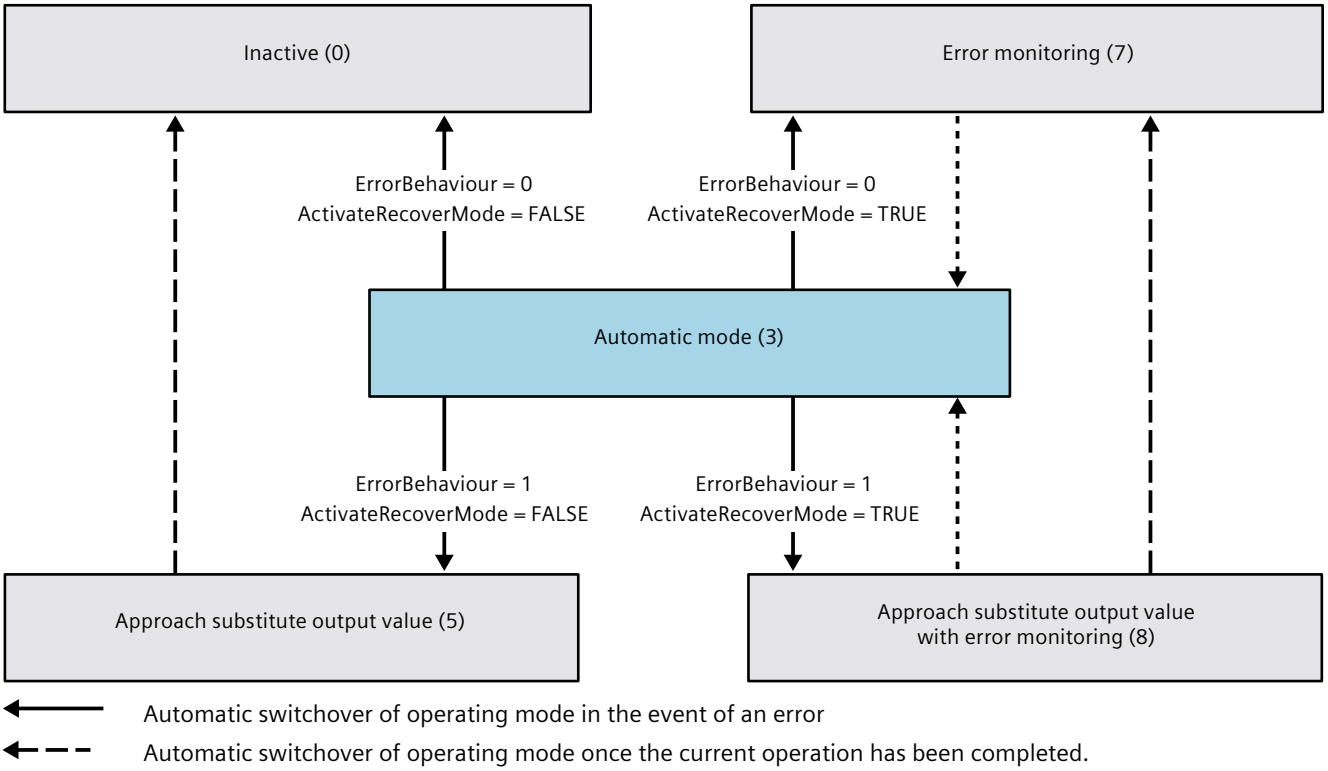

Automatic switchover of operating mode in automatic and manual modes (PID_3Step V1.0)

PID_3Step automatically switches the operating mode in the event of an error. The following diagram illustrates the influence of ErrorBehaviour and ActivateRecoverMode on this switchover of operating mode.

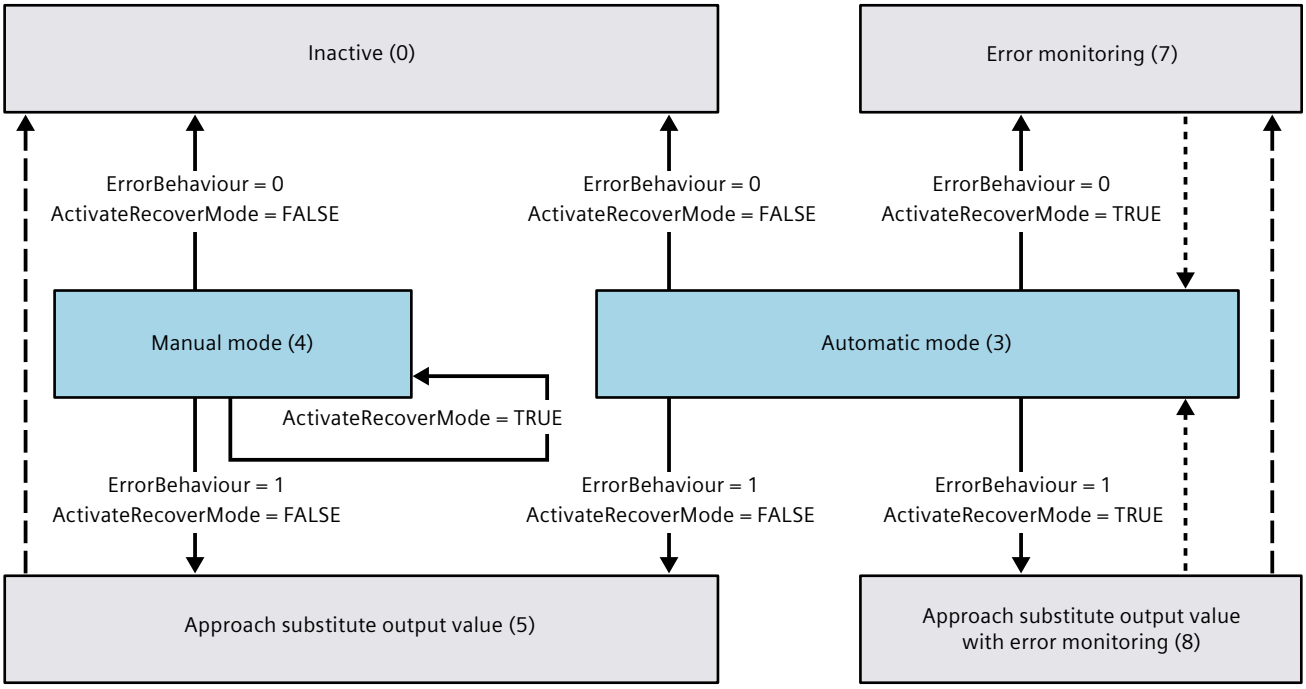

Automatic switchover of operating mode in the event of an error

Automatic switchover of operating mode once the current operation has been completed.

Automatic switchover of operating mode when error is no longer pending.

See also

Tag ActivateRecoverMode V1 (Page 360)
ErrorBits V1 parameter (Page 358)

11.2.5.7 ErrorBits V1 parameter

If several errors are pending simultaneously, the values of the error codes are displayed with binary addition. The display of error code 0003, for example, indicates that the errors 0001 and 0002 are pending simultaneously.

ErrorBits (DW#16#...)	Description
0000	There is no error.
0001	The "Input" parameter is outside the process value limits. • Input > Config.InputUpperLimit or • Input < Config.InputLowerLimit If ActivateRecoverMode = TRUE and ErrorBehaviour = 1, the actuator moves to the substitute output value. If ActivateRecoverMode = TRUE and ErrorBehaviour = 0, the actuator stops in its current position. If ActivateRecoverMode = FALSE, the actuator stops in its current position. PID_3Step V1.1 You can move the actuator in manual mode. PID_3Step V1.0 Manual mode is not possible in this state. You cannot move the actuator again until you eliminate the error.
0002	Invalid value at "Input_PER" parameter. Check whether an error is pending at the analog input. If automatic mode was active before the error occurred, ActivateRecoverMode = TRUE, and the error is no longer pending, PID_3Step switches back to automatic mode.
0004	Error during fine tuning. Oscillation of the process value could not be maintained.
0020	Pretuning is not permitted in automatic mode or during fine tuning.
0080	Error during pretuning. The output value limits are not configured correctly or the process value does not react as expected. Check whether the limits of the output value are configured correctly and match the control logic. Also make sure that the process value does not oscillate strongly before starting pretuning.
0100	Error during fine tuning resulted in invalid parameters.
0200	Invalid value at "Input" parameter: Value has an invalid number format. If automatic mode was active before the error occurred, ActivateRecoverMode = TRUE, and the error is no longer pending, PID_3Step switches back to automatic mode.
0400	Calculation of output value failed. Check the PID parameters.
0800	Sampling time error: PID_3Step is not called within the sampling time of the cyclic interrupt OB. If automatic mode was active before the error occurred, ActivateRecoverMode = TRUE, and the error is no longer pending, PID_3Step switches back to automatic mode. If this error occurred during simulation with PLCSIM, see the notes under Simulating PID_3Step V1 with PLCSIM (Page 153).
1000	Invalid value at "Setpoint" parameter: Value has an invalid number format. If automatic mode was active before the error occurred, ActivateRecoverMode = TRUE, and the error is no longer pending, PID_3Step switches back to automatic mode.
2000	Invalid value at Feedback_PER parameter. Check whether an error is pending at the analog input. The actuator cannot be moved to the substitute output value and remains in its current position. Manual mode is not possible in this state. You must deactivate position feedback (Config. FeedbackOn = FALSE) to move the actuator from this state. If automatic mode was active before the error occurred, ActivateRecoverMode = TRUE, and the error is no longer pending, PID_3Step switches back to automatic mode.

ErrorBits (DW#16#...)	Description
4000	Invalid value at Feedback parameter. Value has an invalid number format. The actuator cannot be moved to the substitute output value and remains in its current position. Manual mode is not possible in this state. You must deactivate position feedback (Config. FeedbackOn = FALSE) to move the actuator from this state. If automatic mode was active before the error occurred, ActivateRecoverMode = TRUE, and the error is no longer pending, PID_3Step switches back to automatic mode.
8000	Error during digital position feedback. Actuator_H = TRUE and Actuator_L = TRUE. The actuator cannot be moved to the substitute output value and remains in its current position. Manual mode is not possible in this state. In order to move the actuator from this state, you must deactivate the "Actuator endstop" (Config.ActuatorEndStopOn = FALSE). If automatic mode was active before the error occurred, ActivateRecoverMode = TRUE, and the error is no longer pending, PID_3Step switches back to automatic mode.

11.2.5.8 Reset V1 parameter

A rising edge at Reset triggers a change to "Inactive" mode, and errors and warnings are reset. A falling edge at Reset triggers a change to the most recently active operating mode. If automatic mode was active before, switchover to automatic mode is bumpless.

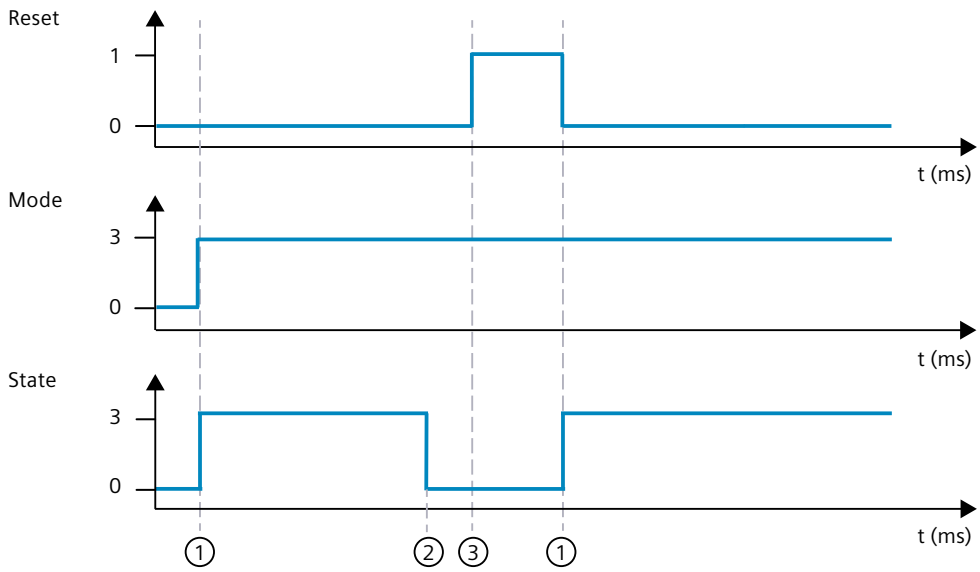

① Activation
② Error
③ Reset

11.2.5.9 Tag ActivateRecoverMode V1

The effect of the ActivateRecoverMode variable depends on the version of the PID_3Step.

Behavior in version 1.1

The ActivateRecoverMode variable determines the behavior in the event of an error in automatic mode. ActivateRecoverMode is not effective during pretuning, fine tuning and transition time measurement.

ActivateRecover-Mode	Description
FALSE	In the event of an error, PID_3Step switches to "Inactive" or "Approach substitute output value" operating mode. The controller is activated by a reset or a change in Retain.Mode.
TRUE	If errors occur frequently in automatic mode, this setting has a negative effect on the control response. In this case, check the ErrorBits parameter and eliminate the cause of the error. If one or more errors occur, PID_3Step switches to "Approach substitute output value with error monitoring" or "Error monitoring" mode: • 0002h: Invalid value at parameter Input_PER. • 0200h: Invalid value at parameter Input. • 0800h: Sampling time error • 1000h: Invalid value at parameter Setpoint. • 2000h: Invalid value at parameter Feedback_PER. • 4000h: Invalid value at parameter Feedback. • 8000h: Error in digital position feedback. With errors 2000h, 4000h and 8000h, PID_3Step **cannot** approach the configured substitute output value. As soon as the errors are no longer pending, PID_3Step switches back to automatic mode.

Behavior in version 1.0

The ActivateRecoverMode variable determines the behavior in the event of an error in automatic and manual mode. ActivateRecoverMode is not effective during pretuning, fine tuning and transition time measurement.

ActivateRecover-Mode	Description
FALSE	In the event of an error, PID_3Step switches to "Inactive" or "Approach substitute output value" operating mode. The controller is activated by a reset or a change in Retain.Mode.
TRUE	**Errors in automatic mode** If errors occur frequently in automatic mode, this setting has a negative effect on the control response. In this case, check the ErrorBits parameter and eliminate the cause of the error. If one or more errors occur, PID_3Step switches to "Approach substitute output value with error monitoring" or "Error monitoring" mode: • 0002h: Invalid value at parameter Input_PER. • 0200h: Invalid value at parameter Input. • 0800h: Sampling time error • 1000h: Invalid value at parameter Setpoint. • 2000h: Invalid value at parameter Feedback_PER. • 4000h: Invalid value at parameter Feedback. • 8000h: Error in digital position feedback. With errors 2000h, 4000h and 8000h, PID_3Step **cannot** approach the configured substitute output value.

ActivateRecover-Mode	Description
	As soon as the errors are no longer pending, PID_3Step switches back to automatic mode. **Errors in manual mode** If one or more of the following errors occur, PID_3Step stays in manual mode: • 0002h: Invalid value at parameter Input_PER. • 0200h: Invalid value at parameter Input. • 0800h: Sampling time error • 1000h: Invalid value at parameter Setpoint. • 2000h: Invalid value at parameter Feedback_PER. • 4000h: Invalid value at parameter Feedback. • 8000h: Error in digital position feedback. With errors 2000h, 4000h and 8000h, you **cannot** move the valve to a suitable position.

See also

PID_3Step V1 static tags (Page 345)
State and Retain.Mode V1 parameters (Page 352)

11.2.5.10 Tag Warning V1

If several warnings are pending simultaneously, their values are displayed with binary addition. The display of warning 0003, for example, indicates that the warnings 0001 and 0002 are pending simultaneously.

Warning (DW#16#...)	Description
0000	No warning pending.
0001	The point of inflection was not found during pretuning.
0002	Oscillation increased during fine tuning.
0004	The setpoint was limited to the configured limits.
0008	Not all the necessary controlled system properties were defined for the selected method of calculation. The PID parameters were instead calculated using the TuneRuleTIR = 3 method.
0010	The operating mode could not be changed because ManualEnable = TRUE.
0020	The cycle time of the calling OB limits the sampling time of the PID algorithm. Improve results by using shorter OB cycle times.
0040	The process value exceeded one of its warning limits.
0080	Invalid value at Retain.Mode. The operating mode is not switched.
0100	The manual value was limited to the limits of the controller output.
0200	The rule used for tuning produces an incorrect result, or is not supported.
0400	Method selected for transition time measurement not suitable for actuator. The transition time cannot be measured because the actuator settings do not match the selected measuring method.
0800	The difference between the current position and the new output value is too small for transition time measurement. This can produce incorrect results. The difference between the current output value and new output value must be at least 50% of the entire control range.
1000	The substitute output value cannot be reached because it is outside the output value limits.

The following warnings are deleted as soon as the cause is eliminated:

- 0004
- 0020
- 0040
- 0100

All other warnings are cleared with a rising edge at Reset.

11.2.5.11 Tag SUT.State V1

SUT.State	Name	Description
0	SUT_INIT	Initialize pretuning
50	SUT_TPDN	Determine start position without position feedback
100	SUT_STDABW	Calculate the standard deviation
200	SUT_GET_POI	Find the point of inflection
300	SUT_GET_RISETM	Determine the rise time
9900	SUT_IO	Pretuning successful
1	SUT_NIO	Pretuning not successful

11.2.5.12 Tag TIR.State V1

TIR.State	Name	Description
-100	TIR_FIRST_SUT	Fine tuning is not possible. Pretuning will be executed first.
0	TIR_INIT	Initialize fine tuning
200	TIR_STDABW	Calculate the standard deviation
300	TIR_RUN_IN	Attempt to reach the setpoint with the maximum or minimum output value
400	TIR_CTRLN	Attempt to reach the setpoint with the existing PID parameters (if pretuning has been successful)
500	TIR_OSZIL	Determine oscillation and calculate parameters
9900	TIR_IO	Fine tuning successful
1	TIR_NIO	Fine tuning not successful

11.3 PID_Temp

11.3.1 New features of PID_Temp

PID_Temp V2.0

- **Use for exclusive cooling applications**

  From PID_Temp V2 the instruction can also be used for exclusive cooling applications.

  The heating output can be deactivated via Config.ActivateHeating = FALSE.

  Pretuning for cooling is also possible without prior pretuning for heating.
- **Temporary deactivation of heating**

  PID_Temp V2.0 offers the possibility of deactivating heating temporarily in automatic mode for controllers with active heating and cooling (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE) by setting DisableHeating = TRUE.
- **Manual stopping of the integral action**

  The integral action can be held in positive or negative direction by the static tags PIDCtrl.IntegralHoldPositive and PIDCtrl.IntegralHoldNegative.
- **Active limitation of the integral action and change of the output value limits in automatic mode**

  In addition to the direction-dependent stopping of the integral component, this is actively limited.

  This allows the change of the output value limits in automatic mode.
- **Improved anti-windup behavior in the cascade**

  The handling of the integral action of a master controller when its slave controllers are in limitation depends on the direction.

PID_Temp V1.1

- **Use with S7-1200 G2**

  As of PID_Temp V1.1, the instruction can also be used on an S7-1200 G2.

  Older versions of the instruction are not supported on S7-1200 G2.
- **Response of the output value on switchover from "Inactive" operating mode to "Automatic mode"**

  The new option IntegralResetMode = 4 was added and defined as default. With IntegralResetMode = 4, the integral action is automatically preassigned when switching from "Inactive" mode to "Automatic mode" so that a control deviation results in a jump of the PID output value with identical sign.
- **Initialization of the integral action in automatic mode**

  The integral action can be initialized in automatic mode with the OverwriteInitialOutputValue and PIDCtrl.PIDInit tags. This simplifies the use of PID_Temp for override controls.

11.3.2 Compatibility with CPU and FW

The following table shows which version of PID_Temp can be used on which CPU.

CPU	FW	PID_Temp
S7-1200	as of V4.2	V1.1 V1.0
	V4.1	V1.0
S7-1200 G2	as of V4.1	V2.0 V1.1
	V1.0 to V4.0	V1.1
S7-1500	as of V4.1	V2.0 V1.1
	V3.0 to V4.0	V1.1
	V2.0 to V2.9	V1.1 V1.0
	V1.7 to V1.8	V1.0

11.3.3 CPU processing time and memory requirement as of PID_Temp V1

CPU processing time

Typical CPU processing times of the PID_Temp technology object as of Version V1.0, depending on CPU type and operating mode for standard, F, T and TF CPUs.

CPU	FW	Typ. CPU processing time Automatic mode	Typ. CPU processing time pre-tuning and fine tuning
CPU 1211	≥ V4.1	290 µs	450 µs
CPU 1212			
CPU 1214			
CPU 1215			
CPU 1217			
CPU 1212 G2	≥ V1.0	130 µs	180 µs
CPU 1214 G2			
CPU 1216 G2	≥ V4.0	25 µs	45 µs
CPU 1217 G2			
CPU 1510SP	≤ V2.9	85 µs	140 µs
CPU 1511			
CPU 1511C			
CPU 1512C			
CPU 1512SP			
CPU 1513			
CPU 1515		80 µs	110 µs

CPU 1516	≤ V2.9	80 µs	110 µs
CPU 1517	≤ V3.1	12 µs	18 µs
CPU 1518		6 µs	9 µs
CPU 1510SP	V3.0, V3.1	75 µs	110 µs
CPU 1511			
CPU 1511C			
CPU 1512C			
CPU 1512SP			
CPU 1513			
CPU 1514SP			
CPU 1515		60 µs	90 µs
CPU 1516			
CPU 1510SP	≥ V4.0	60 µs	80 µs
CPU 1511			
CPU 1511C			
CPU 1512C			
CPU 1512SP			
CPU 1513			
CPU 1514SP			
CPU 1515			
CPU 1516			
CPU 1516T		4 µs	8 µs
CPU 1517		3 µs	6 µs
CPU 1518		2 µs	4 µs

Typical CPU processing times of the PID_Temp technology object as of Version V1.0, depending on the CPU type and operating mode for R/H-CPUs in the RUN-Redundant system state.

CPU	**FW**	**Typ. CPU processing time Automatic mode**	**Typ. CPU processing time pre-tuning and fine tuning**
CPU 1513R	V3.0, V3.1	110 µs	160 µs
CPU 1515R		100 µs	140 µs
CPU 1513R	≥ V4.0	100 µs	140 µs
CPU 1515R			
CPU 1517H		5 µs	8 µs
CPU 1518HF			

Memory requirement

Memory requirement of an instance DB of the PID_Temp technology object as of Version V1.0.

Memory requirement	Memory requirement of the instance DB of PID_Temp V1	Memory requirement of the instance DB of PID_Temp V2.x
Load memory requirement	Approx. 4700 bytes	Approx. 4750 bytes
Total work memory requirement	1280 bytes	1306 bytes
Retentive work memory requirement	100 bytes	100 bytes

11.3.4 PID_Temp

11.3.4.1 Description of PID_Temp

Description

The PID_Temp instruction provides a PID controller with integrated tuning for temperature processes. PID_Temp can be used for exclusive heating or heating/cooling applications.

From PID_Temp V2 the instruction can also be used for exclusive cooling applications.

The following operating modes are possible:

- Inactive
- Pretuning
- Fine tuning
- Automatic mode
- Manual mode
- Substitute output value with error monitoring

For a more detailed description of the operating modes, see the State parameter.

PID algorithm

PID_Temp is a PIDT1 controller with anti-windup and weighting of the proportional and derivative actions. The PID algorithm operates according to the following transfer function (control zone and dead zone deactivated):

$$y = K_p \left[(b \cdot w - x) + \frac{1}{T_I \cdot s} (w - x) + \frac{T_D \cdot s}{a \cdot T_D \cdot s + 1} (c \cdot w - x) \right]$$

The table below shows the meaning of the icons used in the transfer function and in the subsequent figures:

Icon	Description	Associated parameters of the PID_Temp instruction
y	Output value of the PID algorithm	-
K_p	Proportional gain	Retain.CtrlParams.Heat.Gain Retain.CtrlParams.Cool.Gain CoolFactor
s	Laplace operator	-
b	Proportional action weighting	Retain.CtrlParams.Heat.PWeighting Retain.CtrlParams.Cool.PWeighting
w	Setpoint	CurrentSetpoint
x	Process value	ScaledInput
T_I	Integration time	Retain.CtrlParams.Heat.Ti Retain.CtrlParams.Cool.Ti
T_D	Derivative action time	Retain.CtrlParams.Heat.Td Retain.CtrlParams.Cool.Td
a	Derivative delay coefficient (derivative delay $T1 = a \times T_D$)	Retain.CtrlParams.Heat.TdFiltRatio Retain.CtrlParams.Cool.TdFiltRatio
c	Derivative action weighting	Retain.CtrlParams.Heat.DWeighting Retain.CtrlParams.Cool.DWeighting
DeadZone	Dead zone width	Retain.CtrlParams.Heat.DeadZone Retain.CtrlParams.Cool.DeadZone
ControlZone	Control zone width	Retain.CtrlParams.Heat.ControlZone Retain.CtrlParams.Cool.ControlZone

PID_Temp block diagram

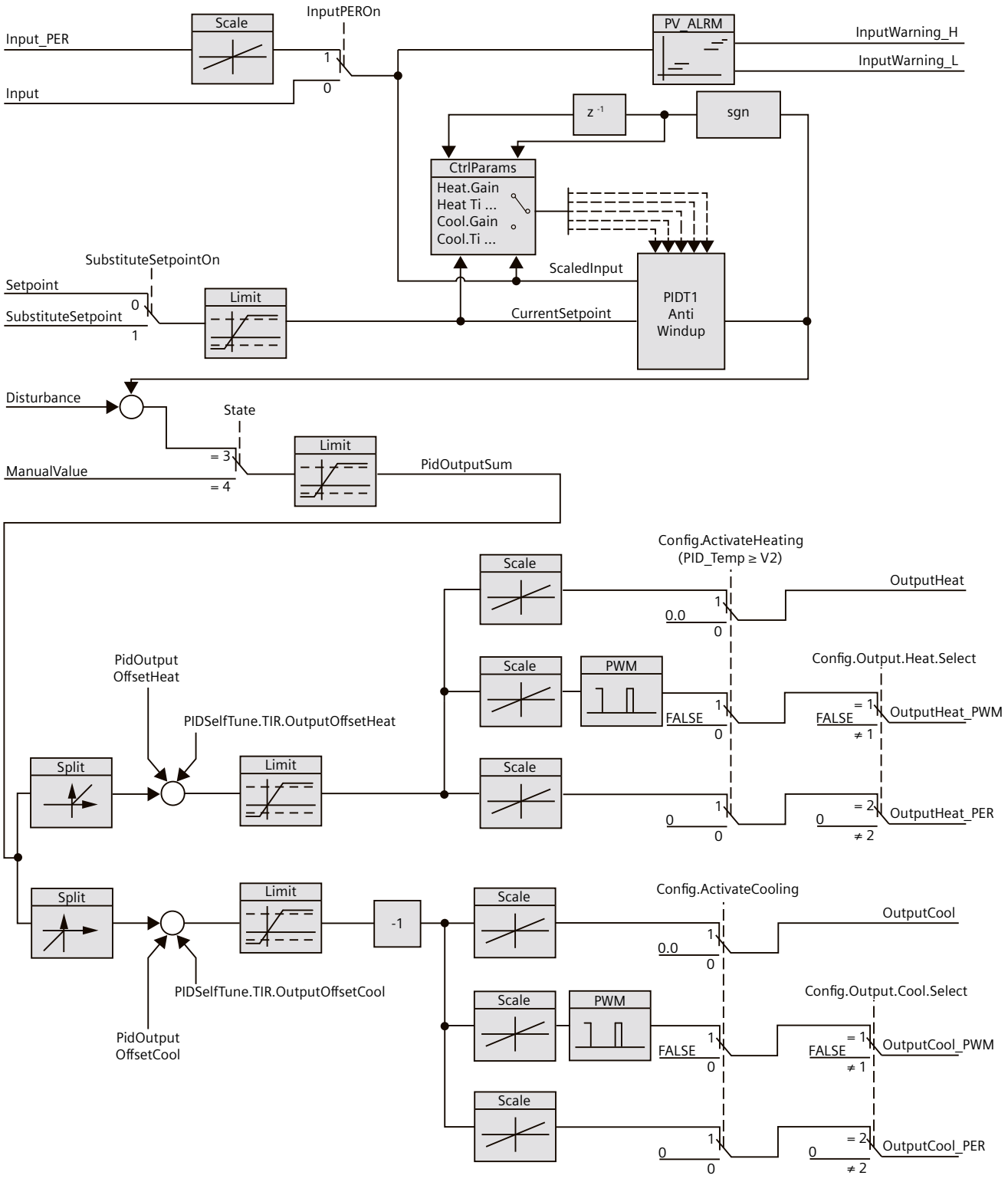

Block diagram of PIDT1 with anti-windup

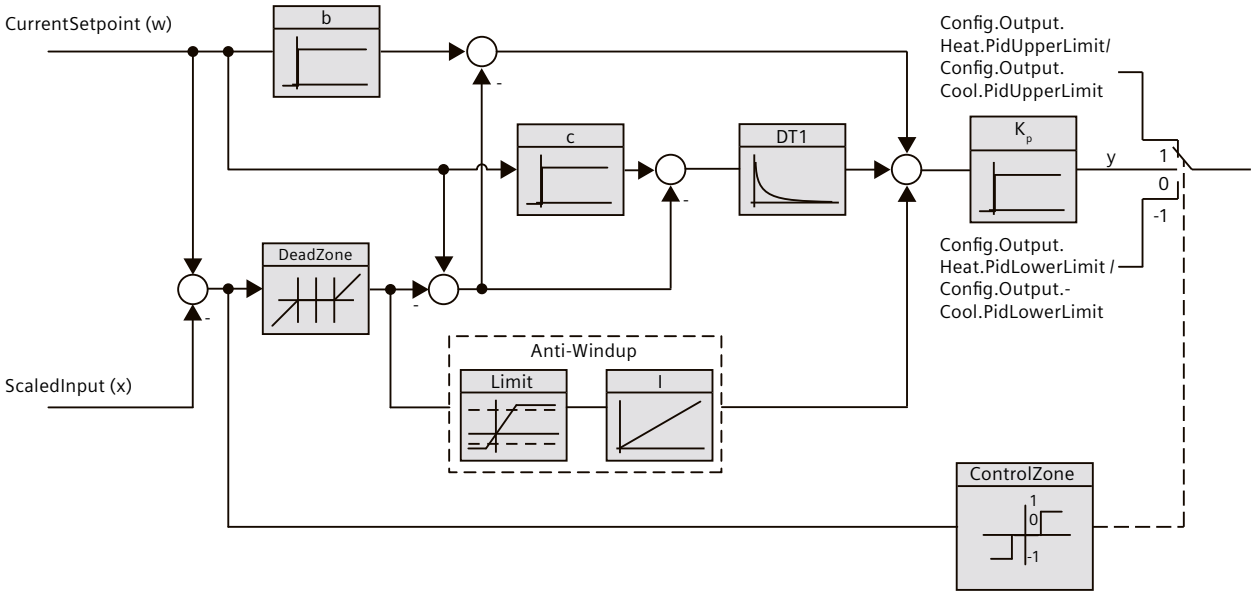

Call

PID_Temp is called in the constant time scale of a cyclic interrupt OB.

Download to device

The actual values of retentive tags are only updated when you download PID_Temp completely.

Download technology object to device (Page 46)

Startup

When the CPU starts up, PID_Temp starts in the operating mode saved in the Mode in/out parameter. To switch to "Inactive" operating mode during startup, set RunModeByStartup = FALSE.

Response to errors

The response in the event of an error is determined by the tags SetSubstituteOutput and ActivateRecoverMode. If ActivateRecoverMode = TRUE, the behavior also depends on the error that has occurred.

SetSubstitu-teOutput	ActivateR-ecoverMode	Configuration editor > Basic settings of output > Set PidOutputSum to	Reaction
Not relevant	FALSE	Zero (inactive)	Switch to "Inactive" (State = 0) mode The output value of the PID algorithm and all outputs for heating and cooling are set to 0. The scaling of the outputs for heating and cooling is not active.
FALSE	TRUE	Current value while error is pending	Switch to "Substitute output value with error monitoring" mode (State = 5) The current output value is transferred to the actuator while the error is pending.
TRUE	TRUE	Substitute output value while error is pending	Switch to "Substitute output value with error monitoring" mode (State = 5) The value at SubstituteOutput is transferred to the actuator while the error is pending.

In manual mode, PID_Temp uses ManualValue as output value, unless ManualValue is invalid.

- If ManualValue is invalid, SubstituteOutput is used.
- If ManualValue and SubstituteOutput are invalid, Config.Output.Heat.PidLowerLimit or Config.Output.Cool.PidUpperLimit is used.

The Error parameter indicates if an error is pending. When the error is no longer pending, Error = FALSE. The ErrorBits parameter shows which errors have occurred. ErrorBits is reset by a rising edge at Reset or ErrorAck.

11.3.4.2 Mode of operation of PID_Temp

Monitoring process value limits

You specify the high limit and low limit of the process value in the Config.InputUpperLimit and Config.InputLowerLimit tags. If the process value is outside these limits, an error occurs (ErrorBits = 16#0000_0001).

You specify a high and low warning limit of the process value in the Config.InputUpperWarning and Config.InputLowerWarning tags. If the process value is outside these warning limits, a warning occurs (Warning = 16#0000_0040), and the InputWarning_H or InputWarning_L output parameter changes to TRUE.

Limiting the setpoint

You specify a high limit and low limit of the setpoint in the Config.SetpointUpperLimit and Config.SetpointLowerLimit tags. PID_Temp automatically limits the setpoint to the process value limits. You can limit the setpoint to a smaller area. PID_Temp checks whether this area is within the process value limits. If the setpoint is outside these limits, the high or low limit is used as the setpoint, and output parameter SetpointLimit_H or SetpointLimit_L is set to TRUE.

The setpoint is limited in all operating modes.

Substitute setpoint

You can specify a substitute setpoint at the SubstituteSetpoint tag and activate it with SubstituteSetpointOn = TRUE. In this way, you can temporarily specify the setpoint directly, for example for a slave controller in a cascade, without having to change the user program. The limits set for the setpoint also apply to the substitute setpoint.

Heating and cooling

With the default setting Config.ActivateHeating = TRUE and Config.ActivateCooling = FALSE, PID_Temp only uses the outputs for heating (OutputHeat, OutputHeat_PWM, OutputHeat_PER). The output value of the PID algorithm (PidOutputSum) is scaled and output at the outputs for heating. You specify with Config.Output.Heat.Select if OutputHeat_PWM or OutputHeat_PER is calculated. OutputHeat is always calculated.

With Config.ActivateCooling = TRUE, you can also activate the outputs for cooling (OutputCool, OutputCool_PWM, OutputCool_PER). If the heating and cooling is activated, positive output values of the PID algorithm (PidOutputSum) are scaled and output at the outputs for heating. Negative output values of the PID algorithm are scaled and output at the outputs for cooling. You specify with Config.Output.Cool.Select if OutputCool_PWM or OutputCool_PER is calculated. OutputCool is always calculated.

The following methods are available to calculate the PID output value with activated heating and cooling:

- Cooling factor (Config.AdvancedCooling = FALSE):

  The output value calculation for cooling takes place with the PID parameters for heating, taking into consideration the configurable cooling factor Config.CoolFactor. This method is suitable if the heating and cooling actuators have a similar time response but different gains. If this method is selected, pretuning and fine tuning for cooling as well as the PID parameter set for cooling are not available. You can only execute the tuning for heating.

- PID parameter switching (Config.AdvancedCooling = TRUE):

  The output value calculation for cooling takes place by means of a separate PID parameter set. Based on the calculated output value and the control deviation, the PID algorithm decides whether the PID parameter for heating or cooling is used. This method is suitable if the heating and cooling actuators have different time responses and different gains. Tuning for heating and cooling is available if this method is selected.

As of PID_Temp V2, with Config.ActivateHeating = FALSE you can also deactivate the outputs for heating (OutputHeat, OutputHeat_PWM, OutputHeat_PER) and with Config.ActivateCooling = TRUE you can activate only the outputs for cooling. This means you can use PID_Temp for exclusive cooling applications.

In this configuration, the output value is calculated using the PID parameters for cooling. PID_Temp continues to work with normal control logic: If the setpoint value is below the process value, this results in a negative output value of the PID algorithm (PidOutputSum). This is scaled and output as a positive value at the outputs for cooling. A lower output value of the PID algorithm (PidOutputSum) or a lower manual value (ManualValue) leads to a higher value at the outputs for cooling due to the scaling.

Example with default setting: ManualValue = -50.0 -> OutputCool = 50.0, ManualValue = -100.0 -> OutputCool = 100.0

Output value limits and scaling

Depending on the operating mode, the PID output value (PidOutputSum) is calculated automatically by the PID algorithm or by the manual value (ManualValue) or the configured substitute output value (SubstituteOutput).

The PID output value is limited as defined in the configuration.

- If heating is activated and cooling is deactivated, Config.Output.Heat.PidUpperLimit is the high limit and Config.Output.Heat.PidLowerLimit the low limit.
- If heating and cooling are activated, Config.Output.Heat.PidUpperLimit is the high limit and Config.Output.Cool.PidLowerLimit the low limit.
- If heating is deactivated and cooling is activated, Config.Output.Cool.PidUpperLimit is the high limit and Config.Output.Cool.PidLowerLimit the low limit.

The PID output value is scaled and output at the outputs for heating and cooling. Scaling can be defined separately for each output and is specified in the structures Config.Output.Heat or Config.Output.Cool with 2 value pairs each:

Output	Value pair	Parameter
OutputHeat	Value pair 1	PID output value high limit (heating) Config.Output.Heat.PidUpperLimit, Scaled high output value (heating) Config.Output.Heat.UpperScaling
	Value pair 2	PID output value low limit (heating) Config.Output.Heat.PidLowerLimit, Scaled low output value (heating) Config.Output.Heat.LowerScaling
OutputHeat_PWM	Value pair 1	PID output value high limit (heating) Config.Output.Heat.PidUpperLimit, Scaled high PWM output value (heating) Config.Output.Heat.PwmUpperScaling
	Value pair 2	PID output value low limit (heating) Config.Output.Heat.PidLowerLimit, Scaled low PWM output value (heating) Config.Output.Heat.PwmLowerScaling
OutputHeat_PER	Value pair 1	PID output value high limit (heating) Config.Output.Heat.PidUpperLimit, Scaled high analog output value (heating) Config.Output.Heat.PerUpperScaling

When the heating and cooling are activated, Config.Output.Heat.PidLowerLimit and Config.Output.Cool.PidUpperLimit must have the value 0.0.

Output	Value pair	Parameter
OutputHeat_PER	Value pair 2	PID output value low limit (heating) Config.Output.Heat.PidLowerLimit, Scaled low analog output value (heating) Config.Output.Heat.PerLowerScaling
OutputCool	Value pair 1	PID output value low limit (cooling) Config.Output.Cool.PidLowerLimit, Scaled high output value (cooling) Config.Output.Cool.UpperScaling
	Value pair 2	PID output value high limit (cooling) Config.Output.Cool.PidUpperLimit, Scaled low output value (cooling) Config.Output.Cool.LowerScaling
OutputCool_PWM	Value pair 1	PID output value low limit (cooling) Config.Output.Cool.PidLowerLimit, Scaled high PWM output value (cooling) Config.Output.Cool.PwmUpperScaling
	Value pair 2	PID output value high limit (cooling) Config.Output.Cool.PidUpperLimit, Scaled low PWM output value (cooling) Config.Output.Cool.PwmLowerScaling
OutputCool_PER	Value pair 1	PID output value low limit (cooling) Config.Output.Cool.PidLowerLimit, Scaled high analog output value (cooling) Config.Output.Cool.PerUpperScaling
	Value pair 2	PID output value high limit (cooling) Config.Output.Cool.PidUpperLimit, Scaled low analog output value (cooling) Config.Output.Cool.PerLowerScaling

When the heating and cooling are activated, Config.Output.Heat.PidLowerLimit and Config.Output.Cool.PidUpperLimit must have the value 0.0.

Example:

Output scaling when using output OutputHeat (cooling deactivated; Config.Output.Heat.PidLowerLimit may be unequal to 0.0):

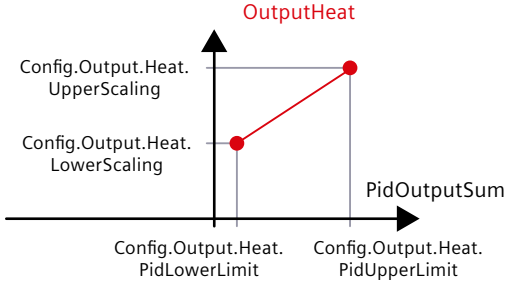

Example:

Output scaling when using output OutputHeat_PWM and OutputCool_PER (heating and cooling activated; Config.Output.Heat.PidLowerLimit and Config.Output.Cool.PidUpperLimit must have the value 0.0):

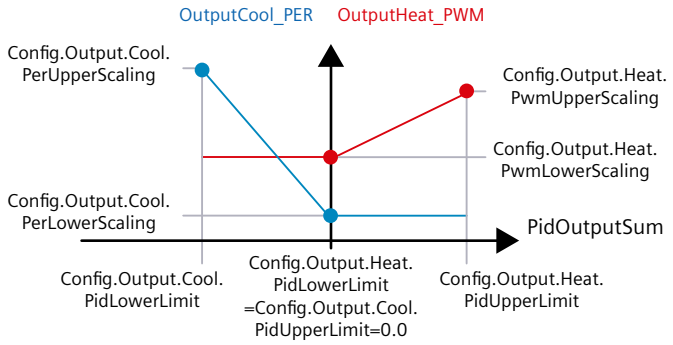

With the exception of the "Inactive" operating mode, the value at an output is always located between its scaled high output value and scaled low output value, for example, for OutputHeat always between Config.Output.Heat.UpperScaling and Config.Output.Heat.LowerScaling.

If you want to limit the value at the associated output, you therefore have to adapt these scaling values as well.

Cascading

PID_Temp supports you when you use cascade control (see: Program creation (Page 190)).

Substitute output value

In the event of an error, PID_Temp can output a substitute output value that you define at the SubstituteOutput tag. The substitute output value must be within the limits for the PID output value. The values at the outputs for heating and cooling resulting from the substitute output value are the result of the configured output scaling.

Monitoring signal validity

The values of the following parameters are monitored for validity when used:

- Setpoint
- SubstituteSetpoint
- Input
- Input_PER
- Disturbance
- ManualValue
- SubstituteOutput
- PID parameters in the structures Retain.CtrlParams.Heat and Retain.CtrlParams.Cool.

Monitoring the sampling time PID_Temp

Ideally, the sampling time is equivalent to the cycle time of the cyclic interrupt OB. The PID_Temp instruction measures the time interval between two calls. This is the current sampling time. On every switchover of operating mode and during the initial startup, the mean value is formed from the first 10 sampling times. Too great a difference between the current sampling time and this mean value triggers an error (Error = 16#0000_0800).

The error occurs during tuning if:

- New mean value >= 1.1 x old mean value
- New mean value <= 0.9 x old mean value

The error occurs in automatic mode if:

- New mean value >= 1.5 x old mean value
- New mean value <= 0.5 x old mean value

If you deactivate the sampling time monitoring (CycleTime.EnMonitoring = FALSE), you can also call PID_Temp in OB1. You must then accept a lower control quality due to the deviating sampling time.

Sampling time of the PID algorithm

The controlled system needs a certain amount of time to respond to changes in the output value. It is therefore not advisable to calculate the output value in every cycle. The sampling time of the PID algorithm (Retain.CtrlParams.Heat.Cycle or Retain.CtrlParams.Cool.Cycle) represents the time between two calculations of the output value. It is calculated during tuning and rounded to a multiple of the sampling time PID_Temp (CycleTime.Value). All other functions of the PID_Temp are executed at every call.

If heating and cooling are activated with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.Advanced.Cooling = TRUE), the PID_Temp uses a separate sampling time of the PID algorithm for heating and cooling. In all other configurations, only the sampling time of the PID algorithm for heating or cooling is used.

If you use OutputHeat_PWM or OutputCool_PWM, the sampling time of the PID algorithm is used as the period duration of the pulse width modulation. The accuracy of the output signal is determined by the ratio of the PID algorithm sampling time to the cycle time of the OB. The cycle time should be no more than a tenth of the PID algorithm sampling time.

If the sampling time of the PID algorithm and thus the period duration of the pulse width modulation is very high when OutputHeat_PWM or OutputCool_PWM is used, you can specify a deviating shorter period duration with the Config.Output.Heat.PwmPeriode or Config.Output.Cool.PwmPeriode (Page 422) parameters in order to improve smoothing of the process value.

Control logic

PID_Temp can be used for heating or heating/cooling applications. From PID_Temp V2 the instruction can also be used for exclusive cooling applications. PID_Temp works firmly with normal control logic.

An increase of the PID output value (PidOutputSum) is intended to increase the process value. The values at the outputs for heating and cooling resulting from the PID output value are the result of the configured output scaling.

An inverted control logic or negative proportional gain are not supported.

If you only need an output value for your application in which an increase is to reduce the process value (for example, discharge control), you can use PID_Compact with inverted control logic.

11.3.4.3 Input parameters of PID_Temp

The names of the following parameters apply both to the data block and to access via the Openness API.

Parameter	Data type	Default	Description
Setpoint	REAL	0.0	Setpoint of the PID controller in automatic mode Permissible value range: Config.SetpointUpperLimit ≥ Setpoint ≥ Config.SetpointLowerLimit Config.InputUpperLimit ≥ Setpoint ≥ Config.InputLowerLimit
Input	REAL	0.0	A tag of the user program is used as source for the process value. If you are using Input parameter, then Config.InputPerOn = FALSE must be set.
Input_PER	INT	0	An analog input is used as the source of the process value. If you are using Input_PER parameter, then Config.InputPerOn = TRUE must be set.
Disturbance	REAL	0.0	Disturbance variable or precontrol value
ManualEnable	BOOL	FALSE	• A FALSE -> TRUE edge activates "Manual mode", State = 4, Mode remains unchanged. As long as ManualEnable = TRUE, you cannot change the operating mode via a rising edge at ModeActivate or use the commissioning dialog. • A TRUE -> FALSE edge activates the operating mode that is specified by Mode. We recommend that you change the operating mode using Mode and ModeActivate only.
ManualValue	REAL	0.0	Manual value This value is used as the PID output value (PidOutputSum) in manual mode. The values at the outputs for heating and cooling resulting from this manual value are the result of the configured output scaling (structures Config.Output.Heat and Config.Output.Cool). For controllers with activated heating output and cooling output (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE), define: • a positive manual value to output the value at the outputs for heating • a negative manual value to output the value at the outputs for cooling

Parameter	Data type	Default	Description
			The permitted value range is determined by the configuration. • Heating output activated (Config.ActivateHeating = TRUE) and cooling output deactivated (Config.ActivateCooling = FALSE): Config.Output.Heat.PidUpperLimit ≥ ManualValue ≥ Config.Output.Heat.PidLowerLimit • Heating output activated (Config.ActivateHeating = TRUE) and cooling output activated (Config.ActivateCooling = TRUE): Config.Output.Heat.PidUpperLimit ≥ ManualValue ≥ Config.Output.Cool.PidLowerLimit • Heating output deactivated (Config.ActivateHeating = FALSE) and cooling output activated (Config.ActivateCooling = TRUE): Config.Output.Cool.PidUpperLimit ≥ ManualValue ≥ Config.Output.Cool.PidLowerLimit
ErrorAck	BOOL	FALSE	• FALSE -> TRUE edge ErrorBits and Warning are reset.
Reset	BOOL	FALSE	Restarts the controller. • FALSE -> TRUE edge – Switch to "Inactive" mode – ErrorBits and Warning are reset. • As long as Reset = TRUE, – PID_Temp remains in "Inactive" mode (State = 0). – you cannot change the operating mode with Mode and ModeActivate or ManualEnable – You cannot use the commissioning dialog. • TRUE -> FALSE edge – If ManualEnable = FALSE, PID_Temp switches to the operating mode that is stored in the Mode parameter. – If Mode = 3 (automatic mode), the integral action is treated as configured with the tag IntegralResetMode.
ModeActivate	BOOL	FALSE	• FALSE -> TRUE edge PID_Temp switches to the operating mode that is saved at the Mode input.

11.3.4.4 Output parameters of PID_Temp

The names of the following parameters apply both to the data block and to access via the Openness API.

Parameter	Data type	Default	Description
ScaledInput	REAL	0.0	Scaled process value
OutputHeat	REAL	0.0	Output value (heating) in REAL format The PID output value (PidOutputSum) is scaled with the two value pairs Config.Output.Heat.PidUpperLimit, Config.Output.Heat.UpperScaling and Config.Output.Heat.PidLowerLimit, Config.Output.Heat.LowerScaling and output in REAL format at OutputHeat. For PID_Temp V1.x OutputHeat is always calculated. For PID_Temp as of V2, OutputHeat is only calculated if the heating output is activated (Config.ActivateHeating = TRUE).

Parameter	Data type	Default	Description
OutputCool	REAL	0.0	Output value (cooling) in REAL format The PID output value (PidOutputSum) is scaled with the two value pairs Config.Output.Cool.PidUpperLimit, Config.Output.Cool.LowerScaling and Config.Output.Cool.PidLowerLimit, Config.Output.Cool.UpperScaling and output in REAL format at OutputCool. OutputCool is only calculated if the cooling output is activated (Config.ActivateCooling = TRUE).
OutputHeat_PER	INT	0	Analog output value (heating) The PID output value (PidOutputSum) is scaled with the two value pairs Config.Output.Heat.PidUpperLimit, Config.Output.Heat.PerUpperScaling and Config.Output.Heat.PidLowerLimit, Config.Output.Heat.PerLowerScaling and output as analog value at OutputHeat_PER. OutputHeat_PER is only calculated if the heating output is activated (Config.ActivateHeating = TRUE) and Config.Output.Heat.Select = 2.
OutputCool_PER	INT	0	Analog output value (cooling) The PID output value (PidOutputSum) is scaled via the two value pairs Config.Output.Cool.PidUpperLimit, Config.Output.Cool.PerLowerScaling and Config.Output.Cool.PidLowerLimit, Config.Output.Cool.PerUpperScaling and output as an analog value at OutputCool_PER. OutputCool_PER is only calculated if the cooling output is activated (Config.ActivateCooling = TRUE) and Config.Output.Cool.Select = 2.
OutputHeat_PWM	BOOL	FALSE	Pulse-width modulated output value (heating) The PID output value (PidOutputSum) is scaled with the two value pairs Config.Output.Heat.PidUpperLimit, Config.Output.Heat.PwmUpperScaling and Config.Output.Heat.PidLowerLimit, Config.Output.Heat.PwmLowerScaling and output as pulse-width modulated value (variable switch on and switch off times) at OutputHeat_PWM. OutputHeat_PWM is only calculated if the heating output is activated (Config.ActivateHeating = TRUE) and Config.Output.Heat.Select = 1.
OutputCool_PWM	BOOL	FALSE	Pulse-width modulated output value (cooling) The PID output value (PidOutputSum) is scaled with the two value pairs Config.Output.Cool.PidUpperLimit, Config.Output.Cool.PwmLowerScaling and Config.Output.Cool.PidLowerLimit, Config.Output.Cool.PwmUpperScaling and output as pulse-width modulated value (variable switch on and switch off times) at OutputCool_PWM. OutputCool_PWM is only calculated if the cooling output is activated (Config.ActivateCooling = TRUE) and Config.Output.Cool.Select = 1.
SetpointLimit_H	BOOL	FALSE	If SetpointLimit_H = TRUE, the absolute high limit of setpoint is reached (Setpoint ≥ Config.SetpointUpperLimit or Setpoint ≥ Config.InputUpperLimit). The setpoint high limit is the minimum of Config.SetpointUpperLimit and Config.InputUpperLimit.
SetpointLimit_L	BOOL	FALSE	If SetpointLimit_L = TRUE, the absolute low limit of the setpoint has been reached (Setpoint ≤ Config.SetpointLowerLimit or Setpoint ≤ Config.InputLowerLimit). The setpoint low limit is the maximum of Config.SetpointLowerLimit and Config.InputLowerLimit.
InputWarning_H	BOOL	FALSE	If InputWarning_H = TRUE, the process value has reached or exceeded the warning high limit (ScaledInput ≥ Config.InputUpperWarning).
InputWarning_L	BOOL	FALSE	If InputWarning_L = TRUE, the process value has reached or fallen below the warning low limit (ScaledInput ≤ Config.InputLowerWarning).

Parameter	Data type	Default	Description
State	INT	0	The State parameter (Page 410) shows the current operating mode of the PID controller. You can change the operating mode using the input parameter Mode and a rising edge at ModeActivate. For pretuning and fine tuning, you specify with Heat.EnableTuning and Cool.EnableTuning whether tuning takes place for heating or cooling. • State = 0: Inactive • State = 1: Pretuning • State = 2: Fine tuning • State = 3: Automatic mode • State = 4: Manual mode • State = 5: Substitute output value with error monitoring
Error	BOOL	FALSE	If Error = TRUE, at least one error message is pending in this cycle.
ErrorBits	DWORD	DW#16#0	The ErrorBits parameter (Page 416) shows which error messages are pending. ErrorBits is retentive and is reset with a rising edge at Reset or ErrorAck.

11.3.4.5 In/out parameters of PID_Temp V2

The names of the following parameters apply both to the data block and to access via the Openness API.

Parameter	Data type	Default	Description
Mode	INT	4	At Mode, specify the operating mode to which PID_Temp is to switch. Options are: • Mode = 0: Inactive • Mode = 1: Pretuning • Mode = 2: Fine tuning • Mode = 3: Automatic mode • Mode = 4: Manual mode The operating mode is activated by: • Rising edge at ModeActivate • Falling edge at Reset • Falling edge at ManualEnable • Cold restart of CPU if RunModeByStartup = TRUE For pretuning and fine tuning, you specify with Heat.EnableTuning and Cool.EnableTuning whether tuning takes place for heating or cooling. Mode is retentive. A detailed description of the operating modes can be found in State and Mode parameters (Page 410).
Master	DWORD	DW#16#0	Interface for cascade control (Page 188) If this PID_Temp instance is used as slave controller in a cascade (Config.Cascade.IsSlave = TRUE), assign the Master parameter at the instruction call with the Slave parameter of the master controller. Example: Call of a slave controller "PID_Temp_2" with master controller "PID_Temp_1" in SCL: ---------- `"PID_Temp_2"(Master := "PID_Temp_1".Slave, Setpoint := "PID_Temp_1".OutputHeat);` ---------- Slave controllers exchange information about operating mode, limitation and substitute setpoint with their master controller via this interface. Keep in mind that the call of the master controller has to take place before the call of the slave controller in the same cyclic interrupt OB.

Parameter	Data type	Default	Description
Slave	DWORD	DW#16#0	Interface for cascade control Slave controllers exchange information about operating mode, limitation and substitute setpoint with their master controller via this interface. See description of Master parameter.

See also

PID_Temp state and mode parameters (Page 410)
Program creation (Page 190)

11.3.4.6 Static tags of PID_Temp

NOTE

Change the tags identified with (1) only in "Inactive" mode to prevent malfunction of the PID controller.

The names of the following variables apply both to the data block and to access via the Openness API.

Tag	Data type	Default	Description
IntegralResetMode	Int	V1.0: 1, as of version V1.1: 4	The IntegralResetMode tag (Page 424) determines how the integral action PIDCtrl.IOutputOld is preassigned when switching from "Inactive" operating mode to "Automatic mode". This setting only works for one cycle. • IntegralResetMode = 0: Smooth • IntegralResetMode = 1: Delete • IntegralResetMode = 2: Hold • IntegralResetMode = 3: Preassign • IntegralResetMode = 4: Like setpoint change (only for PID_Temp with version ≥ 1.1)
OverwriteInitialOutputValue	REAL	0.0	If one of the following conditions is met, the integral action PIDCtrl.IOutputOld is preassigned automatically as if PIDOutputSum = OverwriteInitialOutputValue in the previous cycle: • IntegralResetMode = 3 when switching from "Inactive" operating mode to "Automatic mode" • IntegralResetMode = 3, TRUE -> FALSE edge at parameter Reset and parameter Mode = 3 • PIDCtrl.PIDInit = TRUE in "Automatic mode" (available as of PID_Temp Version 1.1)
RunModeByStartup	BOOL	TRUE	Activate operating mode at Mode parameter after CPU restart • If RunModeByStartup = TRUE, PID_Temp starts in the operating mode stored in the Mode parameter after CPU startup. • If RunModeByStartup = FALSE, PID_Temp remains in "Inactive" mode after CPU startup.
LoadBackUp	BOOL	FALSE	If LoadBackUp = TRUE, the last set of PID parameters is reloaded from the CtrlParamsBackUp structure. The set was saved prior to the last tuning. LoadBackUp is automatically set back to FALSE. The acceptance is bumpless.

Tag	Data type	Default	Description
SetSubstituteOutput	BOOL	TRUE	Selection of the output value while an error is pending (State = 5): • If SetSubstituteOutput = TRUE and ActivateRecoverMode = TRUE, the configured substitute output value SubstituteOutput is output as a PID output value as long as an error is pending. • If SetSubstituteOutput = FALSE and ActivateRecoverMode = TRUE, the actuator remains at the current PID output value as long as an error is pending. • If ActivateRecoverMode = FALSE, SetSubstituteOutput does not take effect. • If SubstituteOutput is invalid (ErrorBits = 16#0002_0000), the substitute output value cannot be output. In this case, Config.Output.Heat.PidLowerLimit or Config.Output.Cool.PidUpperLimit is used as a PID output value.
PhysicalUnit	INT	0	Unit of measurement of the process value and setpoint, e.g., °C, or °F. PhysicalUnit serves the display in the editors and has no influence on the behavior of the control algorithm in the CPU. When importing PID_Temp up to V1.1 via the Openness API, PhysicalUnit is reset to the default value. When importing PID_Temp as of V2.0 via the Openness API, the value of PhysicalUnit is retained.
PhysicalQuantity	INT	0	Physical quantity of the process value and setpoint, e.g., temperature. PhysicalQuantity serves the display in the editors and has no influence on the behavior of the control algorithm in the CPU. When importing PID_Temp up to V1.1 via the Openness API, PhysicalQuantity is reset to the default value. When importing PID_Temp as of V2.0 via the Openness API, the value of PhysicalQuantity is retained.
ActivateRecoverMode	BOOL	TRUE	The ActivateRecoverMode (Page 419) tag determines the response in the event of an error.
Warning	DWORD	0	The Warning (Page 421) tag shows the warnings since Reset = TRUE or ErrorAck =TRUE. Warning is retentive.
Progress	REAL	0.0	Progress of current tuning phase as a percentage (0.0 - 100.0)
CurrentSetpoint	REAL	0.0	CurrentSetpoint always displays the currently effective setpoint. This value is frozen during tuning.
CancelTuningLevel	REAL	10.0	Permissible fluctuation of setpoint during tuning. Tuning is not canceled until: • Setpoint > CurrentSetpoint + CancelTuningLevel or • Setpoint < CurrentSetpoint - CancelTuningLevel
SubstituteOutput	REAL	0.0	The substitute output value is used as PID output value as long as the following conditions are met: • One or more errors are pending in automatic mode for which ActivateRecoverMode is in effect • SetSubstituteOutput = TRUE • ActivateRecoverMode = TRUE The values at the outputs for heating and cooling resulting from the substitute output value are the result of the con-

Tag	Data type	Default	Description
			figured output scaling (structures Config.Output.Heat and Config.Output.Cool). For controllers with activated heating output and cooling output (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE), define: • a positive substitute output value to output the value at the outputs for heating • a negative substitute output value to output the value at the outputs for cooling The permitted value range is determined by the configuration. • Heating output activated (Config.ActivateHeating = TRUE) and cooling output deactivated (Config.ActivateCooling = FALSE): Config.Output.Heat.PidUpperLimit ≥ SubstituteOutput ≥ Config.Output.Heat.PidLowerLimit • Heating output activated (Config.ActivateHeating = TRUE) and cooling output activated (Config.ActivateCooling = TRUE): Config.Output.Heat.PidUpperLimit ≥ SubstituteOutput ≥ Config.Output.Cool.PidLowerLimit • Heating output deactivated (Config.ActivateHeating = FALSE) and cooling output activated (Config.ActivateCooling = TRUE): Config.Output.Cool.PidUpperLimit ≥ SubstituteOutput ≥ Config.Output.Cool.PidLowerLimit
PidOutputSum	REAL	0.0	PID output value PidOutputSum displays the output value of the PID algorithm. Depending on the operating mode, it is either calculated automatically or defined by the manual value or the configured substitute output value. The values at the outputs for heating and cooling resulting from the PID output value are the result of the configured output scaling (Config.Output.Heat and Config.Output.Cool structures). The PidOutputSum is limited as defined in the configuration. • Heating output activated (Config.ActivateHeating = TRUE) and cooling output deactivated (Config.ActivateCooling = FALSE): Config.Output.Heat.PidUpperLimit ≥ PidOutputSum ≥ Config.Output.Heat.PidLowerLimit • Heating output activated (Config.ActivateHeating = TRUE) and cooling output activated (Config.ActivateCooling = TRUE): Config.Output.Heat.PidUpperLimit ≥ PidOutputSum ≥ Config.Output.Cool.PidLowerLimit • Heating output deactivated (Config.ActivateHeating = FALSE) and cooling output activated (Config.ActivateCooling = TRUE): Config.Output.Cool.PidUpperLimit ≥ PidOutputSum ≥ Config.Output.Cool.PidLowerLimit

Tag	Data type	Default	Description
PidOutputOffsetHeat	REAL	0.0	Offset of the PID output value for heating PidOutputOffsetHeat is added to the value that results from PidOutputSum for the heating branch. Enter a positive value for PidOutputOffsetHeat to receive a positive offset at the outputs for heating. The resulting values at the outputs for heating are the result of the configured output scaling (Config.Output.Heat structure). This offset can be used for actuators which need a fixed minimum value, for example, fans with minimum speed. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE).
PidOutputOffsetCool	REAL	0.0	Offset of the PID output value for cooling PidOutputOffsetCool is added to the value that results from PidOutputSum for the cooling branch. Enter a negative value for PidOutputOffsetCool to receive a positive offset at the outputs for cooling. The resulting values at the outputs for cooling are the result of the configured output scaling (Config.Output.Cool structure). This offset can be used for actuators which need a fixed minimum value, for example, fans with minimum speed. Only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE).
SubstituteSetpointOn	BOOL	FALSE	Activates the substitute setpoint as controller setpoint. • FALSE = the Setpoint parameter is used. • TRUE = the SubstituteSetpoint parameter is used as setpoint SubstituteSetpointOn can be used to specify the setpoint of a slave controller in a cascade directly without having to change the user program.
SubstituteSetpoint	REAL	0.0	Substitute setpoint If SubstituteSetpointOn = TRUE, the SubstituteSetpoint parameter is used as setpoint. Permissible value range: Config.SetpointUpperLimit ≥ SubstituteSetpoint ≥ Config.SetpointLowerLimit, Config.InputUpperLimit ≥ SubstituteSetpoint ≥ Config.InputLowerLimit
DisableHeating	BOOL	FALSE	DisableHeating = TRUE deactivates the heating branch for heating/cooling controllers (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE) in automatic mode by limiting PidOutputSum to the high limit 0.0. PidOutputOffsetHeat and the output scaling for the heating outputs remain active. This parameter is set/reset by the user manually and is not automatically reset by the PID_Temp instruction. DisableHeating is available as of PID_Temp Version 2.0.
DisableCooling	BOOL	FALSE	DisableCooling = TRUE deactivates the cooling branch for heating/cooling controllers (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE) in automatic mode by limiting PidOutputSum to the low limit 0.0. PidOutputOffsetCool and the output scaling for the cooling outputs remain active.

Tag	Data type	Default	Description
			DisableCooling can be used for tuning of multi-zone applications (Page 195) to temporarily deactivate the cooling branch as long as all controllers have not completed their tuning yet. This parameter is set/reset by the user manually and is not automatically reset by the PID_Temp instruction.
AllSlaveAutomaticState	BOOL	FALSE	If this PID_Temp instance is used as master controller in a cascade (Config.Cascade.IsMaster = TRUE), AllSlaveAutomaticState = TRUE indicates that all slave controllers are in automatic mode. Tuning, manual mode or automatic mode of the master controller can only be executed accurately if all slave controllers are in automatic mode. AllSlaveAutomaticState is only determined if you interconnect the master controller and slave controller with the Master and Slave parameters. For details, see the Master parameter.
NoSlaveSubstituteSetpoint	BOOL	FALSE	If this PID_Temp instance is used as master controller in a cascade (Config.Cascade.IsMaster = TRUE), NoSlaveSubstituteSetpoint = TRUE indicates that no slave controller has activated its substitute setpoint. Tuning, manual mode or automatic mode of the master controller can only be executed accurately if no slave controller has activated its substitute setpoint. NoSlaveSubstituteSetpoint is only determined if you interconnect the master controller and slave controller with the Master and Slave parameters. For details, see the Master parameter.
Heat.EnableTuning	BOOL	TRUE	Enabling of tuning for heating Heat.EnableTuning must be set for the following tuning (at the same time or prior to the start with Mode and ModeActivate): • Pretuning heating • Pretuning heating and cooling • Fine tuning heating Tuning for heating is only possible if the heating output is activated (Config.ActivateHeating = TRUE). This parameter is not automatically reset by the PID_Temp instruction.
Cool.EnableTuning	BOOL	FALSE	Enabling of tuning for cooling Cool.EnableTuning must be set for the following tuning (at the same time or prior to the start with Mode and ModeActivate): • Pretuning cooling • Pretuning heating and cooling • Fine tuning cooling The tuning for cooling is only possible when the heating output and the cooling output with the PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated. This parameter is not automatically reset by the PID_Temp instruction.

Tag	Data type	Default	Description
Config.InputPerOn(1)	BOOL	TRUE	If InputPerOn = TRUE, the Input_PER parameter is used for detecting the process value. If InputPerOn = FALSE, the Input parameter is used.
Config.InputUpperLimit(1)	REAL	120.0	High limit of the process value Input and Input_PER are monitored to ensure adherence to this limit. If the limit is exceeded, an error is output and the reaction is determined by ActivateRecoverMode. At the I/O input, the process value can be a maximum of 18% higher than the nominal range (overrange). This means the limit cannot be exceeded when you use an I/O input with the pre-setting for high limit and process value scaling. When pretuning is started, the difference between high and low limit of the process value is checked to determine whether the distance between setpoint and process value meets the necessary requirements. InputUpperLimit > InputLowerLimit
Config.InputLowerLimit(1)	REAL	0.0	Low limit of the process value Input and Input_PER are monitored to ensure adherence to this limit. If the limit is undershot, an error is output and the reaction is determined by ActivateRecoverMode. InputLowerLimit < InputUpperLimit
Config.InputUpperWarning(1)	REAL	3.402822e+-38	Warning high limit of the process value Input and Input_PER are monitored to ensure adherence to this limit. If the limit is exceeded, a warning is output at the Warning parameter. • If you set InputUpperWarning outside the process value limits, the configured absolute process value high limit is used as the warning high limit. • If you configure InputUpperWarning within the process value limits, this value is used as the warning high limit. InputUpperWarning > InputLowerWarning
Config.InputLowerWarning(1)	REAL	-3.402822e+38	Warning low limit of the process value Input and Input_PER are monitored to ensure adherence to this limit. If the limit is undershot, a warning is output at the Warning parameter. • If you set InputLowerWarning outside the process value limits, the configured absolute process value low limit is used as the warning low limit. • If you configure InputLowerWarning within the process value limits, this value is used as the warning low limit. InputLowerWarning < InputUpperWarning
Config.SetpointUpperLimit(1)	REAL	3.402822e+-38	High limit of setpoint Setpoint and SubstituteSetpoint are monitored to ensure adherence to this limit. If the limit is exceeded, a warning is output at the Warning parameter. • If you configure SetpointUpperLimit outside the process value limits, the configured process value absolute high limit is used as the setpoint high limit. • If you configure SetpointUpperLimit within the process value limits, this value is used as the setpoint high limit. SetpointUpperLimit > SetpointLowerLimit

Tag	Data type	Default	Description
Config.SetpointLowerLimit(1)	REAL	-3.402822e+38	Low limit of the setpoint Setpoint and SubstituteSetpoint are monitored to ensure adherence to this limit. If the limit is undershot, a warning is output at the Warning parameter. • If you set SetpointLowerLimit outside the process value limits, the configured process value absolute low limit is used as the setpoint low limit. • If you set SetpointLowerLimit within the process value limits, this value is used as the setpoint low limit. SetpointLowerLimit < SetpointUpperLimit
Config.ActivateHeating(1)	BOOL	TRUE	Activate heating output Config.ActivateHeating is available as of PID_Temp V2.0. • Config.ActivateHeating = FALSE Heating output deactivated • Config.ActivateHeating = TRUE Heating output activated If you are using the heating and cooling output, the controller must not be configured as master controller (Config.Cascade.IsMaster must be FALSE) . PID_Temp V1.x always behaves like Config.ActivateHeating = TRUE.
Config.ActivateCooling(1)	BOOL	FALSE	Activate cooling output • Config.ActivateCooling = FALSE Cooling output deactivated • Config.ActivateCooling = TRUE Cooling output activated If you are using the heating and cooling output, the controller must not be configured as master controller (Config.Cascade.IsMaster must be FALSE) .
Config.AdvancedCooling(1)	BOOL	TRUE	Method for heating/cooling • Cooling factor (Config.AdvancedCooling = FALSE) The output value calculation for cooling takes place with the PID parameters for heating (Retain.CtrlParams.Heat structure) taking into consideration the configurable cooling factor Config.CoolFactor. This method is suitable if the heating and cooling actuators have a similar time response but different gains. Pretuning and fine tuning for cooling are not available when you select this method. You can only execute the tuning for heating. • PID parameter switching (Config.AdvancedCooling = TRUE) The output value calculation for cooling takes place by means of a separate PID parameter set (Retain.CtrlParams.Cool structure). This method is suitable if the heating and cooling actuators have different time responses and different gains. Tuning for heating and cooling is available if this method is selected. Config.AdvancedCooling only takes effect if the heating output and cooling output are activated (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE).

Tag	Data type	Default	Description
Config.CoolFactor(1)	REAL	1.0	Cooling factor If Config.AdvancedCooling = FALSE, Config.CoolFactor is considered as factor in the calculation of the output value for cooling. This allows different gains of heating and cooling actuators to be taken into account. Config.CoolFactor is not set automatically or adjusted during tuning. You must correctly configure Config.CoolFactor manually with the ratio "heating actuator gain/cooling actuator gain". Example: Config.CoolFactor = 2.0 means that the gain of the heating actuator is twice as high as the gain of the cooling actuator. Config.CoolFactor only takes effect if the heating output and cooling output are activated (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE) and cooling factor is selected as method for heating/cooling (Config.AdvancedCooling = FALSE). Config.CoolFactor > 0.0
Config.InputScaling.UpperPointIn(1)	REAL	27648.0	Scaling Input_PER high Input_PER is scaled based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn. Only takes effect if Input_PER is used for process value acquisition (Config.InputPerOn = TRUE). UpperPointIn > LowerPointIn
Config.InputScaling.LowerPointIn(1)	REAL	0.0	Scaling Input_PER low Input_PER is scaled based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn. Only takes effect if Input_PER is used for process value acquisition (Config.InputPerOn = TRUE). LowerPointIn < UpperPointIn
Config.InputScaling.UpperPointOut (1)	REAL	100.0	Scaled high process value Input_PER is scaled based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn. Only takes effect if Input_PER is used for process value acquisition (Config.InputPerOn = TRUE). UpperPointOut > LowerPointOut
Config.InputScaling.LowerPointOut (1)	REAL	0.0	Scaled low process value Input_PER is scaled based on the two value pairs UpperPointOut, UpperPointIn and LowerPointOut, LowerPointIn. Only takes effect if Input_PER is used for process value acquisition (Config.InputPerOn = TRUE). LowerPointOut < UpperPointOut

Tag	Data type	Default	Description
Config.Output.Heat.Select(1)	INT	1	Selecting the output value for heating Config.Output.Heat.Select specifies which outputs are used for heating: • Heat.Select = 0 - OutputHeat is used • Heat.Select = 1 - OutputHeat and OutputHeat_PWM are used • Heat.Select = 2 - OutputHeat and OutputHeat_PER are used Outputs that are not used are not calculated and remain at their default value. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE).
Config.Output.Heat.PwmPeriode(1)	REAL	0.0	Period duration of the pulse width modulation (PWM) for heating (OutputHeat_PWM output) in seconds: • Heat.PwmPeriode = 0.0 The sampling time of the PID algorithm for heating (Retain.CtrlParams.Heat.Cycle) is used as period duration of the PWM. • Heat.PwmPeriode > 0.0 The value is rounded off to an integer multiple of the PID_Temp sampling time (CycleTime.Value) and used as period duration of the PWM. This setting can be used to improve the smoothing of the process value with a long sampling time of the PID algorithm. The value must meet the following conditions: – Heat.PwmPeriode ≤ Retain.CtrlParams.Heat.Cycle, – Heat.PwmPeriode > Config.Output.Heat.MinimumOnTime – Heat.PwmPeriode > Config.Output.Heat.MinimumOffTime Heat.PwmPeriode only takes effect if the heating output is activated (Config.ActivateHeating = TRUE) and OutputHeat_PWM is selected as output for heating (Heat.Select = 1). See also PwmPeriode tag (Page 422).
Config.Output.Heat.PidUpperLimit	REAL	100.0	PID output value high limit for heating For controllers with activated heating output (Config.ActivateHeating = TRUE), the PID output value (PidOutputSum) is restricted to this high limit. Heat.PidUpperLimit forms a value pair together with the following parameters for scaling of the PID output value (PidOutputSum) to the outputs for heating: • Heat.UpperScaling for OutputHeat • Heat.PwmUpperScaling for OutputHeat_PWM • Heat.PerUpperScaling for OutputHeat_PER If you want to limit the value at the associated output, you must also adjust these scaling values. As of Version 2.0, PID_Temp supports the change of the output value limits in automatic mode. Up to Version 1.1, these may only be changed in the inactive or manual modes. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE). Heat.PidUpperLimit > Heat.PidLowerLimit

Tag	Data type	Default	Description
Config.Output.Heat.PidLowerLimit	REAL	0.0	PID output value low limit for heating For controllers with activated heating output (Config.ActivateHeating = TRUE) and deactivated cooling output (Config.ActivateCooling = FALSE), the PID output value (PidOutputSum) is restricted to this low limit. For controllers with activated heating output (Config.ActivateHeating = TRUE) and activated cooling output (Config.ActivateCooling = TRUE), the value must be 0.0. Heat.PidLowerLimit forms a value pair together with the following parameters for scaling of the PID output value (PidOutputSum) to the outputs for heating: • Heat.LowerScaling for OutputHeat • Heat.PwmLowerScaling for OutputHeat_PWM • Heat.PerLowerScaling for OutputHeat_PER If you want to limit the value at the associated output, you must also adjust these scaling values. As of Version 2.0, PID_Temp supports the change of the output value limits in automatic mode. Up to Version 1.1, these may only be changed in the inactive or manual modes. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE). The permitted value range is determined by the configuration. • Heating output activated and cooling output deactivated (Config.ActivateHeating = TRUE, Config.ActivateCooling = FALSE): Heat.PidLowerLimit < Heat.PidUpperLimit • Heating output and cooling output activated (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE): Heat.PidLowerLimit = 0.0
Config.Output.Heat.UpperScaling	REAL	100.0	Scaled high output value for heating Heat.UpperScaling and Heat.PidUpperLimit form a value pair for scaling of the PID output value (PidOutputSum) to the output value for heating (OutputHeat). The OutputHeat value is always located between Heat.UpperScaling and Heat.LowerScaling. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE). Heat.UpperScaling ≠ Heat.LowerScaling
Config.Output.Heat.LowerScaling	REAL	0.0	Scaled low output value for heating Heat.LowerScaling and Heat.PidLowerLimit form a value pair for scaling of the PID output value (PidOutputSum) to the output value for heating (OutputHeat). The OutputHeat value is always located between Heat.UpperScaling and Heat.LowerScaling. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE). Heat.UpperScaling ≠ Heat.LowerScaling

Tag	Data type	Default	Description
Config.Output.Heat.PwmUpperScaling	REAL	100.0	Scaled high PWM output value for heating Heat.PwmUpperScaling and Heat.PidUpperLimit form a value pair for scaling of the PID output value (PidOutputSum) to the pulse-width modulated output for heating (OutputHeat_PWM). The OutputHeat_PWM value is always located between Heat.PwmUpperScaling and Heat.PWMLowerScaling. Heat.PwmUpperScaling only takes effect if the heating output is activated (Config.ActivateHeating = TRUE) and OutputHeat_PWM is selected as output for heating (Heat.Select = 1). 100.0 ≥ Heat.PwmUpperScaling ≥ 0.0 Heat.PwmUpperScaling ≠ Heat.PwmLowerScaling
Config.Output.Heat.PwmLowerScaling	REAL	0.0	Scaled low PWM output value for heating Heat.PwmLowerScaling and Heat.PidLowerLimit form a value pair for scaling of the PID output value (PidOutputSum) to the pulse-width modulated output for heating (OutputHeat_PWM). The OutputHeat_PWM value is always located between Heat.PwmUpperScaling and Heat.PwmLowerScaling. Heat.PwmLowerScaling only takes effect if the heating output is activated (Config.ActivateHeating = TRUE) and OutputHeat_PWM is selected as output for heating (Heat.Select = 1). 100.0 ≥ Heat.PwmLowerScaling ≥ 0.0 Heat.PwmUpperScaling ≠ Heat.PwmLowerScaling
Config.Output.Heat.PerUpperScaling	REAL	27648.0	Scaled high analog output value for heating Heat.PerUpperScaling and Heat.PidUpperLimit form a value pair for scaling of the PID output value (PidOutputSum) to the analog output value for heating (OutputHeat_PER). The OutputHeat_PER value is always located between Heat.PerUpperScaling and Heat.PerLowerScaling. Heat.PerUpperScaling only takes effect if the heating output is activated (Config.ActivateHeating = TRUE) and OutputHeat_PER is selected as output for heating (Heat.Select = 2). 32511.0 ≥ Heat.PerUpperScaling ≥ -32512.0 Heat.PerUpperScaling ≠ Heat.PerLowerScaling
Config.Output.Heat.PerLowerScaling	REAL	0.0	Scaled low analog output value for heating Heat.PerLowerScaling and Heat.PidLowerLimit form a value pair for scaling of the PID output value (PidOutputSum) to the analog output value for heating (OutputHeat_PER). The OutputHeat_PER value is always located between Heat.PerUpperScaling and Heat.PerLowerScaling. Heat.PerLowerScaling only takes effect if the heating output is activated (Config.ActivateHeating = TRUE) and OutputHeat_PER is selected as output for heating (Heat.Select = 2). 32511.0 ≥ Heat.PerLowerScaling ≥ -32512.0 Heat.PerUpperScaling ≠ Heat.PerLowerScaling

Tag	Data type	Default	Description
Config.Output.Heat.MinimumOn-Time(1)	REAL	0.0	Minimum on time of the pulse width modulation for heating (OutputHeat_PWM output) A PWM pulse is never shorter than this value. The value is rounded off to: Heat.MinimumOnTime = n × CycleTime.Value Heat.MinimumOnTime only takes effect if the heating output is activated (Config.ActivateHeating = TRUE) and OutputHeat_PWM is selected as output for heating (Heat.Select = 1). 100000.0 ≥ Heat.MinimumOnTime ≥ 0.0
Config.Output.Heat.MinimumOff-Time(1)	REAL	0.0	Minimum off time of the pulse width modulation for heating (OutputHeat_PWM output) A PWM pause is never shorter than this value. The value is rounded off to: Heat.MinimumOffTime = n × CycleTime.Value Heat.MinimumOffTime only takes effect if the heating output is activated (Config.ActivateHeating = TRUE) and OutputHeat_PWM is selected as output for heating (Heat.Select = 1). 100000.0 ≥ Heat.MinimumOffTime ≥ 0.0
Config.Output.Cool.Select(1)	INT	1	Selecting the output value for cooling Config.Output.Cool.Select specifies which outputs are used for cooling: • Cool.Select = 0 - OutputCool is used • Cool.Select = 1 - OutputCool and OutputCool_PWM are used • Cool.Select = 2 - OutputCool and OutputCool_PER are used Outputs that are not used are not calculated and remain at their default value. Only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE).

Tag	Data type	Default	Description
Config.Output.Cool.PwmPeriode(1)	REAL	0.0	Period duration of the pulse width modulation for cooling (OutputCool_PWM output) in seconds: • Cool.PwmPeriode = 0.0, Config.ActivateHeating = TRUE and Config.AdvancedCooling = FALSE: The sampling time of the PID algorithm for heating (Retain.CtrlParams.Heat.Cycle) is used as period duration of the PWM. • Cool.PwmPeriode = 0.0 and Config.ActivateHeating = FALSE or Cool.PwmPeriode = 0.0 and Config.AdvancedCooling = TRUE: The sampling time of the PID algorithm for cooling (Retain.CtrlParams.Cool.Cycle) is used as period duration of the PWM. • Cool.PwmPeriode > 0.0: The value is rounded off to an integer multiple of the PID_Temp sampling time (CycleTime.Value) and used as period duration of the PWM. This setting can be used to improve the smoothing of the process value with a long sampling time of the PID algorithm. The value must meet the following conditions: – Cool.PwmPeriode ≤ Retain.CtrlParams.Cool.Cycle or Retain.CtrlParams.Heat.Cycle – Cool.PwmPeriode > Config.Output.Cool.MinimumOnTime – Cool.PwmPeriode > Config.Output.Cool.MinimumOffTime Only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE) and OutputCool_PWM is selected as output for cooling (Cool.Select = 1). See also PwmPeriode tag (Page 419).
Config.Output.Cool.PidUpperLimit	REAL	0.0	PID output value high limit for cooling For controllers with activated heating output and cooling output (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE), the value must be 0.0. For controllers with deactivated heating output (Config.ActivateHeating = FALSE) and activated cooling output (Config.ActivateCooling = TRUE), the PID output value (PidOutputSum) is restricted to this high limit. Cool.PidUpperLimit forms a value pair together with the following parameters for scaling of the PID output value (PidOutputSum) to the outputs for cooling: • Cool.LowerScaling for OutputCool • Cool.PwmLowerScaling for OutputCool_PWM • Cool.PerLowerScaling for OutputCool_PER If you want to limit the value at the associated output, you must also adjust these scaling values. As of Version 2.0, PID_Temp supports the change of the output value limits in automatic mode. Up to Version 1.1, these may only be changed in the inactive or manual modes. Only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE).

Tag	Data type	Default	Description
			The permitted value range is determined by the configuration. • Heating output and cooling output activated (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE): Cool.PidUpperLimit = 0.0 • Heating output deactivated and cooling output activated (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE): Cool.PidUpperLimit > Cool.PidLowerLimit
Config.Output.Cool.PidLowerLimit	REAL	-100.0	PID output value low limit for cooling For controllers with activated cooling output (Config.ActivateCooling = TRUE), the PID output value (PidOutputSum) is restricted to this low limit. Cool.PidLowerLimit forms a value pair together with the following parameters for scaling of the PID output value (PidOutputSum) to the outputs for cooling: • Cool.UpperScaling for OutputCool • Cool.PwmUpperScaling for OutputCool_PWM • Cool.PerUpperScaling for OutputCool_PER If you want to limit the value at the associated output, you must also adjust these scaling values. As of Version 2.0, PID_Temp supports the change of the output value limits in automatic mode. Up to Version 1.1, these may only be changed in the inactive or manual modes. Only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE). Cool.PidLowerLimit < Cool.PidUpperLimit
Config.Output.Cool.UpperScaling	REAL	100.0	Scaled high output value for cooling Cool.UpperScaling and Cool.PidLowerLimit form a value pair for scaling of the PID output value (PidOutputSum) to the output value for cooling (OutputCool). The OutputCool value is always located between Cool.UpperScaling and Cool.LowerScaling. Only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE). Cool.UpperScaling ≠ Cool.LowerScaling
Config.Output.Cool.LowerScaling	REAL	0.0	Scaled low output value for cooling Cool.LowerScaling and Cool.PidUpperLimit form a value pair for scaling of the PID output value (PidOutputSum) to the output value for cooling (OutputCool). The OutputCool value is always located between Cool.UpperScaling and Cool.LowerScaling. Only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE). Cool.UpperScaling ≠ Cool.LowerScaling
Config.Output.Cool.PwmUpperScaling	REAL	100.0	Scaled high PWM output value for cooling Cool.PwmUpperScaling and Cool.PidLowerLimit form a value pair for scaling of the PID output value (PidOutputSum) to the pulse-width modulated output for cooling (OutputCool_PWM). The OutputCool_PWM value is always located between Cool.PwmUpperScaling and Cool.PwmLowerScaling. Cool.PwmUpperScaling only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE) and

Tag	Data type	Default	Description
			OutputCool_PWM is selected as output for cooling (Cool.Select = 1). 100.0 ≥ Cool.PwmUpperScaling ≥ 0.0 Cool.PwmUpperScaling ≠ Cool.PwmLowerScaling
Config.Output.Cool.PwmLowerScaling	REAL	0.0	Scaled low PWM output value for cooling Cool.PwmLowerScaling and Cool.PidUpperLimit form a value pair for scaling of the PID output value (PidOutputSum) to the pulse-width modulated output for cooling (OutputCool_PWM). The OutputCool_PWM value is always located between Cool.PwmUpperScaling and CoolPwm.LowerScaling. Cool.PwmLowerScaling only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE) and OutputCool_PWM is selected as output for cooling (Cool.Select = 1). 100.0 ≥ Cool.PwmLowerScaling ≥ 0.0 Cool.PwmUpperScaling ≠ Cool.PwmLowerScaling
Config.Output.Cool.PerUpperScaling	REAL	27648.0	Scaled high analog output value for cooling Cool.PerUpperScaling and Cool.PidLowerLimit form a value pair for scaling of the PID output value (PidOutputSum) to the analog output value for cooling (OutputCool_PER). The OutputCool_PER value is always located between Cool.PerUpperScaling and Cool.PerLowerScaling. Cool.PerUpperScaling only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE) and OutputCool_PER is selected as output for cooling (Cool.Select = 2). 32511.0 ≥ Cool.PerUpperScaling ≥ -32512.0 Cool.PerUpperScaling ≠ Cool.PerLowerScaling
Config.Output.Cool.PerLowerScaling	REAL	0.0	Scaled low analog output value for cooling Cool.PerLowerScaling and Cool.PidUpperLimit form a value pair for scaling of the PID output value (PidOutputSum) to the analog output value for cooling (OutputCool_PER). The OutputCool_PER value is always located between Cool.PerUpperScaling and Cool.PerLowerScaling. Cool.PerLowerScaling only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE) and OutputCool_PER is selected as output for cooling (Cool.Select = 2). 32511.0 ≥ Cool.PerLowerScaling ≥ -32512.0 Cool.PerUpperScaling ≠ Cool.PerLowerScaling
Config.Output.Cool.MinimumOnTime(1)	REAL	0.0	Minimum on time of the pulse width modulation for cooling (OutputCool_PWM output) A PWM pulse is never shorter than this value. The value is rounded off to: Cool.MinimumOnTime = n × CycleTime.Value Cool.MinimumOnTime only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE) and OutputCool_PWM is selected as output for cooling (Cool.Select = 1). 100000.0 ≥ Cool.MinimumOnTime ≥ 0.0

Tag	Data type	Default	Description
Config.Output.Cool.MinimumOff-Time(1)	REAL	0.0	Minimum off time of the pulse width modulation for cooling (OutputCool_PWM output) A PWM pause is never shorter than this value. The value is rounded off to: Cool.MinimumOffTime = n × CycleTime.Value Cool.MinimumOffTime only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE) and OutputCool_PWM is selected as output for cooling (Cool.Select = 1). 100000.0 ≥ Cool.MinimumOffTime ≥ 0.0
If you are using PID_Temp in a cascade (Page 188), the master controller and slave controller exchange information via the Master and Slave parameters. You need to make the interconnection. For details, see the Master parameter.			
Config.Cascade.IsMaster(1)	BOOL	FALSE	The controller is master in a cascade and provides the slave setpoint. Set IsMaster = TRUE if you are using this PID_Temp instance as master controller in a cascade. A master controller defines the setpoint of a slave controller with its output. A PID_Temp instance can be master controller and slave controller at the same time. If the controller is used as a master controller, only the heating output (Config.ActivateHeating = TRUE, Config.ActivateCooling = FALSE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) may be activated.
Config.Cascade.IsSlave(1)	BOOL	FALSE	The controller is slave in a cascade and receives its setpoint from the master. Set IsSlave = TRUE if you are using this PID_Temp instance as slave controller in a cascade. A slave controller receives its setpoint (Setpoint parameter) from the output of its master controller (OutputHeat or OutputCool parameter). A PID_Temp instance can be master controller and slave controller at the same time.
Config.Cascade.AntiWindUpMode(1)	INT	1	Anti-Windup behavior in the cascade Options are: • AntiWindUpMode = 0 The anti-windup functionality is deactivated. The master controller does not respond to the limit of its slave controllers. • AntiWindUpMode = 1 The integral action of the master controller is reduced in the ratio "Slaves in limit" to "Number of slaves" ("CountSlaves" parameter). This reduces the effects of the limitation on the control behavior. • AntiWindUpMode = 2 The integral action of the master controller is held as soon as a slave controller is in the limit. Only takes effect if the controller is configured as master controller (Config.Cascade.IsMaster = TRUE).

Tag	Data type	Default	Description
Config.Cascade.CountSlaves(1)	INT	1	Number of subordinate slaves Here you enter the number of directly subordinate slave controllers which receive their setpoint from this master controller. Only takes effect if the controller is configured as master controller (Config.Cascade.IsMaster = TRUE). 255 ≥ CountSlaves ≥ 1
CycleTime.StartEstimation	BOOL	TRUE	If CycleTime.EnEstimation = TRUE, CycleTime.StartEstimation = TRUE starts automatic determination of the PID_Temp sampling time (cycle time of the calling OB). CycleTime.StartEstimation = FALSE is set once measurement is complete.
CycleTime.EnEstimation	BOOL	TRUE	If CycleTime.EnEstimation = TRUE, the PID_Temp sampling time is determined automatically. If CycleTime.EnEstimation = FALSE, the sampling time PID_Temp is not determined automatically and must be configured correctly manually with CycleTime.Value.
CycleTime.EnMonitoring	BOOL	TRUE	If CycleTime.EnMonitoring = FALSE, the PID_Temp sampling time is not monitored. If PID_Temp cannot be executed within the sampling time, no error (ErrorBits = 16#0000_0800) is output and PID_Temp does not respond as configured with ActivateRecoverMode.
CycleTime.Value(1)	REAL	0.1	PID_Temp sampling time (cycle time of the calling OB) in seconds CycleTime.Value is determined automatically and is usually equivalent to the cycle time of the calling OB.
You can reload values from the CtrlParamsBackUp structure with LoadBackUp = TRUE.			
CtrlParamsBackUp.SetByUser	BOOL	FALSE	Saved value of Retain.CtrlParams.SetByUser
CtrlParamsBackUp.Heat.Gain	REAL	1.0	Saved proportional gain for heating
CtrlParamsBackUp.Heat.Ti	REAL	20.0	Saved integration time for heating in seconds
CtrlParamsBackUp.Heat.Td	REAL	0.0	Saved derivative action time for heating in seconds
CtrlParamsBackUp.Heat.TdFiltRatio	REAL	0.2	Saved derivative delay coefficient for heating
CtrlParamsBackUp.Heat.PWeighting	REAL	1.0	Saved weighting of the proportional action for heating
CtrlParamsBackUp.Heat.DWeighting	REAL	1.0	Saved weighting of the derivative action for heating
CtrlParamsBackUp.Heat.Cycle	REAL	1.0	Saved sampling time of the PID algorithm for heating in seconds
CtrlParamsBackUp.Heat.ControlZone	REAL	3.402822e+-38	Saved control zone width for heating
CtrlParamsBackUp.Heat.DeadZone	REAL	0.0	Saved dead zone width for heating
CtrlParamsBackUp.Cool.Gain	REAL	1.0	Saved proportional gain for cooling
CtrlParamsBackUp.Cool.Ti	REAL	20.0	Saved integration time for cooling in seconds
CtrlParamsBackUp.Cool.Td	REAL	0.0	Saved derivative action time for cooling in seconds
CtrlParamsBackUp.Cool.TdFiltRatio	REAL	0.2	Saved derivative delay coefficient for cooling
CtrlParamsBackUp.Cool.PWeighting	REAL	1.0	Saved proportional action weighting factor for cooling
CtrlParamsBackUp.Cool.DWeighting	REAL	1.0	Saved derivative action weighting factor for cooling
CtrlParamsBackUp.Cool.Cycle	REAL	1.0	Saved sampling time of the PID algorithm for cooling in seconds

Tag	Data type	Default	Description
CtrlParamsBackUp.Cool.ControlZone	REAL	3.402822e+-38	Saved control zone width for cooling
CtrlParamsBackUp.Cool.DeadZone	REAL	0.0	Saved dead zone width for cooling
PIDSelfTune.SUT.CalculateParamsHeat	BOOL	FALSE	The properties of the heating branch of the controlled system are saved during pretuning for heating. If SUT.CalculateParamsHeat = TRUE, the PID parameters for heating (Retain.CtrlParams.Heat structure) are recalculated on the basis of these properties. This enables you to change the parameter calculation method (PIDSelfTune.SUT.TuneRuleHeat parameter) and recalculate the PID parameters, without having to repeat the tuning. SUT.CalculateParamsHeat is set to FALSE after the calculation. Only possible if the pretuning was successful (SUT.ProcParHeatOk = TRUE).
PIDSelfTune.SUT.CalculateParamsCool	BOOL	FALSE	The properties of the cooling branch of the controlled system are saved during tuning for cooling. If SUT.CalculateParamsCool = TRUE, the PID parameters for cooling (Retain.CtrlParams.Cool structure) are recalculated on the basis of these properties. This enables you to change the parameter calculation method (PIDSelfTune.SUT.TuneRuleCool parameter) and recalculate the PID parameters, without having to repeat the tuning. SUT.CalculateParamsCool is set to FALSE after the calculation. Only possible if the pretuning was successful (SUT.ProcParCoolOk = TRUE). Only takes effect when the heating output and the cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated.
PIDSelfTune.SUT.TuneRuleHeat	INT	2	Method for PID parameter calculation with pretuning for heating Options are: • SUT.TuneRuleHeat = 0: PID according to CHR • SUT.TuneRuleHeat = 1: PI according to CHR • SUT.TuneRuleHeat = 2: PID for temperature processes according to CHR (results in a slower and rather asymptomatic control response with lower overshoot than SUT.TuneRuleHeat = 0) (CHR = Chien, Hrones and Reswick) Only with SUT.TuneRuleHeat = 2 is the control zone Retain.CtrlParams.Heat.ControlZone automatically set during pretuning for heating.
PIDSelfTune.SUT.TuneRuleCool	INT	2	Method for PID parameter calculation with pretuning for cooling Options are: • SUT.TuneRuleCool = 0: PID according to CHR • SUT.TuneRuleCool = 1: PI according to CHR • SUT.TuneRuleCool = 2: PID for temperature processes according to CHR (results in a slower and rather asymptomatic control response with lower overshoot than SUT.TuneRuleCool = 0)

Tag	Data type	Default	Description
			(CHR = Chien, Hrones and Reswick) Only with SUT.TuneRuleCool = 2 is the control zone Retain.CtrlParams.Cool.ControlZone automatically set during pretuning for cooling. Only takes effect when the heating output and the cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated.
PIDSelfTune.SUT.State	INT	0	The SUT.State tag indicates the current phase of pretuning: • State = 0: Initialize pretuning • State = 100: Calculate standard deviation for heating • State = 200: Calculate standard deviation for cooling • State = 250: Calculate standard deviation for cooling • State = 300: Determine point of inflection for heating • State = 400: Determine point of inflection for cooling • State = 450: Determine point of inflection for cooling • State = 500: Heat to setpoint after point of inflection for heating • State = 600: Heat to setpoint after point of inflection for cooling • State = 700: Compare efficiency of the heating actuator and cooling actuator • State = 800: Heating and cooling activated • State = 900: Cooling activated • State = 1000: Determine delay time after switch-off of heating. • State = 1100: Cool to setpoint after point of inflection for cooling • State = 1200: Determine delay time after switch-off of cooling. • State = 9900: Pretuning successful • State = 1: Pretuning not successful
PIDSelfTune.SUT.ProcParHeatOk	BOOL	FALSE	TRUE: The calculation of the process parameters for pretuning heating was successful. The PID parameters can be recalculated with PIDSelfTune.SUT.CalculateParamsHeat = TRUE. FALSE: No pretuning for heating has been performed or the calculation of the process parameters has failed. The PID parameters can only be recalculated after successful tuning. PID_Temp sets this tag automatically during tuning.
PIDSelfTune.SUT.ProcParCoolOk	BOOL	FALSE	TRUE: The calculation of the process parameters for pretuning cooling was successful. The PID parameters can be recalculated with PIDSelfTune.SUT.CalculateParamsCool = TRUE. FALSE: No pretuning for cooling has been performed or the calculation of the process parameters has failed. The PID parameters can only be recalculated after successful tuning. PID_Temp sets this tag automatically during tuning.

Tag	Data type	Default	Description
PIDSelfTune.SUT.AdaptDelayTime	INT	0	The AdaptDelayTime tag determines the adjustment of the delay time at the operating point (only for pretuning that is started with a distance between the setpoint and process value). Options are: • SUT.AdaptDelayTime = 0: No adaptation of delay time. The phase SUT.State = 1000 or SUT.State = 1200 is skipped. This option results in a shorter tuning time than with SUT.AdaptDelayTime = 1. • SUT.AdaptDelayTime = 1: Adaptation of the delay time to the setpoint in phase SUT.State = 1000 or SUT.State = 1200 by temporarily switching off the heating or cooling. This option results in a longer tuning time than withSUT.AdaptDelayTime = 0. It can improve the control response if the process behavior depends significantly on the operating point (non-linearity). This option should not be used for multi-zone applications with strong thermal connections.
PIDSelfTune.SUT.CoolingMode	INT	0	The CoolingMode tag determines the manipulated variable output to determine the cooling parameters for pretuning heating and cooling. Options are: • SUT.CoolingMode = 0: Switch off heating and switch on cooling after reaching the setpoint. The SUT.State = 700 phase is skipped. Phase SUT.State = 500 is followed by phase SUT.State = 900. This option can improve the control response if the gain of the cooling actuator is low compared to the gain of the heating actuator. It results in a shorter tuning time than with SUT.CoolingMode = 1 or 2. • SUT.CoolingMode = 1: Switch on cooling in addition to heating after reaching the setpoint. The SUT.State = 700 phase is skipped. Phase SUT.State = 500 is followed by phase SUT.State = 800. This option can improve the control response if the gain of the cooling actuator is high compared to the gain of the heating actuator. • SUT.CoolingMode = 2: After heating up to the setpoint, a decision is automatically made in phase SUT.State = 700 as to whether heating is switched off. Phase SUT.State = 500 is followed by phase SUT.State = 700 and then SUT.State = 800 or SUT.State = 900. This option requires more time than options 0 and 1.

Tag	Data type	Default	Description
PIDSelfTune.TIR.RunIn	BOOL	FALSE	Use the RunIn tag to specify the sequence of fine tuning during start from automatic mode. • RunIn = FALSE If fine tuning is started from automatic mode, the system uses the existing PID parameters to control to the setpoint (TIR.State = 500 or 600). Only then will fine tuning start. • RunIn = TRUE PID_Temp tries to reach the setpoint with minimum or maximum output value (TIR.State = 300 or 400). This can produce increased overshoot. Fine tuning then starts automatically. RunIn is set to FALSE after fine tuning. When fine tuning starts from inactive or manual mode, PID_Temp reacts as described under RunIn = TRUE.
PIDSelfTune.TIR.CalculateParamsHeat	BOOL	FALSE	The properties of the heating branch of the controlled system are saved during fine tuning for heating. If TIR.CalculateParamsHeat = TRUE, the PID parameters for heating (Retain.CtrlParams.Heat structure) are recalculated on the basis of these properties. This enables you to change the parameter calculation method (PIDSelfTune.TIR.TuneRuleHeat parameter) and recalculate the PID parameters, without having to repeat the tuning. TIR.CalculateParamsHeat is set to FALSE after the calculation. Only possible if fine tuning heating was successful beforehand (TIR.ProcParHeatOk = TRUE).
PIDSelfTune.TIR.CalculateParamsCool	BOOL	FALSE	The properties of the cooling branch of the controlled system are saved during fine tuning for cooling. If TIR.CalculateParamsCool = TRUE, the PID parameters for cooling (Retain.CtrlParams.Cool structure) are recalculated on the basis of these properties. This enables you to change the parameter calculation method (PIDSelfTune.TIR.TuneRuleCool parameter) and recalculate the PID parameters, without having to repeat the tuning. TIR.CalculateParamsCool is set to FALSE after the calculation. Only possible if fine tuning cooling was successful beforehand (TIR.ProcParCoolOk = TRUE). Only takes effect when the heating output and the cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated.
PIDSelfTune.TIR.TuneRuleHeat	INT	0	Method for parameter calculation during fine tuning for heating

Tag	Data type	Default	Description
			Options are: • TIR.TuneRuleHeat = 0: PID automatic • TIR.TuneRuleHeat = 1: PID fast (faster control response with higher amplitudes of the output value than with TIR.TuneRuleHeat = 2) • TIR.TuneRuleHeat = 2: PID slow (slower control response with lower amplitudes of the output value than with TIR.TuneRuleHeat = 1) • TIR.TuneRuleHeat = 3: ZN PID • TIR.TuneRuleHeat = 4: ZN PI • TIR.TuneRuleHeat = 5: ZN P (ZN=Ziegler-Nichols) To be able to repeat the calculation of the PID parameters for heating with TIR.CalculateParamsHeat and TIR.TuneRuleHeat = 0, 1 or 2, the previous fine tuning also has to have been executed with TIR.TuneRuleHeat = 0, 1 or 2. If this is not the case, TIR.TuneRuleHeat = 3 is used. The recalculation of the PID parameters for heating with TIR.CalculateParamsHeat and TIR.TuneRuleHeat = 3, 4 or 5 is always possible.
PIDSelfTune.TIR.TuneRuleCool	INT	0	Method for parameter calculation during fine tuning for cooling Options are: • TIR.TuneRuleCool = 0: PID automatic • TIR.TuneRuleCool = 1: PID fast (faster control response with higher amplitudes of the output value than with TIR.TuneRuleCool = 2) • TIR.TuneRuleCool = 2: PID slow (slower control response with lower amplitudes of the output value than with TIR.TuneRuleCool = 1) • TIR.TuneRuleCool = 3: ZN PID • TIR.TuneRuleCool = 4: ZN PI • TIR.TuneRuleCool = 5: ZN P (ZN=Ziegler-Nichols) To be able to repeat the calculation of the PID parameters for cooling with TIR.CalculateParamsCool and TIR.TuneRuleCool = 0, 1 or 2, the previous fine tuning also has to have been executed with TIR.TuneRuleCool = 0, 1 or 2. If this is not the case, TIR.TuneRuleCool = 3 is used. The recalculation of the PID parameters for cooling with TIR.CalculateParamsCool and TIR.TuneRuleCool = 3, 4 or 5 is always possible. Only takes effect when the heating output and the cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated.

Tag	Data type	Default	Description
PIDSelfTune.TIR.State	INT	0	The TIR.State tag indicates the current phase of "fine tuning": • State = 0: Initialize fine tuning • State = 100: Calculate standard deviation for heating • State = 200: Calculate standard deviation for cooling • State = 300: Attempting to reach setpoint for heating with two-step control using heating • State = 400: Attempting to reach setpoint for cooling with two-step control using cooling • State = 500: Attempting to reach setpoint for heating with PID control • State = 600: Attempting to reach setpoint for cooling with PID control • State = 700: Calculate standard deviation for heating • State = 800: Calculate standard deviation for cooling • State = 900: Determine oscillation and calculate parameters for heating • State = 1000: Determine oscillation and calculate parameters for cooling • State = 9900: Fine tuning successful • State = 1: Fine tuning not successful If the fine tuning of a heating/cooling controller (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE) stops for a longer period of time at TIR.State = 900 or 1000 and Progress = 1.0 without change, note the information about the tuning offset under PID_Temp state and mode parameters (Page 410)
PIDSelfTune.TIR.ProcParHeatOk	BOOL	FALSE	TRUE: The calculation of the process parameters for fine tuning heating was successful. The PID parameters can be recalculated with PIDSelfTune.TIR.CalculateParamsHeat = TRUE. FALSE: No fine tuning for heating has been performed or the calculation of the process parameters has failed. The PID parameters can only be recalculated after successful tuning. PID_Temp sets this tag automatically during tuning.
PIDSelfTune.TIR.ProcParCoolOk	BOOL	FALSE	TRUE: The calculation of the process parameters for fine tuning cooling was successful. The PID parameters can be recalculated with PIDSelfTune.TIR.CalculateParamsCool = TRUE. FALSE: No fine tuning for cooling has been performed or the calculation of the process parameters has failed. The PID parameters can only be recalculated after successful tuning. PID_Temp sets this tag automatically during tuning.
PIDSelfTune.TIR.OutputOffsetHeat	REAL	0.0	Tuning offset heating of the PID output value TIR.OutputOffsetHeat is added to the value that results from PidOutputSum for the heating branch. To receive a positive offset at the outputs for heating, define a positive value for TIR.OutputOffsetHeat. The resulting values at the outputs for heating are the result of the configured output scaling (Config.Output.Heat structure). This tuning offset can be used in controllers with activated heating and cooling output and PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) for fine tuning cooling. If the outputs for cooling are not active at the setpoint that is to be tuned (PidOutputSum > 0.0), fine tuning cooling is not possible. In this case, enter a positive tuning offset heating which

Tag	Data type	Default	Description
			is higher than the PID output value (PidOutputSum) at the setpoint in the steady state before you start tuning. This step increases the values at the outputs for heating and activates the outputs for cooling (PidOutputSum < 0.0). Fine tuning cooling is now possible. When fine tuning is complete, TIR.OutputOffsetHeat is reset to 0.0. Major changes at TIR.OutputOffsetHeat in one step can result in temporary overshoots. Config.Output.Heat.PidUpperLimit ≥ PIDSelfTune.TIR.OutputOffsetHeat ≥ Config.Output.Heat.PidLowerLimit
PIDSelfTune.TIR.OutputOffsetCool	REAL	0.0	Tuning offset cooling of the PID output value TIR.OutputOffsetCool is added to the value that results from PidOutputSum for the cooling branch. To receive a positive offset at the outputs for cooling, define a negative value for TIR.OutputOffsetCool. The resulting values at the outputs for cooling are the result of the configured output scaling (Config.Output.Cool structure). This tuning offset can be used in controllers with activated heating and cooling output (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE) for fine tuning heating. If the outputs for heating are not active at the setpoint that is to be tuned (PidOutputSum < 0.0), fine tuning heating is not possible. In this case, enter a negative tuning offset cooling which is lower than the PID output value (PidOutputSum) at the setpoint in the steady state before you start tuning. This step increases the values at the outputs for cooling and activates the outputs for heating (PidOutputSum > 0.0). Fine tuning heating is now possible. When fine tuning is complete, TIR.OutputOffsetCool is reset to 0.0. Major changes at TIR.OutputOffsetCool in one step can result in temporary overshoots. Config.Output.Cool.PidUpperLimit ≥ PIDSelfTune.TIR.OutputOffsetCool ≥ Config.Output.Cool.PidLowerLimit
PIDSelfTune.TIR.WaitForControlIn	BOOL	FALSE	Waiting with fine tuning after reaching the setpoint If TIR.WaitForControlIn = TRUE, fine tuning waits in between reaching the setpoint (TIR.State = 500 or 600) and calculation of the standard deviation (TIR.State = 700 or 800) until a FALSE -> TRUE edge is given at TIR.FinishControlIn. TIR.WaitForControlIn can be used for simultaneous fine tuning of several controllers in multi-zone applications (Page 195) to synchronize tuning of the individual zones. It ensures that all zones have reached their setpoints before the actual tuning starts. The influence of thermal connections between the zones on tuning can be reduced in this way. TIR.WaitForControlIn only takes effect if fine tuning is started from automatic mode with PIDSelfTune.TIR.RunIn = FALSE.

Tag	Data type	Default	Description
PIDSelfTune.TIR.ControlInReady	BOOL	FALSE	If the setpoint is reached during fine tuning, PID_Temp sets TIR.ControlInReady = TRUE. If TIR.WaitForControlIn = TRUE has been set before, PID_Temp waits for additional tuning steps until an edge FALSE -> TRUE is given at TIR.FinishControlIn. If TIR.WaitForControlIn = FALSE, PID_Temp continues the tuning directly and TIR.ControlInReady is not relevant.
PIDSelfTune.TIR.FinishControlIn	BOOL	FALSE	If TIR.WaitForControlIn = TRUE and TIR.ControlInReady = TRUE, a FALSE -> TRUE edge at TIR.FinishControlIn stops the wait and fine tuning resumes.
PIDCtrl.PIDInit	BOOL	FALSE	PIDCtrl.PIDInit is available as of PID_Temp version 1.1. If PIDCtrl.PIDInit = TRUE in "Automatic mode", the integral action PIDCtrl.IOutputOld is preassigned automatically as if PidOutputSum = OverwriteInitialOutputValue in the previous cycle. This can be used for a Override control with PID_Temp (Page 198).
PIDCtrl.IntegralHoldPositive	BOOL	FALSE	Manual stop of the integral action in the positive direction PIDCtrl.IntegralHoldPositive is available as of PID_Temp Version 2.0.
PIDCtrl.IntegralHoldNegative	BOOL	FALSE	Manual stop of the integral action in the negative direction PIDCtrl.IntegralHoldNegative is available as of PID_Temp Version 2.0.
PIDCtrl.IOutputOld(1)	REAL	0.0	Integral action in last cycle
Retain.CtrlParams.SetByUser(1)	BOOL	FALSE	Enable manual input of PID parameters If Retain.CtrlParams.SetByUser = TRUE, the PID parameters are editable. Retain.CtrlParams.SetByUser is used for configuring the controller in the TIA Portal and has no influence on the behavior of the control algorithm in the CPU. SetByUser is retentive.
Retain.CtrlParams.Heat.Gain(1)	REAL	1.0	Active proportional gain for heating Heat.Gain is retentive. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE). Heat.Gain ≥ 0.0
Retain.CtrlParams.Heat.Ti(1)	REAL	20.0	Active integration time for heating in seconds The integral action for heating is switched off with Heat.CtrlParams.Ti = 0.0. Heat.Ti is retentive. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE). 100000.0 ≥ Heat.Ti ≥ 0.0
Retain.CtrlParams.Heat.Td(1)	REAL	0.0	Active derivative action time for heating in seconds The derivative action for heating is switched off with Heat.CtrlParams.Td = 0.0. Heat.Td is retentive. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE). 100000.0 ≥ Heat.Td ≥ 0.0
Retain.CtrlParams.Heat.TdFiltRatio(1)	REAL	0.2	Active derivative delay coefficient for heating

Tag	Data type	Default	Description
			The derivative delay coefficient delays the effect of the derivative action. Derivative delay = derivative action time × derivative delay coefficient • 0.0: Derivative action is effective for one cycle only and therefore almost not effective. • 0.5: This value has proved useful in practice for controlled systems with **one** dominant time constant. • > 1.0: The greater the coefficient, the longer the effect of the derivative action is delayed. Heat.TdFiltRatio is retentive. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE). Heat.TdFiltRatio ≥ 0.0
Retain.CtrlParams.Heat.PWeighting(1)	REAL	1.0	Active weighting of the proportional action for heating The proportional action may weaken with changes to the setpoint. Values from 0.0 to 1.0 are applicable. • 1.0: Proportional action for setpoint change is fully effective • 0.0: Proportional action for setpoint change is not effective The proportional action is always fully effective when the process value is changed. Heat.PWeighting is retentive. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE). 1.0 ≥ Heat.PWeighting ≥ 0.0
Retain.CtrlParams.Heat.DWeighting (1)	REAL	1.0	Active weighting of the derivative action for heating The derivative action may weaken with changes to the setpoint. Values from 0.0 to 1.0 are applicable. • 1.0: Derivative action is fully effective upon setpoint change • 0.0: Derivative action is not effective upon setpoint change The derivative action is always fully effective when the process value is changed. Heat.DWeighting is retentive. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE). 1.0 ≥ Heat.DWeighting ≥ 0.0
Retain.CtrlParams.Heat.Cycle(1)	REAL	1.0	Active sampling time of the PID algorithm for heating in seconds CtrlParams.Heat.Cycle is calculated during tuning and rounded to an integer multiple of CycleTime.Value. If Config.Output.Heat.PwmPeriode = 0.0, Heat.Cycle is also used as period duration of the pulse width modulation for heating. If Config.Output.Cool.PwmPeriode = 0.0 and Config.ActivateCooling = TRUE and Config.AdvancedCooling = FALSE, Heat.Cycle is also used as period duration of the pulse width modulation for cooling. Heat.Cycle is retentive. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE). 100000.0 ≥ Heat.Cycle > 0.0

Tag	Data type	Default	Description
Retain.CtrlParams.Heat.ControlZone (1)	REAL	3.402822e+-38	Active control zone width for heating The control zone for heating is switched off with Heat.ControlZone = 3.402822e+38. Heat.ControlZone is only set automatically during pretuning heating or pretuning heating and cooling if PIDSelfTune.SUT.TuneRuleHeat = 2 is selected as method of the parameter calculation. For controllers with activated heating output (Config.ActivateHeating = TRUE) and deactivated cooling output (Config.ActivateCooling = FALSE) or controllers with activated heating and cooling output and cooling factor (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = FALSE) the control zone is located symmetrically between Setpoint – Heat.ControlZone and Setpoint + Heat.ControlZone. For controllers with activated heating output and cooling output and PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE), the control zone is located between Setpoint – Heat.ControlZone and Setpoint + Cool.ControlZone. Heat.ControlZone is retentive. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE). Heat.ControlZone > 0.0
Retain.CtrlParams.Heat.DeadZone(1)	REAL	0.0	Active dead zone width for heating (see PID parameters (Page 170)) The dead zone for heating is switched off with Heat.DeadZone = 0.0. Heat.DeadZone is not set automatically or adjusted during tuning. You must correctly configure Heat.DeadZone manually. When the dead zone is switched on, the result can be a permanent control deviation (deviation between setpoint and process value). This can have a negative effect on fine tuning. For controllers with activated heating output (Config.ActivateHeating = TRUE) and deactivated cooling output (Config.ActivateCooling = FALSE) or controllers with activated heating and cooling output and cooling factor (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = FALSE), the dead zone is located symmetrically between Setpoint – Heat.DeadZone and Setpoint + Heat.DeadZone. For controllers with activated heating output and cooling output and PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE), the dead zone is located between Setpoint – Heat.DeadZone and Setpoint + Cool.DeadZone. Heat.DeadZone is retentive. Only takes effect if the heating output is activated (Config.ActivateHeating = TRUE). Heat.DeadZone ≥ 0.0

Tag	Data type	Default	Description
Retain.CtrlParams.Cool.Gain(1)	REAL	1.0	Active proportional gain for cooling Cool.Gain is retentive. Only takes effect when the heating output and the cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated. Cool.Gain ≥ 0.0
Retain.CtrlParams.Cool.Ti(1)	REAL	20.0	Active integration time for cooling in seconds The integral action for cooling is switched off with Cool.CtrlParams.Ti = 0.0. Cool.Ti is retentive. Only takes effect when the heating output and the cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated. 100000.0 ≥ Cool.Ti ≥ 0.0
Retain.CtrlParams.Cool.Td(1)	REAL	0.0	Active derivative action time for cooling in seconds The derivative action for cooling is switched off with Cool.CtrlParams.Td = 0.0. Cool.Td is retentive. Only takes effect when the heating output and the cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated. 100000.0 ≥ Cool.Td ≥ 0.0
Retain.CtrlParams.Cool.TdFiltRatio(1)	REAL	0.2	Active derivative delay coefficient for cooling The derivative delay coefficient delays the effect of the derivative action. Derivative delay = derivative action time × derivative delay coefficient • 0.0: Derivative action is effective for one cycle only and therefore almost not effective. • 0.5: This value has proved useful in practice for controlled systems with one dominant time constant. • > 1.0: The greater the coefficient, the longer the effect of the derivative action is delayed. Cool.TdFiltRatio is retentive. Only takes effect when the heating output and the cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated. Cool.TdFiltRatio ≥ 0.0

Tag	Data type	Default	Description
Retain.CtrlParams.Cool.PWeighting(-1)	REAL	1.0	Active weighting of the proportional action for cooling The proportional action may weaken with changes to the setpoint. Values from 0.0 to 1.0 are applicable. • 1.0: Proportional action for setpoint change is fully effective • 0.0: Proportional action for setpoint change is not effective The proportional action is always fully effective when the process value is changed. Cool.PWeighting is retentive. Only takes effect when the heating output and the cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated. 1.0 ≥ Cool.PWeighting ≥ 0.0
Retain.CtrlParams.Cool.DWeighting (1)	REAL	1.0	Active weighting of the derivative action for cooling The derivative action may weaken with changes to the setpoint. Values from 0.0 to 1.0 are applicable. • 1.0: Derivative action is fully effective upon setpoint change • 0.0: Derivative action is not effective upon setpoint change The derivative action is always fully effective when the process value is changed. Cool.DWeighting is retentive. Only takes effect when the heating output and the cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated. 1.0 ≥ Cool.DWeighting ≥ 0.0
Retain.CtrlParams.Cool.Cycle(1)	REAL	1.0	Active sampling time of the PID algorithm for cooling in seconds CtrlParams.Cool.Cycle is calculated during tuning and rounded to an integer multiple of CycleTime.Value. If Config.Output.Cool.PwmPeriode = 0.0 and also Config.ActivateHeating = FALSE or Config.AdvancedCooling = TRUE, Cool.Cycle is also used as period duration of the pulse width modulation for cooling. If Config.Output.Cool.PwmPeriode = 0.0, Config.ActivateHeating = TRUE and Config.AdvancedCooling = FALSE, Heat.Cycle is used as period duration of the pulse width modulation for cooling. Cool.Cycle is retentive. Only takes effect when the heating output and the cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated. 100000.0 ≥ Cool.Cycle > 0.0

Tag	Data type	Default	Description
Retain.CtrlParams.Cool.ControlZone (1)	REAL	3.402822e+-38	Active control zone width for cooling The control zone for cooling is switched off with Cool.ControlZone = 3.402822e+38. Cool.ControlZone is only set automatically during pretuning cooling or pretuning heating and cooling if PIDSelfTune.SUT.TuneRuleCool = 2 is selected as method of the parameter calculation. For controllers with activated heating output and cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE), the control zone is located between Setpoint - Heat.ControlZone and Setpoint + Cool.ControlZone. For controllers with deactivated heating output (Config.ActivateHeating = FALSE) and activated cooling output (Config.ActivateCooling = TRUE), the control zone is located symmetrically between Setpoint - Cool.ControlZone and Setpoint + Cool.ControlZone. Cool.ControlZone is retentive. Only takes effect when the heating output and the cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated. Cool.ControlZone > 0.0
Retain.CtrlParams.Cool.DeadZone(1)	REAL	0.0	Active dead zone width for cooling (see PID parameters (Page 170)) The dead zone for cooling is switched off with Cool.DeadZone = 0.0. Cool.DeadZone is not set automatically or adjusted during tuning. You must correctly configure Cool.DeadZone manually. When the dead zone is switched on, the result can be a permanent control deviation (deviation between setpoint and process value). This can have a negative effect on fine tuning. For controllers with activated heating output and cooling output and PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE), the dead zone is located between Setpoint - Heat.DeadZone and Setpoint + Cool.DeadZone. For controllers with deactivated heating output (Config.ActivateHeating = FALSE) and activated cooling output (Config.ActivateCooling = TRUE), the dead zone is located symmetrically between Setpoint - Cool.DeadZone and Setpoint + Cool.DeadZone. Cool.DeadZone is retentive. Only takes effect when the heating output and the cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE) or only the cooling output (Config.ActivateHeating = FALSE, Config.ActivateCooling = TRUE) is activated. Cool.DeadZone ≥ 0.0

11.3.4.7 PID_Temp state and mode parameters

Correlation of the parameters

The State parameter shows the current operating mode of the PID controller. You cannot change the State parameter.

With a rising edge at ModeActivate, PID_Temp switches to the operating mode saved in the Mode in-out parameter.

Heat.EnableTuning and Cool.EnableTuning specify for pretuning and fine tuning, if tuning takes place for heating or cooling.

When the CPU is switched on or switches from Stop to RUN mode, PID_Temp starts in the operating mode saved in the Mode parameter. To retain PID_Temp in "Inactive" mode, set RunModeByStartup = FALSE.

Meaning of values

State / Mode	Description of operating mode
0	**Inactive** The following output values are output in "Inactive" mode: • 0.0 as PID output value (PidOutputSum) • 0.0 as output value for heating (OutputHeat) and output value for cooling (OutputCool) • 0 as analog output value for heating (OutputHeat_PER) and analog output value for cooling (OutputCool_PER) • FALSE as PWM output value for heating (OutputHeat_PWM) and PWM output value for cooling (OutputCool_PWM) This does not depend on the configured output value limits and scaling in the structures Config.Output.Heat and Config.Output.Cool.
1	**Pretuning** The pretuning determines the process response to a jump change of the output value and searches for the point of inflection. The PID parameters are calculated from the maximum rate of rise and dead time of the controlled system. You obtain the best PID parameters when you perform pretuning and fine tuning. PID_Temp offers different pretuning types depending on the configuration: • Pretuning heating: A jump change is output at the output value heating, the PID parameters for heating are calculated (Retain.CtrlParams.Heat structure), and control to the setpoint then takes place in automatic mode. If the process behavior strongly depends on the operating point, an adaptation of the delay time can be activated at the setpoint with PIDSelfTune.SUT.AdaptDelayTime. • Pretuning heating and cooling: A jump is output at the output value heating. As soon as the process value is close to the setpoint, a jump change is output at the output value cooling. The PID parameters for heating (Retain.CtrlParams.Heat structure) and cooling (Retain.CtrlParams.Cool structure) are calculated. Then, control to the setpoint takes place in automatic mode. If the process behavior strongly depends on the operating point, an adaptation of the delay time can be activated at the setpoint with PIDSelfTune.SUT.AdaptDelayTime. Depending on the effect of the cooling actuator compared to the heating actuator, the quality of tuning can be influenced by whether or not the heating and cooling outputs are operated simultaneously during tuning. You can specify this with PIDSelfTune.SUT.CoolingMode.

State / Mode	Description of operating mode
	• Pretuning cooling: A jump change is output at the output value cooling and the PID parameters for cooling are calculated (Retain.CtrlParams.Cool structure). Then, control to the setpoint takes place in automatic mode. Depending on the configuration, the pretuning cooling can be started from two different operating states: – After pretuning for heating and with process value close to the setpoint: This option is available for all versions of PID_Temp, for controllers with activated heating output and cooling output with PID parameter switching (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE, Config.AdvancedCooling = TRUE). – Process value with sufficient distance to the setpoint: This option is also available for PID_Temp from V2.0 for controllers with activated cooling output (Config.ActivateCooling = TRUE) regardless of the activation of the heating output (Config.ActivateHeating). If the process behavior is heavily dependent on the operating point, setting PIDSelfTune.SUT.AdaptDelayTime for this option can be used to adapt the delay time to the setpoint. If you want to tune the PID parameters for heating and cooling, you can expect improved control response by carrying out "Pretuning heating" and subsequently "Pretuning cooling" than by carrying out "Pretuning heating and cooling". However, carrying out pretuning in two steps takes more time. **General requirements for pretuning:** • The PID_Temp instruction is called in a cyclic interrupt OB. • Inactive (State = 0), manual mode (State = 4), or automatic mode (State = 3) • ManualEnable = FALSE • Reset = FALSE • The setpoint and the process value lie within the configured limits. **Requirements for pretuning heating:** • Heat.EnableTuning = TRUE • Cool.EnableTuning = FALSE • The heating output is activated (Config.ActivateHeating = TRUE). • The process value must not be too close to the setpoint. |Setpoint - Input| > 0.3 * |Config.InputUpperLimit - Config.InputLowerLimit| and |Setpoint - Input| > 0.5 * |Setpoint| • The setpoint is greater than the process value. Setpoint > Input **Requirements for pretuning heating and cooling:** • Heat.EnableTuning = TRUE • Cool.EnableTuning = TRUE • The heating output and cooling output are activated (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE). • The PID parameter switching is activated (Config.AdvancedCooling = TRUE). • The process value must not be too close to the setpoint. |Setpoint - Input| > 0.3 * |Config.InputUpperLimit - Config.InputLowerLimit| and |Setpoint - Input| > 0.5 * |Setpoint| • The setpoint is greater than the process value. Setpoint > Input **Requirements for pretuning cooling with process value close to the setpoint:** • Heat.EnableTuning = FALSE • Cool.EnableTuning = TRUE • The heating output and cooling output are activated (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE). • The PID parameter switching is activated (Config.AdvancedCooling = TRUE).

State / Mode	Description of operating mode
	• "Pretuning heating" or "Pretuning heating and cooling" has been carried out successfully, if possible at the same setpoint. Successful execution is indicated by PIDSelfTune.SUT.ProcParHeatOk = TRUE. • The process value must be close to the setpoint. |Setpoint - Input| < 0.05 * |Config.InputUpperLimit - Config.InputLowerLimit| **Requirements for pretuning cooling with distance between process value and setpoint** • PID_Temp as of V2.0 • Heat.EnableTuning = FALSE • Cool.EnableTuning = TRUE • The cooling output is activated (Config.ActivateCooling = TRUE). • If the heating output is activated (Config.ActivateHeating = TRUE), PID parameter switching must also be activated (Config.AdvancedCooling = TRUE). • The process value must not be too close to the setpoint. |Setpoint - Input| > 0.3 * |Config.InputUpperLimit - Config.InputLowerLimit| and |Setpoint - Input| > 0.5 * |Setpoint| • The setpoint is less than the process value. Setpoint < Input The more stable the process value is, the easier it is to calculate the PID parameters and the more precise the result will be. Noise on the process value can be tolerated as long as the rate of rise of the process value is significantly higher compared to the noise. This is most likely the case in operating modes "Inactive" or "Manual mode". The setpoint is frozen in the CurrentSetpoint tag. Tuning is canceled when: • Setpoint > CurrentSetpoint + CancelTuningLevel or • Setpoint < CurrentSetpoint - CancelTuningLevel The method for calculation of the PID parameters can be specified separately for heating and cooling with PIDSelfTune.SUT.TuneRuleHeat and PIDSelfTune.SUT.TuneRuleCool. Before the PID parameters are recalculated, they are backed up in the CtrlParamsBackUp structure and can be reactivated with LoadBackUp. After successful pretuning, the switch is made to automatic mode. After unsuccessful pretuning, the switch to the mode is determined by ActivateRecoverMode. The phase of pretuning is indicated with PIDSelfTune.SUT.State. For starting pretuning in automatic mode, it is recommended to perform the required setpoint change simultaneously with the rising edge at ModeActivate. If the setpoint is changed first and the pretuning is started later, the output value in automatic mode is adjusted accordingly and causes a change to the process value. This can have a negative effect on the subsequent pretuning or prevent it from starting.
2	**Fine tuning** Fine tuning generates a constant, limited oscillation of the process value. The PID parameters are tuned for the operating point from the amplitude and frequency of this oscillation. PID parameters from fine tuning usually have better master control and disturbance characteristics than PID parameters from pretuning. You obtain the best PID parameters when you perform pretuning and fine tuning. PID_Temp automatically attempts to generate an oscillation greater than the noise of the process value. Fine tuning is only minimally influenced by the stability of the process value. PID_Temp offers different fine tuning types depending on the configuration: • Fine tuning heating: PID_Temp generates an oscillation of the process value with periodic changes at the output value heating and calculates the PID parameters for heating (Retain.CtrlParams.Heat structure). • Fine tuning cooling: PID_Temp generates an oscillation of the process value with periodic changes at the output value cooling and calculates the PID parameters for cooling (Retain.CtrlParams.Cool structure). **Temporary tuning offset for heating/cooling controllers**

State / Mode	Description of operating mode
	If PID_Temp is used as a heating/cooling controller (Config.AcitvateHeating = TRUE, Config.ActivateCooling = TRUE), the PID output value (PidOutputSum) at the setpoint has to fulfill the following requirements so that process value oscillation can be generated and fine tuning can be carried out successfully: • Positive PID output value for fine tuning heating • Negative PID output value for fine tuning cooling If this requirement is not met, you can define a temporary offset for fine tuning which is output at the output with the opposite effect: • Offset for cooling output (PIDSelfTune.TIR.OutputOffsetCool) with fine tuning heating. Before starting tuning, enter a negative tuning offset cooling that is lower than the PID output value (PidOutputSum) at the setpoint in the stationary state. • Offset for heating output (PIDSelfTune.TIR.OutputOffsetHeat) with fine tuning cooling. Before starting tuning, enter a positive tuning offset heating that is higher than the PID output value (PidOutputSum) at the setpoint in the stationary state. The defined offset is balanced by the PID algorithm so that the process value remains at the setpoint. The height of the offset allows the PID output value to be adapted correspondingly so that it fulfills the requirement mentioned above. To avoid larger overshoots of the process value when defining the offset, it can also be increased in several steps. If PID_Temp exits the fine tuning mode, the tuning offset is reset. Example for definition of an offset for fine tuning cooling: • Without offset: – Setpoint = Process value (ScaledInput) = 80 °C – PID output value (PidOutputSum) = 30.0 – Output value heating (OutputHeat) = 30.0 – Output value cooling (OutputCool) = 0.0 Oscillation of the process value around the setpoint cannot be generated with the cooling output alone. Fine tuning would fail here. • With definition of an offset for heating output (PIDSelfTune.TIR.OutputOffsetHeat) = 80.0 – Setpoint = Process value (ScaledInput) = 80 °C – PID output value (PidOutputSum) = -50.0 – Output value heating (OutputHeat) = 80.0 – Output value cooling (OutputCool) = -50.0 By defining an offset for the heating output, the cooling output can now create an oscillation of the process value around the setpoint. Fine tuning can now be carried out successfully. **General requirements for fine tuning:** • The PID_Temp instruction is called in a cyclic interrupt OB. • No disturbances are expected. • The setpoint and the process value lie within the configured limits. • The control loop has stabilized at the operating point. The operating point is reached when the process value corresponds to the setpoint. When the dead zone is switched on, the result can be a permanent control deviation (deviation between setpoint and process value). This can have a negative effect on fine tuning. • ManualEnable = FALSE • Reset = FALSE • Automatic (State = 3), inactive (State = 0) or manual (State = 4) mode

State / Mode	Description of operating mode
	Requirements for fine tuning heating: • Heat.EnableTuning = TRUE • Cool.EnableTuning = FALSE • The heating output is activated (Config.ActivateHeating = TRUE). • If PID_Temp is configured as heating/cooling controller (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE), the heating output must be active at the operating point at which tuning is to take place (PidOutputSum > 0.0 - see Tuning offset). **Requirements for fine tuning cooling:** • Heat.EnableTuning = FALSE • Cool.EnableTuning = TRUE • The cooling output is activated (Config.ActivateCooling = TRUE). • If the heating output is activated (Config.ActivateHeating = TRUE), PID parameter switching must also be activated (Config.AdvancedCooling = TRUE). • If PID_Temp is configured as heating/cooling controller (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE), the cooling output must be active at the operating point at which tuning is to take place (PidOutputSum < 0.0 - see Tuning offset). **The course of fine tuning is determined by the mode from which it is started:** • Automatic mode (State = 3) with PIDSelfTune.TIR.RunIn = FALSE (default) Start fine tuning from automatic mode if you wish to improve the existing PID parameters through tuning. PID_Temp controls the system using the existing PID parameters until the control loop has stabilized and the requirements for fine tuning have been met. Only then will fine tuning start. • Inactive (State = 0), manual mode (State = 4), or automatic mode (State = 3) with PIDSelfTune.TIR.RunIn = TRUE Attempts are made to reach the setpoint with the minimum or maximum output value: – with minimum or maximum output value heating for fine tuning heating – With minimum or maximum output value cooling for fine tuning cooling. This can produce increased overshoot. When the setpoint is reached, fine tuning is started. If the setpoint cannot be reached, PID_Temp does not abort tuning automatically. The setpoint is frozen in the CurrentSetpoint tag. Tuning is canceled when: • Setpoint > CurrentSetpoint + CancelTuningLevel or • Setpoint < CurrentSetpoint - CancelTuningLevel The method for calculation of the PID parameters can be specified separately for heating and cooling with PIDSelfTune.TIR.TuneRuleHeat and PIDSelfTune.TIR.TuneRuleCool. Before the PID parameters are recalculated, they are backed up in the CtrlParamsBackUp structure and can be reactivated with LoadBackUp. The controller changes to automatic mode after successful fine tuning. After unsuccessful fine tuning, the switch to the mode is determined by ActivateRecoverMode. The "Fine tuning" phase is indicated with PIDSelfTune.TIR.State.
3	**Automatic mode** In automatic mode, PID_Temp corrects the controlled system in accordance with the parameters specified. The controller switches to automatic mode if one the following requirements is fulfilled: • Pretuning successfully completed • Fine tuning successfully completed • Changing of the Mode in-out parameter to the value 3 and a rising edge at ModeActivate. The switchover from automatic mode to manual mode is only bumpless if carried out in the commissioning editor. The ActivateRecoverMode tag is taken into consideration in automatic mode.

State / Mode	Description of operating mode
4	**Manual mode** In manual mode, you specify a manual PID output value in the ManualValue parameter. The values at the outputs for heating and cooling resulting from this manual value are the result of the configured output scaling. With the preset output scaling, specify a negative manual value to obtain a positive value at the outputs for cooling. Example with default setting: ManualValue = -50.0 -> OutputCool = 50.0, ManualValue = -100.0 -> OutputCool = 100.0 You can also activate this operating mode using ManualEnable = TRUE. We recommend that you change the operating mode using Mode and ModeActivate only. The switchover from manual mode to automatic mode is bumpless. The ActivateRecoverMode tag is taken into consideration in manual mode.
5	**Substitute output value with error monitoring** The control algorithm is deactivated. The SetSubstituteOutput tag determines which PID output value (PidOutputSum) is output in this operating mode. • SetSubstituteOutput = FALSE: Last valid PID output value • SetSubstituteOutput = TRUE: Substitute output value (SubstituteOutput) You cannot activate this operating mode using Mode = 5. In the event of an error, it is activated instead of "Inactive" operating mode if all the following conditions are met: • Automatic mode (State = 3) • ActivateRecoverMode = TRUE • One or more errors have occurred in which ActivateRecoverMode (Page 419) is effective. As soon as the errors are no longer pending, PID_Temp switches back to automatic mode. With the preset output scaling, specify a negative substitute output value to obtain a positive value at the outputs for cooling. Example with default setting: SubstituteOutput = -50.0 -> OutputCool = 50.0, SubstituteOutput = -100.0 -> OutputCool = 100.0.

ENO characteristics

If State = 0, then ENO = FALSE.

If State ≠ 0, then ENO = TRUE.

Automatic switchover of operating mode during commissioning

Automatic mode is activated following successful pretuning or fine tuning. The following table shows how Mode and State change during successful pretuning.

Cycle no.	Mode	State	Action
0	4	4	Set Mode = 1
1	1	4	Set ModeActivate = TRUE
1	4	1	Value of State is saved in Mode parameter Pretuning is started
n	4	1	Pretuning successfully completed
n	3	3	Automatic mode is started

PID_Temp automatically switches the operating mode in the event of an error.

The following table shows how Mode and State change during pretuning with errors.

Cycle no.	Mode	State	Action
0	4	4	Set Mode = 1
1	1	4	Set ModeActivate = TRUE
1	4	1	Value of State is saved in Mode parameter Pretuning is started
n	4	1	Pretuning canceled
n	4	4	Manual mode is started

If ActivateRecoverMode = TRUE, the operating mode saved in the Mode parameter is activated. When you start pretuning or fine tuning, PID_Temp has saved the value of State in the Mode in-out parameter. This means PID_Temp switches to the mode from which tuning was started.

If ActivateRecoverMode = FALSE, the system switches to "Inactive" operating mode.

See also

Output parameters of PID_Temp (Page 377)

In/out parameters of PID_Temp V2 (Page 379)

11.3.4.8 PID_Temp ErrorBits parameter

If several errors are pending simultaneously, the values of the ErrorBits are displayed with binary addition. The display of ErrorBits = 16#0000_0003, for example, indicates that the errors 16#0000_0001 and 16#0000_0002 are pending simultaneously.

ErrorBits (DW#16#...)	Description
0000_0000	There is no error.
0000_0001	The "Input" parameter is outside the process value limits. • Input > Config.InputUpperLimit or • Input < Config.InputLowerLimit If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Temp remains in automatic mode. If manual mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Temp remains in manual mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Temp switches to the operating mode saved in the Mode parameter.
0000_0002	Invalid value at "Input_PER" parameter. Check whether an error is pending at the analog input. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Temp outputs the configured substitute output value. As soon as the error is no longer pending, PID_Temp switches back to automatic mode. If manual mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Temp remains in manual mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Temp switches to the operating mode saved in the Mode parameter.

ErrorBits (DW#16#...)	Description
0000_0004	Error during fine tuning. The oscillation of the process value could not be maintained. If PID_Temp is used as a heating/cooling controller (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE), then in order to generate a process value oscillation and successfully carry out the fine tuning, the PID output value (PidOutputSum) at the setpoint must be • positive for fine tuning heating • negative for fine tuning cooling If this requirement is not met, use the tuning offsets (PIDSelfTune.TIR.OutputOffsetCool and PIDSelfTune.TIR.OutputOffsetHeat tags), see Fine tuning (Page 182). If there was ActivateRecoverMode = TRUE before the error occurred, PID_Temp cancels the tuning and switches to the operating mode saved in the Mode parameter.
0000_0008	Error at start of pretuning heating/cooling. The process value is too close to the setpoint or greater/less than the setpoint. Start fine tuning. The tuning requirements are described under parameters State and Mode PID_Temp (Page 410). If ActivateRecoverMode = TRUE before the error occurred, PID_Temp cancels the tuning and switches to the operating mode saved in the Mode parameter.
0000_0010	The setpoint was changed during tuning. You can set the permitted fluctuation of the setpoint at the CancelTuningLevel tag. If ActivateRecoverMode = TRUE before the error occurred, PID_Temp cancels the tuning and switches to the operating mode saved in the Mode parameter.
0000_0020	Pretuning is not permitted during fine tuning. If ActivateRecoverMode = TRUE before the error occurred, PID_Temp remains in fine tuning mode.
0000_0040	Error during pretuning. Cooling could not reduce the process value. If ActivateRecoverMode = TRUE before the error occurred, PID_Temp cancels the tuning and switches to the operating mode saved in the Mode parameter.
0000_0100	Error during fine tuning resulted in invalid parameters. If ActivateRecoverMode = TRUE before the error occurred, PID_Temp cancels the tuning and switches to the operating mode saved in the Mode parameter.
0000_0200	Invalid value at "Input" parameter: Value has an invalid number format. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Temp outputs the configured substitute output value. As soon as the error is no longer pending, PID_Temp switches back to automatic mode. If manual mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Temp remains in manual mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Temp switches to the operating mode saved in the Mode parameter.
0000_0400	Calculation of output value failed. Check the PID parameters. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Temp outputs the configured substitute output value. As soon as the error is no longer pending, PID_Temp switches back to automatic mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Temp switches to the operating mode saved in the Mode parameter.
0000_0800	Sampling time error: PID_Temp is not called within the sampling time of the cyclic interrupt OB. It is recommended to call PID_Temp in a cyclic interrupt OB without conditions and to activate or deactivate it via the operating mode at the Mode parameter. Conditional calls or the call in OB1 can have a negative effect on the control quality. Monitoring of the sampling time can be disabled with CycleTime.EnMonitoring = FALSE. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Temp remains in automatic mode. If manual mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Temp remains in manual mode.

ErrorBits (DW#16#...)	Description
	If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Temp switches to the operating mode saved in the Mode parameter. If this error occurred during simulation with PLCSIM, see the notes under Simulating PID_Temp with PLCSIM (Page 202).
0000_1000	Invalid value at "Setpoint" parameter or "SubstituteSetpoint": Value has an invalid number format. If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Temp outputs the configured substitute output value. As soon as the error is no longer pending, PID_Temp switches back to automatic mode. If manual mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Temp remains in manual mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Temp switches to the operating mode saved in the Mode parameter.
0001_0000	Invalid value at ManualValue parameter. Value has an invalid number format. If ActivateRecoverMode = TRUE before the error occurred, PID_Temp remains in manual mode and uses SubstituteOutput as PID output value. As soon as you specify a valid value in ManualValue, PID_Temp uses it as the PID output value.
0002_0000	Invalid value at SubstituteOutput tag. Value has an invalid number format. PID_Temp remains in the "Substitute output value with error monitoring" mode or manual mode and uses Config.Output.Heat.PidLowerLimit or Config.Output.Cool.PidUpperLimit as PID output value. As soon as you specify a valid value in SubstituteOutput, PID_Temp uses it as the PID output value.
0004_0000	Invalid value at Disturbance parameter. Value has an invalid number format. If automatic mode was active and ActivateRecoverMode = TRUE before the error occurred, Disturbance is set to zero. PID_Temp remains in automatic mode. If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred , PID_Temp switches to the operating mode saved in the Mode parameter. If Disturbance in the current phase has no effect on the output value, tuning is not be canceled.
0020_0000	Error in master in the cascade (Page 188): Slaves are not in automatic mode or have enabled a substitute setpoint and are preventing tuning of the master. If ActivateRecoverMode = TRUE before the error occurred, PID_Temp cancels the tuning and switches to the operating mode saved in the Mode parameter.
0040_0000	Pretuning heating is not permitted while cooling is active. The tuning requirements are described under parameters State and Mode PID_Temp (Page 410). If ActivateRecoverMode = TRUE before the error occurred, PID_Temp cancels the tuning and switches to the operating mode saved in the Mode parameter.
0080_0000	The process value must be close to the setpoint or have sufficient distance to the setpoint to start pretuning cooling. The tuning requirements are described under parameters State and Mode PID_Temp (Page 410). If ActivateRecoverMode = TRUE before the error occurred, PID_Temp cancels the tuning and switches to the operating mode saved in the Mode parameter.
0100_0000	Error at start of tuning: Heat.EnableTuning and Cool.EnableTuning are not set or do not match the configuration. The tuning requirements are described under parameters State and Mode PID_Temp (Page 410). If ActivateRecoverMode = TRUE before the error occurred, PID_Temp cancels the tuning and switches to the operating mode saved in the Mode parameter.
0200_0000	Pretuning of cooling with process value close to the setpoint requires successful pretuning heating. The tuning requirements are described under parameters State and Mode PID_Temp (Page 410). If ActivateRecoverMode = TRUE before the error occurred, PID_Temp cancels the tuning and switches to the operating mode saved in the Mode parameter.

ErrorBits (DW#16#...)	Description
0400_0000	Error at start of fine tuning: Heat.EnableTuning and Cool.EnableTuning must not be set simultaneously. The tuning requirements are described under parameters State and Mode PID_Temp (Page 410). If ActivateRecoverMode = TRUE before the error occurred, PID_Temp cancels the tuning and switches to the operating mode saved in the Mode parameter.
0800_0000	Error during calculation of the PID parameters resulted in invalid parameters. The invalid parameters are discarded and the original PID parameters are retained unchanged. If this error occurs during pretuning, make sure that: • Pretuning heating or pretuning heating and cooling: The PID output value is not already limited by the high limit for heating before the start of the pretuning. • Pretuning cooling: The PID output value is not already limited by the low limit for cooling before the start of the pretuning. For starting a pretuning in automatic mode, it is recommended to perform the required setpoint change simultaneously with the rising edge at ModeActivate. This prevents the PID output value from running into the limitation between the setpoint change and the start of the pretuning. Alternatively, this can also be achieved by starting from manual mode or "Inactive" mode. A distinction is made between the following scenarios: • If automatic mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Temp remains in automatic mode. • If manual mode was active before the error occurred and ActivateRecoverMode = TRUE, PID_Temp remains in manual mode. • If pretuning or fine tuning mode was active and ActivateRecoverMode = TRUE before the error occurred, PID_Temp switches to the operating mode saved in the Mode parameter.

11.3.4.9 PID_Temp ActivateRecoverMode tag

The ActivateRecoverMode tag determines the response in the event of an error. The Error parameter indicates if an error is pending. When the error is no longer pending, Error = FALSE. The ErrorBits parameter shows which errors have occurred.

Automatic mode and manual mode

NOTICE
Your system may be damaged. If ActivateRecoverMode = TRUE, PID_Temp remains in automatic mode or in manual mode even if there is an error and the process value limits are exceeded. This may damage your system. It is essential to configure how your controlled system reacts in the event of an error to protect your system from damage.

ActivateRecover-Mode	Description
FALSE	PID_Temp switches to "Inactive" mode in the event of an error. The controller is only activated by a falling edge at Reset or a rising edge at ModeActivate.
TRUE	**Automatic mode** If errors occur frequently in automatic mode, this setting has a negative effect on the control response, because PID_Temp switches between the calculated PID output value and the substitute output value at each error. In this case, check the ErrorBits parameter and eliminate the cause of the error.

ActivateRecover-Mode	Description
TRUE	If one or several of the following errors occur and automatic mode was active before the error occurred, PID_Temp remains in automatic mode: • 0000001h: The "Input" parameter is outside the process value limits. • 0000800h: Sampling time error • 0040000h: Invalid value at Disturbance parameter. • 8000000h: Error during calculation of the PID parameters If one or several of the following errors occur and automatic mode was active before the error occurred, PID_Temp switches to "Substitute output value with error monitoring" mode: • 0000002h: Invalid value at Input_PER parameter. • 0000200h: Invalid value at Input parameter. • 0000400h: Calculation of output value failed. • 0001000h: Invalid value at Setpoint parameter or SubstituteSetpoint. As soon as the errors are no longer pending, PID_Temp switches back to automatic mode. If the following error occurs in "Substitute output value with error monitoring" mode, PID_Temp sets the PID output value to Config.Output.Heat.PidLowerLimit as long as this error is pending: • 0020000h: Invalid value at SubstituteOutput tag. Value has an invalid number format. This behavior is independent of SetSubstituteOutput.
	Manual mode If one or several errors occur and manual mode was active before the error occurred, PID_Temp remains in manual mode. If the following error occurs in manual mode, as long as this error is pending, PID_Temp sets the PID output value to SubstituteOutput: • 0010000h: Invalid value at ManualValue parameter. Value has an invalid number format. If the error 0010000h is pending in manual mode and the following error occurs, PID_Temp sets the PID output value to Config.Output.Heat.PidLowerLimit as long as this error is pending: • 0020000h: Invalid value at SubstituteOutput tag. Value has an invalid number format. This behavior is independent of SetSubstituteOutput.

Pretuning and fine tuning

ActivateRecover-Mode	Description
FALSE	PID_Temp switches to "Inactive" mode in the event of an error. The controller is only activated by a falling edge at Reset or a rising edge at ModeActivate.
TRUE	If the following error occurs, PID_Temp remains in the active mode: • 0000020h: Pretuning is not permitted during fine tuning. The following errors are ignored: • 0010000h: Invalid value at ManualValue parameter. • 0020000h: Invalid value at SubstituteOutput tag. When any other error occurs, PID_Temp cancels the tuning and switches to the mode from which tuning was started.

11.3.4.10 PID_Temp Warning tag

If several warnings are pending simultaneously, the values of the Warning tag are displayed with binary addition. The display of warning 16#0000_0003, for example, indicates that the warnings 16#0000_0001 and 16#0000_0002 are pending simultaneously.

Warning (DW#16#....)	Description
0000_0000	No warning pending.
0000_0001	The point of inflection was not found during pretuning.
0000_0004	The setpoint was limited to the configured limits.
0000_0008	Not all the necessary controlled system properties were defined for the selected method of calculation. Instead, the PID parameters were calculated using the method TIR.TuneRuleHeat = 3 or TIR.TuneRuleCool = 3.
0000_0010	The operating mode could not be changed because Reset = TRUE or ManualEnable = TRUE.
0000_0020	The cycle time of the calling OB limits the sampling time of the PID algorithm. Improve results by using shorter OB cycle times.
0000_0040	The process value exceeded one of its warning limits.
0000_0080	Invalid value at Mode. The operating mode is not switched.
0000_0100	The manual value was restricted to the limits of the PID output value.
0000_0200	The specified rule for tuning is not supported. No PID parameters are calculated.
0000_1000	The substitute output value cannot be reached because it is outside the output value limits.
0000_4000	The specified selection of the output value for heating and/or cooling is not supported. Only the output OutputHeat or OutputCool is used.
0000_8000	Invalid value at PIDSelfTune.SUT.AdaptDelayTime. The default value 0 is used.
0001_0000	Invalid value at PIDSelfTune.SUT.CoolingMode. The default value 0 is used.
0002_0000	The simultaneous activation of heating and cooling (Config.ActivateHeating = TRUE, Config.ActivateCooling = TRUE) is not supported for a controller that is used as a master (Config.Cascade.IsMaster = TRUE). PID_Temp works as a heating controller. Deactivate the heating or cooling by setting Config.ActivateHeating or Config.ActivateCooling to FALSE.
0004_0000	Invalid value at Retain.CtrlParams.Heat.Gain, Retain.CtrlParams.Cool.Gain or Config.CoolFactor. PID_Temp supports only positive values for proportional gain (heating and cooling) and cooling factor. Automatic mode remains active with PID output value 0.0. The integral component is stopped.

The following warnings are deleted as soon as the cause has been remedied or you repeat the action with valid parameters:

- 16#0000_0001
- 16#0000_0004
- 16#0000_0008
- 16#0000_0040
- 16#0000_0100

All other warnings are cleared with a rising edge at Reset or ErrorAck.

11.3.4.11 PwmPeriode tag

If the PID algorithm sampling time (Retain.CtrlParams.Heat.Cycle or Retain.CtrlParams.Heat.Cycle) and thus the time period of the pulse width modulation is very high when OutputHeat_PWM or OutputCool_PWM is used, you can specify a deviating shorter period duration with the Config.Output.Heat.PwmPeriode or Config.Output.Cool.PwmPeriode parameters in order to improve smoothing of the process value.

Time period of the pulse width modulation at OutputHeat_PWM

Time period of the PWM at output OutputHeat_PWM depending on Config.Output.Heat.PwmPeriode:

- Heat.PwmPeriode = 0.0 (default)

  The sampling time of the PID algorithm for heating (Retain.CtrlParams.Heat.Cycle) is used as period duration of the PWM.

- Heat.PwmPeriode > 0.0

  The value is rounded off to an integer multiple of the PID_Temp sampling time (CycleTime.Value) and used as period duration of the PWM.

  The value must meet the following conditions:

  – Heat.PwmPeriode ≤ Retain.CtrlParams.Heat.Cycle
  – Heat.PwmPeriode > Config.Output.Heat.MinimumOnTime
  – Heat.PwmPeriode > Config.Output.Heat.MinimumOffTime

Time period of the pulse width modulation at OutputCool_PWM

Time period of the PWM at output OutputCool_PWM depending on Config.Output.Cool.PwmPeriode and the method for heating/cooling:

- Cool.PwmPeriode = 0.0, Config.ActivateHeating = TRUE and Config.AdvancedCooling = FALSE:

  The sampling time of the PID algorithm for heating (Retain.CtrlParams.Heat.Cycle) is used as period duration of the PWM.

- Cool.PwmPeriode = 0.0 and Config.ActivateHeating = FALSE

  or

  Cool.PwmPeriode = 0.0 and Config.AdvancedCooling = TRUE:

  The sampling time of the PID algorithm for cooling (Retain.CtrlParams.Cool.Cycle) is used as period duration of the PWM.

- Cool.PwmPeriode > 0.0:

  The value is rounded off to an integer multiple of the PID_Temp sampling time (CycleTime.Value) and used as period duration of the PWM.

  The value must meet the following conditions:

  – Cool.PwmPeriode ≤ Retain.CtrlParams.Cool.Cycle or Retain.CtrlParams.Heat.Cycle
  – Cool.PwmPeriode > Config.Output.Cool.MinimumOnTime
  – Cool.PwmPeriode > Config.Output.Cool.MinimumOffTime

Config.Output.Cool.PwmPeriode only takes effect if the cooling output is activated (Config.ActivateCooling = TRUE) and OutputCool_PWM is selected as output for cooling (Config.Output.Cool.Select = 1).

When you use PwmPeriode, the accuracy of the PWM output signal is determined by the ratio of PwmPeriode to the PID_Temp sampling time (cycle time of the OB). PwmPeriode should be at least 10 times the PID_Temp sampling time.

If the sampling time of the PID algorithm is not an integer multiple of PwmPeriode, each last period of the PWM within the sampling time of the PID algorithm is extended accordingly.

Example for OutputHeat_PWM

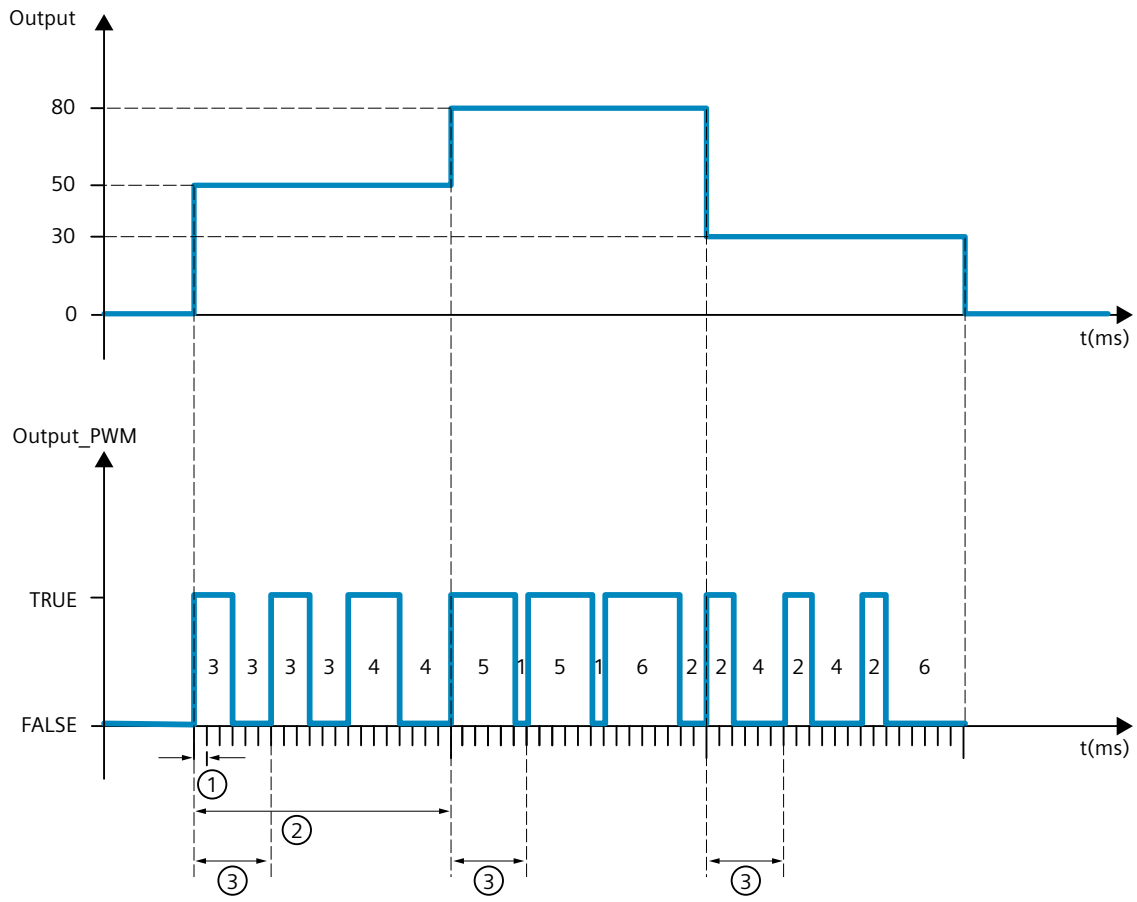

① PID_Temp sampling time = 100.0 ms (cycle time of the calling cyclic interrupt OB, CycleTime.Value tag)

② PID algorithm sampling time = 2000.0 ms (Retain.CtrlParams.Heat.Cycle tag)

③ Time period of the PWM for heating = 600.0 ms (Config.Output.Heat.PwmPeriode tag)

11.3.4.12 IntegralResetMode tag

The IntegralResetMode tag determines how the integral action PIDCtrl.IOutputOld is preassigned:

- When switching from "Inactive" operating mode to "Automatic mode"
- With edge TRUE -> FALSE at parameter Reset and parameter Mode = 3

This setting only works for one cycle and only takes effect if the integral action is activated (Retain.CtrlParams.Heat.Ti and Retain.CtrlParams.Cool.Ti > 0.0 tags).

IntegralReset-Mode	Description
0	Smooth The value of PIDCtrl.IOutputOld is preassigned so that the switchover is bumpless, which means "Automatic mode" starts with the output value = 0.0 (PidOutputSum parameter) and there is no jump of the output value regardless of the control deviation (setpoint – process value).
1	Delete We recommend setting the weighting of the proportional action (Retain.CtrlParams.Heat.PWeighting and Retain.CtrlParams.Cool.PWeighting tags) to 1.0 when this option is used. The value of PIDCtrl.IOutputOld is deleted. Any control deviation will cause the PID output value to jump. The direction of the output value jump depends on the active weighting of the proportional action (Retain.CtrlParams.Heat.PWeighting and Retain.CtrlParams.Cool.PWeighting tags) and the control deviation: • Active proportional action weighting = 1.0: Output value jump and control deviation have identical signs. Example: If the process value is less than the setpoint (positive control deviation), the PID output value jumps to a positive value. • Active proportional action weighting < 1.0: For large system deviations, the PID output value jump and control deviation have identical signs. Example: If the process value is much less than the setpoint (positive control deviation), the PID output value jumps to a positive value. For small system deviations, the PID output value jump and control deviation have different signs. Example: If the process value is just below the setpoint (positive control deviation), the PID output value jumps to a negative value. This is usually not desirable, because it results in a temporary increase in the control deviation. The smaller the configured weighting of the proportional action, the greater the control deviation must be to receive a PID output value jump with identical sign. We recommend setting the weighting of the proportional action (Retain.CtrlParams.Heat.PWeighting and Retain.CtrlParams.Cool.PWeighting tags) to 1.0 when this option is used. Otherwise, you may experience the undesirable behavior described for small control deviations. Alternatively, you can also use IntegralResetMode = 4. This option guarantees identical signs of the PID output value jump and control deviation independent of the configured weighting of the proportional action and the control deviation.
2	Hold The value of PIDCtrl.IOutputOld is not changed. You can define a new value using the user program.
3	Preassign The value of PIDCtrl.IOutputOld is automatically preassigned as if PidOutputSum = OverwriteInitialOutputValue in the last cycle.
4	Like setpoint change (only for PID_Temp with version ≥ 1.1) The value of PIDCtrl.IOutputOld is automatically preassigned so that a similar PID output value jump results as for a PI controller in automatic mode in case of a setpoint change from the current process value to the current setpoint. Any control deviation will cause the PID output value to jump. The PID output value jump and control deviation have identical signs.

IntegralReset-Mode	Description
	Example: If the process value is less than the setpoint (positive control deviation), the PID output value jumps to a positive value. This is independent of the configured weighting of the proportional action and the control deviation.

If IntegralResetMode is assigned a value outside the valid value range, PID_Temp behaves as with the preassignment of IntegralResetMode:

- PID_Temp up to V1.0: IntegralResetMode = 1
- PID_Temp as of V1.1: IntegralResetMode = 4

11.4 PID basic functions

11.4.1 CONT_C

11.4.1.1 Description CONT_C

The CONT_C instruction is used on SIMATIC S7 automation systems to control technical processes with continuous input and output variables. You can assign parameters to enable or disable sub-functions of the PID controller and adapt it to the process. In addition to the functions in the setpoint and process value branches, the instruction implements a complete PID controller with continuous output value output and the option of manually influencing the value of the output value.

Application

You can use the controller as a PID fixed setpoint controller, or in multi-loop control systems, also as a cascade, blending or ratio controller. The functions of the controller are based on the PID control algorithm of the sampling controller with an analog signal, if necessary extended by including a pulse shaper stage to generate pulse-width modulated output signals for two or three step controllers with proportional actuators.

Call

The CONT_C instruction has an initialization routine that is run through when input parameter COM_RST = TRUE is set. During initialization, the integral action is set to the initialization value I_ITVAL. All the signal outputs are set to zero. COM_RST = FALSE has to be set after the initialization routine has been completed.

The calculation of the values in the control blocks is only correct if the block is called at regular intervals. You should therefore call the control blocks in a cyclic interrupt OB (OB 30 to OB 38). Enter the sampling time in the CYCLE parameter.

Error information

The error message word RET_VAL is not evaluated by the block.

11.4.1.2 How CONT_C works

Setpoint branch

The setpoint is entered in floating-point format at the SP_INT input.

Process value branch

The process value can be input in I/O or floating-point format. The function CRP_IN converts the I/O value PV_PER to a floating-point format -100 to +100 % in accordance with the following rule:

Output of CRP_IN = PV_PER * 100 / 27648

The PV_NORM function scales the output of CRP_IN according to the following rule:

Output of PV_NORM = (output of CRP_IN) *PV_FAC + PV_OFF

PV_FAC has a default of 1 and PV_OFF a default of 0.

Forming the error signal

The difference between the setpoint and process value is the error signal. To suppress a minor sustained oscillation due to manipulated variable quantization (e.g. with a pulse width modulation with PULSEGEN), the error signal is applied to a dead band (DEADBAND). With DEADB_W = 0, the dead band is switched off.

PID Algorithm

The PID algorithm operates as a position algorithm. The proportional, integral (INT), and differential (DIF) actions are connected in parallel and can be activated or deactivated individually. This allows P, PI, PD, and PID controllers to be configured. Pure I controllers are also possible.

Manual value processing

It is possible to switch over between manual and automatic mode. In manual mode, the manipulated variable is corrected to a manually selected value.

The integral action (INT) is set internally to LMN - LMN_P - DISV and the derivative action (DIF) is set to 0 and synchronized internally. Changeover to automatic mode is therefore bumpless.

Manipulated value processing

You can use the LMNLIMIT function to limit the manipulated value to selected values. Alarm bits indicate when a limit is exceeded by the input variable.

The LMN_NORM function normalizes the output of LMNLIMIT according to the following rule:

LMN = (output of LMNLIMIT) * LMN_FAC + LMN_OFF

LMN_FAC has a default of 1 and LMN_OFF a default of 0.

The manipulated value is also available in I/O format. The CRP_OUT function converts the LMN floating-point value to a I/O value according to the following rule:

LMN_PER = LMN * 27648 / 100

Feedforward control

A disturbance variable can be added at the DISV input.

11.4.1.3 CONT_C block diagram

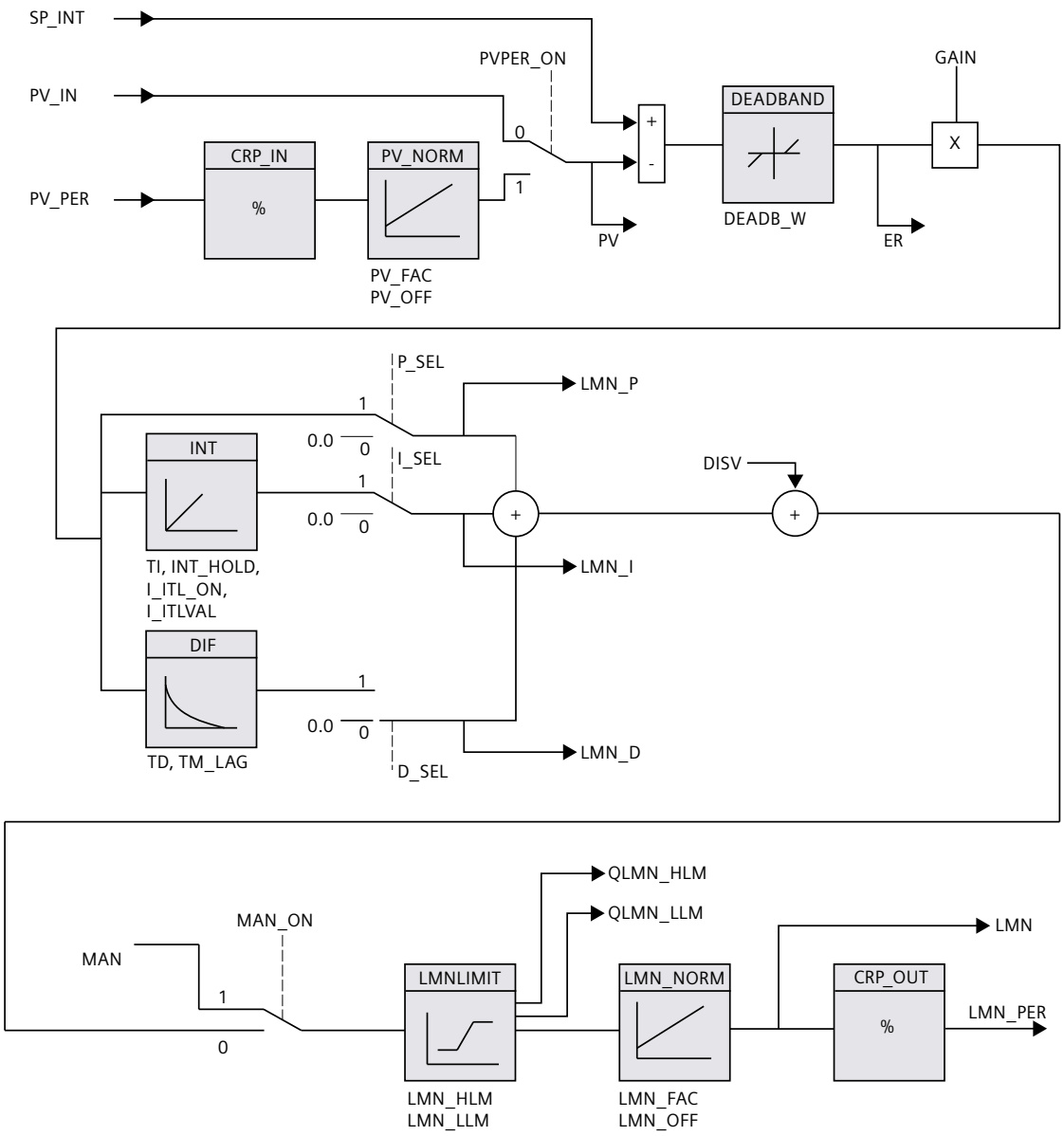

11.4.1.4 Input parameter CONT_C

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1130

Parameters	Data type	Default	Description
COM_RST	BOOL	FALSE	The instruction has an initialization routine that is processed when the "Restart" input is set.
MAN_ON	BOOL	TRUE	If the input "Enable manual mode" is set then the control loop is interrupted. A manual value is set as the manipulated value.
PVPER_ON	BOOL	FALSE	If the process value is to be read in from the I/Os, the PV_PER input must be interconnected with the I/Os and the "Enable process value I/Os" input must be set.
P_SEL	BOOL	TRUE	The PID actions can be switched on and off individually in the PID algorithm. P-action is on when the "Enable P-action" input is set.
I_SEL	BOOL	TRUE	The PID actions can be switched on and off individually in the PID algorithm. I action is on when the input "I-action on" is set.
INT_HOLD	BOOL	FALSE	The output of the integral action can be frozen. For this the input "I-action hold" must be set.
I_ITL_ON	BOOL	FALSE	The output of the integral action can be set at the I_ITLVAL input. For this the input "Set I-action" must be set.
D_SEL	BOOL	FALSE	The PID actions can be switched on and off individually in the PID algorithm. D-action is on when the input "Enable D-action" is set.
CYCLE	TIME	T#1s	The time between block calls must be constant. The "Sampling time" input specifies the time between block calls. CYCLE >= 1ms
SP_INT	REAL	0.0	The input "Internal setpoint" is used to specify a setpoint. Permissible are values from -100 to 100 % or a physical variable 1).
PV_IN	REAL	0.0	At the "Process value input" you can assign parameters to a commissioning value or you can interconnect an external process value in floating-point format. Permissible are values from -100 to 100 % or a physical variable 1).
PV_PER	WORD	W#16#0000	The process value in I/O format is interconnected with the controller at the "Process value I/0" input.
MAN	REAL	0.0	The "Manual value" input is used to set a manual value using the operator interface functions. Permissible are values from -100 to 100 % or a physical variable 2).
GAIN	REAL	2.0	The "Proportional gain" input specifies controller amplification.
TI	TIME	T#20s	The "Integration time" input determines the time response of the integral action. TI >= CYCLE
TD	TIME	T#10s	The "Derivative action time" input determines the time response of the derivative action. TD >= CYCLE
TM_LAG	TIME	T#2s	Time lag of the D-action The algorithm of the D-action contains a delay for which parameters can be assigned at the input "Time lag of the D-action". TM_LAG >= CYCLE/2
DEADB_W	REAL	0.0	A dead band is applied to the system deviation. The "Dead band width" input determines the size of the dead band. DEADB_W >= 0.0 (%) or a physical variable 1)

Parameters	Data type	Default	Description
LMN_HLM	REAL	100.0	The manipulated value is always restricted to a high limit and low limit. The "High limit of manipulated value" input specifies the high limit. Permissible are real values starting at LMN_LLM (%) or a physical variable 2).
LMN_LLM	REAL	0.0	The manipulated value is always restricted to a high limit and low limit. The "Low limit of manipulated value" input specifies the low limit. Permissible are real values up to LMN_HLM (%) or a physical variable 2).
PV_FAC	REAL	1.0	The "Process value factor" input is multiplied by the process value. The input is used to scale the process value range.
PV_OFF	REAL	0.0	The input "Process value offset" is added to the process value. The input is used to scale the process value range.
LMN_FAC	REAL	1.0	The "Manipulated value factor" input is multiplied with the manipulated value. The input is used to scale the manipulated value range.
LMN_OFF	REAL	0.0	The input "Manipulated value offset" is added to the process value. The input is used to scale the manipulated value range.
I_ITLVAL	REAL	0.0	The output of the integral action can be set at the I_ITL_ON input. The initialization value is indicated at the input "Initialization value of the integral-action." Permissible are values of -100.0 to 100.0 (%) or a physical variable 2).
DISV	REAL	0.0	For feedforward control, the disturbance variable is interconnected to the "Disturbance variable" input. Permissible are values of -100.0 to 100.0 (%) or a physical variable 2).

1) Parameters in the setpoint and process value branches with the same unit

2) Parameters in the manipulated value branch with the same unit

11.4.1.5 Output parameters CONT_C

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1131

Parameter	Data type	Default	Description
LMN	REAL	0.0	The effective "Manipulated value" is output in floating point format at the "Manipulated value" output.
LMN_PER	WORD	W#16#0000	The manipulated value in I/O format is interconnected on the input "Manipulated value I/O" with the controller.
QLMN_HLM	BOOL	FALSE	The manipulated value is always restricted to a high limit and low limit. The output "High limit of manipulated value reached" indicates that the high limit has been reached.
QLMN_LLM	BOOL	FALSE	The manipulated value is always restricted to a high limit and low limit. The output "Low limit of manipulated value reached" indicates that the low limit has been reached.
LMN_P	REAL	0.0	The "P-action" output contains the proportional action of the manipulated variable.
LMN_I	REAL	0.0	The "I-action" output contains the integral action of the manipulated variable.
LMN_D	REAL	0.0	The "D-action" output contains the derivative action of the manipulated variable.
PV	REAL	0.0	The effective process value is output at the "Process value" output.
ER	REAL	0.0	The effective system deviation is output at the "Error signal" output.

11.4.2 CONT_S

11.4.2.1 Description CONT_S

The CONT_S instruction is used on SIMATIC S7 automation systems to control technical processes with binary output value output signals for actuators with integrating behavior. During parameter assignment, you can activate or deactivate sub-functions of the PI step controller to adapt the controller to the controlled system. In addition to the functions in the process value branch, the instruction implements a complete proportional-plus-integral-action controller with binary output value output and the option of manually influencing the value of the output value. The step controller operates without a position feedback signal.

Application

You can use the controller as a PI fixed setpoint controller or in secondary control loops in cascade, blending or ratio controllers, however you cannot use it as the primary controller. The functions of the controller are based on the PI control algorithm of the sampling controller supplemented by the functions for generating the binary output signal from the analog actuating signal.

Call

The CONT_S instruction has an initialization routine that is run through when input parameter COM_RST = TRUE is set. All the signal outputs are set to zero. COM_RST = FALSE has to be set after the initialization routine has been completed.

The calculation of the values in the control blocks is only correct if the block is called at regular intervals. You should therefore call the control blocks in a cyclic interrupt OB (OB 30 to OB 38). Enter the sampling time in the CYCLE parameter.

Error information

The error message word RET_VAL is not evaluated by the block.

11.4.2.2 Mode of operation CONT_S

Setpoint branch

The setpoint is entered in floating-point format at the SP_INT input.

Process value branch

The process value can be input in I/O or floating-point format. The function CRP_IN converts the I/O value PV_PER to a floating-point format -100 to +100 % in accordance with the following rule:

Output of CRP_IN = PV_PER * 100 / 27648

The PV_NORM function normalizes the output of CRP_IN according to the following rule:

Output of PV_NORM = (output of CRP_IN) * PV_FAC + PV_OFF

PV_FAC has a default of 1 and PV_OFF a default of 0.

Forming the error signal

The difference between the setpoint and process value is the error signal. To suppress a small constant oscillation due to the manipulated variable quantization (for example, due to a limited resolution of the manipulated value by the control valve), a dead band is applied to the error signal (DEADBAND). With DEADB_W = 0, the dead band is switched off.

PI step algorithm

The instruction operates without position feedback. The I-action of the PI algorithm and the assumed position feedback signal are calculated in **one** integral action (INT) and compared with the remaining P-action as a feedback value. The difference is applied to a three-step element (THREE_ST) and a pulse shaper (PULSEOUT) that generates the pulses for the control valve. The switching frequency of the controller can be reduced by adapting the response threshold of the three-step element.

Feedforward control

A disturbance variable can be added at the DISV input.

11.4.2.3 Block diagram CONT_S

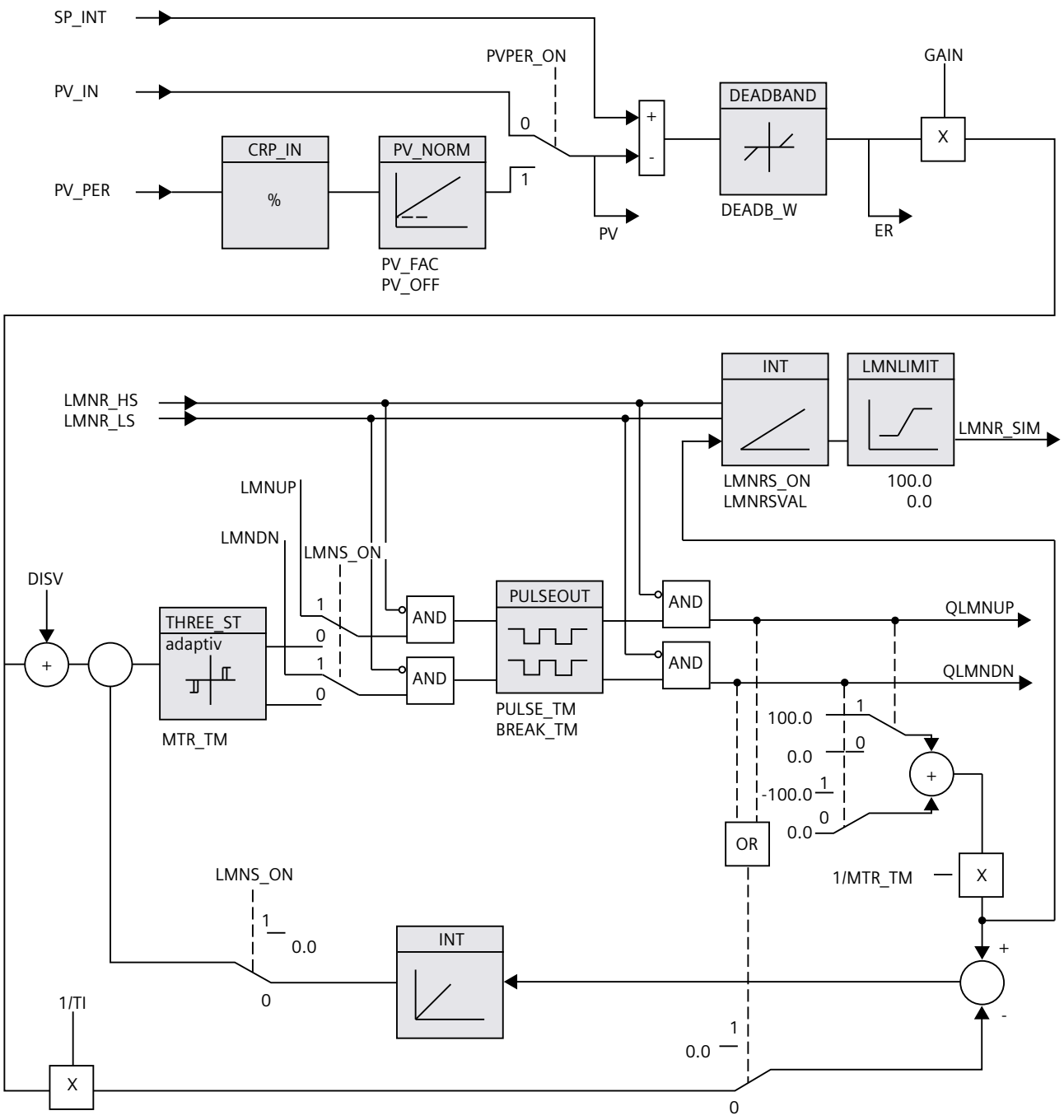

11.4.2.4 Input parameters CONT_S

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1132

Parameters	Data type	Default	Description
COM_RST	BOOL	FALSE	The block has an initialization routine that is processed when the "Restart" input is set.
LMNR_HS	BOOL	FALSE	The signal "Control valve at high endstop" is interconnected at the input "High endstop signal of position feedback". LMNR_HS=TRUE means: The control valve is at high end-stop.
LMNR_LS	BOOL	FALSE	The signal "Control valve at low endstop" is interconnected on the input "Low endstop signal of position feedback". LMNR_LS=TRUE means The control valve is at low endstop.
LMNS_ON	BOOL	FALSE	Manipulated value signal processing is switched to manual mode at the "Enable manual mode of manipulated signal".
LMNUP	BOOL	FALSE	The output signal QLMNUP is operated in manual mode of the manipulated value signals at the input "Manipulated value signal up".
LMNDN	BOOL	FALSE	The output signal QLMNDN is operated in manual mode of the manipulated value signals at the input "Manipulated value signal down"
PVPER_ON	BOOL	FALSE	If the process value is to be read from the I/O then the input PV_PER must be interconnected with the I/O and the input "Enable process value I/O" must be set.
CYCLE	TIME	T#1s	The time between block calls must be constant. The "Sampling time" input specifies the time between block calls. CYCLE >= 1ms
SP_INT	REAL	0.0	The input "Internal setpoint" is used to specify a setpoint. Permissible are values from -100 to 100 % or a physical variable [1].
PV_IN	REAL	0.0	At the "Process value input" you can assign parameters to a commissioning value or you can interconnect an external process value in floating-point format. Permissible are values from -100 to 100 % or a physical variable [1].
PV_PER	WORD	W#16#0-000	The process value in I/O format is interconnected with the controller at the "Process value I/O" input.
GAIN	REAL	2.0	The "Proportional gain" input specifies controller amplification.
TI	TIME	T#20s	The "Integration time" input determines the time response of the integral action. TI >= CYCLE
DEADB_W	REAL	1.0	A dead band is applied to the system deviation. The "Dead band width" input determines the size of the dead band. Permissible are values from 0 to 100 % or a physical variable [1].
PV_FAC	REAL	1.0	The "Process value factor" input is multiplied by the process value. The input is used to scale the process value range.
PV_OFF	REAL	0.0	The input "Process value offset" is added to the process value. The input is used to scale the process value range.
PULSE_TM	TIME	T#3s	You can assign a minimum pulse time at the parameter "Minimum pulse time". PULSE_TM >= CYCLE

Parameters	Data type	Default	Description
BREAK_TM	TIME	T#3s	You can assign a minimum break time at the parameter "Minimum break time". BREAK_TM >= CYCLE
MTR_TM	TIME	T#30s	The time required by the actuator to move from limit stop to limit stop is entered at the "Motor actuating time" parameter. MTR_TM >= CYCLE
DISV	REAL	0.0	For feedforward control, the disturbance variable is interconnected to the "Disturbance variable" input. Permissible are values from -100 to 100 % or a physical variable [2].

[1] Parameters in setpoint and process value branches with identical unit

[2] Parameters in the manipulated value branch with same unit

11.4.2.5 Output parameters CONT_S

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1133

Parameters	Data type	Default	Description
QLMNUP	BOOL	FALSE	If the output "Manipulated value signal up" is set then the control valve should be open.
QLMNDN	BOOL	FALSE	If the output "Manipulated value signal down" is set then the control valve should be closed.
PV	REAL	0.0	The effective process value is output at the "Process value" output.
ER	REAL	0.0	The effective system deviation is output at the "Error signal" output.

11.4.3 PULSEGEN

11.4.3.1 Description PULSEGEN

The instruction PULSEGEN serves as the structure of a PID controller with impulse output for proportional actuators. PULSEGEN transforms the input value INV (= LMN of the PID controller) through modulation of the impulse width in an impulse sequence with a constant period duration, which corresponds with the cycle time with which the input value is updated.

Application

You can use the PULSEGEN instruction to configure two- or three-step PID controllers with pulse width modulation. The function is normally used in conjunction with the continuous controller CONT_C.

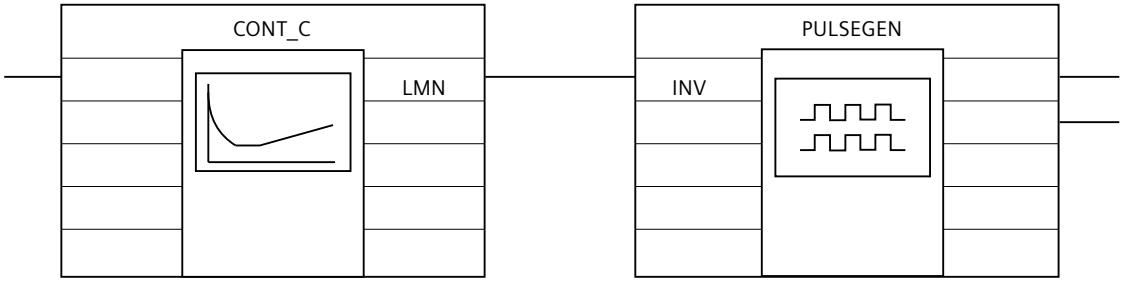

Call

The PULSEGEN instruction has an initialization routine that is run through when input parameter COM_RST = TRUE is set. All the signal outputs are set to zero. COM_RST = FALSE has to be set after the initialization routine has been completed.

The calculation of the values in the control blocks is only correct if the block is called at regular intervals. You should therefore call the control blocks in a cyclic interrupt OB (OB 30 to OB 38). Enter the sampling time in the CYCLE parameter.

Responses in the event of an error

The error message word RET_VAL is not evaluated by the block.

11.4.3.2 Mode of operation PULSEGEN

Impulse width modulation

The duration of a pulse per period duration is proportional to the input variable. The cycle assigned via PER_TM is not identical to the processing cycle of the PULSEGEN instruction. Rather, a PER_TM cycle is made up of several processing cycles of the PULSEGEN instruction, whereby the number of PULSEGEN calls per PER_TM cycle determines the accuracy of the pulse width.

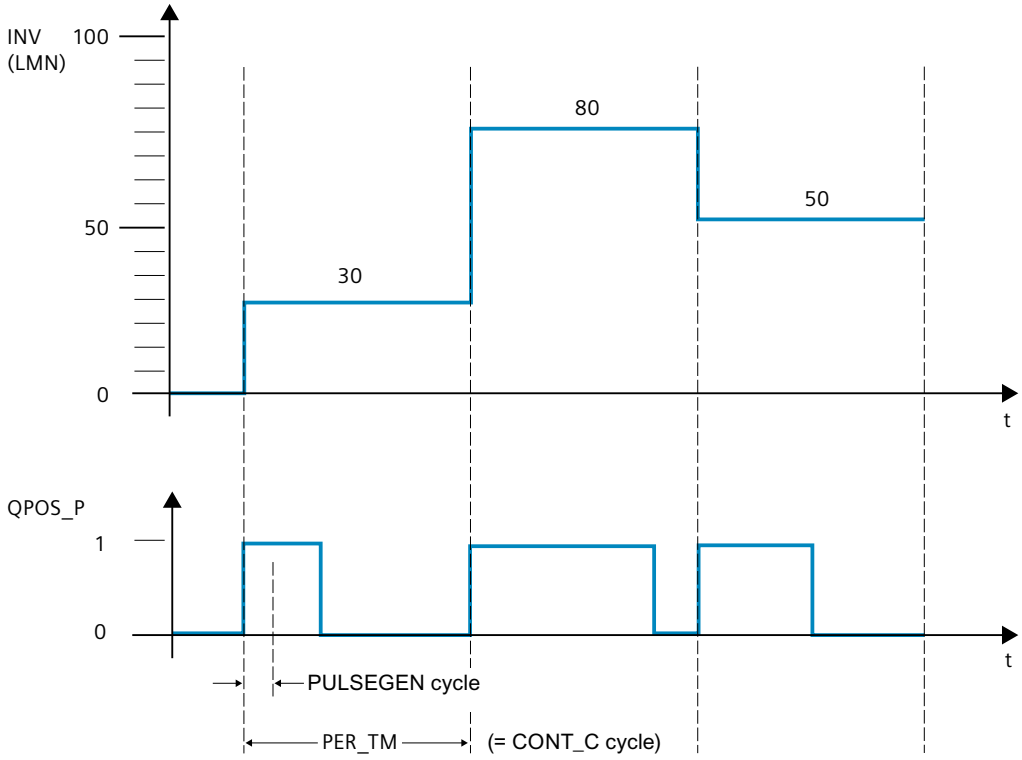

An input variable of 30% and 10 PULSEGEN calls per PER_TM mean the following:

- "One" at the QPOS_P output for the first three calls of PULSEGEN (30% of 10 calls)
- "Zero" at the QPOS_P output for seven further calls of PULSEGEN (70% of 10 calls)

Block diagram

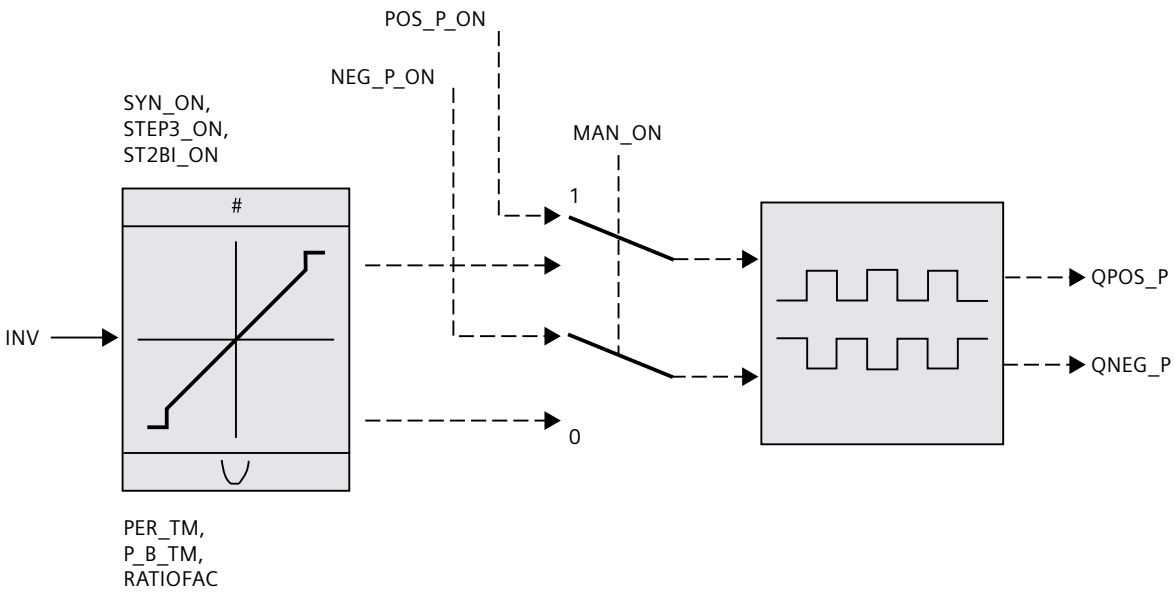

Accuracy of the manipulated value

With a "Sampling ratio" of 1:10 (CONT_C calls to PULSEGEN calls) the accuracy of the manipulated value in this example is restricted to 10%, in other words, set input values INV can only be simulated by a pulse duration at the QPOS_P output in steps of 10 %.

The accuracy is increased as the number of PULSEGEN calls per CONT_C call is increased.

If PULSEGEN is called, for example, 100 times more often than CONT_C, a resolution of 1 % of the manipulated value range is achieved.

NOTE

The reduction ratio of the call frequency must be programmed by the user.

Automatic synchronization

It is possible to automatically synchronize the pulse output with the instruction that updates the input variable INV (e.g. CONT_C). This ensures that a change in the input variable is output as quickly as possible as a pulse.

The pulse shaper evaluates the input value INV at intervals corresponding to the period duration PER_TM and converts the value into a pulse signal of corresponding length.

Since, however, INV is usually calculated in a slower cyclic interrupt class, the pulse shaper should start the conversion of the discrete value into a pulse signal as soon as possible after the updating of INV.

To allow this, the block can synchronize the start of the period using the following procedure:

If INV changes and if the block call is not in the first or last two call cycles of a period, a synchronization is performed. The pulse duration is recalculated and in the next cycle is output with a new period.

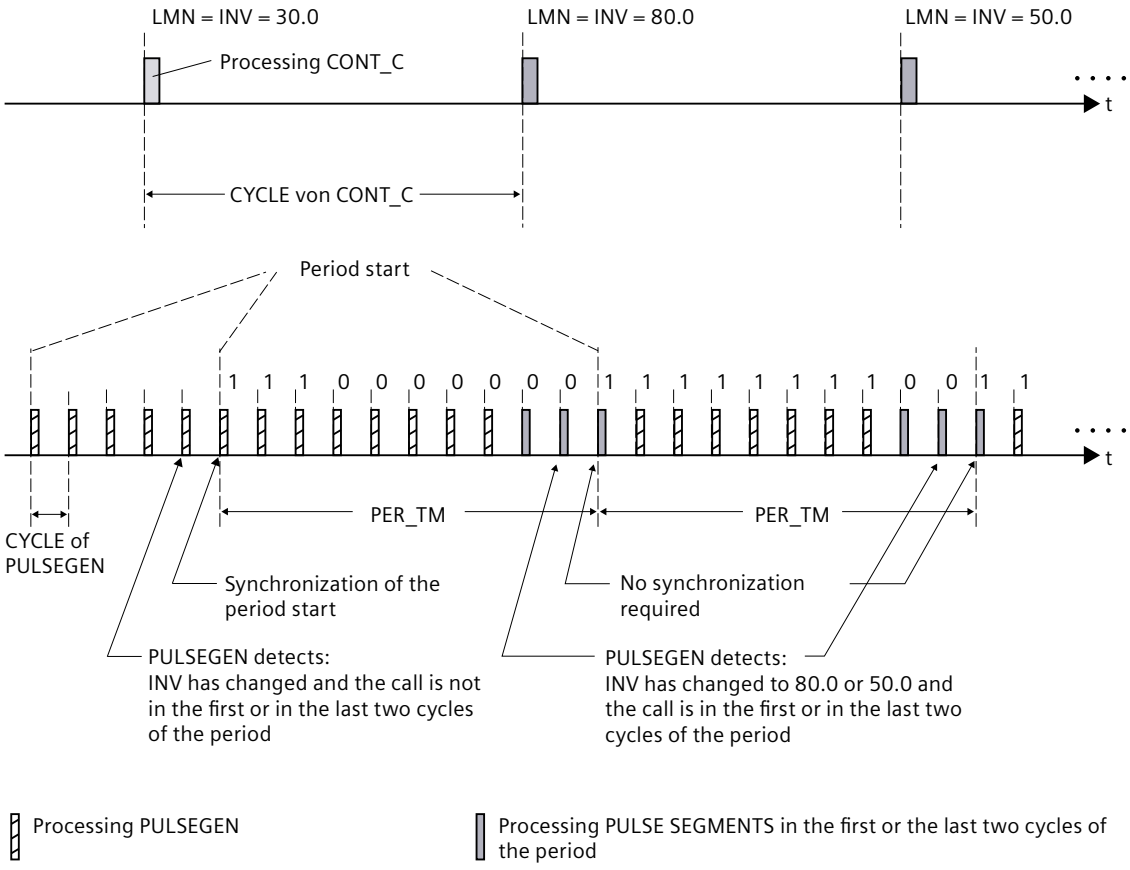

The automatic synchronization is switched off, if SYN_ON = FALSE.

NOTE

The start of a new period and subsequent synchronization usually leads to a certain imprecision when the old value of INV (i.e. of LMN) is mapped to the pulse signal.

11.4.3.3 Mode of operation PULSEGEN

Modes

Depending on the parameters assigned to the pulse shaper, PID controllers with a three-step output or with a bipolar or unipolar two-step output can be configured. The following table illustrates the setting of the switch combinations for the possible modes.

Mode	MAN_ON	STEP3_ON	ST2BI_ON
Three-step control	FALSE	TRUE	Any
Two-step control with bi-polar Manipulating range (-100 % to 100 %)	FALSE	FALSE	TRUE
Two-step control with unipolar Manipulating range (0 % to 100 %)	FALSE	FALSE	FALSE
Manual mode	TRUE	Any	Any

Manual mode in two/three-step control

In the manual mode (MAN_ON = TRUE), the binary outputs of the three-step or two-step controller can be set using the signals POS_P_ON and NEG_P_ON regardless of INV.

Control	POS_P_ON	NEG_P_ON	QPOS_P	QNEG_P
Three-step control	FALSE	FALSE	FALSE	FALSE
	TRUE	FALSE	TRUE	FALSE
	FALSE	TRUE	FALSE	TRUE
	TRUE	TRUE	FALSE	FALSE
Two-step control	FALSE	Any	FALSE	TRUE
	TRUE	Any	TRUE	FALSE

11.4.3.4 Three-step control

Three-step control

In "Three-step control" mode, it is possible to generate three statuses of the actuating signal. For this, the status values of the binary output signals QPOS_P and QNEG_P are assigned to the respective operating statuses of the actuator. The table shows the example of a temperature control:

Output signals	Heat	Off	Cool
QPOS_P	TRUE	FALSE	FALSE
QNEG_P	FALSE	FALSE	TRUE

The pulse duration is calculated from the input variable via a characteristic curve. The form of the characteristic curve is defined by the minimum pulse duration or minimum interval and the ratio factor. The normal value for the ratio factor is 1.

The "doglegs" in the curves are caused by the minimum pulse duration or minimum interval.

Minimum pulse duration or minimum interval

A correctly assigned minimum pulse duration or minimum interval P_B_TM can prevent short on/off times, which reduce the working life of switching elements and actuators. Small absolute values of input variable LMN that could otherwise generate a pulse duration shorter than P_B_TM are suppressed. Large input values that would generate a pulse duration longer than PER_TM - P_B_TM are set to 100% or -100%.

The duration of positive or negative pulses is calculated by multiplying the input variable (in %) by the period duration:

Pulse duration = INV / 100 * PER_TM

The following figure shows a symmetrical characteristic curve of the three-step controller (ratio factor = 1).

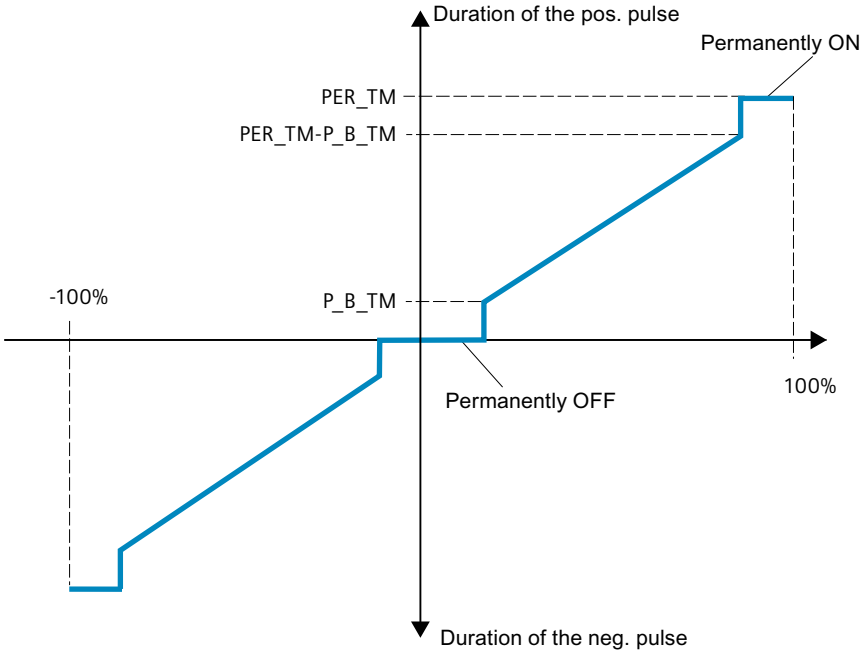

Asymmetrical three-step control

Using the ratio factor RATIOFAC, the ratio of the duration of positive to negative pulses can be changed. In a thermal process, for example, this would allow different system time constants for heating and cooling.

Ratio factor < 1

The pulse duration at the negative pulse output, calculated by multiplying the input variable by the period duration, is multiplied by the ratio factor.

Positive pulse duration = INV /100 * PER_TM

Negative pulse duration = INV / 100 * PER_TM * RATIOFAC

The following figure shows the asymmetrical characteristic curve of the three-step controller (ratio factor = 0.5):

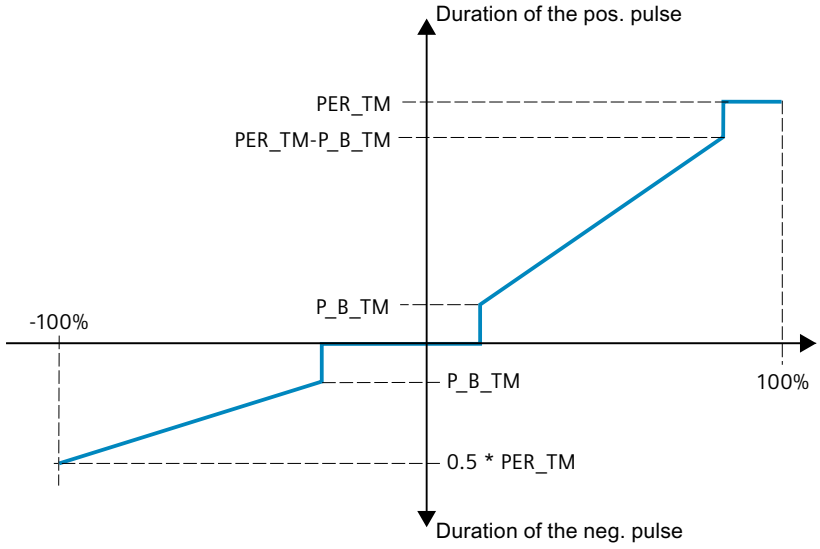

Ratio factor > 1

The pulse duration at the positive pulse output, calculated by multiplying the input variable by the period duration, is divided by the ratio factor.

Positive pulse duration = INV / 100 * PER_TM / RATIOFAC

Negative pulse duration = INV / 100 * PER_TM

11.4.3.5 Two-step control

In two-step control, only the positive pulse output QPOS_P of PULSEGEN is connected to the on/off actuator. Depending on the manipulated value range used, the two-step controller has a bipolar or a unipolar manipulated value range.

Two-step control with bipolar manipulated variable range (-100% to 100%)

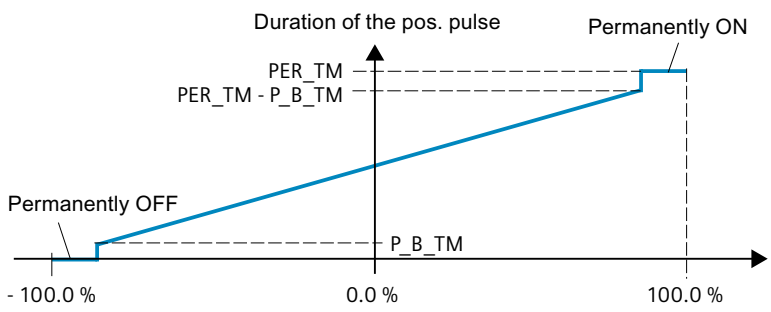

Two-step control with unipolar manipulated variable range (0% to 100%)

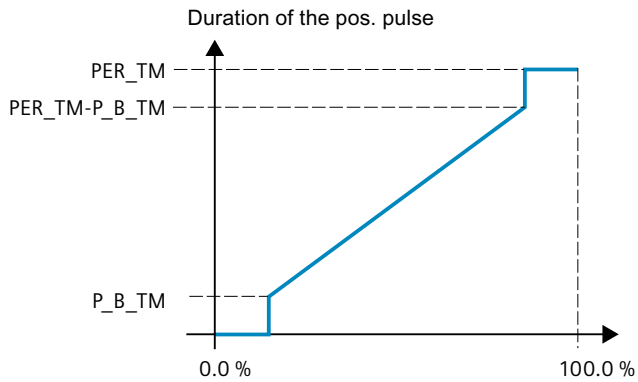

The negated output signal is available at QNEG_P if the connection of the two-step controller in the control loop requires a logically inverted binary signal for the actuating pulses.

Pulse	Actuator On	Actuator Off
QPOS_P	TRUE	FALSE
QNEG_P	FALSE	TRUE

11.4.3.6 Input parameters PULSEGEN

The values of the input parameters are not limited in the block. There is no parameter check.

Table 3-1134

Parameters	Data type	Default	Description
INV	REAL	0.0	At the input parameter "Input variable" an analog manipulated variable is connected. Values from -100 to 100 % are permitted.
PER_TM	TIME	T#1s	At the parameter "Period duration" the constant period duration of the pulse width modulation is entered. This corresponds to the sampling time of the controller. The ratio between the sampling time of the pulse shaper and the sampling time of the controller determines the accuracy of the pulse width modulation. PER_TM >=20*CYCLE
P_B_TM	TIME	T#50 ms	You can assign a minimum pulse/break time at the parameter "Minimum pulse/break time". P_B_TM >= CYCLE
RATIOFAC	REAL	1.0	Using the "Ratio factor" input parameter the ratio of the duration of positive to negative pulses can be changed. In a thermal process, this would, for example, allow different time constants for heating and cooling to be compensated (for example, in a process with electrical heating and water cooling). Values from 0.1 to 10.0 are permitted.
STEP3_ON	BOOL	TRUE	At the input parameter "Enable three-step control" the appropriate mode is activated. In three-step control both output signals are active.
ST2BI_ON	BOOL	FALSE	At the input parameter "Enable two-step control for bipolar manipulated value range" you can select from the modes "Two-step control for bipolar manipulated value range" and "Two-step control for unipolar manipulated value range". STEP3_ON = FALSE is required.
MAN_ON	BOOL	FALSE	Setting the input parameter "Enable manual mode" allows the output signals to be set manually.

Parameters	Data type	Default	Description
POS_P_ON	BOOL	FALSE	For manual mode three-step control, the output signal QPOS_P can be operated on the input parameter "Positive pulse on". In manual mode with two-step control, QNEG_P is always set inversely to QPOS_P.
NEG_P_ON	BOOL	FALSE	For manual mode three-step control, the output signal QNEG_P can be operated on the input parameter "Negative pulse on". In manual mode with two-step control, QNEG_P is always set inversely to QPOS_P.
SYN_ON	BOOL	TRUE	By setting the input parameter "Enable synchronization", it is possible to synchronize the pulse output automatically with the block that updates the input variable INV. This ensures that a change in the input variable is output as quickly as possible as a pulse.
COM_RST	BOOL	FALSE	The block has an initialization routine that is processed when the input "Restart" is set.
CYCLE	TIME	T#10ms	The time between block calls must be constant. The "Sampling time" input specifies the time between block calls. CYCLE >= 1ms

11.4.3.7 Output parameter PULSEGEN

Table 3-1135

Parameters	Data type	Default	Description
QPOS_P	BOOL	FALSE	The output parameter "Output signal positive pulse" is set if a pulse will be output. In three-step control, this is always the positive pulse. In two-step control, the QNEG_P is always set inversely to QPOS_P.
QNEG_P	BOOL	FALSE	The output parameter "Output signal negative pulse" is set if a pulse will be output. In three-step control, this is always the negative pulse. In two-step control, QNEG_P is always set inversely to QPOS_P.

11.4.4 TCONT_CP

11.4.4.1 Description TCONT_CP

The instruction TCONT_CP is used to control temperature processes with continuous or pulsed control signals. The controller functionality is based on the PID control algorithm with additional functions for temperature processes. To improve the control response with temperature processes, the block includes a control zone and reduction of the proportional component if there is a setpoint step change.

The instruction can set the PI/PID parameters itself using the controller optimization function.

Application

The controller controls one actuator; in other words, with one controller you can either heat or cool but not both. If you use the block for cooling, GAIN must be assigned a negative value. This inversion of the controller means that if the temperature rises, for example, the manipulated variable LMN and with it the cooling action is increased.

Call

The instruction TCONT_CP must be called with a constant bus cycle time. To achieve this, use a cyclic interrupt priority class (for example, OB35 for an S7-300).

The TCONT_CP instruction has an initialization routine that is run through when input parameter COM_RST = TRUE is set. During initialization, the integral action is set to the initialization value I_ITVAL. All the signal outputs are set to zero. Following execution of the initialization routine, the block sets COM_RST back to FALSE. If you require initialization when the CPU restarts, call the block in OB100 with COM_RST = TRUE.

See also

Operating principle of the pulse generator (Page 453)

Block diagram TCONT_CP (Page 456)

11.4.4.2 Mode of operation TCONT_CP

Setpoint branch

The setpoint is entered at input SP_INT in floating-point format as a physical value or percentage. The setpoint and process value used to form the control deviation must have the same unit.

Process value options (PVPER_ON)

Depending on PVPER_ON, the process value can be read in, in the I/O or floating-point format.

PVPER_ON	Process Value Input
TRUE	The process value is read in via the analog I/Os (PIW xxx) at input PV_PER.
FALSE	The process value is acquired in floating-point format at input PV_IN.

Process value format conversion CRP_IN (PER_MODE)

The CRP_IN function converts the I/O value PV_PER to floating-point format depending on the PER_MODE switch according to the following rules:

PER_MODE	Output of CRP_IN	Analog Input Type	Unit
0	PV_PER * 0.1	Thermoelements; PT100/NI100; standard	°C;°F
1	PV_PER * 0.01	PT100/NI100; climate;	°C;°F
2	PV_PER * 100/27648	Voltage/current	%

Process value scaling PV_NORM (PF_FAC, PV_OFFS)

The PV_NORM function calculates the output of CRP_IN according to the following rule:

"Output of PV_NORM" = "Output of CRP_IN" * PV_FAC + PV_OFFS

It can be used for the following purposes:

- Process value adjustment with PV_FAC as process value factor and PV_OFFS as process value offset.
- Scaling of temperature to percentage

  You want to enter the setpoint as a percentage and must now convert the measured temperature value to a percentage.
- Scaling of percentage to temperature

  You want to enter the setpoint in the physical temperature unit and must now convert the measured voltage/current value to a temperature.

Calculation of the parameters:

- PV_FAC = range of PV_NORM/range of CRP_IN;
- PV_OFFS = LL (PV_NORM) - PV_FAC * LL(CRP_IN);

  where LL: Low limit

The scaling is switched off with the default values (PV_FAC = 1.0 and PV_OFFS = 0.0). The effective process value is output at the PV output.

NOTE

With pulse control, the process value must be transferred to the block in the fast pulse call (reason: mean value filtering). Otherwise, the control quality can deteriorate.

Example of Process Value Scaling

If you want to enter the setpoint as a percentage, and you have a temperature range of -20 to 85 °C applied to , CRP_IN you must normalize the temperature range as a percentage.

The diagram below shows an example of adapting the temperature range -20 to 85 °C to an internal scale of 0 to 100 %:

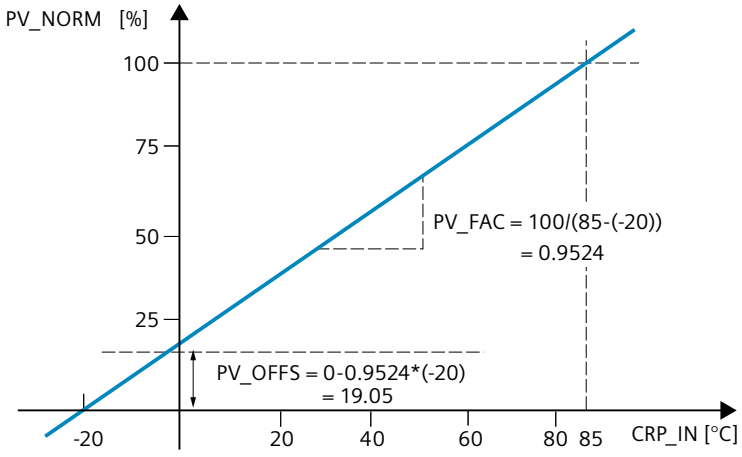

Forming the control deviation

The difference between the setpoint and process value is the control deviation before the dead zone.

The setpoint and process value must exist in the same unit.

Dead zone (DEADB_W)

To suppress a minor sustained oscillation due to the manipulated variable quantization (for example, in pulse width modulation with PULSEGEN) a dead zone is applied to the (DEADBAND) control deviation. With DEADB_W = 0.0, the dead zone is disabled. The effective control deviation is indicated by the ER parameter.

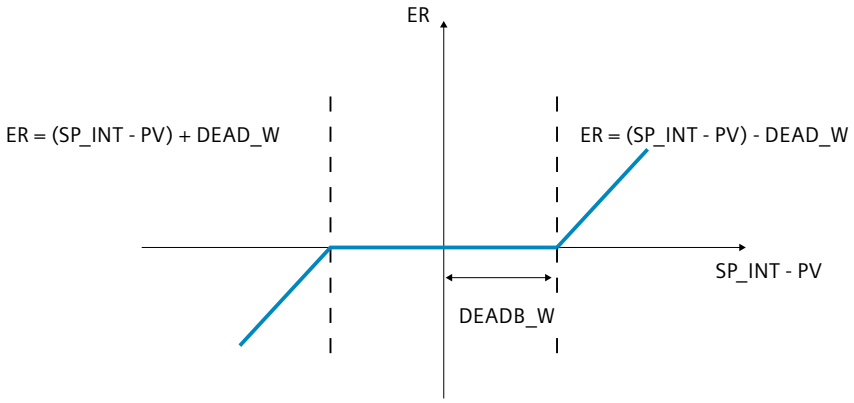

PID algorithm

The following figure shows the block diagram of the PID algorithm.

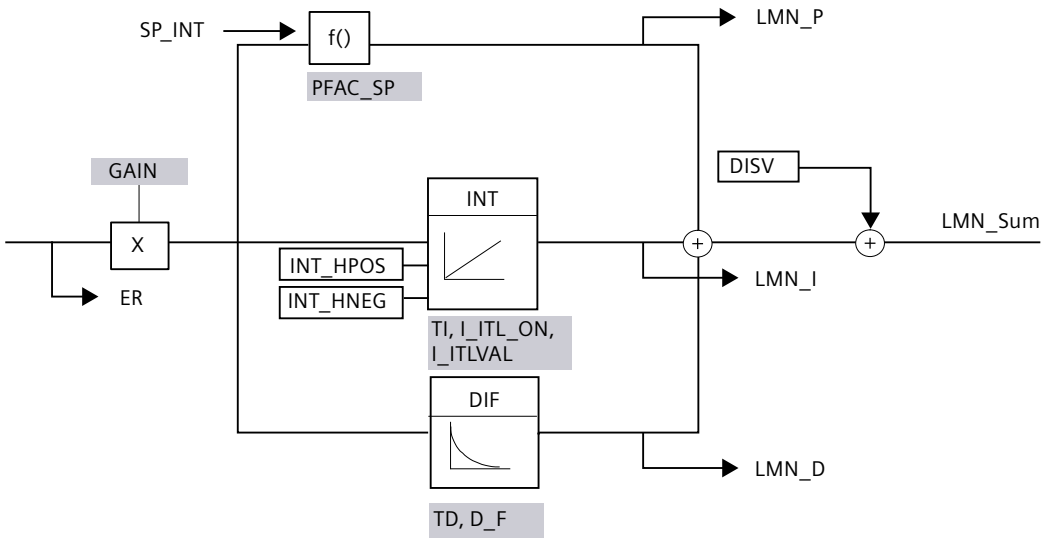

PID algorithm (GAIN, TI, TD, D_F)

The PID algorithm operates as a position algorithm. The proportional, integral (INT), and derivative (DIF) actions are connected in parallel and can be activated or deactivated individually. This allows P, PI, PD, and PID controllers to be configured.

Controller tuning supports PI and PID controllers. Controller inversion is implemented using a negative GAIN (cooling controller).

If you set TI and TD to 0.0, you obtain a pure P controller at the operating point.

The step response in the time range is:

$$LMN_Sum(t) = GAIN \cdot ER(0) \cdot \left(1 + \frac{1}{TI} \cdot t + D_F \cdot e^{\frac{-t}{TD\ /\ D_F}}\right)$$

Where:

LMN_Sum(t) the manipulated variable in the controller's automatic mode

ER (0) is the step height of the normalized control deviation

GAIN is the controller gain

TI is the integration time

TD is the derivative action time

D_F is the derivative factor

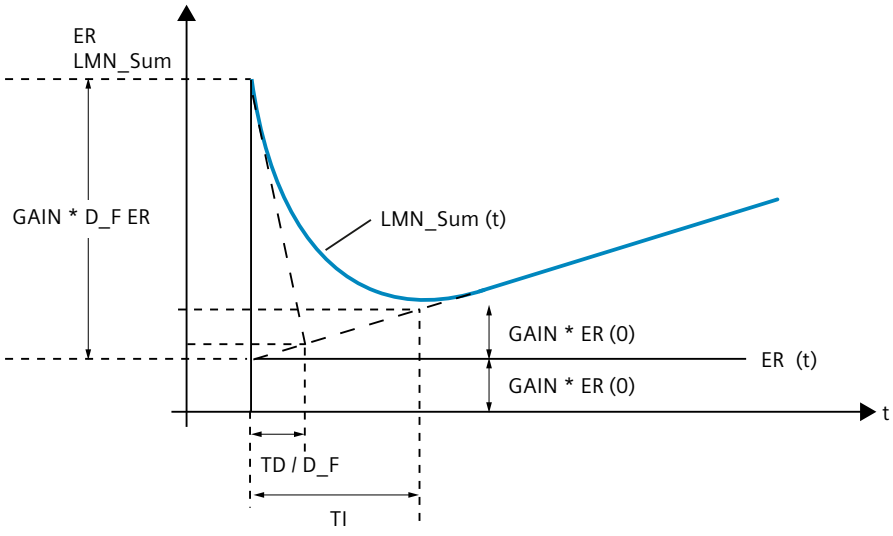

Integral action (TI, I_ITL_ON, I_ITLVAL)

In manual mode, it is corrected as follows: LMN_I = LMN - LMN_P - DISV.

If the output value is limited, the integral action is halted. If the control deviation moves the integral action back in the direction of the output range, the integral action is enabled again.

The integral action is also modified by the following measures:

- The integral action of the controller is deactivated by TI = 0.0
- Weakening of the proportional action when setpoint changes occur
- Control zone
- The output value limits can be modified online

Weakening of the proportional action when setpoint changes occur (PFAC_SP)

To prevent overshoot, you can weaken the proportional action using the "Proportional factor for setpoint changes" parameter (PFAC_SP). Using PFAC_SP, you can select continuously between 0.0 and 1.0 to decide the effect of the proportional action when the setpoint changes:

- PFAC_SP = 1.0: Proportional action for setpoint change is fully effective
- PFAC_SP = 0.0: Proportional action for setpoint change is not effective

The weakening of the proportional action is achieved by compensating the integral action.

Derivative action (TD, D_F)

- The derivative action of the controller is deactivated by TD = 0.0
- If the derivative action is active, the following relationship should apply:

  TD = 0.5 * CYCLE * D_F

Parameter Settings of a P or PD Controller with Operating Point

In the user interface, deactivate the integral action (TI = 0.0) and possibly also the derivative action (TD = 0.0). Then make the following parameter settings:

- I_ITL_ON = TRUE
- I_ITLVAL = operating point;

Feedforward control (DISV)

A disturbance variable can be added at the DISV input.

Calculating the output value

The diagram below is the block diagram of the output value calculation:

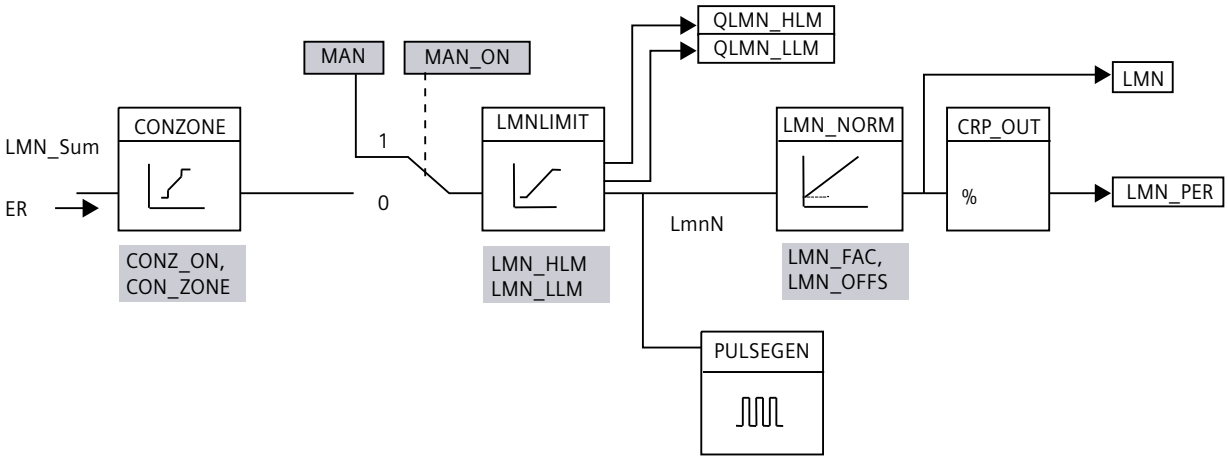

Parameter configuration interface

Instruction call interface

Parameter configuration interface, call interface

Control zone (CONZ_ON, CON_ZONE)

If CONZ_ON = TRUE, the controller operates with a control zone. This means that the controller operates according to the following algorithm:

- If process value PV exceeds the setpoint SP_INT by more than CON_ZONE, the value LMN_LLM is output as the manipulated variable.
- If the process value PV falls below setpoint SP_INT by more than CON_ZONE, LMN_HLM is output.
- If the process value PV is within the control zone (CON_ZONE), the output value takes its value from the PID algorithm LMN_Sum.

NOTE

Changing the manipulated variable from LMN_LLM or LMN_HLM to LMN_Sum occurs under compliance of a hysteresis of 20% of the control zone.

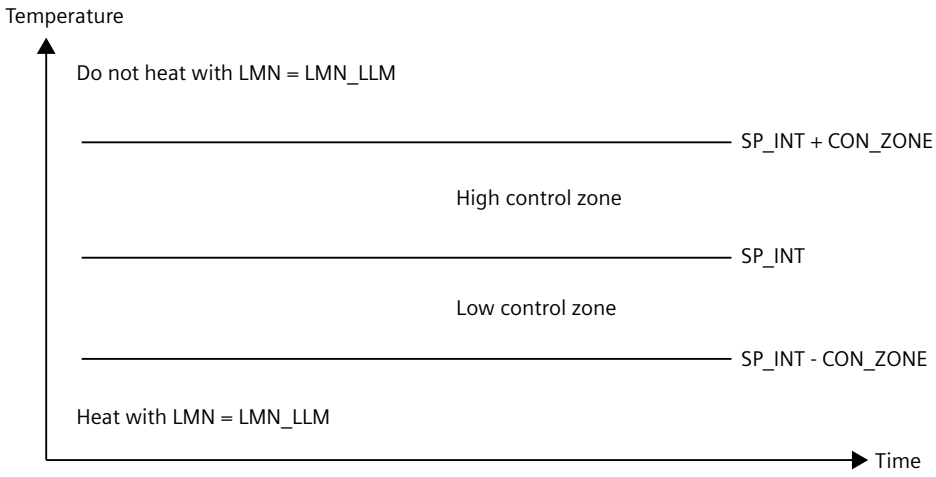

NOTE

Before enabling the control zone manually, make sure that the control zone band is not too narrow. If the control zone band is too small, oscillations will occur in the manipulated variable and process value.

Advantage of the Control Zone

When the process value enters the control zone, the D-action causes an extremely fast reduction of the manipulated variable. This means that the control zone is only useful when the D-action is activated. Without a control zone, only the reducing proportional action would essentially reduce the manipulated variable. The control zone leads to faster settling without overshoot or undershoot if the output minimum or maximum manipulated variable is a long way from the manipulated variable required for the new operating point.

Manual value processing (MAN_ON, MAN)

You can change over between manual and automatic mode. In manual mode, the manipulated variable is corrected to a manually selected value.

The integral action (INT) is set internally to LMN - LMN_P - DISV and the derivative action (DIF) is set to 0 and synchronized internally. Changeover to automatic mode is therefore bumpless.

NOTE

The MAN_ON parameter has no effect during tuning.

Output value limit LMNLIMIT (LMN_HLM, LMN_LLM)

The LMNLIMIT function is used to limit the output value to the limits LMN_HLM and LMN_LLM. If these limits are reached, this is indicated by the message bits QLMN_HLM and QLMN_LLM.

If the output value is limited, the integral action is halted. If the control deviation moves the integral action back in the direction of the output range, the integral action is enabled again.

Changing the Manipulated Value Limits Online

If the range of the output value is reduced and the new unlimited value of the output value is outside the limits, the integral action and therefore the output value shifts.

The output value is reduced by the same amount as the output value limit changed. If the output value was unlimited prior to the change, it is set exactly to the new limit (described here for the high output value limit).

Scaling of output value LMN_NORM (LMN_FAC, LMN_OFFS)

The LMN_NORM function normalizes the output value according to the following rule:

LMN = LmnN * LMN_FAC + LMN_OFFS

It can be used for the following purposes:

- Output value scaling with LMN_FAC as output value factor and LMN_OFFS as output value offset.

The output value is also available in I/O format. The CRP_OUT function converts the LMN floating-point value to an I/O value according to the following rule:

LMN_PER = LMN * 27648/100

The scaling is switched off with the default values (LMN_FAC = 1.0 and LMN_OFFS = 0.0). The effective output value is sent to output LMN.

Save controller parameters SAVE_PAR

If you classify the current controller parameters as utilizable, you can save these before a manual change in structure parameters provided specifically for this in the instance DB of the instruction TCONT_CP. If you optimize the controller, the saved parameters are overwritten by the values that were valid prior to tuning.

PFAC_SP, GAIN, TI, TD, D_F, CONZ_ON and CONZONE are written to the structure PAR_SAVE.

Reloading Saved Controller Parameters UNDO_PAR

The last controller parameter settings you saved can be activated for the controller again using this function (in manual mode only).

Change between PI and PID parameters LOAD_PID (PID_ON)

Following tuning, the PI and PID parameters are stored in the PI_CON and PID_CON structures. Depending on PID_ON, you can use LOAD_PID in manual mode to write the PI or PID parameters to the effective controller parameters.

PID parameters PID_ON = TRUE	PI parameters PID_ON = FALSE
• GAIN = PID_CON.GAIN • TI = PID_CON.TI • TD = PID_CON.TD	• GAIN = PI_CON.GAIN • TI = PI_CON.TI

NOTE

The controller parameters are only written back to the controller with UNDO_PAR or LOAD_PID, if the controller gain is not equal to 0:

With LOAD_PID, the parameters are only copied if the corresponding GAIN <> 0 is (either the PI or PID parameters). This strategy takes into account the situation that no tuning has yet been made or that PID parameters are missing. If PID_ON = TRUE and PID.GAIN = FALSE, PID_ON is set to FALSE and the PI parameter is copied.

- D_F, PFAC_SP are preset by the tuning. These can then be modified by the user. LOAD_PID does not change these parameters.
- With LOAD_PID, the control zone is always recalculated (CON_ZONE = 250/GAIN), even if CONZ_ON = FALSE.

See also

Operating principle of the pulse generator (Page 453)

Block diagram TCONT_CP (Page 456)

11.4.4.3 Operating principle of the pulse generator

The function PULSEGEN transforms the analog manipulated value LmnN through pulse width module into an impulse sequence with the period duration PER_TM. PULSEGEN is switched on with PULSE_ON = TRUE and is processed in the cycle CYCLE_P.

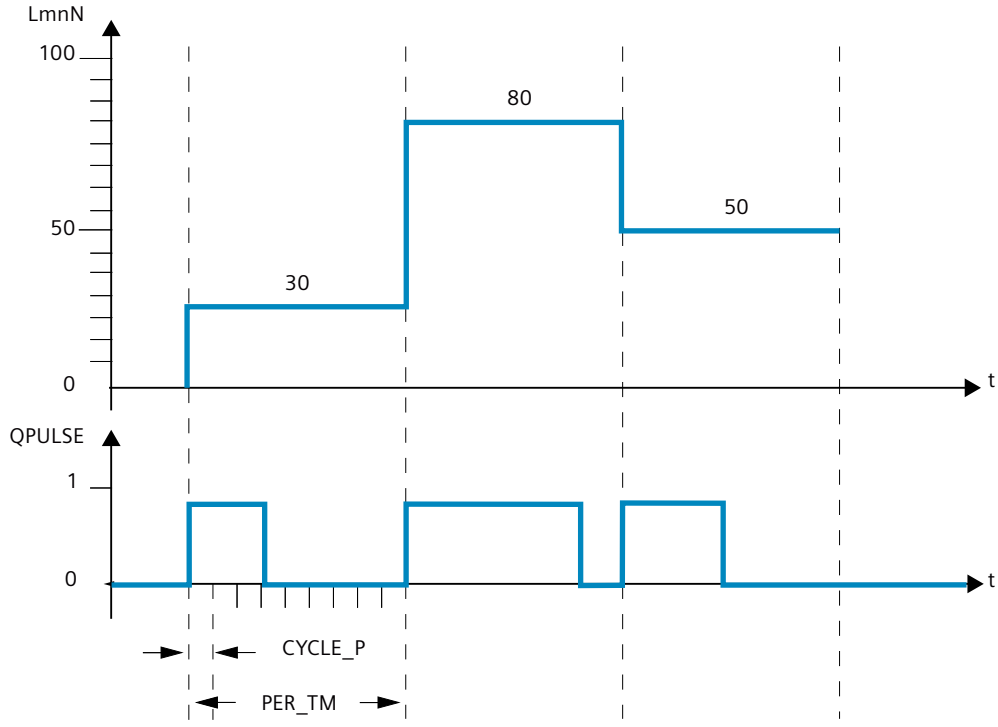

A manipulated value of LmnN = 30% and 10 PULSEGEN calls per PER_TM therefore means:

- TRUE at output QPULSE for the first three PULSEGEN calls
  (30% of 10 calls)
- FALSE at output QPULSE for seven further PULSEGEN calls
  (70% of 10 calls)

The duration of a pulse per pulse repetition period is proportional to the manipulated variable and is calculated as follows:

Pulse duration = PER_TM * LmnN /100

By suppressing the minimum pulse or break time, the characteristic curve of the conversion develops "knees" in the start and end regions.

The following diagram illustrates two-step control with a unipolar manipulated variable range (0% to 100%):

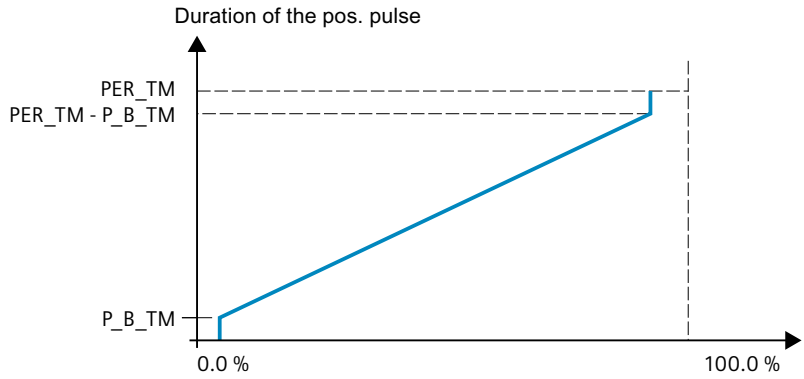

Minimum pulse or minimum break time (P_B_TM)

Short on or off times hinder the lifespan of actuators and fine controlling units. These can be avoided by setting a minimum pulse duration or minimum break time P_B_TM.

Small absolute values of input variable LmnN that could otherwise generate a pulse duration shorter than P_B_TM are suppressed.

Large input values that would generate a pulse duration greater than PER_TM - P_B_TM are set to 100%. This reduces the dynamic response of pulse generation.

Set values of P_B_TM ≤ 0,1 * PER_TM are recommended for the minimum pulse duration and the minimum break duration.

The "knees" in the curves in the diagram above are caused by the minimum pulse or minimum break times.

The following schematic illustrates the switching response of the pulse output:

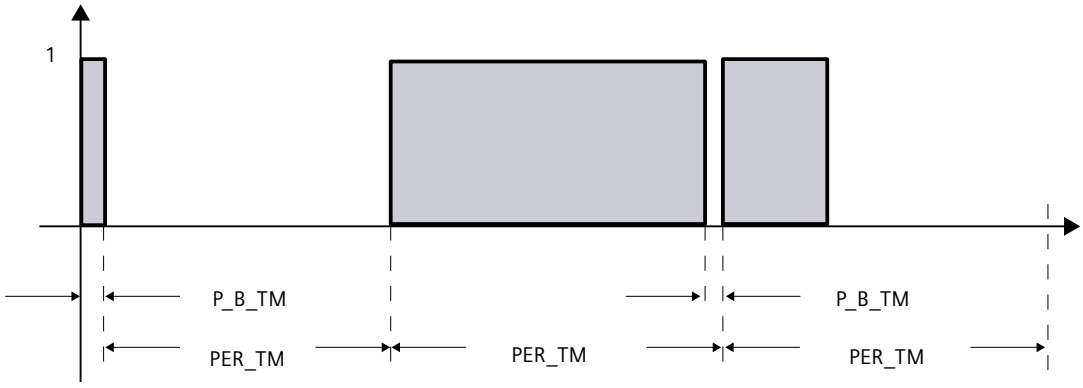

Accuracy of pulse generation

The smaller the pulse generator CYCLE_P is compared to the period duration PER_TM, the more precise the pulse width modulation is. To achieve sufficiently accurate control, the following relationship should apply:

CYCLE_P ≤ PER_TM/50

The manipulated value is transformed with a resolution of ≤ 2 % into an impulse.

NOTE

When calling the controller in the pulse shaper cycle, you must note the following:

Calling the controller in the pulse shaper cycle will cause the process value to be averaged. As a result, at output PV, different values may be at input PV_IN and PV_PER. If you want to track the setpoint value, you must save the process value at input parameter PV_IN at the call times for complete controller processing (QC_ACT = TRUE). For pulse shaper calls occurring between these times, you must supply the input parameters PV_IN and SP_INT with the saved process value.

See also

Description TCONT_CP (Page 443)
Mode of operation TCONT_CP (Page 444)
Block diagram TCONT_CP (Page 456)
Input parameters TCONT_CP (Page 457)
Output parameters TCONT_CP (Page 458)
In/out parameters TCONT_CP (Page 458)
Static variables TCONT_CP (Page 459)
Parameter STATUS_H (Page 463)
Parameters STATUS_D (Page 464)

11.4.4.4 Block diagram TCONT_CP

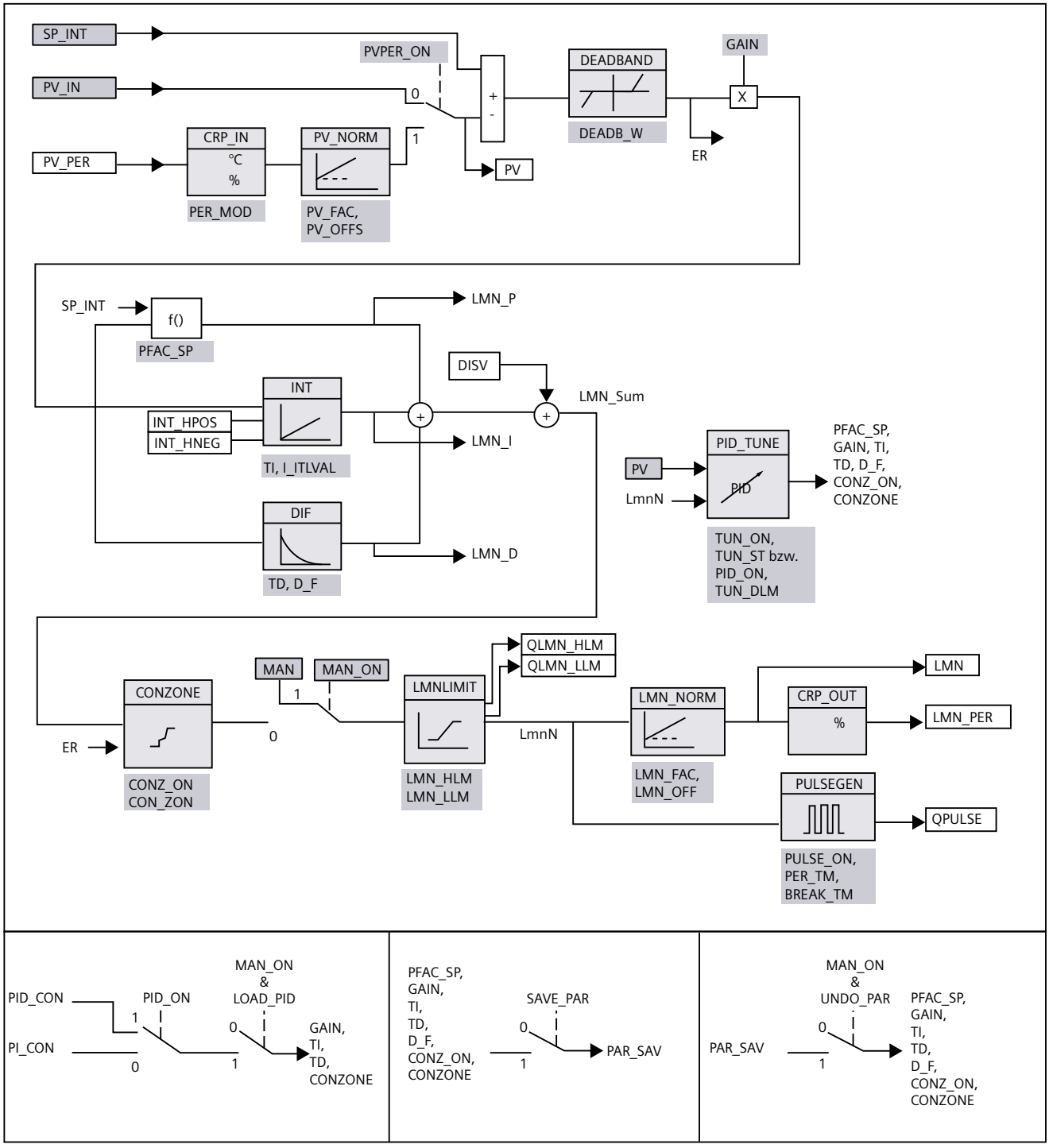

See also

Description TCONT_CP (Page 443)
Mode of operation TCONT_CP (Page 444)
Operating principle of the pulse generator (Page 453)
Input parameters TCONT_CP (Page 457)
Output parameters TCONT_CP (Page 458)
In/out parameters TCONT_CP (Page 458)
Static variables TCONT_CP (Page 459)
Parameter STATUS_H (Page 463)
Parameters STATUS_D (Page 464)

11.4.4.5 Input parameters TCONT_CP

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1136

Parameters	Address	Data type	Default	Description
PV_IN	0.0	REAL	0.0	At the "Process value input" you can assign parameters to a commissioning value or you can interconnect an external process value in floating-point format. The valid values depend on the sensors used.
PV_PER	4.0	INT	0	The process value in I/O format is interconnected with the controller at the "Process value I/O" input.
DISV	6.0	REAL	0.0	For feedforward control, the disturbance variable is interconnected to the "Disturbance variable" input.
INT_HPOS	10.0	BOOL	FALSE	The output of the integral action can be held in the positive direction. For this, the input INT_HPOS must be set to TRUE. In a cascade control, INT_HPOS of the primary controller is connected to QLMN_HLM of the secondary controller.
INT_HNEG	10.1	BOOL	FALSE	The output of the integral action can be held in the negative direction. For this, the input INT_HNEG must be set to TRUE. In a cascade control, INT_HNEG of the primary controller is connected to QLMN_LLM of the secondary controller.
SELECT	12.0	INT	0	If the pulse shaper is on, there are several ways of calling the PID algorithm and pulse shaper: • SELECT = 0: The controller is called in a fast cyclic interrupt priority class and the PID algorithm and pulse shaper are processed. • SELECT = 1: The controller is called in OB1 and only the PID algorithm is processed. • SELECT = 2: The controller is called in a fast cyclic interrupt priority class and only the pulse shaper is processed. • SELECT = 3: The controller is called a slow cyclic interrupt priority class and only the PID algorithm is processed.

See also

Operating principle of the pulse generator (Page 453)
Block diagram TCONT_CP (Page 456)

11.4.4.6 Output parameters TCONT_CP

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1137

Parameter	Address	Data type	Default	Description
PV	14.0	REAL	0.0	The effective process value is output at the "Process value" output. The valid values depend on the sensors used.
LMN	18.0	REAL	0.0	The effective "Manipulated value" is output in floating point format at the "Manipulated value" output.
LMN_PER	22.0	INT	0	The manipulated value in I/O format is interconnected with the controller on the output "Manipulated value I/O".
QPULSE	24.0	BOOL	FALSE	The manipulated value is pulse-width-modulated at the QPULSE output.
QLMN_HLM	24.1	BOOL	FALSE	The manipulated value is always restricted to a high limit and low limit. The output QLMN_HLM signals that the high limit has been reached.
QLMN_LLM	24.2	BOOL	FALSE	The manipulated value is always restricted to a high limit and low limit. The output QLMN_LLM signals that the low limit has been reached.
QC_ACT	24.3	BOOL	TRUE	This parameter indicates whether continuous control component will be processed the next time the block is called (relevant only when SELECT has the value 0 or 1).

See also

Operating principle of the pulse generator (Page 453)
Block diagram TCONT_CP (Page 456)
Parameter STATUS_H (Page 463)
Parameters STATUS_D (Page 464)

11.4.4.7 In/out parameters TCONT_CP

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1138

Parameters	Address	Data type	Default	Description
CYCLE	26.0	REAL	0.1 s	Sets the sampling time for the PID algorithm. In phase 1, the tuner calculates the sampling time and enters it in CYCLE. CYCLE > 0.001 s
CYCLE_P	30.0	REAL	0.02 s	At this input, you set the sampling time for the pulse shaper action. In phase 1, the TCONT_CP instruction calculates the sampling time and enters it in CYCLE_P. CYCLE_P > 0.001 s

Parameters	Addres-s	Data type	Default	Description
SP_INT	34.0	REAL	0.0	The input "Internal setpoint" is used to specify a setpoint. The valid values depend on the sensors used.
MAN	38.0	REAL	0.0	The "Manual value" input is used to set a manual value. In automatic mode, it tracks the manipulated value.
COM_RST	42.0	BOOL	FALSE	The block has an initialization routine that is processed when the COM_RST input is set.
MAN_ON	42.1	BOOL	TRUE	If the input "Enable manual mode" is set then the control loop is interrupted. The manual value MAN is set as manipulated value.

See also

Operating principle of the pulse generator (Page 453)
Block diagram TCONT_CP (Page 456)

11.4.4.8 Static variables TCONT_CP

The names of the following variables apply both to the data block and to access via the Openness API.

Table 3-1139

Parameters	Address	Data type	Default	Description
DEADB_W	44.0	REAL	0.0	A deadband is applied to the control deviation. The "Deadband width" input determines the size of the deadband. The valid values depend on the sensors used.
I_ITLVAL	48.0	REAL	0.0	The output of the integrator can be set at the I_ITL_ON input. The initialization value is applied to the "Initialization value of the I-action" input. During a restart COM_RST = TRUE, the I-action is set to the initialization value. Values from -100 to 100 % are permitted.
LMN_HLM	52.0	REAL	100.0	The output value is always restricted to a high limit and low limit. The "Manipulated value high limit" input specifies the high limit. LMN_HLM > LMN_LLM
LMN_LLM	56.0	REAL	0.0	The output value is always restricted to a high limit and low limit. The "Manipulated value low limit" input specifies the low limit. LMN_LLM < LMN_HLM
PV_FAC	60.0	REAL	1.0	The "Process value factor" input is multiplied by the "Process value I/O". The input is used to scale the process value range.
PV_OFFS	64.0	REAL	0.0	The "Process value offset" input is added to the "Process value I/O". The input is used to scale the process value range.
LMN_FAC	68.0	REAL	1.0	The "Output value factor" input is multiplied with the output value. The input is used to scale the output value range.
LMN_OFFS	72.0	REAL	0.0	The "Output value offset" input is added to the output value. The input is used to scale the output value range.
PER_TM	76.0	REAL	1.0 s	The period duration of the pulse width modulation is entered at the PER_TM parameter. The relationship of the period duration to the sampling time of the pulse shaper determines the accuracy of the pulse width modulation. PER_TM ≥ CYCLE

Parameters	Address	Data type	Default	Description
P_B_TM	80.0	REAL	0.02 s	You can assign a minimum pulse or break time at the parameter "Minimum pulse/break time". P_B_TM is internally limited to > CYCLE_P.
TUN_DLMN	84.0	REAL	20.0	Process excitation for controller tuning results from a output value step change at TUN_DLMN. Values from -100 to 100 % are permitted.
PER_MODE	88.0	INT	0	You can use this switch to enter the type of I/O module. The process value at input PV_PER is then scaled as follows at the PV output. • PER_MODE = 0: Thermocouples; PT100/NI100; standard PV_PER * 0.1 Unit: C, °F • PER_MODE = 1: PT100/NI100; climate PV_PER * 0.01 Unit: C, °F • PER_MODE = 2: Current/voltage PV_PER * 100/27648 Unit: %
PVPER_ON	90.0	BOOL	FALSE	If the process value is to be read in from the I/Os, the PV_PER input must be interconnected with the I/Os and the "Enable process value I/Os" input must be set.
I_ITL_ON	90.1	BOOL	FALSE	The output of the integrator can be set at the I_ITLVAL input. The "Set I-action" input must be set for this.
PULSE_ON	90.2	BOOL	FALSE	If PULSE_ON = TRUE is set, the pulse shaper is activated.
TUN_KEEP	90.3	BOOL	FALSE	The mode changes to automatic only when TUN_KEEP changes to FALSE.
ER	92.0	REAL	0.0	The effective control deviation is output at the "Control deviation" output. The valid values depend on the sensors used.
LMN_P	96.0	REAL	0.0	The "P-action" output contains the proportional action of the manipulated tag.
LMN_I	100.0	REAL	0.0	The "integral action" output contains the integral action of the manipulated tag.
LMN_D	104.0	REAL	0.0	The "D-action" output contains the derivative action of the manipulated tag.
PHASE	108.0	INT	0	The current phase of controller tuning is indicated at the PHASE output. • PHASE = 0: No optimization mode; automatic or manual mode • PHASE = 1: Ready to start tuning; check parameters, wait for excitation, measure the sampling times • PHASE = 2: Actual tuning: Searching for point of inflection with constant output value. Entering the sampling time in instance DB. • PHASE = 3: Calculating the process parameters. Saving valid controller parameters prior to tuning. • PHASE = 4: Controller design • PHASE = 5: Following up the controller to the new manipulated variable • PHASE = 7: Validating the process type
STATUS_H	110.0	INT	0	STATUS_H indicates the diagnostic value via the search for the point of inflection during the heating process.
STATUS_D	112.0	INT	0	STATUS_D indicates the diagnostic value via the controller design during the heating process.
QTUN_RUN	114.0	BOOL	0	The tuning manipulated tag has been applied, tuning has started and is still in phase 2 (searching for point of inflection).
PI_CON	116.0	STRUCT		PI controller parameters
GAIN	+0.0	REAL	0.0	PI controller gain %/phys. Unit

Parameters	Address	Data type	Default	Description
TI	+4.0	REAL	0.0 s	PI integration time [s]
PID_CON	124.0	STRUCT		PID controller parameters
GAIN	+0.0	REAL	0.0	PID controller gain
TI	+4.0	REAL	0.0s	PID integration time [s]
TD	+8.0	REAL	0.0s	PID derivative action time [s]
PAR_SAVE	136.0	STRUCT		The PID parameters are saved in this structure.
PFAC_SP	+0.0	REAL	1.0	Proportional factor for setpoint changes Values from 0.0 to 1.0 are permitted.
GAIN	+4.0	REAL	0.0	Controller gain %/phys. Unit
TI	+8.0	REAL	40.0 s	Integration time [s]
TD	+12.0	REAL	10.0 s	Derivative action time (s)
D_F	+16.0	REAL	5.0	Derivative factor Values from 5.0 to 10.0 are permitted.
CON_ZONE	+20.0	REAL	100.0	Control zone band If the control deviation is greater than the control zone band, the high output value limit is output as output value. If the control deviation is less than the negative control zone band, the low output value limit is output as the output value. CON_ZONE ≥ 0.0
CONZ_ON	+24.0	BOOL	FALSE	Enable control zone
PFAC_SP	162.0	REAL	1.0	PFAC_SP specifies the effective P-action when there is a setpoint change. This is set between 0 and 1. • 1: P-action has full effect if the setpoint changes. • 0: P-action has no effect if the setpoint changes. Values from 0.0 to 1.0 are permitted.
GAIN	166.0	REAL	2.0	The "Proportional gain" input specifies controller amplification. The direction of control can be reversed by giving GAIN a negative sign. %/phys. Unit
TI	170.0	REAL	40.0 s	The "Integration time" (integral-action time) input defines the integrator's time response.
TD	174.0	REAL	10.0 s	The "Derivative-action time" (rate time) input decides the time response of the differentiator.
D_F	178.0	REAL	5.0	The derivative factor decides the lag of the D-action. D_F = derivative-action time/"Lag of the D-action" Values from 5.0 to 10.0 are permitted.
CON_ZONE	182.0	REAL	100.0	If the control deviation is greater than the control zone band, the high output value limit is output as output value. If the control deviation is less than the negative control zone band, the low output value limit is output as the output value. The valid values depend on the sensors used.
CONZ_ON	186.0	BOOL	FALSE	You can use CONZ_ON =TRUE to enable the control zone.
TUN_ON	186.1	BOOL	FALSE	If TUN_ON=TRUE, the output value is averaged until the output value excitation TUN_DLMN is enabled either by a setpoint step-change or by TUN_ST=TRUE.
TUN_ST	186.2	BOOL	FALSE	If the setpoint is to remain constant during controller tuning at the operating point, a output value step-change by the amount of TUN_DLMN is activated by TUN_ST=1.

Parameters	Address	Data type	Default	Description
UNDO_PAR	186.3	BOOL	FALSE	Loads the controller parametersPFAC_SP, GAIN, TI, TD, D_FCONZ_ON and CON_ZONE from the data structure PAR_SAVE (only in manual mode).
SAVE_PAR	186.4	BOOL	FALSE	Saves the controller parameters PFAC_SP, GAIN, TI, TD, D_F, CONZ_ON and CON_ZONE in the data structure PAR_SAVE.
LOAD_PID	186.5	BOOL	FALSE	Loads the controller parametersGAIN, TI,TD depending on PID_ON from the data structure PI_CON or PID_CON (only in manual mode)
PID_ON	186.6	BOOL	TRUE	At the PID_ON input, you can specify whether or not the tuned controller will operate as a PI or PID controller. • PID controller: PID_ON = TRUE • PI controller: PID_ON = FALSE With certain process types it is nevertheless possible that only a PI controller will be designed despite PID_ON = TRUE.
GAIN_P	188.0	REAL	0.0	Identified process gain. In the case of process type I, GAIN_P tends to be estimated too low.
TU	192.0	REAL	0.0	Identified time lag of the process. TU ≥ 3*CYCLE
TA	196.0	REAL	0.0	Identified recovery time of the process. In the case of process type I, TA tends to be estimated too low.
KIG	200.0	REAL	0.0	Maximum process value rise at manipulated tag excitation from 0 to 100 % [1/s] GAIN_P = 0.01 * KIG * TA
N_PTN	204.0	REAL	0.0	The parameter specifies the order of the process. "Non-integer values" are also possible. Values from 1.01 to 10.0 are permitted.
TM_LAG_P	208.0	REAL	0.0	Time constants of a PTN model (practical values only for N_PTN >= 2).
T_P_INF	212.0	REAL	0.0	Time from process excitation until the point of inflection.
P_INF	216.0	REAL	0.0	Process value change from process excitation until the point of inflection. The valid values depend on the sensors used.
LMN0	220.0	REAL	0.0	Output value at the start of tuning Detected in phase 1 (mean value). Values from 0 to 100 % are permitted.
PV0	224.0	REAL	0.0	Process value at the start of tuning
PVDT0	228.0	REAL	0.0	Process value slew rate at start of tuning [1/s] Sign adapted.
PVDT	232.0	REAL	0.0	Current process value slew rate [1/s] Sign adapted.
PVDT_MAX	236.0	REAL	0.0	Max. change in the process value per second [1/s] Maximum derivative of the process value at the point of inflection (sign adapted, always > 0); is used to calculate TU and KIG.
NOI_PVDT	240.0	REAL	0.0	Noise action in PVDT_MAX in % The higher the noise action, the less accurate (less aggressive) the control parameters.
NOISE_PV	244.0	REAL	0.0	Absolute noise in process value Difference between maximum and minimum process value in phase 1.

Parameters	Address	Data type	Default	Description
FIL_CYC	248.0	INT	1	Number of cycles of the mean value filter The process value is determined through FIL_CYC cycles. FIL_CYC is increased from 1 to a max. of 1024 if needed.
POI_CMAX	250.0	INT	2	Maximum number of cycles after point of inflection This time is used to find another (i.e. better) inflection point for measuring noise. The tuning is completed only after this time.
POI_CYCL	252.0	INT	0	Number of cycles after inflection point

See also

Operating principle of the pulse generator (Page 453)
Block diagram TCONT_CP (Page 456)

11.4.4.9 Parameter STATUS_H

STATUS_H	Description	Remedy
0	Default, or no/no new controller parameters	
10000	Tuning completed + suitable controller parameters found	
2xxxx	Tuning completed + controller parameters uncertain	
2xx2x	Point of inflection not reached (only if excited via setpoint step-change)	If the controller oscillates, weaken the controller parameters, or repeat the test with a smaller manipulated value difference TUN_DLMN.
2x1xx	Estimation error (TU < 3*CYCLE)	Reduce CYCLE and repeat attempt. Special case for PT1-only process: Do not repeat test, if necessary reduce controller parameters.
2x3xx	Estimation error TU too high	Repeat test under better conditions.
21xxx	Estimation error N_PTN < 1	Repeat test under better conditions.
22xxx	Estimation error N_PTN > 10	Repeat test under better conditions.
3xxxx	Tuning canceled in phase 1 owing to faulty parameter assignment:	
30002	Effective manipulated value differential < 5%	Correct manipulated value differential TUN_DLMN.
30005	The sampling times CYCLE and CYCLE_P differ by more than 5% of the measured values.	Compare CYCLE and CYCLE_P with the cycle time of the cyclic interrupt priority class and note any loop scheduler. Check CPU load. An excessively loaded CPU can result in prolonged sampling times that are inconsistent with CYCLE or CYCLE_P.

NOTE

If you cancel tuning in phase 1 or 2, STATUS_H = 0 is set. However, STATUS_D still displays the status of the last controller calculation.

The higher the value of STATUS_D, the higher the order of the control process, the greater the TU/TA ratio and the gentler the controller parameters will be.

See also

Operating principle of the pulse generator (Page 453)

Block diagram TCONT_CP (Page 456)

11.4.4.10 Parameters STATUS_D

STATUS_D	Description
0	No controller parameters were calculated.
110	N_PTN <= 1.5 Process type I fast
121	N_PTN > 1.5 Process type I
200	N_PTN > 1.9 Process type II (transition range)
310	N_PTN >= 2.1 Process type III fast
320	N_PTN > 2.6 Process type III
111, 122, 201, 311, 321	Parameters have been corrected from phase 7.

NOTE

The higher the value of STATUS_D, the higher the order of the control process, the greater the TU/TA ratio and the gentler the controller parameters will be.

See also

Operating principle of the pulse generator (Page 453)

Block diagram TCONT_CP (Page 456)

11.4.5 TCONT_S

11.4.5.1 Description TCONT_S

The TCONT_S instruction is used on SIMATIC S7 automation systems to control technical temperature processes with binary manipulated value output signals for actuators with integrating behavior. The functionality is based on the PI control algorithm of the sampling controller. The step controller operates without a position feedback signal.

Application

You can also use the controller in a cascade control as a secondary position controller. You specify the actuator position via the setpoint input SP_INT. In this case, you must set the process value input and the parameter TI (integration time) to zero. An application might be, for example, temperature control with heating power control using pulse-break activation and cooling control using a butterfly valve. To close the valve completely, the manipulated variable (ER*GAIN) should be negative.

Call

The instruction TCONT_S must be called with a constant bus cycle time. To achieve this, use a cyclic interrupt level (e.g. OB35 with S7-300). The sampling time is specified at the CYCLE parameter.

CYCLE sampling time

The CYCLE sampling time match the time difference between two calls (cycle time of the cyclic interrupt OB taking into account the reduction ratios).

The controller sampling time should not exceed 10% of the calculated integration time of the controller (TI). Generally, you must set the sampling time to a much lower value to achieve the required accuracy of the step controller.

Required accuracy G	MTR_TM	CYCLE = MTR_TM*G	Comment
0.5%	10 s	0.05 s	The sampling time is determined by the required accuracy of the step controller.

Start-up

The TCONT_S instruction has an initialization routine that is run through when input parameter COM_RST = TRUE is set. Following execution of the initialization routine, the block sets COM_RST back to FALSE. All outputs are set to their initial values. If you require initialization when the CPU restarts, call the block in OB100 with COM_RST = TRUE.

See also

Block diagram TCONT_S (Page 470)

11.4.5.2 Mode of operation TCONT_S

Setpoint branch

The setpoint is entered at input SP_INT in floating-point format as a physical value or percentage. The setpoint and process value used to form the control deviation must have the same unit.

Process value options (PVPER_ON)

Depending on PVPER_ON, the process value can be read in, in the I/O or floating-point format.

PVPER_ON	Process Value Input
TRUE	The process value is read in via the analog I/Os (PIW xxx) at input PV_PER.
FALSE	The process value is acquired in floating-point format at input PV_IN.

Process value format conversion CRP_IN (PER_MODE)

The CRP_IN function converts the I/O value PV_PER to floating-point format depending on the PER_MODE switch according to the following rules:

PER_MODE	Output of CRP_IN	Analog Input Type	Unit
0	PV_PER * 0.1	Thermoelements; PT100/NI100; standard	°C;°F
1	PV_PER * 0.01	PT100/NI100; climate;	°C;°F
2	PV_PER * 100/27648	Voltage/current	%

Process value scaling PV_NORM (PF_FAC, PV_OFFS)

The PV_NORM function calculates the output of CRP_IN according to the following rule:

"Output of PV_NORM" = "Output of CRP_IN" * PV_FAC + PV_OFFS

It can be used for the following purposes:

- Process value adjustment with PV_FAC as process value factor and PV_OFFS as process value offset.
- Scaling of temperature to percentage

  You want to enter the setpoint as a percentage and must now convert the measured temperature value to a percentage.
- Scaling of percentage to temperature

  You want to enter the setpoint in the physical temperature unit and must now convert the measured voltage/current value to a temperature.

Calculation of the parameters:

- PV_FAC = range of PV_NORM/range of CRP_IN;
- PV_OFFS = LL (PV_NORM) - PV_FAC * LL(CRP_IN);

  where LL: low limit

The scaling is switched off with the default values (PV_FAC = 1.0 and PV_OFFS = 0.0). The effective process value is output at the PV output.

Example of Process Value Scaling

If you want to enter the setpoint as a percentage, and you have a temperature range of -20 to 85 °C applied to , CRP_IN you must normalize the temperature range as a percentage.

The diagram below shows an example of adapting the temperature range -20 to 85 °C to an internal scale of 0 to 100 %:

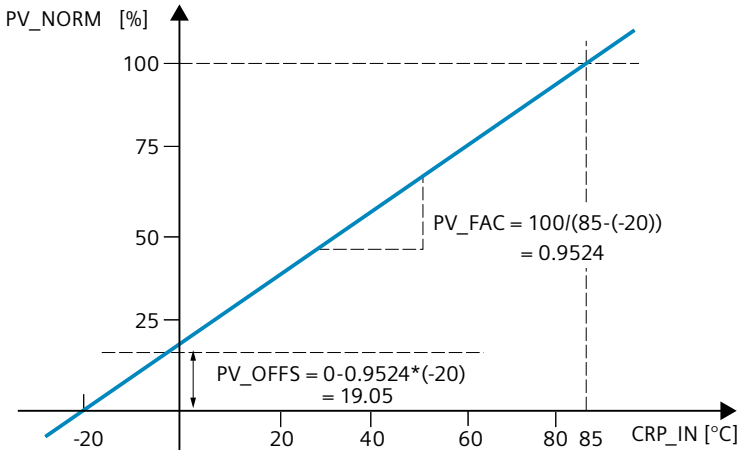

Forming the control deviation

The difference between the setpoint and process value is the control deviation before the dead zone.

The setpoint and process value must exist in the same unit.

Dead zone (DEADB_W)

To suppress a minor sustained oscillation due to the manipulated variable quantization (for example, in pulse width modulation with PULSEGEN) a dead zone is applied to the (DEADBAND) control deviation. With DEADB_W = 0.0, the dead zone is disabled.

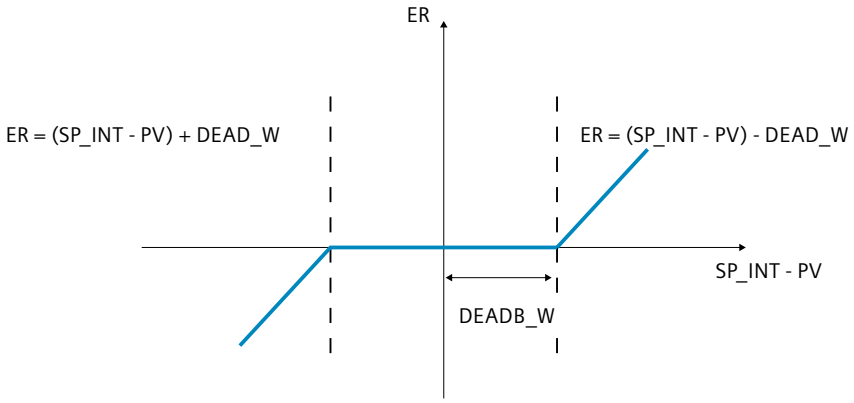

PI step controller algorithm

The instruction TCONT_S operates without position feedback. The I-action of the PI algorithm and the assumed position feedback signal are calculated in an integrator (INT) and compared as a feedback value with the remaining proportional action. The difference is applied to a three-step element (THREE_ST) and a pulse shaper (PULSEOUT) that generates the pulses for the control valve. Adapting the response threshold of the three-step element reduces the switching frequency of the controller.

Weakening of the proportional action when setpoint changes occur

To prevent overshoot, you can weaken the proportional action using the "Proportional factor for setpoint changes" parameter (PFAC_SP). Using PFAC_SP, you can now select continuously between 0.0 and 1.0 to decide the effect of the proportional action when the setpoint changes:

- PFAC_SP = 1.0: Proportional action for setpoint change is fully effective
- PFAC_SP = 0.0: Proportional action has no effect in the setpoint change

As in the case of the continuous controller, a value of PFAC_SP < 1.0 can reduce the overshoot if the motor run time MTR_TM is small compared with the recovery time TA and the ratio is TU/TA < 0.2. If MTR_TM reaches 20% of TA, only a slight improvement can still be achieved.

Feedforward control

A disturbance variable can be added at the DISV input.

Manual value processing (LMNS_ON, LMNUP, LMNDN)

With LMNS_ON, you can change between manual and automatic mode. In manual mode, the actuator is halted and the integral action (INT) is set to 0 internally. Using LMNUP and LMNDN, the actuator can be adjusted to OPEN and CLOSED. Switching over to automatic mode therefore involves a bump. As a result of the GAIN, the existing control deviation leads to a step change in the internal manipulated variable. The integral component of the actuator, however, results in a ramp-shaped excitation of the process.

See also

Block diagram TCONT_S (Page 470)

11.4.5.3 Block diagram TCONT_S

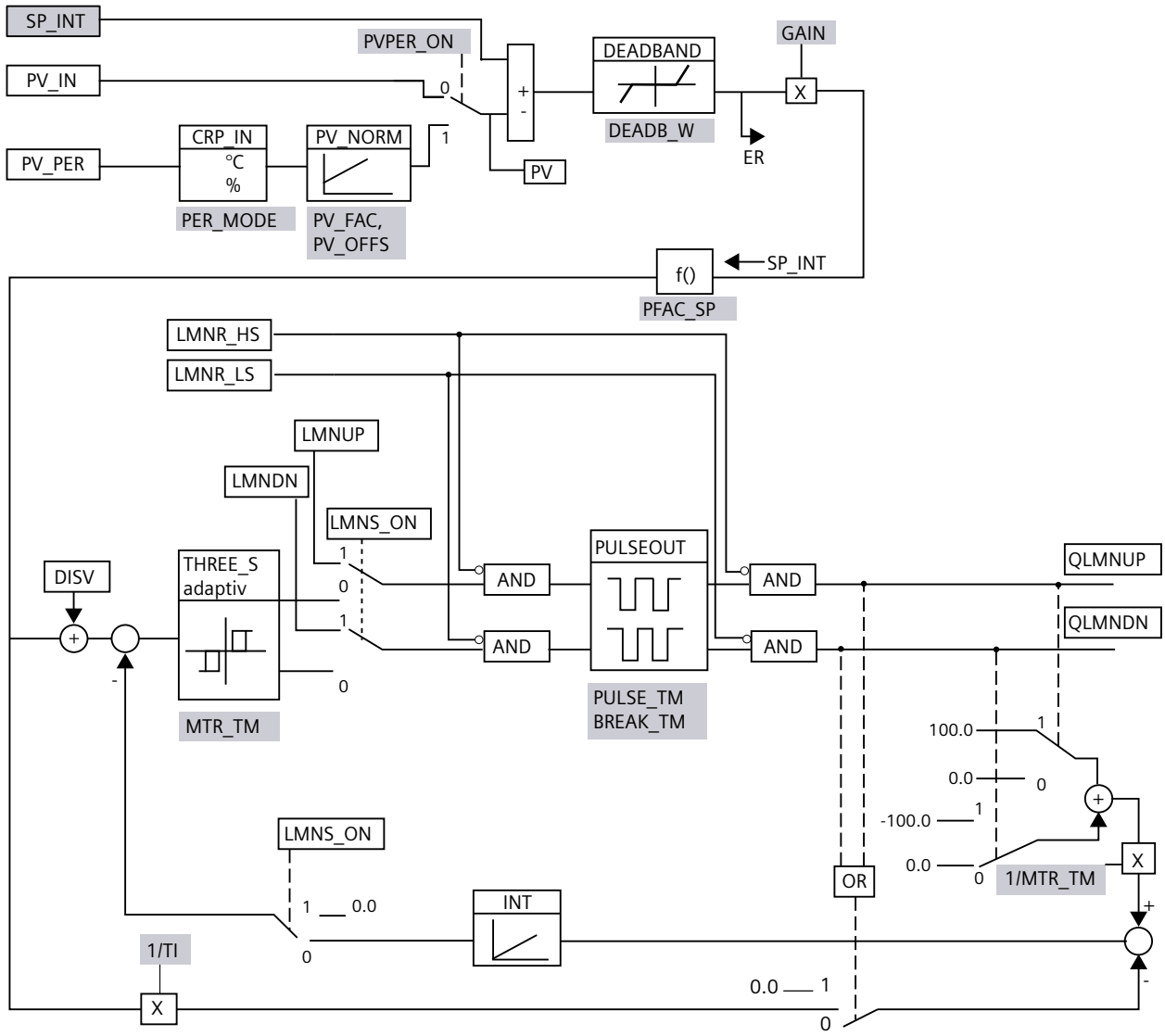

Parameter configuration interface

Instruction call interface

Parameter configuration interface, call interface

See also

Description TCONT_S (Page 465)
Mode of operation TCONT_S (Page 466)
Input paramters TCONT_S (Page 471)
Output parameters TCONT_S (Page 472)
In/out parameters TCONT_S (Page 472)
Static variables TCONT_S (Page 472)

11.4.5.4 Input paramters TCONT_S

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1140

Parameters	Address	Data type	Default	Description
CYCLE	0.0	REAL	0.1 s	At this input, you enter the sampling time for the controller. CYCLE ≥ 0.001
SP_INT	4.0	REAL	0.0	The input "Internal setpoint" is used to specify a setpoint. The valid values depend on the sensors used.
PV_IN	8.0	REAL	0.0	At the "Process variable input" you can assign parameters to a commissioning value or you can interconnect an external process value in floating-point format. The valid values depend on the sensors used.
PV_PER	12.0	INT	0	The process value in I/O format is interconnected with the controller at the "Process value I/O" input.
DISV	14.0	REAL	0.0	For feedforward control, the disturbance variable is interconnected to the "Disturbance variable" input.
LMNR_HS	18.0	BOOL	FALSE	The signal "Control valve at high endstop" is interconnected on the input "High endstop signal of position feedback". • LMNR_HS=TRUE: The control valve is located at the high endstop.
LMNR_LS	18.1	BOOL	FALSE	The signal "Control valve at low endstop" is interconnected on the input "Low endstop signal of position feedback". • LMNR_LS=TRUE: The control valve is located at the low endstop.
LMNS_ON	18.2	BOOL	TRUE	Manipulated value signal processing is switched to manual mode at the "Enable manual mode of manipulated signal".
LMNUP	18.3	BOOL	FALSE	In manual mode of manipulated signals, the output parameter QLMNUP is operated at the input parameter "Manipulated signal up".
LMNDN	18.4	BOOL	FALSE	In manual mode of the manipulated signals, the output parameter QLMNDN is operated at the input parameter "Manipulated signal down".

See also

Block diagram TCONT_S (Page 470)

11.4.5.5 Output parameters TCONT_S

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1141

Parameters	Address	Data type	Default	Description
QLMNUP	20.0	BOOL	FALSE	If the output "Manipulated value signal up" is set then the control valve should be open.
QLMNDN	20.1	BOOL	FALSE	If the output "Manipulated value signal down" is set then the control valve should be closed.
PV	22.0	REAL	0.0	The effective process value is output at the "Process value" output.
ER	26.0	REAL	0.0	The effective system deviation is output at the "Error signal" output.

See also

Block diagram TCONT_S (Page 470)

11.4.5.6 In/out parameters TCONT_S

The names of the following parameters apply both to the data block and to access via the Openness API.

Table 3-1142

Parameters	Address	Data type	Default	Description
COM_RST	30.0	BOOL	FALSE	The block has an initialization routine that is processed when the COM_RST input is set.

See also

Block diagram TCONT_S (Page 470)

11.4.5.7 Static variables TCONT_S

The names of the following variables apply both to the data block and to access via the Openness API.

Table 3-1143

Parameters	Address	Data type	Default	Description
PV_FAC	32.0	REAL	1.0	The "Process value factor" input is multiplied by the process value. The input is used to scale the process value range.
PV_OFFS	36.0	REAL	0.0	The input "Process value offset" is added to the process value. The input is used to scale the process value range. The valid values depend on the sensors used.
DEADB_W	40.0	REAL	0.0	A deadband is applied to the control deviation. The "Deadband width" input determines the size of the deadband. DEADB_W ≥ 0.0

Parameters	Addre-ss	Data type	Default	Description
PFAC_SP	44.4	REAL	1.0	PFAC_SP specifies the effective P-action when there is a setpoint change. • 1: P-action has full effect if the setpoint changes. • 0: P-action has no effect if the setpoint changes. Values from 0.0 to 1.0 are permitted.
GAIN	48.0	REAL	2.0	The "Proportional gain" input specifies controller amplification. The direction of control can be reversed by giving GAIN a negative sign. %/phys. Unit
TI	52.0	REAL	40.0 s	The "Integration time" (integral-action time) input defines the integrator's time response.
MTR_TM	56.0	REAL	30 s	The runtime from endstop to endstop of the control valve is entered at the "Motor actuating time" parameter. MTR_TM ≥ CYCLE
PULSE_TM	60.0	REAL	0.0 s	A minimum pulse time can be configured at the "Minimum pulse time" parameter.
BREAK_TM	64.0	REAL	0.0 s	You can assign a minimum break time at the parameter "Minimum break time".
PER_MODE	68.0	INT	0	You can use this switch to enter the type of I/O module. The process value at input PV_PER is then scaled as follows at the PV output. • PER_MODE = 0: Thermocouples; PT100/NI100; standard PV_PER * 0.1 Unit: C, °F • PER_MODE = 1: PT100/NI100; climate PV_PER * 0.01 Unit: C, °F • PER_MODE = 2: Current/voltage PV_PER * 100/27648 Unit: %
PVPER_ON	70.0	BOOL	FALSE	If the process value is to be read in from the I/Os, the PV_PER input must be interconnected with the I/Os and the "Enable process value I/Os" input must be set.

See also

Block diagram TCONT_S (Page 470)

11.4.6 Integrated system functions

11.4.6.1 CONT_C_SF

CONT_C_SF

The instruction CONT_C_SF is integrated in the S7-300 compact CPUs. The instruction must not be transmitted to the S7-300 CPU during loading. The scope of function corresponds with the instruction CONT_C.

See also

Description CONT_C (Page 425)
How CONT_C works (Page 426)
CONT_C block diagram (Page 427)
Input parameter CONT_C (Page 428)
Output parameters CONT_C (Page 429)

11.4.6.2 CONT_S_SF

CONT_S_SF

The instruction CONT_S_SF is integrated in the S7-300 compact CPUs. The instruction must not be transmitted to the S7-300 CPU during loading. The scope of function corresponds with the instruction CONT_S.

See also

Description CONT_S (Page 430)
Mode of operation CONT_S (Page 431)
Block diagram CONT_S (Page 432)
Input parameters CONT_S (Page 433)
Output parameters CONT_S (Page 434)

11.4.6.3 PULSEGEN_SF

PULSEGEN_SF

The instruction PULSEGEN_SF is integrated in the S7-300 compact CPUs. The instruction must not be transmitted to the S7-300 CPU during loading. The scope of function corresponds with the instruction PULSEGEN.

See also

Description PULSEGEN (Page 435)
Mode of operation PULSEGEN (Page 436)
Mode of operation PULSEGEN (Page 439)
Three-step control (Page 439)
Two-step control (Page 441)
Input parameters PULSEGEN (Page 442)
Output parameter PULSEGEN (Page 443)

11.5 Polyline

11.5.1 Compatibility with CPU and FW

The following table shows which version of Polyline can be used on which CPU:

CPU	FW	Polyline
S7-1200	as of V4.2	V1.0
S7-1200 G2	V1.0 or higher	V1.0
S7-1500-based CPUs	as of V2.0	V1.0

11.5.2 Description Polyline

Description

The Polyline instruction maps input value Input onto output value Output using a characteristic curve. The characteristic curve is defined as a polyline with maximum 50 points. Linear interpolation is performed between the points. You can fit the polyline to the desired characteristic curve using the number and configuration of the points.

The Polyline instruction can be used, for example, to linearize non-linear characteristics of sensors or actuators.

Interpolation calculation

Polyline calculates the output value at the Output parameter for the input value at the Input parameter that lies between point values x_i and x_{i+1} with a linear interpolation. The linear interpolation is calculated according to the following formula:

$$Output = \frac{(Input - x_i)}{(x_{i+1} - x_i)} (y_{i+1} - y_i) + y_i$$

With parameter Reset = TRUE, an alternative output value can also be specified using the SubstituteOutput parameter.

Polyline data

The value pairs for the polyline are contained in the Static area of the instruction.

NOTE

- The minimum number of value pairs to be configured is 2.
- The maximum number of value pairs to be configured is 50.
- For a valid configuration, the x values must be specified in ascending order.

To allow the polyline data to be changed without the changes taking effect immediately, the value pairs of the polyline are duplicated and contained in the following structures:

- UserData

  The polyline data in this structure can be edited.

  Make use of this structure to specify or change the polyline data. Changes in this structure do not affect the interpolation calculation until the check and duplication of the data to the WorkingData structure is initiated. This happens by setting Validate = TRUE or automatically during the first processing of Polyline after the operating state transition of the CPU from STOP to RUN.

  The preassignment of values in this structure does not represent a valid configuration. To use the values for the interpolation calculation, change the tags to valid values.

- WorkingData

  The polyline data in this structure cannot be edited. This data is used for the interpolation calculation. Do not manually change the data in this structure.

Both structures have the same data type and thus the same content:

- NumberOfUsedPoints

  Number of points used for the interpolation calculation.

- Point

  The array with 50 elements contains value pairs of points Point[i].x and Point[i].y with index "i" from 1 to 50.

The following figure shows a polyline with four points:

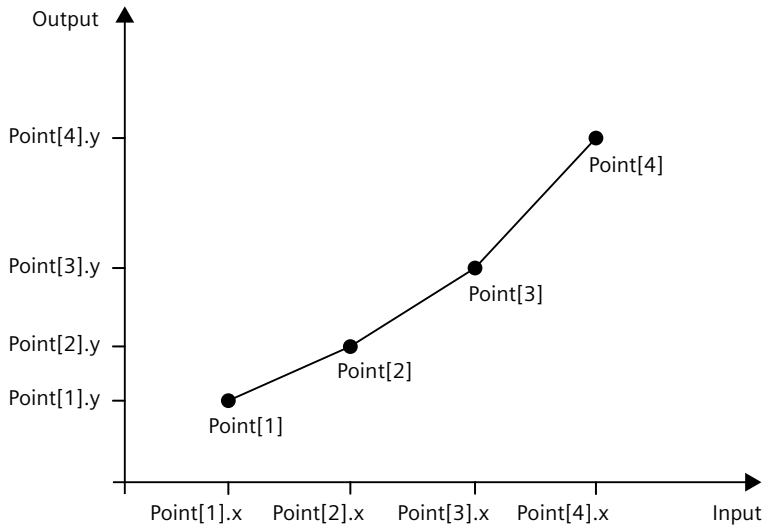

Call

Polyline is called in an OB as a single-instance DB, Polyline is called in an FC as a single-instance DB or parameter instance DB; Polyline can be called as a single-instance DB, as a multi-instance DB and as a parameter instance DB in an FB.

When the instruction is called, no technology object is created. Polyline configuration is available for individual instances in the Inspector window of the programming editor.

Startup

The tags in the UserData and WorkingData structures are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN.

If you change the actual values in the UserData structure in online mode and these values are to be retained after the operating state transition of the CPU from STOP to RUN, back up these values in the start values of the data block.

At the first call of the Polyline instruction after the operating state transition of the CPU from STOP to RUN, the data in the UserData structure is automatically checked for validity. If the check is successful, the data is transferred to the WorkingData structure.

Response to errors

The Polyline instruction detects different errors that may occur during interpolation calculation. The result of the interpolation calculation can be output at the output despite a pending error. If an error prevents correct calculation of the interpolation result, a substitute output value is output at the output.

You specify the substitute output value that is output if an error occurs that prevents correct calculation of the interpolation result as follows at the ErrorMode tag:

ErrorMode	Output
0	Value of the Input parameter
1	Value of the SubstituteOutput parameter
2	The last valid result of interpolation calculation 0.0 if there is no valid result

The following applies in addition for all values of the ErrorMode tag:

- If the substitute output value is not a valid REAL value, 0.0 is output as output value.
- The substitute output value is limited to the value range of the data type REAL. Only then is the substitute output value output at the Output parameter.
- The ErrorMode tag only takes effect when the Reset = FALSE parameter is set. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter.

The Error parameter indicates if an error is pending. When the error is no longer pending, Error is set to FALSE. The ErrorBits parameter shows which errors have occurred. ErrorBits is retentive and is reset only by a positive edge at the Reset or ErrorAck parameter.

11.5.3 Operating principle Polyline

Polyline data

To change the polyline, you edit the values in the UserData structure. The values are then checked for validity and transferred to the WorkingData structure. Only in the WorkingData structure are the values used for the interpolation calculation.

The values are checked and transferred when

- You set the Validate parameter to TRUE while the Reset parameter is set to FALSE.
- Polyline is called for the first time after the change of operating state of the CPU from STOP to RUN while the Reset parameter is set to FALSE.

  If Polyline has already been called, for example in OB100, another automatic check of the values is not performed at the subsequent calls.

If the polyline data in the UserData structure is invalid, the previous polyline data in the WorkingData structure remains unchanged and a corresponding error message is output. If the check was performed for the first time, no valid values are available in the WorkingData structure and a corresponding error message is output. In this case, the Output parameter is specified with the substitute output value that you configure with the ErrorMode tag.

The check and transfer of the values from the UserData structure requires more CPU processing time than the interpolation calculation. In time-critical applications, the first

execution of Polyline can be in startup OB 100. In this way, the time-consuming one-time check and transfer of the polyline data can be completed before the cyclic application program sections.

Validity of the polyline data

When the values in the UserData structure are checked, they must meet the following conditions so that a valid polyline is available for the interpolation calculation:

- 2 ≤ UserData.NumberOfUsedPoints ≤ 50
- UserData.Point[j].x < UserData.Point[j+1].x with index j = 1..(UserData.NumberOfUsedPoints – 1)
- -3.402823e+38 ≤ UserData.Point[i].x ≤ 3.402823e+38 with index i = 1..UserData.NumberOfUsedPoints
- -3.402823e+38 ≤ UserData.Point[i].y ≤ 3.402823e+38 with index i = 1..UserData.NumberOfUsedPoints
- UserData.Point[i].x and UserData.Point[i].y are valid REAL values (≠ NaN) with index i = 1..UserData.NumberOfUsedPoints

If one or more conditions are not met during the check, the values in the UserData structure are not transferred to the WorkingData structure. A corresponding error message is output at the ErrorBits (Page 483) parameter.

The preassignment of values in the UserData structure does not represent a valid configuration. Change the tags to valid values so that the tags can be used for the interpolation calculation.

NOTE

If more than the maximum number of 50 points are needed for your application, use two or more instances of Polyline.

Calculating the output value

If the input value at the Input parameter is below the first x-value or above the last x-value of the utilized points, configure the preassignment of the Output parameter with the following settings at the OutOfRangeMode tag:

- OutOfRangeMode = 0

  The output value is extrapolated with the slope of the first or last two points.

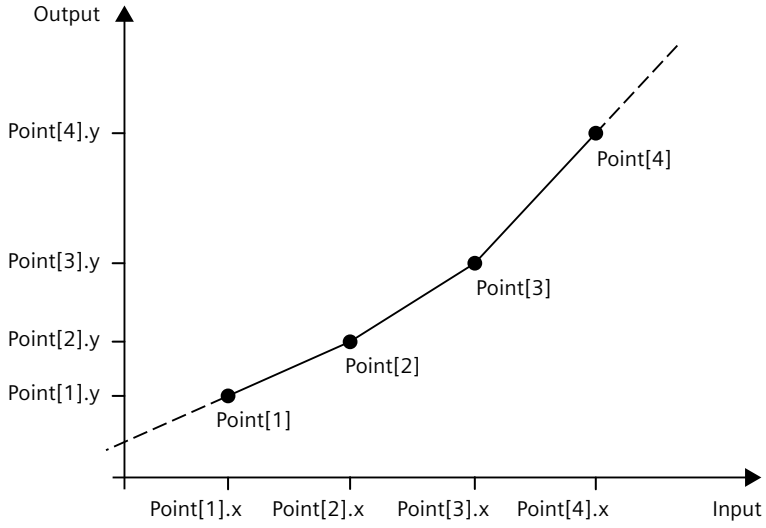

  If the OutOfRangeMode tag lies outside the permissible value range of 0 to 1, the default preassignment 0 becomes effective.

- OutOfRangeMode = 1

  The output value is limited to the y-value of the first or last point.

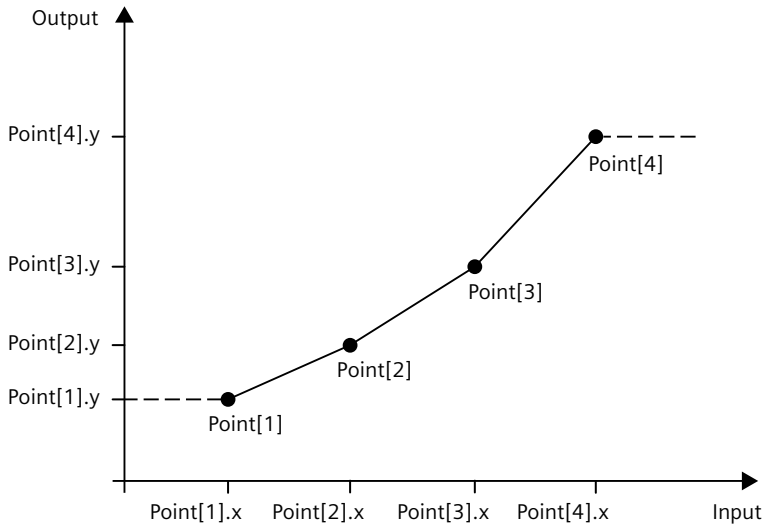

The Output parameter has a permissible value range of a REAL data type of -3.402823e+38 to 3.402823e+38. The output value at the Output parameter is checked for validity each time the Polyline instruction is executed. If the interpolation calculation yields an invalid REAL value, the output value is replaced with the setting at the ErrorMode tag.

Enable behavior EN/ENO

If one of the following conditions is met, enable output ENO is set to FALSE.

- Enable input EN is set to TRUE and the Output parameter is specified by a substitute output value in case of error messages ErrorBits ≥ 16#0001_0000.
- Enable input EN is set to FALSE.

Otherwise, the enable output ENO is set to TRUE.

Currently utilized points

The NextXIndex index outputs the index of the next higher x-value for the current input value. You can use this to determine the points that are being used for the current interpolation calculation.

WorkingData.Point[NextXIndex-1].x < Input ≤ WorkingData.Point[NextXIndex].x

Example:

- If the value of the Input parameter is between WorkingData.Point[3].x and WorkingData.Point[4].x, the NextXIndex tag has the value 4.
- If the value of the Input parameter is less than WorkingData.Point[1].x, the NextXIndex tag has the value 1.
- If the value of the Input parameter is greater than WorkingData.Point[WorkingData.NumberOfUsedPoints].x and is thus greater than the last x-value of the polyline, the NextXIndex tag has the value of the WorkingData.NumberOfUsedPoints + 1 tag. Consequently, maximum permissible value of the NextXIndex tag is 51.

11.5.4 Input parameters of Polyline

Parameter	Data type	Default	Description
Input	REAL	0.0	Input value
Substitu-teOutput	REAL	0.0	SubstituteOutput is used as the substitute output value when • Reset = TRUE or • An error with error message ErrorBits ≥ 16#0001_0000 prevents correct calculation of the interpolation result, and the configured value of ErrorMode is 1 .

Parameter	Data type	Default	Description
Validate	BOOL	FALSE	If Validate is set to TRUE, the polyline data in UserData is checked for validity and transferred to WorkingData.
ErrorAck	BOOL	FALSE	Deletes the error messages • Edge FALSE -> TRUE ErrorBits is reset
Reset	BOOL	FALSE	Performs a restart of the instruction • Edge FALSE -> TRUE ErrorBits is reset. • As long as Reset is set to TRUE, the substitute output value SubstituteOutput is output at the output. • As long as Reset is set to FALSE, the interpolation calculation is performed.

11.5.5 Output parameters of Polyline

Parameter	Data type	Default	Description
Output	REAL	0.0	Output value
Error	BOOL	FALSE	When Error is set to TRUE, at least one error is currently pending.
ErrorBits	DWORD	DW#16#0	The ErrorBits parameter (Page 483) shows which error messages are pending. ErrorBits is retentive and is reset at a positive edge at Reset or ErrorAck .

11.5.6 Static tags of Polyline

Tag	Data type	Default	Description
UserData	AuxFct_Point-Table	-	Input area for polyline data The polyline data in the UserData structure can be edited. Changes in this structure do not affect the interpolation calculation until the check and duplication of the data to the WorkingData structure is initiated.
UserData.NumberOfUsedPoints	INT	0	Number of points used for the interpolation calculation Permissible value range: 2 to 50
UserData.Point	Array[1..50] of AuxFct_Point	-	Points for the interpolation calculation The array with 50 elements of data type AuxFct_Point contains the value pairs of the points.
UserData.Point[i]	AuxFct_Point	-	Point for the interpolation calculation An element with index "i" from the "Point" array.
UserData.Point[i].x	REAL	0.0	x-value of the point Permissible value range: Point[i].x < Point[i+1].x
UserData.Point[i].y	REAL	0.0	y-value of the point
WorkingData	AuxFct_Point-Table	-	Display area of the currently active polyline data The polyline data in the WorkingData structure cannot be edited. It is used for the interpolation calculation.

Tag	Data type	Default	Description
WorkingData.NumberOfUsedPoints	INT	0	Number of points used for the interpolation calculation Permissible value range: 2 to 50
WorkingData.Point	Array[1..50] of AuxFct_Point	-	Points for the interpolation calculation The array with 50 elements of type AuxFct_Point contains the value pairs of the points.
WorkingData.Point[i]	AuxFct_Point	-	Point for the interpolation calculation An element with index "i" from the "Point" array.
WorkingData.Point[i].x	REAL	0.0	x-value of the point Permissible value range: Point[i].x < Point[i+1].x
WorkingData.Point[i].y	REAL	0.0	y-value of the point
ErrorMode	INT	0	Selection of the substitute output value following an error • 0 = Input • 1 = SubstituteOutput • 2 = Last valid output value Permissible value range: 0 to 2
OutOfRangeMode	INT	0	Selection of the output value if the input value lies outside the defined x-values • 0 = Maintain slope • 1 = y-value of the first/last point Permissible value range: 0 to 1
NextXIndex	INT	2	Index of the next x-value Used for monitoring the index of the breakpoints that are being used for the current interpolation calculation. The following condition applies: WorkingData.Point[NextXIndex-1].x < Input ≤ WorkingData.Point[NextXIndex].x Do not change this value.

11.5.7 ErrorBits parameter

If several errors are pending simultaneously, the values of the ErrorBits are displayed with binary addition. The display of ErrorBits = 16#0000_0003, for example, indicates that the errors 16#0000_0001 and 16#0000_0002 are pending simultaneously.

For Polyline, the errors output at the ErrorBits parameter are divided into two categories:

- Errors with error messages ErrorBits < 16#0001_0000
- Errors with error messages ErrorBits ≥ 16#0001_0000

Errors with error messages ErrorBits < 16#0001_0000

If one or more errors with error messages ErrorBits < 16#0001_0000 are pending, Polyline reacts as follows:

- The output value is determined as follows despite this error:
  - When Reset = FALSE, interpolation calculation
  - When Reset = TRUE, output of SubstituteOutput
- The output parameter Error is set.
- The enable output ENO is not changed.

The output parameter Error is deleted as soon as there are no longer any errors.

ErrorBits (DW#16#...)	Description
0000_0000	No error is pending.
0000_0001	**Cause of error and response to error:** The Output parameter was limited to -3.402823e+38 or +3.402823e+38. **Solution:** If the interpolation value is output at the output (Reset = FALSE and ErrorBits < 16#0001_0000), check the following tags used in the interpolation calculation: • Input • WorkingData.Point[i].x • WorkingData.Point[i].y When ErrorBits ≥ 16#0001_0000 and Reset = FALSE, the substitute output value is limited on its output. In this case, check the following parameters depending on the set value at the ErrorMode tag: • Input • SubstituteOutput When Reset = TRUE, check the SubstituteOutput parameter.
0000_0002	**Cause of error:** One or more tags in the UserData structure have invalid values while the polyline data is checked (Validate = TRUE and Reset = FALSE). **Response to error:** The polyline data in the UserData structure is not transferred to the WorkingData structure so that the changes made in the UserData structure will not become effective. The Polyline FB continues the interpolation calculation with the unchanged and valid polyline data in the WorkingData structure. **Solution:** Ensure that the following conditions are met when the Validate parameter is set to TRUE: • 2 ≤ UserData.NumberOfUsedPoints ≤ 50 • UserData.Point[j].x < UserData.Point[j+1].x with index j = 1..(UserData.NumberOfUsedPoints - 1) • -3.402823e+38 ≤ UserData.Point[i].x ≤ 3.402823e+38 with index i = 1..UserData.NumberOfUsedPoints • -3.402823e+38 ≤ UserData.Point[i].y ≤ 3.402823e+38 with index i = 1..UserData.NumberOfUsedPoints • UserData.Point[i].x and UserData.Point[i].y are valid REAL values (≠ NaN) with index i = 1..UserData.NumberOfUsedPoints

Errors with error messages ErrorBits ≥ 16#0001_0000

If one or more errors with error messages ErrorBits ≥ 16#0001_0000 are pending, Polyline reacts as follows:

- The output value cannot be determined as expected. The substitute output value is output instead.
- The output parameter Error is set.
- The enable output ENO is set to FALSE.

As soon as there are no longer errors with error messages ErrorBits ≥ 16#0001_0000, Polyline reacts as follows:

- The output value is determined as follows:
  - When Reset = FALSE, interpolation calculation
  - When Reset = TRUE, output of SubstituteOutput
- The enable output ENO is set to TRUE.

The output parameter Error is deleted as soon as there are no longer any errors.

<table>
<tr><th>ErrorBits (DW#16#...)</th><th colspan="3">Description</th></tr>
<tr><td>0001_0000</td><td colspan="3">Cause of error:
The SubstituteOutput or Input parameter that is being used as the output value has no valid REAL value.
Response to error:
The output is set to 0.0.
Solution:
Make sure that the parameter used as output value is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF). The parameter that is used as output value depends on Reset and ErrorMode:</td></tr>
<tr><td></td><td>Reset</td><td>ErrorMode</td><td>Output value</td></tr>
<tr><td></td><td>FALSE</td><td>0</td><td>Input</td></tr>
<tr><td></td><td>FALSE</td><td>1</td><td>SubstituteOutput</td></tr>
<tr><td></td><td>TRUE</td><td>-</td><td>SubstituteOutput</td></tr>
<tr><td>0002_0000</td><td colspan="3">Cause of error:
The Input parameter has no valid REAL value, while the interpolation calculation is being performed (Reset = FALSE).
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. When ErrorMode = 0, 0.0 is used as output value.
The NextXIndex tag is not updated as long as the Input parameter has an invalid REAL value
Solution:
Make sure that the parameter Input is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF).</td></tr>
<tr><td>0004_0000</td><td colspan="3">Cause of error:
The interpolation calculation yields an invalid REAL value for the Output parameter.
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. The NextXIndex tag can have an invalid value as long as this error is pending.
Solution:
Check the REAL values in the WorkingData structure for validity.
Additional information:
If you want to change the polyline data, first edit the UserData structure and then set parameter Validate = TRUE. Do not manually change the data of the WorkingData structure.</td></tr>
</table>

ErrorBits (DW#16#...)	Description
0008_0000	**Cause of error:** One or more tags in the UserData structure have invalid values while the polyline data is checked. **Response to error:** The polyline data in the UserData structure is not transferred to the WorkingData structure so that the values in the UserData structure do not become effective. FB Polyline does not output the interpolation value at the Output parameter because no valid polyline data is contained in the WorkingData structure. The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. **Solution:** Ensure that the following conditions are met when the polyline data is checked: • 2 ≤ UserData.NumberOfUsedPoints ≤ 50 • UserData.Point[j].x < UserData.Point[j+1].x with index j = 1..(UserData.NumberOfUsedPoints – 1) • -3.402823e+38 ≤ UserData.Point[i].x ≤ 3.402823e+38 with index i = 1..UserData.NumberOfUsedPoints • -3.402823e+38 ≤ UserData.Point[i].y ≤ 3.402823e+38 with index i = 1..UserData.NumberOfUsedPoints • UserData.Point[i].x and UserData.Point[i].y are valid REAL values (≠ NaN) with index i = 1..UserData.NumberOfUsedPoints **Additional information:** The polyline data in the UserData structure is checked when • The Validate parameter is set to TRUE while the Reset parameter is set to FALSE or • Polyline is called for the first time with parameter Reset = FALSE after the operating state transition of the CPU from STOP to RUN. Note that all tags in the UserData and WorkingData structures are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN.

11.6 SplitRange

11.6.1 Compatibility with CPU and FW

The following table shows which version of SplitRange can be used on which CPU:

CPU	FW	SplitRange
S7-1200	as of V4.2	V1.0
S7-1200 G2	V1.0 or higher	V1.0
S7-1500-based CPUs	as of V2.0	V1.0

11.6.2 SplitRange description

Description

The SplitRange instruction converts the input value into an output value. The input value is located in the value range that is limited by Points.x1 and Points.x2. The output value is located in the value range that is limited by Points.y1 and Points.y2.

The following figure shows the relevant characteristic of an example configuration of the SplitRange instruction:

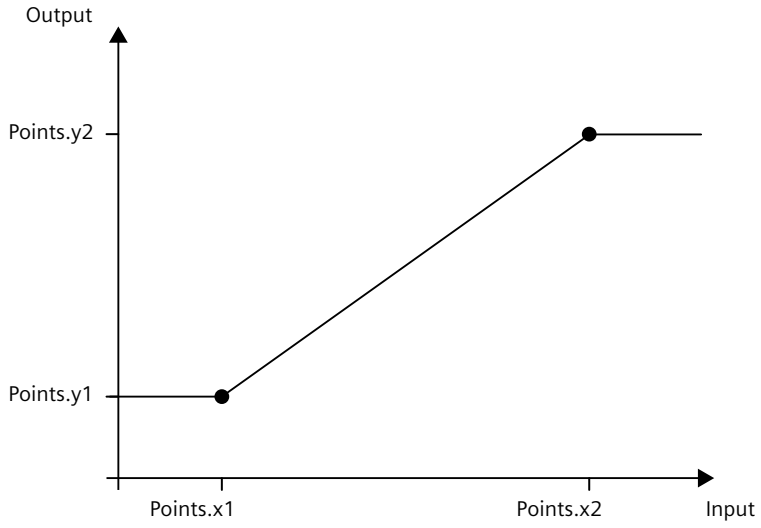

Use SplitRange when you need to control a process that is influenced by multiple actuators. SplitRange splits the output value range of the PID controller into multiple subranges. Assign a subrange to each actuator. The user program calls the block once per subrange. The input value of each SplitRange instance is connected to the output value of the PID controller.

The figure below shows an example of a control loop with two SplitRange instances and two actuators:

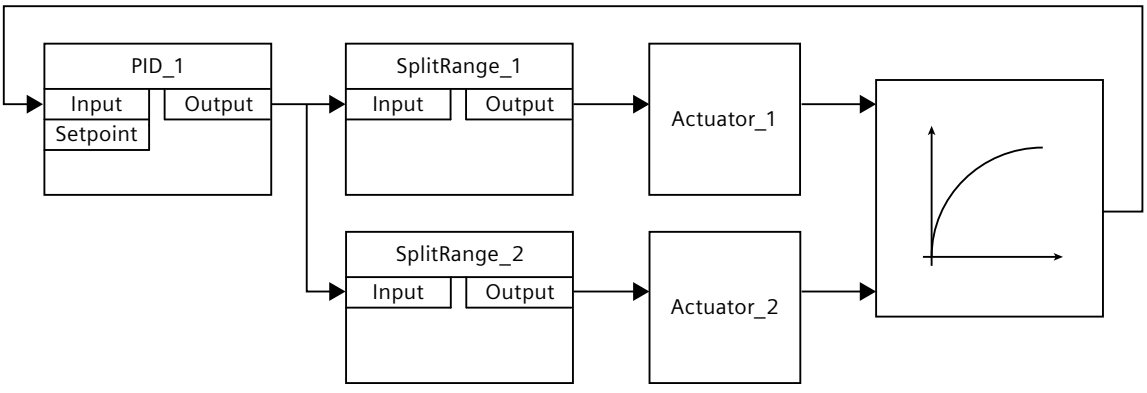

Validity of the SplitRange data

The value pairs in the Points structure define the input and output value range of SplitRange. The two value pairs are located in the static area of the block SplitRange.

SplitRange checks whether the following conditions are met for each call so that valid values are available for the calculation of the output value:

- Points.x1 < Points.x2
- Points.x1, Points.y1, Points.x2 and Points.y2 are within the permitted value range from -3.402823e+38 to 3.402823e+38
- Points.x1, Points.y1, Points.x2 and Points.y2 are valid REAL values (≠ NaN e.g. 16#7FFF_FFFF)

If one or more of these conditions are not met, correct calculation of the output value is not possible. A corresponding error message is output at the ErrorBits parameter.

The preassignment of the x and y values with 0.0 does not represent a valid configuration. Change the tags to valid values so that the tags can be used for the calculation of the output value.

Enable behavior EN/ENO

If one of the following conditions is met, enable output ENO is set to FALSE.

- Enable input EN is set to TRUE and the Output parameter is specified by a substitute output value in case of error messages ErrorBits ≥ 16#0001_0000.
- Enable input EN is set to FALSE.

Otherwise, the enable output ENO is set to TRUE.

Call

In an OB or FC, SplitRange is called as single-instance DB. In an FB, SplitRange can be called as a single-instance DB, as a multi-instance DB, and as a parameter instance DB.

When the instruction is called, no technology object is created. No parameter assignment interface or commissioning interface is available. You assign the SplitRange parameters directly using the instance DB and commission SplitRange using a watch table of the user program in the CPU or HMI.

Startup

The tags in the static area of SplitRange are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN.

If you change the actual values in the Points structure in online mode and these values are to be retained after the operating state transition of the CPU from STOP to RUN, back up these values in the start values of the data block.

Response to errors

The SplitRange instruction detects different errors that can occur during the calculation of the output value. The result of the calculation can be output at the output despite a pending error. If an error prevents correct calculation of the output value, a substitute output value is output at the output.

You specify the substitute output value that is output if an error occurs that prevents correct calculation of the output value as follows at the ErrorMode tag:

ErrorMode	Output
0	Value of the Input parameter
1	Value of the SubstituteOutput parameter
2	The last valid result of output value calculation 0.0 if there is no valid result

The following applies in addition for all values of the ErrorMode tag:

- If the substitute output value is not a valid REAL value, 0.0 is output as output value.
- The substitute output value is limited to the value range of the data type REAL. Only then is the substitute output value output at the Output parameter.
- The ErrorMode tag only takes effect when the Reset = FALSE parameter is set. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter.

The Error parameter indicates if an error is pending. When the error is no longer pending, Error is set to FALSE. The ErrorBits parameter shows which errors have occurred. ErrorBits is retentive and is reset only by a positive edge at the Reset or ErrorAck parameter.

11.6.3 SplitRange input parameters

Parameter	Data type	Default	Description
Input	REAL	0.0	Input value
Substitu-teOutput	REAL	0.0	SubstituteOutput is used as the substitute output value when • Reset = TRUE or • An error with error message ErrorBits ≥ 16#0001_0000 prevents correct calculation of the output value, and the configured value of ErrorMode is 1.
ErrorAck	BOOL	FALSE	Deletes the error messages • Edge FALSE -> TRUE ErrorBits is reset
Reset	BOOL	FALSE	Performs a restart of the instruction • Edge FALSE -> TRUE ErrorBits is reset. • As long as Reset is set to TRUE, the substitute output value SubstituteOutput is output at the output. • As long as Reset is set to FALSE, the calculation of the output value is performed.

11.6.4 SplitRange output parameters

Parameter	Data type	Default	Description
Output	REAL	0.0	Output value
ErrorBits	DWORD	DW#16#0	The ErrorBits parameter (Page 490) shows which error messages are pending. ErrorBits is retentive and is reset at a positive edge at Reset or ErrorAck .
Error	BOOL	FALSE	When Error is set to TRUE, at least one error is currently pending.

11.6.5 SplitRange static tags

Tag	Data type	Default	Description
Points	AuxFct_SplitRang-e_Points	-	Points data
Points.x1	REAL	0.0	x-value of point 1 Permissible value range: Points.x1 < Points.x2
Points.y1	REAL	0.0	y-value of point 1
Points.x2	REAL	0.0	x-value of point 2 Permissible value range: Points.x1 < Points.x2
Points.y2	REAL	0.0	y-value of point 2
ErrorMode	INT	0	Selection of the substitute output value following an error • 0 = Input • 1 = SubstituteOutput • 2 = Last valid output value Permissible value range: 0 to 2

11.6.6 ErrorBits parameter

If several errors are pending simultaneously, the values of the ErrorBits are displayed with binary addition. The display of ErrorBits = 16#0000_0003, for example, indicates that the errors 16#0000_0001 and 16#0000_0002 are pending simultaneously.

For SplitRange, the errors output at the ErrorBits parameter are divided into two categories:

- Errors with error messages ErrorBits < 16#0001_0000
- Errors with error messages ErrorBits ≥ 16#0001_0000

Errors with error messages ErrorBits < 16#0001_0000

If one or more errors with error messages ErrorBits < 16#0001_0000 are pending, SplitRange reacts as follows:

- The output value is determined as follows despite this error:
  - When Reset = FALSE, output value calculation
  - When Reset = TRUE, output of SubstituteOutput
- The output parameter Error is set.
- The enable output ENO is not changed.

The output parameter Error is deleted as soon as there are no longer any errors.

ErrorBits (DW#16#...)	Description
0000_0000	No error is pending.
0000_0001	**Cause of error and response to error:** The Output parameter was limited to -3.402823e+38 or +3.402823e+38. **Solution:** When ErrorBits ≥ 16#0001_0000 and Reset = FALSE, the substitute output value is limited on its output. In this case, check the following parameters depending on the set value at the ErrorMode tag: • Input • SubstituteOutput When Reset = TRUE, check the SubstituteOutput parameter.

Errors with error messages ErrorBits ≥ 16#0001_0000

If one or more errors with error messages ErrorBits ≥ 16#0001_0000 are pending, SplitRange reacts as follows:

- The output value cannot be determined as expected. The substitute output value is output instead.
- The output parameter Error is set.
- The enable output ENO is set to FALSE.

As soon as there are no longer errors with error messages ErrorBits ≥ 16#0001_0000, SplitRange reacts as follows:

- The output value is determined as follows:
  - When Reset = FALSE, output value calculation
  - When Reset = TRUE, output of SubstituteOutput
- The enable output ENO is set to TRUE.

The output parameter Error is deleted as soon as there are no longer any errors.

<table>
<tr><th>ErrorBits (DW#16#...)</th><th colspan="3">Description</th></tr>
<tr><td rowspan="5">0001_0000</td><td colspan="3">Cause of error:
The SubstituteOutput or Input parameter that is being used as the output value has no valid REAL value.
Response to error:
The output is set to 0.0.
Solution:
Make sure that the parameter used as output value is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF). The parameter that is used as output value depends on Reset and ErrorMode:</td></tr>
<tr><td>Reset</td><td>ErrorMode</td><td>Output value</td></tr>
<tr><td>FALSE</td><td>0</td><td>Input</td></tr>
<tr><td>FALSE</td><td>1</td><td>SubstituteOutput</td></tr>
<tr><td>TRUE</td><td>-</td><td>SubstituteOutput</td></tr>
<tr><td>0002_0000</td><td colspan="3">Cause of error:
The Input parameter has no valid REAL value while the calculation of the output value is being performed (Reset = FALSE).
Response to error:</td></tr>
</table>

ErrorBits (DW#16#...)	Description
	The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. When ErrorMode = 0, 0.0 is used as output value. **Solution:** Make sure that the parameter Input is a valid REAL value (≠NaN e.g. 16#7FFF_FFFF).
0004_0000	**Possible causes of error:** • One or more tags in the Points structure have invalid values. • The calculation of the output value yields an invalid REAL value for the Output parameter. **Response to error:** The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. **Solution:** Ensure that the following conditions are met: 1. Points.x1 < Points.x2 2. Points.x1, Points.y1, Points.x2 and Points.y2 are within the permitted value range from -3.402823e+38 to 3.402823e+38 3. Points.x1, Points.y1, Points.x2 and Points.y2 are valid REAL values (≠ NaN e.g. 16#7FFF_FFFF) **Additional information:** Note that all tags in the Points structure are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN.

11.7 RampFunction

11.7.1 Compatibility with CPU and FW

The following table shows which version of RampFunction can be used on which CPU:

CPU	FW	RampFunction
S7-1200	as of V4.2	V1.0
S7-1200 G2	V1.0 or higher	V1.0
S7-1500-based CPUs	as of V2.0	V1.0

11.7.2 RampFunction description

Description

The RampFunction instruction limits the slew rate of a signal. RampFunction outputs a signal jump at the input as ramp function of the output value.

Use the RampFunction to prevent signal jumps, for example, in the following cases:

- Between setpoint source and setpoint input of the controller to achieve a smoother response without influencing the disturbance reaction.
- Between the controller output and the actuator input to preserve the actuator, for example, a motor with gears or the process.

The following limits can be set for the slew rate:

- Increasing slew rate in positive value range
- Decreasing slew rate in positive value range
- Increasing slew rate in negative value range
- Decreasing slew rate in negative value range

In addition, the RampFunction instruction limits the output value to the high and low limit.

When the slew rate limit or the low or high limit are reached, RampFunction sets the associated output bit to TRUE.

Function chart

The following figure shows the RampFunction instruction and a function chart as an example:

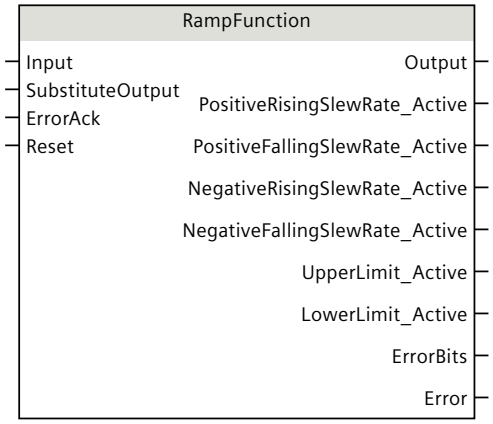

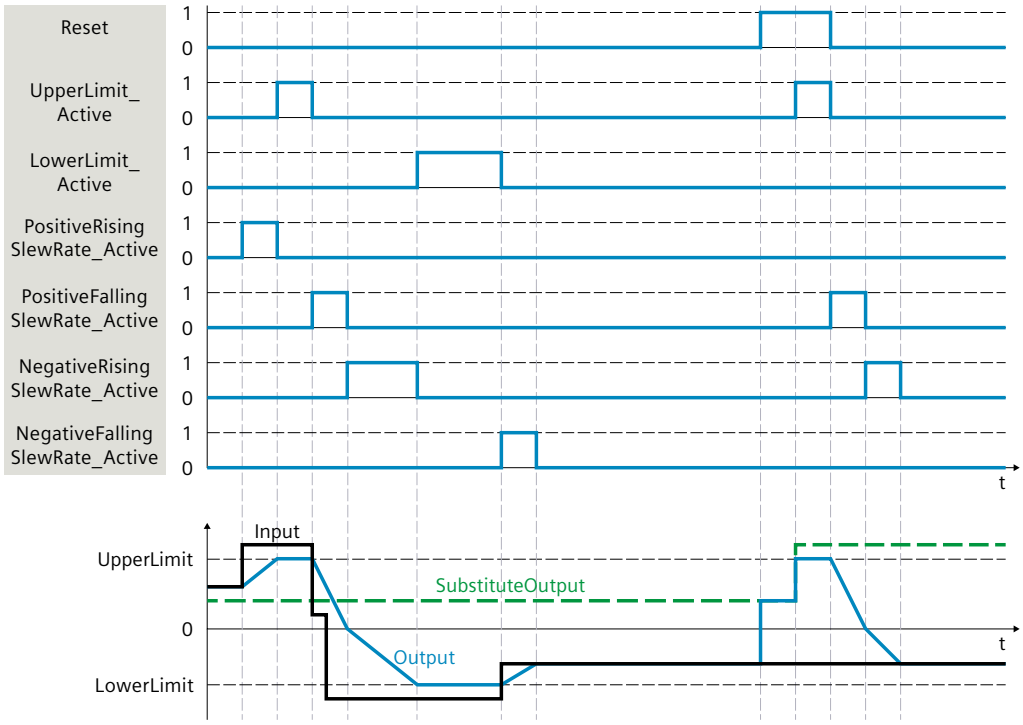

Call

In an OB or FC, RampFunction is called as single-instance DB. In an FB, RampFunction can be called as a single-instance DB, as a multi-instance DB, and as a parameter instance DB.

When the instruction is called, no technology object is created. No parameter assignment interface or commissioning interface is available. You assign the RampFunction parameters directly using the instance DB and commission RampFunction using a watch table of the user program in the CPU or HMI.

Startup

The tags in the static area of RampFunction are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN.

If you change the actual values of the limits in online mode and these values are to be retained after the operating state transition of the CPU, back up these values in the start values of the data block.

Specify the initialization value for the Output parameter at the StartMode tag.

During the first call of RampFunction after the

- Operating state transition of the CPU

or

- Execution of "Load start values as actual values" (only with "All values" option, not with "Only setpoints" option)

the initialization value is output at the Output parameter.

For subsequent calls, RampFunction calculates the output value, starting from this initialization value, based on the input value and the slew rate limits.

The following table shows the dependency between the StartMode tag and the Output parameter. The values in the Output column are output at the Output parameter after the operating state transition of the CPU.

StartMode	Output	Example
0	Value of the Input parameter	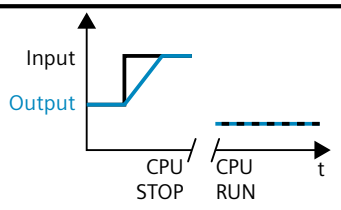
1	Value of the SubstituteOutput parameter	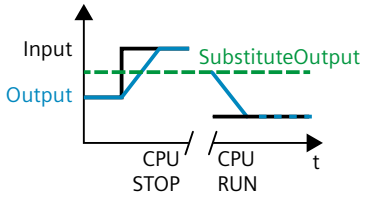

StartMode	Output	Example
2	Remains unchanged. Output parameter is retentive.	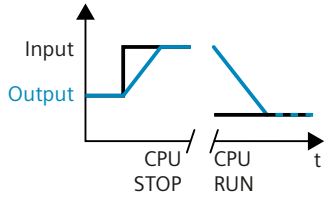
3	0.0	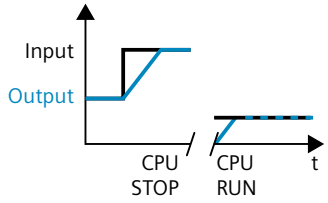
4	Value of the LowerLimit tag	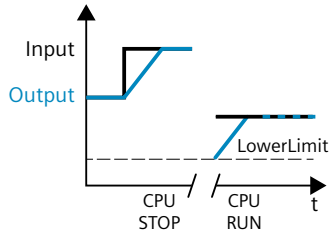
5	Value of the UpperLimit tag	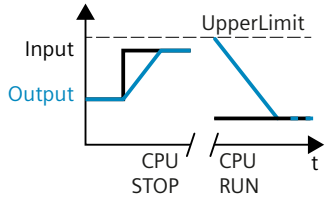

The following applies in addition for all values of the StartMode tag:

- When the values of the UpperLimit and LowerLimit tags are valid, the initialization value is limited to the value range of these tags. Only then is the initialization value output at the Output parameter.
- If the initialization value is not a valid REAL value, the substitute output value is output at the Output parameter. The substitute output value is configured by the ErrorMode tag. The substitute output value is limited by the value range of the tags UpperLimit and LowerLimit. If the substitute output value is also not a valid REAL value, 0.0 is output at the Output parameter. For subsequent calls, the instruction calculates the output value starting from this substitute output value.
- The StartMode tag only takes effect when the Reset = FALSE parameter is set at the first call of the instruction and at the same time no error with error message ErrorBits ≥ 16#0002_0000 is pending. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter. If an error with error message ErrorBits ≥ 16#0002_0000 is pending, the substitute output value that is configured at the ErrorMode tag is output at the Output parameter.

Response to errors

The RampFunction instruction detects different errors that can occur during the calculation of the output value. The result of this calculation can be output at the output despite a pending error. If an error prevents correct calculation of the output value, a substitute output value is output at the output.

Specify the substitute output value that is output if an error occurs that prevents correct calculation of the output value at the ErrorMode tag.

The following table shows the dependency between the ErrorMode tag and the substitute output value that is output by the RampFunction at the Output parameter:

ErrorMode	Output
0	Value of the Input parameter
1	Value of the SubstituteOutput parameter
2	The last valid output value at the Output parameter
3	0.0
4	Value of the LowerLimit tag
5	Value of the UpperLimit tag

The following applies in addition for all values of the ErrorMode tag:

- If the substitute output value is not a valid REAL value, 0.0 is output as output value.
- When the values of the UpperLimit and LowerLimit tags are valid, the substitute output value is limited to the value range of these tags. Only then is the substitute output value output at the Output parameter.
- The ErrorMode tag only takes effect when the Reset = FALSE parameter is set. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter.
- If an error is pending that prevents correct calculation of the output value, RampFunction changes at the Output parameter from the calculated output value to the substitute output value. A jump of the output value can occur, depending on the value of the ErrorMode tag.

The Error parameter indicates if an error is pending. When the error is no longer pending, Error is set to FALSE. The ErrorBits parameter shows which errors have occurred. ErrorBits is retentive and is reset only by a positive edge at the Reset or ErrorAck parameter.

11.7.3 RampFunction mode of operation

Limiting the slew rate

You can configure four limits for the slew rate of the input signal. The following factors determine which limit is currently in effect:

- Sign of the output value at the Output parameter
- Change of direction of the absolute value of the output value at the Output parameter

The following table shows the effective tags for the slew rate limit depending on the Output parameter:

Output	Effective tag
Output ≥ 0 and |Output| rising	PositiveRisingSlewRate
Output ≥ 0 and |Output| falling	PositiveFallingSlewRate
Output < 0 and |Output| rising	NegativeRisingSlewRate
Output < 0 and |Output| falling	NegativeFallingSlewRate

The absolute value of the slew rate limits defines the maximum change of the output value per second.

Example:

The following scenario applies for the example:

- PositiveRisingSlewRate = 10.0
- Call time of RampFunction = 0.1 s
- Input > Output ≥ 0.0

Result:

The output value Output increases by 1.0 per call (10.0 per second) until the value at the Input parameter has been reached.

To disable the slew rate limit for one or more areas, set the corresponding tag to the value 3.402823e+38.

When the output value Output is currently limited by a slew rate limit, RampFunction sets the associated output bit to TRUE:

- PositiveRisingSlewRate_Active
- PositiveFallingSlewRate_Active
- NegativeRisingSlewRate_Active
- NegativeFallingSlewRate_Active

When the Reset parameter is set to TRUE, the slew rate limits are not in effect. This means jumps at the SubstituteOutput parameter result in jumps at the Output parameter.

RampFunction checks whether the following conditions for the tags PositiveRisingSlewRate, PositiveFallingSlewRate, NegativeRisingSlewRate and NegativeFallingSlewRate are met for each call:

- Values are within the permitted value range greater than 0.0 up to 3.402823e+38
- Values are valid REAL values (≠ NaN e.g. 16#7FFF_FFFF)

If one or more conditions are not met, the substitute output value is output at the Output parameter. A corresponding error message is output at the ErrorBits parameter.

Limiting the output value

The output value Output is always limited to the value range of the tags UpperLimit and LowerLimit as long as these tags have valid values.

When the output value Output is currently limited by this value range, RampFunction sets the associated output bit to TRUE:

- UpperLimit_Active
- LowerLimit_Active

The limit of the output value has a higher priority than the limit of the slew rate. Changes of the tags UpperLimit and LowerLimit therefore result in jumps of the output value Output, if this is required to observe the limits of the tags UpperLimit and LowerLimit. The limiting of the slew rate is not taken into account in this case.

Example:

If the UpperLimit is reduced from 100.0 to 80.0 while the values of the parameters Input and Output are 90.0, the output value Output jumps to 80.0. The output value Output jumps to 80.0 regardless whether or not it violates the configured limit for the slew rate.

RampFunction checks whether the following conditions are met for each call:

- LowerLimit < UpperLimit
- LowerLimit and UpperLimit are within the permitted value range from -3.402823e+38 to 3.402823e+38
- LowerLimit and UpperLimit are valid REAL values (≠ NaN e.g. 16#7FFF_FFFF)

If one or more conditions are not met, the substitute output value is output at the Output parameter. A corresponding error message is output at the ErrorBits parameter.

In addition, RampFunction checks for each call whether the output value Output has the permitted value range of a REAL data type from -3.402823e+38 to 3.402823e+38. If the calculation of the output value yields an invalid REAL value, the substitute output value is output at the Output parameter. You configure the substitute output value at the ErrorMode tag.

Enable behavior EN/ENO

If one of the following conditions is met, enable output ENO is set to FALSE.

- Enable input EN is set to TRUE and the Output parameter is specified by a substitute output value in case of error messages ErrorBits ≥ 16#0001_0000.
- Enable input EN is set to FALSE.

Otherwise, the enable output ENO is set to TRUE.

Measuring the cycle time automatically

To calculate the slew rate of the output value RampFunction needs the time that has expired since the last call of RampFunction.

By default, the cycle time is measured automatically and output as of the second call at the CycleTime.Value tag. RampFunction measures the cycle time for each call of the instruction and can therefore be used in non-isochronous call cycles, e.g. in OB1.

Note that conditional calls of the instruction, active breakpoints, or the loading of snapshots as actual values during automatic measurement of the cycle time will extend the cycle time value.

If measurement of the cycle time returns no valid result, RampFunction calculates the current output value with the last valid cycle time. In addition, RampFunction outputs an error message at the ErrorBits parameter.

When you disable automatic measurement of the cycle time by setting the CycleTime.EnableMeasurement tag = FALSE, you must enter the cycle time manually at the CycleTime.Value tag. RampFunction checks the CycleTime.Value tag for validity at each call.

Automatic measurement of the cycle time with breakpoints

When breakpoints are active between two calls of RampFunction, automatic measurement of the cycle time results in the actual time that has elapsed between two calls. When one breakpoint is active, the CPU is in HOLD operating state.

NOTE

The active breakpoints extend the time period between two calls of RampFunction.

The longer the time period between two calls, the greater the maximum permitted change of the output value at the Output parameter.

Example:

The following scenario applies for the example:

- PositiveRisingSlewRate = 10.0
- Call time of RampFunction = 0.1 s
- Input > Output ≥ 0.0

Result without breakpoints:

The output value Output increases by 1.0 per call until the value at the Input parameter has been reached.

Result with an active breakpoint of ten seconds:

With the next call, the output value Output increases by 100.0.

If you do not need the calculation of the output value based on the actual time with active breakpoints, follow these steps:

- Disable automatic measurement of the cycle time by setting the tag CycleTime.EnableMeasurement = FALSE.
- Enter the cycle time manually at the CycleTime.Value tag.

11.7.4 RampFunction input parameters

Parameter	Data type	Default	Description
Input	REAL	0.0	Input value
SubstituteOutput	REAL	0.0	SubstituteOutput is used as the substitute output value when • Reset = TRUE or • An error with error message ErrorBits ≥ 16#0001_0000 prevents correct calculation of the output value, and the configured value of ErrorMode is 1.
ErrorAck	BOOL	FALSE	Deletes the error messages • Edge FALSE -> TRUE ErrorBits is reset
Reset	BOOL	FALSE	Performs a restart of the instruction • Edge FALSE -> TRUE ErrorBits is reset. • As long as Reset is set to TRUE, the substitute output value SubstituteOutput is output at the output. • As long as Reset is set to FALSE, the calculation of the output value is performed.

11.7.5 RampFunction output parameters

Parameter	Data type	Default	Description
Output	REAL	0.0	Output value
PositiveRisingSlewRate_Active	BOOL	FALSE	When PositiveRisingSlewRate_Active = TRUE, the output value is currently limited by PositiveRisingSlewRate .
PositiveFallingSlewRate_Active	BOOL	FALSE	When PositiveFallingSlewRate_Active = TRUE, the output value is currently limited by PositiveFallingSlewRate.
NegativeRisingSlewRate_Active	BOOL	FALSE	When NegativeRisingSlewRate_Active = TRUE, the output value is currently limited by NegativeRisingSlewRate.
NegativeFallingSlewRate_Active	BOOL	FALSE	When NegativeFallingSlewRate_Active = TRUE, the output value is currently limited by NegativeFallingSlewRate.
UpperLimit_Active	BOOL	FALSE	When UpperLimit_Active = TRUE, the output value is currently limited by UpperLimit.
LowerLimit_Active	BOOL	FALSE	When LowerLimit_Active = TRUE, the output value is currently limited by LowerLimit.
ErrorBits	DWORD	DW#16#0	The ErrorBits parameter (Page 502) shows which error messages are pending. ErrorBits is retentive and is reset at a positive edge at Reset or ErrorAck .
Error	BOOL	FALSE	When Error = TRUE, at least one error is currently pending.

11.7.6 RampFunction static tags

Tag	Data type	Default	Description
PositiveRisingSlewRate	REAL	10.0	Limit for slew rate of the output value per second in positive range with rising absolute value With PositiveRisingSlewRate = 3.402823e+38, this slew rate limit is disabled. Permissible value range: > 0.0
PositiveFallingSlewRate	REAL	10.0	Limit for slew rate of the output value per second in positive range with falling absolute value With PositiveFallingSlewRate = 3.402823e+38, this slew rate limit is disabled. Permissible value range: > 0.0
NegativeRisingSlewRate	REAL	10.0	Limit for slew rate of the output value per second in negative range with rising absolute value With NegativeRisingSlewRate = 3.402823e+38, this slew rate limit is disabled. Permissible value range: > 0.0
NegativeFallingSle-wRate	REAL	10.0	Limit for slew rate of the output value per second in negative range with falling absolute value With NegativeFallingSlewRate = 3.402823e+38, this slew rate limit is disabled. Permissible value range: > 0.0
UpperLimit	REAL	100.0	High limit of output value Permissible value range: > LowerLimit
LowerLimit	REAL	0.0	Low limit of output value Permissible value range: < UpperLimit
ErrorMode	INT	2	Selection of the substitute output value following an error • 0 = Input • 1 = SubstituteOutput • 2 = Last valid output value • 3 = 0.0 • 4 = LowerLimit • 5 = UpperLimit Permissible value range: 0 to 5
StartMode	INT	2	Selecting the output value for the first call of the instruction • 0 = Input • 1 = SubstituteOutput • 2 = Last output value • 3 = 0.0 • 4 = LowerLimit • 5 = UpperLimit Permissible value range: 0 to 5
CycleTime	AuxFct_CycleTime	-	Cycle time data
CycleTime.Value	REAL	0.1	Time interval between two calls of the instruction in seconds Permissible value range: > 0.0
CycleTime.EnableMeas-urement	BOOL	TRUE	Automatic measurement of the cycle time • FALSE = Deactivated • TRUE = Activated

11.7.7 ErrorBits parameter

If several errors are pending simultaneously, the values of the ErrorBits are displayed with binary addition. The display of ErrorBits = 16#0000_0003, for example, indicates that the errors 16#0000_0001 and 16#0000_0002 are pending simultaneously.

For RampFunction, the errors output at the ErrorBits parameter are divided into two categories:

- Errors with error messages ErrorBits < 16#0001_0000
- Errors with error messages ErrorBits ≥ 16#0001_0000

Errors with error messages ErrorBits < 16#0001_0000

If one or more errors with error messages ErrorBits < 16#0001_0000 are pending, RampFunction reacts as follows:

- The output value is determined as follows despite this error:
  - When Reset = FALSE, output value calculation
  - When Reset = TRUE, output of SubstituteOutput
- The output parameter Error is set.
- The enable output ENO is not changed.

The output parameter Error is deleted as soon as there are no longer any errors.

ErrorBits (DW#16#...)	Description
0000_0000	No error is pending.
0000_0002	**Cause of error:** The measurement of the cycle time yields in an invalid value while the output value is being calculated (Reset = FALSE). **Response to error:** If a valid value of the cycle time has already been measured, RampFunction calculates the output value based on the last value of the CycleTime.Value tag. If no valid value of the cycle time was previously measured, RampFunction still outputs the output value configured with the StartMode tag at the Output parameter.

Errors with error messages ErrorBits ≥ 16#0001_0000

If one or more errors with error messages ErrorBits ≥ 16#0001_0000 are pending, RampFunction reacts as follows:

- The output value cannot be determined as expected. The substitute output value is output instead.
- The output parameter Error is set.
- The enable output ENO is set to FALSE.
- The output value limit remains active as long as the tags LowerLimit and UpperLimit have valid values.

- The slew rate limit is no longer active. Jumps at the output value can occur in one of the following scenarios:
  - When the error is detected, RampFunction switches from the calculated output value to the replacement output value. Whether a jump occurs depends on the value of the tag ErrorMode.
  - The substitute output value is changed while it is active.

As soon as there are no longer errors with error messages ErrorBits ≥ 16#0001_0000, RampFunction reacts as follows:

- The output value is determined as follows:
  - When Reset = FALSE, output value calculation
  - When Reset = TRUE, output of SubstituteOutput
- The enable output ENO is set to TRUE.

The output parameter Error is deleted as soon as there are no longer any errors.

ErrorBits (DW#16#...)	**Description**		
0001_0000	**Cause of error:** The SubstituteOutput parameter or a different tag that is being used as output value has no valid REAL value. **Response to error:** The output is set to 0.0 and limited by the tags LowerLimit and UpperLimit. **Solution:** Make sure that the tag used as output value is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF). The tag that is used as output value depends on Reset and ErrorMode:		
	Reset	**ErrorMode**	**Output value**
	FALSE	0	Input
	FALSE	1	SubstituteOutput
	FALSE	4	LowerLimit
	FALSE	5	UpperLimit
	TRUE	-	SubstituteOutput
0002_0000	**Cause of error:** The Input parameter has no valid REAL value while the calculation of the output value is being performed (Reset = FALSE). **Response to error:** The substitute output value is output at the Output parameter that is configured at the ErrorMode tag and is limited by the tags UpperLimit and LowerLimit. When ErrorMode = 0, 0.0 is used as output value. **Solution:** Make sure that the parameter Input is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF).		
0004_0000	**Cause of error:** The calculation of the output value yields an invalid REAL value for the Output parameter. **Response to error:** The substitute output value is output at the Output parameter that is configured at the ErrorMode tag and is limited by the tags UpperLimit and LowerLimit. **Solution:**		

ErrorBits (DW#16#...)	Description
	Check all tags involved in the calculation of the output value: • Input • PositiveRisingSlewRate • PositiveFallingSlewRate • NegativeRisingSlewRate • NegativeFallingSlewRate • CycleTime.Value These tags have valid values. The calculation of the output value fails in this combination of tags.
0008_0000	**Cause of error:** The LowerLimit or UpperLimit tag has an invalid value. **Response to error:** The following value is output at the Output parameter, depending on the Reset parameter: • Reset = FALSE The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. • Reset = TRUE The value of the SubstituteOutput parameter is output at the Output parameter. In both cases, the Ouput parameter is limited to the value range of the REAL data type from -3.402823e+38 to 3.402823e+38. **Solution:** Ensure that the following conditions are met: 1. LowerLimit < UpperLimit 2. LowerLimit and UpperLimit are within the permitted value range from -3.402823e+38 to 3.402823e+38 3. LowerLimit and UpperLimit are valid REAL values (≠ NaN e.g. 16#7FFF_FFFF)
0010_0000	**Cause of error:** At least one of the following tags has invalid values while the calculation of the output value is being performed (Reset = FALSE): 1. PositiveRisingSlewRate 2. PositiveFallingSlewRate 3. NegativeRisingSlewRate 4. NegativeFallingSlewRate **Response to error:** The substitute output value is output at the Output parameter that is configured at the ErrorMode tag and is limited by the tags UpperLimit and LowerLimit. **Solution:** Ensure that the following conditions are met for all four tags listed above: • The values are within the permitted value range greater than 0.0 up to 3.402823e+38 • The values are valid REAL values (≠ NaN e.g. 16#7FFF_FFFF)
0020_0000	**Cause of error:** The tag (configured with StartMode) for the initialization of the Output parameter at the first call of the instruction does not have a valid REAL value. **Response to error:** The substitute output value is output with the first call of the instruction at the Output parameter that is configured at the ErrorMode tag and is limited by the tags LowerLimit and UpperLimit. For subsequent calls, RampFunction calculates the output value starting from this substitute output value. **Solution:** Make sure that the tag for initializing the parameter Output is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF). When Reset = FALSE is set, the initialization takes effect with the first call of the instruction after the operating state transition of the CPU from STOP to RUN. The tag that is used for the initialization of the Output parameter depends on StartMode: • StartMode = 1: Substitute Output • StartMode = 2: Output

ErrorBits (DW#16#...)	Description
0040_0000	**Cause of error:** The CycleTime.Value tag has an invalid value, while the calculation of the output value is being performed (Reset = FALSE). **Response to error:** The substitute output value is output at the Output parameter that is configured at the ErrorMode tag and is limited by the tags UpperLimit and LowerLimit. **Solution:** Ensure that the following conditions are met: • 0.0 < CycleTime.Value ≤ 3.402823e+38 • CycleTime.Value is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF) **Additional information:** To automatically calculate the value of the CycleTime.Value tag, set the CycleTime.EnableMeasurement tag to TRUE.

11.8 RampSoak

11.8.1 Compatibility with CPU and FW

The following table shows which version of RampSoak can be used on which CPU:

CPU	FW	RampSoak
S7-1200	as of V4.2	V1.0
S7-1200 G2	V1.0 or higher	V1.0
S7-1500-based CPUs	as of V2.0	V1.0

11.8.2 Description of RampSoak

Description

You can use the RampSoak instruction to generate an output value that follows a configurable profile on a time-dependent basis. Every point of this profile has a target value and a time value. When the profile is executed, the target value of the current point is reached within the time value.

The following figure shows a profile with 4 points:

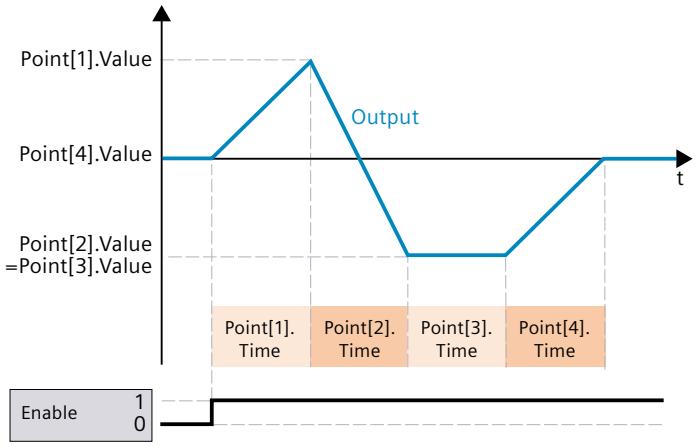

The RampSoak instruction can be used, for example, to provide a setpoint value profile for regulating a temperature process.

Calculation of the output value

The output value is calculated with an interpolation between the current point and the previous point according to the following formula:

$$\text{Output}(t) = \text{Point}[i].\text{Value} - \frac{\text{RemainingTime_Point}}{\text{Point}[i].\text{Time}} (\text{Point}[i].\text{Value} - \text{Point}[i-1].\text{Value})$$

The *i* represents the value of the CurrentPoint parameter.

On the basis of the time that has elapsed, a determination is made as to which points from the profile are currently used for calculating the output value.

Call

In an OB or FC, RampSoak is called as single-instance DB. In an FB, RampSoak can be called as a single-instance DB, as a multi-instance DB, and as a parameter instance DB.

When the instruction is called, no technology object is created. No parameter assignment interface or commissioning interface is available. You assign the RampSoak parameters directly using the instance DB and commission RampSoak using a watch table of the user program in the CPU or HMI.

Startup

The tags in the static area of RampSoak and hence also the profile data in the UserData and WorkingData structures are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN.

If you change the actual values in the UserData structure in online mode and these values are to be retained after the operating state transition of the CPU from STOP to RUN, back up these values in the start values of the data block.

At the first call of the RampSoak instruction after the operating state transition of the CPU from STOP to RUN, the data in the UserData structure is automatically validated. If the check is successful, the data is transferred to the WorkingData structure.

With the tag StartMode (Page 515), you can define the starting behavior of the RampSoak instruction at the first call after the operating state transition of the CPU from STOP to RUN.

Response to errors

If the output value cannot be correctly calculated, the RampSoak instruction instead outputs a substitute output value and an error with an error message ErrorBits >= 16#0002_0000. You can use the tag ErrorMode (Page 524) to define the substitute output value as follows:

Error-Mode	Output
0	Value of the WorkingData.StartValue tag Make sure that the profile data in UserData is validated with the Validate parameter and accepted after WorkingData. If the profile data has never been verified and accepted, the default value 0.0 of WorkingData.StartValue is used.
1	Value of the SubstituteOutput parameter
2	The last valid output value of the profile execution 0.0, if no valid output value of the profile execution is available.
3	0.0

The following applies in addition for all values of the ErrorMode tag:

- If the substitute output value is not a valid REAL value, 0.0 is output as output value.
- The substitute output value is limited to the value range -3.402823e+38 .. +3.402823e+38 of the data type REAL. Only then is the substitute output value output at the Output parameter.
- The ErrorMode tag only takes effect when the Reset = FALSE parameter is set. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter or 0.0 is output at the Output parameter.

The Error parameter indicates if an error is pending. When the error is no longer pending, Error is set to FALSE. The ErrorBits parameter shows which errors have occurred. ErrorBits is retentive and is reset only by a positive edge at the Reset or ErrorAck parameter.

11.8.3 Operating principle RampSoak

11.8.3.1 Configuring and validating profile data

Configuring profile data

You can configure the profile in the static structure UserData.

It contains the following elements:

- NumberOfUsedPoints

  Number of points used for the profile.

- StartValue

  Optional output value when the profile execution is started (Page 515), stopped (Page 518) or ended.

- Point

  The array with 50 elements contains value pairs of the points Point[i].Value and Point[i].Time:

  – Point[i].Value

    The output value is changed to this value in steps as long as the point is active, and reaches this value within the time Point[i].Time.

  – Point[i].Time

    This value defines the duration of the point in seconds.

The following figure shows a profile with 6 points. Point number 5 has a duration of 0 seconds, which results in skipping of the output value.

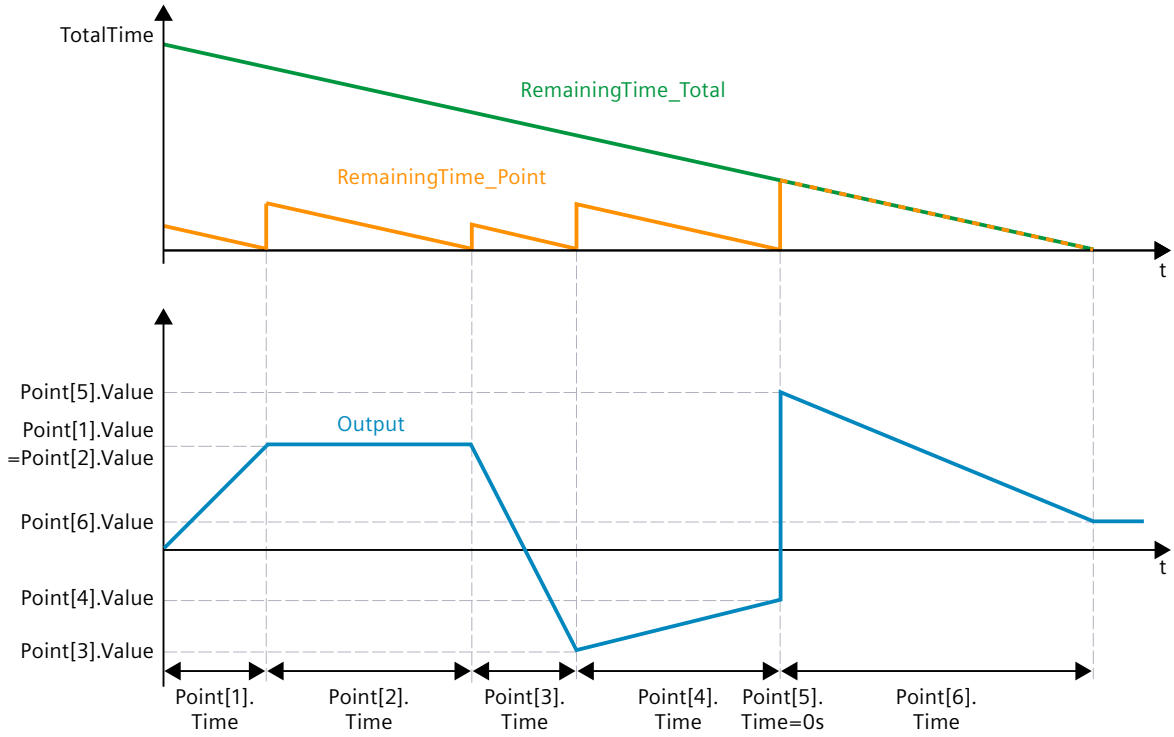

Validating the profile data

Before the profile data is used for the profile execution, a validation of the profile data in the UserData structure is necessary.

The validation is triggered as follows:

- When you set the Validate parameter to TRUE.
- When the parameter Enable is set to TRUE for the first time after the operating state change of the CPU from STOP to RUN and no validation of the profile data has been carried out previously.

The following conditions are checked for the profile data in the UserData structure:

- 1 ≤ UserData.NumberOfUsedPoints ≤ 50
- NextPoint ≤ UserData.NumberOfUsedPoints
- When the profile execution is activated (Enable = TRUE):
  - CurrentPoint ≤ UserData.NumberOfUsedPoints
- -3.402823e+38 ≤ UserData.StartValue ≤ 3.402823e+38
- -3.402823e+38 ≤ UserData.Point[i].Value ≤ 3.402823e+38 with index *i* = 1..UserData.NumberOfUsedPoints

- 0.0 ≤ UserData.Point[i].Time ≤ 3.402823e+38 with index *i* = 1..UserData.NumberOfUsedPoints
- 0.0 < UserData.Point[1].Time + UserData.Point[2].Time +...+ UserData.Point[UserData.NumberOfUsedPoints].Time ≤ 3.402823e+38

Effects of the profile data validation and possible error messages

When the conditions are fulfilled, the new profile data in the UserData structure is transferred to the WorkingData structure and used for the profile execution. The TotalTime parameter is updated. The RemainingTime_Total parameter is updated when the profile is executed.

NOTE

The value and duration of the current point are temporarily stored and also remain unchanged after a successful validation of the new profile data until the current point is completed. The new profile data is used from the start of the next point.

If one of the conditions is not fulfilled, the existing profile data in the WorkingData structure remains unchanged. An error with the error message ErrorBits = 16#0000_0004 (Page 524) is pending.

If the Enable parameter or the Next parameter is set to TRUE, but there is no valid profile data present in the WorkingData structure, then an error with the error message ErrorBits = 16#0008_0000 (Page 524) will be pending.

NOTE

If you do not change the default values in the UserData structure, the validation of the profile data fails.

NOTE

You cannot change the offline values of the WorkingData structure. If you want to change the profile data, first edit the UserData structure and then set parameter Validate = TRUE.

11.8.3.2 Executing a profile

To execute a profile and calculate the output value, you need validated profile data and a positive edge at the Enable parameter.

Starting and stopping profile execution - Enable parameter

You can start the profile execution and calculation of the output value with a positive edge at the Enable parameter. The profile execution starts with the point that is specified at the in-out parameter NextPoint.

You can stop the profile execution with a negative edge at the parameter Enable.

If the profile is stopped or completely run, the in-out parameter NextPoint is automatically set to 1. Thus, the next profile execution starts from the first point of the profile if the in-out parameter NextPoint is not changed.

You can configure the behavior at the start, stop and completion of the profile execution with the static tags StartMode (Page 515) and StopMode (Page 518).

The profile execution only determines the output value at the Output parameter, if Reset = FALSE. If RESET = TRUE is set, then an activated profile execution is continued in the background.

The following graphic shows how the input parameters Enable, Reset and Hold determine the execution of the profile:

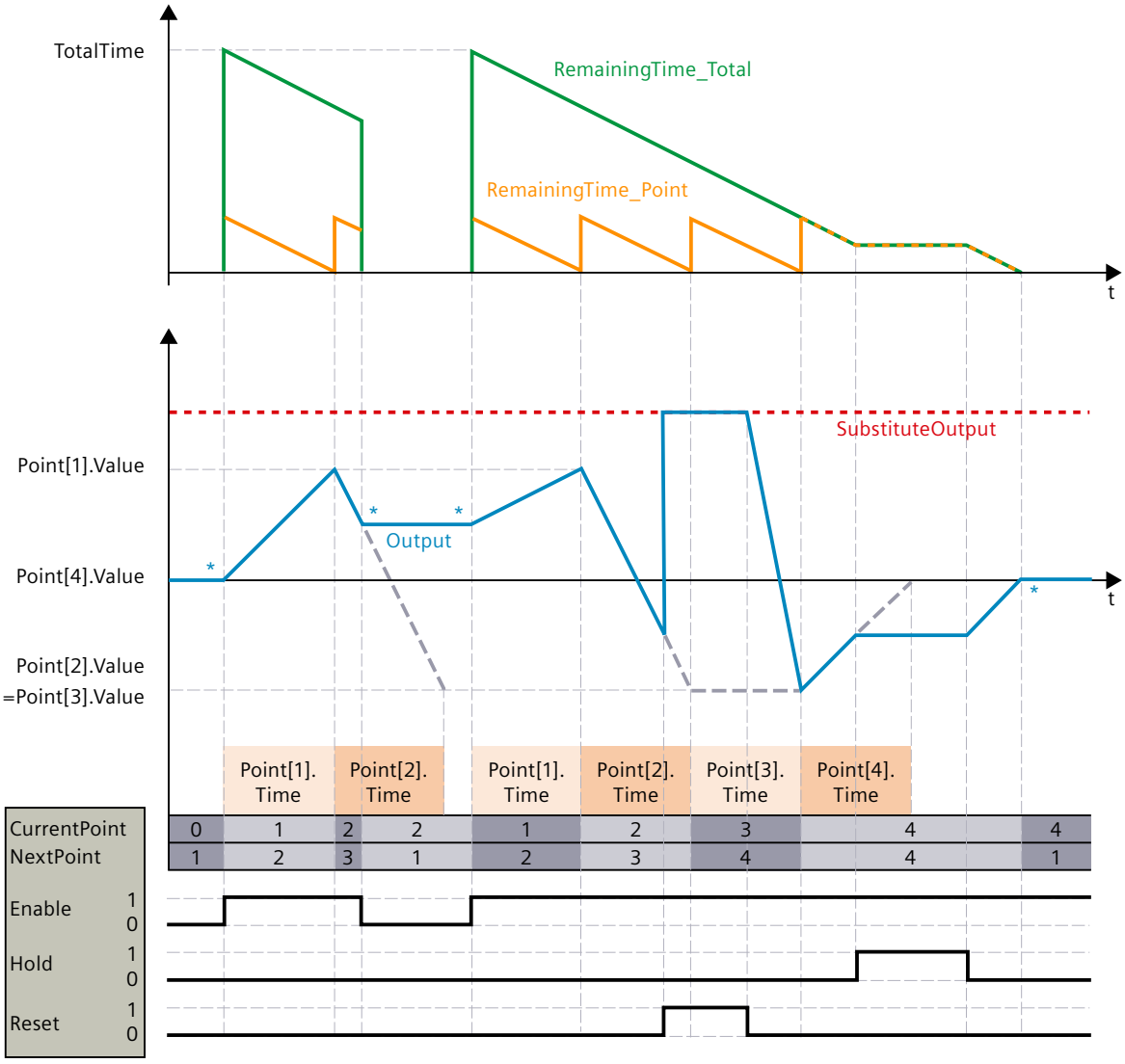

In this example, the starting and stopping behavior of the profile execution (marked with an *) is shown with the default StartMode = StopMode = 2 (start from last output value / keep last output value).

Holding profile execution - Hold parameter

You can use the parameter Hold = TRUE to pause the activated profile execution.

The Hold = TRUE parameter has the following effect:

- The Output, CurrentPoint, NextPoint, RemainingTime_Total, and RemainingTime_Point parameters remain unchanged.
- An edge at the parameters Enable or Next is delayed and only becomes effective when Hold = FALSE.
- If the Reset parameter changes from TRUE to FALSE, the Hold parameter influences the changes at the Output parameter. You can find more information in the description of the Reset parameter.

The Hold parameter has no effect on the processing of the Validate and ErrorAck parameters.

Overwrite output value - Reset parameter

With the parameter Reset = TRUE, you can reset the instruction and overwrite the output value at the Output parameter with the value of the SubstituteOutput parameter.

An activated profile execution is continued in the background. Using the parameters Enable, Hold and Next continues to be possible.

If the profile execution is still active (Enable=TRUE and the profile not yet fully run through) and the parameter Reset changes from TRUE to FALSE, the behavior depends on the Hold parameter:

- Hold = FALSE

  The Output parameter is changed in increments from the SubstituteOutput to the value of the current point and reaches it within the remaining time of the current point (RemainingTime_Point).
- Hold = TRUE

  The Output parameter jumps from the SubstituteOutput to the value of the paused profile execution.

If the profile execution is no longer active (Enable=FALSE or the profile fully run through) and the Reset parameter changes from TRUE to FALSE, the Output parameter jumps to the last value of the profile execution.

Continuing the profile execution with a certain point - Next parameter

With a positive edge at the Next parameter, you can continue the profile execution with Point[NextPoint].

When the profile execution is deactivated, the parameter Next = TRUE has the following effect:

- The Output parameter assumes the value of Point[NextPoint].Value.
- The CurrentPoint parameter assumes the value of NextPoint.
- The NextPoint parameter is increased. If NextPoint is the last point of the profile, then the value of NextPoint becomes 1.

When the profile execution is activated, the parameter Next = TRUE has the following effect:

- The Output parameter is changed in increments from its current value to the value of Point[NextPoint].Value and reaches it during Point[NextPoint].Time.
- The RemainingTime_Point parameter assumes the value of Point[NextPoint].Time.
- The RemainingTime_Total parameter is updated accordingly.
- The CurrentPoint parameter assumes the value of NextPoint.
- The NextPoint parameter is increased. If NextPoint is the last point of the profile, then the new value is dependent on StopMode. You can find more information in the description of the NextPoint parameter.

NOTE

At the first call of the RampSoak instruction after the operating state transition of the CPU from STOP to RUN, the behavior is determined by StartMode. The Next parameter is only effective with the following calls.

An example profile with the Next parameter is available in the following section "Continuing the profile execution with a certain point - NextPoint parameter".

Continuing the profile execution with a certain point - NextPoint parameter

The NextPoint parameter determines with which point the profile execution is continued.
If the current point has been completed, the RampSoak instruction automatically updates the value of the NextPoint parameter to the next point of the profile.
Through a change in the value of the NextPoint parameter, you can determine that the profile execution should be continued with another point.

The NextPoint parameter can influence the behavior of the profile execution in the following manner, if it is deactivated:

- If there is a positive edge at parameter Next then parameter Output assumes the value of Point[NextPoint].Value.
- When the profile execution is started, NextPoint represents the first CurrentPoint. The Output parameter is changed in increments from the value that is defined by StartMode to the value of Point[NextPoint].Value and reaches it during Point[NextPoint].Time.

The NextPoint parameter can influence the behavior of the profile execution in the following manner, if it is activated:

- Without positive edge at parameter Next:

  When the current point has been completed, the process continues with NextPoint.
- With positive edge at parameter Next:

  The process continues with NextPoint.

While the last point of the profile execution is active (CurrentPoint = WorkingData.NumberOfUsedPoints), StopMode determines, in the following manner, how the value of NextPoint is updated automatically:

- StopMode <> 4

  While the last point is active: NextPoint = CurrentPoint = WorkingData.NumberOfUsedPoints.

  The profile execution finished after the last point.

- StopMode = 4

  While the last point is active: NextPoint = 1.

  The profile execution restarts after the last point.

If the profile is stopped or completely run, the in-out parameter NextPoint is automatically set to 1. Thus, the next profile execution starts from the first point of the profile if the in-out parameter NextPoint is not changed.

The following graphic shows how the Next and NextPoint parameters determine the profile execution: If the automatic change of NextPoint is subsequently overwritten by a user input, this is marked with →:

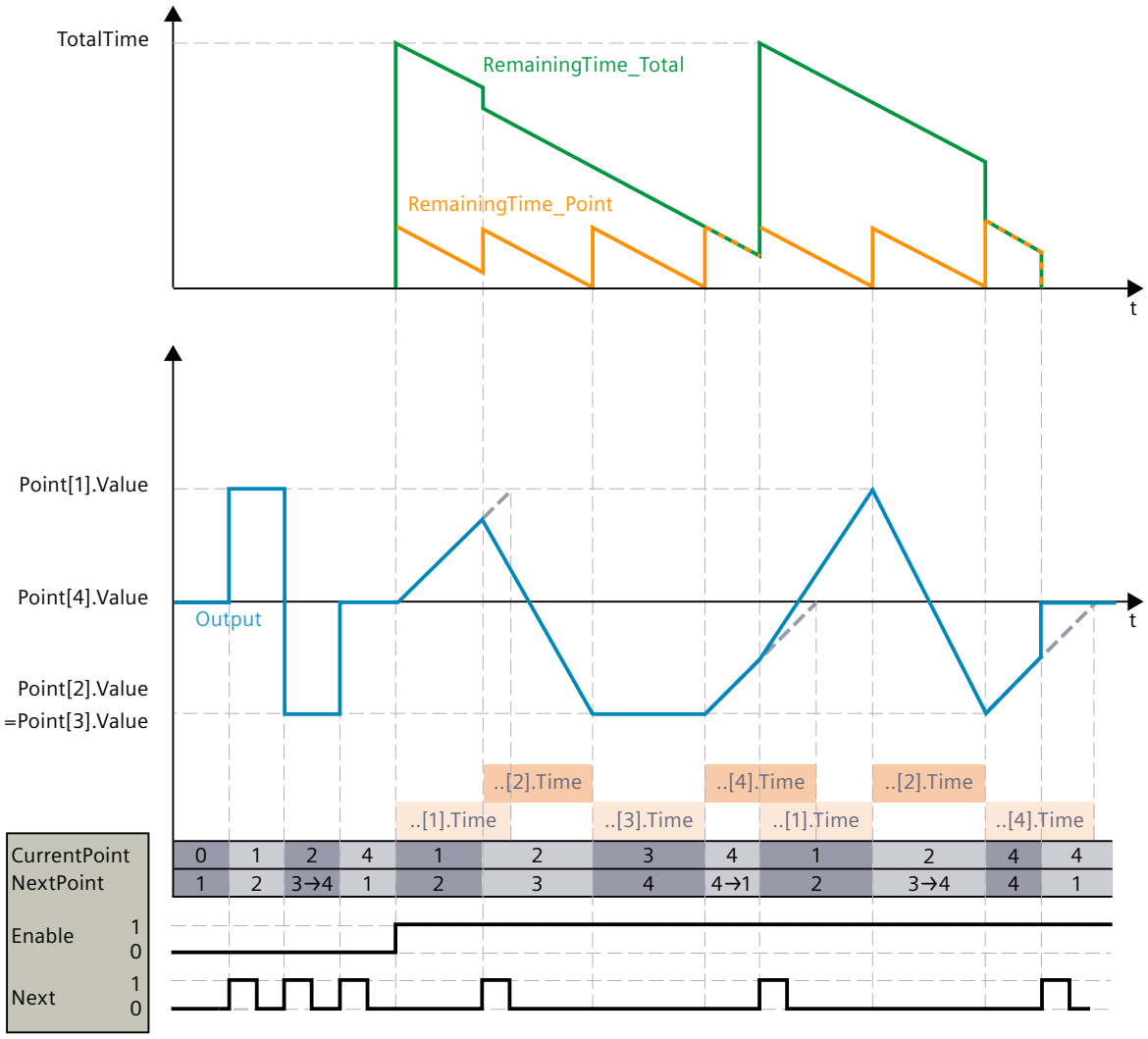

In this example, the stopping behavior of the profile execution is shown with StopMode <> 4.

11.8.3.3 Configuring the starting behavior - static tag StartMode

With the StartMode tag, you can define the behavior of the RampSoak instruction in the following cases.

- When the RampSoak instruction is executed after the operating state transition of the CPU from STOP to RUN (restart).
- The profile execution is started.
- Execution of "Load start values as actual values" (only with "All values" option, not with "Only setpoints" option).

The following settings of the StartMode tag are possible:

- StartMode = 0

  The Output parameter assumes the value of WorkingData.StartValue.

  The profile execution starts from this value if, after a restart of the CPU, Enable = TRUE is set or if Enable changes from FALSE to TRUE.

  The following graphic shows the start of the profile execution and restart of the CPU with StartMode = 0:

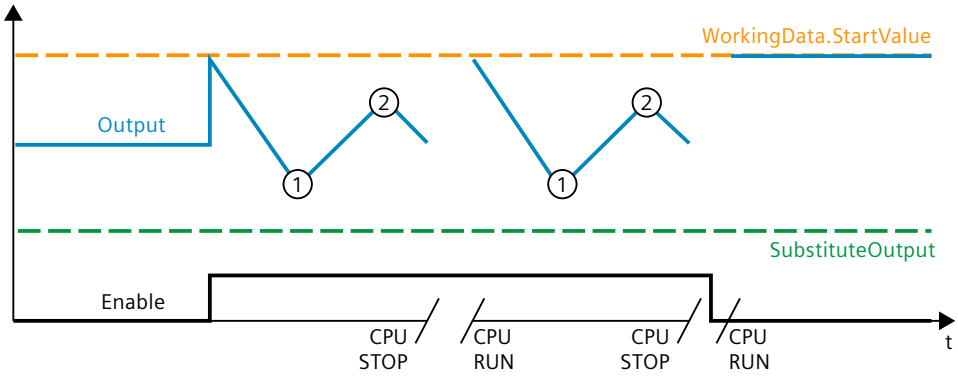

NOTE

With this setting, the profile data must be validated with the first call of the instruction after the CPU restart and assumed by the WorkingData. Otherwise, the default value 0.0 of WorkingData.StartValue is used.

- StartMode = 1

  The Output parameter assumes the value of SubstituteOutput.

  The profile execution starts from this value if, after a restart of the CPU, Enable = TRUE is set or if Enable changes from FALSE to TRUE.

The following graphic shows the start of the profile execution and restart of the CPU with StartMode = 1:

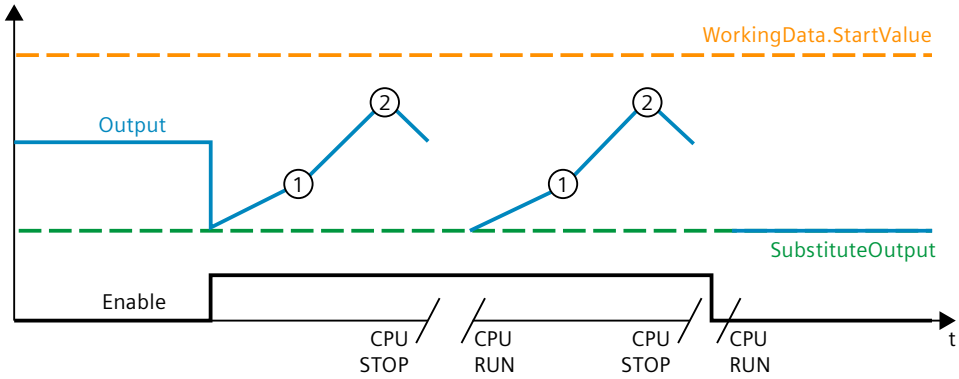

- StartMode = 2

  The Output parameter remains unchanged.

  The profile execution starts from the unchanged value of the Output parameter, if, after a restart of the CPU, Enable = TRUE is set or if Enable changes from FALSE to TRUE.

  The following graphic shows the start of the profile execution and restart of the CPU with StartMode = 2:

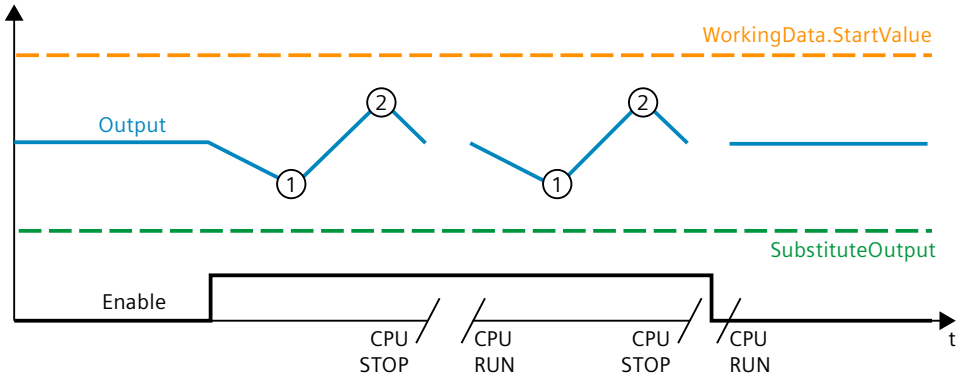

- StartMode = 3

  The Output parameter adopts the value 0.0.

  The profile execution starts from this value if, after a restart of the CPU, Enable = TRUE is set or if Enable changes from FALSE to TRUE.

The following graphic shows the start of the profile execution and restart of the CPU with StartMode = 3:

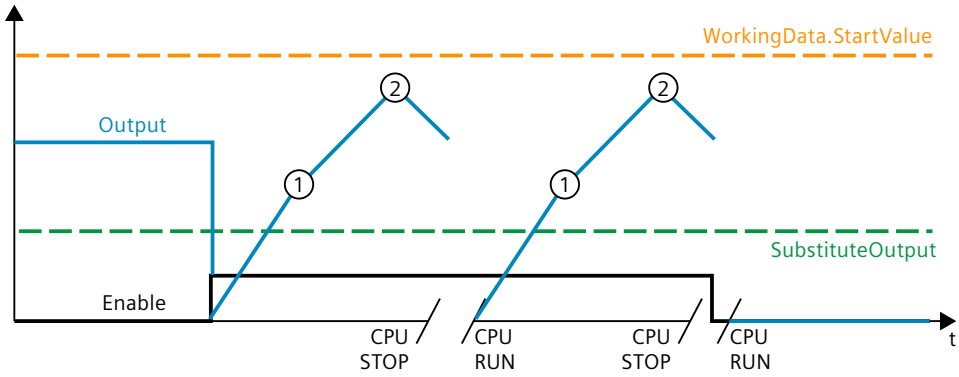

- StartMode = 4

  The Output parameter remains unchanged.

  The profile execution continues if, after the restart of the CPU, Enable = TRUE remains set and the profile execution was activated before the restart.

  The profile execution starts from the unchanged value of the Output parameter, if, after a restart of the CPU, Enable = TRUE is set and the profile execution was deactivated before the restart or if Enable changes from FALSE to TRUE.

  The following graphic shows the start of the profile execution and restart of the CPU with StartMode = 4:

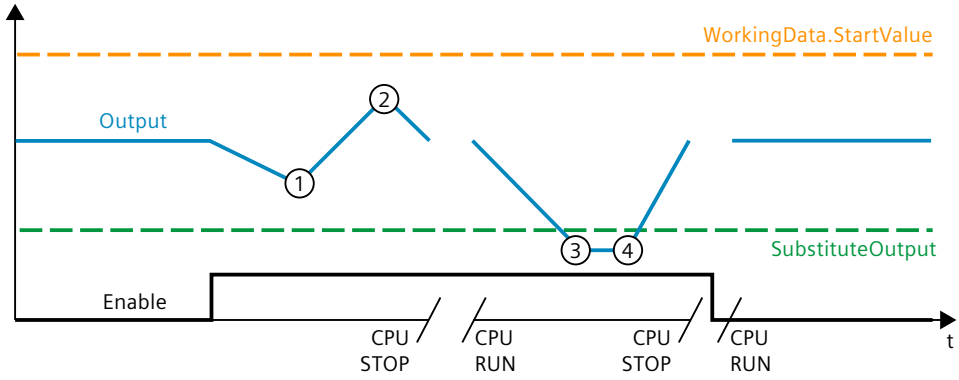

The following applies in addition for all values of the StartMode tag:

- The Enable parameter, the StartMode tag and the profile data in the UserData and WorkingData structures are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN. Make sure that at the first call of the RampSoak instruction, after the operating status transition of the CPU from STOP to RUN, these tags have suitable values to achieve the desired behavior.
- The value selected through StartMode is limited to the value range of the REAL data type. Only then is it output at the Output parameter.
- If the value selected through StartMode is not a valid REAL value, the substitute output value is output at the Output parameter. The substitute output value is configured by means of the ErrorMode tag and is limited to the value range of the REAL data type. If the profile execution is activated, it starts from this substitute output value.

- Only if the parameter Reset = FALSE has been set and, at the same time, there is no error pending with an error message ErrorBits ≥ 16#0002_0000, does the StartMode tag act on the Output parameter. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter. If an error with error message ErrorBits ≥ 16#0002_0000 is pending, the substitute output value that is configured at the ErrorMode tag is output at the Output parameter.

11.8.3.4 Configuring the stopping behavior - static tag StopMode

With the StopMode tag, you can define the behavior of the RampSoak instruction in the following cases.

- The profile execution is finished in that the last point has been reached.
- The profile execution is stopped by resetting Enable.

The value that is set through StopMode is used as the output value until a new action, for example the start of the profile execution, is triggered.

The following settings of the StopMode tag are possible:

- StopMode = 0

  The Output parameter assumes the value of WorkingData.StartValue.

  The following graphic shows how the execution of a profile with 5 points is ended and stopped with StopMode = 0:

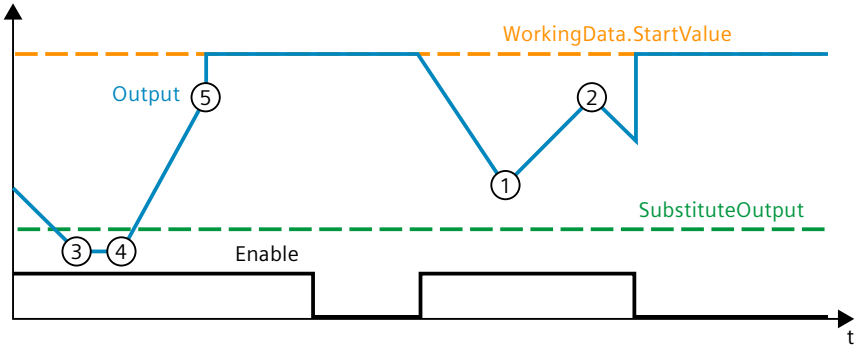

- StopMode = 1

  The Output parameter assumes the value of SubstituteOutput.

  The following graphic shows how the execution of a profile with 5 points is ended and stopped with StopMode = 1:

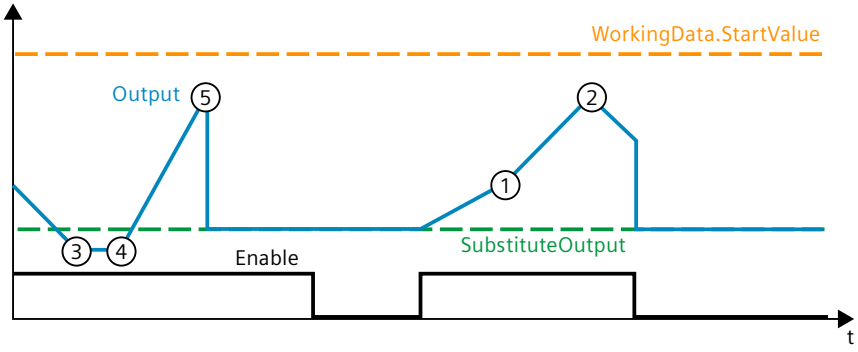

- StopMode = 2

  The Output parameter assumes the last valid value of the profile execution.

  The following graphic shows how the execution of a profile with 5 points is ended and stopped with StopMode = 2:

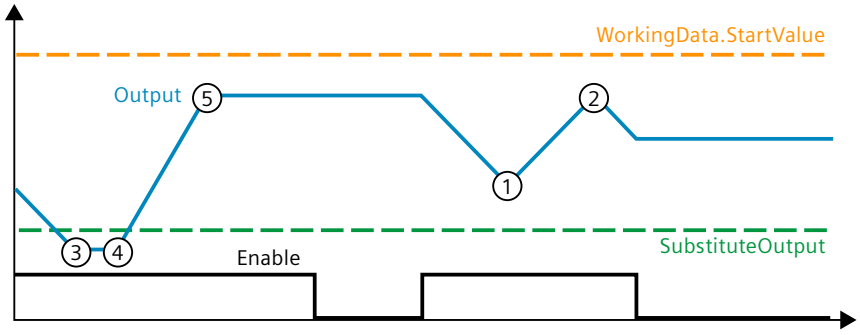

- StopMode = 3

  The Output parameter adopts the value 0.0.

  The following graphic shows how the execution of a profile with 5 points is ended and stopped with StopMode = 3:

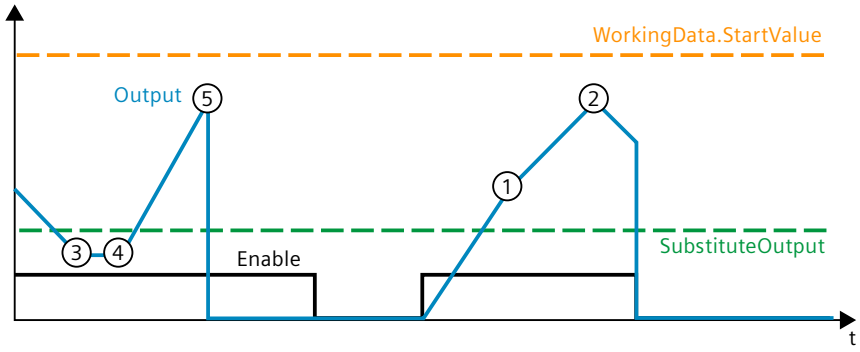

- StopMode = 4

  If the profile execution has ended with the last point, it is automatically restarted and it is continued with WorkingData.Point[1]. As long as Enable is not reset, the profile execution is repeated.

  If the profile execution is stopped with Enable = FALSE, then the Output parameter assumes the last valid value of the profile execution.

The following graphic shows how the execution of a profile with 5 points is ended and stopped with StopMode = 4:

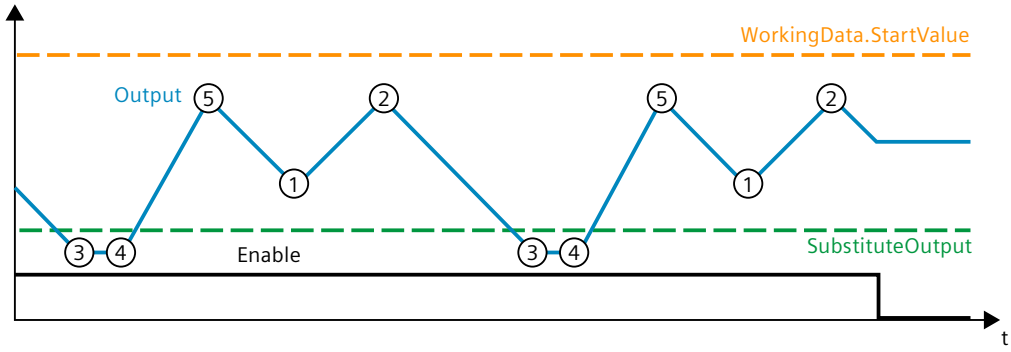

The following applies in addition for all values of the StopMode tag:

- The value selected through StopMode is limited to the value range of the REAL data type. Only then is it output at the Output parameter.
- If the value selected through StopMode is not a valid REAL value, the substitute output value is output at the Output parameter and then retained. The substitute output value is configured by means of the ErrorMode tag and is limited to the value range of the REAL data type.
- Only if the parameter Reset = FALSE has been set and, at the same time, there is no error pending with an error message ErrorBits ≥ 16#0002_0000, does the StopMode tag act on the Output parameter. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter. If an error with error message ErrorBits ≥ 16#0002_0000 is pending, the substitute output value that is configured at the ErrorMode tag is output at the Output parameter.

11.8.3.5 Measuring the cycle time

Measuring the cycle time automatically

To calculate the output value, RampSoak needs the time that has expired since the last call of RampSoak.

By default, the cycle time is measured automatically and output as of the second call at the CycleTime.Value tag. RampSoak measures the cycle time for each call of the instruction and can therefore be used in non-isochronous call cycles, e.g. in OB1.

Note that conditional calls of the instruction, active breakpoints, or the loading of snapshots as actual values during automatic measurement of the cycle time will extend the cycle time value.

If measurement of the cycle time does not return a valid result, RampSoak calculates the current output value with the last valid cycle time. In addition, RampSoak outputs an error message at the ErrorBits parameter.

When you disable automatic measurement of the cycle time by setting the CycleTime.EnableMeasurement = FALSE tag, you must enter the cycle time manually at the CycleTime.Value tag. RampSoak checks the CycleTime.Value tag for validity at each call.

Automatic measurement of the cycle time with breakpoints

When breakpoints are active between two calls of RampSoak, automatic measurement of the cycle time gives the actual time that has elapsed between two calls. When one breakpoint is active, the CPU is in the HOLD operating state.

NOTE

The active breakpoints extend the time period between two calls of RampSoak.

The longer the time period between two calls, the greater the change of the output value at the Output parameter. Points can be skipped depending on the elapsed time and the configured profile data.

If you do not need the calculation of the output value based on the actual time with active breakpoints, follow these steps:

- Disable automatic measurement of the cycle time by setting the tag CycleTime.EnableMeasurement = FALSE.
- Enter the cycle time manually for the CycleTime.Value tag.

11.8.3.6 Enable behavior EN/ENO

If one of the following conditions is met, enable output ENO is set to FALSE.

- Enable input EN is set to TRUE and an error with the error message ErrorBits ≥ 16#0001_0000 is pending.
- Enable input EN is set to FALSE.

In all other cases the enable output ENO is set to TRUE.

11.8.4 Input parameter RampSoak

Parameter	Data type	Default	Description
Enable	BOOL	FALSE	The profile execution and calculation of the output value is started with a positive edge at the Enable parameter. The profile execution is stopped with a negative edge at the Enable parameter.
Hold	BOOL	FALSE	If Hold is set to TRUE, the execution of the profile is paused. The output value remains constant.
Next	BOOL	FALSE	With a positive edge at the Next parameter the profile execution is continued with Point[NextPoint].
SubstituteOutput	REAL	0.0	SubstituteOutput is used as a substitute output value when Reset = TRUE or one of the following modes is currently in effect: • ErrorMode = 1 • StartMode = 1 • StopMode = 1
Validate	BOOL	FALSE	If Validate is set to TRUE, the profile data in UserData is checked for validity and transferred to WorkingData.
ErrorAck	BOOL	FALSE	Deletes the error messages • Edge FALSE -> TRUE ErrorBits is reset.

Parameter	Data type	Default	Description
Reset	BOOL	FALSE	Resets the instruction. • Edge FALSE -> TRUE ErrorBits is reset. • As long as Reset is set to TRUE, the substitute output value SubstituteOutput is output at the output. If the profile is executed at the same time, then that process runs in the background. • As long as Reset is set to FALSE, the output value is determined by the profile execution.

11.8.5 Output parameter RampSoak

Parameter	Data type	Default	Description
Output	REAL	0.0	Output value The output value is retentive.
CurrentPoint	INT	0	Number of the point that is currently being used for the profile execution and calculation of the output value.
TotalTime	REAL	0.0	Total time of the profile (summation of the times of all the points used) in seconds
Remaining-Time_Total	REAL	0.0	Remaining time of the profile in seconds
Remaining-Time_Point	REAL	0.0	Remaining time of the current point in seconds
ErrorBits	DWORD	16#0	The ErrorBits (Page 524) parameter shows which error messages are present. ErrorBits is retentive and is reset when there is a positive edge at Reset or ErrorAck.
Error	BOOL	FALSE	When Error is set to TRUE, at least one error is currently pending.

11.8.6 In-out parameter RampSoak

Parameter	Data type	Default	Description
NextPoint	Int	1	Number of the point that will be used next. Permissible value range: 1 to WorkingData.NumberOfUsedPoints

11.8.7 Static tags RampSoak

Tag	Data type	Default	Description
UserData	AuxFct_RampSoa-k_Profile	-	The profile data is input in the UserData structure. The profile data in the UserData structure can be edited. Changes in this structure affect the execution of the profile only when the validation and copying of the data into the WorkingData structure are initiated.
UserData.Num-berOfUsedPoints	INT	0	Number of points of the profile used Permissible value range: 1 to 50

Tag	Data type	Default	Description
UserData.Start-Value	REAL	0.0	StartValue is used as an optional output value if one of the following modes is currently in effect: • ErrorMode = 0 • StartMode = 0 • StopMode = 0
UserData.Point	Array[1..50] of AuxFct_RampSoa-k_Point	-	Points of the profile
UserData.Point[i]. Value	REAL	0.0	Output value of this point
UserData.Point[i]. Time	REAL	0.0	Duration of this point in seconds Permissible value range: Point[i].Time ≥ 0.0
WorkingData	AuxFct_RampSoa-k_Profile	-	The profile data currently in effect is displayed in the WorkingData structure. The profile data in the WorkingData structure cannot be edited.
WorkingData.Nu-mberOfUsed-Points	INT	0	Number of points of the profile used Permissible value range: 1 to 50
WorkingData.Star-tValue	REAL	0.0	WorkingData.StartValue is used as an optional output value if one of the following modes is currently in effect: • ErrorMode = 0 • StartMode = 0 • StopMode = 0
WorkingData.Poi-nt	Array[1..50] of AuxFct_RampSoa-k_Point	-	Points of the profile
WorkingData.Poi-nt[i].Value	REAL	0.0	Output value of this point
WorkingData.Poi-nt[i].Time	REAL	0.0	Duration of this point in seconds Permissible value range: Point[i].Time ≥ 0.0
ErrorMode	INT	2	Selection of the substitute output value following an error • 0 = WorkingData.StartValue • 1 = SubstituteOutput • 2 = last valid output value of the profile execution • 3 = 0.0 Permissible value range: 0 to 3 If the value of ErrorMode does not correspond to the permissible range of values, then ErrorMode = 2.
StartMode	INT	2	Selection of the starting behavior • 0 = WorkingData.StartValue • 1 = SubstituteOutput • 2 = start from the last output value • 3 = 0.0 • 4 = continue from the last output value Permissible value range: 0 to 4 If the value of StartMode does not correspond to the permissible range of values, then StartMode = 2.

Tag	Data type	Default	Description
StopMode		2	Selection of the stopping behavior • 0 = WorkingData.StartValue • 1 = SubstituteOutput • 2 = last valid output value of the profile execution • 3 = 0.0 • 4 = cyclical operation Permissible value range: 0 to 4 If the value of StopMode does not correspond to the permissible range of values, then StopMode = 2.
CycleTime	AuxFct_CycleTime	-	Cycle time data
CycleTime.Value	REAL	0.1	Cycle time in seconds (time interval between two calls) Permissible value range: CycleTime.Value > 0.0
CycleTime.Enable Measurement	BOOL	TRUE	Automatic measurement of the cycle time • FALSE = Deactivated • TRUE = Activated

11.8.8 ErrorBits parameter

If several errors are pending simultaneously, the values of the ErrorBits are displayed with binary addition. The display of ErrorBits = 16#0000_0003, for example, indicates that the errors 16#0000_0001 and 16#0000_0002 are pending simultaneously.

With RampSoak, the errors output at the ErrorBits parameter are divided into two categories:

- Errors with error messages ErrorBits < 16#0001_0000

  The output value can be calculated despite the error.
- Errors with error messages ErrorBits ≥ 16#0001_0000

  The error prevents a calculation of the output value. A substitute output value is output.

Errors with error messages ErrorBits < 16#0001_0000

If one or more errors with error messages ErrorBits < 16#0001_0000 is/are pending, RampSoak reacts as follows:

- The output value is determined as follows despite this error:
  - If Reset = FALSE output value calculation through the execution of the profile
  - When Reset = TRUE, output of SubstituteOutput
- The output parameter Error is set.
- The enable output ENO is not changed.

The output parameter Error is deleted as soon as there are no longer any errors.

ErrorBits (DW#16#...)	Description
0000_0000	No error is pending.
0000_0001	**Cause of error and response to error:** The Output parameter was limited to -3.402823e+38 or +3.402823e+38. **Solution:**

ErrorBits (DW#16#...)	Description
	If ErrorBits < 16#0001_0000 and Reset = FALSE, the output value is limited, while it is determined through StartMode or StopMode. In this case, check the following parameters depending on the set value at the StartMode or StopMode tags: • WorkingData.StartValue • SubstituteOutput When ErrorBits ≥ 16#0001_0000 and Reset = FALSE, the substitute output value is limited on its output. In this case, check the following parameters depending on the set value at the tag ErrorMode: • WorkingData.StartValue • SubstituteOutput When Reset = TRUE, check the SubstituteOutput parameter. **Additional information:** If you want to change the WorkingData.StartValue, first edit the UserData.StartValue and then set the parameter Validate = TRUE. Do not manually change the data of the WorkingData structure.
0000_0002	**Cause of error:** The measurement of the cycle time yields an invalid value while the execution of the profile is activated (Enable = TRUE). **Response to error:** If a valid value of the cycle time has already been measured, RampSoak continues execution of the profile based on this last value of the CycleTime.Value tag. If no valid value of the cycle time was previously measured, RampSoak still outputs the output value configured with the tag StartMode at the Output parameter.
0000_0004	**Cause of error:** One or more tags in the UserData structure have invalid values while the profile data is checked. **Response to error:** The profile data in the UserData structure is not transferred to the WorkingData structure, so the changes made in the UserData structure do not become effective. **Solution:** Ensure that the following conditions are met when the profile data is checked: • 1 ≤ UserData.NumberOfUsedPoints ≤ 50 • -3.402823e+38 ≤ UserData.Point[i].Value ≤ 3.402823e+38 with index *i* = 1..UserData.NumberOfUsedPoints • 0.0 ≤ UserData.Point[i].Time ≤ 3.402823e+38 with index *i* = 1..UserData.NumberOfUsedPoints • -3.402823e+38 ≤ UserData.StartValue ≤ 3.402823e+38 • NextPoint ≤ UserData.NumberOfUsedPoints • 0.0 < UserData.Point[1].Time + UserData.Point[2].Time +...+ UserData.Point[UserData.NumberOfUsedPoints].Time ≤ 3.402823e+38 • With execution of the profile activated: CurrentPoint ≤ UserData.NumberOfUsedPoints **Additional information:** The profile data in the UserData structure are checked in the following cases: • If the Validate parameter is set to TRUE. • Or if RampSoak is called after the operating state transition of the CPU from STOP to RUN for the first time with the parameter Enable = TRUE and there was no validation of the profile data carried out previously. Note that all tags in the UserData and WorkingData structures are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN.
0000_0008	**Cause of error:** The NextPoint parameter has an invalid value. **Response to error:** NextPoint is reset to the last valid value. **Solution:** Ensure that the following condition is met: • 1 ≤ NextPoint ≤ WorkingData.NumberOfUsedPoints

Errors with error messages ErrorBits ≥ 16#0001_0000

If one or more errors with error messages ErrorBits ≥ 16#0001_0000 is/are pending, RampSoak reacts as follows:

- The output value cannot be determined as expected. The table below shows the reaction of the Output parameter and the execution of the profile.
- The output parameter Error is set.
- The enable output ENO is set to FALSE.

As soon as there are no longer errors with error messages ErrorBits ≥ 16#0001_0000, RampSoak reacts as follows:

- The output value is determined as follows:
  - If Reset = FALSE, output value through the execution of the profile
  - When Reset = TRUE, output of SubstituteOutput
- The enable output ENO is set to TRUE.

The output parameter Error is deleted as soon as there are no longer any errors.

<table>
<tr><th>ErrorBits (DW#16#...)</th><th>Description</th></tr>
<tr><td>0001_0000</td><td>Cause of error:
The SubstituteOutput parameter or the WorkingData.StartValue tag is currently used for determining the output value, but does not have any valid REAL value.
Response to error:
If Reset = TRUE and SubstituteOutput is a valid REAL value, then SubstituteOutput continues to be output at the parameter Output.
In all other cases, parameter Output is set to 0.0.
Solution:
Make sure that the SubstituteOutput parameter and the WorkingData.StartValue tag are valid REAL values (≠NaN, e.g. 16#7FFF_FFFF). The tag that is used depends on Reset the pending errors and ErrorMode:
<table>
<tr><th>Reset</th><th>ErrorBits</th><th>ErrorMode</th><th>Tag used</th></tr>
<tr><td>-</td><td>>= 16#0002_0000</td><td>0</td><td>WorkingData.StartValue</td></tr>
<tr><td>-</td><td>>= 16#0002_0000</td><td>1</td><td>SubstituteOutput</td></tr>
<tr><td>TRUE</td><td>-</td><td>-</td><td>SubstituteOutput</td></tr>
</table>
Additional information:
If you want to change the WorkingData.StartValue, first edit the UserData.StartValue and then set the parameter Validate = TRUE. Do not manually change the data of the WorkingData structure.</td></tr>
<tr><td>0004_0000</td><td>Cause of error:
The calculation during the execution of the profile yields an invalid REAL value.
Response to error:
Execution of the profile is aborted.
If Reset = FALSE, the substitute output value that is configured at the ErrorMode tag is output at the Output parameter and then retained.
If Reset = TRUE, then SubstituteOutput continues to be output at the Output parameter.
Solution:
Validate the REAL values in the WorkingData structure and, if required, start execution of the profile once again.
Additional information:
If you want to change the profile data, first edit the UserData structure and then set parameter Validate = TRUE. Do not manually change the data of the Struktur WorkingData.</td></tr>
</table>

ErrorBits (DW#16#...)	Description
0008_0000	**Cause of error:** The Enable parameter or the Next parameter is set to TRUE, but there is no valid profile data present in the WorkingData structure. **Response to error:** Parameter Enable and parameter Next are not effective. If Reset = FALSE, the substitute output value that is configured at the ErrorMode tag is output at the Output parameter. If Reset = TRUE, then SubstituteOutput continues to be output at the Output parameter. **Solution:** Input valid profile data in the UserData structure and then set the parameter Validate = TRUE. In this manner, the profile data is transferred after validation to the WorkingData structure. **Additional information:** If parameter Enable or parameter Next is still set to TRUE, they become effective as soon as valid profile data is present in the WorkingData structure. A fresh positive edge is not required. Note that all tags in the UserData and WorkingData structures are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN.
0010_0000	**Cause of error:** The tag (configured with StopMode) which determines the output value when the execution of the profile has ended or been stopped does not have any valid REAL value. **Response to error:** If Reset = FALSE, the substitute output value that is configured at the ErrorMode tag is output at the Output parameter and then retained. If Reset = TRUE, then SubstituteOutput continues to be output at the Output parameter. **Solution:** Make sure that the tag is a valid REAL value (≠ NaN for example, 16#7FFF_FFFF). The tag that is used depends on StopMode: • StopMode = 0: WorkingData.StartValue • StopMode = 1: SubstituteOutput **Additional information:** If you want to change the WorkingData.StartValue, first edit the UserData.StartValue and then set the parameter Validate = TRUE. Do not manually change the data of the WorkingData structure.
0020_0000	**Cause of error:** The tag (configured with StartMode), which determines the output value when the instruction is called for the first time, or the execution of the profile is started, does not have a valid REAL value. **Response to error:** If Reset = FALSE, the substitute output value that is configured at the ErrorMode tag is output at the Output parameter and then retained. If the execution of the profile is activated (Enable = TRUE), it starts initially from this substitute output value. If Reset = TRUE, then SubstituteOutput continues to be output at the Output parameter. **Solution:** Make sure that the tag is a valid REAL value (≠ NaN for example, 16#7FFF_FFFF). The tag that is used depends on StartMode: • StartMode = 0: WorkingData.StartValue • StartMode = 1: SubstituteOutput • StartMode = 2: Output **Additional information:** If you want to change the WorkingData.StartValue, first edit the UserData.StartValue and then set the parameter Validate = TRUE. Do not manually change the data of the WorkingData structure.

ErrorBits (DW#16#...)	Description
0040_0000	**Cause of error:** The CycleTime.Value tag has an invalid value while the execution of the profile is activated (Enable = TRUE). **Response to error:** Execution of the profile is paused. If Reset = FALSE, the substitute output value that is configured at the ErrorMode tag is output at the Output parameter. If Reset = TRUE, then SubstituteOutput continues to be output at the Output parameter. Execution of the profile is continued as soon as this error is not present any more. If execution of the profile is stopped beforehand, the substitute output value is retained. **Solution:** Ensure that the following conditions are met: • 0.0 < CycleTime.Value ≤ 3.402823e+38 • CycleTime.Value is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF) **Additional information:** To automatically calculate the value of the tag CycleTime.Value, set the tag CycleTime.EnableMeasurement to TRUE.

11.9 Filter_PT1

11.9.1 Compatibility with CPU and FW

The following table shows which version of Filter_PT1 can be used on which CPU:

CPU	FW	Filter_PT1
S7-1200	as of V4.2	V1.0
S7-1200 G2	V1.0 or higher	V1.0
S7-1500-based CPUs	as of V2.0	V1.0

11.9.2 Description of Filter_PT1

Description

The instruction Filter_PT1 is a proportional transfer element with a first-order lag, also referred to as PT1 element.

You can use Filter_PT1 for the following purposes:

- Low-pass filter to attenuate high frequency components, such as noise, in a signal.
- Delay element to smooth signal step changes, for example, from the setpoint or the output value of a controller.
- Process simulation block to implement a closed control loop within the CPU. This means, for example, that you can test controllers before commissioning.

You can specify the following filter parameters:

- Proportional gain (Gain)
- Lag time constant (Lag)

NOTE

Differences between a continuous-time PT1 element and Filter_PT1

Because Filter_PT1 is executed in a PLC program, Filter_PT1 is a discrete-time implementation of a PT1 element. Discrete-time systems cannot have the same properties as the corresponding continuous-time model. Depending on the cycle time, discrete-time systems can emulate a continuous-time system well: The smaller and more constant the cycle time, the smaller the conformity error between the properties of Filter_PT1 and the properties of a continuous-time PT1 element. The properties of a continuous-time PT1 element are the transfer function, the time response and the frequency response which are described below.

For a good simulation of the frequency response, a maximum cycle time of one-tenth of the shortest period duration of the input signal components is recommended. For example, a signal with frequency components of up to 50 Hz has a minimum period duration of 20 ms. To achieve good simulation of the frequency response, a maximum cycle time of 2 ms is recommended for this example.

Transfer function of a PT1 element

The following formula shows the transfer function of a PT1 element, whereby s is equal to the Laplace operator:

$$G(s) = \frac{\text{Output(s)}}{\text{Input(s)}} = \frac{\text{Gain}}{1 + \text{Lag} \cdot s}$$

Time response of a PT1 element

The step response is the response of the output value to a step change of the input value.

The step response for a step change of the input value from 0 to ΔInput can be calculated using the following formula:

$$Output(t) = \Delta Input \cdot Gain \cdot (1 - e^{-\frac{t}{Lag}})$$

The following figure shows the step response of a PT1 element:

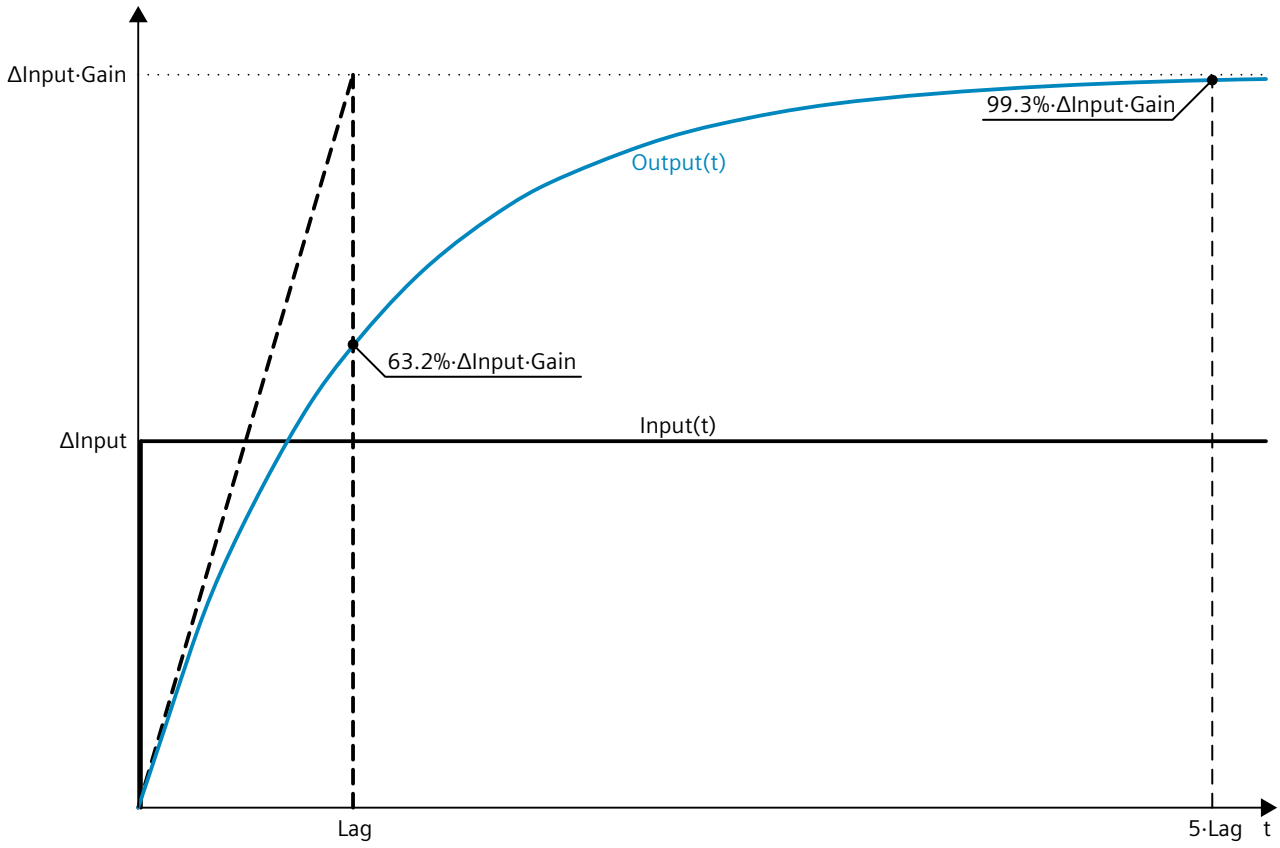

Frequency response of a PT1 element

The frequency response of a transfer element is described by the amplitude response and the phase response.

The amplitude response describes the gain of a signal through the transfer element depending on the angular frequency of the signal.

The following equation describes the amplitude response of a PT1 element:

$$|G(\omega)| = \frac{\text{Gain}}{\sqrt{1 + (\omega \cdot \text{Lag})^2}}$$

$\lvert G(\omega)\rvert$	Signal gain as a function of the angular frequency
ω	Angular frequency

The following figure shows the amplitude response of a PT1 element:

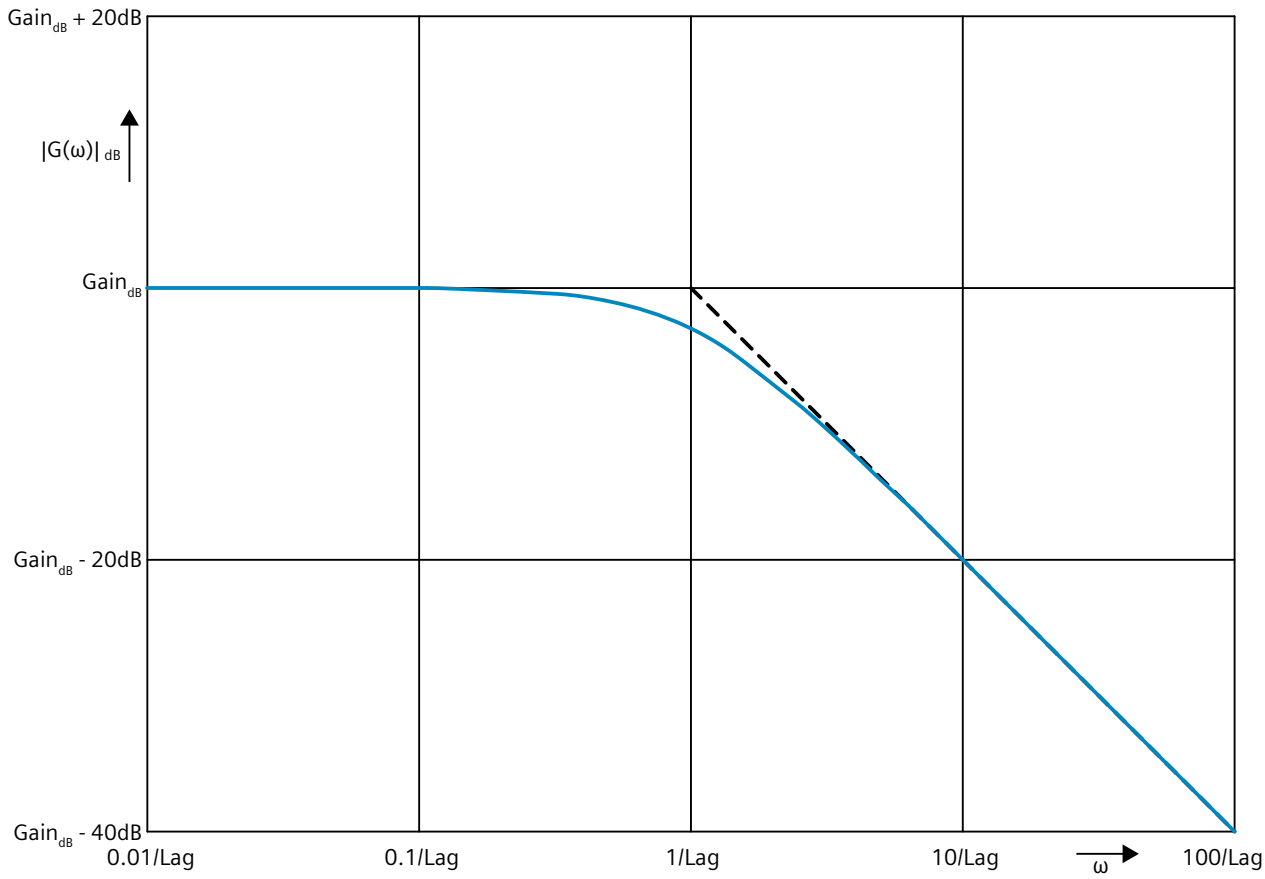

The phase response describes the phase offset of a signal through the transfer element depending on the angular frequency of the signal.

The following equation describes the phase response of a PT1 element:

$$\varphi(\omega) = -\tan^{-1}(\omega \cdot \text{Lag})$$

φ(ω)	Phase offset as a function of the angular frequency
ω	Angular frequency

The following figure shows the phase response of a PT1 element:

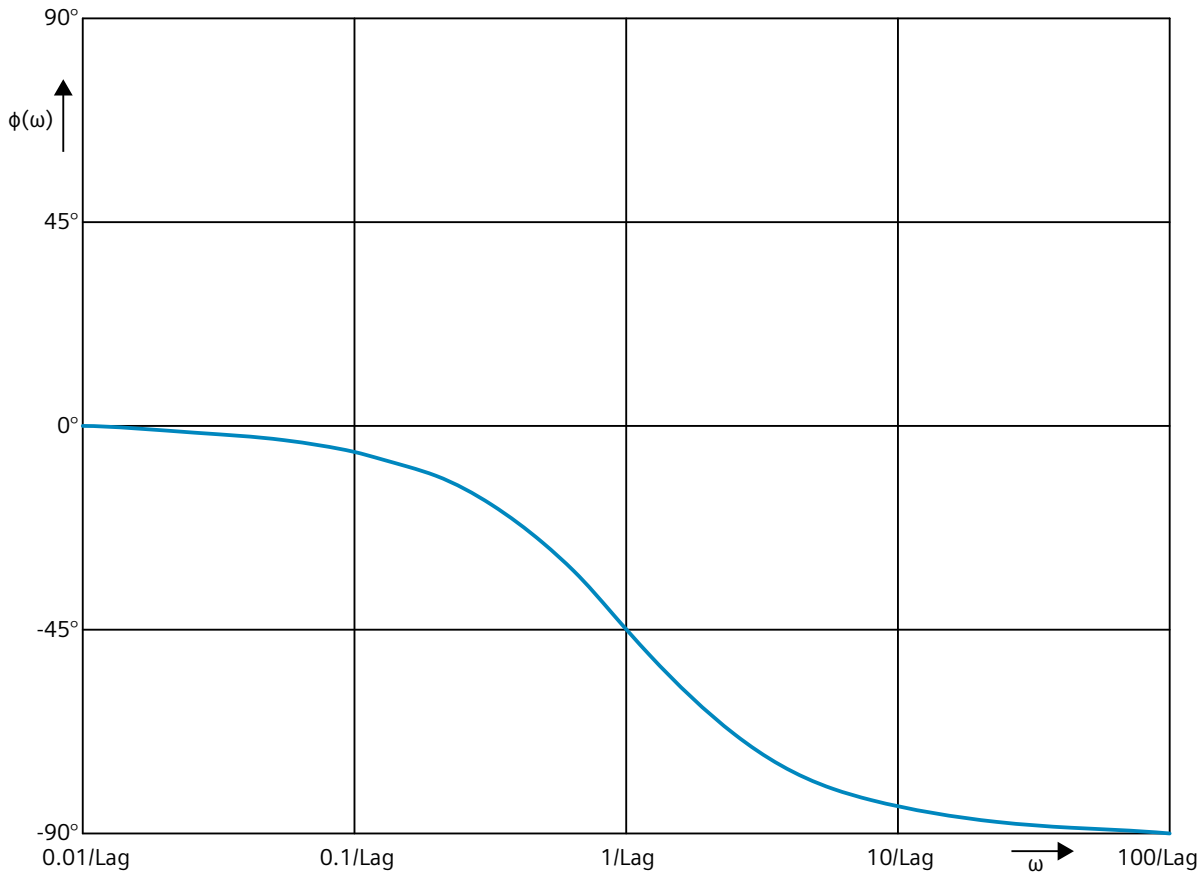

Call

In an OB or FC, Filter_PT1 is called as single-instance DB. In an FB, Filter_PT1 can be called as a single-instance DB, as a multi-instance DB, and as a parameter instance DB.

When the instruction is called, no technology object is created. No parameter assignment interface or commissioning interface is available. You assign the Filter_PT1 parameters directly using the instance DB and commission Filter_PT1 using a watch table of the user program in the CPU or HMI.

Startup

The tags in the static area of Filter_PT1 are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN. If you change the actual values in online mode and these values are to be retained after the operating state transition of the CPU, back up these values in the start values of the data block.

Specify the initialization value for the Output parameter at the StartMode tag.

During the first call of Filter_PT1 after the

- Operating state transition of the CPU

or

- Execution of "Load start values as actual values" (only with "All values" option, not with "Only setpoints" option)

the initialization value is output at the Output parameter.

For subsequent calls, Filter_PT1 calculates the output value, starting from this initialization value, based on the input value and the filter configuration.

The following table shows the dependency between the StartMode tag and the Output parameter. The values in the Output column are output at the Output parameter after the operating state transition of the CPU.

StartMode	Output	Example
0	Value of the Input parameter	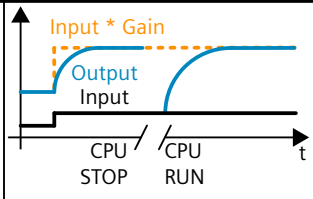
1	Value of the SubstituteOutput parameter	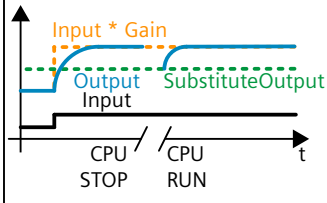
2	Remains unchanged Output parameter is retentive Default setting Is used when StartMode is not in the range 0...4	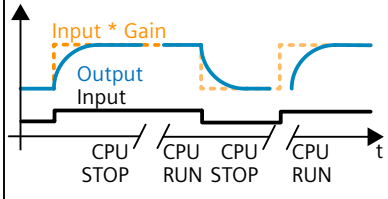
3	0.0	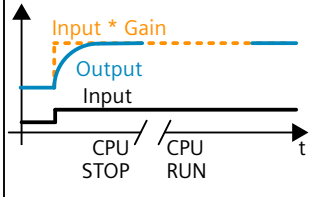
4	Value of the Input * Gain product	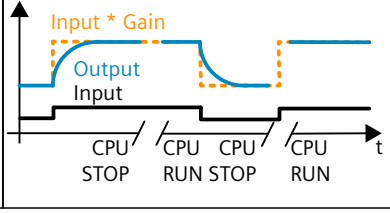

The following applies in addition for all values of the StartMode tag:

- The initialization value is limited to the value range of the data type REAL. Only then is the initialization value output at the Output parameter.
- If the initialization value is not a valid REAL value, the substitute output value is output at the Output parameter. The substitute output value is configured by the ErrorMode tag. The substitute output value is limited to the value range of the data type REAL before it is output at the Output parameter. If the substitute output value is also not a valid REAL value, 0.0 is output at the Output parameter. For subsequent calls, the instruction calculates the output value starting from this substitute output value.
- The StartMode tag only takes effect when the Reset = FALSE parameter is set at the first call of the instruction and at the same time no error with error message ErrorBits ≥ 16#0002_0000 is pending. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter. If an error with error message ErrorBits ≥ 16#0002_0000 is pending, the substitute output value that is configured at the ErrorMode tag is output at the Output parameter.

Response to errors

The Filter_PT1 instruction detects different errors that can occur during the calculation of the output value. The result of this calculation can be output at the output despite a pending error. If an error prevents correct calculation of the output value, a substitute output value is output at the output.

Specify the substitute output value that is output if an error occurs that prevents correct calculation of the output value at the ErrorMode tag.

The following table shows the dependency between the ErrorMode tag and the substitute output value that is output by the Filter_PT1 at the Output parameter:

ErrorMode	Output
0	Value of the Input parameter
1	Value of the SubstituteOutput parameter
2	The last valid filter output value 0.0 if no valid filter output value is available Default setting Is used when ErrorMode is not in the range 0...4
3	0.0
4	Value of the Input * Gain product

The following applies in addition for all values of the ErrorMode tag:

- If the substitute output value is not a valid REAL value, 0.0 is output as output value.
- The substitute output value is limited to the value range of the data type REAL. Only then is the substitute output value output at the Output parameter.
- The ErrorMode tag only takes effect when the Reset = FALSE parameter is set. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter.

The Error parameter indicates if an error is pending. When the error is no longer pending, Error is set to FALSE. The ErrorBits parameter shows which errors have occurred. ErrorBits is retentive and is reset only by a positive edge at the Reset or ErrorAck parameter.

11.9.3 Operating principle Filter_PT1

Reset response

Filter_PT1 behaves as follows depending on the Reset parameter:

- If the Reset =TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter.
- If the Reset = FALSE parameter is set, the value that is output at the Output parameter is calculated by the filter algorithm.
- When the Reset parameter is set from FALSE to TRUE, the value at the Output parameter changes directly to the value of the SubstituteOutput parameter. An output jump can occur during this transition. In addition, the ErrorBits parameter is reset.
- When the Reset parameter is set from TRUE to FALSE, the filtering algorithm is added so that the transition is bumpless.

Enable behavior EN/ENO

If one of the following conditions is met, enable output ENO is set to FALSE.

- Enable input EN is set to TRUE and the Output parameter is specified by a substitute output value in case of error messages ErrorBits ≥ 16#0001_0000.
- Enable input EN is set to FALSE.

Otherwise, the enable output ENO is set to TRUE.

Measuring the cycle time automatically

To calculate the output value, Filter_PT1 needs the time that has expired since the last call of Filter_PT1.

By default, the cycle time is measured automatically and output as of the second call at the CycleTime.Value tag. Filter_PT1 measures the cycle time for each call of the instruction and can therefore be used in non-isochronous call cycles, e.g. in OB1.

Note that conditional calls of the instruction, active breakpoints, or the loading of snapshots as actual values during automatic measurement of the cycle time will extend the cycle time value. A cycle time that is too long is identified as error with error message ErrorBits = 16#0008_0000.

If measurement of the cycle time returns no valid result, Filter_PT1 calculates the current output value with the last valid cycle time. In addition, Filter_PT1 outputs an error message at the ErrorBits parameter.

When you disable automatic measurement of the cycle time by setting the CycleTime.EnableMeasurement tag = FALSE, you must enter the cycle time manually at the CycleTime.Value tag. Filter_PT1 checks the CycleTime.Value tag for validity at each call.

Automatic measurement of the cycle time with breakpoints

When breakpoints are active between two calls of Filter_PT1, automatic measurement of the cycle time results in the actual time that has elapsed between two calls. When one breakpoint is active, the CPU is in HOLD operating state.

NOTE

The active breakpoints extend the time period between two calls of Filter_PT1.

The longer the time period between two calls, the greater the change of the output value at the Output parameter.

Furthermore, it is possible that the longer time intervals violate the condition Lag ≥ CycleTime.Value/2 and an error with the error message ErrorBits = 16#0008_0000 is therefore identified.

If you do not need the calculation of the output value based on the actual time with active breakpoints, follow these steps:

- Disable automatic measurement of the cycle time by setting the tag CycleTime.EnableMeasurement = FALSE.
- Enter the cycle time manually at the CycleTime.Value tag.

11.9.4 Input parameter Filter_PT1

Parameter	Data type	Default	Description
Input	REAL	0.0	Input value
Substitu-teOutput	REAL	0.0	SubstituteOutput is used as the substitute output value when • Reset = TRUE or • An error with error message ErrorBits ≥ 16#0001_0000 prevents the correct calculation of the output value, and ErrorMode is configured to the value 1.
ErrorAck	BOOL	FALSE	Deletes the error messages • Edge FALSE -> TRUE ErrorBits is reset.
Reset	BOOL	FALSE	Performs a restart of the instruction • Edge FALSE -> TRUE ErrorBits is reset. • As long as Reset is set to TRUE, the substitute output value SubstituteOutput is output at the output. • As long as Reset is set to FALSE, the calculation of the output value is performed.

11.9.5 Output parameter Filter_PT1

Parameter	Data type	Default	Description
Output	REAL	0.0	Output value The output value is retentive.
ErrorBits	DWORD	DW#16#0	The ErrorBits parameter (Page 537) shows which error messages are pending. ErrorBits is retentive and is reset upon a positive edge at Reset or ErrorAck.
Error	BOOL	FALSE	When Error is set to TRUE, at least one error is currently pending.

11.9.6 Static tags Filter_PT1

Tag	Data type	Default	Description
Gain	REAL	1.0	Proportional gain
Lag	REAL	25.0	Lag time constant in seconds Permissible value range: Lag ≥ CycleTime.Value/2
ErrorMode	INT	2	Selection of the substitute output value following an error • 0 = Input • 1 = SubstituteOutput • 2 = Last valid filter output value • 3 = 0.0 • 4 = Input * Gain Permissible value range: 0 to 4
StartMode	INT	2	Selecting the output value for the first call of the instruction • 0 = Input • 1 = SubstituteOutput • 2 = Last output value • 3 = 0.0 • 4 = Input * Gain Permissible value range: 0 to 4
CycleTime	AuxFct_CycleTime	-	Cycle time data
CycleTime.Value	REAL	0.1	Cycle time in seconds (time interval between two calls) Permissible value range: CycleTime.Value > 0.0
CycleTime.Enable Measurement	BOOL	TRUE	Automatic measurement of the cycle time • FALSE = Deactivated • TRUE = Activated

11.9.7 ErrorBits parameter

If several errors are pending simultaneously, the values of the ErrorBits are displayed with binary addition. The display of ErrorBits = 16#0000_0003, for example, indicates that the errors 16#0000_0001 and 16#0000_0002 are pending simultaneously.

For Filter_PT1, the errors output at the ErrorBits parameter are divided into two categories:

- Errors with error messages ErrorBits < 16#0001_0000
- Errors with error messages ErrorBits ≥ 16#0001_0000

Errors with error messages ErrorBits < 16#0001_0000

If one or more errors with error messages ErrorBits < 16#0001_0000 are pending, Filter_PT1 reacts as follows:

- The output value is determined as follows despite this error:
  - When Reset = FALSE, output value calculation by the filter algorithm
  - When Reset = TRUE, output of SubstituteOutput
- The output parameter Error is set.
- The enable output ENO is not changed.

The output parameter Error is deleted as soon as there are no longer any errors.

ErrorBits (DW#16#...)	Description
0000_0000	No error is pending.
0000_0001	**Cause of error and response to error:** The Output parameter was limited to -3.402823e+38 or +3.402823e+38. **Solution:** If the value determined by the filter function is output at the output (Reset = FALSE and ErrorBits < 16#0001_0000), check the following tags used in the filter calculation: • Input • Gain • Lag • CycleTime.Value When ErrorBits ≥ 16#0001_0000 and Reset = FALSE, the substitute output value is limited on its output. In this case, check the following parameters depending on the set value at the tag ErrorMode: • Input • SubstituteOutput • The product of Input and Gain When Reset = TRUE, check the SubstituteOutput parameter.
0000_0002	**Cause of error:** The measurement of the cycle time yields in an invalid value while the output value is being calculated (Reset = FALSE). **Response to error:** If a valid value of the cycle time has already been measured, Filter_PT1 calculates the output value based on the last value of the CycleTime.Value tag. If no valid value of the cycle time was previously measured, Filter_PT1 still outputs the output value configured with the StartMode tag at the Output parameter.

Errors with error messages ErrorBits ≥ 16#0001_0000

If one or more errors with error messages ErrorBits ≥ 16#0001_0000 are pending, Filter_PT1 reacts as follows:

- The output value cannot be determined as expected. The substitute output value is output instead.
- The output parameter Error is set.
- The enable output ENO is set to FALSE.

As soon as there are no longer errors with error messages ErrorBits ≥ 16#0001_0000, Filter_PT1 reacts as follows:

- The output value is determined as follows:
  - When Reset = FALSE, output value calculation by the filter algorithm
  - When Reset = TRUE, output of SubstituteOutput
- The enable output ENO is set to TRUE.

The output parameter Error is deleted as soon as there are no longer any errors.

<table>
<tr><th>ErrorBits (DW#16#...)</th><th>Description</th></tr>
<tr><td>0001_0000</td><td>Cause of error:
The SubstituteOutput parameter or a different tag that is being used as output value has no valid REAL value.
Response to error:
The output is set to 0.0.
Solution:
Make sure that the tag used as output value is a valid REAL value (≠NaN e.g. 16#7FFF_FFFF). The tag that is used as output value depends on Reset and ErrorMode:
<table>
<tr><th>Reset</th><th>ErrorMode</th><th>Output value</th></tr>
<tr><td>FALSE</td><td>0</td><td>Input</td></tr>
<tr><td>FALSE</td><td>1</td><td>SubstituteOutput</td></tr>
<tr><td>FALSE</td><td>4</td><td>Product of Input and Gain</td></tr>
<tr><td>TRUE</td><td>-</td><td>SubstituteOutput</td></tr>
</table></td></tr>
<tr><td>0002_0000</td><td>Cause of error:
The Input parameter has no valid REAL value while the calculation of the output value is being performed (Reset = FALSE).
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. When ErrorMode = 0, 0.0 is used as output value.
Solution:
Make sure that the parameter Input is a valid REAL value (≠NaN e.g. 16#7FFF_FFFF).</td></tr>
<tr><td>0004_0000</td><td>Cause of error:
The calculation of the output value yields an invalid REAL value for the Output parameter.
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter.
Solution:
Check all tags involved in the calculation of the output value:
• Input
• Gain
• Lag
• CycleTime.Value
These tags have valid values. The calculation of the output value fails in this combination of tags.</td></tr>
<tr><td>0008_0000</td><td>Cause of error:
The Lag or Gain tag has an invalid value, while the calculation of the output value is being performed (Reset = FALSE).
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter.
Solution:</td></tr>
</table>

ErrorBits (DW#16#...)	Description
	Ensure that the following conditions for the values of the Gain and Lag tags are met: • -3.402823e+38 ≤ Gain ≤ 3.402823e+38 • CycleTime.Value/2 ≤ Lag ≤ 3.402823e+38 • The values are valid REAL values (≠ NaN, for example 16#7FFF_FFFF) **Additional information:** Note that the condition CycleTime.Value/2 ≤ Lag may be violated in the following scenarios: • The time interval between two calls of Filter_PT1 is longer than 2 * Lag, for example, due to conditional calls in the program sequence or active breakpoints. • A snapshot of the Filter_PT1 instance DB is loaded into the CPU as actual values, and the snapshot was created more than 2 * Lag ago. In these scenarios, an error message ErrorBits = 16#0008_0000 is detected during automatic measurement of the cycle time.
0020_0000	**Cause of error:** The tag (configured with StartMode) for the initialization of the Output parameter at the first call of the instruction does not have a valid REAL value. **Response to error:** The substitute output value is output with the first call of the instruction at the Output parameter that is configured at the ErrorMode tag. For subsequent calls, Filter_PT1 calculates the output value starting from this substitute output value. **Solution:** Make sure that the tag for initializing the parameter Output is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF). When Reset = FALSE is set, the initialization takes effect with the first call of the instruction after the operating state transition of the CPU from STOP to RUN. The tag that is used for the initialization of the Output parameter depends on StartMode: • StartMode = 1: SubstituteOutput • StartMode = 2: Output • StartMode = 4: Product of Input and Gain
0040_0000	**Cause of error:** The CycleTime.Value tag has an invalid value, while the calculation of the output value is being performed (Reset = FALSE). **Response to error:** The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. **Solution:** Ensure that the following conditions are met: • 0.0 < CycleTime.Value ≤ 3.402823e+38 • CycleTime.Value is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF) **Additional information:** To automatically calculate the value of the CycleTime.Value tag, set the CycleTime.EnableMeasurement tag to TRUE.

11.10 Filter_PT2

11.10.1 Compatibility with CPU and FW

The following table shows which version of Filter_PT2 can be used on which CPU:

CPU	FW	Filter_PT2
S7-1200	as of V4.2	V1.0
S7-1200 G2	V1.0 or higher	V1.0
S7-1500-based CPUs	as of V2.0	V1.0

11.10.2 Description of Filter_PT2

Description

The instruction Filter_PT2 is a proportional transfer element with a second-order lag, also referred to as PT2 element.

You can use Filter_PT2 for the following purposes:

- Low-pass filter to attenuate high frequency components, such as noise, in a signal.
- Delay element to smooth signal step changes, for example, from the setpoint or the output value of a controller.
- Process simulation block to implement a closed control loop within the CPU. This means, for example, that you can test controllers before commissioning.

You can specify the following filter parameters:

- Proportional gain (Gain)
- Time constant (TimeConstant)
- Damping (Damping)

NOTE

Differences between a continuous-time PT2 element and Filter_PT2

Because Filter_PT2 is executed in a PLC program, Filter_PT2 is a discrete-time implementation of a PT2 element. Discrete-time systems cannot have the same properties as the corresponding continuous-time model. Depending on the cycle time, discrete-time systems can emulate a continuous-time system well: The smaller and more constant the cycle time, the smaller the conformity error between the properties of Filter_PT2 and the properties of a continuous-time PT2 element. The properties of a continuous-time PT2 element are the transfer function, the time response and the frequency response which are described below.

For a good simulation of the frequency response, a maximum cycle time of one-tenth of the shortest period duration of the input signal components is recommended. For example, a signal with frequency components of up to 50 Hz has a minimum period duration of 20 ms. To achieve good simulation of the frequency response, a maximum cycle time of 2 ms is recommended for this example.

Transfer function of a PT2 element

The following formula shows the transfer function of a PT2 element, whereby s is equal to the Laplace operator:

$$G(s) = \frac{\text{Output(s)}}{\text{Input(s)}} = \frac{\text{Gain}}{1 + 2 \cdot \text{Damping} \cdot \text{TimeConstant} \cdot s + \text{TimeConstant} \cdot s}$$

If Damping ≥ 1, the PT2 element can be described as two PT1 elements switched in series:

$$G(s) = \frac{\text{Output(s)}}{\text{Input(s)}} = \frac{\text{Gain}}{(1 + \text{Lag}_1 \cdot s) \cdot (1 + \text{Lag}_2 \cdot s)}$$

The lag time constants of the PT1 elements switched in series are calculated as follows:

$$Lag_{1/2} = TimeConstant \cdot \left(Damping \pm \sqrt{Damping^2 - 1}\right)$$

Time response of a PT2 element

The step response is the response of the output value to a step change of the input value.

The step response for a step change of the input value from 0 to ΔInput can be calculated using the following formulas:

The following formula applies to Damping < 1:

$$Output(t) = \Delta Input \cdot Gain \cdot \left(1 - e^{-\frac{\text{Damping}}{\text{TimeConstant}} \cdot t} \cdot \left[\cos\left(\frac{\sqrt{1 - \text{Damping}^2}}{\text{TimeConstant}} \cdot t\right) + \frac{\text{Damping}}{\sqrt{1 - \text{Damping}^2}} \cdot \sin\left(\frac{\sqrt{1 - \text{Damping}^2}}{\text{TimeConstant}} \cdot t\right)\right]\right)$$

The following formula applies to Damping = 1:

$$Output(t) = \Delta Input \cdot Gain \cdot \left(1 - e^{-\frac{t}{\text{TimeConstant}}} - \frac{t}{\text{TimeConstant}} \cdot e^{-\frac{t}{\text{TimeConstant}}}\right)$$

The following formula with the above calculated Lag_1 and Lag_2 applies to Damping > 1:

$$Output(t) = \Delta Input \cdot Gain \cdot \left(1 - \frac{\text{Lag}_1}{\text{Lag}_1 - \text{Lag}_2} \cdot e^{-\frac{t}{\text{Lag}_1}} + \frac{\text{Lag}_2}{\text{Lag}_1 - \text{Lag}_2} \cdot e^{-\frac{t}{\text{Lag}_2}}\right)$$

The following figure shows the step response of a PT2 element with various values for the damping:

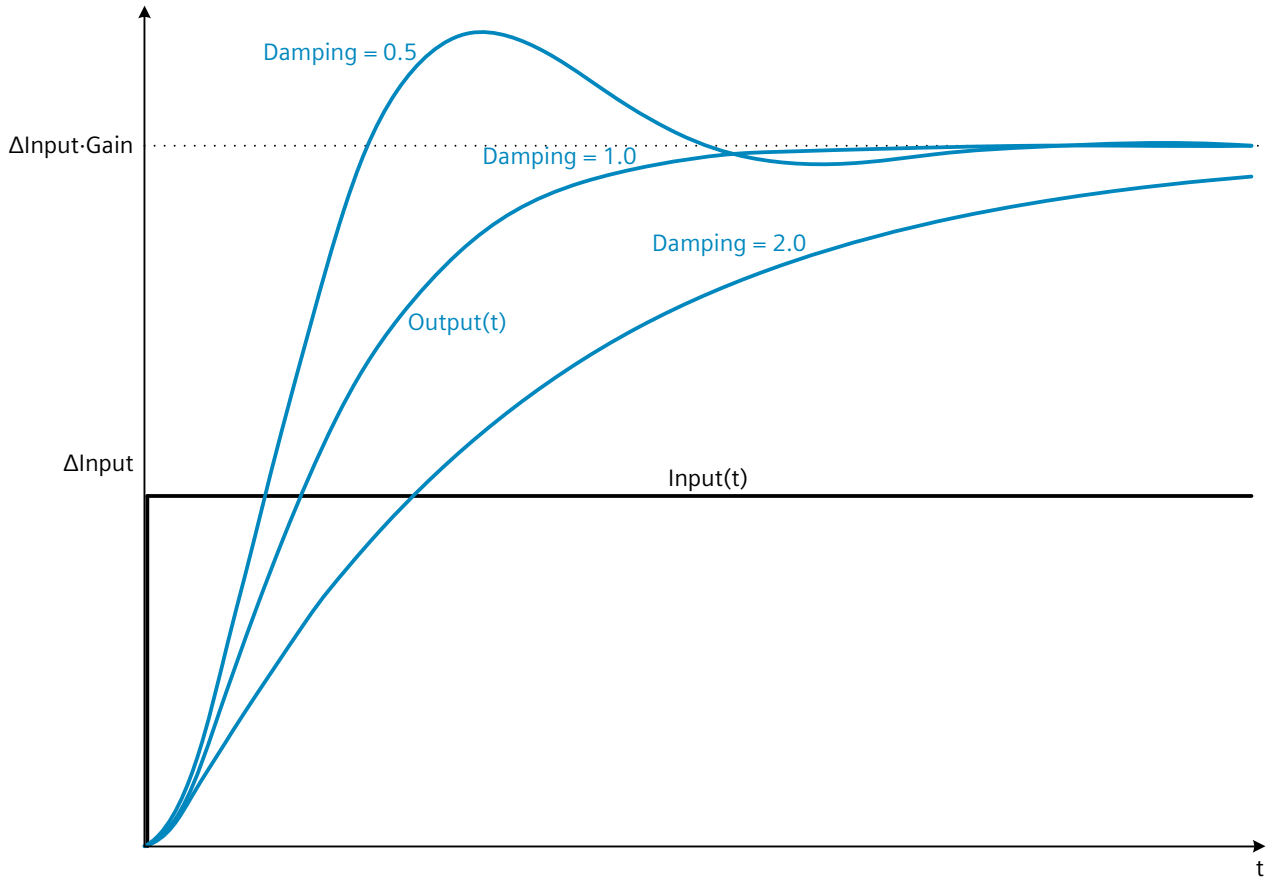

Frequency response of a PT2 element

The frequency response of a transfer element is described by the amplitude response and the phase response.

The amplitude response describes the gain of a signal through the transfer element depending on the angular frequency of the signal.

The following equation describes the amplitude response of a PT2 element:

$$|G(\omega)| = \frac{\text{Gain}}{\sqrt{(1 - [\omega \cdot \text{TimeConstant}]^2)^2 + (\omega \cdot 2 \cdot \text{Damping} \cdot \text{TimeConstant})^2}}$$

$\lvert G(\omega)\rvert$	Signal gain as a function of the angular frequency
ω	Angular frequency

The following figure shows the amplitude response of a PT2 element with a damping of 0.4 and 1.0:

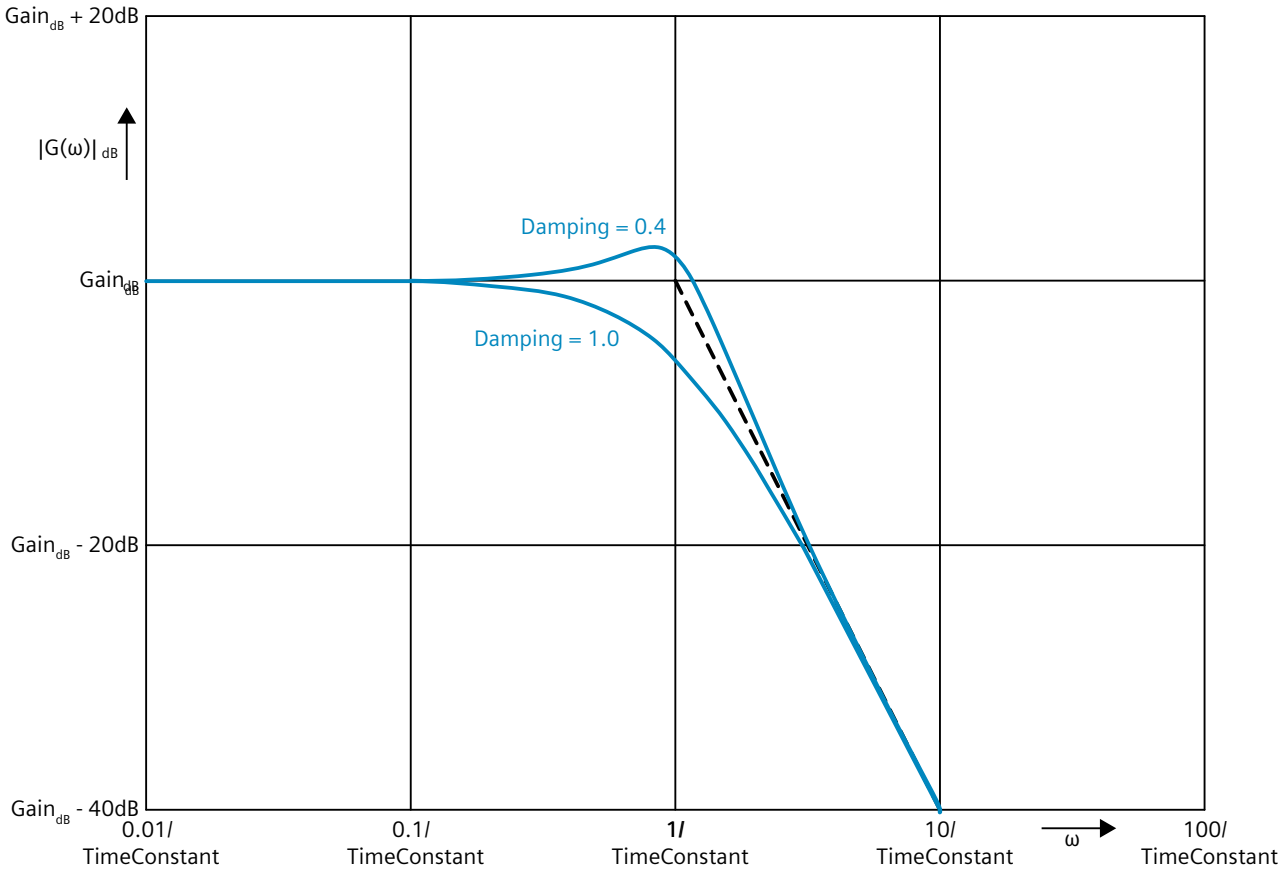

NOTE

When Damping < 1/√2, a resonance peak appears in the amplitude response.

The phase response describes the phase offset of a signal through the transfer element depending on the angular frequency of the signal.

The following equation describes the phase response of a PT2 element:

$$\varphi(\omega) = -\tan^{-1}\left(\frac{\omega \cdot 2 \cdot \text{Damping} \cdot \text{TimeConstant}}{1 - (\omega \cdot \text{TimeConstant})^2}\right)$$

φ(ω) Phase offset as a function of the angular frequency

ω Angular frequency

The following figure shows the phase response of a PT2 element:

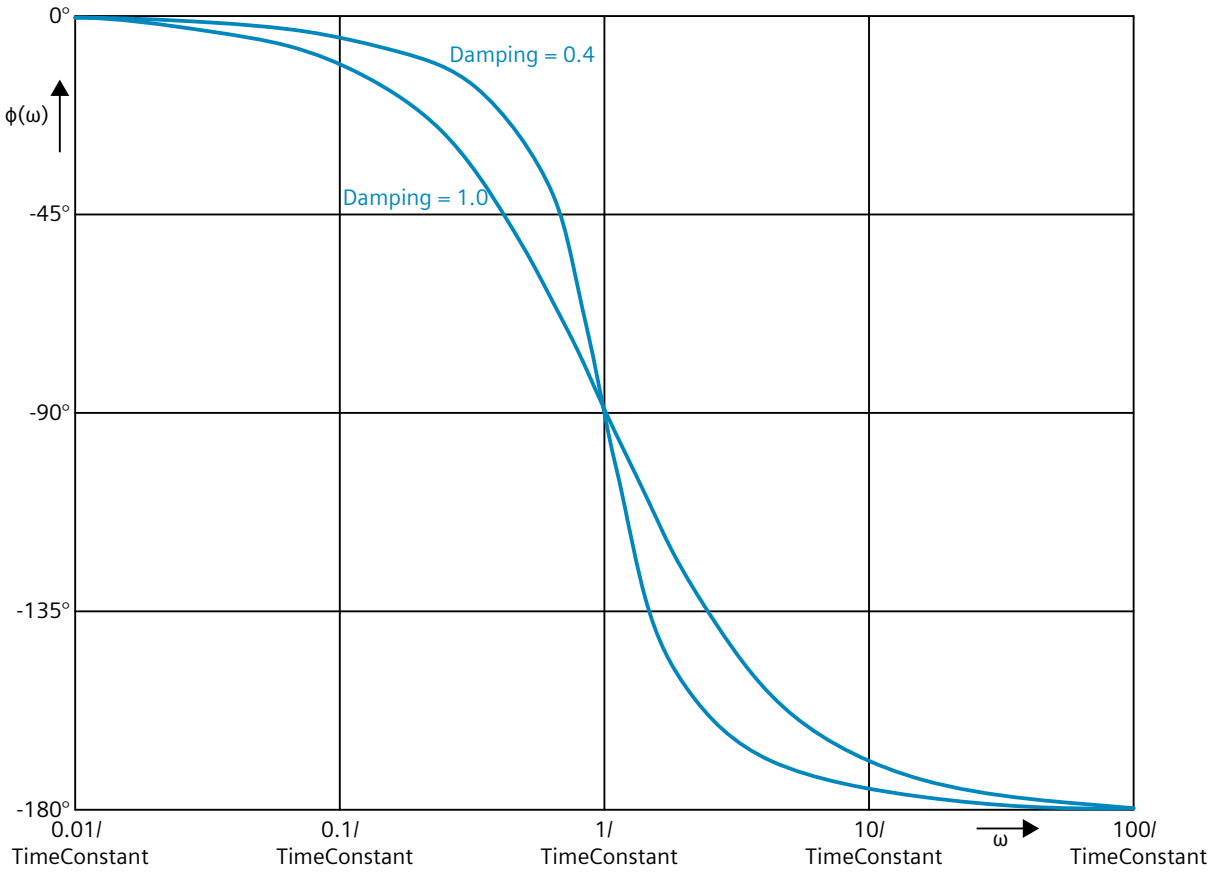

Call

In an OB or FC, Filter_PT2 is called as single-instance DB. In an FB, Filter_PT2 can be called as a single-instance DB, as a multi-instance DB, and as a parameter instance DB.

When the instruction is called, no technology object is created. No parameter assignment interface or commissioning interface is available. You assign the Filter_PT2 parameters directly using the instance DB and commission Filter_PT2 using a watch table of the user program in the CPU or HMI.

Startup

The tags in the static area of Filter_PT2 are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN. If you change the actual values in online mode and these values are to be retained after the operating state transition of the CPU, back up these values in the start values of the data block.

Specify the initialization value for the Output parameter at the StartMode tag.

During the first call of Filter_PT2 after the

- Operating state transition of the CPU

or

- Execution of "Load start values as actual values" (only with "All values" option, not with "Only setpoints" option)

the initialization value is output at the Output parameter.

For subsequent calls, Filter_PT2 calculates the output value, starting from this initialization value, based on the input value and the filter configuration.

The following table shows the dependency between the StartMode tag and the Output parameter. The values in the Output column are output at the Output parameter after the operating state transition of the CPU.

StartMode	Output	Example
0	Value of the Input parameter	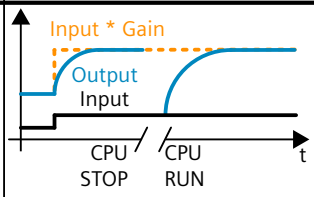
1	Value of the SubstituteOutput parameter	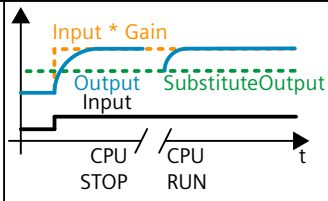
2	Remains unchanged Output parameter is retentive Default setting Is used when StartMode is not in the range 0...4	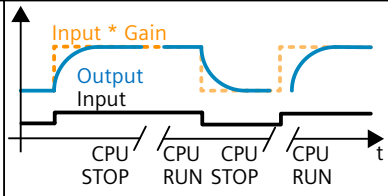
3	0.0	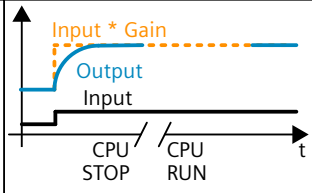
4	Value of the Input * Gain product	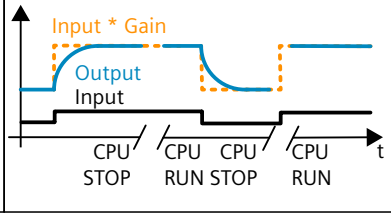

The following applies in addition for all values of the StartMode tag:

- The initialization value is limited to the value range of the data type REAL. Only then is the initialization value output at the Output parameter.
- If the initialization value is not a valid REAL value, the substitute output value is output at the Output parameter. The substitute output value is configured by the ErrorMode tag. The substitute output value is limited to the value range of the data type REAL before it is output at the Output parameter. If the substitute output value is also not a valid REAL value, 0.0 is output at the Output parameter. For subsequent calls, the instruction calculates the output value starting from this substitute output value.
- The StartMode tag only takes effect when the Reset = FALSE parameter is set at the first call of the instruction and at the same time no error with error message ErrorBits ≥ 16#0002_0000 is pending. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter. If an error with error message ErrorBits ≥ 16#0002_0000 is pending, the substitute output value that is configured at the ErrorMode tag is output at the Output parameter.

Response to errors

The Filter_PT2 instruction detects different errors that can occur during the calculation of the output value. The result of this calculation can be output at the output despite a pending error. If an error prevents correct calculation of the output value, a substitute output value is output at the output.

Specify the substitute output value that is output if an error occurs that prevents correct calculation of the output value at the ErrorMode tag.

The following table shows the dependency between the ErrorMode tag and the substitute output value that is output by the Filter_PT2 at the Output parameter:

ErrorMode	Output
0	Value of the Input parameter
1	Value of the SubstituteOutput parameter
2	The last valid filter output value 0.0 if no valid filter output value is available Default setting Is used when ErrorMode is not in the range 0...4
3	0.0
4	Value of the Input * Gain product

The following applies in addition for all values of the ErrorMode tag:

- If the substitute output value is not a valid REAL value, 0.0 is output as output value.
- The substitute output value is limited to the value range of the data type REAL. Only then is the substitute output value output at the Output parameter.
- The ErrorMode tag only takes effect when the Reset = FALSE parameter is set. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter.

The Error parameter indicates if an error is pending. When the error is no longer pending, Error is set to FALSE. The ErrorBits parameter shows which errors have occurred. ErrorBits is retentive and is reset only by a positive edge at the Reset or ErrorAck parameter.

11.10.3 Operating principle Filter_PT2

Reset response

Filter_PT2 behaves as follows depending on the Reset parameter:

- If the Reset =TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter.
- If the Reset = FALSE parameter is set, the value that is output at the Output parameter is calculated by the filter algorithm.
- When the Reset parameter is set from FALSE to TRUE, the value at the Output parameter changes directly to the value of the SubstituteOutput parameter. An output jump can occur during this transition. In addition, the ErrorBits parameter is reset.
- When the Reset parameter is set from TRUE to FALSE, the filtering algorithm is added so that the transition is bumpless.

Enable behavior EN/ENO

If one of the following conditions is met, enable output ENO is set to FALSE.

- Enable input EN is set to TRUE and the Output parameter is specified by a substitute output value in case of error messages ErrorBits ≥ 16#0001_0000.
- Enable input EN is set to FALSE.

Otherwise, the enable output ENO is set to TRUE.

Measuring the cycle time automatically

To calculate the output value, Filter_PT2 needs the time that has expired since the last call of Filter_PT2.

By default, the cycle time is measured automatically and output as of the second call at the CycleTime.Value tag. Filter_PT2 measures the cycle time for each call of the instruction and can therefore be used in non-equidistant call cycles, e.g. in OB1.

Note that conditional calls of the instruction, active breakpoints, or the loading of snapshots as actual values during automatic measurement of the cycle time will extend the cycle time value. A cycle time that is too long is identified as error with error message ErrorBits = 16#0008_0000.

If measurement of the cycle time returns no valid result, Filter_PT2 calculates the current output value with the last valid cycle time. In addition, Filter_PT2 outputs an error message at the ErrorBits parameter.

When you disable automatic measurement of the cycle time by setting the CycleTime.EnableMeasurement tag = FALSE, you must enter the cycle time manually at the CycleTime.Value tag. Filter_PT2 checks the CycleTime.Value tag for validity at each call.

Automatic measurement of the cycle time with breakpoints

When breakpoints are active between two calls of Filter_PT2, automatic measurement of the cycle time results in the actual time that has elapsed between two calls. When one breakpoint is active, the CPU is in HOLD operating state.

NOTE

The active breakpoints extend the time period between two calls of Filter_PT2.

The longer the time period between two calls, the greater the change of the output value at the Output parameter.

Furthermore, it is possible that the longer time intervals violate the condition TimeConstant ≥ CycleTime.Value/2 and an error with the error message ErrorBits = 16#0008_0000 is therefore identified.

If you do not need the calculation of the output value based on the actual time with active breakpoints, follow these steps:

- Disable automatic measurement of the cycle time by setting the CycleTime.EnableMeasurement tag = FALSE.
- Enter the cycle time manually at the CycleTime.Value tag.

11.10.4 Input parameter Filter_PT2

Parameter	Data type	Default	Description
Input	REAL	0.0	Input value
Substitu-teOutput	REAL	0.0	SubstituteOutput is used as the substitute output value when • Reset = TRUE or • An error with error message ErrorBits ≥ 16#0001_0000 prevents the correct calculation of the output value, and ErrorMode is configured to the value 1.
ErrorAck	BOOL	FALSE	Deletes the error messages • Edge FALSE -> TRUE ErrorBits is reset.
Reset	BOOL	FALSE	Performs a restart of the instruction • Edge FALSE -> TRUE ErrorBits is reset. • As long as Reset is set to TRUE, the substitute output value SubstituteOutput is output at the output. • As long as Reset is set to FALSE, the calculation of the output value is performed.

11.10.5 Output parameter Filter_PT2

Parameter	Data type	Default	Description
Output	REAL	0.0	Output value The output value is retentive.
ErrorBits	DWORD	DW#16#0	The ErrorBits parameter (Page 550) shows which error messages are pending. ErrorBits is retentive and is reset upon a positive edge at Reset or ErrorAck.
Error	BOOL	FALSE	When Error is set to TRUE, at least one error is currently pending.

11.10.6 Static tags Filter_PT2

Tag	Data type	Default	Description
Gain	REAL	1.0	Proportional gain
TimeConstant	REAL	25.0	Time constant in seconds Permissible value range: TimeConstant ≥ CycleTime.Value/2
Damping	REAL	1.0	Damping Permissible value range: Damping > 0.0
ErrorMode	INT	2	Selection of the substitute output value following an error • 0 = Input • 1 = SubstituteOutput • 2 = Last valid filter output value • 3 = 0.0 • 4 = Input * Gain Permissible value range: 0 to 4
StartMode	INT	2	Selecting the output value for the first call of the instruction • 0 = Input • 1 = SubstituteOutput • 2 = Last output value • 3 = 0.0 • 4 = Input * Gain Permissible value range: 0 to 4
CycleTime	AuxFct_CycleTime	-	Cycle time data
CycleTime.Value	REAL	0.1	Cycle time in seconds (time interval between two calls) Permissible value range: CycleTime.Value > 0.0
CycleTime.Enable Measurement	BOOL	TRUE	Automatic measurement of the cycle time • FALSE = Deactivated • TRUE = Activated

11.10.7 ErrorBits parameter

If several errors are pending simultaneously, the values of the ErrorBits are displayed with binary addition. The display of ErrorBits = 16#0000_0003, for example, indicates that the errors 16#0000_0001 and 16#0000_0002 are pending simultaneously.

For Filter_PT2, the errors output at the ErrorBits parameter are divided into two categories:

- Errors with error messages ErrorBits < 16#0001_0000
- Errors with error messages ErrorBits ≥ 16#0001_0000

Errors with error messages ErrorBits < 16#0001_0000

If one or more errors with error messages ErrorBits < 16#0001_0000 are pending, Filter_PT2 reacts as follows:

- The output value is determined as follows despite this error:
  - When Reset = FALSE, output value calculation by the filter algorithm
  - When Reset = TRUE, output of SubstituteOutput
- The output parameter Error is set.
- The enable output ENO is not changed.

The output parameter Error is deleted as soon as there are no longer any errors.

ErrorBits (DW#16#...)	Description
0000_0000	No error is pending.
0000_0001	**Cause of error and response to error:** The Output parameter was limited to -3.402823e+38 or +3.402823e+38. **Solution:** If the value determined by the filter function is output at the output (Reset = FALSE and ErrorBits < 16#0001_0000), check the following tags used in the filter calculation: • Input • Gain • TimeConstant • Damping • CycleTime.Value When ErrorBits ≥ 16#0001_0000 and Reset = FALSE, the substitute output value is limited on its output. In this case, check the following parameters depending on the set value at the tag ErrorMode: • Input • SubstituteOutput • The product of Input and Gain When Reset = TRUE, check the SubstituteOutput parameter.
0000_0002	**Cause of error:** The measurement of the cycle time yields in an invalid value while the output value is being calculated (Reset = FALSE). **Response to error:** If a valid value of the cycle time has already been measured, Filter_PT2 calculates the output value based on the last value of the CycleTime.Value tag. If no valid value of the cycle time was previously measured, Filter_PT2 still outputs the output value configured with the StartMode tag at the Output parameter.

Errors with error messages ErrorBits ≥ 16#0001_0000

If one or more errors with error messages ErrorBits ≥ 16#0001_0000 are pending, Filter_PT2 reacts as follows:

- The output value cannot be determined as expected. The substitute output value is output instead.
- The output parameter Error is set.
- The enable output ENO is set to FALSE.

As soon as there are no longer errors with error messages ErrorBits ≥ 16#0001_0000, Filter_PT2 reacts as follows:

- The output value is determined as follows:
  - When Reset = FALSE, output value calculation by the filter algorithm
  - When Reset = TRUE, output of SubstituteOutput
- The enable output ENO is set to TRUE.

The output parameter Error is deleted as soon as there are no longer any errors.

<table>
<tr><th>ErrorBits (DW#16#...)</th><th>Description</th></tr>
<tr><td>0001_0000</td><td>Cause of error:
The SubstituteOutput parameter or a different tag that is being used as output value has no valid REAL value.
Response to error:
The output is set to 0.0.
Solution:
Make sure that the tag used as output value is a valid REAL value (≠NaN e.g. 16#7FFF_FFFF). The tag that is used as output value depends on Reset and ErrorMode:
<table>
<tr><th>Reset</th><th>ErrorMode</th><th>Output value</th></tr>
<tr><td>FALSE</td><td>0</td><td>Input</td></tr>
<tr><td>FALSE</td><td>1</td><td>SubstituteOutput</td></tr>
<tr><td>FALSE</td><td>4</td><td>Product of Input and Gain</td></tr>
<tr><td>TRUE</td><td>-</td><td>SubstituteOutput</td></tr>
</table></td></tr>
<tr><td>0002_0000</td><td>Cause of error:
The Input parameter has no valid REAL value while the calculation of the output value is being performed (Reset = FALSE).
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. When ErrorMode = 0, 0.0 is used as output value.
Solution:
Make sure that the parameter Input is a valid REAL value (≠NaN e.g. 16#7FFF_FFFF).</td></tr>
<tr><td>0004_0000</td><td>Cause of error:
The calculation of the output value yields an invalid REAL value for the Output parameter.
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter.
Solution:
Check all tags involved in the calculation of the output value:
• Input
• Gain
• TimeConstant
• Damping
• CycleTime.Value
These tags have valid values. The calculation of the output value fails in this combination of tags.</td></tr>
<tr><td>0008_0000</td><td>Cause of error:
The Gain, TimeConstant or Damping tag has an invalid value, while the calculation of the output value is being performed (Reset = FALSE).
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter.
Solution:</td></tr>
</table>

ErrorBits (DW#16#...)	Description
	Ensure that the following conditions for the values of the Gain, TimeConstant and Damping tags are met: • -3.402823e+38 ≤ Gain ≤ 3.402823e+38 • CycleTime.Value/2 ≤ TimeConstant ≤ 3.402823e+38 • 0.0 < Damping ≤ 3.402823e+38 • The values are valid REAL values (≠ NaN, for example 16#7FFF_FFFF) **Additional information:** Note that the condition CycleTime.Value/2 ≤ TimeConstant may be violated in the following scenarios: • The time interval between two calls of Filter_PT2 is longer than 2 * TimeConstant, for example, due to conditional calls in the program sequence or active breakpoints. • A snapshot of the Filter_PT2 instance DB is loaded into the CPU as actual values, and the snapshot was created more than 2 * TimeConstant ago. In these scenarios, an error message ErrorBits = 16#0008_0000 is detected during automatic measurement of the cycle time.
0020_0000	**Cause of error:** The tag (configured with StartMode) for the initialization of the Output parameter at the first call of the instruction does not have a valid REAL value. **Response to error:** The substitute output value is output with the first call of the instruction at the Output parameter that is configured at the ErrorMode tag. For subsequent calls, Filter_PT2 calculates the output value starting from this substitute output value. **Solution:** Make sure that the tag for initializing the parameter Output is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF). When Reset = FALSE is set, the initialization takes effect with the first call of the instruction after the operating state transition of the CPU from STOP to RUN. The tag that is used for the initialization of the Output parameter depends on StartMode: • StartMode = 1: SubstituteOutput • StartMode = 2: Output • StartMode = 4: Product of Input and Gain
0040_0000	**Cause of error:** The CycleTime.Value tag has an invalid value, while the calculation of the output value is being performed (Reset = FALSE). **Response to error:** The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. **Solution:** Ensure that the following conditions are met: • 0.0 < CycleTime.Value ≤ 3.402823e+38 • CycleTime.Value is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF) **Additional information:** To automatically calculate the value of the CycleTime.Value tag, set the CycleTime.EnableMeasurement tag to TRUE.

11.11 Filter_DT1

11.11.1 Compatibility with CPU and FW

The following table shows which version of Filter_DT1 can be used on which CPU:

CPU	FW	Filter_DT1
S7-1200	as of V4.2	V1.0
S7-1200 G2	V1.0 or higher	V1.0
S7-1500-based CPUs	as of V2.0	V1.0

11.11.2 Description of Filter_DT1

Description

The instruction Filter_DT1 is a differentiator with a first-order lag, also referred to as DT1 element.

You can use Filter_DT1 for the following purposes:

- High-pass filter to attenuate low frequency components in a signal.
- Differentiator to calculate the derivation of a signal, such as the speed from position values.
- Feedforward control to lessen the effect of measurable disturbances on the process.

You can specify the following filter parameters:

- Derivative action time (Td)
- Lag time constant (Lag)

NOTE

Differences between a continuous-time DT1 element and Filter_DT1

Because Filter_DT1 is executed in a PLC program, Filter_DT1 is a discrete-time implementation of a DT1 element. Discrete-time systems cannot have the same properties as the corresponding continuous-time model. Depending on the cycle time, discrete-time systems can emulate a continuous-time system well: The smaller and more constant the cycle time, the smaller the conformity error between the properties of Filter_DT1 and the properties of a continuous-time DT1 element. The properties of a continuous-time DT1 element are the transfer function, the time response and the frequency response which are described below.

For a good simulation of the frequency response, a maximum cycle time of one-tenth of the shortest period duration of the input signal components is recommended. For example, a signal with frequency components of up to 50 Hz has a minimum period duration of 20 ms. To achieve good simulation of the frequency response, a maximum cycle time of 2 ms is recommended for this example.

Transfer function of a DT1 element

The following formula shows the transfer function of a DT1 element, whereby s is equal to the Laplace operator:

$$G(s) = \frac{\text{Output}(s)}{\text{Input}(s)} = \frac{\text{Td} \cdot s}{1 + \text{Lag} \cdot s}$$

Time response of a DT1 element

The step response is the response of the output value to a step change of the input value.

The step response for a step change of the input value from 0 to ΔInput can be calculated using the following formula:

$$\text{Output}(t) = \Delta\text{Input} \cdot \frac{\text{Td}}{\text{Lag}} \cdot e^{-\frac{t}{\text{Lag}}}$$

The following figure shows the step response of a DT1 element:

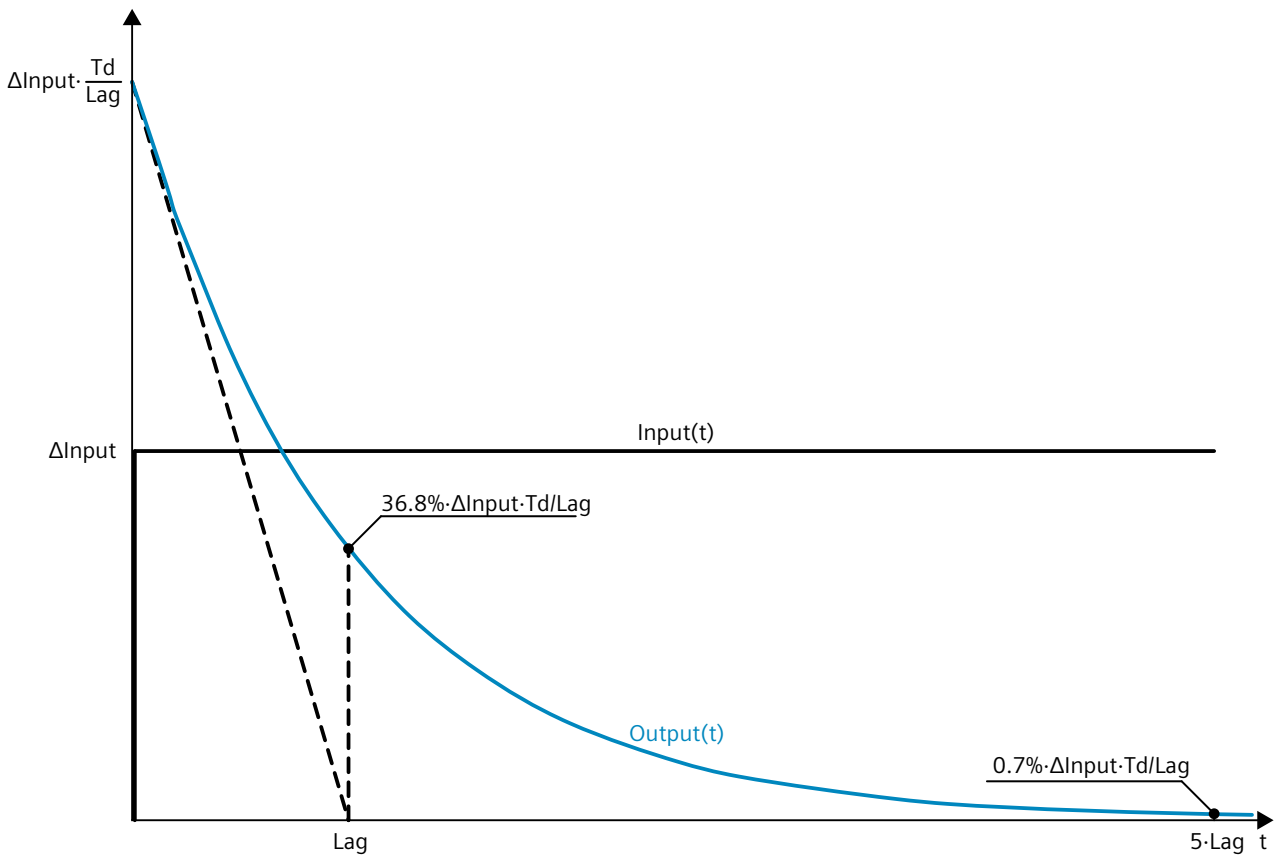

To disable the lag, set the Lag parameter to the minimum value CycleTime.Value / 2. In this case, changes to the input value are multiplied by Td / CycleTime.Value and output at the Output parameter. After one cycle, the output value is 0.0.

The following figure shows the step response in case of Lag = CycleTime.Value / 2:

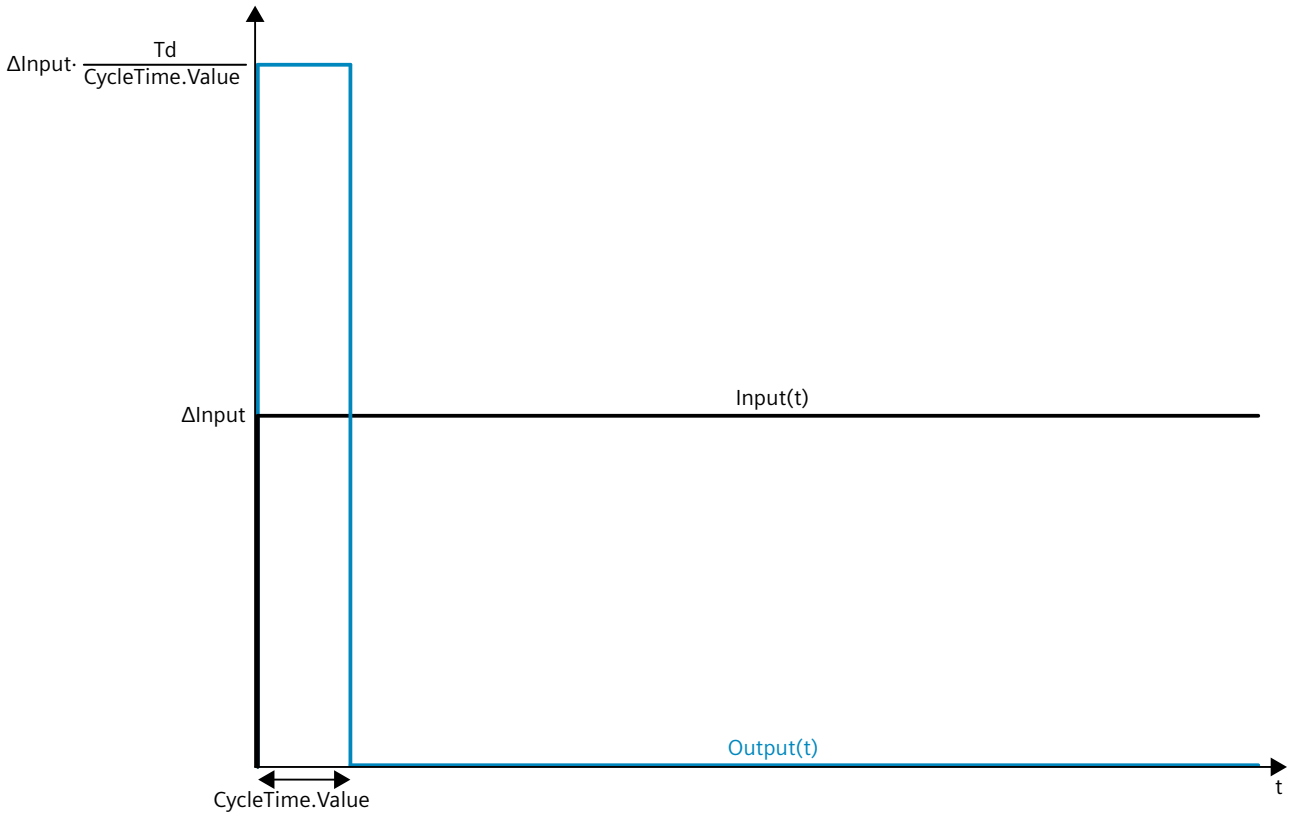

Frequency response of a DT1 element

The frequency response of a transfer element is described by the amplitude response and the phase response.

The amplitude response describes the gain of a signal through the transfer element depending on the angular frequency of the signal.

The following equation describes the amplitude response of a DT1 element:

$$|G(\omega)| = \frac{\omega \cdot \mathrm{Td}}{\sqrt{1 + (\omega \cdot \mathrm{Lag})^2}}$$

$\lvert G(\omega)\rvert$	Signal gain as a function of the angular frequency
ω	Angular frequency

The following figure shows the amplitude response of a DT1 element:

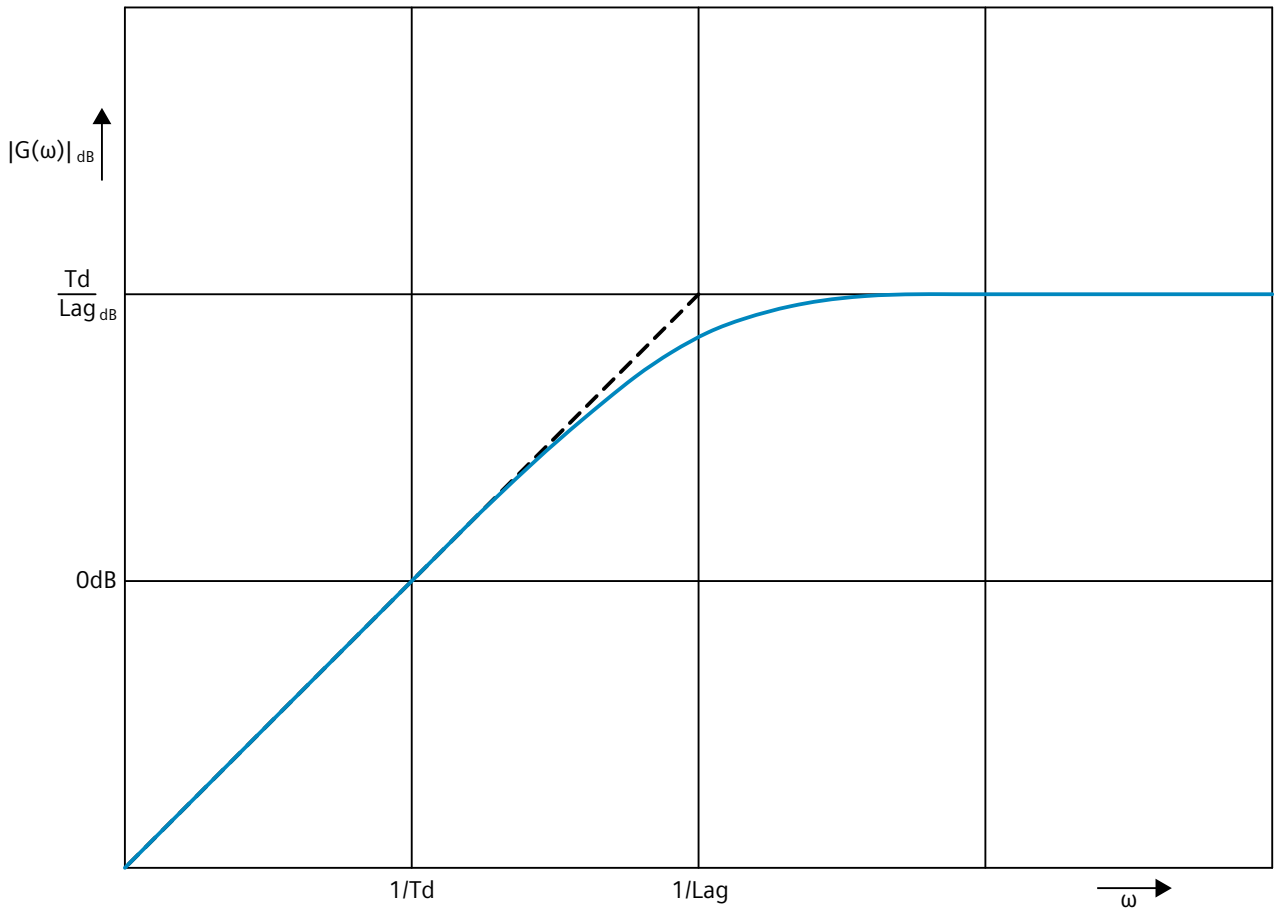

The phase response describes the phase offset of a signal through the transfer element depending on the angular frequency of the signal.

The following equation describes the phase response of a DT1 element:

$$\varphi(\omega) = \tan^{-1}(\omega \cdot \mathrm{Lag})$$

φ(ω)	Phase offset as a function of the angular frequency
ω	Angular frequency

The following figure shows the phase response of a DT1 element:

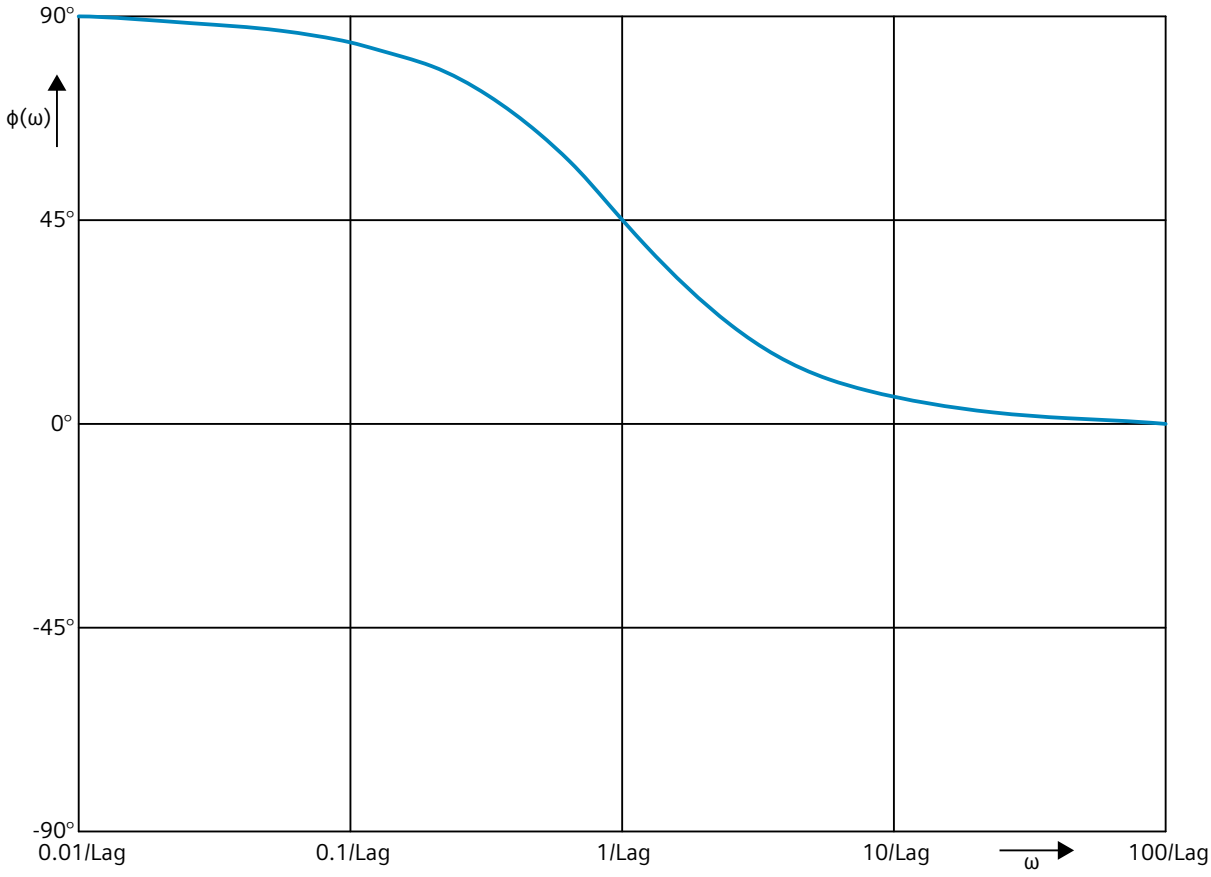

Call

In an OB or FC, Filter_DT1 is called as single-instance DB. In an FB, Filter_DT1 can be called as a single-instance DB, as a multi-instance DB, and as a parameter instance DB.

When the instruction is called, no technology object is created. No parameter assignment interface or commissioning interface is available. You assign the Filter_DT1 parameters directly using the instance DB and commission Filter_DT1 using a watch table of the user program in the CPU or HMI.

Startup

The tags in the static area of Filter_DT1 are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN. If you change the actual values in online mode and these values are to be retained after the operating state transition of the CPU, back up these values in the start values of the data block.

Specify the initialization value for the Output parameter at the StartMode tag.

During the first call of Filter_DT1 after the

- Operating state transition of the CPU

or

- Execution of "Load start values as actual values" (only with "All values" option, not with "Only setpoints" option)

the initialization value is output at the Output parameter.

For subsequent calls, Filter_DT1 calculates the output value, starting from this initialization value, based on the input value and the filter configuration.

The following table shows the dependency between the StartMode tag and the Output parameter. The values in the Output column are output at the Output parameter after the operating state transition of the CPU.

StartMode	Output	Example
0	Value of the Input parameter	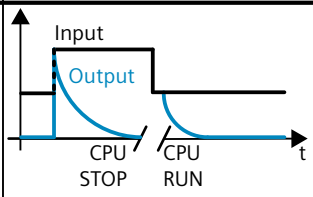
1	Value of the SubstituteOutput parameter	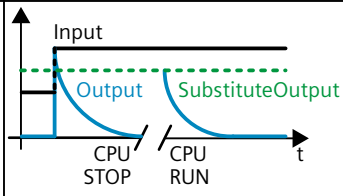
2	Remains unchanged Output parameter is retentive Default setting Is used when StartMode is not in the range 0...3	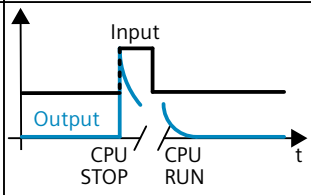
3	0.0	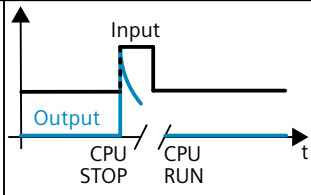

The following applies in addition for all values of the StartMode tag:

- The initialization value is limited to the value range of the data type REAL. Only then is the initialization value output at the Output parameter.
- If the initialization value is not a valid REAL value, the substitute output value is output at the Output parameter. The substitute output value is configured by the ErrorMode tag. The substitute output value is limited to the value range of the data type REAL before it is output at the Output parameter. If the substitute output value is also not a valid REAL value, 0.0 is output at the Output parameter. For subsequent calls, the instruction calculates the output value starting from this substitute output value.

- The StartMode tag only takes effect when the Reset = FALSE parameter is set at the first call of the instruction and at the same time no error with error message ErrorBits ≥ 16#0002_0000 is pending. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter. If an error with error message ErrorBits ≥ 16#0002_0000 is pending, the substitute output value that is configured at the ErrorMode tag is output at the Output parameter.

Response to errors

The Filter_DT1 instruction detects different errors that can occur during the calculation of the output value. The result of this calculation can be output at the output despite a pending error. If an error prevents correct calculation of the output value, a substitute output value is output at the output.

Specify the substitute output value that is output if an error occurs that prevents correct calculation of the output value at the ErrorMode tag.

The following table shows the dependency between the ErrorMode tag and the substitute output value that is output by the Filter_DT1 at the Output parameter:

ErrorMode	Output
0	Value of the Input parameter
1	Value of the SubstituteOutput parameter
2	The last valid filter output value 0.0 if no valid filter output value is available Default setting Is used when ErrorMode is not in the range 0...3
3	0.0

The following applies in addition for all values of the ErrorMode tag:

- If the substitute output value is not a valid REAL value, 0.0 is output as output value.
- The substitute output value is limited to the value range of the data type REAL. Only then is the substitute output value output at the Output parameter.
- The ErrorMode tag only takes effect when the Reset = FALSE parameter is set. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter.

The Error parameter indicates if an error is pending. When the error is no longer pending, Error is set to FALSE. The ErrorBits parameter shows which errors have occurred. ErrorBits is retentive and is reset only by a positive edge at the Reset or ErrorAck parameter.

11.11.3 Operating principle Filter_DT1

Reset response

Filter_DT1 behaves as follows depending on the Reset parameter:

- If the Reset =TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter.
- If the Reset = FALSE parameter is set, the value that is output at the Output parameter is calculated by the filter algorithm.
- When the Reset parameter is set from FALSE to TRUE, the value at the Output parameter changes directly to the value of the SubstituteOutput parameter. An output jump can occur during this transition. In addition, the ErrorBits parameter is reset.
- When the Reset parameter is set from TRUE to FALSE, the filtering algorithm is added so that the transition is bumpless.

Enable behavior EN/ENO

If one of the following conditions is met, enable output ENO is set to FALSE.

- Enable input EN is set to TRUE and the Output parameter is specified by a substitute output value in case of error messages ErrorBits ≥ 16#0001_0000.
- Enable input EN is set to FALSE.

Otherwise, the enable output ENO is set to TRUE.

Measuring the cycle time automatically

To calculate the output value, Filter_DT1 needs the time that has expired since the last call of Filter_DT1.

By default, the cycle time is measured automatically and output as of the second call at the CycleTime.Value tag. Filter_DT1 measures the cycle time for each call of the instruction and can therefore be used in non-isochronous call cycles, e.g. in OB1.

Note that conditional calls of the instruction, active breakpoints, or the loading of snapshots as actual values during automatic measurement of the cycle time will extend the cycle time value. A cycle time that is too long is identified as error with error message ErrorBits = 16#0008_0000.

If measurement of the cycle time returns no valid result, Filter_DT1 calculates the current output value with the last valid cycle time. In addition, Filter_DT1 outputs an error message at the ErrorBits parameter.

When you disable automatic measurement of the cycle time by setting the CycleTime.EnableMeasurement tag = FALSE, you must enter the cycle time manually at the CycleTime.Value tag. Filter_DT1 checks the CycleTime.Value tag for validity at each call.

Automatic measurement of the cycle time with breakpoints

When breakpoints are active between two calls of Filter_DT1, automatic measurement of the cycle time results in the actual time that has elapsed between two calls. When one breakpoint is active, the CPU is in HOLD operating state.

NOTE

The active breakpoints extend the time period between two calls of Filter_DT1.

The longer the time period between two calls, the greater the change of the output value at the Output parameter.

Furthermore, it is possible that the longer time intervals violate the conditions Lag ≥ CycleTime.Value/2 or Td ≥ CycleTime.Value. An error is then detected with the error message ErrorBits = 16#0008_0000 .

If you do not need the calculation of the output value based on the actual time with active breakpoints, follow these steps:

- Disable automatic measurement of the cycle time by setting the CycleTime.EnableMeasurement tag = FALSE.
- Enter the cycle time manually at the CycleTime.Value tag.

11.11.4 Input parameter Filter_DT1

Parameter	Data type	Default	Description
Input	REAL	0.0	Input value
Substitu-teOutput	REAL	0.0	SubstituteOutput is used as the substitute output value when • Reset = TRUE or • An error with error message ErrorBits ≥ 16#0001_0000 prevents the correct calculation of the output value, and ErrorMode is configured to the value 1.
ErrorAck	BOOL	FALSE	Deletes the error messages • Edge FALSE -> TRUE ErrorBits is reset.
Reset	BOOL	FALSE	Performs a restart of the instruction • Edge FALSE -> TRUE ErrorBits is reset. • As long as Reset is set to TRUE, the substitute output value SubstituteOutput is output at the output. • As long as Reset is set to FALSE, the calculation of the output value is performed.

11.11.5 Output parameter Filter_DT1

Parameter	Data type	Default	Description
Output	REAL	0.0	Output value The output value is retentive.
ErrorBits	DWORD	DW#16#0	The ErrorBits parameter (Page 563) shows which error messages are pending. ErrorBits is retentive and is reset upon a positive edge at Reset or ErrorAck.
Error	BOOL	FALSE	When Error is set to TRUE, at least one error is currently pending.

11.11.6 Static tags Filter_DT1

Tag	Data type	Default	Description
Td	REAL	25.0	Derivative action time in seconds Permissible value range: Td ≥ CycleTime.Value
Lag	REAL	5.0	Lag time constant in seconds Permissible value range: Lag ≥ CycleTime.Value/2
ErrorMode	INT	2	Selection of the substitute output value following an error • 0 = Input • 1 = SubstituteOutput • 2 = Last valid filter output value • 3 = 0.0 Permissible value range: 0 to 3
StartMode	INT	2	Selecting the output value for the first call of the instruction • 0 = Input • 1 = SubstituteOutput • 2 = Last output value • 3 = 0.0 Permissible value range: 0 to 3
CycleTime	AuxFct_CycleTime	-	Cycle time data
CycleTime.Value	REAL	0.1	Cycle time in seconds (time interval between two calls) Permissible value range: CycleTime.Value > 0.0
CycleTime.Enable Measurement	BOOL	TRUE	Automatic measurement of the cycle time • FALSE = Deactivated • TRUE = Activated

11.11.7 ErrorBits parameter

If several errors are pending simultaneously, the values of the ErrorBits are displayed with binary addition. The display of ErrorBits = 16#0000_0003, for example, indicates that the errors 16#0000_0001 and 16#0000_0002 are pending simultaneously.

For Filter_DT1, the errors output at the ErrorBits parameter are divided into two categories:

- Errors with error messages ErrorBits < 16#0001_0000
- Errors with error messages ErrorBits ≥ 16#0001_0000

Errors with error messages ErrorBits < 16#0001_0000

If one or more errors with error messages ErrorBits < 16#0001_0000 are pending, Filter_DT1 reacts as follows:

- The output value is determined as follows despite this error:
  - When Reset = FALSE, output value calculation by the filter algorithm
  - When Reset = TRUE, output of SubstituteOutput
- The output parameter Error is set.
- The enable output ENO is not changed.

The output parameter Error is deleted as soon as there are no longer any errors.

ErrorBits (DW#16#...)	Description
0000_0000	No error is pending.
0000_0001	**Cause of error and response to error:** The Output parameter was limited to -3.402823e+38 or +3.402823e+38. **Solution:** If the value determined by the filter function is output at the output (Reset = FALSE and ErrorBits < 16#0001_0000), check the following tags used in the filter calculation: • Input • Td • Lag • CycleTime.Value When ErrorBits ≥ 16#0001_0000 and Reset = FALSE, the substitute output value is limited on its output. In this case, check the following parameters depending on the set value at the tag ErrorMode: • Input • SubstituteOutput When Reset = TRUE, check the SubstituteOutput parameter.
0000_0002	**Cause of error:** The measurement of the cycle time yields in an invalid value while the output value is being calculated (Reset = FALSE). **Response to error:** If a valid value of the cycle time has already been measured, Filter_DT1 calculates the output value based on the last value of the CycleTime.Value tag. If no valid value of the cycle time was previously measured, Filter_DT1 still outputs the output value configured with the StartMode tag at the Output parameter.

Errors with error messages ErrorBits ≥ 16#0001_0000

If one or more errors with error messages ErrorBits ≥ 16#0001_0000 are pending, Filter_DT1 reacts as follows:

- The output value cannot be determined as expected. The substitute output value is output instead.
- The output parameter Error is set.
- The enable output ENO is set to FALSE.

As soon as there are no longer errors with error messages ErrorBits ≥ 16#0001_0000, Filter_DT1 reacts as follows:

- The output value is determined as follows:
  - When Reset = FALSE, output value calculation by the filter algorithm
  - When Reset = TRUE, output of SubstituteOutput
- The enable output ENO is set to TRUE.

The output parameter Error is deleted as soon as there are no longer any errors.

<table>
<tr><th>ErrorBits (DW#16#...)</th><th>Description</th></tr>
<tr><td>0001_0000</td><td>Cause of error:
The SubstituteOutput parameter or a different tag that is being used as output value has no valid REAL value.
Response to error:
The output is set to 0.0.
Solution:
Make sure that the tag used as output value is a valid REAL value (≠NaN e.g. 16#7FFF_FFFF). The tag that is used as output value depends on Reset and ErrorMode:
<table>
<tr><th>Reset</th><th>ErrorMode</th><th>Output value</th></tr>
<tr><td>FALSE</td><td>0</td><td>Input</td></tr>
<tr><td>FALSE</td><td>1</td><td>SubstituteOutput</td></tr>
<tr><td>TRUE</td><td>-</td><td>SubstituteOutput</td></tr>
</table></td></tr>
<tr><td>0002_0000</td><td>Cause of error:
The Input parameter has no valid REAL value while the calculation of the output value is being performed (Reset = FALSE).
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. When ErrorMode = 0, 0.0 is used as output value.
Solution:
Make sure that the parameter Input is a valid REAL value (≠NaN e.g. 16#7FFF_FFFF).</td></tr>
<tr><td>0004_0000</td><td>Cause of error:
The calculation of the output value yields an invalid REAL value for the Output parameter.
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter.
Solution:
Check all tags involved in the calculation of the output value:
• Input
• Td
• Lag
• CycleTime.Value
These tags have valid values. The calculation of the output value fails in this combination of tags.</td></tr>
<tr><td>0008_0000</td><td>Cause of error:
The Lag or Td tag has an invalid value, while the calculation of the output value is being performed (Reset = FALSE).
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter.
Solution:
Ensure that the following conditions for the values of the Td and Lag tags are met:
• CycleTime.Value ≤ Td ≤ 3.402823e+38
• CycleTime.Value/2 ≤ Lag ≤ 3.402823e+38
• The values are valid REAL values (≠ NaN, for example 16#7FFF_FFFF)</td></tr>
</table>

ErrorBits (DW#16#...)	Description
	Additional information: Note that the conditions CycleTime.Value/2 ≤ Lag and CycleTime.Value ≤ Td may be violated in the following scenarios: • The time interval between two calls of Filter_DT1 is longer than 2 * Lag or Td, for example, due to conditional calls in the program sequence or active breakpoints. • A snapshot of the Filter_DT1 instance DB is loaded into the CPU as actual values, and the snapshot was created more than 2 * Lag or Td ago. In these scenarios, an error message ErrorBits = 16#0008_0000 is detected during automatic measurement of the cycle time.
0020_0000	**Cause of error:** The tag (configured with StartMode) for the initialization of the Output parameter at the first call of the instruction does not have a valid REAL value. **Response to error:** The substitute output value is output with the first call of the instruction at the Output parameter that is configured at the ErrorMode tag. For subsequent calls, Filter_DT1 calculates the output value starting from this substitute output value. **Solution:** Make sure that the tag for initializing the parameter Output is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF). When Reset = FALSE is set, the initialization takes effect with the first call of the instruction after the operating state transition of the CPU from STOP to RUN. The tag that is used for the initialization of the Output parameter depends on StartMode: • StartMode = 1: SubstituteOutput • StartMode = 2: Output
0040_0000	**Cause of error:** The CycleTime.Value tag has an invalid value, while the calculation of the output value is being performed (Reset = FALSE). **Response to error:** The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. **Solution:** Ensure that the following conditions are met: • 0.0 < CycleTime.Value ≤ 3.402823e+38 • CycleTime.Value is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF) **Additional information:** To automatically calculate the value of the CycleTime.Value tag, set the CycleTime.EnableMeasurement tag to TRUE.

11.12 Filter_Universal

11.12.1 Compatibility with CPU and FW

The following table shows which version of Filter_Universal can be used on which CPU:

CPU	FW	Filter_Universal
S7-1200 G2	V1.0 or higher	V1.0
S7-1500-based CPUs	as of V2.0	V1.0

11.12.2 Description Filter_Universal

Description

The Filter_Universal instruction is a configurable filter of the order 1 to 10.

It is used to manipulate a signal in such a way that specific frequency components of this signal are either allowed through or attenuated.

Filter_Universal can be used for the following purposes:

- High-pass filter
- Low-pass filter
- Bandpass filter
- Bandstop filter

The following filter parameters can be specified based on the corresponding tags in order to achieve the desired filter behavior:

- Type (Type tag)
- Frequency (Frequency tag)
- Bandwidth (Bandwidth tag)
- Order (Order tag)
- Characteristic (Characteristic tag)

An extended description of the filter parameters and corresponding tags can be found in section Filter parameters (Page 569).

Call

Filter_Universal requires a constant cycle time and therefore needs to be called in a cyclic interrupt OB.

In an OB or FC, Filter_Universal is called as a single-instance DB. In a function block, Filter_Universal can be called as a single-instance DB, as a multi-instance DB, and as a parameter instance DB.

When the instruction is called, no technology object is created. In the Inspector window of the programming editor, a parameterization interface is available for individual instances. This represents the amplitude response resulting from the configured filter parameters.

Startup

The tags in the static area of Filter_Universal are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN. If you change the actual values in online mode and these values are to be retained after the operating state transition of the CPU from STOP to RUN, back up these values in the start values of the data block.

With the tag StartMode (Page 574), you can define the start behavior of the Filter_Universal instruction at the first call after the operating state transition of the CPU from STOP to RUN.

Response to errors

If the output value cannot be correctly calculated, the Filter_Universal instruction instead outputs a substitute output value and an error with an error message ErrorBits >= 16#0002_0000. You can use the tag ErrorMode (Page 581) to define the substitute output value as follows:

ErrorMode	Output
0	Value of the Input parameter
1	Value of the SubstituteOutput parameter
2	Last valid filter output value 0.0 if no valid filter output value is available
3	0.0

The following applies in addition for all values of the ErrorMode tag:

- If the substitute output value is not a valid REAL value, 0.0 is output as output value.
- The substitute output value is limited to the value range -3.402823e+38 .. +3.402823e+38 of the data type REAL. Only then is the substitute output value output at the Output parameter.
- The ErrorMode tag only takes effect when the Reset = FALSE parameter is set. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter or 0.0 is output at the Output parameter.

The Error parameter indicates if an error is pending. When the error is no longer pending, Error is set to FALSE. The ErrorBits parameter shows which errors have occurred. ErrorBits is retentive and is reset only by a positive edge at the Reset or ErrorAck parameter.

Filter_Universal returns to output value calculation through the filter algorithm as soon as there are no more pending errors with error messages ErrorBits ≥ 16 0002_0000. Switchover depends on the filter type:

- For high-pass and bandpass filters (Type = 1 or 2), the filter algorithm is set up as if it were in a steady state with Output = 0.0. If the Input parameter remains constant, the output value will jump to Output = 0.0. If the Input parameter changes, the output value jumps to an appropriate value.
- For low-pass and bandstop filters (Type = 0 or 3), the filter algorithm is set up as if it were in a steady state with Output = SubstituteOutput. Switchover is bumpless.

11.12.3 Operating principle Filter_Universal

11.12.3.1 Filter parameters

The filter parameters Type, Frequency, Bandwidth, Characteristic and Order can be specified based on the corresponding tags in order to achieve the desired filter behavior.

Filter type

The filter type determines the general transfer behavior for the different frequency components of the input signal. It is defined by the Type tag.

The following table shows the different filter types:

Type	Description	Application example
0	Low-pass filter: The filter allows frequency components below the cutoff frequency through, and attenuates frequency components above the cutoff frequency.	Noise reduction at a measured input value to obtain smoother signal characteristics
1	High-pass filter: The filter allows frequency components above the cutoff frequency through, and attenuates frequency components below the cutoff frequency.	Suppression of DC or low frequency components, e.g. DC component in signal
2	Bandpass filter: The filter allows frequency components within a specific range around the center frequency through, and attenuates frequency components outside of this range.	Determination of the wanted signal with a specific frequency range from a signal that contains additional frequency components
3	Bandstop filter: The filter attenuates frequency components within a specific range around the center frequency, and allows frequency components outside of this range through.	Attenuation of interferences in a specific frequency range, e.g. interruptions due to the line frequency

Frequency and bandwidth

For low-pass and high-pass filters, the cutoff frequency is determined by the Frequency tag. The cutoff frequency is the frequency at which the gain is reduced to $1/\sqrt{2} \approx 0.707 \approx -3$dB. A sinusoidal input signal with amplitude 1.0 and a frequency equal to the cutoff frequency will result in a sinusoidal output signal with amplitude 0.707.

The ratio of output value to input value (gain) depending on the frequency can be shown in the amplitude response. The value 0 dB corresponds to a gain = 1.0.

The following figure shows the amplitude response of a low-pass filter with Frequency = 100 Hz (Order = 10, Characteristic = 2):

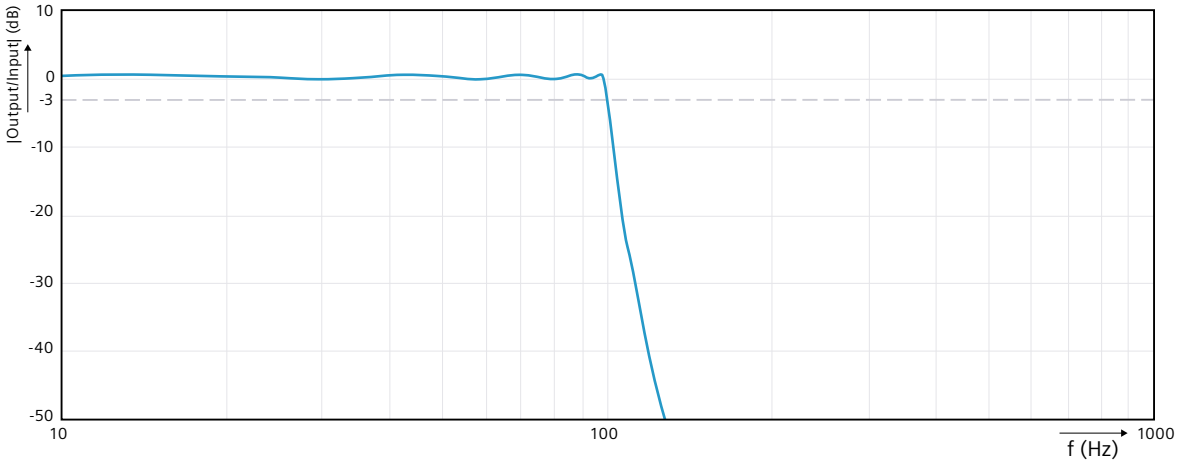

Bandpass and bandstop filters have a low and a high cutoff frequency whose position is defined by the center frequency and bandwidth. The following table shows the corresponding tags that are configured for such filters:

Tag	Description
Frequency	Determines the center frequency that is the geometrical mean of the low and high cutoff frequency. In logarithmic frequency scaling, the center frequency is midway between the low and high cutoff frequency.
Bandwidth	The bandwidth determines the difference between the low and high cutoff frequency. It defines the width of the frequency range that is attenuated or allowed through.

The following figure shows the amplitude response of a bandpass filter with Frequency = 100 Hz and different values for the tag Bandwidth (Order = 10, Characteristic = 2):

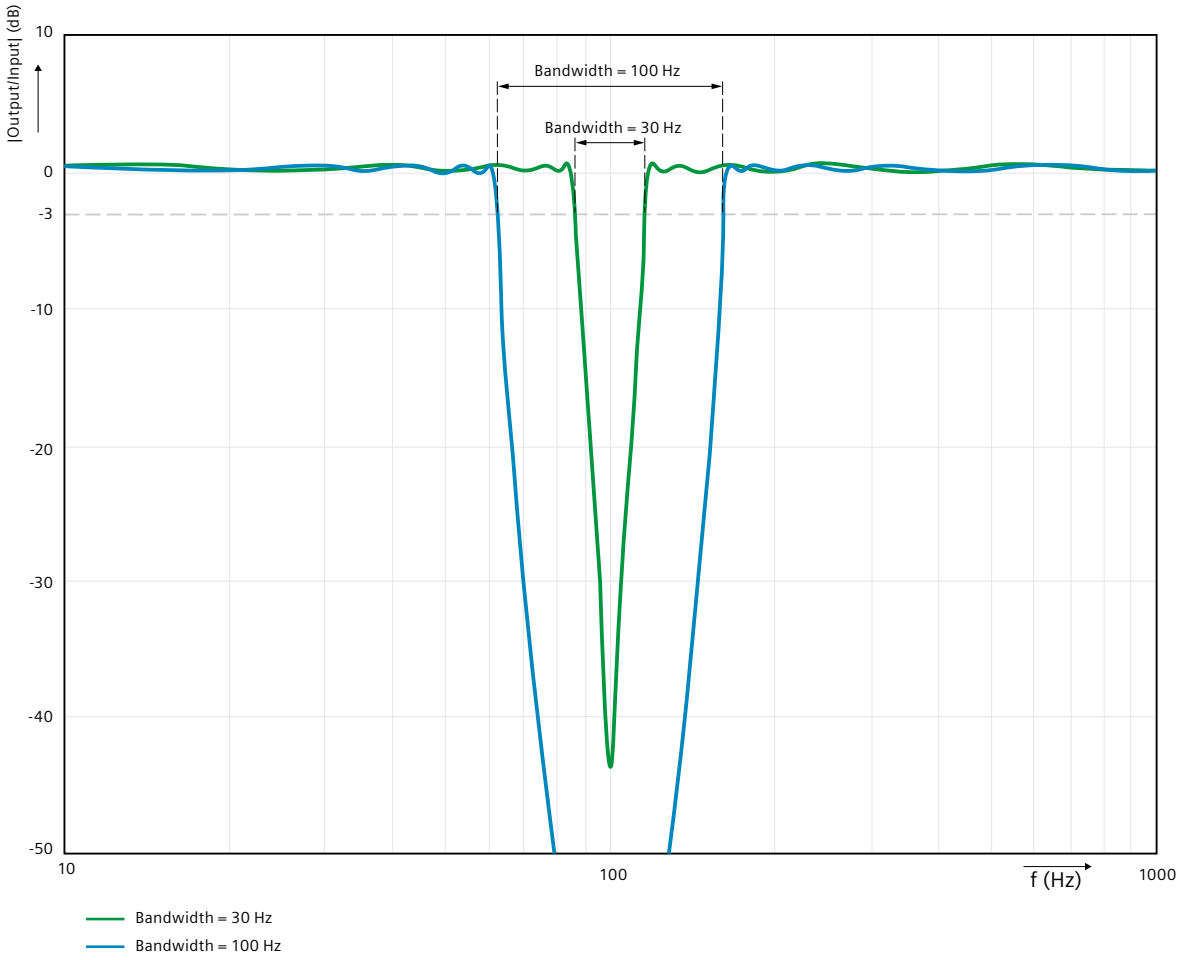

The maximum cutoff or center frequency that can be used depends on the cycle time. The permitted range of values is Frequency < 0.5 / CycleTime.Value.

The maximum bandwidth that can be used depends on the cycle time and the center frequency. The permitted range of values is Bandwidth < 0.5 / CycleTime.Value - Frequency.

NOTE

To avoid aliasing, the sampling rate for the Filter_Universal (= 1 / cycle time) must be at least double the maximum frequency of the processed signals or signal components. The recommendation is to set a cycle time that is lower than this limit.

Example: A signal with frequency components up to 100 Hz requires a sampling rate greater than 200 Hz. This corresponds to a maximum cycle time of 5 ms, but the recommendation is to set a lower value.

Order

The filter order determines how quickly attenuation increases beyond the cutoff frequency. This corresponds to the slope of the amplitude response beyond the cutoff frequency. The filter order is defined by the Order tag.

With a higher-order filter:

- The same frequency is attenuated more strongly beyond the cutoff frequency. The amplitude response shows a higher slope.
- Increases the execution time of Filter_Universal.
- The overshoot of the step response increases after an input jump for Butterworth and Chebyshev filter characteristic (Characteristic tag = 1 or 2).

For bandpass and bandstop filters, the recommendation is to use only higher order filters; otherwise, the desired filter effect in the frequency range around the center frequency may not be reached.

Values from 0 to 10 can be configured at the Order tag for the filter order.

With the setting Order = 0, the filter has no effect and Output = Input.

Characteristic

The filter characteristic is defined by the Characteristic tag.

This affects:

- The ripple of the amplitude response in the passband
- The slope of the amplitude response beyond the cutoff frequency (how fast attenuation increases)
- The overshoot in the step response after an input jump

Three characteristics can be configured for Filter_Universal based on the Characteristic tag:

Characteristic	Description
0	Bessel: This filter has a flat amplitude response in the passband. The slope of the amplitude response beyond the cutoff frequency is smaller as compared to the Butterworth filter and Chebyshev filter. The step response only shows a small overshoot.
1	Butterworth: This filter has a flat amplitude response in the passband. The slope of the amplitude response beyond the cutoff frequency is greater as compared to the Bessel filter and smaller as compared to the Chebyshev filter. The overshoot of the step response is greater as compared to the Bessel filter and smaller as compared to the Chebyshev filter.
2	Chebyshev Type I: This filter has a 0.5 dB ripple of the amplitude response in the passband. The slope of the amplitude response beyond the cutoff frequency is greater as compared to the Bessel filter and to the Butterworth filter. The step response shows a greater overshoot as compared to the Bessel filter and the Butterworth filter.

The following figure shows the effect of different order and characteristic values on the amplitude response of the low-pass filter:

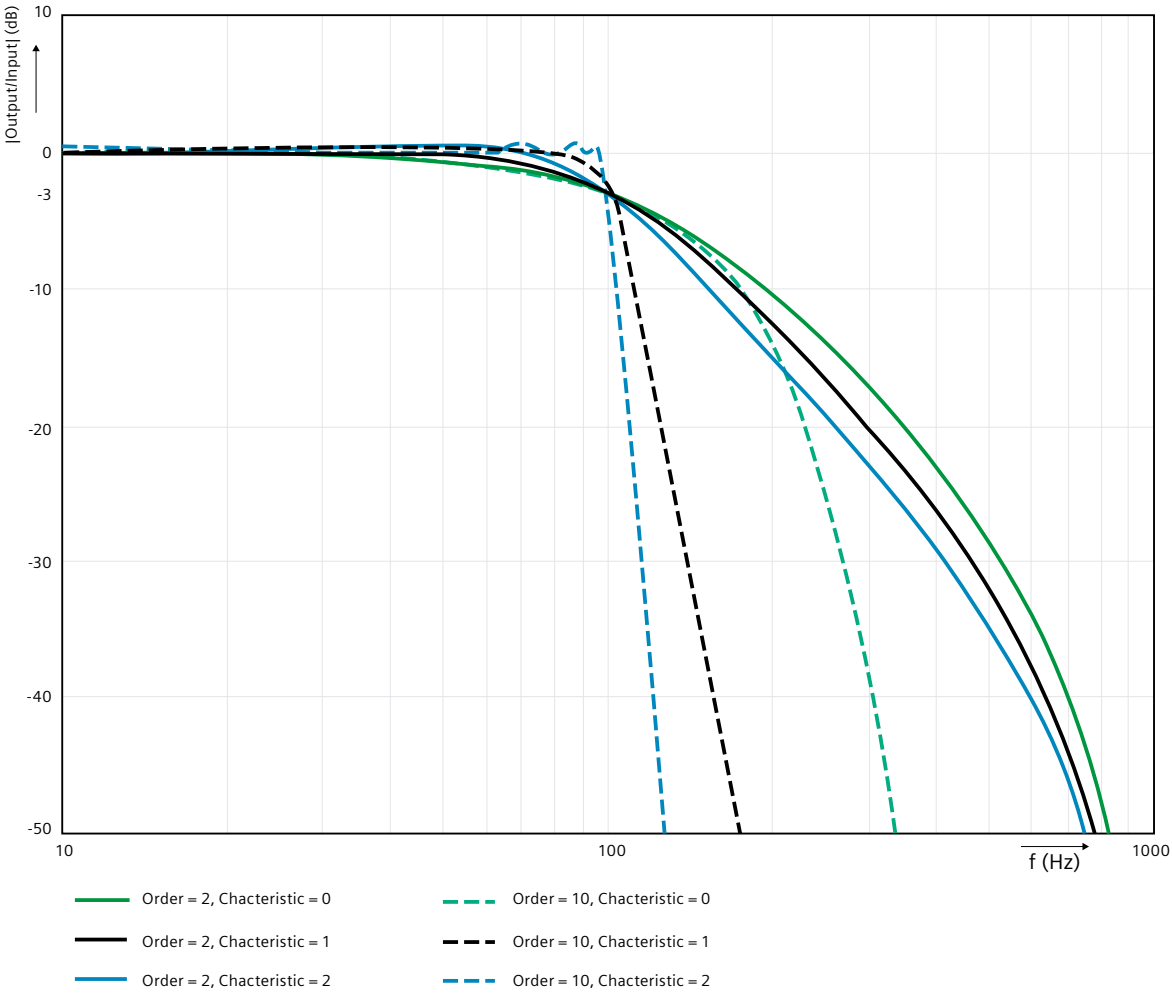

Changing filter parameters

Before the filter algorithm calculates the output value, Filter_Universal needs to determine the filter coefficients once based on the filter parameters. This is triggered in the following situations:

- On the first execution after the change of operating state of the CPU from STOP to RUN
- Every time the filter parameters are changed
- When "Load start values as actual values" is executed

The following conditions for the filter parameters are checked in this process:

- 0.0 < Frequency < 0.5 / CycleTime.Value
- 0.0 ≤ Bandwidth < 0.5 / CycleTime.Value - Frequency
- 0 ≤ Type ≤ 3
- 0 ≤ Characteristic ≤ 2
- 0 ≤ Order ≤ 10

If one of these conditions is not met and Reset = FALSE at the same time, correct calculation of the output value by the filter algorithm is not possible. In this case, an error message is output and a substitute output value is output at the Output parameter until all filter parameters have a valid value.

When all values are valid, the filter coefficients are determined once and saved internally for the filter algorithm calculation.

The reaction of the output value to valid changes to the filter parameters depends on the filter type:

- For high-pass and bandpass filters (Type = 1 or 2), the filter algorithm is set up as if it were in a steady state with Output = 0.0. If the Input parameter remains constant, the output value will jump to Output = 0.0. If the Input parameter changes, the output value jumps to an appropriate value.
- For low-pass and bandstop filters (Type = 0 or 3), the filter algorithm is set up as if it were in a steady state with Output = SubstituteOutput. Switchover is bumpless.

For time-critical applications, it should be taken into account that determining the filter coefficient requires a multiple of the execution time for calculating the filter algorithm.

11.12.3.2 Initializing output values

The Output parameter is initialized after the following actions for the first execution:

- Operating state change of the CPU from STOP to RUN
- Execution of "Load start values as actual values" with the option "All values"

The first value of the Output parameter depends on the filter type:

- For high-pass and bandpass filters (Type = 1 or 2), the first value of the parameter Output = 0.0.
- For low-pass and bandstop filters (Type = 0 or 3), the first value of the Output parameter can be configured via the StartMode tag.

For subsequent calls, Filter_Universal calculates the output value, starting from this initialization value, with consideration of the input value and the filter parameters.

The following settings of the StartMode tag are possible for low-pass and bandstop filters:

- StartMode = 0

  The Output parameter assumes the value of the Input parameter.

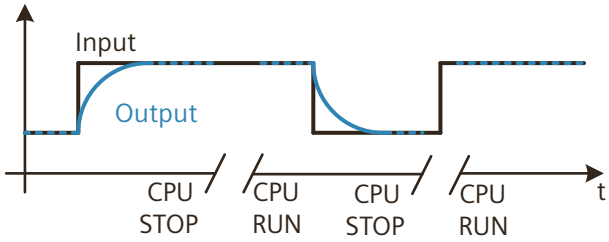

- StartMode = 1

  The Output parameter assumes the value of the SubstituteOutput parameter.

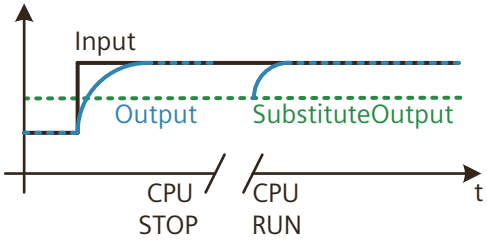

- StartMode = 2

  The Output parameter remains unchanged.

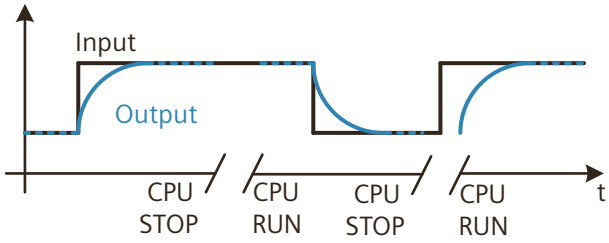

- StartMode = 3

  The Output parameter adopts the value 0.0.

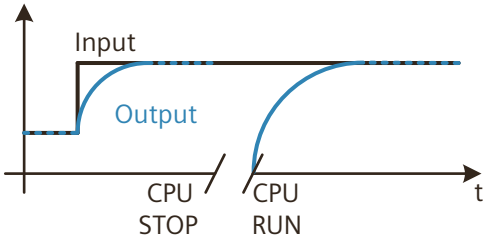

The following applies in addition for all values of the StartMode tag:

- The StartMode tag and the filter parameters are not retentive. These tags are initialized with the start values after each operating state transition of the CPU from STOP to RUN. Make sure that at the first call of the Filter_Universal instruction, after the operating state transition of the CPU from STOP to RUN, these tags have suitable values to achieve the desired behavior.
- The value selected through StartMode is limited to the value range of the REAL data type. Only then is it output at the Output parameter.
- If the value selected through StartMode is not a valid REAL value, the substitute output value is output at the Output parameter. The substitute output value is configured by means of the ErrorMode tag and is limited to the value range of the REAL data type. If the substitute output value is also not a valid REAL value, 0.0 is output at the Output parameter. For subsequent calls, the instruction calculates the output value starting from this substitute output value.
- Only if the parameter Reset = FALSE has been set and, at the same time, there is no error pending with an error message ErrorBits ≥ 16#0002_0000, does the StartMode tag act on the Output parameter. If the Reset = TRUE parameter is set, the value of the SubstituteOutput parameter is output at the Output parameter. If an error with error message ErrorBits ≥ 16#0002_0000 is pending, the substitute output value that is configured at the ErrorMode tag is output at the Output parameter.

11.12.3.3 Final value in steady state

If the input value is constant, the output value of the Filter_Universal should also reach a constant final value after some time:

- Output = 0.0 for high-pass and bandpass filters (Type = 1 or 2)
- Output = Input for low-pass and bandstop filters (Type = 0 or 3)

The limited accuracy of the floating point arithmetic can have the result that this final value is not reached exactly.

This is more common with odd ordered filters (tag Order = 1, 3, 5, 7, or 9) than with even ordered filters.

In addition to choosing a even filter order, setting the tag FinalValueMode = 1 can help to achieve the final value. If the absolute value of the output value does not change for several cycles, this setting converts the output value to the final value. This option is only effective with a constant input value.

Using the FinalValueMode = 1 option can almost double the calculation time of the filter algorithm. The effect on the execution time depends on the filter parameters, input value and cycle time. For time-critical applications, you can check whether use of the FinalValueMode = 1 tag is necessary or whether the behavior with FinalValueMode = 0 is adequate.

Depending on the filter parameters, input value and cycle time, it is possible that the final value is already reached exactly with the FinalValueMode = 0 option and the FinalValueMode = 1 option is not necessary.

Example:

The following table shows the effect of the FinalValueMode tag on the output value of a low-pass filter with Frequency = 120.0, Order = 1, Characteristic = 2 and CycleTime.Value = 0.001, on an input jump from 1.0 to 0.0:

Time in seconds	Input	Output with FinalValueMode = 0	Output with FinalValueMode = 1
-0.001	1.0	1.0000000	1.0000000
0.000	0.0	0.7163693	0.7163693
0.001	0.0	0.3100007	0.3100007
...	0.0	...	...
0.075	0.0	-4.597156E-17	-4.597156E-17
0.076	0.0	4.597156E-17	4.597156E-17
0.077	0.0	-4.597156E-17	-4.597156E-17
0.078	0.0	4.597156E-17	0.0000000
0.079	0.0	-4.597156E-17	0.0000000
...	0.0	+/-4.597156E-17	0.0000000

11.12.3.4 Use in time-critical applications

The execution time of Filter_Universal depends to a significant effect on its configuration. With a standard configuration (CycleTime.EnableDetection = TRUE, FinalValueMode = 1), it is not possible for all CPU types to execute a higher order filter in the fastest possible cycle time. When Filter_Universal is used for high signal frequencies, such fast cycle times can be necessary. For example, signal frequencies of up to 2 kHz require a cycle time of at most 250 µsec.

The following adjustments to the configuration can help to reduce the execution time of Filter_Universal in a time-critical application:

- Reduction of the filter order (Order tag) if the desired filter behavior can still be achieved in this way.
- Setting of FinalValueMode to 0 if this does not cause a relevant difference in the filter behavior for constant input values as compared to FinalValueMode = 1.
- Setting of CycleTime.EnableDetection to FALSE and manual specification of the CycleTime.Value tag. This only has an effect on the execution time of the first call, or after the filter parameters have been changed.

The current operating state of Filter_Universal has an effect on the execution time. Determining the filter coefficients during the first execution or after a change to the filter parameters requires a multiple of the execution time required to calculate the filter algorithm with constant parameters.

11.12.3.5 Call environment and automatic detection of the cycle time

To calculate the output value, Filter_Universal requires a constant cycle time and therefore needs to be called in a cyclic interrupt OB. With the default configuration, Filter_Universal detects the cycle time of the OB automatically and saves it in the CycleTime.Value tag. This happens in the following situations:

- On the first execution after the change of operating state of the CPU from STOP to RUN
- Every time the filter parameters are changed
- When "Load start values as actual values" is executed

If the automatic detection of the cycle time does not return a valid result or Filter_Universal is not called in a cyclic interrupt OB, correct calculation of the Output parameter is not possible. In this case, an error message is output and a substitute output value is output at the parameter until until a valid cycle time of a cyclic interrupt OB is detected.

Please note that changes to the call rate due to conditional calls of Filter_Universal lead to deviations between the detected and actual cycle time, which influences the filter behavior. Therefore, avoid conditional calls of Filter_Universal.

Active breakpoints or the loading of snapshots as actual values have no effect on the automatic detection of the cycle time.

When you disable automatic detection of the cycle time by setting the CycleTime.EnableDetection = FALSE tag, you must enter the cycle time manually at the CycleTime.Value tag. Filter_Universal checks the Variable CycleTime.Value tag for validity at each call.

Deactivating the automatic detection of the cycle time reduces the execution time of the Filter_Universal, which can be helpful for time-critical applications.

If automatic detection of the cycle time is disabled, Filter_Universal does not output an error message for calls outside of a cyclic interrupt OB alarm. The output value is calculated by the filter algorithm. Calls outside of a cyclic interrupt OB can have a negative effect on the filter behavior, because the actual cycle time is not constant in this case.

11.12.3.6 Reset response

The Filter_Universal instruction behaves as follows depending on the Reset parameter:

- If the parameter Reset = TRUE is set, the value of the SubstituteOutput parameter is output at the Output parameter.
- If the parameter Reset = FALSE, the value that is output at the Output parameter is calculated by the filter algorithm.
- When the Reset parameter is set from FALSE to TRUE, the value at the Output parameter changes directly to the value of the SubstituteOutput parameter. An output jump can occur during this transition. In addition, the ErrorBits parameter is reset.
- If the Reset parameter is set from TRUE to FALSE, the behavior depends on the filter type:
  - For high-pass and bandpass filters (Type = 1 or 2), the filter algorithm is set up as if it were in a steady state with Output = 0.0. If the Input parameter remains constant, the output value will jump to Output = 0.0. If the Input parameter changes, the output value jumps to an appropriate value.
  - For low-pass and bandstop filters (Type = 0 or 3), the filter algorithm is set up as if it were in a steady state with Output = SubstituteOutput. Switchover is bumpless.

11.12.3.7 Enable behavior EN/ENO

If one of the following conditions is met, enable output ENO is set to FALSE:

- Enable input EN is set to TRUE and the Output parameter is specified by a substitute output value in case of error messages ErrorBits ≥ 16#0001_0000.
- Enable input EN is set to FALSE.

Otherwise, the enable output ENO is set to TRUE.

11.12.4 Input parameter Filter_Universal

Parameter	Data type	Default	Description
Input	REAL	0.0	Input value
Substitu-teOutput	REAL	0.0	SubstituteOutput is used as a substitute output value when Reset = TRUE or one of the following modes is currently in effect: • ErrorMode = 1 • StartMode = 1
ErrorAck	BOOL	FALSE	Deletes the error messages. • Edge FALSE -> TRUE ErrorBits is reset.
Reset	BOOL	FALSE	Resets the instruction • Edge FALSE -> TRUE ErrorBits is reset. • As long as Reset is set to TRUE, the substitute output value SubstituteOutput is output. • As long as Reset is set to FALSE, the calculation of the output value is performed. • Edge TRUE -> FALSE – For high-pass and bandpass filters (Type 1 or 2), the filter algorithm is set up as if it were in a steady state with Output = 0.0. – For low-pass and bandstop filters (Type 0 or 3), the filter algorithm is set up as if it were in a steady state with Output = SubstituteOutput.

11.12.5 Output parameter Filter_Universal

Parameter	Data type	Default	Description
Output	REAL	0.0	Output value The output value is retentive.
ErrorBits	DWORD	16#0	The ErrorBits parameter (Page 581) shows which error messages are pending. ErrorBits is retentive and is reset upon a rising edge at Reset or ErrorAck.
Error	BOOL	FALSE	When Error is set to TRUE, at least one error is currently pending.

11.12.6 Static tags Filter_Universal

Tag	Data type	Default	Description
Frequency	REAL	50.0	Cutoff frequency of low-pass and high-pass or center frequency of bandpass and bandstop in Hz Permissible value range: 0.5/CycleTime.Value > Frequency > 0.0
Bandwidth	REAL	0.0	Bandwidth of bandpass and bandstop in Hz Permissible value range: 0.5/CycleTime.Value - Frequency > Bandwidth ≥ 0.0
Type	INT	0	Filter type • 0 = Low-pass filter • 1 = High-pass filter • 2 = Bandpass filter • 3 = Bandstop filter Permissible value range: 0 to 3
Characteristic	INT	0	Filter characteristic • 0 = Bessel • 1 = Butterworth • 2 = Chebyshev with 0.5 dB ripple in the passband Permissible value range: 0 to 2
Order	INT	2	Filter order (at Order = 0, Output = Input) Permissible value range: 0 to 10
ErrorMode	INT	2	Selection of the substitute output value following an error • 0 = Input • 1 = SubstituteOutput • 2 = Last valid filter output value • 3 = 0.0 Permissible value range: 0 to 3 If the value of ErrorMode does not correspond to the permissible range of values, then ErrorMode = 2.
StartMode	INT	2	Selection of the first output value for low-pass and bandstop filter • 0 = Input • 1 = SubstituteOutput • 2 = Last output value • 3 = 0.0 Permissible value range: 0 to 3 If the value of StartMode does not correspond to the permissible range of values, then StartMode = 2.
FinalValueMode	INT	1	Selection of the behavior in steady state • 0 = Deviations between output value and final value possible • 1 = Output value reaches final value exactly Permissible value range: 0 to 1 If the value of FinalValueMode does not correspond to the permissible range of values, then FinalValueMode = 1.
CycleTime	AuxFct_CycleTimeDetection	-	Cycle time data
CycleTime.Value	REAL	0.001	Cycle time in seconds (interval between two calls) Permissible value range: CycleTime.Value > 0.0
CycleTime.EnableDetection	BOOL	TRUE	Automatic detection of the cycle time • FALSE = Deactivated • TRUE = Activated

11.12.7 ErrorBits parameter

If several errors are pending simultaneously, the values of the ErrorBits are displayed with binary addition. The display of ErrorBits = 16#0000_0003, for example, indicates that the errors 16#0000_0001 and 16#0000_0002 are pending simultaneously.

With Filter_Universal, the errors output at the ErrorBits parameter are divided into two categories:

- Errors with error messages ErrorBits < 16#0001_0000
  The output value can be calculated despite the error.
- Errors with error messages ErrorBits ≥ 16#0001_0000
  The error prevents calculation of the output value. A substitute output value is output.

Errors with error messages ErrorBits < 16#0001_0000

If one or more errors with error messages ErrorBits < 16#0001_0000 is/are pending, Filter_Universal reacts as follows:

- The output value is determined as follows despite this error:
  - When Reset = FALSE, output value calculation by the filter algorithm
  - When Reset = TRUE, output of SubstituteOutput
- The output parameter Error is set.
- The enable output ENO is not changed.

The output parameter Error is deleted as soon as there are no longer any errors.

ErrorBits (DW#16#...)	Description
0000_0000	No error is pending.
0000_0001	**Cause of error and response to error:** The Output parameter was limited to -3.402823e+38 or +3.402823e+38. **Solution:** If the value determined by the filter function is output at the output (Reset = FALSE and ErrorBits < 16#0001_0000), check the Input parameter. When ErrorBits ≥ 16#0001_0000 and Reset = FALSE, the substitute output value is limited on its output. In this case, check the following parameters depending on the set value at the tag ErrorMode: • Input • SubstituteOutput When Reset = TRUE, check the SubstituteOutput parameter.

Errors with error messages ErrorBits ≥ 16#0001_0000

If one or more errors with error messages ErrorBits ≥ 16#0001_0000 is/are pending, Filter_Universal reacts as follows:

- The output value cannot be determined as expected. The substitute output value is output instead.
- The output parameter Error is set.
- The enable output ENO is set to FALSE.

As soon as there are no longer errors with error messages ErrorBits ≥ 16#0001_0000, Filter_Universal reacts as follows:

- The output value is determined as follows:
  - When Reset = FALSE, output value calculation by the filter algorithm
  - When Reset = TRUE, output of SubstituteOutput
- The enable output ENO is set to TRUE.

The output parameter Error is deleted as soon as there are no longer any errors.

<table>
<tr><th>ErrorBits (DW#16#...)</th><th>Description</th></tr>
<tr><td>0001_0000</td><td>Cause of error:
The SubstituteOutput parameter or a different tag that is being used as output value has no valid REAL value.
Response to error:
The output is set to 0.0.
Solution:
Make sure that the tag used as output value is a valid REAL value (≠NaN e.g. 16#7FFF_FFFF). The tag that is used as output value depends on Reset and ErrorMode:
<table>
<tr><th>Reset</th><th>ErrorMode</th><th>Output value</th></tr>
<tr><td>FALSE</td><td>0</td><td>Input</td></tr>
<tr><td>FALSE</td><td>1</td><td>SubstituteOutput</td></tr>
<tr><td>TRUE</td><td>-</td><td>SubstituteOutput</td></tr>
</table></td></tr>
<tr><td>0002_0000</td><td>Cause of error:
The Input parameter has no valid REAL value while the calculation of the output value is being performed (Reset = FALSE).
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. When ErrorMode = 0, 0.0 is used as output value.
Solution:
Make sure that the parameter Input is a valid REAL value (≠NaN e.g. 16#7FFF_FFFF).</td></tr>
<tr><td>0004_0000</td><td>Cause of error:
The calculation of the output value yields an invalid REAL value for the Output parameter.
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter.
Solution:
Check all tags involved in the calculation of the output value:
• Input
• Frequency
• Bandwidth
• Type
• Characteristic
• Order
• CycleTime.Value
These tags have valid values. The calculation of the output value fails in this combination of tags.</td></tr>
<tr><td>0008_0000</td><td>Cause of error:
One or more filter parameters have an invalid value while the calculation of the output value is being performed (Reset = FALSE).
Response to error:
The substitute output value that is configured at the ErrorMode tag is output at the Output parameter.
Solution:</td></tr>
</table>

ErrorBits (DW#16#...)	Description
	Ensure that the following conditions for the values of the filter parameters are met: • 0.0 < Frequency < 0.5 / CycleTime.Value • 0.0 ≤ Bandwidth < 0.5 / CycleTime.Value - Frequency • 0 ≤ Type ≤ 3 • 0 ≤ Characteristic ≤ 2 • 0 ≤ Order ≤ 10
0010_0000	**Cause of error:** Automatic detection of the cycle time failed because Filter_Universal is not called in a cyclic interrupt OB. **Response to error:** The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. **Solution:** Make sure that Filter_Universal is called in a cyclic interrupt OB. **Additional information:** Automatic detection of the cycle time can be disabled by setting the tag CycleTime.EnableDetection = FALSE. You then need to specify the cycle time manually at the Variable CycleTime.Value. Calling of Filter_Universal outside of a cyclic interrupt OB can have a negative effect on the filter behavior, because the actual cycle time fluctuates in this case.
0020_0000	**Cause of error:** The tag (configured with StartMode) for the initialization of the Output parameter at the first call of the instruction does not have a valid REAL value. **Response to error:** The substitute output value is output with the first call of the instruction at the Output parameter that is configured at the ErrorMode tag. For subsequent calls, Filter_Universal calculates the output value starting from this substitute output value. **Solution:** Make sure that the tag for initializing the parameter Output is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF). When Reset = FALSE is set, the initialization takes effect with the first call of the instruction after the operating state transition of the CPU from STOP to RUN. The tag that is used for the initialization of the Output parameter depends on StartMode: • StartMode = 1: SubstituteOutput • StartMode = 2: Output
0040_0000	**Cause of error:** The CycleTime.Value tag has an invalid value, while the calculation of the output value is being performed (Reset = FALSE). **Response to error:** The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. **Solution:** Ensure that the following conditions are met: • 0.0 < CycleTime.Value ≤ 3.402823e+38 • CycleTime.Value is a valid REAL value (≠ NaN e.g. 16#7FFF_FFFF) **Additional information:** To automatically calculate the value of the CycleTime.Value tag, set the CycleTime.EnableDetection tag to TRUE.
0080_0000	**Cause of error:** An internal error occurred during automatic detection of the cycle time. **Response to error:** The substitute output value that is configured at the ErrorMode tag is output at the Output parameter. **Solution:** Make sure that Filter_Universal is called in a cyclic interrupt OB. If the error continues to occur, contact SIMATIC Customer Support. **Additional information:** Automatic detection of the cycle time can be disabled by setting the tag CycleTime.EnableDetection = FALSE. You then need to specify the cycle time manually at the CycleTime.Value tag.

SIEMENS

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SIMATIC

S7-1500, ET 200MP, ET 200SP High-precision input/output with Time-based IO

Function Manual

12/2024

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Preface

Purpose of the documentation

This function manual will support you when you use "Time-based IO" technology with the S7-1500, ET 200MP, and ET 200SP systems.

The documentation deals with the following topics:

- Using "Time-based IO" technology
- Functions of the "Time-based IO" technology
- Hardware and software requirements for "Time-based IO"
- Configuring the "Time-based IO" function with STEP 7 (TIA Portal)

Basic knowledge required

The following knowledge is required in order to understand the Function manual:

- General knowledge of automation technology
- Knowledge of the industrial automation system SIMATIC
- Proficiency with STEP 7 (TIA Portal)
- Knowledge about isochronous mode

Scope of the documentation

The following documentation is valid for all components of the S7-1500, ET 200MP and ET 200SP systems that support the "Time-based IO" technology.

Conventions

The following terms are used as synonyms in this documentation:

- **TIO module**: This term is used as synonym for I/O modules of the type:
  - ET 200MP TM Timer DIDQ 24x24V
  - ET 200SP TM Timer DIDQ 10x24V
- **TIO_Time**: This term is used as synonym for the shared time base (relative time) of the TIO modules.
- **Jitter**: This is a general term that includes various time influences affecting accuracy. This means that:
  - for input data: Deviation of the measured time from the actual event.
  - for output data: Deviation of the actual switching time from the specified time.

You should also pay particular attention to notes such as the one shown below:

NOTE

The notes contain important information on the product, handling the product or on part of the documentation to which particular attention should be paid.

Additional support

The range of technical documentation for the individual SIMATIC products and systems can be found on the Internet (http://www.siemens.com/simatic-tech-doku-portal).

For more information about configuration of Time-based IO, see the following FAQs in the Siemens Industry Online Support:

- Entry ID 109738186 (https://support.industry.siemens.com/cs/ww/en/view/109738186)
- Entry ID 109736374 (https://support.industry.siemens.com/cs/ww/en/view/109736374)

Additional information on isochronous mode is available in the Isochronous mode (http://support.automation.siemens.com/WW/view/en/49948856) and PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/109755401) manuals.

Industry Mall

The Industry Mall is the catalog and order system of Siemens AG for automation and drive solutions on the basis of Totally Integrated Automation (TIA) and Totally Integrated Power (TIP).

You can find catalogs for all automation and drive products on the Internet (https://mall.industry.siemens.com) and in the Information and Download Center (https://www.siemens.com/automation/infocenter).

Security information

Siemens provides products and solutions with industrial cybersecurity functions that support the secure operation of plants, systems, machines, and networks.

In order to protect plants, systems, machines, and networks against cyber threats, it is necessary to implement – and continuously maintain – a holistic, state-of-the-art industrial cybersecurity concept. Siemens products and solutions form one element of such a concept.

Customers are responsible for preventing unauthorized access to their plants, systems, machines and networks. Such systems, machines and components should only be connected to an enterprise network or the internet if and to the extent such a connection is necessary and only when appropriate security measures (e.g. firewalls and/or network segmentation) are in place.

For more information on industrial cybersecurity measures, please visit (http://www.siemens.com/industrialsecurity).

Siemens' products and solutions undergo continuous development to make them more secure. Siemens strongly recommends that product updates are applied as soon as they are available and that the latest product versions are used. Use of product versions that are no longer supported, and failure to apply latest updates may increase customer's exposure to cyber threats.

To stay informed about product updates, subscribe to the Siemens Industrial Cybersecurity RSS Feed here (http://www.siemens.com/industrialsecurity).

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Function Manuals Documentation Guide 1

1.1 Function Manuals Documentation Guide

The documentation for the SIMATIC S7-1500 automation system, for the 1513/1516pro-2 PN, SIMATIC Drive Controller CPUs based on SIMATIC S7-1500 and the SIMATIC ET 200MP, ET 200SP, ET 200AL and ET 200eco PN distributed I/O systems is arranged into three areas.

This arrangement enables you to access the specific content you require.

You can download the documentation free of charge from the Internet (https://support.industry.siemens.com/cs/ww/en/view/109742705).

Basic information

The system manuals and Getting Started describe in detail the configuration, installation, wiring and commissioning of the SIMATIC S7-1500, SIMATIC Drive Controller, ET 200MP, ET 200SP, ET 200AL and ET 200eco PN systems. Use the corresponding operating instructions for 1513/1516pro-2 PN CPUs.

The STEP 7 online help supports you in the configuration and programming.

Examples:

- Getting Started S7-1500
- System manuals
- Operating instructions ET 200pro and 1516pro-2 PN CPU
- Online help TIA Portal

Device information

Equipment manuals contain a compact description of the module-specific information, such as properties, wiring diagrams, characteristics and technical specifications.

Examples:

- Equipment manuals for CPUs
- Equipment manuals for interface modules
- Equipment manuals for digital modules
- Equipment manuals for analog modules
- Equipment manuals for communication modules
- Equipment manuals for technology modules
- Equipment manuals for power supply modules
- Equipment manuals for BaseUnits

General information

The function manuals contain detailed descriptions on general topics relating to the SIMATIC Drive Controller and the S7-1500 automation system.

Examples:

- Function Manual Diagnostics
- Function Manual Communication
- Function Manuals Motion Control
- Function Manual Web Server
- Function Manual Cycle and Response Times
- PROFINET Function Manual
- PROFIBUS Function Manual

Product Information

Changes and supplements to the manuals are documented in a Product Information. The Product Information takes precedence over the device and system manuals.

You will find the latest Product Information on the Internet:

- S7-1500/ET 200MP (https://support.industry.siemens.com/cs/de/en/view/68052815)
- SIMATIC Drive Controller (https://support.industry.siemens.com/cs/de/en/view/109772684/en)
- Motion Control (https://support.industry.siemens.com/cs/de/en/view/109794046/en)
- ET 200SP (https://support.industry.siemens.com/cs/de/en/view/73021864)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109765611)

Manual Collections

The Manual Collections contain the complete documentation of the systems put together in one file.

You will find the Manual Collections on the Internet:

- S7-1500/ET 200MP/SIMATIC Drive Controller (https://support.industry.siemens.com/cs/ww/en/view/86140384)
- ET 200SP (https://support.industry.siemens.com/cs/ww/en/view/84133942)
- ET 200AL (https://support.industry.siemens.com/cs/ww/en/view/95242965)
- ET 200eco PN (https://support.industry.siemens.com/cs/ww/en/view/109781058)

1.2 SIMATIC Technical Documentation

Additional SIMATIC documents will complete your information. You can find these documents and their use at the following links and QR codes.

The Industry Online Support gives you the option to get information on all topics. Application examples support you in solving your automation tasks.

Overview of the SIMATIC Technical Documentation

Here you will find an overview of the SIMATIC documentation available in Siemens Industry Online Support:

Industry Online Support International
(https://support.industry.siemens.com/cs/ww/en/view/109742705)

Watch this short video to find out where you can find the overview directly in Siemens Industry Online Support and how to use Siemens Industry Online Support on your mobile device:

Quick introduction to the technical documentation of automation products per video (https://support.industry.siemens.com/cs/us/en/view/109780491)

YouTube video: Siemens Automation Products - Technical Documentation at a Glance (https://youtu.be/TwLSxxRQQsA)

Retention of the documentation

Retain the documentation for later use.

For documentation provided in digital form:

1. Download the associated documentation after receiving your product and before initial installation/commissioning. Use the following download options:
   - Industry Online Support International: (https://support.industry.siemens.com)

     The article number is used to assign the documentation to the product. The article number is specified on the product and on the packaging label. Products with new, non-compatible functions are provided with a new article number and documentation.
   - ID link:

     Your product may have an ID link. The ID link is a QR code with a frame and a black frame corner at the bottom right. The ID link takes you to the digital nameplate of your product. Scan the QR code on the product or on the packaging label with a smartphone camera, barcode scanner, or reader app. Call up the ID link.
2. Retain this version of the documentation.

Updating the documentation

The documentation of the product is updated in digital form. In particular in the case of function extensions, the new performance features are provided in an updated version.

1. Download the current version as described above via the Industry Online Support or the ID link.
2. Also retain this version of the documentation.

mySupport

With "mySupport" you can get the most out of your Industry Online Support.

Registration	You must register once to use the full functionality of "mySupport". After registration, you can create filters, favorites and tabs in your personal workspace.
Support requests	Your data is already filled out in support requests, and you can get an overview of your current requests at any time.
Documentation	In the Documentation area you can build your personal library.
Favorites	You can use the "Add to mySupport favorites" to flag especially interesting or frequently needed content. Under "Favorites", you will find a list of your flagged entries.
Recently viewed articles	The most recently viewed pages in mySupport are available under "Recently viewed articles".
CAx data	The CAx data area gives you access to the latest product data for your CAx or CAe system. You configure your own download package with a few clicks: • Product images, 2D dimension drawings, 3D models, internal circuit diagrams, EPLAN macro files • Manuals, characteristics, operating manuals, certificates • Product master data

You can find "mySupport" on the Internet. (https://support.industry.siemens.com/My/ww/en)

Application examples

The application examples support you with various tools and examples for solving your automation tasks. Solutions are shown in interplay with multiple components in the system - separated from the focus on individual products.

You can find the application examples on the Internet.
(https://support.industry.siemens.com/cs/ww/en/ps/ae)

1.3 Tool support

The tools described below support you in all steps: from planning, over commissioning, all the way to analysis of your system.

TIA Selection Tool

The TIA Selection Tool tool supports you in the selection, configuration, and ordering of devices for Totally Integrated Automation (TIA).

As successor of the SIMATIC Selection Tools , the TIA Selection Tool assembles the already known configurators for automation technology into a single tool.

With the TIA Selection Tool , you can generate a complete order list from your product selection or product configuration.

You can find the TIA Selection Tool on the Internet.
(https://support.industry.siemens.com/cs/ww/en/view/109767888)

SINETPLAN

SINETPLAN, the Siemens Network Planner, supports you in planning automation systems and networks based on PROFINET. The tool facilitates professional and predictive dimensioning of your PROFINET installation as early as in the planning stage. In addition, SINETPLAN supports you during network optimization and helps you to exploit network resources optimally and to plan reserves. This helps to prevent problems in commissioning or failures during productive operation even in advance of a planned operation. This increases the availability of the production plant and helps improve operational safety.

The advantages at a glance

- Network optimization thanks to port-specific calculation of the network load
- Increased production availability thanks to online scan and verification of existing systems
- Transparency before commissioning through importing and simulation of existing STEP 7 projects
- Efficiency through securing existing investments in the long term and the optimal use of resources

You can find SINETPLAN on the Internet
(https://new.siemens.com/global/en/products/automation/industrial-communication/profinet/sinetplan.html).

See also

PRONETA Professional (https://support.industry.siemens.com/cs/ww/en/view/109781283)

Time-based IO basics 2

2.1 Using Time-based IO

Many processes in a plant require a relatively precise reproducibility as far as time is concerned. The reproducibility can be optimized to a limited extent by shorter CPU cycle times. The use of high-precision input/output with Time-based IO provides a more accurate reproducibility than the one that can be achieved by optimizing the CPU cycle time. An additional advantage of Time-based IO is the independence from the time scale of the application cycle.

Below is a selection of typical areas of application that can benefit from this technology.

Defined response times

An output signal that responds with a precise delay time that is independent of the application cycle can be output by adding a specified time to the time stamp of an edge at the digital input.

Length measurement

The length of a product passing by can be determined by the difference between two input time stamps and an associated travel speed.

Cam controller

The ongoing movement can be extrapolated from a synchronous position information (for example, from a counter module or an axis). Based on this result, the time of a switching position (cam position) is calculated and transferred to the TIO module (output). This way the switch event takes place at the required position.

Dosing

By specifying a switch-on and a switch-off edge to a time-controlled digital output, a valve can be opened for a specific time and the amount of liquid can be dosed accordingly.

2.2 Time behavior of Time-based IO

2.2.1 Time behavior of standard technology

The time behavior of the inputs/outputs depends on the following factors for standard technology:

- CPU program (program structure)
- Bus cycle times (fieldbus, backplane bus)
- Cycle time of the I/O modules
- Internal cycle time of sensors/actuators

A deterministic statement as to

- when an input event (e.g., sensor signal) has taken place
- when the output event has an effect on the input event (e.g., output switches)

will become inaccurate due to the time factors listed above.

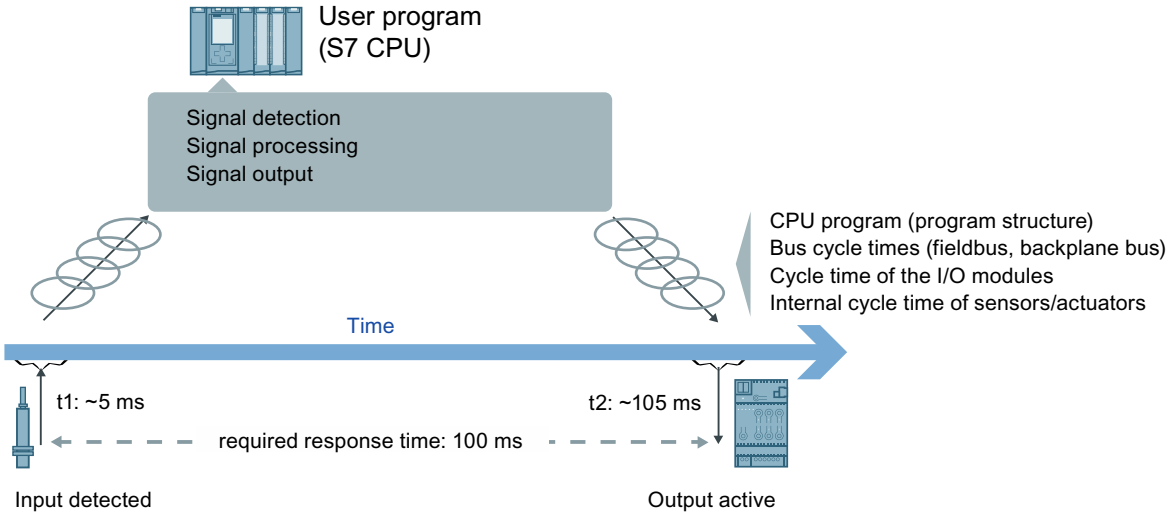

2.2.2 Time-based IO properties

Time-controlled I/O functionality

Time-based IO stands for time-based processing of I/O signals. All input signals are referred to one time (TIO_Time). The input signals receive the time stamp t1. After signal processing, the output event can also be linked with the TIO_Time and output at the required time. Output takes place at time t2.

Here an example for Time-based IO:

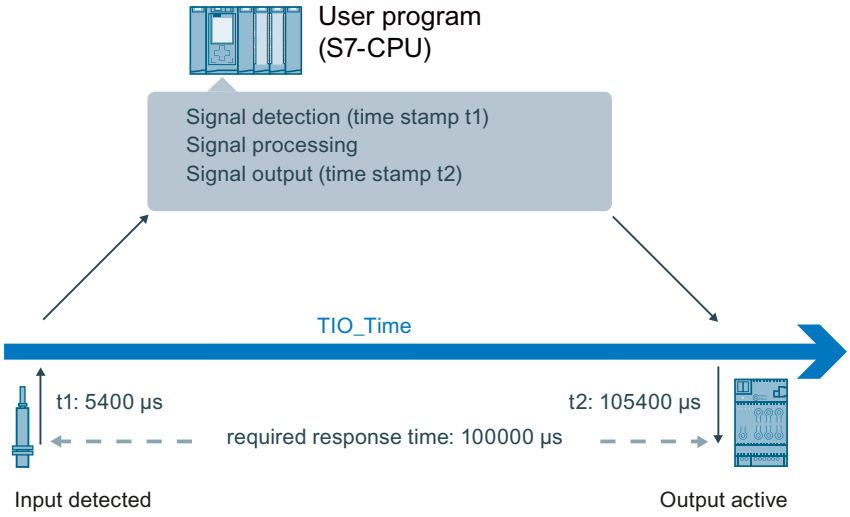

Independence and focus of Time-based IO

The shared time basis (TIO_Time) of all components involved is the basis for Time-based IO. By using TIO_Time, the accuracy of the output with Time-based IO does not depend on:

- CPU program (program structure)
- Bus cycle times (fieldbus, backplane bus)
- Cycle time of the I/O modules

The focus of Time-based IO is not on the I/O response time but on the predictability (determinism) of I/O signals. With Time-based IO, it is possible to respond to an input signal with an output signal within a defined time. Keep in mind the system-dependent minimum response time when using Time-based IO.

Time-based IO stands for:

- I/O functionalities executed with high precision
- I/O processes with time stamp

Accuracy

Accuracy is crucial for the performance capability of Time-based IO.

The accuracy is a property of the TIO modules and indicates the deviation with which the required response is achieved. For Time-based IO, the accuracy and reproducibility of the response is in the millisecond range.

Response time

In addition to a very high accuracy, a minimum response time to an input event can result depending on the configuration.

The response time is the time between the input event and the required output event.

For the minimum response time:

3 × application cycle T_{APP}

2.3 System environment

Introduction

Possible system configurations with PROFINET for the use of Time-based IO are shown below.

Use with STEP 7 (TIA Portal)

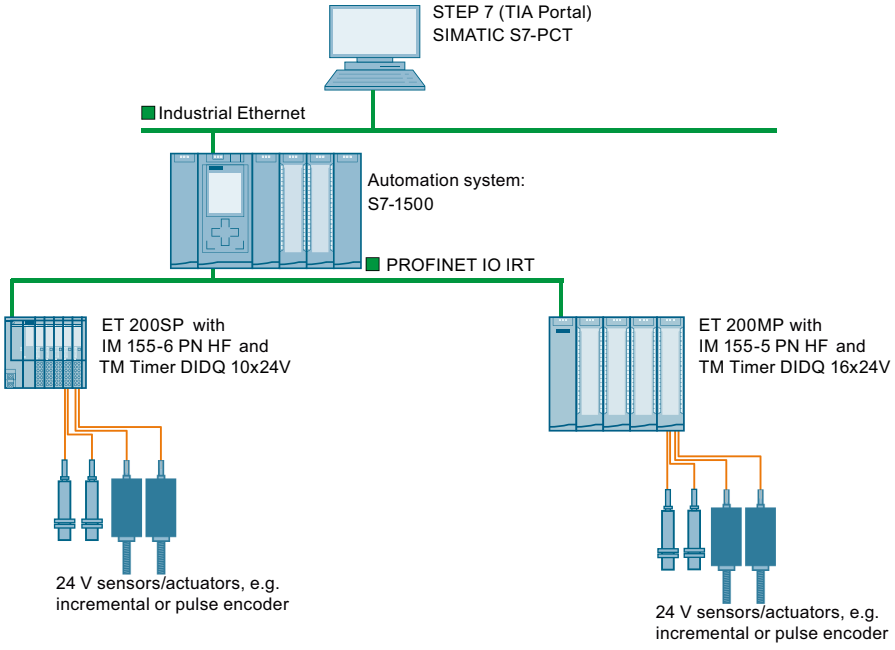

2.4 Hardware requirements

Introduction

The properties of the hardware components required for Time-based IO are listed below. You will also find specific modules as an example.

Requirements

Component	Properties	Examples
CPU	Isochronous mode/ PROFINET IO IRT: provides defines response time and high-precision plant behavior.	• CPU 1511-1 PN
ET 200 interface module	Supports isochronous mode	• ET 200SP with IM 155-6 PN HF (as of firmware V2.1) • ET 200MP with IM 155-5 PN HF
I/O module	TIO module	• ET 200SP: TM Timer DIDQ 10x24V • ET 200MP: TM Timer DIDQ 24x24V

See also

Requirements (Page 20)

2.5 Configuration software requirements

Introduction

Below is a list of the software versions which support the "Time-based IO" function.

Requirements

Configuration software	Requirements	Supported hardware components	Additional information
STEP 7 (TIA Portal) V16 and above	PROFINET IO IRT or isochronous mode on the backplane bus	• S7-1500 automation system • ET 200SP and ET 200MP distributed I/O systems • TM Timer DIDQ 24x24V • TM Timer DIDQ 10x24V	STEP 7 (TIA Portal) online help

Additional information on isochronous mode is available in the Isochronous mode (http://support.automation.siemens.com/WW/view/en/49948856) and PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/109755401) manuals.

TIO instructions

The TIO instructions are specific function blocks for use of Time-based IO. The following TIO instructions are available:

- TIO_SYNC
- TIO_DI
- TIO_DI_ONCE
- TIO_DQ

2.6 Technical implementation

Introduction

The information below will help you better understand the core aspects of Time-based IO and find out which SIMATIC functions are used to implement the described aspects.

Synchronization of involved modules (shared time basis)

The Time-based IO technology uses isochronous mode for all involved stations.

Isochronous mode enables multiple TIO modules to be synchronized to a shared time basis. The basis of the shared time basis for the TIO modules is the relative time TIO_Time.

Additional information on isochronous mode is available in the Isochronous mode (http://support.automation.siemens.com/WW/view/en/49948856) and PROFINET with STEP 7 (https://support.industry.siemens.com/cs/ww/en/view/109755401) manuals.

TIO_Time

The TIO_Time is the central time basis to which all time stamps refer.

TIO_Time has the following properties:

- Shared time basis for all TIO modules which are synchronized with the TIO instruction TIO_SYNC.
- The time starts counting again with each CPU startup.
- The TIO_Time has data type LTime (e.g. LT#14s830ms652us315ns).
- All valid time stamps refer to TIO_Time:
  - Input time stamps of the TIO modules are converted to the TIO_Time in the TIO instructions TIO_DI and TIO_DI_ONCE.
  - In the TIO instruction TIO_DQ, output time stamps are converted to the output time stamp of the TIO modules.
- The value of TIO_TIME corresponds to the current time with respect to TIO instructions and is updated with the call of TIO_SYNC. If you want an output to relate not to a previous input time stamp but to the current time, you can use the value of TIO_TIME as basis for the output time stamp. Example: Output of an edge in 20 ms: TIO_DQ.TimeStampRE=TIO_SYNC_DATA.TIO_TIME+LT#20ms)

TIO instructions in the isochronous OB

The TIO instructions must be called in a "Synchronous Cycle" or "MC-PostServo" OB.

You can find additional information in the chapter Programming.

NOTE

The TIO instructions also support geared down isochronous mode. With a clock reduction ratio, the application cycle is longer than the send clock.

NOTE

The TIO instructions must be called in an "MC-PreServo" OB.

If you use an OB of the "MC-PostServo" type, you can decide separately for each TIO model whether it is used with Motion Control technology objects or with TIO instructions.

If you call the TIO instructions in an "MC-PostServo" type OB, you need to use the IPO model and also cannot use any reduction ratio.

Calling TIO instructions in an OB of the type "MC-PostServo" with reduction ratio "MC-Servo" can result in incorrect calculation of time stamps.

Modes for updating the process image

In isochronous mode, you can influence the order of the update of the process image partition of the input and output data. In doing so, you can select the following program execution models:

- IPO model (application cycle factor = 1)
- OIP model (application cycle factor >= 1)

The abbreviations I, P, O stand for the following processes: I = Input, P= Processing, O = Output.

Additional information on the application cycle factor is available in the PROFINET with STEP 7 (http://support.automation.siemens.com/WW/view/en/49948856) Manual.

IPO model (application cycle factor = 1)

The user program is started after the delay time. Start by updating the corresponding process image partition of the inputs in the user program by calling the SYNC_PI system instruction. Processing is started next (for example, calculation of the time stamps). The corresponding process image partition of the outputs is updated at the end of the user program in the CPU by SYNC_PO.

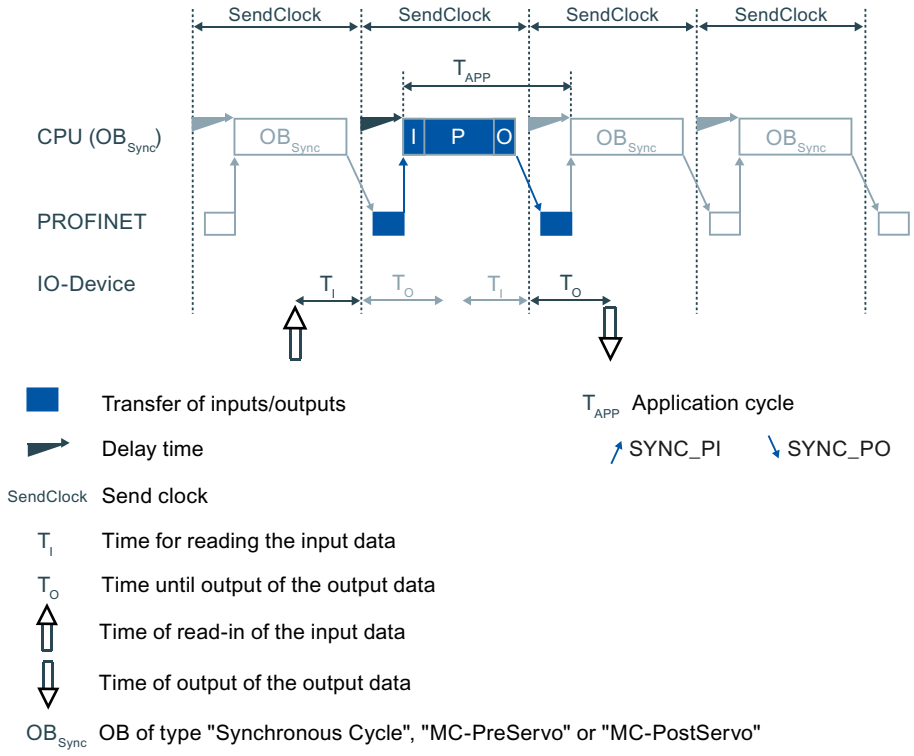

Properties of the IPO model:

- Supports shorter response times
- The application cycle must not be greater than the send clock.
  This gives the application less time than with the OIP model.

OIP model (application cycle factor >= 1)

The user program is started after the delay time. In PIP_Mode 0, the TIO_SYNC instruction updates the process image. In the other modes, you start by updating the corresponding process image partition of the outputs in the user program by calling the SYNC_PO system instruction. As a result, the output data that was calculated in the previous network cycle will become active during the next network cycle (T_O). Next the corresponding process image partition of the inputs is updated in the CPU by SYNC_PI. Processing starts after the data is transmitted (for example, calculation of the time stamps).

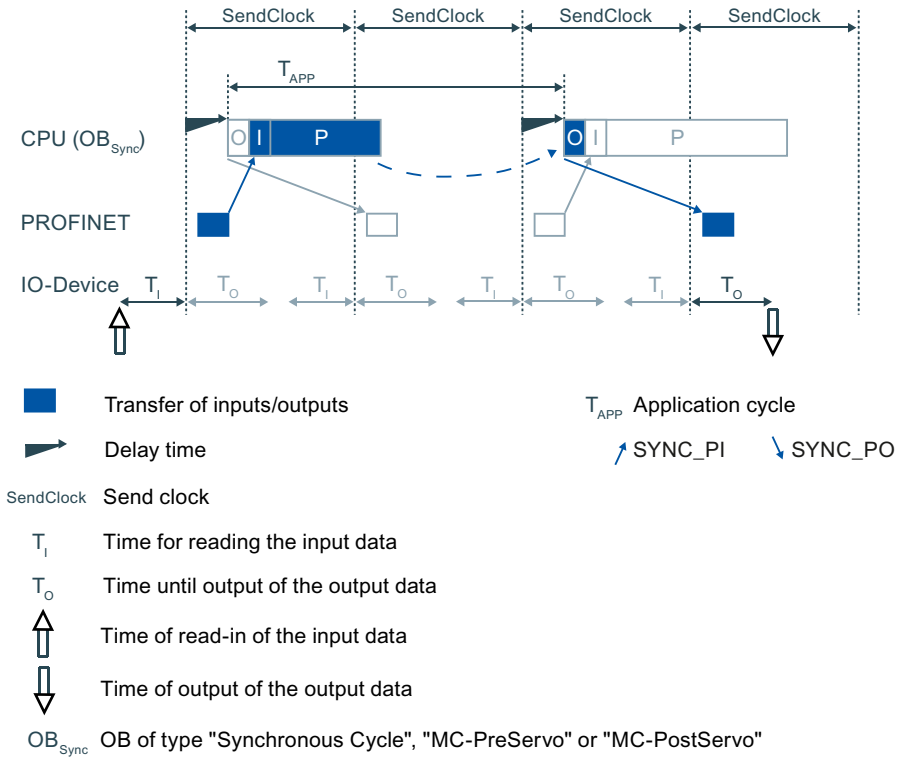

Properties of the OIP model:

- The response time is longer than with the IPO model.
- It is one application cycle longer than permitted by the send clock.

  This gives the application more time than with the IPO model.

Influence of accuracy

To estimate the accuracy you need the accuracy of

- TIO module
- Sensor/ actuator

Consult the data sheets of the respective module regarding the accuracy value.

You have to add the individual jitters of the TIO modules and the sensors/actuators. You can neglect any other influencing factors.

Configuring and parameter assignment 3

3.1 Requirements

Introduction

You need additional software components to use Time-based IO. You must also have created the standard configuration for your project.

Below you will learn more about the standard configuration for Time-based IO.

Requirements

In STEP 7 (TIA Portal):

- The project has been created.
- The CPU has been created and the parameters are assigned.
- Automation system and modules have been created and the parameters have been assigned.
- When using an ET 200 station: The connection has been created and the parameters are assigned via PROFINET.
- A "Synchronous Cycle" or "MC-PostServo" type OB has been created.

See also

System environment (Page 14)

Configuration software requirements (Page 15)

3.2 Settings for Time-based IO

Below you will find an overview of which settings have to be made for which components of Time-based IO.

Table 3-1144 Overview of settings for Time-based IO

Component	Where adjustable[1]	Properties to be set	Additional information
When using an ET 200 station: PROFINET subnet	Properties of the PROFINET subnet > sync domain	Create sync domain or edit properties of sync domain	• PROFINET function manual (http://support.automation.siemens.com/WW/view/en/49948856) • Online help in the STEP 7 (TIA Portal) information system
		Specify devices of the sync domain: • Specify CPU as sync master. • Specify ET 200 interface module as sync slave with RT class "IRT".	

Component	Where adjustable[1]	Properties to be set	Additional information
S7-1500 station	Properties of the PROFINET interface > isochronous communication	Enable isochronous mode	• Function Manual Isochronous Mode (https://support.industry.siemens.com/cs/ww/en/view/109755401) • PROFINET function manual (http://support.automation.siemens.com/WW/view/en/49948856) • Manual Technology Module TM Timer DIDQ 24x24V (https://support.industry.siemens.com/cs/ww/en/view/109974309) • Manual Technology Module TM Timer DIDQ 10x24V (https://support.industry.siemens.com/cs/ww/en/view/95153951) • Online help in the STEP 7 (TIA Portal) information system
ET 200 station			
TIO module	Properties of the TIO module > I/O addresses	Enable isochronous mode	
	Properties of the TIO module > I/O addresses	Assign or create a "Synchronous Cycle" or "MC-PostServo" type OB	
	Properties of the TIO module > I/O addresses	Assignment of I/O addresses to the process image partition (e.g., PIP1)	
	Properties of the TIO module > Basic parameters	Configure "Module use from the user program"	
	Properties of the TIO module > Basic parameters/Channel parameters	For TM Timer DIDQ 10x24V: If required, assign parameters for Configuration "Use input/output individually"	
		Parameter assignment for use of Timer DI and Timer DQ	
Isochronous OB (Synchronous Cycle or MC-PostServo)	Properties of the Isochronous OB > Isochronous mode	Adjust application cycle, if necessary	

[1] Describes the topic area in the configuration software.

Setting for Time-based IO

If you have no special response time requirements, the following setting is suitable as a starting point:

- Send clock: 2 ms
- Application cycle: 4 ms
- Assignment to the process image partition: PIP1
- PIP_Mode: 0 (OIP model)

FAQ

For more information, see the following FAQs in the Siemens Industry Online Support:

- Entry ID 109738186 (https://support.industry.siemens.com/cs/ww/en/view/109738186)
- Entry ID 109736374 (https://support.industry.siemens.com/cs/ww/en/view/109736374)

Programming

4

4.1 Overview of instructions

Introduction

Time-based IO is used with special instructions (TIO instructions). The TIO_SYNC TIO instruction is responsible for synchronizing all involved TIO modules and creates a unique time basis (TIO_Time) to which all actions are referenced.

Additional instructions undertake the reading in of process input signals with associated time stamps and/or the time-controlled output of process output signals.

NOTE

The TIO instructions are helpful for general time-based IO applications. For special applications, such as cam controllers, there are also separate technology objects, for example, TO_CamOutput.

NOTE

The TIO instructions use the time stamp functions of the TIO modules. The other functions of the TIO modules can be used independently of the TIO instructions in applications.

TIO instructions

Instruction	Short description
TIO_SYNC	Synchronizes the TIO modules and provides the time basis for Time-based IO
TIO_DI	Detects the edges at the digital input (Timer DI) and supplies the associated time stamp
TIO_DI_ONCE	• Detects the edges at the digital input (timer DI) once and provides the associated time stamp • Controls a timer DI channel which is configured as an edge-triggered enable for another channel.
TIO_DQ	Outputs time-controlled edges at the digital output (Timer DQ)

4.2 Programming of Time-based IO

Introduction

To use Time-based IO, the TIO instructions must be called in an isochronous OB. The application can also run in another OB. This allows you to shorten the runtime of the isochronous OB.

You need the following TIO instructions according to the required task:

TIO module	TIO instructions
• TM Timer DIDQ 24x24V • TM Timer DIDQ 10x24V	• Per digital input, one TIO_DI or TIO_DI_ONCE for read-in • Per digital output, one TIO_DQ for output • One TIO_SYNC (for up to eight TIO modules)

This section below describes the programming of the CPU for Time-based IO.

Requirements

Hardware configuration in STEP 7 (TIA Portal):

- The TIO modules are assigned to an isochronous network.
- The TIO modules are assigned to a shared process image partition.
- The process image partition is assigned to an isochronous OB.
- The TIO modules are configured for use with instructions from the "Time-based IO" library.

Additional information on configuration of Time-based IO is available in the section Settings for Time-based IO (Page 20).

Procedure

1. Create a TIO instruction, TIO_SYNC, in the isochronous OB.
2. Connect all TIO modules to be synchronized at the TIO_SYNC TIO instruction using parameters HWID_1 to HWID_8.

   The HWID can be found in the hardware configuration under "Properties > System constants".

   NOTE

   Use of symbolic constants is generally preferred instead of absolute numerical values when interconnecting.

3. Set the data update mode at the TIO_SYNC instruction at the PIP_Mode input parameter.

   The description of the modes is available in the chapter Technical implementation (Page 16).

   The parameter assignment of the TIO_SYNC TIO instruction is complete.

4. For the following instructions, note the call sequence depending on the selected value for PIP_Mode:

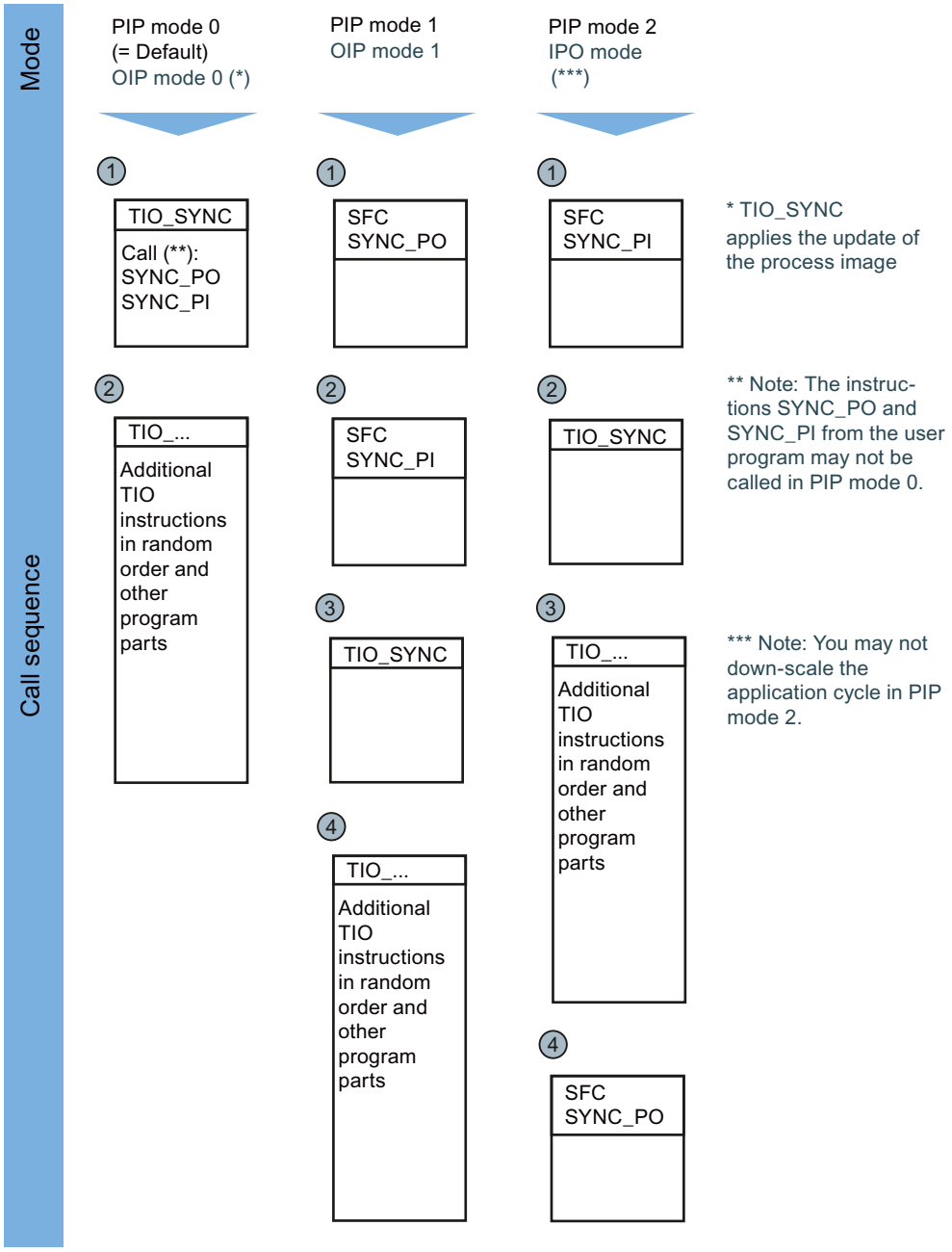

5. Add the TIO instructions for read-in/output required for your application in the isochronous OB.
6. At the TIO instructions for read-in/output, interconnect in each case the input/output TIO_SYNC_Data with the same name output at the TIO_SYNC.
7. At the TIO instructions for read-in/output, assign parameters for the input parameters HWID (see "Properties > System constants" in hardware configuration) and Channel.
The Time-based IO functionality is successfully programmed.

8. Interconnect the Time-based IO functionality with your application, such as evaluating the read-in time stamp in a step sequencer in another OB.
9. If TIO_SYNC does not automatically read out the send clock: Define the send clock manually, e.g. in OB100.
10. Compile and download the entire project to the CPU.

Result

You have completed programming the use of Time-based IO.

FAQ

For more information, see the following FAQs in the Siemens Industry Online Support:

- Entry ID 109738186 (https://support.industry.siemens.com/cs/ww/en/view/109738186)
- Entry ID 109736374 (https://support.industry.siemens.com/cs/ww/en/view/109736374)

4.3 Time-based IO

4.3.1 TIO_SYNC: Synchronizing TIO modules

Description

TIO_SYNC is the basis for all other TIO instructions. TIO_SYNC synchronizes TIO modules to a shared time basis TIO_Time.

You can synchronize up to 8 TIO modules with TIO_SYNC. All TIO modules must be assigned to the same process image partition (PIP). If you select "0" for the input parameter PIP_Mode, you assign the number of the process image partition at the PIP_PART input parameter.

Additional information on configuration of Time-based IO is available in the Configuration and parameter assignment section.

Startup characteristics

At the startup of the CPU, the TIO_SYNC instruction receives and checks the input parameters once and initializes the TIO_Time.

You have several options for handling the optional parameters SendClock, AppCycleFactor and ToTimes:

- SendClock, AppCycleFactor and ToTimes can be read in automatically each time the system is started. This results in a time delay during startup, but the values are always consistent.
- Automatically read in SendClock, AppCycleFactor and ToTimes at each startup and apply the read-in values as set values during commissioning. This results in fast subsequent startups, but is inconsistent after changes in the hardware configuration (repeat commissioning necessary).
- Manually define SendClock, AppCycleFactor and ToTimes before the first call of the instruction, for example, in OB100:

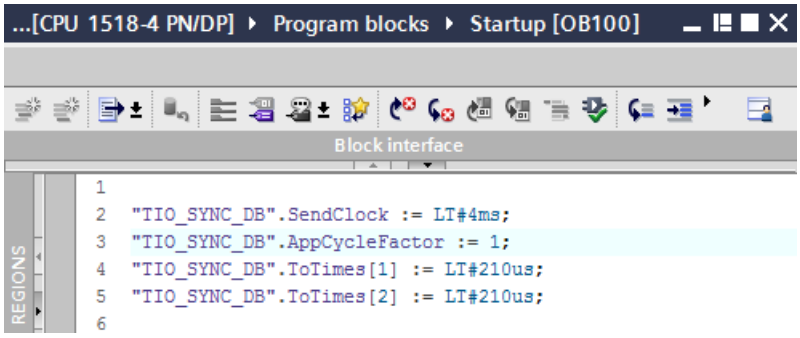

This results in a fast startup, but you need to manually update the values after changes to the hardware configuration.

You will find information about the parameters in the table below.

NOTE

Automatic reading of SendClock, AppCycleFactor and ToTimes is recommended

The automatic reading of SendClock, AppCycleFactor and ToTimes is recommended to ensure the consistency of the parameters even with subsequent changes in the hardware configuration. You activate the automatic reading via the parameter value AppCycleFactor = 0.

If startup takes place without errors, the instruction changes to normal operation. In the event of an error, the instruction does not change to normal operation and generates an error message.

Operating principle

In normal operation, the instruction ensures synchronization of all TIO modules configured at the HWID input.

The calculated TIO_Time for the instructions of the TIO modules is provided at the TIO_SYNC_Data output.

Reaction to error

The Error output indicates if the instruction was processed correctly. In the event of an error, the cause of the error is displayed at the Status output.

Parameter

The table below shows the parameters of the TIO_SYNC instruction.

Parameter	Declaration in library version		Data type	Default	Description
	< V2.0	≥ V2.0	S7-1500		
HWID_1 … HWID_8*	Input		HW_IO	65535	Hardware identifier for TIO module from hardware configuration
PIP_Mode*	Input		PIP	0	Mode for the data update**: • 0: OIP model with internal update of the process image by SYNC_PO and SYNC_PI. • 1: OIP model without internal update of the process image • 2: IPO model without internal update of the process image
PIP_PART*	Input		USInt	1	Only relevant if PIP_Mode = 0 Number of the process image partition which is to be updated isochronously.
TIO_SYNC_ Data	Output		"TIO_ SYNC_ Data"		Calculated system time for the TIO instructions of the TIO modules and internal data used for synchronization. See UDT TIO_SYNC_Data (Page 47).
Status	Output		DWord	16#0	Status of the instruction: see description of Status parameter
Error	Output		Bool	False	Error = True: An error has occurred. For detailed information see Status parameter. Error is reset as soon as the error is corrected.
OperatingState		Static	Int	0	Internal operating state of the instruction: • 0: Input parameters are checked • 1: Optional parameters are read out • 2: Read-out parameters are checked • 3: Normal operation (all parameters OK, TIO modules synchronized) As soon as operating state 3 is reached, time stamps can be read in and edges can be output. If you want to repeat the synchronization of the TIO modules and the readout of the optional parameters, you can set the operating state to 0.
SendClock	Input	Static	LTime	LT#0ns	Send clock of the sync domain. Apply the send clock from the PROFINET configuration. Note: If you use the parameter value AppCycleFactor = 0, SendClock can be left as the default (automatic reading of the parameters).

* Checked once at startup of the CPU

** The IPO model (PIP_Mode = 2) provides the shortest response times, but it also places the highest demands on system performance. Processing of all TIO instructions and other program sections must be completed within one send clock.
Select the OIP model (PIP_Mode = 0) only if you use only *one* instance of the TIO_SYNC instruction per process image partition so that the SYNC_PI and SYNC_PO instructions are not called more than once in the isochronous OB. In addition, do not call SYNC_PI and SYNC_PO in the other program sections in the OIP model.

Parameter	Declaration in library version		Data type	Default	Description
	< V2.0	≥ V2.0	S7-1500		
AppCycleFactor		Static	UInt	0	Application cycle factor: • Range of values: 0 <= AppCycleFactor <= 85 • 0: SendClock, AppCycleFactor and ToTimes are read in automatically The application cycle T_{APP} is calculated as follows: T_{APP} = AppCycleFactor × SendClock
ToTimes		Static	LTime array [1...8]	LT#0ns	T_o for each TIO module: Time for output of isochronous output data. Note: If you use the parameter value AppCycleFactor = 0, ToTimes can be left as the default (automatic reading of the parameters).

* Checked once at startup of the CPU

** The IPO model (PIP_Mode = 2) provides the shortest response times, but it also places the highest demands on system performance. Processing of all TIO instructions and other program sections must be completed within one send clock.
Select the OIP model (PIP_Mode = 0) only if you use only *one* instance of the TIO_SYNC instruction per process image partition so that the SYNC_PI and SYNC_PO instructions are not called more than once in the isochronous OB. In addition, do not call SYNC_PI and SYNC_PO in the other program sections in the OIP model.

NOTE

The TIO instructions must be called in an "MC-PreServo" OB.

If you use an OB of the "MC-PostServo" type, you can decide separately for each TIO model whether it is used with Motion Control technology objects or with TIO instructions.

If you call TIO_SYNC in an "MC-PostServo" type OB, you need to use PIP_Mode = 2 and also cannot use any reduction ratio.

Status parameter

Error codes or status information is output as double word at the Status output.

The double word is divided as follows:

Error code (DW#16#...)	Meaning
z0yywwww	Error of a system function: • during startup (z = 1) • during normal operation (z = 0) System functions with subordinate use are coded in yy: See table with error codes. wwww specifies the RET_VAL of the system function. The error information is available in the help for the system function.
z0yy0000	An error that does not originate in a system function. This error receives a consecutive error number yy. The error can occur: • during startup (z = 1) • during normal operation (z = 0)

Table with error codes

Error code (DW#16#...)	Meaning	Solution
00000000	No error.	—
1001xxxx	An error has occurred with system function RD_SINFO. The low word xxxx displays the error information of the RET_VAL return value from RD_SINFO.	• Read the description of the RD_SINFO in the STEP 7 (TIA Portal) information system. • Make sure that TIO_SYNC is called in a "Synchronous Cycle" or "MC-PostServo" OB.
10020000	The read cycle time of the isochronous OB is invalid (LT#0ms or negative). The instruction can only be used without errors in an isochronous OB.	• Correct the value of the cycle time. • Make sure that TIO_SYNC is called in a "Synchronous Cycle" or "MC-PostServo" OB.
10030000	The TIO_SYNC instruction is not called in an isochronous OB. The instruction can only be used without errors in an isochronous OB.	Make sure that TIO_SYNC is called in a "Synchronous Cycle" or "MC-PostServo" OB.
10040000	The assigned value at the PIP_Mode input parameter is outside the valid range of 0 to 2.	Correct the value at the PIP_Mode input parameter.
10050000	The configured send clock is outside the permitted range of 0 < SendClock <= 4 ms.	Correct the value of the send clock.
0006xxxx*	An error has occurred during execution of the SYNC_PI system function. The low word xxxx displays the error information of the RET_VAL return value from SYNC_PI.	Read the description of the SYNC_PI in the STEP 7 (TIA Portal) information system.
0007xxxx*	An error has occurred during execution of the SYNC_PO system function. The low word xxxx displays the error information of the return value RET_VAL from SYNC_PO.	Read the description of the SYNC_PO in the STEP 7 (TIA Portal) information system.
10080000	At least one of the hardware identifiers does not belong to a TIO module.	Check the values of input parameters HWID_1 to HWID_8. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration.
10090000	HWID_1 is not a valid hardware identifier. Possible causes: • No module with this hardware identifier available. • The CPU went to RUN mode before the module was supplied with voltage.	Check the value of the respective input parameter. In each case, specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
100A0000	HWID_2 is not a valid hardware identifier. Possible cause: No module with this hardware identifier available.	
100B0000	HWID_3 is not a valid hardware identifier. Possible cause: No module with this hardware identifier available.	
100C0000	HWID_4 is not a valid hardware identifier. Possible cause: No module with this hardware identifier available.	
100D0000	HWID_5 is not a valid hardware identifier. Possible cause: No module with this hardware identifier available.	

* Available only when "0" is selected for the input parameter PIP_Mode.

Error code (DW#16#...)	Meaning	Solution
100E0000	HWID_6 is not a valid hardware identifier. Possible cause: No module with this hardware identifier available.	Check the value of the respective input parameter. In each case, specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
100F0000	HWID_7 is not a valid hardware identifier. Possible cause: No module with this hardware identifier available.	
10100000	HWID_8 is not a valid hardware identifier. Possible cause: No module with this hardware identifier available.	
10110000	The value at input parameter PIP_PART is outside the valid range of 1 ... 31.	Correct the value at the PIP_PART input parameter.
10120000	The value "2" is configured at the input parameter PIP_Mode, while the value > 1 (reduction ratio) is configured at the static parameter AppCycleFactor.	Correct the value at the PIP_Mode input parameter. PIP_Mode with the value "2" does not allow a reduction ratio.
x0130000	MC-Servo (OB91) is not isochronous to the bus cycle time.	Correct the value of the cycle time of the MC-Servo to the value of the bus cycle time. Note: Calling TIO instructions in an OB of the type "MC-PostServo" with reduction ratio "MC-Servo" can result in incorrect calculation of time stamps.
x014xxxx	An error has occurred when reading the data record. The low word xxxx indicates the error information of the instruction RDREC.	Read the description of the instruction RDREC in the STEP 7 (TIA Portal) information system.
x0FF0000	General internal error.	—

* Available only when "0" is selected for the input parameter PIP_Mode.

4.3.2 TIO_DI: Reading in edges at digital input and associated time stamps

Description

TIO_DI continuously detects the edges at a digital input of a TIO module and returns the associated time stamps.

Startup characteristics

During startup of the CPU, the instruction TIO_DI applies the input parameters once and checks the following:

- Checking HWID
- Checking to see if the number of the digital input (Channel) is in the permitted range (depending on addressed module and channel configuration)
- Checking TIO_SYNC_Data.ERROR: Is an error present at TIO_SYNC?
- Checking TIO_SYNC_Data.TO_TIMES for plausibility (0 ms to 4 ms)
- Checking to see whether the OB is isochronous

If startup takes place without errors, the instruction changes to normal operation. In the event of an error, the instruction does not change to normal operation and generates an error message.

Functional description

In normal operation, the instruction detects the edges at a digital input and the associated time stamps of the last valid, defined edge pair from the preceding isochronous cycle. Use the input parameter EdgeSel to determine the edges for which time stamps are detected.

You connect the input TIO_SYNC_Data with the output of the same name of the TIO_SYNC instruction. This ensures a shared time basis.

The following figure shows an example of the behavior of LEC when a read-in job is started with EdgeSel = 3 (rising and falling edge, order depending on occurrence).

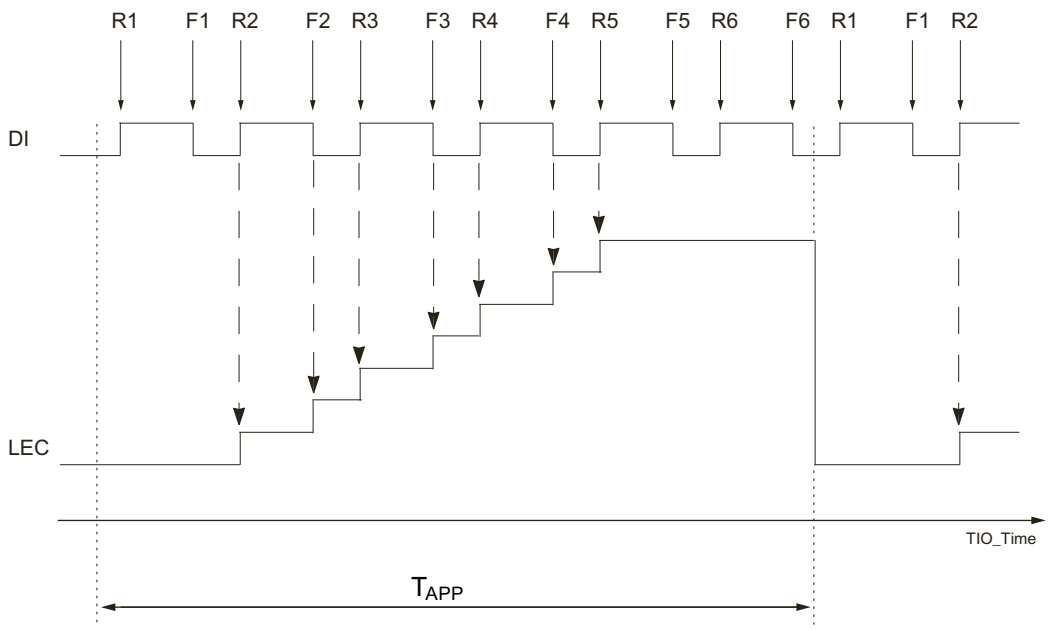

T_{APP}	Application cycle
Rn	Specified times of a positive DI edge
Fn	Specified times of a falling DI edge

The module can count a maximum of seven edges per application cycle. LEC = 7 means therefore that seven or more edges have been counted.

Reaction to error

The Error output indicates if the instruction was processed correctly. In the event of an error, the cause of the error is displayed at the Status output.

Parameter

The table below shows the parameters of the TIO_DI instruction.

Parameter	Declaration in library version		Data type	Default	Description
	< V2.0	≥ V2.0	S7-1500		
HWID*	Input		HW_IO	0	Hardware identifier for TIO module from hardware configuration
Channel*	Input		UInt	0	Number (0 ... m) of the digital input of the connected TIO module
EdgeSel	Input		UInt	3	Specify the edges for which time stamps are detected: 0_D: Invalid 1: Two rising edges 2: Two falling edges 3: Rising and falling edge (order depending on occurrence) 4: First rising, then falling edge 5: First falling, then rising edge 6 to 255: Invalid EdgeSel can be changed during normal operation.
DI	Output		Bool	False	Status of digital input. If an inversion of the digital input is configured, this parameter is inverted as well.
TimeStampRE	Output		LTime	LT#0ns	Time stamp: Time at which a positive edge was detected. Exception: EdgeSel = 2: Time at which a falling edge has been detected (if *multiple* falling edges have occurred during the application cycle).
TimeStampFE	Output		LTime	LT#0ns	Time stamp: Time at which a falling edge was detected. Exception: EdgeSel = 1: Time at which a rising edge has been detected (if *multiple* rising edges have occurred during the application cycle).
EventCountRE	Output		UInt	0	Counter: Is incremented with each new, valid time stamp at a positive edge. The counter is reset with each CPU startup.
EventCountFE	Output		UInt	0	Counter: Is incremented with each new, valid time stamp at a falling edge. The counter is reset with each CPU startup.
LEC	Output		UInt	0	Counter: Number of edges for which no time stamp could be saved. The module can count a maximum of seven edges per application cycle. The counter is reset with each new application cycle.
Status	Output		DWord	16#0	Status of the instruction: see description of Status parameter
Error	Output		Bool	False	Error = True: An error has occurred. For detailed information see Status parameter. Error is reset as soon as the error is corrected.
TIO_SYNC_Data*	Input	InOut	"TIO_SYNC_Data"		System time provided for the TIO instructions of the TIO modules by the TIO_SYNC instruction. See UDT TIO_SYNC_Data (Page 47). Connect this input parameter with the "TIO_SYNC_Data" output parameter of the TIO_SYNC instruction.

* Checked once at startup of the CPU

Status parameter

Error codes or status information is output as double word at the Status output.

The double word is divided as follows:

Error code (DW#16#...)	Meaning
z0yywwww	Error of a system function: • during startup (z = 1) • during normal operation (z = 0) System functions with subordinate use are coded in yy: See table with error codes. wwww specifies the RET_VAL of the system function. The error information is available in the help for the system function.
z0yy0000	An error that does not originate in a system function. This error receives a consecutive error number yy. The error can occur: • during startup (z = 1) • during normal operation (z = 0)

Table with error codes

Error code (DW#16#...)	Meaning	Solution
00000000	No error.	—
10010000	The assigned number of the digital input at the Channel input parameter is outside the permitted range (depending on addressed module and channel configuration).	Correct the value at the Channel input parameter.
10020000	The TIO_DI instruction is not called in an isochronous OB. The instruction can only be used without errors in an isochronous OB.	Make sure that TIO_DI is called in a "Synchronous Cycle" or "MC-PostServo" OB.
10030000	An error occurred when reading the HWID input parameter.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
x0040000	The data in TIO_SYNC_Data is invalid/incorrect.	Check the TIO_SYNC instruction and the interconnection of its TIO_SYNC_Data output.
1005xxxx	An error has occurred during execution of the RD_SINFO system function. The low word xxxx displays the error information of the RET_VAL return value from RD_SINFO.	• Read the description of the RD_SINFO in the STEP 7 (TIA Portal) information system. • Make sure that TIO_DI is called in a "Synchronous Cycle" or "MC-PostServo" OB.
10060000	No TIO module found. Possible cause: The module configured using the hardware identifier is not a TIO module.	• Make sure that the configured module is a TIO module. • Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration.
10070000	An internal error occurred during the address calculation.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.

Error code (DW#16#...)	Meaning	Solution
00080000	TIO module is not synchronized using the TIO_SYNC instruction. The error code can also indicate that: • A job was already present before the first run of the instruction. • The assigned number at the Channel input parameter is not a digital input.	Check the instruction TIO_SYNC.
10090000	The read cycle time of the isochronous OB is outside the permitted range of 0 < T_{APP} <= 16 ms and is therefore invalid. The instruction can only be used without errors in an isochronous OB.	• Correct the cycle time. • Make sure that TIO_DI is called in a "Synchronous Cycle" or "MC-PostServo" OB.
100A0000	The time T_O of the TIO model stored in TIO_SYNC_Data is outside the permissible range of 0 < T_o <= 4 ms.	Check the instruction TIO_SYNC.
100Bxxxx	An error has occurred during execution of the RD_ADDR system function. The low word xxxx displays the error information of the RET_VAL return value from RD_ADDR.	Read the description of the RD_ADDR in the STEP 7 (TIA Portal) information system.
000C0000	The converted time stamp is invalid. Possible cause: Communication error	Check the communication with the TIO module.
000D0000	The Quality Information of the digital input indicates that an error has occurred at the digital input.	Check the supply voltage L+/1L+/2L+.
000E0000	The assigned number at the Channel input parameter is not a digital input configured as Timer DI.	• Check the channel configuration (only for TM Timer DIDQ 24x24V). • Check the operating mode of the digital input.
000F0000	The assigned value at the EdgeSel input parameter is outside the valid range of 1 to 5.	Correct the value at the EdgeSel input parameter.
10100000	The send clock is outside the permitted range of 0 < SendClock <= 4 ms and is therefore invalid. The error code can also indicate that • The data in TIO_SYNC_Data is invalid or does not exist. • The TIO_DI instruction is not called in an isochronous OB.	Correct the send clock.
x0130000	MC-Servo (OB91) is not isochronous to the bus cycle time.	Correct the value of the cycle time of the MC-Servo to the value of the bus cycle time. Note: Calling TIO instructions in an OB of the type "MC-PostServo" with reduction ratio "MC-Servo" can result in incorrect calculation of time stamps.
10140000	The configured value at the HWID input parameter is not present in the structure at the TIO_SYNC_Data parameter. The HWID and TIO_SYNC_Data parameters are not consistent.	Correct the value at the HWID input parameter or the structure at the TIO_SYNC_Data parameter.
x0FF0000	General internal error.	—

4.3.3 TIO_DI_ONCE: Reading in edges once at the digital input and associated time stamps

Description

TIO_DI_ONCE detects the edges at a digital input of a TIO module **once** and returns the associated time stamps. Alternatively, you can use this instruction to control a timer DI channel that is configured as an edge-triggered enable for another channel.

Startup characteristics

During startup of the CPU, the instruction TIO_DI_ONCE applies the input parameters once and checks the following:

- Checking HWID
- Checking to see if the number of the digital input (Channel) is in the permitted range (depending on addressed module and channel configuration)
- Checking TIO_SYNC_Data.ERROR: Is an error present at TIO_SYNC?
- Checking TIO_SYNC_Data.TO_TIMES for plausibility (0 ms to 4 ms)
- Checking to see whether the OB is isochronous

If startup takes place without errors, the instruction changes to normal operation. In the event of an error, the instruction does not change to normal operation and generates an error message.

Functional description: Time stamp detection

In normal operation, the instruction detects the edges at a digital input and the associated time stamps of the **first** valid, defined edge pair after the start of a read-in job. Use the input parameter EdgeSel to determine the edges for which time stamps are detected. To detect a new edge pair, a new positive edge is required at the REQ input parameter of the instruction.

You connect the input TIO_SYNC_Data with the output of the same name of the TIO_SYNC instruction. This ensures a shared time basis.

The figure below shows an example for the reaction of the bits DONE and BUSY at the start of a read-in job (EdgeSel = 4).

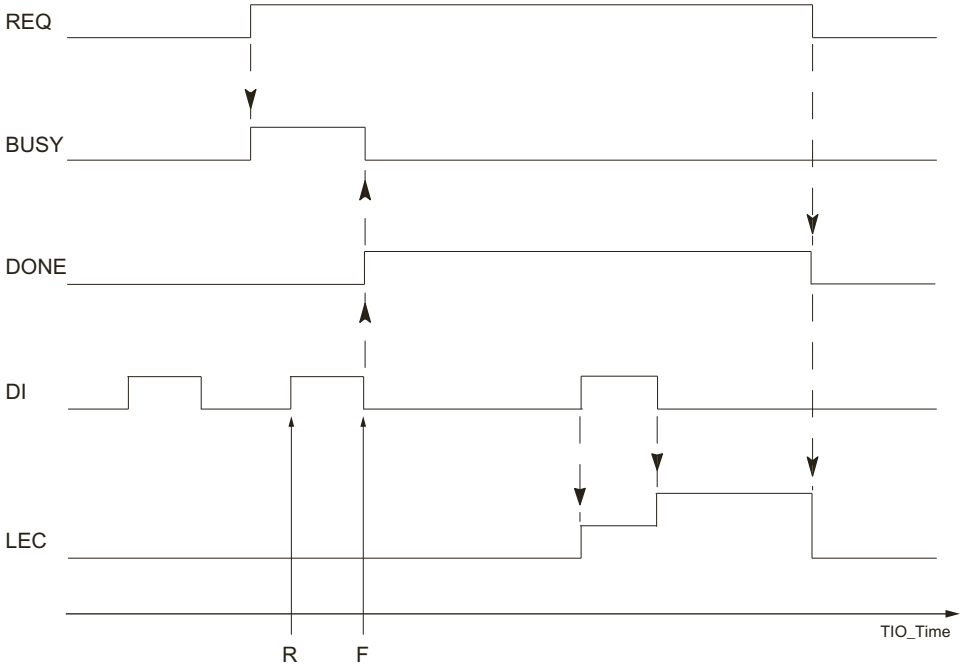

R Read-in time of the positive DI edge

F Read-in time of the falling DI edge

Functional description: edge-triggered enable

You can use this instruction to control a timer DI channel that is configured as an edge-triggered enable for another channel.

Example:

For a TIO module TM Timer DIDQ 10x24V, the following is configured in the hardware configuration for DQ0/DI0:

- Configuration DQ/DI group = timer DQ with enable
- HW enable by DI0 = edge-triggered
- DQ0 is not inverted

In this case, use the instruction TIO_DQ for DQ0 and the instruction TIO_DI_ONCE for DI0. You can control the enable by means of the input parameters REQ and EdgeSel of TIO_DI_ONCE. As soon as TIO_DI_ONCE has recorded a time stamp according to the value of EdgeSel, the enable is considered granted. You take the enable back by resetting REQ.

The following figure shows an example with EdgeSel = 4n (first positive, then falling edge). In this case the first valid positive edge at DI0 grants the enable for DQ0 after the start of a read-in job.

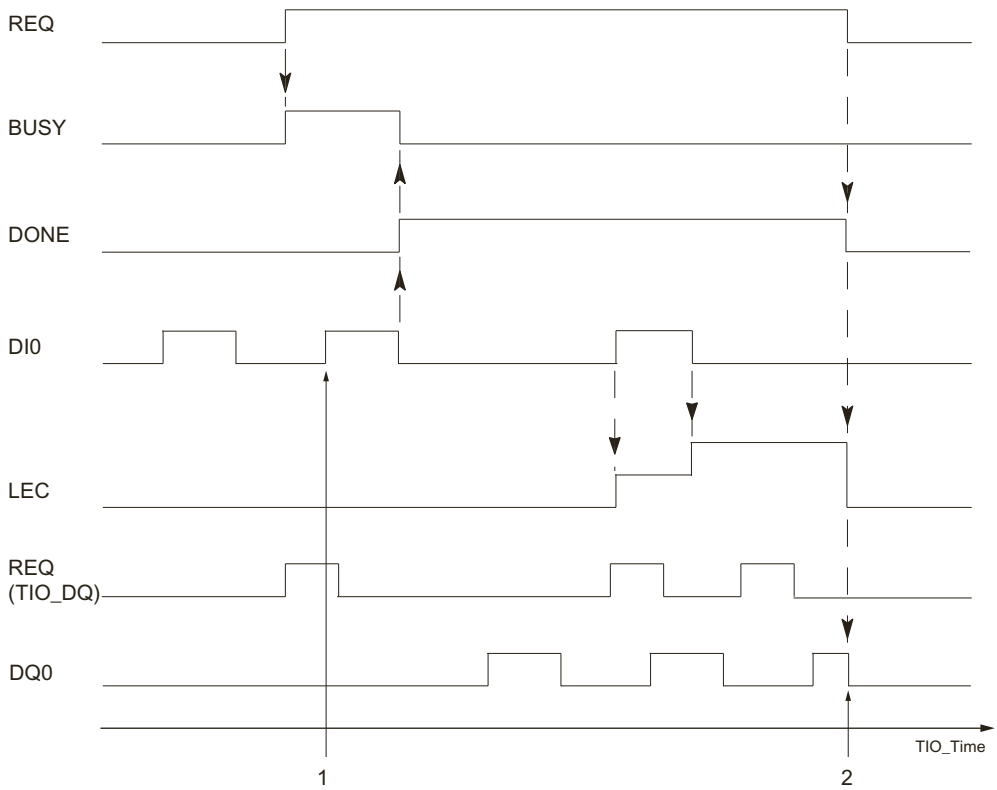

1 Start of enable at positive edge of enable input

2 End of enable when falling edge at REQ

If required, you can use the time stamps detected by the instruction for your application.

Reaction to error

The Error output indicates if the instruction was processed correctly. In the event of an error, the cause of the error is displayed at the Status output.

Parameter

The table below shows the parameters of the TIO_DI_ONCE instruction.

Parameter	Declaration	Data type	Default	Description
		S7-1500		
REQ	Input	Bool	False	Starts the job at a positive edge.
HWID*	Input	HW_IO	0	Hardware identifier for TIO module from hardware configuration
Channel*	Input	UInt	0	Number (0 ... m) of the digital input of the connected TIO module

* Checked once at startup of the CPU

Parameter	Declaration	Data type S7-1500	Default	Description
EdgeSel	Input	UInt	3	Specify the edges for which time stamps are detected: 0_D: Invalid 1: Two rising edges 2: Two falling edges 3: Rising and falling edge (order depending on occurrence) 4: First rising, then falling edge 5: First falling, then rising edge 6 to 255: Invalid If edge-triggered enable is used, the following also applies: 1: Enable at first positive DI edge 2: Enable at first falling DI edge 3: Enable at first DI edge 4: Enable at first positive DI edge 5: Enable at first falling DI edge EdgeSel can be changed during normal operation.
DONE	Output	Bool	False	DONE = True: The job was completed without errors.
BUSY	Output	Bool	False	BUSY = True: The job has not yet been completed.
Error	Output	Bool	False	Error = True: An error has occurred. For detailed information see Status parameter. Error is reset as soon as the error is corrected.
Status	Output	DWord	16#0	Status of the instruction: see description of Status parameter
DI	Output	Bool	False	Status of digital input. If an inversion of the digital input is configured, this parameter is inverted as well.
TimeStampRE	Output	LTime	LT#0ns	Time stamp: EdgeSel = 1: The last but one read-in time at which a positive edge was detected (if *multiple* positive edges have occurred). EdgeSel = 2: The last read-in time at which a falling edge was detected (if *multiple* falling edges have occurred). EdgeSel = 3; 4; 5: The last read-in time at which a falling edge was detected.
TimeStampFE	Output	LTime	LT#0ns	Time stamp: EdgeSel = 1: The last read-in time at which a positive edge was detected (if *multiple* positive edges have occurred). EdgeSel = 2: The last but one read-in time at which a falling edge was detected (if *multiple* falling edges have occurred). EdgeSel = 3; 4; 5: The last read-in time at which a positive edge was detected.
LEC	Output	UInt	0	Counter: Number of edges for which no time stamp could be saved. The module can count a maximum of seven edges during REQ. The counter is reset with the falling edge at REQ.
TIO_SYNC_Data*	InOut	"TIO_SYNC_Data"		System time provided for the TIO instructions of the TIO modules by the TIO_SYNC instruction. See UDT TIO_SYNC_Data (Page 47). Connect this input parameter with the "TIO_SYNC_Data" output parameter of the TIO_SYNC instruction.
Initialized	Static	Bool	False	Instruction is initialized and ready

* Checked once at startup of the CPU

Status parameter

Error codes or status information is output as double word at the Status output.

The double word is divided as follows:

Error code (DW#16#...)	Meaning
z0yywwww	Error of a system function: • during startup (z = 1) • during normal operation (z = 0) System functions with subordinate use are coded in yy: See table with error codes. wwww specifies the RET_VAL of the system function. The error information is available in the help for the system function.
z0yy0000	An error that does not originate in a system function. This error receives a consecutive error number yy. The error can occur: • during startup (z = 1) • during normal operation (z = 0)

Table with error codes

Error code (DW#16#...)	Meaning	Solution
00000000	No error.	—
10010000	The assigned number of the digital input at the Channel input parameter is outside the permitted range (depending on addressed module and channel configuration).	Correct the value at the Channel input parameter.
10020000	The TIO_DI_ONCE instruction is not called in an isochronous OB. The instruction can only be used without errors in an isochronous OB.	Make sure that TIO_DI_ONCE is called in a "Synchronous Cycle" or "MC-PostServo" OB.
10030000	An error occurred when reading the HWID input parameter.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
x0040000	The data in TIO_SYNC_Data is invalid/incorrect.	Check the TIO_SYNC instruction and the interconnection of its TIO_SYNC_Data output.
1005xxxx	An error has occurred during execution of the RD_SINFO system function. The low word xxxx displays the error information of the RET_VAL return value from RD_SINFO.	• Read the description of the RD_SINFO in the STEP 7 (TIA Portal) information system. • Make sure that TIO_DI_ONCE is called in a "Synchronous Cycle" or "MC-PostServo" OB.
10060000	No TIO module found. Possible cause: The module configured using the hardware identifier is not a TIO module.	• Make sure that the configured module is a TIO module. • Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration.
10070000	An internal error occurred during the address calculation.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.

Error code (DW#16#...)	Meaning	Solution
00080000	TIO module is not synchronized using the TIO_SYNC instruction. The error code can also indicate that: • A job was already present before the first run of the instruction. • The assigned number at the Channel input parameter is not a digital input.	Check the instruction TIO_SYNC.
10090000	The read cycle time of the isochronous OB is outside the permitted range of 0 < T_{APP} <= 16 ms and is therefore invalid. The instruction can only be used without errors in an isochronous OB.	• Correct the cycle time. • Make sure that TIO_DI_ONCE is called in a "Synchronous Cycle" or "MC-PostServo" OB.
100A0000	The time T_O of the TIO model stored in TIO_SYNC_Data is outside the permissible range of 0 < T_o <= 4 ms.	Check the instruction TIO_SYNC.
100Bxxxx	An error has occurred during execution of the RD_ADDR system function. The low word xxxx displays the error information of the RET_VAL return value from RD_ADDR.	Read the description of the RD_ADDR in the STEP 7 (TIA Portal) information system.
000C0000	The converted time stamp is invalid. Possible cause: Communication error	Check the communication with the TIO module.
000D0000	The Quality Information of the digital input indicates that an error has occurred at the digital input.	Check the supply voltage L+/1L+/2L+.
000E0000	The assigned number at the Channel input parameter is not a digital input configured as Timer DI.	• Check the channel configuration (only for TM Timer DIDQ 24x24V). • Check the operating mode of the digital input.
000F0000	The assigned value at the EdgeSel input parameter is outside the valid range of 1 to 5.	Correct the value at the EdgeSel input parameter.
10100000	The send clock is outside the permitted range of 0 < SendClock <= 4 ms and is therefore invalid. The error code can also indicate that • The data in TIO_SYNC_Data is invalid or does not exist. • The TIO_DI instruction is not called in an isochronous OB.	Correct the send clock.
x0130000	MC-Servo (OB91) is not isochronous to the bus cycle time.	Correct the value of the cycle time of the MC-Servo to the value of the bus cycle time. Note: Calling TIO instructions in an OB of the type "MC-PostServo" with reduction ratio "MC-Servo" can result in incorrect calculation of time stamps.
10140000	The configured value at the HWID input parameter is not present in the structure at the TIO_SYNC_Data parameter. The HWID and TIO_SYNC_Data parameters are not consistent.	Correct the value at the HWID input parameter or the structure at the TIO_SYNC_Data parameter.
x0FF0000	General internal error.	—

4.3.4 TIO_DQ: Output edges time-controlled at the digital output

Description

TIO_DQ enables a digital output of a TIO module to be switched at specified times.

Startup characteristics

During startup of the CPU, the instruction TIO_DQ applies the input parameters once and checks the following:

- Checking HWID
- Checking to see if the number of the digital input (Channel) is in the permitted range (depending on addressed module and channel configuration)
- Checking TIO_SYNC_Data.Error: Is an error present at TIO_SYNC?
- Checking TIO_SYNC_Data.TO_TIMES for plausibility (0 ms to 4 ms)
- Checking to see whether the OB is isochronous

If startup takes place without errors, the instruction changes to normal operation. The input parameters REQ, Out_Mode, TimeStampRE and TimeStampFE can be changed during normal operation. In the event of an error, the instruction does not change to normal operation and generates an error message.

Functional description

The instruction outputs edges time-controlled at a digital output during normal operation.

- At the time defined at the TimeStampRE input parameter, a positive edge is output at the digital output.
- At the time defined at the TimeStampFE input parameter, a falling edge is output at the digital output.

Depending on the program execution model, a time stamp must exceed the following value:

Program execution model	**TimeStampRE> ... TimeStampFE > ...**
IPO model	TIO_Time + T_{APP} + T_O
OIP model	TIO_Time + T_{APP} + SendClock + T_O

Use the input parameter Out_Mode to determine if only one edge or both edges are output.

You connect the input TIO_SYNC_Data with the output of the same name of the TIO_SYNC instruction. This ensures a shared time basis.

You start an output job with a positive edge at the REQ parameter. You can only start a new job when there is no error pending and no job is active. When the output job is started, the digital output is switched at the times defined with TimeStampRE and TimeStampFE.

- If the digital output is already set at time TimeStampRE, the output job is not transferred to the module for the positive edge.
- If the digital output is not set at time TimeStampFE, the output job is not transferred to the module for the negative edge.

This means the digital output is not switched in both cases.

The job is done when the last application cycle is executed before the second output time is reached (DONE). Status and Error are constantly being updated during the job runtime. You can cancel an active output job by changing TimeStampRE or TimeStampFE to an invalid time stamp, e.g. LT#5µs.

The figure below shows an example for the reaction of the bits DONE and BUSY at the start of an output job under the following conditions:

- Out_Mode = 2 (both edges are output)
- The two time stamps are not changed between the start of the job and the output.

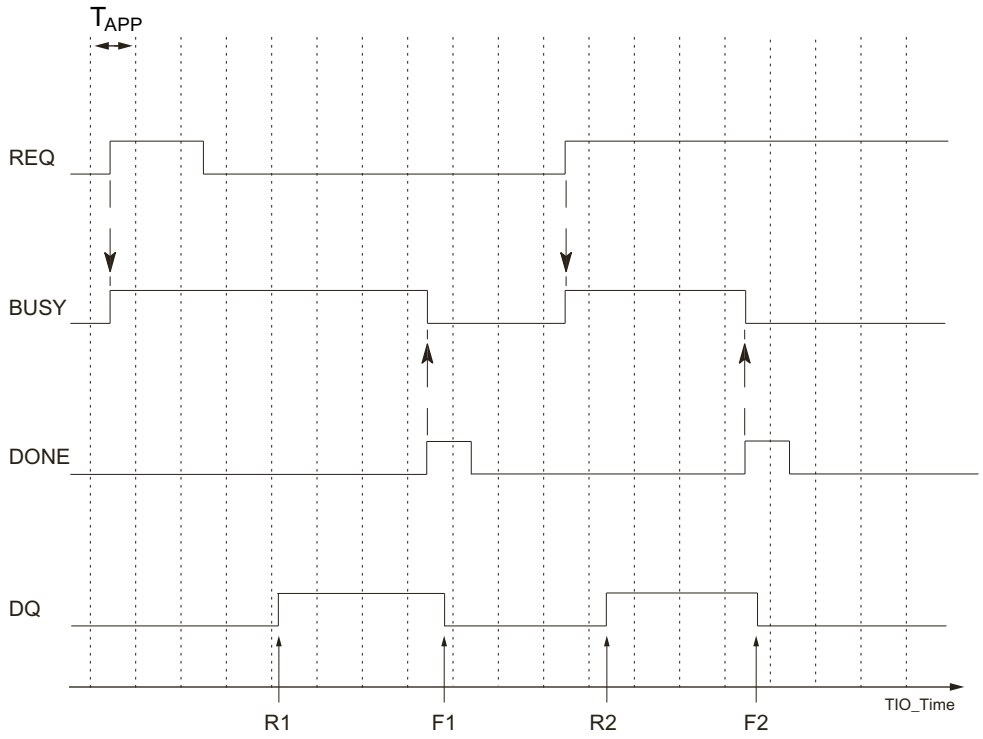

T_{APP}	Application cycle
R1, R2	Specified times of a positive DQ edge
F1, F2	Specified times of a falling DQ edge

NOTE

Once the job has been started with a positive edge at REQ, you can change the output times with a new input of TimeStampRE and TimeStampFE without having to restart the job.

Constraint:

If a changed time stamp is less than two application cycles before the output time (TimeStampRE - TIO_Time < 2*T_{APP} or TimeStampFE - TIO_Time < 2*T_{APP}), it is not taken into consideration. In this case, the last valid time stamp is used because it was already transferred to the TIO module.

NOTE

If you specify the same value for TimeStampRE and TimeStampFE, the instruction ignores the job and does not output an edge.

If you specify the value 0 for TimeStampRE or TimeStampFE, you can output the respective edge directly at the digital output with the input parameter Out_Mode = 3. This gives you the option to implement a direct control from the TIO module without time stamp in manual mode. You can use the direct control to interrupt an ongoing job.

Reaction to error

The Error output indicates if the instruction was processed correctly. In the event of an error, the cause of the error is displayed at the Status output.

Parameter

The table below shows the parameters of the TIO_DQ instruction.

Parameter	Declaration in library version		Data type	Default	Description
	< V2.0	≥ V2.0	S7-1500		
REQ	Input		Bool	False	Starts the job at a positive edge.
HWID*	Input		HW_IO	0	Hardware identifier for TIO module from hardware configuration
Channel*	Input		UInt	0	Number (0 ... m) of the digital output of the connected TIO module
Out_Mode	Input		UInt	2	Specify the output mode for the edges at the digital output: 0: Only rising edge is output (TimeStampRE). 1: Only falling edge is output (TimeStampFE). 2: Both edges are output (TimeStampRE and TimeStampFE). 3: Each edge is output directly if TimeStampRE = 0 or TimeStampFE = 0 If both time stamps have the value "0" or if no time stamp has the value "0", no edge is output. 4 to 255: Invalid
TimeStampRE	Input		LTime	LT#0ns	Time stamp: Time when a positive edge is to be output.
TimeStampFE	Input		LTime	LT#0ns	Time stamp: Time when a falling edge is to be output.
StatusDQ	Output		Bool	False	Actual status of the digital output. If an inversion of the digital output is configured, StatusDQ is inverted as well. StatusDQ shows the internal state of the digital output independent of the effect of any configured HW enable.
DONE	Output		Bool	False	DONE = True is displayed for one cycle: The job was completed without errors.
BUSY	Output		Bool	False	BUSY = True: The job has not yet been completed.
Error	Output		Bool	False	Error = True: An error has occurred. In this case, BUSY and DONE are set to False. For detailed information see Status parameter. Error is reset as soon as the error is corrected.
Status	Output		DWord	16#0	Status of the instruction: see description of Status parameter
TIO_SYNC_Data*	Input	InOut	"TIO_SYNC_Data"		System time provided for the TIO instructions of the TIO modules by the TIO_SYNC instruction. See UDT TIO_SYNC_Data (Page 47). Connect this parameter with the TIO_SYNC_Data output parameter of the TIO_SYNC instruction.

* Checked once at startup of the CPU

Status parameter

Error codes or status information is output as double word at the Status output.

The double word is divided as follows:

Error code (DW#16#...)	Meaning
z0yywwww	Error of a system function: • during startup (z = 1) • during normal operation (z = 0) System functions with subordinate use are coded in yy: See table with error codes. wwww specifies the RET_VAL of the system function. The error information is available in the help for the system function.
z0yy0000	An error that does not originate in a system function. This error receives a consecutive error number yy. The error can occur: • during startup (z = 1) • during normal operation (z = 0)

Table with error codes

Error code (DW#16#...)	Meaning	Solution
00000000	No error.	—
10010000	The assigned number of the digital output at the Channel input parameter is outside the permitted range (depending on addressed module and channel configuration).	Correct the value at the Channel input parameter.
10020000	The TIO_DQ instruction is not called in an isochronous OB. The instruction can only be used without errors in an isochronous OB.	Make sure that TIO_DQ is called in an OB of the type "Synchronous Cycle" or "MC-PostServo".
10030000	An error occurred when reading the HWID input parameter.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.
x0040000	The data in TIO_SYNC_Data is invalid/incorrect.	Check the TIO_SYNC instruction and the interconnection of its TIO_SYNC_Data output.
1005xxxx	An error has occurred during execution of the RD_SINFO system function. The low word xxxx displays the error information of the RET_VAL return value from RD_SINFO.	• Read the description of the RD_SINFO in the STEP 7 (TIA Portal) information system. • Make sure that TIO_DQ is called in a "Synchronous Cycle" or "MC-PostServo" OB.
10060000	No TIO module found. Possible cause: The module configured using the hardware identifier is not a TIO module.	• Make sure that the configured module is a TIO module. • Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration.
10070000	An internal error occurred during the address calculation.	Check the value at the HWID input parameter. Specify the hardware identifier of the TIO module from its module properties in the hardware configuration. An internal system constant of data type Hw_SubModule is available for the symbolic addressing.

Error code (DW#16#...)	Meaning	Solution
x0080000	TIO module is not synchronized using the TIO_SYNC instruction. The error code can also indicate that: • A job was already present before the first run of the instruction. • The assigned number at the Channel input parameter is not a digital output.	Check the instruction TIO_SYNC.
10090000	The read cycle time of the isochronous OB is LT#0ms or has as negative value and is therefore invalid. Correct the value. The instruction can only be used without errors in an isochronous OB.	• Correct the cycle time. • Make sure that TIO_DQ is called in a "Synchronous Cycle" or "MC-PostServo" OB.
100A0000	The time T_O of the TIO model stored in TIO_SYNC_Data is outside the permissible range of $0 < T_o <= 4$ ms.	Check the instruction TIO_SYNC.
100Bxxxx	An error has occurred during execution of the RD_ADDR system function. The low word xxxx displays the error information of the RET_VAL return value from RD_ADDR.	Read the description of the RD_ADDR in the STEP 7 (TIA Portal) information system.
000C0000	One or both time stamps at the TimeStampRE and TimeStampFE input parameters are invalid. The error is only signaled for the duration of one application cycle.	Check the TimeStampRE and TimeStampFE input parameters.
000D0000	The Quality Information of the digital output indicates that an error has occurred at the digital output.	• Check the parameter assignment of the digital output. • Check the supply voltage L+/1L+/2L+. • Check the wiring of the digital output for short-circuit, overload, and overtemperature.
000E0000	The number configured at the Channel input parameter is not a digital output configured as Timer DQ.	• Check the channel configuration (only for TM Timer DIDQ 24x24V). • Check the operating mode of the digital output.
100F0000	The read cycle time of the OB of type "Synchronous Cycle" is too long: $T_{APP} > 16$ ms.	Configure a smaller multiple of the send clock as the cycle time.
10100000	The send clock is outside the permitted range of 0 < SEND_CLOCK <= 4 ms and is therefore invalid. The error code can also indicate that • The data in TIO_SYNC_Data is invalid or does not exist. • The TIO_DQ instruction is not called in an isochronous OB.	Correct the send clock.
00110000	The assigned value at the Out_Mode input parameter is outside the valid range of 0 to 3.	Correct the value at the Out_Mode input parameter.
x0130000	MC-Servo (OB91) is not isochronous to the bus cycle time.	Correct the value of the cycle time of the MC-Servo to the value of the bus cycle time. Note: Calling TIO instructions in an OB of the type "MC-PostServo" with reduction ratio "MC-Servo" can result in incorrect calculation of time stamps.
10140000	The configured value at the HWID input parameter is not present in the structure at the TIO_SYNC_Data parameter. The HWID and TIO_SYNC_Data parameters are not consistent.	Correct the value at the HWID input parameter or the structure at the TIO_SYNC_Data parameter.
x0FF0000	General internal error.	—

4.3.5 UDT TIO_SYNC_Data

Description

The data type UDT TIO_SYNC_Data contains the central structure and data for synchronization of the modules and passing of the TIO_Time.

Parameter

Parameter	Data type	Description
	S7-1500	
TIO_TIME	LTime	Shared time basis (relative time) of the TIO modules
PIP_MODE	USInt	Mode for data update (is forwarded by the PIP_Mode input parameter of the TIO_SYNC instruction)
APP_CYC	LTime	Application cycle of the "MC-PostServo" or "Synchronous Cycle", "MC-PreServo" OB
SEND_CLOCK	LTime	Send clock of sync domain (is forwarded by the SendClock parameter of the TIO_SYNC instruction)
SYNC_MODULES	HW_IO array [1...8]	Hardware identifiers of the TIO modules from hardware configuration
TO_TIMES	UDInt-Array [1...8]	T_O for each TIO module:
TIO_TIME_BASE	LTime	Internal use
TBASE	LTime	
ERROR	Bool	